OPERATING INSTRUCTIONS

FLOWSIC150 CARFLOW
Exhaust Gas Flow Meter

Description
Installation
Operation
Maintenance

SICK
Sensor Intelligence.

Document Information

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Legal Information
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Warning Symbols

Hazard (general)

Hazards by electrical voltage

Warning Levels / Signal Words

WARNING
Risk or hazardous situation which *could* result in severe personal injury or death.

CAUTION
Hazard or unsafe practice which could result in personal injury or property damage.

NOTICE
Hazards which *could* result in property damage

Information symbols

Important technical information for this product

Important information on electric or electronic functions

Nice to know

Supplementary information

FLOWSIC150 CARFLOW

1 Important Information

About this document
Main hazards
Authorized personnel
Intended use

1.1 About this document

These Operating Instructions describe the measuring system FLOWSIC150 CARFLOW. They contain basic information concerning the measuring method, layout and functions of the overall system and its components as well as installation, start-up, maintenance, error location and clearance.

These Operating Instructions only cover standard applications conforming with the specified technical data. Additional information and assistance for special applications are available from your SICK representative. We certainly recommend consulting SICK's specialists for your special application.

1.2 Main hazards

1.2.1 Safety information and protective measures

1.2.1.1 General information

Handling or using the device incorrectly can result in personal injury or material damage. Therefore, it is imperative that you observe the following points to prevent damage.

- The legal stipulations and associated technical regulations relevant for the respective system must be observed when preparing and carrying out work.
- All work must be carried out in accordance with the local, system-specific conditions and with due consideration to operating hazards and specifications.
- The Operating Instructions belonging to the measuring system as well as system documentation must be available on site. The instructions for preventing danger and damage contained in these documents must be observed at all times.
- Depending on the particular hazard potential, an adequate quantity of suitable protection devices and personal safety equipment must be available and used by the personnel.

1.2.1.2 Hazard through electrical equipment

Make sure the power supply is switched off before working on mains connections or live components. Replace any protection against accidental contact removed before reconnecting the power supply.

1.2.1.3 Hazard through hot surfaces

All parts of the measuring path of the FLOWSIC150 CARFLOW are heated continuously when the device is switched on and the hot exhaust gas can cause very high surface temperatures. There is a risk of burns!

The device operator must take precautions to prevent contact with hot surfaces. Special attention must be paid to the following:

– No parts of the device (especially parts carrying exhaust gas) may be touched or covered during operation
– Device parts carrying exhaust gas must be free from inflammable and combustible substances before the device is switched on.
– Suitable measures must be taken to prevent damage in the proximity of the device arising from the higher heat radiation
– All work on the device may only be carried out when the device is disconnected from the mains and has cooled down (at least 1 hour out of operation)
– Only put the device into operation when fully installed with all covers.

1.2.1.4 Preventive measures for operating safety

If the FLOWSIC150 CARFLOW is used together with control technology, the operator must ensure neither failures nor incorrect measurements can lead to operating states that could cause damage or be dangerous.

To guard against device malfunctions, the prescribed maintenance and inspection tasks must be carried out regularly by qualified, experienced personnel.

1.2.1.5 Recognizing and avoiding malfunctions

Any deviations from normal operation must be regarded as a serious indication of a functional impairment. These include:

– Significant drifts in the measuring results.
– Increased power input.
– A rise in system component temperatures.
– Triggering of monitoring devices.
– Smoke or unusual odors.

In order to avoid malfunctions that can cause direct or indirect personal injury or property damage, the operator must ensure:

► The maintenance personnel responsible can reach the site immediately, and at any time.
► The maintenance personnel are sufficiently qualified to be able to react correctly in the case of FLOWSIC150 CARFLOW malfunctions and consequent operating disturbances (e.g. when used for control purposes).
► In case of doubt, that the defective equipment is switched off immediately.
► Switching off the equipment does not indirectly cause further malfunctions.

1.3 Authorized personnel

Persons responsible for safety must ensure the following:

- Work on the measuring system may only be carried out by qualified persons and verified by responsible skilled persons.
  Due to their professional training, knowledge or instructions, as well as their knowledge of the relevant standards, regulations, health and safety regulations and equipment conditions, qualified persons shall be assigned by the person responsible for personal and plant safety to carry out such work. Qualified persons must be able to identify possible dangers and to take preventive action in due time.
  Skilled persons are persons in accordance with DIN VDE 0105 or IEC 364, or directly comparable standards.
- These persons must have exact knowledge on hazards arising from operation, e.g. through hot and toxic gases, gas-liquid mixtures or other media as well as adequate knowledge of the measuring system gained through training.

1.4 Intended use

1.4.1 Purpose of the device

The FLOWSIC150 CARFLOW measuring system serves non-reactive determination of a volume flow with standardized pressure and temperature in the exhaust gas line of engines on engine test benches and roller type dynamometers in the automobile industry. It may only used as specified by the manufacturer.

1.4.2 Correct use

The device may only be used as described in these Operating Instructions. Pay special attention to the following information:

- The usage of the technical data corresponds to the specifications on allowable use as well as assembly, connection, ambient and operating conditions (see the order documents, device pass, type plates and documentation delivered with the device).
- All measures required to maintain the device, e.g. for maintenance and inspection, transport and storage are complied with.

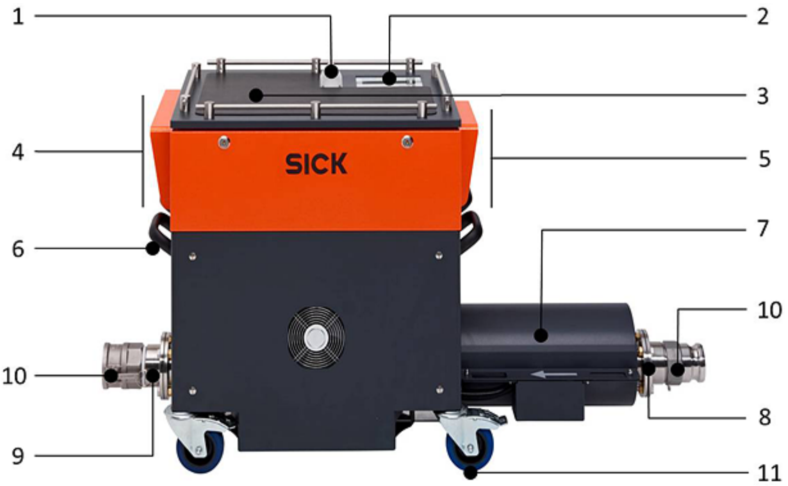
FLOWSIC150 CARFLOW

2 Product Description

2.1 System features

The FLOWSIC150 CARFLOW measuring system serves non-reactive measurement of the gas flow rate, pressure and temperature in the exhaust gas line of engines on engine test benches and roller type dynamometers in the automobile industry. The volume flow standardized for pressure and temperature is determined from these measured variables and output.

Fig. 1 FLOWSIC150 CARFLOW



1 Control lamp for system status
2 LC-Display and operating elements
3 Device cover with rubberized surface
4 Main switch and connection elements
5 Connections for external heating hoses
6 Grips
7 Preheated section with flow rectifier
8 Exhaust gas inlet
9 Exhaust gas outlet
10 Customer-specific connection pieces
11 Blockable rollers

Features and advantages

- Real-time ultrasonic exhaust gas flow rate measurement
- Independent of pressure, temperature and gas composition
- Excellent measuring precision
- Usable for exhaust gas temperatures up to 600 °C
- Direct measurement in undiluted exhaust gas
- Heated measuring path
- Minimum exhaust gas back pressure
- Small floor space, mobile, flexible connection options
- High measured data quality through high measuring precision and stability
- Reliable flow rate measurement also for low flow rates and when idle
- Reliable operation through design for high exhaust gas temperatures
- Versatile concept – ideally suitable for use on existing test benches
- Reduced investment costs through mobile use on several test benches
- Comfortable installation without effect on engine characteristics and exhaust gas analysis systems
- Extended service life through patented sensor cooling
- Low operating costs through low maintenance requirements

2.2 System layout

The FLOWSIC150 CARFLOW is connected to the exhaust gas line of the engine test bench using exchangeable connection elements. The device is available in two versions (connection diameter 2.5 and 4 inches) for different measuring ranges. A flow rectifier is integrated in the gas inlet to reduce the influence of inlet disturbances on measuring precision due to the slightest pressure loss. The sample gas line is heated along the complete measuring path to prevent condensation.

For this purpose, 3 heating controls are fitted for the areas inlet section (preheater), measuring line (pipe) and measuring cell (body). Two further heating controls allow connecting auxiliary heated sample gas lines to the device (available as option).

> ***NOTICE:***
> Observe the electrical connection data in the Technical Data (→ p. 66, § 6.1) when connecting external, heated sample gas lines!

The measuring cell contains the ultrasonic probes for determining the gas flow rate (details → p. 14, 2.4) from which the volume flow is calculated.

The integrated pressure and temperature measurement is done in close proximity to the measuring cell. The exhaust gas volume flow is then normalized to standard conditions using these values. The measuring signals for temperature and pressure are read into the evaluation unit synchronously to each gas flow rate measurement.

Two sheathed thermoelements measure the exhaust gas temperature at different points in the flow profile. A weighted average is then calculated in order to determine the representative gas temperature in the flow profile as exactly as possible. An instrument amplifier with cold junction compensation records and then digitalizes the temperature signals. A hose connects the pressure tapping connection to the pressure sensor in the evaluation unit. The measuring range is 700 mbar to 1300 mbar (absolute).

A heater is fitted in the electronics housing to prevent condensation on the control electronics after measurement at very low ambient temperatures (e.g. climate test) and subsequent warming up.

An electronic control regulates the temperature in the electronics housing to an adjustable setpoint value.

2.3 Auxiliary components

Height adjustment

The FLOWSIC150 CARFLOW has an integrated height adjustment with an adjustment range of approx. 190 mm. This allows flexible positioning of the measure tube center to ensure the inlet section is as straight as possible during vehicle measurements. The height adjustment can be operated at any time when the device is switched on using the buttons on the device. The height of the inlet and outlet sections can be set independent of each other.

> **!** ***NOTICE:***
> Only move the device in the lowest level of the height adjustment to avoid damaging the adjustment elements!

Connection variants for inlet and outlet

Customer-specific connection pieces serve integration of the FLOWSIC150 CARFLOW in the exhaust gas line of the vehicle and engine test benches. Flange connections are fitted on the gas inlet and outlet (dimensions → p. 67, Fig. 46). Connection pieces are available for these flange connections which reduce the diameter to a standardized nominal width (4" or 2.5"). The connection pieces have a seal on the device side, are screwed to the device and provide a permanent, gas-tight and maintenance-free connection. The seals used are resistant to high temperatures with low wear.

Various connection pieces are available for integration in the exhaust gas line. In this case, the user must check the suitability of the connection pieces (e.g. with regard to temperature and pressure loss) with regard to the application in question.

> **!** ***NOTICE:***
> Selecting suitable seals is the responsibility of the user. Take the expected exhaust temperature range into account when selecting suitable seal materials!

Table 1 shows the available connection options:

Table 1 Connection options for inlet and outlet

Connection piece	Connection dimension	Seal	Female/male distinction	Remark
E-Line	2,5" 4"	Yes	Yes	
Marman	2,5" 4"	No	No	
Tri-Clamp	2,5" 4“	Yes	Yes	
Type G outer thread in accordance with ISO 228/1	2,5" 4"	No	No	
Kamlok	2,5" 4"	Yes	Yes	For outer threads
Welding neck flange	2,5" 4"	Yes	No	
ANSI B16.5 #150	4"	Yes	No	

The “welding neck flange” allows realizing individual connection solutions.

> **!** ***NOTICE:***
> Quick connect couplings without seals do not provide gas-tight connections. Hot combustion exhaust gases can escape with the risk of burns and poisoning. Process connections without seals may only be used in sufficiently ventilated plants with appropriate monitoring technology! Local safety regulations must be complied with!

The device operator is solely responsible for selecting and using connection pieces!

Work surface

The top side of the device can be used as storage space. The display and control units are protected against penetration by liquids.

Sensor cooling including emergency power supply

The FLOWSIC150 CARFLOW uses ultrasonic sensors with a patented, internal sensor cooling.

Here, ambient air flows continuously through the ultrasonic sensors to protect the temperature-sensitive piezoceramic against excess temperatures. The cooling air cannot penetrate the sample gas line. The ambient air is guided to the ultrasonic sensors using cooling air blowers and cooling hoses. A coarse filter prevents dirt particles penetrating the cooling system.

The temperature of the ultrasonic sensors is continuously monitored. A malfunction message is output should the temperature exceed a defined threshold. In this case, in order to protect the device, the throughflow of hot exhaust gases must be the interrupted as quickly as possible, and the fault leading to the sensor temperature exceeding the allowable temperature identified and cleared. All sensor cooling components are monitored. A malfunction message is output via the device when malfunctions occur.

If the device voltage supply is interrupted because the sensor temperature is too high, an emergency battery keeps the sensor cooling running until the sensors have sufficiently cooled down.

> **!** ***NOTICE:***
> An acoustic warning (long tone) is output as long as sensor cooling runs with the emergency battery. If possible, switch the device on until the sensors have cooled down.
> Sensor cooling remains active until the measuring cell (body) has cooled down to a temperature below 200 °C. An acoustic warning (long tone) is also output when the temperature limit of the sensor or the measuring cell is exceeded.

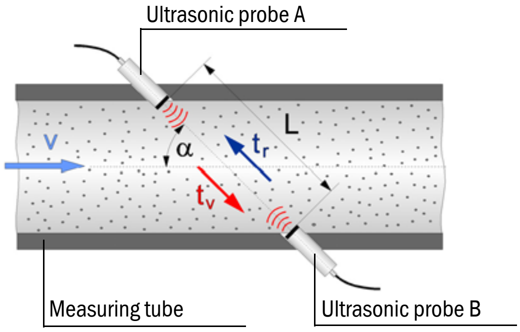
> **!** ***NOTICE:***
> An acoustic warning is output (sequence of short tones) when the charge level of the emergency battery is too low. Sensor cooling is then no longer ensured. The device must be switched on again to prevent damage to the sensors.

2.4 # Measuring principle

2.4.1 ## Measuring method

The FLOWSIC150 CARFLOW works according to the principle of ultrasonic transit time difference measurement. It has eight structurally identical ultrasonic probes. The probes of each pair are arranged opposite each other in the measuring cell at a defined angle to the flow axis and create a direct measuring path.

Fig. 2 Measuring principle



The FLOWSIC150 CARFLOW has a 4-path measurement setup. The measuring paths cross in the measuring cell. The gas velocity is measured separately for each measuring path and then a weighted average calculated under consideration of various correction factors defined by the parameters from the factory calibration.

The ultrasonic signals cross the measuring tube from probe to probe. When no gas is flowing, the signals travel at the same speed (sound velocity) in both directions. When gas is flowing, the signal becomes faster in flow direction and slower against the flow. The transit time (t_{AB}) is therefore shorter with the flow and longer against the flow (t_{BA}) (→ Fig. 2).

The ultrasonic probes work alternately as sender and receiver. Their main component is a piezoceramic coupled to a diaphragm. To send signals, an AC voltage displaces the piezoceramic in mechanical oscillations (piezoelectric effect) that are transferred to the gas via the diaphragm. The oscillations spread out in the gas as acoustic waves and then impinge the diaphragm of the opposite probe after a transit time depending on the sound and gas velocities. These waves are then transferred to the piezoceramic as mechanical oscillations, converted to an electric voltage (inverse piezoelectric effect) and passed on for signal analysis.

The high precision signal algorithm determines the transit time difference of the acoustic signals and calculates the flow velocity of the exhaust gas under consideration of a correction factor dependent on a Reynolds number. This very precise transit time calculation also ensures recording of very low flow velocities up to 20.001 m/s. The geometric dimensions of the measuring tube and the pressure and temperature values are then used to calculate the normalized volume flow from the flow velocity.

> +i The specified measuring precision (→ p. 66, §6.1) is valid for the device calibrated at the factory with integrated flow rectifier with adequately long and straight inlet and outlet sections, and a fully developed flow profile. The device can be calibrated under deviating conditions or with special inlet geometry on request. An additional flow rectifier could then be necessary in the inlet area under certain circumstances (available as option).

2.4.2 Determining the gas velocity

Sound transit time in flow direction:

(1) $$t_{AB} = \frac{L}{c + v_{path} \cdot \cos\alpha}$$

L: Measuring path length
c: Sound velocity
v_{path}: Path velocity
α: Measuring path angle

Sound transit time against flow direction

(2) $$t_{BA} = \frac{L}{c - v_{path} \cdot \cos\alpha}$$

Path velocity v_{path} is calculated from the difference between the transit times:

(3) $$v_{path} = \frac{L}{2 \cdot \cos\alpha} \cdot \left(\frac{1}{t_{AB}} - \frac{1}{t_{BA}}\right)$$

Several measuring paths are arranged across the cross-section of the flow profile which means differences in the flow profile can be considered better and the exhaust gas velocity can be calculated with high precision. Average area velocity v_A is calculated by averaging the weighted single path velocities $v_{path\ i}$.

(4) $$v_A = \frac{1}{N} \sum_{i=1}^{N} w_i \cdot v_{path\ i}$$

N: Number of measuring paths
v_A: Average area velocity
w_i: Weighting factor for a measuring path

If measurement fails on one measuring path, the flow velocity can still be calculated with a low reduction in precision and maintaining the measurement setup by calculating a default value for the failed path.

2.4.3 Calculating the volume flow

Current volume flow Q_B is calculated using the path velocity and cross-sectional area of the measuring tube:

(5) $$Q_B = v_A \cdot A = v_A \cdot \frac{D^2 \cdot \pi}{4}$$

A: Cross-sectional area in measuring tube
Q_B: Volume flow act.

Volume flow in standard state Q_N is calculated from volume flow act. and the current measured values for pressure and temperature in the measuring tube:

$$Q_N = \frac{P}{P_0} \cdot \frac{T_0}{T} \cdot Q_B$$

P_0, T_0: Pressure and temperature in standard state
P, T: Pressure and temperature in operating state

2.4.4 Determining the sound velocity

Gas sound velocity c in the current state can be calculated from the sum of measured transit times t_{AB} and t_{BA}.

(6) $$c = \frac{L}{2} \cdot \left(\frac{1}{t_{AB}} + \frac{1}{t_{BA}}\right)$$

A theoretical sound velocity can be calculated from gas composition, pressure and temperature. This should match the measured sound velocity. The sound velocity then provides an excellent option for system diagnosis.

2.4.5 Compensating a path error

The relation of the flow velocities of the measuring paths to each other is used to compensate a path error. These mainly depend mainly depend on the complexity of the flow profiles and the magnitude of the flow velocity itself.

2.4.5.1 Functional principle

Individual path relations P_{path} are calculated continuously during uninterrupted operation.

$$P_{path} = \frac{v_{path}}{v_A} \tag{7}$$

This relation for each path is passed to an adaptive averaging calculation. Statistical fluctuations caused by turbulence are well suppressed by the averaging and, without slowing down the adaption to new flow profile situations at the same time.

In addition to adaptive learning of path relations, low (1 - 8 m/s) and high flow velocities are differentiated. This improves compensation because path relations are more stable at high velocities. Path relations under 1 m/s are not adapted.

2.4.5.2 Adaptive compensation of one or several path errors

The self-diagnosis implemented in the system (→ p. 23, §2.6) can filter out implausible single results with excellent reliability. If the relation between accepted and rejected single measurements on a measuring path exceeds an allowable threshold, this path is then excluded from the average flow velocity calculation v_A (equation 8). In this case, the average flow velocity is calculated from the valid measured values of the remaining paths and the adapted path relations using the following formula.

$$v_A = \frac{\sum_{i=1}^{N} b_i \cdot w_i \cdot \frac{v_{path\ i}}{P_{path\ i}}}{\sum_{i=1}^{N} b_i \cdot w_i} \tag{8}$$

b_i: Status bit for path i
$b_i = 0$: Path not active
$b_i = 1$: Path active

The system signals path error compensation with status signal “Maintenance request”. Measurement uncertainty is higher for the complete system during this operating mode.

> The failure of several paths is compensated according to the same principle.

