

Operation guide

# Rotary position sensors SAE J1939 Digital output DST X510 and DST X520



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**1. General Information**

**1.1 Contact**

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**1.2 General**

This document represents a Danfoss SAE J1939 definition for HALL-effect single turn rotary sensors.

## 2. Abbreviations and terms

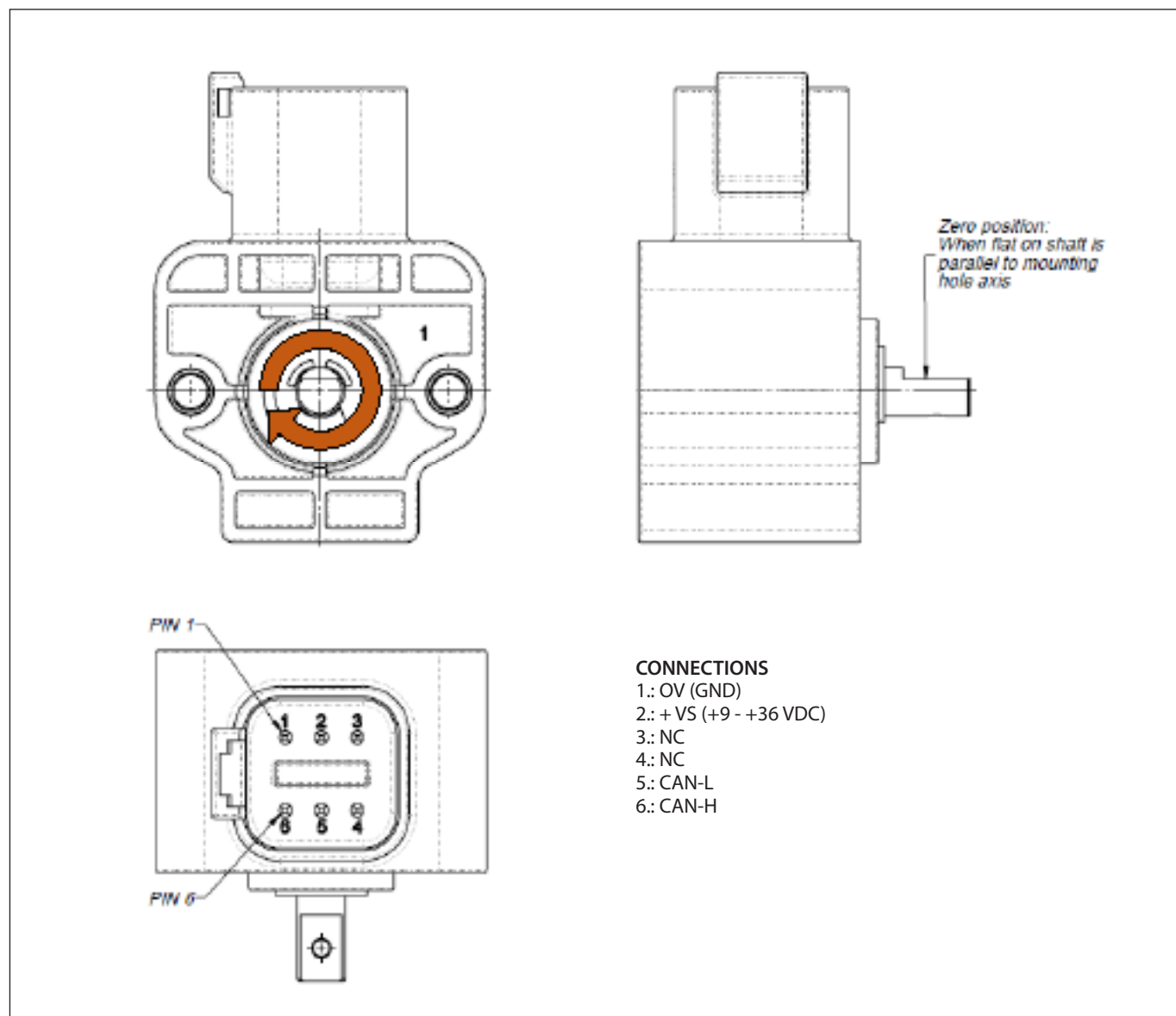
| Abbreviation / Term | Definition                      |
|---------------------|---------------------------------|
| SAE                 | Society of Automotive Engineers |
| ECU                 | Electronic Control Unit         |
| CA                  | Controller Application          |
| PDU                 | Protocol Data Unit              |
| NMT                 | Network Management              |
| PGN                 | Parameter Group Number          |
| AC                  | Address Claiming                |
| MSB                 | Most Significant Byte           |
| LSB                 | Least Significant Byte          |
| SOF                 | Start Of Frame                  |
| RTR                 | Remote Transmission Request     |
| CRC                 | Cyclic Redundancy Check         |
| ACK                 | Acknowledgement                 |
| EOF                 | End Of Frame                    |
| SRR                 | Substitute Remote Request       |
| IDE                 | Identifier Extension            |
| POST                | Power On Self Test              |
| CW                  | Clockwise                       |
| CWW                 | Counterclockwise                |

