Technical Manual

Kübler

Sendix® absolut

Absolute Singleturn Encoder

Series M3658, M3678

SAE J1939

pulses for automation

Liability to modification without notice

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Document information

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1 General

SAE J1939

The **Society of Automotive Engineers** (SAE) Truck Bus Control and Communications Subcommittee has developed a family of standards concerning the design and use of devices that transmit electronic signals and control information among vehicle components. SAE 1939 is a **high-speed, CLASS C-type** communication network designed to support real-time closed loop control functions between electronic control devices that are physically distributed throughout the vehicle. It is used for off-highway machines in applications such as construction, material handling , forestry machines etc. The application focus is on the power trains and chassis of commercial vehicles. The protocol is used in heavy vehicles for on-street and off-road operations (construction machines). Related to J1939 are the ISOBUS according to ISO11783 for agricultural machines, NMEA2000 for maritime use, and the ISO 11992 truck & trailer interface. Similarly, the FMS standard is based on J1939 communication.

J1939 is structured in several parts based on a ISO Open System Interconnect (OSI) Model. The OSI Model defines a **set of Profiles** for communication, each performing different functions.

J1939 is a **multimaster** system with decentralized network management without channel-based communication. It supports up to 254 logical nodes and 30 physical ECUs per segment. The information is described as parameters (signals) and combined on 4 data pages in parameter groups (PGs). Each parameter group can be identified via a unique number, the parameter group number (PGN). Irrespective of this, each signal is assigned a unique SPN (suspect parameter number).

The majority of the communication usually occurs **cyclically** and can be received by all ECUs without explicit request of data (broadcast). In addition, the parameter groups are optimized to a length of 8 data bytes. This enables very efficient use of the CAN protocol. Particular information such as configuration data or diagnostic data can be exchanged exclusively between two ECUs (peer-to-peer). The specification of the communication, broadcast or peer-to-peer, is a property of the parameter group used. Thus, in addition to the definition of which parameters are transmitted, the transmission type also depends on the parameter group.

If larger data quantities must be transmitted, transport protocols (TPs) are used: **BAM** (Broadcast Announce Message) and **CMDT** (Connection Mode Data Transfer). With BAM TP, the transmission of the data occurs via broadcast. There is no control data flow (handshake) between the sender and receiver. With **CMDT TP**, the data is exchanged between precisely two ECUs. In case of error, the control data flow that takes place here allows a restarting of communication without a complete repetition of the data transmission. In addition, the CMDT TP allows a receive confirmation of the data by the receiver.

So that **peer-to-peer** communication is possible on a CAN network, each ECU must be assigned a **unique address** in the range from 0 to 253. To avoid the mistaken occurrence during operation of two ECUs with the same address, a clever strategy is required – the network management (NM). With J1939, the NM is organized decentrally. That is, each ECU must implement a minimum functionality of the NM. The tasks of the NM are:

- Resolution of address conflicts (minimum requirement)
- Ongoing check as to whether ECU addresses are assigned in duplicate on a network (minimum requirement)
- Change of the ECU addresses at runtime
- Unique identification of an ECU with the help of a name that is unique worldwide
- This name also serves to identify which functionality an ECU has on the network

2 The SAE J1939 set of profiles

The SAE J1939 set of profiles is based on the Controller Area Network (CAN) data link layer (ISO 11898-1) using the extended frame format (29-bit identifiers). Several documents have undergone revision after the initial publication in 1998. The specifications have been added to, parts taken off and clarified. The set of specifications, available from SAE (www.sae.org), includes:

- **J1939/11 Physical Layer (250 kbit/s, shielded twisted pair)**
- **J1939/12 Physical Layer (twisted quad of wires and active bus termination)**
- **J1939/13 Off-Board Diagnostic Connector**
- **J1939/15 Reduced Physical Layer (250 kbit/s, unshielded twisted pair)**
- **J1939/21 Data Link Layer**
- **J1939/31 Network Layer**
- **J1939/71 Vehicle Application Layer**
- **J1939/73 Application Layer Diagnostics**
- **J1939/81 Network Management**

The naming of the layers is not always compliant to the OSI reference model and to CiA's recommend terminology. The J1939/21 and J1939/31 define partly an application layer, and the J1939/71 and J193973 specify an application profile.

SAE J1939/11

This physical layer specification is based on the ISO 11898-2 standard (high-speed CAN physical layer). It defines a single, linear, shielded twisted-pair of wires running around the vehicle linking each of its ECUs together. The topology is supposed to be a linear bus running at 250 kbit/s with termination resistors to reduce reflections. A J1939 network can be made of multiple bus sections, each one linked with a bridge. The main function of the bridge is to provide electrical isolation between different segments so that electrical failure of one system will not cause such failure to an adjacent system. For example, the failure of the CAN/J1939 system on the trailer should not cause the failure of the truck's tractor main CAN/J1939 control system. The maximum number of ECUs is 30, and the maximum bus length is 40m.

