FGH

Integrated Control Unit
Version 1
# User Manual

Contents

1   Installation

The ICU is designed for back of panel mounting in either vertical or horizontal orientation. Fixing is by means of the four off slots in the side plates which are intended for M4 screws. Fixing centres are 247mm and 160mm. When secured to the panel there is a 4mm gap underneath the unit, this is to allow easy air flow from the internal fan. Take care not to block up this gap.

Slot 1   Slot 2   Slot 3   Slot 4   Slot 5   CPU   Power Supply
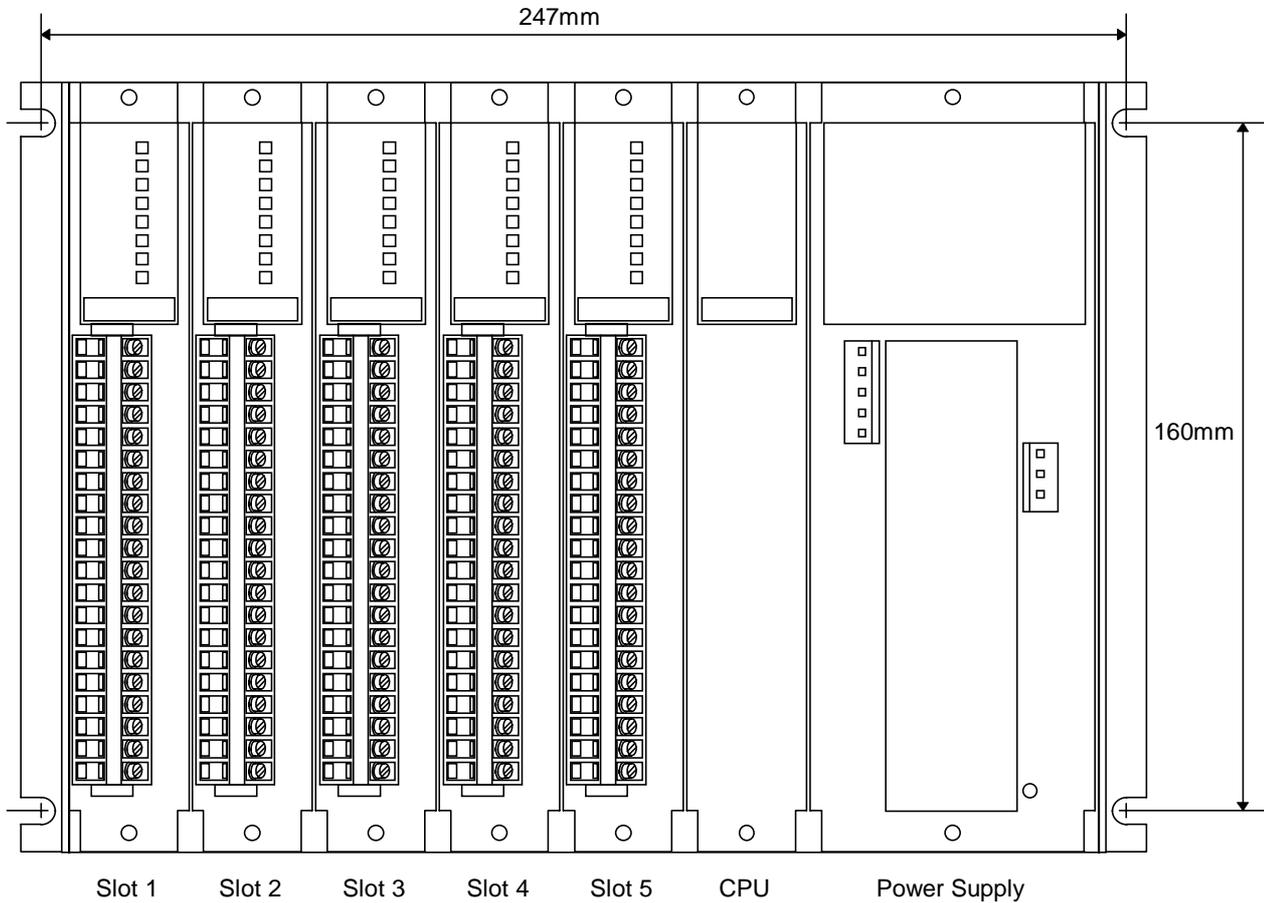
2   Electrical Connections.

All connections to the unit are via screw terminal blocks suitable for 2.5mm^2 cables. Connections to the five input/output slots are via five, 20 way terminal blocks and vary according to the types of card fitted.

2.1   Mains Connection.

Mains power should be connected to the green, 3 way terminal block. A good earth connection should be provided to the earth terminal and this connects to the metal case of the ICU
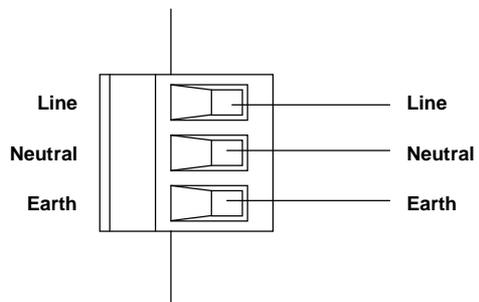
2.2   Serial Communications Connection.

The serial communications may be connected using either the two or four wire system. The instrument uses a balanced voltage communications system which will perform well under most situations provided some simple guidelines are observed.

1. The communications wiring should be implemented using screened twisted pair cable. The cable screen should be earthed at one point only.

2. The cable should be routed well away from sources of electrical noise such as motors, contactors and any other high voltage wiring.

3. The network should be wired as a daisy chain, taking the wires into one instrument and hence on to the next. Wiring spurs should be avoided. Take care to continue the cable screen on to the next instrument.

4. For long cable runs or noisy environments it may be necessary to fit a terminating resistor to the network. The terminator (a 200Ω resistor) should be fitted between RX+ and RX- on both the computer and the furthest instrument. For two wire networks this resistor should be fitted at the computer end only. Only one such terminator should be fitted on each wire pair.

2.2.1 4 Wire RS422 Connection.
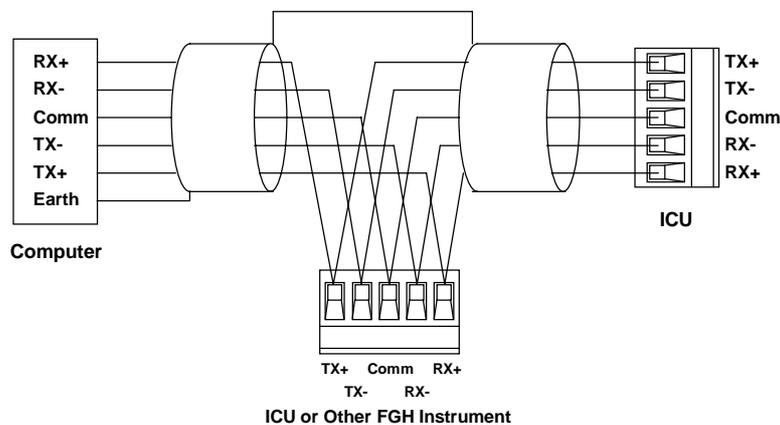
The above diagram shows the connections for 4 wire RS422 operation. This method of connection uses a separate pair of wires for transmission and reception and is the preferred connection method. Although called the '4 wire' connection, a fifth common wire is shown on the diagram. This wire should be fitted if at all possible. Otherwise the common terminal of the ICU should be connected to earth.

2.2.2 2 Wire RS485 Connection.
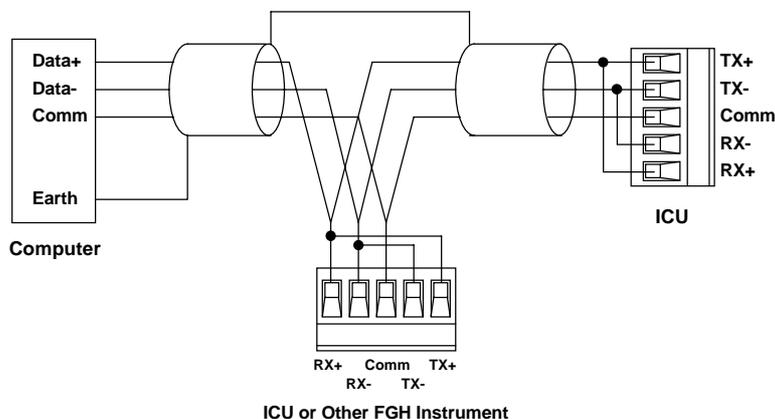
The above diagram shows the connections for 2 wire RS485 operation. This method of connection uses a single pair of wires for both transmission and reception with the data

direction being controlled by the currently active device. As in the 4 wire connection, a common wire is shown on the diagram. This wire should be fitted if at all possible. Otherwise the common terminal of the ICU should be connected to earth.

2.3   Slot I/O cards.

There are five general purpose I/O slots into which may be fitted a wide variety of I/O modules almost without restriction.

WARNING
Make sure that the power is removed from both the ICU and any other connected equipment before attempting to fit or remove any I/O modules or making any connections to them.

2.4   Analog Input Connections.

There are three types of analog input card types available designated A1, A2 and A3.

Terminal	A1	A2	A3
1	Channel 0 +	Channel 0 +	Channel 0 RT1
2	Channel 0 -	Channel 0 -	Channel 0 RT2
3	Channel 1 +	Channel 1 +	Channel 1 RT1
4	Channel 1 -	Channel 1 -	Channel 1 RT2
5	Channel 2 +	Channel 2 +	Channel 2 RT1
6	Channel 2 -	Channel 2 -	Channel 2 RT2
7	Channel 3 +	Channel 3 +	Channel 3 RT1
8	Channel 3 -	Channel 3 -	Channel 3 RT2
9	Channel 4 +	Channel 4 +	Channel 4 RT1
10	Channel 4 -	Channel 4 -	Channel 4 RT2
11	Channel 5 +	Channel 5 +	Channel 5 RT1
12	Channel 5 -	Channel 5 -	Channel 5 RT2
13	Channel 6 +	Channel 6 +	Channel 6 RT1
14	Channel 6 -	Channel 6 -	Channel 6 RT2
15	Channel 7 +	Channel 7 +	Channel 7 RT1
16	Channel 7 -	Channel 7 -	Channel 7 RT2
17	NC	NC	NC
18	NC	NC	Common RT3-
19	NC	NC	Common RT3-
20	NC	NC	Common RT3-

Table 2.4 Analog Output Connections.

2.4.1   Voltage Input Card type A1.

This card may be used for all types of DC voltage input. It is software configurable for thermocouple inputs, -10 to +100mV, -0.1 to +1V and -1 to +10V ranges. All voltage channels are isolated from each other to 250VAC RMS. The connections for this card are given in table 2.4 column A1.

2.4.2   Current Input Card type A2.

This card is used for DC -2 to 20mA current inputs. It is software configurable for range and engineering units. All input channels are isolated from each other to 250VAC RMS. The connections for this card are given in table 2.4 column A2.