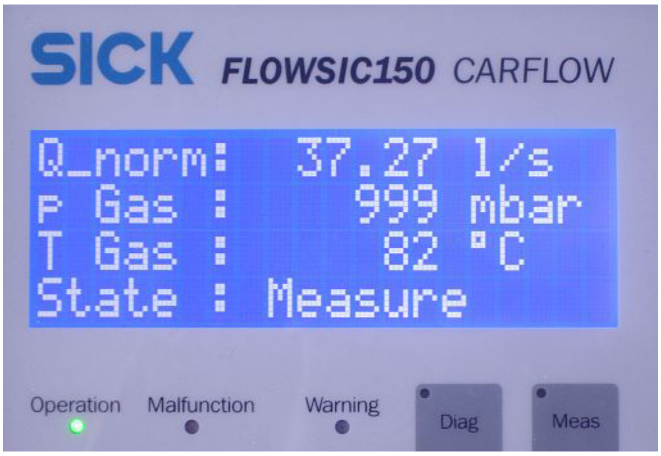
2.4.5.3 Statistical compensation of one or several path errors

Statistical path relations are used for compensation when no statistically stable values are available for the path relations at the time a path error occurs.

2.5 Display and operating elements, communication

Elements for display, operation and communication are located on the top side of the device.

Fig. 3 Control panel



Displays

Display element		Explanation
LC-Display	Measured values	Q_norm: Normalized volume flow (std.) p Gas: Barometric exhaust gas pressure T Gas: Exhaust gas pressure, average value from both sensors State: Device status
	Diagnosis values (→ Fig. 4)	Diag1 Q_act: Current volume flow (act.) VoG : Velocity of Gas / flow velocity T Gas: Gas temperature, average value from both sensors T VoS: Acoustic temperature, from sound velocity
		Diag2 Pipe: Actual temperature, heater “Pipe“ Body: Actual temperature, heater “Body” Sens: Actual temperature, ultrasonic sensors Ref: Actual temperature, reference point for thermoelements Pre: Actual temperature, heater “Preheater“ Ex1: Actual temperature, external heating connection 1 Ex2: Actual temperature, external heating connection 2 Ex3: Actual temperature, external heating connection 3
		Diag3 Warnings: Active warning messages
		Diag4 Errors: Active malfunction messages
LED on display/ control lamp for group status	Operation	Normal measuring operation
	Warning	Warning active, measuring operation is still ensured but possibly with restricted precision, cause of warning(s) can be viewed on the display or read out using SOPAS. List of warnings, see Table X (Display_Fehler_Warnungen.xlsx)
	Malfunction	Device malfunction active, measuring operation not ensured Cause of malfunction (s) can be viewed on the display or read out using SOPAS. List of malfunctions → p. 20, Table 2 and → p. 21, Table 3

Control buttons

Control button	Function
Meas	Displays the current measured values in the display.
Diag	Switches the display to display diagnosis values. Press the button several times for sequential display of available diagnosis screens.

Fig. 4 Diagnosis values

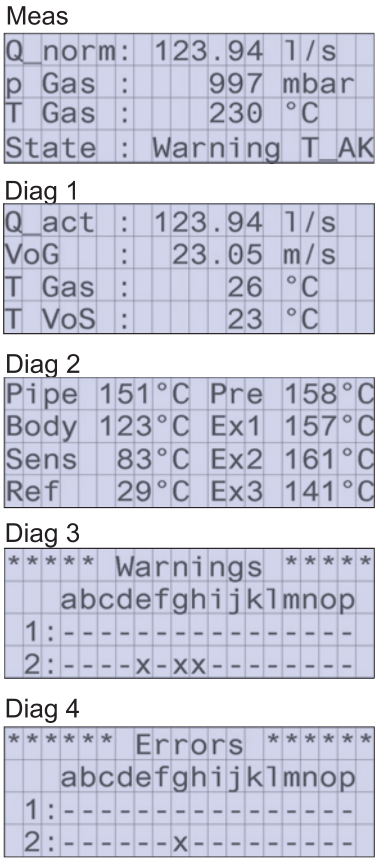


Table 2 Warning messages

	1	2
a	**Reduced accuracy**	*Not supported*
	Path failure compensation or not enough paths configured	
b	**High noise level – Disturbing noise level too high**	**T Ext3**
	Ext. Temp. 3	Temperature > 350 °C or still below [nominal – control deviation] with active control
c	**AGC limit**	**Ext. Temp 2**
	Ext. Temp. 2	Temperature > 350 °C or still below [nominal – control deviation] with active control
d	**AGC difference**	**Ext. Temp 1**
	Ext. Temp. 1	Temperature > 350 °C or still below [nominal – control deviation] with active control
e	*Not supported*	**Temp. preheater**
		Temperature > 350 °C or still below [nominal – control deviation] with active control
f	*Not supported*	**T sense too high**
		Temperature > 220 °C
G	**Blower failed**	**Temp. Pipe**
	Blower not rotating (hardware recognition)	Temperature > 350 °C or still below [nominal – control deviation] with active control
H	**Circuit breaker F5**	**Temp. Body**
	Fuse monitoring of external power circuits External Heater 2	Temperature > 200 °C or still below [nominal – control deviation] with active control
I	**Circuit breaker F4**	**Temp. Gas2**
	Fuse monitoring of external power circuits External Heater 1	Temperature > 600 °C
j	**Circuit breaker F2/F3**	**Temp. Gas In**
	Fuse monitoring for internal power circuits	Temperature > 600 °C
k	*Not supported*	**Temp. Gas1**
		Temperature > 600 °C
l	**Voltage 24V too low**	**Heat up phase**
	Voltage (24 V) < 22 V	One of the temperatures (Body, Preheater, Pipe, Ext1, Ext2, Ext3) is still below [nominal - control deviation] when activated and Test mode not on)
m	**T Ref2 > 140°F**	**Power saving mode**
	Temperature > 60 °C	Heaters (apart from Case) only working with 10% of their maximum heating output (activated by AK command PWDN)
n	**T Ref1 > 140°F**	*Not supported*
	Temperature > 60 °C	
o	**T Ref (average)**	**System test active**
	Temperature, average value (T_REF1, T_REF2) > 60 °C;	Test mode active (switched on with SOPAS ET)
p	**Voltage Accu too low**	**Factory settings active**
	Voltage < 10.5 V	Default values loaded

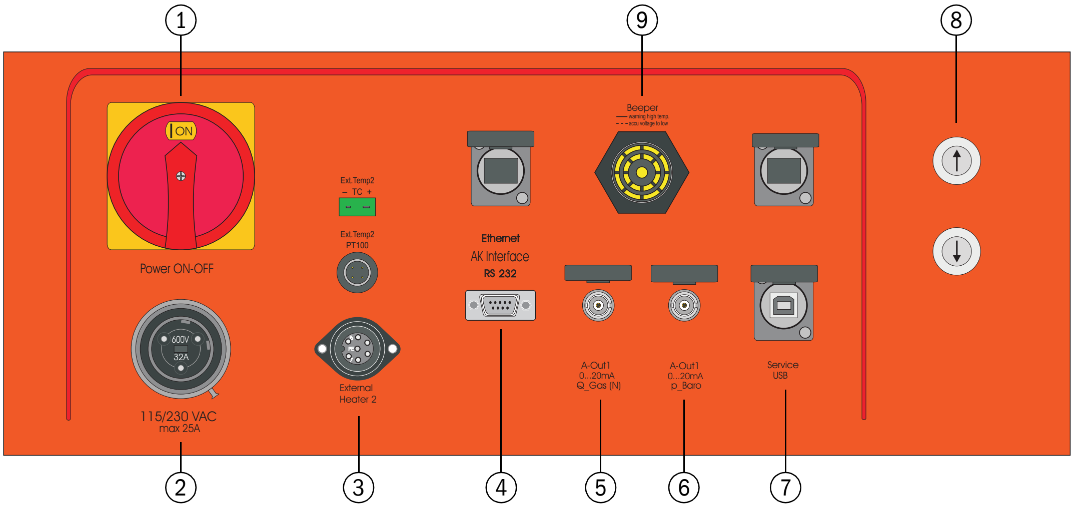
Table 3 Error messages

	1	2
a	*Not supported*	*Not supported*
b	**Overvoltage Preheater**	*Not supported*
	Voltage monitoring hardware Preheater and external heaters	
c	**Overvoltage Body/Pipe**	*Not supported*
	Voltage monitoring hardware internal heaters Body and Pipe	
d	*Not supported*	*Not supported*
e	*Not supported*	*Not supported*
f	*Not supported*	**No signal found**
		No signal found for all configured sensors
G	*Not supported*	**Noise too high**
		Ambient noise too high for all configured sensors (SNR too low)
H	*Not supported*	**No sensor found**
		No sensor found (group message)
I	*Not supported*	*Not supported*
j	*Not supported*	*Not supported*
k	*Not supported*	*Not supported*
l	*Not supported*	*Not supported*
m	*Not supported*	**Flash error**
		Hardware access to external Flash
n	*Not supported*	**CRC**EEPROM
		EEPROM parameter CRC
o	*Not supported*	**HW**EEPROM
		Hardware access to EEPROM
p	*Not supported*	**CRC Code Error**
		CRC code range validation failed

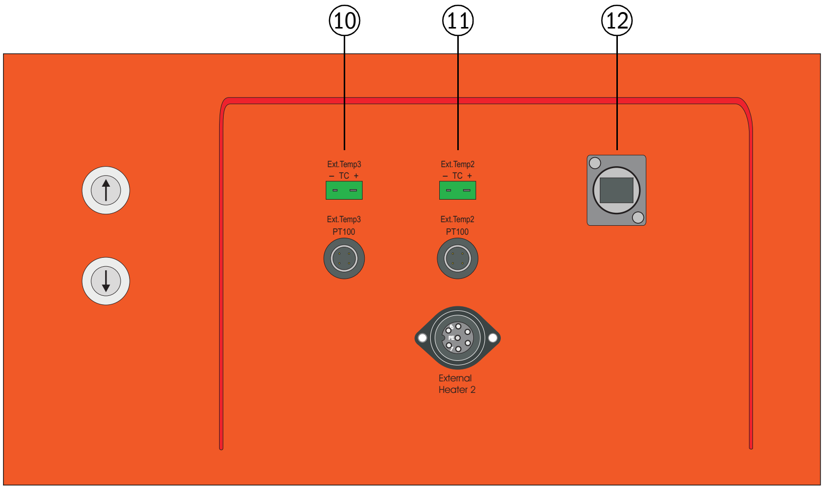
Connection and operating elements

Fig. 5 Connections

Outlet side



Inlet side



1 Device main switch
2 Mains connection 115/230 V AC, max. 25 A, connection via 3-pole socket, type Bulgin900 Buccaneer
3 Connection option for external temperature sensors (PT100/or TE type K) or external heater line
4 AK interface, selectable connection via 9-pole D-Sub plug or via Ethernet
5 Analog output 1, type BNC, output of normalized volume flow with 10 Hz
6 Analog output 2, type BNC, output of barometric exhaust gas pressure with 10 Hz
7 Service interface USB type B or Ethernet
8 Buttons for electrical height adjustment
9 Beeper, for acoustic warning for excess probe temperature
Continuous tone: Excess probe temperature, no mains voltage supply, probe cooling via 12 V emergency power supply active
Intermittent tone: No mains voltage supply, critical state of 12 V emergency power supply, risk of probe damage when operating with high temperatures
10 Connection option for external temperature sensors (PT100/or TE type K)
11 Connection option for external temperature sensors (PT100/or TE type K) or external heater line
12 Cable duct for using internal connection options

2.6 Self-diagnosis

The relation between sound and path velocities as well as the signal amplification are monitored continuously during measuring operation. Deviations of monitored parameters from the specified nominal values are classified as warnings and signaled. This allows initiating measures to prevent a possible system malfunction in good time.

Signaling thresholds can be adapted to individual application requirements during start-up or during operation This allows generating optimized state warnings.

> Status signal “Maintenance” has no influence on the device function.

Parameter	Threshold	Warning message	Remark
Sound velocity	> 5 m/s	Warning SOS Deviation	This message is output when the deviation of the measured sound velocity of a path from the average value of all paths exceeds the specified threshold. The momentary flow velocity is used as weighting factor to prevent temperature stratifications triggering when flow velocities are very low. Used as indicator whether the path measures the correct transit time or not. **Information:** Ensure plausible states (especially temperature stratifications) for normal operation when setting this parameter.
Receive amplification	> 10 dB	Warning AGC Deviation	The absolute difference between both amplified factors of a path is evaluated and must be below the threshold. **Notice:** High flow velocities can also be the cause of a higher difference of the amplification setting.
	> 50 dB	Warning AGC Limit	The absolute value of the receiver amplification is monitored.
			If a path triggers one of these alarms, this can indicate an error on the ultrasonic sensors, electronics, probe cables or parameter settings (signal model, control thresholds).

More detailed diagnosis functions are implemented in the area of signal processing and the system. In particular, checking the plausibility of received ultrasonic signals and the resulting ultrasonic signal transit times determined ensure high reliability of the measured values output.

2.7 Electrical components

A special cable connector provides power to the device (Bulgin 900 series “Buccaneer“ type PX0911/03/S).

The device can be used with 115 V or 230 V mains voltage. Set the supply voltage before device start-up (→ p. 30, §3.1).

Circuit breakers F1 ... F5 and a fault current circuit breaker ensure internal protection of the power circuits.

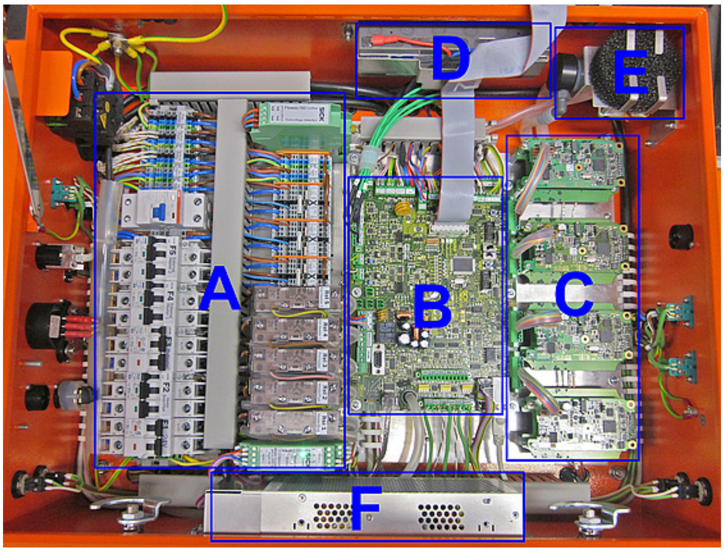
Table 4 Circuit breakers function

F1	24 V power supply unit for electronics and height adjustment
F2	Power circuit for heater elements “Body“ and “Pipe“
F3	Power circuit for heater element “Preheater“
F4	Power circuit for external heater 1 (“external Heater 1")
F5	Power circuit for external heater 2 (“external Heater 2")

Circuit breakers F2 ... F5 are fitted with signal contacts. A warning is output when triggered or switched off manually.

Fig. 6 provides an overview of the components in the electronics housing.

Fig. 6 Electronics



Range	Description
A	General electric, circuit breakers, relays and circuit breakers
B	Master electronics, inputs and outputs (FL150 CCU)
C	Measuring electronics for the 4 measuring paths (FL150 SE)
D	12 V emergency power battery
E	Cooling air blower with filter
F	24 V power supply unit

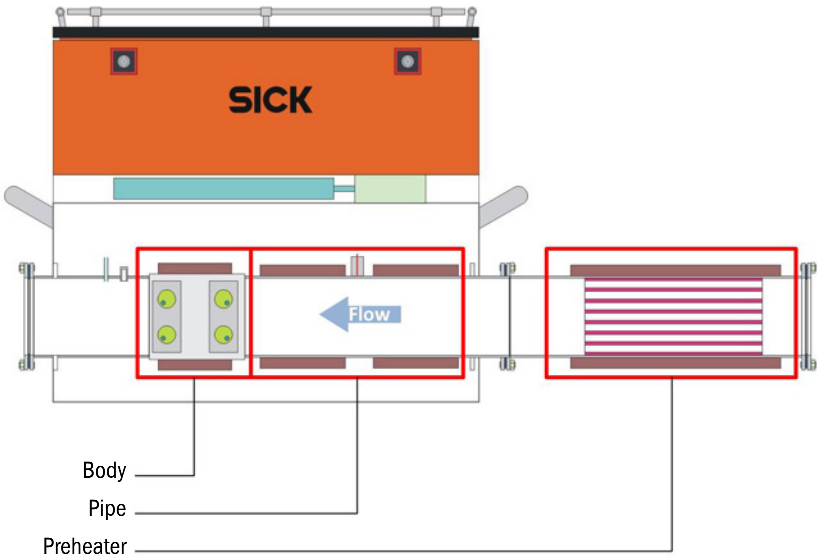
2.8 Measuring path heating

The measuring path of the FLOWSIC150 CARFLOW is heated by electrical heating elements. These serve avoiding condensation effects and provide thermal flow conditioning. Refer to Fig. 7 for the location and designation of the heating elements. Nominal temperatures are adjustable using the device software or per AK command and are controlled electronically. After the device has been switched on for the first time, a warning is output until the set nominal temperatures are reached.

To reduce the power input during idle times, an AK command can be used to reduce the heating output to a value adjustable in SOPAS.

> A warning is output when the external heating controllers are activated using SOPAS but, however, no external heaters are connected to the device. This can be acknowledged temporarily by touching the display with text “FLOWSIC150 CARFLOW“. The warnings remain active but no longer affect the status display on the device. Deactivate the external heating controllers via SOPAS when the device is used for a longer period without external heater lines.

Fig. 7 Heater



2.9 External connections for heated lines

The FLOWSIC150 CARFLOW has two connections for external heater lines and 3 connections for external temperature sensors. External heater lines are connected with 7-pole plugs. See Fig. 8 for the connector pin assignment. The following values are valid for the maximum common power input of both heater line connections when connecting external heater lines:

Voltage supply	Power input
115 V	Max. 1000 W
230 V	Max. 1600 W

Type K (NiCr-Ni) thermolements as well as type PT100 resistance thermometers can be connected as external temperature sensors. The slide switches on the CCU circuit board (→ p. 28, Fig. 10) must be set correctly depending on the type connected.

+i Using the external heating connections increases the device power input. Ensure suitable connectors and cables as well as adequate mains fuses are used, in particular, when using 115 V supply voltage.

CAUTION: Hazard through unsuitable cable connectors (USA)
The delivered cable connector is approved up to 15 A for devices for the USA market. It is mandatory to use a cable connector with a permissible rated current of 25 A when using external heater lines.

Either type K (NiCr-Ni) thermoelements or PT100 resistance thermometers can be connected as external temperature sensors. Set the type used for each connections using the slide switches on the main board (→ p. 28, Fig. 10).

Alternatively, the 7-pole connector of the external heating connection can be used to connect the external temperature sensors. See Fig. 9 (→ p. 27) on switching external connections.

