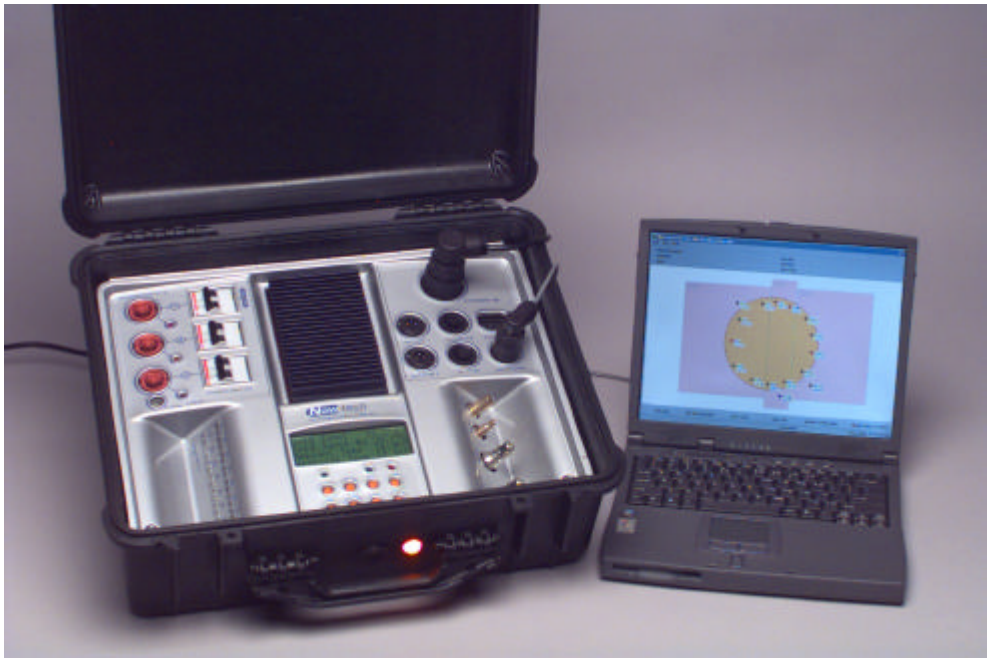
Novatech CONTROLS PTY. LTD.

HBC-4301
Hot Bonding Controller

Advanced Operators Manual, Calibration



January 2006

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Edition - November 2005
It describes the HBC-4301 control case software version 1.53, 2nd August 2005

The product described in this manual and products for use with it, are subject to continuous developments and improvement. All information of a technical nature and particulars of the product and its use (including the information in this manual) are given by Novatech Controls in good faith. However, it is acknowledged that there may be errors or omissions in this manual. A list of details of any amendments or revisions to this manual can be obtained upon request from Novatech Controls Technical Enquiries. Novatech Controls welcome comments and suggestions relating to the product and this manual.

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1. INTRODUCTION TO THE CALIBRATION PROCEDURE

- It is recommended by the manufacturer of the HBC-4301 hot bonding controller that the calibration procedure should be carried out every 12 months.
- The calibration must be done by personnel qualified to calibrate electronic instruments.
- The test equipment used to do the calibration must be calibrated by a certified laboratory and be within the calibration period.

The procedure described in this document includes the calibration and a check of the functions of the HBC-4301 control case.
The calibration of the HBC-4301 control case is set from the control case by using the keypad and the display.

1.1 Equipment required for the calibration

I. Ambient temperature sensor
RTD sensor class A.
Accuracy ± 0.15°C @ 0°C

II. Thermocouple mV generator
Thermocouple type K and J
Range 0 to 300°C
Accuracy 0.1°C

III. Digital multimeter
Resolution 0.01mV in the range 0 to 100mV
Resolution 0.1mV in the range 100 to 1000mV
Accuracy 0.05% ± 1 digit

IV. Vacuum measuring instrument
Resolution 0.1 kPa in the range -100 kPa to 0
Accuracy 0.5% ± 1 digit

V. Digital mW meter
Resolution 0.1 Ω

1.2 Hardware

The HBC-4301 measurement system uses multiple analogue to digital converters (ADC) to achieve a high level of accuracy and reliability.

- **ADC #1** measures the thermocouple inputs
- **ADC #2** measures the vacuum and pressure sensors and the cold junction temperature
- **ADC #3** is used to measure the backup cold junction temperature, the heatsink temperature and the case temperature.

The HBC-4301 has self-checking hardware built into the measuring circuitry. During normal operation, the ADC is checked against a stable reference voltage every 30 seconds. This arrangement allows for any drift in the analogue circuitry to be compensated for.

The calibration routine is broken down into six main sections.

- Checking the DC power supply voltages
- Setting the date / time
- Setting the reference voltages
- Calibrating the ambient temperature sensors
- Fine tuning the calibration of the thermocouples
- Calibrating the vacuum system

The calibration of the analogue inputs rely on the setting of reference voltage levels in the set up menu of the HBC-4301. This enables the micro controller to automatically compensate for drift in the electronic components between calibrations.

The calculation of the thermocouple temperature requires an accurate measurement of the temperature at the point where the thermocouple wire (or thermocouple compensating wire) is joined to copper wires. This is achieved in the HBC-4301 by using two solid-state temperature sensors mounted in thermal contact with the thermocouple input connectors.

