M01-CAN

Pressure Transmitter

with

CANopen Interface

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1 History

Version	Date	Name	Change
1.00r0	06.03.08	MB	Document created
1.01r0	20.03.08	MB	Media temperature according to datasheet
1.02r0	19.05.08	AKR	Prefixes for physical units added (see 0x6131)
1.03r0	02.07.08	AKR	Meaning of status-bits added (see 0x6150)
1.04r0	29.07.08	AKR	Object 0x1005 (SYNC) is rw
1.04r1	14.10.08	AKR	Value for autozero added (see 0x6125)
1.05r0	19.02.10	AKR	Bitrates 40 kBit/s and 400 kBit/s added
1.05.r1	17.05.10	MB	Message PDO with signed values
1.05r2	03.12.10	AKR	Error description revised
1.05r3	18.03.11	AKR	Hint for “decimal digits” and “physical unit” added
1.06r0	11.04.11	AKR	chapter LSS added, information about bit rates added
1.07r0	16.08.11	AKR	- COB-ID emergency message is always ro - description of COB-ID in chapter *5.6* added - chapter *5.5 Configuration of the transmit PDO* added

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2 General

The pressure transmitter M01-CAN measures the physical quantity pressure. The range depends on the sensor which is used in the transmitter and is 25…800 bar. The measured value is transmitted on the CAN-Bus with the CANopen protocol. The transmitter takes 1000 samples per second, does filtering and converts the raw value into the output format.

The CAN2.0B interface is able to run up to a speed of 1 Mbit/sec with 11-bit and 29-bit identifiers.

The CAN protocol complies with the CANopen specification DS301, the pressure transmitter function is presented by the CANopen device profile DS404. The possible configurations can be set with the object dictionary. Heartbeat and emergency messages guarantee high reliability.

With the “Layer setting services” (LSS, DSP305 V2.0), the desired bit rate and node-Id can be set easily.

3 CAN Interface

The device includes a Full CAN controller specified to CAN 2.0B. The physical layer of the 2-wire interface is specified according to ISO 11898. The wires are protected against short-circuit. By adjusting the rise and fall times of the CAN signals, the noise emission is minimized. The bus termination resistor is *not* included in the device.

4 M01-CAN Specification

4.1 Supply Voltage +U_S

Supply voltage:	9…36 VDC, protected against reverse polarity
Current consumption at U_S = 24 VDC:	I < 50 mA typical, IMAX < 100 mA

4.2 CAN Interface

Physical layer:	2-wire interface, 5 V level according to ISO 11898 Protected against short-circuit
max. Bit rate:	1 Mbit/sec
Signal rise time:	Bit rate < 125 Kbit/sec 12 V/µsec (without bus) Bit rate ≥ 125 Kbit/sec >24 V/µsec (without bus)
Bus termination:	external
Protokoll:	CANopen DS301, Device Profile DS404

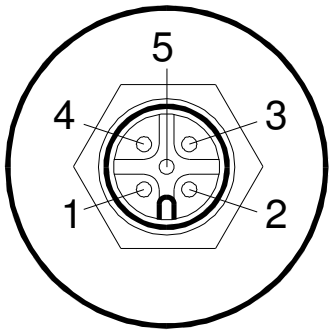
4.3 Environment

EMC:	noise emission	according to EN 50 081-2
	noise immunity	according to EN 50 082-2
Operating temperature:	-40…+125°C	
Media temperature:	-40…+150°C	

4.4 Connector Pin Assignment (CiA DR303-1)

The pin connection for the used 5 pole M12 connector is shown below (fig.: connector front view).

PIN	Assignment
1	CAN shield, PE
2	$+U_B$, +24VDC
3	GND, 0V
4	CAN_H, CAN+
5	CAN_L, CAN-



5 CANopen communication

5.1 Summary of the CANopen functions

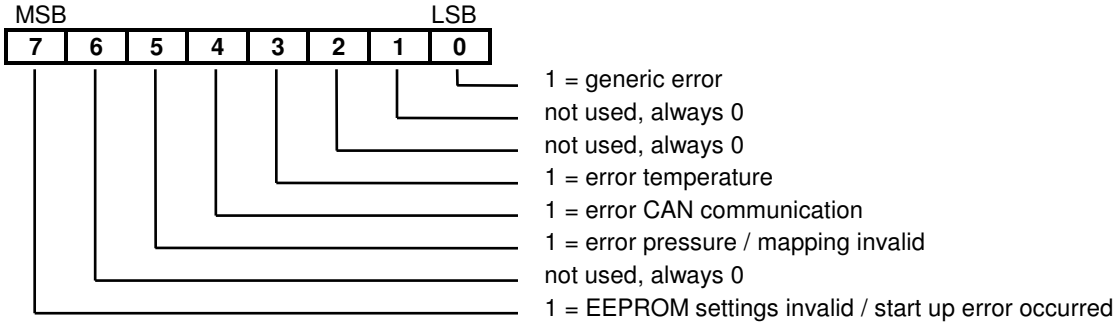
CANopen type:	NMT slave
Network bootup:	minimum bootup
COB Id placing:	pre-defined connection set, SDO
Node Id:	object (specific entry)
Bitrate:	object (specific entry)
Number of PDOs:	PDO1 synchronous, asynchronous PDO-mapping configurable
Emergency message:	supported
Heartbeat:	supported
Device profile:	DS404
Layer setting services:	supported

