FGH

INSTRUCTION MANUAL

P250A

FGH CONTROLS LTD
Openshaw Way, Letchworth
Herts. SG6 3ER
Tel: +44 (0)1462 686677
Fax: +44 (0)1462 671860

P250A MANUAL   Issue 1 November 1983

Contents

1. Unpacking & Inspection

Carefully unpack the instrument and perform a visual inspection. If there are any signs of damage, particularly if the packing is damaged, notify FGH Controls Ltd or your local distributor from whom the instrument was purchased immediately and retain the original package.

2. Mechanical Installation

The P250A is intended for horizontal panel mounting and is designed to fit the DIN 1/2
standard:- Width   186mm –0 +1.1
Height   92mm –0 +0.8
The internal panel fixing clamps are suitable for panel thickness up to 5mm.

The approx weight of the instrument is 2.6kg.
Since the P250A incorporates integral temperature sensors at its rear terminals to achieve cold junction compensation for its thermocouple inputs, it is important that the instrument is mounted in a position such that it is not subject to rapid or excessive changes in ambient temperature such as would occur due to draughts or radient heating from adjacent hot surfaces. Rapid changes in ambient temperatures may result in errors in control.
The front panel controls are not environmentally sealed and are proof against neither dust nor water contamination. In environments where dust or water spray is likely to be a hazard, it is strongly recommended that the instruments front panel be protected.

3. Electrical Installation

3.1 General

The electrical connections are shown in Table 1. The terminal blocks used in the instrument are designed to suit cables from 0.5 to 1.5 sq mm. When connecting cables it is neither desirable nor necessary to undo the terminal screws beyond approx' one and a half turns since this opens the cable entry hole to its maximum. Any further unscrewing of these screws will only increase the possibility of the screws becoming free with the attendant danger of lost or cross threaded screws.
The insulation stripping length is 7mm and the total cable insertion depth is 18mm.
Try as far as possible to segregate and to keep segregated the low voltage sensor cables from the high voltage supply and relay cables.

3.2 Power Connections

The instrument is suitable for use on either 110V or 240V 50/60Hz supplies by means of an internal preset soldered wire link. Ensure that the P250A is set for the correct voltage since inadvertent connection of 240V to an instrument set for 110V will result in immediate permanent damage to the instrument. The instrument must be earthed by means of the earth stud on the rear panel whenever the supply is connected.
It is recommended that the supply is fused externally using a 0.25AF fuse.
The instrument consumes approx' 7VA.

3.3 Sensors Inputs

The P250A provides automatic cold junction compensation by sensing the temperature of its sensor input terminals.
It is therefore essential that the compensation (extension) cable be of the correct type and that it be wired right up to the sensor terminals at the rear of the instrument.
The upscale burnout feature results in a flow of approx' 0.1µA through the thermocouple and its compensation cable, this will result in errors of measurement and control with very long runs of compensation cable. Errors of approx' –1°C can be expected where the compensation cable resistance is 100Ω for precious metal sensors or 400Ω for base metal sensors. Each sensor input is galvanically isolated to a maximum of 250V RMS.

3.4 Relay Outputs

The P250A provides four form A function relay contacts, one of which will close for each of the four program positions; Ready, Rate 1, Dwell and Rate 2.
These relay contacts are rated at:- **250V RMS Resistive Load.**
There are no arc suppression components fitted to these contacts. If the load to be switched is significantly inductive then very high transient voltages may occur across the load as the contacts break the current in the load. Such high voltages and the resultant arc lead to excessive erosion of the relay contacts or indeed flashover on the PCB, it is therefore recommended that inductive loads be arc suppressed, see Fig 1 for general recommendations.

The P250A provides a single form A time proportioning relay contact for each of its internal controllers. **Note:** Depending on the model supplied, output 2 may not be operative.
These relays are rated at: **250V RMS Resistive Load.**
These contacts are internally arc suppressed by means of a CR Network and a voltage dependant resistor.

The status of these relays are shown by means of the front panel LED'S.

3.5 **Other Inputs/Outputs**

Further inputs and outputs are provided as follows:-

3.5.1 A remote start and remote reset input on terminals 19 & 18 respectively. These are operated by means of an external voltage free contact closure to terminal 16 as indicated in Table 1.

3.5.2 A hold input on terminal 17. When connected to common on terminal 16 this causes a hold condition on the programmer, see Section 4.

3.5.3 A setpoint output on terminal 15. This output is a pseudo digital “PWM” setpoint, see section 7 for further details.

4. **Setting Up and Modes of Operation**

4.1 The P250A generates a setpoint temperature-time profile as illustrated in Fig 2. This is set as follows:-

1. Set the required rate of rise of temperature (in °C) on the three digit rate 1 switch.

2. Set the required temperature (in°C) at which rate 1 terminates on the four digit switch.

3. Set the required dwell time (in hours and tenths of hours) on the three digit dwell switch.

4. Set the required rate of fall of temperature (in°C per Hr) on the three digit rate 2 switch.

5. A setting of zero on rate 1 or rate 2 switches will be interpreted as a step change (infinite rate).

The resultant setpoint generated by the above settings will be used by the P250A as a common setpoint for the two internal controllers. These controllers measure input 1 and input 2 and generate time-proportional outputs, output 1 and output 2. It is necessary to set the proportional bands of these controllers.

