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Tractors and machinery for agriculture and forestry — Serial control and communications data network —

Part 3:
Data link layer

Tracteurs et matériels agricoles et forestiers — Réseaux de commande et de communication de données en série —

Partie 3: Couche liaison de données

Reference number
ISO 11783-3:2007(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

ISO 11783-3 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 19, *Agricultural electronics*.

This second edition cancels and replaces the first edition (ISO 11783-3:1998), which has been technically revised.

ISO 11783 consists of the following parts, under the general title *Tractors and machinery for agriculture and forestry — Serial control and communications data network*:

— *Part 1: General standard for mobile data communication*

— *Part 2: Physical layer*

— *Part 3: Data link layer*

— *Part 4: Network layer*

— *Part 5: Network management*

— *Part 6: Virtual terminal*

— *Part 7: Implement messages application layer*

— *Part 8: Power train messages*

— *Part 9: Tractor ECU*

— *Part 10: Task controller and management information system data interchange*

— *Part 11: Mobile data element dictionary*

— *Part 12: Diagnostics services*

— *Part 13: File server*

Sequence control is to form the subject of a future part 14.

Introduction

ISO 11783 specifies a communications system for agricultural equipment based on the CAN 2.0 B [1] protocol. SAE J 1939 documents1), on which parts of ISO 11783 are based, were developed jointly for use in truck and bus applications and for construction and agriculture applications. Joint documents were completed to allow electronic units that meet the truck and bus SAE J 1939 specifications to be used by agricultural and forestry equipment with minimal changes. General information on ISO 11783 is to be found in ISO 11783-1.

The purpose of ISO 11783 is to provide an open, interconnected system for on-board electronic systems. It is intended to enable electronic control units (ECUs) to communicate with each other, providing a standardized system.

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this part of ISO 11783 may involve the use of a patent concerning the controller area network (CAN) protocol referred to throughout the document.

ISO takes no position concerning the evidence, validity and scope of this patent.

The holder of this patent has assured ISO that he is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from:

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Germany

Attention is drawn to the possibility that some of the elements of this part of ISO 11783 may be the subject of patent rights other than those identified above. ISO shall not be held responsible for identifying any or all such patent rights.

1) Society of Automotive Engineers, Warrendale, PA, USA.

Tractors and machinery for agriculture and forestry — Serial control and communications data network —

Part 3: **Data link layer**

1 Scope

ISO 11783 as a whole specifies a serial data network for control and communications on forestry or agricultural tractors and mounted, semi-mounted, towed or self-propelled implements. Its purpose is to standardize the method and format of transfer of data between sensors, actuators, control elements, and information-storage and -display units, whether mounted on, or part of, the tractor or implement. It is intended to provide open system interconnect (OSI) for electronic systems used by agricultural and forestry equipment. This part of ISO 11783 describes the data link layer and the use of CAN extended data frames by the network.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11783-1:2007, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 1: General standard for mobile data communication*

ISO 11783-5, *Tractors and machinery for agriculture and forestry — Serial control and communications data network — Part 5: Network management*

ISO 11898-1, *Road vehicles — Controller area network (CAN) — Part 1: Data link layer and physical signalling*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11783-1 apply.

4 General description

The data link layer enables 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 through a consistent message frame format.

5 Technical requirements

5.1 Message frame format

5.1.1 General

The message frame format shall conform to the CAN requirements. The CAN specification referenced throughout this part of ISO 11783 is specified in ISO 11898-1. When there are differences between the CAN specification and this part of ISO 11783, then this part of ISO 11783 shall be the governing document.

The CAN document specifies, in an information-routing-related discussion, that controller addresses are not used. While this is true for some applications of CAN it is not true for ISO 11783. The definition of the ISO 11783 network requires that controller addressing be used to prevent multiple controllers from using the same CAN identifier field. Many additional requirements exist in ISO 11783 that are not specified by CAN.

ISO 11898-1 specifies two message frame formats: base frame and extended frame. ISO 11898-1 *compatibility* implies that messages of both formats can potentially be present on a single network, by using certain bit coding which allows for the recognition of the different formats. Up to this point, ISO 11783 also accommodates both message frame formats. However, ISO 11783 only defines a full strategy for standardized communications using the extended frame format. All base frame format messages are for proprietary use following the rules defined in this part of ISO 11783.

ISO 11783 controllers shall therefore use the extended frame format. Base frame format messages may reside on the network, but only in accordance with this part of ISO 11783.

NOTE Base frame controllers do not respond to network management messages and are not able to support the strategy for standardized communications.

The CAN data frame is parsed into different bit fields, as shown in Figure 1. The number and parsing of the bits in the arbitration and control field differs between the CAN base and CAN extended frame messages. CAN base frame messages, as shown in Figure 1 a), contain 11 identifier bits in the arbitration field, whereas the arbitration field of CAN extended frame messages, as shown in Figure 1 b), contain 29 identifier bits. ISO 11783 has further defined the identifier bits in the arbitration field of the CAN message frame formats. These definitions are given in Table 1.

5.1.2 Message frame format according to ISO 11783 (ISO 11898-1 extended frame format)

The CAN extended frame message, illustrated by Figure 1, encompasses a single protocol data unit (PDU). The PDU consists of seven predefined fields, assimilated from information provided by the application layer:

— Priority;

— Extended Data Page (EDP),

— Data Page (DP);

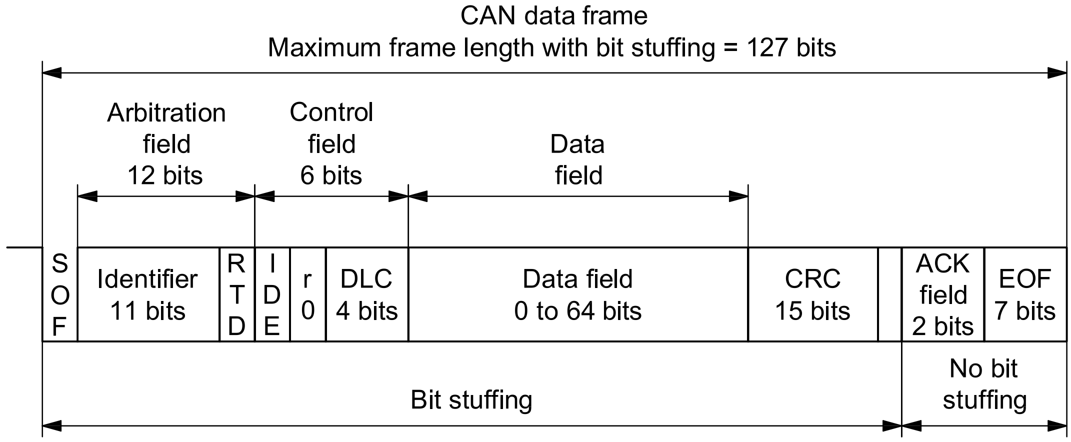
— PDU Format (PF),

— PDU Specific (PS), which can be Destination Address (DA), Group Extension (GE) or proprietary;

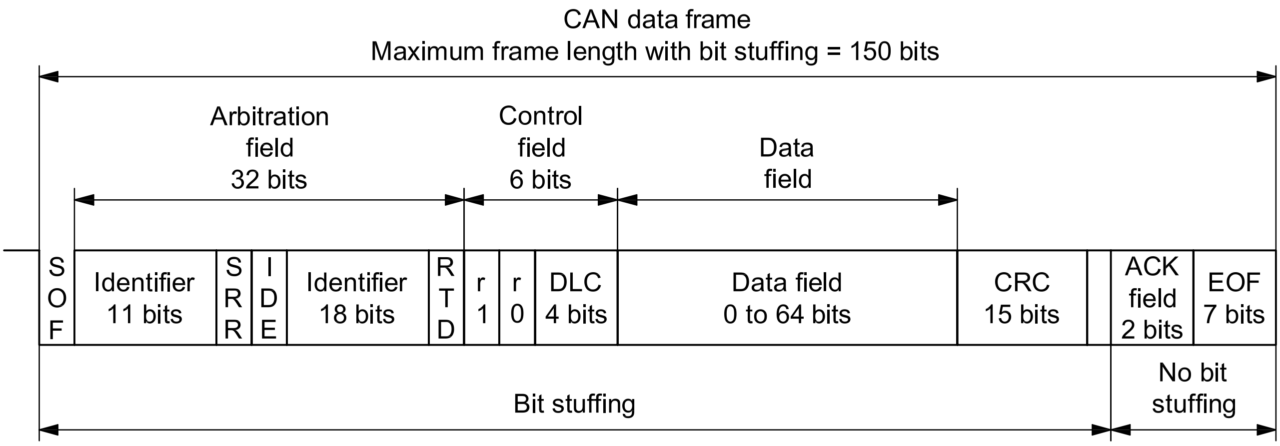
— Source Address (SA);

— Data.