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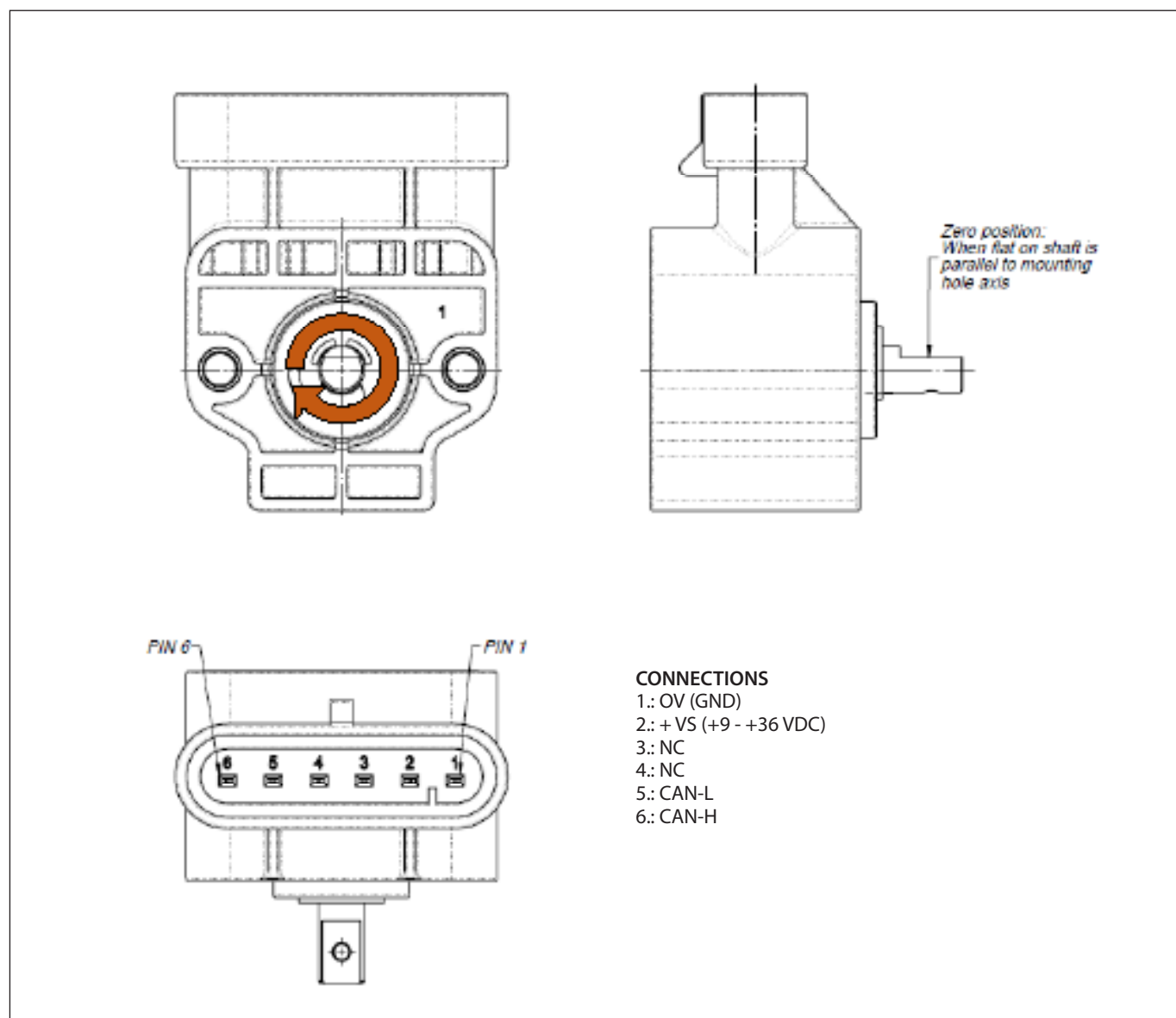
## 3. Reference documents

| Document   | Contents  |
|--|---|
| J1939 - Recommended Practice for a Serial Control & Communications Vehicle Network |   |
| J1939/11 - Physical layer - 250k bits/s, Shield Twisted Pair                       | Bus physical properties   |
| J1939/13 - Off-Board Diagnostic Connector  | Standard connector for diagnostic purpose   |
| J1939/21 - Data Link Layer   | CAN frame (29-bit identifier, PGN etc.), transport protocol functions, and 5 types of message types: Commands, Requests, Broadcasts/Responses, Acknowledgement, and Group Functions |
| J1939/31 - Network Layer   | Services and functions needed for intercommunication between different segments of a J1939 network  |
| J1939/71 - Vehicle Application Layer   | Standard parameters which are grouped together in a message frame and given a PGN   |
| J1939/73 - Application Layer - Diagnostics   | Functions and messages for accessing diagnostic and calibration data  |
| J1939/81 - Network Management  | Information about the content of an ECU Name and how the ECU claims an addressing using that Name   |

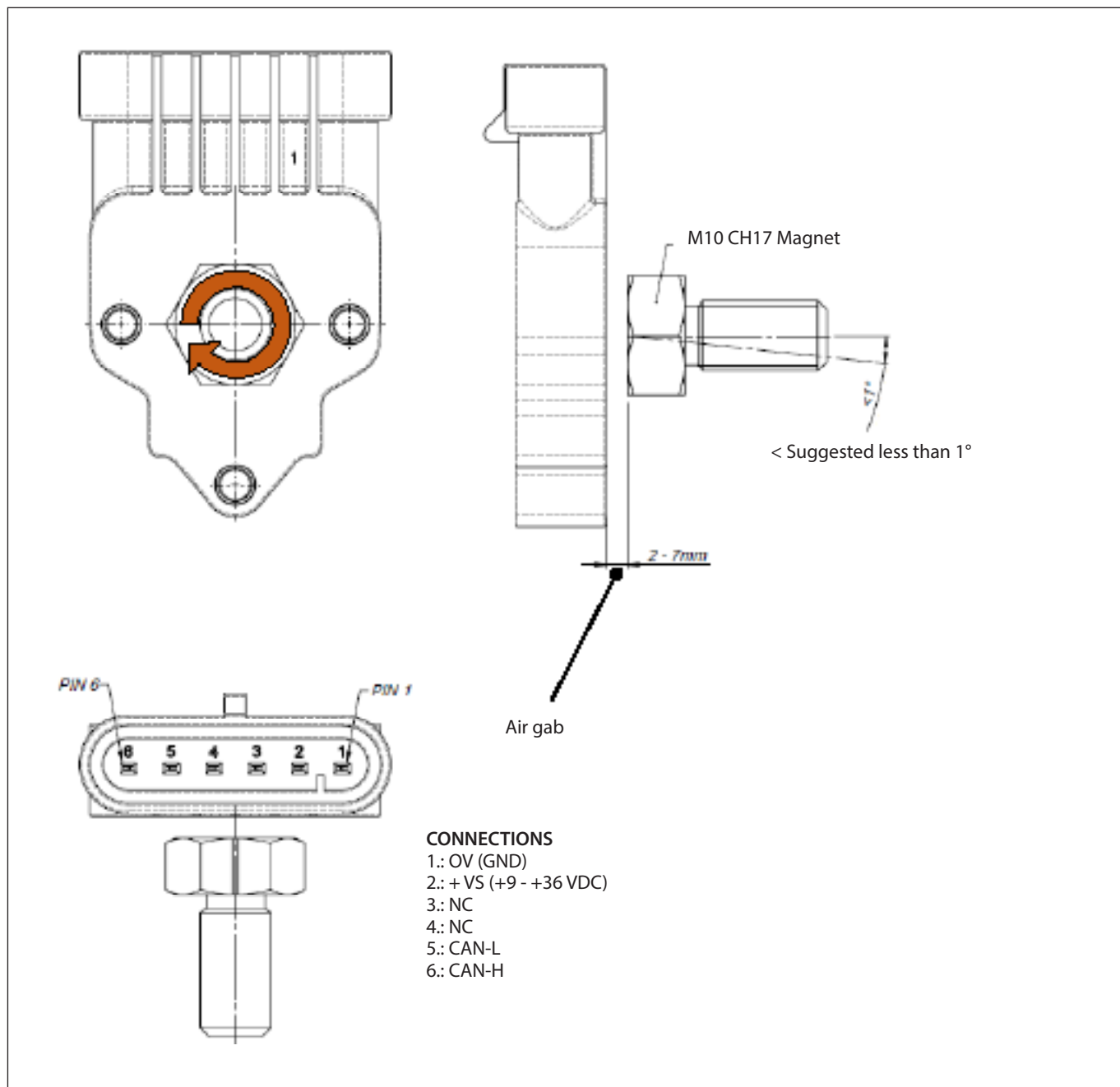
**4. Electrical Connections**    **4.1 Deutsch version with shaft and Block diagram**



