![Temposonics logo] **Temposonics**
AN AMPHENOL COMPANY

Operating Manual

MH Series - Temposonics® MH Digital CANopen, CANopen Safety, SAE J1939

Magnetostrictive Linear Position Sensors

Contents

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.

① Temposonics®
   Connector system (IP69K)   ② Flange housing   ③ Position magnet   ④ Pressure pipe
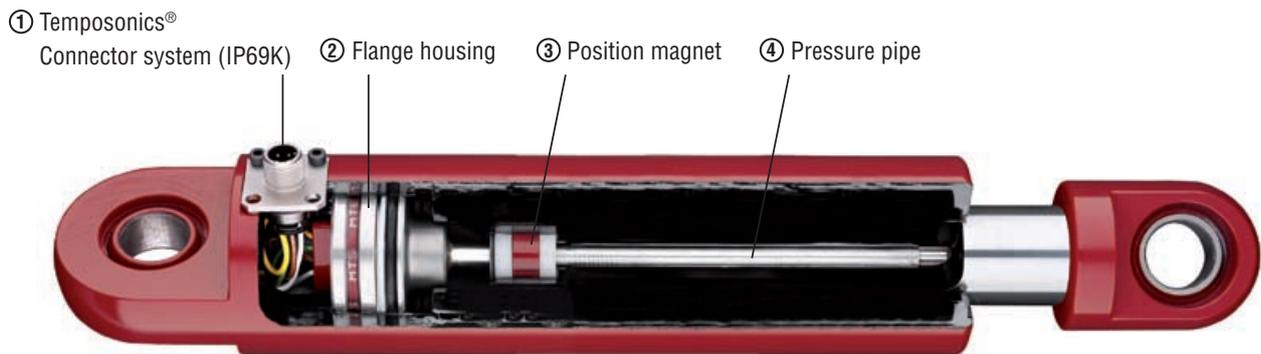
Simple Mechanics

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
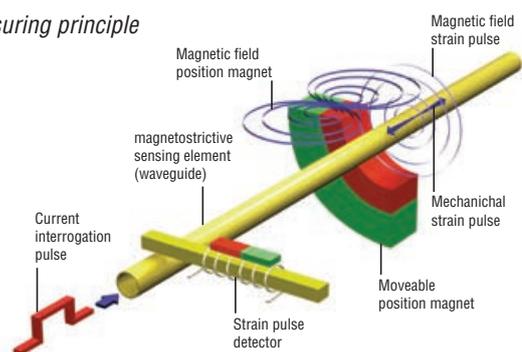
2. Temposonics® MH series digital

Temposonics® MH series sensors are designed for hydraulic cylinders. With the digital output configuration they are qualified to operate on electronic controls of mobile machines. Sensors with different bus protocols CANopen, CANopen Safety and SAE J 1939 are suitable for network 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 tewarranty 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 documenta-
  tion.

** see MTS sales and supply conditions, e.g. available for download from www.mtssensor.com

Symbols

Symbol	Meaning
i	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 sensors are equipped with an M12 connector. For simple connection to a CAN bus, the connector pin allocation is in compliance with the CiA-DR 303-1 specification.

⚠️ Detailed information on the mechanical installation of the sensor into the mobile hydraulic cylinder is given in the installation manual. 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 diagram

Connection type: M12x1 connector system, 5-pin connector

Pin assignment M12 connector

	F	S
12 / 24 VDC	2	1
GND	3	3
CAN_HI	4	4
CAN_LO	5	2
n.c.	1	5
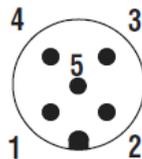
Fig. Core output of MH sensors CANbus

4.2 Order of connection

MH sensor with digital output

Correct Connection
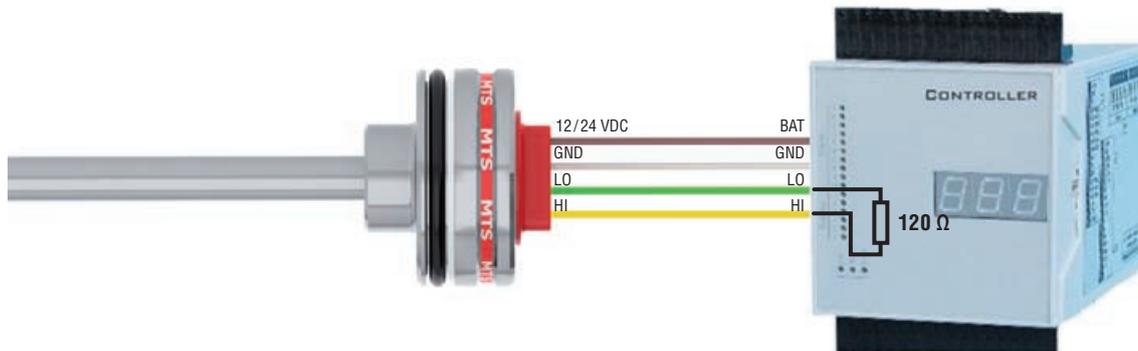
Please pay attention to connecting sequence!

