Manual

Absolute Encoder SAE J1939
(with bus cover)

Content

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1 Introduction

1.1 Scope of delivery

Please check the delivery upon completeness prior to commissioning.
Depending on encoder configuration and part number delivery is including:
- Basic encoder
- Bus cover
- CD with describing file and manual (also available as download in the Internet)

1.2   Product assignment

Solid shaft encoders

Product	Function	Product family
BMSV 58	Singleturn	MAGRES
BMMV 58	Multiturn	MAGRES
GCAMW	Singleturn	magtivo
GCMMW	Multiturn	magtivo
GBAMW	Singleturn	multivoPlus
GBLMW	Multiturn	multivoPlus
GBMMW	Multiturn	multivoPlus
GEMMW	Multiturn (stainless steel)	multivo
GXAMW	Singleturn	multivo
GXLMW	Multiturn	multivo
GXMMW	Multiturn	multivo

End shaft encoders

Product	Function	Product family
BMSH 58	Singleturn	MAGRES
BMMH 58	Multiturn	MAGRES
GCAMS	Singleturn	magtivo
GCMMS	Multiturn	magtivo
GBAMS	Singleturn	multivoPlus
GBLMS	Multiturn	multivoPlus
GBMMS	Multiturn	multivoPlus
GXAMS	Singleturn	multivo
GXLMS	Multiturn	multivo
GXMMS	Multiturn	multivo

Hollow shaft encoders

Product	Function	Product family
GBAMH	Singleturn	multivoPlus
GBLMH	Multiturn	multivoPlus
GBMMH	Multiturn	multivoPlus
GEMMH	Multiturn (stainless steel)	multivo
G0LMH	Multiturn	multivoPlus
G0AMH, G1AMH, G2AMH	Singleturn	multivo
G0MMH, G1MMH, G2MMH	Multiturn	multivo

2 Safety precautions and operating instructions

Supplementary information
- This manual is intended as a supplement to already existing documentation (catalogues, product information and assembly instructions).
- The manual must be read without fail before initial commissioning of the equipment.

Intended purpose of the equipment
- The encoder is a precision measurement device. It is utilized for acquisition of angular positions and revolutions and to prepare and supply measured values in the form of electrical output signals for the follow-on device systems. The encoder may only be used for this purpose.

Commissioning
- The encoder may only be installed and assembled by authorised, qualified experts.
- Observe the operating instructions of the machine manufacturer.

Safety precautions
- Prior to commissioning the equipment, check all electrical connections.
- If installation, electrical connection or any other work performed at the encoder or at the equipment is not correctly executed, this can result in a malfunction or failure of the encoder.
- Steps must be taken to exclude any risk of personal injury, damage to the plant or to the operating equipment as a result of encoder failure or malfunction by providing suitable safety precautions.
- Encoders must not be operated outside the specified limited values (see detailed product documentation).

Failure to comply with the safety remarks can result in malfunctions, personal injury or damage to property.

Transport and storage
- Only ever transport or store encoders in their original packaging.
- Never drop encoders or expose them to major vibrations.

Assembly
- Avoid impacts or shocks on the housing and shaft / hollow shaft.
- Avoid any twist or torsion on the housing.
- Do not open the encoder or perform any mechanical changes.

The shaft, ball bearings, glass pane or electronic components can be damaged. In this case, safe and reliable operation is no longer guaranteed.

Electrical commissioning
- Do not make any electrical changes at the encoder.
- Do not carry out any wiring work when the encoder is live.
- Never plug or unplug the electrical connection when the encoder is live.
- Ensure that the entire plant is installed in line with EMC requirements. The installation environment and wiring affect the electromagnetic compatibility of the encoder. Install the encoder and supply cables separately or at a long distance from cables with high interference emissions (frequency converters, contactors etc.)
- Where working with consumers which have high interference emissions, make available a separate power supply for the encoder.
- Completely shield the encoder housing and connecting cable.
- Connect the encoder to the protective earth (PE) conductor using shielded cable. The braided shield must be connected to the cable gland or plug. Ideally, aim at bilateral connection to protective earth (PE), the housing via the mechanical assembly, the cable shield via the downstream connected devices. In case of earth loop problems, earth on one side only as a minimum requirement.

Failure to observe these instructions can result in malfunctions, material damage or personal injury.