An additional method of fine-tuning the temperature reading has also been incorporated into the software in the HBC-4301. This allows both the low temperature and high temperature end of the temperature scale to be adjusted.

The incoming compressed air supply and the vacuum level generated by vacuum pump #1 is measured with an internal sensor. These sensors and the external vacuum sensors are measured with a separate analogue to digital converter (ADC)

1.3 Software

The calibration of the HBC-4301 control case can be all done from the local keypad and display.

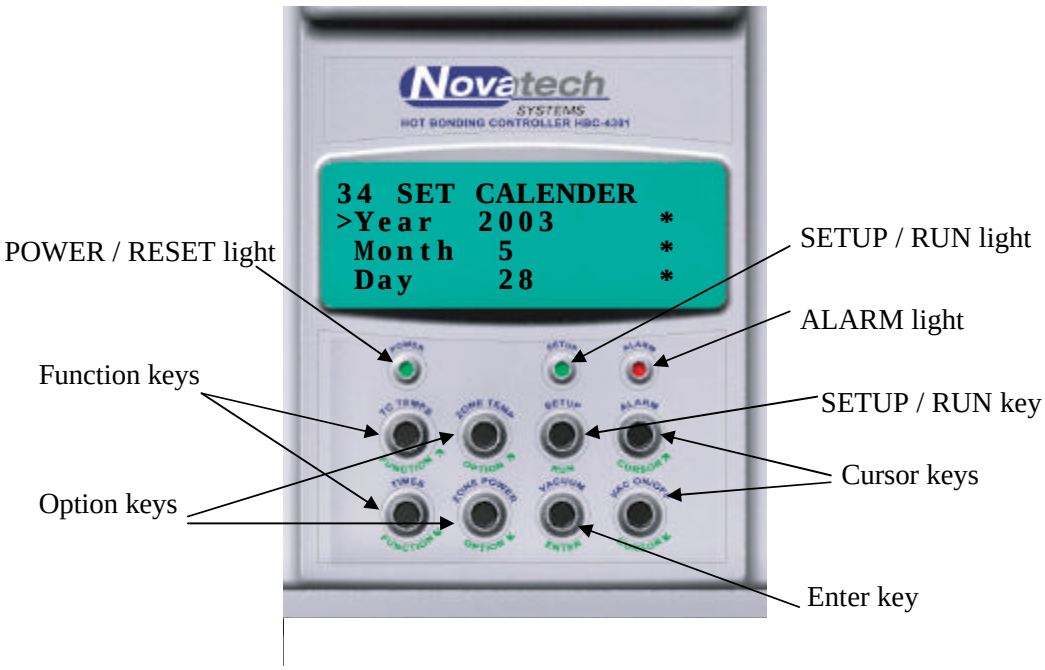


Fig. 1 HBC-4301 Control case keypad and display

The figure 1 shows the function of the keys when the controls case is in **SETUP** and the **Extended SETUP** modes.

The set up mode menu functions are listed in the HBC-4301 Operators Manual. The additional calibration functions that are used in this calibration operation are not normally available to the operator.

To gain access to the menu items used for the calibration –

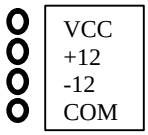
1. Press and hold the **SETUP** button before the power is turned on, and then turn on the power. Hold the button for 5 seconds after the control case was turned on and then release it
2. The message “Extended Setup Mode” will be displayed on the bottom line of the display. Wait for the initialisation procedure which takes about 20 seconds
3. Press the **SETUP** button
4. Press the **FUNCTION Up** button several times until the highest function number is seen on the top LH side of the display. If this is function # 48 (Cal External Vac 2), the HBC-4301 is in the extended set up mode. If the highest number is only function # 33 (local mode) or 31 (primary or secondary mode), turn the power off and repeat the process from step 1.

2. POWER SUPPLY CHECK & COLD START PROCEDURE

2.1 Power Supply

The DC power rails used by the electronics are derived from a switch mode power supply mounted in the base of the HBC-4301. There are labelled test points for all the DC voltages accessible under the metal cover plate on the HBC4300-1 PCB.

The test points are in the top right hand corner of the HBC4300-1 PCB, near the connector that connects the power supply to the Main PCB. The shield must be removed to gain access to these test points. They are labelled –



Check that the rails are within the following specifications by measuring from "COM" to the other three pins.

VCC +5v Digital circuits	+/- 0.1v
+12v Analogue circuits	+/- 0.3v
-12v Analogue circuits	+/- 0.3v

2.2 Cold Start Procedure

All the menu functions including the calibration constants are stored in a battery-backed memory module (BBRAM). The battery for this module is built into the module and cannot be changed. It has a specified life of 10 years.

The factory default menu items can be reset into the BBRAM by performing a COLD-START. This procedure is performed when the control case is first manufactured and it should not be necessary to perform it again unless there is concern that the BBRAM contents have been corrupted.

WARNING:
A cold-start will remove all the calibration settings and the menu options of the control case and set them all to factory defaults.
Do not do this unless there appears to be a serious problem with the control case.