Order	Wire color	Assignment
1	BN	12 / 24 VDC
2	WH	GND
3	GN	CAN_Lo
4	YE	CAN_Hi

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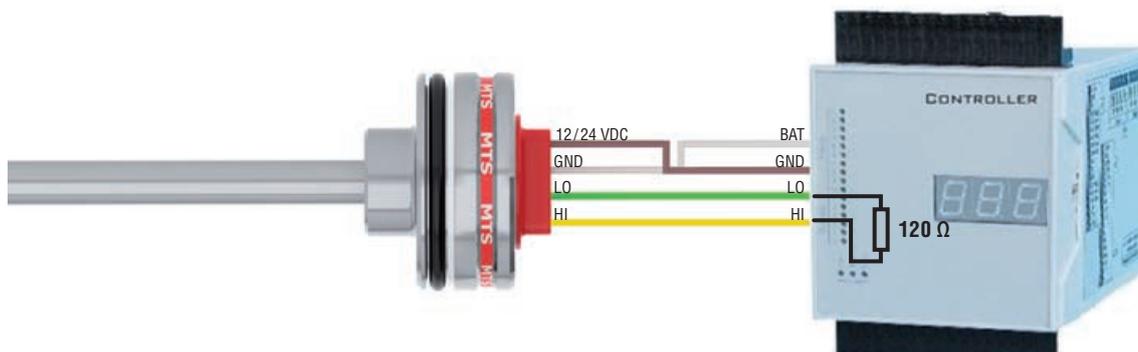
Protection against wrong polarity of VDC-GND is always ensured. The signal must always be connected to the controller input.

4.3 Bus termination / Network connection

In a 2-wire bus system like a CAN bus, serial data transmission is used, whereby the voltage difference between CAN_HI and CAN_LO is the bit information. To attenuate signal reflections at the open end of the bus, the data lines must be connected using a 120 Ω terminating resistor. The resistor should be inserted between the CAN_HI and CAN_LO data lines.

4.4 Connection in the network

Node ID: 01

Node ID: 10

Node ID: 7F

12 / 24 VDC
GND
HI
LO

12 / 24 VDC
GND
HI
LO

12 / 24 VDC
GND
HI
LO

BAT
HI
LO
GND

CONTROLLER

120 Ω
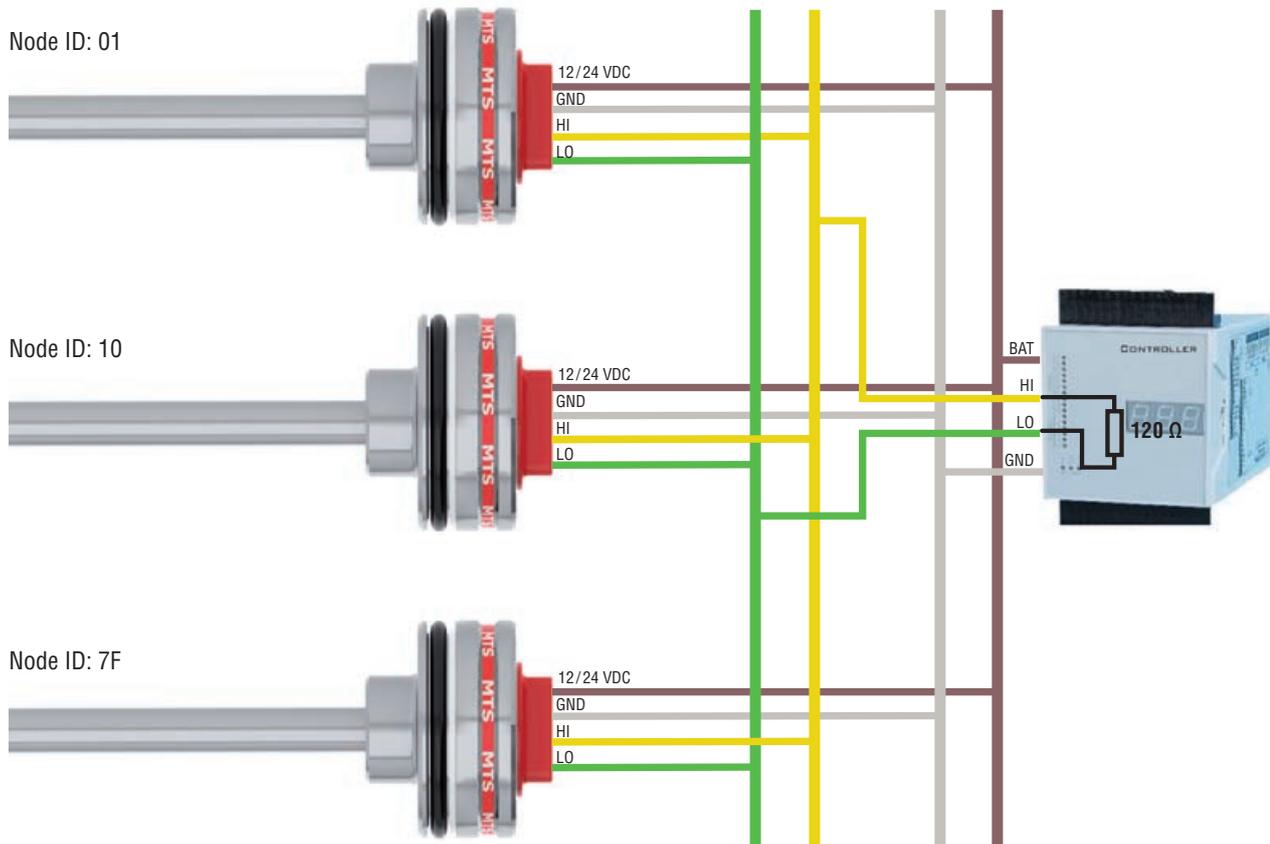
Caution!
Please pay attention to individual Node ID's in network.

