TECHNICAL INFORMATION

Linear Encoder

SAE J1939 Protocol

MAX®

SICK
Sensor Intelligence.

Product described

MAX® - SAE J1939 Protocol

Manufacturer

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Legal information

Original document

This document is an original document of SICK AG.

CE

Contents

1 About this document

1.1 Purpose of this document

This document describes the implementation of the standard J1939 protocol in the linear encoder.

The linear encoder supports:

- SAE J1939 Top Level Document
- SAE J1939-71 Application Layer
- SAE J1939-81 Network Management

1.2 Target group

This document is intended for expert personnel who configure and operate the linear encoder.

The following qualifications are required for these activities:

- Knowledge of the current safety regulations and of the operation and control of the devices in their particular application
- Knowledge of automation systems
- Knowledge of the J1939 standard
- Knowledge of how to use automation software

1.3 Abbreviations used

General

CA	Controller Application
CAN	Controller Area Network
CANopen®	An application layer Protocol of CAN
CiA	CAN in Automation e.V.
EDS	Electronic Data Sheet
EEPROM	Electrically Erasable Programmable Read-only Memory
LSB	Least significant bit
MSB	Most significant bit
PLC	Programmable Logic Controller
PMR	Physical Measuring Range
RAM	Random Access Memory
SAE	Society of Automotive Engineers

Configuration

BAM	Broadcast Announce Message
CoB	Communication Object
CoB-ID	Communication Object Identifier
CoS	Change of State
DM	Diagnostic messages
EMGY	Emergency message
NMT	Network management
Node ID	Node identifier
OP	Operational
PGN	Parameter group number
ro	Read only
RTR	Remote Transmission Request = request telegram for PDOs
rw	Read Write
Rx	The linear encoder is the consumer of the CAN data frame.
SA	Source address

SAFEOP	Safe Operational
SRDO	Safety-relevant data object
TP	Transport protocol
Tx	The linear encoder is the producer of the CAN data frame.
wo	Write only

2 Safety information

2.1 General notes

Should humans be at risk, or operating equipment potentially be damaged in the event of a malfunction or failure of the device, this must be prevented by means of suitable protective devices, e. g., emergency shutdown systems.

If the device is not functioning correctly, it must be taken out of operation and secured against unauthorized operation.

To guarantee proper operation of the device, please observe the following:

- Protect the device against mechanical stress during installation
- Do not open the device
- Connect the device with the correct polarity, supply voltage and control pulses
- Observe the permissible operating and ambient conditions for the device
- Regularly check the device for correct operation and document the results

2.2 Intended use

2.2.1 Responsibility of user

Designated users

see "Target group", page 4.

Correct project planning

- This document assumes that appropriate project planning has been carried out before delivery of the device (e.g. based on the SICK application questionnaire), and the device is in the required delivery state based on that planning (see supplied system documentation).
  - ▶ If you are not certain whether the device corresponds to the state defined during project planning or in the supplied system documentation, please contact SICK Customer Service.

Special local conditions

In addition to the instructions in this Technical Information, follow all local laws, technical rules and company-internal operating directives applicable at the respective device installation location.

Read operating instructions

- Read and follow the information in these operating instructions
- Follow all safety notes
- If there is anything you do not understand, please contact SICK Customer Service

Retention of documents

These operating instructions:

- Must be made available for reference.
- Must be passed on to new owners.

2.3 Purpose of the device

The MAX® linear encoder is designed for position measurements in mobile hydraulic applications and therefore can be used to control the hydraulic components of construction machinery, e.g. in hydraulic cylinders. The rugged housing offers optimal protection against dust, climatic influences, vibrations, surrounding media as well as electrical and magnetic fields.

The device is an accessory and must be connected to a suitable electronic control unit.

3 J1939-21 data link

This chapter contains general information about using the CAN protocol with extended 29-bit CAN identifiers. This 29-bit CAN frame format is the only format allowed for J1939 CAN messages. Standard 11-bit CAN frames can, however, also be used in the network.

3.1 Protocol data unit

The protocol data unit provides a framework for organizing the key information that is sent with every CAN data frame. The extended CAN data frame used in the SAE J1939 protocol is composed of seven fields. The 29-bit identifier is composed of six fields.

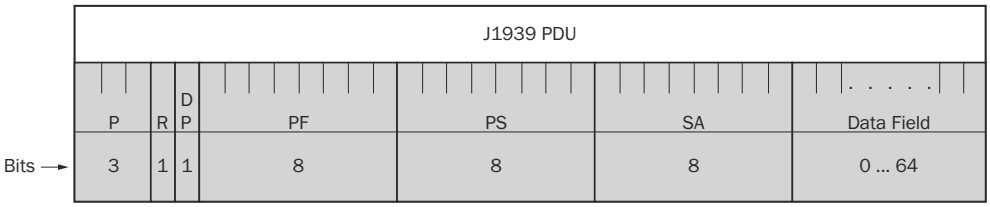

Figure 1: Extended CAN data frame definition

P – Priority

These three bits are used to optimize message latency for transmission (3 bits).

R – Reserved

Always 0 (1 bit).

DP – Data Page

Only 0 is used (1 bit).

PF – PDU Format

This field is used to specify the parameter group number (PGN). Parameter group numbers identify or label information that require one or more CAN data frames to transmit them. The PDU Format is the middle byte of the parameter group number.

PS – PDU Specific

This field depends on the value of PDU Format, and contains either a destination address or a group extension, depending on PDU Format. If the value of the PDU Format field is less than 240, the PDU Specific field contains a destination address. If the value of the PDU Format field is between 240 and 255, the PDU Specific field contains a group extension value. PDU2 format messages are global messages.

Table 1: PDU definition

	PDU Format field	PDU Specific field
PDU1 format	0 - 239	Destination address
PDU2 format	240 - 255	Group extension

Specific Destination Address (DA)

This field defines the specific address to which the message is being sent. All other destinations should ignore this message. In the case of the global destination address (255), all devices are required to listen and respond as message recipients.

Group Extension (GE)

The Group Extension field provides 4069 parameter groups per page.