(See 5.2 for a detailed description of each field and 5.3 for PDU formats.)



a) CAN base frame format



b) CAN extended frame format

Figure 1 — CAN data frames

The fields are then packaged into one or more CAN data frames and sent over the physical media to other network controllers. The layers of the OSI model that ISO 11783 supports are shown in Figure 2. It is possible that some parameter group definitions require more than one CAN data frame in order to send their information.

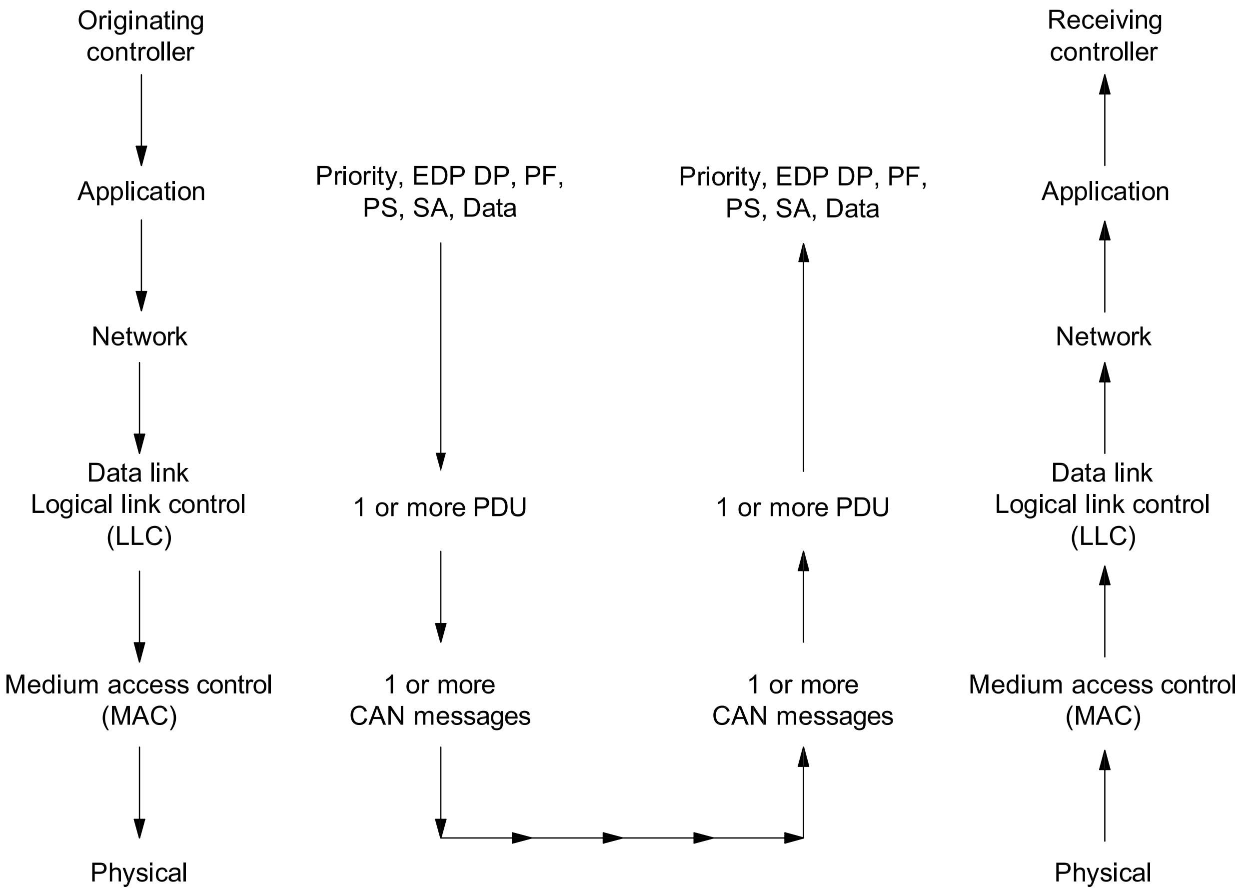


Figure 2 — Application of OSI model according to ISO 11783

Table 1 shows the arbitration and control fields of the 29 bit identifier for CAN, 29 bit identifier for ISO 11783 and 11 bit identifier for CAN, and the use of the 11 bit identifier on an ISO 11783 network. A complete definition for each of the bit field assignments according to ISO 11783 is given in 5.3. In ISO 11783, the CAN data frame data field is described as Bytes 1 to 8. Byte 1's MSB (most significant bit), Bit 8, is the first bit sent closest to the data length code (DLC). Byte 8's LSB (least significant bit), Bit 1, is the last of the data bits to be sent and is closest to the cyclic redundancy check (CRC) field. See Figure 3.

NOTE Base frame controllers can use source addressing in their arbitration and control fields, but these addresses are not used by ISO 11783 controllers.

When the extended data page (EDP) is equal to 1 and the data page (DP) is equal to 1, the CAN frame is identified as an ISO 15765-3 formatted frame. ISO 15765-3 specifies diagnostics on CAN for road vehicles. Therefore, the processing of this specific CAN frame format does not follow the definitions specified in ISO 11783.

Table 1 — Mapping of ISO 11783 into CAN arbitration and control fields

Bit number	29 bit identifier		11 bit identifier	
	CAN	ISO 11783	CAN	ISO 11783 [b]
1	SOF	SOF [a]	SOF	SOF [a]
2	ID28	P3	ID11	P3
3	ID27	P2	ID10	P2
4	ID26	P1	ID9	P1
5	ID25	EDP	ID8	ID8 [a]
6	ID24	DP	ID7	ID7 [a]
7	ID23	PF8	ID6	ID6 [a]
8	ID22	PF7	ID5	ID5 [a]
9	ID21	PF6	ID4	ID4 [a]
10	ID20	PF5	ID3	ID3 [a]
11	ID19	PF4	ID2	ID2 [a]
12	ID18	PF3	ID1	ID1 [a]
13	SRR (r)	SRR [a]	RTR (x)	RTR [a] (d)
14	IDE (r)	IDE [a]	IDE (d)	IDE [a]
15	ID17	PF2	R0	R0 [a]
16	ID16	PF1	DLC4	DLC4
17	ID15	PS8	DLC3	DLC3
18	ID14	PS7	DLC2	DLC2
19	ID13	PS6	DLC1	DLC1
20	ID12	PS5		
21	ID11	PS4		
22	ID10	PS3		
23	ID9	PS2		
24	ID8	PS1		
25	ID7	SA8		
26	ID6	SA7		
27	ID5	SA6		
28	ID4	SA5		
29	ID3	SA4		
30	ID2	SA3		
31	ID1	SA2		
32	ID0	SA1		
33	RTR (x)	RTR [a] (d)		
34	r1	r1 [a]		
35	r0	r0 [a]		
36	DLC4	DLC4		
37	DLC3	DLC3		
38	DLC2	DLC2		
39	DLC1	DLC1		

SOF	Start of Frame bit	EDP	Extended Data Page according to ISO 11783
ID##	Identifier bit number (#)	SA#	Source Address bit number (#) according to ISO 11783
SRR	Substitute Remote Request	DP	Data Page according to ISO 11783
RTR	Remote Transmission Request bit	PF#	PDU Format bit number (#) according to ISO 11783
IDE	Identifier Extension bit	PS#	PDU Specific bit number (#) according to ISO 11783
r#	CAN reserved bit number (#)	(d)	dominant bit
DLC#	Data Length Code bit number (#)	(r)	recessive bit
P#	Priority bit number (#) according to ISO 11783	(x)	bit state dependent on message

[a] CAN-defined bit, unchanged in ISO 11783.

[b] Required format of proprietary 11 bit identifiers.

