Novatech CONTROLS PTY. LTD.

# Combustion Controller

## Model 1633


August 2009

# CONTENTS



## APPENDICES



**Note: This manual includes software modifications up to Version 3.24, October, 2005**




All correspondence should be addressed to:

Technical Enquires
Novatech Controls Pty Ltd
309 Reserve Road
Cheltenham Victoria 3192
Australia

Phone: Melbourne +61 3 9585 2833
Fax: Melbourne +61 3 9585 2844
Website: http://www.novatech.com.au/

# USING THIS MANUAL

The Novatech 1633 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 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 a heated probe 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 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 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 then the Model 1633 analyser with a heated probe 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).

**CAUTION 4**

The reducing oxygen signal from the analyser and the associated alarm relay can be used as an explosive warning or trip. This measurement assumes complete combustion. If incomplete combustion is possible then this signal will read less reducing and should not be used as an alarm or trip. A true excess combustibles analyser, normally incorporating a catalyst or thermal conductivity bridge, would be more appropriate where incomplete combustion is possible.
Also read the probe electrical shock caution in Section 2.5 and the probe heater interlock caution in Section 3.6.

**CAUTION 5**

If an external pressure transducer is used to feed the process pressure to the analyser for pressure compensation, it is essential that the pressure transducer is accurate and reliable. An incorrect reading of pressure will result in an incorrect reading of oxygen. It is therefore possible that an explosive level of fuel could be calculated in the analyser as a safe mixture.

**CAUTION 6**

FIL-3 filter. If the optional FIL-3 has been fitted to the 1231 probe in this installation, please read the Important Notice in section 1.2.

# 1

# SPECIFICATIONS

Section
Number

## 1.1 MODEL 1633 COMBUSTION CONTROLLER

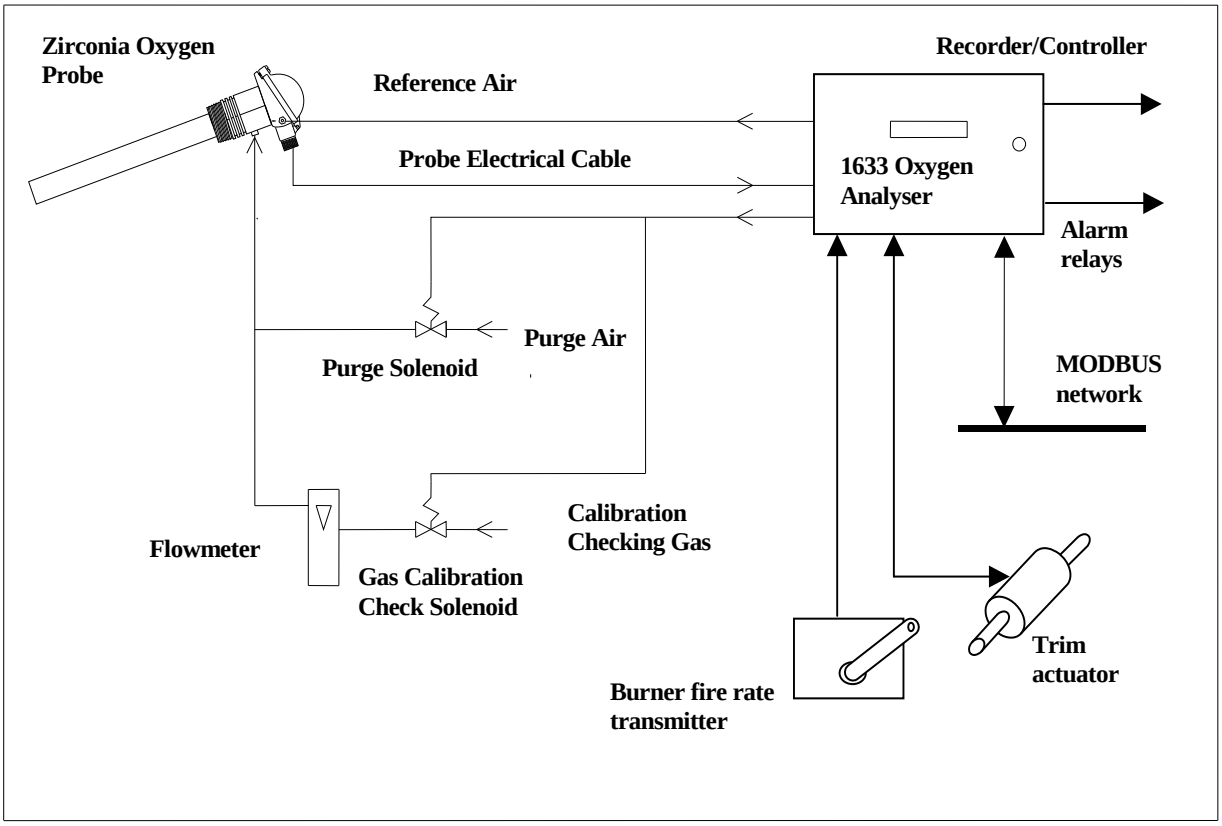
### DESCRIPTION

The Novatech model 1633 combustion controller / transmitter provides in-situ measurement for oxygen in furnaces, kilns and boilers and flue gases with temperatures from ambient up to 1400°C (2550°F). The analyser provides local indication of oxygen plus thirteen other selectable variables.

Two linearised and isolated 4 to 20 mA output signals are provided. 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 1633 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 air / fuel ratio combustion control to provide fuel savings
- Used for product quality control in ceramic and metal processing industries
- Simple to install
- Linear output of % oxygen for recording or control
- Built in safety features
- 26 different alarm conditions that warn the operator of combustion, probe, or analyser problems
- RS 485 MODBUS network capability
- Isolated RS 232-C printer / computer interface
- Safety interlock relay for heated probes




*Oxygen Probe and Transmitter System*

## SPECIFICATIONS

**Inputs**

- Zirconia oxygen probe, heated or unheated
- Burner feedback transmitter (Novatech BFT-20 or equivalent)
- Trim control actuator feedback
- Furnace, kiln or flue thermocouple, field selectable as type K or R.
- Main flame established safety interlock (for heated probes only)
- Purge pressure switch
- Dual Fuel selector
- Remote alarm accept

**Outputs**

- Two linearised 4 to 20 mA DC outputs, max. load 1000Ω.
- Mains voltage up / down trim actuator
- Common alarm relay
- Three other alarm relays with field selectable functions

**Computer**

- MODBUS RS 485 network, or RS 232-C for connection of a computer terminal or printer for diagnostics of the analyser, probe, sensor or combustion process.

**Range of Output 1**

Field selectable from the following:

| *Output Selection* | *Range* |
|---|---|
| Linear oxygen | 0.0 to 0.1% oxygen to 0.0 to 100.0 % oxygen |
| Log oxygen | 0.1 to 20 % oxygen, fixed |
| Reducing | $10^{-1}$ to $10^{-30}$ % oxygen, fixed |
| Reducing | 1ppm to 100 % oxygen, fixed |
| Linear oxygen, very low range | -10% to 100.0 % oxygen, fixed |
| Deficiency | 0.00 to 0.01 % (100ppm) to 0.00 to 10.00 % oxygen |

**Range of Output 2**

Field selectable from the following:

| *Output* | *Zero Range* | *Span Range* |
|---|---|---|
| Oxygen Sensor EMF | 0 to 1100 mV in 100 mV steps | 1000 to 1300 mV in 100 mV steps |
| Log Oxygen | 0.1% $O_2$ Fixed | 20% $O_2$ Fixed |
| Aux. Temperature | 0 to 100°C (32 to 210°F) in 1 degree steps | 100 to 1400°C (210 to 2550°F) in 100 degree steps |
| Linear Oxygen | 0% oxygen, fixed | 1 to 100% |
| Reducing Oxygen | $10^{+2}$ (100%) to $10^{-10}$ % oxygen in one decade steps, non-overlapping | $10^{-3}$ to $10^{-30}$ % oxygen in one decade steps. Min span 2 decades. |
| Efficiency | 0 % Fixed | 100 % Fixed |
| Carbon Dioxide | 0 to 10 % | 2 to 20 % |
| Oxygen Deficiency | 0 to 20% $O_2$ deficiency | 0 to 100% $O_2$ excess |
| Combustibles % | 0 fixed | 0.5 to 2.0 % |

**Range of Indication, Upper Line**

- Auto ranging from 10-30 to 100% 02

**Indication Choice, Lower Line**

Any or all of the following can be selected for lower line display:

- Run Hours since last service
- Date of last service
- Burner firing rate
- Trim actuator position
- Oxygen probe EMF
- Oxygen probe temperature
- Auxiliary temperature
- Oxygen probe impedance
- Ambient temperature
- Boiler efficiency
- Oxygen deficiency
- Combustibles %
- Carbon dioxide

The oxygen deficiency output can be used in the same way as a combustibles analyser to signal the extent of reducing conditions of combustion processes.

**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 (-15 to 130°F)
- 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 (10 lbs.)

**Dimensions**

- 280mm (11”) W x 180mm (7”) H x 95mm (3.75”) D

**Degree of Protection**

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

**Mounting**

- Suitable for wall or surface mounting.

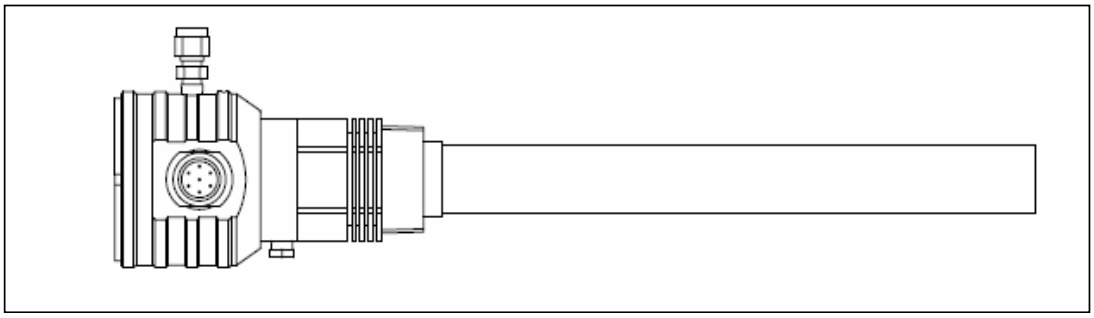
## 1.2 SERIES 1230 OXYGEN PROBES & SENSORS

### DESCRIPTION

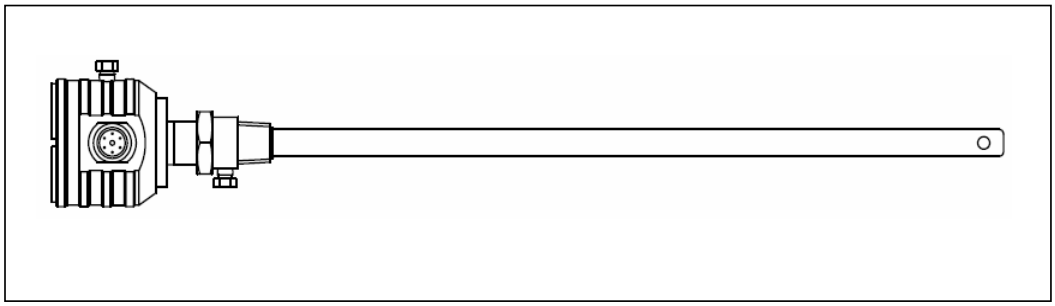
Novatech series 1230 oxygen probes and sensors employ state-of-the-art zirconia sensors and advanced materials, which provide the following benefits:

- 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.

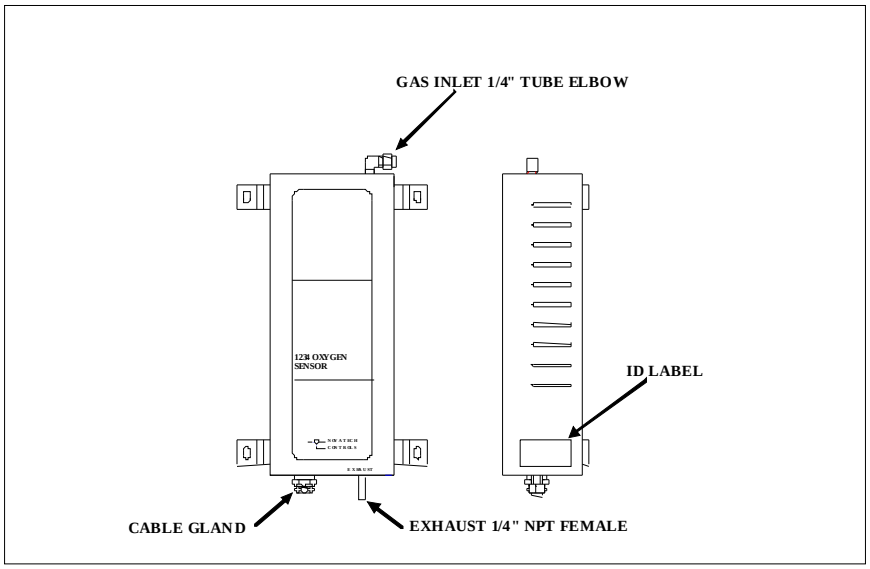
All Novatech oxygen probes are designed and manufactured to exacting standards of performance and reliability. Series 1230 probes are the result of extensive research and development by Novatech, industry and government agencies. Novatech Controls provides application and after sales support for oxygen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

# Important Notice Regarding
# 1231 Probe Option - FIL-3

**WARNING:** The only identifiable standard for flame arresters for general use is British Standard BS7224:1990. British Standard BS7224:1990 refers to an operating environment up to 200 Degrees Centigrade.

The FIL-3 device optionally fitted to 1231 Heated Zirconia Probes (the “Probes" or "Probe") operate in an environment considerably greater than 200 Degrees Centigrade.

Therefore, we know of no Australian, British or USA standard applicable to flame arresters or their testing above 200 degrees Centigrade. Consequently, the FIL-3 device cannot be certified as a safety device.

The probe is only one of several potential sources of ignition. Extreme care is required when using the probes during the start up processes of a combustion appliance.

The Novatech Burner Interlock Relay facility, which is a standard part of the Novatech Analyser, is designed to be wired to the main safety shut-off fuel valves in a way that can shutdown the probe heater when the fuel valves are closed.

The risk of ignition of flammable gas mixture at the hot end of the Probe can only be minimised by correct use, maintenance and operation of the FIL-3 device. The user of the FIL-3 device is responsible for verification and maintenance and correct use and operation of the FIL-3 device.

THE USER AGREES THAT IT USES THE PROBE AND THE FIL-3 DEVICE AT ITS SOLE RISK. NOVATECH CONTROLS PTY LTD, TO THE FULL EXTENT PERMITTED BY LAW, GIVES NO WARRANTIES OR ASSURANCES AND EXCLUDES ALL LIABILITY (INCLUDING LIABILITY FOR NEGLIGENCE) IN RELATION TO THE PROBE AND THE FIL-3 DEVICE.

The user must ensure that it correctly follows all instructions in relation to the Probe and FIL-3 device, correctly understands the specifications of the Probe and FIL-3 device and ensures that the Probe and FIL-3 device are regularly inspected and maintained.

FIL-3 equipped Probes should be inspected at least once a year for corrosion and more frequently is there is any reason to suspect that corrosion may have occurred.

# OXYGEN PROBE SPECIFICATIONS

| MODEL | 1231 | 1232 |
|---|---|---|
| **Application** | Combustion flue gases below 900°C (1650°F) Refer to note 1 | Combustion flue gases above 700°C (1290°F) with no contaminants. eg. natural gas, light oils |
| **Temperature Range** | 0 to 900°C. Refer to note 2 (32 to 1650°F) | 700 to 1400°C (1470 to 2550°F) |
| **Length** | 250 to 2000 mm (10” to 80”) | 500 to 1500 mm (20” to 60”) |
| **Process Connection** | 1 ½" BSP or NPT | ¾" BSP or NPT |
| **Electrical Connection** | Weatherproof plug-in connector or optional screw terminals. The plug connector is supplied with the cable. Ex d 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 |
| **Thermocouple** | K, integral | R, integral |
| **Response Time** | Typically < 4 secs. | Typically < 1 sec |
| **Head Temperature** | -25 to 100°C (-15 to 210°F) with weatherproof connector<br>-25 to 150°C (-15 to 300°F) with screw terminals | |
| **Reference Air** | Ambient air 50 to 500 cc / min (6 to 60 scfm). Pump supplied with analyser | |
| **Ref Air Connection** | 1/4" Tube | Integral air line in probe cable. Barbed fitting to 3/16" ID PVC tube. |
| **Filter** | Removable sintered titanium alloy particulate filter, 30 micron, optional 15 micron available. Refer to note 2 | |
| **Calibration Check Gas Connection** | 1/8" NPT female | 1/8" NPT female |
| **Weight** | 2 kg (4.4 lb) plus 165 g (5.8 oz) / 100 mm (4”) length | 1 kg (2.2 lb) plus 100 g (3.5 oz) / 100 mm (4”) length |

**Notes:**

1. Care must be taken to avoid contact with explosive or inflammable gases with 1231 heated probes and 1234 oxygen sensors when hot. Novatech analysers have built in safety protection.
2. Process gas temperature must be below 800°C if the filters are fitted.

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 (1650°F).***

| 1231 - | U Length - | Outer Sheath - | Internal Thermocouple - | Mounting Thread |
|---|---|---|---|---|
| Basic model | 2. 250mm (10”)<br>3. 500mm (20”)<br>4. 750mm (30”)<br>5. 1000mm (40”)<br>6. 1500mm (60”)<br>7. 2000mm (80”) | 1. 316 SS max 850°C (1560°F)<br>2. Inconel *(1) | 1. Type K max 900°C (1650°F) | 1. 1 ½ BSP<br>2. 1 ½ 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 (1290-2550°F).***

| 1232 - | U Length - | Outer Sheath - | Internal Thermocouple - | Mounting Thread |
|---|---|---|---|---|
| Basic model | 3. 500mm (20”)<br>4. 750mm (30”)<br>5. 1000mm (40”)<br>6. 1500mm (60”) | 1. 253 MA-max 1000°C (1830°F)<br>3. High Purity Alumina max 1300°C (2370°F) Horizontal max 1400°C (2550°F) Vertical<br>4. 446 SS max 1000°C (1830°F) | 1. Nil *(2)<br>4. Type R max 1400°C (2550°F) | 1. 3/4” BSP fixed<br>2. 3/4” NPT fixed |

## 1234 SENSOR SPECIFICATIONS

| | |
|---|---|
| Range of measurement: | 1 ppm to 100% oxygen |
| Output: | EMF = $2.154.10^{-2}.T.\log_e$ (0.209 / oxygen level of the sample) |
| Accuracy: | ± 1% |
| Thermocouple: | Type K |
| Heater: | 110 VAC 50/60Hz, 100 watts |
| Heater proportional band: | 80°C (175°F) |
| Speed of Response: | Less than 100 milliseconds |
| Sample flow rate: | 1 to 5 litres / minute (120 to 600 scfm) |
| Differential Pressure: | 80 to 800 mm (3 to 30”) WG gives a flow of 1 to 5 litres / min (120 to 600 scfm) |
| Process Connections: | 1/4” NPT female, inlet and outlet |
| Dimensions: | 300 mm (11.81”) high by 125 mm (4.92”) wide by 88 mm (3.46”) deep |
| Weight: | 2.2 Kg (4.85 lbs.) |

## 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, automatic gas calibration checks are required by Environmental Protection Authorities and by engineering management in Power Stations, Oil Refineries and similar large end users.

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 flue gas 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 1633 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 O2 close to the normal level in the gas stream being measured, to ensure fast recovery.
- A 100 kPa (15 psi) clean and dry instrument air 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 100 kPa (0 to 15 psi).

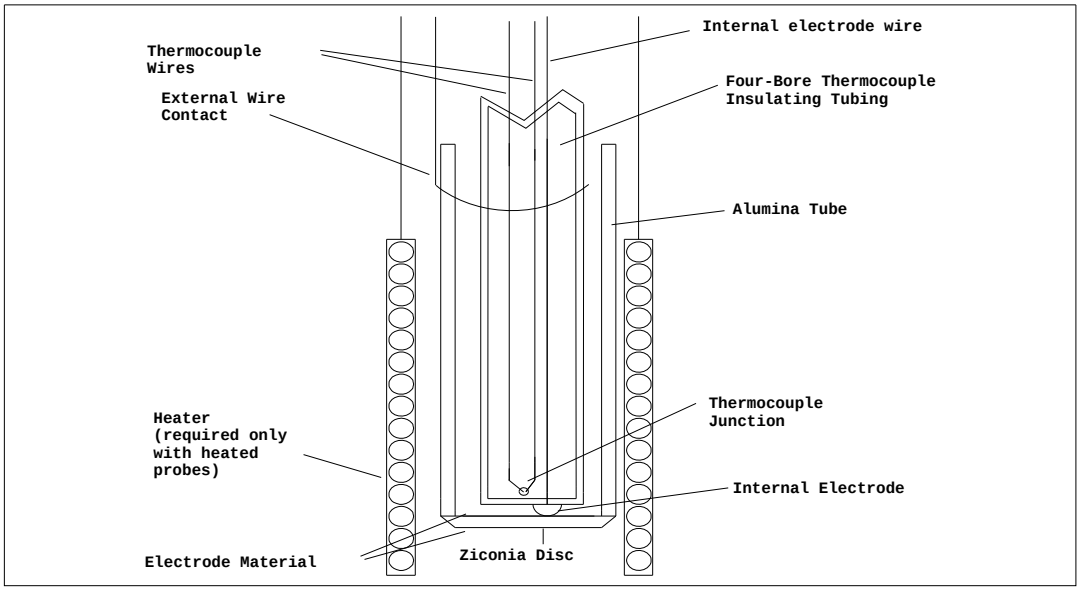
# 2

# DESCRIPTION

Section
Number

## 2.1 THE ZIRCONIA SENSOR

The analyser input is provided for a solid electrolyte oxygen probe, which contains a zirconia element and thermocouple. The probe is designed to be inserted into a boiler or furnace exit gas flue or similar process. A 1234 sensor is designed to be installed outside of the flue or process. Sampling lines and filters are not required for in-situ probes but they are required for 1234 sensors. 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 1633 combustion controller. The internal construction of a probe is shown as follows.




*Schematic View of a Zirconia Sensor Assembly*

The heater control in the 1633 analysers consists of a time proportioning temperature controller and solid state relay so that the thermocouple junction is controlled to over 700°C (1300°F). Probes operating in a combustion environment above 650°C (1200°F) 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 (1200°F)), 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 1633 transmitter solves this equation which is valid above 650°C (1200°F). The probe heater, or the process maintains the sensor temperature at this level.

## 2.2 THE OXYGEN PROBE

The probe assembly provides a means of exposing the zirconia sensor to the atmosphere to be measured with sensor, thermocouple and heater wires connected via the analyser lead. Reference air is fed via the plug for unheated probes and via a separate gas thread connection for heated probes.
Connections are provided on probes for an in-situ gas calibration check. A cleaning purge of air can be admitted via the calibration gas check entry. The outer sheath of probes can be metal or ceramic, depending on the application. Calibration check can be achieved on 1234 sensors using a three way solenoid which blocks the sample and at the same time admits a calibration check gas to the sensor. Purging a probe for any dust build up can be achieved in the same way.

In-situ zirconia oxygen probes will give a lower oxygen reading than a sampled gas measurement on a chromatograph or paramagnetic analyser because the flue gas contains a significant level of water vapour and a sampling system removes the water vapour through condensation. The oxygen content then appears as a higher percentage of the remaining gas. For example: If the gas contained five parts oxygen and fifteen parts moisture, removing the moisture would leave the oxygen at 5.88%. This phenomena will depend on the fuel and the completeness of combustion. They are common to all in-situ oxygen sensors.