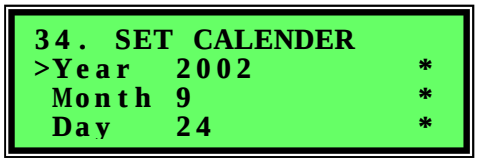
1. While the power is turned off, remove the 2 screws in the front corners of the control case
2. Lift the hinged control panel up from the front using the handle near the keypad
3. Remove the 3 screws and the cover over the PCB in the rear left of the base of the control case
4. Remove the black link called COLD START on the left of the small PCB
5. Turn the power on to the control case
6. Wait until the message “Replace C/S Link” is shown on the display
7. Replace the COLD START link
8. Close the control case control panel
9. **The HBC-4301 will now need calibrating.**

NOTE: The accuracy of the HBC-4301 ***without*** calibration is generally +/- 1.5°C at 20°C and +/- 3°C at 300°C.

3. DATE / TIME SETTINGS

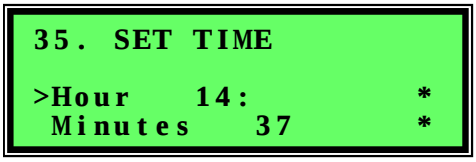
Enter the Extended Setup mode as described in section 1.3, Software.
The current date and time is set by using menu items #34 and #35.

3.1 Date



The **cursor** keys will move the cursor between year / month / day.
Option keys will change the value. The **enter** key will put the asterisk at the end of the line and save the date in the BBRAM / RTC.

3.2 Time



The **cursor** keys will move the cursor between hour / minute.
Option keys will change the value. The **enter** key will put the asterisk at the end of the line and save the time in the BBRAM / RTC.

4.1 Thermocouple voltage reference

```
36. REF VOLTAGES
>Ref TC 12.21 mV    *
 Ref #1 53.90 mV    *
 Ref #2 485.0 mV    *
```

Measure and record the thermocouple reference voltage at the test points with the multimeter.

The TC reference is measured on the thermocouple input PCB model HBC-4300-3. The PCB is mounted on the underside of the main control console in the HBC-4301 control case.

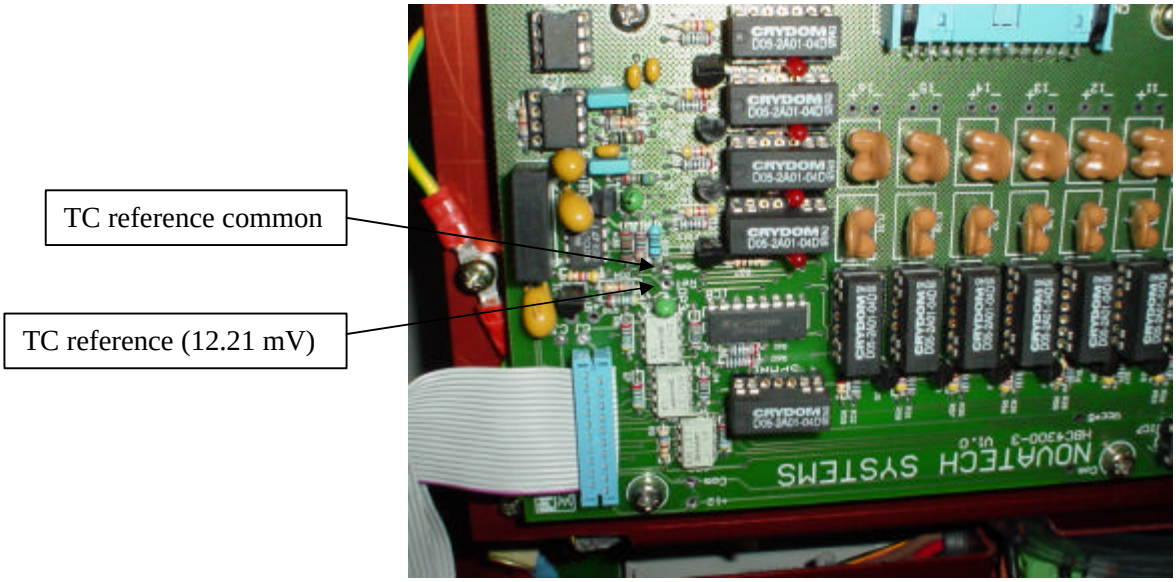


Fig. 2 HBC-4300-3 Thermocouple Input PCB as it is mounted in the Control Case

Set the number on the display to the voltage that was measured on the multimeter.

The **cursor** keys will move the cursor between the three reference voltage entry lines.
Option keys will change the value. The **enter** key will put the asterisk at the end of the line and save the value in the BBRAM / RTC.

4.2 Main PCB input voltage references

```
36. REF VOLTAGES
 Ref TC 12.21 mV    *
>Ref #1 53.90 mV    *
 Ref #2 485.0 mV    *
```

Measure and record the thermocouple reference voltage at the test points, with the multimeter.