3 Product families

The product family architecture is modular. Depending on what is required from the encoder, the basic encoder and bus covers can be combined at will with the selected bus system.
The basic encoders differ in terms of accuracy, ambient conditions and the utilized sensing principle.

Bus cover
The bus cover accommodates the field bus interface and the complete electronics for processing the measured values. EtherNet/IP communication is performed via the specialized EtherNet/IP-ASIC ERTEC200 with integrated high-performance microcontroller ARM9.

Magres / magtivo®
Utilizes a magnetic sensing principle and endures harsh industrial environments.

Procoder / multivo®
Utilizes a photoelectric sensing principle and is the recommended product for precise applications.

Dignalizer / activo® / multivo*Plus*®
Utilizes a photoelectric sensing principle with integrated analog/digital signal conversion and is the product to choose for ultra-precise sensing applications.

The bus covers differ by the respectively integrated bus interface.
Available bus interfaces: CANopen, DeviceNet, EtherCAT, Ethernet/IP, Profibus-DP, Profinet, Powerlink, Power over EtherCAT, SAE J1939, SSI.
All encoders enable parameterization by bus interface.

Functional principle:
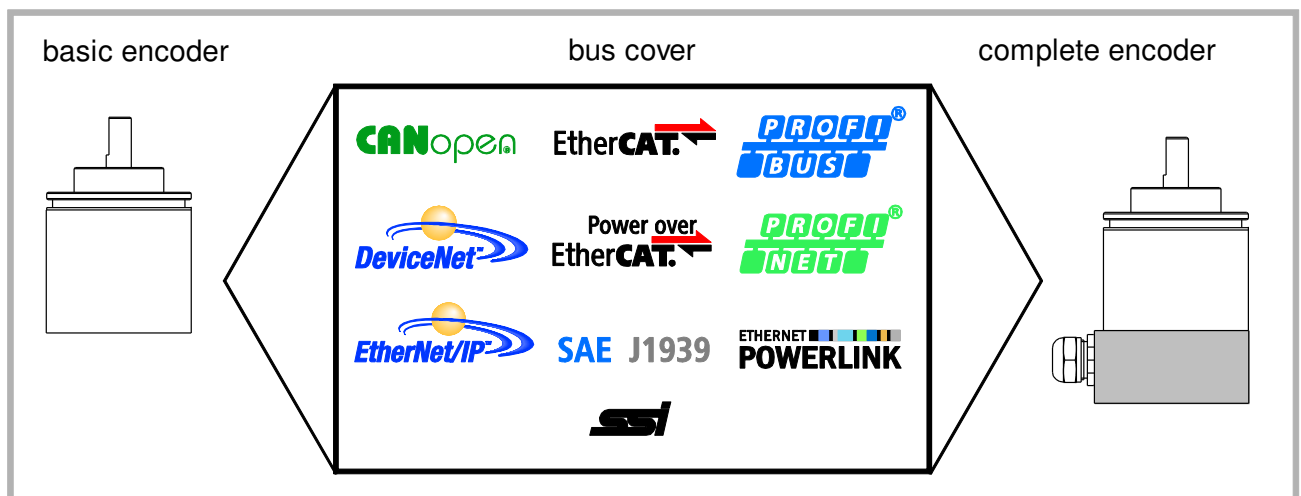
4 CAN-Bus

4.1 CAN-Bus

CAN bus (CAN: Controller Area Network) was originally developed by Bosch and Intel as a means of fast, low-cost data transmission in automotive applications. Today, CAN bus is utilized also in industry automation. There are several bus systems based on CAN, with extended or simplified protocols:
CANopen , DeviceNet, SAE J1939

4.1.1 CAN bus properties

• Data rate of 1 MBaud within 40 m network range

• Bilaterally closed network

• Bus media: twisted-pair cable

• Real time capability: Defined maximum waiting time for high-priority messages.

• In theory 127 users in one bus, but in fact only 32 are possible (driver-relevant).

• Secured data consistency across the network. Damaged messages are notified as faulty for all network nodes.

• Message-oriented communication
  Message identification is by a message identifier which is utilized by the network nodes to verify whether the message is of individual relevance.

• Broadcasting, multicasting
  All network nodes receive each message simultaneously, thus enabling synchronization.

• Multimaster capability
  Each user in the fieldbus is allowed to transmit and receive data without depending on a master's priority. Each user is allowed to start its message when the bus is not occupied. Messages being sent simultaneously are subject to a priority filter and the user with the highest priority will prevail.

