



SERVOTOUGH LaserExact (Model 2950)

Operator Manual

(For Windows Software v. 6.1)

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1. INTRODUCTION

1.1 Safety Information

Read this manual and ensure that you fully understand its content before you attempt to install, use or maintain the Laser monitor. Important safety information is highlighted in this manual as WARNINGS and CAUTIONs, which are used as follows:

	<p style="text-align: center;">WARNING</p> <p>Warnings highlight specific hazards which, if not taken into account, may result in personal injury or death.</p>
-----------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------

<p style="text-align: center;">CAUTION</p> <p>Cautions highlight hazards which, if not taken into account, can result in damage to the Laser monitor or to other equipment or property.</p>

This manual also incorporates “be aware of” information, which is used as follows:


- ☞ This highlights information which it is useful for you to be aware of (for example, specific operating conditions, and so on).

1.2 General

This manual contains information of installation, operation and maintenance of the SERVOTOUGH LaserExact Monitor. A description of the SERVOTOUGH LaserExact Monitor and its basic features is also included.

Please read sections 3 and 4 carefully before using the SERVOTOUGH LaserExact Monitor. It is a sophisticated instrument utilising state-of-the-art electronic and laser technology. Installation and maintenance of the instrument requires care and preparation. Failure to do so may damage the instrument and void the warranty.

- ☞ There are no user serviceable parts in the SERVOTOUGH LaserExact.

	<p style="text-align: center;">WARNING</p> <p>The Laser monitor must not be used as personal protective equipment.</p>
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**WARNING**

The Safe Area monitor is only suitable for use in unclassified areas.

**WARNING**

The ATEX Zone 2 and CSA CL I Div 2 Hazardous area variant cannot be used for oxygen enriched samples; that is, gases over 21% O₂. If used with gases containing over 21% O₂ the hazardous area certification is invalidated.

**WARNING**

The Safe Area, GP and ATEX Zone 2 Variants are certified for use with a flammable samples at a pressure of 0.8 to 1.1 bar absolute. If used with a flammable sample beyond these limits, the hazardous area certification is invalidated.

1.3 Measuring principle

The SERVOTOUGH LaserExact Monitor is an optical instrument transmitting infrared laser light multiple times through a measurement chamber (the LaserExact cell). Two mirrors are mounted inside the cell and the laser beam is reflected between these many times resulting in a measurement path of between 0.7 and approximately 11m. The measuring technique is based on measuring the absorption of light by the gas molecules present in the cell.

The measuring principle is infrared single-line absorption spectroscopy, which is based on the fact that each gas has distinct absorption lines at specific wavelengths. The measuring principle is illustrated in Figure 1-1.

The laser wavelength is scanned across a chosen absorption line of the gas to be measured. The absorption line is carefully selected to avoid cross interference from other (background) gases. The detected light intensity varies as a function of the laser wavelength due to absorption of the targeted gas molecules in the optical path between the diode laser and detector. In order to increase the sensitivity the wavelength modulation technique is employed: The laser wavelength is slightly modulated while scanning the absorption line. The detector signal is spectrally decomposed into frequency components at harmonics of the laser modulation frequency. The second harmonics of the signal is used to measure the concentration of the absorbing gas.

The line amplitude and line width are both extracted from the second harmonics line shape, which makes the measured concentration insensitive to line shape variations (line broadening effect) caused by background gases.

NOTE: The SERVOTOUGH LaserExact Monitor measures the concentration of only the FREE molecules of the specific gas, thus not being sensitive to the molecules bound with some other molecules into complexes and to the molecules attached to or dissolved in particles and droplets. Care should be taken when comparing the measurements with the results from other measurement techniques.

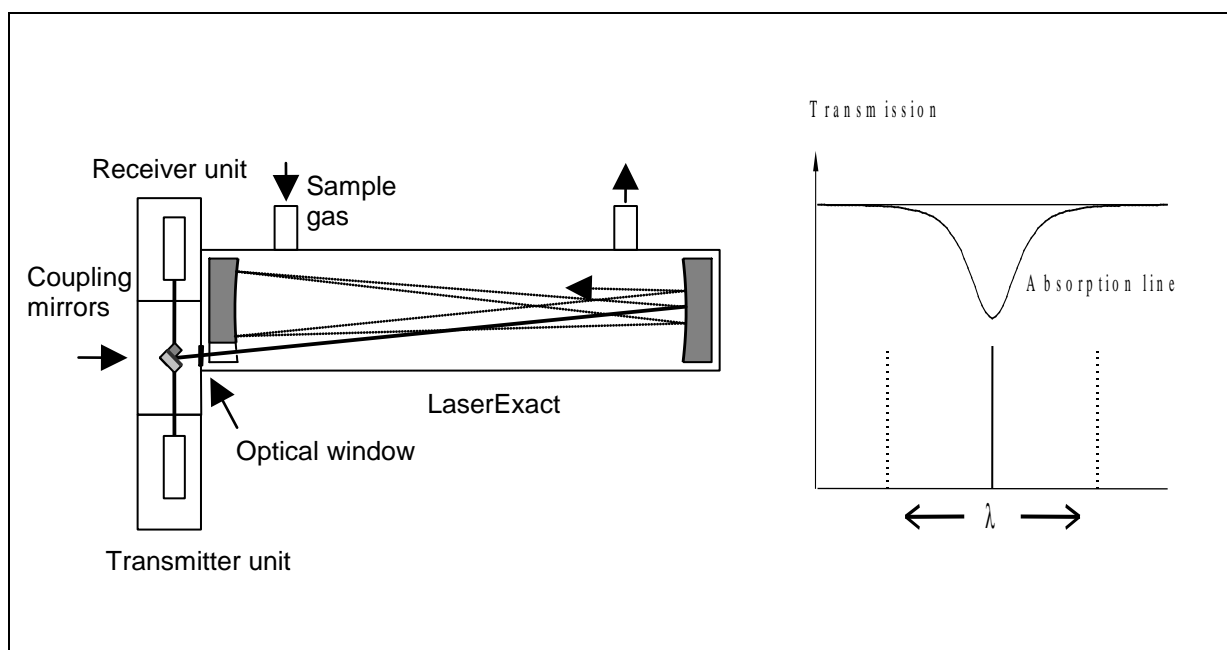


Figure 1-1: Measuring Principle SERVOTOUGH LaserExact Monitor

1.4 Instrument description

The SERVOTOUGH LaserExact Monitor consists of 3 modules:

- Cabinet
- LaserExact cell (under an optional protective cover)
- Laser beam alignment chamber (under an optional protective cover)

The cabinet is connected to the laser beam alignment chamber, which couples the laser beam into the LaserExact cell. After multiple passes through the cell, the beam exits back into the alignment chamber and is coupled onto the detector.

The transmitter inside the cabinet contains a temperature stabilised diode laser with collimating optics. The laser is tuned to a specific wavelength and frequency and is modulated to enable gas detection. The wavelength is unique for each gas to be measured and is within the range from 0.7 to 2.4 μm (700 and 2400 nm). By varying the DC supply current the laser wavelength is scanned over the absorption line of the gas.

The transmitter is located within the cabinet enclosure and also contains the main electronics board and the display. Communication with the electronics is provided through an RS-232 connection to a PC, enabling service and calibration of the instrument. In addition, communication via an Ethernet connector is possible.

The receiver inside the cabinet contains a detector connected to the receiver electronics with a short cable. The detected signal is amplified and transmitted back to the transmitter unit through electrical cables.

The laser beam alignment chamber contains two adjustable mirrors. The first mirror controls the coupling of the beam into the cell and is adjusted to obtain the correct angle of incidence; the second mirror controls the coupling of the beam onto the detector and is adjusted to focus the beam on the detector centre.

The LaserExact cell with volume 0.875 litres (875 ml) is made of electro-polished stainless steel. Two cell mirrors are mounted inside the cell volume, one at each end of the cell. In the cell mirror next to the alignment chamber there is a slit, through which the laser beam enters and leaves the cell volume. A wedged sapphire window separates the cell from the alignment chamber.

A block diagram of the instrument electronics is shown in Figure 1-2. The transmitter electronics takes care of all calculations and monitoring operations. Three relays are integrated in the auxiliary electronics board. The integrated relays are warning, error and gas alarm relays. The operator can set the gas alarm relay in the software. The integrated relay functions are further explained in Section 6.8.

The RS-232 or Ethernet service port is connected to an external PC during installation, calibration and if service is required. Normally this port should not be in use. Optionally a modem can be implemented, which enables long distance communication with the instrument for service purposes.

The LCD continuously displays the gas concentration, laser beam transmission and instrument status (warning and fault messages). In Section 5.4 an array of the different fault messages is given.

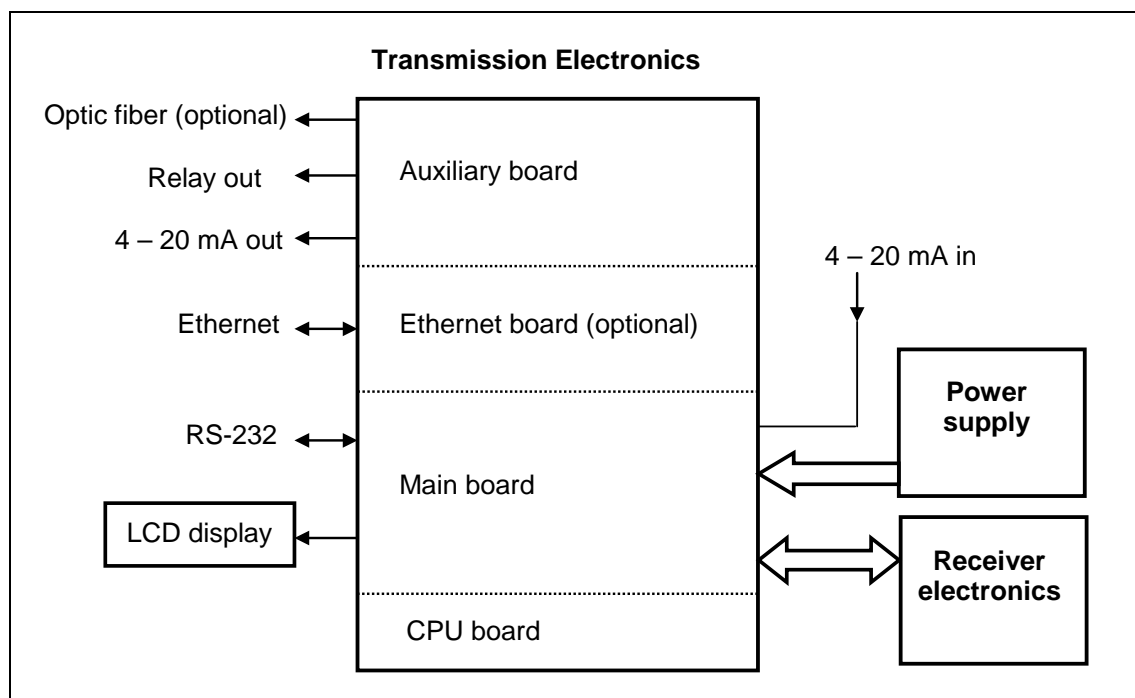


Figure 1-2: Block diagram of instrument electronics

1.5 Software

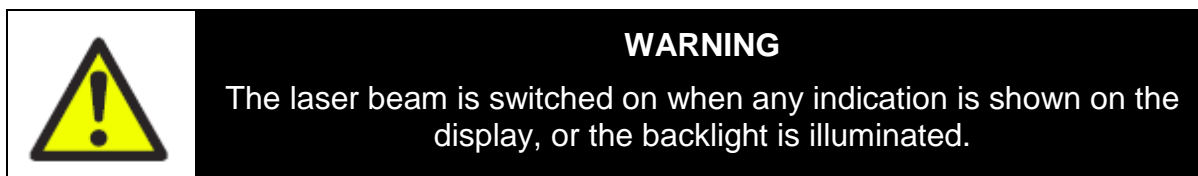
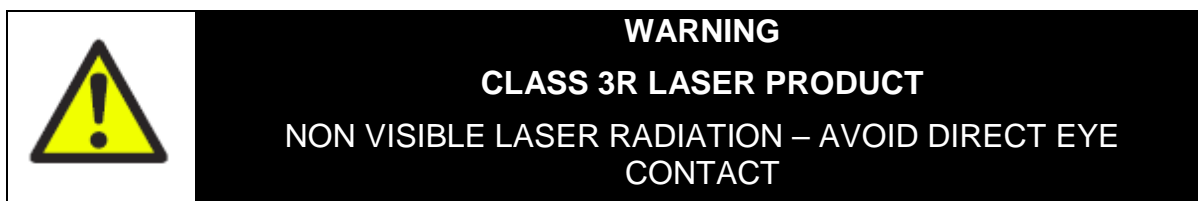
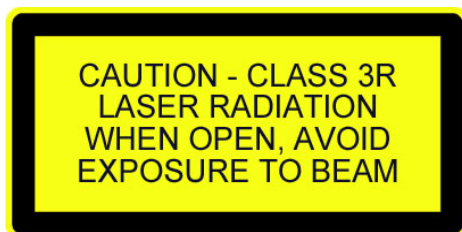
Software for the SERVOTOUGH LaserExact Monitor consists of 2 programs:

1. A program hidden to the user and integrated in the CPU electronics, running the micro controller on the CPU card. The program performs all necessary calculations and self-monitoring tasks.
2. A Windows-based program running on a standard PC connected through the RS-232 connection. The program enables communication with the instrument during installation, service and calibration.



The operator will need to use the PC-based program only during installation and calibration and not during normal operation of the instrument. See Chapter 4 for more details.

1.6 Laser Classification

The diode lasers used in the SERVOTOUGH LaserExact Monitors operate in the **near infrared (NIR)** range between 700 and 2400 nm depending on the gas to be measured. The lasers have an output power and optical arrangement, which according to IEC 60825-1 2007 classifies the SERVOTOUGH LaserExact Monitors as **Laser Class 3R Laser Product**. Accordingly, the product bears the following markings:



1.7 Product Data

Manufacturer	NEO Monitors AS
Country of origin	Norway
Model:	SERVOTOUGH LaserExact (LaserGas™ II Multipass)
Dimensions (L x H x W):	571 x 627 x 200mm
Mass:	28kg
Environmental conditions:	
Operating temperature:	-20°C to +55°C
Storage temperature	-20°C to +55°C
Apparatus is suitable for indoor use	
Operating pressure range:	101.3kPa, -20%, +10% (1.013bar, -20%, +10%)
Maximum operating altitude:	2000m
Protection classification	IP65
Electrical Data:	
Input power supply unit (mains):	100 – 240 VAC, 50/60 Hz, 50 VA Max.
Input direct (DC):	18-36V DC, 20W Max.
4 - 20 mA output:	500 Ohm Max. isolated
Relay output:	1 A at 30 V DC/AC
Laser Class:	Class 3R according to IEC 60825-1:2007
Laser power:	Max 40mW at 700 to 2400nm
Approvals:	
ATEX Zone 2:	 II 3 G Ex nA nC op is Gc IIC T4  II 3 D Ex td A22 IP65 T100°C
CSA:	Class 1 Division 2 Groups A, B, C, D; T4 non-incendive

2. PREPARATIONS

2.1 Tools and other equipment

No special tools are necessary to install and calibrate the equipment.

2.2 Flow conditions

The volume of the standard LaserExact cell is 875 ml. The flow of the target gas will determine the measurement time. The complete cell volume needs to be replaced by “new” gas before a new reasonable measurement point is logged.

2.3 Cell Materials

A list of the standard cell materials is given below. As these materials are exposed to the gas mix; therefore, it should be verified that the gas does not adversely affect any of them. Other cell materials may be available on request (contact SERVOMEX).

- Stainless steel, type AISI 316L
- BK7 mirrors coated with Au and SiO (optional MgF2 overcoat). NB: The Au is protected but the BK7 is exposed to the gas.
- Sapphire window (for beam entrance)
- O-rings, Viton (other materials on request)

2.4 Cables and electrical connections

There are no constraints on the length of the optional optical fibre, but the user should verify that the cable length for the 4-20 mA analogue current output from the cabinet unit does not influence the measurements (due to inductance etc.). The Service PC cable is 3 metres long, but can be extended to approximately 10 metres. If electrical connections have to be made at installation, refer to Chapter 6 for details.



WARNING

Ensure that the electrical installation of the Laser monitor conforms to all applicable local and national electrical safety requirements.



WARNING

Wiring to or from this device, which enters or leaves the system enclosure, must utilize wiring methods suitable for Class 1, Division 2 and/or Zone 2 Hazardous Locations, as appropriate for the installation.

2.5 Sticky gases

Special care should be taken for reactive and “sticky” gases such as NH_3 , HCl and H_2S . Because of the nature of these gases, it is difficult to obtain the correct concentration in the cell due to possible adsorption and desorption in the connection tubes. Make sure that the extractive system is appropriate.

3. INSTALLATION



WARNING

You must install and use the Laser monitor in accordance with the requirements of this section and subsequent sections of the manual. If you do not, people may be injured, the protection facilities incorporated into the design of the Laser monitor may not operate as intended, measurements may not be accurate, or the Laser monitor may be damaged.



WARNING

The Laser monitors are not suitable for use in hazardous areas unless the correct certification labels have been affixed.

Instructions Specific to Hazardous Area Installations



WARNING

The ATEX Zone 2 and CSA CL I Div 2 Hazardous area variants cannot be used for oxygen enriched samples; that is, gases over 21% O₂. If used with gases containing over 21% O₂ the hazardous area certification is invalidated.



WARNING

The ATEX Zone 2 variants are not suitable for use with a process atmosphere that requires EPL Ga (e.g.: Zone 0). If used within this process atmosphere, the hazardous area certification may be invalidated.

3.1 Labelling

Versions suitable for use in Hazardous areas will be labelled with relevant markings for:

ATEX Zone 2:

Ⓔ II 3 G Ex nA nC op is Gc IIC T4

Ⓔ II 3 D Ex td A22 IP65 T100°C

CSA:

GP and Class 1 Division 2 Groups A, B, C, D; T4 non-incendive

3.2 Installation and adjustments

The installation procedure described in this section refers to Figure 3-1.

