Operating Instructions

inertialSENSOR ACC5703

ACC5703

3-axes acceleration sensor

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1. Safety

System operation assumes knowledge of the operating instructions.

1.1 Symbols Used

The following symbols are used in these operating instructions:

⚠ CAUTION	Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.
NOTICE	Indicates a situation that may result in property damage if not avoided.
➡	Indicates a user action.
i	Indicates a tip for users.

1.2 Warnings

⚠ CAUTION

Connect the power supply and the display/output device according to the safety regulations for electrical equipment.
> Risk of injury

> Damage to or destruction of the sensor

NOTICE

The supply voltage must not exceed the specified limits.
> Damage to or destruction of the sensor

No sharp or heavy objects should be allowed to affect the cables. Avoid folding the cables. Do not bend more tightly than the minimum bending radius of the cables.
> Damage or destruction of the cable, failure of the measuring device

Do not crush the cable. Protect the sensor cable against damage.
> Damage or destruction of the cable, failure of the measuring device, data loss

Ensure that the coupling nuts of the connectors are firmly tightened.
> Damage or destruction of the cable, failure of the measuring device

1.3 Notes on CE Marking

The following apply to the ACC5703:
- EU Directive 2014/30/EU
- EU Directive 2011/65/EU

Products which carry the CE mark satisfy the requirements of the EU directives cited and the European harmonized standards (EN) listed therein. The EU Declaration of Conformity is available to the responsible authorities according to EU Directive, article 10, at:

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The measuring system is designed for use in industrial environments and meets the requirements.

1.4 Intended Use

The ACC5703 is designed for use in industrial applications. It is used for
- measuring acceleration
- measuring vibration of manoeuvrable components

- The system must only be operated within the limits specified in the technical data, see 2.3.
- The sensor must be used in such a way that no persons are endangered or machines and other material goods are damaged in the event of malfunction or total failure of the sensor.
- Take additional precautions for safety and damage prevention in case of safety-related applications.

1.5 Proper Environment

- Protection class: [1] IP 67
- Operating temperature: -40 ... +85 °C (-40 ... +185 °F)
- Storage temperature: -40 ... +85 °C (-40 ... +185 °F)
- Ambient pressure: Atmospheric pressure

1) With M12 connector

2. Functional Principle, Technical Data

2.1 Functional Principle

With the principle of an acceleration sensor, forces that change the velocity of an object are measured and transformed into an electric output signal.

Therefore the sensor is mounted on the maneuverable component. The expected moves correspond to the measurement axes. The included MEMS-Element converts the acceleration into a usable electric signal.

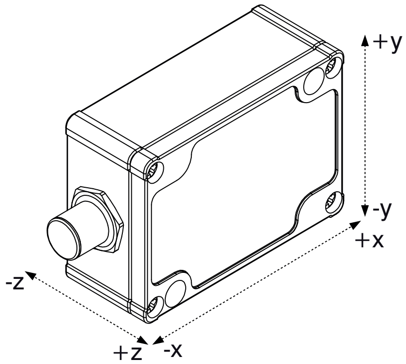


Fig. 1 Three axes acceleration sensor

2.2 Structure and Electrical Connection

The sensor is ready for operation immediately after connecting the power supply and will provide the acceleration as electric value at the analog output.

The ACC5703 is available with analog (current, voltage and switching output) as well as RS485 interface for configuring of the sensor using the software.

Power supply and signal output are connected through a 8-contact (M12) connector on the sensor's housing.