• Priorization of messages
  The identifier defines the priority of the message, thus a quick transmission of important messages is ensured.

• Residual error probability
  Safety procedures in the network reduce the probability of an undiscovered flaw in data transmission to below 10^{-11}. In practical terms, it is possible to ensure a 100% reliable transmission.

• Function checking
  Localization of faulty or failed stations. The CAN protocol encompasses a network node monitoring function. The function of faulty network nodes is restricted respectively the faulty nodes are completely decoupled from the network.

• Data transmission with short error recovery time
  Faulty messages are most probably detected by virtue of several error detection mechanisms. Upon detecting an error the message is automatically retransmitted.

The bus cable links the individual users in the CAN bus network. Each network user can transmit and receive messages. There is a serial data transmission among the network users.

4.2 SAE J1939

SAE J1939 is the vehicle bus standard developed by the Society of Automotive Engineers (SAE) and used for communication and diagnostics among components of cars, heavy duty trucks, utility and specialized vehicles. J1939 is based on the physical layer of CAN bus.

SAE J1939 protocol is used in the commercial vehicle area for communication throughout the vehicle. Several international standards for trucks and trailer rigs, forest and agricultural machines as well as for marine applications are based on SAE J1939. Data transmission method, content and structure of the message as well as data packets are defined by the relevant specification.

J1939: General network description.
J1939/0X: General application description.
J1939/01: Utility vehicles, trucks and buses.
J1939/7X: Application Layer.
J1939/71: Vehicle Application Layer. Vehicle.
J1939/73: Application Layer Diagnostics,
J1939/81: Network Management.
J1939/31: Network Layer. Bridge, Router, Gateway, Filter.
J1939/21: Data Link Layer.
J1939/1X: Physical Layer.
J1939/11: Physical Layer, STP cable, 250 kbit/s.
J1939/12: Physical Layer, star quad, 250 kbit/s.
J1939/13: Off-Board Diagnostic connector

SAE J1939 uses the 29-bit/"extended" identifier in the CAN data frame.

An eight-bit address and a standard header which contains an index called PGN (Parameter Group Number) is embedded in the message's 29-bit identifier.

The 8-bit address embedded in the identifier is used as source and destination address for the SAE-J1939 nodes. The information is output as signals and compiled in PGNs.

The SAE-J1939 protocol applied in commercial and railway vehicles, agricultural machines and ships considers segmentation, flow control, transmission method, message acknowledgement yes/no and specifies the content of the message.

4.2.1 PGN Definitions for SAE J1939 encoder

PGN = Parameter Group Number

J1939 definition	Default
Baudrate	250Kbit/s
Default Address	172 (0xAC)
Arbitrary Address Capable	1
Industry Group	5
Vehicle System	0
System Instance	0
ECU Instance	0
Function	142 (0x8E)
Function Instance	0
Manufacturer	343 (0x157)
Identity Number	Device-specific

PGN 65450: Encoder position, speed, diagnosis

PGN 65450: Encoder position, speed, diagnosis	Proprietary B, Broadcast communication
Transmission repetition rate	50ms
Data Length	8 bytes
PDU format PF	255 (0xFF)
PDU specific PS	0xAA
Default priority	6
Parameter group number PGN	65450 (0xFFAA)

Structure of the 8-byte CAN data field

Bytes 1 - 4: encoder absolute position
Data length/type: 4 byte, U32
Resolution: steps
Value range: refer to encoder type under 6.3.3 (depending on the basic encoder)

Bytes 5 - 6: encoder speed
Data length/type: 2 byte, S16
Resolution: rpm
Value range: +- 32768 (observe the admissible maximum speed)

Byte 7 – 8: encoder diagnosis
Data length/type: 2 byte, U16

Bit position	Meaning	Function	Default
Bit 7.0-7.7	Reserved		0
Bit 8.0-8.3	Reserved		0
Bit 8.4	Battery warning	0 lithium battery voltage OK 1 lithium battery voltage low	0
Bit 8.5-8.6	Reserve		0
Bit 8.7	Position alarm	0 position data OK 1 position data faulty	0

PGN 61184: Encoder parameters

PGN 61184: Encoder parameters	Proprietary A, Peer-to-Peer communication
Transmission repetition rate	0 ms, acyclic (on request)
Data Length	8 bytes
PDU format PF	0xEF (239)
PDU specific PS	8 Bit Destination address
Default priority	6
Parameter group number PGN	61184 (0xEF00)

