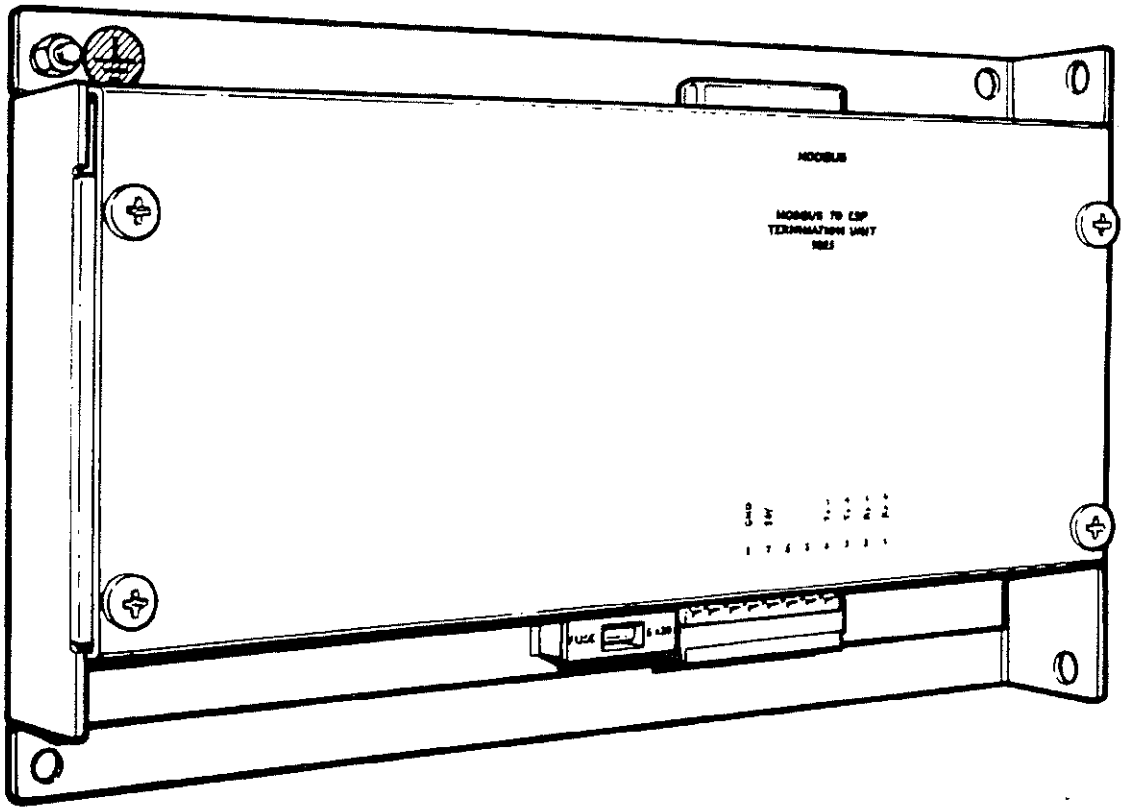
CEGELEC
INDUSTRIAL CONTROLS

PROTOCOL CONVERTER

9021-4001



GEM80 USER INFORMATION

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1.1 Introduction

Although programmable controllers from different manufacturers generally store process variables as similar data types, there is no direct mapping of process variables between the data bases of controllers. Process variables generally fall into four categories which dictate the functions that may be performed by some controllers. These categories are:

1) Analog inputs
2) Analog outputs
3) Digital inputs
4) Digital outputs

These categories may be mapped as a contiguous address space in some data bases, or as four or more discrete spaces. Each address space may not be contiguous on a specific machine since inputs and outputs may be mixed or there may be gaps present in the addresses used.

The PROTOCOL CONVERTOR unit is a device which converts a subset of the MODBUS Remote Terminal Unit protocol (RTU) to a subset of the Extended Simple Protocol (ESP) programming port messages used on the GEM 80 Controllers. The MODBUS protocol device will always act as the master device, with all GEM 80 equipment acting as slaves. The protocol convertor will act as a slave to the MODBUS machine in a point-to-point configuration and as a master to one or more GEM 80 Controllers configured as tributaries on an ESP link.

