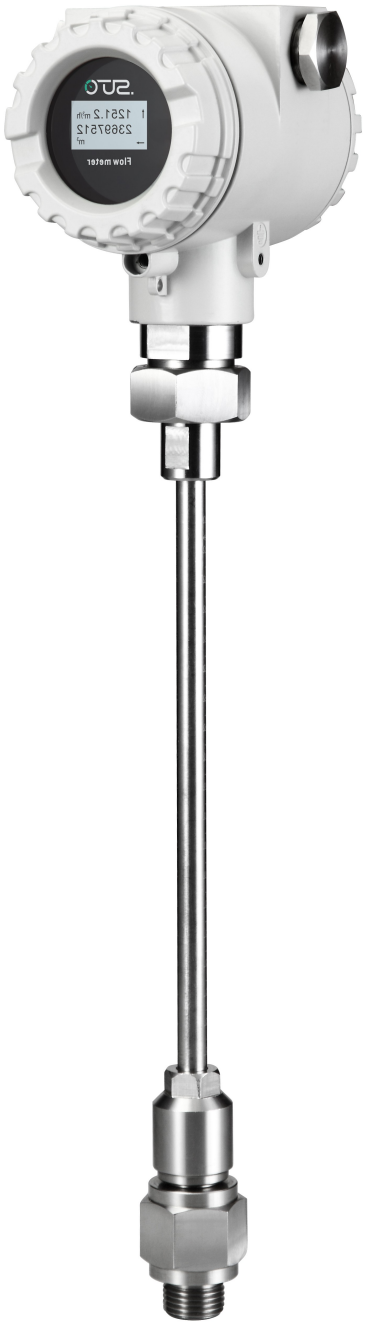
English

Instruction and operation manual



S450

Thermal mass flow sensor

Dear Customer,

Thank you for choosing our product.

Please read this manual in full before starting up the device and carefully observe the instructions stated. The manufacturer cannot be held liable for any damage which occurs as a result of non-observance or non-compliance with this manual.

Should the device be tampered with in any manner other than a procedure which is described and specified in the manual, the warranty is canceled and the manufacturer is exempt from liability.

The device is destined exclusively for the described application.

SUTO offers no guarantee for the suitability for any other purpose. SUTO is also not liable for consequential damage resulting from the delivery, capability or use of this device.

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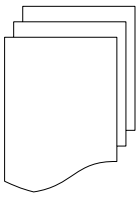
1. Safety instructions



Please check if this instruction manual accords to the product type.

Please observe all notes and instructions indicated in this manual. It contains essential information which must be observed before and during installation, operation and maintenance. Therefore this instruction manual must be read carefully by the technician as well as by the responsible user / qualified personnel.

This instruction manual must be available at the operation site of the flow sensor at any time. In case of any obscurities or questions, regarding this manual or the product, please contact the manufacturer.

WARNING!

Compressed air!

Any contact with quickly escaping air or bursting parts of the compressed air system can lead to serious injuries or even death!

- Do not exceed the maximum permitted pressure range (see sensors label).
- Only use pressure tight installation material.
- Avoid that persons get hit escaping air or bursting parts of the instrument.
- The system must be pressureless during maintenance work.

WARNING!

Voltage used for supply!

Any contact with energized parts of the product, may lead to an electrical shock which can lead to serious injuries or even death!

- Consider all regulations for electrical installations.
- The system must be disconnected from any power supply during maintenance work.
- Any electrical work on the system is only allowed by authorized qualified personal.

ATTENTION!

Permitted operating parameters!

Observe the permitted operating parameters, any operation exceeding this parameters can lead to malfunctions and may lead to damage on the instrument or the system.

- Do not exceed the permitted operating parameters.
- Make sure the product is operated in its permitted limitations.
- Do not exceed or undercut the permitted storage and operation temperature and pressure.
- The product should be maintained and calibrated frequently, at least annually.

General safety instructions

- It is allowed to use the product in explosive areas. Please contact the manufacturer.
- Please observe the national regulations before/during installation and operation.

Remarks

- It is not allowed to disassemble the product.
- Always use spanner to mount the product properly.

ATTENTION!

Measurement values can be affected by malfunction!

The product must be installed properly and frequently maintained, otherwise it may lead to wrong measurement values, which can lead to wrong results.

- Always observe the direction of the flow when installing the sensor. The direction is indicated on the housing.
- Do not exceed the maximum operation temperature at the sensors tip.
- Avoid condensation on the sensor element as this will affect the accuracy enormously.

Storage and transportation

- Make sure that the transportation temperature of the sensor without display is between -30 ... +70°C and with display between -10 ... +60°C.
- For transportation it is recommended to use the packaging which comes with the sensor.
- Please make sure that the storage temperature of the sensor is between -10 ... +50°C.
- Avoid direct UV and solar radiation during storage.
- For the storage the humidity must be <90% with no condensation.

2. Application

The S450 is a flow sensor which is designed to measure the consumption of compressed air and gases. The S450 works based on the principle of thermal mass flow. Its permissible operating parameters can be found in the technical data section.

The S450 can measure the following values:

- Velocity of the compressed air or gas.
- Volume flow of the compressed air or gas.
- Total consumption of the compressed air or gas.

The default factory settings are: Velocity in m/s, Volume flow in m^3/h and Total Consumption in m^3. Other units can be programmed by the optional display or the service kit.

The S450 flow sensor is developed to be used in explosive areas.

The S450 flow sensor is mainly used in compressed air systems and processes gases measurement in industrial environment.

3. Features

- Direct measurement of mass flow and standard flow without the need of pressure and temperature compensation.
- Insertion type for bigger pipes.
- No moving parts, no clogging.
- All Sensor parts which come into contact with the measurement medium are made of stainless steel 316L.
- Robust metal enclosure is suitable for outdoor applications in harsh environments.
- Wireless bluetooth interface for connecting on site.
- Optional display directly on the sensor, showing flow rate, consumption, medium temperature and diagnostic result.

4. Technical data

4.1 General

CE	
Measuring range	0.4 ... 92.7 sm/s (standard range calibration) 0.8 ... 185 sm/s (max range calibration) 1.0 … 224 sm/s (high speed calibration) (See Appendix A for flow measurement ranges in different tube diameters) * sm/s: standard meter per second
Parameters	Standard unit flow: m^3/h Available units: m^3/min, l/min, l/s, cfm, kg/h, kg/min, kg/s Standard velocity unit: m/s
Reference conditions	ISO1217, 20 °C, 1000 mbar (Standard-Unit) DIN1343, 0 °C, 1013.25 mbar (Norm-Unit)
Principle of measurement	Thermal mass flow
Sensor	Resistive sensor
Measured medium	Air, gas (non corrosive gas)
Operating temperature	-40 ... +150°C (Medium temperature) -40 ... +65°C (Ambient temperature)
Humidity of the meas. medium	< 90%, no condensation
Operating pressure	0 ... 4.0 MPa (>1.6 MPa needs the installation device.)
Housing material	Al alloy
Material of the probe tube, sensor head and screwing	Stainless steel 1.4404 (SUS 316L)
Protection class	IP67
Dimensions	See dimensional drawing on the next page
Display (optional)	128 x 64
Tube diameter	From DN15 (1/2”) upwards

Screwing thread	G1/2” (ISO 228/1)
Weight	1.75 kg (220 mm version)