Default Settings: **Bitrate 125 kbit/s**
NodeID 1

5.2 Object Dictionary: Communication Profile

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
1000	00	Device Type	Unsigned32	ro	0x00020194	DSP404 analog input block
1001	00	Error Register	Unsigned8	ro	0x00	

Error register (Index 1001H):



Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
1003		Pre-defined Error Field				
	00	Number of errors	Unsigned8	rw	0x01	Write 0: clear errors
	01	Standard Error Field	Unsigned32	ro		

Standard Error Field (Index 1003H, 01):

MSB Bit31…24	Bit23…16	Bit15…0 LSB
not used, always 0	Error Register (Index 1001H)	Error Code: 0x8100 communication error 0x6161 internal software error (EEPROM settings invalid) 0x6363 PDO mapping error 0x6300 data error (start up error) 0x4000 temperature error 0xF011 pressure error

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
1005	00	COB-ID SYNC	Unsigned32	rw	0x80	
1008	00	Manufacturer Device Name	String	ro	„M01-CANopen“	
1009	00	Manufacturer Hardware Version	String	ro	„x.xxrx“	
100A	00	Manufacturer Software Version	String	ro	„x.xxrx“	
1010		Store parameters				
	00	Number of entries	Unsigned8	ro	0x01	
	01	Save all parameters	Unsigned32	rw	0x1	Data will be saved with the command 0x65766173 (ASCII: „save“)
1011		Restore default parameters				
	00	Number of entries	Unsigned8	ro	0x1	
	01	Restore default parameters	Unsigned32	rw	0x1	Default values will be restored with the command 0x64616F6C (ASCII: „load“) Reset of device required
1014	00	COB ID Emergency message	Unsigned32	ro	0x81	0x00000080 + Node-ID
1016		Consumer heartbeat time				
	00	Number of entries	Unsigned8	ro	0x1	
	01	Consumer heartbeat time	Unsigned32	rw	0	
1017	00	Producer heartbeat time	Unsigned16	rw	0	
1018		Identity object				

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Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
	00	Number of entries	Unsigned8	ro	0x4	
	01	Vendor Id	Unsigned32	ro	0x23D	STW-Vendor-Id
	02	Product Code	Unsigned32	ro		STW article number
	03	Revision number	Unsigned32	ro		Firmware version
	04	Serial number	Unsigned32	ro		STW internal serial number
1800		Transmit PDO1 parameter				
	00	Number of entries	Unsigned8	ro	0x5	
	01	COB ID used by PDO	Unsigned32	rw	0x181	(0x00000180 + Node-ID)
	02	Transmission type	Unsigned8	rw	0x1	Only 0x01 (sync) or 0xFF (async) with delta and/or event timer
	03	Inhibit Time	Unsigned16	rw	0	
	04	Reserved	Unsigned8	rw	0	
	05	Event Timer	Unsigned16	rw	0x3E8	
1A00		Transmit PDO1 mapping				
	00	Number of entries	Unsigned8	ro	0x2	
	01	PDO mapping for the 1. application object to be mapped	Unsigned32	rw	0x91300120	Pressure as int32: 0x91300120 Pressure as float32: 0x61300120 Status pressure as uint8: 0x61500108 Temperature as int32: 0x91300220 Temperature as float32: 0x61300220 Status temperature as uint8: 0x61500208 Meaning of status bits (if set): Bit 0: pressure/temperature value invalid Bit 1: positive overload Bit 2: negative overload
	02	PDO mapping for the 2. application object to be mapped	Unsigned32	rw	0x61500108	
1F80	00	NMT start up	Unsigned32	rw	4	0x00000004: The NMT master has to start the NMT slave. 0x00000008: NMT slave shall enter the NMT state *Operational* after the NMT state *Initialisation* autonomously (self start-ing).

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5.3 Object Dictionary: Manufacturer Specific Profile

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
3000	00	Pressure overflow counter	Unsigned16	rw	0	Counter for overpressure
3001	00	Pressure underflow counter	Unsigned16	rw	0	Counter for underpressure
3002	00	Temperature overflow counter	Unsigned16	rw	0	Counter for overtemperature
3003	00	Temperature underflow counter	Unsigned16	rw	0	Counter for undertemperature
4F00	00	Bit rate	Unsigned8	rw	0x4	* see following table. Changes take effect after reset node or power on.
4F01	00	Node ID	Unsigned8	rw	0x1	1…127; Changes take effect after reset node or power on.

* Bit rates:
The indices 5, 6 and 7 have been changed from firmware release V1.08r6 to V1.09r0. In the following table the corresponding indices can be selected:

	Bit rate [kbit/s]	
Index	through firmware V1.08r6	firmware from V1.09r0
0	1000	1000
1	800	800
2	500	500
3	250	250
4	125	125
5	50	--
6	20	50
7	--	20
100	100	100
101	40	40
102	400	400

Hint: Bit rates 40kbit/s and 400kbit/s are only supported by firmware V1.08r0 and higher.