The protocol convertor will operate with all 16 bit micro-processor GEM 80 Controllers. These are the GEM 80/160, 300 and 310 series.

1.2 Specifications

Power Supply Ratings	20 to 30 volts dc
Power Consumption	3.6 watts
Temperature Range:	0° to 50°C (operating) -20°C to 85°C (storage)
Number of possible GEM 80 Controllers on the link	14
Maximum length of ESP:	depends on the number of tributaries and data rate link (refer to the *GEM 80 Serial Communications Manual*, Publication Number T457)

MODBUS port

Communications Medium . . .	RS232
baud rate	9600
parity	odd
data bits	8
start bits	1
stop bits	1

ESP port

Communications Medium . . .	Active Current Loop (20mA)
baud rate	9600
parity	none
data bits	8
start bits	1
stop bits	1

Note...The 20mA current loop can drive 14 passive devices.

2.1 General Operation

The protocol conversion equipment acts as a slave to the MODBUS master in a point-to-point configuration and as a master to one or more GEM 80 Controllers configured as slaves on an ESP link. In general, messages from the MODBUS master are ignored unless a GEM 80 with the corresponding address is present. If addresses are matched, protocol conversion takes place.

2.2 Initial Operation On Power Up

On power up the converter unit will establish its interrupt structure, configure both serial ports, create and initialise flags and memory locations. Before proceeding to the main program loop the 'Active List' is constructed by polling the 'P' tables of the tributaries over the working address range 1-14 inclusive.

The information returned by the tributaries is stored as the 'Relocation Table' which is used to map the GEM table address space to that of the MODBUS host. As the polling proceeds the address of the tributary being polled is displayed on the seven segment LED. The address will remain on the display until a valid response is obtained or a timeout occurs. Under normal operation the response from the tributaries will occur so quickly that the displayed address may be imperceptible and only the absent or inoperative addresses will be observed. An active slave will therefore be conspicuous as a 'gap' in the sequentially displayed addresses. Tributaries 1 to 9 are displayed directly on the 7 segment display, tributaries 10 to 14 are represented by a unique code generated by the display driver.

The converter will not respond to MODBUS messages until the initial poll cycle is complete.

Having established the 'Active List' and 'Relocation Table' the program will then proceed to the main loop.

2.3 Main Loop Operation

The main program loop will sequentially display tributary addresses on the 'Active List'. As the program idles through the main loop, it examines the state of a flag which is set on 'Character Received Interrupt'. When this flag becomes set, indicating a valid MODBUS request received, the program will remove the tributary address from the active list and proceed to poll the p tables at that address. If no response is gained from the poll, a retry is initiated after a timeout period of approximately 700ms. If no response is received to the retry an exception code 4 will be returned. If the response to the polling is corrupt (as determined by the CRC codes) a retry will be initiated followed by an exception code 4 should the retry also be unsuccessful. Message conversion will only take place if the P-table polling is successful, the conversion will take place after the relocation tables are updated to ensure correct mapping of the memory address spaces of the GEM and MODBUS devices. When a valid GEM response is received by the converter then the tributary is replaced on the active list. Should there be no response from the GEM to the

converted message the program will idle until a further MODBUS message is received and no exception code will be raised.

2.4 Relocation Constants

In order to assist the user in the mapping function, the P-table locations P55, P56, P57 and P58 are used as relocation constants. The protocol convertor will read these values to obtain the offset for a respective table start location. The relocation function is limited but provides the user with a method of reserving tables for internal use in the GEM 80 which will not be accessed by the protocol conversion equipment.