4.2 Electrical data

Power supply	16 ... 30 VDC, 5 W

4.3 Output-signals

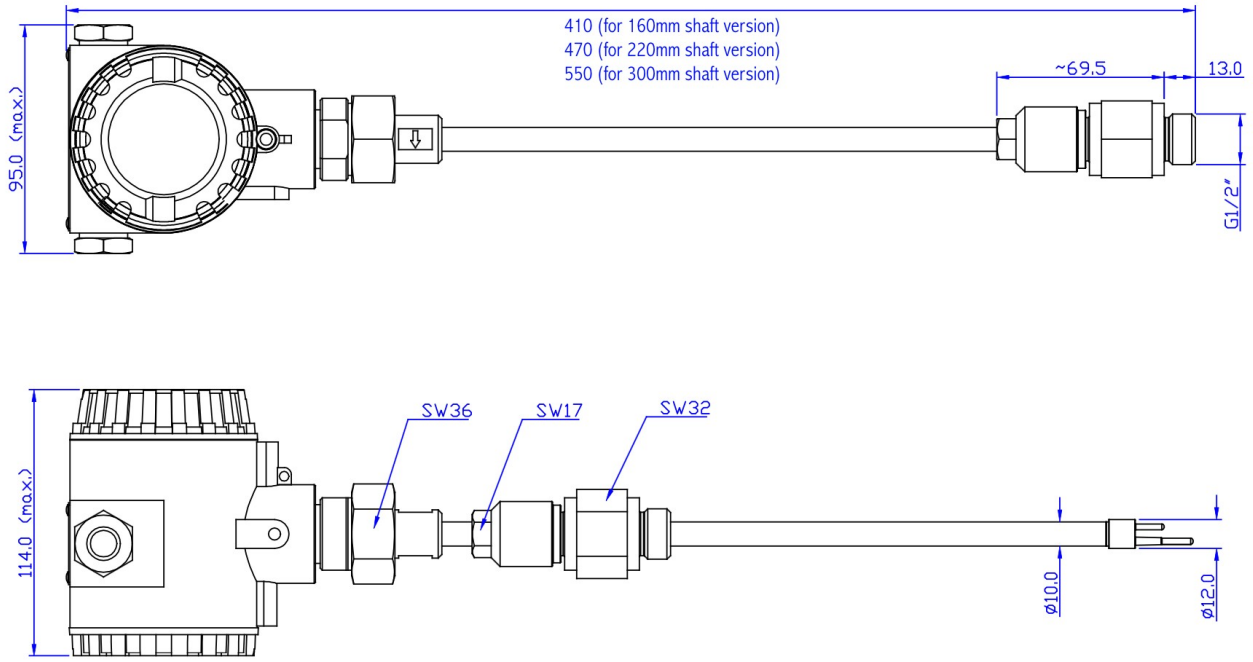
Analog output	See chapter 9.1
Pulse output	See chapter 9.2
HART output	See chapter 9.3
Modbus output	See chapter 9.4
M-Bus output	See chapter 9.5

4.4 Accuracy

Accuracy*	±(1.5% of reading + 0.3% full scale)
Repeatability	0.25% of reading
Stated accuracy at	Ambient/process temperature 23°C±3°C Ambient/process humidity <90% Process pressure at 0.6 MPa

* The specified accuracy is valid only within the minimum and maximum flow rates that are stated in Appendix A.1.

5. Dimensional drawing



6. Determination of the installation point

To maintain the accuracy stated in the technical data, the sensor must be inserted in the centre of a straight pipe section with unhindered flow characteristics.
Unhindered flow characteristics are achieved if the sections in front of the sensor (inlet) and after the sensor (outlet) are sufficiently long, absolutely straight and free of obstructions such as edges, seams, curves etc..
Please consider that enough space exists at your site for an adequate installation as described in this manual.

ATTENTION!

Wrong measurement may occur if the sensor is not installed correctly.

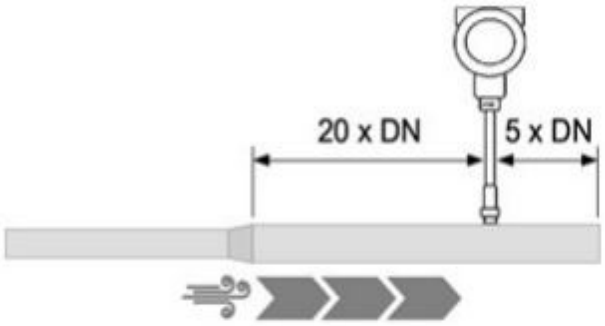
- Pay careful attention to the design of the inlet and outlet sections. Obstructions can cause counter-flow turbulence as well as turbulence in the direction of the flow.
- It is strongly recommend not to install S450 permanently in wet environment which exists usually right after a compressor outlet.

7. Inlet and outlet sections

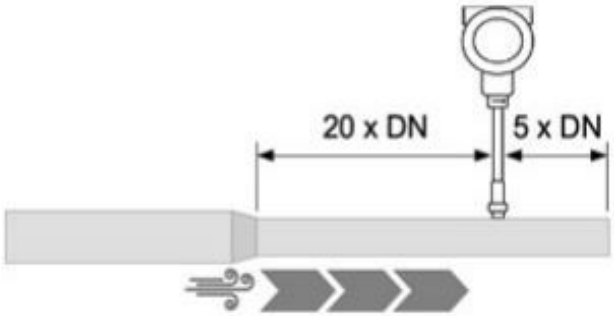
The following figures show the necessary equalizing sections in relation to existing obstructions. If it is not possible to observe the indicated equalizing sections, deviations in measuring results have to be expected.

Note: If there is any combination of below situations, the longest straight inlet section must be maintained.

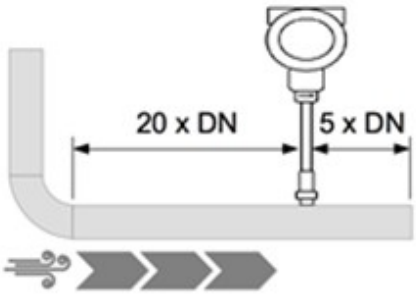
- Expansion



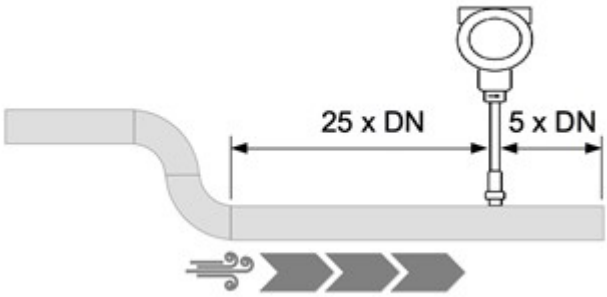
- Reduction



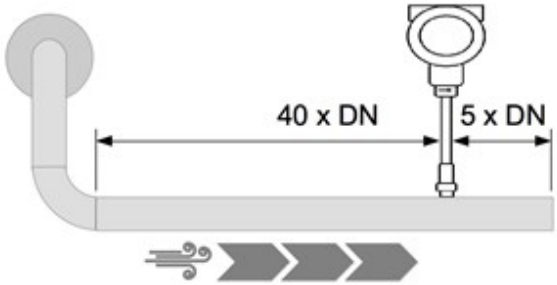
- 90° Bend



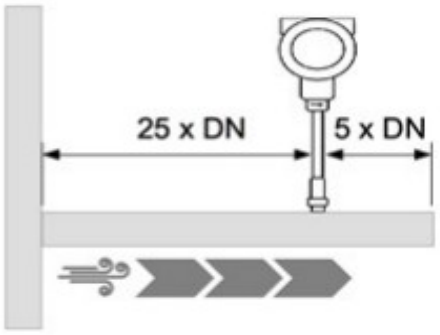
- 2×90° Bend



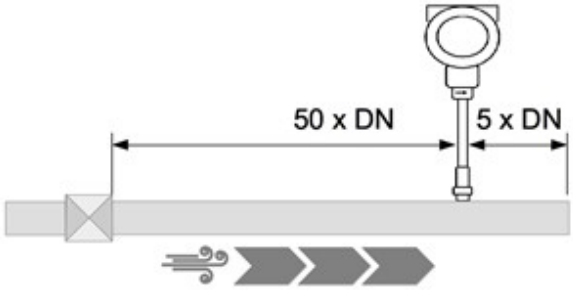
- 3 dimensional Bend



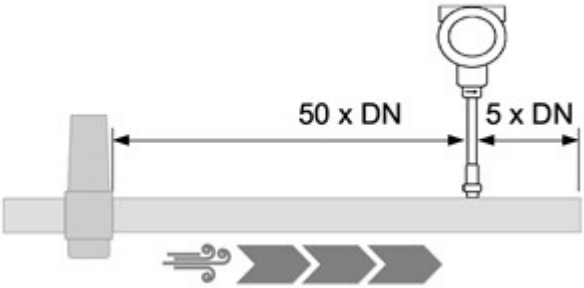
- T-piece



- Shut-off valve



- Filter or similar (unknown objects)



8. Installation

Before installing the sensor, please make sure that all components listed below are included in your package.

Qty	Description	Item No.
1	Sensor	S695 0450
1	Sealing ring	No P/N
1	Alignment key	No P/N
1	G ½” ball valve	A554 0008
1	Bluetooth dongle	No P/N
1	Instruction manual	No P/N
1	Calibration certificate	No P/N

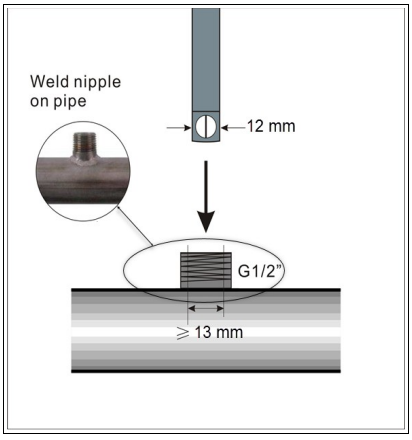
ATTENTION!