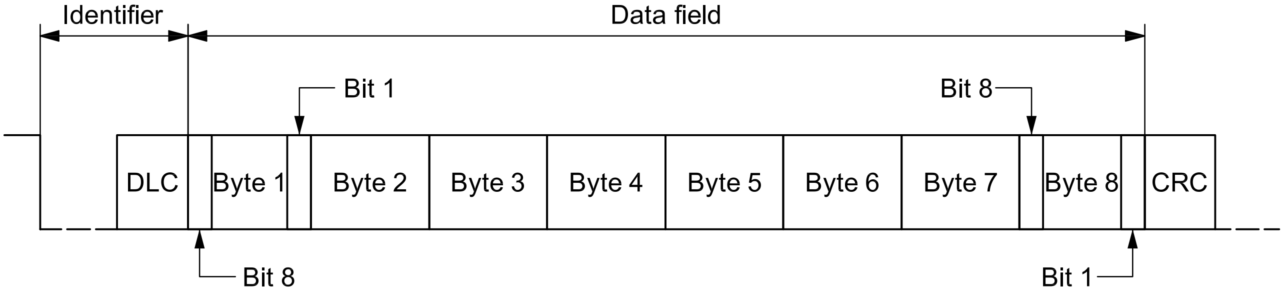


Figure 3 — CAN data field

5.1.3 Parameter group numbers (PGN)

Whenever it is necessary to identify a parameter group in the data field of a CAN data frame, this is expressed in 24 bits. The 24 bit value is sent least significant byte (LSB) first — see Table 2, also according to which the most significant byte (MSB) is sent third and the middle byte second and the LSB first. The 24 it PGN is determined from the following constituent components: 6 bits set to zero, Extended Data Page bit, Data Page bit, PDU Format field (8 bits), and Group Extension field (8 bits).

The procedure for the bit fields to be converted to PGN is as follows. The six MSB of the PGN are set to zero. Then the Extended Data Page bit, Data Page bit and PDU Format field are copied into the next 10 bits. If the PF value is less than 240 (FO_{16}) then the LSB of the PGN is set to zero. Otherwise, it is set to the value of the GE field. See Table 2 for an illustration of the PGN, their corresponding bits and their conversion to a decimal number.

NOTE Not all 131 072 combinations (2^{17}) are available to be assigned as PGN. Only a total of 8 672 combinations are available for assignment (calculated as: 2 pages × [240 +(16 × 256)] = 8 672, using the conventions specified in this part of 11783. See ISO 11783-1 for the latest PGN assignments.

Table 2 — Parameter group number (PGN) examples

PGN constituent components					PGN		Numbers of assignable PGs	Cumulative numbers of PGs	ISO- or manufacturer-assigned
PGN (MSB) Byte 1 sent third in CAN data frame			PGN Byte 2 sent second in CAN data frame	PGN (LSB) Byte 3 sent first in CAN data frame	Dec$_{10}$	Hex$_{16}$			
Bits 8–3	EDP	DP	PF	PS					
	Bit 2	Bit 1	Bits 8–1	Bits 8–1					
0	0	0	0	0	0	000000$_{16}$			ISO
							239	239	
0	0	0	238	0	60 928	00EE00$_{16}$			
0	0	0	239	0	61 184	00EF00$_{16}$	1	240	MF
0	0	0	240	0	61 440	00F000$_{16}$			ISO
							3 840		
0	0	0	254	255	65 279	00FEFF$_{16}$		4 080	
0	0	0	255	0	65 280	00FF00$_{16}$			
							256		MF
0	0	0	255	255	65 535	00FFFF$_{16}$		4 336	
0	0	1	0	0	65 536	010000$_{16}$			
0	0	1	238	0	126 464	01EE00$_{16}$	239		ISO
0	0	1	239	0	126 720	01EF00$_{16}$	240	4576	MF
0	0	1	240	0	126 976	01F000$_{16}$			
							4 096		ISO
0	0	1	255	255	131 071	01FFFF$_{16}$		8 672	

5.1.4 ISO 11783 support of ISO 11898-1 base frame format messages

Controllers on the ISO 11783 network may support the CAN base frame (11 bit identifier) message format. Though these are not compatible with the ISO 11783 message structure, to accommodate the co-existence of the two formats, a minimum level of definition is given. This minimum definition allows controllers that use this format to not interfere with other controllers. CAN base frame format messages are defined as being proprietary. In reference to 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 SA of the PDU. Priority bits are described in 5.2.2. The SA is defined in ISO 11783-1:2007, Annex B.

Incorrect bus arbitration can occur when two messages, one base frame and one extended frame, access the bus at the same time. The source address (SA) is a higher relative priority in the base frame messages than in the extended frame messages. The message with an 11 bit identifier (base frame) can have an SA indicating a higher priority than that of the Extended Data Page bit, Data Page bit and PDU Format of the 29 bit identifier (extended frame) message. The three priority bits should be used to achieve the correct bus arbitration.

IMPORTANT — ISO 11783 defines a full strategy for standardized communications using the extended frame format. Hardware conforming to ISO 11898-1 shall not be used on the network, since these versions of hardware do not allow the extended frame messages to be communicated.

5.2 Protocol data unit (PDU)

5.2.1 General

The applications and/or network layer provide a string of information that is assimilated into a protocol data unit. The protocol data unit provides a framework for organizing the information that is essential to each CAN data frame sent. The protocol data unit (PDU) of the ISO 11783 network shall consist of the seven fields listed in 5.1.2 and specified below. These fields shall then be packaged into one or more CAN data frames and sent over the physical media to other network controllers. There is only one PDU per CAN data frame.

NOTE Some PGN definitions require more than one CAN data frame for sending the corresponding data.

Certain of the CAN data frame fields are left out of the PDU definition because they are controlled entirely by the CAN specification and are invisible to all of the OSI layers above the data link layer. These include the SOF, SRR, IDE, RTR, CRC, ACK and EOF fields, and parts of the control field. They are defined by the CAN protocol definition and remain unmodified by ISO 11783.

The PDU fields (see Figure 4) are specified in 5.2.2 to 5.2.8.

	Priority	EDP,	DP,	PF,	PS,	SA,	Data
No. of bits	...3...,	.1.,	.1.,	...8...,	...8...,	...8...,	...64...

Figure 4 — PDU fields

5.2.2 Priority (P)

Priority bits are used to optimize message latency for transmission onto the bus only. They should be globally masked off by the receiving controller (ignored). The priority of any message may be set from highest, 0 (000_2), to lowest, 7 (111_2). The default for all control oriented messages is 3 (011_2). The default for all other informational, proprietary, request and NACK messages is 6 (110_2). This permits the priority to be raised or lowered in the future as new PGN values are assigned and bus traffic changes. A recommended priority is assigned to each PGN when it is added to the application layer standards. However, the priority field should be reprogrammable to allow for network tuning by the manufacturers if the need arises.

5.2.3 Extended data page (EDP)

This bit is used in conjunction with the data page bit to determine the structure of the CAN identifier of the CAN data frame. All ISO 11783 messages shall set the extended data page bit to ZERO on transmit. (See Table 3 for the defined uses of the EDP and DP fields.) It is possible that future definitions will expand the PDU Format field, defining new PDU formats, expanding the priority field, or increasing the address space.

5.2.4 Data page (DP)

The DP bit is used in conjunction with the EDP bit to determine the structure of the CAN identifier of the CAN data frame. With the EDP set to 0, the DP bit selects between page 0 and page 1 of the PGN descriptions. See Table 3.

Table 3 — Definition of extended data page (EDP) and data page (DP) use

EDP Bit 25	**DP Bit 24**	**Description**
CAN ID Bit 25	CAN ID Bit 24	
0	0	ISO 11783 page 0 PGN
0	1	ISO 11783 page 1 PGN
1	0	ISO 11783 reserved
1	1	ISO 15765-3 defined PGN

NOTE The EDP and DP of the CAN 29 bit identifier being set to "11" identifies it as an ISO 15765-3 message. This means that the rest of the CAN identifier is *not* set up as specified by ISO 11783; CAN frames following this format are not described in ISO 11783.

5.2.5 PDU Format (PF)

PF is an 8 bit field that determines the PDU format and is one of the fields used to determine the PGN assigned to the CAN data field. PGN are used to identify or label commands, data, some requests, acknowledgements and negative acknowledgements, as well as for identifying or labelling information that requires one or more CAN data frames to communicate the information. If there is more information than can fit in eight data bytes, a multi-packet message is required to be sent. If there are eight or less 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 rotations per minute. Even though a PGN label can be used for one parameter, it is recommended that multiple parameters be grouped so that all 8 B of the data field are used.

NOTE B is the symbol for the unit byte, according to IEC 60027-2.

