



SURFACE VEHICLE RECOMMENDED PRACTICE

J1939™-22

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CAN FD Data Link Layer

RATIONALE

This document facilitates the use of SAE J1939 networks utilizing CAN with flexible data rate (CAN FD) data frame format for communication use cases. This data link layer definition provides additional and unique capability compared to SAE J1939-21 to take advantage of the larger frame payload capability.

This revision includes an update to Figure 34 to match the bit positions in Figure 35.

FOREWORD

This series of SAE Recommended Practices have been developed by the Truck and Bus Control and Communications Network Committee of the Truck and Bus Electrical and Electronics Steering Committee. The objectives of the committee are to develop information reports, recommended practices, and standards concerned with the requirements, design, and usage of devices that transmit electronic signals and control information among vehicle components. The usage of these recommended practices is not limited to truck and bus applications; other applications may be accommodated with immediate support being provided for construction and agricultural equipment, and stationary power systems.

These SAE Recommended Practices are intended as a guide toward standard practice and are subject to change so as to keep pace with experience and technical advances.

This data link layer is used for all SAE J1939 applications on an SAE J1939-17 physical layer.

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For more information on this standard, visit
https://www.sae.org/standards/content/J1939-22_202107

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1. SCOPE

The SAE J1939 documents are intended for light-, medium-, and heavy-duty vehicles used on or off road, as well as appropriate stationary applications which use vehicle derived components (e.g., generator sets). Vehicles of interest include, but are not limited to, on- and off-highway trucks and their trailers, construction equipment, and agricultural equipment and implements.

The purpose of these documents is to provide an open interconnect system for electronic systems. It is the intention of these documents to allow electronic control units to communicate with each other by providing a standard architecture.

This particular document, SAE J1939-22, describes the data link layer using the flexible data rate as defined in ISO 11898-1, December 2015. The flexible data rate capability in CAN (commonly called CAN FD) is implemented as a transport layer in order to allow for functional safety, cybersecurity, extended transport capability, and backward compatibility with SAE J1939DA.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1939	Recommended Practice for a Serial Control and Communications Heavy Duty Vehicle Network
SAE J1939-17	CAN FD Physical Layer
SAE J1939-21	Data Link Layer
SAE J1939-31	Network Layer
SAE J1939-71	Vehicle Application Layer
SAE J1939-81	Network Management
SAE J1939DA	Digital Annex

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 11898-1:2015 Road Vehicles - Controller Area Network (CAN) - Part 1: Data Link Layer and Physical Signalling

2.2.2 AUTOSAR Publications

Copies of these documents are available online at <https://www.autosar.org/>.

Specification of I-PDU Multiplexer AUTOSAR Classic Release R20-11

Specification of CAN Network Management AUTOSAR Classic Release R20-11

3. DEFINITIONS

Many terms and definitions are defined in SAE J1939 documents and are not repeated here. Only the additional new terms are listed here.

3.1 APPLICATION LAYER PROTOCOL DATA UNIT (A_PDU)

This SAE J1939 application layer protocol data unit contains the Parameter Group data and supporting metadata necessary for use in a D_PDU.

3.2 ASSURANCE DATA

The results of calculation for cybersecurity and/or functional safety coverage of the A_PDU (e.g., CRC).

3.3 CAN DATA FRAME

The ISO 11898-1 MAC sub-layer comprises the protocol data unit (PDU) containing the ID field (11 bit or 29 bit) and the data field (up to 64 bytes).

3.4 CLASSICAL BASE FRAME FORMAT (CBFF)

An ISO 11898-1 CAN data frame with an 11-bit identifier, a single bit rate, and a maximum data field length of 8 bytes.

3.5 CLASSICAL EXTENDED FRAME FORMAT (CEFF)

An ISO 11898-1 CAN data frame with a 29-bit identifier, a single bit rate, and a maximum data field length of 8 bytes.

3.6 C-PG PAYLOAD LENGTH

Length of the PG data including assurance data from functional safety and/or cybersecurity coverage.

3.7 DATALINK LAYER PROTOCOL DATA UNIT (D_PDU)

This SAE J1939 datalink layer protocol data unit contains one or more A_PDUs formatted for transmission by the CAN controller.

3.8 FD BASE FRAME FORMAT (FBFF)

An ISO 11898-1 CAN data frame with an 11-bit identifier, a flexible bit rate, and a maximum data field length of 64 bytes.

3.9 FD EXTENDED FRAME FORMAT (FEFF)

An ISO 11898-1 CAN data frame with a 29-bit identifier, a flexible bit rate, and a maximum data field length of 64 bytes.

3.10 LARGE MESSAGE

A large message is considered to be a PG with more than 60 data bytes or an A_PDU that doesn't fit in a Multi-PG C-PG due to large data size and large assurance data together.

3.11 NAME

An 8-byte value as specified in SAE J1939-81 which uniquely identifies the primary function of a CA and its instance in a vehicle network.

3.12 SEGMENT

One of multiple CAN data frames used when a PG is defined with more data to be transmitted than fits in a single CAN FD frame.

4. ABBREVIATIONS

ACK	Acknowledgment ¹
ACKM	Acknowledgement PG
A_PDU	Application Layer Protocol Data Unit
AppPI	Application Protocol Indicator
BAM	Broadcast Announce Message
BRS	Bit Rate Switch (refer to ISO 11898-1:2015)
CA	Controller Application (refer to SAE J1939-81)
CAN	Controller Area Network (refer to ISO 11898-1)
CAN FD	Controller Area Network - Flexible Data Rate
CAN ID	Controller Area Network Identifier
CBFF	Classical Base Frame Format (refer to ISO 11898-1:2015)
CEFF	Classical Extended Frame Format (refer to ISO 11898-1:2015)
CM	Connection Management
C-PG	Contained Parameter Group
CPGN	Contained Parameter Group Number
CRC	Cyclic Redundancy Check
CS	Cybersecurity
CTS	Clear to Send
DA	Destination Address
DLC	Data Length Code
DP	Data Page
D_PDU	Datalink Layer Protocol Data Unit
DT	Data Transfer
EDP	Extended Data Page
EOF	End of Frame (refer to ISO 11898-1:2015)
EOMS	End of Message Status
FBFF	Flexible Data Rate Base Frame Format (refer to ISO 11898-1:2015)

¹ In this document, ACK refers to the Acknowledgement PG with the control byte set to a value indicating positive acknowledgment.

FD	Flexible Data Rate
FDF	FD Format Indicator Bit (refer to ISO 11898-1:2015)
FEFF	Flexible Data Rate Extended Frame Format (refer to ISO 11898-1:2015)
FS	Functional Safety
GE	Group Extension
ID	Identifier
IDE	Identifier Extension Bit (refer to ISO 11898-1:2015)
LSB	Least Significant Byte or Least Significant Bit
MF	Manufacturer
MSB	Most Significant Byte or Most Significant Bit
NA	Not Allowed
NACK	Negative Acknowledgment ²
P	Priority
PDU	Protocol Data Unit
PF	PDU Format
PG	Parameter Group
PGN	Parameter Group Number
PS	PDU Specific
RTR	Remote Transmission Request
RTS	Request to Send
SA	Source Address
SOF	Start of Frame bit (refer to ISO 11898-1:2015)
SPN	Suspect Parameter Number
SRR	Substitute Remote Request
TP	Transport Protocol
T_PDU	Transport Layer Protocol Data Unit
T _h	Hold Time
T _r	Response Time

² In this document, NACK refers to the Acknowledgement PG with the control byte set to a value indicating negative acknowledgement.

5. OPERATING PRINCIPLES/OVERVIEW

This document endeavors to maintain compatibility with all Parameter Groups in SAE J1939. However, the manner by which Parameter Groups are transmitted differs from SAE J1939-21. SAE J1939-22 is specified to maximize the use of the CAN FD network bandwidth, provide integral support for functional safety and cybersecurity measures, and provide improved large data transport services. Consequently, some SAE J1939-21 messaging services are not permitted on SAE J1939-22 networks and some SAE J1939-21 messaging services have limited use on SAE J1939-22 networks.

