SAE J1939 Protocol for Joystick (J2.., J3.., J6..)

Preliminary User Manual

Inhaltsverzeichnis

1 Scope

This document represents the SAE J1939 Controller Area Network (CAN) message protocol for elobau joystick series J2, J3 and J6.

2 Abbreviations and Acronyms

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

Tab. 1: Abbreviations and terms

3 Overview

3.1 Introduction

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) is exchanged between electronic control units (ECUs) on a vehicle.

It defines the data's priority, size, scaling, and offset.

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

3.2 CAN 29 Bit ID Field

Priority			R	DP	PDU Format (PF)							
28	27	26	25	24	23	22	21	20	19	18	17	16

PDU Specific (PS)								Source Address							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Priority – these bits control the bus arbitration and message latency of the CAN message relative to other messages. The priority is defined for each message transmitted.

R1 – Reserved by SAE. This shall be set to 0 for all messages transmitted and shall be validated as being 0 for all messages received.

DP – Data Page - This shall be set to 0 for all messages transmitted and shall be validated as being 0 for all messages received.

PF Field – Transmitted message identifier. The PF field is defined for each message transmitted.

PS Field – Transmitted message identifier extension or destination address. The PS field is defined for each message transmitted. See individual Joystick PGN definitions for PF and PS field information.

Source Address – Transmitted message identifier. The source address is defined for each component on the CAN network. The following table describes the joystick source address default coding.

Joystick No.	Source Adress	
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

Source Address is selected in the free range of 85 thru 127 of the Industry Group #0 –Global. This industry group applies to all. See also for information SAE J1939 Top level document (Feb. 2007 chapter 3.2.4)

3.3 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, Extended Data Page (1 bit), Data Page (1 bit), PDU Format (8 bits) and PDU Specific (8 bits).

There are two types of Parameter Group Numbers:

- Global PGNs identify parameter groups that are sent to all (broadcast). On global PGNs the PDU Format is 240 or greater and the PDU Specific field is a Group Extension. Here the PDU Format, PDU Specific, Data Page and Extended Data Page are used for identification of the corresponding Parameter Group.
- Specific PGNs are for parameter groups that are sent to particular devices (peer-to-peer). Here the PDU Format, Data Page and Extended Data Pare are used for identification of the corresponding Parameter Group. The PDU Format is 239 or less and the PDU Specific field is set to 0.

Sample of a PGN:

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

3.4 Suspect Parameter Number – SPN

The SPN is a 19bit number used to identify each parameter of a parameter group or component. It 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.

4 Zero Position after Power On + 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.

5 Network Management (Address Claiming Process)

The address claiming process uses the J1939 address claiming message (AC) and the request message (RQST).

For more details about the address claiming process refer to SAE J1939-81.

6 Error Handling

All errors can be divided in signal errors and system errors.

All signal errors are signalised within the corresponding signal message (BJM1-10, EJM1-10) and as diagnostic trouble code within the DM1 message.

All system errors are signalised as diagnostic trouble code within the DM1 message (DM1) and some of them have additional outcome.

All detectable errors are defined as Diagnostic Trouble Codes (DTCs). A DTC is made up of four independent fields, as follows:

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

The joystick uses standard suspect parameter numbers (SPNs) as well as proprietary suspect parameter numbers (Proprietary SPNs) from 520192 / 0x7F000 through 524287 / 0x7FFFF.

6.1 Error Detection

All detectable errors are described in the following table.

DTC OC + SPN CM	DTC FMI (3)	DTC SPN	Lamp Information	Name	Indication / Behaviour	Remarks
127	12	520192	Red	Application Program Checksum Error	Joystick sends / receives no CAN message and remains in this state.	CRC32 Power On Test.
127	12	520193	Red	Parameter Checksum Error	Joystick sends / receives no CAN message and remains in this state. Only Memory Access (DM14/DM15/DM16) possible.	CRC32 This error is also set until first parameter saving process. Power On Test.
127	4	2660	Amber	X Axis, Signal 1, Out of Range Low	Indication within BJM.	(4) (9)
127	3	2660	Amber	X Axis, Signal 1, Out of Range High	Indication within BJM.	(4) (9)
127	4	520660	Amber	X Axis, Signal 2, Out of Range Low	Indication within BJM.	(1) (4) (9)
127	3	520660	Amber	X Axis, Signal 2, Out of Range High	Indication within BJM.	(1) (4) (9)
127	14	2660	Amber	X Axis, Plausibility Error	Indication within BJM.	(2) (4) (9)
127	4	2661	Amber	Y Axis, Signal 1, Out of Range Low	Indication within BJM.	(5) (9)
127	3	2661	Amber	Y Axis, Signal 1, Out of Range High	Indication within BJM.	(5) (9)
127	4	520661	Amber	Y Axis, Signal 2, Out of Range Low	Indication within BJM.	(1) (5) (9)
127	3	520661	Amber	Y Axis, Signal 2, Out of Range High	Indication within BJM.	(1) (5) (9)
127	14	2661	Amber	Y Axis, Plausibility Error	Indication within BJM.	(2) (5) (9)
127	4	2662	Amber	Thumb Wheel A, Signal 1, Out of Range Low	Indication within EJM.	(6) (9)
127	3	2662	Amber	Thumb Wheel A, Signal 1, Out Of Range High	Indication within EJM.	(6) (9)
127	4	520662	Amber	Thumb Wheel A, Signal 2, Out Of Range Low	Indication within EJM.	(1) (6) (9)
127	3	520662	Amber	Thumb Wheel A, Signal 2, Out Of Range High	Indication within EJM.	(1) (6) (9)