Source Address (SA)

There should only be one device on the network with a given source address. The Source Address field therefore ensures the CAN identifier is unique, as required by CAN.

Data Field

The J1939 protocol data unit (PDU) can contain up to 8 bytes, as per the definition of the CAN data frame. A parameter group, on the other hand, can contain up to 1785 bytes. A segmented (multi-packet) data transmission therefore needs to be used in this case. This segmented data transmission is defined in the J1939 transport protocol. The linear encoder only supports the transport protocol for configuring the source address (see "Commanded Address message", page 18).

3.2 Parameter group number

The PGN uniquely identifies the parameter group (PG) that is being transmitted in the message. Every PG (grouping of specific parameters) has its own specific definition comprising the assignment of each parameter within an 8-byte data field (size in bytes, location of the LSB), and the transmission rate and priority of the message.

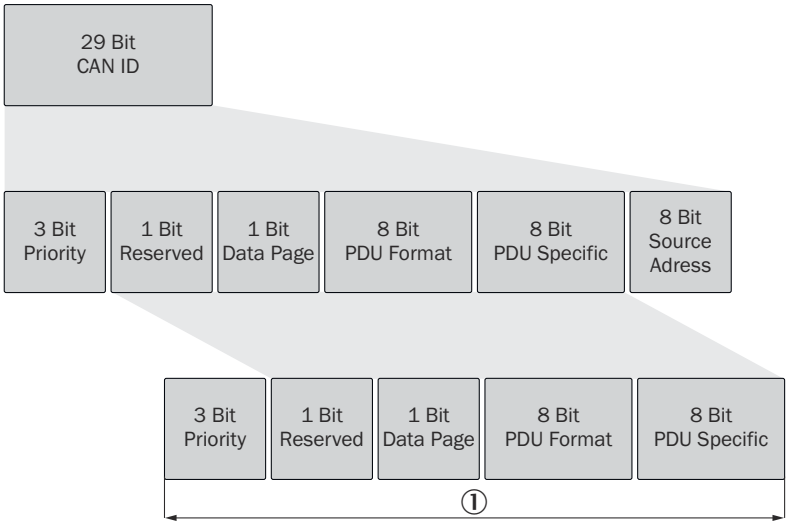

Figure 2: Parameter group number

① 24-bit parameter group number

The parameter group number has been extended to 24 bits for internal purposes. Only data page 0, however, is supported for the linear encoder. The reserved bit is set to zero, i.e. the high byte of the parameter group number is always zero.

3.3 Proprietary B parameter group number

This parameter group number is used for manufacturer-specific purposes. It uses the PDU2 format. The data length must be defined by the manufacturer.

Table 2: Proprietary B PGN definition

Proprietary B parameter group number	
Transmission rate	As per user requirements
Data length	8 byte (in general 0–1785)

Proprietary B parameter group number	
Data page	0
PDU format	255
PDU specific	Group extension
Default priority	6
Parameter group number	65280 to 65535 ($00FF00_{16}$ to $00FFFF_{16}$)
Source address	0 to 253

In the case of the linear encoder, the Proprietary B parameter group number is used for the Data Record message.

Table 3: Proprietary B linear encoder data field

Data field	
Byte D0 bits 8-1	Least significant byte of the position
Byte D1 bits 8-1	2nd least significant byte of the position
Byte D2 bits 8-1	3rd least significant byte of the position
Byte D3 bits 8-1	Most significant byte of the position
Byte D4 bits 8-1	Least significant byte of the speed
Byte D5 bits 8-1	Most significant byte of the speed
Byte D6 bits 8-1	Status
Byte D7 bits 8-1	Error code

The transmission rate and the PDU Specific value can be changed by the user via application configurable messaging (see "J1939-74 Application Configurable Messaging", page 21).

3.4 Transport protocol

Some parameter group numbers are defined with a data length of over 8 bytes. Since a CAN data frame is limited to just 8 bytes per message, the parameter group must be packaged into a sequence of messages of 8 bytes each. The relevant functions, for example for packaging and reassembly, are defined in the transport protocol (TP).

In the case of the linear encoder, this transport protocol is only used when programmatically setting a new source address using the SAE J1939 Commanded Address command. This command only uses the multi-packet broadcast message.

3.4.1 Multi-packet broadcast message

Multi-packet broadcast messages are sent to the global address of the J1939 network. This message consists of two types of messages.

Transport Protocol – Connection Management (TP.CM)

To transmit a multi-packet message, a node must first send a Broadcast Announce Message (BAM). The Broadcast Announce Message is embedded in the Transport Protocol – Connection Management message.

Table 4: TP.CM PGN definition

Transport Protocol – Connection Management	
Transmission rate	as required
Data length	8 bytes
Data page	0
PDU format	236

Transport Protocol – Connection Management	
PDU specific	255 (global address)
Default priority	7
Parameter group number	60416 $(00EC00)_{16}$
Source address	0 to 253

Table 5: Data field for the TP.CM Broadcast Announce Message (BAM)

Transport Protocol – Connection Management	
Byte 1	Control byte = 32 (2016h) for BAM
Byte 2	Message size (low byte)
Byte 3	Message size (high byte)
Byte 4	Total number of packets
Byte 5	Reserved = 255 (FF_{16}h)
Byte 6	Parameter group number (low byte)
Byte 7	Message size (middle byte)
Byte 8	Parameter group number (high byte)

Transport Protocol – Data Transfer (TP.DT)

Table 6: TP.DT PGN definition

Transport Protocol – Data Transfer	
Transmission rate	as required
Data length	8 bytes
Data page	0
PDU format	235
PDU specific	255 (global address)
Default priority	7
Parameter group number	60160 $(00EB00)_{16}$
Source address	0 to 253

Table 7: PGN TP.DT data field

Transport Protocol – Data Transfer	
Byte 1	Sequence number (1–255)
Byte 2	Data
Byte 3	Data
Byte 4	Data
Byte 5	Data
Byte 6	Data
Byte 7	Data
Byte 8	Data

The last packet of a multi-packet PGN may require less than eight data bytes. All unused data bytes in the last packet are set to 255 (FF_{16}h).

