TECHNICAL MANUAL

TunnelTech 100 Series

TunnelTech 101

Visibility & Cold Smoke Detection

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CODEL International Ltd is a UK company based in the heart of the Peak District National Park at Bakewell, Derbyshire. The company specialises in the design and manufacture of high-technology instrumentation for the monitoring of combustion processes and atmospheric pollutant emissions.

The constant search for new products and existing product improvement keeps CODEL one step ahead. With a simple strategy, to design well-engineered, rugged, reliable equipment, capable of continuous operation over long periods with minimal maintenance, CODEL has set standards both for itself and for the rest of the industry.

All development and design work is carried out 'in-house' by experienced engineers using proven state-of-the-art CAD and software development techniques, while stringent assembly and test procedures ensure that the highest standards of product quality, synonymous with the CODEL name, are maintained.

High priority is placed upon customer support. CODEL's dedicated team of field and service engineers will assist with any application problem to ensure that the best possible use is derived from investment in CODEL quality products.

If you require any further information about CODEL or its products, please contact us using one of the numbers below or alternatively visit our web site.

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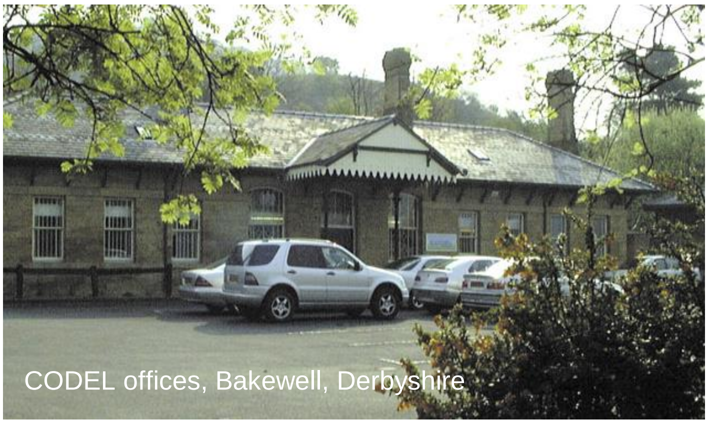
CODEL offices, Bakewell, Derbyshire

Over the past 15 years CODEL tunnel sensors have been supplied to more than 400 road and rail tunnels throughout the world. Our impressive reference list includes Eurotunnel (France), Mont Blanc Tunnel (France), Dartford Tunnel (UK), Lane Cove Tunnel (Australia), Snow Mountain Tunnel (Taiwan) and the SMART Tunnel in Malaysia, plus many others throughout China, Italy, Switzerland and South Korea placing CODEL as a world leader in tunnel atmosphere monitoring.

CODEL's tunnel sensor range is further extended by additional sensors for the measurement of CO, NO, Visibility and Wind Speed and Direction.

Additional product data sheets: TunnelTech 200 Series Air Quality Monitors for the Measurement of Carbon Monoxide, Nitric Oxide & Visibility & TunnelTech 300 Series Air Flow Monitor for the Measurement of Wind Speed & Direction, are available to download from our web site: www.codel.co.uk.

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Contents

IMPORTANT

The warning signs (and meanings) shown below, are used throughout these instructions and are intended to ensure your safety while carrying out installation, operation and maintenance procedures. Please read these instructions fully before proceeding.

Caution, risk of electric shock.

Caution, risk of danger.

Caution, hot surface.

Earth (ground) terminal.

Protective conductor terminal

1. System Description

1.1. TunnelTech 101 – Visibility measurement and Cold Smoke Detection

The TunnelTech 101 system shown in Figure 1 uses visible light channels to measure visibility. The system consists of a transmitter and receiver, the transmitter projects a visible beam to a detector unit mounted 6m away in the receiver. The specific absorption at the light transmitted over the 6m path is measured to determine the visibility dimming coefficient within the path of the beam. A high-powered modulated LED is used for the visible light source.

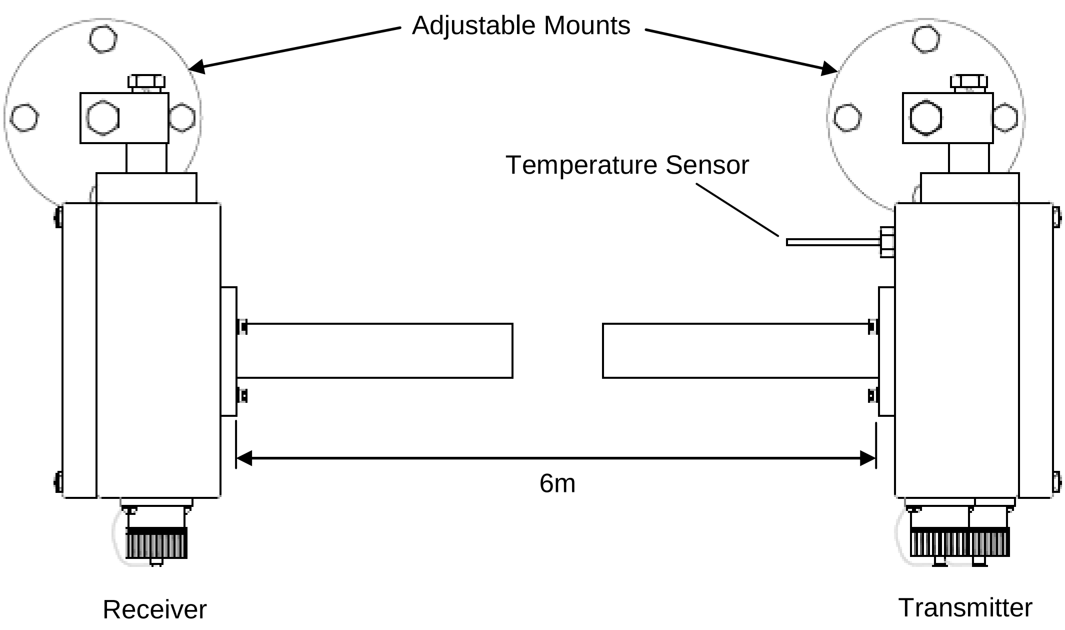


Figure 1: TunnelTech 101 – air quality monitor for visibility measurement and cold smoke detection.

1.2. Measurement Elements

The visibility sensor produces a beam of light from a pulsed LED focused by a lens to a receiver unit mounted 6m away. An internal detector within the transmitter monitors the brightness of the emitted pulses of light. The transmitted beam is gathered by the receiver unit lens and focussed onto a receiving detector. The ratio of signals from the two detectors provides the measurement of transmissivity.

1.3. LED Control

Operation of the emitting LED is controlled by the on-board processor. A continuous series of pulses is applied to the LED. Each pulse is less than 100µsec in duration. These very brief duration pulses enable the instrument to operate without interference from other light sources within the tunnel.