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.

VDC (+12/24 V)
GND (0V)
Signalausgang / Signal out

Kabelschirm / Cable shield (option)

Cylinder an Chassis (GND)

Chassis GND

ECU

+12 / 24 VDC

BAT

GEN

M

Diesel Motor / Diesel Engine

A   B

a

P   T

P

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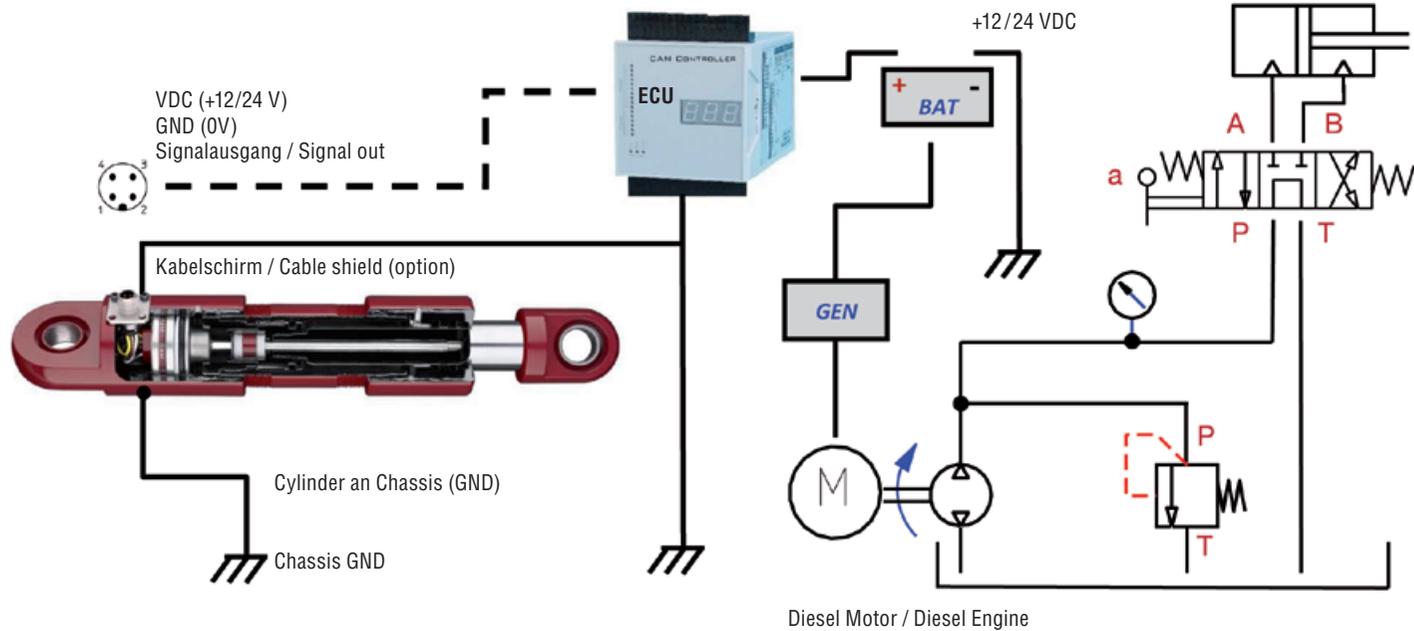
- Electrical power supply from battery (charged by generator)
- Load dump protection and EMC requirements acc. to vehicle standards

