

# **GEM 80/310 Series**

## Technical Manual

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**GEM80/310 SERIES TECHNICAL MANUAL**

**T1438 Issue 2 06/91**

Please incorporate the following amendment:-

Page 170, Section 17.5, Line 23

Delete 82030/111

Insert 82030/153

Please retain this errata sheet with the document for reference.



**GEM80/310 SERIES TECHNICAL MANUAL****T1438      Issue 2      06/91**

Please incorporate the following amendment:-

**Page 7**

Insert new Section 1.7 and 1.7.1 attached

**Page iii**

Add new Section 1.7 and 1.7.1 references to the CONTENTS

**Page 33, Section 5.4.5**

Insert a Note as follows immediately below the heading:-

Note...      In the event of F-tables being set, the associated input drops to zero and the associated outputs freeze. It is the user's responsibility to take any necessary action within the program to ensure safe plant operation under these conditions.

**Page 89, Table 10.1 continued, Numerical Tests**

Delete the item 'Array Sort' completely

Please retain this Errata Sheet with the document for reference.



## 1.7 Radio Frequency Interference (RFI)

This section is intended as a guide for users who wish to operate CEGELEC Industrial Controls electronic products in the vicinity of a radio transmitter. The transmitter may be of the static or the hand-held portable type. Unrestricted use of a transmitting device could result in a malfunction of the equipment. This in turn could cause a breakdown of plant equipment and injury to personnel. CEGELEC products are designed to function satisfactorily within a RFI field strength of 10V/m over a frequency range of 30MHz to 1GHz.

### 1.7.1 Transmitter Output

The field strength generated by a radio transmitter, received at a point 'p' in free space, is a function of the power output of the transmitter and the distance from the transmitter aerial.

$$E = \sqrt{\frac{377 P_t}{4 \pi r^2}} \quad \text{or} \quad r = \frac{5.5}{E} \sqrt{P_t}$$

where  $E$  = Field strength at point 'p', in Volts per metre (V/m).

$P_t$  = Power output of the transmitter, in Watts.

$r$  = Distance of point 'p' from the transmitter, in metres.

**Note...** At two metres, the power required to give a field strength of 10V/m is 13 Watts.

The following assumptions have been made in the formula above:-

1. The antenna gain is unity.
2. The antenna is isotropic.
3. The Transmitter and the products are in free space.
4. Far field conditions exist where the wave impedance is 377 ohms.
5. In the near field, both the electric and the magnetic components of the field must be considered. Calculations based on the formula above which result in distances less than two metres are incorrect.

Using the formula above, the distance between the transmitter and the equipment should be calculated and must never be less than two metres.



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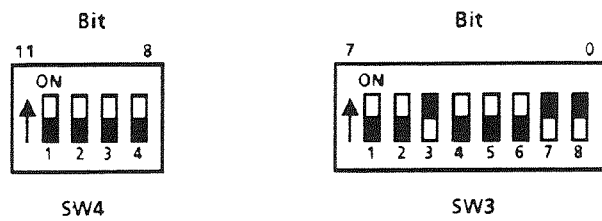
T1438 Issue 2 06/91

Please incorporate the following amendment:-

Page 32, Figure 5.3

Delete the figure

Insert the new figure below:-



Please retain this Errata Sheet with the document for reference.



## 1 DESCRIPTION

The new 160 and 310 Enhanced Controllers replace the existing 164/5/6 and 310 Controllers and incorporate all the features of those controllers. The new controllers contain an Enhanced Ladder Processor type 8235 which replaces the 8211 Ladder Processor. This new Ladder Processor can execute the ladder program 2 to 3 times faster than the 8211 Ladder Processor.

The new ladder processor has a object code capacity of 311 Kbytes which is resident on-board.

## 2 FEATURES

311 Kbytes of object RAM

High-speed floating point mathematics

Increased data table capacity

Increased source code (user instructions) capacity

Single width IMAGEM and STARNET

## 3 SPECIFICATION

### 3.1 RAM capacity

Object code capacity is increased to 311 Kbytes of onboard RAM. This is equivalent to a maximum of approximately 52,000 User Instructions (at an average of 6 bytes per instruction), an increase in capacity of 15,000 User Instructions.

| Memory allocation                    | 160 Series |        | 310 Series |        |
|--------------------------------------|------------|--------|------------|--------|
|                                      | 256K       | 512K   | 256K       | 512K   |
| Compiled code                        | 311K       | 311K   | 311K       | 311K   |
| Source code                          | 56K        | 184K   | 56K        | 184K   |
| Source/Data                          | 64K        | 64K    | 64K        | 64K    |
| Offline                              | 0K         | 64K    | 0K *       | 0K *   |
| Video                                | 64K        | 128K   | 64K *      | 64K *  |
| Instructions 20K data tables         | 20,000     | 50,000 | 20,000     | 50,000 |
| Spare 64K Blocks (for Video/Offline) | 0          | 0      | 0          | 2      |

The controllers come with 256K RAM as standard and can be increased to 512K by ordering an extra RAM module 8272-4024.

\* The 310 controller can also be fitted with extra offline and video RAM (Contractually ordered).



### 3.2 Maths functions

An 80C187 floating point co-processor is fitted for high-speed floating point maths performance.

### 3.3 Instruction Times

**Table 1-1 Instruction Timing Examples**

| INSTRUCTION       | TIMING      | INSTRUCTION               | TIMING       |
|-------------------|-------------|---------------------------|--------------|
| AND with constant | 0.4 $\mu$ s | ADD with constant         | 9.3 $\mu$ s  |
| AND with table    | 2.1 $\mu$ s | ADD with table            | 12.2 $\mu$ s |
| OR                | 2.1 $\mu$ s | SUB with constant         | 9.2 $\mu$ s  |
| INV               | 0.3 $\mu$ s | SUB with table            | 10.6 $\mu$ s |
| -] [-             | 2.6 $\mu$ s | COUNT                     | 12.0 $\mu$ s |
| -]/[-             | 2.6 $\mu$ s | DELAY with constant value | 10.0 $\mu$ s |
| -( )-             | 4.3 $\mu$ s | DELAY with table value    | 14.6 $\mu$ s |
| -<OUT>-           | 2.3 $\mu$ s | SEQR                      | 10.2 $\mu$ s |

### 3.4 Central Highway Modules

The 160 controller can accept any 1 of the following 3 modules:-

Single width IMAGEM 8284-4001 (fits in slot to the left of the 8285)

Single width STARNET 8268-4101 (fits in slot to the right of the 9285)

Double width GEMLAN\_D 8279-4001 (fits in slot to the right of the 9285)

The 310 controller can also be fitted with any combination of second I/O Processor, extra RAM modules and the above to a maximum of 6 extra processors or to the maximum capacity of central highway slots, which is:-

3 slots for the 311

7 slots for the 312

14 slots for the 313

## 4 APPLICATION NOTES

**4.1** Object RAM is not battery backed nor is it possible for object RAM to be blown into EPROM, instead the user program, P Tables and (if specified by the user in the normal way) off-line data are blown into EPROM with the object code being re-generated whenever a recompile or run command is issued.

**4.2** The E7 and E8 timers now have a resolution of 1mS.

**4.3** The data table capacity has been increased by moving the editor messages out of the data table RAM. This memory is also used for storing source code and there is a movable boundary between the 2 areas. This gives 64K additional memory for source code and messages.

**4.4** In order for existing versions of IMAGEM to be able to access the editor messages the IMAGEM firmware must be upgraded to 76301/114/4565-4568 issue C or later.

**!** Note: the X[0] construct giving the base address of the strings must be used when accessing editor messages. Programming 'tricks' attempting to speed up access to the messages by using the equivalent P Table address are no longer supported.

**4.4** When a user program is downloaded to the GEM80 it is possible that the program may contain null messages at the end of the P Table. If this condition occurs then the GEM80 will remove the null messages either when the messages are edited or when a recompile occurs.

If this causes differences to occur when the user program is verified then the program in the system programmer can be brought into line with the program in the GEM80 by entering a message in the programmer with a message number greater than the last defined message.

**4.5** The Data Table S1 is reserved for system use and should not be written to.

## **5 ORDERING CODES**

|                                             |   |           |
|---------------------------------------------|---|-----------|
| GEM80/160 Controller 256K (ac power supply) | : | 8870-4461 |
| GEM80/160 Controller 256K (dc power supply) | : | 8870-4462 |
| GEM80/311 Controller 256K (ac power supply) | : | 8870-4859 |
| GEM80/311 Controller 256K (dc power supply) | : | 8870-4860 |
| GEM80/312 Controller 256K (ac power supply) | : | 8870-4869 |
| GEM80/312 Controller 256K (dc power supply) | : | 8870-4870 |
| GEM80/313 Controller 256K (ac power supply) | : | 8870-4879 |
| GEM80/313 Controller 256K (dc power supply) | : | 8870-4829 |

For upgrades from standard to enhanced systems please contact GEM80 Customer Support.

Table (i) Skill Grades

| SKILL<br>GRADE | JOB DESCRIPTIONS                                                                                                                                                        |          |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|                | Proposed by                                                                                                                                                             |          |
|                | Supplier                                                                                                                                                                | Customer |
| A              | Operating and Maintenance Staff with NO Electrical Knowledge.                                                                                                           |          |
| B              | Operating and Maintenance Staff (Electrical Fitter, Wireman) with some electrical knowledge; not permitted to work on live apparatus.                                   |          |
| C              | Authorised and Competent Staff (Electrician, Commissioning Engineer) with high degree of expertise: Trained to work on live apparatus: Fully conversant with apparatus. |          |

## GRADE/TASK/SKILL SCHEDULE FOR ELECTRICAL APPARATUS.

Table (ii) shows the operator skill grade required to carry out a specified task, on apparatus described in this manual.

Table (ii) Operator Skill Grade.

| Ref. | APPARATUS GRADE                                                                                                                   | ISOLATION                                     | NO POWER                                                      | REQUIRES POWER                      |                                                 |
|------|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------------------------------|-------------------------------------|-------------------------------------------------|
|      | Description                                                                                                                       | Carried out by                                | Setting, Cleaning, Adjusting, Routine Maintenance & Servicing | Setting, Adjusting, Routine Testing | Troubleshooting, Special Testing, Commissioning |
| 1    | Simple 100% isolation. Requires no electrical knowledge to isolate.                                                               | A, B, C                                       | B, C                                                          | C                                   | C                                               |
| 2    | Simple 100% isolation. Requires some electrical knowledge to isolate.                                                             | B, C                                          | B, C                                                          | C                                   | C                                               |
| 3a   | 100% isolation possible. Requires Expertise, Training, etc. and knowledge of the apparatus.                                       | C                                             | B, C                                                          | C                                   | C                                               |
| 3b   |                                                                                                                                   | C                                             | C                                                             | C                                   | C                                               |
| 4    | 100% isolation not possible because:- Impracticable, Unreasonable, Undesirable                                                    | C                                             | C                                                             | C                                   | C                                               |
| 5    | Apparatus supplied as loose items, chassis, etc., for which the customer is responsible for wiring, assembly, etc., (see Para.6). | Grade of skill cannot be defined by supplier. |                                                               |                                     |                                                 |

## 1. Compliance with Instructions in this manual

The purchaser should comply with the instructions and information in this manual and all personnel to be associated with the apparatus under this contract should be made familiar with the information contained herein. The user should note that the requirements of this Foreword apply only to the apparatus supplied for installation and use in the United Kingdom (U.K.) and which are therefore subject to the U.K. Health and Safety at Work Act, 1974 and Amendments of 1987, but provide prudent safety guidelines for users outside the U.K.

The user should note any local or national safety precautions that are to be taken.

The equipment has been designed to operate in an industrial environment, the details of which are given within this manual. Care must be observed that these conditions are maintained at all times and your attention is particularly drawn to the electromagnetic emission and susceptibility conditions, and the protection of the enclosure, which will be changed when covers are removed and enclosure doors are open.

## 2. Guidance Notes for Users on the Safety of Personnel using Electrical Apparatus.

The above Act stipulates that electrical apparatus shall be designed, tested and installed to be safe and without risk to health when properly used and that information is provided on the conditions necessary for safety and on any hazards which could arise during normal use and how these are to be avoided...See Section 6 of HSAWA.

The above Act stipulates that the User, on his part, shall ensure that his employees are informed, trained and supervised and use proper working procedures to ensure their safety. He is advised to comply with the information provided in order to maintain the plant in a safe condition...See Section 2 of HSAWA.

Compliance with these two basic requirements ensures that under normal healthy plant operating conditions, the apparatus will be safe for use by electrically unskilled operators.

With certain categories of apparatus as identified later in this Section, safety hazards may arise when it is necessary to gain access by opening enclosures, removing covers, etc., in order to carry out maintenance work, testing, setting-up, etc. This is especially the case when the apparatus cannot be completely isolated before working on it, as, for example, where circuits must be energised for the purpose of carrying out electrical tests.

As it is often impracticable or impossible to achieve hazard free conditions when working with energised circuits, the main burden of responsibility for the safe conduct of those carrying out the work rests on those under whose authority they act...See Section 2 of HSAWA.

## 3. Installation, Operation and Maintenance.

The Purchaser is advised to ensure that the apparatus supplied by the Company to the purchaser's order is correctly installed, in a suitable location, by technically qualified and competent persons experienced in the class of work involved.

The rules for ensuring the safety of personnel can be summarised under the following headings.

### 3.1 During Normal Use

Ensure that the plant operators:-

Are fully conversant with all controls, particularly those for emergency shut down.

Comply with safety warning notices and keep all enclosures shut.

Are trained to recognise signs of maloperation and know what action to take in the event of trouble or difficulty.

### 3.2 During Maintenance and Testing or Other Work involving Electrical Competence.

Ensure that only suitably skilled persons are permitted to carry out work and that they:-

Isolate the apparatus completely, wherever possible, before opening enclosures and starting work.

Comply with safe working procedures.

Are conversant with the information provided, particularly on measures relating to their safety.

Recognise the hazards which can arise when working on energised apparatus and take all the necessary precautions.

## 4. Voltages greater than 650V.

The purchaser's attention is drawn to the Electricity Regulations (Factories Act 1961) Ref.18d, in relation to work done on any apparatus of nominal voltage greater than 650V.

## 5. Access to the apparatus described in this Manual.

The apparatus is allocated:-

GRADE REFERENCE : 3a (Cubicle Mounted) : 5 (Loose Items)

referring to the GRADE/TASK/SKILL GRADE Schedule of this Foreword.

### Note

The grade reference applies only to that apparatus covered by this manual and not access to other products/apparatus which may be linked to it as part of a comprehensive installation.

Table (i) describes SKILL GRADES of the Jobs referred to in the GRADE/TASK/SKILL SCHEDULE.

## 6. Apparatus supplied as loose items, chassis, etc.

The apparatus supplied has been designed in accordance with the relevant Standards to operate at its designed rating and under normal accepted good practice; however, where the apparatus is supplied as "loose items" and energised, it could constitute a safety hazard. Since the customer will be arranging for the mounting, wiring and assembly of the apparatus into a structure or enclosure, the ultimate responsibility to conform with the HSAWA will rest with the Customer or associated sub-contractor.

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## 1.1 Manual Overview

### 1.1.1 Introduction

This manual describes the operation, installation and maintenance of the GEM 80/310 series of Controllers. It is intended to be used by qualified Technical Personnel engaged in operating and maintaining plant controlled by GEM 80 equipment.

### 1.1.2 General Information

A Programmable Controller (PC) is a solid state electronic device designed to interact with the industrial environment. It employs an easily programmable memory for the internal storage of instructions which can implement many functions including relay logic replacement, arithmetic and data manipulation. These functions control Machines and Processes by way of the Controller's analog or digital input/output modules which interface with either locally or remotely located plant equipment. The more powerful PCs can provide Process Management information; drive printers, visual displays and colour monitors; control other PCs; be part of Local Area Networks and yet still offer the simplest relay replacement function.

GEM 80 Controllers have been successfully installed in many countries, in industries as diverse as Automotive, Mining, Electricity Generation, Water Treatment, Food, Oil, Gas and Steel.

A typical GEM 80 controlled system is illustrated in Figure 1.4. The Controller communicates with System and Plant components in a variety of ways including ribbon cable highways, serial communication links, programmer connection ports and video processor outputs. Safety in a fault situation is provided by the Watchdog contacts.

To make a working system it is necessary to:

- (1) Select a Controller.
- (2) Select I/O equipment.
- (3) Select Video equipment.
- (4) Mount and wire the equipment and connect plant services and output devices to I/O.
- (5) Hard-wire watchdog and safety circuits.
- (6) Connect a programmer and enter a program.

This manual details how such a system can be achieved and includes fault finding, maintenance and spares information.

Before handling the GEM 80 your attention is drawn to Section 18, Safety and Handling Information.

## 1.2 GEM 80/310 Range

### 1.2.1 Description

These Controllers offer up to 32,768 I/O points and 4 serial links. Four standard memory options are available, 192K, 256K, 384K or 512K.

They can handle analog I/O and digital I/O, and the flexible structure of GEM 80 allows interface to a wide range of plant equipment.

Though these controllers can be operated in the stand-alone mode, they also operate in distributed controller schemes with data interchange through serial communication links for supervisory or co-ordinated operations.

The GEM 80/310 series are user-programmable in GEM 80 Control Language using either a System Programmer or a Portable Programmer, and are compatible with the whole GEM 80 family.

### 1.2.2 Specification Summary

#### I/O

Verification I/O. - 1,024 words

Basic I/O. - up to 2,048 I/O points can be converted from the Verification I/O Highway using 4 Expanders.

Both quantities can be doubled by adding a second (slave) I/O Processor and Expanders.

Remote I/O. - See Remote I/O Verification User Information, Publication No.T463.

Fast I/O - Up to 32 slots are available for Fast I/O modules.

#### Communication

One Programming Port per I/O Processor.

Built-in serial ports - Two per I/O Processor.

STARNET See User Information. Publication No.T464.

CORONET See User Information. Publication No.T465.

#### Memory

See Table 10.3 for Memory Allocation.

#### Instructions

|        |                     |
|--------|---------------------|
| 192K - | 5,000 instructions  |
| 256K - | 12,000 instructions |
| 384K - | 24,000 instructions |
| 512K - | 37,000 instructions |

Memory support - battery or EPROM

Data logging - up to 1Mbyte off-line RAM for data storage including 512K bytes for additional video formats.

# 1. INTRODUCTION

## Program

Typical execution time - 5ms/1,000 instructions  
Format - GEM 80 rung ladder diagram

## Video

Video processors - up to 4 IMAGEMS  
Video memory - 32K expandable to 544K

## Power Requirements

Input Voltage  
: 88-264V a.c. 45-63Hz  
: 88-250V d.c.  
OR  
: 19-60V d.c. only

Each Power Module consumes less than 360W.

## Environment

Operating Temperature 0 to +60°C  
Storage Temperature -20 to +70°C  
Humidity 5 to 95% RH non-condensing

## Mounting

19 inch (482mm) rack mounting

## Additional Facilities

- (1) Floating point mathematics.
- (2) On-line program changes.
- (3) Remote programming from serial links.
- (4) Built-in text editor for generation of printer port messages.
- (5) Flexible data table sizes.
- (6) Built-in clock for time and date.
- (7) Comprehensive monitoring supported by diagnostic messages.
- (8) Transfer of user program and pre-set data to EPROM.

### 1.2.3 GEM 80/310 Models

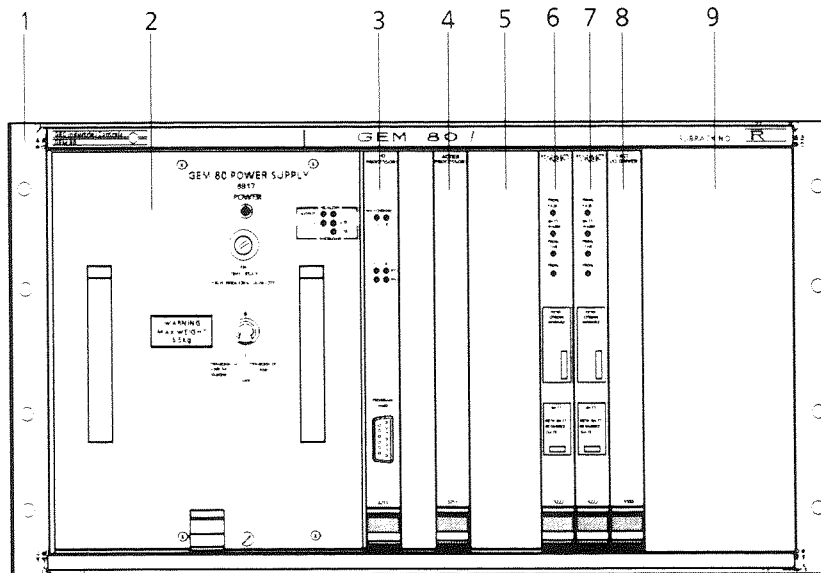
The GEM 80/310 series range consists of three models, GEM 80/311, GEM 80/312 and the GEM 80/313. These models are detailed in the following sections.

### 1.2.4 Hardware Layout

The basic controller hardware layouts are shown in Figures 1.1, 1.2 and 1.3.

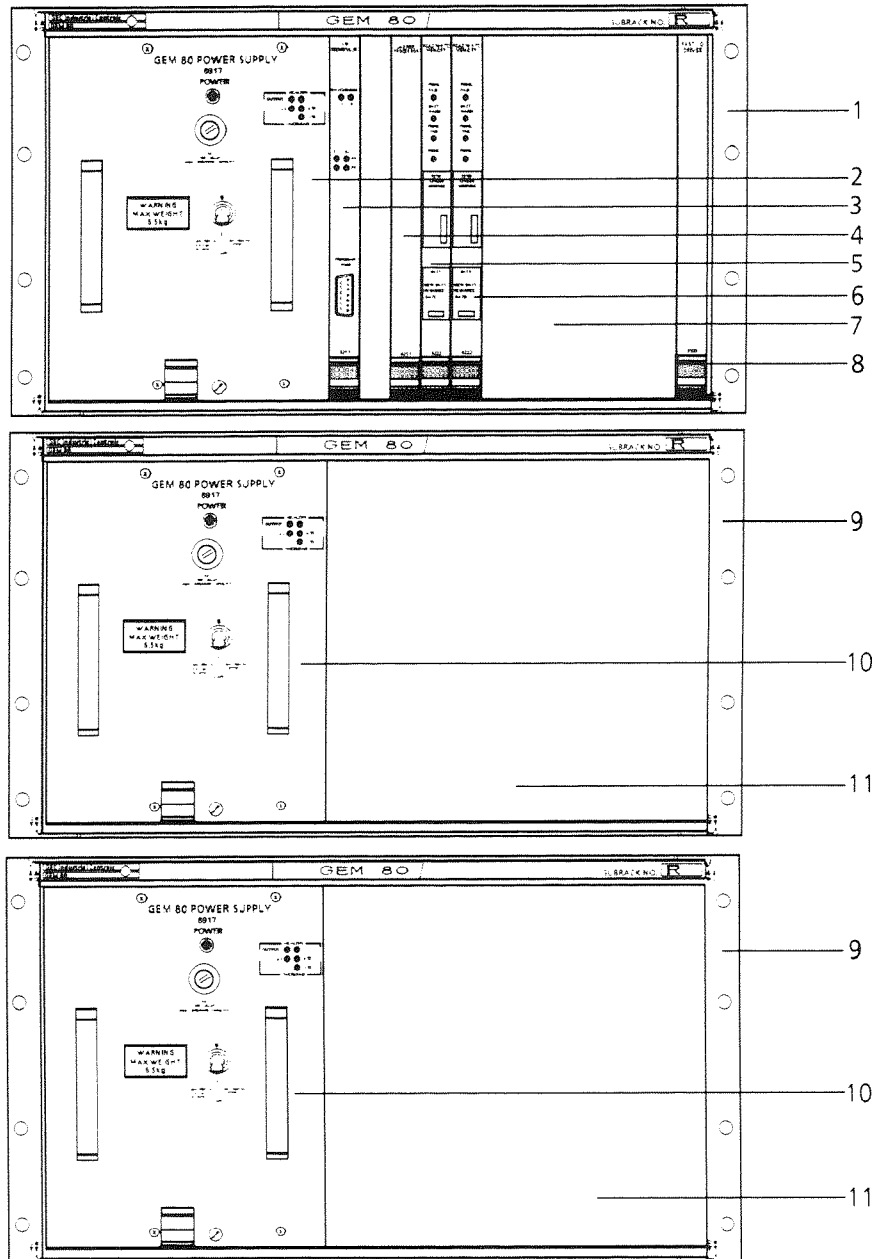
These figures show one I/O processor fitted. Each controller consists of a subrack, or subracks, with power modules, processor modules and memory modules. In a system where Fast I/O equipment is not needed, the Fast I/O subracks are not required and the Fast I/O driver must not be fitted.

**Note...** A Spacer, not shown in the following subrack and system illustrations, is fitted to the bottom of all subracks as shown in Figure 12.1.



- |                                                                                                  |                                                           |
|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| 1. Subrack                                                                                       | 6. Read/Write Memory Module on 384K or 512K option        |
| 2. Power Module                                                                                  | space with 192K and 256K options                          |
| 3. I/O Processor (Master)                                                                        | 7. Read/Write Memory Module                               |
| 4. Ladder Processor                                                                              | 8. Optional Fast I/O driver                               |
| 5. Space for either a 2nd I/O Processor, IMAGEM,<br>STARNET or 2 extra Read/Write Memory Modules | 9. 4 single-width spaces for optional Fast I/O<br>modules |

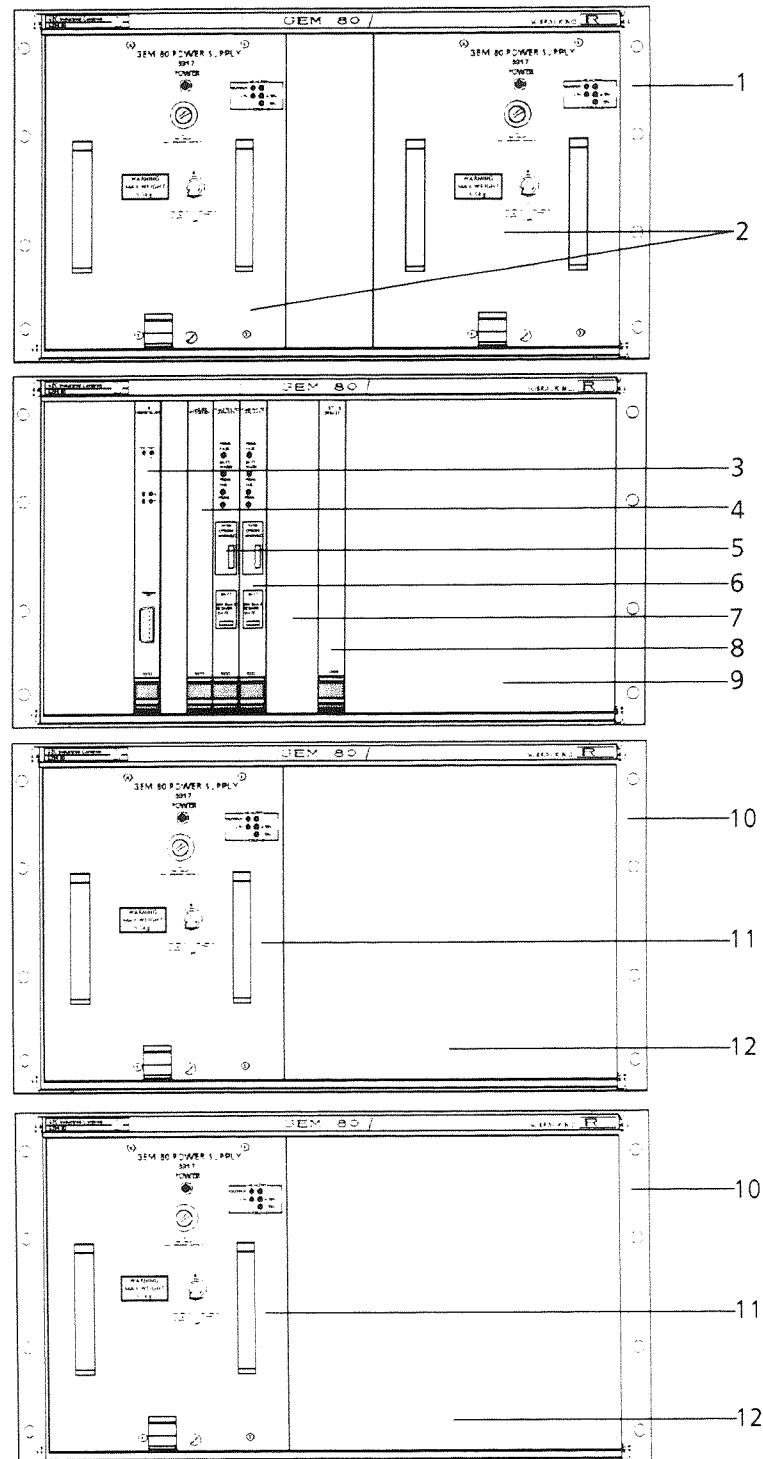
Figure 1.1 - GEM 80/311 Hardware Layout



- |                                                                                        |                                                                                                             |
|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| 1. Subrack                                                                             | 7. Six spaces for STARNET, IMAGEM, 2nd I/O processor or memory modules                                      |
| 2. Power Module                                                                        | 8. Optional Fast I/O driver                                                                                 |
| 3. I/O Processor (Master)                                                              | 9. Optional Fast I/O subrack                                                                                |
| 4. Ladder Processor                                                                    | 10. Optional Power Module                                                                                   |
| 5. Read/Write Memory module                                                            | 11. Space for additional Fast I/O modules. Up to 12 single-width Fast I/O modules when power module fitted. |
| 6. Read/Write Memory module on 384K or 512K options, space with 192K and 256K options. |                                                                                                             |

Figure 1.2 - GEM 80/312 Hardware Layout

# 1. INTRODUCTION



- |    |                                                  |     |                                                                                                                                                                                                                                                  |
|----|--------------------------------------------------|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. | Subrack                                          | 8.  | Optional Fast I/O driver                                                                                                                                                                                                                         |
| 2. | Power Modules                                    | 9.  | Eleven spaces for 2nd I/O processor, STARNET, IMAGEM or memory. 2nd I/O Processor, if fitted, must be fitted in slots 11 and 12. Slot 19 can only be used for memory. (Note: 2nd I/O processor occupies 2 spaces, memory modules occupy 1 space) |
| 3. | I/O Processor (Master)                           | 10. | Optional Fast I/O subrack                                                                                                                                                                                                                        |
| 4. | Ladder Processor                                 | 11. | Optional Power Module                                                                                                                                                                                                                            |
| 5. | Read/Write Memory Module                         | 12. | Space for optional Fast I/O Modules                                                                                                                                                                                                              |
| 6. | Read/Write Memory Module                         |     |                                                                                                                                                                                                                                                  |
| 7. | Two spaces for STARNET, IMAGEM or Memory Modules |     |                                                                                                                                                                                                                                                  |

Figure 1.3 - GEM 80/313 Hardware Layout

### 1.2.5 GEM 80/310 Options

The basic configurations shown in Section 1.2.4 have spaces available for I/O processors, IMAGEM, STARNET, video memory and Fast I/O modules. Table 1.1 shows the maximum capacities available for each controller with each combination.

It can be seen from Table 1.1 that the GEM 80/312 has extensive video and Fast I/O facilities. GEM 80/313 is an extremely powerful controller with a very large capacity and is well suited to supervisory, video or logging applications. GEM 80/311 on the other hand does not have as large a video or Fast I/O capacity but offers all the advantages of 310 series controllers.

Table 1.1 - Controller Maximum Capacities

|                                                 | GEM 80/311 |   |       | GEM 80/312 |    |   |       |   |   |   | GEM 80/313 |    |   |   |    |       |   |   |   |   |
|-------------------------------------------------|------------|---|-------|------------|----|---|-------|---|---|---|------------|----|---|---|----|-------|---|---|---|---|
| Number of I/O Processors                        | 1          |   | 2     | 1          |    |   | 2     |   |   |   | 1          |    |   |   |    | 2     |   |   |   |   |
| Number of IMAGEM modules accomodated            | 1          | 0 | 0     | 3          | 2  | 1 | 0     | 2 | 1 | 0 | 4          | 3  | 2 | 1 | 0  | 4     | 3 | 2 | 1 | 0 |
| Number of STARNET modules accomodated           | 0          | 1 | 0     | 0          | 1  | 2 | 3     | 0 | 1 | 2 | 1          | 2  | 3 | 4 | 5  | 0     | 1 | 2 | 3 | 4 |
| Max. number of I/O points                       | 16384      |   | 32768 | 16384      |    |   | 32768 |   |   |   | 160384     |    |   |   |    | 32768 |   |   |   |   |
| Number of serial communication ports            | 2          |   | 4     | 2          |    |   | 4     |   |   |   | 2          |    |   |   |    | 4     |   |   |   |   |
| Number of subracks (without fast I/O equipment) | 1          |   |       | 1          |    |   |       |   |   |   | 2          |    |   |   |    |       |   |   |   |   |
| Number of fast I/O subracks                     | 0          |   |       | 0          | 1  |   | 2     |   |   | 0 |            | 1  |   |   | 2  |       |   |   |   |   |
| Max number of slots for fast I/O equipment      | 4          |   |       | 0          | 12 |   | 24    |   |   | 0 |            | 12 |   |   | 24 |       |   |   |   |   |
| Number of power supplies                        | 1          |   |       | 1          | 2  |   | 3     |   |   | 2 |            | 3  |   |   | 4  |       |   |   |   |   |

### 1.3 Typical GEM 80/310 System

Figure 1.4 shows a typical GEM 80/310 system. The Controller communicates with the outside world through:

- (1) Verification and Basic I/O Highway
- (2) Serial Communication Links
- (3) Fast I/O module Inputs and Outputs
- (4) Video Processor Outputs
- (5) Programmer Connection Ports
- (6) Watchdog Contacts

#### (1) Verification and Basic I/O Highways

The Verification and Basic Input/Output highways are medium speed parallel digital highways used for transferring data between the controller and Basic I/O modules or Operator Input Units. Physically, these highways consist of 26-way ribbon cables, the length of which is subject to the loading restrictions detailed in Section 5.2 and Table 5.6.

The Verification and Basic I/O is designed for connecting to such devices as push-buttons, relays, lamps, solenoids, interlocks and limit switches. It provides an interface between the controller circuits and plant-side circuits.

The Operator Interface Units comprise LCD units, thumb-wheel switches etc., which allow operators to input control commands to GEM 80 and to monitor plant status.

Full details of Basic and Verification I/O and Operator Interface Units are in the relevant Product Data Sheets. Further information is also available in Section 5 of this manual.

# 1. INTRODUCTION

## (2) Serial Communication Links

Communication between GEM 80 Controllers and other peripherals, such as printers and keyboards, is most commonly achieved by the well-proved 20mA current loop format using the GEM 80 Extended Simple Protocol (ESP). Other available formats include the CORONET Local Area Network (LAN) and the STARNET facility. Further details can be found in the Serial Communications Manual, Publication No.T457.

The serial links allow data to be interchanged between equipment up to several miles apart. Cable costs are very low as only a few wires are needed. Two-wire, four-wire or fibre-optic serial links can be set up and the 2-wire and 4-wire systems operate in a 20mA current loop (where 20mA = 0, 0mA = 1).

Further information on serial links is in Section 6.

## (3) Fast I/O Module

There is a wide choice of equipment for connection to the Fast I/O. Applications fall into the following categories :-

- (1) Analog I/O
- (2) Counter Inputs
- (3) Extra Serial Communications Ports (Programmable Serial Communications 8847 allows data exchanges with almost any other mini, micro or mainframe computer)

Full details are given in GEM 80 Product Data Sheets, User Information Sheets and Section 7 of this manual.

## (4) Video Processor Outputs

Plant video monitors can be connected to the video processor outputs. Monitors may be connected for alarm display, plant mimics, interactive operator displays and other applications. Further details are available in the IMAGEM Product Data Sheet, Publication No.T524 and Section 8 of this manual.

## (5) Programmer Connection Ports

System Programmers can be connected directly to the I/O Processor or by way of a serial port for loading and monitoring the ladder diagram programs.

## (6) Watchdog Contacts

These are designed to provide an output to shut down the plant in the event of a problem on the plant or in the GEM 80. See Section 9 for further details.

## 1.4 Choosing a Site to Install GEM 80

The area in which GEM 80 equipment is to be installed must fulfil the following conditions :-

- (1) An environment must be maintained as detailed in Section 1.4.1.
- (2) A power supply must be available as detailed in Section 1.4.2.
- (3) Adequate access must be available for maintenance and commissioning.

### 1.4.1 Environment

The following environmental conditions apply for all GEM 80 equipment :-

Temperature : 0 to +60°C\* operating  
                  : -20°C to +70°C storage

Humidity : 5 to 95% non-condensing

\* Particular items may need de-rating; refer to Product Data Sheets for actual figures. (e.g. Compact Output Modules on large load currents).

GEM 80 equipment must not be used in corrosive atmospheres (e.g. Benzene, acid fumes, etc.) without special precautions being taken.

Where large amounts of airborne dust are present, adequate precautions should be taken to prevent the ingress of this dust into GEM 80 modules, particularly those contained in the controller subracks. The equipment may, for example, be mounted in a sealed enclosure, with filtered vents.

Any rapid change in temperature should also be avoided, as this causes condensation on GEM 80 equipment in areas of high humidity.

### 1.4.2 Power Supply Requirements

The Controllers use 110V/220V a.c. 50/60 Hz. or d.c. or 24V/48V d.c. (Section 11 gives full details). In some cases it is advisable to fit a line conditioner (ferro-resonant CVT) in the feed to the controller (see GEM 80 Power Supply Requirements User Information leaflet for details).

## 1.5 Receipt of GEM 80

When the equipment arrives on site it should be carefully unpacked and inspected for any sign of damage. The modules contain static sensitive devices and the handling precautions in Section 18.9 must be observed. Lithium batteries, which should also be treated carefully, are fitted in some modules; see Section 18.10 for details.

The complete consignment should be checked against the delivery note for any loss in transit. If any damage has occurred, or any parts are missing, contact GEC Industrial Controls Limited, Kidsgrove, immediately and quote the following details :-

- (1) List of damaged or missing items.
- (2) Description of any damage.
- (3) Package numbers.
- (4) Delivery/Advice Note numbers and dates and any other reference numbers such as order and item numbers.

**Note...** Failure to inform GEC Industrial Controls Limited, Kidsgrove of damage to goods or shortages, within three days from receipt of equipment will be held to free GEC Industrial Controls Limited from liability.

## 1.6 Storing GEM 80 Before Installation

Equipment which is not required for immediate installation should be stored in a clean, dry atmosphere at a reasonably constant temperature (-20 °C to +70°C). To prevent dust getting into the cubicles, they should be covered with a suitable canvas tarpaulin or heavy duty polythene sheet and any loose equipment should be kept in the boxes in which it was supplied, these having been re-sealed after checking for damage.

Where equipment is unavoidably subjected to high humidity (e.g. for short pre-commissioning periods during installation in a humid location), it is recommended that the cubicle be fitted with anti-condensation heaters and the equipment be thoroughly dried out prior to first application of power. Such heaters should be automatically switched on whenever the GEM 80 equipment is subsequently shut down.

Where inactive storage times are expected to exceed 9 months, the shelf life of electrolytic capacitors may be exceeded. It is therefore recommended that units with electrolytic capacitors such as controllers, power supplies and some compact I/O modules, are powered up every 9 months.

# 1. INTRODUCTION

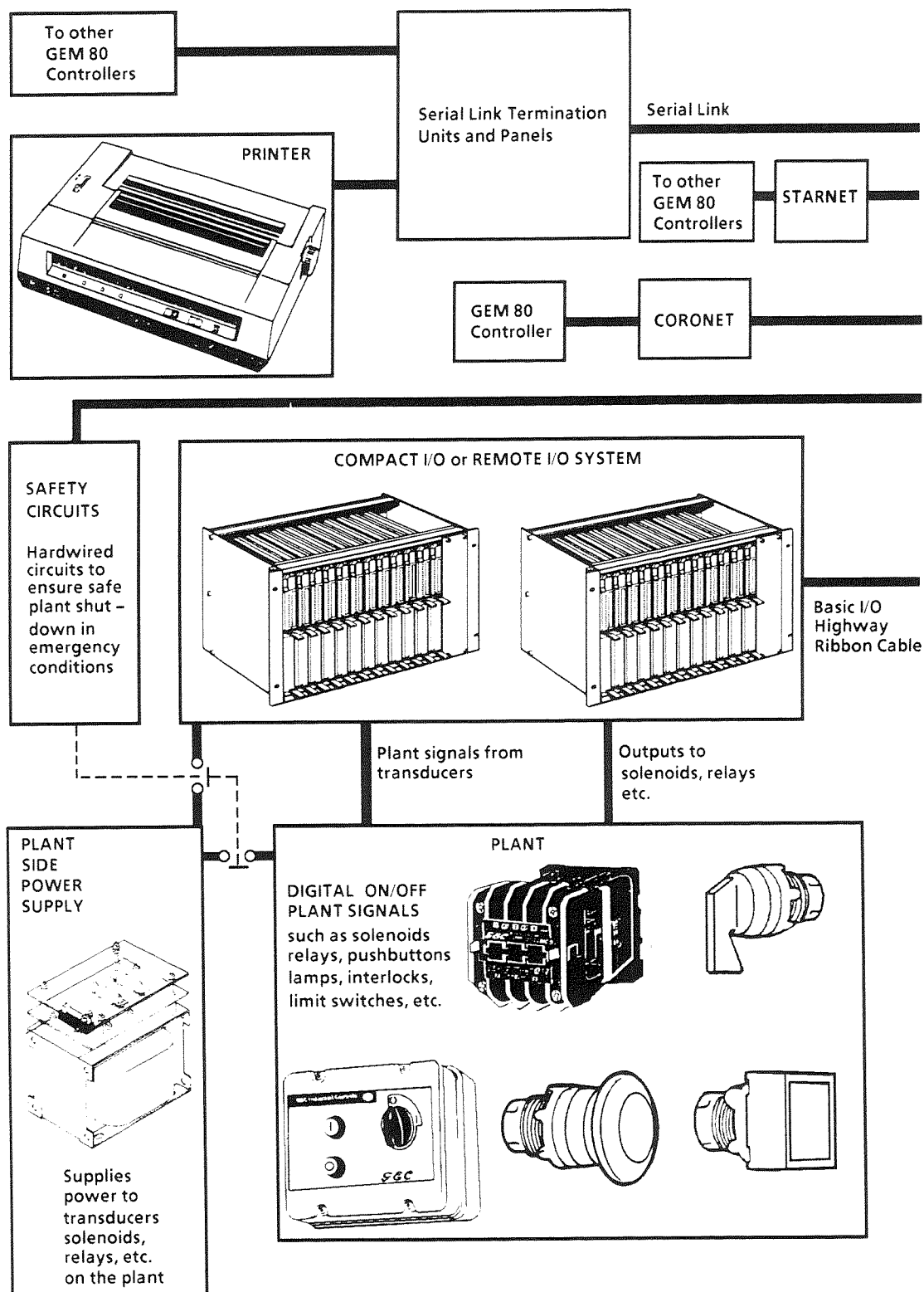


Figure 1.4 GEM 80/310 Series System Diagram.

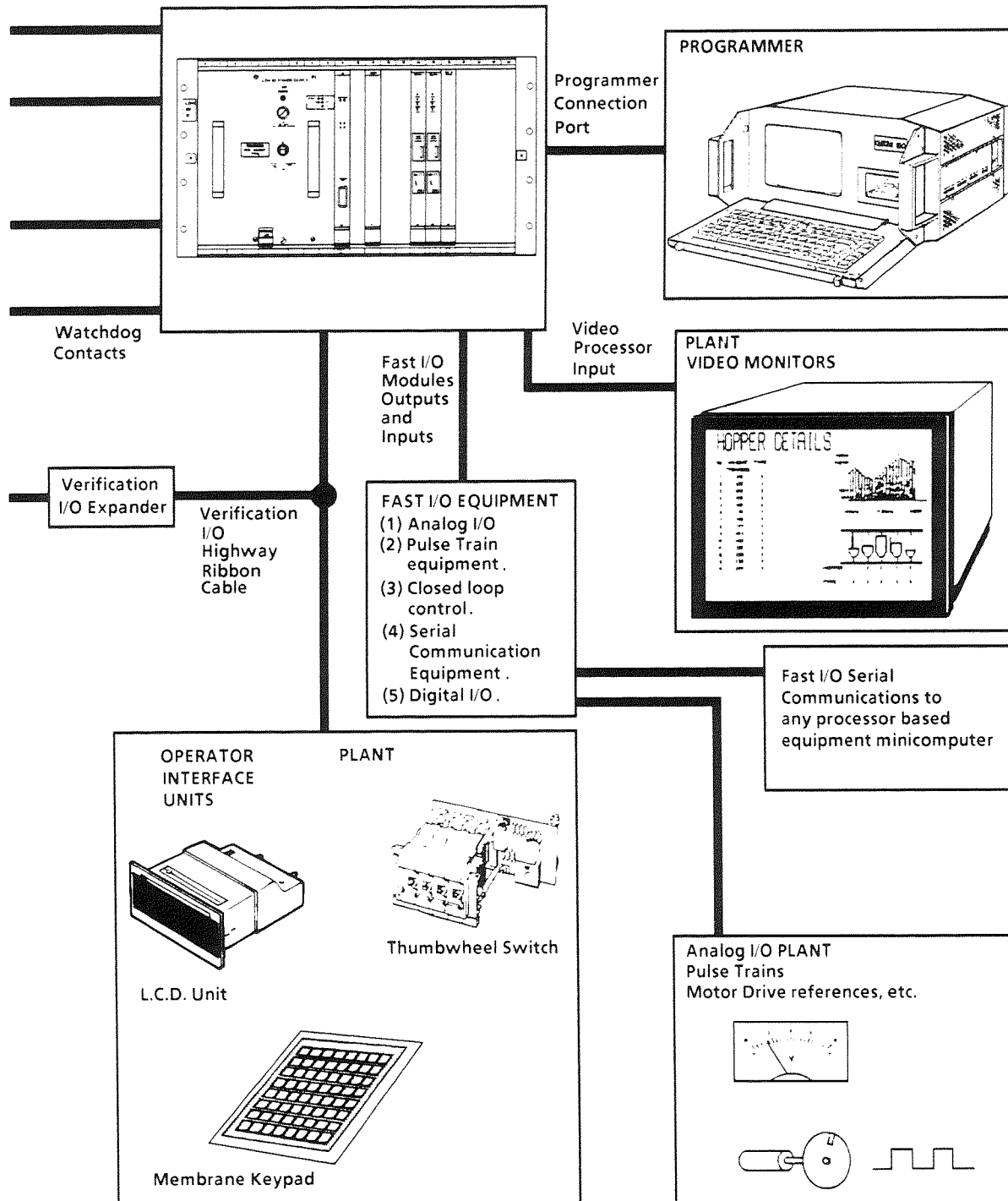


Figure 1.4 GEM 80/310 Series System Diagram.

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## 1. INTRODUCTION

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### 2.1 Mechanical Structure

The GEM 80/310 series of controllers consists of plug-in modules mounted in a subrack which has been manufactured from flame retardant material to UL94V-0. The subrack is constructed from clip-together mouldings with clip-on backplanes. Integral guides provide a total of 21 slots for module insertion but a slot selection strip ensures that only the slots relevant to the application are used.

A retention mechanism has been built into the subrack to provide module security in high shock or vibration applications. This consists of two sliders which pass through notches cut into the upper and lower edges of the printed circuit boards. Pointers at each end of the sliders indicate whether the modules are 'locked' (●) or 'unlocked' (○). When the Controller is being used in normal applications these sliders should be left in the unlocked position.

The subrack has been designed to facilitate either front or rear mounting. Mounting details are contained in Section 12 of this Manual.

The plug-in modules are inserted at the front of the subrack in the appropriate positions as indicated by the subrack label. Channelled by the integral guides, the modules push-fit into connectors at the back of the subrack. These connectors are mounted on printed circuit boards referred to as 'backplanes'. Mechanical coding ensures that modules cannot be inserted into the wrong connector. If insertion becomes difficult, the module is probably incorrectly positioned.

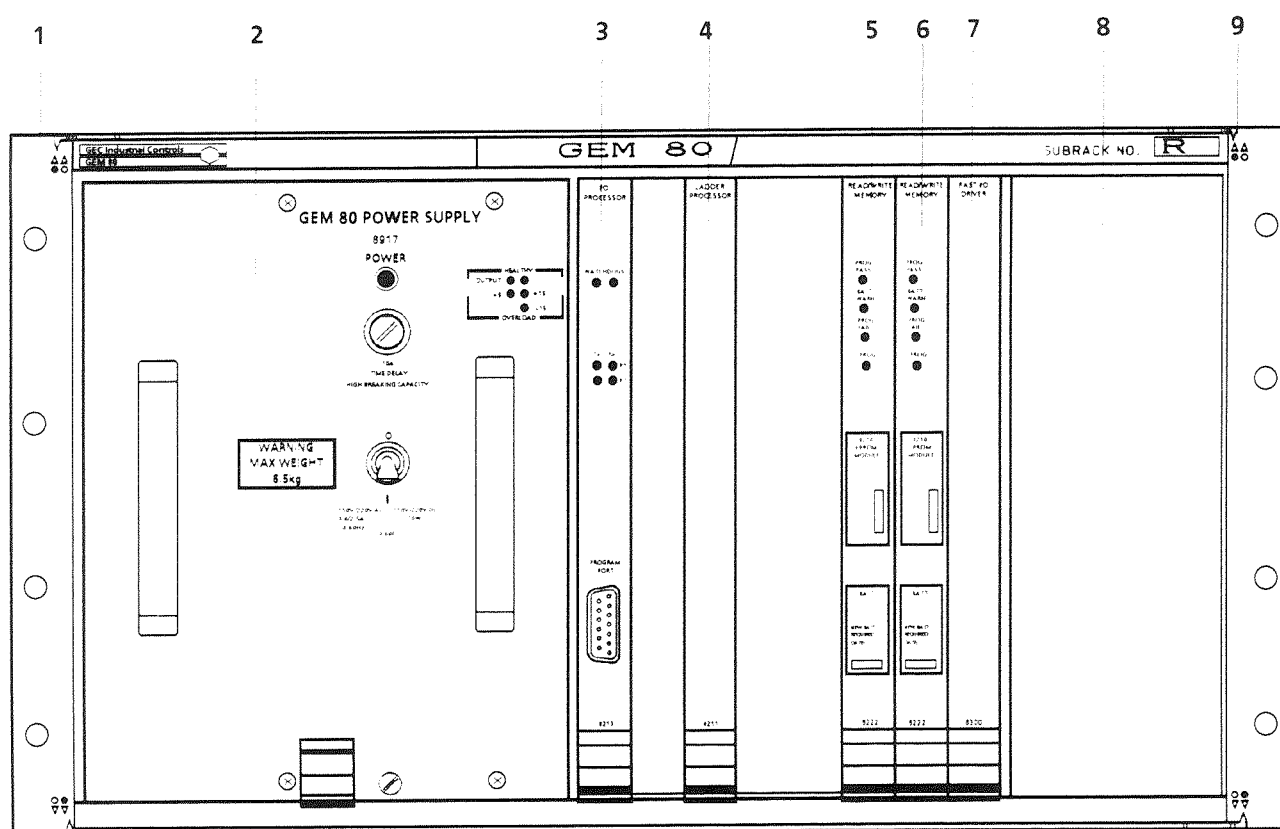
The subrack which contains the various processor modules, and the power supply module is referred to as the Controller Subrack. I/O modules and additional power supply modules require mounting in a separate subrack which is referred to as the I/O Subrack.

### 2.2 Controller Subrack Labelling

A label indicating the model number and the subrack reference number (usually R0, R1 or R2) is fitted into the upper rail. The lower rail holds a label which indicates the Power Supply and Controller Modules type numbers. The user should mark module re-order numbers on this label.

## 2. HARDWARE IDENTIFICATION

### 2.3 Controller Front Panel Indicators and Controls



- |    |                          |    |                                   |
|----|--------------------------|----|-----------------------------------|
| 1. | Controller Subrack       | 6. | Memory Module                     |
| 2. | Power Supply Module 8917 | 7. | Fast I/O Driver Module            |
| 3. | I/O Processor Module     | 8. | Space for Fast I/O Driver Modules |
| 4. | Ladder Processor Module  | 9. | Module Retention Slider           |
| 5. | Memory Module            |    |                                   |

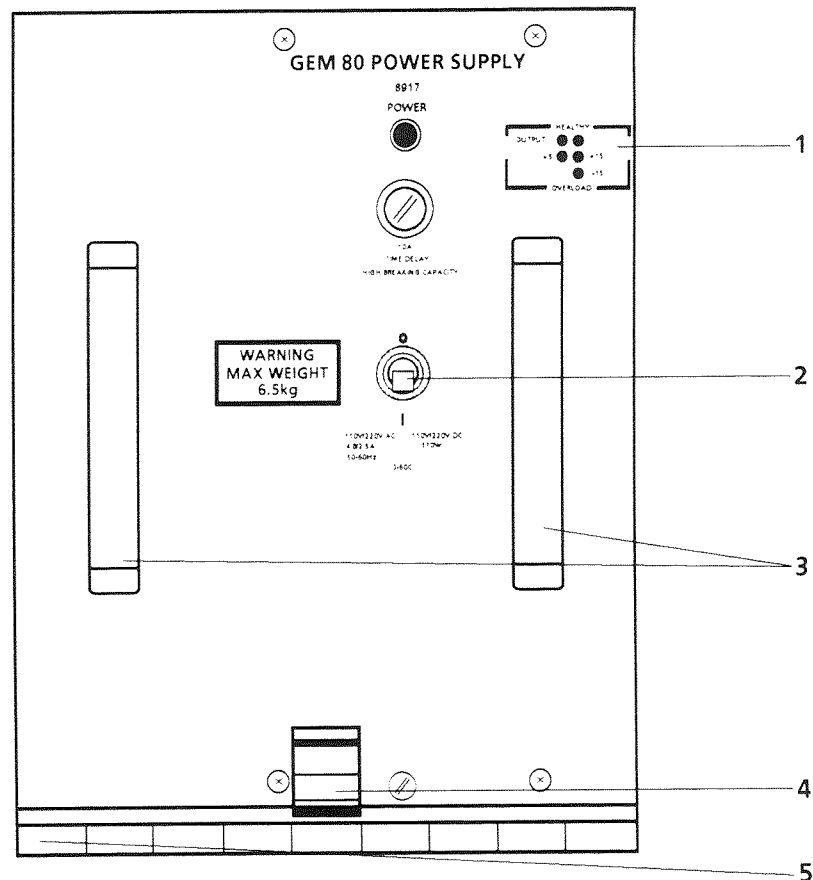
Figure 2.1 - GEM 80/311 Controller - Controller Subrack Layout

### 2.3.1 Module Descriptions

#### (1) Power Supply Modules

The Power Supply module provides the power required for the modules contained in the controller subrack. This subrack contains either one 8917 (a.c. or d.c.) or one 8918 (d.c. only) Power Supply Module, dependent upon the User's supply parameters.

The 8917 Power Supply module is illustrated in Figure 2.2. Detailed specifications on the power supply modules are contained in Section 11 of this manual.

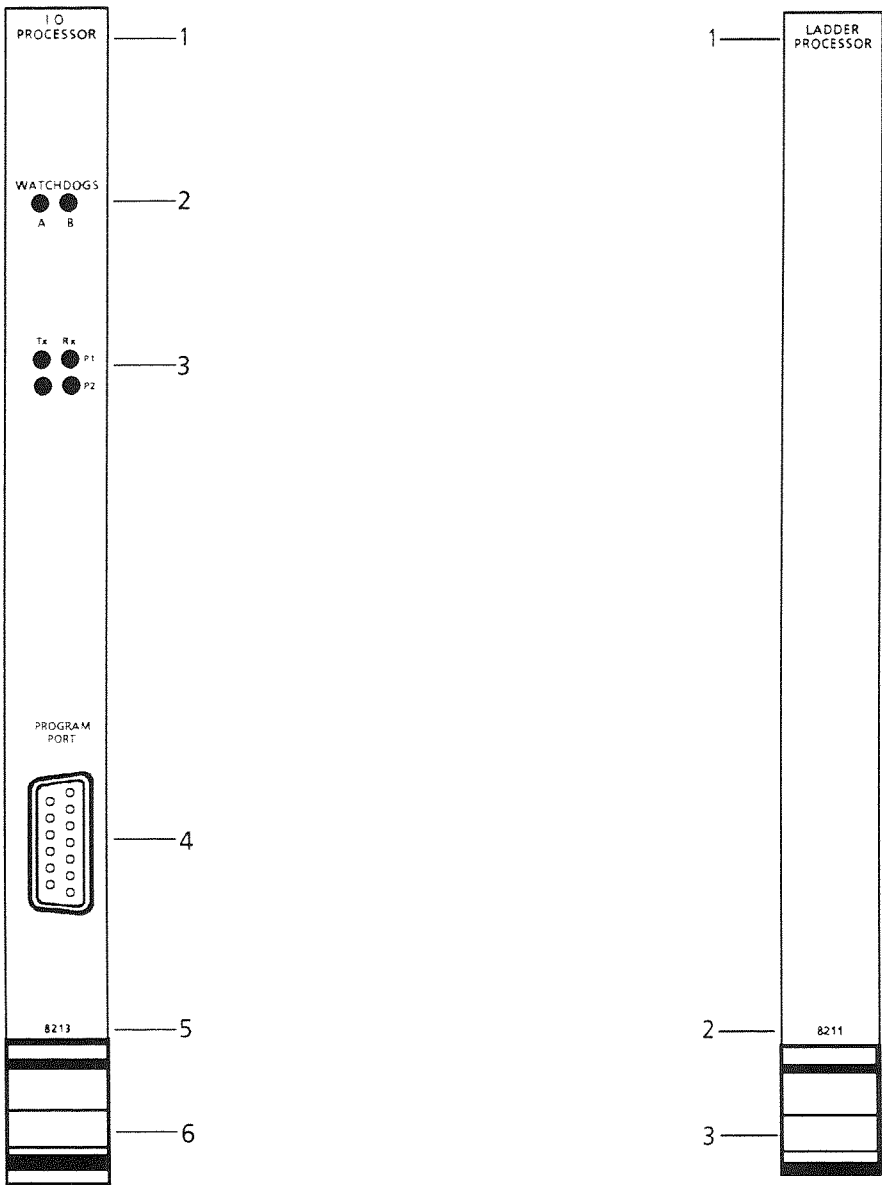


- |                        |                         |
|------------------------|-------------------------|
| 1. Indicator Lamps     | 4. Ejection Handle      |
| 2. Power Supply Switch | 5. Module Ordering Code |
| 3. Lifting Handles     |                         |

**Figure 2.2 - 8917 Power Supply Module - 110V to 240V a.c. or 110V to 220V d.c.**

The module is inserted from the front of the subrack. Care should be exercised when inserting the module to ensure that it slides directly down the slots and enters the backplane connectors with the minimum of force.

The module is withdrawn by operating the ejection handle to release the connectors and, using the lifting handles, pulling the module along the slots until it is clear of the subrack.

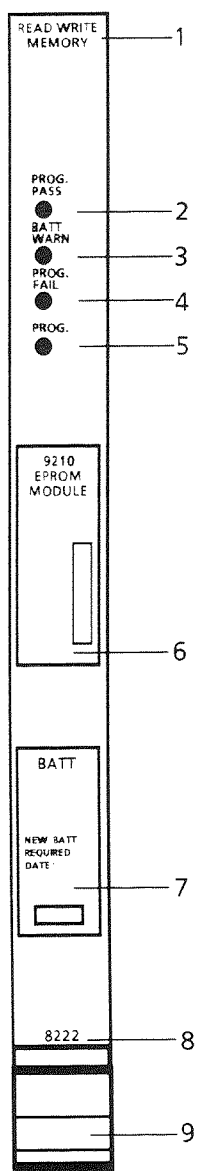


- 1. Module Function Label
- 2. Watchdog Lamps
- 3. Serial Communication Lamps
- 4. Programmer Port
- 5. Module Ordering Code
- 6. Ejection Handle

Figure 2.3 - I/O Processor Front Panel

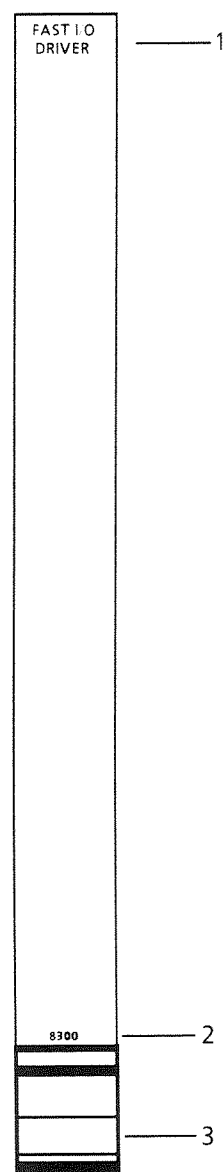
- 1. Module FunctionLabel
- 2. Module Ordering Code
- 3. Ejection Handle

Figure 2.4 - Ladder Processor Module - Front Panel



1. Module Function Label
2. 'PROG PASS' LED
3. Battery Warning Lamp (Lit for Battery Low)
4. 'PROG FAIL' LED
5. 'PROG' LED
6. EPROM Module
7. Battery
8. Module Ordering Code
9. Ejection Handle

Figure 2.5 - Read/Write Memory Module Front Panel



1. Module Function Label
2. Module Ordering Code
3. Ejection Handle

Figure 2.6 - Fast I/O Driver Module Front Panel

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## 2. HARDWARE IDENTIFICATION

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## 3.1 Controller Architecture

Figure 3.1 shows the Controller architecture. It has several memories and several micro-processors, each performing different duties and all connected to the Central Highway so that data can be interchanged between processors and memories.

The I/O Processor controls data movement between the Verification I/O Highway, Serial Communications Ports or the Programmer Port and the Memory modules.

The ladder processor executes the compiled user program.

The Fast I/O driver provides a buffer for data exchanges between the Central Highway and the Fast I/O modules.

The video processors output a picture from data stored in the video memory and host controller memory.

The user memory holds the following categories of information :-

- (1) Program instructions in 'compiled' form. See section 3.2.3 for further information.
- (2) Program instructions in 'uncompiled' form, referred to as 'source' program. See section 3.2.3 for further information.
- (3) Data tables, detailed in Section 4.
- (4) Video memory. See Section 8 for further information.
- (5) Mailboxes, used for inter-module message passing.
- (6) Off-line data storage.

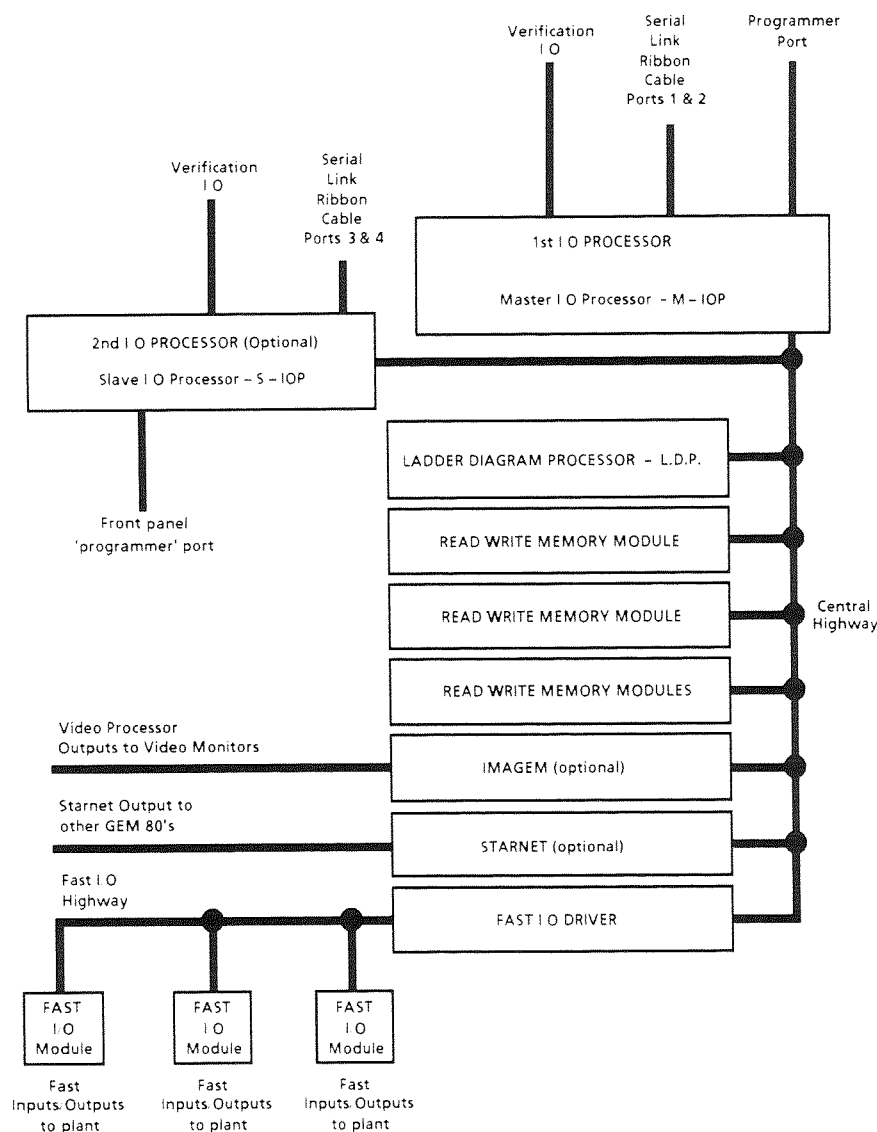


Figure 3.1 - Controller Architecture

## 3. CONTROLLER ARCHITECTURE AND OPERATION

### 3.2 Controller Operation

#### 3.2.1 Controller Operating Cycle

Controller operation is divided into three phases, a start-up procedure, an operating cycle and a fault shut-down procedure. The start-up procedure includes checking the controller (self-test) and compiling of the user program and on satisfactory completion allows the system to be run. The operating cycle is a continuous cycle in which input data is read and the output data is derived by the controller, based on the input data and the user program. The operating cycle also includes self-test checks. In the event of a fault, the controller enters a fault shut-down phase and is designed to shut down in an orderly fashion. Figure 3.2 shows the operating cycle in more detail.

The cycle time may be either undefined, in which case the program free runs and repeats as soon as it can, or it may be pre-set to a regular defined interval.

If a repetition interval has been set which is shorter than either the program execution time or the I/O scan time, the repetitive cycle will not be regular, and the controller free runs. If the program is short, so that its execution time is shorter than the I/O scan time, the user program waits at the end of its execution until the I/O scan is complete before repeating. If, as is more usual in practical applications, the program takes longer to execute than the I/O scan, the next I/O scan does not begin until after the program execution has been completed.

The output scan is the first item in the cycle. If a regular repetition interval has been pre-set, a waiting period is inserted after the program execution at the end of the cycle. The program execution time itself varies due to blocks within the user program, and so the waiting period also varies in order to make the cycle time up to the pre-set interval. The timing of the output scan is therefore held to a regular interval, varying very little, which is an advantage for continuous analog control applications.

Data written by the user into the P-table determines whether the controller is free-running or pre-set. See Section 4.6 for details.

Cycle time calculation and measurement is discussed in Section 10.8.

#### 3.2.2 Self-test

Information on the self-test system is detailed in Section 15 - Fault Finding.