PGN 61184 enables parameter read and write of the following:

- Sense of rotation
- Resolution
- Total resolution
- Preset
- PGN 65450 cycle time (position, speed, diagnosis)
- Software version (read only)

Refer also to separate description

5 Commissioning

5.1 Mechanical assembly

Solid shaft encoders
- Attach the encoder using the mounting holes and three screws (square flange: 4 screws) provided at the encoder flange. Observe thread diameter and depth.
- There is an alternative assembling option in any angular position by eccentric fixings, see under accessories.
- Provide a proper connection between drive shaft and encoder shaft by using an appropriate coupling. The shaft ends must not touch each other. The coupling must compensate temperature and mechanical tolerances. Observe the maximum permissible axial or radial shaft load. For appropriate couplings please refer to accessories.
- Tighten the mounting screws firmly.

Hollow shaft encoders
- Clamping ring
  Prior to mounting the encoder open the clamping ring completely. Push encoder onto the drive shaft and tighten the clamping ring firmly.
- Mounting element with rubber spring element
  Attach the encoder to the drive shaft and insert the cylindrical pin into the mounting element (provided by customer) together with the rubber spring element.
- Mounting angle
  Attach the encoder to the drive shaft. Insert the mounting angle into the encoder's rubber spring element and fasten the mounting angle at the contact surface.
- Stud screw
  Attach the encoder to the drive shaft and insert the stud screw (provided by customer) into the encoder's rubber spring element
- Spring washer
  Fasten the spring washer at the mounting holes of the encoder housing using screws. Attach the encoder onto the drive shaft and fasten the spring washer at the contact surface.

5.2 Electrical connection

Storage and transport of the bus cover whilst in the ESD bag only. The bus cover must fully rest against the housing and must firmly screwed on.
To perform electrical connection remove the bus cover as follows:

- Release the fastening screws of the bus cover
- Carefully loosen the bus cover and lift off in an axial direction

5.2.1 Attaching the bus cover

- Release the cap nut of the cable gland.
- Push the cap nut and seal insert with contact sleeve onto the cable sheath.
- Strip the cable sheath and cores, shorten the shield film where it exists (see fig.)
- Bend the braided shield by approx. 90°.
- Push the seal insert with contact sleeve along as far as the braided shield. Slide the seal insert with contact sleeve and cable flush into the cable gland and tighten the cap nut.
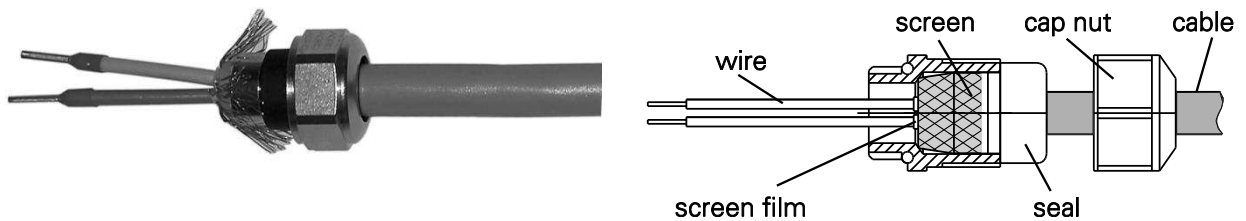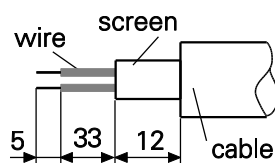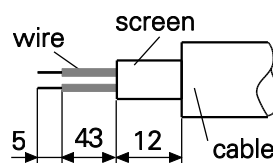
Standard encoders
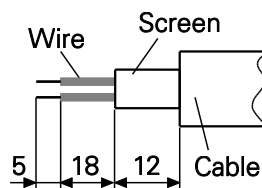
**G0AMH, G0MMH, GBAMH and GBMMH**

Bus cable

Supply cable

- Terminals with the same designation are interconnected.
- For power supply use only cable gland 3. Cable gland 1 or 2 can be used at will for the bus cable. Observe the permissible cable core cross sections.
- Insert the cores using the shortest route from the cable gland to the terminal strip. Observe the admissible core cross-section. Use isolated core end sleeves.
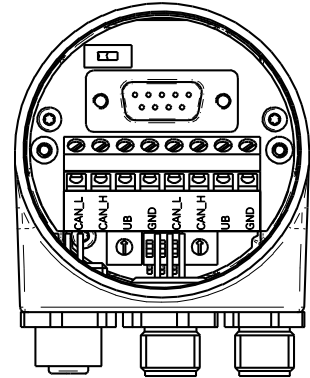- Avoid crossing over data lines with the supply line.