## 2.3 THE ANALYSER

The top line of the analyser display will read oxygen in either % or ppm.
The 1633 analyser is a transmitter with two 4 to 20 mA outputs. One output is linear oxygen with selectable span. The second output can be selected as oxygen deficiency, combustibles, auxiliary temperature, reducing oxygen, percent carbon dioxide, sensor EMF or a logarithmic oxygen range. Four alarm relays are provided. Refer to the sections 4.2 and 4.3 for more details.

The 1633 analyser is designed to operate with one heated or unheated zirconia probe in a combustion process. The analyser will alarm when there is a high difference between the measured oxygen level and the required set point oxygen. It can transmit and display the oxygen signal.

In addition, a fixed oxygen set point, or a set point characterised to the burner firing rate can be used. The analyser will then be able to control the air / fuel ratio to maintain the optimum burner efficiency and the safest operating conditions. The analyser has been designed to operate on boilers using dual fuels, and two independent characterisation tables can be entered. The analyser will automatically go into a safe neutral control mode in the event of a probe failure.

A MODBUS network connection in the analyser allows up to 31 analysers to be networked together back to a central computer.

If a heated probe is being used, the analyser will maintain the temperature of the sensor to over 700°C (1300°F). If the flue gas temperature is above 720°C (1330°F), the probe heater will cut out completely and the process will provide probe heating. 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).

## 2.4 ALARMS

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

## 2.5 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.

## 2.6 APPLICATIONS WHERE SENSING POINT IS NOT AT ATMOSPHERIC PRESSURE

To apply the 1633 analyser to processes that have pressure at the point of measurement significantly above or below atmospheric pressure, then compensation must be applied. (Refer to Set-up Steps 30 and 31 in Section 5.5

## 2.7 OXYGEN SENSOR IMPEDANCE

The zirconia sensor 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 checks the zirconia sensor impedance every 24 hours and if the impedance is above the maximum level for a specific temperature then the impedance alarm(Sensor Fail) will be activated. Typical sensor impedance is 1 KΩ to 8 KΩ at 720°C (1320°F).
The impedance measurement can be updated manually whenever the sensor is over 700°C (1290°F) by pressing the "AUTOCAL" button while in "RUN" mode. The "Z" will appear in the top RH corner of the display for 3 seconds to confirm the measurement.

## 2.8 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 three seconds. Should the input electronics drift slightly then the drift will be automatically compensated for within the microprocessor. If the calibration factors are found to be have been changed more than expected, an 'ADC Warning' alarm is generated. 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 had a component replaced. 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 when the 'AUTOCAL' button is pressed, and when the analyser goes through the start up procedure. If the output calibration factors are found to have changed more than expected, the 'DAC Warning' alarm will occur. If either output has a fault, the 'DAC 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. Each of the output channels have three menu items which provide manual calibration (set-up 11 to 16). If manual is selected in set-up 11 or 13, the 'AUTO CAL' will be skipped and the manual calibration factors will be retained. See section 5.5 set-up 11, and section 6.3 for more details.

All output signals will drop to 0 mA for 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.

## 2.9 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 a calibrated gas mixture into the probe via a solenoid valve 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 32 and 37 to 42 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 flue gas 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, an automatic gas cycle can be started by pressing the 'CAL' buttons in RUN mode. Pressing any other button will terminate the cycle.

## 2.10 AUTO PURGE

In oil and coal fired plants, 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, maximum 100 kPa (14.5 psi), will automatically back-flush the probe filter on a timed basis. Refer to Set-up steps 32 and 34 to 36 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.

## 2.11 RS 485 MODBUS NETWORK & RS 232C PORT

The serial port has two functions. -

- It can be configured to connect up to 31 analysers together on a MODBUS RS485 network.

Each individual analyser can be interrogated by a computer or PLC. The values of oxygen, oxygen sensor EMF, oxygen sensor temperature, oxygen sensor impedance can be read over the network. The alarms status can also be checked over the network.
For the connection details, see Section 3.15.

- It can be used to log the analyser readings by connecting the analyser to a printer, a data logger, or any computer using an RS232-C com port.

When it is to be used to log the analyser readings, use set-up step 55 to selected the items to be sent to the data logger. The log period may be selected in set-up step 56, and the baud rate may be set in set-up step 57. 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.

## 2.12 AUXILIARY TEMPERATURE THERMOCOUPLE

A flue thermocouple must be connected to the AUX thermocouple input when the combustibles and / or combustion efficiency display is required.
The AUX thermocouple may also be used to monitor and display any process temperature.

## 2.13 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.

## 2.14 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.)
A cold start will place all the factory default menu items in the battery backed memory. A separate instruction will also replace the two characterisation tables with the factory default tables. (See Section 6.1)

# 3

# INSTALLING & COMMISSIONING

Section Number

## INSTALLATION

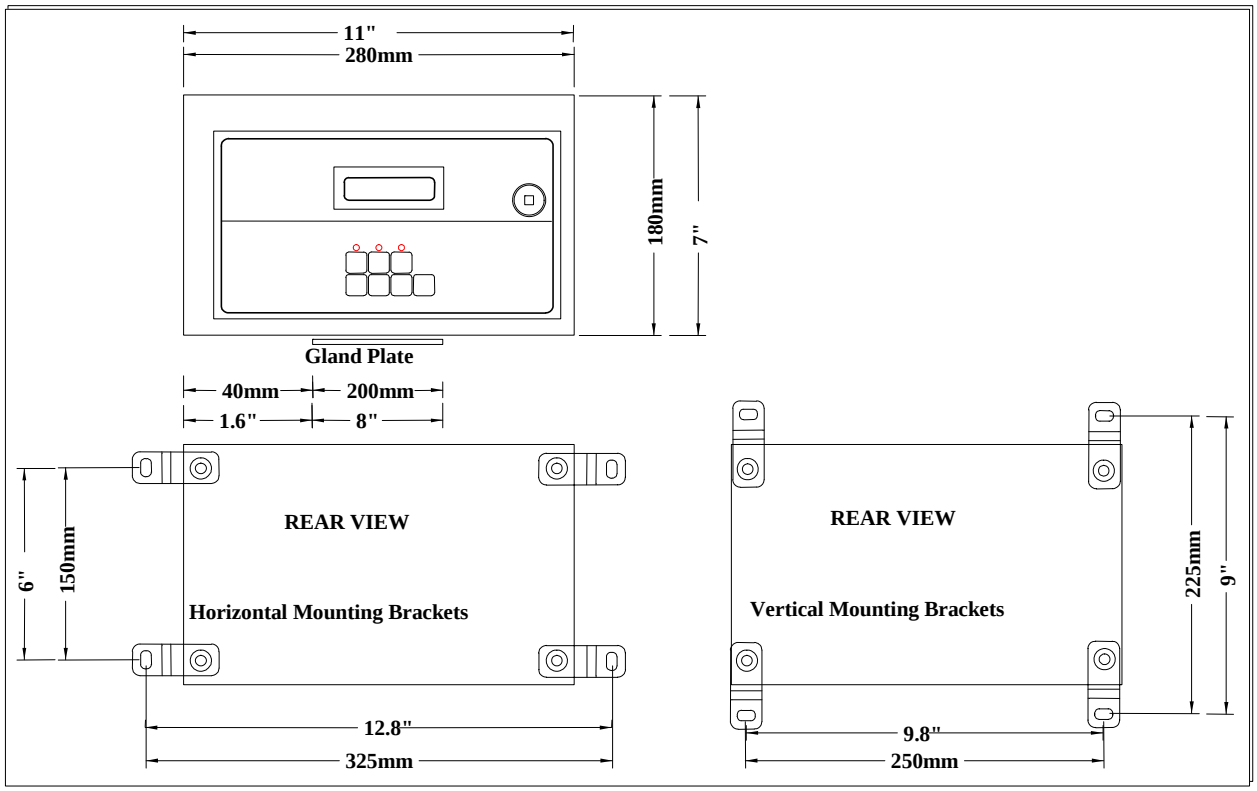


## COMMISSIONING

# INSTALLATION

## 3.1 MOUNTING THE ANALYSER

Surface mount the transmitter case on to a flat surface or bracket, using the four mounting brackets provided. Make sure the ambient temperature is below 50°C, and that the radiated heat from furnaces and boilers is kept to a minimum.




*Case Mounting Dimensions*

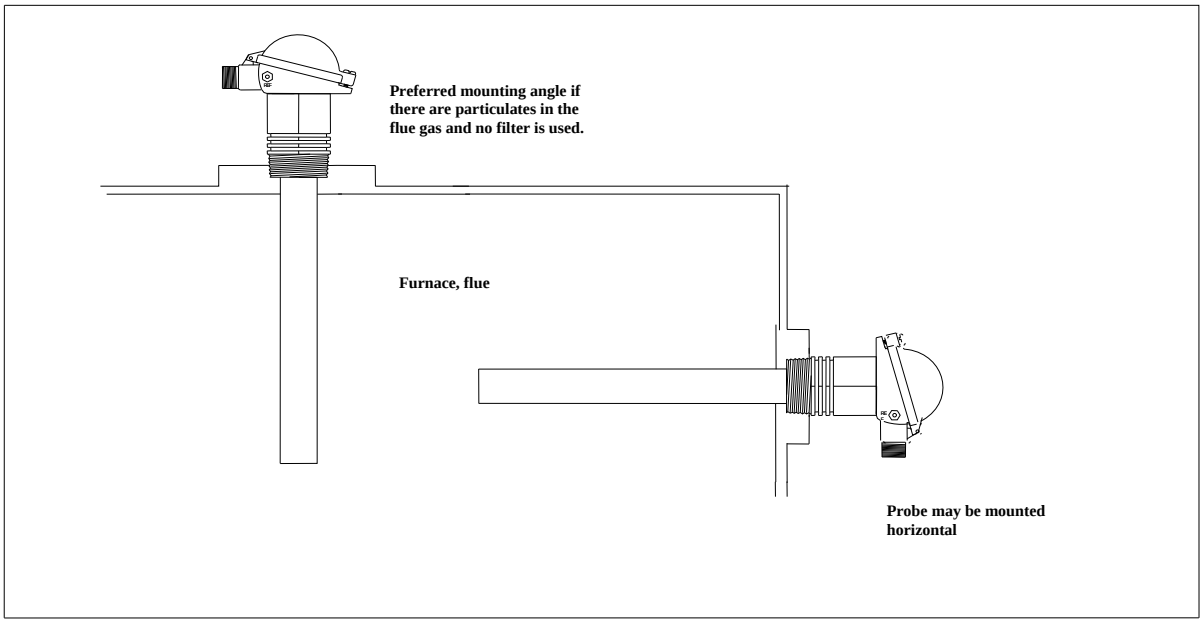
## 3.2A INSTALLING A 1231 OXYGEN PROBE

Weld a BSP or NPT socket to the flue in a suitable position for flue gas sensing. For the correct size of socket refer to probe data in Section 1. The closer to the source of combustion the smaller will be sensing lag time, allowing better control.

The probe has a typical response time of less than four seconds, so most of the delay time is normally the transit time of the gas from the point of combustion to the point of sensing.

Probes can be mounted at any angle. If there are any particulates in the flue gas, a 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 flue gas is 1000°C (1830°F), it should take approximately five minutes to install a 500 mm (20”) probe, moving it in about 50 mm (2”) steps.




*Oxygen Probe Mounting*

## CAUTION

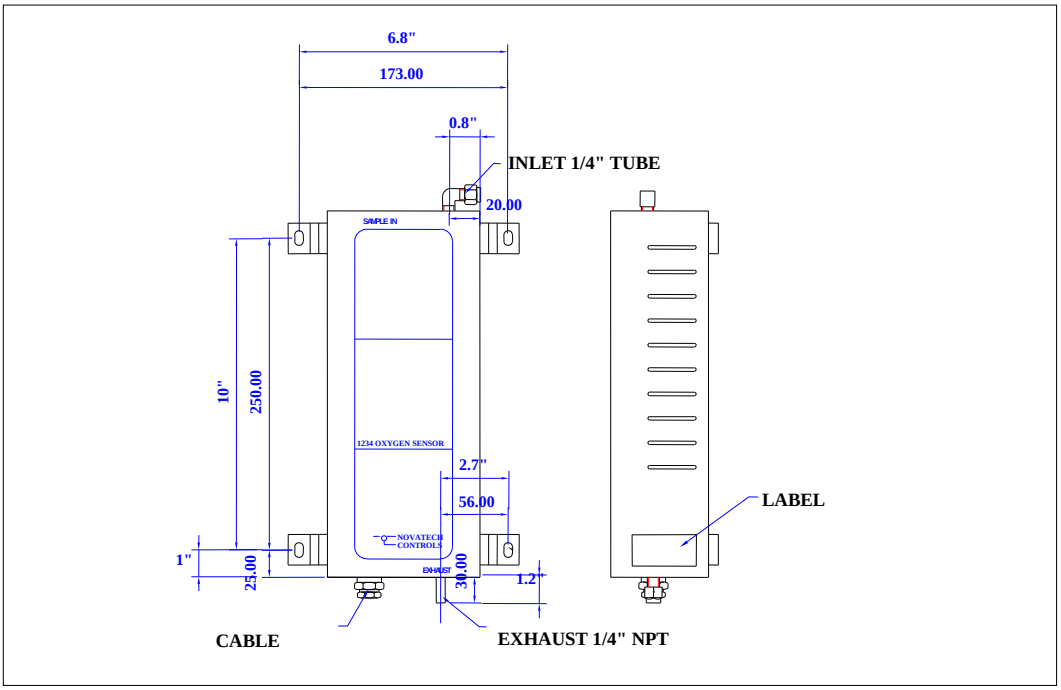
It is important that there is no air in leakage upstream of the oxygen sensing point, otherwise there will be a high oxygen reading.

If the probe is to be installed on a bend in the flue, it is best located on the outer circumference of the bend to avoid dead pockets of flue gas flow. While the standard 1231 probe with a 'U' length of 250 mm (10") will suit most low temperature flue applications, it is occasionally necessary to have a longer probe with the sensing tip in the center of the flue gas stream.

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

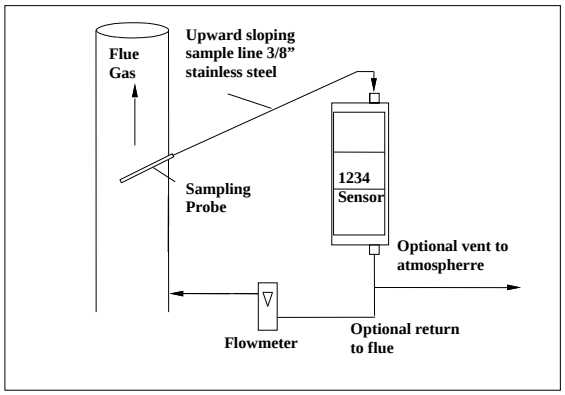
## 3.2B INSTALLING A 1234 OXYGEN SENSOR

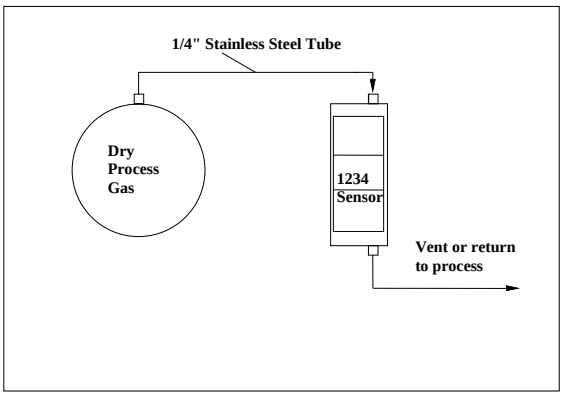
**Mounting** - Screw the 1234 sensor to a wall or similar surface with the piping connections at the bottom.




*1234 Sensor Mounting Dimensions*

**Sample Piping** - Connect the gas sample piping to the "sample in" port. If the process, boiler, kiln or furnace has a positive pressure, no suction will be required. If the sample is under a negative pressure, connect a pump to the "inlet" port as shown below. The flow rate should be within the range of 1 to 5 litres / minute (120 to 600 scfm).




## 3.3 INSTALLING THE AUXILIARY THERMOCOUPLE

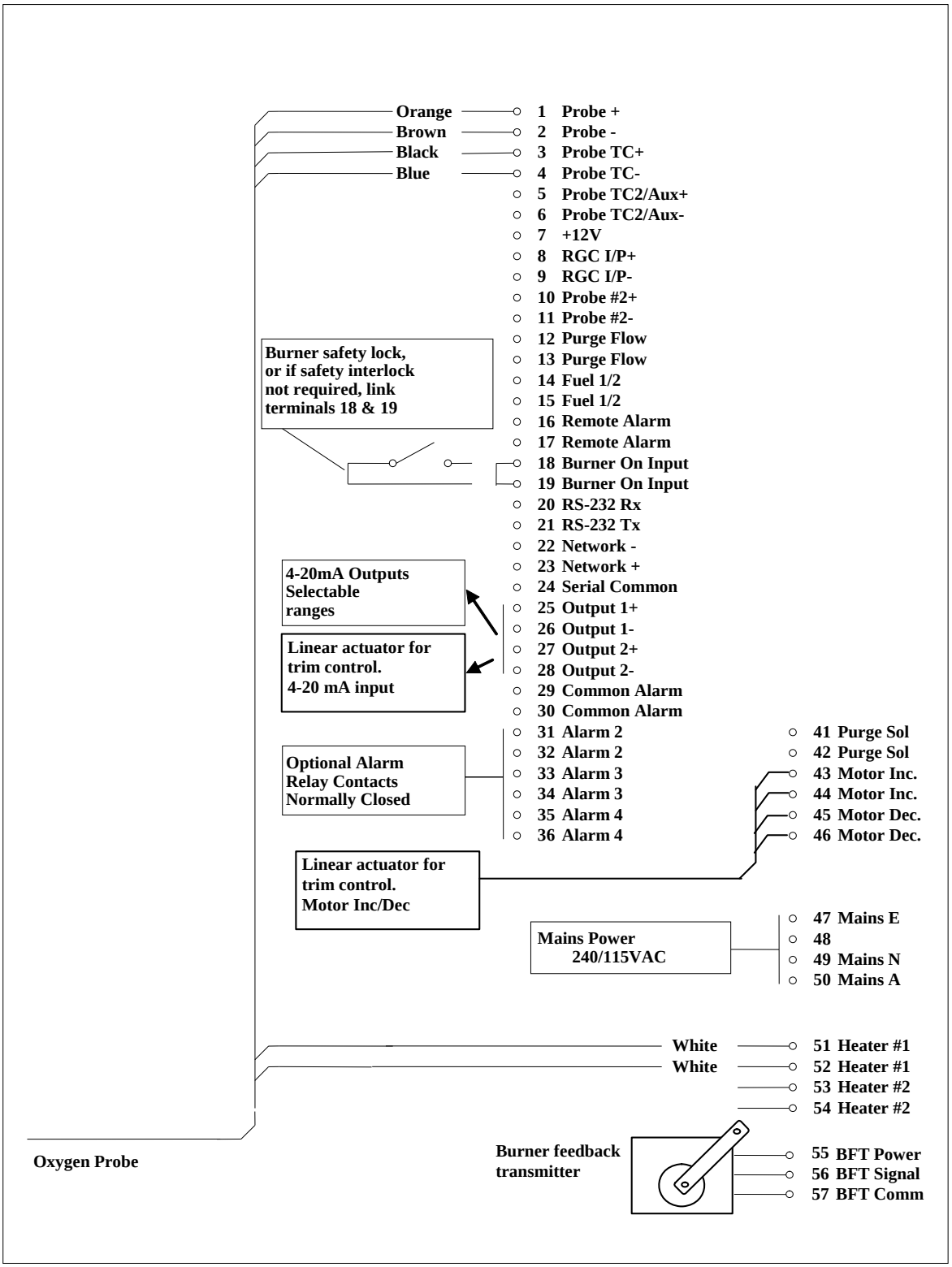
Weld a 1/2 inch BSP mounting socket to the flue within about 300 mm (12"), and upstream of the oxygen probe. The thermocouple should be of similar length to the oxygen probe to prevent flue temperature distribution errors.

## 3.4 SHIELD CONNECTIONS

All external wiring to the 1633 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.

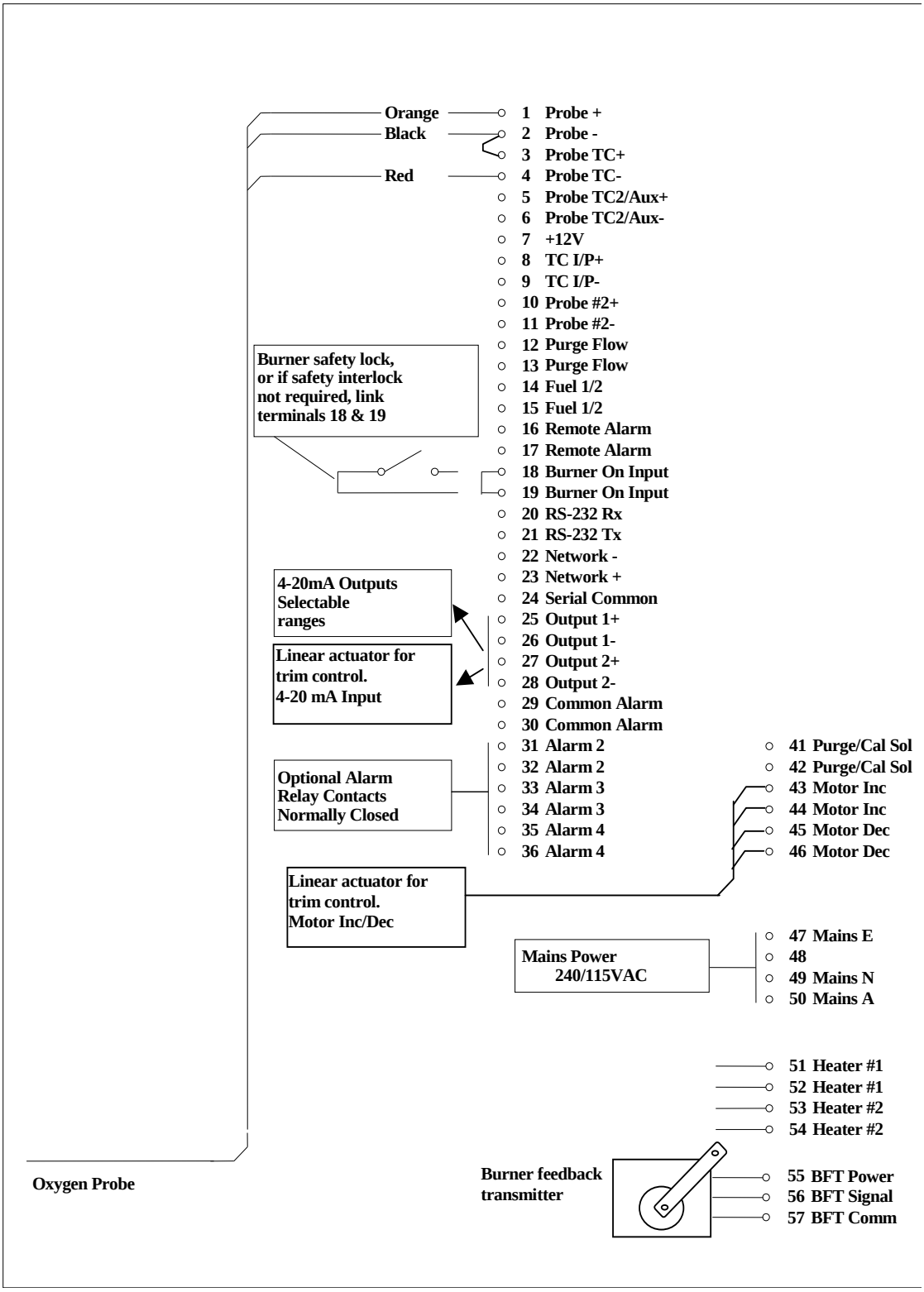
## 3.5 ELECTRICAL CONNECTIONS

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 1633 Analyser and a 1231 / 1234 Heated Probe*

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 1633 Analyser and a 1232 Unheated Probe*

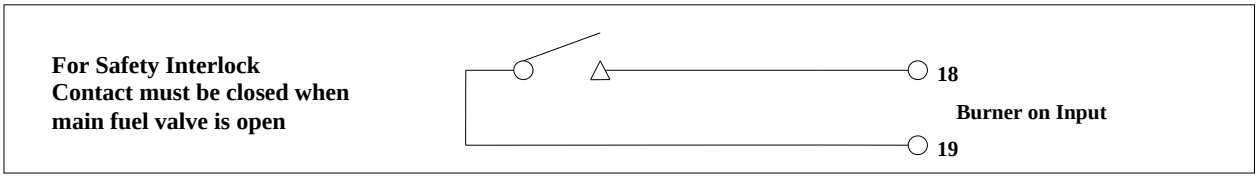
## 3.6 HEATER INTERLOCK RELAYS

**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 leaks into the combustion appliance when the fuel valve is closed. When power is removed from the main fuel valve the heater should also 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.