If at any time during the execution of a program input 1 (and input 2 if output 2 operative) deviates from the setpoint by more than an amount determined by the hold band, then a hold condition will occur. It is necessary to set the hold band of this controller(s). When a hold condition is detected the P250A can respond in a number of different ways. You must set the hold mode and the hold type. The proportional band, hold band, hold mode and type are set by means of an internally mounted DIL switch.

Access may be gained to the DIL switch by removing the four front panel-fixing screws and then gently disengaging the panel from the bezel and digital switches. Note the front panel push buttons are still wired to the internals of the P250A and the front panel cannot be completely removed. Refer to Fig 3.

4.2 **Proportional Band**

This is determined by the first three switches of the DIL switch, both controllers within the P250A share a common proportional band setting. Refer to Fig 4, as can be seen, as the input increases towards and then exceeds the setpoint the amount of power delivered by the controller to the process decreases from 100% to 0%. The proportional band is defined as that change of input necessary to reduce the power from 100& to 0%, thus the power delivered is dependant upon the difference (error) between the setpoint and the input.

The proportional band of the P250A is positioned with respect of the setpoint such that when the setpoint is zero then the amount of power (P) delivered to the process at zero error is 0% whereas when the setpoint is at its maximum, P at zero is 100%. The setpoint is however, always within the proportional band. This somewhat baffling feature of the P250A has been included so as to reduce the errors in the control action and to reduce any overshoots at the end of rates over a wide range of setpoint values.

The controllers within the P250A regulate the power delivered to the load by a technique known as "time-proportioning". The controllers output is a form A relay, to deliver 100% power the relay is energised continuously, to deliver 0% power the relay is de-energised continuously, to deliver a percentage P then the relay is energised for P% of the cycle time and de-energised for 100-p% of the cycle time where the cycle time is a constant 20 seconds (approx'). To achieve the minimum error between the controller's input and its setpoint it is clearly important that the proportional band be set to as small a value as possible, the proportional band cannot be reduced below a certain critical value however since a point is reached where the load begins to fluctuate or "hunt" about setpoint and never settles down to a stable level. The critical value for the minimum proportional band and the magnitude of the load fluctuations depend on a complex manner upon the time delay introduced by the load itself between the controller's output relay and the controller's input.

To achieve best control of the load, therefore, a compromise can be reached between these two conflicting requirements of accuracy and stability as follows:-

4.2.1 Set the maximum proportional band (32°C) by switching on switches 1, 2 & 3.

4.2.2 Set the rates and level switches as required for the process but ensure that the dwell switch is set for a reasonably long period of time to ensure the adequate time is allowed for the load to stabilise and adjustments and observations to be made.

4.2.3 Start the programmer and process then fast rate the setpoint up to the level (see section 5).

4.2.4 Monitor the process until a stable condition is reached. The error between setpoint and load temperatures should be constant and less than 16°C.

4.2.5 Reduce the proportional band to 24°C by operating switches 1,2 & 3 as per Fig 3. Introduce a disturbance into the process by reducing the setpoint by say 10°C for a short time and then returning it to its original value.

4.2.6 Monitor the process until a stable condition is once again reached, the error should be now less than 12°C.

4.2.7 Continue reducing the proportional band in a similar manner until the critical value of proportional band setting is discovered. As previously explained the load temperature will be seen to fluctuate, sometimes quite widely, about setpoint and will never settle down to a stable value. The period of this fluctuation can sometimes be very long, dependent upon the nature of the load, so ensure that observation is maintained for long enough at each setting of proportional band so as to be sure if the load temperature really is fluctuating or not.

4.2.8 Take this critical value of proportional band setting and, as nearly as possible with the increments available, set the proportional band to twice this critical value. The load temperature will now stabilise and the error between it and the setpoint will be the minimum obtainable with the process controlled by proportional-only control.

4.2.9 If the process is such that a wide variety of loads have to be controlled from time to time, then either the above procedure will have to be replaced for each load or a further compromise must be made between a proportional band setting large enough to give good stability with the load most difficult to control and proportional band setting small enough to give an acceptable degree of error with the most stable load.

All the above is illustrated diagrammatically in Fig 5.

4.3 **Hold Band**

This is determined by switches 4 & 5 of the DIL switch. The P250A recognises a hold condition whenever the load temperature deviates from its current setpoint by an amount determined by the hold band. Both controllers, if fitted, within the P250A share a common hold band. As can be seen from fig 4 the hold band is equally disposed about the setpoint and is settable in multiples of the proportional band. Therefore if the proportional band is set to, say, 16°C and the holdband is set to x4 then the hold band will be equal to 64°C.

