R67047.0002 - 6

Manual

Encoder with
SAE J1939 Interface

SAE J1939

pulses for automation

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1 Document

This is the English translation of the original manual in German language.

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Legal Notices

2 General Information

Please read this document carefully before working with the product, mounting it or starting it up.

2.1 Target Group

The device may only be planned, mounted, commissioned and serviced by persons having the following qualifications and fulfilling the following conditions:

- Technical training.
- Briefing in the relevant safety guidelines.
- Constant access to this documentation.

2.2 Symbols used / Classification of the Warnings and Safety instructions

⚠ DANGER	**Classification:** This symbol, together with the signal word **DANGER** , warns against immediately imminent threat to life and health of persons. The non-compliance with this safety instruction will lead to death or severe adverse health effects.
⚠ WARNING	**Classification:** This symbol, together with the signal word **WARNING** , warns against a potential danger to life and health of persons. The non-compliance with this safety instruction may lead to death or severe adverse health effects.
⚠ CAUTION	**Classification:** This symbol, together with the signal word **CAUTION** , warns against a potential danger for the health of persons. The non-compliance with this safety instruction may lead to slight or minor adverse health effects.
ATTENTION	**Classification:** The non-compliance with the **ATTENTION** note may lead to material damage.

NOTICE	**Classification:** Additional information relating to the operation of the product, and hints and recommendations for efficient and trouble-free operation.

2.3 Other Applicable Documents

NOTICE	**Technical Data** All technical data, as well as the mechanical and electrical characteristics, are specified in the data sheets of the corresponding device variant, for special versions in the.corresponding quotation / customer drawing of the product.

The above mentioned documents, the original declarations of conformity and the relevant certificates can be downloaded from our homepage:

www.kuebler.com/en/docu-finder

3 Product Description

3.1 Technical Data Sendix M36xx, M36xxA, M58xx, M58xxA

Singleturn technology	Magnetic
Multiturn technology	Magnetic, electronic counter, Energy Harvesting
Singleturn resolution (MUR)	Max. 14 bits (default 14 bits)
Multiturn resolution (NDR)	Max. 29 bits (default 18 bits)
Multiturn resolution (TMR)	Max. 32 bits (default 32 bits)
Accuracy	± 1° (over the whole temperature range)
Repeatability	± 0.2°
Data up-to-dateness	2 ms

Mechanical characteristics for the Sendix M36xx, M36xxA encoders

Maximum rotary speed IP65 IP67	 6000 min^{-1}, 3000 min^{-1} (continuous operation) 4000 min^{-1}, 2000 min^{-1} (continuous operation)
Starting torque (at 20 °C) IP65 IP67	 < 0,007 Nm < 0,01 Nm
Permissible shaft load radial axial	 40 N 20 N
Protection level acc. to EN 60529	IP65, IP67
Working temperature range	-40 °C ... +85 °C
Materials Shaft/Hollow shaft Flange Housing Cable	 Stainless steel Aluminum Die-cast zinc PVC
Shock resistance according to EN 60068-2-27	2500 m/s^2, 6 ms
Vibration resistance according to EN 60068-2-6	300 m/s^2, 10 ... 2000 Hz

Mechanical characteristics for the Sendix M58xx M58xxA encoders

Maximum rotary spee IP65	 6000 min^{-1}, 3000 min^{-1} (continuous operation)
Starting torque (at 20 °C) IP65	 < 0,01 Nm
Permissible shaft load radial axial	 80 N 40 N
Protection level acc. to EN 60529	IP65
Working temperature range	-40 °C ... +85 °C
Materials Shaft/Hollow shaft Flange Housing Cable	 Stainless steel Aluminum Die-cast zinc PVC
Shock resistance according to EN 60068-2-27	5000 m/s^2, 6 ms
Vibration resistance according to EN 60068-2-6	300 m/s^2, 10 ... 2000 Hz

Electrical characteristics for the Sendix M36xx, M36xxR, M36xxA, M36xxAR, M58xx, M58xxA encoders

Supply voltage	10 … 30 V DC
Current consumption	Max. 30 mA (without load)

Output	RS485 for SAE J1939
Type of connection	Cable or connector
Interface	SAE J1939 Interface CAN Transceiver according to ISO 11898

Mechanical characteristics for the Sendix M36xxR encoders

Maximum rotary speed IP67	 4000 min^{-1}, 2000 min^{-1} (continuous operation)
Starting torque (at 20 °C) IP67	 < 0,01 Nm
Permissible shaft load radial axial	 80 N 40 N
Protection level acc. to EN 60529	IP65, IP67, IP69k
Working temperature range	-40 °C ... +85 °C
Materials Shaft/Hollow shaft Flange Housing Cable	 V2A / V4A Stainless steel V4A / Aluminum V4A / Die-cast zinc PVC
Shock resistance according to EN 60068-2-27	5000 m/s^2, 4 ms
Vibration resistance according to EN 60068-2-6	300 m/s^2, 10 ... 2000 Hz

3.2 Supported Standards and Protocols

The J1939 encoders of the M36X8/M3668R/M5868 series support the SAE J1939 protocol. The encoder supports the allocation of a new J1939 node ID by means of the "Commanded Address" function of the J1939 protocol through the corresponding PG defined in the standard (see Glossary).

A .dbc file for Vector CANalyzer / CANoe, which contains the PGs supported and used by the encoder, is available on the Kübler website.

