Novatech CONTROLS PTY. LTD.

Dew Point Analyser

Model 1638

August 2009

CONTENTS

APPENDICES

Note: This manual includes software modifications up to Version 8.11, May, 2006

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USING THIS MANUAL

The Novatech 1638 Oxygen Transmitter has a variety of user-selectable functions.

They are simple to use because each selection is menu driven. For options you are not sure about; read the manual on that particular item.

Please read the safety information below and the 'Installation' section before connecting power to the analyser.

CAUTION 1

The probe or sensor heater is supplied with mains voltage. This supply has electrical shock danger to maintenance personnel. Always isolate the analyser before working with the probe or sensor.
The EARTH wire (green) from a heated probe or sensor must ALWAYS be connected to earth.

CAUTION 2

Combustion or atmosphere control systems can be dangerous. Burners must be mechanically set up so that in the worst case of equipment failure, the system cannot generate explosive atmospheres. This danger is normally avoided with flue gas trim systems by adjustment so that in the case of failure the appliance will not generate CO in excess of 400 ppm in the flue. The CO level in the flue should be measured with a separate CO instrument, normally an infrared or cell type.

CAUTION 3

The oxygen sensor which is heated to over 700°C (1300°F) and is a source of ignition. Since raw fuel leaks can occur during burner shutdown, the analyser has an interlocking relay that removes power from the probe or sensor heater when the main fuel shut-off valve power is off. If this configuration does not suit or if it is possible for raw fuel to come into contact with a hot oxygen probe or sensor then the Model 1638 analyser with a heated probe or sensor will not be safe in your application.
An unheated probe can be utilised in such applications, however the oxygen readings are valid only above 650°C (1200°F).

1

SPECIFICATIONS

Section
Number

1.1 MODEL 1638 OXYGEN & DEW POINT ANALYSER

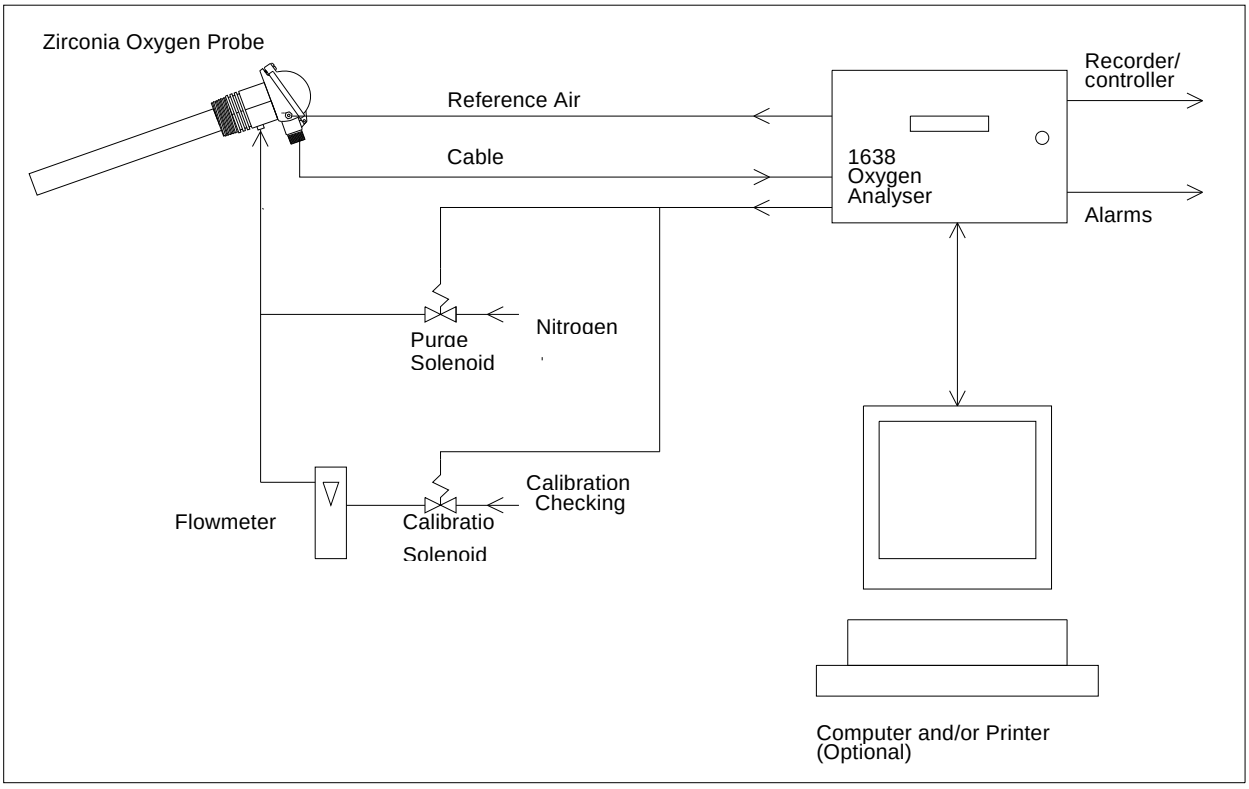
DESCRIPTION

The Novatech model 1638 oxygen analyser / transmitter provides in-situ measurement for one or two oxygen probes in annealing and other furnaces with protective atmospheres of hydrogen / nitrogen. The analyser provides local indication of oxygen and dew point plus sixteen other selectable variables.

One or two oxygen sensing probes in one process can be controlled from one analyser to providing an average and/or individual probe signals. Two linearised and isolated 4 to 20 mA output signals are provided for oxygen and for dew point. Alarms are displayed at the analyser and relay contacts activate remote alarm devices. The analyser, which is available for heated or unheated zirconia oxygen probes, provides automatic on-line gas calibration check of the probe and filter purging. The electronics self-calibrates all inputs every minute.

The 1638 has a keyboard for selecting the output range, thermocouple type, etc., as well as maintenance and commissioning functions. The instrument is microprocessor based and all adjustments are made using the keyboard.

- Used for product quality control to avoid blueing or browning of steel products during the annealing process
- Used for monitoring hydrogen / nitrogen protective atmospheres in applications such as lead holding furnaces
- Automatic selection of second probe on probe failure
- Simple to install
- Linear output of % oxygen and dew point for recording or control
- Built in safety features
- 24 different alarm conditions that warn the operator of oxygen, dew point, probe or analyser problems
- Isolated RS 232-C printer/computer interface and an RS 485 MODBUS network interface
- Safety interlock relay for heated oxygen probes



Oxygen Probe and Analyser System

SPECIFICATIONS

Inputs

- Zirconia oxygen probe, heated or unheated
- Furnace thermocouple, field selectable as type K or R
- Process purge complete / main flame established safety interlock (for heated probes)
- Purge pressure switch
- Remote alarm accept

Outputs

- Two linearised 4 to 20 mA DC outputs, max. load 1000Ω
- Common alarm relay
- Three other alarm relays with selectable functions

Computer

- RS 232-C or RS 485 for connection of a computer terminal or printer for diagnostics of the analyser, sensing probe, or process. This connection is suitable for network connection to computers, DCSs or PLCs using MODBUS protocol.

Range of Output 1

Field selectable from the following:

Output	*Zero Range*	*Span Range*
Dew point	-60°C to +20°C	-40°C to +40°C
	-76°F to +84°F	-56°F to +104°F
Linear oxygen	0 to 99 %	1 to 100 %
Oxygen, reducing range	1.0^{-16} % oxygen	1.0^{-30} % oxygen
If 2 probes are used -		
Linear oxygen, probe 1	0 to 99 %	1 to 100 %
Reducing oxygen output probe 1	1.0^{-16} % oxygen	1.0^{-30} % oxygen
Dew point, probe 1	-60°C to +20°C	-40°C to +40°C
	-76°F to +84°F	-56°F to +104°F
Linear O_2, probe 1 & 2 averaged	0 to 99 %	1 to 100 %
Reducing O_2 , probe 1 & 2 averaged	1.0^{-16} % oxygen	1.0^{-30} % oxygen
Dew point, probe 1 & 2 averaged	-60°C to +20°C	-40°C to +40°C
	-76°F to +84°F	-56°F to +104°F

Note:
The average dew point, linear O_2 and Reducing O_2 selections will automatically select to the operating probe if one probe fails, or selects probe 1 if both probes fail.

Range of Output 2

Field selectable from the following:

Output	*Zero Range*	*Span Range*
Linear O_2	0 to 99 %	1 to 100 %
Oxygen, reducing range	1.0^{-16} % oxygen	1.0^{-30} % oxygen
Dew point	-60°C to +20°C	-40°C to +40°C
	-76°F to +68°F	-40°F to +104°F
Sensor EMF	0 to 1200 mV in 100 mV steps	100 to 1300 mV in 100 mV steps
Aux Temperature	0 to 1300°C in 100°C steps	100 to 1400°C in 100°C steps
If 2 probes are used -		
Linear O_2 , probe 2	0 to 99 %	1 to 100 %
Oxygen, reducing range, probe 2	1.0^{-16} % oxygen	1.0^{-30} % oxygen
Dew point, probe 2	-60°C to +20°C	-40°C to +40°C
	-76°F to +68°F	-40°F to +104°F
Probe EMF 1	0 to 1200 mV in 100 mV steps	100 to 1300 mV in 100 mV steps
Probe EMF 2	0 to 1200 mV in 100 mV steps	100 to 1300 mV in 100 mV steps

Range of Indication, Upper Line

- Oxygen auto ranging from 10^{-30} to 100 %
- Dew point -60 °C to +40 °C, -76 °F to +104 °F

Indication Choice, Lower Line
Any or all of the following can be selected for lower line display:

- Dew point probe 1
- Dew point probe 2 **
- Dew point probe 1 and 2 averaged **
- Date - time
- Run Hours since last service
- Date of last service
- Oxygen probe 2 **
- Oxygen probe 1 and 2 averaged **
- Probe EMF 1
- Probe EMF 2 **
- Temperature probe 1
- Auxiliary Temperature *
- Temperature probe 2 **
- Impedance probe 1
- Impedance probe 2 **
- Ambient Temperature
- Ambient Relative Humidity

* If the analyser is enabled for 1 probe
** If the analyser is enabled for 2 probes

Accuracy

- ±1% of actual measured oxygen value with a repeatability of ±0.5% of measured value.

Relay Contacts

- 0.5A 24 VAC, 1A 36 VDC

Environmental Rating

- Operating Temperature: -25 to 55°C
- Relative Humidity: 5 to 95% (non-condensing)
- Vibration: 10 to 150Hz (2g peak)

Power Requirements

- 240 or 110V, 50/60 Hz, 105 VA (heated probe)
- 240 or 110V, 50/60 Hz, 5 VA (unheated probe)

Weight

- Analyser, 3.75 kg

Degree of Protection

- IP65 without reference air pump
- IP54 with reference air pump

Mounting

- Suitable for wall or surface mounting.

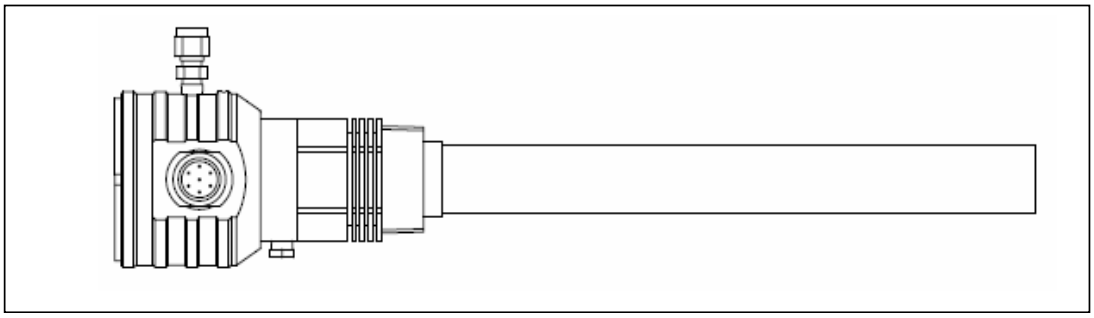
1.2 SERIES 1230 OXYGEN PROBES & SENSORS

DESCRIPTION

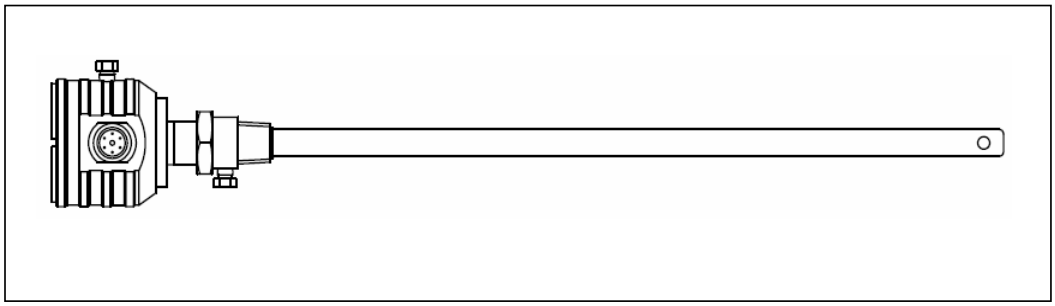
Novatech series 1230 oxygen probes and sensors employ state-of-the-art zirconia sensors and advanced materials, which provide the following benefits:

- Improved control due to fast response time to typically less than four seconds
- Cost-efficient design provides improved reliability
- Longer-life probes with greater resistance to corrosion from sulphur and zinc contaminants in flue gas
- Low cost allows maintenance by replacement
- Reduced probe breakage due to greater resistance to thermal shock and mechanical damage during installation and start-up
- Series 1230 probes are simple to install and maintain. All models provide direct measurement of oxygen level. On-line automatic calibration check is available if required. Probes may be used with Novatech combustion controllers and some analyser models from other manufacturers.

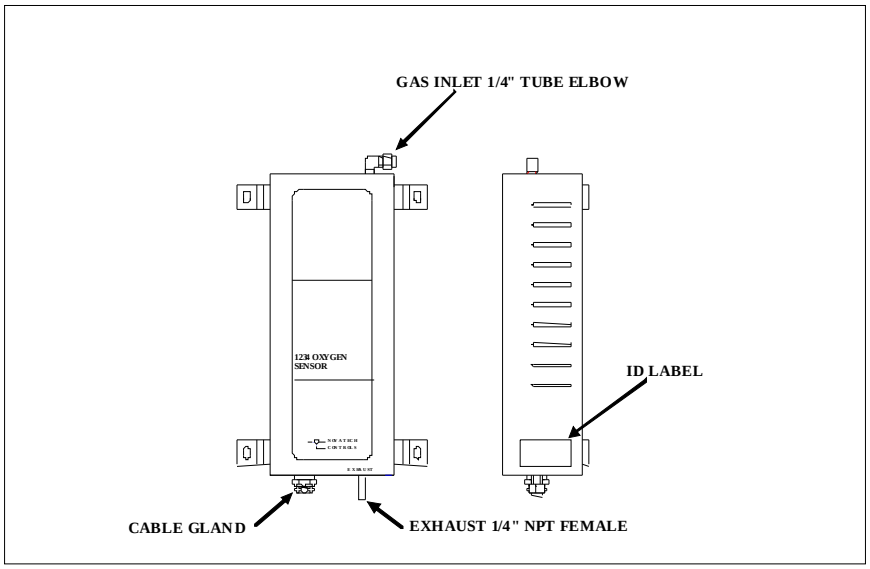
All Novatech oxygen probes are designed and manufactured to exacting standards of performance and reliability. Series 1230 probes are the result of extensive research and development by Novatech, industry and government agencies. Novatech Controls provides application and after sales support for oxygen probes, sensors and analysers, worldwide.



Model 1231 Heated Oxygen Probe



Model 1232 Unheated Oxygen Probe



Model 1234 Oxygen Sensor

STANDARD PROBE 'U' LENGTHS

1231
250 mm (10")
350 mm (14")
500 mm (20")
750 mm (30")
1000 mm (40")
1500 mm (60")
2000 mm (80")

1232
500 mm (20")
750 mm (30")
1000 mm (40")
1500 mm (60")

Ordering Information

1. Probe insertion length (from process end of mounting thread to probe sensing tip).
2. Mounting thread (process connection), BSP or NPT (for size of thread refer to specifications).
3. Lagging extension length, if required.
4. If model 1232 probe, state preferred thermocouple type (refer to specifications).

OXYGEN PROBE SPECIFICATIONS

MODEL	1231	1232
Application	Furnaces operating below 900°C refer to note 1	Furnaces operating above 700°C with no contaminants.
Temperature Range	0 to 900°C (0 to 500°C with filter fitted)	700 to 1400°C
Length	250 to 2000 mm	500 to 1000 mm
Process Connection	1 1/2" BSP or NPT	3/4" BSP or NT
Electrical Connection	Weather-proof plug-in connector or optional screw terminals. The plug connector is supplied with the cable. Ex(e) heads have screw terminals.	
Cable	Order a specific length with the analyser except for hazardous installations where the cable is supplied by the customer.	
Heater	Yes	No
Furnace Thermocouple	Refer to note 3	R or S, integral
Response Time	Typically < 4 secs.	Typically < 1 sec
Head Temperature	-25 to 100°C with weatherproof connector -25 to 150°C with screw terminals	
Reference Gas	Ambient air 50 cc/min approx. Pump supplied with analyser	
Ref Air Connection	1/4" Tube	Integral air line in probe cable or external ¼" tube.
Optional Filter	Sintered titanium alloy particulate filter, replaceable, 30 or 15 micron.	
Calibration Check Gas Connection	1/8" NPT female	1/8" NPT female
Weight	2 kg plus 165 g / 100 mm	1 kg plus 100 g / 100 mm

Notes:

1. Care must be taken to avoid contact with explosive or inflammable gases with 1231 heated probes. Novatech analysers have built in safety protection.
2. Please contact factory for corrosives other than sulphur or zinc. We can provide test materials to try in your atmosphere.

OXYGEN PROBE MODEL SELECTION GUIDE

Heated probes-temperature range 0-900°C.

1231 -	**U Length -**	**Outer Sheath -**	**Internal Thermocouple -**	**Mounting Thread**
Basic model	2. 250mm 3. 500mm 4. 750mm 5. 1000mm 6. 1500mm 7. 2000mm	1.316 SS max 850°C 2. Inconel *(1)	1. Type K max 900°C	1. BSP 2. NPT

*Note:

1. The Inconel option has all inconel wetted parts except for the ceramic sensor and viton 'O' rings.

Unheated probes for clean gases-temperature range 700-1400°C.

1232 -	**U Length -**	**Outer Sheath -**	**Internal Thermocouple -**	**Mounting Thread**
Basic model	3. 500mm 4. 750mm 5. 1000mm 6. 1500mm	1. 253 MA-max 1200°C 3. High Purity Alumina max 1300°C Horizontal max 1400°C Vertical 4. 446 SS max 1000°C	1. Nil *(2) 4. Type R max 1400°C	1. 3/4" BSP fixed 2. 3/4" NPT fixed

*Note:

1. For applications up to 1200°C it may be more economical to use a separate type "K" or "N" thermocouple than the internal "R" thermocouple. It is important that a separate thermocouple senses the same temperatures as the oxygen probe tip.

1.3 PURGE & CALIBRATION CHECK ACCESSORIES

Due to the absolute measurement characteristics of zirconia sensors and the self calibration features of Novatech analysers, probe calibration checks with calibrated gas are not normally required. In some installations however customers prefer the have a calibration check facility.

Novatech probes and analysers provide a ready method of connecting on-line calibration check gases. They provide on-line automatic checking of probe and analyser calibration, as well as a probe purge facility.

The absolute characteristics of zirconia sensors require only one calibration check gas to properly check the probe's performance. Where required however, the dual gas calibration check facility can be utilised.

Dirty furnace applications often require the back purge facility to keep a probe filter free from blockage. (In these applications, it is more reliable to install probes pointing vertically downwards with no filter). Purge and calibration check solenoid valves can be operated manually or automatically from a 1638 analyser.

The external components required for automatic / manual gas calibration checking are:

- A calibration check gas flow meter/regulator
- A mains voltage (240 or 110 VAC) solenoid valve for each calibration check gas

The external components required for automatic / manual purging are:

- A mains voltage (240 or 110 VAC) purge solenoid valve
- A purge pressure switch, 0 to 35 kPa (0 to 5 psi), to test for filter blockage.

The user should supply:

- Span gas cylinder(s), typically 2 % oxygen in nitrogen or a similar percentage of 0_2 close to the normal level in the gas stream being measured, to ensure fast recovery.
- A 100 kPa (15 psi) clean and dry nitrogen supply when filter purging is required.

1.4 FILTER PURGE PRESSURE SWITCH

To automatically sense a blocked probe filter, a pressure sensor should be connected to the 'purge' line to the probe 'cal' port. It should be adjusted so that it energises just above the purge pressure with a new or clean filter installed. The switch contacts should be connected to terminals 12 & 13 (PURGE FL SWITCH). If the filter is still blocked or partly blocked after an auto purge cycle, the pressure switch will energise and cause a 'Probe Filter Blocked' alarm. The contacts must be normally closed.

The pressure switch should have an adjustable range of 0 to 35 kPa (0 to 5 psi).

2

DESCRIPTION

Section
Number

DESCRIPTION

2.1 THE ANNEALING PROCESS (OR OTHER SIMILAR APPLICATIONS)

The annealing process is carried out in an atmosphere of hydrogen and nitrogen to protect the surface of the steel from oxidising and discolouring during the annealing process. There is usually some air leakage in a furnace and the hydrogen serves to “mop up” the oxygen by combining with it to form water vapour.

2.2 THE OBJECTIVE OF ATMOSPHERE MONITORING

The primary objective of monitoring the furnace atmosphere is to be able to measure whether the steel product in the furnace will become oxidised during the process and to raise an alarm to warn the operator that there is a problem.

2.3 WHAT DO WE NEED TO MEASURE?

The variable that we need to measure to monitor the atmosphere to prevent oxidation of the product is the oxygen partial pressure at the surface of the steel. At any particular furnace temperature, there is a unique oxygen partial pressure, above which the steel will tend to oxidise and below which no oxidation will occur. The steel acts as a catalyst in the hydrogen / nitrogen bringing the gas at the surface close to chemical equilibrium. The composition of the gas at the surface is normally different from that of the gas nearby. For example, trace oxygen is quickly converted to water vapour.

In the gas, a reaction to form water vapour requires collisions involving two hydrogen molecules and one oxygen molecule, the probability of which is low. On the surface of the steel, one or the other of the molecules becomes partly immobilised. This increases the probability of successful collisions to form water vapour. Essentially, gas molecules are held on the steel surface, waiting for the complementary molecule(s) to arrive.

2.4 ZIRCONIA OXYGEN PROBE MEASUREMENT

The catalytic process which occurs on the surface of the steel also occurs on a zirconia oxygen sensor. This means that the measurement of the oxygen level with a zirconia oxygen sensor exactly duplicates the equilibrium conditions of the gas at the surface of the steel. It measures the oxidation potential of the gas or its potential to damage or discolour the steel.

2.5 OTHER TYPES OF OXYGEN MEASUREMENT

Other types of oxygen analysers such as a paramagnetic analyser measure the unreacted molecular level of oxygen in the furnace atmosphere, which has no direct thermodynamic relationship with the effect of the gas on the steel. These analysers are not useful for measuring the oxidation potential in annealing furnace atmospheres.

2.6 DEW POINT MEASUREMENT

Dew point measurement was commonly used in the past because dew point analysers were the only technology available at the time. Dew point can be related to the oxidation potential of the furnace atmosphere but the relationship depends on how much hydrogen is available at the surface of the steel. With dew point held constant, if the hydrogen level varies, so will the oxidation potential of the atmosphere. Dew point measurement is not the best method of measurement because of this. Also dew point instruments normally have limited reliability in on-line applications on annealing furnaces.

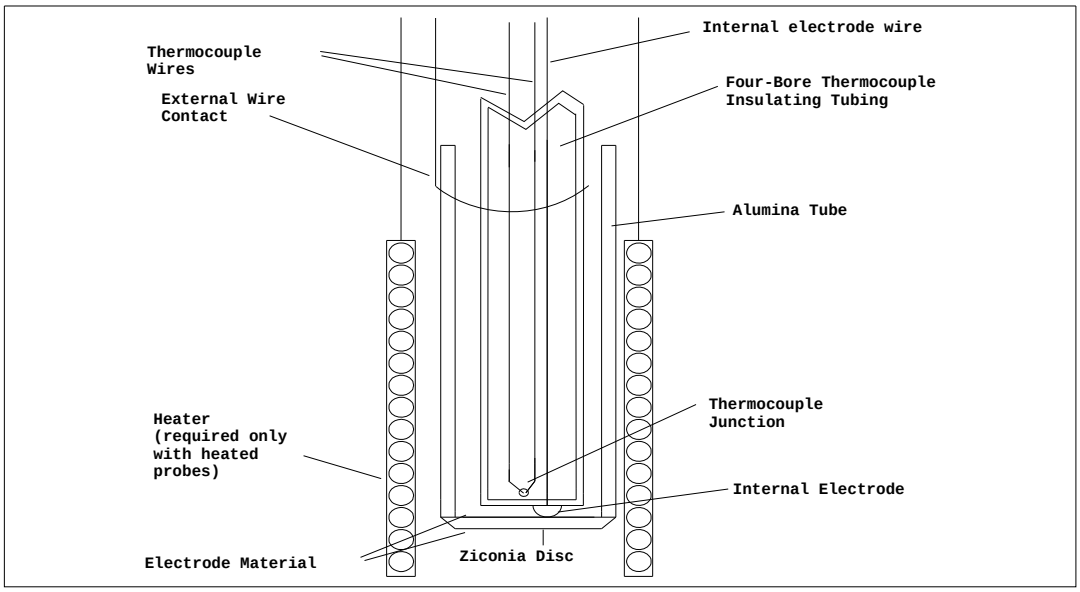
With a known hydrogen level, the dew point in the furnace can be calculated. This is provided as an output on a standard Novatech 1638 analyser but we recommend the use of the oxygen output from the same analyser. Both outputs are available simultaneously for operators who are more used to furnace dew point levels. The dew point output however is only an approximate guide if the hydrogen level in the furnace varies.