2.4.3 Resistance Input Card type A3.

This card is used for resistance (0 to 800Ω) or Rtd inputs. Inputs should be connected in 3-wire mode. All input channels share a common third wire connection and hence are NOT isolated. The connections for this card are given in table 2.4 column A3
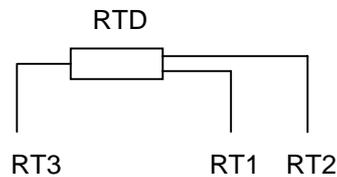
For successful RTD measurement the user should ensure that all three wires from each RT are of the same length and gauge. Unused resistance inputs should be shorted out between RT1, RT2 and RT3.

2.5 Analog Output Connections.

There are two types of analog output card types available designated B1 and B2.

Terminal	B1(mV)	B2(mA)	B2 (V)
1	Channel 0 +	Channel 0 sink	NC
2	NC	NC	Channel 0 +
3	Channel 0 -	Common	Channel 0 -
4	Not Used	Not Used	Not Used
5	Channel 1 +	Channel 1 sink	NC
6	NC	NC	Channel 1 +
7	Channel 1 -	Common	Channel 1 -
8	Not Used	Not Used	Not Used
9	Channel 2 +	Channel 2 sink	NC
10	NC	NC	Channel 2 +
11	Channel 2 -	Common	Channel 2 -
12	Not Used	Not Used	Not Used
13	Channel 3 +	Channel 3 sink	
14	NC	NC	Channel 3 +
15	Channel 3 -	Common	Channel 3 -
16	Not Used	Not Used	Not Used
17	NC	NC	NC
18	NC	NC	NC
19	NC	Supply +15V	NC
20	NC	Common	NC

Table 2.5 Analog Output Connections.

2.5.1 Thermocouple Output Card Type B1.

This card is used for low level (-10 to +100mV) analog outputs. It is a four channel card and there is NO isolation between channels as the negative output terminals are electrically connected internally. This card may be configured in software to perform as a thermocouple retransmission output.

Its output connections are given in table 2.5 column B1.

2.5.2 V and mA Output Card Type B2.
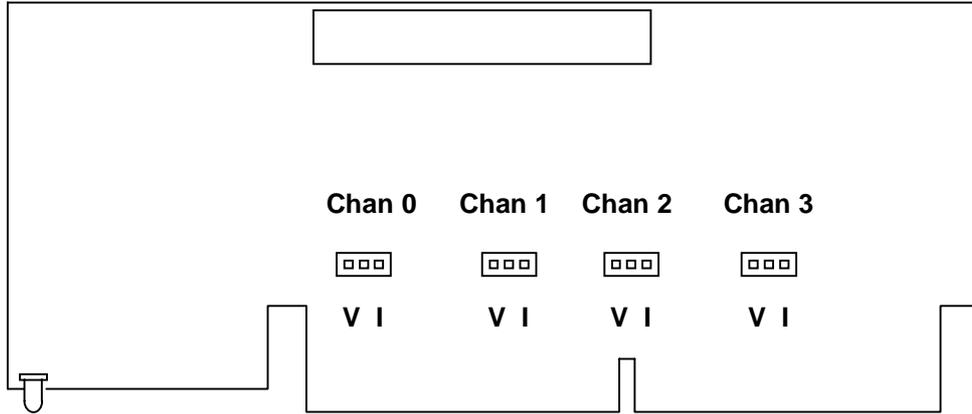
Each channel on this card can be set for either a voltage or current output by means of a jumper link. With the jumper link in the V position, the analog output channel will provide an output signal in the range -1V to +10V.

In the I position the channel will provide a 0 to 20mA current sink output. Please note that there is NO isolation between channels as the output negative terminals are electrically connected internally.

The 20mA outputs are current sink only. This means that will NOT provide the loop power by themselves. A 15V loop power supply is provided on terminals 19 and 20 which may be used to power up to four loops if necessary.
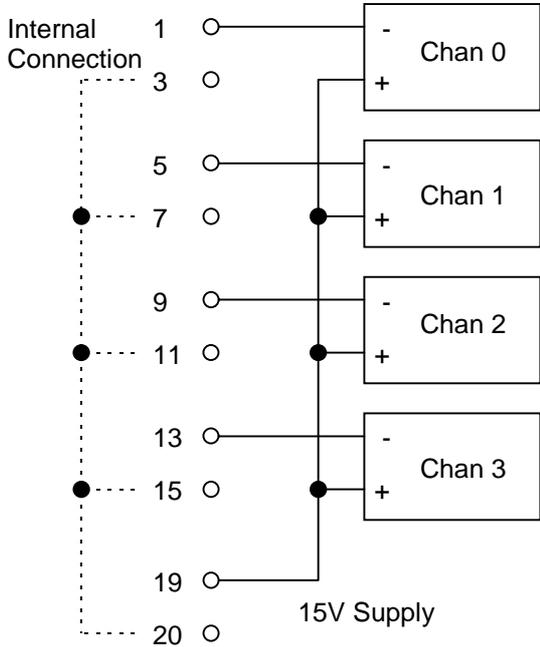
20mA Output Connection using internal supply
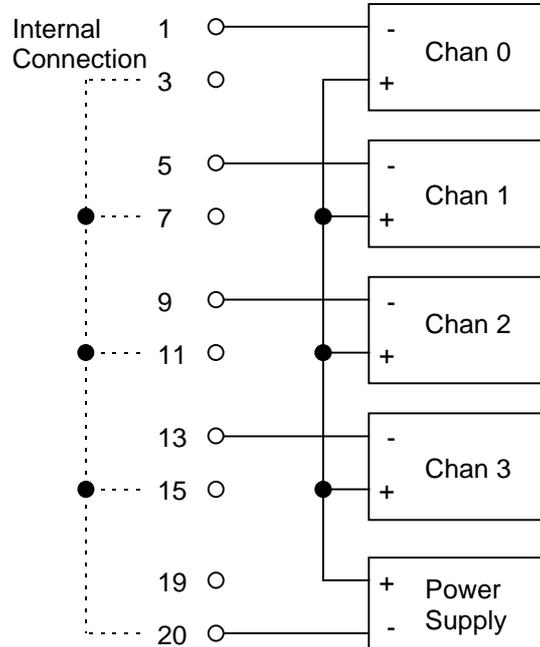
20mA Output Connection using external supply

2.6   Digital Input Connections.

Terminal	C1	C2
1	Channel 0 +	Channel 0
2	Channel 0 -	Channel 0
3	Channel 1 +	Channel 1
4	Channel 1 -	Channel 1
5	Channel 2 +	Channel 2
6	Channel 2 -	Channel 2
7	Channel 3 +	Channel 3
8	Channel 3 -	Channel 3
9	Channel 4 +	Channel 4
10	Channel 4 -	Channel 4
11	Channel 5 +	Channel 5
12	Channel 5 -	Channel 5
13	Channel 6 +	Channel 6
14	Channel 6 -	Channel 6
15	Channel 7 +	Channel 7
16	Channel 7 -	Channel 7
17	NC	NC
18	NC	NC
19	Supply +10V	NC
20	Supply 0V	NC

Table 2.6 Digital Input Connections.

2.6.1 Low Voltage DC Digital Input Card Type C1.

This card is designed to accept low level DC digital inputs up to 32V DC.
The connections for this card are given in table 2.6 column C1.
The card also provides a 10V power supply on terminals 19 and 20 for energising
voltage free contacts as necessary.

2.6.2 High Voltage AC Digital Input Card Type C2.

This card is designed to accept high level AC digital inputs up to 250V AC.
The connections for this card are given in table 2.6 column C2.

2.7   Digital Output Connections.

Terminal	D1	D2
1	Channel 0 NO	Channel 0 NO
2	Channel 0 Com	Channel 0 Com
3	Channel 1 NO	Channel 1 NO
4	Channel 1 Com	Channel 1 Com
5	Channel 2 NO	Channel 2 NO
6	Channel 2 Com	Channel 2 Com
7	Channel 3 NO	Channel 3 NO
8	Channel 3 Com	Channel 3 Com
9	Channel 4 NO	Channel 4 NO
10	Channel 4 Com	Channel 4 Com
11	Channel 5 NO	Channel 5 NO
12	Channel 5 Com	Channel 5 Com
13	Channel 6 NO	Channel 6 NO
14	Channel 6 Com	Channel 6 Com
15	Channel 7 NO	Channel 7 NO

16	Channel 7 Com	Channel 7 Com
17	NC	NC
18	NC	NC
19	NC	NC
20	NC	Common *

Table 2.7 Digital Output Connections.

2.7.1 Relay Output Card type D1.

This card provides eight, form A relay outputs. The connection details are given in table 2.7 column D1

Each output is protected with an RC snubber which may result in a small leakage current (3mA at 250VAC 50Hz) flowing when the relay contacts are open. This leakage current may cause problems on very light AC loads. If this problem is apparent, DO NOT remove the snubbers. Instead it is recommended that a 10K 10 Watt resistor be connected across the load. This resistor will run quite hot so take care to position it in a safe place.

2.7.2 Solid State Switch Output Card type D2.

This card provides eight solid state switch channels which may be used to switch light AC or DC loads (up to 100V dc or RMS. AC at 50mA). Each switch is normally isolated from all the others to 250V AC but may be commoned to terminal 20 if required by fitting the appropriate jumper link on the card. The connections for this card are given in table 2.7 column D2.
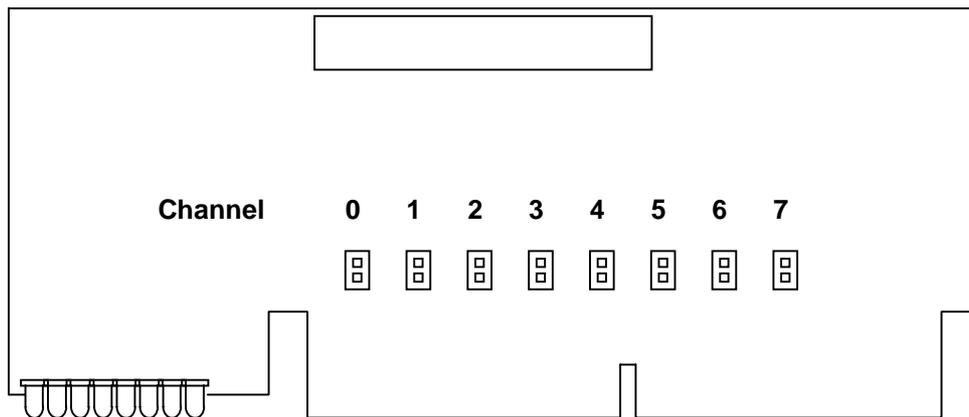
If the jumper link for the channel is fitted then the switch will be commoned to terminal 20.