+24 VDC
GND (0V)
LO
HI

2 cable shield

1

1

Chassis GND

2

VDC (+) GND (-)
Power supply

HI   RT   LO

RT= 120 Ω

Input Controller
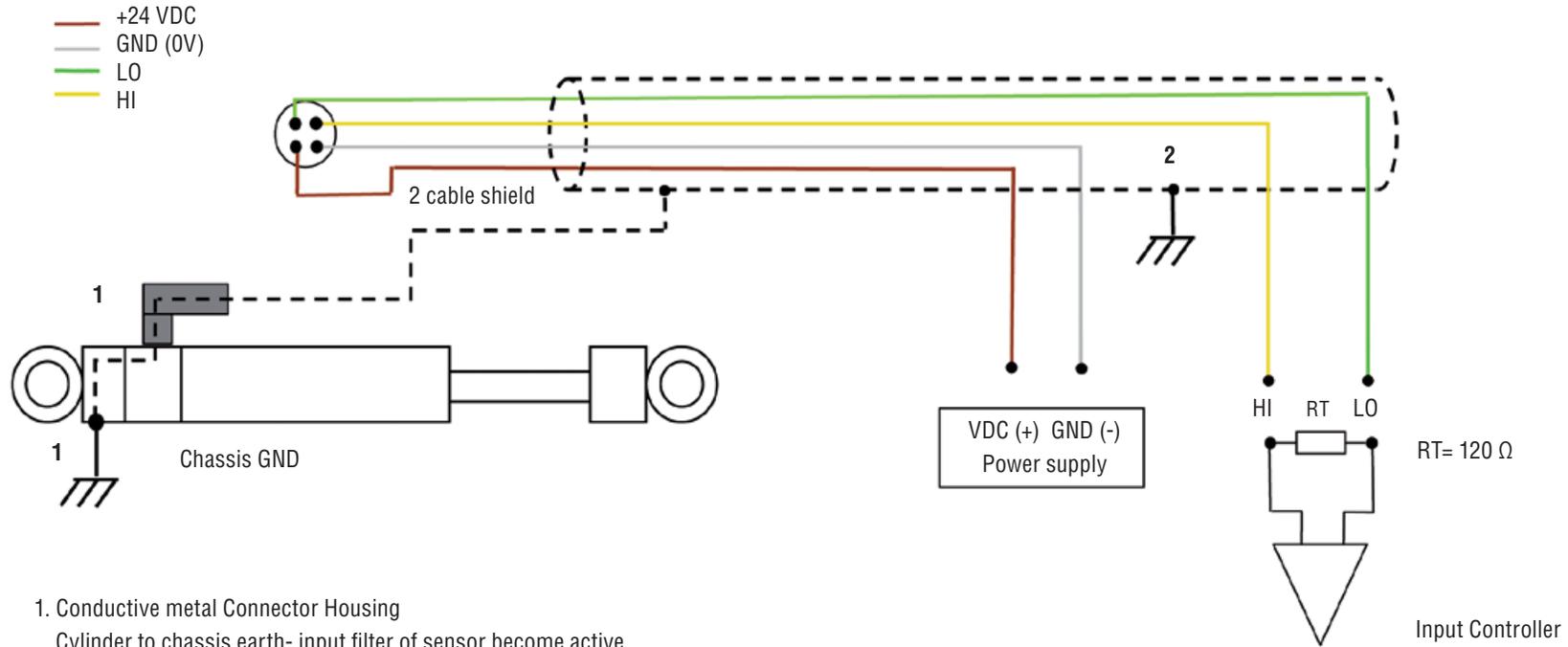
1. Conductive metal Connector Housing
   Cylinder to chassis earth- input filter of sensor become active.

2. Cable shield connected to chassis GND on both sides:
   Protection against electro-magnetic interference.

Shortcut	Sensor	ECU
HI / LO 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 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.

5.2 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.
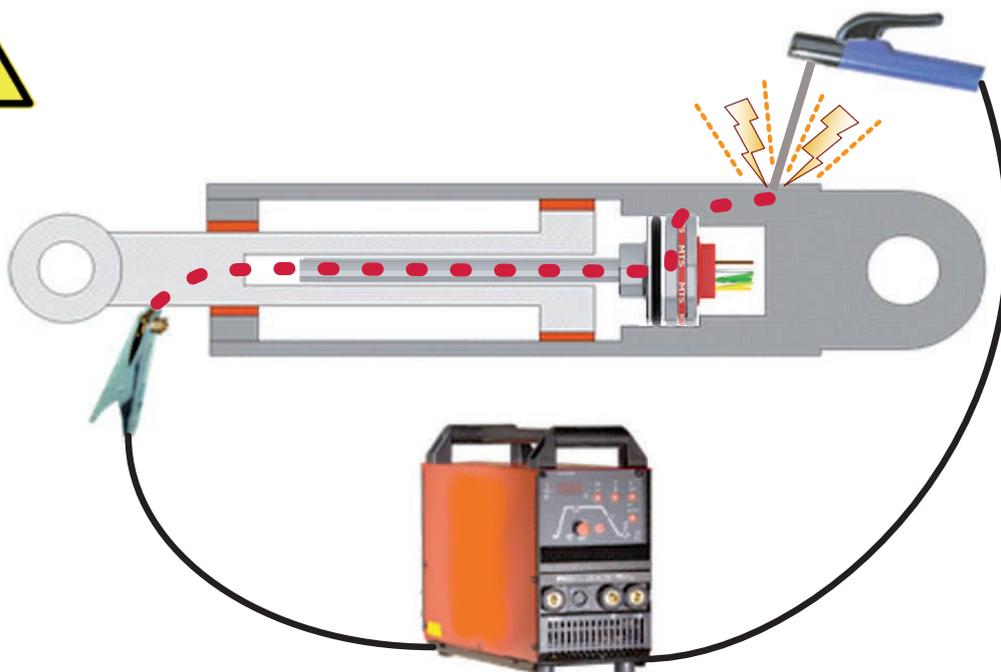
6. What should be done in the event of functional disorder?
6.1 Typical installation faults and their consequences

Cause	Consequences
Faulty pin allocation	No signal
Ambient temperature too high	Component failure
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 cores
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	Liquids 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 = 5 mm
Faulty connection of ground / shield	Output signal trouble or destruction of electronics

