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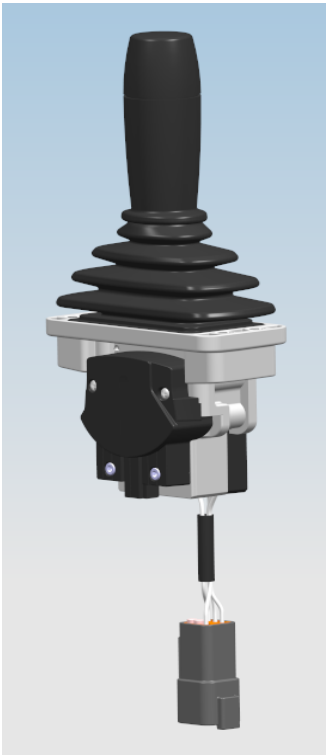

Robust-Joystick J7
SAE J1939 Protocol

1.00 • 12/08/2014

1 Scope

This document represents the SAE J1939 Controller Area Network (CAN) message protocol for the Robust-Joystick J7 of elobau GmbH & Co. KG .

2 Abbreviations and Acronyms

Acronym	Definition and Meaning
SAE	Society of Automotive Engineers
SA	Source Address
DA	Destination Address
DP	Data Page
PF	PDU Format
PS	PDU Specific
PGN	Parameter Group Number
BJM	Basic Joystick Message
EJM	Extended Joystick Message
NACK	Negative Acknowledgement
NA	Not Available
ADC	Analogue Digital Converter
DTC	Diagnostic Trouble Code
SPN	Suspect Parameter Number
FMI	Failure Mode Indicator
CRC	Cyclic Redundancy Check
AC	Address Claiming
RQST	Request Message

Tab. 1: Abbreviations and Acronyms

3 Description

SAE J1939 is a high level communications protocol, which operates on a Controller Area Network (CAN) bus. J1939 specifies exactly how information (e. g. Joystick position) ist exchanged between electronic control units (ECUs) on a vehicle.
The communications protocol defines the data's

- priority,
- size,
- scaling,
- offset.

The standard goes on to define many other aspects, including message timeouts, the network speed and the physical layer.

3.1 Communications protocol

3.1.1 CAN 29 Bit ID Field

29 Bit Identifier																											
Priority			R1	DP	PF								PS								SA						
28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Fig. 1: 29 Bit Identifier

Priority	Definied for each message transmitted.	These bits control the bus arbitration and message latency of the CAN message relative to other messages.
R1	Reserved by SAE.	R1 shall be set to 0 for all messages transmitted and shall be validated as being 0 for all messages received.
DP	Data Page	The Data Page shall be set to 0 for all messages transmitted and shall be validated as being 0 for all messages received.
PF (PDU Format)	Transmitted message identifier.	The PF field is defined for each message transmitted.

PS (PDU Specific)	Transmitted message identifier extension or destination address.	The PS field ist defined for each message transmitted.
Source Address	Transmitted message identifier.	The Source Address ist defined for each component on the CAN network.

The following table describes the joystick source address default coding:

Joystick No.	Source Address	
1	0x70	112
2	0x71	113
3	0x72	114
4	0x73	115
5	0x74	116
6	0x75	117
7	0x76	118
8	0x77	119
9	0x78	120
10	0x79	121

Tab. 2: Joystick Source Address

The Source Address is selected in the free range of 85 thru 127 of the Industry Group #0 – Global. This industry group applies to all.

3.1.2 Parameter Group Number - PGN

At the heart of J1939 is the Parameter Group Number (PGN), which is a unique number assigned to every J1939 message.
The PGN serves to identify the message and its data. The PGN typically will contain a group of parameters. In the standard there is a total of 8,672 PGNs.
For the PGN a 24 bit value is used that has the following constituent components:

- 6 bits set to 0 ,
- 1 bit Extended Data Page,
- 1 bit Data Page,
- 8 bit PDU Format
- 8 bit PDU Specific.