2.7 IN-SITU OXYGEN PROBES

There are very few oxygen probes on the market, which can operate reliably in an annealing furnace atmosphere at furnace temperatures. Novatech probes have been developed in co-operation with BHP steel for annealing furnace applications to provide a reliable measurement for monitoring both continuous and batch furnaces. BHP now have 60 Novatech probes and analysers installed to protect their products during the annealing process. These sensing probes give long life with no need for calibration. The most important feature however is that Novatech oxygen probes measure the oxygen partial pressure just as it occurs at the surface of the steel.

2.8 THE ZIRCONIA SENSOR

The analyser input is provided from a solid electrolyte oxygen probe, which contains a zirconia element and thermocouple. The probe is designed to be inserted into a furnace. Sampling lines and filters are not required for in-situ probes. When a sampling line is required, the sample flows to the sensor under process pressure in most applications. In applications where the process pressure is negative or neutral, a suction pump will be required. A reference air pump is provided in the 1638 oxygen analyser. The internal construction of a probe is shown as follows.



Schematic View of a Sensor Assembly

The heater control in the 1638 analysers consists of a time proportioning temperature controller and solid state relay so that the thermocouple junction is controlled to 720°C. Probes operating in a combustion environment above 650°C do not require a heater. When exposed to different oxygen partial pressures at the outside and inside of the sensor, an EMF (E) is developed which obeys the Nernst equation:

$$E(millivolts) = \frac{RT}{4F}\log_e\left(\frac{(PO_2)inside}{(PO_2)outside}\right)$$

Where T is the temperature (K) at the disc (>650°C), R is the gas constant, F is the Faraday constant and (PO_2) INSIDE and (PO_2) OUTSIDE are the oxygen partial pressures at the inner and outer electrodes, respectively, with the higher oxygen partial pressure electrode being positive.

If dry air at atmospheric pressure, (21 % oxygen) is used as a reference gas at the inner electrode, the following equations are obtained:

$$E(millivots) = 2.154\times10^{-2}T\log_e\frac{0.21}{(PO_2)outside}$$

Transposing this equation

$$(\%O_2)outside(ATM) = 0.21\exp\frac{-46.421ER}{T}$$

The 1638 transmitter solves this equation which is valid above 650°C. The probe heater, or the process maintains the sensor temperature at this level.

2.9 THE ANALYSER

The 1638 analyser is a transmitter with two 4 to 20 mA outputs. One output is % oxygen or dew point with selectable zero and span. The second output can be selected as dew point, oxygen, auxiliary temperature or sensor EMF. Four alarm relays are provided. Refer to the sections 4.2 and 4.3 for more details.

The 1638 analyser is designed to operate with either one or two heated or unheated, zirconia probes in one process. If two probes are being used, the analyser can average the two oxygen and dew point signals, alarm when there is a high difference, transmit and display the average and/or individual oxygen signals.
If heated probes are being used, the analyser will maintain the temperature of the sensor(s) at 720°C. The analyser solves the Nernst equation and will provide accurate oxygen measurements up to 1500°C (2730°F), although most probes are suitable only to 1400°C (2250°F). 1231 heated probes are limited to 900°C (1650°F).

2.10 ALARMS

Refer to OPERATOR FUNCTIONS Section 4 for details on alarm functions.

2.11 HEATER

CAUTION

The probe heater is supplied with mains voltage. This supply has electrical shock danger to maintenance personnel. Always isolate the analyser before working with the probe.
The EARTH wire (green) from the probe / sensor must ***always*** be connected to earth.

The heater is supplied from the mains power directly, and the temperature is controlled initially at over 700°C (1300°F) after turn on.

2.12 APPLICATIONS WHERE SENSING POINT IS NOT AT ATMOSPHERIC PRESSURE

To apply the 1638 analyser to processes, when the pressure at the point of measurement is significantly above or below atmospheric pressure, then compensation must be applied. (Refer to Set-up Steps 34 and 35 in Section 5.5). If two sensors are being used, they must be close to the same pressure.

2.13 PROBE IMPEDANCE

The probe impedance is a basic measurement of the reliability of the oxygen reading. A probe with a high impedance reading will eventually produce erroneous signals. The analyser regularly checks the probe impedance and if the impedance is above the maximum level for a specific temperature then the impedance alarm will be activated. Typical probe impedance is 1 KΩ to 8 KΩ at 720° C.

2.14 AUTO CALIBRATION – ELECTRONICS

The analyser input section is self calibrating. There are no adjustments. The analog to digital converter input stages are checked against a precision reference source and calibrated once every minute. Should the input electronics drift slightly then the drift will be automatically compensated for within the microprocessor. If a large error occurs due to an electronic fault then an ‘ADC CAL FAIL’ alarm will occur.

A one-off calibration procedure of the precision reference sources should never need to be repeated for the instrument life unless the instrument has been repaired. For a description of the calibration procedure, refer to ‘Setting Up The Analyser’ Section 5.5, items 7, 8 9 and 10.

The digital to analog converters or output section of the analyser are tested for accuracy every minute and if they are found to have an error then a ‘ADC CAL FAIL’ alarm will occur. The D/A sections are re-calibrated by pressing the ‘AUTO CAL’ button on the keyboard while in 'SET-UP' mode.

All output signals will drop to 0 mA for a one second period. It is suggested that a D/A re-calibration be performed after the instrument has stabilised, approximately 30 minutes after first switching on and after Setting Up The Analyser Section 5.5, items 6, 7, 8 and 9 have been completed, and then annually.

2.15 AUTO CALIBRATION CHECKING – PROBES

On-line automatic gas calibration check is not normally required. Where it is required however, the probe can be checked for accuracy in-situ and on-line. Solenoid valves can admit up to two calibrated gas mixtures into the probe via solenoid valves under microprocessor control on a timed basis. For details on installation refer Section 3.11. For details on setting up this facility refer to Set-up steps 41 to 53 in Section 5.5.

During probe auto calibration checking, the analyser output will freeze and remain frozen for a further adjustable period, allowing the probe time to recover and continue reading the furnace oxygen level.

Calibration check gases may be manually admitted by pressing the 'CAL' buttons on the keyboard while in 'RUN' mode. The analyser output is frozen during the pressing of these buttons and immediately becomes active when the button is released. If calibration gas checking is enabled in the Set-up menu for either gas, an automatic gas cycle can be started by pressing the 'CAL' buttons in RUN mode. The cycle can be terminated by pressing any other button.

2.16 AUTO PURGE

In steel annealing applications it is expected that the furnace will be gas fired. However, in oil and coal fired plant, it is possible for the probe sensing filter to become blocked. An automatic purge cycle can be set up so that a blast of air or nitrogen, maximum 100 kPa., will automatically back-flush the probe filter on a timed basis. Refer to Set-up steps 36 to 40 in Section 5.5. A purge pressure switch will sense if there is insufficient flow to clear the filter during the purge cycle. In this case a 'PROBE FILTER' alarm will occur. The probe can be manually purged from the keyboard while in 'RUN' mode. The analyser output is not frozen during or after the pressing of this button.
Automatic or manual purge is not available if two probes are being used. However, one of the gas check output could be used to purge the filter.

2.17 RS 485 AND RS 232C PORT

The serial port is for connecting a printer, a data logger, or any computer with an RS485 MODBUS or 232-C port. It can be used to monitor the transmitter and process by logging the values of functions selected in step 70 of the Set-up menu in Section 5.5. The log period may be selected in step 71, and the baud rate may be set in set-up step 72. Alarms, including the time they occurred, will be transmitted to the printer and computer whenever they are first initiated, accepted and cleared. The protocol for the serial port is eight data bits, one stop bit, no parity. Please contact the factory for further details on serial communications with external systems such as computers, DCS's or PLC's. The MODBUS address is set in step 81 of the set-up menu.

2.18 AUXILIARY TEMPERATURE THERMOCOUPLE

A furnace thermocouple should also be connected when an additional temperature display or transmitted signal is required. This input is not available if two probes are being used.

2.19 WATCHDOG TIMER

The watchdog timer is started if the microprocessor fails to pulse it within any one second period, (ie. fails to run its normal program). The microprocessor will then be reset up to three times until normal operation is resumed. Reset cycles are displayed by the POWER light on the keyboard. A steady 'ON' light indicates normal operation. If the program has not resumed normal operation after three attempts to reset, the common alarm relay will be activated. The reset function will continue repeatedly after the alarm. If a successful reset is achieved, the alarm will be cancelled and the analyser will continue to run normally.

2.20 BACK-UP BATTERY

The transmitter's RAM and real-time clock are backed up by a lithium battery in the event of power failure. All set-up variables are saved and the clock is kept running for approximately ten years with the power off. The battery module should be replaced every 8 years. (It is the battery shaped device clipped in a socket labelled M1 on the 1630-1 PCB)

3

INSTALLING & COMMISSIONING

Section Number

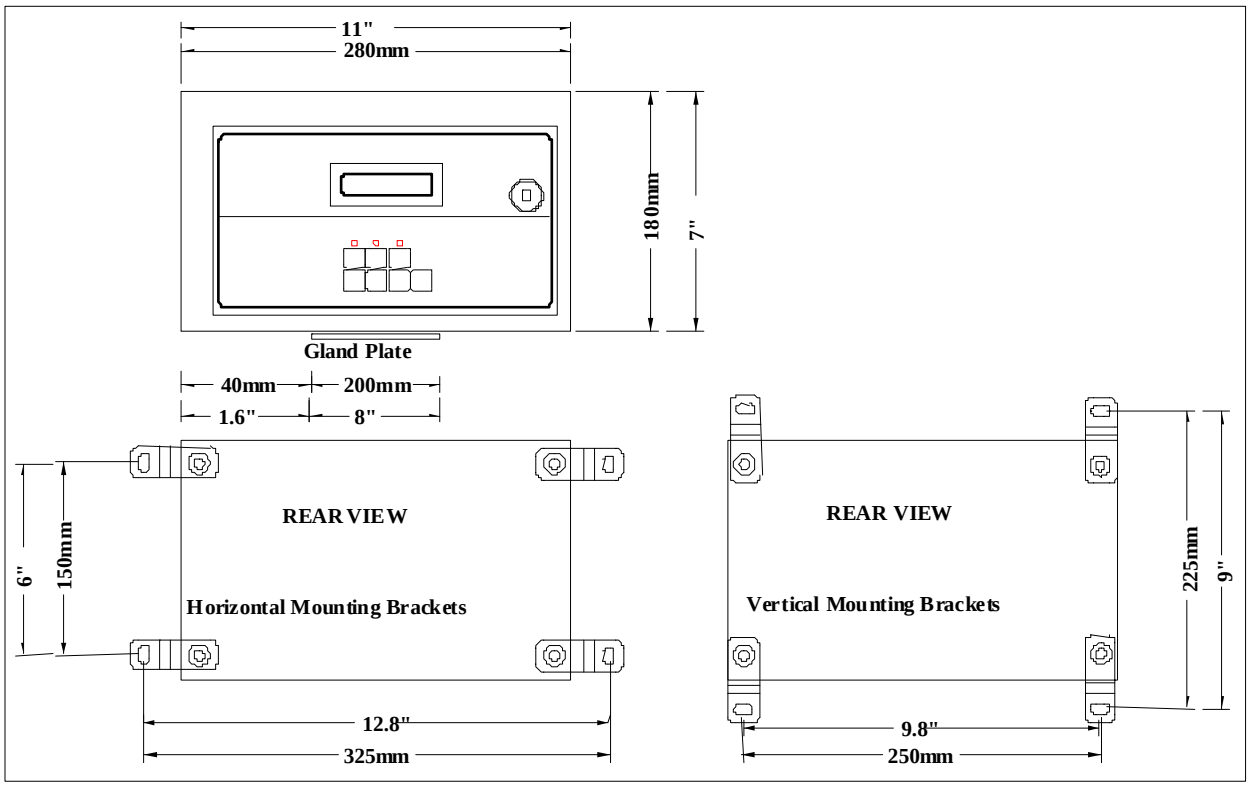
INSTALLATION

COMMISSIONING

INSTALLATION

3.1 MOUNTING THE ANALYSER

Surface mount the transmitter case on to a flat surface or bracket, using the four mounting brackets provided.



Case Mounting Dimensions

3.2 INSTALLING A 1231 OXYGEN PROBE

Weld a BSP or NPT socket to the furnace in a suitable position for sensing the furnace atmosphere. For the correct size of socket refer to probe data in Section 1. The oxygen probe is normally installed pointing **vertially upwards** in removable cover, coil annealing furnace. Probes can be mounted at any angle. If there are any particulates in the furnace, the filter can be omitted by pointing the probe vertically downwards. Otherwise the filters may have to be replaced periodically.

If installing a probe into a hot environment, slide the probe in slowly to avoid thermal shock to the internal ceramic parts. If the furnace is 1000°C, it should take approximately ten minutes to install a 500 mm. probe, moving it in about 20 mm steps.

CAUTION

The oxygen probe should protrude into the furnace at least 25 mm. If the furnace has high velocity fan circulation a filter should be used on 1231 oxygen probes or, in extreme cases, a flow diverting vane. Without a filter or vane the fan velocity can cool the 1231 heater.

Although it is rare, occasionally a probe may sense oxygen vastly differently from the average reading in the furnace. If it occurs, then the probe should be moved, or a longer probe installed. This phenomena is normally caused by stratification of the furnace atmosphere.

3.3 INSTALLING THE AUXILIARY THERMOCOUPLE

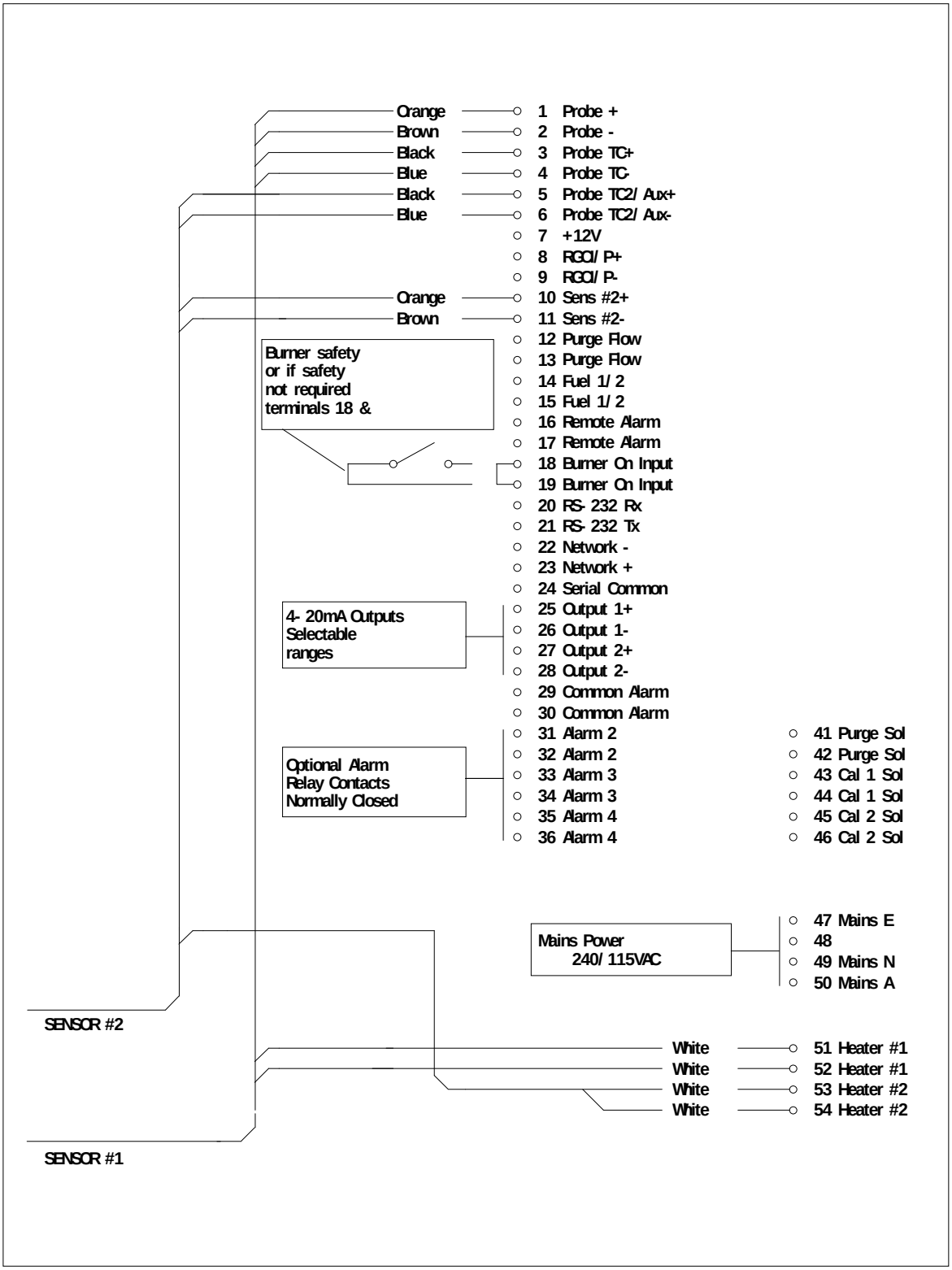
Weld a 1/2 inch BSP mounting socket to the furnace within about 300 mm, and upstream of the oxygen probe. The thermocouple should be of similar length to the oxygen probe to prevent furnace temperature distribution errors.

3.4 SHIELD CONNECTIONS

All external wiring to the 1638 analyser should be shielded. Do not connect shields at the field end. Simply clip off and insulate. An extra terminal strip may be required to connect all shields together. This should be supplied by the installer.

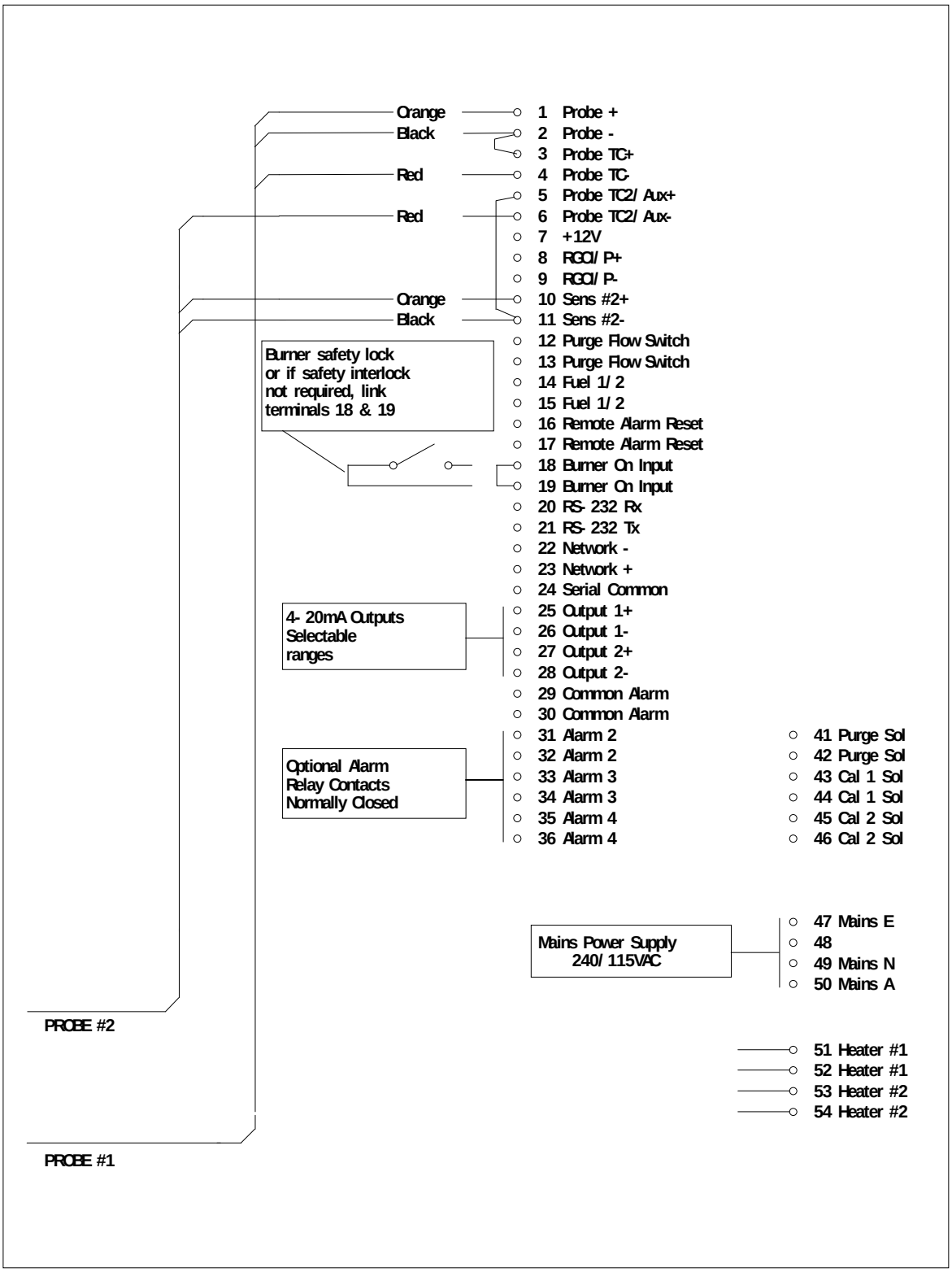
3.5 ELECTRICAL CONNECTIONS

All wiring should comply with local electrical codes. The printed circuit boards are fully floating above earth. All earth and shield connections should be connected to the earth stud on the LHS inside the case. Before connection of mains power check that the 115 / 230 volt power selector switch is set to the correct voltage.



Connection Diagram for 1638 Analyser and one or two 1231 Heated Sensors

All wiring should comply with local electrical codes. The printed circuit boards are fully floating above earth. All earth and shield connections should be connected to the earth stud on the LHS inside the case. Before connection of mains power check that the 115 / 230 volt power selector switch is set to the correct voltage.



Connection Diagram for 1638 Analyser and one or two 1232 Unheated Sensors

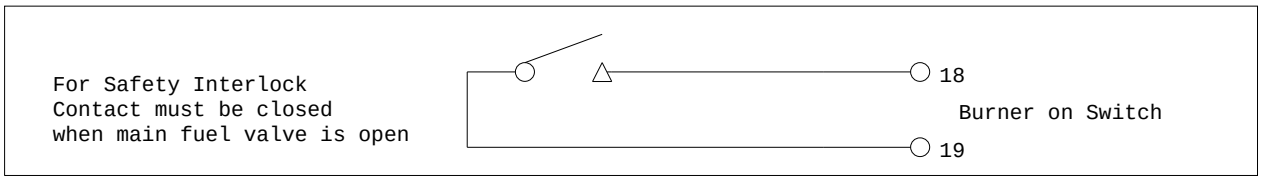
3.6 HEATER INTERLOCK RELAYS

CAUTION

Explosion protection for heated probes is achieved by switching the power to the probe heater off whenever the main fuel valve is closed.

The principle of safety is that if the main fuel valve is open then main flame has been established. With this primary source of ignition on, the probe heater can be safely switched on. The most dangerous situation is if fuel or hydrogen leaks into the furnace when the fuel valve is closed. When power is removed from the main fuel valve the heater should be switched off.