DTC OC + SPN CM	DTC FMI (3)	DTC SPN	Lamp Information	Name	Indication / Behaviour	Remarks
127	14	2662	Amber	Thumb Wheel A, Plausibility Error	Indication within EJM.	(2) (6) (9)
127	4	2663	Amber	Thumb Wheel B, Signal 1, Out of Range Low	Indication within EJM.	(7) (9)
127	3	2663	Amber	Thumb Wheel B, Signal 1, Out Of Range High	Indication within EJM.	(7) (9)
127	4	520663	Amber	Thumb Wheel B, Signal 2, Out Of Range Low	Indication within EJM.	(1) (7) (9)
127	3	520663	Amber	Thumb Wheel B, Signal 2, Out Of Range High	Indication within EJM.	(1) (7) (9)
127	14	2663	Amber	Thumb Wheel B, Plausibility Error	Indication within EJM.	(2) (7) (9)
127	4	2664	Amber	Thumb Wheel C, Signal 1, Out of Range Low	Indication within EJM.	(8) (9)
127	3	2664	Amber	Thumb Wheel C, Signal 1, Out Of Range High	Indication within EJM.	(8) (9)
127	4	520664	Amber	Thumb Wheel C, Signal 2, Out Of Range Low	Indication within EJM.	(1) (8) (9)
127	3	520664	Amber	Thumb Wheel C, Signal 2, Out Of Range High	Indication within EJM.	(1) (8) (9)
127	14	2664	Amber	Thumb Wheel C, Plausibility Error	Indication within EJM.	(2) (8) (9)
127	4	2685	Amber	Button 1, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2685	Amber	Button 1, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2685	Amber	Button 1, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2686	Amber	Button 2, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2686	Amber	Button 2, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2686	Amber	Button 2, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2687	Amber	Button 3, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2687	Amber	Button 3, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2687	Amber	Button 3, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2688	Amber	Button 4, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2688	Amber	Button 4, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2688	Amber	Button 4, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2689	Amber	Button 5, Out of Range Low	Indication within BJM.	(10) (9)

DTC OC + SPN CM	DTC FMI (3)	DTC SPN	Lamp Information	Name	Indication / Behaviour	Remarks
127	3	2689	Amber	Button 5, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2689	Amber	Button 5, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2690	Amber	Button 6, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2690	Amber	Button 6, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2690	Amber	Button 6, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2691	Amber	Button 7, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2691	Amber	Button 7, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2691	Amber	Button 7, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2692	Amber	Button 8, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2692	Amber	Button 8, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2692	Amber	Button 8, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2693	Amber	Button 9, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2693	Amber	Button 9, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2693	Amber	Button 9, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2694	Amber	Button 10, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2694	Amber	Button 10, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2694	Amber	Button 10, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2695	Amber	Button 11, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2695	Amber	Button 11, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2695	Amber	Button 11, Stuck at Start up	Indication within BJM.	(10) (9)
127	4	2696	Amber	Button 12, Out of Range Low	Indication within BJM.	(10) (9)
127	3	2696	Amber	Button 12, Out Of Range High	Indication within BJM.	(10) (9)
127	2	2696	Amber	Button 12, Stuck at Start up	Indication within BJM.	(10) (9)

Tab. 3: Diagnostic Trouble Codes

The column “Lamp information” specifies which lamp has to be set active in the DM1 message according to the occurred error (Lamp On = 01, Lamp Off = 00, see J1939-73). Lamp flash will not be supported. Refer to chapter 8.7 for detailed information.