5.1 Maximize Use of CAN FD Network Bandwidth

- All SAE J1939-22 messages shall use FBFF or FEFF data frames with ISO 11898-1 BRS set so that the frame bit rate switching is used.
- CEFF data frames, per SAE J1939-21, shall not be transmitted on an SAE J1939-22 network, except for the following two exceptions. The first exception allows the Address Claimed PG to be sent as a single CEFF data frame, per SAE J1939-21. The second exception allows a device to transmit CEFF data frames (per SAE J1939-21) only to determine if the network is an SAE J1939-22 network; CEFF frames shall be ceased once a device determines it is connected to an SAE J1939-22 network.
- CBFF data frames, per SAE J1939-21, shall not be transmitted on an SAE J1939-22 network. The FBFF CAN ID structure for SAE J1939-22 is incompatible with CBFF CAN ID structure for SAE J1939-21.
- The FEFF data frames match the SAE J1939-21 method for addressing.
- SAE J1939 PGs shall not be sent using a single FEFF data frame, in a manner similar to a single CEFF data frame in SAE J1939-21. This is disallowed because not all PGs have a fixed data length; thus it is impossible to identify the end of valid data and the start of padding bytes for some PGs.
- SAE J1939 PGs shall be sent using the Multi-PG transport mechanism and the FD Transport Protocol.
- The Address Claimed PG shall not be sent using the Multi-PG transport mechanism; it shall be sent as either a single FEFF data frame (per J1939-22) or a single CEFF data frame (per SAE J1939-21).
- Non-SAE J1939 defined Transport Protocols shall use FBFF data frames (D_PDU3) with the applicable AppPI. Non-SAE J1939 defined Transport Protocols may also use the Multi-PG transport mechanism or FD Transport Protocol with any SAE J1939 assigned PGs for those non-SAE J1939 protocols, such as PGNs 512 and 52480. The ISO15765 defined Transport Protocol may use either FBFF data frames with AppPI defined in [Table 6](#) or FEFF data frames with the ISO15765 assigned PGNs in SAE J1939DA without using the Multi-PG or FD Transport Protocol defined in this document. This exception is made because the ISO FD-capable transport method was published prior to the methods defined in this document.
- Multi-PG transport mechanism provides a method to combine multiple PGs into a single FEFF data frame thus optimizing bandwidth. This method is analogous to an AUTOSAR Container-PDU. These requirements apply to all PG Data Pages. The FEFF Multi-PG transport mechanism allows Multi-PG data frames to be sent destination specific or globally. The FBFF Multi-PG transport mechanism only allows Multi-PG data frames to be sent globally.
- When sending a Destination Specific FEFF Multi-PG data frame, all the included PGs must be Destination Specific (PDU1) PGs directed to the same Destination Address specified in the CAN identifier field. Globally broadcast (PDU2) PGs shall not be included in a Destination Specific FEFF Multi-PG data frame.
- The PS field in the CPGN for an A_PDU1 C-PG shall not include a Destination Address; instead, the PS field shall be set to 0. This is for AUTOSAR compatibility since AUTOSAR message routing (i.e., PG identification) is controlled by the contents of the CAN Header only. The Destination Address for the A_PDU1 C-PG shall be derived from the Multi-PG message address. See [6.5.3.6.2](#) for details.
- PGs shall be ordered within the Multi-PG message from oldest to newest where the first PG is the oldest and the last is more recent. Extracting the PGs should also be done in chronological order. See [6.5](#) for details.

5.2 Integral Support for Functional Safety and Cybersecurity

- The Multi-PG transport mechanism allows for functional safety and/or cybersecurity content for each PG contained in the data frame.
- The FD Transport Protocol allows for functional safety and/or cybersecurity content for the transmitted PG.

5.3 Improved Large Data Transport Services

- The FD Transport Protocol is capable of significantly larger data transmission sizes and provides for up to eight concurrent destination specific transfers and up to four concurrent broadcast transfers.
- The SAE J1939-21 Transport Protocol shall not be used on an SAE J1939-22 network; specifically, the Transport Protocol - Data Transfer PG (TP.DT) (PGN 60160) and the Transport Protocol - Connection Mgmt PG (TP.CM) (PGN 60416) shall not be sent by any CAN controller on an SAE J1939-22 network segment.
- The FD Transport Protocol shall only be used when the data size of the transported PG, including any assurance data, is too large for the maximum size of a C-PG in a Multi-PG data frame.

5.4 AUTOSAR Compatibility

This document intends to achieve compatibility with AUTOSAR at the time of publication. The CAN wake feature of AUTOSAR NM may use FBFF with the BRS disabled for hardware compatibility reasons.

6. TECHNICAL REQUIREMENTS

This document provides guidelines for the reliable transfer of data across the SAE J1939-17 physical layer. This document provides methods to package multiple SAE J1939 messages, transport large data sets, and has provisions to protect content for functional safety and cybersecurity.

Hardware that does not conform to SAE J1939-17 shall not be used on an SAE J1939-22 network to avoid disruption of network operation.

This document is organized in layers by means of protocols and services as shown in [Figures 1](#) and [2](#). These figures show a flow of data through the layers and are not a design specification for implementation but rather a conceptual model to understand this document's organization. This document covers the content within the blue dashed outlines.