3   Configuration DIL Switch.

The DIL switch sets up the basic ICU
configuration for baud rate, address and
communications protocol. To gain access to
the DIL switch, remove the two screws
securing the cover plate on the CPU card
and remove the cover. The DIL switch is
then exposed. Use a small non conductive
instrument such as a ball point pen to move
the switches to the required positions.
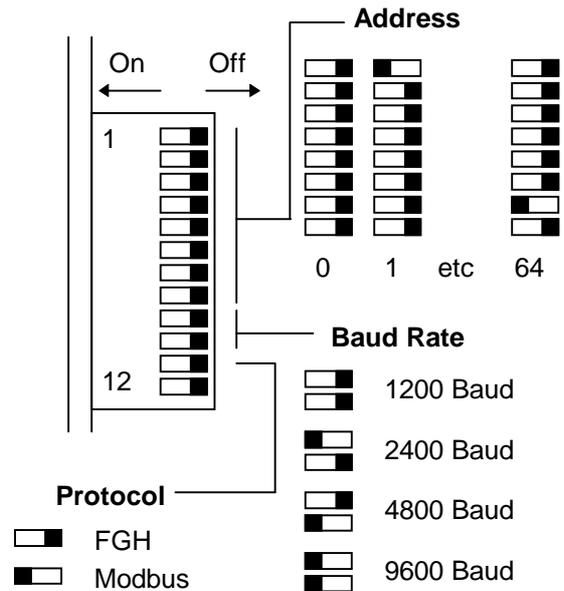
4   Serial Communications.

4.1   Message construction.

Messages to and from the instrument vary in form depending on, amongst other things, the
type of message and its contents. There are three basic message types:-

4.1.1   Write messages.

Write messages to the instrument take the following form.

WAAPSSD..D<CR>

where **W**   = write message header
AA   = instrument address
P   = parameter code
SS   = secondary parameter field
D..D   = numeric data field

messages to the instrument may have the fields separated by spaces. These spaces will be
ignored. Messages from the instrument will not contain spaces.

The <CR> at the end of the message is a carriage return. (Hex 0D). Each message written
to the instrument must be terminated with, and each message from the instrument will be
terminated with a carriage return.

4.1.2   Read messages.

Read messages to the instrument take the following form.

RAAPSS<CR>

where **R**   = read message header
AA   = instrument address
P   = parameter code to be read
SS   = secondary parameter field

Again the message must be terminated with a <CR>, and spaces may be included if desired.

4.1.3 Set instrument status messages.

Set messages to the instrument take the following form.

SAAC<CR>

where **S** = set message header
AA = instrument address
C = set parameter code to be performed

Again the message must be terminated with a <CR>, and spaces may be included if desired.

4.2 Message header.

This may be;
ASCII **R** signifying a Read
ASCII **W** signifying a Write
ASCII **S** signifying a Set.

The **R** header is used whenever data is being read from the instrument. When this header is used the data field is absent. The **W** header is used to write data to the instrument. The **S** header is used to set the status of the instrument.

4.3 Instrument address.

Each instrument must be given a unique address between 0 and 99. This is set on the configuration DIL switch see section 3. The address field of the message, consisting of two ASCII characters determines to which instrument the message is directed. The instrument ignores the message unless it corresponds to its own address.

4.3.1 Wildcard addresses.

If desired, a group of instruments can be written to together by using a wildcard character (large X) in place of one or both of the address characters. e.g.

W6XD010001<CR>

would result in all instruments on that communication line with addresses of 60 to 69 having their digital output register D1 being turned on.

Instruments written to with wildcard addresses do not reply.

4.4 Message parameter code.

The parameter code field of the message is a single ASCII character. In a write message this corresponds to one of the parameters listed in paragraph 4.7, 'parameter codes'. In the case of set messages, this is still a single ASCII character, but corresponds to one of the 'set status codes' listed in paragraph 4.8.

4.5   Secondary parameter field .

This field is used to specify the secondary reference required for some messages to the instrument. This should be a two digit field, left padded with a zero if required.

4.6   Message data field.

The message data field consists of between four and eight ASCII characters and carries the data associated with the specified parameter. There are 4 types of data field, the type depending on the particular parameter being accessed. The parameter code tables in section 4.7 specify the data field format for each parameter.

4.7   ICU read/write parameter codes.

Each parameter within the ICU is assigned a single alpha code.
Please note that some parameters use coded data fields, the code meanings are listed after the table.

Code	SS Field	R/W	Parameter	Data field type
A	Channel 00-39	R	Analog Input Value	1
B	Channel 00-39	R/W	Analog Output Value	1
C	Channel 00-39	R	Digital Input Value (0 or 1)	1
D	Channel 00-39	R/W	Digital Output Value (0 or 1)	1
E	Channel 00-39	R	Analog Output flags	2
F	Channel 00-39	R	Analog Input flags	3
G	Slot 00-04	R	Digital Input byte (0 to 255)	1
H	Slot 00-04	R/W	Digital Output byte (0 to 255)	1
I	Channel 00-39	R/W	Analog Input Ignore flag (0 or 1)	1
J	Controller 00-07	R/W	Proportional Band	1
K	Controller 00-07	R/W	Integral Time in sec	1
L	Controller 00-07	R/W	Derivative Time in sec	1
M	Profiler 00-05	R	Profiler Status	4
N		R/W	Profile Pointer	1
O	Segment 00-04	R/W	Profile Segment Rate	1
P	Segment 00-04	R/W	Profile Segment Level	1
Q	Segment 00-04	R/W	Profile Segment Dwell time	1
R	Profiler 00-05	R	Profiler Running Segment	1
S	Profiler 00-05	R	Profiler Running Profile	1
T				
U				
V				
W				
X				
Y				
Z	Profiler 00-05	W	Alternative profile control	5

Please note.
For the purposes of serial communications addressing slot, controller and profilers are numbered from zero. Thus in serial communications, physical slots are numbered 0 to 4, controllers are numbered 0 to 7 and profilers are numbered 0 to 5.

4.8   ICU Set status codes.

Writing a set command to the instrument with a parameter as follows will produce the specified action if the address field matches the address of the instrument. In the examples given the instrument address is assumed to be 20.

CODE	MESSAGE	REPLY	MEANING
S	S20S<CR>	*20S<CR>	Start profiler
R	S20R<CR>	*20R<CR>	Reset profiler
H	S20H<CR>	*20H<CR>	Hold profiler
F	S20F<CR>	*20F<CR>	Free hold on profiler

4.9   Response from read or write.

The response of the instrument to a satisfactory read or write message with the correct address will be of the general form (unless an address wildcard is used, see para 4.3.1):

*AAPSSD..D<CR>

The instrument will respond with a string of ASCII characters. The header will consist of an asterisk (Hex 2A).

The **AA**, **P** and **SS** fields will be exactly the same as in the message which prompted the response. The **SS** field will only be present for some messages to and from the instrument.

The format of the data field **D..D** is specific to the parameter code used and these field types are described in section 4.12.

4.10   Set status response.

The response of the controller to a satisfactory 'set status' message with the correct address will be of the general form (unless a wildcard address is used):

*AAP<CR>

The controller will respond with a string of ASCII characters. The header will consist of an asterisk (Hex 2A). The header will be followed by an address (AA) showing the address of the responding instrument in ASCII, 00 to 99.

after the address is a single ASCII character showing the 'set status' mnemonic used

This is followed by a <CR> to complete the message return.

4.11   Error responses.

Two sorts of error in a received message may be detected by the ICU, these are:

4.11.1 Corrupt message response.

Noise or interference during the transmission of the message causing corruption of one or more characters so that it was no longer valid. The receiver within the instrument detects this, and as long as it was not the address that was corrupted, the ICU responds as follows;

?AAC<CR>

where **AA** is the address of the instrument responding
C =   **P** for detected parity error
F for detected overflow error
O for detected receiver overrun

4.11.2 Syntax error response.

Messages that were correctly received but don't make sense, as long as the address part was o.k. generate the following response;

?AANN<CR>

where **AA** = address of the instrument responding
NN = two digit ASCII HEX error code

Error code binary weightings:

bit7 = Illegal trailer
bit6 = Tx buffer overflow
bit5 = Illegal number of characters
bit4 = Illegal data
bit3 = Illegal parameter code
bit2 = Rx buffer overflow
bit1 = Illegal header
bit0 = Write to read only parameter

4.12   Data fields.

There are five different type of data fields used on the ICU.

4.12.1 Data field type 1.

This is the most common of the data field types and is used for simple numeric data. The data field consists of 4 numeric characters preceded by an optional minus sign.

For example to read analog input channel A10 on ICU address 3.

The computer would send **W03A10<CR>**

The instrument would respond   ***03A100234<CR> (value of A10 is 234)**

Note that the data field is padded out to 4 characters in both the query and response messages.

4.12.2 Data field type 2.

This type of data field is only used when reading the status of an analog output with parameter code E. The returned data field is a four digit decimal number with bit weightings as follows.

Bits 0 to 1   Not used
Bit 2   Output is invalid.
Bit 3   Output is for internal use only.

Bits 4 to 7   Not used.

For example. To query the status of analog output 15.

The computer would send **R00E15<CR>**

The ICU may respond   ***00E150008<CR>**
Indicating that the analog output was for internal use only.

4.12.3 Data field type 3.

This type of data field is only used when reading the status of an analog input with parameter code F. The returned data field is a four digit decimal number with bit weightings as follows.

Bits 0 to 3   Not used
Bit 4   Input is ignored from HC Block calculations when set.
Bit 5   Input is under ranged.
Bit 6   Input is over ranged.
Bit 7   Thermocouple input is broken.

For example. To query the status of analog input 15.

The computer would send **R00F15<CR>**

The ICU may respond   ***00F150128<CR>**
Indicating that the analog input thermocouple was broken.

4.12.4 Data field type 4.

This type of data field is only used when reading the status of a profiler with parameter code M. The returned data field is a four digit decimal number with bit weightings as follows.

Bit 0   Profiler Running
Bit 1   Profiler is ramping.
Bit 2   Profiler is ramping up.
Bit 3   Profiler is in hold.
Bits 4 to 7   Not used.

For example. To query the status of profiler number 2.

The computer would send **R00M02<CR>**

The ICU may respond   ***00M020011<CR>**
Indicating that the profiler was running a downward ramp and was currently in hold.

4.12.5 Data field type 5.

This type of data field is used only on parameter 'Z'. It provides an alternative method of profiler control for SCADA systems which do not support the SET STATUS message type. Parameter 'Z' is a write only parameter. The values written to it will perform the following functions on the profiler.

Value   0   Resets (stops) profiler execution.
Value   10P   Starts profiler execution of profile number P.
Value   200   Holds (pauses) profiler execution.
Value   300   Frees hold. (Resume execution after pause).

Examples.
To start profiler number 3 running profile number 2.
The computer would send   **W00Z030102<CR>**
The ICU would respond   ***00Z030102<CR>**

To stop profiler number 4.
The computer would send   **W00Z040000<CR>**
The ICU would respond   ***00Z040000<CR>**

5   Configuration.

5.0   General.

The ICU consists of a CPU system and up to 5 general purpose input/output slots. Each of these slots may be fitted with an I/O card of one of four basic types:-

Type A   Analog input cards which accept analog signals from the plant such as thermocouple or RTD inputs. Up to 40 such inputs may be fitted.