Fig. 8 Connector pin assignment for heated lines

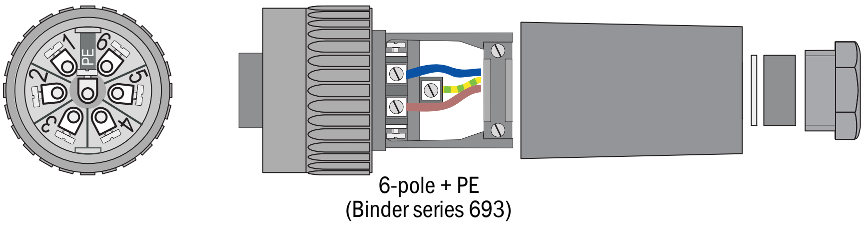
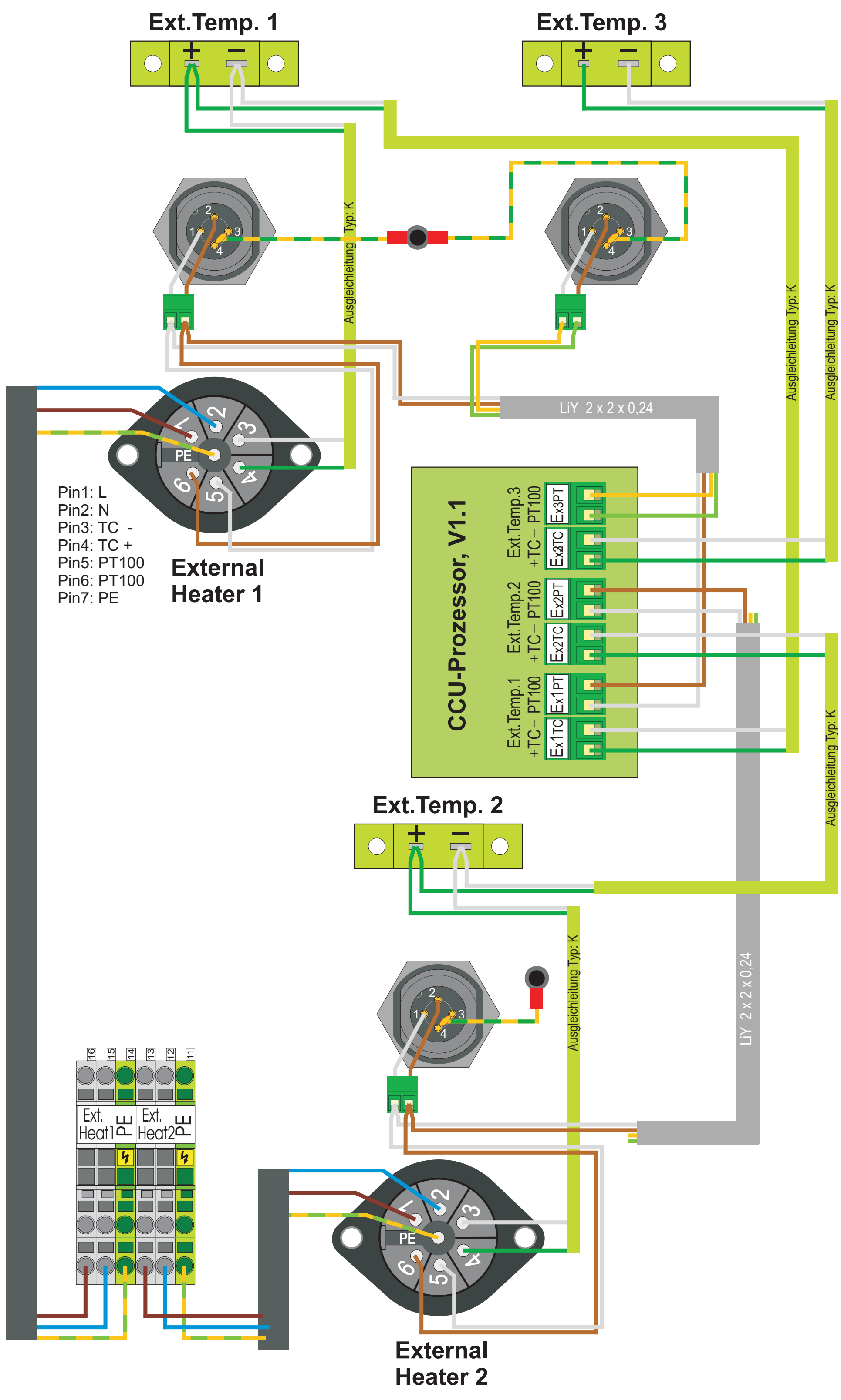


Table 5 Pin assignment

Connection	Socket type	Pin						
		1	2	3	4	5	6	7
External heater	Binder series 693	L	N	TC-	TC+	PT100	PT100	PE
Ext. temp. PT100	Binder series 713	PT100	PT100	PE	PE			

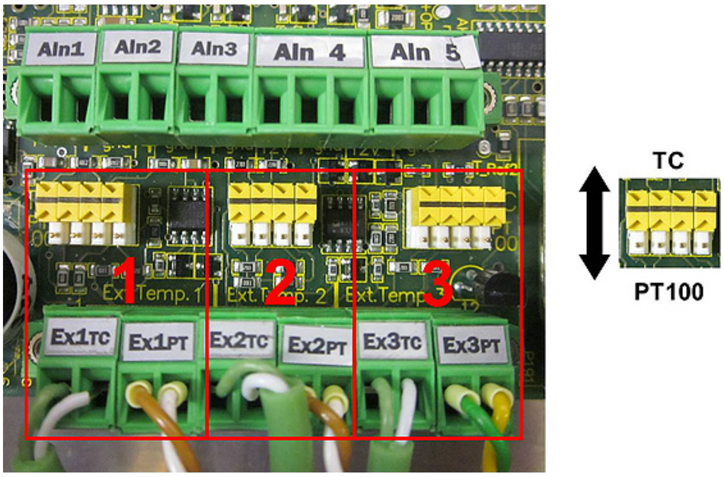
Subject to change without notice

Fig. 9 External connection assignment



Subject to change without notice

Fig. 10 Slide switches on the CCU circuit board



2.10 Digital interfaces

The FLOWSIC150 CARFLOW has two groups of interfaces, a service interface and an AK interface.

Service interface

The service interface serves to connect and configure SOPAS ET. Connection is made via USB or Ethernet.

AK interface

The AK interface serves to inquire and change certain parameters in the FLOWSIC150 CARFLOW using the AK protocol.

Connection is made via a 9-pole D-Sub plug or Ethernet.

The AK interface works according to the master-slave principle so that all communication from outside must be initialized with an AK command and then a reply sent by the FLOWSIC150 CARFLOW. Parameter changes are only temporary and are reset to the SOPAS ET settings when the device is switched off.

Detailed documentation of the AK interface is contained in a separate document on the Product CD.

Terminal mode

Selection switches on the CCU circuit board serve to activate terminal mode on both serial interface groups (→ p. 56, §4.3.4.1). In this mode, measured values are output via the serial interface with 1 Hz and can be recorded by a terminal program (e.g. HyperTerminal). SOPAS ET serves to select the measured values to be output (→ p. 57, 4.3.4.2).

FLOWSIC150 CARFLOW

3 Installation

Necessary work

Connecting external heater lines and temperature sensors

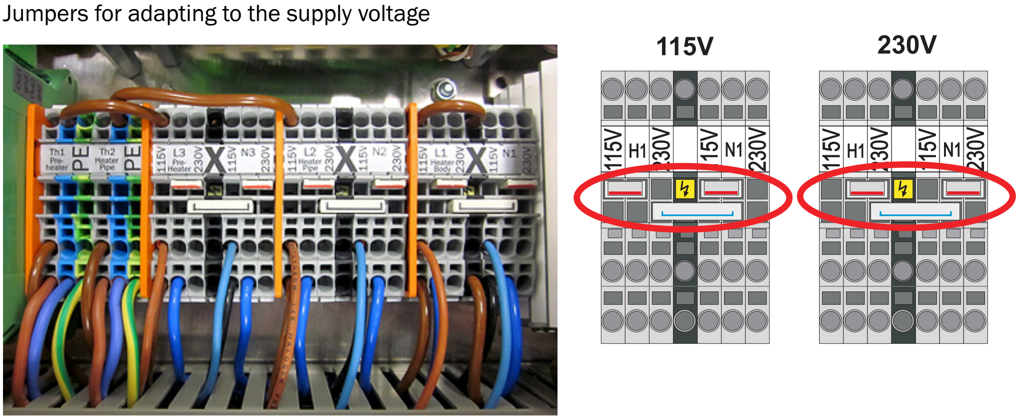
Flow path

3.1 Necessary work

WARNING: General hazards
- ► Observe the relevant safety regulations as well as the safety instructions in Section 1 during all work.
- ► Only connect the measuring system to the exhaust gas line when the plant is at a standstill!
- ► Take suitable protective measures to protect against possible local or system-specific hazards.

- ► Connect the exhaust gas line to the respective connection elements on the gas inlet and outlet of the measuring tube.
- ► Check jumper assignment on terminals 31 to 51 in the control cabinet depending on the supply voltage available and correct when necessary (→ Fig. 11).

Fig. 11 Jumpers for adapting to the supply voltage



- ► Connect the mains cable included in the scope of delivery to voltage supply 115 / 230 V AC and the socket “115/230 VAC“ on the FLOWSIC150 CARFLOW (→ p. 23, 2.6).
- ► Connect analog output 1 (A-Out1) for the main measured value with a coaxial cable to the BNC plug-in connector (→ p. 23, 2.6).

Optional
- ► Connect an AK interface via RS232 or Ethernet
- ► Connect external temperature sensors (Ext.Temp)
- ► Connect external heater lines (External Heater)
- ► Activate the controllers for external heater lines using SOPAS ET (→ p. 49, §4.2.4)

A warning is created when controllers for external heater lines are activated but no temperature signal is available for the heater lines. This does not impair the FLOWSIC150 CARFLOW measuring function.

3.2 Information on connecting external heater lines and temperature sensors

Observe the information in §3.1 (→ p. 30) on connecting external heater lines and temperature sensors.

WARNING: **Electrical hazards**

230 V supply:

- The maximum power input of connected heater lines must not exceed 1600 W.
- The device supply power circuit must be fused with 16 A.

115 V supply:

- The maximum power input of connected heater lines must not exceed 1000 W (max. 800 W per heating connection).
- Use a suitable connection cable and plug for currents up to 25 A for the FLOWSIC150 CARFLOW voltage supply (the connector delivered with the device may only be used up to a maximum of 15 A and is not suitable for device operation with external heater lines).
- The device supply power circuit must be fused with 25 A.

3.3 Flow path

The installation situation and the concordance between calibration and fitting conditions have a decisive effect on the measuring precision of the FLOWSIC150 CARFLOW in the exhaust gas line. Measuring precision rises as the concordance of the fitting conditions in the plant with the calibration conditions at the factory improves.

The factory calibration is carried out on the SICK flow test bench, when not otherwise ordered, with straight inlet and outlet sections at least 20 times the length of the rated diameter of the measuring path (20D).

When possible, maintain a straight inlet section at least 20D long and a straight outlet section at least 10D long when installing the FLOWSIC150 CARFLOW. These values are valid for the paths before and after the measuring cell in the FLOWSIC150 CARFLOW.

Fig. 12 and Table 6 show the inlet and outlet sections of the device itself and the additional inlet and outlet sections required. Suitable heated and unheated inlet extensions are available as options for the FLOWSIC150 CARFLOW.

Fig. 12 Inlet and outlet sections

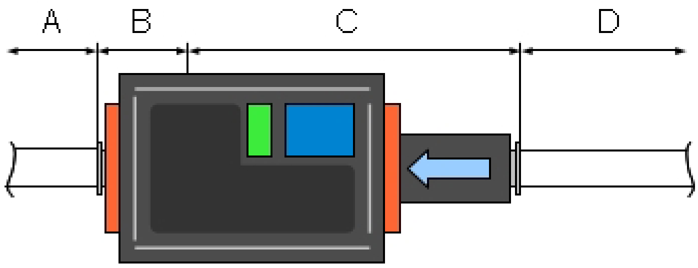


Table 6 Inlet and outlet sections

Connection	Device internal inlet section (C)	Additional straight inlet (D)	Device internal outlet section (B)	Additional straight outlet (A)
2.5 inches	15D	Min. 5D (0.32 m)	4D	Min. 6D (0.38 m)
4 inches	10D	Min. 10D (1 m)	3D	Min. 7D (0.71 m)

Should it not be possible to install the device with specified inlet and outlet conditions, the following measures can be taken to ensure the highest possible measuring precision:

- Factory calibration with customer-specific inlet and outlet sections
- Using an additional flow rectifier on the device inlet (available as an option, *consider higher pressure loss!*)
- Device readjustment after insulation using a regression with a suitable reference measurement and entering the regression coefficients in SOPAS (→ p. 53, §4.3.1)
- Analysis of customer-specific installation conditions by SICK using a CAD simulation and creation of a recommendation on achieving the best possible measuring precision (available as an option)

FLOWSIC150 CARFLOW

4 Start-up and Operation

Basics

Configuring

Program SOPAS ET

4.1 Basics

4.1.1 General information

Start-up primarily involves entering basic parameters and configuring both analog outputs → p. 48, §4.2.3). In certain cases (e.g. with unfavorable inflow conditions), it may also be necessary to recalibrate the FLOWSIC150 CARFLOW after installation (→ p. 55, §4.3.3).

The SOPAS ET program is delivered to set parameters. The required settings can be easily configured using the software menus. Other functions (such as data backup and graphical display functions) are also available (→ p. 53, §4.3).

4.1.2 Installing SOPAS ET

Prerequisites for configuring using SOPAS ET

- Laptop/PC with:
  - Processor: Pentium III (or comparable type)
  - VGA graphic card
  - USB interface (alternative - RS232 via adapter)
  - Working memory (RAM): At least 512 MB
  - Operating system: MS-Windows 2000/XP/Vista/7 (not Windows 95/98/NT)
- USB interface cable for connecting to a laptop/PC and FLOWSIC150 CARFLOW.
- The SOPAS ET software as well as the USB driver (scope of delivery) must be installed on the laptop/PC.
- The voltage supply must be switched on.

Installing SOPAS ET

► Insert the enclosed CD into the disk drive on the PC, select the language, choose “Software” and follow the instructions.

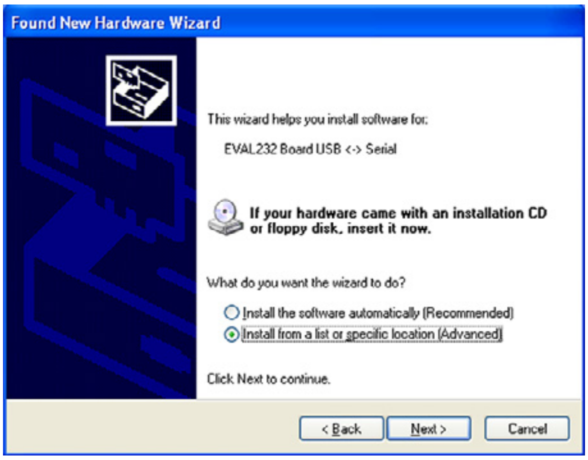
Installing the USB driver

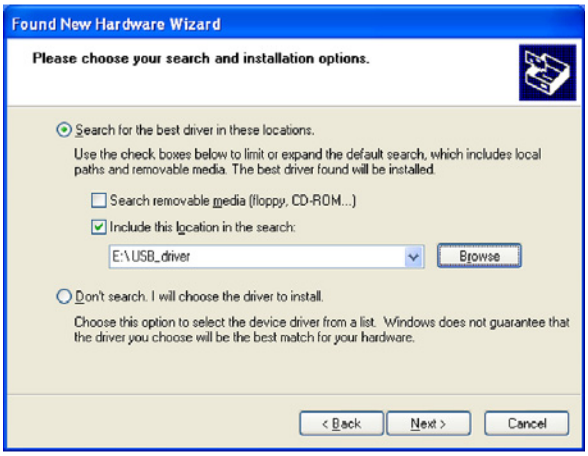
A special software driver is required for communication between SOPAS ET and the measuring system via the USB interface. This must be installed on the laptop/PC:

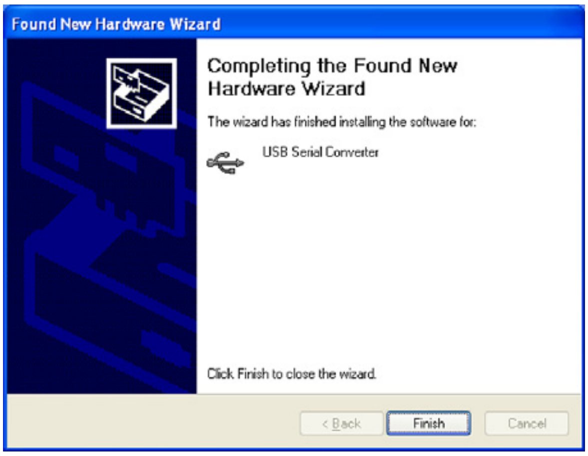
► Connect the USB interface cable to the PC.
  A message appears on the screen that new hardware has been found.

► Insert the delivered CD in the PC drive and follow the installation instructions.

Fig. 13 Installing the USB driver







Subject to change without notice

4.1.3 Connecting the device

4.1.3.1 Basic settings

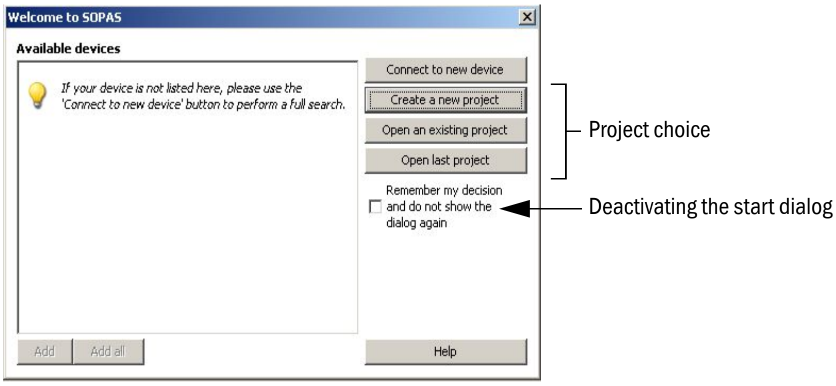
1 Connect the USB cable to the service interface of the FLOWSIC150 CARFLOW (→ p. 23, 2.6) and laptop/PC.

2 Switch the measuring system on.

3 Start the software from the “SICK\SOPAS” start menu.

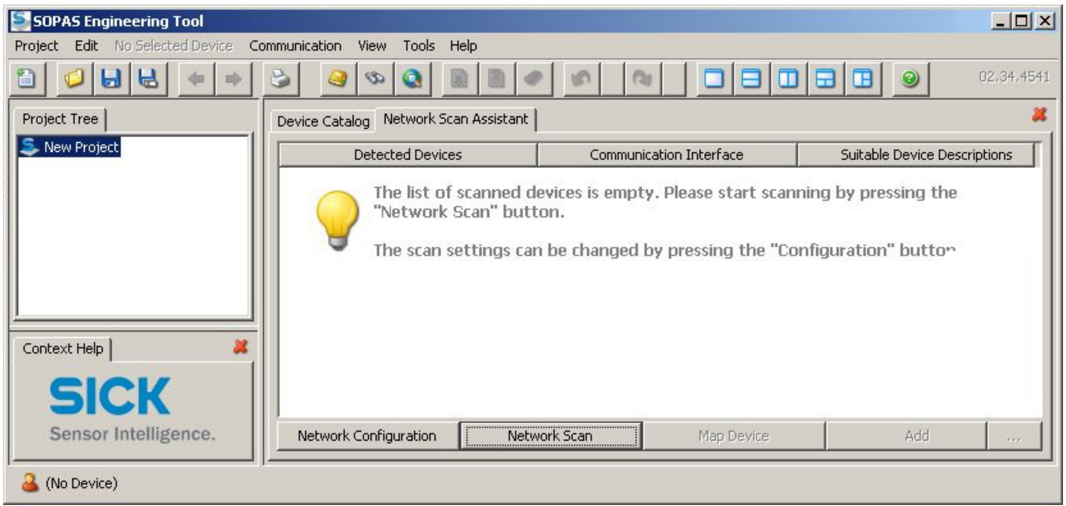
››› The Start dialog appears on the screen (can be suppressed for further program usage).

Fig. 14 Start dialog



The following Start menu is shown after clicking “Create a new project”.

Fig. 15 Start menu



4 If necessary, set the desired language in menu “Tools / Language” → p. 37, Fig. 16), confirm with “Yes” and restart the program.