The definition of two proprietary PGN allows both PDU1 and PDU2 formats to be used. The interpretation of the proprietary information varies between manufacturers.

EXAMPLE Even though two different engines can use the same source address, it is probable that one manufacturer's proprietary communications will be different from another's.

5.2.6 PDU Specific (PS)

The PS field is an 8 bit field whose definition depends on its PDU format, which determines whether it will be a DA or GE field. See Table 4.

Table 4 — Definition of PDU Specific (PS) field

PDU format	PF	PS
PDU1	0–239	Destination Address (DA)
PDU2	240–255	Group Extension (GE)

The DA field defines the specific address to which the message is being sent. Any other controller should ignore this message. The global destination address (255) requires all controllers to listen and respond accordingly as message recipients.

The GE field, in conjunction with the four least significant bits of the PF field, provides for 4 096 parameter groups per data page. These are only available using the GE format PDU (PDU2).

NOTE When the four most significant bits of the PDU format field are set it indicates that the PS field is a GE field.

In addition, 240 parameter groups are provided in each data page for use only in the destination-specific format PDU (PDU1 format). In total, 8 672 parameter groups are available to be defined using the two data pages currently available.

This total is calculated as follows: $[240 + (16 \times 256)] \times 2 = 8\,672$, with 240 representing the number of PDU format field values available per data page (i.e. PDU1 format, PS field = DA), 16 the number of PDU format values per GE value (i.e. PDU2 format only), 256 the number of possible GE values (i.e. PDU2 format only), and 2 the number of data page states (both PDU formats).

See also 5.3.

5.2.7 Source Address (SA)

The SA field is 8 bits long. There shall only be one controller on the network with a given source address.

NOTE For address management and allocation, and procedures to prevent duplication of SA, see ISO 11783-5.

5.2.8 Data field

5.2.8.1 Data from 0 to 8 B

When eight or less bytes of data are required for expressing a given parameter group, then all eight data bytes of the CAN data frame may be used. It is recommended that 8 B be allocated or reserved for all PGN assignments likely to expand in the future. This provides a means of adding parameters easily and avoiding incompatibility with previous revisions that only define part of the data field. Once the number of bytes of data associated with a PGN is specified it cannot be changed (and cannot become multi-packet either, unless originally defined as such). The CAN data length code (DLC) is set to the defined parameter group "data length" value when it is 8 B or less; otherwise, when the PG data length is 9 or greater, the CAN DLC is set to 8. For example, the REQUEST PGN, 59 904, has a PG data length of 3, so the CAN DLC is set to 3. An individual group function (see 5.4.6) shall use the same data field length because the CAN identifier is always identical; while the CAN data field is used to convey the specific group subfunctions. These group functions require many different interpretations based on the CAN data field.

5.2.8.2 Data from 9 B to 1 785 B

When nine to 1 785 data bytes are needed to express a given parameter group, the communication of this data is done in multiple CAN data frames. The term *multi-packet* is used to describe this type of parameter group. A parameter group defined as being multi-packet capable, having less than nine 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 parameter group has nine or more data bytes to transfer, the *transport protocol* function is used. The *transport function connection management* capability is used to set up and close out the communication of the multi-packet parameter groups. The *transport protocol data transfer* capability is used to communicate the data itself in a series of CAN data frames (packets) containing the "packetized" data. Additionally, the transport protocol function provides flow control and handshaking capabilities for destination-specific transfers (see 5.10).

All CAN data frames associated with a particular multi-packet response shall have a DLC of 8. All unused data bytes are set to "Not Available". The number of bytes per packet is fixed; however, ISO 11783 defines multi-packet messages that have a variable and or fixed number of packets. The PGN for active diagnostic codes is an example of a multi-packet message that has a variable number of packets. Parameter groups that are defined as multi-packet only use the transport protocol when the number of data bytes to be sent exceeds eight in number.

5.3 Protocol data unit (PDU) formats

5.3.1 General

The available PDU formats, illustrated in Figure 5, are defined as PDU1 (PS = DA) and PDU2 (PS = GE). PDU1 allows for direction of the CAN data frame to a specific destination address (controller); PDU2 only communicates CAN data frames that are not destination-specific. Two separate PDU formats are created to provide more possible parameter group number combinations while still providing for destination-specific communications. Proprietary parameter group definitions are assigned so that both PDU formats can be used for proprietary communications. A standardized method for proprietary communications is defined to prevent possible conflicts in identifier usage.

The definition of two proprietary PGN allows both PDU1 and PDU2 formats to be used. The interpretation of the proprietary information varies by manufacturer.

EXAMPLE An engine manufacturer's proprietary communications can be different from those of another engine manufacturer, even though they both use the same source address.

	Priority	EDP,	DP,	PF,	PS(DA),	SA,	Data
No. of bits	...3...,	.1.,	.1.,	...8...,	...8...,	...8...,	...64...

a) PDU1

	Priority	EDP,	DP,	PF,	PS(GE),	SA,	Data
No. of bits	...3...,	.1.,	.1.,	...8...,	...8...,	...8...,	...64...

b) PDU2

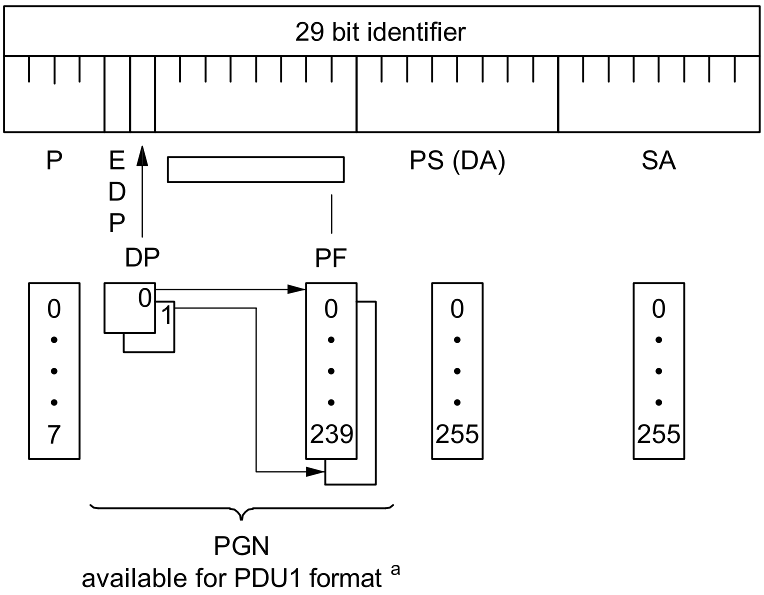
Figure 5 — Available PDU formats

5.3.2 PDU1 format

The PDU1 format provides for applicable parameter groups to be sent to either specific or global destination(s). 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 value of that field is 0 to 239, the message is in the PDU1 format. The format of the PDU1 message is illustrated by Figure 5. See also Figure 6.



a Currently, 2 × 240 = 480.

Figure 6 — PDU1 format

Parameter groups requiring a destination (PDU1) and minimal latency start at PF = 0 and go incrementally towards x (or x1).

Parameter groups requiring a destination where latency is not critical start at PF = 239 and go decrementally towards x (or x1).

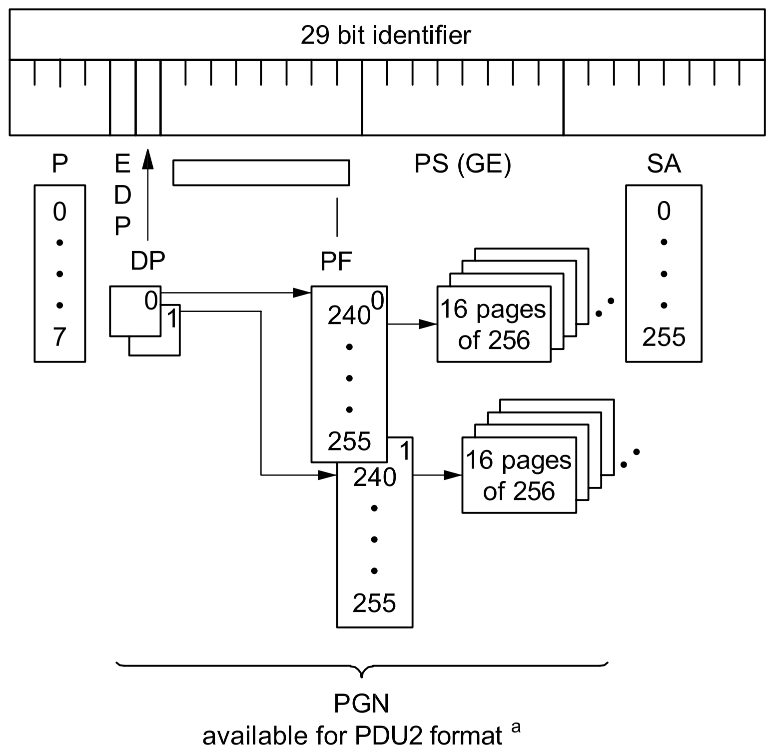
See Table 7.