2.3 Technical Data

Model		ACC5703-8
Number of axes		3
Measuring range		± 0 g … ± 8 g (configurable)
Resolution	Digital	0.016 mg
	Analog	Current: < 0.24 mg / voltage < 0.31 mg
Noise		Typ. 30 µg / √Hz
Sensitivity (analog output)	Current	< 4 mA/g
	Voltage	< 1 V/g
Zero		12 mA or 2.5 V
Linearity		Typ. 0.45 % FSO
Frequency range		0 ... 1000 Hz (configurable)
Sampling rate		Up to 4 kHz
Cross axis sensitivity		1 % FSO
Temperature stability		Typ. ± 0.2 mg / K
Supply voltage		5 … 32 VDC
Power consumption		< 3 W
Temperature range	Operation	-40 … +85 °C (-40 ... +185 °F)
	Storage	-40 … +85 °C (-40 ... +185 °F)
Digital interface		RS485
Analog output		Current 4 … 20 mA (max. 390 Ω) Voltage 0.5 … 4.5 V (min. 1 KΩ)
Switching output		0 / 5 V (min. 1 KΩ)
Protection class		IP 67 (plugged state)

Model	**ACC5703-8**
Shock	DIN EN 60068-2-27 (1500 g, 0.5 ms, half-sine shock, 3 x in each direction)
Weight	Approx. 250 g
Material	Die-cast aluminum
Installation	Screw connection via mounting holes (M4)
Connection	M12 connector, 8-pin
Start-up time	< 500 ms

FSO = Full Scale Output

All specifications valid at a room temperature of +25 °C (+77 °F)

Article designation

ACC 5703 -8 -SA -U/I

-U/I: Output
U = voltage 0.5 ... 4.5 V,
I = current 4 ... 20 mA,
switching output 0 / 5 V

-SA: Connection:
SA = axial plug

-8: Measuring range in g

5703: High Performance acceleration sensor

Response time	
Sampling frequency [Hz]	**Time [ms]**
4000	0.88
2000	1.25
1000	2.03
500	3.51
250	6.52
125	12.59
62.5	24.43
31.25	47.84
15.625	96.5
7.813	189.83
3.906	384.56

Fig. 2 Table response time

3. Delivery

3.1 Unpacking, Included in Delivery

1 Sensor ACC5703

1 Operating Instructions

- Carefully remove the components of the measuring system from the packaging and ensure that the goods are forwarded in such a way that no damage can occur.
- Check the delivery for completeness and shipping damage immediately after unpacking.
- If there is damage or parts are missing, immediately contact the manufacturer or supplier.

Optional accessories are available in the appendix, see A 1.

3.2 Storage

Storage temperature:	-40 ... +85 °C (-40 ... +185 °F)
Humidity:	5 - 95 % (non-condensing)

4. Installation and Assembly

4.1 Sensor Cable Assembly

NOTICE

No sharp or heavy objects should be allowed to affect the cables. Avoid folding the cables. Do not bend more tightly than the minimum bending radius of the cables.
> Damage or destruction of the cable, failure of the measuring device

Do not crush the cable. Protect the sensor cable against damage.
> Damage or destruction of the cable, failure of the measuring device

Ensure that the coupling nuts of the connectors are firmly tightened.
> Damage or destruction of the cable, failure of the measuring device

4.2 Sensor Assembly

The sensor is fixed into place with the help of two through bores for M4 screws.

The sensor is mounted at the manoeuvrable component. The orientation of the measurement axes x, y, z is to be respected in relation to the expected moves of the component.