5.4 Object Dictionary: Device Profile

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
6110		Ai_Sensor_Type				
	00	Number of entries	Unsigned8	ro	0x2	
	01	Ai_Sensor_Type_1	Unsigned16	ro	0x5A	90 = pressure sensor
	02	Ai_Sensor_Type_2	Unsigned16	ro	0x64	100 = temperature sensor
6124		Ai_Input_Offset				
	00	Number of entries	Unsigned8	ro	0x1	
	01	Ai_Input_Offset_1	Float32	rw	0	pressure offset
6125		Ai_Input_Autozero				
	00	Number of entries	Unsigned8	ro	0x1	
	01	Ai_Input_Autozero_1	Unsigned32	wo		Autozero for pressure 0x6F72657A (ASCII: „zero“)
6130		Ai_Input_PV				
	00	Number of entries	Unsigned8	ro	0x2	
	01	Ai_Input_PV_1	Float32	ro		actual pressure value
	02	Ai_Input_PV_2	Float32	ro		actual temperature value
6131		Ai_Physical_Unit_PV				
	00	Number of entries	Unsigned8	ro	0x2	
	01	Ai_Physical_Unit_PV_1	Unsigned32	rw	0x00220000	Pressure unit: 0x00AB0000: psi 0x004E0000: bar 0x00220000: Pa Prefixes (only for psi, bar): 0xFF__0000: 10^{-1} (deci) 0xFE__0000: 10^{-2} (centi) 0xFD__0000: 10^{-3} (milli) Hint: also dependents on “decimal digits”, Index 0x6132
	02	Ai_Physical_Unit_PV_2	Unsigned32	rw	0x002D0000	Temperature unit: 0x002D0000: °C 0x00AC0000: °F 0x00050000: K
6132		Ai_Decimal_Digits_PV				
	00	Number of entries	Unsigned8	ro	0x2	
	01	Ai_Decimal_Digits_PV_1	Unsigned8	rw	0	Range depends on the physical unit and prefix: [0…3] with unit psi [0…5] with unit bar [0] with unit Pa
	02	Ai_Decimal_Digits_PV_1	Unsigned8	rw	0	[0…5]
6133		Ai interrupt delta input PV				
	00	Number of entries	Unsigned8	ro	0x2	
	01	PV_1	Float32	rw	0	Pressure (default 0: disabled)
	02	PV_2	Float32	rw	0	Temperature (default 0: disabled)
6134		Ai interrupt lower limit input PV				
	00	Number of entries	Unsigned8	ro	0x2	
	01	PV_1	Float32	rw	-2147483648	Pressure (-2147483648: disabled)
	02	PV_2	Float32	rw	-2147483648	Temperature (-2147483648: disabled)
6135		Ai interrupt upper limit input PV				
	00	Number of entries	Unsigned8	ro	0x2	

Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
	01	PV_1	Float32	rw	2147483520	Pressure (2147483520: disabled)
	02	PV_2	Float32	rw	2147483520	Temperature (2147483520: disabled)
6148		Ai_span_start				
	00	Number of entries	Unsigned8	ro	0x2	
	01	Ai_span_start_1	Float32	ro		Pressure
	02	Ai_span_start_2	Float32	ro		Temperature
6149		Ai_span_end				
	00	Number of entries	Unsigned8	ro	0x2	
	01	Ai_span_end_1	Float32	ro		Pressure
	02	Ai_span_end_2	Float32	ro		Temperature
6150		Ai status				
	00	Number of entries	Unsigned8	ro	0x2	
	01	PV_1	Unsigned8	ro	0	Pressure: Bit 0 = 1: invalid Bit 1 = 1: pos. overload Bit 2 = 1: neg. overload
	02	PV_2	Unsigned8	ro	0	Temperature: Bit 0 = 1: invalid Bit 1 = 1: pos. overload Bit 2 = 1: neg. overload
61A0		Ai_filter_type				
	00	Number of entries	Unsigned8	ro	0x1	
	01	Ai_filter_type_1	Unsigned8	rw	1	0: no filter 1: moving average 2: repeating average
61A1		Ai_filter_constant				
	00	Number of entries	Unsigned8	ro	0x1	
	01	Ai_filter_constant_1	Unsigned8	rw	30	
7100		Ai_input_FV				
	00	Number of entries	Unsigned8	ro	0x2	
	01	Ai_input_FV_1	Integer16	ro		act. ADC pressure value
	02	Ai_input_FV_2	Integer16	ro		act. ADC temperature value
9124		Ai_input_offset				
	00	Number of entries	Unsigned8	ro	0x1	
	01	Ai_input_offset_1	Integer32	rw	0	Offset for pressure
9130		Ai_input_PV				
	00	Number of entries	Unsigned8	ro	0x2	
	01	Ai_input_PV_1	Integer32	ro		actual pressure value
	02	Ai_input_PV_2	Integer32	ro		actual temperature value
9133		Ai interrupt delta input PV				
	00	Number of entries	Unsigned8	ro	0x2	
	01	PV_1	Integer32	rw	0	Pressure (default 0: disabled)
	02	PV_2	Integer32	rw	0	Temperature (default 0: disabled)
9134		Ai interrupt lower limit input PV				
	00	Number of entries	Unsigned8	ro	0x2	
	01	PV_1	Integer32	rw	-2147483648	Pressure (-2147483648: disabled)
	02	PV_2	Integer32	rw	-2147483648	Temperature (-2147483648: disabled)
9135		Ai interrupt upper limit input PV				
	00	Number of entries	Unsigned8	ro	0x2	
	01	PV_1	Integer32	rw	2147483520	Pressure (2147483520: disabled)

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Index (HEX)	Sub Index	Name	Type	Access	Default	Comment
	02	PV_2	Integer32	rw	2147483520	Temperature (2147483520: disabled)
9148		Ai_span_start				
	00	Number of entries	Unsigned8	ro	0x2	
	01	Ai_span_start_1	Integer32	ro		Min. pressure
	02	Ai_span_start_2	Integer32	ro		Min. operating temperature
9149		Ai_span_end				
	00	Number of entries	Unsigned8	ro	0x2	
	01	Ai_span_end_1	Integer32	ro		Max. pressure
	02	Ai_span_end_2	Integer32	ro		Max. operating temperature

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5.5 Configuration of the transmit PDO

This chapter describes the configuration of the transmit PDO.

