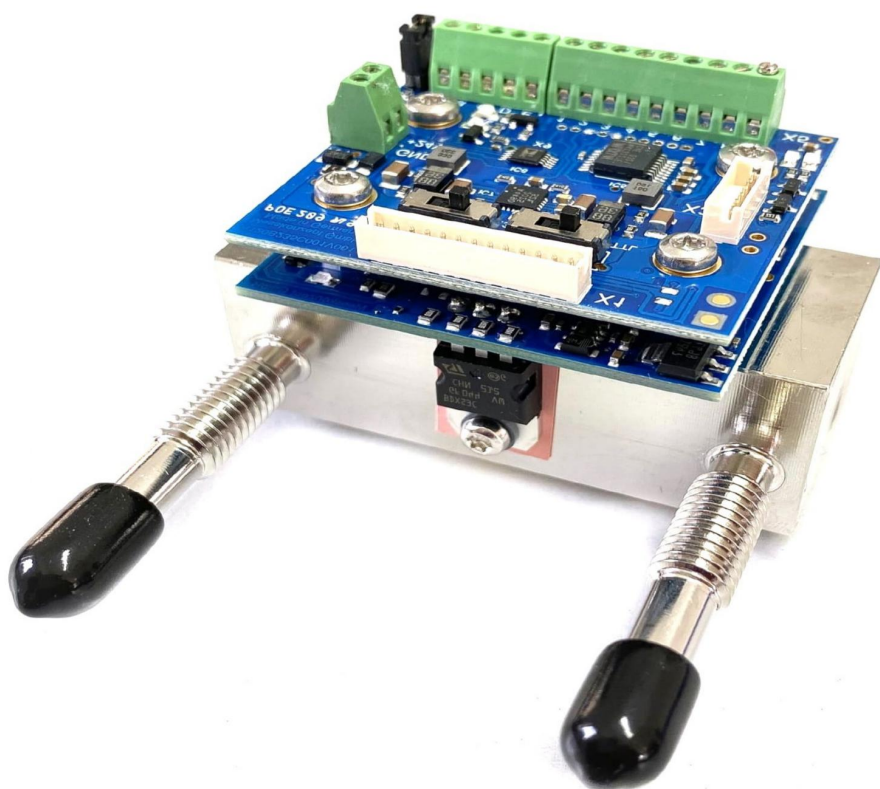


Operating Manual

FTC320-OEM

Gas analysis using thermal conductivity measurement



About this manual

Thank you for using the Messkonzept FTC320-OEM. It has been designed and manufactured using highest quality standards to give you trouble-free and accurate measurements.

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This document is protected by copyright. Neither the whole nor any part of it or the information contained in it may be adapted or reproduced in any form except with the prior written approval of Messkonzept.

All information of technical nature and particulars of the product and its use (including the information in this manual) are given by Messkonzept with careful studies. However, it is acknowledged that there may be errors or omissions in this manual. Images and drawings may not be in scale. For the latest revisions to this manual contact Messkonzept or visit www.messkonzept.de Messkonzept welcomes comments and suggestions relating to the product and this manual.

Please Note!

The design of this instrument is subject to continuous development and improvement. Consequently, this instrument may incorporate minor changes in detail from information contained in this manual.

Important!

In correspondence concerning this instrument, please specify the type number and serial number as given on the type label on the right side of the instrument.

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Chapter 1

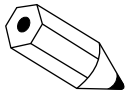
Operator Safety

This section provides information and warnings which must be followed to ensure safe operation and retain the instrument in safe condition. Read this section carefully before installing and using the FTC320-OEM.

1.1 Notes on Safety Instructions and Icons



This icon draws attention to application errors or actions that can lead to safety risks including the injury of persons or malfunctions or even possibly the destruction of the device.



This icon indicates an additional function or hint.

1.2 Safety Instructions



Warning!

- For the safe operation of the device, please pay regard to all instructions and warnings in this manual.
- Only put the device into operation after it has been installed properly. A competent and authorized person is required for installation, connection and operation of the device. Please read and follow this manual for the installation.
- Defective devices must be disconnected from the process! This applies for apparent damages of the device, such as physical damages, but also in the case of observed malfunctions in the operation. Separate the device's gas-inlet and gas-outlet from the process and disconnect the power supply from the device.
- Make sure that the electrical installation protection against accidental contact adheres to the applicable safety regulations. The device must be connected to protective earth before all other connections.
- Repairs should only be carried out by Messkonzept.
- Beware of the hot surface (up to 80 °C) of the metallic body of the device.

1.3 Intended Use

- The FTC-series of gas analyzers offer high-precision measurement and detection of non-corrosive, dust-, condensate-, aerosol and oil mist-free gases. Condensate and corrosive tolerant variants are available on request. For more detailed information and solutions about this regard, Please contact info@messkonzept.de.
- Upon installation, the protection class has to be considered. OEM-devices with protection class IP00 demand thermal insulation and electric isolation, as well as mechanical protection for operation.
- FTC-series gas analyzers do not have a metrology marking in the sense of EU directive 2014/32/EU. Therefore, they cannot be used in e.g. medical or pharmaceutical laboratory analyses or in the manufacture of pharmaceuticals in pharmacies based on a doctor's prescription.
- The specifications of the device and its manual have to be observed strictly. Please fill out questionnaire (2.01.1FB180619MPL1) for registration of your measuring task, if your intended use does not comply with intended use described above. Based on the information given in the questionnaire Messkonzept will examine the measuring task and possibly authorize it.
- Combustible gases: The inner gas path of the detector is checked for leaks. The supply of flammable gases is permitted, but the tightness of the connections and the detector must be checked before commissioning and regularly during operation. Gas leaks can cause an explosive atmosphere!
- Ignitable gases: Our appliances are designed in such a way that ignition will not occur if gases up to temperature class T3 are supplied during correct operation; the maximum surface temperature is below 200 °C. A fault in the appliance can lead to ignition. Users of our appliances must always

carry out an individual risk assessment before use, from which the necessary protective measures must be derived and implemented. The use of flame arresters as part of the individual concept for handling flammable mixtures is strongly recommended. We will be happy to provide you with an individual quotation if you require flame arresters.

1.4 Disposal Instructions

The device must not be disposed of as municipal waste (domestic waste).

If the appliance is to be disposed of, please send it directly to us (with sufficient postage). We will dispose of the components properly and in an environmentally friendly manner.

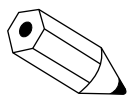
Chapter 2

Measurement Principle

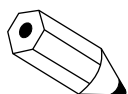
Thermal Conductivity Detectors (TCD) have been used in the chemical industry since the 1920s as the first process gas analyzers for the quantitative composition of gas mixtures. Every gas has a unique heat conductivity that is governed by its molar mass and viscosity. The measurement is based on the principle that the thermal conductivity of a gas mixture is dependent on the thermal conductivity of its gas components and their fractional amounts in the mixture. Thus, the concentrations of different components of a gas mixture can be calculated from the thermal conductivity.

The main advantage of the TCD's measurement principle compared with the wide spread infrared analysis technique is that it is not limited to gases with a permanent dipole moment. It can identify noble gases (He, Ar, Ne, etc.) as well as homonuclear gases such as H_2 and N_2 . Furthermore, it is robust and cost effective. The principle of thermal conductivity measurement works best if the analyzed gas components' thermal conductivity vary greatly. For TC measurement based analysis, one of the following conditions must be met:

- The mixture contains only two different gases (binary mixture), e.g. CO_2 in N_2 or H_2 in N_2 .
- The thermal conductivity of two or more components is similar but different than that of the measuring gas, e.g. measuring H_2 or He in a mixture of O_2 and N_2 (quasi binary mixture.)
- The mixture contains more than two gases and the volumetric fractions of all but two components (or component groups) are constant over time.
- The mixture contains more than two gases, of which all but two components' concentrations can be determined through other measurement principles (as employed in the FTC400 through cross-sensitivity compensation of IR- and TC-sensor information).



The thermal conductivity of gases rises with temperature and the slope of the increase with temperature is different for different gases. Upon request, it can be checked whether the temperature of heat sink and/or source should be changed in order to improve the accuracy or to avoid cross-sensitivity effects.



Cross-sensitivity is the sensitivity of the measurement on other gases different than the measured component.