Fig. 16 Changing the language setting

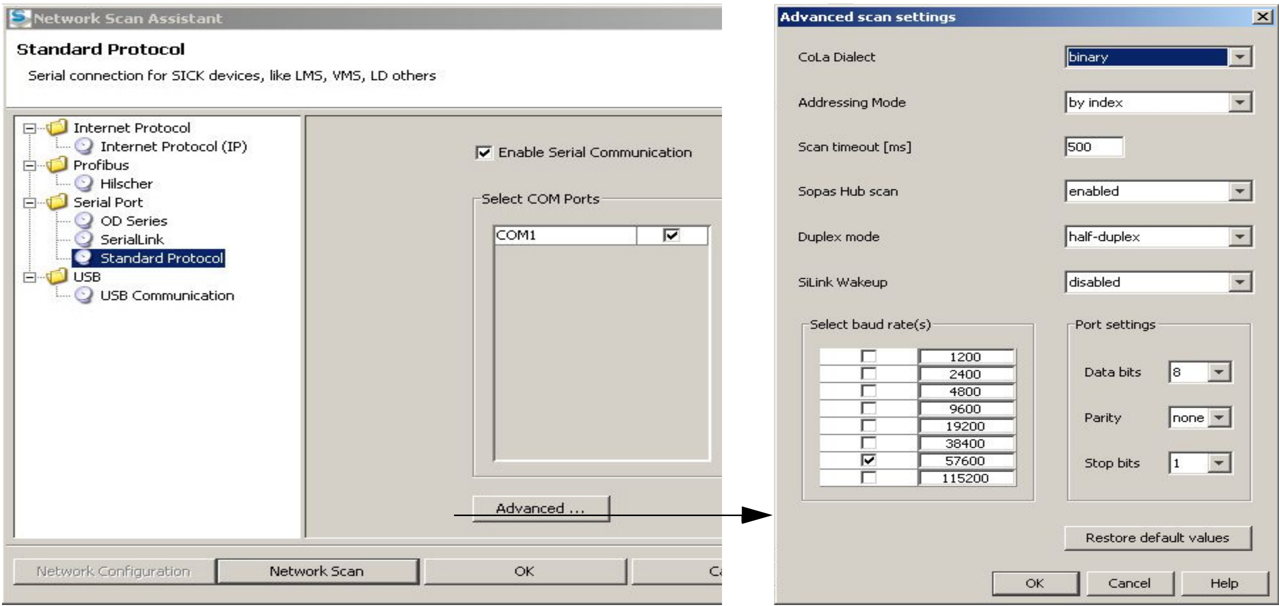
4.1.3.2 Configuring the interface

COM port

1 Click “Network Configuration” in the Start menu (→ p. 36, Fig. 15) and select the “Standard Protocol” menu.

2 In the group “Select COM Ports”, select the interface that appears after connecting the MCU and laptop/PC, click “Advanced” and configure as shown in Fig. 17 (settings only need to be made the first time a connection is made to the measuring system).

Fig. 17 COM port selection and configuration

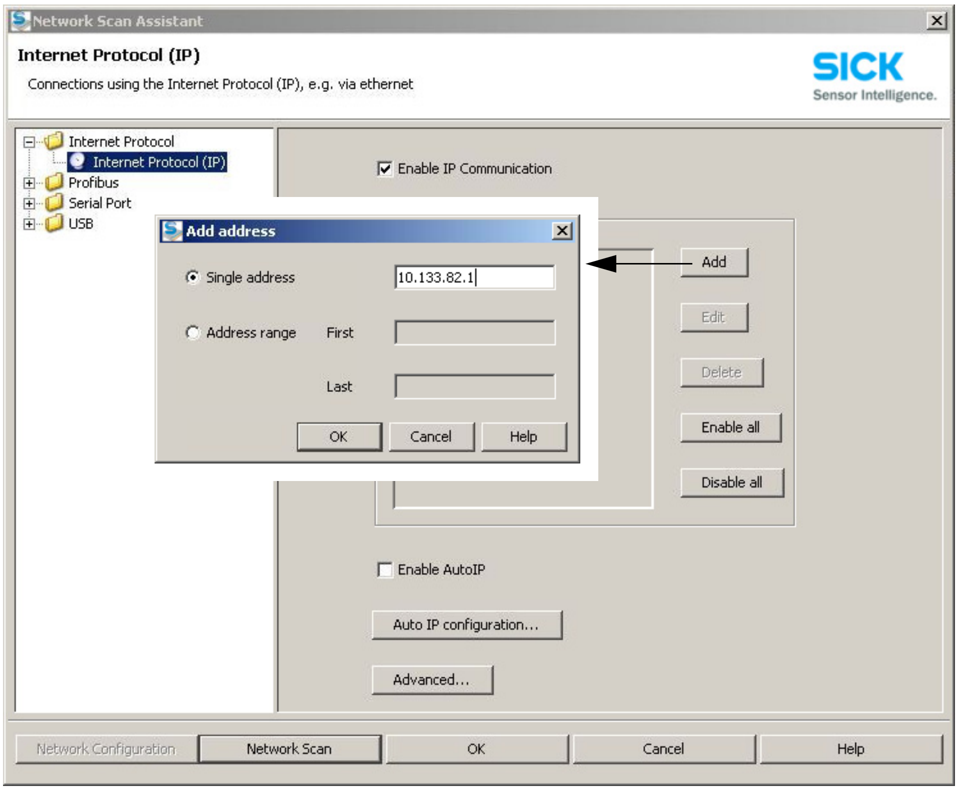


Ethernet

> **+i** The Lantronix Ethernet interface (→ p. 59, §4.5) must be configured correctly to connect to the FLOWSIC150 CARFLOW via Ethernet.

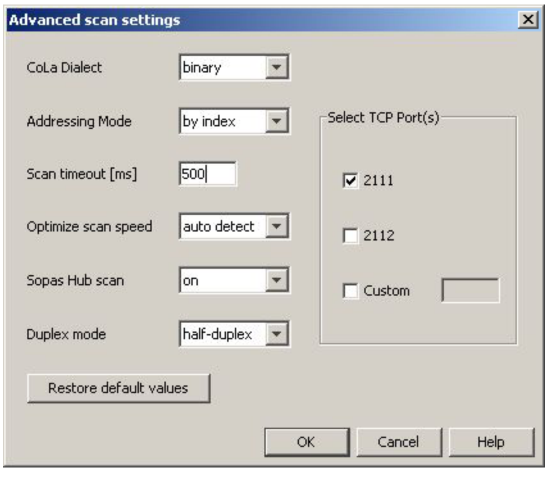
1 Click “Network Configuration” in the Start menu (→ p. 36, Fig. 15) and select the “Internet Protocol” menu.
2 Click “Add”, enter the IP address and confirm with “OK”.

Fig. 18 Ethernet interface selection (settings example)



3 Click “Advanced” and configure the interface as shown in Fig. 19.

Fig. 19 Ethernet interface configuration

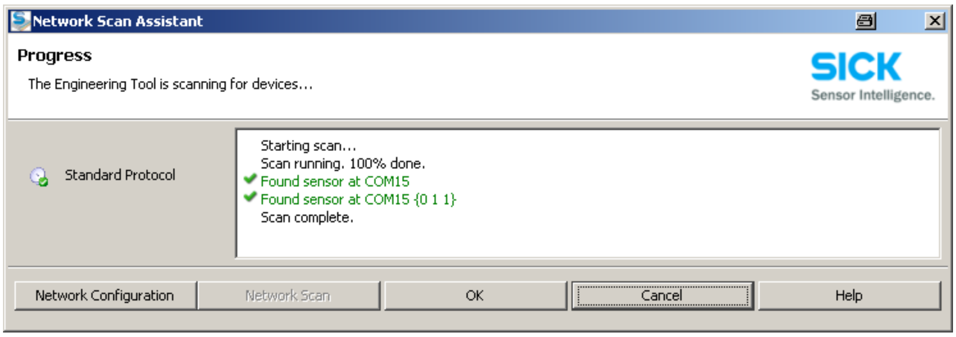


4.1.3.3 Using the directory “Network Scan Assistant” to create a connection

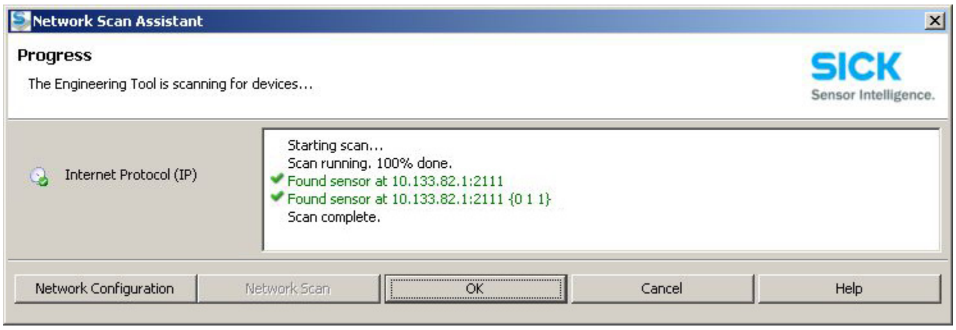
1 Click “Network Scan” in directory “Network Scan Assistant“.

Fig. 20 Search for connected devices

Connection via COM port



Connection via Ethernet:



Problems on connections via Ethernet can be due to incorrect addressing → Contact your system administrator.

2 Confirm search for connected devices with “OK”.

4.1.3.4 Connecting using the "Connection Wizard" menu

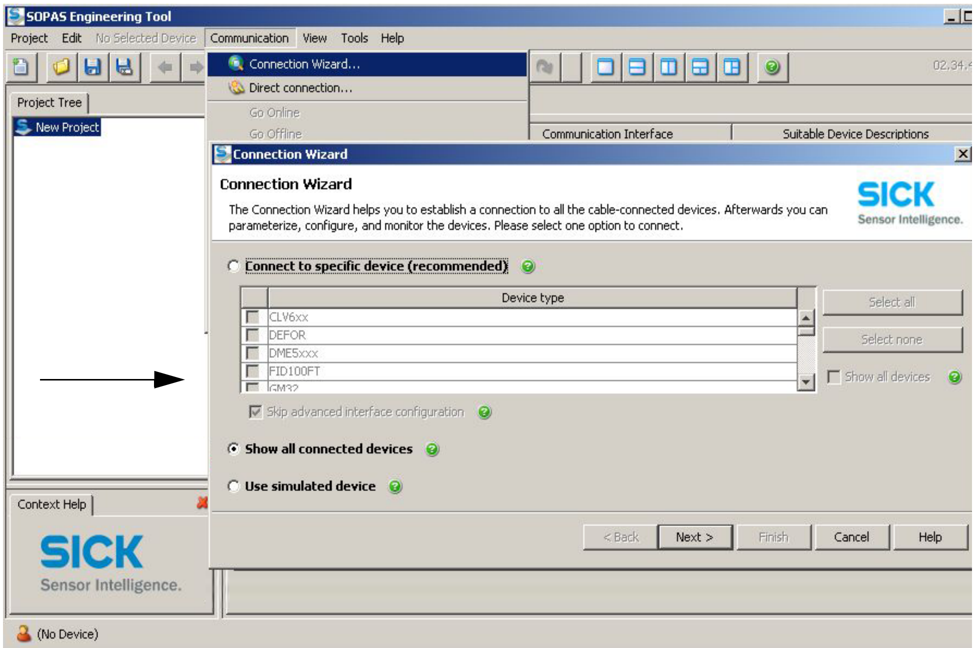
Available as from SOPAS ET Version 02.32

- "Connect to new device" calls up the "Connection Wizard" menu
- "Create new project" calls up the "Network Scan Assistant" menu

1 Click "Connect to new device" in the Start menu (→ p. 36, Fig. 14).

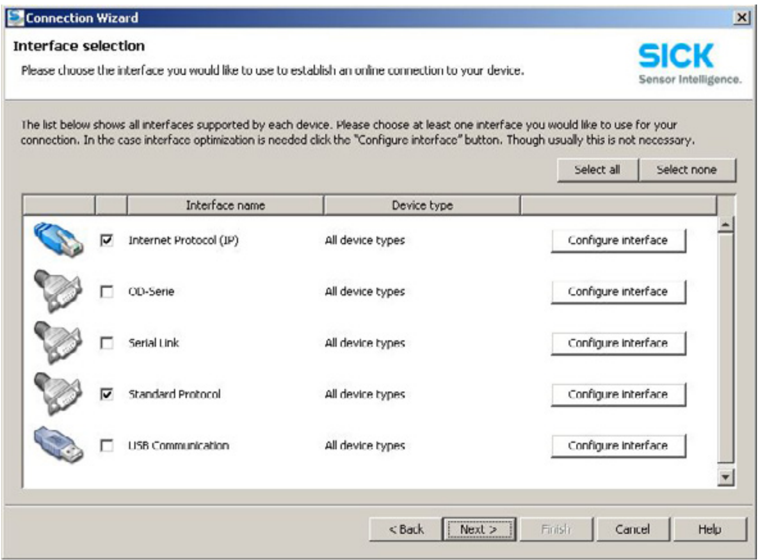
2 Select menu "Connection Wizard" and activate selection "Show all connected devices".

Fig. 21 Menu "Connection Wizard"



3 Click "Next" and select the interface ("Standard Protocol" for connection via COM port, "Internet Protocol (IP)" for connection via Ethernet).

Fig. 22 Interface selection

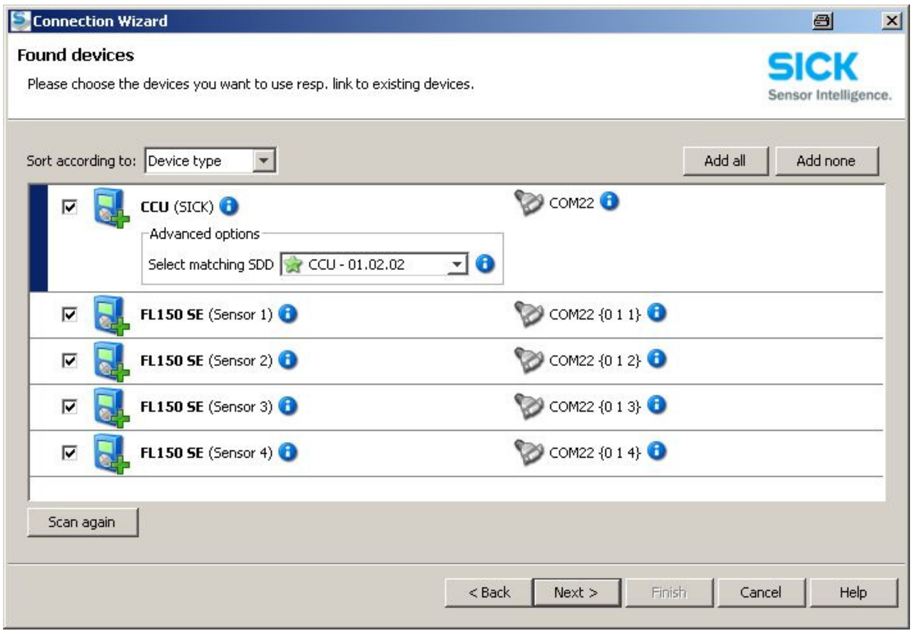


4 Check the interface configuration settings as shown in §4.1.3.2 (→ p. 37) and change as necessary.

5 Click "Next".

Fig. 23 Search for connected devices

Connection via COM port



4.1.3.5 Device list

Five individual devices are shown in SOPAS ET after successful connection to FLOWSIC150 CARFLOW:

- 1x CCU (Carflow Control Unit)
- 4x FL150 SE (sensor electronics for each individual ultrasonic path)

Sensor electronics (FL150 SE) contain sensor and diagnosis values of the individual ultrasonic paths. The sensor electronics do not normally need to be configured. The sensor electronics pass all sensor values and important diagnosis values to the CCU.

The CCU is the main operating interface for the FLOWSIC150 CARFLOW. Device configuration and operation run only via the CCU.

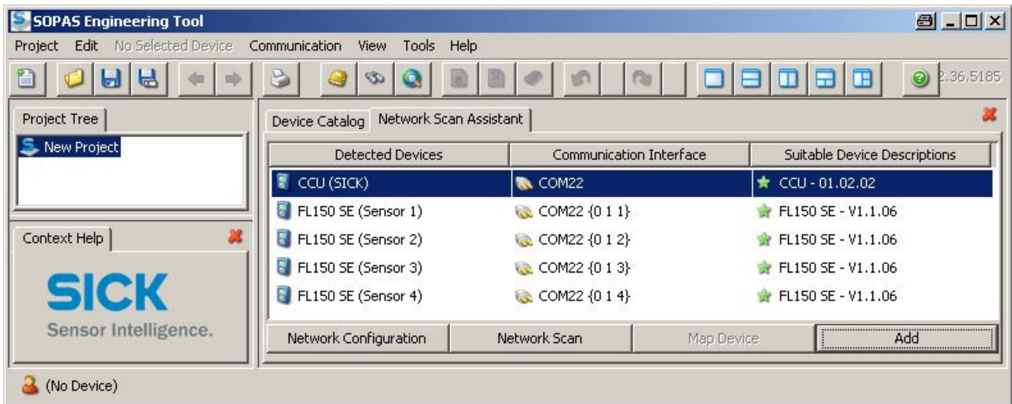
> It is useful to enter the sensor electronics in the project tree in order to be able to create a SOPAS project file for diagnostic purposes (→ p. 50, §4.2.5).

4.1.3.6 **Selecting a device**

Connecting via the COM port using the Network Scan Assistant

Select the desired device file in directory “Connection Wizard / Detected devices” and move it to window “Project Tree” (drag and drop or double-click per mouse, or use click “Add”).

Fig. 24 Select device



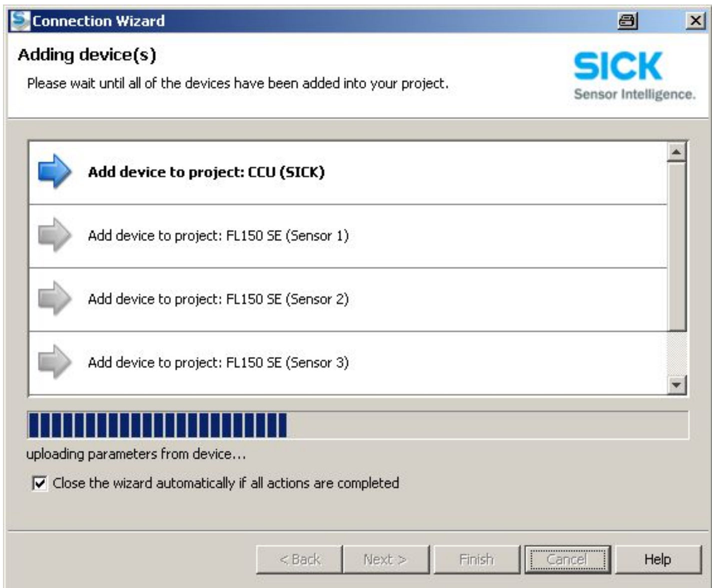
Connecting via “Connection Wizard”

In window “Connection Wizard / Detected devices” (→ p. 41, Fig. 23), activate the checkbox for the desired device file and click “Next”. This transfers the device file to window “Project Tree”.

Individual menus in the project tree can now be opened. Double-clicking a menu opens this menu automatically in the right working area.

> +i After the device has been loaded and work with the Connection Wizard finished, the right working area remains shown with a commentary from the unused Network Scan Assistant, including an empty list of “found devices”. The devices have however been loaded by the Connection Wizard in this case.

Fig. 25 Device file transfer



4.1.4 Information on using SOPAS ET

Password

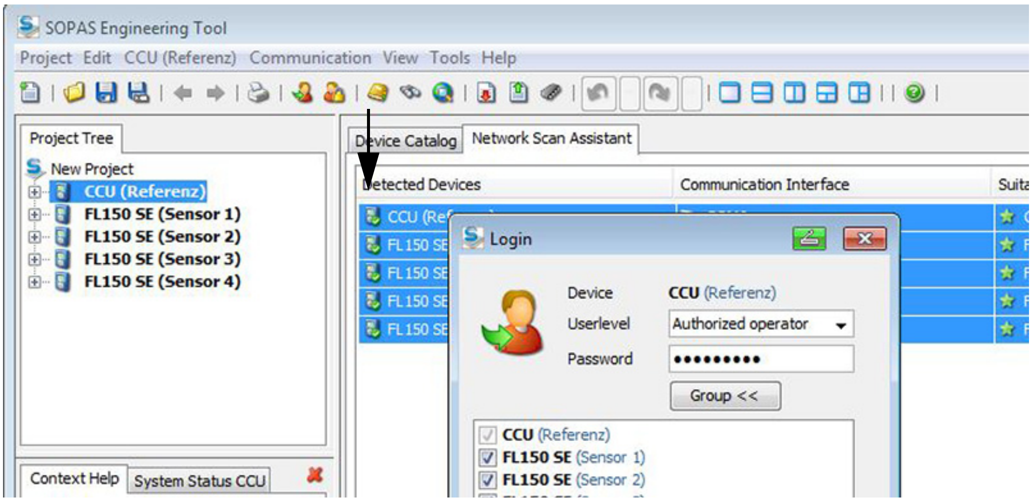
Certain device functions are first accessible after a password has been entered (→ Fig. 26).
Access rights are assigned in 3 user levels:

User level		Access to
0	“Operator” (machine supervisor) *	Displays of measured values and system status
1	“Authorized Operator” (Authorized Client) *[1]	Displays, inquiries and parameters required for start-up or adjustment to customer-specific demands and diagnosis
2	“Service”	Displays, inquiries as well as the main parameters required for service tasks (e.g. diagnosis and clearance of possible malfunctions)

[1] Depending on the program version.

