

# Temposonics®

Absolute, Non-Contact Position Sensors



## MH Series

Temposonics® MH Analog  
MH / MS / MT

Document Part Number  
551290 Revision B

## Operating Manual



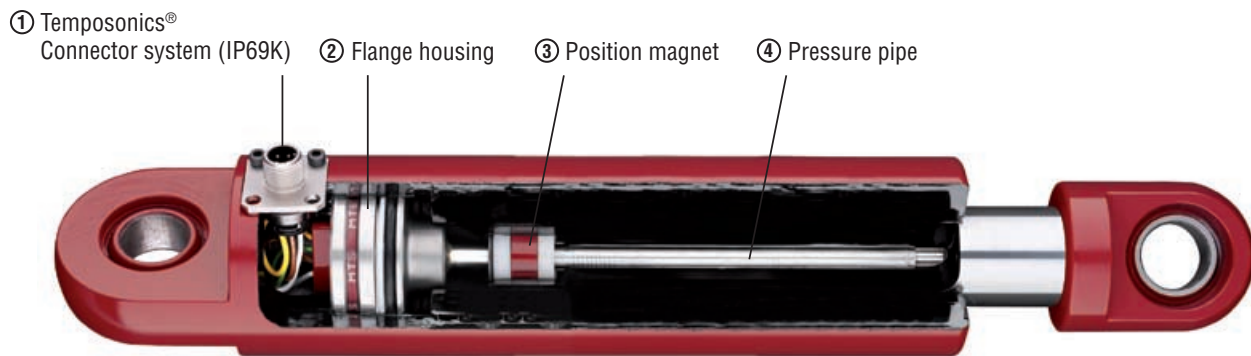
All specifications are subject to change. Contact MTS for specifications and engineering drawings that are critical to your application. Drawings contained in this document are for reference only.  
Please visit [www.mtssensor.com](http://www.mtssensor.com) for the actual support documentation- related to your selected model.

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## 1. Product description and technology

Temposonics® sensors can be used in versatile mobile machines without any restriction and replace contact-based linear sensors like potentiometers. Highly dynamic systems are controlled safely by means of Temposonics® sensors, thus enhancing the productivity, availability and quality of the working process of the machine. Insensitive to vibration, shocks, dust and weathering influence and electro-magnetic disturbances. Temposonics® MH-Series sensors are successfully used in front axle and articulated frame steering cylinders, hydraulic jacks and in steering systems for hydraulic units on agricultural and construction machinery.



### Simple Mechanics

The extremely robust sensor consists of the following main parts:

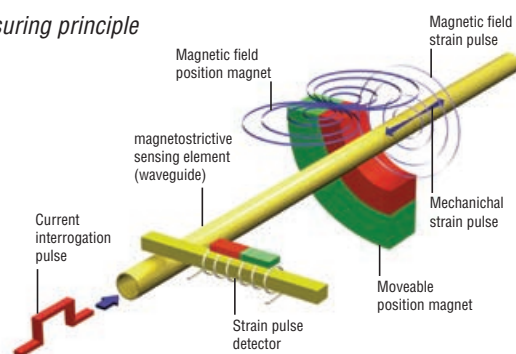
- ① The innovative connector system which is easy to install in a few seconds, any soldering or crimping needless, dust-and waterproof up to IP69K.
- ② The flange housing with built-in electronics and signal converter.
- ③ The position magnet as only moving part, which is assembled into the piston bottom. This permanent magnet travels wear-free and contactless along the pressure pipe and measures the actual position.
- ④ The pressure pipe placed within the drilled piston rod contains the protected magnetostrictive sensing element.

- Due to small dimensions MH sensors require only little space
- Suitable for operating pressures up to 350 bar
- Unaffected by surrounding media such as ageing or foaming oil
- Insensitive to shock and vibration
- Designed for all current supply voltages (12/24 VDC)
- Temposonics® sensors offer all common used output signals:
  - Analog: VDC/mA
  - PWM
  - Bus protocols: CANopen, SAE J1939

### Magnetostriction

Temposonics® linear sensors are based on the magnetostrictive technology. By measuring the actual position with a non-contact position magnet the sensor operates 100% wear-free. The absolute operating principle enables reliable readings without any reference point or recalibration. A mechanical strain pulse is triggered by the travelling position magnet. The runtime of this ultrasonic wave is measured precisely and compiled into standard electronic output signals.

#### Measuring principle



## 2. Temposonics® MH series analog

Temposonics® MH series sensors are designed for hydraulic cylinders. With the analog output configuration they are qualified to operate on electronic controls of mobile machines. Sensors with different analog output signals (mA/ VDC) are suitable for applications on vehicles.

## 3. Safety and operating instructions

Before starting the sensors operation, please, read this documentation carefully and follow the safety instructions.

This technical documentation provides information on the mechanical installation of Temposonics® sensors by qualified personnel\* or trained service technicians who are familiar with sensor projecting and handling.

### Intended use



Temposonics® MH series sensors are designed to use on mobile machines or vehicles with a battery power supply (12/24VDC). The sensors are built acc. to actual electrical engineering standards and meet the state of technology. EMC requirements for interference emission and immunity for mobile machines and vehicles fulfilled. Technical rules and notes for installation and operation in vehicle electronics to keep in mind.