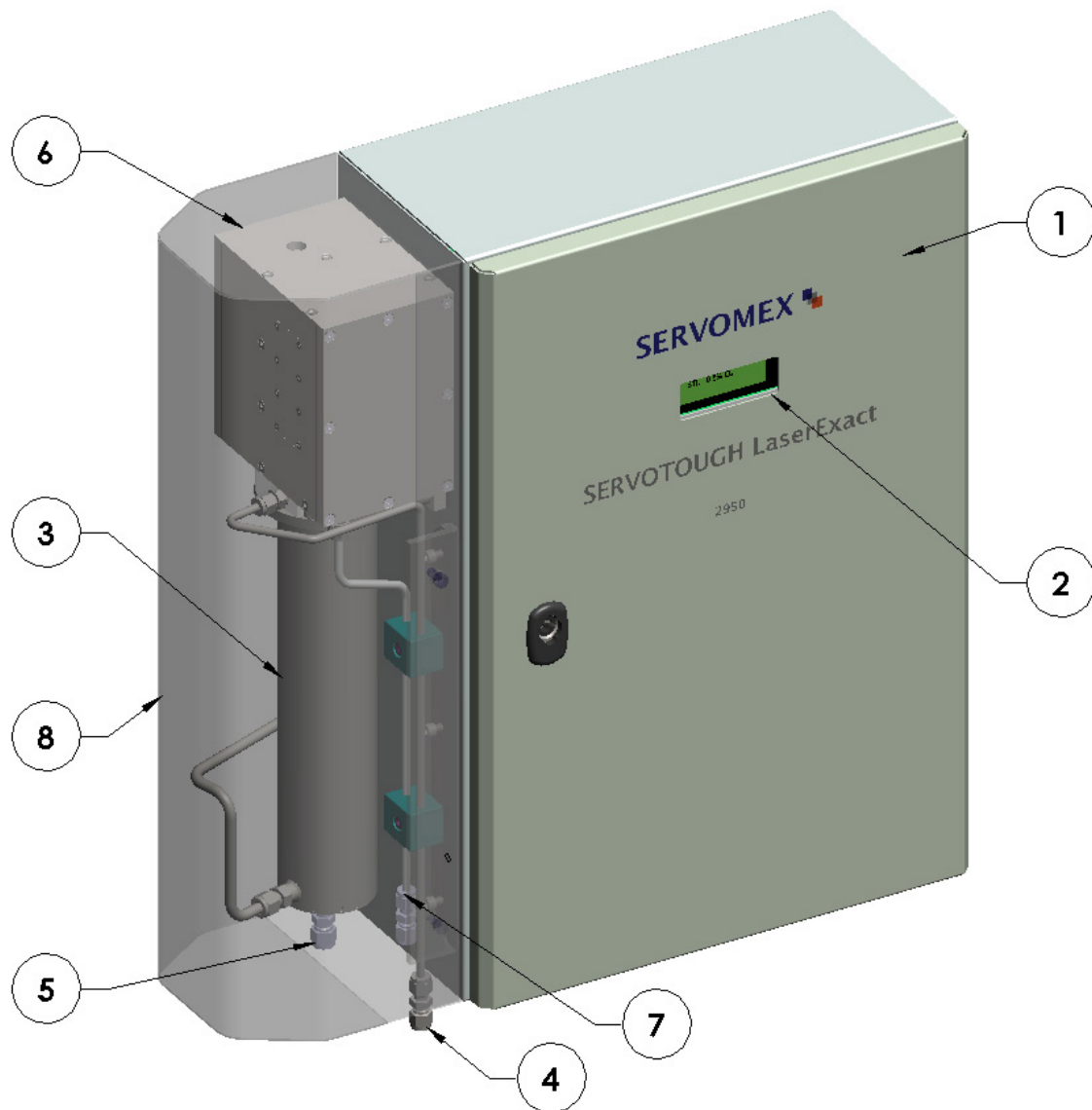


Figure 3-1: SERVOTOUGH LaserExact Monitor Overview

1. Cabinet
2. Display
3. LaserExact cell
4. Gas inlet (std. 6 mm SS pipe)
5. Gas outlet (std. 8 mm SS pipe)
6. Laser beam alignment chamber
7. Alignment Chamber Purge gas inlet (std. 6 mm Swagelok)
8. Optional protective shroud (shown transparent for clarity)

3.2.1 SERVOTOUGH LaserExact installation



WARNING

You must not modify the Laser monitor in any way (either mechanically or electrically). If you do, the certification of the monitor will be invalidated, and it may not operate safely.



WARNING

The Laser monitor is heavy (see section 1.7). Take care to handle the analyser safely and securely during installation.



WARNING

The Laser monitor must be installed by a suitably skilled and competent technician or engineer in accordance with this manual and to the special conditions of installation contained within the manual.



WARNING

Make sure that power is disconnected or switched off before connecting any cable.



WARNING

Obey the safety instructions given below when you install the Laser monitor; if you do not, the monitor certification may be invalidated, the monitor may not operate correctly, or it may be damaged.



WARNING

You must mount the Laser monitor on a structure which is capable of supporting the mass of the Laser monitor (refer to product data).



WARNING

Sample and calibration gases may be toxic, asphyxiant or flammable. Ensure that the external connections are leak free at full operating pressure before use of sample or calibration gases and that they vent to avoid exposure to personnel.



WARNING

If using toxic, asphyxiant or flammable sample or calibration gases, open cabinet or alignment chamber enclosures in a force ventilated open area, or in another appropriate environment in which any hazardous gases are directed away from the user.



WARNING

The ATEX Zone 2 and CSA CL I Div 2 Hazardous area variant cannot be used for oxygen enriched samples; that is, gases over 21% O₂. If used with gases containing over 21% O₂ the hazardous area certification is invalidated.



WARNING

Power shall only be applied to the analyser when the alignment chamber is fully assembled in accordance with the instructions below and the beam cannot be accessed.

CAUTION

Do not install the Laser monitor on a surface which is subject to high levels of vibration or sudden jolts. If you do, sample measurements may not be accurate, or the monitor may be damaged.

The environmental conditions for the SERVOTOUGH LaserExact Monitor are listed in the product data section 1.7 of this manual.

Read thoroughly all instructions prior to installation.

All external parts are made of stainless steel or aluminium. All threads should be lubricated using suitable grease before installation. Please note that there is no separate mains switch on instrument.

Inspect, test and replace seals regularly to ensure that external connections are leak free at full operating pressure at all times.



WARNING

The cabinet contains a small battery. Do not open when an explosive atmosphere may be present.

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To install the instrument follow the steps below (see also Figure 3-1).

1. Install the instrument in an upright position. Use the mounting tabs provided with the analyser.
2. Connect the sample gas tubes as follows:
 - Gas INLET 6mm OD (front of unit)
 - Gas OUTLET 8mm OD (rear of unit)
 - Metric Swagelok fitting are supplied loose for use, however other connectors may be used provided they are compatible with the inlet and outlet pipes provided. Therefore gas inlet and outlet must not be confused. We recommend stainless steel tubes.
3. If applicable connect a purge INLET to the alignment chamber (connection between the inlet and outlet pipes)
4. Connect optional output signals (4-20 mA, warning relays, etc.) to the "Auxiliary" terminals inside the cabinet (use the auxiliary cable gland, Figure 6-1). Refer to Section 6.3.
5. Connect external 4-20 mA temperature and pressure probes (ref. Section 6.2 and 6.5). This is optional as some instruments operate without probes. Input signals are connected to the terminals inside the cabinet.
6. Open the gas lines. Check all connections for gas leaks before operating the monitor.


The SERVOTOUGH LaserExact Monitor can now be switched on. This procedure is described in Section 3.3.

3.2.2 Purging of laser beam alignment chamber

Note that some instruments may require purging with Nitrogen or clean dry air for measurement purpose i.e. the target gas must be removed from the internal measurement path to achieve sufficient measurement accuracy, or to ensure toxic or flammable gases do not build up within the chamber. Examples are low level O₂ or CO₂ instruments for measurement or H₂S or HCl for toxic/flammable.

In this case the laser beam alignment chamber (one Swagelok connection) must be purged (see Figure 3-2). Since there are optical surfaces inside this chamber, the cleanness of the gas must be ensured and additional filtering may be necessary.

The purge flow must not be high to avoid overpressure inside. It is recommended setting the flow to around 0.5 l/min. The purge flow will be vented to atmosphere through the purge outlet port at the base of the cabinet (see Figure 3-2).



WARNING

The user must monitor the sample flow rate out from the measuring cell. A fall in flow rate could indicate a gross leak of sample gas into the LaserExact enclosure.

In the event of a suspected leak, ensure you follow all warnings regarding purging of the sample system before inspecting the unit.

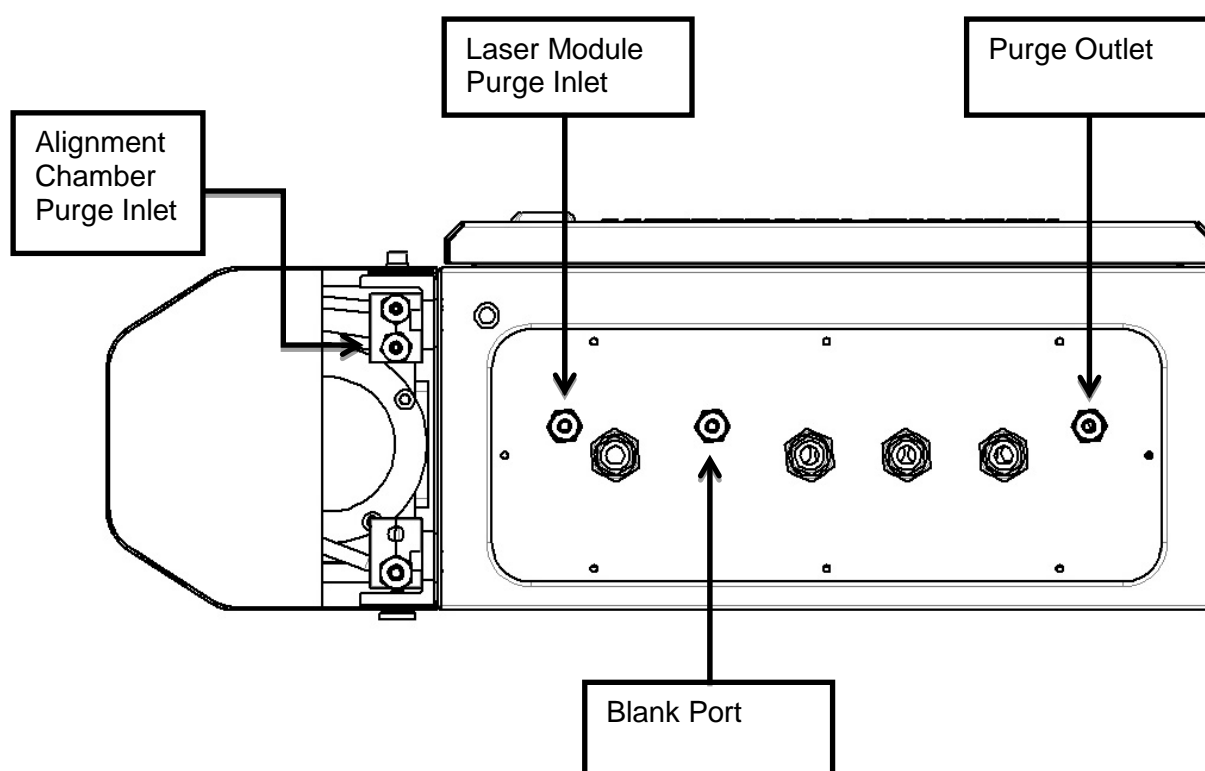


Figure 3-2: Purge connections

3.2.3 Laser module purge

A second purge system may also be fitted to the LaserExact monitor. This purge is for measurement purposes only and is usually included for low level measurements of gases such as O₂ and CO₂. This purge is connected through a ¼" OD SS pipe on the unit (see Figure 3.2) and is a high pressure Laser Module purge and requires a purge pressure of 2bara.

3.3 Start-up

Switch on the electronics. The LCD on the cabinet will enter start-up mode showing:

STL MONITOR 6.1a1	
- power -	
Self-test	OK
Start-up	0.998



WARNING

The laser beam is switched on when any indication is shown on the display, or the backlight is illuminated.

The start-up sequence will make sure the laser is tuned to the correct temperature before it is switched on, and the instrument performs a self-test on all systems. Allow about 5 minutes for the instrument to start the laser.

The instrument is aligned for maximum transmission at the factory. When the laser has started up the LCD should show a transmission close to 100% unless the alignment has changed during transport. Let the instrument run for at least one hour before eventually realigning the instrument as to allow the temperature of the instrument to stabilize and stresses in mechanical parts to settle. If the transmission is below 90% fine adjustment of the mirrors inside the laser beam alignment chamber is recommended to maximise the transmission (refer to Section 3.4). If the LCD shows «Laser line-up error» and «Low transmission» a more comprehensive realignment or cleaning of the mirrors may be required. Please refer to Section 5.2.2 or contact your local distributor for assistance.

3.4 Alignment of laser beam



WARNING

CLASS 3R LASER PRODUCT

NON VISIBLE LASER RADIATION – AVOID DIRECT EYE CONTACT

Necessary tools for the adjustment procedure:

- 1 pcs 2mm Allen key for the alignment chamber lid
- 1 pcs 2mm Allen key for the alignment chamber mirrors
- 1 pcs 5mm Allen key to remove the protective cover

1. Remove the outer protective cover by removing front screws and lifting off the cover.
2. Make sure that the following bolts and nuts are tightened firmly:
 - The four bolts fastening the laser unit to the alignment chamber (accessible from the inside of the cabinet)
 - The four bolts fastening the inner rod with the mirrors to the alignment chamber (accessible only after removing the cell body by loosening the four bolts fixing it to the beam alignment chamber).
3. Leave the instrument switched ON, and remove the lid to the left on the laser beam alignment chamber by unscrewing the eight screws (see Figure 3-3).
4. Alignment of the laser beam to ensure maximum signal is accomplished by measuring the alignment voltage with a voltmeter and the supplied cable with miniature power plug. The alignment voltage varies from 0V at 0% transmission to -3V (typically) at 100% transmission. The alignment voltage is measured by connecting a voltmeter to the white plug J14 "line-up voltage" inside the cabinet using the supplied cable.
5. There are two mirrors inside the laser beam alignment chamber; the input-coupling mirror is the one closer to the cell (see Figure 3-4). Carefully adjust the two screws on the input-coupling mirror to maximise the voltmeter reading. First adjust one screw until maximum voltage, and then adjust the other screw. Repeat until the voltage has reached a maximum.
6. The output-coupling mirror is the mirror further away from the cell (see Figure 3-4). Carefully adjust the two screws on the output-coupling mirror to maximise the voltmeter reading. First adjust one screw until maximum voltage, and then adjust the other screw. Repeat until the voltage has reached a maximum.
7. Disconnect the voltmeter and close the cabinet.
8. Remount the lid on the laser beam alignment chamber and tighten the screws firmly.

Having completed the previously described operations successfully, the installation and process parameters need to be set correctly using a PC and the SERVOTOUGH LaserExact software to enable correct measurements. Setting of these parameters is explained in Section 4.

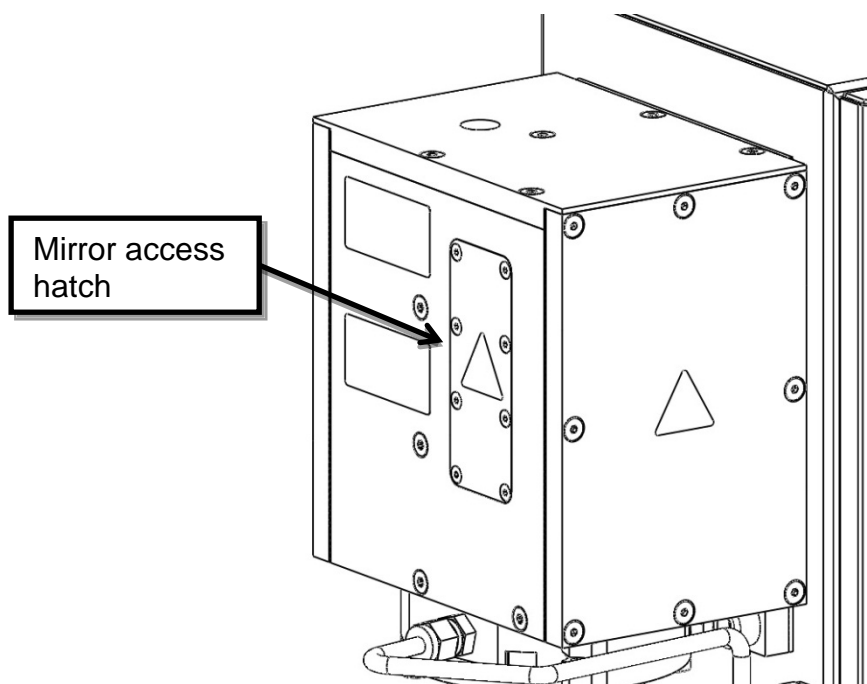


Figure 3-3: Alignment chamber access panel

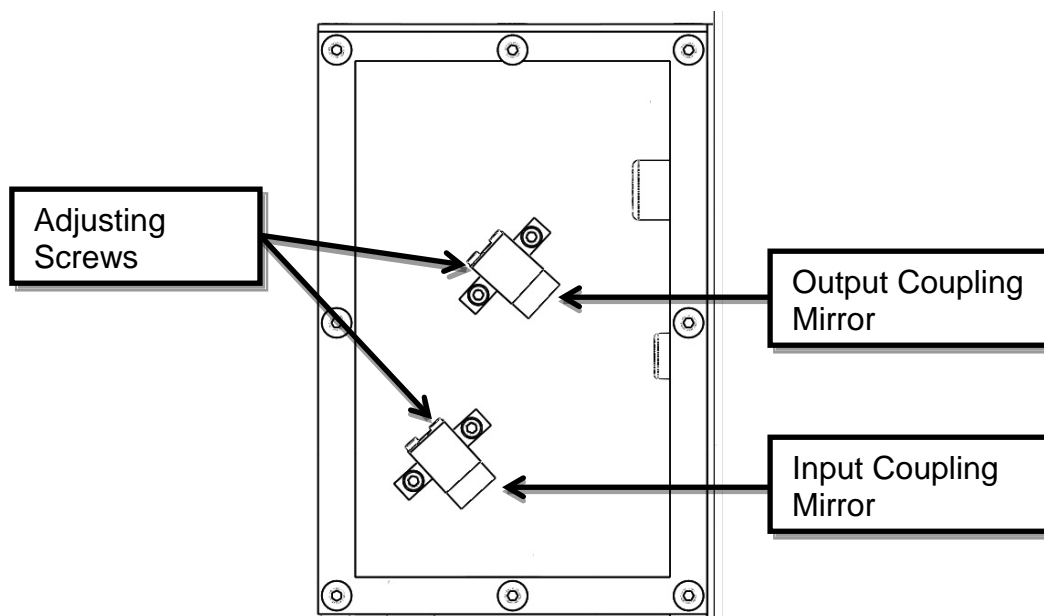


Figure 3-4: Coupling mirrors

3.5 Connecting a PC

The software for service communication with the SERVOTOUGH LaserExact is supplied with the instrument and will run under Windows98/2000/XP/Vista/7. The service program requires no installation. Please note that the PC should be placed in an explosion safe area. For long distance communication we recommend to use the optional Ethernet connection.