#### 3.2.3 Compilation

The user program is stored in two forms, one for use in editing is called the 'source' program and the other for execution by the controller, is called the 'compiled' program. Conversion between the two is called 'compilation' and is carried out under the following conditions :-

1. At power up (automatically).
2. On halt/run transitions (automatically).
3. When the user issues a 'recompile' command while the program is running.
4. On single cycle when the program has been changed since the controller was last running.

Compilation not only converts the program into an executable form but also checks the source program to verify that it can be executed.

Any error detected during compilation prevents the program being executed and if the controller was previously running a version of the program it continues to run this 'old' program. The errors are reported by text messages and a detailed discussion of compilation and associated problems is given in Section 15 - Fault Finding.

#### 3.2.4 On-line Program Changes

There are two versions of the program held in memory, compiled and uncompiled. While the compiled version of program is running and controlling the plant, the user can edit the uncompiled or source version without halting the controller. A print-out of his modified version may also be obtained, or dumped it onto tape, again without halting the controller.

To incorporate the changes made to the source version of the program into the running version, the user can give a 'recompile' command from the programmer. This causes the controller to pause while compilation is in progress. During this time, all outputs are frozen and all inputs are ignored. Assuming that compilation is successful, the controller continues to run but using the modified program. If compilation is unsuccessful, the controller resumes running the previously compiled version of the program.

There is only one version of the P-table and any changes to the data contained in it affect the running program immediately, without re-compilation being necessary.

#### 3.2.5 Serial Links

The operation of the serial link is discussed in Section 6.

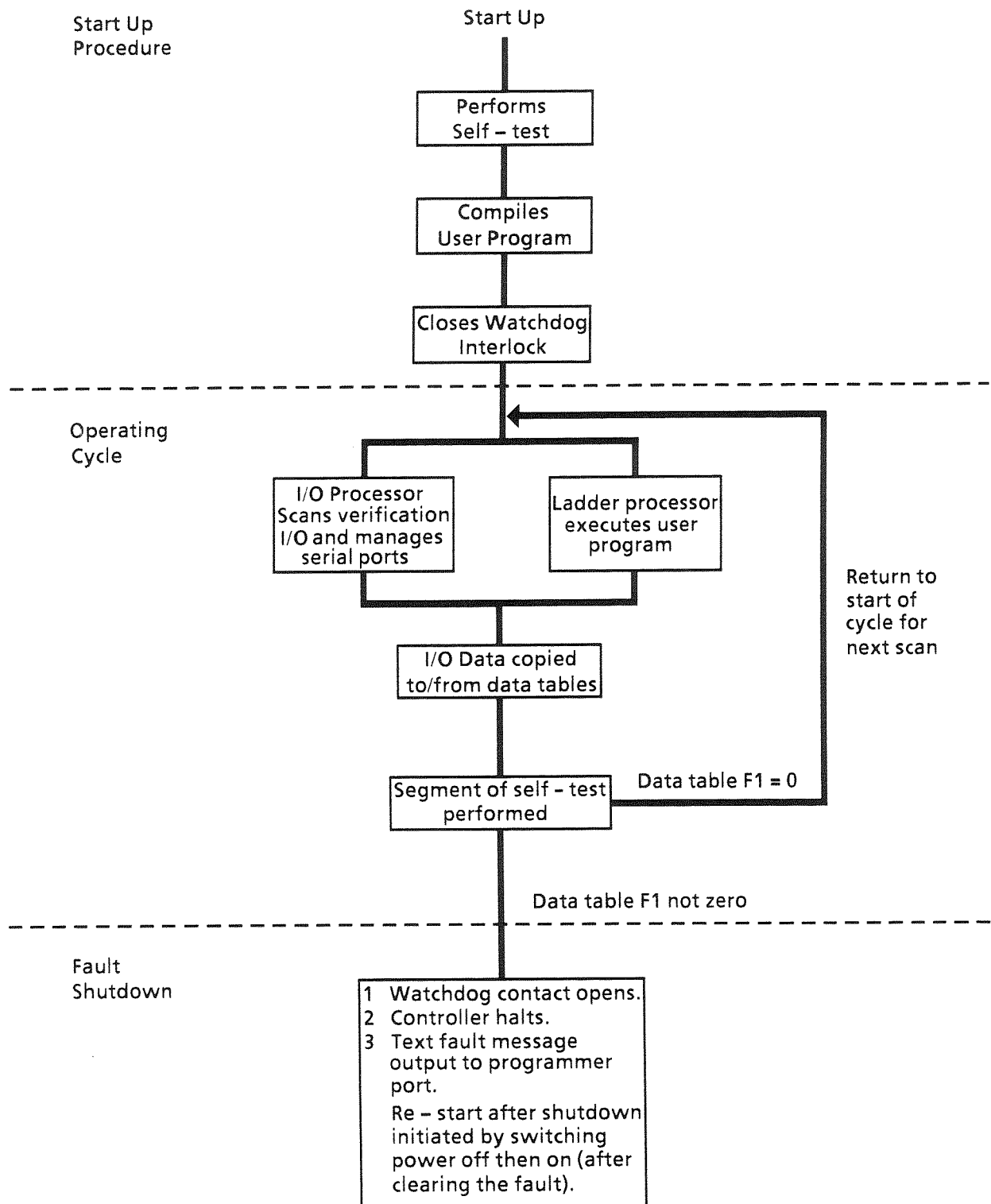


Figure 3.2 - Controller Operating Cycle

### 3.2.6 Message Output Facility

The controller includes facilities for entering and editing message format definitions. These definitions are similar to the 'pictures' or 'images' found in some programming languages, and can include either or both literal and replacement characters. The message formats are handled as a single list which the controller automatically shuffles as the definitions are entered, edited or deleted. A print-out facility lists the message formats in a numbered and readily understandable form.

The controller can be programmed to output messages to any selected port using the Special Functions S38 PRITEXT and T38 PRINT.

### 3.2.7 Programmer Units

#### 3.2.7.1 Displays

To obtain the correct display of diagnostic messages and to use the on-line program change facility, one of the following is needed :-

an 8922 System Programmer,

α 9022 Enhanced System Programmer,

an 8940 Enhanced System Programmer with disk storage,

an 8920 Portable Programmer version 4.5 (or later) firmware.

**Note...**The 8922 System Programmer and the 8920 Portable Programmer cannot display Floating Point information.

With earlier versions of the portable programmer, the general edit mode of messages cannot be entered for printers, VDUs or other display devices. If an 8920 Portable Programmer is available, but with firmware version earlier than 4.5 it is recommended that the factory be consulted about having the unit updated to the latest firmware version.

#### 3.2.7.2 Languages

With an 8940 or α 9022 System Programmer, the screen menus can be displayed in English, French, Italian, German, Spanish or Flemish. For earlier versions of the programmer, the screen menus appear in a single language only, dependent on the ordering code of the programmer.

#### 3.2.7.3 Remote Programming

An 8922, 8940 or 9022 System Programmer can operate on a multi-drop serial link connected to several controllers, and at whatever signalling rate is selected. The 8920 Portable Programmer can operate only on a point-to-point link at 9,600 bits/s, and therefore can only be connected to one controller at a time. The signalling rate which is satisfactory for the given distance between the controller and programmer can be found by consulting the Serial Links User Information leaflet, Publication No.T456.

### 3.2.8 Off-Line Program Debugging

If the TEST INPUTS mode is selected from a Programmer:

1. The watchdog does not close.
2. All I/O scanning is suspended.
3. All I/O self-tests are suspended.
4. All compilation checks on the presence of both Verification and Basic I/O are suspended.

Using the TEST INPUTS mode, a program can be de-bugged on a system in the office without any I/O present. Program timing is not significantly altered compared with when the I/O is present.

### 3.2.9 Loading Programs

Before loading a program, it is recommended that a CLEAR STORE command is always issued, for the following two reasons :-

- (1) The area of P-table which holds printer messages is not normally write-accessible except via the message editor facility. The CLEAR STORE command allows data to be loaded to the whole of the P-table.
- (2) The controller allocates memory space for the data tables according to the content of the ladder program. The CLEAR STORE command sets all data table areas to their minimum size, and ensures that unnecessary space has not been allocated by the previous version of the program.

When a CLEAR STORE command is issued, the whole of the P-table is cleared except for P0 to P149. These table locations include the configuration data for the serial links.

These sections of P-table are not cleared because the GEM 80/310 series Controllers may be programmed either from the front port of the I/O processor, or remotely via one of the serial ports. If the controller lost data about the serial port configurations, it might become impossible for the controller to communicate with a remote System Programmer. This data is therefore retained even when the rest of the memory is cleared.

**Note...**When a program is loaded, any instructions and P-table data already in store are overwritten. If as recommended, the store is cleared before loading, P0 to P149, which are not cleared, will be overwritten by data from the program being loaded. Where the controller is being programmed remotely through one of the serial ports, the configuration data being loaded must be the same for this port as the values already in store. Otherwise, communication will be lost after a re-compilation or power off/on.

Note also that when the data being loaded includes messages, the message area made write-accessible by the CLEAR STORE command becomes write-protected again after compilation, except via the message editor.

### 3.2.10 Program Scan Times

These Controllers operate on a repetitive I/O scan and program execution cycle. The cycle time may be either:

- (1) Undefined. The program free runs and repeats as soon as it can.
- (2) Pre-set to a regular defined interval. The pre-set value is set in a P-table location.

#### 3.2.10.1 Free Running Cycle Time

The cycle consists of the execution of the user program plus an exchange of I/O data with the data tables. The total scan time is the sum of:

- (1) The I/O data exchange time.
- (2) The greater of the I/O scan time and the program execution time.

where:

I/O exchange time =  $750\mu\text{s}$

and

I/O scan time (by I/O processor) =

2ms plus 0.4ms per 16-bit I/O word.

Program execution time =

- (1)  $5\mu\text{s}$  average per instruction
- (2) plus extra for each Special Function used. (Refer to Section 10)

#### 3.2.10.2 Pre-set Cycle Time

If the cycle time is pre-set, the processors insert a waiting period at the end of each cycle, making all cycles virtually the same length. The pre-set cycle time must of course be longer than the free running time. This is the way to run the controller wherever time dependent Special Functions are used.

#### 3.2.10.3 Free Running Program Cycle

The I/O and Ladder processors perform a cycle which is represented diagrammatically in Figure 3.2. It is extremely unlikely that the I/O processor and Ladder processor tasks would take exactly the same length of time, so the processor which finishes first waits for the other.

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### 3. CONTROLLER ARCHITECTURE AND OPERATION

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## 4.1 Introduction

The Data Tables consist of 16-bit binary words of data stored in the memory and accessed by their address.

## 4.2. Data Table Addressing

Each word is stored in the memory at a specific address. These addresses consist of a letter of the alphabet followed by a number, for example, A20, B200, P41, etc. If, for example, we were to look at the content of data table address 'G1' it may be:

| BIT No. | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|
| VALUE   | 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |

We may only be interested in the content of one bit of G1, for example, bit 4.

In this case we would look at data table address G1.4 and we would find G1.4 = 1.

## 4.3 Decimal, Binary, Hexadecimal and Floating Point Numbers

The data table content can be interpreted as:

- (1) an equivalent decimal number.
- (2) 16 individual bits each of value 1 or 0.
- (3) an equivalent hexadecimal number. For example, address G2 may contain:

| BIT No. | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|
| VALUE   | 1  | 0  | 1  | 0  | 1  | 1  | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |

which can be interpreted as:

BINARY 1 0 1 0 1 1 0 0 0 0 1 1 0 1 0 1

DECIMAL -21,451

HEXADECIMAL @AC35

### 4.3.1 Decimal

As shown in the above example, when converting from binary to decimal, 2's complement working is used. Bit 15 is taken as the sign bit and the number displayed will be within the range +32,767 to -32,768. When bit 15 = 1 a negative number is represented and when bit 15 = 0 a positive number or zero is represented.

### 4.3.2 Hexadecimal

The numbers are to base 16 and are preceded by an @ symbol to distinguish them from decimal. The range of numbers covered is from @0000 to @FFFF.

### 4.3.3 Floating Point Numbers

The GEM 80 normally deals with 16-bit integer values. The 310 series uses a maths co-processor which allows floating-point arithmetic.

Each floating-point number is held as two consecutive tables in the Q-table. Thus the floating-point locations are addressed as Q0, Q2, Q4, Q6 etc. Special Functions to deal with the floating-point operations are detailed in Section 10 (User Program)

Where a floating-point location is addressed by a floating-point instruction, checks are made to ensure that the correct table location is referenced. If there is a fault, a compilation error is given. Where Q-tables are accessed by other instructions, checks are not made.

Q-tables can be accessed only by the enhanced System Programmer. Floating-point numbers are displayed in the data tables to 6 decimal places. When monitoring runs, floating-point numbers are displayed to two decimal places. Section 10 gives more information on using the System Programmer.

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## 4. DATA TABLES

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### 4.4 Data Table Content and Addresses

Table 4.1 shows the addresses for the controller and also the information which is to be found in these memory locations.

### 4.5 Data Table Sizes

Data tables E, F, S and V are a fixed size, as shown in Table 4.1. Data table sizes are computed by the controller from the User Program so that if for example, the highest G-table address in the User Program is G345 then G0 to G345 will be reserved. Where addresses are implied, e.g. when using LOCATE and MOVE, the user must include a dummy rung or rungs to declare the highest address. See Section 10 for full details.

When constructing the User Program it should be borne in mind that memory wastage occurs if large gaps of unused data tables are left with only high numbered and low numbered tables used. Also, even if only one or two bits of a word are used (e.g. G104.1) the whole word G104 is reserved by the controller.

System Programmers with software version 1.8 or earlier and all Portable Programmers cannot work with bit addresses above 999.15. This restriction means for example, G999.15 can be used, but address G1000.1 cannot be used, as individual bits cannot be accessed. However, word G1000 can be used and words up to 24,000 can be used where access to individual bits is not required. The limitation is on the System Programmer itself where there is space for only 7 characters on the screen. Data Tables and Program Instructions are held in an area of memory of 24,000 words. One table location occupies one word and one instruction occupies two words.

### 4.6 P-Data Table

Data in the P(Preset)-Table falls into the following categories :- (See Table 4.2)

- (1) Data entered by the user to control program repetition interval, serial link operational data and Fast LO self-test.
- (2) Pre-set data values entered by the user for use in the program.
- (3) Storing Printer Text Messages. The user should access printer text messages through the editor system detailed in Section 6.7.
- (4) Configuration of Verification I/O. The P-Table data is not cleared at power off or at halt/run transition, although a clear store command clears P51, P52 and address P150 upwards. The content of the other P-tables can be altered by over-writing. Like other data tables, the size of the P-table is derived by the controller as described in Section 4.5.

### 4.7 E-Data Table

The E-table data comprises timing markers, flags and duration of the previous program scan. The table is available for the user program to read and the information it contains is shown in Table 4.3.

#### 4.7.1 Time and Date

This is generated from a crystal controlled oscillator mounted in the power module. The accuracy is better than one minute per month and the clock runs while the controller is halted but stops during controller power interruption. The built-in calendar is correct for the lengths of all months up to the year 2099. Addresses E1 to E6 store the time and date (see Table 4.3). To set the correct time and date simply write the correction into these tables with the programmer. More information on the programmer is contained in Section 10.2.

#### 4.7.2 Program Scan Time

E7 holds the duration of the previous program scan.

Table 4.1 - GEM 80/310 Data Tables

| Function    | Data Table                              | Content                                                                                                                                                          | Minimum Table Size | Maximum Table Size                                   | Cleared to Zero at Halt/Run Transition | Cleared to Zero at Power Off | Cleared to Zero by Clear Store Command | For Further Details see Section |
|-------------|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------------------------------------------|----------------------------------------|------------------------------|----------------------------------------|---------------------------------|
| I/O         | Verification and Basic I/O Highway Data | <b>A</b> This table of addresses stores the states of INPUT transducers connected to the Verification and Basic I/O highways                                     | 0                  | 1024 words (each 16 bits) with one I/O Processor and | YES<br>Except if R0.0 set              | YES                          | YES                                    | 5                               |
|             |                                         | <b>B</b> This table of addresses stores the OUTPUT states (derived from the execution of the user program) for output to the Verification and Basic I/O highways | 0                  | 2,048 words (each 16 bits) with two I/O Processors   | YES<br>Except if R0.0 set              | YES                          | YES                                    | 5                               |
|             | Fast I/O                                | <b>C</b> This table stores INPUT data sent to the controller from Fast I/O modules                                                                               | 0                  | Size depends on Fast I/O equipment                   | YES<br>Except if R0.0 set              | YES                          | YES                                    | 7                               |
|             |                                         | <b>D</b> This table stores OUTPUT data derived from the execution of the user program for output to the Fast I/O modules                                         |                    |                                                      | YES<br>Except if R0.0 set              | YES                          | YES                                    | 7                               |
|             | Serial Communication Links Data         | <b>J</b> This table stores data RECEIVED by the controller through the serial communications links                                                               | 0                  | 512 words (each 16 bits) with one I/O processor and  | YES<br>Except if R0.0 set              | YES                          | YES                                    | 6                               |
|             |                                         | <b>K</b> This table stores data derived by execution of the user program for TRANSMISSION on the serial communication links                                      |                    | 1,024 words (each 16 bits) with two I/O processors   | YES                                    | YES                          | YES                                    | 6                               |
|             | Serial Link Control                     | <b>I</b> This table enables the user program to control serial link exchanges                                                                                    | 100                | 100                                                  | YES                                    | YES                          | YES                                    | 6                               |
|             | VIDEO CONTROL                           | <b>L</b> Video Format Control Data                                                                                                                               | 32                 |                                                      | YES                                    | YES                          | YES                                    | 8                               |
| PRESET DATA | <b>P0 to P149</b>                       | Controls Program Repetition Interval, System Identification Codes, Serial Link operational data (signalling rate, printer data, etc.)                            | 150                |                                                      | NO                                     | NO                           | NO (except P51 & P52)                  | 4.6                             |
|             |                                         | Remainder of Program for Special Functions and printer text messages                                                                                             |                    |                                                      | NO                                     | NO                           | YES                                    | 4.6                             |

## 4. DATA TABLES

Table 4.1 continued

| Function           | Data Table | Content                                                                                                                                                                                                                          | Minimum Table Size | Maximum Table Size | Cleared to Zero at Halt/Run Transition | Cleared to Zero at Power Off | Cleared to Zero by Clear Store Command | For Further Details see Section |
|--------------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------------|----------------------------------------|------------------------------|----------------------------------------|---------------------------------|
| GENERAL WORK SPACE | R          | These tables are available for the user program to use for storing counter values, sequencers and general data.                                                                                                                  | 1                  |                    | NO                                     | NO                           | Yes (except for RO)                    |                                 |
|                    | W          |                                                                                                                                                                                                                                  | 0                  |                    | NO                                     | NO                           | YES                                    |                                 |
|                    | GH         | These tables are available for the user program to use for storing counter values, sequencers and general data.                                                                                                                  | 0                  |                    | YES except if RO.0 set                 | YES                          | YES                                    |                                 |
|                    | NOU        | These tables are available to the user for STARNET message exchange and control when STARNET fitted or as General Work Space when not used by STARNET.                                                                           | 0                  |                    | YES                                    | YES                          | YES                                    | 6                               |
| TIMING AND FLAGS   | E          | These tables are written to by the controller and indicate overflow, time date and timing flags. They are cleared when power first applied.                                                                                      | 9                  | 9                  | NO                                     | NO(except E0)                | NO                                     | 4.7                             |
| FAULT CODES        | F          | These tables contain fault codes, which are written by the controller as a result of the built-in self-test routines or as a result of execution of the user program (Some tables are available for the user to use as desired). | 542                | 542                | NO                                     | YES                          | NO                                     | 15.11                           |
| MAINTAINER         | M          | Available for user programmed tests. Write access from programmer with key removed. Accessible in Data List mode only.                                                                                                           | 0                  |                    | YES                                    | YES                          | YES                                    |                                 |
| FLOATING POINT     | Q          | Available to user for Floating Point data.                                                                                                                                                                                       | 0                  |                    | YES                                    | YES                          | YES                                    |                                 |
| EPROM              | S          | Available to the user for RAMEPROM Control (only values 0, 1 and 2 used)                                                                                                                                                         | 1                  | 1                  | NO                                     | NO                           | NO                                     | 10.7                            |
| MEMORY USAGE       | V          | Available to the user for READ only. These tables contain internal controller statistics                                                                                                                                         | 65                 | 65                 | NO                                     | NO                           | NO                                     | 15.11                           |

Table 4.2 - P-Data Table

| Address                                 | Content                                                                                                                                                                                                    | Remarks                                                                                                                                                                                                                                                                                                                                    |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| P0                                      | Available for user's system identification code                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                            |
| P1                                      | Program repetition interval (scan rate) Range 10 to 9,500 (ms), zero for free-running                                                                                                                      | Resolution 10ms                                                                                                                                                                                                                                                                                                                            |
| P2                                      | Length of pre-set message area in bytes<br><b>Note...</b> This effectively limits the message length.                                                                                                      | Should not be written to by user. Automatically updated by message editor.                                                                                                                                                                                                                                                                 |
| P3-P14<br>P15-P26<br>P27-P38<br>P39-P50 | Serial link configuration data for port 1<br>Serial link configuration data for port 2<br>Serial link configuration data for port 3<br>Serial link configuration data for port 4                           | See Sections 6.5, 6.6 and 6.7 for details                                                                                                                                                                                                                                                                                                  |
| P51                                     | Controls exercising of self-test facility on intelligent (double-width) Fast I/O modules.<br><br>P51.0 to P51.7 for modules 0,2,4,6,8,10,12,14, and<br>P51.8 to P51.15 for modules 16,18,20,22,24,26,28,30 | Only even numbered slots may use this facility.<br><br>See description of F44 in Fault Finding Section.<br>Cleared by CLEAR STORE command<br><br>Limits data transfers to the corresponding module to 62 words and causes all of the first block of 32 to be transferred if any of the 2nd block are transferred.                          |
| P52                                     | As P51 except that full status-linking provided irrespective of the state of the corresponding bit in P51. Bit-module correspondence as for P51.                                                           | As P51                                                                                                                                                                                                                                                                                                                                     |
| P53                                     | Gives start location of configuration data for Verification I/O                                                                                                                                            | See relevant Data Sheets for Verification I/O modules                                                                                                                                                                                                                                                                                      |
| P54-P59                                 | Reserved for future system use.                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                            |
| P60-P72                                 | Configuration data for STARNET (if fitted).                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                            |
| P73-P99                                 | Reserved for future system use.                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                            |
| P100-P115                               | File sizes for Off-line Data Storage facility.                                                                                                                                                             | File sizes are in the range 0 to 32,000 words. Specifying 0 de-configures the block and all subsequent non-zero entries are ignored. Specifying a negative value selects a file size of the absolute value of the number entered and indicates that the contents of all files in that block are to be protected by a checksum calculation. |
| P100                                    | File size for block 0                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                            |
| P101-P115                               | File sizes for blocks 1-15                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                            |
| P116                                    | Off-line Data Storage in EPROM Flags                                                                                                                                                                       | Each bit corresponds to a block of off-line storage. (Bit 0 = Block 0 etc) If the bit is set, that block of data is also copied when the user program is copied to EPROM.                                                                                                                                                                  |
| P117-P149                               | Reserved for future system use                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                            |

Printer text messages are also stored in the P-table, but they should be accessed using only the editor provided. Attempts to examine or modify the messages in any other way should not be made, although mal-operation does not result if it is.

## 4. DATA TABLES

Table 4.3 E-Data Table

| Address                                                      | Content                                                                                                                  | Remarks                                                                                                                                               |
|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| E0.0                                                         | 0.1 second timing marker                                                                                                 | Set ON for one program cycle at 0.1 second intervals                                                                                                  |
| E0.1                                                         | 1 second timing marker                                                                                                   | Set ON for one program cycle at 1 second intervals                                                                                                    |
| E0.6                                                         | Recompile Flag Marker                                                                                                    | Set on for one program cycle after a recompile                                                                                                        |
| E0.7                                                         | Limit flag set ON or OFF after each ADD or SUB instruction.                                                              | Can be used more than once in program                                                                                                                 |
| E0.8 Port 1<br>E0.9 Port 2<br>E0.10 Port 3<br>E0.11 Port 4   | Buffer filling flags for printer ports. Set ON when insufficient room in printer buffer for one complete line of output. | Port 3 and 4 used when a slave I/O Processor is installed                                                                                             |
| E0.12 Port 1<br>E0.13 Port 2<br>E0.14 Port 3<br>E0.15 Port 4 | Buffer empty flags for printer ports. Set ON when all pending printer output has been transmitted by a port.             | Port 3 and 4 used when a slave I/O Processor is installed                                                                                             |
| E1<br>E2<br>E3                                               | Seconds (0 - 59)<br>Minutes (0 - 59)<br>Hours (0 - 23)                                                                   | Time                                                                                                                                                  |
| E4<br>E5<br>E6                                               | Date (as appropriate to month, 1-31)<br>Month (1 - 12)<br>Years (0 - 99 or 1901 - 2099)                                  | Date                                                                                                                                                  |
| E7                                                           | Duration of previous program scan                                                                                        | In lms units. This has a resolution of 10ms. On a halt-to-run transition, or on a single cycle, this is set to 100.                                   |
| E8                                                           | Running clock                                                                                                            | In lms units. This has a resolution of 10 ms. It is a 16-bit unsigned value. On halt-to-run transition, or on a single cycle, it is updated by 100ms. |

## 5.1 Introduction

The Verification I/O Highway is a bi-directional parallel medium speed highway used for transferring data between a host controller (with Verification capability) and Verification I/O modules. The Verification I/O highway provides security against the transfer of corrupted data between the controller and the I/O Modules.

The Verification I/O transfer provides 'address/data checkwords' and 'data confirm words' during the I/O transfer. Outputs are not written to the plant unless the address/data checkword sent by the controller is mathematically verified within the I/O device. Any corruption which occurs during the transfer is indicated by a data confirm word. If the transfer remains corrupted after five attempts, a fault flag is set.

The I/O modules used in the system may be either Verification I/O modules or Basic I/O modules. However, Basic I/O modules require to be interfaced through a Verification I/O Expander.

## 5.2 Verification I/O Highway

The GEM 80 Controller can handle up to 1,024 words on the Verification I/O highway which can contain either 16,384 ON/OFF states or 1,024 numeric values (range +32,767 or -32,768) or any mixture. These quantities are doubled when two I/O Processors are fitted.

The Verification I/O highway is carried on a 26-way ribbon which comes from the second ribbon cable socket at the rear of the I/O Processor, the first socket is not used. A separate ribbon is used for each I/O Processor. Each Verification ribbon carries 1,024 A/B addresses. The master I/O Processor uses the lower range (0-1,023) and the second or slave I/O Processor uses the upper range (1,024-2,047). Figure 5.1 shows the location of the connections on the upper backplane of the processor subrack.

The Verification I/O ribbon can be 'daisy chained' to successive Verification I/O subracks. However, there is a limitation on the length of ribbon cable used, imposed by the method of feeding the +15V supply.

If the +15V Power is directly connected to the I/O subrack, the limiting factor is cable capacitance in which case the following formula applies :-

$$L = 83 - 0.42(M + S)$$

where:

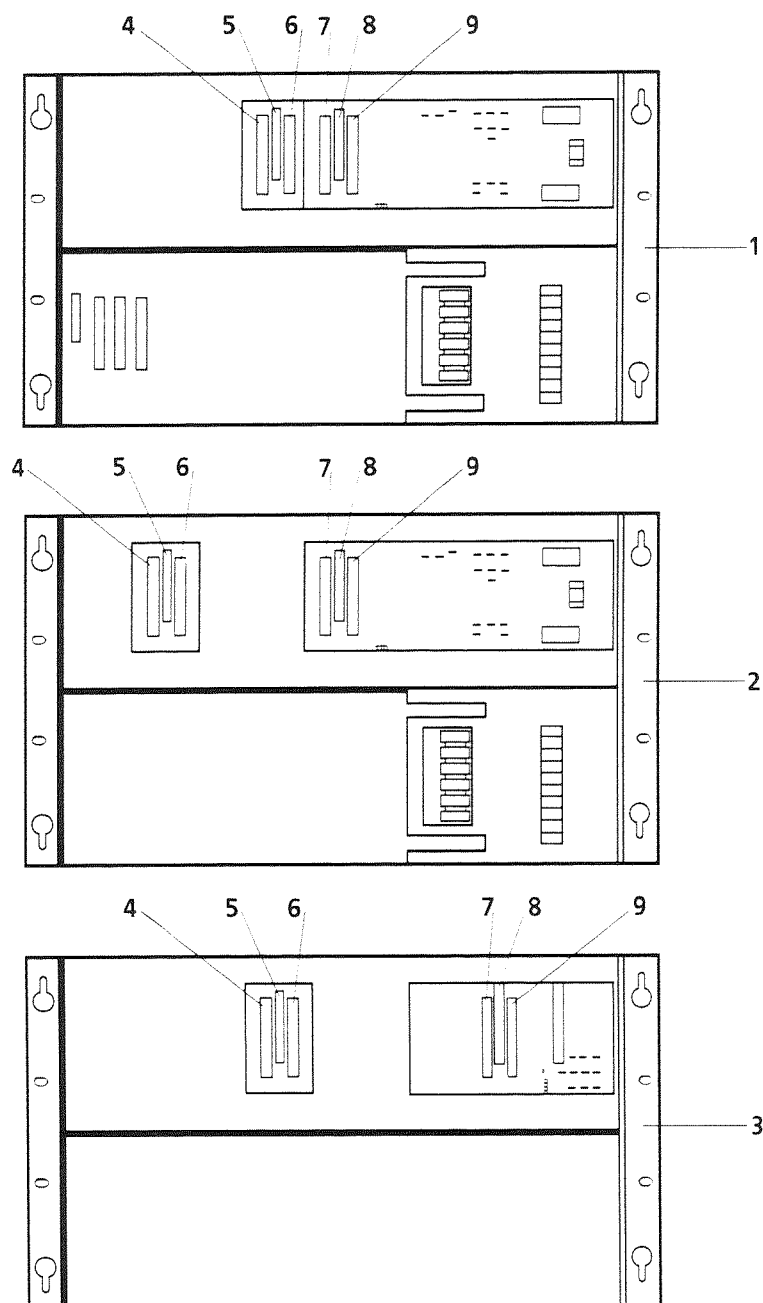
M = Quantity of modules on the Verification I/O ribbon, including I/O modules, I/O Processor, Verification I/O expanders and Remote I/O Controllers.

S = Quantity of subracks.

L = Total ribbon length in metres.

If the +15V power is supplied down the Verification I/O ribbon, the equivalent formula for length becomes:

$$L = 52 - 0.42(M + S)$$



- |                                                     |                                                      |
|-----------------------------------------------------|------------------------------------------------------|
| 1. GEM 80/311                                       | 6. Not Used                                          |
| 2. GEM 80/312                                       | 7. Verification I/O Connector (Master I/O Processor) |
| 3. GEM 80/313                                       | 8. Serial Link Connector (Master I/O Processor)      |
| 4. Verification I/O Connector (Slave I/O Processor) | 9. Not Used                                          |
| 5. Serial Link Connector (Slave I/O Processor)      |                                                      |

Figure 5.1 Location of Verification I/O and Serial Link Connectors

### 5.3 Basic I/O Highway.

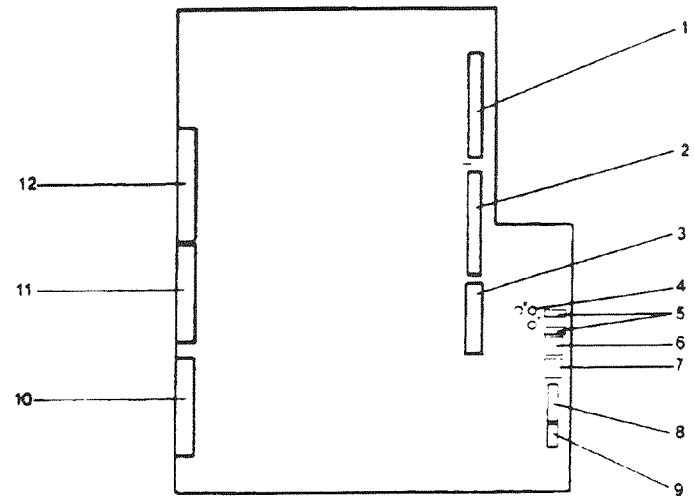
In most installations there is a requirement for a combination of Verification and Basic I/O modules. Where this requirement exists one or more verification to basic expander modules can be used. This module is the Verification I/O Expander.

### 5.4 Verification I/O Expander 8191-4004

#### 5.4.1 Introduction

The 8191 Verification Expander module mounts into a 12-slot I/O subrack and converts the Verification highway into one or two Basic I/O ribbons. This allows Basic I/O modules to be used on the Verification I/O highway and assigned any valid address. It is a double width module which occupies no I/O space and appears to the host controller as  $n \times 16$ -bit I/O modules, where  $n$  is the range of addresses selected by the range switch up to a maximum of 32 addresses.

The 8191 Expander module fits at the right-hand end of the 12-slot I/O sub-rack 8859-4003. Two ribbon cable connectors are mounted on the circuit board. The top one, PL4, provides Basic I/O highway connections and the lower one, PL5, provides Verification I/O highway connections. Ribbon cables from PL4 and PL5 connect to corresponding connectors on the upper backplane of the subrack. The Verification ribbon input from the I/O Processor or from the previous expander module is connected to ribbon socket PL3 of the 8191 module. This ribbon can then be daisy-chained on to the next 8191 Expander module.



1. PL4 - Basic I/O Ribbon Cable 1 to Backplane.
2. PL5 - Verification I/O Ribbon to Backplane.
3. PL7 - 20-Way Connector for Alternative Power Supply
4. LK5 - Refer to 5.7.2, 5.7.3, 5.7.4 and 5.7.5
5. F3/4 - +15V/0V Push-on Terminals
6. SW1 - Range Switch
7. SW2 - Range Switch
8. SW3 - Address Switch
9. SW4 - Address Switch
10. PL3 - Verification I/O Ribbon Connector
11. PL2 - Basic I/O Ribbon 2 Connector
12. PL1 - Basic I/O Ribbon 1 Connector

Figure 5.2 - 8191-4004 Verification I/O Expander Module

## 5. I/O HIGHWAY

### 5.4.2 Address Setting

Two banks of address switches, SW3 and SW4, are used to set the base address of the 8191 Expander Module itself on the Verification I/O highway. Once this base address has been established, the range switches, SW1 and SW2 are then set to the range of Basic I/O addresses to be used. (Up to a maximum of 32).

The number of addresses on the Verification I/O highway is dependent on the host controller but can be up to a maximum of 4,096 (0 to 4,095) which is  $2^{12}$ . To cater for this maximum, the 8191 requires twelve address switches.

The twelve switches are located at the bottom rear corner of the module and are accessible without removing the plastic protective cover. They are in a group of eight, bits 0-7, and a group of four, bits 8-11. When a switch is in the ON position, that bit is a logical '1'.

Figure 5.3 shows the layout of the address switches and illustrates that switches for bits 0 (1), 1 (2), and 5 (32) are set to the logical '1' position, giving a base address of 35 ( $1 + 2 + 32$ ) for the 8191.

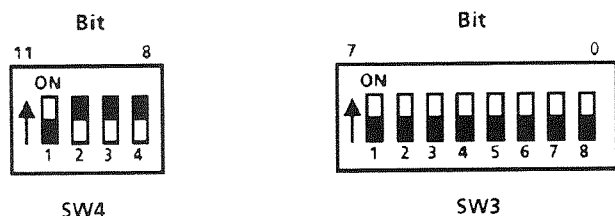


Figure 5.3 - Address Switches

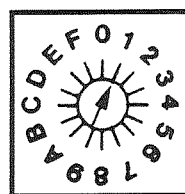
### 5.4.3 Range Setting

As mentioned previously, the module can accommodate up to 32 addresses. The Range Switches (SW1 and SW2) are used to indicate to the host controller the size of the block of addresses to which the module will respond.

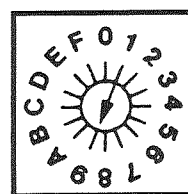
The range switches are located above and adjacent to the address switches and take the form of two 16-position hex rotary switches, the positions being identified 0 to F. They should be set within the range @00 to @1F (0 to 31 decimal). If, for example, they are both set to 0 and the address switches are set to the address 35 as shown in Figure 5.3, the module responds only to address 35. If, however, the range switches are set to @1F (31 decimal), the maximum allowable, the module responds to addresses in the range 35 to 66 ( $35 + 31$ ).

If the switches are set to @20 or higher neither Basic I/O ribbon is scanned.

Figure 5.4 shows the Range Switches set to @19 (25 decimal). Using the example shown in Figure 5.3, the module will respond to addresses within the range 35 to 60.



SW2



SW1

Figure 5.4 - Range Switches

Table 5.1 shows how the range switches affect the address block size.

Table 5.1 Range Switch Operation

| Range Switch Setting |    | Top Address | Range Switch Setting |    | Top Address |
|----------------------|----|-------------|----------------------|----|-------------|
| S2                   | S1 |             | S2                   | S1 |             |
| 0                    | 0  | Base (n)    | 1                    | 0  | n + 16      |
| 0                    | 1  | n + 1       | 1                    | 1  | n + 17      |
| 0                    | 2  | n + 2       | 1                    | 2  | n + 18      |
| 0                    | 3  | n + 3       | 1                    | 3  | n + 19      |
| 0                    | 4  | n + 4       | 1                    | 4  | n + 20      |
| 0                    | 5  | n + 5       | 1                    | 5  | n + 21      |
| 0                    | 6  | n + 6       | 1                    | 6  | n + 22      |
| 0                    | 7  | n + 7       | 1                    | 7  | n + 23      |
| 0                    | 8  | n + 8       | 1                    | 8  | n + 24      |
| 0                    | 9  | n + 9       | 1                    | 9  | n + 25      |
| 0                    | A  | n + 10      | 1                    | A  | n + 26      |
| 0                    | B  | n + 11      | 1                    | B  | n + 27      |
| 0                    | C  | n + 12      | 1                    | C  | n + 28      |
| 0                    | D  | n + 13      | 1                    | D  | n + 29      |
| 0                    | E  | n + 14      | 1                    | E  | n + 30      |
| 0                    | F  | n + 15      | 1                    | F  | n + 31      |

The module address corresponds to the first address of the address block. When the size of the address block is set by the Range Switch, care must be taken to ensure that the automatically assigned addresses in the block do not overlap any other previously allocated addresses as this will cause highway errors.

It must be remembered that the base address of the module must be at least the number of addresses in the block less than the maximum number of I/O addresses available in the host controller. If this rule is not observed it will result in the loss of one or more of the top addresses in the block. For example, if the maximum I/O address of the host controller is 512 I/O words and the module is given a base address of 491, only 22 addresses are available. If the Range Switches are then set to @1D (block size of 30), the top 8 addresses will be un-available or lost.

### 5.4.4 Examples of Addressing

#### Example 1

A system has a requirement for a combination of Verification and Basic I/O modules. There are 5 Verification I/O modules which require a total of 80 addresses (5 x 16) and a number of Basic I/O modules requiring an additional 28 addresses.

If the Verification I/O modules are fitted into the lowest available addresses (i.e. 0 to 79) on the highway, the first address available for Basic I/O is 80. To set this base address, the address switches are set to 0000 0101 0000. The range switches are set to 27, giving a range of the required 28 addresses and a top address of 107. The expander module will now respond to addresses within the range 80 to 107.

#### Example 2

In this example, Verification I/O modules have been arbitrarily allocated addresses 64 and above. The Basic I/O requirement of 47 addresses can be allocated to the lowest addresses on the highway, i.e. 0 to 46. The Basic I/O is split between four subracks, the first pair requiring 30 addresses and the second pair 17 addresses. As an expander can only accommodate a maximum of 32 addresses, two expanders are required.

The first expander covers addresses 0 to 29, therefore the address switches need to be set to 0 for a base address of 0 with the range switches set to 29.

The second expander has a base address of 30 so its address switches are set to 0000 0001 1110. To assign a total of 17 addresses to this expander, an additional 16 addresses are required, therefore the range switches are set to 16. Between them, the two expanders now respond to addresses within the range 0 to 46 (47 addresses).

### 5.4.5 Fault Indication

Each word of I/O has a corresponding pair of bits in an F-table location to indicate incorrect operation of that address. The least significant bit of each pair is the fault bit and the most significant bit is the fail bit. Under normal operation, all the F-table locations monitoring I/O operation are at zero.

If any of the strobe or data lines for a particular ribbon are not working correctly, the fail bit and the fault bit are set in all the F-table locations for that ribbon to indicate that all data is being transferred incorrectly.

Failure of the expander module or a highway fault results in all bits in the appropriate F-table locations being set to 1.

If the expander module finds a fault with the Basic I/O ribbons, a pattern of bits is written into the appropriate F-table locations.

If any address lines become shorted together or to a supply, only the fault bits in the F-table locations for those addresses are set to 1.

Figure 5.5 shows the fault bit/address relationship for Basic I/O Ribbons 1 and 2 for an 8191 Verification I/O Expander module which has its base address set to zero and the range switches set for 32 addresses, i.e. the range switches set to 31.

If the expander had any strobe or data lines shorted, the bit pattern 1111 1111 1111 1111 (all the fail bits) would be set in tables F45 and F46 for ribbon 1, and F47 and F48 for ribbon 2.

If the expander module responds to addresses 0 to 31 and address line A6 on ribbon 1 is shorted to 0V, the fault bits will be set for addresses 12 and 13 in fault table F46. The bit pattern will be 0000 1111 0000 0000.

Should the same expander have address line A1 shorted to address line A2 on ribbon 2, the fault bits will be set for addresses 18, 19, 20 and 21 in fault table F47. The bit pattern in F47 will be 0000 1111 1111 0000.

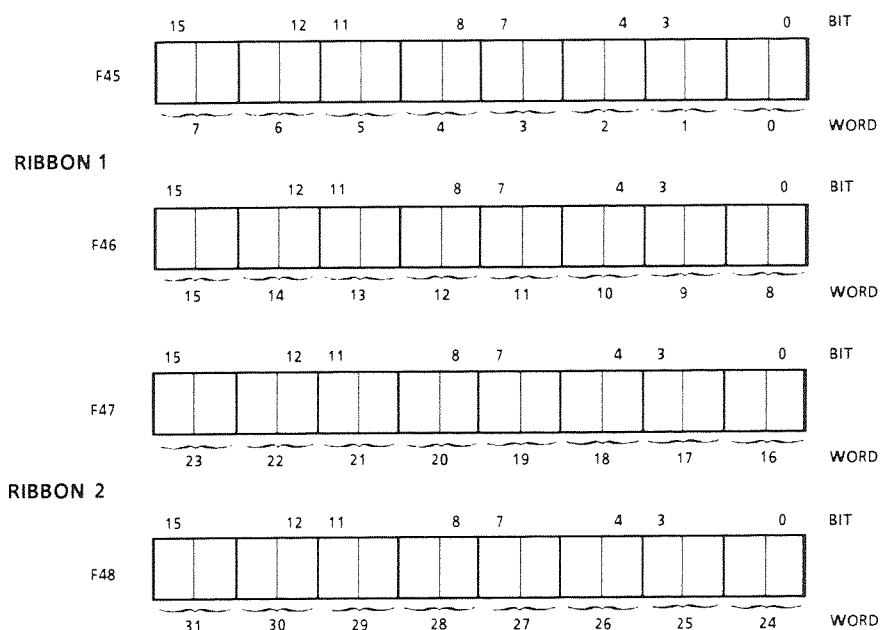


Figure 5.5 - Fault Bit/Address Relationship

## 5.5 Data Table Addresses

### 5.5.1 Ribbon Cable Addresses

Each Basic I/O Highway ribbon cable from the Verification I/O Expander Module can be connected to up to 256 I/O points or up to sixteen 16-bit words or a mixture of 16-bit words and I/O points.

The state of each I/O point is stored in the controller data tables. Data INPUT to the controller through the Verification and Basic I/O ribbon cables is stored in the A-data tables. Data to be OUTPUT by the controller through the Verification and Basic I/O ribbon cables is stored in the B-data tables.

Each Basic I/O ribbon cable carries data to and from the Input and Output points to sixteen data table memory locations.

### 5.5.2 Unit Address Settings

Each unit on the Basic I/O has a specific address which is defined by setting the address and range switches on the Expander and by setting the address decoder switches on the subrack. There are three decoder switches (S1, S2 and S3) on the 8857-4006 and 8859-4003 I/O subracks. These switches are set where a mix of 8- or 16-point modules are fitted.

The GEM 80 uses 16-bit words and, as each decoder switch setting corresponds to two 16-bit words, each switch determines the address of either four 8-point modules or two 16-point modules. This is illustrated in Table 5.2 and Table 5.3. Table 5.2 applies to 8-point modules and determines the addresses of quartets of modules. Table 5.3 applies to 16-point modules and determines the addresses of pairs of modules.

#### (1) 8859-4003 12-slot I/O Subrack

This subrack accommodates up to twelve 8-, 16- or 32-point modules and its application is fully explained in the User Information Sheet, Publication No.T1504.

#### (2) 8857-4006 8-slot Compact I/O Subrack.

This subrack has space for up to eight 8-, 16- or 32-point Basic I/O modules and a 9032 Power Supply Module. The User Information Sheet, Publication No.T1503 contains full details of this Unit.

#### (3) Operator Interface Units

|         |                   |                       |
|---------|-------------------|-----------------------|
| 8872    | Membrane Keyboard | - input/output 32-bit |
| 8944    | Thumbwheel Input  | - input               |
| 8932/33 | Decade Display    | - output              |

These units have one address decoder switch with ten positions numbered 0 to 9. Settings 8 and 9 indicate that the switch is unused. Each setting on the decoder switch represents 2 address locations (32 I/O points) in the host controller. The actual address of the Operator Interface Unit therefore depends on the setting of the decoder switch, the address setting of the Expander Module itself, and whether it is connected to Ribbon 1 or Ribbon 2 of the 8191 Expander. Full details of these units are contained in the relevant User Information Sheet.

#### (4) Decoder Switch Settings

Decoder switch settings determine different addresses on different Ribbon cables. Table 5.4(a) illustrates the addresses when the 8191 base address is set to 0. Table 5.4(b) illustrates the addresses when the 8191 base address is set to 73

Table 5.2. Decoder Switch used with 8-point Modules

|      | Second Word       |                  | First Word        |                  | Switch Used |
|------|-------------------|------------------|-------------------|------------------|-------------|
|      | Points<br>8 to 15 | Points<br>0 to 7 | Points<br>8 to 15 | Points<br>0 to 7 |             |
| SLOT | 4                 | 3                | 2                 | 1                | S1          |
|      | 8                 | 7                | 6                 | 5                | S2          |
|      | 12                | 11               | 10                | 9                | S3          |

Table 5.3 Decoder Switch used with 16-point Modules

|      | Second Word | First Word | Switch Used |
|------|-------------|------------|-------------|
| SLOT | 2           | 1          | S1          |
|      | 4           | 3          | S2          |
|      | 6           | 5          | S3          |

Table 5.4 (a) Decoder Switch Settings

| RIBBON<br>CABLE | SWITCH SETTING |         |         |         |         |         |         |         |
|-----------------|----------------|---------|---------|---------|---------|---------|---------|---------|
|                 | 0              | 1       | 2       | 3       | 4       | 5       | 6       | 7       |
| 1 (lower)       | 0 & 1          | 2 & 3   | 4 & 5   | 6 & 7   | 8 & 9   | 10 & 11 | 12 & 13 | 14 & 15 |
| 2 (upper)       | 16 & 17        | 18 & 19 | 20 & 21 | 22 & 23 | 24 & 25 | 26 & 27 | 28 & 29 | 30 & 31 |

Table 5.4 (b) Decoder Switch Settings

| RIBBON<br>CABLE | SWITCH SETTING |         |         |         |         |          |           |           |
|-----------------|----------------|---------|---------|---------|---------|----------|-----------|-----------|
|                 | 0              | 1       | 2       | 3       | 4       | 5        | 6         | 7         |
| 1 (lower)       | 73 & 74        | 75 & 76 | 77 & 78 | 79 & 80 | 81 & 82 | 83 & 84  | 85 & 86   | 87 & 88   |
| 2 (upper)       | 89 & 90        | 91 & 92 | 93 & 94 | 95 & 96 | 97 & 98 | 99 & 100 | 101 & 102 | 104 & 105 |

**Note...**

DECODER SWITCH SETTINGS 8 & 9 INDICATE THAT THE SWITCH IS NOT USED.

## (5) Addressing Verification I/O Modules

The address position of Verification I/O modules on the Verification I/O highway is determined by setting switches on the module itself. These switches are set to the required base address. Care must be exercised when setting the address 'window', to ensure that the address requirements do not overlap. Additional details can be found in the relevant data sheets for the modules.

## (6) Addressing Basic I/O modules

As previously stated, Basic I/O modules are addressed through the 8191 Expander module. The actual addresses on the Verification I/O highway are determined by setting the base address switches on the 8191 Expander module itself.

The address decoder switches on I/O subracks form part of the complete addressing system. These combine a number of fixed and variable address locations.

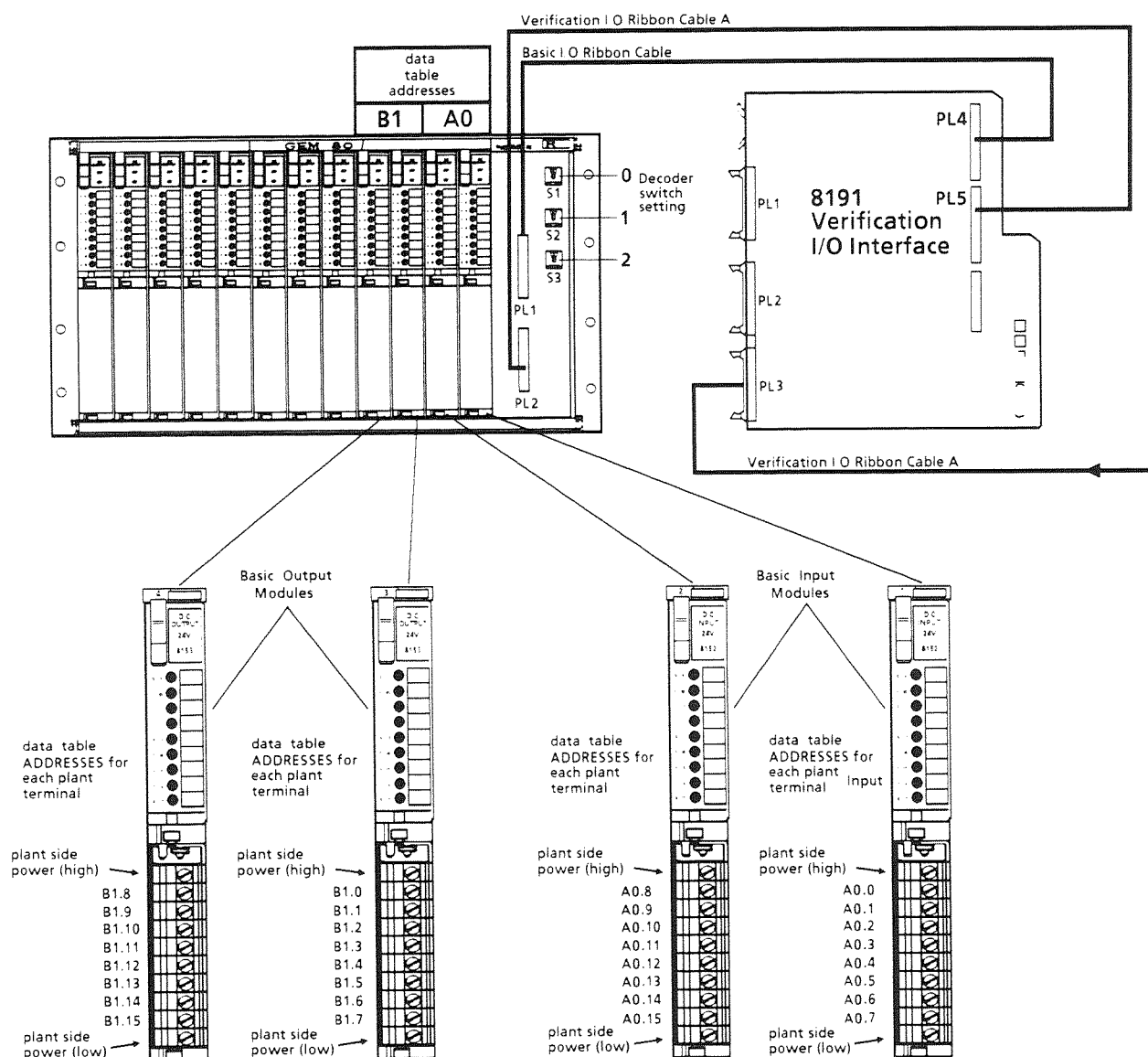


Figure 5.6 (Part 1) - 8859 I/O Subrack Connected to GEM 80/311

The method of addressing used in GEM 80 is best illustrated by the examples shown in Figures 5.6 and 5.7. In Figure 5.6, a GEM 80/311 Controller is shown connected to an 8859 I/O subrack via the Verification I/O ribbon cable from the I/O processor. To emphasise the data table content, only the Basic I/O modules are shown in this example.

The 8191 Verification I/O Expander base selection switches are set to 0. The range switches are set to 12, allowing further Basic I/O modules to be addressed in a second subrack. The top address decoder switch (S1) on the 8859 Basic I/O subrack is set to zero, so module numbers 1 to 4 are addresses 0 and 1. Module numbers 1 and 2 are Basic Input modules and as input addresses are A-table, module numbers 1 and 2 must be address A0.

Each module has 8 channels, so the two modules together have 16 channels and form one 16-bit word, A0, which stores the input states for these 16 channels.

Module numbers 3 and 4 are Basic Output modules and as output addresses are B-table, so data table B1 stores the 16 output states for these channels.

In this example, address A0 is Input so address B0 does not exist and similarly B1 is Output so address A1 does not exist.

8-point module pairs form one word, so each pair of modules must be the same, either both Input modules or both Output modules. Each module has 8 channels, so the two modules have 16 channels and form one 16-bit word A0. Word A0 stores the input states for these 16 channels. Module numbers 3 and 4 are compact output modules and output addresses are B-table, so data table B1 stores the 16 output states for these channels.

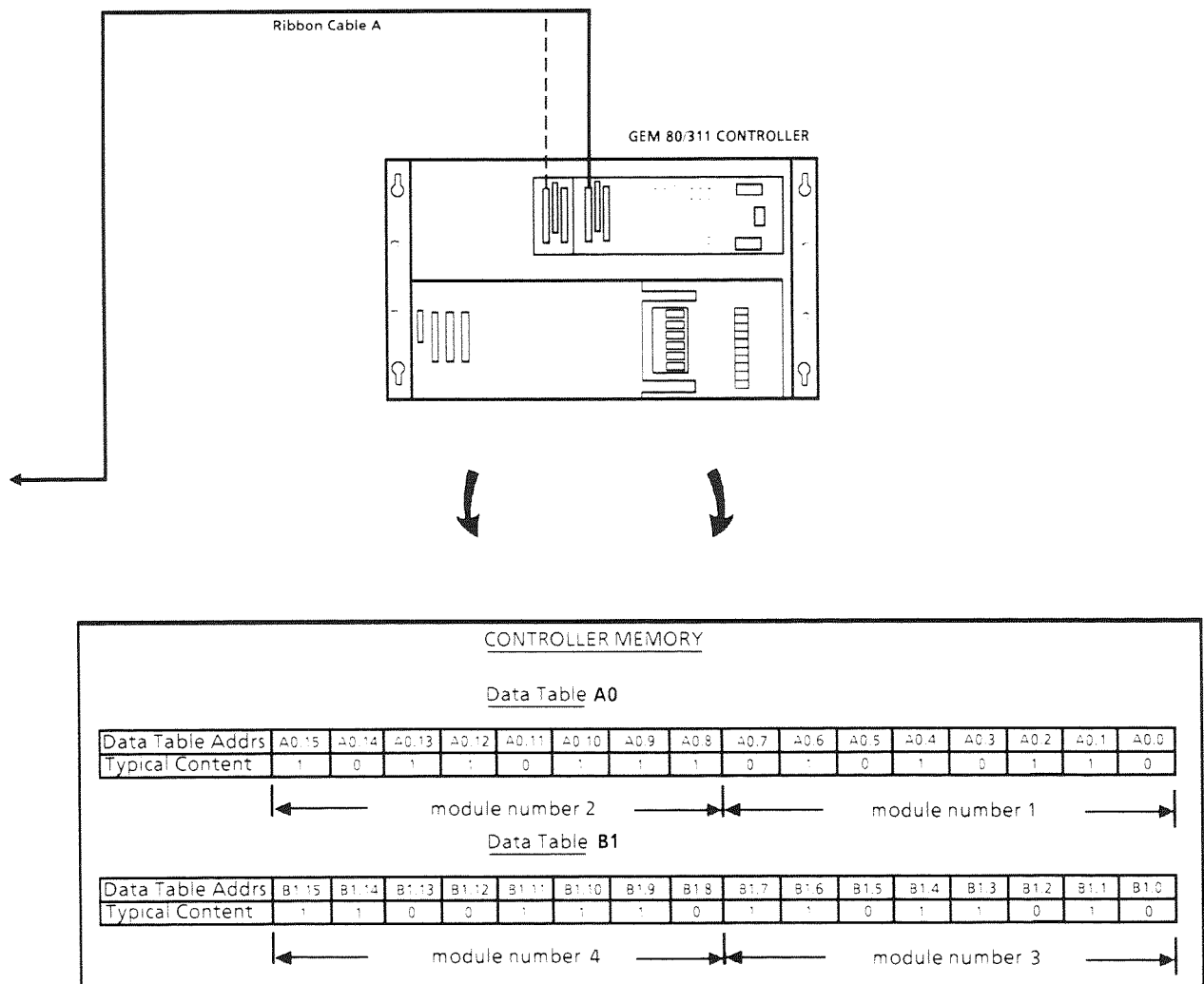


Figure 5.6 (Part 2) - 8859 I/O Subrack Connected to GEM 80/311

## 5. I/O HIGHWAY

In the example in Figure 5.7, a system needs A/B0 to A/B575 of I/O. The requirement is broken down as follows :-

Verification I/O Modules      A/B0 to A/B150  
                                          A/B181 to A/B300  
                                          A/B311 to A/B559

Basic I/O Modules                A/B151 to A/B180  
                                          A/B301 to A/B310  
                                          A/B560 to A/B575

The I/O modules are to be sited in four locations:

1. A/B0 to A/B180
2. A/B181 to A/B310
3. A/B311 to A/B405
4. A/B406 to A/B575

The subracks are shown separately to illustrate the 'daisy chaining' capability of the Verification I/O ribbon.

**Note...**The subracks are labelled as being Basic or Verification in order to emphasise the different address requirement.

In practice, both Verification and Basic I/O modules can be accommodated in the same subrack. As previously explained, the 8191 Verification I/O Expander must be employed when Basic I/O modules are to be addressed.

The base address of each 8191 is set by the two DIP switches SW3 and SW4. SW3 gives the least significant digit. (See Figure 5.3). The range of the address 'window' is set by the two HEX switches SW1 and SW2, with SW1 giving the least significant digit. (See Figure 5.4).

### Expander No.1

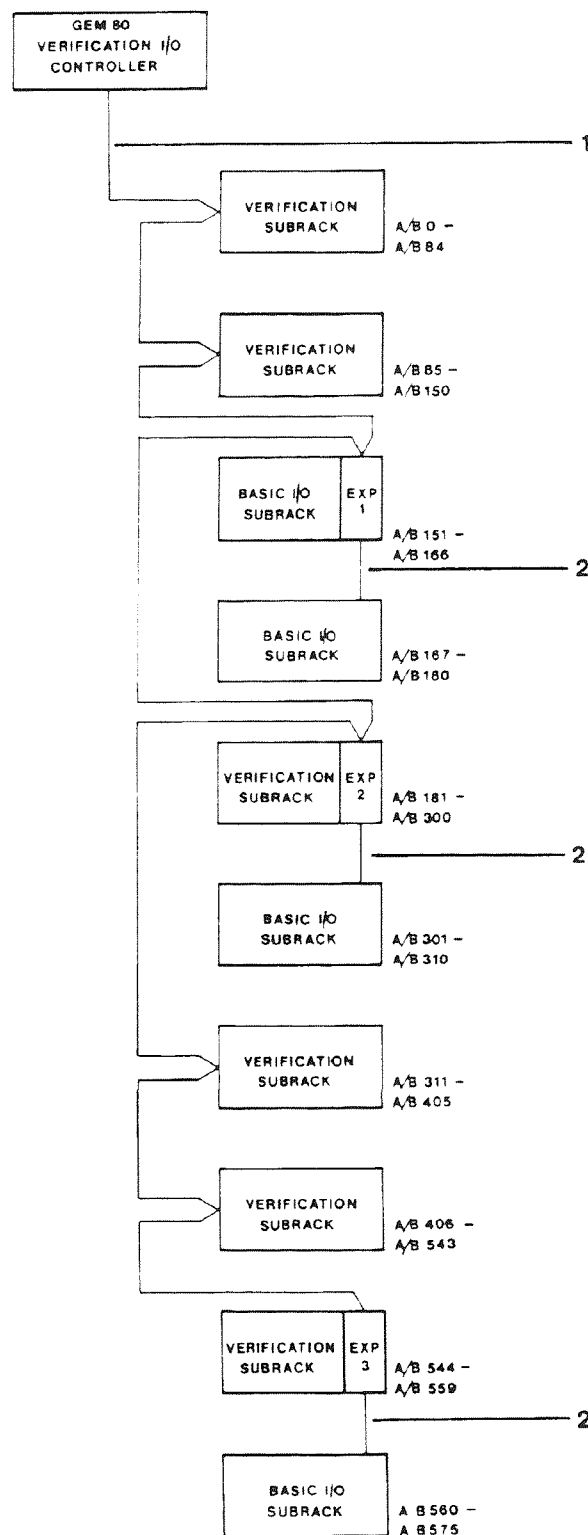
Base Address = 151: SW4 = 0000, SW3 = 10010111.  
 Range         = 29: SW2 = 1,     SW1 = D.

### Expander No.2

Base Address = 301: SW4 = 0001, SW3 = 00101101.  
 Range         = 9: SW2 = 0,     SW1 = 9.

### Expander No.3

Base Address = 560: SW4 = 0010, SW3 = 00110000.  
 Range         = 15: SW2 = 0,     SW1 = F.



1. Verification I/O Highway
2. Basic I/O Highway

Figure 5.7 - Typical Verification I/O System

## 5.6 I/O Module Configuration

The most convenient method of arranging the I/O modules in a complete system is to start with the 8-point modules, continue with the 16-point and finish with the 32-point modules, ensuring that all module details and addresses are progressively recorded. The I/O Subrack User Information Sheet, Publication No.T1432 gives more detailed instructions.

It is important to be aware of the details and addresses of all the modules fitted and to ensure that an address is used **ONCE ONLY**. It is also necessary to calculate the current in each of the Ribbon cables. In order to assist in recording these parameters, blank tables have been provided which can be copied as required.

### CAUTION

**Ensure that each module has a unique address or the system will not work. Also ensure that where subrack switches are not being used for addressing, they are set to position 8 or 9.**

#### 5.6.1 Verification I/O modules

Verification I/O modules may be positioned in any of the slots in the subrack. The precise address is determined by switches on the module and is not affected by its slot position.

#### 5.6.2 Basic I/O modules

Each I/O point can be used only once. Any combination of 8-, 16- and 32-point Basic I/O modules is allowable provided the module address as defined by the 8191 Expander Module, the Decoder switch setting and/or the slot position, is unique.

#### 5.6.3 Possible Combinations of Basic I/O and Verification modules

Verification I/O modules can go in any slot provided its address does not violate the address windows already allocated to Verification I/O Expanders. Verification I/O modules will not affect the Basic I/O.

## 5.7 Power for Verification and Basic I/O Equipment

### 5.7.1 Introduction

Power for I/O equipment may be supplied from a combination of the following sources :-

- (1) Controller Power Module PM1 (R0 slots 3 to 10)
  - (2) Controller Power Module PM2 (R0 slots 11 to 18)
  - (3) From 9032 Power Modules mounted in an 8857 subrack
  - (4) An external +15V/5V power source
- (1) and (2) apply to the GEM 80/313 only.

Section 11 gives full details of the power available from PM1 and PM2 which can be either 8917 or 8918 power modules. Subtract the consumption figures given in Table 11.2 for the Central Highway modules to obtain the power available to the Basic and Verification I/O equipment.

In addition to the power consumed by the I/O equipment, the 8191 Verification I/O Expander requires its own power which is drawn from either PM1 or PM2 through the Verification I/O ribbon cable. The current carrying capacity of this cable is specified in Table 5.6. The 8191 requires 900mA for its own use and it can be seen that with 3 or more expanders being used, the maximum current for the I/O ribbon cable will be exceeded.

The power drawn by the 8191 Verification I/O Expander through the Verification I/O ribbon cable for the I/O modules fitted and for its own requirements can be reduced by supplying the requirement through an alternative route.

The following paragraphs describe the methods open to the user. Figure 5.8 should be copied and filled in for each ribbon cable. Figure 5.9 shows an example of how this is done. Current consumption figures can be found in Section 11 of this manual or in the relevant User Information Sheets.

To establish the power available in the Controller Power Supply module, see Section 11.2

Figure 5.10 can then be filled in to allocate power sources to specific ribbon cables. Figure 5.11 gives an example.

The power available in the 8857 subrack with a 9032-4002 Power module is 2A at +15V. See Table 11.2 in Section 11, Power Supplies for the trade-off between the +15V and +5V supplies.

The Verification I/O modules require a +5V supply. This is not available on the Verification I/O ribbon. The +5V is therefore supplied either from the power module in the I/O subrack in which the Verification I/O module is fitted, a power module from an adjacent subrack or a separate (external) supply.

See the I/O Subrack Manual, Publication No.T1432 for specific connection details. The current available in the 8857 subrack with a 9032-4002 Power Module is 7A at +5V.

It is recommended that Tables 5.5.1 and 5.5.2 should be completed as an aid to addressing and to draw attention to the +5V requirement of Verification I/O modules.

## 5. I/O HIGHWAY

Table 5.5 USER TABLES (Copy as required)

Table 5.5.1 8-Slot I/O Subrack

RACK NO. ....

RIBBON NO. ....

| Slot            | 8          | 7          | 6          | 5          | 4          | 3          | 2          | 1          | Decoder<br>Switches                       |
|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------------------------------------|
| Module          |            |            |            |            |            |            |            |            | S1 =                                      |
| I/O Points      | 32/16<br>8 | 32/16<br>8 | 32/16<br>8 | 32/16<br>8 | 32/16<br>8 | 32/16<br>8 | 32/16<br>8 | 32/16<br>8 | S2 =                                      |
| Address         |            |            |            |            |            |            |            |            | S3 =                                      |
| Current<br>(mA) |            |            |            |            |            |            |            |            | Total Current<br>used in Subrack<br>_____ |

Table 5.5.2 12-Slot I/O Subrack

RACK NO. ....