The sensors are intended for measuring tasks in the field of mobile hydraulics. They are considered as accessories and must be connected to suitable evaluation electronics, e.g. a PLC, IPC, indicator or another type of electronic control unit. As a prerequisite to ensure perfect and safe sensor operation, correct transport, storage, mounting, commissioning and careful operation are mandatory. The sensors may be used only in safe condition. To maintain this condition and ensure safe operation, installation, connection and service work may be performed only by qualified and authorized personnel.

### Information related to danger

Information related to danger is intended for your personal safety and for the safety of the described product or connected equipment against damage.

### Installation and operation

If failure or functional disorder of the sensors cause danger for persons or imply a hazard of damage to operating facilities, additional safety measures such as plausibility checks, limit switches, EMERGENCY OFF systems, protective devices, etc. must be provided to prevent it. In the event of trouble, shut down the sensor and protect it against unauthorized operation.

To maintain the sensor operability, it is indispensable to observe the following information:

- Protect the sensor against mechanical damage during installation and operation.
- Don't open or dismantle the sensor.
- Connect the sensor carefully and make sure that the polarity of connections, the operating voltage as well as the shape and duration of control pulses are correct.
- Use only approved power supply units.
- Observing the permissible sensor limit values for operating voltage and environmental conditions etc. as specified in the product documentation is indispensable.
- Check and document the function of the position sensor regularly.
- Before activating the equipment, make sure that nobody's safety is impaired by starting machines.

### Repairs

Repairs on the sensor may only be performed by MTS or a body that has been explicitly authorized by MTS.

### Warranty



The MTS warranty period for the sensors and the accessories included in the scope of supplies in the event of material defects and faults occurred although the intended use has been observed is 12 months from the reception of products. The MTS liability is limited to repair or replacement for every defective component of the unit. Warranty for defects due to incorrect use or excessive strain of the product as well as for wear parts is excluded. MTS rejects any liability for consequences or side effects in case of violation of the warranty provisions\*\*, independent of whether warranty has been assured or expected. This is also applicable in the event of an error or negligence committed by the company.

MTS explicitly refrains from making any additional warranty promises. Representatives, agents, dealers and members of the personnel are not authorized to increase or change the warranty conditions.

- \* Qualified personnel means persons who are
- familiar with the projection of safety concepts for automation equipment.
  - competent in the field of EMC.
  - have been trained adequately for commissioning and service work
  - familiarized with the operation of the equipment and know the information required for perfect operation given in the product documentation.

\*\* see MTS sales and supply conditions, e.g. available for download from [www.mtssensor.com](http://www.mtssensor.com)

### Symbols

| Symbol  | Meaning   |
|---|---|
|  | This sign identifies an important information   |
|  | This sign indicates that, the personnel damage such as death or bodily injury, or considerable damage to property are susceptible to occur, unless appropriate precautions are taken. |

## 4. Electrical connection

Temposonics® MH series sensors are equipped with an M12 connector. For electrical wiring pin assignment has to be checked. Optionally, the sensors are available with single wire or PUR cable outlet. Please use suitable mating connectors.



Detailed information relating to the mechanical installation of the sensor in the mobile hydraulic cylinder is given in the installation instructions. During installation, make sure that cables are located correctly inside the cylinder. The cables must not be squeezed and should be laid without mechanical stress.

### Protection types

To connect the sensor under harsh environmental conditions, ideally a PUR cable with an integral connector and a stainless steel lock nut should be used. For connection according to protection types IP68 and IP69K, a corresponding tested mating plug is required.

### 4.1 Connecting diagrams, pin allocation, conductor colors

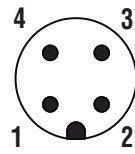
#### Type MH Analog

##### Connector system M12

4 x 0,25 mm<sup>2</sup>

##### Pin assignment connector system M12

|           | E | G | H |
|-----------|---|---|---|
| 12/24 VDC | 2 | 1 | 1 |
| GND (OV)  | 3 | 3 | 3 |
| Signal    | 4 | 4 | 2 |
| n.c.      | 1 | 2 | 4 |



Top view:  
male pin connector



##### Single wires

3 x 0,5 mm<sup>2</sup>

##### Wire assignment single wires

|           | Wire color |
|-----------|------------|
| 12/24 VDC | BN         |
| GND (OV)  | WH         |
| Signal    | GN         |



##### PUR cable:

3 x 0,5 mm<sup>2</sup>

##### Wire assignment PUR-cable

|           | Wire color |
|-----------|------------|
| 12/24 VDC | BN         |
| GND (OV)  | WH         |
| Signal    | GN         |



**Type MS Analog**

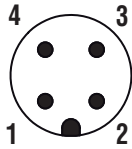
**Connector system M12**

4 x 0,25 mm<sup>2</sup>



**Pin assignment connector system M12**

|           | <b>E</b> | <b>G</b> | <b>H</b> |
|-----------|----------|----------|----------|
| 12/24 VDC | 2        | 1        | 1        |
| GND (OV)  | 3        | 3        | 3        |
| Signal    | 4        | 4        | 2        |
| n.c.      | 1        | 2        | 4        |