4.4 Hold Mode

The hold mode selected determines the way in which the P250A responds to a hold condition.

4.4.1 If switches 6 & 7 are both off then the hold condition is totally ignored.

4.4.2 If switches 6 & 7 are both on then the P250A goes into a hold state for deviations both above and below the hold band.

4.4.3 If switch 6 is on and 7 is off then the P250A goes into a hold state only when the load temperature exceeds the setpoint by one half the hold band, deviations below setpoint are totally ignored.

4.4.4 If switch 7 is on and switch 6 is off then the P250A goes into a hold state only when the load temperature falls below the setpoint by one half of the hold band, deviations above setpoint are totally ignored.

4.4.5 The hold state is defined as a rate hold, switch 8 off, or a dwell hold, switch 8 on.

4.5 Rate Hold

This state only has effect when the P250A is executing rate 1 of rate 2. When in rate hold the P250A maintains a constant setpoint irrespective of the rate switch settings for as long as the rate hold condition persists, see Fig 6.

4.6 Dwell Hold

This state only has effect when the P250A is executing its dwell time. If a hold state occurs during the dwell then the dwell timing is suspended during the period for which the hold state exists. As can be seen from Fig 6 the P250A will maintain its setpoint at the setting of the level switch for a period equal to the dwell switch setting plus those times during which a dwell hold existed.

4.7 Hold Indication

The presence of a hold state is indicated by means of the “decimal point” to the lower right hand corner of the digital display.

4.8 Hold Acknowledge Relay Option

The hold acknowledge - ‘HACK ‘- relay option provides a single, form A, relay contact in place of the standard ‘READY’ contact (see section 3.4). This contact is connected between terminals 9 and 10. Please read the notes about rating and arc suppression in section 3.4 before connecting to this contact.

5. Running the Programme

Once the rate, level and dwell switches are set on the P250A’s front panel and the proportional band, hold band and hold mode switches inside have been set the programme may be run.

Switch on the supply. Immediately a number of apparently random events will occur, these are not symptomatic of a fault bur are a consequence of the correct operation of the instrument. The following sequence should happen:- Immediately upon switching on nothing will appear to happen, then the digital display and LED’s on the front panel will flicker randomly and rapidly, during this period the output relays may energise at random. After this period the sequence of events is determined by the state that the P250A was in when it was last de-energised. If the P250A was running its programme when last de-energised see section 5.5, if however, the P250A had finished its programme and was in its ready state the random display flicker will cease and will show 0, the ready relay only will be energised and the display status LED’s will indicate setpoint. All other LED’s and relays will de-energise.

5.1 The programme may be run either by pressing the front panel start button or by closing terminal 16 (COM) to 19 (Remote Start) whereupon the display will go blank for a nominal 7 seconds, the ready relay remains energised. During this 7 second period the P250A will automatically put its setpoint at this temperature, the display is re-energised and will therefore indicate this temperature as the starting temperature of the programme (see also section 5.7). The ready relay is de-energised, rate 1 relay is energised and the programme status LED's will indicate rate 1. At this point the programme has started and the controller output relays are enabled and begin to function in their time-proportioning mode. Thus it can be seen that Input 1 must be used rather than Input 2 if only one controller is employed.

5.2 At ant time during the programme the P250A may be reset back to its ready state with its setpoint resetting to 0 by either pressing the front panel reset button or by closing terminal 16 (COM) to 18 (Remote Reset). Note that the rest overrides all functions and if the remote reset is maintained then the P250A cannot be started until that reset is removed.

5.3 During either rate 1 or rate 2 the rate switch settings may be manually overridden from the front panel. Once the programme has been started subsequent presses of the start button have no effect, if however the start button is pressed and whilst pressed the F button is also pressed then the setpoint will move at the rate of approx' 100°C per second for as long as both F and start are pressed. Upon release of the F button the normal programme will resume.

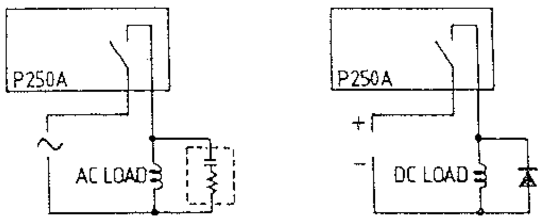


FIG.1

Use proprietary contact suppressor network, R=100Ω (Typical)

Anode to load negative. Diode must be voltage rating greater than load voltage, current rating greater than load C=0.1µF, current.