6.2 Test and programming

A separate test device can be used for testing the sensor functionality. For function testing, and in order to minimize the sources of trouble during testing, the test device should be connected to the sensor only directly. Via a PC, the sensor function can be tested and basic sensor settings (node ID, baud rate, cycle time) can be realized very easily.
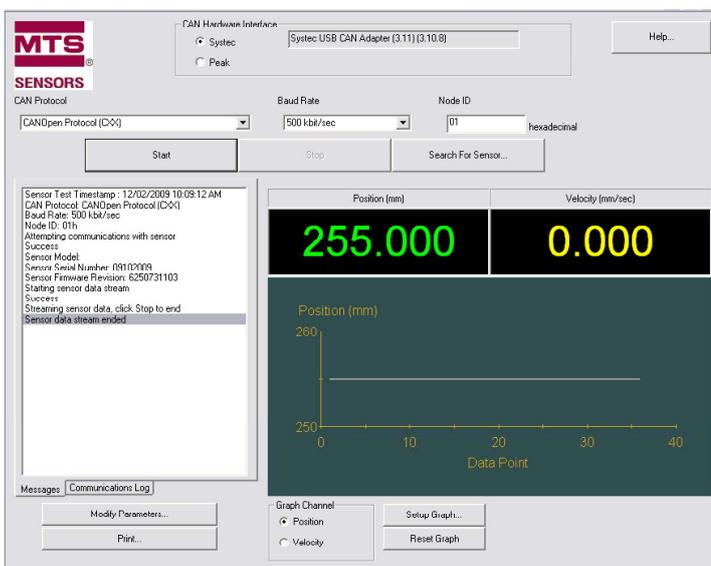
Fig. Software of the Temposonics® MH series CAN test kit (order number: 254267)

7. CAN Bus protocols

The ISO 11898 international standard CAN bus (Controller Area Network) is a machine level, open field bus for fast serial data transfer between a central process control system (master) and decentralized intelligent field instruments (slaves). Various protocols, which have been developed for a variety of applications and by different user groups can be used for data transfer.

Depending on order, Temposonics® MH sensors support the following protocols: CANopen, CANopen Safety or SAE J1939. The selected config-uration affects the integration into the network and the operating characteristics of the sensor. According to the specific version, the following commissioning and control procedure is required.

> **i** Please take notice of the following programming instructions:
> 901 491 SAE J1939, 901 492 CANopen Safety, 901 493 CANopen

8. System description and modes of operation

CANopen

The CANopen version of the Temposonics® MH sensor is suitable for operation as a slave in CAN bus networks using the CiA Stan-dard DS 301 V3.0 data protocol. The protocol corresponds to the DS 406 V3.1 encoder profile. The sensor is directly connected to the bus, thus representing a node in the bus system.

Four different modes of operation that correspond to the states defined in the CANopen standard are used. Initiated by the control-ler, these network modes are:

Initialization: Sensor starting phase. The sensor undergoes hardware initialization and loads the standard configuration which has been saved previously.

Pre-Operational: In this mode, the sensor can be configured via the CAN bus.

Operational: In this mode of operation, the sensor sends process data. The sensor loads measurement information onto the CAN bus.

Stopped: When this mode has been activated, the sensor stops communicating and waits for further commands.

CANopen Safety

For safety-relevant applications, the CANopen safety protocol (EN 50325-5) has been specified as a further development of CANopen. The pro-tocol corresponds to CiA standard DS 304. Temposonics® sensors with CANopen safety implementation are certified according to SIL2 (IEC/EN 61508) and can be used in safety-critical areas. Fundamentally, the protocol is based on the CANopen protocol, however, only certified compo-nents may be used.

The protocol enables safety oriented devices to be used together with devices that aren't safety-oriented in CANopen network. In this way, reli-able control systems similar to those realized in conventionally wired technology can be implemented. For this purpose, safety-critical data is transmitted redundantly.

SAE J1939

SAE J1939 is a multi-master protocol developed especially for applications in the mobile field. The specification has been developed by the Soci-ety of Automotive Engineers and is used for commercial and conveyor vehicles as well as for construction, agricultural and forestry machines.

A network consists of various ECUs (Electronic Control Units), each of which is able to control several CAs (Controller Applications). Messages are addressed to a CA. After starting the operation, automatic assignment of the bus sharing units takes place. When it has been completed, the CAN bus sharing units are fully operable.

9. Communication objects

CANopen & CANopen Safety

The information flow of function data and user-specific information is subject to a data protocol according to OSI model (ISO 7498). The CiA (CAN in Automation) user organization is in charge of the CAN bus technology and its further development.

During the „operational" mode of operation, the evaluation electronics integrated in the sensor convert the measured information into CAN messages and send them onto the bus, where the information is read and processed by the control system. For this purpose, the characteristics and functions of the sensor are stored in the internal object directory (see below).

The CAN bus uses the following communication objects for data transfer on the bus:

SDO (Service Data Object)
parameters relating to the sensor configuration are introduced or read using the SDO. This is performed by access to the internal object directory of the sensor. To process SDOs, the sensor must be in the „pre-operational" or „operational" mode.

PDO (Process Data Object)
The real-time data transfer of position and velocity states is performed by PDO messages and generated in operating condition ‚operational' only.

NMT (Network Management)
for control of the network and individual component status. Can be also used for monitoring using the following objects:

SYNC-Object
synchronizes the bus communication, i.e. synchronous PDOs are sent to the control system after receiving a SYNC object.