P55 is the relocation constant for GEM 'A' tables
P56 is the relocation constant for GEM 'B' tables
P57 is the relocation constant for GEM 'G' tables
P58 is the relocation constant for GEM 'H' tables

2.5 Process Variable Types

In GEM 80 systems, both analog and digital process variables may be referenced in the GEM 80 'A' and 'B' tables and also 'C' and 'D' tables in some controllers. In order to achieve the required mapping function between the GEM 80 and the MODBUS device, it is necessary to move certain process variables from our 'A' and 'B' tables (or 'C' and 'D' tables) into a general work-space area ready for the mapping process. The areas chosen are as follows:

'A' tables correspond to digital inputs to the Distributed Control System (DCS)
'B' tables correspond to digital outputs to the DCS
'G' tables correspond to analog inputs to the DCS
'H' tables correspond to analog outputs to the DCS

You will require additional rungs in the ladder program or, if large amounts of process data are to be relocated, the use of the LOCATE and MOVE or COLLATE Special Functions may prove more efficient.

2.6 Supported Function Codes

Only the MODBUS function codes shown in Table 2.1 below are supported by the protocol convertor.

Table 2.1 Supported Function Codes

FUNCTION	REGISTER TYPE	DESCRIPTION	GEM TABLES	MAXIMUM WORD/BITS PER
1	DIGITAL OUTPUT 0XXXX	READ MULTIPLE BITS	B	2000 BITS
2	DIGITAL INPUT 1XXXX	READ MULTIPLE BITS	A	2000 BITS
3	ANALOGUE OUTPUTS 4XXXX	READ MULTIPLE WORDS	H	125 WORDS
4	ANALOGUE INPUTS 3XXXX	READ MULTIPLE WORDS	G	125 WORDS
5	DIGITAL OUTPUT 0XXXX	WRITE SINGLE BIT	B	1 BIT
6	ANALOGUE OUTPUTS 4XXXX	WRITE SINGLE WORD	H	1 WORD
8	N/A	FOLDBACK	N/A	N/A
15	DIGITAL OUTPUTS 0XXXX	WRITE MULTIPLE BITS	B	800 BITS
16	ANALOGUE OUTPUTS 4XXXX	WRITE MULTIPLE WORDS	H	100 WORDS

2.7 Supported Exception Codes

If the protocol convertor receives a corrupt message or NAK response from a GEM 80 tributary, or does not receive a reply in the appropriate time out period, no response will be sent to the MODBUS master.

The protocol converter supports exception codes 1, 2, 3 and 4.

Exception Code 1, Illegal Function:

This exception code is returned when a function code outside of the range 1-14 (inclusive) is encountered. In addition this code is generated if the fifth byte in a function 5 is other than 00 or FF hex.

Exception Code 2, Illegal Address:

This exception code is generated if the GEM response to a read or write request is an ESP message containing an ASCII '?' (this is distinguished from a data byte 3F hex as data bytes must exist in pairs). This will occur if, in a read request, the start table is non-existent or, in a write request the start table is non-existent, and/or the writing of tables crosses a table boundary. This code is also returned if the maximum number of bits/bytes dealt with by a particular function is exceeded

Exception Code 3, Illegal Data Value:

This exception code is generated if a read request crosses a table boundary. This is detected when the number of returned tables is less than the requested number.

Exception Code 4, Failure In Associated Device:

This exception code is returned if the P-table poll retry preceding a converted message is unsuccessful, either because there is no response or the response is corrupt.

3.1 Connection Data

Table 3.1 Connection Data

UNIT CONNECTIONS	
MODBUS	ESP+PSU
2 - Transmit Data 3 - Receive Data 7 - Signal Ground	1 - Rx+ 2 - Rx- 3 - Tx+ 4 - Tx- 7 - 24V dc 8 - GND

3.1.1 Point-to-Point Communications Link

The diagram below shows the connection details for a point-to-point communications link between a single MODBUS master, a protocol converter and a GEM80 Controller. The protocol converter acts as master to the GEM80 Controller, and as a slave to the MODBUS device.

Caution...If earth loops exist between a protocol converter and a GEM80 Controller they can present a possible hazard. Earth loops are most likely to occur if the current sources from the 8924 are used to drive the protocol converter; this situation should be avoided. Only the current sources of the protocol converter should be used and not those of the 8924 termination panel.

If an earth loop is suspected, disconnect the power and check all earth wiring.

To prevent the current sources of the 8924 being used accidentally ensure that all servicing and maintenance personnel are familiar with the procedures and practices outlined in this section.