The Level 1 password is “sickoptic”.

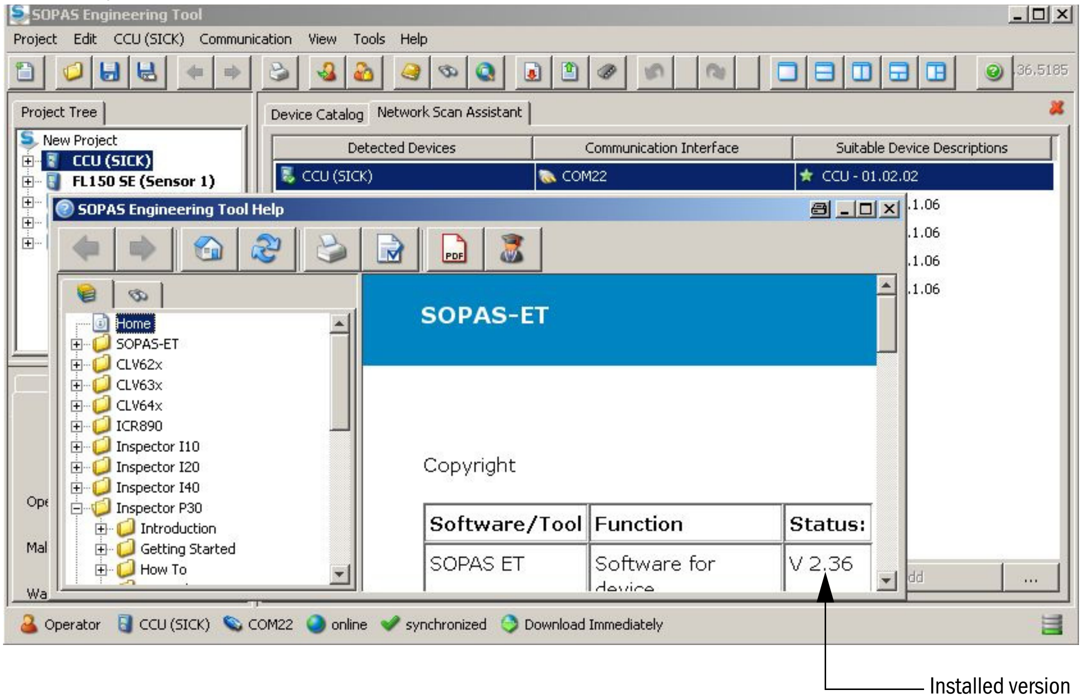
Fig. 26 Password entry and language selection



4.1.5 **Online Help**

The individual menus and setting options are described in detail in the online help and are therefore not described further here.

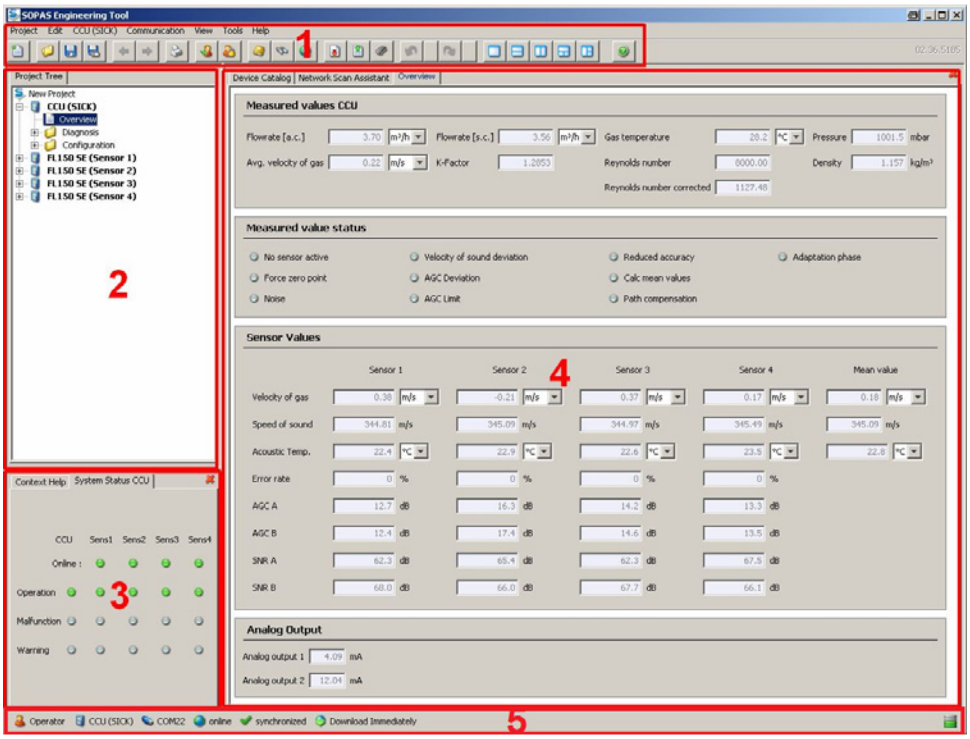
Fig. 27 Online Help



4.2 Start-up and Operation

SOPAS ET is split into four main areas (→ Fig. 28):

Fig. 28 Program areas in SOPAS ET



1	Menu bar and shortcut buttons
2	Project tree – contains devices currently available
3	Overview of system status and context texts
4	Display and parameter area

After the FL150 CCU (Carflow Control Unit) has been entered in the project tree, various diagnosis and configuration menus are available depending on the user level.

All user levels can access the diagnostic menu. The terminal output and measuring point name can be changed as from user level 1.

In the parameter window, user level 0 can only access the heating controllers. User level 1 can also access parameter windows for application parameters, input/output parameters and calibration coefficients.

Information explaining selected parameters is available via the context help (bottom left) and as tooltips. Tooltips appear after a short delay when the mouse pointer is moved over the relevant display or setting value.

The FLOWSIC150 CARFLOW is ready for measurement and configured when delivered. Start-up is limited to checking and, when necessary, setting application-specific parameters.

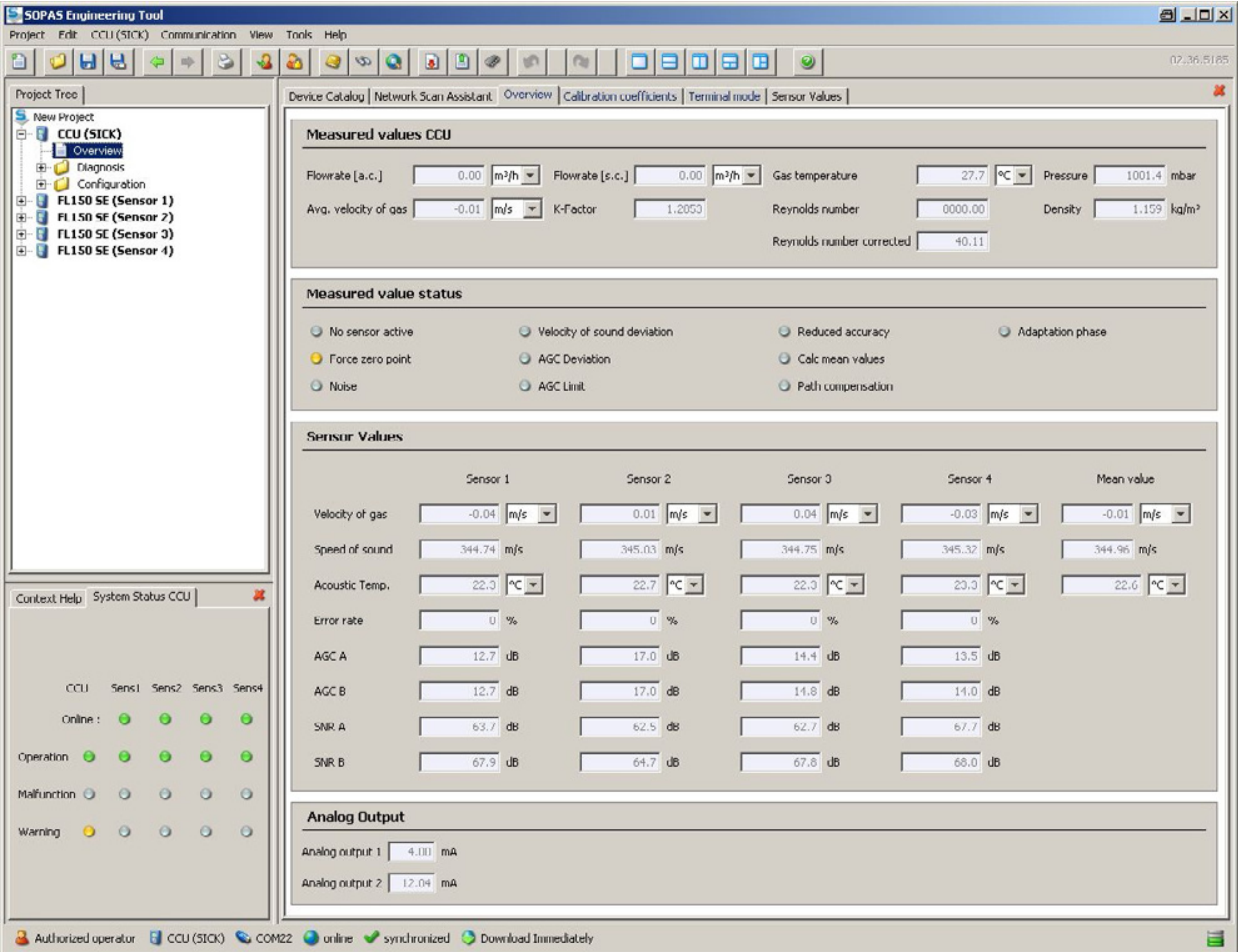
1 Connect the service interface of the FLOWSIC150 CARFLOW to the SOPAS ET computer.
2 Switch the device on.
3 Enter the device FL150 CCU (Carflow Control Unit) in the project tree of a new project (→ p. 36, §4.1.3).
4 Switch to user level 1 (→ p. 43, §4.1.4).

4.2.1 Overview

Window “Overview“ (→ Fig. 29) shows the most important measured values of the device.

- Measured and diagnosis data of the four ultrasonic paths
- Measured and correction factor values of the complete measuring device
- Important status messages
- Output value of the analog outputs

Fig. 29 Screen “Overview“



4.2.2 Configuring the application parameters

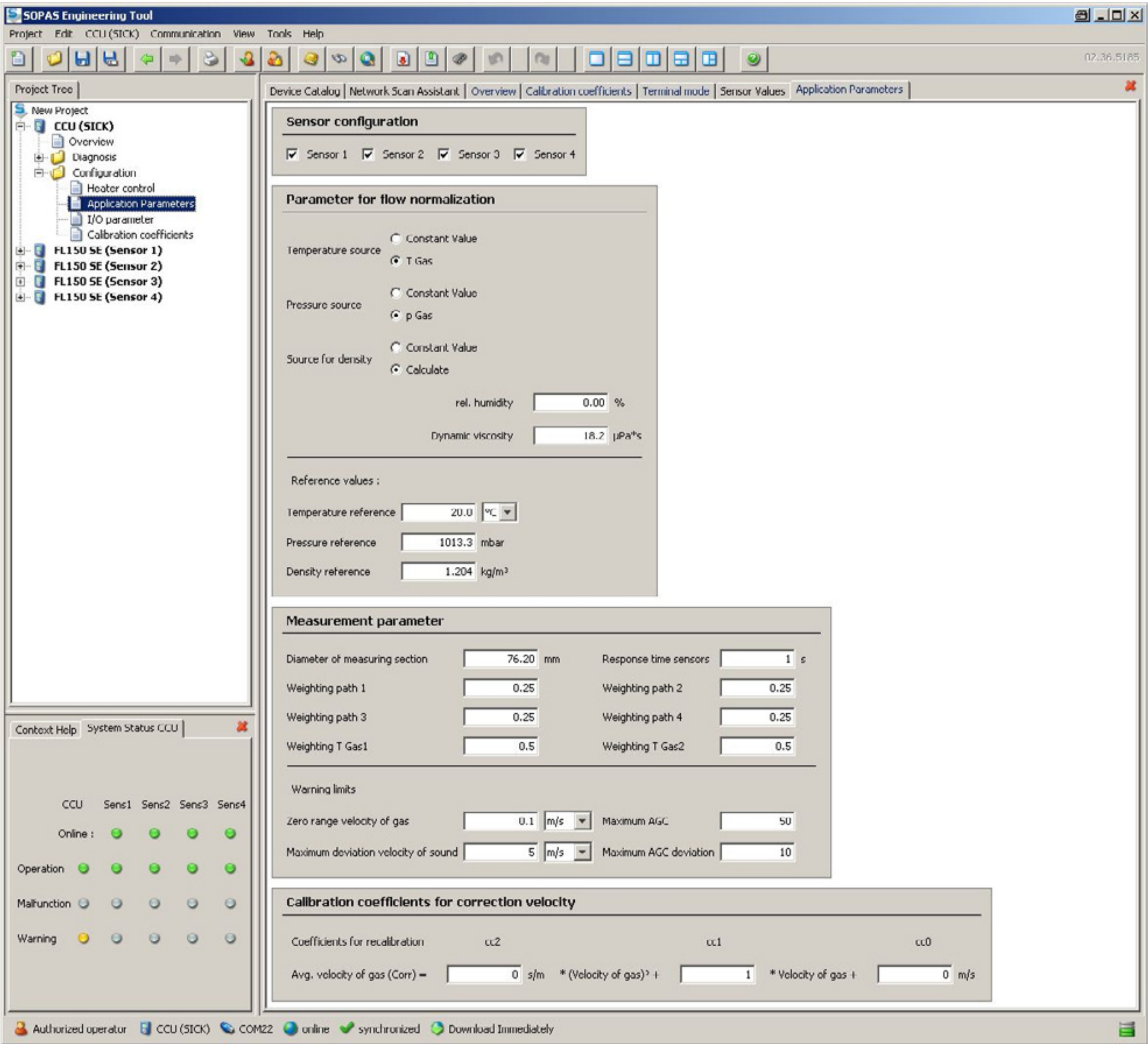
Normalization

The “Application Parameters” window (→ Fig. 30) serves to view and change parameters for normalizing the exhaust gas volume flow. Fixed values can also be used instead of the device-internal pressure and temperature sensors values for normalization. The exhaust gas volume flow is normalized based on the reference values set.

Zero point range

A zero point range for the gas velocity can be entered in the “Measurement parameter” area. The volume flow is set to “NULL” when below this value to suppress zero point noise and negative flow rate values. This is indicated in the display by showing the flow rate value in parentheses (Q_norm: **[0.00]** l/s).

Fig. 30 “Application Parameter” window



4.2.3 Configuring the analog outputs

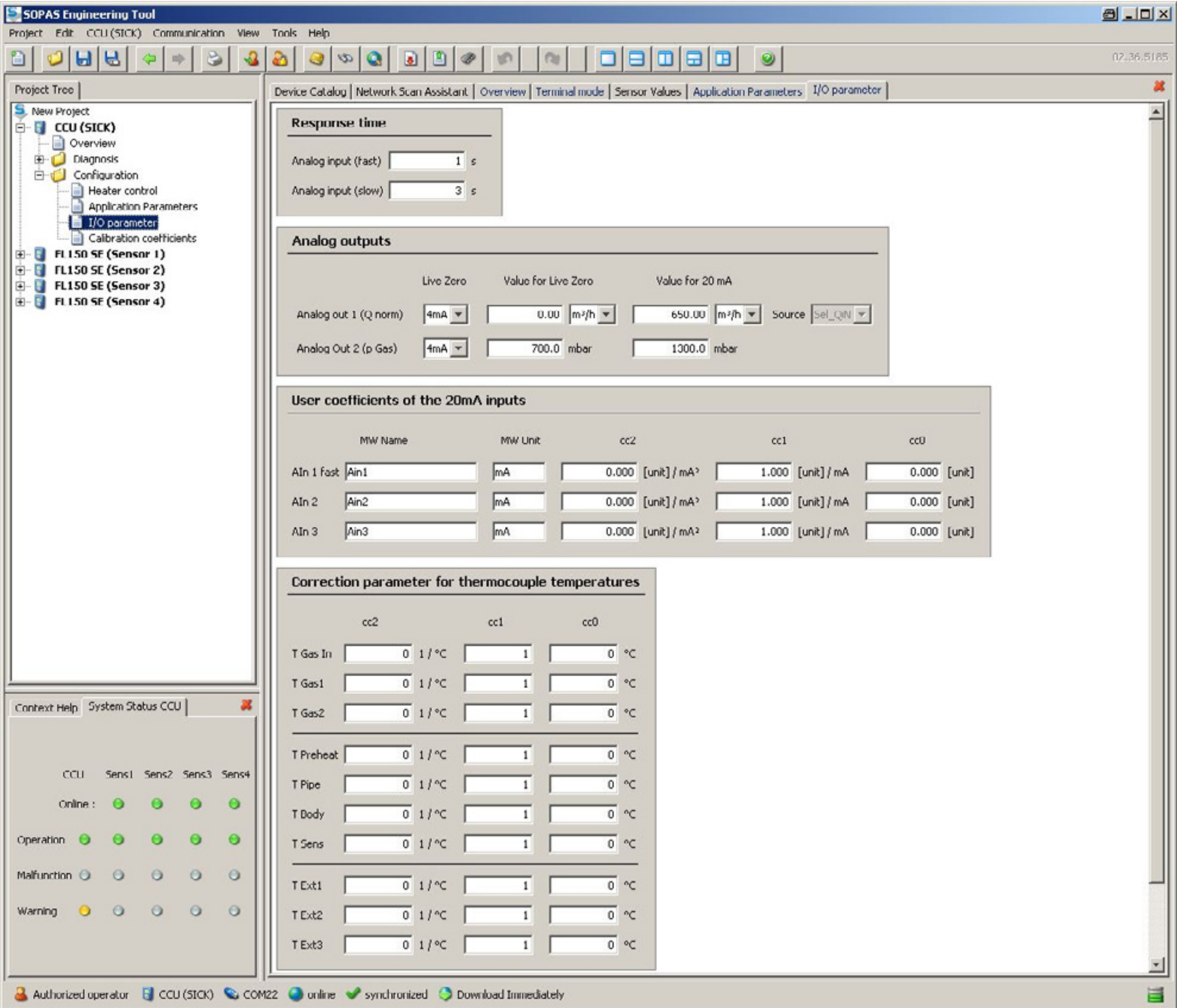
Window “I/O parameter” (→ Fig. 31) serves to configure the device analog outputs as well as to set the physical units of measure to be used for display outputs and AK interface (→ Table 7).

Table 7 Units for display and AK interface Table

Physical variable	Unit	
	Metric	Imperial
Flow rate values	l/s	ft^3/min
Velocities	m/s	ft/s
Temperatures	°C	°F

To set the analog outputs, select the LiveZero value (0/2/4 mA) and enter the lower and upper measuring range limit values. The specified measuring range for the device variant is already set at the factory.