Type B   Analog output cards which provide analog signals to the plant such as setpoints or control outputs. Up to 20 such outputs may be fitted.

Type C   Digital input cards which accept digital inputs from the plant such as push buttons or switches. Up to 40 such inputs may be fitted.

Type D   Digital output cards which provide digital signals to the plant such as control relays or alarm outputs. Up to 40 such outputs may be fitted.

The data associated with each channel of each card is stored inside the ICU in a register.

Analog Input (*A*) Registers
For type A cards (analog inputs) there are 40 registers designated A0 to A39. Each of these registers can store a number between -9999 and +9999. Each analog input may thus be uniquely identified by its register number A0 up to A39.
Analog input registers are assigned to physical I/O slots in groups of eight (8 inputs per card). Table 5.0 below shows the correspondence between slot number and registers. So an analog input card plugged into slot 2 for example would occupy registers **A8** to **A15** inclusive.
Any **A** registers which do not correspond to actual analog input cards may be used by the user to store intermediate results from internal controllers, profilers, **HC** or **IF** block calculations.

Analog Output (*B*) Registers
For type B cards (analog outputs) there are 40 registers designated B0 to B39. Each of these registers can store a number between -9999 and +9999.
Each analog output may thus be uniquely identified by its register number B0 up to B39.
Analog output registers are assigned to physical I/O slots in groups of four (4 outputs per card). Since there is a maximum of 20 analog output channel, there are an extra 20 B registers available which do not correspond to actual physical outputs. These are

included for the user to use as internal variables. Table 5.0 below shows the correspondence between slot number and registers. So an analog output card plugged into slot 2 for example would occupy registers **B4** to **B7** inclusive.
Any **B** registers which do not correspond to actual analog output cards may be used by the user to store intermediate results from internal controllers, profilers, **HC** or **IF** block calculations.

Digital input (*C*) Registers

For type C cards (digital inputs) there are 40 registers designated C0 to C39. Each of these registers stores a digital state 0 or 1.
Each digital input may thus be uniquely identified by its register number C0 up to C39. Digital input registers are assigned to physical I/O slots in groups of eight (8 inputs per card). The table below shows the correspondence between slot number and registers. So a digital input card plugged into slot 2 for example would occupy registers **C8** to **C15** inclusive.
Any **C** registers which do not correspond to actual digital input cards may be used by the user to store intermediate results from **IF** block calculations.

Digital Output (*D*) Registers

For type D cards (digital outputs) there are 40 registers designated D0 to D39. . Each of these registers stores a digital state 0 or 1.
Each digital output may thus be uniquely identified by its register number D0 up to D39. Digital output registers are assigned to physical I/O slots in groups of eight (8 outputs per card). The table below shows the correspondence between slot number and registers. So a digital output card plugged into slot 2 for example would occupy registers **D8** to **D15** inclusive.
Any **D** registers which do not correspond to actual digital input cards may be used by the user to store intermediate results from **IF** block calculations.

	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Spare
Analog Inputs	A0 to A7	A8 to A15	A16 to A23	A24 to A31	A32 to A39	
Analog Outputs	B0 to B3	B4 to B7	B8 to B11	B12 to B15	B16 to B19	B20 to B39
Digital Inputs	C0 to C7	C8 to C15	C16 to C23	C24 to C31	C32 to C39	
Digital Outputs	D0 to D7	D8 to D15	D16 to D23	D24 to D31	D32 to D39	

Table 5.0 Correspondence between registers and slot numbers

As well as providing a basic input/output capability, the ICU is able to manipulate and generate outputs for itself.

Hot Cold Calculation Blocks

Allow the user to calculate the hottest, coldest, average and spread of a group of analog inputs. These results may be output directly or stored internally. See section 5.5 for further information.

IF Blocks

Allow the user to set up alarm conditions or numerical calculations and perform basic interlock functions.

Setpoint Profilers

Provide basic setpoint ramp and dwell facilities.

PID Controllers
Provide basic PID control algorithms.

Configuration of the ICU is performed using the program ICUSETUP which is supplied on floppy disk with the instrument.

All configuration on the ICU is performed off-line. This means that changes made to the configuration do not take effect until the new configuration is exported to the ICU.

5.1   Installing ICUsetup.

The ICU setup program is designed to run on computers with Microsoft® Windows™, 32 bit operating systems such as Window 95 or NT. It will NOT run in Windows 3.1.

The utility program ICUSetup is supplied on a single 1.44Mb floppy disk. Insert the floppy disk into a suitable drive and from the Start Menu invoke RUN to run A:\setup.exe and follow the instructions on screen.

To remove ICUSetup from your system at any time use the Add/Remove Programs utility in Control Panel.

Once installed the ICU setup program will be available for use. To run the program click on FGH ICU Setup Utility from the Start Menu Programs list.

When the ICUSetup program is invoked the default configuration file (Default.icu) is loaded automatically. As standard this is a blank configuration, but may be overwritten as required.

5.2   Configuring the ICU for the first time.

When delivered from the factory the ICU configuration will be blank. Configuration may be performed in any order but generally it is best to set up the input and output channels first entering meaningful comments where possible. This will make it easier in later stages when configuring controllers and profilers.
There are nine dialog boxes provided for configuration of the various parts of the ICU.

> Analog inputs
> Analog outputs
> Digital inputs
> Digital outputs
> Hot/Cold calculation blocks
> IF condition blocks
> PID Controllers
> Profilers
> Profile Editing

Remember, changes made to any of these configurations do not take effect until the set-up is exported to the ICU.

5.2.1   Exporting the configuration to the ICU.

Select **File|Export** from the main menu and the Export dialog box will appear.
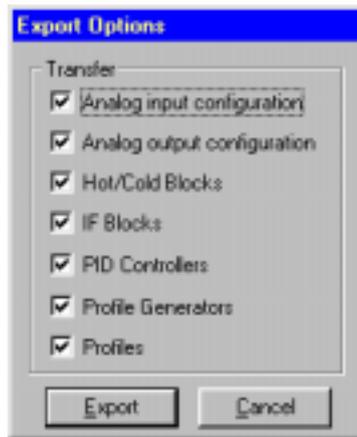
Use this box to select the elements of the configuration that you wish to send to the ICU.

5.2.2 Saving the configuration to disk.

In order that the full configuration data may be recalled at a later date for modification, the configuration should be saved to disk. To save the information select **File|Save As** from the main menu and enter a unique file name for the ICU. The configuration is saved to disk in text format with a .icu extension.

5.2.3 Modifying an existing configuration.

If the configuration of the ICU to be modified has been saved to disk then load the file by selecting **File|Open** from the main menu. This will retrieve the complete ICU set-up from disk including any comments entered.
If the configuration was not saved to disk, then it may be retrieved directly from the ICU in part or in whole by selecting **File|Import** from the main menu. In this case any comments previously entered will not be retrieved since they are not stored within the ICU.

Modify the ICU configuration as required using the configuration dialog boxes provided.

Export the new configuration to the ICU by selecting **File|Export** from the main menu. If only a small area of the set-up has actually been changed then this area in isolation may be exported as required.

Remember to save the modified configuration to disk by selecting **File|Save** or **File|Save As** from the main menu.

5.2.4 Recalling a saved configuration file.

To retrieve an ICU configuration file from disk select **File|Open** from the main menu and double click the .icu file of interest. The ICU file will be loaded immediately.
Alternatively, from Windows Explorer double click on any .icu file and ICUSetup will automatically be invoked with the required file already loaded.

5.3   Setting the serial communications parameters.

From the control bar press the port button or select **Communications** from the menu.
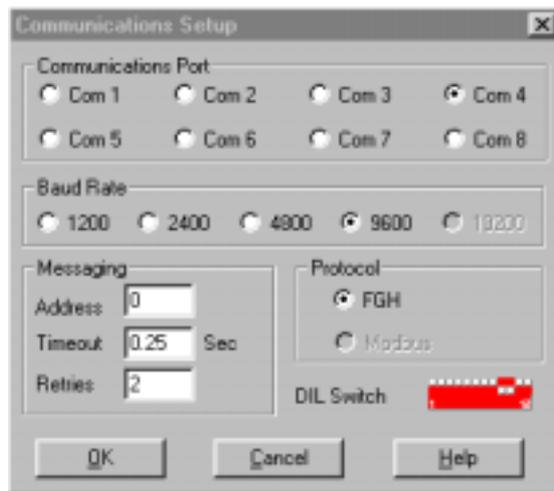
Click on the appropriate buttons for communications port, Baud rate and protocol for the ICU. Enter the ICU address with which you wish to communicate. The illustration of the DIL switch changes dynamically to show how the actual ICU DIL switch should be set to match the parameters entered.

5.4   Setting up the I/O.

ICUSetup enables you to quickly configure the inputs and outputs to the ranges of your choice. The set-up information is modified in the computer memory and may then be exported to the actual ICU when required. See section 5.2 for further information on import and export. This means that the I/O configuration may be done off line in advance and finally exported to the ICU at a later date.

5.4.1 Analog Inputs.

From the control bar press the Analog Input button or **select Configuration| Analog Inputs** from the menu. The Analog Input configuration box will appear. Use the tabs at the top to select the I/O slot of interest.
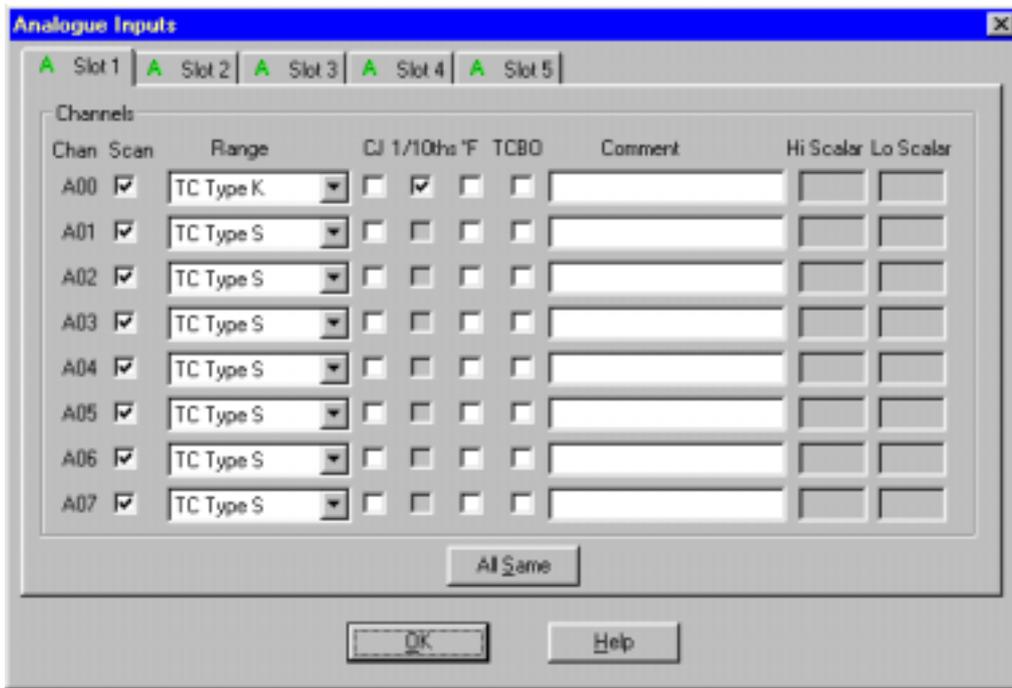
For each input, select the range, units and precision of measurement required and enter any desired comment. Thermocouple inputs may have cold junction compensation (CJ) if required and thermocouple break detection may be enabled if required. Only base metal thermocouples (K, T and J) may be measured in tenths.