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 = 0mV +/- « Signal Plausibility Limit »

   Case 2: Signal (on Channel) 2 has the opposite direction of signal (on Channel) 1.
   Signal 1 + Signal 2 = 5000mV +/- « Signal Plausibility Limit »

   This « Plausibility Error » causes also an error within the corresponding signal message. Plausibility Error will be displayed in case that Signal Plausibility Limit 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
9:	Abnormal Update Rate
12:	Bad Intelligent Device Or Component
14:	Special Instruction

4. The SPN of these DTCs is depending of the BJM definition. The SPN in this error table is valid for BJM 1 **X-Axis** Position. The definition of the SPNs for BJM 2 to BJM 10 **X-Axis** position can be calculated as follows:

SPN BJM 2	=	SPN BJM 1 + 37
SPN BJM 3	=	SPN BJM 2 + 37
SPN BJM 4	=	SPN BJM 3 + **1760** (jump in SPN numbering) SPN BJM 5 = SPN BJM 4 + 37
SPN BJM 6	=	SPN BJM 5 + 37
SPN BJM 7	=	SPN BJM 6 + 37
SPN BJM 8	=	SPN BJM 7 + 37
SPN BJM 9	=	SPN BJM 8 + 37
SPN BJM 10	=	SPN BJM 9 + 37

5. The SPN of these DTCs is depending of the BJM definition. The SPN in this error table is valid for BJM 1 **Y-Axis** Position. The definition of the SPNs for BJM 2 to BJM 10 **Y-Axis** position can be calculated as follows:

SPN BJM 2	=	SPN BJM 1 + 37
SPN BJM 3	=	SPN BJM 2 + 37
SPN BJM 4	=	SPN BJM 3 + **1763** (jump in SPN numbering) SPN BJM 5 = SPN BJM 4 + 37
SPN BJM 6	=	SPN BJM 5 + 37
SPN BJM 7	=	SPN BJM 6 + 37
SPN BJM 8	=	SPN BJM 7 + 37
SPN BJM 9	=	SPN BJM 8 + 37
SPN BJM 10	=	SPN BJM 9 + 37

6. The SPN of these DTCs is depending of the EJM definition. The SPN in this error table is valid for EJM 1 **Thumb Wheel A** Position. The definition of the SPNs for EJM 2 to EJM 10 **Thumb Wheel A** position can be calculated as follows:

SPN EJM 2	=	SPN EJM 1 + 37
SPN EJM 3	=	SPN EJM 2 + 37
SPN EJM 4	=	SPN EJM 3 + **1780** (jump in SPN numbering) SPN EJM 5 = SPN EJM 4 + 37
SPN EJM 6	=	SPN EJM 5 + 37
SPN EJM 7	=	SPN EJM 6 + 37
SPN EJM 8	=	SPN EJM 7 + 37
SPN EJM 9	=	SPN EJM 8 + 37
SPN EJM 10	=	SPN EJM 9 + 37

7. The SPN of these DTCs is depending of the EJM definition. The SPN in this error table is valid for EJM 1 **Thumb Wheel B** Position. The definition of the SPNs for EJM 2 to EJM 10 **Thumb Wheel B** position can be calculated as follows:

SPN EJM 2	=	SPN EJM 1 + 37
SPN EJM 3	=	SPN EJM 2 + 37
SPN EJM 4	=	SPN EJM 3 + **1783** (jump in SPN numbering) SPN EJM 5 = SPN EJM 4 + 37
SPN EJM 6	=	SPN EJM 5 + 37
SPN EJM 7	=	SPN EJM 6 + 37
SPN EJM 8	=	SPN EJM 7 + 37
SPN EJM 9	=	SPN EJM 8 + 37
SPN EJM 10	=	SPN EJM 9 + 37

8. The SPN of these DTCs is depending of the EJM definition. The SPN in this error table is valid for EJM 1 **Thumb Wheel C** Position. The definition of the SPNs for EJM 2 to EJM 10 **Thumb Wheel C** position can be calculated as follows:

SPN EJM 2	=	SPN EJM 1 + 37
SPN EJM 3	=	SPN EJM 2 + 37
SPN EJM 4	=	SPN EJM 3 + **1786** (jump in SPN numbering) SPN EJM 5 = SPN EJM 4 + 37
SPN EJM 6	=	SPN EJM 5 + 37
SPN EJM 7	=	SPN EJM 6 + 37
SPN EJM 8	=	SPN EJM 7 + 37
SPN EJM 9	=	SPN EJM 8 + 37
SPN EJM 10	=	SPN EJM 9 + 37

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

10. The SPN of these DTCs is depending of the BJM definition. The SPN in this error table is valid for BJM 1 **Grip Button 1-12** Position. The definition of the SPNs for BJM 2 to BJM 10 **Grip Button 1- 12** position can be calculated as follows:

SPN BJM 2	=	SPN BJM 1 + 37
SPN BJM 3	=	SPN BJM 2 + 37
SPN BJM 4	=	SPN BJM 3 + **see Table** SPN Error Code Grip Buttons 1-12 Difference BJM4 to BJM 3 [9] (jump in SPN numbering) SPN BJM 5 = SPN BJM 4 + 37
SPN BJM 6	=	SPN BJM 5 + 37
SPN BJM 7	=	SPN BJM 6 + 37
SPN BJM 8	=	SPN BJM 7 + 37
SPN BJM 9	=	SPN BJM 8 + 37
SPN BJM 10	=	SPN BJM 9 + 37