4 Installation

4.1 Electrical Installation

4.1.1 General Information for the Connection

ATTENTION	**Destruction of the device** Before connecting or disconnecting the signal cable, always disconnect the power supply and secure it against switching on again.
NOTICE	**General safety instructions** Make sure that the whole plant remains switched off during the electrical installation. Make sure that the operating voltage is switched on or off simultaneously for the device and the downstream device.
NOTICE	**Traction relief** Always mount all cables with traction relief.
NOTICE	**Interference susceptibility** Proceed as follows: • Connect the shield to the device housing. • Comply with the maximum cable length for stub lines and for the total length of the bus network. • Check the maximum supply voltage on the device.
ATTENTION	**Wear of the memory module** Only applies to devices that write parameter data via the EEPROM: Avoid too frequent writing of the non-volatile memory.. It is used e.g. when setting a preset value. The memory module is designed for approximately 500,000 write cycles. If the maximum number of write cycles is exceeded, single memory areas may be damaged and errors may occur.
NOTICE	**Use shielded data lines** Use exclusively shielded data lines to comply with the EMC requirements (EN 55011 Class B / EN 61000-6-:2007) and minimize interference emissions / external interference.

4.1.2 Connection Color Coding

Part of the cables are identified by a color coding, part of them by a numerical coding. Abbreviation of the colors :

Abbreviation	Color	Abbreviation	Color
WH	White	BU	Blue
BN	Brown	RD	Red
GN	Green	BK	Black
YE	Yellow	VT	Violet
GY	Gray	GY-PK	Gray-Pink
PK	Pink	RD-BU	Red-Blue

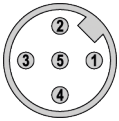
ATTENTION	Destruction of the electronics
	When confectioning the sensor cable, always take care to ensure sufficient ESD protection.

4.1.3 Connection Legend

+V:	Supply voltage +V DC
0V:	Ground GND (0V)
CAN_H:	Positive CAN Signal (Dominant High)
CAN_L:	Negated CAN-Signal (Dominant Low)
CAN_GND:	CAN-Ground
PH ⏚:	Connector housing (cable shield is applied on the connector housing), protective earth

4.1.4 Terminal Assignment M36, M58

Interface	Type of connection	Cable					
2	M36: 1, 2, A, B M58: 2, B	Signal	+V	0 V	CAN_GND	CAN_H	CAN_L
		Color	BN	WH	GY	GN	YE

Interface	Type of connection	M12 connector, 5-pole						Connector
			Bus IN					
2	M36: 3, 4	Signal	+V	0 V	CAN_GND	CAN_H	CAN_L	
	M58: 4	Pin	2	3	1	4	5	

5 Commissioning and Operation

DANGER

Risk of injury due to rotating shafts

Hair and loose clothing can be caught by rotating shafts.

- Prepare all work as follows:

⇨ Switch the operating voltage off and stop the drive shaft.

⇨ Cover the drive shaft if the operating voltage cannot be switched off.

5.1 Function and Status LED

The device is equipped with a LED for displaying:

- CAN bus status and error messages
- Status and error messages of the J1939 address claiming
- The condition of an internal diagnosis

Green = CAN BUS status

Red = CAN ERR display

Display	LED	Meaning	Error cause	Note
Bus off		No connection to the CAN bus No voltage supply	Data line interruption Wrong baud rate Interchanged data line	Observe the combination with the ERR LED If ERR LED is also off, please check the voltage supply[3]
Bus on		Connection to the bus Address claimed	No error	Cyclic PGN transfer is active (if cycle time not equal to 0)
ERR off		Device operates error-free	No error	Observe the combination with the BUS LED
ERR on		BUS OFF status	Bus short-circuit No bus Wrong baud rate No address yet or address claim lost (address conflict)	

The various LED messages can also be displayed in combination.

Display	LED	Meaning	Error cause	Note
ERR + BUS flashing		Fast alternate flashing of green and red LED	Data connection with sensor faulty Sensor faulty	Device must be sent back to manufacturer for repair
ERR + BUS flashing		Simultaneous fast flashing of green and red LED (300 ms)	Watchdog error	Device must be sent back to manufacturer for repair
BUS + ERR flashing		Green constantly on and fast flashing of red LED (300 ms)	Configuration error Encoder DiagData [▶ 22]	Faulty device paramet-erizing. Config. values invalid

5.2 Quick Start Guide

5.2.1 Default Settings

The encoder has been set in the factory as follows:

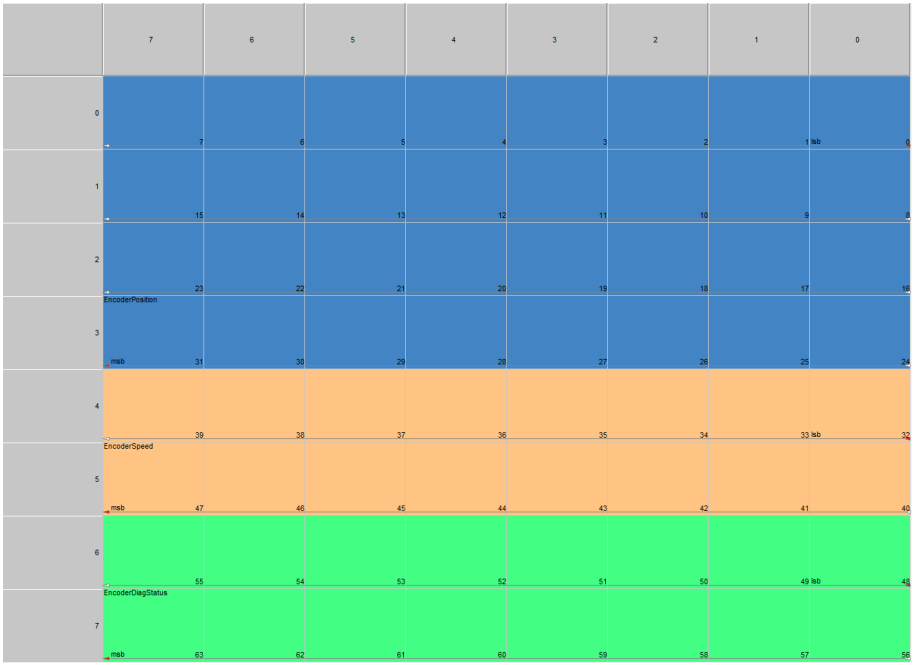
NOTICE	**TMR for singleturn devices**
	For singleturn devices, TMR = MUR.

Byte	Name	Standard value	Note
0 … 1	OperatingParameter	0x04	Scaling: Active Direction of rotation: CW)
2 … 5	MUR	0x4000	16,384 steps
6 … 9	TMR	0x10000000	268,435,456 steps
10 … 13	SensorCycleTime	0x32	50 ms
14	CANBusTermination	0x01	ON
15 … 18	SensorPresetValue	n/a	
19	SensorPresetEnable	n/a	
20	BaudRate	0x01	250 kbps
	J1939 address	0x20	32

5.2.1.1 Communication Objects

Signals

The PG with the signals has the following structure:

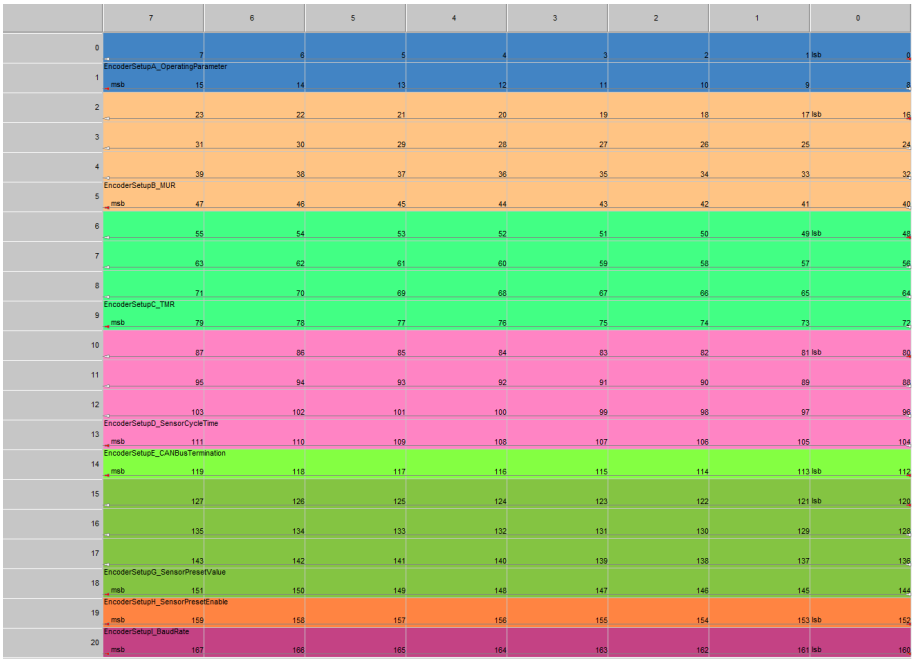


As standard, the encoder uses the following PG numbers for data transmission:

Signals transmission: PG No. 0xFFAA

Service data

The PG with the configuration data has the following structure:



IMG-ID: 9007199324843659

As standard, the encoder uses the following PG number for data transmission:

Configuration receipt: PG No. 0xEF00

5.2.2 Configuration Possibilities

The following parameters can be programmed via the CAN bus:

- Scaling, if necessary
- Direction of rotation:
- Measuring range
- Zero points or preset value

This data can be parameterized via the configuration PG. No separate save command is necessary to change the values. When switching the appliance on, all parameters are loaded from a flash memory. These parameters have previously been stored persistently.

NOTICE	**Wear of the flash memory**
	Every time the configuration PG is sent to the encoder, the configuration is written internally in the flash memory of the encoder. Every write operation stresses the flash memory module. This module is designed for max. about 10,000 write cycles.

The distribution of the signals sent by the encoder (position, speed, diagnosis) on the sent data frames is fixedly defined in the firmware.

The PG numbers (or CAN identifiers) for sending measured data and receiving the configuration can be defined individually in the factory. In addition, all components of the J1939 NAME sent during address claim can be defined to customer's specifications. For further information about possible changes, please contact the Kübler Support or Sales.

See form sheet for configuration: kuebler.com/konfiguration_M36_M58

NOTICE	**No function to reset to factory settings**
	The encoder has no function to reset to factory settings, since the writing of the configuration via PG and the setting of a node ID via address claim already cover all adjustable parameters.

