



Twickenham
Scientific Instruments

The Helium Depth Indicator (HDI)

Instruction manual, release 4.3

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Note: Users who have used the HDI before are requested to consult appendix A2 which highlights physical changes to the unit.

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Operating Instructions for HDI Helium Depth Indicator.

Preamble

The Helium Depth Indicator (HDI) is a completely new concept in the instrumentation for accurately measuring the liquid helium level in storage dewars, transfer dewars, experimental helium baths and all other situations where liquid helium is used. The great potential for control of all aspects of the measurement invigorates the hot wire method of measurement for helium probes (see later), and allows its use in situations where only specially modified units could be used before.

In addition, the unit can be configured, via the front panel controls, to operate nitrogen probes manufactured by Twickenham.

At the core of this flexibility is an 8032 processor. It is here that the algorithm for making the measurement, the output of the reading to the display and to the analogue output stage, and the control of the power supply is located.

The user selection of the frequency of measurement and automatic probe detection – or preset probe choice – are made by a series of menus that are shown on the display, and controlled by the three front panel buttons. Once the selections are made, they are stored in EEPROM, and are retained for use even when the HDI is turned off.

This manual describes the basic operation of the HDI, and probes, as well as instructions as to how to control them.

Physical description

The HDI is housed in a standard box to DIN 47300, which can be either rack mounted or bench mounted. The box is 144w x 72h x 200d, and will neatly occupy half a 2U section of a 19" rack. Both rack mounting ears and bench mounting feet are supplied with the instrument.

The weight of the instrument is 1.5 kg, but careful design has ensured that the heavy parts are as close to the front of the instrument as possible, so that there is not an excessive strain on the rack mounting ears.

External description.

The front panel is simply furnished with an eight digit dot matrix LCD display, and three push button switches. These three switches are used to set and control all the functions of the HDI; details are given in 'Operation of the HDI'.

The switches have two sets of legends. The upper set, namely *Mode Read Probe* describe the function of the button under normal operating conditions. Of the lower set, *Enter* describes the function of the button while in the Mode or Probe changing condition. However, in the calibration and parameter modes, the lower legends – *Enter +* describe the functions of these buttons.

The Back Panel

The back panel has all the connectors, calibration adjustments and other switches that are required for its operation. These are:

IEC mains power connector, with integral mains power switch, voltage selector and dual fuse holder;

24V battery pack input;

Analogue signal output and inhibit input connector;

Four trim adjustments, labelled P, Q, R, S;

Probe connector (2 probe connectors with the -2 option);

9 way DB9F type connector for the serial port;

9 way DB9M type connector for control and alarm option if ordered.

The mains power inlet module is the dominant feature of the back panel. This includes a standard IEC connector input. Within this module is the mains power switch, which operates both line and neutral, and is on when rocked so that '1' is depressed. To the side of these is a combined mains voltage selector and dual fuse

holder. The mains selector has two positions: '115' for 90–127 V ac operation, when the fuses should be 1A HRC (T); and '230' for 190–250 V ac operation, when the fuses should be 630mA HRC (T).

To open the mains selector, to either change the setting or for changing fuses, firstly remove the mains cable. Using a small blade screwdriver or similar, hook in the small slot at the left side near the window showing the mains voltage selection, and gently lever the hinged lid. The hinged lid cannot open if the mains cable is in place, as a safety measure. It is then possible to gently lever out the mains selector and fuse holder. In changing fuses, be careful not to bend the 20mm fuse adaptor too far back.

WARNING: The case of this instrument is connected to mains earth.

There is also a 24 V External power socket to the side of the mains inlet. This input will accept 24 V dc or 18 V ac, but is primarily designed for battery pack operation for portable applications. The mains power switch is not operational for this power input, which means that the unit will be operational for all the time that power is applied to the *24V External Power* connector. It can, however, be shut down from the front panel by selecting STANDBY, when the current consumption falls to about 50 mA.

Internal Description

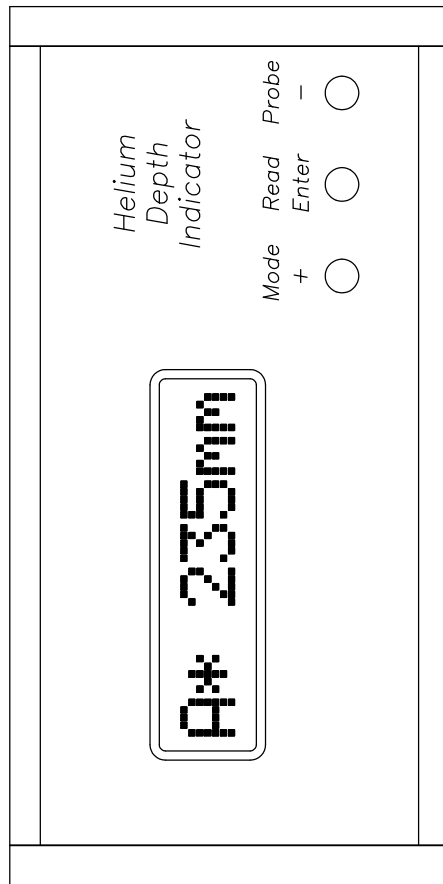
NOTE:

- 1 **There are no user serviceable parts inside this unit.**
- 2 Always remove the mains connector before opening the lid of the HDI, as there are live connections and printed circuit tracks inside. Note the warning symbols on the safety cover plate over these live connections.

The HDI consists of two main printed circuit boards, on which all components except the display and probe connector are mounted. The top, or Power PCB is directly connected to the back panel via the IEC mains inlet and DB9F connector. The bottom, or main PCB extends the whole interior depth of the case, and holds all the control circuitry.

Cleaning the HDI

Most of the instrument is either anodised aluminium or epoxy paint coated, and can be cleaned with a damp cloth or similar. However, the display is liable to attack by most solvents; to remove marks, petroleum benzene is the recommended agent.



Issue		Date	Modifications	Signed	Materials Specification:		Finish Specification:	
					TWICKENHAM SCIENTIFIC INSTRUMENTS.			
					TITLE			
					Front view of HDI			
					Dimensions:		Scale:	
					Tolerance:		1:1	
					Design		Drawing No.	
					Drawn		HDI/FRONT	
					Date		Part number	
					Sheet		of	



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Bench or panel mounting of the HDI

The HDI is supplied ready for bench mounting. It is fitted with a base plate on which four feet have been attached. The two front feet can be adjusted so as to raise the front of the instrument up.

The HDI can also be easily adapted for panel mounting. The base plate, with the feet on, should be removed as follows. Hold the instrument upside down. There is one cross-head screw in the centre at the back of the instrument which holds the base plate on. Remove this screw, and then slide the base plate to the back. Do not allow any wires or other items fall into the exposed printed circuit board. The spare blank panel supplied with the HDI (usually packed on the top of the HDI within the foam packing) can then be slid in, from the back, and attached in using the cross head screw. Ensure that the countersink in this panel is on the outward facing side.

The HDI is then ready for panel mounting. A rectangular cutout of 138 mm wide by 66 mm high in the panel is sufficient, as the HDI is presented to the panel from the front and is mounted through the panel.

In the accessory pack there are a two bolt - brass collar - aluminium bracket fixings. These are used to secure the HDI to the panel from the back - the following drawing shows how these are attached, and note that the panel itself has not been shown in the drawing for clarity. The HDI is held against the front of the panel by the front flange around the front panel, and the two bolts push against the back of the panel, securing it.

Principle of operation.

The HDI and helium probe use the familiar ‘hot wire’ method of detecting the depth of the liquid. The HDI contains all the circuitry to run the probe, measure the resistance of the normal state length of the active element, and then interpret the result as the depth of the helium.

The active element of the probe is a fine NbTi wire, whose superconducting transition temperature is above the boiling point of liquid helium. At the top of the wire is a small heater. The probe is wired so as to measure the resistance of the element using a four terminal technique.

The cycle of operation of the controller is as follows.

At the start of the measurement sequence, the controller turns on the measurement power supply. At first, the helium probe is excited by a boost current, which is in excess of the measuring current. This heats the top of the element and causes the normal/superconducting interface to propagate down the element. When this interface reaches the surface of the liquid, the much greater cooling power available causes the propagation to cease. This is detected by the HDI control, which then switches to the measure current; there is a timeout in this part of the sequence to protect the probe.

When the measure current is supplied, the HDI measures the voltage a number of times using a 12 bit A–D converter, and then deduces the resistance of the element. Once the resistance of the element is known, the HDI can compute the depth of the helium with the knowledge of the calibration of the probe which has to be entered into the unit. This number is then displayed on the screen, along with the probe identification and the measurement unit. The microprocessor also produces a signal that generates the analogue output signal, be it 4 – 20 mA or analogue voltage.

Once this cycle is performed, the measurement power supply is turned off, and the unit waits until the next measurement is to be taken. As the act of measurement causes a significant amount of heat to be generated in the cryostat, the readings are usually taken intermittently. The display always shows the last reading taken.

In the continuous mode of operation, the measurement current is always on, and no boost current is applied.

The parameters, such as the timings, are set by the microprocessor. The firmware also allows for a number of parameters to be user configurable, and special versions of the firmware can be prepared to allow for particular requirements; however for the

majority of applications, the default values and scheme used by the microprocessor will be found to be suitable.

The HDI can also be used with the Nitrogen probes manufactured by Twickenham; the unit needs to be configured via the front panel controls to operate these probes, with this setting up giving the operational parameters required by the Nitrogen probe. All the parameters required to configure a Helium probe into the HDI are performed in precisely the same way for the Nitrogen probe, with the addition of the configuration menu S23 which sets up the HDI to operate a Nitrogen probe rather than a Helium probe.

