1730 Series Transmitter

Diagnostics Mode Reference Manual

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Diagnostics Mode v1.08

What is Diagnostics Mode

The 1730 Series Transmitter is a microprocessor driven controller designed by Novatech Controls that can be pre-loaded with several different firmware versions to suit various applications.

In *standard operation* the 1730 Series Transmitter runs a real-time operating system; a loop of automated tasks which involve several highly inter-connected systems. Due to this closely integrated nature, it can be difficult to isolate and diagnose specific hardware problems. For this reason, the purpose of the Diagnostics Mode is to halt all other processes and isolate each particular piece of hardware or specific sub-system so that it can be individually tested.

This reference manual covers the all aspects of the Diagnostics Mode, describes how the transmitter should respond to various tests, and provide *detailed technical advice* on what may be the likely cause of various fault conditions.

Finally it must be noted that fault diagnosis will often require a high level of electronic knowledge, access to datasheets, schematics, various equipment including a digital multimeter (DMM), Multi-function calibrator, and for some tests an oscilloscope. Repair may require access to replacement parts and specialised equipment including surface-mount soldering equipment.

Please read the warnings and considerations below before continuing.

High Voltage Warning

In order to test the heater and purge/cal solid state relays (SSRs) the transmitter must switch them on. This will only occur in the tests that are specifically required to test the SSRs, and should only pulse the output for a maximum of 30ms each second. During this time the outputs will be connected to live mains.

It is safe to leave oxygen probes connected during these tests, they will not be damaged or heat up more than a few degrees. For testing the mains current feedback transformer it is actually required that an oxygen probe is present.

Considerations Before Running the Diagnostics Mode

Be advised that while in Diagnostics Mode the transmitter <u>will be offline</u> and all standard operations such as reading and re-transmitting of process variables will be stopped. It may however for the purposes of testing still retransmit various signals over the 4-20mA outputs, digital communications systems, energise the relay outputs, purge/cal solenoids and heater power outputs.

Before you proceed if you have any control systems connected to the 1730 transmitter you should disconnect these from the transmitter or consider what affect this may have if left connected.

NOTE: Before proceeding, please ensure you have read the relevant sections of the manual, have the required electrical qualifications and have obtained any required authorization before proceeding.

Abbreviations Used Throughout this Manual

- DMM – Digital Multimeter. Testing tool, supplied by the technician
- MCU – Microprocessor. For the 1730 series transmitter this refers to component IC17, located on the lower central part of the main board.

Entering Diagnostics Mode

To switch the transmitter to Diagnostics Mode you will need;

- Medium size flat head screwdriver to unscrew front case screws
- Small flat-head screw driver to change DIP switch position

Before continuing, *disconnect power* to the transmitter.

This should be done before opening the front case of the transmitter to eliminate the risk of electrical shock.

After power has been disconnected, use the medium sized flat-head screwdriver to unscrew the four screws on the front of the transmitter case. The screws are captive spring-loaded and will spring clear of the base once fully unscrewed.

Open the case to reveal the inside electronics.

The lower left-hand side of the main PCB has a set of four DIP switches which can be accessed through a hole in the shield (if fitted). It is not necessary to remove the EMI shield to access Diagnostics Mode, however it may be required to remove the shield for further testing at a later stage.

While the transmitter is switched off, use a small flat-head screwdriver to move the bottom DIP switch (labelled DIAG) to the right.

Re-connect power to the transmitter and switch on.

At this point, instead of displaying the Novatech logo and usual runtime information the display will say 'Loading Diagnostics…' with a version number on the second line. The version number indicates the version of the Diagnostics Mode module compiled into the current EEPROM.

If the device powers up as described then you can skip the next chapter relating to power failure.

Total Power Failure

If the transmitter fails to power up when mains power is re-connected and switched on, you should proceed to checking the mains circuitry for faults.

- Visually inspect the circuit board, mains power plug and mains power isolation switch SW2 checking that the connector wires and connectors are firmly inserted, and that SW2 is in the ON position. Look for any blackened areas or scorch marks on the PCB or connectors that may indicate a fault. Take particular note of the components marked VR3, VR4, VR5, VR6, VR7.

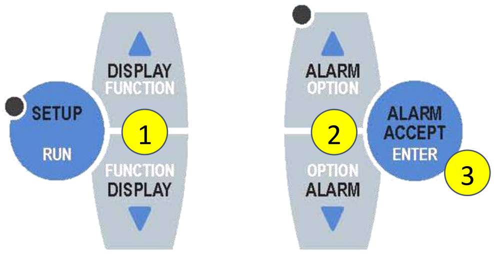
- Switch off the transmitter and remove the PCB fuse marked FS1 located adjacent to the main AC-DC converter. If you find that this fuse is blown then it is very likely the Main AC-DC converter block PS5 is damaged and will require replacement.

If PS5 is faulty it will cause FS1 to blow. If you replace blown FS1 without replacing faulty PS5 and try switching the device back on you may notice the lights come on for about a second, then the device going dead again as PS5 will immediately blow FS1.

Diagnostics Mode Keypad Interaction

The Diagnostics Mode consists of a series of numbered tests with user interaction being provided using the local keypad and display.

Each individual test is designed to focus on a specific hardware component within the transmitter. While some tests are fully automatic and non-interactive, others have several options that can be adjusted by the operator using the keypad.



1. Function Up/Down – Change the test number
2. Option Up/Down – Change the test option
3. Enter – Toggle test option

The Option Up/Down and Enter keys perform different functions depending on the test. Please refer to specific test application notes to see what keys are enabled for specific tests and their specific function

Pre Diagnostics Mode Tests

During the initialisation of Diagnostics Mode the transmitter performs two basic tests to confirm that the display and keypad are functioning properly.

Testing the Display

On entering Diagnostics Mode the display test flashes a series of patterns on the display, and given that there is no feedback to electronically confirm whether the display updated correctly it is up to the technician to observe and determine whether the display is functioning properly.

The display test rapidly cycles through showing all pixels on, then all pixels off, then two patterns where pixels alternate on or off. If the display contains any dead pixels, or if any regions are not updating properly it should be immediately obvious to the technician.

The test can be repeated by power cycling the transmitter to restart Diagnostics Mode

Failure in this test would indicate a problem related to either the LCD module, the display PCB, or the keypad/display bus buffers on the main PCB. In the majority of cases the solution would be to replace the entire display PCB including the LCD module. It has also been observed that in some cases when there has been voltage spiking on the mains, or if high voltage has been incorrectly applied to any of the burner input or BFT inputs then the display bus buffer IC1 on the main PCB may be damaged.

On completion the transmitter immediately progresses to the second preliminary test.

Testing the Keypad

This second preliminary test will check the functionality of the interrupt driven hardware informing the MCU when a key press is detected, as well as testing each of the physical buttons integrated into the lexan on the front panel of the transmitter.

The transmitter will display the message 'Press All Keys…', and the technician should press each key on the front panel one at a time. While being depressed, the display will indicate on the display which button is being detected. Once all eight buttons have been individually pressed and released the transmitter will progress to the numbered diagnostics mode tests.

The keypad inputs are transmitted to the main PCB along the same data bus as the display. Changes to the keypad triggers an interrupt on the MCU, which causes the device to process the key press. If this interrupt is not working properly then Diagnostics Mode will inform the technician of this fault. In this case the keypad will continue to work in Diagnostics Mode, but will not work in the normal runtime loop.

The cause of a keypad interrupt failure may be the SPI chip IC7 on the display PCB is damaged, or that the transistor buffer TR1 (display PCB v1.0E and earlier) or NAND gate IC8 on the display PCB is damaged. In either case, the easiest way to fix a keypad interrupt failure is to swap out the entire display PCB and repeat the test.

Diagnostics Mode Tests

01. Reference Voltages Summary

Overview: This ***non-interactive*** test gives a summary of the three main voltage references as read by the internal ADC.

