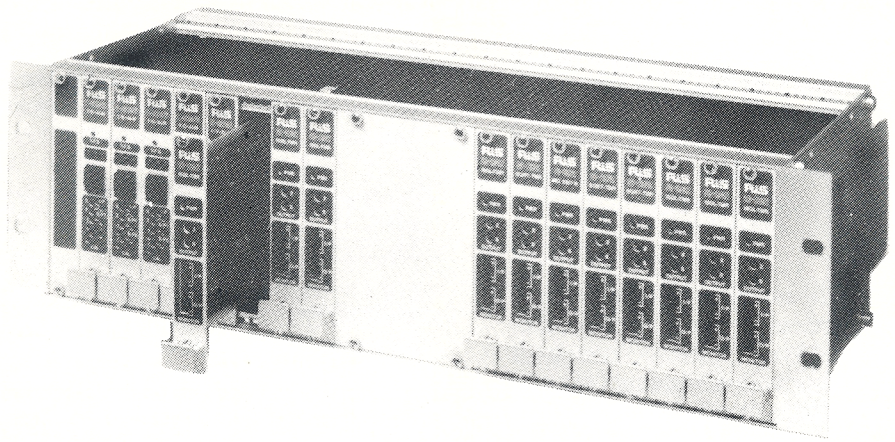
Signal Conditioning Equipment



INTRODUCTION

Several manufacturers of process control equipment produce ranges of signal conditioning transmitter modules which are suitable for providing an interface between analogue plant signal inputs or outputs and GEM 80 controllers. These manufacturers can usually provide suitable 19" rack-mounted subracks and termination arrangements for their transmitter modules.

ANALOGUE INPUTS

GEM 80 16-channel Fast I/O input equipments type 8840 are described in Product Data Sheet T211. They will accept signals which have a common mode voltage of only a few volts relative to earth. Also, all 16 channels have the same signal range (set by 4 wire-wrap links on the module backplane).

In the GEM 80 range of equipment, there are also analogue input modules and analogue input multiplexers in the compact I/O range which couple to the basic I/O highway. These have either only a few channels or, in the case of a multiplexer, channels which are all subject to the same input range.

By using signal conditioning transmitter modules, with 1 transmitter module per channel, signals can be accepted into the GEM 80 which have different spans, common mode voltages which are much higher above earth, and which are isolated from each other.

Further, signal conditioning transmitter input modules often provide additional facilities not present on straight analogue input modules. For instance, thermocouple transmitter modules normally provide cold junction compensation; resistance temperature detector (RTD), slidewire and strain gauge transmitter modules normally provide current sources for excitation of these devices.

ANALOGUE OUTPUTS

GEM 80 16-channel Fast I/O output equipments type 8841 are described in Product Data Sheet T212. They provide non-isolated output signals which have one side connected to the GEM 80 signal ground. Also, all 16 channels have the same signal range, determined by the ordering code of the 8312 or 8313 module included in the equipment.

In the GEM 80 range of equipment, there are also analogue output modules in the compact I/O range which couple to the basic I/O highway. These have fewer channels per module, which are also all subject to the same output range.

By using signal conditioning transmitter modules, with 1 transmitter module per channel, signals can be provided by the GEM 80 which have different spans, and which are entirely isolated from the GEM 80 controller and from each other.

EQUIPMENT REQUIREMENTS

We would recommend that the type of signal conditioning equipment you choose meets the following requirements:

- Physically compact. Where you are using GEM 80 Fast I/O analogue input and output modules, you should be able to mount the 16 signal conditioning transmitter modules which connect to one 16-channel analogue I/P or O/P module in one 19" rack-mounted subrack.

  Where you are using GEM 80 Basic I/O analogue modules, you may have only the odd one or two channels requiring signal conditioning, and the need for compactness becomes less important. Instead of using subrack mounted signal conditioning transmitter modules, you might in this case prefer to use individual stand-alone signal conditioning transmitter units.

- Easy wiring. You should be able to connect any subrack of signal conditioning transmitter modules direct to the GEM 80 controller subrack by ribbon cable. The plant side connections should have suitable terminals for plant wiring.

- Performance. The signal conditioning transmitter modules or units should meet your needs as regards accuracy, speed of response, warm-up time, etc.

RECOMMENDATIONS

The following points are general recommendations on the way in which you specify signal conditioning transmitter modules.