Once the depth of cryogen is deduced by the microprocessor, the signal can be processed as required. Producing an analogue signal in one of two standard formats is just one example. The HDIc (HDI with control and alarm option) exploits this to control two internal independent relays which in turn are used to control pumps and similar equipment for automatic cryostat refills. With an additional, two probe input, option, the HDI can monitor two probes, and operate the relays according to the level as monitored by each probe. Examples of this use are for one probe in the measurement cryostat and one in the storage dewar of an autofilling system; alternatively, the HDI could operate a nitrogen probe, with automatic refilling, as a ‘background’ task, while showing the helium level on the display.

A ‘shutdown’, or Alarm signal is also output when the level in the experimental cryostat gets below its preset minimum. All these preset levels are entered into the memory of the HDIc, via the front panel buttons.

The control unit is designed to operate helium probes in storage dewars, baths around superconducting magnets etc. With careful setting of the currents (see section 5), operation of probes in near vacuum above a pumped helium bath can be achieved, but *operation with the default currents may destroy the element*. It will measure the depth of a cooled helium bath, even with $T < T_{\Lambda}$ as long as precautions are taken and the HDI is on standby mode once the helium level has dropped to almost zero.

Please contact the staff of Twickenham if you do need to operate the HDI and probe in these régimes, and they will advise the best approach.

Wiring up the HDI

There are a number of connectors in the back panel, and this section describes the wiring of all of these.

1. Mains connector.

This is an IEC mains inlet, with combined switch, voltage selector and fuse holder. A suitable IEC mains lead for the country of destination is supplied.

2. 24 V connector.

This is a 2.1 mm coaxial connector. 24 V dc or ac can be supplied to this socket, with no external or internal switches or changes. Either polarity can be used to connect the dc power to this connector. A suitable connector is supplied.

3. Inhibit/Analogue signal

The four way Inhibit/Analogue signal connector has some markings above and below it.

Above it the legend $+ ANL -$

When either the $-V$ or $-T$ option is selected (Analogue voltage outputs), then the $+$ and $-$ show the polarity of the two pins.

When the $-A$ option is selected (4 – 20 mA), then the $+$ and $-$ show the polarity of the current flow.

Above it is the legend $Y INH X$. A current of between 3 and 15 mA (5 - 20 V) flowing through this connector (in either direction) will inhibit the instrument from making readings. Further details are in the External Inhibit section.

4. Probe input.

The probe input connector is wired so as to take both A and B type probes. Each pin is connected as follows:

A V+ (Probe B)

B I+ (Probe B)

C I+ (Probe A)

D V- (Probes A and B)

E V+ (Probe A)

F I- (Probes A and B)

5. Serial port.

A standard DB9F connector for serial port connections.

External wiring and EMC regulations

There are a few points that should be noted when installing an HDI into a system to ensure the integrity of the system as a whole, in accordance with the CE mark.

The installer must ensure that any common mode voltages applied to any port, other than the mains input, are less than 50V peak with respect to earth.

HDI to probe

For an HDI being connected to a probe with the standard 7 pin connector, the manufacturer's cable (six core cable with screen) should be used. The screen is earth bonded at the HDI.

HDI Analogue Output / External Inhibit

For the purposes of the HDI's EMC qualification, an unscreened cable length of 1 m was taken as being a representative use of this port. The installer must make a judgement, considering the length of cable runs and the electro-magnetic environment, with a view to selecting the screened cable if appropriate.

HDI Serial port

The interface cable should be screened with the screen terminated in a metal hood bonded to the instrument via properly tightened jack screws.

HDI control and alarm connector (HDIc only)

The interface cable should be screened with the screen terminated in a metal hood (supplied) bonded to the instrument via properly tightened jack screws. Interface cables are not normally supplied with the instrument.

Helium Probes.

Although there are a large number of types of probe available, the most popular are those where the sensor wires are housed in a stainless steel tube. There are three standard probes available:

SS-1050-550-7M-21, wired to operate on channel A.

SS-1270-900-7M-21 and SS-1500-1100-7M-21, wired to operate on channel B.

Details of the probe part numbers are given in the probe applications note (supplied with each probe), and in the appendix at the back of this manual; it is also in the probe sales literature.

Custom-made stainless steel probes are manufactured on request with an enormous range of active and total lengths. For historical reasons, probes with an active length of less than 555 mm are wired as Type A, and greater than this length as Type B; however, there are occasional variations for specific customer applications. Probe test sheets will give the wiring of the seven pin connector. One advantage of the dual wiring is that it can allow two probes, one type A and one type B to be connected in parallel; the HDI is then able to monitor two helium depths.

For permanent installations within cryostats, probes with an outer housing of Tufnol (TF- prefixes) and pultruded Glass Fibre (GF- prefixes) are also manufactured. These are wired to a suitable connector at the top of the cryostat, and from there via a cable to the probe input of the HDI; again, wiring for type A or type B is required.

Nitrogen Probes.

Nitrogen probes are manufactured both as an instrument in their own right and also to complement the Helium probe in an installation. Nitrogen probes that are to be operated by the HDI are wired to operate on one of the two channels, and this channel is a component of the part number of the probe.

When the Nitrogen probe is to be operated with a Helium probe with one HDI, the rule governing the wiring of the Helium probe will take precedence, and therefore dictate the channel to which the Nitrogen probe will be wired to operate on.

In order to operate the Nitrogen probe successfully with the HDI, the instrument has to be configured so that it will operate the nitrogen probe in the optimum manner. This is done via the front panel buttons, using the *Mode* menu obtained when this button is held in while the unit is turned on. Full details of this are given in section 5.

Operation of the HDI

The HDI needs to be connected to a power source (either ac mains or 24 V dc), and in the case of the mains, the mains power switch set to '1' (on). The display will show

HDI v4.4

for the HDI. This is the initial firmware version message.

Various internal checks are made while this message is on the display. Once these have been performed, the unit will automatically change, and show a message, of which this is a typical example:

A 235mm

The first character indicates which probe is being read, and this is the same identifying character as the probe type discussed above. For example, for helium probes, A generally indicates probes with an active length less than 555 mm. The second character here is shown blank. This indicates that the HDI is in the fast reading mode. When a reading is actually being taken, a * character appears in this position. When the HDI is in the slow reading mode, a ● or ⋮ character appears in this position, to be replaced by the * character while the reading is being taken. When the HDI is in the continuous reading mode, the second character is a C, to be replaced by the * character when the displayed reading is updated.

The next four characters are reserved for the depth reading, and the last two are for the units. In the above example, the depth as measured by the last reading (which was very recent, as the unit is in fast read mode), was 235 mm.

Unless it has been altered by the *Mode* menu, the HDI defaults to the automatic channel detection mode, that is it will check for the presence of a probe on either channel, and then display the value for the connected probe that it found.

Modes of operation.

The HDI has four modes of operation. The order that they are presented in the mode selection menu (see below) is Fast, Slow, Standby, Continuous. However, in order of decreasing power consumption and helium boil off caused by the measurement, they are Continuous, Fast, Slow and Standby.

The Fast and Slow modes are very similar. For helium probes, the measurement is started with the application of a boost current, which is then switched to the measurement current when the measurement is actually taken. The current is then switched off until the next measurement is made. For nitrogen probes, a constant power is applied to the probe. The only difference in these two modes is the time interval between the measurements. In the Fast mode, the time interval is three seconds. In the Slow mode, the interval is set by the user in multiples of 256 seconds, the multiple (the number that is entered into the HDI) lying in the range 0 to 255; this corresponds to reading intervals from approximately 4.25 minutes to over 18 hours. The default value of the multiple is 1, that is the reading will be taken approximately every 4.25 minutes. The value of 0 stops the HDI making any automatic readings, but it will still take a reading every time the *Enter* button is pressed, and it will continue to show the previous reading. When the timing interval is set to 0, the second character is a **:** as opposed to a **•**. This particular setting would be appropriate for experiments where the currents flowing in the probe affect the experiment, for example in SQUID experiments, and there is not a signal available to use the External Inhibit function as described in section 6.

In the Continuous mode, the measuring current is always on. The ***** flashes on the display every time the display is updated, approximately once a second. This mode would normally only be used for liquefier systems (or similar), because of the relatively large amount of power that would be supplied to the probe, and thus the helium bath. It would not be appropriate for experimental cryostats except in exceptional circumstances.

In the Standby modes, the entire measurement sequence is suspended. This mode is most appropriate for battery pack operation, to minimise power consumption.

The HDI features built-in protection for helium probes. Should the resistance of the superconducting element ever be 15% greater than the value stored in memory for that channel (stored as an active length), the current source will immediately shut down for the rest of the measurement cycle. This will help to protect probes and prevent burn out of the element. If such a state is detected, the display will, for example, read

B - HIGH

This message may occur if the HDI is incorrectly set up for the active length of the probe being operated, and this can be checked for with the *Probe* menus.

Dual probe operation

If the HDI has the -2 or -L option and is suitably configured in menu S24 INP2 (see later), it can be set up to operate either any one or both probes.

The two probes are referred to here as the ‘background’ probe and the ‘foreground’ probe. They are only distinguished in that the reading of the level of the foreground probe is shown on the display, whereas the reading of the background probe is not. Of course, it is possible to change channels so that the second probe becomes the foreground.

Using the serial port, it is possible to obtain the reading of the background channel without having to switch the display (foreground) probe.

If the two analogue output option has also been selected and configured S25 ANL2, signals proportional to the cryogen levels will be available, and will *not* swap over if the foreground and background probes are swapped over by use of the *Probe* button.

When the dual probe operation is selected, the measurement sequence is altered. When either the Fast or Slow modes are selected, the first reading taken is the background reading, and this is indicated by the second character of the display showing a # character, for example

A# 280mm

which is immediately followed by a reading of the foreground probe, indicated by the usual * character, as shown here

A* 280mm

At the end of this cycle, the HDI will wait until the next reading cycle is to be started, as determined by the *Mode* menu.