Option Up/Down: no operation
Enter: no operation

The purpose of this test is to provide a quick overview of the three main ADC reference voltages as read by the reference voltage feedback and calibration circuit. At a glance it may be possible to confirm whether the ADC circuitry is working properly or requires further testing.

The display has a table with three rows and three columns. Each row shows the reference voltage, ADC count number for the zero mV reference and the ADC count number for the span mV reference.

50mV	275 ± 75	3450 ± 645
200mV	275 ± 75	3450 ± 645
1200mV	275 ± 75	3450 ± 645

If all of the numbers on both the middle and right column read within tolerance then it can be safely assumed that the voltage reference circuitry, analog channel selection circuitry, multiplexers, gain circuitry and ADC chips are working correctly.

If any of the numbers are reading outside of the expected ranges, especially if any are reading 0 or 4095 then there is a problem with the analog circuitry.

Potential faults are the DC-DC isolated power supply PS4, the two voltage regulators IC11,IC27, the voltage reference IC25, channel selection multiplexers IC8,IC9, gain op-amp IC14, gain select multiplexer IC24, analog-digital converter IC23, or the analog switch IC7.

Before doing any more tests, check the four reference voltage test points on the main PCB (Ref 1.. Ref4) and the two analog test points marked +12 & -12 above PS4 (relative to Acom)

The test point values should read:

	Ideal Voltage	Min mV (-5%)	Max mV (+3%)	
Ref1	47.2 mV	44.8 mV	48.7 mV	
Ref2	189.1 mV	179.6 mV	194.8 mV	
Ref3	1227 mV	1165.6 mV	1263.9 mV	
Ref4	2500 mV	2375 mV	2575 mV	
+12	12.0 V	11.4 V	12.6 V	(±5%)
-12	-12.0 V	-11.4 V	-12.6 V	(±5%)

In some cases where high voltage has damaged one or more components in the analog circuitry it is possible that the damaged component may be drawing excess current and pulling the voltage references and AVcc/AVee down. It may be necessary to systematically remove components one at a time to identify the root cause of the problem.

The order for which the ICs are removed may depend on the history of the device. In some cases power surges have been known to damage IC7, which in turn may damage IC25. Excess heat, or long service life may cause PS4 to fail.

02. Reference 50mV

03. Reference 200mV

04. Reference 1200mV

05. Reference Zero

Overview: These four tests lock the analog multiplexer to the respective analog reference voltage feedback channels. The MCU repeatedly samples the selected analog channel and displays the results on the second line formatted in either raw ADC counts, or as an un-calibrated voltage.[1]

Option Up/Down: change the gain selection for the analog input.
Enter: no operation

The objective of these four tests it to confirm that the channel selection and gain select multiplexers are working. To confirm that each channel is being selected the technician can is a DMM to measure the differential voltage between the two test points on the PCB marked M+ and M-. If the channel selection is working properly then the voltage measured between these two test points should be very close to the same voltage measured between the selected reference test point and ground.

If the voltage differential does not match this voltage then there is a problem with the channel selection circuitry. The problem may be that one of the channel selection multiplexers IC8 or IC9 is not working, or possibly that the channel selection I/O lines between the MCU and the IC8/IC9 are not working. The procedure for troubleshooting would be to check the port lines P8-0..2 are functioning, which may require removing IC8/IC9. If they are working then IC8/IC9 should be replaced.

[1] Un-calibrated meaning that default calibration values are used in the calculation of the voltage. The voltage displayed should be accurate to within ±2%, any slight inaccuracy should not be taken as an indication of hardware fault.

To test the gain circuitry the technician can change the gain using the option up/down keys. The gain multiplexer IC24 changes the feedback resistor for one of the op-amp channels on IC14, resulting in four possible gain ranges for the analog signal into the ADC. The objective is that each reference voltage will have one optimal gain range to amplify the analog voltage to approximately 85% of the analog

The gain for each of the gain selection channels are as follows:

Range	Physical Gain	Saturation Voltage
0	40.7	57.5mV
1	10.4	225.4mV
2	1.75	1334.3mV
3	1	2338.4mV

Not all gain ranges are available for all of the reference voltages, as higher gains will immediately saturate the analog signal for the higher reference voltages. It is however possible to apply lower gains to the lower reference channels to confirm that the gain selection is working.

If the gain selection is not working then the problem may be the gain selection multiplexer IC24, the op-amp IC14, or possibly the gain selection I/O lines from the MCU pins P8-3..4. The procedure for troubleshooting would be to check the I/O lines to the multiplexer are working, and then replace IC14 followed by IC24.

06. Probe 1 Temperature Input Channel

07. Probe 1 EMF Input Channel

08. Probe 2 Temperature Input Channel

09. Probe 2 EMF Input Channel

Overview: These four tests lock the analog multiplexer to the respective analog input channels. The MCU repeatedly samples the selected analog channel and displays the results on the second line formatted in either raw ADC counts, or as an un-calibrated voltage.[2]

Option Up/Down: change the gain selection for the analog input.
Enter: no operation

The objective of these four tests it to confirm that the hardware specific to the off-board analog inputs is working. Before performing these tests it is important to confirm first that the analog input selection and gain circuitry is working by performing diagnostics tests 02 through to 05 on the previous page.

The process is identical to the previous tests for checking the reference voltages; the channels selected however correspond to the four analog inputs on the terminals used for oxygen EMF and temperature. To test these channels it is necessary to have some sort of calibrated source generator connected to the channel being tested.

For testing the temperature input channels, the signal source must be capable of simulating a K-type thermocouple, cold junction compensated signal in the range of -50°C to 1500°C.

[2] Un-calibrated meaning that default calibration values are used in the calculation of the voltage. The voltage displayed should be accurate to within ±2%, any slight inaccuracy should not be taken as an indication of hardware fault.

For testing the probe EMF input channels, the signal source must be capable of sending a DC voltage signal in the range of -50mV to 2000mV.

NOTE: Signals outside of the range of -50mV to 2400mV may damage the analog input circuitry.

By modulating the output from the signal generator, the transmitter should be able to quickly and accurately reflect the voltage or temperature changes on the second line of the display.

Failure to reflect these changes would indicate some fault between the input terminals and the channel selection multiplexer components IC8/IC9. This may be caused by broken solder joints, damaged tracks or ancillary components such as pull-up resistors.

Both of the temperature inputs have pull-up resistors that will cause the signal to read 1371.1°C if they are open-circuit.

10. Ambient Temperature Sensor

Overview: The transmitter has a solid-state temperature sensor IC4 that is used to monitor case temperature and for thermocouple cold-junction compensation. The sensor is located in the top-left corner of the main PCB directly above the input terminals for probe #1, the analog output signal is sent directly to the MCU.

Option Up/Down: no operation
Enter: no operation

The display should indicate ambient temperature in degrees Celsius. It should read close to room temperature, possibly a couple of degrees higher due to heat dissipated from the transmitter circuitry. To confirm the sensor is live reading temperature, try to warm it by touching it lightly with a finger, or cooling it using air from a can.

The output from the temperature sensor can be read using a DMM as a DC signal via the unmarked test-point directly adjacent to IC4. The component is a Texas Instruments LM50, which should output an analog signal of 500mV offset plus 10mV/°C. For example at 25°C the signal should be (500mV + 25x10mV = 750mV)

The order for testing this sensor would be to confirm that the component IC4 is working using a DMM on the unmarked adjacent test-point, then check whether the signal is being transmitted to MCU pin P10_0.

11. Ambient RH Sensor

Overview: The transmitter has a solid-state relative humidity sensor IC30 that is used for oxygen calculations. The sensor is located in the top-left corner of the main PCB above the analog input circuitry. The analog signal is buffered via an op-amp IC31 and attenuated using two resistors, this signal is sent directly to the MCU.