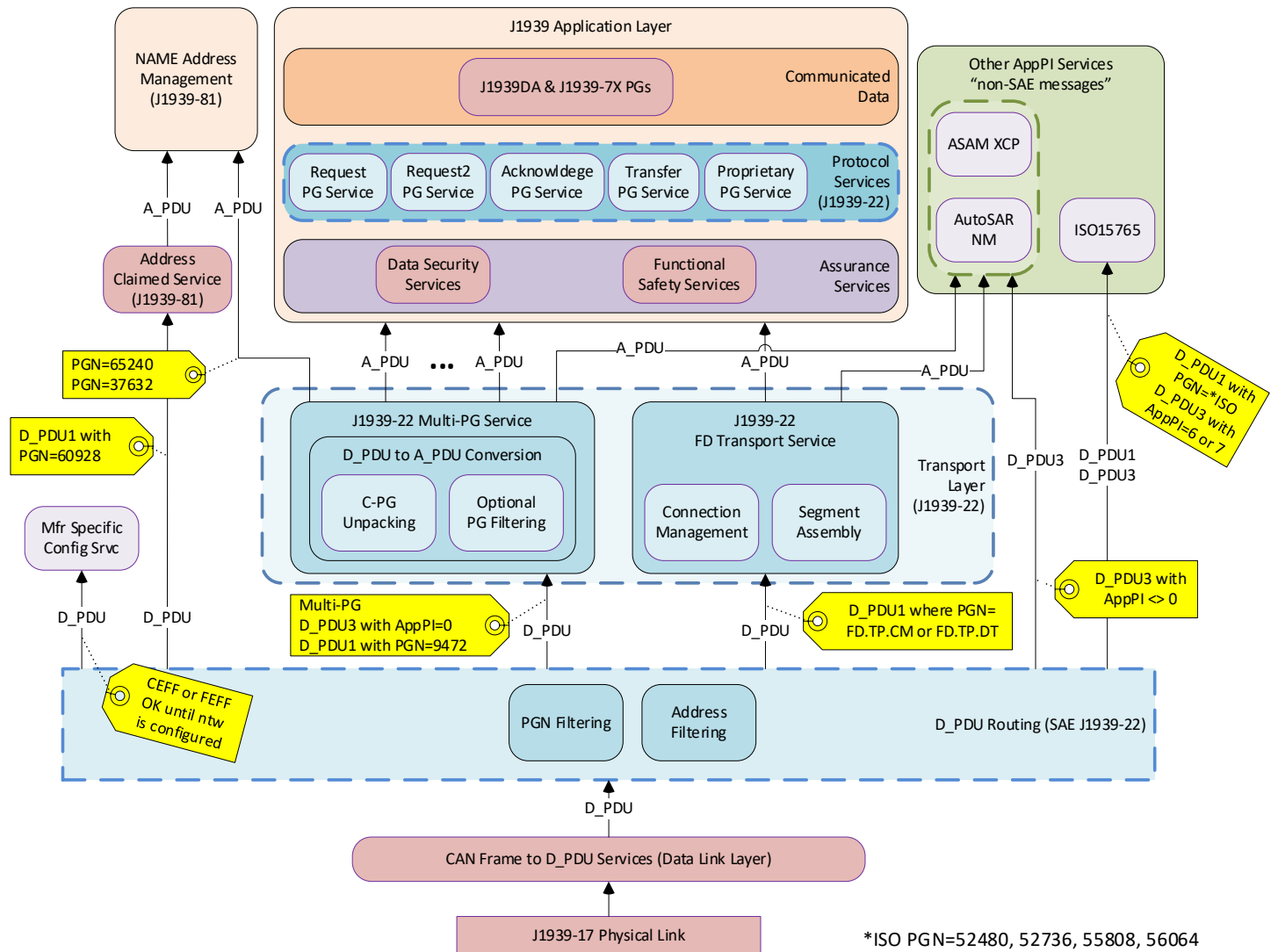


Figure 1 - Receive model

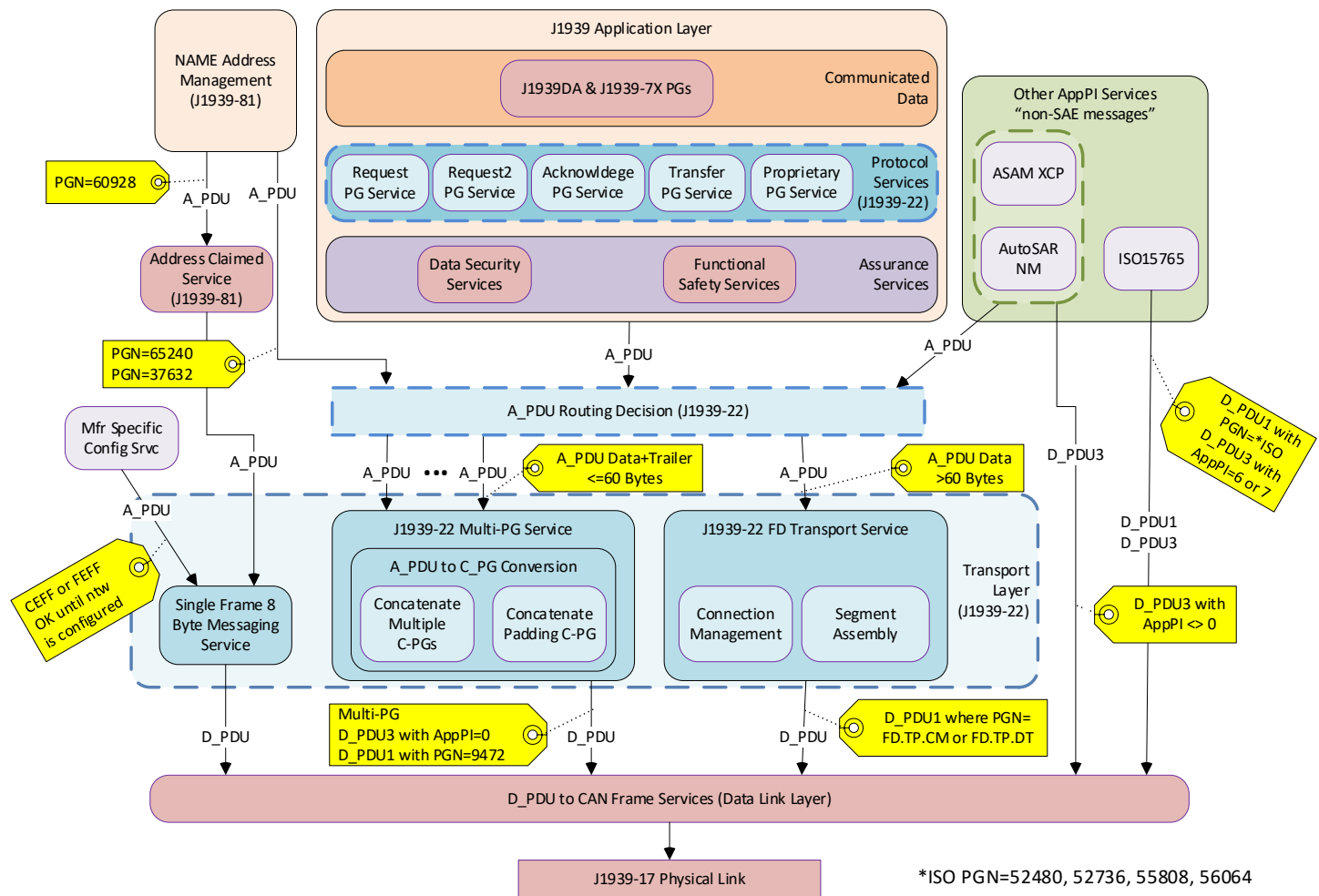


Figure 2 - Transmit model

References to sections related to terms in the figures:

- A_PDU is explained in [6.1](#)
- D_PDU is explained in [6.2](#)
- Multi-PG is explained in [6.5](#)
- FD Transport Service is explained in [6.6](#)
- Request Service is explained in [6.10.1](#)
- Request2 Service is explained in [6.10.2](#)
- Acknowledge Service is explained in [6.10.3](#)
- Transfer Service is explained in [6.10.5](#)

6.1 Application Protocol Data Unit (A_PDU)

In SAE J1939-21, there is only one Application PDU (A_PDU) per CAN data frame. In SAE J1939-22, multiple A_PDUs may be combined within a single Multi-PG facilitated by the larger payload capability of CAN FD. Additionally, some Parameter Group (PG) definitions require more space than is supported by a single CAN FD data frame to send the corresponding data. Flexible Data Transport Protocol (FDTP) messages are used to transport PGs with more data than fits in a single CAN FD data frame.

The attributes of Application Protocol Data Unit (A_PDU) data include application data and can also include identification data, functional safety data, and/or cybersecurity data. [Table 1](#) shows some common data attributes in no particular order. Individual implementations may include additional data, as needed.

Table 1 - Application protocol data attributes

Attribute	Transmit	Receive	Reference
PGN value	Include	Include	6.1.3
PG data and PG size	Include	Include	6.5.3.2
Functional safety assurance data and FS size (if applicable)	Include	Include	6.5.3.6.1
Cybersecurity assurance data and CS size (if applicable)	Include	Include	6.5.3.6.1
Destination Address (if A_PDU1)	Include	See Note 1	6.3.1.5.1
Source Address (if applicable)	See Note 2	Include	6.3.3.1
Priority	Include	See Note 3	6.3.1.1
Transmit latency constraints	Include	N/A	6.5.4

Notes:

1. For example, a gateway would need this passed up to the application or perhaps an ECU which contains more than one Controller Application (multiple source addresses).
2. Necessary for an ECU which contains more than one Controller Application (multiple source addresses).
3. Priority shall not be used as a filter and thus has no reason to be passed on to the application.

6.1.1 A_PDU1 Format

The A_PDU1 Format is used for destination specific Parameter Groups.

6.1.2 A_PDU2 Format

The A_PDU2 Format is used for global Parameter Groups.

6.1.3 Parameter Group Number (PGN)

The Parameter Group Number is a unique numeric value assigned to each SAE J1939 Parameter Group that is used to identify an SAE J1939 PG. The numeric value is derived from four individual component values: Extended Data Page (EDP), Data Page (DP), PDU Format (PF), and PDU Specific (PS). The PGN is expressed as a 24-bit value in SAE J1939 documentation and when identifying a Parameter Group Number (PGN) in the data field of a CAN data frame. [Figure 3](#) illustrates the constituent component bit fields, placement, and transmission order.

The procedure for converting the identifier fields to a 24-bit value is shown in the “placement” illustration in [Figure 3](#):

- The six most significant bits are set to zero.
- EDP, DP, and PF are copied into the next 10 bits.
- Lastly, if the PF value is less than 240 (F0_h), then the least significant byte of the PGN is set to zero. Otherwise, it is set to the PS value.

When identifying a Parameter Group Number (PGN) in the data field of a CAN data frame, the 24-bit value is sent LSB first, middle byte second, and MSB third, as illustrated by the “Transmission Order” illustration in [Figure 3](#).

See [Table 2](#) to correlate the constituent components to the PGN ranges and types. Note that not all 2^{17} (or 131072) combinations are available for assignment using the conventions specified in this document. The conventions specified yield 8672 PGNs (calculated as: 2 pages * [240 + (16*256)] = 8672 PGs). Refer to SAE J1939DA for the complete list of assigned PGNs. See [6.3.1](#) for further description of the identifier fields.