If the continuous mode of operation of the probe is selected, the dual probe operation is suspended, and the continuous mode is only operating on the foreground probe, which under these circumstances is the only probe under operation.

All of the above is still valid if one, or both of the probes connected to the HDI are nitrogen probes. So long as the correct special option is selected (as discussed in section 5), the HDI will take the correct readings and generate signals as defined by the set points, and not be affected as to whether the cryogen is nitrogen or helium.

First level of operation of the switches.

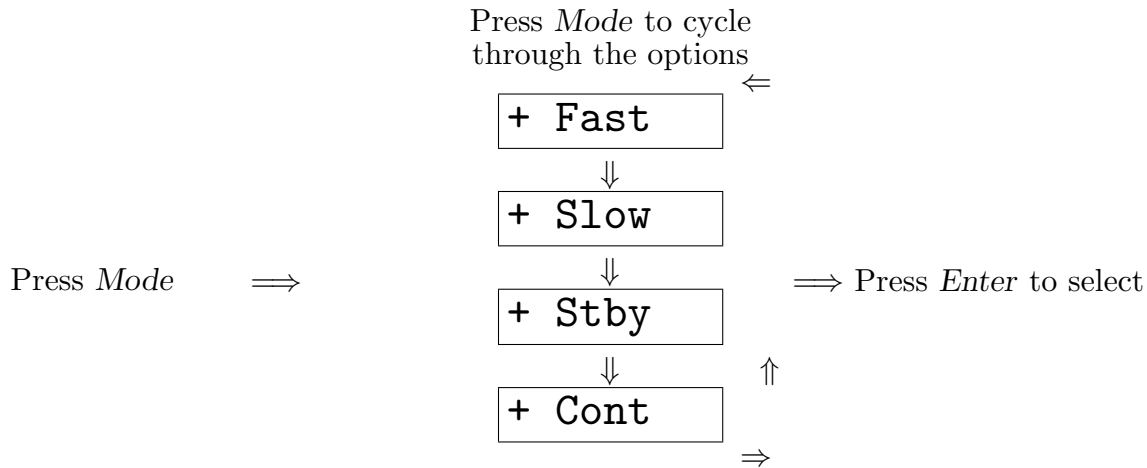
When the HDI is in one of the front panel menus, pressing either *Mode* or *Probe* selects one choice of the appropriate menu. Usually this will be the currently stored configuration for that menu choice. While making the selection or viewing the possible choices within each menu, further button presses are required. If no button is pressed within 5 seconds of the previous press, the unit will revert to normal operation without making any change. Only after *Enter* has been pressed with the choice be accepted, stored, and acted upon when the unit returns to normal operation. The *Read* button has its own action, described below.

Read

Except in the STANDBY mode, pressing the *Read* button on the front panel at any time will automatically cause a reading to be taken, even if there is an inhibit signal supplied to the unit.

Mode

This configures the HDI for the mode of operation (either the update interval for reading or how the probe is energised) for reading the cryogen probe.



Having selected the required mode of operation, and pressing *Enter*, the HDI returns to the normal mode of operation, working in the newly selected mode.

If the Standby mode is selected, the display will show the message

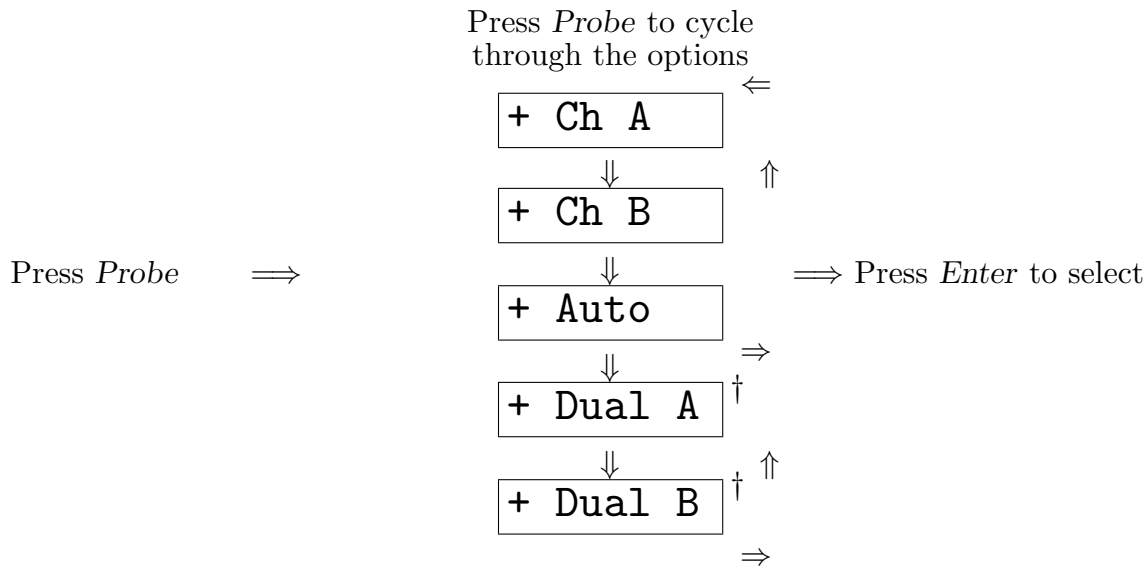
STANDBY

If either the fast, slow or continuous modes of operation are selected, the HDI will immediately take a reading after the *Enter* button is pressed to select the mode. The HDI will then operate in whichever mode is selected, with all the parameters pertinent to that mode.

At the same time, the choice is saved in EEPROM. This choice will remain in memory until changed by the user; loss of power, intentional or otherwise, will not affect the unit.

Probe

This allows for the selection of the channel to which the probe is attached, that is wiring type A or wiring type B.



† The two menus Dual A and Dual B will only appear for the HDI with the -2 or -L options, where the menu S24 has been set for two input channels (see below). Otherwise, only the first three items appear in the menu.

Normally, but not always, standard (-7M-) type A helium probes have an active length of less than 555 mm, and type B helium probes have an active length greater than this. This is for historical, not technical reasons.

If one or two Nitrogen probes are being used, then before the HDI can operate the probe correctly, the special options menu (S23) also has to be adjusted (see table 5.1 and the accompanying notes). Nitrogen probes indicate which channel they are wired for in their product number, channel A being very much preferred. Although it has to be selected, there is no special indication on the display that the channel being displayed is operating a Nitrogen probe. The setting of the special options menu

ensures that the HDI is optimised in both power to, and in reading back the output of, the nitrogen probe on that channel.

Once either probe type A or type B is selected as the displayed channel, the HDI will then do a test to ensure that it can detect the selected probe. If it cannot do so, then the display will show

A - OPEN

for channel A, or

B - OPEN

for channel B, indicating an open circuit has been found. If this occurs, first check that the correct probe type has been selected. However, certain fault conditions of the probe and the interconnecting cable will mean that the HDI cannot detect it. If the HDI cannot detect the probe, check all items using the fault finding guide given later.

The automatic probe selection mode will try and detect which probe wiring type, if any, is connected to the probe input. The HDI will initially check to see if there is a type A probe; if there is no such probe connected, it will then try and detect a type B probe. If it cannot detect either type of probe, the display alternates between the two displays shown above, changing at each reading interval, indicating that there is not a probe connected to the probe input. If there is a probe connected to the HDI, the same checks as indicated above need to be performed.

Note that with the -2 or -L option on the HDI, with two probes connected, and the automatic probe detection option is selected then the unit will just operate and display the first probe detected.

Note also that if a nitrogen probe is connected to the HDI that has not been configured correctly, the display will show erroneous readings, and the probe could ultimately sustain damage; the nitrogen probe must not operated on an incorrectly configured HDI.

When the required selection is made, and the *Enter* button pressed, the choice is saved in EEPROM. This choice will remain in memory until changed by the user; loss of power, intentional or otherwise, will not affect the unit.

As would be expected, while working in the mode selection and the probe selection menus, readings of cryogen depth are suspended at the point in the cycle where the menu was accessed.

Second level of operation of the switches.

The second level of operation of the switches are for the setting of the basic parameters of measurement and control. As such, these rarely need to be changed, except for special applications.

Operation of the buttons within the Calibration menus

In the Calibration menus, the functions of the $+$ and $-$ buttons are as follows. When they are initially pressed, they will increase or decrease the value displayed by one. If the button is held in, then the autorepeat feature starts, and the figure will increase or decrease in units of 10. However, it does this from the *initial* value. For example, the displayed sequence on pressing the $+$ when a value of 550 is shown is: 550 — 551 — 560 — 570 ...

The *Enter* button is used to enter the selected value into the memory of the HDI, and to move on to the next menu.

Calibration of the controller to the probe(s): Probe button.

For the controller to read the correct depth of cryogen when used with a particular probe, it must be calibrated to that probe by entering the active length of the probe into the controller's memory. Since there are two channels, two different calibrations can be entered. Note that this process is identical for both helium and nitrogen probes, although configuration of the type of probe has to be done in another menu.

For controllers that are purchased with probe(s), the controller will be calibrated to the probe(s). If one of the two types is unused, the default calibration will be set.

The default values are for helium probes on both channels with the following active lengths:

Channel A: 550 mm

Channel B: 1100 mm

For controllers that are purchased without a probe, the default calibrations will automatically be used by the controller, unless a specific calibration has been requested by the customer. In any case, it is a straight forward operation to change the calibration.

At the same time, values to trim the analogue output signals are also entered. This allows for a number of options.

Analogue signal trim values

After the active length of the probe has been set in the calibration menu, the system prompts for the analogue output trim value.

If the HDI is calibrated to a particular probe, and there is no special requirements for the analogue output, then this value should be set to normal case value as discussed below. However, the flexibility of this setting also allows for other uses of the analogue output to be considered.

–A option. The normal case value is the same as the active length of the probe, so that 20 mA corresponds to the maximum reading. The trim value can be changed so that the 4 – 20 mA scales over a restricted range, giving full output at a selected depth - the value of the analogue trim entered - of the cryogen.