RIBBON NO. ....

| Slot            | 12         | 11      | 10         | 9       | 8          | 7       | 6          | 5       | 4          | 3          | 2          | 1          | Decoder Switches                          |
|-----------------|------------|---------|------------|---------|------------|---------|------------|---------|------------|------------|------------|------------|-------------------------------------------|
| Module          |            |         |            |         |            |         |            |         |            |            |            |            | S1 =                                      |
| I/O Points      | 32/16<br>8 | 16<br>8 | 32/16<br>8 | 16<br>8 | 32/16<br>8 | 16<br>8 | 32/16<br>8 | 16<br>8 | 32/16<br>8 | 32/16<br>8 | 32/16<br>8 | 32/16<br>8 | S2 =                                      |
| Address         |            |         |            |         |            |         |            |         |            |            |            |            | S3 =                                      |
| Current<br>(mA) |            |         |            |         |            |         |            |         |            |            |            |            | Total Current<br>used in Subrack<br>_____ |

RIBBON CABLE NUMBER 

| Item No. | Equipment | No. of Bits | Where Used | Rack No./Location | Address Range | Worst Case +15V Consumption mA |
|----------|-----------|-------------|------------|-------------------|---------------|--------------------------------|
| 1        |           |             |            |                   |               |                                |
| 2        |           |             |            |                   |               |                                |
| 3        |           |             |            |                   |               |                                |
| 4        |           |             |            |                   |               |                                |
| 5        |           |             |            |                   |               |                                |
| 6        |           |             |            |                   |               |                                |
| 7        |           |             |            |                   |               |                                |
| 8        |           |             |            |                   |               |                                |
| 9        |           |             |            |                   |               |                                |
| 10       |           |             |            |                   |               |                                |
| 11       |           |             |            |                   |               |                                |
| 12       |           |             |            |                   |               |                                |
| 13       |           |             |            |                   |               |                                |
| 14       |           |             |            |                   |               |                                |
| 15       |           |             |            |                   |               |                                |
| 16       |           |             |            |                   |               |                                |
| 17       |           |             |            |                   |               |                                |
| 18       |           |             |            |                   |               |                                |
| 19       |           |             |            |                   |               |                                |
| 20       |           |             |            |                   |               |                                |
| 21       |           |             |            |                   |               |                                |
| 22       |           |             |            |                   |               |                                |
| 23       |           |             |            |                   |               |                                |
| 24       |           |             |            |                   |               |                                |
| 25       |           |             |            |                   |               |                                |
| 26       |           |             |            |                   |               |                                |
| 27       |           |             |            |                   |               |                                |
| 28       |           |             |            |                   |               |                                |
| 29       |           |             |            |                   |               |                                |
| 30       |           |             |            |                   |               |                                |
| 31       |           |             |            |                   |               |                                |
| 32       |           |             |            |                   |               |                                |

Total +15V current used by this ribbon cable

Length in metres of this ribbon cable

Check that +15V consumption is less than maximum ribbon cable current given in Table 5.6.

YES NO

Figure 5.8 - Basic I/O Ribbon Cable Blank Form

## 5. I/O HIGHWAY

| RIBBON CABLE NUMBER <span style="border: 1px solid black; display: inline-block; width: 100px; height: 1.2em; vertical-align: middle;"></span> |                      |             |                    |                   |               |                                |
|------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------------|--------------------|-------------------|---------------|--------------------------------|
| Item No.                                                                                                                                       | Equipment            | No. of Bits | Where Used         | Rack No./Location | Address Range | Worst Case +15V Consumption mA |
| 1                                                                                                                                              | 8110(9-66V dc Input) | 8           | Conveyor Interlock | R1 slot 1         | A0.0/A0.7     | 8.4                            |
| 2                                                                                                                                              | 8110(9-66V dc Input) | 8           | Conveyor Interlock | R1 slot 2         | A0.8/A0.15    | 8.4                            |
| 3                                                                                                                                              | 8111(110V ac Input)  | 8           | Conveyor Tracker   | R1 slot 3         | A1.0/A1.7     | 6.5                            |
| 4                                                                                                                                              | 8111(110V ac Input)  | 8           | Conveyor Tracker   | R1 slot 4         | A1.8/A1.15    | 6.5                            |
| 5                                                                                                                                              | 8114(110V ac Output) | 8           | Track Sensor 9-12  | R1 slot 5         | B2.0/B2.7     | 81.0                           |
| 6                                                                                                                                              | 8114(110V ac Output) | 8           | Track Sensor 9-12  | R1 slot 6         | B2.8/B2.15    | 81.0                           |
| 7                                                                                                                                              | 8111(110V ac Input)  | 8           | Safety Cubicle     | R2 slot 1         | A3.0/A3.7     | 6.5                            |
| 8                                                                                                                                              | 8111(110V ac Input)  | 8           | Safety Cubicle     | R2 slot 2         | A3.8/A3.15    | 6.5                            |
| 9                                                                                                                                              | 8114(110V ac Output) | 8           | Operator Desk      | R2 slot 3         | B4.0/B4.7     | 81.0                           |
| 10                                                                                                                                             | 8114(110V ac Output) | 8           | Operator Desk      | R2 slot 4         | B4.8/B4.15    | 81.0                           |
| 11                                                                                                                                             |                      |             |                    |                   |               |                                |
| 12                                                                                                                                             |                      |             |                    |                   |               |                                |
| 13                                                                                                                                             |                      |             |                    |                   |               |                                |
| 14                                                                                                                                             |                      |             |                    |                   |               |                                |
| 15                                                                                                                                             |                      |             |                    |                   |               |                                |
| 16                                                                                                                                             |                      |             |                    |                   |               |                                |
| 17                                                                                                                                             |                      |             |                    |                   |               |                                |
| 18                                                                                                                                             |                      |             |                    |                   |               |                                |
| 19                                                                                                                                             |                      |             |                    |                   |               |                                |
| 20                                                                                                                                             |                      |             |                    |                   |               |                                |
| 21                                                                                                                                             |                      |             |                    |                   |               |                                |
| 22                                                                                                                                             |                      |             |                    |                   |               |                                |
| 23                                                                                                                                             |                      |             |                    |                   |               |                                |
| 24                                                                                                                                             |                      |             |                    |                   |               |                                |
| 25                                                                                                                                             |                      |             |                    |                   |               |                                |
| 26                                                                                                                                             |                      |             |                    |                   |               |                                |
| 27                                                                                                                                             |                      |             |                    |                   |               |                                |
| 28                                                                                                                                             |                      |             |                    |                   |               |                                |
| 29                                                                                                                                             |                      |             |                    |                   |               |                                |
| 30                                                                                                                                             |                      |             |                    |                   |               |                                |
| 31                                                                                                                                             |                      |             |                    |                   |               |                                |
| 32                                                                                                                                             |                      |             |                    |                   |               |                                |

Total +15V current used by this ribbon cable

Length in metres of this ribbon cable

Check that +15V consumption is less than maximum ribbon cable current given in Table 5.6.

358.8

less than 10 m.

YES

Figure 5.9 - Basic I/O Ribbon Cable Form Example

| Ribbon Cable                             | Controller Subrack with 9017 or 9018 | 8857 with 9032 Power Module Rack No. _____ | 8857 with 9032 Power Module Rack No. _____ | 8857 with 9032 Power Module Rack No. _____ | External + 15V Power Module | External + 15V Power Module |
|------------------------------------------|--------------------------------------|--------------------------------------------|--------------------------------------------|--------------------------------------------|-----------------------------|-----------------------------|
| 1                                        |                                      |                                            |                                            |                                            |                             |                             |
| 2                                        |                                      |                                            |                                            |                                            |                             |                             |
| 3                                        |                                      |                                            |                                            |                                            |                             |                             |
| 4                                        |                                      |                                            |                                            |                                            |                             |                             |
| 5                                        |                                      |                                            |                                            |                                            |                             |                             |
| 6                                        |                                      |                                            |                                            |                                            |                             |                             |
| 7                                        |                                      |                                            |                                            |                                            |                             |                             |
| 8                                        |                                      |                                            |                                            |                                            |                             |                             |
| 9                                        |                                      |                                            |                                            |                                            |                             |                             |
| 10                                       |                                      |                                            |                                            |                                            |                             |                             |
| 11                                       |                                      |                                            |                                            |                                            |                             |                             |
| 12                                       |                                      |                                            |                                            |                                            |                             |                             |
| 13                                       |                                      |                                            |                                            |                                            |                             |                             |
| 14                                       |                                      |                                            |                                            |                                            |                             |                             |
| 15                                       |                                      |                                            |                                            |                                            |                             |                             |
| 16                                       |                                      |                                            |                                            |                                            |                             |                             |
| Total Consumption from each power source |                                      |                                            |                                            |                                            |                             |                             |
| Total Available from each power source   |                                      |                                            |                                            |                                            |                             |                             |
|                                          |                                      |                                            |                                            |                                            |                             |                             |
| ( Spare power available )                |                                      |                                            |                                            |                                            |                             |                             |

Figure 5.10 - Allocation of power sources to Ribbon Cables

| Ribbon Cable                             | Controller Subrack with 9017 or 9018 | 8857 with 9032 Power Module Rack No. ____ | 8857 with 9032 Power Module Rack No. ____ | 8857 with 9032 Power Module Rack No. ____ | External +15V Power Module | External +15V Power Module |
|------------------------------------------|--------------------------------------|-------------------------------------------|-------------------------------------------|-------------------------------------------|----------------------------|----------------------------|
| 1                                        |                                      |                                           |                                           |                                           |                            |                            |
| 2                                        | 550mA                                |                                           |                                           |                                           |                            |                            |
| 3                                        | 420mA                                |                                           |                                           |                                           |                            |                            |
| 4                                        |                                      | 625mA                                     |                                           |                                           |                            |                            |
| 5                                        |                                      | 700mA                                     |                                           |                                           |                            |                            |
| 6                                        |                                      | 780mA                                     |                                           |                                           |                            |                            |
| 7                                        |                                      | 900mA                                     |                                           |                                           |                            |                            |
| 8                                        |                                      | 900mA                                     |                                           |                                           |                            |                            |
| 9                                        |                                      | 875mA                                     |                                           |                                           |                            |                            |
| 10                                       |                                      |                                           | 700mA                                     |                                           |                            |                            |
| 11                                       |                                      |                                           | 900mA                                     |                                           |                            |                            |
| 12                                       |                                      |                                           |                                           |                                           |                            |                            |
| 13                                       |                                      |                                           |                                           |                                           |                            |                            |
| 14                                       |                                      |                                           |                                           |                                           |                            |                            |
| 15                                       |                                      |                                           |                                           |                                           |                            |                            |
| 16                                       |                                      |                                           |                                           |                                           |                            |                            |
| Total Consumption from each power source | 970mA                                | 4780mA                                    | 1600mA                                    |                                           |                            |                            |
| Total Available from each power source   | 1300mA                               | 5000mA                                    | 5000mA                                    |                                           |                            |                            |
| ↑                                        | 970mA                                | 4780mA                                    | 1600mA                                    |                                           |                            |                            |
| ( Spare power available )                | 330mA                                | 220mA                                     | 3400mA                                    |                                           |                            |                            |

Figure 5.11 - Example of Allocation of power sources to Ribbon Cables

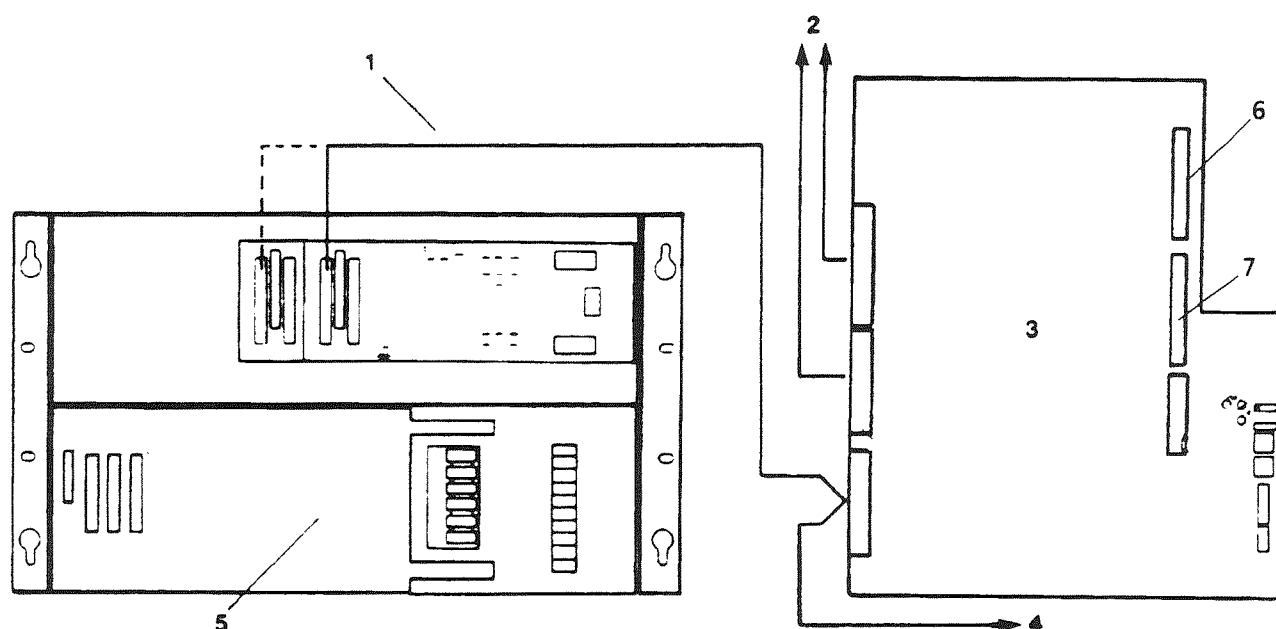
### 5.7.2 Powering I/O Equipment via the Verification Ribbon Cable

Power is supplied through the Verification I/O ribbon cable.

This cable has a limited current carrying capacity, see Table 5.6 for details. In addition to the power consumed by the I/O equipment, the 8191 Verification I/O Expander requires its own power which can be drawn through the Verification ribbon cable. Figure 5.12 shows the connections for this option. Link LK5 on the Expander must be fitted in position 'B' when power is supplied through the Verification I/O Ribbon Cables. Figure 5.2 shows the position of LK5 on the module.

Table 5.6 I/O Ribbon Cable Current Carrying Capacity

| Length of I/O Ribbon (Metres) | Maximum Current Carried (Amps) |
|-------------------------------|--------------------------------|
| 10                            | 2.1                            |
| 15                            | 1.4                            |
| 20                            | 1.05                           |
| 25                            | 0.84                           |
| 30                            | 0.7                            |



All wiring is VERY CLEAN (see Segregation in Section 13.5)

1. Verification I/O Ribbon
2. Basic I/O Ribbons
3. 8191 Verification I/O Expander
4. To Other Verification I/O Expanders or Verification I/O Modules
5. GEM 80 Controller
6. Connection to Basic I/O Subrack backplane
7. Connection to Verification I/O Subrack backplane

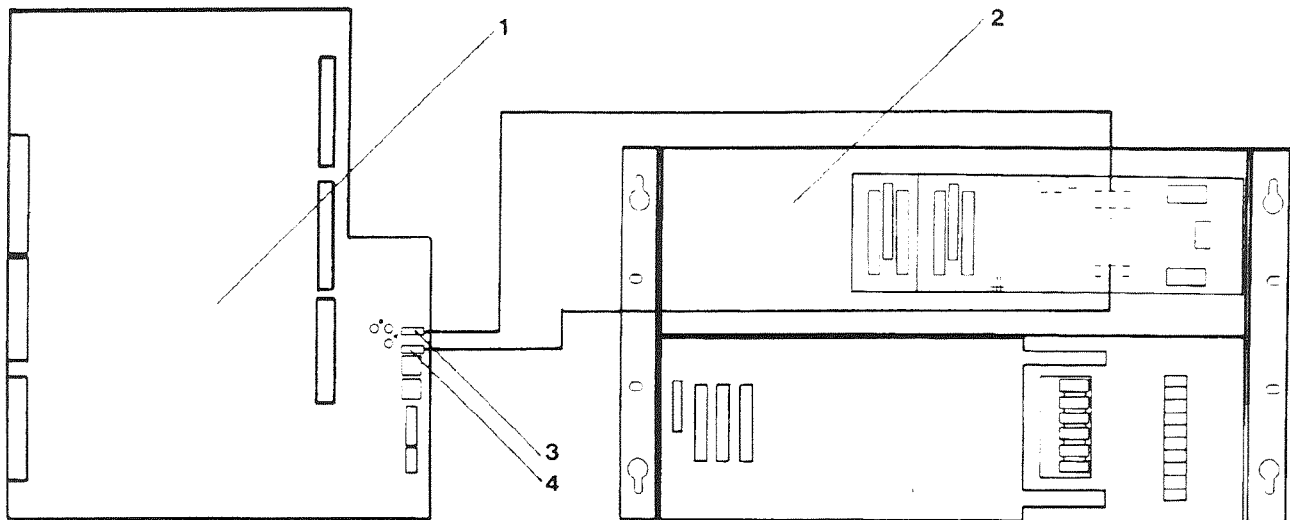
Figure 5.12 - Powering I/O Equipment from Power Module Via Verification Ribbon Cable

## 5. I/O HIGHWAY

### 5.7.3 Powering I/O from Power Module via Terminals on the Backplane

I/O power may be drawn from the Power Supply Module via the terminals on the backplane and connected to the 8191 Verification I/O Expanders through the push-on terminals F3 and F4 (F3 = +15V connection, F4 = 0V connection). See Figure 5.13 for details.

Where this option is used, LK5 must be placed in the 'A' position. With the link in this position the Verification I/O Ribbon +15V is isolated from the +15V from the separate supply. Figure 5.13 shows the position of LK5.



All wiring is VERY CLEAN (see Segregation in Section 13.5)

1. 8191 Verification I/O Module
2. GEM 80 Controller
3. Push-on Terminal for +15V
4. Push-on Terminal for 0V
5. Link LK5

Figure 5.13 - Powering I/O Equipment from Power Supply Module

#### 5.7.4 Powering I/O from 8857 Subrack with 9032 Power Module

The 9032 power module accepts 110 or 220V a.c. single phase power input or a d.c. input of 22-85V.

A.C. power input connections are on the front of the power module as shown in Figure 2.3. The A.C. power input is via an a.c. power connector, PL4, which is supplied loose with the equipment. Live, neutral and earth connections are as marked on the connector.

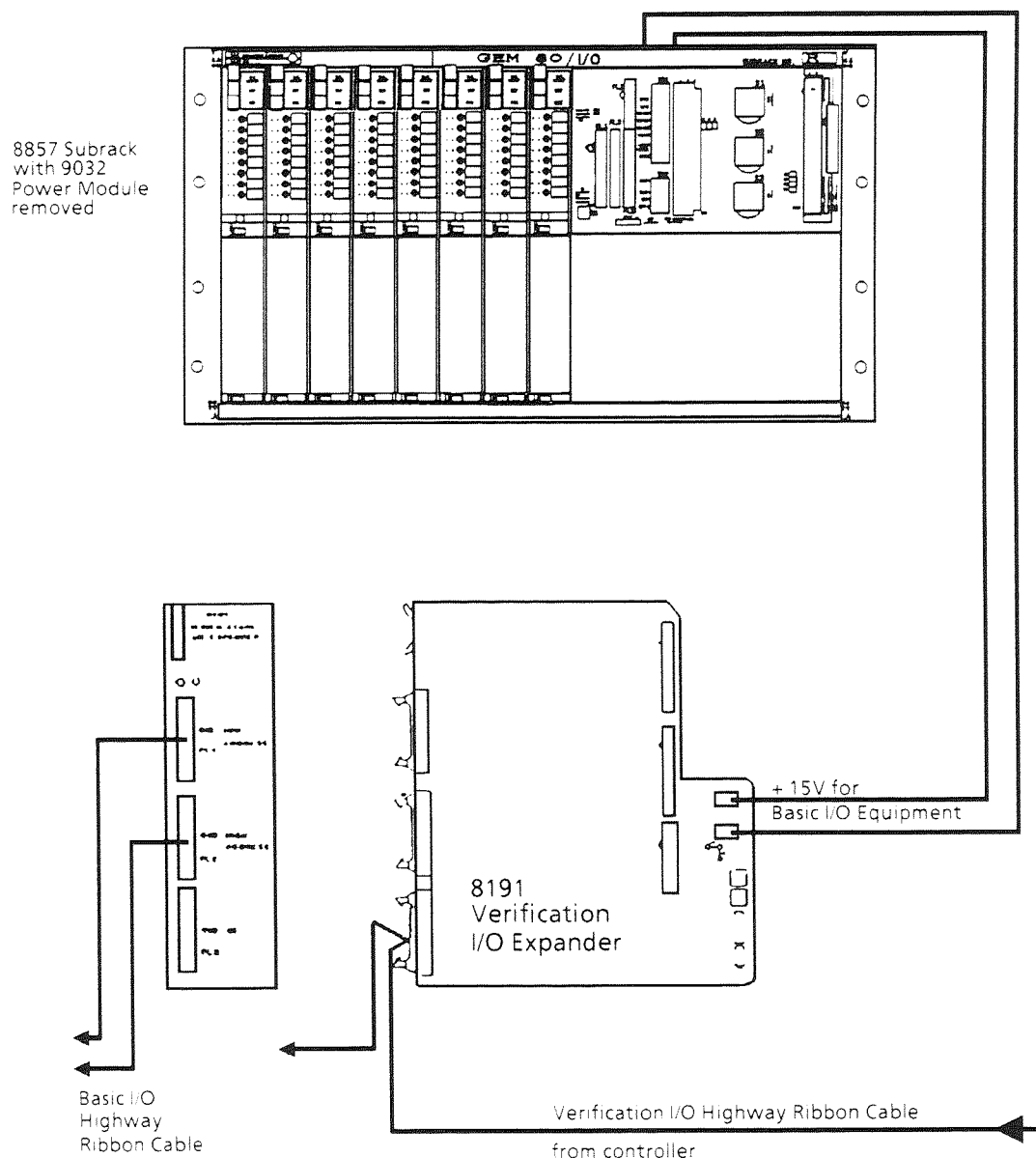
Figure 5.16. shows connections for safety earths and signal grounds which must be fitted in accordance with Section 13.5.

Before powering up the subrack, check that the voltage selector is at the correct setting.

The power available in the 8857 subrack from the 9032 power module is 5 Amperes at +15V.

Access to the output connections, on the upper backplane, is gained by withdrawing the power module and removing the blanking panel.

Figure 5.14 shows the connection when powering I/O equipment from a 9032 power module in an 8857 subrack. In these circumstances LK5 in the 8191 Verification I/O Expander must be placed in the 'A' position and Basic I/O power is supplied via PL4. The power for the 8191 module itself is also supplied via PL4. See Figure 5.2 for the position of LK5.



All wiring is VERY CLEAN (see Segregation in Section 13.5)

Figure 5.14 - Powering I/O from 9032 Power Supply in 8857 Subrack

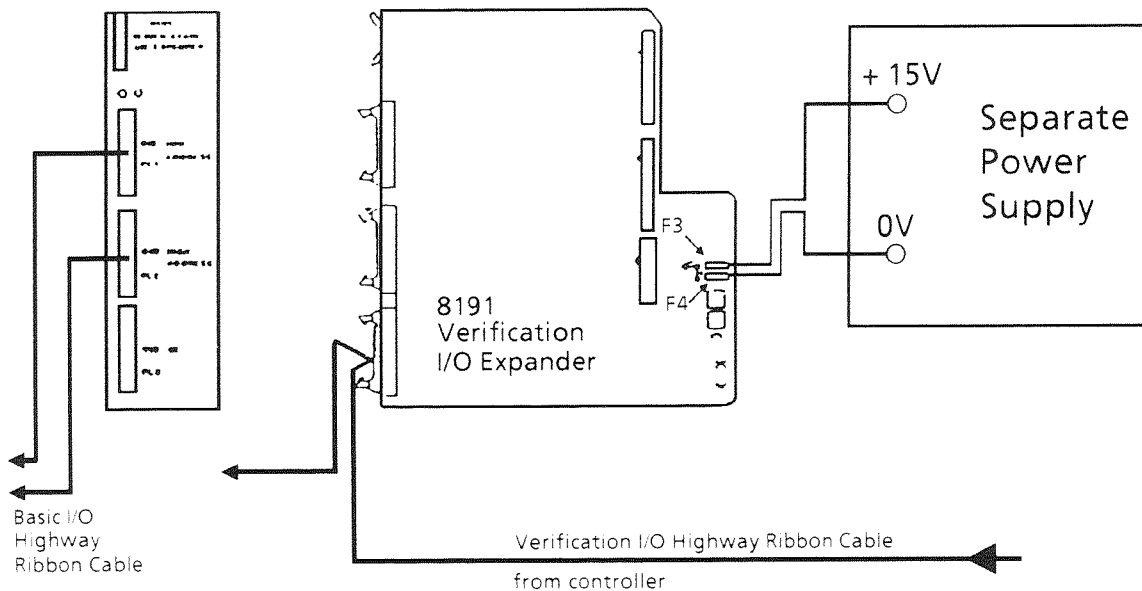
## 5. I/O HIGHWAY

### 5.7.5 External +15V Power Source

When +15V power is supplied from an external +15V power pack, LK5 in the 8191 Verification I/O Expander must be placed in the 'A' position. See Figure 5.2 for the position of LK5.

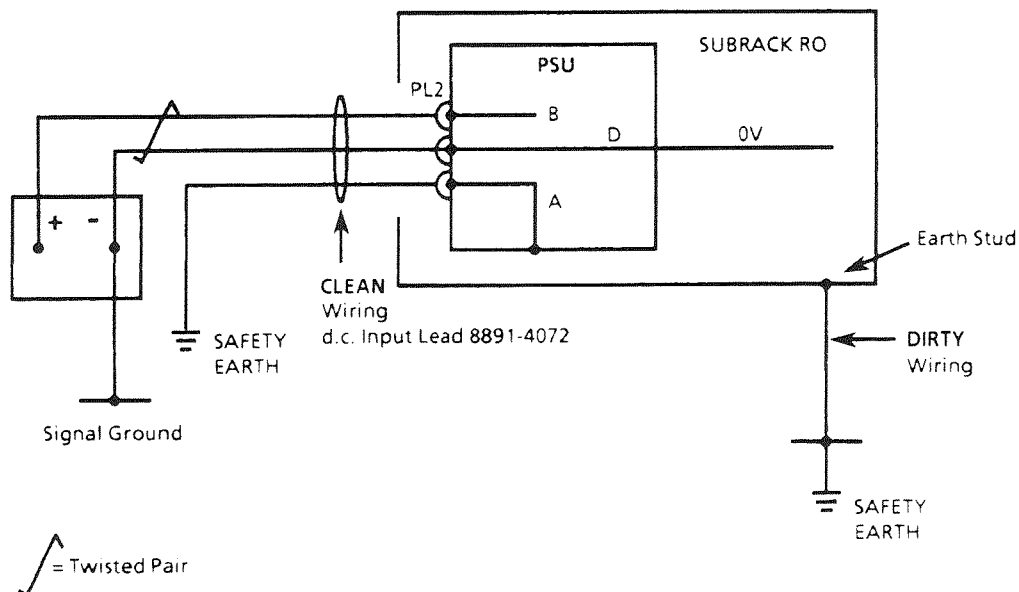
The +15V supply should be connected to the push-on terminal F3 and the 0V supply should be connected to terminal F4. (see Figure 5.15 for details).

The external supply must be capable of  $+15V \pm 0.5V$  with 50mV maximum peak-to-peak ripple. In order to prevent damage to p.c.b.s under fault conditions, the power supply should be set to trip at a current overload of 10A.



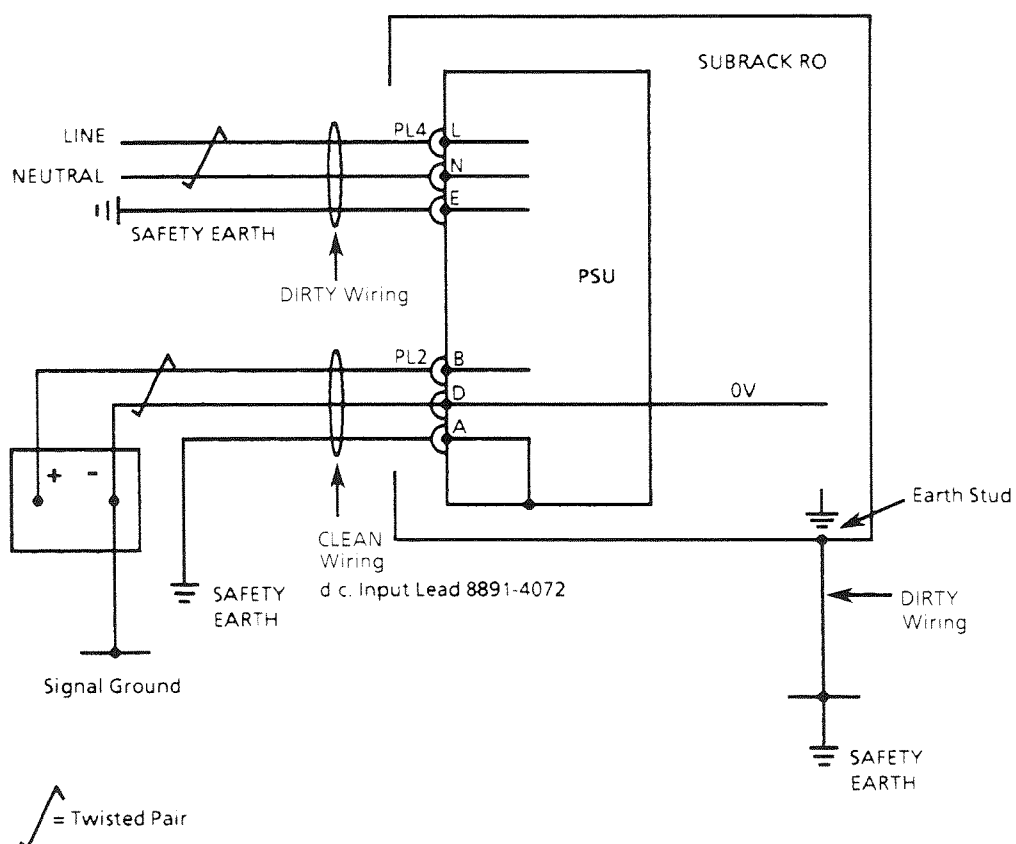
All wiring is VERY CLEAN (see Segregation in Section 13.5)

Figure 5.15 - Powering Basic I/O from an External Power Supply



All wiring is VERY CLEAN (see Segregation in Section 13.5)

Figure 5.16 - Signal Ground and Safety Earth Connection for d.c. Input



All wiring is VERY CLEAN (see Segregation in Section 13.5)

Figure 5.17 - Signal Ground and Safety Earth Connection for a.c. and d.c. Input

## 5. I/O HIGHWAY

### 5.8 Basic and Verification I/O Ribbon Cables

#### 5.8.1 26-Way Ribbon Cable for Basic and Verification I/O Highway

This cable connects to the Basic I/O or Verification I/O sockets on the Controller subrack and then to each item of Verification or Basic I/O equipment in turn with a 'daisy chain' connection.

There are three cabling options available which may be ordered:

- (1) Standard ready assembled cables.
- (2) Non-standard ready assembled.
- (3) Parts only to assemble as required.

##### (1) Standard Ready Assembled Cables

These cables are for connecting between the controller and up to three subracks of I/O modules. There are four different cables available, each having a pre-defined length between the first socket (Controller) and the 2nd socket (1st I/O subrack) - length A. The length between I/O subracks (sockets 2, 3 & 4) is one metre in each case, see Figure 5.18 for details.

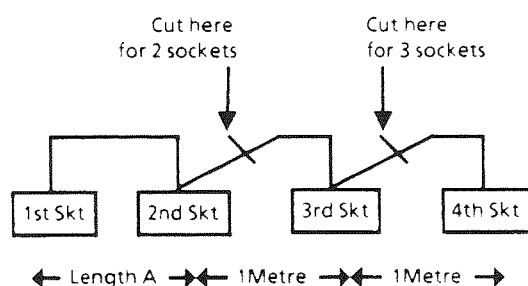


Figure 5.18 - Standard Ready Assembled I/O Ribbon Cables.

If you require either 2- or 3-socket cable, the ribbon cable should be cut as close as possible to the last socket required.

Ordering codes for these cables are given in Table 5.7

Table 5.7 Ordering Codes for Standard Ready Assembled Cables

| Length A (metres) | Length between Connectors 2,3 & 4 (metres) | Number of Sockets | Ordering Codes |
|-------------------|--------------------------------------------|-------------------|----------------|
| 1.25              | 1                                          | 4                 | 8890-4611      |
| 2                 | 1                                          | 4                 | 8890-4612      |
| 3                 | 1                                          | 4                 | 8890-4613      |
| 4                 | 1                                          | 4                 | 8890-4614      |

#### (2) Non-Standard Ready Assembled Cables

Cables may be ordered ready assembled to your requirements. The length between sockets can be specified as required to suit your installation and up to 9 sockets can be fitted.

Use part A of Figure 5.19 and notify us of your requirements.

#### (3) Parts to Make Up Your Own Cables

Use part B of Figure 5.19. See Appendix A for cable assembly information.

##### Ribbon Cable

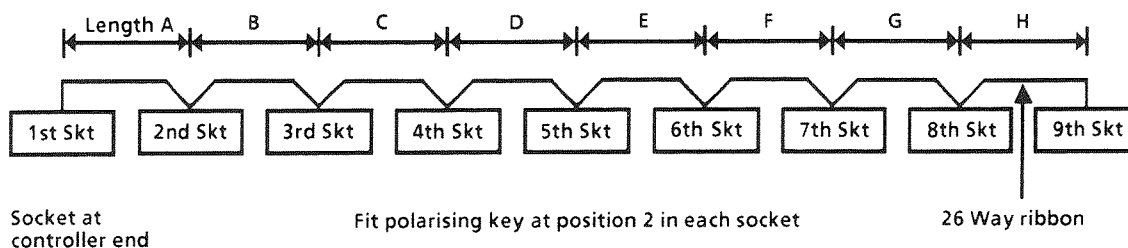
26-way flat ribbon, width 33mm  
ITT Type 455-240-26 or equivalent

##### Connectors

Harting Type 0918 516 5823 connector  
Polarising key in position 2

#### 5.8.2 Segregation of 26-Way Verification and Basic I/O Highway Ribbon Cable

These ribbon cables are noise sensitive; they should be as short as possible and segregated from other noisy cables. With cubicle mounted controllers, it is not recommended to run this cable outside the cubicle, or cubicle suite. Section 13, Installation, covers the cabling and segregation of these I/O ribbons.



## Notes

- 1 Complete Part A only when ordering assembled cables.
- 2 Complete Part B only when ordering parts to make up your own cables.

## PART A – ASSEMBLED CABLES (Delete if not required)

| No. of Sockets | Order Code  |
|----------------|-------------|
| 2              | 8890 – 4601 |
| 3              | 8890 – 4602 |
| 4              | 8890 – 4603 |
| 5              | 8890 – 4604 |
| 6              | 8890 – 4605 |
| 7              | 8890 – 4606 |
| 8              | 8890 – 4607 |
| 9              | 8890 – 4608 |

| No. of Sockets                    |                  |          |          |          |
|-----------------------------------|------------------|----------|----------|----------|
| Order Code                        | 8890–460         | 8890–460 | 8890–460 | 8890–460 |
| Ribbon No. (1,2 etc.)             |                  |          |          |          |
| Length                            | Length in metres |          |          |          |
| A                                 |                  |          |          |          |
| B                                 |                  |          |          |          |
| C                                 |                  |          |          |          |
| D                                 |                  |          |          |          |
| E                                 |                  |          |          |          |
| F                                 |                  |          |          |          |
| G                                 |                  |          |          |          |
| H                                 |                  |          |          |          |
| Finished Length (Total of A to H) |                  |          |          |          |

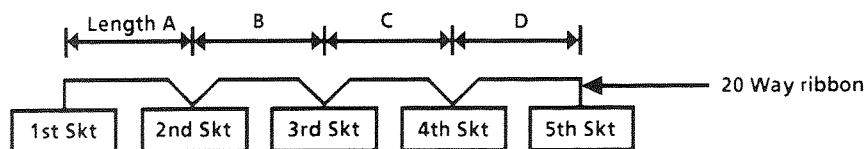
## PART B – PARTS (Delete if not required)

| Part                   | Order Code | Comments                | Length (metres)* | No. off |
|------------------------|------------|-------------------------|------------------|---------|
| Ribbon Cable (26 Way)  | 56685/418  | Max. Length = 30 Metres |                  |         |
| Socket (26 Way)        | 80560/098  |                         |                  |         |
| Polarising Key & Label | 8890–4004  | 1 Per Socket            |                  |         |

\* Add 20mm per socket to finish length to allow for socket termination

Figure 5.19 - 26-Way Basic I/O Highway Ribbon Cables.

## 5. I/O HIGHWAY



Socket at controller end

Fit polarising key at position 10 in each socket

### Notes

- 1 Complete Part A only when ordering assembled cables.
- 2 Complete Part B only when ordering parts to make up your own cables.

### PART A – ASSEMBLED CABLES (Delete if not required)

| No. of Sockets | Order Code  | No. of Sockets                    |                  |          |
|----------------|-------------|-----------------------------------|------------------|----------|
| 2              | 8890 – 4615 | Order Code                        | 8890–461         | 8890–461 |
| 3              | 8890 – 4616 | Length                            | Length in metres |          |
| 4              | 8890 – 4617 | A                                 |                  |          |
| 5              | 8890 – 4618 | B                                 |                  |          |
|                |             | C                                 |                  |          |
|                |             | D                                 |                  |          |
|                |             | Finished Length (Total of A to D) |                  |          |

### PART B – PARTS (Delete if not required)

| Part                   | Order Code | Comments                | Length (metres)* | No. off |
|------------------------|------------|-------------------------|------------------|---------|
| Ribbon Cable (20 Way)  | 56685/414  | Max. Length = 30 Metres |                  |         |
| Socket (20 Way)        | 80560/090  |                         |                  |         |
| Polarising Key & Label | 8890–4004  | 1 Per Socket            |                  |         |

\* Add 20mm per socket to finish length to allow for socket termination

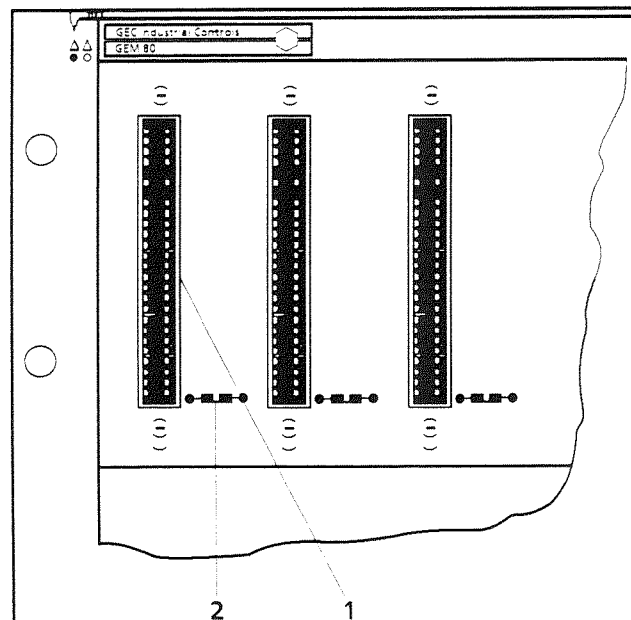
Figure 5.20 - 20-Way Ribbon Cable for +15V Basic I/O Power

### 5.9 I/O Module Interlock System

I/O subracks include a circuit consisting of links within the Basic and Verification I/O modules and subracks. This is arranged so that when all the modules are fitted, a series chain of links is completed giving a short circuit condition. However, if a module is removed, the chain is broken giving an open circuit. It is envisaged that this system could be used by the user to interlock with a relay coil or an input channel of an I/O module. If required, this may be part of the system healthy checks in the user program, so that if the I/O input channel to which these interlocks connect is high, all I/O modules are fitted.

For the circumstances where the I/O subrack is not completely full of modules, a shorting link is fitted on the backplane (a zero ohm resistor) so that the series chain of interlocks would be completed by the zero ohm resistors if no modules were put in the subrack. To activate the module interlock system, it is necessary to cut out the zero ohm resistors at each connection where an I/O module is fitted.

**Note...** The zero ohm resistor is located immediately to the right of the I/O module connector as illustrated in Figure 5.21. A typical module interlock circuit is shown in Figure 5.22.



1. Connector for I/O Module
2. Associated zero ohm resistor (cut out when Module is to be fitted)

Figure 5.21 I/O Module Interlock System, Zero Ohm Resistors

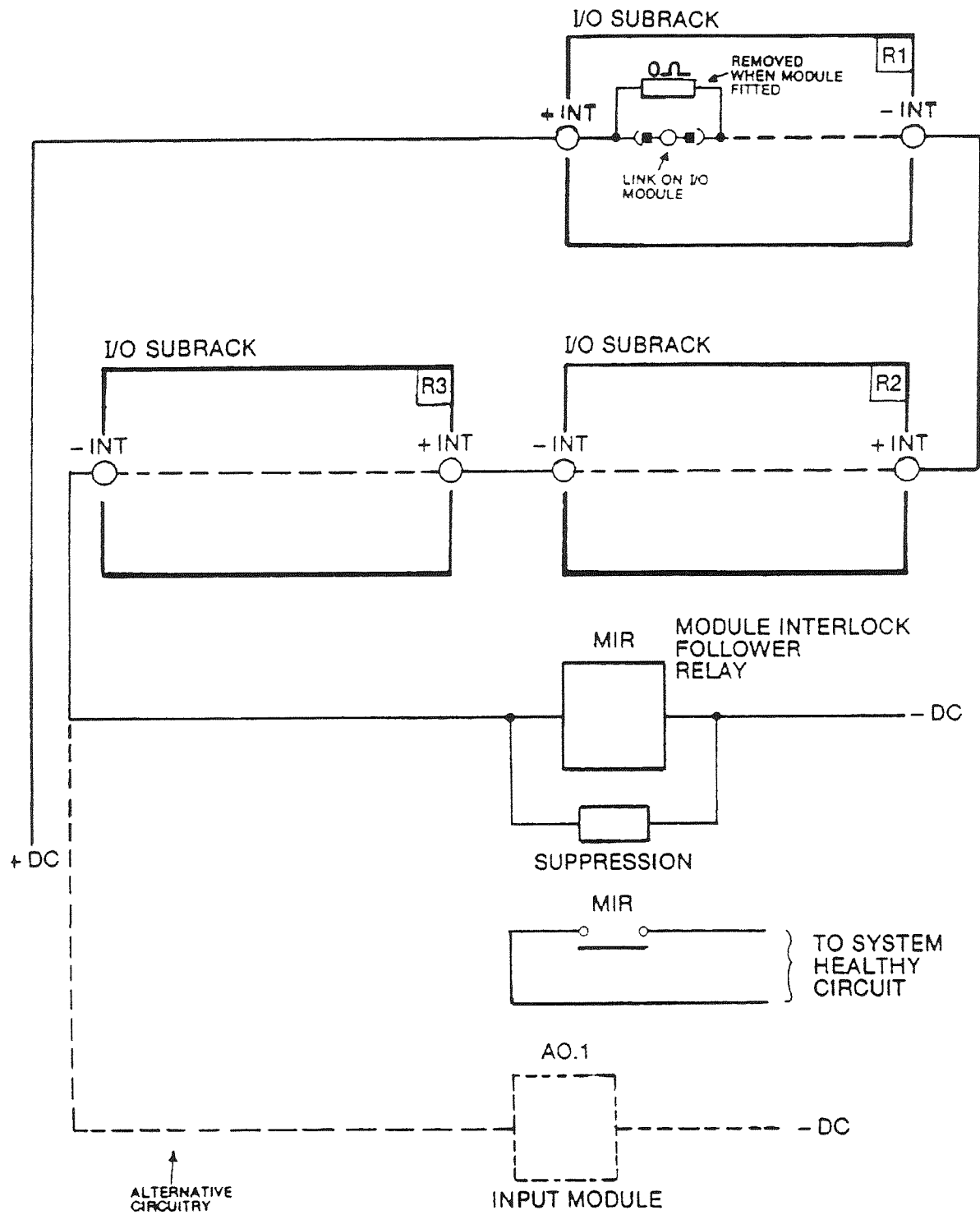


Figure 5.22 Typical Module Interlock Circuit.

### 5.10 Output Enable Modules

Some output modules incorporate 'output enable' circuitry. This ensures that all outputs are held in the OFF state until:

(1) An enable signal at +15V d.c. 10% is present

and

(2) The GEM 80 Controller initiates the output 'ON'.

The enable signal is applied to the subrack and enables all 'output enable' modules contained in the subrack. The enable signal would normally be provided via the watchdog follower relay so that the outputs are inhibited on initial switch on and when the watchdog contacts open.

Subracks which have this feature are:

8857-4006 - Power Supply and 8-slot I/O subrack

8859-4003 - 12-slot I/O subrack

#### 5.10.1 Output Enable Connections

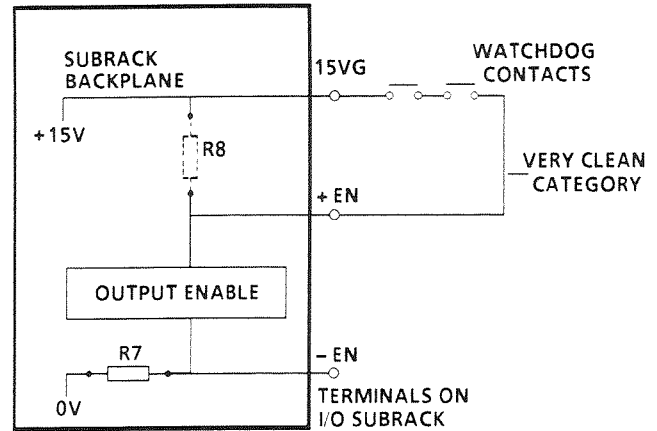
Output Enable connections to the subracks are shown in Figures 5.23 and 5.24. Figure 5.23 illustrates the use of GEM 80 +15V power supplies and Figure 5.24 illustrates the use of external +15V power supplies. The zero ohm resistors shown in dotted outline should be removed when used with the relevant power supplies.

#### 5.10.2 Wiring Segregation

The segregation category depends on the power supply providing the enable signal. If the signal is derived from the controller power supply or another GEM 80 power module, it is considered to be VERY CLEAN and must be separated from any DIRTY plant-side wiring. If however, the signal is supplied from a remote power supply which is also supplying DIRTY circuits, the enable wiring can run with other DIRTY plant-side wiring. It MUST NOT be run alongside CLEAN or VERY CLEAN wiring.

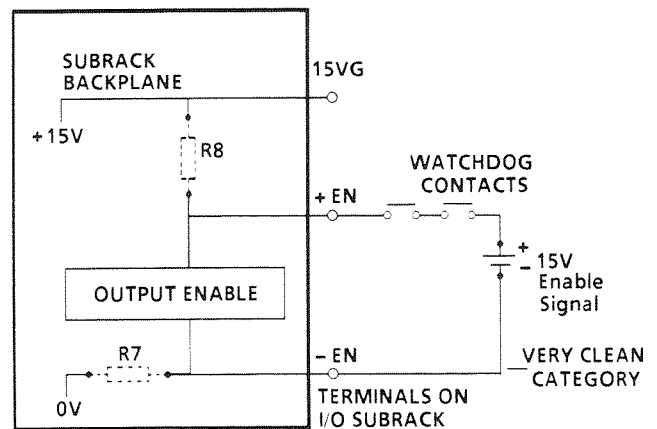
#### 5.10.3 Wiring Size

The maximum size of wiring which can be terminated at +EN and -EN terminals is 2.5 sq.mm. The terminals are located on Terminal Block, TB2 on the upper backplane of the I/O subrack.



Resistor R8 must be removed

Figure 5.23 - Connection of Output Enable Signal using the GEM 80 Power Supply



Resistors R7 and R8 must be removed

Figure 5.24 - Connection of Output Enable Signal using a External Power Supply

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## 5. I/O HIGHWAY

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## 6.1 General

The 310 series controllers have up to four standard serial ports. The backplane for each I/O Processor has a communications connector which provides two serial ports.

Further serial ports can be added using Fast I/O serial communications modules or STARNET modules. See the relevant User Information Sheets for connection details.

The Master I/O Processor has ports 1 and 2; the slave I/O Processor (if fitted) has ports 3 and 4. Figure 5.1 shows the serial port connections.

The signalling rate is user adjustable between 110 and 9,600 bits per second. These rates are selected by pre-set data for each port.

## 6.2 Applications

The serial ports are used for the following types of application :-

- (1) Data table exchange with other GEM 80 controllers or other intelligent devices, for supervisory operations or co-ordinated operation of GEM 80 controllers. Details are given in Section 6.3.
- (2) Output and input of alpha-numeric characters for intelligent devices, printers, VDUs or keyboards. Details are given in Section 6.7.
- (3) Programming the controller (remote programming). Details are given in Section 6.9.

## 6.3 Data Table Exchange with other GEM 80 Controllers.

By data set into the P-(preset) data table, any of the four ports can be configured as one of the following :-

- (1) Control Port.
- (2) Tributary Port.
- (3) Printer Port.
- (4) CORONET LAN.
- (5) GEMSTART Contactor Control Unit (CCU)

### 6.3.1 Point-to-Point Control Port

Figure 6.1 shows a point-to-point serial link in which two controllers interchange data. One controller's serial communication port is set up as a control port and the other as a tributary port.

The control port is responsible for all activity on the serial link and the tributary responds only when a message inviting a reply is addressed to it.

Figure 6.2 shows an example of a point-to-point serial communication link between two controllers (4-wire current loop). Up to 128 input and output words can be exchanged and the serial link can be run in either the free-running mode or the user-control mode, depending on data set in the control port P-Data table. Serial links can be 2-wire or 4-wire connection to 8924 and full connection details are in the Serial Interface Termination Unit Information Sheet, Publication No.T456

The 310 series of GEM 80 Controllers operate a communication protocol known as Extended Simple Protocol (ESP). ESP is the GEM 80 protocol commonly used with 20mA current loop signalling. The protocol uses asynchronous communication with 1 start bit, 8 data bits and 1 stop bit.

The protocol provides high confidence that data transmission errors are detected at the receiving end and that detected errors are corrected by automatic re-transmission.

This system allows up to 128 data tables to be transferred. It remains compatible with existing systems whose limit is 32 data tables provided that message lengths are restricted to 32 words or less on the route to that system. A GEM 80/310 series Controller acting as a tributary may receive and transmit up to 128 words.

Sections 6.5 and 6.6 detail the data which needs to be written into the P-table and where data arrives and is transmitted from, for a tributary port.

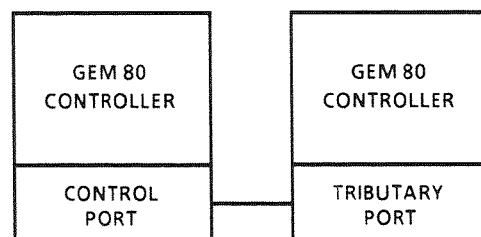
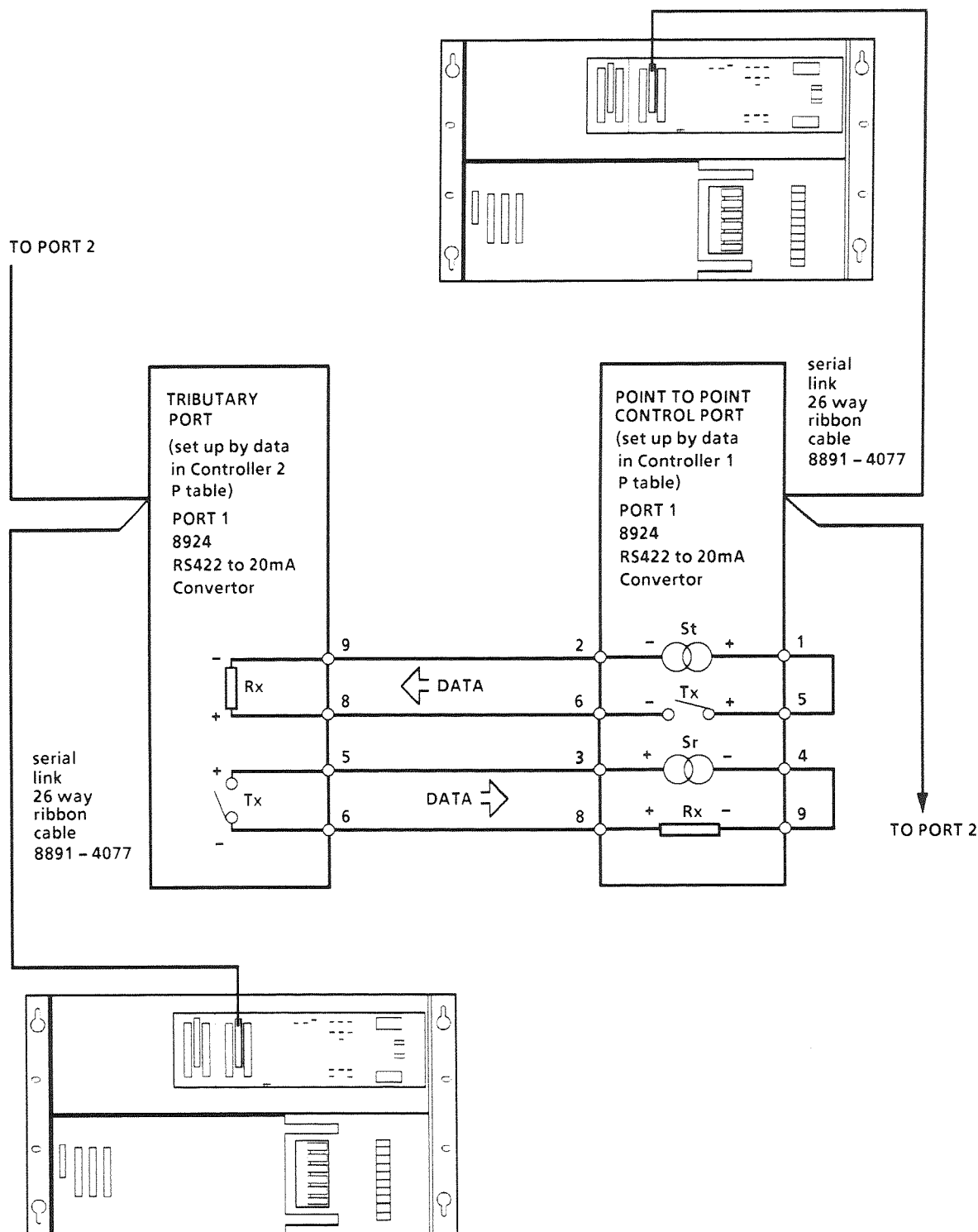


Figure 6.1 Point-to-Point Serial Link

## 6. SERIAL COMMUNICATION LINKS



**Note...**When the 8924 is used for Port 2 (Master I/O Processor) or Port 4 (Slave I/O Processor), a link must be fitted between terminals 15 and 16 on the 8924 terminal block.

Figure 6.2 Point-to-Point Serial Communications Link Between Two 300 Series Controllers, 4-wire 20mA.

### 6.3.2 Multi-drop Link

Figure 6.3 shows a multi-drop serial link in which up to 8 controllers can interchange data. The serial port of one controller is set up as a control port and the others are set up as tributary ports. The control port communicates with each tributary on a cyclic basis. Communication directly between tributaries is not possible, although data can be exchanged between tributaries via the control port.

Figure 6.4 shows an example of a typical multi-drop link.

Up to 128 input and output words of data can be exchanged and the serial link can be run in either the free-running mode or the user-control mode depending on data set in the P-table. Full connection details for 4-wire and 2-wire links are shown in 8924 Product Data Sheet, Publication No.T527 and the Serial Communications Manual, Publication No.T457.

Sections 6.5 and 6.6 detail the data which must be written into the P-table and where data arrives and is transmitted from.

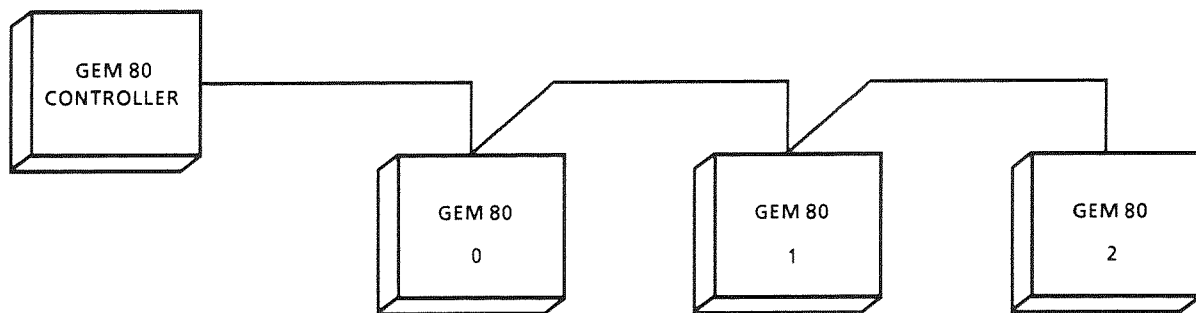


Figure 6.3 - Multi-drop Serial Link

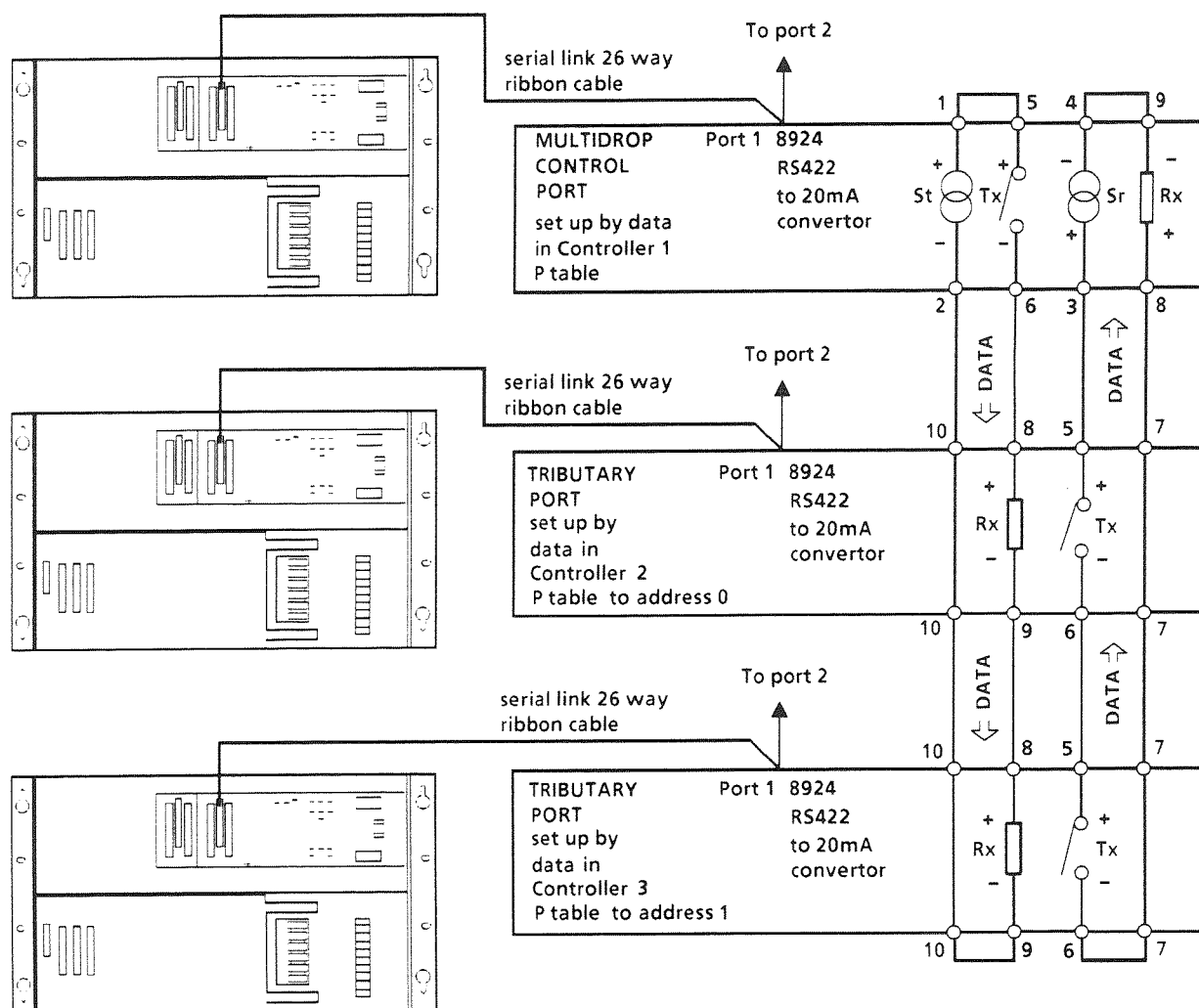


Figure 6.4 - Multi-drop Serial Communication Link Between Three Controllers, 4-wire 20mA

## 6.4 Data Tables Used by Serial Links

The Serial Communication Links read and write data in data tables, J, K, P, I and F. Table 6.1 details these.

Data written into the P-table by the user determines whether the port is a Tributary Port, Control Port, Printer Port, or set for CORONET or GEMSTART Contactor Control Unit (CCU). Table 6.2 shows how to tell which mode the port is set to operate in. For example, a '0' in P4 indicates port 1 is set as a printer port.

## 6.5 Tributary Port

### 6.5.1 General

Table 6.3 shows the address and what data the user must write into these addresses to enable the port to operate as a tributary port.

When the port is configured as a tributary port, data is received at the data table addresses shown in Table 6.4. Data to be transmitted by the controller is at data table addresses shown in Table 6.5 and I-table information to operate the serial link in the user-control mode is shown in Table 6.6.

Re-compile to implement changes to P-table (no need to power down). Changes to message length are effective immediately.

Table 6.1 Data Table Used by Serial Communications Links

| DATA TABLE LOCATION |                                                                                                                                               |                                         |              |              |               |
|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------|--------------|---------------|
| Data Table          | Content                                                                                                                                       | Port 1                                  | Port 2       | Port 3       | Port 4        |
| J                   | Holds INPUT data sent to the controller                                                                                                       | J0 to J255                              | J256 to J511 | J512 to J767 | J768 to J1023 |
| K                   | Holds OUTPUT data to be sent to other controllers                                                                                             | K0 to K255                              | K256 to K511 | K512 to K767 | K768 to K1023 |
| P                   | Data entered by the user into this table forms operation parameters for the serial port (signalling rate, control port or printer port, etc.) | P3 to P14                               | P15 to P26   | P27 to P38   | P39 to P50    |
| I                   | Holds information about control of serial link for user-control mode                                                                          | I0 to I8                                | I9 to I17    | I18 to I26   | I27 to I35    |
| F                   | Fault diagnosis table                                                                                                                         | See Section 15 for further information. |              |              |               |
| E                   | Timing and Flags                                                                                                                              | See Section 4 for further information.  |              |              |               |

Table 6.2 - Determining Operating Mode of a Serial Port

| Port | Data Table Address | Content | Mode                                    | Further details in paragraph |
|------|--------------------|---------|-----------------------------------------|------------------------------|
| 1    | P4                 | 0       | PRINTER                                 | 6.7                          |
|      |                    | 1       | TRIBUTARY                               | 6.5                          |
|      |                    | 2       | CONTROL                                 | 6.6                          |
|      |                    | 3       | CONTROL (Flexible J K table allocation) | 6.6.1                        |
|      |                    | 4       | CORONET                                 | 6.13                         |
|      |                    | 6       | GEMSTART CCU                            | 6.12                         |
| 2    | P16                | 0       | PRINTER                                 | 6.7                          |
|      |                    | 1       | TRIBUTARY                               | 6.5                          |
|      |                    | 2       | CONTROL                                 | 6.6                          |
|      |                    | 3       | CONTROL (Flexible J K table allocation) | 6.6.1                        |
|      |                    | 6       | GEMSTART CCU                            | 6.12                         |
| 3    | P28                | 0       | PRINTER                                 | 6.7                          |
|      |                    | 1       | TRIBUTARY                               | 6.5                          |
|      |                    | 2       | CONTROL                                 | 6.6                          |
|      |                    | 3       | CONTROL (Flexible J K table allocation) | 6.6.1                        |
|      |                    | 4       | CORONET                                 | 6.13                         |
|      |                    | 6       | GEMSTART CCU                            | 6.12                         |
| 4    | P40                | 0       | PRINTER                                 | 6.7                          |
|      |                    | 1       | TRIBUTARY                               | 6.5                          |
|      |                    | 2       | CONTROL                                 | 6.6                          |
|      |                    | 3       | CONTROL (Flexible J K table allocation) | 6.6.1                        |
|      |                    | 6       | GEMSTART CCU                            | 6.12                         |

Other values of content should not be used

## 6. SERIAL COMMUNICATION LINKS

Table 6.3 - P-Table Data for Tributary Port Usage

| Function                                                                    | Content                                                                                                                                                                                                                                                                                                                         | Port 1 | Port 2 | Port 3 | Port 4 |
|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|--------|--------|
| Signalling Rate                                                             | enter 110 for 110 bits/s.<br>enter 300 for 300 bits/s.<br>enter 600 for 600 bits/s.<br>enter 1,200 for 1,200 bits/s.<br>enter 2,400 for 2,400 bits/s.<br>enter 4,800 for 4,800 bits/s.<br>enter 9,600 for 9,600 bits/s.<br>enter 0 for port not in use<br><br>enter -ve baud rates for extended time out. See Section 6.6.2 (c) | P3     | P15    | P27    | P39    |
| Operation Mode                                                              | enter 1 for tributary port                                                                                                                                                                                                                                                                                                      | P4     | P16    | P28    | P40    |
| Free-running/user control                                                   | enter 0 for free-running<br>enter 1 for user-control<br>See Section 6.5.2 for explanation                                                                                                                                                                                                                                       | P5     | P17    | P29    | P41    |
| Tributary address                                                           | enter 0 to 14 (GEM 80 control ports uses 0 to 7). When GEM 80 programmable serial comms. modules, STARNET or computers provide the control port, addresses up to 14 can be used.                                                                                                                                                | P6     | P18    | P30    | P42    |
| Quantity of data table locations to be transmitted (Free-Running Mode Only) | enter 0 to 128                                                                                                                                                                                                                                                                                                                  | P7     | P19    | P31    | P43    |
|                                                                             | not used                                                                                                                                                                                                                                                                                                                        | P8-14  | P20-26 | P32-38 | P44-50 |

Table 6.4 - J-Table for Tributary Port

| Function | Content                         | Port 1 | Port 2   | Port 3   | Port 4    |
|----------|---------------------------------|--------|----------|----------|-----------|
| J-Table  | Data Received by the Controller | J0-255 | J256-511 | J512-767 | J768-1023 |

Table 6.5 - K-Table for Tributary Port

| Function | Content                                  | Port 1 | Port 2   | Port 3   | Port 4    |
|----------|------------------------------------------|--------|----------|----------|-----------|
| K-Table  | Data to be Transmitted by the Controller | K0-255 | K256-511 | K512-767 | K768-1023 |

Table 6.6 - I-Table for Tributary Port (User-Control Mode Only)

| Function                                  | Content                                                                                                                                 | Port 1 | Port 2 | Port 3 | Port 4 |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------|--------|--------|--------|
| Flags                                     | SEND FLAG is bit 0 of the words shown on the right (I0, I9 etc.)<br>RECEIVE FLAG is bit 8 of the words shown on the right (I0, I9 etc.) | I0     | I9     | I18    | I27    |
| Quantity of words received or transmitted | bits 8-15 received length<br>bits 0-7 length to transmit                                                                                | I1     | I10    | I19    | I28    |

## 6.5.2 Operation as a Tributary Port

Data Table transfers only occur between user program scans and the I-table is also only examined between scans in the user-control mode.

For J/K-table exchanges between controllers the user can select either user-control mode or free-running mode.

In either mode an indication is provided in F41 bits 0 to 3 when a port has not received a valid message for a period of approximately 30 seconds.