1.4. Detector Element

Two silicon detectors are utilised one to measure the initial brightness of the emitted light (Vis Tx), the other to measure the intensity of the received light (Vis Rx) after transmission to the receiver unit.

The processor takes a series of measurements immediately prior to 'pulsing' the emitter LED in order to monitor the inherent background levels of light intensity. Then a series of measurements is made while the LED is illuminated and again after the LED is switched to check that the background levels haven't changed. The high frequency at which this occurs provides the device with extremely high immunity from the effects of background lighting.

1.5. Diagnostic Data

Measurements of transmissivity and opacity are calculated from the two detector measurements. First the detector measurements are smoothed to improve signal to noise and calculations made as follows:

Transmissivity = (Set Cal Vis) Vis Rx/Vis Tx

Set Cal Vis is the calibration constant to set the measurement of transmissivity to 100% in a clear environment.

opacity = 100 – transmissivity %

Opacity is a direct reading of the attenuation of light. Zero opacity equates to a totally clean light path and 100% to total light attenuation.

In order to be able to resolve to a precision of 0.01%, opacity is redefined as:

opacity = 10000 – (Set Cal Vis) Vis Rx/Vis Tx

and to ensure a 'live' zero the opacity measurement is given an off-set of 2000. Thus:

opacity = 12000 – (Set Cal Vis) Vis Rx/Vis Tx

1.6. Calibration

It is normal for these instruments to be calibrated during a tunnel closure when it is expected that the opacity will be zero. The instrument can be calibrated by selecting a calibrate mode where, instead of calculating opacity using a fixed calibration factor, the instrument assumes an opacity value of zero and calculates the calibration factor required.

Set Cal Vis = 10000 x Vis Tx/Vis Rx

1.7. Auto Zero

The measurement of opacity is dependent upon the optical surfaces of the instrument remaining clean. If the surfaces of the instrument lenses become contaminated it will reduce the intensity of the received light and increase the opacity measured value. Over a period of time, it is normal to observe a slow build-up of optical contamination resulting in a steady increase in the measured opacity value. This appears as a persistent positive output drift.

There are two cures for this problem. One is to clean the optical surfaces on a regular basis. However, in a road tunnel regular access is not usually possible without a tunnel closure.

The second method is to automatically compensate for such a build-up of contamination. The technique used by TunnelTech 101 relies on the assumption that there will always be periods of low real opacity during the course of the day. These periods usually occur at night when traffic loading is low. These periods provide a reference condition for the measurement.

During normal operation, the effect of contamination is to slowly increase the measured value of opacity. To compensate for this the instrument is programmed to slowly reduce its measured value of opacity at a rate faster than that at which contamination would increase.

Over a period of time, this will result in the instrument reading slightly low. However, during the periods of zero opacity, this effect would cause the instrument to be displaying a negative opacity. Since negative opacity is an impossible value the negative offset can be quickly rectified and the calibration corrected.

In this way periods of zero opacity, whenever they occur, are utilised to correct the calibration of the measurement allowing long periods of operation without maintenance and the cleaning of optical lenses.

1.8. Temperature Measurement

The instrument is provided with a PT100 temperature sensor mounted on the transmitter unit, to enable a continuous measurement of air temperature

2. Principles of Operation

Visibility and Cold Smoke Detection both rely on the amount of light obscuration within the tunnel atmosphere being determined. This obscuration is quantified by determining the visibility coefficient. A visibility sensor is programmed to measure low levels of visibility coefficient and thus light obscuration experienced during normal tunnel operation. A Cold Smoke Detector is programmed to detect the high levels of visibility and light obscuration that would be produced by smoke emissions from a tunnel fire.

Both sensors use the same technology and principles at operation.

2.1. Visibility Coefficient

Visibility Dimming Coefficient (abbreviated to Dim K or Vis K)

Fine particles suspended in the atmosphere will scatter a beam of light so that the intensity of the beam reduces as it passes through the air. This reduction in visibility is directly proportional to the concentration of suspended dust particles.

The intensity of a beam of light follows the Lambert Beer law:

$$I = I_o e^{-KL}$$

where K is a parameter known as the visibility coefficient and is proportional to the concentration of the suspended particles and L is the path length of the beam.

I/I_o is the ratio of the measured beam intensity and that of the initial intensity I_o and is known as the transmissivity (T) of the system:

$$T = e^{-KL}$$

Thus visibility coefficient :

$$K = \frac{1}{L} \cdot \log_e \frac{1}{T}$$

where L = 6m & T is the measured transmissivity.

A visibility sensor measures the transmissivity of a light beam from a source of known brightness over a fixed path length to enable a value of the visibility coefficient to be deduced. The units of measurement for this coefficient are m^{-1} and the typical span range would be 0 - 0.015m^{-1} or 0 -15$(km)^{-1}$.

2.2. Meteorological Visibility

An alternative method of presenting this data is in the form of meteorological visibility. This is defined as the distance over which the intensity of transmitted light falls to 5% of its initial value. It represents the distance over which a person can see in a hazy or dusty environment.

In this case, $I = 0.05 \times I_o$ thus T = 0.05

and since $K = \frac{1}{L} \cdot \log_e \frac{1}{T}$

visibility $L = \frac{1}{K} \log_e 20 = \frac{2.99}{K}$

Thus, for a K value of 0.003, the visibility in metres is 2.99/0.003 = 1000m. Both K factor and visibility are calculated by the sensor and are available for output.

3. Specifications

3.1. General

Construction

- Stainless Steel 316 Ti – other grades available on request.

Safety & EMC

- shielded to comply with 2006/95/EEC
- EN61326-1:2006 & EN50270:2006

Ambient temperature

- -20^{o}C to +50^{o}C.

Dimensions

- Ø150mm x 81mm x 150mm

Power

- 24V DC, 20VA

3.2. Visibility Measurement

Measurement path

- 6m

Visibility measuring range (standard)

- Visibility : 0-15 x 10^{-3} m^{-1}
- other ranges selectable on setup.

Air temperature

- PT100 resistance thermometer - range -20°C to +105°C

Averaging time

- 1 to 12 minutes.

Accuracy

- Visibility - ±0.2 x 10^{-3} m^{-1}

- Temperature ± 0.2°C

Outputs

- analogue - 2 x 4-20mA, 200V common mode isolation - fully configurable for visibility and temperature measurement.
- max. load 500Ω
- logic – 1x volt-free contacts SPCO, 0.5A @ 125V AC, 2A @ 30V DC, 0.5A @ 100V DC
- RS485 serial interface.

3.3. RS485 Interface

Power

- USB powered.

PC Communications

- USB port.

The serial USB RS485 interface is used as a temporary connection with the TunnelTech 101 during commissioning and for diagnostic communications.

The operation function and operation of the interface are contained in Appendix A: Communication & RS485 Connection.