For linear inputs, enter the required engineering scalars to convert the measurement to the units you desire. The valid range for the scalars is -9999 to +9999.

Analog input channels which do not correspond to physical inputs do not need to be configured unless they are to be used as input registers for hot/cold calculation blocks. Real analog inputs which are not used may be taken out of the input scan by un-checking the **Scan** checkbox. This will speed up the input update time for the other inputs.

Example.

A 4-20mA analog input is required to represent a signal of 0 to 100.0 Psi. To achieve this the low scalar should be set to -250 (value to be given at 0mA) and the high scalar should be set to 1000 (value at 20mA). Further, since a resolution of 0.1 Psi is required, the tenths checkbox should be ticked.

5.4.2   Analog Outputs.

From the control bar press the Analog Output button or select **Configuration| Analog Outputs** from the menu. The Analog Output configuration box will appear. Use the tabs at the top to select the IO slot of interest and then the up and down arrow buttons to select the channel.

An analog output can work in one of two modes. Select the required mode for the output by clicking the **Linear** or **Characterised** radio button.

Linear mode.
The analog output will be scaled to output a linear signal when its corresponding B register contains a number between the **From** (minimum output) and **To** (maximum output) values entered. The **From** and **To** values may be crossed over if required in order to provide an inverted output. A percentage **bias** value may be entered to enable elevated or suppressed zero outputs to be configured.
Example 1.
A 4 to 20mA is required to retransmit the analog quantity 0 to 2000mBar stored in the ICU. To achieve this the **From** value should be set to 0, the **To** value 2000 and the **Bias** to 20%.

Example 2.
A -1 to +10V output is required to retransmit a pressure signal of -1.00 to +10.00 Bar. To achieve this the **From** value should be set to -100, the **To** value 1000 and the **Bias** value to -10%. (-10% of the positive span will provide the required -1V offset)

Characterised mode.
This mode of operation is used to retransmit a thermocouple type signal from a 100mV analog output card. Use the **Range** selector box to select the thermocouple type required and check the **1/10ths** and **°F** check boxes to specify how the B register number is to be interpreted.
Note. Characterised thermocouple outputs are retransmitted **without** cold junction compensation. This means that they should be connected in copper wire to a measuring instrument with its cold junction switched off.

Example.
A type K thermocouple output is required for retransmission to an external controller. The retransmission value is stored in a B register in tenths degree C. To achieve this output the range selector should be set to **TC Type K** and the **1/10ths** check box should be ticked.

5.4.3 Digital Inputs.

From the control bar press the Digital Input button or **select Configuration| Digital Inputs** from the menu. The Digital Input configuration box will appear. Use the tabs at the top to select the I/O slot of interest.

Digital Input Setup ☒

| **C** Slot 1 | **C** Slot 2 | **C** Slot 3 | **C** Slot 4 | **C** Slot 5 |

Digital Input Channels

Chan   Comment

C00 [   ]

C01 [   ]

C02 [   ]

C03 [   ]

C04 [   ]

C05 [   ]

C06 [   ]

C07 [   ]
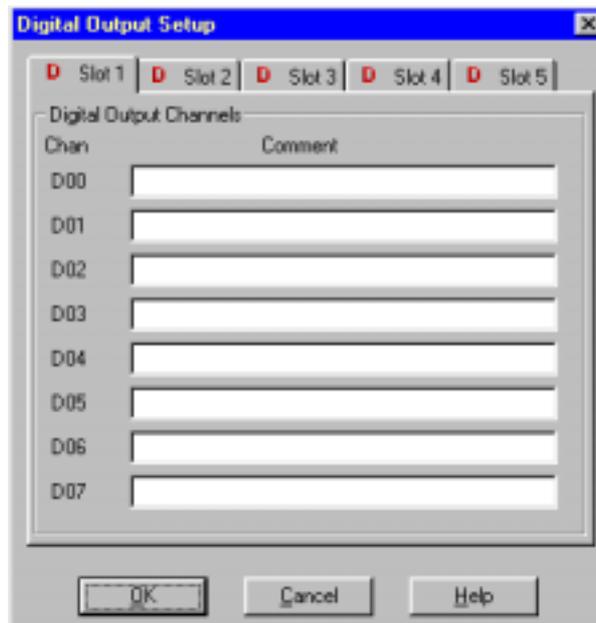
[OK]   [Cancel]   [Help]

The only thing to be set up for digital inputs is the optional comment.
Enter any comments required in the boxes provided.

5.4.4 Digital Outputs.

From the control bar press the Digital Output button or **select Configuration| Digital Outputs** from the menu. The Digital Output configuration box will appear. Use the tabs at the top to select the I/O slot of interest.

Digital Output Setup ☒

| **D** Slot 1 | **D** Slot 2 | **D** Slot 3 | **D** Slot 4 | **D** Slot 5 |

Digital Output Channels

Chan   Comment

D00 [   ]

D01 [   ]

D02 [   ]

D03 [   ]

D04 [   ]

D05 [   ]

D06 [   ]

D07 [   ]

[OK]   [Cancel]   [Help]

The only thing to be set up for digital outputs is the optional comment.
Enter any comments required in the boxes provided.

5.5   Hot/Cold Calculation Blocks.

From the control bar press the Hot/Cold button or **select Configuration| Hot/Cold Blocks** from the menu. The Hot/Cold block configuration box will appear. Use the tabs at the top to select the HC block of interest. The icon on each tab is illuminated if the HC block is currently enabled.
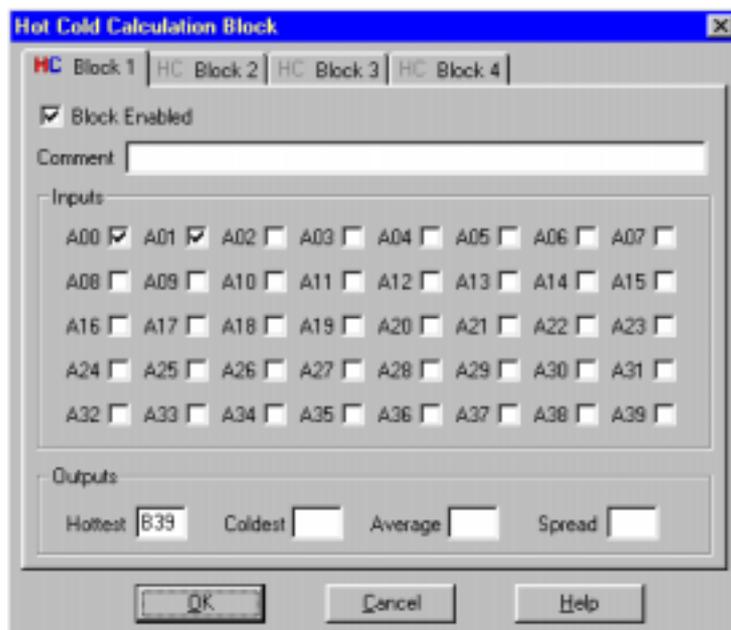
The standard ICU contains four calculation blocks, each of which can be used to calculate the hottest, coldest, mean and spread of a group of analog inputs. Although the calculation blocks are usually used for temperatures, they may be used with any input types to calculate the maximum and minimum values etc.

If the block is to be used check the **Enabled** box and enter a comment if required. In the **Inputs** group, check the box for each **A** register required in the calculation.

In the **Outputs** group, enter the destination registers for the calculation results. If a particular result is not required then leave the appropriate destination box blank.
If a result is required to be used as an input in a different **HC** block then that result must be stored in a vacant A register.

The HC block calculates the hottest, coldest, mean and spread of the selected inputs using numerical comparisons only. It does not take into consideration the temperature units and resolution of the inputs selected. So it is up to the user to ensure that all the selected input values are of a comparable type. Outputs from the block are in the same units as the selected inputs.

If any input to the calculation block is found to be broken (thermocouples only) or is set to be ignored, then that input will **NOT** be included in the calculation. If the condition arises such that all the selected inputs are ignored then all of the selected output registers will be set to be invalid.

5.6 IF Blocks.

IF blocks allow the user to execute a series of simple IF/THEN/ELSE language elements. Up to 50 such elements are allowed on the standard ICU.

Each IF block consists of three parts. The IF section performs a simple condition test on any I/O register. If the condition evaluates to be true, the THEN operation is performed. If the condition evaluates to be false, the ELSE operation is performed.
IF blocks are executed in numerical order at the rate of approx. 30 blocks per second.

IF blocks allow the user to perform a variety of tasks such as alarms, hold bands, interlocks and mathematics. As such, they are a very powerful tool and great care should be taken to ensure that real input data registers (A or C) are not overwritten with calculation results.

Please note.
It is possible for errors to occur in IF block calculations. The user may specify operations to be performed on registers which contain invalid data. In these circumstances if the ICU detects such an error, the IF block will NOT be executed.