This is set by the OD entry *TPDO1 mapping* (index 0x1A00) and its sub indices. The sub index 1 defines the first value (lower position) transmitted by the PDO. Also the sub index 2 defines the second value transmitted by the PDO.

The default values of these sub indices are 0x91300120 (sub index 1) and 0x61500108 (sub index 2):

Name	Index	Subindex	Value
TPDO1 Mapping	0x1a00		
-> TPDO1 Mapping - Nr Of Mapped Objects	0x1a00	0x00	0x2
-> TPDO1 Mapping - value 1	0x1a00	0x01	0x91300120
-> TPDO1 Mapping - value 2	0x1a00	0x02	0x61500108

That means:
The first value which will be sent by the transmit PDO is the value of the OD index 0x9130 with the sub index 0x01 and the length 0x20 bits (=> 0x91300120). It is the pressure value (signed integer 32 bit).
The second value of the transmit PDO is the OD index 0x6150 with the sub index 0x01 and the length 0x08 bits (=> 0x61500108). It is the pressure status (unsigned integer 8 bit).

So the transmit PDO can be look like the following message:

Transmit PDO (example)

	ID	DLC	Data					
			Byte 0					Byte 7
TPDO	0x180 + Node-ID	5	0xA0 (pres. LSB)	0x86	0x01	0x00 (pres. MSB)	0x00 (pres. status)	not available

This example shows a pressure value of 100000 (= 0x186A0) and the status 0 (valid).

The units of the sent values are defined by the settings of the following object dictionary entries:

- *AI Physical unit PV* (index 0x6131): these specify the physical units of the values of indices 0x6130 and 0x9130.
- *AI Decimal digits PV* (index 0x6132): these specify the decimal digits of the integer values of the index 0x9130. 1 means that the value is multiplied by 10, 2 means multiplied by 100, …

The possible settings can be seen in chapter 5.4 .

Hint:
Only the following object dictionary indices are mappable:

- index 0x6130, sub index 0x01 (pressure, float32)
- index 0x6130, sub index 0x02 (temperature, float32)
- index 0x6150, sub index 0x01 (pressure status)
- index 0x6150, sub index 0x02 (temperature status)
- index 0x9130, sub index 0x01 (pressure, integer32)
- index 0x9130, sub index 0x02 (temperature, integer32)

Example mapping:

To get the pressure value with float 32 bit and the temperature value with signed integer 32 bit, the sub index 1 has to be set to 0x61300120 (0x6130, 0x01, 0x20) and the sub index 2 to 0x91300220 (0x9130, 0x02, 0x20).

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5.6 Emergency Message

Emergency messages show an internal device error. If the error situation for the device has changed, it will send an emergency message with the current error code.

An error code 0x0000 shows that all errors are removed.

The current error situation could be read out with the object profile entry “Pre-defined Error Field” index 0x1003, sub index 1.

The COB-ID of an emergency message is shown in the communication profile of the object dictionary, index 0x1014 (= 0x80 + NodeID).

Construction of the emergency message:

Data			
Byte 0			Byte 7
Error Code LSB	Error Code MSB	Error Register (Index 0x1001)	not used

Error Codes

Error Code	Bedeutung
0x8100	Error CAN-communication
0x6161	internal Software-error (EEPROM settings invalid)
0x6363	PDO-mapping error
0x6300	Data-error (start up error)
0x4000	Error temperature
0xF011	Error pressure

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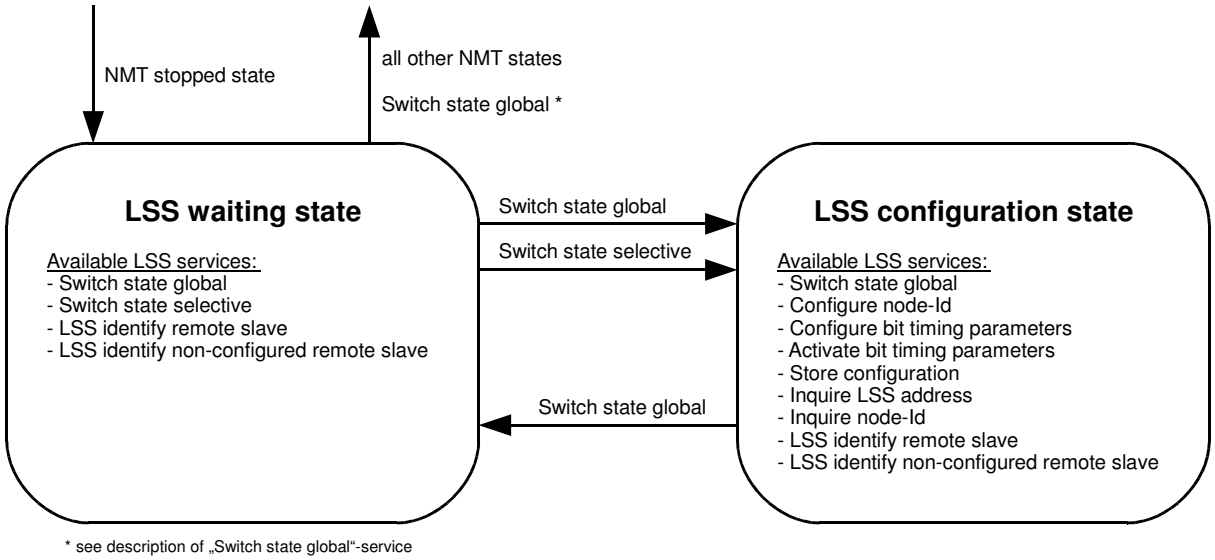
6 Layer setting services