Option Up/Down: no operation
Enter: no operation

The display should show ambient air relative humidity as percentage. The reading will vary depending on the ambient conditions.

The output from the humidity sensor can be read using a DMM as a DC signal via the unmarked test-point directly adjacent to IC30. The component is a Honeywell HIH-4000-002, which outputs a linearised voltage of ~825mV @ 0% RH through to ~3.75V @ 100% RH. The signal is sent to the MCU via op-amp IC31 to buffer the signal and R127 & R128 that attenuate the signal by 50%.

The order for troubleshooting this sensor would be to confirm that the component IC31 is working using a DMM on the unmarked adjacent test-point, then to check the output of op-amp IC31 at each of the output pins, then check whether the signal is being transmitter to MCU pi P10_5.

12. Reference Air Pump Current

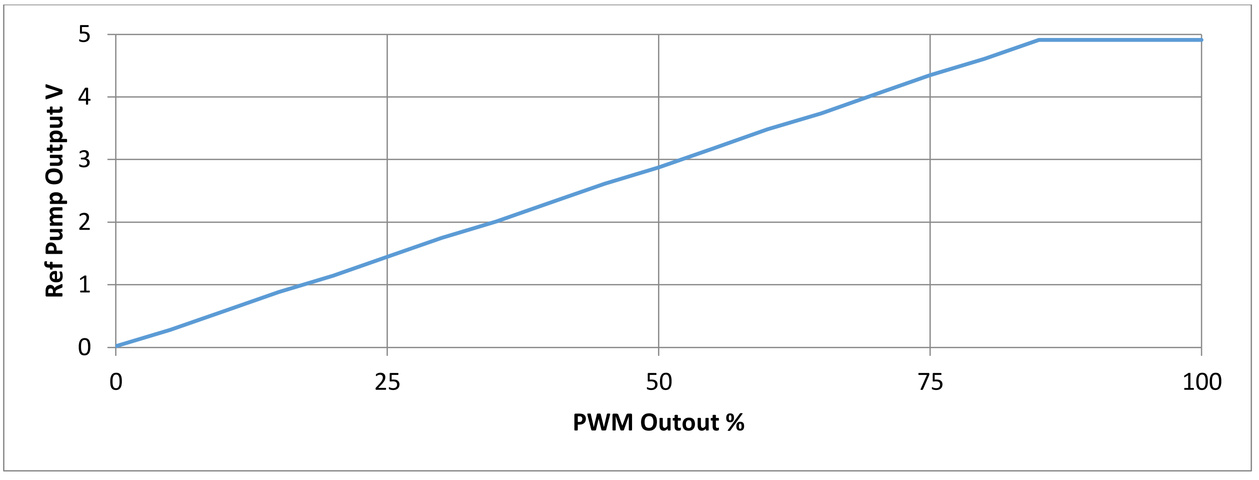
Overview: The reference air pump drive circuitry is designed to power a small DC pump using a controlled digital pulse. This allows the MCU to adjust the speed of the pump by modulating the output voltage. The circuit is designed to provide a continuous current of ~100mA, with a maximum continuous current of ~250mA. The drive circuitry has integrated load detection that is used to monitor current usage so that the MCU can switch the pump off if the output is overloaded to prevent damage to the drive circuitry.

Option Up/Down: increase/decrease the digital PWM pulse (pump voltage)
Enter: no operation

The display indicates both PWM (pulse with modulation) output level in percentage, as well as current detected using the feedback system. There are in effect two symbiotic systems being tested at once; the pump drive voltage and the current feedback system. In standard operation the pump should start turning once the PWM level reaches a certain level, the current should also rise according to use.

It is noted that with some pumps, when the motor sticks the pump can draw considerable current.

To test the PWM output and pump voltage, remove the reference air pump and use a DMM to measure the DC voltage across the ref pump output terminals. Use the option keys to change the PWM output and observe the changes to the voltage displayed on the DMM. The voltage should follow a linear path from ~0V @ 0% PWM, saturating at ~5V @ ~85% PWM output.



If the voltage on the ref pump output terminals does not respond as described when changing the PWM output, use an oscilloscope to check the trace at test-point P1, located adjacent to R110. The trace should show a digital pulse with a mark to space ratio corresponding to the PWM output. This trace is input into an op-amp IC29 which drives the transistor TR9. If the digital trace is present, but no corresponding voltage, replace TR9, test again, replace IC29 if still not working.

To test the current feedback there are several methods. The easiest option would be to use a known working CM-15 reference air pump as supplied by Novatech. With the PWM output set to 100% the pump should run with a smooth cadence and draw a continuous current of ~60mA. Another way to test this would be to place a 1/4w 100 ohm resistor between the ref air pump terminals. The current drawn should also display ~50mA @ 100% PWM.

If the voltage output is working and current feedback is not working then check the output from the op-amp IC29, and check MCU pin P10_1.

13. Mains Detection

Warning: This test requires a heated probe to be connected to the Heater 1 output, and will involve switching on mains power to this probe in short bursts.

Overview: Mains detection is achieved by measuring the AC current used to power the heated probe. The transmitter measures frequency by detecting the zero crossover points of the alternating current signal, and it calculates voltage by assuming the known impedance of the probe heater. This assumption is easily invalidated if the device attached to Heater 1 is not a Novatech Controls supplied model 1231 or 1234 heated probe.

Note: To enable mains power output to Probe 1 a link must be inserted between the burner input terminals 10 &11 creating a short-circuit.

Option Up/Down: no operation
Enter: no operation

With the probe plugged into Heater 1 output and the burner input link present the transmitter should be able to immediately detect a mains voltage and frequency.

Also note, if mains cannot be detected, first check the fuses FS2 and FS3 are not open-circuit.

If the feedback circuit is giving incorrect results then the transmitter current transformer T1 or gain resistor R108 may be damaged. Given that the current transformers used are made to order for this specific application, it may be difficult to obtain suitable replacements. The board may need to be returned to Novatech Controls for repair.

If there is a fault with the mains detection circuitry then it is possible to override automatic mains detection using options in the Calibration Menu, allowing the transmitter to continue operating.

Mains detection is also used during runtime to monitor the switching of the solid-state relay (SSR) that regulates the probe temperature. If mains detection is not working then it is quite possible that the SSR short-circuit protection is also not working. In this scenario, if a SSR fails short-circuit this fault may not be detected by the analyser resulting in the probe being irreparably damaged.

14. SSR Relay Tests

Warning: This test requires a mains powered load to be connected to each of the four relay outputs in order. It will involve switching on mains power to each of the outputs in short bursts.

Overview: The transmitter contains four solid-state relays (SSRs), namely the two heater outputs and the two purge/cal control relays. The four SSR outputs also have an electromechanical relay RL3 that is used to isolate the mains voltage from the four SSRs. This test can be used to individually switch each SSR and displays the ADC feedback from the current sensing circuit in raw counts.

Option Up/Down: next/previous relay
Enter: no operation

The current detection circuit measures the total AC load across all of the SSR outputs. This test is designed to show how this load changes when each of the relays is pulsed. It can help to confirm that the burner relay, an electromechanical relay RL3 is functioning and whether any of the four solid-state relays have failed short-circuit. Finally it also confirms that the current transformer and feedback circuit is working.

Note: To enable mains power output to Probe 1 a link must be inserted between the burner input terminals 10&11 creating a short-circuit. The electromechanical relay RL3 cannot be energised without this link being present.

The first test should be to check using a DMM whether there is any mains present on any of the four output terminals with the burner relay is off. To switch off the burner relay press the option keys until the display says 'Burner Relay Off', and when selecting this option it should be possible to hear the contacts in the mechanical relay changing. With the burner relay off the terminals should be physically isolated from mains, if there is any mains on the outputs with the burner off then the electromechanical relay RL3 has failed.