1. Copy the software supplied with the CD onto the hard disk into a specified directory, which may be called for example "LaserExact".
2. Connect a PC serial port to the RS-232 connection on the connection PCB (Figure 6-1) using the supplied serial cable and gender changer. The service program uses the serial port configured as 9600 baud, no parity, 8 bits and 1 stop bit. If network communication is used, connect the network cable to the Base-T connector on the connection PCB (Figure 6-1). Note that in this case the serial cable must be disconnected from the instrument.
3. Thoroughly check the following parameters against the installation details and set them using the software (see Chapter 4 for detailed description):
 - Process gas pressure and temperature (Chapter 4.3.5)
 - Instrument gas alarm level (Chapter 4.3.6)
 - Gas concentration corresponding to 4 and 20 mA (Chapter 4.3.5)
 - Concentration averaging (Chapter 4.3.5)
 - Instrument time (Chapter 4.3.5)
 - Gas concentration unit (Chapter 4.3.6)
 - Optical path parameters (Chapter 4.3.5)

Having completed the setting of all necessary parameters, the instrument is in normal operation mode and should indicate this by updating the gas concentration on the LCD periodically. Operation, maintenance and calibration of the instrument are further explained in Chapter 5.

3.6 Installing a modem

Note that an optional modem must be located outside the Ex area.

A standard 56k analogue modem is connected to the instrument via the service connector (ref. Figure 6-1). Use a null modem cable or an adapter together with the RS-232 cable between modem and instrument. NB: A gender changer may be required between the cables.

In addition to the modem connected to the instrument, a standard 56k analogue modem capable of 9600 baud has to be connected to one of the PC's serial ports. At start-up of the instrument the modem is initialised, and at start-up of the service program the PC-modem is initialised. No additional configuration of the modems is necessary. Reset the instrument!

4. THE SERVICE PROGRAM

The instrument calculates the gas concentration from the measured signal, which depends on several process parameters. The instrument must therefore be configured for the specific installation. With the service program the user communicates with the instrument and changes installation or process relevant settings. With a PC connected to the instrument via a standard serial communication port the operator can perform the following major tasks:

1. Monitor the measured concentration and the laser beam transmission;
2. Plot the measured concentration as a function of time;
3. Log the concentration and other control parameters to a file;
4. Display the measured signal;
5. Save the measured signal and other control parameters to a file;
6. Observe and erase the instrument error logging;
7. Configure the 4-20 mA process temperature and pressure inputs;
8. Configure the 4-20 mA measurement output;
9. Change the measurement averaging time;
10. Set the gas alarm level;
11. Set the optical path parameters;
12. Change the concentration unit;
13. Change the format of the displayed concentration;
14. Change the instrument clock time;
15. Calibrate the instrument;
16. Save all instrument parameters to a file;
17. Restore the instrument parameters from a file.
18. Configure the (optional) Ethernet connection

Through different menus the necessary installation parameters may be set. After setting the necessary parameters the PC is no longer needed. The SERVOTOUGH LaserExact has all the parameters stored in the internal memory. The PC can therefore be disconnected and the SERVOTOUGH LaserExact can be turned off and on without resetting the parameters.

4.1 Software start-up

After starting the program a welcome screen will display a selection of instrument to PC connections:



The version of the service program is printed in the right bottom corner (in the example above V1.2.7.3).

For direct serial or modem connection, select the PC serial port from the dropdown list of available ports and press the corresponding button. When using a modem, you will be asked for a telephone number to dial. If the first digit in this phone number is zero, the software will pause after dialling the zero before dialling the rest of the digits. If additional pausing is needed, apply ",", between the digits.

If communication via LAN is used, you will be asked for IP address and port number: The IP address and port numbers are typically set to default values 192.168.1.237 and 5001, respectively. If the IP address and port number need to be changed, run the program with direct serial connection and configure TCP/IP parameters as described in Section 4.3.8.

After the connection with the instrument has been established you are prompted to start the program in User or Advanced mode.

Press <User mode> to start the program. This program mode provides a simplified interface with limited access to the instrument setting parameters and should be used during installation and normal operation of the instrument. A password is only required for Advanced mode that enables full access to all the instrument setting parameters. This program mode should be used during service adjustment of the

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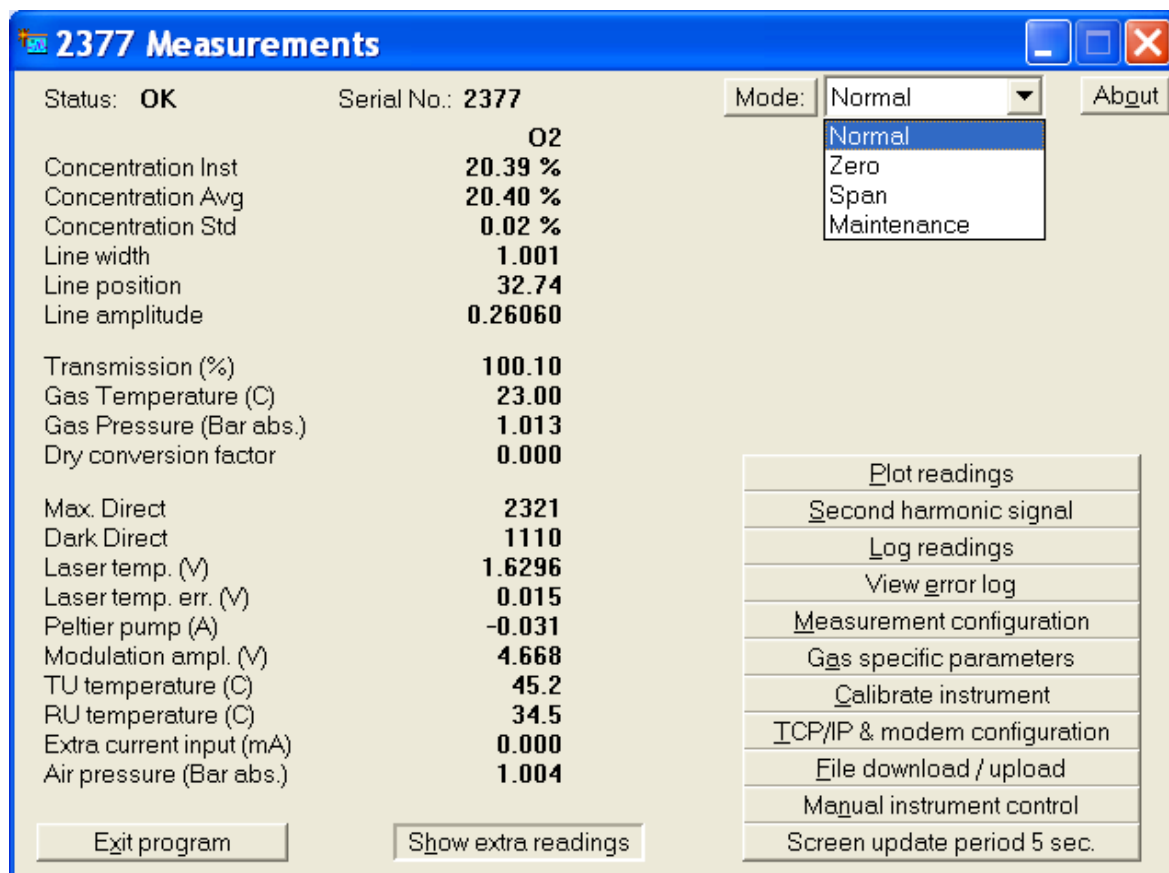
instrument. Your local distributor or SERVOMEX can provide the password on request.

Note that if the connection is moved to another instrument the program must be shut down and run again. It is possible to run several program windows simultaneously to communicate with different instruments using one PC.

The service program can also be started without a connection to an instrument by pressing <Demo mode>. This is for demonstration purposes of the service program. Two extra files are needed for this mode to work: *.dmp or *.rea and *.set or *.stt. These files can be created using the service program when a PC is connected to an instrument. The files are created by downloading the instrument readings to *.rea and settings to *.set (ref. Section 4.3.9). Alternatively, one can use the files supplied with the service program on the CD. These files were downloaded from the instrument at the factory prior to shipment.

4.2 The measurement menu

After pressing the <User mode> button the program opens the **Measurements** menu. The example below is for an instrument measuring oxygen.



2377 Measurements	
Status: OK	Serial No.: 2377
Mode: Normal	
O2	
Concentration Inst	20.39 %
Concentration Avg	20.40 %
Concentration Std	0.02 %
Line width	1.001
Line position	32.74
Line amplitude	0.26060
Transmission (%)	100.10
Gas Temperature (C)	23.00
Gas Pressure (Bar abs.)	1.013
Dry conversion factor	0.000
Max. Direct	2321
Dark Direct	1110
Laser temp. (V)	1.6296
Laser temp. err. (V)	0.015
Peltier pump (A)	-0.031
Modulation ampl. (V)	4.668
TU temperature (C)	45.2
RU temperature (C)	34.5
Extra current input (mA)	0.000
Air pressure (Bar abs.)	1.004

Plot readings
Second harmonic signal
Log readings
View error log
Measurement configuration
Gas specific parameters
Calibrate instrument
ICP/IP & modem configuration
File download / upload
Manual instrument control
Screen update period 5 sec.

Exit program Show extra readings

The serial number of the instrument is shown in the title line of the menu. The bottom right of the screen shows different menus which can be accessed either by

pressing the buttons or by pressing the underlined shortcut letters (e.g. <S> for Second harmonic signal). By pressing <Exit menu> one can always go back to the previous menu. The description of each menu will follow.

The rest of the screen is used to display different readings parameters. By default only the main readings parameters are displayed. By pressing <Show extra readings> all parameters are displayed. (NB: <Show extra readings> is activated in the example above).

The instrument readings update period is set by pressing <Screen update period>, which is 5 seconds by default. This time should not be shorter than the time required to calculate the concentration (the update time of the LCD).

The parameters are explained in detail below:

Status: The instrument status which may be SLEEPMODE / STARTUP / OK / WARNING / ERROR. See Section 5.1.

Serial Nr: Serial number of the SERVOTOUGH LaserExact.

Mode: The measuring mode of the instrument. By clicking on the mode button 4 different measuring modes may be selected. See Section 5.1 for details.

Concentration Instant: Displays the last value calculated by the SERVOTOUGH LaserExact with no averaging. This is in the following called a primary measurement.

Concentration Average: Displays the running average calculated by the SERVOTOUGH LaserExact (not by the service program) from the last N values, where N is the averaging count specified in menu <Measurement configuration>. A description of the averaging method will be given in that subsection.

Concentration Standard: Gives an estimate of the running standard deviation also calculated by the SERVOTOUGH LaserExact. This number indicates how much the calculated gas concentration fluctuates from its average value. If the gas concentration is truly constant it will provide a measure of the instrument precision.

Line width: Relative measure of the width of the absorption line. In combination with the line amplitude it determines the integrated absorption, which in turn is used to calculate the gas concentration. The reference line width parameter is equal to 1.000 at T=23°C and P= 1.013 bar (1 atm.) and when the gas composition is equal to those used when calibrating the instrument. The line width increases with gas pressure and decreases with gas temperature. It also depends on the gas composition, for example water vapour broadens the absorption lines significantly.

Line position: The position of the line peak (maximum absorption) in samples of the AD converter [0..63]. The value should be close to the reference line position, which is given in the menu <Gas specific parameters> for the corresponding line. The instrument automatically tracks the line, i.e. if it deviates more from the reference position than a given value, the instrument adjusts the laser temperature and thereby the wavelength.

Line amplitude: Relative measure of the peak of the absorption line of the second harmonic signal. If this value approaches 0.5-1.0 the absorption is strong and saturation of the AD converter may be very close (actual saturation initiates the ERROR). In the region 0.01-0.1 the signal is good. Below 0.01 the signal is approaching the low level below which line width cannot be measured and line tracking is off.

Transmission (%): Indicates how much light the receiver detects in % of the maximum value. If the optical windows or the mirrors are covered with dust and the transmission drops below a pre-set level, a warning will appear on the display of the SERVOTOUGH LaserExact Cabinet. The cell window or the mirrors inside the cell may have to be cleaned (see Section 5.2.2). The warning will also appear for improper alignment of the mirrors in the beam alignment chamber.

Gas temperature (°C): The temperature currently used to calculate the gas concentration. It may be a fixed value set by the user, the value measured by a 4-20 mA current T-probe or the value measured by the instrument itself optically or electrically. Optically measured temperature is called Spectral temperature. Electrically measured temperature is the temperature measured by the embedded temperature sensors (only used when the gas temperature is equal to ambient temperature) offset-corrected to be equal the ambient air temperature. In the example above the gas temperature is set equal to the Spectral temperature. These settings can be configured in the <Measurement configuration> menu.

Gas Pressure (Bar abs.): The pressure in Bar absolute currently used to calculate the gas concentration. It may be a fixed value set by the user, the value measured by a 4-20 mA current P-probe or the value measured by the instrument itself using the embedded pressure sensor (mainly for O₂ instruments and only used when the gas pressure is equal to the ambient air pressure). This is configured in the <Measurement configuration> menu.

Dry conversion factor: Factor currently used to multiply the gas concentration if dry basis conversion is selected (see Section 4.3.5). The initial (wet) concentration reading may be converted to dry reading if the H₂O concentration is known. If dry basis conversion is not activated the factor is always 1.0.

Max. Direct: Maximum value of the direct signal in the levels of AD converter [0 - 4096]. This value together with *Dark Direct* determines the value of the light transmission.

Dark Direct: Optical zero of the direct signal measured when the laser is switched off for a short period. The unit is the same as for *Max. Direct*.

Laser temp. (V): The voltage across the thermistor located in the vicinity of the diode laser. Higher voltages indicate lower laser temperature. Changing laser temperature changes the laser wavelength.

Laser temp. error: The amplified difference in Volts between the measured *Laser Temp* and the reference value. Should be around 0.000. It indicates the quality of the laser temperature regulation and thus the quality of the wavelength stabilization.

Peltier pump (A): The current drawn by the Peltier element.

Modulation ampl. (V): Amplitude of the high frequency modulation voltage to the laser.

TU/RU temp.: The temperatures measured by the embedded thermistors located inside the transmitter and receiver unit.

Extra current input (mA): Current measured on extra current input (Flow 4-20 mA input).

Air pressure (Bar): The ambient pressure measured by the embedded pressure sensor located inside the cabinet.

4.3 The program menus

4.3.1 Plot readings

Plot readings plots the measured average and instant concentration of gases, transmission and spectral temperature (if measured). Two different plots can be shown simultaneously. Clicking on the axis labels modifies the scale of the plot.

4.3.2 Second harmonic signal

Second harmonic signal displays signals recorded by the instrument for calculation of the gas concentration. This signal is also useful for inspection and analysis of the absorption spectra, verification of proper laser function, and fault diagnostics. In total three curves are displayed: the normalised second harmonic signal as detected (pink curve) and the same signal after filtering with two different filters (yellow and blue curves). For some instruments only one filter is applied to the signal.