3.4. Modbus Protocol

Use the TunnelTech program to**,**

Edit the 7F3C file:

The numbers and locations are in hexadecimal	- Location 7F3C	=	00	Codel
		=	01	MODBUS
	- Location 7F1F	=	the address the AQM is to use as MODBUS slave (01 = address 1, 02 = address 2, 0A = address 10 etc, range 01 to FE.)	

Change only the above 2 bytes, then save and send the file to the TunnelTech AQM.

Note that the AQM will still communicate on address 255 with the TunnelTech software. This is to allow communications if an AQM address and protocol is unknown.

Our Modbus can handle the following functions:

0x03: Read Holding Register

0x06: Pre-set Single Register

0x10: Pre-set Multiple Registers

(*See Appendix A for more information)*

4. Installation

Be sure to observe all necessary safety precautions at all times during installation.

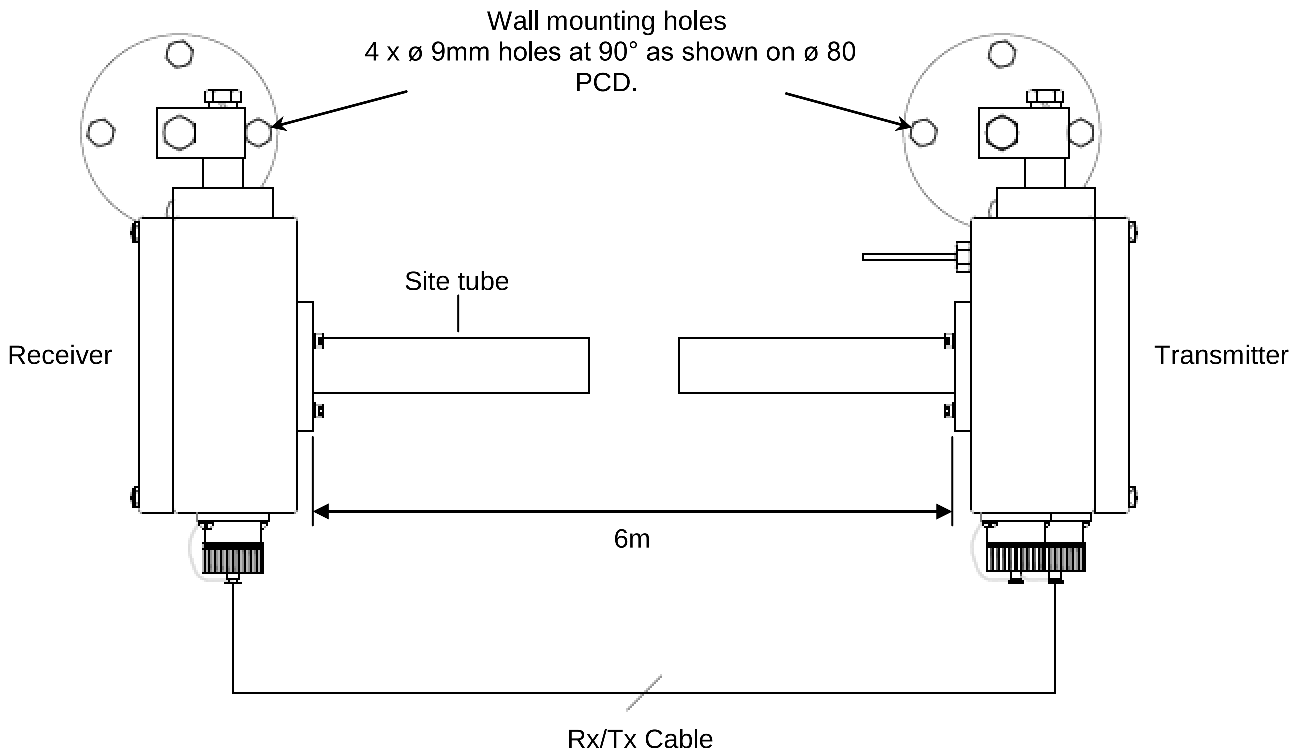
All cable gland entry holes are drilled and tapped M20 x 1.5 and are fitted with blanking plugs. Cable glands are to be supplied by the customer according to the cables used during installation.

4.1. Mounting Details

After unpacking the equipment check, using the packing list provided, that all items are present. The TunnelTech 101 Air Quality Monitor (AQM) is carried on a pair of fabricated mounting brackets (if supplied).

4.1.1. TunnelTech 101 (AQM)

The AQM comprises a transmitter and receiver unit. Secure the AQM to the tunnel wall by the mounting-brackets supplied using 4 x M8 bolts (by others) such that the transmitter and receiver are 6m apart. The transmitter and receiver should be mounted horizontally and arranged as illustrated in Figure 2.



Site tubes are supplied and should be bolted onto the mounting brackets using the 3 x M6 bolts provided.

Figure 2: TunnelTech AQM – Mounting holes

4.2. Connections

Wiring should only be undertaken by a qualified technician.

The following electrical schematic (Figure 3) illustrates the connections for the system. A soldered connection is required between the cable and the corresponding plug or socket.

