SURFACE VEHICLE RECOMMENDED PRACTICE	J1939™-21	OCT2018
	Issued 1994-07 Revised 2018-10 Superseding J1939-21 JUN2018	
(R) Data Link Layer		

RATIONALE

This revision of the SAE J1939-21 Recommended Practice includes the following changes:

- A final set of edits have been made to align this document with data frame format definitions that were updated in ISO 11898-1:2015
- References to ISO documents used in this Recommended Practice have been corrected to identify the document and date of publication
- Updated interframe timing for TP.BAM messages
- Implementation rules for TP.CM_CTS and TP.CM_RTS messages have been updated, including guidance for error handling
- Additional rules about responding to a Request message are included in the notes to Table 5
- Binary numbering formats have been changed to include a subscripted letter b after the binary number (e.g., 010_b)
- Hexadecimal numbering formats have been changed to include a subscripted letter h after the hexadecimal number (e.g., FE_h)

There have also been formatting changes designed to improve consistency (particularly with the use of abbreviations) and to correct errors in the text and in illustrations. Finally, some of the diagrams from the previous version of the document have been replaced with new diagrams, as the Drawing functionality that was available in Microsoft Word 2010 has been removed from Microsoft Word 2013, preventing changes from being made to the diagrams.

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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. It is the characteristic that is common across all SAE J1939 applications.

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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 J1939-21, describes the data link layer using the Classical Extended Frame Format (CEFF) with 29-bit IDs, as defined in ISO 11898-1, December 2015. For SAE J1939, no alternative data link layers are permitted.

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 Serial Control and Communications Heavy Duty Vehicle Network - Top Level Document

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 Road Vehicles - Controller Area Network (CAN) - Part 1: Data Link Layer and Physical Signaling, December 2015

ISO 11992-4 Road Vehicles - Interchange of Digital Information on Electrical Connections Between Towing and Towed Vehicles - Part 4: Diagnostic Communication, May 2014

3. DEFINITIONS

Terms and definitions are defined in SAE J1939.

4. ABBREVIATIONS

ACK	Acknowledgment[1]
ACKM	Acknowledgement PG
BAM	Broadcast Announce Message
CAN	Controller Area Network (refer to ISO 11898-1)
CAN FD	CAN Flexible Data Rate
CAN ID	Controller Area Network Identifier
CBFF	Classical Base Frame Format
CEFF	Classical Extended Frame Format
CM	Connection Management
CRC	Cyclic Redundancy Check
CTS	Clear to Send
DA	Destination Address
DLC	Data Length Code
DP	Data Page
DT	Data Transfer
EDP	Extended Data Page
EOF	End of Frame (refer to ISO 11898-1:2015)
FBFF	FD Base Frame Format (refer to ISO 11898-1:2015)
FDF	FD Format indicator (refer to ISO 11898-1:2015)
FEFF	FD Extended Frame Format
GE	Group Extension
ID	Identifier
IDE	Identifier Extension (refer to ISO 11898-1:2015)
LSB	Least Significant Byte or Least Significant Bit
MF	Manufacturer
MSB	Most Significant Byte or Most Significant Bit

[1] In this document, ACK refers to the Acknowledgement PG (ACKM) with the control byte set to a value indicating positive acknowledgement, rather than the CAN in-frame ACK field.

NA	Not Allowed
NACK	Negative Acknowledgment
P	Priority
PDU	Protocol Data Unit
PF	PDU Format
PG	Parameter Group (a reference to the message)
PGN	Parameter Group Number (a reference to a specific PG/frame identification number)
PS	PDU Specific
RTR	Remote Transmission Request
RTS	Request to Send
SA	Source Address
SOF	Start of Frame (refer to ISO 11898-1:2015)
SPN	Suspect Parameter Number
SRR	Substitute Remote Request
TP	Transport Protocol
T_h	Hold Time
T_r	Response Time
un	Undefined

5. TECHNICAL REQUIREMENTS

The data link layer provides for the reliable transfer of data across the physical link. This consists of sending the CAN Data Frame with the necessary synchronization, sequence control, error control, and flow control. The flow control is accomplished by a consistent message/frame format.

5.1 Message/Frame Format

The SAE J1939 message format conforms to CAN requirements. The CAN specification referenced throughout this document is ISO 11898-1. It should be noted that when there are differences between the ISO 11898-1 specification and SAE J1939, then SAE J1939 is the guiding document. SAE J1939 does not use all of the functions defined in ISO 11898-1.

The definition of the SAE J1939 network requires that node addressing be used to prevent multiple nodes from using the same CAN ID field. Many additional requirements exist in SAE J1939 that are not specified by ISO 11898-1.

ISO 11898-1 contains the specification for four message formats: Classical Base Frame Format (CBFF) and Flexible Data Rate Base Frame Format (FBFF), which use 11-bit IDs; and Classical Extended Frame Format (CEFF) and Flexible Data Rate Extended Frame Format (FEFF), which use 29-bit IDs. ISO 11898-1 compatibility implies that messages of any format can potentially be present on a single network by using certain bit codings that allow for the recognition of the different formats. By contrast, SAE J1939 only supports the CBFF and CEFF CAN Data Frame formats. SAE J1939 only defines a full strategy for standardized communications using the CEFF format. CBFF format messages are for proprietary use following the rules defined in this document. SAE J1939 devices MUST use the CEFF format. CBFF format messages can reside on the network, but only as described in this document.

CAN FD controllers are available and may be connected to an SAE J1939-21 network. SAE J1939-21 does not support the FBFF or FEFF frame formats. CAN FD controllers attached to an SAE J1939-21 network are expected to conform to the SAE J1939 rules outlined in this and other SAE J1939 documents, and must use the 29-bit CEFF arbitration field as defined by J1939-21. CAN FD features must not be used while the SAE J1939-21 network is in operation because J1939 devices are not guaranteed to be CAN FD tolerant.

NOTE: CBFF devices do not respond to SAE J1939 network management messages and are not able to support the strategy for standardized communications.

The CAN Data Frame is parsed into different bit fields. The number and parsing of the bits in the arbitration and control fields differ between CBFF and CEFF messages. CBFF messages contain 11 identifier bits in the arbitration field, and CEFF messages contain 29 identifier bits in the arbitration field. SAE J1939 has further defined the identifier bits in the arbitration field of the CAN Data Frame formats. These definitions can be seen in Table 1.

5.1.1 SAE J1939 Message Format (Based on ISO 11898-1 CEFF Format)

The CEFF-based message encompasses a single Protocol Data Unit (PDU). PDUs consist of seven predefined fields. These fields are assimilated from information provided by the application layer. The fields 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)
Data

These fields are packaged into one or more CAN Data Frames and sent over the physical media to other network devices. It should be recognized that some Parameter Group Number definitions require more than one CAN Data Frame to send their information.

Table 1 shows the arbitration and control fields of the following message formats: 29-bit identifier for CAN CEFF format messages; 29-bit identifier for SAE J1939 messages; 11-bit identifier for CAN CBFF format messages; and the 11-bit identifier for SAE J1939 compatibility. A complete definition for each of the SAE J1939 bit field assignments can be found in the sections that define the SAE J1939 Protocol Data Unit (see 5.2). Throughout this document the CAN Data Frame's Data field is discussed as byte 1 through 8. Byte 1's most significant bit (bit 8) is the first bit sent and is closest to the DLC field. Byte 8's least significant bit (bit 1) is the last of the data bits to be sent and is closest to the CRC Field.

Messages with EDP equal to one and DP equal to one are messages for communication between a towing vehicle and one or more towed vehicles as defined in ISO 11992-4. Therefore, the processing of the CAN Data Frame will not follow the definitions provided by SAE J1939 specifications. The user should consult the ISO 11992-4:2014 specifications for further guidance.

Messages with EDP equal to one and DP equal to zero are reserved for future assignment by the SAE J1939 committee. Any messages present on a SAE J1939 datalink that use these values will require unique handling rules as the rules specified in SAE J1939-21 will not apply to these messages. When messages using these values are defined by the SAE J1939 committee, handling rules will be specified in a future version of the SAE J1939-21 document.

Table 1 - Mapping of SAE J1939 into CAN'S arbitration and control fields

29-bit Identifiers CAN	29-bit Identifiers SAE J1939	Frame Bit Position	11-bit Identifiers CAN	11-bit Identifiers SAE J1939†
SOF	SOF*	1	SOF	SOF*
ID 28	P 3	2	ID 28	P 3
ID 27	P 2	3	ID 27	P 2
ID 26	P 1	4	ID 26	P 1
ID 25	EDP	5	ID 25	SA 8
ID 24	DP	6	ID 24	SA 7
ID 23	PF 8	7	ID 23	SA 6
ID 22	PF 7	8	ID 22	SA 5
ID 21	PF 6	9	ID 21	SA 4
ID 20	PF 5	10	ID 20	SA 3
ID 19	PF 4	11	ID 19	SA 2
ID 18	PF 3	12	ID 18	SA 1
SRR (r)	SRR*	13	RTR (x)	RTR (d)
IDE (r)	IDE*	14	IDE (d)	IDE*
ID 17	PF 2	15	FDF (d)	FDF*
ID 16	PF 1	16	DLC 4	DLC 4
ID 15	PS 8	17	DLC 3	DLC 3
ID 14	PS 7	18	DLC 2	DLC 2
ID 13	PS 6	19	DLC 1	DLC 1
ID 12	PS 5	20		
ID 11	PS 4	21		
ID 10	PS 3	22		
ID 9	PS 2	23		
ID 8	PS 1	24		
ID 7	SA 8	25		
ID 6	SA 7	26		
ID 5	SA 6	27		
ID 4	SA 5	28		
ID 3	SA 4	29		
ID 2	SA 3	30		
ID 1	SA 2	31		
ID 0	SA 1	32		
RTR (x)	RTR (d)	33		
FDF (d)	FDF*	34		
r0 (d)	r0*	35		
DLC 4	DLC 4	36		
DLC 3	DLC 3	37		
DLC 2	DLC 2	38		
DLC 1	DLC 1	39		

NOTES

SOF - Start of Frame Bit
ID ## - Identifier Bit #n
EDP - SAE J1939 Extended Data Page
SRR - Substitute Remote Request
RTR - Remote Transmission Request Bit
IDE - Identifier Extension Bit
P # - SAE J1939 Priority Bit #n
FDF - FD Format bit
DLC # - Data Length Code Bit #n
SA # - SAE J1939 Source Address Bit #n
DP - SAE J1939 Data Page
PF # - SAE J1939 PDU Format Bit #n

r0 - CAN Reserved Bit #0
(r) - recessive bit
(d) - dominant bit
PS # - SAE J1939 PDU Specific Bit #n
(x) - bit state dependent on message
* ISO 11898-1 Defined Bit, Unchanged in SAE J1939
† Required format of proprietary 11-bit identifiers for compatibility with SAE J1939

5.1.2 Parameter Group Number (PGN)

Whenever it is necessary to identify a Parameter Group Number (PGN) in the Data field of a CAN Data Frame, it will be expressed in 24 bits. The 24-bit value is sent LSB first, middle byte second, and MSB third, and has the following constituent components:

6 bits set to zero
EDP
DP
PF (8 bits)
PS (8 bits)

The procedure for converting the identifier fields to a PGN is as follows:

a. The six most significant bits of the PGN are set to zero.

b. EDP, DP, and PF are copied into the next 10 bits.

c. If the PF value is less than 240 (F0h), then the least significant byte of the PGN is set to zero. Otherwise it is set to the value of the PS field.

See Table 2 for an illustration of the constituent component bit fields and their corresponding PGN. 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). The Cumulative Number of PGNs column in Table 2 identifies the number of PGNs possible. Refer to SAE J1939 Digital Annex for the complete list of assigned PGNs

Table 2 - Parameter group number examples (SAE USE EDP=0)

PGN Constituent Components	PGN Constituent Components	PGN Constituent Components	PGN Constituent Components	PGN Constituent Components					
PGN (MSB)	PGN (MSB)	PGN (MSB)	PGN	PGN (LSB)					
Byte 1	Byte 1	Byte 1	Byte 2	Byte 3					
Sent Third in CAN Data Frame			Sent Second in CAN Data Frame	Sent First in CAN Data Frame					
	EDP	DP	PF	PS	PGN	PGN	Number of Assignable PGNs	Cumulative Number of PGNs	SAE or Manufacturer Assigned
Bits 8 to 3	Bit 2	Bit 1	Bits 8 to 1	Bits 8 to 1	Dec	Hex_h			
0	0	0	0	0	0	000000_h			SAE
							239	239	
0	0	0	238	0	60928	$00EE00_h$			
0	0	0	239	0	61184	$00EF00_h$	1	240	MF
0	0	0	240	0	61440	$00F000_h$			SAE
							3840		
0	0	0	254	255	65279	$00FEFF_h$		4080	
0	0	0	255	0	65280	$00FF00_h$			
							256		MF
0	0	0	255	255	65535	$00FFFF_h$		4336	
0	0	1	0	0	65536	010000_h			
							239	4575	SAE
0	0	1	238	0	126464	$01EE00_h$			
0	0	1	239	0	126720	$01EF00_h$	1	4576	MF
0	0	1	240	0	126976	$01F000_h$			
							3840		
0	0	1	254	255	130815	$01FEFF_h$		8416	SAE
0	0	1	255	0	130816	$01FF00_h$			
							256		MF
0	0	1	255	255	131071	$01FFFF_h$		8672	
TOTALS							8672	8672	

5.1.3 Support of ISO 11898-1 CBFF Format Messages

It is recognized that controllers on the SAE J1939 network may support CBFF messages. Though these are not compatible with the SAE J1939 message structure, to accommodate the coexistence of the two formats, a minimum level of definition is given. This minimum definition allows devices that use this format to not interfere with other devices. CBFF messages are defined to be proprietary. Referencing Table 1, the 11-bit identifier field is parsed as follows: the three most significant bits are used as Priority bits; the eight least significant bits identify the Source Address (SA) of the PDU. Priority bits are described in 5.2.1. The SA is defined in the Source Address Table (refer to SAE J1939 Digital Annex).

NOTE: Incorrect bus arbitration could occur when two or more controllers, one of which is sending a CBFF message, attempt to access the bus at the same time. The Source Address has a higher relative priority in CBFF messages than in CEFF messages. The CBFF message could have an SA field indicating a higher priority than the EDP bit, DP bit, and PF of the SAE J1939 message. The three Priority bits should be used to achieve the correct message sequence.

SAE J1939 only defines a full strategy for standardized communications using the CEFF message format. Hardware that does not conform to ISO 11898-1, as well as hardware that uses only the FBFF or FEFF message formats, MUST NOT be used on an SAE J1939 network, to avoid disruption of network operation.

5.2 Protocol Data Unit (PDU)

The applications and/or network layer provide a string of information that is assimilated into a Protocol Data Unit (PDU). The PDU provides a framework for organizing the information that is key to each CAN Data Frame that is sent. The SAE J1939 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 fields are packaged into one or more CAN Data Frames and sent over the physical media to other network devices. There is only one PDU per CAN Data Frame.

Some Parameter Group (PG) definitions require more than 8 data bytes and thus require more than one CAN Data Frame to send the corresponding data. Transport Protocol (TP) messages are used to transport PGs with more than 8 data bytes.

Some of the CAN Data Frame fields have been intentionally left out of the J1939 PDU definition because they are defined and controlled entirely by ISO 11898-1 and are invisible to all of the OSI layers above the data link layer. The fields that are controlled in this manner include the SOF, SRR, IDE, RTR, FDF, r0, CRC, ACK, and EOF fields. The seven PDU fields are illustrated in Figure 1. Each of the fields within the PDU is defined in the subsequent sections.