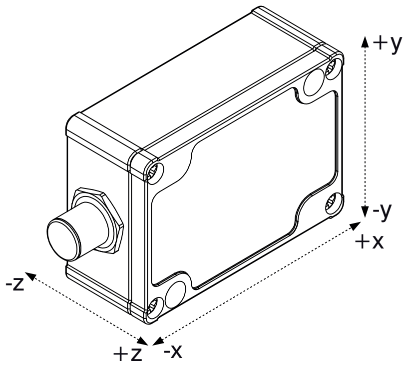


Fig. 3 Installation orientation, measurement axis

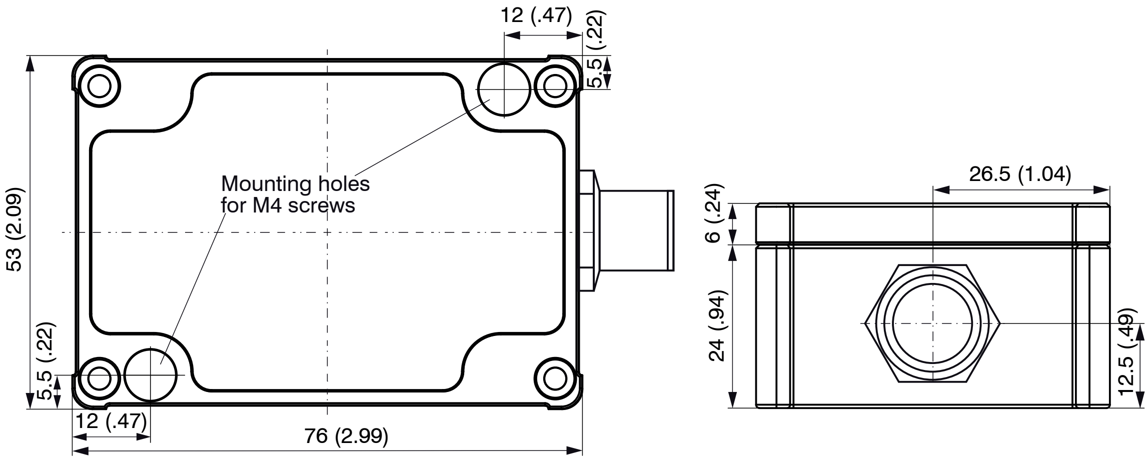


Fig. 4 Dimensional drawing, dimensions in mm (inches), not to scale

4.3 Pin Assignment

➡ Connect the open cable end in accordance with the color coding, see Fig. 5.

Pin [1]	Color [2]	Description	
1	White	Output channel 2	
2	Brown	GND (Output)	
3	Green	Output channel 3	
4	Yellow	RS485+	
5	Gray	Output channel 1	
6	Black/pink	GND (Supply)	
7	Blue	RS485-	
8	Red	Supply +	View of solder pin side, 8-pin, A-coded, female connector

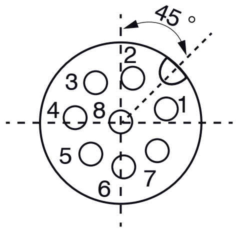


Fig. 5 Pin assignment of the 8-pin, A-coded, female connector

1) - SA - Connector
2) PCx/8-M12 Power supply and output cable, see A 1.

4.4 Current and Voltage Output

The sensor makes the acceleration value available as analog output variable either as current or voltage value on separate pins.

Three output channels can be configured independently with the following settings.

Each output channel can be operated in continuous operation mode or switching operation mode.

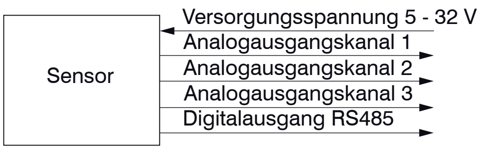


Fig. 6 Current and voltage output

Selection of measurement axis (x, y, z) at every channel possible
Off (zero output)
Continuous mode, current 4 - 20 mA
Continuous mode, voltage 0.5 - 4.5 V
Switching mode, voltage 0 - 5 V

Fig. 7 Operation modes of the analog output channels

4.4.1 Continuous Operation Mode

The sensor makes the acceleration value available as analog output variable either as current or voltage value on separate pins, depending on the configuration using the software tool of Micro-Epsilon.

In this process, the symmetrical measurement range in the unit g is scaled to the respective analog range.

The sensitivity increases with decreasing measurement range as only a small acceleration range is scaled to the same output range, see Fig. 8, see Fig. 9.