Also refer to

Contact [33]

5.3 Protocol Features

5.3.1 Data Transmission

5.3.1.1 Service Data Transmission

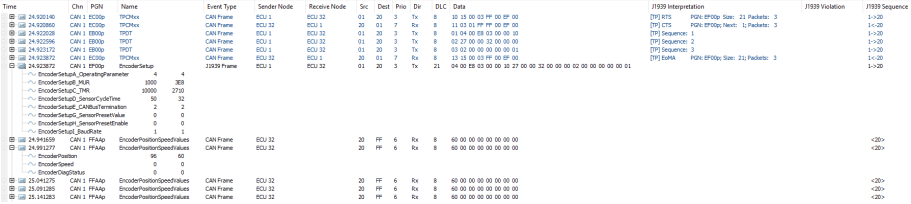
We recommend, to transmit the data in the configuration data PG to the encoder, a tool such as e.g. Vector CANoe, CANalyzer or a J1939 software stack.

The configuration data is - as specified in document SAE J1939/21 – transmitted via J1939 CMDT transfer. A configuration is in principle possible also without J1939 stack or tool.

The transmission via EncoderSetup PG with listing of the raw frames on the bus starts at moment 24.920140 and is concluded at moment 24.923872.

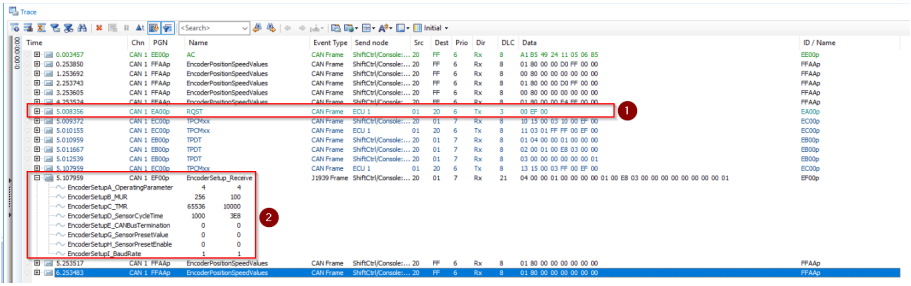
To this purpose, you must sent the frames marked with Dir: "Tx" (RTS and Sequence 1-3) and you receive as an answer the two frames marked with "Rx" (CTS and EoMA).

After the configuration, how the encoder starts sending measured data can be seen as from moment 24.941659 ("EncoderPositionSpeedValues").



IMG-ID: 70185995

The factory-set configuration data (default values) can be read by request PGN. For this purpose, simply send the hex value 0xEF00 to the device. The parameters PresetValue and PresetEnable are always returned as 0. (2)



IMG-ID: 159283083

5.3.1.2 Process Data Transmission

Process data transmission is possible in two ways:

- Time-controlled by the internal cyclic Sensor Cycle Time, in a values range from 5 to 65535 milliseconds. A value 0 is also valid and switches the time-controlled cyclic transmission off.
- Upon request by a request PG (0xEA00).

NOTICE	**RTR frames**
	Answering to RTR frames is not supported, as RTR requests are not part of the J1939 standard. Request PG (0xEA00) allows requesting the measured data from the encoder, even when Sensor Cycle Time is set to 0.

5.4 Configuration Parameters Description

5.4.1 Operating Parameter

Code sequence:

0 = increasing measured values for clockwise rotation (cw)

1 = increasing measured values for counter-clockwise rotation (cw)

Scaling:

0 = active

1 = not active

Default setting: 0x04 (Scaling: Active, Direction of rotation: CW)

Bit number	Function	Bit = 0	Bit = 1
0 (least significant bit)	Code sequence / Direction of rotation	cw	ccw
1	Reserved bit, must always be set to 0.		
2	Scaling	Not active	Active
4 ... 15	Reserved bits, must always be set to 0.		

5.4.2 MUR

This parameter sets the desired resolution per revolution. The encoder calculates internally the corresponding scaling factor. The calculated scaling factor MURF (by which the physical position value is multiplied) is calculated according to the following formula:

MURF = Measuring steps per revolution / phys. resolution singleturn

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^{7}…2^{0}$	$2^{15}…2^{8}$	$2^{23}…2^{16}$	$2^{31}…2^{34}$

Values range: 1.... maximum physical resolution (16384) 2^{14} bits

Only valid if scaling (OperatingParameter bit2) is activated.

NOTICE	**MUR and TMR values are only taken into consideration when scaling is active.**

5.4.3 TMR

NOTICE	**TMR for singleturn devices**
	For singleturn devices, TMR = MUR.

This parameter sets the total number of measuring steps for singleturn and multiturn. The maximum physical resolution is multiplied by a factor. The factor is always < 1. In the event of the overflow of the scaled total position of the measuring steps, the encoder restarts from position zero.

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \ldots 2^0$	$2^{15} \ldots 2^8$	$2^{23} \ldots 2^{16}$	$2^{31} \ldots 2^{34}$

Values range multiturn: 1.... maximum physical resolution (4,294,967,296) 2^{32} bits

Values range singleturn: 1.... maximum physical resolution (16,384) 2^{14} bits

When changing TMR /MUR, the system also checks the TMR/MUR ratio.

If TMR is set to a value that leads to an invalid ratio, an error message is returned via EncoderDiagData and the new value is rejected. The old value remains active in the encoder. Only valid if scaling (OperatingParameter bit2) is activated.