The next test is to confirm that each of the solid-state relays in turn can switch mains voltage both on and off. To test that none of the SSR have failed short-circuit, use the option keys to set the transmitter to 'All SSRs off'. In this position, RL3 is energised, all SSRs should be off. Plug the probe into each output in turn and observe the 'mA counts' line. A normal number for no load should be ~8 counts. If this number is significantly higher, or if plugging the heater into any one of the outputs causes this to rise then this would be an indication that the SSR being tested has shorted.

Lastly, plug the heater into each output in turn and use the option key to enable the selected output. While doing this observe the mA counts, which should rise to ~140 counts when switched on to indicate that it is sensing the load of the probe heater. If this does not happen then either the SSR has failed open-circuit, or there is a problem with the current detection circuit.

To identify whether the SSR or the current detection circuit that has failed will require some sort of physical load that can be observed whether it is being switched on or off, such as a mains voltage neon indicator. If the problem is with the detection circuit then it is likely the device will need to be returned to Novatech Controls for repair.

15. BFT Analog Input

Overview: The BFT is an analog input located near the bottom-left corner of the main PCB. It is used for some applications for ancillary readings such as measuring process pressure. The BFT measures a DC signal in the range of 0-2500mV. Testing will require the use of a source generator capable of outputting voltage in this range.

Option Up/Down: no operation
Enter: no operation

With the BFT open circuit, there is some internal pull-up circuitry that will hold the BFT input at some level for PCB version 1.2 Rev G and older. This level varies slightly, but should be ~635mV. Starting with PCB version 1.2 Rev H and newer the BFT will drop to 0mV when open circuit.

Connect an external signal generator to the BFT input and check that the voltage output from the generator matches the display. If there is a fault then check the track between the terminal and MCU pin P10_4.

Test input range 0-2400mV with LK2 open, the display should match the signal generator. Secondly, place a short across LK2 and use the signal generator to test the input range 0-20mA. LK2 will place a 120 ohm resister across the terminals, so the voltage on the display should be 120x Input mA.

If there is any non-linearity while testing current with LK2 shorted, consider removing Zener diode D14 as this is the cause of any linearization problem. Some newer firmware versions include software linearization to remove the affect of D14, however it is far easier to fix this problem with hardware.

16. 4-20mA Output 1 Calibration Test

17. 4-20mA Output 2 Calibration Test

Overview: This is a non-interactive test that can show at a simple glance whether both the 4-20mA output circuitry and internal calibration feedback circuitry is working.

Option Up/Down: repeat the test
Enter: no operation

The 1730 transmitter has two isolated 4-20mA output channels. For testing purposes the transmitter is capable of re-routing the output from terminals using an electromechanical relay through a fixed load resistor and back into one of the analog inputs on the MCU. When you enter this menu, or press one of the option keys to repeat the test, the transmitter redirects the analog input and performs a series of automatic tests on the respective isolated 4-20mA output channel and displays the results on the screen.

The first test involves automatically setting the output to ~4mA and reading the return signal on the ADC in raw counts. This first reading is displayed after the word 'Zero' and should be in the range of 11000±7000 counts. Typically this number is ~10300.

Next the device automatically sets the output to ~20mA and reads the return signal on the ADC in raw counts. This second reading is displayed after the word 'Span' and should be in the range of 43000±3000 counts. Typically this number is ~43000.

The third line will either say 'Output OK', 'WARNING' or 'FAIL' depending on whether the Zero and Span numbers are within expected tolerances. If this line says 'Output OK' then it is safe to assume the output is working. If the automatic testing fails then either the output circuitry is damaged, or the feedback circuitry has failed.

If the feedback circuitry has failed then it is still possible to use the output once it has been manually calibrated. Refer to the device Technical Manual for further information. Continue reading the next to Diagnostic tests for information on how to determine the specific point of failure of the analog output.

18. 4-20mA Output 1 DAC Test

19. 4-20mA Output 2 DAC Test

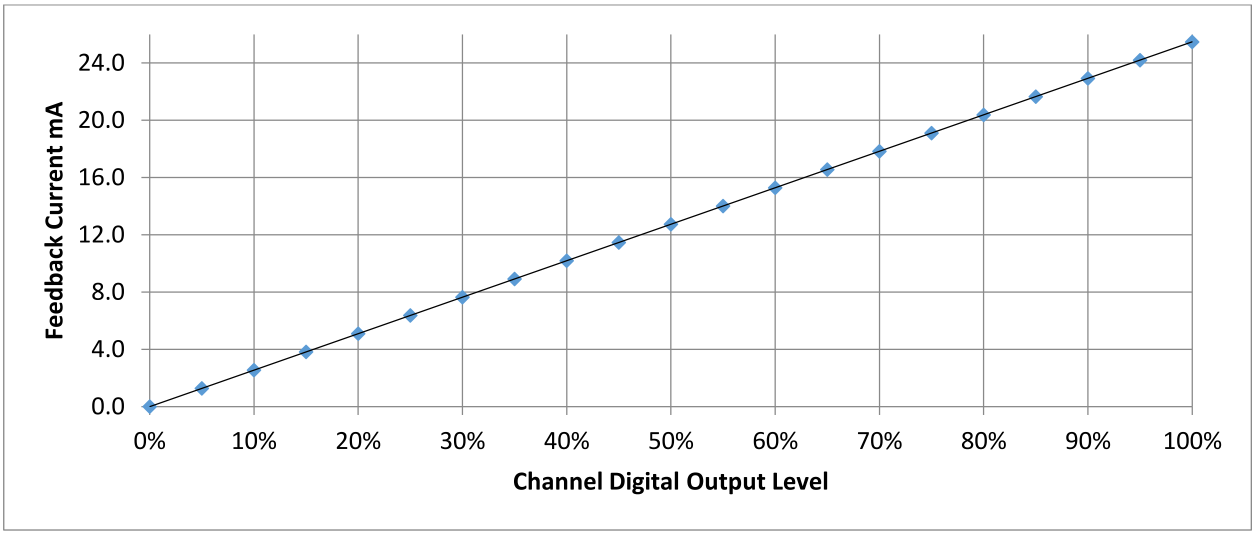
Overview: These two tests follow on from Diagnostics test #16 & #17 and allow a more comprehensive set of options for a technician to diagnose the specific point of failure for the two isolated analog outputs. These tests allows each of the 4-20mA analog output channels to be manually set to specific levels, and manipulate the cal feedback relay.

Option Up/Down: increase/decrease the 4-20mA output level as a percentage of full scale
Enter: toggle the feedback relay on or off

The two 4-20mA output channels on the 1730 transmitter have dedicated isolated hardware to convert a 16-bit signal from the MCU into a proportional analog output. This output signal can be switched via a feedback relay through a fixed load resistor and read by the MCU as part of the self diagnostics process, although doing so un-couples the outputs from the terminals. The transmitter cannot monitor the outputs during standard operation, only during calibration or diagnostics.

By using the option keys, the output level can be set as a percentage of full scale at ~25mA. Pressing the enter key toggles the feedback resistor, which allows the technician to read the output either on the terminals on the PCB, or via the feedback to the MCU.

In standard operation, with the cal feedback enabled, the transmitter should read ~0mA @ 0%, ~12.7mA @ 50% and ~25mA @ 100% output, with the output current tracking a linear path between these points.



If the outputs are not tracking as described then the first thing to check should be the analog voltage reference points next to the DC-DC converter for the channel in question. For channel 1 this is the three test-points labelled D1com,+12,-12 adjacent to PS3, for channel 2 this is the test-points labelled D2com,+12,-12 adjacent to PS2. If these test points are reading correct voltages then the next thing to test is the output terminals DMM to confirm whether the problem is with the output drive circuitry, or the cal feedback circuitry.