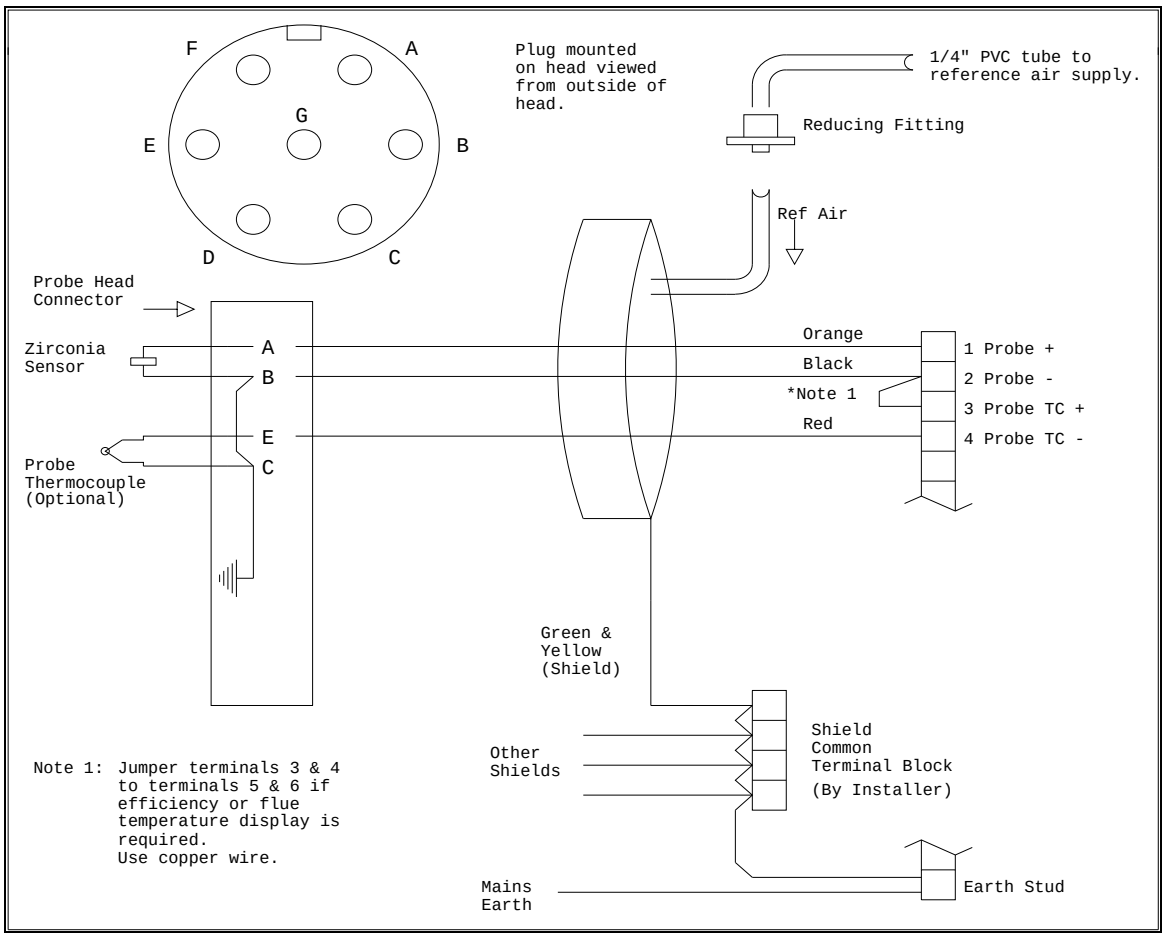
To achieve this protection, connect a main fuel valve voltage free contact to the 'BURNER ON SWITCH' terminals 18 & 19. When the main fuel valve is open, the voltage free contact should be closed. For installations where there is no risk of explosion, connect a link between terminals number 18 & 19.



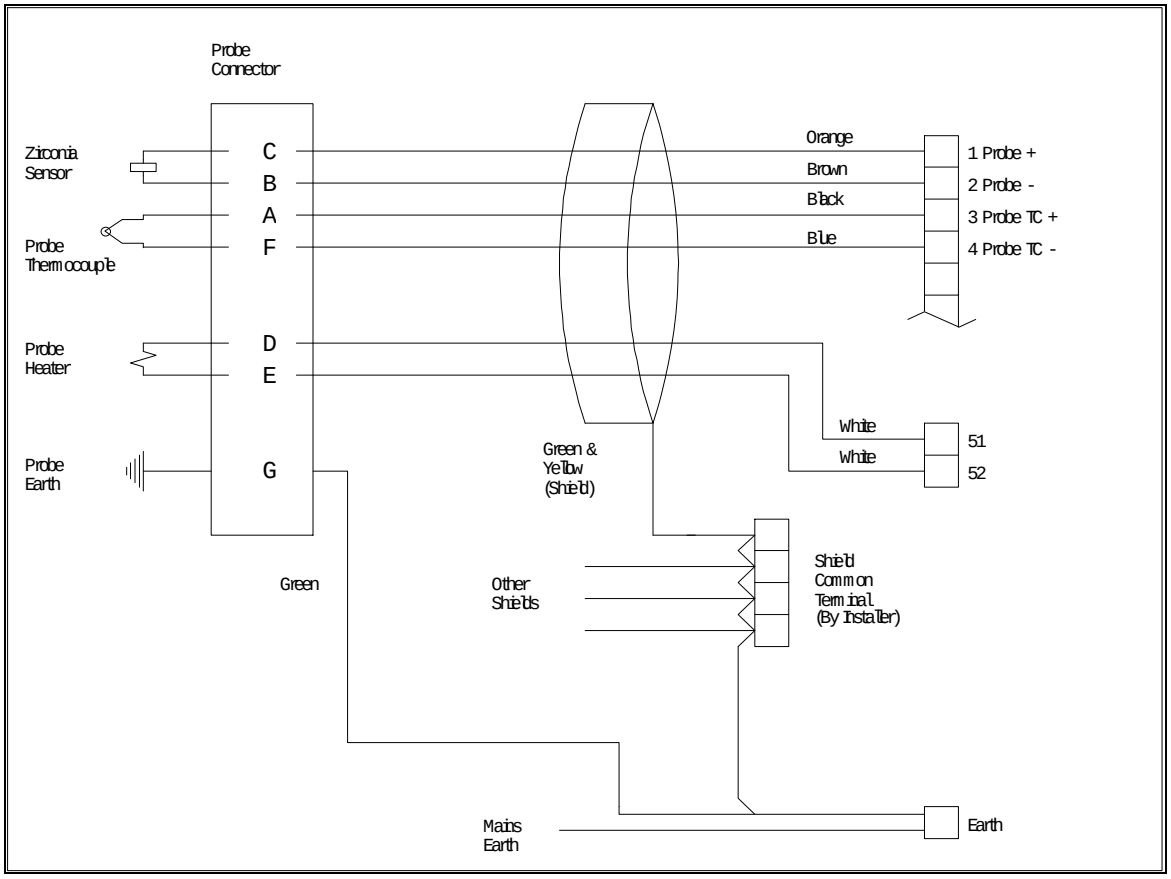
Heater Supply Interlock Connection For Heated Probes

3.7 CONNECTING AN OXYGEN PROBE CABLE

Connect the probe lead as shown in the following drawings. Unheated probe leads have integral reference air tube. An adaptor has been supplied to connect this tube to quarter inch flexible PVC tubing, from the air pump or reference air supply.



Connection of Probe Cable for Unheated Probes Model 1232



Connection of Probe Cable for Heated Probes Model 1231

3.8 CONNECTING THE AUXILIARY THERMOCOUPLE (OPTIONAL)

For 1231 heated probes, the auxiliary thermocouple must be a separate TC with the junction isolated from earth, mounted near to and upstream of the oxygen probe. It can be either type K or R. It is optional. If efficiency, oxygen deficiency or auxiliary temperature display or transmitted signals are not required, then an auxiliary TC is not necessary.

3.9 CONNECTING THE OUTPUT CHANNELS

The two 4 to 20 mA DC output channels are capable of driving into a 1000Ω load.

3.10 CONNECTING THE ALARMS

A common alarm, which should be connected for all installations initiates on alarms functions described below. Three additional alarm relays are available for selectable functions as listed in Section 4.2 and 4.3. Each relay has normally closed contacts. The contacts will open in alarm condition except for the optional horn function which operates with normally open contacts. Relays are connected as follows:

Relay	**Terminal Numbers**
Common Alarm	29 & 30
Alarm 2	31 & 32
Alarm 3	33 & 34
Alarm 4	35 & 36

Common Alarms All of the following conditions will cause a common alarm -

ADC Warning
DAC Warning
ADC Calibration Fail
DAC Calibration Fail
Sensor 1 Fail
Sensor 2 Fail **
Heater 1 Fail
Heater 2 Fail **
Sensor 1 TC Open
Sensor 2 TC Open **
Aux. TC Open
Reference Air Pump Fail
Mains Frequency Check fail
Probe Filter Blocked
Gas 1 or 2 Calibration Check Error
Memory device fail
Burner bypass Switch on
Watchdog Timer

The watchdog timer is a special alarm. It will force the common alarm to activate in the event of a microprocessor failure. There will not be an alarm message displayed, but the analyser will reset.

Alarms can be accepted by either pressing the alarm button (viewing the alarm messages), or by temporarily closing a switch connected to terminals 16 & 17, REM ALARM RESET.

Alarm relay 2 to 4 Select any one or all of the following for each relay. Refer 5 to Section 5.5, steps 54 to 66

Oxygen Deviation High **
Dew point Deviation High **
High oxygen probe 1
High oxygen probe 2
High dew point probe 1
High dew point probe 2
High oxygen deviation between probes
High dew point deviation between probes
Probe under temperature
Calibration check in progress
Probe purge in progress
Alarm horn function (Relay 4 only)

** These alarms are only available if two sensors are selected

3.11 CONNECTING THE AUTOMATIC PURGE AND CALIBRATION CHECK SYSTEM

CAUTION

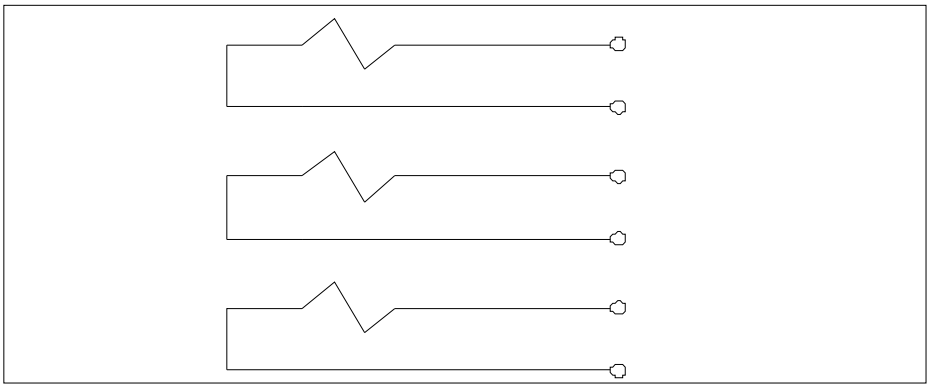
The purge and calibration solenoid valves are supplied with mains voltage. This supply has electrical shock danger to maintenance personnel. Always isolate the analyser before working with the purge and calibration solenoid valves.

The on-line auto purge and calibration check system is optional. For details on its operation refer to Sections 1.3, 1.4, 2.9 and 2.10.

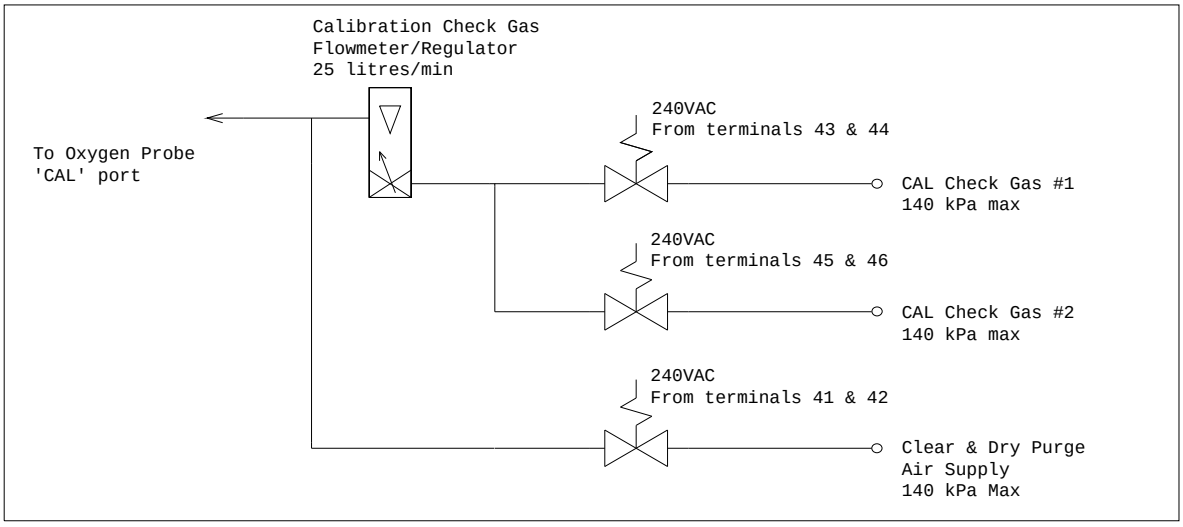
To automatically sense a blocked probe filter, a pressure sensor should be connected to the 'purge' line to the probe 'cal' port. It should be adjusted so that it energises just above the purge pressure with a new or clean filter installed. The switch contacts should be connected to terminals 12 & 13 (PURGE FL SWITCH).
If the filter is still blocked or partly blocked after an auto purge cycle, the pressure switch will energise and cause a 'Probe Filter Blocked' alarm.

After installation the purge/cal system should be tested thoroughly for leaks. Any leaks can cause significant errors if the furnace is at negative pressure. If the furnace is at positive pressure, an outward leak can cause corrosion in the purge/cal system piping and fittings.

Note: If two probes are being used, the purge is not available, and Cal 2 gas must be connected to probe 2.



Automatic Purge & Calibration check System Wiring Schematic



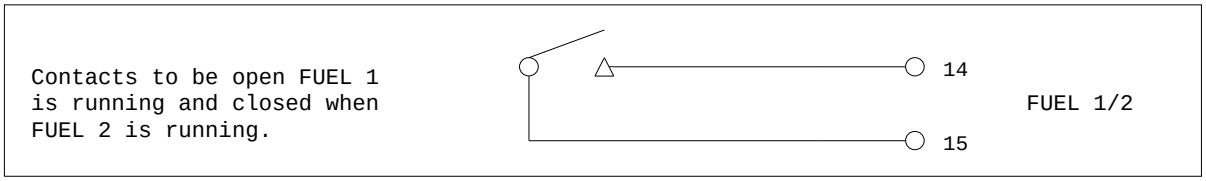
Automatic Purge & Calibration check System Piping Schematic

3.12 CONNECTING REFERENCE AIR

A 1/4" tube connector on the analyser should be connected via a nylon, copper or stainless steel tube to the 'REF' connector on the probe.
If two probes are being used, a "T" union must be supplied to provide reference air supply to both probes.

3.13 CONNECTING THE DUAL FUEL INPUT

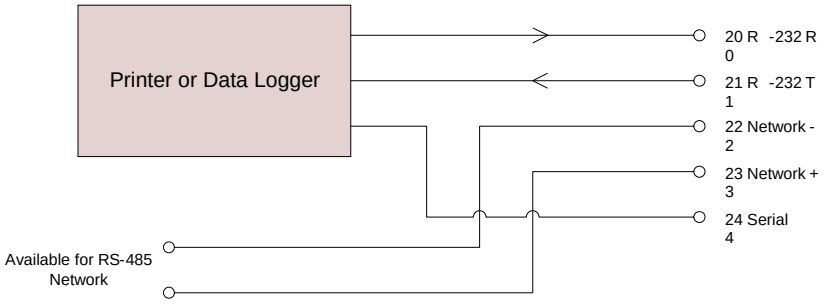
If efficiency display is required and the appliance is capable of firing more than one fuel, then an external contact must be connected for the analyser to determine which fuel is being burnt. See Figure 3.12 for details.



Fuel Selector Input Contact Connection

3.14 CONNECTING THE PRINTER

A printer with a serial port, or a data logger, or a computer terminal may be connected to RS 232-C or the network port. Data is logged out of the port as arranged in Set-up steps 70 and 71. The baud rate is selectable in set-up step 72. The RS-232 protocol for the serial port is eight data bits, one stop bit, no parity.



Serial Port Connections

3.15 CONNECTING THE ANALYSER TO A MODBUS™ NETWORK

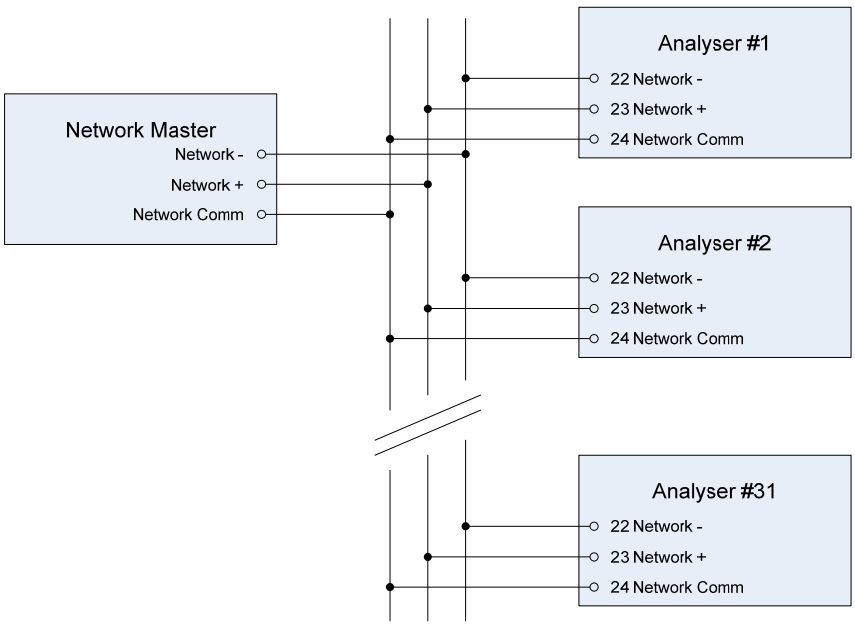
The analyser can be networked to other analysers and to a network master. The network uses the analyser RS485 port. Up to 31 analysers can be connected to the network, and can be interrogated by the Network Master.

NOTE: Hardware Protocol Selection
For the RS485 port on the analyser to operate, the link LK3 on the 1630-1 printed circuit board (mounted on the door of the analyser) must be set to the RS485 position. The LK3 is accessed by removing the cover from the door PCB. It is located at the bottom of the circuit board.
NOTE: Terminating Resistor
There is a terminating 100 ohm resistor fitted to the 1630-1 PCB. Link LK2, in the bottom left-hand corner of the PCB on the door, is used to connect the terminating resistor. Link LK2 must be removed on all analysers except the analyser on the end of the network line. If the network line from the analysers is taken from the middle of the analyser network string, a terminating resistor should be enabled with LK2 at each end if the network line.

The protocol of the network is –

```
Baud Rate   9600
Parity      none
Stop Bits   1
RS485       Half Duplex
Mode        RTU (binary mode)
```

For more details see Section 2.12 and Appendix 6.



Network Connections

3.16 CONNECTING POWER

Before commissioning the probe, sensor or transmitter, read the CAUTION paragraphs at the front of this manual. Check that the mains supply voltage switch is set for the correct supply voltage, and that the green / yellow EARTH wire MUST be connected to earth.

3.17 COMMISSIONING – SET-UP MODE

Press the SET-UP button to select the 'SET-UP' mode. Most of the default settings of the functions will be correct, or will have been pre-set at the factory. Refer to Section 5.5 for more details.

Check the following set-up functions -

2 to 6	Date /time
7 to 10	Reference voltages
11 & 12	Probe offset
22 & 23	Sensor type
26 to 28	Output channel #1
29 to 31	Output channel #2
37	Auto purge
41	Auto gas calibration checking
54 to 69	Alarm set-up
80	Hydrogen level

3.18 COMMISSIONING – RUN MODE

When the analyser is turned on it will go to RUN mode. The SET-UP/RUN button will toggle between the two modes. The upper line of the display will now read '% OXYGEN'. If the probe temperature is not above 650°C, a "Probe Low Temperature" message will be flashed on the lower line. The probe temperature can be checked on the lower line of the display.

3.19 BURNER BYPASS SWITCH

Heated probes and sensors should have their heater supply interlocked. If the combustion appliance is not running, then power will not be supplied to the heater. To commission an oxygen probe when the main burner is turned off, switch power off the analyser, remove the probe from the furnace.

Re-apply power to the analyser, press the BURNER BY-PASS switch into the 'DOWN' or 'ON' position. This will apply power to the probe heater even when the plant is not running. The offset can now be set and calibration checked with appropriate calibration check gases (typically 2% oxygen in nitrogen).

Ensure that the burner by-pass switch and the power are turned off before the probe is re-installed. An alarm will occur if the BURNER BY-PASS switch is turned on (down) during normal operation.

3.20 CHECKING THE ALARMS

If any alarms are present the alarm LED will be lit, either flashing or steady. To interpret the alarms, press the alarm button until all alarm functions have been displayed. Rectify the cause of each alarm until no further alarms appear on the display. For details on the operation of the alarm button and the alarm functions refer to Section 4.

3.21 PROBE CALIBRATION

The zirconia sensor provides an absolute measurement of oxygen partial pressure. There are no calibration adjustments, apart from 'SENSOR OFFSET', for the probe. The probe EMF is either correct or replacement is required. To check that the probe is functioning correctly, firstly check that the high impedance alarm is not activated causing a 'SENSOR FAIL' alarm. The actual impedance can be displayed on the lower line. It should be less than 9 KΩ at 720°C.

Once it has been established that the impedance is normal, the offset may be set using the millivolt level marked on the oxygen probe. Refer to Section 5.5.11. The probe offset can be tested on site. A small flow of air must be admitted to both the 'REF' and 'CAL' ports when testing the probe offset. If the probe is in the process, the air must fully purge the probe sensor without interference from the process gas sample.

3.22 FILTER PURGING

Purging probe filters is controlled from the 'PURGE' button on the analyser when in 'RUN' mode. If 'AUTO PURGE' has been enabled in set-up 37, pressing the PURGE button will start the automatic cycle. Pressing any other button will cancel the auto purge cycle. If AUTO PURGE was not enabled, the purge solenoid will only stay open for as long as the button is pressed. Gradually adjust the purge gas supply regulator, increasing the pressure until sufficient flow is obtained to clear the filter. This is best checked with a dirty filter after a period of operation, by withdrawing the probe from service and watching any build up on the filter being blown off at the set pressure. Normally 30 kPa (5 psi) is adequate but the air pressure may be set as high as 100 kPa (15 psi).

3.23 CALIBRATION GAS CHECK

If the installation has a filter purge facility, set this up first. Refer to the previous paragraph. Press the 'CAL 1 or 'CAL 2' button while in 'SET UP' mode to obtain a reasonable flow through the calibration check gas flow meter. If air is being used as a calibration check gas, use the air from the regulator for filter purge. Then, when setting up a gas for calibration checking, set the pressure from the calibration gas cylinder so that it is the same as the pressure set on the air regulator. Then the setting on the rotameter / flow regulator will be the same as that for the air flow. Required flows are about 2 litres per minute.

Air is not the best gas for calibration checking on a zirconia sensor. The output of a zirconia sensor with reference air is zero millivolts. It is better to choose a gas value which provides a reasonable output from the sensor and which is near to the process oxygen level. A cylinder with 2% oxygen in nitrogen is a commonly used calibration gas. The maximum pressure on the calibration check gas cylinder regulators is 100 kPa (15 psi).

Note: If two probes were selected in set-up 1, 'Cal Gas 2' must be connected to probe 2.

3.24 DUST IN THE FURNACE

For unheated probes with no filter, entrained solids or dust in the furnace does not present a problem unless the dust, when settled, is not porous. Allow the dust in the process to build up on the probe. It will form a porous layer slowing the response time. To avoid mechanical abrasion of the electrode material in installations with unheated oxygen probes, pack 'SAFFIL' or equivalent alumina based ceramic fibre in the sensing holes to protect the electrode. Do not use silica based ceramic fibres such as 'KAOWOOL', which can attack the electrode at high temperatures. Once the dust has built up the response time of the probe will be slower.

For heated probes the preferred method of mounting for dust laden applications is facing vertically downwards with the filter removed. Probes can also be mounted horizontally with no filter with some dusts. An occasional automatic back purge is helpful in this case.

Normally heated probes are supplied with filters for applications with particulate in the furnace. The probe response time should be tested when the probe is first installed, and then regularly until it remains constant for a significant period. Filter purging should be set up on the time periods determined by these tests. To test the probe response time, use a stop watch to obtain the time for a probe to achieve a 63 % change from one reading to another. If a probe filter blocks completely in a short period of time, then there is no option but to use the probe without the filter.

4

OPERATOR FUNCTIONS

Section
Number

OPERATOR FUNCTIONS (RUN MODE)

4.1 DISPLAY BUTTON

The upper line on the display will always read % oxygen for probe 1. The following are available for display on the lower line.

1. DEW POINT MEASURED BY PROBE 1
2. DEW POINT MEASURED BY PROBE 2 **
3. DEW POINT AVERAGE MEASURED BY PROBES 1 AND 2 **
4. OXYGEN PROBE 2 **
5. OXYGEN AVERAGE OF PROBES 1 AND 2 **
6. SENSOR 1 EMF (millivolts)
7. SENSOR 2 EMF (millivolts) **
8. SENSOR 1 TEMPERATURE
9. SENSOR 2 TEMPERATURE ** or AUXILIARY TEMPERATURE
10. SENSOR 1 IMPEDANCE
11. SENSOR 2 IMPEDANCE **
12. AMBIENT TEMPERATURE
13. AMBIENT RELATIVE HUMIDITY
14. DATE / TIME
15. RUN HOURS SINCE LAST SERVICE
16. DATE OF LAST SERVICE

** available when 2 sensors selected in set-up 1

Any number of these variables can be displayed sequentially by pressing the 'DISPLAY' button. Items can be selected for display or deleted in Set-up step 33 on the keyboard. In addition to the above lower line displays, the analyser will automatically display:

"Sensor 1 Temp Low", when probe one is below 650°C
"Sensor 2 Temp Low", when probe two is below 650°C

"Gas 1 ON", "Gas 2 ON" for Calibration check Gas 1 or 2

"Purging Probe"

"Sensor 1 Thermocouple Wrong Polarity"
"Sensor 2 Thermocouple Wrong Polarity"

"Aux Thermocouple Wrong Polarity"

NOTE:

2. The run time will be the period of time the BURNER ON SWITCH (terminals 18 & 19) contact is closed (ie. main fuel valve open). If no explosion protection is required, a permanent bridge between the BURNER ON SWITCH terminals will register run time whenever the analyser is powered.