SAE J1939/21

The SAE J1939/21 is the heart of the J1939 set of specifications. It describes commonly used messages such as Request, Acknowledgement, and Transport Protocol messages. The Transport Protocol specifies the breaking up of large amounts of data into multiple CAN-sized frames, along with adequate communication and timing to support effective frame transmission between nodes. Slight modifications have added flexibility to the Transport Protocol, allowing the sender (server) of data to specify the number of CAN frames to be sent at any one time. Previously, this number was greatly determined by the receiver's (client's) limitations in the number of frames it could receive. The 29-bit identifier comprises the following sub-fields: priority, reserve, data page, PDU format, PDU specific, and source address. The source address field ensures unique CAN identifiers, so no two nodes can ever transmit the very same CAN identifier. In the beginning, J1939 grouped several parameters (signals) together into a Parameter Group (PG). Each PG was then assigned a number: its PGN (Parameter Group Number). The PGN identifier contained a reserve bit, a data page bit, a PDU format field, and a PDU-specific field. This structure has since caused some confusion with regard to PDU1-type (destination-specific) messages. Since the PDU-specific (group extension) field becomes the Destination Address in a PDU1 message, the question arose if the PGN changes, which is does not. The PGN is a static number referring to the data being transmitted and should be considered independently of the CAN identifier.

SAE J1939/31

This specification describes bridge functionality, how CAN messages from one network to an another are transferred. The message filter function in the bridge reduces the transmission of CAN messages in the individual network segments.

SAE J1939/71

The so-called application layer (in CiA terms it is an application profile), all parameters as well as assembled messages called parameter groups are specified. Each CAN message is referenced by a unique number, the PGN (parameter group number). The latest release of the J1939/71 document incorporates several approved additions, and brings the total number of defined messages up to almost 150. New message additions support anti-theft, fuel-specific, turbocharger, ignition, and tire pressure functions, among others. These additions and enhancements include the addition of the "source address of controlling device" parameter to several engine, transmission and brake controller messages. Inclusion of this parameter in a message will allow the receiving device to identify the original source of the message (e.g., a particular device from a bridged network).

SAE J1939/73

Additions to the diagnostics document (J1939/73) involve memory access, start/stop functions, binary data transfer, security, and calibration information. Memory access is provided with security levels. The start/stop message is used during diagnostics performance, to quieten other devices (including nodes providing bridges to other networks). Revisions of the J1939/73 document also provide clarification regarding DTC (diagnostic trouble code) encoding in the data field. This encoding, previously interpreted differently by various manufacturers, was standardized, utilizing the reserved bit as the Conversion Method (CM) bit.

SAE J1939/81

The J1939/81 Draft includes state diagrams for initialization and more clearly defines constraints on the use of addresses. The J1939/82 Draft specifies the proper procedure for self-compliance and presents a scripting language that tightly defines compliance processes, and the J1939/83 Tutorial Draft provides an explanation of J1939.
For more detailed information please visit www.sae.org

3 Parameter groups (PG)

Parameter groups combine similar or associated signals. In the specification **SAE J1939-71** the parameter groups are defined with the signals they contain. In addition, some manufacturer-specific parameter groups can be used. Parameter groups with up to 8 data bytes are transmitted in a **CAN message**. With more than 8 bytes, a transport protocol is used. Each parameter group is addressed uniquely via a number (**Parameter Group Number PGN).** For this number, a 16-bit value is used that is composed of the PDU format and PDU specific. There are two types of parameter group numbers (PGNs):

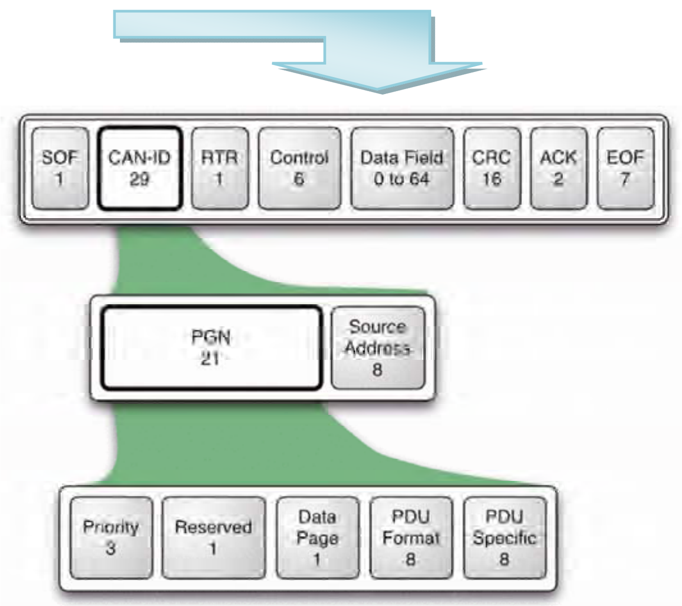
• **Global PGNs** for parameter groups that are sent to all (broadcast). Here all 16 bits of the PGN are used; the value of the upper 8 bits (PDU format) **must be greater than 239 ($F0_{16}$)**

• **Specific PGNs** for parameter groups that are sent to particular devices (peer-to-peer). With these PGNs, only the higher-value 8 bits (PDU format) are valid and the value must be smaller than 240. The lower-value byte (PDU specific) is always 0.