–V option. The normal case value is 2000, corresponding to (approximately) 2 mV/mm. The output can be scaled so that the voltage scales to the reading in simple terms, for example 1 mV/mm, or 2 mV/mm.

The display reading is divided by the analogue output trim value, and then scaled onto the 4 – 20 mA scale or as a percentage of full analogue voltage (4.1V). By altering this divisor value, the above mentioned examples can be generated. For example, a setting of 2050 will generate a 2 mV/mm output in the –V option.

–T option. The normal case value is the same as the active length of the probe, so that 10 V corresponds to the maximum reading. The trim value can be changed so that the 0 – 10 V scales over a restricted range, giving a full output at a selected depth - the value of the analogue trim entered - of the cryogen.

Calibrating the HDI to the probes - Second level *Probe*

The second level *Probe* menus are accessed by depressing the *Probe* button, and switching on the HDI, or switching on the HDI and pressing the *Probe* button while the initial firmware version number message is being shown. After this initial message, the display will show:

S01

Releasing the *Probe* button brings up the second level *Probe* menus.

Channel A Active length

Press *+* or *-* to
set the active length

⇒

S0A 550

⇒ Press *Enter* to select ⇒

Channel A Analogue Trim

Press *+* or *-* to
set the trim value

⇒

S1A 550

⇒ Press *Enter* to select ⇒

Channel B Active length

Press *+* or *-* to
set the active length

⇒

S0B 1100

⇒ Press *Enter* to select ⇒

Channel B Analogue Trim

Press *+* or *-* to
set the trim value

⇒

S1B 1100

⇒ Press *Enter* to select ⇒

After the *Enter* button has been pressed, the HDI will have finished all the calibrations, and stored them in EEPROM. It will then revert to normal operation with the parameters such as mode, display channel as previously set, but with the new probe parameters as just set in this menu.

Setting of the reading interval for the Slow mode, setting the operating currents for driving the probes, and setting special options: Mode button.

The time interval between readings when the unit is operated in the Slow mode is the first menu S20. The basic ‘unit’ of time is 256 seconds; that is the time interval is set as a multiple of 256 seconds. The number that is entered into the HDI is the number of multiples of 256 seconds that is required. The default value is 1, but it can be set as high as 255; a setting of 0 was discussed earlier.

The boost and measure currents (S22 and S21 respectively) for helium probes are set in units of an incremental current units. Each ‘step’ is equal to a nominal incremental current of 0.5 mA. It is not important that an exact value of current can be set (for example exactly 100 mA), as the current is noted internally by the HDI in its calculation of the resistance. The number of incremental steps is added to the nominal minimum current value of 24.5 mA. The nominal output current is given by the equation

$$I_{\text{out}} = 24.5 + 0.5n$$

where n is the number entered into the HDI. The minimum value of n is 0, the maximum is 255. Note that the current is a nominal value, which is noted internally so as to produce an accurate value of the resistance of the normal state length of the superconducting element.

The Boost current is applied first, to its preset value, and this is applied for a minimum of 500 ms and then until one of two events occur. These are:

1. The transition has run down the element and stopped at the level of the liquid helium - the usual situation; or
2. The boost current has been applied for 2.5 s, when it will time out and immediately switch to the measure current.

The Measure current is then applied, to its preset value, and the measurement of the resistance of the element is then made.

The numbers calculated to give the currents should then be entered in the two menus S21 (measure) and S22 (boost). Unless a special option has been selected on menu S23, these values entered will operate on both channels, so either one or two probes connected to the HDI will operate with these altered current values.

There are a number of circumstances where this arrangement is not desired; it is possible to change how the probes are controlled using the configuration menu S23, the details of which are given below.

For an HDI operating two helium probes, it is possible to set the configuration so that one probe will operate with the default values while the other probe is under the direction of the values entered under these menus. The default values (that is 150 mA Boost current, 100 mA Measure current) which are pre-programmed into the HDI, are proven to be suitable for operation of helium probes in baths of liquid helium at 4.2K, and in many other circumstances. Hence an HDI monitoring and/or controlling a cryostat with two helium probes, one measuring the helium bath and one operating in a reduced pressure system can be set up to give the optimum working parameters for each probe. The selection of which channel is for the probe under control and which channel is for the default operation probe is made under the same menu.

If one or two nitrogen probes are being used, and these have to be selected in the same configuration menu (S23), the HDI will over-ride the boost and measure currents and power the probe for optimum performance.

WARNING

It is possible to damage, or destroy a helium probe if care is not taken in setting the Boost and Measure currents. See also the Disclaimer section in the appendices. Under normal operating conditions, the default values of 150 mA for Boost and 100 mA for Measure are adequate. Mostly these current values will only need to be altered for one of two reasons:

1. The HDI is being used to operate a helium probe made by another manufacturer, and the rating of the probe is significantly different to those manufactured by Twickenham; or
2. The HDI will be operating helium probes which are operating in volumes of liquid helium that are being pumped, for example in 1.2 K pots for ^3He or Dilution Refrigerators. This category does not include probes which are operating in systems with lambda plates or pump plates, where the main bath of liquid helium is cooled, but is not directly pumped on; for this situation, the default values of the current are normally suitable.

Only in exceptional circumstances will the current values need to be altered for Twickenham probes operating in baths of (4.2 K) liquid helium. If such a case is

thought necessary, please contact the staff of Twickenham first for advice. Application notes for operating different probes or probes under unusual conditions are available.

Special options

The default value for the special option S23, for the HDI or HDIc operating helium probes only is 0. Selection of the high current (-H) option for operating some non-Twickenham helium probes, the selection of a nitrogen probe etc., is done by setting the number according to the following table.

S23 option number	Function
0	Standard HDI; up to 2 Helium probes
1	High Current (-H) option (also requires factory fitted components)
2	Helium probe channel A, Nitrogen probe channel B
3	Nitrogen probe channel A, Helium probe channel B
4	Nitrogen probes on both channels A and B
5	Controlled He probe channel A, default operation He probe channel B
6	Default operation He probe channel A, controlled He probe channel B
7	Dual element probes - See Application note 15.

Table 5.1 The features and probe type and operation selection offered by menu S23.

Hardware configuration

The menus S24 and S25 select the number of probe input channels and analogue output channels respectively for the HDI. Unless the relevant hardware options have been installed, these two menus should be set to S24 INP1 and S25 ANL1 for correct operation.

Entering in the time interval, operational currents and hardware configuration - second level *Mode*

The second level *Mode* menus are accessed by depressing the *Mode* button, and switching on the HDI, or switching on the HDI and pressing the *Probe* button while the initial firmware version number message is being shown. After this initial message, the display will show:

S01

Releasing the *Mode* button brings up the second level *Mode* menus.

Slow mode timing multiple

Press + or - to
set the timing multiple

⇒ S20 1 ⇒ Press *Enter* to select ⇒

Measure current value

Press + or - to
adjust the Measure current

⇒ S21 155 ⇒ Press *Enter* to select ⇒

Boost current value

Press + or - to
adjust the Boost current

⇒ S22 253 ⇒ Press *Enter* to select ⇒

Special options - see table 5.1 or application note

Press + or - to
select a special option

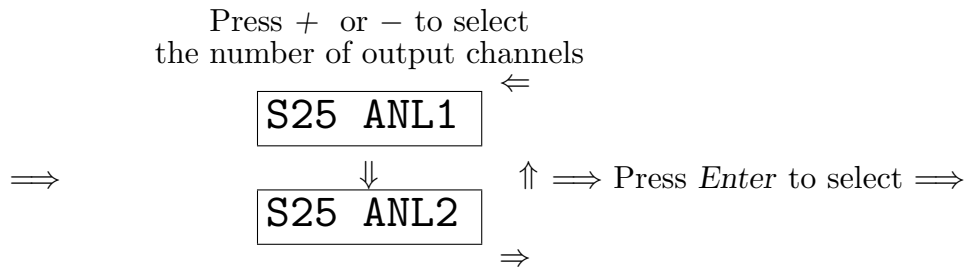
⇒ S23 0 ⇒ Press *Enter* to select ⇒

HDI input channels selection

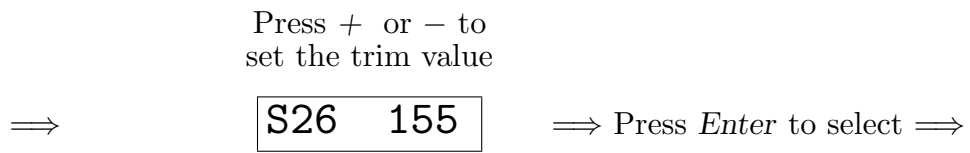
Press + or - to select
the number of input channels

⇒ S24 INP1 ←
S24 INP2 ↑ ⇒ Press *Enter* to select
 ⇒

HDI analogue outputs selection



HDI calibration value - see Appendix 3



After the *Enter* button has been pressed, the HDI will have finished all the calibrations, and stored them in EEPROM. It will then revert to normal operation with the parameters such as mode, display channel as previously set, but with the new probe parameters as just set in this menu.

General system diagnostics: *Enter* button.

Access to system diagnostics can be obtained as a double check of the functions of the HDI. Under normal conditions there would be no need to access these at all.

When powered up under these conditions, the display will show

S01

When the *Enter* button is released, the display will show, for example

S02	0
-----	---

Successive presses of the *Enter* button brings up other, reserved diagnostic functions of the HDI. Power down to leave this menu.

Summary of the characters displayed on the front panel.