Fig. 31 “I/O parameter” window



4.2.4 Heating control

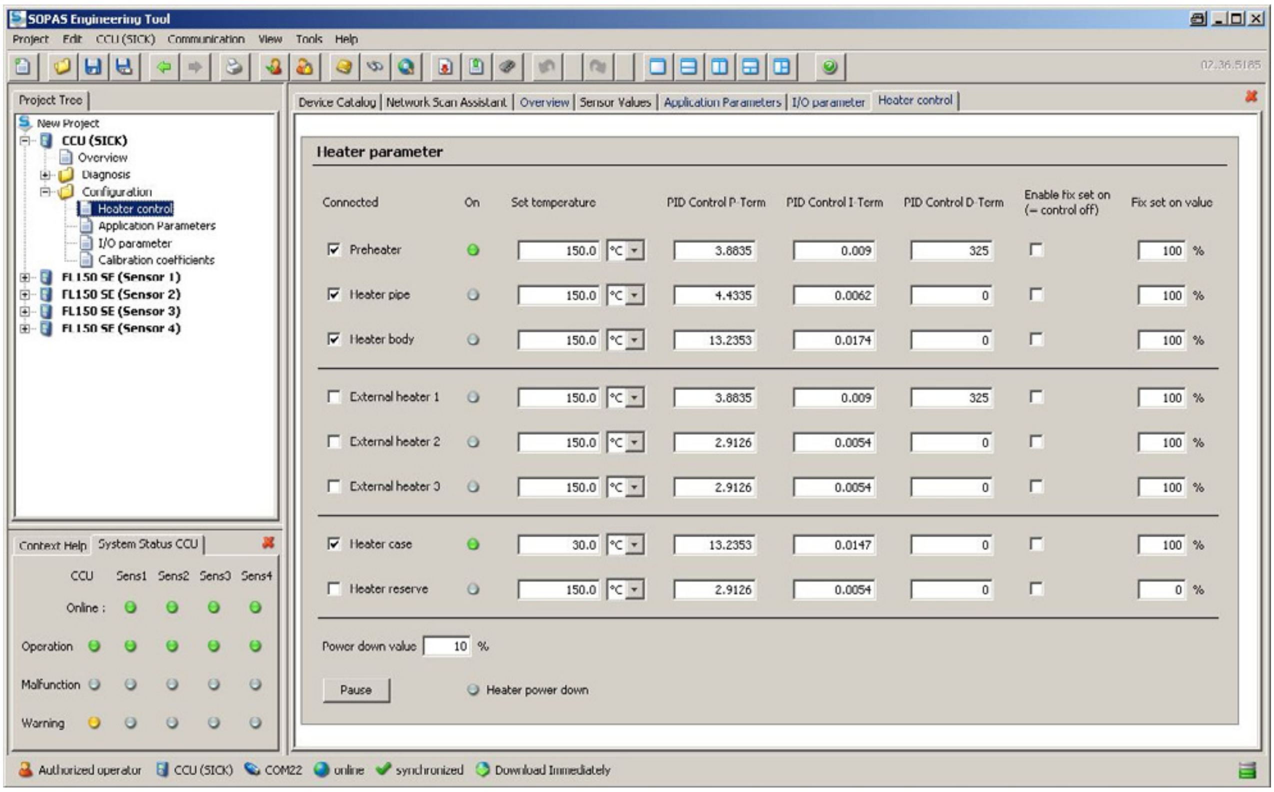
Activating/deactivating

Window “Heater control“ (→ Fig. 32) serves to activate the heating controls of the FLOWSIC150 CARFLOW, to specify nominal values and, when necessary, to change controller parameters.

Activate the heater “Preheater“ (inlet section), “Heater Pipe“ (sample gas line), “Heater Body“ (measuring cell) and “Heater Case“ (electronics housing) for proper device operation to prevent condensation effects in the sample gas line. Any additional external heater lines connected to the device (→ p. 31, §3.2) can also be activated here.

Thermostats and circuit breakers prevent the heaters overheating.

Fig. 32 “Heater control“ window



Nominal values

Select the nominal temperatures for the heaters so that they are at least 30 K above the exhaust gas dew point. The operating LEDs show the switch-on duration of the heaters.

Control parameters

Heater controller parameters are set at the factory. Changes may only be made under consideration of control behavior. Controllers can be deactivated by activation with a fixed switch-on duration.

Pause mode

In order to reduce the device power input, the switch-on duration for the heaters can be reduced to an adjustable fixed value by activating pause mode. Pause mode can also be activated with an AK command.

4.2.5 Data saving and recording

All parameters relevant for the collection, processing and input/output of measured values as well as current measured values can be saved and printed. This simplifies reentering set device parameters (e.g. after a firmware update) as well as registering device data or device states for diagnosis purposes.

The following options are available:

Saving as a project

This storage option creates a complete image of the SOPAS ET user interface with all device parameters and measured values current at the time of saving. Saving as a project file (*.spr) is recommended for most purposes.

Creating protocols

Device data and parameters are recorded In the parameter protocol. A diagnosis protocol can also be created for the FLOWSIC150 CARFLOW sensors (FL150 SE) for analyzing the device function and recognizing possible malfunctions.

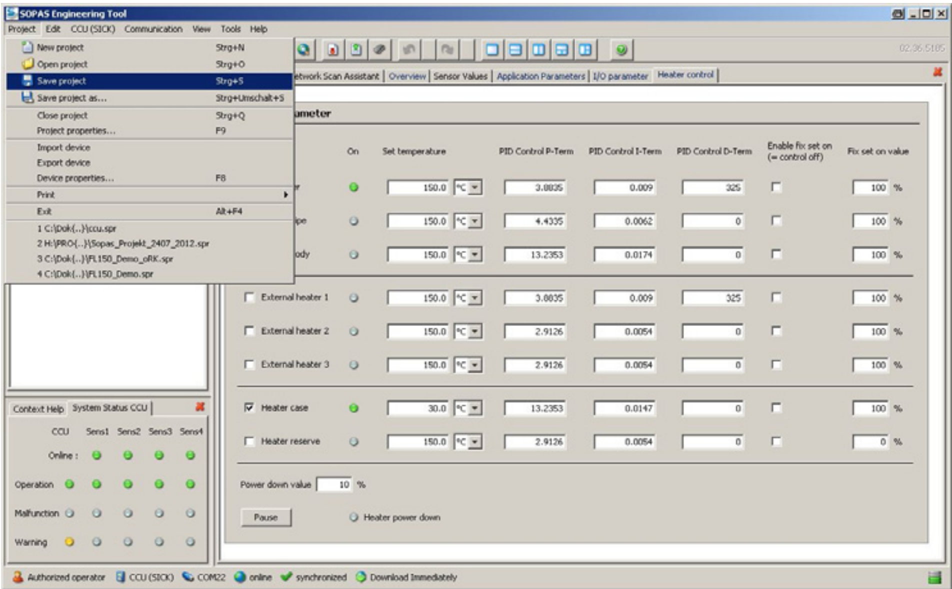
Recording and saving a data log in the recorder

The SOPAS ET data recorder serves to record measured values and parameters as desired. The data can then be exported or viewed with SOPAS. Data logs are suitable for recording dynamic processes.

Saving as a project (→ Fig. 33)

1 Load the CCU and all four FL150 SE in a project and switch “online“.
2 Call up menu “Project / Save project“ and specify the target directory and file name.

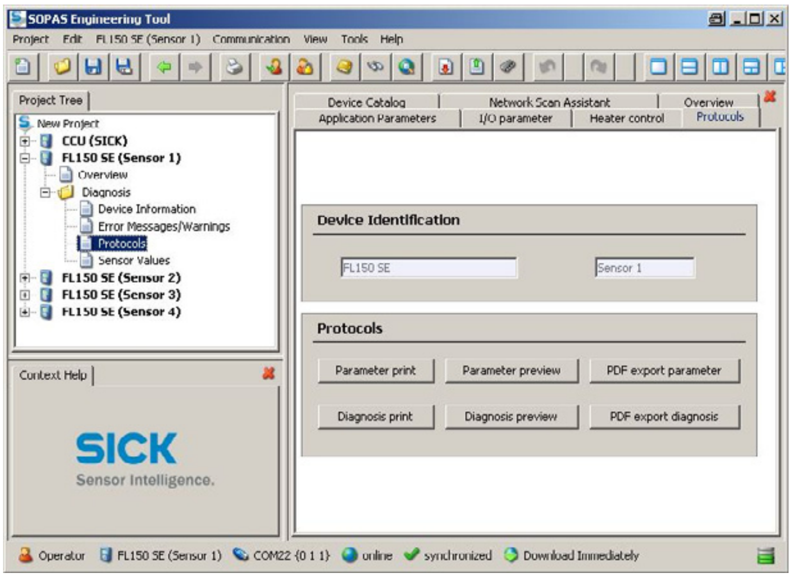
Fig. 33 Saving a project



Creating protocols (→ Fig. 34)

1 Select the device in the project tree.
2 Call up "Diagnosis / Protocols" in the project tree.
3 Click the desired protocol type.

Fig. 34 "Protocols" window



Recording and saving a data log in the recorder (→ Fig. 35)

1 Load the desired devices (CCU, sensors) into the project tree.

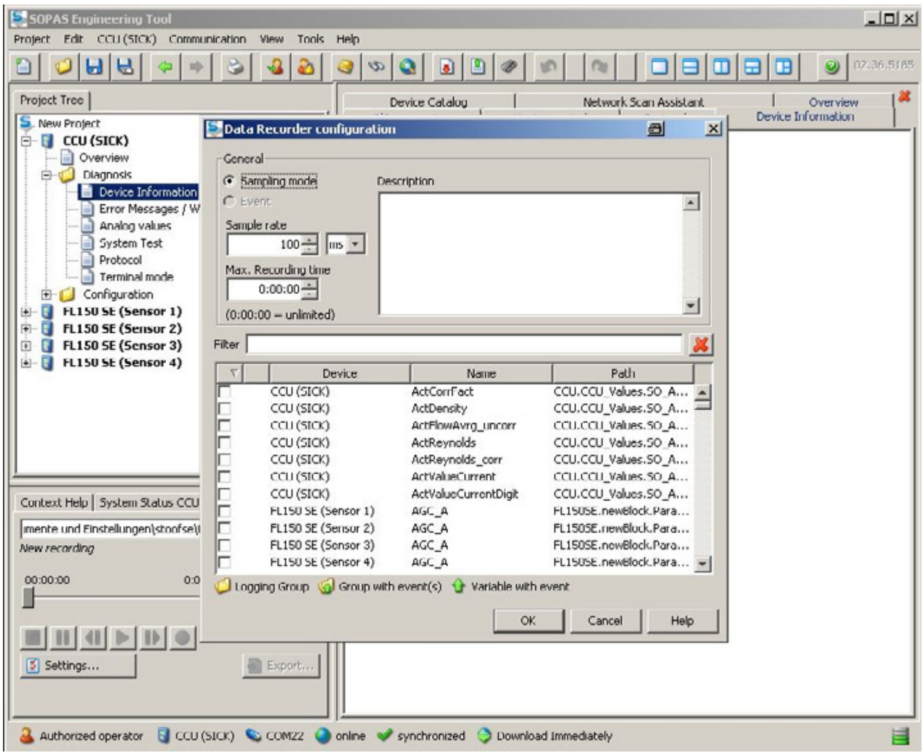
2 Call up menu “Tools / Data Recorder”.

›› The data recorder appears at the bottom left.

3 Click “Settings” to select the recording frequency, recording duration and parameters.

4 Create a target file for the data logs (symbol).

Fig. 35 Data recorder



► Buttons designed in accordance with the usual pictograms for these functions serve to control the recorder functions

+i To view the recorder data log in SOPAS, save the active project as well and load the recorder data before viewing.

4.3 Advanced operation and configuration

Further configuration options are available for experienced users to set the FLOWSIC150 CARFLOW to meet individual requirements. Always create a backup copy of a SOPAS project file before making changes to the following parameters to be able to reset back to the factory parameter settings if necessary (→ p. 50, §4.2.5)

> **!** Changes to the following parameters could lead to reduced measuring precision.
> Changes should only be made by experienced users.

4.3.1 Application parameters

Measuring parameter

Window "Measurement parameter" (→ p. 47, Fig. 30) serves to change the contribution of the individual ultrasonic measuring paths using weighting factors and to change thermoelements to measure the exhaust gas temperature on the complete system.

The measuring cell diameter (Body) is dictated by the construction and should not be changed.

Increasing the response time for the sensor values can smoothen flow rate measurement. This reduces the measuring dynamic.

Warning limits

Adapting the warning limits for self-diagnosis of the FLOWSIC150 CARFLOW. Thresholds are used to signal irregularities of ultrasound measurement, such as described in §2.6 (→ p. 23).

Calibration coefficients for gas velocity

The calibration coefficients serve to readjust the ultrasonic volume flow measurement of the FLOWSIC150 CARFLOW. The set coefficients serve as correction function to the factory calibration and allow application-specific recalibration of the device for special installation conditions that can deviate from the factory calibration conditions. Special installation situations can already be integrated in the calibration at the factory on request.

4.3.2 Input/output parameters

Response time for analog inputs

Adapting the response times in the “Response time” window (→ p. 48, Fig. 31) allow individual measured value smoothing. See Table 8 for an overview of fast and slow analog inputs.

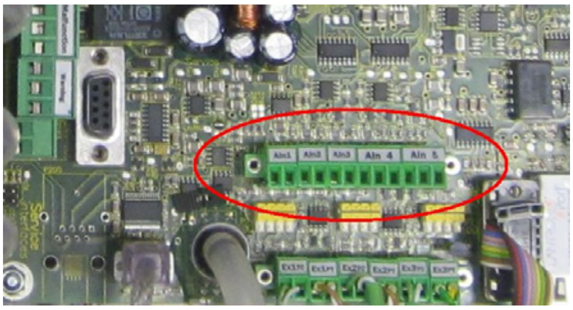
Table 8 Analog inputs overview

Analog inputs 10 Hz	Analog inputs 1 Hz
Exhaust gas pressure (pgas)	Component temperatures (Body, Pipe, Preheater, Sensors, Case)
Exhaust gas temperature 1 and 2 (Tgas1, Tgas2)	External temperature inputs
Exhaust gas temperature, inlet (Tgasin)	Battery voltage
Reference temperature for TE	Reserve Ain2 / Ain3 (on CCU circuit board)
Reserve Ain1 (on CCU circuit board)	24V

Coefficients for analog inputs

Optional analog inputs are available for use on the FLOWSIC150 CARFLOW circuit board (→ Fig. 36). These can be used as required and configured and calibrated using the coefficients.

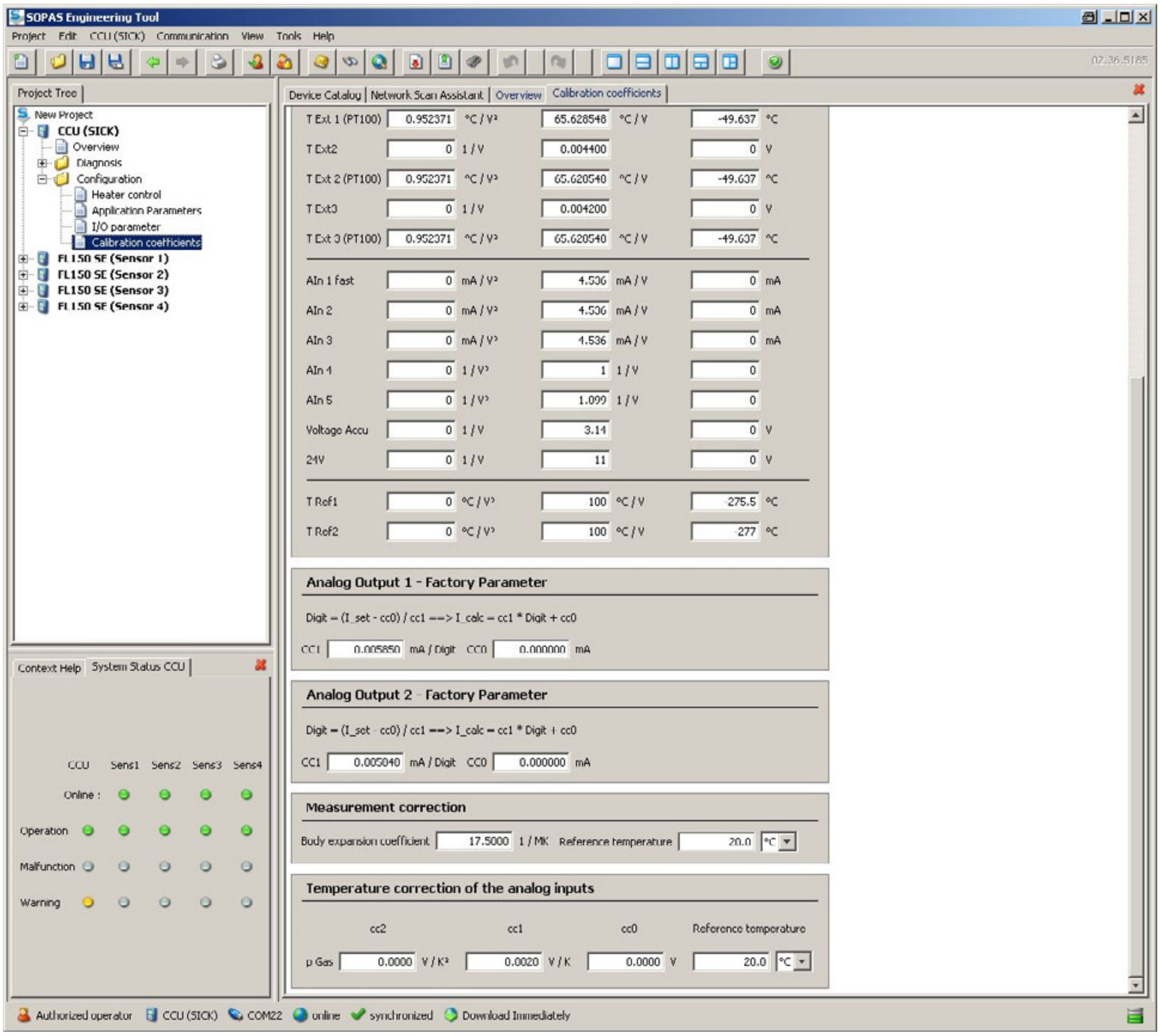
Fig. 36 Analog inputs



4.3.3 Calibration coefficients

Window “Calbration coefficients“ (→ Fig. 37) serves to view and change the regression coefficients of all analog inputs and outputs of the FLOWSIC150 CARFLOW. The inputs and outputs are calibrated at the factory. Changing coefficients leads to a change in behavior of the inputs and outputs, and should only be made for recalibration purposes.

Fig. 37 Window “Calbration coefficients“



Measurement correction

The value of the expansion coefficients serves to adapt the ultrasonic parameters (path length and angle) relating to the thermal expansion of the measuring cell at high temperatures. The default value should not be changed.

Temperature correction of the analog inputs

This function serves to compensate the influence of the temperature on the barometric pressure sensor. Changes can be appropriate when using the device outside the specification (e.g. with extreme ambient temperatures).

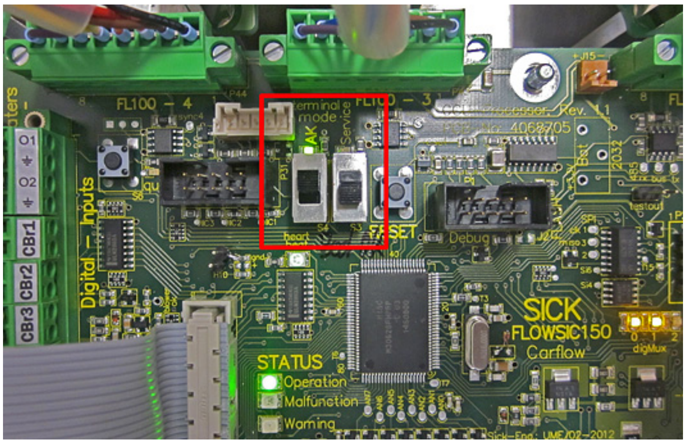
4.3.4 Output of measured values in terminal mode

4.3.4.1 Selection switch for terminal mode

Terminal mode is available for the AK interface and the service interface of FLOWSIC150 CARFLOW and serves extended diagnosis of measured value output and signal processing. In terminal mode, the configured measured values are output continuously with a fixed frequency via the selected interface. A terminal program is required for visualization and recording (e.g. HyperTerminal).

Terminal mode can be activated for each interface using hardware switches on the CCU master board (→ Fig. 38). The original interface function is deactivated as long as terminal mode is activated for an interface. Terminal mode is signaled on the display as status “T_AK“ (terminal mode AK interface) or “T_SV“ (terminal mode service interface).