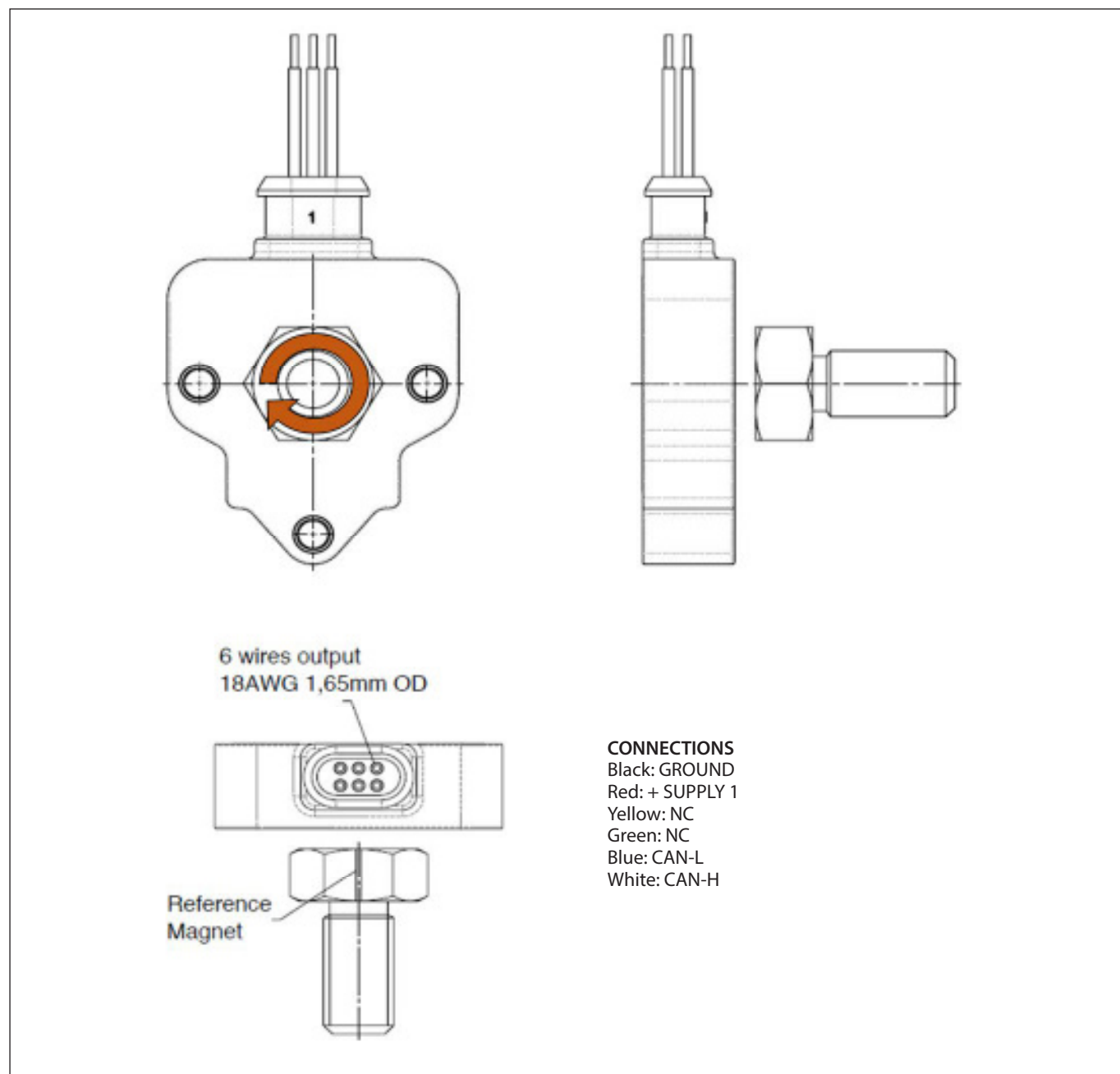
#### 4.2 AMP version with shaft



### 4.3 AMP version without shaft



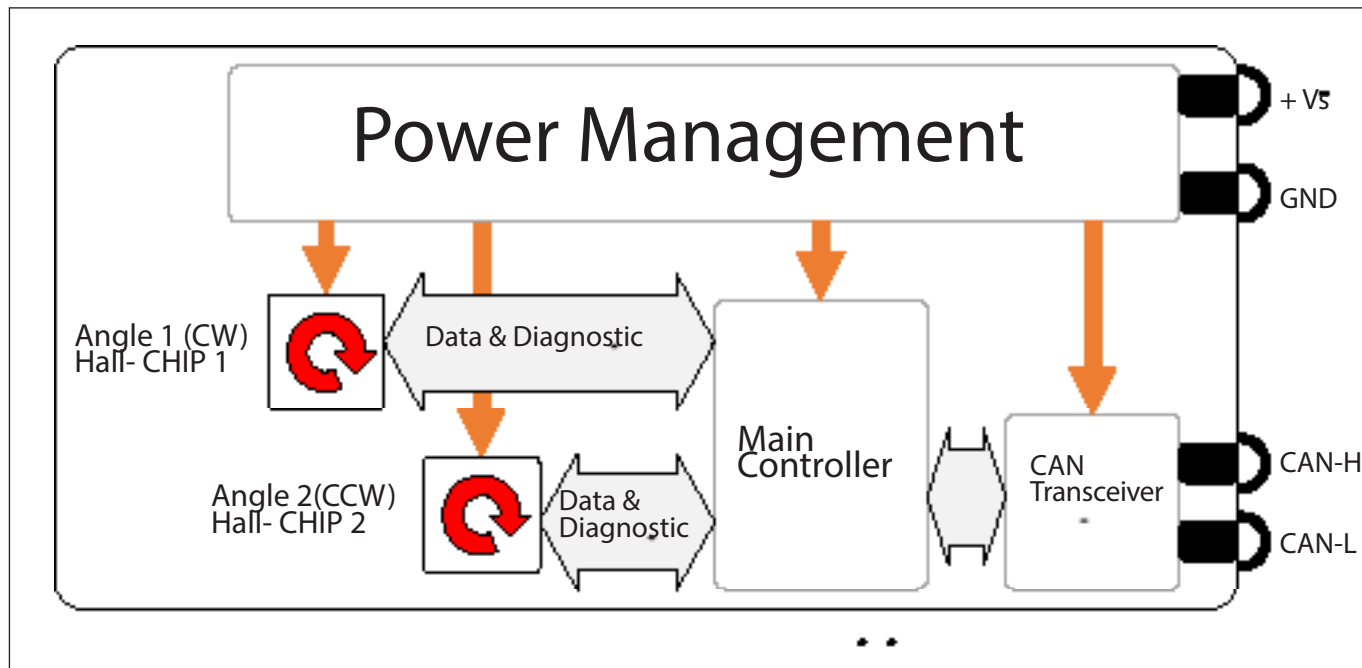
#### 4.4 Cable without shaft



**NOTE:**

Make sure that the CANbus is terminated. The impedance measured between CAN-H and CAN-L must be  $60\ \Omega$  that means the cable must be connected to a  $120\ \Omega$  resistor on each end of the bus line. Internally the transducer is not terminated with resistor of  $120\ \Omega$ . Do not confuse the signal lines of the CANbus, otherwise communication with the transducer is impossible.

#### 4.5 Danfoss Hall-effect rotary sensor: Block diagram



#### 5. Default SAE J1939 definitions

- **Data rate:** 250 kbps
- **Arbitrary Address Capable:** 1
- **Transmission rate:** 100 ms
- **Identifier:** 18FF0B15h
- **PGN:** 65291 (OFF0Bh) - "Proprietary B"
- **Source Address:** 21(15h)
- **Priority:** 6
- **Data:**
  - Byte 0, 1: Angle 1 position unsigned int. 16 bit: 0 - 3599 (CW/CCW according to the ordering code, Angle position 0 - 359.9°; 0.1° resolution)
  - Byte 2, 3: Angle 2 position 0 - 3599 (CW/CCW according to the ordering code, Angle position 0 - 359.9°, 0.1° resolution)
  - Byte 4, 5, 6: 0xFF - Not in use
  - Byte 7: Error code
- **Diagnostic message:** DM 13 only supported

The current data rate of Danfoss Hall-effect single-turn rotary sensors with SAE J1939 output is 250 kbps. A typical message containing 8 data bytes is 128 bits long (excluding bits used for bit stuffing) which in time is approximately 500 μs.