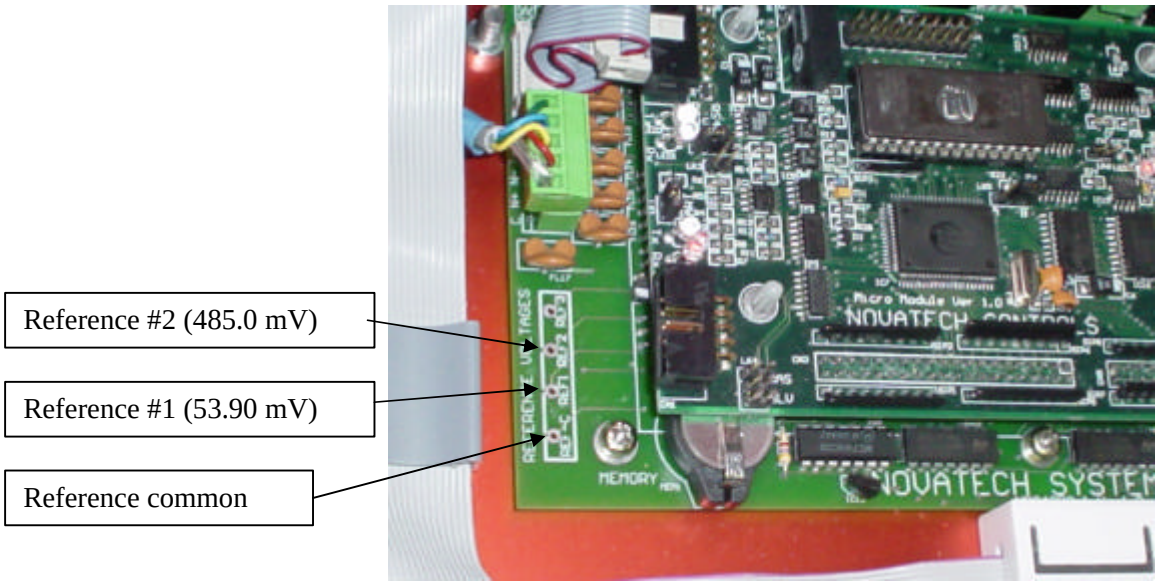


Fig. 3 HBC-4300-1 Main PCB reference voltages

The Ref #1 and Ref #2 test points are measured on the main PCB model HBC-4300-1. The PCB is mounted in the rear left hand corner of the base chassis in the HBC-4301 control case.

Set the number on the display to the voltage that was measured on the multimeter and push “Enter”.

The **cursor** keys will move the cursor between the three reference voltage entry lines.
Option keys will change the value. The **enter** key will put the asterisk at the end of the line and save the value in the BBRAM / RTC.

This completes the reference voltage setting and the both the thermocouple ADC and the main ADC calibration. The automatic calibration software and circuitry will now maintain the accuracy of the amplifier and the ADC. It will also compensate for any drift or scale changes that might occur as a result of ambient temperature changes.

4.3 Select the thermocouple type

The software has been written to allow for either type K or type J thermocouples. However the thermocouple input connectors used on the HBC-4301 have been designed to be used with a specific thermocouple type.

NOTE: If the thermocouple type is changed without changing the thermocouple input connectors an error of up to 15°C may occur.

The **cursor** keys or the **option** keys will move the cursor between the two-thermocouple types. The **enter** key will put the asterisk at the end of the line and save the thermocouple type in the BBRAM.

5. Cold Junction and Ambient Temperature Sensors

The cold junction and ambient temperature sensors are a critical part of the measurement of temperature. The calibration must be performed accurately or all of the thermocouple measurements will have a temperature offset error.

The reliability of the cold junction temperature measurement is so important that two independent sensors have been designed into the HBC-4301. The sensors use separate circuitry to maintain the independence of the reading.

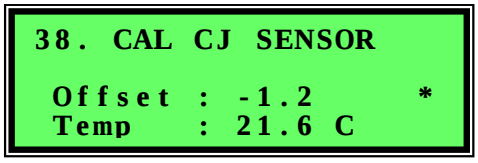
The reliability of the cold junction temperature measurement is improved by averaging the reading from dual temperature sensors. This reading is then compared to a third sensor. If a temperature error is detected an alarm is raised.

The cold junction temperature sensors must be calibrated before the thermocouple inputs are calibrated.

5.1 Cold junction temperature sensor.

Use a calibrated temperature indicator to measure the temperature in the area between the two input PCB's.

1. While the power is turned off, remove the 2 screws in the front corners of the control case. Hinge the control panel up from the front using the handle near the keypad. Place the temperature probe into the area between the two thermocouple input PCB's. Leave the control console open for at least 30 minutes for the temperature to stabilise.



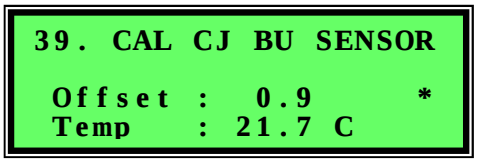
2. Turn the power back on with the extended menus available.

3. Use the **option** keys to adjust the offset temperature up or down until the displayed temperature is the same as the independent temperature probe. Press the **enter** key to put the asterisk at the end of the line and save the data in the BBRAM.

4. Press the **setup / run** key to return to **run** mode.

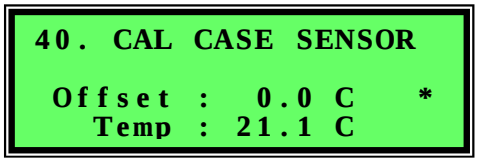
5.2 Cold junction backup temperature sensor.