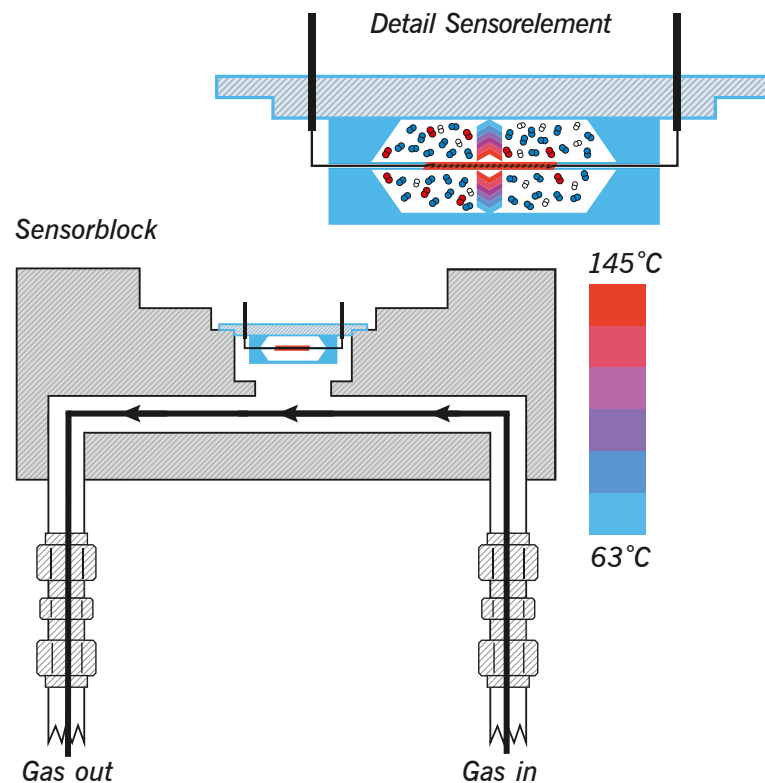


Figure 2.1: Schematic drawing of thermal conductivity measurement. The sensor is mounted in the stainless steel block that is kept at a constant temperature.

The FTC320-OEM contains a TC sensor that analyzes the quantitative composition of gas mixtures. The measurement is based on the heat transfer between a heat source and a heat sink.

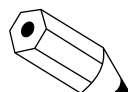
The measuring gas is led through a stainless steel block that is kept at a constant temperature of 63°C (for most applications). The block temperature is stabilized using a control loop - it serves as a heat sink of constant temperature. A micro mechanically manufactured membrane with a thin-film resistor serves as heat source. A control loop stabilizes the membrane temperature at 135°C (for most applications).

Above and below the membrane two small cavities are etched into the silicon. These cavities are filled with measuring gas by diffusion. The surfaces opposite to the membrane are thermally connected with the heat sink. Through maintaining a constant temperature gradient between the two opposite surfaces, the heat flow is dependent of the gas mixture's thermal conductivity alone. Hence the voltage needed to keep the membrane temperature constant is a reliable measure for the thermal conductivity of the mixture and can be used further to determine the gas mixture's composition.

Table 2.1 lists typical gas pairs and their measuring ranges.

Measuring Gas	Carrier Gas	Basic range	Smallest range	Smallest range at end
H ₂	He	20% - 100%	20% - 40%	85% - 100%
H ₂	CH ₄	0% - 100%	0% - 0.5%	98% - 100%
H ₂	N ₂ or air	0% - 100%	0% - 0.5%	98% - 100%
H ₂	Ar	0% - 100%	0% - 0.4%	99% - 100%
H ₂	CO ₂	0% - 100%	0% - 0.5%	98% - 100%
He	N ₂ or air	0% - 100%	0% - 0.8%	97% - 100%
He	Ar	0% - 100%	0% - 0.5%	98% - 100%
CH ₄	N ₂ or air	0% - 100%	0% - 2%	96% - 100%
CH ₄	Ar	0% - 100%	0% - 1.5%	97% - 100%
O ₂	N ₂	0% - 100%	0% - 15%	85% - 100%
O ₂	Ar	0% - 100%	0% - 2%	97% - 100%
NH ₃	H ₂	0% - 100%	0% - 5%	95% - 100%
N ₂	Ar	0% - 100%	0% - 3%	97% - 100%
N ₂	CO ₂	0% - 100%	0% - 3%	97% - 100%
CO	H ₂	0% - 100%	0% - 2%	99% - 100%
Ar	N ₂ or air	0% - 100%	0% - 3%	97% - 100%
Ar	CO ₂	0% - 100%	0% - 50%	80% - 100%
CO ₂	N ₂ or air	0% - 100%	0% - 3%	96% - 100%
CO ₂	Ar	0% - 100%	0% - 20%	50% - 100%
SF ₆	N ₂ or air	0% - 100%	0% - 2%	96% - 100%

Table 2.1: The measuring ranges of typical gas compositions for analysis with the FTC320-OEM given in Vol. %.



The **basic range** is the largest possible measuring range and is set as standard. Linearization is carried out over the basic range. The smallest measuring ranges at the beginning and end of the basic range are made possible by a separate calibration.

Chapter 3

Calibration Instructions

This section explains how the readjustment of the device should be planned and carried out on site. Different installation, dew point, pressure, flow rate and test gas quality can lead to a shift in the indication right from the start. In addition, the reading may vary by 2% of the smallest measuring range per week, e.g., measuring H₂ in N₂, the drift per week may be 100 ppm.

3.1 Offset and Gain Calibration

The aim of calibration is to ensure that the measured concentration matches the specified test gas concentration. This is achieved by the correct adjustment of two calibration parameters, called "offset" and "gain", which correspond to the ordinate intercept and the slope of a linear equation calculated in the device. Figures 3.1 and 3.2 explain how offset and gain correction works.

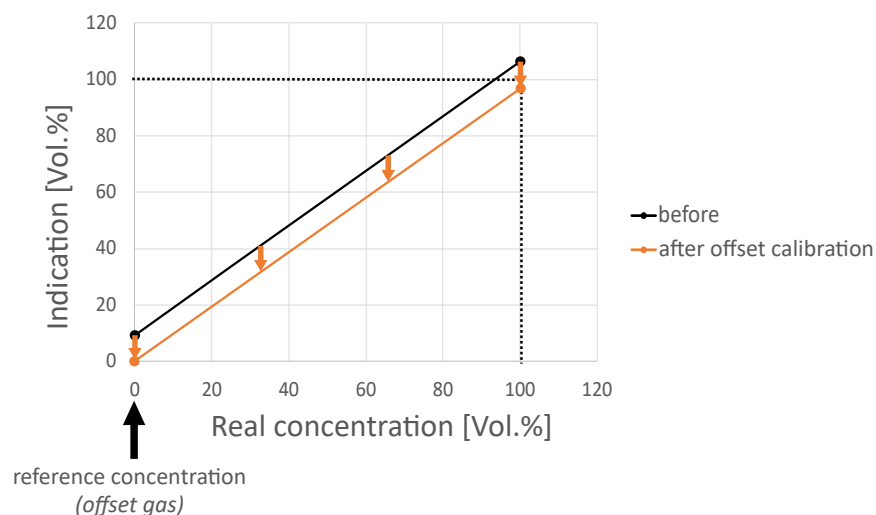


Figure 3.1: Offset calibration.

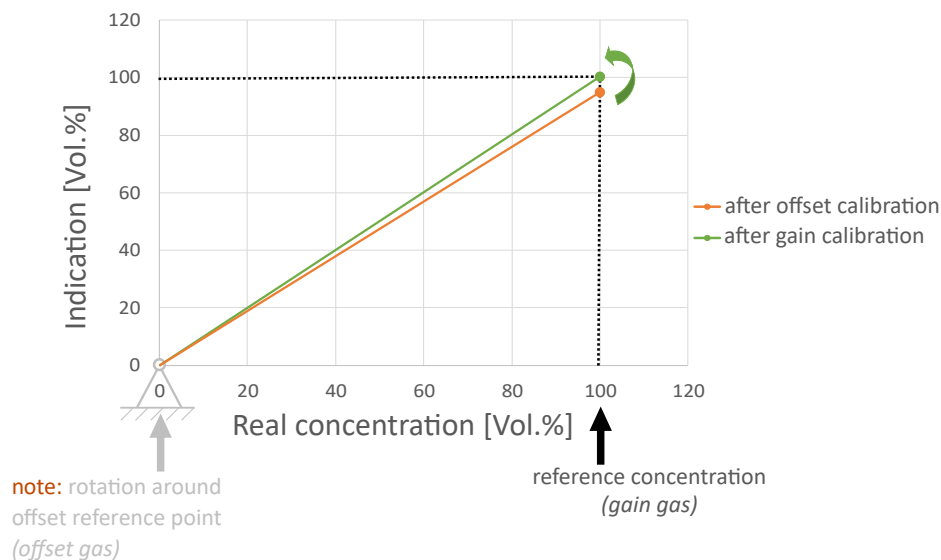


Figure 3.2: Gain calibration after offset calibration.