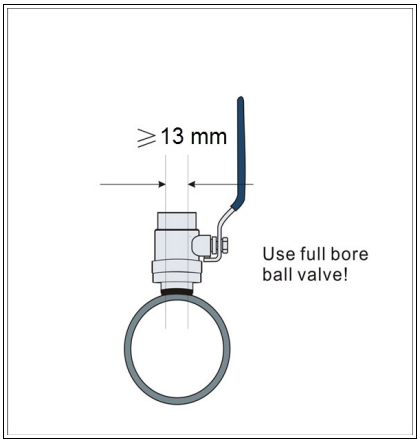
Do not insert the sensor with strong force. It may happen that the sensor tip strikes on the pipe inner wall and the sensor gets damaged!

8.1 Installation requirements

To install the sensor a ball valve or a nozzle is needed.

- The inner thread must be G 1/2”.
- The diameter of the hole must be ≥ 13mm. Otherwise the shaft can not be inserted in.



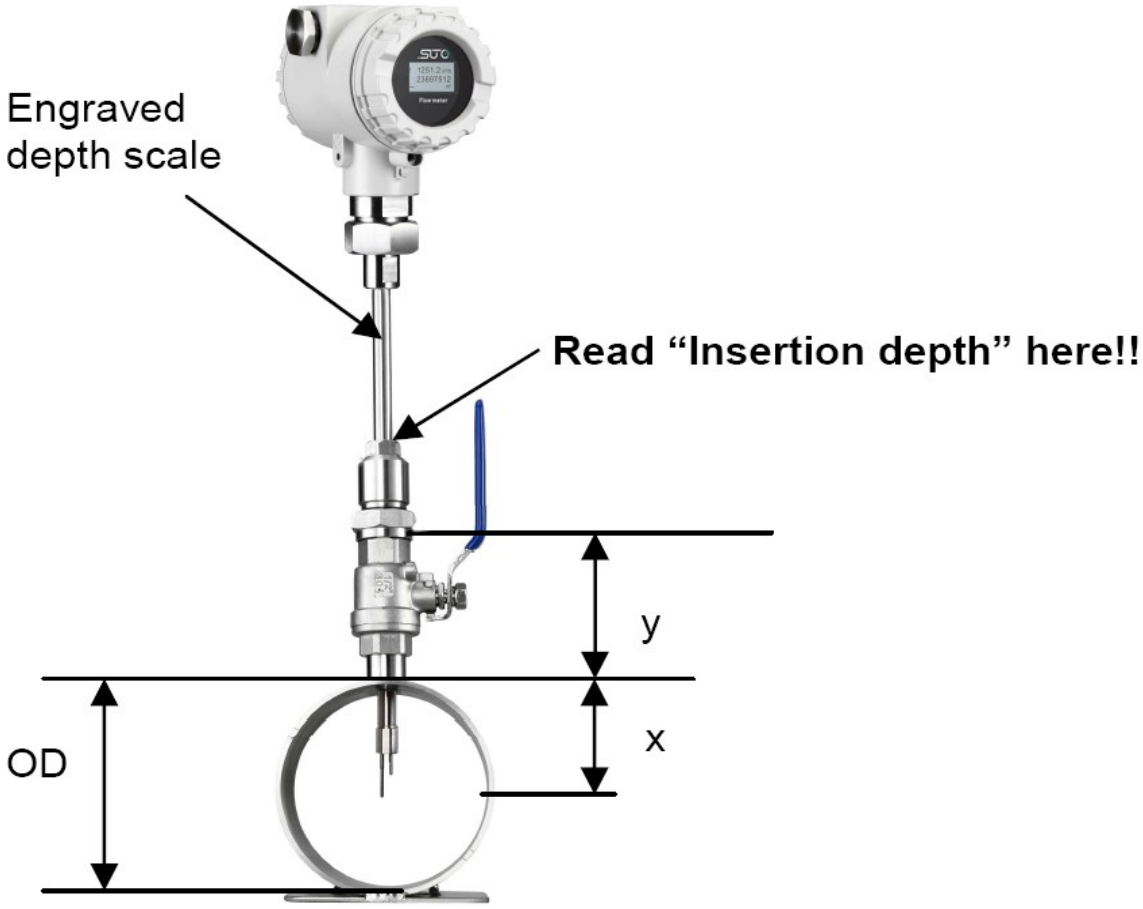


8.2 Installation procedure

The following steps explain the procedure of an appropriate installation.

Determination of the insertion depth of the sensor

The sensor tip must be placed in the center of the pipe. For this the probe shaft has a scale. To determine the right position please calculate the insertion depth as described below.



$$\textbf{Insertion depth} = x + y$$

$$x = \frac{OD}{2}\,;\, OD = \text{Outer diameter of pipe}$$

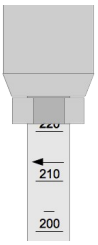
Example for a 2” pipe and an 87 mm ball valve:

$$y = 87\text{ mm}\,;\, OD = 60.3\text{ mm}$$

$$x = \frac{OD}{2} = \frac{60.3\text{ mm}}{2} = 30.15\text{ mm}$$

$$\textbf{Insertion depth} = 30.15\text{ mm} + 87\text{ mm} = 117.15\text{ mm}$$

Installation of the sensor



First please observe the flow direction indicated on the shaft. It must match the flow direction of the compressed air or gas.

1. Close the ball valve.

2. The sensor tip must be be completely covered by the connection head (see photo on the left).

3. Underlay the “O-shaped” sealing ring to the groove in the connection head.

4. Screw the connection head tightly to the ball valve

5. Align the flow sensor with the flow direction by observing the flow direction indicated on the shaft.

6. Open the ball valve and tighten the clamp sleeve manually.

7. Move the flow sensor slightly to the determined insertion depth by means of the scale.

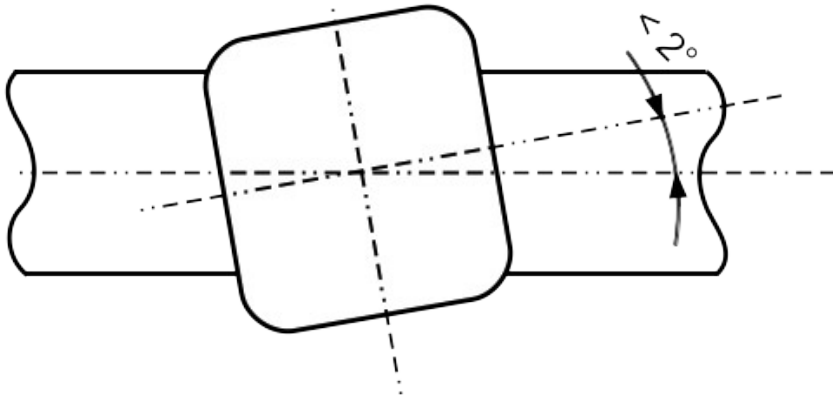
8. Tighten the clamp sleeve at the connection head so that the flow sensor can no longer be moved by the pressure in the pipe. However it should be possible to move the sensor shaft by hand.

9. With the aid of the alignment key, make sure that the actual flow direction is same as the arrow shows (the angle deviation should not be larger than ± 2° to the perfect position, please see picture on the next page).

10. Tighten the clamp sleeve with the clamping torque 20 … 30 Nm.

11. Check the installation depth again because sometimes the shaft is moved from its original position by the compressed air.

Maximum angle deviation of a proper installation:



Removal of the sensor

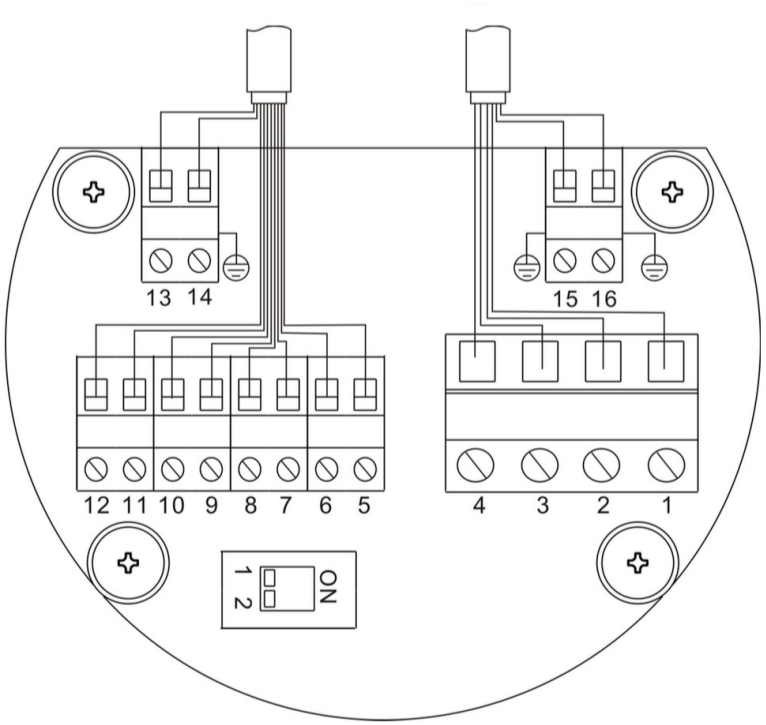
1. Hold the flow sensor firmly.
2. Release the clamp sleeve from the connection head.
3. Pull out the shaft slowly until the value “10” can be read at the scale.
4. Close the ball valve.
5. Release the connection head and unscrew the flow sensor.