A typical display:

A# 235m \bar{x}

Position	Character	Meaning
1	A	Probe A being displayed.
	B	Probe B being displayed.
	A †	Probe A displayed: Alarm active†.
	B †	Probe B displayed: Alarm active†.
2	*	Fast mode, between readings
	•	Fast, slow or continuous mode, reading being taken
	•	Slow mode, between readings
	:	Slow mode, reading only when <i>Enter</i> is pressed
	#	Dual probe operation, background reading
3, 4, 5, 6	—	The four numerical digits of the reading (leading zeros suppressed)
7	m	First character of units
8	m	Second character of units (no active relay)
	m̄	Units character indicating an active relay†*
	x	Relay X active†*
	y	Relay Y active†*
	x̄	Both relays X and Y active†*
		* m̄ alternates with x , y or x̄

Table 5.2 Description of characters on the HDI († HDIc only) display. Each position has a particular type of function assigned to it. This table excludes error messages.

External Inhibit function

There are cases where the currents flowing in the level gauge probe cause electrical or magnetic signals that disturb the detection system of an experiment, for example in SQUID based systems. The external inhibit function is designed so that suspension of depth measurements can be controlled automatically by other electronics, or from a computer output. In this way the system controller can ensure that the level gauge will not take a reading while data are being collected.

The inhibit signal is a current of between 3 and 15 mA passing through the inhibit signal inputs, the bottom two single pole sockets on the four way connector on the back panel connector, in either direction. This allows for the signal to be generated by a current loop control system or by an external voltage of between 5 – 20 V. This input is optically isolated.

This signal will inhibit the HDI from making any readings only when it is in the slow mode of operation. It is masked, that is registered but ignored, when the HDI is in the fast or continuous modes of operation. When in the slow mode, the inhibit state is indicated on the front panel display. The dot in the second character position, indicating slow mode, is replaced by an **I** character. The last reading will also be shown on the display. Thus in an uninhibited state, the display would show

A• 235mm

and with the inhibit signal active the display shows

AI 235mm

When the inhibit signal is dropped, the instrument will immediately take a reading of the depth, and then continue with the timings set for the slow mode of operation. In this way, the inhibit signal not only controls the suspension of the reading operation, but also can be used to take readings only when required – for example by computer, controlling the inhibit signal and reading the analogue output.

When the HDI is in the inhibit state, the front panel buttons are still active. It is therefore possible to use the *Mode* button to change the mode, to Fast or Standby. Upon selection of either of these modes, the inhibit signal will be masked; in the fast mode the inhibit signal is ignored, and in the Standby mode the system will not make

any measurements, even if the inhibit signal is dropped. It is also possible to change the displayed and active probe with the *Probe* button. Upon selection of the other probe, or automatic, the HDI will make a reading of the new probe, and then return to the inhibited state, displaying the new probe's depth reading.

The *Read* button on the front panel also overrides the inhibit state; it will allow for one reading to be taken immediately, and then return to the inhibited state, displaying the new helium depth value.

Analogue signal output

The HDI is factory fitted with one of three analogue outputs: either 4 – 20 mA (the –A option); an analogue voltage proportional to the depth of cryogen, defined in millivolts of output per millimeter of depth (–V option); or an analogue voltage spanning 0 - 10 V (–T option). The option is decided at the time of ordering and is factory fitted. The default is the –A option.

In all cases, the signal for the analogue output is available from the top two single pole sockets of the four way connector on the back panel, labelled *+ ANL -*. In these cases, the signal corresponds to the displayed probe channel.

4 – 20 mA (–A) option

The –A option provides a 4 – 20 mA analogue output. The output is 4 mA when the displayed probe reads a depth of 0 mm, and 20 mA when the probe reads its maximum value, with the factory settings in the appropriate calibration menu; this can be adjusted as required.

Analogue voltage output (–V) option

The –V option provides an analogue voltage output, defined by a mV/mm scaling factor. The output is 0 V when the displayed probe reads a depth of 0 mm, and gives a maximum reading of the active length of the probe multiplied by the scaling factor. The maximum possible output is approximately 4.1 V. The scaling factor can be adjusted in the appropriate calibration menu from the front panel, with a factory default of just under 2 mV/mm.

0 - 10 V Analogue output (–T) option

The –T option provides a 0 - 10 V analogue output. The output is 0 V when the displayed probe reads a depth of 0 mm, and 10 V when the probe reads its maximum value, with the factory settings in the appropriate calibration menu; this can be adjusted as required.

Analogue output under the various operating situations

The analogue output will track the reading on the display. In Slow, Fast or Continuous modes, the value of the output will correspond to the number on the display, which shows the last reading taken by the HDI. However, in the Standby mode, the analogue output will be set to minimum, that is 4 mA (–A) or 0 V (–V or –T).

Should the HIGH state arise, then the analogue output will again be set to minimum, that is 4 mA (–A) or 0 V (–V or –T).

Potentiometer controls

The four preset potentiometers that are accessible from the back panel are to allow trimming of certain signals of the instrument. The potentiometers, labelled *P Q R S*, are all multi-turn operation components.

Potentiometer *P*

Potentiometer *P* controls the display contrast. Minimum contrast is when the adjustment is fully anticlockwise.

The contrast of the display is temperature compensated, to avoid the need for frequent re-adjustment; all LCD displays show a temperature dependence of their contrast. The range of adjustment is such that when the potentiometer is fully anticlockwise, then no characters will be visible.

To adjust the display contrast, turn the control fully clockwise; this will allow the character outlines to be seen, but the angle of view will be limited. Backing off the contrast control will increase the viewing angle until a point is reached where the contrast starts to fall. The correct adjustment is just before this point.

Potentiometer *Q*

Potentiometer *Q* is a calibration factor to cope principally with probes with different types of superconducting elements. As received, this has been factory set to operate with all the probes manufactured by Twickenham. It does not need to be adjusted in any way when used with these probes for normal operation. For settings for other manufacturers, or for continuous use at other measure currents, see the appendices at the back of the manual.

Potentiometer *R*

Potentiometer *R* is used to trim the offset value of the analogue output, that is to zero for the $-V$ and $-T$ options and to 4 mA for the $-A$ option. Although factory set, it can be trimmed if necessary.

In order to ensure the HDI will give a zero reading, connect up a probe when it is at room temperature; thus it will show a zero reading. Connect a voltmeter ($-V$, $-T$) or milliammeter ($-A$) to the $+$ and $-$ outputs of the Analogue output connector, and turn on the HDI. Adjust this potentiometer for the correct reading, as appropriate for the $-V$ and $-T$ (0 V) or $-A$ (4 mA) option.

Potentiometer S

Potentiometer S is used to adjust the gain of the analogue output, so that it will read the maximum of 4.1 V for the $-V$ option, 10 V for the $-T$ option or 20 mA for the $-A$ option. Although factory set, it can be trimmed if necessary. When the unit is running, ensure that the HDI reading for the display channel is maximum, that is equal to the active length set for that channel, and that the entered scaling factor is such as to give a maximum output at maximum reading (see section 5); then adjust this potentiometer for the correct reading, as appropriate for the $-V$, $-T$ or $-A$ option.

Fault Finding

If a fault is suspected, it is necessary to establish whether it is in the controller, the probe or the interconnecting cable; it should be borne in mind that the latter two items are susceptible to mechanical damage. The following is a short guide to location of the fault; please contact Twickenham for advice and help.

A. The probe.

Helium probes will not function if the ventilation holes are blocked with solid air or ice. If this is suspected, then the probe should be removed from the dewar and allowed to warm up to room temperature and dry out before replacing.

The superconducting element (measured across the voltage terminals) of the probe has a resistance of approximately $0.170 \Omega\text{mm}^{-1}$ of active length at nitrogen temperature, and $0.167 \Omega\text{mm}^{-1}$ when at about 10 K. When the probe resistance is measured in air at room temperature its resistance corresponds to the full active length of the probe; for example 550 mm of active length gives approximately 100Ω

The test sheet supplied with each probe give the resistances between all possible pairs of wires. Resistances should be measured and compared with this data sheet. There will be small variations due to differences in room temperature.

It is most important that there are no shorts between the active probe connections and the probe outer case; this should be checked with a test voltage of 30 V in series with a $47 \text{ k}\Omega$ resistor, to ensure that no current is flowing.

Nitrogen probes can be checked with the procedure on the applications note.

B. Interconnecting cable

It is straightforward to test the cable; it is wired up with A - A, B - B etc. Check that all the connections A through to F are connected; H, the centre pin connected to the screen of the cable to act as a earthed shield.

C. The controller.

If the controller itself is suspected of making erroneous results, it is possible to check this. Short together pins A and B, and pins D and F and wire these pairs to a 100Ω 1W resistor. Ensure the instrument is set to read the B channel. The instrument should read 501 mm when set up for an active length of 1100 mm, and calibrated for a Twickenham probe.

Operation of the HDIc; the control functions

The HDIc can be distinguished from the HDI externally by the extra 9 way male D type connector (DB9M) fitted to the back panel. Also, on power on, the initial firmware message shown by the display is

HDIcV4.4

This section describes the extra features of the HDIc, how they operate and how the control parameters are entered into the unit.

Physical description

Apart from the DB9M connector on the back panel, there are no other external distinguishing features between the HDI and the HDIc. The wiring of the nine way connector is shown in table 10.1.

Pin number	Function
1	Relay X Normally closed contact
2	Relay X Common contact
3	Relay Y Normally open contact
4	Nominal 24 V line via 100 Ω 2.5 W resistor
5	0 V line
6	Relay X Normally open contact
7	Relay Y Normally closed contact
8	Relay Y Common contact
9	Open collector output – Alarm output

Table 10.1 Description of the pin assignments of the DB9M connector for the HDIc.

Additional functions of the HDIc

The additional functions of the HDI with the control option (HDIc) are the control and alarm signals that are driven by the current status of the cryogen level(s) being monitored compared to set points that have been entered. These signals can then be used to operate, for example, automatic filling systems. Each of the two relays, and the alarm, can be assigned to either channel; and each of these control functions have two set points, resulting in six in all: **Rx0** (Relay x off), **Rx1** (Relay x on), **Ry0**, **Ry1**, **A0** (alarm off) and **A1** (alarm on). In the following, reference to **Rv** refers to either **Rx** or **Ry**.