A PF equal to 239 (Extended Data Page bit = 0 and Data Page bit = 0) is assigned for proprietary use. In this case the PS field is a destination address (see 5.4.6). The PGN for Proprietary A is 61184.

5.3.3 PDU2 format

The PDU2 format may only be used to communicate parameter groups as global messages. PDU2 format messages can be requested or sent as unsolicited messages. Selection of the PDU2 format at the time a PGN is assigned prevents that PGN from ever being able to be directed to a specific destination. The PS field contains a GE.

PDU2 format messages are defined as being those where the PF value is equal to 240 to 255 (see Table 5). The format of the PDU2 message is illustrated by Figure 5. Also see Figure 7.



[a] Currently, 2 × 16 × 256 = 8 192.

Figure 7 — PDU2 format

The PGN of messages that are sent at fast update rates (generally less than 100 ms) start at PF = 240 and increment towards y (or y1).

The PGN of messages that are only requested, sent on change, or are sent at slow update rates (generally greater than 100 ms) start at PF = 254 and go decrementally towards y (or y1).

See Table 7.

A PF equal to 255 (Extended Data Page bit = 0 and Data Page bit = 0) is assigned for proprietary use. The PS field is left to be defined and used by each manufacturer (see 5.4.6). The PGN for Proprietary B is 63 280 to 65 535.

5.4 Message types

5.4.1 General

There are five message types currently supported:

— Commands;

— Requests;

— Broadcasts/Responses;

— Acknowledgements;

— Group Functions.

The specific message type is recognized by its assigned PGN. The RTR bit (defined in the CAN protocol for remote frames) is not to be used in the recessive state (logical 1). Therefore, Remote Transmission Request (RTR = 1) is not available for use in the ISO 11783 network.

Multi-byte parameters that appear in the data field of a CAN data frame shall be placed LSB first. Exceptions are noted where applicable (i.e. ASCII data). If a 2 B 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 MSB in Byte 8.

5.4.2 Command

The command message type categorizes those parameter groups that command 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 (PS = DA) and PDU2 format (PS = GE) messages can be used for commands. Example command modes include Transmission Control, Address Request and Torque/Speed Control.

5.4.3 Request

The Request message type, identified by the PGN, provides the ability to request information globally or from a specific destination. Requests specific to one destination are known as *destination-specific* requests. The information below assigns a PGN to the Request PGN parameter group. The information is in the same format as parameter group definitions in ISO 11783.

Parameter group name:	REQUEST
Definition:	used to request a parameter group from a network controller or controllers
Transmission repetition rate:	per user requirements, generally recommended that requests occur no more than two or three times per second
Data length:	3 B (The CAN frame for this PG shall set the DLC to 3.)
Data page:	0
PF:	234
PS:	DA (global or specific)
Default priority:	6
Parameter group number:	59 904 ($00EA00_{16}$)
Bytes:1, 2, 3	PGN being requested (see 5.1.3 for field definition and byte order)

Table 5 lists the request/response possibilities for PDU1 and PDU2 format PGN. It clarifies that the originating controller of a message determines whether the destination is specific or global, based on whether the request was to a specific or global DA. Table 5 also illustrates that for unsolicited messages the originating controller may transmit to a specific or global DA for PDU1 and PDU2 PGN with more than 8 B. For PDU2 PGN with 8 B or less, the originating controller may only send the data globally.

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

PDU Format	Data length B	Request PGN 59 904	Response	TP used
1	$\leqslant 8$	DA specific	DA specific	Not allowed
1	$\leqslant 8$	DA global	DA global	Not allowed
1	$\leqslant 8$	None	DA global	Not allowed
			DA specific	Not allowed
1	> 8	DA specific	DA specific	RTS/CTS
1	> 8	DA global	DA global	BAM
1	> 8	None	DA global	BAM
			DA specific	RTS/CTS
2	$\leqslant 8$	DA specific	DA global	Not allowed
2	$\leqslant 8$	DA global	DA global	Not allowed
2	$\leqslant 8$	None	DA global	Not allowed
2	> 8	DA specific	DA specific	RTS/CTS
2	> 8	DA global	DA global	BAM
2	> 8	None	DA global	BAM
			DA specific	RTS/CTS

General rules of operation for determining whether to send a PGN to a global or specific destination

a) If the request is sent to a global address, then the response is sent to a global address.

A NACK (see 5.4.5) is not permitted as a response to a global request.

b) If the request is sent to a specific address, then the response is sent to a specific address.

A NACK is required if the PGN is not supported.

If the data length is 8 B or more, the transport protocol RTS/CTS shall be used for the response to a specific address.

Exceptions:

— PDU2 format PGN with 8 B or less may only be sent to a global destination because there is no destination address field in the PDU2 format.

— The Address Claim PGN is sent to the global destination address even though the request for it was to a specific destination address (see ISO 11783-5).

c) For periodic broadcasts or unsolicited messages, PDU1 or PDU2 format PGN may be sent to a global or specific destination address.

Exception:

— PDU2 format PGN with 8 B or less may only be sent to a global destination because there is no destination address field in the PDU2 format.

d) Exceptions to these rules do exist, as can be seen from the above. The exceptions are noted in the applicable document in the section in which the PGN is defined. There are two types:

— the response destination address does not specify the source address of the request — some examples have been noted above (Address Claim PGN and Acknowledgment PGN);

— the PGN does not support all forms of the available addressing, i.e. some PGN are not designed to support the address capability that is available for PDU1 or PDU2 format messages.

Table 6 gives two examples of how the Request PGN is used.

Table 6 — Use of specified fields in ISO 11783 PDU1 format

Message type	PGN	PS (DA)	SA	Data 1	Data 2	Data 3
Global Request	59 904	255 (Responder)	SA1 (Requester)	PGN LSB [a]	PGN	PGN MSB [a]
Specific Request	59 904	SA2 (Responder)	SA1 (Requester)	PGN LSB [a]	PGN	PGN MSB [a]
[a] The parameter group number (PGN) in the data field is used to identify the information being requested.						

A response is always required from a specified destination (not global), even if it is a NACK indicating that the particular PGN value is not supported. A global request shall not be responded to with a NACK when a particular PGN is not supported by a controller.

NOTE 1 Some PGN are multi-packet, so several CAN data frames can occur for a single request.

The Request PGN can be directed to a specific destination address to determine if a specific parameter group is supported (i.e. does the requested destination address transmit the specific group?). The response to the request determines whether the PGN is supported. If it is supported then the receiving controller shall send the requested information. If the Acknowledgment PGN is appropriate, then the control byte shall be set to 0 or 2 or 3. If it is not supported, the receiving controller shall send the Acknowledgment PGN with the control byte set to one, for Negative Acknowledgment. The remaining portions of the ISO 11783 PDU format and parameter group shall be filled in appropriately (see 5.4.5). It is not possible to determine whether a controller acts upon the PG (when received) by using this method.

NOTE 1 "Not supported" means that the PG is not transmitted.

5.4.4 Broadcast/Response

The Broadcast/Response message type can be either an unsolicited broadcast of information from a controller or the response to a command or request.

5.4.5 Acknowledgement

There are two forms of acknowledgement available. The first form is provided for by the CAN protocol. It consists of an "in-frame" acknowledgement confirming that a message is received by at least one controller. In addition, messages are further acknowledged by the absence of CAN error frames. Their absence acknowledges that all other powered and connected controllers received the message correctly.

The second form of acknowledgement is a response of a "normal broadcast" or "ACK" or "NACK" to a specific command or request as provided for by an application layer. The definition of the Acknowledgment parameter group is shown below. The type of acknowledgement required for some parameter groups is defined in the applications layer.

For Group Function parameter groups (see 5.4.6) the Group Function Value parameter allows a controller to identify the specific group function that is being acknowledged. The Group Function Value is unique to each Group Function PG. It is desirable that the Group Function Values only use the range 0 to 250.