There are two types of PGNs:

Global PGNs	identify parameter groups that are sent to all (broadcast). For identification on the corresponding parameter group are used: ▪ PDU Format (PF), ▪ PDU Specific (PS), ▪ Data Page (DP), ▪ Extended Data Page (DP). On global PGNs the PDU Format is 240 or greater and the PDU Specific field is a group extension.

Specific PGN	are for parameter groups that are sent to particular devices (peer-to-peer). For identification of the corresponding parameter group are used: ▪ PDU Format (PF), ▪ Data Page (DP), ▪ Extended Data Page (DP). The PDU Format is 239 or less and the PDU Specific field is set to 0.

Example of a PGN:

Name:	Basic Joystick Message 1 – BJM1
Data Length	8 bytes
Extended Data Page:	0
Data Page:	0
PDU Format:	253
PDU Specific:	214
Default Priority	3
PGN:	64982 (0x00FDD6)

Tab. 3: Example of a PGN

3.1.3 Suspect Parameter Number - SPN

The SPN is a 19 bit number used to identify each parameter of a parameter group or component.
The SPN is especially used for diagnostic purpose to report and identify abnormal operation of the Controller Application.
The SPN has a range from 0 to 524287. The proprietary parameters have a reserved range from 520192 to 524287.

3.2 Zero-Position after POWER ON and BUS OFF

If configured, after POWER ON or BUS OFF, axis and thumb wheel signals must be in Zero-position, otherwise the Zero-position is sent permanently.
The joystick allows a limited number of BUS OFF states. After a BUS OFF the joystick goes back on CAN. If the defined number of BUS OFF states is exceeded, the joystick is not allowed to connect again to CAN.
The number of allowed BUS OFF states is defined in the parameter set.

4 Network Management (Address Claiming Process)

The Address Claiming process uses the J1939 Address Claiming message (AC) and the Request message (RQST).
See also:

- Request (RQST) [▶ 17]
- Address Claiming (AC) [▶ 20]

For more details about the Address Claiming process: refer to „SAEJ1939-81“.

5 Error Handling

All errors can be divided in signal errors and system errors.
All signal errors are signalised within the corresponding signal message (BJM1, 2, ..., 10) and as Diagnostic Trouble Code (DTC) within the DM1 message (DM1).
All system errors are signalised as DTC within the DM1 message. Some of them have additional outcome.
All detectable errors are defined as DTCs.
A DTC is made up of four independent fields, as follows:

Suspect Parameter Number (SPN)	19 bit
Failure Mode Identifier (FMI)	5 bit
Occurrence Count	7 bit (not used: 127 / 0x7F)
SPN Conversion Method	1 bit (0: DTC represent as Intel format)

The joystick uses standard SPNs as well as proprietary SPNs from 520192 / 0x7F000 to 524287 / 0x7FFFF.

5.1 Error Detection

All detectable errors are described in the following table:

DTC OC+SPN CM	DTC FMI (3)	DTC SPN	Name	Indication / Behaviour	Remark
127	12	520192	Application Program Checksum Error	Joystick sends/ receives no CAN message and remains in this state.	CRC32 Power On Test.
127	12	520193	Parameter: Checksum Error	Joystick sends/ receives no CAN message and remains in this state.	CRC32 Power On Test.

DTC OC+SPN CM	DTC FMI (3)	DTC SPN	Name	Indication / Behaviour	Remark
127	4	2660	X-axis, signal 1, out of range low	Indication within BJM	(4) (5)
127	4	2661	Y-axis, signal 1, out of range low	Indication within BJM	(4) (5)
127	3	2660	X-axis, signal 1, out of range high	Indication within BJM	(4) (5)
127	3	2661	Y-axis, signal 1, out of range high	Indication within BJM	(4) (5)
127	4	520660	X-axis, signal 2, out of range low	Indication within BJM	(1) (4) (5)
127	4	520661	Y-axis, signal 2, out of range low	Indication within BJM	(1) (4) (5)
127	3	520660	X-axis, signal 2, out of range high	Indication within BJM	(1) (4) (5)
127	3	520661	Y-axis, signal 2, out of range high	Indication within BJM	(1) (4) (5)
127	14	2660	X-axis, plausibility error	Indication within BJM	(2) (4) (5)
127	14	2661	Y-axis, plausibility error	Indication within BJM	(2) (4) (5)

Tab. 4: Diagnostic Trouble Codes

X- or Y-axis error output is dependent on the configured axis.