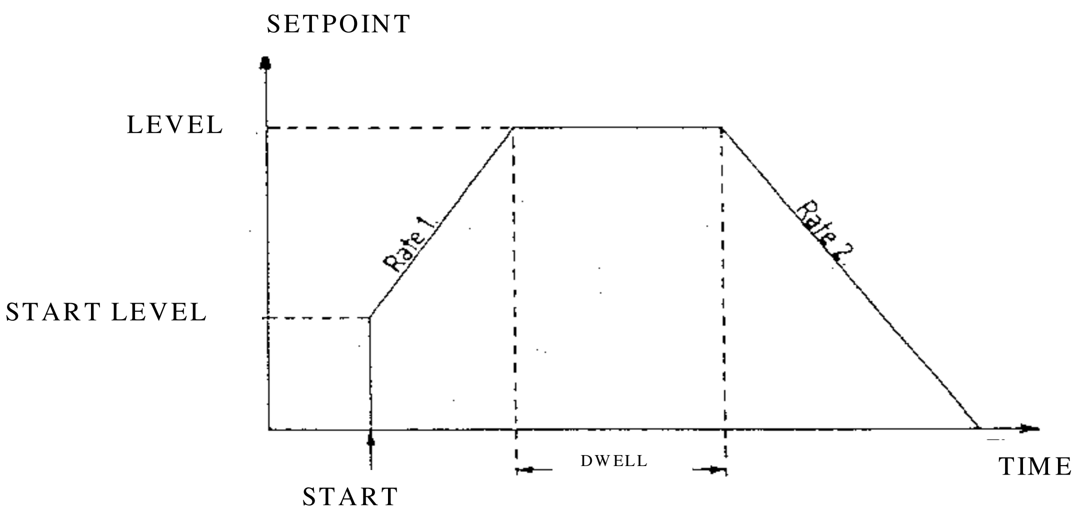
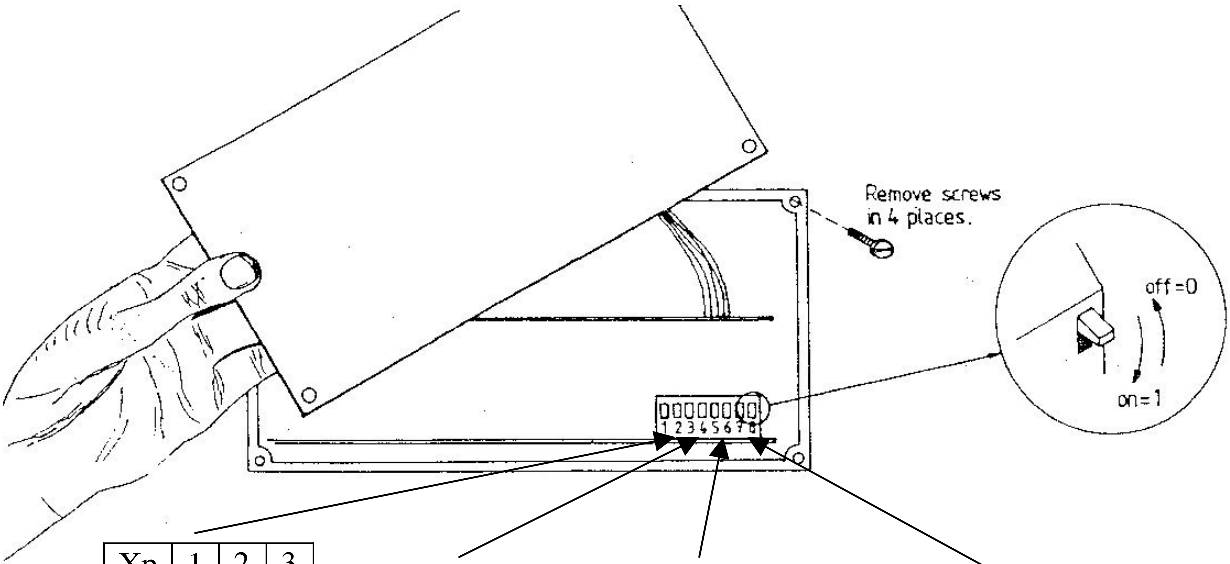