For a determination of offset and gain a two-point calibration must be performed. The concentration of the offset test gases should be close to the start-point, and the concentration of the span (Gain) test gas should be close to end-point of the measuring range (a difference of $\pm 10\%$ of the measuring range from the start- or end-point is permissible). For instance, when measuring H₂ in O₂ at a measuring range from 0 Vol.% – 100 Vol.%, use pure O₂ as offset test gas (Offset Gas = 0 Vol.% H₂ in O₂) and pure H₂ as the gain test gas (Gain Gas = 100 Vol.% H₂ in O₂).

two-point calibration always requires an offset calibration directly before a gain calibration! **A one-point calibration, in which only a new offset value is determined, is sufficient in most cases.** It is suitable for correcting drift or changes in operating parameters such as flow rate, pressure, or dew point. Compared to the offset, the gain is stable over years and practically unaffected by changes in flow or pressure. In the case of a pure offset calibration, a test gas with any concentration in the measuring range can be used but must be set before starting the offset calibration.

3.2 Performance check with test gas

During a performance test, the response of the device to a test gas that is within the measuring range is monitored and recorded. In contrast to a calibration, the settings of the device are not changed. An inspection of the recorded performance test might uncover phenomena that can be obscured by repeated calibration. This applies, for example, to a persistent signal drift or a periodicity in the signal curve due to unsteady flow, pressure, or dewpoint. The correct indication of the test gas is almost always sufficient to prove that the device is working properly.

3.3 Test Gas Quality

A test gas of sufficient quality for your application should be used for performance testing and calibration. For calibration, Messkonzept uses gases with the following purities:

H ₂	He	N ₂	Ar	O ₂	CO ₂	CH ₄
5.0	5.0	5.0	4.6	4.5	4.5	3.5

Table 3.1: Recommended calibration gas purities.

The gas purities are selected so that the devices comply with the specifications for the smallest measuring range. Messkonzept recommends gases of the same purity for on-site calibration. If your own requirements differ, please choose the appropriate gas purity. Please contact Messkonzept if you would like advice.

3.4 Criteria For Test and Calibration

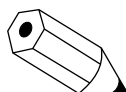
Carry out a test or calibration under - as far as possible - similar physical conditions to those used for the measurement, e.g. pressure, flow, temperature, filtration, dew point, etc.

A performance test and, if necessary, calibration with test gases is required if one of the following criteria is met:

- After new installation of the device or after it was serviced.
- After changes to the sample preparation system and outlet that affect, for example, pressure, flow, temperature, filtration, dew points, etc.
- In a regular cycle, depending on the desired accuracy - but at least once a year! To determine the appropriate time interval, we recommend starting with a more frequent recorded performance test and determining the optimum interval from these results. The time between tests/calibrations can be in the range of:
 - months for a measurement task in the basic or medium measuring ranges.
 - days to weeks for small measurement (low- or sub-vol%) ranges.
 - directly before each measurement if maximum accuracy is required.

3.5 Gas Supply during Calibration

Ensure that the appropriate test gas has fully entered the device before performing an offset or gain calibration. You should monitor the signal for stability to ensure this. After activating the calibration routine, a sampling phase of 10 seconds begins. Keep the gas supply stable and continuous during this phase.



Please note that any large change in flow, pressure or concentration, for example when opening a valve for the test gas flow, will cause a certain disturbance to the thermostated measurement in the FTC320-OEM. This is particularly the case if you accidentally had a very high gas flow, even for a very short time. It may take a while for the temperatures in the FTC320-OEM to reach equilibrium again and for the measurement indication to provide a stable and reproducible value in the ppm range. For measurements of the highest precision, this can take 10-20 minutes, see Figure 3.3.

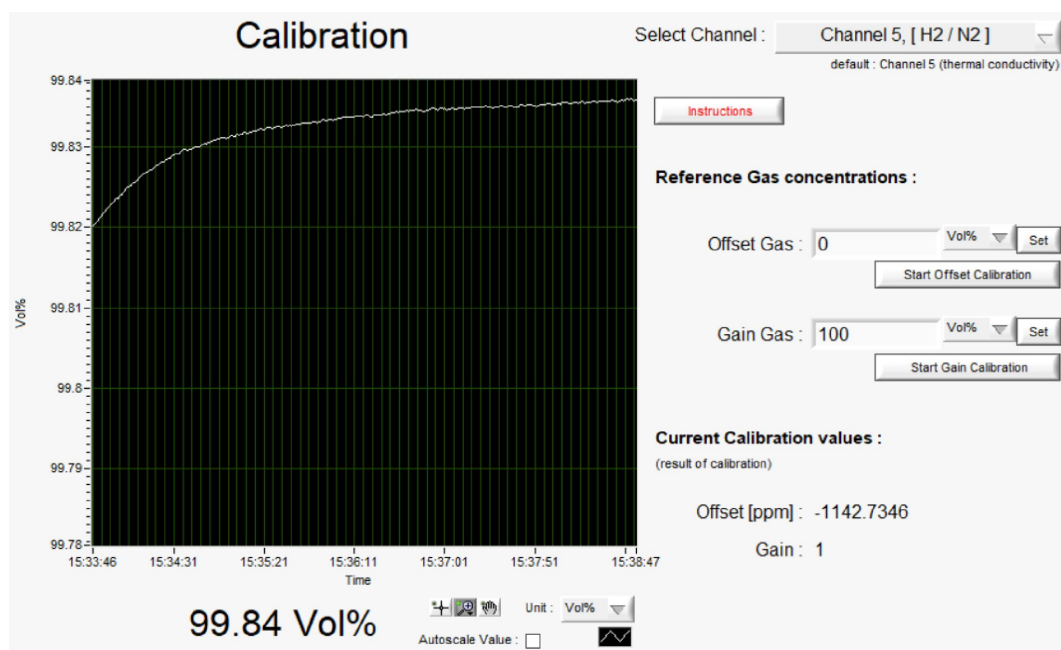


Figure 3.3: After a sudden change in flow, pressure or gas concentration it may take some minutes for the measurement to stabilize to ppm precision.

3.6 Use of Substitute Gases

Instead of using toxic or explosive gases for calibration, substitute gases may be used. A substitute gas has (at a certain concentration) the same thermal conductivity as the test gas it is substituting, such it can also be used for the calibration instead. Please contact Messkonzept for details on possible substitute gases for your application.

Chapter 4

Installation of the Instrument

4.1 Mounting

The bottom view of the FTC320-OEM shows four M3 thread holes which can be used for the fixation of the detector (see Figure 4.1). Do not mount directly on heat conductive surface. Use insulating spacers (min. 4mm thick) and stainless-steel screws, to minimize the heat dissipation from the 63°C hot detector body. For bulkhead mounting, two spacers and two M8 nuts are available upon request.

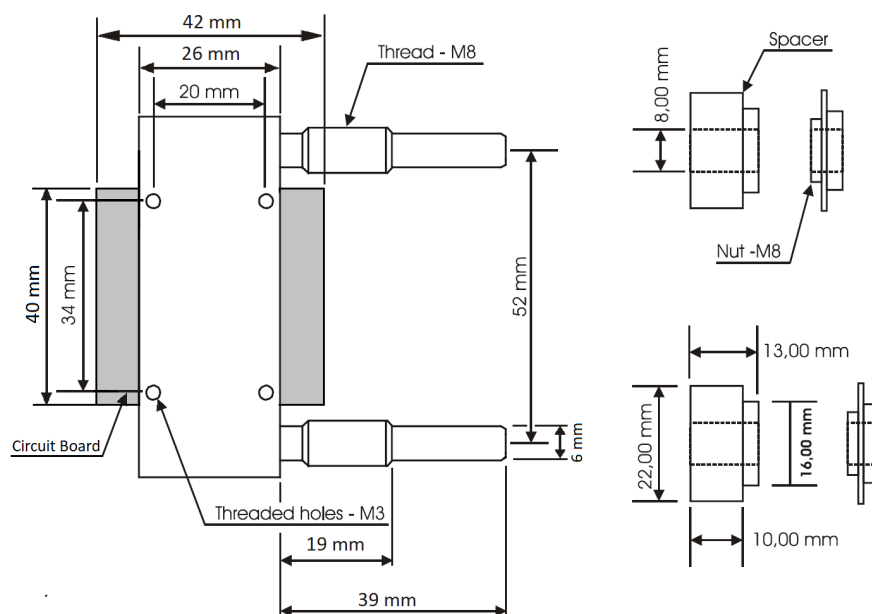


Figure 4.1: Dimensions of the FTC320-OEM and fixation points.



Warning!

- Beware of the hot surface (up to 80°C) of the metallic body of the device.