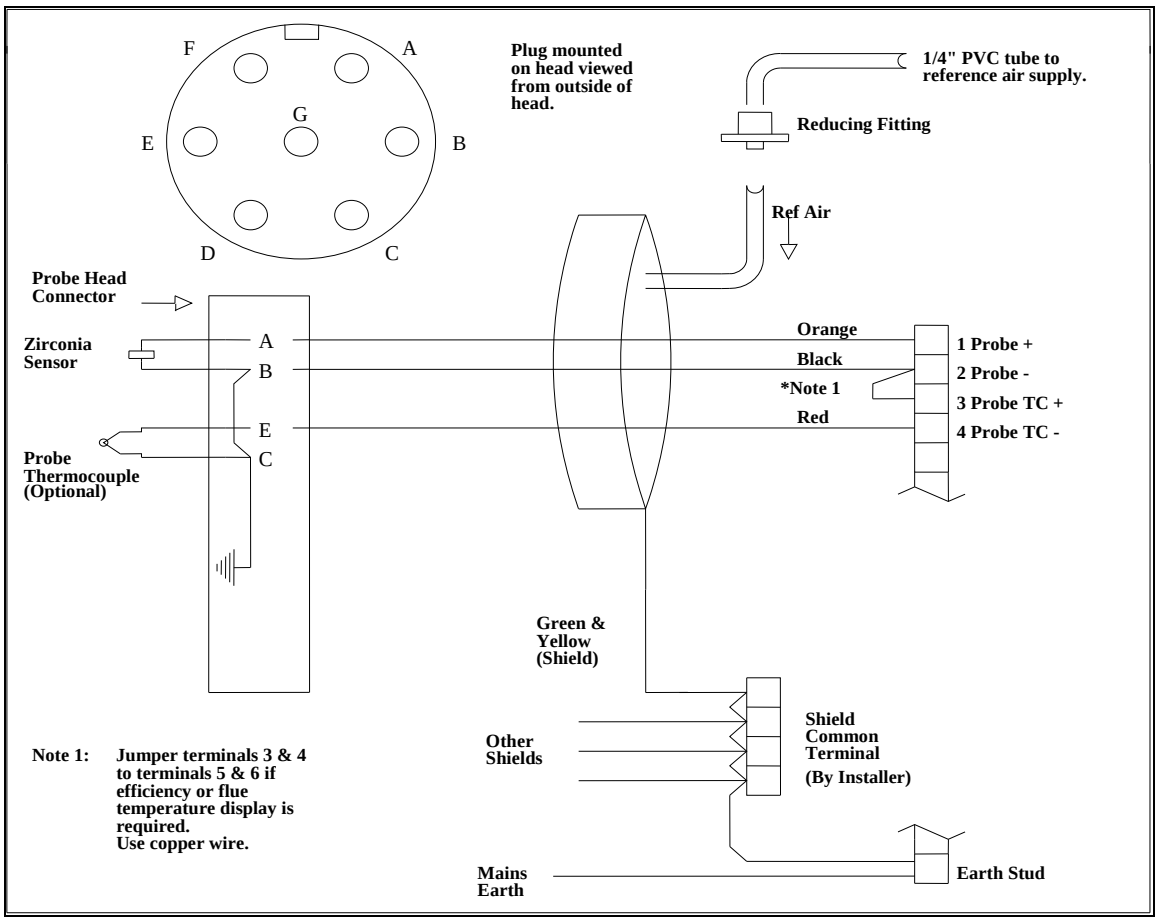

*Heater Supply Interlock Connection for Heated Probes*

If a safety interlock is not required, a wire must be connected between terminals 18 &19 to enable –

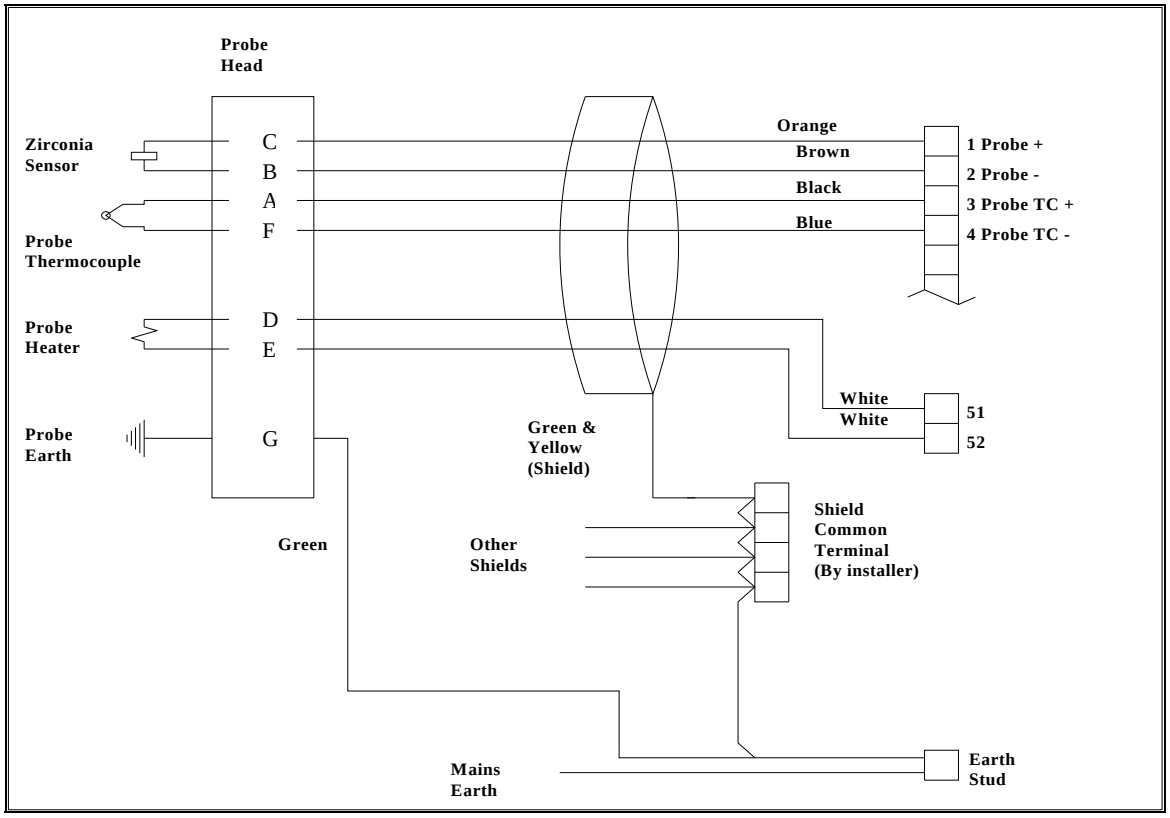
- The heaters on heated probes
- Process alarms
- Auto-purge and auto-cal checking.

## 3.7A 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.



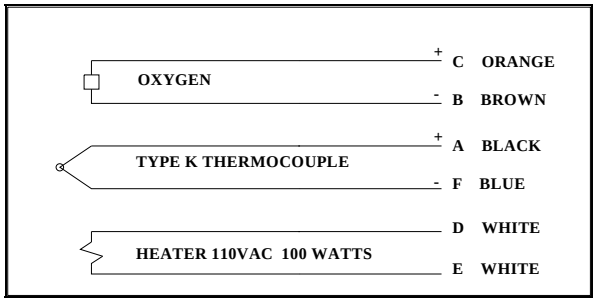

*Connection of Probe Cable for Unheated Probes Models 1232.*




*Connection of Probe Cable for Heated Probes Model 1231.*

## 3.7B CONNECTING A 1234 SENSOR CABLE

Remove the two screws from the cable gland end of the 1234 sensor. Connect the wiring as shown below. Be sure to connect an earth to the earth stud. Replace the end plate. Tighten the cable gland onto the cable.




*Connecting a 1234 Sensor Cable*

## 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 a K or R type thermocouple. It is optional. If the auxiliary temperature is not to be displayed or transmitted, then an auxiliary TC is not necessary.
It is necessary to have the auxiliary thermocouple connected and installed in the flue near the oxygen probe when it is required to read the boiler efficiency.

## 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 that 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 Calibration Warning
ADC Calibration Fail
DAC Calibration Warning
DAC Calibration Fail
Oxygen Sensor Fail
Oxygen Heater Fail
Oxygen Sensor TC Open
Aux. TC Open
Reference Air Pump Fail
Reference Air Fail **
Mains Frequency Check fail
Probe Filter Blocked
Gas Calibration Check Error
Burner bypass Switch on
Watchdog Timer

** This alarm is only available if a flow sensor is installed in CN8 on the 1630-2 PCB

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 72 to 74

High oxygen
Low oxygen
Very low oxygen
Oxygen deviation from set point
Neutral trim mode in operation
Probe under temperature
Calibration check in progress
Probe purge in progress
Alarm horn function (Relay 4 only)

## 3.11 CONNECTING THE AUTOMATIC PURGE AND CALIBRATION CHECK SYSTEM

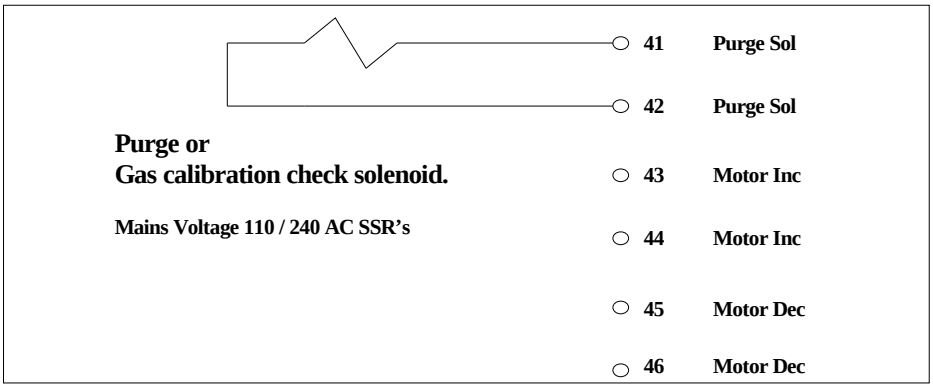
**CAUTION**

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. Either an automatic purge or an automatic gas calibration check can be used, but not both together.

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 flue is at negative pressure. If the flue is at positive pressure, an outward leak can cause corrosion in the purge / cal system piping and fittings.



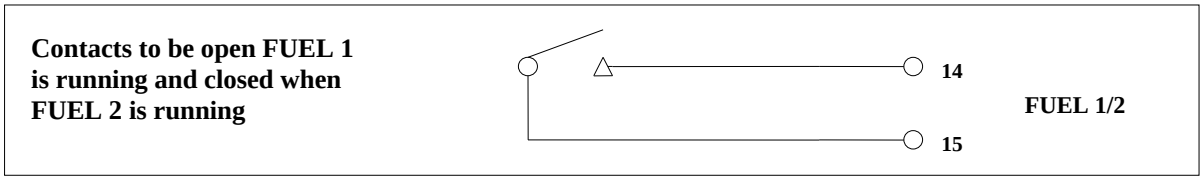

*Automatic Purge or Calibration check System Wiring Schematic*

## 3.12 CONNECTING REFERENCE AIR

For 1234 sensors, no reference air connection is required. For oxygen 1231 probes, 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 'Internal' is selected in set-up 86, and a reference airflow sensor is connected to CN8 on the 1630-2 (terminal) PCB, the reference air pump is cycled on and off each minute.

## 3.13 CONNECTING THE DUAL FUEL INPUT

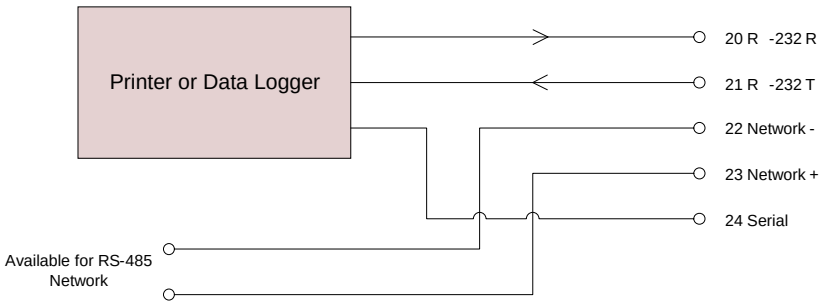
If combustibles or maximum carbon dioxide display is required and the appliance is capable of firing more than one fuel, then an external contact must be connected for the analyser to determine which fuel is being burnt. See Figure 3.12 for details.




*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 55 and 56. The baud rate is selectable in set-up step 57. 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

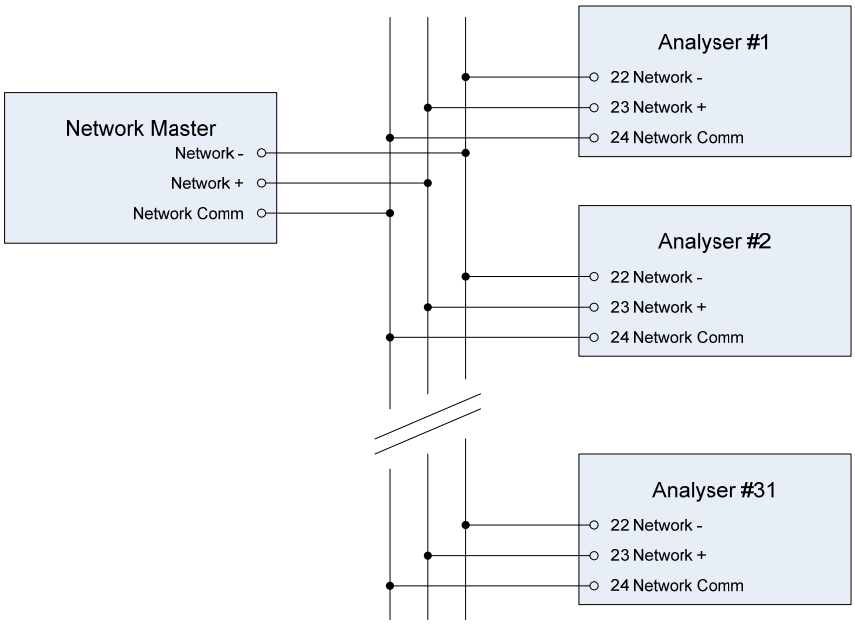
The analyser can be networked to other analysers and to a network master. The network uses the analyser RS485 port. Up to 31 analysers can be connected to the network, and can be interrogated by the Network Master.

NOTE: 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.

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 2.11 and Appendix 6.

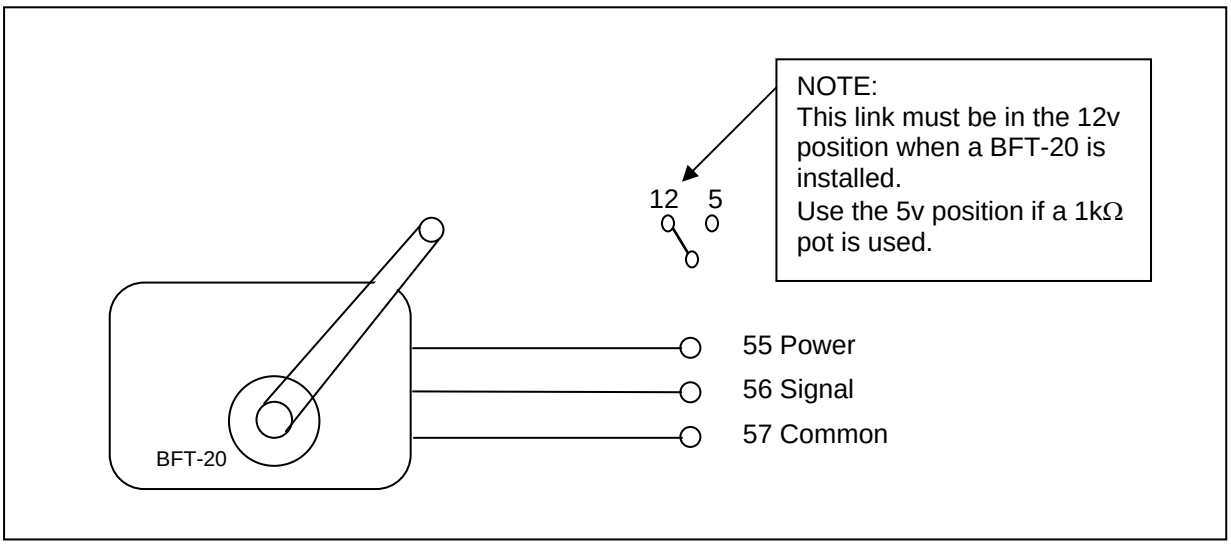



*Network Connections*

## 3.16 CONNECTING THE BURNER FEEDBACK TRANSMITTER

Connect the burner feedback transmitter if-

Characterised oxygen set point is required.
Characterised monitoring of the boiler oxygen level is required.
A display of the burner firing rate is required.



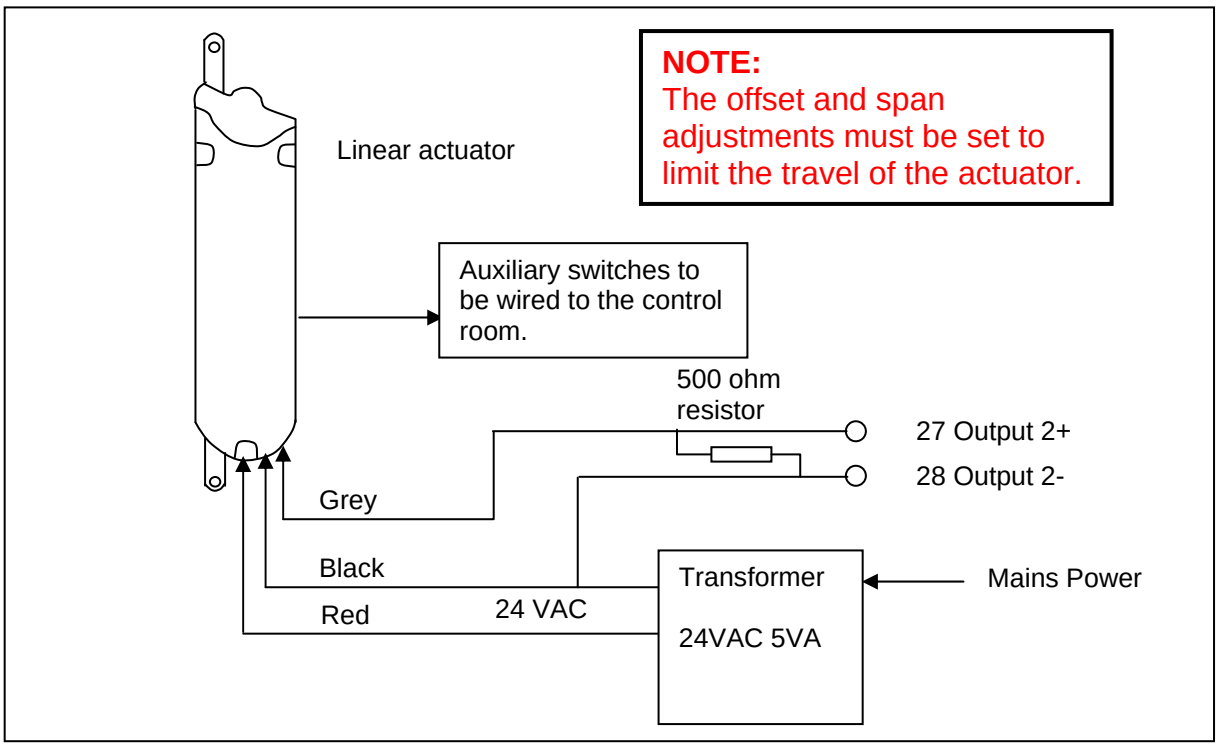

*Burner Feedback Connections*

## 3.17 CONNECTING THE TRIM ACTUATOR

The trim actuator is the motor that will adjust the air / fuel ratio. The 1633 has been designed to drive either a -

1. 4-20mA signal driven actuator
2. Motor increase / decrease control actuator

### 4-20 mA Signal Driven Actuator




*4-20 mA Input Trim Actuator Connections*

The 1633 controller uses 4-20mA output channel 2 to control the position of the linear actuaror. It must also be supplied with an external 24VAC power.

Replace the link on the burner between the gas control valve and the air control damper with a new linkage that includes the linear actuator. The actuator should not be required to use more than 50mm of travel.

Use the MANUAL mode of the 1633 to set the travel of the actuator to the required distance using the offset and span adjustments on the linear actuator. If the offset and span adjustments are set correctly, the actuator will not be able to drive past the required air rich position. However the auxiluary position switches can be used to warn the operator of a malfunction in the actuator.

## Motor Increase / Decrease Driven Actuator

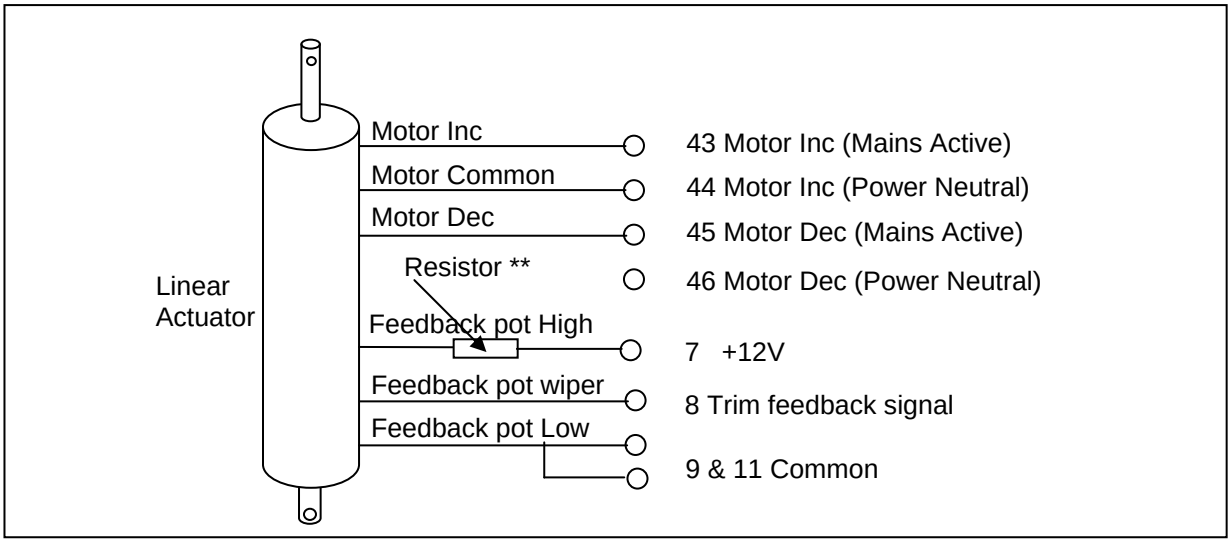
The 1633 controller can drive a motor style actuator. The "Motor Inc" and "Motor Dec" outputs from the 1633 controller will provide power to the actuator.