Heartbeat-Object
The Heartbeat Object is for error control purposes and signal the presence of a node and its state. The Heartbeat is a periodic message of a device to one or several other network nodes. It indicates that the sending node is still working properly.

Emergency-Object
sends error messages. As the priority of error messages is generally higher than the priority of PDOs, error messages are transmitted prior to PDOs.

The structure of a message in the CANopen protocol is as follows:

SOF	Arbitration	Control	Data field	CRC	ACK		EOF	Interframe space
1	11	1	6	0..8 Bytes	15	1	1	1	7	≥ 3

Fig. CAN bus data protocol

CANopen Safety – Redundant Data Transmission
To meet the high safety requirements for SIL applications, the CANopen Safety protocol provides redundant data transmission of safety-critical information. The safety functions are realized via special communication objects termed SRDOs (Safety Related Data Objects).

SRDO (Safety Related Data Objects)
For detection of transmission errors, messages are transferred redundantly in SRDOs. Each data set is sent in two separate messages, whereby the second message is sent bitwisely inverted with a different identifier. The interval at which two SRDOs are sent is predetermined by the SRVT (Safety Related Validation Time) and the SCT (Safeguard Cycle Time). This interval between two SRDOs must not be exceeded, otherwise the SRDO is not valid and rejected by the receiver.

SAE J1939

SAE J1939 is provided with extended message arbitration. Compared to CANopen, the message identifier has been extended to 29 bits. Due to this protocol extension, different message prioritization and assignment of bus sharing units is implemented. For large quantities of data, in particular, utilization of a separate transport protocol is possible. The communication objects are:

PDU (Protocol Data Unit)
In general, the protocol distinguishes two types of messages. The PDU1 message format is used for peer-to-peer data transmission. Messages in PDU2 format are addressed to all bus sharing units.

PG (Parameter Groups)
Process data and parameters in a message are transmitted in groups. This means that a standard set of parameters is read or transmitted with a message. This parameter group data structure determined in the protocol permits an efficient bus load.

PGN (Parameter Group Number)
PGN is used for explicit and standardized identification of parameter group.

SPN (Suspect Parameter Number)
Is given by protocol and used for unique identification of parameter signal. Hereby all J1939 compatible devices are informed about the parameter structure.

TP (Transport Protocol)
is used for separate data transmission above 8 Bytes.

According to the SAE J1939 protocol, a message has the following structure:

PDU									
SOF	Arbitration identifier					Control	Data field	CRC	ACK	EOF
1	Priority 3	2	PDU Format 8	PDU Specific 8	Source 8	6	0..8 Bytes	15	1	1	1	7

Fig. CAN bus data protocol with J1939 identifier

10. Starting the operation

After having performed the electrical connection to the network, the sensor is ready to start the operation and configuration. Prior to the actual system start-up, however, the communication parameters for operation in the CAN bus must be set. Only the basic procedure is described in these operating instructions. For the applicable commands used to realize the sensor setting, please, refer to the enclosed programming instructions.

10.1 Node parameter setting

CANopen & CANopen Safety

To operate the sensor in the CAN bus, the network characteristics must be defined. The basic settings for integration of a bus sharing unit are made using LSS (Layer Setting Services). Each sensor (node) in the CAN network is provided with a unique definition due to its LSS address. This address is composed as follows.

LSS Adress:

	CANopen	CANopen Safety
Vendor-ID	0x40	
Product-code	Cxx 0x43787800	Sxx 0x53787800
Revision number	1.01 0x312E3031	2.00 0x322E3030
Serial number	e.g. 04301234	

Moreover, parameters specific to the CAN bus, such as baud rate and node ID are configured and saved via the LSS service. Both the baud rate and the node ID of the sensor must be configured for operation in the particular CAN bus.

Setting the Node ID
A number (node ID) must be assigned to each node. The number is used for identification of the node in a CANopen network. Each individual node ID must be unique. The node ID CANopen is within a range of 1-127, the node id CANopen Safety is within a range of 0 - 64, and can already be preset when ordering. To enable correct operation of the network, the node ID in the CAN bus must be unique.

The node ID of the sensor can be set using the following command sequence:

CANopen

Data source	COB-ID	Data	Destination
Controller	0x7e5	04; 01; 00; 00; 00; 00; 00; 00	Sensor
Controller	0x7e5	11; **7d***; 00; 00; 00; 00; 00; 00	Sensor
Sensor	0x7e4	11; 00; 00; 00; 00; 00; 00; 00	Controller

* Node address values within 1 and 127 are possible (e.g. 125).
  Changes of the node address are effective immediately.

To save the node address permanently, the following command must be sent:

Data source	COB-ID	Data	Destination
Controller	0x7e5	17	Sensor
Sensor	0x7e4	17; 00; 00; 00; 00; 00; 00; 00	Controller

While programming the node id only one user can be connected.

Setting the Baud Rate
The baud rate indicates the speed at which the sensor and the entire CAN bus are operated. Setting the same baud rate both for the sensor and for the entire network is mandatory.
The maximum possible baud rate and thus the transmission capacity is limited by the cable length of the overall CAN network. The sensor is delivered with a preset, order-dependent baud rate. If this baud rate must be changed, this can be performed via the LSS service.