From the control bar press the **IF** button or select Configuration|IF Blocks from the menu. The IF block selector box will appear.
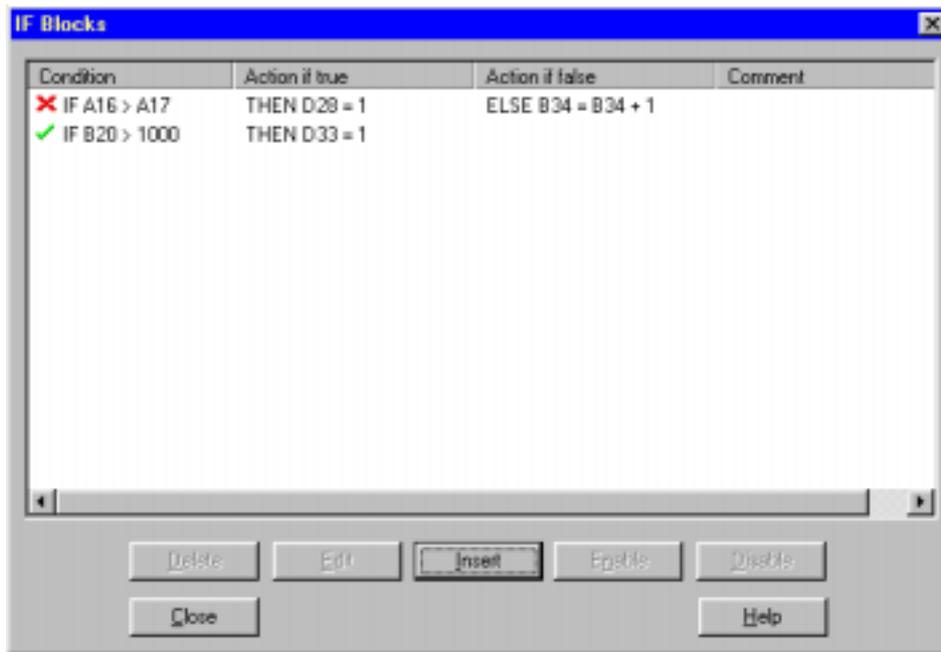
This dialog box allows the user to view the current list of IF blocks loaded. Each IF block is displayed in plain language along with either a green tick or a red cross. The green tick means that this IF block is enabled and will be executed by the ICU. A red cross means that the IF block is disabled and will NOT be executed.
IF blocks may be inserted, deleted and edited from this screen as required by first selecting the block and then pressing the operation button as required. For example, to edit an IF block first click on the required line and then press the **Edit** button. The IF block editor will then appear.
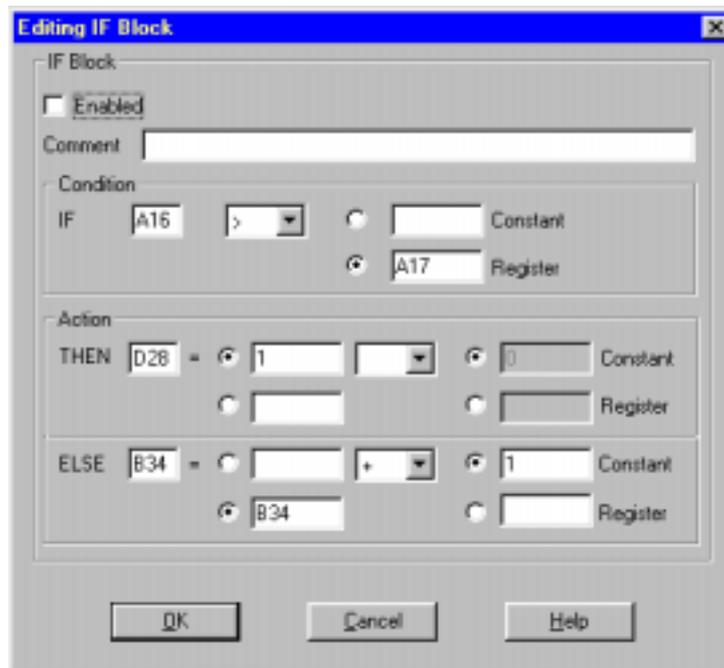
5.6.1 IF condition.

The IF condition may be used to compare any I/O register with another register or numerical constant. Both analog (A or B) and digital (C or D) registers may be used in the condition test. Digital registers always evaluate to be either 0 (off) or 1 (on). All the standard comparisons are available.

A > B	True when register A is greater than register B
A >= B	True when register A is greater than or equal to register B
A < B	True when register A is less than register B
A <= B	True when register A is less than or equal to register B
A = B	True when register A is equal to register B
A AND B	True when the logical AND of register A and register B is non zero
A OR B	True when the logical OR of register A and register B is non zero
A XOR B	True when the logical exclusive OR of register A and register B is non zero

The values for B above may be either registers or constants.
Press the **Help** button for information about the meaning of the individual field shown.

5.6.2 THEN operation.

This operation is performed when the IF condition evaluates to be true.
Operations that may be performed are as follows.

A = B	Register A is made equal to B
A = B + C	Register A is made equal to the sum of registers B and C
A = B - C	Register A is made equal to register B minus register C
A = B × C	Register A is made equal to the product of registers B and C
A = B ÷ C	Register A is made equal to register B divided by register C
A = B AND C	Register A is made equal to the logical AND of registers B and C
A = B OR C	Register A is made equal to the logical OR of registers B and C
A = B XOR C	Register A is made equal to the logical exclusive OR of registers B and C

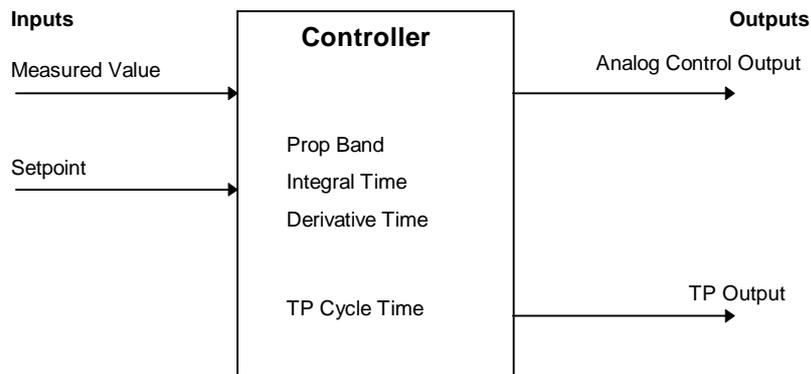The values for B and C above may be either registers or constants.

5.6.3 ELSE operation.

This operation is performed when the IF condition evaluates to be false.
Operations that may be performed are exactly as listed for the THEN condition above.

5.7   PID Controllers.

The standard ICU may have up to eight internal PID controllers. All the user has to do is to specify the input (measured value), setpoint and output registers which the controller is to use.

Inputs

Measured Value

Setpoint

Controller

Prop Band
Integral Time
Derivative Time

TP Cycle Time

Outputs

Analog Control Output

TP Output

ICU controllers are unitless controllers and will compare inputs and setpoints in a purely numerical fashion. This means that it is up to the user to ensure that the setpoint and measured variable registers use the same units of data.

Controller outputs are reverse acting only and are ranged -1000 to +1000 units. Forward acting and heat/cool controllers may be implemented by processing the controller output using IF blocks before passing to a real output.

Since the ICU controllers are acting on scanned inputs, they are not suitable for use on fast processes. Depending on the number of analog inputs fitted it may be up to 8 seconds (0.2 sec's per analog input scanned) between successive samples of the controlled variable. This means that the controller output can be delayed by this amount which may cause instability on a fast process.

From the control bar press the **PID** button or select Configuration|PID Controllers from the menu. The Controller configuration dialog box will appear. Select the controller number that you wish to configure by pressing the appropriate selector tab.
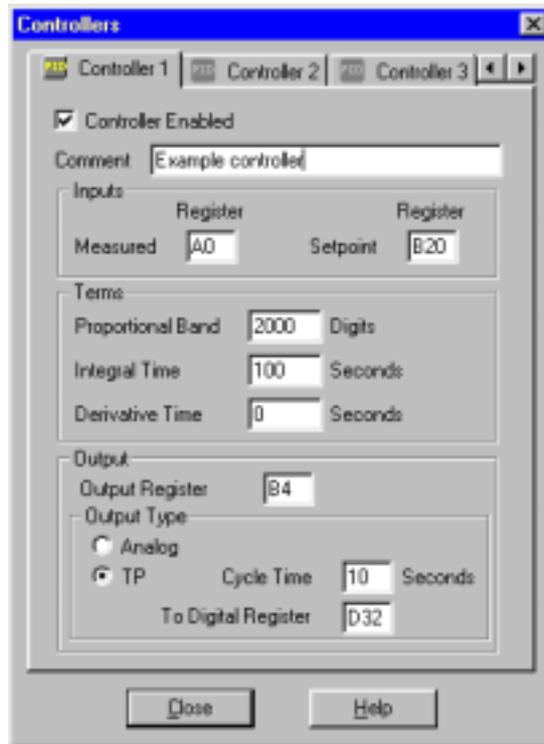
Enable the controller by checking the **enabled** box and enter the controller comment as required.

Fill in the boxes on screen. Press the **Help** button for further information on the meaning of each field.

5.8   Profile Generators.

The ICU may have up to 6 internal profile generators as standard which may be used to execute any of the 6 available internally stored profiles.

Each profile generator has three control inputs for start/stop and hold purposes and four event outputs signifying running, up ramp, down ramp and dwell conditions. These signals may be generated and processed using the IF block language as required to perform any interlocks or hold functions required.
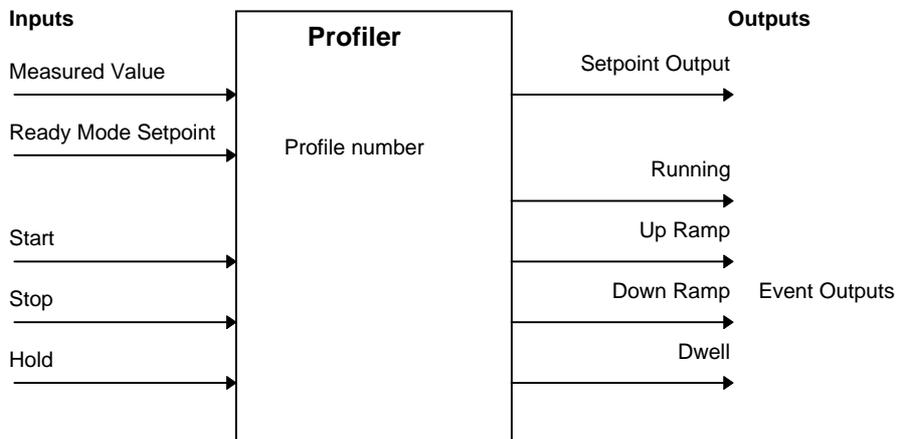
The profiler has two operating modes, READY and RUNNING. In the ready mode the profiler merely transfers its ready mode setpoint to the output register. If no ready mode output register is specified a value of zero will be used.

When the profiler is started the first ramp will commence from the current value of the profiler measured value register. Again if the MV register is not specified or invalid the first ramp will start from zero. The profiler will then execute its selected profile until it encounters a profile end or is stopped prematurely by its STOP register becoming true.

To configure a profile generator, from the control bar press the **PROFILER** button or select Configuration|Profilers from the menu. The Profiler configuration dialog box will appear. Select the profiler number that you wish to configure by pressing the appropriate selector tab.
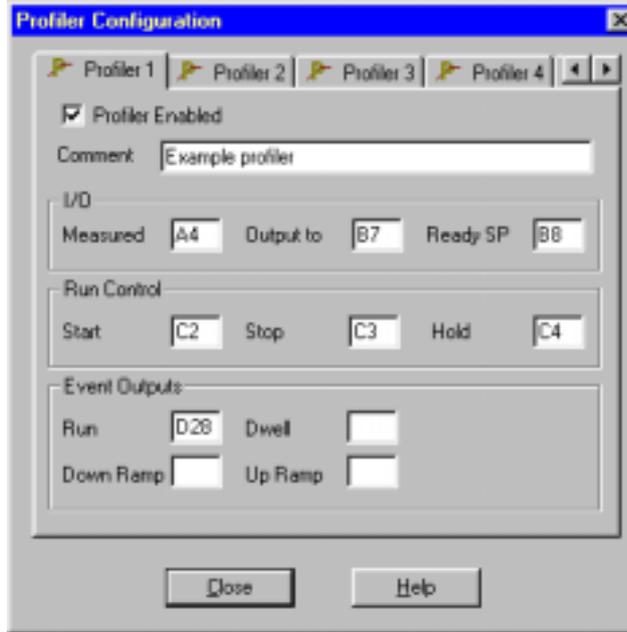
Enable the profiler by checking the **enabled** box and enter the comment as required.