Top view:  
male pin connector

**Single wires**

3 x 0,25 mm<sup>2</sup>

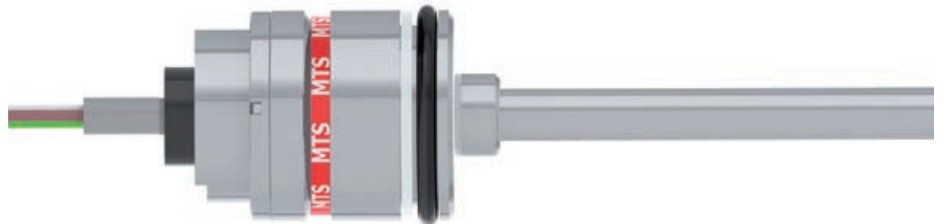


**Wire assignment single wires**

|           | <b>Wire color</b> |
|-----------|-------------------|
| 12/24 VDC | BN                |
| GND (OV)  | WH                |
| Signal    | GN                |
| n.c.      | YE                |

**PUR cable**

3 x 0,5 mm<sup>2</sup>



**Wire assignment PUR-cable**

|           | <b>Wire color</b> |
|-----------|-------------------|
| 12/24 VDC | BN                |
| GND (OV)  | WH                |
| Signal    | GN                |

**Type MT Analog**

**Connector system M12 (2xM12x1)**

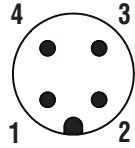
Connector 4 pin = (channel A (•)) and 5 pin = (channel B (••))

The channels are marked with dots on the housing.



**Channel A (•) 4 pin connector**

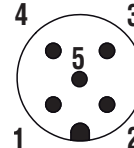
|           | Pin |
|-----------|-----|
| 12/24 VDC | 1   |
| GND (0V)  | 3   |
| Signal    | 4   |
| n.c.      | 2   |



Top view:  
male pin connector

**Channel B (••) 5 pin connector**

|           | Pin |
|-----------|-----|
| 12/24 VDC | 1   |
| GND (0V)  | 3   |
| Signal    | 2   |
| n.c.      | 4   |
| n.c.      | 5   |



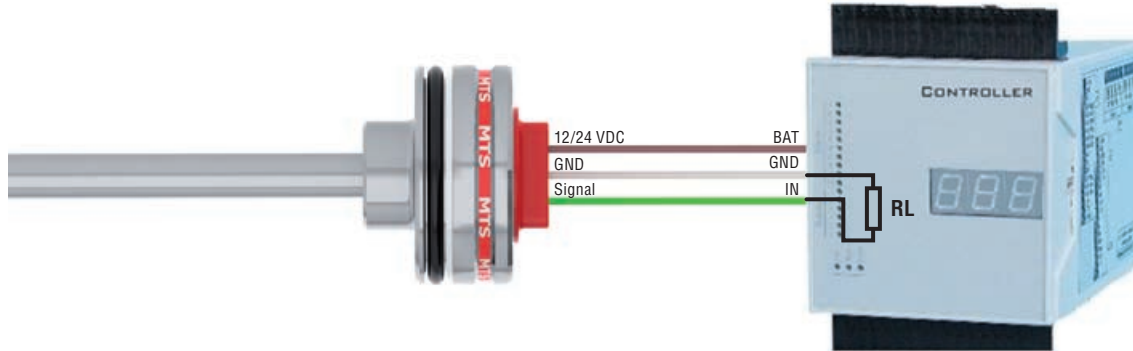
Top view:  
male pin connector



#### 4.2 Order of connection

##### MH sensors with analog output (VDC/mA)

##### Correct connection



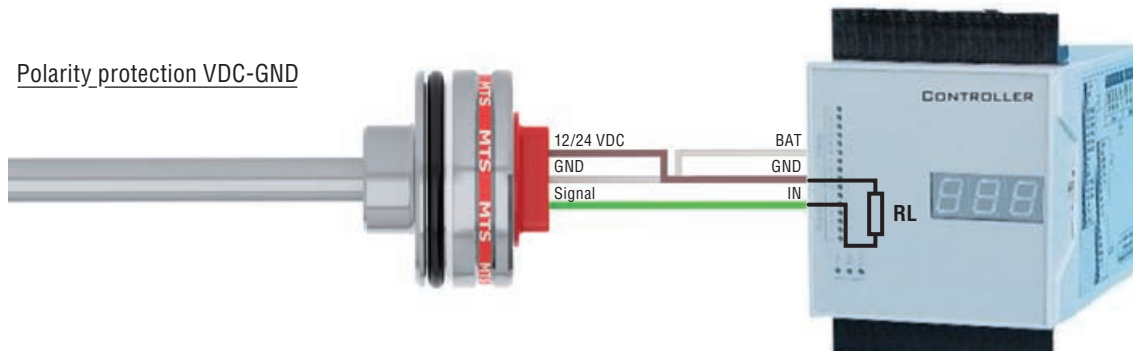
| VDC                    | mA                  |
|------------------------|---------------------|
| RL > 10 kΩ @ 12/24 VDC | RL < 250 Ω @ 12VDC  |
|                        | RL < 500 Ω @ 24 VDC |

Please pay attention to connecting sequence!



| Order | Wire color | Assignment |
|-------|------------|------------|
| 1     | BN         | 12/24 VDC  |
| 2     | WH         | GND (OV)   |
| 3     | GN         | Signal     |

##### Polarity protection VDC-GND



Protection against wrong polarity of VDC-GND is always ensured. Signal must always be connected to the controller input.