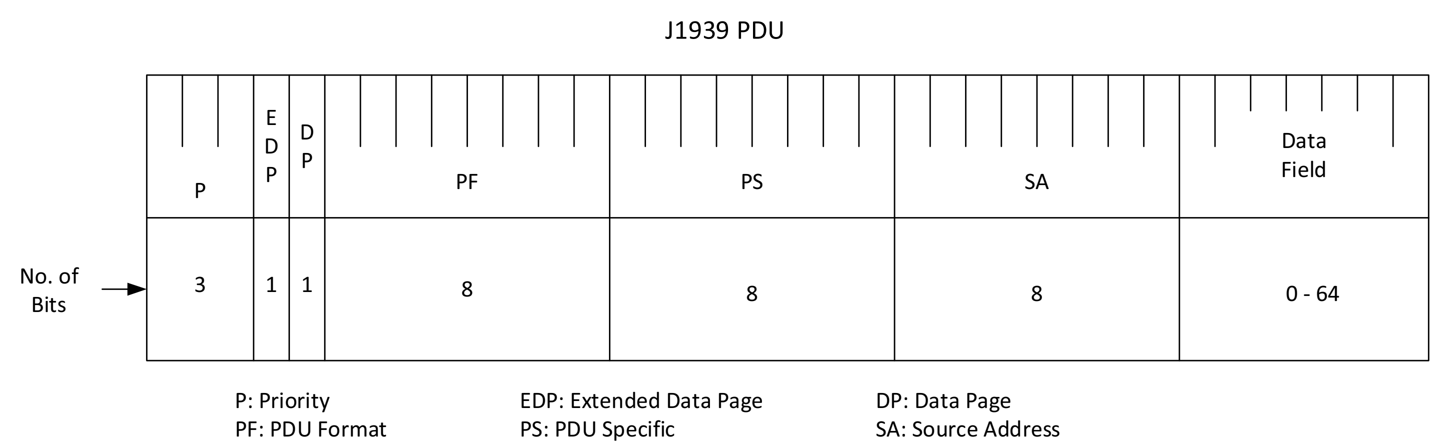


Figure 1 - Protocol data unit

5.2.1 Priority (P)

These three bits are used to optimize message latency for transmission onto the bus only. They should be globally masked off by the receiver (ignored). The priority of any message 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 PGN when it is added to the application layer document. However, the Priority field should be reprogrammable to allow for network tuning by the OEM should the need arise.

5.2.2 Extended Data Page (EDP)

The EDP is used in conjunction with the DP to determine the structure of the CAN ID of the CAN Data Frame. All SAE J1939 messages shall set EDP to zero on transmit. See Table 3 to find the defined uses of the EDP and DP. Future definitions with EDP set to one could expand the PDU Format field, define new PDU formats, or increase the address space.

5.2.3 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 zero, the DP selects between page 0 and page 1 of PGN descriptions. See Table 3. Also see Figure 2 to see the SAE J1939 Parameter Group Number template.

Table 3 - 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	ISO 11992-4 defined

NOTE: When the EDP and DP of the CAN 29-bit ID are set to 11_b, the frame is identified as an ISO 11992-4:2014 diagnostic message. This means that the rest of the CAN ID is NOT set up the same as SAE J1939 specifies. CAN Data Frames following this format are not described in the SAE J1939 series of SAE recommended practices.

EDP	DP	PF	PS	Parameter Group Definition	Multipacket	PGN
0	0	0	DA	PDU1 Format – 100 ms or less	Not Allowed	0
0	0	1	DA		Not Allowed	256
Boundary X				↓ ↑		
0	0	238	DA	PDU1 Format – greater than 100 ms	Allowed	60928
0	0	239	DA	PDU1 Format – Proprietary A	Allowed	61184
0	0	240	0	PDU2 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 Format – greater than 100 ms	Allowed	65279
0	0	255	0-255	PDU2 Format – Proprietary B	Allowed	65280-65535
0	1	0	DA	PDU1 Format – 100 ms or less	Not Allowed	65536
0	1	1	DA		Not Allowed	65792
Boundary X1				↓ ↑		
0	1	238	DA	PDU1 Format – greater than 100 ms	Allowed	126464
0	1	239	DA	PDU1 Format – Proprietary A2	Allowed	126720
0	1	240	0	PDU2 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 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

Figure 2 - SAE J1939 parameter group number template

5.2.4 PDU Format (PF)

The PDU Format is an 8-bit field that defines whether a PGN has a PDU1 or PDU2 Format, and is one of the fields used to determine the PGN assigned to the Data field. PGNs are used to identify or label commands, data, some requests, acknowledgments, and negative-acknowledgments. PGNs identify or label information that may require one or more CAN Data Frames to communicate the information. If there is more information than fits in 8 data bytes, then a multipacket message needs to be sent (see 5.10). If there are 8 or fewer data bytes, then a single CAN Data Frame is used. A PGN can represent one or more parameters, where a parameter is a piece of data, such as engine rpm. Even though a PGN label can be used for one parameter, it is recommended that multiple parameters be grouped so that all 8 bytes of the Data field are used.

The definition of proprietary PGNs has been established allowing both PDU1 and PDU2 Formats to be used. The interpretation of the proprietary information varies by manufacturer. For example, even though two different engines may use the same source address, manufacturer "A's" proprietary communications are likely to be different from manufacturer "B's."

5.2.5 PDU Specific (PS)

The PDU Specific field is an 8-bit field and its definition depends on 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 4. See Figure 2 for the range of PGNs.

Table 4 - PDU specific

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

5.2.5.1 Destination Address (DA)

This field defines the specific address to which the message is being sent. Note that any other device should ignore this message. The global DA (255) requires all devices to listen and respond accordingly as message recipients.

5.2.5.2 Group Extension (GE)

The GE field, in conjunction with the four least significant bits of the PF field (note that when the four most significant bits of the PF field are set, it indicates that the PS field is a GE), provides for 4096 PGNs per data page. These 4096 PGNs are only available using the PDU2 Format. In addition, 240 PGNs are provided in each data page for use only in the PDU1 Format. In total, 8672 PGNs are available to be defined using the two data pages currently available.

The total number of PGNs available can be calculated as follows in Equation 1:

$$(240 + (16 \times 256)) \times 2 = 8672 \qquad \text{(Eq. \#1)}$$

where:

240 = number of PF field values available per data page (i.e., PDU1 Format, PS Field equals DA)
16 = PF values per GE value (i.e., PDU2 Format)
256 = number of possible GE values (i.e., PDU2 Format)
2 = number of defined DP values (both PDU Formats)

5.2.6 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, as required by CAN. 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 J1939 Digital Annex for SA assignments.

5.2.7 Data Field

5.2.7.1 Data from 0 to 8 Bytes

When 8 bytes or fewer of data are required for expressing a given PG, then all 8 data bytes of the CAN Data Frame can be used. It is generally recommended that 8 data bytes be allocated or reserved for all PGN assignments which are likely to expand in the future. This provides a means to easily add parameters and not be incompatible with previous revisions that only defined part of the Data field. Once the number of data bytes associated with a PG is specified, the number of data bytes cannot be changed, and the PG cannot become multipacket unless originally defined as multipacket. The CAN Data Length Code (DLC) is set to the defined PG “Data Length” value when it is 8 bytes or less, and to 8 in each CAN Data Frame for PGs whose Data Length is 9 or more bytes. For example, the Request PGN 59904, has the PG Data Length as 3 so the CAN DLC is set to 3. It is important to note that an individual group function PG (see 5.4.5) must use the same length Data field because the CAN ID will be identical while the Data field will be used to convey the specific group subfunctions, therefore requiring many different interpretations based on the Data field.

5.2.7.2 Data from 9 to 1785 Bytes

When a PG is defined with between 9 and 1785 bytes of data to be transmitted, the communication of this data is done in multiple CAN Data Frames. Thus, the term multipacket is used to describe this type of PG. A PG defined as multipacket capable, having fewer than 9 data bytes to transfer in a specific instance, shall be sent in a single CAN Data Frame with the DLC set to 8. When a particular PG has more than 8 data bytes to transfer, Transport Protocol (TP) is used. The Transport Protocol Connection Management (TP.CM) PGN is used to set up and close out the communication of the multipacket PGs. The Transport Protocol Data Transfer (TP.DT) PGN is used to communicate the data itself in a series of CAN Data Frames (packets) containing the packetized data. Additionally, Transport Protocol provides flow control and handshaking capabilities for destination-specific transfers using Request to Send (RTS) and Clear to Send (CTS) messages. See 5.10.

All CAN Data Frames associated with a particular multipacket response are required to have a DLC of 8. All unused data bytes are set to “not available” (see SAE J1939-71). The number of bytes per packet is fixed; however, SAE J1939 defines multipacket messages that have a variable and/or a fixed number of packets. The PG for active diagnostic codes (DM1) is an example of a multipacket message that has a “variable” number of packets. PGs that are defined as multipacket only use TP when the number of data bytes to send exceeds eight.

5.3 Protocol Data Unit (PDU) Formats

The available PDU formats are illustrated in Figure 3. Two PDU formats are defined: PDU1 Format (PS = DA) and PDU2 Format (PS = GE). PDU1 Format allows for direction of the CAN Data Frame to a specific DA (device). The PDU2 Format can only communicate CAN Data Frames that are not destination-specific. The creation of two separate PDU formats was established in order to provide more possible PGN combinations while still providing for destination-specific communications. Proprietary PG definitions have been assigned so that both PDU formats are available for proprietary communications. A standardized method was established for proprietary communications to prevent possible conflicts in identifier usage.

The definition of proprietary PGs has been established allowing both PDU1 and PDU2 Formats to be used. The interpretation of the proprietary information varies by manufacturer. For example engine manufacturer “A’s” proprietary communications are likely to be different than engine manufacturer “B’s” even though they both use the same source address.

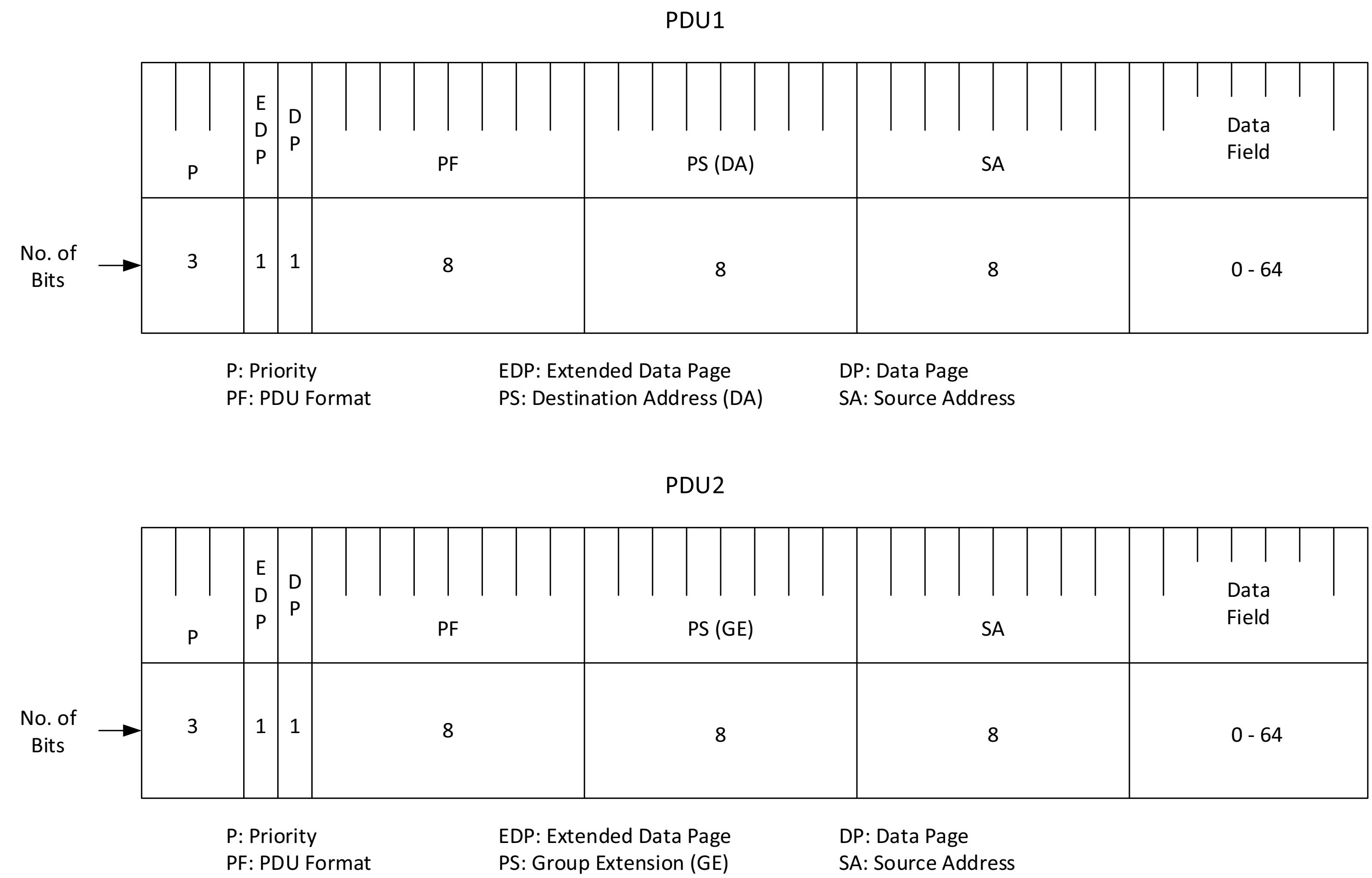


Figure 3 - Available PDU formats

5.3.1 PDU1 Format

This format allows applicable PGs to be sent to either a specific or global DA. The PS field contains a DA. PDU1 Format messages can be requested or sent as unsolicited messages.

PDU1 Format messages are determined by the PF field. When the PF field value is 0 to 239, the message is a PDU1 Format message. The formatting of the PDU1 Format message is illustrated in Figure 3. Also see Figure 4, PDU1 Format.

PGs requiring a DA and minimal latency start at PF = 0 and increment toward x (or x1). See Figure 2.

PGs requiring a DA where latency is not critical start at PF = 238 and decrement toward x (or x1). See Figure 2.

Two PGs with PF equal to 239, with EDP = 0 and DP = 0 or 1, are assigned for proprietary use. The PS field contains a DA (see 5.2.5). The Proprietary A PGN is 61184 and the Proprietary A2 PGN is 126720. See 5.4.5 for descriptions of the Proprietary A and Proprietary A2 PGs.

NOTE: The global DA should not be used with Proprietary A and Proprietary A2 PGs.

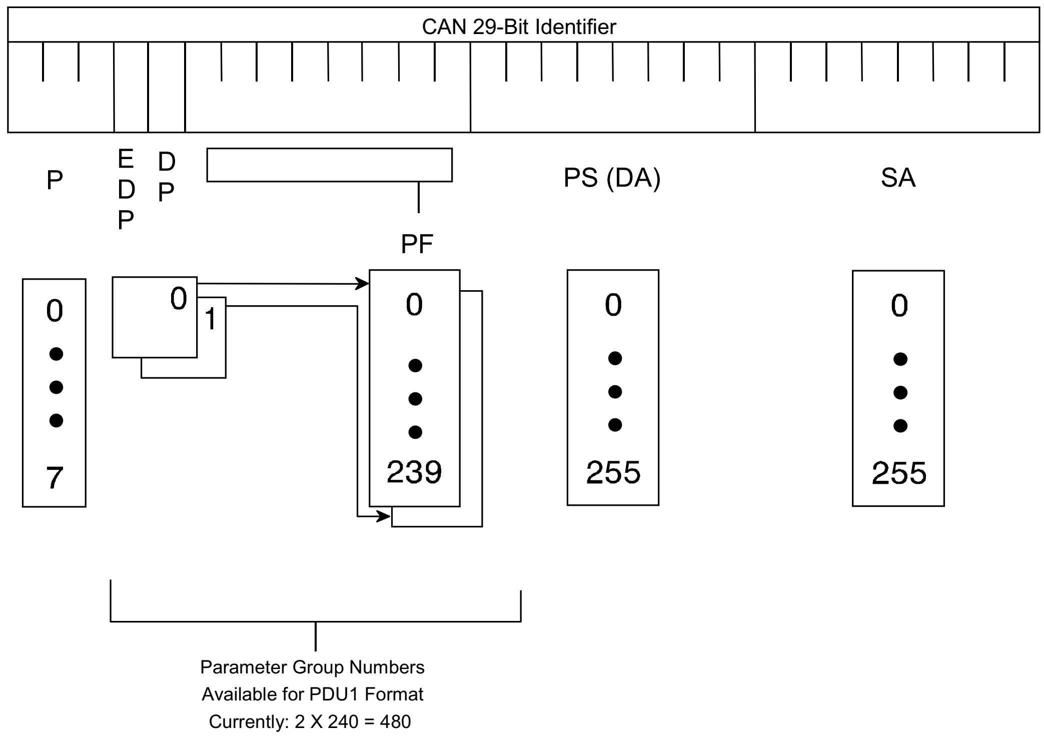


Figure 4 - PDU1 format

5.3.2 PDU2 Format

This format can only be used to communicate PGs to the global DA; the global DA is implied by the PDU2 Format and does not appear in the arbitration field. PDU2 Format messages can be requested or sent as unsolicited messages. Selection of PDU2 Format, at the time a PGN is assigned, prevents that PG from ever being able to be directed to a specific DA (unless multipacket and TP RTS/CTS protocol is used). The PS field contains a Group Extension.