3. This timer can be used as a probe replacement and/or boiler service schedule aid. The start time is reset by changing the 'SERVICE DAY' in set-up mode on the keyboard.

4. If you hold the display button down as you switch on the power, the maximum ambient temperature which the instrument has been subjected to, will be displayed. This temperature should be less than 50°C.

4.2 ALARM BUTTON

Repeatedly pressing the 'ALARM' button will produce alarm displays in sequence on the lower line of the LCD display. If an alarm has cleared prior to pressing the 'ALARM' button, it will not re-appear on a second run through the alarms. Active alarms which have been previously displayed will have 'acc' (accepted in lower case), displayed alongside. New alarms will not have 'ACC' (in upper case) displayed until a second press of the 'ALARM' button. After the last active alarm is indicated, the lower line of the display will return to the last displayed lower line variable. Alarms may also be accepted remotely by a temporary closure of a switch connected to terminal 16 & 17, 'REMOTE ALARM RESET'.

The alarm 'LED' will flash when there is an un-accepted alarm. Pressing the 'ALARM' button will cause the LED to go steady if any alarms are still active, or extinguish if there are no active alarms. The horn relay will operate when an alarm occurs. Pressing 'ALARM' will mute a horn relay (if one of the user configurable relays have been selected as a 'Horn' relay) which will re-initiate on any new alarms.

4.3 ALARM SCHEDULE

4.3.1 SUMMARY OF ALARMS – COMMON ALARM

1. 'Sensor 1 Fail'
2. 'Sensor 2 Fail'

Oxygen cell or electrode failure (high impedance), (inhibited under 650°C).

3. 'Heater 1 Fail'
4. 'Heater 2 Fail'

In the first 20 minutes of power being applied to the heater after being switched on, this alarm will not occur, but a 'Sensor # Lo Temp' display will occur and common alarm relay will be activated. Refer to Section 6.11. If an ADC alarms occurs, the heaters will automatically be turned off.

5. 'Sensor 1 TC Open'
6. 'Sensor 1 TC Open'

Probe thermocouple is open circuit. The heater in heated probes will switch off.

7. 'Aux TC Open'

Stack thermocouple is open circuit. If the thermocouple is not needed, select "NO T/C" for "Aux TC Type" or place a short circuit between terminals 5 & 6.

8. 'Ref Pump Fail'

The reference air pump in the analyser has failed.

9. 'ADC Cal Fail'

The analog to digital converter has been found to fall outside the normal calibration specifications. In this case the probe heater will automatically be turned off.

10. 'Mains Freq'

The sample of the mains frequency has failed.

11. 'DAC Cal Fail'

The digital to analog and voltage isolator circuit has been found to fall outside the normal calibration specifications. This check is only performed when the 'AUTO CAL' button is pressed. Refer to Section 6.3.

12. 'Probe Filter

Blocked probe filter. This test is only performed when automatic purging of the probe is requested. Refer to step 36 in the set-up menu Section 5.5. This alarm will not reset until the next purge cycle which can be initiated manually or automatically.

13. 'Gas 1 Cal Err'

Probe does not correctly calibrate to calibration check gas 1.

14. 'Gas 2 Cal Err'

Probe does not correctly calibrate to calibration check gas 2.

15. ‘Burner bypass’
The safety interlock relay has been bypassed by turning on the ‘BURNER BYPASS’ switch on the terminal printed circuit board. Refer to Section 3.18

16. ‘Watchdog Timer’
Microprocessor error. This alarm will not appear on the display. The common alarm relay will be forced open circuit. If the watchdog timer senses a malfunction in the microprocessor, it will attempt to reset the analyser every 2 seconds. After two resets the alarm relay contacts will go open circuit.

17. ‘BB RAM Fail”
The battery backed memory module has failed in service. The device normally lasts 10 years. It is the plug-in battery like module on the 1630 -1 board, labelled M1.

4.3.2 SUMMARY OF ALARMS – SELECTABLE ALARMS

NOTE: The process alarms must be enabled in set-up 54 if required.
There are three user configurable alarm relays. Any or all of the following functions can be selected for each relay.

18. ‘Dew Point 1 High”
The dew point measured by probe 1 (Dew Point 1 High) is above the limit set in set-up 59, and has been there for longer than the time set in set-up 60.
19. ‘Dew Point 2 High”
The dew point measured by probe 2 (Dew Point 2 High) is above the limit set in set-up 61, and has been there for longer than the time set in set-up 62.

20. ‘Oxygen % 1 High”
The oxygen measured by probe 1 (Oxygen % 1 High) is above the limit set in set-up 55, and has been there for longer than the time set in set-up 56.
21. ‘Oxygen % 2 High”
The oxygen measured by probe 2 (Oxygen % 2 High) is above the limit set in set-up 57, and has been there for longer than the time set in set-up 58.

22. ‘Oxygen % deviation High”
The oxygen difference measured by probe 1 and 2 is above the limit set in set-up 65, and has been there for longer than the time set in set-up 66.

23. ‘Dew point deviation High”
The dew point difference measured by probe 1 and 2 is above the limit set in set-up 63, and has been there for longer than the time set in set-up 64.

24. ‘Probe Temperature’
The probe temperature is under 650°C. The oxygen an dew point readings are therefore invalid. If the sensor heater has been on for more than 20 minutes and the temperature is less than 650°C a ‘heater fail’ alarm will occur.
NOTE:
The ‘Probe Temp’ relay function is used with unheated probes to indicate oxygen reading is invalid (the probe is below 650°C), in case the process temperature falls below this level. For heated probes this relay will be energised while the probe is heating up from ambient.

25. ‘Cal in Progress’
A calibration check is occurring, either manual (in RUN mode) or automatic

26. ‘Probe Purge’
A probe purge is occurring, either manual (in RUN mode) or automatic

27. Alarm Horn
This is not an alarm condition. If one of the three user configureable alarm relays have ‘Alarm Horn’ enabled, the relay will have closed contacts only when there is an un-accepted alarm on the analyser. Press the alarm button twice to accept any new alarm and to cancel the horn relay. This is only available on relay 4.

4.3.3 ALARM RELAYS

The alarm relays are fail safe. That is, the contacts will be closed during normal operation, and will be open circuit if there is an alarm or if the power is removed from the analyser.

4.4 POWER LAMP

Illuminates when power is connected to the analyser. If the lamp is flashing, the watchdog timer is attempting to reset the microprocessor. Replace the 1630-1 microprocessor PCB.

4.5 BURNER BYPASS SWITCH

This switch is mounted on the terminal PCB near the POWER switch.
Before the heater in a heated probe, or the alarms will be enabled, the probes must be enabled. There are two ways of doing this.
Use the safety interlock on terminals 18 & 19 (BURNER ON switch), or press the BURNER BYPASS switch to the ON position. While the BURNER BYPASS switch is on there will be an alarm, “Burner Bypass”.
If it is not needed to have the analyser interlocked with the combustion appliance terminals 18 & 19 can be connected together.

5

SETTING UP THE TRANSMITTER

Section
Number

SET-UP MODE SUMMARY

5.1 SET-UP MODE FUNCTIONS

1 Number of Sensors
2 Calender Year
3 Calender Month
4 Calender Day
5 Real time clock Hour
6 Real time clock Minutes
7 Reference voltage #1
8 Reference voltage #2
9 Reference voltage #3
10 Reference voltage #4
11 Sensor 1 offset
12 Sensor 2 offset
13 Output channel number 1 calibration
14 Output channel number 1 calibration, 4mA trim
15 Output channel number 1 calibration, 20mA trim
16 Output channel number 2 calibration
17 Output channel number 2 calibration, 4mA trim
18 Output channel number 2 calibration, 20mA trim
19 Service record year
20 Service record month
21 Service record day
22 Sensor 1 Type
23 Sensor 2 Type
24 Sensor 1 Thermocouple Type
25 Sensor 2, Auxiliary Thermocouple Type
26 Transmitter Output Channel 1 scale
27 Transmitter Zero Channel 1
28 Transmitter Span Channel 1
29 Transmitter Output Channel 2 scale
30 Transmitter Zero Channel 2
31 Transmitter Span Channel 2
32 Centigrade/Fahrenheit Selection
33 Lower Line Display Functions
34 Flue Pressure mm/inches/kilopascals
35 Flue Pressure Value

36 Purge/Cal Time
37 Automatic Purge

Set-up steps 38to 40 will be skipped automatically if ‘No’ is selected in set-up step 37.

38 Time Between Purges
39 Purge Duration
40 Purge Freeze Time

41 Number of Cal Gases

Set-up steps 42 to 47 may be skipped automatically, depending on the selection in set-up step 41.

42 Oxygen Content of Cal Gas 1
43 Maximum Acceptable Positive Error Gas 1
44 Maximum Acceptable Negative Error Gas 1
45 Period Between Gas 1 Autocals
46 Duration of Autocal Gas 1
47 Freeze Time Gas 1

48 Oxygen Content Of Cal Gas 2
49 Maximum Acceptable Positive Error Gas 2
50 Maximum Acceptable Negative Error Gas 2
51 Period Between Gas 2 Autocals
52 Duration of Autocal Gas 2
53 Freeze Time Gas 2
54 Process alarm enable

Set-up steps 55 and 66 may be skipped automatically, depending on the selection in set-up steps 54 and 85.

55 High oxygen alarm sensor #1 level
56 High oxygen alarm sensor #1 delay time
57 High oxygen alarm sensor #2 level
58 High oxygen alarm sensor #2 delay time
59 High dew point sensor #1 level
60 High dew point sensor #1 delay time
61 High dew point sensor #2 level
62 High dew point sensor #2 delay time
63 High dew point deviation level
64 High dew point deviation delay time
65 High oxygen deviation level
66 High oxygen deviation delay time

Set-up steps 67 and 70 may be skipped automatically, depending on the selection in set-up steps 54 and 85.

67 High pre-reaction oxygen warning alarm sensor #1 level
68 High pre-reaction oxygen alarm sensor #1 level
69 High pre-reaction oxygen warning alarm sensor #2 level
70 High pre-reaction oxygen alarm sensor #2 level

71 Alarm relay number 2 function select
72 Alarm relay number 3 function select
73 Alarm relay number 4 function select

74 Data to Print
75 Print Log Period
76 Printer Baud Rate

77 Reference air pump mode selection

Set-up steps 78 may be skipped automatically, depending on the selection in set-up step 77.

78 Reference air RH

79 Damping factor
80 Digital output filter enable

81 External hydrogen level input enable

Set-up steps 82 and 83 may be skipped automatically, depending on the selection in set-up step 81.

82 External hydrogen level input zero level
83 External hydrogen level input span level

Set-up step 84 may be skipped automatically, depending on the selection in set-up step 81.

84 Fixed hydrogen level

85 Instrument operating mode. Pre-reaction oxygen or Dew point
86 MODBUS address, 0 for no MODBUS communications

5.2 SET-UP & RUN MODES

For the SET-UP mode keyboard to operate, press the SET-UP / RUN button. The set-up light will come on when the set-up mode has been entered.

NOTE:
Set-up mode cannot be entered if the keyboard lock switch on the inside of the analyser is in the UP position. The keyboard lock switch can be found on the door PCB (1630-2), on the lock side, at the top. If access is attempted while the keyboard is locked, the message **'Illegal Access'** will be displayed.

The temperature of a heated probe may fall if the set-up mode is used for more than 2 minutes.
While the analyser is in set-up mode the outputs will be frozen. All the of the functions written in BLUE will now operate. If there are not any buttons pressed for 1 minute the analyser will automatically revert to RUN mode.
If purges or an auto-calibration check occurs while the analyser is in set-up mode, they will be delayed until the analyser is returned to RUN mode.

To cancel an automatic purge or calibration check cycle, press AUTO CAL button while in RUN mode.

5.3 FUNCTION SELECT

When the SET-UP mode is entered, the analyser will automatically read the last set-up function selected.

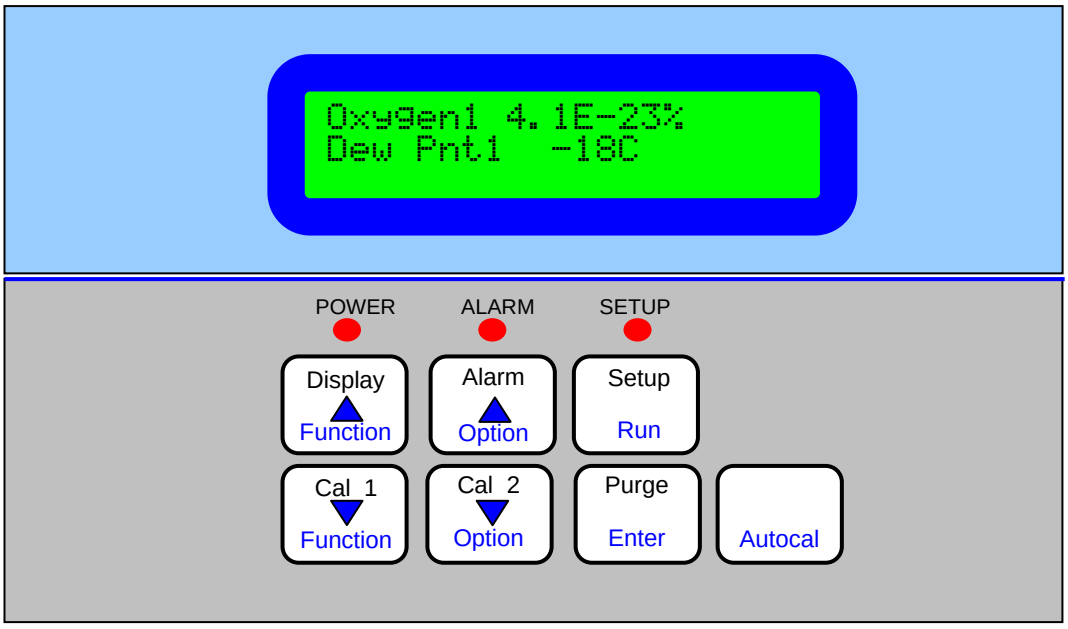
To select other functions, operate the 'FUNCTION ⮝' button to increment to the next function, or 'FUNCTION ⮟' to decrement to the previous function.

5.4 ENTER OPTION OR VALUE

A. Options.
To step through the available options for each function press the 'OPTION ⮝' or 'OPTION ⮟' buttons.
When the required option is selected press the 'ENTER' button. An asterisk will then appear alongside the option selected. When stepping through the set-up functions, the display will always first indicate the last options entered.
The 'Lower Line Select' and 'Data To Print' set-up items 33 and 70 are multiple options. One or more options may be selected for these functions.

B Values

To set a value for a particular function press the 'OPTION ⮝' button to increase the value and the 'OPTION ⮟' button to decrease the value. A momentary press will change the value one digit. Holding the button will change the value more quickly. Once the correct option or value is displayed it can be entered into the analyser's memory by pressing the 'ENTER' button. When a value has been entered an asterisk will appear at the R.H.S. of the lower line.



5.5 SET-UP FUNCTION DETAILS

Note: The * indicates the default setting after a COLD-START. See Section 6.1

1. Number of Sensors

Options

Select the number of oxygen probes or sensors being used.

1 Sensor *

2 Sensors

2. Calender Year

Options

Select the current year for the real time clock/calendar.

The cold start default sets the date and time to the software version date.

3. Calender Month

Options

Select the current month for the real time clock/calendar.

4. Calender Day

Options

Select the current day for the real time clock/calendar.

5. Real time clock hour

Options Select the current hour for the real time clock. (24 hour format)

6. Real time clock minutes

Options

Select the current minutes for the real time clock.

7. Reference Voltage # 1 (about 27.5 mV's)

Options

Set the value of the reference voltage as read on a 3 1/2 digit multimeter (See Section 6.2 for further details).

27.55 mV *

8. Reference Voltage # 2 (about 194 mV's)

Options

Set the value of the reference voltage as read on a 3 1/2 digit multimeter (See Section 6.2 for further details).

193.60 mV *

9. Reference Voltage # 3 (about 1200 mV's)

Options

Set the value of the reference voltage as read on a 3 1/2 digit multimeter (See Section 6.2 for further details).

1202.00 mV *

10. Reference Voltage # 4 (about 2500 mV's)

Options

Set the value of the reference voltage as read on a 3 1/2 digit multimeter (See Section 6.2 for further details).

2479.00 mV *

Set-up items 7 to 10 are used to calibrate the A/D of the instrument. This should be done 30 minutes or more after the instrument has been on. The calibration constants are retained in battery backed memory unless a 'COLD START' is performed. Connect a 3 1/2 digit multimeter negative lead to the test point marked 'C' to the right of the PCB on the inside of the door (labelled 'REF VOLTS'). Measure the four voltages on the test point marked 1 to 4 with the positive lead. Refer to Figure 6.2 in the 1638 manual. Enter the measured values in set-up items 7 to 10. Whenever new values are entered the D/A section should be re-calibrated, Refer to Section 6.3.

11. Set Probe or Sensor 1 Offset

12. Set Probe or Sensor 2 Offset (When 2 sensors are selected in set-up 1)

A new EMF offset must be entered whenever a new oxygen probe or sensor is installed to calibrate for any offset an individual probe or sensor may have. Each probe or sensor will have an offset value noted on a removable tag. Enter the 'SENSOR OFFSET' value with the underline polarity,
eg. if offset value is -1.2 mV. enter -1.2 mV. The typical maximum is 2mV.

To check a probe or sensor offset on site, the probe or sensor must be sensing air with reference air and allowed to settle at the probe operating temperature for 30 minutes. Read the offset in 'RUN' mode in millivolts on the lower line. Offset errors can occur if the sensor does not have some air passing over it. A gentle flow of air in the calibration check port can be provided by a reference air pump or similar.
For heated probes or sensors, if the combustion appliance is not operational and the probe or sensor heater is interlocked with the 'BURNER ON' signal, the 'BURNER BYPASS' switch should be set to 'ON to power the probe heater after removing the probe from the flue.

CAUTION DANGER

Return the BURNER BYPASS switch to normal (off) before installing the probe in the flue.

For unheated probes, the probe sensing tip must be raised to at least 650°C with a portable furnace. (Available as an accessory).

Determine the probe or sensor offset in 'RUN' mode. Select 'Sensor EMF' on the lower line. With probe in air, stabilised at temperature for 30 minutes, read the 'Sensor EMF'. Switch back to 'set-up' mode and enter 'Sensor Offset' of equal value and the same polarity.
eg. If the measured 'SENSOR OFFSET' was -1.2 mV, enter -1.2 mV.

When reading the EMF offset, the flue pressure compensation must be set. If the probe has been removed from the flue, set the flue pressure compensation to 0 in set-up step 35.

13. 4-20mA Calibration Options, Channel #1

Select the calibration method for the 4-20mA output channel #1.
The output channels can be either calibrated by simply pressing the 'AUTO CAL' button, or can be trimmed at both the 4mA and 20mA ends of the scale using an external multimeter.
Options:
1. Auto Calibration *
2. Manual Calibration
3. Set 4mA Trim
4. Set 20mA Trim

If 'AUTO CAL' is selected, the output channel is calibrated when 'Auto Cal' is initiated from the keyboard (See section 6.3).
If 'MAN CAL' is selected, it is necessary to trim both ends of the 4-20mA output range using the 4mA and 20mA options in this menu item. Selecting 'MAN CAL' inhibits the 'Auto Cal' process of this channel.
Always do the 4mA trim first, and then the 20mA trim. After trimming both ends of the scale, return the 'CALIBRATION OPTIONS' menu option back to 'MAN CAL' (not 'AUTO CAL'), or the calibration factors will be over written by the next 'AUTO CAL'.

For more details on calibrating the output channels, see section 6.3.

NOTE: If the analyser will only stay in either '4mA TRIM' or '20mA TRIM' modes for 30 minutes before it automatically returns to 'MAN AL'.

14. Calibrate 4mA, Channel #1

This menu item only appears if 'Set 4mA Trim' is selected in Set-up 13.
Range: 0 to 25mA, Default is 4.00mA
For full details on the calibration of the 4-20mA output channels, see section 6.3.

15. Calibrate 20mA, Channel #1

This menu item only appears if 'Set 20mA Trim' is selected in Set-up 13.
Range: 0 to 25mA, Default is 20.00mA

16. 4-20mA Calibration Options, Channel #2

Select the calibration method for the 4-20mA output channel #1.
For more details, see Set-up 13 and section 6.3.
Options:
1. Auto Calibration *
2. Manual Calibration
3. Set 4mA Trim
4. Set 20mA Trim

17. Calibrate 4mA, Channel #2

This menu item only appears if 'Set 4mA Trim' is selected in Set-up 16.
Range: 0 to 25mA, Default is 4.00mA
For full details on the calibration of the 4-20mA output channels, see section 6.3.

18. Calibrate 20mA, Channel #2

This menu item only appears if 'Set 20mA Trim' is selected in Set-up 16.
Range: 0 to 25mA, Default is 20.00mA

19. Enter Service Year

For a new 'DATE OF LAST SERVICE', enter the service 'YEAR'. This can represent the last time the probe or sensor was serviced or the last time the boiler was serviced. It is recommended that probes and sensors be refurbished every two years

20. Enter Service Month

Enter the current 'MONTH'.

21. Enter Service Day

End the current 'DAY' of the month. Altering these values will reset the 'RUN TIME'.

22. Sensor 1 Type

23. Sensor 2 Type

Options

Model No.	Enter the probe or sensor model number in use	
1. 1231/1234 Heated	*	Heated Probe or sensor
2. 1232 Unheated		Unheated Probe

24. Probe or Sensor 1 Thermocouple Type

25. Probe or Sensor 2 Thermocouple Type (When 2 sensors are selected in set-up 1)
Auxiliary Thermocouple Type (When 1 sensor is selected in set-up 1)

The probe can have either a type K, R, or N thermocouple as a sensor temperature detector. A 1231 probe or a 1234 sensor will always have a K thermocouple, and a 1232 will usually have an R thermocouple.
Options

1. K	*	Check in the manual Section 1
2. R		for the probe model number.
3. NO T/C		If no TC type is to be used for an Auxiliary use.

26. Transmitter Output Channel 1

Select the type of output required from Channel 1. All of the outputs from channel #1 are signals generated from probe #1, even if two sensors are selected in set-up 1. Normally dew point would be selected as the prime output signal. The reducing output is fixed at 10^{-16} % to 10^{-30} % oxygen to cover the range of dew point readings. For the range of the outputs see the table below.

Options:

1. Linear oxygen probe 1
2. Reducing oxygen, probe 1
3. Dew point, probe 1 * (only available if Dew point is selected in set-up 85)
4. Pre-reaction oxygen, probe 1 * (only available if Pre-reaction is selected in set-up 85)
5. Linear oxygen probe 1 and 2 averaged (only available if 2 sensors are selected in set-up 1)
6. Reducing oxygen, probe 1 and 2 averaged (only available if 2 sensors are selected in set-up 1)
7. Dew point, probe 1 and 2 averaged (only available if 2 sensors are selected in set-up 1 and if Dew point is selected in set-up 85)
8. Pre-reaction oxygen, probe 1 and 2 averaged (only available if 2 sensors are selected in set-up 1 and if Pre-reaction is selected in set-up 85)
9. No Output

Note:
The average dew point, pre-reaction oxygen, linear O_2 and Reducing O_2 selections will automatically select the operating probe if one probe fails, or selects probe 1 if both probes fail.

27. Transmitter Zero Channel 1

Select transmitter zero for output Channel 1. See table below.

28. Transmitter Span Channel 1

Select transmitter span for output Channel 1. See table below.

Output	Zero Range	Span Range	Default Setting
LINEAR OXYGEN #1	0 to 99% oxygen	1 to 100% oxygen	0 to 100%
REDUCING OXYGEN #1	10^{-16} % fixed	10^{-30}	10^{-16} to 10^{-26}
DEW POINT #1	-60 to +20 °C -76 to +68 °F 1 ° steps	-40 to +40 °C -8 to +104 °F 1 ° steps	-60 to +40 °C
PRE-REACTION OXYGEN #1	0 oxygen fixed	1 to 10.0% oxygen	0 to 4.0%
LINEAR OXYGEN #1 and #2	0 to 99% oxygen	1 to 100% oxygen	0 to 100%
REDUCING OXYGEN #1 and #2	10^{-16} %	10^{-30}	10^{-16} to 10^{-30}
DEW POINT #1 and #2	-60 to +20 °C -76 to +68 °F 1 ° steps	-40 to +40 °C -8 to +104 °F 1 ° steps	-60 to +40 °C
PRE-REACTION OXYGEN #1 and #2	0 fixed oxygen	1 to 10.0% oxygen	0 to 4.0%

Note:
The last four items (average of probe 1 and 2) are only available if two sensors are selected in set-up 1

29. Transmitter Output Channel 2

Select transmitter output for output Channel 2.