The M01-CAN with CANopen (V1.09r0 and higher) supports the Layer setting services. These services and protocols are used to inquire the settings of the LSS address (object 0x1018), the bit rate and the node-Id. Also the bit rate and the node-Id could be changed by the LSS.



Some requirements/hints must be observed when using the LSS:

- The producer heartbeat time must be 0 (= default; object 0x1017)
- The M01-CAN must be in NMT stopped state
- In LSS configuration state, no NMT-command will be executed
- Only a stored bit rate and node-Id will appear in the object dictionary (0x4F00 and 0x4F01)
- The LSS address consists of four values:
  - Vendor-Id:

    Object dictionary index 0x1018, sub-index 1: always 0x23D
  - Product-code:

    Object dictionary index 0x1018, sub-index 2: order number of this M01-CAN (BCD)

- Revision-number:

  Object dictionary index 0x1018, sub-index 3: software version of this M01-CAN (BCD)

- Serial-number:

  Object dictionary index 0x1018, sub-index 4: a unique serial number

6.1 Supported services

All services of DSP305 V2.0 can be used. The supported parameters of the services can be found in this section. The CAN identifiers are reserved for LSS:

- 0x7E5 for commands from LSS master
- 0x7E4 for answers from LSS slave

Switch state global:

	Data							
	Byte 0							Byte 7
Command	command specifier request	mode	reserved	reserved	reserved	reserved	reserved	reserved

command specifier request: 0x04

mode:
- 0x00 switches to waiting state
- 0x01 switches to configuration state

Hints:

- After storing a new node-Id, the “Switch state global” service with the parameter “switches to waiting state” will activate the last stored node-Id and it will be used immediately. So after that, the M01-CAN will transmit the bootup-message and stays in NMT preoperational state.
- Once the LSS configuration state has been left, all not stored data is no longer available.

Switch state selective:

	Data							
	Byte 0							Byte 7
Command	command specifier request	data LSB	data	data	data MSB	reserved	reserved	reserved
Answer	command specifier answer	reserved	reserved	reserved	reserved	reserved	reserved	reserved

command specifier request:
- 0x40 vendor-Id
- 0x41 product-code
- 0x42 revision-number
- 0x43 serial-number

command specifier answer: 0x44

Hint: the revision-number can be ignored by using 0.

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Configure node-Id:

	Data							
	Byte 0							Byte 7
Command	command specifier request	node-Id	reserved	reserved	reserved	reserved	reserved	reserved
Answer	command specifier answer	error code	spec. error	reserved	reserved	reserved	reserved	reserved

command specifier request: 0x11
node-Id: 1…127

command specifier answer: 0x11
error code: 0 protocol successfully completed
1 node-Id out of range
spec. error: always 0

Configure bit timing parameters:

	Data							
	Byte 0							Byte 7
Command	command specifier request	table se-lector	table index	reserved	reserved	reserved	reserved	reserved
Answer	command specifier answer	error code	spec. error	reserved	reserved	reserved	reserved	reserved

command specifier request: 0x13
table selector: 0 standard CiA bit timing table
0x80 STW bit timing table
table index: **standard CiA bit timing table:**
0 1 Mbit/s
1 800 kbit/s
2 500 kbit/s
3 250 kbit/s
4 125 kbit/s
5 reserved
6 50 kbit/s
7 20 kbit/s
STW bit timing table:
102 400 kbit/s
100 100 kbit/s
101 40 kbit/s

command specifier answer: 0x13
error code: 0 protocol successfully completed
1 bit timing not supported
spec. error: always 0

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Activate bit timing parameters:

	Data							
	Byte 0							Byte 7
Command	command specifier	switch_ delay	reserved	reserved	reserved	reserved	reserved	reserved

command specifier: 0x15
switch_delay: The duration of the two periods of time to wait. See DSP305 for more details. Unit: milliseconds.

Hints:

- Only the last saved bit timing will be activated by this service.
- After setting the new bit timing valid, the M01-CAN will transmit the bootup-message, but also it will stay in NMT stopped state.

Store configuration:

	Data							
	Byte 0							Byte 7
Command	command specifier request	reserved	reserved	reserved	reserved	reserved	reserved	reserved
Answer	command specifier answer	error code	spec. error	reserved	reserved	reserved	reserved	reserved

command specifier request: 0x17

command specifier answer: 0x17
error code: 0 protocol successfully completed
1 node-Id out of range
255 see spec. error
spec. error: only with error code 255:
1 nothing to store

Inquire LSS address:

	Data							
	Byte 0							Byte 7
Command	command specifier request	reserved	reserved	reserved	reserved	reserved	reserved	reserved
Answer	command specifier answer	data LSB	data	data	data MSB	reserved	reserved	reserved

command specifier request: 0x5A vendor-Id
0x5B product-code
0x5C revision-number
0x5D serial-number

command specifier answer: like request
data: requested value

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Inquire node-Id:

	Data							
	Byte 0							Byte 7
Command	command specifier request	reserved	reserved	reserved	reserved	reserved	reserved	reserved
Answer	command specifier answer	node-Id	reserved	reserved	reserved	reserved	reserved	reserved

command specifier request: 0x5E

command specifier answer: 0x5E
node-Id: node-Id

Hint: the return value of the node-Id will be the valid and stored value from EEPROM.