4.2 Housing and insulation

Thermal insulation and Electromagnetic protection

The FTC320-OEM must not be exposed to any air flow, e.g. from fans. That's why Messkonzept strongly recommends using housing for the FTC320-OEM. The ambient atmosphere should not be corrosive. The use of additional insulation is optional, but may become necessary for ambient temperatures below 0°C. Do not use flammable material for insulation. It should be temperature-resistant up to 120°C. The circuit boards must not be covered by the insulation. The system is equipped with a thermal fuse that interrupts the current to the heaters when the temperature rises above 110°C. Please consider the waste heat from other appliances in the vicinity. They must not cause a temperature rise above 50°C in the ambient.

The product FTC320-OEM does not meet Electromagnetic Compatibility (EMC) requirements without proper shielding and housing. EMC measures must be implemented by the customer.

4.3 Gas Connections

The gas inlet and outlet tubes, see figure 4.2, as well as the device's body are made of stainless steel 1.4404. The outer diameters of the gas inlet and outlet tubes are 6mm. The inner gas duct is heated up to 63°C (versions with higher temperatures available on demand). Condensation in the sample gas lines and connections must be strictly avoided. Heated lines and connections can be used in order to prevent condensation. With proper heated lines and connections, a dew point up to 50°C is permissible.

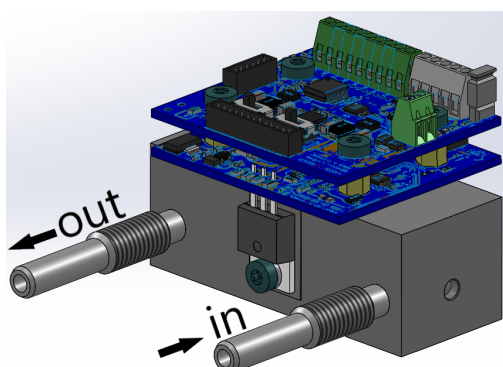


Figure 4.2: The gas in- and outlet of the FTC320-OEM



Warning!

The gas led into the device must not contain any dust, condensate or potentially condensing matter unless the FTC unit is equipped with a filter membrane protecting against condensate and dust. Liquid droplets or dust will immediately destroy the sensor element upon contact. If your gas sample may not be dust-, condensate- or corrosion-free, please state this in your request and we will provide you with a suitable FTC320-OEM unit.

4.4 Electrical Connection

The electric connectors of the FTC320-OEM are shown in Figure 4.3. Connections are to be realized with cables of from 20 AWG to 22 AWG which fit into the screw terminals.

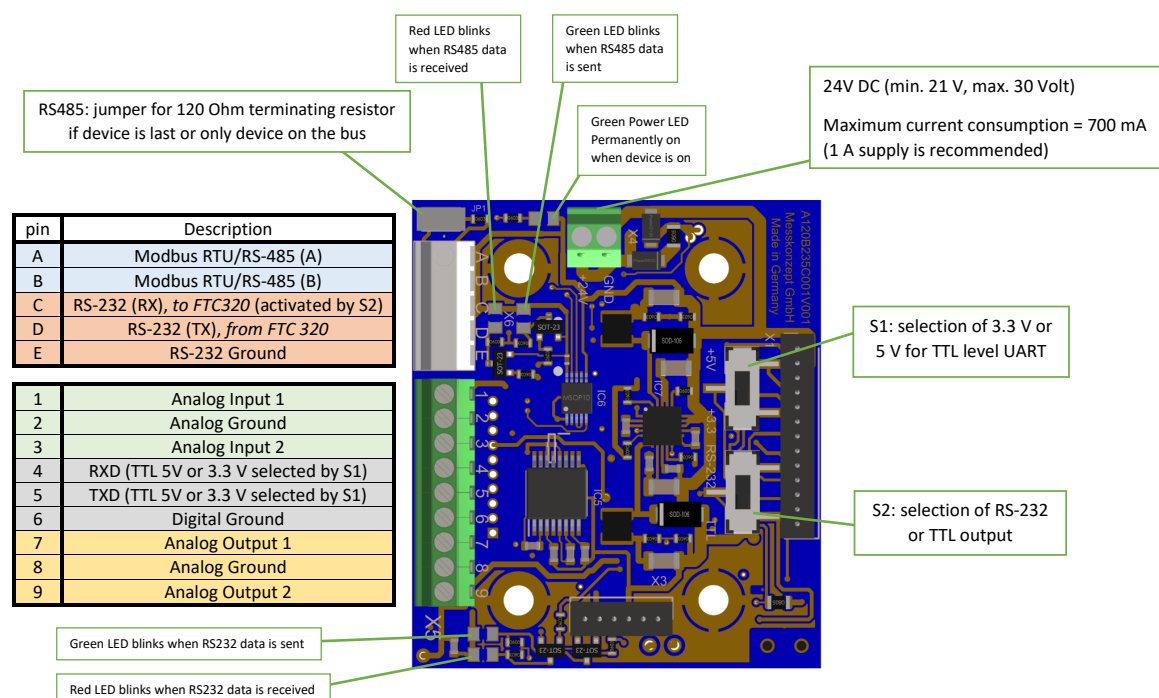


Figure 4.3: The electrical connections to and from the FTC320-OEM .

Three green LEDs are located on the PCB (see Figure 4.3). One should be permanently on when the device is properly on. It can be found in Figure 4.3.

The second green LED is blinking when RS232 data is sent by the FTC320-OEM (see bottom left on figure 4.3). The red LED next to it blinks when data is received.

The third green LED blinks when data is successfully transferred via RS485 (ModBus), it is shown in Figure 4.3. The red LED next to it blinks red when data is received via RS485 (ModBus) connection.

If the red or green RS232/RS485 LED is permanently on, there is a communication error, please check cable connections and correctness of voltage level settings, given in Table 4.1.

4.5 Analogue Voltage Output

The Analogue outputs can be used to output the currently measured gas concentration as an analogue voltage between 0-10V.

The FTC320-OEM is equipped with two analogue outputs: These two non-isolated outputs with a range of 0V to 10V are named Analogue Output 1 and Analogue Output 2. Figure 4.3 shows where to connect the Analogue Outputs.

The Analogue Outputs can be set to different modes. These modes, shown in Table 4.1, can be set for each output separately.

Output Mode	Voltage Range	Error Indication
0V - 10V	Output voltage range 0V - 10V Cutoffs 0V - 10.5V	—
0V - 5V	Output voltage range 0V - 5V Cutoffs 0V - 5V	—
2V - 10V (Err)	Output voltage range 2V - 10V Cutoffs 1.9V - 10.25V	Error value 1.5V

Table 4.1: The available modes of the analogue outputs.

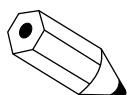
The output mode pre-selected in your instrument can be found in the manufacturing Protocol shipped with the device. If you are unsure or you lost the device protocol, please contact Messkonzept.

4.6 Analogue Input

The FTC320-OEM is equipped with two analogue inputs. These two non-isolated inputs are named Analogue Input 1 and Analogue Input 2. Figure 4.3 shows where to connect the Analogue Inputs. The Analogue inputs may be used to read a voltage signal (0-10 V) from an external signal source. This feature is typically used to let the FTC320-OEM compensate the gas measurement for cross-sensitivities to disturbances that can not be directly measured by the FTC320-OEM itself.

The analogue inputs are typically not be pre-configured by Messkonzept. Their configuration is only done upon request.

Please see the manufacturing protocol shipped with the device to find out if and how the inputs are configured in your device.



The output mode as well as the input can be configured using SetApp3.0, a software offered by Messkonzept. For more information, please read the SetApp3.0 manual.

Chapter 5

Digital Communication

In this chapter a short introduction into the digital communication with the FTC320-OEM is given. The goal is to provide a quick overview of the available features and to assist you in selecting which digital interface to use depending on your requirements. For more detailed information, please look into the separate documentation on SetApp3.0 or the manual on Serial Communication, respectively. Both are available from the Messkonzept homepage.

5.1 Overview

Depending on your application you may want to use either the RS232 interface, the RS485 interface, or both simultaneously. Both interfaces grant access to all ~500 internal device parameters through different communication protocols, which each have their own advantages/disadvantages:

RS232 or 3.3V / 5V TTL:

- Human-readable Serial Communication (ASCII characters)
- Quick troubleshooting, laboratory scale experimental setups
- SetApp3.0 (user interface with timeline plot, calibration, data logger, change parameters, backup & restore all parameters)
- Integration into PLC or other software systems requires some programming to interpret the custom communication protocol

RS485:

- ModBus-RTU
- Easier integration into PLC or other software systems
- Multiple devices on the same bus possible

Following, in subsection 5.1.1 the parameter list of the FTC320-OEM and special commands, relevant to both RS232/TTL or RS485 communication, are introduced. In section 5.2 and section 5.3 more specific information about both interfaces are given, each highlighting some key features and giving some practical application examples.