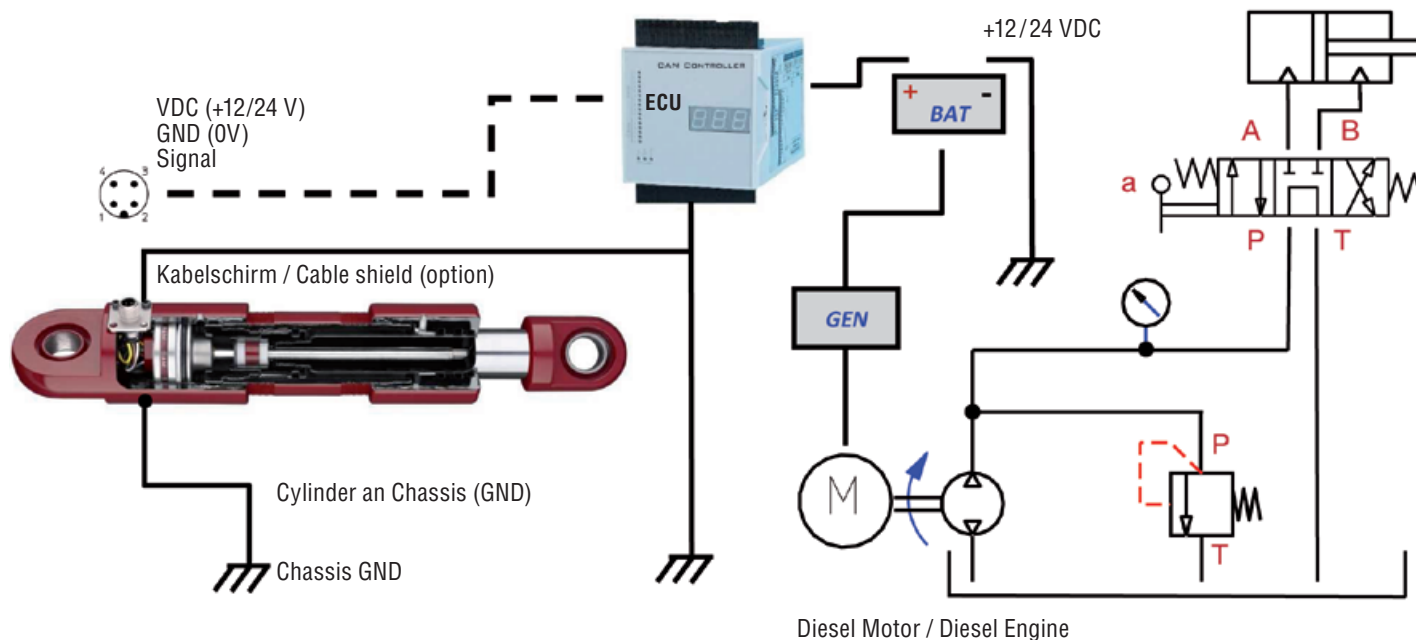
4.3 Diagram for connection to the vehicle electronics