Note...The 0V terminal of the 24Vdc power supply should be run to signal ground or similar clean earthing point.

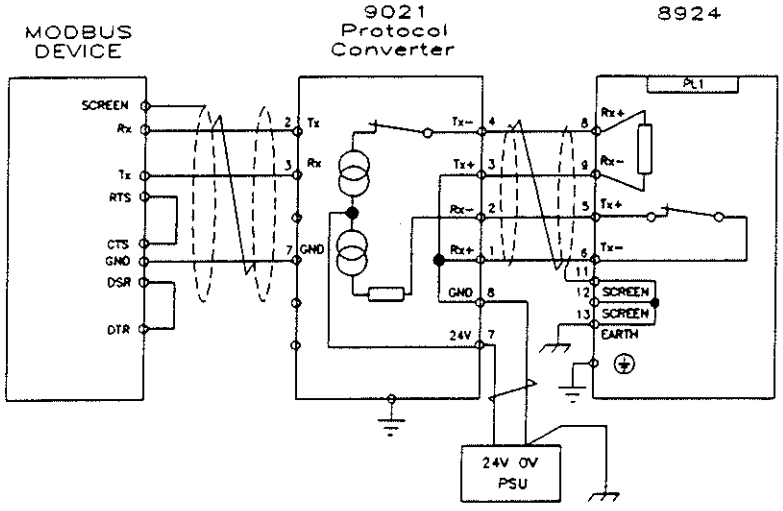

Figure 3.1 Point-to-Point Communication Link Connections

3.1.2 Multi-Drop Communications Link

The diagram below shows the connection details for a multi-drop 4-wire communications link between a single MODBUS master, a protocol converter and several GEM80 Controllers (no more than 14 max). The protocol converter acts as master to the GEM80 Controller and as a slave to the MODBUS device.

GEM 80 tributaries may be added using more 8924 termination panels using the typical twin pair wiring connections shown in the GEM 80 Serial Communications Manual, Publication Number T457.

Caution...If earth loops exist between a protocol converter and a GEM80 Controller they can present a possible hazard. Earth loops are most likely to occur if the current sources from the 8924 are used to drive the protocol converter; this situation should be avoided. Only the current sources of the protocol converter should be used and not those of the 8924 termination panel.

If an earth loop is suspected, disconnect the power and check all earth wiring.

To prevent the current sources of the 8924 being used accidentally ensure that all servicing and maintenance personnel are familiar with the procedures and practices outlined in this section.

Note...The 0V terminal of the 24Vdc power supply should be run to signal ground or similar clean earthing point.