Signals between the signal conditioning transmitters and the GEM 80

To allow detection of signal conditioning transmitter module failure, broken wires, or supply loss, you should use signal ranges having an elevated zero, e.g. use a span of 1-5V or 2-10V (*not* 0-5V or 0-10V) for the signal between the transmitters and the GEM 80, corresponding to the working span of the plant signal, in the same way that process control signals are commonly made 4-20mA.

You should also consider any possible conditions in which signals might have to go beyond their normal operating range. For instance, if you use a GEM 80 analogue input module which can accept voltages in the range ±10.235V, then you would have 0.235V in hand if you used 2-10V input signals, but over 5V in hand if you used 1-5V signals. On the debit side, allowing a large over-range will reduce the signal accuracy under normal operating conditions.

Preset Calibrations

Most signal conditioning transmitter modules have screwdriver-adjust potentiometers for setting the range and span. Unless you specifically request otherwise, manufacturers may supply their transmitter modules uncalibrated, and it is then up to your instrument technicians to set them up to the required calibration.

Alternatively, where you do *not* have experienced instrument engineers or technicians, you should call for the manufacturer to supply signal conditioning transmitter modules pre-calibrated to your requirements when you place your order on the manufacturer. You should also make sure that the manufacturer suitably labels the transmitter modules so you can distinguish between those of the same type but preset to different calibrations.

When ordering pre-calibrated transmitter modules, check with your supplier on the calibration conditions. Most signal conditioning transmitter modules generate some heat, causing their temperature under normal operating conditions to be, say, 20°C above ambient. For the best accuracy, this temperature rise should be catered for by your supplier calibrating the transmitter modules at, say, 40 or 45°C, rather than at room temperature.

Equipment Availability

In case of failure of a signal conditioning transmitter module, you will normally put the plant back on stream by replacing the faulty transmitter module with a spare module.

If you hold a stock of spare uncalibrated transmitter modules, then your instrument technician will first have to set up any replacement module to the required calibration. Since most types of signal conditioning transmitter module take some time to warm up and stabilise (often 30 minutes or more), then you cannot perform accurate calibration until the end of the warm-up period. The plant down time could therefore be high.

If, on the other hand, you hold a stock of spare calibrated transmitter modules (whether these have been calibrated by yourselves or by the manufacturer), then you don't need to re-calibrate, and plant outage is reduced.

Hot Spares

Because most types of signal conditioning transmitter module take a few minutes to warm-up, then, until that time has elapsed, they will not perform to the manufacturer's published accuracy figures. This applies equally whether your spare modules are uncalibrated or pre-calibrated.

To minimise such warm-up time problems, we therefore recommend that, where feasible, you keep your spare transmitter modules powered up in a spare subrack or enclosure, in a location physically close to the operating modules. You can then quickly replace a faulty transmitter module with one which is already warmed up.

Where transmitter modules provide current outputs for excitation purposes (e.g. for RTD's, slidewires, strain gauges, etc.) then you should store the spare modules, not only powered up, but also with dummy load circuits simulating the actual circuits they will be required to drive. If you don't do this, some circuit components on the transmitter modules will not stabilise at their correct operating temperatures, and the transmitter modules (even though they are warm) are not properly warmed up.

Linearisation

For the best accuracy, you should avoid ordering signal conditioning transmitter modules which provide a linear output against temperature for thermocouple or RTD inputs. Linearisation is normally carried out on these transmitters by analogue circuitry, which is liable to drift with ambient temperature. Linearisation can be carried out a lot more accurately, *with no drift*, using the FGEN special function S30 within your GEM 80 program. Further, non-linearised signal conditioning input transmitter modules are cheaper than linearised ones. To save you the trouble of calculating the data table values, we have given these values for some of the commoner types of thermocouple and temperature ranges in Tables 2 to 5 at the end of this leaflet.

Similarly, where a square root function is required (e.g. to determine flow from differential pressure across an orifice plate or venturi), it is simpler and more accurate to use the SQRT special function S12 in the GEM 80 controller program than to purchase signal conditioning transmitter modules which themselves extract the square root from a process signal input signal.