PDU2 Format messages are defined to be those where the PF field is equal to 240 to 255 (see Figure 2). The formatting of the PDU2 Format message is illustrated in Figure 3. Also see Figure 5, PDU2 Format.

The PGNs of messages that are sent at fast update rates (generally less than 100 ms) start at PF = 240 and increment toward y (or y1). See Figure 2.

The PGNs of messages that are only requested, sent on change, or sent at slow update rates (generally greater than every 100 ms) start at PF = 254 and decrement toward y (or y1). See Figure 2.

512 PGNs with PF equal to 255, with EDP = 0 and DP = 0 or 1, are assigned for proprietary use. In this case the PDU Specific field is left to be defined and used by each manufacturer (see 5.4.5). The PGNs for Proprietary B with DP = 0 cover the range 65280 to 65535, while the PGNs for Proprietary B with DP = 1 cover the range 130816 to 131071. See 5.4.5 for a description of the Proprietary B message.

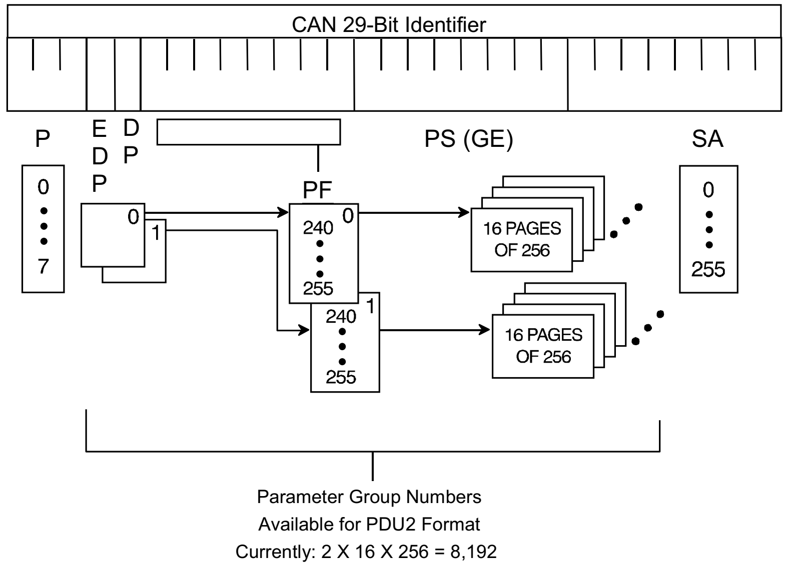


Figure 5 - PDU2 format

5.4 Message Types

There are five message types currently supported. These types are the following: Commands, Requests, Broadcasts/Responses, Acknowledgment, and Group Functions. The specific message type is recognized by its assigned PGN. Refer to the SAE J1939 Digital Annex document for examples of PGN assignments. The RTR bit (defined in ISO 11898-1 for remote frames) shall not be used in the recessive state (logical 1). Therefore, Remote Transmission Requests (RTR = 1) are not available for use in SAE J1939.

Multibyte parameters that appear in the Data field of a CAN Data Frame are placed least significant byte first. Exceptions are noted where applicable (i.e., ASCII data). So if a 2-byte parameter were to be placed in bytes 7 and 8 of the CAN DATA Frame, the LSB would be placed in byte 7 and the most significant byte in byte 8.

5.4.1 Command

This message type categorizes those PGs that convey a command to a specific or global destination from a source. The destination is then supposed to take specific actions based on the reception of this command message type.

Both PDU1 Format (PS = DA) and PDU2 Format (PS = GE) messages can be used for commands. Example command type messages may include “Transmission Control,” “Address Request,” “Torque/Speed Control,” etc.

5.4.2 Request

This message type, identified by the PGN, provides the capability to request information globally or from a specific DA. Requests specific to one DA are known as destination-specific requests. The information in Figure 6 shows the PG definition for the “Request PGN”. Table D1 in Appendix D has the Suspect Parameter Number (SPN) assignments to parameters in this message. Additional SAE J1939 PGs define a request and response sequence. The request response behavior identified in Table 5 is applicable unless otherwise specified, as well as the notes to Table 5 which provide additional clarification.

Parameter Group Name:	**Request (RQST)**
Definition:	Used to request a Parameter Group from a network device or devices.
Transmission repetition rate:	Per user requirements, generally recommended that requests occur no more than 2 or 3 times per second.
Data length:	3 bytes (The CAN frame for this PG shall set the DLC to 3.)
Extended Data Page:	0
Data page:	0
PDU Format:	234
PDU Specific:	Destination Address (global or specific)
Default priority:	6
Parameter Group Number:	59904 (00EA00$_h$)
Byte 1, bits 8-1	LSB of PGN being requested (most significant at bit 8)
Byte 2, bits 8-1	Second byte of PGN being requested (most significant at bit 8)
Byte 3, bits 8-1	MSB of PGN being requested (most significant at bit 8)

See 5.1.2 for additional clarification on byte content

Figure 6 - Request PG definition

Table 5 iterates the request/response possibilities for PDU1 and PDU2 Format PGs. It clarifies that the transmitter of a message determines whether the destination is specific or global based on whether the request was to a specific destination address or to a global destination address. Note that some PGs are multipacket and require Transport Protocol (TP) use, so several CAN Data Frames can occur as a result of a single request.

Table 5 also shows that for unsolicited messages the transmitter has the choice of transmitting to a specific destination address or to a global destination address for PDU1 PGs and PDU2 PGs with more than 8 bytes. For PDU2 PGs with 8 bytes or less, the transmitter can only send the data globally.

Table 5 - PDU1 and PDU2 transmit, request, and response requirements

PDU Format of Requested PG	Data Length of Requested PG	Request PGN 59904 and Other Applicable PGNs	Response	TP Used
1	≤8 bytes	DA Specific	DA Specific	NA
1	≤8 bytes	DA Global	DA Global	NA
1	≤8 bytes	none	DA Global	NA
			DA Specific	NA
1	>8 bytes	DA Specific	DA Specific	RTS/CTS
1	>8 bytes	DA Global	DA Global	BAM
1	>8 bytes	none	DA Global	BAM
			DA Specific	RTS/CTS
2	≤8 bytes	DA Specific	DA Global	NA
2	≤8 bytes	DA Global	DA Global	NA
2	≤8 bytes	none	DA Global	NA
2	>8 bytes	DA Specific	DA Specific	RTS/CTS
2	>8 bytes	DA Global	DA Global	BAM
2	>8 bytes	none	DA Global	BAM
			DA Specific	RTS/CTS

Notes to Table 5 - General rules of operation for determining whether to send a PG to a global or specific destination:

1. If the Request or applicable PG is sent to the global DA (global request), then the response is sent to the global DA.
    a) A NACK (ACKM with control byte = 1) must not be generated if the controller does not support the requested PG.
    b) A BUSY (ACKM with control byte = 3) may be generated if the controller supports the requested PG, but cannot respond within t_r for the network segment.
    c) An ACKM (control byte = 0 or 1) is not desired as a response to a global request for a supported PG. However, a global request is allowed to be responded to with an ACK or a NACK for the result of the action taken when the requested PG (e.g., DM3, DM11) is supported by a node and the requested PG allows or requires an ACKM response. These cases will be documented in the appropriate SAE J1939 Recommended Practice document.
    d) An ACKM (with control byte = 2) may be generated as warranted.
    e) A controller shall not send both an ACKM and a PG response.
2. If the Request or applicable PG is sent to a specific DA, then a response is required.
    a) A NACK is required if the PGN is not supported.
    b) If the data length is more than 8 bytes, a destination-specific Transport Protocol session (using RTS and CTS messages) must be used to transmit the response.
    c) Responses shall be made to a specific DA, with the following exceptions:
        i) PDU2 Format PGs that are 8 bytes or less in length can only be sent to a global DA because there is no DA field in the PDU2 Format.
        ii) The Address Claim PG is sent to the global DA even though the request for it may have been to a specific DA (refer to SAE J1939-81).
        iii) The Acknowledgment PG response uses a global DA even though the PG that causes Acknowledgment was sent to a specific DA.
3. For periodic broadcasts or unsolicited messages
    a) PDU1 Format PGs or PDU2 Format PGs can be sent to a global or specific DA.
        i) Exception: PDU2 Format PGs with 8 bytes or less can only be sent to a global DA because there is no DA field in the PDU2 Format.
4. Exceptions to these rules do exist and are specifically noted when this is the case. These exceptions are noted in the applicable document and section where the PG is defined. Two different types of exceptions are included:
    a) When the response DA does not specify the SA of the request. Some examples have been noted above (e.g., Address Claim PG and Acknowledgment PG).
    b) When the PG does not support all forms of the available addressing. That is, some PGs may not be designed to support the address capability that is available for PDU1 or PDU2 Format messages.

The Request PGN can be directed to a specific DA to determine if a specific PGN is supported (i.e., does the requested DA transmit the specific PG?) The response to the request determines whether the PG is supported. If it is supported, then the responding device shall send the requested information. If the Acknowledgment PG is appropriate, then the control byte shall be set to zero or two or three, as appropriate. If it is not supported, the responding device sends the Acknowledgment PG with the control byte set to one, for NACK. The remaining portions of the SAE J1939 PDU format and PG must be filled in appropriately (see 5.4.4). Note that per the definitions in this paragraph the phrase “not supported” means that the PG is not transmitted. It is not possible to determine whether a device will act upon the received PG by using this method.

If a device fails to get a response (either the PG or the ACKM) to a Request within T_r, then the device may resend or retry the same Request. The number of retries for a specific Request should be limited to two retries, i.e., the Request is issued a total of three times. If the device fails to get a response (either the PG or the ACKM) to the Request after the third retry, then the device should abandon further request attempts for the same information or the device may wait for an extended period of time (minutes rather than seconds) before attempting to request the same information.

5.4.3 Broadcast/Response

This Message Type can be an unsolicited broadcast of information from a device or it can be the response to a Command or a Request.

5.4.4 Acknowledgment

There are two forms of acknowledgment available. The first form is provided for in the CAN Data Frame. It consists of an "in-frame" acknowledgment which confirms that a message has been received by at least one node. In addition, messages are further acknowledged by the absence of CAN error frames. Their absence acknowledges that all other powered and connected devices received the message correctly.

The second form of acknowledgment is the response of a normal broadcast, ACK, or NACK message to a specific command or request as provided for by an application layer. The definition of the Acknowledgment PG (ACKM) is contained in Figure 7. Table D1 in Appendix D has the SPN assignments to parameters in this message. The type of acknowledgment required for some PGs is defined in the applications layer.

For Group Function PGs (see 5.4.5) the Group Function Value parameter allows a device to identify the specific group function that is being acknowledged. The Group Function Values are unique to each Group Function PG. It is desirable that the Group Function Values only use the range 0 to 250.

Each form of the Acknowledgment PG includes an address acknowledge byte that contains the SA of the originator of the request that the Acknowledgment PG is directed towards. Since the Acknowledgment PG is always directed to the global DA, these parameters allow the receiver to know the target being acknowledged. In Figure 7 these parameters, in byte 5, are Address Acknowledged, Address Negative Acknowledgment, Address Access Denied, and Address Busy.

Parameter Group Name:	**Acknowledgment (ACKM)**
Definition:	The Acknowledgment PG is used to provide a handshake mechanism between transmitting and receiving devices. See Table 5 and notes to Table 5 for further information about using the Acknowledgement PG.
Transmission repetition rate:	Upon reception of a PGN that requires this form of acknowledgment.
Data length:	8 bytes
Extended Data Page:	0
Data Page:	0
PDU Format:	232
PDU Specific:	Destination Address[2] = Global (255)
Default priority:	6
Parameter Group Number:	59392 (00E800h)

Data ranges for parameters used by this Message Type:

Control byte: See detailed message definitions immediately following the parameter definitions:

0	Positive Acknowledgment (ACK)
1	Negative Acknowledgment (NACK)
2	Access Denied
3	Cannot Respond
4 to 127	Reserved for assignment by SAE

SPECIAL ACKNOWLEDGEMENT CASES ONLY FOR WHEN THE REQUEST2 UTILIZES THE EXTENDED IDENTIFIER TYPE

128	Positive Acknowledgment (ACK) for Request2 having an Extended Identifier Type of "One Byte Extended Identifier"
129	Negative Acknowledgment (NACK) for Request2 having an Extended Identifier Type of "One Byte Extended Identifier"
130	Access Denied for Request2 having an Extended Identifier Type of "One Byte Extended Identifier"
131	Cannot Respond for Request2 having an Extended Identifier Type of "One Byte Extended Identifier"
132 to 143	Reserved for assignment by SAE
144	Positive Acknowledgment (ACK) for Request2 having an Extended Identifier Type of "Two Byte Extended Identifier"
145	Negative Acknowledgment (NACK) for Request2 having an Extended Identifier Type of "Two Byte Extended Identifier"
146	Access Denied for Request2 having an Extended Identifier Type of "Two Byte Extended Identifier"
147	Cannot Respond for Request2 having an Extended Identifier Type of "Two Byte Extended Identifier"
148 to 159	Reserved for assignment by SAE
160	Positive Acknowledgment (ACK) for Request2 having an Extended Identifier Type of "Three Byte Extended Identifier"
161	Negative Acknowledgment (NACK) for Request2 having an Extended Identifier Type of "Three Byte Extended Identifier"
162	Access Denied for Request2 having an Extended Identifier Type of "Three Byte Extended Identifier"
163	Cannot Respond for Request2 having an Extended Identifier Type of "Three Byte Extended Identifier"
164 to 254	Reserved for assignment by SAE
255	Don't care/take no action

[2] The global destination address makes it possible to filter on one CAN ID for all Acknowledgment messages.

Group Function Value	0 to 250	Definition is specific to the individual PG, when applicable.

Most often it is located as the first byte in the Data field of the applicable Group Function PG.