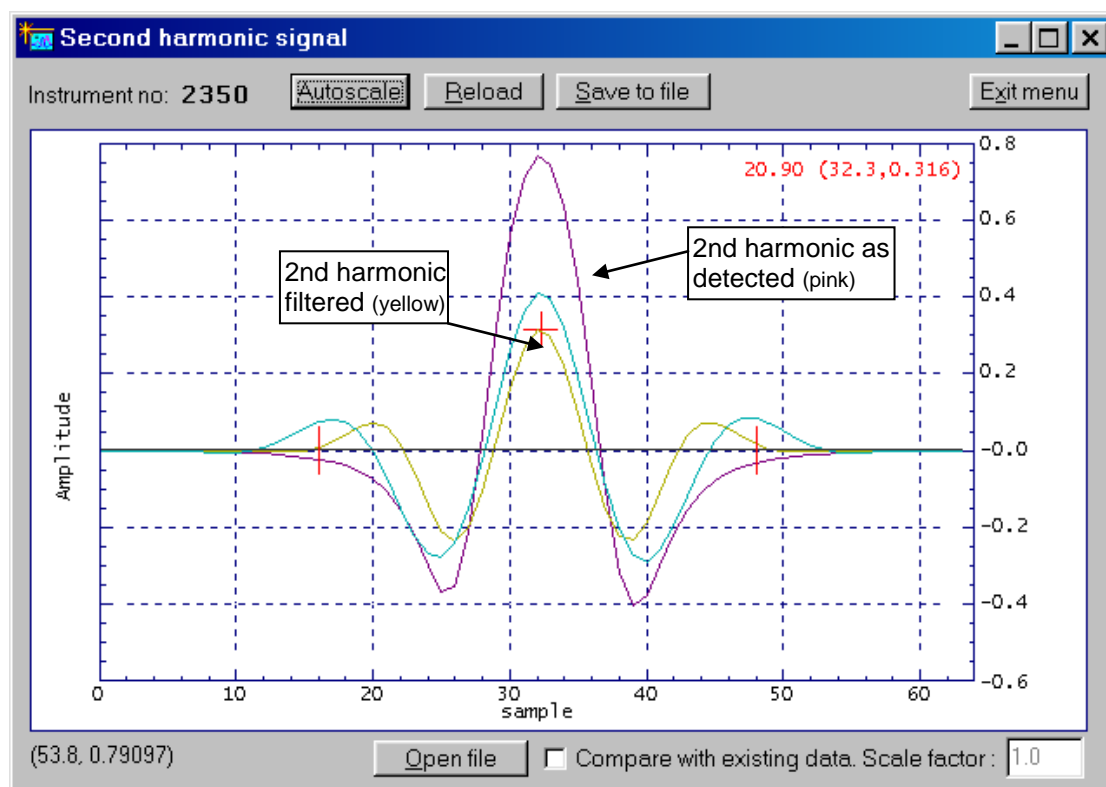
The example given below displays the signal from an oxygen absorption line. The peak of the yellow curve is marked with a red cross. The instantaneous gas concentration as measured from this line; the sample number and position of the peak are printed in the upper right corner in parenthesis. The latter are referred to

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as *Line position* and *Line amplitude* described in previous Section 4.2. The line position must be within the acceptance window marked by the two vertical red lines. For some instruments such as dual gas instruments more than one absorption line is plotted.

With the <Reload> button the second harmonics signal is updated. The data can be saved to file (<Save to file>) for later analysis. This is equivalent to <Download readings> in the **File download/upload** menu (Section 4.3.9). The scale of the axes is modified by clicking on the axes labels.

It is possible to open a previously saved signal and scale it to compare with existing signal. There will be shown two curves for each signal.



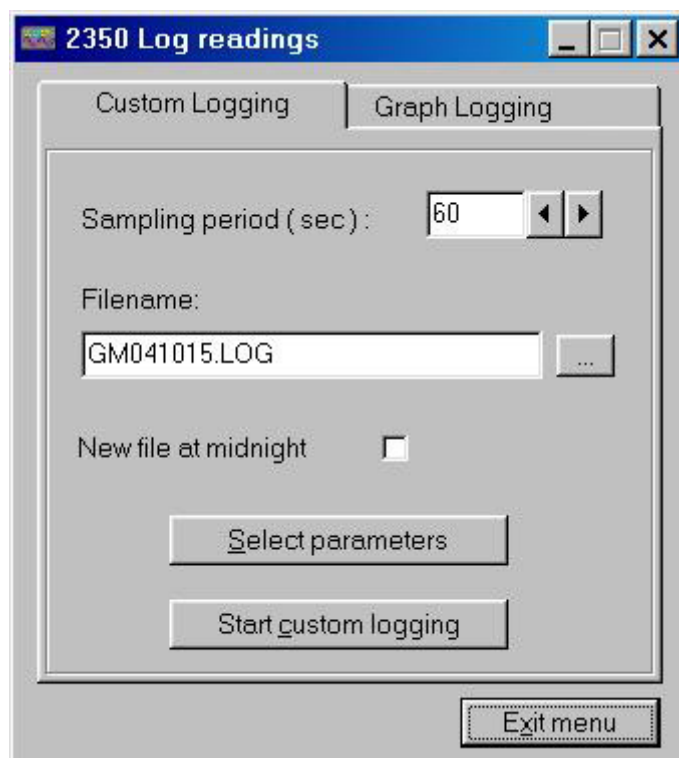
4.3.3 Log readings

With <Custom Logging> all data displayed in the **Measurements** menu can be logged to an ASCII file at specified regular intervals. The sampling period (logging interval), file directory, and the filename are user defined (default filename is "gmYYMMDD.log"). If <New file at midnight> is selected the program will create a new logging file at every midnight with the default filename reflecting the new date.

Before logging <Select Parameters> should be pressed and the parameters of interest should be marked. The selected parameters are automatically arranged in columns in the logging file. The first column is always seconds after the last midnight (PC time) and the last two columns are always the instrument status (-4 (sleepmode)/ -1 (startup)/ 0 (ok)/ 1 (warning)/ 2 (error)) and the measurement

mode (0 (ok)/ 1 (zero)/ 2 (span)). Parameters can be added to or deleted from the logging file without interrupting the logging process. The configuration of the logging file may be modified (e.g. specify text qualifier, data separator, add comment on top etc.).

The second possibility to log data is *Graph logging*. In this case the data are logged into an ASCII file, which is compatible with data presentation programs. The output format cannot be selected, the filename cannot be changed and <New file at midnight> is always selected.



4.3.4 View error log

After pressing <View error log> the program downloads the log of the instrument's errors and warnings (see Section 5.4 for description of the errors) including the date and time of their last activation and deactivation. The currently active errors and warnings are marked with a cross (x), while the inactive errors are marked with a dash (-). <Save error log> saves the current list of errors to a text file. <Clear error log> clears all the errors and warnings from the instrument's internal memory.

The instrument also stores the log (System log) of internal status and self-test information. This information is useful for advanced diagnostics and fault-finding and downloaded to a text file by pressing <Save system log>. Older system information may be downloaded by pressing <Rewind system log 100 lines> and subsequently <Save system log>.

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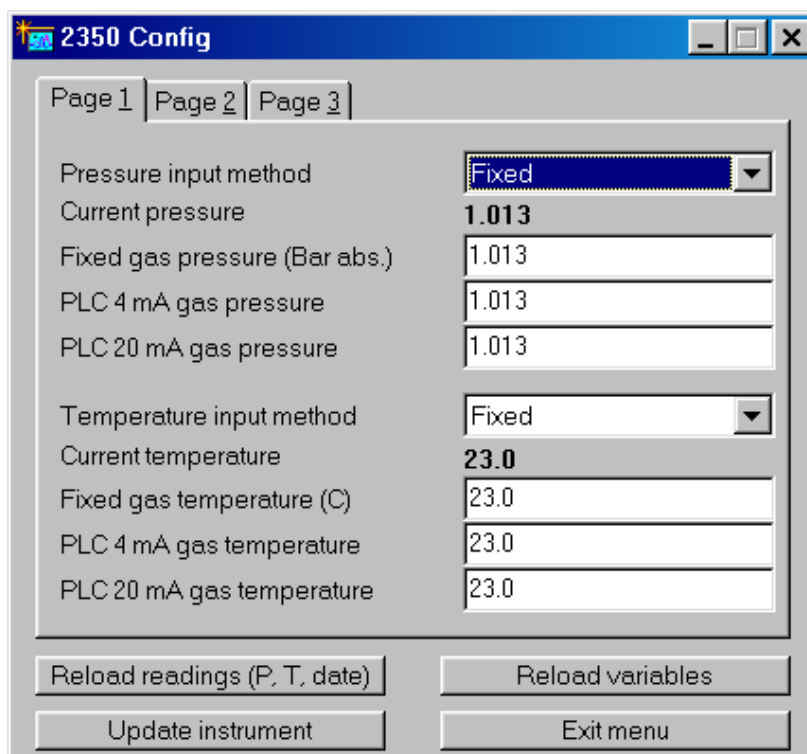
In case of instrument failure it is always useful to download the error log and the system log and send both files to SERVOMEX for diagnostics.

4.3.5 Measurement configuration

In this menu the most important parameters can be set:

Gas pressure	(page 1)
Gas temperature	(page 1)
Pressure / temperature input method	(page 1)
Pressure / temperature PLC input range	(page 1)
Concentration averaging	(page 2)
Optical path variables	(page 2)
Instrument time	(page 2)

Note that the parameters are modified in the program but the instrument is not updated with the new values until the button <Update instrument> is pressed.



The screenshot shows a software window titled "2350 Config" with three tabs: "Page 1", "Page 2", and "Page 3". The "Page 1" tab is selected. The window contains two main sections for configuration. The first section is for "Pressure input method", which is set to "Fixed". Below this, there are four input fields: "Current pressure" (1.013), "Fixed gas pressure (Bar abs.)" (1.013), "PLC 4 mA gas pressure" (1.013), and "PLC 20 mA gas pressure" (1.013). The second section is for "Temperature input method", which is also set to "Fixed". Below this, there are four input fields: "Current temperature" (23.0), "Fixed gas temperature (C)" (23.0), "PLC 4 mA gas temperature" (23.0), and "PLC 20 mA gas temperature" (23.0). At the bottom of the window, there are four buttons: "Reload readings (P, T, date)", "Reload variables", "Update instrument", and "Exit menu".

Gas pressure and temperature

The strength of the absorption line and line width are pressure and temperature dependent. This is compensated for by calculating a correction factor based on deviation of pressure and temperature from the standard atmosphere ($P=1.013$ bar, $T=23$ C). For relative concentration units (ppm, %, mg/Nm^3 , g/Nm^3) the gas pressure and temperature are in addition directly involved in calculation of the

concentration through the ideal gas law. Therefore, correct setting of gas pressure and temperature is important for the accuracy of the measurement. *Current pressure* and *Current temperature* are the values used for calculation at present. These values are only downloaded from the instrument after an update of parameters or explicitly after pressing <Reload readings (P, T, date)>.

Note that the gas pressure is always specified in bar **absolute**. To convert pressure from bar gauge to bar absolute use the following relation:

$$P(\text{bara}) = 1.013 + P(\text{barg})$$

To convert pressure from Psig to bar absolute use the following relation:

$$P(\text{bara}) = 1.013 + P(\text{psig})/14.5$$

Note that the gas temperature is always specified in Celsius. To convert temperature from Fahrenheit to Celsius the following relation can be used:

$$T(\text{C}) = (T(\text{F}) - 32)/1.8$$

To convert temperature from Kelvin to Celsius the following approximate relation can be used:

$$T(\text{C}) = T(\text{K}) - 273$$

Pressure and temperature input method

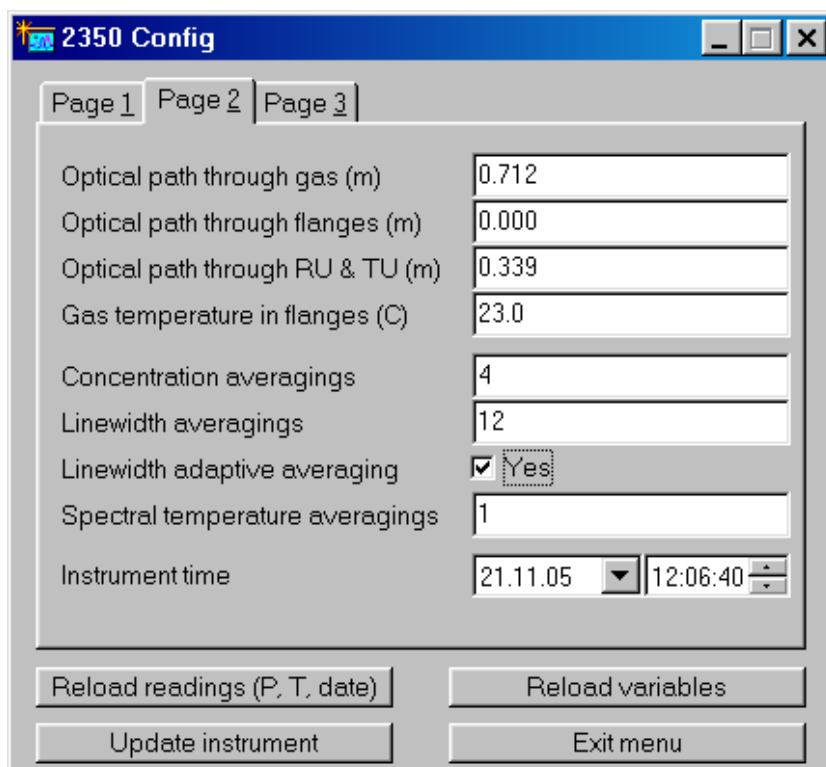
<Pressure/Temperature input method> defines if the values are fixed or read with one of the following methods: Current loop, Internal, Spectral, and Serial.

If method “Current loop” is activated the values are input from the corresponding 4-20 mA current input. In this case the PLC 4 mA and PLC 20 mA values must be specified.

Method “Internal” sets the gas pressure equal to the ambient pressure measured by the internal pressure sensor (*Air pressure* in **Measurements** menu). The gas temperature is set equal to the average of the measured temperatures inside the RU and TU (*TU* and *RU Temp* in **Measurements** menu), which are offset corrected to be approximately equal to the ambient temperature.

Method “Spectral” (only for temperature) sets the gas temperature equal to the temperature measured spectroscopically. This method is only applicable for instruments measuring gas temperature like the O₂ +Temperature monitor.

Method “Serial”: Pressure and temperature input through RS-232 or Ethernet connector (requires special data packet, contact SERVOMEX for details).



2350 Config

Page 1 Page 2 Page 3

Optical path through gas (m) 0.712

Optical path through flanges (m) 0.000

Optical path through RU & TU (m) 0.339

Gas temperature in flanges (C) 23.0

Concentration averagings 4

Linewidth averagings 12

Linewidth adaptive averaging ☒ Yes

Spectral temperature averagings 1

Instrument time 21.11.05 12:06:40

Reload readings (P, T, date) Reload variables

Update instrument Exit menu

Optical path variables

The signal detected by the SERVOTOUGH LaserExact is proportional to the total absorption between the laser and the detector. To compensate properly for the absorption in air inside the optical units, the monitor must know some parameters described below. Please note that this is important only for monitors that measure atmospheric gases, such as O₂, H₂O, CH₄, etc.

The contribution to the absorption is divided into three regions: the measurement region (LaserExact cell), the laser beam alignment chamber, and the internal instrument region (the laser unit).

The following lengths apply for the analyser with standard cell:

- Measurement region 11.412m
- Laser beam alignment chamber 0.240m
- Instrument region 0.003m

These lengths are all factory set (still they can be changed in the software if necessary).

If the measured gas is not present in the alignment chamber or instrument region the only relevant parameter is the (factory set) path length through measured gas. The temperature in the alignment chamber (parameter <GAS TEMPERATURE IN FLANGES> is also irrelevant in this case.

The absorption depends not only on the gas concentration, but also on the pressure and temperature. It is assumed that gas concentration, pressure, and temperature are constant throughout each of these regions, but not necessarily the same for two regions. The gas temperature in the laser beam alignment

chamber can be specified, whereas the pressure is assumed the same as in the sample gas.

Note: The gas temperature and the optical path length through the laser beam alignment chamber are specified with the parameters <GAS TEMPERATURE IN FLANGES> and <OPTICAL PATH THROUGH FLANGES>. The temperature must be specified as accurately as possible.

Temperature sensors inside the cabinet measure the ambient air temperature. The ambient pressure is either measured by the internal pressure sensor or assumed to be equal to 1.013 bar (760 mm Hg = 1 atm) if it is not installed.

After specification of all optical path variables the gas concentrations in the laser beam alignment chamber and transmitter unit must be specified in the <GAS SPECIFIC PARAMETERS> menu.

Note: Proper setting of the optical path parameters is important for correct measurements.

Concentration averaging

The amount of primary measurements used to calculate the averaged concentration (*Concentration Avg* in **Measurements** menu). The instrument measures and calculates the gas concentration at regular intervals. A primary measurement (*Concentration Instant* in **Measurements** menu) takes approximately 1-4 seconds depending on the gas type. The instrument calculates a “running” average of the primary measurements, which is then output in the following three ways: 1) printed on the display in the electronics unit, 2) driven through the 4-20 mA analogue output, and 3) transmitted as a digital signal in the optical fibre output (optional). All these output channels use the averaged gas concentration. The display and the current loop are updated after every primary measurement, while new data is transmitted through the fibre optic output after the defined averaging time. The amount of averaging is specified by the averaging count ($T_{av} = N \times T_{prim}$).

Line width averaging:

Specifies the number of line width averaging.

Line width adaptive averaging:

Switched OFF = the rolling average (as for concentration) applies.

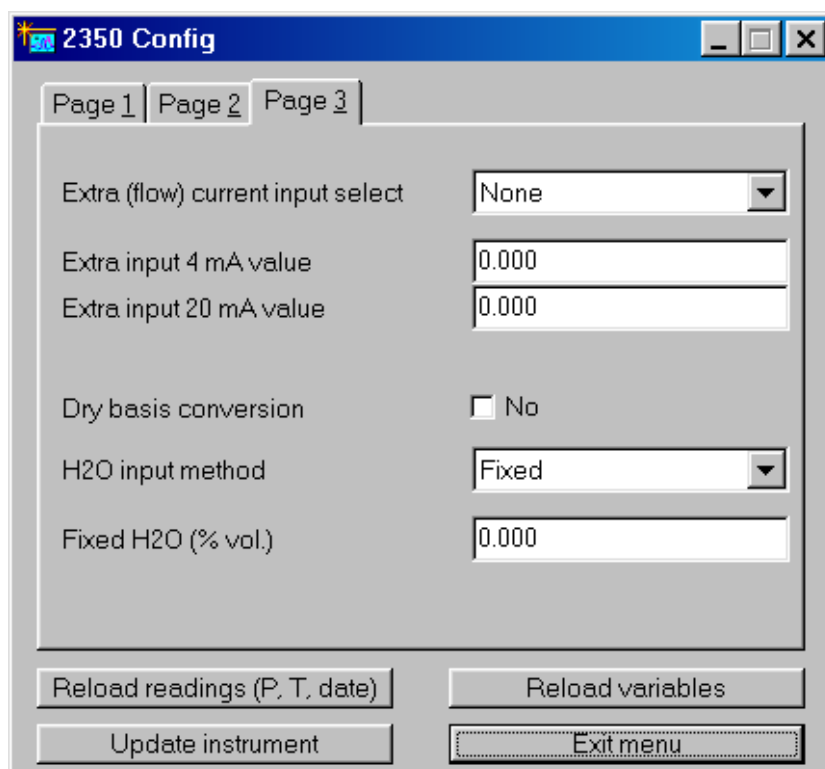
Switched ON = the number of averaging depends on the signal strength i.e. weak signals are averaged longer. NB: This will only be effective if line width averaging is specified > 10.