5.1.1 Parameter List and Special Commands

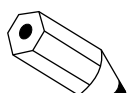
The FTC320-OEM has approximately 500 internal parameters. Some of these parameters are read-only, such as the measured gas concentration values or raw signals. Other parameters can be written to change the device configuration. One parameter takes a special role: P12 is used to trigger tasks/actions, such as a calibration routine.



Proceed with caution when setting any parameters or triggering actions! Improper handling of parameters may misconfigure your device to show wrong measurement values or even cause permanent physical damage to the device.

Following you find a short-list of some important parameters, most of which are going to be used later in this chapter.

- **P0** *Serial Number*: Serial number of the device. It may be helpful to read out this value to test the bus communication or to identify a device amongst others on the same bus
- **P1** *Concentration5*: Calibrated gas concentration (in ppm) of channel 5 (Thermal Conductivity measurement)
- **P12** *Perform Task*: Triggers special commands when set to specific values, e.g. the value 250 will trigger offset calibration of channel 5. After execution of the command is completed, the value of the parameter is automatically reset to 0.
- **P496** *Offset_Gas5*: Test gas concentration (in ppm) used for offset calibration of channel 5 (Thermal Conductivity measurement).
- **P497** *Gain_Gas5*: Test gas concentration (in ppm) used for gain calibration of channel 5 (Thermal Conductivity measurement)



For a complete list of all parameters and special commands, please see your device's manufacturing protocol and read the Serial Communication Manual.

5.2 RS232 / TTL interface

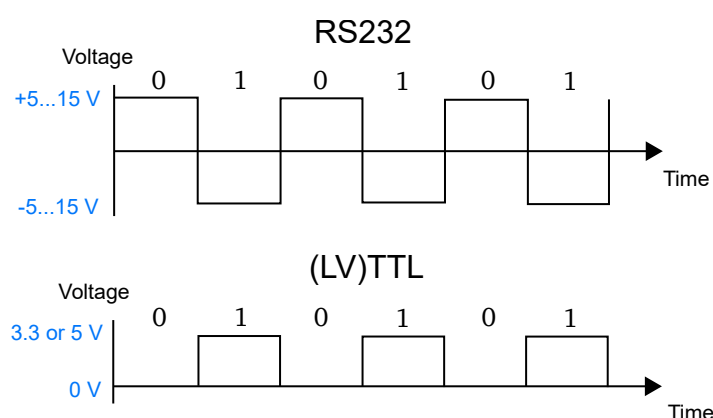


Figure 5.1: Logic signal encoding of RS232 and (LV)TTL

The FTC320-OEM provides serial communication at selectable voltage levels, adaptable to your system: RS232 is an industry standard for serial communication. It allows the transmission of data between the

FTC320-OEM and many computing or control systems in the field.

TTL (Transistor Transistor Logic) serial is commonly used for communication in small distance embedded or laboratory applications. Some microcontrollers use 5 V logic (TTL), others use 3.3 V logic (LVTTTL).

5.2.1 Interface setup

You may need to change the switch combinations of S1 and S2 (see Figure 5.2) to select the voltage level for Serial Communication. **Verify the switches' positions before connecting external hardware that may be damaged by too high voltage signals!**

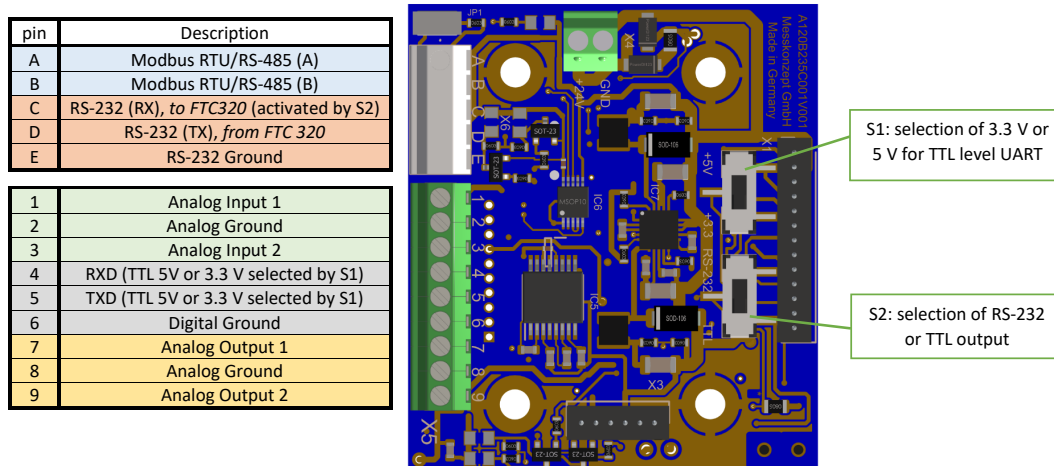


Figure 5.2: The electrical connections to and from the FTC320-OEM .

The following table explains possible switch combinations, the orientation reference used (Up/Down) is the same as in Figure 5.2:

Mode		Switch combinations	
Name	Voltage levels	Position of switch 1 S1	Position of switch 2 S2
Full RS232	-12V to +12V	-	Up (RS232)
TTL	0- 5V	Up (5V)	Down (TTL)
LVTTTL	0- 3.3V	Down (3.3V)	Down (TTL)

Table 5.1: Possible switch combinations of S1 and S2

The settings for the RS232 communication are:

- Baudrate: 19.2 kBaud
- Parity: none
- Stop bits: 1

5.2.2 SetApp 3.0

SetApp 3.0 is a free software for communication with the FTC320-OEM. It can be downloaded from the Messkonzept website. RS232 (can also be on TTL level) must be connected to a Windows PC in order to use SetApp3.0.

To give a quick introduction into SetApp 3.0, following are some brief examples in how to read measurement values and how to calibrate. **Please review the SetApp3.0 manual for more information.**

Main Plot in SetApp 3.0

After connecting SetApp 3.0 to the FTC320-OEM, you can see the currently measured signal in the main plot window, see Figure 5.3.

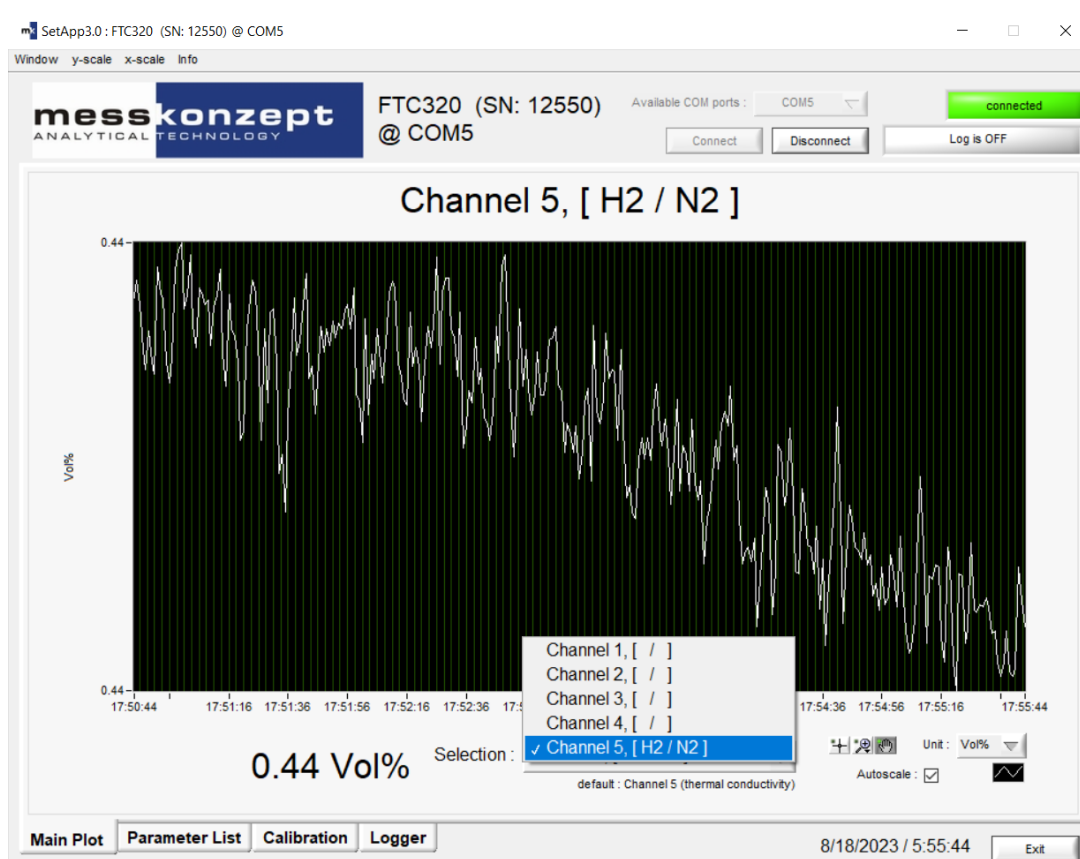


Figure 5.3: Main Plot view in SetApp3.0

Calibration in SetApp 3.0

Calibration of the instrument can be performed conveniently through the user interface of SetApp3.0. Before starting with the actual calibration, please read the general information on calibration given in section 3.1. Also, please take note of the more detailed "Instructions" page which can be accessed from on the calibration tab in SetApp 3.0 - another resource for information is the user manual for SetApp 3.0.