Wire length	Baud rate [kBit/s]	Table index
< 25 m	1.000	00
< 50 m	800	01
< 100 m	500	02
< 250 m	250	03
< 500 m	125	04
< 1000 m	50	06
< 2500 m	20	07
< 5000 m	10	08

Fig. Baud rate depending on the cable length (CiA DS 301)

Baud rate setting:

CANopen

Data source	COB-ID	Data	Destination
Controller	0x7e5	04; 01; 00; 00; 00; 00; 00; 00	Sensor
Controller	0x7e5	13; 00; **02***; 00; 00; 00; 00; 00	Sensor
Sensor	0x7e4	13; 00; 00; 00; 00; 00; 00; 00	Controller

* Table Index

After sending 'save network parameter' command and with following power on of the sensor the baud rate setting becomes active. To save the baud rate following command will be send:

Data source	COB-ID	Data	Destination
Controller	0x7e5	17; 00; 00; 00; 00; 00; 00; 00	Sensor
Sensor	0x7e4	17; 00; 00; 00; 00; 00; 00; 00	Controller

SAE J1939

In the SAE J1939 specification, the maximum length of the network is limited to 40 meters and the baud rate is fixed to 250 kBit/sec. This means that these parameters don't require setting during integration of the sensor.
Furthermore, the number of nodes is limited to 30 ECUs (Electronic Control Units). However, each ECU can control several CAs (Controller Applications). In total, an overall number of 253 Controller Applications can be realized in the network.

NMT (Network Management)
SAE J1939 supports extended network management. This management requires network registration (Address Claiming) by the bus sharing units with a unique address prior to starting the system. The regular bus operation is started only after all bus sharing units have logged in successfully. During operation, the correct address assignment is checked continuously. During operation, a new source address can be assigned. In addition to the source address, each bus sharing unit is provided with a unique name for identification in the network and for prioritization of the address determination. The name conventions are designed according to the SAE J1939/81 specification and composed as follows:

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4		Byte 5	Byte 6		Byte 7		
Identity Number		Manufacturer Code		ECU Instance	Function Instance	Function	Reserved	Vehicle System	Vehicle System Instance	Industry Group	Arbitrary Address Capable

Fig: structure on user in network acc. to J 1939

J1939

J1939: Setting the Source Address (sensor label: 07 20 01 23)

Data source	COB-ID	Data	Destination
Controller	0x10ff54d4	**01**; **nSA***; 23; 01; 20; 07; 00; 00	Transducer
Transducer		No response	Controller

* nSA: new Source Address

The setting of the nSA can't last longer than 750 ms, otherwise a timeout will occur.

10.2 System start

CANopen & CANopen Safety

After configuration of the node parameters, the sensor can be integrated into the network. When switching on, or after reset, the sensor undergoes hardware initialization. During this procedure, all components are set into a defined initial state. Subsequently, the sensor loads the instrument and communication-specific parameters from an EEPROM and saves them for configuration.

When the initialization has been completed, the sensor transmits a boot-up message to the network master saying that the sensor is now in pre-operational mode and including its node ID in the network. In this network, the sensor can be configured using the service data objects (SDOs) (see also: Setting the Operating Parameters).

According to the CANopen standard, the SDO identifiers are formed automatically using the node IDs. The communication via SDOs for configuration of the sensor represents peer-to-peer communication from the network master to the sensor.

The identifiers for the remaining objects are defined according to the CANopen standard as well. However, a change can be realized in the CANopen network at all times via a DBT master. If the need arises, changed parameters can be saved in EEPROM and are used for configuration automatically when switching on for the next time.

After completing the settings, the sensor is switched from pre-operational to operational mode using a Start_Remote_Node command. During this mode, data can be transmitted (via PDOs). There are two possible ways for transmission of the PDOs. Either the sensor sends its data cyclically, or data transmission is triggered by reception of a SYNC object.

i	To send position messages, please run ‚node start' message first

Data source	COB-ID	Data	Destination
Controller	0x000	01; **00***; 00; 00; 00; 00; 00; 00	Sensor

CANopen

* 00   Starts all node ID
Source address   Starts only one node ID

To stop position data's, send the ‚Enter Pre-Operational' message first.

Data source	COB-ID	Data	Destination
Controller	0x000	80; **00***; 00; 00; 00; 00; 00; 00	Sensor

* 00   Set all node ID in Pre-Operational mode
Source address   Set only one node ID in Pre-Operational mode

SAE J1939

After connecting the sensor to the network and switching on, the sensor attempts to register with the network master using a source address. This address claiming is performed automatically by the network. After assignment of a unique network address, the sensor starts sending the position data. At the same time, the sensor is ready for reception of configuration data.

10.3 Setting the operating parameters

CANopen & CANopen Safety

At system start-up (power-on, reset), the sensor saves the operating parameters stored in the EEPROM. When switching on, these are the factory-set parameters, or the data which has already been changed and saved. Changes are made e.g. via SDOs when the pre-operational mode is activated. The identifiers are set to the corresponding default value and saved automatically by programming the node ID. Subsequent revision is possible.

These operating parameters of the Temposonics® MH series are stored in the object directory of the sensor.

It serves as a basis for realization of the internal characteristics and functions and of the external communication. For this purpose, the object directory is divided into „Communication Profile" and „Device Profile".