Data Definition	EDP	DP	PF								PS																																																													
	b17	b16	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0																																																						
	MSb										LSb																																																													
Placement	MSb								Byte 3								LSb								MSb								Byte 2								LSb								MSb								Byte 1								LSb							
	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1																																								
	0	0	0	0	0	0	b17	b16	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0																																																
Transmission Order	MSb								Byte 1								LSb								MSb								Byte 2								LSb								MSb								Byte 3								LSb							
	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1																																								
	b7	b6	b5	b4	b3	b2	b1	b0	b15	b14	b13	b12	b11	b10	b9	b8	0	0	0	0	0	0	0	b17	b16																																															

Figure 3 - Parameter group number transmission order

Table 2 - Parameter group number examples

EDP	DP	PF	PS	PGN	PGN	Number of Assignable PGNs	Cumulative Number of PGNs	SAE or Manufacturer Assigned
Bit 2	Bit 1	Bits 8 to 1	Bits 8 to 1	Dec	Hex			
0	0	0 - 238	0	0 - 60928	000000 _h - 00EE00 _h	239	239	SAE
0	0	239	0	61184	00EF00 _h	1	240	MF
0	0	240 - 254	0 - 255	61440 - 65279	00F000 _h - 00FEFF _h	3840	4080	SAE
0	0	255	0 - 255	65280 - 65535	00FF00 _h - 00FFFF _h	256	4336	MF
0	1	0 - 238	0	65536 - 126464	010000 _h - 01EE00 _h	239	4575	SAE
0	1	239	0	126720	01EF00 _h	1	4576	MF
0	1	240 - 254	0 - 255	126976 - 130815	01F000 _h - 01FEFF _h	3840	8416	SAE
0	1	255	0 - 255	130816 - 131071	01FF00 _h - 01FFFF _h	256	8672	MF

Parameter group assignments do not have fixed boundaries between fast and slow types but they do have fixed boundaries between PDU1 and PDU2 types. These boundaries are shown in [Table 3](#). Boundary X indicates the separation between PDU1 Fast and PDU1 Slow for Data Page 0. PGN assignments are made upon Request where the fast PGN assignments increase in numerical value and the slow PGN assignments decrease in numerical value. Eventually the two will meet at Boundary X. Likewise, Boundary Y denotes the separation between PDU2 Fast and PDU2 Slow for Data Page 0. Boundary X1 and Y1 represent the same concept for Data Page 1 but the slow/fast boundaries are unlikely to be the same. See [6.2.1](#) and [6.2.2](#) for details about PDU Formats and assignment strategy.

Table 3 - SAE J1939 Parameter Group Number template

EDP	DP	PF	PS	Parameter Group Definition	TP Segmented	PGN
0	0	0	DA	PDU1 Fast Format - 100 ms or less	Not Allowed	0
0	0	1	DA		Not Allowed	256
Boundary X				↓		
				↑		
0	0	238	DA	PDU1 Slow Format - greater than 100 ms	Allowed	60928
0	0	239	DA	PDU1 Format - Proprietary A	Allowed	61184
0	0	240	0	PDU2 Fast Format - 100 ms or less	Not Allowed	61440
0	0	240	1		Not Allowed	61441
Boundary Y				↓		
				↑		
0	0	254	254		Not Allowed	65278
0	0	254	255	PDU2 Slow Format - greater than 100 ms	Allowed	65279
0	0	255	0 - 255	PDU2 Format - Proprietary B	Allowed	65280 - 65535
0	1	0	DA	PDU1 Fast Format - 100 ms or less	Not Allowed	65536
0	1	1	DA		Not Allowed	65792
Boundary X1				↓		
				↑		
0	1	238	DA	PDU1 Slow Format - greater than 100 ms	Allowed	126464
0	1	239	DA	PDU1 Format - Proprietary A2	Allowed	126720
0	1	240	0	PDU2 Fast Format - 100 ms or less	Not Allowed	126976
0	1	240	1		Not Allowed	126977
Boundary Y1				↓		
				↑		
0	1	254	254		Not Allowed	130814
0	1	254	255	PDU2 Slow Format - greater than 100 ms	Allowed	130815
0	1	254	0 - 255	PDU2 Format - Proprietary B	Allowed	130816 - 131071

LEGEND:

EDP: Extended Data Page

PF: PDU Format

DA: Destination Address

DP: Data Page

PS: PDU Specific

PGN: Parameter Group Number

TP Segmented: Transport Protocol for large messages

6.1.4 Services for A_PDU Routing

The services are based on the PG size + FS size + CS size specified for the A_PDU. The decision flow is depicted in [Figure 4](#). If the additive size is less than or equal to 60 bytes then a Multi-PG service shall be used. See [6.5](#) for Multi-PG functional details. If the additive size is greater than 60 data bytes, the FD Transport Protocol (FD.TP) is used. See [6.6](#) for FD Transport Protocol functional details. The FD Transport Protocol is used to transmit the A_PDU data as a series of segmented CAN data frames. For flow control, the FD Transport Protocol Connection Management (FD.TP.CM) PG is used to set up and close out the communication of the segmented PG data. The FD Transport Protocol Data Transfer (FD.TP.DT) PG is used to communicate the data in a series of CAN data frames (segments) containing the segmented data. Additionally, the FD Transport Protocol provides flow control and handshaking capabilities for destination specific transfers using Request to Send (RTS) and Clear to Send (CTS) messages.

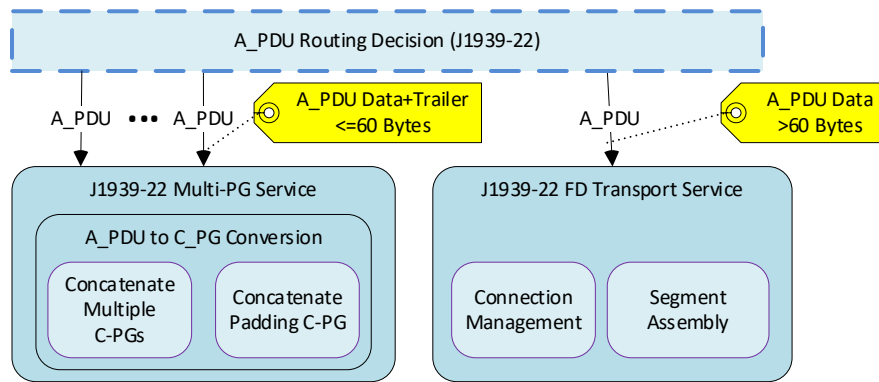
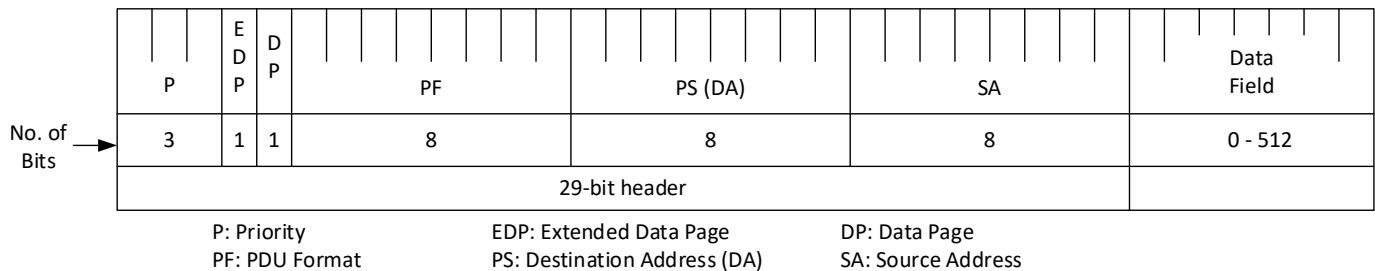