### (a) Free-Running Mode (Tributary Port)

When Free-running mode is selected, the reply to a received message is generated immediately, at the end of the program scan the quantity of locations for the reply being taken from the P-table.

### (b) User-Control Mode (Tributary Port)

User-control mode uses data in the I-table to control the generation of reply. I-table is set to indicate reception and length of received message. The transmission of the reply is initiated at the end of the program scan in which the I-table bit is set. The length of the message transmitted is taken from the I-table. The following description is for port 1 but applies equally to all ports if the relevant data tables are substituted.

When a message is received the data is placed in J0 onwards as when free-running. The number of locations written to is placed in bits 8 to 15 of I1 (this may be extracted using SWAP (S4) and masking the result) and bit I0.8 is set ON. The user is thus notified of the arrival of a message. Appropriate action may then be taken and the data for the reply placed in K0 onwards. The length of this data is placed in bits 0 to 7 of I1. When the user has set bit I0.8 OFF and I0.0 ON the reply is generated. I0.0 is set OFF to indicate this.

## 6.6 Control Port

### 6.6.1 General

Table 6.7 shows the P-table addresses and data the user must write into these addresses to enable the port to operate as a control port.

When the port is configured as a control port data is received and transmitted at the data table addresses shown in Table 6.9.

I-table information to operate the serial link in the user-control mode is shown in Table 6.10.

Re-compile to implement changes to P-table (no need to power down). Changes to transmission lengths and tributary selections are effective immediately.

Table 6.7 - P-table for ESP Control Port

| Function                                                                    | Content                                                                                                                                                                                                                                                                                                                     | Port 1                   | Port 2                   | Port 3                   | Port 4                   |
|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Signalling Rate                                                             | enter 110 for 110 bits/s.<br>enter 300 for 300 bits/s.<br>enter 600 for 600 bits/s.<br>enter 1,200 for 1,200 bits/s.<br>enter 2,400 for 2,400 bits/s.<br>enter 4,800 for 4,800 bits/s.<br>enter 9,600 for 9,600 bits/s.<br>enter 0 for port not in use<br>enter -ve baud rates for extended time out. See Section 6.6.2 (c) | P3                       | P15                      | P27                      | P39                      |
| Operation Mode                                                              | enter 2 for ESP control port                                                                                                                                                                                                                                                                                                | P4                       | P16                      | P28                      | P40                      |
| Free-running/user control                                                   | enter 0 for free-running<br>enter 1 for user-control.                                                                                                                                                                                                                                                                       | P5                       | P17                      | P29                      | P41                      |
| Indication of number of tributaries (Free-running mode only)                | enter a HEX code to set bit 0 to 7<br>This enables data to be sent to tributaries 0 to 7 respectively (bit 8 to 15 unused)                                                                                                                                                                                                  | P6                       | P18                      | P30                      | P42                      |
| Quantity of data table locations to be transmitted (Free Running Mode Only) | To Trib address 0 (enter 0 to 128)<br>To Trib address 1 (enter 0 to 128)<br>To Trib address 2 (enter 0 to 128)<br>To Trib address 3 (enter 0 to 128)                                                                                                                                                                        | P7<br>P8<br>P9<br>P10    | P19<br>P20<br>P21<br>P22 | P31<br>P32<br>P33<br>P34 | P43<br>P44<br>P45<br>P46 |
| Bits 8 to 15 not used                                                       | To Trib address 4 (enter 0 to 128)<br>To Trib address 5 (enter 0 to 128)<br>To Trib address 6 (enter 0 to 128)<br>To Trib address 7 (enter 0 to 128)                                                                                                                                                                        | P11<br>P12<br>P13<br>P14 | P23<br>P24<br>P25<br>P26 | P35<br>P36<br>P37<br>P38 | P47<br>P48<br>P49<br>P50 |

## 6. SERIAL COMMUNICATION LINKS

Table 6.8 - P-table for ESP Control Port

Note... The total number of tables assigned in P7 to P14 (P19 to P26, P31 to P38, P43 to P50) must NOT exceed 256.

| Function                                                           | Content                                                                                                                                                                                                                                                                                                                                                                                                                                              | Port 1                               | Port 2                                            | Port 3                                               | Port 4                                               |                                                      |
|--------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------------------------|------------------------------------------------------|------------------------------------------------------|------------------------------------------------------|
| Signalling Rate                                                    | enter 110 for 110 bits/s.<br>enter 300 for 300 bits/s.<br>enter 600 for 600 bits/s.<br>enter 1,200 for 1,200 bits/s.<br>enter 2,400 for 2,400 bits/s.<br>enter 4,800 for 4,800 bits/s.<br>enter 9,600 for 9,600 bits/s.<br>enter 0 for port not in use<br>enter -ve baud rates for extended<br>time out. See Section 6.6.2 (c)                                                                                                                       | P3                                   | P15                                               | P27                                                  | P39                                                  |                                                      |
| Operation Mode                                                     | enter 3 for ESP control port                                                                                                                                                                                                                                                                                                                                                                                                                         | P4                                   | P16                                               | P28                                                  | P40                                                  |                                                      |
| Free-running/user control                                          | enter 0 for free-running<br>enter 1 for user-control.                                                                                                                                                                                                                                                                                                                                                                                                | P5                                   | P17                                               | P29                                                  | P41                                                  |                                                      |
| Indication of number of<br>tributaries (Free-running mode<br>only) | enter a HEX code to set bit 0 to 7<br>This enables data to be sent to<br>tributaries 0 to 7 respectively (bits 8<br>to 15 unused)                                                                                                                                                                                                                                                                                                                    | P6                                   | P18                                               | P30                                                  | P42                                                  |                                                      |
| Quantity of data table locations<br>to be transmitted              | Free-running mode<br>Low Byte - Number of<br>tables to<br>transmit to<br>tributary<br>High Byte - Max. number of<br>tables assigned<br>for data<br>received from<br>tributary if<br>greater than low<br>byte.<br>User-control mode<br>Low Byte - Max. number of<br>tables to be<br>assigned for<br>transmission.<br>High Byte - Max. number of<br>tables assigned<br>to route for data<br>reception if<br>greater than low<br>byte.<br>Route address | 0<br>1<br>2<br>3<br>4<br>5<br>6<br>7 | P7<br>P8<br>P9<br>P10<br>P11<br>P12<br>P13<br>P14 | P19<br>P20<br>P21<br>P22<br>P23<br>P24<br>P25<br>P26 | P31<br>P32<br>P33<br>P34<br>P35<br>P36<br>P37<br>P38 | P43<br>P44<br>P45<br>P46<br>P47<br>P48<br>P49<br>P50 |

Table 6.9 - J- and K-Table Addresses for Control Port (Operation Mode 2)

| Function            | Content | Port 1     | Port 2     | Port 3     | Port 4      |
|---------------------|---------|------------|------------|------------|-------------|
| Tributary address 0 |         | J/K0-31    | J/K256-287 | J/K512-543 | J/K768-799  |
| Tributary address 1 |         | J/K32-63   | J/K288-319 | J/K544-575 | J/K800-831  |
| Tributary address 2 |         | J/K64-95   | J/K320-351 | J/K576-607 | J/K832-863  |
| Tributary address 3 |         | J/K96-127  | J/K352-383 | J/K608-639 | J/K864-895  |
| Tributary address 4 |         | J/K128-159 | J/K384-415 | J/K640-671 | J/K896-927  |
| Tributary address 5 |         | J/K160-191 | J/K416-447 | J/K672-703 | J/K928-959  |
| Tributary address 6 |         | J/K192-223 | J/K448-479 | J/K704-735 | J/K960-991  |
| Tributary address 7 |         | J/K224-255 | J/K480-511 | J/K736-767 | J/K992-1023 |

Table 6.10 - I-Table for ESP Control Port

Note... The I-tables may be used to control an ESP control port only if the port is in user-control mode, i.e. P5 = 1.

| Function                                   | Content                                                                                                                                                                                                                                   | Port 1            | Port 2 | Port 3 | Port 4 |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------|--------|--------|
| Flags                                      | SEND FLAGS are bits 0 to 7 of the 16-bit words shown to the right (I0, I9 etc.).<br>RECEIVE FLAGS are bits 8 to 15 of the 16-bit words shown to the right (I0, I9 etc.).<br><br>Each bit applies to tributary addresses as shown below :- |                   |        |        |        |
|                                            |                                                                                                                                                                                                                                           | I0                | I9     | I18    | I27    |
|                                            | SEND FLAGS                                                                                                                                                                                                                                |                   |        |        |        |
|                                            | RECEIVE FLAGS                                                                                                                                                                                                                             |                   |        |        |        |
|                                            | bit                                                                                                                                                                                                                                       | tributary address | bit    |        |        |
|                                            | 0                                                                                                                                                                                                                                         | 0                 | 8      |        |        |
|                                            | 1                                                                                                                                                                                                                                         | 1                 | 9      |        |        |
|                                            | 2                                                                                                                                                                                                                                         | 2                 | 10     |        |        |
|                                            | 3                                                                                                                                                                                                                                         | 3                 | 11     |        |        |
|                                            | 4                                                                                                                                                                                                                                         | 4                 | 12     |        |        |
| 5                                          | 5                                                                                                                                                                                                                                         | 13                |        |        |        |
| 6                                          | 6                                                                                                                                                                                                                                         | 14                |        |        |        |
| 7                                          | 7                                                                                                                                                                                                                                         | 15                |        |        |        |
| Quantity of words received or transmitted. | tributary address 0 (enter 1 to 32)                                                                                                                                                                                                       | I1                | I10    | I19    | I28    |
| bits 0 to 7 transmit length.               | tributary address 1                                                                                                                                                                                                                       | I2                | I11    | I20    | I29    |
| bits 8 to 15 receive length                | tributary address 2                                                                                                                                                                                                                       | I3                | I12    | I21    | I30    |
|                                            | tributary address 3                                                                                                                                                                                                                       | I4                | I13    | I22    | I31    |
|                                            | tributary address 4                                                                                                                                                                                                                       | I5                | I14    | I23    | I32    |
|                                            | tributary address 5                                                                                                                                                                                                                       | I6                | I15    | I24    | I33    |
|                                            | tributary address 6                                                                                                                                                                                                                       | I7                | I16    | I25    | I34    |
|                                            | tributary address 7                                                                                                                                                                                                                       | I8                | I17    | I26    | I35    |

## 6. SERIAL COMMUNICATION LINKS

Table 6.11 - I-Table for EESP Control Port

Note... The I-tables may be used to control an EESP control port, only if the port is in user-control mode, i.e. P5 = 1.

| Function                     | Content                                                                                                                                                                                                                                   | Port 1                  | Port 2 | Port 3 | Port 4 |     |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|--------|--------|--------|-----|
| Flags                        | SEND FLAGS are bits 0 to 7 of the 16-bit words shown to the right (I0, I9 etc.).<br>RECEIVE FLAGS are bits 8 to 15 of the 16-bit words shown to the right (I0, I9 etc.).<br><br>Each bit applies to tributary addresses as shown below :- |                         |        |        |        |     |
|                              |                                                                                                                                                                                                                                           | I0                      | I9     | I18    | I27    |     |
|                              | SEND FLAGS                                                                                                                                                                                                                                |                         |        |        |        |     |
|                              | RECEIVE FLAGS                                                                                                                                                                                                                             |                         |        |        |        |     |
|                              | bit tributary address bit                                                                                                                                                                                                                 |                         |        |        |        |     |
|                              | 0 0 8                                                                                                                                                                                                                                     |                         |        |        |        |     |
|                              | 1 1 9                                                                                                                                                                                                                                     |                         |        |        |        |     |
|                              | 2 2 10                                                                                                                                                                                                                                    |                         |        |        |        |     |
|                              | 3 3 11                                                                                                                                                                                                                                    |                         |        |        |        |     |
|                              | 4 4 12                                                                                                                                                                                                                                    |                         |        |        |        |     |
| 5 5 13                       |                                                                                                                                                                                                                                           |                         |        |        |        |     |
| 6 6 14                       |                                                                                                                                                                                                                                           |                         |        |        |        |     |
| 7 7 15                       |                                                                                                                                                                                                                                           |                         |        |        |        |     |
| Quantity of words            | tributary address 0 (enter 1 to 128)                                                                                                                                                                                                      | I1                      | I10    | I19    | I28    |     |
| received or transmitted.     | tributary address 1 (enter 1 to 128)                                                                                                                                                                                                      | I2                      | I11    | I20    | I29    |     |
| bits 0 to 7 transmit length. | tributary address 2 (enter 1 to 128)                                                                                                                                                                                                      | I3                      | I12    | I21    | I30    |     |
| bits 8 to 15 receive length  | tributary address 3 (enter 1 to 128)                                                                                                                                                                                                      | I4                      | I13    | I22    | I31    |     |
|                              | tributary address 4 (enter 1 to 128)                                                                                                                                                                                                      | I5                      | I14    | I23    | I32    |     |
|                              | tributary address 5 (enter 1 to 128)                                                                                                                                                                                                      | I6                      | I15    | I24    | I33    |     |
|                              | tributary address 6 (enter 1 to 128)                                                                                                                                                                                                      | I7                      | I16    | I25    | I34    |     |
|                              | tributary address 7 (enter 1 to 128)                                                                                                                                                                                                      | I8                      | I17    | I26    | I35    |     |
|                              | Tributary address of route                                                                                                                                                                                                                | route 0 (enter 0 to 14) | 151    | 159    | 167    | 175 |
|                              | route 1 (enter 0 to 14)                                                                                                                                                                                                                   | 152                     | 160    | 168    | 176    |     |
| route 2 (enter 0 to 14)      | 153                                                                                                                                                                                                                                       | 161                     | 169    | 177    |        |     |
| route 3 (enter 0 to 14)      | 154                                                                                                                                                                                                                                       | 162                     | 170    | 178    |        |     |
| route 4 (enter 0 to 14)      | 155                                                                                                                                                                                                                                       | 163                     | 171    | 179    |        |     |
| route 5 (enter 0 to 14)      | 156                                                                                                                                                                                                                                       | 164                     | 172    | 180    |        |     |
| route 6 (enter 0 to 14)      | 157                                                                                                                                                                                                                                       | 165                     | 173    | 181    |        |     |
| route 7 (enter 0 to 14)      | 158                                                                                                                                                                                                                                       | 166                     | 174    | 182    |        |     |

## 6.6.2 Operation as a Control Port

Data table transfers only occur between user program scans, and the I-table is also only examined between scans in the user-control mode. The control port can be operated in the user-control mode or the free-running mode, either mode being user selectable.

### (a) Free-running Mode

Transfers occur automatically on a cyclic basis to tributaries in use. Transmission is taking place on a continuous basis and the J/K tables are updated between user program scans. The message length is in the P-table.

When free-running mode is selected, the controller cycles round the routes indicated by the pre-set data to be in use, and attempts a J/K exchange, transmitting the quantity of locations requested in the P-table. If a valid reply is not received after the system of re-tries has been exhausted, the route is classified as failed and the corresponding bit in F42 or F43 is set ON. When one of the serial ports is configured for free running ESP operation and is set up as a control port, it is capable of communicating with 8 tributaries. In the event of a tributary failing to communicate, the errors are not clocked up on a cyclic scan basis but only after 8 complete scans. If a failed route re-commences communication, the F-table bit is set OFF and the route is no longer classified as failed.

### (b) User-control Mode

A transfer only occurs when an I-table bit is set. The destination of the data is determined by which bit of the I-table is set.

User-control mode allows the user to vary the transmitted message lengths and also to select dynamically which routes are to be used. To initiate a message transfer on a particular route, the following procedure should be adopted :- (example refers to port 3 route 3)

- (i) Set bits 0 to 7 of I22 to number of locations to transmit.
- (ii) Set the desired data from K608 onwards.
- (iii) Set I18.11 OFF and set I18.3 ON. When the message has been generated, I18.3 is set OFF. The user can now begin assembling the next message for this route in K608 onwards.
- (iv) If the transfer fails F43.3 is set ON. If the transfer succeeds, a reply is returned from tributary 3. The data received is placed in J608 upwards and bits 8 to 15 of I22 contain the number of locations written. I18.11 is set ON to indicate that the reply has arrived.

It is possible to request transfers on several routes simultaneously. In this situation the requests are handled in order of route number, a transfer on a particular route being completed before the next is commenced.

### (c) Extended Time-out Option

When a GEM 80 control port outputs a message, it waits for a period (which varies with the signalling rate) before assuming that the tributary is not going to respond, e.g. at 9,600 bits/s this period is 0.5s to 0.75s. Refer to Table 6.12. Actual timings may be up to 0.25 seconds less than those shown in this table.

To assist in avoiding false time-outs when communicating with a tributary port configured in user-control mode, the GEM 80 control port provides the option of increasing the standard time-out values, e.g. at 2,400 bits/s from 1.25s to 2.5s.

This is achieved by setting the signalling rate to the negative of that required, e.g. to select extended time-outs on port 1 at a signalling rate of 9,600 bits/s, P3 should be set to -9,600. Table 6.12 shows the relationship between the signalling rate and the standard and extended time-out periods.

If a message is received which is longer than the space allocated, the message is rejected as if a transmission error had occurred.

Table 6.12 Time-out Periods

| SPEED<br>(Bits/s) | MAXIMUM TIME (seconds) |          |          |          |          |          |
|-------------------|------------------------|----------|----------|----------|----------|----------|
|                   | MESSAGE LENGTH (words) |          |          |          |          |          |
|                   | 0-32                   |          | 33-64    |          | 65-128   |          |
|                   | standard               | extended | standard | extended | standard | extended |
| 9,600             | 00.75                  | 01.50    | 01.50    | 03.00    | 03.00    | 06.00    |
| 4,800             | 01.00                  | 02.00    | 02.00    | 04.00    | 04.00    | 08.00    |
| 2,400             | 01.25                  | 02.50    | 02.50    | 05.00    | 05.00    | 10.00    |
| 1,200             | 01.75                  | 03.50    | 03.50    | 07.00    | 07.00    | 14.00    |
| 600               | 02.75                  | 05.50    | 05.50    | 11.00    | 11.00    | 22.00    |
| 300               | 05.00                  | 10.00    | 10.00    | 20.00    | 20.00    | 40.00    |
| 110               | 13.75                  | 27.50    | 27.5     | 55.00    | 55.00    | 110.00   |

### 6.7 Printer/Keyboard Ports

#### 6.7.1 Specification

##### Application

Input/Output to and from intelligent devices.  
Output of text and numeric data to printer, Teletype (TTY) compatible VDU, etc.  
Input of characters or strings from keyboard.  
Option of automatic echoing and editing of input. Also supports XON-XOFF protocol in this mode.

##### Characteristics

Depends on termination panel (e.g. 20mA current loop for panel type 8924).

ASCII character set (equivalent to ISO-7).

1 start bit, 7 character bits, optional parity of 8th character bit, 2 stop bits.

Parity options configurable by pre-set data for odd, even or no parity on output, and odd, even or stripped parity on input.

Automatic insertion of up to 132 null characters as 'padding' at the end of each line, to suit particular printers.

##### Capacity

Buffer for up to 507 characters in each direction.  
Line length up to 132 characters.  
Indications when output buffer has room for one full line or is completely empty.  
Buffers empty automatically as data is transferred.

#### 6.7.2 Setting Up a Printer/Keyboard Port

Table 6.13 shows the P-table addresses and the data the user must write to these addresses to enable the port to operate as a Printer/Keyboard Port.

Changes to the P-table are implemented on RECOMPILE (no need to power down).

Table 6.11 - P-table for Printer/Keyboard Port

| Function                           | Content                                                                                                                                                                                                                                                 | Port 1 | Port 2 | Port 3 | Port 4 |
|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|--------|--------|
| Signalling Rate                    | enter 110 for 110 bits/s.<br>enter 300 for 300 bits/s.<br>enter 600 for 600 bits/s.<br>enter 1,200 for 1,200 bits/s.<br>enter 2,400 for 2,400 bits/s.<br>enter 4,800 for 4,800 bits/s.<br>enter 9,600 for 9,600 bits/s.<br>enter 0 for port not in use. | P3     | P15    | P27    | P39    |
| Select Printer                     | enter 0 for printer port                                                                                                                                                                                                                                | P4     | P16    | P28    | P40    |
| Mode                               | enter 0 for direct<br>enter 1 for terminal operation of<br>a Printer/Keyboard Port (see 6.7.3<br>for details).                                                                                                                                          | P5     | P17    | P29    | P41    |
| Quantity of characters<br>per line | enter a value between 1 and 132<br>(usually 80 or 132)                                                                                                                                                                                                  | P6     | P18    | P30    | P42    |
| Padding Constant                   | enter quantity of characters to be<br>output after each carriage<br>return with 'line feed' per<br>instruction.                                                                                                                                         | P7     | P19    | P31    | P43    |
| Parity Enable                      | enter 0 for 8 data bits, NO<br>PARITY<br>enter 1 for 7 data bits with<br>PARITY bit                                                                                                                                                                     | P8     | P20    | P32    | P44    |
| Parity Select                      | enter 0 for even parity<br>enter 1 for odd parity (only<br>applies when Parity Enable is 1)                                                                                                                                                             | P9     | P21    | P33    | P45    |
|                                    | not used                                                                                                                                                                                                                                                | P10-14 | P22-26 | P34-38 | P46-50 |

### 6.7.3 Operation of a Printer/Keyboard Port

Figure 6.5 shows an example of a serial printer connected in a 20mA current loop from an 8924 unit, driven by a controller. The Printer/Keyboard port can operate in either 'Direct Mode' or in 'Terminal Mode'.

#### (a) Direct Mode

This mode is intended for use with a printer and a separate serial input device, such as a matrix keyboard. The port has two cyclic buffers, one for input and one for output. Data can be written to the output buffer, and read from the input buffer, by means of Special Functions. Otherwise these buffers cannot be accessed from the ladder diagram program.

All characters received from the keyboard are directly transferred to the input cyclic buffer as they arrive. The only exception is that, if parity is enabled, any character with a parity error is replaced by @FF.

Output data is taken from the output cyclic buffer after the previous output has finished. However, transmission does not commence until an ETX (@03) character or an end-of-line marker (@0A) is found. An end-of-line marker is transmitted as carriage-return (@0D), line-feed (@0A), plus any user defined quantity of NUL (@00) characters. An ETX character is not itself transmitted, but simply initiates output from the cyclic buffer, allowing partial lines to be output.

**Note...** Many printers do not display any characters until a carriage-return or a line-feed is received.

#### (b) Terminal Mode

This mode is specifically intended for interactive operator interfacing using a Teletype (TTY) compatible VDU. It performs the functions of auto-echoing and line-editing without the need for user programming.

## 6. SERIAL COMMUNICATION LINKS

The VDU is expected to have the following characteristics (ASCII character names are shown in parentheses) :-

- (i) Pressing the carriage-return key generates @0D (CR).
- (ii) Pressing the Delete/Rubout key generates @7F (DEL).
- (iii) Receipt of @0D, @0A (CR,LF) moves the cursor to the left-hand edge of the screen on the next line, scrolling the display if on the last line of the screen.
- (iv) Receipt of @00 (NUL) does not perform any action.
- (v) Receipt of @07 (BEL) sounds an audible alarm.
- (vi) Receipt of @08 (BS) moves the cursor one character position to the left.
- (vii) Receipt of @20 (SP) blanks out the current display position.
- (viii) Receipt of @1A (SUB) displays some non-blank character.

As for direct mode, the port has an input cyclic buffer and an output cyclic buffer. Data can be written to the output buffer, and read from the input buffer, by means of Special Functions. Otherwise these buffers cannot be accessed from the ladder diagram program.

However, the input channel has a separate input line buffer in addition to the input cyclic buffer. All received characters are initially stored in the line buffer. They are transferred to the input cyclic buffer only when a @0D (CR) is received and, until this happens, cannot be read by the controller. As characters are received into the line buffer, they are echoed back to the VDU via the output channel and, with the following exceptions, are displayed on the VDU screen.

- (i) Any non-printing character other than CR, DEL, XON or XOFF is discarded (not loaded into the line buffer) and echoed as BEL.
- (ii) XOFF is discarded, and causes output (including echoing) to be suspended.
- (iii) XON is discarded, and causes output suspended by XOFF to resume.
- (iv) DEL is discarded, and causes the previous character loaded into the line buffer to be removed. It is normally echoed as BS, SP, BS. If, however, the line buffer is already empty, BEL is echoed.
- (v) CR is echoed as CR, LF, plus the user-defined quantity of NUL characters. It is stored in the line buffer as an end-of-line marker (@0A). Once this has been done, the contents of the line buffer are transferred to the input cyclic buffer, and the line buffer is cleared.
- (vi) Any character other than CR which would cause the line buffer to contain as many characters as the user-programmed line length is discarded, and echoed as BEL.

- (vii) When parity is enabled, any character received with a parity error is replaced in the line buffer with @FF, and is echoed back to the VDU as SUB. Thus, if the VDU displays an upside-down question mark for SUB (@1A), the operator is able to back space to any symbol of this type on the line and overkey the character to re-transmit it to the Printer/Keyboard port. After the end of the line has been reached, however, as indicated by CR, any such error cannot subsequently be corrected.

XOFF and XON are generated automatically by some VDUs (e.g. DEC VT101 set up for smooth scroll). They may also usually be generated by keying Ctrl-S and Ctrl-Q respectively.

Output data is taken from the output cyclic buffer after the previous output has finished. However, transmission does not commence until an ETX (@03) character or an end-of-line marker (@0A) is found. An end-of-line marker is transmitted as carriage-return (@0D), line-feed (@0A), plus any user defined quantity of NUL (@00) characters. An ETX character is not itself transmitted, but simply initiates output from the cyclic buffer, allowing partial lines to be output.

The exception to this is if the program calls for output to commence while the operator is also keying in data at the keyboard. In this case, the output skips to a new line (by sending CR, LF, and NULs if programmed), then displays the output line. Upon completion of the output line, the contents of the line buffer are re-output (preceded by CR-LF plus NULs if the cursor is not already at the left-hand margin), followed by the echo of any characters which were entered during the output.

### 6.7.4 Operation of Printer Buffer Store

The buffers used by Printer/Keyboard ports utilise the memory space which would otherwise have been used for J- and K-tables if the port had been configured as a Control or as a Tributary port. The blocks of J- and K-table addresses given in Table 6.9 for the particular port must NOT be:

- referenced in the user program.
- used for the value tables of Special Functions.
- written to via a Programmer (although they may be monitored).

To furnish the user program with information regarding the state of the output buffer, two flags called the 'empty flag' and the 'filling flag' are provided. See Table 4.3 for more information.

The empty flag is set ON between program scans when the cyclic buffer is empty and all characters have been transmitted. It is set OFF by execution of any Special Function which outputs to that buffer.

The filling flag is set on during execution of any Special Function which outputs to the cyclic buffer and leaves it with room for less than one line of output. The quantity depends on the pre-set line length. It is re-set between program scans by the printer driver removing characters from the buffer so that room for one full line is once more available.

A special case of the filling flag being set occurs when a Special Function attempts to output more characters than there is space for in the buffer. The output is truncated so as not to overwrite the data already in the buffer; the last character to be placed in the buffer is an exclamation mark (!), and the appropriate fault code is generated by the Special Function.

Overflow of the input buffer can occur, resulting in the oldest data being overwritten and lost.

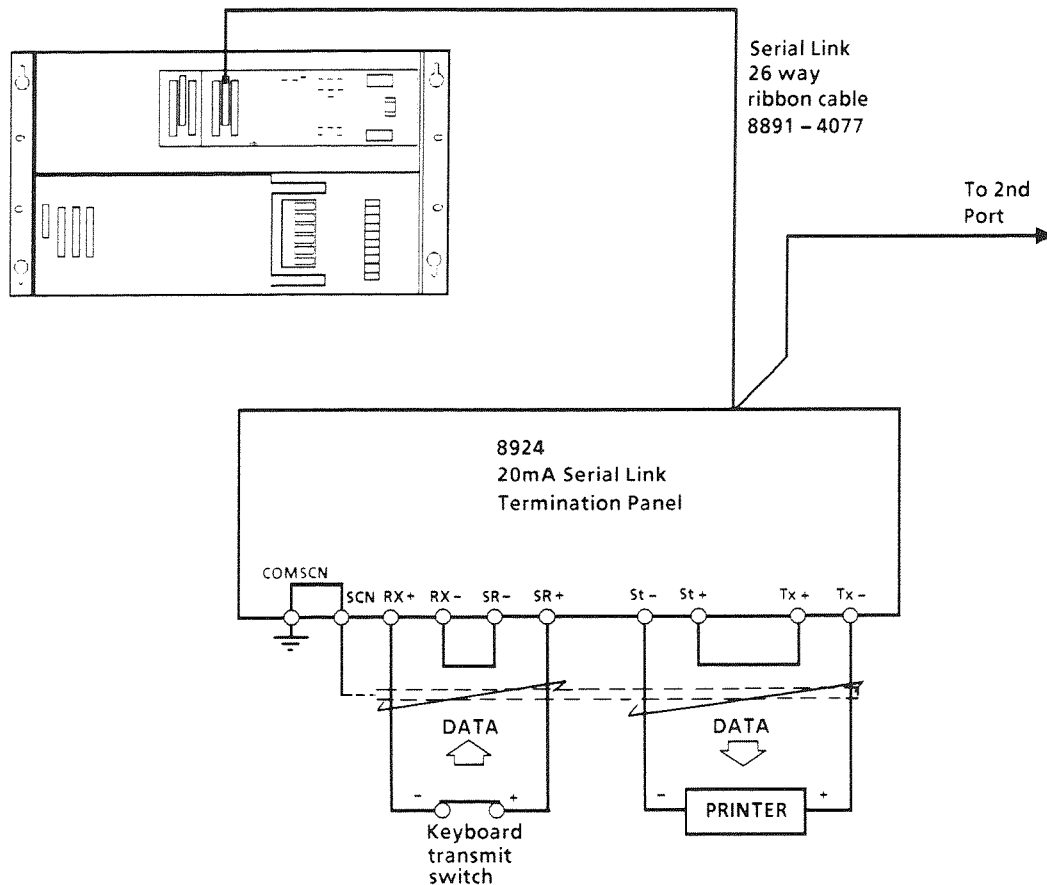


Figure 6.5 - Connection of 20mA Current Loop Printer Keyboard to a Serial Port

### 6.8 Remote Programming

Remote programming and monitoring facilities are available on all serial ports. These facilities are available when the controller port is configured as a tributary. The controller automatically recognises the programming messages without any additional switching.

A System Programmer must be used, since it has a selectable signalling rate and the slow signalling rate necessary for long distance serial links can be set up. The Portable Programmer works at 9,600 bits/s only and can only be used for short distance serial links.

When remote programming is being undertaken, the system prevents more than one programming channel from altering the program simultaneously by activating a locking mechanism.

The lock is released by issuing a Run or Recompile command. Should a user neglect to issue such a command the system releases the locking mechanism after a period of five minutes has elapsed during which no access to the locked item has been made. If the user program lock has been activated by a user on another port, any attempt to access the User Program results in a LINK REJECTED message being displayed on the programming unit of the user who is locked out. If the message editor lock has been activated the editor option is removed from the initial menu. See also Section 3.2.4, On-line Program Changes and Section 10.2.1, Programmer Units.

### 6.9 Fibre-Optic Serial Links

An 8927 Fibre-Optic Transceiver may be connected to 8924 RS422 to 20mA converter using adaptor cable 8891-4079 to provide fibre-optic serial links.

## 6. SERIAL COMMUNICATION LINKS

### 6.10 Maximum Length of Serial Links

The maximum link length depends on:

- (a) Driving voltage provided by current sources (15V or 30V in standard GEM 80 equipment, depending on whether a -15V power rail is available. 15V applies to MINIGEM, GEM 80/100 and 140 series; 30V to GEM 80/300 series).
- (b) Choice of single/twin pair cable.
- (c) Signalling rate.
- (d) Cable capacitance and resistance.
- (e) Number of tributaries in the link.
- (f) Voltage drop of transmit switches and receive loads. Standard GEM 80 circuits have a typical 1.0V drop for Tx, and a range of 1.1 to 1.5V drop for Rx.

There is an overall length limitation due to the voltage drop in the cable, which is independent of the signalling rate. Any link may be extended beyond the limits due to 20mA working, by introducing proprietary modems. Modems allow very long links, limited by propagation delays, which may give time-out problems if they exceed 100ms.

A further discussion of this topic is available in Serial Links User Information, Publication No.T418. This shows in more detail the improvement gained with 30V supplies, fibre-optics and other cables.

### 6.11 Ribbon Cable Connection Details

#### Cable

26-way flat ribbon, 33mm wide  
ITT type 455-240-26 or equivalent  
Maximum length - 2metres

#### Connectors

Harting type 0918 526 5823 connector  
Polarising key in position 10

#### Segregation

Category 1 (very sensitive to noise)

Section 13, Installation, covers the installation of serial link ribbon cables.

### 6.12 GEMSTART Contactor Control Unit (CCU) Option.

#### 6.12.1 Introduction

The GEMSTART CCU provides the necessary control and protection facilities required for Low Voltage Motor Starter applications. Within the GEM 80, the GEMSTART CCU option is selected by the P-table configuration shown in Table 6.2. The facility allows direct control of GEMSTART CCUs by a GEM 80 controller through the serial link ports using an 8587 Termination Unit.

#### 6.12.2 P-tables

Table 6.14 shows the configuration data which must be entered into the P-table if the GEM 80 serial links have been set up to operate in the CCU mode. Table 6.2 illustrates the value of the P-table entry which determines the various operating modes of a serial port.

Table 6.14 Serial Port Configuration (Port 1)

| P-Table | Value     | Comment                                                                      |
|---------|-----------|------------------------------------------------------------------------------|
| P3      | 300-9,600 | Signalling Rate                                                              |
| P4      | 6         | CCU Mode                                                                     |
| P5      | 0         | Free-running mode                                                            |
| P6      | 0-63      | Lowest Address of CCU range                                                  |
| P7      | 0-63      | Highest Address of CCU range                                                 |
| P8      | X         | The table letter of the retained tables for configuration data in ASCII code |
| P9      | XX        | Table number of retained tables as specified in P8                           |
| P10     |           | <b>CCU Configuration flag</b>                                                |
|         | 0         | No master                                                                    |
|         | 1         | CCU master                                                                   |
|         | 2         | GEM master                                                                   |

**Note...**P3 to P9 take effect only on RECOMPILE (no need to power down). P10, which determines the configuration to use if there is a configuration conflict can be changed with a System Programmer and takes immediate effect.

#### 6.12.3 J/K-Tables

These tables hold the data to be sent and the data to be received from the GEMSTART CCU. Four locations in each table are reserved for each GEMSTART CCU. The interpretation of the data contained in these tables is detailed in the GEMSTART CCU Technical Manual, Publication No. 78234.

### 6.12.4 I-Table

This table is used to control serial link exchanges. I0.0 for Link 1 and I9.0 for Link 2 are used as SEND flags when the GEM 80 sends new configuration data to the GEMSTART CCU. The user sets up the new configuration data in the User tables and places the address of the affected GEMSTART CCU in I1. On setting I0.0, the new configuration is continually transmitted to the GEMSTART CCU until the addressed unit acknowledges the data. The I0.0 flag is then cleared automatically.

### 6.12.5 User specified tables

Using P8 and P9, the user can specify which table is used to contain the configuration data for the GEMSTART CCUs. The User Specified tables must be allocated in contiguous locations with 5 words per GEMSTART CCU plus 5 words to hold the IOP control information. The allocated tables are then split, the first 5 tables for CONTROL data (NON USER CHANGEABLE), the rest of the tables containing CONFIGURATION DATA (USER CHANGEABLE). The configuration tables are used in order of GEMSTART CCU address starting at the address in P6 and ending at the address in P7. The control information should not be changed, otherwise the configuration is lost.

During re-compilation, only the configuration data used before re-compiling is considered valid. Therefore, any new GEMSTART CCU included in the scan has its configuration data set to zero. The GEM configuration data is updated by the GEMSTART CCU once communications are established.

If the control information in the user tables is altered, all the GEMSTART CCUs on the scan will have the GEM 80's copy of the configuration data set to zero. Again this is updated by the GEMSTART CCUs during the first few scans. To program the GEMSTART CCU from the GEM 80, the configuration data is placed in the user selectable tables at the appropriate address.

For example: if P8 = ASCII 'R' and P9 = 5, the configuration information starts at R5. R5 to R9 contain the control data (non-user changeable) R10 contains the start of the configuration data for CCU 0, R15 for CCU 1 etc.

See the GEMSTART CCU Technical Manual for details of the values to place in these tables. Once the desired values have been placed in the tables, the I-Table can be used to re-configure the CCU by placing the CCU address in I1 (I10 for Link 2) and setting I0 to 1. After the message has been sent and acknowledged by the CCU, I0 is cleared to zero.

### 6.12.6 F-Table

F-tables are used for diagnostics and error counting. Refer to Section 15, Fault Finding, Table 15.8 for details.

## 6.13 CORONET Option

### 6.13.1 Introduction

CORONET is a Local Area Network (LAN), communication system. Unlike the ESP serial link provided by the I/O processor, CORONET allows any controller on the network to communicate with any other controller at any time. This type of communication greatly improves any multi-controller system, because controllers can now exchange data directly. This differs from ESP which operates a 'master/slave' network, where all communication is channelled through one 'master' controller.

Communication between controllers operating on a CORONET LAN is known as 'peer-to-peer' because all the controllers on the network are considered to be 'masters' and have equal priority.

Up to 32 controllers, or other units such as system programmers, or IBM or DEC computers if these are part of the system, may be serviced on the CORONET LAN. It is also possible to double, treble or quadruple the size of the network by the use of gateway units.

### 6.13.2 8193 CORONET Interface Module

The 8193 CORONET Interface module is a single width module which can be slotted into any location in a Verification I/O subrack. However, on a Basic I/O subrack, the 8193 must be inserted into the slot next to the Power Supply module.

Opto-isolation is provided at the output stage to the LAN, and connection is made by a 3-way socket. The LAN is powered by an on-board regulator which is also isolated from the GEM 80 power supplies.

A 26-way socket connects directly to the 26-way serial link ribbon cable provided by the I/O processor. A 9-way 'D' type socket is also provided for the connecting a printer or VDU. All three sockets are mounted on the front panel of the 8193 module for ease of access.

### 6.13.3 Operation

The CORONET LAN is operated in control mode only. Unlike ESP however, receptions and transmissions are handled totally separately. Data is transferred via the Controller's J/K tables and the I-table is used to control data transfers.

The CORONET LAN does not exchange data with another GEM 80; only one-way transfers can be accomplished. If exchange of data is required, it must be written in the User program.

### 6.13.4 Additional Information

More detailed information can be obtained on the CORONET LAN by consulting the Serial Communications Manual, Publication No.T457 and the CORONET Interface Module User Information, Publication No.T465.

## 6. SERIAL COMMUNICATION LINKS

### 6.14 STARNET

#### 6.14.1 Introduction

The GEM 80 STARNET module fits into the Central Highway of the Controller to provide two or four additional serial links, depending on the module chosen. If there is sufficient space on the central highway, up to five STARNET modules can be fitted to each controller. This gives a total of 10 or 20 serial links, with each link being an independent communication facility configurable by software. Each port can be configured to provide a range of data rates up to 180k bits/s and a choice of two protocols, High Level Data Link (HDLC) or Extended Simple Protocol (ESP).

#### 6.14.2 Hardware

##### 6.14.2.1 STARNET Module

The STARNET module occupies one slot or two adjacent slots in the Central Highway of the Controller subrack.

##### 6.14.2.2 Backplane PCB

For the single width module providing two serial links, one ribbon connector is mounted on the backplane carrying Port 0 and 1. The double width module which provides four serial links has two ribbon connectors, PL1 and PL2, mounted on the backplane. PL1 carries Port 0 and 1; PL2 carries Port 3 and 4.

##### 6.14.2.3 Termination Panel or Units

Each STARNET port requires a termination panel or termination unit to provide electrical isolation and flexibility in line driving. For more comprehensive details of the capabilities of these units, see the Serial Link User Information, Publication No.T456. and the Serial Communications Manual, Publication No.T457.

#### 6.14.3 Operation

Before commencing operation, each STARNET port must be configured. The port address must be established; it must be decided whether a particular port is a primary or secondary and if a primary, how many partners are connected. The mode of operation and port type have to be specified.

The choices available and the final configuration depend on the application. The Special Function T33, CONFIG, provides all the facilities to configure the STARNET module.

##### 6.14.3.1 Configuration Data

Configuration data can be written into any data tables usable by the Special Function T33, CONFIG. Each port on the STARNET module requires a block of seven words. The total block of 14 words (for a single width module) or 28 words (for a double width module), must be consecutive. The first block of seven words is reserved for port 0, the next block of seven for port 1 and so on. Precise details of the function of each word can be found in the Software Data Sheet T33, CONFIG.

##### 6.14.3.2 Modes of Operation

The primary objective of any port on the STARNET module is to communicate with other GEM 80 equipment. The two alternative modes of operation offered by STARNET are Special Function Operation, where the messages can be contained in any data table, or Table Exchange, where dedicated data tables (N and O Tables) are used.

##### 6.14.3.3 Data Tables

###### (a) P-table

As well as being used to configure the STARNET module, The P-table is used where the Table Exchange mode has been allocated to any port on the STARNET module. Two words in the P-table are reserved for each module. P60/61 are reserved for STARNET module 0, P62/63 for module 1, up to P68/69 for module 4.

The first word for the module defines the 'block size' and the second word defines the 'number of blocks' for that module. The 'block size' defines the quantity of locations in the N- and O-tables to be allocated for each route and must be set to the largest quantity of locations likely to be used for either input or output. This block size will be in the range 1 - 111.

The 'number of blocks' defines the maximum number of secondaries to which any port on that module is likely to multi-drop. This range is 1 - 31.

###### (b) N- and O-Table

In Table Exchange mode, these data tables are reserved for storing incoming messages (N-table) and for storing messages prior to transmission (O-table).

###### (c) U-Table

In Table Exchange mode this table provides the means for the user to control and monitor the activity on the STARNET links. There are four words allocated (by P-table data) to every partner on every port.

#### 6.14.4 Protocol

Two protocols are available with the STARNET module. High level Data Link Control (HDLC) and Extended Simple Protocol (ESP).

### 6.14.4.1 HDLC

This is a bit-orientated synchronous protocol operating with a choice of bit rates - 48k and 180k bits per second. Three methods of data encoding are offered, NRZI, FMO and FMI, the selection being made when the ports are configured. If this protocol is chosen, Termination Unit 8587 must be used to convert the RS422 standard output from the STARNET module into the RS485 standard.

### 6.14.4.2 ESP

This is the protocol normally used in GEM 80 controllers. The protocol uses asynchronous communication with a start bit, a stop bit and 8 data bits.

Data rates available in STARNET;

1.2K, 2.4K, 4.8K and 9.6K bits per second.

### 6.14.5 Power Supplies

External power supplies are not required for the STARNET modules. The module plugs directly into the GEM 80 Controller Central Highway backplane and draws power from the GEM 80 Controller power supply. The module draws 2.4A from the +5V supply.

### 6.14.6 Connections

The backplane p.c.b. carries two plugs for connection to the termination panels. Data is presented at these plugs in the RS422 standard and must be converted to the required standard by the relevant termination panel, depending on which protocol is chosen. For full details of the STARNET module including more information on operation, software and connections see the User Information Sheet, Publication No.T464.

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## 6. SERIAL COMMUNICATION LINKS

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## 7.1 Introduction

The Fast I/O equipment itself is detailed in the GEM 80 Product Data Sheets and User Information. The wide choice of equipment is designed for applications falling into three categories:

- (1) Analog I/O.
- (2) Counter Input.
- (3) Extra Serial Communication Ports (Programmable Serial Communication 8847 allows data exchanges with almost any other mini, micro, or main-frame computer).

In systems where Fast I/O is not required, the Fast I/O driver, additional Fast I/O subracks and associated power modules are omitted. Physically, Fast I/O equipment consists of a module, plant terminals, an interconnecting cable and a subrack backplane. The modules plug into spaces specially reserved for them in the subracks, as shown in Figures 1.1, 1.2 and 1.3.

## 7.2 Memory Addresses for Fast I/O Input and Output Data

Data INPUT to the controller from Fast I/O equipment is stored in the C-table and Data to be OUTPUT by the controller is stored in the D-table. For each Fast I/O module, there are 32 x 16-bit words reserved for INPUT and 32 x 16-bit words reserved for OUTPUT. For instance, the first slot can use C/D0 to C/D31 and the second slot can use C/D32 to C/D63 etc. The lowest table addresses for any given slot are referred to as the 'base addresses', e.g. C/D0, C/D32 etc.

The actual addresses are detailed in Table 7.1 and are related to the Fast I/O module number.

Fast I/O addresses are included in the scan starting from the base address for a particular module slot, and continuing to the highest address included in the ladder scan for that module. The scanning then jumps to the base address for the next module slot. The Controller works out separately which C-table and which D-table addresses to include in the scan.

The configuration data in the P-table must be set to declare the positions of any Fast I/O modules which are double width and may use up to 64 C-table words and 64 D-table words.

For example if address C47 is included in the ladder program, then normally addresses C32 to C47 inclusive are scanned. If the first slot is configured as a double width module, addresses C0 to C47 inclusive would be scanned.

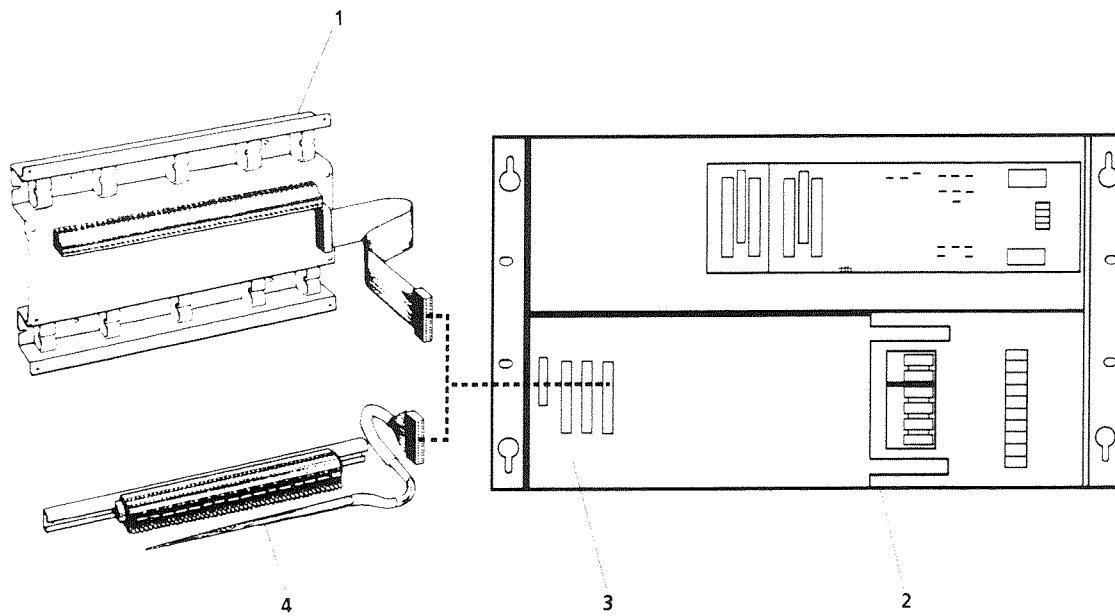
When compilation is attempted, the program will not run if an invalid Fast I/O address is used, because there will not be any response from the invalid address. The Programmer screen displays a diagnostic message.

The Fast I/O module number is derived from the position in which the Fast I/O module is fitted in the subrack.

## 7.3 Fitting Fast I/O Equipment

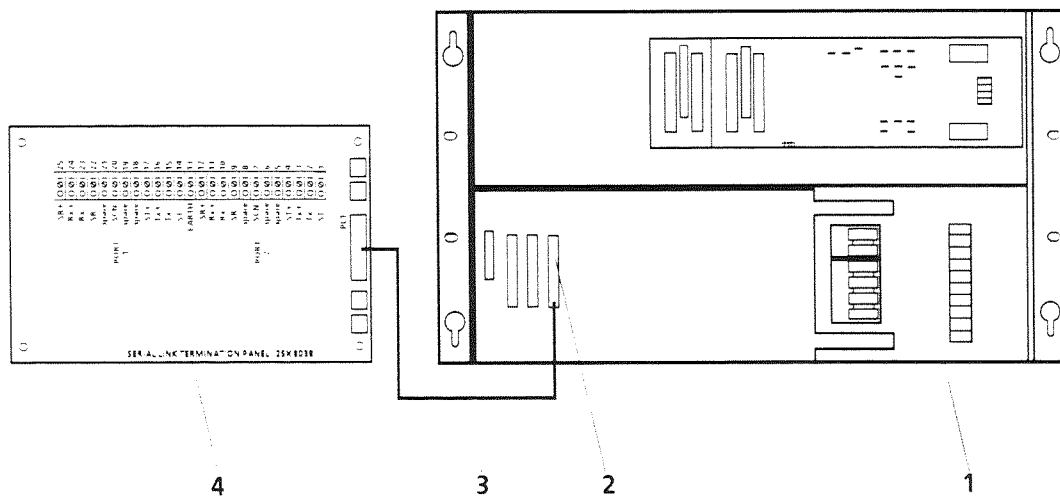
The illustrations following show connections to a GEM 80/311, with the Fast I/O module concerned fitted in position 0. The set up is similar for other controllers and Fast I/O modules fitted in other positions. The interconnecting cable from each Fast I/O module plugs into the connector in the lower backplane at the back of the Fast I/O module concerned.

- (1) Analog Input/Output Equipment Connection  
- Figure 7.1 (8840 and 8841)
- (2) Serial Communication Equipment Connection 8847, etc.  
- Figure 7.2 (20mA current loop)
- (3) Counter Interface 8846  
- Figure 7.1



1. Terminal panel
2. GEM 80/311 Controller
3. Backplane at rear of Fast I/O module in position 0
4. Terminal rail

Figure 7.1 - 8840, 8841, and 8846 Connections to terminal rail or panel GEM 80/311 (Fast I/O module in position 0)



1. GEM 80/311 Controller
2. Backplane at rear of Fast I/O module in position 0
3. 20-way ribbon cable
4. Serial link termination panel (8038, when current loop is employed)

Figure 7.2 - 8847 Programmable Serial Communications Fitted in GEM 80/311 (position 0) Connected to 8038 (20mA Current Loop)

Table 7.1 - Fast I/O Addresses

## Fast I/O Subrack Slot Number

| C & D-Table<br>Address | Module<br>Number | GEM 80/311 | GEM 80/312 & 313<br>16-way Fast I/O<br>Subracks | GEM 80/312 & 313<br>12-way Fast I/O<br>Subracks |
|------------------------|------------------|------------|-------------------------------------------------|-------------------------------------------------|
| 0 to 31                | 0                | 17         | 3                                               | 9                                               |
| 32 to 63               | 1                | 18         | 4                                               | 10                                              |
| 64 to 95               | 2                | 19         | 5                                               | 11                                              |
| 96 to 127              | 3                | 20         | 6                                               | 12                                              |
| 128 to 159             | 4                |            | 7 1st                                           | 13 1st                                          |
| 160 to 191             | 5                |            | 8 Fast                                          | 14 Fast                                         |
| 192 to 223             | 6                |            | 9 I/O                                           | 15 I/O                                          |
| 224 to 255             | 7                |            | 10 Subrack                                      | 16 Subrack                                      |
| 256 to 287             | 8                |            | 11                                              | 17                                              |
| 288 to 319             | 9                |            | 12                                              | 18                                              |
| 320 to 351             | 10               |            | 13                                              | 19                                              |
| 352 to 383             | 11               |            | 14                                              | 20                                              |
| 384 to 415             | 12               |            | 15                                              |                                                 |
| 416 to 447             | 13               |            | 16                                              |                                                 |
| 448 to 479             | 14               |            | 17                                              |                                                 |
| 480 to 511             | 15               |            | 18                                              |                                                 |
| 512 to 543             | 16               |            |                                                 | 9                                               |
| 544 to 575             | 17               |            |                                                 | 10                                              |
| 576 to 607             | 18               |            |                                                 | 11                                              |
| 608 to 639             | 19               |            |                                                 | 12                                              |
| 640 to 671             | 20               |            |                                                 | 13 2nd                                          |
| 672 to 703             | 21               |            |                                                 | 14 Fast                                         |
| 704 to 735             | 22               |            |                                                 | 15 I/O                                          |
| 736 to 767             | 23               |            |                                                 | 16 Subrack                                      |
| 768 to 799             | 24               |            |                                                 | 17                                              |
| 800 to 831             | 25               |            |                                                 | 18                                              |
| 832 to 863             | 26               |            |                                                 | 19                                              |
| 864 to 895             | 27               |            |                                                 | 20                                              |
| 896 to 927             | 28               |            |                                                 |                                                 |
| 928 to 959             | 29               |            |                                                 |                                                 |
| 960 to 991             | 30               |            |                                                 |                                                 |
| 992 to 1,023           | 31               |            |                                                 |                                                 |

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## 7. FAST I/O

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## 8.1 Introduction to IMAGEM

The IMAGEM Graphic Video system consists of a pair of modules - a Video output module and a Video processor module. One or more module pairs can be plugged into the central highway of a suitable GEM 80 Controller. The Graphic Video system accesses the controller's data tables both for data for display and for control information which determines the required display. The display is specified by user-defined formats which contain textual, numeric, presentation and control information.

Up to four formats can be displayed on each IMAGEM Video system. The formats themselves are stored in a battery-supported memory on the central highway, and are common to all IMAGEM Video systems in that subrack. The system is designed to be self-contained, and needs no support other than a standard GEM 80 programming unit (either a Portable Programmer or a System Programmer).

## 8.2 L-Data Table

The display is controlled by the content of the L-table (see Table 8.1). The controller writes data to the L-table to select the required display. Each video processor outputs one picture at a time and each picture can be divided into four formats. When displaying more than one format on the screen at the same time, they may overlap. When this occurs a format called by a higher L-table number overwrites any format called by a lower L-table number where it overlaps. Details which are outside the screen area can be included when programming the definition of a format. By using a WINDOW command, any particular rectangular area that has been defined can be selected to appear on the monitor screen. If the formats being displayed at any particular time do not fill the complete area of the screen, the unfilled area continues to display whatever was previously called up. This could, when first using the system, be part of the 'IMAGEM' default format. Formats are defined using the IMAGEM Display Language, which uses easily remembered English keywords. Apart from instructions affecting the presentation (e.g. sizes and colours), each format normally consists of text (including both letters and numbers) and graphic constructions.

## 8.3 Connecting Video Monitors

Figure 8.1 shows an example of connections to IMAGEM. The termination panel shown has four outputs, three outputs to drive a colour monitor (RGB) and a composite sync. output which must be used to ensure correct synchronisation of colour monitors or colour printers. When 'daisy-chaining' monitors, make sure that the 75ohm high impedance input switches on each monitor are correctly set. Set the last monitor switches to 75ohm and all previous monitors in the chain to high impedance. Further details are available in Application Data on Video Monitors, Publication No.T493 and Product Data on Imagem, Publication No.T524.

Also included in T493 are details on recommended co-axial cables and connectors. Reference should also be made to Appendix C of this manual for co-axial assembly instructions.

If a monochrome monitor is to be connected, the IMAGEM program must be written to display various shades of the chosen colour (either RED, GREEN or BLUE). The monitor is then connected to the relevant connector on the termination panel and to the composite sync. output.

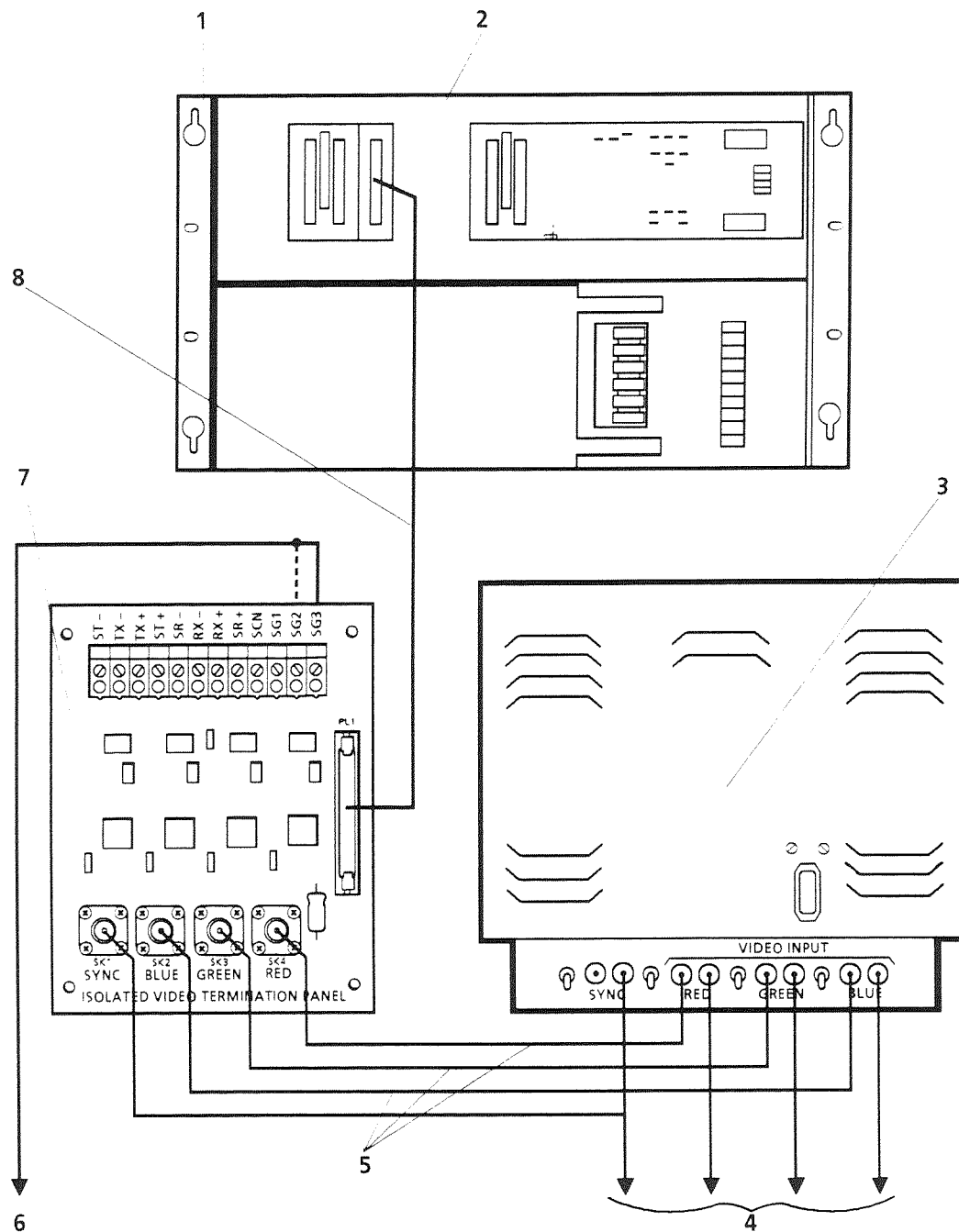
## 8.4 IMAGEM Compatibility

GEM 80/310 series controllers accommodate the IMAGEM graphic video only and NOT character-based video systems.

Further details of IMAGEM programming and other information on the video is available in either the Product Data Sheets or the IMAGEM Programming Manual.

Table 8.1 - L-table

| Location             | Function                                                                                         |
|----------------------|--------------------------------------------------------------------------------------------------|
| L0 to 3              | IMAGEM 0 display formats<br>L0 = format 1<br>L1 = format 2<br>L2 = format 3<br>L3 = format 4     |
| L4 to 7              | IMAGEM 1 display formats<br>L4 = format 1<br>L5 = format 2<br>L6 = format 3<br>L7 = format 4     |
| L8 to 11             | IMAGEM 2 display formats<br>L8 = format 1<br>L9 = format 2<br>L10 = format 3<br>L11 = format 4   |
| L12 to 15            | IMAGEM 3 display formats<br>L12 = format 1<br>L13 = format 2<br>L14 = format 3<br>L15 = format 4 |
| L16                  | Screen update counter for IMAGEM 0                                                               |
| L20                  | Screen update counter for IMAGEM 1                                                               |
| L24                  | Screen update counter for IMAGEM 2                                                               |
| L28                  | Screen update counter for IMAGEM 3                                                               |
| Remainder of L-table | Used to transfer data from IMAGEM to ladder processor                                            |



1. GEM 80/311 Controller
2. Video Processor (IMAGEM)
3. Video Display Monitor (Colour)
4. To other colour displays and colour printers
5. Low loss 75 ohm coaxial cable
6. Signal Ground Connection
7. Video Termination Panel
8. Ribbon Cable

Figure 8.1 Connections to IMAGEM

### 9.1 Introduction

The Controller includes automatic self-tests. For more details, refer to the Self-Test Information Leaflet, Publication No.T424. There are two types of test:

- those performed when the controller is initially powered up, and
- those performed continuously while the controller is running.

Diagnostic information obtained from these tests is stored in an area of memory known as the F-table, and diagnostic messages are sent to the programmer screen when connected to an I/O processor.

The controller includes two built-in relays called Watchdog relays. These relays have their Normally Open (NO) contacts connected in series.

- When the system is running normally and in a healthy condition, the content of table location F1 is zero. The Watchdog relays are energized, and their normally-open contacts are closed.
- When the system is tripped, either by the user program or by the self-test finding a fault, the content of table location F1 is generally non-zero. The Watchdog relays de-energize, their normally-open contacts open, and the controller halts.

The self-testing includes both hardware circuits and firmware routines, so that failures of microprocessor devices can be found rapidly. This allows the controller to be tripped immediately before it can make any serious errors. If a microprocessor has gone down, it may not be possible to get any diagnostic information sent to the Programmer.

The Watchdog relays also de-energize whenever you halt the controller.

The controller can be tripped and the watchdog relays de-energised by writing a non-zero value to table location F1 from your program.

### 9.2 Safety and the User Program

The program can be arranged to take particular courses of action when certain error conditions arise, but these only work while the controller is up and running correctly. For those exceptional conditions where it malfunctions, the controller does not necessarily respond to the instructions contained in the program.

Therefore, safety circuits MUST:

- be hard-wired;
- operate independently of the Controller.

### 9.3 Power Up Conditions

When the Controller is first powered up, its output equipment can give spurious outputs until the Watchdog relays have pulled in. During this time, the controller performs its start-up checks, and the state of the outputs cannot be guaranteed.

Therefore, the outputs must be suppressed until after the Watchdog relays have pulled in. There are two ways in which this can be done:

1. Some types of output module include an output enable circuit which suppresses the outputs until a signal is applied to the I/O subrack. Therefore it can be arranged to apply the enable signal through a contact of a watchdog follower relay.
2. Other types of output module do not include this enable circuit, and so the plant-side power must not be applied until after the watchdog has pulled in. Therefore the plant-side power must be arranged to be applied through a contact of a watchdog follower relay.

Method (1) allows several outputs of different voltage levels to be suppressed with a single contact. On the other hand, the electronic circuitry on each module is relied on to be working correctly. Therefore, for ultimate safety, where outputs operate moving machinery or otherwise provide a personnel hazard, Method (2) should be used, even though it involves several contacts, one for each plant-side power voltage.

### 9.4 Power Loss, Emergency Stops, Push-buttons and Moving Machinery

In the event of a power cut to the the controller, it shuts down in a controlled fashion, and re-starts automatically when power is restored. If moving machinery must not start moving again without intervention by the operator, the plant-side power supply must not be re-applied until an external relay circuit has been operated.

Where moving machinery must be stopped if the controller malfunctions, brakes and braking circuits must be hard-wired.

While normal start/stop push-buttons can be wired via the I/O, emergency stop push-buttons must be hard-wired. Use a chain of normally closed push-buttons of the stop lock-off type for emergency stop circuits. Mount them locally near moving equipment, so that any maintenance person can have confidence that, if the local button has been pushed down, no-one can start the equipment again until the local button has been re-set.

## 9. WATCHDOG AND SAFETY CIRCUITS

### 9.5 Typical Watchdog Circuits

Figure 9.1 shows a typical watchdog safety circuit. The input equipment is energized when the plant-side power supply is on. However, the output equipment is only energized when the watchdog follower relay is energized and the plant-side power supply is applied. Other interlocks, such as emergency stop push-buttons, can be connected in this circuit as required in series with the Watchdog contacts. A single emergency stop push-button is shown but in practice there could be several in series.

### 9.6 Watchdog Contact Ratings

Circuit

Two series connected volt-free contacts are provided.

Rating

a.c. 200VA 1A 250V make/break

d.c. 100W 1A 250V make/break

Operation

Closed when the host controller is healthy and its status is running with normal inputs. Held closed during user program on-line re-compilation.

### 9.7 Watchdog Connections

Figures 11.2, and 11.3 show the location of the watchdog terminals.

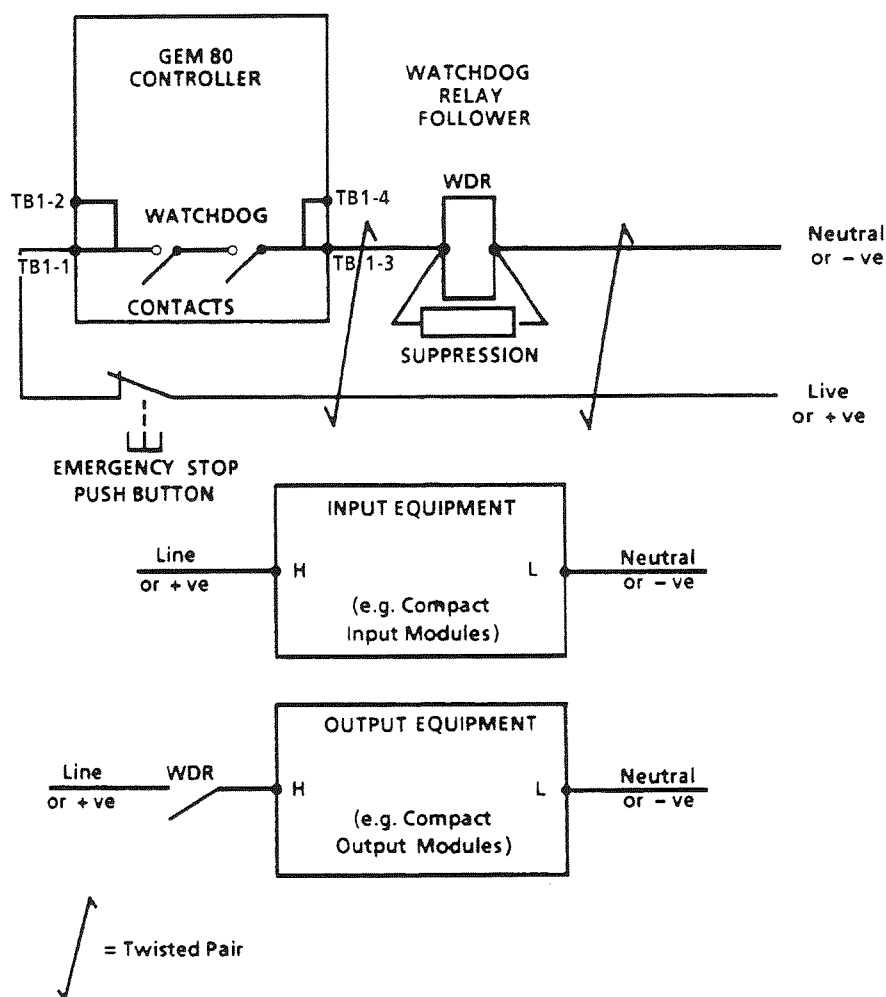


Figure 9.1 - Typical Watchdog Circuit

## 10.1 Introduction

This section contains brief details of GEM 80 Ladder Diagram Programming. The subject is dealt with in detail in the GEM 80 Programming Manual.