**Machine ground**

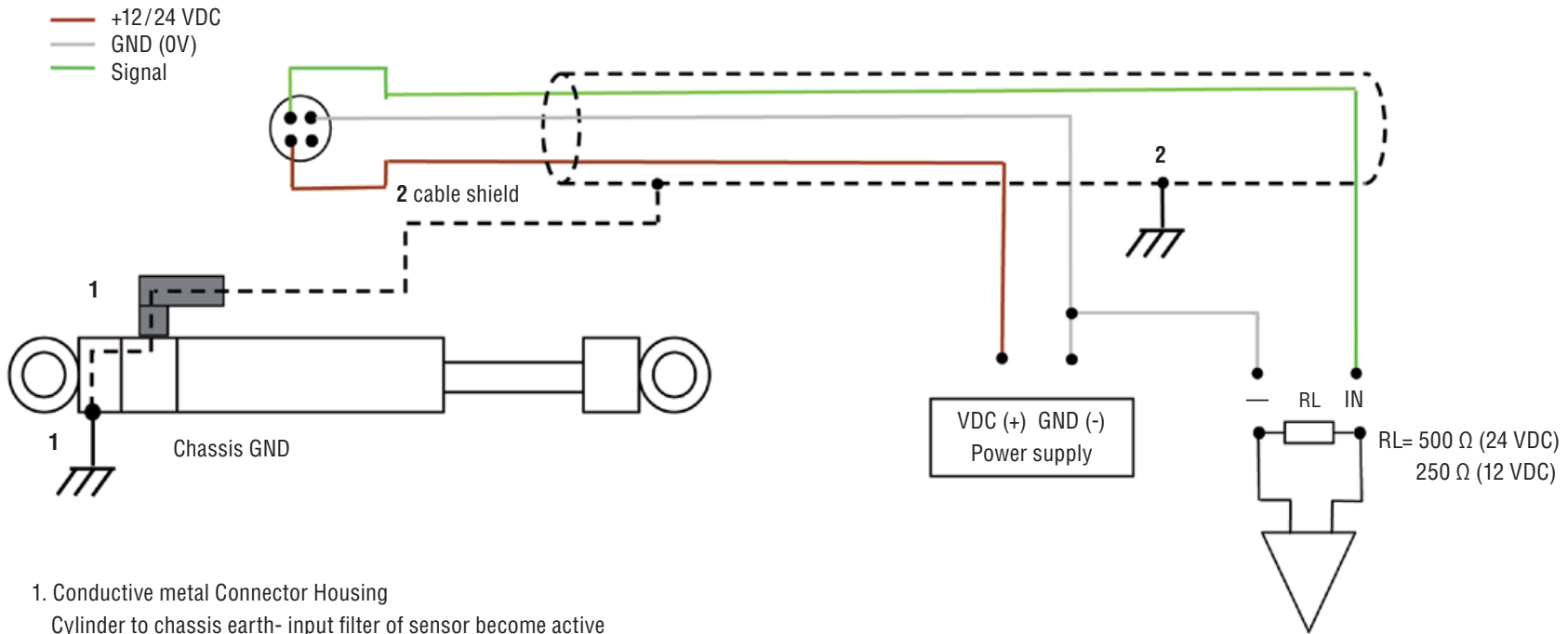
To ensure perfect operation of the sensor, the hydraulic cylinder must be connected to the machine ground. Equipotential bonding is often ensured by the mechanical contact between the cylinder and other machine elements. If the cylinder is connected with the machine separately, separate grounding, for example via a grounding strap directly on the cylinder must be ensured.

**Cable shielding**

In the installed condition, the sensor is shielded sufficiently by the metal hydraulic cylinder. For this reason, no separate shielding is taken via the M12 connector. If a shielded cable is used, certain applications may require checking, if both ends of the shielding must be connected to the machine ground. When checking, the effect of any high voltage and high frequency field in the vicinity on the shield and on the signals in the cable should be taken into account.



- Electrical power supply from battery (charged by generator)
- Load dump protection and EMC requirements acc. to vehicle standards



Signal GND and power supply GND (E.g. mA-signal)

1. Conductive metal Connector Housing  
Cylinder to chassis earth- input filter of sensor become active
2. Cable shield connected to chassis GND on both sides:  
Protection against electro-magnetic interference

| Shortcut                 | Sensor | ECU |
|--------------------------|--------|-----|
| Signal to Chassis (GND)  | ☺      |     |
| +24 VDC to Chassis (GND) | ☺      | ☹   |
| GND to Chassis (GND)     | ☺      |     |

Within the ECU a protection from +24 VDC to Chassis GND must be installed.

## 5. Operation and function

### 5.1 Filter circuitry (noise)

Any resistor causes for example thermal noise, which is more or less evident at the output of the circuitry if amplified accordingly. Additionally, external effects such as the supply voltage ripple or electro-magnetic fields in the immediate vicinity can affect the noise spectrum.

To minimize noise, the use of a filter is mandatory with analog measurement. A suitable solution for noise suppression is the following filter with a limiting frequency of approx. 3 kHz. (noise reduction factor 3.6 - see figure below). The signal delay is within the cycle time and changes the dynamic behavior only insignificantly.

#### Sensor with analog output

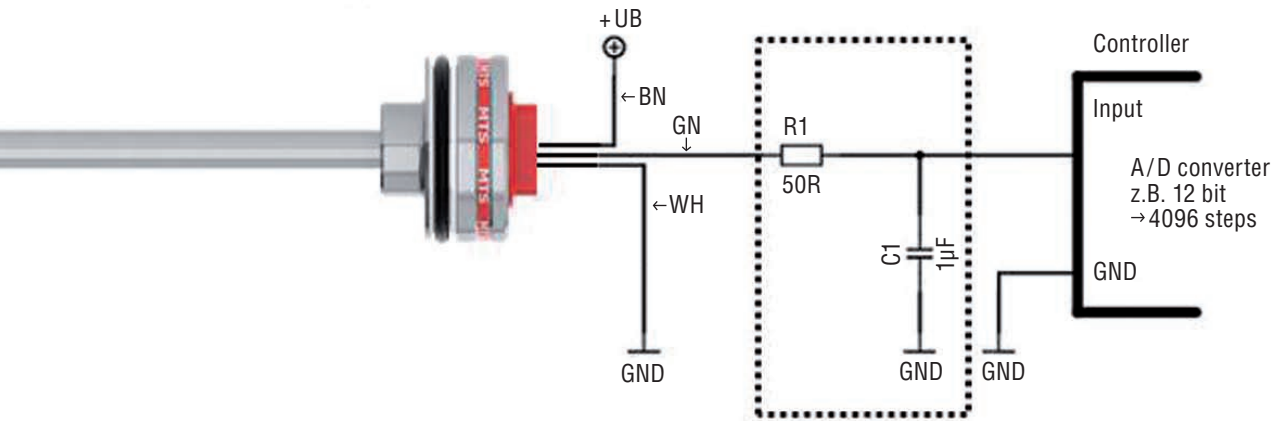


Fig.: Filter at the controller input

**Please pay attention:** The resolution of the sensor output is influenced by the A/D converter of ECU input.

- e.g. 8 bit = 256 steps
- 10 bit = 1024 steps
- 12 bit = 4096 steps

#### Signal output characteristic during power up time:

The sensor is ready to run after the power up time.