Button	**SPN BJM 4 = SPN BJM 3 +**
Grip Button 1, 5 and 9	1745
Grip Button 2, 6 and 10	1743
Grip Button 3, 7 and 11	1741
Grip Button 4, 8 and 12	1739

Tab. 4: SPN Error Code Grip Buttons 1-12 Difference BJM4 to BJM 3

7 CAN Communication

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

8 Joystick Messages

8.1 Basic Joystick Message 1-10 (BJM1-BJM10)

The Basic Joystick Message (BJM) is 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	Remarks
Transmission Rate	100ms (default)	PARA
Data Length	8	
Extended Data Page	0	
Data Page	0	
Default Priority	3 (default)	PARA
Parameter Group Number (PGN)	Refer to table PGN	
Parameters	Refer to table parameters	

Tab. 5: **Basic Joystick Message (BJM) Definition**

The PGN (Parameter Group Number) for the Basic Joystick Message (BJM) can be configured by parameter (PARA). The following table describes the PGN (Parameter Group Number) for the Basic Joystick Message (BJM):

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: **Joystick PGN definition for BJM**

The following table shows the Basic Joystick Message (BJM) parameters:

Parameter Position		Length	Description
Byte 1	Bit 8...7	2 Bit	X-Axis Position (Bit 2...1)
	Bit 6...5	2 Bit	X-Axis Right Position Status
	Bit 4...3	2 Bit	X-Axis Left Position Status
	Bit 2...1	2 Bit	X-Axis Neutral Position Status
Byte 2	Bit 8...1	8 Bit	X-Axis Position (Bit 10...3)
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)
Byte 5	Bit 8...7	2 Bit	X-Axis Detent Position Status
	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
	Bit 6...5	2 Bit	Grip Button 2 Status
	Bit 4...3	2 Bit	Grip Button 3 Status
	Bit 2...1	2 Bit	Grip Button 4 Status
Byte 7	Bit 8...7	2 Bit	Grip Button 5 Status
	Bit 6...5	2 Bit	Grip Button 6 Status
	Bit 4...3	2 Bit	Grip Button 7 Status
	Bit 2...1	2 Bit	Grip Button 8 Status

Parameter Position		Length	Description
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 CAN-Module is normally mounted on the X-axis. The Y-axis is only used when the joystick has a second axis. It is allowed to have the axis assignment changed (e.g. for some customer reason). It is also possible that only one axis is configured. In case of a not used axis, the value 1023 (0x3FF) is sent.

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. Not used buttons are configured with value 0.

X/Y-Axis Status has two bits for representation:

00	Not In Position
01	In Position
10	Error Indicator
11	Not Available (NA)

Each Button has two bits for representation:

00	Button Not Pressed
01	Button Pressed
10	Error Indicator
11	Not Available (NA)

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

8.2 Extended Joystick Message 1-10 (EJM1-EJM10)

The Extended Joystick Message (EJM) is used to transfer the information about the measured status of up to 3 thumb wheels of the joystick grip. This message will not be sent in case that all three thumb wheels are not used (marked with configuration parameters).

The Basic Joystick Message (BJM) is 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	Remarks
Transmission Rate	100ms (default)	PARA
Data Length	8	
Extended Data Page	0	
Data Page	0	
Default Priority	3 (default)	PARA
Parameter Group Number (PGN)	Refer to table PGN	
Parameters	Refer to table parameters	

Tab. 8: **Basic Joystick Message (BJM) Definition**

The PGN (Parameter Group Number) for the Extended Joystick Message (EJM) can be configured by parameter (PARA). The following table describes the PGN (Parameter Group Number) for the Extended Joystick Message (EJM):

Joystick No.	Extended Joystick Message	PGN
1	EJM1	0xFDD7
2	EJM2	0xFDD9
3	EJM3	0xFDDB
4	EJM4	0xFD2F
5	EJM5	0xFD2D
6	EJM6	0xFD2B
7	EJM7	0xFD29
8	EJM8	0xFD27
9	EJM9	0xFD25
10	EJM10	0xFD23

Tab. 9: Joystick PGN definition for EJM

The following table shows the Extended Joystick Message (EJM) parameters:

Parameter Position		Length	Description
Byte 1	Bit 8…7	2 Bit	Thumb Wheel A Position (Bit 2...1)
	Bit 6…5	2 Bit	Thumb Wheel A Top / Right Position Status
	Bit 4…3	2 Bit	Thumb Wheel A Down / Left Position Status
	Bit 1…2	2 Bit	Thumb Wheel A Neutral Position Status
Byte 2	Bit 1…8	8 Bit	Thumb Wheel A Position (Bit 10...3)
Byte 3	Bit 8…7	2 Bit	Thumb Wheel B Position (Bit 2...1)
	Bit 6…5	2 Bit	Thumb Wheel B Top / Right Position Status
	Bit 4…3	2 Bit	Thumb Wheel B Down / Left Position Status
	Bit 1…2	2 Bit	Thumb Wheel B Neutral Position Status
Byte 4	Bit 1…8	8 Bit	Thumb Wheel B Position (Bit 10...3)
Byte 5	Bit 8…7	2 Bit	Thumb Wheel C Position (Bit 2...1)
	Bit 6…5	2 Bit	Thumb Wheel C Top / Right Position Status
	Bit 4…3	2 Bit	Thumb Wheel C Down / Left Position Statu
	Bit 1…2	2 Bit	Thumb Wheel C Neutral Position Status
Byte 6	Bit 1…8	8 Bit	Thumb Wheel C Position (Bit 10...3)
Byte 7	Bit 8…7	2 Bit	Thumb Wheel A Detent Position Status
	Bit 6…5	2 Bit	Thumb Wheel B Detent Position Status
	Bit 4…3	2 Bit	Thumb Wheel C Detent Position Status
	Bit 1…2	2 Bit	not used (NA)
Byte 8	Bit 1…8	8 Bit	not used (NA)

Tab. 10: Basic Joystick Message (BJM) parameters

A/B/C-Thumb Wheel Position is analogue signal which is proportional to the thumb wheel 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.

The thumb wheel can be mounted in horizontal or vertical orientation. The position status is dependent on the orientation. If the orientation is vertical, the position status are “Top” and “Down”, if the orientation is horizontal, the position status are “Right” and “Left”.

For the not used thumb wheel the value 1023 (0x3FF) is sent.

A/B/C-Thumb Wheel Status has two bits for representation:

00	Not In Position
01	In Position
10	Error Indicator
11	Not Available (NA)

8.3 Joystick Lamp Command Message (JLCM)

The Joystick Lamp Command Message (JLCM) is used to control the joystick button and thumb wheel LEDs. Which LED is controlled by which lamp is defined in the datasheet of the Joystick.

The JLCM has to be sent cyclic.

	Definition	Remarks
Transmission Rate	Min. 4500ms Max. 100ms	Timeout after approximately 5000ms. Max. Update rate limited to limit Bus load.
Data Length	8	
Extended Data Page	0	
Data Page	0	
Default Priority	3	
Parameter Group Number (PGN)	0x9900	
PDU Format	0x99	
PDU Specific	DA	DA: Destination Address
Parameters	Refer to table parameters.	

Tab. 11: Joystick Lamp Command Message (JLCM) definition

The following table shows the Extended Joystick Message (JLCM) parameters:

Parameter Position		Length	Description
Byte 1	Bit 8...7	2 Bit	Lamp 4 Command
	Bit 6...5	2 Bit	Lamp 3 Command
	Bit 4...3	2 Bit	Lamp 2 Command
	Bit 2...1	2 Bit	Lamp 1 Command
Byte 2	Bit 8...7	2 Bit	Lamp 8 Command
	Bit 6...5	2 Bit	Lamp 7 Command
	Bit 4...3	2 Bit	Lamp 6 Command
	Bit 2...1	2 Bit	Lamp 5 Command
Byte 3	Bit 8...7	2 Bit	not used (NA)
	Bit 6...5	2 Bit	not used (NA)
	Bit 4...3	2 Bit	Lamp 10 Command
	Bit 2...1	2 Bit	Lamp 9 Command
Byte 4	Bit 8...7	2 Bit	not used (NA)
	Bit 6...5	2 Bit	not used (NA)
	Bit 4...3	2 Bit	not used (NA)
	Bit 2...1	2 Bit	not used (NA)
Byte 5	Bit 8...7	2 Bit	not used (NA)
	Bit 6...5	2 Bit	not used (NA)
	Bit 4...3	2 Bit	not used (NA)
	Bit 2...1	2 Bit	not used (NA)
Byte 6	Bit 8...7	2 Bit	not used (NA)
	Bit 6...5	2 Bit	not used (NA)
	Bit 4...3	2 Bit	not used (NA)
	Bit 2...1	2 Bit	not used (NA)
Byte 7	Bit 8...7	2 Bit	not used (NA)
	Bit 6...5	2 Bit	not used (NA)
	Bit 4...3	2 Bit	not used (NA)
	Bit 2...1	2 Bit	not used (NA)
Byte 8	Bit 8...7	2 Bit	not used (NA)
	Bit 6...5	2 Bit	not used (NA)
	Bit 4...3	2 Bit	not used (NA)
	Bit 2...1	2 Bit	not used (NA)

Tab. 12: Joystick Lamp Command Message (JLCM) parameters

Each LED has two bits for representation:

00	LED off
01	LED on
10	LED blink (periodically off/on) – blinking frequency is set to 1Hz
11	Not Available (NA) or not installed or no change on previously LED function

8.4 Request (RQST)

This message type can be used to request Parameter Group Number (PGN) information globally (source address 255) or from specific destination. That means the Destination Address (DA) can be globally or specific.