Timing requests

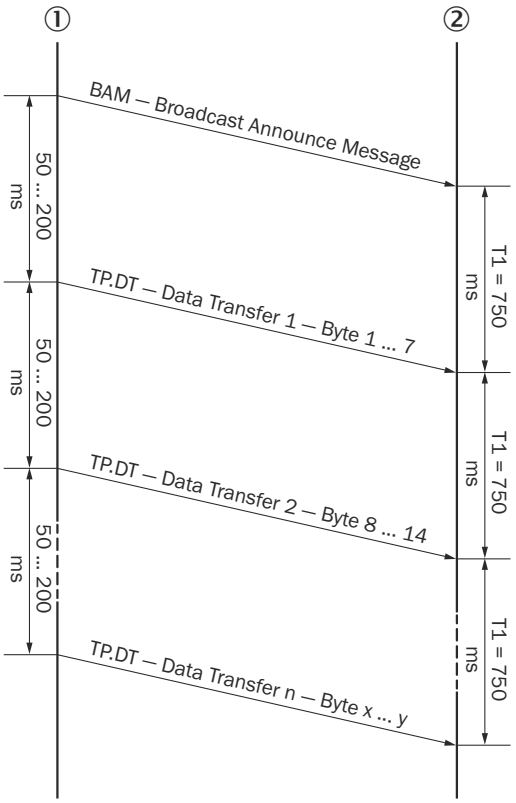

Figure 3: Data transfer per Broadcast Announce Message

① Transmitting node

② Receiving node

The time interval between message packets is between 50 ms and 200 ms. A timeout occurs if more than 750 ms elapses between two messages. The connection is then closed. The connection is also closed when the last data transfer packet (TP.DT) has been sent.

4 J1939-81 network management

The network management in a SAE J1939 network manages the source addresses, associates these addresses with a specific function, and detects and reports network-related errors. The network management also specifies the initialization process.

4.1 Overview of state transitions

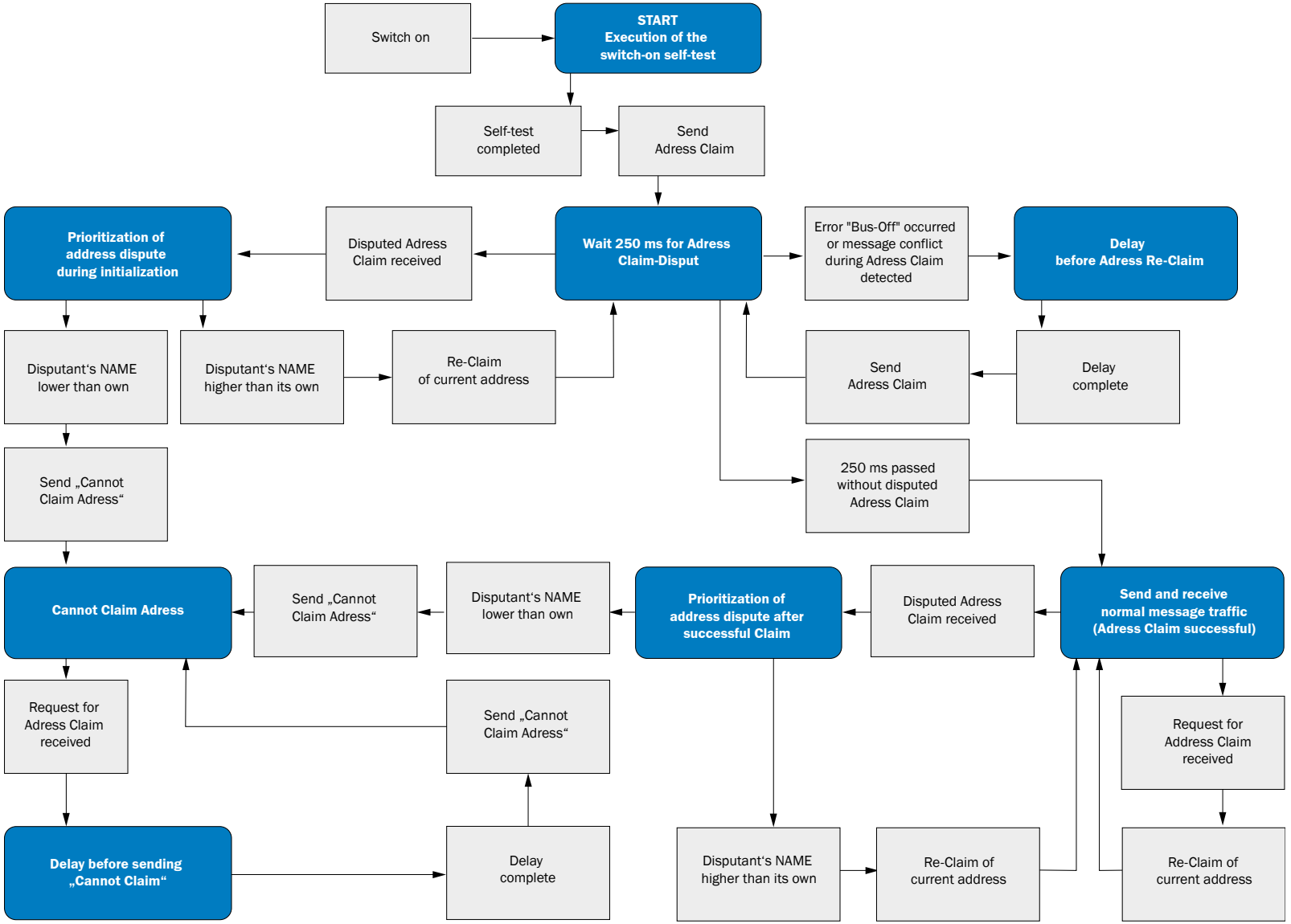

Figure 4: Schematic of the state transitions when switching on the device

4.2 Network state machine

The delay of 250 ms may not apply for CAs claiming addresses in the 0–127 or 248–253 range.