Spectral temperature averaging:

Specifies the number of spectral temperature averaging.

Instrument time

The instrument has a built-in clock, which also runs when power is off. Using this menu the instrument time should be set equal to the local time. The current instrument time is only downloaded from the instrument after an update of parameters or explicitly after pressing <Reload readings (P, T, date)>.



Extra (flow) current input select

Configures the extra (denoted as “Flow”) current input to the instrument. It can be set to “None”, “Gas - % vol”, “Gas - g/Nm³”, “Gas – g/m³”, and “Flow”. Input “None” simply deactivates the extra current input. For all other inputs the 4 mA and 20 mA values must be specified. The current input can be used to connect an external gas sensor (typically an H₂O sensor for dry basis conversion) to the instrument. In this case “Gas” input with the corresponding concentration unit should be selected. The measured input current can be monitored in the **Measurements** menu.

Input “Flow” is currently not implemented.

Dry basis conversion

The primary measurements of the gas concentration are on wet basis, except if moisture is removed by a sampling system installed between process and analyser. The instrument can also present the results on dry basis if the H₂O concentration is known. If <Dry basis conversion> is selected the instrument converts the measured concentrations according to the following simple equation:

$$N(\text{dry}) = N \cdot 100 / (100 - \text{H}_2\text{O}(\%))$$

where N is the originally measured gas concentration on wet basis and $H_2O(\%)$ is the input H_2O concentration in % vol. The factor that multiplies N is *Dry conversion factor* which can be monitored in the **Measurements menu**.

H_2O input method

The following input methods for the H_2O concentration can be selected: Fixed, Current loop, Measured, Calculated.

Method “Fixed” sets the H_2O concentration equal to the manually specified value.

With method “Current loop” the H_2O concentration is input from an external H_2O sensor via the Extra (Flow) current input. In this case Extra (flow) current input select must be set to “Gas-unit”, where “unit” corresponds to the output concentration unit of the external H_2O sensor. The 4 and 20 mA values must be specified. Method “Measured” can be used when the SERVOTOUGH Laser monitor is configured to measure several gases and one of them is H_2O . The maximum H_2O concentration used for dry basis conversion with this method is limited to 50% vol. If the measured concentration exceeds this value the value used for dry basis conversion will still be 50% vol. When method “Calculated” is selected, the instrument calculates saturated water vapour concentration based on the gas temperature and pressure input values. The calculated H_2O concentration is then used for dry basis conversion. The maximum gas temperature for this method is about 90°C and the maximum calculated H_2O concentration is limited to 70% vol. The same H_2O limit is used also for “Fixed” and “Current loop” methods.

4.3.6 Gas specific parameters

If the instrument monitors more than one absorption line a selection menu with the relevant gases appears first.

Upon selection of one gas the following menu is displayed:

Measured gas

Displays the gas type. Cannot be modified if the program runs in User mode.

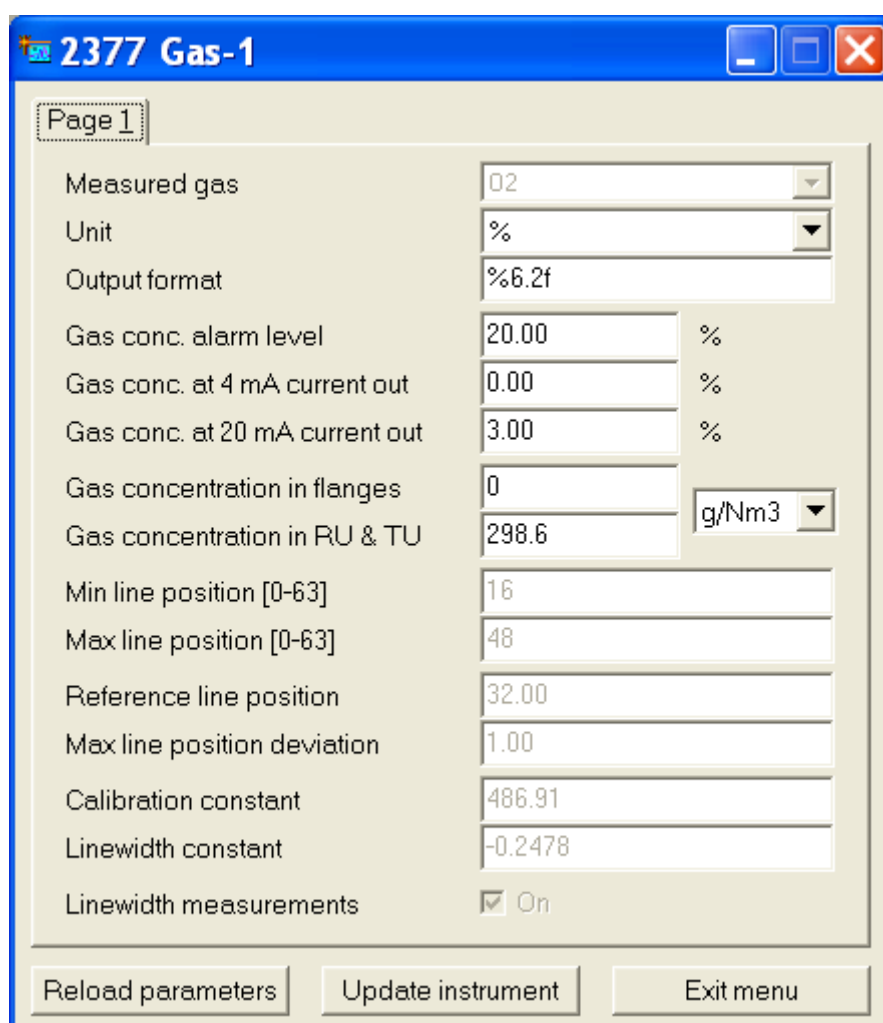
Unit

Select the appropriate unit for output of the gas concentration from the dropdown list.

The units may be grouped in two different categories, the absolute units: g/m^3 , mg/m^3 and ug/m^3 (*ug* refers to micrograms) and the relative units: %, *ppm*, *ppb*, g/Nm^3 , mg/Nm^3 and ug/Nm^3 .

Some more specific units are also available such as $\%*m$, $ppm*m$ and $ppb*m$. These units are often used for Open Path SERVOTOUGH Laser monitors and represent the concentration recalculated to 1 meter optical path length. Note that the actual path length in **Measurement configuration** menu should nevertheless be set to the correct value.

The primary unit used by the instrument to calculate the gas concentration from the absorption line is the absolute unit g/m^3 . All other units are calculated from this primary unit assuming the ideal gas law is applicable.



Parameter	Value	Unit
Measured gas	02	
Unit	%	
Output format	%6.2f	
Gas conc. alarm level	20.00	%
Gas conc. at 4 mA current out	0.00	%
Gas conc. at 20 mA current out	3.00	%
Gas concentration in flanges	0	
Gas concentration in RU & TU	298.6	g/Nm ³
Min line position [0-63]	16	
Max line position [0-63]	48	
Reference line position	32.00	
Max line position deviation	1.00	
Calibration constant	486.91	
Linewidth constant	-0.2478	
Linewidth measurements	<input checked="" type="checkbox"/> On	

Reload parameters Update instrument Exit menu

The relative units g/Nm^3 , mg/Nm^3 and ug/Nm^3 are the values obtained from the conversion of the absolute units (g/m^3 , mg/m^3 and ug/m^3) to standard pressure and temperature assuming the ideal gas law. According to the European standard which applies for the SERVOTOUGH LaserExact Monitor these values are $P = 1.013 \text{ Bar}$ and $T = 0^\circ\text{C}$. Please note that the US standard for the relative units g/Nm^3 and mg/Nm^3 deviates with regard to standard temperature and refers to 25°C .

Note that the gas concentration is always measured on “wet basis”, i.e. no correction is done for water vapour present in the process gas.

Output format

The numerical format of the gas concentration on the LCD display and in most parts of the service program.

The format is presented according to the programming language C (%6.2f means that the floating number will be presented with 2 decimals and 6 digits including the decimal point, e.g. 123.45).

Gas conc. alarm level

The gas concentration level for which the alarm relay is activated. The gas alarm level is specified in the currently active unit for gas concentration. If a different unit is later selected, the gas alarm level will not automatically be converted to the new unit but must be set manually. The alarm level is selected individually for different gases, although the alarm relay is common. Thus, if the concentration of any of the measured gas is above its alarm level, the alarm relay is activated. To exclude one or several gases from activating the alarm the corresponding alarm levels are set to deliberately unreachable values. See also Section 6.9 for different configurations of the gas alarm relay.

Gas concentration in flanges, RU and TU

The gas concentrations in the laser beam alignment chamber and the laser unit are located here, since they are individual for each gas. The corresponding optical lengths are common for all and are, therefore, specified in the <MEASUREMENT CONFIGURATION> menu. The gas concentration in the laser beam alignment chamber is specified with the parameter <GAS CONCENTRATION IN FLANGE>. The gas concentration in the laser unit is per default zero (filled with nitrogen) but can be modified with the parameter <GAS CONCENTRATION IN RU & TU> if necessary.

Note that the unit of the gas concentration in the alignment chamber is always g/Nm³ irrespective of the unit chosen for the measured gas concentration. For O₂ SERVOTOUGH LaserExact Monitors, if the alignment chamber is purged by air, the concentration of O₂ should be set to 298.6 g/Nm³. If the measured gas is not present in air and in the alignment chamber the gas concentrations must be set to zero.

Min/Max line position [0-63]

These values define the acceptance window (in samples) for the line position in the second harmonic signal (see Section 4.3.2). The values cannot be modified if the program runs in User mode.

Reference line position

Specifies the position of the absorption line (in samples) in the second harmonic signal. The value cannot be modified if the program runs in User mode.

Max line position deviation

Specifies the maximum deviation of the line position (in samples) from the reference line position. In case the deviation is larger than the specified value the instrument will adjust the laser temperature to bring the line back to the reference position. The value cannot be modified if the program runs in User mode.

Calibration constant

The constant used in calculation of the gas concentration. The calibration constant is modified after calibration (see Section 4.3.7). The value cannot be modified manually in this menu if the program runs in User mode.

Line width constant

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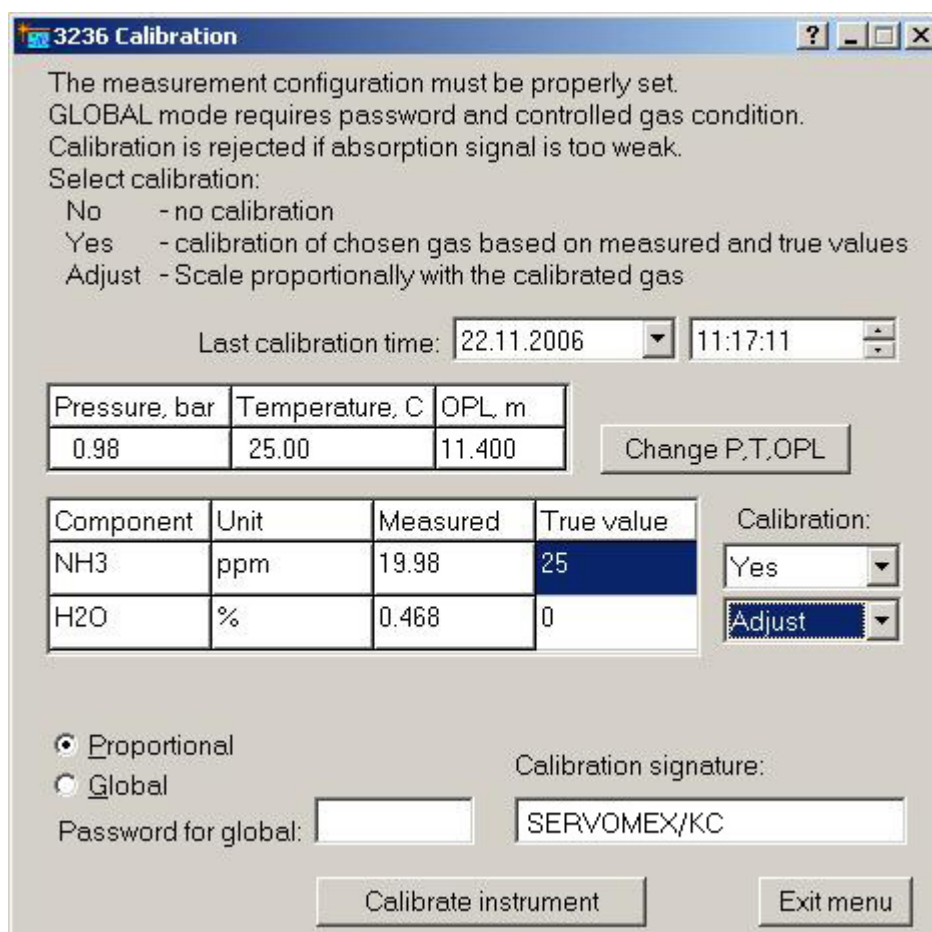
The constant used to calculate the line width, which in turn is used to calculate the gas concentration. The line width constant can be modified together with the calibration constant after calibration (see Section 4.3.7). The value cannot be modified manually in this menu if the program runs in User mode.

Line width measurement

This parameter switches the line width measurement function ON and OFF. If switched OFF the theoretical line width for the given gas pressure and temperature is used. If switched ON the line width is measured from the shape of the second harmonic absorption line. The value cannot be modified manually in this menu if the program runs in User mode.

4.3.7 Calibrate instrument

Calibration of all gases and the spectral temperature (if applicable) is carried out in this menu. The example below is for an instrument measuring two gases.



The measurement configuration must be properly set.
GLOBAL mode requires password and controlled gas condition.
Calibration is rejected if absorption signal is too weak.
Select calibration:
No - no calibration
Yes - calibration of chosen gas based on measured and true values
Adjust - Scale proportionally with the calibrated gas

Last calibration time: 22.11.2006 11:17:11

Pressure, bar	Temperature, C	OPL, m
0.98	25.00	11.400

Change P,T,OPL

Component	Unit	Measured	True value
NH3	ppm	19.98	25
H2O	%	0.468	0

Calibration: Yes Adjust

☒ Proportional
☐ Global

Password for global: SERVOMEX/KC

Calibration signature:

Calibrate instrument Exit menu

There are two available calibration modes: "PROPORTIONAL" and "GLOBAL", which can be toggled. The default calibration mode is **PROPORTIONAL**. In this mode the instrument performs proportional adjustment of the calibration constant based on the measured and supplied concentrations. There are no special

requirements to the gas parameters and signal quality. The PROPORTIONAL calibration may be done whenever it appears necessary to the user that the instrument measurements should be adjusted, for example during measurement of process gas. Please note the following:

- All gases can be calibrated individually. The true gas value is specified and "Calibration" is set to "Yes" from the corresponding dropdown list.
- For gases that are not to be calibrated, "Calibration" is set to "No" from the corresponding dropdown list.

It is also possible to auto-calibrate gases. Gas A is calibrated by filling in the true value and selecting "yes". Gas B is auto-calibrated by setting the correct value to zero and select "adjust". In this case the calibration constants for line amplitude and line width for gas B are adjusted according to the calibration of gas A. This is useful if only one calibration gas is available or if the relative ratio of the measured concentrations after the calibration shall be preserved.

In the example above, NH₃ gas is calibrated to 25 ppm. The calibration constants for H₂O will be adjusted accordingly.

Enter your initials for identification of calibration.

Press <Calibrate instrument> to update the instrument with a new calibration. The instrument will use the currently measured average concentration to perform all necessary calculations. The new calibration will be stored permanently. The calibration time will be updated automatically.

SERVOMEX calibrates all instruments under controlled conditions using certified gas. This calibration is then verified for the specified range of temperature and pressure. There is no need to calibrate the instrument upon reception.

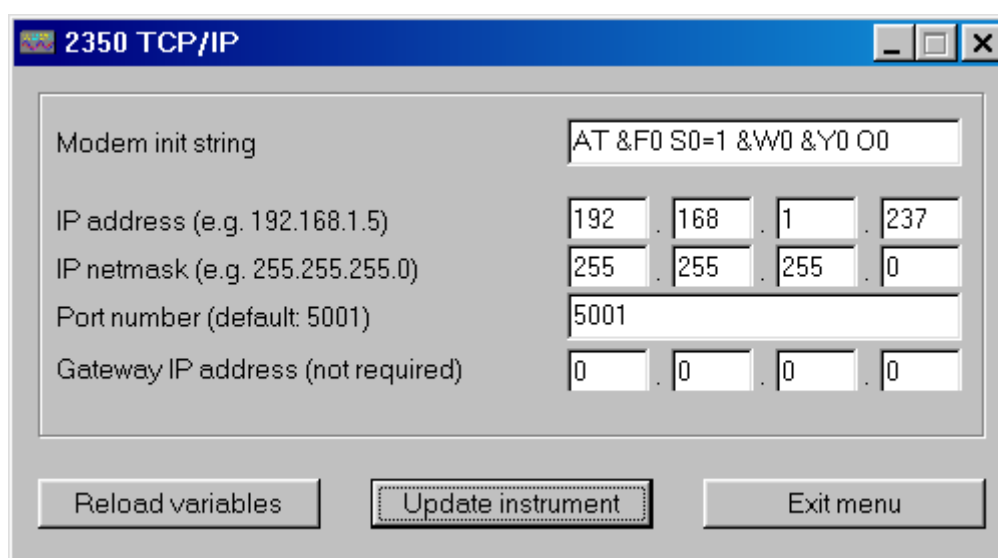
In the **GLOBAL** calibration mode the instrument performs reference measurements of the absorption line width in addition to the line amplitude. The calibration constant and reference line width are then adjusted based on these measurements. This calibration procedure requires stable and controlled conditions of the reference gas. It should be performed using a test cell and a certified mixture of measured gas with nitrogen and only if it was verified that the current calibration is not valid. The procedure requires technical skills and some experience in handling gas mixtures. As a rule only qualified personnel should perform GLOBAL calibration after major services. General recommendations concerning this calibration option are given in Section 5.3. To calibrate the instrument proceed in the same way as described above for PROPORTIONAL calibration mode. The only difference is that the program will ask for a password, which is available from the local distributor or the factory. The GLOBAL calibration, if performed correctly (ref. Section 5.3), guarantees the validity of the calibration parameters in the specified pressure and temperature range.