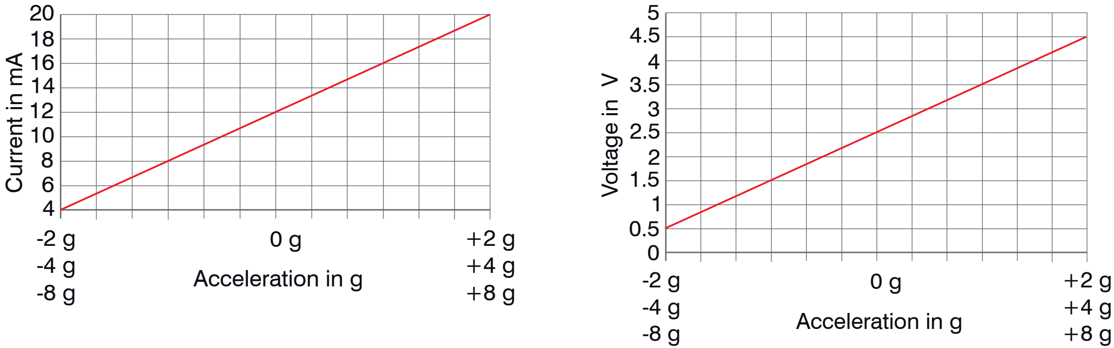


Fig. 8 Scaling of the acceleration measurement range to analog output variable current or voltage

Range digital [g]	Resolution digital RS485 [mg]	Resolution analog current [mg]	Resolution analog voltage [mg]	Sensitivity analog current [mA/g]	Sensitivity analog voltage s[V/g]
±2	0.004	0.06	0.076	4.0	1.0
±4	0.008	0.12	0.15	2.0	0.5
±8	0.016	0.24	0.31	1.0	0.25

Fig. 9 Examples of resolution (mg) and sensitivity (mA/g) depending on the configured measurement range

4.4.2 Switching Operation Mode

The switching mode, configurable via Software, switches the analog voltage output to 5 V when the acceleration value reaches the trigger-level “on-level” and switches back to 0 V when the acceleration value falls below the “off-level”.

Selection of measurement axis (x, y, z) (vector addition (xy, xz, yz, xyz) $\sqrt{(x^2+y^2+z^2)}$ possible at every channel)	
On-level [g]	Switching hysteresis
Off-level [g]	Rise- / Fall-time $< 10\,\mu s$
Edge triggered (switching when reaching the level considering the minimum hold time, see Fig. 13)	
Edge triggered with delay (switching after specified time during which the level is reached permanently)	

Fig. 10 Settings of switching mode

That functionality can be used, for example, as safety feature which switches off a machine if high vibrations occur. The trigger-levels take effect symmetrically, i.e. in the positive and negative acceleration range at the same absolute value, see Fig. 11.

The output values at the digital interface in switching mode are either zero or equal to the “on-level” as long as the trigger condition is met.

The duration of the rising and falling edge is $t < 10\,\mu s$, see Fig. 12.

Two different modes are selectable:
- Edge triggered, i.e. immediate switching when reaching the trigger-level.
- Edge triggered with delay, i.e. switching after specified time during which the trigger-level is reached permanently.

The minimum hold time of the switching status depends on the selected sampling rate, see Fig. 13.

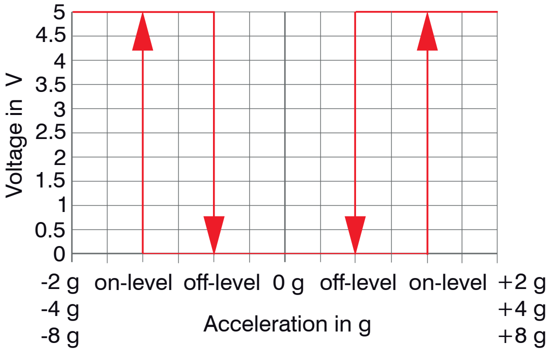


Fig. 11 Hysteresis of the trigger-levels in switching operation

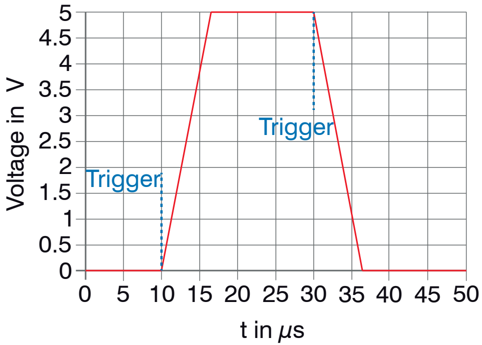


Fig. 12 Rising and falling edge of the voltage output in switching mode, t < 10 µs