Use the same procedure as described in section 5.1 to calibrate the backup cold junction sensor.



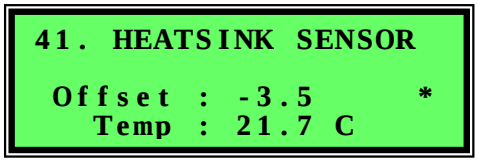
5.3 Case temperature sensor.

Use the same procedure as described in section 5.1 to calibrate the ambient temperature sensor.



5.4 Heatsink temperature sensor.

Use the same procedure as described in section 5.1 to calibrate the heatsink temperature sensor.



6.1 Low temperature calibration.

If the previous calibration procedures have been completed correctly, the error in the thermocouple temperature measurements should be less than 2°C. To enable the calibration to be fine-tuned, an automatic calibration facility has been included in the software of the HBC-4301 to trim the measurements at both the low and the high end of the temperature scale.

Connect the thermocouple mV generator to the #1 thermocouple input on the HBC-4301. Set the generator to 20°C.

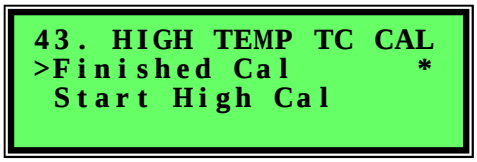
Leave the equipment for 10 minutes for the temperature of the connector to stabilise.

Use the **cursor** keys or the **option** keys to move the cursor to Start Low Cal. The **enter** will put the asterisk at the end of the line.

A short calibration cycle will commence within 2 seconds. All the thermocouple inputs will be trimmed to read 20°C.

6.2 High temperature calibration.

Use the procedure described in section 6.1 to trim the thermocouple accuracy at 200°C.



Connect the thermocouple mV generator to the #1 thermocouple input on the HBC-4301. Set the generator to 200°C.

Leave the equipment for 10 minutes for the temperature of the connector to stabilise.

Use the **cursor** keys or the **option** keys to move the cursor to “Start High Cal”. The **enter** key will put the asterisk at the end of the line.

A short calibration cycle will commence within 2 seconds. All the thermocouple inputs will be trimmed to read 200°C.

7. VACUUM AND PRESSURE SENSORS

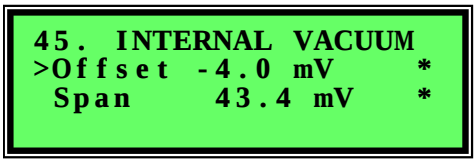
The electronics involved in the measurement of the internal vacuum and internal pressure is calibrated by using the procedure described in section 4.2, Main PCB input voltage references. However the actual sensors need to be calibrated.

7.1 Internal vacuum sensor

The internal vacuum sensor is internally connected to the second vacuum pump and the **Vacuum #2** quick-connect.

Select the vacuum display by pressing the **vacuum** key.

Turn **off** vacuum pump #2 using the **Vacuum** key and the **VAC ON/OFF** key.



Press the **Setup / Run** key to go to the set up mode.

Use the **option** keys to change the **Offset** value, returning to **run** mode to check the **INT VAC**, which is displayed when the **Vacuum** key is pressed. An increase in the **Offset** value will decrease the internal vacuum measurement.

Adjust the **Offset** until the **INT VAC** reads 0 kPa.

Connect the compressed air supply to the HBC-4301 **AIR IN** quick-connect.
Set the air supply pressure to 600 kPa. (87 PSI)
Connect an independent vacuum-measuring instrument to the **VACUUM 2** quick-connect.
Turn **on** vacuum pump #2 using the **Vacuum** key and the **VAC ON/OFF** key.

Set the vacuum pump #2 to manual 100% with the following set up function settings –

Function number	Function name	Option
Function #20	Vacuum Mode	Manual
Function #21	Set Vacuum level	100%

NOTE: Function # 20 will not be displayed unless **Vacuum** is selected in function # 31 (**External Inputs**).

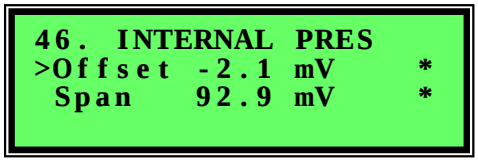
Use the **option** keys to change the **Span** value, returning to **run** mode to check the **INT Vac**, which is displayed when the **Vacuum** key is pressed. An increase in the **Span** value will decrease the internal vacuum measurement.

Adjust the **Span** value until the **INT VAC** is the same as the external vacuum-measuring instrument.

Because the HBC-4301 has been designed to accept vacuum and pressure sensors made by different manufacturers, the calibration adjustments need to be large. This will not affect the accuracy.

7.2 Internal pressure sensor

The internal pressure sensor is internally connected to the **AIR IN** quick-connect.
Select the pressure display by pressing the **vacuum** key.
Make sure the compressed air is not connected to the HBC-4301.



Press the Setup / Run key to go to the set up mode.

Use the **option** keys to change the **Offset** value, returning to **run** mode to check the **INT PRES**, which is displayed when the **Vacuum** key is pressed. An increase in the **Offset** value will decrease the internal pressure measurement.