Calibration mode PROPORTIONAL/GLOBAL is common for all gases. Nevertheless, it is possible to calibrate one gas in global mode and another in proportional mode. In this case the mode is set to GLOBAL and the line width

measurements for the gas, which should be calibrated proportionally, must be switched OFF in **Gas specific parameters** menu (only for the program running in Advanced mode). It can be switched back ON after the calibration. Calibration mode is not applicable to the spectral temperature.

4.3.8 TCP/IP and modem configuration

TCP/IP parameters of the embedded Ethernet board (optional) and the initialising string of a modem can be configured using this menu.



Modem init string

This string is used to initialise the modem connected to the instrument via a null modem cable (see Section 3.6). The string is sent to the modem during start-up of the instrument. If the string has been modified, the instrument should be restarted in order to re-initialise the connected modem. Normally the string should be the same as in the example above: "AT &F0 S0=1 &W0 &Y0 00". If it is not, modify it and update the instrument.

IP address

The address assigned to the Ethernet board of the instrument. Default IP address is typically set to 192.168.1.237 for LAN communication. The user can assign any free local IP address or a valid global IP address for direct internet connection.

IP netmask

Defines the subnet mask for LAN connection. Default netmask is 255.255.255.0.

Port number

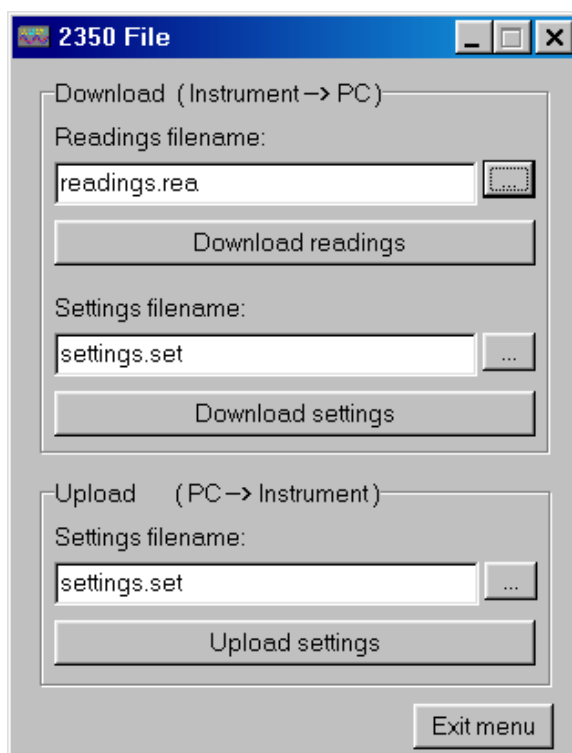
Specifies the port number for TCP/IP communication. Default port number is 5001, but the user can assign any free port number.

Gateway IP address

The address of a server used to route TCP/IP traffic to/from the Ethernet board to another network. This is normally not needed for local communication, but may be needed when the Ethernet board is setup for internet connection.

4.3.9 File download / upload

The menu allows the user to save/restore instrument data to/from file.



Two different types of data can be downloaded from the instrument to a PC and saved into ASCII text files: the instrument readings and the instrument settings. The readings file contains the measured data shown in the **Measurements** menu. The settings file contains all static parameters of the instrument including those in the different menus described above.

The filenames can be edited. We recommend using the file extension *.rea* or *.dmp* for the instrument readings and the extension *.set* or *.stt* for the instrument settings. If an existing file name is chosen the new data are appended to this file.

After pressing <Download readings> the readings data are downloaded and written to a file with the specified name. The data can be viewed and analysed. Alternatively, the instrument readings can be downloaded from the **Second harmonic signal** menu.

After pressing <Download settings> the instrument setting parameters are downloaded and written to a file with the specified name. The setting file is useful as backup of the instrument settings. It is advisable to save instrument settings before modifying the instrument parameters, and before and after each calibration.

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It is possible to upload instrument settings from a PC, thus updating the instrument with new settings or restoring a previously saved instrument configuration. It is important to ensure that the settings file is correct and actually belongs to this SERVOTOUGH LaserExact Monitor. The settings file can be edited with any text editor and parameters, which should not be uploaded, can be removed.

Note that updating the instrument with wrong settings such as laser current and laser temperature may damage the laser.

4.3.10 Manual instrument control

Enter Sleepmode

The instrument will be forced into Sleepmode

Reset Microcontroller

Microcontroller is reset

Collect AD statistics

For service purpose only

Current loops and digital i/o

This menu is for testing the relays and 4-20 mA inputs or outputs mainly during installation of the analyser. Note that the instrument will be set into sleep mode for these tests.

Save system log

See section 4.3.4.

Rewind system log 100 lines

See section 4.3.4.

5. OPERATION, MAINTENANCE AND CALIBRATION

5.1 Operating modes

After having set all necessary instrument parameters as described in chapter 4, the instrument is ready for operation. During continuous operation, the SERVOTOUGH LaserExact Monitor may be in any of these three modes:

1. Start-up mode
2. Measuring mode (or normal mode)
3. Fault mode (or Error mode / Sleep mode)

1. Start-up mode: After turning on the power the instrument runs through initialising, self-test and start-up before starting measurements. This is indicated by appropriate texts in the instrument display (LCD). The instrument stays in start-up mode until the laser temperature stabilises within acceptable limits. The LCD typically shows the following:

MONITOR 6.1a1		
- power -		
Self-test		OK
Start-up		0.356

In the upper right corner of the LCD the software version used by the instrument is printed. In this case the version is 6.1a1.

The next row shows the cause for the instrument being in start-up mode. Normally it will show *-power-* indicating that the power has recently has been switched on. In case of a restart due to unexpected software or hardware conditions the word *-watchdog-* would be printed instead.

If the self-test has passed successfully, a number appears in the lower right corner of the LCD. This number decreases as the laser temperature stabilises. When the number is below 0.3, the instrument slowly powers up the laser. The start-up mode normally lasts less than 3 minutes.

2. While the operating mode is «measuring», the instrument can be in 4 measuring modes:

- a) «Normal»: Normal measurement,
- b) «Zero»: Not applicable for LaserExact analyser
- c) «Span»: Not applicable for LaserExact analyser
- d) «Maintenance»: Measurements as normal but with relay 3 indicating maintenance (if configured for maintenance, see Section 6.9).

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The measuring mode is defined by input through digital communication (e.g. with service program see Section 4.2),

a) In normal mode the measured gas concentration is periodically 1) printed on the LCD, 2) output to the 4-20 mA current loop (PLC) (optional), and 3) output to the optical fibre cable (optional). Measurements can also be polled through serial cable (RS232) with the service program, or through an Ethernet cable (optional). The measured gas concentration is updated every 1-5 seconds depending on factory settings which are optimised for the application. If the instrument can measure two gases the LCD might look as follows:

Tr	100 %	6.1a1
CO	21.32 %	
CO2	32.64 %	

The LCD shows the measured average gas concentration(s) in the chosen unit and the laser beam transmission, which indicates how much light hits the detector relative to the maximum value (calibrated by the factory).

In case of a warning, the instrument continues to measure the gas concentration as usual while displaying the message in the bottom line. In case of an error, the LCD shows <INSTR. ERROR> instead of the concentration, and displays the message in the bottom line. If the optional auxiliary board is installed a warning causes the WARNING relay to deactivate (i.e. open), but it does not affect the PLC output. An error condition causes both the WARNING and ERROR relays to deactivate, and the PLC output is optionally set to 2 mA (ref. Section 6.8). An explanation of LCD messages is given in Section 5.4.

b) and c)

Zero and span check functionality is not applicable for this analyser.


d) In maintenance mode the instrument will continue to measure as normal but relay 3 will indicate a maintenance situation (assuming that relay 3 is configured for maintenance, see Sections 6.8 and 6.9 for details). This mode is mainly required for emission monitoring applications regulated by authorities.

3. Fault mode is entered when the instrument has detected a severe failure (e.g. overheating), which might permanently damage the instrument. In this case the instrument stops measuring the gas concentration and most instrument functions are turned off. The WARNING and ERROR relays are deactivated (opened), the GAS ALARM relay is activated and the PLC output is optionally set to 2 mA (ref. Section 6.8). This operating mode is indicated on the LCD with <INSTRUMENT OFF>, no gas concentration is displayed, and the bottom line of the display indicates the nature of

the fault (See Section 5.4). The instrument automatically attempts a restart after one hour.

5.2 Maintenance

The SERVOTOUGH LaserExact Monitor is designed to reduce maintenance to a minimum. Experience has shown that a maintenance interval of more than three months is acceptable for most applications. The maintenance operations described in this section will secure a continuous and safe operation of the monitor.

	<p style="text-align: center;">WARNING</p> <p>If using toxic, asphyxiant or flammable sample or calibration gases, open cabinet or alignment chamber enclosures in a force ventilated open area, or in another appropriate environment in which any hazardous gases are directed away from the user.</p>
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5.2.1 Routine maintenance

For best performance we recommend to routinely carry out the follows steps:

- Check optical transmission regularly. This can be done automatically by use of instrument output or WARNING relay or similar.
- Adjust alignment when necessary (see Section 3.4).
- Consider cleaning the LaserExact cell when transmission is very low (see Section 5.2.2). At very low transmission the LCD will show «Laser line-up error» alternating with «Low transmission».
- For applications that normally have zero gas: Check instrument response by applying some gas at least once every three months. Use sufficient gas to give a large instrument response for at least 10 minutes (at least 70 minutes after power on). No warnings or errors should be displayed during the test. For certain instruments this procedure is not necessary as the laser is tracking on another absorption line than the “zero gas” line (e.g. H₂O line for an HF instrument). Contact SERVOMEX if you are in doubt about your instrument.
- Check calibration every 12 months (depending on the required accuracy). Recalibrate if necessary. (See below.)
- At each calibration check, save instrument settings and measurement data recorded with some gas (“setting-files” and “dump-files”). This is for tracking purposes in case of future service issues.

5.2.2 Servicing the LaserExact cell

Dust or other contamination on the cell mirrors will reduce the signal level. The instrument is designed to allow a considerable reduction of the signal level (down to 10-30%) without influencing the quality of the measurements. However, if the signal level drops below the level of reliable measurements, the LCD shows «Low transmission», and the cell should be cleaned. The procedure for opening and cleaning the cell is described below.

1. Make sure that the instrument is switched OFF.
2. Disconnect the sample gas tubes.
3. Check if low transmission is due to poor alignment of the mirrors in the beam alignment chamber (follow the procedure of Section 3.4). If this procedure does not improve the transmission level, continue with the following steps.
4. The analyser should be moved to a clean office or laboratory space before opening the measurement cell. The following procedure requires care and experience. We recommend you ask your local dealer for assistance.
5. Remove the body of the LaserExact cell from the beam alignment chamber instrument by unscrewing the four bolts. Note: The cell is heavy! Carefully lower the body the cell. It is important to move it straight down. Tilting the cell body could cause damage to the mirrors. The inner rod with the two mirrors attached to it is now visible. Note: The mirror surface is very fragile. Do not touch the mirror surface. Doing so is likely to permanently damage the mirror.
6. Clean the mirror surface with clean air or nitrogen (blow dry). If not sufficient the mirror surface may be rinsed with a non-abrasive detergent (e.g. Acetone or Isopropanol) and blown dry afterwards. The mirrors should NOT be rubbed with paper or clothing. This may adversely affect the mirror surface and subsequently the instrument transmission.
7. Check if the window between the cell and beam alignment chamber is contaminated. The window is visible through the slot in the upper mirror. If the window is contaminated contact your local dealer for further assistance.
8. Reassemble the cell by carefully sliding the body of the cell over the inner rod. Tighten the four bolts fixing the cell body to the beam alignment chamber.
9. Reconnect the sample gas tubes.
10. Switch the instrument ON and check the transmission. If necessary realign the instrument as described in Section 3.4.

In the unlikely event that mirrors have been damaged; note that single mirrors can be replaced. This is a more comprehensive procedure so please contact your local distributor for assistance.

5.3 Calibration of the instrument

The SERVOTOUGH LaserExact Monitor is factory calibrated using a certified gas mixture and a calibration certificate is supplied together with the instrument. There is therefore no need for the user to calibrate the instrument upon reception.

After some period of operation the instrument parameters may change due to ageing of the diode laser. In this case a new calibration might be necessary. We recommend verifying calibration of the instrument once a year using a certified test gas. Per default the certified test gas must be a mixture of **Nitrogen** with the measured gas. There are exceptions though i.e. instruments with special tuning that require calibration in a balance different from N₂. Please refer to the calibration certificate for the specific instrument.

Since the calibration of the instrument affects all subsequent measurements, the user should verify the need for a new calibration. We do not recommend performing a calibration if the instrument readings deviate less than 2 – 3 % from the nominal value within the recommended concentration levels indicated below. This is the typical absolute accuracy for calibration gas mixtures. One should also account for the precision of the SERVOTOUGH LaserExact Monitor, which is about 1% of the measured value. For O₂ SERVOTOUGH LaserExact Monitors the deviation should not exceed 0.2 % vol. when the values for the cell pressure and temperature are correctly set in the instrument.

The second harmonic technique used in the SERVOTOUGH Laser monitors is intrinsically a baseline-free technique. Therefore, a calibration of the zero level is never done. If one attempts to calibrate the zero level, the service program will display an error message. The monitor can only be calibrated if it detects absorption signal amplitude above a predefined level. This level is factory set and is typically 20 times the detection limit for an optical path length of 1 m.

To obtain the optimal signal-to-noise ratio the gas concentrations of Table 5-1 should be used.

Measured gas	Recommended concentration range
HCl	10 – 20 ppm
NH ₃	20 – 40 ppm
O ₂	ca. 1%
CO ₂ , HCN, CH ₄	50 – 100 ppm
H ₂ S	30 – 200 ppm
CO	100 – 1000 ppm
NO	50 – 500 ppm

Table 5-1: Recommended gas concentrations for calibration.

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If only a gas mixture with higher gas concentration is available, dilute the gas mixture with nitrogen using a calibrated gas mixing system to the specified values above. Significantly lower concentrations should not be used because the measurements might be influenced by noise as well as by adsorption and desorption processes in the cell and the tubes.

**WARNING**

If using toxic, asphyxiant or flammable sample or calibration gases, open cabinet or alignment chamber enclosures in a force ventilated open area, or in another appropriate environment in which any hazardous gases are directed away from the user.

Follow the steps described below to perform verification and calibration.

1. Let the instrument operate for at least 1 hour before performing the verification and/or calibration.
2. Run the service program (ref. Section 4.1 for start-up).
3. Check that the fixed temperature and pressure settings are correct, or that the PLC inputs for the gas temperature and pressure are correct (i.e. set to calibration conditions).
4. Introduce the calibration gas into the cell. Wait until the system reaches stable levels.
5. Check if the reading is in agreement with the concentration of the certified gas. If required, perform calibration (PROPORTIONAL or GLOBAL) as described in Section 4.3.7.
6. Save the instrument settings to a file as described in Section 4.3.9.
7. If applicable re-set the pressure and temperature parameters to process conditions (ref. Section 4.3.5).
8. The calibration is completed and the monitor can be used for measurement.

Note that when gas is flushed through the cell, the cell pressure is higher than the ambient pressure. The pressure difference depends on the flow rate and the diameter and length of the outlet tubes. It is therefore highly recommended to measure the gas pressure close to the cell, using an absolute pressure sensor in order to provide the instrument with correct gas pressure during the verification and calibration procedure. If only the ambient pressure is known or the pressure sensor is located far away from the cell, one can switch off the gas flow before calibration, wait 1 minute for the readings to stabilise and subsequently perform calibration. In this case the gas pressure is equal to the ambient pressure.

Special care should be taken for reactive and “sticky” gases such as HF, NH₃, HCl and H₂S. Because of the nature of these gases, it is difficult to obtain the required concentration in the cell due to adsorption and desorption in the connection tubes. The following recommendations should then be followed:

- Use Teflon connection tubes.
- Use the shortest possible length of the tubes.
- When flushing calibration gas through the cell, use large flow rates such as 5-7 L/min.
- Wait until the concentration in the cell has stabilised.
- Check that the measured concentration remains the same with an increasing flow. If it does, the concentration in the cell most likely has reached the expected value.

5.3.1 PROPORTIONAL versus GLOBAL calibration

Line broadening compensation requires a large number of parameters to be measured. These parameters are critical for accuracy, but only when line broadening compensation is used. Most of the parameters seldom or never need to be adjusted.

PROPORTIONAL calibration:

This calibrates the span of the gas concentration by adjusting the proportionality between the peak amplitude of the absorption line and the gas concentration. Only the *proportional calibration constant* is affected by PROPORTIONAL calibration.

GLOBAL calibration:

Calibrates both the gas concentration span and line width parameters. It is important to follow the calibration procedure carefully and specify to the instrument the exact pressure and temperature of the calibration cell. The P, and T values can be set fixed with the service program, or use 4-20 mA inputs if such probes are connected to the calibration cell. One can also use the internal sensors if these are close to the values for the calibration cell. It is also important to use dry gas mixed with nitrogen. For O₂, dry air can be used.

USE GLOBAL calibration:

- If spectral properties of laser is believed to have drifted. This can be evaluated by qualified service personnel from dump-files recorded with the instrument when it is measuring on a calibration gas.
- After major instrument services such as replacement of laser module, main board or receiver board. (Qualified service personnel only!)
- After adjustment of laser parameters (modulation amplitude or phase, or other laser currents). (Qualified service personnel only!)