NOTICE	**MUR and TMR values are only taken into consideration when scaling is active.**

5.4.4 Preset Value

The position value of the encoder is set to the preset value input. This allows e.g. aligning the zero position of the encoder with the zero position of the machine.

The PresetValue value must be smaller than the TMR value set.

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \ldots 2^0$	$2^{15} \ldots 2^8$	$2^{23} \ldots 2^{16}$	$2^{31} \ldots 2^{24}$

Values range multiturn: 1.... maximum physical resolution (4,294,967,296) 2^{32} bits

Values range singleturn: 1.... maximum physical resolution (16,384) 2^{14} bits

5.4.5 Preset Enable

The position value of the encoder is set to the preset value defined in PresetValue if PresetEnable has the value 1. For all other PresetEnable values, the value defined in PresetValue is ignored.

This allows e.g. aligning the zero position of the encoder with the zero position of the machine.

NOTICE	Simultaneous baud rate change Please note: If PresetEnable has the value 0x01, BaudRate must be set to 0xFF, since a simultaneous baud rate change and setting of the preset value in the same config datagram is not supported by the encoder.

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \ldots 2^0$	$2^{15} \ldots 2^8$	$2^{23} \ldots 2^{16}$	$2^{31} \ldots 2^{24}$

Values range: 0.... maximum physical resolution (4294967295) 2^{32} bits

5.4.6 Sensor Cycle Time

Defines the cycle time in milliseconds with which the current position is transmitted via measured data PG. The timer-controlled transmission becomes active as soon as SensorCycleTime > 0 is input in the configuration PGN.

If a value smaller than 5 is input in SensorCycleTime, the encoder uses the value 5.

Values range: 5 ... FFFFh (65535) cycle time in milliseconds

5.4.7 Baud Rate

This byte allows modifying the baud rate by software. The new baud rate is saved in the encoder immediately after the receipt of the configuration.

In case of a change of the currently active baud rate, the encoder re-starts with the new baud rate and sends its address claim and, when appropriate, measured data with the new baud rate.

NOTICE	Simultaneous baud rate change Please note: If PresetEnable has the value 0x01, BaudRate must be set to 0xFF, since a simultaneous baud rate change and setting of the preset value in the same config datagram is not supported by the encoder.

Data content:

Byte 0
$2^7 \ldots 2^0$

Value	Action
1	Set the baud rate to 250 kbps
2	Set the baud rate to 500 kbps
0xFF	Do not change the baud rate
Other values	Do not change the baud rate (reserved)

5.4.8 CAN Bus Termination

This byte allows activating or de-activating the CAN bus termination (120 Ω) per Software. As a standard, this value is set to 0x01, i.e. the encoder is terminated.

In case of a change the setting is taken over immediately upon receipt and saved in the encoder.

Data content:

Byte 0
$2^7 \ldots 2^0$

Values range 0 ... 1

Value	Action
0	Termination off
1	Termination on
0xFF	Do not change the termination
Other values	Do not change the termination (reserved)

5.4.9 Encoder Position

The device returns the current position value (possibly multiplied by the scaling factor).

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \ldots 2^0$	$2^{15} \ldots 2^8$	$2^{23} \ldots 2^{16}$	$2^{31} \ldots 2^{24}$

Values range multiturn: 1.... maximum physical resolution (4,294,967,296) 2^{32} bits

Values range singleturn: 1.... maximum physical resolution (16,384) 2^{14} bits

The TMR/MUR ratio is active when scaling is active, otherwise the 32-bit (MT) or 14-bit (ST) raw position of the sensor is output.

5.4.10 Encoder Speed

The encoder returns the currently calculated speed in RPM as a signed 16-bit value.

Data content:

Byte 4	Byte 5
$2^7 \ldots 2^0$	$2^{15} \ldots 2^8$

Values range: 0 ... ± maximum speed 12000 RPM

5.4.11 Encoder DiagData

The encoder returns its current operating state in the EncoderDiagData bytes.

In failure-free operation, EncoderDiagData has the value 0.

NOTICE	Pay attention to the values range If EncoderDiagData contains a value different from 0, the values measured by the encoder might be faulty.

Value	Action
0	No error
0xEE00	General error in the sensor
0xEE01	Invalid MUR value: MUR 0 or MUR larger than 16384 (maximum singleturn resolution)
0xEE02	Invalid TMR value: TMR 0
0xEE03	Preset value larger than TMR
Other values	Other faults

5.5 Examples

5.5.1 Changing the Device Parameters

This example uses fictitious values to illustrate the transmission of the data.

NOTICE	Exemplary configuration data This example is only intended for illustration and therefore contains invalid configuration data.

Configuration data	Byte	Hex value (fictitious)	Endian hex value	Decimal value
OperatingParameter	2	0102	0201	258
MUR	4	03040506	06050403	50595078
TMR	4	0708090A	0A090807	117967114
SensorCycleTime	4	0B0C0D0E	0E0D0C0B	185339150
CANBusTermination	1	0F	0F	15
SensorPresetValue	4	10111213	13121110	269554195
SensorPresetEnable	1	14	14	20
BaudRate	1	15	15	21

The desired data must first be Endian-converted, thus swapped byte by byte. This is necessary because J1939 transfers the data starting with the lowest-order byte.

Then the data is concatenated and sent as shown in the layout.