Within the power up time the output signal is ‚high‘: the indicated value is  $\geq$  F.S.O = Full Scale Output.

| Output type | F.S.O     | Output „high“ |
|-------------|-----------|---------------|
| mA (A01)    | 20 mA     | 22 mA         |
| VDC (v11)   | 4.75 Volt | 4.85 Volt     |
| VDC (v12)   | 4.50 Volt | 4.60 Volt     |
| VDC (v02)   | 9.50 Volt | 9.65 Volt     |

#### Inrush current/selection of suitable fuse

To select the correct fuse, please pay attention to the maximum current load and response time. The short time inrush current peak must be considered when the sensor is in power on mode.

Please pay attention to actual valid data sheets and specifications!

## 5.2 Set point tolerance zero to full scale

At MTS, the sensor set points are calibrated with a tolerance of  $\pm 1$  mm. When installing in cylinders, please note that any additional tolerances must be taken into account. During teach-in, all tolerances in the cylinder-and-sensor system are eliminated. The piston rod drives towards the zero or full scale. The measured signals are programmed accordingly in the controller.

During operation without teach-in, the following tolerances should be taken into account (values are applicable to magnet 401032):

### Example: Measuring range 400 mm

(Signal span 4000 mV)

Signal: 0.5 – 4.5 V  
Span: 4000 mV  
Set point tolerance (SP):  $\pm 1$  mm  $\hat{=}$  10 mV  
Magnet tolerance (M):  $\pm 1$  mm (max.)  
Cylinder tolerance (Z):  $\pm 1$  mm

SP: : typ. zero or full scale tolerance  
M: max. tolerance of the magnet  
Z: adequate tolerance of the magnet

Electric signal with all tolerances:  
 $M + Z + SP = 3$  mm

$3$  mm  $\hat{=}$  30 mV

(Signal span 16mA)

Signal: 4...20 mA  
Span: 16 mA  
Set point tolerance:  $\pm 1$  mm  $\hat{=}$  0,04 mA  
Magnet tolerance:  $\pm 1$  mm (max.)  
Cylinder tolerance:  $\pm 1$  mm

Electric signal with all tolerances:  
 $M + Z + SP = 3$  mm

$3$  mm  $\hat{=}$  0,12 mA

Please ask for tolerances of other magnet types.

### 5.2.1 Set point tolerance VDC, e.g. 400 mm

@ Zero: 0,5 V  $\pm$  30 mV

For the zero, the permissible tolerance is: 0.5 V  $\pm$  30 mV

@ Full scale: 4.5 V  $\pm$  30 mV

For the full scale, the permissible tolerance is: 4.5 V  $\pm$  30 mV

|      | Min    | Max    |
|------|--------|--------|
| Null | 0.47 V | 0.53 V |
| F.S. | 4.47 V | 4.53 V |

### 5.2.2 Set point tolerance mA, e.g. 400 mm

@ Zero: 4 mA  $\pm$  0.12 mA

For the zero, the permissible tolerance is: 4 mA  $\pm$  0.12 mA

@ Full scale: 20 mA  $\pm$  0.12 mA

For the full scale, the permissible tolerance is: 20 mA  $\pm$  0.12 mA

|      | Min      | Max      |
|------|----------|----------|
| Null | 3.88 mA  | 4.12 mA  |
| F.S. | 19.88 mA | 20.12 mA |

After installing the sensor in the cylinder, the deviations from the required signal values are within the defined tolerances. These deviations must be taken into account by the control systems, or when determining limit values.

| Typical values       |     |     |      |
|----------------------|-----|-----|------|
| Cylinder stroke (mm) | 250 | 500 | 1000 |
| Tolerances (mV)      | 50  | 30  | 15   |

| Typical values       |      |      |      |
|----------------------|------|------|------|
| Cylinder stroke (mm) | 250  | 500  | 1000 |
| Tolerances (mV)      | 0.20 | 0.10 | 0.5  |

### 5.3 Insulation checks

Part of the testing performed on off-road mobile machinery can be insulation checks. During these checks, high voltages are applied to determine the dielectric strength of the cables against the housing (insulation resistance). For testing, all connecting cables must be disconnected from the sensors. Otherwise, stray voltage flowing through the sensor protective circuitry against ground can cause damage or failure of these components and of the sensors.