With this breakdown of the PGN, 240 + (16 * 256) = 8672 different parameter groups are possible. With the transmission of a parameter group, the PGN is coded in the CAN identifier.

Sample of a Parameter Group definition:

Name: Engine temperature
Transmission rate: 1s
Data length: 8 bytes
Data page: 0
PDU format: 254
PDU specific: 238
Default priority: 6
PG Number: 65,262 ($FEEE_{16}$)



Description of **Data Field** :
(Byte Nr.)

1	Engine coolant temperature
2	Fuel temperature
3,4	Engine oil temperature
5,6	Turbo oil temperature
7	Engine intercooler temperature
8	Not defined

4 Network Management

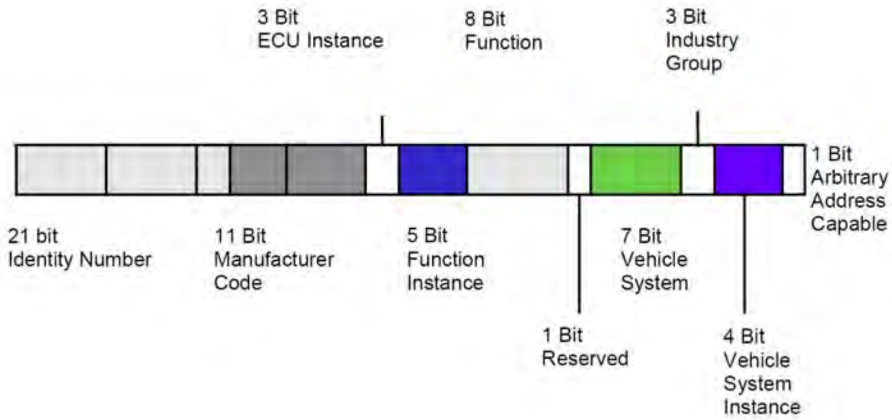
On a J1939 network, each device has a **unique** address. Each message that is sent by a device contains this source address.
There are 255 possible addresses:

0..253 – Valid addresses of an ECU
254 – Zero
255 – Global

Each device type has a preferred address (see [1]). Before a device may use an address, it must register itself on the bus. This procedure is called "**address claiming"(ACL)** .

Thereby the device sends an "**AddressClaim**" parameter group with the desired source address. This PG contains a **64-bit device** name. If an address is already used by another device, then the device whose device name has the higher priority has received the address. The device name contains some information about the device and describes its function.

64 BIT Device Name



Since the function of a device is contained in the name, the address can be changed at will and the correct device is always addressed that provides the required functionality.

Interpretation of the CAN Identifier

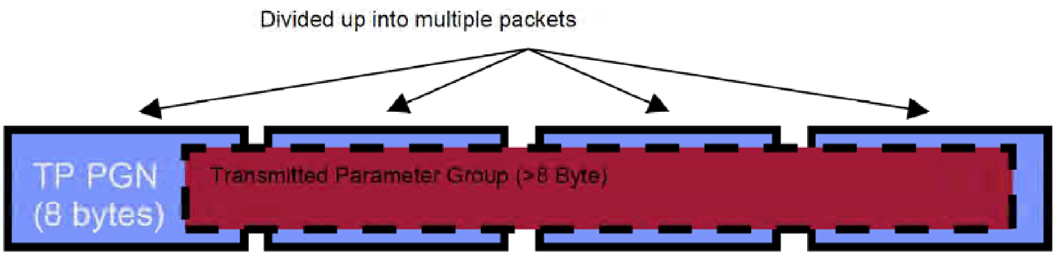
The CAN identifier of a J1939 message contains PGN, source address, priority, data page bit, and a target address (only for a peer-to-peer PG). The identifier is composed as follows:

Priority 3 Bit	Reserved 1 Bit	Data page 1 Bit	PDU format 8 Bit	PDU specific 8 Bit	Source address 8 Bit

With PDU format < 240 (peer-to-peer), PDU specific contains the target address. Global (255) can also be used as target address. Then the parameter group is aimed at all devices. In this case, the PGN is formed only from PDU format. With PDU format >= 240 (broadcast), PDU format together with PDU specific forms the PGN of the transmitted parameter group.