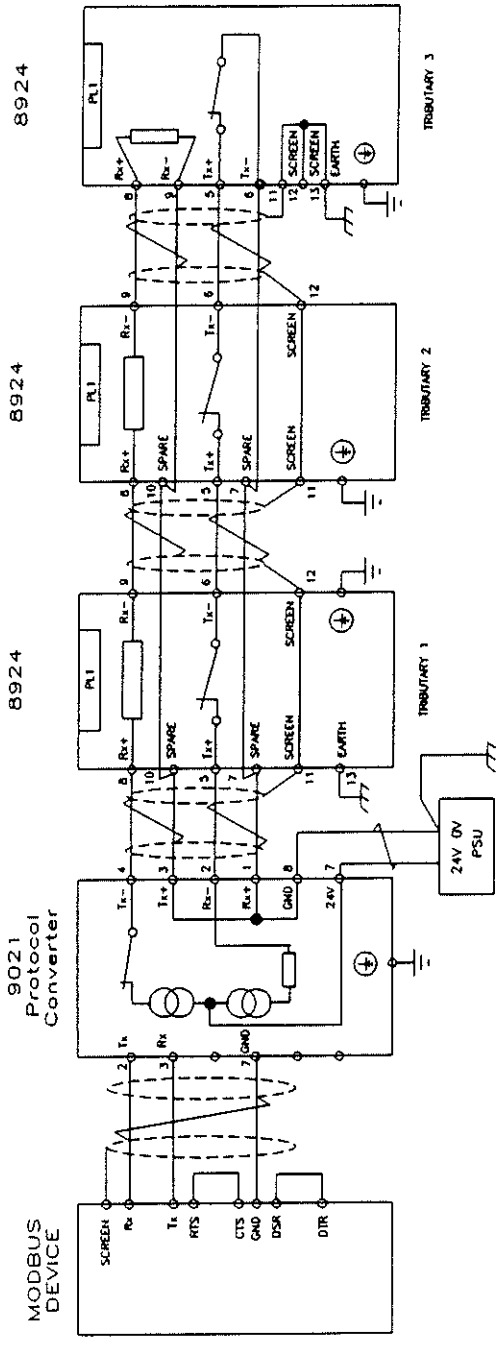

Figure 3.2 Multi-drop 4-Wire Communications Link

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4.1 Example

In this example we are using a HONEYWELL TDC 3000 device to operate as a supervisory system over a GEM 80 310 Controller, using port 1 of the controller as a tributary. The TDC machine communicates via a subset of the MODBUS RTU protocol and all relevant MODBUS functions are supported by the protocol convertor. It has been found that the communication time-out value (3 secs) is sufficiently large to enable the protocol convertor to operate.

The GEM 80 addresses shown in Table 4.1 require mapping onto the Honeywell I/O structure.

Table 4.2 shows the relationship between the GEM 80 data tables and the HONEYWELL data types.

Table 4.1 GEM 80 Address Locations

GEM80 ADDRESS	TYPE
A0.0 - A0.15	Digital Input
A2.0 - A2.10	Digital Input
A3.0 - A3.15	Digital Input
A5	Analog Input
A6	Analog Input
B8.0 - B8.15	Digital Output
A9	Analog Input
A10.0 - A10.15	Digital Input
B11.0 - B11.10	Digital Output
B15	Analog Output
B16	Analog Output

Table 4.2 GEM 80/HONEYWELL Relationship

RELOCATION CONSTANT	GEM80 DATA TABLE	I/O DATA TYPE	HONEYWELL
P55	A	Digital Input	1
P56	B	Digital Output	0
P57	G	Analog Input	3
P58	H	Analog Output	4

Table 4.3 shows the P-table settings required to configure Port 1 of the 310 Controller as a tributary.

Table 4.3 P-Table settings for Port 1

P-Table Setup	
P3	9600
P4	1
P5	0
P6	1
P7	32 (max)

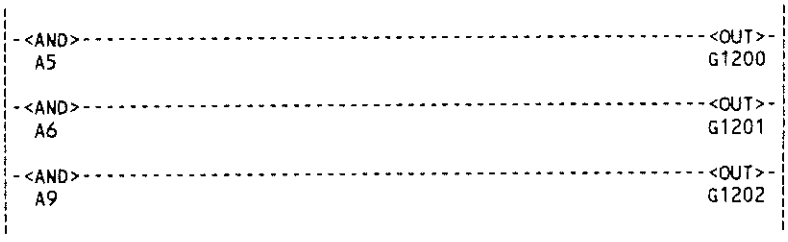
Table 4.4 shows the P-table settings required to map the GEM 80 addresses into the HONEYWELL TDC 3000.

Table 4.4 GEM 80 P-table data

TYPE	P-TABLE	GEM80 ADDRESS	HONEYWELL ADDRESS
Digital Input	P55 = 0	A0.0 - A0.15 A2.0 - A2.10 A3.0 - A3.15 A10.0 - A10.15	10001 - 10016 10033 - 10043 10049 - 10064 10161 - 10176
Digital Output	P56 = 8	B8.0 - B8.15 B11.0 - B11.10	00001 - 00016 00049 - 00059
Analog Input	P57 = 1200	G1200 G1201 G1202	30001 30002 30003
Analog Output	P58 = 600	H600 H601	40001 40002

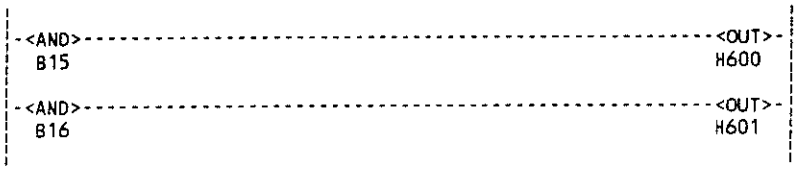
Note that analog inputs A5, A6 and A9 must be moved to specific G-table locations by executing rungs in the ladder program.