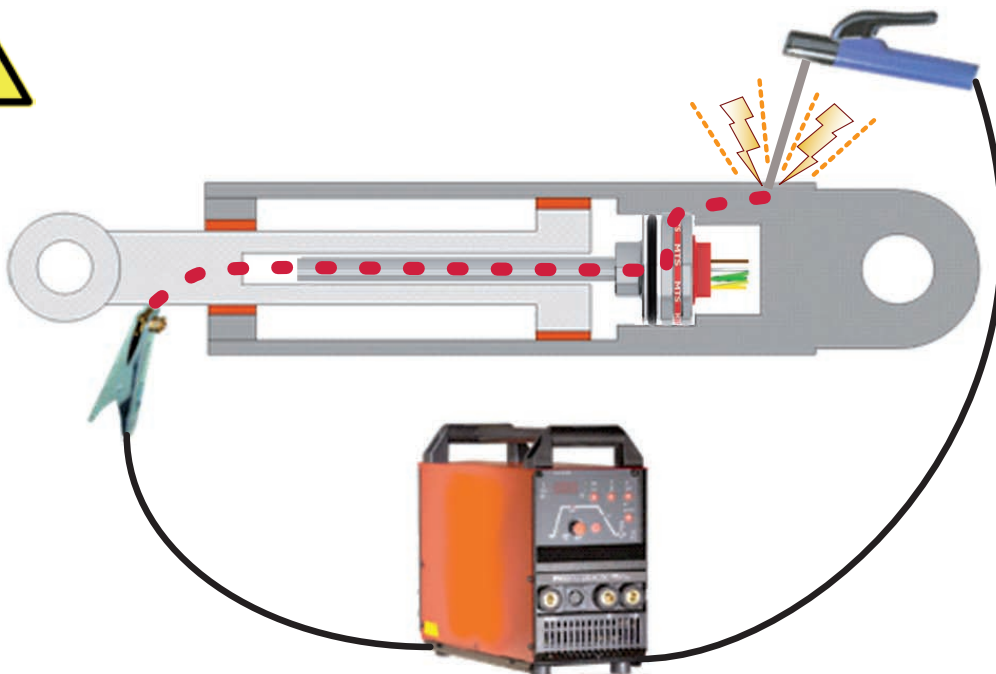
### 5.4 Welding



After installing the cylinder in machines, welding work on adjacent components can be necessary. If a grounding tong is applied directly or too closely to the cylinder, welding currents can be transmitted to the sensor via the cylinder and cause burning of the sensor pipe or damage of internal sensor components. Cylinders mostly consist of two assemblies: the lower part with the cylinder pipe (Figure, shown in dark gray) and the piston with the piston rod (light gray). These components are isolated electrically from each other by gaskets, bearings and slide rails. This means that, normally, no current flow is possible. With cylinders, however, the welding current may be transmitted from the piston to the cylinder pipe. In this case, an electrical connection causes the entire welding current to flow through the sensor pipe and the sensor head, thus damaging the electronics. Moreover, the cylinder and/or the gaskets are destroyed.

**For this reason, the instructions given below must be followed:**

- Cut or disconnect all sensor connections during welding.
- Never fasten the grounding point at the piston rod or at the cylinder pipe.
- Never perform welding work on a part of the cylinder, if a sensor has been installed.
- Never perform welding work near a cylinder, if a sensor has been installed.
- Due to isolating bearings, plastic slide bearings or grease in the contact points, electric potentials/voltages can build up at every bearing point of machines. Accordingly, similar effects as on hydraulic cylinders can be produced.



## 6. What should be done in the event of functional disorder?

### 6.1 Typical installation faults/consequences

| Cause  | Consequences   |
|--|--|
| Faulty pin allocation                                | No signal  |
| Ambient temperature too high                         | Possible damage to components – no sensor signal   |
| Cylinder borehole too small                          | Component damage, because the sensor has been hammered down too violently.   |
| Cylinder borehole after welding too small            | Component damage, because the sensor has been hammered down too violently.   |
| Pointed or sharp edges                               | Damage to cables and conductors  |
| Rude sensor handling                                 | Destruction of internal components, cables and connectors  |
| Welding after installation                           | High-energy voltage peaks or currents are fed to the sensor head, damage of housing components or electronics components.              |
| Destruction of cables                                | Short circuit, electronics failure   |
| Untight connectors                                   | Liquid can penetrate into the sensor housing through cables or strands and cause short circuit or corrosion of electronics components. |
| Distance washers missing or installed in wrong order | Signal offset $\approx$ 5 mm   |
| Faulty ground /shield connection                     | Output signal trouble or destruction of the electronics  |

## 6.2 Checking the sensor function

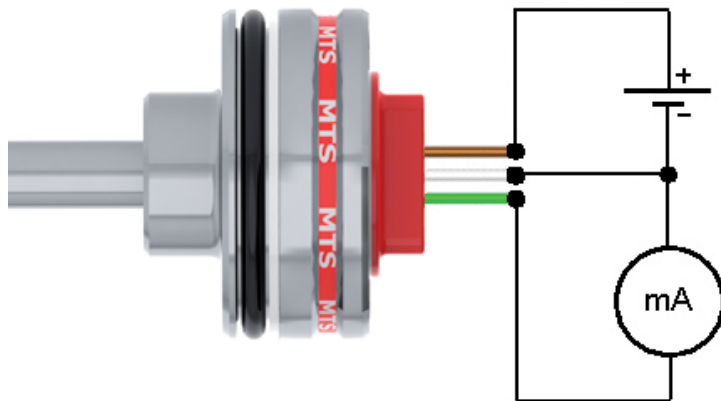
### Analog sensors (current or voltage output and PWM)