First, choose the channel to be calibrated from the drop-down menu at top right of the calibration tab, see Figure 5.4. Enter the offset gas concentration (the test gas concentration to which the measurement

will be adjusted by calibration) and choose the unit (Vol% or ppm).

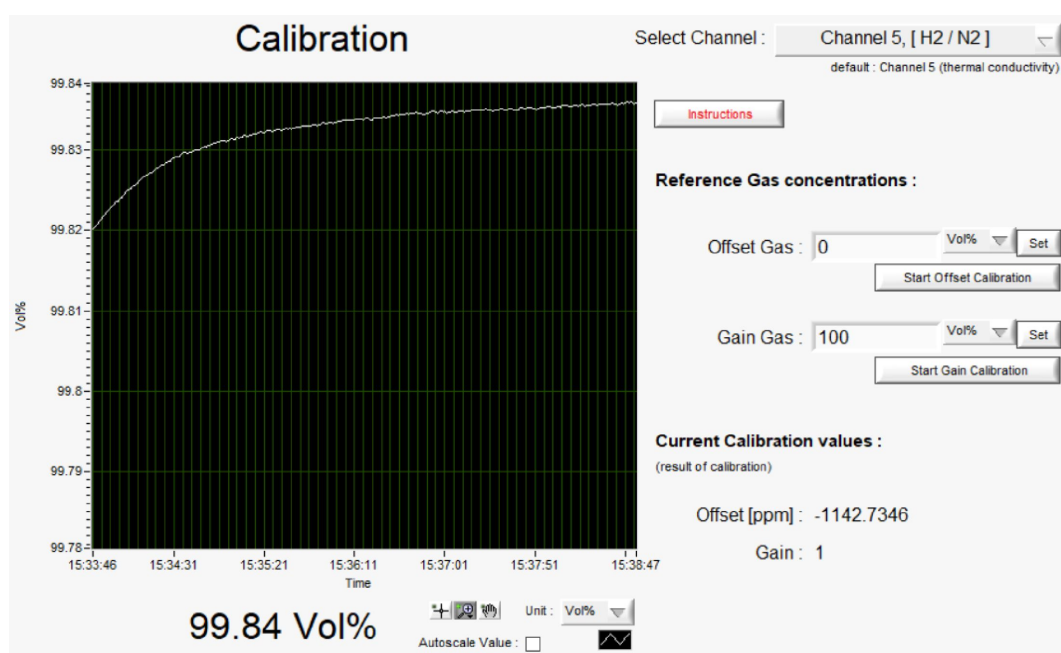
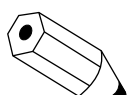


Figure 5.4: The calibration window

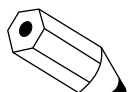
Apply the test gas used for offset calibration and wait for the measurement to stabilize (watch the plot on the left). The time for stabilization depends strongly on the dead volume in the gas duct leading to the device. To observe the value with high precision, change the unit to ppm (selection below the plot window). When the measurement has stabilized, click on **Start Offset Calibration**. The sampling takes 10 seconds. After that, the measurement indication should equal the reference gas concentration.

For thermal conductivity measurement, a single point (offset) calibration is typically sufficient. If you wish to also calibrate the gain, please do so **after** prior offset-calibration.

The suggested procedure is different for measurement of O₂ with an external electrochemical sensor (typically routed over channel 1). This sensor should only be gain-calibrated (without prior offset-calibration). Typically this is done with air (20.95 Vol.% O₂ in dry air) at the same flow rate that is used in typical operation in your process.



Always do an offset calibration first before doing a gain calibration!



In most cases an offset calibration alone is sufficient for the proper performance of the device! First check if there is a deviation before possibly calibrating!

5.2.3 RS232 communication in a terminal emulator (e.g. Tera Term)

When connected via the RS232 or TTL level interface, a terminal emulator such as Tera Term, may be used to interact with the FTC320-OEM. All device parameters and device functions can be reached through this interface.

The settings for the RS232 communication are:

- Baudrate: 19.2 kBaud
- Parity: none
- Stop bits: 1
- Transmit carriage return [CR] to execute a command

The basic commands for parameter handling are shown in Table 5.2 below. **Commands** in are written in bold font, while parameter numbers are underlined. *Passed values* are indicated in italic font. "Pn" is an abbreviation for "Parameter number".

Action	Command	Example
Get parameter name	P(<u>Pn</u>)N	P<u>2</u>N (Get name of parameter 2)
Get parameter value	P(<u>Pn</u>)?	P<u>1</u>? (Get value of parameter 1)
Set parameter value	P(<u>Pn</u>)=F<i>set_value</i>	P<u>496</u>=F0 (Set parameter 496 to value 0)

Table 5.2: Different commands and their actions

A command is executed by sending a [CR] (carriage return). You may need to adjust the settings of your terminal emulator to send a [CR] when you hit the Enter-Key in your terminal emulator.

Two special commands: **mk?** and **pk?** can be used to check if connection to a device was successful. As a response to these commands the FTC320-OEM will read back general device information either in multiple-line (mk?) or single-line output (pk?), see Figure 5.6.

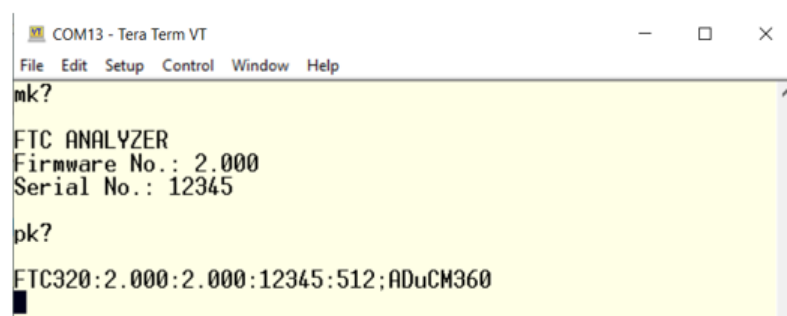


Figure 5.5: Response of the FTC320-OEM to the special commands mk? and pk?

Reading measurement values

The currently measured gas concentration by the thermal conductivity channel (channel 5) can be read from Parameter P1 using the command **P1?** followed by [CR] (carriage return), see Figure 5.6.

Here the connected device is showing a gas concentration of 585646.9 ppm. The FTC320-OEM handles all gas concentration values in the physical unit ppm (parts per million) internally. Divide by 10000 ppm/Vol.% to get the concentration as 58.56 Vol.%.

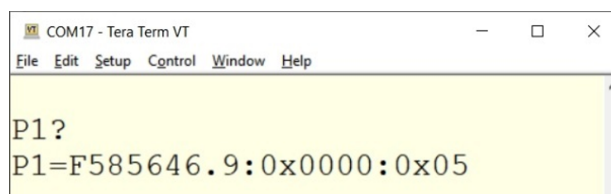


Figure 5.6: The commands *P1?* followed by [CR] reads out the currently measured gas concentration in the unit ppm

In Table 5.3 the complete response syntax to parameter query is explained briefly. Please review the manual on Serial Communication with the FTC320 for more detailed information.