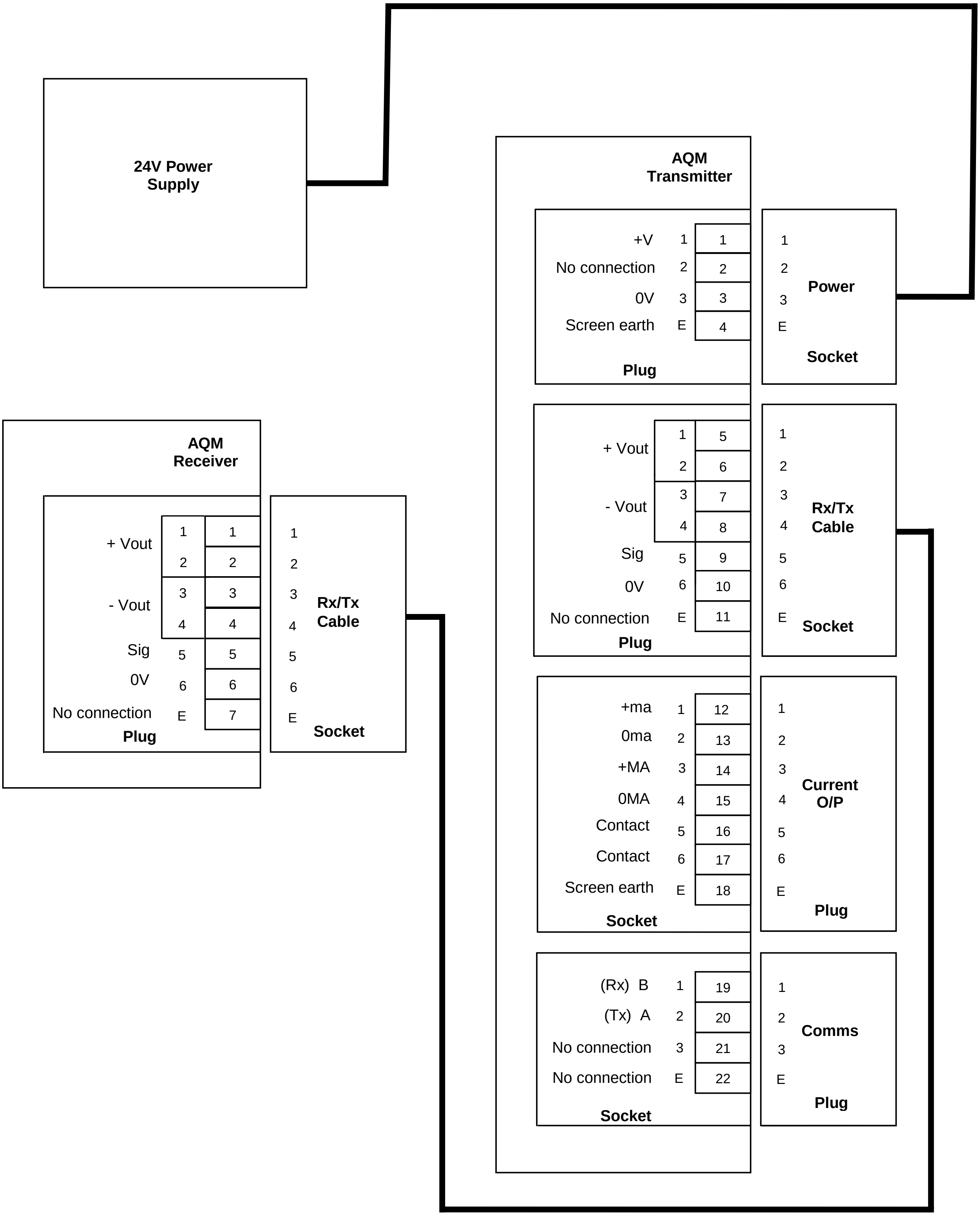


Figure 3: Electrical Schematic

4.3. Alignment of AQM Sensor

Note – Align the transmitter and receiver prior to connecting power.

The AQM transmitter and receiver units should be mounted horizontally and should be properly aligned for optimum performance.

4.3.1 Laser Adapter Assembly

Mount the laser onto the adapter as shown in Figure 4.

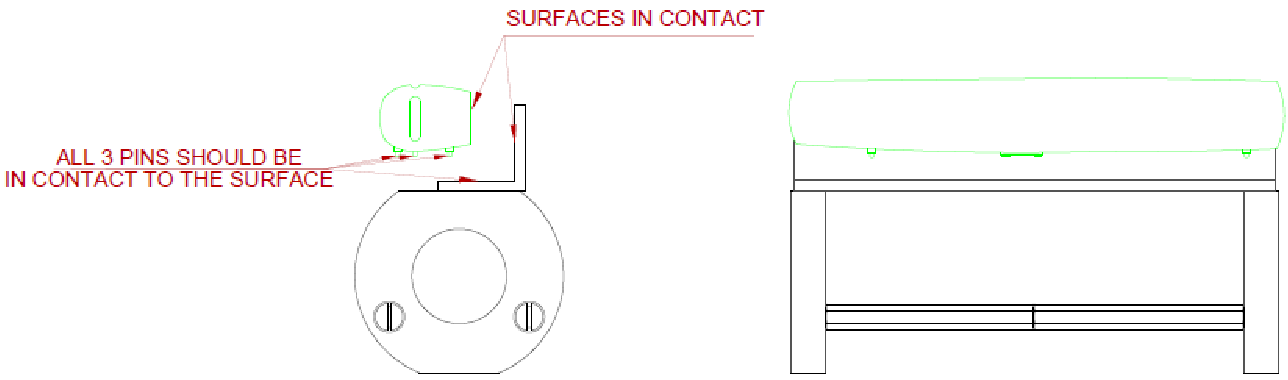


Figure 4: Mounting Laser

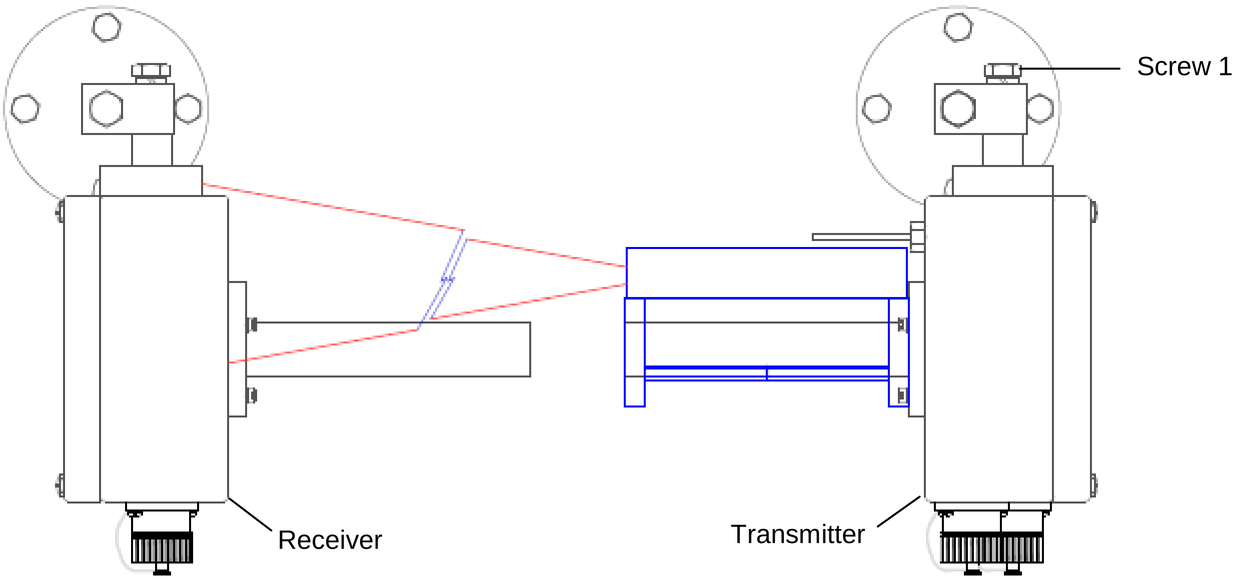
Fit the assembly illustrated in Figure 4 onto the transmitter site tube. Make sure the plate of the adapter and the sight tube connect flush in the orientation shown below.

4.3.2 Horizontal Alignment of Transmitter

4.3.2.1

Slide the laser adaptor over the sight tube so that the laser pointer is at the top of the sight tube. Ensure that the holes in the adaptor flange locate onto the heads at the sight tube mounting bolts.