Bus cover – solid shaft / end shaft
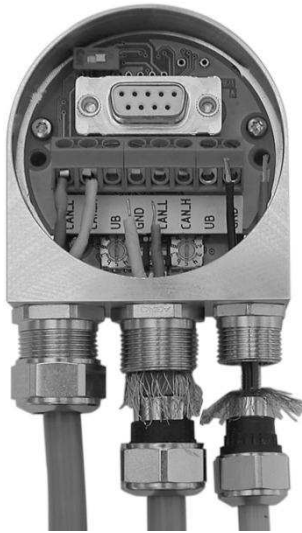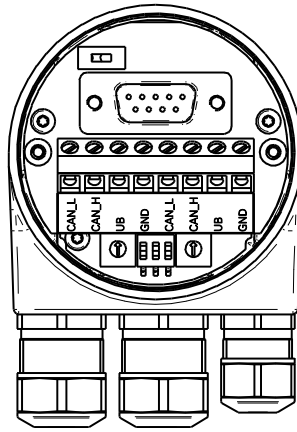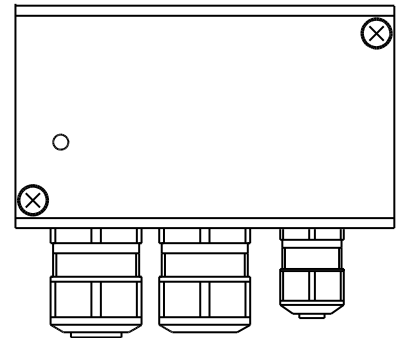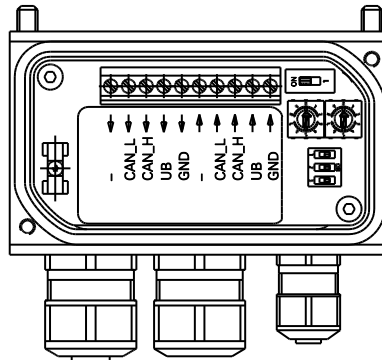

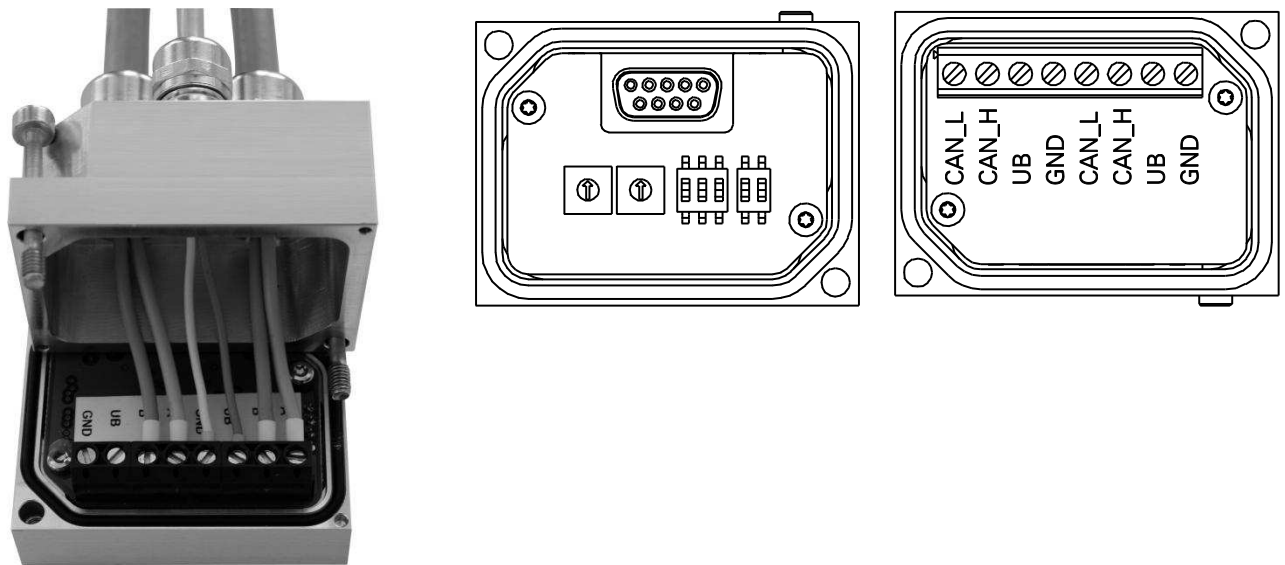| 1 | 2 | 3 | Cable gland | M12 connector |