The feedback potentiometer in side the linear actuator is used by the 1633 controller to determine the actuator position when the 1633 is operating in the NEUTRAL mode.

Replace the link on the burner between the gas control valve and the air control damper with a new linkage that includes the linear actuator. The actuator should not be required to use more than 50mm of travel.

After the linear actuator has been mounted on the burner, use the MANUAL mode on the 1633 controller to run the actuator from the fully withdrawn position to the 50mm extended position.

Use set-up function 63 (Trim Pot Span) to set the full scale output of the feedback pot. Measure the voltage between screw terminals 8 and 9 when the motor is in the air rich extended position. Enter this voltage into set-up 63. The trim motor position can be displayed on the lower line of the analyser. See set-up 29, or for more details see appendix 7.3.2.




*Motor Driving Trim Actuator Connections*

The resistor in series with the trim feedback pot must be chosen to allow a maximum trim feedback signal of 4VDC. Select the trim motor pot resistance-

| ** | Trim motor Pot Resistance | Series Resistor Value |
|---|---|---|
| | 135 ohms | 270 ohms |
| | 1 k ohms | 2.2 k ohms |

# COMMISSIONING

## 3.18 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.

## 3.19 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 -

| | |
|---|---|
| 1 to 5 | Date / time |
| 6 to 9 | Reference voltages |
| 10 | Probe offset |
| 20 | Oxygen Sensor type |
| 22 & 24 | Output channel #1 |
| 26 to 27 | Output channel #2 |
| 34 to 36 | Auto purge |
| 37 to 42 | Auto gas calibration checking |
| 70 to 78 | Alarm set-up |

## 3.20 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 (1200°F), a "Probe Low Temperature" message is flashed on the lower line. The probe temperature can be checked on the lower line of the display.

## 3.21 BURNER BY-PASS 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 flue or the flue connection from the 1234 sensor.

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.

## 3.22 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.

## 3.23 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 zirconia sensor EMF is either correct or a replacement is required. To check that the probe is functioning correctly, firstly check that the high impedance alarm, 'SENSOR FAIL', is not active. The actual impedance can be displayed on the lower line. It should be less than 9 KΩ at 720°C (1320°F).

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 5.5.10. 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 to avoid interference from the process gas sample. Novatech probes can easily achieve this with or without a probe filter and a gas flow of only 1 to 5 litres / minute (120 to 600 scfm) for a 1231 probe and up to 20 litres / minute (2400scfm) for an unheated probe.

## 3.24 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 32, 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 air 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).

## 3.25 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 airflow. The flow required is 1 to 5 litres / minute (120 to 600 scfm) ) for a 1231 probe and up to 20 litres / minute (2400scfm) for an unheated probe.

Air is not the best gas for calibration checking on a zirconia sensor. The output of a zirconia sensor with air on both sides of the sensor 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).

## 3.26 DUST IN THE FLUE GAS

For unheated probes with no filter, entrained solids or dust in the flue gas 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 particulates in the flue gas. 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 stopwatch 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.

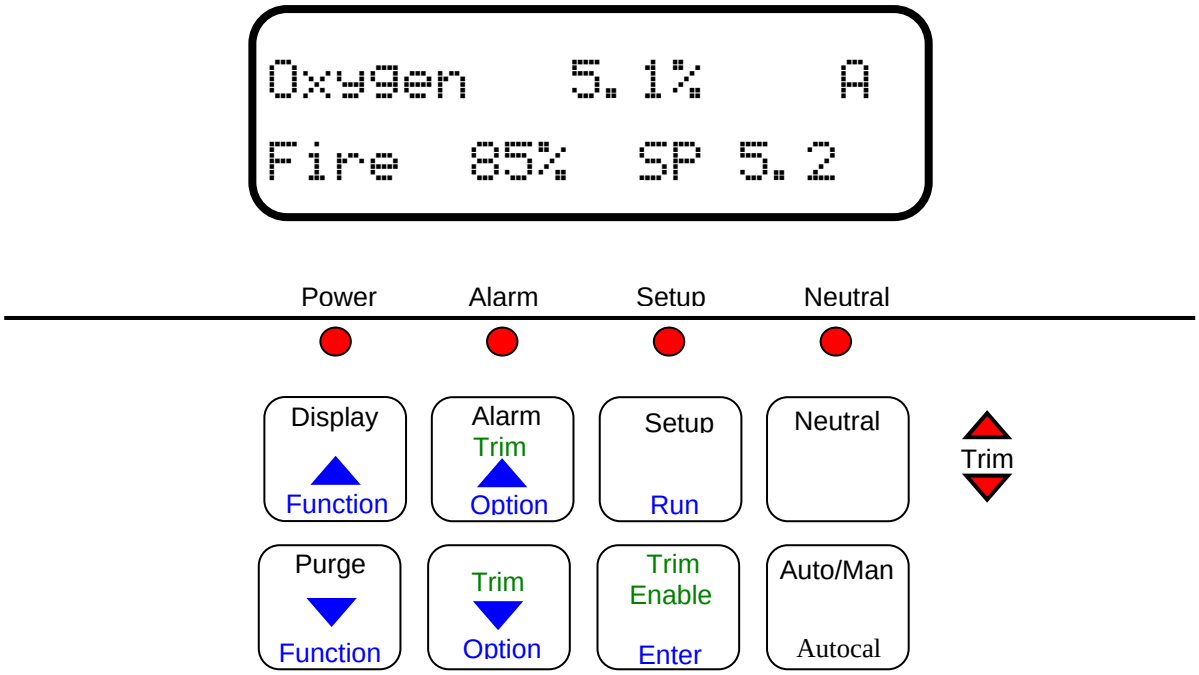
## 3.27 STRATIFICATION

If the analyser and probe have been fully tested and the oxygen readings in the flue gas are incorrect, gas stratification may be occurring. The phenomena cannot be anticipated for any particular installation. Generally, large flues have oxygen differences of approximately one percent across the flue. Occasionally an oxygen error of several percent may occur in a flue of any size. Moving the probe to a new location normally solves this problem.

# 4

# OPERATOR FUNCTIONS

Section
Number




## 4.1 DISPLAY BUTTON

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

1. Run hours since last service
2. Date of last service
3. Boiler firing rate / oxygen set point
4. Trim actuator position
5. Probe EMF (millivolts)
6. Probe temperature
7. Auxiliary temperature
8. Probe impedance, A measure of integrity of the sensor's electrode, the part of the probe that normally wears out first.
9. Ambient temperature
10. Boiler efficiency %
11. Oxygen deficiency %
12. Combustibles %
13. Carbon dioxide %, dry. Calculated from the oxygen reading. Assumes complete combustion.

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 29 on the keyboard. In addition to the above lower line displays, the analyser will automatically display:

"Probe Temp Low", when the oxygen probe is below 650°C (1200°F)

"Gas ON" for Calibration check Gas 1

"Purging Probe"

"Probe Thermocouple Wrong Polarity"

"Aux Thermocouple Wrong Polarity"

**NOTE:**

1. 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.

2. This timer can be used as a probe replacement and / or boiler service schedule aid. Changing the 'SERVICE DAY' in set-up mode on the keyboard resets the start time.

3. 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 (130°F).

## 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. 'Probe Fail'
Oxygen sensor or electrode failure (high impedance); (inhibited under 650°C (1200°F)).

2. 'Heater Fail'
In the first 20 minutes of power being applied to the heater after being switched on, this alarm will not occur, but a 'Probe 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.

3. 'Probe TC Open'
Probe thermocouple is open circuit. The heater in heated probes will switch off.

4. '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.

5. 'Ref Pump Fail'
The reference air pump in the analyser has failed.

6. 'Ref Air Fail'
The reference gas supply from the air pump in the analyser to the probe is blocked, or there is not sufficient airflow.

7. 'ADC Warning'
The analog to digital converter has been found to fall outside the normal calibration specifications. The ADC is working accurately, but the reference voltages may not be set correctly. See Section 5.5.6.

8. 'ADC Cal Fail'
The analog to digital converter has been found to fall well outside the normal calibration specifications. In this case the oxygen sensor heater will automatically be turned off. The cause is most likely a hardware failure.

9. 'Mains Freq'
The sample of the mains frequency has failed.

10. 'DAC Warning'
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.

11. ‘DAC Cal Fail’
The digital to analog and voltage isolator circuit has been found to well fall outside the normal calibration specifications. This check is only performed when the ‘AUTO CAL’ button is pressed. Refer to Section 6.3. One of the output channels is probably not working.

12. ‘Probe Filter’
Blocked probe filter. This test is only performed when automatic purging of the probe is selected. Refer to step 32 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 Cal Err’
Probe does not correctly calibrate to calibration check gas.

14. ‘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 3.21

15. ‘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 three reset attempts the alarm relay contacts will go open circuit.

16. ‘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

There are three user configurable alarm relays. Any or all of the following functions can be selected for each relay.

**NOTE:** The process alarms will only be activated if enabled in set-up 43.

17. ‘O2% Low’
The measured oxygen level is below the level set in set-up 46, and the alarm delay set in set-up 47 has expired. See Section 5.5.64 for more details.

18. ‘O2% Very Low’
The measured oxygen level is below the level set in set-up 50, and the alarm delay set in set-up 51 has expired. See Section 5.5.66 for more details.

19. ‘O2% High’
The measured oxygen level is above the level set in set-up 44, and the alarm delay set in set-up 45 has expired. See Section 5.5.62 for more details.

20. ‘Oxygen Deviation High’
The oxygen as read by the oxygen probe differs from the oxygen set point by an amount greater than the level set in set-up 48, for a period longer than that set in set-up 49.

21. ‘Neutral Trim’
When an alarm situation is detected, the analyser will automatically go to the neutral trim state. This will provide a safe firing condition in the event of a probe or analyser failure. When the analyser is running in NEUTRAL mode the selected relay will be activated.

22. ‘Probe Temperature’
The probe temperature is under 650°C (1200°F). The oxygen reading is therefore invalid. If the probe heater has been on for more than 20 minutes and the temperature is less than 650°C (1200°F) 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 (1200°F) ), 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.

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

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

25. Alarm Horn

This is not an alarm condition. If one of the three user configurable alarm relays have 'Alarm Horn' enabled; the relay will have closed contacts only when there is an unaccepted 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 probe 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".

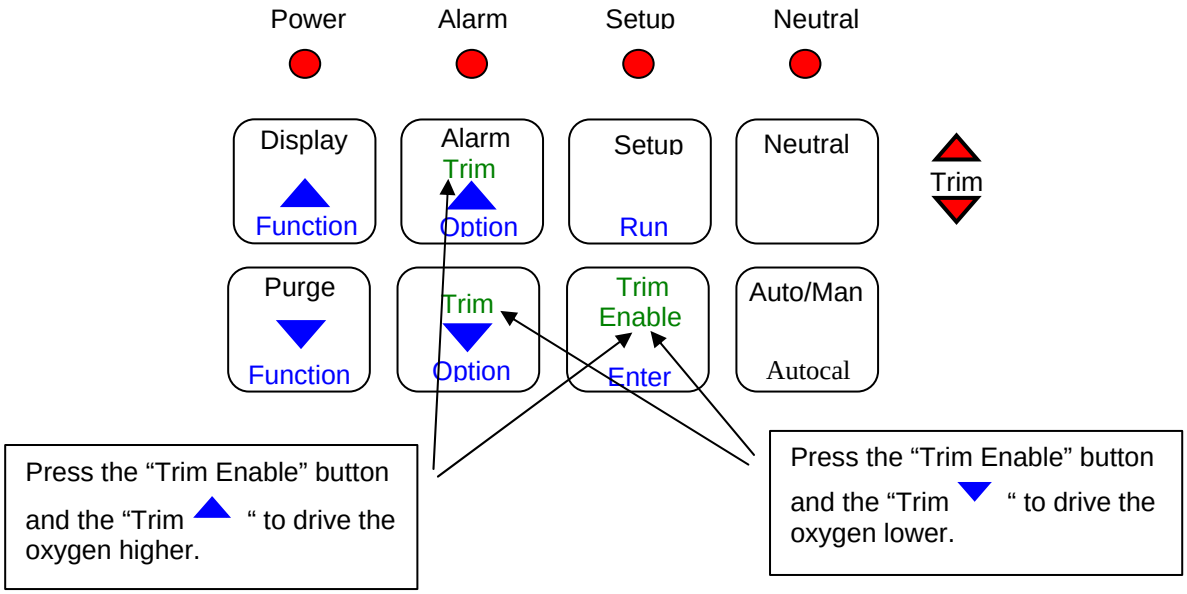
If it is not needed to have the analyser interlocked with the combustion appliance terminals 18 & 19 can be connected together.

## 4.6 DISPLAY BACKLIGHT

If the ambient temperature measured inside the analyser cabinet exceeds 35°C, the backlight will be turned off one minute after the keypad is used. This is aimed at reducing one of the major sources of heat within the cabinet when the ambient temperature is high. The backlight will come on again as soon as a button is pressed.

The internal reference air pump (if fitted) will start cycling on and off every minute, above 35°C.

## 4.7 MANUAL TRIM CONTROL BUTTONS




Set the 1633 controller into MANUAL mode by pressing the Auto / Man button. An “M” will flash in the upper right of the display to confirm either MANUAL or AUTO trim control mode.
Both of the buttons shown above must be pressed together to move the actuator outputs of the 1633 controller. The Trim LED’s will light to confirm the outputs are operating. Make sure that the oxygen moves up or down in the same direction as the button arrows. If the oxygen does not change in the correct direction, reverse the action of the actuator.

# 5

# SETTING UP THE TRANSMITTER

Section
Number

# SET-UP MODE SUMMARY

## 5.1 SET-UP MODE FUNCTIONS

1. Calendar Year
2. Calendar Month
3. Calendar Day
4. Real time clock Hour
5. Real time clock Minutes
6. Reference voltage #1
7. Reference voltage #2
8. Reference voltage #3
9. Reference voltage #4
10. Probe offset
11. Output channel number 1 calibration
12. Output channel number 1 calibration, 4mA trim
13. Output channel number 1 calibration, 20mA trim
14. Output channel number 2 calibration
15. Output channel number 2 calibration, 4mA trim
16. Output channel number 2 calibration, 20mA trim

17. Service record year
18. Service record month
19. Service record day
20. Probe Type
21. Probe Thermocouple Type
22. Auxiliary Thermocouple Type
23. Transmitter Output Channel 1 scale
24. Transmitter Span Channel 1

Set-up steps 25 to 27 will be skipped automatically if '4-20mA FWD' or '4-20mA REV' is selected in set-up step 60.

25. Transmitter Output Channel 2 scale
26. Transmitter Zero Channel 2
27. Transmitter Span Channel 2

28. Centigrade / Fahrenheit Selection
29. Lower Line Display Functions
30. Flue Pressure mm / inches / kilopascals
31. Flue Pressure Value

32. Automatic Purge / Cal?

Set-up steps 32 will be skipped automatically if 'Neither' is selected in set-up step 33.

33. Purge / Cal Start Time

Set-up steps 34 to 36 will be skipped automatically depending on the selection in set-up step 32.

34. Time between Purges
35. Purge Duration
36. Purge Freeze Time

Set-up steps 37 to 42 may be skipped automatically depending on the selection in set-up step 32.

37. Oxygen Content of Cal Gas
38. Maximum Acceptable Positive Error Gas
39. Maximum Acceptable Negative Error Gas
40. Period Between Gas Autocal Checks
41. Duration of Gas Autocal Check
42. Duration of Freeze Time

43. Process alarm enable

Set-up steps 44 to 51 will be skipped automatically if 'No' is selected in set-up step 43.

44. High oxygen alarm level
45. High oxygen alarm delay time

46. Low oxygen alarm level
47. Low oxygen alarm delay time
48. Oxygen Deviation Alarm
49. Oxygen Deviation Alarm Delay
50. Very low oxygen alarm level
51. Very low oxygen alarm delay time

52. Alarm relay number 2 function select
53. Alarm relay number 3 function select
54. Alarm relay number 4 function select

55. Data to Print
56. Print Log Period
57. Printer Baud Rate

58. Set Point Option

Set-up steps 59 to 70 may be skipped automatically, depending on the selection in set-up step 58.

59. Enter Local Set Point
60. Trim Control Actuator
61. Burner Minimum
62. Burner Maximum
63. Trim Feedback Pot Span

64. Characterisation Entry Method
65. Enter Characterisation Point #
66. Set Firing Rate Characterisation Point Value
    Set Oxygen Level Characterisation Point Value
67. Set Neutral Trim Position Characterisation Point Value
68. Set Proportional Band Characterisation Point Value
69. Set Dead Band Characterisation Point Value
70. Finished Options
71. Print Characterisation Table.

72. Damping factor

Set-up steps 74 to 86 may be skipped automatically, fuel information is not required.

73. Single or Dual Fuel

Set-up steps 75 to 80 will be skipped automatically, depending on the selection in set-up step 74.

74. Fuel #1 ‘A’ Value
75. Fuel #1 ‘H’ Value
76. Fuel #1 ‘O’ Value
77. Fuel #1 ‘N’ Value
78. Fuel #1 ‘S’ Value
79. Fuel #1 ‘M’ Value

Set-up steps 81 to 86 will be skipped automatically, depending on the selection in set-up step 74.

80. Fuel #2 ‘A’ Value
81. Fuel #2 ‘H’ Value
82. Fuel #2 ‘O’ Value
83. Fuel #2 ‘N’ Value
84. Fuel #2 ‘S’ Value
85. Fuel #2 ‘M’ Value

86. Reference Air Pump Options

Set-up steps 88 will be skipped automatically, depending on the selection in set-up step 87.

87. Reference Air Relative Humidity

88. MODBUS Address

## 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.

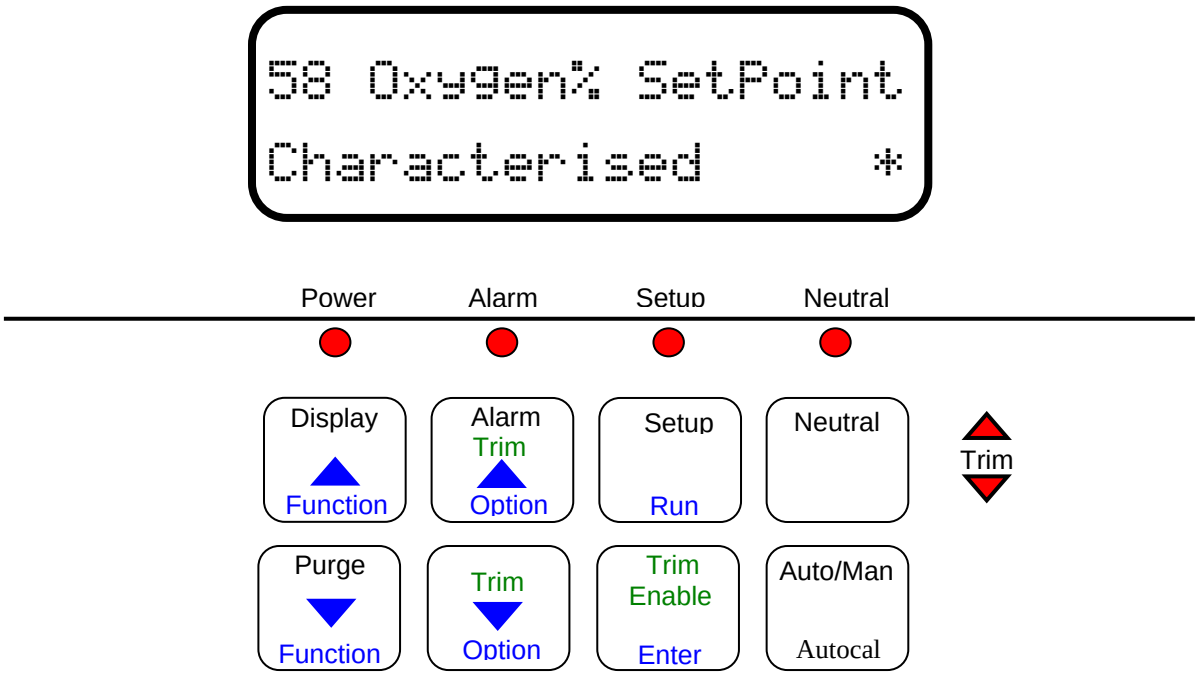
## 5.4 ENTER OPTION OR VALUE

### 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 29 and 55 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.




*1633 Combustion controller Keyboard*

## 5.5 SET-UP FUNCTION DETAILS

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

### 1. Calendar 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.

### 2. Calendar Month

**Options**

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

### 3. Calendar Day

**Options**

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

### 4. Real time clock hour

**Options**

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

### 5. Real time clock minutes

**Options**

Select the current minutes for the real time clock.

### 6. Reference Voltage # 1 (about 27.5 mV)

**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 *

### 7. Reference Voltage # 2 (about 194 mV)

**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 *

## 8. Reference Voltage # 3 (about 1200 mV)

**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 *

## 9. Reference Voltage # 4 (about 2500 mV)

**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 6 to 9 are used to calibrate the A/D of the instrument. This should be done 30 minutes or more after the instrument has been on, approximately once every year. 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 1633 manual. Enter the measured values in set-up items 6 to 9. Whenever new values are entered the D/A section should be re-calibrated, Refer to Section 6.3.

## 10. Set Probe Offset

A new EMF offset must be entered whenever a new oxygen probe is installed to calibrate for any offset an individual probe may have. Each probe will have an offset value noted on a removable tag. Enter the 'PROBE OFFSET' value with the underline polarity,
eg. if offset value is -1.2 mV. enter -1.2 mV. The typical maximum is 0.8 mV.

To check a probe offset on site, the probe 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, if the combustion appliance is not operational and the probe 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 (1200°F) with a portable furnace.

Determine the probe offset in RUN mode. Select 'Probe EMF' on the lower line. With probe in air, stabilised at temperature for 30 minutes, read the 'Probe EMF'. Switch back to set-up mode and enter 'Probe Offset' of equal value and the same polarity.
eg. If the measured 'PROBE 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 set up to the value to 0 in set-up step 31.

## 11. 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: The analyser will only stay in either '4mA TRIM' or '20mA TRIM' modes for 30 minutes before it automatically returns to 'MAN CAL'.

## 12. Calibrate 4mA, Channel #1

This menu item only appears if 'Set 4mA Trim' is selected in Set-up 11.
**Range**: 0 to 25mA, Default is 4.00mA
For full details on the calibration of the 4-20mA output channels, see section 6.3.

## 13. Calibrate 20mA, Channel #1

This menu item only appears if 'Set 20mA Trim' is selected in Set-up 11.
**Range**: 0 to 25mA, Default is 20.00mA

## 14. 4-20mA Calibration Options, Channel #2

Select the calibration method for the 4-20mA output channel #1.
For more details, see Set-up 11 and section 6.3.

**Options:**

1. Auto Calibration *
2. Manual Calibration
3. Set 4mA Trim
4. Set 20mA Trim

## 15. Calibrate 4mA, Channel #2

This menu item only appears if 'Set 4mA Trim' is selected in Set-up 14.
**Range**: 0 to 25mA, Default is 4.00mA
For full details on the calibration of the 4-20mA output channels, see section 6.3.