Loosen screw 1 slightly to allow movement at the bracket. Position the laser line onto the centre of the receiver site tube then tighten screw 1, see Figure 5.



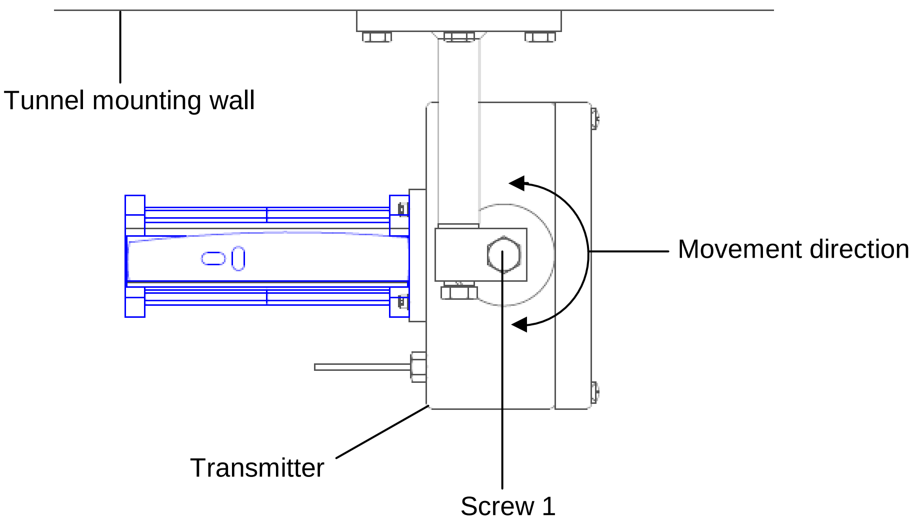


Figure 5: Horizontal Alignment

4.3.2.2 Vertical Alignment

Position the laser adaptor so that the laser pointer is located at the side of the mounting tube.

Loosen screw 2 slightly to allow movement at the bracket. Position the laser line onto the centre of the receiver site tube then tighten screw 2, see Figure 6.

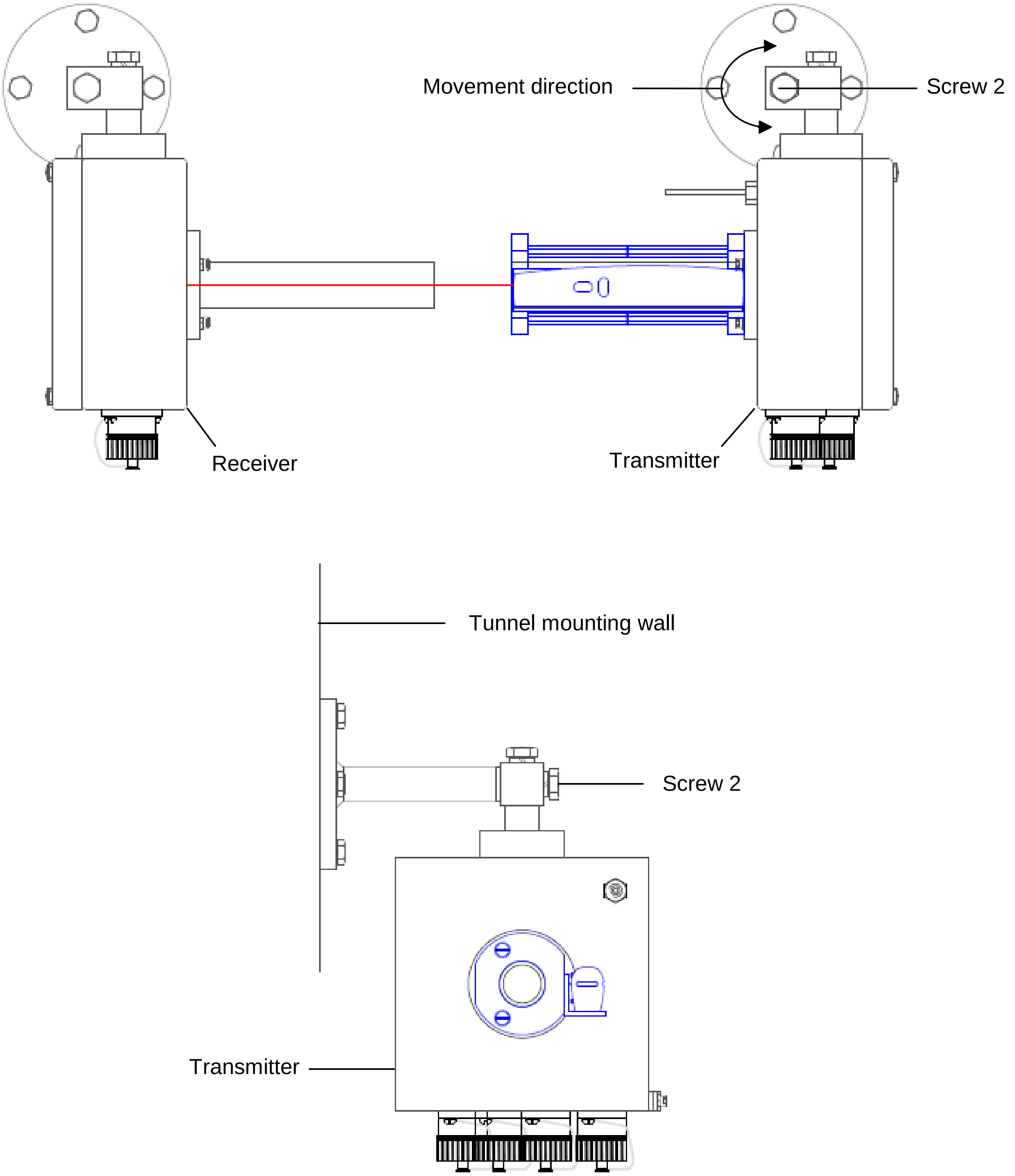


Figure 6: Vertical Alignment

4.3.3 Alignment at Receiver

Repeat the procedures described in 4.3.2 to adjust the receiver alignment.

5. Commissioning

5.1. Alignment

Ensure the transmitter and receiver are correctly aligned before connecting the power

5.2. Power Up

Turn on the power and leave for 10 minutes. During this period the data will be invalid. The system will then automatically adjust the gain and set up the detector levels to the following;

- Rx 10,000 +/- 1000
- Tx 10,000 +/- 1000

This will only take a few seconds.

5.3. Calibration

The system will then go into a calibration routine which will last a minute. The analyser will now be running in a zero condition.

5.4. Milliamp Output

The mA output ranges are factory set as 4 – 20 mA.

5.5. RS485 Modbus

All analysers are pre-configured to provide an RS485 Modbus output.