Adjust the **Offset** until the **INT PRES** reads 0 kPa.

Connect the compressed air supply to the HBC-4301 **AIR IN** quick-connect.
Set the air supply pressure to 600 kPa. Check the pressure with an independent pressure-measuring instrument.
Turn **off** vacuum pump #2 using the **Vacuum** key and the **VAC ON/OFF** key.

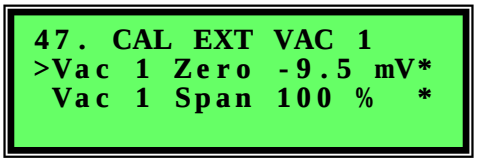
Use the **option** keys to change the **Span** value, returning to **run** mode to check the **INT PRES**, which is displayed when the **Vacuum** key is pressed. An increase in the **Span** value will decrease the internal pressure measurement.

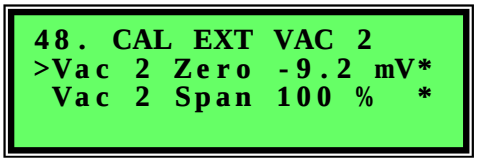
Adjust the **Span** value until the **INT PRES** is 600 kPa.

7.3 External vacuum sensor inputs

NOTE: The following settings must be made before calibration of the vacuum/pressure system –
Function #1, Control Mode, must have “Local” selected.
Function #31,Display Units, must have “Vac/Pres” set to “Vacuum”, “Min” set to -1bar and “Max” set to 0bar.
Function #32, Display Units, must have the Vacuum set to “kPa” and the pressure set to “kPa”.

Use a 4-20mA generator to simulate the vacuum of -7kPa (18.9mA) and -86kPa (6.2mA).





Use the cursor key to select Zero or Span. Use the **option** keys to change the **Zero / Span** value, returning to **run** mode to check the **VACUUM 1** (or 2), which is displayed when the **Vacuum** key is pressed.

Connect the 4-20mA generator to the VACUUM 1 input connector. Set the current to 18.9mA (set the **Zero**) and then set the current to 6.2mA (set the **span**).
Adjust the **Zero** and then the **Span** until the **VACUUM 1** (and 2) read the same as the simulated values.

8. POWER OUTPUT LEVELS AND THE VACUUM PUMPS

The heater outputs and the vacuum pumps provide outputs from the HBC-4301.

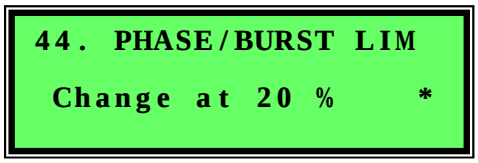
The heater outputs are able to drive with both burst mode (with a 300ms cycle time) and using phase firing where the outputs are turned on and off within each half mains voltage cycle (100 or 120 times per second). The heater outputs must be checked in both modes.

8.1 Heater outputs.

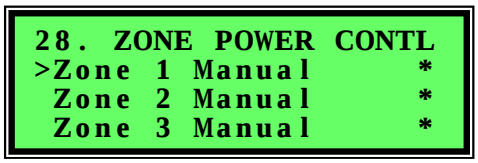
There are no adjustments on the heater outputs so therefore there is not a calibration procedure. However the output drive levels must be checked at several power levels.

The drive mode will automatically change from phase to burst at a preset level determined by set up function #44. The change over point can be set to between 0 and 20%. Above this point the outputs will always drive in burst mode.

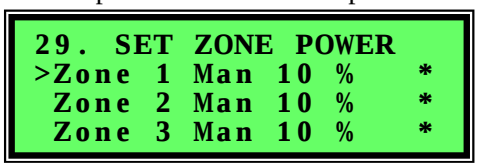
Set the phase / burst change point to 20%



Set all the heater outputs to **Manual** control in set up function #28.



Connect a mains voltage 100W lamp to the outputs.
Set the power level of the outputs to the required levels in set up function #29.



Follow the table below to confirm the operation of all three outputs.

Power level	Phase / Burst	Action to check	Power LED
0%	-	Lamp is off	Off
8 %	Phase	Lamp is barely turned on	On with low intensity
25%	Burst	Lamp flashes at approx. 25% duty cycle	25% flash
50%	Burst	Lamp flashes at approx. 50% duty cycle	50% flash
100%	Burst	Mains voltage on lamp constantly	On

8.2 Vacuum pump #1

There are two vacuum pumps in the HBC-4301. Pump #1 can simply be turned on and off. Pump #2 can be controlled by turning the pump on and off 16 times per second. The on / off ratio is varied to control the vacuum level. Neither of the vacuum pumps can be calibrated but they must be checked for the ability to generate a vacuum at a specific leak rates.