Fill in input and output register boxes as required. Press the **Help** button for further information on each field.

5.9   Profile Editor.

ICUSetup may be used to edit the 6 internal ICU profiles. Each profile consists of up to 5 segments and each segment consists of a ramp to a level followed by a dwell.

To edit a profile, from the control bar press the **PROFILE EDIT** button or select Configuration|Profile Editor from the menu. The Profile editor dialog box will appear. Select the profile number that you wish to edit by pressing the appropriate selector tab.
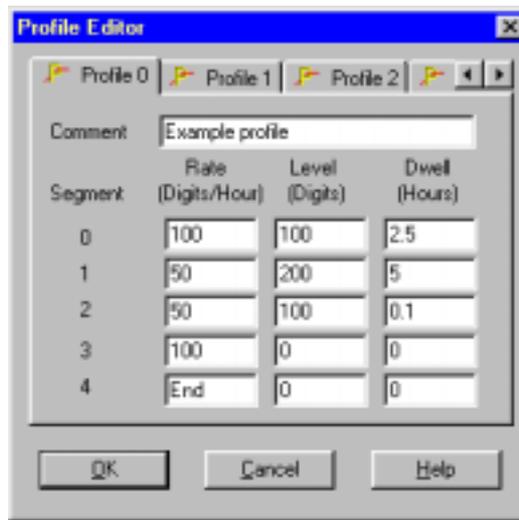
Use the Rate boxes to enter the required ramp rate in digits per hour. Alternatively enter zero (or the word Step) to execute a step change or -1 (or the word End) to cause the profile to end. The valid ramp rate range is 0 to 9999 digits per hour.

Use the Level boxes to enter the dwell level in digits. The valid range of entries is -9999 to +9999 digits.

Use the Dwell time boxes to enter the required dwell time in hours. The valid range of entries is 0.0 to 99.9 hours.
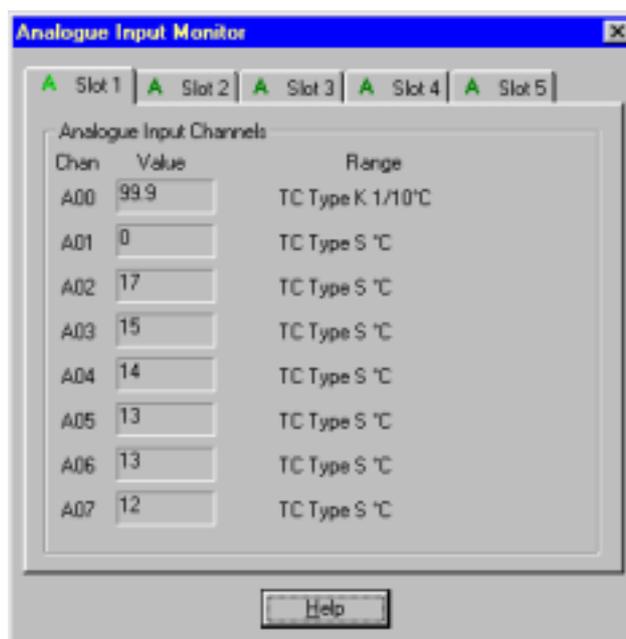
6   Monitoring.

ICUSetup may be used to monitor many aspects of ICU operation. There are 6 monitor utility screens provided which may be invoked as required for this purpose.

6.1   Monitoring Analog Inputs.

To monitor the analog inputs select Monitor| Analog Inputs from the menu bar. The Analog Input monitor box will then be displayed.

This box is used to monitor the current status of the analog inputs connected to the ICU.

Use the tabs at the top of the box to select the slot number of interest. Slots which correspond to an actual analog input board are indicated by a light green **A**. Slots which do not correspond to actual analog input boards are indicated by a dark green **A.**

The box shows the status of all eight analog inputs on the currently selected slot along with their associated comments and ranges.

The current values of the inputs are shown in the boxes in the 'Value' column. If an input is a broken thermocouple with break detection enabled then the value is shown as 'Broken'. Also if the input channel is not scanned then the value will be shown as ,Broken'.

Alongside each analog input value are three small indicators. The red up arrow symbol shows that the input is overranged. The blue down arrow symbol shows that the input is underranged and the blue *i* symbol indicates that the input is switched to be ignored in any calculation which uses it.

The 'Range' column shows the ranging information currently applied to the inputs. This may be either 'Linear' or a thermocouple law.

To view the inputs on a different slot, press the associated tab on the tab control.

6.2   Monitoring Analog Outputs.

To monitor the analog outputs select Monitor| Analog Outputs from the menu bar. The Analog Output monitor box will then be displayed.
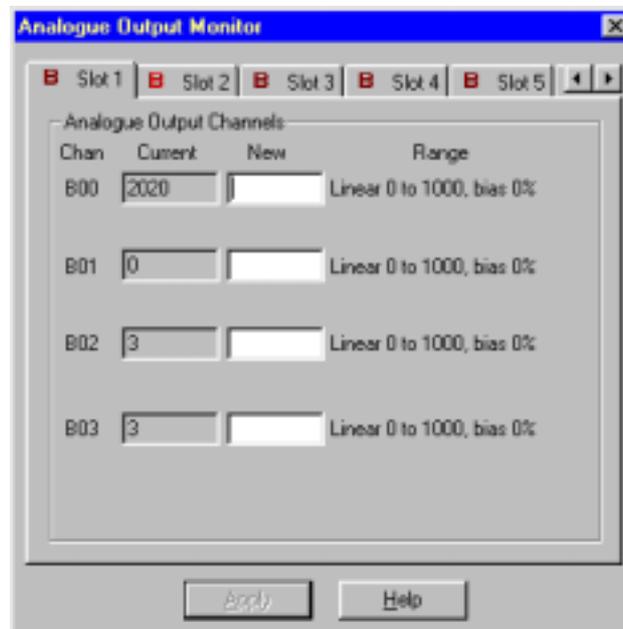
This box is used to monitor the current status of the analog outputs connected to the ICU.

Use the tabs at the top of the box to select the slot number of interest. Slots which correspond to an actual analog output board are indicated by a light red **B**. Slots which do not correspond to actual analog output boards are indicated by a dark red **B.**

The box shows the status of all four analog outputs on the currently selected slot along with their associated comments and ranges.

The current values of the outputs are shown in the boxes in the 'Current' column. If a value has been neither used nor set manually then the value is shown as 'Invalid'.

The 'Range' column shows the ranging information currently applied to the outputs. This may be either 'Linear' or a thermocouple law.

To view the outputs on a different slot, press the associated tab on the tab control.

An output value may be set manually by entering the new value required into the edit box in the 'New' column. If the 'New' edit box is greyed out then the analog output is driven by the result of an internal calculation and manual entry is disallowed. Press the **APPLY** button to write your changes to the ICU.

6.3   Monitoring Digital Inputs.

To monitor the digital inputs select Monitor| Digital Inputs from the menu bar. The Digital Input monitor box will then be displayed.

This box is used to monitor the current status of the digital inputs connected to the ICU.

Use the tabs at the top of the box to select the slot number of interest. Slots which correspond to an actual digital input board are indicated by a light green **C**. Slots which do not correspond to actual digital input boards are indicated by a dark green **C.**

The box shows the status of all eight digital inputs on the currently selected slot along with their associated comments..
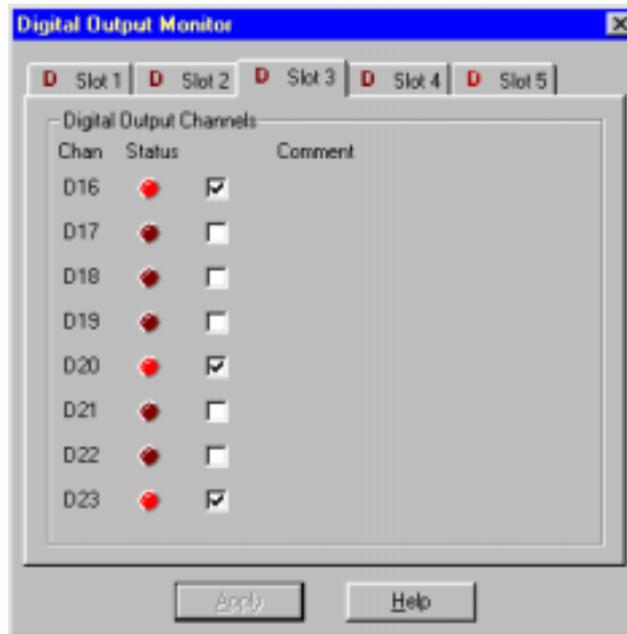
An input which is **OFF** is shown as a dark green LED.

An input which is **ON** is shown as a light green LED.

To view the inputs on a different slot, press the associated tab on the tab control.

6.4   Monitoring Digital Outputs.

To monitor the digital outputs select Monitor| Digital Outputs from the menu bar. The Digital Output monitor box will then be displayed.

This box is used to monitor the current status of the digital outputs generated by the ICU.

Use the tabs at the top of the box to select the slot number of interest. Slots which correspond to an actual digital output board are indicated by a light red **D**. Slots which do not correspond to actual digital output boards are indicated by a dark red **D.**

The box shows the status of all eight digital outputs on the currently selected slot along with their associated comments.

An output which is OFF is shown as a dark red LED.

An output which is ON is shown as a light red LED.

To view the outputs on a different slot, press the associated tab on the tab control.

An output condition may be set manually by checking or unchecking the checkbox next to the output status LED. Press the **APPLY** button to write your changes to the ICU.

6.5   Monitoring PID Controllers.

To monitor the PID Controllers select Monitor| PID Controllers from the menu bar. The Controller monitor box will then be displayed.
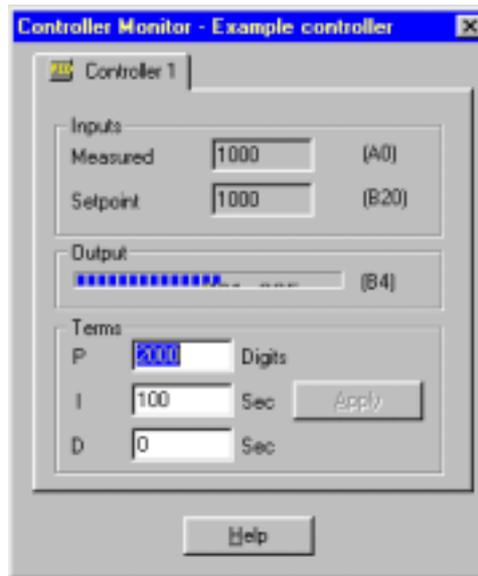
This box is used to monitor the current status of the internal PID controllers.
Note that decimal points are **not** shown in controller monitors.