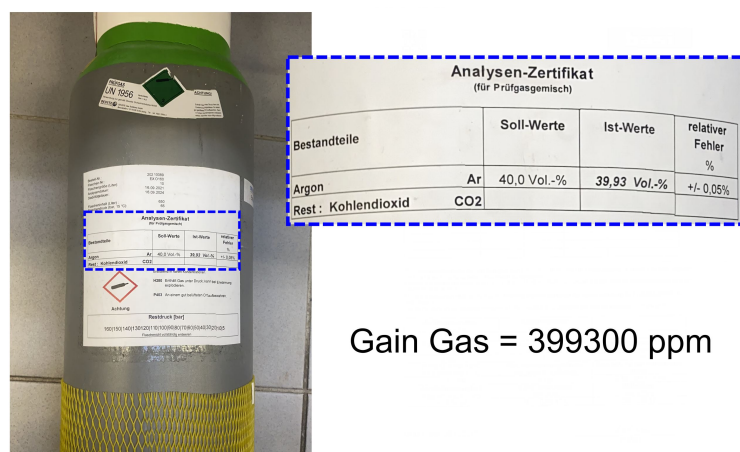
P1	=	F	585646.9	:	0x0001	:	0x05
Queried parameter, here 1		Datatype, here float (F)	Value, here 58.56 Vol. %		Device status- bitmask		Command status

Table 5.3: Response of the FTC320-OEM to the query **P1?**

Calibration

Before starting with the actual calibration, please read the general information on calibration given in section 3.1. Following, the commands for calibration via RS232 (can be TTL level) are explained on a practical example. We assume a device with measuring range 0-40 Vol% Ar in CO₂ using the following test gases:

- start point: 100 Vol.% CO₂ (= 0 Vol.% Ar in CO₂)
- end point: 39.93 Vol.% Ar in CO₂ (see Figure 5.7)



Gain Gas = 399300 ppm

Figure 5.7: Test gas bottle used for checking / calibration of the range's end point. The imprint on the bottle shows the concentration value, here 39.93 Vol. % = 399300 ppm.

1. Set gain- and offset- test gas concentration values.

P496=F0

P	496	=	F	0
Parameter "Offset test gas (channel 5)"				0 ppm

P497=F399300

P	497	=	F	399300
Parameter "Gain test gas (channel 5)"				399300 ppm

2. Apply offset test gas to the FTC320-OEM and wait for the signal to stabilize, you may read out the currently measured concentration signal by sending **P1?** to the device repeatedly.
3. Calibrate Offset.

P12=F250

P	12	=	F	250
Parameter "Special Command"				Task "Calibrate Offset"

Calibration sampling takes 10s. The device will answer with "P12=F0" when the calibration is completed. Please verify if the calibration was successful by reading out the measurement value using the command **P1?** again. Now the indication should equal the previously configured "Offset Gas" concentration (here: 0 ppm).

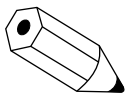
4. Apply your gain-gas concentration to your device and wait for signal to stabilize (5-10 mins). If the measurement value already satisfies your precision requirements, there is no need for a gain calibration.
5. If not: Calibrate Gain.

P12=F251

P	12	=	F	251
	Parameter "Special Command"			Task "Calibrate Gain"

Please verify if the calibration was successful by reading out the measurement value again using command **P1?**. In our example the device should now be showing a value of 399300 ppm.

To be absolutely sure that gain calibration was successful over the whole range, you may want to apply the offset test gas once more to see that the indication is still showing correctly (here: 0 ppm).



Always do an offset calibration first before possibly doing a gain calibration! Reversing the procedure would result in a worse calibration result! In most cases an offset calibration alone is sufficient for the proper performance of the device! First check if there is a deviation before possibly calibrating!

Custom Software

You may need to create own software to interface with the device, e.g. to perform automatic calibrations or other interactions via RS232. If you want to design such software, please read the Serial Communication manual for more detailed information about all device parameters.

5.3 RS485 interface

This chapter only gives a small introduction into the use of the Modbus with the FTC320-OEM. More detailed information on the Modbus communication, including bus configuration parameters and a complete list of all registers, can be found in the Manual on Serial Communication.

Using the RS485 interface all parameters in the FTC320-OEM can be accessed similarly as through the RS232 interface. The main difference is in the used communication protocol: The Modbus-RTU standard is used.

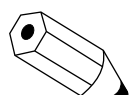
5.3.1 RS485 Bus Setup (Modbus)

RS485 allows for reliable serial communication, especially in environments that require long-distance data transmission and noise immunity. The used Modbus RTU standard allows for easy integration into a great variety of systems.

RS485 supports multi point connection, allowing multiple devices to communicate over the same network.

The default setting for the RS485 communication are:

- Baudrate: 19.2 kBaud
- Parity: none
- Stop bits: 1
- Address: 1



Parameter 16 (P16) is used to change the ModBus address (default: 1). Each address on a bus with multiple devices must be unique.

5.3.2 Function Codes

The FTC320-OEM uses the following function codes:

- **03 (0x03) Read Holding Registers**
 - Read device parameters (*parameter list*, same as in RS232 communication) in 32-bit format, either float32 or UINT32. Two Modbus Registers combined in big-endian notation (ABCD) yield the complete parameter value
 - Register Address = Parameter Number * 2
e.g. Gas concentration measured by thermal conductivity (P1, see parameter list):
start address: 2, number of registers: 2, format: float32
- **04 (0x04) Read Input Registers**
 - addresses 000-026: short-list of most important device parameters formatted in float32
 - addresses 100-126: short-list of most important device parameters formatted in INT16/UINT16 (with decimal shift)
- **08 (0x08) Diagnostics**

• 16 (0x10) Write Multiple Holding Registers

- Write device parameters (*parameter list*, same as in RS232 communication) in 32-bit format, either float32 or UINT32. The two Modbus Registers that make up one parameter should be written in the same write operation, using big-endian notation (ABCD).
- Register Address = Parameter Number * 2
e.g. Perform Task (P12, see parameter list):
start address: 24, number of registers: 2, format: UINT32



Proceed with caution when writing to the Holding Registers! You may misconfigure your device to give a wrong measurement indication or even damage the hardware of your device! Messkonzept will accept no liability for damage caused by improper configuration.

5.3.3 Reading measurement values

The current gas concentration measured by thermal conductivity (channel 5) can be read by:

- Function code: 3 (Read Holding Registers)
Start address: 2
Number of registers: 2
Interpret as: float32, big-endian (ABCD)

Note that the gas concentration is represented in the unit ppm. You can convert the number to Vol.% by dividing it by 10000 ppm/Vol.%.

Modbus Holding Registers

Address (dec)	Address (hex)	Parameter number	Parameter Name	Data type	read/write
0	0x0000	0	Serial_No	UINT32	r/w
2	0x0002	1	Conc5_TC	float32	r/-
4	0x0004	2	Block_Temp	float32	r/-
6	0x0006	3	TCS_Rm_mV	float32	r/-
8	0x0008	4	Status_Matrix	UINT32	r/-
10	0x000A	5	Firmw_Vers	float32	r/-
12	0x000C	6	ArticleNo_A	UINT32	r/w
14	0x000E	7	ArticleNo_B	UINT32	r/w
16	0x0010	8	ArticleNo_V	UINT32	r/w
18	0x0012	9	Operation_Hrs	UINT32	r/w
20	0x0014	10	Access_Level	UINT32	r/w
22	0x0016	11	T90_Response	float32	r/w
24	0x0018	12	Perform_Task	UINT32	r/w
26	0x001A	13	Expert_Passw	UINT32	r/w
28	0x001C	14	User_Passw	UINT32	r/w
30	0x001E	15	Setup_Matrix	UINT32	r/w
32	0x0020	16	Modbus_Address	UINT32	r/w
34	0x0022	17	RS485_Baudrate	UINT32	r/w
36	0x0024	18	RS485_Parity	UINT32	r/w
38	0x0026	19	Errors_Status	UINT32	r/-
40	0x0028	20	Ignore_Errors	UINT32	r/w
42	0x002A	21	MaintR_Status	UINT32	r/-
44	0x002C	22	Limits_Status	UINT32	r/-
46	0x002E	23	Relay1_Setup	UINT32	r/w
48	0x0030	24	Relay1_Trigger	UINT32	r/w
50	0x0032	25	Relay2_Setup	UINT32	r/w

Table 5.4: Excerpt from the Serial Communication Manual: The holding registers contain all device parameters.

5.3.4 Calibration via RS485

The RS485 interface can also be used to calibrate the FTC320-OEM. The procedure is the same as for the RS232 communication, as explained in section 5.2.3, only the parameter values are instead written into holding registers. See Table 5.5 for a translation of the parameter numbers to holding registers.

Address (dec)	Address (hex)	Parameter number	Parameter Name	Data type	read/write
24	0x0018	12	Perform_Task	UINT32	r/w
992	0x03E0	496	Offset_Gas5	float32	r/w
994	0x03E2	497	Gain_Gas5	float32	r/w

Table 5.5: Excerpt from the Serial Communication Manual: Holding Registers needed for calibration of the thermal conductivity channel (channel 5).

For a detailed example of the calibration procedure via RS485, please see the Serial Communication Manual found on the Messkonzept website.