Set the cal feedback to disabled, and using the DMM, check whether the analog signal can be seen on the output terminals on the PCB. If the outputs are working, but the cal feedback is not then there is a problem with the cal feedback. Check the cal feedback relay RL1/RL2 is switching, whether there is an analog signal on the load resistor R27, and finally check the track between R27 and the MCU pin P10_3. If the output is not registering an analog signal when the cal feedback is both on and off then the problem is likely with the output drive circuitry.

The two outputs have test points, labelled D1 and D2 which are located on the PCB next to the output power transistor TR4/TR5. Relative to the isolated digital common labelled D1com and D2com adjacent to the respective DC-DC converter, these analog test points should give an analog signal linearly proportional to the output level percentage. It should be scaled 0mV @ 0% output and 2500mV @ 100% output, tracking a linear path for each step change between these two points. If this analog signal is present then skip the next paragraph regarding the oscilloscope.

Using an oscilloscope, check the output signal from the MCU pin P7_4 for channel 1, pin P7_6 for channel 2. An easy test point can be found on the resistor right before the optocouple OP5/OP6. A digital signal with a variable mark to space ratio should be seen. This mark to space ratio should change when the option keys are used to increase and decrease the output level percentage. If this signal is present, next check the output of the optocouple. If the optocouple is working and there is no analog signal on the D1/D2 test point then replace the transistor TR6/TR7 and voltage reference IC15/IC16 components as required.

If there is an analog signal at D1/D2, but not on the output then the problem is likely to be the power transistor TR4/TR5 or the op-amp IC12/IC13. Check also that the light emitting diode LED4/LED5 is working and that the legs of the LED have not become twisted inside the long standoff.

20. Digital Inputs

Overview: The digital inputs being tested include the four inputs from the dip-switch SW1, the 0.1" jumper SW5 and the two inputs on the terminals marked 'Flow SW' and 'Burner Input'.

Option Up/Down: no operation
Enter: no operation

To test each of the dip-switch inputs, toggle them each individually and confirm that the display changes to reflect a change in the physical state. If any of these digital inputs do not work as expected then try manually shorting the associated pins on the IC using a small piece of wire to test whether the dip-switch is damaged. Check the tracks going back to the MCU for damage.

To check SW5 use a small jumper to short the pins, observing the state change on the display accordingly. If this does not work as expected then check the track to the MUC pin P2_6.

To check the Flow SW and burner input use a small terminal connector to short the terminal input pins 16 & 17 for the Purge Flow Switch, and terminal input pins 10 & 11 for the burner input.

If these digital inputs fail to work as expected, check the associated circuitry and tracks to the MCU. Both inputs have a transistor between the input and the MCU for protection. The burner input also has two micro-fuses in series with each pin and a transient voltage suppressor across the terminals for additional protection. If any of these devices are damaged then consider the cause for this damage while replacing the damaged components.

21. Alarm Relays

Overview: The 1730 series has four mains-power rated alarm relays that can be programmed to perform various functions. Each of these relays is independently controlled via the MCU. This test individually energises each relay allowing the contacts to be tested using a DMM

Option Up/Down: select next/previous relay
Enter: no operation

As each relay is selected the relay solenoid is energised and the two terminals corresponding to that relay should be shorted. Use a DMM to check continuity between the terminals and check that they make a continuous circuit when the relay is energised and open circuit when the relay is de-energised.

If any of the relays fail to operate as expected, check the trace from the MCU to the transistorT10-T13 for the correct signal, then replace the relay and transistor as required.

22. LED Test – Lexan and Main PCB

Option Up/Down: select next/previous relay
Enter: no operation

This test is used to check that all the LEDs that are built into the lexan on the front of the case work, and that the RS485 LED on the main PCB works. Cycling through each of the LEDs using the option keys should enable each selected LED in turn to confirm that they work.

Option Up/Down: select next/previous LED
Enter: no operation

If any of the lexan LEDs are not working then check the signal on the flexible cable between the display PCB and the lexan. The lexan itself is unserviceable, so any failed LEDs would require the replacement of the lexan label.

23. LCD Backlight

Overview: The backlight on the LCD display can be enabled and disabled from the MCU. This test can check what state the backlight is in, and whether it is functioning properly.

Option Up/Down: toggle the backlight on/off
Enter: no operation

If the backlight is not working then the LCD module will need replacing. The LCD module itself can be replaced individually. Alternatively the whole display circuit board with LCD module can be ordered as a complete assembly allowing for simple swap-out replacement.

24. RS232 Port

Overview: This non-interactive test allows for simple automated testing of the RS-232 serial communications on the transmitter. To test the RS-232 port place a jumper between terminal pins 18 & 19 – RS-232 Tx and RS-232 Rx.

Option Up/Down: no operation
Enter: no operation

The serial port continuously transmits a string of characters, while simultaneously listening for a response. By placing a loop between the Tx and Rx terminals the device will continuously receive the string of characters that it transmits therefore confirming that both transmit and receive are working.

If both transmit and receive are working the words 'Loopback ON' will appear on the display. If these words do not appear when there is a short between terminals then there is a problem with the Tx or Rx circuitry.

Before testing any of the serial port circuitry, first check the voltage test-points located adjacent to PS1 marked SGnd,+12,-12. On the newer boards there is also a +5 test point added. Confirm that each of the test points measure the correct voltage with respect to SGnd.

Testing for serial port problems will require tracing the signal output from the MCU using an oscilloscope. The testing itself is broken down into testing the Tx circuitry first, then if it can be seen that this works, test the Rx circuitry second.

The first test should be to observe the Tx and Rx and 485 LEDs. During this test, the 485 LED should be off. If the 485 LED is on then check the track between resistor R38 and the MCU pin P2_4.

If the Rx LED is on when the loopback jumper is OFF then there is a problem with either the logic chips IC18, IC19, or the optocouple OP4. Using a DMM, check some of the states of the pins. If IC18_9 and IC18_10 are high and IC18_8 is low then likely it is not IC18. If IC19_3 is high and IC19_4 is low then replace OP4.

With the loopback jumper OFF the Tx LED should give a short flash every second and the Rx LED should stay off. If the Tx LED is not flashing then this suggests that the signal from the MCU is not getting as far as the LED. Use an oscilloscope to trace the signal through OP3 and IC10 to find the problem, also confirming that the Tx LED is working and does not have twisted legs inside the standoff.

Once the Tx LED is flashing, use the oscilloscope to test the signal on the Tx terminal #18. If you can see the Tx LED flashing, and the signal on the Tx terminal then move on to testing the Rx circuitry. Place the loopback jumper between the Tx and Rx terminals to continue testing.

With the loopback on the Rx LED and the Tx LED should flash on together each second. If the Rx LED is not flashing, use the oscilloscope to test where the signal stops working by tracing it through IC10 OP4, then IC18 & IC19 logic gates.

25. RS485 Port

Overview: These tests are designed to check the functionality of the RS485 port by individually toggling different port lines used by the RS485 hardware. The quickest way to confirm whether the RS-485 port is working is to configure the port for use using runtime and try polling the device using the simple Modbus Master PC Software available to download on the Novatech Controls website. If this suggests that there is a problem then this diagnostic test can be used to assist in isolating the problem.

Option Up/Down: toggle different port line
Enter: no operation

By toggling each port line individually it is possible using an oscilloscope to trace the oscillating signals one at a time through each logic gate and optical component to confirm whether they are working. The option to toggle P6_0 is used to confirm OP1 is working. The option to toggle P6_3 is used to confirm OP2 is working by shorting the Tx and Rx pins on IC6. To test OP3 use the automatic process for testing the RS232 port from the previous test. If all three optocouples OP1, OP2 & OP3 are shown to be working, replace IC6.

26. EEPROM & BBRAM

Overview: This is a non-interactive test that displays the status of the three main non-volatile storage devices present on the transmitter. It tests whether the device is present and can be successfully read.