LSS identify remote slave:

	Data							
	Byte 0							Byte 7
Command	command specifier request	data LSB	data	data	data MSB	reserved	reserved	reserved
Answer	command specifier answer	reserved	reserved	reserved	reserved	reserved	reserved	reserved

command specifier request: 0x46 vendor-Id
0x47 product-code
0x48 revision-number-low
0x49 revision-number-high
0x4A serial-number-low
0x4B serial-number-high

command specifier answer: 0x4F

Hints:
- The revision-number-low and revision-number-high can be ignored by using 0.
- To identify the slave, the shown order of the requests must be observed.

LSS identify non-configured remote slave:

	Data							
	Byte 0							Byte 7
Command	command specifier request	reserved	reserved	reserved	reserved	reserved	reserved	reserved
Answer	command specifier answer	reserved	reserved	reserved	reserved	reserved	reserved	reserved

command specifier request: 0x4C

command specifier answer: 0x50

6.2 LSS example

This example of the usage of the Layer setting services shows the changing of the node-Id from 1 to 5 and the changing of the bit rate to 250kbit/s. Only one slave has to be connected to the CAN bus if using this example.

No.	Service	CAN-Id	DLC	Data								Dir	Comment
				D0	D1	D2	D3	D4	D5	D6	D7		
	NMT boot-up	0x701	1	0x00								Rx	boot-up message from slave
1	NMT stopped	0x000	2	0x02	0x00							Tx	set slave to NMT stopped state
2	Switch state global: LSS configuration state	0x7E5	8	0x04	0x01	0x00	0x00	0x00	0x00	0x00	0x00	Tx	set slave to LSS configuration state
3	Configure node-Id	0x7E5	8	0x11	0x05	0x00	0x00	0x00	0x00	0x00	0x00	Tx	set new node-Id: 5
		0x7E4	8	0x11	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Rx	answer: ok
4	Configure bit timing parameters	0x7E5	8	0x13	0x00	0x03	0x00	0x00	0x00	0x00	0x00	Tx	set new bit rate: 250kbit/s
		0x7E4	8	0x13	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Rx	answer: ok
5	Store configuration	0x7E5	8	0x17	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Tx	store the new settings to EEPROM
		0x7E4	8	0x17	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Rx	answer: ok
6	Activate bit timing parameters	0x7E5	8	0x15	0x64	0x00	0x00	0x00	0x00	0x00	0x00	Tx	activate the new bit rate after 100ms
		0x701	1	0x00								Rx	boot-up message from slave with new bit rate (but with old node-Id!)
7	Switch state global: LSS waiting state	0x7E5	8	0x04	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Tx	set all slaves to LSS waiting state
		0x705	1	0x00								Rx	boot-up message from slave (with new node-Id)

Direction: Tx: message from (NMT/LSS) master
Rx: message from slave

Hint: services no. 6 and 7 can be replaced by a power supply cycle.

7 CAN Communication without CANopen Functionality

7.1 Basic Configuration

The CAN pressure transmitter can be used without any problems in CAN networks without CANopen functionality. Before using the M01-CAN, the following basic configurations should be set:

1. Bit rate, default is 125 kbit/s, object 0x4F00
2. Node Id, default is 1, object 0x4F01.
   The CAN identifier will be created from the node-Id (see table 7.5). All CAN identifiers are 11 bit identifiers (default setting).
3. Additional settings (phys. unit, etc.) can be found in the object dictionary (*5.4 Object Dictionary: Device Profile*) and in *7.4 Change Node Configuration Manually*.
4. The new settings are saved with object 0x1010/01. The 0x65766173 (ASCII: „save“) must be entered here. The settings will be saved to non-volatile memory.

7.2 Network Operation without CANopen Master

After connecting the transmitter to the supply voltage, the transmitter will send a boot-up message with the CAN identifier 0x700 + Node-Id (default 0x701) with one data byte (content = 0) if no error is detected.

If an error is detected the error code (see *5.6 emergency message*) will be sent together with the CAN identifier.

The pressure transmitter is now in the “Pre_Operational_State”. With the CANopen command “Start_Remote_Node” the pressure transmitter will be activated:

„Start_Remote_Node“

	ID	DLC	Data							
			Byte 0							Byte 7
Command „Start_ Remote_ Node“	0x000	2	0x01	Node-ID or 0x00 (all CA-Nopen members)						

The “Start_Remote_Node” will be answered with a data message (PDO) with the CAN identifier 0x180 + Node Id (default 0x181). Now the CAN transmitter sends cyclically (default setting) PDOs with the pressure value and the status.

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Construction of the message for pressure measurement (PDO):

	ID	DLC	Data							
			Byte 0							Byte 7
PDO message	0x180 + Node-ID	5	Pressure Signed32 LSB	Pressure Signed32	Pressure Signed32	Pressure Signed32 MSB	Pressure Status			

The values of the pressure measurement or the temperature measurement can be also read as 32 bit integer or 32 bit float. The choice is done by the PDO mapping and is described in *5.5 Configuration of the transmit PDO*.