### 10.1.1 Ladder Diagram Language

The Controller User Program uses GEM 80 ladder diagram language which can be illustrated by a simple example.

The circuit for a relay, energized by a push-button, would be represented in GEM 80 Ladder Diagram Language as shown in Figure 10.1. A normally open push-button or contact is represented by -] [- symbol and a relay coil by -( )- symbol. A0.0 and B1.1 are data table addresses. A0.0 (bit 0 of 16-bit word A0) is an input data table and stores the state of I/O equipment connected to the controller relating to address A0.0 (as detailed in Section 5.3). B1.1 (bit 1 of 16-bit word B1) is an output data table and depending on the result of executing the user program B1.1, is set to 1 or 0 and the I/O equipment connected to the controller relating to B1.1 (as detailed in section 5.3) is controlled by this signal.

This very simple example shows the basic idea of the ladder diagram language. The instruction set is very large and while it is easy to understand and program in GEM 80 ladder diagram language, the language is also very powerful. It offers considerable advantages in simplicity, reliability, flexibility and power over relay and integrated circuit logic systems for industrial applications.

Figure 10.2 shows two rungs of a ladder diagram program. Each rung is composed of elements and up to 10 series elements are allowed in each rung. Figure 10.2 also shows that a rung can have several branches. Each rung may have up to 5 parallel branches and up to 20 loops (branch open/branch closed).

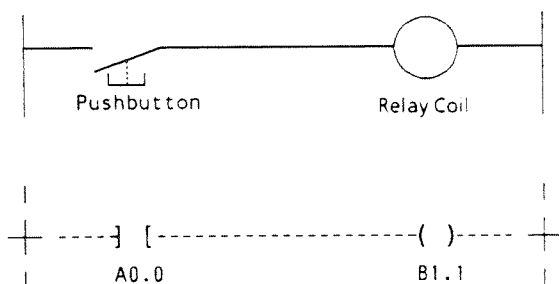


Figure 10.1 - Ladder Diagram Language

### 10.1.2 The Instruction Set

The comprehensive instruction set includes standard GEM 80 instructions and 'Special Functions'.

They fall into the following categories :-

- (1) Relay Replacement Functions
- (2) Logic Functions
- (3) Maths. Functions(Integer and Floating Point)
- (4) Signal Processing
- (5) Closed Loop Control
- (6) Binary Tests
- (7) Binary Manipulation
- (8) Numerical Tests
- (9) Numerical Manipulation
- (10) Block Instructions
- (11) Data Moving Instructions
- (12) Code Conversion
- (13) Serial Port Alphanumeric Input and Output
- (14) Output Functions
- (15) Off-line Data Manipulation
- (16) STARNET Special Functions

Table 10.1 details the instruction set

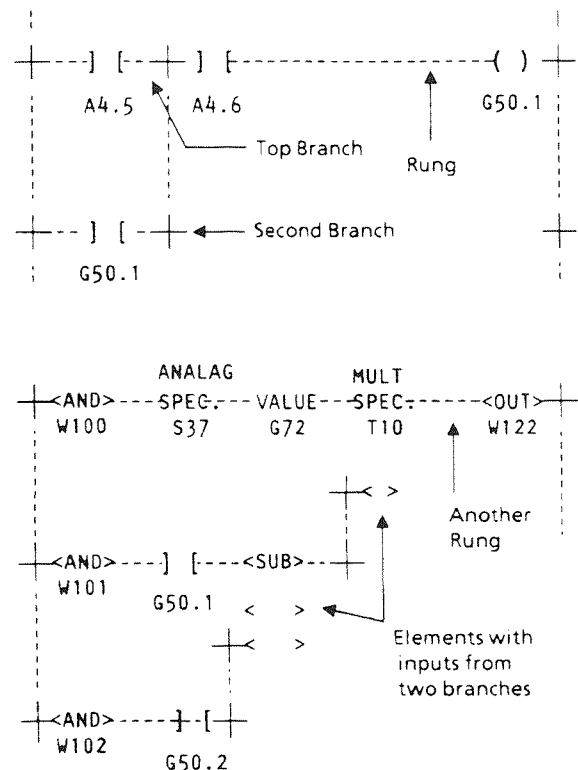


Figure 10.2 - Two Rungs of Ladder Diagram Language

## 10. USER PROGRAM

Table 10.1 - Instruction Set

| Function                       |                             | Instruction | Special Function | Remarks                                               | Number of Instructions | Number of Table Locations used by VALUE | Execution Time in microseconds |
|--------------------------------|-----------------------------|-------------|------------------|-------------------------------------------------------|------------------------|-----------------------------------------|--------------------------------|
| 1. Relay replacement functions | N/O contact                 | ---) [---   | -                | Functions as a normally open relay contact            | 1                      |                                         | 5                              |
|                                | N/C contact                 | ---)/[---   | -                | Functions as a normally closed relay contact          | 1                      |                                         | 5                              |
|                                | Coil                        | ---( )---   | -                | Functions as a relay coil                             | 1                      |                                         | 5                              |
|                                | Time Delay                  | DELAY       | -                | Time range 100ms to 54 minutes                        | 1                      |                                         | 5                              |
|                                | Counter                     | COUNT       | -                | capacity 32,767 (re-settable)                         | 1                      |                                         | 5                              |
|                                | Sequencer                   | SEQR        | -                | 16-step sequencer with reset                          | 1                      |                                         | 5                              |
| 2. Logic functions             | Logic AND                   | AND         | -                | bit-by-bit ANDing of 2 x 16-bit words                 | 1                      | -                                       | 5                              |
|                                | Logic AND group of words    | ANDGRP      | T24              | bit-by-bit ANDing of 2 groups of 16-bit words         | 2                      | 3                                       | See note 10                    |
|                                | Logic OR                    | OR          | -                | bit-by-bit ORing of 2 x 16-bit words                  | 1                      | -                                       | 5                              |
|                                | Logic OR group of words     | ORGRP       | T25              | bit-by-bit ORing of 2 groups of 16-bit words          | 2                      | 3                                       | See note 10                    |
|                                | Logic exclusive OR          | XOR         | -                | bit-by-bit XORing of 2 x 16-bit words                 | 1                      | -                                       | 5                              |
|                                | Exclusive OR group of words | XORGRP      | T26              | bit-by-bit XORing of 2 groups of 16-bit words         | 2                      | 3                                       | See note 10                    |
|                                | Sequence Diagnostics        | SEQDIAG     | T19              | Enable automatic monitoring of any sequence of events | 2                      | 11 + N (See also note 26)               | 5                              |
| 3. Maths functions             | Addition                    | ADD         | -                | Floating Point and Integer Arithmetic                 | 1                      | -                                       | 5                              |
|                                | Array addition              | ADDARRAY    | T12              | Limits +32,767 to -32,768                             | 2                      | 3                                       | See note 5                     |
|                                | Subtraction                 | SUB         | -                | Floating Point and Integer Arithmetic                 | 1                      | -                                       | 5                              |
|                                | Array subtraction           | SUBARRAY    | T13              | Limits +32,767 to -32,768                             | 2                      | 3                                       | See note 5                     |
|                                | Multiply                    | MULT        | T10              | Floating Point and Integer Arithmetic                 | 1                      | -                                       | 30                             |
|                                | Array multiplication        | MULARAY     | T14              | Integer multiplication Limits +32,767 to -32,768      | 2                      | 3                                       | See note 6                     |
|                                | Division                    | DIV         | T11              | Floating Point and Integer Arithmetic                 | 2                      | 1                                       | 48                             |
|                                | Array division              | DIVARRAY    | T15              | Integer division Limits +32,767 to -32,768            | 2                      | 4                                       | See note 6                     |
|                                | Linear Conversion           | LINCON      | S11              | Provides arithmetic calculations                      | 2                      | 4 (See also note 12)                    | 130                            |

Table 10.1 continued

| Function                  |                           | Instruction | Special Function | Remarks                                                                               | Number of Instructions | Number of Table Locations used by VALUE | Execution Time in microseconds |
|---------------------------|---------------------------|-------------|------------------|---------------------------------------------------------------------------------------|------------------------|-----------------------------------------|--------------------------------|
| Maths functions continued | Array Linear Conversion   | CONARAY     | S10              | Provides multiplication, division and addition calculations for two arrays of data    | 2                      | 3 + 3N (See also note 13)               | See note 1                     |
|                           | Square Root               | SQRT        | S12              | Limits +32,767 to -32,768                                                             | 2                      | 1                                       | 225                            |
|                           | Checksum                  | CHKSUM      | T9               | Calculates the checksum of Data Table contents                                        | 2                      | 1                                       |                                |
|                           | Standard Deviation        | STDDEV      | T18              | Calculate mean and standard deviation of a number of values                           | 2                      | 11                                      |                                |
|                           | Sine                      | SIN         | S70              | Provides the sine of an angle (Floating Point)FP.                                     | 1                      |                                         | 200 See Note 26.               |
|                           | Cosine                    | COSINE      | S71              | Provides the cosine of an angle FP.                                                   | 1                      |                                         | 200 See Note 26.               |
|                           | Tangent                   | TANGENT     | S72              | Provides the tangent of an angle. FP.                                                 | 1                      |                                         | 200 See Note 26.               |
|                           | Arcsine                   | ASIN        | S80              | Provides the angle of a sine function. FP.                                            | 1                      |                                         | 300 See Note 26.               |
|                           | Arcosine                  | ACOS        | S81              | Provides the angle of a cosine function. FP.                                          | 1                      |                                         | 300 See Note 26.               |
|                           | Arctangent                | ARCTAN      | S82              | Provides the angle of a tangent function. FP.                                         | 1                      |                                         | 300 See Note 26.               |
|                           | Degrees to radians        | DEGRAD      | S75              | Converts degrees to radians. FP.                                                      | 1                      |                                         | 15 See Note 26.                |
|                           | Radians to degrees        | RADDEG      | S85              | Converts radians to degrees. FP.                                                      | 1                      |                                         | 15 See Note 26.                |
|                           | Log to the base 10        | LOG10       | S73              | Provides the logarithm to base 10 of a value. FP.                                     | 1                      |                                         | 100 See Note 26.               |
|                           | Log to the base e         | LOGE        | S74              | Provides the logarithm to base e of a value. FP.                                      | 1                      |                                         | 100 See Note 26.               |
|                           | Pi                        | PI          | S77              | Provides 'PI' in FP.                                                                  | 2                      |                                         | 4 See Note 26.                 |
|                           | Exponential               | EXP         | S84              | Raises 'e' to a specified power. FP.                                                  | 2                      |                                         | 140 See Note 26.               |
|                           | Power                     | POWER       | T70              | Raises a value to a specified power. FP.                                              | 1                      |                                         | 140 See Note 26.               |
|                           | Floating Point Scale      | FSCALE      | T73              | Multiplies a value to a specified power of 10. FP.                                    | 1                      |                                         | 50 See Note 26.                |
| 4. Signal Processing      | Debounce Input Signal     | DBOUNCE     | S0               | Provides signal conditioning to logic signals prone to spurious or transient problems | 2                      | 5 (See also note 12)                    | 92                             |
|                           | Function Generator        | FGEN        | S30              | Four quadrant operation                                                               | 2                      | 4 + N (See also note 13)                | 380                            |
|                           | Dead Band                 | DEDBAND     | S31              | Includes offset                                                                       | 2                      | 3 (See also note 12)                    | 55                             |
|                           | Limiter                   | LIMIT       | S32              | High and low limits                                                                   | 2                      | 3 (See also note 12)                    | 85                             |
|                           | Ramp Generator            | RAMP        | S33              | Comprehensive Ramp generator (includes rounding)                                      | 2                      | 15 (See also note 12)                   | 3600                           |
|                           | First Order Time Constant | ANALAG      | S37              | Smooths fluctuating numerical values                                                  | 2                      | 5 (See also note 12)                    | 214                            |

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Table 10.1 continued

| Function                    | Instruction                    | Special Function | Remarks                                                                        | Number of Instructions | Number of Table Locations used by VALUE | Execution Time in microseconds |
|-----------------------------|--------------------------------|------------------|--------------------------------------------------------------------------------|------------------------|-----------------------------------------|--------------------------------|
| Signal Processing Continued | Time Constant                  | TCNST            | S60 Programmable time constant                                                 | 2                      |                                         |                                |
|                             | Ramp Generator                 | RAMPGEN          | S61 Ramp Signal time dependent                                                 | 2                      |                                         |                                |
| 5. Closed Loop Control      | Absolute 3 Term Controller     | PIDABS           | S34 Provides absolute proportional, integral and derivative control            | 2                      | 15 (See note 12)                        | 520                            |
|                             | Incremental 3 Term Controller  | PIDINC           | S35 Provides incremental proportional, integral and derivative control         | 2                      | 9 (See note 12)                         | 330                            |
|                             | Incremental Output PID Control | INCOUT           | S36                                                                            | 2                      | 5 (See note 12)                         | 225                            |
|                             | PID Control                    | PIDCON           | T60 PID Control with mode select                                               | 2                      |                                         |                                |
|                             | Programmable PID Control       | PIDSIM           | T61 Programmable PID control                                                   | 2                      |                                         |                                |
| 6. Binary Tests             | High State                     | HISTATE          | S3 Reports bit number of highest bit of 16-bit word set on (1)                 | 1                      | -                                       | 42                             |
|                             | Bits ON                        | BITSON           | S26 Reports number of bits set on (1) in a group of 16-bit words               | 2                      | 2                                       | See note 3                     |
|                             | Compare Group                  | CMPGRP           | T21 Compares two groups of 16 bits and reports details of the first difference | 2                      | 3                                       | See note 8                     |
|                             | Get Bit                        | GETBIT           | T22 Performs a test of on state individual bits in group of words              | 2                      | 2                                       | 150                            |
| 7. Binary Manipulation      | Swap 1/2 Locations             | SWAP             | S4 Swap 1/2 locations                                                          | 1                      | -                                       | 1                              |
|                             | Invert                         | INVERT           | - Inverts each bit of 16-bit word                                              | 1                      | -                                       | -                              |
|                             | Invert Group                   | INVGRP           | S25 Inverts each bit of a group of 16-bit words                                | 2                      | 3                                       | See note 2                     |
|                             | Shift                          | SHIFT            | S27 Left and right shift on a group of 16-bit words                            | 2                      | 3                                       | See note 4                     |
|                             | Rotate                         | ROTATE           | S28 Left and right rotation on a group of 16-bit words                         | 2                      | 3                                       | See note 4                     |
|                             | Put Bit                        | PUTBIT           | T23 Allows setting and re-setting of individual bits in groups of words        | 2                      | 3                                       | See note 9                     |
|                             | Shift Bits in Word             | QSHIFT           | T27 Shifts bits of word left or right                                          | 1                      | 0                                       | 22                             |
|                             | Rotate Bits in Word            | QROTATE          | T28 Rotates bits of word left or right                                         | 1                      | 0                                       | 22                             |

Table 10.1 continued

| Function                     |                                   | Instruction              | Special Function          | Remarks                                                                                                            | Number of Instructions          | Number of Table Locations used by VALUE | Execution Time in microseconds |
|------------------------------|-----------------------------------|--------------------------|---------------------------|--------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------------------------------------|--------------------------------|
| 8. Numerical Tests           | Compare                           | COMPARE                  | T0                        | These special functions                                                                                            | 2                               | 1                                       | 52                             |
|                              | Comparison                        | EQ                       | T1                        | report if:<br>(a) X = Y                                                                                            | 1                               | 0                                       | 7                              |
|                              |                                   | NE                       | T2                        | (b) X not equal to Y                                                                                               | 1                               | 0                                       | 7                              |
|                              |                                   | GT                       | T3                        | (c) X greater than Y                                                                                               | 1                               | 0                                       | 7                              |
|                              |                                   | LT                       | T4                        | (d) X less than Y                                                                                                  | 1                               | 0                                       | 7                              |
|                              |                                   | GE                       | T5                        | (e) X greater than/ = Y                                                                                            | 1                               | 0                                       | 7                              |
|                              |                                   | LE                       | T6                        | (f) X less than/ = Y                                                                                               | 1                               | 0                                       | 7                              |
|                              | Select Maximum in Array           | MAXARRAY                 | S13                       | Maximum value in array                                                                                             | 2                               | 3                                       | See note 17                    |
|                              | Select Minimum in Array           | MINARRAY                 | S14                       | Minimum value in array                                                                                             | 2                               | 3                                       | See note 17                    |
|                              | Select Maximum                    | MAX                      | T7                        | Maximum of two inputs                                                                                              | 1                               | 0                                       | 85                             |
|                              | Select Minimum                    | MIN                      | T8                        | Minimum of two inputs                                                                                              | 1                               | 0                                       | 85                             |
|                              | Compare Array                     | CMPARRAY                 | T16                       | Array comparison                                                                                                   | 2                               | 4                                       | See note 18                    |
| Delay Array                  | DELARRAY                          | S15                      | Multiple delay array      |                                                                                                                    |                                 |                                         |                                |
| Array Sort                   | SORT                              | S16                      | Data array numerical sort |                                                                                                                    |                                 |                                         |                                |
| 9. Numerical Manipulation    | Negate                            | NEGATE                   | S5                        | Changes the sign of a number.                                                                                      | 1                               | 0                                       | 4                              |
|                              | Absolute                          | ABS                      | S6                        | Makes a number positive.                                                                                           | 1                               | 0                                       | 5                              |
|                              | Non-zero                          | NONZERO                  | S7                        | Outputs all 16 bits if input is non-zero                                                                           | 1                               | 0                                       | 8                              |
|                              | Floating Point Conversion         | FPOINT                   | S76                       | Floating Point to integer                                                                                          |                                 |                                         |                                |
|                              | Error Flag                        | FPFLAGS                  | S78                       | Floating Point maths error                                                                                         | 1                               |                                         |                                |
|                              | Integer Conversion                | FIX                      | S79                       | Floating Point to multiple integer                                                                                 | 2                               |                                         |                                |
|                              | 10. Block Instructions            | Enclose                  | START OF                  | -                                                                                                                  | Conditionally executed block of | 1                                       |                                |
| conditionally executed rungs |                                   | BLOCK<br>END OF<br>BLOCK | -                         | ladder diagram instructions can be nested to a depth of 16                                                         | 1                               |                                         |                                |
| 11. Data Moving              | Locate Data Table Address         | LOCATE                   | S20                       | These two special functions are usually used together for moving groups of data from one area of memory to another | 2                               | 1                                       | 132                            |
|                              | Move Data Between Table Addresses | MOVE                     | T20                       |                                                                                                                    | 2                               | 0 or 1                                  | See note 7                     |
|                              | Cyclic Store                      | STORE                    | T30                       | First in first out store                                                                                           | 2                               | 4 + N                                   | See note 270                   |
|                              | Get Word                          | GETWORD                  | S19                       | Indirect data access                                                                                               | 2                               | 1                                       | 65                             |
|                              | Fill Array                        | FILL                     | T17                       | Array set up                                                                                                       | 2                               | 0 or 1                                  | See note 19                    |
|                              | Put Word                          | PUTWORD                  | T29                       | Indirect output                                                                                                    | 2                               | 1                                       | 70                             |
|                              | Collate                           | COLLATE                  | T37                       | Collates random bits or words into a group of adjacent data table locations                                        | 1                               | 0                                       |                                |

## 10. USER PROGRAM

Table 10.1 continued

| Function                                      |                             | Instruction | Special Function | Remarks                                                                        | Number of Instructions | Number of Table Locations used by VALUE | Execution Time in microseconds |
|-----------------------------------------------|-----------------------------|-------------|------------------|--------------------------------------------------------------------------------|------------------------|-----------------------------------------|--------------------------------|
| 12. Code Conversion                           | B.C.D. input conversion     | BCDIN       | S1               | Converts up to 4 decades of binary.                                            | 1                      | 0                                       | 89                             |
|                                               | B.C.D. output conversion    | BCDOUT      | S2               | Converts binary to up to 4 decades of binary codeddecimal                      | 1                      | 0                                       | 66                             |
|                                               | Convert Gray Code to Binary | GRAYBIN     | S9               | Converts gray code input                                                       | 2                      | 1                                       |                                |
| 13. Serial Port Alphanumeric Input and Output | Print Text                  | PRITEXT     | S38              | Enables messages stored in controller memory to be output to serial port       | 2                      | (C + 1)/2 See note 14                   | 360                            |
|                                               | Print                       | PRINT       | T38              | Enables user definable messages to be output on a serial port                  | 2                      | N See note 16                           | See note 11                    |
|                                               | Character Input             | CHARIN      | T39              | Enables characters input on the serial ports to be stored in controller memory | 2                      | (C + 1)/2 See note 14                   | 315                            |
|                                               | Message Store               | GETTEXT     | S21              | Store message strings                                                          | 2                      |                                         |                                |
| 14. Output Functions                          | Output                      | OUT         | -                | Outputs 16-bit word to a specified data table location                         | 1                      |                                         | 5                              |
|                                               | Output                      | OUTPUT      | S8               | Intermediate output from rung                                                  | 2                      | 1                                       | 6                              |
| 15. Off-line Data Manipulation                | Clear Off-line Data         | CLEAR       | S29              | Re-set off-line data                                                           | 2                      | 0 or 1                                  | See note 24                    |
|                                               | Put Off-line Data           | PUT         | T31              | Off-line data storage                                                          | 2                      | 2                                       | See note 25                    |
|                                               | Get Off-line Data           | GET         | T32              | Off-line data retrieval                                                        | 2                      | 2                                       | See note 25                    |
| 16. STARNET Special Functions                 | Configure STARNET           | CONFIG      | T33              | STARNET set-up                                                                 | 2                      | 1                                       | See note 21                    |
|                                               | STARNET Send Data           | SEND        | T34              | Transmit outgoing data                                                         | 2                      | 2                                       | See note 22                    |
|                                               | STARNET Reception           | RECEIVE     | T35              | Receive incoming data                                                          | 2                      | 3                                       | See note 23                    |
|                                               | STARNET Statistics          | STATS       | T36              | Report STARNET errors and statistics                                           | 2                      | 1                                       | 2600                           |

## Notes on Table 10.1

1.  $247 + (166 \times \text{Qty of locations})$
2.  $214 + (9 \times \text{Qty of locations})$
3. Simple operation : 113 Group operation :  $128 + (74 \times \text{Qty of locations})$
4.  $186 + (30 \times \text{Qty of locations})$
5.  $355 + (32 \times \text{Qty of locations})$
6.  $390 + (42 \times \text{Qty of locations})$
7.  $220 + (3 \times \text{Qty of locations})$
8.  $250 + (24 \times \text{Qty of locations})$
9. Simple operation : 60  
Group operation : 160
10.  $312 + (19 \times \text{Qty of locations})$
11.  $(8 \times \text{Message number}) + 1400$  for pure text OR  
1600 to 2400 for mixture of text and numbers
12. Typically uses stated number of locations in both  
preset and working tables
13. N = number of tabulated points or array length
14.  $(\text{message length} + 1)/2$
15.  $4 + \text{store length}$
16. N = quantity of numbers to be output
17.  $151 + (15 \times \text{Qty. of locations})$
18. Constant  
:  $138 + (13 \times \text{Qty. of locations})$  2 Arrays  
:  $302 + (16 \times \text{Qty. of locations})$
19.  $85 + (2 \times \text{Qty. of locations})$
20. Reset Mode : less than 1,000  
Acquire Mode : 2,000  
Calculate : 6,000
21.  $11,800 + 1,200$  per channel
22.  $1,400 + 1,600$  per block of 111 words +  $(7 \times \text{Qty. of locations})$
23.  $1,800 + 1,100$  per block of 111 words +  $(7 \times \text{Qty. of locations})$
24.  $445 + ((6 + \text{no. of words in file}) \times (\text{no. of files to be cleared}) \times 2)$
25.  $515 + (3.7 \times \text{Qty of locations})$   
and  $20 + (5 \times \text{file size of checksum protection configured})$
26.  $N = 2 \times \text{Number of transitions}$

## 10.1.3 Instruction Capacity and Memory Allocation

The instruction capacity depends on the memory size. Table 10.2 shows the approximate capacity for each memory size with 10,000 and 20,000 data tables.

Table 10.2 Instruction Capacity

| Capacity                                                                       | Nominal Controller Memory Size |        |        |              |
|--------------------------------------------------------------------------------|--------------------------------|--------|--------|--------------|
|                                                                                | 192K                           | 256K   | 384K   | 512K         |
| Number of instructions (with 10,000 data tables)                               | 5,400                          | 11,000 | 26,500 | 37,000       |
| Number of instructions (with 20,000 data tables)                               | 5,000                          | 6,000  | 22,000 | 37,000       |
| Number of bytes available in source code for both data tables and instructions | not relevant                   | 64K    | 128K   | not relevant |

Each program instruction occupies four bytes of memory as source code and an average of six bytes of memory as compiled code. Each data table occupies two bytes of source memory.

If the number of data tables is known, the approximate program capacity is the lower of:

(1) The maximum number of instructions based on compiled code size (see Table 10.2)

and

(2) Maximum number of instructions based on source code size.

$$\text{Equals } B_n - (2 \times D_n) / 4$$

where:

$B_n$  = number of bytes available for data tables and instructions.

$D_n$  = number of data table locations.

These limits may be exceeded with programs using a particular mix of instructions. This cannot be guaranteed in advance.

The memory allocation is shown in Table 10.3

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Table 10.3 Memory Allocation

| Allocation                 | Content                                                                                                          | Nominal controller memory size |        |        |        |
|----------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------|--------|--------|--------|
|                            |                                                                                                                  | 192K                           | 256K   | 384K   | 512K   |
| Standard Memory            | Source code + data tables                                                                                        | 64K                            | 64K    | 64K    | 64K    |
|                            | Extension space for source code                                                                                  | --                             | --     | 64K    | 128K   |
|                            | Compiled code                                                                                                    | 32K                            | 96K    | 160K   | 224K   |
|                            | Video formats                                                                                                    | 32K                            | 32K    | 32K    | 32K    |
|                            | Mailbox                                                                                                          | 64K                            | 64K    | 64K    | 64K    |
| Optional Additional Memory | Optional Additional Video formats                                                                                | 512K                           | 512K   | 512K   | 512K   |
|                            | Optional additional Off-line storage<br>(where off-line storage is used, at least<br>64K of memory is required.) | 1024K                          | 1024K  | 1024K  | 1024K  |
| Maximum totals             |                                                                                                                  | 1,728K                         | 1,792K | 1,920K | 2,048K |

## 10.2 The Programmer

### 10.2.1 Programmer Units

To obtain the correct display of diagnostic messages and to use the on-line program change facility, the user needs an 8922, 8940 or 9022 system programmer, an IBM compatible PC with an emulator package or an 8920 portable programmer, version 4.5 software (or later). Further, without programmers of the above types, the user is not able to enter the general edit mode of messages for printers, VDUs or other display devices.

Users who already own 8920 portable programmers but with software versions earlier than 4.5 are therefore recommended to have their units updated to the latest software version.

**Note...** If used for remote programming, the system programmers can operate on a multi-drop serial link connected to several controllers and at a user selected signalling rate. However, the 8920 portable programmer can only operate on a point-to-point link operating at 9,600 bits/s, and can therefore only be connected to one controller at any one time. The user should check on the signalling rate that is satisfactory for the given distance between the controller and programmer.

See the Serial Communications Manual, Publication No.T457. If the required distance is too great, a lower signalling rate than 9,600 bits/s may be necessary, in which case the 8920 portable programmer may not be usable and a system programmer must be used.

### 10.2.2 Connecting the Programmer

Figure 10.3 shows a System Programmer connected to the controller. If program print-outs are not initially required, connection to a printer is not necessary. Programs can be stored on tape or disk and the programming facilities in the System Programmer itself may be sufficient to develop programs without connecting to the controller.

Figure 10.4 shows an 8920 Portable Programmer connected to the controller. The audio cassette recorder should be connected for program storage but the printer may not initially be necessary.

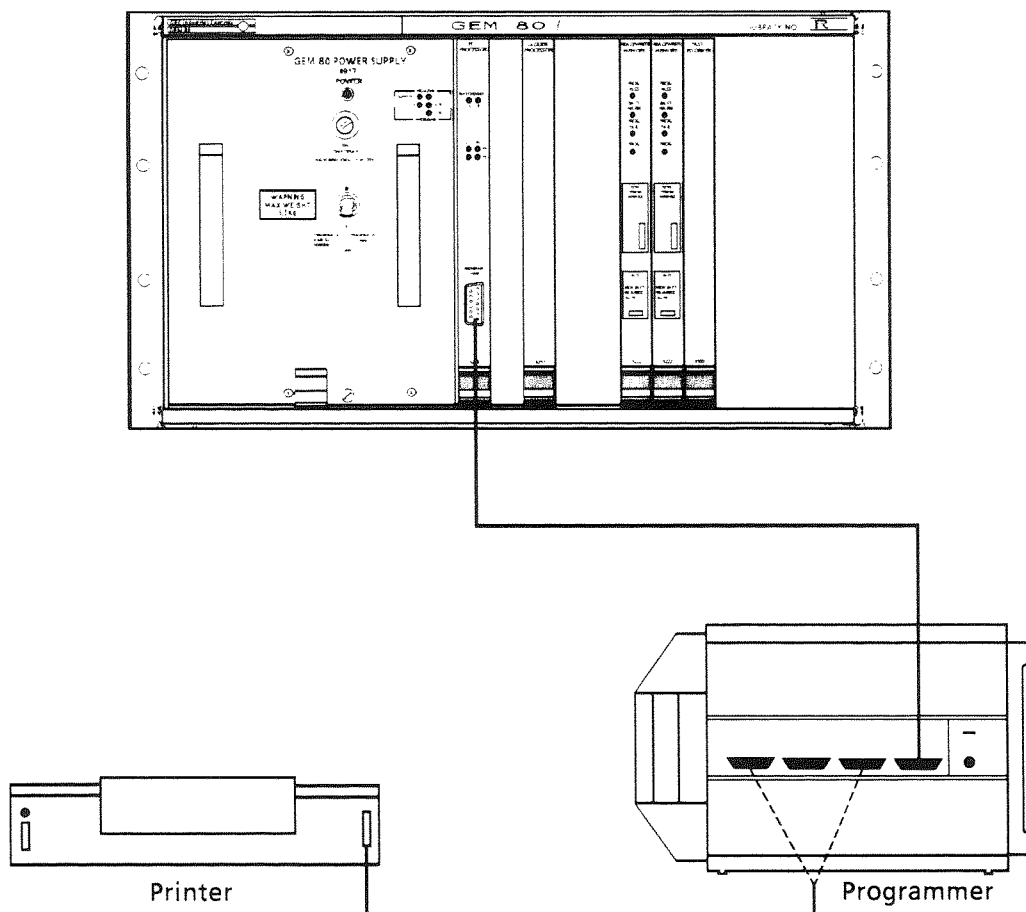
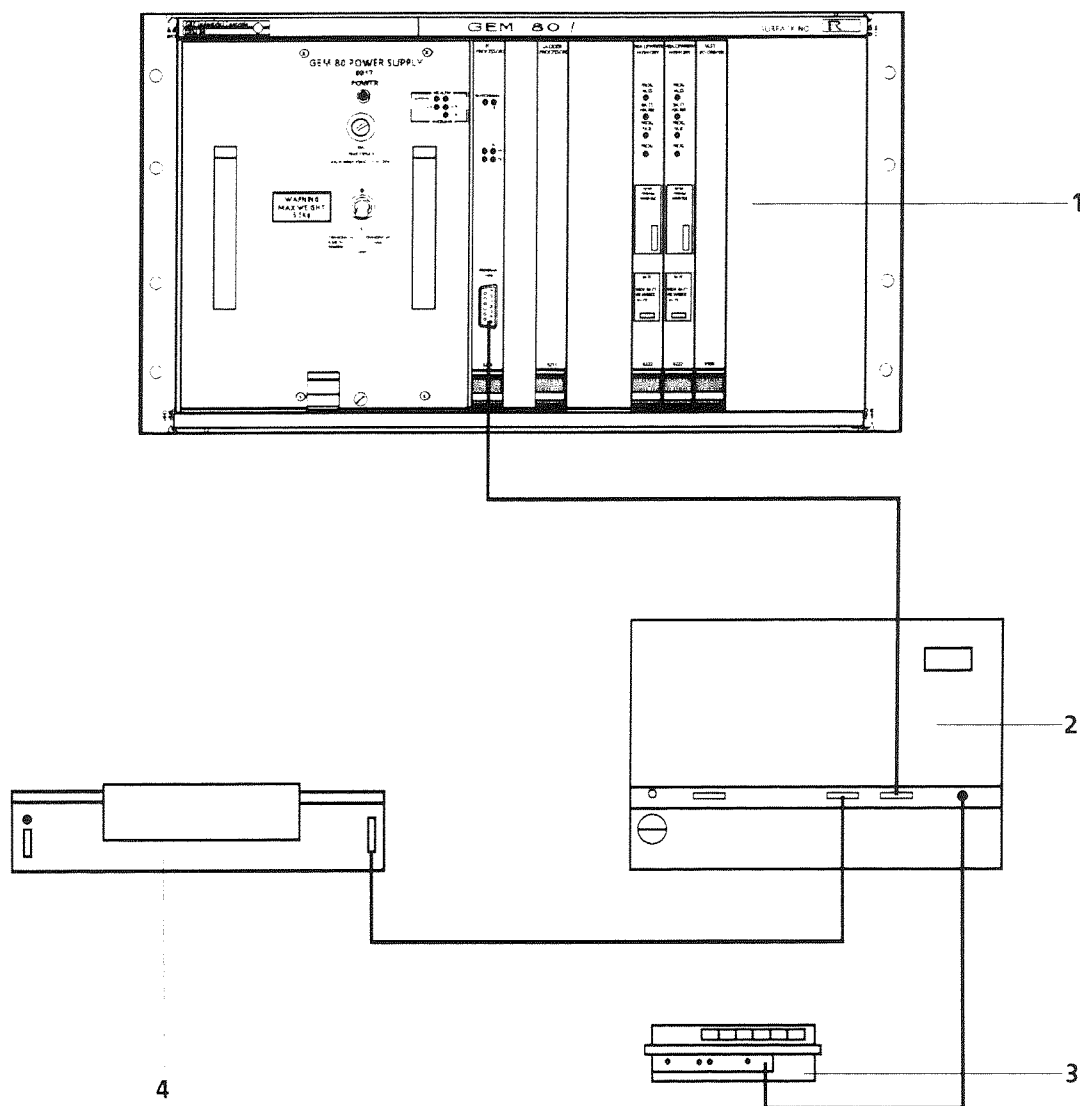


Figure 10.3 - Interconnections for System Programmer and Printer



1. GEM 80/311 Controller
2. Portable Programmer
3. Tape Recorder
4. Printer

Figure 10.4 -Interconnection for Portable Programmer, Printer and Tape Recorder

### 10.3 Programming the Controller

Details on how to program the controller and use of the Standard Instruction Set are contained in the GEM 80 Programming Manual, Publication No.T391.

### 10.4 Special Functions

#### 10.4.1 Introduction

Special Functions are pre-written software routines and are called up in the ladder diagram program using the 'SPEC' key. It is located at the top left-hand side of the keyboard.

The special functions are detailed in Table 10.1 and cover multiply, divide, function generator, closed loop controls, etc. All Special Functions are described in Software Data Sheets.

To call up a special function:

- (1) press the 'SPEC' key
- (2) write the special function number, e.g. T10. or write the special function mnemonic, e.g. MULT.

### 10.4.2 Read/Write Access to the Memory for Special Functions

All data tables are read/write accessible by pre-written software routines, apart from the following :-

- F0-F40 not accessible
- F41-F249 read only
- F250-F349 read/write
- F350-F541 read only

P-table and V-table are read only.

Any J-K-table corresponding to a port which is configured for printer operation is not accessible.

### 10.4.3 Array and Group Special Functions

Array and group special functions use addresses of data tables as inputs (in VALUE set up list). These must be obtained using the LOCATE Special Function in the program since the internal addresses move about when a program is re-compiled. Constants, which are derived by inspection of the output from LOCATE in a different program, should not be used. As a general rule LOCATE must be used every time an internal address is required.

### 10.4.4 Implied Addresses in Special Functions

Where addresses are implied, e.g. when using LOCATE and MOVE, the user must include a dummy rung or rungs to declare the highest address. See Section 10.8.2 for full details.

### 10.4.5 Use of Floating Point Special Functions

Integer or floating point numbers can be passed along a rung from one function to another. Integer to floating point conversion is performed automatically when required by outputting a result into an appropriate Q-table location. Floating point to integer conversion must be performed explicitly by the user using a Special Function otherwise a compilation error occurs.

Where a function can operate in integer or floating point form, if all inputs to the function are integer, the function performs an integer calculation and outputs an integer value. If any or all of the inputs are floating point, a floating point calculation is performed and the output is floating point.

Where a function references a table, reference to Q-table gives a floating point value. Other tables give an integer value.

## 10.5 Serial Communication Port

### 10.5.1 Alphanumeric Input

Alpha-numeric information can be input to the controller through any of the serial ports using Special Function T39, CHARIN. See the Software Data Sheets for further details.

### 10.5.2 Alphanumeric Output

Alphanumeric information can be output on any of the serial ports using Special Function S38, PRITEXT. General text and numeric output is provided by the Special Function T38, PRINT. See the Software Data Sheets for further details.

### 10.5.3 Editing Alphanumeric Output Messages

#### (a) Printer Port Messages

The items used by PRINT to generate output are called messages and may contain fixed text and format definitions for numeric output in any combination. The fixed text may also contain end-of-line markers so that one message can generate several lines of output. The messages are stored as part of the P-table and may be loaded and dumped with the User Program. They are protected from access by Special Functions and from being written to by the programming unit when in data list mode. If an attempt is made to write to the message area of the P-table, the messages are moved and the extra P-table created filled with zeros. The quantity of messages which can be stored in a system is restricted only by the memory occupied by data tables and the User Program. Remember however that data table P2 contains the length of the pre-set message area in bytes and is therefore limited to the maximum number which can be stored, i.e 32,767. Each message can contain up to 255 bytes, although this could define considerably more characters for output because a format definition only occupies 2 bytes.

The system is provided with an editor to enable the user to enter, examine, update and take a hard copy of the messages available to the user program. The editor is accessed using a programming unit connected to any tributary port. (This includes the front panel port). Where more than one programmer have been connected, a similar locking mechanism to that described in section 6 is implemented. The lock is released when the Exit command is executed.

Messages are entered in a manner which is intended to be similar to the way they are displayed when used by PRINT. Fixed text is enclosed by quotes ("); format definitions employ a pictorial representation where '^' (caret) is used to represent leading spaces, '0' is used to represent leading zeros and '#' is used to represent significant digits. End of line markers are entered by typing carriage-return and may be placed inside or outside quotes. A comma is used to separate format definitions from each other and from fixed text.

**Note...**On the 8920 Portable Programmer, the caret symbol (^) is obtained by pressing the upward arrow key.

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A format definition specifies how the contents of one data table will be formatted for output. Four quantities need to be specified; the field width, whether leading zeros are to be output, the number of characters after and including the decimal point, and the scaling as a power of ten. The first two quantities are limited to a maximum value of 15.

### Examples:

"This is a fixed text containing 2 end-of-line markers"

^ ^ ^ ^ # # . #      defines a field width of 7 with  
1 decimal place

^ ^ ^ ^ # . # #      as above but with 2 decimal  
places

000 # . # #      as above but with leading  
zeros

With appropriate scaling the second format above could display as '1.23' or '123.45' depending on the value in the data table; i.e. the field width is fixed, not the quantity of leading spaces. The same is true if leading zeros are specified.

### (b) Using the Editor

After loading a taped program containing messages, the program must be compiled before using the editor. The editor cannot be entered until this has been done.

Whenever the editor is ready to accept input it will output the ""greater than"" symbol ">" known as the prompt. Entry of input is terminated in one of two ways:

(a) By pressing the ESC key which aborts the current command;

(b) By pressing the ""less than"" symbol "<" known as the terminator.

The terminator is only recognized when not enclosed by quotes, i.e. not part of the fixed text. An editor command consists of:

a command identifier which tells the editor what to do,

an optional command body which supplies additional information to the editor and

a terminator which signals the editor to start processing the command.

The command identifier may be a single character or the entire command name, e.g. the exit command may be entered as E or EX or EXIT. The exit and help commands do not require a command body.

The command identifiers and their actions are as follows :-

### E

Stands for Exit. Terminates the editing session and causes the programming unit to return to initial selection.

### H

Stands for Help. Displays a list of the available commands on the programming unit screen.

### D,L

Stand for Display and List respectively. The actions of the commands are very similar. The command body is a list of messages whose contents are to be displayed. The structure of this input is a list of 'output requests' separated by commas. Each output request may contain a single message number or a range represented by two numbers separated by a dash (-). Zero length messages are not displayed. For example the following commands could be used to display messages 1, 2 and 3 :-

D1,2,3 or  
D1-2,3 or  
D1,2-3 or  
D1-3

The output of each message is prefixed with the message number and has the terminator appended. One blank line is output before any subsequent display. Output of a list of messages may be aborted by pressing the ESC key. The difference between D and L is that D produces output only on the programming unit screen while L produces a listing on the printer attached to the programming unit.

A format definition will be displayed as it was entered, except that the leading spaces, zeros and significant digits are displayed in a normalized form, with only one significant digit before the decimal point. For example, a format entered as ^ # # # . # # will be displayed as ^ # . # # .

### M

Stands for Message and is the command for adding new messages and replacing existing ones. The editor automatically repositions other messages if the size of an existing message is changed. The command body contains the message number to be updated followed by an equals symbol (=) followed by the new contents. This may consist of fixed text delimited by quotes and format definitions to describe how a data table value will be output. The different fields are separated by commas.

A format definition uses '0', '#', and '^' to pictorially describe the layout of the number in terms of character positions before and after the decimal point (if present). The caret (^) is used to signify leading spaces, a zero (0) is used to signify leading zeros and the hash symbol (#) significant digits. If a message contains format definitions, a subsequent prompt is issued to request the user to enter the scaling values to be applied to the data table contents. The scaling is entered as '/' or '\*' followed by a number which is a power of ten. The '/' indicates division and the '\*' multiplication. Each scaling value may be separated from the others by an optional comma.

End-of-line markers may be included in the message by typing carriage-return either within a block of fixed text or between format definitions. In the latter case quotes are not needed but the preceding format definition must end with a comma. Non-printing characters (or characters not available on the keyboard) may be included in fixed text by entering their hexadecimal value preceded by '@' and delimited by a comma, e.g. '@' itself may be entered as '@40'.

### (c) Errors

The following error messages are produced by the editor, and the likely cause is given where appropriate.

'Unrecognized command'

The first letter of the current line was not a command identifier.

'Invalid command line'

The current command line does not conform to the structure expected by the editor. An arrow indicates the approximate point where the error was detected. The usual cause is a mis-placed or missing comma or quote during message entry.

'Message not found'

The message number supplied to Display or List was beyond the highest message currently stored.

'Insufficient space for item'

While attempting to create space for a new (or expanded) message the editor found that there was not enough memory available. The message is not stored and any existing messages are left unchanged.

## 10.6 Program Development

Programs can be developed prior to installation and commissioning. By connecting the 8902 I/O Simulation panel, limited operational tests can be performed on the programs developed. For further information on program development, see Sections 1 and 3 of the GEM 80 Programming Manual Ladder Diagram Language.

## 10.7 Programming Procedures

### 10.7.1 Clear Store

Before loading a program, the user is recommended to always issue a clear store command, for the following two reasons :-

(a) The area of P-table used for holding printer messages is not normally write-accessible except via the message editor facility. The 'clear store' command allows data to be loaded to the whole of the P-table.

(b) The controller allocates memory space for the data tables according to the content of the program. To ensure that unnecessary space has not been allocated by the 'old' version of the program, use of the 'clear store' command sets all data table areas to their minimum size first.

Clear store is discussed in detail in Section 15.

### 10.7.2 Declare Highest Address

Since data table sizes are computed by the controller from the user program (Section 4.5), in some cases where addresses are not specifically stated in the user program, problems can occur.

If the user wishes to access and use any P-table he must explicitly declare the table in the program, so securing the address range.

For example:

```
-----<AND>-----<OUT>
          P6000                                G0
```

Figure 10.5 P6000 Highest Address

Some special functions use groups of addresses which are not specifically written in the user program (LOCATE, MOVE, etc.) and the user must declare the highest address in each table where this occurs.

For example:

```
-----<AND>-----<AND>-----<AND>-----<OUT>
          G6000      W800      R50                                G1
```

Figure 10.6 Declaring Highest Addresses

## 10. USER PROGRAM

### 10.7.3 Store Program on Cassette or Disk

As programming proceeds and especially when complete, copies of the program should be dumped either onto digital or audio cassette or disk even if they are untested, so that at each stage as the program is developed, a nearly up to date copy of the program is available. This enables the programmer to back track quickly if necessary, by clearing store and re-loading, and gives back-up should unforeseen problems occur. Both program instructions and P-table can be stored on tape or disk.

In fact, two records should be maintained by alternately dumping the program first onto one tape or disk then the other at each stage of development. On completion, you should store two identical final programs which should be filed separately in two secure locations.

### 10.7.4 Transfer of Program, Presets and Video Formats to EPROM

Optionally you can transfer your program and P-table to EPROM for more permanent storage. Early models of the GEM 80/310 Series were fitted with the type 8220 RAM module. This module is not capable of supporting EPROM. A RAM/EPROM module type 8222 is needed as a replacement with one EPROM sub-module Type 9210 for each 8222. The 9210 sub-module, which must be ordered separately, plugs in at the front of the 8222. Later models of the 310 series Controller have the RAM/EPROM Module type 8222 fitted as standard.

The RAM memory continues to hold:

- the I/O tables
- those tables whose contents change while the program is executed.

The EPROM sub-module holds:

- the P-table
- the source and compiled versions of the program
- IMAGEM video program (where applicable).

To transfer the P-table and compiled version of program to the EPROM sub-module, the value of S0 must be set via an 8922, 8940 or 9022 System Programmer.

Valid S0 values for this location are:

- 0 Controller runs from RAM
- 1 Controller runs from EPROM
- 2 Controller programs EPROM

**Note...** S0 can only be changed when the controller is halted. When the controller is running, S0 is write protected.

To program an EPROM sub-module, halt the controller and set the value to 2. This causes the following sequence to occur :-

- I/O scanning ceases
- any video processors halt on time out
- EPROM is checked:
  - that it is present
  - that it is programmable
  - that it is of sufficient size for the program
- if EPROM check is unsuccessful:
  - error message (#610) displayed on programmer
  - controller remains halted
  - S0 remains unchanged. Cannot run controller until S0 is re-set to 0
- if EPROM check is successful:
  - programming of EPROM begins
  - 'PROG' LED on front panel lit

**Note...** Do not remove the EPROM sub-module while the 'PROG' LED is lit.

- as programming proceeds, EPROM is checked for correctly stored data
- if EPROM fails to store data correctly:
  - error message (#608) displayed on programmer
  - 'PROG FAILED' LED lit
  - controller remains halted
  - S0 remains unchanged. Cannot run controller until S0 is re-set to 0.
- if EPROM stores data successfully:
  - message displayed on programmer 'EPROMS SUCCESSFULLY PROGRAMMED'
  - 'PROG PASSED' LED lit
  - S0 table value set to 1
  - controller remains halted
- controller is now ready to run in EPROM; type control/run.

If the controller has been running from EPROM but it is required to remove the EPROM sub-module, the controller must be halted and the S0 location set to a value of 0. This causes the contents of the EPROM to be copied to RAM. When copying has finished, the 'PROG PASSED' LED goes out, and a message is displayed on the programmer, 'NOW READY TO RUN IN RAM'. The controller runs in RAM, once the EPROM sub-module has been removed, and control/run has been typed.

If the controller has been running in RAM, but it is required to run from EPROM, halt the controller, insert an EPROM sub-module containing a valid program and set the S0 location to a value of 1. Provided the EPROM is valid, this causes the controller to destroy the contents of RAM and switch to the program in EPROM. The 'PROG PASSED' LED lights, indicating that the EPROM contains a valid program and a message is displayed on the programmer, 'NOW READY TO RUN IN EPROM'. The controller will run from EPROM when commanded via the programmer.

## SAFETY WARNING NOTE

IF THE CONTROLLER IS SET UP WITH ITS PROGRAM IN EPROM, AND THE 8222 MODULE DOES NOT HAVE A BATTERY FITTED, IT WILL ALWAYS COME UP IN THE 'RUN' STATUS WHEN POWERED UP.

If the controller is set up with its program in EPROM, and if a battery is fitted in the 8222 module, when powered up, the controller normally comes up in the same status (RUN or HALTED) as it previously had when powered down.

However, if the battery should fail while the controller is powered down, the controller automatically comes up in RUN status the next time it is powered up (as for a system without a battery). To guard against this happening, make use of the battery warning F-table bit F41.4 in the program. This bit could be used to trip the controller or take any other appropriate action which will guarantee safe operation of your system.

## 10.7.5 Watchdog Trip Initiated by User Program

Watchdog trips initiated by the User Program may be achieved by writing a non-zero fault code into F1 and holding this non-zero code for at least 100ms plus total scan time.

This is achieved by enclosing the instruction to write to F1 in an obey block, such as that shown below :-

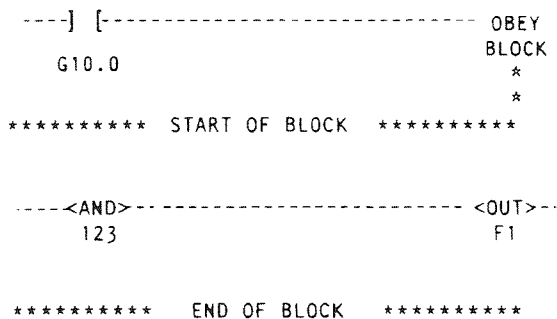


Figure 10.7 Watchdog Trips and User Program

G10.0 is set on only when the watchdog trip is required, and only when G10.0 is on will the block be obeyed. Then AND 123 puts code 123 into F1 (i.e. a non-zero code) so the watchdog trip will occur.

If G10.0 re-sets to zero before the next scan, the obey block is not obeyed and the non-zero F1 code is maintained (as it should be).

Restart procedure is the same as for any other F1 trip, so that if a programmer is connected it will display F1 = 123 and the author of the user program must have documented the meaning of F1 = 123 in such a way that a rectification procedure can be initiated. For example, F1 = 123 may be a shut-down occurring because a limit switch signal has not been received. Once this has been rectified, G10.0 should be arranged to re-set to zero and the controller power should be turned on and off (re-setting F1). The system can then be re-started.

THE FOLLOWING TYPE OF RUNG MUST NOT BE USED.

WRONG:

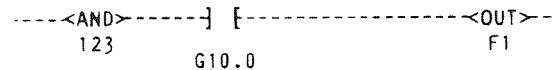


Figure 10.8 Incorrect use of F1

This type of rung **MUST NOT** be used. The reason being that while G10.0 is off, zero is written into F1. If other rungs are writing non-zero (requesting a watchdog trip) this rung over-writes that request back to zero. It is therefore impossible for a non-zero code to be maintained in F1 for the required length of time, i.e. 100ms plus total scan time.

## 10.8 Scan Times Calculation

A GEM 80 controller performs a cycle which is repeated at a regular time interval which may be free-running or pre-set by the user. The cycle comprises the execution of the user program plus an exchange of I/O data with the user's tables. The total scan time is the I/O data exchange time plus the greater of the basic I/O scan time and the program execution time.

I/O scan time (by I/O processor):

2.0ms plus 0.4ms per 16-bit I/O word.

I/O exchange time: 750 microseconds

Program execution time:

5 microseconds average per instruction  
plus extra for each special function used.  
Block instructions may be used to reduce the  
execution time for each program scan by  
arranging for parts of the program to be skipped.

The controller stores the duration of the previous program scan in data table E7. The value in E7 is in milliseconds.

## 10.9 User Program Blank Forms

The blank forms in this section may be copied as required.

## 10. USER PROGRAM

### 10.9.1 GEM 80 Programming Sheet

This blank form is for GEM 80 rung ladder diagram program development. It allows space for up to 10 series elements across the page and up to two five-branch rungs on each page, with comments.

[illegible]

## 10.9.2 GEM 80 Data Table Location Usage Record

This blank form is for the programmer to fill in as the GEM 80 rung ladder diagram program is developed, to record the data table addresses used, their purpose, and mnemonics.



## GEM 80/TABLE LOCATION BIT USAGE RECORD

| REF           |         |                     |            |
|---------------|---------|---------------------|------------|
| ADDRESS RANGE |         |                     |            |
| MNEMONIC      | ADDRESS | DESCRIPTION/REMARKS | * BIT REF. |
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|               | 7       |                     |            |
|               | 8       |                     |            |
|               | 9       |                     |            |
|               | 0       |                     |            |
|               | 1       |                     |            |
|               | 2       |                     |            |
|               | 3       |                     |            |
|               | 4       |                     |            |
|               | 5       |                     |            |
|               | 6       |                     |            |
|               | 7       |                     |            |
|               | 8       |                     |            |
|               | 9       |                     |            |
|               | 0       |                     |            |
|               | 1       |                     |            |
|               | 2       |                     |            |
|               | 3       |                     |            |
|               | 4       |                     |            |
|               | 5       |                     |            |
|               | 6       |                     |            |
|               | 7       |                     |            |
|               | 8       |                     |            |
|               | 9       |                     |            |
|               | 0       |                     |            |
|               | 1       |                     |            |
|               | 2       |                     |            |
|               | 3       |                     |            |
|               | 4       |                     |            |
|               | 5       |                     |            |
|               | 6       |                     |            |
|               | 7       |                     |            |
|               | 8       |                     |            |
|               | 9       |                     |            |
|               | 0       |                     |            |
|               | 1       |                     |            |
|               | 2       |                     |            |
|               | 3       |                     |            |
|               | 4       |                     |            |
|               | 5       |                     |            |
|               | 6       |                     |            |
|               | 7       |                     |            |
|               | 8       |                     |            |
|               | 9       |                     |            |
|               | 0       |                     |            |
|               | 1       |                     |            |
|               | 2       |                     |            |
|               | 3       |                     |            |
|               | 4       |                     |            |
|               | 5       |                     |            |
|               | 6       |                     |            |
|               | 7       |                     |            |
|               | 8       |                     |            |
|               | 9       |                     |            |
|               | 0       |                     |            |
|               | 1       |                     |            |
|               | 2       |                     |            |
|               | 3       |                     |            |
|               | 4       |                     |            |
|               | 5       |                     |            |
|               | 6       |                     |            |
|               | 7       |                     |            |
|               | 8       |                     |            |
|               | 9       |                     |            |
|               | 0       |                     |            |
|               | 1       |                     |            |
|               | 2       |                     |            |
|               | 3       |                     |            |
|               | 4       |                     |            |
|               | 5       |                     |            |
|               | 6       |                     |            |
|               | 7       |                     |            |
|               | 8       |                     |            |
|               | 9       |                     |            |
|               | 0       |                     |            |
|               | 1       |                     |            |
|               | 2       |                     |            |
|               | 3       |                     |            |
|               | 4       |                     |            |
|               | 5       |                     |            |
|               | 6       |                     |            |
|               | 7       |                     |            |
|               | 8       |                     |            |
|               | 9       |                     |            |

10. USER PROGRAM

10.9.3 GEM 80 Data Table Location Bit Usage Record

Where individual bits of 16-bit data tables are used, such as basic I/O, this form allows a record of the mnemonic and purpose of each bit.



GEM 80/TABLE LOCATION BIT USAGE RECORD

|               |
|---------------|
| REF           |
| ADDRESS RANGE |

| MNEMONIC | ADDRESS | DESCRIPTION/REMARKS |
|----------|---------|---------------------|
|          | *0      |                     |
|          | *1      |                     |
|          | *2      |                     |
|          | *3      |                     |
|          | *4      |                     |
|          | *5      |                     |
|          | *6      |                     |
|          | *7      |                     |
|          | *8      |                     |
|          | *9      |                     |
|          | *10     |                     |
|          | *11     |                     |
|          | *12     |                     |
|          | *13     |                     |
|          | *14     |                     |
|          | *15     |                     |
|          | *0      |                     |
|          | *1      |                     |
|          | *2      |                     |
|          | *3      |                     |
|          | *4      |                     |
|          | *5      |                     |
|          | *6      |                     |
|          | *7      |                     |
|          | *8      |                     |
|          | *9      |                     |
|          | *10     |                     |
|          | *11     |                     |
|          | *12     |                     |
|          | *13     |                     |
|          | *14     |                     |
|          | *15     |                     |
|          | *0      |                     |
|          | *1      |                     |
|          | *2      |                     |
|          | *3      |                     |
|          | *4      |                     |
|          | *5      |                     |
|          | *6      |                     |
|          | *7      |                     |
|          | *8      |                     |
|          | *9      |                     |
|          | *10     |                     |
|          | *11     |                     |
|          | *12     |                     |
|          | *13     |                     |
|          | *14     |                     |
|          | *15     |                     |

|                         |   |   |   |   |  |
|-------------------------|---|---|---|---|--|
| ISSUE<br>DATE<br>AUTHOR | A | B | C | D |  |
|-------------------------|---|---|---|---|--|

## 10.9.4 Blank Form for P-table values (copy as required)

This form allows the user to record P-table values.

| Address | Value | Function                                                          |
|---------|-------|-------------------------------------------------------------------|
| P0      |       | User system identification code                                   |
| P1      |       | Program repetition interval (ms)                                  |
| P2      |       | Not write accessible to user                                      |
| P3-P14  |       | Port 1 configuration data as per section 6                        |
| P15-P26 |       | Port 2 configuration data as per section 6                        |
| P27-P38 |       | Port 3 configuration data                                         |
| P39-P50 |       | Port 4 configuration data                                         |
| P51     |       | Fast I/O Self-test                                                |
| P52     |       | Fast I/O Self-test                                                |
| P53     |       | Contains Start Address of Configuration data for Verification I/O |
| P60-P99 |       | STARNET Configuration Data                                        |
| P100    |       | Off-Line Data Block 0                                             |
| P101    |       | Off-Line Data Block 1                                             |
| P102    |       | Off-Line Data Block 2                                             |
| P103    |       | Off-Line Data Block 3                                             |
| P104    |       | Off-Line Data Block 4                                             |
| P105    |       | Off-Line Data Block 5                                             |
| P106    |       | Off-Line Data Block 6                                             |
| P107    |       | Off-Line Data Block 7                                             |
| P108    |       | Off-Line Data Block 8                                             |
| P109    |       | Off-Line Data Block 9                                             |
| P110    |       | Off-Line Data Block 10                                            |
| P111    |       | Off-Line Data Block 11                                            |
| P112    |       | Off-Line Data Block 12                                            |
| P113    |       | Off-Line Data Block 13                                            |
| P114    |       | Off-Line Data Block 14                                            |
| P115    |       | Off-Line Data Block 15                                            |
| P116    |       | Off-Line Data Storage in EPROM                                    |

## 10. USER PROGRAM

### 10.9.5 Blank Form for Highest Addresses (copy as required)

This form allows the user to record the highest addresses in the G,H,L,M,N,O,P,Q,R,U, and W tables.

Cleared at power down

|         | HIGHEST<br>ADDRESS<br>DECLARED | HIGHEST<br>ADDRESS<br>USED | Page or line<br>of program<br>where used |
|---------|--------------------------------|----------------------------|------------------------------------------|
| G-TABLE |                                |                            |                                          |
| H-TABLE |                                |                            |                                          |
| L-TABLE |                                |                            |                                          |
| M-TABLE |                                |                            |                                          |
| N-TABLE |                                |                            |                                          |
| O-TABLE |                                |                            |                                          |
| Q-TABLE |                                |                            |                                          |
| U-TABLE |                                |                            |                                          |

Retained through power down

|         | HIGHEST<br>ADDRESS<br>DECLARED | HIGHEST<br>ADDRESS<br>USED | Page or line<br>of program<br>where used |
|---------|--------------------------------|----------------------------|------------------------------------------|
| P-TABLE |                                |                            |                                          |
| R-TABLE |                                |                            |                                          |
| W-TABLE |                                |                            |                                          |

## 10.9.6 (a) Blank Form for F-table values (copy as required)

This form allows the user to record user programmed F-tables values.

User documented F-Table F250 to F299

| Address | Contents | Address | Contents |
|---------|----------|---------|----------|
| F250    |          | F275    |          |
| F251    |          | F276    |          |
| F252    |          | F277    |          |
| F253    |          | F278    |          |
| F254    |          | F279    |          |
| F255    |          | F280    |          |
| F256    |          | F281    |          |
| F257    |          | F282    |          |
| F258    |          | F283    |          |
| F259    |          | F284    |          |
| F260    |          | F285    |          |
| F261    |          | F286    |          |
| F262    |          | F287    |          |
| F263    |          | F288    |          |
| F264    |          | F289    |          |
| F265    |          | F290    |          |
| F266    |          | F291    |          |
| F267    |          | F292    |          |
| F268    |          | F293    |          |
| F269    |          | F294    |          |
| F270    |          | F295    |          |
| F271    |          | F296    |          |
| F272    |          | F297    |          |
| F273    |          | F298    |          |
| F274    |          | F299    |          |

## 10. USER PROGRAM

### 10.9.6 (b) Blank Form for F-table values (copy as required)

This form allows the user to record user programmed F-tables values.

User documented F-Table F300 to F349

| Address | Contents | Address | Contents |
|---------|----------|---------|----------|
| F300    |          | F325    |          |
| F301    |          | F326    |          |
| F302    |          | F327    |          |
| F303    |          | F328    |          |
| F304    |          | F329    |          |
| F305    |          | F330    |          |
| F306    |          | F331    |          |
| F307    |          | F332    |          |
| F308    |          | F333    |          |
| F309    |          | F334    |          |
| F310    |          | F335    |          |
| F311    |          | F336    |          |
| F312    |          | F337    |          |
| F313    |          | F338    |          |
| F314    |          | F339    |          |
| F315    |          | F340    |          |
| F316    |          | F341    |          |
| F317    |          | F342    |          |
| F318    |          | F343    |          |
| F319    |          | F344    |          |
| F320    |          | F345    |          |
| F321    |          | F346    |          |
| F322    |          | F347    |          |
| F323    |          | F348    |          |
| F324    |          | F349    |          |

## 10.10 Blank Form for Serial Link P-table (copy as required)

## 10.10.1 Port 1

Type of port

TRIBUTARY POINT-TO-POINT CONTROL MULTI-DROP CONTROL PRINTER 

Connected to:

|   | CONTROLLER TITLE | PORT | TYPE OF PORT |
|---|------------------|------|--------------|
| 1 |                  |      |              |
| 2 |                  |      |              |
| 3 |                  |      |              |
| 4 |                  |      |              |
| 5 |                  |      |              |
| 6 |                  |      |              |
| 7 |                  |      |              |
| 8 |                  |      |              |

Configuration Data:

| Address | Value | Trib/Control               | Printer          |
|---------|-------|----------------------------|------------------|
| P3      |       | signalling rate            | signalling rate  |
| P4      |       | operation mode             | operation mode   |
| P5      |       | free-running/user control  | terminal direct  |
| P6      |       | tributaries                | characters/line  |
| P7      |       | data transmitted address 0 | padding constant |
| P8      |       | data transmitted address 1 | parity enable    |
| P9      |       | data transmitted address 2 | parity enable    |
| P10     |       | data transmitted address 3 |                  |
| P11     |       | data transmitted address 4 |                  |
| P12     |       | data transmitted address 5 |                  |
| P13     |       | data transmitted address 6 |                  |
| P14     |       | data transmitted address 7 |                  |

Data received J0 to J255 - User Control Data I0 to I8 (see Section 6.5 and 6.6 for details)

Data to be Transmitted K0 to K255 - Fault Analysis F42, F43, F173-F188 (see Table 15.6 for details)

## 10. USER PROGRAM

### 10.10 (cont). Blank Form for Serial Link P-table (copy as required)

#### 10.10.2 Port 2

Type of port

TRIBUTARY

POINT-TO-POINT CONTROL

MULTI-DROP CONTROL

PRINTER

Connected to:

|   | CONTROLLER TITLE | PORT | TYPE OF PORT |
|---|------------------|------|--------------|
| 1 |                  |      |              |
| 2 |                  |      |              |
| 3 |                  |      |              |
| 4 |                  |      |              |
| 5 |                  |      |              |
| 6 |                  |      |              |
| 7 |                  |      |              |
| 8 |                  |      |              |

Configuration Data:

| Address | Value | Trib/Control               | Printer          |
|---------|-------|----------------------------|------------------|
| P15     |       | signalling rate            | signalling rate  |
| P16     |       | operation mode             | operation mode   |
| P17     |       | free-running/user control  | terminal/direct  |
| P18     |       | tributaries                | characters line  |
| P19     |       | data transmitted address 0 | padding constant |
| P20     |       | data transmitted address 1 | parity enable    |
| P21     |       | data transmitted address 2 | parity enable    |
| P22     |       | data transmitted address 3 |                  |
| P23     |       | data transmitted address 4 |                  |
| P24     |       | data transmitted address 5 |                  |
| P25     |       | data transmitted address 6 |                  |
| P26     |       | data transmitted address 7 |                  |

Data received J256 to J511 - User Control Data I9 to I17 (see Section 6.5 and 6.6 for details)

Data to be Transmitted K256 to K511 - Fault Analysis F42, F4C, F189-F204 (see Table 15.6 for details)

## 10.10 (cont). Blank Form for Serial Link P-table (copy as required)

## 10.10.3 Port 3

Type of port

TRIBUTARY POINT-TO-POINT CONTROL MULTI-DROP CONTROL PRINTER 

Connected to:

|   | CONTROLLER TITLE | PORT | TYPE OF PORT |
|---|------------------|------|--------------|
| 1 |                  |      |              |
| 2 |                  |      |              |
| 3 |                  |      |              |
| 4 |                  |      |              |
| 5 |                  |      |              |
| 6 |                  |      |              |
| 7 |                  |      |              |
| 8 |                  |      |              |

Configuration Data:

| Address | Value | Trib Control               | Printer          |
|---------|-------|----------------------------|------------------|
| P27     |       | signalling rate            | signalling rate  |
| P28     |       | operation mode             | operation mode   |
| P29     |       | free-running/user control  | terminal/direct  |
| P30     |       | tributaries                | characters line  |
| P31     |       | data transmitted address 0 | padding constant |
| P32     |       | data transmitted address 1 | parity enable    |
| P33     |       | data transmitted address 2 | parity enable    |
| P34     |       | data transmitted address 3 |                  |
| P35     |       | data transmitted address 4 |                  |
| P36     |       | data transmitted address 5 |                  |
| P37     |       | data transmitted address 6 |                  |
| P38     |       | data transmitted address 7 |                  |

Data received J512 to J767 - User Control Data I18 to I26

Data to be Transmitted K512 to K767 - Fault Analysis F42, F43, F205-F220 (see Table 15.6 for details)

## 10. USER PROGRAM

### 10.10 (cont). Blank Form for Serial Link P-table (photocopy as required)

#### 10.10.4 Port 4

Type of port

TRIBUTARY

POINT-TO-POINT CONTROL

MULTI-DROP CONTROL

PRINTER

Connected to:

| CONTROLLER TITLE | PORT | TYPE OF PORT |
|------------------|------|--------------|
| 1                |      |              |
| 2                |      |              |
| 3                |      |              |
| 4                |      |              |
| 5                |      |              |
| 6                |      |              |
| 7                |      |              |
| 8                |      |              |

Configuration Data:

| Address | Value | Trib/Control               | Printer          |
|---------|-------|----------------------------|------------------|
| P39     |       | signalling rate            | signalling rate  |
| P40     |       | operation mode             | operation mode   |
| P41     |       | free-running user control  | terminal/direct  |
| P42     |       | tributaries                | characters line  |
| P43     |       | data transmitted address 0 | padding constant |
| P44     |       | data transmitted address 1 | parity enable    |
| P45     |       | data transmitted address 2 | parity enable    |
| P46     |       | data transmitted address 3 |                  |
| P47     |       | data transmitted address 4 |                  |
| P48     |       | data transmitted address 5 |                  |
| P49     |       | data transmitted address 6 |                  |
| P50     |       | data transmitted address 7 |                  |

Data received J768 to J1023 - User Control Data I27 to I35

Data to be Transmitted K768 to K1023 - Fault Analysis F42, F43, F221-236 (see Table 15.6 for details)

## 11.1 Power Supply Requirements

Table 11.1 details the power supply requirements and the performance of the 8917 and 8918 power modules. Table 11.2 details the power supply requirements and the performance of the 9032 power module used in the I/O subracks.