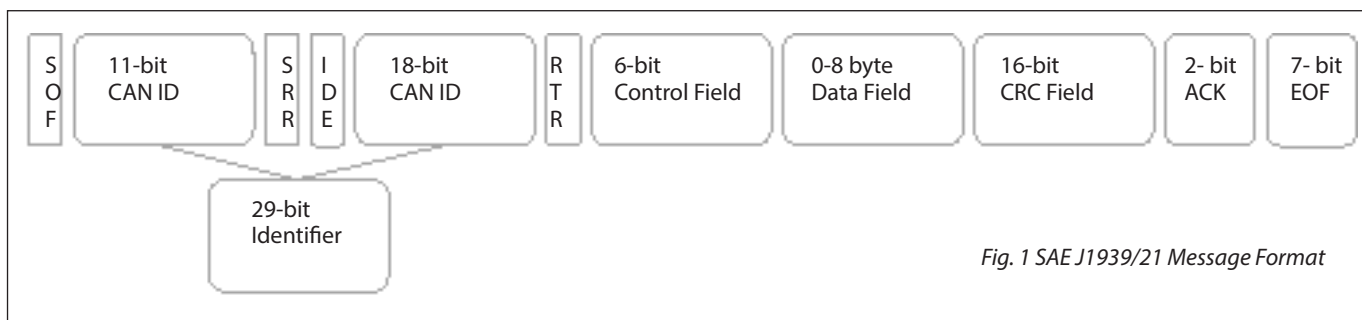


Fig. 1 SAE J1939/21 Message Format



J1939 uses 29-bit identifier defined within CAN 2.0B protocol shown in table 1.4

The device is configured as Arbitrary Address Capable device, thus it can claim other addresses, sending the Address Claimed message with the source address in the range 128 to 247 inclusive

If no other Address Claimed message with the same Source Address is received, or if the arbitration is won, the device uses that address and begins regular network communications with that address. If no address in the range of 128 to 247 is available (arbitration always lost), the device sends the Cannot Claim Address message using the NULL address (254). In this case, regular network communications are suspended.

|     |          |          |           |             |                     |                |
|-----|----------|----------|-----------|-------------|---------------------|----------------|
| -   | 3 bits   | 1 bit    | 1 bit     | 8 bits      | 8 bits              | 8 bits         |
|     | Priority | Reserved | Data page | PDU format  | PDU specific        | Source Address |
|     |          |          |           | < 240: PDU1 | Destination Address |                |
|     |          |          |           | ≥ 240: PDU2 | Group extension     |                |
| PGN |          |          |           |             |                     |                |