Figure 4 - A_PDU routing service

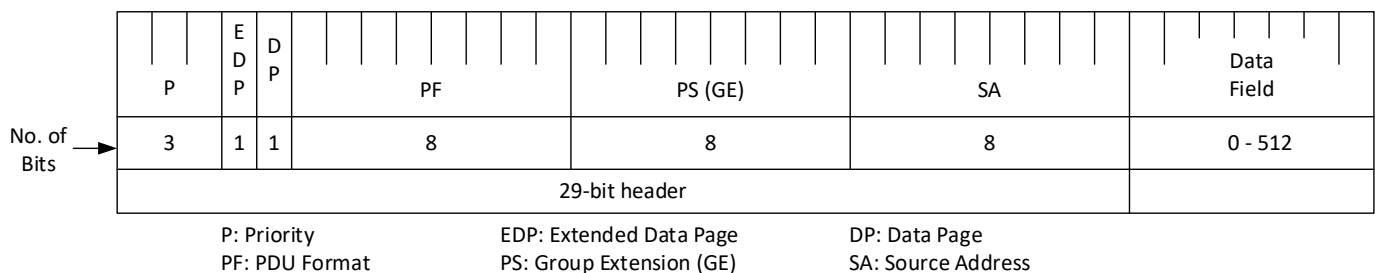
6.2 Datalink Layer Protocol Data Unit (D_PDU)

The available D_PDU Formats are illustrated in [Figure 5](#). Two D_PDU Formats are defined when representing a PG with a FEFF CAN ID: D_PDU1 Format (PS = DA) and D_PDU2 Format (PS = GE). The D_PDU1 Format allows for direction of the CAN data frame to a specific DA (device). The D_PDU2 Format can only carry A_PDUs that are not destination specific. The third format, D_PDU3, is defined for use when FBFF CAN IDs are used and is also not destination specific. These formats are used when sending an A_PDU (like Address Claimed), for the Multi-PG CAN ID, and for segmented transport.

D_PDU1



D_PDU2



D_PDU3

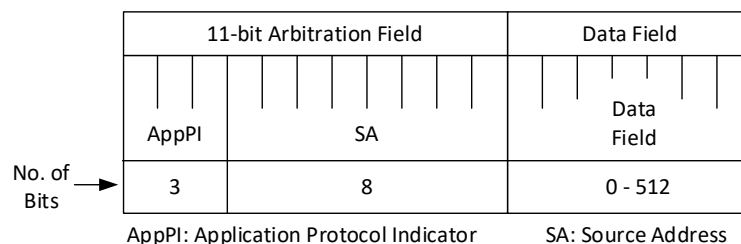


Figure 5 - Available D_PDU Formats

6.2.1 D_PDU1 Format

This format allows applicable PGs to be sent to either a specific or global DA. The PS field contains a Destination Address (DA). The D_PDU1 Format can be used for content Requested by a CA or can be sent unsolicited.

The D_PDU1 Format is determined by the PF field. A PF field value between 0 to 239 is defined as a D_PDU1 Format. The formatting of a D_PDU1 message is illustrated in [Figure 5](#). Also see [Figure 6](#).

PGs requiring a DA and minimal latency are assigned starting with PF = 0 and incrementing to larger values. The term used for these is “PDU1 Fast.”

PGs requiring a DA where latency is not critical are assigned starting with PF = 238 and decrementing to smaller values. The term used for these is “PDU1 Slow.” The junction where PDU1 Slow meets PDU1 Fast is shown in [Table 3](#) as boundary X.

Two D_PDU1 PGs, with EDP = 0 and DP = 0 or 1, are assigned for proprietary use. The Proprietary A PGN is 61184 and the Proprietary A2 PGN is 126720. See [6.10.4](#) for descriptions of the Proprietary A and Proprietary A2 PGs.

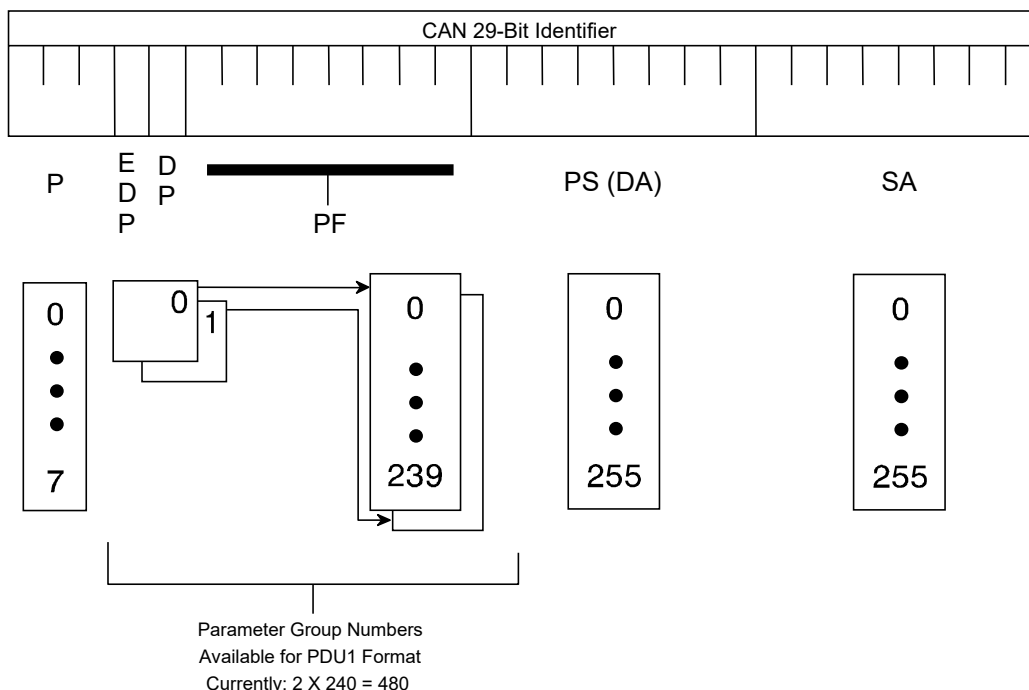


Figure 6 - D_PDU1 Format

6.2.2 D_PDU2 Format

This format can only be used to communicate PGs to the global DA; the global DA is implied by the D_PDU2 Format and does not appear in the arbitration field. The D_PDU2 Format can be used for Requested or unsolicited content. Selection of D_PDU2 Format, at the time a PGN is assigned, prevents that PG from ever being able to be directed to a specific DA. The PS field contains a Group Extension (see [6.3.1.5.2](#)).

The D_PDU2 Format has a PF field from 240 to 255 (see [Table 3](#)). The D_PDU2 Format is illustrated in [Figure 5](#). Also see [Figure 7](#).

The PGNs of messages that are sent at fast update rates (generally less than 100 ms) start with PF = 240 and increment in value.

The PGNs of messages that are only Requested, sent on change, or sent at slow update rates (generally greater than 100 ms) start with PF = 254 and decrement in value.

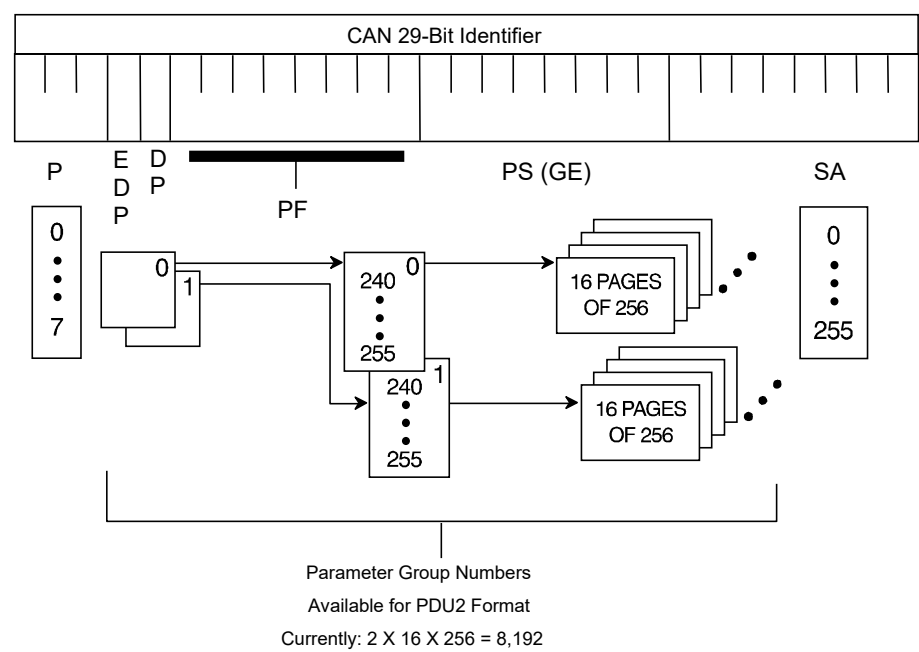


Figure 7 - D_PDU2 Format

6.2.3 D_PDU3 Format

This format can only be used to communicate Multi-PG or Proprietary content globally; the global DA is implied by the D_PDU3 Format and does not appear in the arbitration field. Other protocols may use an 11-bit identifier field as well but are not defined in this document other than how to set the AppPI to denote which protocol is in use. The Source Address defines the sender of the message; so for a given protocol, there is only 1 proprietary CAN ID and 1 Multi-PG CAN ID which may be used in the D_PDU3 format for each source address. [Figure 8](#) shows a representation of the bit positions and [Table 6](#) indicates the full AppPI enumeration.