Parameter group name:	ACKNOWLEDGEMENT
Definition:	parameter group used to provide a handshake mechanism between transmitting and receiving controllers
Transmission repetition rate:	upon reception of a PGN that requires this form of acknowledgement
Data length:	8 B
Data page:	0
PF:	232
PS:	DA
Default priority:	6
Parameter group number:	59 392 ($00E800_{16}$)

Data ranges for parameters used by this message type:

Control byte:	0 to 3	See definitions below.
	4 to 255	Reserved for assignment in a future International Standard.
Group Function Value	0 to 250	Definition is specific to the individual PGN, when applicable. Most often it is located as the first byte in the data field of the applicable Group Function parameter group.
	251 to 255	Follows the conventions defined in ISO 11783-7.

Positive Acknowledgement: control byte = 0

Byte:	1	Control byte = 0, Positive Acknowledgement (ACK)
Byte:	2	Group Function Value (if applicable) (see 5.4.6)
Byte:	3 to 4	Reserved for assignment in a future International Standard; send each of these bytes as FF_{16}
Byte:	5	Address Acknowledged
Byte:	6	PGN of requested information (8 LSB of parameter group number, Bit 8 MSB)
Byte:	7	PGN of requested information (second byte of parameter group number, Bit 8 MSB)
Byte:	8	PGN of requested information (8 MSB of parameter group number, Bit 8 MSB)

Negative Acknowledgement: control byte = 1

Byte:	1	Control byte = 1, Negative Acknowledgement (NACK)
Byte:	2	Group Function Value (if applicable) (see 5.4.6)
Byte:	3 to 4	Reserved for assignment in a future International Standard, send each of these bytes as FF_{16}
Byte:	5	Address Negative Acknowledgment
Byte:	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)
Byte:	2	Group Function Value (if applicable) (see 5.4.6)
Byte:	3 to 4	Reserved for assignment in a future International Standard, send each of these bytes as FF_{16}
Byte:	5	Address Access Denied
Byte:	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)
Byte:	2	Group Function Value (if applicable) (see 5.4.6)
Byte:	3 to 4	Reserved for assignment in a future International Standard, send each of these bytes as FF_{16}
Byte:	5	Address Busy
Byte:	6 to 8	PGN of requested information (see above)

5.4.6 Group Function

The Group Function message type is used for groups of special functions (proprietary functions, network management functions, multi-packet transport functions, etc.). Each group of functions is recognized by its assigned PGN. The information below assigns the PGN to the Group Function parameter group. The function itself is defined within the data structure (typically the first byte of the data field). More detailed explanation of the group function's proprietary and transport protocol is given in the following subclauses. The proprietary group function provides a means of transmitting proprietary messages in a way that eliminates CAN identifier 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 this part of ISO 11783 are not sufficient.

A request using PGN 59 904 (see 5.4.3) can be used to determine if a specific parameter group of the Group Function message type is supported. If supported, then the receiving controller sends the Acknowledgement PGN with the control byte equal to zero for Positive Acknowledgement, or equal to two for Access Denied or equal to 3 for Cannot Respond. If not supported, the receiving controller sends the Acknowledgement PGN with the control byte set to one, for Negative Acknowledgement. The remaining portions of the ISO 11783-specified PF and parameter group shall be filled in appropriately (see 5.4.5).

NOTE "Not supported" means that the PG is not transmitted. It is not possible to determine whether a controller acts upon the PG (when received) by using this method.

Parameter group name:	PROPRIETARY A
Definition:	Proprietary PG that uses destination-specific PDU Format to allow manufacturers to direct their proprietary communications to a specific destination controller. How the data field of this message is used is at the option of the manufacturer, as is the use of proprietary messages, provided that significant percentages (2 % or more) of system network utilization are avoided.
Transmission repetition rate:	per user requirements
Data length:	0 to 1 785 B (multi-packet supported)
Data page:	0
PF:	239
PS:	DA
Default priority:	6
Parameter group number:	61 184 ($00EF00_{16}$)
Bytes: 1 to 8	manufacturer-specific use (see 5.1.3)

Data ranges for parameters used by this group function: none defined by ISO.

Parameter group name:	PROPRIETARY A2
Definition:	Proprietary PG that uses destination-specific PDU Format to allow manufacturers to direct their proprietary communications to a specific destination controller. How the data field of this message is used is at the option of the manufacturer, as is the use of proprietary messages, provided that significant percentages (2 % or more) of system network utilization are avoided.
Transmission repetition rate:	per user requirements
Data length:	0 to 1 785 B (multi-packet supported)
Data page:	1
PF:	239
PS:	DA
Default priority:	6
Parameter group number:	126 720 ($01EF00_{16}$)
Bytes: 1 to 8	manufacturer-specific use (see 5.1.3)

Data ranges for parameters used by this group function: none defined by ISO.

Parameter group name:	PROPRIETARY B
Definition:	Proprietary PG that uses the PDU2 Format message to allow manufacturers to define the PS (GE) field content as they desire. However, significant percentages (2 % or more) of system network utilization shall be avoided. How the PS (GE) and data fields of this message are used is at the option manufacturer. The data length of these messages may be set by each manufacturer. Therefore, two manufacturers may use the same GE value and it can have a different data length code. Receiving controllers of this information need to differentiate between the two manufacturers.
Transmission repetition rate:	per user requirements
Data length:	0 to 1 785 B (multi-packet supported)
Data page:	0
PF:	255
PS field:	GE (manufacturer-assigned)
Default priority:	6
Parameter group number:	65 280 to 65 535 ($00FF00_{16}$ to $00FFFF_{16}$)
Bytes: 1 to 8	manufacturer-defined usage (see 5.1.3)

Data ranges for parameters used by this group function:

Manufacturer-defined usage results with the data length code being unique per component supplier and source address. Caution should be taken when using the Proprietary B parameter group (PGN = 65 280) because multiple source addresses can use the same Proprietary B PGN value for different purposes.

5.4.7 Request2

The Request2 PG has the added capability of specifying whether the receiving controller uses the Transfer PGN 51 712. By specifying that the receiving controller use the Transfer PGN, it provides the ability for the receiving controller to report the data set for all controllers it is tasked with reporting (see 5.4.8), including that which the receiving controller would normally report upon receiving the same PGN requested in PGN 59 904 (properly formatted for TRANSFER PGN) and the data set for each controller it is tasked to report. For instance, if the Use Transfer PGN parameter is yes (01), the response shall include all known data relative to the requested PGN. When Use Transfer PGN is 00, the effect of the Request2 PGN is the same as the Request PGN (59 904). The response to the Request2 when the Use Transfer PGN equals 00 is not sent using the Transfer PGN, and it is sent exactly the same as it would be had the request been made using the Request PGN (i.e. PGN 59 904). The information below assigns the PGN to the Request2 parameter group.

The Request2 and Transfer PGN are required in cases where a given controller is tasked with reporting a PGN and data about more than one controller.

EXAMPLE Implement Identification, Component ID and Software Identification PGN.

The support of REQUEST2 is optional.

Parameter group name:	REQUEST2
Definition:	Used to request a PGN from network controller or controllers and to specify whether the response uses or does not use the Transfer PGN.
Transmission repetition rate:	Per user requirements, generally recommended that requests occur no more than 2 or 3 times per second. When a controller supports Request2, a NACK is required if the PG being asked for with a destination-specific address is not supported, see PGN 59392.
Data length:	8 B (multi-packet supported)
Data page:	0
PF:	201

PS:	destination-specific (global or specific)
Default priority:	6
Parameter group number:	51 456 ($00C900_{16}$)

Bytes 1 to 3:	Requested PGN
Byte 4:	Special instructions
Bits 3 to 8:	Reserved for assignment in a future International Standard
Bits 1 to 2:	Use Transfer PGN for response (00 = No, 01 = Yes, 10 = Undefined, 11 = Not Allowed)
Bytes 5 to 8:	Reserved for assignment in a future International Standard

5.4.8 Transfer

The Transfer PGN provides a mechanism for reporting multiple data sets for a given PGN in response to Request2 (see 5.4.7) These multiple sets of data for a given PGN require that each data set have a length and be labelled with four bytes from the ISO 11783-5 NAME. The four bytes of the NAME identify each controller. The controller responding to the request shall report the same information it would with PGN 59 904 as the first data set in this response. If a controller only has one data set then it shall respond with the one data set utilizing the Transfer PG.