Table1: Structure of 29 bit identifier

## 6. Getting started

- When the sensor is turned on, it sends an Address Claimed message according to PGN 60928 as shown in the example of Fig. 2 (page 10). The message is composed of:
  - **Identifier:** 18EEFFXXh (Tabel 2)
  - **Data Field:** device Name (Tabel 3)
- After the sensor has acquired a valid address, it starts sending the angle position message according to PGN 65291 as shown in the example of Fig. 3 (page 10). The message is composed of:
  - **Identifier:** 0x18FF0BXXh (Tabel 4)
  - **Data Field:** Angle position (Tabel 5)

*In case of an error occurs, the angle position message will be sent with Angle 1 and Angle 2 MSB = 0xFF and LSB = 0xFF.*

|                    |             |          |           |                  |                                   |                |
|--------------------|-------------|----------|-----------|------------------|-----------------------------------|----------------|
| 18h                |             |          |           | EEh              | FFh                               | XXh            |
| 000                | 110         | 0        | 0         | 1110 1110        | 1111 1111                         | 0001 0101      |
| -                  | 3 bits      | 1 bit    | 1 bit     | 8 bits           | 8 bits                            | 8 bits         |
|                    | Priority: 6 | Reserved | Data page | PDU format: PDU1 | PDU specific: Destination Address | Source Address |
| PGN 60928 (0EE00h) |             |          |           |                  |                                   |                |

Table 2: PNG 60928 Address Claimed: Identifier definition

|                      |                 |                        |                      |                        |                   |              |           |                |              |                       |                |                         |
|----------------------|-----------------|------------------------|----------------------|------------------------|-------------------|--------------|-----------|----------------|--------------|-----------------------|----------------|-------------------------|
| XXh                  | XXh             | XXh                    | 5Bh                  | XXh                    | XXh               | XXh          | XXh       | XXh            |              |                       |                |                         |
| xxxx xxxx            | xxxx xxxx       | 100                    | x xxxx               | 0101 1011              | x xxxx            | xxx          | xxxx xxxx | xxxx xxxx      | 0            | x                     | xxx            | xxxx                    |
| 8 bits               | 8 bits          | 3 bits                 | 5 bits               | 8bits                  | 5 bits            | 3 bits       | 8 bits    | 7 bits         | 1 bit        | 1 bit                 | 3 bits         | 4 bits                  |
| Identity number, LSB | Identity number | Manufacturer code, LSB | Identity number, MSB | Manufacturer code, MSB | Function instance | ECU instance | Function  | Vehicle system | Reserved bit | Arbitrary address bit | Industry group | Vehicle system instance |

Table 3: PNG 60928 Address Claimed: Name definition

| Field                   | Description   |
|-------------------------|---|
| Arbitrary address bit   | 0: Single Address Capable device (not implemented)<br>1: Arbitrary Address Capable device |
| Industry group          | 2: Agricultural and Forestry Equipment<br>3: Construction Equipment                       |
| Vehicle system instance | 0   |
| Vehicle system          | 0   |
| Reserved bit            | 0   |

| Field             | Description                |
|-------------------|----------------------------|
| Function          | 142 (8Eh): Rotary Sensor   |
| Function instance | 0                          |
| ECU instance      | 0                          |
| Manufacturer code | 732 (2D Ch): Danfoss A/S   |
| Identity number   | Programmed by: Danfoss A/S |

Table 4: Danfoss J1939 Name definition for HaLL-effect single turn rotary sensors

| 18h                       |                    |                 |                  | FFh                     | 0Bh                                  | XXh                   |
|---------------------------|--------------------|-----------------|------------------|-------------------------|--------------------------------------|-----------------------|
| 000                       | 110                | 0               | 0                | 1111 1111               | 0000 1011                            | 0001 0101             |
|                           | 3 bits             | 1 bit           | 1 bit            | 8 bits                  | 8 bits                               | 8 bits                |
| -                         | <b>Priority: 6</b> | <b>Reserved</b> | <b>Data page</b> | <b>PDU format: PDU2</b> | <b>PDU specific: Group extension</b> | <b>Source Address</b> |
| <b>PGN 65291 (0FF0Bh)</b> |                    |                 |                  |                         |                                      |                       |

Table 5: PGN 65291 Proprietary B: Identifier definition

| XXh   | XXh   | XXh          | XXh          | FFFFFFh                         | XXh   |
|---|---|--------------|--------------|---------------------------------|---|
| xxxx xxxx   | xxxx xxxx   | xxxx xxxx    | xxxx xxxx    | 1111 11111 1111 1111 11111 1111 | xxxx xxxx   |
| 8 bits  | 8 bits  | 8 bits       | 8 bits       | 24 bits                         | 8 bits  |
| Angle 1, MSB  | Angle 1, LSB  | Angle 2, MSB | Angle 2, LSB | Reserved                        | Error Code  |
| <b>Data type:</b> 16-bit unsigned integer<br><b>Resolution:</b> 0.1 deg<br><b>Ex.:</b> 008Ah = 138 = 13.8 deg | <b>Data type:</b> 16-bit unsigned integer<br><b>Resolution:</b> 0.1 deg<br><b>Ex.:</b> 0D7Ch = 3452 = 345.2 deg |              |              |                                 | 0000 0000 No error<br>0000 0001 Angle 1 sensor chip error<br>0000 0010 Angle 2 sensor chip error<br>0000 0100 Magnetic field too high/low<br>0010 0000 Program checksum error<br>0100 0000 Parameter checksum error |