Check the status of the system and connect to the TunnelTech software address 255.

Connect the comms cable to the Transmitter checking the following;

- Detector level – for a zero condition.
- Read memory location 0100, if the value is greater than 0000 the output of the system is not valid and must be checked.

If using a number of sensors connected by Modbus, the address of each head must be set up. This can be done by changing the address location 7F1F, this is a hex value.

01 – 1
02 – 2
03 – 3

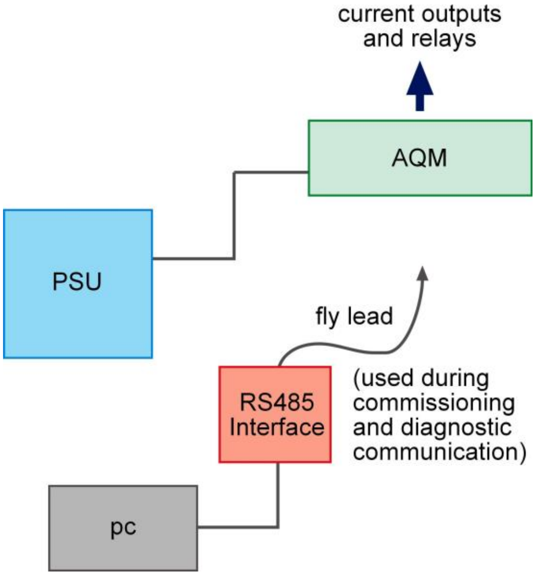
Etc.

6. Data Communication

6.1. Hardware Configuration

6.1.1. System

The PSU supplies power to the AQM. The current and relay outputs of the AQM communicate measurement data to the tunnels' DCS system.



6.2. Address Numbers

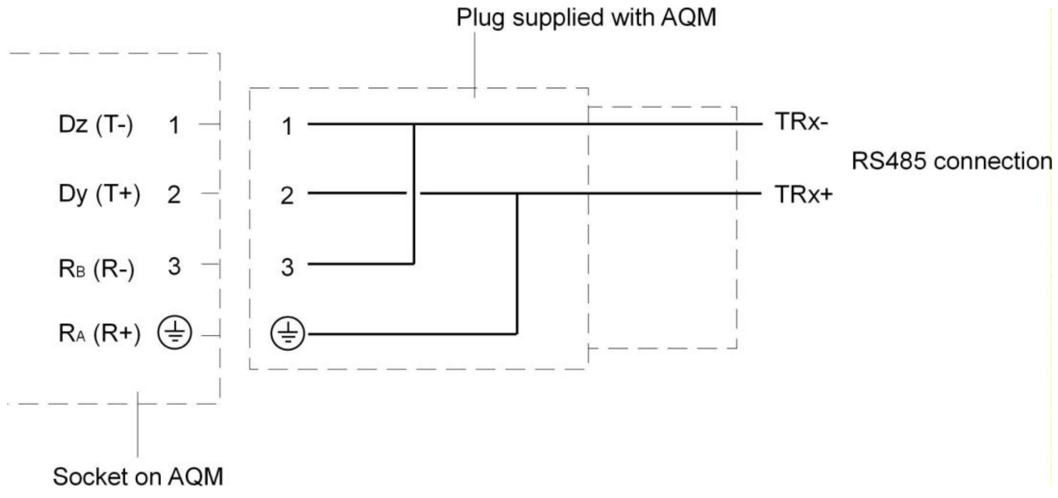
Because communications between the interface and the sensor is serial digital, it is necessary for each sensor to be allocated an address number – **the default address is 1 and should not be changed**.

7. List of Figures

Appendix A: Communication & RS485 Connection

The serial communication output of the TunnelTech 101 AQM RS485 is taken via the 4-way chassis plug. The following wiring schematic and photograph illustrate the connections.

All AQMs are equipped with RS485 and will have labels indicating 'RS485'. Connections in the plug are as follows:



Note that in the plug terminal 1 must be linked to terminal 3 and terminal ⏚ must be linked to terminal 2. If no communications are present first check the address switch setting and if this does not cure the problem swap the polarity of TRx lines + and -.

Standard MODBUS Communication with CODEL MODBUS TunnelTech (TT) 101 AQM

Summary

Using standard MODBUS protocol function 03 allows a host to obtain the contents of one or more holding registers in the CODEL MODBUS TT Air Quality Monitor (AQM), this can be seen in appendix B. The request frame from the host (typically a DCS or SCADA) defines the relative address of the first holding register followed by the total number of consecutive registers to be read.

The response frame from the CODEL TT AQM lists the contents of the requested registers, returning 2 bytes per register with the most significant byte first. A maximum of 125 registers can be accessed per request. The formats of the request and response frames are detailed below, where 'X' and 'n' are hexadecimal variables. An example of a MODBUS register map is shown below.

Host Request Frame

01	Address
03	Function code
XX XX	Address of starting register
00 XX	Number of consecutive registers to be read
XX XX	CRC

Slave Response (from CODEL MODBUS TT AQM)

01	Address
03	Function code
XX	Byte count
XX XX …to… …to…	Date from starting register
XX XX	Date from nth register
XX XX	CRC

Standard baud rate - 4800

Bits per byte
- 1 start bit
- 8 data bits (least significant sent first)
- 1 stop bit
- no parity

The MODBUS output from the T4 AQM is at 4800 baud format: 1 start bit, 8 data bits, no parity, 1 stop bit.

The MODBUS output from the TT AQM will be connected via RS485.

The TT AQM comms is Standard Modbus protocol with RTU framing and only function code 03 is supported.

The TT AQM will be a MODBUS slave device.

Appendix B: TunnelTech AQM visibility Features

TunnelTech AQM

Data Validity Status:

Control Register = 0x0100 (CODEL) - 0x0080 (Modbus) - Read Only Register

High Byte:

- bit 0 : Power Up
- bit 1 : Zero Cal
- bit 2 : Auto Detector Setup
- bit 3 : Not Used
- bit 4 : Not Used
- bit 5 : Not Used
- bit 6 : Not Used
- bit 7 : Maintenance

Low Byte:

- bit 0 : Dt Below Threshold
- bit 1 : Dt Saturation
- bit 2 : Dr Below Threshold
- bit 3 : Dr Saturation
- bit 4 : Contamination Above Threshold
- Bit 5 : Not Used
- Bit 6 : Not Used
- Bit 7 : Not Used

Command List:

Control Register 0x019E (CODEL) - 0x00CF (Modbus) - Read and Write Register

High byte:
0x00 : always 0x00

Low byte: (0x019F)