Options:

1. Linear oxygen % probe 2 (or probe 1, if 1 sensor is selected in set-up 1)
2. Reducing oxygen, probe 2 (or probe 1, if 1 sensor is selected in set-up 1)
3. Dew point, probe 2 (or probe 1, if 1 sensor is selected in set-up 1)
4. Pre-reaction oxygen, probe 2 (only available if 2 sensors are selected in set-up 1 and if Pre-reaction is selected in set-up 85)
5. EMF sensor 1
6. EMF sensor 2 (not available if 1 sensor is selected in set-up 1)
7. Auxiliary thermocouple (not available if 2 sensors are selected in set-up 1, or if NO TC is selected in set-up 25)
8. No Output

30. Transmitter Zero Channel 2

The output zero and span of Channel 2 is set in set-up steps 30 and 31. Range limits are shown below.

31. Transmitter Span Channel 2

Output	Zero Range	Span Range	Default Setting
LINEAR OXYGEN #2	0 to 99% oxygen	1 to 100% oxygen	0 to 100%
REDUCING OXYGEN #2 (see Note 1)	10^{-1} to 10^{-25} % oxygen in one decade steps,	10^{-5} to 10^{-30} % oxygen in one decade steps. Min span five decades.	10^{-16} to 10^{-26}
DEW POINT #2	-60 to +20 °C -76 to +68 °F 1 ° steps	-40 to +40 °C -8 to +104 °F 1 ° steps	-60 to +40 °C
PRE-REACTION OXYGEN #2	0 oxygen fixed	1 to 10.0% oxygen	0 to 4.0%
SENSOR EMF #1	0 to 1200 mV in 100 mV steps	100 to 1300 mV in 100 mV steps	0 to 1300mV
SENSOR EMF #2	0 to 1200 mV in 100 mV steps	100 to 1300 mV in 100 mV steps	0 to 1300mV
AUX TEMPERATURE	0 to 100 °C in 100 ° C steps	100 to 1400 °C in 100 ° C steps	0 to 1300°C

NOTE

1: Note that the reducing oxygen span is shown on the display as the exponent only. -1 represents 10^{-1} % oxygen.

32. Centigrade/Fahrenheit Selection

Select whether displays and outputs are to be in ° Celsius or Fahrenheit

Options:

1. Celsius (Centigrade) *
2. Fahrenheit

33. Lower Line Display Functions

In the run mode the upper line on the LCD display will always read % oxygen. The lower line can be set to read one or more of the following. Select as many as are required to be displayed by pressing the 'ENTER' button. Those selected will have an asterisk displayed alongside.

Options:

1. Probe 2 oxygen **
2. Probe 1 and 2 oxygen averaged **
3. Sensor 1 EMF
4. Sensor 2 EMF **
5. Probe 1 temperature
6. Probe 2 temperature, Auxiliary temperature (this will depend if one or two sensors are selected in set-up 1)
7. Sensor 1 impedance
8. Sensor 2 impedance **
9. Ambient temperature
10. Relative humidity
11. Dew point probe 1
12. Dew point probe 2 **
13. Pre-reactive oxygen probe 1
14. Pre-reactive oxygen probe 2 **
15. Dew point probe 1 and 2 averaged **
16. Date and time
17. Run hours since last service
18. Date of last service

** This will not appear if only one sensor is selected in set-up 1

If no lower line options are required then do not enter any. If options already selected are required to be deleted, select the required option and press the 'ENTER' button. The asterisk will be removed.

34. Flue Pressure

Enter flue pressure units, eg. 3 mm W.G.

Options:

mm W.G. *
Kilopascals
Inches W.G.

35. Flue Pressure Value

Enter flue pressure e.g. 3 mm WG. The default setting is 0

Limits :

-200 to +200 mm W.G.
-9 to +9 inches W.G.
-200 to +200 kpa.

36. Purge / Cal Time

Set the first purge to occur at the correct time-of-day. If purging is not required but on-line auto gas calibration check is required, enter a time-of-day value suitable for the auto calibration checks. Cal Gas 1 will be tested ten minutes after the purge/cal time and Cal Gas 2, 20 minutes after. If neither purge nor auto calibration check is required, ignore this time setting.

Range:

0 to 23 hours in one hour steps. The default time is 12 noon.

37. Automatic Purge

For some oil and coal fired plant, probe filters are necessary and should be back-purged with sufficient frequency to avoid blocked filters. The outputs will be frozen during purging. If no purge is required, set-up steps 38, 39 and 40 will be skipped.

Options:

Yes
No *

38. Time Between Purges

Set the time between purges eg. a two hourly purge or a 100 hourly purge.

Range:

1 to 199 hours. Default setting is 24 hours.

39. Purge Duration

Set up purge duration to a number between three and ten seconds. The filter is actually purged in less than one second, but three seconds are required for the purge flow switch to check that the filter is not blocked.

Range:

0 to 10 seconds. Default setting is 10 seconds.

40. Purge Freeze Time

After the purge period the transmitter output will remain fixed (frozen) for an adjustable period to allow the probe reading to return to the correct process level and avoid output 'bumps'. The freeze period time required will depend on the probe response time and thus its design, and whether it has a filter or not.

To determine the required freeze time, manually perform a purge while the plant is in operation and note the time required for the reading to return to the correct process level within approximately 0.5 % oxygen.

Range:

100 to 1000 seconds in ten second steps. Default setting is 60 seconds.

41. Number of Cal Gases

Select the number of cal gases 0, 1 or 2. For example, one may be air (20.9 % oxygen) and the other 2 % oxygen

Options:

No Cal Gases *
Single Gas
Two Cal Gas

During the timed calibration check periods the transmitter outputs will be frozen and the analyser will alarm if readings are not within the accuracy limits sets in set-up steps 43 and 44. If autocal is not required enter 'NO CAL GAS' and the transmitter will step to set-up 54.

42. Oxygen Content of Cal Gas 1

Enter value of Cal Gas 1 (to one decimal point).

Range:

0.1 to 20.9 % oxygen. Default setting is 8.0 % oxygen.

43. Maximum Acceptable Positive Error Gas 1

Set the maximum positive error above which the 'Gas 1 Cal Error' alarm will be initiated after the timed period set in set-up step 47.

Range:

0.1 to 3.0 % oxygen. The default setting is 0.5 % oxygen.

44. Maximum Acceptable Negative Error Gas 1

Set the maximum negative error below which the 'Gas 1 Cal Error' alarm will be initiated after the timed period set in set-up step 47.

Range:

0.1 to 3.0 % oxygen. The default setting is 0.2 % oxygen.

45. Period Between Gas 1 Autocals

Set the number of hours between autocal Gas 1. A typical time would be 24 or 168 hours. (Daily or weekly).

Range:

1 to 1999 hours. The default setting is 1 hour.

46. Duration Of Autocal Gas 1

Set the number of seconds that the autocal gas solenoid will be open. At the end of this period, if the oxygen level measured is not within the limits set for Cal Gas 2, an 'Gas 2 Cal Error' will initiate. To determine the minimum time required for a particular length or design of probe to settle, manually admit cal gas while observing the oxygen reading in 'RUN' mode. Typical minimum times vary from 15 seconds to 90 seconds, depending on the probe length and gas plumbing arrangement. If there is a filter fitted to the oxygen probe, the calibration check reading will be much closer to the actual gas value.

Range:
0 to 90 seconds. The default setting is 10 seconds.

47. Freeze Time Gas 1

After the Cal Gas 1 period, the transmitter output will remain fixed (frozen) for an adjustable period to allow the probe reading to return to the correct process level and avoid output 'bumps'. The freeze period time required will depend on the probe response time, and whether or not it has a filter fitted.

Range:
10 to 100 seconds in ten second steps. The default setting is 30 seconds. To determine the required freeze time, manually perform a calibration check with Gas 1 while the plant is in operation and note the time required for the reading to return to the correct process level within approximately 0.5 % oxygen.

48 to 53. Cal Gas 2 Parameters

Enter the same requirements for Cal Gas 2 as per set-up steps 42 to 47 for Cal Gas 1. Cal Gas 2 could typically be 2 % oxygen in nitrogen.

54. Process Alarm Enable

If process alarms are not required, 'NO' can be selected. There will not be any process related alarms generated, and all process alarms will be cancelled, if 'NO' is selected.
The process alarms are High dew point, High dew point deviation, High pre-reaction oxygen, High oxygen, Low oxygen, Oxygen deviation, and Very low oxygen.
Options:
Yes
No *

55. High Oxygen Alarm #1

Set the operating point for the high oxygen alarm relay. This alarm monitors the oxygen level from probe 1.
The alarm level is set as an exponent value.
ie. If the alarm level is set to -18, an alarm will be initiated (after the time set in set-up 56) if the oxygen measured by probe 1 is 1.0^{-18} %or higher.
This menu item will only appear if Dew point is selected in set-up 85.
Range:
-10 to -25. The default setting is -18.

56. High Oxygen Delay #1

Typically set at 10 seconds. This delay is to avoid nuisance alarms when the furnace is undergoing transitions in firing rate or gas changes which can cause it to deviate from the oxygen set point, but recover quickly.
This menu item will only appear if Dew point is selected in set-up 85.
Range:
0–999 seconds. The default setting is 10 seconds.

57. High Oxygen Alarm #2

Set the operating point for the high oxygen alarm relay. This alarm monitors the oxygen level from probe 2.
The alarm level is set as an exponent value.
ie. If the alarm level is set to -18, an alarm will be initiated (after the time set in set-up 58) if the oxygen measured by probe 1 is 1.0^{-18} %or higher.
This menu item will only appear if Dew point is selected in set-up 85.
Range:
-10 to -25. The default setting is -18.

58. High Oxygen Delay #2

Typically set at 10 seconds. This delay is to avoid nuisance alarms when the furnace is undergoing transitions in firing rate or gas changes which can cause it to deviate from the oxygen set point, but recover quickly.
This menu item will only appear if Dew point is selected in set-up 85.

Range:
0–999 seconds. The default setting is 10 seconds.

59. High Dew Point #1

Set the operating point for the high dew point alarm relay. This alarm monitors the dew point level from probe 1.
This menu item will only appear if Dew point is selected in set-up 85.
The alarm level is set in degrees Centigrade.

Range:
-60 to -40. The default setting is -15.

60. High Dew Point Delay #1

Typically set at 10 seconds. This delay is to avoid nuisance alarms when the furnace is undergoing transitions in firing rate or gas changes which can cause it to deviate from the dew point set point, but recover quickly.
This menu item will only appear if Dew point is selected in set-up 85.

Range:
0–999 seconds. The default setting is 10 seconds.

61. High Dew Point #2

Set the operating point for the high dew point alarm relay. This alarm monitors the dew point level from probe 2.
The alarm level is set in degrees Centigrade.
This menu item will only appear if Dew point is selected in set-up 85.

Range:
-60 to -40. The default setting is -15.

62. High Dew Point Delay #2

Typically set at 10 seconds. This delay is to avoid nuisance alarms when the furnace is undergoing transitions in firing rate or gas changes which can cause it to deviate from the dew point set point, but recover quickly.
This menu item will only appear if Dew point is selected in set-up 85.

Range:
0–999 seconds. The default setting is 10 seconds.

63. High Dew Point Deviation

Set the operating point for the high dew point deviation alarm relay. This alarm monitors the dew point difference between probe 1 and probe 2.
The alarm level is set in degrees Centigrade.
This menu item will only appear if Dew point is selected in set-up 85.

Range:
-60 to -40. The default setting is 5.

64. High Dew Point Deviation Delay

Typically set at 10 seconds. This delay is to avoid nuisance alarms when there are short term deviations in the atmosphere at the two probes.
This menu item will only appear if Dew point is selected in set-up 85.

Range:
0–999 seconds. The default setting is 10 seconds.

65. High Oxygen Deviation

Set the operating point for the high dew point alarm relay. This alarm monitors the dew point level from probe 2.
The alarm level is set in decades of oxygen %. ie. If the alarm level is set to 2, the oxygen of one probe would have to be 100 times or 2 decades higher than the other.
This menu item will only appear if Dew point is selected in set-up 85.

Range:
1-25 % oxygen decades. The default setting is 2.

66. High Oxygen Deviation Delay

Typically set at 10 seconds. This delay is to avoid nuisance alarms when the furnace is undergoing transitions in firing rate or gas changes which can cause it to deviate from the dew point set point, but recover quickly.
This menu item will only appear if Dew point is selected in set-up 85.

Range:
0–999 seconds. The default setting is 10 seconds.

67. High Pre-reaction Oxygen #1 Warning

Set the operating point for the high pre-reaction oxygen warning alarm relay. This alarm monitors the pre-reaction oxygen level from probe 1. This alarm could be used to give an early warning that the oxygen is rising in the appliance. Perhaps corrective action could be taken when this alarm is activated. If the oxygen continues to rise and reaches the alarm level set in the next menu item a higher level of control should be acted on. ie. The operator should start the shutdown sequence.
The alarm level is set in %.
This menu item will only appear if Pre-reaction is selected in set-up 85.

Range:
0.01 to 5.00. The default setting is 1.00.

68. High Pre-reaction Oxygen #1 Alarm

If the pre-reaction reaches this alarm level it is recommended that the shutdown sequence is started for the appliance.
The alarm level is set in %.
This menu item will only appear if Pre-reaction is selected in set-up 85.

Range:
0.01 to 5.00. The default setting is 2.50.

69. High Pre-reaction Oxygen #2 Warning

Set the operating point for the high pre-reaction oxygen warning alarm relay. This alarm monitors the pre-reaction oxygen level from probe 2 in the same way that set-up 67 monitors the pre-reaction oxygen level from probe 1.
The alarm level is set in %.
This menu item will only appear if Pre-reaction is selected in set-up 85.

Range:
0.01 to 5.00. The default setting is 1.00.

70. High Pre-reaction Oxygen #2 Alarm

This alarm monitors the pre-reaction oxygen level from probe 2 in the same way that set-up 69 monitors the pre-reaction oxygen level from probe 1.
The alarm level is set in %.
This menu item will only appear if Pre-reaction is selected in set-up 85.

Range:
0.01 to 5.00. The default setting is 2.50.

71. Alarm Relay #2

Any or all of the following alarm functions may be used to activate the alarm relay. They may be selected or de-selected using the 'ENTER' buttons as in set-up step 33.

Options :
1. Dew point 1 high
2. Dew point 2 high
3. Oxygen 1 high
4. Oxygen 2 high
5. Oxygen deviation
6. Heater SSR Fail
7. Dew point deviation
8. Probe temperature
9. Gas calibration in progress
10. Purging probe in progress

72. Alarm Relay #3

Alarm relay #3 has the same functions available as alarm relay #2. See SET-UP 71.

73. Alarm Relay #4

Alarm relay #4 has the same functions available as alarm relay #2. See SET-UP 71.
In addition an alarm horn function is also available.
If 'Horn' is selected it will override any other selections. A relay selected as a 'Horn' driver will have the relay contacts open circuit if there is an un-accepted alarm, and closed when a new alarm occurs.

74. Data to Print

Any or all of the following values may be printed on a printer or computer connected to port 2. They may be selected or de-selected using the 'ENTER' buttons as in set-up step 33. The log period follows in set-up step 75. A sample of a print-out is contained in Appendix 3. RS to 232C protocol is :

Data word length	Eight bits
Stop bits	One
Parity	None

Oxygen from probe 1 is always printed, plus any of the following

Options :

1. Probe 2 oxygen **
2. Probe 1 and 2 oxygen averaged **
3. Sensor 1 EMF
4. Sensor 2 EMF **
5. Sensor 1 temperature
6. Sensor 2 temperature, Auxiliary temperature (this will depend if one or two sensors are selected in set-up 1)
7. Sensor 1 impedance
8. Sensor 2 impedance **
9. Ambient temperature
10. Relative humidity
11. Dew point probe 1
12. Dew point probe 2 **
13. Dew point probe 1 and 2 averaged **
14. Date to time
15. Run hours since last service
16. Date of last service

** This will not appear if only one sensor is selected in set-up 1

75. Print Log Period

Select the time interval between data print outs on the printer.

Range:

1 to 2000 minutes

76. Printer Baud Rate

Select the correct BAUD rate for data to be transmitted out of the port to the printer.

Options:

1200
2400
4800
9600 *

77. Reference Air Selection

The reference air supply for the oxygen sensor is normally supplied from the analyser. If the internal pump is not being used, 'External' must be selected to stop the 'Ref Pump Fail' alarm. If an external air supply that has a known relative humidity, select 'Instrument Air'. This will allow the relative humidity level to be entered in set-up 78.
Less than half a litre per minute provides sufficient reference air for any sensor.

Note: If 'Internal' is selected, and a reference airflow sensor is connected to CN8 on the 1630-2 (terminal) PCB, the pump is cycled on and off within a minute.

Options

Internal *
External
Instrument air

78. Reference Air Relative Humidity

This selection will only appear if 'Instrument Air' is selected in set-up 73.
If the reference air is being supplied from an instrument air supply, the relative humidity will be different from the ambient air being measured within the analyser. In this case set the set the RH to the RH of the air supply. As a guide, the RH of a compressor driven air supply is up to 10%.

Range:
1-100%

79. Damping Factor

Each time a new reading is read from the oxygen probe or sensor, the new reading is averaged with the last readings taken, before the new average is either displayed on the LCD, or sent to the 4 to 20 mA output. The smoothing of the oxygen signal is an exponential function. If a factor of 5 is used, a step change of input signal will take about 5 seconds to reach 63% of the change on the output/display. A value of zero entered here will mean that every new reading from the probe or sensor will be sent to the display unaltered.

Range
0 to 20. Default setting is 5. Zero will turn the damping off.

80. Digital Output Filter Enable

If the dew point reading on the display or on the 4-20 output reads short duration unexpected changes, the digital filter may be enabled to exclude these nuisance diversions.

Options
Yes
No *

81. External Hydrogen Level Input Enable

If the hydrogen level in the furnace varies by more than 15% of the hydrogen value, automatic on line compensation can be made by feeding the hydrogen level into the 1638 analyser. The signal must be proportional to hydrogen, but can represent any range (zero and span) from 0 to 100%.
The signal can either be a 0 to 5 volt or a 0 to 20 mA level.
Normally the hydrogen in the furnace is constant, and therefore select 'No' in this function, and set a hydrogen level in set-up 84.

Options
Yes
No *

82. External Hydrogen Level Input Zero Level

Set the zero level of your hydrogen level signal.
If your signal is proportional to hydrogen from 5 to 20 %, set this function to 5 %.

Range
0 to 100 Default setting is 0 %

83. External Hydrogen Level Input Span Level

Set the span level of your hydrogen level signal.
If your signal is proportional to hydrogen from 5 to 20 %, set this function to 20 %.

Range
0 to 100 Default setting is 100 %

84. Fixed Hydrogen Level

Set the hydrogen of the furnace to be used in the calculation of dew point. This is not required if an external hydrogen input is being used (set-up steps 82 and 83)

Range
0.0 to 100.0 Default setting is 6.5 %

85. Pre-reaction Oxygen or Dew Point Instrument Mode Selection

The 1638 has been designed to measure oxygen in a hydrogen/nitrogen atmosphere. However, to simplify the operation of the instrument, the 4-20mA output ranges, the alarms and the lower line displays will tailored to suit the selected instrument mode.

Options

Dew Point *

Pre-reaction Oxygen

Range

0 to 100 Default setting is 100 %

86. MODBUS™ Address

This function is used when networking of one or more analyser back to a master computer or data acquisition system is required. For more details on the functions of the MODBUS™ see Section 2.12, and Appendix 6.

The valid range of MODBUS™ addresses is from 1 to 31. Any analyser with zero selected as the MODBUS™ address will have the MODBUS™ disabled, and the DATA log function enabled.

For the connection details, see Section 3.15.

NOTE: If the MODBUS™ address is changed, the analyser must be turned off and back on for the address change to take effect.

Range

0-31 Default setting is 0 which disables the MODBUS communications.

6

MAINTENANCE

Section
Number

TRANSMITTER MAINTENANCE

PROBE MAINTENANCE

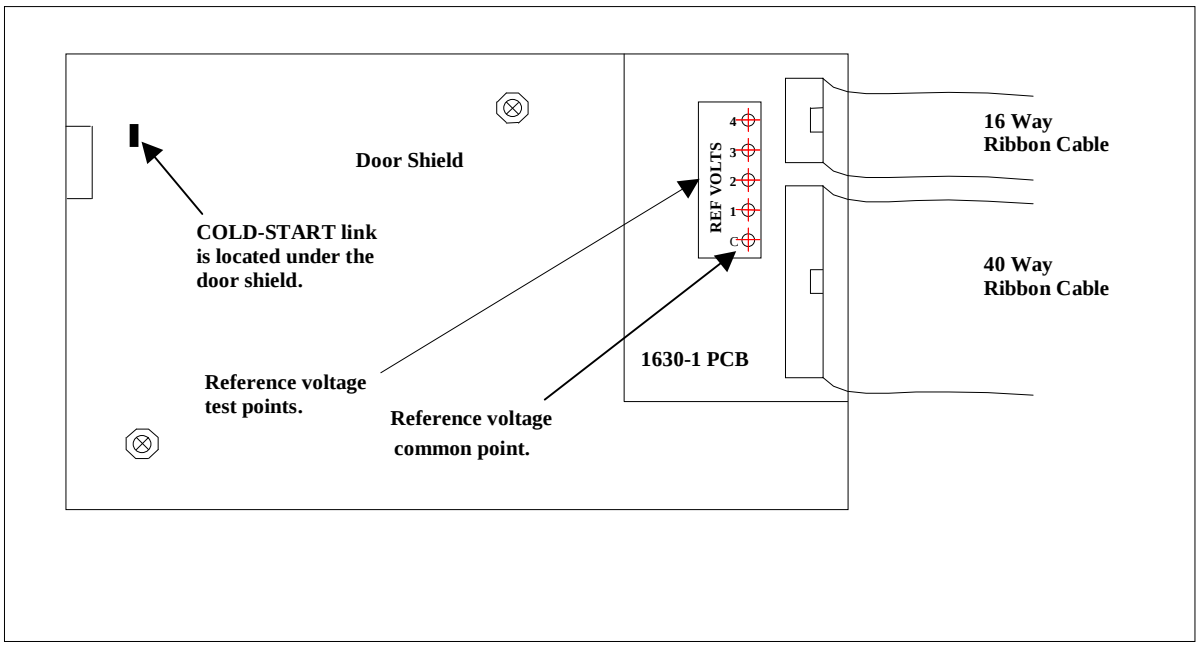
6.1 COLD START

A 'COLD START' will resets all 'Set-up' mode entries to their normal default values. 'COLD START' will show on the display for a second prior to a microprocessor initialising sequence, which takes about seven seconds.
After a 'COLD START', it is necessary to set all new variables in the 'SET-UP' mode, including calibration voltages and time and date.

To initiate a 'COLD START' -
Turn the mains power off
Remove the 'COLD START LINK' (this is located on the door PCB, next to the keyboard lock switch, behind the shield)
Turn the mains power on. The message "Cold Start....." will be displayed.
Leave the LINK off until the message "Replace c/s Link" is displayed. Replace the LINK.
The date and version number of the software will be displayed.

A 'WARM START', which is performed by applying power with the COLD START LINK in its place, will retain all data previously entered in the Set-up mode.

6.2 A/D CALIBRATION



Location of Calibration Test Points

The analyser maintains its accuracy over a very long by continuously checking itself against internal stabilised references. The only calibration required is to set the actual values of these references into battery backed memory. The analyser will read these references every minute and update its zero and span correction factors. See Section 5.5.7 to 10.
These references should be checked every 12 months. An AUTOCAL of the analog output section should always be performed if these references are altered. See Section 6.3.

6.3 D/A (4-20MA OUTPUT CHANNELS) CALIBRATION

The calibration can either be done using the 'Auto Cal' or 'Manual Cal'.

Auto Cal

The 'Auto Cal' mode is selected in set-up 13 (and 16 for channel 2).
The analyser will automatically divert the output back to the input, measure the offset and span, and record the calibration factors for each channel.
If either of the channels are selected to be calibrated manually, the factors will not be changed by an 'Auto Cal'.

Manual Cal

The 'Manual Cal' mode is selected in set-up 13 (and 16).
Set the 4mA calibration first and then the 20mA calibration.

1. Select 'Set 4mA Trim' in set-up 13 (or 16).
2. Return to RUN mode.
3. Measure the output on the channel to be calibrated with a digital multimeter. If the current is not exactly 4.00mA, return to set-up mode and change the 4mA calibration factor in set-up 14 (or 17).
4. Re-measure the current while back in RUN mode until the current is within 3.9 to 4.1mA.
5. Return to set-up mode and select 'Manual Cal' in set-up 13 (or 16).

Set the 20mA calibration factor.

6. Select 'Set 20mA Trim' in set-up 13 (or 16).
7. Return to RUN mode.
8. Measure the output on the channel to be calibrated with a digital multimeter. If the current is not exactly 20.00mA, return to set-up mode and change the 20mA calibration factor in set-up 15 (or 18).
9. Re-measure the current while back in RUN mode until the current is within 19.9 to 20.1mA.
10. Return to set-up mode and select 'Manual Cal' in set-up 13 (or 16).

This calibration is now saved in battery backed memory until

The factors are changed in the manual calibration
The analyser is forced into a COLD-START (see section 6.1)
The calibration mode in set-up 13 (or 16) is changed to Auto Cal and an Auto Cal is initiated.

NOTE: The 4mA or the 20mA trim mode will only be held on the output channels for 30 minutes before automatically returning to 'Manual Cal' mode in set-up 13 (or 16).