During the experiment, when the liquid level falls below a **Rv1** or **A1** set point, the relay(s) or alarm outputs are turned on. The HDIc continues to monitor the level and will assume that the level will be rising (for example in an automatic filling system), so that when it reaches the **Rv0** or **A0** set point, it will turn off the relay or alarm.

Two set points are allowed for each signal so as to allow hysteresis. This is needed for automatic filling systems (the low level and the high level), but also for the alarm signal where it may be needed in systems where the cryogen level is genuinely fluctuating slightly, whereas with a single set point there would tend to be oscillation of the control or alarm signal as the mean level moved through this set point. However, do note the special case of when the two set points are set equal to each other, which is discussed later.

The **Rv1** and **Rv0** signals are provided by the closing (switching ON, or 1) and opening (switching OFF, or 0) of the normally open relay contacts within the HDIc. Each relay is rated at 24 V 0.5 A ac/dc, providing an on-off control signal. The Alarm signal is provided by an open collector output.

Status reports of operation of the HDIc

Whenever the HDIc is operating one of the control or alarm signals, there is a visual indication on the display.

Whenever a control relay is active, its 'on' status is indicated on the display, no matter whether the relay that is active is assigned to the displayed channel or not. When the v relay is active, the last character of the units alternates between the usual character barred (\bar{m}) and the relay identifier v; should both relays be active, a complex y over x character is alternated with the barred character.

For example, with Probe A as the display probe, and a **Rx1** set point of, say, 240 mm (Rx assigned to channel A), when the level falls below that level, the relay will close. The display then alternate between

A 239mx

and

A 239m̄

This signal could be being used, for example, by an automatic filling system.

When the liquid level rises above the **Rx0** set point (say 1350mm), the relay will then open, and stop the transfer. The alternating barred and identifier character will then stop, and the display will then return to the normal state

A 1351mm

If, during operation, the level drops below **A1** set point (say 200 mm), the Alarm signal is given out. The Alarm status is also shown on the display by the changing of the probe identifying character from Black on White to the inverse

▣ 200mx

The alarm signal will switch off when the cryogen level rises above the **A0** set point. In dual probe operation, and in the event of the alarm being allocated to the non-display (background) channel, the probe identifying character will still change to this inverse point. Therefore it may be that the inverse **A** character is showing, but it is indicating that the level of channel B has dropped below the **A1** set point.

When operating in the Slow mode, and one or both of the control signals are raised, for example because of the falling level, the HDI will automatically switch to the Fast mode for the duration of the control status being on. This is primarily for the auto-filling situations when the HDI is normally operated in the Slow mode (where the minimum time between readings is 256 seconds); the switch to the fast mode prevents the possibility of the cryogen level rising above the maximum level - or overspilling - between two successive readings.

Dual probe operation

If the HDIc has the -2 or -L option and is suitably configured **S24 INP2**, it can be set up to operate the internal relays or alarm to operate according to the cryogen level for either or both probes.

The two probes are referred to here as the ‘background’ probe and the ‘foreground’ probe. They are only distinguished in that the reading of the level of the foreground probe is shown on the display, whereas the reading of the background probe is not. Of course, it is possible to change channels so that the second probe becomes the foreground.

One purpose of this dual mode of operation with the HDIc is for situations where the HDIc can monitor one helium (or nitrogen) level, and set any alarm and/or control signal assigned to that channel as the level varies as a background task, perhaps because it is not the measurement of interest for the operation; whereas the measure that is of interest can be shown on the display, and will also set any alarm and/or control signal assigned to that channel.

Two examples are presented to illustrate the use of the dual probe operation with the HDIc.

Firstly, the background task may be set to be the automatic filling of the nitrogen tank of a cryostat, an important but not very interesting task, whereas the foreground task, the helium level in the same cryostat, being of rather more interest, is the level shown on the display.

Secondly, the background task may be set to monitor the helium level in a transfer dewar, with the alarm set in case there is a danger of emptying this dewar; the foreground task is the helium level in the cryostat receiving the helium during the transfer.

All of the discussion of the configuration of the set point values and channel allocations can be applied to the HDIc whether or not it has the two channel input facility or not; but if the HDIc is a single channel unit, assigning alarm or relays to the other channel may give unexpected results, in that that alarm or relay may be active when the user had not intended it.

The Control and Alarm Set Points menu operation

All the set points are entered via the front panel controls with menus offered by the display.

In the set point menus, the functions of the + and – buttons are the same as that for the settings of the standard HDI unit, as described in section 5.

When the set point menu is selected, it is necessary to go right through the sequence of operations; however, if a particular set point does not need to be changed, then pressing *Enter* will take the sequence to the next stage immediately. All other comments concerning the operation of the menus as discussed in section 5 also apply for these menus.

The Alarm or Relay signal will become active if the cryogen level falls through the value assigned to the **A1** or **Rv1** parameter respectively. Similarly, the Alarm or Relay signal will become inactive (stop) if the cryogen level rises through the value assigned to the **A0** or **Rv0** parameter respectively.

There is one important case to consider with respect to the way the control parameters have been entered. The control signal will be active if the cryogen level is between the **Rv0** and **Rv1** set points, having fallen through the **Rv1** set point. However, if the HDIc is switched on, and the reading for that channel is between the two set points, it will default to the *OFF* state.

Entering the set points

The cryogen level set point menus are accessed by pressing *Enter*, and while holding it in, pressing *Probe*.

Alarm on set point (Channel allocation performed under the *Enter /Mode* menu)

Press + or – to
adjust the ON set point

Hold in *Enter*;
press *Probe* ⇒

A1	200
-----------	-----

 ⇒ Press *Enter* to select ⇒

Alarm off set point

Press + or – to
adjust the OFF set point

⇒

A0	275
-----------	-----

 ⇒ Press *Enter* to select ⇒

Relay X on set point (*Channel allocation performed under the Enter /Mode menu*)

Press + or - to
adjust the ON set point

⇒

Rx1	300
-----	-----

 ⇒ Press *Enter* to select ⇒

Relay X off set point

Press + or - to
adjust the OFF set point

⇒

Rx0	600
-----	-----

 ⇒ Press *Enter* to select ⇒

Relay Y on set point (*Channel allocation performed under the Enter /Mode menu*)

Press + or - to
adjust the ON set point

⇒

Ry1	300
-----	-----

 ⇒ Press *Enter* to select ⇒

Relay Y off set point

Press + or - to
adjust the OFF set point

⇒

Ry0	600
-----	-----

 ⇒ Press *Enter* to select ⇒

After the *Enter* button has been pressed, all the set points will have been entered into the HDIc, and stored in EEPROM. The HDIc will then revert to normal operation with these parameters in operation.

Special considerations for set points

As there are no particular limits in how the set points are entered into the HDIc, there are a number of possibilities that may arise. These can be used to advantage for special circumstances.

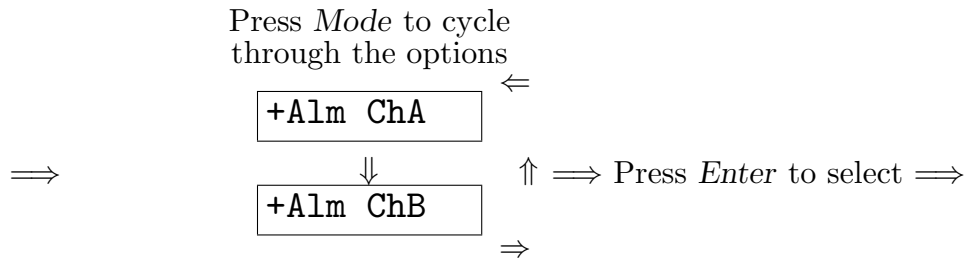
In the case where the **Rv0** set point is set *lower* than the **Rv1** set point [or **A0** lower than **A1**], then the relay signal [alarm output] will operate in the opposite sense to that described in the previous section. That is the output will normally be on except when the off setpoint is triggered (by a falling cryogen level) and the signal will remain off until the on set point is triggered.

There are two special cases that can occur with the set points, either for the **Rv1 Rv0** or the **A1 A0** points, when the **+Rv AUT** or **+Alm AUT** (the automatic modes of operation) are selected in the control mode menus, as described below.

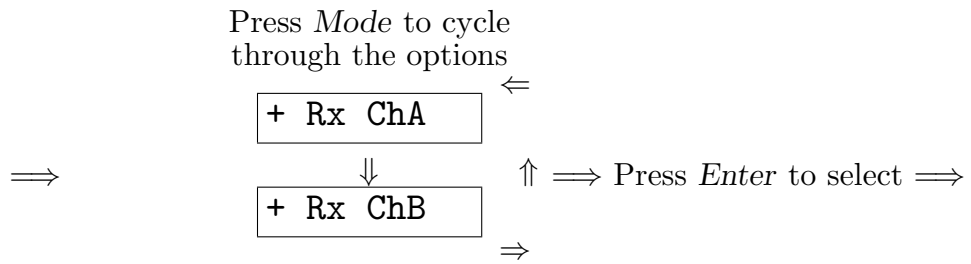
The first case is when the **Rv1** and **Rv0**, [or **A1** and **A0**] are set equal to each other, and not equal to zero. In this case, the relay v output [alarm output] will default to *ON* all the time. If the two set points are equal to each other and zero, then the relay v output [alarm output] will default to *OFF* all the time.

It should be stressed that control or alarm states generated by these two special cases are overridden by the settings in the control mode menus, that is selecting them to be *OFF* or, in the case of the relays only, *ON* will override the status generated by these special values of the set points. Note that the alarm cannot be forced into the *ON* state.