Connect a vacuum hose to **VACUUM 1** quick-connect. At the remote end of the hose, connect the following items as show in the diagram below –

Vacuum transducer, -1 to 0 Atm., 4-20mA output
Needle valve
Flow meter, 0 to 5 l/min

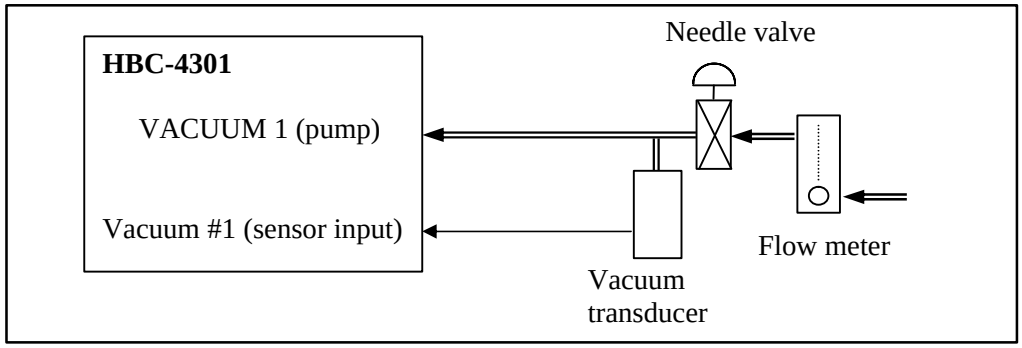


Fig. 4 Vacuum pump pumping rate test

Adjust the air supply pressure to 500 kPa and connect it to the air supply quick connect.

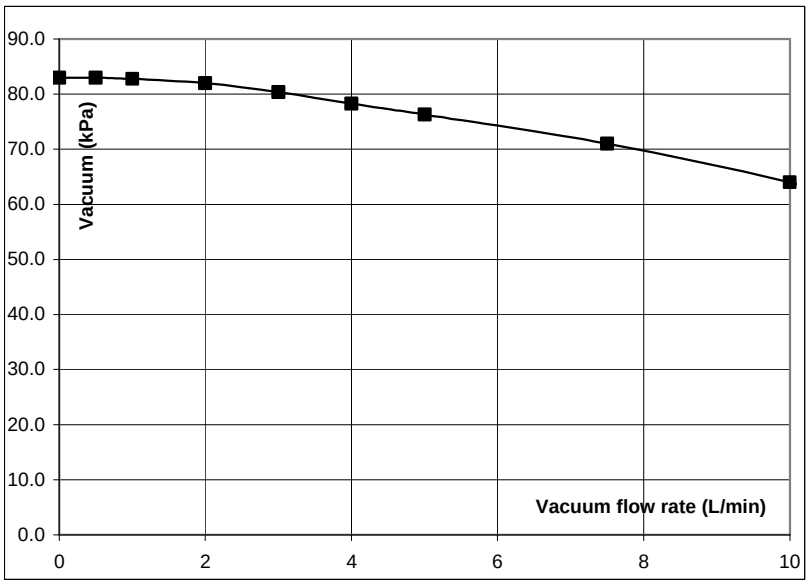


Fig. 5 Vacuum level at specific leak rates

It should be possible to achieve a vacuum level of –85 kPa using vacuum pump #1 with the needle valve closed. As the needle valve is opened, and the leak rate increased, the vacuum should drop in accordance with the above graph. The supply pressure for this test was 500kPa.

If it is not possible to achieve the level of vacuum shown on the graph, check the filter fitted into the vacuum pump, or replace the pump.

8.3 Vacuum pump #2

Vacuum pump #2 can be operated in both a **Manual** mode and an **Automatic** mode.

Use the configuration shown in figure 4, but connect the vacuum hose to **VACUUM 2**.

To put the pump into **Manual** mode, press the **VACUUM** button to show the status of the vacuum pumps. One press will show the status of pump #1 and the second press will show the status of pump #2. The pump will be turned on or off by then pressing the **VAC ON/OFF** button while displaying the pump #2 status.

1. Press the **SETUP** button to enter the set up mode.
2. Use the Function keys to find the set up function #20. Select **Manual** mode. Press the **ENTER** button.
3. Go to set up function #21. Set the vacuum drive percentage level to 100%. Press the **ENTER** button.
4. Press the **SETUP** button to return to the **RUN** mode.

This will make vacuum pump #2 pump at the maximum rate. The pumping performance should therefore be the same as shown on the graph in figure 5 for pump #1. If it is not possible to achieve the level of vacuum shown on the graph, check the filter fitted into the vacuum pump, or replace the pump.

Check the **Automatic** control of pump #2 to 65 kPa by the following procedure –

1. Set the incoming air supply pressure to 650 kPa.
2. Press the **SETUP** button to enter the set up mode.
3. Use the **Function** keys to find the set up function #20. Select **Automatic** mode. Press the **ENTER** button.
4. Go to set up function #23. Set the vacuum control level to 65 kPa. Press the **ENTER** button.
5. Press the **SETUP** button to return to the **RUN** mode.

Leak Rate	**Vacuum set to-**	**Min vacuum**	**Max vacuum**
0.1 l/min	-65 kPa	65 kPa	68 kPa
0.5 l/min	-65 kPa	58 kPa	71 kPa
1.0 l/min	-65 kPa	56 kPa	71 kPa
2.0 l/min	-65 kPa	46 kPa	68 kPa

During a 1-minute test, check the vacuum at the above leak rates.

9. SAFETY CHECK

9.1 Earth leak detectors (Residual Current Detectors, RCD).

The HBC-4301 has been designed to protect the operator from electric shock by using a separate RCD on each heater circuit. The RCD also doubles as the on / off switch for the circuit.