6.4 PUMP REPLACEMENT

The reference air pump is mounted on the 1630-2 PCB in the base of the analyser. The operation of the pump is monitored by the analyser and alarms will be shown if a fault occurs. ("Pump Fail" alarm, "Pump Blocked" alarm)
To replace the pump, unplug all the field wiring terminals. ie. Probe connectors, power connector etc.
Unplug the 10 way and the 40 way ribbon connectors. Remove the 5 captive screws that retain the terminal PCB in the base of the case. Remove the PCB from the case. The pump can now be un-screwed, and the wires un-plugged.

6.5 BACK-UP BATTERY REPLACEMENT

The back-up battery is contained within the battery-like real time clock/memory module, plugged into socket M2. It is rated for an average service life of greater than ten years. The module is not re-chargeable and should be replaced every three years with a stored transmitters with power off or every eight years with a transmitters which have had the power on. The memory module must be purchased from Novatech Controls or an agent of Novatech Controls.
After replacing the battery, re-enter all set-up mode functions.

6.6 ELECTRONIC REPAIRS

Electronic schematics are included in Appendix 4. A competent electronic technician could perform troubleshooting with these schematics, aided by the analyser self-diagnostic alarms. It is recommended that service be performed on a change-over circuit board basis. A fast turn-around or replacement service is available from Novatech or accredited service agents. Other service aids, including a test EPROM firmware package and probe input simulator are also available.

6.7 INSTALLING A NEW PROBE OR SENSOR

Whenever a new oxygen probe or sensor is installed, the millivolt offset value should be entered. To achieve this refer to set-up 11 (and 12 for the second sensor).

The probe or sensor offset is noted on a tag or label attached to probe or sensor. To check an offset on site, the probe must be sensing air with reference air connected and allowed to settle at the operating temperature for 10 minutes. Read the offset in 'RUN' mode in millivolts on the lower line. Offset errors can occur if the sensor does not have some air passing over it. A gentle flow of air in the calibration check port can be provided by a reference air pump or similar. If a probe is in a process with the process running, the air purge on the sensing side of the sensor will only be successful if the probe has a filter or small sensing hole. Probes with open sensing ends or with large sensing holes allow the process gas to mix with the calibration gas, giving a false reading.

For heated probes or sensors, if the combustion appliance is not operational and the probe or sensor heater is interlocked with the 'FUEL ON' signal, the 'BURNER BYPASS' switch should be set to 'BYPASS' to power the probe or sensor heater after removing the probe from the flue. For unheated probes, the sensing tip must be raised to at least 650°C with a portable furnace.

CAUTION DANGER

Return the 'BURNER BYPASS' switch to normal (off) before installing the probe in the flue.

6.8 TEST EQUIPMENT REQUIRED

All measurements are simplified if an analyser is connected to the probe or sensor. Readings can then be easily taken of sensor impedance, EMF, temperature and percent oxygen. The analyser also provides proper heater control for heated probes or sensors.

The following tests are described using readily available workshop equipment where an analyser is not available. If an analyser is available the same test procedures will apply. First check all alarms on the analyser, allowing time for the probe or sensor to heat up after switch on.

An instrument to measure sensor EMF and temperature is required. A 3 1/2 or 4 1/2 digit multimeter will perform both measurements.

A separate temperature indicator to suit the probe or sensor thermocouple type is also useful, although not necessary.

A reference air pump is required and a cylinder of calibration check gas e.g. 2 % oxygen in nitrogen. The cylinder should have a pressure and flow regulator. Both of these are inexpensive devices available from gas supply companies. The calibration check gas should be chromatograph tested to an accuracy of 0.1 % oxygen.

TEST EQUIPMENT FOR UNHEATED PROBES

A small test furnace capable of raising the probe tip temperature to 720 °C is required. The furnace should have a uniform temperature for about 50 mm either side of the sensor tip.

TEST EQUIPMENT FOR HEATED PROBES

If a 1638 analyser is available at the test location then no other equipment will be required. If not, then a controllable power source for the heater is required. A Variac (variable transformer), set to approximately 100 or 240 volts will regulate the sensor temperature to 720° C.

6.9 TESTING A PROBE OR SENSOR

With the sensor heated to approximately 720 °C, either from a small test furnace or its own internal heater, connect a digital multimeter to the sensor electrode conductors. Connect the multimeter positive to the internal electrode conductor. Connect reference air to and apply a gentle purge of air to the probe calibration check port. Reference air flow should be the smallest flow available (less than 50 cc per minute). The multimeter should read zero millivolts ± two millivolts. If not, then there is a problem with the probe electrodes and the sensor needs refurbishing. Normally a faulty probe electrode is indicated with a high source impedance. 1234 sensors do not require reference air but a gentle flow of air should be admitted into the sample connection.

To test the source impedance, set the multimeter to read ohms and take a measurement within a couple of seconds, of the sensor impendence. Reverse the multimeter and repeat the reading. Take the average of the two readings for an approximate measurement of impedance. If the impedance is above 10kΩ, then the probe or sensor needs to be replaced. The sensor must be 720°C or above for this measurement. The reason that impedance measurements need to be performed quickly, is that the zirconia sensor polarises with the DC voltage from the multimeter across it.

If the probe or sensor tests reveal less than 2 mV offset and a good impedance reading, the next step is to apply a calibration check gas. The calibration check gas should be inserted in the calibration check port. With the calibration check gas flowing, the sensor should develop an EMF according to the tables in Appendix 1. If the EMF reading is low then there may be insufficient calibration check gas flow. Increase the calibration check gas until the reading is correct. An excessive calibration check gas flow will cause cooling on one surface of the sensor, giving temperature differential errors on the sensor.

As an alternative, using the reference air port, the calibration check gas can be inserted into the inside of a probe sensor. This requires a lower flow rate, and thus lower usage of calibration check gas. The flow rate should be similar to that of the reference air, which should be removed for internal calibration check. The sensor EMF reading will be identical but negative in polarity. A small flow of air should be flowing over the outside of the sensor, when testing in this way.

Occasionally, a sensor can develop offset with a polluted electrode caused by contaminants in the flue gas stream. In this case the impedance may be OK but the output incorrect. This phenomena is rare.

6.10 PROBE OR SENSOR THERMOCOUPLE

Although some unheated probes are specified without a thermocouple, most probes, both heated and unheated, have an integral thermocouple which is fitted in to the four bore insulator. The analyser has an alarm function which will advise the operator of an open circuit thermocouple, however bench testing can be performed by simply measuring the thermocouple continuity.

6.11 HEATER FAILURE

For heated probe or sensors, a heater failure will cause a ‘PROBE TEMPERATE’ or ‘HEATER FAIL’ alarm. Heaters can be tested with a continuity test. The heater impedance should be approximately 100Ω. Should the heater be open or short circuited, replace the probe or sensor.

6.12 FILTER BLOCKAGE

For oxygen probes or flow guide tubes with filters in installations with entrained solids in the flue gas, it is sometimes necessary to replace the filter. Filters are normally cleared with back purging. However fine fly-ash, or other particles can ultimately completely block a filter necessitating filter replacement. A new probe filter can be fitted

APPENDIX 1

PROBE OR SENSOR EMF TABLES

ZIRCONIA OXYGEN SENSOR OUTPUT (mV)
PROBE TYPE 1231, SENSOR TYPE 1234

OXYGEN %	Probe EMF @ 720°C (1320°F)	OXYGEN %	Probe EMF @ 720°C (1320°F)
20.95	0	10.0	15.930
20.5	0.517	9.5	17.033
20.0	1.046	9.0	18.196
19.5	1.589	8.5	19.426
19.0	2.147	8.0	20.730
18.5	2.719	7.5	22.120
18.0	3.306	7.0	23.607
17.5	3.911	6.5	25.204
17.0	4.533	6.0	26.930
16.5	5.173	5.5	28.808
16.0	5.834	5.0	30.867
15.5	6.515	4.5	33.145
15.0	7.219	4.0	35.695
14.5	7.947	3.5	38.590
14.0	8.700	3.0	41.940
13.5	9.481	2.5	45.913
13.0	10.292	2.0	50.797
12.5	11.134	1.5	57.135
12.0	12.011	0.9	66.182
11.5	12.925	0.4	82.168
11.0	13.881	0.2	99.518
10.5	14.881	0.1	114.347

'K' Type TC 29.965 mV @ 720°C (1320°F)

These tables are based on the Nernst equation:

$$EMF = \frac{T \log_e\left(\frac{O_2}{20.95}\right)}{-46.421}$$ Where T is temperature° K

ZIRCONIA OXYGEN PROBE OUTPUT (mV)
PROBE TYPE 1232

	TEMPERATURE °C (°F)								
OXYGEN %	**600 (1110)**	**700 (1290)**	**800 (1470)**	**900 (1650)**	**1000 (1830)**	**1100 (2010)**	**1200 (2190)**	**1300 (2370)**	**1400 (2550)**
20	0.873	0.973	1.073	1.173	1.273	1.373	1.473	1.573	1.673
19.5	1.349	1.504	1.658	1.813	1.967	2.122	2.276	2.431	2.585
19	1.838	2.048	2.259	2.469	2.680	2.890	3.100	3.311	3.521
18.5	2.339	2.607	2.875	3.143	3.411	3.679	3.947	4.215	4.483
18	2.855	3.182	3.509	3.835	4.162	4.489	4.816	5.143	5.470
17.5	3.385	3.772	4.160	4.547	4.935	5.323	5.710	6.098	6.485
17	3.930	4.380	4.830	5.280	5.730	6.180	6.630	7.080	7.530
16.5	4.491	5.006	5.520	6.034	6.549	7.063	7.578	8.092	8.606
16	5.070	5.651	6.231	6.812	7.393	7.973	8.554	9.135	9.715
15.5	5.667	6.316	6.965	7.614	8.263	8.913	9.562	10.211	10.860
15	6.284	7.004	7.723	8.443	9.163	9.882	10.602	11.322	12.042
14.5	6.922	7.714	8.507	9.300	10.093	10.885	11.678	12.471	13.263
14	7.582	8.450	9.318	10.187	11.055	11.923	12.792	13.660	14.528
13.5	8.266	9.212	10.159	11.106	12.052	12.999	13.946	14.892	15.839
13	8.976	10.004	11.032	12.060	13.087	14.115	15.143	16.171	17.199
12.5	9.713	10.826	11.938	13.051	14.163	15.276	16.388	17.500	18.613
12	10.481	11.682	12.882	14.082	15.283	16.483	17.684	18.884	20.084
11.5	11.282	12.574	13.866	15.158	16.450	17.742	19.034	20.326	21.618
11	12.118	13.506	14.893	16.281	17.669	19.057	20.445	21.833	23.220
10.5	12.993	14.481	15.969	17.457	18.945	20.433	21.921	23.409	24.897
10	13.911	15.504	17.097	18.690	20.283	21.876	23.469	25.063	26.656
9.5	14.875	16.579	18.283	19.986	21.690	23.394	25.097	26.801	28.504
9	15.892	17.712	19.533	21.353	23.173	24.993	26.813	28.633	30.453
8.5	16.967	18.911	20.854	22.797	24.740	26.684	28.627	30.570	32.513
8	18.108	20.182	22.255	24.329	26.403	28.477	30.551	32.625	34.698
7.5	19.322	21.535	23.747	25.960	28.173	30.386	32.599	34.812	37.025
7	20.619	22.981	25.342	27.704	30.065	32.427	34.788	37.150	39.511
6.5	22.013	24.534	27.056	29.577	32.098	34.619	37.140	39.661	42.182
6	23.519	26.212	28.906	31.600	34.293	36.987	39.680	42.374	45.067
5.5	25.155	28.036	30.917	33.798	36.679	39.560	42.442	45.323	48.204
5	26.948	30.035	33.121	36.207	39.293	42.380	45.466	48.552	51.639
4.5	28.930	32.243	35.557	38.870	42.183	45.496	48.810	52.123	55.436
4	31.145	34.712	38.279	41.846	45.413	48.980	52.547	56.115	59.682
3.5	33.657	37.512	41.366	45.221	49.076	52.930	56.785	60.640	64.494
3	36.557	40.743	44.930	49.117	53.303	57.490	61.677	65.864	70.050
2.5	39.986	44.565	49.145	53.724	58.304	62.883	67.463	72.042	76.622
2	44.183	49.243	54.303	59.364	64.424	69.484	74.544	79.604	84.665
1.5	49.594	55.274	60.954	66.634	72.314	77.994	83.674	89.354	95.034
1	57.221	63.774	70.327	76.881	83.434	89.988	96.541	103.094	109.648
0.5	70.258	78.305	86.351	94.398	102.445	110.491	118.538	126.584	134.631
0.2	87.493	97.514	107.534	117.554	127.575	137.595	147.616	157.636	167.657
Thermocouple mV									
'K' Type	24.905	29.129	33.275	37.326	41.276	45.119	48.838	52.410	-
'J' Type	33.102	39.132	45.494	51.877	57.953	63.792	69.553	-	-
'R' Type	5.583	6.743	7.950	9.205	10.506	11.850	13.228	14.629	16.040
'S' Type	5.239	6.275	7.345	8.449	9.587	10.757	11.951	13.159	14.373
'N' Type	20.613	24.527	28.455	32.371	36.256	40.087	43.846	47.513	-

These tables are based on the Nernst equation:

$$EMF = \frac{T \log_e\left(\frac{O_2}{20.95}\right)}{-46.421}$$ Where T is temperature° K

Thermocouple information from NIST ITS-90 data tables

Dew Point Calculations at 720°C & 900°C

	Hydrogen level 6.5 % Sensor temperature 720 °C		Hydrogen level 6.5 % Sensor temperature 900 °C	
EMF from sensor	Oxygen %	Dew Point °C	Oxygen %	Dew Point °C
950	1.09E-18	43.29	9.91E-16	23.15
960	6.83E-19	39.30	6.67E-16	20.01
970	4.28E-19	35.34	4.49E-16	16.91
980	2.68E-19	31.42	3.03E-16	13.87
990	1.68E-19	27.57	2.04E-16	10.89
1000	1.05E-19	23.78	1.37E-16	7.96
1010	6.60E-20	20.06	9.23E-17	5.08
1020	4.14E-20	16.41	6.21E-17	2.25
1030	2.59E-20	12.83	4.18E-17	-0.37
1040	1.62E-20	9.33	2.82E-17	-2.73
1050	1.02E-20	5.91	1.90E-17	-5.05
1060	6.38E-21	2.56	1.28E-17	-7.34
1070	4.00E-21	-0.54	8.59E-18	-9.58
1080	2.51E-21	-3.32	5.79E-18	-11.80
1090	1.57E-21	-6.05	3.90E-18	-13.97
1100	9.84E-22	-8.72	2.62E-18	-16.11
1110	6.17E-22	-11.35	1.77E-18	-18.22
1120	3.86E-22	-13.92	1.19E-18	-20.29
1130	2.42E-22	-16.45	8.00E-19	-22.33
1140	1.52E-22	-18.92	5.39E-19	-24.33
1150	9.51E-23	-21.35	3.63E-19	-26.31
1160	5.96E-23	-23.74	2.44E-19	-28.25
1170	3.73E-23	-26.08	1.64E-19	-30.17
1180	2.34E-23	-28.38	1.11E-19	-32.05
1190	1.47E-23	-30.63	7.45E-20	-33.90
1200	9.19E-24	-32.85	5.01E-20	-35.73
1210	5.76E-24	-35.02	3.38E-20	-37.53
1220	3.61E-24	-37.16	2.27E-20	-39.30
1230	2.26E-24	-39.25	1.53E-20	-41.05
1240	1.42E-24	-41.31	1.03E-20	-42.77
1250	8.87E-25	-43.34	6.94E-21	-44.47
1260	5.56E-25	-45.33	4.67E-21	-46.14
1270	3.48E-25	-47.28	3.14E-21	-47.78
1280	2.18E-25	-49.21	2.12E-21	-49.40
1290	1.37E-25	-51.10	1.42E-21	-51.00
1300	8.58E-26	-52.95	9.59E-22	-52.58
1310	5.37E-26	-54.78	6.46E-22	-54.13
1320	3.37E-26	-56.58	4.35E-22	-55.67
1330	2.11E-26	-58.35	2.93E-22	-57.18
1340	1.32E-26	-60.09	1.97E-22	-58.67
1350	8.29E-27	-61.80	1.33E-22	-60.14
1360	5.19E-27	-63.48	8.93E-23	-61.59
1370	3.25E-27	-65.14	6.01E-23	-63.02
1380	2.04E-27	-66.77	4.05E-23	-64.43
1390	1.28E-27	-68.38	2.72E-23	-65.82
1400	8.01E-28	-69.96	1.83E-23	-67.20

APPENDIX 2

% OXYGEN SCALE TO LOGARITHMIC

OXYGEN %	FULL SCALE %
0.1	0
0.15	7.65
0.2	13.1
0.3	20.7
0.4	26.2
0.6	33.8
0.8	39.2
1	43.5
1.5	51.1
2	56.5
3	64.2
4	69.6
6	77.3
8	82.7
10	86.9
12	90.4
14	93.3
16	95.8
18	98
20	100

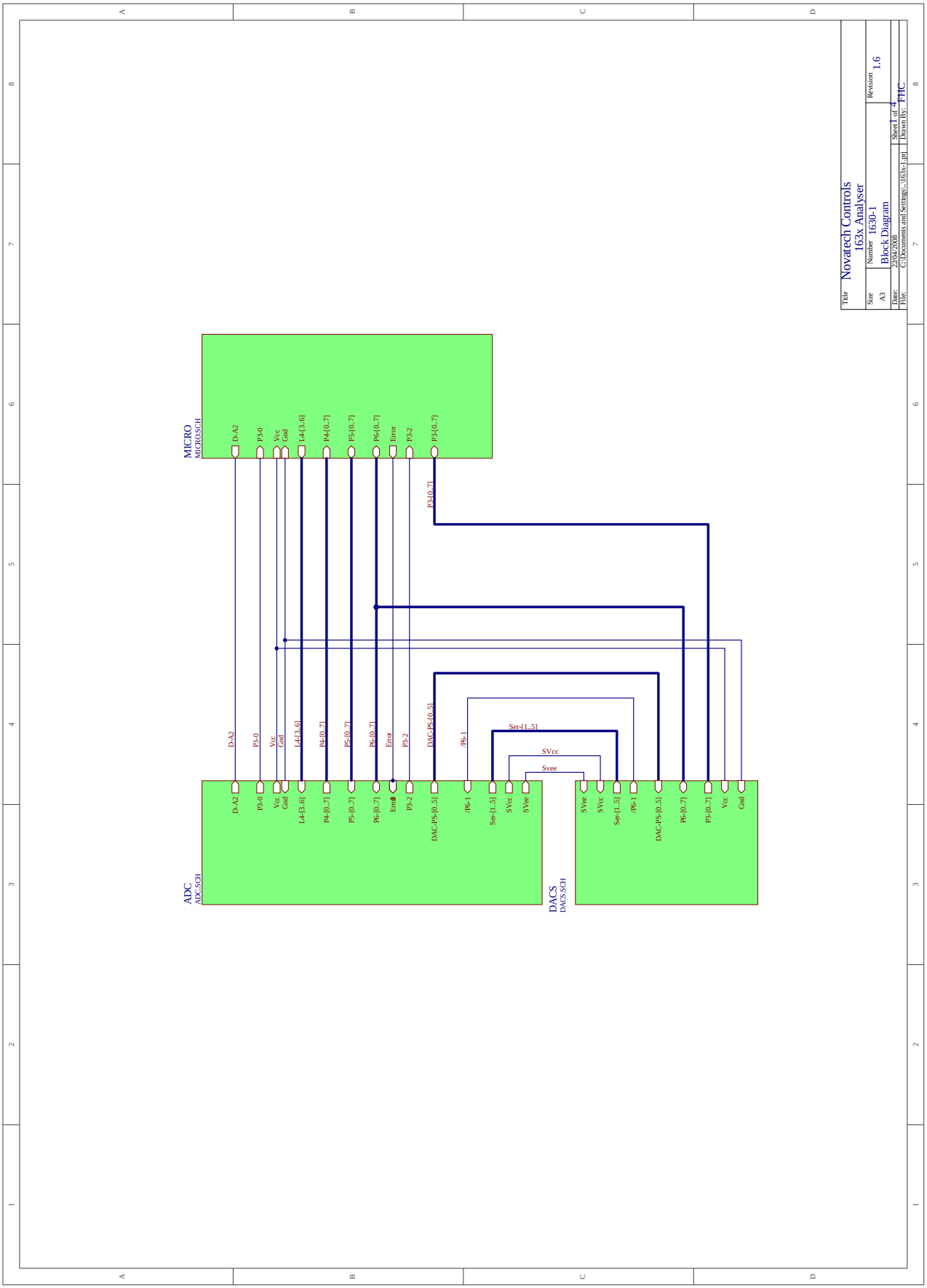
APPENDIX 3

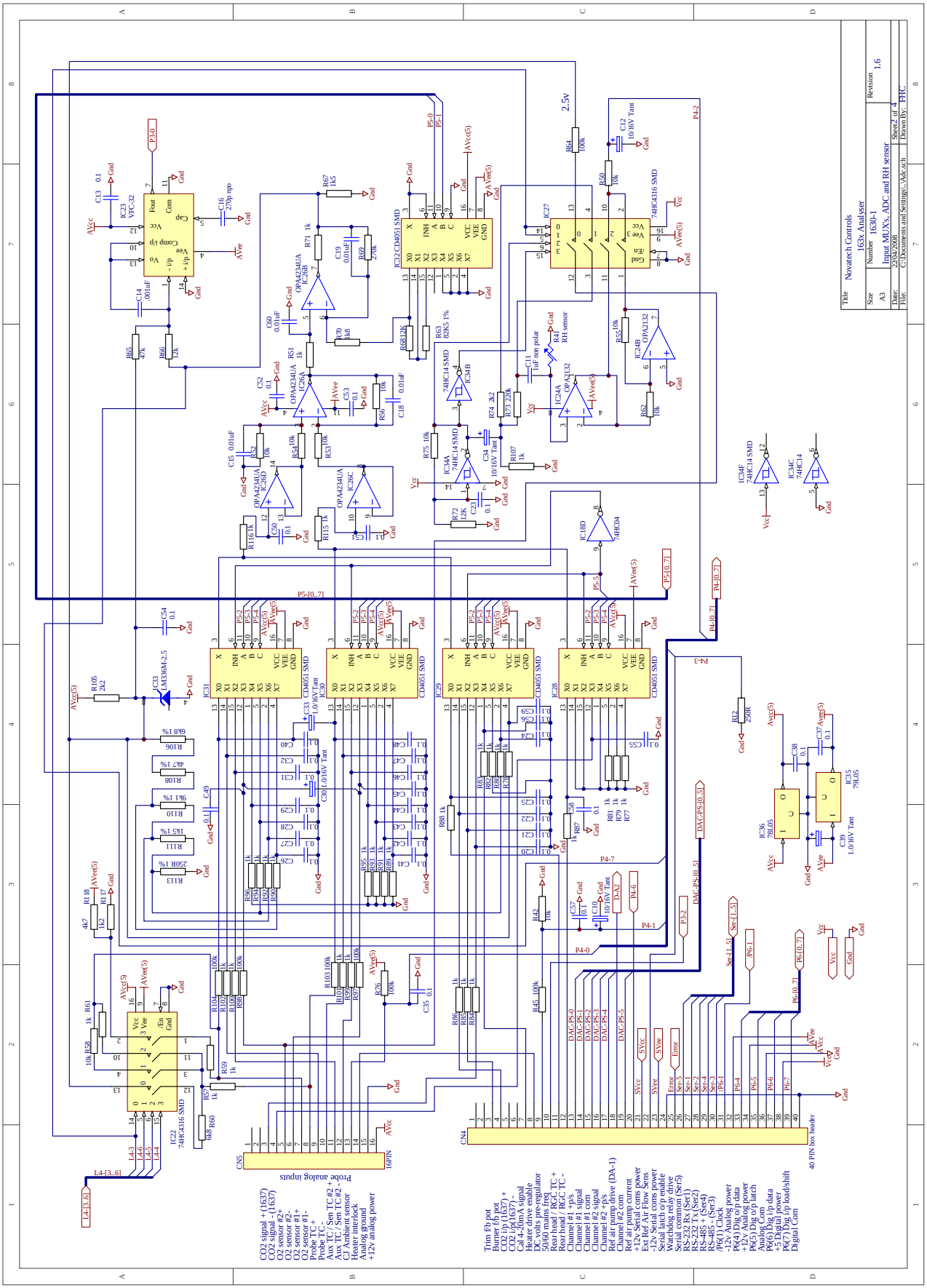
SAMPLE LOG PRINT OUT

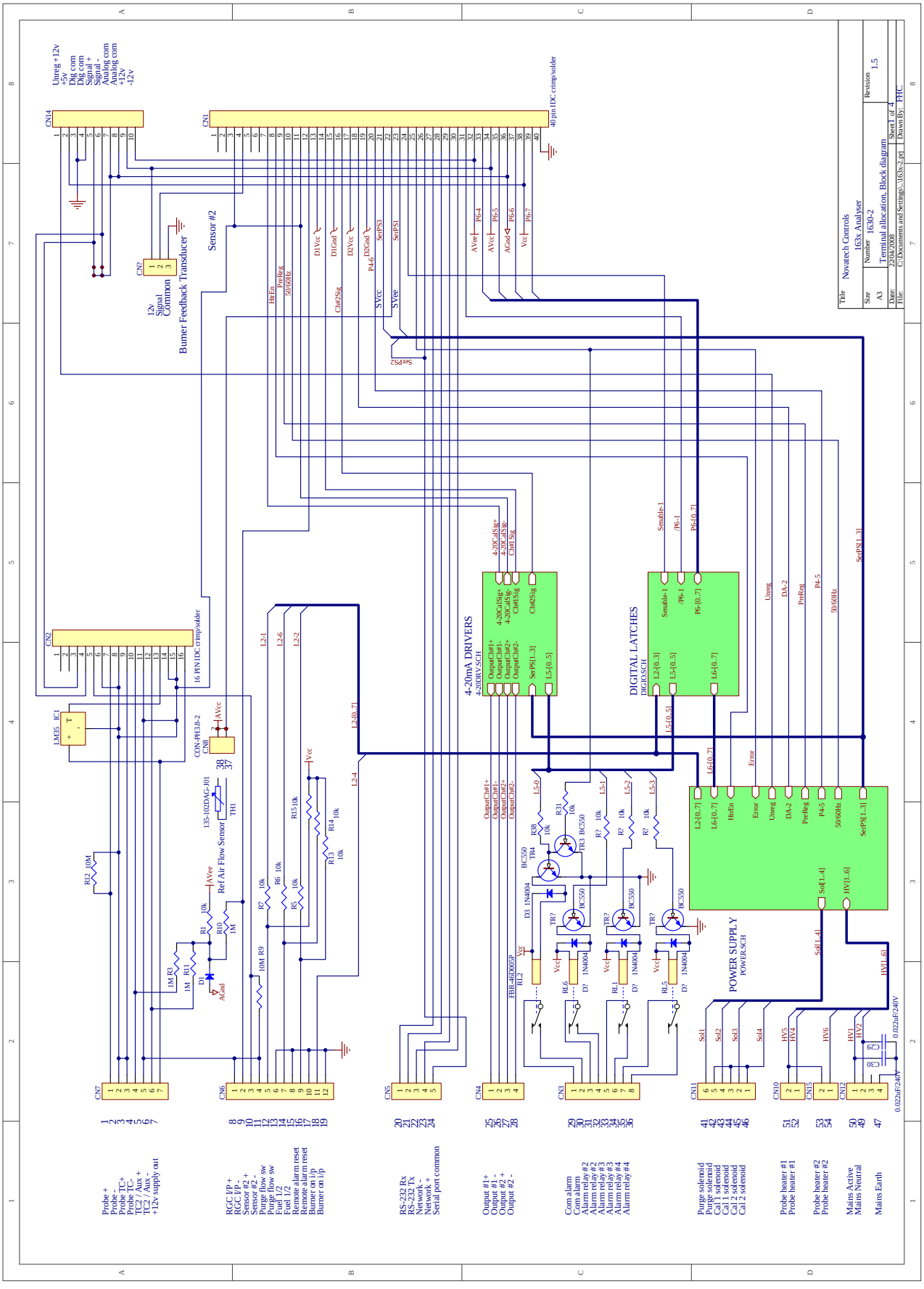
Novatech Controls 04-07-1995 06:13:59
Oxygen % 1.86
EMF 1 mV 38.0
Probe Temp 458C
Ambient T 21.9C
Servc'd 03/07/95
Humidity 43%
Sensor 1 Imp 5.7K
Next Purge at 06:00:00 17-10-1995
Next Print at 06:27:00 17-10-1995
06:00:11 04-07-1995 Heater 1 Fail Is Active
06:00:13 04-07-1995 O2% Low Is Active
02:33:17 04-07-1995 RefPump Fail Accepted