FIG.2



Xp	1	2	3
1	0	0	0
4	1	0	0
8	0	1	0
12	1	1	0
16	0	0	1
20	1	0	1
24	0	1	1
32	1	1	1

Xh	4	5
X2	1	0
X4	0	1
X6	1	1

Hmode	6	7
None	0	0
Over	1	0
Under	0	1
Both	1	1

Hmode	8
Rate	0
Dwell	1

FIG.3

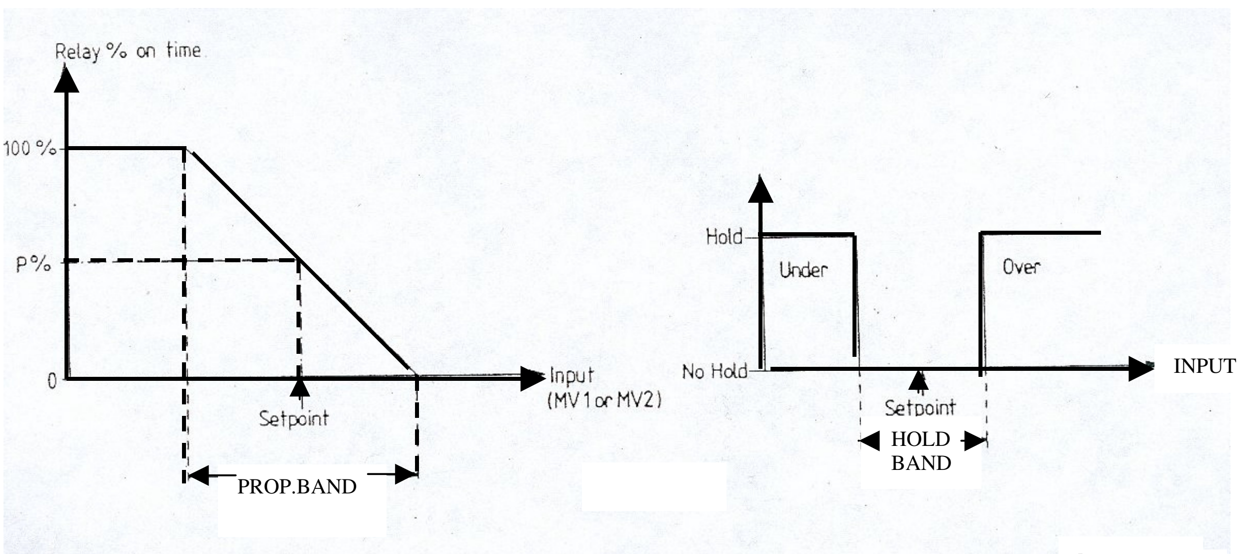


FIG.4

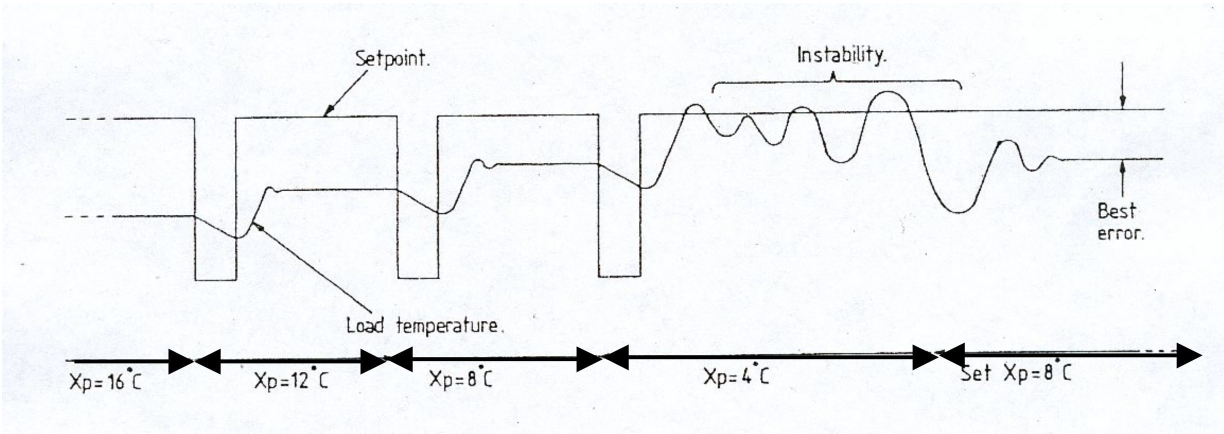
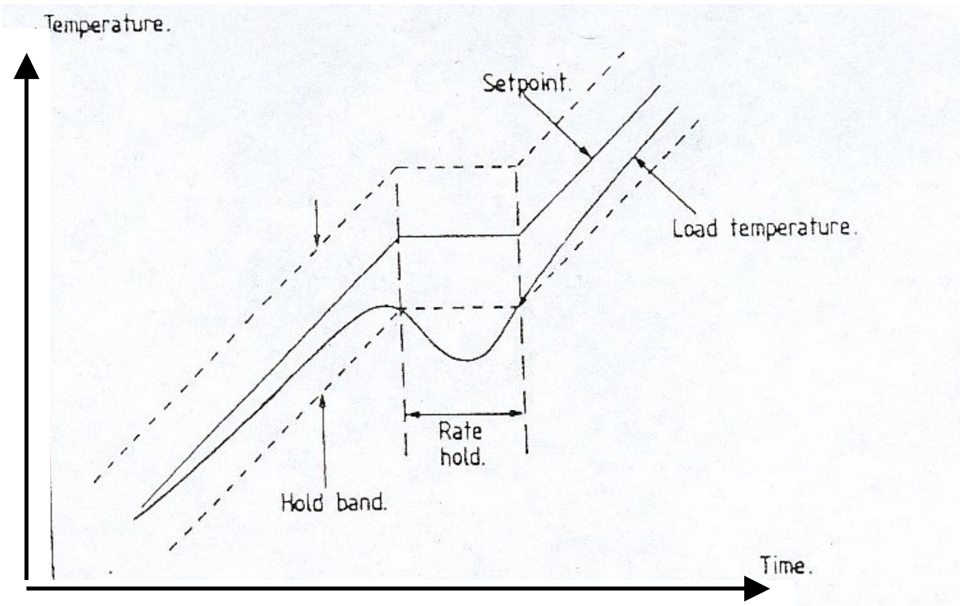
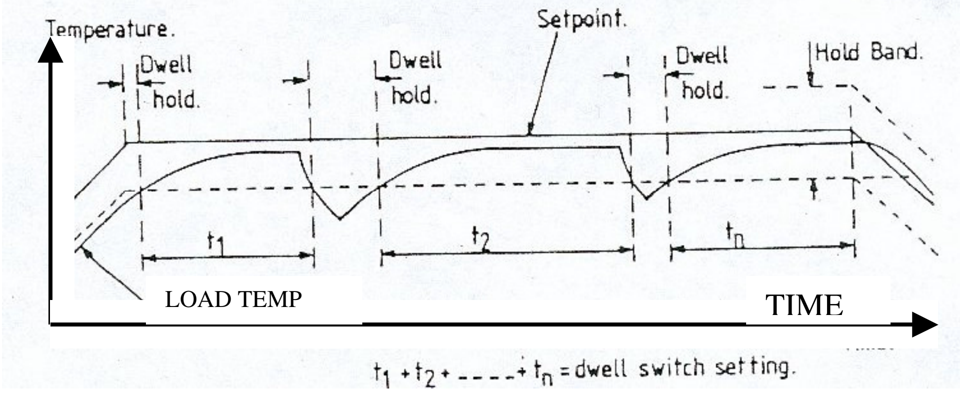