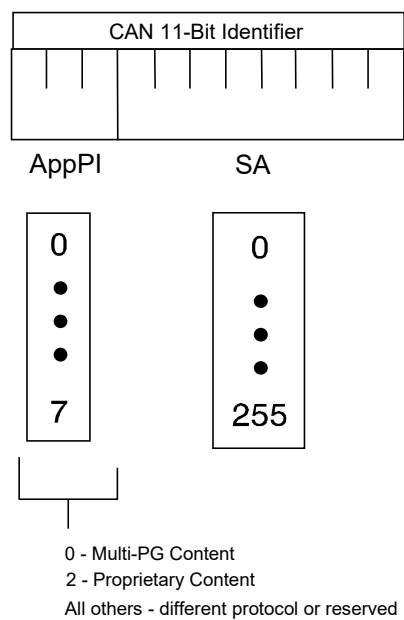


Figure 8 - D_PDU3 Format

6.3 D_PDU Fields

The applications and/or network layer provide a string of information that is assimilated into a data link layer Protocol Data Unit (D_PDU). The D_PDU provides a framework for organizing the information that is key to each CAN data frame that is sent. The SAE J1939-22 FEFF D_PDU consists of seven fields: (1) P, (2) EDP, (3) DP, (4) PF, (5) PS (which can be a Destination Address or Group Extension), (6) SA, and (7) Data. The SAE J1939-22 FBFF D_PDU consists of three fields: (1) AppPI, (2) SA, and (3) Data. The fields are packaged into a CAN data frame and sent over the physical media to other network devices.

Some of the CAN data frame fields have been intentionally left out of the SAE J1939 D_PDU definition because they are defined entirely by ISO 11898-1. Fields that are controlled in this manner include the SOF, RRS, IDE, FDF, r0, BRS, ESI, CRC, ACK, and EOF fields. They are not forwarded to the application.

The D_PDU fields illustrated in [Figures 9](#) and [10](#) are defined in the subsequent sections.

6.3.1 FEFF D_PDU Fields

6.3.1.1 Priority (P)

The CAN data frame priority shall be per ISO 11898-1. The value within the CAN ID field determines the priority. A low value (the identifier being all zeros) has a high priority, while the largest CAN ID has the lowest priority (the identifier being all ones).

Three bits are used by the application layer to optimize message latency for transmission onto the bus only. They shall be masked off by the receiver (ignored). The priority of any FEFF data frame can be set from highest, 0 (000_b), to lowest, 7 (111_b). The default for all control-oriented messages is 3 (011_b). The default for all other informational, proprietary, Request, and ACK messages is 6 (110_b). This permits the priority to be raised or lowered in the future as new PGNs are assigned and bus traffic changes. A recommended value is assigned to each PG when the PGN is assigned. However, the Priority field should be configurable to allow for network tuning by the OEM should the need arise.

NOTE: Undesired bus arbitration can occur between contending FBFF and FEFF frames. An FBFF frame will nearly always win bus arbitration over an FEFF frame because the first three CAN ID bits of most FBFF frames will be “000” which contends against the first three bits of the FEFF frame which are the Priority bits. When bus arbitration occurs between an FBFF frame and an FEFF frame with a Priority other than zero, then the FBFF frame will always win bus arbitration. When bus arbitration occurs between an FBFF frame and an FEFF frame with a “0” Priority, then the frame winning bus arbitration will depend on the SA of the FBFF frame and the PGN in the FEFF frame.

6.3.1.2 Extended Data Page (EDP)

The EDP is used in conjunction with the DP to determine the structure of the CAN ID field. See [Table 4](#) for the defined meaning of the EDP and DP combinations. Future definitions with EDP set to 1 could expand the PDU Format field, define new PDU Formats, or increase the address space. When messages using these values are defined by the SAE J1939 committee, handling rules will be specified in a future version of the SAE J1939 documents.

6.3.1.3 Data Page (DP)

The DP is used in conjunction with the EDP to determine the structure of the CAN ID of the CAN data frame. With the EDP set to 0, the DP selects between page 0 and page 1 of PGN descriptions as shown in [Table 4](#). Also see [Table 3](#) to see the SAE J1939 Parameter Group Number template.

Table 4 - Definition of Extended Data Page and Data Page use

Extended Data Page (bit 25) CAN ID (bit 25)	Data Page (bit 24) CAN ID (bit 24)	Description
0	0	SAE J1939 page 0 PGNs
0	1	SAE J1939 page 1 PGNs
1	0	SAE J1939 reserved
1	1	Reserved

6.3.1.4 PDU Format (PF)

The PDU Format is an 8-bit field that defines whether a PG has a PDU1 or PDU2 Format, and is one of the fields used to identify the PGN. When the PF value for a PG is below 240, then the PG has a PDU1 Format—a format that supports specifying the Destination Address for each instance of the PG. When the PF value is 240 to 255, then the PG has a PDU2 Format—a format that does not support any Destination Addressing.

6.3.1.5 PDU Specific (PS)

The PDU Specific field is an 8-bit field and its definition depends upon the PF field. Depending on the PF field, it can be a Destination Address (DA) or a Group Extension (GE). If the value of the PF field is below 240, then the PS field is a DA. If the value of the PF field is 240 to 255, then the PS field contains a GE value. See [Table 5](#) for the PDU ranges. See [Table 3](#) for the range of PGNs.

Table 5 - PDU specific

	PDU Format Field	PDU Specific Field
PDU1 Format	0 to 239	Destination Address
PDU2 Format	240 to 255	Group Extension

6.3.1.5.1 Destination Address (DA)

The PS field is interpreted as a Destination Address value when the PF value is 0 to 239. The Destination Address value identifies the specific address to which the message is being sent. Note that any other device should ignore this message. The global DA (255) as the Destination Address, requires all devices to listen and respond accordingly as message recipients.

6.3.1.5.2 Group Extension (GE)

The PS field is interpreted as a Group Extension value when the PF value is 240 to 255. The GE field serves as the least significant byte of the PGN number providing for 256 unique PGN values for a given PF value.

6.3.2 FBFF D_PDU Field

6.3.2.1 Application Protocol Indicator (AppPI)

The Application Protocol Indicator is a 3-bit enumeration defining how to interpret the contents of the data field. This field is only used in the identifier field of FBFF Frames as the first three bits (bits 28, 27, and 26). Bit 28 is the most significant bit of the three. See [6.2.3](#) for context. This document discusses usage of messages formatted using an AppPI value of 000_b and 010_b. Other values of AppPI can exist on the same datalink but are not explained in this document. The assigned values of AppPI are shown in [Table 6](#).

Table 6 - Application Protocol Indicator

Value	Definition
000 _b	Multi-PG
001 _b	AUTOSAR CAN-NM (wake)
010 _b	Proprietary
011 _b	XCP
100 _b	Reserved
101 _b	Reserved
110 _b	ISO15765 Functional Addressing
111 _b	ISO15765 Physical Addressing

6.3.3 Common D_PDU Fields

6.3.3.1 Source Address (SA)

The Source Address field is 8 bits long. There shall only be one device on the network with a given SA. Therefore, the SA field assures that the CAN ID is unique. Address management and allocation is detailed in SAE J1939-81. Procedures are defined in SAE J1939-81 to prevent duplication of SAs. Refer to SAE J1939DA for preferred source address assignments.

6.3.3.2 D_PDU Data Field

The Data Field contains the payload of the D_PDU. The content is dependent upon the CAN ID. The byte length of the D_PDU Data field is required to be one of the valid lengths specified by the CAN FD Data Length Code (DLC), as described in ISO 11898-1.