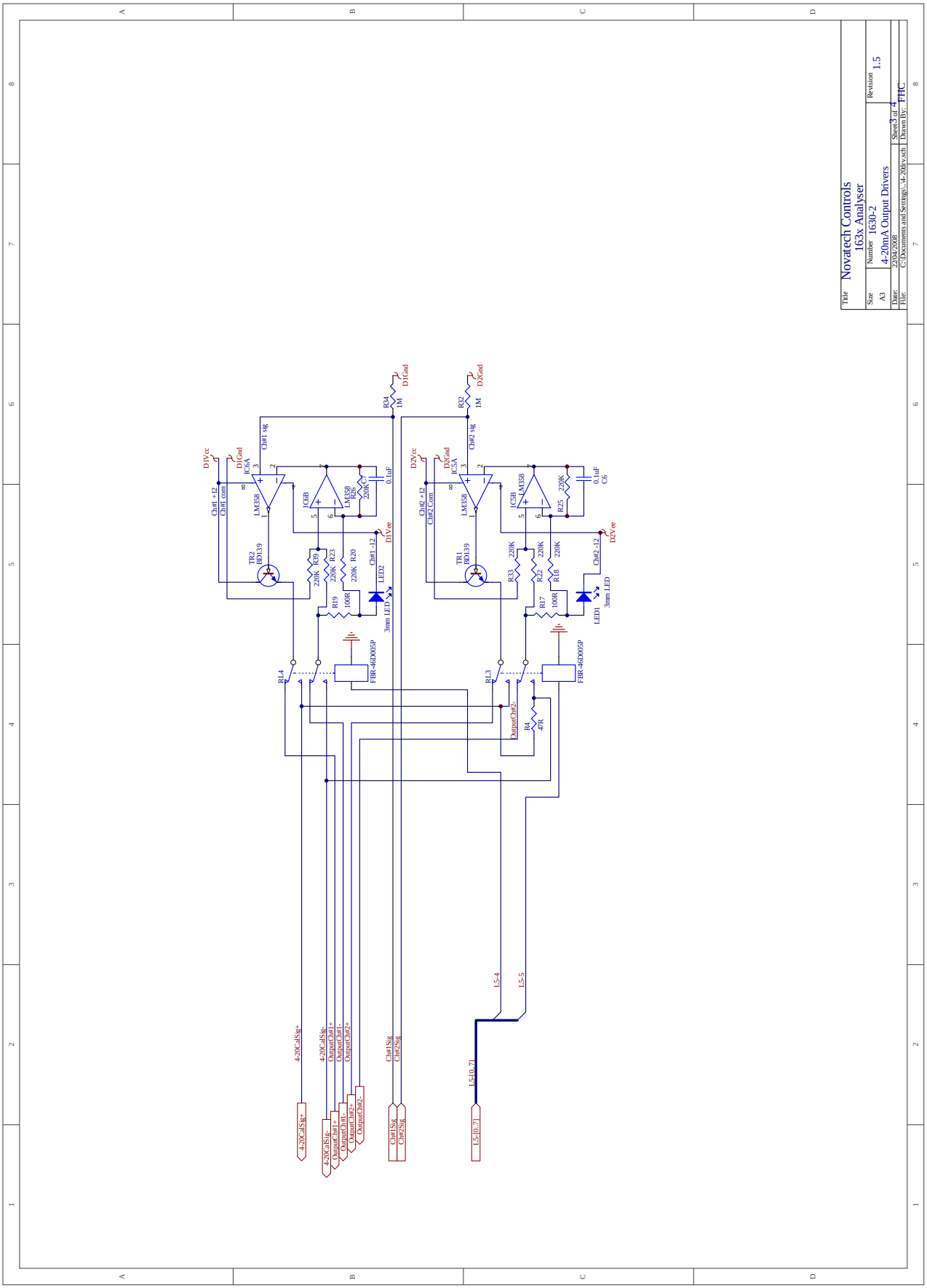
APPENDIX 4

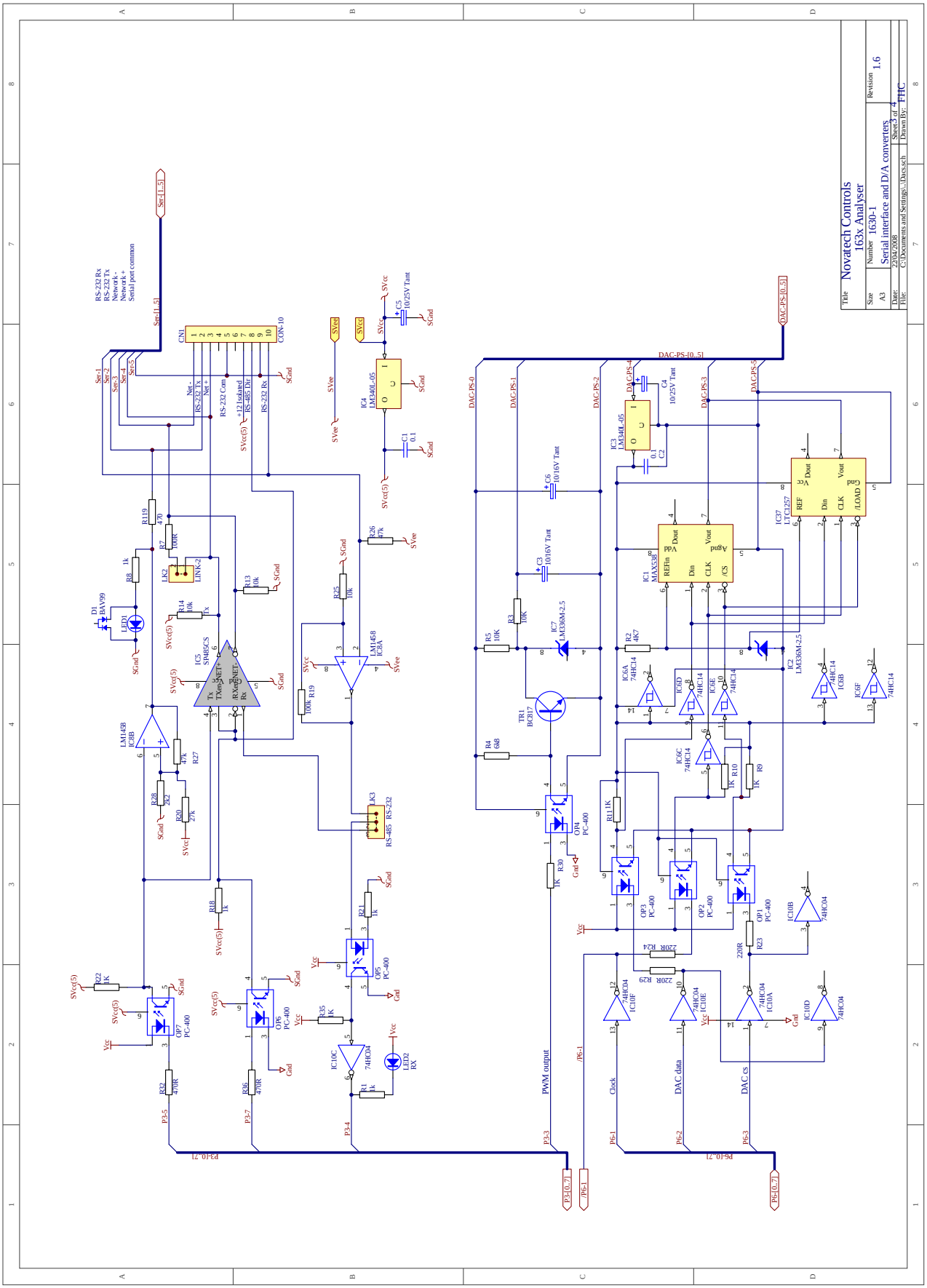
CIRCUIT SCHEMATICS

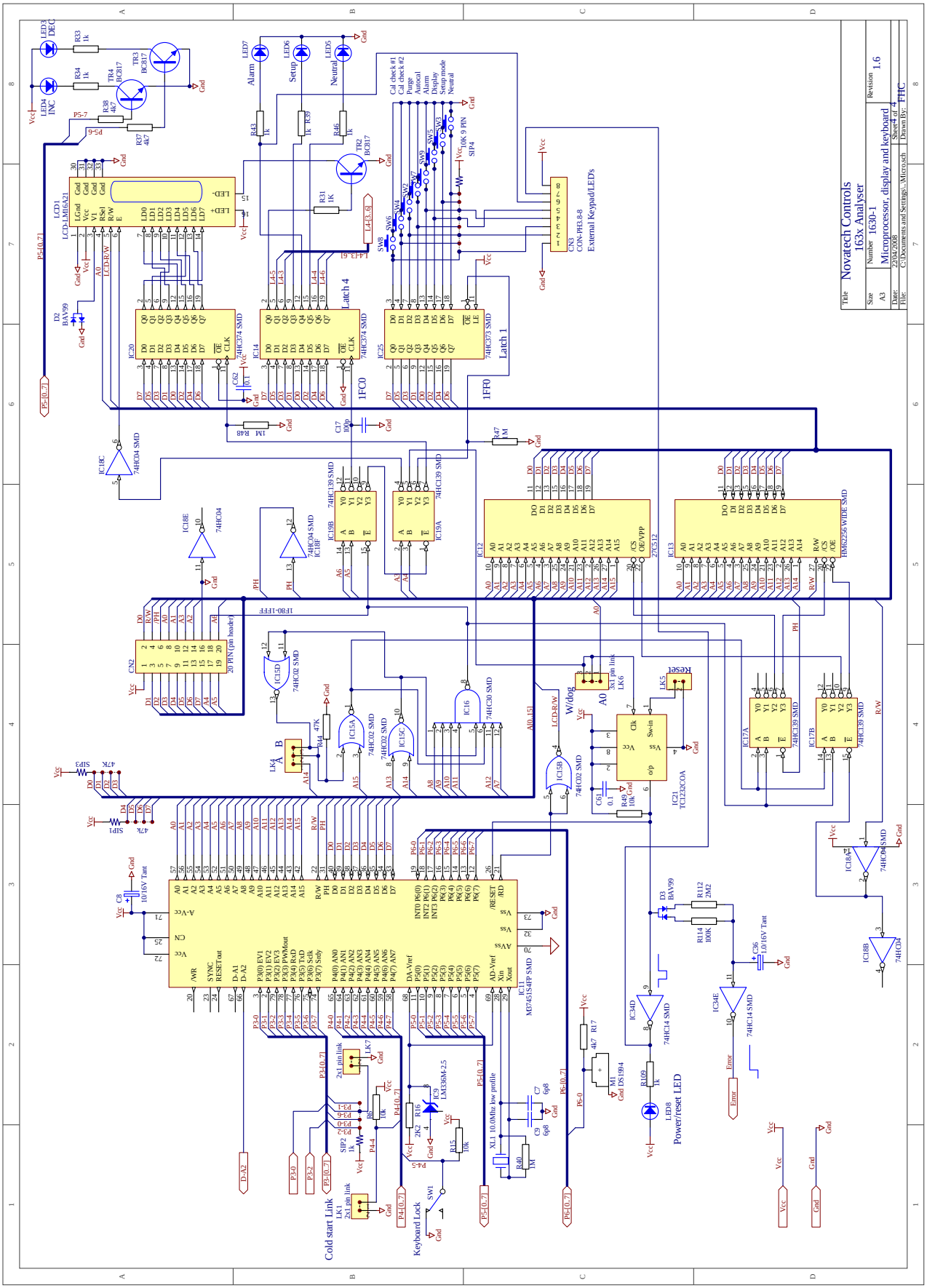

Title
Novatech Controls
163x Analyser
Size
A3
Number
1630-1
Block Diagram
Revision
1.6
Date:
27/04/2008
Sheet 1 of 4
File:
C:\Documents and Settings\...\163x-1.prj
Drawn By:
FHC
MICRO
MICRO.SCH
D-A2
P3-0
Vcc
Gnd
L4[3..6]
P4[0..7]
P5[0..7]
P6[0..7]
Error
P3-2
P3[0..7]
P3[0..7]
ADC
ADC.SCH
DACS
DACS.SCH
Ser[1..5]
SVcc
Svee
/P6-1
DAC-P5[0..5]

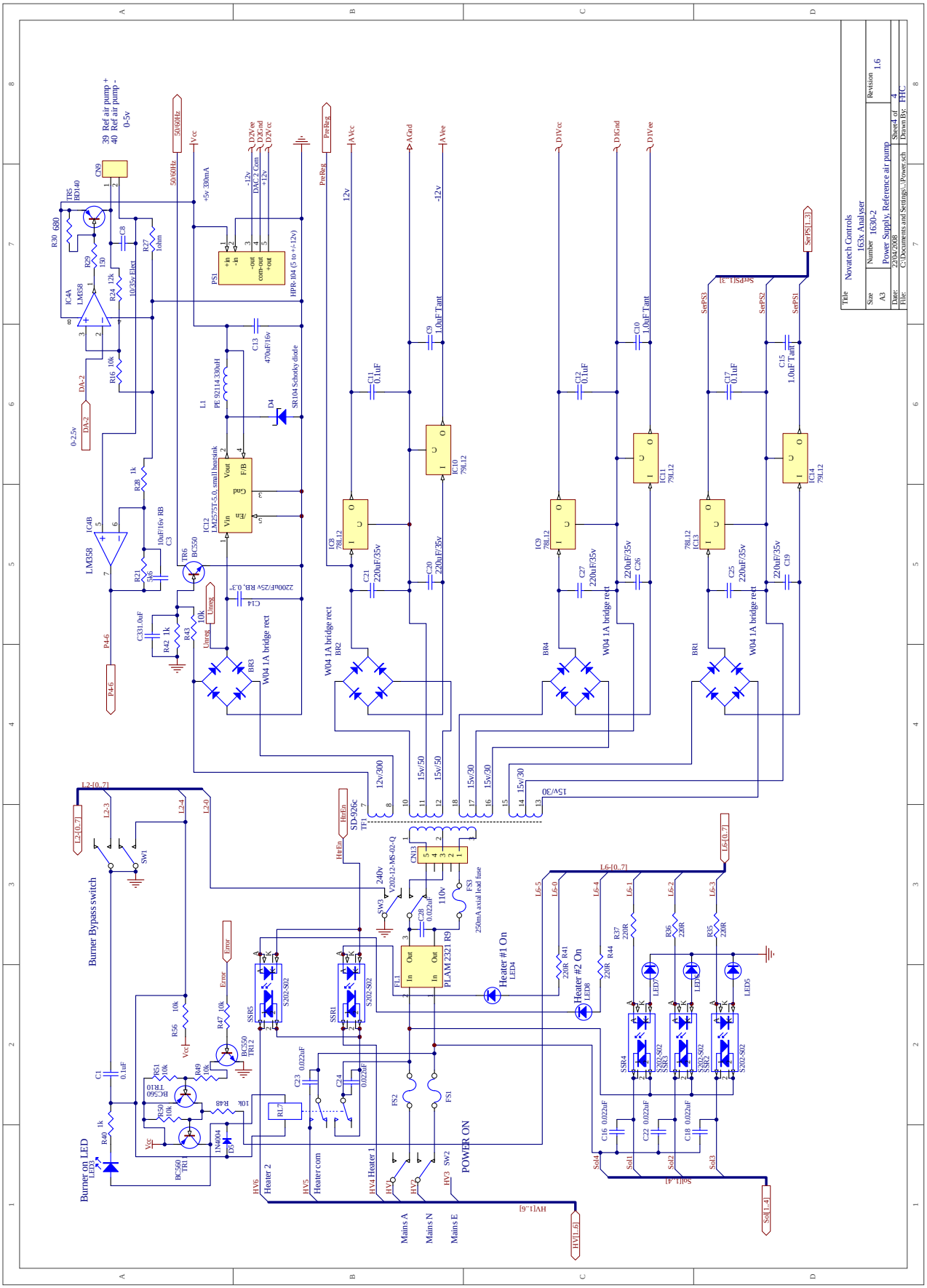

Title
Novatech Controls
163x Analyser
Size
A3
Number
1630-1
Revision
1.6
Input MUX's, ADC and RH sensor
Date:
23/04/2008
Sheet 2 of 4
File:
C:\Documents and Settings\Adc.sch
Drawn By:
FHC
Probe analog inputs
CN5
16PIN
CN4
40 PIN box header
Trim f/b pot
Barometric pot
CO2 i/p (1637) -
CO2 i/p(1637) +
Cal 4-20mA signal
Heater drive enable
Dew point temp regulator
50/60 mains freq
Rear head / RGC TC +
Rear head / RGC TC -
Channel #1 +p/s
Channel #1 signal
Channel #2 com
Channel #2 signal
Channel #2 +p/s
Ref air pump drive (DA-1)
Channel #2 com
Ref air pump current
+12v Serial coms power
Ext Ref Air Flow Sens
-12v Serial coms power
Serial latch o/p enable
Valve/Log relay drive
Serial comms (Ser5)
RS-232 Rx (Ser1)
RS-232 TX (Ser2)
RS-485 + (Ser3)
RS-485 - (Ser4)
P6(1) Dig o/p clock
+12v Analog power
P6(4) Dig o/p data
-12v Analog power
P6(5) Dig o/p latch
Analog com
P6(6) Dig i/p data
+5 Digital power
P6(7) Dig i/p load/shift
Digital Com
CO2 signal + (1637)
CO2 signal - (1637)
O2 sensor #2+
O2 sensor #2-
O2 sensor #1+
O2 sensor #1-
Probe TC +
Probe TC -
Aux TC / Sen TC #2 +
Aux TC / Sen TC #2 -
GJ Ambient sensor
Heater interlock
Analog ground
+12v analog power

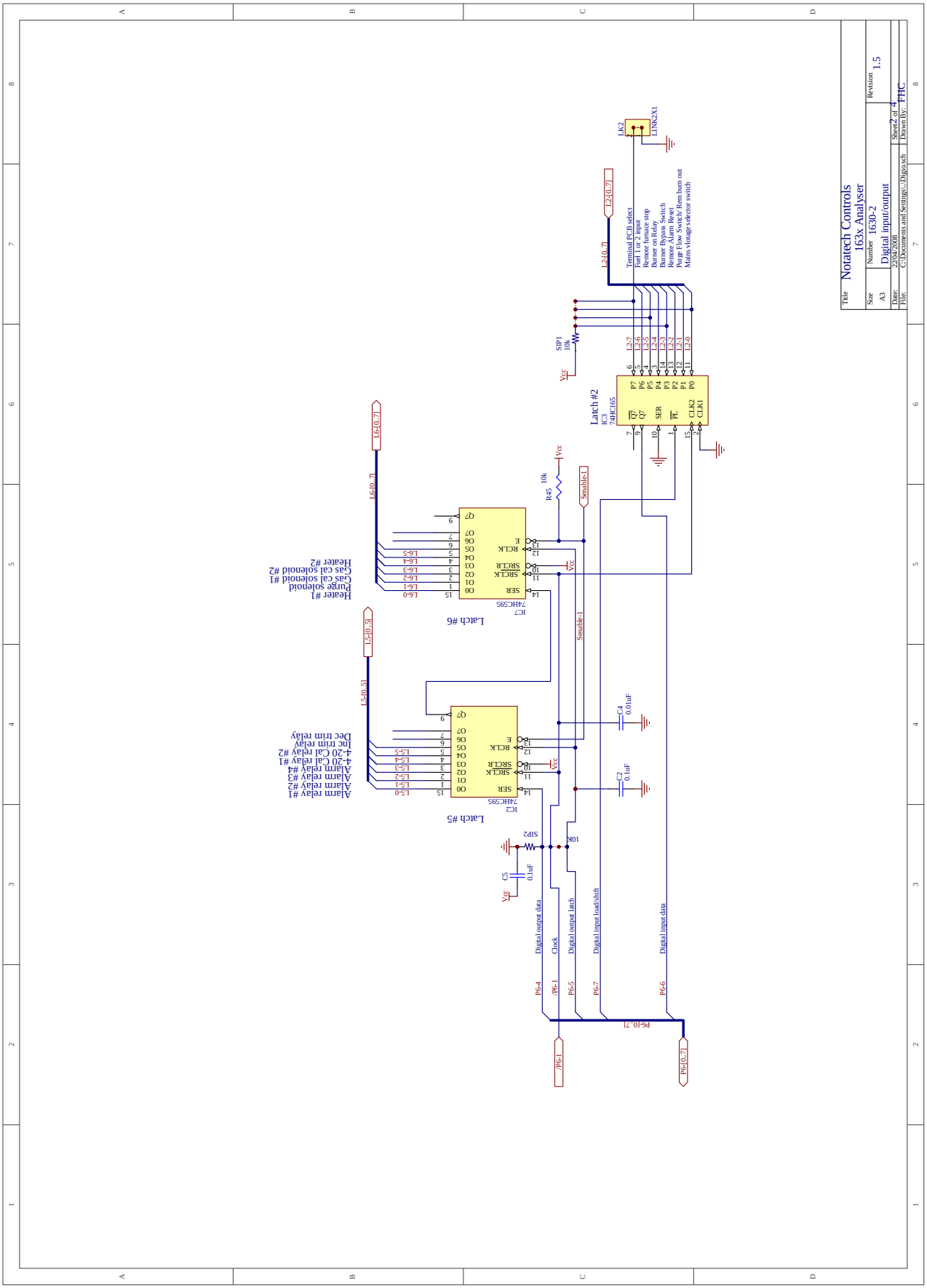

Unreg +12v
+5v
Dig com
Dig com
Signal +
Signal -
Analog com
Analog com
+12v
-12v
CN14
CN1
40 pin IDC crimp/solder
Sensor #2
Burner Feedback Transducer
12v
Signal
Common
CN2
HtrEn
PreReg
50/60Hz
Chn2Sig
D1Vcc
D1Gnd
D2Vcc
P4-6
D2Gnd
SetPS3
SetPS1
SVcc
SVee
SetPS2
AVee
P6-4
AVcc
P6-5
AGnd
P6-6
Vcc
P6-7
Title
Novatech Controls
163x Analyser
Size
A3
Number
1630-2
Revision
1.5
Date:
27/04/2008
Sheet of
4
File:
C:\Documents and Settings...163x2.ddb
Drawn By:
FHC
4-20mA DRIVERS
4-20DRVS.SCH
OutputChn1+
OutputChn1-
OutputChn2+
OutputChn2-
SetPS[1..3]
L5-[0..3]
4-20CalSig+
4-20CalSig-
ChnSig
Chn2Sig
DIGITAL LATCHES
DIGIO.SCH
Sensable-1
/P6-1
P6-[0..7]
L2-[0..3]
L5-[0..3]
L6-[0..7]
Unreg
DA-2
PreReg
P4-5
50/60Hz
Error
HtrEn
L2-[0..7]
L6-[0..7]
L6-[0..7]
Sol[1..4]
HV[1..6]
POWER SUPPLY
POWER.SCH
Sol1
Sol2
Sol3
Sol4
HV5
HV4
HV6
HV1
HV2
0.022uF/240V
LM35
IC1
CON-PH3.8-2
CN8
135-102DAG-J01
TH1
Ref Air Flow Sensor
R12 10M
R1 10k
R10 1M
R2 1M
R3 1M
R11
D4
AGnd
R7 10k
R6 10k
R5 10k
R15 10k
R14 10k
R13 10k
R9 10M
L2-1
L2-6
L2-3
L2-4
L2-[0..7]
R38 10k
R34 10k
R2 10k
TR3 BC550
TR4
BC550
TR2
D3 1N4004
RL2
FBR-J6D005P
RL6
RL1
RL5
D? 1N4004
L5-0
L5-1
L5-2
L5-3
CN7
CN6
CN5
CN4
CN3
CN11
CN10
CN15
CN12
Probe +
Probe -
Probe TC+
Probe TC-
TC2 / Aux +
TC2 / Aux -
+12v supply out
RGC I/P +
RGC I/P -
Sensor #2 +
Sensor #2 -
Purge flow sw
Purge flow sw
Fuel 1/2
Fuel 1/2
Remote alarm reset
Remote alarm reset
Burner on i/p
Burner on i/p
RS-232 Rx
RS-232 Tx
Network -
Network +
Serial port common
Output #1+
Output #1-
Output #2 +
Output #2 -
Com alarm
Com alarm
Alarm relay #2
Alarm relay #2
Alarm relay #3
Alarm relay #3
Alarm relay #4
Alarm relay #4
Purge solenoid
Purge solenoid
Cal 1 solenoid
Cal 1 solenoid
Cal 2 solenoid
Cal 2 solenoid
Probe heater #1
Probe heater #1
Probe heater #2
Probe heater #2
Mains Active
Mains Neutral
Mains Earth