FIG.5



RATE HOLD



DWELL HOLD **FIG.6**

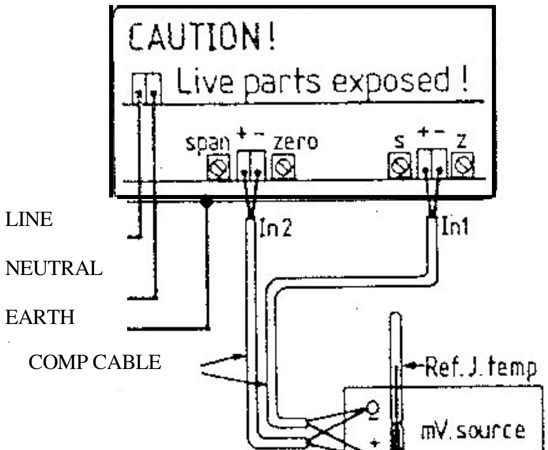

CAUTION!
Live parts exposed !
span
+ -
zero
s
+ -
z
In2
In1
LINE
NEUTRAL
EARTH
COMP CABLE
Ref. J. temp
mV. source

FIG.7

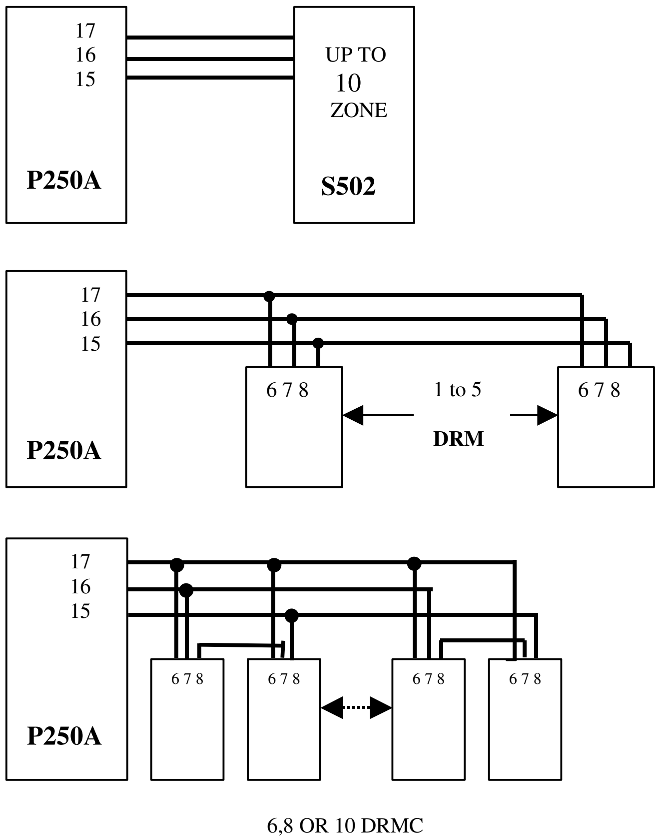

17
16
15
UP TO
10
ZONE
P250A
S502
17
16
15
6 7 8
1 to 5
DRM
6 7 8
P250A
17
16
15
6 7 8
6 7 8
6 7 8
6 7 8
P250A
6,8 OR 10 DRMC