8.3 Electrical connection

When installing the cables please consider following point:

- Keep the stripped and twisted length of cable shield as short as possible.
- Screen and ground the signal lines.
- Unused cable entries must be closed with closers.
- Cable outer diameter should be between 6 and 8 mm.
- Single wire cross-section should be between 0.25 ... 0.75 mm^2.
- The thread size for the cable glands is M20 / 1.5.

Connection diagram



Pin	Pulse and analog	Modbus	M-Bus	HART
1	GND_{SDI}	GND_{SDI}	GND_{SDI}	GND_{SDI}
2	$+V_B$	$+V_B$	$+V_B$	$+V_B$
3	$-V_B$	$-V_B$	$-V_B$	$-V_B$
4	SDI	SDI	SDI	SDI
5	D1	D1	D1	D1
6	D2	D2	D2	D2

Pin	Pulse and analog	Modbus	M-Bus	HART
7	P1	P1	P1	
8	P2	P2	P2	
9	$-I_1$	$-I_1$	$-I_1$	$-I_1$ / -HART
10	$+I_1$	$+I_1$	$+I_1$	$+I_1$ / +HART
11	$-I_2$	+D	M1	
12	$+I_2$	-D	M2	
13		GND_M		
14	Earth	Earth	Earth	Earth
15	Earth	Earth	Earth	Earth
16	Earth	Earth	Earth	Earth

Legend to pin assignment

SDI = Digital signal (internal use)

GND_{SDI} = Ground for SDI

$+V_B$ = Positive supply voltage

$-V_B$ = Negative supply voltage

$+I_1$ = Positive signal output (analog 1)

$-I_1$ = Negative signal output (analog 1)

$+I_2$ = Positive signal output (analog 2)

$-I_2$ = Negative signal output (analog 2)

P1 = Pulse output 1

P2 = Pulse output 2

D1 = Direction input D1 (flow switch)

D2 = Direction input D2 (flow switch)

+D = Modbus data+

-D = Modbus data -

M1 = M-Bus 1

M2 = M-Bus 2

9. Signal outputs

9.1 Analog output

The S450 in the standard configuration comes with 2 analog outputs and 1 pulse output. All signals are electrically isolated. The analog output can be used as an active output (current is sourced through the positive connection pin) or passive output. In the passive configuration a current signal is modulated into the external signal voltage.

Active	:	4 to 20mA, RL < 400 Ω
Passive	:	4 to 20mA, supply voltage 18 ... 30 VDC, RL < 500 Ω
For HART	:	RL ≥ 250 Ω
Uncertainly	:	< 0.3 % of reading
Resolution	:	0.005 mA

9.2 Pulse output

No switch, no polarity required, galv. Isolate
Max. rating: 30 VDC, 200 mA
Pulse width: 10 ... 100 msec (depending on flow rate)

The maximum number of pulse per second is limited to 45 pulse per second. As a result depending on the flow rate and the selected consumption unit the maximum flow rate is limited to the values in the table below.

Unit	Max flow		
Pulse / consumption unit	1/1	1/10	1/100
m^3/h	162,000	1,620,000	16,200,000
m^3/min	2,700	27,000	270,000
l/min	2,700	27,000	270,000
cfm	2,700	27,000	270,000
Kg/h	162,000	1,620,000	16,200,000
Kg/min	2,700	27,000	270,000
Kg/s	45	450	4,500
	Default	To be configured by service software	

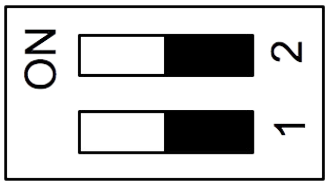
9.3 HART output

The HART signal is modulated on analog output 1. In case S450 is used in a multi drop configuration (more than 1 salve on the 4-20 mA line) the analogue output can not be used anymore.

Device type	: Slave
Polling address	: 1 to 15 Bus address can be set through software
Physical interface	: BELL 202
Protocol version	: V 5.2
Tag	: S450
Tag description	: Flow meter
Frame/parity/Stop	: 8, O, 1

9.4 Modbus output

The version with modbus comes with one analog output and one pulse output. The modbus communication requires to activate terminal resistors at the last device on the bus system. If the S450 is the last device on the bus system, the DIP switches on the connector board should be set to “ON” position.



Termination resistor network switch

Device type	: Slave
Address range	: 1 to 251 Bus address can be set through software
Physical interface	: RS485 in accordance with EIA/TIA-485 standard
Baudrates	: 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 Baud
Transm. mode	: ASCII, RTU
Response time	: Direct data access = 0 to 255 ms (can be configured)

Remarks

- Modbus communication settings can be changed by the service software.

Index	Channel description	Unit	Resolution	Format	Length	Modbus address
0	Velocity	m/s	0.1	FLOAT	4 Byte	0
1	Flow	m^3/h	0.1	FLOAT	4 Byte	6
2	Consumption	m^3	1	UNIT32	4 Byte	12
3	Reverse consumption	m^3	1	UNIT32	4 Byte	18
4	Medium temperature	°C	0.1	FLOAT	4 Byte	24
5	Ambient temperature	°C	0.1	FLOAT	4 Byte	36

Remarks

- all numbers are in the little-endian format.
- Function code: 03.
- Different units have different resolutions.

9.5 M-Bus output

The version with M-Bus comes with one analog output and one pulse output.

Device type	: Slave
Address range	: 1 to 251 Bus address can be set through software
Physical interface	: Meter-Bus, EN1434-3
Baudrates	: 300, 2400, 9600 Baud
Frame/parity/Stop	: 8, E, 1

10. Configuration

In order to fully utilize the functionality of S450 a configuration is required. There are various parameters which need to be set in the flow meter. The table below gives an overview about the available settings.

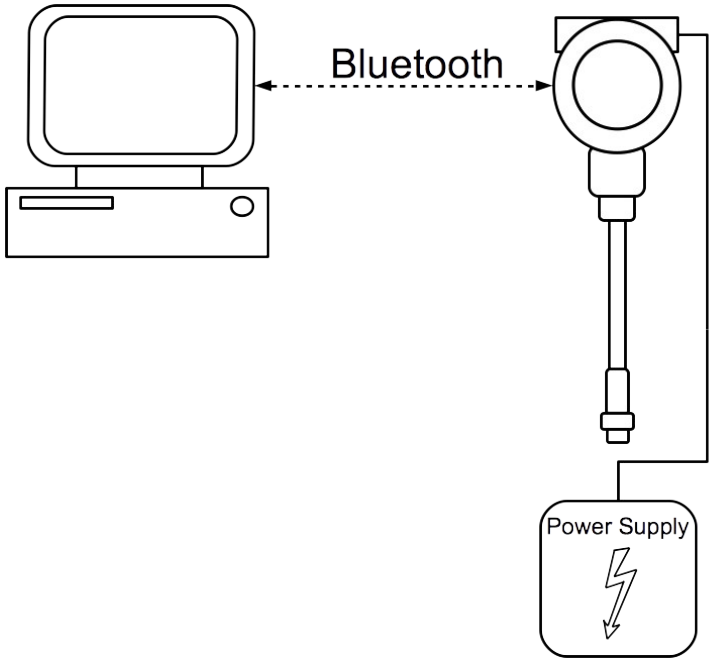
Area	Available settings	Default
Measurement	Tube diameter Flow unit Consumption unit Reference conditions Gas type selection Consumption counter Operation pressure Flow direction	54.0 m^3/h m^3 P_s = 1000 hPA T_s = 20 °C Air 0 m^3 0.6 MPa Standard
Analog output 1	Measurement channel Scaling Active / passive	Flow 4 mA: 0 m^3/h 20 mA: max flow Active
Analog output 2	Measurement channel Scaling Active / passive	Medium Temperature 4 mA: -50 °C 20 mA: 150 °C Active
Pulse output	Pulse / Alarm Pulses per consumption unit	Pulse 1
HART	Fieldbus address Manufacturer ID Device type code	0 255 0
Modbus	Device address Baudrate Framing/parity/Stop bit Transmission mode	1 19200 8, N, 1 RTU
M-Bus	Address Manufacturer code Baudrate	0 END 300

Configuration settings must be done through the service software which is included in the scope of delivery. The service software can be installed on any PC with windows operating system. To communicate with the sensor the PC needs to have a Bluetooth interface, if the PC doesn't have a Bluetooth interface the dongle which comes with the sensor can be used. Alternatively a service kit can be used which is as option available. Through the service kit the S450 is connected to one USB port of the PC.