The Request2 and Transfer PGN are useful in cases where a given controller is tasked with reporting a PGN and data about more than one controller. Examples include PGN such as Implement Identification, Component ID and Software Identification. The information below assigns the PGN to the Transfer parameter group.

Parameter group name:	TRANSFER
Definition:	Used for transfer of data in response to a Request2 when “Use Transfer PGN for Response” is set to Yes.
Transmission repetition rate:	in response to a Request2 PGN with “Use Transfer PGN” = 01
Data length:	9 to 1785 B (multi-packet supported)
Data page:	0
PF:	202
PS:	DA (specific or global)
Default priority:	6
Parameter group number:	51 712 ($00CA00_{16}$)

Bytes 1 to 3:		PGN requested by Request2 (see Table 2 for PGN ordering)
Byte 4:		Length of data for the reported PGN associated to the controller identified (e.g. identity in Bytes 5 to 8)
Bytes 5 to 8:		Identity of controller associated to the PGN and data — ISO 11783-5 defines 4 B from the NAME used in Bytes 5 to 8
Byte 5:	Bits 4 to 8	Function Instance (most significant at Bit 8)
	Bits 1 to 3	ECU Instance (most significant at Bit 3)
Byte 6:	Bits 1 to 8	Function (most significant at Bit 8)
Byte 7:	Bits 2 to 8	Device Class (most significant at Bit 8)
	Bit 1	Reserved
Byte 8:	Bit 8	Self Configurable Capable
	Bits 5 to 7	Industry Group (most significant at Bit 7)
	Bits 1 to 4	Device Class Instance (MSB Bit 4)
Bytes 9 to x:		Data field containing one or more data sets. Where a data set includes “PGN requested by Request2”, “Controller Identity”, and “PGN requested by Request2’s data” (See format definitions 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 PGN data (length = b + c + d);

c identity of ECU to which field d is associated;

d requested PGN data for specific ECU;

b second data set — length of concatenated ECU identity and associated PGN data;

c identity of ECU to which field d is associated;

d requested PGN data for second specific ECU.

EXAMPLE For a given vehicle, the engine ECU knows the VIN numbers for the tractor and the trailer. Another controller sends the Request2 directed to the global destination, requesting the VIN with "Use Transfer PGN" set to 01. The response from the Engine might be

— BAM transfer of the Transfer PGN reporting the VIN for the tractor and VIN for the trailer, or

— if the request had the "Use Transfer PGN" set to 00, a response of BAM transfer of the VIN for the tractor but not utilizing the Transfer PGN.

5.5 Message priority

The CAN data frame priority shall be in accordance with ISO 11898-1. The value within the CAN identifier field determines the message priority. A low value (the 29 bit identifier set to all zeros) is the highest priority, while the largest CAN identifier is the lowest priority (the 29 bit identifier set to all ones). The assignments are identified in the application layer following the guidelines given in 5.9.

5.6 Bus access

When the bus is free, any controller may start to transmit a frame. If two or more controllers 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 ensures that neither information nor time is lost. The originating controller with the frame of the highest priority gains bus access.

5.7 Contention-based arbitration

During arbitration, every originating controller compares the level of the bit transmitted with the level that is monitored on the bus. If these levels are equal, the controller may continue to send. When a *recessive* level is sent and a *dominant* level is monitored, that controller loses arbitration and shall withdraw without sending another bit. When a dominant level is sent and a recessive level monitored, that controller detects a bit error.

5.8 Error detection

The following measures are provided for detecting errors:

— originating controllers compare the bit levels to be transmitted with the bit level detected on the bus;

— bit cyclic redundancy check (CRC);

— variable bit stuffing with a stuff width of 5;

— frame format check.

NOTE For a more detailed explanation of these error detection techniques, see ISO 11898-1.

5.9 Assignment process for SA and PGN

5.9.1 General

The protocol data units that are available provide for the two formats, PDU1 and PDU2. Parameter groups are assigned specifically to use either the PDU1 or PDU2 format. Once a format is assigned, the other format is not available for that parameter group. The PDU1 format shall be used whenever it is necessary to direct a parameter group to a specific destination. The assignment of a parameter group shall be done using the following characteristics:

— priority,

— update rate,

— importance of the data in the packet to other network controllers,

— length of the data associated with the parameter group.

In order to help with this assignment process a request form is available for use when requesting new SA or PGN assignments.

Table 7 provides a template for assigning PGN. Note that the priority column is used to assign a default priority value for each PGN. The priority field may be programmable for each PGN value so that network tuning can be performed by an OEM (original equipment manufacturer), if necessary. Although any PGN can be requested, requests are strongly discouraged for messages that are already periodically broadcasted.

Messages shall be assigned a PGN that requires a destination only if it is a parameter intended to directly control (command) one of several specific controllers. Otherwise a PGN shall be selected without a destination so that any controller may access the parameters within the message.

Preferred SA are assigned in a linear fashion without concern for message priority, update rate, or importance.

PGN are assigned linearly to the various sections in Table 7 based on the criteria provided in the PGN and SA Request form. Note that multi-packet messages are not permitted when the repetition rate is greater than or equal to 10 Hz.

5.9.2 Address assignment criteria

The number of unassigned addresses in ISO 11783 is limited and new address assignments shall be made efficiently. The maximum number of addresses assigned within the system shall not exceed 256. Additions to the address definitions shall therefore be limited to units that provide specific functions within the tractor or implement. Examples of specific functions include the currently defined addresses for engine, transmission, brakes and fuel system. Functions proposed for new address assignments within this International Standard should have a scope similar to currently defined addresses and be useful to most ISO 11783 users.

ISO 11783 controllers shall support address self-configuring in accordance with ISO 11783-5.

5.9.3 Parameter group assignment criteria

The number of unassigned parameter groups available in ISO 11783 is limited when compared to the large number that might be proposed for forestry or agricultural applications. The need for large numbers of parameter groups is alleviated by features incorporated into ISO 11783. Three primary communication methods exist within ISO 11783, the appropriate use of each of which allows effective use of the available parameter groups:

— PDU1 format (PS = DA, allowing destination-specific communications);

— PDU2 format (PS = GE);

— proprietary communications using two predefined proprietary PGN.

Each of these methods has an appropriate use. Destination-specific parameter groups are needed where the same message can be directed to one or another destination. A torque control message is defined in ISO 11783 which can be sent to an engine. In the case of more than one engine, this message is to be sent only to the desired engine and a destination-specific parameter group is required and assigned.

PDU2 format communications apply in several situations, including messages sent from single or multiple sources to a single destination, and those sent from single or multiple sources to multiple destinations. PDU2 communications cannot be used where a message is to be sent to one or another destination and not to both.

Proprietary communications are provided by the use of the proprietary PGN. Different PGN have been assigned for non-destination-specific proprietary communications and for destination-specific proprietary communications. This allows for two alternative functions:

a) a specific source can send its proprietary message in a PDU2 Format (non-destination-specific) with the PS field identified as desired by the user;

b) use of PDU1 format (destination-specific) allowing for situations where a diagnostic controller directs its communication to a specific destination out of a possible group of controllers.

EXAMPLE 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:

— when it is unnecessary for standardized communications;

— when it is important to communicate proprietary information.

Much of the communication between controllers constructed by a single manufacturer does not require standardization. The information that is communicated is not generally useful to other controllers on the network. In this situation the proprietary parameter group may be used.

When parameter group assignment is contemplated, proprietary, and then PDU2 format communications methods should be considered. If proprietary information is being communicated, or if 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 direction of the message to a particular controller, a PDU2 format assignment should be sought. Finally, if the information is of general interest but requires direction to one or another controllers, then destination-specific addressing is needed and a destination PDU1 format parameter group assignment should be sought.

5.9.4 Data field definition

Minimizing message overhead with CAN-based systems requires full use of the data field (all 8 B). Except in the case of very time critical messages, related parameters should be grouped to fill the eight-byte data field. Following this principal conserves PGN for future assignment. Strong justification is needed to allow definition of parameter groups that result in sparsely used data fields.