FIG.8

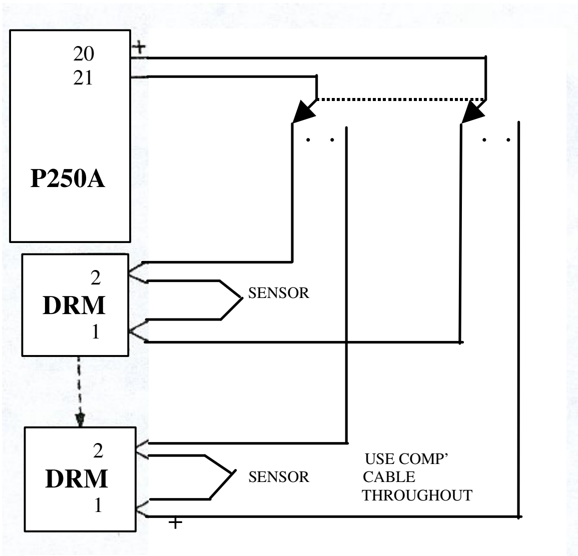


FIG.9

5.4 If at any time it is necessary to monitor the actual temperatures sensed at input 1 or 2 this may be achieved by the use of the F button. Pres the F button and hold it pressed, after a nominal 2 seconds the display status LED's will indicate input 2 and the display will show the actual temperature. This condition will persist for as long as the F button is held. Release the F button and after a further 5 seconds the display status LED's will indicate input 1 and the display will show the actual temperature, this condition will resist for 5 seconds whereupon the display will return to showing setpoint, if however the F button is again pressed whilst input 1 is being shown then the display will continue to show input 1 for as long as the F button is held. This facility in no way effects the programme that is running.

5.5 If, during the executing of a program, the supply to the P250A is interrupted and then restored the P250A responds in a number of ways as follows:-

5.5.1 If the interruption occurred during rate 1 then upon restoration of the supply the temperature at input 1 is measured and the setpoint is put equal to this temperature. The programme will then continue in rate 1.

5.5.2 If the interruption occurred during dwell then upon restoration of the supply the temperature at input1 is measured and the setpoint is put equal to this temperature, if this is different from the level setting the the programme reverts to rate 1 and the setpoint will change at rate 1 until the level is again attained, at which point the dwell time re-commences from zero. If however, the temperature at input 1 is found to be still equal to the level setting then the programme continues in dwell and executes the remainder of the unexpired dwell time.

5.5.3 If the interruption occurred during rate 2 then, as above the programme re-commences upon restoration with the setpoint equal to the temperature at input 1, the programme will then continue in rate 2.

5.5.4 During the period thst the supply is interrupted the programme status is stored within the P250A in battery powered Cmos RAM. The battery takes a nominal 100hrs to charge fully. A fully charged battery will enable will enable the RAM to store the programme status for in excess of 1000hrs, it is unlikely that storage will be required for longer than a few tens of minutes, the battery attains sufficient charge for this after only two hours of powered operation.

5.6 If at any time during the programme it is found necessary to modify the set programme then this may be done as follows:-

5.6.1 Whilst rate 1 is being executed tne setting of rate 1 may be changed, after which the setpoint will change at the newly set rate until the level is reached. Note: a setting of zero is equal to zero rate of change. During rate 1 the level may be changed, if it is changed to a value equal to the setpoint then 1 will end and dwell will begin, if it is changed to a value less than the setpoint then rate 1 will reverse sign and reduce the setpoint at rate 1 until the newly set level is reached. During rate 1 both dwell and rate 2 may be altered at will.

5.6.2 Whilst the dwell is being executed the level may be changed, at which point the dwell is terminated and the programme state reverts back to rate 1. The setpoint will then change at rate 1 until the newly set level is reached at which point the dwell time recommences from zero.. During the dwell both dwell and rate 2 may be altered.

5.6.3 During rate 2 the setting of rate 2 may be changed, after which rate 2 continues at the newly set rate. Note: a setting of zero is equal to zero rate of change.

5.7 Each of the two built-in temperature controllers is fitted with upscale burnout as standard. In the event of an open circuit sensor the measured temperature will apparently increase slowly to a value greatly in excess of the span of the P250A. If this occurs during the execution of a programme then the apparent steady increase at the P250A's input will reduce and eventually turn fully off the output, a hold condition will also be initiated if hold has been selected. If a programme is started with input 1 open circuit, and hence burned out, then rate 1 will commence from a setpoint of zero rather than the temperature of input 1. Burnout takes a nominal sixty seconds between the sensor going open circuit and the measured temperature reaching the span of the P250A.

5.8

6. **Calibration Procedure**

The following is only written as a guide to the general procedure to be employed when re-setting the instrument's calibration. The high quality components and circuitry used results in an instrument with good long term stability and so it is unlikely that adjustments will be required to the factory set span and zero controls except after protracted periods of use. To ensure that the procedure is executed to an acceptable accuracy the equipment employed should be of a high standard and the reference junction must be maintained at a known constant temperature for the duration of the procedure.