	251 to 255	Follows conventions defined in SAE J1939-71

Detailed message definitions:

Positive Acknowledgment: Control byte = 0

Byte:	1	Control byte = 0, Positive Acknowledgment (ACK)
	2	Group Function Value (If applicable)
	3 to 4	Reserved for assignment by SAE, these bytes should be filled with FFh
	5	Address Acknowledged
	6	PGN of requested information (LSB of parameter group number, bit 8 most significant)
	7	PGN of requested information (2nd byte of parameter group number, bit 8 most significant)
	8	PGN of requested information (MSB of parameter group number, bit 8 most significant)

Negative Acknowledgment: Control byte = 1

Byte:	1	Control byte = 1, Negative Acknowledgment (NACK)
	2	Group Function Value (if applicable)
	3 to 4	Reserved for assignment by SAE, these bytes should be filled with FFh
	5	Address Negative Acknowledgement
	6 to 8	PGN of requested information (see above)

Access Denied: Control byte = 2

Byte:	1	Control byte = 2, Access Denied (PGN supported but security denied access)
	2	Group Function Value (if applicable)
	3 to 4	Reserved for assignment by SAE, these bytes should be filled with FFh
	5	Address Access Denied
	6 to 8	PGN of requested information (see above)

Cannot Respond: Control byte = 3

Byte:	1	Control byte = 3, Cannot Respond (PGN supported but ECU is busy and cannot respond now. Re-request the data at a later time.)
	2	Group Function Value (if applicable)
	3 to 4	Reserved for assignment by SAE, these bytes should be filled with FFh
	5	Address Busy
	6 to 8	PGN of requested information (see above)

SPECIAL ACKNOWLEDGEMENT CASES WHEN THE REQUEST2 UTILIZES THE EXTENDED IDENTIFIER TYPE (Control byte equal to 128 to 163)

Positive Acknowledgment: Control byte = 128 and Extended Identifier Type "One Byte Extended Identifier":

Byte:	1	Control byte = 128, Positive Acknowledgment (ACK) Extended Identifier Type
	2	Group Function Value = Extended Identifier Type (least significant byte) – byte 1
	3	Group Function Value = Extended Identifier Type - filled with FFh
	4	Group Function Value = Extended Identifier Type (most significant byte) - filled with FFh
	5	Address Acknowledged
	6	PGN of requested information (LSB of parameter group number, bit 8 most significant)
	7	PGN of requested information (2nd byte of parameter group number, bit 8 most significant)
	8	PGN of requested information (MSB of parameter group number, bit 8 most significant)

Negative Acknowledgment: Control byte = 129 and Extended Identifier Type “One Byte Extended Identifier":

Byte:	1	Control byte = 129, Negative Acknowledgment (NACK)
	2	Group Function Value = Extended Identifier Type (least significant byte)
	3	Group Function Value = Extended Identifier Type - filled with FFh
	4	Group Function Value = Extended Identifier Type (most significant byte) - filled with FFh
	5	Address Negative Acknowledgement
	6 to 8	PGN of requested information (see above)

Access Denied: Control byte = 130 and Extended Identifier Type “One Byte Extended Identifier":

Byte:	1	Control byte = 130, Access Denied (PGN supported but security denied access)
	2	Group Function Value = Extended Identifier Type (least significant byte)
	3	Group Function Value = Extended Identifier Type - filled with FFh
	4	Group Function Value = Extended Identifier Type (most significant byte) - filled with FFh
	5	Address Access Denied
	6 to 8	PGN of requested information (see above)

Cannot Respond: Control byte = 131 and Extended Identifier Type “One Byte Extended Identifier":

Byte:	1	Control byte = 131, Cannot Respond (PGN supported but ECU is busy and cannot respond now. Re-request the data at a later time.)
	2	Group Function Value = Extended Identifier Type (least significant byte)
	3	Group Function Value = Extended Identifier Type - filled with FFh
	4	Group Function Value = Extended Identifier Type (most significant byte) - filled with FFh
	5	Address Busy
	6 to 8	PGN of requested information (see above)

Positive Acknowledgment: Control byte = 144 and Extended Identifier Type "Two Byte Extended Identifier":

Byte:	1	Control byte = 144, Positive Acknowledgment (ACK) Extended Identifier Type
	2	Group Function Value = Extended Identifier Type (least significant byte) – byte 1
	3	Group Function Value = Extended Identifier Type – byte 2
	4	Group Function Value = Extended Identifier Type (most significant byte) - filled with FFh
	5	Address Acknowledged
	6 to 8	PGN of requested information (see above)

Negative Acknowledgment: Control byte = 145 and Extended Identifier Type “Two Byte Extended Identifier":

Byte:	1	Control byte = 145, Negative Acknowledgment (NACK)
	2	Group Function Value = Extended Identifier Type (least significant byte) – byte 1
	3	Group Function Value = Extended Identifier Type – byte 2
	4	Group Function Value = Extended Identifier Type (most significant byte) - filled with FFh
	5	Address Negative Acknowledgement
	6 to 8	PGN of requested information (see above)

Access Denied: Control byte = 146 and Extended Identifier Type “Two Byte Extended Identifier":

Byte:	1	Control byte = 146, Access Denied (PGN supported but security denied access)
	2	Group Function Value = Extended Identifier Type (least significant byte) – byte 1
	3	Group Function Value = Extended Identifier Type – byte 2
	4	Group Function Value = Extended Identifier Type (most significant byte) - filled with FFh
	5	Address Access Denied
	6 to 8	PGN of requested information (see above)

Cannot Respond: Control byte = 147 and Extended Identifier Type “Two Byte Extended Identifier":

Byte:	1	Control byte = 147, Cannot Respond (PGN supported but ECU is busy and cannot respond now. Re-request the data at a later time.)
	2	Group Function Value = Extended Identifier Type (least significant byte) – byte 1
	3	Group Function Value = Extended Identifier Type – byte 2
	4	Group Function Value = Extended Identifier Type (most significant byte) - filled with FFh
	5	Address Busy

	6 to 8	PGN of requested information (see above)
Positive Acknowledgment: Control byte = 160 and Extended Identifier Type "Three Byte Extended Identifier":		
Byte:	1	Control byte = 160, Positive Acknowledgment (ACK) Extended Identifier Type
	2	Group Function Value = Extended Identifier Type (least significant byte) – byte 1
	3	Group Function Value = Extended Identifier Type – byte 2
	4	Group Function Value = Extended Identifier Type (most significant byte) – byte 3
	5	Address Acknowledged
	6 to 8	PGN of requested information (see above)
Negative Acknowledgment: Control byte = 161 and Extended Identifier Type “Three Byte Extended Identifier":		
Byte:	1	Control byte = 161, Negative Acknowledgment (NACK)
	2	Group Function Value = Extended Identifier Type (least significant byte) – byte 1
	3	Group Function Value = Extended Identifier Type – byte 2
	4	Group Function Value = Extended Identifier Type (most significant byte) – byte 3
	5	Address Negative Acknowledgement
	6 to 8	PGN of requested information (see above)
Access Denied: Control byte = 162 and Extended Identifier Type “Three Byte Extended Identifier":		
Byte:	1	Control byte = 162, Access Denied (PGN supported but security denied access)
	2	Group Function Value = Extended Identifier Type (least significant byte) – byte 1
	3	Group Function Value = Extended Identifier Type – byte 2
	4	Group Function Value = Extended Identifier Type (most significant byte) – byte 3
	5	Address Access Denied
	6 to 8	PGN of requested information (see above)
Cannot Respond: Control byte = 163 and Extended Identifier Type “Three Byte Extended Identifier":		
Byte:	1	Control byte = 163, Cannot Respond (PGN supported but ECU is busy and cannot respond now. Re-request the data at a later time.)
	2	Group Function Value = Extended Identifier Type (least significant byte) – byte 1
	3	Group Function Value = Extended Identifier Type – byte 2
	4	Group Function Value = Extended Identifier Type (most significant byte) – byte 3
	5	Address Busy
	6 to 8	PGN of requested information (see above)

Figure 7 - Acknowledgment PG definition

5.4.5 Group Function

This message type is used for groups of special functions (e.g., proprietary functions, network management functions, multipacket transport functions, etc.). Each group function is recognized by its assigned PGN. See Figure 8, Figure 9, and Figure 10. Table D1 in Appendix D has the SPN assignments to parameters in these messages. The function itself is defined within the data structure (typically the first byte of the Data field). More detailed explanation of the group functions Proprietary and Transport Protocol will be given in the sections to follow. The Proprietary group function provides a means to transmit proprietary messages in a way that eliminates CAN ID usage conflicts between different manufacturers. It also provides a means for receiving and distinguishing proprietary messages for use when desired. Group Functions may need to provide their own request, ACK, and/or NACK mechanisms if the messages defined in SAE J1939-21 are not sufficient.

A request using PGN 59904 (see 5.4.2) can be used to find out if a specific PGN of the message type, Group Function, is supported by a controller application. If it is supported, then the responding device sends the Acknowledgment PG with the control byte equal to zero, for Positive Acknowledgment, or equal to two, Access Denied or equal to three, Cannot Respond. If it is not supported, the responding device sends the Acknowledgment PG with the control byte set to one, for Negative Acknowledgment. The remaining portions of the SAE J1939 PDU format and PGN must be filled in appropriately (see 5.4.4). Note that per the definitions in this paragraph the phrase “not supported” means that the PG is not transmitted. It is not possible to determine whether a device will act upon the received PG by using this method.

Parameter Group Name:	**Proprietary A (PROPA)**
Definition:	This proprietary PG uses the destination-specific PDU1 Format allowing manufacturers to direct their proprietary communications to a specific destination node. How the Data field of this message is used is up to each manufacturer. Use of proprietary messages is at the manufacturer’s discretion with the constraint that significant percentages (2% or more) of vehicle network utilization must be avoided.
Transmission repetition rate:	Per user requirements
Data length:	0 to 1785 bytes (multipacket supported)
Extended Data Page:	0
Data Page:	0
PDU Format:	239
PDU Specific:	Destination Address. The global DA should not be used.
Default priority:	6
Parameter Group Number:	61184 ($00EF00_h$)
Bytes: 1 to 8	Manufacturer specific use (see 5.1.2)

Data ranges for parameters used by this Group Function:
None defined by SAE

Figure 8 - Proprietary A PG definition

Parameter Group Name:	**Proprietary A2 (PROPA2)**
Definition:	This proprietary PG uses the destination-specific PDU1 Format allowing manufacturers to direct their proprietary communications to a specific destination node. How the Data field of this message is used is up to each manufacturer. Use of proprietary messages is at the manufacturer’s discretion with the constraint that significant percentages (2% or more) of vehicle network utilization must be avoided.
Transmission repetition rate:	Per user requirements
Data length:	0 to 1785 bytes (multipacket supported)
Extended Data Page:	0
Data Page:	1
PDU Format:	239
PDU Specific:	Destination Address. The global DA should not be used.
Default priority:	6
Parameter Group Number:	126720 ($01EF00_h$)
Bytes: 1 to 8	Manufacturer specific use

Data ranges for parameters used by this Group Function:
None defined by SAE

Figure 9 - Proprietary A2 PG definition

Parameter Group Name:	**Proprietary B (PROPB)**
Definition:	This proprietary PG uses the PDU2 Format message allowing manufacturers to define the PS (GE) field content as they desire. However, significant percentages (2% or more) of vehicle network utilization must be avoided. How the PS (GE) and Data fields of this message are used is up to each manufacturer. The data length of these messages has been left up to each manufacturer. Therefore, two manufacturers, say of transmissions, may use the same GE value and it may very well have a different Data Length Code. Receivers of this information would need to differentiate between the two manufacturers.
Transmission repetition rate:	Per user requirements
Data length:	0 to 1785 bytes (multipacket supported)
Extended Date Page:	0
Data Page:	0 or 1
PDU Format:	255
PDU Specific:	Group Extension (manufacturer assigned)
Default priority:	6
Parameter Group Number:	65280 to 65535 ($00FF00_h$ to $00FFFF_h$) 130816 to 131071 ($01FF00_h$ to $01FFFF_h$)
Bytes: 1 to 1785	Manufacturer defined usage

Data ranges for parameters used by this Group Function:

Manufacturer defined usage allows the Data Length Code to be different per component supplier and SA. Caution should be used when using the Proprietary B PGNs because multiple SAs can use the same Proprietary B PGN for different purposes.

Figure 10 - Proprietary B PG definition

5.4.6 Request2

The Request2 PG provides the capability for the requestor to specify whether the responder should use the Transfer PGN 51712. By identifying that the responder should use the Transfer PGN, it provides the ability for the responder to report the data set for all devices it is tasked with reporting (see 5.4.6). All devices include what the responding device would normally report upon receiving the same PGN requested in PGN 59904 (properly formatted for Transfer PG) and the data set for each device it is tasked to report. For instance if the “Use Transfer PGN” parameter is 01_b, the response shall include all data known relative to the requested PG. When “Use Transfer PGN” is 00_b, the effect of the Request2 PGN is the same as if the Request PGN 59904 was used. See Figure 11. Table D1 in Appendix D has the SPN assignments to parameters in this message.

The Request2 and Transfer PGNs are required in cases where a given ECU is tasked with reporting a PG and data for more than one controller application. Examples include PGs such as Vehicle Identification, Component ID and Software Identification.

If a device fails to get a response (either the requested PG or NACK) to a Request within T_r, then the device may resend or retry the same Request. The number of retries for a specific Request should be limited to two retries, i.e., the Request is issued a total of three times. If the device fails to get a response (either the requested PG or NACK) to the Request after the third retry, then the device should abandon further request attempts for the same information or the device may wait for an extended period of time (minutes rather than seconds) before attempting to request the same information.

The support of Request2 is optional.

Parameter Group Name:		**Request2 (RQST2)**
Definition:		Used to Request a PG from network device or devices and to specify whether the response should use the Transfer PGN or not.
Transmission repetition rate:		Per user requirements, generally recommended that requests occur no more than 2 or 3 times per second. When a device supports Request2, a NACK is required if the PGN requested from a specific DA is not supported (refer to PGN 59392).
Data length:		8 bytes (multipacket supported)
Extended Data Page:		0
Data Page:		0
PDU Format:		201
PDU Specific:		Destination Address (global or specific)
Default priority:		6
Parameter Group Number:		51456 ($00C900_h$)
Bytes 1 to 3:		Requested PGN
Byte 4:		Special Instructions
	Bits 8 to 6:	Reserved for SAE assignment
	Bits 5 to 3:	Control Indicating Extended Identifier Type (Extended Identifier conveyed in data bytes 5 through 7)
	Bits 2 to 1:	Use Transfer PGN for response (00_b = No, 01_b=Yes, 10_b = undefined, 11_b = NA)
Byte 5:		Extended Identifier Byte 1 (least significant byte)
Byte 6:		Extended Identifier Byte 2
Byte 7:		Extended Identifier Byte 3 (most significant byte)
Byte 8:		Reserved for SAE assignment

Data ranges for parameters used by this Message Type:

Control Indicating Extended Identifier Type: 000_b to 111_b, see definitions below

	000_b	No Extended Identifier. None of the data bytes are used for identifier/control values. Used when requesting a PG that does not have Group Function/Extended Identifier bytes. Indicator that the device supports the new Request2 special instruction functionality. Data bytes 5 to 7 of the Request 2 PG are set to 255 (FF_h).
	001_b	1-Byte Extended Identifier. Data byte 5 of the Request2 PG contains the 1-byte identifier/control value that would match the requested PG's data byte 1. Data bytes 6 to 7 of the Request2 PG are set to 255 (FF_h).
	010_b	2-Byte Extended Identifier. Data byte 5 of the Request2 PG contains the byte identifier/control value that would match the requested PG's data byte 1 and data byte 6 of the Request2 PG contains the identifier/control value that would match the requested PG's data byte 2. Data bytes 7 of the Request2 PG is set to 255 (FF_h).
	011_b	3-Byte Extended Identifier. Data byte 5 of the Request2 PG contains the byte identifier/control value that would match the requested PG's data byte 1, data byte 6 of the Request2 PG contains the identifier/control value that would match the requested PG's data byte 2, and data byte 7 of the Request2 PG contains the identifier/control value that would match the requested PG's data byte 3.
	100_b to 110_b	Reserved for future SAE definition
	111_b	Take no action. Not Applicable
Group Function Value	0 to 250	Definition is specific to the individual PG, when applicable. Most often it is located as the first byte in the Data field of the applicable Group Function PG.
	251 to 255	Follows conventions defined in SAE J1939-71

Figure 11 - Request2 PG format

5.4.7 Transfer

The Transfer PG provides a mechanism for reporting multiple data sets for a given PG in response to a Request2 (see 5.4.6). See Figure 12 for the definition of a “data set.” These multiple sets of data for a given PG require that each data set have a length and be labeled with four bytes from the SAE J1939-81 Name. The four bytes of the Name identify each device. The device responding to the request shall report the same information it would with RQST PGN 59904 as the first data set in this response. If a device only has one data set, then it shall respond with the one data set utilizing the Transfer PG.

The Request2 and Transfer PGs are useful in cases where a given ECU is tasked with reporting a PG and data about more than one controller application. Examples include PGs such as Vehicle Identification, Component ID, and Software Identification.

See Figure 12. Table D1 in Appendix D has the SPN assignments to parameters in this message.