0x0A : AutoDetectorGainsCmd	0x0A	//Auto Detector Gain Command
0x10 : CalibrateVisCmd	0x10	//Calibration Command
0x1A : AutoDetectorGains_CalibrateVisCmd	0x1A	//Auto Detector Gain and Calibration Command
0x20 : EEPROM_ASCII_InstructionCmd	0x20	// initiate EEPROM_ASCII_Instruction Command located in 7E30
0x21 : MaintenanceStartCmd	0x21	
0x22 : MaintenanceStopCmd	0x22	

Power Up Option:

Control Register 0x7F18 (CODEL) - 0x3F8C (Modbus) - Read and Write Register

High byte : (0x7F18)
0x01 - 0xFF : ON -> this number represent the delay in minutes for power up command to be triggered
0x00 : OFF -> Power up commmand is off

Low byte : (0x7F19)

0x0A : AutoDetectorGainsCmd	0x0A	//Auto Detector Gain Command
0x10 : CalibrateVisCmd	0x10	//Calibration Command
0x1A : AutoDetectorGains_CalibrateVisCmd	0x1A	//Auto Detector Gain and Calibration Command
Other : Default to CalibrateVisCmd	0x10	//Calibration Command

Appendix C: EEPROM Modbus map

Modbus Address		Description	CODEL : Byte Address
Decimal	Hexadecimal		
16256	3F80	//	0x7F00
16257	3F81	DtThreshold_EEPROM	0x7F02
16258	3F82	DrThreshold_EEPROM	0x7F04
16259	3F83	VizDetectorSmoothingFactor_EEPROM	0x7F06
16260	3F84	DtSaturation_EEPROM	0x7F08
16261	3F85	DrSaturation_EEPROM	0x7F0A
16262	3F86	//	0x7F0C
16263	3F87	VizScalingFactor_EEPROM	0x7F0E
16264	3F88	//	0x7F10
	3F89_H	//	0x7F12
16265	3F89_L	//VizSmoothingFactor_EEPROM	0x7F13
16266	3F8A	//	0x7F14
	3F8B	//	0x7F16
16267	0000	VIZCalCycles_EEPROM	0x7F17
	3F8C_H	PowerUpCounter_EEPROM	0x7F18
16268	3F89_L	PowerUpComd_EEPROM	0x7F19
16269	3F8D		0x7F1A
16270	3F8E	//VizDtMinimumThreshold_EEPROM	0x7F1C
	3F8F_H	SpeciesPointer_EEPROM	0x7F1E
16271	3F8F_L	COMMSADDRESS_EEPROM	0x7F1F
16272	3F90	//	0x7F20
16273	3F91	//	0x7F22
16274	3F92	//	0x7F24
16275	3F93	//	0x7F26
16276	3F94	//	0x7F28
16277	3F95	//	0x7F2A
16278	3F96	//	0x7F2C
16279	3F97	AirTemperatureSmoothingFactors_EEPROM	0x7F2E
16280	3F98	PathLength_EEPROM	0x7F30
16281	3F99	//	0x7F32
16282	3F9A	//	0x7F34
16283	3F9B	//	0x7F36
16284	3F9C	OpacitySmoothingFactors_EEPROM	0x7F38
16285	3F9D	//	0x7F3A
16286	3F9E	COMMSPROTOCOL_EEPROM	0x7F3C
16287	3F9F	//ATCOpacity_EEPROM	0x7F3F
16288	3FA0	//	0x7F40
16289	3FA1	//	0x7F42
16290	3FA2	//	0x7F44
16291	3FA3	//	0x7F46
16292	3FA4	//	0x7F48
16293	3FA5	//	0x7F4A
16294	3FA6	//	0x7F4C
16295	3FA7	//	0x7F4E
16296	3FA8	AutoZeroThreshold_EEPROM	0x7F50

16297	3FA9	AutoZeroIncrementAmount_EEPROM	0x7F52
16298	3FAA	AutoZeroDecrementAmount_EEPROM	0x7F54
	3FAB_H	AutoZeroIncrementCount_EEPROM	0x7F56
16299	3FAB_L	AutoZeroDecrementCount_EEPROM	0x7F57
16300	3FAC	AutoZeroMaxThreshold_EEPROM	0x7F58
16301	3FAD	//	0x7F5A
16302	3FAE	//	0x7F5C
16303	3FAF	TxTemperatureSmoothingFactorEEPROM	0x7F5E
16304	3FB0	mA1DACSpan_EEPROM	0x7F60
16305	3FB1	mA1DACZero_EEPROM	0x7F62
16306	3FB2	mA2DACSpan_EEPROM	0x7F64
16307	3FB3	mA2DACZero_EEPROM	0x7F66
16308	3FB4	//	0x7F68
16309	3FB5	//	0x7F6A
16310	3FB6	//	0x7F6C
	3FB7_H	DtxHarwareGainWiperPosition_EEPROM	0x7F6E
16311	3FB7_L	DrxHarwareGainWiperPosition_EEPROM	0x7F6F
16312	3FB8	Setcal_Smoothed_EEPROM	0x7F70
16313	3FB9	//	0x7F72
16314	3FBA	//	0x7F74
16315	3FBB	//	0x7F76
16316	3FBC	//	0x7F78
16317	3FBD	//	0x7F7A
16318	3FBE	//	0x7F7C
16319	3FBF	//	0x7F7E
16320	3FC0	mA1AbsLocation_EEPROM	0x7F80
	3FC1_H	mA1Type_EEPROM	0x7F82
16321	3FC1_L	mA1DataValidity_EEPROM	0x7F83
	3FC2_H	mA1SmoothingCoefficient_EEPROM	0x7F84
16322	3FC2_L	mA1Span_EEPROM	0x7F85
	3FC3_H		0x7F86
16323	3FC3_L	mA1Zero_EEPROM	0x7F87
	3FC4_H		0x7F88
16324	3FC4_L	Alarm1AbsLocation_EEPROM	0x7F89
	3FC5_H		0x7F8A
16325	3FC5_L	Alarm1SmoothingCoefficient_EEPROM	0x7F8B
	3FC6_H	Alarm1Direction_EEPROM	0x7F8C
16326	3FC6_L	Alarm1Level_EEPROM	0x7F8D
	3FC7_H		0x7F8E
16327	3FC7_L	Alarm1DataType_EEPROM	0x7F8F
16328	3FC8	mA2AbsLocation_EEPROM	0x7F90
	3FC9_H	mA2Type_EEPROM	0x7F92
16329	3FC9_L	mA2DataValidity_EEPROM	0x7F93
	3FCA_H	mA2SmoothingCoefficient_EEPROM	0x7F94
16330	3FCA_L	mA2Span_EEPROM	0x7F95
	3FCB_H		0x7F96
16331	3FCB_L	mA2Zero_EEPROM	0x7F97
	3FCC_H		0x7F98
16332	3FCC_L	Alarm2AbsLocation_EEPROM	0x7F99