Communication Profile
The Communication Profile contains the parameters decisive for communication, such as identifier settings, PDO configuration, etc. The sensor includes the encoder communication profile (Device Profile for Encoder – DS406 Vers. 3.1). The advantage: Devices supplied by various manufacturers can be connected in a network and replaced very easily, because all units with the same communication profile have mostly identical parameters.

PDO-Übertragungsart (Transmission Type)
By default, the PDO transmission type is set to asynchronous, i.e. the sensor transmits its process data independently according to the preset cycle time. However, the PDO transmission type can also be set for transmission of process data only after reception of a SYNC message.

PDO Objekt-Mapping
The sensor doesn't support dynamic mapping.
The preset mapping parameters cannot be changed.
PDO1 transmits the position and speed.

Error Messages
The position sensor sends emergency objects automatically as soon as there are errors.

Device Profile
Parameters which are important for sensor operation, e.g. position and speed resolution or cycle time are stored in the Device Profile. In this context, note that some operating parameters are important:

Resolution
After delivery, the sensor resolution is 100 µm. As standard, the resolution of the motion speed is set to 1mm/s.
For detailed information, see the programming instructions.

Cycle Time
The cycle time defines the transmission period for the asynchronous PDO. Values between 1 and 65535 ms can be selected.
A cyclic transmission of the position value is set, when the cyclic timer is programmed > 0. Changing the cycle time (Object 6200) cause a direct change of the PDO1 event timer. (see DS406 V3.0) Setting the cycle time shall match the configuration of the CAN network. A short cycle time, slow Baud rate and too many network users may lead to a bus overload.

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CANopen

Set the cycle time with following commands (e.g. 10, Node-ID = 127*)

Data source	COB-ID	Data	Destination
Controller	0x67f*	22; 00; 62; 00; 0A; 00; 00; 00	Sensor
Sensor	0x5ff*	60; 00; 62; 00; 00; 00; 00; 00	Controller

Save cylcle time: The command ‚save parameters' must be executed.

Data source	COB-ID	Data	Destination
Controller	0x67f*	22; 10; 10; 01; 73; 61; 76; 65	Sensor
Sensor	0x7ff*	60; 10; 10; 01; 00; 00; 00; 00	Controller

Hint: The answer of the sensor can last up to 600 ms.

For a detailed list of additional operating parameters and the possible settings, please refer to the programming instructions in section „Object Dictionary".

SAE J1939

The SAE J1939 sensor operating parameters can be set analogously to the CANopen sensor. The sensor can receive configuration messages during operation and saves the settings immediately after receiving the message. The following operating parameters are configurable:

Cycle Time (Transmission Repetition Rates)
The transmission Repetition Rate (Update Rate) is the interval at which a new position value is available at the sensor output. Depending on application and bus load due to other bus sharing units, it is recommendable to set the cycle time. The value is within a range of 0 - 65635 ms.

Set the cycle time with following commands (e.g. 100*)

Data source	COB-ID	Data	Destination
Controller	0x18B2**SAMA**	4D; 54; 53; 00; 64*; 00*; 00; 00	Sensor

SA – MH CAN J1939 standard sensor Source Address
MA – Master Source Address
*z.B. 64; 00: Bytes to configure transmission repetition rates

10.4 Sensor data during operation

CANopen & CANopen Safety

For data output, the Temposonics® MH series position sensor provides a process data object (PDO). The PDO includes the data for position and speed.

Data Format
The position data resolution is fixed to 100 µm and the resolution of speed data is 1mm/s. However, the adjusted values can be read out also under index 6005 of the object directory. Design is always as a 32-bit integer value for position data and as a 16 bit integer value for speed data.

Identifier	DLC	D0	D1	D2	D3	D4	D5
180h + NodeID	6	Position Magnet 1				Speed Magnet 1	

Fig. PDO allocation when using the default settings

The position and speed are calculated using the following formula:

Position [µm] = position value [counts] * 100µm
Speed [mm/s] = speed value [counts] * 1 mm/s

SAE J1939

For data output, the Temposonics® MH series position sensor provides a Data Record Message.

Identifier	DLC	D0	D1	D2	D3	D4	D5	D6	D7
0x18 PFPSSA	8	Position		Speed		Status	Error Code	Limit Status	0xFF

Fig. Allocation of parameter information to the PDU when using the default setting

PF – the PDU format is fixed to 255 (0xFF).

PS – PDU Specific can be 0-255 (0x00 - 0xFF)

SA – MH CAN J1939 standard sensor Source Address

10.5 Error messages (emergency object)

CANopen & CANopen Safety

Emergency objects are always sent when the internal error status register has changed (also if an error occurred and has been corrected). The object consists of 8 data bytes. It has the following structure:

Identifier	DLC	D0	D1	D2	D3	D4	D5	D6	D7
0x80 + NodeID	8	Error Code		Error register	Manufacturer-specific				

Fig. Structure of an emergency object

With Temposonics® MH series sensors, the following errors can occur in the emergency object:

Error code	Meaning
0x0000	Sensor operates correctly
0x5000	Device hardware error (if appropriate, no magnet)
0x6300	Data Set error

SAE J1939

SAE J1939 vSAE J1939 does not provide separate error objects. The error status is transmitted with each PDU that has been sent.

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Document Part Number:
551291 Revision B (EN)

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