Bus cover – hollow shaft G1 and G2

1   2   3

Bus cover – hollow shaft G0 and GB

Note: Both rotary switches and 3-pole DIP switch are without function.

5.2.2 Terminal assignment

Terminal	Meaning
CAN_L	CAN Bus Signal (dominant Low)
CAN_H	CAN Bus Signal (dominant High)
UB	Volltage supply 10...30 VDC
GND	Ground for UB

Terminals with the same significance are interconnected.

- Carefully dock the bus cover onto the D-SUB connector provided at the basic encoder. Then press only via the sealing rubber, taking care not to tilt. The bus cover must rest fully against the basic encoder.
- Tighten both the fastening screws firmly in the same direction.

There is only an optimized connection between encoder housing and braided shield of the connecting cable if the bus cover is resting fully on the basic encoder (form- locking).

5.2.3 User address

User address default is 172.
Each address claiming will add 1 to the encoder address if a user with a superior NAME-prioritiy (= inferior numerical value) is registered in the bus.

5.2.4 Baudrate

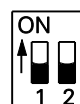The Baudrate is permanent 250 kbit/s and cannot be altered.

5.2.5 Terminating resistor

If the networked encoder is the final device in the bus line, the bus must be terminated by resistor. The resistor is provided in the bus cover and activated by setting the one-pole DIP switch to "ON" (default: OFF).

ON = Final user
OFF = User X

Switch 1:   ON = Final user
            OFF = User X
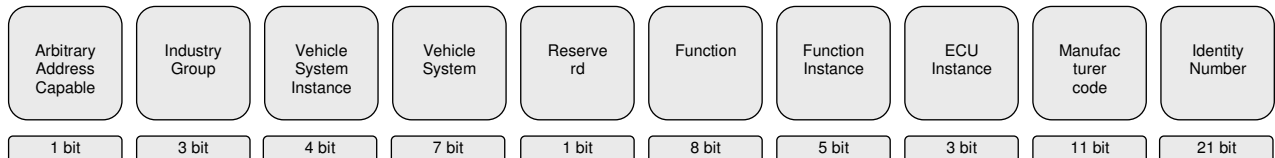Switch 2:   without function

6 SAE J1939 Operation

6.1 NAME-Field

The device will transmit its J1939 NAME field after power on.

J1939/81 specifies a 64-bit NAME – message for the clear identification of each ECU (electronic control unit). The NAME Field comprises 10 entries, 5 are SAE-specific and 5 either represent the network properties or are vendor-specific. For more information please refer to J1939/81.