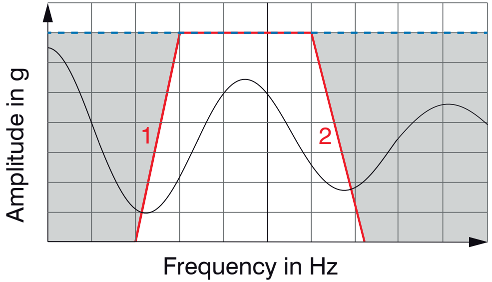
Sampling rate (Hz)	Minimum hold time of switching status (ms)
4000	25
2000	25
1000	25
500	26
250	28
125	32
62.5	32
31.25	32
15.625	64
7.8125	128
3.90625	256

Fig. 13 Minimum hold time of the switching status

4.5 Configuration of Sampling Rate and Low- and High-pass Filter

Parameters, like sampling rate or filter frequencies, are adaptable in a wide range in order to match the respective application.

The high-pass is configured to reduce influences of low frequencies especially to hide earth acceleration. The low-pass is configured to hide disturbances at high frequency.



1 Highpass to hide earth acceleration
2 Lowpass to hide disturbances

Fig. 14 Configuration of filter to reduce influences

Different low-pass filter settings, see Fig. 15, cause the sampling rate to change respectively. The chosen low-pass frequencies furthermore have influence on the available high-pass filter options.

Low-pass f_{LP} [Hz] (configurable)	**Sampling rate [Hz]**	**High-pass f_{HP} [Hz] (optional, configurable)**
1000	4000 [1]	0.00952 … 9.88
500	2000 [1]	0.00476 … 4.94
250	1000	0.00238 … 2.47
125	500	0.00119 … 1.235
62.5	250	0.000595 … 0.6175
31.25	125	0.0002975 … 0.30875
15.625	62.5	0.00014875 … 0.154375
7.813	31.25	7.4375e-5 … 0.0771875
3.906	15.625	3.71875e-5 … 0.03859
1.953	7.813	1.859e-5 … 0.0193
0.977	3.906	9.296e-6 … 0.009648

Fig. 15 Table dependency between sampling rate and low- and high-pass settings

1) Digital interface RS485 is enabled only up to 1000 Hz sampling rate. At higher rates only the analog output is active.

4.6 Digital Output RS485

You can read out the measured data in digital form using the RS485 interface in a sampling rate up 1000 Hz. For higher sampling rates only the analog operation is possible. The PC software sensorTool, see A 2, permits configuration of the sensor and the visualization of the measured data, see A 1. The bus protocol required to read out the measured data in your own applications is described in the appendix, see A 4.

Additionally, you can use the IF1032/ETH interface converter by MICRO-EPSILON MESSTECHNIK GmbH & Co. KG, to read out the measured data via Ethernet.

5. Operation

The measurement device is already calibrated when delivered. Calibration by the user is not necessary. After connection to the operating voltage, the sensor is immediately ready for operation and independently initiates the measurement.

Additionally, the digital RS485 interface is ready to react to enquiries by the master (periodic retrieval of measured data).

For sensor configuration please use the power supply and output cable with USB/RS485 converter, see A 1 as well as the software of MICRO-EPSILON.

i Allow the sensor to warm up for approximately 10 minutes after connection of the voltage supply.

6. Liability for Material Defects

All components of the device have been checked and tested for functionality at the factory. However, if defects occur despite our careful quality control, MICRO-EPSILON or your dealer must be notified immediately.

The liability for material defects is 12 months from delivery.

Within this period, defective parts, except for wearing parts, will be repaired or replaced free of charge, if the device is returned to MICRO-EPSILON with shipping costs prepaid. Any damage that is caused by improper handling, the use of force or by repairs or modifications by third parties is not covered by the liability for material defects. Repairs are carried out exclusively by MICRO-EPSILON.