Novatech Controls
163x Analyser
Number 1630-2
4-20mA Output Drivers
Revision 1.5
Sheet 3 of 4
Drawn By: FHC
Date: 27/04/2008
File: C:\Documents and Settings\...\4-20drv.sch
Size A3
D1Vcc
D1Gnd
Chn1 +12
Chn1 com
IC6A
LM358
Chn1 sig
IC6B
LM358
R24 1M
D1Gnd
0.1uF
C7
D1Vee
TR2 BD139
R39 220K
R23 220K
R20 220K
R19 100R
Chn1 -12
LED2
3mm LED
RL4
FBR-46D005P
D2Vcc
D2Gnd
Chn2 +12
Chn2 Com
IC5A
LM358
Chn2 sig
IC5B
LM358
R32 1M
D2Gnd
0.1uF
C6
R25 220K
TR1 BD139
R33 220K
R22 220K
R18 220K
R17 100R
Chn2 -12
D2Vee
LED1
3mm LED
RL3
FBR-46D005P
R4 47R
OutputChn2-
4-20CalSig+
4-20CalSig-
OutputChn1+
OutputChn1-
OutputChn2+
OutputChn2-
Chn1Sig
Chn2Sig
L5-4
L5-5
L5-[0..7]


Title
Novatech Controls
163x Analyser
Size
A3
Number
1630-1
Serial interface and D/A converters
Revision
1.6
Date:
27/04/2008
Sheet 3 of 4
File:
C:\Documents and Settings\...\Docs.sch
Drawn By:
FHC
CON-10
LINK-2
SP485CS
LM1458
LM1438
LM336M-2.5
LM340L-05
MAX536
LTC1257
74HC14
74HC04
PC-400
BC817
BAV99
RS-232 Rx
RS-232 Tx
Network -
Network +
Serial port common
RS-232 Conn
+12 Isolated
RS-485 Dir.
RS-232 Rx
RS-232
RS-485
PWM output
DAC data
Clock
DAC cs
DAC-PS-0
DAC-PS-1
DAC-PS-2
DAC-PS-3
DAC-PS-4
DAC-PS-5
DAC-PS-[0..5]


Novatech Controls
163x Analyser
Number 1630-1
Revision 1.6
Microprocessor, display and keyboard
Size A3
Date: 23/04/2008
Sheet 4 of 4
File: C:\Documents and Settings\..\Micros.sch
Drawn By: FHC
Cold start Link
Keyboard Lock
Power/reset LED
External Keypad/LED's
Latch 1
Latch 4
W/dog
Reset
Error


Title
Novatech Controls
163x Analyser
Size
A3
Number
1630-2
Revision
1.6
Power Supply, Reference air pump
Date:
27/04/2008
Sheet
4
of
4
File:
C:\Documents and Settings...\Power.sch
Drawn By:
PHC
Burner Bypass switch
Burner on LED
Heater 1
Heater 2
Heater com
POWER ON
Mains A
Mains N
Mains E
Heater #1 On
Heater #2 On
W04 1A bridge rect
PLAM 2321 R9
39 Ref air pump +
40 Ref air pump -
0-5v
0-2.5v
+5v 300mA
12v
-12v
15v/30
240v
110v
250mA axial lead fuse


Notatech Controls
163x Analyser
Number 1630-2
Digital input/output
Revision 1.5
Sheet 2 of 4
Drawn By: FHC
Date: 29/04/2008
File: C:\Documents and Settings...\Digio.sch
Size A3
Latch #6
Latch #5
Latch #2
Heater #1
Purge solenoid
Gas cal solenoid #1
Gas cal solenoid #2
Heater #2
Alarm relay #1
Alarm relay #2
Alarm relay #3
Alarm relay #4
4-20 Cal relay #1
4-20 Cal relay #2
Inc trim relay
Dec trim relay
Terminal PCB select
Field 1 or 2 input
Remote furnace stop
Burner on Relay
Burner Bypass Switch
Remote Alarm Reset
Remote Purge Switch
Remote Heater burn out
Mains voltage selector switch
Digital output data
Clock
Digital output latch
Digital input load/shift
Digital input data

APPENDIX 5

MODBUS™ REGISTER MAP AND APPLICATION NOTES

Modbus Functions Supported are:-

ReadHolding Register Function 3
WriteHolding Register Function 6 (for allowable addresses only)

Introduction.

The 1638 Analyser implements the MODBUS™ slave protocol, it is intended to work in conjunction with a MODBUS™ master.

This is accomplished by setting the MODBUS™ address to some non-zero value in the range 1-31, setting the jumper positions to select the RS485 half duplex configuration, and re-starting the analyser.

The master must be configured as follows:-

Baud Rate	9600
Parity	None
Stop Bits	1
RS485	Half Duplex
Mode	RTU (binary mode)

A typical transaction would be to read the current value of a variable from the analyser.

The master sends a ReadHoldingRegister packet, with the appropriate address and the analyser responds with data at that address.

The Register Addresses are as follows, to convert to Schneider addresses for earlier model PLC's address space, add 40001 to each address.
or for later model PLC's with linear address space the address corresponds directly to %MW XXXX address.

For Example, to read probe temperature setpoint -
Read %MW1436 which is equivalent to holding register 41437 = 40001 + 1436

Some data is 32 bit data (double) which requires some care to ensure that the word order is correctly interpreted.

For Example, OXYGEN32, (dual probe) which is at address 2052 is interpreted as follows.

2052 contains the high 16 bits for probe 1 oxygen
2053 contains the low 16 bits for probe 1 oxygen

2054 contains the high 16 bits for probe 2 oxygen
2055 contains the low 16 bits for probe 2 oxygen

Configuration and Setup Addresses

Holding Reg.	*Function*	*Description*
716	Probe #1 offset	10 = 1.0mV
717	Probe #2 offset	10 = 1.0mV

Purge and calibration-check gas control related variables

754	Purge enable	0= off, 1= on
749	Gas calibration check	0= off, 1= 1 gas, 2= 2 gasses

Process measured and calculated variables

2048	Probe #1 OXYGEN	Floating point mantissa and exponent 1174 -2 = 11.74%
2050	Probe #2 OXYGEN	Floating point mantissa and exponent 1174 -5 = .01174%
2052	Dew point, °C	-2345 = -23.45 °C
2054	Dew point, °C	-2345 = -23.45 °C
2056	Probe #1 EMF	100,000 = 100.000 mV
2058	Probe #2 EMF	100,000 = 100.000 mV
2060	Probe #1 temperature	7000 = 700 °C
2062	Probe #2 temperature	7000 = 700 °C
2064	Probe #1, Impedance	1,000 = 1 k Ω
2066	Probe #2, Impedance	1,000 = 1 k Ω
2068	Oxygen average of 2 probes	Floating point mantissa and exponent 1174 -3 = 1.174%
2070	Dew Point average of 2 probes	-2345 = -23.45 °C
2072	Ambient temperature	246 = 24.6
2074	Ambient RH	561 = 56.1
2076	ALRM-ARRAY	Array of current alarm status. See below
2092	ALRM-TIMES	Array of timestamp of alarms

Alarm array order -

1. Heater 1 fail
2. Sensor1 fail (Impedance too high)
3. Probe 1 filter blocked
4. Probe 1 thermocouple open circuit
5. Reference air Pump fail
6. Battery backed RAM fail
7. Mains frequency measurement fail
8. ADC warning (outside normal specifications, but still accurate)
9. DAC warning (outside normal specifications, but still accurate)
10. Dew Point 1 High
11. Dew Point 2 High
12. Oxygen % 1 High
13. Oxygen % 2 High
14. Heater SSR fail
15. Dew Point deviation too high between oxygen probes
16. Gas 1 calibration error
17. Gas 2 calibration error
18. Burner bypass switch on
19. Aux. thermocouple open circuit
20. ADC calibration fail
21. DAC Calibration fail
22. Probe Calibration
23. Heater 2 Fail
24. Sensor 2 Fail (Impedance too high)
25. Probe 2 thermocouple open circuit
26. Probe temperature below 650 °C
27. Gas calibration check in Progress
28. Probe Purging in progress
29. Alarm horn
30. Probe Temperature high

1638 Modbus Holding Registers for Alarms

The 1638 Modbus analyser has 30 alarm and warning states, all of which can be checked via Modbus.
These 30 alarm and warning states cover all aspects of the operation of the analyser.
For each of the 30 alarms, the 1638 has 5 possible states for each alarm:

0 Inactive
1 Timer Delay
2 Active
3 Accepted
4 Self Cleared

All alarm states are self explanatory except the timer delay state. In this state, the physical conditions required to trigger the alarm have already been met, but the alarms timed delay is preventing the alarm from being active. If the delay timer finishes counting down before the alarm state has been self cleared, the alarm will become active.

For checking alarms via Modbus, it is recommended to treat all alarms in a 'timer' state the same as inactive.

16-bit Byte Order Architecture

The 1638 Analyser uses 'big endian' byte architecture, meaning that for a 16-bit address block, the most significant byte (msb) appears first, followed by the least significant byte (lsb) second.

This becomes important for reading alarm states from the 1638 holding registers as all Modbus registers are treated as 16-bit variables. For the 1638 Modbus alarm holding registers, each 16-bit register contains two 8-bit alarm states, meaning that to check any single alarm state via Modbus will require 2 alarm states to be received, the second may be discarded.

This table shows the holding register and the relevant byte for each of the alarms states:

A#	Description	HR#
1	Heater 1 Fail	2076
2	Sensor 1 Fail	2076
3	Probe 1 Filter	2077
4	Probe 1 TC Open	2077
5	Reference Air Pump Fail	2078
6	Battery Backup Memory Fail	2078
7	Mains Power Fail	2079
8	ADC Warning	2079
9	DAC Warning	2080
10	Dew Point 1 High	2080
11	Dew Point 2 High	2081
12	Oxygen 1 High	2081
13	Oxygen 2 High	2082
14	Heater SSR Fail	2082
15	Dew Point Deviation	2083

A#	Description	HR#
16	Gas 1 Calibration Error	2083
17	Gas 2 Calibration Error	2084
18	Burner Bypass	2084
19	AUX TC Open	2085
20	ADC Calibration Fail	2085
21	DAC Calibration Fail	2086
22	Probe Calibration Fail	2086
23	Heater 2 Fail	2087
24	Sensor 2 Fail	2087
25	Probe 2 TC Open	2088
26	Probe Temp	2088
27	Calibration in Progress	2089
28	Probe Purge	2089
29	Alarm Horn	2090
30	Probe Temperature High	2090

For example, if you wished to read the state of the Heater SSR Fail Alarm, you would be looking for the msb from the holding register 2082. This would mean that for big endian byte order, you would be looking at the first byte in the analyser response if you requested a read single register from register 2082.

Declaration of Conformity

Application of Council Directives:

89/336/EEC (92/31/EEC)
72/23/EEC

Standards to which conformity is declared:

EN550011.1:1995 (ISM, Group 1, Class B)
EN55014:1995 (Clause 4.2)
EN50082-2 (Industrial)
EN61010-1
AS61000.4.5:1999
IEC-68-2-2
IEC-68-2-3
AS1099.2.6

Manufacturer's name: **Novatech Controls Pty Ltd**

Manufacturer's address: 309 Reserve Road
Cheltenham VIC 3192
AUSTRALIA

Type of equipment: Oxygen Transmitter

Equipment Class: ISM, Group 1, Class B

Model Number: 1630 Series Transmitter
1231 Oxygen Probe
1234 Oxygen Sensor

I hereby declare that the equipment specified herein conforms to the above directive(s) and standards(s).

Full Name: **Fraser Chapman**
Position: **R & D Manager**

1. ***Interpretation***

In these conditions:

(a) `Seller' means Novatech Controls Pty. Ltd. ABN 57 006 331 700 of 309 Reserve Road, Cheltenham Victoria, 3192 which is the seller of the goods.

(b) `Buyer' means the buyer of the goods specified in the seller's quotation, or in the buyer's order for the goods.

(c) `Goods' means the products and, if any, services specified in Buyer's, orders or Seller's order acknowledgments from time to time.

(d) Nothing in these conditions shall be read or applied so as to exclude, restrict or modify or have the effect of excluding, restricting or modifying any condition, warranty, guarantee, right or remedy implied by law (including the Trade Practices Act 1974) and which by law cannot be excluded, restricted or modified.

2. ***General***

These conditions (which shall only be waived in writing signed by the seller) prevail over all conditions of the buyer's order to the extent of any inconsistency.

3. ***Terms of sale***

The goods and all other products sold by the seller are sold on these terms and conditions.

4. ***Seller's quotations***

Unless previously withdrawn, seller's quotations are open for acceptance within the period stated in them or, when no period is so stated, within 60 days only after its date. The seller reserves the right to refuse any order based on this quotation within 7 days after the receipt of the order.

5. ***Packing***

The cost of any special packing and packing materials used in relation to the goods are at the buyer's expense notwithstanding that such cost may have been omitted from any quotation.

6. ***Shortage***

The buyer waives any claim for shortage of any goods delivered if a claim in respect for short delivery has not been lodged with seller within seven (7) days from the date of receipt of goods by the buyer.

7. ***Drawings, etc.***

(a) All specifications, drawings, and particulars of weights and dimensions submitted to the buyer are approximate only and any deviation from any of these things does not vitiate any contract with the seller or form grounds for any claim against the seller.

(b) Except as referred to in Clause 13.1 herein, the descriptions, illustrations and performances contained in catalogues, price lists and other advertising matter do not form part of the contract of sale of the goods or of the description applied to the goods.

(c) Where specifications, drawings or other particulars are supplied by the buyer, the seller's price is made on estimates of quantities required. If there are any adjustments in quantities above or below the quantities estimated by seller and set out in a quotation, then any such increase or decrease are to be adjusted on a unit rate basis according to unit prices set out in the quotation.

8. ***Performance***

Any performance figures given by the seller are estimates only. The seller is under no liability for damages for failure of the goods to attain such figures unless specifically guaranteed in writing. Any such written guarantees are subject to the recognised tolerances applicable to such figures.

9. ***Acknowledgment regarding facilities for repairs or parts***

The buyer acknowledges that the seller does not promise or represent that facilities for the repair of the goods, or that parts of the goods are or will be available. The buyer must ensure that each purchaser of the goods from the buyer receives notice that the seller does not promise that facilities for the repair of the goods will be available; or parts for the goods will be available.

10. ***Delivery***

(a) The delivery times made known to the buyer are estimates only and the seller is not be liable for late delivery or non-delivery.

(b) The seller is not be liable for any loss, damage or delay occasioned to the buyer or its customers arising from late or non-delivery or late installation of the goods.

(c) The seller may at its option deliver the goods to the buyer in any number of instalments unless there is an agreement in writing between the parties to the effect that the buyer will not take delivery by instalments.

(d) If the seller delivers any of the goods by instalments, and any one of those instalments is defective for any reason:

(i) it is not a repudiation of the contract of sale formed by these conditions; and

(ii) the defective instalment is a severable breach that gives rise only to a claim for compensation.

11. ***Passing of risk***

Risk in the goods passes to the buyer upon the earlier of:

(a) actual or constructive delivery of the goods to the buyer; or

(b) collection of the goods from the seller or any bailee or agent of the seller by the buyer's agent, carrier or courier.

12. ***Loss or damage in transit***

(a) The seller is not responsible to the buyer or any person claiming through the buyer for any loss or damage to goods in transit caused by any event of any kind by any person (whether or not the seller is legally responsible for the person who caused or contributed to that loss or damage).

(b) The seller must provide the buyer with such assistance as may be necessary to press claims on carriers so long as the buyer:

(i) has notified the seller and the carriers in writing immediately after loss or damage is discovered on receipt of goods; and

(ii) lodges a claim for compensation on the carrier within three (3) days of the date of receipt of the goods.

13. ***Guarantee***

13.1 The seller's liability for goods manufactured by it is limited to making good any defects by repairing the defects or at the seller's option by replacement, within a period as specified in Seller's catalogues or other product literature for specified cases or not exceeding twelve (12) calendar months after the goods have been dispatched (whichever is the lesser period) so long as:

(a) defects have arisen solely from faulty materials or workmanship;

(b) the damage does not arise from:

(i) improper adjustment, calibration or operation by the buyer;

(ii) the use of accessories including consumables, hardware, or software which were not manufactured by or approved in writing by the seller;

(iii) any contamination or leakages caused or induced by the buyer;

(iv) any modifications of the goods which were not authorised in writing by the seller;

(v) any misuse of the goods by the buyer or anyone for whom the buyer has legal responsibility (including a minor);

(vi) any use or operation of the goods outside of the physical, electrical or environmental specifications of the goods;

(vii) inadequate or incorrect site preparation; and

(viii) inadequate or improper maintenance of the goods.

(ix) fair wear and tear of the product in an environment in respect of which the Seller has informed the Buyer in catalogues or other product literature that the period of usefulness of the product is likely to be shorter that twelve 12 months.

(c) the goods have not received maltreatment, inattention or interference;

(d) accessories of any kind used by the buyer are manufactured by or approved by the seller;

(e) the seals of any kind on the goods remain unbroken; and

(f) the defective parts are promptly returned free of cost to the seller.

13.2 The seller is not liable for and the buyer releases the seller from any claims in respect of faulty or defective design of any goods supplied unless such design has been wholly prepared by the seller and the responsibility for any claim has been specifically accepted by the seller in writing. In any event the seller's liability under this paragraph is limited strictly to the replacement of defective parts in accordance with para 13.1 of these conditions.

13.3 Except as provided in these conditions, all express and implied warranties, guarantees and conditions under statute or general law as to merchantability, description, quality, suitability or fitness of the goods for any purpose or as to design, assembly, installation, materials or workmanship or otherwise are expressly excluded. The seller is not liable for physical or financial injury, loss or damage or for consequential loss or damage of any kind arising out of the supply, layout, assembly, installation or operation of the goods or arising out of the seller's negligence or in any way whatsoever.

14. ***Seller's liability***

14.1 The seller's liability for a breach of a condition or warranty implied by Div 2 of Pt V of the Trade Practices Act 1974 (other than s 69) is limited to:

(a) in the case of goods, any one or more of the following:

(i) the replacement of the goods or the supply of equivalent goods;

(ii) the repair of the goods;

(iii) the payment of the cost of replacing the goods or of acquiring equivalent goods;

(iv) the payment of the cost of having the goods repaired; or

(b) in the case of services:

(i) the supplying of the services again; or

(ii) the payment of the cost of having the services supplied again.

14.2 The seller's liability under s 74H of the Trade Practices Act 1975 is expressly limited to a liability to pay to the purchaser an amount equal to:

(a) the cost of replacing the goods;

(b) the cost of obtaining equivalent goods; or

(c) the cost of having the goods repaired, whichever is the lowest amount.

15. ***Prices***

(a) Unless otherwise stated all prices quoted by vendor are net, exclusive of Goods and Services Tax (GST) and the buyer agrees to pay to the seller any GST in addition to the price.

(b) Prices quoted are those ruling at the date of issue of quotation and are based on rates of freight, insurance, customs duties, exchange, shipping expenses, sorting and stacking charges, cartage, the quotation, cost of materials, wages and other charges affecting the cost of production ruling on the date is made.

(c) If the seller makes any alterations to the price of the goods or to any of their inputs either before acceptance of or during the currency of the contract, these alterations are for the buyer's account.

16. ***Payment***

The purchase price in relation to goods is payable net and payment of the price of the goods must be made on or before the thirtieth day from the date of invoice unless other terms of payment are expressly stated in these conditions in writing.

17. ***Rights in relation to goods (Romalpa clause)***

The seller reserves the following rights in relation to the goods until all accounts owed by the buyer to the seller are fully paid:

(a) ownership of the goods;

(b) to enter the buyer's premises (or the premises of any associated company or agent where the goods are located) without liability for trespass or any resulting damage and retake possession of the goods; and

(c) to keep or resell the goods including any goods repossessed pursuant to 17(b) above;

If the goods are resold, or goods manufactured using the goods are sold, by the buyer, the buyer shall hold such part of the proceeds of any such sale as represents the invoice price of the goods sold or used in the manufacture of the goods sold in a separate identifiable account as the beneficial property of the seller and shall pay such amount to the seller upon request. Notwithstanding the provisions above the seller shall be entitled to maintain an action against the buyer for the purchase price and the risk of the goods shall pass to the buyer upon delivery.

18. ***Buyer's property***

Any property of the buyer under the seller's possession, custody or control is completely at the buyer's risk as regards loss or damage caused to the property or by it.

19. ***Storage***

The seller reserves the right to make a reasonable charge for storage if delivery instructions are not provided by the buyer within fourteen days of a request by the seller for such instructions. The parties agree that the seller may charge for storage from the first day after the seller requests the buyer to provide delivery instructions.

20. ***Returned goods***

(a) The seller will not be under any duty to accept goods returned by the buyer and will do so only on terms to be agreed in writing in each individual case.

(b) If the seller agrees to accept returned goods from the buyer under para (a) of this clause, the buyer must return the goods to the seller at the seller's place of business referred to at the head of these conditions.

21. ***Goods sold***

All goods to be supplied by the seller to the buyer are as described on the purchase order agreed by the seller and the buyer and the description on such purchase order modified as so agreed prevails over all other descriptions including any specification or enquiry of the buyer.

22. ***Cancellation***

No order may be cancelled except with consent in writing and on terms which will indemnify the seller against all losses.

23. ***Indemnity***

The buyer indemnifies on a continuing basis on a fully indemnity basis the seller from and against any liability, loss, expense or demand for or arising from any false, misleading, deceptive or misdescriptive representation or statement made by the buyer in respect of the goods to any person. This indemnity survives termination of this agreement by either part for any reason.

24. ***Exclusion of representations and arrangements***

Except as referred to in Clause 13.1herein, these terms and conditions supersede and exclude all prior and other discussions, representations (contractual or otherwise) and arrangements relating to the supply of the goods or any part of the goods including, but without limiting the generality of the foregoing, those relating to the performance of the goods or any part of the goods or the results that ought to be expected from using the goods.

25. ***No waiver***

The failure of any part to enforce the provisions of this agreement or to exercise any rights expressed in this agreement is not to be a waiver of such provisions or rights an does not affect the enforcement of this agreement.

26. ***Force Majeure***

If by reason of any fact, circumstance, matter or thing beyond the reasonable control of the seller, the seller is unable to perform in whole or in part any obligation under this agreement the seller is relieved of that obligation under this agreement to the extent and for the period that it is so unable to perform and is not liable to the buyer in respect of such inability.

27. ***Buyer Acknowledgement***

The Buyer acknowledges that the above provisions of these Conditions of Sale are reasonable and reflected in the price and the Buyer accepts the risks of the Buyer associated with these Conditions of sale and/or shall issue accordingly.

28. ***Place of contract***

(a) The contract for sale of the goods is made in the state of Victoria Australia.

(b) The parties submit all disputes arising between them to the courts of such state and any court competent to hear appeals from those courts of first instance.