This results in the following data stream, which must be transmitted to the encoder, by concatenating the values in the right column of the table:

02 01 06 05 04 03 0A 09 08 07 0E 0D 0C 0B 0F 13 12 11 10 14 15

This data must now be distributed over several CAN frames and transmitted per CMDT transport protocol. The transport protocol is necessary because at the maximum 8 user data bytes can be transmitted per CAN frame.

All mentioned CAN frames must be transmitted and received as extended frames (29-bit identifier).

There must be a dwell of at least 50 ms between the transmission of the frames.

A CMDT connection must be set up first, with the parameters coded in the sent packet. The requesting control device of the customer has generally address 0x01. The sensor has address 0x20.

- Control byte: 0x10
- Message size: 0x15
- Total number of packets: 3
- Maximum number of packets: 0xFF
- PG number: 0xEF00
- Source address: 0x01
- Destination address: 0x20

For this purpose, the following RTS packet must be sent to the sensor and the CTS answer from the sensor must be waited for:

	Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
Transmit RTS request on CAN ID: 0x18EC2001	10	15	00	03	FF	00	EF	00
Receive CTS answer on CAN ID: 0x18EC0120	11	03	01	FF	FF	00	EF	00

In the next step, the control device transmits the configuration data in three CAN frames to the sensor.

The byte 0 of the frames always contains the sequence number in the data transmission.
The bytes 1-7 consecutively contain the raw data, in this example the following data:

02 01 06 05 04 03 0A 09 08 07 0E 0D 0C 0B 0F 13 12 11 10 14 15

There must be a dwell of at least 50 ms between the transmission of the frames.

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 1, CAN-ID: 0x18EB2001	01	02	01	06	05	04	03	0A

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 2, CAN-ID: 0x18EB2001	02	09	08	07	0E	0D	0C	0B

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 3, CAN-ID: 0x18EB2001	03	0F	13	12	11	10	14	15

At the end of the transmission, the encoder confirms the successful transmission:

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Receipt EoMA, CAN-ID: 0x18EC0120	13	15	00	03	FF	00	EF	00

The receipt of the confirmation completes the configuration of the encoder.

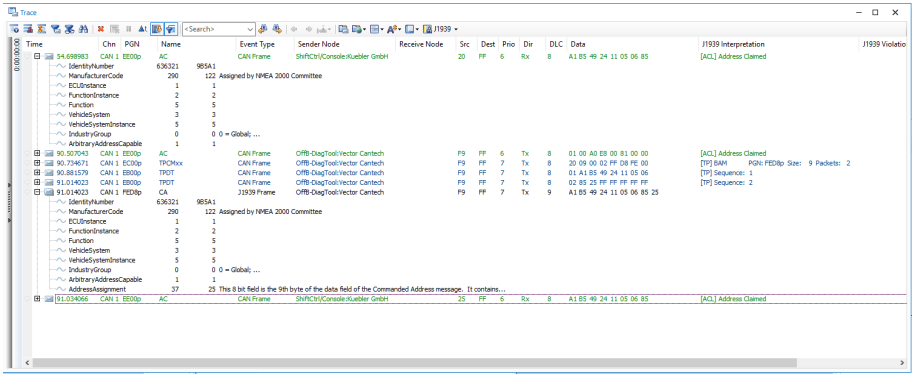
5.5.2 Changing the Device Address

The device address of the encoder can be modified by sending the "Commanded Address" (CA) PGN to the encoder.

Results:

- The new address is stored in non-volatile manner in the flash memory of the encoder.
- The encoder re-starts with the new address.
- The encoder sends its address claim and, when appropriate, measured data, from the new address.

To illustrate, the example shows the data exchange log of an address change.
The cyclic measured data transmission has been switched off for this example.



IMG-ID: 70111627

- At moment 54.69 the encoder registers, after switching the voltage supply on, on the bus with its address 0x20.
- At moment 90.50 the diagnosis tool registers on the bus (here: Vector CANalyzer).
- From moment 90.73 to 91.01 the diagnosis tool sends the "Commanded Address" (CA) PGN to the encoder. This transmission is distributed by the J1939 BAM protocol over three physical CAN frames. It is visible that the J1939 NAME or the address claim appears again. The new address 0x25 and five 0xFF filling bytes are at the end of the transmission.

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Send TP, BAM, CAN-ID: 0x18EB2001	20	09	00	02	FF	D8	FE	00

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 1, CAN-ID: 0x18EB2001	01	A1	B5	49	24	11	05	06

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 2, CAN-ID: 0x18EB2001	02	85	25	FF	FF	FF	FF	FF

- At moment 91.03 the encoder registers again on the bus with the new address 0x25.

5.5.3 Switching Back to Factory Setting

In this example, the encoder is reset to the configuration values specified under "Default settings". Also the preset value is set to 0.

Multiturn:

Configuration data	Byte	Hex value	Endian hex value	Decimal value
OperatingParameter	2	04	0400	4
MUR	4	4000	00400000	16384
TMR	4	10000000	00000010	268435456
SensorCycleTime	4	32	32000000	50
CANBusTermination	1	01	01	1
SensorPresetValue	4	00000000	00000000	0
SensorPresetEnable	1	01	01	1
BaudRate	1	01	01	1

Singleturn:

Configuration data	Byte	Hex value	Endian hex value	Decimal value
OperatingParameter	2	04	0400	4
MUR	4	4000	00400000	16384
TMR	4	4000	00400000	16384
SensorCycleTime	4	32	32000000	50
CANBusTermination	1	01	01	1
SensorPresetValue	4	00000000	00000000	0
SensorPresetEnable	1	01	01	1
BaudRate	1	01	01	1

The desired data must first be Endian-converted, thus swapped byte by byte. This is necessary because J1939 transfers the data starting with the lowest-order byte. Then the data is concatenated and sent as shown in the layout.