	3FCD_H		0x7F9A
16333	3FCD_L	Alarm2SmoothingCoefficient_EEPROM	0x7F9B
	3FCE_H	Alarm2Direction_EEPROM	0x7F9C
16334	3FCE_L	Alarm2Level_EEPROM	0x7F9D
	3FCF_H		0x7F9E
16335	3FCF_L	Alarm2DataType_EEPROM	0x7F9F

Appendix D: Ram Modbus map

Modbus Address		Description	CODEL : Byte Address
Decimal	Hexadecimal		
	0080_H	AQMModeStatus_RAM	0x0100
128	0080_L	AQMPerformanceStatus_RAM	0x0101
129	0081	//	0x0102
130	0082	//	0x0104
131	0083	//	0x0106
132	0084	//	0x0108
133	0085	//	0x010A
134	0086	//	0x010C
135	0087	//	0x010E
136	0088	Drx_Act_Inst_RAM	0x0110
137	0089	Dtx_Ref_Inst_RAM	0x0112
138	008A	//	0x0114
139	008B	//	0x0116
140	008C	//	0x0118
141	008D	//	0x011A
142	008E	Drx_Act_Sat_C_RAM	0x011C
143	008F	Dtx_Ref_Sat_C_RAM	0x011E
144	0090	//	0x0120
145	0091	//	0x0122
146	0092	//	0x0124
147	0093	//	0x0126
148	0094	//	0x0128
149	0095	//	0x012A
150	0096	//	0x012C
151	0097	//	0x012E
152	0098	Drx_Act_Smoothed_RAM	0x0130
153	0099	Dtx_Ref_Smoothed_RAM	0x0132
154	009A	//	0x0134
155	009B	//	0x0136
156	009C	//	0x0138
157	009D	//	0x013A
158	009E	Vis_D_Range_Flag_RAM	0x013C
159	009F	//	0x013E
160	00A0	//	0x0140
161	00A1	//	0x0142
162	00A2	//	0x0144
163	00A3	Opacity_Smoothed_RAM	0x0146
164	00A4	//	0x0148
165	00A5	//	0x014A
166	00A6	Opacity_S_Delta_RAM	0x014C
167	00A7	//	0x014E
168	00A8	//	0x0150
169	00A9	//	0x0152
170	00AA	//	0x0154
171	00AB	Vis_Metres_RAM	0x0156

172	00AC	Vis_Km_1_RAM	0x0158
173	00AD	//	0x015A
174	00AE	//	0x015C
175	00AF	Vis_Fault_Flag_RAM	0x015E
176	00B0	//	0x0160
177	00B1	//	0x0162
178	00B2	//	0x0164
179	00B3	Opacity_Inst_RAM	0x0166
180	00B4	//	0x0168
181	00B5	//	0x016A
182	00B6	Delta_Opacity_RAM	0x016C
183	00B7	//	0x016E
184	00B8	//	0x0170
185	00B9	//	0x0172
186	00BA	//	0x0174
187	00BB	//	0x0176
188	00BC	//	0x0178
189	00BD	//	0x017A
190	00BE	//	0x017C
191	00BF	//	0x017E
192	00C0	//	0x0180
193	00C1	//	0x0182
194	00C2	//	0x0184
195	00C3	//	0x0186
196	00C4	SetCalVis_Smoothed_RAM	0x0188
197	00C5	//	0x018A
198	00C6	//	0x018C
199	00C7	Opacity_Yautos_RAM	0x018E
200	00C8	//	0x0190
201	00C9	//	0x0192
202	00CA	//	0x0194
203	00CB	//	0x0196
204	00CC	SetCalVis_Inst_RAM	0x0198
205	00CD	Power_up_counter_RAM	0x019A
206	00CE	Low_det_counter_RAM	0x019C
207	00CF_H	Cal_init_countdown_RAM	0x019E
	01CF_L	CommandFlag_RAM	0x019F
208	00D0	//	0x01A0
209	00D1	//	0x01A2
210	00D2	//	0x01A4
211	00D3	//	0x01A6
212	00D4	Drx_Act_Remainder_RAM	0x01A8
213	00D5	Dtx_Ref_Remainder_RAM	0x01AA
214	00D6	//	0x01AC
215	00D7	//	0x01AE
216	00D8	//	0x01B0
217	00D9	//	0x01B2
218	00DA	//	0x01B4
219	00DB	//	0x01B6

220	00DC	//	0x01B8
221	00DD	//	0x01BA
222	00DE	Tx_Temp_Remainder_RAM	0x01BC
223	00DF	Air_Temp_Remainder_RAM	0x01BE
	00E0_H	AQMModeStatus_Copy_RAM	0x01C0
224	01E0_L	AQMPerformanceStatus_Copy_RAM	0x01C1
225	00E1	//	0x01C2
226	00E2	Drx_Act_Inst_Copy_RAM	0x01C4
227	00E3	Dtx_Ref_Inst_Copy_RAM	0x01C6
228	00E4	Drx_Act_Smoothed_Copy_RAM	0x01C8
229	00E5	Dtx_Ref_Smoothed_Copy_RAM	0x01CA
230	00E6	SetCalVis_Smoothed_Copy_RAM	0x01CC
231	00E7	SetCalVis_Inst_Copy_RAM	0x01CE
232	00E8	Transmissivity_Copy_RAM	0x01D0
233	00E9	Opacity_Inst_Copy_RAM	0x01D2
234	00EA	Delta_Opacity_Copy_RAM	0x01D4
235	00EB	Opacity_Meas_RAM	0x01D6
236	00EC	Vis_Metres_Meas_RAM	0x01D8
237	00ED	Vis_Km_1_Meas_RAM	0x01DA
238	00EE	//	0x01DC
239	00EF	//	0x01DE
240	00F0	Tx_Temperature_C_Smoothed_RAM	0x01E0
241	00F1	Air_Temperature_C_Smoothed_RAM	0x01E2
242	00F2	Opacity_Meas_RAM	0x01E4
243	00F3	Vis_Metres_Meas_RAM	0x01E6
244	00F4	Vis_Km_1_Meas_RAM	0x01E8
245	00F5	Transmissivity_RAM	0x01EA
246	00F6	//	0x01EC
	00F7_H	VisDRangeFlag_Meas_RAM	0x01EE
247	01F7_L	Cal_inProgress_RAM	0x01EF
248	00F8	//	0x01F0
	00F9_H	VisDet_ErrorCalFlag_RAM	0x01F1
249	01F9_L	//	0x01F2
250	00FA	//	0x01F4
251	00FB	//	0x01F6
252	00FC	//	0x01F8
253	00FD	//	0x01FA
	00FE_H	//	0x01FC
254	01FE_L	Head_Identifier_RAM	0x01FD
	00FF_H	SIU_Comms_RAM	0x01FE
255	01FF_L	SIU_Data_RAM	0x01FF