Further claims can not be made. Claims arising from the purchase contract remain unaffected. In particular, MICRO-EPSILON shall not be liable for any consequential, special, indirect or incidental damage. In the interest of further development, MICRO-EPSILON reserves the right to make design changes without notification.

For translations into other languages, the German version shall prevail.

7. Service, Repair

If the sensor is defective, please send us the affected parts for repair or exchange.

If the cause of a fault cannot be clearly identified, please send the entire measuring system to:

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Königbacher Str. 15
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info@micro-epsilon.de
www.micro-epsilon.com

8. Decommissioning, Disposal

➡ Remove the power and output cable from the sensor.

Incorrect disposal may cause harm to the environment.

➡ Dispose of the device, its components and accessories, as well as the packaging materials in compliance with the applicable country-specific waste treatment and disposal regulations of the region of use.

Appendix

A 1 Accessories

Designation	Description
PC3/8-M12	Power supply and output cable, 3 m long
PC5/8-M12	Power supply and output cable, 5 m long
PC10/8-M12	Power supply and output cable, 10 m long
PC10/8-M12	Power supply and output cable, for drag chain use, 10 m long
PC15/8-M12	Power supply and output cable, 15 m long
PC2/8-Sub-D	Power supply and output cable with USB / RS485 converter, 2,8 m long

A 2 PC Software sensorTOOL

You will find the software for the sensor for free at:
www.micro-epsilon.com

A 3 Factory Settings

Low-pass filter: 62,5 Hz

Sampling rate: 250 Hz

High-pass filter: Disabled

Measurement range: ±2 g

Sensitivity: 4 mA/g or 1 V/g

Output signal: 4 ... 20 mA

Active axes: Channel 1: “x”, channel 2: “y”, channel 3: “z”, see Fig. 3

A 4 Digital Interface RS485

A 4.1 Hardware Interface

The interface is a half-duplex RS485 interface, which means that one cable pair is jointly used for sending and receiving.

Baud rate	230400 b/s
Data format	1 start bit, 8 data bits, 1 parity bit even, 1 stop bit
Bus address	126

Fig. 16 Settings of the RS485 interface

A terminating resistance of 120 Ω is required between the A- and B-line of the RS485 interface at the beginning and the end of the RS485 bus. A terminating resistor of the RS485 line is not incorporated in the sensor. It is therefore allowed to connect several sensors to one bus cable.

A 4.2 Protocol

The sensor acts as RS485 slave. As the system uses a half-duplex protocol, only the master can initiate communication. Each device at the RS485 bus requires its own address. The master sends an enquiry with the destination address to the bus and only the slave with this address answers accordingly.

A 4.2.1 Reading Measurement Data

Master: Request data						
Byte:	SD	DA	SA	FC	FCS	ED
Value:	0x10	x	x	0x4C	x	0x16
		FCS				

Slave: Response data										
Byte:	SD	LE	LE rep	SD rep	DA	SA	FC	Data[]	FCS	ED
Value:	0x68	x	x	0x68	x	x	0x08	x	x	0x16
					FCS					

Designations	
SD	Start Delimiter (0x10: datagram without data, 0x68: datagram with variable length)
LE	Length (number of bytes without SD, LE, LE rep, SD rep, FCS, ED)
LE rep	LE repeated
SD rep	SD repeated
DA	Destination Address (default 0x7E = 126)
SA	Source Address (e. g. 0x01)
FC	Function Code
FCS	Checksum (sum of all bytes without SD, LE, LE rep, SD rep, FCS, ED, overflow at 256)
ED	End Delimiter
Data[]	Measurement data, variable number, little endian

The measurement data consists of one status byte, one measured values counter, number of measured values, and the measured data. The measured values counter increases continuously with each sampled value. It represents the number of measured values buffered in the sensor since the last enquiry by the master and therefore represents the number of the measured values transmitted in this package (floats).

A new sampled measurement value is saved to the internal buffer of the sensor. The maximum number of values which can be saved is 19 for each measurement axis. Therefore, an enquiry by the master must reach the sensor within a certain time, that depends on the set sampling rate, in order to read the content from the internal memory and ensure uninterrupted sampling (periodic enquiry).