Fig. 38 Selection switch for terminal mode



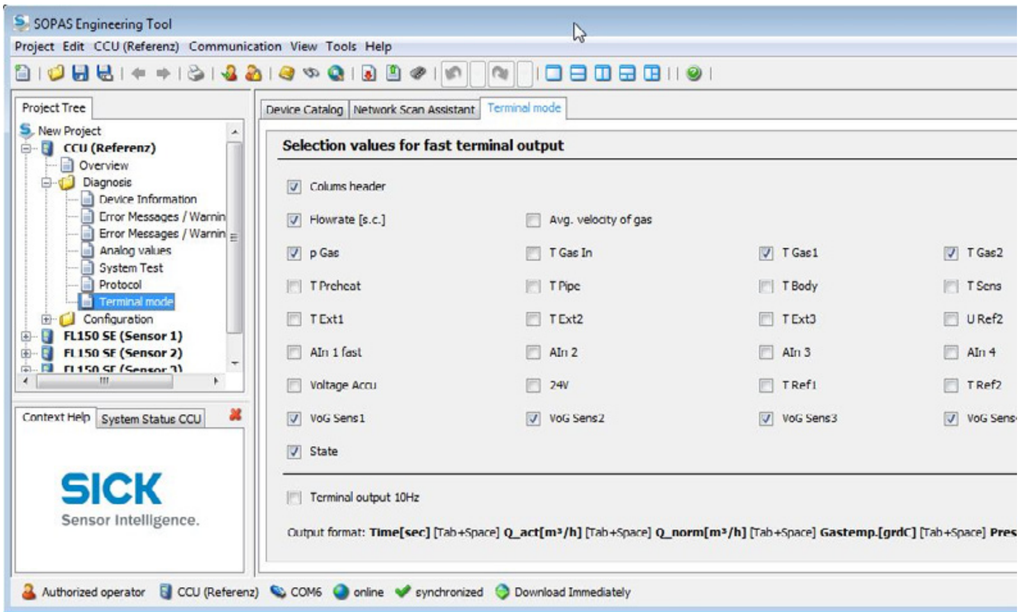
4.3.4.2 Configuring terminal mode

The window for configuring terminal mode is available as from user level 1 under “Diagnosis” in the project tree (→ p. 57, Fig. 39). The measured data can be selected to define which data are to be output via the interface in terminal mode.

The parameters for terminal output are:

Baud rate:	57.6 kBaud
Data bits:	8 bits
Parity:	None
Stop bits:	1
Frequency:	1 Hz

Fig. 39 Window for configuring terminal output



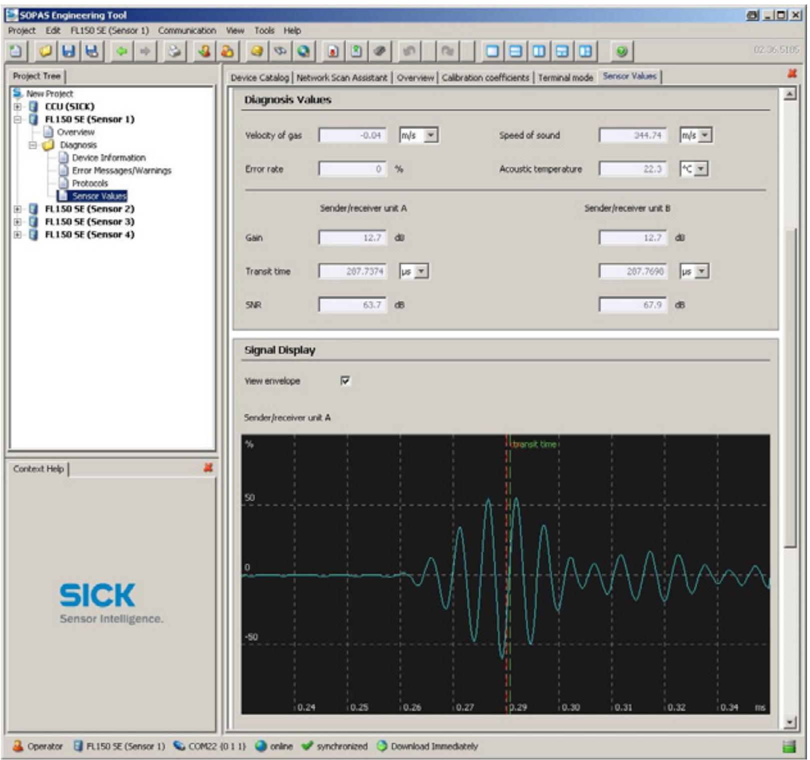
4.4 Diagnosis options in SOPAS ET

SOPS ET provides numerous diagnosis windows for device diagnosis. A short description of the windows available for the Carflow Control Unit (CCU) follows:

Window	Functions
Device info	Device identification characteristics, installation location can be entered individually by the user.
Error messages / warnings	Shows the possible and active device errors and warnings.
Analog values	Clear overview of voltages and physical values for all analog inputs and outputs.
System test	Shows the system state and allows, by activating the system test, manual activation of various device components and output of test flows to the analog outputs for diagnosis purposes.
Protocols	Allows creating parameter protocols (→ p. 50, §4.2.5).
Terminal mode	→ p. 56, §4.3.4.

On the basis of the system state display at the bottom left in SOPAS, warnings and errors active on the sender/receiver units are displayed. These must be loaded to the project tree to diagnose individual sender/receiver units of the measuring paths (device name: FL150 SE (sensor x)). These also contains various diagnosis windows. In particular, the ultrasonic signals can be visualized and analyzed under “Sensor Values” (→ Fig. 40).

Fig. 40 Window “Sensor Values”



4.5 Configuring the Lantronix Ethernet interface

4.5.1 Function of the Ethernet interface

The Ethernet interface from Lantronix interface is used on both RS232 interfaces of the FLOWSIC150 CARFLOW to allow access to the RS232 interface on the AK interface as well as on the service interface per TCP or UDP protocol.

The XPort Ethernet is configured using the Lantronix tool “DeviceInstaller“ on the product CD. Refer to the Technical documentation on the product CD for more detailed information on the Lantronix converter.

4.5.2 Configuring the Ethernet interface (short instructions)

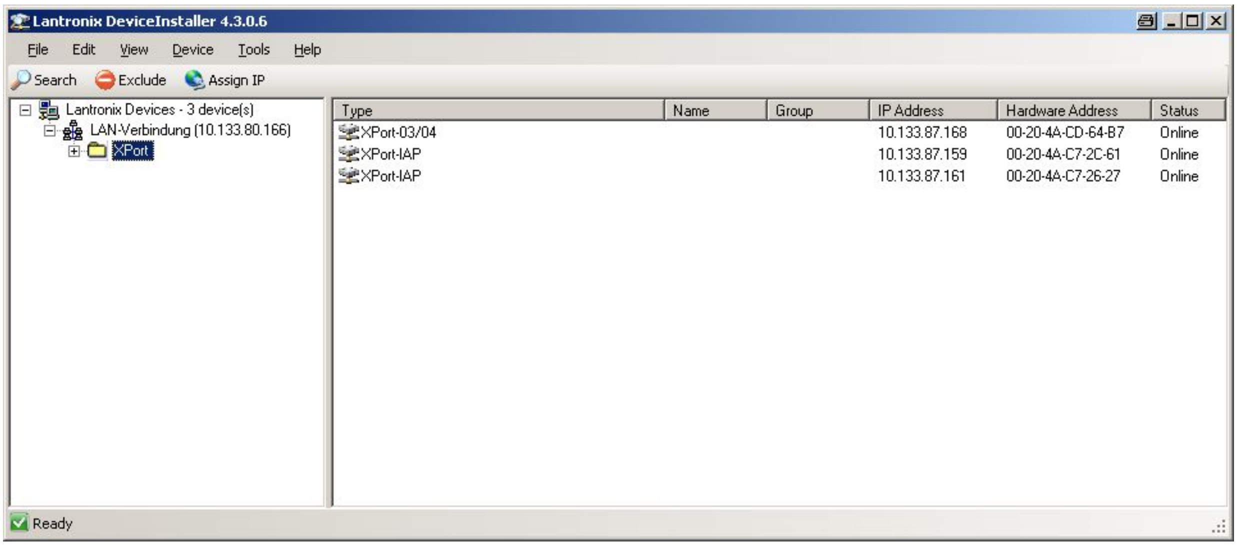
1 Install the “Lantronix DeviceInstaller“ program on your PC.
2 Connect the desired interface per Ethernet cable to your PC.
3 Start the “Lantronix DeviceInstaller”.

››› An automatic scan for Lantronix products is started.

If the XPort converter is not found, make sure the connection to the converter address range is not prevented by firewalls or company safety software and the device is switched on.

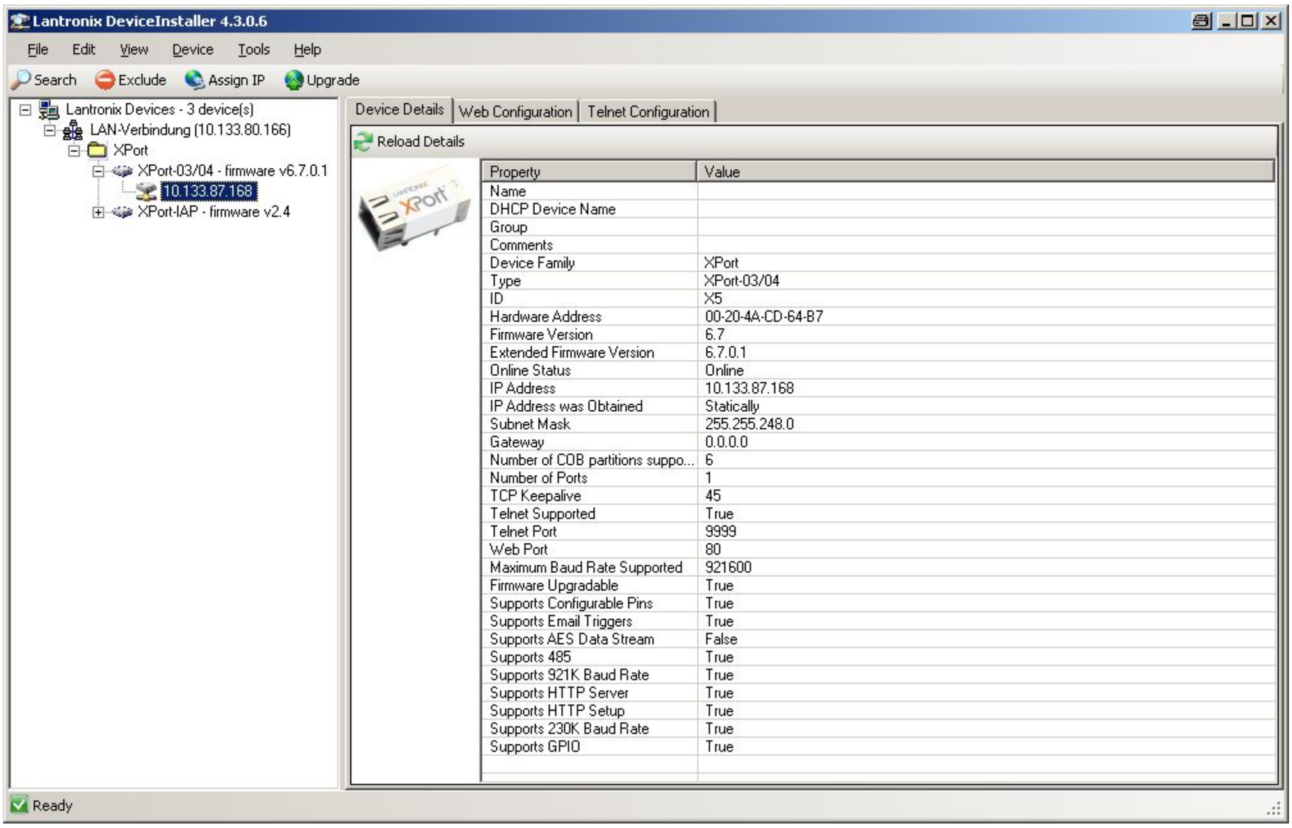
››› The available XPort converters are shown in the device list when the scan is successful (→ Fig. 41).

Fig. 41 Device list in “Lantronix DeviceInstaller“



4 Double-click the converter in the list to call up the details on the converter configuration in register “DeviceDetails“ (→ Fig. 42).

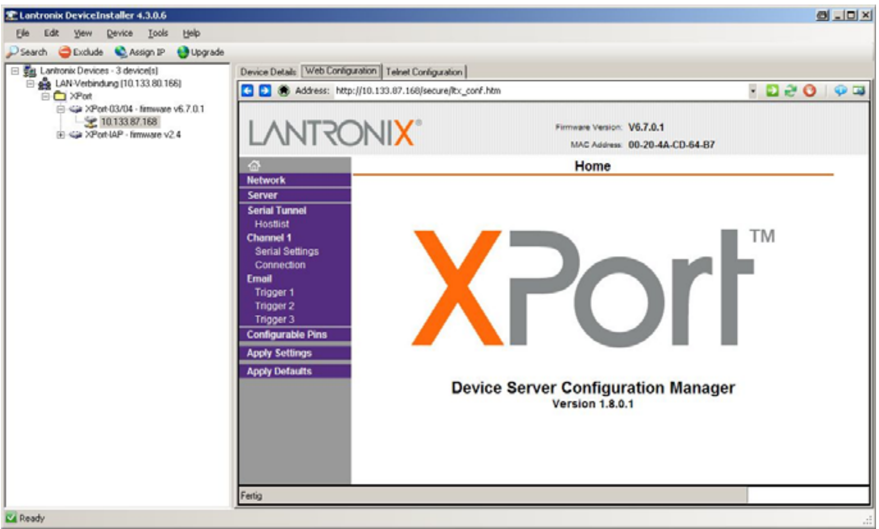
Fig. 42 Window in “Lantronix DeviceInstaller“ for converter configuration



5 Click “GO” to the right of the address line in the register “Web Configuration“ and confirm the password prompt with “Enter”.

››› The browser-based configuration tool for the converter appears (→ Fig. 43).

Fig. 43 Lantronix configuration tool for a converter



6 Make the desired settings and save the changes with menu item “Apply Settings“.

FLOWSIC150 CARFLOW

5 Maintenance

Maintenance request
Routine checks

5.1 General

5.1.1 Maintenance request

The FLOWSIC150 CARFLOW is a measuring system with low maintenance. The use of titanium and high-quality stainless steel for parts having contact with the exhaust gas (measuring tube, ultrasonic probes) ensures these resist corrosion when the device is used in accordance with the specification.

Apart from that, the active measuring path of the FLOWSIC150 CARFLOW has no mechanical moving parts.

Maintenance tasks are mainly routine plausibility checks of the measured values determined by the FLOWSIC150 CARFLOW and cleaning work.

5.1.2 Maintenance intervals

The plant operator must define the maintenance intervals. The intervals depend on specific operating parameters such as how the system is run and ambient conditions. We recommend starting with shorter maintenance intervals (e.g. 4 weeks) and then extending these in steps to match the respective situation. The activities required and their completion must be documented by the operator in a Maintenance Manual.

5.2 Routine checks

The device state can be read off directly on the operating and display elements on the top side of the FLOWSIC150 CARFLOW. Warnings and malfunctions are signaled using the operating display. Additional information on device status is shown in the “State” line. in the case of active warnings/malfunctions, these can be displayed by clicking “Diag” several times. Identification is done using Tables (→ p. 20, Table 2 / → p. 21, Table 3). This information is also on the inside of the device cover.

5.2.1 Measuring the gas temperature

The sound velocity depends on the temperature and therefore the gas temperature can be determined using the transit time measurement of the ultrasound in the gas. Comparing the acoustic temperature determined with the values of the sheathed thermal couples allows a simple method of checking the plausibility of gas temperature measurement. These reference measurements must be carried out with air.

Steps required

1 Disconnect the FLOWSIC150 CARFLOW from the exhaust gas line.

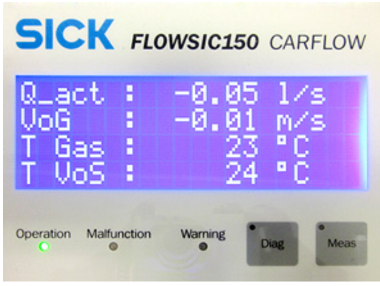
> ***NOTICE:***
> Always observe and follow the required safety measures!

2 Switch the internal heating off.

3 Wait until the measuring tube has cooled down to the ambient temperature.

4 Click “Diag” once until the display shown below appears.

Fig. 44 Display on the LC-Display during the gas temperature measurement function check



←Temperature measured with the sheathed thermoelement
←Temperature determined acoustically

Result

The gas temperature is measured correctly when the difference between the two temperature values is not larger than 10 °C.

> When the device is heated, temperature stratifications in the measuring tube can cause larger differences between the temperature determined acoustically and the temperature measured by the sheathed thermoelement. If the device function is to be checked when the device is heated, we recommend using hot air blowers or similar equipment (e.g. drier) to create an even temperature distribution across the tube cross-section.

5.2.2 Sound velocity

The plausibility of the measured gas velocity and the volume flow calculated therefrom can be checked by comparing the theoretical sound velocity and the sound velocity measured by the FLOWSIC150 CARFLOW as well as by comparing the sound velocities in the individual paths.

Parameter	Standard value	Error	Remark
Difference between theoretical and measured sound velocity	≤ ± 0.5 m/s	≥ ± 2 m/s	When calculating the theoretical sound velocity, the gas composition, pressure and especially the temperature must match the values on the measuring point during protocol recording.
Differences between sound velocities in the paths on multipath systems	≤ ± 0.5 m/s	≥ ± 2 m/s	The values are only valid for flowing gas. When no gas or low flow rates are present, temperature stratifications occur which, especially in a hot measuring cell, can cause differences in the sound velocities > 10 m/s in the individual paths.

Deviations from the standard values specified in the Table can be an indication of malfunctions. Apart from the routine checks, it is also possible to create a data backup (→ p. 50, §4.2.5) and send it to SICK for evaluation.

5.2.3 Checking the measuring tube for deposits

Heavy soot deposits can occur in the measuring cell and on the ultrasonic probes during exhaust gas measurements on diesel engines. Repeated path failures are an indication. To avoid measurement problems, we recommend, under consideration of the respective usage duration and check cycle intensity, checking the FLOWSIC150 CARFLOW for soot deposits and to clean the active measuring path, measuring tube and ultrasonic probes when necessary.

Steps required

1 Disconnect the FLOWSIC150 CARFLOW from the exhaust gas line.

> **!** ***NOTICE:***
> ► Always observe and follow the required safety measures!

2 Switch the internal heating off.

3 Wait until the measuring tube has cooled down to the ambient temperature.

4 Clean the measuring tube and ultrasonic probes carefully with a soft brush or similar.

> **!** ***NOTICE:***
> ► Do not use hard brushes to avoid damaging the probe surfaces!
> ► Do not damage the sheathed thermoelements in the measuring tube during cleaning!

5.2.4 Further maintenance work

Only have further maintenance work (including removing and fitting the ultrasonic probes) carried out by trained personnel. These tasks are described in the Service Manual for the FLOWSIC150 CARFLOW.