1. Signal 2 can have opposite or same direction of signal 1 and is not visible within the corresponding signal message.
   Signal 2 is only used for plausibility check. If Signal 2 has an “out of range” error it causes also an error within the corresponding signal message.
2. Plausibility calculation:
   There are two types of plausibility test:

- case 1:
  Signal 2 has the same direction of signal 1.
  Signal 1 - Signal 2 = 0 mV ± <Maximal Difference Signal 1_2>
- case 2:
  Signal (on channel) 2 has the opposite direction of signal (on channel) 1.
  Signal 1 + Signal 2 = 5000 mV ± <Maximal Difference Signal 1_2>
- This “plausibility error” causes also an error within the corresponding signal message. Plausibility Error will be displayed in case that maximal difference signal 1_2 value is greater than 0 and if plausibility type is not 0.

3. Supported FMI codes:

2	data erratic, intermittent or incorrect
3	voltage above normal, or shorted to high source
4	voltage below normal, or shorted to low source
12	bad intelligent device or component
14	special instruction

4. The SPN of this DTCs is depending of the joystick definition. The SPN in this error table is valid for joystick 1. The definition of the SPNs for joystick 2 to joystick 10 can be calculated as follows:

SPN Joystick 2	=	SPN Joystick 1 + 37
SPN Joystick 3	=	SPN Joystick 2 + 37
SPN Joystick 4	=	SPN Joystick 3 + irregular step in SPN numbers, refer to SAE J1939-71
SPN Joystick 5	=	SPN Joystick 4 + 37
SPN Joystick 6	=	SPN Joystick 5 + 37
SPN Joystick 7	=	SPN Joystick 6 + 37
SPN Joystick 8	=	SPN Joystick 7 + 37
SPN Joystick 9	=	SPN Joystick 8 + 37
SPN Joystick 10	=	SPN Joystick 9 + 37

5. Debounce filter / debounce counter
   To guarantee reliability of the joystick a debounce filter shall be implemented.
   Debounce time: 200 ms

6 CAN Communication

The joystick will be connected to a Controller Area Network (ISO 11898, CAN Specification 2.0B) using SAE J1939 protocol with a baudrate of 250 kbit/s.

7 Joystick Messages

7.1 Basic Joystick Message 1-10 (BJM)

The BJM 1-10 (BJM1-BJM10)) are used to transfer the information about the measured status of the joystick x-axis and y-axis and up to 12 buttons of the joystick grip.

	Definition	Remark
Transmission Rate	**see data sheet**	
Data Length	8	
Extended DP	0	
DP	0	
Default Priority	**3**	
PGN	see PGN definition for BJM [▶ 14]	
Parameter	see Basic Joystick Message (BJM) parameters [▶ 14]	

Tab. 5: Basic Joystick Message (BJM) definition

The following table shows the BJM parameters:

Joystick No.	Basic Joystick Message	PGN
1	BJM1	0xFDD6
2	BJM2	0xFDD8
3	BJM3	0xFDDA
4	BJM4	0xFD30
5	BJM5	0xFD2E
6	BJM6	0xFD2C
7	BJM7	0xFD2A
8	BJM8	0xFD28
9	BJM9	0xFD26
10	BJM10	0xFD24

Tab. 6: PGN definition for BJM

The following table shows the BJM parameters:

Parameter Position		Length	Description
Byte 1	Bit 8 … 7	2 bit	X-axis position (Bit 2 ... 1) – optional
	Bit 6 … 5	2 bit	X-axis right position status – optional
	Bit 4 … 3	2 bit	X-axis left position status – optional
	Bit 2 … 1	2 bit	X-axis neutral position status – optional
Byte 2	Bit 8 … 1	8 bit	X-axis position (Bit 10 ... 3) – optional
Byte 3	Bit 8 … 7	2 bit	Y-axis position (Bit 2 ... 1)
	Bit 6 … 5	2 bit	Y-axis forward position status
	Bit 4 … 3	2 bit	Y-axis back position status
	Bit 2 … 1	2 bit	Y-axis neutral position status
Byte 4	Bit 8 … 1	8 bit	Y-axis position (Bit 10 ... 3)