## 16. Calibrate 20mA, Channel #2

This menu item only appears if 'Set 20mA Trim' is selected in Set-up 14.
**Range**: 0 to 25mA, Default is 20.00mA

## 17. Enter Service Year

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

## 18. Enter Service Month

Enter the current 'MONTH'.

## 19. Enter Service Day

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

## 20. Probe Type

**Options:**

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

## 21. Probe Thermocouple Type

## 22. Auxiluary Thermocouple Type

The probe can have either a type K, or R 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. |

**NOTE**

For heated probes, the flue (auxiliary) thermocouple is a separate sensor from the oxygen probe. If no thermocouple is required, select option 'NO T/C'. In this case auxiliary temperature read outs will not be operable.

## 23. Transmitter Output Channel 1

Select the type of output required from Channel 1. Linear is the most common output required. The logarithmic output is often used when connected to an analog indicator that will then give an exploded view of the oxygen range near the normal operating level. You can draw your own scale using data in Appendix 3.

**Options:**

1. Linear oxygen *
2. Logarithmic oxygen
3. Reducing oxygen, Range fixed at $10^{-1}$ to $10^{-30}$% oxygen
4. Reducing oxygen, Range fixed at $10^{+2}$ to $10^{-4}$% oxygen (100% to 1 ppm)
5. Very low oxygen (1 ppm to 10,000 ppm, 1%)
6. Oxygen deficiency (-5% to +10% oxygen)

Linear output spans are adjustable in Set-up step 24.
The reducing output is for special applications requiring extreme reducing conditions eg. ceramic surface treatment.
The logarithmic output is fixed at 0.1 to 20 % oxygen and the reducing output is fixed at either $10^{-1}$ to $10^{-30}$% oxygen or $10^{+2}$ to $10^{-4}$% oxygen.
The oxygen deficiency scale can be used to follow the normal oxygen level, but also track any excursions into the fuel rich operation.
If any of the latter four are selected, set-up 24 will be skipped.

## 24. Transmitter Span Channel 1

Applicable only to linear outputs. Select transmitter span for output Channel 1. For combustion applications, typical linear spans are 0 to 10 % or 0 to 21 % oxygen.
Default setting is 10.0%.

## 25. Transmitter Output Channel 2

Select transmitter output for output Channel 2.

**Options:**

1. Oxygen Sensor EMF *
2. Logarithmic oxygen, 0.1 to 20 %
3. Auxiliary (Flue) temperature
4. Linear oxygen %
5. 1 x $10^{+2}$ to $10^{-30}$% oxygen, for reducing conditions.
6. Efficiency
7. $CO_2$ maximum
8. Combustibles %

## 26. Transmitter Zero Channel 2

The output zero and span of Channel 2 is set in set-up steps 25 and 27. Range limits are shown below.

## 27. Transmitter Span Channel 2

| Output | Zero Range | Span Range | Default Setting |
|---|---|---|---|
| OXYGEN SENSOR EMF | 0 to 1100 mV in 100 mV steps | 100 to 1300 mV in 100 mV steps | 0 to 100 mV |
| LOG OXYGEN (see Note 1) | 0.1 % oxygen fixed | 20 % oxygen fixed | |
| AUX TEMPERATURE | 0 to 1300 °C (32 to 2370°F) in 100° steps | 100 to 1400 °C (210 to 2550°F) in 100° steps | 0 to 1300 °C (32 to 2370°F) |
| LINEAR OXYGEN | 0 to 99% | 1 to100% oxygen | 0 to 10% oxygen |
| REDUCING OXYGEN (see Note 2) | 100% to $10^{-10}$ % oxygen in one decade steps, non overlapping | $10^{-3}$ to $10^{-30}$ % oxygen in one decade steps. Min span five decades | 100% to $10^{-30}$ % |
| LINEAR OXYGEN | 0 Fixed | 1 to 20 % | |
| THEORETICAL MAX $CO_2$ | 0 to 10 % | 2 to 20 % | |
| BURNER EFFICIENCY | 0 fixed | 100 % fixed | |
| COMBUSTIBLES | 0 fixed | 2 % fixed | |

**NOTE**

1: For log oxygen scale details, Refer to Appendix 3.

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

3. Always check that the "*" is on the RH end of the lower line to lock in the selection before leaving the function.

## 28. Centigrade / Fahrenheit Selection

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

**Options:**

1. Celsius (Centigrade) *
2. Fahrenheit

## 29. 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. Run hours since last service
2. Date of last service
3. Firing-rate / oxygen-set-point
4. Trim actuator position
5. Oxygen Sensor EMF
6. Probe temperature
7. Auxiliary temperature
8. Probe impedance
9. Ambient temperature
10. Efficiency
11. Oxygen Deficiency
12. Combustibles
13. Max $CO_2$

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.

**NOTE**

1. A flue thermocouple must be connected to Terminals 5 and 6 to obtain a proper reading for option 7 and 10 (Refer to Section 3.5).

## 30. Flue Pressure

Enter flue pressure, eg. 3 mm (0.12") W.G.

**Options:**

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

## 31. Flue Pressure Value

Enter flue pressure e.g. 3 mm (0.12") WG. The default setting is 0.

**Limits** :

-3000 to +3000 mm
-3000 to +3000 inches W.G.
-3000 to +3000 kpa

## 32. Automatic Purge / Cal

An automatic cycle for a probe filter purge or a system gas calibration check can be enabled with this menu item.
For complete system calibration checking a gas with a known oxygen percentage can be piped to the probe. The resulting measurement is then compared to the known oxygen level and the acceptable error limits. If the reading is not within the limits a 'Gas Cal Error' alarm will be generated.
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 'Neither' is selected, set-up steps 33 to 42 will be skipped. If 'Cal Check' is selected set-up steps 34 to 36 will be skipped. If 'Auto Purge' is selected set-up steps 37 to 42 will be skipped.

**Options:**

Neither *
Gas Cal Check
Auto Purge

## 33. Purge / Cal Start Time

Set the first purge / cal 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. If neither purge nor auto calibration check is required, this item will not appear.

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

## 34. 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.

## 35. 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 200 seconds. Default setting is 10 seconds.

## 36. 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.

## 37. Oxygen Content Of Cal Gas

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

**Range:**

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

## 38. Maximum Acceptable Positive Error Gas

Set the maximum positive error above which the 'Gas Cal Error' alarm will be initiated after the timed period set in set-up step 40.

**Range:**

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

## 39. Maximum Acceptable Negative Error Gas

Set the maximum negative error below which the 'Gas Cal Error' alarm will be initiated after the timed period set in set-up step 40.

**Range:**

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

## 40. Period Between Gas Autocals

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

**Range:** 1 to 1999 hours. The default setting is 168 hours (one week).

## 41. Duration Of Autocal Gas

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, an 'Gas 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.

## 42. Freeze Time Gas

After the Cal Gas 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 a certified gas bottle 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.

## 43. 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 oxygen, Low oxygen, Oxygen deviation, and Very low oxygen.

**Options:**

Yes

No *

## 44. High Oxygen Alarm

Set the operating point for the high oxygen alarm relay.

**Range:**

0.1 –30.0% oxygen. The default setting is 10.0 % oxygen.

## 45. High Oxygen Delay

Typically set at 30 seconds. This delay is to avoid nuisance alarms when the burner is undergoing transitions in firing rate that can cause it to deviate from the oxygen set point, but recover quickly.

**Range:**

0–200 seconds. The default setting is 60 seconds.

## 46. Low Oxygen Alarm

Set the operating point for the low oxygen alarm relay. Typically set at 2.0% oxygen, depending on the burner, it can be used as a safety warning.

**Range:**

0.1 –21% oxygen. The default setting is 2.5 % oxygen.

## 47. Low Oxygen Delay

Typically set at 30 seconds. This delay is to avoid nuisance alarms when the burner is undergoing transitions in firing rate that can cause it to deviate from the oxygen set point, but recover quickly.

**Range:**

0–200 seconds. The default setting is 10 seconds.

## 48. Oxygen Deviation Alarm

Set the alarm level for the oxygen deviation. For example, if the oxygen set point was 5.0% oxygen, and the deviation alarm was set to 1.0%, the oxygen deviation alarm would be initiated if the actual oxygen level exceeded 6.0% or fell below 4.0%, after the delay time set in step 43.

**Range:**

0.1 –21% oxygen. The default setting is 2.0 % oxygen.

## 49. Oxygen Deviation Alarm Delay

Typically set at 30 seconds. This delay is to avoid nuisance alarms when the burner is undergoing transitions in firing rate which can cause it to deviate from the oxygen set point, but recover quickly.

**Range:**

0–200 seconds. The default setting is 30 seconds.

## 50. Very Low Oxygen Alarm

Set the operating point for the very low oxygen alarm relay, typically 0.5% oxygen. This limit can be used as a shut down on a boiler as the normal operating level should never be this low.

**Range:**

0.001 –2.000% oxygen. The default setting is 0.500 % oxygen.

## 51. Very Low Oxygen Delay

Set the very low oxygen alarm delay to the smallest possible period to avoid nuisance alarms / shut-downs, but still maintain the fastest response to a fuel rich atmosphere

**Range:**

0–200 seconds. The default setting is 2 seconds.

## 52. 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 29.

**Options :**

1. Low oxygen
2. High oxygen
3. Very low oxygen
4. Oxygen deviation between the oxygen set point and the measured oxygen level
5. Probe under temperature
6. Calibration check in progress
7. Probe purge in progress
8. Neutral trim

## 53. Alarm Relay #3

Alarm relay #3 has the same functions available as alarm relay #2. See set-up 52.

## 54. Alarm Relay #4

Alarm relay #4 has the same functions available as alarm relay #2. See set-up 52.
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 unaccepted alarm, and closed when a new alarm occurs.
The default is ‘Neutral Trim’.

## 55. 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 29. The log period follows in set-up step 56. A sample of a print out is contained in Appendix 4. RS232C protocol is :

| | |
|---|---|
| Data word length | Eight bits |
| Stop bits | One |
| Parity | None |

Oxygen and the current date / time is always printed, plus any of the following:

**Options :**

1. Run hours since last service
2. Date of last service
3. Firing-rate / oxygen-set-point
4. Trim actuator position
5. Oxygen Sensor EMF
6. Probe temperature
7. Auxiliary temperature
8. Probe impedance
9. Ambient temperature
10. Efficiency
11. Oxygen Deficiency
12. Combustibles
13. Max $CO_2$

If MODBUS is selected by having a valid (non zero) address selected in set-up item 88, the data log function will not operate.

## 56. Print Log Period

Select the time interval between data print outs on the printer.
When the print period is selected below “1 minute”, the selection will automatically switch to “seconds”. The time can then be selected up to 120 seconds. Above 120 seconds the time will switch automatically back to minutes.
NOTE: The print log could be up to 2 seconds after the expected time.

**Range:**

5 to 120 seconds, 1 to 2000 minutes

## 57. Printer Baud Rate

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

**Options:**

300
1200
2400
4800
9600 *

## 58. Set Point Option

The set point is the level of oxygen in the boiler that the 1633 analyser will attempt to maintain.
This set point may be selected to come from either a calculated level which is ‘CHARACTERISED’ from the burner firing rate using the characterisation table entered by the user (Refer to Maintenance Sections 6.5.17 to 6.5.23), a ‘LOCAL FIXED’ set point. (Refer to Maintenance Section 6.5.16), or a 4–20 mA ‘REMOTE’ signal to terminals 8 and 9 (RGC I/P +/-).

**Options:**

1. Characterised *
2. Local Fixed
3. Remote

Note that when ‘LOCAL FIXED’ or ‘REMOTE’ set point is selected, the ‘NEUTRAL’ position, ‘PROPORTIONAL BAND’ and ‘DEAD BAND’ are still entered into the characterisation table in set up mode, POINT #1. (Refer to Sections 6.5.18 and 6.5.20 to 6.5.23). If it is not required to have the ‘NEUTRAL ’ position, ‘PROPORTIONAL BAND’ and ‘DEAD BAND’ characterised to the burner firing rate, then remove the firing rate transmitter from terminals 55, 56 and 57, and replace it with a link between terminals 56 and 57. Now the ‘NEUTRAL’ position, ‘PROPORTIONAL BAND’ and ‘DEAD BAND’ may also be entered into POINT #1.

## 59. Enter Local Set Point

If non characterised operation of the boiler is required, this value is used as the fixed set point.(See Set-up step 58)

**Range:**
0.1 – 100.0%. The default setting is 5.0%.

## 60. Trim Control Actuator

The trim actuator may be a 4–20 mA input or mains voltage input for driving a motor up and down. The 1633 analyser may also be used to monitor the boiler only, without actually trimming the oxygen. In this mode, the analyser will still produce alarms on oxygen deviation etc., but will disable the output to the trim actuator.

**Options:**

1. Motor Driving
2. 4-20mA Forward *
3. 4-20mA Reverse
4. Monitor only

## 61. Burner Minimum

In order to calibrate the burner firing rate transmitter for the range of low fire to high fire, the minimum and maximum positions for the transmitter must be entered into the analyser. Set the boiler to low fire and press the ENTER button. This will record the value of the transmitter.

**Range:**
0 – 500

## 62. Burner Maximum

Set the boiler to high fire and press ENTER. This will record the value for the transmitter.

**Range:**
0 – 500

If the difference between the values entered for low fire (Set-up step 61)and high fire is less than 50, the message 'SPAN IS LOW' is displayed on the lower line of the display. In this case, re-adjust the linkages to the firing rate transmitter until the transmitter covers a greater arc. If the linkages are altered, re-enter set-up steps 61 and 62.

## 63. Trim Feedback Pot Span

When a "Motor Driving" actuator is selected in set-up 60, the trim actuator must be mechanically set up to limit the travel. The full withdrawn position of the actuator must be the air-reduction end. The lengthened end of the actuator travel must be the excess air end and must be limited to the maximum level excess air required.
To allow for the trim feedback pot to be scaled over the travel range being used, the full range voltage expected from the pot can be entered in this function.

**Range:**
0.0 – 5.0 V The default setting is 1.0 V.

## 64. Characterisation Entry Method

A choice is available to enter values into the characterisation table from known values in 'MANUAL' or from true values in 'ACTUAL'. It is normal when setting up a boiler to enter values in 'ACTUAL'. It is more convenient to actually set the boilers, measuring the CO levels, and observing the flame to obtain the optimum point and have the microprocessor register this level.

'MANUAL' entry is used when the characteristics of the boiler are already known. To avoid having to make all of the actual measurements on the boiler, the table can simply be entered manually.

The firing rate, % oxygen, neutral position, proportional band and dead band can be entered for each of up to ten characterised points.

**Options:**

1. Manual *
2. Actual

## 65. Enter Characterisation Point #

Up to ten positions can be used to form a characterised curve for flue gas oxygen level (air / fuel ratio), and neutral position. It is important that the whole of the firing range be covered. For best accuracy, the greater the variations through the firing range, the greater the number of points should be entered. Use the option buttons to select the point to be edited, and press ENTER.

**Range:**
1 – 10

## 66. Set Firing Rate Characterisation Point Value

If 'MANUAL' was selected in characterised entry mode, this function allows for the firing rate at which the following oxygen, neutral, proportional band and dead band values are to be related.

If 'ACTUAL' was selected, the firing rate % and the actual oxygen % are read from the burner feedback transmitter and oxygen probe, and are entered into the characterisation table when the ENTER button is pressed..

**SET OXYGEN LEVEL CHARACTERISATION POINT VALUE**

For each firing rate adjusted on the burner, a number would have been displayed on the lower left-hand side of the display. Once the burner has been correctly set by observing the CO level and the flame, the actual oxygen level will be displayed. This can be entered in memory by pressing the ENTER button. As usual, an asterisk will appear on the right hand side of the display once the value has been selected.

## 67. Set Neutral Trim Position Characterisation Point Value

A safety (excess air) setting is provided for the trim motor in the event of an alarm, or the NEUTRAL mode being selected.
If ACTUAL was selected, the trim actuator can be moved by returning to RUN mode, holding the TRIM button, and using the OPTION buttons. (The analyser must also be in MANUAL mode using the AUTO / MAN button to be able to adjust the trim motor) The trim position will be shown on the lower line of the display in RUN mode. When the excess air level has been correctly adjusted in this way, return to SETUP mode and press the ENTER button.
If MANUAL was selected, the OPTION UP / DOWN buttons will alter the trim motor position number, but will not move the trim motor.

## 68. Set Proportional Band Characterisation Point Value

Enter a typical proportional band, e.g. 2.0%, and switch to RUN mode so that the boiler can trim. If no hunting occurs (control cycling or overshoot), reduce the proportional band setting by approximately half and check for hunting.

Hunting may be induced by switching the trim motor to MANUAL using the AUTO / MAN button, and driving it a short distance, then switching back to AUTO mode. Continue this process until hunting is induced into the trim system. Then switch back to set-up mode and increase the proportional band setting by a factor of two. e.g. if the proportional band was at 4%, increase to 8%.

Switch again to RUN mode and allow the boiler to trim, inducing a process 'bump' on the trim motor to check that hunting will not be induced in normal operation.

## 69. Set Dead Band Characterisation Point Value

The next step is to set the dead band. The dead band sets the sensitivity of the system and could be typically set at 0.2%.

The dead band is measured and set in % oxygen, i.e. a setting of 0.2% DB will allow the actual oxygen reading to fluctuate 0.1% either side of the set point without any control action being taken by the analyser.

Too wide a dead band setting would allow the system to drift to slightly beyond the dead band. Too narrow a dead band will cause the trim motor to operate too frequently and maybe even hunt. The trim motor should not be activated more than about once every minute under steady state conditions.

## 70. Set Finished Options

Once the complete burner range from low fire to high fire has been covered by characterisation entry points, select FINISHED, press ENTER and then FUNCTION UP. A complete table of oxygen, neutral, proportional band and dead band positions for each firing rate entered, will be printed on a printer / computer if connected to the serial port. If no printer is connected there will be some delay while the processor writes the necessary table information to the serial port.

## 71. Print Characterisation Table

Printing the characterised table is in progress. Wait six seconds for completion, and the set-up menu will return to set-up step 72.

## 72. Damping Factor

Each time a new reading is read from the oxygen probe, 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 number of readings that are averaged together is adjustable with this function. A value of five for example, means that the new reading from the probe and the previous four readings are averaged together before being displayed. A value of one entered here will mean that every new reading from the probe will be sent to the display unaltered.

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 8 seconds to reach 63% of the change on the output / display.

**Range**

1 to 20. The default setting is 5.

## 73. Single or Dual Fuel

Enter single or dual fuel (for the efficiency calculation). This step and steps 74 to 85 will be skipped if efficiency, oxygen deficiency combustibles %, or maximum $CO_2$ is not selected in Set-up steps 25, 29 or 55 for display or output on the transmitter channels or the printer port.

**Options:**

1. Single *
2. Dual

## 74. Fuel Number 1 'A' Value

'A' is the heat of combustion of the fuel per gram atom of contained carbon.
Enter the correct value of 'A' (Refer notes in Appendix 1).

## 75. Fuel Number 1 'H' Value

'H' is the hydrogen / carbon atom ratio in the fuel.
Enter the correct value of 'H' (Refer notes in Appendix 1).

## 76. Fuel Number 1 'O' Value

'O' is the oxygen / carbon atom ratio in the fuel.
Enter the correct value of 'O' (Refer notes in Appendix 1).

## 77. Fuel Number 1 'N' Value

'N' is the nitrogen / carbon atom ratio in the fuel.
Enter the correct value of 'N' (Refer notes in Appendix 1).

## 78. Fuel Number 1 'S' Value

'S' is the sulphur / carbon atom ratio in the fuel.
Enter the correct value of 'S' (Refer notes in Appendix 1).

## 79. Fuel Number 1 'M' Value

'M' is the ratio of water molecules to carbon atoms in the fuel. Enter the correct value of 'M' (Refer notes in Appendix 1). For single fuel applications the next set-up step will be 86, for dual fuel the next step is 80

## 80. Fuel Number 2 'A' Value

'A' is the heat of combustion of the fuel per gram atom of contained carbon.
Enter the correct value of 'A' (Refer notes in Appendix 1).

## 81. Fuel Number 2 'H' Value

'H' is the hydrogen / carbon atom ratio in the fuel.
Enter the correct value of 'H' (Refer notes in Appendix 1).

## 82. Fuel Number 2 'O' Value

'O' is the oxygen / carbon atom ratio in the fuel.
Enter the correct value of 'O' (Refer notes in Appendix 1).

## 83. Fuel Number 2 'N' Value

'N' is the nitrogen / carbon atom ratio in the fuel.
Enter the correct value of 'N' (Refer notes in Appendix 1).

## 84. Fuel Number 2 'S' Value

'S' is the sulphur / carbon atom ratio in the fuel.
Enter the correct value of 'S' (Refer notes in Appendix 1).

## 85. Fuel Number 2 'M' Value

'M' is the ratio of water molecules to carbon atoms in the fuel.
Enter the correct value of 'M' (Refer notes in Appendix 1).

## 86. Reference Air Selection

The reference air supply for the oxygen sensor or probe 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 87. Half a litre per minute provides sufficient reference air for any sensor.
**Note:** If 'Internal' is selected, and a reference air flow 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

## 87. Reference Air Relative Humidity

This selection will only appear if 'Instrument Air' is selected in set-up 86.
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 about 10%.
**Range:**
1-100%

## 88. 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 2.11, 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 The default setting is 0.

# 6

# MAINTENANCE

Section
Number

## TRANSMITTER MAINTENANCE



## PROBE MAINTENANCE

## 6.1 COLD START

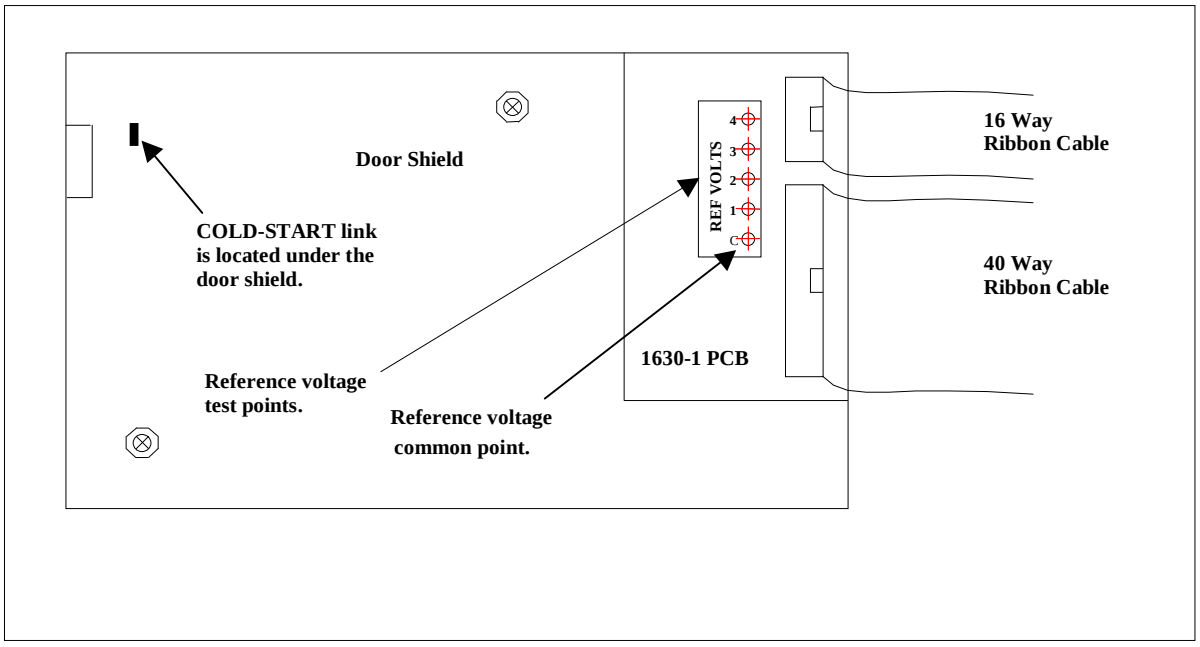
A 'COLD START' will reset all 'Set-up' mode entries to their factory default values.
The characterisation table can also be reset to the factory default at the same time as the other set-up menu items if required.
'COLD START' will show on the display for a second prior to a microprocessor initialising 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' ***without*** resetting the characterisation tables-
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.