Table 6: PGN 65291 Proprietary B: Angle position definition

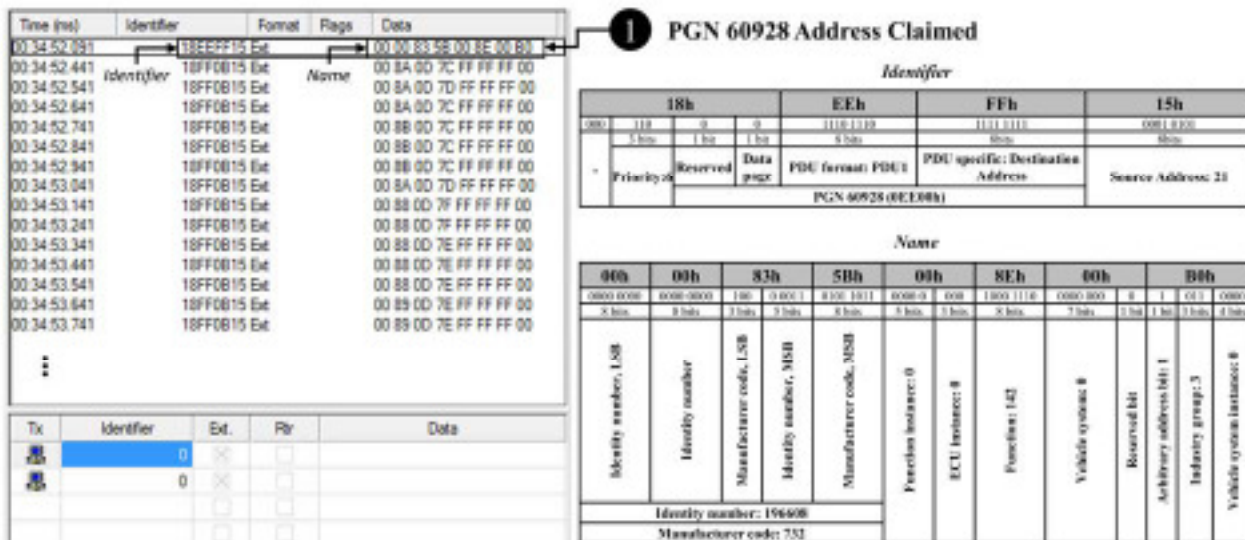


Fig. 2: Example: Address Claimed message

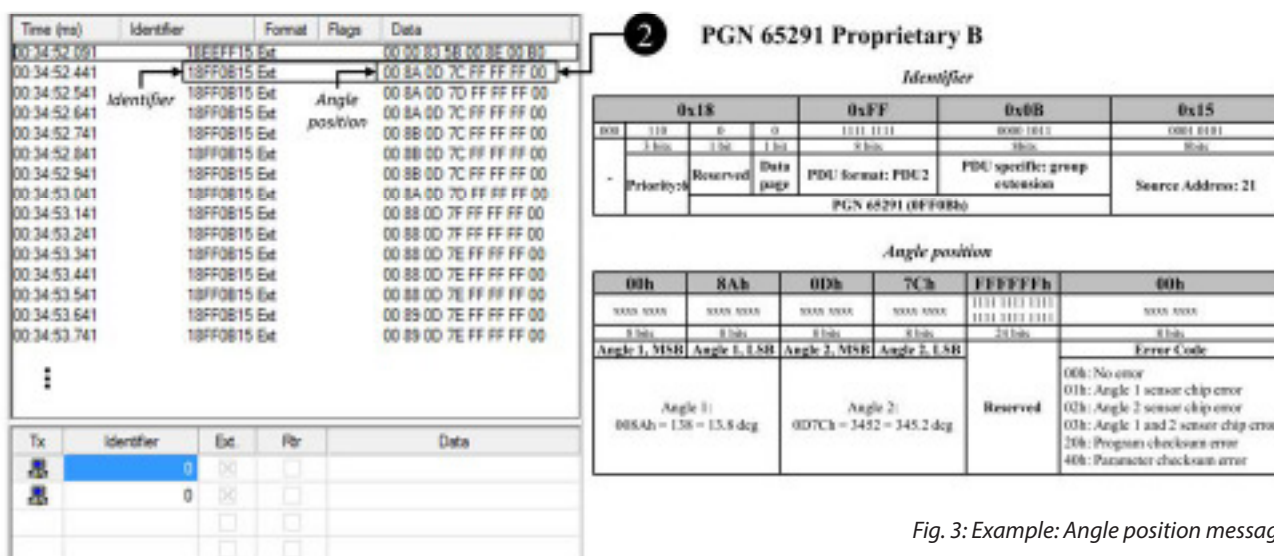


Fig. 3: Example: Angle position message

**7. How to change the name**

The Name of the sensor can be configured by sending Destination Specific - Proprietary Configurable Message 1 according to PNG 45312 as shown in the example in Fig.4 (page 12). The message is composed of:

- **Identifier:** 18BXXXh (table 7)
- **Note:** Consider that the Destination Address is the address of the sensor, while the Source Address refers to the address of the user CAN controller that sends the message.
- **Data field:** Proprietary Configurable Message 1 (table 8)

| 18h                       |                    |                 |                  | B1h                     | XXh                                      | XXh                   |
|---------------------------|--------------------|-----------------|------------------|-------------------------|--|-----------------------|
| 000                       | 110                | 0               | 0                | 1011 0001               | XXXX XXXX                                | XXXX XXXX             |
|                           | 3 bits             | 1 bit           | 1 bit            | 8 bits                  | 8 bits                                   | 8 bits                |
|                           | <b>Priority: 6</b> | <b>Reserved</b> | <b>Data page</b> | <b>PDU format: PDU1</b> | <b>PDU specific: Destination Address</b> | <b>Source Address</b> |
| <b>PGN 45312 (0B100h)</b> |                    |                 |                  |                         |  |                       |

Table 7: PGN 45312 Proprietary Configurable Message 1: Identifier definition

| 6765672h                                | XXh               | XXh          | XXh       | XXh            | XXh          | XXh                   | XXh            |                         |
|---|-------------------|--------------|-----------|----------------|--------------|-----------------------|----------------|-------------------------|
| 0110 0111 0110 0101 0110 0110 0111 0010 | xxxx x            | xxx          | xxxx xxxx | xxxx xxx       | 0            | x                     | xxx            | xxxx                    |
| 32 bits                                 | 5 bits            | 3 bits       | 8 bits    | 7 bits         | 1 bit        | 1 bit                 | 3 bits         | 4 bits                  |
| ASCII code: "gefr"                      | Function instance | ECU instance | Function  | Vehicle system | Reserved bit | Arbitrary address bit | Industry group | Vehicle system instance |

Table 8: PGN 45312 Proprietary Configurable Message 1: Messenger definition

**PGN 45312 Proprietary Configurable Message 1**

*Identifier*

| 18h                       | B1h        | 15h        | 09h  |
|---------------------------|------------|------------|--|
| 000<br>3 bits             | 0<br>1 bit | 0<br>1 bit | 1011 0001<br>8 bits  |
| -<br>Priority: 6          | Reserved   | Data page  | PDU format: PDU1<br>PDU specific: Destination Address: 21<br>Source Address: 0 |
| <b>PGN 45312 (0B100h)</b> |            |            |  |