## 11.2 Controller Power Distribution and Consumption

### 11.2.1 General

GEM 80/310 series can have up to four power modules fitted and the user must check that the power consumed by the various GEM 80 equipment does not exceed the power available from each power module.

### 11.2.2 Controller Power Distribution

#### (1) GEM 80/311

This controller has one power module which supplies all controller power including host controller to:

- (a) Basic I/O equipment
- (b) Verification I/O equipment
- (c) Serial links
- (d) Fast I/O equipment

#### (2) GEM 80/312

This controller can have up to three power modules. The modules in the Fast I/O subracks supply power to the Fast I/O equipment. The module in the controller subrack R0 supplies all the equipment in that subrack including the host controller power requirement for Verification and Basic I/O equipment and serial links.

For small amounts of Fast I/O, with only one Fast I/O subrack, it may be possible to omit the power module in this subrack and derive all power from the power module in the controller subrack R0. Similarly, for larger amounts of Fast I/O requiring two Fast I/O subracks, it may sometimes be possible to omit the power module in one of these subracks and derive all power from the power module in the other.

This applies equally to GEM 80/312 and GEM 80/313.

#### (3) GEM 80/313

This controller can have up to four power modules. The ones in the Fast I/O subrack supply power to the Fast I/O equipment. The two in subrack reference R1 divided as shown in Figure 11.1. Figure 11.1 shows that the left-hand power module in R0 (slots 0 to 8) supplies modules fitted in R1 (slots 3 to 10) and the right-hand power module in R0 (slots 9 to 17) supplies R1 (slots 11 to 20). The second I/O processor is usually fitted in slots 11 and 12 and in these circumstances, power for this I/O processor is provided by the right-hand power module.

The left-hand power module therefore supplies the I/O equipment and serial ports connected to the 1st (master) I/O Processor and the right-hand power module supplies the I/O equipment and serial port connected to the 2nd (slave) I/O Processor.

# 11. POWER SUPPLIES

Table 11.1 Power Module Specification

|                                     | 8917 Power Module                                                                                                                                                                                                                                                                                                                    | 8918 Power Module                                                                                                                                                                       |
|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Nominal power input                 | 110 to 240V a.c.<br>50/60Hz. Single phase<br>110 to 220V d.c.<br>Single range (no adjustment necessary).                                                                                                                                                                                                                             | 24 to 48V d.c.<br><br>Single range (no adjustment necessary).                                                                                                                           |
| Operating range                     | 88-264V a.c. 45-60Hz.<br><b>OR</b> 88-250V d.c.<br>Input can be floating, positive earth, or negative earth                                                                                                                                                                                                                          | 19-60V d.c.<br><br>Input can be floating, positive earth, or negative earth                                                                                                             |
| Current Available (in Amps)@ 0-40°C | 26.0A at +5V<br>7.0A at +15V<br>1.0A at -15V                                                                                                                                                                                                                                                                                         | 20.0A at +5V<br>6.0A at +15V<br>1.0A at -15V                                                                                                                                            |
| Current Available (in Amps)at 60°C  | 16.9A at +5V<br>4.55A at +15V<br>0.65A at -15V                                                                                                                                                                                                                                                                                       | 13.0A at +5V<br>3.9A at +15V<br>0.65A at -15V                                                                                                                                           |
| Consumption                         | 350W per power module when supplying full rated load.<br>Consumption decreases approximately linearly with decreasing load.<br>For a.c. operation, input current at full rated load consists of pulses of approximately 35A peak and 0.5ms duration each half cycle.<br>For d.c. operation, input current is substantially constant. | 302W per power module when supplying full rated load.<br>Consumption decreases approximately linearly with decreasing load.<br>Input current is substantially constant (not pulsating). |
| Inrush                              | 2.6A maximum at 121V a.c.<br>6A maximum at 264V a.c.<br>4A at 250V d.c.<br>For a.c. operation, current peaks decay over approximately 500ms.<br><br>For d.c. operation, current decays exponentially with 125ms time constant.<br><br>Suitable for operation from a current limited source.                                          | 3.6A at 24V<br>7.2A at 48V<br>(i.e. 0.15A per volt)<br><br>Current decays exponentially with 125ms time constant.<br><br>Suitable for operation from a current limited source.          |

Table 11.1 Power Module Specification (cont.)

|                           | 8917 Power Module                                                                                                                                                                                                                                                             | 8918 Power Module                                                                                                                                                                                                                                                             |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Input supply interruption | 30ms ride-through on 110V a.c. at full load.<br><br>170ms ride-through on 220V a.c. at full load.<br><br>Shutdown after ride-through time.<br><br>Automatic recovery when supply resumes.                                                                                     | 6ms ride-through on nominal 24V at full load.<br><br>50ms ride-through on nominal 48V at full load.<br><br>Shutdown after ride-through time.<br><br>Automatic recovery when supply resumes.                                                                                   |
| Under-voltage shutdown    | Shutdown if any output voltage falls 5% below nominal value.                                                                                                                                                                                                                  | Shutdown if any output voltage falls 5% below nominal value.                                                                                                                                                                                                                  |
| Over-voltage shutdown     | Shutdown if any output voltage rises 20% above nominal value.                                                                                                                                                                                                                 | Shutdown if any output voltage rises 20% above nominal value.                                                                                                                                                                                                                 |
| Self-test                 | Under-voltage detection circuits tested regularly by master I/O processor.                                                                                                                                                                                                    | Under-voltage detection circuits tested regularly by master I/O processor.                                                                                                                                                                                                    |
| Multiple power modules    | All power modules tested simultaneously with more than 1 power module (i.e. GEM 80/312 with Fast I/O, and GEM 80/313 systems.)<br><br>Power modules cross-interlocked for controlled system start-up/shutdown.<br><br>A fault on any power module will cause system shutdown. | All power modules tested simultaneously with more than 1 power module (i.e. GEM 80/312 with Fast I/O, and GEM 80/313 systems.)<br><br>Power modules cross-interlocked for controlled system start-up/shutdown.<br><br>A fault on any power module will cause system shutdown. |
| Status indication LEDs    | Power ON (red).<br>Control supply healthy (green).<br>+5V overload (red).<br>+15V overload (red).<br>-15V overload (red).                                                                                                                                                     | Power ON (red).<br>Control supply healthy (green).<br>+5V overload (red).<br>+15V overload (red).<br>-15V overload (red).                                                                                                                                                     |

Table 11.2 9032-4002 Power Supply Module  
Specification

|                                     |                                                                                                              |                                                                                                                                                                                                           |
|-------------------------------------|--------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Nominal power input                 | 110 or 220V a.c.<br>50/60Hz<br>22 to 85V d.c.                                                                | Two a.c. ranges<br>switch selectable.                                                                                                                                                                     |
| Operating range                     | 88-121V a.c. 45-63Hz<br>OR 204-264V a.c.<br>45-63 Hz<br>OR 22-85V d.c.                                       |                                                                                                                                                                                                           |
| Current available in Amps at 0-60°C | 7.0A at +5v<br>2.0A at +15V                                                                                  | The current available from the 15V rail may be increased up to a maximum of 5A by trading off 2A at +5V for every additional 1A required at +15V.                                                         |
| Consumption                         | 100W per Power module when supplying full rated load. Decreases approximately linearly with decreasing load. | For a.c. operation, input current at full rated load consists of pulses of up to 3.5A peak and up to 5.5 ms duration each half cycle.<br><br>For d.c. operation, input current is substantially constant. |
| Inrush                              | 50A at 110V a.c.<br>25A at 240V a.c.<br>86A at 48V d.c.<br>(i.e. 1.8A/V)                                     | For either a.c. or d.c. operation, current peak decays exponentially with a 4ms time constant.<br><br>Suitable for operation from a current limited source.                                               |

Table 11.2 9032-4002 Power Supply Module  
Specification (cont.)

|                           |                                                                                                       |                                                                           |
|---------------------------|-------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Input supply interruption | 20ms ride-through on 110V or 220V a.c. at full load.<br>20ms ride-through on nominal 48V at full load | Shutdown after ride-through time. Automatic recovery when supply resumes. |
| Under-voltage protection  | Shutdown if any output falls 5% below nominal value.                                                  |                                                                           |
| Over-voltage protection   | Shutdown if any output rises 27% above nominal value.                                                 |                                                                           |
| Self test                 | No self test when used for Verification or Basic I/O.                                                 |                                                                           |
| Status indication LEDs    | Power ON (green).<br>+5V healthy (green). +15V healthy (green).                                       |                                                                           |

## 11. POWER SUPPLIES

### 11.2.3 Power Consumed from Power Module

Table 11.2 details the power consumed by each item of equipment.

Table 11.3 Current Consumption in milliamps.

|                                                                       | + 5V         | +15V      | -15V |
|-----------------------------------------------------------------------|--------------|-----------|------|
| Ladder processor                                                      | 1,610        | 40        |      |
| I/O processor<br>Extra per<br>Verification I/O<br>ribbon              | 2,400        | 30<br>105 | 40   |
| 8220 Series RAM<br>Modules<br>See Note.                               | 800          |           |      |
| 8222 Series<br>RAM/EPROM<br>Modules<br>Extra for EPROM<br>sub-modules | 1,000<br>500 |           |      |
| IMAGE video<br>processor                                              | 3,300        |           |      |
| STARNET module                                                        | 2,400        |           |      |
| Fast I/O driver                                                       | 1,000        | 50        |      |
| 8191 Expander Unit                                                    |              | 900       |      |
| 8924 20mA serial<br>unit<br>extra per 20mA<br>source                  | 220          | 10<br>20  | 20   |
| 8587 HDLC term.<br>unit                                               | 170          | 120       |      |
| See relevant data<br>sheets for specific<br>I/O modules.              |              |           |      |

**Note...**8220 modules, which do not support EPROM, were supplied for early models of GEM80/310 controllers.

### 11.3 Power Supply, Watchdog, Safety Earth, Signal Ground Connections

A.C. power, 0V, and watchdog terminals are located on terminal boards at the rear of the power module. A safety earth, stud shown in Figure 11.2, is fitted to the terminal bracket. Safety earth studs are also located on the subrack side cheeks at the rear of the mains input filter.

Further information on signal grounds, safety earths and watchdog contacts is detailed as follows :-

- (1) Safety Earths - The equipment must be earthed by a secure safety earth connection of minimum cross-sectional area 2.5 sq.mm. See Section 13.5.2 for connection details.
- (2) Signal Grounds - See Section 13.5.3 for connection details.
- (3) Watchdog Contact - See Section 9 for connection details.

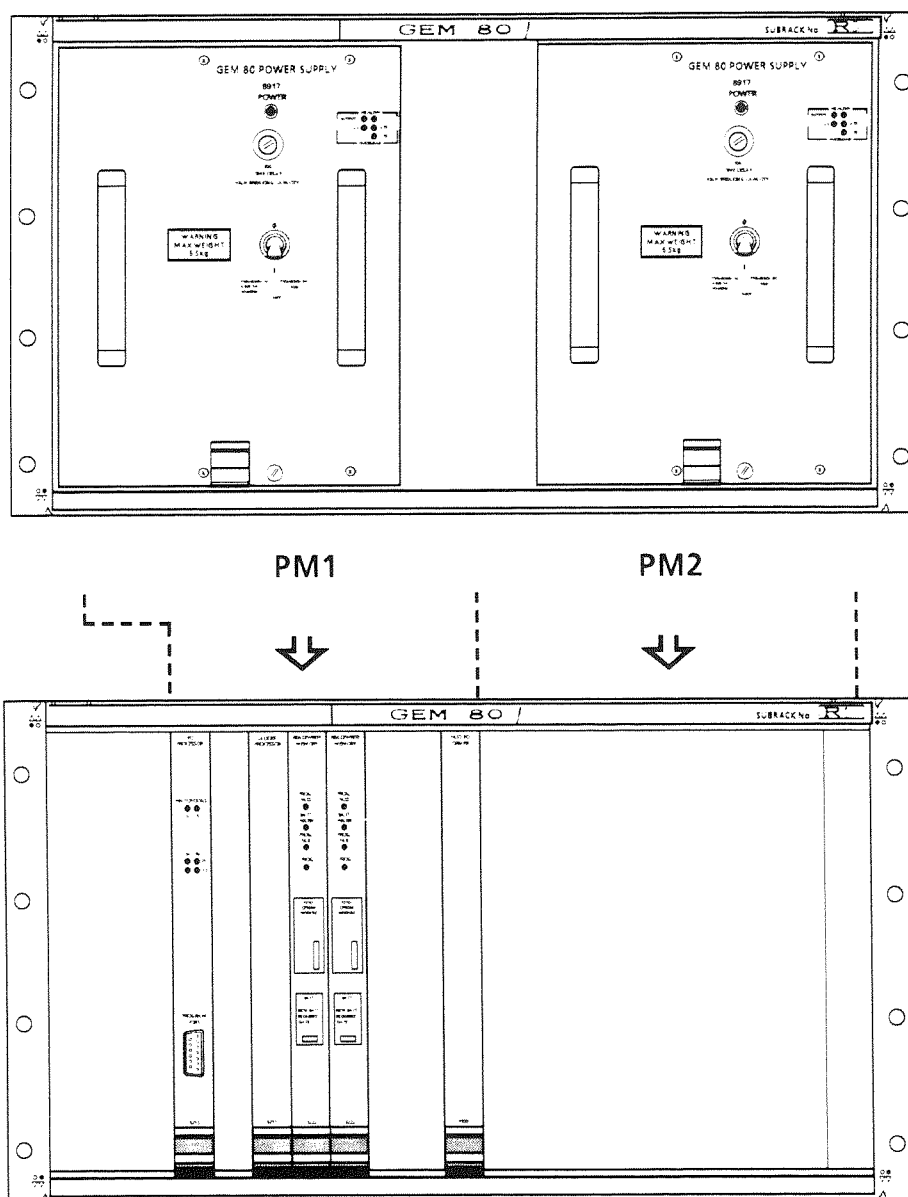
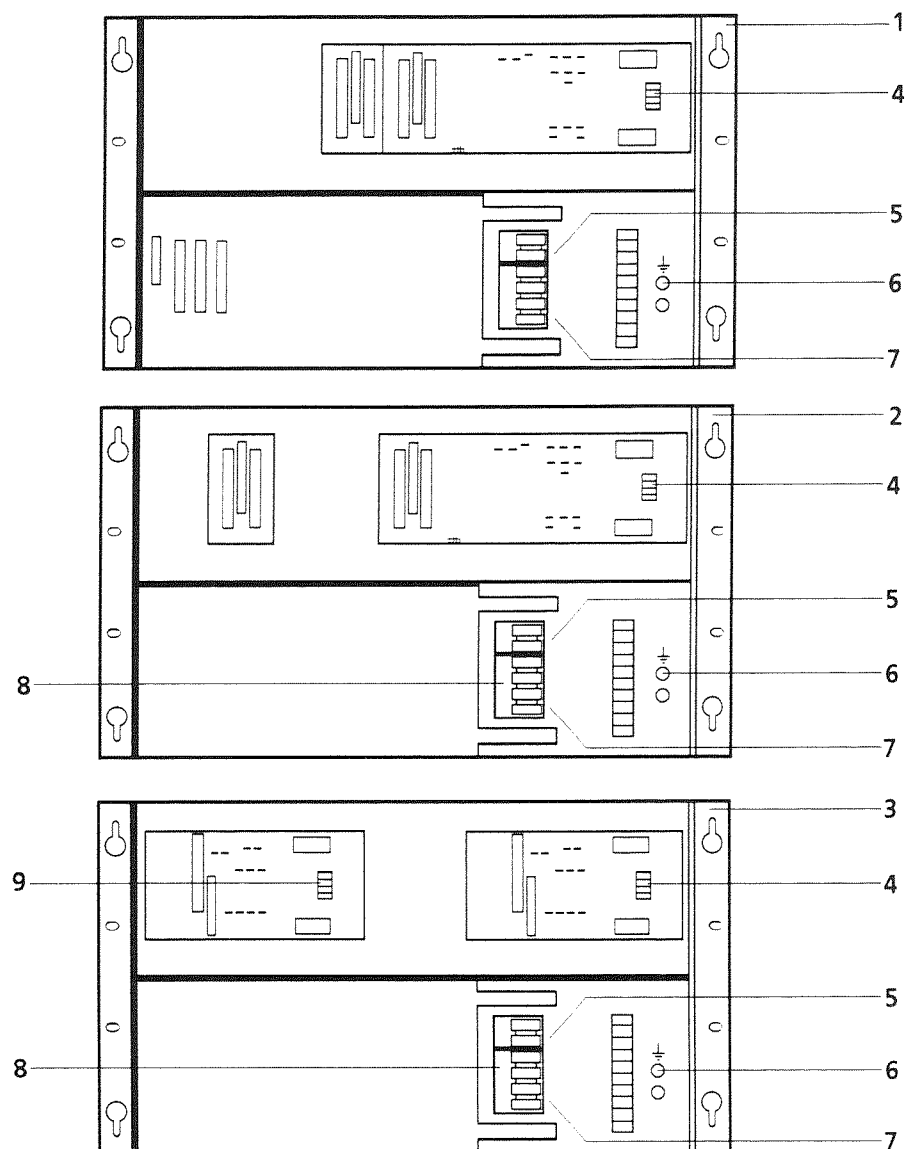
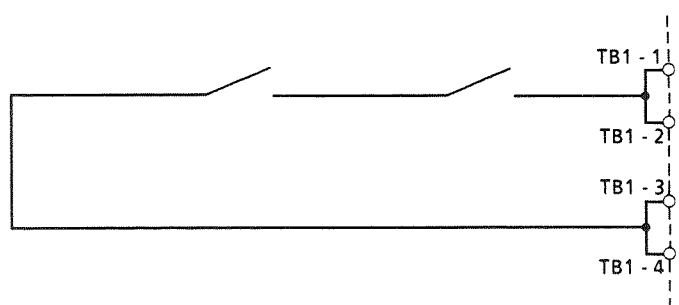


Figure 11.1 - GEM 80/313 Power Supplies Distribution for Subrack References R0 and R1



- |                                                                         |                                          |
|-------------------------------------------------------------------------|------------------------------------------|
| 1. GEM 80/311.                                                          | 5. 0V terminals for signal ground.       |
| 2. GEM 80/312.                                                          | 6. Earth connection studs.               |
| 3. GEM 80/313. (Power supplies subrack)                                 | 7. A.C. input to Power Module 2 (L2,N2). |
| 4. Watchdog contact terminals TB1, see Figure 11.3 for further details. | 8. A.C. input to Power Module 1 (L1,N1). |
|                                                                         | 9. Not used.                             |

Figure 11.2 Power Supply Watchdog Safety Earth and Signal Ground Terminals (8917 Power Module)



The watchdog contact terminals are located on TB1 as shown in Figure 11.2. Figure 11.3 shows the internal connections within the GEM 80 controller relating to the watchdog contacts.

When two Power Modules (8917 or 8918) are used in the GEM 80/313, the watchdog terminals on Power Module 1 (supplying the Master I/O Processor) only should be connected.

Figure 11.3 Watchdog Circuit Inside GEM 80 Controller.

| Slot Number | Re – order Numbers | Description                      | Power Consumed (A) |       |      |
|-------------|--------------------|----------------------------------|--------------------|-------|------|
|             |                    |                                  | + 5V               | +15V  | –15V |
| Subrack     | 8870 –             | Subrack                          | —                  | —     | —    |
| 0 to 8      |                    | Power Module                     |                    |       |      |
| 9           | 8213 – 431 *       | 1st I/O Processor                | 2.4                | 0.133 | 0.04 |
| 11          | 8211 – 431 *       | Ladder Processor                 | 1.6                | 0.04  |      |
| 12          |                    |                                  |                    |       |      |
| 13          |                    |                                  |                    |       |      |
| 14          |                    |                                  |                    |       |      |
| 15          | 8222 – 4001        | Memory Module                    |                    |       |      |
| 16          | 8300 – 4003        | Fast I/O Driver                  | 1.0                | 0.05  |      |
| 17          |                    |                                  |                    |       |      |
| 18          |                    |                                  |                    |       |      |
| 19          |                    |                                  |                    |       |      |
| 20          |                    |                                  |                    |       |      |
|             |                    | Power consumed by ribbon cable A |                    |       |      |
|             |                    | Power consumed by ribbon cable B |                    |       |      |
|             |                    | Power consumed by ribbon cable C |                    |       |      |
|             |                    | Power consumed by ribbon cable D |                    |       |      |
|             |                    | Power consumed by 8924 Port 1    |                    |       |      |
|             |                    | Power consumed by 8924 Port 2    |                    |       |      |
|             |                    | Power consumed by 8924 Port 3    |                    |       |      |
|             |                    | Power consumed by 8924 Port 4    |                    |       |      |
|             |                    | TOTAL<br>POWER<br>CONSUMED       |                    |       |      |

|                       | + 5V | +15V | –15V |
|-----------------------|------|------|------|
| Total Power Available |      |      |      |
| Total Power Consumed  |      |      |      |
| Difference            |      |      |      |

Figure 11.4 GEM 80/311 Controller

## 11. POWER SUPPLIES

| Slot Number                      | Re – order Numbers | Description       | Power Consumed (A) |       |      |
|----------------------------------|--------------------|-------------------|--------------------|-------|------|
|                                  |                    |                   | +5V                | +15V  | -15V |
| Subrack                          | 8870 –             | Subrack           | —                  | —     | —    |
| 0 to 8                           |                    | Power Module      |                    |       |      |
| 9                                | 8213 – 431*        | 1st I/O Processor | 2.4                | 0.133 | 0.04 |
| 11                               | 8211 – 431*        | Ladder Processor  | 1.6                | 0.04  |      |
| 12                               | 8222 – 4001        | Memory Module     |                    |       |      |
| 13                               |                    |                   |                    |       |      |
| 14                               |                    |                   |                    |       |      |
| 15                               |                    |                   |                    |       |      |
| 16                               |                    |                   |                    |       |      |
| 17                               |                    |                   |                    |       |      |
| 18                               |                    |                   |                    |       |      |
| 19                               |                    |                   |                    |       |      |
| 20                               | 8300 – 4003        | Fast I/O Driver   | 1.0                | 0.05  |      |
| Power consumed by ribbon cable A |                    |                   |                    |       |      |
| Power consumed by ribbon cable B |                    |                   |                    |       |      |
| Power consumed by ribbon cable C |                    |                   |                    |       |      |
| Power consumed by ribbon cable D |                    |                   |                    |       |      |
| Power consumed by 8924 Port 1    |                    |                   |                    |       |      |
| Power consumed by 8924 Port 2    |                    |                   |                    |       |      |
| Power consumed by 8924 Port 3    |                    |                   |                    |       |      |
| Power consumed by 8924 Port 4    |                    |                   |                    |       |      |
| TOTAL<br>POWER<br>CONSUMED       |                    |                   |                    |       |      |

|                       | +5V | +15V | -15V |
|-----------------------|-----|------|------|
| Total Power Available |     |      |      |
| Total Power Consumed  |     |      |      |
| Difference            |     |      |      |

Figure 11.5 GEM 80/312 Controller

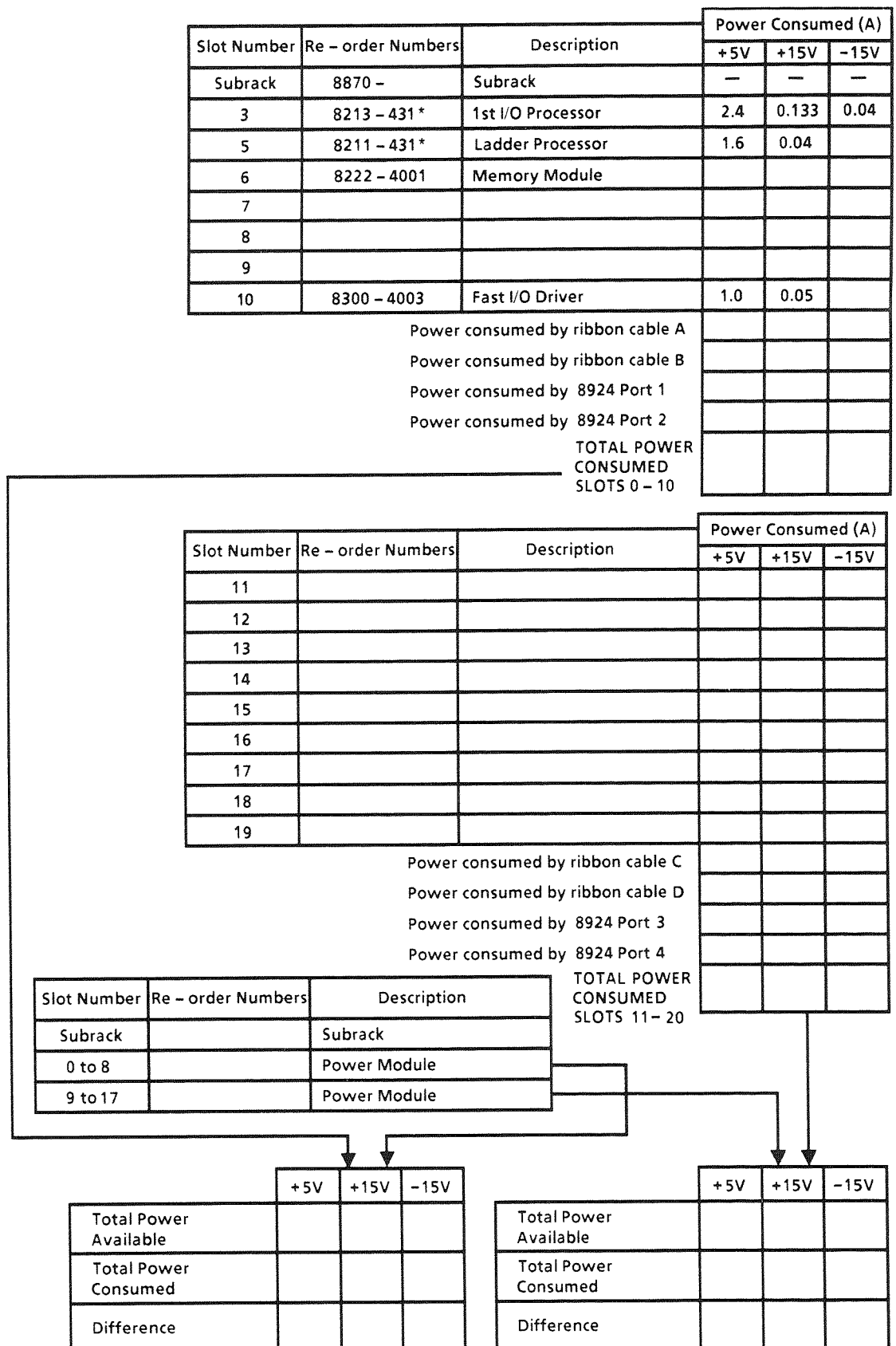


Figure 11.6 GEM 80/313 Controller

## 11. POWER SUPPLIES

| Slot Number                | Re - order Numbers | Description  | Power Consumed (A) |      |      |
|----------------------------|--------------------|--------------|--------------------|------|------|
|                            |                    |              | +5V                | +15V | -15V |
| Subrack                    |                    | Subrack      | —                  | —    | —    |
| 0 to 8                     |                    | Power Module |                    |      |      |
| 9                          |                    |              |                    |      |      |
| 10                         |                    |              |                    |      |      |
| 11                         |                    |              |                    |      |      |
| 12                         |                    |              |                    |      |      |
| 13                         |                    |              |                    |      |      |
| 14                         |                    |              |                    |      |      |
| 15                         |                    |              |                    |      |      |
| 16                         |                    |              |                    |      |      |
| 17                         |                    |              |                    |      |      |
| 18                         |                    |              |                    |      |      |
| 19                         |                    |              |                    |      |      |
| 20                         |                    |              |                    |      |      |
| TOTAL<br>POWER<br>CONSUMED |                    |              |                    |      |      |

|                       | +5V | +15V | -15V |
|-----------------------|-----|------|------|
| Total Power Available |     |      |      |
| Total Power Consumed  |     |      |      |
| Difference            |     |      |      |

Figure 11.7 GEM 80/312 Fast I/O Subrack with Power Module

| Slot Number                | Re – order Numbers | Description | Power Consumed (A) |       |       |
|----------------------------|--------------------|-------------|--------------------|-------|-------|
|                            |                    |             | + 5V               | + 15V | - 15V |
| Subrack                    | 8893 –             | Subrack     |                    |       |       |
| 3                          |                    |             |                    |       |       |
| 4                          |                    |             |                    |       |       |
| 5                          |                    |             |                    |       |       |
| 6                          |                    |             |                    |       |       |
| 7                          |                    |             |                    |       |       |
| 8                          |                    |             |                    |       |       |
| 9                          |                    |             |                    |       |       |
| 10                         |                    |             |                    |       |       |
| 11                         |                    |             |                    |       |       |
| 12                         |                    |             |                    |       |       |
| 13                         |                    |             |                    |       |       |
| 14                         |                    |             |                    |       |       |
| 15                         |                    |             |                    |       |       |
| 16                         |                    |             |                    |       |       |
| 17                         |                    |             |                    |       |       |
| 18                         |                    |             |                    |       |       |
| TOTAL<br>POWER<br>CONSUMED |                    |             |                    |       |       |

Figure 11.8 GEM 80/312 Fast I/O Subrack without Power Module

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## 11. POWER SUPPLIES

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## 12. SUBRACK SPECIFICATIONS AND MOUNTING INSTRUCTIONS

### 12.1 Introduction

The subrack is constructed from 'clip together' mouldings with 'clip on' backplanes. Module guides, on a 0.4 inch pitch, are an integral part of the moulding.

Modules are inserted from the front of the subrack and are retained in position by sliders built into the subrack. Dimensions for the subrack are illustrated in Figure 12.1.

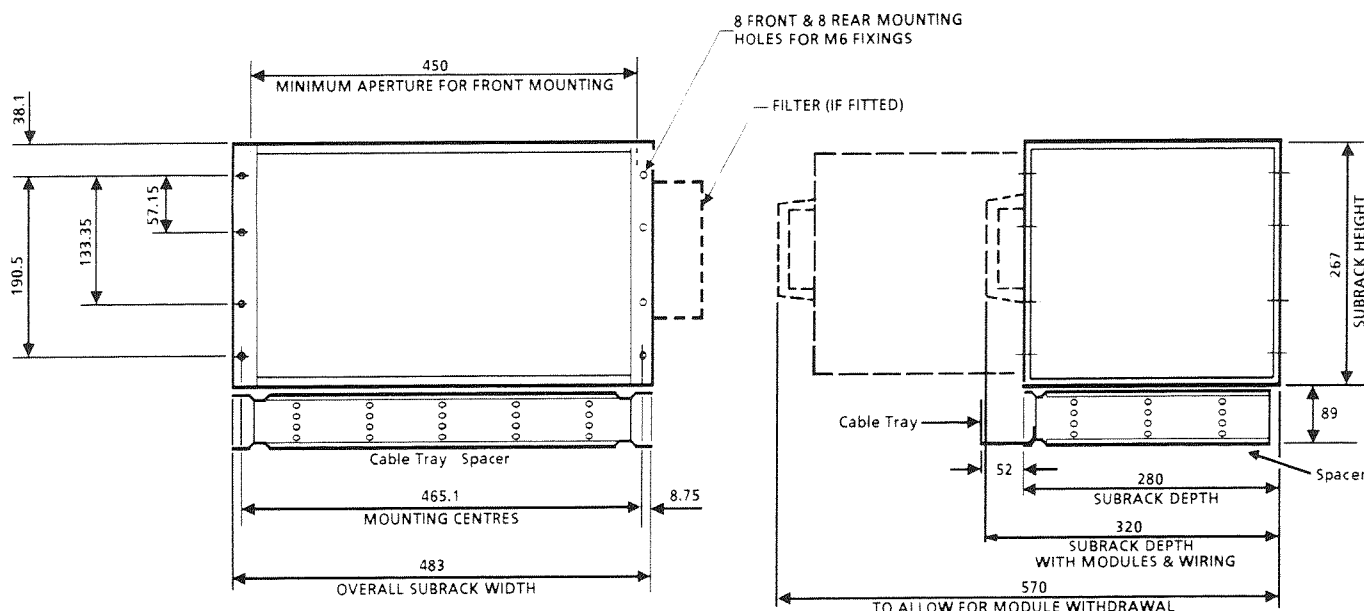


Figure 12.1 - Subrack Dimensions

### 12.2 Specification

|                                            |                                                                                                                                                                                                                                     |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Weight with backplanes but without modules | : 4.75kg                                                                                                                                                                                                                            |
| Mounting                                   | : 19in. (482mm) rack mounting                                                                                                                                                                                                       |
| Temperature                                | : 0 to 60°C operating<br>-20 to +70°C storage                                                                                                                                                                                       |
| Humidity                                   | : 5 to 95% RH non-condensing                                                                                                                                                                                                        |
| Dimensions                                 | : 356mm high x 483mm wide x 320mm deep with modules and front connectors fitted. Allow 15mm for plant-side wiring.<br>The 6U high subrack has mounting dimensions consistent with IEC297:1 (1975) - Dimensions of Panels and Racks. |
| Fire resistance                            | : UL94V-0                                                                                                                                                                                                                           |

**Note...** The weight and dimensions shown relate to one empty subrack such as a GEM80/311 or GEM80/312 controller. A GEM80/313 comprises two subracks, therefore the height and weight figures must be doubled. A Fast I/O subrack has the same weight and dimensions as a single subrack. Consequently, one or two sets of height and weight figures must be added to the controller, dependent upon the number of Fast I/O subracks required.

An allowance must be made to the subrack width by adding 27mm for each filter fitted.

### 12.3 Mounting

The subrack has a very simple mounting procedure which utilises the side plate front or rear flange for fixing purposes. Both front and rear flanges have four fixing holes. Under normal circumstances only the top and bottom holes are required to secure the subrack assembly, however in conditions of high shock/vibration it may be necessary to use the additional holes. To aid rear mounting, the top hole on each rear flange has a 'keyhole' shape.

#### 12.3.1 Front Flange Mounting.

**Note...** Front flange mounting requires a flat surface at the rear of the mounting panel.

To assist with the mounting procedure, threaded inserts have been fitted in the subrack fixing holes which accommodate the mounting screws. In order to give clearance for the mounting screws, 7mm holes are required in the mounting panel. Mounting pegs are provided which enable the subrack to be held in the 'mounted' position prior to securing with the fixing screw.

- (1) When direct access to the rear face of the mounting panel is possible, the subrack mounting procedure is as follows :-
  - (a) Insert a mounting peg into the top fixing hole of each of the subrack flanges.
  - (b) Offer the subrack assembly up to the rear of the mounting panel and locate the two pegs in the top fixing holes of the panel. The pegs will hold the assembly in the correct fixing position.

## 12. SUBRACK SPECIFICATIONS AND MOUNTING INSTRUCTIONS

- (c) Fit and tighten the lower fixing screws in position.
- (d) Replace the mounting pegs with the upper fixing screws.
- (e) Tighten all securing screws to a torque of 28lbf.ins (3.16 Nm).
- (2) If direct access to the rear of the mounting panel is NOT possible, the subrack assembly mounting procedure is as follows :-
  - (a) Ensure that the space at the rear of the mounting panel is a minimum of 600mm wide and 500mm deep with an aperture of 450mm.
  - (b) Insert a mounting peg into the top fixing hole of each of the subrack flanges.
  - (c) Insert the subrack assembly sideways through the mounting panel aperture, rotate the subrack to offer the front of the assembly to the rear of the mounting panel and locate the two pegs in the top fixing holes of the panel. The pegs will hold the assembly in the correct fixing position.
  - (d) Repeat items (1)(c) to (1)(e) above.

### 12.3.2 Rear Flange Mounting

Rear fixing is either by inserts fitted into the rear mounting panel or by self-tapping screws. The length of the screws is 7mm + the length required into the rear mounting panel and the screw head should be POSIPAN.

Each rear flange has four fixing holes. Under normal circumstances only the top and bottom holes are required to secure the subrack assembly, however in conditions of high shock/vibration it may be necessary to use the additional holes. To aid rear mounting, the top hole on each flange has a 'keyhole' shape.

Subrack mounting using the rear flanges is carried out as follows :-

- (1) Insert a mounting screw into each of the uppermost fixing holes on the mounting panel leaving at least 10mm of thread projecting.
- (2) Offer the subrack assembly up to the mounting panel, allowing the screw heads to pass through the keyhole shape. The subrack assembly locates onto the screws and is held in position prior to securing.
- (3) Insert the two lower fixing screws.
- (4) Tighten all four screws to a torque of 28lbf.ins (3.16 Nm).

### 12.4 Subrack Spacer

A subrack spacer, part number 8891-4604, is fitted below each subrack to provide a 2U(88.5mm) space between subracks. The spacer must be earthed to the subrack earth stud.

Multi-rack assemblies can be made up prior to mounting into an enclosure. The spacer below an upper subrack is fitted to the top of the lower subrack. Fixing dimensions for each subrack are as given in Figure 12.1 with a pitch of 356mm between subracks. Mounting is similar to that described previously except that mounting pegs or mounting screws are only required to be fitted to the top subrack.

### 13.1 Introduction

System builders must ensure that power supply units are removed from subracks before shipping. However, GEM 80 equipment may be supplied loose by the factory for the customer to mount in an enclosure. The installation procedure is as follows:-

- (1) Plan the layout of GEM 80 equipment in the cubicle, allowing 2U space for spacer between subracks and observing rack panel and wiring segregation requirements described in Figures 13.3 and 13.8.
- (2) Assemble the enclosure and fix in position.
- (3) Mount the equipment in the cubicle.
- (4) Cable the equipment.
- (5) Connect plant cables to GEM 80 Equipment.
- (6) Set address decoder switches and mark labels.
- (7) Install modules.

Where GEM 80 equipment is supplied already fitted in cubicles, the installation procedure is:

- (1) Move the cubicle and fix in position.
- (2) Connect plant cables to GEM 80 equipment.
- (3) Check Address Decoder switches and mark labels.
- (4) Install modules.

Whenever it is necessary to handle GEM 80 modules, the handling precautions detailed in Section 18.9 must be observed.

## 13.2 Planning the Layout of GEM 80 in a Cubicle

### 13.2.1 General

In laying out the equipment the following recommendations are made :-

- (1) Determine whether plant cables will enter at the top or bottom of the cubicle and leave adequate space for plant cable glanding.
- (2) Equipment or wiring which carries signals which could contain electromagnetic noise from the plant is termed 'dirty'. Equipment or wires which carry filtered, noise-free signals is termed 'clean'. Establish areas for mounting 'clean' equipment such as controller, serial link termination units etc. Establish areas for mounting 'dirty' equipment such as I/O subracks.
- (3) If possible fit 'dirty' equipment in separate enclosures from 'clean' equipment. Where all equipment is to be mounted in one cubicle, fit 'dirty equipment' near the entry of the plant cables. This prevents 'dirty cables' passing close to 'clean equipment'.

- (4) Provide separate trunking for 'clean' and 'dirty' plant cables.
- (5) Fit a signal ground bar and safety earth bar in the GEM 80 controller enclosure close to the point of entry of the plant cables.
- (6) Subracks should be mounted above each other to form a column of equipment to produce a cooling chimney effect. Do not obstruct the flow of air through the 'chimney'.

### 13.2.2 Examples of Cubicle Layout

Figures 13.1 and 13.2 show examples of typical cubicle layout. Clearly many different layouts are possible, depending on GEM 80 equipment required, and the cubicle dimensions and fittings.

### 13.2.3 Positioning of GEM 80 Controller

It is recommended that the controller be mounted at a reasonable height for access (i.e. between waist and eye level) to permit:

- (1) Connection of programmer
- (2) Access to control switches
- (3) Viewing of indication devices
- (4) Module removal and replacement

### 13.2.4 Access Requirements

- (1) Controller - Access is required to the front and rear of the controller.
- (2) I/O - Decoder switches and ribbon cable connection can be accessed from the front, the plug-in modules slide in from the front.
- (3) I/O Module Front Panels - Access to the front of the I/O subrack is required.
- (4) Termination Panels - Access is required to the front of these panels to allow connection and disconnection of plant wires and controller connections.

### 13.2.5 Heat Dissipation of I/O Modules

I/O equipment in particular can in some cases produce large heat dissipations. See Product Data Sheets for details.

Where plant circuits use high operating currents, care must be taken to avoid hotspots and overheating so that the ambient temperature in the enclosure never exceeds the environmental conditions for temperature, given in Section 1.4.1.

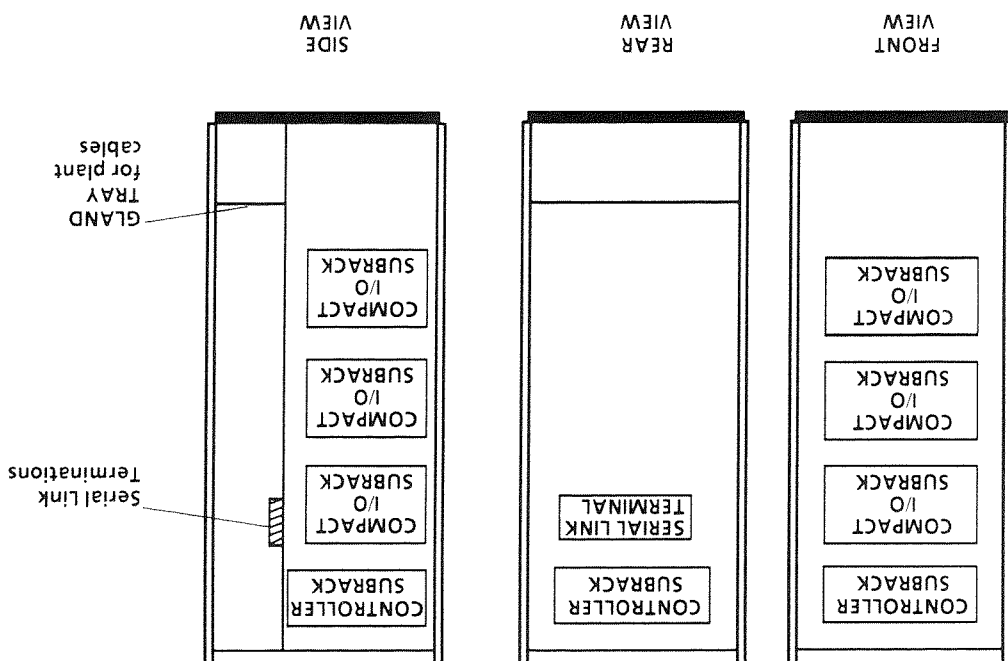


Figure 13.1 - Typical GEM 80 Single Cubicle Layout

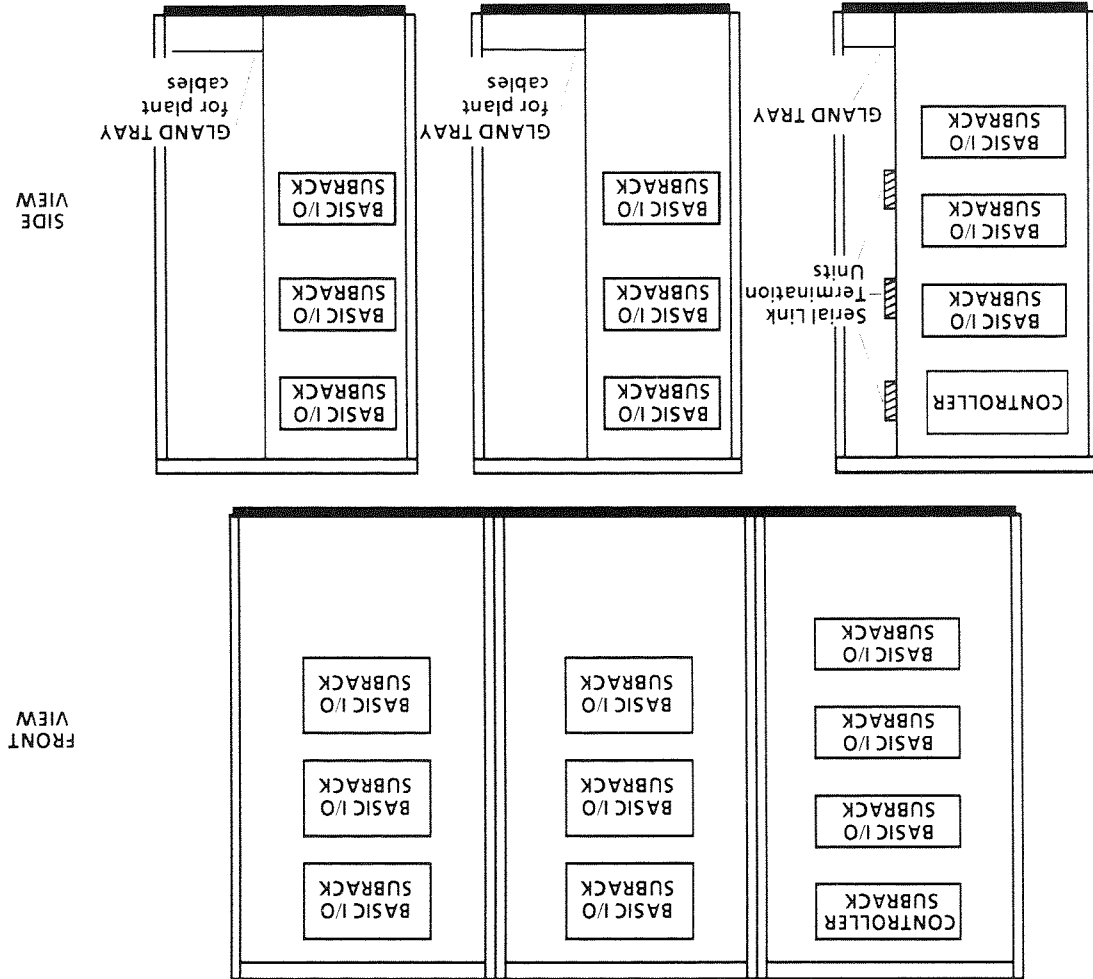


Figure 13.2 - Typical GEM 80 3-Cubicle Layout

### 13.2.6 Verification/Basic I/O Ribbon Cable

The Verification/Basic I/O ribbon cable can be run up to 10 metres without de-rating (the maximum I/O load being 2.1A). With de-rating the cable can be run to 30 metres (see Section 5. for de-rating). This cable is noise sensitive and is best kept short; it should not be run outside the equipment cubicle for cubicle mounted GEM 80.

### 13.2.7 Minimum Panel Spacings

To help remove the possibility of noise problems, the minimum panel spacings given at Figure 13.3 must be achieved.

### 13.2.8 Cable Routing and Segregation

GEM 80 interconnecting cables are categorised into groups and these separate groups must be run physically separated by at least the distances given in Section 13.5.4 and Figure 13.8.

### 13.2.9 Pre-cut Ribbon Cable Lengths

Some GEM 80 equipment is supplied with ready made ribbon cables of a pre-cut length (as detailed in the Product Data Sheets).

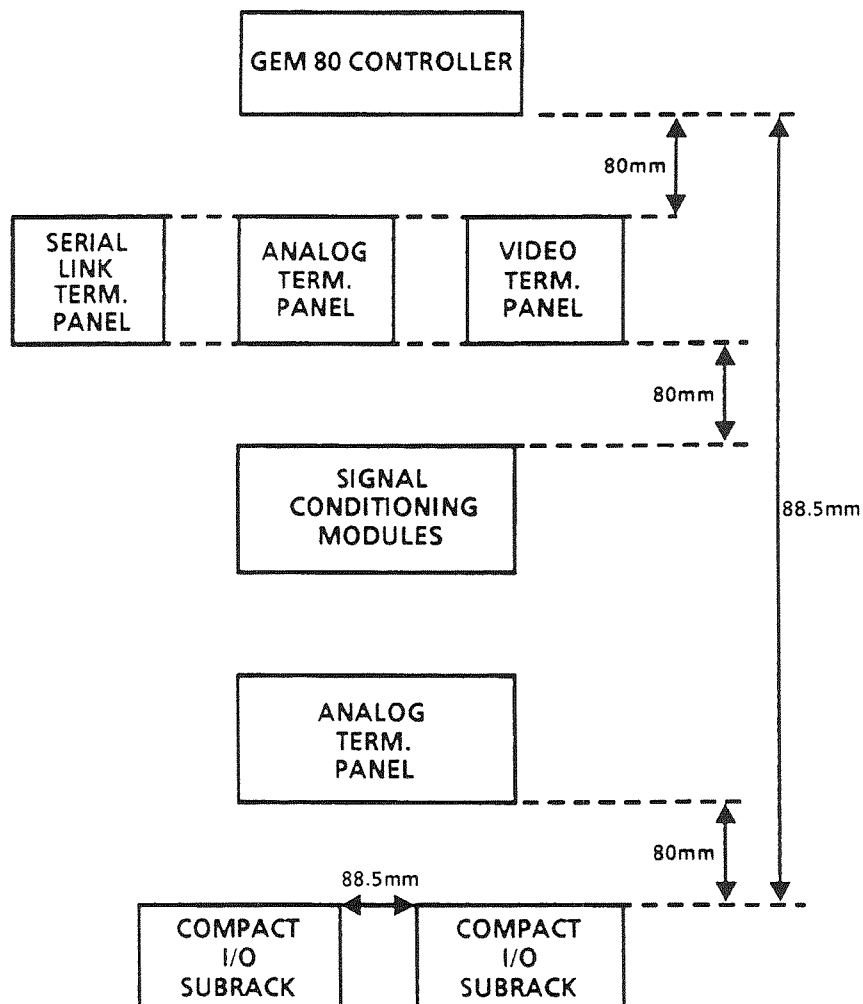


Figure 13.3 Minimum Panel Spacings for GEM 80/310 Series Controllers

## 13. INSTALLATION

### 13.3 Cubicles

The cubicle should now be erected and the various cubicle fixtures and fittings incorporated.

#### 13.3.1 Movement of Cubicles

When equipment is supplied ready mounted in cubicles, the cubicles can be moved into the required position either by lifting or rolling.

Where the user provides an enclosure, similar techniques may be used provided the weights are evenly distributed. Adequate lifting bars should also be fitted.

##### (1) Lifting

Cubicles should be lifted using rope slings attached to each cubicle. See Figures 13.4 and 13.5.

##### (2) Rolling

Cubicles which are being moved in a building of restricted height or without lifting facilities may be rolled into position using scaffolding poles as detailed at Figure 13.6.

#### 13.3.2 Cubicle Foundations

The site should be prepared to the Foundation Tolerances as follows :-

- (1) Mounting hole positions  $\pm 1.5\text{mm}$ .
- (2) Mounting Plane Face, flat to within 2mm per 1m x 1m area (Not to be convex)
- (3) Mounting plane, level in both directions within 1mm/m ( $4'$  arc) max. deviation from level; 10mm when the length of the foundations exceeds 10m.
- (4) The above tolerances must NOT be cumulative.

### 13.4 Mounting GEM 80 Equipment

After making sure that the modules fit into the subracks, Remove the modules and fit the empty subracks into the cubicle. The order of work depends on the cubicle layout but usually the following order of work is recommended :-

- (1) Fit all mounting channels or trunking
- (2) Fit transformers
- (3) Fit termination panels
- (4) Fit subracks

Fixing details for the GEM 80 equipment are given in the Product Data Sheets, and in Section 12, of this manual.

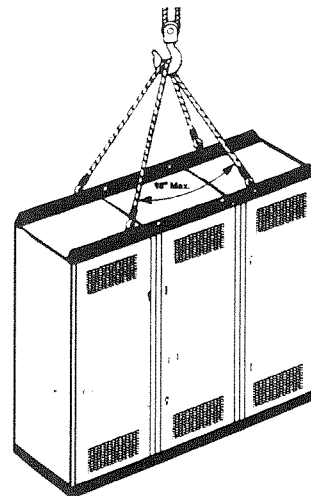


Figure 13.4 - Cubicle Lifting - Typical Q80 Cubicle Suite

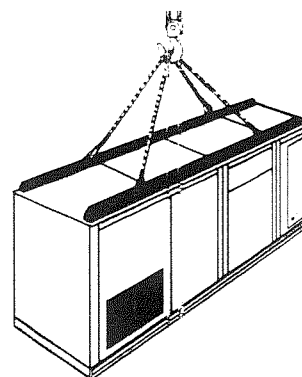


Figure 13.5 - Cubicle Lifting - Typical QP Cubicle Suite

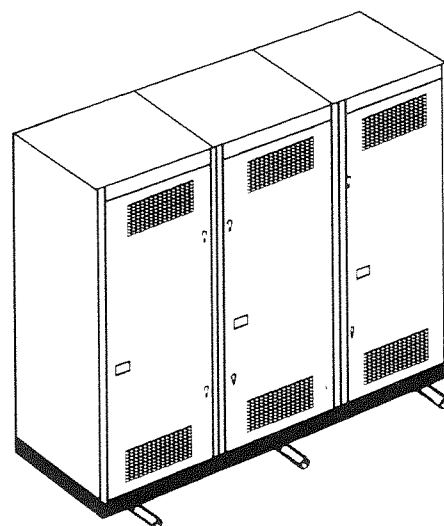


Figure 13.6 - Cubicle Rolling

## 13.5 Cabling GEM 80

### 13.5.1 Tools for Cabling

#### (1) Ribbon Cables

No special tools are required for the installation of factory assembled ribbon cables. Tools required for assembling connectors onto ribbon cables, if the user wishes to assemble his own cables, are detailed in Appendix A.

**Tools are available for hire from GEC Industrial Controls Ltd., Kidsgrove.**

#### (2) Push-on Connections

BICC Pre-insulated terminals are recommended for all push-on type connectors.

Push-on connections are required for connecting +5V, +15V and -15V to the subrack backplane using 6.3mm connectors type BD-B638F.

The recommended tool for crimping these connectors is type BMR2P1.

Connectors and tools are available from:

BICC Components Limited,  
PO Box 4,  
Hall Lane  
Prescott,  
Merseyside.  
L34 5UR.  
Telephone: 051-430-7555  
Telex: 628811

#### (3) Fibre-Optic Cables

Serial Links using fibre-optic cables require special tools and termination methods which are detailed in Appendix B.

### 13.5.2 Safety Earth Wiring

It is essential that the GEM 80 system is properly earthed and a safety earth circuit must be connected. See Figures 11.2 and 13.7 for the location of the earth studs. Safety earth cable must be a minimum of 2.5mm<sup>2</sup> (green/yellow) insulated wire and must be fitted in accordance with the segregation requirements in Section 13.5.4.

### 13.5.3 Signal Ground Wiring

#### (1) Signal Ground Bar

This should be fitted in the controller enclosure. It should be insulated from the safety earth bar as shown in Fig. 13.7. A removable jumper wire should be fitted between the safety earth bar and the signal ground bar. This link should be a minimum of 2.5 mm<sup>2</sup>. The signal ground bar is the local common point for all the enclosure signal ground wires and should be connected to the plant instrument or clean earth system. See Section 13.6 for alternatives/details.

#### (2) GEM 80 0V

This should be run directly from the 0V connection on the controller subrack to the signal ground bar. Minimum wire size should be 1.5 mm<sup>2</sup> run as a VERY CLEAN wire in accordance with the segregation requirements in 13.5.4. Fig. 13.7 shows the location of the 0V connections.

#### (3) Screen Signal Grounds

These should run from signal ground terminals on termination units to the signal ground bar. They should be run with the cable whose screen is being connected to signal ground, and in accordance with the segregation requirements in 13.5.4.

### 13.5.4 Wiring Segregation Within GEM 80 Cubicles

Electrical noise and electromagnetic interference can be introduced into a micro-electronic system through the cables and wires connected to it.

To avoid this, wiring which could carry noise (i.e. dirty cables) needs to be kept away from cables which are sensitive to noise, these cables are then kept 'clean' (i.e. free of electrical noise).

The wiring segregation within the cubicle is shown in Figure 13.8. Wires which fall in the same group can be run together, however, wires falling into different groups cannot be run together although their paths may cross at right angles. Wires of different groups must be spaced apart by at least the distances shown in Figure 13.8.

Spacings may be reduced:

- (1) For runs of less than one metre - spacings may be halved
- (2) Within the vicinity of connections a minimum spacing of 25mm should be aimed for

### 13.5.5 Interconnecting GEM 80

- (1) Connecting Power Supplies - see Section 11 and 5.
- (2) Connecting Verification I/O Highway Ribbon Cable - see Section 5.
- (3) Connecting Watchdog and Safety Circuits - see Section 9.
- (4) Connecting Serial Links Ribbon Cables - see Section 6.
- (5) Other equipment - see relevant Product Data Sheet or User Information.

## 13. INSTALLATION

When using AMELEC or ROCHESTER signal conditioning panels, do not connect the S.G. terminal to ground.

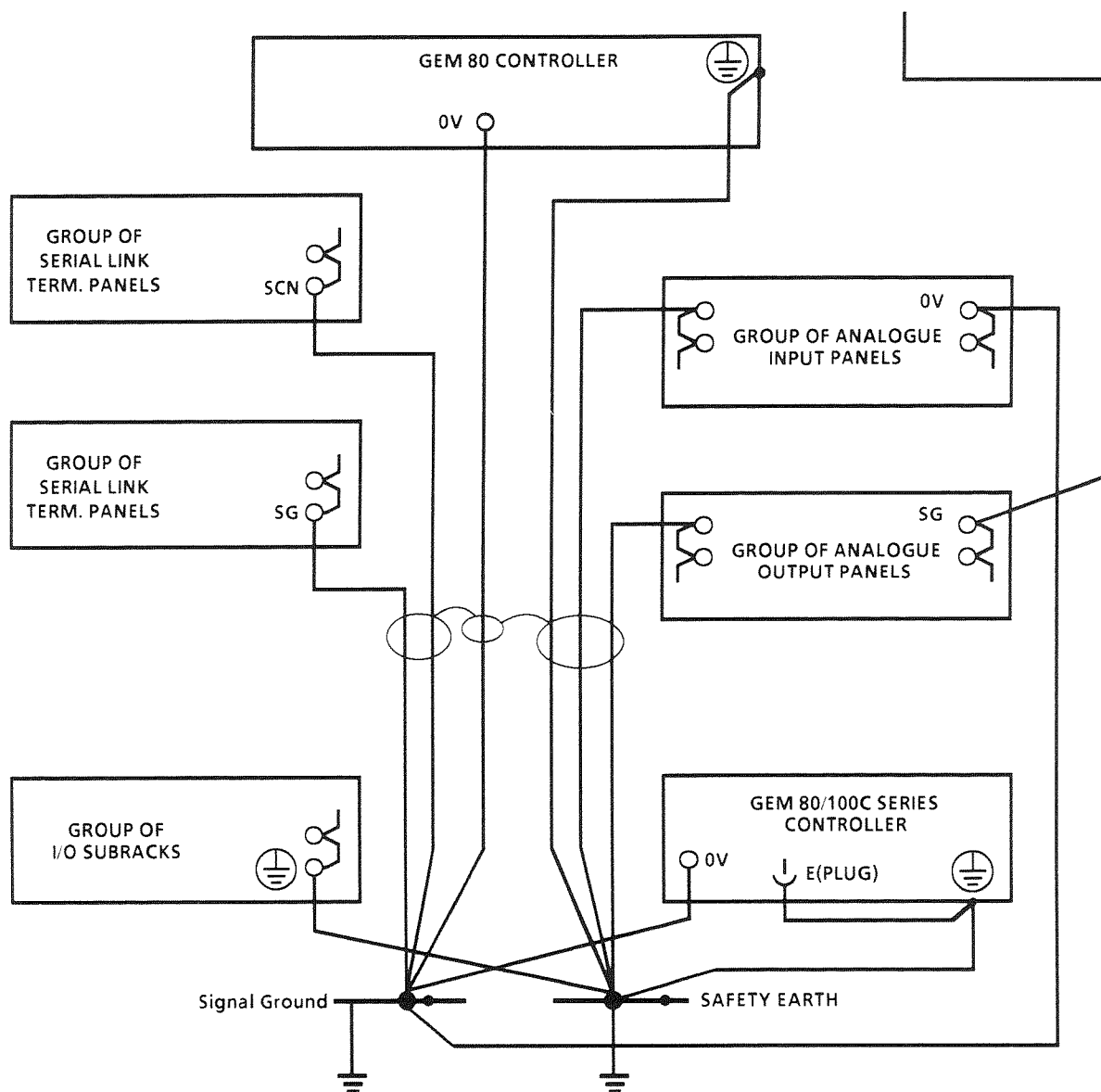


Figure 13.7 - GEM 80/310 Series Signal Grounds and Earthing - typical example

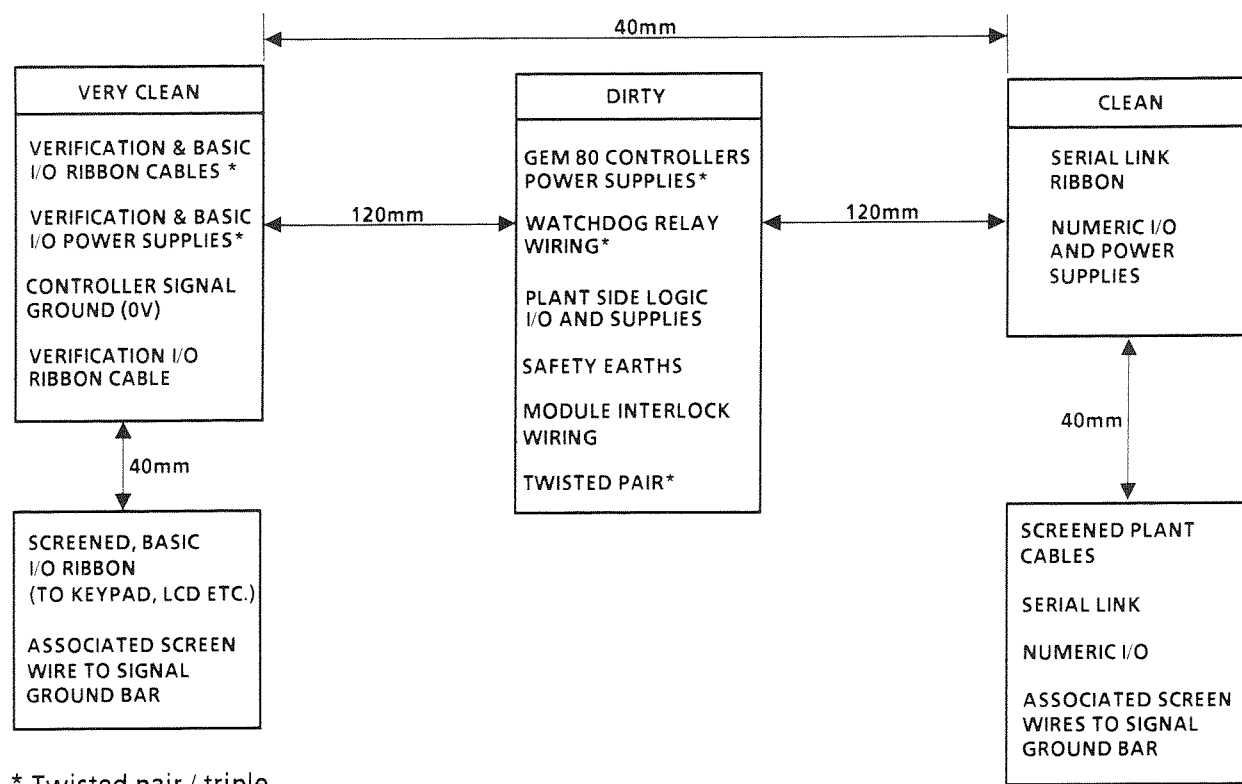


Figure 13.8 - Wiring Segregation

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### 13.6 Plant Cabling External to GEM 80 Cubicles.

#### 13.6.1 General

Conductors of CLEAN groups should NEVER go in the same cable as conductors of DIRTY groups. It is also recommended that CLEAN analog signals are run in a different cable from CLEAN digital signals.

CLEAN cables should be screened. Screened cables should be connected to signal ground at one end only to avoid earth loops. The preferred end is that at which the current or voltage source exists.

#### 13.6.2 Segregation

##### (1) General

The spacing between CLEAN and DIRTY cables should be at least 360mm (i.e. increased by a factor of 3 on spacings within the enclosure).

This distance may be halved (180mm) if the CLEAN and DIRTY cables are run in separate earthed steel conduit or trunking.

The spacings given above may be halved for a cumulative total of 10 metres and at the point of entry to the equipment.

##### (2) Basic I/O Ribbons (to keypad, LCD, etc.)

Should be run in screened ribbon, preferably in earthed steel trunking.

##### (3) Signal Ground

In the majority of applications, the incoming safety earth wire is adequate for signal ground purposes. If it proves inadequate or if the user has a separate clean earth system, a clean earth cable is required.

This should be:

- (1) Run separately from all other cables
- (2) Insulated
- (3) Kept clear of machinery bedplates/mounting brackets, etc., and any other noise generating equipment, e.g. electrical welding machines
- (4) As short as possible and connected directly to the clean earth system or as close to the plant earth source as is practicable
- (5) Run in 4.6 mm<sup>2</sup> cable

#### 13.6.3 Further Information on Plant Cabling

See Table 13.1

Table 13.1 - Plant Cabling

| Unit                                                             | Location of Connections                                     | Size of Conductors                                      | Remarks                                                                                                                                                                                                                                                                           |
|------------------------------------------------------------------|-------------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Compact I/O Subrack                                              | Lower, Front part of individual 8-Point Compact I/O modules | Up to 1.5mm <sup>2</sup> ; - one conductor per terminal | On 8-way I/O modules only, the plastic shroud must be fitted after plant terminations have been made.<br>On 16-way modules, the shroud is integral.<br>On 32-way modules there is a D-Type connector to the terminal rail.                                                        |
| Serial Link Termination Panel (4-wire)                           | Upper, front part of the termination panel                  | Up to 2.5mm <sup>2</sup>                                | Recommended cable is 16/0.20mm twin twisted pairs with overall screen. Maximum serial link cable lengths and recommended types are detailed in User Information Sheets.                                                                                                           |
| Serial Link Termination Panel (2-wire)                           | Lower, front part of the termination panel                  | Up to 2.5mm <sup>2</sup>                                | Recommended cable is 16/0.20mm twin twisted pairs with overall screen. Maximum serial link cable lengths are detailed in User Information Sheets.                                                                                                                                 |
| Fibre-Optical Transceiver Unit                                   | Lower, underside part of the unit                           | See Product Data Sheets under 'Application Notes'       | Termination of fibre-optic cable is made by a Radiall SMA Connector.<br><b>CAUTION...</b> Special techniques/tools are required to terminate fibre-optic cable. See Appendix C. Maximum fibre-optic cable lengths and recommended cables are detailed in the Product Data Sheets. |
| Serial Communications Termination Panel                          | Upper and lower front part of the termination panel         | Up to 2.5mm <sup>2</sup>                                |                                                                                                                                                                                                                                                                                   |
| Analog Termination Panel (used with Analog Input/Output Modules) | Upper, front part of the termination panel                  | Up to 2.5mm <sup>2</sup>                                | See the Product Data Sheets for detailed information on plant terminations.                                                                                                                                                                                                       |
| Contact Input and Lamp Driver                                    | Connections marked PL2 and PL3                              | 34-way twisted ribbon cable                             |                                                                                                                                                                                                                                                                                   |

### 13.6.4 Compact I/O Plant-Side Power Supply Connection

(1) The I/O Subrack plant-side power supply cabling must be protected by a fuse. For 1.5mm<sup>2</sup>PVC insulated (30/0.25) cable, the total maximum current must not exceed 12A at an ambient temperature of 60°C, and must be short circuit protected by a fuse rated at less than 60A. For ambient temperatures above 60°C, the total maximum current taken by the cable must be de-rated accordingly.