To initiate a 'COLD START' ***including*** resetting the characterisation tables-
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)
Hold the 'FUNCTION DOWN' and the 'AUTOCAL' buttons.
Turn the mains power on. The message "Cold Start....." will be displayed.
Hold the buttons until the message "Cold Start....." is displayed.
To confirm the resetting of the characterisation table "Init Char Table" 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 including the characterisation table.

## 6.2 A/D CALIBRATION




*Location of Calibration Test Points*

The analyser maintains its accuracy over a year 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 11 (and 14 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, an 'Auto Cal' will not change the factors.

*Manual Cal*

The 'Manual Cal' mode is selected in set-up 11 (and 14).
Set the 4mA calibration first and then the 20mA calibration.

1. Select 'Set 4mA Trim' in set-up 11 (or 14).
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 12 (or 15).
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 11 (or 14).

Set the 20mA calibration factor.

6. Select 'Set 20mA Trim' in set-up 11 (or 14).
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 13 (or 16).
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 11 (or 14).

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 11 (or 14) 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 11 (or 14).

## 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.
The nuts for the pump screws are captive into the PCB, enabling the pump to be removed WITHOUT removing the PCB. The pump wires can be unplugged.

## 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 in a stored transmitter with power off or every eight years with transmitters that 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 5. 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 changeover 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

Whenever a new oxygen probe is installed, the millivolt offset value should be entered. To achieve this, refer to set-up 10.

The probe offset is noted on a tag or label attached to probe. 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 30 minutes. Read the offset in 'RUN' mode in millivolts on the lower line. Offset errors can occur if the probe 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 oxygen 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, if the combustion appliance is not operational and the probe heater is interlocked with the 'FUEL ON' signal, the 'BURNER BYPASS' switch should be set to 'BYPASS' to power the probe heater after removing the probe from the flue. For unheated probes, the sensing tip must be raised to at least 650°C (1200°F) 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. Readings can then be easily taken of probe impedance, EMF, temperature and percent oxygen. The analyser also provides proper heater control for heated probes.

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 to heat up after switch on.

An instrument to measure probe 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 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 over 700°C (1300°F) is required. The furnace should have a uniform temperature for about 50 mm (2") either side of the sensor tip.

### TEST EQUIPMENT FOR HEATED PROBES

If a 1633 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 60 volts will regulate the probe temperature to over 700°C (1300°F).

## 6.9 TESTING A PROBE

With the probe heated to over 700°C (1300°F), either from a small test furnace or its own internal heater, connect a digital multimeter to the probe 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 airflow should be 50 to 500 cc / minute (6 to 60 scfm). 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 probe 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 needs to be replaced. The probe must be over 700°C (1300°F) 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 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 probe should develop an EMF according to the tables in Appendix 2. 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 probe 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 probe can develop an 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 phenomenon is rare.

## 6.10 PROBE 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 that 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 probes, a heater failure will cause a ‘PROBE UNDER TEMP’ 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.

## 6.12 FILTER BLOCKAGE

For oxygen probes 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. The filters can be replaced with new ones.

# APPENDIX 1

## CONSTITUENT VALUES FOR FUELS

If the transmitter is set up to have readout or output of combustibles or maximum carbon dioxide, then the fuel constituents must be entered. Any or all of the variables can be modified and entered in set-up steps 39 to 45 and 46 to 51. (Refer to Section 5.5). Your fuel supplier or chemist should be able to give you all these values.

**A** is the heat of combustion of the fuel per gram atom of contained carbon.

**H** is the H/C atom ratio in the fuel.

**O** is the O/C atom ratio in the fuel.

**N** is the N/C atom ratio in the fuel.

**S** is the S/C atom ratio in the fuel.

**M** is the ratio of $H_2O$ molecules to C atoms in the fuel

| FUEL | A | H | O | N | S | M |
|---|---|---|---|---|---|---|
| Blast Furnace Gas | 50.55 | 0.08 | 1.3 | 3.08 | b | a |
| Coke Oven Gas | 256.88 | 5.6 | 0.25 | 0.23 | b | a |
| Producer Gas | 101.98 | 1.18 | 1.02 | 2.9 | b | a |
| Natural Gas | 209.9 | 3.86 | 0 | 0.1 | 0 | 0 |
| Propane, Natural | 176.4 | 2.69 | 0 | 0 | 0 | 0 |
| Butane, Refinery | 166.1 | 2.34 | 0 | 0 | 0 | 0 |
| Methanol | 172.59 | 3.97 | 1 | - | - | - |
| Gasoline, Motor | 157.58 | 2.01 | 0 | 0 | 0 | 0 |
| No 1 Distillate Oil | 149.65 | 1.83 | 0 | - | 0 | - |
| No 2 Distillate Oil | 145.18 | 1.71 | - | - | 0 | - |
| No 4 Fuel Oil | 145.54 | 1.6 | - | - | 0.01 | 0 |
| No 5 Residual Oil | 142.25 | 1.44 | - | 0 | 0 | 0 |
| No 6 Residual Oil | 136.52 | 1.25 | 0.01 | 0 | 0 | 0 |
| Wood, Non-Resinous | 110.91 | 2.26 | 1.07 | 0 | 0 | c |
| Coal, Bituminous | 116.88 | 0.74 | 0.05 | 0 | 0 | 0.03 |
| Coal, Anthracite | 104.98 | 0.35 | 0.05 | 0 | 0.01 | 0.04 |
| Coke | 99.63 | 0.11 | 0.01 | 0.01 | 0 | 0.01 |

**a.** The moisture level varies depending on the process details. The calculated values assume M = O.

**b.** The sulphur level varies depending on the process details. The calculated values assume S = O.

**c.** Variable.

**Values calculated from the North American Combustion Handbook, Tables 2.1a and 2.1b.**

# APPENDIX 2

## 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

# APPENDIX 3

## % 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 |

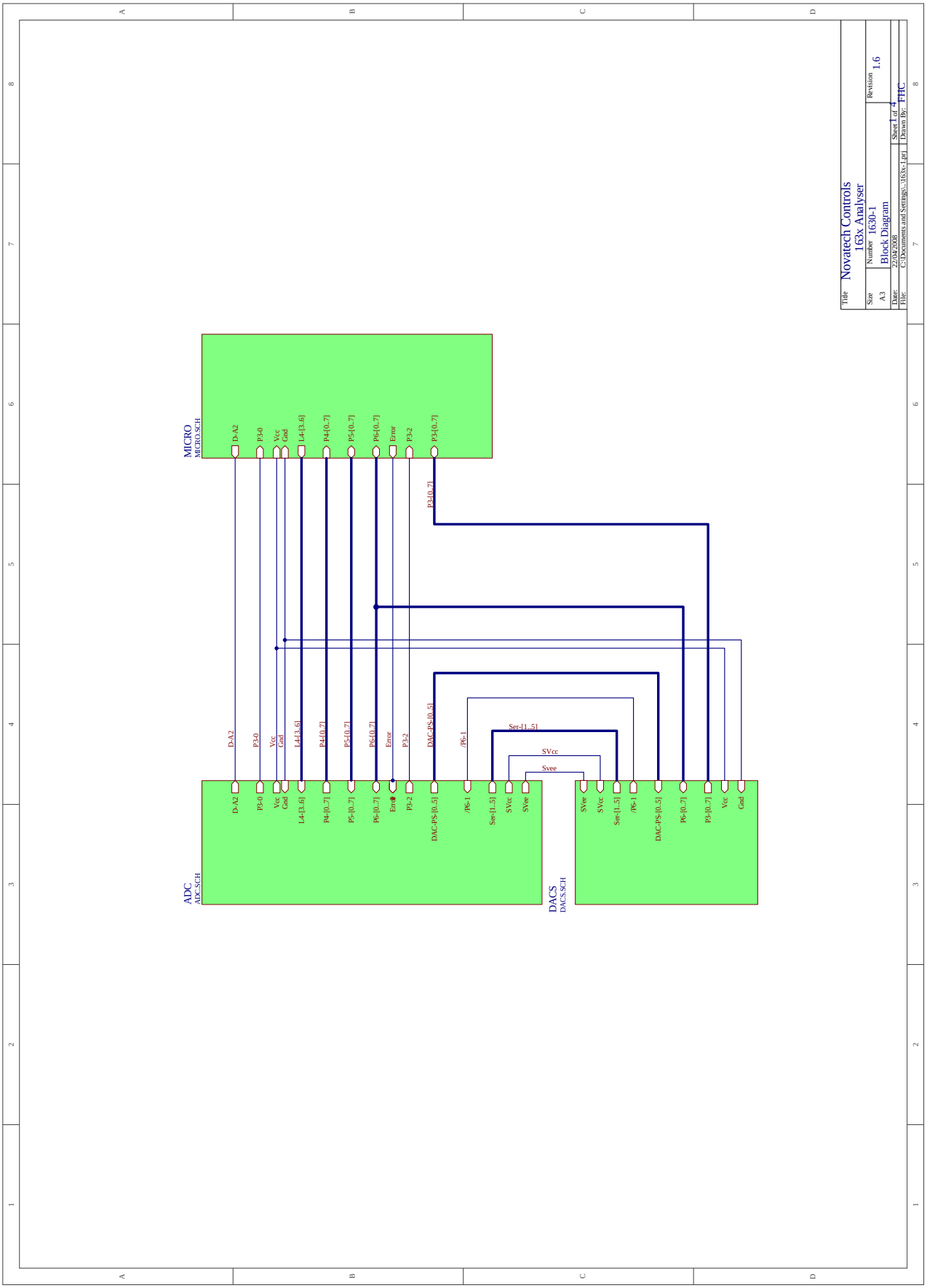
# APPENDIX 4

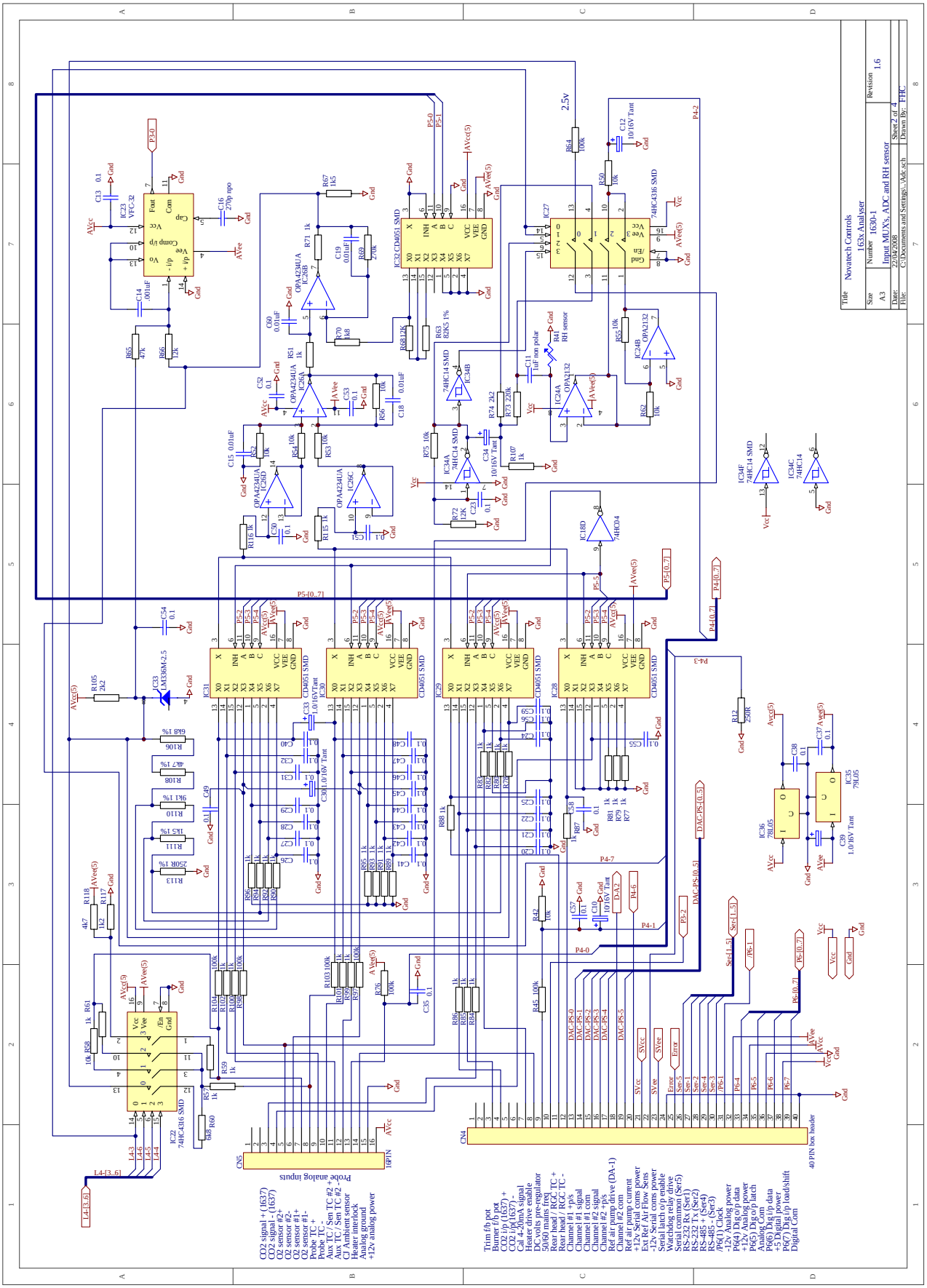
## SAMPLE LOG PRINT OUT

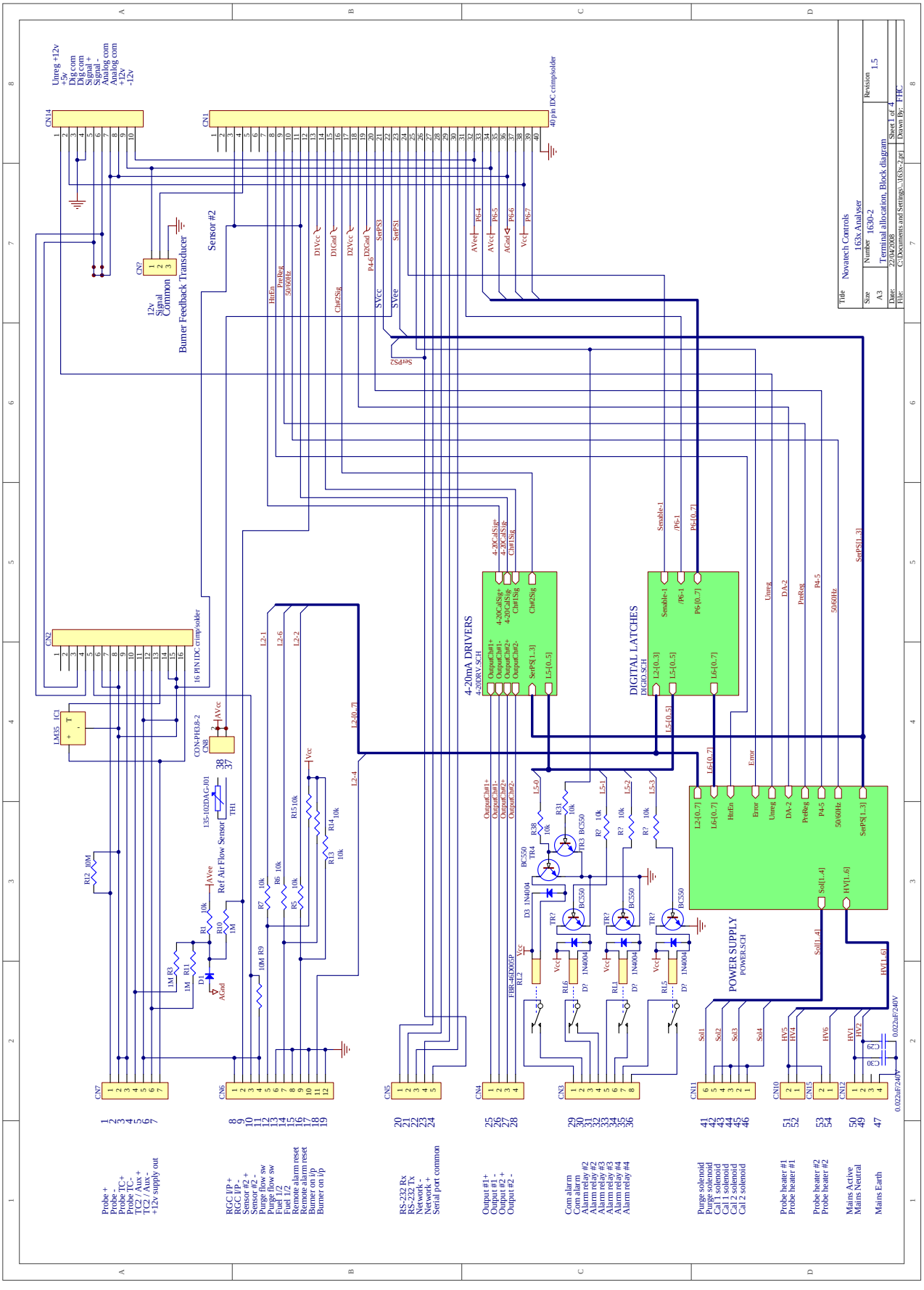
Novatech Controls 29-08-2000 12:52:28
Oxygen % 5.2%
Runtime 1325:49
Fire 83% SP 5.1 %
Trim= 90%
Emf mV 29.9
Probe Temp 723 C
Aux Deg 219 C
Probe Imp 0.0K
Efficiency 88.0%
Combstbles 0.00 %
Next Print at 12:57:28 29-08-2000
07:49:29 29-08-2000 RefPump Fail Accepted