Bluetooth

Bluetooth provides a convenient way for configuring the sensor. Meet the following conditions to ensure a successful wireless communication:

- S450 needs to be powered up.
- The distance between S450 and PC is not more than 5 meters.
- The PC Bluetooth antenna must point roughly in the direction of the display (front part).
- Follow the instructions in the service software and the help file.



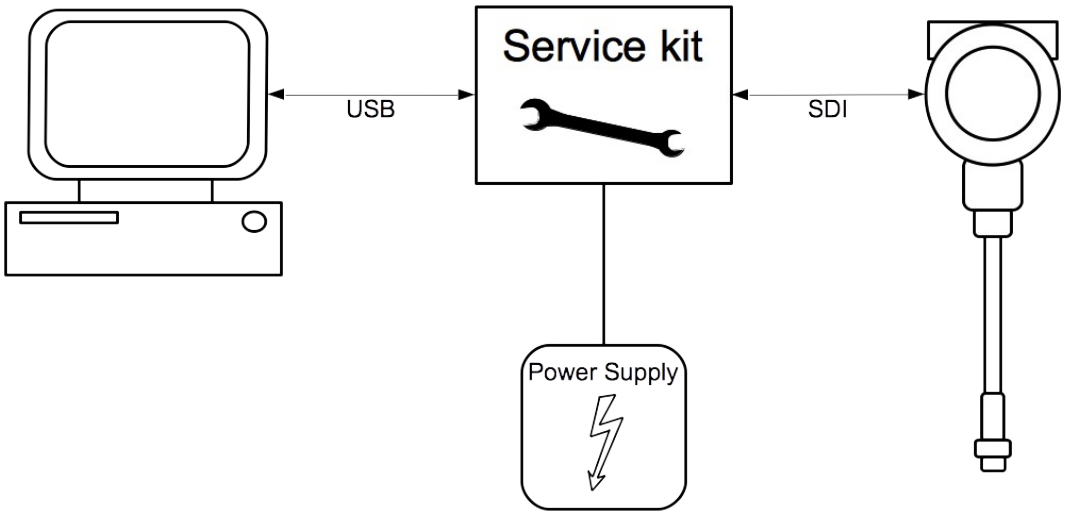
11. Optional extra accessories

11.1 Sensor display

With the Sensor display it is possible to show the values of the velocity, the flow and the consumption, moreover it shows error messages.

11.2 Service kit

The diagram below shows the connection when using the optional service kit. Please ensure that also in this case the power supply of either S450 or of the service kit is connected because the USB port cannot provide enough power supply.



12. Calibration

The sensor is calibrated ex work. The exact calibration date is printed on the certificate which is supplied together with the sensor. The accuracy of the sensor is regulated by the on site conditions, parameters like oil, high humidity or other impurities can affect the calibration and furthermore the accuracy. However we recommend to calibrate the instrument at least once per year. The calibration is excluded from the instruments warranty. For this please contact the manufacturer.

13. Maintenance

To clean the sensor it is recommended to use distilled water or isopropyl alcohol only. If the contamination can not be removed the sensor must be inspected and maintained by the manufacturer.

14. Disposal or waste

Electronic devices are recyclable material and do not belong in the household waste.
The device, the accessories and its packings must be disposed according to your local statutory requirements.
The dispose can also be carried by the manufacturer of the product. Please contact the manufacturer for details.

15. Warranty

SUTO provides a warranty for this product of 24 months covering the material and workmanship under the stated operating conditions from the date of delivery. Please report any findings immediately and within the warranty time. If faults occurring during the warranty time SUTO will repair or replace the defective unit, without charge for labour and material costs but there is a charge for other service such as transport and packing costs.
Excluded from this warranty is:

- Damage caused by:
  - Improper use and non-adherence to the instruction manual.
  - Use of unsuitable accessories.
  - External influences (e.g. damage caused by vibration, damage during transportation, excess heat or moisture).

The warranty is canceled when one of the following situations occurs:

- The user opens the measurement instrument without a direct request written in this instruction manual.
- Repairs or modifications are undertaken by third parties or unauthorized persons.
- The serial number has been changed, damaged or removed.

Other claims, especially those for damage occurring outside the instrument are not included unless responsibility is legally binding.

Warranty repairs do not extend the period of warranty.

ATTENTION!

Batteries have a reduced warranty time of 12 months.

Appendix A – Flow measurement ranges

A.1 Volumetric flow ranges

Stated measuring ranges are valid under following conditions:

- Standard flow in air
- Reference pressure: 1000 hPa
- Reference Temperature: +20°C

Inch	DN	S-Range (m^3/h)	M-Range (m^3/h)	HS-Range (m^3/h)
1/2”	DN15	0.2 ... 45.6	0.4 ... 91.0	0.48 ... 110.16
3/4”	DN20	0.4 ... 89.1	0.9 ... 177.8	1.09 ... 215.3
1”	DN25	0.6 ... 147.7	1.2 ... 294.7	1.82 ... 356.85
1 1/2”	DN40	1.5 ... 366.7	2.9 ... 731.9	4.36 ... 886.18
2”	DN50	2.4 ... 600	4.8 ... 1198	7.26 ... 1450.04
2 1/2”	DN65	4.1 ... 1027	8.2 ... 2049	12.1 ... 2480.44
3”	DN80	5.7 ... 1424	11.4 ... 2841	16.94 ... 3441.91
4”	DN100	8.7 ... 2183	17.4 ... 4357	24.2 ... 5275.71
5”	DN125	20 ... 3419.6	38 ... 6824.4	45.9 ... 8263.09
6”	DN150	20 ... 4930	39 ... 9839	70.18 ... 11913.10
8”	DN200	35 ... 8786	70 ... 17533	106.48 ... 21229.51
10”	DN250	55 ... 13744	110 ... 27429	165.77 ... 33210.69
12”	DN300	79 ... 19815	158 ... 39544	239.58 ... 47880.39

A.2 Analog output

Scaling table analogue output (standard range)