- Check the connections and the pin allocation
- Check the supply voltage
- Disconnect the sensor and test it in connection with an external power supply (e.g. car battery)
- Use a Temposonics® test unit. The operating instructions of the test unit are available for downloading from the log-in area under [www.mtssensor.com](http://www.mtssensor.com)
- Use the multimeter in accordance with the explanation.



### Measuring the 4...20 mA output signal

Measure the 4...20 mA output signal using a multimeter and select the mA measuring range. Connect the multimeter with the green signal conductor and the white 0 V conductor. Connect the (+12/24 VDC) supply voltage to the brown conductor and 0 V (-0 V) to the white conductor.

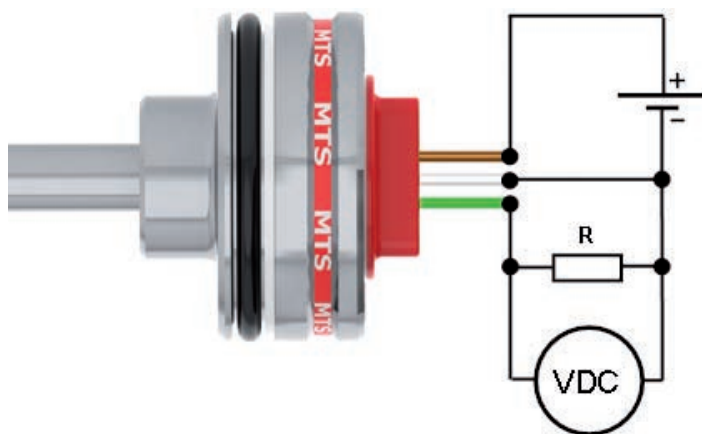


Supply voltage  
12/24 VDC

**Measuring using a multimeter (mA)**

Multimeter

Alternatively, the 4-20 mA output signal can be measured using a resistor (e.g. 100 Ω), which is connected with the green signal conductor and the white 0 V conductor. Now, select the VDC measuring range of the multimeter and connect the multimeter in parallel to the resistor.



Supply voltage  
12/24 VDC

**Measuring using a multimeter (VDC) and a resistor**

Multimeter

Example:

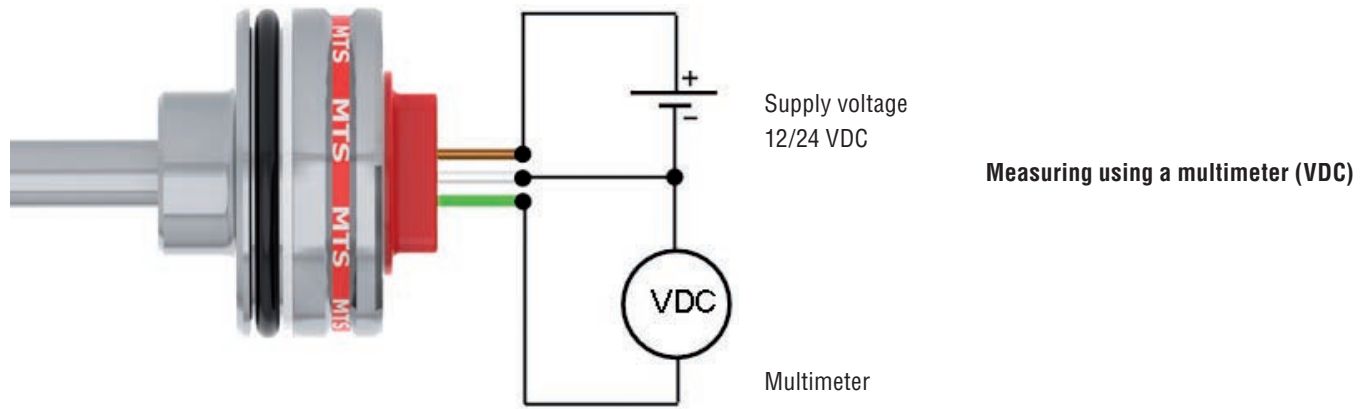
With a 100 Ω resistor, the following values are displayed.

| Supply voltage | at 4mA (Null Zone) | at 20mA (End Position) |
|----------------|--------------------|------------------------|
| 12 VDC, 24 VDC | 0,4 V              | 2 V                    |



**Measuring the VDC output signal**

Use a multimeter and select the VDC multimeter measuring range to measure the output signal (0.25 – 4.75 VDC; 0.5 – 4.5 VDC and 0.5 – 9.5 VDC). Connect the multimeter with the green signal conductor and the white 0 V conductor. Connect the supply voltage (+12/24 VDC) to the brown conductor and 0 V (-0 V) to the white conductor.



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