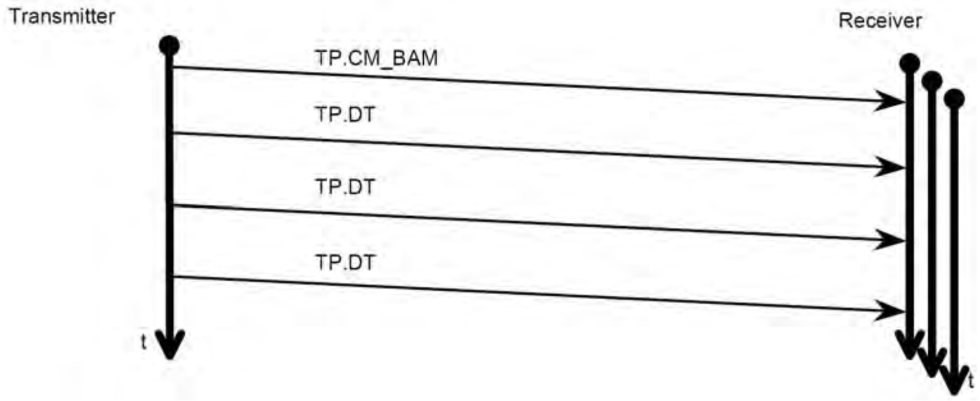
5 Transport Protocols

Parameter groups that contain **more than 8 data bytes** are transmitted with a transport protocol.

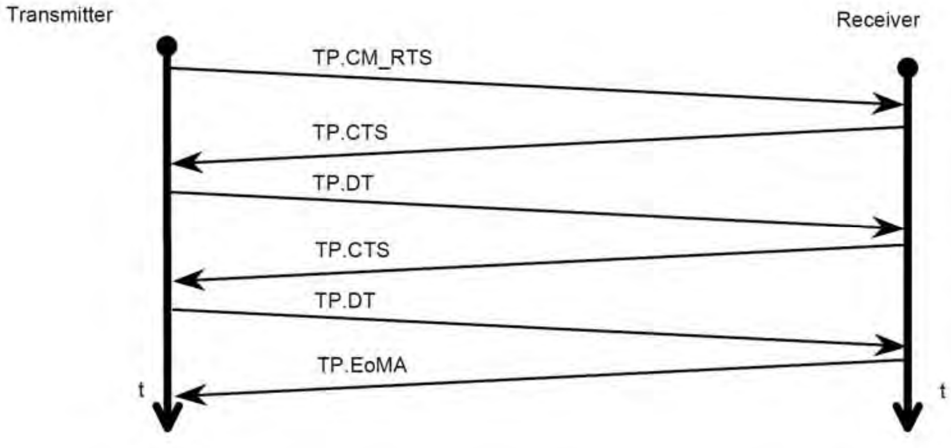


For peer-to-peer and broadcast transmission, there are two different protocols. For the transport protocols, there are two special parameter groups available, which are used for the connection management (TP.CM) and the transmission of the data (TP.DT). For broadcast transmission, the BAM protocol is used.

Here, after a **BAM-PG** (Broadcast Announce Message), the transmitter sends all data PGs at a minimum interval of **50ms**.



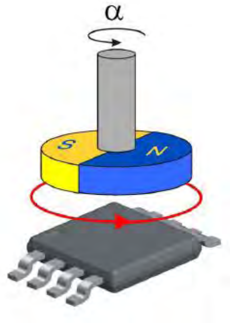
With the peer-to-peer transmission, the transmitter initiates the connection with a "request to send" message. The receiver then controls the transport protocol with "clear to send" and "end of message acknowledge."



6 Power Supply and CAN-bus connection

Power supply

Sensor:	**Magnetic Hall -Sensor**
	14 Bit Resolution / 9 Bit Accuracy
Power supply:	**8 ... 30 VDC**
Current consumption:	typ. **22mA** at 24 VDC
	max. 49 mA at 10 VDC
Reverse polarity protection:	yes
CAN Transceiver:	82C251 / short cuircuit tested
Galvanic Isolation:	no
J1939 Interface	**adapted**



Short name	Description	Cable color
CG	**CAN Ground**	**gray**
CL	**CAN_Low (-)**	**yellow**
CH	**CAN_High (+)**	**green**
0V	**0Volt power**	**white**
+V	**+UB power**	**brown**

CAN - M12 Connector

Short name	Description	PIN Nr.	Color
CG	**CAN Ground**	**1**	**GY**
CL	**CAN_Low (-)**	**5**	**YE**
CH	**CAN_High (+)**	**4**	**GN**
0V	**0 Volt power**	**3**	**WH**
+V	**+UB power**	**2**	**BN**