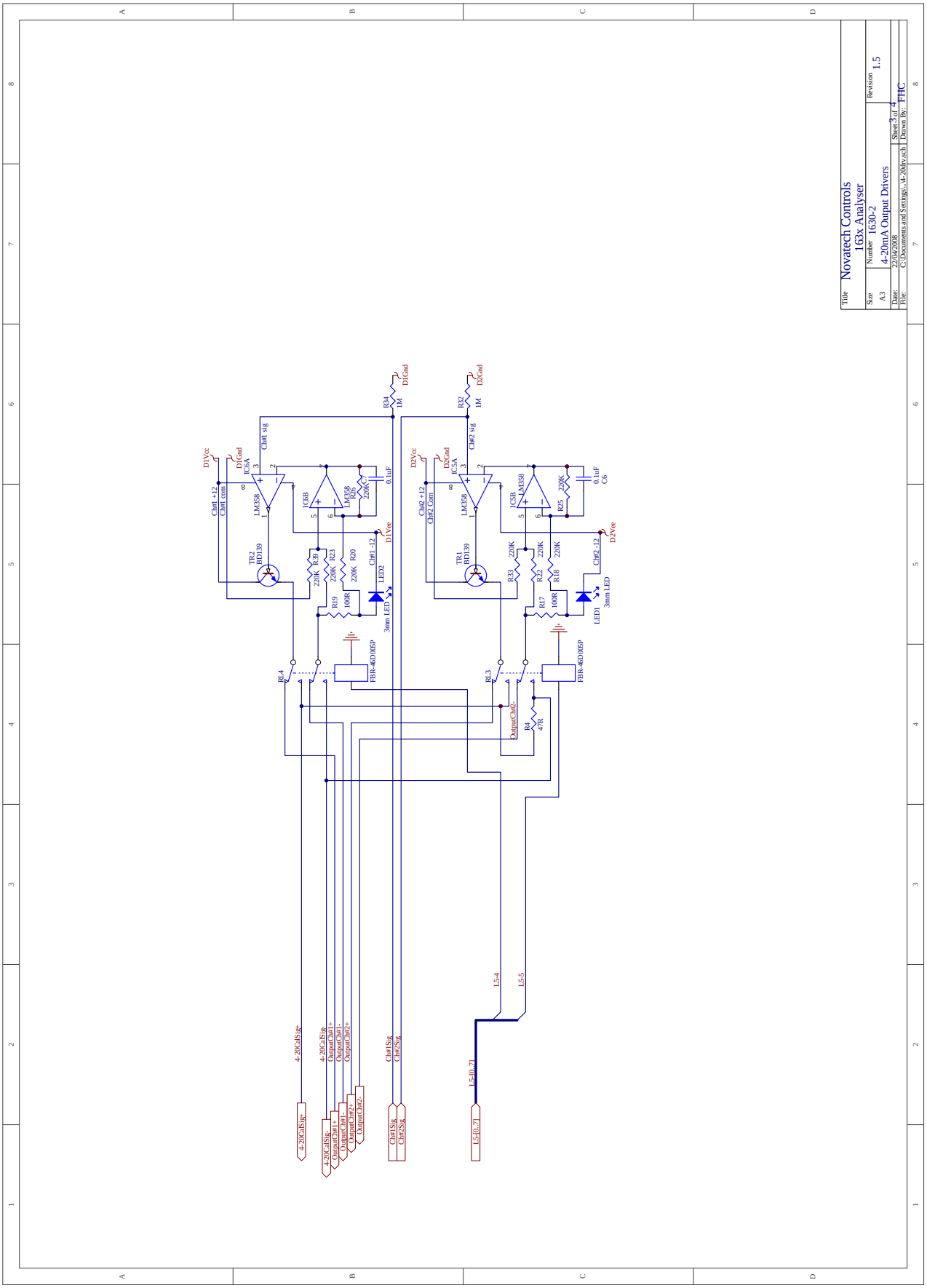
# APPENDIX 5

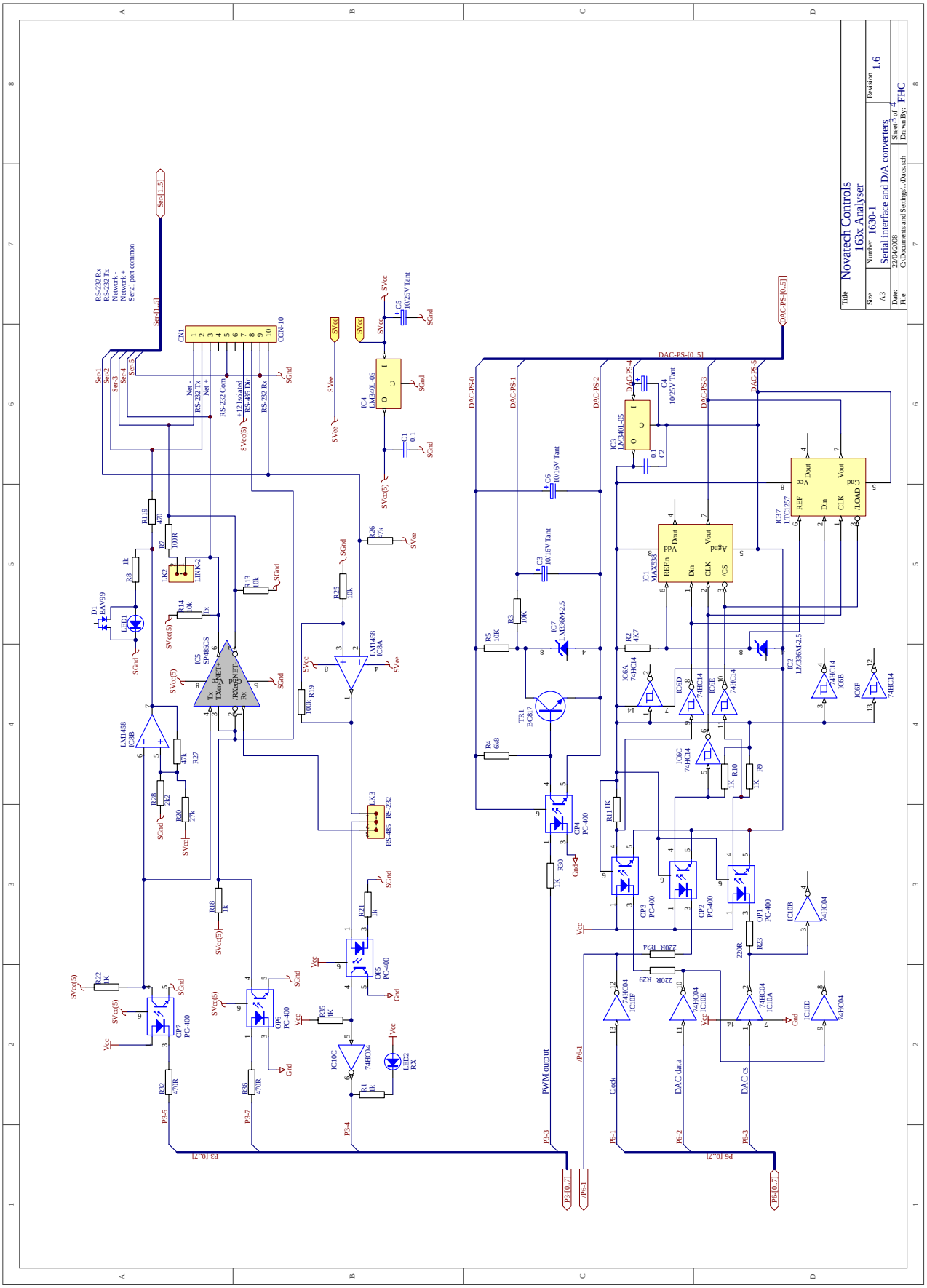
## CIRCUIT SCHEMATICS

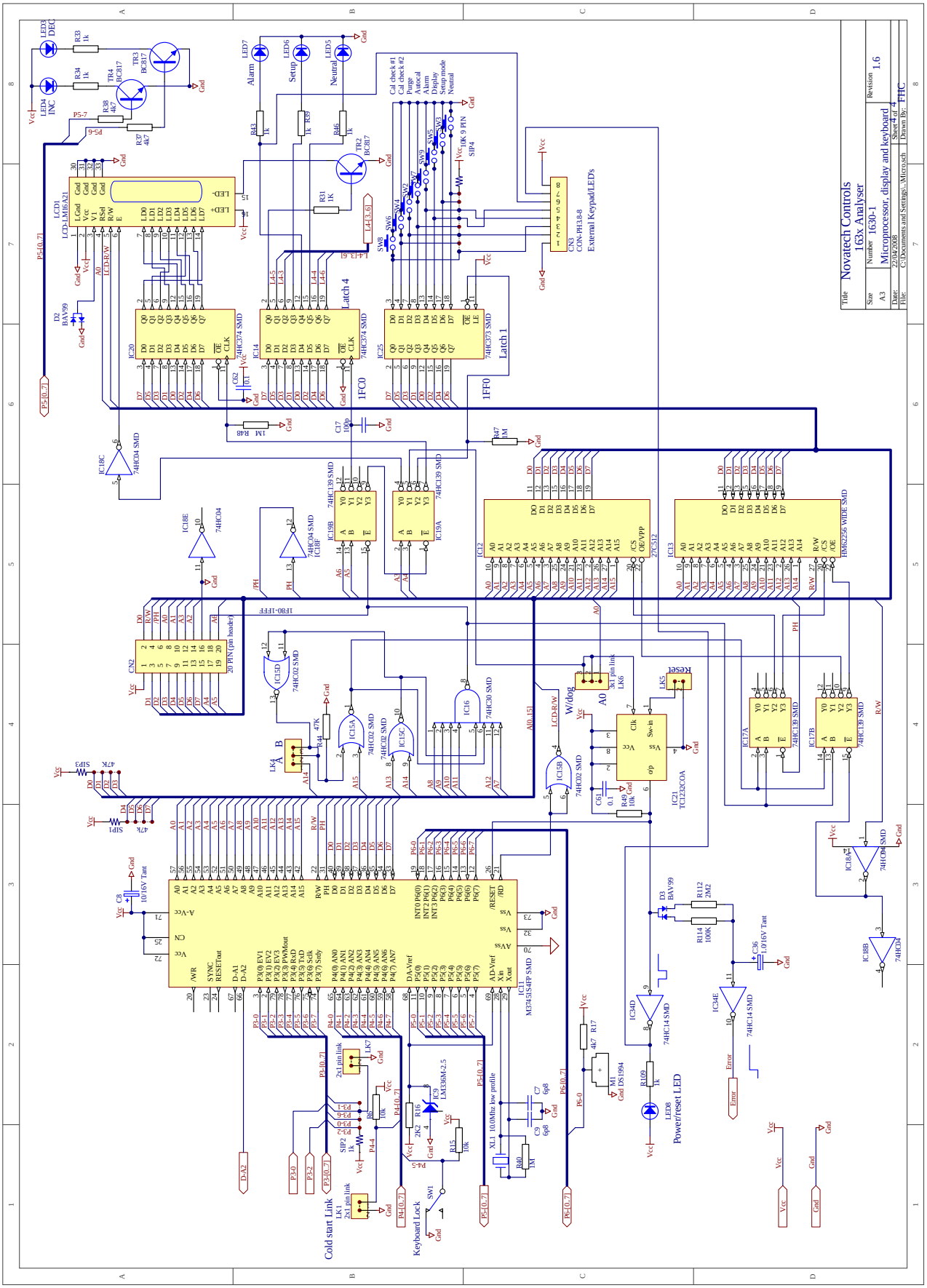

Novatech Controls
163x Analyser
Number 1630-1
Block Diagram
Revision 1.6
Size A3
Date: 27/04/2008
File: C:\Documents and Settings\...\163x-1.prj
Sheet 1 of 4
Drawn By: FHC
MICRO
MICRO.SCH
D-A2
P3-0
Vcc
Gnd
L4-[3..6]
P4-[0..7]
P5-[0..7]
P6-[0..7]
Error
P3-2
P3-[0..7]
P3-[0..7]
ADC
ADC.SCH
DACS
DACS.SCH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

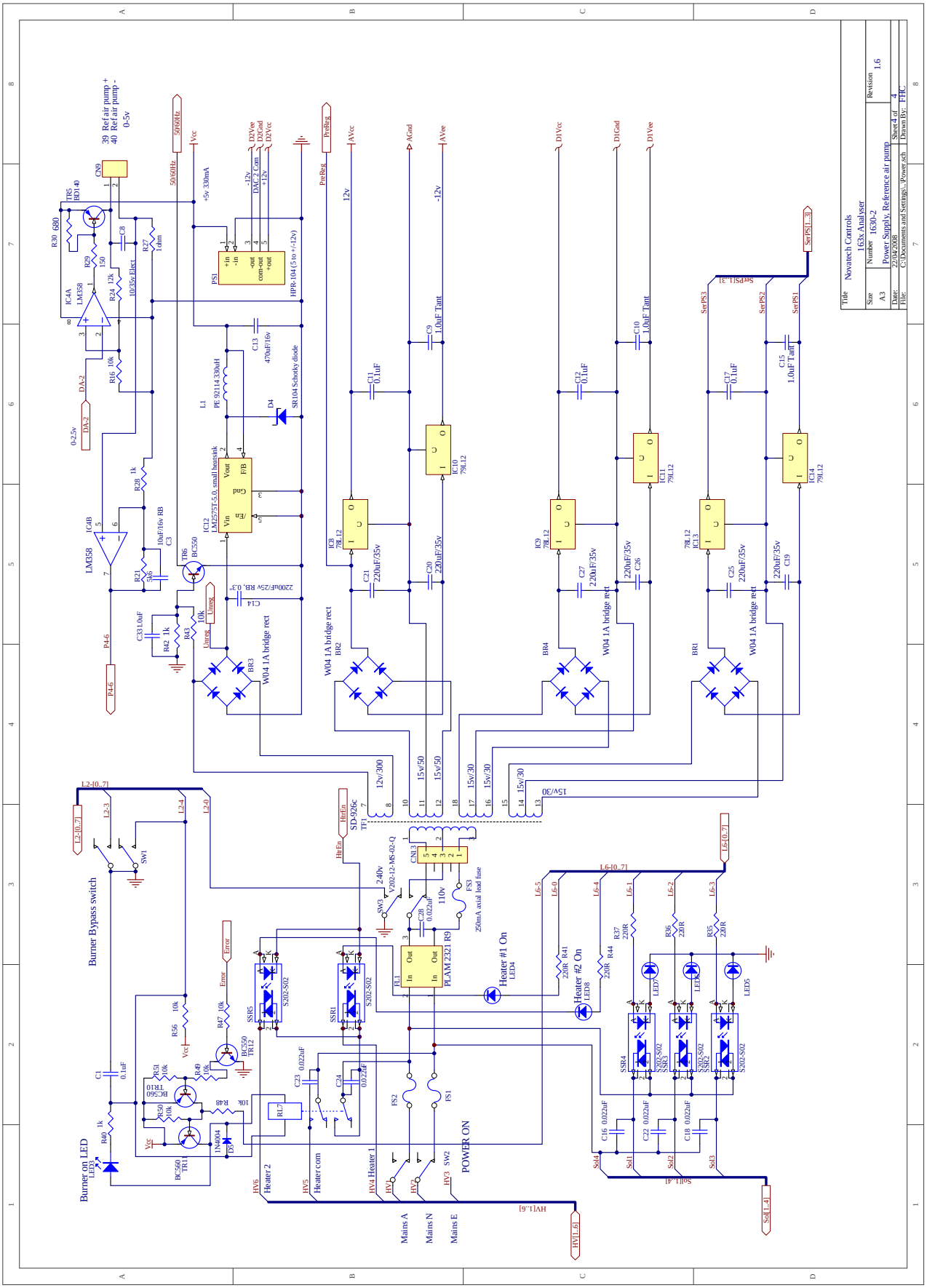

Title
Novatech Controls
163x Analyser
Size
A3
Number
1630-1
Revision
1.6
Date:
22/04/2008
Sheet 2 of 4
File:
C:\Documents and Settings\Ade.sch
Drawn By:
FHC
2.5v
Probe analog inputs
CN5
CN4
40 PIN box header
CO2 signal + (1637)
CO2 signal - (1637)
O2 sensor #2-
O2 sensor #2+
O2 sensor #1+
O2 sensor #1-
Probe TC +
Probe TC -
Aux TC / Sen TC #2 +
Aux TC / Sen TC #2 -
CJ Ambient sensor
Heater interlock
Analog ground
+12v analog power
Trim fb pot
Burner fb pot
CO2 i/p (1637) +
CO2 i/p(1637) -
Cal 4-20mA signal
Heater drive enable
DAC-PS reference regulator
50/60 mains freq
Rear head / RGC TC +
Rear head / RGC TC -
Channel #1 +p's
Channel #1 signal
Channel #1 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
Watchdog relay drive
Serial data clock (Ser5)
RS-232 Rx (Ser1)
RS-232 Tx (Ser2)
RS-485 + (Ser3)
RS-485 - (Ser4)
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

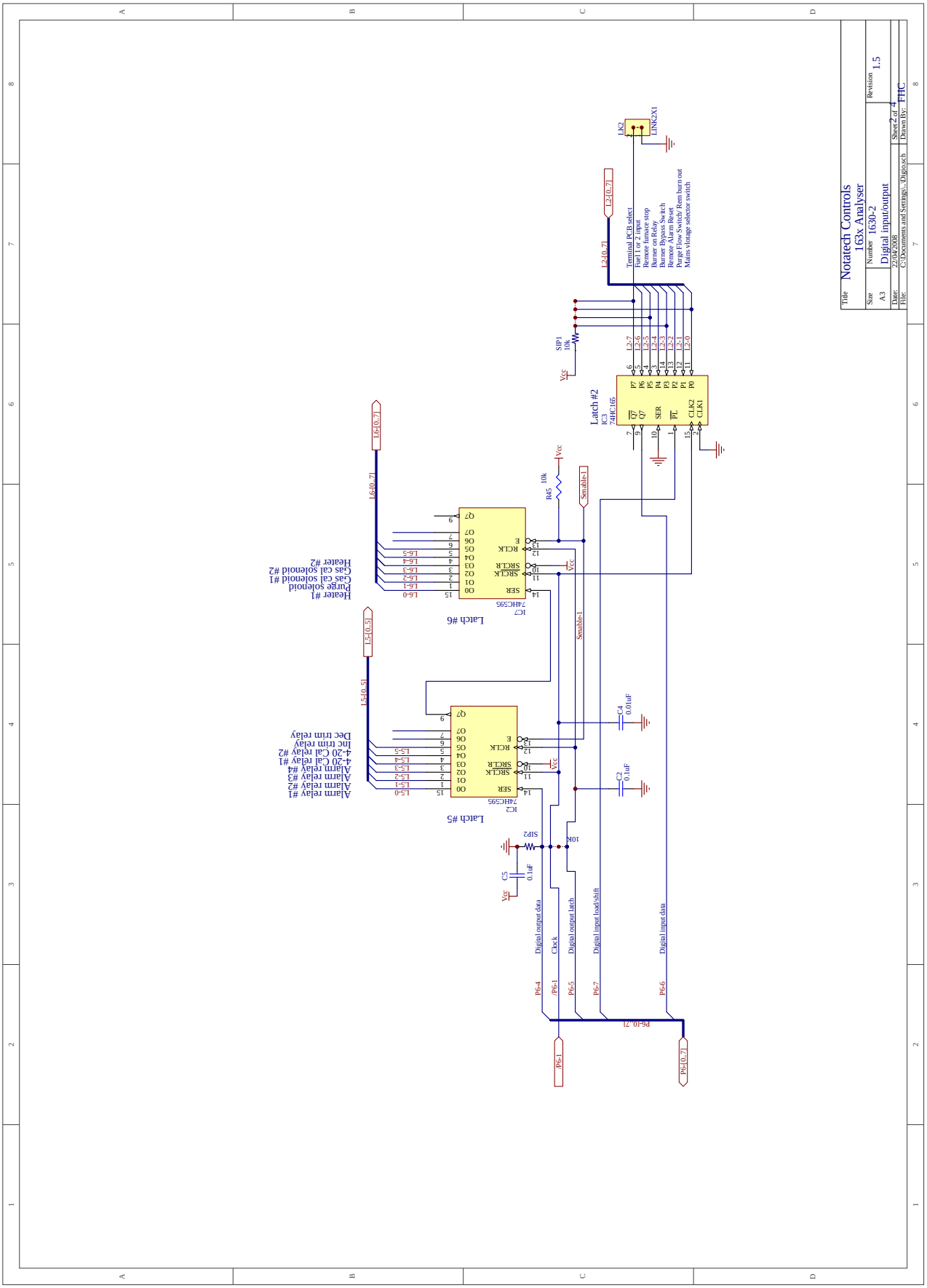

Unreg +12v
+5v
Dig com
Dig com
Signal +
Signal -
Analog com
Analog com
+12v
-12v
CN14
CN1
40 pin IDC crimpsolder
Burner Feedback Transducer
12v
Signal
Common
CN2
Sensor #2
HtrEn
PreReg
50/60Hz
Chn2Sig
D1Vcc
D1Gnd
D2Vcc
P4-6 D2Gnd
SerPS3
SerPS1
SVcc
SVee
SerPS2
AVcc
P6-4
P6-5
P6-6
P6-7
Title
Novatech Controls
163x Analyser
Size
A3
Number
1630-2
Revision
1.5
Date:
27/04/2008
Sheet 1 of 4
File:
C:\Documents and Settings\..163x-2.pcb
Drawn By:
FHC
4-20mA DRIVERS
4-20DRV.SCH
OutputChn1+
OutputChn1-
OutputChn2+
OutputChn2-
4-20CalSig+
4-20CalSig-
ChnFSig
Chn2Sig
SerPS[1..3]
L5-[0..5]
DIGITAL LATCHES
DIGIO.SCH
Senable-1
/P6-1
P6-[0..7]
L2-[0..3]
L5-[0..5]
L6-[0..7]
POWER SUPPLY
POWER.SCH
Sol1
Sol2
Sol3
Sol4
HV1
HV2
HV4
HV5
HV6
0.022uF/240V
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
Size A3
Date: 27/04/2008
Sheet 3 of 4
Drawn By: FHC
File: C:\Documents and Settings\...\4-20drv.sch1
D1Vcc
D1Gnd
D2Vcc
D2Gnd
Ch#1 sig
Ch#2 sig
Ch#1 +12
Ch#1 com
Ch#2 +12
Ch#2 Com
IC6A
IC6B
IC5A
IC5B
LM358
TR1 BD139
TR2 BD139
R4 1M
R2 1M
R39 220K
R23 220K
R20 220K
R19 100R
R33 220K
R22 220K
R18 220K
R17 100R
R25 220K
0.1uF C7
0.1uF C6
Ch#1 -12
Ch#2 -12
D1Vee
D2Vee
LED2 3mm LED
LED1 3mm LED
RL4
RL3
FBR-4D3/0SP
R4 47R
OutputCh#2-
L5-4
L5-5
L5-[0..7]
4-20CalSig
4-20CalSig-
OutputCh#1+
OutputCh#1-
OutputCh#2+
OutputCh#2-
Ch#1Sig
Ch#2Sig


Novatech Controls
163x Analyser
Number 1630-1
Serial interface and D/A converters
Revision 1.6
Size A3
Date 27/04/2008
File C:\Documents and Settings\...\Docs.sch
Sheet 3 of 4
Drawn By: FHC
CN1
CON-10
IC1 MAX536
IC2 LM336M-2.5
IC3 LM340L-05
IC4 LM340L-05
IC5 SP485CS
IC6 74HC14
IC7 LM336M-2.5
IC10 74HC04
IC37 LTC1257
IC8A LM1458
IC8B LM1458
TR1 BC817
D1 BAV99
LED1
LED2
LK2 LINK-2
LK3 RS-485 RS-232
OP1 PC-400
OP2 PC-400
OP3 PC-400
OP4 PC-400
OP5 PC-400
OP6 PC-400
OP7 PC-400
RS-232 Rx
RS-232 Tx
Network -
Network +
Serial port common
RS-232 Conn
+12 Isolated
RS-485 Dir.
RS-232 Rx
RS-232 Tx
Net -
Net +
Ser-1..5
DAC-PS-0..5
PWM output
DAC data
DAC cs
Clock
P3-0..7
P6-0..7
SVcc
SVee
SGnd
Vcc
Gnd


Novatech Controls
163x Analyser
Number 1630-1
Revision 1.6
Micropocessor, display and keyboard
Sheet 4 of 4
Drawn By: FHC
Cold start Link
Keyboard Lock
Power/reset LED
External Keypad/LED's
Latch 1
Latch 4
W/dog
Reset
Alarm
Setup
Neutral
Error


Novatech Controls
163x Analyser
Number 1630-2
Power Supply, Reference air pump
Revision 1.6
Size A3
Date 27/04/2008
Sheet 4 of 4
File C:\Documents and Settings...\Power.sch
Drawn By: TFHC
Burner Bypass switch
Burner on LED
Heater #1 On
Heater #2 On
POWER ON
Mains A
Mains N
Mains E
W04 1A bridge rect
LM358
PLAM 2321 R9
SD-926c
LM2575T-5.0, small heatsink
HPR-104 (5 to +/-12v)
39 Ref air pump +
40 Ref air pump -
0-5v
0-2.5v
+5v 330mA
12v
-12v
15v/30
240v
110v
250mA axial lead fuse


Notatech Controls
163x Analyser
Title
Size
A3
Number 1630-2
Digital input/output
Revision 1.5
Date: 22/04/2008
Sheet 2 of 4
File: C:\Documents and Settings...\Digital.sch
Drawn By: FHC
LK2
LINK2X1
L2[0..7]
Terminal BCB select
Feel 1 or 2 input
Remote furnace stop
Burner on Relay
Burner Bypass Switch
Remote Alarm Reset
Burner Test Switch
Remote burn out
Mains vlotage selector switch
SIP1
10k
Vcc
Latch #2
IC3
74HC165
L6[0..7]
Latch #6
IC7
74HC595
R45
10k
Sensible-1
Heater #1
Purge solenoid
Gas cal solenoid #1
Gas cal solenoid #2
Heater #2
L5[0..5]
Latch #5
IC2
74HC595
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
SIP2
10K
C5
0.1uF
C4
0.01uF
C2
0.1uF
Digital output data
Clock
Digital output latch
Digital input load/shift
Digital input data
P6-4
/P6-1
P6-5
P6-7
P6-6
P6-[0..7]
/P6-1

# APPENDIX 6

## MODBUS™ REGISTER MAP AND APPLICATION NOTES

Modbus Functions Supported are:-

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

*Introduction.*

The 1633 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 position LK3 on the 1630-1 PCB 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 set point.