Chapter 6

Specifications

6.1 Specification of Thermal Conductivity Measurement

Attribute	Range/ Precision
Linearity	< 1% of range
Warm up time	Approx. 20 min; up to 1h for highest precision
T90- time	< 1 sec (at proper flow rate)
Noise	< 1% of smallest range
Drift at zero point	< 2% of smallest range per week
Repeatability	< 1% of range
Drift of span	< 0.2% of smallest range
Error due to change of ambient temperature	< 1% of smallest range per 10° C
Error due to change of flow within the recommended ranges	< 1% of within recommended range given in Table 6.2
Error due to change of pressure (800 kPa < P < 1200 kPa)	< 1% of smallest range per 10 hPa

Table 6.1: Specification of TC measurement

6.2 Flow and Calibration Specifications

Article No.:	Description	Calibration	Flow at Atmosphere Pressure
A140B900	Without protection	calibrated at 60 l/h	Recommended value 60 l/h Recommended range 40 l/h – 80 l/h Permissible range 10 l/h – 120 l/h
A140B901	Protection against corrosion	Calibrated at 60 l/h	Recommended value 60 l/h Recommended range 40 l/h – 80 l/h Permissible range 10 l/h – 120 l/h
A140B902	Protection against condensate and dust	Calibrated at 60 l/h	Recommended value 60 l/h Recommended range 40 l/h – 150 l/h Permissible range 10 l/h – 300 l/h
A140B903	Protection against corrosion, condensate and dust	Calibrated at 60 l/h	Recommended value 60 l/h Recommended range 40 l/h – 150 l/h Permissible range 10 l/h – 300 l/h
A140B907	Low sample gas flow Protection against condensate and dust	Calibrated at 10 l/h	Recommended value 10 l/h Recommended range 3 l/h- 20 l/h Permissible range 1 l/h - 60 l/h
A140B907	Low sample gas flow Protection against condensate and dust	Calibrated at 30 l/h	Recommended value 30 l/h Recommended range 20 l/h- 40 l/h Permissible range 1 l/h - 60 l/h
A140B908	Low sample gas flow Protection against corrosion, condensate and dust	Calibrated at 10 l/h	Recommended value 10 l/h Recommended range 3 l/h- 20 l/h Permissible range 1 l/h- 60 l/h

Table 6.2: Specifications of the variants of the product

6.3 Materials of FTC320-OEM Exposed to The Measured Gas

Article No.	Material
A140B900	
A140B901	Stainless Steel AISI 316Ti; Viton [®] (FKM); Glass (SiO ₂); Silicon (Si); Silicon nitride (Si ₃ N ₄) ;
A140B902	Aluminum oxide (AL ₂ O ₃); Gold (Au);
A140B907	Iron-Nickel Alloy Dilaton 29/18 (NiCo2918)(Gold plated)
A140B907	

Table 6.3: Materials of the device that come into contact with the measurement gas.

Article No.	Material
A140B903	Stainless Steel AISI 316Ti; Viton [®] (FKM); Glass (SiO ₂); Silicon (Si);
A140B908	Silicon nitride (Si ₃ N ₄) ; Aluminum oxide (AL ₂ O ₃); Inert Polymer

Table 6.4: Materials of the device that come into contact with the measurement gas.

6.4 Electrical Specifications

Inputs and Outputs	Feature	Property
Analogue Input 1 and 2	Voltage range	0 to 10 V
	Reference potential	ground
	Input resistance	approx. 50 kOhm
	Resolution	24 bit
Analogue Output 1 and 2	Voltage output maximum	0 to 10.5 V
	Reference potential	ground
	Load resistance	min. 50 kOhm
	Resolution	16 bit
	Accuracy	0.1 V
Power Supply	Voltage range	24 V DC, Permissible range 21V to 30V
	Max. current	1A
	Typical current draw	500mA
	Protective measure	PELV (Protective Extra Low Voltage)

Table 6.5: Electric Specifications

6.5 Permissible Conditions of The Sample to Be Measured

Pressure (absolute)	For flammable and toxic gases: maximum 3 bar absolute. For other gases: maximum 10 bars absolute.
Gas temperature	At 60 l/h: - max. 80 °C at 25 °C ambient temperature - max. 50 °C at 50 °C ambient temperature - min. -20 °C for version without glass beads - min. -5 °C for version with glass beads
Dust, aerosols, oil mist, fluids	Avoid at all costs (e.g. via separator/filter), the option "Protection against condensate and dust" can prevent impairment of the measuring capability
corrosive gases	Only with corrosion-tolerant design and after consulting Messkonzept
Humidity and Water (condensate/drops)	Condensation must be prevented in the entire gas sample path. The "Protection against condensate and dust" option can prevent the sensor element from being destroyed by water

Table 6.6: Properties of the sample gas

6.6 Environmental Conditions

Operating temperature	Under -0 °C (32 ° F), insulation might be required (Check chapter 4.2) Up to 50 °C (-4 °F to 122 °F)
Storage temperature	-25 °C to 70 °C (-15 °F to 160 °F) (not-condensing)
Protection class	IP 00

Table 6.7: Environmental conditions

6.7 Dimensions

Dimensions	75mm*64mm*45mm
Weight	max. 330 g
Mounting	Check chapter 4.1

Table 6.8: Dimensions

Chapter 7

Views of the device

The 3D STEP model is available on the website on request

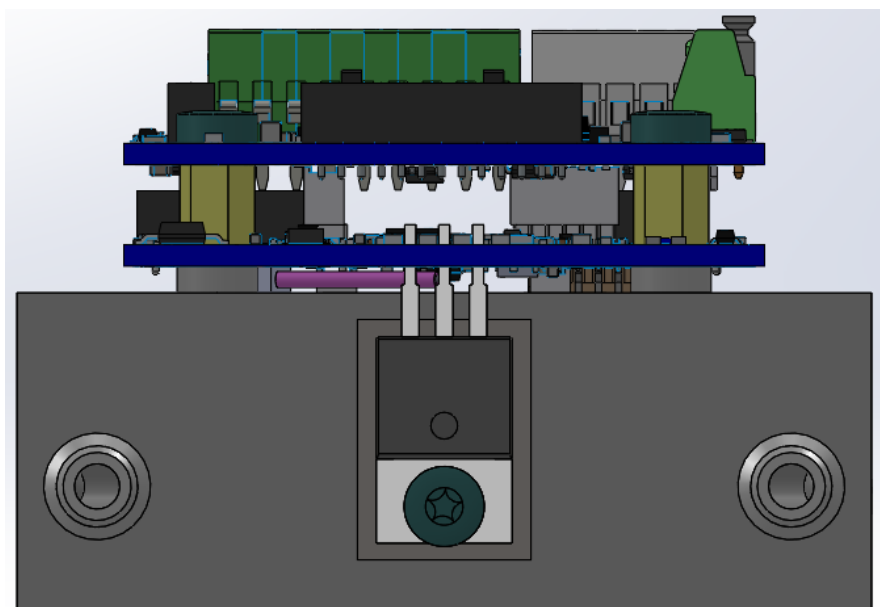


Figure 7.1: View of the FTC320-OEM from the front side.

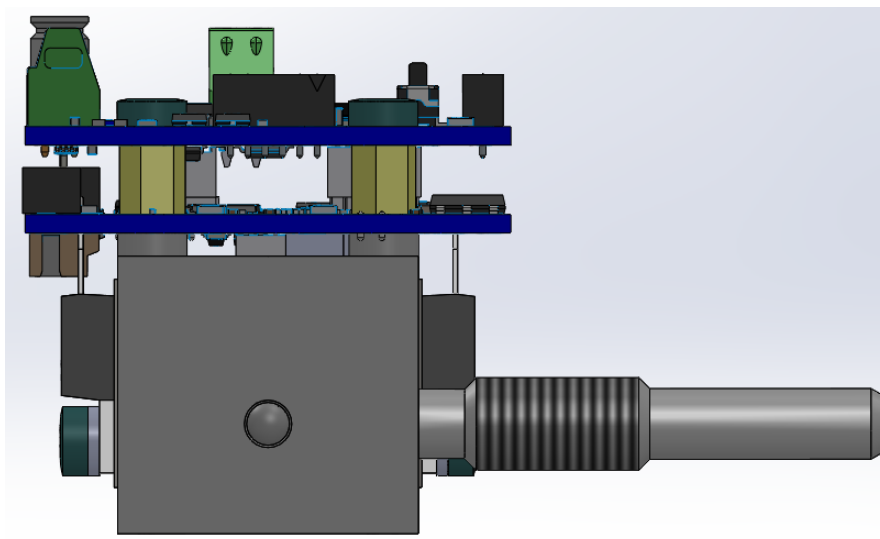


Figure 7.2: View of the FTC320-OEM from the left side.

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