T

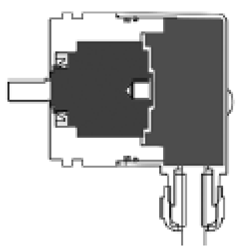
Terminal M12-Connector

Mechanical characteristics:

Max. speed:	6000 min^{-1}
Starting torque	< 0,06 Nm
Weight:	approx. 0,2 kg
Protection acc. to EN 60 529:	IP 67 (IP 69k on request)
Working temperature:	–40 °C ... +85 °C
Materials:	Shaft: stainless steel, Flange: aluminium, Housing: die cast zinc, Cable: PUR
Shock resistance acc. to DIN-IEC 68-2-27:	5000 m/s^2, 6 ms
Vibration resistance acc. to DIN-IEC 68-2-6:	300 m/s^2, 10 ... 2000 Hz
Permanent shock resistance acc. to DIN-IEC 68-2-29	1000 m/s^2, 2 ms
Vibration (broad-band random) to DIN-IEC 68-2-64	5 ... 2500 Hz, 100 m/s^2 - rms

All-round protection thanks to Safety-Lock*plus*™ and Sensor-Protect™ technology

Safety-Lock*plus*™:
IP69k protection on the flange side, robust bearing assemblies with interlocking bearings, mechanically protected shaft seal



Sensor-Protect™:
Fully encapsulated electronics, separate mechanical bearing assembly

7 Default settings on delivery

On delivery the following software parameters have been factory set.

Process data	Protocol	Message	PGN	Default
Baudrate	J1939			250 kBit/s
Termination				On
Address claiming				On
	DefaultAddress	**ECU**		**0x14 (20dez)**
	Arbitrary Address Capable			**1**
	Industry Group			**0x5 (Process Controller)**
	System			**0x0 (Non specific)**
	System Instance			**0x0 (Non specific)**
	EC Instance			**0x0 (Non specific)**
	Function			**0x8E (142_{10})**
	Function Instance			**0x0 (Non specific)**
	Manufacturer			**0x122 (290_{10})**
	Identity Number			**0x123456**
Position	**Cyclic, acyclic**	**BAM**	**$FF30_{16}$**	
			Bit 0...31	Position value
			Bit 32..63	Speed signed value
			Bit 64...71	Working Area state (*optional)
			Bit 72..104	Offset value
Position	**Cyclic, acyclic**	**P-to-p**	**$CBF4_{16}$**	
			Bit 0...31	Position value
			Bit 32..63	Speed signed value
SetupPGN	**Data**	**TP.CM**	**$EC00_{16}$**	**$EF14_{16}$**
Bit 0...15	Operating Parameter			0 = Scaling off
Bit 16..47	Sensor MUR			16384 (14 Bit resolution)
Bit 48..79	SensorTMR			16384
Bit 80..111	SensorCycleTime			50 ms
Bit 112..119	SensorCANBusTermination			1 = on
Bit 120..151	SensorCycleTimeBAM			**0 ms**
Bit 151..184	SensorPresetValue			0
Bit 184	SensorPresetEnable			0 = off

Once the CAN bus has been looped through, it must be terminated between CAN+ and CAN- at both ends using 120 ohm bus termination resistors.

8 Special PGN Assignments

PGN $CBF4_{16}$ **Encoder Position value with speed**

Within the J1939 encoder **two services (BAM, peer-to-peer)** are available.

- **Cyclic** as a response to an internal timer cycle (presetable wit SetupPGN)

The encoder transmits the current position and speed value (adjusted possibly by the scaling factor)

Data content:

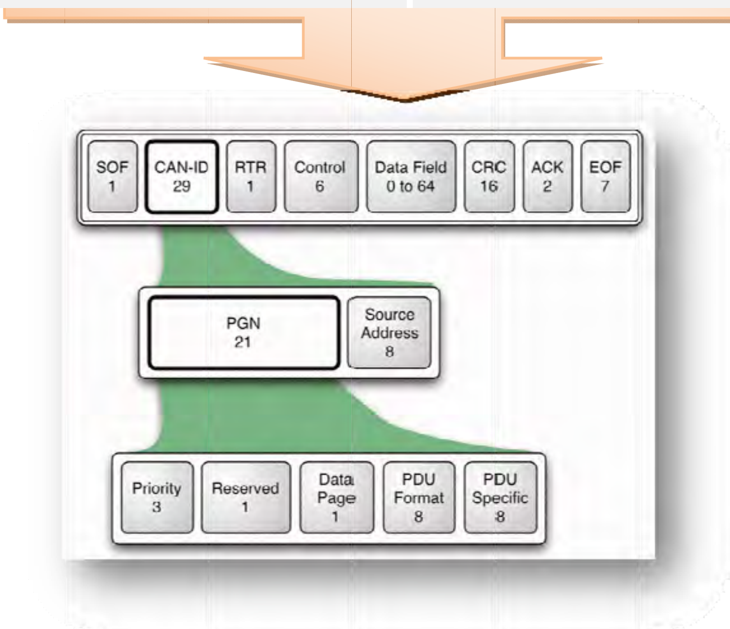
Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \dots 2^0$	$2^{15} \dots 2^8$	$2^{23} \dots 2^{16}$	$2^{31} \dots 2^{24}$