The CAN Data Length Code (DLC), described ISO 11898-1, specifies pre-defined sizes for data fields lengths for CAN FD of 0, 1, 2, 3, 4, 5, 6, 7, 8, 12, 16, 20, 24, 32, 48, and 64 bytes. The data field is required to be one of these defined valid lengths.

The DLC shall be set to a code indicating a data field length that is greater than or equal to the application data field length. Unless specified otherwise, the unused bytes shall be padded with AA_h (alternating bits of 1 and 0) when the application data does not completely fill the specified message length. This padding value is selected in order to minimize the insertion of stuff bits.

6.4 Frame Format

All devices shall use FBFF and FEFF frames to transmit the messages defined in this document. Devices shall tolerate the reception of FBFF, FEFF, and CEFF frames. CEFF frames are tolerated for network configuration upon startup and for Address Claimed messages only. ISO 11898-1 specifies four frame formats (D_PDUs): Classical Base Frame Format (CBFF) and flexible data rate Base Frame Format (FBFF), which use 11-bit CAN IDs; and Classical Extended Frame Format (CEFF) and flexible data rate Extended Frame Format (FEFF), which use 29-bit CAN IDs.

The CAN specification referenced throughout this document is ISO 11898-1:2015. It should be noted that when there are differences between the ISO 11898-1 specification and this document, then this document is the guiding document. This document does not use all of the functions defined in ISO 11898-1.

[Figure 9](#) specifies the use of identifier bits ID0 through ID28 in the arbitration field of data frames in the FEFF format. [Figure 10](#) specifies the use of identifier bits ID18 through ID28 in the arbitration field of data frames in the FBFF format. The control field bits are unchanged from the ISO 11898-1 definition for either frame type.

6.4.1 SAE J1939 Message Format (Mapped to ISO 11898-1 Data Frames in FEFF Format)

The FEFF CAN ID field, shown in [Figure 9](#), is divided into six fields. These fields are assimilated from information provided by the application and are identical to specifications given in SAE J1939-21. The fields specified in [6.3](#) are:

- Priority (P)
- Extended Data Page (EDP)
- Data Page (DP)
- PDU Format (PF)
- PDU Specific (PS, which can be a Destination Address or Group Extension)
- Source Address (SA)

ISO 11898-1 specifies that the data field is byte-wise scalable from 0 to 64 bytes. Byte 1's most significant bit is the first bit sent and follows directly after the control field. Byte 64's least significant bit is the last data bit of the data field and is followed by the CRC Field.

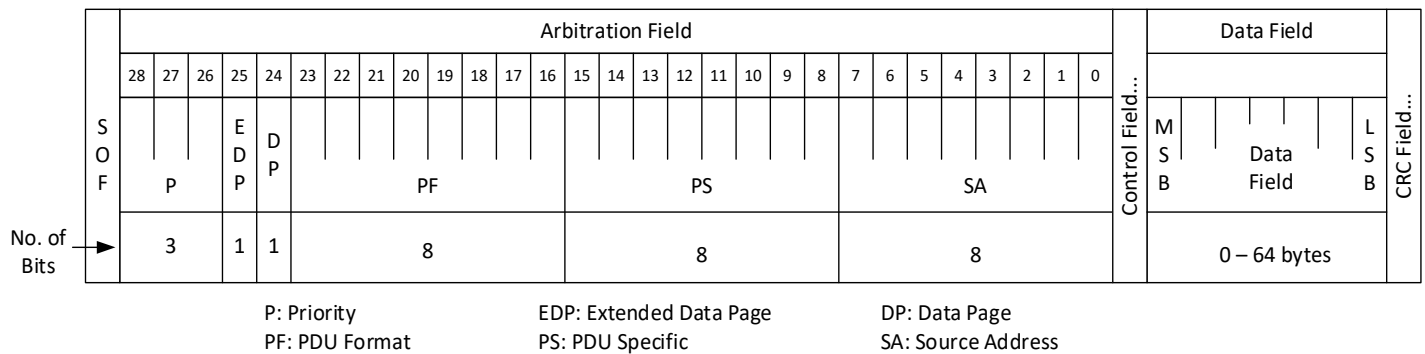


Figure 9 - 29-bit identifier layout

6.4.2 SAE J1939 Message Format (Mapped to ISO 11898-1 Data Frames in FBFF Format)

The FBFF CAN ID field, shown in [Figure 10](#), is divided into two fields. These fields are assimilated from information provided by the application. The fields specified in [6.3](#) are:

- Application Protocol Indicator (AppPI)
- Source Address (SA)

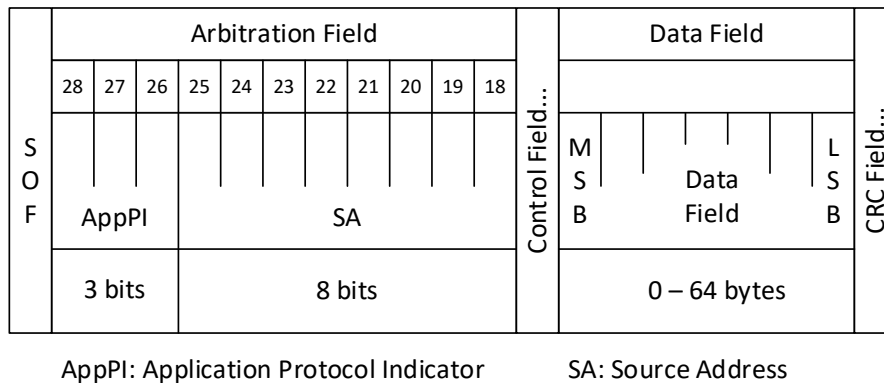


Figure 10 - 11-bit identifier layout

6.4.3 Support of CBFF and CEFF

Data frames in the CEFF format shall not be transmitted on an SAE J1939-22 network, except for the following two exceptions. The first exception allows the Address Claimed PG to be sent as single CEFF data frame, per SAE J1939-21. The second exception allows a device to transmit CEFF data frames (per SAE J1939-21) only to determine if the network is an SAE J1939-22 network. CEFF frames shall be ceased once a device determines it is connected to an SAE J1939-22 network.

CBFF data frames, per SAE J1939-21, shall not be transmitted on an SAE J1939-22 network. The content in the first 3 bits of the FBFF CAN ID has been defined in SAE J1939-22 differently from those same bits for the CBFF CAN ID defined in SAE J1939-21.

NOTE: It is recognized that controllers on existing SAE J1939-21 networks support CEFF and CBFF frame formats. These are not compatible with the SAE J1939-22 message structure which defines payloads larger than 8 bytes. It is also understood that many software stacks (particularly AUTOSAR compliant ones) will not expose the difference between messages mapped to CBFF/CEFF and FBFF/FEFF data frames and thus messages that are unique at the datalink layer are no longer unique at the application layer. For example, this is particularly important in the 11-bit identifier case where the first 3 bits in SAE J1939-21 are defined as priority bits but in SAE J1939-22 these bits are defined as an Application Protocol Indicator. So a message produced in SAE J1939-21 (CBFF) format but interpreted in an SAE J1939-22 (FBFF) format will not be interpreted correctly in most cases (unless the priority happened to be set as 010_b which is the proprietary identifier).

6.5 Multi-PG Protocol

Multi-PG protocol provides a transport mechanism to carry multiple SAE J1939 PGs in a single CAN FD data frame. Each PG, together with its Header content, included in the Multi-PG is referred to as a contained Parameter Group (C-PG). The C-PG format maintains the SP to PG relationship regardless of the physical layer or datalink layer used. This protocol can be used to transport multiple A_PDU1, multiple A_PDU2, or a combination of A_PDU1 and A_PDU2 messages in a single frame as specified in 6.5.2. Each A_PDU is formatted into a C-PG and multiple C-PGs may be packed into a single Multi-PG data frame. The Multi-PG protocol also provides a standard mechanism for optionally adding cybersecurity and/or functional safety to each C-PG within the Multi-PG.

6.5.1 Multi-PG Format

There are two forms of D_PDU for Multi-PG. The first form uses FEFF and is illustrated in Figure 11 and further defined in Figure 13. In this form, the PGN value shall be the Parameter Group Number shown in Figure 13. The other form uses FBFF as illustrated in Figure 12 and further defined in Figure 14. Both forms are used to implement a Multi-PG D_PDU.