General rules of operation for determining whether to send a Parameter Group Number (PGN) to a global or specific destination:

- If the Request 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 Request 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 Requests occur no more than 2 or 3 times per second.

	Definition	Remarks
Transmission Rate	Per user requirement.	
Data Length	3	
Extended Data Page	0	
Data Page	0	
Default Priority	6	
Parameter Group Number (PGN)	0xEA00	
PDU Format	0xEA	
PDU Specific	DA	DA: Destination Address
Parameters	Refer to table parameters.	

Tab. 13: Request (RQST) definition

Parameter Position		Length	Description
Byte 3...1	Bit 24...1	3 Bytes	Parameter Group Number (PGN) being requested. See table PGN field definition.

Tab. 14: Request (RQST) parameters

The following table shows the field definition and the byte order of the Parameter Group Number (PGN) in the data field of the Request message.

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

Tab. 15: PGN field definition and byte order

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

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

Tab. 16: Supported PGNs

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

Posistion	Data Ex-ample	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. 17: NACK example

8.5 Software Identification (SOFT)

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

	Definition	Remarks
Transmission Rate	On request.	
Data Length	Variable	
Extended Data Page	0	
Data Page	0	
Default Priority	6	
Parameter Group Number (PGN)	0xFEDA	

Tab. 18: Software Identification (SOFT) definition

Parameter Position		Length	Description
Byte 1	Bit 8...1	8 Bits	Number of Software Identification Fields (0x02)
Byte 2	Bit 8...1	8 Bits	SW Version Major
Byte 3	Bit 8...1	8 Bits	SW Version Minor
Byte 4	Bit 8...1	8 Bits	'*'
Byte 5	Bit 8...1	8 Bits	HW Version
Byte 6	Bit 8...1	8 Bits	'*'
Byte 7	Bit 8...1	8 Bits	FBL Version Major. In case of no FBL (0x00)
Byte 8	Bit 8...1	8 Bits	FBL Version Minor. In case of no FBL (0x00)

Tab. 19: Software Identification (SOFT) parameters

8.6 Address Claiming (AC)

The Address Claiming (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 Request (RQST) message.

The Address Claiming (AC) message contains the 64 bit J1939 Name Field. For more details about the address claiming process refer to SAE J1939-81.

	Definition	Remarks
Transmission Rate	As required.	
Data Length	8	
Extended Data Page	0	
Data Page	0	
Default Priority	6	
Parameter Group Number (PGN)	0xEE00	
PDU format	0xEE	
PDU specific	0xFF	Global address
Parameters	Refer to table parameters.	

Tab. 20: Address Claiming (AC) definition

Parameter Position		Length	Description
Byte 1	Bit 8...1	8 Bits	Name - Identity Number LSB
Byte 2	Bit 8...1	8 Bits	Name - Identity Number Second Byte
Byte 3	Bit 8...6	3 Bits	Name - Manufacturer Code LSB
	Bit 5...1	5 Bits	Name - Identity Number MSB
Byte 4	Bit 8...1	8 Bits	Name - Manufacturer Code MSB
Byte 5	Bit 8...8	5 Bits	Name - Function Instance
	Bit 3...1	3 Bits	Name - ECU Instance
Byte 6	Bit 8...1	8 Bits	Name - Function
Byte 7	Bit 8...2	7 Bits	Name - Vehicle System
	Bit 1	1 Bit	Name - Reserved
Byte 8	Bit 8	1 Bits	Name - Arbitrary Address Capable
	Bit 7...5	3 Bits	Name - Industry Group
	Bit 4...1	4 Bits	Name - Vehicle System Instance

Tab. 21: Address Claiming (AC) parameters

J1939 Joystick Name Definition:

Name	Value	Remarks
Identity Number	0	
Manufacturer Code	152 / 0x98	
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 or alternatively 2 = Agricultural and Forestry Equipment
Arbitrary Address Capable	0	

Tab. 22: J1939 Joystick Name Definition

8.7 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	Remarks
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	

	Definition	Remarks
Extended Data Page	0	
Data Page	0	
Default Priority	6	
Parameter Group Number (PGN)	0xFECA	
Parameters	Refer to table parameters.	