Measured Value box.
Displays the measured value for the controller in digits. The source register name is
displayed alongside.

Setpoint box.
Displays the setpoint value for the controller in digits.

Output bargraph.
Shows the current controller output. The bargraph is ranged 0 to 100%

Proportional band box.
Shows the currently set value of the proportional band from 1 to 9999 digits. This value
may be changed by overwriting the value in this box with the required new value and
then pressing **APPLY**.

Integral time box.
Shows the currently set value of the integral time from 1 to 2000 seconds. This value
may be changed by overwriting the value in this box with the required new value and
then pressing **APPLY**. To turn off the integral action, enter the value 0.

Derivative time box.
Shows the currently set value of the derivative time from 1 to 1000 seconds. This value
may be changed by overwriting the value in this box with the required new value and
then pressing the **APPLY**. To turn off the derivative action, enter the value 0.

To view the status of a different controller, press the associated tab on the tab control.

6.6   Monitoring Profilers.

To monitor the profilers select Monitor| Profilers from the menu bar. The profiler monitor
box will then be displayed.
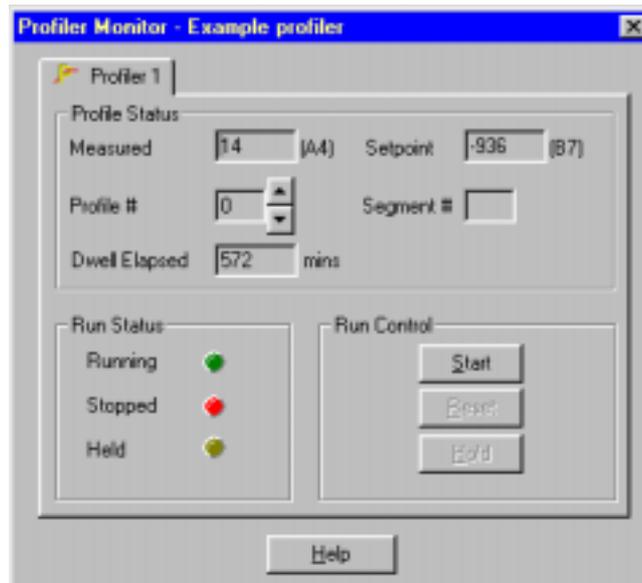
This box is used to monitor the current status of the internal profile generators.
Note that decimal points are **not** shown in profiler monitors.

Profile Status group.
> **Measured Value box.**
> Displays the measured value for the profiler in digits. The source register name is displayed alongside.
> **Setpoint box.**
> Displays the setpoint output for the profiler in digits.
> **Profile # box.**
> Displays the profile number currently being executed by the profiler. If the profiler is not running then the required profile may be set using the up/down buttons.
> **Segment # box.**
> Displays the segment number currently being executed by the profiler. Alongside the box is an icon which indicates the current profiler action. This may be a red up arrow (indicating an upward ramp), a blue down arrow (indicating a downward ramp) or a green right point arrow (indicating a dwell) If the profiler is not running then this box will be blank.
> **Dwell Elapsed box.**
> Displays the current dwell elapsed time in minutes.

Run Status group.
> **Running LED**.
> When lit this green LED indicates that the profiler is running.
> **Stopped LED**.
> When lit this red LED indicates that the profiler is stopped.
> **Held LED**.
> When lit this yellow LED indicates that the profile is held (pausing).

Run Control group.
> **Start** button.
> Press this button to start the profiler. The profile number to be started should be selected in the Profile # box described above.
> **Stop** button.

Press this button to stop the profiler.
Hold button.
Press this button to hold the profiler. Press again to release the hold.

To view the status of a different profiler, press the associated tab on the tab control.

7   Calibration.

This section provides calibration procedures for the ICU analog inputs and outputs.

Calibration should only be performed by authorised competent personnel and only when the ICU is not currently being used to control the process.

Ensure that both the ICU and any test equipment to be used have been switched on and left to stabilise for at least 30 minutes before any calibration is attempted.

7.1   Analog Inputs.

The ICU has one analog to digital converter which is shared between all analog input channels. This means that it is not necessary to individually calibrate every analog input channel. Only the individual ranges need to be calibrated.

1.   Connect an appropriate signal source to an analog input of the required type.

2.   From the main menu select **Calibrate** | **Analog inputs** to call up the Analog input calibration dialog box.
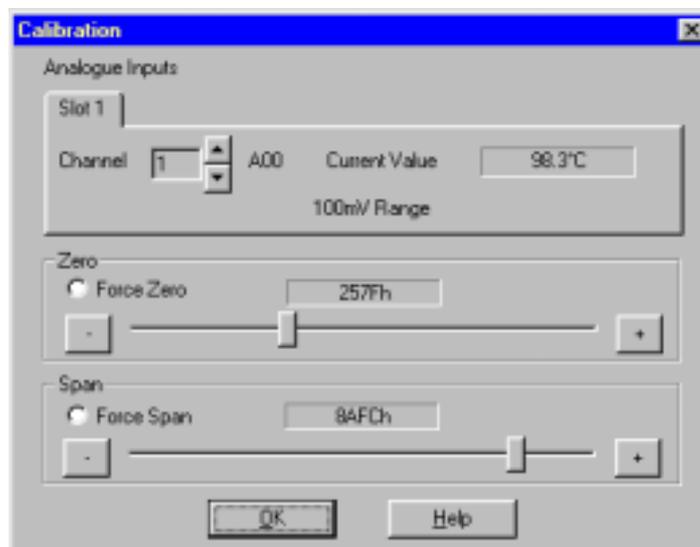
3.   Select the slot and channel number required for the connected signal source.

4.   Set the signal source to the zero value given in the table 7.1.

5.   Adjust the zero control until the analog input reads the correct value.

6.   Set the signal source to the span value given in the table 7.1.

7.   Adjust the span control until the analog input reads the correct value.

8.   Repeat from step 4 until no further adjustment is required.

Only one input of each type need be calibrated.

Table 7.1 Input calibration points.

	100mV Range	**1V Range**	**10V Range**	**20mA Range**	**Pt100 Range**
Zero at	0.000mV	0.0000V	0.000V	0.000mA	100.00Ω (0°C)
Span at	100.000mV	1.0000V	10.000V	20.000mA	390.26Ω (850°C)

7.2   Analog Outputs.

All fitted analog output channels need to be calibrated individually. The following procedure needs to be performed for each analog output in turn.

1.   Connect an appropriate measuring instrument to the required analog output.

2.   From the main menu select **Calibrate** | **Analog outputs** to call up the Analog output calibration dialog box
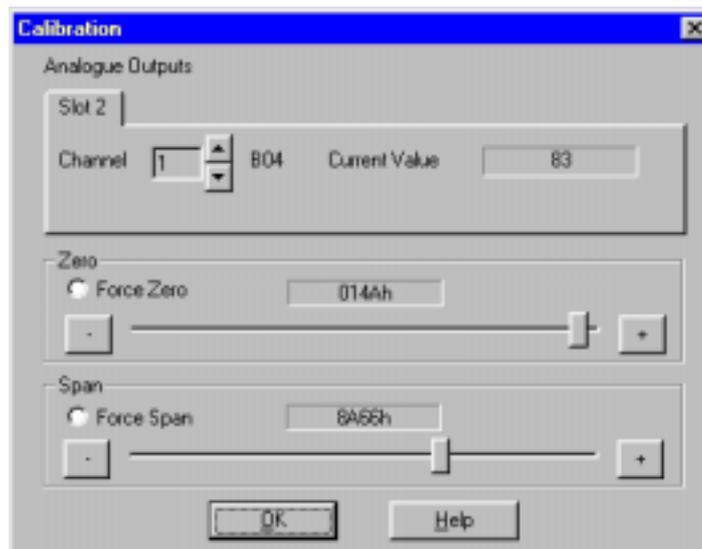
3.   Select the slot and channel number required.

4.   Press the **Force Zero** button to force the output to its zero value.

5.   Adjust the zero control until the measuring instrument reads the correct value given in table 7.2.

6.   Press the **Force Span** button to force the output to its span value.

7.   Adjust the span control until the measuring instrument reads the correct value given in table 7.2.

8.   Repeat from step 4 until no further adjustment is required.

Unlike analog inputs, each analog output channel needs to be individually calibrated.

Table 7.2 Output calibration points.

	100mV Range	1V Range	10V Range	20mA Range
Zero at	0.000mV	0.0000V	0.000V	0.000mA
Span at	100.000mV	1.0000V	10.000V	20.000mA

7.3   Cold Junctions.

The ICU has one cold junction sensor on every thermocouple input card fitted but each sensor shares a common calibration setting. Calibration should thus be performed on one card only.

1.   Fix a thermometer so as to measure the actual temperature of the TC input cards' terminal block. This thermometer should ideally be a thermocouple probe screwed temporarily into one of the terminals of the block. Similarly, but less accurate, results may be obtained using a mercury in glass thermometer positioned such that its bulb remains in physical contact with the terminal block.
Connecting the probe or positioning the thermometer will inevitably change the temperature of the terminal block due to handling. It is essential for accurate calibration :-

- That the terminal block and its cold junction sensor be allowed to stabilise after handling for at least 15 minutes.

- That the ambient temperature is between +15°C and +30°C and remains stable during the calibration period.

- That the terminal block is shielded from draughts and direct sunlight during the calibration period.

2.   From the main menu select **Calibrate** | **Cold Junction** to call up the Cold Junction calibration dialog box
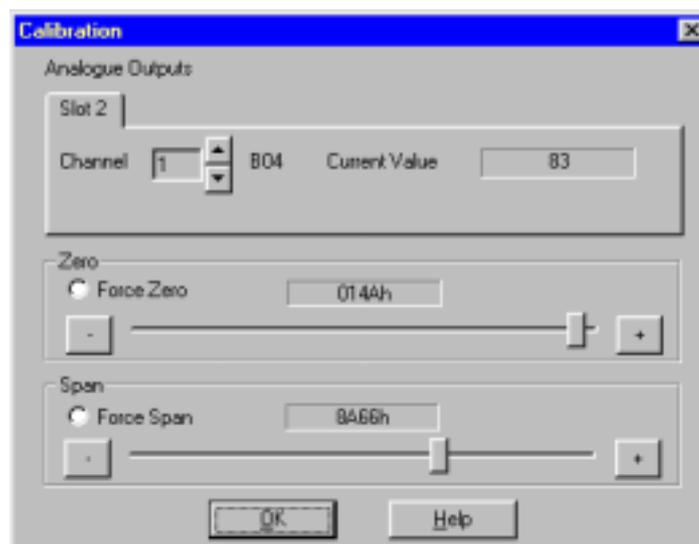
3.   Adjust the zero control until the displayed CJ temperatures agree as close as possible to the thermometer.