This results in the following data stream, which must be transmitted to the encoder, by concatenating the values in the right column of the table:

Multiturn:

04 00 00 40 00 00 00 00 00 10 32 00 00 00 01 00 00 00 00 01 01

Singleturn:

04 00 00 40 00 00 00 40 00 00 32 00 00 00 01 00 00 00 00 01 01

This data must now be distributed over several CAN frames and transmitted per CMDT transport protocol. The transport protocol is necessary because at the maximum 8 user data bytes can be transmitted per CAN frame.

All mentioned CAN frames must be transmitted and received as extended frames (29-bit identifier).

There must be a dwell of at least 50 ms between the transmission of the frames.

A CMDT connection must be set up first. The requesting control device has address 0x01 and the sensor has address 0x20. The parameters coded in the sent packet are:

- Control Byte: 0x10
- Message Size: 0x15
- Total number of Packets: 3
- Maximum number of Packets: 0xFF
- PG Number: 0xEF00
- Source Address: 0x01
- Destination Address: 0x20

For this purpose, the following RTS packet must be sent to the sensor and the CTS answer from the sensor must be waited for:

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit RTS request on CAN-ID: 0x18EC2001	10	15	00	03	FF	00	EF	00
Receive CTS answer on CAN-ID: 0x18EC0120	11	03	01	FF	FF	00	EF	00

In the next step, the control device transmits the configuration data in three CAN frames to the sensor.

It is visible that byte 0 of the frames always contains the sequence number in the data transmission. Bytes 1-7 consecutively contain the raw data. These are in this example:

Multiturn:

04 00 00 40 00 00 00 00 00 10 32 00 00 00 01 00 00 00 00 01.

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 1, CAN-ID: 0x18EB2001	01	04	00	00	40	00	00	00

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 2, CAN-ID: 0x18EB2001	02	00	00	10	32	00	00	00

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 3, CAN-ID: 0x18EB2001	03	01	00	00	00	00	01	01

Singleturn:

04 00 00 40 00 00 00 40 00 00 32 00 00 00 01 00 00 00 00 01 01

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 1, CAN-ID: 0x18EB2001	01	04	00	00	40	00	00	00

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 2, CAN-ID: 0x18EB2001	02	40	00	00	32	00	00	00

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Transmit TP, sequence number: 3, CAN-ID: 0x18EB2001	03	01	00	00	00	00	01	01

At the end of the transmission, the encoder confirms the successful transmission:

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Receipt EoMA, CAN-ID: 0x18EC0120	13	15	00	03	FF	00	EF	00

The receipt of the confirmation completes the configuration of the encoder.

6 Annex

6.1 Decimal / Hexadecimal conversion table

Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
0	*0*	51	*33*	102	*66*	153	*99*	204	*CC*
1	*1*	52	*34*	103	*67*	154	*9A*	205	*CD*
2	*2*	53	*35*	104	*68*	155	*9B*	206	*CE*
3	*3*	54	*36*	105	*69*	156	*9C*	207	*CF*
4	*4*	55	*37*	106	*6A*	157	*9D*	208	*D0*
5	*5*	56	*38*	107	*6B*	158	*9E*	209	*D1*
6	*6*	57	*39*	108	*6C*	159	*9F*	210	*D2*
7	*7*	58	*3A*	109	*6D*	160	*A0*	211	*D3*
8	*8*	59	*3B*	110	*6E*	161	*A1*	212	*D4*
9	*9*	60	*3C*	111	*6F*	162	*A2*	213	*D5*
10	*0A*	61	*3D*	112	*70*	163	*A3*	214	*D6*
11	*0B*	62	*3E*	113	*71*	164	*A4*	215	*D7*
12	*0C*	63	*3F*	114	*72*	165	*A5*	216	*D8*
13	*0D*	64	*40*	115	*73*	166	*A6*	217	*D9*
14	*0E*	65	*41*	116	*74*	167	*A7*	218	*DA*
15	*0F*	66	*42*	117	*75*	168	*A8*	219	*DB*
16	*10*	67	*43*	118	*76*	169	*A9*	220	*DC*
17	*11*	68	*44*	119	*77*	170	*AA*	221	*DD*
18	*12*	69	*45*	120	*78*	171	*AB*	222	*DE*
19	*13*	70	*46*	121	*79*	172	*AC*	223	*DF*
20	*14*	71	*47*	122	*7A*	173	*AD*	224	*E0*
21	*15*	72	*48*	123	*7B*	174	*AE*	225	*E1*
22	*16*	73	*49*	124	*7C*	175	*AF*	226	*E2*
23	*17*	74	*4A*	125	*7D*	176	*B0*	227	*E3*
24	*18*	75	*4B*	126	*7E*	177	*B1*	228	*E4*
25	*19*	76	*4C*	127	*7F*	178	*B2*	229	*E5*
26	*1A*	77	*4D*	128	*80*	179	*B3*	230	*E6*
27	*1B*	78	*4E*	129	*81*	180	*B4*	231	*E7*
28	*1C*	79	*4F*	130	*82*	181	*B5*	232	*E8*
29	*1D*	80	*50*	131	*83*	182	*B6*	233	*E9*
30	*1E*	81	*51*	132	*84*	183	*B7*	234	*EA*

Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
31	*1F*	82	*52*	133	*85*	184	*B8*	235	*EB*
32	*20*	83	*53*	134	*86*	185	*B9*	236	*EC*
33	*21*	84	*54*	135	*87*	186	*BA*	237	*ED*
34	*22*	85	*55*	136	*88*	187	*BB*	238	*EE*
35	*23*	86	*56*	137	*89*	188	*BC*	239	*EF*
36	*24*	87	*57*	138	*8A*	189	*BD*	240	*F0*
37	*25*	88	*58*	139	*8B*	190	*BE*	241	*F1*
38	*26*	89	*59*	140	*8C*	191	*BF*	242	*F2*
39	*27*	90	*5A*	141	*8D*	192	*C0*	243	*F3*
40	*28*	91	*5B*	142	*8E*	193	*C1*	244	*F4*
41	*29*	92	*5C*	143	*8F*	194	*C2*	245	*F5*
42	*2A*	93	*5D*	144	*90*	195	*C3*	246	*F6*
43	*2B*	94	*5E*	145	*91*	196	*C4*	247	*F7*
44	*2C*	95	*5F*	146	*92*	197	*C5*	248	*F8*
45	*2D*	96	*60*	147	*93*	198	*C6*	249	*F9*
46	*2E*	97	*61*	148	*94*	199	*C7*	250	*FA*
47	*2F*	98	*62*	149	*95*	200	*C8*	251	*FB*
48	*30*	99	*63*	150	*96*	201	*C9*	252	*FC*
49	*31*	100	*64*	151	*97*	202	*CA*	253	*FD*
50	*32*	101	*65*	152	*98*	203	*CB*	254	*FE*
								255	*FF*

6.2 Setting the Baud Rate

The line length must be taken into consideration when defining the topology and the baud rate. The maximum length of the CAN bus is mainly limited by its signal propagation time. The multi-master arbitration process assumes that the signals reach all participants at the same time, i. e. before the sampling within a bit cycle. The signal propagation time in every network component (transceiver, optocoupler, CAN controller) is approximately constant. Therefore the final bus length primarily depends on the baud rate.

Baud rate [kbit/s]	Bus length [m]
1000	< 20
500	< 100
250	< 250
125	< 500
50	< 1000
20	< 2500
10	< 5000

The relevant literature often indicates the value of 40 m for 1 Mbit/s.
This leads to the formula:

- Bit rate * line length < 1 Mbit/s * 40 m

In addition, the following physical framework parameters apply:

- Runtime of a driver stage = 20 ns
- Propagation of the electrical wave on the line = 17 cm/s
- Scanning of the bit at 70% of the bit time.

However, this does not apply to networks with optical electrical isolation of the CAN controllers. In a "worst case" consideration, the value can reduce to 5 m with 1 Mbit/s. However, in practice, a line length of 20 m can be achieved without problems. Repeaters must be used for lengths >1000 m.

Line resistance

The line resistance must not be ignored. A loss on the signal line occurs over the whole length of the line.

In this case, the "worst case" would be when a node transmits at the beginning of the bus line and a node receives at the end of the line.

The strength of the differential signal at the receiving node depends on the following factors:

- Generated differential voltage of the transmitting node
- Line resistance RL = L * ρ, with L = line length [m] and ρ = resistance per m [Ohm/m]
- Differential input resistance of the receiving node

7 Contact

You want to contact us:

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Kübler's worldwide applications team is available on site all over the world for technical advice, analysis or installation support.

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Glossary

Baud Rate

The baud rate is the transmission rate. It is related with the nominal bit timing. The maximum possible baud rate depends on many factors that influence the signal propagation time on the bus. There is a substantial link between the maximum baud rate and the bus length and cable type. Various baud rates are defined between 10 kbit/s and 1 Mbit/s in CANopen.

CA

Commanded Address

CAN

Controller Area Network

CANalyzer

CANalyzer is an analysis software of Vector Informatik GmbH.

ccw

counterclockwise, counting direction

CMDT

Connection Mode Data Transfer

COB

Communication Object. Transport unit in the CAN network (CAN message). Data is sent through the network in a COB.

CRC

Cyclic Redundancy Check

CTS

Clear To Send

cw

clockwise, counting direction

Diag

Diagnostic

EDS File

The EDS (Electronic Data Sheet) file is provided by the manufacturer of a CANopen device. It has a standardized format for the description of devices. The EDS file contains information about: • File description (name, version, creation date, etc.) • General device information (manufacturer name and code) • Device name and type, version, LMT address • Supported baud rates and boot-up capability • Description of the supported objects by their attributes.

EEPROM

Electrically erasable programmable read-only memory. Nonvolatile electronic memory elements whose saved information can be erased electrically.

ID

Identifier. Univocal designation of a CAN message. The identifier determines the priority of the COB in the network.

MT

Multiturn

MUR

Measuring Units per Revolution

NDR

Number of Distinguishable Revolutions

PG

Parameter Group

PGN

Parameter Group Number

RTS

Request To Send

ST

Singleturn

TMR

Total Measuring Range

XOR Operation

A bit by bit exclusive OR. It is used for two bit sequences having the same length and performs the logical XOR operation for every pair of corresponding bits. The resulting bit is 1 if the two bits are different and 0 if they are equal.

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