Parameter Group Name:		**Transfer (XFER)**
Definition		Used for transfer of data in response to a Request2 when the “Use Transfer PGN for response” is set to “Yes”
Transmission repetition rate:		In response to a Request2 PG with “Use Transfer PGN” = 01_b
Data length:		9 to 1785 bytes (multipacket supported)
Extended Data Page:		0
Data Page:		0
PDU Format:		202
PDU Specific:		Destination Address (global or specific)
Default priority:		6
Parameter Group Number:		51712 ($00CA00_h$)
Bytes 1 to 3:		(a) PGN requested by Request2 (see Table 2 for PGN ordering)
Byte 4:		(b) Length of data for the reported PG associated to the device identified (e.g., Controller Application Identity in bytes 5-8). Length value is the total of this byte, length of identity bytes (i.e., bytes 5-8), and the associated PG data. So the length is b + c + d.
Bytes 5 to 8:		(c) Identity of device associated to the PGN and data (i.e., Controller Application Identity) SAE J1939-81 defines the four bytes of the Name used here in bytes 5 through 8.
Byte 5:	Bits 8 to 4	Function Instance (most significant at bit 8)
	Bits 3 to 1	ECU Instance (most significant at bit 3)
Byte 6:	Bits 8 to 1	Function (most significant at bit 8)
Byte 7:	Bits 8 to 2	Vehicle System (most significant at bit 8)
	Bit 1	Reserved
Byte 8:	Bit 8	Arbitrary Address Capable
	Bits 7 to 5	Industry Group (most significant at bit 7)
	Bits 4 to 1	Vehicle System Instance (most significant at bit 4)
Bytes 9 to x:		(d) Data of reported PGN in bytes 1-3
Byte x+1 to n		Repeating information for 2nd and following shall contain: “Controller Application Identity,” Length, and “PGN requested by Request2’s data.” See format definition below.

Format:

a,b,c,d,b,c,d,b,c,d...

a: PGN requested by Request2 when “transfer mode” is set to yes
b: First Data Set: Length of concatenated ECU identity and associated PG data
The length = b + c + d
c: Identity of Controller Application to which field “d” is associated
d: Requested PG’s data for specific Controller Application
b: Second Data Set: Length of concatenated Controller Application Identity and associated PG data
c: Identity of Controller Application to which field “d” is associated
d: Requested PG’s data for second specific Controller Application
... etc.

Example: For a given vehicle the engine ECU knows the VIN numbers for the tractor and the trailer. Another device sends the Request2 directed to the global destination, requesting the VIN with “Use Transfer PGN” set to 01_b. The response from the engine might be:

BAM transfer of the “Transfer” PG reporting the VIN for the tractor and VIN for the trailer

If the request had the “Use Transfer PGN” set to 00_b, the response would be:

BAM transfer of the VIN for the tractor but not utilizing the Transfer PG

Figure 12 - Transfer PG format

5.5 Message Priority

The CAN Data Frame priority shall be per ISO 11898-1. The value within the CAN ID field determines the message priority. A low value (the 29-bit identifier being all zeros) has a high priority, while the largest CAN ID has the lowest priority (the 29-bit identifier being all ones). The assignments are identified in the applications layer following the guidelines spelled out in 5.9 of this document and as defined in SAE J1939.

5.6 Bus Access

When the bus is free, any node may start to transmit a frame. If two or more nodes start to transmit frames at the same time, the bus access conflict is resolved by contention-based arbitration using the CAN Data Frame Identifier. The mechanism of arbitration guarantees that neither information nor time is lost. The transmitter with the frame of the highest priority gains bus access (refer to ISO 11898-1).

5.7 Contention-Based Arbitration

During arbitration, every transmitter compares the level of the bit transmitted with the level that is monitored on the bus. If these levels are equal, the node may continue to send. When a “recessive” level is sent and a “dominant” level is monitored, that node has lost arbitration and must withdraw without sending one more bit. When a “dominant” level is sent and a “recessive” level is monitored, that node detects a bit error (refer to ISO 11898-1).

5.8 Error Detection

The following measures are taken for detecting errors:

a. 15-bit Cyclic Redundancy Check (CRC)

b. Variable Bit Stuffing with a stuff width of 5

c. Frame format check

Transmitters compare the bit levels being transmitted with the bit level detected on the bus.

A more detailed explanation regarding these error detection techniques is available in ISO 11898-1.

5.9 Assignment Process for Source Addresses and Parameter Group Numbers

The Protocol Data Units that are available provide for two different formats, PDU1 Format and PDU2 Format. PGNs are assigned specifically to use either PDU1 Format or PDU2 Format. Once assigned to a format, the other is not available for that PGN. PDU1 Format must be used anytime it is necessary to direct a PG to a specific DA. The assignment of a PGN should be done while keeping in mind the following characteristics: priority, update rate, importance of the data in the packet to other network devices, and length of the data associated with the given PG. In order to help with this assignment process, a request form has been created which should be used when requesting new SA or PGN assignments (refer to the SAE J1939 Request Processing Form at the SAE Standard Works web pages).

Figure 2 provides a template for assigning PGNs. Note that the Priority column is used to assign a default priority value for each PGN. The Priority field should be programmable for each PGN value so that network tuning can be performed by an OEM if necessary. Although any PGN could be requested, requests are strongly discouraged for messages that are already periodically broadcast.

Messages should be assigned a PGN using the PDU1 Format that requires a DA only if it is a parameter intended to directly control (command) one of several specific devices. Otherwise, a PGN should be assigned to use the PDU2 Format so that any device can have access to the parameters within the message.

SAs are assigned in a linear fashion without concerns for message priority, update rate, or importance.

PGNs are assigned linearly to the various sections of Figure 2 based on the criteria provided on the PGN and Source Address Request form. Note that multipacket messages are not permitted when the repetition rate is greater than or equal to 10 times/second.

5.9.1 Address Assignment Criteria

The number of unassigned SAs in SAE J1939 is limited and new SA assignments must be made efficiently. The maximum number of SAs assigned within the system cannot exceed 256. Additions to the address definitions therefore must be limited to significant functions within the vehicle. Examples of significant functions include the currently defined addresses for engine, transmission, brakes, fuel system, etc. Functions proposed for new address assignments within the standard should have a scope similar to currently defined addresses and should be useful to most SAE J1939 users.

Some devices use the available dynamic address allocation scheme. In this case the dynamic address can be set by the service tool and/or can be allocated at the time the network is powered up. Special precautions must be taken when using the dynamic address allocation scheme since not all network devices support this mode of operation.

5.9.2 PGN Assignment Criteria

The number of unassigned PGNs available in SAE J1939 is limited when compared to the large number that might be proposed for on-highway trucks and other applications. The need for large numbers of PGNs is alleviated by features built into SAE J1939. Three primary communication methods exist within SAE J1939 and appropriate use of each type allows effective use of the available PGNs. The three communications methods are:

a. PDU1 Format (PS = DA, allowing destination-specific communications)

b. PDU2 Format Communications (PS = GE)

c. Proprietary Communications using predefined proprietary PGNs

Each of the communications methods has an appropriate use. Destination–specific (PDU1 Format) PGNs are needed where the same message must be directed to one DA. SAE J1939 currently defines a torque control message that may be sent to an engine. In the case of more than one engine, this message must be sent only to the desired engine and a destination-specific PGN is needed and has been assigned.

PDU2 Format communications apply in several situations, including:

a. Messages sent from a single or multiple sources to a single destination

b. Messages sent from a single or multiple sources to multiple destinations

PDU2 Format communications cannot be used where a message must be sent to a specific DA.

The third communications method in SAE J1939, proprietary communications, is provided by the use of the proprietary PGNs. 512 PGNs have been assigned for nondestination-specific proprietary communications and two PGNs have been assigned for destination–specific proprietary communications. This allows for two functions: (a) a specific SA can send its proprietary message in a PDU2 Format (nondestination–specific) with the PS field identified as desired by the user; or (b) a specific SA can send its proprietary message in a PDU1 Format (destination–specific) to a specific DA. For example, destination-specific proprietary messages can be used in situations where a service tool must direct its communication to a specific DA out of a possible group of controllers. This case can arise when an engine uses more than one controller but wants to be able to perform diagnostics while all of its controllers are connected to the same network. In this case the proprietary protocol needs to be able to be destination-specific.

Proprietary communications are useful in two situations:

a. Where it is unnecessary to have standardized communications

b. Where it is important to communicate proprietary information

Much of the communications between nodes constructed by a single manufacturer do not require standardization. The information communicated is not generally useful to other devices on the network. In this situation the proprietary PGNs can be used.

When PGN assignment is contemplated, proprietary and then PDU2 Format communications methods should be considered first. If proprietary information is being communicated, or the information to be communicated is not of general interest, the proprietary method should be used. If the information is of general interest and does not require messages to be directed to a particular node, a PDU2 Format PGN assignment should be sought. Finally if the information is of general interest and requires messages to be directed to one DA, then destination–specific addressing is needed and a PDU1 Format PGN assignment should be sought.

5.9.3 Data Field Definition

Minimization of message overhead with CAN-based systems requires full use of the Data field (all 8 bytes). Except in the case of very time-critical messages, related parameters should be grouped to fill the 8-byte Data field. Following this principle conserves PGNs for future assignment. Strong justification is needed to allow definition of PGNs that result in sparsely-used Data fields.

5.10 Transport Protocol Functions

Transport Protocol functions are described as a part of the data link layer with the recognition that Transport Protocol functionality is subdivided into two major functions: Message Packetization and Reassembly; and Connection Management. These functions are described in the following sections.

In the following paragraphs the term “originator” corresponds to the ECU or device that transmits the RTS message, and the term “responder” corresponds to the ECU or device that transmits the CTS message.

5.10.1 Message Packetization and Reassembly

Messages greater than 8 bytes in length are too large to fit into a single CAN Data Frame. They must therefore be broken into several smaller packets, and those packets transmitted in separate CAN Data Frames. At the destination end, the individual CAN Data Frames must be received and parsed and the original message reassembled from the received packets.

5.10.1.1 Message Packets

The CAN Data Frame includes an 8-byte Data field. Because the individual packets which comprise a large message must be identified individually so that they may be reassembled correctly, the first byte of the Data field is defined as the sequence number of the packet.

Individual message packets are assigned a sequence number of 1 to 255. This yields a maximum message size of (255 packets * 7 bytes/packet) = 1785 bytes.

5.10.1.2 Sequence Numbers

Sequence numbers are assigned to packets for transmission on the network during message packetization and then used on reception of packets to reassemble them back into a message.

Sequence numbers shall be assigned to individual packets beginning with one and continuing sequentially until the entire message has been packetized and transmitted. The packets shall be sent sequentially in ascending order starting with packet 1.

5.10.1.3 Packetization

A large message is defined as one whose data does not fit into the Data field of a single CAN Data Frame (i.e., messages with more than 8 bytes of data).

For the purposes of this protocol, a large message is considered to be a PG that has associated with it nine or more data bytes. The first Data Transfer (TP.DT) packet contains the sequence number one in its first data byte, followed by the first 7 bytes of the data. The second TP.DT packet contains the sequence number two in its first data byte, followed by the next 7 bytes of the data. The third TP.DT packet contains the sequence number three, followed by the next 7 bytes of data. This process is repeated until all the bytes in the original message have been placed into SAE J1939 messages and transmitted.

Each TP.DT packet (other than the last packet in a transmission sequence) shall include 7 bytes of the original large message. The final TP.DT packet includes the sequence number in the first data byte, 1 to 7 bytes of data from the original large message, and – if there are fewer than 7 data bytes – the remaining bytes filled with FF_h.

The time between packets for multipacket Broadcast Announce (BAM) messages shall be 10 to 200 ms (see 5.12.3). For multipacket messages directed to a specific DA, the originator maintains a maximum time between packets (when the CTS PG allows more than one data frame to be sent per byte 2 of the message) of not more than 200 ms. Responders must be aware that the TP.DT messages containing the data all have the same identifier.

5.10.1.4 Reassembly

Data packets are received sequentially. Each data packet of a multipacket message shall be assembled, in order of sequence number, into a single string of bytes. This string of bytes is passed to the application entity responsible for the large message.

5.10.2 Connection Management

Connection Management (TP.CM) is concerned with the opening, use, and closure of virtual connections between nodes for destination-specific transfers. A virtual connection in the SAE J1939 environment may be considered a temporary association of two nodes for the purpose of transferring a single large message that is described by a single PG (see Appendix C, Figures C1 and C2). In cases where the connection is from one to many there is no flow control or closure provided (see Appendix C, Figure C3).

5.10.2.1 Multipacket Broadcast

Large messages may be nondestination–specific; that is, they may be Broadcast Announce (BAM) messages. To broadcast a multipacket message, a node first transmits the TP.CM_BAM message. This message, which must be transmitted to the global DA, constitutes a large message warning to the nodes on the network. The BAM message contains the PGN of the large message to be broadcast, its size, and the number of packets into which it has been packeted. Nodes interested in the data are then required to allocate the resources necessary to receive and reassemble the message. The Data Transfer (TP.DT) PG is then used to send the associated data.

NOTE: The size of the message data does not include the sequence numbers that are added to each Data Transfer packet.

5.10.2.2 Connection Management for DA-Specific Transfer

A connection is initiated when a node transmits an RTS message to a DA. The RTS message contains the size of the entire message data in bytes, the number of separate messages in which it will be transferred, the maximum number of packets that can be sent in response to one Clear to Send (CTS) message from the DA, and the PGN of the message being transported.

NOTE: The size of the message data does not include the sequence numbers that are added to each Data Transfer packet.

Upon receipt of an RTS message, a node may elect to accept the connection or to reject it. To accept the connection, the responder transmits a CTS message. The CTS message contains the number of packets the node will accept and the sequence number of the first packet it is expecting. The responder must ensure that it has sufficient resources to handle the number of packets it is accepting delivery of. The sequence number of the packet, in the instance of a freshly opened connection, would be one. Note that the CTS message may not allow all the packets of the message to be sent at one time; the originator shall honor a request for a smaller number of packets to be transmitted with each CTS response than the maximum number that are required to send the large message. To reject the connection, the responder sends a TP.Conn_Abort message. The connection may be rejected for any reason, although lack of resources, memory, etc., are likely to be the causes.

The connection is considered established for the originator (i.e., device that sends RTS) when the originator receives a corresponding CTS from the responder (i.e., device that sends CTS). The connection is considered established for the responder when it has successfully transmitted its CTS message in response to an RTS message. These definitions are used to determine which node must send a TP.CM_EndOfMsgACK message to close a connection after completion of the data transfer.A responder should send a TP.Conn_Abort if it has looked at the RTS message and decided not to establish the connection. This allows the originator to move on to a new connection without having to wait for a timeout.

5.10.2.3 Data Transfer

Data transfer begins after the originator of the connection receives the CTS message. An exception is if the data transfer is the result of a BAM announcement, where the CTS and RTS messages are not used. The TP.DT PGN is contained in the 29-bit CAN ID field of each TP.DT packet. The first byte of the Data field will contain the sequence number of the packet.

In the case of destination-specific TP.DT, the responder is responsible for coordinating flow control between the nodes using the CTS message. Originators shall support the “number of packets to send” in byte 2 of the CTS message from the responder. If the responder wants to stop data flow momentarily while a connection is open, it must use the CTS message, setting the “number of packets to send” value in byte 2 equal to zero. In the case where the flow must be stopped for some number of seconds, the responder must repeat the transmission of the CTS message once per T_h interval, with the “number of packets to send” value equal to zero, to assure the originator the connection is not broken. All remaining bit fields are set to ones (don’t care).

Responders shall support the “maximum number of packets per CTS message” in byte 5 of the RTS message from the originator. This requirement is further enumerated in 5.10.3.2.

5.10.2.4 Connection Closure

Two connection closure cases exist in the absence of errors. The first occurs with a BAM data transfer, and the second occurs with a destination-specific data transfer (using RTS and CTS to establish a session). In the case of a BAM data transfer, no connection closure operation is performed beyond the reception of the data itself. See 5.10.3 and 5.10.3.4. In the case of a destination-specific data transfer, upon receipt of the last packet in the message stream, the responder transmits the TP.CM_EndOfMsgACK acknowledgment message to the originator to signal to the originator that the connection is considered closed by the responder. Sending the TP.CM_EndOfMsgACK message is required to free the connection for subsequent use by other devices.