Position range of values: **0.... maximum physical resolution (16384) 14-bit**
Speed range values: **-6000 … +6000 in rpm**

Position	**Cyclic, acyclic**	**P-to-p**	**$^*CBF4_{16}$**	
			Bit 0…31	Position value
			Bit 32..63	Speed signed value in rpm

***Predefined PGN**

Data Field Bit 0… Bit 31	**Bit 32…63**
Position Value (unsigned)	Speed Value (signed) rpm
LSB …. MSB	LSB….MSB
0… 16383	-6000 …. +6000



Predefined cycle time of 50 ms.

PGN $FF30_{16}$ Encoder Position value (BAM-Message with TP.CM)

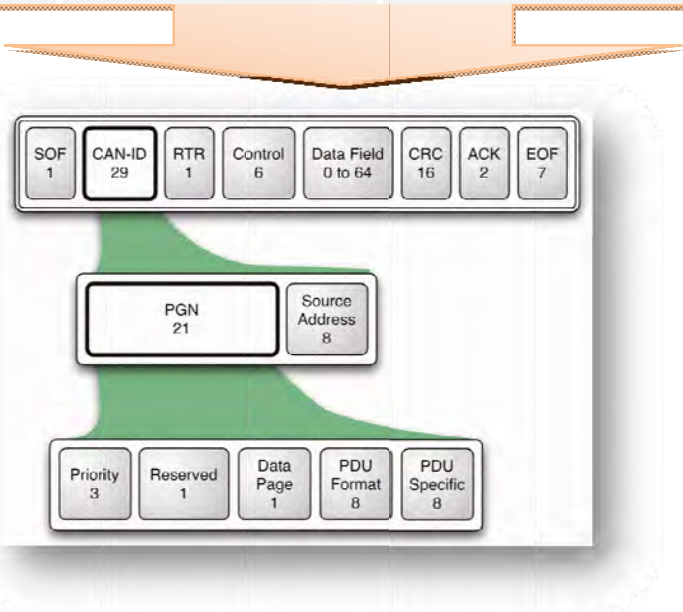
If larger data quantities must be transmitted, transport protocols (TPs) are used: **BAM** (Broadcast Announce Message) and **CMDT** (Connection Mode Data Transfer). With BAM TP, the transmission of the data occurs via broadcast. There is no control data flow (handshake) between the sender and receiver. With CMDT TP, the data is exchanged between precisely two ECUs

BAM-PG (Broadcast Announce Message) - the transmitter sends all data PGs at a predefined interval .

Position	**Cyclic, acyclic**	**BAM**	***$FF30_{16}$**	
			Bit 0…31	Position value
			Bit 32..63	Speed signed value
			Bit 64…71	Working Area state (²optional)
			Bit 72..104	Offset value

*Predefined PGN ²optional implementation necessary

Data Field Bit 0… Bit 31	**Bit 32…63**	**Bit 64…71**	**Bit 72..104**
Position Value (unsigned)	Speed Value (signed)	Working Area State	Offset Value
LSB …. MSB (32 Bit)	LSB….MSB ((32 Bit)	1 Byte	32 Bit
0… 16383	-6000 …. +6000	00…FF16	0….16383



9 Setup PGN

PGN $EF14_{16}$ Setup parameter for Encoder settings

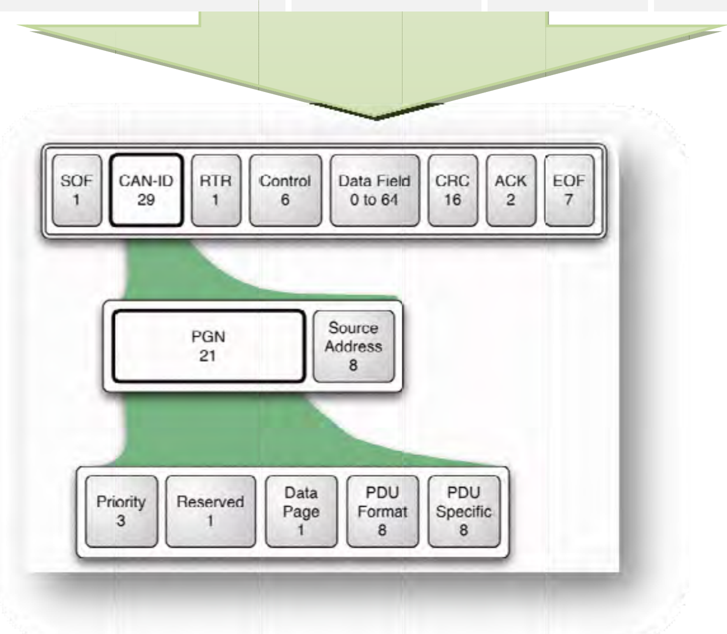
For these special transport protocols, there is a special parameter group available, which are used for the connection management (TP.CM) and the transmission of the data (TP.DT) -> **$EC00_{16}$**