After being switched on, the linear encoder sends an Address Claimed message on the network. This message is a global message that is received by any arbitrary CA in the network. It contains the source address and the unique NAME of the linear encoder.

If the linear encoder does not receive any other Address Claimed messages containing the same source address, it starts transmitting normal Data Record messages. The transmission starts immediately after the Address Claimed message is transmitted, or after a delay of 250 ms if the source address is in the range of 128–247.

If the linear encoder receives an Address Claimed message containing the same source address, it must compare the received NAME with its own NAME.

If the received NAME is lower than its own, the linear encoder must use the NULL address (254) as its source address and send a Cannot Claim Address message.

The Cannot Claim message is sent after a pseudo random delay between 0 and 153 ms. If the linear encoder has a source address of NULL, it does not send the normal Data Record message.

If the received NAME is higher than its own, the linear encoder resends the Address Claim message and starts or continues transmitting the Data Record message, whereby a delay of 250 ms applies if the source address is in the range of 128–247.

If the CAN Bus OFF error condition occurs, the linear encoder must resend its Address Claimed message after a pseudo random delay between 0 and 153 ms.

4.3 J1939 NAME definition

Every CA that transmits messages on a SAE J1939 network must have a unique NAME and successfully acquire an address before being able to transmit normal network traffic. The NAME serves two purposes: firstly to provide a description of operation of the CA, and secondly to provide a numerical value that can be used in the network management of addresses.

Each NAME comprises the fields shown in table 2 and table 3 and is defined as described below.

Table 8: NAME fields

Arbitrary Address Capable	Industry Group	Vehicle System Instance	Vehicle System	Reserved	Function	Function Instance	ECU Instance	Manufacturer Code		Identity Number	
1 bit 4.1.1.2	3 bits 4.1.1.3	4 bits 4.1.1.4	7 bits 4.1.1.5	1 bit 4.1.1.6	8 bits 4.1.1.7	5 bits 4.1.1.8	3 bits 4.1.1.9	11 bits 4.1.1.10		21 bits 4.1.1.11	
Byte 8			Byte 7		Byte 6	Byte 5		Byte 4	Byte 3	Byte 2	Byte 1

Since SICK does not know the final application of the linear encoder, the four high bytes are freely programmable by the customer (except the Arbitrary Address Capable bit), see "Configuration of NAME", page 21.

The manufacturer code is set according to SICK manufacturer codes designated by the SAE committe. The identity number is also written by SICK during production. These two fields cannot be changed by the user. This ensures a unique Name for each sensor produced by SICK even if the user enters identical values in the four high bytes (Byte 5 - 8) by mistake.

4.4 Address management messages

4.4.1 Address Claimed message

The linear encoder sends an Address Claimed message after the following events:

- When it is switched on
- The Address Claimed command is requested
- In the re-claim scenario, i.e. when an Address Claimed message with the same source address is received
- The source address is changed programmatically
- The NAME is changed programmatically

Table 9: Address Claimed message definition

Address Claimed message	
Transmission rate	as required
Data length	8 bytes
Data page	0
PDU format	238
PDU specific	255 (global address)
Default priority	6
Parameter group number	60928 $(00EE00)_{16}$
Source address	0 to 253

Table 10: Structure of NAME in the Address Claimed message

NAME		
Byte D0	Bits 8-1	Least significant byte of the identity number
Byte D1	Bits 8-1	Second byte of the identity number
Byte D2	Bits 8-6	Least significant 3 bits of the manufacturer code
	Bits 5-1	Most significant 5 bits of the identity number
Byte D3	Bits 8-1	Most significant bit of the manufacturer code
Byte D4	Bits 8-4	Function Instance
	Bits 3-1	ECU Instance
Byte D5	Bits 8-1	Function
Byte D6	Bits 8-2	Vehicle System
	Bit 1	Reserved
Byte D7	Bit 8	Arbitrary Address Capable
	Bits 7-5	Industry Group
	Bits 4-1	Vehicle System Instance

Claimed example:

Table 11: Address Claimed message

COB-ID	**Rx/Tx**	**DLC**	**Data**							
			D0	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
18EEF-F00h + source address	Tx/Rx	8	See table 10							

4.4.2 Cannot Claim Source Address message

The linear encoder sends a Cannot Claim Source Address message after the following events:

- The Address Claimed command is requested and the source address is a NULL address (254)
- An Address Claimed message is received with the same source address and a lower NAME than its own

Table 12: Cannot Claim Address message definition

Address Claimed message	
Transmission rate	as required
Data length	8 bytes
Data page	0
PDU format	238
PDU specific	255 (global address)
Default priority	6
Parameter group number	60928 $(00EE00)_{16}$
Source address	254

Table 13: Structure of NAME in the Cannot Claim Address message

NAME		
Byte D0	Bits 8-1	Least significant byte of the identity number
Byte D1	Bits 8-1	Second byte of the identity number
Byte D2	Bits 8-6	Least significant 3 bits of the manufacturer code
	Bits 5-1	Most significant 5 bits of the identity number
Byte D3	Bits 8-1	Most significant bit of the manufacturer code
Byte D4	Bits 8-4	Function Instance
	Bits 3-1	ECU Instance
Byte D5	Bits 8-1	Function
Byte D6	Bits 8-2	Vehicle System
	Bit 1	Reserved
Byte D7	Bit 8	Arbitrary Address Capable
	Bits 7-5	Industry Group
	Bits 4-1	Vehicle System Instance

Cannot Claim Address example:

Table 14: Cannot Claim Address message

COB-ID	**Rx/Tx**	**DLC**	**Data**							
			D0	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
18E-EFFFEh	Tx/Rx	8	See table 10							

4.4.3 Request message for Address Claimed (PGN 60928)

An Address Claimed request message can be used to force the linear encoder to send either an Address Claimed or Cannot Claim Address message depending on the actual source address.