The Connection Abort (TP.Conn_Abort) message is not allowed to be used by responders for a BAM data transfer. See 5.10.3 and 5.10.3.4. In the case of a destination-specific transfer, the originator or responder can, at any time, use TP.Conn_Abort to terminate the connection. See 5.10.2.2 for an explanation of when a connection is considered established for the originator and responder. If the responder should, for example, determine that there are no resources available for processing the message, it may simply abort the connection by issuing the TP.Conn_Abort with abort reason 2 (see Table 6). Upon receipt of the TP.Conn_Abort message, any message packets already passed will be abandoned. A failure of either node may also cause closure of a connection. For example:

a. A gap of more than (T1) seconds has elapsed after receipt of the last packet when more were expected (CTS allowed more)

b. A gap of more than (T2) seconds has elapsed after a CTS was transmitted (originator failure)

c. A lack of CTS or TP.CM_EndOfMsgACK for more than (T3) seconds after the last packet was transmitted (responder failure)

d. A lack of a CTS message for more than (T4) seconds after a TP.CM_CTS message with data byte 2 set to zero to “hold the connection open”

e. A failure of flow control where a responder receives more packets than requested in its CTS message

f. A failure of flow control where an originator receives a request to send more packets than allowed in its RTS message

These are all causes for a connection closure to occur. See Figure C1 and 5.12.3 regarding timeouts. When either the originator or responder decides to close out a connection for any reason including a timeout, it shall send the TP.Conn_Abort message with abort reason 3 from Table 6.

T_r = 200 ms

T_h = 500 ms

T1 = 750 ms

T2 = 1250 ms

T3 = 1250 ms

T4 = 1050 ms

With the definitions in this section and those in all sections under 5.10, the following observations can be made.

1. Connection closure for a BAM data transfer include the following.

   a. A connection is considered closed when the originator:

      i) Sends the last data packet

   b. A connection is considered closed when the responder:

      i) Receives the last data packet

      ii) Has a T1 connection timeout

2. Connection closure for destination-specific data transfers include the following.

   a. A connection is considered closed when the originator:

      i) Receives the TP.CM_EndOfMsgACK at the completion of the data transfer for the entire PG

      ii) Sends a TP.Conn_Abort for any reason (e.g., due to a T3 or T4 timeout)

      iii) Receives a TP.Conn_Abort

   b. A connection is considered closed when the responder:

      i) Sends the TP.CM_EndOfMsgACK at the completion of the data transfer for the entire PG

      ii) Receives a TP.Conn_Abort

      iii) Sends a TP.Conn_Abort for any reason (e.g., including stopping the session early if desired, for a T1 or T2 connection timeout, etc.)

5.10.3 Transport Protocol - Connection Management Messages

This type of message is used to initiate and close connections and also to control flow. Transport Protocol provides the following five connection management messages: the Connection Mode Request To Send, the Connection Mode Clear To Send, the End of Message Acknowledgment, the Connection Abort, and the Broadcast Announce Message. The formats of these messages are shown in Figure 13 below in the PG definition for “Transport Protocol - Connection Management.” Table D1 has the SPN assignments to parameters in this message.

Parameter Group Name:	**Transport Protocol—Connection Management (TP.CM)**
Definition:	Used for the transfer of PGs that have 9 or more bytes of data. A definition of each specific message defined as part of the transport protocol is contained in 5.10.3.1 through 5.10.3.5.
Transmission repetition rate:	Per the PG to be transferred
Data length:	8 bytes
Extended Date Page:	0
Data Page:	0
PDU Format:	236
PDU Specific:	Destination Address
Default priority:	7
Parameter Group Number:	60416 (00EC00$_h$)
Data ranges for parameters used by this Group Function:	
Control byte:	0 to 15, 18, 20 to 31, and 33 to 254 are Reserved for SAE Assignment
Total Message Size, number of bytes:	9 to 1785 (2 bytes), zero to 8 and 1786 to 65535 not allowed
Total Number of Packets:	2 to 255 (1 byte), zero not allowed
Maximum Number of Packets:	2 to 255 (1 byte), zero and one are not allowed
Number of Packets that can be sent:	0 to 255 (1 byte)
Next Packet Number to be Sent:	1 to 255 (1 byte), zero not allowed
Sequence Number:	1 to 255 (1 byte), zero not allowed

Figure 13 - Format of messages for transport protocol

Connection Mode Request to Send (TP.CM_RTS): Destination Specific		
Byte:	1	Control byte = 16, Destination Specific Request_To_Send (RTS)
	2 to 3	Total message size, number of bytes
	4	Total number of packets
	5	Maximum number of packets that can be sent in response to one CTS. FF_h indicates that no limit exists for the originator.
	6 to 8	PGN of the packeted message
	Byte 6	LSB of PGN
	Byte 7	2nd byte of PGN
	Byte 8	MSB of PGN
Connection Mode Clear to Send (TP.CM_CTS): Destination Specific		
Byte:	1	Control byte = 17, Destination Specific Clear_To_Send (CTS)
	2	Number of packets that can be sent. This value shall be no larger than the value in byte 5 of the RTS message.
	3	Next packet number to be sent
	4 to 5	Reserved for assignment by SAE, these bytes should be filled with FF_h
	6 to 8	PGN of the packeted message
End of Message Acknowledgment (TP.CM_EndOfMsgACK): Destination Specific		
Byte:	1	Control byte = 19, End_of_Message Acknowledge
	2 to 3	Total message size, number of bytes
	4	Total number of packets
	5	Reserved for assignment by SAE, this byte should be filled with FF_h
	6 to 8	PGN of the packeted message
Connection Abort (TP.Conn_Abort): Destination Specific		
Byte:	1	Control byte = 255, Connection Abort
	2	Connection Abort reason
	3 to 5	Reserved for assignment by SAE, these bytes should be filled with FF_h
	6 to 8	PGN of the packeted message
Broadcast Announce Message (TP.CM_BAM): Global Destination		
Byte:	1	Control byte = 32, Broadcast Announce Message
	2 to 3	Total message size, number of bytes
	4	Total number of packets
	5	Reserved for assignment by SAE, this byte should be filled with FF_h
	6 to 8	PGN of the packeted message

Figure 14 - Format of messages for transport protocol (continued)

5.10.3.1 Connection Mode Request to Send (RTS)

The RTS message informs a node that another node on the network wishes to open a virtual connection with it. The RTS is a message with the SA field set to that of the originating node, the DA field set to that of the intended recipient of a large message, and the remaining fields set appropriately for the PG being sent.

Byte 5 of this message allows the originator to limit the responder’s number of packets specified in the CTS message. See Figure C4 in Appendix C. A responder shall comply with this limit to ensure that the originator can always retransmit packets that the responder may have not received for whatever reason.

If multiple RTS messages are received from the same SA for the same PGN, then the most recent RTS message shall be acted on and the previous RTS messages will be abandoned. No TP.Conn_Abort message shall be sent for the abandoned RTS messages in this specific case.

The RTS message is only transmitted by the originator of a connection.

5.10.3.2 Connection Mode Clear to Send (CTS)

The CTS message is used to respond to the RTS message. The CTS message informs the originating node that the receiving node is ready for a certain amount of large message data. The amount of large message data cleared to send shall be no larger than the smaller of the two values in byte 4 and byte 5 of the originator's TP.CM_RTS message.

If multiple CTS messages are received after a connection is already established, then the connection shall be aborted. When the originator aborts the connection, it shall send TP.Conn_Abort with abort reason 4 from Table 6.

The responder will not send the next CTS until it has received the last data packet requested in the previous CTS message, or it has timed out. In the case of time out the responder has the choice whether to send a connection abort or to send another CTS message to attempt to keep the connection open.

The following cases exist when data transfer happens with errors:

- A missing or errant packet(s) is detected and the last packet is successfully received. The responder will send a CTS requesting retransmission starting from the missing packet.

- Missing packet(s) including the last packet will lead to time out T1. In this case, the responder can choose to send a CTS or a TP.Conn_Abort with reason 3 from Table 6. See Figure C6.

When the CTS message is used to request the retransmission of data packet(s), it is recommended not to use more than two retransmit requests. When this limit is reached, a connection abort with abort reason 5 from Table 6 shall be sent.

If a CTS message is received while a connection is not established, it shall be ignored.

CTS messages not only control the flow but also confirm correct receipt of any data packet prior to that CTS packet's number. Therefore if information for the previous CTS was corrupted, then a CTS for the corrupted information shall be sent before continuing on to the next sequential packets to be sent. Because of this requirement, the originator of a large message transmission shall use byte 5 of the RTS message as a way to ensure the possibility of retransmission of a packet within the last set of packets cleared to send.

CTS is only transmitted by the responder.

5.10.3.3 End of Message Acknowledgment (TP.CM_EndOfMsgACK)

The TP.CM_EndOfMsgACK message is passed from the recipient of a large message to its originator indicating that the entire message was received and reassembled correctly. The responder can keep the connection open after the last TP.DT message of the session by not immediately sending the TP.CM_EndOfMsgACK. This allows the responder to get a packet resent if necessary.

If an TP.CM_EndOfMsgACK is received by the originator prior to the final Data Transfer, then the originator ignores it.

One TP.CM_EndOfMsgACK is sent to show the originator that the large message transfer has been received and assembled correctly.

TP.CM_EndOfMsgACK is only transmitted by the responder.

5.10.3.4 Connection Abort (TP.Conn_Abort)

The TP.Conn_Abort message is used by either node involved in a virtual connection to close the connection without completing the transfer of the message or to prevent a connection from being initialized.

Upon receipt of an RTS message, a node must determine if there are sufficient resources available to deal with the message for which this connection is sought. For example if the device must acquire memory from the system heap, it may not be able to claim enough to accept the entire message; or a device may simply be too occupied doing other things to expend processor cycles to handle a large message. In these cases a TP.Conn_Abort message may be sent even though the connection has not been established. This may be done in order to allow the originator to attempt another virtual connection without first having to wait for a timeout to occur.

When either the originator or responder decides to close out a connection for any reason, prior to completing the data transfer, including a timeout, it shall send a TP.Conn_Abort message with the appropriate Connection Abort reason. See Table 6 for the list of Connection Abort reasons.

Table 6 - Connection abort reason

Value	Description
0	Reserved for SAE assignment.
1	Already in one or more connection managed sessions and cannot support another.
2	System resources were needed for another task, so this connection managed session was terminated.
3	A timeout occurred, and this is the connection abort to close the session.
4	CTS messages received when data transfer is in progress.
5	Maximum retransmit request limit reached.
6	Unexpected data transfer packet.
7	Bad sequence number (software cannot recover).
8	Duplicate sequence number (software cannot recover).
9	“Total Message Size” is greater than 1785 bytes.
10–249	Reserved for SAE assignment.
250	If a Connection Abort reason is identified that is not listed in the table use code 250.
251–255	Per SAE J1939-71 definitions.

It is intended that the originator (i.e., the RTS node) should immediately stop transmitting after the reception of the TP.Conn_Abort message by the CAN protocol device. If this is not possible, the process to stop transmitting data packets shall take no more than 32 data packets and shall not exceed 50 ms. After sending or receiving a TP.Conn_Abort message, all related data packets received should be ignored. TP.Conn_Abort is transmitted by the originator or the responder.

5.10.3.5 Broadcast Announce Message (BAM)

The TP.CM_BAM (BAM) message is used to inform all the nodes of the network that a large message is about to be broadcast. It defines the parameter group and the number of bytes to be sent. After a BAM message is sent, the TP.DT messages are sent and they contain the packetized broadcast data.

BAM is only transmitted by the originator of a broadcast large message.

5.10.4 Transport Protocol - Data Transfer Message (TP.DT)

The TP.DT message is used to communicate the data associated with a PG. The TP.DT message is an individual packet of a multipacket message transfer (see Figure 14 and Figure 15). For example, if a large message is divided into five packets in order to be communicated, then there would be 5 TP.DT messages. Examples showing TP.DT messages being used can be seen in Appendix C. Table D1 in Appendix D has the SPN assignments to parameters in TP.DT shown in Figure 15.

TP.DT is only transmitted by the originator.

Parameter Group Name:	**Transport Protocol—Data Transfer (TP.DT)**
Definition:	Used for the transfer of data associated with PGs that have more than 8 bytes of data
Transmission repetition rate:	Per the PG to be transferred
Data length:	8 bytes
Extended Data Package:	0
Data Page:	0
PDU Format:	235
PDU specified field:	Destination address Global DA = 255 is required for TP.CM_BAM data transfers Global DA is not allowed for RTS/CTS data transfers
Default priority:	7
Parameter Group Number:	60160 ($00EB00_h$)
Data ranges for parameters used by this Group Function:	
Sequence Number:	1 to 255 (1 byte)
Byte: 1	Sequence Number
2 to 8	Packetized Data (7 bytes). Note the last packet of a multipacket PG may require less than 7 data bytes. The extra bytes should be filled with FF_h.

Figure 15 - Transport protocol - data transfer message (TP.DT)

5.10.5 Connection Constraints

If a node cannot handle another session, then it should reject the connection initiations that are pursued by other nodes. An RTS for a different PGN from the same SA to the same destination as an existing session shall be rejected as well. In either case the newly requested session should be rejected by sending a TP.Conn_Abort with abort reason 1 from Table 6. This allows the device desiring a connection to move on to a new connection without having to wait for a timeout.

5.10.5.1 Number and Type of Connections a Node Must Support

Each node on the network can originate one destination-specific connection transfer with a given DA at a time. This is due to the fact that the TP.DT message only contains the SA and DA and not the PGN of the data being transferred.

Only one multipacket BAM transfer to the global DA can be sent from an originator at a given time. This is a consequence of the TP.DT message not containing the actual PGN or a connection identifier. However, responders (i.e., receiving devices in this specific example) must recognize that multiple multipacket messages can be received, interspersed with one another, from different SAs.

A node must also be able to support one RTS/CTS session and one BAM session concurrently from the same SA. Therefore, the responder must use the DA of the TP.DT messages containing the data to keep them properly separated. One group of the TP.DT messages has a global DA and the other group has a specific DA. The DA MUST be used to distinguish the two because TP.DT messages do not contain the actual PGN or a connection identifier.

Regardless of whether a node can support multiple simultaneous transport protocol sessions (RTS/CTS and/or BAM), it must assure that TP.DT messages from the same SA with different DAs can be differentiated. Receivers must use the DA and SA to keep the data for the messages correct.

5.10.5.2 Intended Transport Protocol Use

Transport Protocol has been developed to provide a mechanism for transferring PGs with 9 or more data bytes (see 5.2.7.2). A PG defined as multipacket capable, having less than 9 data bytes to transfer in specific instance, shall be sent in a single CAN Data Frame with the DLC set to 8 (see 5.2.7.1).

5.10.5.3 Concurrent PG Reception

It is possible that specific PGs defined as multipacket capable may be sent using a single CAN Data Frame when they contain 8 or fewer bytes, and sent using transport protocol when they contain more than 8 bytes. It is possible for these two forms of the same PG to be sent concurrently.

Note that a single CAN Data Frame form of a PG is not a transport protocol session. Receipt of a PG that is defined as having more than 8 data bytes and sent in a single CAN Data Frame does not close out any other active transport protocol sessions that are transferring the same PG.

5.11 PDU Processing Requirements

Processing of the PDUs requires specific procedures to be followed. A suggested sequence for interpreting PDUs is described in Appendix A. Appendix B shows example SAE J1939 message types and PDU formats being used.

Devices must be able to process CAN Data Frames fast enough to prevent losing messages when the data link is at 100% utilization. This also means that in low utilization situations, when there are back-to-back CAN Data Frames, each device must be able to process the messages fast enough not to lose messages due to their back-to-back nature. Processing the CAN Data Frames fast enough does not mean that a response has to be immediately generated but that a new CAN Data Frame must not overrun previous CAN Data Frames.

5.12 Application Notes

5.12.1 High Data Rates

Data that is to be updated at a high rate and has tight latency requirements should, if possible, allow hardware-based message filtering to be used.

5.12.2 Request Scheduling

The scheduling of a request should be canceled if the information to be requested is received prior to the request being sent. That is, if the information is received 50 ms prior to request scheduling, the request shall not be issued. PGs should not be requested if they are recommended to be broadcast. Exceptions may arise when the recommended broadcast time exceeds a special case need.

5.12.3 Device Response Time and Timeout Defaults

All devices, when required to provide a response, must do so within T_r. All devices expecting a response must wait for at least the T3 interval before giving up or retrying. These times assure that any latencies due to bus access or message forwarding across bridges do not cause unwanted timeouts. Different time values can be used for specific applications when required. For instance, for high-speed control messages, a 20 ms response may be expected. Reordering any buffered messages may be necessary to accomplish the faster response. There is no restriction on minimum response time.