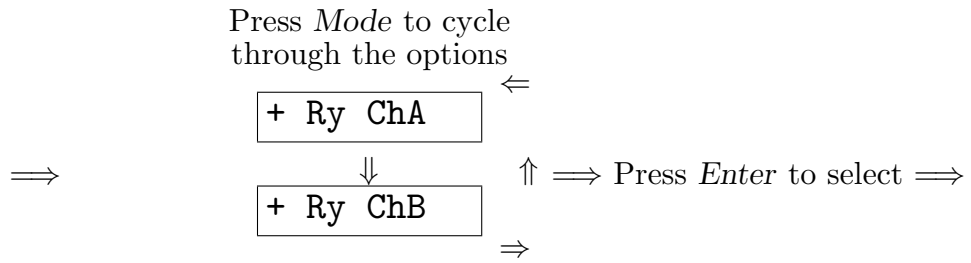
Assignment of Alarm to a channel



Assignment of Relay x to a channel



Assignment of Relay y to a channel



After the *Enter* button has been pressed, all the channel assignments for the relays will have been entered into the HDIc, and stored in EEPROM. The HDIc will then revert to normal operation with these parameters in operation.

Remote operation of the HDI via the serial interface.

Concept

The serial interface concept is one of ‘Speak only when asked’ and brief mnemonics as commands. Commands and responses are restricted to printable ASCII characters. Where a response is sent from the instrument then strings are kept to defined lengths to simplify the control software. The interface is fixed at 9600 baud, No parity, 8 data bits. It is implemented as a three wire link using XON XOFF flow control.

The interface will interpret commands which are equivalent to operating the front panel buttons. In addition there are commands that will cause the instrument to send status reports over the interface. Strings returned after these commands are made up of the read back of a number of alpha commands followed by the numeral they are currently set to; this is to aid readability and the strings are terminated by <CR><LF> (0Ah, 0Dh).

There are a number of points to be aware of in the operation of the interface.

1. Leading zeros are optional on received data but are always included on responses.
2. If a command that requires a numeric argument is transmitted without an argument then it is assumed to be zero.
3. Commands which change any of the HDI internal parameters will trigger a reading and display update. These are indicated in the following tables.
4. Concatenation of commands will be ignored; only the first will be acted upon.

The Halt command – available only through the interface

The Halt command is available to stop the HDI from making any further measurements. It is operated through the interface, but is not cancelled should the interface link fail for whatever reason. Should this occur, the HDI has to be switched off and then on again, to cancel the operation of the Halt command.

In terms of effect, the Halt command is similar to the External Inhibit mode, but it is more general in operation; it will operate in all the modes of operation of the HDI, including Standby.

When in an active measurement mode, the Halted state is indicated on the front panel display. The second character position is replaced by an **H** character. The last

reading will also be shown on the display. Thus in an unhalted state, the display would typically show

Ac 235mm

and when the Halt command is sent the display shows

AH 235mm

When the Halt signal is cancelled, the instrument will immediately take a reading of the depth, and then continue with the timings and currents set for the appropriate mode of operation.

The Halt command is *not* a front panel control 'lock-out'; it is still possible to change the mode of operation, or the display channel; however, once selected, the HDI will not make a new reading, and the display will show (for example)

BH-----mm

Commands with arguments

Commands with arguments are mostly those that change an internal parameter, and would normally be used in an initial set-up of the HDI when connected to the computer. A command consists of one or two alpha characters, followed by a number of numeral characters. The alpha characters define the command, and the numeral characters define the argument. There are two types of argument, which depend upon the structure of the command:

- i Simple commands, such as those that operate in the same way as the front panel controls, take a single numeral character argument. The single numeral value then represents which mode or channel is being selected. For example, the command **M1** selects the slow mode of operation.
- ii Parameter commands, which are usually set on initial set-up, take a multiple numeral character argument. The number thus formed is the same as that which

would be entered in any of the set-up menus selected via the front panel controls. For example, the command **JA1500** sets the active length of channel A to 1500 mm

Commands without arguments

Commands without arguments are mostly those to generate a response from the HDI; the Trigger command (**T**) is an exception. A single such command will generate a string which contains the current values of a number of internal parameters, prefixed by the command code which is used to set that parameter, for ease of identification. For example, the command **E** returns the scaling factors for the analogue output for the two channels. The returned string consists, in this case, of two parameters, and the value of each parameter is prefixed by the command code which is also used to set this parameter. Thus the returned string is **DAnnnnDBnnnn** where n is a numeric character, and the string nnnn makes up the value of the parameter. The prefix **DA** is also the command to set the channel A scaling factor, and likewise for channel B. Thus if the string is **DA0550DB1100**, the scaling factor for channel A is 550 and for channel B is 1100.

The command **G** returns an eight character string **abcdefgh**, which is equivalent to much of the information on the display. If a reading is being made when the command is issued, then the returned string shows the previous reading. The main difference between the string and the display is with the second character.

The first character **a** is the channel identifier, **A** or **B**

The second character **b** either is a star, indicating that a reading is in progress, or else blank, no matter what other character is showing on the display.

If the third character, **c**, is **-**, then the display is showing a message, in which case the characters **defgh** are either **OPEN**, **HIGH**, or **STBY**, although this last message is given differently on the front panel display.

Otherwise the third character **c** is the first character of the four characters **cdef** corresponding to the reading of the depth of the cryogen; leading zeros are not suppressed in this case.

Characters **gh** correspond to the display units, typically **mm**.

Note that the Inhibit status character, **I**, Halt status character **H**, slow mode character **•** or **:** and the continuous mode character **C**, all of which appear at the second

character place on the display are *not* returned with the **G** command, and the additional information is returned using the Status command **S**.

If the HDI is in a set up menu when the remote interface is interrogated, then the **G** command will return four dashes ----

The Status command **S**, returns a different string, **MqPrHsItRXuRYvAwOnnnLnnn**. The characters **q r s t u v w** are single numeral arguments to the simple commands they are prefixed by. However, note the following items

- i **I**, which is *not* a command; it is included so as to indicate the status of the hardware External Inhibit.
- ii **P** as a command is used to select the channel or to select the automatic channel selection, but when read back, there is an extra argument which is identified by the following table. Note that if there is no probe connected, and automatic detection is selected, the currently selected channel is read back; it will then change at the next attempted reading.

Argument	Command function	Status function
0	Channel A	Channel A
1	Channel B	Channel B
2	Automatic	Automatic, selected channel A
3	Automatic	Automatic, selected channel B
4*	Dual, Channel A	Dual, Channel A
5*	Dual, Channel B	Dual, Channel B

Table R.1. The actions of the arguments to the **P** (Probe) parameters for the HDI when issued as a command or when read as part of the status string.

* These parameters are only accessible for HDI units with either the -2 or -L options, and menu S24 INP2.

- iii **R** defines the Relay status for the HDIc, and **A** defines the alarm status for the HDIc. However, the return argument is slightly different to the command argument, as the following table shows:

Argument	Command function	Status function
0	Off	Off
1*	On	On
2	Automatic	Automatic and off
3	Automatic	Automatic and on

Table R.2. The actions of the arguments to the **Rv** (Relay) and **A** (Alarm) parameters for the HDIc when issued as a command or when read as part of the status string. The commands have no effect on an HDI, and when read in the status string, the argument will be 0.

* Not applicable with the **A** command.

- iv The last two commands read back are complex commands, where **nnn** are the numerals which make up the value of the parameter for that command.

Allocation of relay and alarm output to operating channels - HDIc

Each of the two relay outputs and the alarm output can be allocated to either channel quite independently, and can be done via the *Enter Mode* menu system, as described in section 10, or through the interface.

The alarm allocation command, **K**, has one of two arguments, determining which channel it is allocated to. The same Mnemonic and argument is used to identify this setting when the value is read back using the **B** command (details below).

Argument	Allocated channel
0	A
1	B

Table R.3. The arguments for, and the allocation of channels for the alarm by the **K** command.

The relay allocation command, **Q**, can have one of four arguments, reflecting the fact that each relay can be allocated either channel independently. The same Mnemonic and argument is used to identify these settings when the value is read back using the **C** command (details below).

Argument	Relay x	Relay y
0	A	A
1	B	A
2	A	B
3	B	B

Table R.4. The arguments for, and the allocation of channels for the two relays x and y by the **Q** command.

Operating the HDI from a computer.

Any terminal emulation program for a PC, the Microsoft Windows terminal or any other serial port operation will run the HDI. It is expected that users will write programs to control the HDI as one element of a complete system, and the terse command and response set was developed with this in mind.

Command List*Commands that generate no response from the HDI*

Mnemonic	Action
DAnnnn	Sets the scaling factor for channel A to nnnn. $0 < \text{nnnn} < 2000$.
DBnnnn	Sets the scaling factor for channel B to nnnn. $0 < \text{nnnn} < 2000$.
Hn	Halt command: 0 = disabled, 1 = enabled
JAnnnn	Sets the active length for channel A to nnnn. $0 < \text{nnnn} < 2000$.
JBnnnn	Sets the active length for channel B to nnnn. $0 < \text{nnnn} < 2000$.
Lnnn	Sets the time interval in the slow mode to nnn.
Mn	Sets the mode of operation: 0 = Standby, 1 = Slow, 2 = Fast, 3 = Continuous.
Onnn	Sets a special option: see table 5.1
Pn	Sets the displayed probe: See table R.1.
T	Trigger a reading. (Note not read back).
Ynnn	Sets the measure current to nnn. $0 < \text{nnn} < 255$.
Znnn	Sets the boost current to nnn. $0 < \text{nnn} < 255$.

Table R.5. The remote interface commands than do not generate a response from the HDI.