Parameter	Position	Length	Description
Byte 5	Bit 8 … 7	2 bit	X-axis detent position status – optional
	Bit 6 … 5	2 bit	Y-axis detent position status
	Bit 4 … 3	2 bit	not used (NA)
	Bit 2 … 1	2 bit	not used (NA)
Byte 6	Bit 8 … 7	2 bit	Grip button 1 status – not used
	Bit 6 … 5	2 bit	Grip button 2 status – not used
	Bit 4 … 3	2 bit	Grip button 3 status – not used
	Bit 2 … 1	2 bit	Grip button 4 status – not used
Byte 7	Bit 8 … 7	2 bit	Grip button 5 status – not used
	Bit 6 … 5	2 bit	Grip button 6 status – not used
	Bit 4 … 3	2 bit	Grip button 7 status – not used
	Bit 2 … 1	2 bit	Grip button 8 status – not used
Byte 8	Bit 8 … 7	2 bit	Grip button 9 status – not used
	Bit 6 … 5	2 bit	Grip button 10 status – not used
	Bit 4 … 3	2 bit	Grip button 11 status – not used
	Bit 2 … 1	2 bit	Grip button 12 status – not used

Tab. 7: Basic Joystick Message (BJM) parameters

The selection of the desired output axis (X or Y) can be done in the SAX-File.
X/Y-axis Position is analogue signal which is proportional to the axis position. This 10 bit value is in range from 0,0...100,0% (0x000 to 0x3E8), resolution 0,1%/bit, 0 offset. In neutral position value is 0. If an error occurs, value 1022 (0x3FE) is sent. For the not used axis the value 1023 (0x3FF) is sent.
Not used buttons are configured with value 0.
X/Y-axis Status has 2 bits for representation:

00	Not in position

01	In position
10	Error indicator
11	Not available (NA)

Tab. 8: 2 bit representation of X-/Y-axis Status

Each button has 2 bits for representation:

00	Button not pressed
01	Button pressed
10	Error indicator
11	Not available (NA)

Tab. 9: 2 bit representation for each button

If available, the presence sensor is also handled like a button and transmitted via CAN bus as button 12.

7.2 Request (RQST)

This message type can be used to request PGN information globally (SA 255) or from specific destination. That means the DA can be globally or specific.
General rules of operation for determining whether to send a PGN to a global or specific destination:

- If the RQST is sent to a global address, then the response is sent to global address.
  A global response shall not be responded to with a NACK when a particular PGN is not supported by a node.
- If the RQST is sent to a specific address, then the response is sent to a specific address.
  A NACK is required if the PGN is not supported.

It is generally recommended that RQSTs does not occur more than 2 or 3 times per second:

	Definition	Remark
Transmission Rate	Per user requirement	
Data Length	3	
Extended Data Length	0	
DP	0	
Default Priority	6	
PGN	0xEADA	DA = Destination Address
Parameter	see Request (RQST) parameters [▶ 17]	

Tab. 10: Request (RQST) definition

Parameter Position		Length	Description
Byte 3 … 1	Bit 24 … 1	3 bytes	PGN being requested. PGN field definition and byte order [▶ 18]

Tab. 11: Request (RQST) parameters

The following table shows the field definition and the byte order of the PGN in the data field of the RQSTmessage.

Byte 1	Byte 2	Byte 3
PDU Specific (PS)	PDU Format (PF)	0x00

Tab. 12: PGN field definition and byte order

The joystick supports the following PGNs by using this RQST service:

PGN	Name	Acronym
0x00FEDA	Software Identifcation	SOFT
0x00EE00	Address Claiming	AC

Tab. 13: Supported PGNs

NACK message has PGN E8DA and data fields like in following example:

Position	Data Example	Description
Byte 1	0x01	Control byte=1, Negative Acknowledgment (NACK)
Byte 2	0x00	Group function value
Byte 3	0xFF	Reserved for assignment by SAE
Byte 4	0xFF	Reserved for assignment by SAE
Byte 5	0xFF	Address Negative Acknowledgment
Byte 6	0x00	PGN of requested information
Byte 7	0x12	PGN of requested information
Byte 8	0x34	PGN of requested information

Tab. 14: NACK example

7.3 Software Identification (SOFT)

The Software Identification (SOFT) message contains the Software-Version. This message is transmitted as response to a RQST message.