Medium: Air at ISO 1217; 20°C; 1000 mbar

Tube		Flow							
inch	mm	m³/h	m³/min	l/min	l/s	cfm	kg/h	kg/min	kg/s
1/2”	16.10	45.6	0.76	759.8	12.66	26.8	54.1	0.90	0.02
3/4”	21.70	89.1	1.49	1485.2	24.75	52.4	105.8	1.76	0.03
1”	25.00	122.2	2.04	2036.8	33.95	71.9	145.2	2.42	0.04
	26.00	132.9	2.21	2214.8	36.91	78.2	157.8	2.63	0.04
	27.30	147.7	2.46	2461.3	41.02	86.9	175.4	2.92	0.05
	28.50	162.0	2.70	2700.2	45.00	95.4	192.4	3.21	0.05
	30.00	180.9	3.02	3015.5	50.26	106.5	214.9	3.58	0.06
1 1/4”	32.80	218.8	3.65	3647.0	60.78	128.8	259.9	4.33	0.07
	36.00	266.3	4.44	4438.6	73.98	156.7	316.3	5.27	0.09
	36.30	271.1	4.52	4518.6	75.31	159.6	322.0	5.37	0.09
1 1/2”	39.30	320.6	5.34	5343.6	89.06	188.7	380.8	6.35	0.11
	40.00	332.6	5.54	5542.6	92.38	195.7	395.0	6.58	0.11
	41.80	365.0	6.08	6083.2	101.39	214.8	433.5	7.23	0.12
	43.10	389.5	6.49	6491.8	108.20	229.3	462.6	7.71	0.13
	45.80	442.0	7.37	7367.3	122.79	260.2	525.0	8.75	0.15
2”	50.00	530.8	8.85	8846.0	147.43	312.4	630.4	10.51	0.18
	51.20	557.2	9.29	9287.1	154.79	328.0	661.9	11.03	0.18
	53.10	600.1	10.00	10001.5	166.69	353.2	712.8	11.88	0.20
	54.50	632.9	10.55	10548.8	175.81	372.5	751.8	12.53	0.21
	57.50	708.9	11.81	11814.4	196.91	417.2	842.0	14.03	0.23
	60.00	773.7	12.90	12895.5	214.92	455.4	919.0	15.32	0.26
	64.20	889.1	14.82	14818.0	246.97	523.3	1056.0	17.60	0.29
2 1/2”	65.00	912.5	15.21	15208.1	253.47	537.1	1083.8	18.06	0.30
	68.90	1026.5	17.11	17108.6	285.14	604.2	1219.3	20.32	0.34
	70.30	1071.2	17.85	17854.1	297.57	630.5	1272.4	21.21	0.35
	71.10	1095.8	18.26	18262.7	304.38	644.9	1301.5	21.69	0.36
	76.10	1258.3	20.97	20972.2	349.54	740.6	1494.6	24.91	0.42
3”	80.00	1392.3	23.20	23204.9	386.75	819.5	1653.7	27.56	0.46
	82.50	1482.5	24.71	24707.6	411.79	872.5	1760.8	29.35	0.49
	84.90	1570.0	26.17	26166.0	436.10	924.0	1864.7	31.08	0.52
	90.00	1766.4	29.44	29439.4	490.66	1039.6	2098.0	34.97	0.58
4”	100.00	2183.3	36.39	36388.6	606.48	1285.1	2593.3	43.22	0.72
	107.10	2507.4	41.79	41789.4	696.49	1475.8	2978.2	49.64	0.83
	110.00	2645.0	44.08	44083.1	734.72	1556.8	3141.6	52.36	0.87
5”	125.00	3419.6	56.99	56993.8	949.90	2012.7	4061.7	67.70	1.13
	133.70	3912.2	65.20	65203.4	1086.72	2302.6	4646.8	77.45	1.29
6”	150.00	4930.2	82.17	82169.3	1369.49	2901.8	5855.9	97.60	1.63
	159.30	5560.5	92.67	92674.2	1544.57	3272.8	6604.5	110.08	1.83
	182.50	7306.7	121.78	121778.9	2029.65	4300.6	8678.7	144.65	2.41
	190.00	7919.6	131.99	131993.8	2199.90	4661.3	9406.7	156.78	2.61
8”	200.00	8785.7	146.43	146428.3	2440.47	5171.1	10435.4	173.92	2.90
	206.50	9366.0	156.10	156100.8	2601.68	5512.6	11124.7	185.41	3.09
10”	250.00	13744.0	229.07	229067.2	3817.79	8089.4	16324.7	272.08	4.53
	260.40	14929.1	248.82	248818.2	4146.97	8786.9	17732.3	295.54	4.93
12”	300.00	19815.0	330.25	330249.9	5504.16	11662.7	23535.6	392.26	6.54
	309.70	21117.1	351.95	351951.3	5865.85	12429.0	25082.2	418.04	6.97
	339.60	25391.4	423.19	423190.1	7053.17	14944.8	30159.1	502.65	8.38
	400.00	35226.7	587.11	587110.9	9785.18	20733.6	41841.1	697.35	11.62
	500.00	55041.6	917.36	917360.8	15289.35	32396.3	65376.8	1089.61	18.16
	600.00	79260.0	1321.00	1320999.5	22016.66	46650.7	94142.5	1569.04	26.15
	700.00	107881.6	1798.03	1798027.1	29967.12	63496.8	128138.5	2135.64	35.59
	800.00	140906.6	2348.44	2348443.6	39140.73	82934.5	167364.5	2789.41	46.49
	900.00	178334.9	2972.25	2972248.9	49537.48	104964.0	211820.7	3530.35	58.84
	1000.00	220166.6	3669.44	3669443.1	61157.38	129585.2	261507.1	4358.45	72.64

Scaling table analogue output (max. range)
Medium: Air at ISO1217; 20°C; 1000 mbar

Tube		Flow							
inch	mm	m³/h	m³/min	l/min	l/s	cfm	kg/h	kg/min	kg/s
1/2”	16,10	90,98	1,52	1516,31	25,27	53,55	108,06	1,80	0,03
3/4”	21,70	177,84	2,96	2963,94	49,40	104,67	211,23	3,52	0,06
1”	25,00	243,88	4,06	4064,73	67,75	143,54	289,68	4,83	0,08
	26,00	265,20	4,42	4419,99	73,67	156,09	315,00	5,25	0,09
	27,30	294,72	4,91	4912,02	81,87	173,47	350,06	5,83	0,10
	28,50	323,32	5,39	5388,74	89,81	190,30	384,03	6,40	0,11
	30,00	361,08	6,02	6017,98	100,30	212,52	428,88	7,15	0,12
1 1/4”	32,80	436,69	7,28	7278,17	121,30	257,03	518,69	8,64	0,14
	36,00	531,48	8,86	8857,96	147,63	312,82	631,27	10,52	0,18
	36,30	541,06	9,02	9017,70	150,29	318,46	642,66	10,71	0,18
1 1/2”	39,30	639,84	10,66	10664,07	177,73	376,60	759,99	12,67	0,21
	40,00	663,68	11,06	11061,30	184,35	390,63	788,30	13,14	0,22
	41,90	731,90	12,20	12198,30	203,30	430,78	869,33	14,49	0,24
	43,10	777,34	12,96	12955,60	215,93	457,52	923,30	15,39	0,26
	45,80	882,17	14,70	14702,79	245,05	519,22	1047,81	17,46	0,29
2”	50,00	1059,23	17,65	17653,79	294,23	623,44	1258,12	20,97	0,35
	51,20	1112,05	18,53	18534,19	308,90	654,53	1320,86	22,01	0,37
	53,10	1197,59	19,96	19959,88	332,66	704,88	1422,46	23,71	0,40
	54,50	1263,13	21,05	21052,15	350,87	743,45	1500,31	25,01	0,42
	57,50	1414,66	23,58	23577,72	392,96	832,64	1680,29	28,00	0,47
	60,00	1544,12	25,74	25735,30	428,92	908,83	1834,06	30,57	0,51
	64,20	1774,33	29,57	29572,14	492,87	1044,33	2107,49	35,12	0,59
2 1/2”	65,00	1821,03	30,35	30350,57	505,84	1071,82	2162,97	36,05	0,60
	68,90	2048,60	34,14	34143,28	569,05	1205,76	2433,26	40,55	0,68
	70,30	2137,86	35,63	35631,08	593,85	1258,30	2539,29	42,32	0,71
	71,10	2186,80	36,45	36446,65	607,44	1287,10	2597,41	43,29	0,72
	76,10	2511,24	41,85	41853,97	697,57	1478,06	2982,77	49,71	0,83
3”	80,90	2841,44	47,36	47357,42	789,29	1672,41	3374,98	56,25	0,94
	82,50	2958,51	49,31	49308,50	821,81	1741,31	3514,03	58,57	0,98
	84,90	3133,15	52,22	52219,09	870,32	1844,10	3721,45	62,02	1,03
	90,00	3525,11	58,75	58751,80	979,20	2074,80	4187,01	69,78	1,16
4”	100,00	4357,22	72,62	72620,27	1210,34	2564,56	5175,37	86,26	1,44
	107,10	5003,91	83,40	83398,43	1389,97	2945,19	5943,48	99,06	1,65
	110,00	5278,56	87,98	87976,01	1466,27	3106,84	6269,71	104,50	1,74
5”	125,00	6824,50	113,74	113741,61	1895,69	4016,75	8105,93	135,10	2,25
	133,70	7807,53	130,13	130125,42	2168,76	4595,34	9273,54	154,56	2,58
6”	150,00	9839,04	163,98	163984,07	2733,07	5791,04	11686,51	194,78	3,25
	159,30	11096,91	184,95	184948,45	3082,47	6531,40	13180,56	219,68	3,66
	182,50	14581,94	243,03	243032,33	4050,54	8582,61	17319,98	288,67	4,81
	190,00	15805,08	263,42	263418,04	4390,30	9302,52	18772,79	312,88	5,21
8”	200,00	17533,48	292,22	292224,67	4870,41	10319,82	20825,73	347,10	5,78
	206,50	18691,68	311,53	311527,93	5192,13	11001,51	22201,39	370,02	6,17
10”	250,00	27428,75	457,15	457145,91	7619,10	16143,96	32579,03	542,98	9,05
	260,40	29793,76	496,56	496562,71	8276,05	17535,95	35388,11	589,80	9,83
12”	300,00	39544,48	659,07	659074,72	10984,58	23275,01	46969,71	782,83	13,05
	309,70	42143,03	702,38	702383,91	11706,40	24804,46	50056,19	834,27	13,90
	339,60	50673,25	844,55	844554,17	14075,90	29825,16	60188,12	1003,14	16,72
	400,00	70301,30	1171,69	1171688,40	19528,14	41377,80	83501,71	1391,70	23,19
	500,00	109845,79	1830,76	1830763,12	30512,72	64652,81	130471,43	2174,52	36,24
	600,00	158177,93	2636,30	2636298,89	43938,31	93100,05	187878,86	3131,31	52,19
	700,00	215297,74	3588,30	3588295,71	59804,93	126719,51	255724,00	4262,07	71,03
	800,00	281205,22	4686,75	4686753,58	78112,56	165511,20	334006,86	5566,78	92,78
	900,00	355900,35	5931,67	5931672,51	98861,21	209475,12	422727,43	7045,46	117,42