For example:-



Analog outputs B15, B16 must be moved to specific H-table locations by executing rungs in the ladder program.

For example:-



Data being located in the HONEYWELL machine is assigned to a specific address.The address used by the MODBUS protocol is not the same as that used by the HONEYWELL machine. The HONEYWELL machine adds a value of 1 to each address, e.g. register 41967 will have a MODBUS address field of 1966.

4.2 Timing Constraints for MODBUS/ESP Converter

The following are the average times measured from the end of the transmitted message to start of the response string for a GEM 163 with the indicated scan times. It should be noted that the response time is dependant on how far through a particular scan the GEM is when the ESP message arrives.

Table 4.5 Average Timings

FUNCTION NUMBER	AVERAGE RESPONSE TIME IN SECONDS (150 ms scan)	AVERAGE RESPONSE TIME IN SECONDS (300 ms scan)
1	0.88	1.46
2	0.84	1.45
3	0.78	1.45
4	0.84	1.52
5	0.36	0.75
6	0.27	0.43
8	0.27	0.52
15	0.95	1.41
16	0.84	1.58

The times listed below are the average times taken to return the stated exception codes, scan times etc as above.

Table 4.6 Exception Code Return Times

EXCEPTION CODE	CONVERTER GENERATED (150 ms)	GEM GENERATED (150 ms)	CONVERTER GENERATED (300 ms)	GEM GENERATED (300 ms)
1	0.00 (see note 1)	N/A	0.00 (see note 1)	N/A
2	0.15	0.27	0.58	0.51
3	N/A	0.7135	N/A	1.3398
4	1.41	N/A	1.41	N/A

Notes:-

1. The converter returns this exception code immediately on receiving the function number in the incoming string, therefore, the exception code is returned before the full Modbus message has arrived.

Exception codes 1 and 4 are converter generated in the sense that it requires no 'feedback' from the GEM. Exception code 3 is GEM generated; it is the direct result of an ESP response. Exception code 2 can be internally generated; if more than the allowable number of bits/ bytes are requested, or it can be GEM generated if a non-existent start table is requested in an ESP message.(see exception code management for a fuller description of the codes and their use

4.3 Application Hints

1. If only small numbers of analog values are required to be moved, the method shown in the ladder program example should be employed.

2. If the application requires that digital information is exchanged then note that the ladder diagram will write to A tables, effectively inputs to the DCS, and read from B tables, effectively outputs from the DCS. In essence, the GEM 80 is acting as a remote I/O station to the DCS. For non-verification systems, the high A and B tables need to be declared with expanders.

3. If large numbers of analog values, stored in GEM 80 A, B, C or D-tables, require transfer to a MODBUS protocol device, the Special Functions LOCATE (S20) and MOVE (T20) may be used. These functions are only practical when moving areas of contiguous data tables. In the case of discontinuous data tables, Special Function COLLATE (T37) should be used.

4. If analog outputs are to be written to the GEM 80 Controller from the MODBUS protocol machine then suitable ladder program must be used to move the incoming data into the appropriate GEM data table.

5. The MODBUS machine MUST have a sufficiently large communications link time-out value in order for the protocol convertor to operate. This is to allow for the time delays involved in both accessing the GEM 80 Controller and in the processing time of the convertor. As a guide, the time-out value of the MODBUS device must be configured to be at least two seconds but preferably should be greater.

6. The voltage drive capability of the current loop sources in the protocol convertor is 30V, making it possible to connect up to a maximum of 14 GEM 80 Controllers.