Option Up/Down: no operation
Enter: no operation

The first item is the iButton memory device labelled RTC located on the bottom centre of the main PCB. This device may register as either a DS1904 or DS1994 depending on when it was commissioned. If this device fails then the real-time clock and associated timed events may fail to work properly

The second item M24512 is a flash memory component IC29 that stores all of the device calibration and configuration. If this device fails then the transmitter will factory reset every time it is switched on.

The third item labelled AM29F010 refers to the firmware upgrade socket. It is normal for this test to fail unless a properly programmed upgrade EEPROM is plugged into this socket. It is also not necessary for this socket to work for standard runtime operation; only when updating the on-board firmware.

27. Watchdog Timer

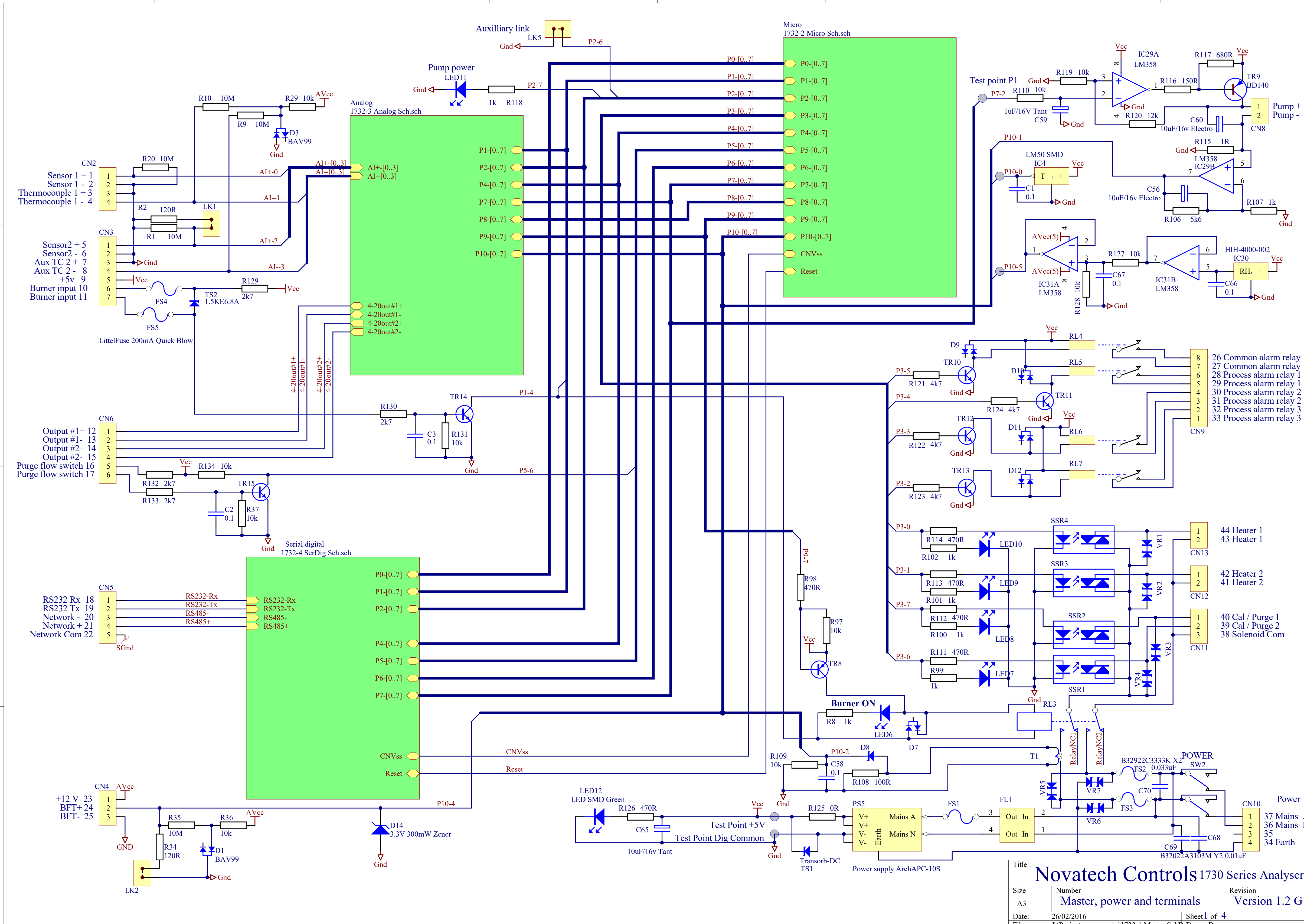
Overview: This tests the internal watchdog timer in the device. If the watchdog timer works then the device should automatically reset approximately 200 milliseconds after pressing one of the option keys to commence the test.

Option Up/Down: commence testing the watchdog timer
Enter: no operation

The device will reset, this is the purpose of the watchdog timer. If the device resets then this test has passed. If the device does not reset then contact Novatech Controls to discuss options.

28. ADC Calibration

This option is not currently used for testing.