(2) I/O module plant-side power supply terminals may be looped together, bearing in mind the load restriction of para 1) above.

\*actual currents depend on the configuration for the system.

### 13.7 Installation of Modules

After cabling, the controller modules can be fitted into the subrack. They contain electro-static sensitive devices and the handling precautions of Section 18 must be observed. The layout of the modules in the controller subracks is shown in Section 1. The slots for the I/O modules are mechanically coded to suit the modules being fitted, therefore, a module only fits into its designated position. These modules must be pushed home into the connectors at the rear of the subrack, so slightly more force is required for the last few millimetres of travel. I/O subracks are also mechanically coded to suit the modules to be fitted.

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### 13.7.1 Module Retention

MODULE RETENTION IS ONLY NECESSARY IN HIGH SHOCK OR VIBRATION APPLICATIONS WHERE THE MODULES COULD BECOME DISCONNECTED.

The subrack has integral sliders at the top and bottom front edges which slide into notches cut into the module p.c.b.s. Open and closed indication is provided by a pointer on the mechanism being positioned opposite the open (○) or the closed (●) symbols marked on the subrack flanges.

Under normal conditions, retention is not required and the sliders should be left in the open position.

However, if module retention is required, the following procedure should be carried out :-

- (1) Ensure the 'slider' is in the open position.
  - (2) Check that each module has a small slot cut into the upper and lower edges of the p.c.b. approximately 10 mm from the front edge.
- Note...** I/O modules may have a blanking plug fitted in the top slot. Before fitting the module into the subrack remove this plug but retain it for future use. Should it be required to insert the module into a metal subrack, the plug must be re-fitted.
- (3) Fit modules into their correct positions in the subrack and ensure that they are all fully inserted.
  - (4) Move the top 'slider' toward the left until the pointer is opposite the closed symbol.
  - (5) Move the bottom 'slider' toward the right until the pointer is opposite the closed symbol. All modules will now be retained in position.

**Note...** Any one module without the cut in the p.c.b edge, still with the blanking plug on or not fully inserted will prevent correct operation of the 'slider'.

- (6) To remove a module, move the upper and lower 'sliders' to the open position and eject the module.

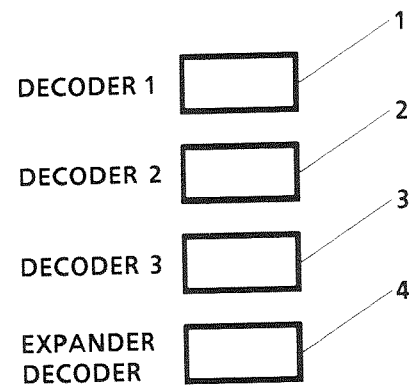
### 13.8 Address Decoder Switches and Address Marking

#### 13.8.1 Address Decoder Switches

The Address Decoder Switches should now be set up, as discussed in Section 5.

#### 13.8.2 Address and Module Label Marking

The data table addresses can be written on the self-adhesive label which is supplied loose for the user to stick on the inside of the right-hand cheek of the subrack, see Figure 13.9. Module type and order numbers should be written on to the lower rail 'slide in' labels of the I/O subracks.



1. Decoder Switch Setting S1
2. Decoder Switch Setting S2
3. Decoder Switch Setting S3
4. Expander Decoder Switch Setting

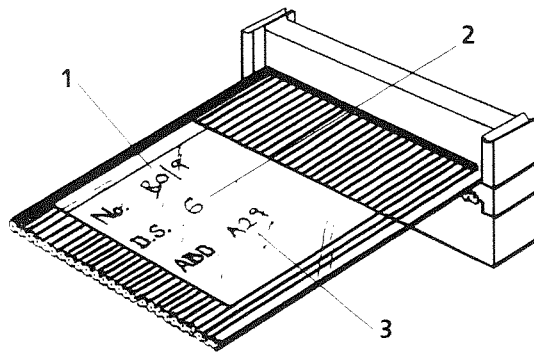
Figure 13.9 - I/O Subrack Label

### 13.8.3 Ribbon Cable Connectors

There is a self-adhesive strip label on the cable next to the connector which has a 'write-on' area for identifying where it connects to and other information, see Figure 13.10 for details.

If extra labels are required, they are available from GEC Industrial Controls on:

Order Ref. 20T0094/01 (10 labels per sheet).



1. Cable Destination (Subrack/Slot No. or Plug No.).
2. Decoder Setting of panel into which Cable plugs (if applicable).
3. Half Panel Address or Address range (if applicable).

Figure 13.10 - Typical Example of Ribbon Cable Labelling

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## 13. INSTALLATION

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## 14.1 Introduction

Your GEM 80 Controller and I/O will have been configured to meet your particular requirements. It is extremely unlikely that these requirements are the same as those of other GEM 80 customers. Therefore, we can only give you general commissioning procedures rather than specific ones for your particular system.

However, you should easily be able to pick out the parts of the procedures listed below which are relevant to your particular system.

## 14.2 Preparation

Before you start commissioning your GEM 80 system, you should already have:

- Installed the equipment and cabled it up, including all earth (ground) connections as given in Section 13 of this manual.
- Cabled up the watchdog and safety circuits in accordance with the guidelines given in Section 9 of this manual and - most important - checked out the operation of these circuits (see Section 14.5 below).
- Plugged in all modules, taking adequate care about how you handle them (see the Safety and Handling Precautions in Section 18 if you don't know the rules to observe). If for any reason a module will not plug in, it is highly likely that you are trying to fit the wrong type for the particular slot in the subrack, and the mechanical interlock is preventing you plugging it in. In this case, don't try to force the module in, but first check that the module ordering code agrees with that given on the subrack label.
- A Programmer unit, with a stock of spare cassettes or disks to suit the model of Programmer.

## 14.3 Documents Required

While commissioning, you should have the following documents readily to hand :-

- GEM 80 Programmer Technical Manual for the particular model of Programmer you are using.
- GEM 80 Ladder Diagram Programming Manual, Publication T300.

These will allow you to write test programs for checking out the equipment. In addition, you will need User Information leaflets or Technical Manuals, depending on your system configuration, for:

- Basic I/O modules.
- Verification I/O modules.
- Fast I/O modules.
- Extra central modules (such as IMAGEM videos).

## 14.4 Overview of Commissioning Procedure

To commission a GEM 80 system, you need to check out everything to eliminate errors. The larger the system, the more things there are to check.

For instance, the cabling people may have connected wires to the wrong terminals. They may have only made one mistake in every thousand terminations, but that's enough - your system won't work the way you expected it to until the error has been put right. If not checked, your system might even cause serious machinery damage by switching on wrong outputs.

So, commissioning requires a methodical, painstaking approach. Don't try to speed up the procedure by cutting corners, or you'll land yourself with problems. The basic principle is to start off with a small amount of equipment, check it out thoroughly, and then, when you're 100% certain that it all works, add on a bit more equipment, check that, and so on. The way we recommend is as follows :-

- Check the hard-wired safety circuits into which the watchdog operates.
- Check the power module.
- Add to this the master I/O processor, ladder processor, and the memory that will contain the ladder program.
- Add to this the basic I/O, inputs first, then outputs.
- Add to this the verification I/O, inputs first, then outputs
- Add to this the fast I/O, again inputs first, then outputs
- Add to this serial links to other Controllers, printers or VDUs
- Add to this any extra central modules, such as off-line data storage memory, videos and associated memory modules, STARNET interface modules, etc.

## 14.5 Safety Circuits Checks

1. If possible, remove the control supply that feeds the safety circuit. If, however, this circuit is continuously energized from a main circuit breaker which cannot readily be opened during commissioning, break the circuit using any convenient contact that can be held open, such as a stop lock-off emergency stop push-button. This is one reason why the watchdog follower relay coil should be connected at the neutral end of the circuit.
2. Check with a multimeter that there is no voltage, relative to ground, on either of the watchdog terminals on the GEM 80 Controller subrack and that they are safe to work on. Then, connect a shorting link across these terminals.

## 14. COMMISSIONING

3. Re-connect the supply to the safety circuit.
4. Check that the watchdog follower relay energizes.
5. Operate each contact in the safety circuit in turn, one at a time.
6. Check that in every case the watchdog follower relay drops out, and re-energizes when each contact is re-made.
7. Break the supply as in paragraph 1 above, remove the shorting link across the watchdog contacts, and then re-apply the supply again.
8. Check that the watchdog follower relay remains de-energized.
9. For further stages in commissioning, especially if your GEM 80 Controller drives moving machinery, you should have an emergency stop push-button sited close to where you are working that you can use as a panic button. If there isn't one there, you may want to install one. Connect it in series with the rest of the safety circuit, and check it out in the same way as you did for all the other contacts.

### 14.6 Power Module Checks

1. Disconnect all I/O equipment by unplugging from the subrack which contains the processor modules:
  - Verification I/O ribbon cables;
  - any Serial I/O ribbon cables, and
  - any Fast I/O ribbon cable.
2. Withdraw all modules from the Controller subrack sufficiently to break their edge-connector connections. The front panel of each module should be, say, about 30mm from the front face of the subrack.
3. Check that the power module is of the correct type, that is, check its voltage and whether it is suitable for a.c. or d.c. or both.
4. Check also that the type number on the power module agrees with the subrack identification for its position.
5. Check that the switch on the power module front panel is set to 'OFF'.
6. Push the power module fully home into the subrack. Switch on the power to the subrack.
7. Check that the POWER indicator lamp on the power module is ON.
8. Set the switch on the power module front panel to ON.
9. Check the LED indicators for healthy conditions.
10. Set the switch on the power module to OFF. Remove the power input.

11. Check that the POWER indicator lamp on the power module is OFF.
12. If your system has more than one power module, repeat the above procedure for each one, finally leaving all power modules OFF.

### 14.7 Basic Central Modules

1. Plug the Master I/O Processor, Ladder Processor, and ladder program memory modules into the subrack. You can find their locations from Figs. 1.1 to 1.3, which show the hardware layout.
  - If your Controller is a 384K or 512K model, you must plug in both the memory modules shown in these diagrams.
  - If your Controller is a 192K or 256K model, you must plug in only one memory module; this will be at slot 15 on a /311, at slot 12 on a /312, or at slot 6 on a /313.
  - If your Controller has any additional memory modules not shown in these diagrams, they must not be plugged in at this stage of commissioning.

**Note...** On the 384K models, the two memory modules are different (one 256K and one 128K). The 128K module must be the left one of the two on /311 Controllers, and the right one of the two on /312 and /313 Controllers. On the 512K models, the two memory modules are both 256K and identical.

2. Check that the lithium/copper-oxide batteries on the Read Write memory modules are connected.
3. Check that the ordering code of each module agrees with that shown on the lower subrack label strip.
4. Power up the Programmer unit that you are going to use.

**Note...** If this is an 8920 Portable Programmer, check the voltage and frequency of your supply before connecting the Programmer, and set it up appropriately first. See the 8920 Product Data Sheet, Publication No.T420, for details. System Programmers 8922/8940/9022 do not require any setting up.

5. Connect the Programmer to any peripheral equipment such as printers. Power this equipment up, first setting it to the correct voltage/frequency as the equipment requires.
6. Connect the Programmer to the I/O processor module in the subrack using the lead that is terminated by a 15-way, D-type connector at each end. Connect the cable end marked 'GEM 80' to the socket on the front panel of the I/O processor module in the Controller, and connect the end marked 'PROG' to the Programmer. This lead is not reversible; if connected incorrectly, you will not be able to communicate correctly between the Programmer and the Controller.

7. Insert the key in the Programmer key-operated switch and obtain the 'PROGRAM' mode. If you don't insert this key it will only be possible to monitor the GEM 80, thus preventing you from entering or editing programs.
8. Re-connect the power input to the subrack(s). Power up the GEM 80 equipment, then set the switch(es) on the power module(s) in the subrack(s) to ON. When the GEM 80 is powered up, a sequence of program self-testing commences.

**Note...** Where your system contains more than one power module, you must set all their switches to ON, as they are cross interlocked. The self-testing sequence only commences after you have switched the last one ON. It makes no difference in what order you operate the switches on the separate power modules.

9. Check the watchdog sequence as follows :-

Using the Programmer, select the mode allowing monitoring/editing of GEM 80 ladder diagram rungs. To keep these procedures brief, we won't usually explain what keys you need to press to get to a particular mode; see the Programmer Technical Manual for details). Then, in the command mode, select 'C' for the CLEAR STORE command.

**Note...** On the 8920 Portable Programmer, 'command mode' is referred to as 'control mode'.

- a) Check reply on the Programmer.

- If there is no link failure, the reply will indicate '310 IOP', in which case skip to check at b).
- If no link is established, the screen will show 'NOT CONNECTED TO GEM 80'. If a link is established but fails subsequently, it will show 'LINK FAILURE'. In either case, continue with the checks below.
- i. Power any of the power modules OFF and ON again, to re-initiate the start up self-test routine. Repeat the CLEAR STORE command from the Programmer.
- ii. Check the reply to see if the link failure has cleared. If so, continue with the checks at b) below.
- iii. If the link failure is still present, check that:
  - the Programmer set-up is correct. (refer to the Programmer Manual, Publication No.T298)
  - the Programmer is correctly plugged into the processor module (as given in paragraph (6) above);
  - the power module is still operating;
  - all subrack modules are correctly plugged into the subrack;

- no pins have been bent on any of the connectors at the rear of the modules.
- iv. Repeat items i. and ii. If the link failure has cleared, skip to checks at b).
- v. If none of these checks succeed, remove each memory module and pull off the connections from the battery. Short together the leads that previously went to the battery. Leave for 10 minutes, then re-connect the battery and replace the memory module.
- vi. Repeat items i. and ii. If the link failure has cleared, skip to checks at b).
- vii. If this check doesn't succeed, replace the I/O processor with another identical processor module, and repeat items i. and ii. above. If the link failure has cleared, proceed with checks at b) below.
- viii. If this check doesn't succeed, replace each memory module with another identical memory module which has had its battery disconnected as in item v. above, and repeat items i. and ii. above. If the link failure has cleared, proceed with checks at b) below.

- b) Put the Controller into 'RUN' mode.

**Note...** If the memory module has previously been used on another controller, and if the contents have not been cleared out, you could get the controller coming up in the RUN condition. If so, put the controller into HALT and then instruct it to RUN.

- c) Check that the watchdog lamps on the I/O processor light and go out a number of times, finally remaining lit.
- d) Check that, at the same time, you can hear the watchdog relays click in and out, finally remaining energized.
- e) Check also that, if there are no breaks in the safety circuit such as emergency stop push-buttons operated, the watchdog follower relay does indeed follow what the watchdog relay is doing, and also finally remains energised.
- f) Satisfactory completion of the watchdog sequence indicates that the GEM 80 system self-checks are healthy. Switch the power module to 'O' in the subrack that contains the processors.
10. If your Controller has a second I/O processor, referred to as the slave I/O processor, plug this in at the appropriate slot and repeat the tests above, starting at paragraph (3).

## 14.8 Loading an Initial User Program

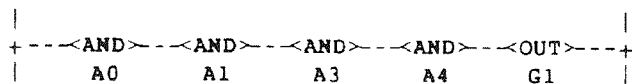
The GEM 80 Controller will not scan the I/O until a suitable user program is entered. Therefore a user program must be loaded before any I/O checks can be made. This program could be the actual one to be used for controlling the plant, or it could be a much simpler and shorter program which is keyed in as the I/O is checked. It is assumed here that a program is keyed in as the checks proceed.

1. Connect the Programmer as given in Section 14.6.
2. Power up the Controller.
3. Key in a program and P-table data as required.
4. Re-compile the program. If you don't want to run the controller, you can do this with the SINGLE CYCLE command.
5. Switch the power OFF.

Each time in future that you want to modify the program, e.g. by adding further rungs, go into the edit mode, perform your modifications, then re-compile the program.

## 14.9 Verification and Basic I/O Logic Inputs

The GEM 80 series controller only scans I/O that is referred to in the user program. You can therefore begin by putting in a rung which contains a number of A-table references and outputs to an internal trash can workspace table location (e.g. G1), such as:



Each A-table word reference is adequate to cause the Controller to scan all the bits contained in it. Thus, including the reference to A3 causes the controller to scan all the bits from A3.0 to A3.15.

1. Check that the address and range switches are correctly set up on the 8191 Verification I/O Expander for the particular inputs you want to check.
2. Check the address switches on the Verification I/O modules.
3. Check address decoder switches are correctly set on 8859 I/O subrack backplanes relevant to the particular inputs you want to check.
4. Re-connect the I/O ribbons cables at the controller.
5. Check that Basic I/O ribbon cables from expanders to subracks are complete.
6. Check plant cabling is completed to the Verification and Basic I/O equipment and to the plant input transducers.

7. Apply plant-side power to I/O input transducers but NOT to I/O output equipment.
8. Power up GEM 80 Controller.
9. Set the Programmer connected to the GEM 80 to the 'MONITOR/EDIT GEM 80 AS DATA LIST' mode.
10. Select the ADDRESS ENTRY mode.
11. Enter input references you want to check, e.g. A6.0, A7.1, etc. You obviously cannot check more than a screenful at once.
12. Press ESCAPE and then select MONITOR mode.
13. Operate the plant devices one at a time.
14. Check that each input state can be seen to change on the Programmer screen when the corresponding plant device is operated.
15. Check also each input by LED indication on the module front panel.

If checks 14 and 15 both fail for an input device, you may have:

- a cable terminated on a wrong terminal or wrong module. Check the input LEDs to see whether another one changes state that ought not to.

If check 14 only fails, you may have:

- a decoder switch wrongly set on either an I/O subrack or a verification I/O expander.
- a ribbon cable not plugged in.

Of course, if check 14 fails but not check 15, another possibility is that you haven't included a reference to the relevant A-table word in your test program.

### 14.10 Other Verification and Basic I/O Inputs

1. If you have any analog inputs, you can in some cases vary the input signal that the transducer provides. In other cases where you can't, you may have to disconnect the transducer temporarily and simulate its output.
2. Check that varying each analog input signal is registered as a change in value in the appropriate A-table word.
3. Check also that the values and changes of value are of the correct polarity; this is most important if you are going to use the signal as the input to a closed loop control. If the polarity is wrong, you can usually put it right by interchanging the connections on two adjacent terminals on a termination panel or terminal rail.
4. If you have any counters, and assuming that pulses are generated by a rotary transducer, spin the pulse generator by whatever means you can provide.
5. Check that the relevant A-table word counts up. If, however, you are using a bi-phase input, check that rotation in one direction causes counting up and in the other direction causes counting down. Check that counting up occurs for the correct direction of rotation; this is most important if you are going to use the signal as the input to a closed loop position control. If the polarity is wrong, you can usually put it right by interchanging the connections on two adjacent terminals, for one of the two phases only, on a termination panel or terminal rail.

**Note...** Once you have included a C-table reference in your program, the GEM 80 starts scanning the Fast I/O. If you have plugged in just the Fast I/O Driver module but no Fast I/O modules, then, once scanning starts, you will get a Fast I/O failure error message.

6. Set the Programmer to the DATA LIST mode, and monitor the C-table addresses you are using. Only a few of these addresses will actually appear in your user program.
7. Carry out tests generally along the same lines as for basic I/O input. The only difference is that, with Fast I/O, all changes to inputs cause changes to the values in C-table rather than A-table.
8. Additional types of modules in the Fast I/O range which have no equivalent in the I/O range are serial comms modules and dedicated controller modules.

The details of these are a bit complicated compared with normal input modules. Rather than unduly extend this Section of the manual, we recommend you to study the User Information leaflets for these modules.

### 14.11 Fast I/O Inputs

If your Controller does not include any Fast I/O input modules, skip to Section 14.13.

1. Switch OFF those power modules that feed the processor subrack and any separate Fast I/O subrack.
2. Insert the Fast I/O Driver module in the processor subrack.
3. Plug in any Fast I/O input modules.
4. Switch on the power modules again. Assuming that the controller was previously running, it should come up running again.
5. Write one or more rungs into your test program that refer to the highest C-table address used by each Fast I/O input module. You do not have to declare every one, as you had to with A-table for the basic I/O inputs, but only the highest one per module.

## 14. COMMISSIONING

### 14.12 Verification, Basic and Fast I/O Outputs

When you have proved as many of the Controller inputs as practical, we recommend you to run a user program that drives the outputs. As before, this could either be your actual program, but is more likely a program you write as you go along just for testing.

Make sure that you still have no plant-side power connected to the output modules. With the Programmer set to the monitor mode, check the way that your program tries to drive I/O outputs by looking at B-table addresses for Verification and Basic I/O and D-table for Fast I/O addresses.

Check also that indicator lamps light on the corresponding I/O output equipment when outputs are driven high by B-table or D-table bits that are '1'.

### 14.13 Connecting Output Equipment

Once you have checked the outputs and found them to operate correctly without plant-side power, the next stage in the commissioning procedure is to connect the plant-side power to them.

As for inputs, you should check that, when you set a particular B-table or D-table bit to '1', the corresponding coil or solenoid energizes. The purpose of the checks, as for inputs, is to verify that all cabling has been correctly carried out.

Check also that no 'fuse blown' indicator lamps light. If one is lit, replace the relevant output module. If, immediately after replacing a module, the fuse blows again, you are probably attempting to drive a load that is not correct for the module's output rating.

### 14.14 Loading the User Program

Once you have checked all the inputs and all the outputs, you are in a position to load the actual program that you or your colleagues have written to control the plant. You can do this from disk or tape via your Programmer.

In exactly the same way as for commissioning the hardware, you need to commission your program in a similar fashion. Don't expect it all to work first go. Commission a small part of the program first, check it as near to 100% as possible, add on a bit more, and so on.

For further tips about program testing, refer to the GEM 80 Ladder Diagram Programming Manual, Publication No.T391.

For the design, setting up and commissioning of closed loop controls, refer to the GEM 80 Closed Loop Control manual, Publication No.T450.

### 14.15 Dedicated Control Modules

Once the main controller program is running, you can commission dedicated controller modules by a similar procedure. That is, check the inputs to the module, check the outputs without plant-side power, then with plant-side power, and finally load and commission the actual program for the module.

**Note...**Dedicated control modules do not include all the features that a GEM 80 Controller has. For instance, you cannot perform on-line program re-compilation. You have to halt the control module each time you want to make a program change.

### 14.16 Serial Links

If your system uses serial links, it is recommended that the system is first run without the serial link connected. If, as a result, the program has to wait for serial link data, you can temporarily alter your program for commissioning purposes to by-pass the section of program that causes problems (that is, put it within START OF BLOCK and END OF BLOCK instructions). Once you have proved that the system satisfactorily works without the serial links, you can connect the serial links again.

**Note...**The Tx lamps on the I/O processors light when these modules attempt to transmit, even if no serial link connections are made.

There are several types of serial link. To keep this Section reasonably brief, we cannot tell you in detail how to commission every individual type. Section 6 of this manual tells you what data to pre-set in P-table for the various types of link.

Several examples of the P-table pre-set data for such varieties of serial port are given in the Serial Communications Manual, Publication No.T457.

#### 14.16.1 Printer Ports

For outputting data to a printer or VDU, include in your program the PRINT Special Function. You must have pre-set the port so that it agrees with what the printer is set for, as regards:

- the data rate (bit/s),
- the character format (quantity of bits/character, odd/even/no parity), and
- any null characters required at the end of a print line (not normally needed on printers which have input buffer memory).

If these are correct, you should be able to output data messages from your program to the printer or VDU.

#### 14.16.2 20mA ESP Serial Links

With a serial link providing communications between different GEM 80 Controllers, you must have commissioned all the controllers before you can fully commission the serial link.

The simplest form of serial link is free-running with standard table allocation. For this type of link, if you place data into the K-table locations at the controller providing the Control port, it should appear in the appropriate J-table locations at the appropriate Tributary. Similarly, if you have placed data into the K-table locations at one of the Tributaries, the Tributary should reply, and the data should appear in the appropriate J-table locations at the Control port.

For more sophisticated types of serial link, you will also need to set values and bits in appropriate locations in I-table to initiate transmission, or to set message destinations.

As with printer ports, Control and Tributary ports only work if they are set to the same data rate.

#### 14.16.3 Further Details

Refer to Section 6 of this manual for the P-table settings you need. See also the section on serial links in the GEM 80 Programming Manual for an introduction to 20 mA ESP serial links. For further details on these, printer ports see the GEM 80 Serial Communications Manual, Publication No.T457

#### 14.17 A Few Final Comments

In the preceding paragraphs, we have not been able to tell you how to commission every type of unit or module you might have in your GEM 80 system - the range is too vast and continuing to grow. However, we hope we have given you a sufficient introduction to commissioning for you to be able to see how, with the help of User Information leaflets and Manuals for particular products, you can commission any modules and units that have not been mentioned.

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## 14. COMMISSIONING

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## 15.1 Introduction

Wherever the fault in the system, the GEM 80 has built-in comprehensive fault finding facilities to indicate possible causes of the fault, not only throughout the plant but also within the GEM 80 itself.

If a fault is detected which does not allow the controller to continue running, watchdogs are tripped, the controller halts, and the fault is reported as a code number and an English language text message. This message is displayed when the programmer is connected. For example:

```
#601 CRC NOT STORED,
PROGRAM MAY HAVE CHANGED
```

Not all error messages halt the controller, e.g. compilation errors which are for information. Error messages are covered in more detail in Section 15.2.

In addition to the error messages there is a data table which contains additional data for fault analysis and an area of memory which the user can program and document himself for fault analysis of problems in the plant. This data table, called the F-table, is covered in Section 10 and later in this Section.

Indicator lamps and monitoring and test facilities are also available as detailed later in this Section.

## 15.2 Error Messages

Error Messages fall into five groups as shown in Table 15.1:

**Table 15.1 - Error Messages**

| Error Message Number | Type of Error Message                 | Refer to Section No. |
|----------------------|---------------------------------------|----------------------|
| # 100 to # 199       | Compilation Errors                    | 15.5                 |
| # 600 to # 699       | System Status                         | 15.6                 |
| # 700 to # 799       | Self-test Failures                    | 15.7                 |
| # 800 to # 899       | Interprocessor Communication Problems | 15.8                 |
| # 900 to # 999       | System Errors                         | 15.9                 |

The error messages use the following abbreviations to identify processors:

M-IOP = Master I/O Processor (1st I/O Processor)

S-IOP = Slave I/O Processor (2nd I/O Processor)

LDP = Ladder Processor

## 15.3 Indicator Lamps

Where a fault is evident, a quick guide to the state of the system can be obtained from the front panel indicators.

Controllers have monitoring lamps mounted on module front panels. Section 2.3 details the meaning of these lamps.

Basic I/O modules have fuse indication lamps. On Input modules, indicator lamps show the plant side state. On Output modules, the indicator lamps show the GEM 80 logic side state. See User Information for details.

The indication lamps give an idea of which parts of the system are faulty, and where the power module is healthy more detailed analysis of the problem is required.

## 15.4 Monitoring and Test Facilities

It is possible to monitor program execution while the GEM 80 is running, subject to observing the safety precautions detailed in Section 18 of this manual.

Full connection details and information on the monitoring facilities available are in the Technical Manual for the System Programmer. Publication Number T298.

## 15.5 Compilation, Compiler Error Messages (# 100 to # 199) and I/O Scanning

### 15.5.1 Compiler Error Messages (# 100 to # 199)

These errors do not halt the controller, and the old program continues to run. Table 15.2 details the compiler error messages.

## 15. FAULT FINDING

### 15.5.2 Compilation Checks

On compilation, the controller makes the following checks :-

- 1) Matching data-table sizes to program requirements by searching for the highest specified location in each table.  
**Note...**1. This does not take into account blocks of data used by Special Functions where only the first location is specified. If such a block of data is at the end of a table, a specific reference must be included to create a large enough table. 2. Also note that existing data table locations no longer required by a program (because rungs have been deleted) are removed.  
This can create confusion in the case of the P-table since they may be created simply by attempting to access them through a programming unit. Consider the situation where an address list containing P1000 has been created and the value 21 written to it. The program (which contains no reference above P500) is then re-compiled.

On re-entering the data list mode, the message INVALID ADDRESS is displayed. If the list is cleared and P1000 re-entered, it will be found to contain 0 and not 21. This is because P1000 had been deleted on re-compilation, but then recreated when the data list was renewed.

- 2) Generating and checking the I/O configuration data for Verification and Basic I/O.
- 3) Checking the legality of data-table accesses, e.g. (OUT) to a P-table is not allowed.
- 4) Varying the structure of the user program, e.g. depth of nesting of Obey Blocks.
- 5) Checking the correctness of VALUE instructions with COUNT, DELAY and special functions. This checking ensures that if a VALUE is required, it is present and of an acceptable type (e.g. write-enabled data table).
- 6) Checking that there is a Start of Block instruction for every End of Block instruction and vice versa.

### 15.5.3 Error Messages #105 and #106 and I/O Scanning

#### I/O Scanning

In a similar way to computing the sizes of data tables, so also a GEM 80 controller computes what I/O ought to be present from the addresses appearing in the user program. It only attempts to read input data from, and send output data to those I/O devices whose addresses appear in the program. The rules the controller uses in its computation of which I/O table words to scan are given below.

#### Verification and Basic I/O

Only those I/O words appearing in the program are included in the I/O scan. For instance, if the program contains a contact referenced A1.0, the whole word A1 is read from the input modules and units.

If you fit a module and set it to an address which is not referred to in your program, this module will not be scanned. Data will not be read from or written to it.

When you attempt compilation, your program will not run if you have used forbidden addresses in your program, and the Programmer screen will display a diagnostic message.

Forbidden addresses are where A-table and B-table addresses have the same number (e.g. A4 and B4) and where addresses have a number greater than the maximum imposed by the hardware.

#### Fast I/O

Each Fast I/O module slot in the controller's subrack or subracks is allocated a possible 32 C-table and 32 D-table words. Thus, the first Fast I/O slot can use C0 to C31 and D0 to D31; the second slot can use C32 to C63 and D32 to D63, etc. The lowest table addresses for any given slot are referred to as the 'base addresses', e.g. C0 and D0, C32 and D32, etc.

In the absence of any configuration data for Fast I/O in P-table, the controller assumes that each Fast I/O module is of single width. In this case, Fast I/O addresses are included in the scan starting from the base address for a particular module slot, and continuing to the highest address included in the ladder program for that module. The computation then jumps to considering addresses beginning at the base address for the next module slot. The controller works out which C-table and which D-table addresses are to be included in the scan.

You must, however, set configuration data in the P-table to declare the positions of any Fast I/O modules requiring status linking. The controller assumes modules to be of double width, using up to 64 C-table words and 64 D-table words.

For example, the inclusion of address C47 in the ladder program would normally cause addresses C32 to C47 inclusive to be scanned. If, however, the first slot was configured for a double width module then addresses C0 to C47 would be scanned.

When compilation is attempted, the program will not run if an invalid Fast I/O address is used because of lack of response from the invalid address, and a diagnostic message is displayed on the Programmer screen.

#### 15.5.4 Programming Routine for Correction of Compilation Errors

To correct a program with several errors the user should use the 'Search' facility to display and modify the first faulty rung. A re-compilation will then give information about the next error. This procedure may be repeated until the program compiles successfully.

**Note...** A single error may cause several to be reported, e.g. an incorrect I/O reference.

If the compilation is successful, the following message is displayed on the programming unit screen for 15 seconds :-

```
"Compiled. Memory Used:
Source  ss.ss%.
Object  oo.oo%.
Data    dd.dd%.
```

This message can be used in conjunction with the V-table to calculate the amount of memory used and memory available. V-table locations V-62, V-63, and V-64 give the number of 1 kbyte blocks allocated to each of 'source', 'object' and 'data' respectively.

The amount of memory available for object code is fixed according to the type of controller and the quantity used can be calculated from the percentage given in the compiled message.

The source and data have a movable boundary between them, and after a recompile, the source is allocated the minimum possible number of 1 kbyte blocks, with any spare blocks being allocated to the data tables (V64).

#### CAUTION...

It should be noted that if the only reference to a B-table is deleted from a program and a re-compilation performed, the I/O hardware associated with that table will no longer be scanned. This could result in outputs being left in an uncontrolled state until the next power up.

## 15. FAULT FINDING

Table 15.2 - Compiler Error Messages

| CODE  | Fault Message                                                            | Possible Causes                                                                                                                                                                                                                                                                                                                            | Recommended Recovery                                                                                                                                                                                                                                                                                                                      |
|-------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| # 101 | SOURCE CORRUPTION<br>ERROR NEAR INSTRUCTION (data),<br>(data) TOTAL      | Could be caused by loading corrupt tape.<br>Could occur whilst programming, i.e. if lead becomes disconnected whilst inserting a complex rung.                                                                                                                                                                                             | Use back-up tape.<br>Re-edit program with lead connected.                                                                                                                                                                                                                                                                                 |
| # 102 | OBJECT RAM FULL.                                                         | Program too large for store.                                                                                                                                                                                                                                                                                                               | Reduce program size.<br>Add additional memory if capacity is available.                                                                                                                                                                                                                                                                   |
| # 103 | BLOCKS OVER NESTED.<br>ERROR NEAR INSTRUCTION (data),<br>(data) TOTAL    | Maximum depth of nesting is 16.<br>End of block command overlooked.                                                                                                                                                                                                                                                                        | Reduce nesting of blocks. Insert missing end of block command, if applicable.                                                                                                                                                                                                                                                             |
| # 104 | DATA TABLE RAM FULL.                                                     | Combined size of instruction source code and data tables is greater than 32,000 words (approximately).<br>Use of large table location references, possibly accidental.                                                                                                                                                                     | Compact data and use smaller data table refs., if possible. If occurs after a large edit, dump to tape, clear store and reload. If necessary after above, reduce quantity of user instructions.                                                                                                                                           |
| # 105 | BASIC I/O Ref.<br>ERROR NEAR INSTRUCTION (data),<br>(data) TOTAL         | Same word referred to as both input and output, e.g. cannot refer to A0 and B0 in same program.<br>Reference over table limit (1,023 with one I/O processor, 2,047 with two).<br>Program may have been written to use two I/O processors and only one is present.<br>Expander unit for referenced I/O may have address set up incorrectly. | Words must be either input or output, not both.<br><br>Change to within limits or add second I/O processor, if necessary.<br><br>On power up, if S-IOP has been removed, the controller will halt. If the power is removed and the S-IOP replaced, the controller will restart in the running state.<br><br>Re-set expander unit address. |
| # 106 | FAST I/O FAULT OR Ref.<br>ERROR NEAR INSTRUCTION (data),<br>(data) TOTAL | Module missing or cannot respond as required (cannot output to an input module).<br>Reference over table limit.<br>May be a faulty/missing I/O driver.                                                                                                                                                                                     | Insert module, or change program/module to correct I/O.<br>Change to within limits.<br>If problem persists, substitute spare.                                                                                                                                                                                                             |

Table 15.2 continued

| CODE  | Fault Message                                                                  | Possible Causes                                                                                                                                                                         | Recommended Recovery                                                                                                                                                                                                                            |
|-------|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| # 107 | SPECIAL (data) NOT INCLUDED.<br>ERROR NEAR INSTRUCTION (data),<br>(data) TOTAL | The specified special function is not available in the controller.<br>Special reference number entered wrongly.                                                                         | Change for defined special, if possible.<br>Edit program.                                                                                                                                                                                       |
| # 109 | INVALID ADDRESS IN VALUE.<br>NEAR INSTRUCTION (data), (data)<br>TOTAL          | Non-existent address specified for VALUE.<br>Writing to a write-protected block or table.<br>Insufficient tables after that in the VALUE table for parameter block of Special Function. | Change to valid address.<br>Change to a write-enabled table.<br>Ensure highest table reference creates sufficient space.                                                                                                                        |
| # 110 | WRITE PROTECT VIOLATION.<br>ERROR NEAR INSTRUCTION (data),<br>(data) TOTAL     | Cannot output to P- or V-tables.                                                                                                                                                        | Alter address to write enabled data table.                                                                                                                                                                                                      |
| # 111 | ILLEGAL J/K REFERENCE.<br>ERROR NEAR INSTRUCTION (data),<br>(data) TOTAL       | Attempting to access a J/K table associated with a non-configured port, or one configured as a printer, or a reference over the table limit.                                            | Configure port correctly, or change address to a different table.<br>If port configured as a printer, then J/K tables corresponding to that port cannot be used.<br>If referencing outside the table limit, then alter to be within the limits. |
| # 112 | ILLEGAL S/T REFERENCE.<br>ERROR NEAR INSTRUCTION (data),<br>(data) TOTAL       | S or T-tables used other than in special function call. Note :- may be trapped by portable programmer.                                                                                  | S and T tables can only be used in special function calls.                                                                                                                                                                                      |
| # 113 | REFERENCE OVER TABLE LIMIT.<br>ERROR NEAR INSTRUCTION (data),<br>(data) TOTAL  | Attempt to read/write from non-existent location in a fixed size table (E,F).                                                                                                           | Alter instruction to be within the limits.                                                                                                                                                                                                      |
| # 118 | INVALID OFF-LINE DATA FILE SIZE.<br>BLOCK No.[data]                            | Maximum range is = 32,000                                                                                                                                                               | Enter correct value in P-table.                                                                                                                                                                                                                 |
| # 119 | INSUFFICIENT MEMORY FOR<br>OFF-LINE DATA                                       | Configuration in P-table incorrect.<br>Memory module missing or failed.                                                                                                                 | Enter correct value in P-table<br>Check module and replace if necessary.                                                                                                                                                                        |

## 15. FAULT FINDING

Table 15.2 continued

| CODE  | Fault Message                            | Possible Causes                                                                                     | Recommended Recovery                                |
|-------|------------------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| # 120 | VALUE INSTRUCTION PRESENT - NOT REQUIRED | Value instruction is present after Special Function which is not needed                             | Delete value instruction                            |
| # 121 | NO FLOATING POINT VARIANT POSSIBLE       | Instruction cannot use floating point data                                                          | Convert to integer before input to Special Function |
| # 122 | INSTRUCTION CANNOT ACCEPT FLOATING POINT | AND instruction which is not at the start of the rung, uses floating point data                     |                                                     |
| # 123 | INSTRUCTION CANNOT ACCEPT INTEGER        | Floating point Special Function cannot use integer data                                             | Convert floating point value to integer             |
| # 124 | INVALID INSTRUCTION ENCOUNTERED          | User program has become corrupted                                                                   | Replace the specified instruction                   |
| # 125 | SPECIAL FUNCTION WITHOUT 'S' OR 'T'      | A Special Function with a table letter other than 'S' or 'T' has been encountered                   | Modify the Special Function                         |
| # 126 | CANNOT ACCESS ODD FLOATING POINT TABLES  | Floating point values (in a pair of Q-table locations) are referenced by the even numbered location | Modify the reference                                |
| # 127 | INSTRUCTION HAS INVALID LETTER           | The associated table letter is outside the range 'A' - 'W'                                          | Modify the instruction                              |
| # 128 | INSTRUCTION NEEDS A TABLE LOCATION VALUE | VALUE is not present, or is a constant where a table location is required                           | Change to a required type of VALUE                  |

Table 15.2 continued

| CODE  | Fault Message                    | Possible Causes                                                                                                   | Recommended Recovery              |
|-------|----------------------------------|-------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| # 129 | INSTRUCTION NEEDS A DATA VALUE   | The preceding Special Function requires a VALUE (either constant or table reference) to follow it                 | Insert appropriate VALUE          |
| # 130 | NO VALUE, AT END OF INSTRUCTIONS | The last instruction has been reached before the VALUE for a Special Function has been found                      | Insert appropriate VALUE          |
| # 131 | RUNG STACK UNDERFLOW             | User program has become corrupted                                                                                 | Replace the specified instruction |
| # 132 | RUNG STACK OVERFLOW              | User program has become corrupted                                                                                 | Replace the specified instruction |
| # 133 | RUNG IMBALANCED                  | Last rung not complete. Usually caused by halting transfer from the System Programmer before transfer is complete | Modify last rung                  |

### 15.5.5 Compilation Errors and the Controller

Compilation errors cause the controller to continue executing the previous version of the user program, and give a fault report from the compilation.

When the controller is running and the user makes changes to the source version of the program, the status is displayed on the Programmer as CHANGED instead of RUNNING until such time as the user re-compiles.

If the controller is running with status CHANGED and there is a power interruption, the controller goes into the halt mode after power up and gives a fault report "PROGRAM DIFFERENT FROM RUNNING VERSION".

As part of the self-test procedures which the controller undertakes, there is a check that there has been no alteration to program instructions and data in P-table. Each time the user makes changes to his program or P-table data, the controller has to re-calculate a CRC value. If power is interrupted before this calculation is complete, the warning message "CRC NOT STORED, PROGRAM MAY HAVE CHANGED" is displayed on power up, and the controller goes into the halt mode. The user may, however, run the program if desired.

### 15.6 System Status at Power Up (# 600 to # 699)

If, during power up self test cycle, one of these fault conditions is detected, the GEM 80 controller will remain in the "halt" condition and return the fault message until the fault is cleared.

## 15. FAULT FINDING

Table 15.3 - System Status Error Messages

| CODE | Fault Message                            | Possible Causes                                                                                                                                                                                                                       | Recommended Recovery                                                                                                                                                                                                                   |
|------|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| #601 | CRC NOT STORED. PROGRAM MAY HAVE CHANGED | The CRC of the user program was being recalculated when the power was removed from the system.                                                                                                                                        | Can ignore and carry on, but program integrity cannot be guaranteed.<br><b>Note...</b> After any alterations to P-tables or source code allow several seconds before power off to ensure complete calculation of CRC. (see Section 5). |
| #602 | PROGRAM DIFFERENT FROM RUNNING VERSION   | This occurs only on power up, if the program was edited and not recompiled before power off. The previously running program has been lost.<br>Changes to any P-table locations may also produce this code.                            | Recompile and run new version or reload un-edited version, as required.                                                                                                                                                                |
| #603 | V-TABLE CORRUPTED, PROGRAM STORE CLEARED | Memory corruption of important data occurred, treated as a new system.<br>Could be caused by turning power off during compilation, or a faulty processor module.<br>It may be a flat battery, but battery warning should occur first. | Power off/on and reload. If problem persists, then suspect processor or data table RAM module, and substitute for spare.<br><br>Check for flat battery, and substitute spare if needed.                                                |
| #604 | NEW SYSTEM, PROGRAM STORE CLEARED        | Brand new system.<br>Occurs if RAM boards are swapped or replaced                                                                                                                                                                     | Continue as for a new system                                                                                                                                                                                                           |
| #605 | S-IOP INCOMPATIBLE, THEREFORE IGNORED    | Slave I/O processor software incompatible with master I/O. System runs as if slave were not there.                                                                                                                                    | Replace slave I/O module with same version as master.                                                                                                                                                                                  |
| #606 | UNABLE TO SWITCH TO RAM                  | Failed to copy program to RAM when the S0 location was set to 0.                                                                                                                                                                      | The 8222 RAM/EPROM module is probably faulty and should be replaced                                                                                                                                                                    |
| #607 | UNABLE TO SWITCH TO EPROM                | Failed to switch to EPROM when the S0 location was set to 1. EPROM is either blank, invalid or not present.                                                                                                                           | Check that valid EPROM sub-modules are inserted in all the 8222 modules and try again.                                                                                                                                                 |

Table 15.3 continued

| CODE | Fault Message                                    | Possible Causes                                                                                                                                                                                                      | Recommended Recovery                                                                                       |
|------|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| #608 | FAILED TO PROGRAM EPROMs                         | One of the EPROM sub-modules contains faulty EPROMs                                                                                                                                                                  | Re-set S0 to 0, replace EPROM sub-modules with erased EPROMs and try to program EPROMs again.              |
| #609 | EPROMs REMOVED DURING POWER DOWN, STORE CLEARED  | Before power down, the controller was running from EPROM. On power up, however, no EPROMs are present, and there is no program in RAM. Therefore, the RAM is cleared and the controller powers up halted and in RAM. | If the EPROMs were removed unintentionally, replace them and set the S0 location to 1.                     |
| #610 | EPROMs NOT FITTED OR NOT PROGRAMMABLE            | Failed to program EPROMs when the S0 location was set to 2, because EPROM is either not blank or not present.                                                                                                        | Re-set S0 to 0, replace EPROM sub-modules with erased EPROMs and try to program EPROMs again.              |
| #611 | CANNOT RUN IN RAM WITH NON-BLANK EPROMs FITTED   | On a halted to run transition with the user program in RAM, non-erased EPROMs were found to be present.                                                                                                              | Remove EPROM sub-modules and try again                                                                     |
| #612 | EPROMs CHANGED DURING POWER DOWN, TABLES CLEARED | Before power down, the controller was running from EPROM. On power up, valid EPROMs were found to be present, but different to those that were previously installed.                                                 | Ensure that the program in EPROM is the program you intend to run before commanding the controller to run. |
| #613 | CANNOT SINGLE STEP IN RAM WITH NON-BLANK FITTED  | Attempted to perform a single scan of the program in RAM when non-erased EPROMs were present.                                                                                                                        | Remove EPROM sub-modules and try again.                                                                    |
| #614 | EPROMs NOT FITTED                                | Attempting to switch to EPROM or to program EPROM with sub-module missing                                                                                                                                            | Insert missing EPROM module and try again                                                                  |

## 15. FAULT FINDING

Table 15.3 continued

| CODE | Fault Message                                                                | Possible Causes                                                       | Recommended Recovery                                                                             |
|------|------------------------------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| #615 | USER ATTEMPTED TO WRITE INVALID VALUE (data) TO DATA TABLE LOCATION S0       | A value other than 0, 1 or 2 was written to table location S0         | Set the S0 table location to the value intended. S0 has already been reset to its previous value |
| #616 | EPROMS ALREADY PROGRAMMED AND ENABLED. RAM DISABLED AND CONTENTS DESTROYED   | Attempted to program EPROMs when the user program is already in EPROM | Reset S0 location to 1 to run in EPROM. There should be no need to re-program EPROMs             |
| #617 | S0 CONTAINS INVALID VALUE: (data)                                            | S0 does not contain the expected value on power-up                    | Write the required value into S0                                                                 |
| #618 | USER PROGRAM IN RAM MUST BE COMPILED BEFORE PROGRAMMING EPROM                | The user program has not been compiled                                | Compile the user program                                                                         |
| #619 | RAM ONLY SYSTEM, VIDEO UNABLE TO PROGRAM EPROMS                              | IMAGEM video processor is an early type which cannot blow EPROMS      | Upgrade video processor                                                                          |
| #620 | USER-PROGRAM IN EPROM (LEVEL (data)) INCOMPATIBLE WITH SYSTEM (LEVEL (data)) | EPROMs were programmed in a different system to this one              | Blow user program into EPROM using the system on which it is required to run                     |
| #621 | PROCESSOR UNABLE TO SUSPEND                                                  | Probably IMAGEM video processor in editing mode                       | Disconnect the System Programmer from IMAGEM                                                     |

## 15.7 Self-test and Self-test Failure Error Messages (#700 to #799)

### 15.7.1 Self-test Error Messages (#700 to #799)

On the occurrence of self-test failure, the controller halts and it will not re-start unless the fault is cleared and power switched off and back on again. Table 15.4 details these error messages. The CRC system referred to in Table 15.4 is discussed in Section 15.10.

### 15.7.2 Self-test System

The self-test system operates as shown below :-

#### Execution

One full cycle of start-up tests on power up.  
I/O tests repeated every scan.  
Regular on-line repetition of running tests.

#### Faults which immediately trip watchdog

1. Supply break longer than the ride-through period. See Section 11.
2. Power module failure.
3. Failure of Ladder or either I/O processor module.
4. No response from either of system memory modules.
5. Fault interfering with data transfer on Fast I/O highways.
6. Power module confidence check.

#### Faults which trip watchdog when detected by running tests

1. Alteration detected in contents of read only memory.
2. Failure of any part of read/write memory to store and recall data.

#### Faults from which recovery is automatic

1. Supply re-applied after break.
2. Corrupt message received on serial link.

#### Faults which user may program to trip watchdog

1. Wrong acknowledgment to message transmitted on serial link.
2. Verification I/O failure.
3. Serial link disconnected or repeated message corruption.
4. Application dependent tests.
5. Failure of battery on a memory module.

## 15.8 Interprocessor Communications (Error Messages #800 to #899)

Table 15.5 details Interprocessor Communications Error Messages.

## 15.9 System Errors (Error Messages #900 to #999)

These errors concern internal mal-operation of the executive software. Try power off/on and if the problem persists it should be reported immediately with details of fault message (they contain variable fields), user program and I/O configuration.

## 15.10 User Program CRC Calculation

All GEM 80 controllers protect the user instructions and pre-set data from unnoticed corruption by calculating a Cyclic Redundancy Check (CRC) on the memory containing them. This is checked at start-up and also as part of the background self-test.

In the GEM 80/310 series, whenever a change to the user program or P-table is made (including those effected by the message editor) re-calculation of the CRC is commenced as a background activity. This may take several seconds, the exact time depends on the memory capacity installed.

Should the power be removed before the calculation is complete, the warning message "CRC NOT STORED, PROGRAM MAY HAVE CHANGED" is displayed on the programming unit screen when the power is re-applied. The system will be halted if it was previously running, although the user may run the program if desired.

## 15. FAULT FINDING

Table 15.4 Self-test Error Messages

| CODE Fault Message                                                           | Possible Causes                                                                                                                                | Recommended Recovery                                                                                                                                          |
|------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| #701 (proc) EPROM CRC TEST FAILURE                                           | On-line test failure.<br>Suspect faulty processor module.                                                                                      | Try power off/on.<br>If problem persists, substitute spare module.                                                                                            |
| #702 OBJECT RAM CRC TEST FAILURE                                             | On-line corruption, probably faulty object RAM module.<br>Less likely: faulty ladder processor.                                                | Power off/on will re-initialize the RAM, but it may fail again.<br>Substitute spare RAM module. If problem still persists, substitute spare processor.        |
| #703 USER PROGRAM CRC TEST FAILURE                                           | Source code corrupted.<br>Faulty data table RAM module.                                                                                        | Try clear store power off/on and re-load. If problem persists, substitute spare RAM module.<br><b>Note...</b> Power off/on without clear will result in #718. |
| #704 V-TABLE CRC TEST FAILURE                                                | On-line RAM failure.<br>Faulty RAM module.                                                                                                     | Power off/on (will give #603) then re-load. If problem persists, substitute spare RAM module.                                                                 |
| #705 (proc) ON-BOARD RAM FAILURE<br>AT (data).WRITTEN (data),<br>READ (data) | Failed processor module.                                                                                                                       | Substitute spare.                                                                                                                                             |
| #706 EXTERNAL RAM FAILURE<br>AT (data).WRITTEN (data),<br>READ (data)        | Faulty data table/source code.                                                                                                                 | Substitute spare.                                                                                                                                             |
| #707 LDP BIT LOGIC TEST FAILURE<br>BIT (data). TEST (data)                   | Failed ladder processor module.                                                                                                                | Substitute spare.                                                                                                                                             |
| #708 (proc) WATCHDOG TEST FAILURE                                            | Suspect failed processor module.<br>Could be a faulty backplane but more likely to get #719 first in this case.                                | Substitute spare processor.<br>If problem persists, or #719 occurs, suspect backplane and substitute spare subrack.                                           |
| #709 PSU TEST FAILURE                                                        | Suspect faulty PSU.<br>Remote possibility of master I/O processor failed.<br>Very remote possibility of the link between the two being faulty. | Substitute spare PSU.<br>If problem persists, substitute spare master I/O processor and check connections.                                                    |
| #710 BATTERY FAILURE                                                         | Flat/disconnected, battery.<br><b>Note...</b> Watchdogs do not trip.                                                                           | Dump program, change battery and re-load.                                                                                                                     |

Table 15.4 continued

| CODE | Fault Message                                | Possible Causes                                                                                                           | Recommended Recovery                                                                                                                                               |
|------|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| #712 | FAST INPUT ERROR ON MODULE (data)            | Faulty module detected on a previously running system.                                                                    | Substitute spare module.                                                                                                                                           |
| #713 | FAST OUTPUT ERROR ON MODULE (data)           | Same as #712                                                                                                              | Substitute spare module.                                                                                                                                           |
| #714 | FAST I/O DRIVER ERROR                        | Highway fault or module failure.                                                                                          | Substitute spare module.<br>If problem persists intermittently, suspect Fast I/O subrack(s) and installation/segregation.                                          |
| #715 | STATUS LINKING FAILURE, MODULE No. (data)    | Intelligent Fast I/O module failure.                                                                                      | Substitute spare.                                                                                                                                                  |
| #716 | USER-REQUESTED WATCHDOG TRIP, F1 = (data)    | F1 set to non-zero value by user program.                                                                                 |                                                                                                                                                                    |
| #717 | (proc) BUS TIMEOUT                           | Faulty processor or RAM board.<br>Noise problems.                                                                         | If problem persists with power off/on, substitute spare processor or RAM module. If problem intermittent, check installation/segregation.                          |
| #718 | PROGRAM CORRUPTED DURING POWER DOWN          | Only apparent on power cycle.<br>P-table or instructions corrupted possibly due to faulty memory module, or flat battery. | Clear store, power off/on and reload, check battery warning indication. If problem persists, substitute spare data table RAM board.                                |
| #719 | (proc) WATCHDOG SELF TRIP                    | Watchdog detected error, contacts open.<br>Faulty backplane or processor module.                                          | Substitute processor module. If problem persists substitute spare subrack.                                                                                         |
| #728 | PROGRAM IN EPROM CORRUPTED DURING POWER DOWN | On power up, the controller attempted to run from EPROM but found that they did not contain a valid program.              | Ensure that the EPROM sub-modules have not been mixed up. If this is not the reason for the fault, re-load the program into RAM and program a fresh set of EPROMs. |

## 15. FAULT FINDING

Table 15.5 Interprocessor Communication Error Messages

| CODE | Fault Message                                                                                                                                                                                                                                                                                                | Possible Causes                                                              | Recommended Recovery                                                                                                                                                                                      |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| #801 | LDP TIMEOUT                                                                                                                                                                                                                                                                                                  | At power-up, possibly faulty ladder processor or object RAM                  | If problem persists on power off/on, replace faulty boards as indicated. If intermittent, suspect installation/segregation. Fault can be caused by removing a processor module while power still applied. |
| #804 | LDP TO IOP TIMEOUT                                                                                                                                                                                                                                                                                           |                                                                              |                                                                                                                                                                                                           |
| #805 | LDP INCOMPATIBLE                                                                                                                                                                                                                                                                                             | Could occur if processors from different releases of software used together. |                                                                                                                                                                                                           |
| #806 | IPC TIMEOUT,(proc) to (data)                                                                                                                                                                                                                                                                                 |                                                                              |                                                                                                                                                                                                           |
| #807 | (proc) IPC ERROR (data)                                                                                                                                                                                                                                                                                      |                                                                              |                                                                                                                                                                                                           |
| #808 | (proc) PROCESSOR TIMEOUT (data) to (procs)<br>e.g.<br>#808 M-IOP Processor Timeout 8 to 0061H<br>(procs) gives the processors to which the timeout may have occurred<br>1 LDP<br>2 MIOP<br>4 SIOP<br>20H VIDEO<br>If more than one processor is reported, the number given will be the sum of numbers above. | Refer to #717                                                                | Refer to #717                                                                                                                                                                                             |
| #809 | CHICS ERROR WHILE CREATING MAILBOX (data)                                                                                                                                                                                                                                                                    | Internal error                                                               | See Section 15.9                                                                                                                                                                                          |
| #810 | CHICS ERROR WHILE WAITING FOR MESSAGE (data)                                                                                                                                                                                                                                                                 | Internal error                                                               | See Section 15.9                                                                                                                                                                                          |
| #811 | CHICS ERROR WHILE SENDING A MESSAGE (data)                                                                                                                                                                                                                                                                   | Internal error                                                               | See Section 15.9                                                                                                                                                                                          |
| #812 | PMES ERROR, WRONG REPLY RECEIVED (data)                                                                                                                                                                                                                                                                      | Internal error                                                               | See Section 15.9                                                                                                                                                                                          |

### 15.11 The F & V Data Tables

Data in the F-table provides further information on fault diagnosis. F250 to F349 are available for user programmed diagnostics. It is recommended that the programmer uses this area for fault analysis for problems within the plant. The content of the F-table is detailed in Table 15.6. The serial link statistics are shown in Table 15.7.

Memory locations F2 to F40 are not write accessible.

From Table 15.7 it can be seen that the serial link statistics are stored in two locations for each item of data. For example, the numbers of attempts to communicate with a tributary port by port 1 is stored in F174 and F173. If for example the upper location (F174) contained 2 and the lower location (F173) contained 10, the number of requests would be:

$$= (65,536 \times \text{content of upper location}) + \text{content of lower location}$$

$$= (65,536 \times 2) + 10$$

$$= 131,072 + 10$$

$$= 131,082.$$

In some cases the serial link statistics are stored as negative numbers and these are to be interpreted by adding 65,536. For example, if F173 contained -20,000, this is to be interpreted as:

$$65,536 - 20,000 = 45,536$$

Table 15.6 The F-Table

| Locations        | Contents                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Remarks                                                                                                                                                    |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|----------|-------|-------|--------|----|-------|--------|--------|----|-------|---|---------|--------|-------|---|---------|----|-------|--------|---------|----|-------|----|---------|--------|-------|----|---------|----|-------|--------|---------|----|-------|---|---|--------|---|---|-------|---|---|--------|---|---|-------|---|---|--------|---|---|-------|---|---|--------|---|---|-------|---|---|--------|---|---|-------|---|---|--------|---|---|-------|---|---|--------|---|---|-------|---|---|--------|---|---|-------|---|---|--------|---|---|-------|---|---|--------|---|---|-------|---|---|--------|---|---|--|
| F0               | Reserved for internal operation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Contents cannot be interpreted by user                                                                                                                     |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F1               | Reserved for user program                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Any non zero value placed in F1 by the user program trips the watchdog, terminates program execution and displays a fixed diagnostic message. (See 10.7.5) |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F2 TO F40        | Auxiliary data for certain error conditions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Contents cannot be interpreted by the user.                                                                                                                |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F41              | Failure bit summary                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                            |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F41.0 to F41.3   | Failure of Ports 1 to 4 when operating as tributaries.<br><br>F41.0 - Port 1.    F41.1 - Port 2.<br>F41.2 - Port 3.    F41.3 - Port 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | No valid message received in previous 30 seconds. Re-set when communication resumed                                                                        |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F41.4            | Memory module battery warning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                            |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F41.5 to F41.7   | Not used                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                            |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F41.8 to F41.11  | Printer Fault<br>F41.8 - Port 1.    F41.9 - Port 2.<br>F41.10 - Port 3.    F41.11 - Port 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                            |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F41.12 to F41.15 | Printer Buffer not available<br>F41.12 - Port 1.    F41.13 - Port 2.<br>F41.14 - Port 3.    F41.15 - Port 4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                            |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F42 and F43      | Control Port Serial Link Failure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Bit set ON if route has failed.<br>Bit set OFF if route resumes correct operation.                                                                         |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
|                  | <table><tr><th>Location</th><th>Port</th><th>Route</th><th>Location</th><th>Port</th><th>Route</th></tr><tr><td>F42.0</td><td>1</td><td>0</td><td>F42. 8</td><td>2</td><td>0</td></tr><tr><td>F42.1</td><td>1</td><td>1</td><td>F42. 9</td><td>2</td><td>1</td></tr><tr><td>F42.2</td><td>1</td><td>2</td><td>F42.10</td><td>2</td><td>2</td></tr><tr><td>F42.3</td><td>1</td><td>3</td><td>F42.11</td><td>2</td><td>3</td></tr><tr><td>F42.4</td><td>1</td><td>4</td><td>F42.12</td><td>2</td><td>4</td></tr><tr><td>F42.5</td><td>1</td><td>5</td><td>F42.13</td><td>2</td><td>5</td></tr><tr><td>F42.6</td><td>1</td><td>6</td><td>F42.14</td><td>2</td><td>6</td></tr><tr><td>F42.7</td><td>1</td><td>7</td><td>F42.15</td><td>2</td><td>7</td></tr><tr><td>F43.0</td><td>3</td><td>0</td><td>F43. 8</td><td>4</td><td>0</td></tr><tr><td>F43.1</td><td>3</td><td>1</td><td>F43. 9</td><td>4</td><td>1</td></tr><tr><td>F43.2</td><td>3</td><td>2</td><td>F43.10</td><td>4</td><td>2</td></tr><tr><td>F43.3</td><td>3</td><td>3</td><td>F43.11</td><td>4</td><td>3</td></tr><tr><td>F43.4</td><td>3</td><td>4</td><td>F43.12</td><td>4</td><td>4</td></tr><tr><td>F43.5</td><td>3</td><td>5</td><td>F43.13</td><td>4</td><td>5</td></tr><tr><td>F43.6</td><td>3</td><td>6</td><td>F43.14</td><td>4</td><td>6</td></tr><tr><td>F43.7</td><td>3</td><td>7</td><td>F43.15</td><td>4</td><td>7</td></tr></table> | Location                                                                                                                                                   | Port     | Route    | Location | Port  | Route | F42.0  | 1  | 0     | F42. 8 | 2      | 0  | F42.1 | 1 | 1       | F42. 9 | 2     | 1 | F42.2   | 1  | 2     | F42.10 | 2       | 2  | F42.3 | 1  | 3       | F42.11 | 2     | 3  | F42.4   | 1  | 4     | F42.12 | 2       | 4  | F42.5 | 1 | 5 | F42.13 | 2 | 5 | F42.6 | 1 | 6 | F42.14 | 2 | 6 | F42.7 | 1 | 7 | F42.15 | 2 | 7 | F43.0 | 3 | 0 | F43. 8 | 4 | 0 | F43.1 | 3 | 1 | F43. 9 | 4 | 1 | F43.2 | 3 | 2 | F43.10 | 4 | 2 | F43.3 | 3 | 3 | F43.11 | 4 | 3 | F43.4 | 3 | 4 | F43.12 | 4 | 4 | F43.5 | 3 | 5 | F43.13 | 4 | 5 | F43.6 | 3 | 6 | F43.14 | 4 | 6 | F43.7 | 3 | 7 | F43.15 | 4 | 7 |  |
| Location         | Port                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Route                                                                                                                                                      | Location | Port     | Route    |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F42.0            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                                                                                                                                          | F42. 8   | 2        | 0        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F42.1            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                                                                                                                                          | F42. 9   | 2        | 1        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F42.2            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 2                                                                                                                                                          | F42.10   | 2        | 2        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F42.3            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3                                                                                                                                                          | F42.11   | 2        | 3        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F42.4            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4                                                                                                                                                          | F42.12   | 2        | 4        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F42.5            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 5                                                                                                                                                          | F42.13   | 2        | 5        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F42.6            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 6                                                                                                                                                          | F42.14   | 2        | 6        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F42.7            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 7                                                                                                                                                          | F42.15   | 2        | 7        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F43.0            | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0                                                                                                                                                          | F43. 8   | 4        | 0        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F43.1            | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1                                                                                                                                                          | F43. 9   | 4        | 1        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F43.2            | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 2                                                                                                                                                          | F43.10   | 4        | 2        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F43.3            | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3                                                                                                                                                          | F43.11   | 4        | 3        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F43.4            | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4                                                                                                                                                          | F43.12   | 4        | 4        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F43.5            | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 5                                                                                                                                                          | F43.13   | 4        | 5        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F43.6            | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 6                                                                                                                                                          | F43.14   | 4        | 6        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F43.7            | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 7                                                                                                                                                          | F43.15   | 4        | 7        |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F44              | Fast I/O Module Failure.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Applicable to Fast I/O modules with internal self-test. Only even numbered slots can accommodate such modules. Configured by P51 and P52.                  |          |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
|                  | <table><tr><th>Location</th><th>Slot No.</th><th>Location</th><th>Slot No.</th></tr><tr><td>F44.0</td><td>0</td><td>F44. 8</td><td>16</td></tr><tr><td>F44.1</td><td>2</td><td>F44. 9</td><td>18</td></tr><tr><td>F44.2</td><td>4</td><td>F44. 10</td><td>20</td></tr><tr><td>F44.3</td><td>6</td><td>F44. 11</td><td>22</td></tr><tr><td>F44.4</td><td>8</td><td>F44. 12</td><td>24</td></tr><tr><td>F44.5</td><td>10</td><td>F44. 13</td><td>26</td></tr><tr><td>F44.6</td><td>12</td><td>F44. 14</td><td>28</td></tr><tr><td>F44.7</td><td>14</td><td>F44. 15</td><td>30</td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Location                                                                                                                                                   | Slot No. | Location | Slot No. | F44.0 | 0     | F44. 8 | 16 | F44.1 | 2      | F44. 9 | 18 | F44.2 | 4 | F44. 10 | 20     | F44.3 | 6 | F44. 11 | 22 | F44.4 | 8      | F44. 12 | 24 | F44.5 | 10 | F44. 13 | 26     | F44.6 | 12 | F44. 14 | 28 | F44.7 | 14     | F44. 15 | 30 |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| Location         | Slot No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Location                                                                                                                                                   | Slot No. |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F44.0            | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | F44. 8                                                                                                                                                     | 16       |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F44.1            | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | F44. 9                                                                                                                                                     | 18       |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F44.2            | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | F44. 10                                                                                                                                                    | 20       |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F44.3            | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | F44. 11                                                                                                                                                    | 22       |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F44.4            | 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | F44. 12                                                                                                                                                    | 24       |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F44.5            | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | F44. 13                                                                                                                                                    | 26       |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F44.6            | 12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | F44. 14                                                                                                                                                    | 28       |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |
| F44.7            | 14                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | F44. 15                                                                                                                                                    | 30       |          |          |       |       |        |    |       |        |        |    |       |   |         |        |       |   |         |    |       |        |         |    |       |    |         |        |       |    |         |    |       |        |         |    |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |       |   |   |        |   |   |  |

# 15. FAULT FINDING

Table 15.6 The F-Table (continued.)