DO NOT use GLOBAL calibration when:

- the instrument is measuring on the process (with process gas).
- the concentration of the calibration is low such that the signal-to-noise ratio is not good.
- the conditions for GLOBAL calibration described above are not satisfied. If recalibration is required in such cases, use PROPORTIONAL calibration instead.

5.4 Troubleshooting the instrument

During operation essential status information about the instrument is displayed on the LCD. The instrument messages and their possible explanations and actions to be taken are given in the table below. If there is no output to the display, please refer section 6.7.

Fault message	Explanations and actions
« Low transmission »	WARNING The optical transmission has dropped below the limit for reliable measurements. This might indicate misalignment of the optical units or contamination of the mirrors in the cell. Check alignment and replace cell if necessary.
« Laser line-up error »	ERROR The laser beam does not reach the detector. Check alignment and replace cell if necessary.
« PLC T-read error »	ERROR Failure reading temperature through 4-20 mA PLC input. Input current from temperature sensor is either above 23.7 mA or below 0.3 mA. Check connections to temperature sensor or use fixed temperature setting in the SERVOTOUGH LaserExact Monitor.
« PLC P-read error »	ERROR Failure reading pressure through 4-20 mA PLC input. Input current from pressure sensor is either above 23.7 mA or below 0.3 mA. Check connections to pressure sensor or use fixed pressure setting in the SERVOTOUGH LaserExact Monitor.
« T-read out of range »	WARNING Input current from temperature sensor is either above 22 mA or below 3.2 mA. The measured gas temperature may be wrong. Check temperature sensor or use fixed temperature setting in the SERVOTOUGH LaserExact Monitor.
« P-read out of range »	WARNING Input current from pressure sensor is either above 22 mA or below 3.2 mA. The measured gas pressure may be wrong. Check pressure sensor or use fixed temperature setting in the SERVOTOUGH LaserExact Monitor.
« P/T out of range »	WARNING Pressure and temperature compensation is outside acceptable range. The accuracy of the measured gas concentration may be reduced. If supplied values are correct, the instrument is operating outside specifications.

Fault message	Explanations and actions
« Ex-read out of range »	WARNING Input current from external gas sensor is either above 22 mA or below 3.2 mA. Check Extra (Flow) current input.
« Voltage supply fail »	The power supply voltage input to the instrument is exceeding acceptable range (for standard instrument; 18-36V). Check and correct voltage. If the error remains, contact service personnel.
« Low laser temp. » « High laser temp. »	ERROR The laser temperature regulation has failed and the laser is too cold/warm. The instrument has entered FAULT mode and attempts automatic restart after one hour. If the cabinet is overheated, cool it down by thermal shielding and/or improved ventilation. If the cabinet is not overheated, the error might indicate a bad electrical contact or other hardware failure. Contact service personnel if repeated.
« Low box temp. » « High box temp. »	ERROR Internal temperature of the cabinet is exceeding the operating limit. The instrument has entered FAULT mode and attempts automatic restart after one hour. Check ambient temperature for the cabinet, and correct by thermal shielding and/or ventilation if temperature is exceeding instrument specifications. Otherwise contact service personnel.
« EEPROM error »	ERROR Failure of the internal memory of the instrument. Upload a backup settings file (with the original settings) to the instrument. Contact service personnel if repeated.
« Self-test fail »	ERROR The instrument has detected a self-test error during start-up. Try to restart the instrument. If the failure remains, write down all messages as they appear on the LCD, download Error log and System log, and contact service personnel.

Fault message	Explanations and actions
« Low line position » « High line position » « No absorption line »	ERROR The instrument has detected a spectroscopic fault. This can have several causes: 1) Unknown interference gas in process, 2) Incorrect laser temperature (wavelength). 3) The cabinet is operating outside acceptable temperature range, or 4) Laser malfunction. Check the instrument with a gas concentration suitable for calibration, and allow it to run continuously for > 70 minutes. If error does not disappear or calibration is significantly wrong contact service personnel.
« Saturation of direct »	ERROR The photo-detector is saturating or transmission is > 130%. If the error remains when the receiver window is obscured, this is an electronic fault. Otherwise the error may occur after replacement of laser module or receiver electronics. Reduce receiver amplification (if possible) or transmission. If the problem cannot be solved contact service personnel.
« Saturation of harm. »	ERROR A second harmonic signal is saturating. This may be for one of the following reasons: 1) The gas concentration is too high. Reduce the amplification for the second harmonic signal in the receiver (contact service personnel for details). 2) If the error remains when the receiver window is obscured, this is an electronic fault. Contact service personnel.
All other error messages	Write down all the LCD messages and contact service personnel.

Table 5-2: Instrument LCD error messages

6. ELECTRICAL CONNECTIONS

Note that in the table columns labelled “DESCRIPTION”, the indicated polarities of the items are for naming only and does not necessarily reflect the polarity of real voltages. All potentials are floating and none of them should be grounded to the cabinet. This applies to all connection tables.



WARNING

Ensure that the electrical installation of the Laser monitor conforms to all applicable local and national electrical safety requirements.



WARNING

Wiring to or from this device, which enters or leaves the system enclosure, must utilize wiring methods suitable for Class 1, Division 2 and/or Zone 2 Hazardous Locations, as appropriate for the installation.



WARNING

Obey the safety instructions given below when you install the Laser monitor; if you do not, the Laser monitor certification may be invalidated, the Laser monitor may not operate correctly, or it may be damaged.



WARNING

Isolate mains power before commencing installation.



WARNING

Make sure that power is disconnected or switched off before connecting any cable.

6.1 Cabinet interface

The electronic interface for the cabinet is depicted in Figure 6-1.

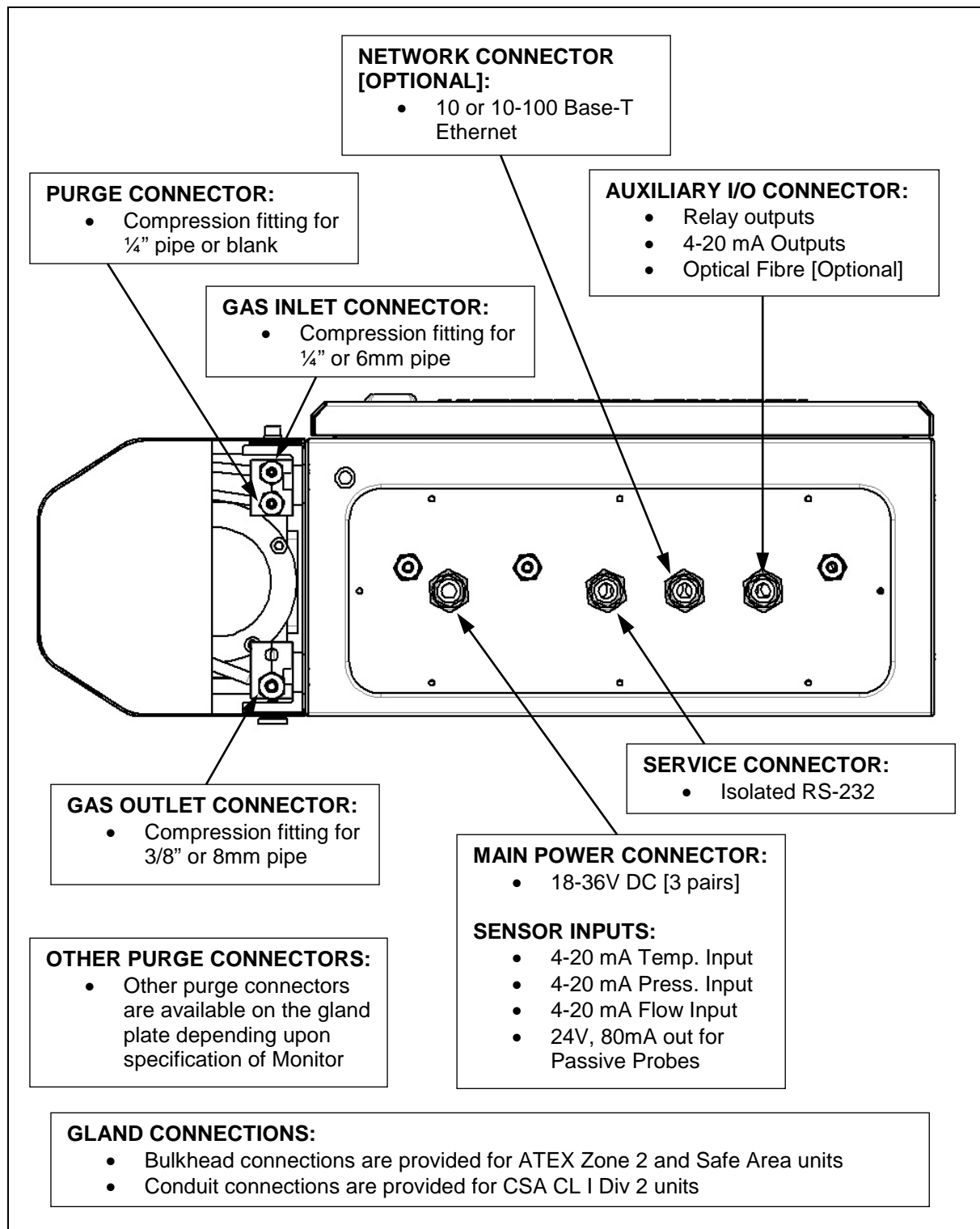


Figure 6-1: Cabinet electronic interface

6.2 Power cable connections

<i>Power & 4-20mA Input</i>				
<i>Junction list</i>	<i>Terminal:</i>	<i>Pair no:</i>	<i>Color code:</i>	<i>Description:</i>
J5	1		N.C.	Temperature Probe -
J5	2		N.C.	Temperature Probe +
J5	3		N.C.	Pressure Probe -
J5	4		N.C.	Pressure Probe +
J5	5		N.C.	Flow Probe -
J5	6		N.C.	Flow Probe +
J5	7		N.C.	Probes +24V
J5	8		N.C.	Probes AGND
J6	+18-36 V In		Red	+18-36V Input
J6	0 V In		Black	0V Input

Table 6-1: Power cable and sensor connections inside the cabinet.

6.3 Auxiliary connections

Connect 4-20 mA outputs and relays contacts according to Table 6-2.

Note that conductors with area 0.14-1.5 mm² (AWG 26-16) must be used. The cable outer diameter must be 7 – 12 mm.

<i>Junction list</i>	<i>Terminal:</i>	<i>Description:</i>
J9	1	Span
J9	2	4-20mA PLS1 Output
J9	3	4-20mA PLS1 GND
J9	4	4-20mA PLS2 Output
J9	5	4-20mA PLS2 GND
J9	6	4-20mA PLS3 Output
J9	7	4-20mA PLS3 GND
J9	8	Span/Zero Com.
J10	9	Relay 1 - A (Error)
J10	10	Relay 1 - B
J10	11	Relay 2 - A (Warning)
J10	12	Relay 2 - B
J10	13	Relay 3 - A (High Gas)
J10	14	Relay 3 - B
J10	15	Zero
J10	16	Chassis

Table 6-2: Cabinet – Auxiliary connections

Relay 'x' – A & B in Table 6-2 refers to the 2 connections on Relay 'x'.

The instrument relays (Error, Warning and Gas Alarm) can be integrated to external circuits (ref. Section 6.8 for relay combinations). They may be connected to 30 V DC/AC and can withstand currents up to 1.0 A. By default the relays are

set “NC”, normally closed. This may be changed to “NO”, normally open with dip switches marked “Rel ‘x’ NC/NO” on the AUX board.

Note that external relays connected to the instrument may induce current or voltages that exceed the above ratings. If in doubt external protection diodes must be implemented to protect the internal instrument relays.

The PLC/PLS (Programmable Logic Controller) 4-20 mA outputs are of ACTIVE type and isolated electrically from the electronics unit’s electronics. Maximum load is 500Ω.

There are up to 3 different 4-20 mA outputs available. Per default only the outputs for gas concentration are implemented.

For single gas instrument the outputs are configured as follows:

PLC1 – output for gas concentration,

PLC2 – optional output for transmission (4mA=0%, 20mA=100% transmission),

PLC3 – not used.

For dual gas instrument the outputs are configured as follows:

PLC1 – output for gas-1 concentration,

PLC2 – output for gas-2 concentration,

PLC3 – optional output for transmission (4mA=0%, 20mA=100% transmission).

For instrument measuring gas and temperature the outputs are configured as follows:

PLC1 – output for gas concentration,

PLC2 – output for spectral temperature,

PLC3 – optional output for transmission (4mA=0%, 20mA=100% transmission).

6.4 RS-232 and Ethernet connections

<i>Junction list</i>	<i>Terminal:</i>	<i>Description:</i>	<i>Comments:</i>
J13	1	Data Carrier Detect	Connected to 4.
J13	2	Transmitt Data	
J13	3	Receive Data	
J13	4	Data Terminal Ready	
J13	5	Ground	
J13	6	Data Set Ready	Connected to 4.
J13	7	Request To Send	Connected with 8.
J13	8	Clear To send	Connected with 7.
J13	9	Ring Indicator	Not Connected.

Table 6-3: Cabinet – RS 232 connection

Alternatively connector J15 may be used (remember gender changer).

Junction list	Terminal:	Color code:	Description:	Comments:
J2	1	White/Orange	TX+	for straight through connection (hub)
J2	2	Orange	TX-	
J2	3	White/Green	RX+	
J2	4	Green	RX-	

Junction list	Terminal:	Color code:	Description:	Comments:
J2	1	White/Green	TX+	for cross over connection (direct to PC)
J2	2	Green	TX-	
J2	3	White/Orange	RX+	
J2	4	Orange	RX-	

Table 6-4: Cabinet – Ethernet connection

6.5 Current loop (4-20 mA) input connections (PLC)

External pressure and temperature probes to the instrument are wired inside the cabinet to the terminals for the power cable connection. The probe outputs are connected to the screw terminals according to Table 6-1 i.e. the probe outputs are connected to the screw terminals marked with Probe+ and Probe- (or +24V for passive probe). Probe refers to Temperature, Pressure or Extra (Flow).

Note that conductors with area 0.14-1.5 mm² (AWG 26-16) must be used. The cable outer diameter must be 7 – 12 mm.

Figure 6-2 and Figure 6-3 show how active and passive 4-20 mA current loop input probes (referred to as PLC) are connected to the instrument. The *Probe+* and *Probe-* constitute differential inputs which are tolerant to common mode voltages up to $\pm 200V$. *Probe+* and *Probe-* are connected internally in the instrument by a 100 Ω resistor, which give a voltage drop of 2V at 20mA. Several instruments can therefore be chain connected to the same probe by connecting *Probe-* of the first instrument to *Probe+* of the next instrument, etc.

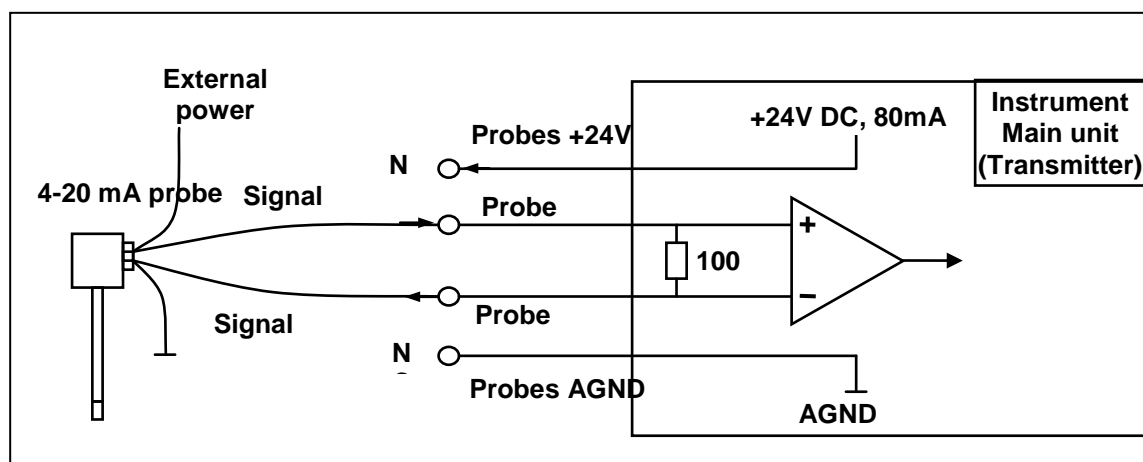


Figure 6-2: Current loop input, active probe

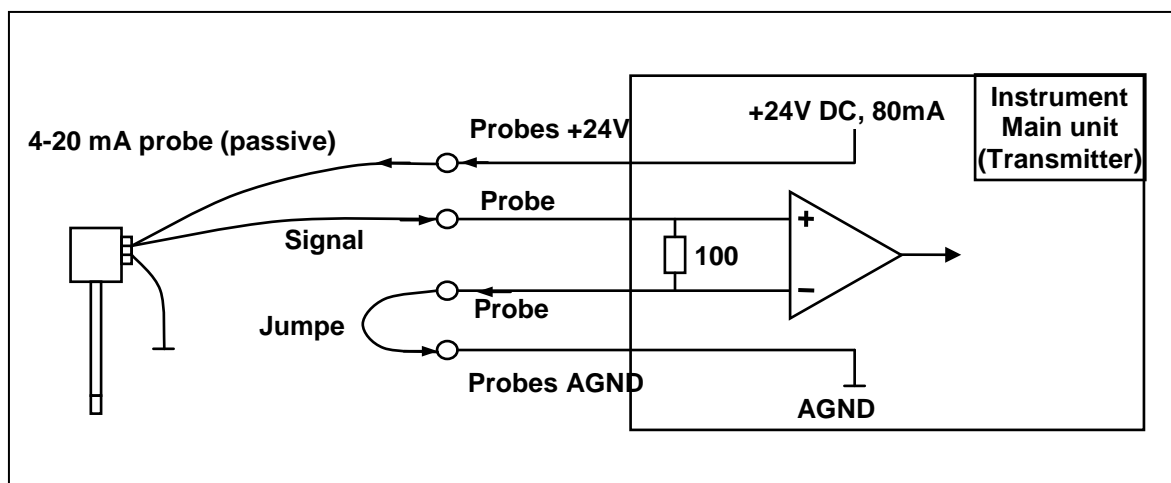


Figure 6-3: Current loop input, passive probe

6.6 Mains power cable connection

The 220 VAC power terminals inside the cabinet can accommodate conductors with area $< 2.5 \text{ mm}^2$ (SERVOMEX uses 1 mm^2).