- Example 1 kHz: 19 values * 1 ms = 19 ms
- Example 250 Hz: 19 values * 4 ms = 76 ms

If the enquiries are not made in time, error flag 0x01 is set in the status byte. The measurement is continued anytime, i.e. the values in the buffer which are not read will be overwritten with updated measurements. The buffer content is, therefore, always updated. The overflow error flag is deleted automatically as soon as the master resumes its periodic enquiries.

The analog output remains unaffected by this. The first measurement value in the Data[] package is the oldest measured value. A measured value is represented as 4-byte float data type in the unit [g][1].

1) $1\ g = 9.81 \frac{m}{s^2}$

Byte	Meaning	Data format
Data[0]	Status byte (contains error flags, normally 0x00	8 bit
Data[1]	Long term values counter [bit 0:7]	Uint 32 bit
Data[2]	Long term values counter [bit 8:15]	
Data[3]	Long term values counter [bit 16:23]	
Data[4]	Long term values counter [bit 24:31]	
Data[5]	Number of measured values in this package	8 bit
Data[6]	Padding byte	8 bit
Data[7]	Padding byte	8 bit
Data[8]	Measured value 1 [bit 0:7]	Float 32 bit
Data[9]	Measured value 1 [bit 8:15]	
Data[10]	Measured value 1 [bit 16:23]	
Data[11]	Measured value 1 [bit 24:31]	
Data[12]	Measured value 2 [bit 0:7]	Float 32 bit
Data[13]	Measured value 2 [bit 8:15]	
Data[14]	Measured value 2 [bit 16:23]	
Data[15]	Measured value 2 [bit 24:31]	
...	...	...
Data[n] n=8+(4*Data [5])	Measured value 1 y-axis [bit 0:7]	Float 32 bit
Data[n+1]	Measured value 1 y-axis [bit 8:15]	
Data[n+2]	Measured value 1 y-axis [bit 16:23]	
Data[n+3]	Measured value 1 y-axis [bit 24:31]	

Byte	Meaning	Data format
Data[n+4]	Measured value 1 y-axis [bit 0:7]	Float 32 bit
Data[n+5]	Measured value 1 y-axis [bit 8:15]	
Data[n+6]	Measured value 1 y-axis [bit 16:23]	
Data[n+7]	Measured value 1 y-axis [bit 24:31]	
...	...	...
Data[n+m] m=4*Data[5]	Measured value 1 z-axis [bits 0:7]	Float 32 bit
Data[n+m+1]	Measured value 1 z-axis [bits 8:15]	
Data[n+m+2]	Measured value 1 z-axis [bits 16:23]	

Fig. 17 Encoding of Measured Data in the Transmission Protocol

A 4.2.2 Example Transmission of a Measurement Value

Master: Request data						
Byte:	SD	DA	SA	FC	FCS	ED
Value:	0x10	0x7E	0x01	0x4C	0xCB	0x16
		FCS				

DA = Destination Address = 0x7E = 126 (slave address)

SA = Source Address = 0x01 (master address)

FCS = Checksum = 0x7E + 0x01 + 0x4C = 0xCB

= 126 + 1 + 76 = 203 (no overflow) at 256)

Slave: Response data										
Byte:	SD	LE	LE rep	SD rep	DA	SA	FC	Data[]	FCS	ED
Value:	0x68	1B	1B	0x68	0x01	0x7E	0x08	x	0x67	0x16
					FCS					

4 measured values = 4 x float = 4 x 4 bytes = 16 data bytes

LE = Length = 16 data bytes + 11 bytes (DA, SA, FC, 1xstatus, 4xstatus, 4xcounter, 1xnumber, 2xpadding byte) = 0x1B = 27

DA = Destination Address = 0x01 (Master)

SA = Source Address = 0x7E = 126 (Slave)

FCS = Checksum = 0x01 + 0x7E + 0x08 + 0x00 (status) + 0x04 (counter) ... = 0x67 (note overflow at 256 each time = reset sum to zero)

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