The values of the pressure measurement or the temperature measurement can be also read from the object dictionary (SDO access) as 32 bit integer or 32 bit float. The floating point format is explained in the appendix (chapter 9.1 *Definition of IEEE 32bit floating point numbers*). This access is independent of the current operational state of the pressure transmitter.

The status provides the following information:

Bit 0: pressure value invalid
Bit 1: positive overload
Bit 2: negative overload

Pressure measurement

Request value of pressure measurement (float32, SDO access):

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Request 0x40	Index LSB 0x30	Index MSB 0x61	Sub Index 0x01	not used			
Answer	0x580 + Node-ID	8	SDO Ack. 0x43	Index LSB 0x30	Index MSB 0x61	Sub Index 0x01	Data LSB	Data	Data	Data MSB

Request value of pressure measurement (integer32, SDO access):

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Request 0x40	Index LSB 0x30	Index MSB 0x91	Sub Index 0x01	not used			
Answer	0x580 + Node-ID	8	SDO Ack. 0x43	Index LSB 0x30	Index MSB 0x91	Sub Index 0x01	Data LSB	Data	Data	Data MSB

Temperature measurement

Request value of temperature measurement (float32, SDO access):

	ID	DLC	Data Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Request 0x40	Index LSB 0x30	Index MSB 0x61	Sub Index 0x02	not used			
Answer	0x580 + Node-ID	8	SDO Ack. 0x43	Index LSB 0x30	Index MSB 0x61	Sub Index 0x02	Data LSB	Data	Data	Data MSB

Request value of temperature measurement (integer32, SDO access):

	ID	DLC	Data Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Request 0x40	Index LSB 0x30	Index MSB 0x91	Sub Index 0x02	not used			
Answer	0x580 + Node-ID	8	SDO Ack. 0x43	Index LSB 0x30	Index MSB 0x91	Sub Index 0x02	Data LSB	Data	Data	Data MSB

7.3 Cyclically Sending

The pressure transmitter M01-CAN is able to send the values of measurements (PDO) cyclic with a programmable time interval.

The event timer is activated by writing 0xFF to the object 0x1800 subindex 2 (transmission type).

The timer interval is written to the object 0x1800 subindex 5 (event timer). The value (unsigned16) is set in units of 1 ms. The value range is from 0 ms to 65535 ms. 0 stops the event timer.

Default settings:

- Transmission type: 0xFF (event timer active)
- Event timer: 1000 ms

Activate Event Timer (SDO Access):

	ID	DLC	Data Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Write 0x2F	Index LSB 0x00	Index MSB 0x18	Sub Index 0x02	Trans-mission Type 0xFF	not used		
Answer	0x580 + Node-ID	8	SDO Ack. 0x60	Index LSB 0x00	Index MSB 0x18	Sub Index 0x02	not used			

Set Event Timer (SDO Access):

	ID	DLC	Data						
			Byte 0						Byte 7
Command	0x600 + Node-ID	8	SDO-Write 0x2B	Index LSB 0x00	Index MSB 0x18	Sub Index 0x05	Timer LSB	Timer MSB	not used
Answer	0x580 + Node-ID	8	SDO Ack. 0x60	Index LSB 0x00	Index MSB 0x18	Sub Index 0x05	not used		

Get Event Timer (SDO Access):

	ID	DLC	Data						
			Byte 0						Byte 7
Command	0x600 + Node-ID	8	SDO-Re-quest 0x40	Index LSB 0x00	Index MSB 0x18	Sub Index 0x05	not used		
Answer	0x580 + Node-ID	8	SDO Ack. 0x4B	Index LSB 0x00	Index MSB 0x18	Sub Index 0x05	Timer LSB	Timer MSB	not used

Note:

If the device is not configured as self starting device the message “start_remote_node” must be sent each time after reset or power up.

The pressure transmitter can sample up to 1000 values of measurement per second. The maximum data rate on the CAN bus depends on the bitrate and the maximum workload.

7.4 Change Node Configuration Manually

The basic configuration of the pressure transmitter can be manually set through the object dictionary with the addresses 0x4F01 (node Id) and 0x4F00 (CAN bitrate). The new settings are active after a reset.

Node Id:

Set Node Id

	ID	DLC	Data					
			Byte 0					Byte 7
Command	0x600 + Node-ID	8	SDO-Write 0x2F	Index LSB 0x01	Index MSB 0x4F	Sub Index 0x00	Node-ID Byte	not used
Answer	0x580 + Node-ID	8	SDO Ack. 0x60	Index LSB 0x01	Index MSB 0x4F	Sub Index 0x00	not used	

Get Node Id

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Request 0x40	Index LSB 0x01	Index MSB 0x4F	Sub Index 0x00	not used			
Answer	0x580 + Node-ID	8	SDO Ack. 0x4F	Index LSB 0x01	Index MSB 0x4F	Sub Index 0x00	Node-ID Byte	not used		

CAN-Bitrate:

Set CAN Bitrate Index

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Write 0x2F	Index LSB 0x00	Index MSB 0x4F	Sub Index 0x00	Bitrate-Index Byte	not used		
Answer	0x580 + Node-ID	8	SDO Ack. 0x60	Index LSB 0x00	Index MSB 0x4F	Sub Index 0x00	not used			