Time between packets of a multipacket message directed to a specific destination is 0 to 200 ms. This means that back-to-back CAN Data Frames can occur and they may contain the same identifier. The CTS mechanism is used to assure a given time spacing between packets. The required time interval between packets of a multipacket BAM message is 10 to 200 ms. The responder shall use a timeout of 750 ms (provides margin allowing for the maximum spacing of 200 ms).

Below is an example using the 1.25s (T3) timing.

a. Maximum forward delay time within a bridge is 50 ms (per SAE J1939-31)

   Total number of bridges = 10 (i.e., 1 tractor + 5 trailers + 4 dollies = 10 bridges)
   Total network delay is 500 ms in one direction.

b. Number of request retries = 2 (3 requests total); this includes the situation where the CTS is used to request the retransmission of data packet(s). If the retransmit request limit is reached, then the connection abort shall be sent with abort reason 5 from Table 6.

c. 50 ms margin for timeouts

Appendix C - Figure C1 and Figure C3 have the timing requirements identified. In Figure C1 the time numbers are computed assuming the worst case number of bridges, 10 bridges. The timeout numbers for receivers are identified as a time value while transmitter requirements are specified as a less than or equal to time value. Note that an originator has transmitter and receiver requirements and that a responder has transmitter and receiver requirements.

5.12.4 Required Responses

A response is required for a global request from all devices that support the requested PGN, including the requester. Acknowledgments are not allowed for global requests (except as outlined in Table 5, Item 1b, 5.4.2, which indicates than an ACK response is permitted for certain PGNs, such as DM3 and DM11).

A device which uses the global DA (255) for a request (e.g., “address request”) shall itself send a response if it has the data requested. This is a requirement because all devices are expected to respond. If the device issuing the request does not respond, then the other network devices may draw the wrong conclusion about the requested information.

Note that a device may be unable to respond to a global request for a supported PGN if the response requires a TP.BAM session and the TP.BAM queue is already in use (see 5.10.5.1). For this reason, a requesting device should issue multiple requests (following an initial timeout) before concluding that PGN data is not available.

5.12.5 Transmission of PGs to Specific or Global Destinations

Most of the time it is desired to send periodically broadcasted PGs to a global destination.

5.12.6 CTS Number of Packet Recommendation

During normal vehicle operation it is recommended that the maximum number of packets that can be sent per CTS message be set to 16.

5.12.7 Error Recovery

Error recovery for conditions that are not described in SAE J1939-21, where responses to queries were not received, are the responsibility of the individual application requirements. These application requirements may be described in another SAE J1939 document or in the device producer’s design requirements for a device or subsystem. For example:

1. There is no error recovery method directly specified for a timed-out destination-specific query; that is, a Request message sent to a non-existent DA will never be answered by an Acknowledgement PG (ACKM) with a Control Byte value of one (Negative Acknowledgement) or a Control Byte value of three (Cannot Respond).

2. When the DA is known to exist, then an error condition is indicated by the lack of response, especially when a value of one should have been sent.

In general, it is the responsibility of the requester to determine whether to repeat the query to meet the needs of the application. It may be the case that the requested data was assigned (or partitioned) to a different device or controller application at another SA. In such a case, a recovery plan may be to send a global request instead of the destination-specific request. Like the recovery described in 5.4.2 for timed out global requests, such recovery methods shall be limited to a reasonable number of attempts and a limited duration of time.

6. NOTES

6.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE TRUCK AND BUS CONTROL AND COMMUNICATIONS NETWORK COMMITTEE OF THE SAE TRUCK AND BUS ELECTRICAL/ELECTRONICS STEERING COMMITTEE

APPENDIX A - SAE J1939 PDU PROCESSING TYPICAL RECEIVE ROUTINE

A.1 RECEIVE INTERRUPT

When a message is received by the microprocessor via the CAN chip, several tests are performed in order to parse it and determine if and where it should be stored. SAE J1939 processing of the CAN Data Frame will not occur if EDP equals 1 and DP equals 1, so the processing shown in Figure A1 does not apply. If EDP equals 0 then the CAN Data Frame can be handled as shown in Figure A1. The three priority bits are used only for bus arbitration and therefore are not needed (used) by the receiving device. Note also that a given device may have more than one SA if it performs multiple functions (see Figure A1).

```
IF PGN = REQUEST PGN AND THE DESTINATION IS SPECIFIC          ; specific request
THEN
    IF DA = ASSIGNED ADDRESS (destination)
    THEN
        SAVE 4 BYTE ID AND 3 DATA BYTES IN REQUEST QUEUE
IF PGN = REQUEST PGN AND THE DESTINATION IS GLOBAL            ; global request
THEN
    SAVE 4 BYTE ID AND 3 DATA BYTES IN REQUEST QUEUE

IF PF < 240
THEN
    IF DA = GLOBAL                                            ; PDU1 Format (DA = global)
    THEN
            USE JUMP TABLE FOR PGN VALUES OF INTEREST AND
            IF SA = ID OF SPECIAL INTEREST
            THEN
               SAVE 8 BYTES OF DATA IN DEDICATED BUFFER
            ELSE
               SAVE 12 BYTE MESSAGE (ID AND DATA) IN CIRCULAR QUEUE
    ELSE (DA = SPECIFIC)                                      ; PDU1 Format (DA = specific)
            USE JUMP TABLE FOR PGN VALUES OF INTEREST AND
            IF SA = ID OF SPECIAL INTEREST VALUES
            THEN
               SAVE 8 BYTES OF DATA IN DEDICATED BUFFER
            ELSE
               SAVE 12 BYTE MESSAGE (ID AND DATA) IN CIRCULAR QUEUE

IF PF > OR = 240
THEN                                                          ; PDU2 Format
            USE JUMP TABLE FOR PGN VALUES OF INTEREST AND
            IF SA = ID OF SPECIAL INTEREST
            THEN
               SAVE 8 BYTES OF DATA IN DEDICATED BUFFER
            ELSE
               SAVE 12 BYTE MESSAGE (ID AND DATA) IN CIRCULAR QUEUE
```

Figure A1 - Typical receive routine

APPENDIX B - COMMUNICATION MESSAGE TYPES

B.1 EXAMPLE OF COMMUNICATION MESSAGE TYPES

This example shows how an engine would typically perform (see Figure B1):

1) BROADCAST/RESPONSE/ACK

Send the engine serial number (Component ID Parameter Group Number = 65259 ($00FEEB_{16}$)).

2) DESTINATION-SPECIFIC REQUEST (PGN 59904)

Receive a specific request for the engine serial number. The message sent back is either a RESPONSE with the data, or a NACK. See item 4) in the examples below.

2A) GLOBAL REQUEST

Receive a global request for the engine serial number. The message sent back is a RESPONSE from a specific device that has the data. Acknowledgments are not used on global requests.

3) COMMAND

For some commands it may be desirable to have a specific acknowledgment that the task has been completed. When this is the case, a message can be sent back as either an ACK = COMMAND COMPLETE or a NACK = COMMAND NOT ABLE TO BE COMPLETED. The example in Figure B1 uses “CF” as the command that will be acknowledged with an ACK or NACK.

4) ACK

Send the NACK message to indicate that the command or request could not be acted upon (invalid request). The NACK message contains the offending Parameter Group Number in the Data field. If the Parameter Group Number in a COMMAND or REQUEST is not recognized by the destination (addressed device), it should still NACK. If the Parameter Group Number is recognized, but the parameter(s) are not available, a normal response is sent back but with the data value(s) set to 255.

	PF	PS (GE, DA)	SA	DATA
1) BROADCAST	254	235 (GE)	000	236912
2) SPECIFIC REQUEST	234	000 (DA)	003	PGN 65259
1) RESPONSE	254	235 (GE)	000	236912
or				
4) NACK	232	255 (DA)	000	01, 255, 255, 255, DA, PGN 65259
2A) GLOBAL REQUEST	234	255 (DA)	003	PGN 65259
1) RESPONSE	254	235 (GE)	000	236912
3) COMMAND	CF	000 (DA)	240	
1) ACK	232	255 (DA)	000	00, 255, 255, 255, DA, PGN for CF
or				
4) NACK	232	255 (DA)	000	01, 255, 255, 255, DA, PGN for CF
or OTHER[1]				

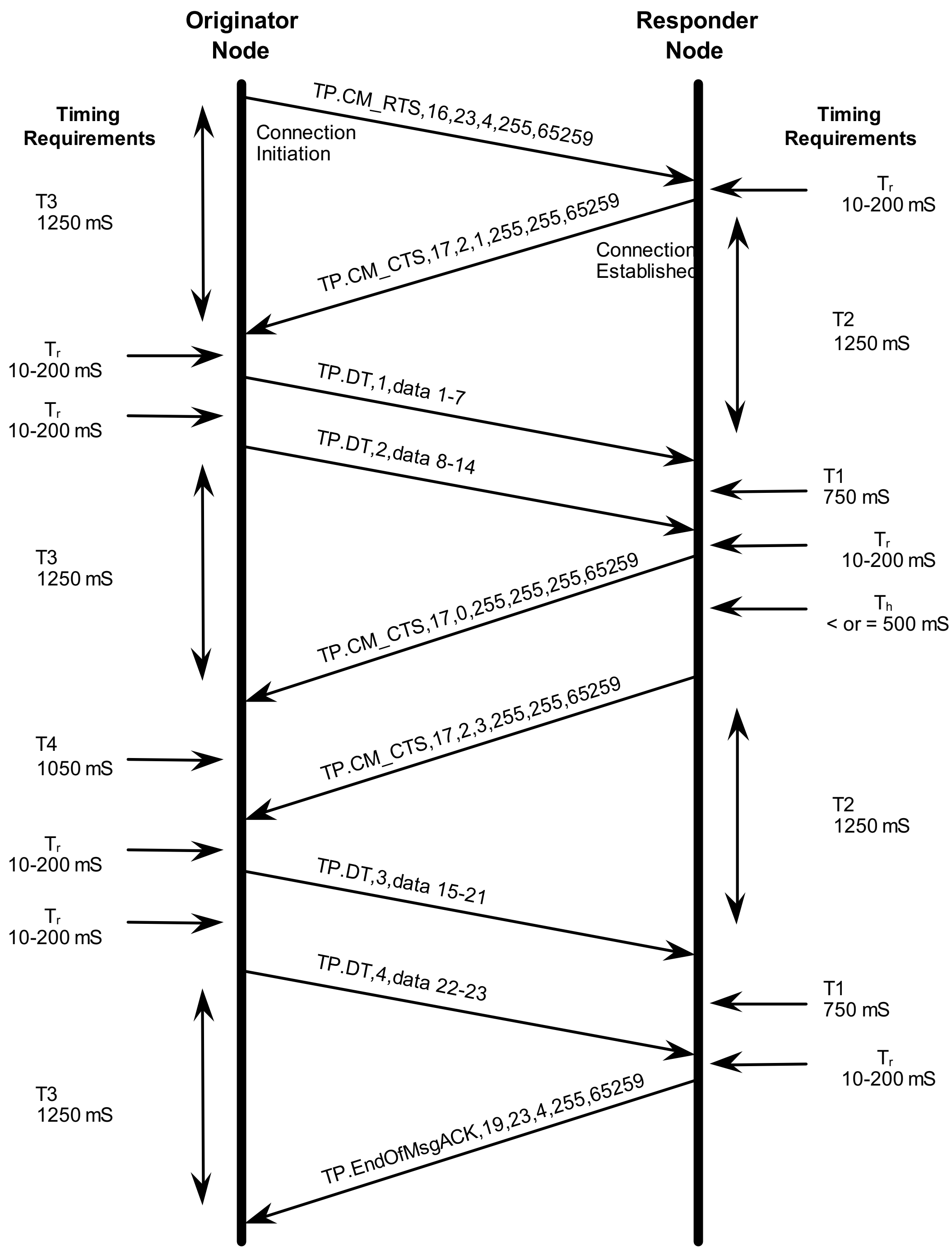
[1] COMMANDs must always have a mechanism for confirming that the action was successful or not. An ACK message is not required if another means is available. This helps to minimize bus traffic. For example, a torque command to the engine can be confirmed by looking at the torque mode bits as well as the torque value coming from the engine.

Figure B1 - Example of communication message types

APPENDIX C - TRANSPORT PROTOCOL TRANSFER SEQUENCES

C.1 CONNECTION MODE DATA TRANSFER

Under normal circumstances, the flow model for data transfer follows Figure C1. The originator sends the TP.CM_RTS indicating there are 23 bytes in the packeted message, which will be transferred in four packets. The PGN for the data in the transfer is 65259, component identification.



NOTE: Timeouts (T1, T2, T3, T4) are described in 5.10.2.4.

Figure C1 - Data transfer without errors

The responder replies with a CTS indicating that it is ready to process two packets, beginning with packet one.

The originating station passes the first two packets across the network using TP.DT. The responder station then issues a CTS indicating that it wants to hold the connection open but cannot receive any packets right now. A maximum of Th later it must send another CTS message to hold the connection. In this example it sends another CTS indicating that it can take two more packets, beginning with packet three. Once packets three and four have been transferred, the responder transmits a TP.EndOfMsgACK message indicating that all the packets expected were transmitted and that the connection is now considered closed. Note that packet four contains 2 bytes of valid data, bytes 22 and 23, the remaining data bytes in this packet are transmitted as 255 (FF16), data not available, such that the message is 8 bytes in length.

Message transfer in the event of an error on the link is shown in Figure C2. The RTS is transferred and responded to properly; then data is lost during the data transfer phase.

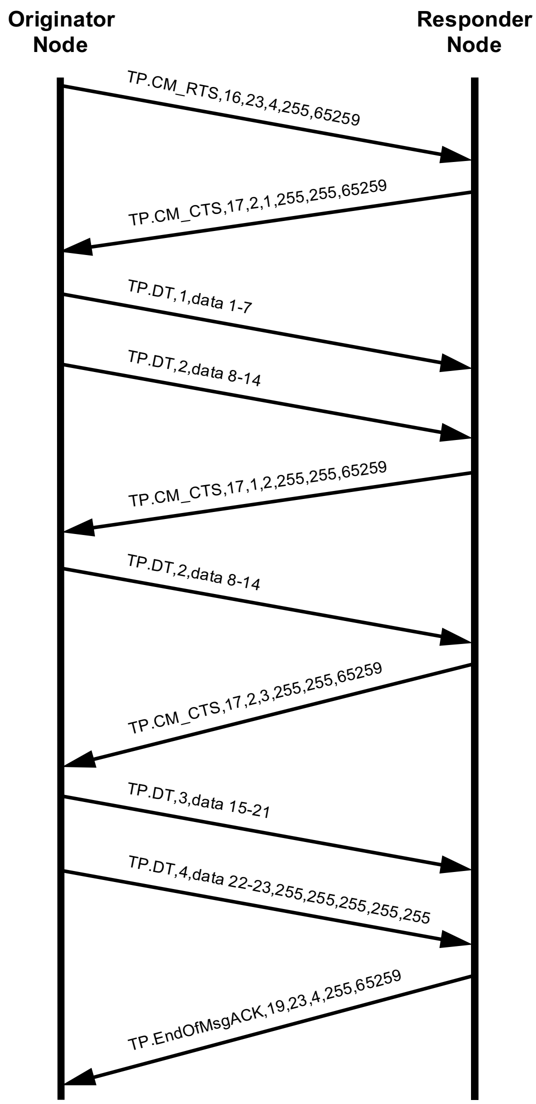


Figure C2 - Data transfer with errors

In this situation, the RTS is sent in the same manner as the earlier example. The first two packets are transferred, but packet two was considered in error by the responder. The responder then transfers a CTS indicating that it wants a single packet, and that packet is packet 2. The originator complies, transferring packet 2. The responder then passes a CTS indicating it wants two packets, starting with packet 3. This CTS is the acknowledgment that packets 1 and 2 were received correctly. Once the last packet is received correctly, the responder passes a TP.EndOfMsgACK signaling that the entire message has been correctly received.

In the situation shown in Figure C3, a node indicates to the network that it is about to transfer a multipacket message utilizing the services of the transport protocol. In this example the PGN 65260, vehicle identification, is being broadcast to the network. The originating node first transmits a BAM (Broadcast Announce Message), followed by the data packets. No acknowledgment is performed by any of the responders (i.e., the receiving nodes in this specific example).