Title: Novatech Controls 1730 Series Analyser

Size: A3

Number: Master, power and terminals

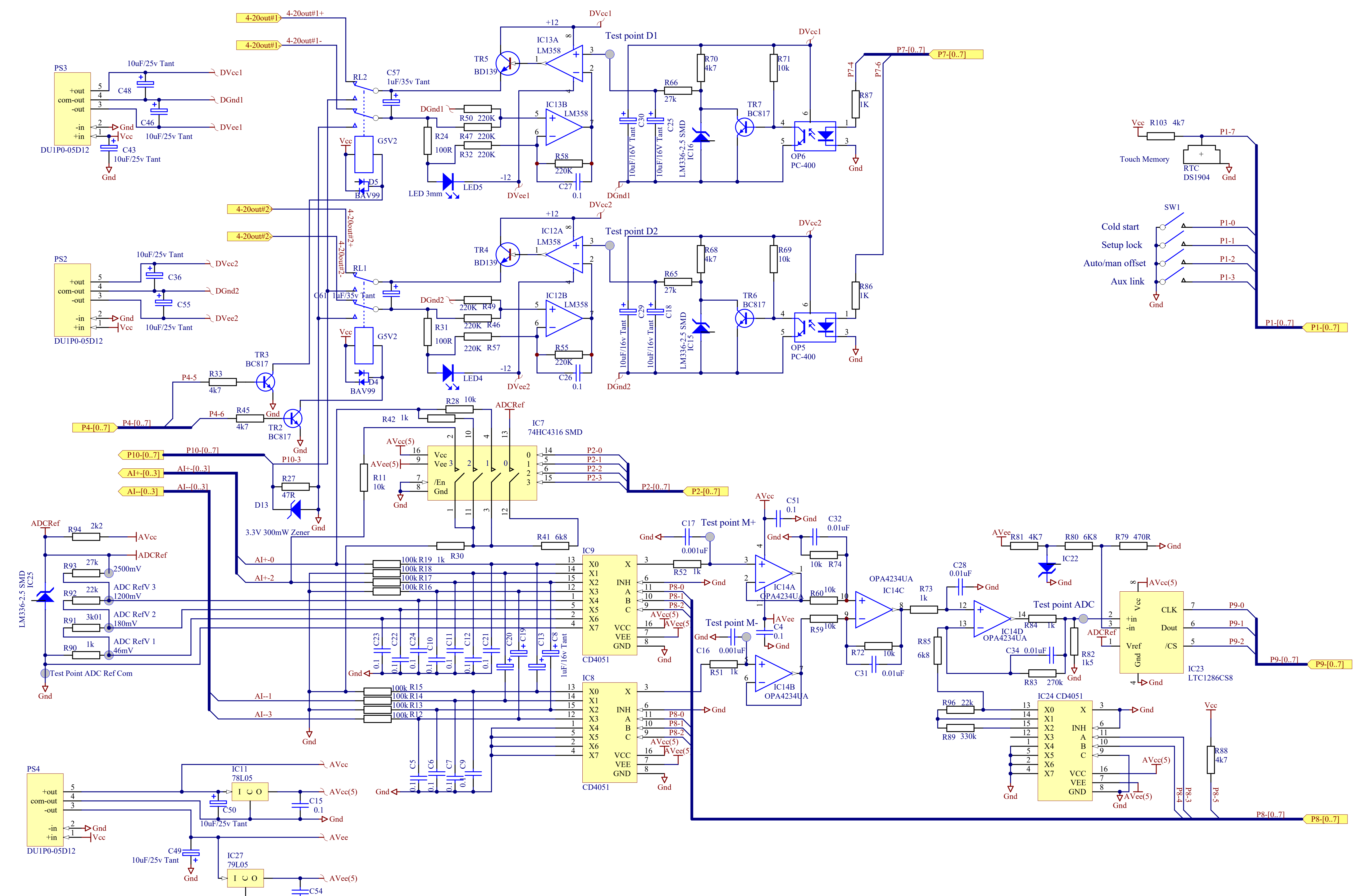
Revision: Version 1.2 G

Date: 26/02/2016

Sheet 1 of 4

File: J:\Projects------------\..\1732-1 Master.SchDoc

Drawn By:

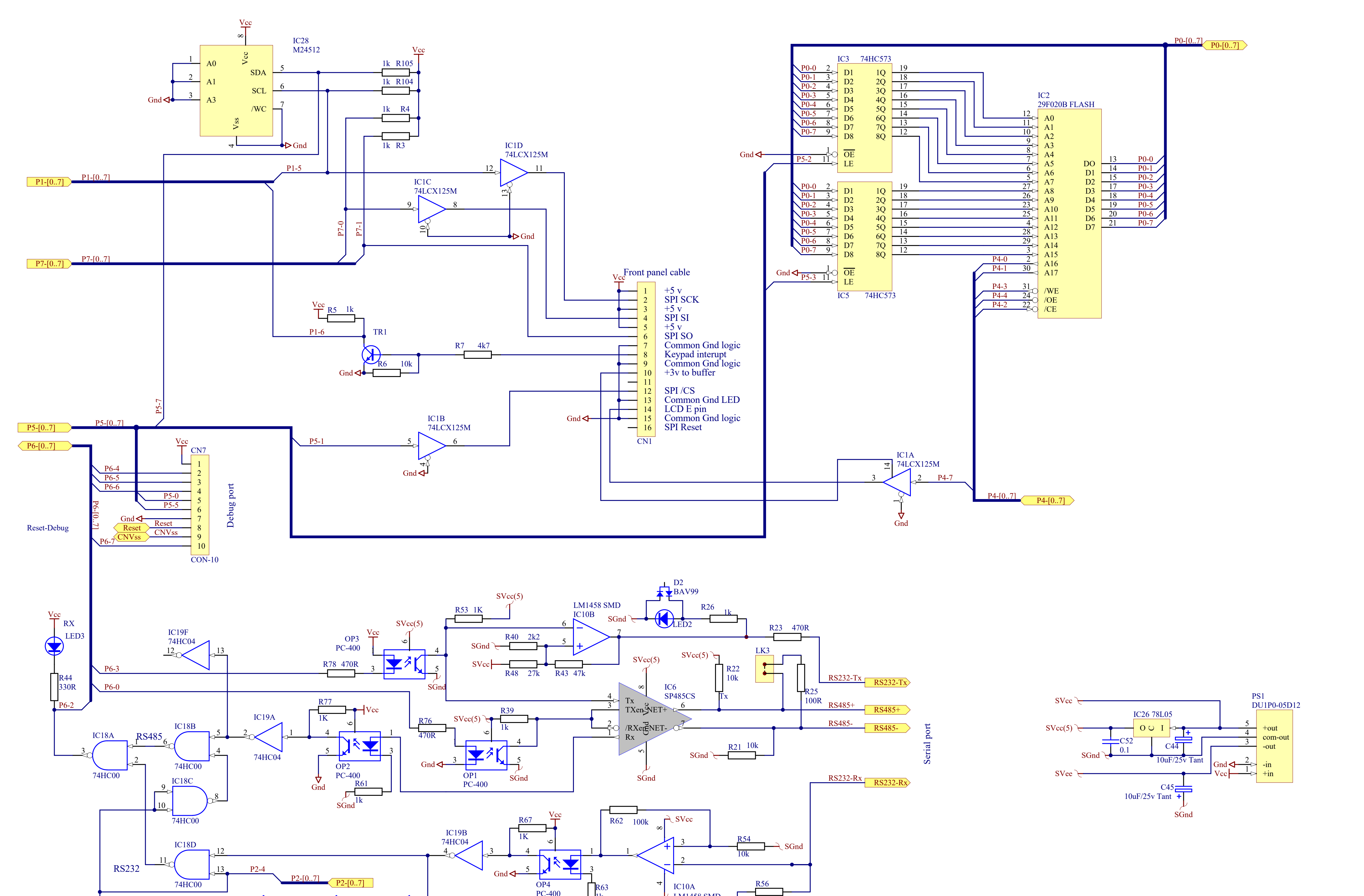


Title: **Novatech Controls** — 1730 Series Analyser

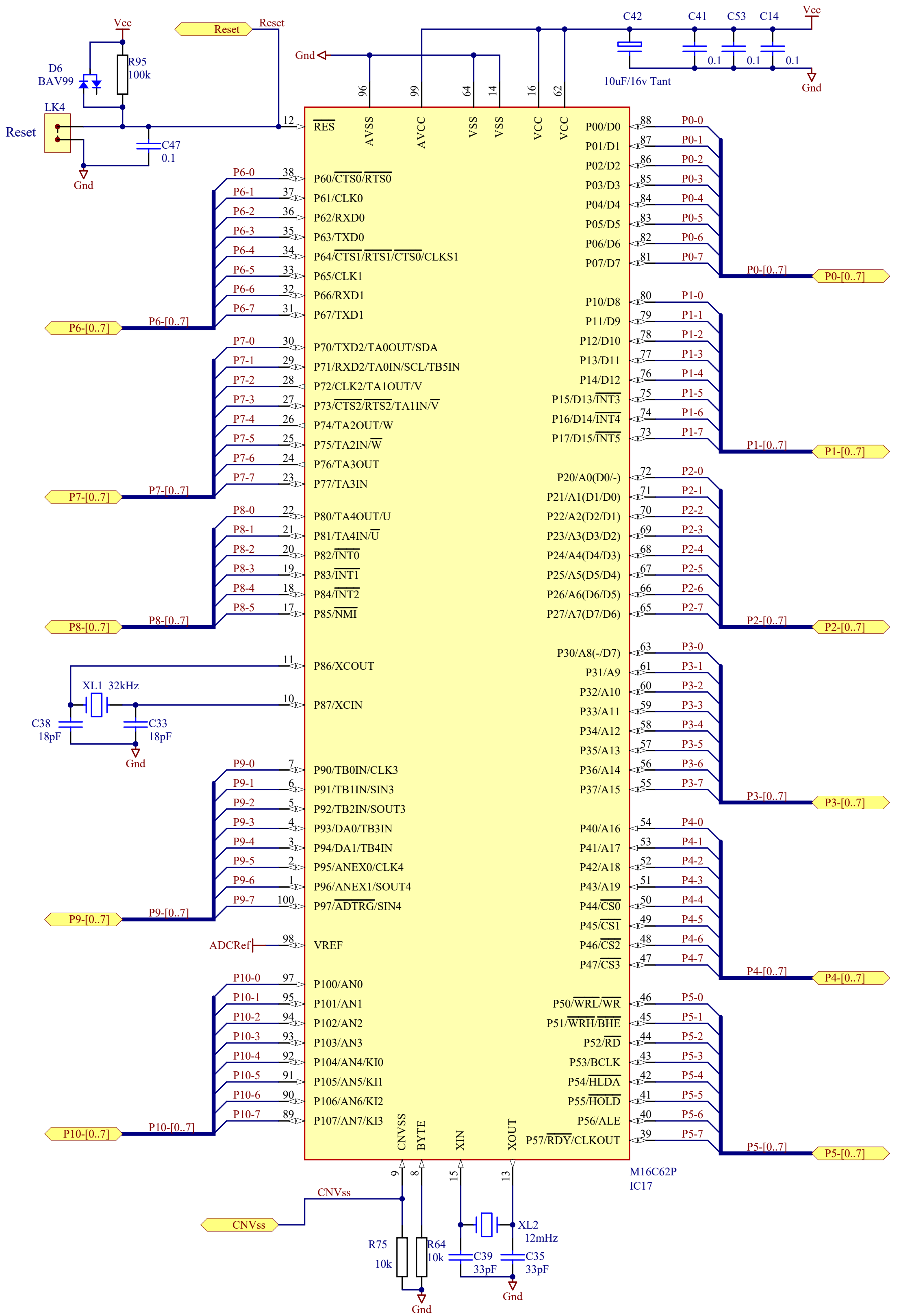
Size	Number	Revision
A3	Analogue inputs and outputs	Version 1.2 G