With a GEM 80 system, you can usually provide logging and indication via the GEM 80 system itself, e.g. using a print-out from a printer connected to the GEM 80 for logging, and using a video display showing bar-charts, etc., for indication. However, if your system is going to use conventional chart recorders and indicators as well as the GEM 80 equipment, then you may find it convenient to use linearising transmitters so that voltages or currents can be monitored directly as meaningful values, even though this will give reduced accuracy.

Current Loops

If you are using 20mA signals on the input side of signal conditioning transmitters, and if you have other equipment in the loop operating from the same signal, then, in case of a transmitter module failure, you may need to maintain loop continuity when the faulty transmitter module is removed. In this case, rather than using current input transmitters, you should mount the shunt resistors externally, and use voltage input transmitters operating from the voltage dropped across the shunt resistors.

Some manufacturers of signal conditioning equipment allow for the mounting of such shunt resistors in their subracks or in their cable termination arrangements.

Signal Ranges

Using pre-set signal conditioning transmitter modules, you should attempt to minimise the number of different calibrations you want; for instance, there would be little gained in having thermocouple input modules for spans of 0-350°C and 0-400°C. It would be more sensible to order them both as 0-400°C, and to allow for the different input signal ranges to the GEM 80 controller within your GEM 80 program. You should therefore be able to limit the different pre-set calibrations you need to an acceptably small number. Some suggested ranges are given in Table 1.

Table 1 - Recommended temperature ranges

Temperature ranges	RTD's			Thermocouples			
	Pt	Cu	Ni	K	T	J	E
−100 to +200°C	X			X	X	X	X
−100 to +1000°C						X	X
−100 to +1100°C				X			
0 to +100°C	X		X				
0 to +150°C	X	X	X	X	X	X	X
0 to +200°C	X	X	X	X	X	X	X
0 to +400°C				X	X	X	X
0 to +600°C				X		X	X
0 to +1000°C				X		X	X

ROCHESTER INSTRUMENT SYSTEMS SC-8300 RANGE

One widely available range of equipment which has been found to meet most users' requirements is the Rochester Instrument Systems SC-8300 range of signal transmitter modules. A summary of these modules, together with subrack and termination arrangements suitable for use with GEM 80 systems, is given below.

The following range of transmitter modules suitable for use with GEM 80 systems were available at June, 1985. Consult Rochester direct for fuller details and additions to the range.

Modules

SC-8300R	Slidewire transmitter (isolated)
SC-8302	Process signal input or output (isolated), e.g. 4-20mA, 0-10V, etc.
SC-8302E	As SC-8302, but with isolated excitation supply (24V d.c. @ 20mA max) for 2-wire transducers.
SC-8326	Millivolt transmitter (isolated).
SC-8326W	Thermocouple transmitter (isolated).
SC-8350	Frequency transmitter (isolated).
SC-8372	RTD transmitter (isolated).
SC-8374	RTD transmitter (non-isolated).

Enclosures

Model 8014	19" rack mounted chassis, for mounting up to 16 transmitter modules of any of the above types, and a Model 8006 power supply unit, 3U high (5.25", 133.5mm)
	Modules may be arranged either as 16 inputs or 16 outputs, but not both.

Ribbon cable connectors (34 pin), 3 off, arranged as:
PL1: 8 x 4-wire inputs, 1st 8 modules
PL2: 8 x 4-wire inputs, 2nd 8 modules
PL3: 16 x 2-wire outputs, all 16 modules

Connectors PL1 and PL2 use different pins, so that you can loop one 34-way ribbon cable via both these connectors to pick up all 16 2-wire inputs on one ribbon when driven from a GEM 80 analogue output module.

Fitted with turret lugs for mounting current loop shunt resistors where you need to maintain loop continuity when a module is withdrawn.

The resistors used by Rochester Instruments for for current loop shunts are 0.1% tolerance, so as to maintain module interchangeability.

Power Supply Units

Model 8006

24V d.c. 2A Power Supply Unit.
Mounts in the centre of a Model 8014 enclosure.

Power input 88-132 or 176-264V 50/60Hz
Voltage range selectable by link change.

Input Termination Panel

Model 8018

19" rack mounted panel, 3U high 8018 (5.25", 133.5mm).

Suitable for accepting ribbon cables from connectors PL1 and PL2 on a Model 8014 enclosure.

Fitted with screw type terminals for plant connections, with 4 terminals per input channel for plant wiring, and 2 terminals per input channel for cable screens.