Tab. 23: Active Diagnostic Trouble Codes (DM1) definition

Parameter Position		Length	Description
Byte 1	Bit 8...7	2 Bits	Malfunction Indicator Lamp Status (not used: 00b)
Byte 1	Bit 6...5	2 Bits	Red Stop Lamp Status (see Table 3)
Byte 1	Bit 4...3	2 Bits	Amber Warning Lamp Status (see Table 3)
Byte 1	Bit 2...1	2 Bits	Protect Lamp Status (not used: 00b)
Byte 2	Bit 8...7	2 Bits	Flash Malfunction Indicator Lamp Status (not used: 11b)
Byte 2	Bit 6...5	2 Bits	Flash Red Stop Lamp Status (not used: 11b)
Byte 2	Bit 4...3	2 Bits	Flash Amber Warning Lamp Status (not used: 11b)
Byte 2	Bit 2...1	2 Bits	Flash Protect Lamp Status (not used: 11b)
Byte 3	Bit 8...1	8 Bits	DTC SPN (LSB - most significant at bit 8)
Byte 4	Bit 8...1	8 Bits	DTC SPN (most significant at bit 8)
Byte 5	Bit 8...6	3 Bits	DTC SPN (MSB - most significant at bit 8)
Byte 5	Bit 5...1	5 Bits	DTC FMI (most significant at bit 5)
Byte 6	Bit 8	1 Bit	DTC SPN Conversion Method (0: DTC represent as
Byte 6	Bit 7...1	7 Bits	DTC Occurrence Count (not used: 127)
Byte 7	Bit 8...1	8 Bits	Not used (0xFF)
Byte 8	Bit 8...1	8 Bits	Not used (0xFF)

Tab. 24: Active Diagnostic Trouble Codes (DM1) parameters

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

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

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

- Indicator Lamps
- Flashing Lamps
- DTC 1
- DTC 2
- DTC n

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.

8.8 Start Stop Broadcast (DM13)

This message is used to start or stop the cyclic broadcast messages of the joystick.

After power on, the joystick starts automatically (if address claiming 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	Remarks
Transmission Rate	On request.	
Data Length	8	
Extended Data Page	0	
Data Page	0	
Default Priority	6	
Parameter Group Number (PGN)	0xDF00	
PDU format	0xDF	
PDU specific	DA	DA: Destination Address
Parameters	Refer to table parameters.	

Tab. 25: DM13 definition

Parameters	Position	Length	Description
Byte 1	Bit 8...7	2 Bits	Current Data Link: 00 Stop Broadcast 01 Start Broadcast 10 Reserved 11 Don't Care / Take no action (leave as is)
Byte 1	Bit 6...5	2 Bits	J1587 – not used
Byte 1	Bit 4...3	2 Bits	J1922 – not used
Byte 1	Bit 2...1	2 Bits	J1939 Network #1, Primary vehicle network
Byte 2	Bit 8...7	2 Bits	J1939 Network #2 – not used
Byte 2	Bit 6...5	2 Bits	ISO 9141 – not used
Byte 2	Bit 4...3	2 Bits	J1850 – not used
Byte 2	Bit 2...1	2 Bits	Other, Manufacturer Specified Port – not used
Byte 3	Bit 8...7	2 Bits	J1939 Network #3 – not used
Byte 3	Bit 6...5	2 Bits	SAE Reserved
Byte 3	Bit 4...3	2 Bits	SAE Reserved
Byte 3	Bit 2...1	2 Bits	SAE Reserved

Parameters	Position	Length	Description
Byte 4	Bit 8...5	4 Bits	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 Bits	Suspend Signal
Byte 6...5	Bit 16...1	16 Bits	Suspend Duration
Byte 7	Bit 8...1	8 Bits	SAE Reserved
Byte 8	Bit 8...1	8 Bits	SAE Reserved

Tab. 26: DM13 parameters

9 Annex A: Joystick Axis Definition

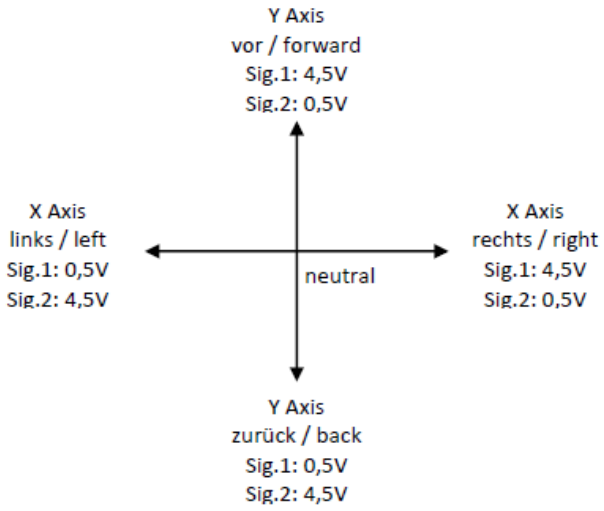

Fig. 1: Joystick Axis Definition

Notes:

- The signal voltage values are ideal values.
- Signal 2 not available in standard version. Optional possible.