Sample transmission

Exported events:

Time	Chn	Dir	ID	PGN	Name	Send node	Src	Dest	Prio	DLC	Data	Attr
425.433090	1	Tx	18EC14F4x	EC00p	TPCM		F4	14	6	8	10 18 00 04 FF 00 EF 00	
0.000940	1	Rx	1CECF414x	EC00p	TPCM	SuspensionSteerAxle	14	F4	7	8	11 04 01 FF FF 00 EF 00	
0.000900	1	Tx	18EB14F4x	EB00p	TPDT		F4	14	6	8	01 00 00 00 04 00 00 00	
0.000610	1	Tx	18EB14F4x	EB00p	TPDT		F4	14	6	8	02 20 00 00 00 00 00 00	
0.000600	1	Tx	18EB14F4x	EB00p	TPDT		F4	14	6	8	03 01 00 00 00 00 88 13	
0.000610	1	Tx	18EB14F4x	EB00p	TPDT		F4	14	6	8	04 00 00 FF FF FF FF FF	
0.001030	1	Rx	1CECF414x	EC00p	TPCM	SuspensionSteerAxle	14	F4	7	8	13 18 00 04 FF 00 EF 00	
0.165790	1	Rx	1CECFF14x	EC00p	TPCM	SuspensionSteerAxle	14	FF	7	8	20 18 00 04 FF 00 EF 00	
0.050280	1	Rx	1CEBFF14x	EB00p	TPDT	SuspensionSteerAxle	14	FF	7	8	01 00 00 00 04 00 00 00	
0.050020	1	Rx	1CEBFF14x	EB00p	TPDT	SuspensionSteerAxle	14	FF	7	8	02 20 00 00 00 00 00 00	
0.050090	1	Rx	1CEBFF14x	EB00p	TPDT	SuspensionSteerAxle	14	FF	7	8	03 01 00 00 00 00 88 13	
0.050020	1	Rx	1CEBFF14x	EB00p	TPDT	SuspensionSteerAxle	14	FF	7	8	04 00 00 FF FF FF FF FF	

SetupPGN		TP.CM	$EF14_{16}$	Defaults
Bit 0…15	Sensor Operating Parameter			0 = Scaling off CW
Bit 16..47	Sensor MUR			16384 (14 Bit resolution)
Bit 48..79	SensorTMR			16384
Bit 80..111	SensorCycleTime		$CB14_{16}$	50 ms
Bit 112..119	SensorCANBusTermination			1 = on
Bit 120..151	SensorCycleTimeBAM		$FF30_{16}$	0 ms
Bit 151..184	SensorPresetValue			0
Bit 184	SensorPresetEnable			0 = off



10 Parameter in Detail

Operating Parameters

Bit 0: Code sequence: 0 = increasing when turning clockwise (cw)
1 = increasing when turning counter-clockwise (ccw)
Default: Bit = 0

Bit 2: Scaling Function: 0 = disable, 1 = enable
Default: Bit = 0

Bit	Function	Bit = 0	Bit =1
0	Code sequence	CW	CCW
1	Not used	Disabled	
2	Enable scaling	**Disabled**	Enabled

Blue = defaults

Measuring Units per Revolution (MUR)

This parameter configures the desired resolution per revolution. The encoder itself then internally calculates the appropriate scale factor. The calculated scaling factor MUR (by which the physical position value will be multiplied) is worked out according to the following formula:

MUR = Measuring units per revolution / phys. resolution Singleturn

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \dots 2^0$	$2^{15} \dots 2^8$	$2^{23} \dots 2^{16}$	$2^{31} \dots 2^{24}$

Range of values: 0....maximum physical resolution (16383) 14-bit
Default setting: **16384 (14-bit)**

After changing the measuring step it is necessary to set the preset value also to zero /or a value.

Total Measuring Range (TMR)

This parameters configures the total number Singleturn measuring steps. A factor will be applied to the maximum physical resolution. The factor is always < 1 .
After the stated number of measuring steps, the encoder will reset itself to zero.

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \dots 2^0$	$2^{15} \dots 2^8$	$2^{23} \dots 2^{16}$	$2^{31} \dots 2^{24}$

Range of values: 0....maximum physical resolution (16383) 14-bit
Default setting: 16384 (14-bit)

After changing the measuring step it is necessary to set the preset value also to zero /or a value.