**changes to be made:** Industry group: old value: 3 → new value: 2  
Vehicle system: old value: 0 → new value: 11

*Proprietary Configurable Message 1*

| 6765672h   | 00h                  | 0Eh             | 14h                 | A0h   |
|--|----------------------|-----------------|---------------------|---|
| 00 00 01 11 01 10 01 01 01 10 01 10 01 11 00 10<br>32 bits | 0000 0<br>9 bits     | 000<br>3 bits   | 1000 1110<br>8 bits | 0001 011<br>7 bits  |
| ASCII code: "gefr"   | Function instance: 0 | ECU instance: 0 | Function: 142       | Vehicle system: 11<br>Reserved bit<br>Arbitrary address bit: 1<br>Industry group: 2<br>Vehicle system instance: 0 |

Fig. 4: Example: How to change the name

**8. How to change the transmission rate**

The Transmission Rate of the sensor can be configured by sending the Destination Specific - Propriarily Configurable Message 2 according to PGN 45568 as shown in the example Fig. 5 (page 13).

The message is composed of:

- **Identifier:** 18B2XXXXh (table 9)
- **Note:** Consider that the Destination Address is the address of the sensor, while the Source Address refers to the address of the user CAN controller that sends the message.
- **Data field:** Propriarily Configurable Message 2 (table 10)

| 18h                       |                    |                 |                  | B1h                     | XXh                                      | XXh                   |
|---------------------------|--------------------|-----------------|------------------|-------------------------|--|-----------------------|
| 000                       | 110                | 0               | 0                | 1011 0010               | XXXX XXXX                                | XXXX XXXX             |
|                           | 3 bits             | 1 bit           | 1 bit            | 8 bits                  | 8 bits                                   | 8 bits                |
|                           | <b>Priority: 6</b> | <b>Reserved</b> | <b>Data page</b> | <b>PDU format: PDU1</b> | <b>PDU specific: Destination Address</b> | <b>Source Address</b> |
| <b>PGN 45568 (0B200h)</b> |                    |                 |                  |                         |  |                       |

Table 9: PGN 45568 Propriarily Configurable Message 2: Identifier definition

| 67656672h                               | XXh  | XXh                   | 0000h               |
|---|--|-----------------------|---------------------|
| 0110 0111 0110 0101 0110 0110 0111 0010 | xxxx xxxx  | xxxx xxxx             | 0000 0000 0000 0000 |
| 32 bits                                 | 8 bits   | 8 bits                | 16 bits             |
| <b>ASCII code: "gefr"</b>               | <b>Transmission rate LSB</b>   | Transmission rate MSB | <b>Reserved</b>     |
|   | <b>Data type:</b> 16-bit unsigned integer<br><b>Resolution:</b> 1 ms<br><b>Range:</b> 10 - 65535; 0= stop transmission<br><b>Ex.:</b> 0032h = 50 = 50 ms |                       |                     |

Table 10: PGN 45568 Propriarily Configurable Message 2: Message definition

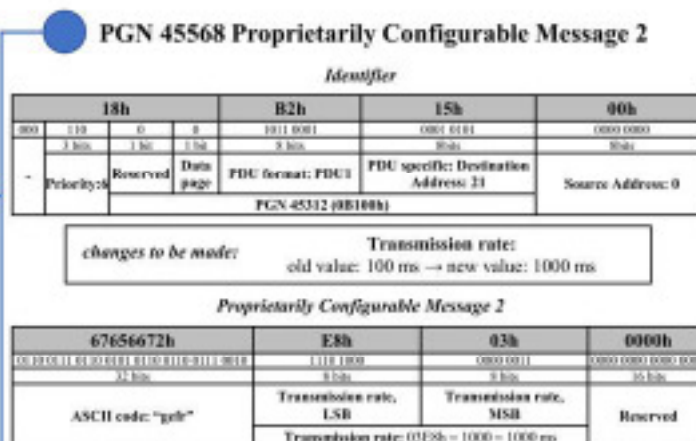
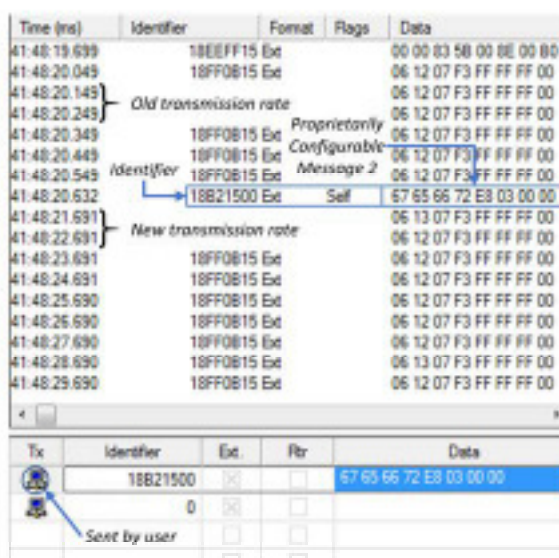


Fig. 5: Example: How to change the transmission rate

**9. How to change the source address**

The Source Address of the sensor can be configured by sending the Command Address Message according to PGN 65240 (FED8h). Since this message is 9-bit long, it is sent by using the Broadcast Announce Message of the Transport Protocol according to PGN 60416 and PGN 60160, as shown in the example Fig. 6 (page 14).