FLOWSIC150 CARFLOW

6 Specifications

Technical Data
Dimensions
Part Nos.
Accessories

6.1 **Technical Data**

Measured data	
Measured variables	Gas flow rate, volume flow (act.), volume flow (std.), exhaust gas temperature, exhaust gas pressure (absolute), sound velocity
Measuring range (volume flow act.)	– 2.5 inch variant 0 ... 180 l/s (0 ... 650 m^3/h; 0 ... 380 ft^3/min)
	– 4 inch variant 0 ... 500 l/s (0 ... 1800 m^3/h; 0 ... 1060 ft^3/min)
Measuring principle	Ultrasonic transit time method, 4 ultrasonic measuring paths, flow-calibrated
Typical measuring precision	± 0.5% of measured value between 0.05 Q_{max} ... Q_{max}
Temperature measurement, internal	2x sheathed thermoelements, type K (NiCr-Ni), weighted average
Pressure measurement	Absolute pressure sensor, measuring range 700 ... 1300 mbar(a)

Displays	
4 line LC-Display,	Measured variables, diagnostic values, warning and malfunction messages, splash-proof
Status LED	Operation, warning, malfunction

Installation	
Exhaust gas temperature	Max. 600 °C
Ambient conditions	Ambient temperature –10 ... 40 °C, air humidity 5 ... 95%
Connection variants for inlet and outlet	Outer thread, type G in accordance with ISO 228/1 (e.g. for Kamlok quick coupling) Quick couplings (Kamlok, E-Line, Marman, Tri-Clamp)
Pressure loss (device)	< 12 mbar (depending on process connection used)

Measured value output and interfaces	
Analog outputs	2x analog output 0/2/4 ... 20 mA, 10 Hz, for volume flow (std.) and exhaust gas pressure, load 760 Ohm, scaling freely configurable
AK interface	RS232 via 9-pole D-Sub plug or Ethernet cable, 1 Hz
Service interface	RS232 via USB, type B or Ethernet cable for configuration and diagnosis using SOPAS ET

Connections for external devices	
Heater line connections	2x, controlled, for PT100 or thermoelement, type (NiCr-Ni), connection via 7-pole plug
Temperature sensors	1x PT100 or thermoelement, type K (NiCr-Ni)

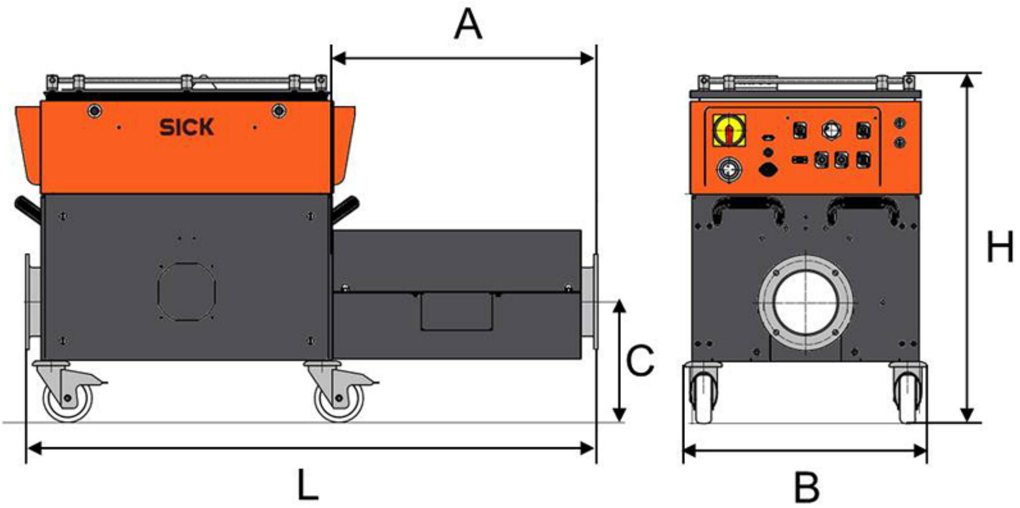
Electrical connection	
Voltage supply	90 ... .125 V AC; 50/60 Hz or 190 ... .250 V AC; 50/60 Hz
Power input	1700 W (without external heater lines)
Max. output of external heater lines	– 190 ... 250 V AC: 1600 W
	– 90 ... 125 V AC: 1000 W

Dimensions, weight	
Weight	– 2.5 inch variant: Approx. 90 kg
	– 4 inch variant: Approx. 140 kg
Dimensions in mm (L x W x H)	– 2.5 inch variant 1060 x 495 x 715
	– 4 inch variant 1180 x 495 x 715

6.2 Dimensions, Part Nos.

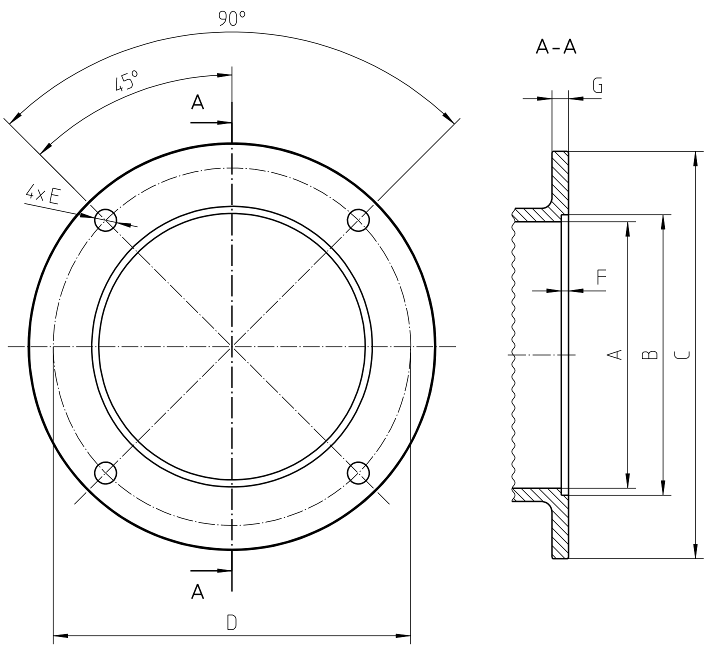
All dimensions in mm.

Fig. 45 Dimensions



FLOWSIC150 CARFLOW type	Part No.	Connection	A	B	C	L	H
FL150_2 24CH6SHFS3S0 Connection dimension 2.5 inches Measuring range 0 ... 180 l/s	1057598	2.5 inches	425	495	130	1060	715
FL150_2 44CH6SHFS3S0 Connection dimension 4 inches Measuring range 0 ... 500 l/s	1057599	4.0 inches	550	495	250	1180	715

Fig. 46 Flange dimensions



Type	Part No.	Connection	A	B	C	D	E	F	G
FL150_2	1057598	2.5 inches	Ø73.2	Ø80	Ø130	Ø108	Ø10.5	2.5	8
FL150_2	1057599	4.0 inches	Ø128.2	Ø135	Ø196	Ø172	Ø10.5	3.5	8

6.3 Accessories

Complete devices			
1 057 599	ZZ	FLOWSIC150 CARFLOW ultrasonic exhaust gas flow meter Rated width 4 inches, gas temperature max. 600 °C, operating volume flow 0... 500 l/s, ambient temperature: –10 ... 40 °C, 4-path measurement, typical measuring precision 0.5% for MV from 0.05 Qmax ... Qmax, assembled completely on roller frame, prepared for process connection	
1 057 598	ZZ	FLOWSIC150 CARFLOW ultrasonic exhaust gas flow meter Rated width 2.5 inches, gas temperature max. 600 °C, operating volume flow 0... 180 l/s, ambient temperature: –10 ... 40 °C, 4-path measurement, typical measuring precision 0.5% for MV from 0.05 Qmax ... Qmax, assembled completely on roller frame, prepared for process connection	
FL150093		Flow calibration with customer-specific inflow conditions	

Process connections [1]			
2 063 441		Connection piece, E-Line, 4 inches, male, with transition piece, welded, process-side without seal, material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 442		Connection piece, E-Line, 4 inches, female, with transition piece, welded, process-side without seal, material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 439		Connection piece, E-Line, 2.5 inches, male, with transition piece, welded, process-side without seal, material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 440		Connection piece, E-Line, 2.5 inches, female, with transition piece, welded, process-side without seal, material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 443		Connection piece, Marman, 4 inches, with transition piece, welded, material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 444		Connection piece, Marman, 2.5 inches, with transition piece, welded, material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 445		Connection piece, Tri-Clamp, 4 inches, with transition piece, welded, process-side without seal, material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 446		Connection piece, Tri-Clamp, 2.5 inches, with transition piece, welded, process-side without seal, material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 447		Connection piece, welded flange neck, 4 inches material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 448		Connection piece, welded flange neck, 2.5 inches material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 449		Connection piece, with outer thread, 4 inches material stainless steel, for FLOWSIC150 CARFLOW	2 pcs
2 063 450		Connection piece, with outer thread, 2.5 inches material stainless steel, for FLOWSIC150 CARFLOW	2 pcs

[1] Process-side without seal. Customer must provide seals suitable for the usage temperature

Sample gas line			
2063451		Gas line, heatable, up to 250 °C, stainless steel corrugated hose, length 1 m, heating output 200 W, temperature sensor Pt100 Rated width 2.5 inches (DN65), prepared for process connection for FLOWSIC150 CARFLOW	
2063452		Gas line, heatable, up to 250 °C, stainless steel corrugated hose, length 1 m, heating output 400 W, temperature sensor Pt100 Rated width 4 inches (DN65), prepared for process connection for FLOWSIC150 CARFLOW	
2063454		Gas line, not heatable, up to 600 °C, stainless steel corrugated hose, length 1 m, rated width 2.5 inches (DIN65), prepared for process connection for FLOWSIC150 CARFLOW	
2063453		Gas line, not heatable, up to 600 °C, stainless steel corrugated hose, length 1 m, rated width 4 inches (DIN100), prepared for process connection for FLOWSIC150 CARFLOW	

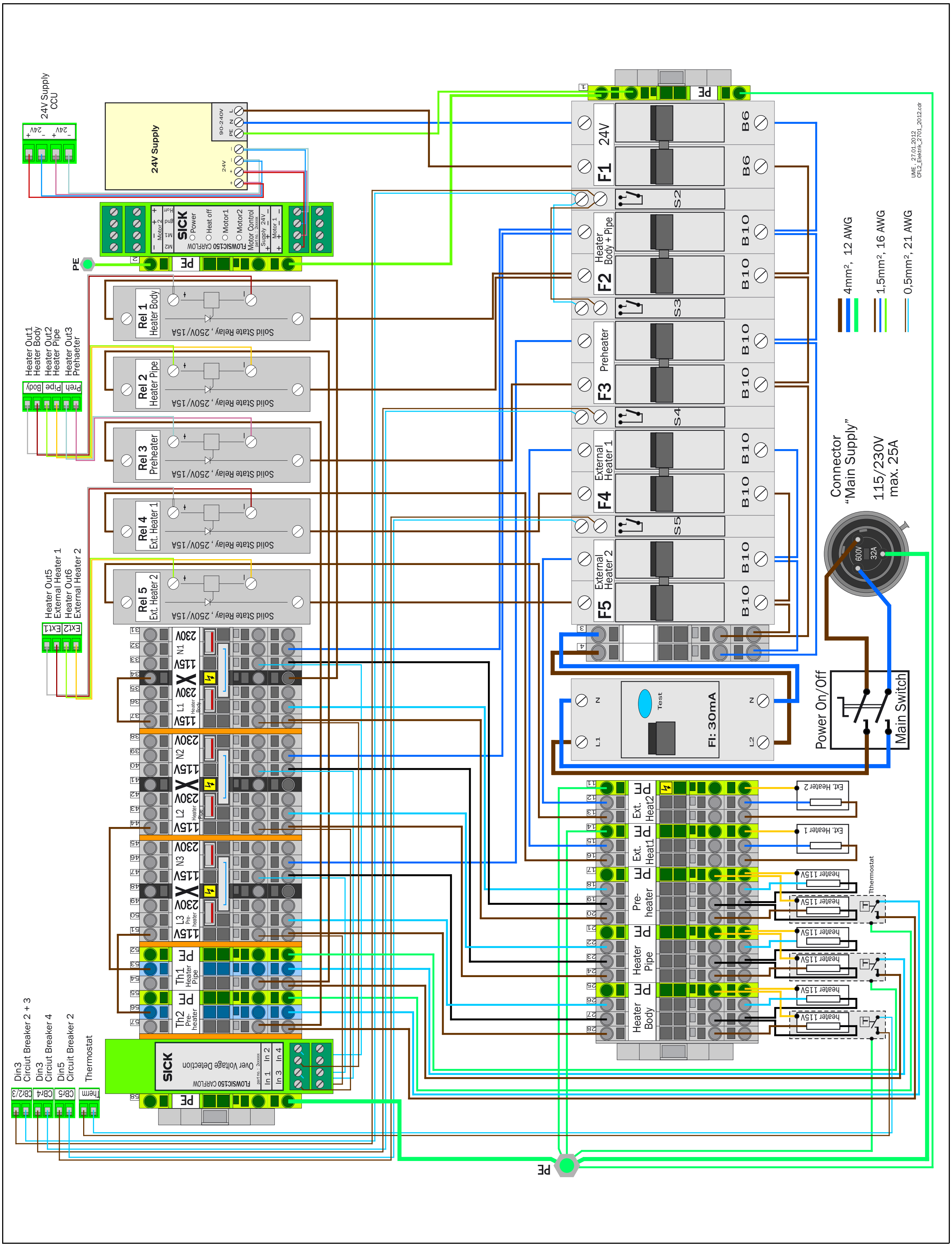
Cables and plugs			
FL15099		Mains cable, length 3 m, with plug, type B, NEMA 5-15, 3-pole for the US market	
FL15098		Mains cable, length 3 m, with shockproof plug, 2-pole for German market	
7040012		Interface cable, serial RS232, length 2 m	
FL15097		Interface cable, Ethernet, length 3 m	
6033633		Interface cable, USB, length 3 m	
6049036		Binder plug, series 693, 6-pole + PE for heating connection	
6033520		Binder plug, series 713, 4-pole, for connection of external PT 100 sensors	

FLOWSIC150 CARFLOW

7 Annex

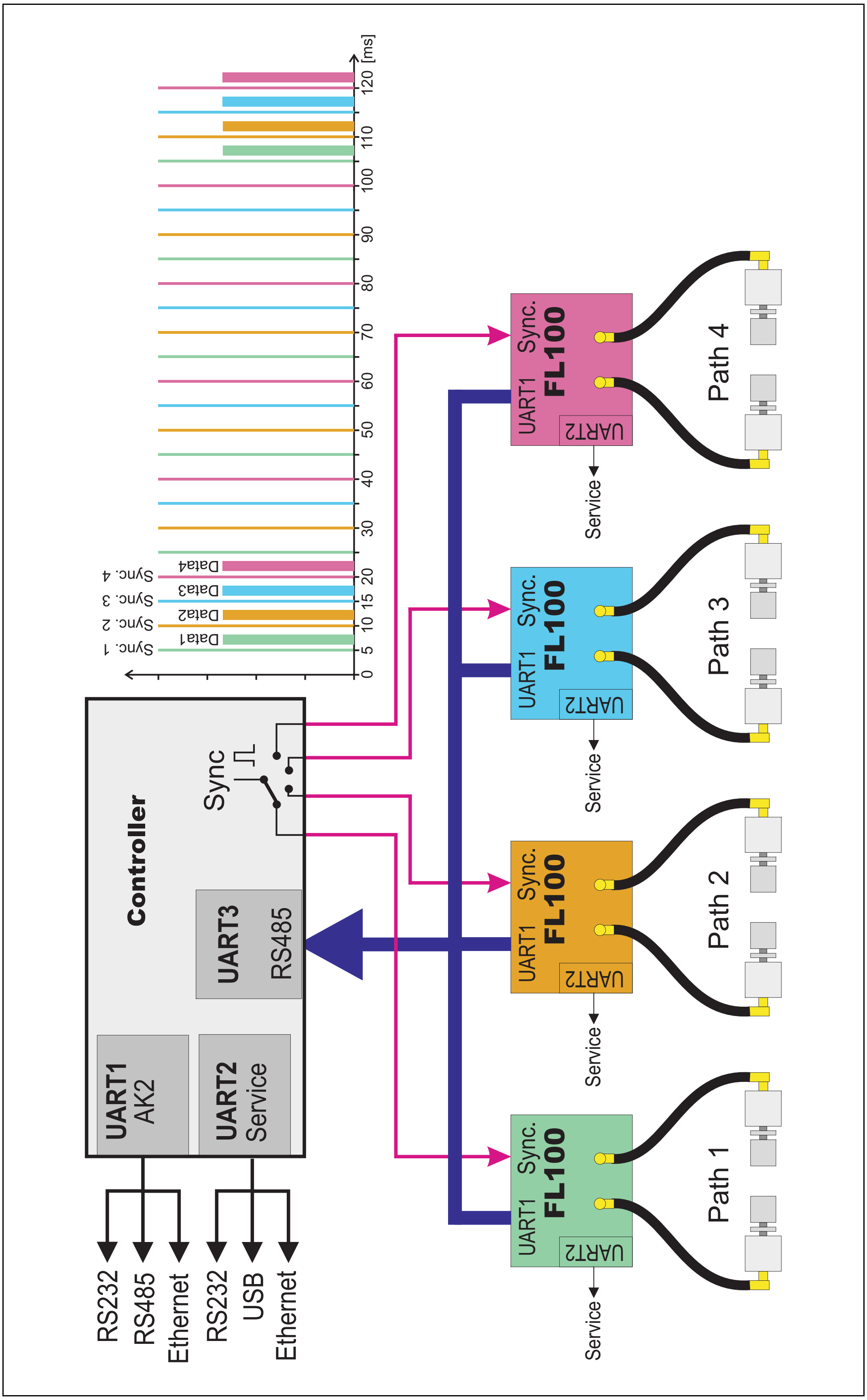
Wiring diagrams
Connection diagrams
Error and warning messages

7.1 Wiring diagram



Subject to change without notice

7.2 Functionality of the electronics



7.3 Overview of error and warning messages

2		1	2		1
	a			a	Reduced accuracy Path failed Genauigkeit reduziert Pfadausfall
	b	Overvoltage Preheater incorrect voltage set Überspannung Preh. Falsche Spannung gesetzt	Ext. Temp. 3 Ext.Temp.3 > 660°F Ext. Temp. 3 Ext.Temp.3 > 350°C	quit b	High Noise Level SNR of any Path to low Störgeräusch hoch SNR von einem Pfad zu klein
	c	Overvoltage Body/Pipe incorrect voltage set Überspannung Body/Pipe Falsche Spannung gesetzt	Ext. Temp. 2 Temp > 660°F or heatup phase Ext. Temp. 2 T > 350°C oder Aufheizphase	quit c	AGC Limit AGC diff. between Paths too high AGC zu hoch Verstärkungsdiff zw. Pfaden > GW
	d		Ext. Temp. 1 Temp > 660°F or heatup phase Ext. Temp. 1 T > 350°C oder Aufheizphase	quit d	AGC Difference AGC (Gain) of a Path to high AGC zu hoch Verstärkung eines Pfades zu hoch
	e		Temp. Prehaeter Temp > 660°F or heatup phase Temp. Prehaeter T > 350°C oder Aufheizphase	e	
Not signal found Ultrasonic signal not found Kein Signal gefunden Kein Ultraschallsignal gefunden	f		T_Sense too high Temp. > 430°F T_Sense zu hoch Temp. Sensor > 220°C	f	
Noise to high SNR too low Störgeräusch zu hoch SNR zu gering	g		Temp. Pipe Temp > 660°F or heatup phase Temp. Pipe T > 350°C oder Aufheizphase	g	Blower failed Gebläaseausfall
Not sensor found Collective message Kein Sensor Sammelmeldung	h		Temp. Body Temp > 390°F or heatup phase Temp. Body T > 200°C oder Aufheizphase	h quit	Circuit Breaker F5 External Heater 2 failed Sicherungsautomat F5 Ausfall Externer Heizer 2
	i		Temp. Gas 2 Temp > 1100°F Temp. Gas 2 Temp. > 600°C	i quit	Circuit Breaker F4 External Heater 1 failed Sicherungsautomat F4 Ausfall Externer Heizer 1
	j		Temp. Gas In Temp > 1100°F Temp. Gas In Temp. > 600°C	j	Circuit Breaker F2/F3 Internal heaters failed Sicherungsautomat F5 Ausfall interne Heizer
	k		Temp. Gas 1 Temp > 1100°F Temp. Gas 1 Temp. > 600°C	k	
	l		Heat up phase Temp. of anny Heater out of.R. Aufheizphase Solltemp. Heizer nicht erreicht	l	Voltage 24V too low Voltage < 22V Spannung 24V zu gering Spannung < 22V
Flash error Flash Fehler	m		Power saving mode Setpoint Heater is low Stromsparmodus Sollwert Heizer niedrig	m	T_Ref2 > 140°F Temperature Cabinet too high T_Ref2 > 60°C Temepratur im Gehäuse zu hoch
CRC EEPROM CRC EEPROM	n			n	T_Ref1 > 140°F Temperature Cabinet too high T_Ref1 > 60°C Temepratur im Gehäuse zu hoch
EEPROM HW EEPROM HW	o		System Test activ Sytem Test by SOPAS Systemtest aktiviert Systemtest mit SOPAS gesetzt	o	Avg. T_Ref1/2 >140°F average too high MW T_Ref1/2 > 60°C Mittelwert im Gehäuse zu hoch
CRC Code Error Problem CRC Code CRC Code Fehler Problem CRC Code	p		Factory setting activ Default parameters loaded Werkseinstellung Standardparameter geladen	p	Voltage Accu too low Accu < 10,5V Spannung Akku zu niedrig Akku < 10,5V

Subject to change without notice

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