Table 15: Cannot Claim Address message definition

Address request message	
Transmission rate	as required
Data length	3 bytes
Data page	0
PDU format	234
PDU specific	Destination address (global or specific)
Default priority	6
Parameter group number	59904 $(00EA00)_{16}$
Source address	any value (except own SA)

Table 16: Request message for Address data field

Data field (Address Claimed PGN)	
Byte D0	00h (low byte of the PGN)
Byte D1	EEh (middle byte of the PGN)
Byte D2	00h (high byte of the PGN)

Example:

Table 17: Request message for Address Claimed

COB-ID	**Rx/Tx**	**DLC**	**Data**							
			D0	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
18EAh**SAMA**	Rx	3	00h	EEh	00h	-	-	-	-	-

SA – Source address of the linear encoder or FFh (global address)

MA – Master source address (any value allowed except the own source address)

4.5 Address configuration

The linear encoder is a Command Configurable Address CA. The source address of a Command Configurable Address CA can be changed using a Commanded Address message.

4.5.1 Commanded Address message

The Commanded Address message is sent using the BAM transport protocol as defined in SAE J1939-21 (see "Transport protocol", page 10).

Table 18: Commanded Address message definition

Commanded Address message	
Transmission rate	as required
Data length	9 bytes
Data page	0
PDU format	254
PDU specific	216
Default priority	6
Parameter group number	65240 $(00FED8_{16})$
Source address	

Table 19: NAME of the Commanded Address destination

NAME		
Byte 1	Bits 8-1	Least significant byte of the identity number
Byte 2	Bits 8-1	Second byte of the identity number
Byte 3	Bits 8-6	Least significant 3 bits of the manufacturer code
	Bits 5-1	Most significant 5 bits of the identity number
Byte 4	Bits 8-1	Most significant bit of the manufacturer code
Byte 5	Bits 8-4	Function Instance
	Bits 3-1	ECU Instance
Byte 6	Bits 8-1	Function
Byte 7	Bits 8-2	Vehicle System
	Bit 1	Reserved
Byte 8	Bit 8	Arbitrary Address Capable
	Bits 7-5	Industry Group
	Bits 4-1	Vehicle System Instance

Table 20: New source address of Commanded Address

Address assignment (new source address)	
Byte 9	
Bits 8-1	New source address Data range: 0–253

Example:

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
1CECFF h**MA**	Rx	8	20h	09h	00h	02h	FFh	D8h	FEh	00h

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
1CEBFF h**MA**	Rx	8	01h	See table 19 Byte 1 to byte 7 of the commanded address						

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
1CEBFF h**MA**	Rx	8	02h	See table 19	See table 20	FFh	FFh	FFh	FFh	FFh
				Byte 8 to byte 9 of the commanded address						

MA – Master source address (any value allowed except the own source address)

The maximum allowable time between each message is 750 ms, after which the BAM transport protocol is aborted.

NOTE

The new source address is activated immediately. The new source address is stored in the non-volatile memory of the linear encoder, i.e. the linear encoder uses the new source address the next time it is switched on.

If the programmatic change is successful, the linear encoder sends an Address Claimed message to avoid a network error if there is another device using the same source address.

4.6 Network error management

Every device in the SAE J1939 network must have a unique source address. Source addresses can be in the range 0 to 253. The source address 254 is the NULL address. It is reserved for network management, and is used for the Cannot Claim Source Address message (see "Cannot Claim Source Address message", page 17). The source address 255 is used exclusively as a destination address to support message broadcasting.

A source address conflict can occur when two or more devices claim the same source address. Whenever a device receives an Address Claimed message (see "Address Claimed message", page 16) containing its own source address, it must compare the NAME of the Address Claimed message. The device with the lowest NAME value can use the claimed source address. The other devices must claim a different source address, or use the NULL address to stop transmitting on the network. The other devices also send an Address Claimed message, and may send a Cannot Claim Source Address (see "Cannot Claim Source Address message", page 17) after a pseudo random delay between 0 and 153 ms.

There is a small probability of two or more devices with the same source address sending an Address Claimed or Cannot Claim Source Address message at the same time. The CAN identifier of these messages will be identical, but the data field will be different. This situation can lead to a CAN error on the device, or put it in the CAN Bus Off state. If this happens, the device must resent the message after a pseudo random delay between 0 and 153 ms.

NOTE

If, in the event of a source address conflict, the linear encoder has the higher NAME, the linear encoder claims the NULL address and stops transmitting the Data Record message. It can then only send the request message for Address Claimed (PGN 60928) (see "Address Claimed message", page 16) or the Commanded Address message (see "Commanded Address message", page 18).

5 J1939-74 Application Configurable Messaging

The linear encoder can be used in a wide variety of applications and under widely different network requirements. The user therefore now has the ability to change certain parameters by means of J1939-74 Application Configurable Messaging.

NOTE
Only the Destination Specific Proprietarily Configurable Messages 1–3 have been implemented in the linear encoder. All other services are not supported.

5.1 Configuration of NAME

The NAME of the linear encoder may differ depending on the application.

Each NAME comprises the fields shown in table 2 and see table 3, page 10 and is defined as described below.

Table 21: NAME fields

Arbitrary Address Capable	Industry Group	Vehicle System Instance	Vehicle System	Reserved	Function	Function Instance	ECU Instance	Manufacturer Code		Identity Number	
1 bit 4.1.1.2	3 bits 4.1.1.3	4 bits 4.1.1.4	7 bits 4.1.1.5	1 bit 4.1.1.6	8 bits 4.1.1.7	5 bits 4.1.1.8	3 bits 4.1.1.9	11 bits 4.1.1.10		21 bits 4.1.1.11	
Byte 8			Byte 7		Byte 6	Byte 5		Byte 4	Byte 3	Byte 2	Byte 1

The Manufacturer Code and Identity Number fields cannot be changed by the user. The linear encoder uses the Destination Specific Proprietarily Configurable Message 1 to programmatically change the NAME. The user can only change bytes 5 to 8.