	Definition	Remark
Transmission Rate	On request	
Data Length	Variable	
Extended Data Page	0	
Data Page	0	
Default Priority	6	
PGN	0xFEDA	
Parameters	see Software Identification (SOFT) parameters [▶ 19]	

Tab. 15: Software Identification (SOFT) definition

Parameter Position		Length	Description
Byte 1	Bit 8 … 1	8 bit	Number of software identification fields (0x02)
Byte 2	Bit 8 … 1	8 bit	Software version major
Byte 3	Bit 8 … 1	8 bit	Software version minor
Byte 4	Bit 8 … 1	8 bit	*
Byte 5	Bit 8 … 1	8 bit	Hardware version
Byte 6	Bit 8 … 1	8 bit	*
Byte 7	Bit 8 … 1	8 bit	Not used (0x00)
Byte 8	Bit 8 … 1	8 bit	Not used (0x00)

Tab. 16: Software Identification (SOFT) parameters

7.4 Address Claiming (AC)

The AC message is sent by the joystick to claim an address on the network after POWER ON.
This message is also transmitted as response to a RQST message.
The AC message contains the 64 bit J1939 name field.
For more details about the AC process: refer to SAE J1939-81.

	Definition	Remark
Transmission Rate	As required	
Data Length	8	
Extended Data Page	0	
Data Page	0	
Default Priority	6	
PGN	0xEE00	
Parameters	see Address Claiming AC parameters [▶ 20]	

Tab. 17: Address Claiming (AC) definition

Parameter Position		Length	Description
Byte 1	Bit 8 … 1	8 bit	Name - identity number LSB
Byte 2	Bit 8 … 1	8 bit	Name - identity number second byte
Byte 3	Bit 8 … 6	3 bit	Name - manufacturer code LSB
	Bit 5 … 1	5 bit	Name - identity number MSB
Byte 4	Bit 8 … 1	8 bit	Name - manufacturer code MSB
Byte 5	Bit 8 … 8	5 bit	Name - function instance
	Bit 3 … 1	3 bit	Name - ECU instance
Byte 6	Bit 8 … 1	8 bit	Name - function

Parameter Position		Length	Description
Byte 7	Bit 8 … 2	7 bit	Name - vehicle system
	Bit 1	1 bit	Name - reserved
Byte 8	Bit 8	1 bit	Name - arbitrary address capable
	Bit 7 … 5	3 bit	Name - industry group
	Bit 4 … 1	4 bit	Name - vehicle system instance

Tab. 18: Address Claiming AC parameters

Example for J7 J1939 Joystick name definition:

Name	Value	Remark
Identity Number	0	
Manufacturer Code	152 / 0x98	elobau GmbH & Co.KG
ECU Instance	0	
Function Instance	0	
Function	66 / 0x42	I/O Controller
Reserved Field	0	
Vehicle System	0	
Vehicle System Instance	0	
Industry Group	3	3 = Construction equipment oder alternatively 2 = Agricultural and forestry equipment
Arbitrary Address Capable	0	

Tab. 19: J1939 Joystick name (default) definition

7.5 Active Diagnostic Trouble Codes (DM1)

The DM1 message should be used to communicate any fault that the joystick can detect. Immediately when a fault is detected, the joystick ECM should transmit this message at a rate of 1 time per second. If a fault is no longer detected, the message shall send one message indicating that there is no longer a fault detected.
The DM1 message shall be broadcasted every one second, even when there is no active error.
For more details about this active diagnostic trouble codes:
refer to SAE J1939-73.