Date: 26/02/2016 Sheet 2 of 4

File: J:\Projects------------\..\1732-3 Analog Sch.SchDoc Drawn By:



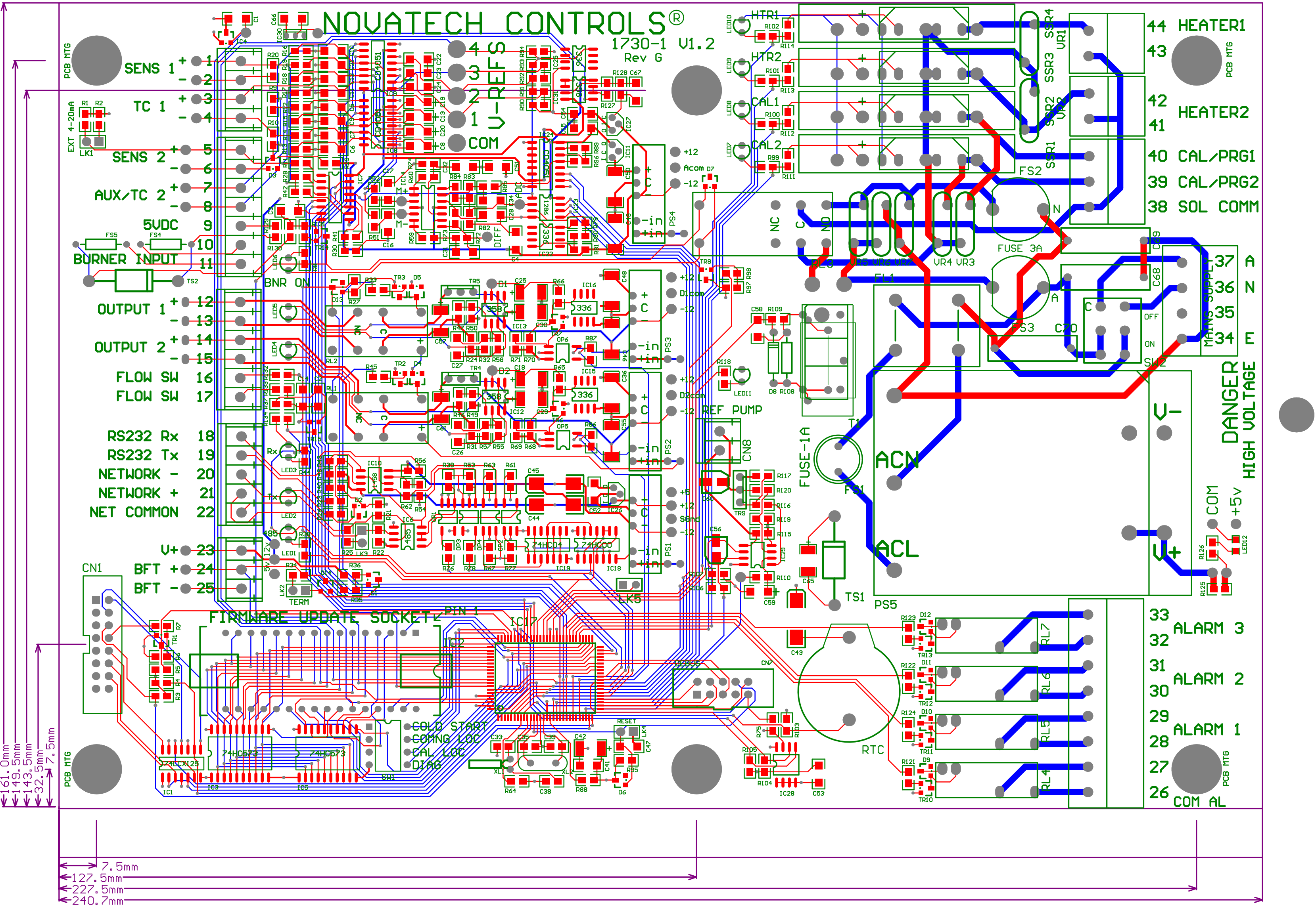
Title	Novatech Controls 1730 Series Analyser
Size	A3
Number	Serial comms and digital I/O
Revision	Version 1.2 G
Date:	26/02/2016
Sheet	3 of 4
File:	J:\Projects------------\..\1732-4 SerDig Sch.Sch
Drawn By:	



Title
Novatech Controls 1730 Series Analyser

Size	Number	Revision
A3	Microprocessor	Version 1.2 G

Date: 26/02/2016 Sheet 4 of 4
File: J:\Projects------------\..\1732-2 Micro Sch.Sch Drawn By:



NOVATECH CONTROLS®
1730-1 V1.2
Rev G
SENS 1 + 1 - 2
TC 1 + 3 - 4
EXT 4-20mA
SENS 2 + 5 - 6
AUX/TC 2 + 7 - 8
5VDC 9
BURNER INPUT 10 11
BNR ON
OUTPUT 1 + 12 - 13
OUTPUT 2 + 14 - 15
FLOW SW 16
FLOW SW 17
RS232 Rx 18
RS232 Tx 19
NETWORK - 20
NETWORK + 21
NET COMMON 22
V+ 23
BFT + 24
BFT - 25
CN1
FIRMWARE UPDATE SOCKET
PIN 1
IC17
4 3 2 1 COM
V-REFS
COLD START
COMMG LOC
CAL LOC
DIAG
RTC
REF PUMP
FUSE-1A
FUSE 3A
ACN
ACL
PS5
V-
V+
DANGER
HIGH VOLTAGE
MAINS SUPPLY
HTR1
HTR2
CAL1
CAL2
44 HEATER1
43
42 HEATER2
41
40 CAL/PRG1
39 CAL/PRG2
38 SOL COMM
37 A
36 N
35
34 E
33 ALARM 3
32
31 ALARM 2
30
29 ALARM 1
28
27
26 COM AL
PCB MTG
COM
+5v
7.5mm
127.5mm
227.5mm
240.7mm
161.0mm
149.5mm
143.5mm
32.5mm
7.5mm

Revision Changelog:

Version 1.03 (04-May-2016)

- Modified ADC counts values in test 01. Reference Voltages Summary

Version 1.02 (May 2016)

- Added chapter on total power failure

Version 1.00 (Feb 2016)

- Initial Release of this document, revised from several other technical documents.