Table 22: Destination Specific Proprietarily Configurable Message 1 definition

Destination Specific Proprietarily Configurable Message 1	
Transmission rate	as required
Data length	8 bytes
Data page	0
PDU format	177
PDU specific	DA (destination address)
Default priority	6
Parameter group number	45312 $(00B100)_{16}$
Source address	0-253

Table 23: Structure of the Destination Specific Proprietarily Configurable Message 1

Destination Specific Proprietarily Configurable Message 1		
Byte D0	Bits 8-1	SICK signature “S”
Byte D1	Bits 8-1	SICK signature “K”
Byte D2	Bits 8-1	SICK signature “A”
Byte D3	Bits 8-1	SICK signature “T”
Byte D4	Bits 8-4	Function Instance
	Bits 3-1	ECU Instance
Byte D5	Bits 8-1	Function
Byte D6	Bits 8-2	Vehicle System

Destination Specific Proprietarily Configurable Message 1		
	Bit 1	Reserved (any value)
Byte D7	Bit 8	Arbitrary Address Capable (any value)
	Bits 7-5	Industry Group
	Bits 4-1	Vehicle System Instance

The linear encoder is not Arbitrary Address Capable, so this bit is defined as ‘any value’.

NOTE
The new NAME of the linear encoder is activated immediately. The new NAME is stored in the non-volatile memory of the linear encoder, i.e. the linear encoder uses the new NAME the next time it is switched on.

If the programmatic change has been successful, an Address Claimed message is sent.

Example

Table 24: Programming of NAME

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
18B1h **SAMA**	Rx	8	53h	4Bh	41h	54h	01h	8Fh	06h	40h

SA – Source address of the linear encoder

MA – Master source address (any value allowed except the own source address SA)

5.2 Configuring the transmission repetition rates (update rates)

The transmission rate of the Data Record message of the linear encoder may differ depending on the application.

The linear encoder uses the Destination Specific Proprietarily Configurable Message 2 to programmatically set the transmission rate. The transmission rate can be in the range of 0–65535 ms. Factory default is 20 ms.

Table 25: Destination Specific Proprietarily Configurable Message 2 definition

Destination Specific Proprietarily Configurable Message 2	
Transmission rate	as required
Data length	8 bytes
Data page	0
PDU format	178
PDU specific	DA (destination address)
Default priority	6
Parameter group number	45568 $(00B200)_{16}$
Source address	0-253

Table 26: Structure of the Destination Specific Proprietarily Configurable Message 2

Destination Specific Proprietarily Configurable Message 2		
Byte D0	Bits 8-1	SICK signature “S”
Byte D1	Bits 8-1	SICK signature “K”
Byte D2	Bits 8-1	SICK signature “A”
Byte D3	Bits 8-1	SICK signature “T”

Destination Specific Proprietarily Configurable Message 2		
Byte D4	Bits 8-1	Low byte of the new transmission rate
Byte D5	Bits 8-1	High byte of the new transmission rate
Byte D6	Bits 8-1	any value
Byte D7	Bit 8-1	any value

NOTE
The new transmission rate of the linear encoder is activated immediately. The new transmission rate is stored in the non-volatile memory of the linear encoder, i.e. the linear encoder uses the new transmission rate the next time it is switched on.

Example

Table 27: Programmatically setting the transmission rate

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
18B2h **SAMA**	Rx	8	53h	4Bh	41h	54h	64h	00h	00h	00h

SA – Source address of the linear encoder

MA – Master source address (any value allowed except the own source address SA)

5.3 Configuring the Data Record parameter group number

The Proprietary B parameter group number (see "Proprietary B parameter group number", page 9) is used for the Data Record message. Depending on the application, the Data Record message will contain a different PGN in the range of 65280 to 65535.

Table 28: Destination Specific Proprietarily Configurable Message 3 definition

Destination Specific Proprietarily Configurable Message 3	
Transmission rate	as required
Data length	8 bytes
Data page	0
PDU format	179
PDU specific	DA (destination address)
Default priority	6
Parameter group number	45824 $(00B300)_{16}$
Source address	0-253

Table 29: Structure of the Destination Specific Proprietarily Configurable Message 3

Destination Specific Proprietarily Configurable Message 3	
Byte D0	
Bits 8-1	SICK signature “S”
Byte D1	
Bits 8-1	SICK signature “K”
Byte D2	
Bits 8-1	SICK signature “A”
Byte D3	
Bits 8-1	SICK signature “T”

Destination Specific Proprietarily Configurable Message 3	
Byte D4	
Bits 8-1	Low byte of the new PGN
Byte D5	
Bits 8-1	High byte of the new PGN (always FF_{16})
Byte D6	
Bits 8-1	any value
Byte D7	
Bit 8-1	any value

NOTE

The new Data Record PGN of the linear encoder is activated immediately. The new Data Record PGN is stored in the non-volatile memory of the linear encoder, i.e. the linear encoder uses the new Data Record PGN the next time it is switched on.

Example

Programmatically setting the Data Record PGN to 65283 ($FF03_{16}$)

Table 30: Programmatically setting the Data Record PGN

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
18B3h **SAMA**	Rx	8	53h	4Bh	41h	54h	03h	FFh	00h	00h

SA – Source address of the linear encoder

MA – Master source address (any value allowed except the own source address SA)

6 J1939-71 Application Layer

The J1939-71 Application Layer describes and defines the parameter group numbers and the suspect parameter numbers. Only the Software Identification and Component Identification PGNs have been implemented in the linear encoder. There are no application-specific suspect parameters that correspond to Data Record information.

6.1 Software identification

The firmware version of the linear encoder can be read using a request command and the Software Identification parameter group number.