| Locations    | Contents                                                                         |               |             |               | Remarks                                                                         |
|--------------|----------------------------------------------------------------------------------|---------------|-------------|---------------|---------------------------------------------------------------------------------|
| F45 - F172   | Used to detect failure on Verification/Basic I/O Highway. (Master I/O Processor) |               |             |               |                                                                                 |
|              | Location                                                                         | I/O Addresses | Location    | I/O Addresses |                                                                                 |
|              | F 45 & F 46                                                                      | 0- 15         | F109 & F110 | 512-527       |                                                                                 |
|              | F 47 & F 48                                                                      | 16- 31        | F111 & F112 | 528-543       |                                                                                 |
|              | F 49 & F 50                                                                      | 32- 47        | F113 & F114 | 544-559       |                                                                                 |
|              | F 51 & F 52                                                                      | 48- 63        | F115 & F116 | 560-575       |                                                                                 |
|              | F 53 & F 54                                                                      | 64- 79        | F117 & F118 | 576-591       |                                                                                 |
|              | F 55 & F 56                                                                      | 80- 95        | F119 & F120 | 592-607       |                                                                                 |
|              | F 57 & F 58                                                                      | 96-111        | F121 & F122 | 608-623       |                                                                                 |
|              | F 59 & F 60                                                                      | 112-127       | F123 & F124 | 624-639       |                                                                                 |
|              | F 61 & F 62                                                                      | 128-143       | F125 & F126 | 640-655       |                                                                                 |
|              | F 63 & F 64                                                                      | 144-159       | F127 & F128 | 656-671       |                                                                                 |
|              | F 65 & F 66                                                                      | 160-175       | F129 & F130 | 672-687       |                                                                                 |
|              | F 67 & F 68                                                                      | 176-191       | F131 & F132 | 688-703       |                                                                                 |
|              | F 69 & F 70                                                                      | 192-207       | F133 & F134 | 704-719       |                                                                                 |
|              | F 71 & F 72                                                                      | 208-223       | F135 & F136 | 720-735       |                                                                                 |
|              | F 73 & F 74                                                                      | 224-239       | F137 & F138 | 736-751       |                                                                                 |
|              | F 75 & F 76                                                                      | 240-255       | F139 & F140 | 752-767       |                                                                                 |
|              | F 77 & F 78                                                                      | 256-271       | F141 & F142 | 768-783       |                                                                                 |
|              | F 79 & F 80                                                                      | 272-287       | F143 & F144 | 784-799       |                                                                                 |
|              | F 81 & F 82                                                                      | 288-303       | F145 & F146 | 800-815       |                                                                                 |
|              | F 83 & F 84                                                                      | 304-319       | F147 & F148 | 816-831       |                                                                                 |
|              | F 85 & F 86                                                                      | 320-335       | F149 & F150 | 832-847       |                                                                                 |
|              | F 87 & F 88                                                                      | 336-351       | F151 & F152 | 848-863       |                                                                                 |
|              | F 89 & F 90                                                                      | 352-367       | F153 & F154 | 864-879       |                                                                                 |
|              | F 91 & F 92                                                                      | 368-383       | F155 & F156 | 880-895       |                                                                                 |
|              | F 93 & F 94                                                                      | 384-399       | F157 & F158 | 896-911       |                                                                                 |
|              | F 95 & F 96                                                                      | 400-415       | F159 & F160 | 912-927       |                                                                                 |
|              | F 97 & F 98                                                                      | 416-431       | F161 & F162 | 928-943       |                                                                                 |
|              | F 99 & F100                                                                      | 432-447       | F163 & F164 | 944-959       |                                                                                 |
|              | F101 & F102                                                                      | 448-463       | F165 & F166 | 960-975       |                                                                                 |
|              | F103 & F104                                                                      | 464-479       | F167 & F168 | 976-991       |                                                                                 |
|              | F105 & F106                                                                      | 480-495       | F169 & F170 | 992-1007      |                                                                                 |
|              | F107 & F108                                                                      | 496-511       | F171 & F172 | 1008-1023     |                                                                                 |
| F173 to F188 | Serial link statistics for Port 1                                                |               |             |               | Only provided when port configured as a Control port. Table 15.7 details these. |
| F189 to F204 | Serial link statistics for Port 2                                                |               |             |               |                                                                                 |
| F205 to F220 | Serial link statistics for Port 3                                                |               |             |               |                                                                                 |
| F221 to F236 | Serial link statistics for Port 4                                                |               |             |               |                                                                                 |
| F237 to F249 | Reserved for future system use.                                                  |               |             |               |                                                                                 |
| F250 to F349 | Available for user programmed diagnostics.                                       |               |             |               |                                                                                 |
| F350 to F413 | Used to store information regarding the current status of the serial link        |               |             |               |                                                                                 |

Table 15.6 The F-Table (continued.)

| Locations   | Contents                                                                        |               |             |               | Remarks |
|-------------|---------------------------------------------------------------------------------|---------------|-------------|---------------|---------|
| F414 - F541 | Used to detect failure on Verification/Basic I/O Highway. (Slave I/O Processor) |               |             |               |         |
|             | Location                                                                        | I/O Addresses | Location    | I/O Addresses |         |
|             | F414 & F415                                                                     | 1024-1039     | F478 & F479 | 1536-1551     |         |
|             | F416 & F417                                                                     | 1040-1055     | F480 & F481 | 1552-1567     |         |
|             | F418 & F419                                                                     | 1056-1071     | F482 & F483 | 1568-1583     |         |
|             | F420 & F421                                                                     | 1072-1087     | F484 & F485 | 1584-1599     |         |
|             | F422 & F423                                                                     | 1088-1103     | F486 & F487 | 1600-1615     |         |
|             | F424 & F425                                                                     | 1104-1119     | F488 & F489 | 1616-1631     |         |
|             | F426 & F427                                                                     | 1120-1135     | F490 & F491 | 1632-1647     |         |
|             | F428 & F429                                                                     | 1136-1151     | F492 & F493 | 1648-1663     |         |
|             | F430 & F431                                                                     | 1152-1167     | F494 & F495 | 1664-1679     |         |
|             | F432 & F433                                                                     | 1168-1183     | F496 & F497 | 1680-1695     |         |
|             | F434 & F435                                                                     | 1184-1199     | F498 & F499 | 1696-1711     |         |
|             | F436 & F437                                                                     | 1200-1215     | F500 & F501 | 1712-1727     |         |
|             | F438 & F439                                                                     | 1216-1231     | F502 & F503 | 1728-1743     |         |
|             | F440 & F441                                                                     | 1232-1247     | F504 & F505 | 1744-1759     |         |
|             | F442 & F443                                                                     | 1248-1263     | F506 & F507 | 1760-1775     |         |
|             | F444 & F445                                                                     | 1264-1279     | F508 & F509 | 1776-1791     |         |
|             | F446 & F447                                                                     | 1280-1295     | F510 & F511 | 1792-1807     |         |
|             | F448 & F449                                                                     | 1296-1311     | F512 & F513 | 1808-1823     |         |
|             | F450 & F451                                                                     | 1312-1327     | F514 & F515 | 1824-1839     |         |
|             | F452 & F453                                                                     | 1328-1343     | F516 & F517 | 1840-1855     |         |
|             | F454 & F455                                                                     | 1344-1359     | F518 & F519 | 1856-1871     |         |
|             | F456 & F457                                                                     | 1360-1375     | F520 & F521 | 1872-1887     |         |
|             | F458 & F459                                                                     | 1376-1391     | F522 & F523 | 1888-1903     |         |
|             | F460 & F461                                                                     | 1392-1407     | F524 & F525 | 1904-1919     |         |
|             | F462 & F463                                                                     | 1408-1423     | F526 & F527 | 1920-1935     |         |
|             | F464 & F465                                                                     | 1424-1439     | F528 & F529 | 1936-1951     |         |
|             | F466 & F467                                                                     | 1440-1455     | F530 & F531 | 1952-1967     |         |
|             | F468 & F469                                                                     | 1456-1471     | F532 & F533 | 1968-1983     |         |
|             | F470 & F471                                                                     | 1472-1487     | F534 & F535 | 1984-1999     |         |
|             | F472 & F473                                                                     | 1488-1503     | F536 & F537 | 2000-2015     |         |
|             | F474 & F475                                                                     | 1504-1519     | F538 & F539 | 2016-2031     |         |
|             | F476 & F477                                                                     | 1520-1535     | F540 & F541 | 2032-2047     |         |

## 15. FAULT FINDING

Table 15.7 - Serial Link Statistics

| Statistic                                                            | F-Table Address             |                             |                             |                             |                             |                             |                             |                             |
|----------------------------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
|                                                                      | Port 1<br>Lower<br>Location | Port 1<br>Upper<br>Location | Port 2<br>Lower<br>Location | Port 2<br>Upper<br>Location | Port 3<br>Lower<br>Location | Port 3<br>Upper<br>Location | Port 4<br>Lower<br>Location | Port 4<br>Upper<br>Location |
| Number of requests                                                   | F173                        | F174                        | F189                        | F190                        | F205                        | F206                        | F221                        | F222                        |
| Number of attempts (request + re-tries)                              | F175                        | F176                        | F191                        | F192                        | F207                        | F208                        | F223                        | F224                        |
| Framing over-run errors (corrupt replies)                            | F177                        | F178                        | F193                        | F194                        | F209                        | F210                        | F225                        | F226                        |
| time-out failures (no replies)                                       | F179                        | F180                        | F195                        | F196                        | F211                        | F212                        | F227                        | F228                        |
| CRC errors (corrupt replies)                                         | F181                        | F182                        | F197                        | F198                        | F213                        | F214                        | F229                        | F230                        |
| Negative acknowledgments                                             | F183                        | F184                        | F199                        | F200                        | F215                        | F216                        | F231                        | F232                        |
| Termination errors                                                   | F185                        | F186                        | F201                        | F202                        | F217                        | F218                        | F233                        | F234                        |
| Data errors (control characters in wrong context or buffer overflow) | F187                        | F188                        | F203                        | F204                        | F219                        | F220                        | F235                        | F236                        |

Table 15.8 Serial Link Diagnostics.

| Route | Location |        |        |        |
|-------|----------|--------|--------|--------|
|       | Port 1   | Port 2 | Port 3 | Port 4 |
| 0     | F350     | F358   | F366   | 374    |
| 1     | F351     | F359   | F367   | 375    |
| 2     | F352     | F360   | F368   | 376    |
| 3     | F353     | F361   | F369   | 377    |
| 4     | F354     | F362   | F370   | 378    |
| 5     | F355     | F363   | F371   | 379    |
| 6     | F356     | F364   | F372   | 380    |
| 7     | F357     | F365   | F373   | 381    |

The diagnostics are defined as:

|               |                                  | Fault Codes                             |
|---------------|----------------------------------|-----------------------------------------|
| Bits 0 to 7   | Address of last message received | 0 Successfule transfer                  |
| Bits 8 to 11  | Fault code                       | 1 Attempted to send zero length message |
| Bits 12 to 13 | Not used                         | 3 Transmission failed (time-outs)       |
| Bit 14        | Set when transfer failed         | 4 Hardware error                        |
| Bit 15        | Set when transfer successful     | 5 NAK received                          |
|               |                                  | 6 CRC of received message failed        |
|               |                                  | 7 Wrong termination reveived            |
|               |                                  | 8 Received message too long             |
|               |                                  | 9 Data error (incorrect data format)    |

### 15.11.1 V-table locations

The majority of the locations in the V-table are for system internal functions and have no significance to the user. However, a few are useful and these are described in Table 15.9.

**Table 15.9 V-Data Table**

| Locations | Contents                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| V1        | The low byte (bits 0-7) contains a value that is incremented after each successful compilation.                                                                                                                                                                                                                                                                                                                                      |
| V58-V59   | A 32-bit number which provides a unique check code for a particular combination of user-program and data-table layout. They may be used within a user program to detect unauthorized interference with that program. They are updated after a program edit or compilation has been completed.<br><b>Note...</b> This depends on the internal memory allocation of the system. Identical programs may produce different check values. |
| V62       | Gives the number of 1 Kbyte blocks of memory allocated to source code                                                                                                                                                                                                                                                                                                                                                                |
| V63       | Gives the number of 1 Kbyte blocks of memory allocated to object code                                                                                                                                                                                                                                                                                                                                                                |
| V64       | Gives the number of 1 Kbyte blocks of memory allocated to data tables                                                                                                                                                                                                                                                                                                                                                                |

- (b) The controller allocates memory space for the data tables according to the content of your program. The CLEAR STORE command sets all data table areas to their minimum size, and ensures that unnecessary space has not been allocated by the previous version of the program.

**Note...** When a program is loaded, any instructions and P-table data already in store are overwritten. If, as we recommend, you clear store before loading, P0 to P149 (which are not cleared, except P51 and P52) will be overwritten by data from the program being loaded.

Where the controller is being programmed remotely via one of the serial ports, the configuration data being loaded must be the same for this port as the values already in store, otherwise communication will be lost after a re-compilation or power off-on.

**Note...** When the data being loaded includes messages, the message area made write-accessible by the CLEAR STORE command becomes write-protected again, except via the message editor, after re-compilation.

## 15.12 Clear Store Command

If the user issues a CLEAR command, part of the P-table is not cleared. This part (P0 to P149 except P51 and P52) is used to hold configuration data for serial links.

The reason for not clearing this section of P-table is that GEM 80/310 series controllers may be programmed either from the front port of the I/O processor(s), or remotely through any of the serial ports. Loss of data about the serial port configurations could make it impossible for the controller to communicate with a remote programmer, and so this data is retained even when the rest of the memory store is cleared.

Before loading a program, the user is recommended to always issue a CLEAR STORE command, for the following two reasons :-

- (a) The area of P-table which holds printer messages is not normally write-accessible except via the message editor facility. The CLEAR STORE command allows data to be loaded to the whole of the P-table.

## 15. FAULT FINDING

### 15.13 Power Module Self-test

#### Self-test

Each output voltage +2%  
Healthy lamp for each output  
Regular exercising of fault detection

### 15.14 Intermittent Tripping Problems

GEM 80 Equipment is normally reliable in operation provided that it is installed in accordance with guidance given in Section 13 of this manual.

If the equipment does trip out, note the following possible causes and consequent remedial action. If repeated tripping occurs keep a log of all trips detailing the fault code, possible explanation and the circumstances under which tripping occurred.

Possible causes of equipment tripping are:

#### (1) Electrical Noise or Electromagnetic Interference

GEM 80 equipment has been tested against noise immunity from RFI and meets the requirements of IEC 801-3 and CEEB specification DN5. However, high levels of RFI noise in close proximity to GEM 80 equipment, especially the controller subrack, can trip out the system. Hand-held transceivers (e.g. 'walkie-talkies') should not be used within 300mm of the controller. Segregation and signal grounds should be installed as detailed in Section 13.

#### (2) Connector/Termination Problems

All connections should be checked. Suspect connections (e.g. mechanically damaged or corroded) should be re-terminated.

#### (3) Overheating

The whole installation should be in line with environmental conditions in 1.4.1. The Compact LO in particular should be installed as per Section 14.

### 15.15 Fault Finding Back-up and Module Repair Service

GEC Industrial Controls Ltd., provide further back-up facilities should the user be unable to rectify faults in the GEM 80 equipment. The following facilities are available :-

- (1) GEM 80 Customer Support - available to any GEM 80 user.
- (2) Gemsquad - a rapid 'service contract' scheme for complete GEM 80 systems.
- (3) Service Exchange - a rapid repair scheme available for certain individual items of GEM 80 equipment.
- (4) Normal Repair Service - available for repair of GEM 80 equipment.

For Customer Support on any aspect of GEM 80 applications, please call:

GEM 80 Customer Services  
Department.  
Telephone: (0782) 783511 Ext. 2651  
or 2574  
Fax: (Group 3) 0782 776329  
Telex: 36293 GECICK

Any faulty modules should be returned for repair to:

GEM 80 Spares and Repairs Dept.  
GEC Industrial Controls Ltd.,  
West Avenue,  
Kidsgrove,  
Stoke on Trent,  
ST7 1TW  
England

Tel: (0782) 783511  
Fax: (Group 3) 0782 776329  
Telex: 36293 GECICK

Where user repair is required on a printed circuit board (p.c.b.), further information on p.c.b. repair may be obtained on request, but when p.c.b.s are repaired by the user, GEC Industrial Controls Ltd., cannot accept any responsibility for faults which may arise.

When faulty modules or units are mailed for repair, they should be returned them in packing which includes anti-static bags next to the electronic circuitry. Where possible, ship them in the original packing.

If it is necessary to ship a complete subrack, first remove any power module from the subrack and pack separately. GEC Industrial Controls cannot accept responsibility for any mechanical damage to the subrack if it is shipped with power modules still plugged in.

## 16.1 General

GEM 80 equipment requires very little maintenance. The memory support batteries have a long life expectancy, the period of which depends upon the extent of their use. Section 16.4 covers this topic.

## 16.2 Spare Modules

The fault finding procedures rely on substitution of suspected faulty modules with spare modules. These spare modules may be stored powered up (i.e. functional spares).

It is recommended that all spare modules are powered up every 9 months.

## 16.3 Cleaning and Visual Inspection of GEM 80

Cleaning and visual inspection of GEM 80 should be carried out at time intervals determined by the customer. The equipment should be isolated from its main supplies and associated equipment.

### General Maintenance and Cleanliness

- a) Dust and dirt should periodically be removed from enclosures using a vacuum cleaner, brushes and soft cloths.

**CAUTION...** Never blow air into an enclosure to remove dust and dirt.

- b) Visual checks should be made for signs of wiring or component damage and any damaged wiring or components should be renewed.
- c) Check all terminations within enclosures for tightness.

## 16.4 Batteries

### 16.4.1 General

The Read/Write memory is supported by a non-rechargeable lithium/copper oxide battery. The battery life times are given below and depend on the proportion of time that the battery is supporting memory, and mains power is switched off :-

| % of Time Supporting Memory | Life     |
|-----------------------------|----------|
| 100%                        | 1.0 yr.  |
| 75%                         | 1.3 yrs. |
| 50%                         | 2.0 yrs. |
| 30%                         | 3.3 yrs. |

When the battery warning lamp is lit or when specified life times have expired the batteries should be renewed.

The batteries have a 10 year shelf life (typical), 5 years minimum.

### 16.4.2 Battery Replacement Procedure

The battery can be changed and the memory content retained, provided that power to the memory, is not interrupted for more than 10 minutes. Observe the Safety and Handling procedures in Section 18. Spares and Re-ordering Codes are detailed in Section 17.

Two types of memory module are available for use with the 310 series of controllers. In the 8220 module, the battery is only accessible by removing the memory module from the controller subrack. In the 8222, the battery is accessible from the front panel of the module. See Figure 2.5

#### 8220 Memory Module

- (1) Switch the controller power off
- (2) Remove the memory module from the controller subrack
- (3) Avoid touching the module with metal tools since it is powered up. Carefully disconnect the leads from the battery mounted on the module. Untie the tie-wrap holding the battery down and remove the battery.
- (4) Fit the new battery and re-connect the lead with the red crimp to the +ve terminal and the other lead to the -ve terminal. Re-tie the tie-wrap to hold the battery in position.
- (5) Insert the module into the controller.
- (6) Switch the controller power on and check that the battery warning lamp is off.
- (7) Dispose of the old battery as detailed in Section 18 - Safety and Handling Information.

#### 8222 Memory Module

- (1) Open the battery cover located on the module front panel.
- (2) Slide the battery out of its mounting.
- (3) Carefully disconnect the leads from the battery.
- (4) Fit the new battery.
- (5) Slide the battery back into position and close the cover.
- (6) Dispose of old the battery as detailed in Section 18 - Safety and Handling Information.

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## 16. MAINTENANCE

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## 17.1 Subracks

## (a) Processor Subracks

| Model      | Subrack Qty | Power Module Type | Power Module Qty | I/O Proc. | Ladder Proc. | 192K RAM | 256K RAM | 128K RAM | Space for Central Modules | Space for Fast I/O | Ordering Code |
|------------|-------------|-------------------|------------------|-----------|--------------|----------|----------|----------|---------------------------|--------------------|---------------|
| 311 (192K) | 1           | 110/220V ac/dc    | 1                | 1         | 1            | 1        | 0        | 0        | 3                         | 4                  | 8870-4857     |
| 311 (192K) | 1           | 24/48V dc         | 1                | 1         | 1            | 1        | 0        | 0        | 3                         | 4                  | 8870-4858     |
| 311 (256K) | 1           | 110/220V ac/dc    | 1                | 1         | 1            | 0        | 1        | 0        | 3                         | 4                  | 8870-4851     |
| 311 (256K) | 1           | 24/48V dc         | 1                | 1         | 1            | 0        | 1        | 0        | 3                         | 4                  | 8870-4852     |
| 311 (384K) | 1           | 110/220V ac/dc    | 1                | 1         | 1            | 0        | 1        | 1        | 2                         | 4                  | 8870-4853     |
| 311 (384K) | 1           | 24/48V dc         | 1                | 1         | 1            | 0        | 1        | 1        | 2                         | 4                  | 8870-4854     |
| 311 (512K) | 1           | 110/220V ac/dc    | 1                | 1         | 1            | 0        | 2        | 0        | 2                         | 4                  | 8870-4855     |
| 311 (512K) | 1           | 24/48V dc         | 1                | 1         | 1            | 0        | 2        | 0        | 2                         | 4                  | 8870-4856     |
| 312 (192K) | 1           | 110/220V ac/dc    | 1                | 1         | 1            | 1        | 0        | 0        | 7                         | 0                  | 8870-4867     |
| 312 (192K) | 1           | 24/48V dc         | 1                | 1         | 1            | 1        | 0        | 0        | 7                         | 0                  | 8870-4868     |
| 312 (256K) | 1           | 110/220V ac/dc    | 1                | 1         | 1            | 0        | 1        | 0        | 7                         | 0                  | 8870-4861     |
| 312 (256K) | 1           | 24/48V dc         | 1                | 1         | 1            | 0        | 1        | 0        | 7                         | 0                  | 8870-4862     |
| 312 (384K) | 1           | 110/220V ac/dc    | 1                | 1         | 1            | 0        | 1        | 1        | 6                         | 0                  | 8870-4863     |
| 312 (384K) | 1           | 24/48V dc         | 1                | 1         | 1            | 0        | 1        | 1        | 6                         | 0                  | 8870-4864     |
| 312 (512K) | 1           | 110/220V ac/dc    | 1                | 1         | 1            | 0        | 2        | 0        | 6                         | 0                  | 8870-4865     |
| 312 (512K) | 1           | 24/48V dc         | 1                | 1         | 1            | 0        | 2        | 0        | 6                         | 0                  | 8870-4866     |
| 313 (192K) | 2           | 110/220V ac/dc    | 2                | 1         | 1            | 1        | 0        | 0        | 12                        | 0                  | 8870-4877     |
| 313 (192K) | 2           | 24/48V dc         | 2                | 1         | 1            | 1        | 0        | 0        | 12                        | 0                  | 8870-4878     |
| 313 (256K) | 2           | 110/220V ac/dc    | 2                | 1         | 1            | 0        | 1        | 0        | 12                        | 0                  | 8870-4871     |
| 313 (256K) | 2           | 24/48V dc         | 2                | 1         | 1            | 0        | 1        | 0        | 12                        | 0                  | 8870-4872     |
| 313 (384K) | 2           | 110/220V ac/dc    | 2                | 1         | 1            | 0        | 1        | 1        | 11                        | 0                  | 8870-4873     |
| 313 (384K) | 2           | 24/48V dc         | 2                | 1         | 1            | 0        | 1        | 1        | 11                        | 0                  | 8870-4874     |
| 313 (512K) | 2           | 110/220V ac/dc    | 2                | 1         | 1            | 0        | 2        | 0        | 11                        | 0                  | 8870-4875     |
| 313 (512K) | 2           | 24/48V dc         | 2                | 1         | 1            | 0        | 2        | 0        | 11                        | 0                  | 8870-4876     |

## (b) Fast I/O Subracks

| Model    | Power Module Type | Power Module Qty. | Space for Fast I/O | Ordering Code |
|----------|-------------------|-------------------|--------------------|---------------|
| 12-slot  | 110/220V ac/dc    | 1                 | 12                 | 8870-4115     |
| 12-slot  | 24/48V dc         | 1                 | 12                 | 8870-4114     |
| 12-slot* |                   | 0                 | 12                 | 8870-4365     |

The above are for optional use with 312 and 313 Controllers when you Fast I/O modules are required. Depending on the quantity of Fast I/O modules, either one or two subracks may be required.

\* For systems, only where there is adequate power available from a power module in another subrack.

## (c) I/O Subracks

| Model   | Power Module (Optional) | I/O Modules | Ordering Code |
|---------|-------------------------|-------------|---------------|
| 12-slot | 0                       | 12          | 8859-4003     |
| 8-slot  | 1 (type 9032-4002)      | 8           | 8857-4006     |

The above are for use with any model of GEM 80/310 series controller where I/O modules are required.

## 17. SPARES AND RE-ORDER CODES

### 17.2 Modules

#### (a) Central modules

The following ordering codes call up additional central modules, plus their associated backplanes, ribbon cables, and isolating termination panels as appropriate.

| Module type                                     | Function                                                                        | Slots used | Equipment called up by ordering code                                                                                 | Ordering Code |
|-------------------------------------------------|---------------------------------------------------------------------------------|------------|----------------------------------------------------------------------------------------------------------------------|---------------|
| Second I/O Processor<br>(maximum 1 per subrack) | For doubling the amount of I/O and serial ports on the controller.              | 2          | I/O processor module.Processor backplane.                                                                            | 8800-4125     |
| IMAGEM Graphic Video<br>(maximum 4 per subrack) | For displaying data taken from the controller's data tables on a video monitor. | 2          | Video processor module.<br>Video output module.<br>Video backplane.<br>Ribbon cable.<br>Isolating termination panel. | 8815-4107     |
| 256K memory module                              | For ladder expansion.                                                           | 1          | Memory module. Socket.                                                                                               | 8222-4001     |
| 256K memory module                              | For off-line data storage.                                                      | 1          | Memory module. Socket                                                                                                | 8810-4127     |
| 128K memory module                              | For ladder expansion.                                                           | 1          | Memory module. Socket                                                                                                | 8222-4012     |
| 128K memory module                              | For additional video formats.                                                   | 1          | Memory module. Socket                                                                                                | 8810-4119     |
| 128K memory module                              | For off-line data storage.                                                      | 1          | Memory module. Socket                                                                                                | 8810-4129     |
| 64K Memory module                               | For additional video formats.                                                   | 1          | Memory module. Socket.                                                                                               | 8810-4120     |
| 256K EPROM submodule                            | For more secure storage of ladder program, presets and video.                   | 1          | EPROM memory submodule, including unprogrammed EPROMs.                                                               | 9210-4001     |
| STARNET module. (Double width module) Note 2.   | For inter-controller communications with block message facility.                | 2          | STARNET module. Backplane.                                                                                           | 8816-4101     |
| Fast I/O Driver                                 | Required only when the system contains Fast I/O modules.                        | 1          | Module only.                                                                                                         | 8300-4003     |

#### Notes...

- 1 The quantity of slots used must be taken into account when assessing how many modules can be fitted into a GEM 80/310 series processor subrack.
- 2 You must specify ribbon cables and termination units separately, depending on how many ports, and of what type you are using.

#### (b) Fast I/O Modules

Details of the Fast I/O Modules are given on individual data sheets in the number ranges 884x and 886x, and are therefore omitted from this section.

**(c) Basic and Verification I/O Modules**

Apart from the items given below, details of Basic and Verification I/O modules are given on individual data sheets and are therefore omitted from this section.

| Module type                    | Function                                                            | Equipment called up by ordering code                                                                                  | Ordering Code |
|--------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|---------------|
| Power Module                   | To provide additional power for Basic and Verification I/O modules. | Module for 110/220V a.c. (isolated) or 24-60V d.c. (non-isolated, negative earth only). Mounts in 8857-4006 subracks. | 9032-4002     |
| Verification I/O expander unit | To provide Basic I/O ribbons for up to 512 points of Basic I/O.     | Expander unit only. Mounts in a 8859-4003 12-slot I/O subrack.                                                        | 8191-4004     |

**17.3. Optional Extras****Ordering Code**

|                                                                                                                                                                                |           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 20mA serial link termination unit (provides terminals for one port).                                                                                                           | 8924-0000 |
| HDLC serial link termination unit (provides terminals for one port).                                                                                                           | 8587-4001 |
| Ribbon cable for connecting either of the above to the controller (connects up to two 8924 units to the processor subrack; max. 1 per I/O processor, or 2 per STARNET module.) | 8891-4077 |
| Fibre-optic interface unit (converts 20mA serial link from an 8924-0000 unit to fibre-optic)                                                                                   | 8927-0000 |
| Cable loom for serial ports 1 or 3 (for connecting the above to an 8924-0000 unit)                                                                                             | 8891-4079 |
| Cable loom for serial ports 2 or 4 (for connecting the above to an 8924-0000 unit)                                                                                             | 8891-4083 |
| Mounting channel (for termination panels)                                                                                                                                      | 8959-0000 |

**17.4. Special Processor Subracks**

If it is required to add further central modules to a processor subrack after it has been delivered, it is a difficult job to fit the necessary backplanes and wire links, etc., which may involve the subrack having to be returned to the factory. Therefore it is strongly recommended that possible future module additions be considered at the ordering stage. A subrack can be prepared to accept further modules, even though these modules might not be purchased until a later date.

**(a) Subrack preparation**

|                                                     |           |
|-----------------------------------------------------|-----------|
| For a second I/O processor                          | 8899-4228 |
| For an IMAGEM graphic video                         | 8899-4230 |
| For a STARNET module                                | 8899-4226 |
| For a 128K/192K/256K RAM or RAM/EPROM memory module | 8899-4227 |

**Note...**The usage of each 64K block of RAM must be defined, e.g. whether required for extension program memory, for formats, or off-line storage, etc.

## 17. SPARES AND RE-ORDER CODES

### (b) Module additions subsequent to original order.

| Module                | Subrack preparation required          | Equipment called up by ordering code                                                                                                | Ordering Code |
|-----------------------|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Second I/O processor  | 8899-4214                             | Module only. When ordering, replace the asterisk by the last digit of the ordering code for the first I/O processor already fitted. | 8213-431*     |
| IMAGEM graphic video  | 8899-4230                             | Video processor module. Video output module. Ribbon Cable. Isolating termination panel.                                             | 8815-4008     |
| STARNET module        | 8899-4226                             | Module only.                                                                                                                        | 8218-4003     |
| 128K RAM memory       | 8899-4227                             | Module only                                                                                                                         | 8222-4012     |
| 256K RAM EPROM memory | 8899-4227                             | RAM/EPROM module, without EPROM submodule                                                                                           | 8222-4001     |
| EPROM submodule       | Requires 8222-4001 module (see above) | Plug-in submodule, including set of unprogrammed EPROM chips.                                                                       | 9210-4001     |

### 17.5. SPARES

Power Module for Controller subracks  
For 88-264V a.c. 45-63Hz or 88-250V d.c. input  
For 19-60V d.c. input

8917-4003  
8918-4003

Power Module for I/O subrack  
For 88-132V a.c. 176-264V a.c. 45-63Hz (isolated)  
or 22-85V d.c. (non-isolated)

9032-4001

CORONET Interface for interface to CORONET LAN  
Module plus connector

8193-4001

Ladder processor module (See note)  
I/O processor module (See note)

8211-431\*  
8213-431\*

**Note...**Replace the asterisk with the final digit appearing on the modules originally supplied; this digit must be identical on the ladder and I/O processors.

IMAGEM graphic video processor

8219-4003

IMAGEM graphic video output module

8216-4003

STARNET module

8218-4003

128K RAM memory module (for additional Video formats)

8222-4012

256K RAM memory module (for additional Video formats)

8222-4001

128K RAM memory module (for off-line data storage)

8222-4012

256K RAM memory module (for off-line data storage)

8222-4001

128K RAM memory module (for ladder extension)

8222-4012

256K RAM memory module (for ladder extension)

8222-4001

EPROM submodule for use with 8222 RAM/EPROM module.

9210-4001

Power fuse for 8917-4003 power supply (10A time delay, high breaking capacity)

82030/111

Power fuse for 8918-4003 power supply (20A time delay, high breaking capacity)

82022 287

Battery for memory module

20T0319.01

### 18.1 Earthing

This equipment must be earthed, see Section 11 of this manual.

### 18.2 High Voltages

Dangerous voltages arising from the mains supply and fed back from the plant wiring may be present within the controller.

### 18.3 Power Down Before Removing Modules or Connectors

To allow safe access, the GEM 80 power and, where applicable, plant-side power should be switched off before any module is withdrawn or replaced.

### 18.4 Power Down Safety Procedure

When maintaining or working on plant controlled by the GEM 80 Controller, the controller and also the plant-side power supplies should be 'locked off' using a padlock, or similar mechanical locking mechanism, to prevent the system being inadvertently powered up. The ON/OFF switch on the Power Module must not be relied on to isolate the controller.

### 18.5 On-line Programming

These controllers accept on-line program changes, but the controller freezes all outputs and ignores all inputs while the program is being re-compiled.

**Note...**The controller cannot tell whether the program change is safe and simply carries out the instructions given.

### 18.6 Testing a GEM 80 System

In test modes the GEM 80 output signals must be disconnected or in some way de-activated to prevent accidental mobilisation of plant and machinery or other possible hazards.

### 18.7 Watchdog and Safety Circuits

The requirements for watchdog and safety circuits of Section 9 must be designed into the system.

### 18.8 System Running Indication

When the 2 green LEDs labelled 'Watchdog' on the I/O processor are illuminated, the Controller is running the user program and may be controlling moving machinery.

### 18.9 Handling Precautions for Printed Circuit Boards (p.c.b.) with Electro-Static Sensitive Devices (ESSD).

#### 18.9.1 Introduction

A number of micro-electronic devices on equipment printed circuit boards (p.c.b.s) are subject to permanent damage due to electrostatic potentials (static) encountered in routine handling, testing and transporting, unless special precautions are observed. For example, static electricity can be generated simply by an operator moving on a chair, brushing against benches or walls or walking across the floor, and so appropriate action must be taken to discharge this 'personal static' when handling individual p.c.b.s. Once the p.c.b.s are plugged into a subrack, they are protected from any static damage.

This section details action for the protection of p.c.b.s from static damage.

#### 18.9.2 Protection of Equipment from Static Damage

Protective measures are required when handling p.c.b.s to prevent damage to Electro-Static Sensitive Devices.

General rules which apply are:

- (1) Personnel handling p.c.b.s shall NOT wear outer clothing which is likely to generate a static charge, e.g. synthetic materials such as nylon; cotton is preferable.
- (2) All personnel handling p.c.b.s shall put themselves in contact with a grounded surface before removing p.c.b.s from their protective packing or from equipment, e.g. by use of a 3M's wrist strap, Velostat type 2063. The wrist strap should be kept on during all p.c.b. handling.
- (3) Avoid finger contact with devices on the p.c.b. and with its connectors.
- (4) If it is necessary to place p.c.b.s down 'unprotected', place them on a static shielding bag, e.g. 3M's type 2100.
- (5) p.c.b.s must be protected by a static shielding bag when out of equipment, e.g. 3M's type 2100.

#### 18.9.3 Protection During Arrival and Handling/Storage at Site

If the p.c.b.s are transported in their own individual packing, remove from the cardboard box, but leave them in the protective static shielding bag or with the conductive foam shorting strip on, until they are plugged into the equipment.

If the boards are to be stored for any length of time, leave them in the original packing until they are needed.

## 18. SAFETY AND HANDLING INFORMATION

### 18.9.4 Protection During Setting Up of Equipment

The following precautions must be taken during testing/setting up operations on equipment containing p.c.b.'s with Electro Static Sensitive Devices:

- (1) All test equipment must be grounded to the same common earth point.
- (2) The System Power and Test Equipment must be switched OFF before inserting or withdrawing p.c.b.s.
- (3) When possible, power supply voltages should be applied before signal inputs, and should be maintained until signal inputs are removed.
- (4) Dielectric strength and insulation resistance tests should not be carried out with the p.c.b.s installed in the equipment.
- (5) Do not use audible continuity tests on p.c.b.s.
- (6) Do not use 'Freeze' aerosols on p.c.b.s.

### 18.9.5 Protection During Maintenance and Spares Handling

If it is necessary to return any p.c.b.s to GEC Industrial Controls Ltd., for repair, they must be enclosed in a static shielding bag, e.g. 3M's type 2100, and suitably protected by wrapping in foam plastic, and packing in a box labelled 'Caution Static Sensitive p.c.b.'.

### 18.9.6 Reference Reading

|         |   |                                                                              |
|---------|---|------------------------------------------------------------------------------|
| BS 5958 | : | Code of Practice for the Control of Undesirable Static Electricity - Part 1. |
| BS 5783 | : | Code of Practice for Handling of Electro Static Sensitive Devices.           |

### 18.9.7 Recommended Anti-static Equipment

The following 3M's Anti-static Equipment is recommended for use :-

- (1) Velostat Wrist Strap Type 2063 - Strap with 1Mohm resistor and alligator clip.
- (2) Transparent Static Shielding Bags Type 2100 - size 10 in. x 12 in.  
(i.e. 254 x 305mm)

### 18.10 GEM 80 Batteries (Memory Support) - Safety Precautions for Disposal and Handling

#### 18.10.1 Handling

##### WARNING...

Until the GEM 80 battery is completely discharged the cells contain Lithium metal, which reacts vigorously with water. It also burns readily in many gases. The electrolyte is a non-corrosive, but flammable liquid.

The GEM 80 Lithium batteries must never be re-charged.

GEM 80 batteries should be stored in a dry area.

For maximum shelf life the temperature should generally be kept between -10°C and +35°C.

#### 18.10.2 Disposal

Under no circumstances must any GEM 80 battery be crushed, incinerated or disposed of in normal waste.

Discharged or unwanted batteries which do not show any signs of physical damage are to be returned to the following address for disposal by the manufacturer :-

Lithium Production Dept.,  
Goods Inwards,  
SOGEA BATTERIES LTD.,  
Castle Works,  
Station Road,  
Hampton,  
Middlesex,  
TW12 2BY,  
England

or returned to the nearest local agent (when outside the U.K.).

They must be securely packaged and any exposed electrical connections adequately covered with insulating tape to avoid short circuit during transit. The package should be marked 'spent batteries'.

### 18.10.3 Damage

Should any GEM 80 batteries become physically damaged the following procedure must be followed :-

- (1) Where applicable, disconnect the battery and remove from the equipment.
- (2) Avoid touching any liquids or internal cell components.
- (3) Cover any exposed electrical connections with insulating tape.
- (4) Place the battery in a plastic bag or container and seal.
- (5) Return to the address given under 'disposal'.
- (6) If electrolyte enters the eye, wash thoroughly with water and seek medical attention immediately.
- (7) If skin, clothing or equipment comes into contact with the electrolyte, wash thoroughly with water.

In the event of a fire, the cell may rupture. However, the amount of lithium involved is very small so any lithium fire will be very minor, lasting only a few minutes. Isolate the supply but investigate only when all signs of combustion have ceased. Cell remains should then be disposed of as described under 'damage'.

Many types of extinguisher are ineffective against lithium and BCF types used on lithium may result in poisonous gases being generated. Graphite based dry powder extinguishers are effective. In practice an extinguisher should not be required and the previous paragraph gives the best course of action.

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## 18. SAFETY AND HANDLING INFORMATION

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## A1 Ribbon Cable Sizes

The ribbon cables detailed at Table A1 are used on GEM 80 equipment :-

Table A.1 Ribbon Cables used on GEM 80 Equipment

| Cable Used For                                                        | No. of Ways | Supplier * | Suppliers Ref. |
|-----------------------------------------------------------------------|-------------|------------|----------------|
| 1) Verification/Basic I/O Highway<br>2) Serial Communications Highway | 26          | Spectra    | 455.240.26     |
| 1) Ext 15V Power Supply (for Basic I/O)<br>2) Power for Lamp Driver   | 20          | Spectra    | 455.240.20     |

\* Denotes GEC Recommended Supplier

**Note...**Following problems with the termination of ribbon cables, we have been advised by the cable manufacturers that:

'ALL RIBBON CABLES ON REELS MUST BE STORED ON END'

Flat storage of these reels leads to compression of the conductor pitching which results in incorrect termination on the connectors.

These tools are available from :-

Thomas & Betts Limited  
Sedgwick Road  
Luton, LU4 9DT  
Bedfordshire

Telephone: Luton (0582) 597271

Telex: 826051 TOMBET G

Telex: 36293 GECICK G

## A2 Ribbon Cable Connectors

The connectors used are detailed in Sections 5 and 6.

## A3 Ribbon Cable Accessories

This is a kit which comprises:

- One - polarizing pin
- One - label

Ordering Code 8890-4004

## A4 Special Tools/Equipment Required for Ribbon Cable/Connector Assembly

The following tools will be required for assembly of connectors onto ribbon cables :-

|                       |                                                                     |
|-----------------------|---------------------------------------------------------------------|
| T & B/Ansley 779-2100 | Tool Frame                                                          |
| T & B/Ansley 779-2150 | Die for use with Tool Frame (suitable for all GEM 80 ribbon cables) |
| T & B/Ansley 779-5030 | Cable Cutter                                                        |

## A5 Ribbon Cable Installation

Ribbon cables used on GEM 80 equipment are normally made up for the customer by GEC Industrial Controls Limited.

For the customer wishing to install his own ribbon cables the procedure detailed below should be followed :-

### (1) Mechanical Polarization

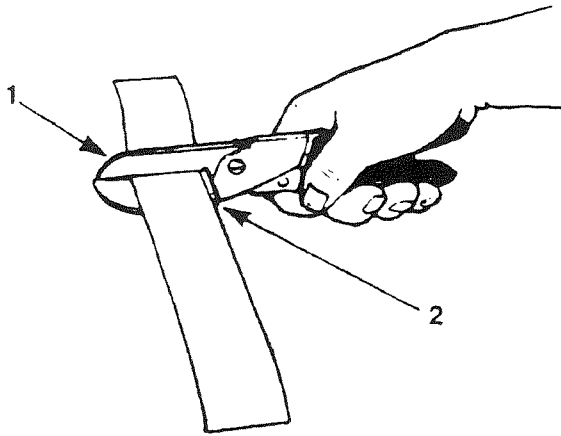
A polarizing pin may be inserted into the socket if required. This pushes into the connector from the socket side.

### Note

This operation must be done BEFORE the connector is fitted to the ribbon cable.

## (2) Termination Using Cable End Connectors

- (a) Cut the ribbon cable to length ensuring that edge of cable is flush with alignment guide on cable cutter as shown at Figure A1.



1. Cable Cutter
2. Alignment Guide

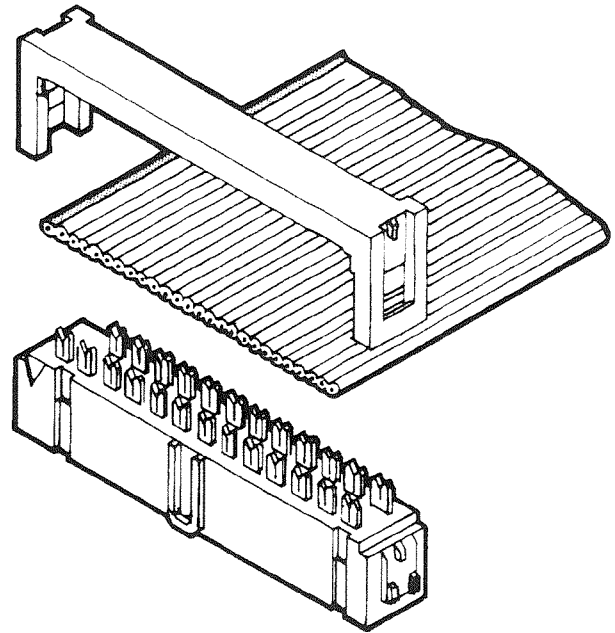
**Figure A1 Ribbon Cable Cutting**

- (b) Twisted pair ribbon cables must always be cut in the center of a flat section.
- (c) Fit cover half way onto insulation base plate ensuring that metal locking clips enter slots in cover (see Figure A2).
- (d) Insert cable between cover and base plate WITH END OF CABLE FLUSH WITH EDGE OF BASE PLATE.

### NOTES

Ensure that colored edge of cable (or brown wire for twisted pair cable) is adjacent to identification mark (pin 1) detailed in Figure A2.

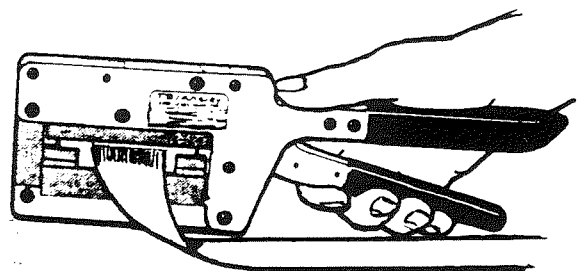
Also ensure that cable is inserted from the 'wrong side' since it will be doubled back when strain relief is fitted (see Figure A5).



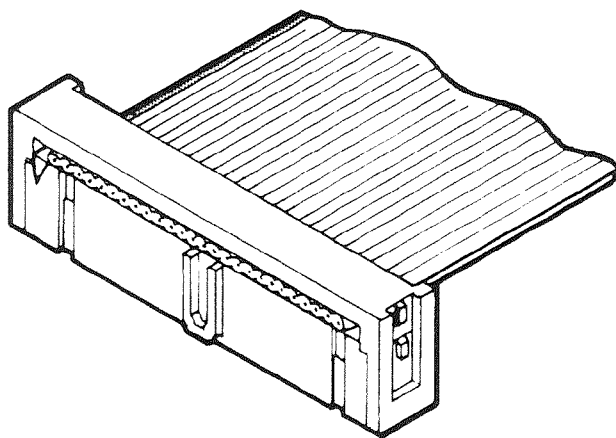
1. Colored Edge of Cable (or brown wire for twisted pair cable).
2. Cable
3. Identification mark
4. Base plate
5. Cover

**Figure A2 Cable End Connectors Fitting of Cable and Cover**

- (e) Using T & B/Ansley hand tool fitted with die, press cover down, ensuring that cable does not move, so that contacts on the base plate penetrate cable insulation (see Figure A3). Ensure that cover is pressed fully home as detailed at Figure A4.



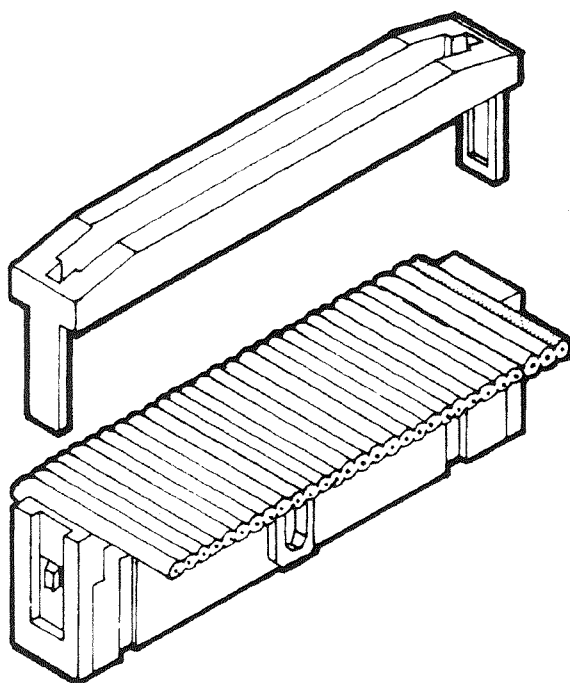
**Figure A3 Use of Hand Tool**



1. Cover
2. Base Plate

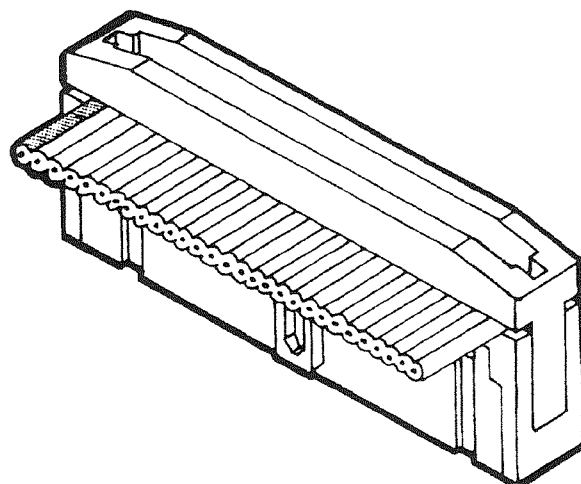
**Figure A4 Clamped Cable**

- (f) Complete ribbon cable label for Basic I/O assembly as detailed in Installation section of this manual.
- (g) Push strain relief down until clips lock into cover indicated by a small 'click' (Figure A6 shows the completed end termination).



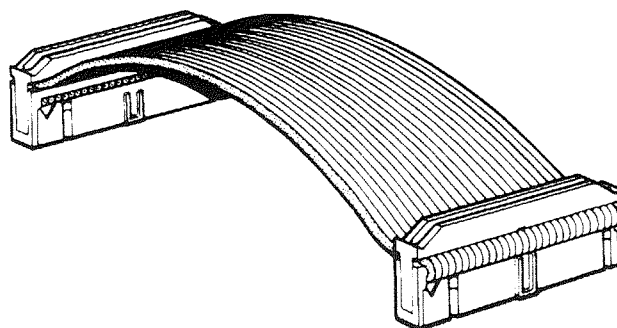
1. Strain Relief
2. Cable Folded Back

**Figure A5 Fitting of Label and Strain Relief**



**Figure A6 Completed End Connection**

When fitting the same cable at both ends, ensure that the cable is inserted from opposite sides of the connectors. The completed ribbon should be as illustrated in Figure A7.

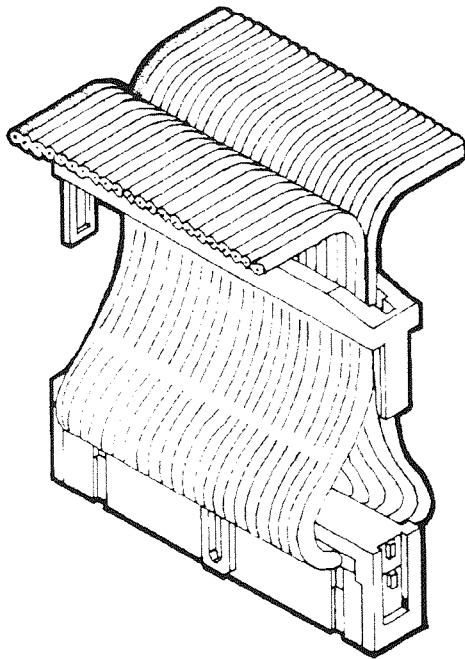


**Figure A7 Completed Ribbon Cable**

## (3) Terminating Middle Connectors

### NOTES

1. This type of connector cannot be assembled unless one free end of cable is available. Always ensure that amount of cable is sufficient to complete length of run.
2. When using twisted pair cable, termination can only be made in the center of flat sections.
  - (a) Pass free end of cable through slot in top of strain relief (i.e. side without clip).
  - (b) Thread enough cable through slot to allow connector to reach header.
  - (c) Mount cover to baseplate as described at (2)(c) to (e).
  - (d) Pass free end of cable back through strain relief as at Figure A.8 and remove slack before pushing strain relief fully home as at (2)(g).



1. Cable
2. Strain Relief
3. Cover
4. Base Plate
5. Identification Mark

Figure A8 Cable Middle Connectors - Fitting of Strain Relief

## (4) Right Angled Bends in Cable

1. Where ribbon cable has to be run flat with a right angled bend the cable can be folded in one of two ways, either a single fold as at Figure A9 or, if this would cause the wrong edge to come out on top, the cable should first be doubled back as at Figure A10.

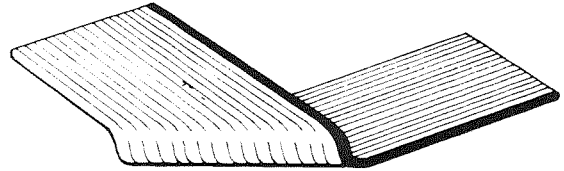


Figure A9 Right Angled Bend - Single Fold

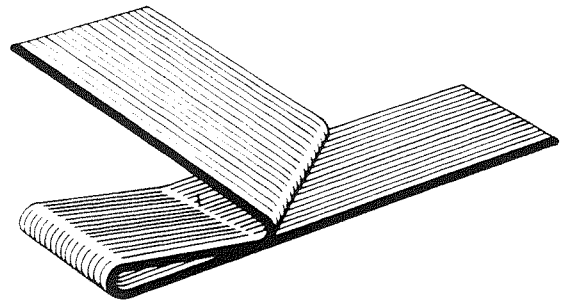


Figure A10 Right Angled Bend - Double Fold

## (5) Fitting Ribbon Cable Label

The label is wrapped around the ribbon cable as shown in Figure A11. Refer to Section 13.8.3 for label marking.

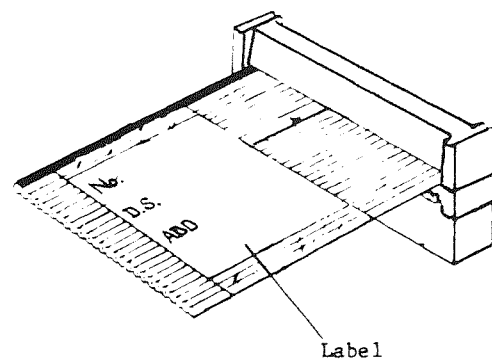


Figure A11 Label Fitting

# APPENDIX B - FIBRE OPTIC CABLE CONNECTIONS FOR FIBRE OPTIC TRANSCEIVER UNITS

## B1 Introduction

This appendix describes the method for terminating fibre optic cables.

### CAUTION....

The fibre optic core is soft and fragile; handle with care and do not bend fibre sharply.

## B2 Fibre Optic Cables

The fibre optic cables detailed in Table B.1 are recommended for use on GEM 80 equipment :-

These cables are available in the U.K. from :-

Pilkington Communications Systems Ltd.  
Kinmel Park,  
Bodelwyddan,  
Rhyl,  
Clwyd  
LL18 5TY.

Table B.1 - Recommended Fibre Optic Cables

| Type                                        | Make/Part No.          |
|---------------------------------------------|------------------------|
| Without armored cladding (core dia. 200 um) | Pilkington LS.QSF 200A |
| With armored cladding (core dia. 200um)     | Pilkington MLS QSF     |

## B3 Special Tools/Equipment Required for Fibre Optic Cable Termination

The tools detailed in Table B.2 should be used to terminate fibre optic cables :-

Table B.2 - Tools for Fibre optic cable termination

| Tool                                                                                          | Make/Part No.                            |
|-----------------------------------------------------------------------------------------------|------------------------------------------|
| Termination kit - comprises fibre cutting tool, crimping tool, positioner and stripping tools | Radiall type F780.010.000                |
| Crimping tool                                                                                 | Radiall type R282.240 with jaws R282.242 |
| Spanner torque wrench                                                                         | Radiall type R282.320                    |

Conventional wire stripping tools are suitable for cutting back the outer sheath of fibre optic cable although great care must be taken not to damage the fibre optic core. A suitable tool is available in the U.K. from Optronics Ltd., as "Ideal Stripmaster".

The Radiall tools are available from :-

Radiall Microwave Components  
Invincible Road  
Farnborough  
Hants

and are also available from :-

Optronics Ltd  
Cambridge Science Park  
Milton Road  
Cambridge  
CB4 4BH

## B4 Cable Terminations and Couplers Required for Fibre Optic Termination

The terminations and couplers detailed in Table B.3 are required for terminating fibre optic cables. They are available from the suppliers mentioned in paragraph B3.

Table B.3 - Terminators/Couplers for Fibre optic cables

| Equipment                                                  | Make/Part No.             |
|------------------------------------------------------------|---------------------------|
| Terminator (for cable with or without armored cladding)    | Radiall type F705.017.040 |
| Panel mounted Cable Coupler                                | Radiall type F705.700.000 |
| Straight cable coupler (for joining two terminated cables) | Radiall type F705.720.000 |

## B5 Fibre Optic Cable Installation - Non Armored Cable Radiall Type

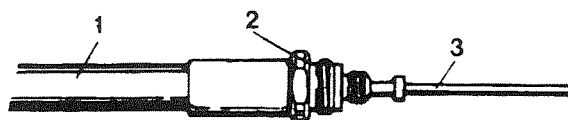
- Cut the fibre optic cable to the required length, + 80mm for each connection made to the cable.
- Strip back the outer sheath 60mm with the wire strippers.

### CAUTION...

Avoid damaging the fibre optic inside the outer sheath.

- Push the metal collar over the outer sheath - see Figure B.1.
- Locate the fibre optic cable carefully onto the cable ferrule assembly, ensuring that the outer sheath is pushed over the knurled part of the ferrule, and butts up against the ferrule body - see Figure B.1.

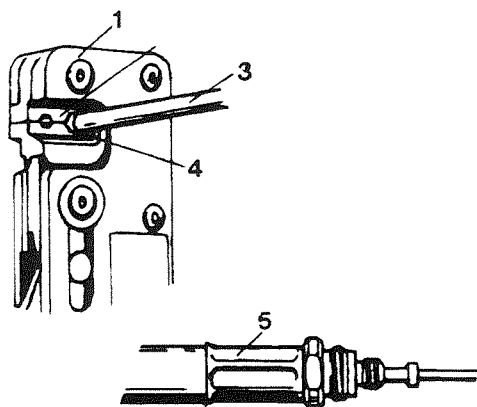
## APPENDIX B - FIBRE OPTIC CABLE CONNECTIONS FOR FIBRE OPTIC TRANSCEIVER UNITS



1. Fibre optic cable - outer sheath
2. Cable ferrule.
3. Fibre optic.

**Figure B.1 - Cable Ferrule - assembly onto fibre optic cable**

- (e) Push the metal collar up to the body of the cable ferrule.
- (f) Using the Radiall Crimping tool, type R282.240 (with jaws type R282.242) crimp the metal collar onto the outer sheath of the cable. Compress the handles of the tool together until the ratchet releases - see Figure B.2.



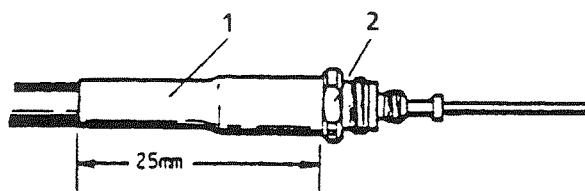
1. Head of crimping tool
2. Jaws of tool
3. Fibre optic cable
4. Metal collar
5. Crimped collar

**Figure B.2. - Crimping of metal collar onto Fibre optic cable**

- (g) Cut some heatshrink sleeving\* to fit over the crimped joint and cable outer sheath.
- (h) Shrink onto the heatshrink sleeving with a 250W hot-air pistol - see Figure B.3.

### CAUTION...

Do not overheat the heatshrink sleeving or the (PVC) outer sheath of the fibre optic cable.



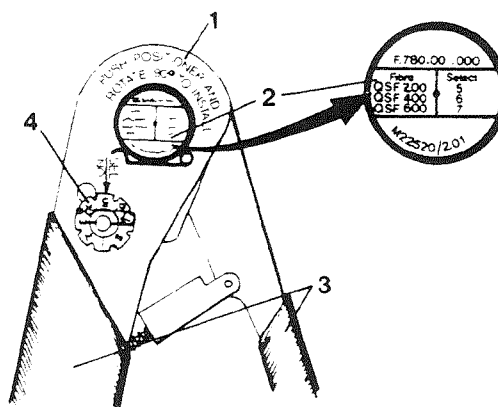
1. Heatshrink sleeve shrunk over crimped metal collar and outer sheath of fibre optic cable
2. Cable ferrule.

**Figure B.3 - Heatshrink sleeving applied over crimped metal collar**

- (i) Using the Daniels crimping tool with the positioner F780.002.000, from the Radiall termination kit, carefully crimp the cable ferrule onto the fibre optic - see Figures B.4 and B.5.

### Note...

Ensure that wheel A is set to the correct setting for the particular diameter of fibre optic used, as indicated by the positioner label - see Figure B.4.



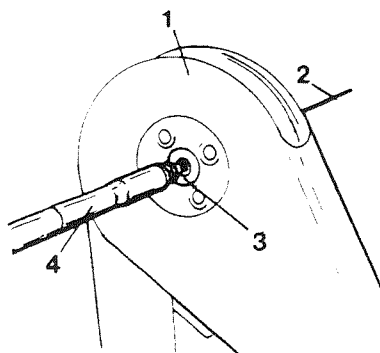
1. Head of tool
2. Positioner
3. Handles of tools
4. Wheel A

**Figure B.4 - Daniels crimping tool and positioner**

\* Recommended make and types of heatshrink sleeving are as follows :-

Hellerman LVR95, 9.5mm internal bore  
or  
Ness NTRV95, 9.5mm internal bore

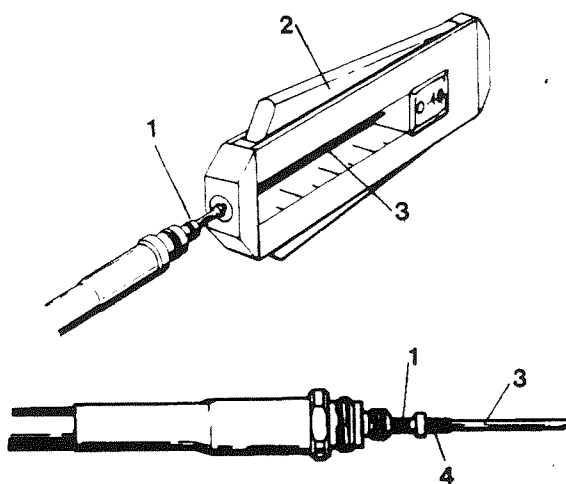
# APPENDIX B - FIBRE OPTIC CABLE CONNECTIONS FOR FIBRE OPTIC TRANSCEIVER UNITS



1. Head of tool
2. Fibre optic
3. Jaws of tool
4. Fibre optic cable/ferrule assembly

**Figure B.5 - Daniels crimping tool**

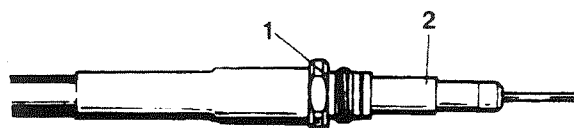
- (j) Remove the crimped ferrule assembly from the tool.
- (k) Carefully strip the protective sheath from the fibre optic using the correct stripping tool shown in Figure B.6 (supplied with Radiall termination kit). Strip back the protective sheath in 20mm lengths to prevent "bunching" of the sheath.



1. Cable ferrule assembly
2. Stripping tool
3. Fibre Optic
4. Protective sheath

**Figure B.6 - Stripping protective sheath from Fibre optic**

- (l) Screw on the optical barrel over the ferrule - see Figure B.7.



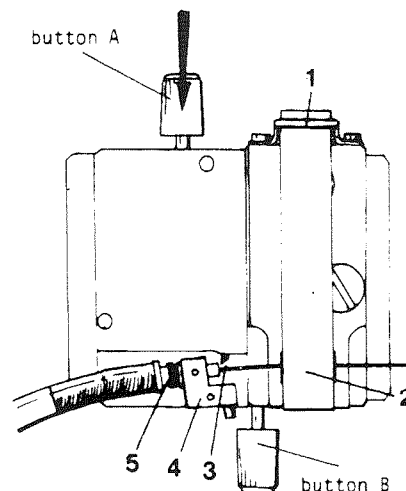
1. Ferrule assembly
2. Optical barrel

**Figure B.7 - Mounting optical barrel**

- (m) Mount the assembly into the cutting tool supplied with the Radiall termination kit - see Figure B.8.

## CAUTION....

To prevent damage to the diamond cutter, never operate the cutting tool (button A) without an optical ferrule assembly fitted in the holder.

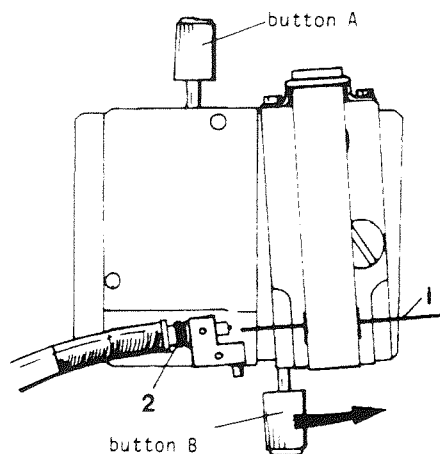


1. Clamp retaining clip
2. Clamp
3. Cutting point
4. Ferrule/barrel assembly holder
5. Ferrule/barrel assembly

**Figure B.8 - Fibre Optic cutting tool**

- (n) Clamp the fibre optic into the V groove on the cutting tool.
- (o) Push knob A smoothly and without excess force to cut the fibre optic.
- (p) Push knob B to pull away the cut fibre - see Figure B.9.

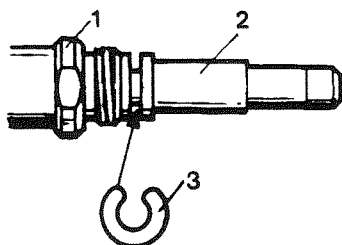
## APPENDIX B - FIBRE OPTIC CABLE CONNECTIONS FOR FIBRE OPTIC TRANSCEIVER UNITS



1. Cut fibre
2. Ferrule barrel assembly

**Figure B.9 - Fibre Optic cutting tool**

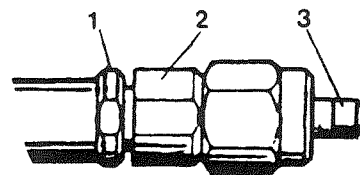
- (q) Remove assembly from the ferrule/barrel assembly holder.
- (r) Unscrew the optical barrel a 1/2 turn and fit the circlip as shown in Figure B.10.
- (s) Screw down the optical barrel onto the circlip - Figure B.10.



1. Ferrule assembly
2. Optical barrel
3. Circlip

**Figure B.10 - Optical barrel and circlip assembly**

- (t) Finally mount the ferrule/barrel assembly into the interface assembly and tighten using the torque wrench, Radial type R.282.320, to 80 to 120N.cm torque. See Figure B.11 for completed termination.



1. Ferrule assembly
2. Interface assembly
3. Optical barrel

**Figure B.11 - Completed termination for Fibre optic cable**

### B6 Fibre Cable Installation - Armored Cable

- (a) Cut the fibre optic to the required length plus 80mm for each connection made to the cable.
- (b) Carefully strip back the outer sheath 60mm with a sharp knife - see Figure B.12.

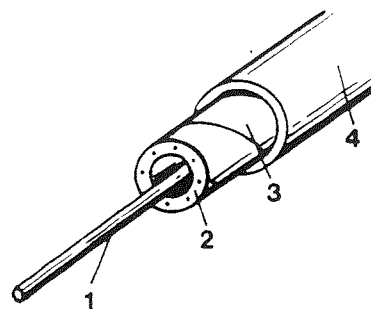
#### CAUTION....

Avoid damaging the aluminium sheath under the outer sheath.

- (c) Carefully strip back the inner sheath with wire strippers as shown in Figure B.12 and trim back the aluminium sheath as required.

#### CAUTION....

Avoid damaging the fibre optic inside the inner sheath.

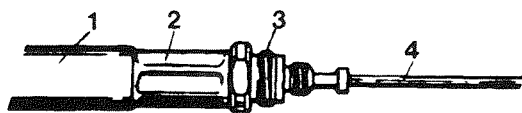


1. Fibre Optic
2. Inner sheath
3. Aluminium sheath
4. Outer sheath

**Figure B.12 - Stripping Armored Fibre Optic Cable**

## APPENDIX B - FIBRE OPTIC CABLE CONNECTIONS FOR FIBRE OPTIC TRANSCEIVER UNITS

- (d) Push the metal collar over the aluminium sheath until it butts up against the outer sheath.
- (e) Locate the fibre optic cable carefully onto the cable ferrule assembly, ensuring that the inner sheath is pushed over the knurled part of the ferrule, and butts up against the ferrule body - see Figure B.13.



- 1. Outer sheath of cable
- 2. Metal collar
- 3. Ferrule assembly
- 4. Fibre Optic

Figure B.13 - Cable ferrule - assembly onto Fibre cable

- (f) Follow the procedure described in paragraphs (f) to (t) in section B5 (non armored cable).

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## APPENDIX B - FIBRE OPTIC CABLE CONNECTIONS FOR FIBRE OPTIC TRANSCIVER UNITS

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