Turning on the **HEATER OUTPUT** #1 RCD (labelled **MASTER**) turns on the power supply for the electronics in the HBC-4301.

There are no serviceable components in the RCD but they should be checked as part of the calibration process.

1. Connect the power supply lead to the HBC-4301 control case.
2. Connect the power supply lead to the wall outlet socket.
3. Turn on all three-power switches (RCD's).
4. One at a time, press the TEST buttons on the edge of the RCD's.
5. The RCD should be seen to switch off.
6. Install the 7k85Ω ballast resistor on each of the outputs.
7. Increase the output power and observe the RCD switch off.

9.2 Earth socket

The **EARTH** socket is wired to the mains supply power inlet socket using 1.5mm^2 cable. Measure the resistance between the **EARTH** socket and the earth pin of the mains supply inlet socket. It should be <0.1 Ω.

NOTE: To effectively measure the resistance of the **EARTH** connector a milliohm meter must be used. A common digital multimeter is not capable of accurately measuring 0.1 Ω.

9.2 Other safety issues

To complete the calibration and safety check, the physical condition of the instrument should be assessed. This will require the control panel to be hinged up. Turn the power off and unplug the mains supply connector from the control panel.

Items to check include (but are not limited to) –

- Cable ties on any wires connected to mains supply voltage connectors
- Earth cables are all securely terminated
- There are no wires pinched by the hinged components
- The insulation film under the HBC4300-3 PCB is installed

Also check –

- LK7 link on the Micro Module PCB is in the W/D (watchdog timer) position (or not installed)
- LK1 link on the HBC4300-1 PCB is off
- LK2 link on the HBC4300-1 PCB is in the RS485 position
- LK3 link on the HBC4300-1 PCB is off
- The calibration sticker has the correct calibration date

10. QUALITY CONTROL REPORT

The value of the calibration and safety check described in this document is distinctly reduced if a detailed full report is not kept. The report must follow a recognised quality system such as ISO9001: 2000.

An example of such a report is included in Appendix B in this manual for guidance purposes only.

APPENDIX A. EXTENDED MENU SUMMARY

The following menu functions are available to the operator when Extended Set Up mode has been selected. This allows access to the menu functions from 34 to 47. These menu items have restricted access, and are intended for use by qualified personnel only.

The Extended Set Up mode is accessed by pressing the SETUP button while the power is turned on. The button can be released when the message “Extended Setup Mode” is shown on the display.

34 Set calendar - year, month & day
35 Set time - hours amd minutes
36 Set reference voltages
37 Set thermocouple type - K or J
38 Calibrate cold junction sensor
39 Calibrate cold junction back up sensor
40 Calibrate case sensor
41 Calibrate heatsink sensor
42 Low temperature thermocouple calibration
43 High temperature thermocouple calibration
44 Phase / Burst power changeover limit
45 Internal vacuum sensor calibration
46 Internal pressure sensor calibration
47 Calibrate external vacuum sensor #1
48 Calibrate external vacuum sensor #2

APPENDIX B. HBC-4301 CALIBRATION CHECK LIST

Novatech Controls - HBC-4301 Checking Procedure

Hot Bonding Controller

Supplied to:		**Date**	
EPROM ver.		**Serial No.**	
PC software ver.		**Order No.**	

Visual check

Paint quality		Cable ties	
Scratches on anodised parts		Ferrites x2	
Watchdog timer link to W/D		Earth straps	
Serial comms link to RS232		Insulating film under power PCB	
Beeper link off			

Voltages

Power supply 5VDC	
Power supply +12VDC	
Power supply -12VDC	
TC Reference (12.3mV +/- 0.3)	
Reference #1 (53.6mV +/- 2.0)	
Reference #2 (481mV +/- 10)	

Calibration

Cold start	
Enter date/time	
Enter reference voltages	
Cal at 20 °C	
Cal at 200 °C	

Accuracy (after calibration)

Temperature checked at …	5	20	100	150	200	290
(+/- 1 °C)						

Measured ambient Temp		°C				
CJ temperature		°C	O/S set to-		+/- 4	
CJ BU temperature		°C	O/S set to-		+/- 4	
Case temperature		°C	O/S set to-		+/- 4	
H/S temperature		°C	O/S set to-		+/- 6	
Ext vac transducer #1	Zero	Span	4.5mA test	19mA test		
88 & 8 kPa, +/- 5						
Ext vac transducer #2	Zero	Span	4.5mA test	19mA test		
88 & 8 kPa, +/- 5						
Int. pressure transducers	O/S	Span	Zero test	(0 +/- 20)	Span test	(500+/- 20)
Int. vacuum transducers	O/S	Span	Zero test	(0 +/- 3)	Span test	(88 +/- 3)

Operation

Power output phase test, min 8%, 20 & 21%		
Power output burst test, 20 & 21%, max 100%		
High current test, 10A on each zone		
RCD trip, test button		
Computer power socket test		
Vac pump #2 manual control, leak rate 2 l/min	100%-	50%-
Vac pump #1, leak rate 2 l/min	100%-	

Additional Checks

Temperature cycle run	
Vacuum transducer plug parallel to blanket	

Final check

EPROM version	
EPROM date	
Serial number sticker	
Calibration sticker	

Signed	
Date	