Scaling table analogue output (high speed range)
Medium: Air at ISO1217; 20 °C; 1000 mbar

Tube		Flow							
inch	mm	m³/h	m³/min	l/min	l/s	cfm	kg/h	kg/min	kg/s
1/2”	16.10	110.16	1.84	1835.96	30.60	64.84	130.84	2.18	0.04
3/4”	21.70	215.33	3.59	3588.77	59.81	126.74	255.76	4.26	0.07
1”	25.00	295.30	4.92	4921.62	82.03	173.81	350.74	5.85	0.10
	26.00	321.11	5.35	5351.77	89.20	189.00	381.40	6.36	0.11
	27.30	356.85	5.95	5947.52	99.13	210.03	423.86	7.06	0.12
	28.50	391.48	6.52	6524.74	108.75	230.42	464.99	7.75	0.13
	30.00	437.20	7.29	7286.64	121.44	257.33	519.29	8.65	0.14
1 1/4”	32.80	528.75	8.81	8812.49	146.87	311.21	628.03	10.47	0.17
	36.00	643.52	10.73	10725.32	178.76	378.76	764.35	12.74	0.21
	36.30	655.12	10.92	10918.73	181.98	385.59	778.14	12.97	0.22
1 1/2”	39.30	774.73	12.91	12912.18	215.20	455.99	920.20	15.34	0.26
	40.00	803.59	13.39	13393.14	223.22	472.97	954.48	15.91	0.27
	41.90	886.19	14.77	14769.83	246.16	521.59	1052.59	17.54	0.29
	43.10	941.21	15.69	15686.78	261.45	553.97	1117.94	18.63	0.31
	45.80	1068.14	17.80	17802.30	296.71	628.68	1268.70	21.15	0.35
2”	50.00	1282.52	21.38	21375.40	356.26	754.87	1523.34	25.39	0.42
	51.20	1346.48	22.44	22441.40	374.02	792.51	1599.31	26.66	0.44
	53.10	1450.06	24.17	24167.64	402.79	853.47	1722.33	28.71	0.48
	54.50	1529.41	25.49	25490.17	424.84	900.18	1816.59	30.28	0.50
	57.50	1712.89	28.55	28548.16	475.80	1008.17	2034.52	33.91	0.57
	60.00	1869.63	31.16	31160.58	519.34	1100.43	2220.69	37.01	0.62
	64.20	2148.38	35.81	35806.27	596.77	1264.49	2551.77	42.53	0.71
2 1/2”	65.00	2204.93	36.75	36748.79	612.48	1297.77	2618.94	43.65	0.73
	68.90	2480.46	41.34	41341.05	689.02	1459.95	2946.22	49.10	0.82
	70.30	2588.55	43.14	43142.50	719.04	1523.56	3074.60	51.24	0.85
	71.10	2647.80	44.13	44129.99	735.50	1558.44	3144.97	52.42	0.87
	76.10	3040.63	50.68	50677.24	844.62	1789.65	3611.57	60.19	1.00
3”	80.90	3440.45	57.34	57340.87	955.68	2024.97	4086.46	68.11	1.14
	82.50	3582.20	59.70	59703.26	995.05	2108.40	4254.82	70.91	1.18
	84.90	3793.65	63.23	63227.43	1053.79	2232.86	4505.98	75.10	1.25
	90.00	4268.24	71.14	71137.32	1185.62	2512.19	5069.68	84.49	1.41
4”	100.00	5275.76	87.93	87929.41	1465.49	3105.20	6266.39	104.44	1.74
	107.10	6058.78	100.98	100979.72	1683.00	3566.07	7196.43	119.94	2.00
	110.00	6391.34	106.52	106522.31	1775.37	3761.80	7591.43	126.52	2.11
5”	125.00	8263.17	137.72	137719.57	2295.33	4863.52	9814.74	163.58	2.73
	133.70	9453.44	157.56	157557.27	2625.95	5564.08	11228.50	187.14	3.12
6”	150.00	11913.22	198.55	198553.68	3309.23	7011.86	14150.16	235.84	3.93
	159.30	13436.25	223.94	223937.58	3732.29	7908.28	15959.17	265.99	4.43
	182.50	17655.97	294.27	294266.18	4904.44	10391.92	20971.22	349.52	5.83
	190.00	19136.96	318.95	318949.42	5315.82	11263.60	22730.29	378.84	6.31
8”	200.00	21229.73	353.83	353828.78	5897.15	12495.35	25216.01	420.27	7.00
	206.50	22632.08	377.20	377201.39	6286.69	13320.75	26881.69	448.03	7.47
10”	250.00	33211.03	553.52	553517.21	9225.29	19547.28	39447.04	657.45	10.96
	260.40	36074.61	601.24	601243.50	10020.73	21232.72	42848.31	714.14	11.90
12”	300.00	47880.89	798.01	798014.80	13300.25	28181.64	56871.44	947.86	15.80
	309.70	51027.24	850.45	850454.04	14174.23	30033.51	60608.58	1010.14	16.84
	339.60	61355.72	1022.60	1022595.32	17043.26	36112.63	72876.43	1214.61	20.24
	400.00	85121.58	1418.69	1418692.98	23644.88	50100.69	101104.78	1685.08	28.08
	500.00	133002.47	2216.71	2216707.78	36945.13	78282.33	157976.22	2632.94	43.88
	600.00	191523.55	3192.06	3192059.20	53200.99	112726.55	227485.75	3791.43	63.19
	700.00	260684.83	4344.75	4344747.24	72412.45	153433.36	309633.38	5160.56	86.01
	800.00	340486.31	5674.77	5674771.91	94579.53	200402.75	404419.11	6740.32	112.34
	900.00	430927.99	7182.13	7182133.20	119702.22	253634.74	511842.94	8530.72	142.18
	1000.00	532009.87	8866.83	8866831.11	147780.52	313129.30	631904.86	10531.75	175.53

Appendix B - Modbus communication example

03 (0x03) Read holding register

Request		Response	
Slave address	1 byte	Slave address	1 byte
Function code	1 byte	Function code	1 byte
Starting address Hi	1 byte	Byte count	1 byte
Starting address Lo	1 byte	Register Hi	1 byte
No. of points Hi	1 byte	Register Lo	1 byte
No. of points Lo	1 byte	:	:
CRC	2 bytes	Register Hi	1 byte
		Register Lo	1 byte
		CRC	2 bytes

05 (0x05) Write single coil

Request		Response	
Slave address	1 byte	Slave address	1 byte
Function code	1 byte	Function code	1 byte
Coil address Hi	1 byte	Coil address Hi	1 byte
Coil address Lo	1 byte	Coil address Lo	1 byte
Data Hi	1 byte	Data Hi	1 byte
Data Lo	1 byte	Data L	1 byte
CRC	2 bytes	CRC	2 bytes

16 (0x10) Write multiple registers

Request		Response	
Slave address	1 byte	Slave address	1 byte
Function code	1 byte	Function code	1 byte
Starting address Hi	1 byte	Starting address Hi	1 byte
Starting address Lo	1 byte	Starting address Lo	1 byte
No. of registers Hi	1 byte	No. of registers Hi	1 byte
No. of registers Lo	1 byte	No. of registers Lo	1 byte
Byte count	1 byte	CRC	2 bytes
Data Hi	1 byte		
Data Lo	1 byte		
:	:		
Data Hi	1 byte		
Data Lo	1 byte		
CRC	2 bytes		

17 (0x11) Report slave ID

Request		Response	
Slave address	1 byte	Slave address	1 byte
Function code	1 byte	Function code	1 byte
CRC	2 bytes	Byte count	1 byte
		Slave ID	2 bytes
		Device run indicator	2 bytes
		Product code	2 bytes
		Product name	20 bytes
		CRC	2 bytes

Appendix C - LRC and CRC calculation

LRC generation

The Longitudinal Redundancy Checking (LRC) field is one byte, containing an 8–bit binary value. The LRC value is calculated by the transmitting device, which appends the LRC to the message. The device that receives recalculates an LRC during receipt of the message, and compares the calculated value to the actual value it received in the LRC field. If the two values are not equal, an error results.