Preset Value

The position value of the encoder will be set to this preset value.
This allows, for example, for the encoder's zero position to be compared with the machine's zero position.

Data content:

Byte 0	Byte 1	Byte 2	Byte 3
$2^7 \dots 2^0$	$2^{15} \dots 2^8$	$2^{23} \dots 2^{16}$	$2^{31} \dots 2^{24}$

Range of values: 0.... maximum physical resolution (16383) 14-bit
Default setting: 0

11 LED states

Green LED = BUS State

Red LED = ERR display

Annunciator	LED	Description	Cause of error	Addendum
Bus OFF		No connection to the ECU [2]	Data transmission line break Incorrect baud rate Inverted data line	Observe combination with ERR LED If ERR LED is also OFF, please check power supply [3]
Bus flashing ca. 100ms		Connection to device e.g. Cyclic transfer	Cyclic transfer	Communication is running
Bus flashing ca. 100msec		Connection to ECU Stopped state	Address claiming procedure is running	
ERR Flashing Ca. 1 sec		Connection to ECU interrupted	No CAN-Frame acknowledge	No bus connection
ERR ON		BUS OFF State	Short circuit on the Bus	

The individual LED annunciators can of course also occur in combinations.

[2] The Master can be a ECU or a second communication partner.
[3] Operating voltage

12 Abbreviations used

CAN	Controller Area Network
CRC	Cyclic Redundancy Check
DA	Destination Address
DLC	Data Length Code
DP	Data Page
DT	Data Transfer
EDP	Extended Data Page
EOF	End of Frame
ID	Identifier
MAC	Medium Access Control
PDU	Protocol Data Unit
PF	PDU Format
PGN	Parameter Group Number
PS	PDU Specific
SA	Source Adddress
SPN	Suspect Parameter Number
TP	Transport Protocol

13 Decimal-Hexadecimal Conversion Table

With numerical data, the decimal values are given as numerals with no affix (e.g. 1408), binary values are identified by the letter b (e.g. 1101b) and hexadecimal values with an h (e.g., 680h) after the numerals.

Dez	**Hex**	Dez	**Hex**	Dez	**Hex**	Dez	**Hex**
0	**00**	32	**20**	64	**40**	96	**60**
1	**01**	33	**21**	65	**41**	97	**61**
2	**02**	34	**22**	66	**42**	98	**62**
3	**03**	35	**23**	67	**43**	99	**63**
4	**04**	36	**24**	68	**44**	100	**64**
5	**05**	37	**25**	69	**45**	101	**65**
6	**06**	38	**26**	70	**46**	102	**66**
7	**07**	39	**27**	71	**47**	103	**67**
8	**08**	40	**28**	72	**48**	104	**68**
9	**09**	41	**29**	73	**49**	105	**69**
10	**0A**	42	**2A**	74	**4A**	106	**6A**
11	**0B**	43	**2B**	75	**4B**	107	**6B**
12	**0C**	44	**2C**	76	**4C**	108	**6C**
13	**0D**	45	**2D**	77	**4D**	109	**6D**
14	**0E**	46	**2E**	78	**4E**	110	**6E**
15	**0F**	47	**2F**	79	**4F**	111	**6F**
16	**10**	48	**30**	80	**50**	112	**70**
17	**11**	49	**31**	81	**51**	113	**71**
18	**12**	50	**32**	82	**52**	114	**72**
19	**13**	51	**33**	83	**53**	115	**73**
20	**14**	52	**34**	84	**54**	116	**74**
21	**15**	53	**35**	85	**55**	117	**75**
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	**17**	55	**37**	87	**57**	119	**77**
24	**18**	56	**38**	88	**58**	120	**78**
25	**19**	57	**39**	89	**59**	121	**79**
26	**1A**	58	**3A**	90	**5A**	122	**7A**
27	**1B**	59	**3B**	91	**5B**	123	**7B**
28	**1C**	60	**3C**	92	**5C**	124	**7C**
29	**1D**	61	**3D**	93	**5D**	125	**7D**
30	**1E**	62	**3E**	94	**5E**	126	**7E**
31	**1F**	63	**3F**	95	**5F**	127	**7F**

14 Additional Sources

SAE J1939 DOCUMENTS

[1] SAE J1939 Recommended Practice for a Serial Control and Communications Vehicle Network
[2] SAE J1939-11 Physical Layer—250K Bits/s, Shielded Twisted Pair
[3] SAE J1939-13 Off-Board Diagnostic Connector
[4] SAE J1939-15 Reduced Physical Layer, 250K Bits/s, Un-Shielded Twisted Pair (UTP)
[5] SAE J1939-21 Data Link Layer
[6] SAE J1939-31 Network Layer
[7] SAE J1939-71 Vehicle Application Layer
[8] SAE J1939-73 Application Layer - Diagnostics
[9] SAE J1939-81 Network Management Protocol

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