Table 31: Software identification definition

Software identification	
Transmission rate	as required
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	218
Default priority	6
Parameter group number	65242 $(FEDA00)_{16}$
Source address	0-253

Table 32: Structure of the Software Identification message

Software identification		
Byte D0	Bits 8-1	4
Byte D1	Bits 8-1	LSB of the software version
Byte D2	Bits 8-1	Middle byte of the software version
Byte D3	Bits 8-1	Middle byte of the software version
Byte D4	Bits 8-1	MSB of the software version
Byte D5	Bits 8-1	0
Byte D6	Bits 8-2	0
Byte D7	Bits 8-1	0

Example

Requesting the software identification

COB-ID	**Rx/Tx**	**DLC**	**Data**							
			D0	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
18EAh**SAMA**	Rx	3	DAh	FEh	00h	-	-	-	-	-

Software identification

Table 33: Requesting the software identification sequence

COB-ID	**Rx/Tx**	**DLC**	**Data**							
			D0	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
18FEDAh**SA**	Tx	8	04h	LSB	MSB	MSB	MSB	00h	00h	00h

SA – Source address of the linear encoder

MA – Master source address (any value allowed except the own source address SA)

6.2 Component identification

The serial number of the linear encoder can be read using a request command and the Component Identification parameter group number.

Table 34: Component identification definition

Component identification	
Transmission rate	as required
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	235
Default priority	6
Parameter group number	65259 $(FEEB00)_{16}$
Source address	0-253

Table 35: Structure of the Component Identification message

Component identification		
Byte D0	Bits 8-1	FFh
Byte D1	Bits 8-1	FFh
Byte D2	Bits 8-1	Low byte of the serial number
Byte D3	Bits 8-1	Middle byte of the serial number
Byte D4	Bits 8-1	Middle byte of the serial number
Byte D5	Bits 8-1	High byte of the serial number
Byte D6	Bits 8-1	FFh
Byte D7	Bits 8-1	FFh

Example

Requesting the component identification

COB-ID	**Rx/Tx**	**DLC**	**Data**							
			D0	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
18EAh**SAMA**	Rx	3	EBh	FEh	00h	-	-	-	-	-

Component identification

Table 36: Requesting the component identification sequence

COB-ID	**Rx/Tx**	**DLC**	**Data**							
			D0	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
18FEEBh**SA**	Tx	8	FFh	FFh	Serial no. low	Serial no. middle	Serial no. middle	Serial no. high	FFh	FFh

SA – Source address of the linear encoder

MA – Master source address (any value allowed except the own source address SA)

6.3 Parameter information

The J1939-71 Application Layer defines so-called SLOT (Scaling, Limit, Offset and Transfer) functions that can be used when adding parameters to J1939. This helps ensure, as far as possible, that data consistency is maintained between parameters of a particular type (temperature, pressure, speed, etc.). Each SLOT provides a range and resolution that is suitable for most parameters of a particular type. If necessary, a different scaling factor or offset can be used.

The following slots can be used for the Data Record message:

Position

SLOT name	SLOT type	Units	Scaling	Range	Offset	Length
SAEds04	Distance	m	0.1 mm/bit	0 to 6,425.5 m m	0 mm	2 bytes

Speed

SLOT name	SLOT type	Units	Scaling	Range	Offset	Length
SAEvl01	Speed, lin-ear	m/s	0.001 m/s per bit	0 to 64.255 m/s	0 m/s	2 bytes

For additional information, see "Data Record message", page 31.

NOTE
There are no corresponding SLOT numbers for the other information in the Data Record message.

NOTE
The Length of Postion bytes in the MAX48 Linear Encoder is 4 bytes to accomodate for lengths more than 6.5 meters. However, if needed, then only two lower bytes can also be utilized for lengths that can be represented within 2 bytes (i.e. upto 6.5 meters).

7 J1939-73 Application Layer Diagnostics

The SAE J1939-73 Application Layer Diagnostics defines functions and messages for accessing diagnostic and calibration data. There are several predefined diagnostic messages (DM).

NOTE
The linear encoder only supports DM13: Stop Start Broadcast.

7.1 Stop Start Broadcast (DM13)

This message is used to stop and start broadcast messages such as the Data Record message of the linear encoder.

Table 37: Stop Start message definition

Stop Start Broadcast for the DM13	
Transmission rate	as required
Data length	8 bytes
Data page	0
PDU format	223
PDU specific	DA (destination address) or global address
Default priority	6
Parameter group number	57088 ($00DF00_{16}$)
Source address	0-253

Table 38: Structure of the Stop Start message

START STOP message data format		
Byte D0	Bits 8-7	Current Data Link
	Bits 6-5	J1587
	Bits 4-3	J1922
	Bits 2-1	J1939 Network #1, Primary vehicle network
Byte D1	Bits 8-7	J1939 Network #2
	Bits 6-5	ISO 9141
	Bits 4-3	J1850
	Bits 2-1	Other, Manufacture Specified Port
Byte D2	Bits 8-7	J1939 Network 2
	Bits 6-5	SAE Reserved
	Bits 4-3	SAE Reserved
	Bits 2-1	SAE Reserved
Byte D3	Bits 8-5	Hold Signal
	Bits 4-1	Suspend Signal
Byte D4	Bits 8-1	Suspend Duration
Byte D5	Bits 8-1	Suspend Duration
Byte D6	Bits 8-1	SAE Reserved
Byte D7	Bits 8-1	SAE Reserved

The linear encoder is assigned to the J1939 Network #1, Primary Vehicle Network or the Current Data Link. The Stop Broadcast timeout is normally 6 s, but can be suspended with a Hold Signal. Once the Stop Broadcast time has elapsed, the linear encoder automatically transmits a Data Record message. After a power on reset, the linear encoder is in the Start Broadcast state.

The individual 2-bit fields in the Stop Start Broadcast command are interpreted as follows:

Table 39: Bit definitions for DM13

Bit	Information
00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don’t care/take no action

Example

Stop Broadcast – Current Data Link

Table 40: Stop Broadcast – Current Data Link

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
18DFh**SAMA**	Rx	8	3Fh	FFh	FFh	FFh	FFh	FFh	FFh	FFh

Table 41: Start Broadcast – Current Data Link

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
18DFh**SAMA**	Rx	8	7Fh	FFh	FFh	FFh	FFh	FFh	FFh	FFh

Stop Broadcast – J1939 Network #1

Table 42: Stop Broadcast – J1939 Network #1

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
18DFh**SAMA**	Rx	8	FCh	FFh	FFh	FFh	FFh	FFh	FFh	FFh

Start Broadcast after Stop Broadcast J1939 Network #1

Table 43: J1939 Network #1 – Start Broadcast

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
18DFh**SAMA**	Rx	8	FDh	FFh	FFh	FFh	FFh	FFh	FFh	FFh

SA – Source address of the linear encoder or global address

MA – Master source address (any value allowed except the own source address SA)

The hold signal indicates to all devices that they should remain in the current Stop Broadcast state. A device requesting a Stop Broadcast must send a hold signal every 5 seconds. If no message is received within 6 seconds, all affected nodes revert to the normal state.