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, OXYGEN1, which is at address 4104 is interpreted as follows.
4104 contains the low 16 bits for probe oxygen
4106 contains the high 16 bits for probe oxygen

| Read / Write Configuration Variables* | | | | |
|---|---|---|---|---|
| **Reg** | **Description** | **Type** | **Valid Range** | **Comments** |
| 714 | Probe Offset | SINT16 | ± 60 | ÷ 10 (mV) |
| 717 | Temperature Display Units | FLAG | [0,1] | 0 - Celsius 1 - Fahrenheit |
| 730 | Number of Fuels | FLAG | [0,1] | 0 - Single 1 - Dual |
| 732 | Fuel 1 A Value | UINT16 | [0,30000] | ÷ 100 |
| 733 | Fuel 1 H Value | UINT16 | [0,1000] | ÷ 100 |
| 734 | Fuel 1 O Value | UINT16 | [0,500] | ÷ 100 |
| 735 | Fuel 1 N Value | UINT16 | [0,500] | ÷ 100 |
| 736 | Fuel 1 S Value | UINT16 | [0,100] | ÷ 100 |
| 737 | Fuel 1 M Value | UINT16 | [0,100] | ÷ 100 |
| 739 | Fuel 2 A Value | UINT16 | [0,30000] | ÷ 100 |
| 740 | Fuel 2 H Value | UINT16 | [0,1000] | ÷ 100 |
| 741 | Fuel 2 O Value | UINT16 | [0,500] | ÷ 100 |
| 742 | Fuel 2 N Value | UINT16 | [0,500] | ÷ 100 |
| 743 | Fuel 2 S Value | UINT16 | [0,100] | ÷ 100 |
| 744 | Fuel 2 M Value | UINT16 | [0,100] | ÷ 100 |
| 745 | Auto Purge/Cal Enable | FLAG | [0,2] | 0 - Disabled 1 - Auto Purge 2 - Auto Cal |
| 750 | Cal Gas Content | UINT16 | [0,210] | ÷ 10 (% Oxygen) |
| 756 | High Oxygen Process Alarm Trigger | UINT16 | [1,300] | ÷ 10 (% Oxygen) |
| 757 | High Oxygen Process Alarm Delay | UINT16 | [1,900] | Seconds |
| 758 | Low Oxygen Process Alarm Trigger | UINT16 | [1,300] | ÷ 10 (% Oxygen) |
| 759 | Low Oxygen Process Alarm Delay | UINT16 | [1,900] | Seconds |
| 760 | Very Low Oxygen Process Alarm Trigger | UINT16 | [1,300] | ÷ 100 (% Oxygen) |
| 761 | Very Low Oxygen Process Alarm Delay | UINT16 | [1,900] | Seconds |
| 762 | Oxygen Deviation Process Alarm Trigger | UINT16 | [1,300] | ÷ 10 (% Oxygen) |
| 763 | Oxygen Deviation Process Alarm Delay | UINT16 | [1,900] | Seconds |
| 764 | Reference Air Pump | FLAG | [0,2] | 0 - Internal 1 - External 2 - Instrument Air |
| 766 | Process Alarms Enabled | FLAG | [0,1] | 0 - Disabled 1 - Enabled |
| 768 | Oxygen Damping Factor | UINT16 | [0,20] | (Readings Averaged) |
| 775 | Instrument Air Relative Humidity | UINT16 | [0,100] | % Relative Humidity |
| 784 | Alarm Relay Configuration Matrix | *see notes* | | Analyser Relay Status |
| | | | | |

* To write values to non-volatile memory which will be retained after reset use the special modbus command $42 (write non-volatile register) command instead of the $06 (write holding register) command

| Read Only Runtime Variables | | | | |
|---|---|---|---|---|
| **Reg** | **Description** | **Type** | | **Comments** |
| 2048 | Probe EMF | F16x2 | | |
| 2052 | Oxygen % | F16x2 | | |
| 2062 | Probe Temperature | F16x2 | | |
| 2066 | Probe Impedance | F16x2 | | Value of -1 indicates Impedance Invalid / Unread |
| 2068 | Air Deficiency | F16x2 | | |
| 2076 | Excess Fuel Value | F16x2 | | |
| 2078 | Combustibles % | F16x2 | | |
| 2080 | Burner Efficiency | F16x2 | | |
| 2084 | Burner Fire Rate | UINT16 | | |
| 2085 | Trim Actuator Pot | UINT16 | | |
| 2094 | Auxilliary Temperature | F16x2 | | |
| 2100 | Ambient Temperature | F16x2 | | |
| 2102 | Humidity | F16x2 | | |
| 2214 | Alarm Status Matrix | *see notes* | | |
| | | | | |
| **Types of Variables** | | | | **Alarm Relay Configuration & Alarm Status Matrix** |
| | | | | 30 x 8bit registers in an array (15 holding registers) |
| UINT16 | 16bit Unsigned Integer | | | - Each register holds 2 x 8bit configuration/status flags for 2 consecutive alarms |
| SINT16 | 16bit Signed Inteter | | | |
| FLAG | 16bit Status Integer, refer to register comments | | | |
| | | | | |
| F16x2 | Floating Point value stored as 2 x 16bit Signed Integers | | | Alarm Relay Configuration Matrix |
| | To obtain the correct floating point value: | | | - The first 4 bits of each configuration flag correspond to the 4 alarm relays and their status regarding that indexed alarm |
| | - let the first 16bit signed integer be the the base B | | | |
| | - let the second 16bit signed integer be the decimal offset D | | | - eg. If bit 3 of the 4th byte in the matrix is set then alarm relay 3 is de-energised when alarm 4 (BBRAM Error) triggers |
| | - the floating point value V = B x 10 ^ D | | | |
| | | | | |
| | | | | Alarm Status Matrix |
| | | | | - Each alarm has a status flag containing a value 0-4: |
| | | | | 0,1 - alarm clear |
| | | | | 2 - alarm active |
| | | | | 3 - alarm accepted |
| | | | | 4 - alarm self cleared (state cleared, awaiting user acknowledgement) |

| List of Alarms in Alarm Matrix | | | | |
|---|---|---|---|---|
| **Index** | **Description** | | **Index** | **Description** |
| 0 | Sensor Fail (High Impedance) | | 15 | ADC Calibration Fail |
| 1 | Heater Fail | | 16 | Burner Bypass Enabled |
| 2 | Probe Thermocouple Open/Ct | | 17 | Neutral Trim |
| 3 | Probe Filter Blocked | | 18 | Reference Air Fail |
| 4 | BBRAM Error | | 19 | Auxiliary TC Open/Ct |
| 5 | Reference Air Pump Fail | | 20 | Probe Calibration Error |
| 6 | ADC Warning | | 21 | DAC Calibration Fail |
| 7 | Mains Frequency Error | | 22 | - |
| 8 | Oxygen% Low (Process Alarm) | | 23 | - |
| 9 | DAC Warning | | 24 | Probe Temperature Low (Status Only) |
| 10 | Oxygen% Very Low (Process Alarm) | | 25 | - |
| 11 | Oxygen% High (Process Alarm) | | 26 | Purge in Progress (Status Only) |
| 12 | - | | 27 | Cal in Progress (Status Only) |
| 13 | Oxygen% Deviation (Process Alarm) | | 28 | - |
| 14 | Gas Calibration Error | | 29 | Alarm Horn (Relay 3 Only) |

# APPENDIX 7

## COMMISSIONING A 1633 COMBUSTION CONTROLLER ON A TYPICAL BOILER

Section
Number

**WARNING:**

It must be recognised that there are extreme risks involved in altering the controls of a boiler. Any work suggested in this document must be carried out by qualified boiler personnel. No responsibility can be taken by Novatech Controls for any damage that may arise from errors in this document.

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

## 7.1.0 INTRODUCTION

This section describes the way in which the Novatech Controls 1633 combustion controller can be installed on an industrial boiler to monitor and control the excess oxygen level. It gives a detailed procedure to allow a qualified boiler operator to totally commission a system.

There are two ways of trimming the air fuel ratio of a boiler.

1. Trim the air damper.
2. Trim the fuel supply.

Usually the option of trimming the air damper is more practical.
Alternatively, a bypass line may be installed around the main fuel control valve and can be trimmed instead of the air damper.

**Notes:**
1. This appendix does not contain a full description of the 1633 combustion controller, and must be used in conjunction with the details provided in the other chapters of this 1633 manual.

2. The following example description will refer to an installation on a gas fired boiler where the main gas valve is controlled by a modulating motor for steam demand, and the model 1633 combustion controller will trim the air damper to maintain the required oxygen level. The principles will be the same for other installations, however some of the mechanical details may differ from this description.

## 7.2.0 GLOSSARY OF TERMS

**Alarm button**
The alarm button is on the front door keypad. Pressing this button can be used to respond to the alarm light, and show the alarm messages on the display.

**Auto Trim mode**
The analyser will use the oxygen set point value to control the trim actuator, if the analyser is also in AUTO mode. It is enabled / disabled by pressing the NEUTRAL button on the front door keypad. The NEUTRAL light will indicate the current status.

**Cold start**
The COLD-START link must be removed to start either of the following two cold start procedure.
When a cold start is instigated, all of the menu items are replaced by default values. These items include the four calibration reference voltages. The factory default values however will provide *display* accuracy of about 4% of the true oxygen reading. Some other factory default menu items may be changed that will drastically effect the 4-20mA outputs or the control and alarm operations.
The characterisation table values will only be reset to the factory defaults if the FUNCTION DOWN and the AUTOCAL buttons are pressed as the power is turned on.
See section 6.1 of the 1633 manual for full details.

**DB, Dead band**
The DB is set in set-up #70 for the selected POINT of the characterisation table. The larger the value entered, the larger the deviation from the set point the measured oxygen value will be allowed to go before any corrective action will be taken by the analyser. See section 5.5.70 of the 1633 manual.

**Display button**
The display button is on the front door keypad. Pressing this button will cause the lower line of the display to scroll through the lower line list available in set-up #29.

**Dual fuel**
The analyser is capable of storing the control parameters for two fuels. Switch between the two fuels by using voltage free contacts on terminals 30 & 31 of the terminal circuit board. An open circuit input selects fuel 1 and allows editing of the variables.

**Inc / Dec lights**
These lamps operate in parallel with the relays that drive the motor inc. and motor dec. output terminals 43 / 44 & 45 / 46, which in turn **Inc**rement or **Dec**rement the trim actuator.

**F% display**
This is the burner firing rate level. See SP% and F% display.

**Linear actuator extension length limit switch**
The linear actuator is used within the range of fully withdrawn to about 20mm extended. There is an internal power limit switch which will stop the motor from extending if the limit switch length is reached.

**Manual trim mode**
The outputs of the analyser are disabled (will not drive the trim actuator automatically). The only way that the actuator may be moved in this mode is to use the TRIM up and TRIM down buttons. The flashing 'A' or 'M' in the top right hand corner of the display will show the current status as either **A**utomatic or **M**anual trim modes.

**Neutral mode**
The analyser will use the neutral position value from the set-up menu item #68 to control the linear actuator (the analyser must also be in the AUTO mode). It is enabled / disabled by pressing the NEUTRAL button on the front door keypad. The NEUTRAL light will indicate the current status.

**Pegs**
Usually the boiler has a set of individual points at which the mechanical air / fuel characteriser are adjusted. Each of these adjusters are known as pegs. They provide convenient points at which to set the electronic characterisation points in the analyser.

**Point**
Values of oxygen, and neutral actuator positions are entered into the characterisation table at up to ten levels of firing rate. These levels are called points. Often they will correspond to 10 of the PEGS.

**Run / Setup mode button**
This is the button on the keypad that toggles between the RUN mode and SETUP mode. The SETUP light will be on when the analyser is in SETUP mode.

**SP% and F% display**
It is possible to display the current oxygen set point and the current firing rate as a percentage on the lower line of the display. Use the display button to scroll through the items on the lower line until the required item is found. See section 5.5.29 of the 1633 manual for full details.

**Trim Characterisation Table**
Appendix 8 of the 1633 manual provides a characterisation table for use by the commissioning engineer to record the values of oxygen, neutral position, PB and DB.

**Trim up and Trim down buttons**
The two buttons on the keypad that are used to manually move the trim actuator in and out. They will only operate in MANUAL trim mode, and when the TRIM button is also pressed at the same time as either the TRIM-UP or TRIM-DOWN button is also pressed.

**PB, Proportional band**
The PB is set in set-up #69 for the selected POINT of the characterisation table. The larger the value entered, the less active the correction control taken by the analyser. Also, the larger the number entered, the slower the oxygen level will be returned to the set point. See section 5.5.69 of the 1633 manual.

## 7.3.0 INSTALLATION

### 7.3.1 THE OXYGEN PROBE

The oxygen sensor will not operate at less than 650°C. Novatech Controls manufactures both heated and unheated probes. Heated probes can reach the operating temperature within ten minutes.
Unheated probes are usually installed in the rear of the firing chamber, where the atmosphere temperature is above 650°C in most firing conditions.
The 1633 combustion controller inhibits the trim mode automatically when the probe temperature is below 650 °C.
Dead pockets of flue gas can sometimes be found after corners in the flue. As a general rule, do not install the oxygen probe within one and a half meters of a corner in the flue.

### 7.3.2 THE TRIM ACTUATOR

The connecting linkage between the fuel and the air setting valves must be changed to allow trim of the air damper.
Check that the length of the rod is shortest when the flame is fuel rich. This is required so that in the event of failure of the analyser or the limit switch in the linear actuator, the boiler is physically limited to a safe fuel rich level.
Measure the distance between the ball joints of the linkage rod connecting the fuel valve to the air damper. Build a new linkage using new ball joints, and including the linear actuator in the rod. The length of the new rod should be 12mm shorter than the original rod, when the linear actuator is fully withdrawn. The travel of the linear actuator will later be adjusted to give typically 50mm of trim.

### 7.3.3 THE BURNER FEEDBACK TRANSMITTER

The 1633 combustion controller is capable of controlling the boiler to an oxygen level that is characterised to the burner firing rate, if so desired. This is selected in the set-up menu, #58 from the options -

- Characterised set point
- Local fixed set point
- Remote 4-20mA set point.

If a characterised set point is not required, the burner feedback transmitter is not necessary.
Select a linkage arm or rod whose movement is directly proportional to the level of firing rate of the boiler. Mount the transmitter in a position that will allow the linkage arm of the transmitter to be coupled to the boiler firing rate linkage. Do not couple the transmitter to the boiler linkage at a point where the trim actuator installed in appendix 7.3.2, will also affect the movement of the firing rate transmitter.
Select the length of the arm of the transmitter so that the when boiler swings through low fire to high fire, the transmitter pointer moves through an angle not into the red area of transmitter label.
To determine the direction of movement of the transmitter, use a voltmeter between the COM and W terminals of the transmitter. The output of the transmitter is between 1 and 5 volts. It should be set up so that the output is low at low fire, and high at high fire.
When the boiler moves the transmitter to the low fire end of its travel, the voltage should be less than 1volt. If it is more than 4 volts, reverse the action with the switch inside the BFT-20 transmitter.
Refer to the 1633 manual section 4.1 for details of how to set the display to read the firing rate as a percentage on the display.
The analyser is designed to use the BFT-20 burner feedback transmitter. However, the link on the circuit board just above CN6 (BFT connector) can be re-soldered to allow a 5 VDC supply to be available at CN6. This will then allow a potentiometer or other such device to be used instead of the BFT-20.

**NOTE:** The burner feedback transmitter model BFT-20, is available from Novatech Controls.

## 7.4.0 SETTING THE WORST CASE FUEL-RICH LEVEL

The trim system must not be able to set the air / fuel ratio to a dangerously fuel rich level. This is accomplished by setting the trim actuator to the fully retracted position (shortest linkage length), and adjusting the air / fuel characterising screws (or pegs) on the boiler so that the carbon monoxide level does not exceed 300 ppm over the full range of boiler firing rate.

**NOTE:**
Check that the length of the rod is shortest when the flame is fuel rich. This is required so that in the event of failure of the analyser or the limit switch in the linear actuator, the boiler is physically limited to a safe fuel rich level.

Set the 1633 combustion controller to NEUTRAL and MANUAL trim mode by using the NEUTRAL and AUTO / MAN buttons on the analyser's keyboard. Use the TRIM up and TRIM down buttons to set the trim actuator to the fully withdrawn position.

Manually set the boiler to low fire.

Using a portable CO monitor, adjust the burner low fire set screw to achieve a CO level of less than 300 PPM, or just before the CO level starts to rise when adjusted in the fuel rich direction.

Repeat this adjustment for each of the burner adjusting screws (or PEGS) on the mechanical combustion air characteriser. Note the values of CO at all the pegs on the trim characterisation table and enter them in the trim characterisation table provided in appendix 8 of the 1633 manual.

## 7.5.0 SELECTING THE TRIM ACTUATOR SPAN

With the 1633 combustion controller in NEUTRAL / MANUAL trim modes.
Set the boiler to 75% of full fire.
Adjust the oxygen excess level by using the TRIM up and down buttons to alter linear actuator length. The oxygen should be set to the worst case oxygen excess level required. The linear actuator should not be required to extend more than 50 mm.
**NOTE:** The TRIM up button should move the linear actuator out, and the TRIM down button should move the actuator in. If these directions are reversed, swap the wires in terminals 43 / 44 & 45 / 46 (MOTOR INC & MOTOR DEC) on the terminal circuit board.
**NOTE:** If the actuator will not go out as far as required, adjust the extension limit switch, and try the trim up button again.
Run the boiler through the full low to high fire range, stopping at about 10 positions through the range (or at each of the PEGs), and check the oxygen level as read on the 1633 combustion controller. Note the levels on trim characterisation table for each of the positions. Mark the PEG at which the oxygen level is highest.
The oxygen level at this peg positions should be adjusted, using the TRIM up and down buttons, to the level desired to be the maximum ever expected in the boiler (taking into account the atmospheric conditions at the time of setting). The level can be changed using the TRIM up and TRIM down buttons.
Once satisfied that this maximum oxygen level on this peg is correct, run through the low to high fire range again, noting the oxygen values on the trim characterisation table. Also note the extension length of the actuator on the trim characterisation table.

## 7.6.0 MAXIMUM EXTENSION LIMIT SWITCH

**IMPORTANT:**
**It is essential that this procedure is carried out accurately. Failure to do so may result in unrestricted control of the air fuel ratio.**

Limit the maximum span of the of the trim actuator by adjusting the extension length limit switch in the actuator. Clockwise adjusts for a longer extension, and vice versa.

1. Use the trim up and down buttons to set the actuator to a short length.
2. Test the limit switch position by using the trim button to find the limit switch cut out position. The actuator will simply stop going out when it has hit the limit switch.
3. Measure and note the extension length of the actuator shaft.
4. Use the TRIM up and down buttons to reduce the extension length by 10mm.
5. Adjust the limit switch clockwise to extend the actuator or counter clockwise to reduce the stroke, as required.
6. Repeat steps 2 to 5 until the maximum actuator length is set by the limit switch.

## 7.7.0 SET THE OXYGEN TRIM LEVEL AND THE NEUTRAL TRIM POSITION

Now that the air / fuel ratio range has been set in appendix 7.7.4 and 7.7.5, two other characterised levels can be set-

1. The oxygen trim position is the oxygen value that the 1633 combustion controller will set when in the trim mode.
2. The neutral trim position is the linkage length that the 1633 combustion controller will set when in the neutral, or no-trim mode.

The 1633 combustion controller has been designed to maintain a pre-determined oxygen level in the boiler. The actual level that it will control to, must be determined by the judgement of the boiler operator / installer. The level may be characterised to the firing rate if a burner firing rate transmitter is installed. Once the level has been determined at a few points through the firing range, the analyser will determine all the in between points automatically.

**Local fixed set point**
If the boiler is required to run at only one level of excess oxygen over the entire firing range, use the set-up #59 (O2% Set Point), LOCAL FIXED option, and the MAINTENANCE #16 (Local Set Point), to set the oxygen value. A burner firing rate transmitter is not necessary in this mode.

**Characterised oxygen set point**
If the boiler is required to run at different oxygen levels, based on the firing rate, a burner firing rate transmitter must be installed.

Use these steps to enter the values of oxygen and neutral trim position into the analyser memory for trim characterisation at each of the PEGs.

7.7.1 Switch the analyser to RUN mode, and NEUTRAL / MANUAL trim control modes.

7.7.2 Select SETUP mode, set-up 64 (CHARACTERISED entry method), and select ACTUAL. In this mode, the ACTUAL values of oxygen and actuator linkage position will be automatically entered into the characterisation table.

7.7.3 Select the RUN mode. Use the DISPLAY button to select the SP% and F% (set point oxygen value and firing rate percentage) on the lower line.

7.7.4 Set the boiler manually to low fire.
The lower line of the analyser should now show F% 0 (low fire).

7.7.5 Use the TRIM up and TRIM down buttons to set the air / fuel ratio to the judged oxygen value, based on flame colour, firing rate, fuel mixture and flue smoke colour. When the flame is correct, return to the SETUP mode.

7.7.6 Step the FUNCTION up to set-up #65 (ENTER POINT #), and select the next point.

7.7.7. Step the FUNCTION up to set-up #66 (O2% #1 FUEL 1). The lower line will show the current ACTUAL firing rate and value of oxygen. Press ENTER. An asterisk (*) will appear at the bottom right end of the display when the entered oxygen value is measured (if measured oxygen varies from the value that was current when the ENTER button was pressed, the asterisk will disappear). To change the value of oxygen set point for this PEG, simply press ENTER while the new oxygen value is displayed.

7.7.8 The NEUTRAL trim position is set to a trim actuator length that generates an oxygen level one to two percent higher than the trim oxygen level. Return the analyser to the RUN mode, and use the TRIM up and TRIM down buttons to generate the oxygen level required for the NEUTRAL trim position.

7.7.9 Return to the SETUP mode, and advance to set-up 67 (NTL #1 FUEL 1), and press the ENTER button. The asterisk will appear to show this ACTUAL trim actuator position has been entered for the NEUTRAL trim position.

7.7.10 As each of the PEGs, and therefore the POINT numbers, are entered into the memory make a note of the values in the copy of the trim characterisation table from the 1633 manual.

7.7.11 Repeat the steps 7.7.4 to 7.7.10 for each of the PEGs (and the corresponding point number in the characterisation table in the analyser memory) in 7.7.6

7.7.12 Run the boiler to different PEGs and observe the flame. If the values need to be changed now, it is easier and more accurate to enter the changes in MANUAL entry mode. Select set-up 64, option MANUAL. Select set-up 65, and the POINT number to be changed. Use the FUNCTION buttons to step to the item to be changed.

7.7.13 Repeat these operations for the second fuel if dual fuels are to be used.

## 7.8.0 CHECK THE TRIM PID SETTINGS

The analyser has default settings of PROPORTIONAL BAND and DEAD BAND entered into the analyser memory when a COLD START (including the characterisation table initialisation) is performed on the analyser. These settings will be close to the appropriate value for optimum control. However, the parameters must be tested for stability of oxygen control at or near all of the PEGs.

7.8.1 Set the analyser into TRIM & AUTO modes using the NEUTRAL and AUTO / MAN buttons. Use the DISPLAY button to show the SP% and F% on the lower line.

7.8.2 Let the boiler stabilise under the analysers' control for a few minutes.

7.8.3 Introduce a step change of the oxygen level by going back to MANUAL trim mode, and using the TRIM up button. After pressing the TRIM up button for a few seconds, wait for the response on the oxygen display.

7.8.4 When the oxygen has changed by 0.5%, return to TRIM / AUTO mode, and watch the INC / DEC lights on the front panel and the 1633. Note if the INC / DEC lights alternate or if the oxygen overshoots the set point.

7.8.5 If the oxygen overshoots the set point significantly, change the PB at this PEG (or on both POINTS or PEGs on either side of the current firing rate) to a larger value. A good initial change of the PB is to double the value. If the PB is made too wide, the time for the boiler to recover from a step change will be increased. If no overshoot is shown, narrow the PB, and test the response to a step change again.

7.8.6 If while watching the response the step change, and waiting for the boiler to re-stabilise, the INC / DEC lights alternate back and forth, widen the PB by doubling the number for the PB at this PEG (or on both POINTS or PEGs on either side of the current firing rate) to a larger value.

7.8.7 Re-test the step response at each of the PEGs until the best response is obtained.

## 7.9.0 CHARACTERISATION TABLE PRINT OUT

The 1633 combustion controller has the facility to print the boiler characterisation table that has been entered. A printer (or computer) with a serial interface can be connected to the serial port on the analyser (see section 3.14, Connecting The Printer, of the 1633 manual).
When the boiler has been totally commissioned, switch the mode switch to SETUP, and use the function buttons to go to set-up 72, Print Characterisation Table. If YES is selected, the 1633 will print the characterisation table.
If dual fuels are being used, the table for the next fuel can be printed by switching the contacts on terminals 14 & 15 to the next fuel, going back to set-up 72, and re-select YES.

# APPENDIX 8

## 1633 COMBUSTION CONTROLLER CHARACTERISATION TABLE

| | |
|---|---|
| Installation / Site: | |
| Date: | |
| FUEL # | |
| FUEL TYPE | |

| | 1633 Entry | | | | | | 1633 Entry | 1633 Entry | 1633 Entry | 1633 Entry |
|---|---|---|---|---|---|---|---|---|---|---|
| **TABLE #** | **PEG #** *Low Fire* | **% FIRE RATE** | **MAXIMUM CO (PPM)** | **MINIMUM $O_2$ %** | **MAXIMUM $O_2$ %** | **ACTUATOR LENGTH** | **TRIM $O_2$ %** | **NEUTRAL POSITION** | **PROP. BAND, % $O_2$** | **DEAD BAND, % $O_2$** |
| **1** | | | | | | | | | | |
| **2** | | | | | | | | | | |
| **3** | | | | | | | | | | |
| **4** | | | | | | | | | | |
| **5** | | | | | | | | | | |
| **6** | | | | | | | | | | |
| **7** | | | | | | | | | | |
| **8** | | | | | | | | | | |
| **9** | | | | | | | | | | |
| **10** | | | | | | | | | | |

*High Fire*

**ALARMS-**

| | LEVEL (%O2) | DELAY (Secs) |
|---|---|---|
| DEVIATION | | |
| LOW Oxygen | | |
| VERY LOW Oxygen | | |
| HIGH Oxygen | | |

# INDEX

## P



## R



## S



## T



## V



## W



## Z

# 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.