	Definition	Remark
Transmission Rate	On request on occurrence or cyclic (1s)	After sending a message because of occurrence of an error the transmission rate will be cyclic 1s again from this message.
Data Length	Variable	
Extended Data Page	0	
Data Page	0	
Default Priority	6	
PGN	0xFECA	
Parameters	see Active Diagnostic Trouble Code DM1 parameters [▶ 23]	

Tab. 20: Active Diagnostic Trouble Codes (DM1) definition

Parameter Position		Length	Description
Byte 1	Bit 8 … 7	2 bit	Malfunction Indicator lamp status (not used: 00b)
Byte 1	Bit 6 … 5	2 bit	Red stop lamp status (not used: 00b)
Byte 1	Bit 4 … 3	2 bit	Amber warning lamp status (not used: 00b)
Byte 1	Bit 2 … 1	2 bit	Protect lamp status (not used: 00b)
Byte 2	Bit 8 … 7	2 bit	Flash malfunction indicator lamp status (not used: 11b)
Byte 2	Bit 6 … 5	2 bit	Flash red stop lamp status (not used: 11b)
Byte 2	Bit 4 … 3	2 bit	Flash amber warning lamp status (not used: 11b)
Byte 2	Bit 2 … 1	2 bit	Flash protect lamp status (not used: 11b)
Byte 3	Bit 8 … 1	8 bit	DTC SPN (LSB - most significant at bit 8)
Byte 4	Bit 8 … 1	8 bit	DTC SPN (most significant at bit 8)
Byte 5	Bit 8 … 6	3 bit	DTC SPN (MSB - most significant at bit 8)
Byte 5	Bit 5 … 1	5 bit	DTC FMI (most significant at bit 5)
Byte 6	Bit 8	1 bit	DTC SPN conversion method (0: DTC represent as Intel format)
Byte 6	Bit 7 … 1	7 bit	DTC occurrence count (not used: 127)

Parameter Position		Length	Description
Byte 7	Bit 8 … 1	8 bit	Not used (0xFF)
Byte 8	Bit 8 … 1	8 bit	Not used (0xFF)

Tab. 21: Active Diagnostic Trouble Code DM1 parameters

The following illustrates the message format for when a request of the DM1 is made and there are 0 active errors, or when there are 0 active errors and the message is being transmitted at its regular one second interval:

Byte 1	Indicator lamp	0x00
Byte 2	Flashing lamp	0xFF
Byte 3 … 6	DTC	0x00000000
Byte 7	Not used	0xFF
Byte 8	Not used	0xFF

Tab. 22: Example for 0 active errors or irregular transmitting interval

The following illustrates the message format for when there is more than one active DTC:

Indicator lamp
Flashing lamp
DTC 1
DTC 2
DTC n

Tab. 23: Example for more than one active DTC

In this case, the transport protocol of SAE J1939-21 will have to be used to send the information because it requires more than 8 data bytes.

7.6 Start Stop Broadcast (DM13)

The DM13 is used to start or stop the cyclic broadcast messages of the joystick. After „POWER ON“ the joystick starts automatically (if AC process is successful) transmitting the BJM and EJM messages. With the stop broadcast command (DM13), this transmission can be stopped.
To keep the joystick in the stop broadcast state, this DM13 message with the command hold current state set have to be sent cyclic every 5 seconds. If the joystick does not receive this command within 6 seconds, it will automatically go back in broadcast mode and send the cyclic broadcast messages BJM and EJM.
For more details about this memory access messages: refer to SAE J1939-73.

	Definition	Remark
Transmission Rate	On request.	
Data Length	8	
Extended Data Page	0	
Data Page	0	
Default Priority	6	
PGN	0xDF00	
Parameters	see Start Stop Broadcast (DM13) parameters [▶ 25]	

Tab. 24: Start Stop Broadcast (DM13) definition

Parameter Position		Length	Description
Byte 1	Bit 8 ... 7	2 bit	Current data link: 00 Stop broadcast 01 Start broadcast 10 Reserved 11 Don’t care / take no action (leave as is)