J1939 NAME Field

Arbitrary Address Capable	Industry Group	Vehicle System Instance	Vehicle System	Reserved	Function	Function Instance	ECU Instance	Manufacturer code	Identity Number
1 bit	3 bit	4 bit	7 bit	1 bit	8 bit	5 bit	3 bit	11 bit	21 bit
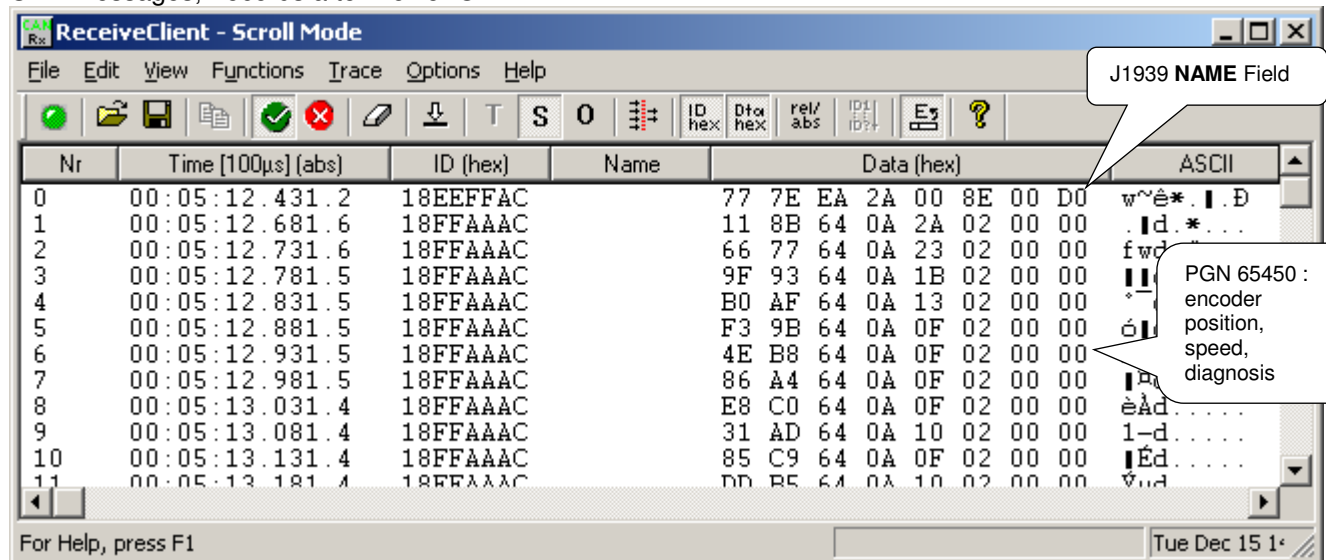
6.2 PGN 65450 Cyclic Input Data

The Name field is followed by cyclic transmission of PGN 65450 for encoder position, speed and diagnosis.

CAN messages, records after Power On

Structure PGN 65450, example

Identifier	CAN data
18FFAAAC	4E B8 64 0A 0F 02 00 00

Byte 7 – 8: encoder diagnosis
0x0000 = no alarms or warnings active

Bytes 5 - 6: encoder speed
0x020F = 527 rpm

Bytes 1 - 4: encoder absolute position
0x0A64B84E = 174372942

6.3   PGN 61184 encoder parameterization

PGN 61184 enables parameter read and write of the following:

- Direction of rotation
- Resolution
- Total resolution
- Preset
- PGN 65450 cycle time (position, speed, diagnosis)
- Software version (read only)
- SAVE non-volatile data saving
- RESTORE restore default

6.3.1 Read parameter (read request)

Read parameter requires a general read request for PGN 61184 (see below).
The parameter index is not provided. Upon every read request the respectively following parameter will be replied.

Example: Read parameter

Identifier	CAN Data	Meaning
18EAAC00	00 EF 00	1. Read request
18EF00AC	*01* **00 00** FF FF FF FF FF	Encoder response Index 01 direction of rotation = 0x0000 =CW
18EAAC00	00 EF 00	2. Read request
18EF00AC	*02* **00 20 00 00** FF FF FF	Encoder response Index 02 resolution = 0x00002000 = 8196 steps/revolution
18EAAC00	00 EF 00	3. Read request
18EF00AC	*03* **00 00 00 20** FF FF FF	Encoder response Index 03 total resolution = 0x20000000 = 536870912 steps
18EAAC00	00 EF 00	4. Read request
18EF00AC	*04* **00 00 00 00** FF FF FF	Encoder response Index 04 Preset = 0
18EAAC00	00 EF 00	5. Read request
18EF00AC	*05* **00 00** FF FF FF FF FF	Encoder response Index 05 PGN 65450 cycle time (position, speed, diagnosis) = 0x0000 = cyclic communication stopped
18EAAC00	00 EF 00	6. Read request
18EF00AC	*06* **00 10 00 00** FF FF FF	Encoder response Index 06 software version = 0x00001000 = V1.00

Upon the next read request the encoder will respond parameter index 01 again, and so on.

6.3.2 Write parameter (write request)

Write parameter requires a general write request for PGN 61184 (see below). Besides the correct identifier the write request must comprise the parameter index and the data corresponding to the parameter's data type.

Please note: The write request is neither acknowledged nor is an error message transmitted when exceeding the range. In this case, the device will ignore the command and retain the actually active parameter.