Fitted with screw terminal block TBA21 for a.c. power connections (when the Model 8014 enclosure is fitted with a Model 8006 power supply unit).

Fitted with screw terminal block TBA20 for signal ground and 24V connections (the 24V terminals allow connection of an external supply where a Model 8006 power supply unit is not used, or, where a Model 8006 unit *is* used, they provide a suitable point for supply monitoring).

Output Termination Panel

Model 8019

19"rack mounted panel, 3U high 8019 (5.25", 133.5mm).

Suitable for accepting the ribbon cable from connector PL3 on an Model 8014 enclosure.

Fitted with screw type terminals for plant connections, with 2 terminals per output channel for plant wiring, and 1 terminal per output channel for cable screens.

Fitted with screw terminal block TBB21 for a.c. power connections (when the Model 8014 enclosure is fitted with a Model 8006 power supply unit).

Fitted with screw terminal block TBB20 for signal ground and 24V connections (the 24V terminals allow connection of an external supply where a Model 8006 power supply unit is not used, or, where a Model 8006 unit *is* used, they provide a suitable point for supply monitoring).

Suggested Method of Use with GEM 80 Controllers

The pin headers (male sockets with latch handles on the printed circuit boards) used on Rochester Instrument Systems equipment are of the 3M's type, and need equivalent sockets (female plugs) on the ribbon cables used with them.

On the ribbon cable supplied with either a GEM 80 analogue input or analogue output equipment to the ordering codes given below, the sockets will generally be suitable for mating direct with these pin headers.

However, earlier versions of GEM 80 ribbons cables used sockets of a different type which looks very similar, but which requires different length latch handles on the pin headers to guarantee correct mating. Check this out first. If the socket at the Rochester Instrument Systems end of the ribbon cable will not mate correctly, you must snip the socket off the ribbon cable, discard it, and fit a 3M's type socket.

Analogue Inputs

See Product Data sheet T211 for 8840 Analogue Input equipments.

The following ordering codes pick up 16-channel input equipments with ribbon cables but without termination panels, and with 5ms input filters. (The use of alternative equipments with 0.5ms input filters is not recommended because of signal conditioning transmitter module residual output ripple).

8840-4021 : For signals in the range −10 to +10V
8840-4022 : For signals in the range −5 to +5V

Input signals from the signal conditioning transmitter modules are unipolarity and do not therefore utilise the whole range. This is of little consequence and only affects the system accuracy marginally.

Ribbon Cabling:

A single ribbon cable socket must be made off on the end of the GEM 80 ribbon cable, and plugged into pin header PL3 on the Model 8014 enclosure. Two 34-way ribbon cables need to be made up to connect pin headers PL1 and PL2 on the enclosure to pin headers PA1 and PA2 respectively on the Model 8018 termination panel. (Note that if only 8 transmitter modules or less are fitted in the enclosure, then only the ribbon from PL1 to PA1 is required, but you are well advised to make off both ribbons in case you need to add extra transmitter modules in the future.)

Analogue Outputs

See Product Data sheet T212 for 8841 Analogue Input equipments.

The following ordering codes pick up 16-channel output equipments with ribbon cables but without termination panels.

8841-4003 : For signals in the range −10 to +10V
8841-4002 : For signals in the range −5 to +5V

Output signals from the signal conditioning transmitter modules are unipolarity and do not therefore utilise the whole range. This is of little consequence and only affects the system accuracy marginally.

Ribbon Cabling:

The ribbon from the GEM 80 needs fitting with two ribbon cable sockets, one plugging into PL1 and one into PL2 on the Model 8014 enclosure. A single 34-way ribbon cable needs to be made up to connect PL3 on the Model 8014 enclosure to PB1 on the Model 8019 termination panel.

Connection Diagrams

The diagrams below show the ribbon connections required. Figure 1 is for inputs from the plant to the GEM 80, and Figure 2 is for outputs from the GEM 80 to the plant.

Where the Model 8018 or Model 8019 termination panel is physically near to the Model 8014 enclosure, then 34-way flat ribbon will be satisfactory, but if the cable runs some distance then it would be better to use twisted pair ribbon (as used on the GEM 80 ribbon) for better noise immunity.