The messages must be sent:

- a) Transport Protocol - Connection Management
  - **Identifier:** 1CECFFXXh (table11)
  - **Data field:** Transport Protocol - Connection Management (table 12).

| 1Ch                |             |          |           | ECh              | FFh                               | XXh            |
|--------------------|-------------|----------|-----------|------------------|-----------------------------------|----------------|
| 000                | 111         | 0        | 0         | 1110 1100        | 1111 1111                         | xxxx xxxx      |
|                    | 3 bits      | 1 bit    | 1 bit     | 8 bits           | 8 bits                            | 8 bits         |
| -                  | Priority: 7 | Reserved | Data page | PDU format: PDU1 | PDU specific: Destination Address | Source Address |
| PGN 60416 (0EC00h) |             |          |           |                  |                                   |                |

Table 11: PGN 60416 Transport Protocol - Connection Management: Identifier definition

| 20h          | 09h                                      | 00h                                      | 02h                     | FFh       | D8h                            | FEh                        | 00h                            |
|--------------|--|--|-------------------------|-----------|--------------------------------|----------------------------|--------------------------------|
| 0110 0111    | 0000 1001                                | 0000 0000                                | 0000 0010               | 1111 1111 | 1101 1000                      | 1111 1110                  | 0000 0000                      |
| 8 bits       | 8 bits                                   | 8 bits                                   | 8 bits                  | 8 bits    | 8 bits                         | 8 bits                     | 8 bits                         |
| Control byte | Total message size, number of bytes, LSB | Total message size, number of bytes, MSB | Total number of packets | Reserved  | PGN of the packet message, LSB | PGN of the package message | PGN of the packet message, MSB |

Table 12: PGN 60416 Transport Protocol - Connection Management - Broadcast Announce Message definition

b) Transport Protocol - Data transfer: Packet 1

- **Identifier:** 1CEBFFXXh (tabel13)
- **Data field:** Transport Protocol - Data Transfer, packet 1 (tabel 14)

| 1Ch                |             |          |           | EBh              | FFh                               | XXh            |
|--------------------|-------------|----------|-----------|------------------|-----------------------------------|----------------|
| 000                | 111         | 0        | 0         | 1110 1011        | 1111 1111                         | xxxx xxxx      |
|                    | 3 bits      | 1 bit    | 1 bit     | 8 bits           | 8 bits                            | 8 bits         |
| -                  | Priority: 7 | Reserved | Data page | PDU format: PDU1 | PDU specific: Destination Address | Source Address |
| PGN 60160 (0EB00h) |             |          |           |                  |                                   |                |

Table 13: PGN 60160 Transport Protocol - Data Transfer: Identifier definition

| 01h              | XXh                  | XXh             | XXh                    |                      | 5Bh                    | XXh               |              | XXh       | XXh            |              |
|------------------|----------------------|-----------------|------------------------|----------------------|------------------------|-------------------|--------------|-----------|----------------|--------------|
| 0000 0001        | xxxx xxxx            | xxxx xxxx       | 100                    | x xxxx               | 0101 1011              | xxxx x            | xxx          | xxxx xxxx | xxxx xxx       | 0            |
| 8 bits           | 8 bits               | 8 bits          | 3 bits                 | 5bits                | 8 bits                 | 5 bits            | 3 bits       | 8 bits    | 7 bits         | 8 bits       |
| Seequence number | Identify number, LSB | Identify number | Manufacturer code, LsB | Identify number, MSB | Manufacturer code, MSB | Function instance | ECU instance | Function  | Vehicle system | Reserved bit |

Table 14: PGN 60160 Transport Protocol - Data Transfer: Packet 1

c) Transport Protocol - Data transfer: Packet 2

- **Identifier:** 1CEBFFXh (tabel15)
- **Data field:** Transport Protocol - Data Transfer, packet 2 (tabel 16)

| 02h                    | XXh                          |                       |                                | XXh                       | FFFFFFFFh                                    |
|------------------------|------------------------------|-----------------------|--------------------------------|---------------------------|--|
| 0000 0010              | x                            | xxx                   | xxxx                           | xxxx xxxx                 | 1111 1111 1111 1111 1111 1111 1111 1111 1111 |
| 8 bits                 | 1 bit                        | 3 bits                | 4 bits                         | 8 bits                    |  |
| <b>Sequence number</b> | <b>Arbitrary address bit</b> | <b>Industry group</b> | <b>Vehicle system instance</b> | <b>New Source Address</b> | <b>Reserved</b>                              |

Table 14: PGN 60416 Transport Protocol - Data Transfer: Packet 2

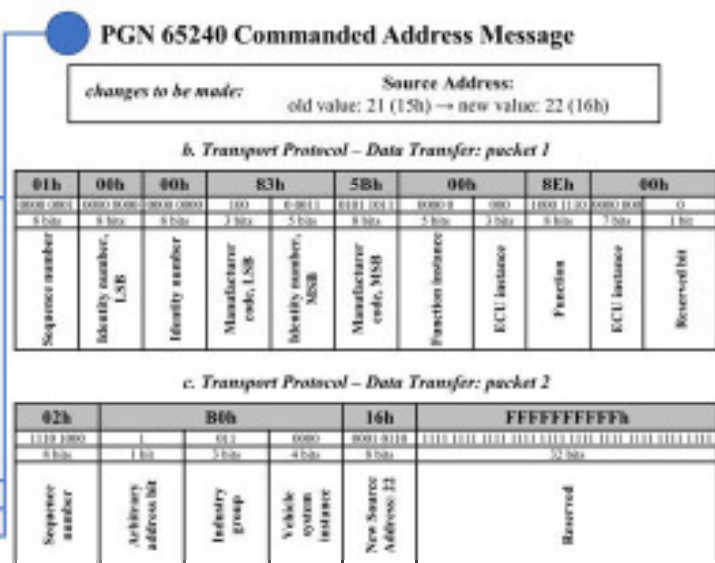
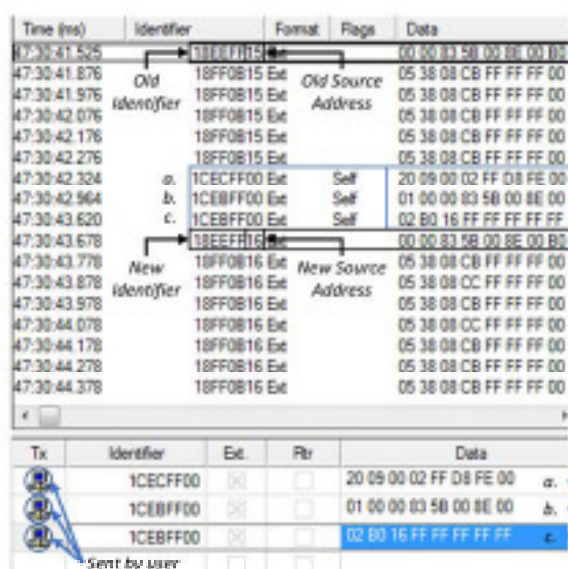


Fig. 6: Example: How to change the Source Address