CAUTION:- IT IS ESSENTIAL **THAT THE METAL CASE OF THE P250A IS EARTHED WHENEVER THE SUPPLY IS CONNECTED – EVEN WHEN THE REAR PANEL IS REMOVED FOR CALIBRATION. LIVE PARTS ARE EXPOSED WHEN THE REAR PANEL IS REMOVED.**

Remove the rear panel of the instrument to gain access to the internal preset span and zero potentiometers of the P250A's two built-in controllers. Connect the P250A as shown in Fig 7, switch the supply on and wait five minutes for the instrument to "warm-up". Set the millivolt source to zero, use the P250A's F button to obtain a reading of Input 1, this should be the temperature of the reference junction plus or minus 1°C. If an error is seen to exist then this may be corrected by slow and careful adjustment of Input 1 zero pot'. Repeat this part of the procedure for Input 2 and Input 2 zero pot'. Now set the millivolt source to the span of the P250A, this will depend on the sensor type for which the P250A is calibrated and the reference junction temperature. **Table 2** shows the span values for the various types of sensor for which the P250A is calibrated at a range of reference junction temperatures, values of span at reference junction temperatures other than those shown may be inter-polated by simple calculation. Use the P250A's F button to obtain a reading of Input 1, this should be 1600°C plus or minus 4°C for types S and R, 1000°C plus or minus 3°C for type J, 1200°C plus or minus 3°C for type K, 400°C plus or minus 2°C for type T and 1800°C plus or minus 3°C for type B. If an error is seen to exist then this may be corrected by slow and careful adjustment of Input 1 span pot'. Note the controls are set back amongst other components and, although there is no danger of an electric shock from these components, it is advisable to use a completely insulated trimming tool to make any adjustments. Repeat this part of the procedure for Input 2 and Input 2 span pot'. Re-check at zero to ensure that any adjustments made to the span controls have not changed the zero reading and the calibration procedure is complete. If span adjustments have significantly affected zero readings then the whole procedure should be repeated until both zero and span readings are correct.

Table 1 Connections

1	SUPPLY LINE	13	OUTPUT 1 PELAY	
2	SUPPLY NEUTRAL	14		
3	2nd RATE RLAY	15	SETPOINT OUTPUT -	
4		16	COMMON +	
5	DWELL RELAY	17	HOLD INPUT -	
6		18	REMOTE RESET	
7	1st RATE RELAY	19	REMOTE START	
8		20	+	INPUT 2
9	READY RELAY	21	-	
10		22	+	INPUT 1
11	OUTPUT 2 RELAY	23	-	
12		STUD	EARTH	

Table 2 Span Values

SPAN in Mv				
Ref.J.Temp	0°C	10°C	20°C	30°C
TYPE S	16.77	16.72	16.66	16.60
TYPE R	18.84	18.79	18.73	18.67
TYPE J	57.94	57.44	56.92	56.41
TYPE K	48.83	48.43	48.03	47.63
TYPE T	20.87	20.48	20.08	19.67
TYPE E	76.36	75.77	75.17	74.56
TYPE B	13.58	13.58	13.58	13.58

7. Additional Controllers

The P250A has up to two built-in controllers, for those applications where further controllers are required the setpoint output and hold input is used. The P250A's setpoint output is a pseudo-digital PWM signal available on terminal 15 (SPO-) and 16 (COM) and will generally only be suitable for controllers within the FGH range of products. See Fig 8.

7.1 The PWM signal from the P250A has a frequency of 42.67Hz, it has a rectangular waveform whose mark-space ratio is proportional to the setpoint. The PWM signal has a maximum voltage of 10V and is constant current limited at 10mA. It is available in two forms; linear, where the mark-space ratio is directly proportional to the setpoint temperature in°C, or non-linear, where the mark-space ratio is directly proportional to the thermo-electric emf of a thermocouple (for which the P250A is calibrated) at the setpoint. The choice between linear and non-linear depends upon which controllers are to be used with the P250A. Series S502 and DRMC instruments require a non-linear remote PWM setpoint signal. The P250A can drive up to five S502/DRMC in parallel or up to ten in series/parallel.

7.2 The hold signals generated by S502 and DRMC series instruments may be connected to the P250A hold input terminal 17 (HOLD-) whereupon any hold condition generated by the remote controllers will be recognised by the P250A as if the hold conditions occurred on input 1 or input 2.

7.3 If it is required to display the actual temperature controlled by these additional to sections 4. controllers then input 2 may be used as a monitoring input by means of an additional 2-pole multi-way switch. See Fig 9. Note that input 2 should never be left open circuit if output 2 is operative or it will "burn-out" up-scale and may cause a hold condition, refer 3 and 4.4 above.

8. Spares & Service

Service of Series P250A instruments is strictly "by return to FGH or their appointed Agents" except by prior arrangement with FGH. Instruments returned for service should be securely packed, preferably in their original packing. Where possible, with fault or malfunction explained please quote the following when returning:-

a) Instrument Type Number

b) Instrument Serial Number

c) Component Type Number or description