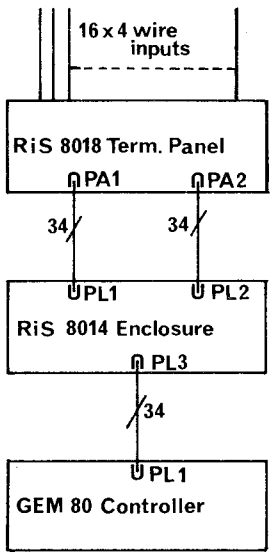


Figure 1 Inputs from GEM 80 to plant

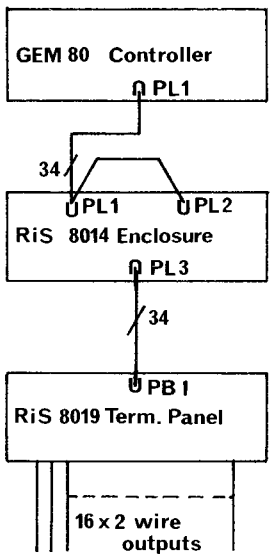


Figure 2 Outputs to plant from GEM 80

THERMOCOUPLE LINEARISATION

The following tables give values which can be used in GEM 80 programs for the linearisation of thermocouples to the recommended ranges given earlier in Table 1. For controllers using GEM 80 Control Language (in ladder diagram format), you can use these values with the special function FGEN (S30), and we have laid out the tables on this basis. For controllers using BASIC language, you can use the same values in an interpolation routine.

The tables have been worked out as follows:

1. The input from the signal conditioning thermocouple input transmitter modules is either in the range 2-10V into a 10V input module (or 1-5V into a 5V input module) which will be converted within the GEM 80 input module into corresponding numeric values in the range 6400-32000.
2. These numeric values are converted by the FGEN special function (or by a BASIC language interpolation routine) into numbers which can be easily monitored as temperature values in degrees C. Depending on the temperature range, the numbers are either 100 times or 10 times the actual temperatures in °C.
3. Data for the thermocouple characteristics on which the straight line segmented approximations are based is taken from the IEC reference tables (IEC465).
4. The linearisation accuracy is given at the foot of the columns. It is clearly possible to produce functions with more segments giving greater accuracies (roughly speaking, using twice as many segments will reduce the errors to a quarter), but against this must be weighed the inherent tolerances of the thermocouples themselves, which may make such higher accuracy functions a waste of table space.

TABLE 2
E TYPE THERMOCOUPLE

Temp. Range	0 to 150°C	0 to 200°C	0 to 400°C	0 to 600°C	0 to 1000°C	−100 to 200°C	−100 to 1000°C	Remarks
Qty.of Loc's	10	10	13	15	25	15	25	No.of tables req.
Zm	–	–	–	–	–	–	–	Fault code
Zm + 1	6400	6400	6400	6400	6400	6400	6400	Lowest input
Zm + 2	5120	5120	3200	2560	1280	2560	1280	Increment
Zm + 3	6	6	9	11	21	11	21	No.of tab.points
Zm + 4	0	0	0	0	0	−10000	−1000	Output values
Zm + 5	3275	4450	594	735	620	−6085	−185	
Zm + 6	6375	8600	1135	1395	1190	−2600	480	
Zm + 7	9350	12550	1650	2010	1730	650	1100	
Zm + 8	12220	16350	2140	2610	2250	3700	1680	
Zm + 9	15000	20000	2620	3190	2750	6650	2235	
Zm + 10			3090	3760	3240	9475	2770	
Zm + 11			3545	4320	3720	12200	3290	
Zm + 12			4000	4885	4200	14850	3805	
Zm + 13				5440	4670	17450	4315	
Zm + 14				6000	5150	20000	4820	
Zm + 15					5620		5330	
Zm + 16					6090		5830	
Zm + 17					6565		6335	
Zm + 18					7045		6845	
Zm + 19					7520		7360	
Zm + 20					8005		7875	
Zm + 21					8500		8400	
Zm + 22					8995		8920	
Zm + 23					9495		9460	
Zm + 24					10000		10000	
	100	100	10	10	10	100	10	Scale Factor (Output change per 1°C)
	0.10	0.12	0.10	0.10	0.10	0.13	0.15	Error (% of span)