7. It is possible for the ladder program to overwrite any MODBUS function code action. To avoid this situation, I/O addresses written to by the MODBUS master device must not be written to in the ladder program

8. This document does not intend to explain the MODBUS protocol and ESP. Information regarding ESP may be found in the GEM 80 Serial Communications Manual. Publication Number, and in the relevant GEM 80 Controller Technical Manual.

4.4 Mounting Details

Figure 4.1 shows the dimensions and mounting details for the MODBUS

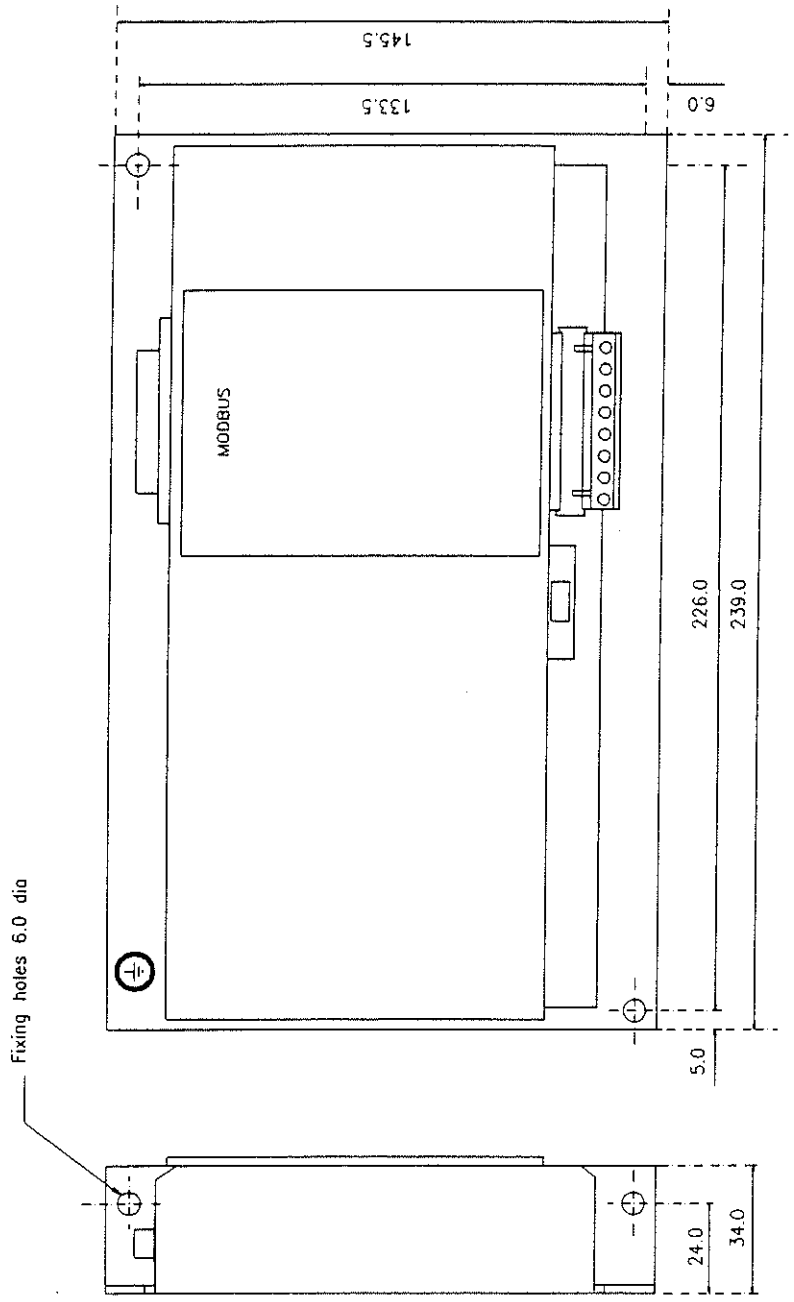


Figure 4.1 Mounting Details

5.1 Ordering Code

Protocol Converter:- 9021/4001

5.2 Additional Information

Further information and help on GEM 80 products or applications can be obtained from:

Your local GEM 80 representative,

or

Customer Service Dept.
Tel. (0782) 783511 Ext. 2651 or 2598
International Code 44 782 783511

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