10 Annex B: Thumb Wheel A/B/C Definition

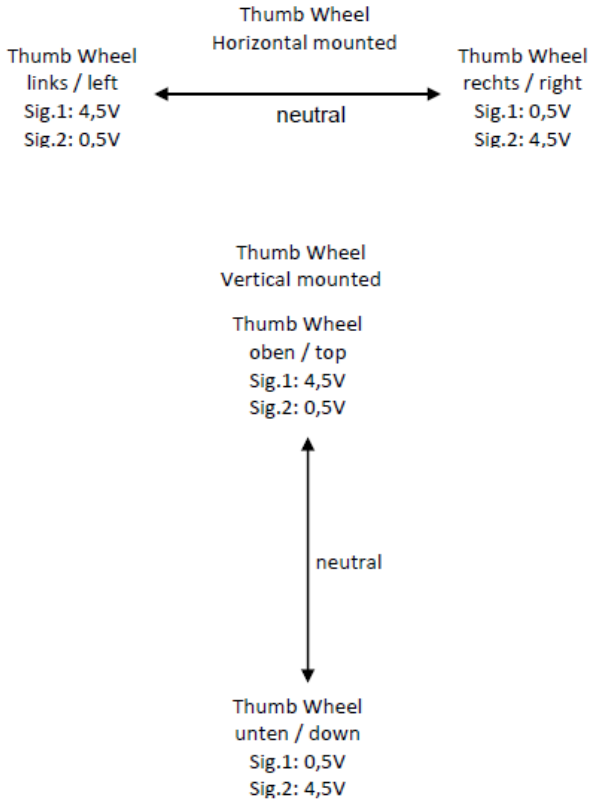

Fig. 2: Thumb Wheel A-B-C Definition

Notes:

- The signal voltage values are ideal values.
- Signal 2 not available in standard version. Optional possible.
- The direction left/right is seen from the operator side That means if the operator moves the thumb wheel from his state of view into the left side, left signal must be generated.

11 Annex C: Thumb Wheel A/B/C LED Definition

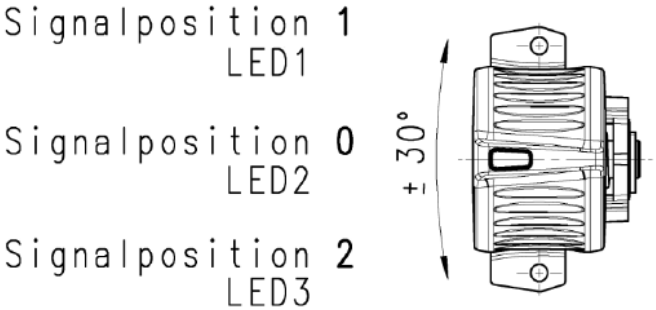

Fig. 3: Thumb Wheel A-B-C LED Definition

12 Annex D: Position, Detent and Direction Definition

This two examples show the J1939 BJM position, detent and direction definition. This examples consider no tolerances.

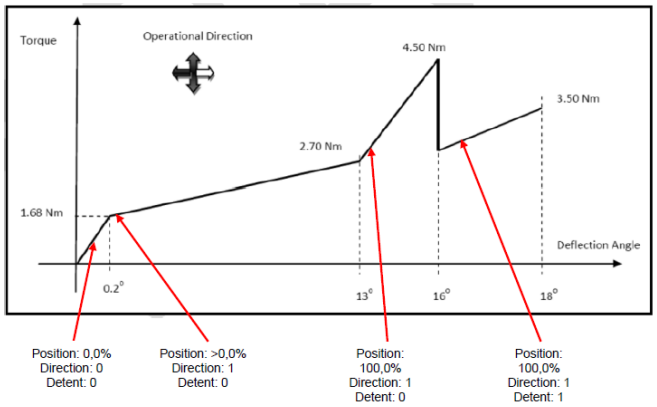

Fig. 4: Example 1 with mechanical detent

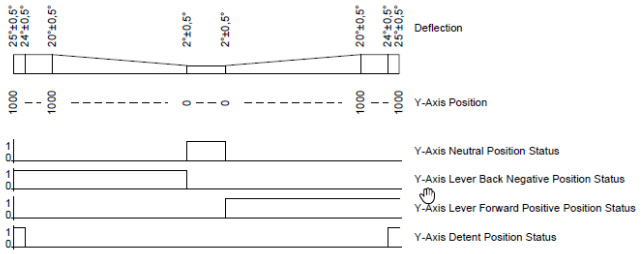

Fig. 5: Example 2 with mechanical detent

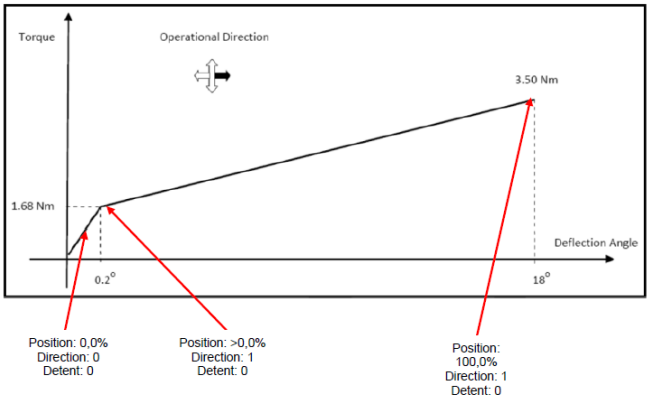

Fig. 6: Example 2 without mechanical detent