Table 44: Bit definitions for the hold signal

Bit states for bits 8-5	Devices to take action
0000	All devices
0001	Devices whose broadcast status has been changed
0010 to 1110	Reserved
1111	Not available

NOTE
The linear encoder will always remain in the Stop Broadcast state if the hold signal bits have the value 0001, regardless of whether the broadcast status has been changed.

Example

DM13 Hold Signal (same for Current Data Link and J939 Network #1)

Table 45: DM13 Hold Signal

COB-ID	Rx/Tx	DLC	Data							
			D0	D1	D2	D3	D4	D5	D6	D7
18DFh**S** **AMA**	Rx	8	FFh	FFh	FFh	0Fh	FFh	FFh	FFh	FFh

SA – Source address of the linear encoder or global address

MA – Master source address (any value allowed except the own source address SA)

NOTE
The linear encoder does not support the Suspend Signal and Suspend Duration functions of DM13 (Stop Start Broadcast).

8 Data Record message

The Data Record message contains the position and speed information of the linear encoder. It also contains status and error code information.

The device automatically begins transmitting a Data Record message after it is switched on.

The transmission rate of the Data Record message can be changed by configuring the transmission repetition rates (update rates) (see "Configuring the transmission repetition rates (update rates)", page 22). The default transmission rate is 20 ms.

Table 46: Data Record PGN definition

Data Record parameter group number	
Transmission rate	20 ms by default Data range 0 – 65535 ms
Data length	8 bytes
Data page	0
PDU format	255 by default
PDU specific	Group extension
Default priority	6 by default
Parameter group number	65535 data range by default 65280 to 65535 ($00FF00_{16}$ to $00FFFF_{16}$)
Source address	0-253

Table 47: Data field of the Data Record linear encoder message

Destination Specific Proprietarily Configurable Message 1		
Byte D0	Bits 8-1	Least significant byte of the position
Byte D1	Bits 8-1	2nd least significant byte of the position
Byte D2	Bits 8-1	3rd least significant byte of the position
Byte D3	Bits 8-1	Most significant byte of the position
Byte D4	Bits 8-1	Least significant byte of the speed
Byte D5	Bits 8-1	Most significant byte of the speed
Byte D6	Bits 8-1	Status
Byte D7	Bits 8-1	Error code

Example

Table 48: Data Record message

COB-ID	**Rx/Tx**	**DLC**	**Data**							
			D0	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**
18h**PFP SSA**	Tx	8	Low byte of the posi-tion	2nd low byte of the posi-tion	3rd low byte of the posi-tion	High byte of the posi-tion	Low byte of the speed	High byte of the speed	Sensor status	Error code

SA – Source address of the linear encoder

PF – PDU format is set to 255 (FF16)

PS – PDU Specific can be between 0 and 255 (016 – FF16) (see "Configuring the Data Record parameter group number", page 23)

Position:

The default resolution is 100 µm.

Position data in [0.1 mm] Intel format as SIGNED32

Data byte 0	LSB of the position data
Data byte 1	LSB2 of the position data
Data byte 2	LSB3 of the position data
Data byte 3	MSB of the position data

Speed

The resolution for speed data is set to 1 mm/s.

VD – Speed data in [1 mm/s] Intel format as SIGNED16

Data byte 4	LSB of the speed data
Data byte 5	MSB of the speed data

SS – Sensor status

Data byte 6	Sensor status

Table 49: Sensor Status Register definition

Sensor status 00h Normal (otherwise see table 50, page 32)

The Voltage bit is set when the supply voltage is beyond the normal operational voltage supply range.

The Temperature bit is set if the internal temperature of the microcontroller of the linear encoder exceeds the normal working temperature range.

The definition of the “Sensor Status Register” is as follows:

Table 50: Sensor Status Register definition

D7	D6	D5	D4	D3	D2	D1	D0
0	T	V	F2	F1	N	M	W

W Working area violation
0 = Magnet inside working area range
1 = Magnet outside working area range

M Manufacturer area violation
0 = Magnet inside permitted measuring range of manufacturer
1 = Magnet outside permitted measuring range of manufacturer
In case of MAX48 J1939, scaled measuring range is same as manufacturer measuring range so these bits set and reset together.

N Position magnet error
0 = One position magnet detected
1 = No magnet

F1 Flash data error
0 = No error when writing to Flash memory
1 = Error encountered while writing to Flash memory

F2 Flash Erase Count exceeded
0 = Flash page erase count in range
1 = Flash page erase count limit exceeded

V Supply voltage violation
0 = Supply voltage inside the permitted range
1 = Supply voltage outside the permitted range

T	Temperature Violation	0 = Temperature inside the permitted range 1 = Temperature outside the permitted range

At all times the value of sensor status register is an OR of all these bit positions. E.g:
0x03 = Magnet detected outside measuring range
0x07 = Magnet moved out of the measuring length and cannot be detected now.
0x04 = No magnet detected at all since power-up OR magnet abruptly disappeared while being inside the measuring range (Magnet broken).

EC – Error Code

Data byte 7	Error code

Table 51: Sensor Error Code Register

D7	D6	D5	D4	D3	D2	D1	D0
M	-	-	-	T	V	-	G

G	Generic Error	0 = No Error 1 = Sensor has an error. This bit is set in case of all errors
V	Voltage Error	0 = No Error 1 = Supply Voltage Error
T	Temperature Error	0 = No Error 1 = Temperature out of range error
M	Manufacturer Error	0 = No Error 1 = Manufacturer Error (All magnet related errors)

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