The LRC is calculated by adding together successive 8–bit bytes in the message, discarding any carries, and then two's complementing the result. The LRC is an 8–bit field, therefore each new addition of a character that would result in a value higher than 255 decimal simply 'rolls over' the field's value through zero. Because there is no ninth bit, the carry is discarded automatically.

A procedure for generating an LRC is:

1. Add all bytes in the message, excluding the starting 'colon' and ending CRLF. Add them into an 8–bit field, so that carries will be discarded.
2. Subtract the final field value from FF hex (all 1's) to produce the ones–complement.
3. Add 1 to produce the twos–complement.

Placing the LRC into the Message

When the 8–bit LRC (2 ASCII characters) is transmitted in the message, the high–order character will be transmitted first, followed by the low–order character. For example, if the LRC value is 61 hex (0110 0001):

Colon	Addr	Func	Data Count	Data	Data	Data	Data	LRC Hi	LRC Lo	CR	LF
								"6" 0x36	"1" 0x31		

Example: an example of a C language function performing LRC generation is shown below.

The function takes two arguments:

```
unsigned char *auchMsg; /* A pointer to the message buffer containing binary data */
                        /* to be used for generating the LRC,                      */
unsigned short usDataLen; /* The quantity of bytes in the message buffer.          */
```

LRC generation function

```
static unsigned char LRC(unsigned char *auchMsg, unsigned short usDataLen)
 {
       unsigned char uchLRC = 0 ;                          /* LRC char initialized */
       while (usDataLen--)                                 /* pass through message buffer */
              uchLRC += *auchMsg++ ;                       /* add buffer byte without carry */
       return ((unsigned char)(-((char)uchLRC))) ;   /* return twos complement */
}
```

CRC generation

The **C**yclical **R**edundancy **C**hecking (CRC) field is two bytes, containing a 16-bit binary value. The CRC value is first generated by the transmitting device, which appends the CRC to the message. The device that receives recalculates a CRC during receipt of the message, and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, an error results.

There are many ways of calculating a CRC checksum. To ensure correct calculation, please refer to [Reference 1] Modbus over serial line, where detailed descriptions and programming examples are available. Even more information and programming examples in different programming languages can be found on: www.modbus.org searching for CRC.

Below is a short text description of how the CRC is calculated. This description is then followed by a C programming example.

1. Load a 16-bit register with FFFF hex (all 1’s). Call this the CRC register.
2. Exclusive OR the first 8-bit byte of the message with the low-order byte of the 16-bit CRC register, putting the result in the CRC register.
3. Shift the CRC register one bit to the right (toward the LSB), zero-filling the MSB. Extract and examine the LSB.
4. (If the LSB was 0): Repeat step 3 (another shift). (If the LSB was 1): Exclusive OR the CRC register with the polynomial value 0xA001 (1010 0000 0000 0001).
5. Repeat steps 3 and 4 until 8 shifts have been performed. When this is done, a complete 8-bit byte will have been processed.
6. Repeat steps 2 through 5 for the next 8-bit byte of the message. Continue doing this until all bytes have been processed.
7. The final content of the CRC register is the CRC value.

8. When the CRC is placed into the message, its upper and lower bytes must be swapped as described below.

Placing the CRC into the message

When the 16-bit CRC (two 8-bit bytes) is transmitted in the message, the low-order byte will be transmitted first, followed by the high-order byte.

For example, if the CRC value is 1241 hex (0001 0010 0100 0001):

Addr	Func	Data count	Data	Data	Data	Data	CRC Lo	CRC Hi
							0x41	0x12

High-order byte table

```
/* Table of CRC values for high–order byte */
static unsigned char auchCRCHi[] = {
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00,
0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1,
0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,
0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01,
0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80,
0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00,
0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0,
0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80,
0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01,
0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1,
0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,
0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01,
0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1,
0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80,
0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81,0x40
} ;
```

Low-order byte table

```
/* Table of CRC values for low–order byte */
static char auchCRCLo[] = {
0x00, 0xC0, 0xC1, 0x01, 0xC3, 0x03, 0x02, 0xC2, 0xC6, 0x06, 0x07, 0xC7, 0x05,
0xC5, 0xC4, 0x04, 0xCC, 0x0C, 0x0D, 0xCD, 0x0F, 0xCF, 0xCE, 0x0E, 0x0A, 0xCA,
0xCB, 0x0B, 0xC9, 0x09, 0x08, 0xC8, 0xD8, 0x18, 0x19, 0xD9, 0x1B, 0xDB, 0xDA,
0x1A, 0x1E, 0xDE, 0xDF, 0x1F, 0xDD, 0x1D, 0x1C, 0xDC, 0x14, 0xD4, 0xD5, 0x15,
0xD7, 0x17, 0x16, 0xD6, 0xD2, 0x12, 0x13, 0xD3, 0x11, 0xD1, 0xD0, 0x10, 0xF0,
0x30, 0x31, 0xF1, 0x33, 0xF3, 0xF2, 0x32, 0x36, 0xF6, 0xF7, 0x37, 0xF5, 0x35,
0x34, 0xF4, 0x3C, 0xFC, 0xFD, 0x3D, 0xFF, 0x3F, 0x3E, 0xFE, 0xFA, 0x3A, 0x3B,
```

```
0xFB, 0x39, 0xF9, 0xF8, 0x38, 0x28, 0xE8, 0xE9, 0x29, 0xEB, 0x2B, 0x2A, 0xEA,
0xEE, 0x2E, 0x2F, 0xEF, 0x2D, 0xED, 0xEC, 0x2C, 0xE4, 0x24, 0x25, 0xE5, 0x27,
0xE7, 0xE6, 0x26, 0x22, 0xE2, 0xE3, 0x23, 0xE1, 0x21, 0x20, 0xE0, 0xA0, 0x60,
0x61, 0xA1, 0x63, 0xA3, 0xA2, 0x62, 0x66, 0xA6, 0xA7, 0x67, 0xA5, 0x65, 0x64,
0xA4, 0x6C, 0xAC, 0xAD, 0x6D, 0xAF, 0x6F, 0x6E, 0xAE, 0xAA, 0x6A, 0x6B, 0xAB,
0x69, 0xA9, 0xA8, 0x68, 0x78, 0xB8, 0xB9, 0x79, 0xBB, 0x7B, 0x7A, 0xBA, 0xBE,
0x7E, 0x7F, 0xBF, 0x7D, 0xBD, 0xBC, 0x7C, 0xB4, 0x74, 0x75, 0xB5, 0x77, 0xB7,
0xB6, 0x76, 0x72, 0xB2, 0xB3, 0x73, 0xB1, 0x71, 0x70, 0xB0, 0x50, 0x90, 0x91,
0x51, 0x93, 0x53, 0x52, 0x92, 0x96, 0x56, 0x57, 0x97, 0x55, 0x95, 0x94, 0x54,
0x9C, 0x5C, 0x5D, 0x9D, 0x5F, 0x9F, 0x9E, 0x5E, 0x5A, 0x9A, 0x9B, 0x5B, 0x99,
0x59, 0x58, 0x98, 0x88, 0x48, 0x49, 0x89, 0x4B, 0x8B, 0x8A, 0x4A, 0x4E, 0x8E,
0x8F, 0x4F, 0x8D, 0x4D, 0x4C, 0x8C, 0x44, 0x84, 0x85, 0x45, 0x87, 0x47, 0x46,
0x86, 0x82, 0x42, 0x43, 0x83, 0x41, 0x81, 0x80, 0x40
};
unsigned short CRC16(unsigned char *puchMsg, unsigned short usDataLen){
  unsigned char uchCRCHi = 0xFF;                    /* high byte of CRC initialized
*/
  unsigned char uchCRCLo = 0xFF;                    /* low byte of CRC initialized
*/
  unsigned uIndex ;                                 /* will index into CRC lookup
table */
  while(usDataLen—)                                 /* pass through message
buffer */
  {
        uIndex = uchCRCHi ^ *puchMsg++ ;            /* calculate the CRC */
        uchCRCHi = uchCRCLo ^ auchCRCHi[uIndex] ;
        uchCRCLo = auchCRCLo[uIndex] ;
   }
   return (unsigned short int)((uchCRCHi << 8) | uchCRCLo);
```