Control and Alarm (HDIC) commands that generate no response – in addition to table R.5

Mnemonic	Action
An	Alarm control: See table R.2.
Kn	Allocation of alarm to channel: See table R.3.
Qn	Allocation of relays to channels: See table R.4
Rn	Relay control: See table R.2
Unnnn	Sets the Alarm on point to nnnn. $0 < nnnn < 2000$.
Vnnnn	Sets the Alarm off point to nnnn. $0 < nnnn < 2000$.
WXnnnn	Sets the Relay x on point to nnnn. $0 < nnnn < 2000$.
XXnnnn	Sets the Relay x off point to nnnn. $0 < nnnn < 2000$.
WYnnnn	Sets the Relay y on point to nnnn. $0 < nnnn < 2000$.
XYnnnn	Sets the Relay off point to nnnn. $0 < nnnn < 2000$.

Table R.6. The remote interface commands than do not generate a response from the HDIC.

Commands that generate a response from the HDI.

Mnemonic	Response
E	Returns the scaling factors for both channels as DAnnnnDBnnnn .
G	Returns the current reading as abcdefgh – see text.
N	Returns the probe active lengths and current settings as JAnnnnJBnnnnYnnnZnnn .
S	Status: Returns the string MqPrHsItRXuRYvAwOnnnLnnn – see text.

Table R.7. The remote interface commands than generate a response from the HDI. The n characters are single digits, and their combination is used in the same way as in the commands that the prefixed character code interprets them.

Control and Alarm (HDIc) commands that generate a response – in addition to table R.7

Mnemonic	Response
B	Returns alarm set points as UnnnnVnnnnKn .
C	Returns relay set points and channel as WXnnnnXXnnnnWYnnnnXYnnnnQn .
F	Returns background probe reading (dual probe operation) Returns ----- in single probe operation

Table R.8. The remote interface commands than generate a response from the HDIc.

Standard Product Warranty

All products manufactured by Twickenham Scientific Instruments Ltd. ('the company') are warranted to be free from defects in materials and workmanship for a period of one year after the date of despatch. At no expense to the purchaser, the company will repair or replace (at our option) any parts which in the sole opinion of the company prove to be defective within the scope of this guarantee. Transportation costs of goods returned to the company for repairs will be prepaid by the purchaser. Goods must not be returned without prior consultation with the company to decide whether an on-site inspection and possible repair should be made. If the defect is determined to be as a result of misuse, improper repair, unauthorised user modification of abnormal operation conditions, then the repairs will be invoiced at cost.

This warranty does not apply to equipment not manufactured by the company, for which the relevant manufacturer's warranty is passed on whenever possible.

Improvements and Alterations

This section highlights any improvement or change to the product which may affect the installation or operation such that there is a real or perceived difference. Users who have used the HDI in the past are asked to read this section to see if how, if at all, these alterations would affect them. Users who are to use the HDI for the first time will not need to read the rest of this section.

Mostly the differences noted here will be physical changes which affect all units, or all units fitted with a particular option. While details may be highlighted here, please refer to the main body of the manual for full details as appropriate. This is not a list of currently available options, variants or minor firmware changes.

HDI serial number HD1290 onwards

Mains voltage selector

The mains voltage selector used for units up to this point is no longer fitted. A substitute mains voltage selector is used, and for most units is fitted such that the unit has to be opened to adjust the mains voltage setting. However, for most applications, it is not anticipated that this is likely to occur. For a few units where it was requested or anticipated that this change might be a regular occurrence, a mains voltage selector of another alternative pattern was used, such that back panel access was still available.

For all units where the mains voltage selector is only accessible by opening the unit, a suitable black legend on yellow label is placed on the back panel indicating the voltage setting of the selector. If this is ever changed, this label should be removed, and the appropriate one substituted.

HDI serial number HD1320 onwards

The changes here do not affect the plug compatibility of the HDI between units.

Mains inlet module

A combined mains inlet with a double pole double throw switch, mains voltage selector and double fuse holder has been incorporated into the back panel of the HDI. A small window in the inlet allows the mains voltage selector setting to be viewed. The correct fuse rating is shown on the accompanying legend. The use of this inlet means that the style of the mains power switch has also changed.

Analogue output and External Inhibit

The 4 way Molex connector used for the Analogue output and External inhibit functions has been moved and rotated by 180°. However, the function allocation to each pin has been unchanged. The result of this is that the Analogue output is now the top two pins, and the External Inhibit is the bottom two pins; the legend around this connector has been altered accordingly.

Any customer who replaces a previous HDI unit with one with a serial number greater than HD1320 will find that the connector has to be rotated, but otherwise it will be fully compatible with previous units.

*HDI serial number HD1346 onwards**Version 4.0 Firmware*

Version 4.0 firmware has significant changes in the operation of the set-up menus, in order to allow easier configuration for options. This also can affect the operation of the *Probe* button. Full details are given in section 5, which has been re-written for this purpose.

Any unit with version 2.0 or higher firmware can be upgraded to version 4.0.

*HDI serial number HD1350 onwards**0 - 10 V analogue output (-T) option*

A third no-cost, factory fitted analogue output option has become available, alongside the HDI-A and HDI-V. The HDI-T has a 0 - 10 V analogue output, and should be specified on ordering.

Recalibration of the HDI.

The two principal reasons for the HDI to be in need of recalibration are firstly if it is to be used with a probe from a different manufacturer, or secondly if the measure current is to be reset to a new value - for example when it is used to measure a helium level in an evacuated chamber. In either case, the procedure is the same.

The only piece of equipment that is required is a $100\ \Omega$, 0.5 %, 1 W, 50 ppm resistor, wired up to operate for channel A or B, as indicated in the main text.

The value of the normal state resistance of the superconducting element at just above the superconducting transition temperature will be needed in order to follow this procedure. For all current probes manufactured by Twickenham, this value is $0.167\ \Omega/\text{mm}$.

When the HDI is to be used with probes from different manufacturers, detailed specification of probes, both of its normal state resistance and the recommended operation current(s) must be obtained. If no boost current is required for the probe, then the boost current can be set either to the minimum value or to the value equal to the measure current as described in section 5 of this manual.

The HDI is able to change both the boost and measure currents via the front panel controls as discussed in section 5. Changing the boost current will have no effect; changing the measure current will not significantly alter the reading given on the HDI, but it may affect the resolution, with a possible change in the last digit of the displayed depth. If it is proposed to operate the HDI with a different value of the measure current for most of the time, we recommend that the HDI is recalibrated.

For operation with a Twickenham probe, the range of currents at which the HDI can be recalibrated is in the range $80 < i < 120\ \text{mA}$. If the measure current is within this range, then the HDI can be directly calibrated. If the measure current is outside the range, then the HDI should be calibrated at the relevant limit, and then the measure current set to the desired limit.

The procedure is as follows:

1. Calculate the equivalent length, ℓ that a resistance of $100\ \Omega$ is equivalent to; for a Twickenham probe, $\ell = 599\ \text{mm}$.
2. If the HDI is being recalibrated because of a change in the measurement current, set the required measurement current (or the nearest limit current) and the calibration menu. These are menus S21 and S24, as described in section 5.

3. With the *Probe* button depressed, switch on the HDI. Note the values of the active lengths (menus SOA and SOB). Set the active length of the required channel (A or B) to maximum (2000 mm), as described in section 5 of this manual. Press the *Enter* button successively until the HDI returns to the normal state of operation.
4. With the HDI in the normal state of operation, use the *Mode* button to select the continuous mode of operation. Use the *Probe* button to select whichever probe channel is being used for recalibration.
5. Connect the $100\ \Omega$ resistor to the *Probe* connector, to simulate a probe on the required channel (A or B). Details for the wiring of the probe connector are given in section 3. Note that recalibration for one channel will operate on *both* channels.
6. Adjust potentiometer *Q* so that the display reads a value equal to $2000 - \ell$; for a Twickenham probe, this value is 1401.
7. Switch off the HDI; holding the *Probe* button in, switch on again, and reset the active length of the probe channel that was used for calibration back to that of the probe that will be used on that channel.
8. If the calibration current is not the same as the required measure current, switch off, and then switch on holding in the *Mode* button, and adjust menu S21 to the required value.

The HDI is now recalibrated to operate the probe it has been calibrated to and for the measurement current that has been set up as discussed at the end of section 5.

Note that this procedure need not be repeated every time the measure current is adjusted.

Disclaimer.

**Operating the HDI, with probes from Twickenham or other manufacturers;
or operating probes with different Boost and Measure currents.**

The company will under no circumstances take any responsibility for damage to a helium level gauge probe, or for any consequential loss, either directly or indirectly, by the use of the Helium Depth Indicator with any probe. This includes any loss or damage incurred by the readings that were obtained from the unit.

Such circumstances can arise from time to time, and the user should be aware of them. *Some* possible cases are listed here.

1. The HDI is used to operate a probe made by another manufacturer, and the currents have not been set up to match the current ratings of that probe.
2. The HDI is set up to operate a probe made by Twickenham with currents in excess of those listed in the probe application note (supplied with every separate probe and following).
3. The HDI is operating a probe which is monitoring a pumped bath of liquid helium, and the currents have not be set to account for the differences in cooling for the superconducting wire in the vacuum as opposed to helium vapour.

If there is doubt, contact the probe manufacturer and ask for details about the electrical rating of the probe. If such information is not available, do ask the staff at Twickenham for advice before undertaking the measurements.

Declaration of conformity

Helium Depth Indicator (HDI), Helium probes.

The HDI, Helium probe and manufacturers interconnecting cable have been tested according to a test plan representing a typical installation, and found to conform to the following standards:

EN 50081–1, Radiated and conducted emissions and mains harmonics;

EN 50082–2, Irradiated susceptibility, ESD and transients;

If the HDI is to be built into a system, it is the responsibility of the system builder to ensure that the EMC performance of the HDI and probe is not compromised. Screened cable should be used wherever possible with the screen properly terminated. The users attention is drawn to the installation notes elsewhere in this manual.

The company is happy to advise on good installation practice.

Jeremy Stevens

January 1996

Signatory for Twickenham Scientific Instruments Ltd.