6.7 Transmitter board - fuses and LED's

The transmitter board has one main fuse and some LED's to indicate status of different supply voltages. Figure 6-4 shows the main / transmitter board layout.

If the LED close to the main fuse ("18-36V Input OK") is lit but the other LED's are not, check the main fuse. If all LED's are dark, check the 24V supply to the instrument. If some LED's are lit and others are not, please note which are lit and which are not lit, and contact your local distributor as the board might have to be serviced.

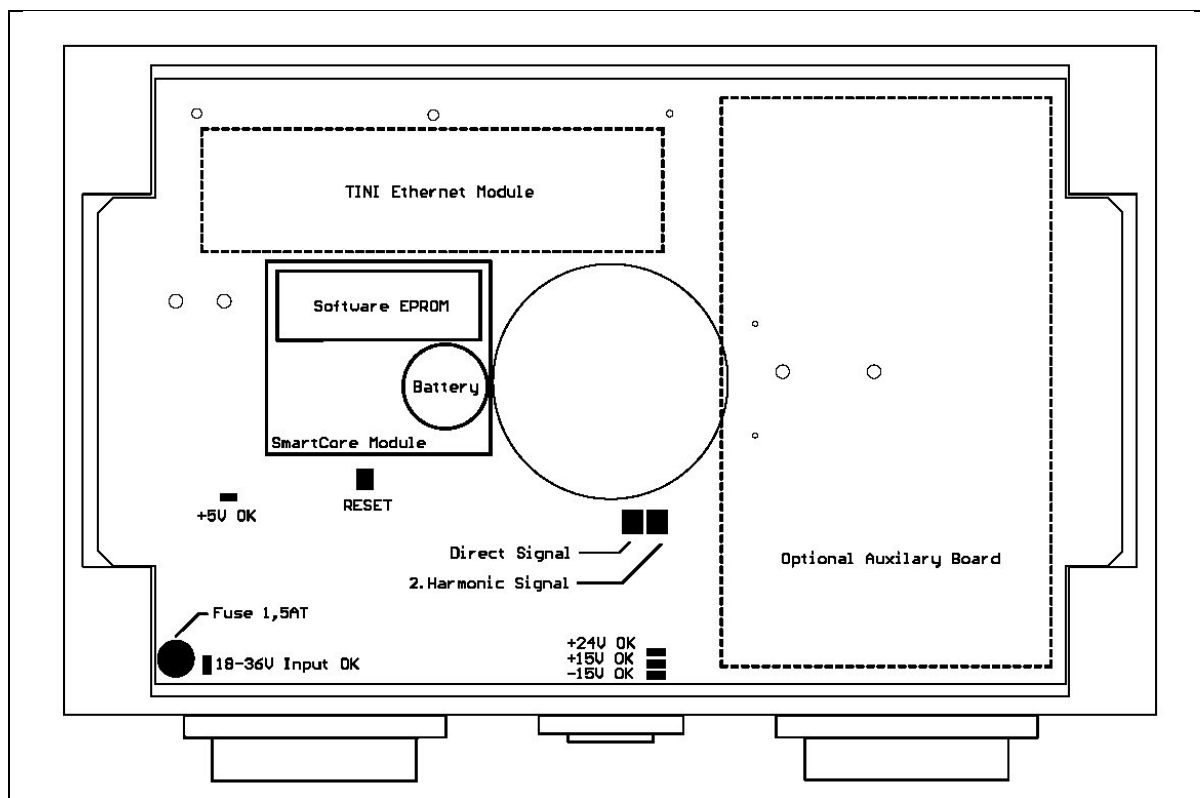


Figure 6-4: Main board, fuses and LED's layout

6.8 Relay indications

The following table shows the different relay indications (next page):

Relay indications:

X = Activated (conducting)

O = Deactivated (not conducting)

	Operating mode	Status and measuring mode	Relay 1 Error	Relay 2 Warn.	Relay 3 Gas alarm (Standard) (Note 1)	Relay 3 Maintenance	Output 4-20 mA	Output Digital
1	Power Off		O	O	O	O	0mA	N.A.
2	Start up		O	X	X	O	0mA	0
3	Measuring, Normal	OK	X	X	X	O	Gas conc.	Gas conc.
4		Warning	X	O	X	O	Gas conc.	Gas conc.
5		Error	O	O	X	O	2mA / Last (2)	Last (2)
6		Gas Alarm	X	X/O	O	O	Gas conc.	Gas conc.
7	Measuring, Maintenance	Zero	X/O (3)	X/O (3)	X (4)	X	Zero conc.	Zero conc.
8		Span	X/O (3)	X/O (3)	X (4)	X	Span conc.	Span conc.
9		Maintenance	X/O (3)	X/O (3)	X/O (4)	X	Gas conc.	Gas conc.
10	Sleep (Fault)	Normal	O	O	X	O (5)	2mA	Last (2)
11		Zero	O	O	X	X (5)	2mA	Last (2)
12		Span	O	O	X	X (5)	2mA	Last (2)
13		Maintenance	O	O	X	X (5)	2mA	Last (2)

Table 6-5: Relay indications and outputs

Relay indications:

X = Activated (conducting)

O = Deactivated (not conducting)

Notes:

- 1 «Relay 3: Gas alarm» is the only function of relay 3 in all software versions prior to 6.1c1 (check with your distributor or SERVOMEX if in doubt about the SW version of your instrument)
- 2 «Last» means the last valid measurement concentration before an error occurred.
- 3 Relays 1 (Error), 2 (Warning) are set as for rows 3-6 independent of the input switch of Normal/Maintenance/Zero/Span.
- 4 If relay 3 is configured for «Gas Alarm» this relay is set as for rows 3-6 independent of the input switch of Normal/Maintenance/Zero/Span, otherwise maintenance mode is indicated.
- 5 When entering sleep (fault) mode, relay 3 is set according to measuring mode immediately before. The state of relay 3 does not change even if attempting to change measuring mode while in sleep mode.

The WARNING relay deactivates when the SERVOTOUGH Monitor detects a possible problem in the measurements, and the instrument measurements may not be correct or accuracy of the measurements reduced. Examples of such cases are low laser beam transmission due to dust on the optical windows or misalignment, or incorrect values of the 4-20 mA PLC inputs for pressure and temperature. A corresponding warning message will be displayed on the bottom line of the LCD.

The ERROR relay deactivates immediately after the instrument has detected a failure. Deactivation of the ERROR relay indicates that the instrument is not able to measure the gas concentration. The error message will be displayed on the LCD.

There are two options for the behaviour of the 4-20 mA PLC output in case of deactivating of the ERROR relay.

Option 1:

Immediately after the ERROR relay has been deactivated the PLC holds the last measured value for a time interval that is proportional to the instrument averaging time. In the current software version the time interval is $\tau = 3 \cdot T$. After that the PLC sets the output to 2mA as an error notification in addition to the ERROR relay.

Option 2:

The 4-20 mA PLC holds the last measured value for the gas concentration until the ERROR relay is activated again. The PLC output is, thus, independent of the errors, and the only error notification is the ERROR relay.

6.9 Configuring relay 3 output

Relay-3 can be configured in three ways by software as

- 1) Normal gas alarm
- 2) Inverted gas alarm
- 3) Maintenance

These three configurations are mutually exclusive. In addition the relay-3 function can be inverted by hardware.

The different functions of relay-3 are selected by setting the parameter "Gas conc alarm level" (see Section 4.3.6).

6.9.1 Normal configuration of relay-3, «Gas Alarm»

Alarm is signified when the measured gas concentration $> \text{abs (Gas conc alarm level)}$ for one or more of the measured gases. Normal configuration:

Alarm OFF = Relay-3 conducting (X)

Alarm ON = Relay-3 isolating (O).

6.9.2 Inverted configuration of relay-3, «Gas alarm»

This is defined by setting the parameter “Gas conc alarm level” < 0 (negative value) for gas-1. Inverted relay-3 function then also applies to gas-2 and gas-3 alarm levels (if applicable) irrespective of their sign. Alarm is signified when the measured gas concentration > abs(Gas conc alarm level) for one or more of the measured gases. Inverted configuration:

Alarm ON = Relay-3 conducting (X)

Alarm OFF = Relay-3 isolating (O).

6.9.3 Maintenance configuration of relay-3

Maintenance indication is done by relay no. 3 by setting the parameter “Gas conc alarm level” = -10^{20} (= -1E20) *for all gaslines, N*, of the instrument (see Section 4.3.6). This ensures that «Gas Alarm» is disabled for all realistic gas concentrations and does not interfere with the maintenance function.

“Normal” measuring mode: Relay-3 isolating (O)











“Zero”, “Span”, or “Maintenance” mode: Relay-3 conducting (X).

6.9.4 Inverting relay-3 output by hardware switch

The AUX-board switch SW1-3/C is by default set to position 3 (REL3_NC). This gives the relay outputs as described in the sections above. When the AUX-board switch SW1-3/C is set to position C (REL3_NO), the relay function is interchanged. This also applies to operating mode “Power off” (see also Section 6.3).

APPENDIX 1 COMPLIANCE AND STANDARDS INFORMATION

- The SERVOTOUGH Laser monitor complies with the European Community "Electromagnetic Compatibility Directive" and "Low Voltage Directive".
- The Laser monitor is rated in accordance to Overvoltage Category II, Pollution Degree 2.
- The Laser monitor complies with the Class B digital apparatus requirements of ICES-003 of Canada through the application of IEC 61000-6-3.
- L'analyseur est conforme aux Conditions B numériques d'appareillage de classe de NMB-003 du Canada par l'application du IEC 61000-6-3.
- This Laser monitor complies with Part 15 of the FCC Rules for Class B equipment. It is suitable for operation when connected to a public utility power supply that also supplies residential environments.
- Servomex Group Ltd is a BS EN ISO 9001 and BS EN ISO 14001 certified organisation.
- NEO Monitors, Norway is a BS EN ISO 9001:2000 certified organisation.

									
<h2 style="margin: 0;">DET NORSKE VERITAS</h2> <h3 style="margin: 0;">TYPE EXAMINATION CERTIFICATE</h3>									
<p>[2] EQUIPMENT INTENDED FOR USE IN POTENTIALLY EXPLOSIVE ATMOSPHERES DIRECTIVE 94/9/EC</p>									
<p>[3] Type Examination Certificate Number:</p> <p>[4] Equipment:</p> <p>[5] Applicant – Manufacturer or Authorized representative:</p> <p>[6] Address:</p> <p>[5] Manufacturer:</p> <p>[6] Address:</p> <p>[7] This equipment and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.</p> <p>[8] DNV certifies that this equipment has been found to comply with the Essential Health and Safety requirements that relate to the design of Category 3 equipment, which is intended for use in potentially explosive atmospheres given in Annex II to the Directive.</p> <p style="padding-left: 40px;">The examination and test results are recorded in confidential reports listed in section 14.</p> <p>[9] Compliance with the Essential Health and Safety Requirements, with the exception of those listed in the schedule of this certificate, has been assessed by reference to:</p> <p>[10] If the sign "X" is placed after the certificate number, it indicates that the equipment is subject to special conditions for safe use specified in the schedule to this certificate.</p> <p>[11] This TYPE EXAMINATION CERTIFICATE relates only to the design, examinations and tests of the specified equipment. If applicable, further requirements of this Directive may apply to the manufacturing process and supply of this equipment. These are not covered by this certificate.</p> <p>[12] The marking of the equipment shall include the following:</p>	<p>DNV-2007-OSL-ATEX-11474 Rev. 6</p> <p>Lasergas II SP, OP and MP Monitors</p> <p>Norsk Elektro Optikk AS Solheimveien 62a, 1471 Lørenskog, Norway</p> <p>NEO Monitors AS Solheimveien 62a, 1471 Lørenskog, Norway</p> <p>EN 60079-0: 2006, EN 60079-15: 2005, EN 61241-0: 2006, EN 61241-1: 2004 and EN 60079-28: 2007</p>								
<table border="0" style="width: 100%;"> <tr> <td style="width: 10%; text-align: center;">  </td> <td style="width: 10%;">II 3 G</td> <td style="width: 10%;">Ex nA nC op is Gc IIC T4</td> <td style="width: 10%;">- 20°C ≤ Tamb ≤ +55°C</td> </tr> <tr> <td style="text-align: center;">  </td> <td>II 3 D</td> <td>Ex tD A22 IP65</td> <td>T100°C</td> </tr> </table>			II 3 G	Ex nA nC op is Gc IIC T4	- 20°C ≤ Tamb ≤ +55°C		II 3 D	Ex tD A22 IP65	T100°C
	II 3 G	Ex nA nC op is Gc IIC T4	- 20°C ≤ Tamb ≤ +55°C						
	II 3 D	Ex tD A22 IP65	T100°C						
<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 45%;"> <p>Høvik, 2011-08-09 for Det Norske Veritas AS</p> <div style="text-align: center;">  Marianne Spæren <i>Certification Manager</i> </div> </div> <div style="width: 45%; text-align: center;">  NORSK AKKREDITERING PROD 019 </div> </div>									
<p><small>Notice: This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid. The digitally signed and electronically distributed document is the original and valid certificate. Ref.: www.dnv.com/digitalsignatures</small></p> <p><small>If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of Det Norske Veritas, then Det Norske Veritas shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 300 000. In this provision "Det Norske Veritas" shall mean the Foundation Det Norske Veritas as well as all its subsidiaries, directors, officers, employees, agents and any other acting on behalf of Det Norske Veritas.</small></p>									

SERVOTOUGH LaserExact Monitor, Operator Manual 02950001A_1

[13]

Schedule[14] **TYPE EXAMINATION CERTIFICATE No.:** DNV-2007-OSL-ATEX-11474

Rev. 6

Certificate History

Revision	Description	Report no.	Issue date
1	Original certificate	2007-3441	2008-01-22
2	Printing error corrected: moved reference standards from item 10 to 9.	2008-3451	2008-04-07
3	Updated according to most recent standards, added "op is" and addition of component.	2009-3376	2009-07-16
4	Updated list of descriptive documents.	2009-3376	2009-07-21
5	Corrected typing error	2009-3376	2009-11-30
6	Updated with an option with power supply, alternate size of LaserGas II MP cabinet Monitors, temperature and pressure sensors is included, change of main PCB and PCB 13390	2009-3376	2011-08-09

[15] Description of Equipment:

The LaserGas-II Monitor is an optical instrument based on transmitting infrared laser light from a transmitter to a solid-state detector inside the receiver. The measurement principle is called infrared single-line absorption spectroscopy.

The LaserGas II Monitor is available in different versions configured for different applications namely: Single Path (SP), Single Path compact, Multipass (MP), Multipass cabinet and Open Path (OP). The different versions are all based on the same electronics. Construction is as described by the manufacturer's descriptive documents and as described below.

Line-connected components are Certified and suitably rated.

All connectors are of the locking type, have a separation force of 15 Newtons or are in non-incendive circuits. A warning is provided regarding engaging/disengaging the field connectors while the circuit live or area is known to be hazardous.

Type Identification

LaserGas II SP Monitors (Single Path)
 LaserGas II SP compact Monitors
 LaserGas II OP Monitors (Open Path)
 LaserGas II MP cabinet Monitors

Electrical Data

18-36VDC, 20W without power supply or
 100 – 240VAC, 20W with power supply

Degrees of protection (IP Code)

IP 65: LaserGas II MP cabinet Monitors.
 IP 66: LaserGas II SP, SP compact and OP Monitors



[16] **Project No:** PRJC-29692-2007-PRC-NOR

If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of Det Norske Veritas, then Det Norske Veritas shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 300,000. In this provision "Det Norske Veritas" shall mean the Foundation Det Norske Veritas as well as all its subsidiaries, directors, officers, employees, agents and any other acting on behalf of Det Norske Veritas.

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TYPE EXAMINATION CERTIFICATE No.: DNV-2007-OSL-ATEX-11474		Rev. 6	
Descriptive documents			
Number	Title	Rev.	Date
EX 14372	List of descriptive documents LaserGas II Ex-n	J	2011-08-02
Routine tests Dielectric strength test according to 60079-15: 2005 clause 6.8.1: Test for insulation from earth or frame: Apply 500V rms or 700V dc in 60 seconds.			
[17] Special conditions for safe use None			
[18] Essential Health and Safety Requirements See part 9 of this certificate			
END OF CERTIFICATE			
<small>If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of Det Norske Veritas, then Det Norske Veritas shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 300.000. In this provision "Det Norske Veritas" shall mean the Foundation Det Norske Veritas as well as all its subsidiaries, directors, officers, employees, agents and any other acting on behalf of Det Norske Veritas.</small>			

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VERITASVEIEN 1, 1322 HØVIK, NORWAY

TEL: (+47) 67 57 99 00

FAX: (+47) 67 57 99 11

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APPENDIX 2 PRODUCT DISPOSAL/APPLICABILITY OF THE WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE) DIRECTIVE 2002/96/EC

- This product is not considered to be within the scope of the Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC.
- This product is not intended for disposal in a municipal waste stream, but shall be submitted for material recovery and recycling in accordance with any appropriate local regulations.
- Additional advice and information on the disposal of this product in accordance with the requirements of the WEEE Directive can be obtained from:

Servomex Group Limited,
Jarvis Brook,
Crowborough,
East Sussex,
TN6 3FB,
England
+44 (0) 1892 652181
Fax: +44 (0) 1892 662253
Global email: info@servomex.com

- All analysers returned to the Servomex Group or one of its appointed agents for servicing, disposal, or any other purpose must be accompanied by a completed decontamination certificate.