The FEFF form of the Multi-PG is transmitted using the D_PDU1 format. The Multi-PG PG is a PDU1 type PG, allowing it to be sent to either a specific destination or to the global destination. When sent as D_PDU1 with a specific Destination Address in the PS field, this Multi-PG is referred to as a Destination Specific D_PDU1 Multi-PG. When sent as D_PDU1 with the global Destination Address (255) in the PS field, this Multi-PG is referred to as a Globally Addressed D_PDU1 Multi-PG.

The FBFF form of Multi-PG is transmitted using the D_PDU3 format and is referred to as a D_PDU3 Multi-PG message. The destination of a D_PDU3 Multi-PG message is always global. The FBFF form of the Multi-PG is identified by having 000_b for the AppPI in the CAN ID.

The destination of the Multi-PG D_PDU serves as the Destination Address of any contained A_PDU1 C-PGs, as specified in 6.5.3.6.2.

The number of C-PGs within a Multi-PG will vary as denoted by “z.” For SAE J1939 PGs, “z” is likely not more than 9, depending on the Payload Length of each C-PG. There is no delimiter between C-PGs because the Header of the C-PG defines its length.

Priority	PGN + DA	SA	C-PG 1	C-PG 2	...	C-PG z
			Multi-PG			
CAN Identifier Field			CAN FD Data Field			

Figure 11 - FEFF Multi-PG Format overview (D_PDU1)

AppPI=0	SA	C-PG 1	C-PG 2	...	C-PG z
		Multi-PG			
CAN Identifier Field		CAN FD Data Field			

Figure 12 - FBFF Multi-PG Format overview (D_PDU3)

While all data field lengths defined in ISO 11898-1 may be used with Multi-PG, when communicating SAE J1939 PGs, the Multi-PG data frame is typically at least 8 bytes long. If the sum total length of all C-PGs packed in a Multi-PG data field does not result in a valid CAN FD data frame length (see [6.3.3.2](#)), the remainder of the Multi-PG data field shall be packed using a padding service C-PG (see [6.5.3.5](#)). The data field padding defined in [6.3.3.2](#) shall not be used to pad the Multi-PG data frame data field to the DLC length. A Multi-PG must have at least one C-PG within it.

When using a (D_PDU1) FEFF Multi-PG, the priority field in the CAN ID may be set according to the C-PG contents. As a general rule, it is appropriate to set the Multi-PG Priority to the highest priority of any of the C-PGs within it.

Parameter Group Name:	FEFF (Extended Frame) Multi-PG (MCPG)
Definition:	Used for the transfer of 1 or more PGs. Each PG follows the C-PG format.
Transmission repetition rate:	As needed
Data length:	4 bytes minimum up to 64 bytes maximum
Extended Data Page:	0
Data Page:	0
PDU Format:	37
PDU Specific:	Destination Address (global or specific)
Default priority:	Highest Priority of the C-PGs contained
Parameter Group Number:	9472 (002500 _h)
Data Field:	
The data field consists of 1 or more C-PGs of TOS 1 through 7 followed by a Padding C-PG (TOS = 0) if required.	
For each C-PG where Type of Service is 1 through 7, the C-PG data format is as follows and repeats for each C-PG:	
Byte:	(a) 1.8 to 1.6 Type of Service (6.5.3.1)
	(b) 1.5 to 1.1 & 2 to 3 Service Header (6.5.3.6)
	(c) 4 Payload Length (6.5.3.2)
	(d) 5 to X C-PG Payload
Data repeats a, b, c, d, a, b, c, d, ...	
A Padding C-PG (TOS = 0) shall be included after the last C-PG (a, b, c, d) if required to pad the message to a DLC length. See 6.5.3.5 for details.	

Figure 13 - FEFF (Extended Frame) Multi-PG

Parameter Group Name:	FBFF (Base Frame) Multi-PG
Definition:	Used for the transfer of 1 or more PGs. Each PG follows the C-PG format.
Transmission repetition rate:	As needed
Data length:	4 bytes minimum up to 64 bytes maximum
Application Protocol Indicator:	0
Data Field:	
The data field consists of 1 or more C-PGs of TOS 1 through 7 followed by a Padding C-PG (TOS = 0) if required.	
For each C-PG where Type of Service is 1 through 7, the C-PG data format is as follows and repeats for each C-PG:	
Byte:	(a) 1.8 to 1.6 Type of Service (6.5.3.1)
	(b) 1.5 to 1.1 & 2 to 3 Service Header (6.5.3.6)
	(c) 4 Payload Length (6.5.3.2)
	(d) 5 to X C-PG Payload
Data repeats a, b, c, d, a, b, c, d, ...	
A Padding C-PG (TOS = 0) shall be included after the last C-PG (a, b, c, d) if required to pad the message to a DLC length. See 6.5.3.5 for details.	

Figure 14 - FBFF (Base Frame) Multi-PG

6.5.2 Packing C-PGs into Multi-PG

The Multi-PG method is used to transport one or more A_PDU1 or A_PDU2 in a single frame. Each A_PDU is formatted into a C-PG and multiple C-PGs may be packed into a single Multi-PG.

There are strict requirements for packing multiple A_PDU PGs (C-PGs) into a Multi-PG. See [Table 7](#) for a summary and [6.7](#) for a decision tree. All D_PDU methods must be supported for reception but the implementer may choose which path or paths to support for transmission; the transport model implementation shown in [Figure 36](#) shows the options.

- A C-PG must be fully contained within a single Multi-PG.
- The Destination Specific D_PDU1 instance of Multi-PG shall contain only A_PDU1 PGs for a single Destination Address (excluding the Global DA 255) and that same Destination Address shall be used in the Multi-PG D_PDU1 CAN ID.
- The Destination Specific D_PDU1 instance of the Multi-PG shall not contain A_PDU2 PGs, shall not contain globally addressed A_PDU1 PGs, and shall not contain A_PDU1 PGs for any other Destination Addresses.
- The Globally Addressed D_PDU1 instance of the Multi-PG shall contain only A_PDU2 PGs and globally addressed A_PDU1 PGs; and the Global DA (255) shall be used in the Multi-PG D_PDU1 CAN ID.
- The D_PDU3 instance of the Multi-PG shall contain only A_PDU2 PGs and globally addressed A_PDU1 PGs; this is permitted since the D_PDU3 is always global.

When packing multiple PGs into a single Multi-PG, the messages shall be packed in the same order they would have been sent if they were individually transmitted. Upon receipt, the ECU shall process the messages in the same order.

When packing multiple A_PDUs (C-PGs) into a Multi-PG message, the combined length of the C-PGs shall not exceed a single CAN FD frame. The FD Transport Protocol service shall not be used for any Multi-PG message. This restriction is established because the segmentation Transport Protocol would add unnecessary overhead and software complication.

Table 7 - Requirements for A_PDU1 and A_PDU2 usage in Multi-PGs

Multi-PG D_PDU	A_PDU1 (Destination Specific PG)		A_PDU2 (Broadcast PG)
	To Specific Address	To Global Address	
Destination Specific D_PDU1 (29-bit)	Allowed (only to same Specific Address)	Not allowed	Not allowed
Globally Addressed D_PDU1 (29-bit)	Not allowed	Allowed	Allowed
D_PDU3 (11-bit)	Not allowed	Allowed	Allowed

6.5.3 C-PG Format

There are two formats possible for a C-PG, shown in [Figure 15](#). The C-PG format is associated with the Type of Service (TOS) value. Every C-PG consists of the C-PG Header followed by the C-PG Payload. The Type of Service (TOS) field occupies the first 3 bits of every C-PG Header.

For TOS values 1 through 7, the C-PG Header shall be 4-bytes in length and the last byte of the C-PG Header shall be the Payload Length (PL) field, which specifies the byte length of the C-PG Payload. The 21 bits of the C-PG Header between the TOS field and the PL field is known as the Service Header. The content and structure of the Service Header shall be specific to each TOS. This format structure allows a recipient to parse C-PGs from the Multi-PG message even if it encounters some C-PGs with unknown TOS values.

For TOS 0 (Padding Service), each bit in the C-PG Header shall be zero. The C-PG Service Header for the padding service can be 1, 2, or 3 bytes long but never less than 1 byte as the TOS field must be present. The TOS 0 C-PG (Padding Service) does not have a Payload Length field because it is only permitted as the last C-PG in the Multi-PG data field.