Parameter Position		Length	Description
Byte 1	Bit 6 ... 5	2 bit	J1587 – not used
Byte 1	Bit 4 ... 3	2 bit	J1922 – not used
Byte 1	Bit 2 ... 1	2 bit	J1939 Network #1 - primary vehicle network
Byte 2	Bit 8 ... 7	2 bit	J1939 Network #2 – not used
Byte 2	Bit 6 ... 5	2 bit	ISO9141 – not used
Byte 2	Bit 4 ... 3	2 bit	J1850 – not used
Byte 2	Bit 2 ... 1	2 bit	Other, manufacturer specified port – not used
Byte 3	Bit 8 ... 7	2 bit	J1939 Network #3 – not used
Byte 3	Bit 6 ... 5	2 bit	SAE reserved
Byte 3	Bit 4 ... 3	2 bit	SAE reserved
Byte 3	Bit 2 ... 1	2 bit	SAE reserved
Byte 4	Bit 8 ... 5	4 bit	Hold signal: 0000 All devices 0001 Devices whose broadcast state has been modified 0010...1110 Reserved 1111 Not available
Byte 4	Bit 4 ... 1	4 bit	Suspend signal
Byte 6 ... 5	Bit 16 ... 1	15 bit	Suspend duration
Byte 7	Bit 8 ... 1	8 bit	SAE reserved
Byte 8	Bit 8 … 1	8 bit	SAE reserved

Tab. 25: Start Stop Broadcast (DM13) parameters

8 Annex

These examples show J1939 BJM position, detent and direction definition.

Example 1:

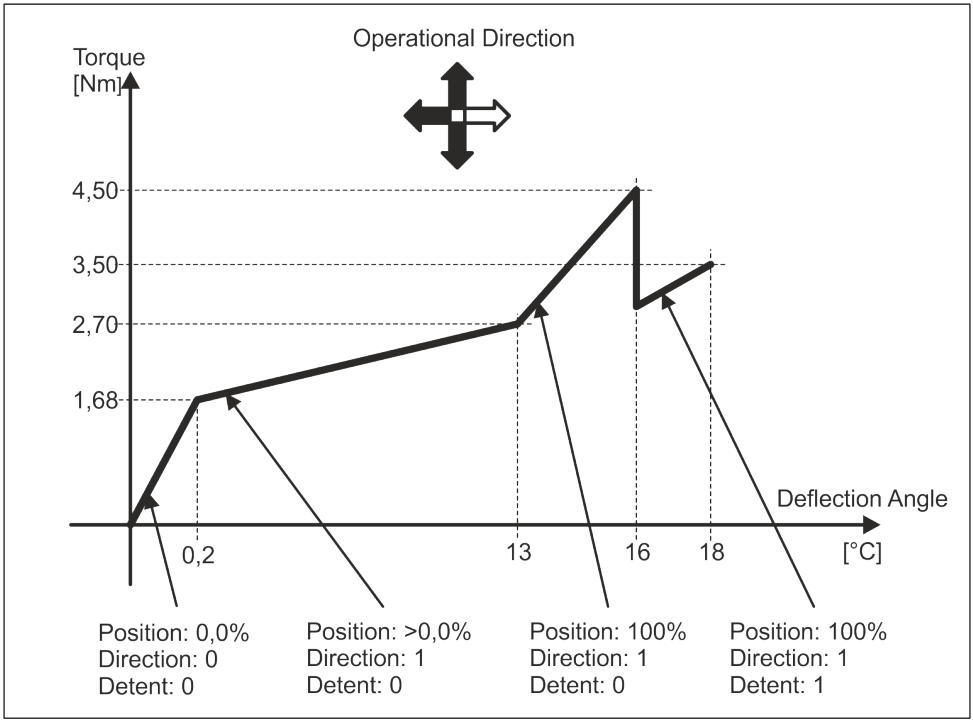

Fig. 2: Example 1 – with mechanical detent

Example 2:

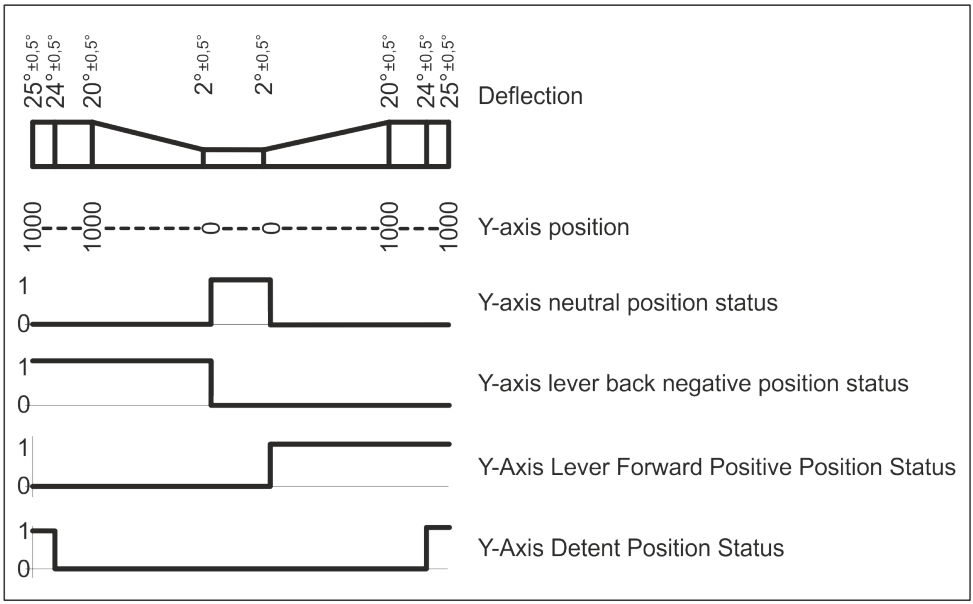

Fig. 3: Example 2 – with mechanical detent

Example 3:

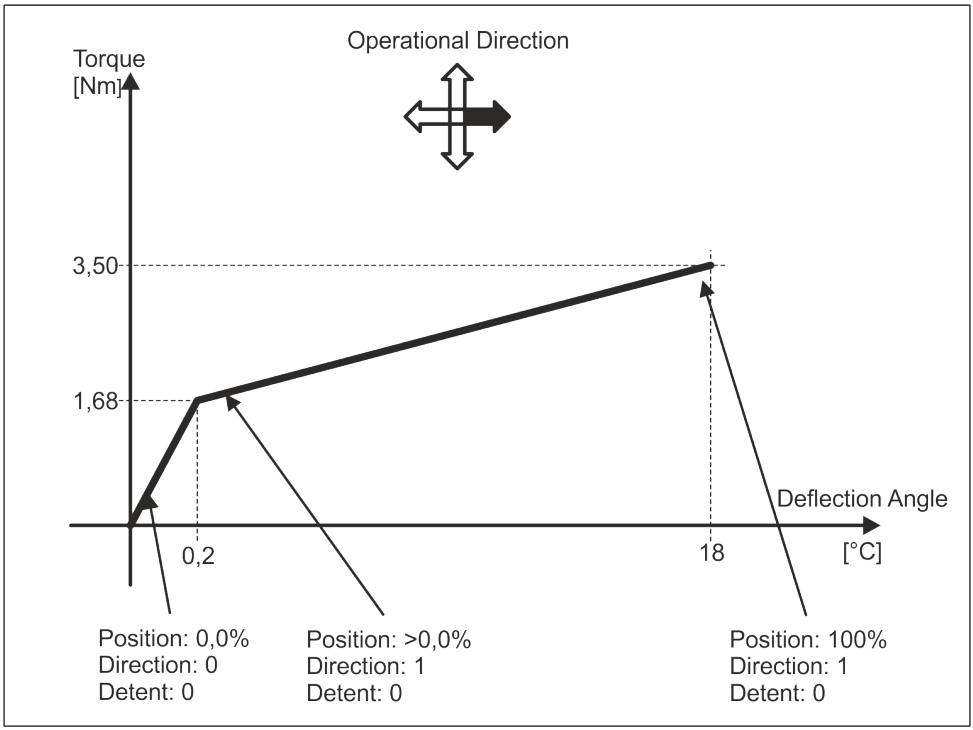

Fig. 4: Example 3 – without mechanical detent

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