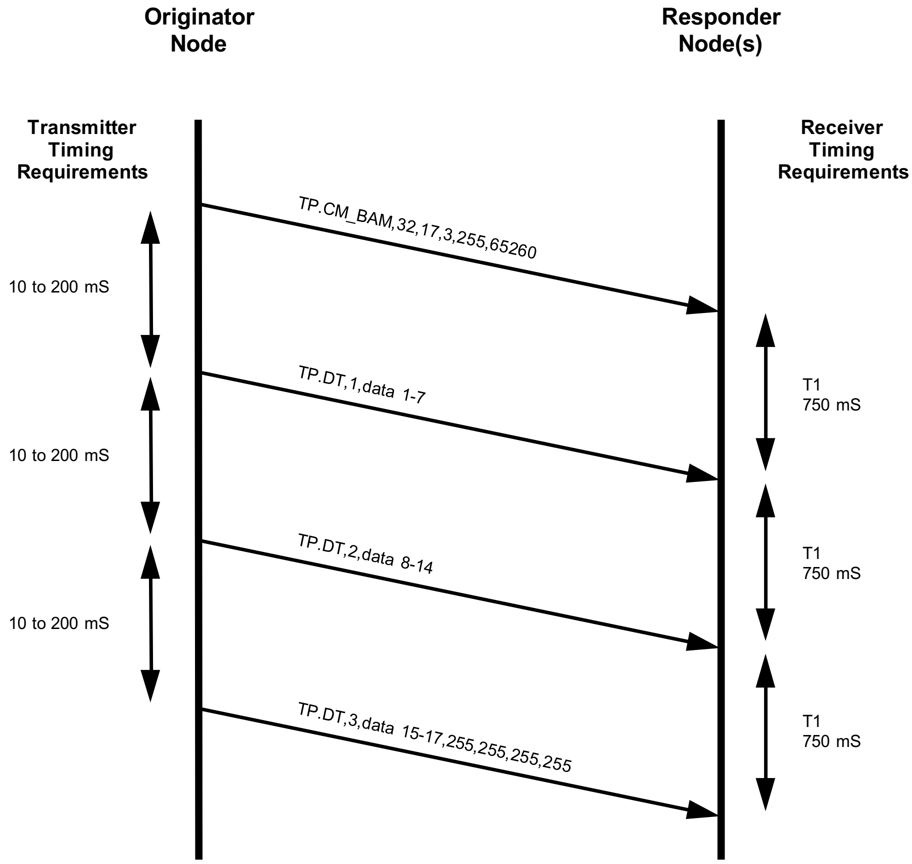


Figure C3 - Broadcast data transfer

In Figure C4, the originator uses the Maximum Number of Packets parameter to limit the number of packets the responder requests to be transferred. In this example both devices support the Maximum Number of Packets parameter as required in 5.9.

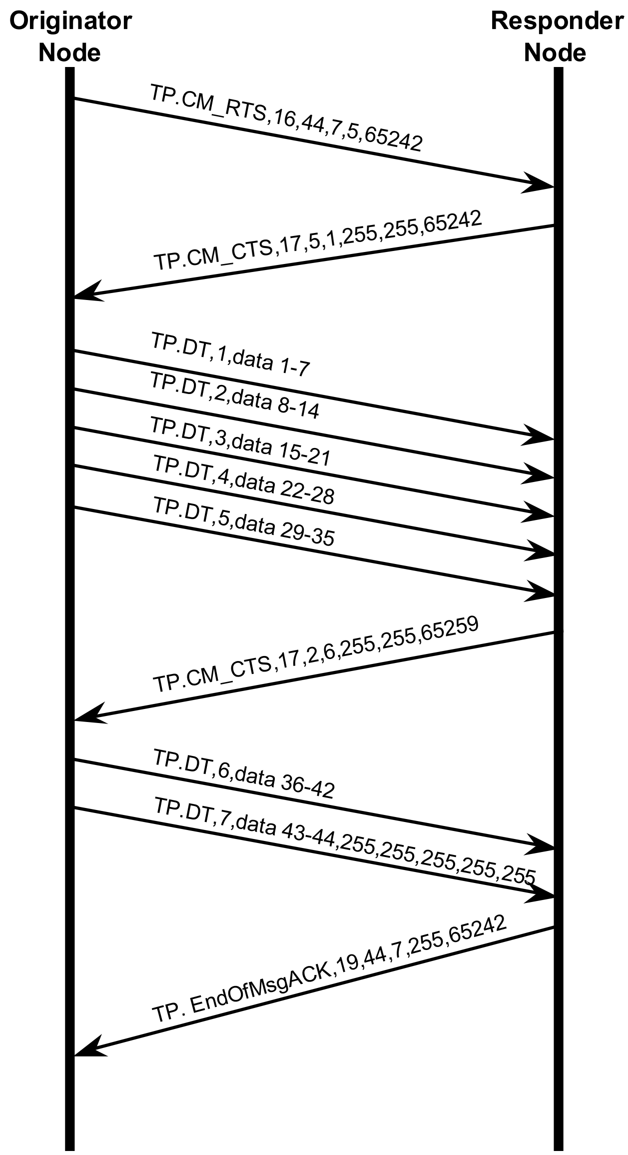


Figure C4 - Data transfer utilizing RTS maximum number of packets capability

Figure C5 shows the case where the last packet in a CTS group is missing. The responder sends a CTS in an attempt to avoid aborting the session.

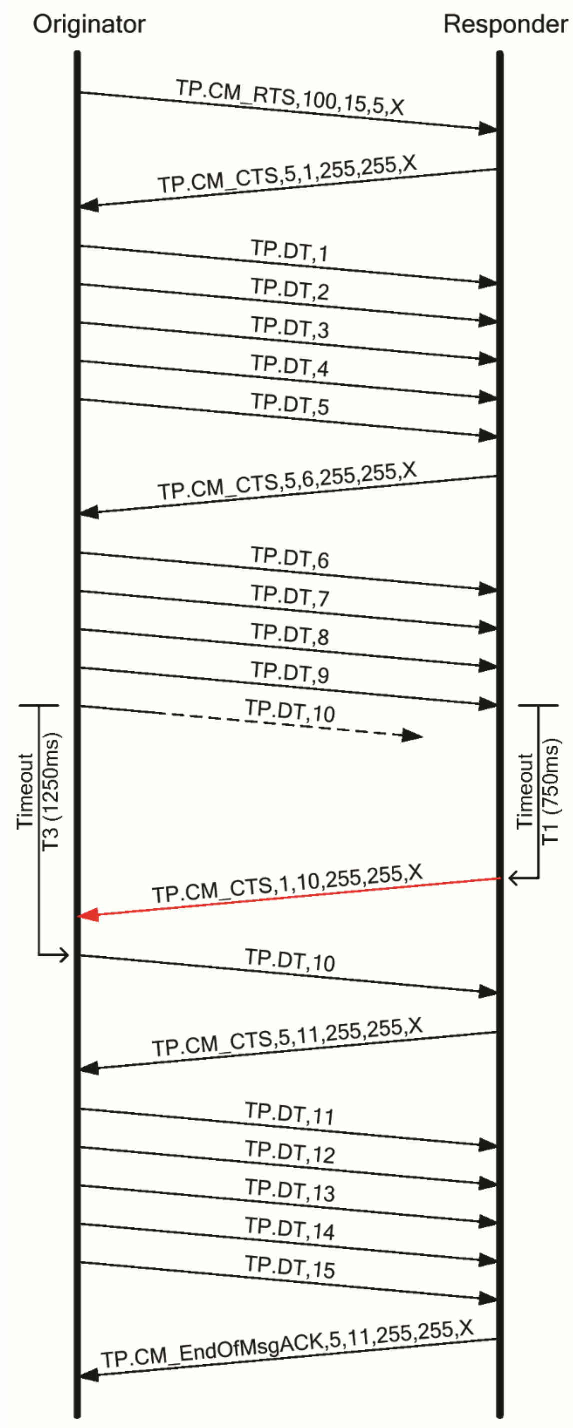


Figure C5 - Responder sending CTS after a time out to prevent session abort

In the case of CTS upon time out, consider the following example:

In the slow originator example (left side, Figure C6), the originator is sending a 12 packet “CTS group,” but the responder's retransmit CTS arrives before the originator sends the last data packet. The originator aborts the session with abort reason 4. This is a possible example where the retransmit CTS does not avoid the session abort.

In the faster originator example (right side, Figure C6), the responder's retransmit CTS arrives after the originator sends the last data packet and before the T3 time out. This is the example where the originator is able to receive the CTS and avoid aborting the session.

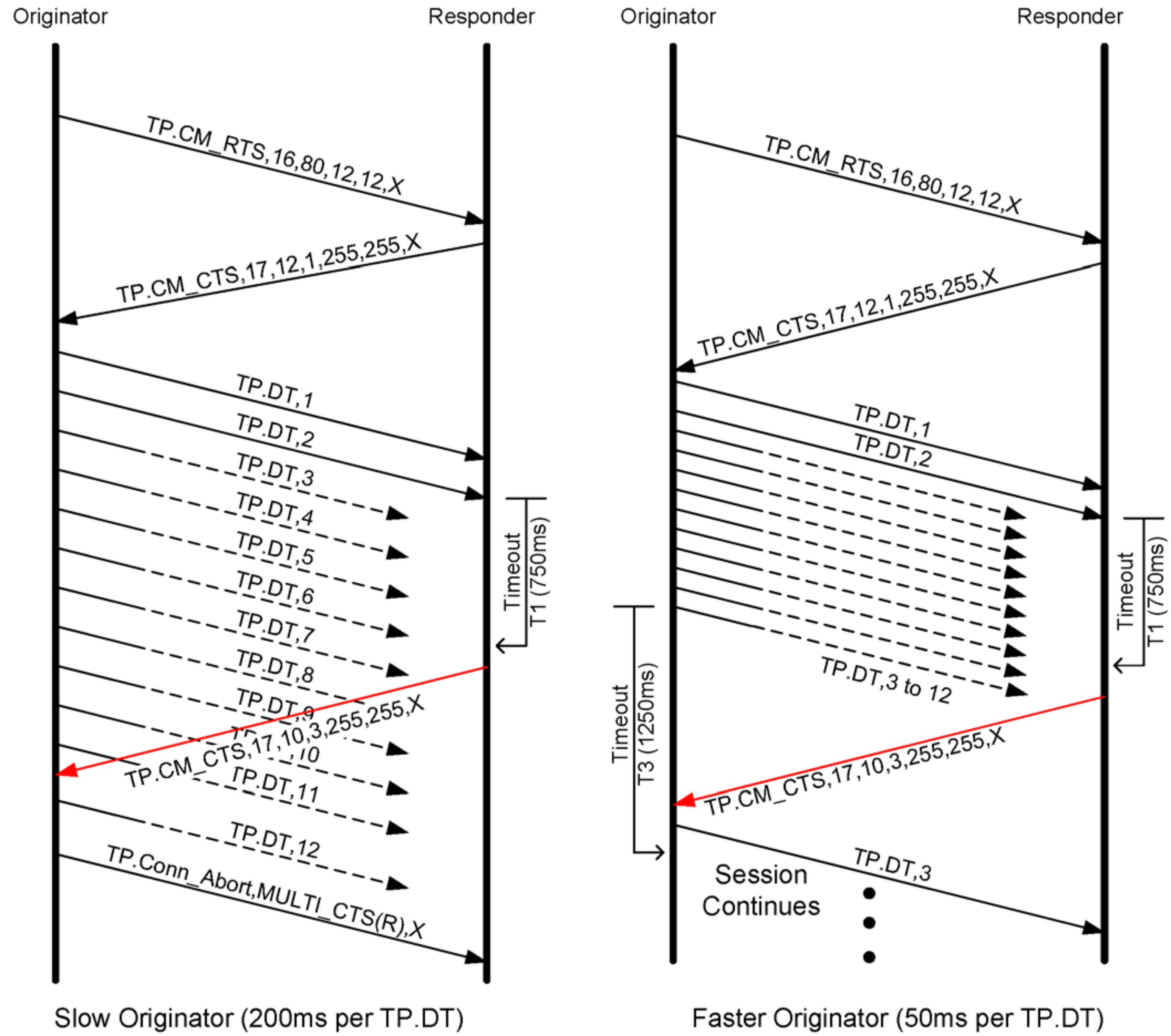


Figure C6 - Examples of originator reaction to a retransmit CTS

APPENDIX D - ASSIGNMENTS OF SPNS FOR SAE J1939-21

D.1 ASSIGNMENT OF SPNS FOR SAE J1939-21

Table D1 shows the SPN assignments for SAE J1939-21 items.

Table D1 – SAE J1939-21 SPN usage

Row Number	PGN or Other Reference	SPN Name	SPN Number	SPN Bits[3]
	PGN 59904 Request	Parameter Group Number (RQST)	2540	24
	PGN 59392 Acknowledge	Control Byte (ACKM)	2541	8
		Group Function Value (ACK) Or Group Function Value = Extended Identifier Type (least significant byte) – byte 1	2542 7334	8 8
		Group Function Value = Extended Identifier Type - filled with FF_{16}	7335	8
		Extended Identifier Type (most significant byte) - filled with FF_{16}	7336	8
		Address Acknowledged (ADD_ACK)	3290	8
		Parameter Group Number (ACK)	2543	24
		Group Function Value (NACK)	2544	8
		Address Negative Acknowledgement (ADD_NACK)	3291	8
		Parameter Group Number (NACK)	2545	24
		Group Function Value (NACK_AD)	2546	8
		Address Access Denied (ADD_AD)	3292	8
		Parameter Group Number (NACK_AD)	2547	24
		Group Function Value (NACK_Busy)	2548	8
		Address Busy (ADD_BUSY)	3293	8
		Parameter Group Number (NACK_Busy)	2549	24
	PGN 61184 Proprietary A	Manufacturer Specific Information (PropA_PDU1)	2550	64 to 14280
	PGN 126720 Proprietary A2	Manufacturer Specific Information (PropA2_PDU2)	3328	64 to 14280
	PGN 65280 to 65535 Proprietary B	Manufacturer Defined Usage (PropB_PDU2)	2551	64 to 14280
	PGN 51456 Request2	Parameter Group Number (RQST2)	2574	24
		Control Indicating Extended Identifier Type	7337	3
		Use Transfer Mode	2575	2
		Extended Identifier Byte 1 (least significant byte)	7338	8
		Extended Identifier Byte 2	7339	8

[3] The numbers in this column represent the size in bits of the data items identified by the SPN. The unit chosen is bits since some items are less than one byte in size.

Row Number	PGN or Other Reference	SPN Name	SPN Number	SPN Bits[3]
		Extended Identifier Byte 3 (Most significant byte)	7340	8
	PGN 51712 Transfer	Parameter Group Number of Requested Information (XFER)	2552	24
		Length of data for the reported PGN (XFER)	2553	8
		"Controller Application Identity" of the ECU for specific data subsets	2554	32
		Transfer Data	2555	72 to 14216
	PGN 60416 Transport Protocol–Connection Management	Control Byte (TP.CM)	2556	8
	TP.CM_RTS	Total Message size (TP.CM_RTS)	2557	16
		Total Number of Packets (TP.CM_RTS)	2558	8
		Maximum Number of Packets (TP.CM_RTS)	2559	8
		Parameter Group Number of packeted message (TP.CM_RTS)	2560	24
	TP.CM_CTS	Number of Packets that can be sent (TP.CM_CTS)	2561	8
		Next Packet Number to be sent (TP.CM_CTS)	2562	8
		Parameter Group Number of packeted message (TP.CM_CTS)	2563	24
	TP.CM_EndofMsgACK	Total Message size (TP.CM_EndofMsgACK)	2564	16
		Total Number of Packets (TP.CM_EndofMsgACK)	2565	8
		Parameter Group Number of packeted message (TP.CM_EndofMsgACK)	2566	24
	TP.Conn_Abort	Connection Abort Reason	2570	8
		Parameter Group Number of packeted message (TP.Conn_Abort)	2571	24
	TP.CM_BAM	Total Message Size (TP.CM_BAM)	2567	16
		Total Number of Packets (TP.CM_BAM)	2568	8
		Parameter Group Number of packeted message (TP.CM_BAM)	2569	24
	PGN 60160 Transport Protocol-Data Transfer	Sequence Number (TP.DT)	2572	8
		Packetized Data (TP.DT)	2573	72 to 14272