TABLE 3
J TYPE THERMOCOUPLE

Temp. Range	0 to 150°C	0 to 200°C	0 to 400°C	0 to 600°C	0 to 1000°C	−100 to 200°C	−100 to 1000°C	Remarks
Qty.of Loc's	8	9	9	9	13	13	13	No.of tables req.
Zm	–	–	–	–	–	–	–	Fault code
Zm + 1	6400	6400	6400	6400	6400	6400	6400	Lowest input
Zm + 2	8533	6400	6400	6400	3200	3200	3200	Increment
Zm + 3	4	5	5	5	9	9	9	No.of tab.points
Zm + 4	0	0	0	0	0	−10000	−1000	Output values
Zm + 5	5180	5225	1044	1563	1362	−5540	650	
Zm + 6	10125	10225	2025	3045	2671	−1550	2040	
Zm + 7	15000	15125	3010	4545	3983	2250	3460	
Zm + 8		20000	4000	6000	5287	5970	4870	
Zm + 9					6531	9510	6240	
Zm + 10					7690	13025	7510	
Zm + 11					8821	16550	8715	
Zm + 12					10000	20000	10000	
	100	100	10	10	10	100	10	Scale factor (Output change per 1°C)
	0.15	0.12	0.18	0.25	0.15	0.17	0.33 for T < 150 0.10 for T > 150	Error (% of span)

TABLE 4
K TYPE THERMOCOUPLE

Temp. Range	0 to 150°C	0 to 200°C	0 to 400°C	0 to 600°C	0 to 1000°C	−100 to 200°C	−100 to 1100°C	Remarks
Qty.of Loc's	8	8	9	9	9	15	21	No.of tables req.
Zm	–	–	–	–	–	–	–	Fault code
Zm + 1	6400	6400	6400	6400	6400	6400	6400	Lowest input
Zm + 2	8533	8533	6400	6400	6400	2560	1600	Increment
Zm + 3	4	4	5	5	5	11	17	No.of tab.points
Zm + 4	0	0	0	0	0	−10000	−1000	Output values
Zm + 5	5078	6690	1003	1525	2540	−6355	−114	
Zm + 6	9985	13235	2013	3060	5000	−3150	620	
Zm + 7	15000	20000	3025	4540	7420	−100	1360	
Zm + 8			4000	6000	10000	2800	2120	
Zm + 9						5650	2865	
Zm + 10						8500	3595	
Zm + 11						11300	4315	
Zm + 12						14150	5030	
Zm + 13						17050	5745	
Zm + 14						20000	6460	
Zm + 15							7185	
Zm + 16							7920	
Zm + 17							8665	
Zm + 18							9425	
Zm + 19							10205	
Zm + 20							11000	
	100	100	10	10	10	100	10	Scale Factor (Output change per 1°C)
	0.15	0.20	0.15	0.15	0.16	0.11	0.15 for T < 100 0.05 for T > 100	Error (% of span)

TABLE 5
T TYPE THERMOCOUPLE

Temp. Range	0 to 150°C	0 to 200°C	0 to 400°C	−100 to 200°C	Remarks
Qty.of Loc's	9	13	13	15	No.of tables req.
Zm	–	–	–	–	Fault code
Zm + 1	6400	6400	6400	6400	Lowest input
Zm + 2	6400	3200	3200	2560	Increment
Zm + 3	5	9	9	11	No.of tab.points
Zm + 4	0	0	0	−10000	Output values
Zm + 5	4185	2925	640	−5815	
Zm + 6	8000	5675	1200	−2200	
Zm + 7	11600	8275	1720	1050	
Zm + 8	15000	10775	2220	4200	
Zm + 9		13200	2680	7100	
Zm + 10		15525	3135	9850	
Zm + 11		17800	3575	12500	
Zm + 12		20000	4000	15100	
Zm + 13				17550	
Zm + 14				20000	
	100	100	10	100	Scale Factor (Output change per 1°C)
	0.20	0.10	0.18	0.18	Error (% of span)

GEC Industrial Controls Limited.
Programmable Controllers Division,
Kidsgrove, Stoke-on-Trent,
Staffordshire ST7 1TW, England.
Tel: Kidsgrove (07816) 3511
FAX (Group 3) Kidsgrove (07816) 76329
Telex: 36293 GECICK

Also at:
Mill Road, Rugby,
Warwickshire CV21 1BD.
Tel: Rugby (0788) 2121

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1 Stanhope Gate, London, W1A 1EH.

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