Get CAN Bitrate Index

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Request 0x40	Index LSB 0x00	Index MSB 0x4F	Sub Index 0x00	not used			
Answer	0x580 + Node-ID	8	SDO Ack. 0x4F	Index LSB 0x00	Index MSB 0x4F	Sub Index 0x00	Bitrate-Index Byte	not used		

NMT startup:

Activate automatic transition to the „Operational_State“

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Write 0x23	Index LSB 0x80	Index MSB 0x1F	Sub Index 0x00	Data LSB 0x08	Data 0x00	Data 0x00	Data MSB 0x00
Answer	0x580 + Node-ID	8	SDO Ack. 0x60	Index LSB 0x80	Index MSB 0x1F	Sub Index 0x00	not used			

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Deactivate automatic transition to the „Operational_State“

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Write 0x23	Index LSB 0x80	Index MSB 0x1F	Sub Index 0x00	Data LSB 0x04	Data 0x00	Data 0x00	Data MSB 0x00
Answer	0x580 + Node-ID	8	SDO Ack. 0x60	Index LSB 0x80	Index MSB 0x1F	Sub Index 0x00	not used			

„save“-command to store all parameters to non-volatile memory

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Re-quest 0x23	Index Lo 0x10	Index Hi 0x10	Sub Index 0x01	ASCII ‚s’ 0x73	ASCII ‚a’ 0x61	ASCII ‚v’ 0x76	ASCII ‚e’ 0x65
Answer	0x580 + Node-ID	8	SDO Ack. 0x60	Index Lo 0x10	Index Hi 0x10	Sub Index 0x01	not used			

„load“-command to restore all default-parameters

	ID	DLC	Data							
			Byte 0							Byte 7
Command	0x600 + Node-ID	8	SDO-Re-quest 0x23	Index Lo 0x11	Index Hi 0x10	Sub Index 0x01	ASCII ‚l’ 0x6C	ASCII ‚o’ 0x6F	ASCII ‚a’ 0x61	ASCII ‚d’ 0x64
Answer	0x580 + Node-ID	8	SDO Ack. 0x60	Index Lo 0x11	Index Hi 0x10	Sub Index 0x01	not used			

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7.5 Reserved CAN Identifiers

The following CAN identifiers are reserved by the CAN protocol:

CAN-Identifier (11Bit), Hex	Description
0x000	NMT, network management
0x080	SYNC, synchronisation message, not used in asynchronous mode (see 5.2)
0x080 + Node Id max. range 0x081…0x0FF	Emergency message
0x180 + Node Id max. range 0x181…0x1FF	PDO1 TX, message with the value of pressure measurement
0x580 + Node Id max. range 0x581…0x5FF	SDO TX, CANopen configuration message
0x600 + Node Id max. range 0x601…0x67F	SDO RX, CANopen configuration message
0x700 + Node Id max. range 0x701…0x77F	CANopen node guarding

8 Extensions

- Device profile DS404
- Heartbeat function
- Different units for the pressure and temperature values available
- Programmable monitoring of the measurement range
- Autozero function
- Offset shift

9 Appendix

9.1 Definition of IEEE 32Bit (single precision) floating point numbers (IEEE-754 standard)

Single precision floating point numbers cover a value range of $-3.4 \cdot 10^{38} \ldots +3.4 \cdot 10^{38}$.

32 bit floating point numbers need 4 byte (32 bit) storage memory. The following table shows the IEEE 32 bit implementation of floating point numbers:

bit position:	31	30…23	22…0
function:	S	exponent	mantissa

S = sign bit

The value can be calculated with this formula:

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$$(-1)^S 2^{(\exp onent-127)}(1+mantissa)$$

The mantissa starts behind the comma (position 2^{-1}). The first number in front of the comma (position 2^0) is always 1 and will not be stored in the mantissa.

Example:

Hex: $400C\ CCEA_{HEX}$
Binary: $0100\ 0000\ 0000\ 1100\ 1100\ 1100\ 1110\ 1010_{BIN}$

Sign bit = 0
Exponent = $10000000_{BIN} = 128_{DEC}$

Mantissa = $00011001100110011101010_{BIN}$
= $0 \cdot 2^{-1} + 0 \cdot 2^{-2} + 0 \cdot 2^{-3} + 1 \cdot 2^{-4} + 1 \cdot 2^{-5} + \ldots + 1 \cdot 2^{-22}$
= 0.100003481_{DEC}

$$400CCCEA_{HEX} = (-1)^0 2^{(128-127)}(1+0.100003481) = 2.200007_{DEC}$$

More examples and IEEE-754 definitions:

hex	decimal
00000000_{HEX}	0.0
$3F800000_{HEX}$	1.0
$BF800000_{HEX}$	-1.0
$FFFFFFFF_{HEX}$	Not a Number (NaN)

9.2 SDO Fighter

The SDO Fighter is a program for reading and writing the objects of the M01-CAN. The objects are defined in the EDS file for the pressure transmitter.

9.3 References

DS301 Application Layer and Communication Profile

DS302-2 Additional Application Layer Functions
Part 2: Network Management

DR303-1 Cabling and Connector Pin Assignment

DS404 Device Profile Measuring Devices and Closed-Loop Controllers

9.4 Definitions

COB	Communication Object Data must be sent inside a COB across a CAN network. There exist 2048 different COBs in a CAN network. A COB contains maximal 8 data bytes.
LSS	Layer setting services
PDO	Process Data Object
SDO	Service Data Object

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