Identifier	CAN Data	Meaning
EFAC00	*01* **01 00** FF FF FF FF FF	Index 01 direction of rotation = 0x0001 =CCW
EFAC00	*02* **00 20 00 00** FF FF FF	Index 02 resolution = 0x00002000 = 8196 steps/turn
EFAC00	*03* **00 00 00 20** FF FF FF	Index 03 total resollution = 0x20000000 = 536870912 steps
EFAC00	*04* **00 00 00 10** FF FF FF	Index 04 Preset = 0x10000000 = 268435456
EFAC00	*05* **64 00** FF FF FF FF FF	Index 05 cycle time PGN 65450 (position, speed, diagnosis) = 0x0064 = 100ms
EFAC00	*FA* 73 61 76 65 FF FF FF	Index 0xFA SAVE, non-volatile parameter saving
EFAC00	*FC* 6C 6F 61 64 FF FF FF	Index 0xFC RESTORE, restore default parameters

„Parameter write request" allows alteration of the parameters printed in bold.

6.3.3 Parameter Index Details

Parameter Index 01   Direction of rotation

Data type	Unsigned 16
Access	ReadWrite
Default	0 = CW
Significance	Direction of rotation
Values	Bit 0 direction of rotation 0 → CW, clockwise 1 → CCW, counter-clockwise

Parameter Index 02   Resolution

Data type	Unsigned 32	
Access	ReadWrite	
Default, Maximum	0x2000 = 8192 = 13bit	→ multivo
	0x1000 = 4096 = 12bit	→ magtivo
	0x40000 = 262144 = 18bit	→ multivoPlus
Significance	Number of steps per turn	
Values	1..Maximum	

Parameter Index 03   Total sensing range

Data type	Unsigned 32	
Access	ReadWrite	
Default, Maximum	0x20000000 = 536870912 = 29bit	→ multivo - Multiturn
	0x2000 = 8192 = 13bit	→ multivo - Singleturn
	0x10000000 = 268435456= 28bit	→ magtivo - Multiturn
	0x1000 = 4096 = 12bit	→ magtivo - Singleturn
	0x80000000 = 2147483648 = 31bit	→ multivoPlus - Multiturn
	0x40000 = 262144 = 18bit	→ multivoPlus - Singleturn
Significance	Total sensing range in steps Conclusion: Number of turns = $\dfrac{\text{total sensing range}}{\text{resolution}}$ Important for muliturn sensing: If the programmed total of turns is unequal to 2^n (1, 2, 4,...65536) the encoder must be re-programmed after having crossed the zero point in currentless state.	
Values	1..Maximum	

Parameter Index 04   Preset

Data type	Unsigned 32
Access	ReadWrite
Default	0h
Significance	Freely programmable position value that is taken as reference point. The related offset calculated by the device is saved.
Values	0..actual total sensing range-1

Parameter Index 05   Cyclic Timer PGN 65450

Data type	Unsigned 16
Access	ReadWrite
Default	50 (50ms)
Significance	Cyclic Timer PGN 65450
Values	0 = Stop cyclic transmission 1..n..65535 = repeating frequency for cyclic transmission is n * ms.

Parameter Index 06   Software Version

Data type	Unsigned 32
Access	ReadOnly
Default	0x00001000
Significance	Software version
Values	Example: 0x00001000 = V1.000

Parameter Index 0xFA   SAVE

Data type	Unsigned 32
Access	Write
Default	0x73617665 = 'save'
Significance	Non-volatile parameter saving in EEprom
Values	0x73617665 = 'save'

Parameter Index 0xFC   RESTORE

Data type	Unsigned 32
Access	Write
Default	0x6C6F6164 = 'load'
Significance	Restore default parameters
Values	0x6C6F6164 = 'load'

...

7 Diagnosis and additional information

7.1 Error diagnosis via fieldbus

The encoder consistently provides diagnostic data (see PGN 65450)
Furthermore alarms and warnings are visualized by a DUO-LED.

7.2 Indicating elements (state indicators)

An integrated DUO-LED is provided at the rear side of the bus cover.

LED green	LED red	State
off	off	no voltage supply
on	off	standard J1939 operation
off	flashing	warning, lithium battery voltage low
off	on for 2,5 sec.	sensor error

7.3 J1939 Glossary / Abbreviations

ECU	Electronic Control Unit
PDU	Protocol Data Unit
PF	Protocol Data Unit Format , 8-Bit Feld im Identifier
PS	Protocol Data Unit Specific, 8-Bit Feld im Identifier
PG	Parameter Group
PGN	Parameter Group Number
SPN	Suspect Parameter Number
GE	Group Extension
DA	Destination Address
SA	Source Address