Table 7 — ISO 11783 PGN template

EDP	DP	PF	PS	Parameter group definition	Multi-packet	PGN
0	0	0	DA	PDU1 Format — Less than 100 ms	NA	000
00	1	DA				256
	.					
Boundary x						
	.					
	.					
00	238	DA		PDU1 Format — Greater than 100 ms	Allowed	60 928
00	239	DA		PDU1 Format — Proprietary A	—	61 184
00	240	0		PDU2 Format — Less than 100ms	NA	61 440
00	240	1				61 441
	.					
Boundary y						
	.					
00	254	254				65 278
00	254	253		PDU2 Format — Greater than 100 ms	Yes	65 279
00	255	un		PDU2 Format — Proprietary B	—	65 280–65 535
01	0	DA		PDU1 Format — Less than 100 ms	NA	65 536
01	1	DA				65 792
	.					
Boundary x1						
	.					
01	238	DA		PDU1 Format — Greater than 100 ms		126 464
01	239	DA		PDU1 Format — Proprietary A2	Allowed	126 720
01	240	0		PDU2 Format — Less than 100 ms	NA	126 976
01	240	1				126 977
	.					
Boundary y1						
	.					
01	255	253				
01	255	254		PDU2 Format — Greater than 100 ms	Allowed	131 070
01	255	255		PDU2 Format — Greater than 100 ms	Allowed	131 071

DP	Data Page (1 bit)	PGN	Parameter group number (3 B)
PF	PDU Format (8 bits)	EDP	Extended Data Page (1 bit)
PS	PDU Specific field (8 bits)	NA	Not Allowed
DA	Destination Address (8 bits)	un	Undefined

5.10 Transport protocol functions

5.10.1 General

Transport protocol functions are described as a part of the data link layer with the recognition that the Transport protocol functionality is subdivided into two major functions: message “packetization” and reassembly, and connection management. These are described in the following subclauses, in which the term *originating controller* corresponds to the controller that transmits the Request to Send message, and *receiving controller* corresponds to the controller that transmits the Clear to Send message.

5.10.2 "Packetization" and reassembly

5.10.2.1 General

Messages greater than 8 B in length are too large to fit into a single CAN data frame. Therefore, they are broken into several smaller packets, and those packets are transmitted in separate CAN data frames. At the receiving controller, the individual message frames are received and reassembled in order of sequence number of the received packets.

5.10.2.2 Message packets

The CAN data frame includes an eight byte data field. Because the individual packets which comprise a large message have to be identified individually so that they can 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 one to 255. This yields a maximum message size of 255 packets × 7 B/packet = 1 785 B.

5.10.2.3 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.

5.10.2.4 "Packetization"

A multi-packet message is defined as one whose data does not fit into the data field of a single CAN data frame (i.e. messages with a data field greater than 8 B).

For the purposes of this protocol, the large message is considered to be a parameter group with a string of nine or more bytes. The first data transfer packet contains the sequence number one and the first seven bytes of the string. The second seven bytes are placed into another data frame along with the sequence number 2, the third with sequence number 3, and so on until all the bytes in the original message have been placed into ISO 11783-specified CAN data frames and transmitted.

Each data transfer packet (other than the last packet in a transmission sequence) shall include 7 B of the original large message. The final packet includes a data field of 8 B, this being the sequence number of the packet and at least 1 B of data related to the parameter group, and then any remaining, unused, bytes set to FF_{16}.

The time between packets for multi-packet broadcast messages shall be 50 ms to 200 ms (see 5.12.3). For multi-packet messages directed to a specific destination, the transmitting controller maintains a maximum time between packets (where CTS allows more than one) of 200 ms. Receiving controllers shall be aware that the packets containing the data all have the same identifier.

5.10.2.5 Reassembly

Data packets are received sequentially. Each data packet of a multi-packet 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.

5.10.3 Connection management

5.10.3.1 General

Connection management is concerned with the opening, use and closure of virtual connections between controllers for destination-specific transfers. A virtual connection in the ISO 11783-specified environment is considered a temporary association of two controllers for the purpose of transferring a single large message that is described by a single PGN (see Annex B, Figures B.1 and B.2). In cases where the connection is from one to many, there is no flow control or closure provided (see Annex B, Figure B.3).

5.10.3.2 Multi-packet broadcast

Multi-packet messages can be non-destination-specific, i.e. they can be broadcast messages. To broadcast a multi-packet message, a controller first transmits a Broadcast Announce Message (BAM). This message, which shall be transmitted to the global destination address, constitutes a large message warning to the controllers 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. Controllers interested in the broadcast data are then required to allocate the resources necessary to receive and reassemble the message. The Data Transfer PGN (PGN = 60 160) is then used to send the associated data.

5.10.3.3 Connection initiation

A connection is initiated when a controller transmits a Request to Send message to a DA. The Request to Send message contains the size of the entire message in bytes, the number of separate messages in which it will be transferred, the maximum number of packets that may be sent in response to one CTS, and the PGN of the message being transported.

Upon receipt of a Request to Send message, a controller may elect to accept the connection or to reject it. To accept the connection, the receiving controller transmits a Clear to Send message. The Clear to Send message contains the number of message packets it may accept and the sequence number of the first packet it is expecting. The receiving controller shall ensure that it has sufficient resources to handle the number of packets of which it is accepting delivery. The sequence number of the packet, in the instance of a freshly opened connection, is 1.

NOTE The Clear to Send message cannot include provision for all the component frames of the message.

To reject the connection, the controller responds with a Connection Abort message. The connection can be rejected for any reason, although lack of resources, memory, etc. can be the cause.

The connection is considered established for the originating controller (i.e. RTS controller) when the originating controller receives a corresponding CTS from the receiving controller (i.e. CTS controller). The connection is considered established for the receiving controller when it has successfully transmitted its CTS message in response to an RTS. These definitions are used to determine when a Connection Abort is to be sent to close a connection. A receiving controller should send a Connection Abort if it has looked at the RTS message and decided not to establish the connection. This allows the originating controller to move on to a new connection without having to wait for a timeout.

5.10.3.4 Data transfer

Data transfer begins after the originating controller of the connection receives the Clear to Send message. An exception is if the data transfer was the result of the BAM — in this case, the Clear to Send message is not used. The PGN for data transfer contains the CAN identifier field of each packet. The first byte of the data field contains the sequence number of the packet.

In the case of destination-specific messages, the receiving controller is responsible for coordinating flow control between the controllers. If the receiving controller wants to stop data flow momentarily while a connection is open, it shall use the Clear to Send message, setting the number of packets to send equal to zero. In the case where the flow is required to be stopped for some number of seconds, the receiving controller shall repeat the transmission of the Clear to Send message once per T_h s (0,5 s) in order to assure the originating controller the connection is not broken. All remaining bit fields are set to ones ("Don't care").

5.10.3.5 Connection closure

Two connection closure cases exist in the absence of errors: the first for a global destination and the second for a specific destination. In the case of the global destination, no connection closure operation is performed beyond the reception of the data itself (see 5.10.4.1 and 5.10.4.5). In the case of destination-specific transfer and upon receipt of the last packet in the message stream, the receiving controller transmits an End of Message acknowledgement to the originating controller of the message. This is the signal to the originating controller that the connection is considered closed by the receiving controller. The End of Message ACK closure is required to free the connection for subsequent use by other controllers.

The Connection Abort message is not allowed to be used by receiving controllers in the case of a global destination message (5.10.4 and 5.10.4.5). In the case of a destination-specific transfer, either the originating or the receiving controller can, at any time, use Connection Abort to terminate the connection. (See 5.10.3.3 for an explanation of when a connection is considered established for the sending and receiving controller.) If the receiving controller, for example, determines that there are no resources available for processing the message, it can abort the connection by issuing the Connection Abort message. Upon receipt of this message, any message packet already passed is abandoned.

A failure of either controller can also cause closure of a connection.

EXAMPLE 1 A time delay of more than T1 s from receipt of the last packet when more were expected (CTS allowed more).

EXAMPLE 2 A time delay of more than T2 s after a CTS was transmitted (originating controller failure).

EXAMPLE 3 A lack of CTS or ACK for more than T3 s after the last packet was transmitted (receiving controller failure).

EXAMPLE 4 A lack of CTS for more than T4 s after CTS (0) message to "hold the connection open".

Any of these examples causes a connection closure to occur.

The timeout values are T_r = 200 ms, T_h = 500 ms, T1 = 750 ms, T2 = 1 250 ms, T3 = 1 250 ms and T4 = 1 050 ms (see also 5.12.3 and Figure B.1 regarding timeouts). When either the originating controller or receiving controller decides to close out a connection for any reason including a timeout, it shall send a Connection Abort message.

With the definitions in this subclause and those given throughout 5.10, the following observations can be made.

a) Connection closure for a broadcast announce message includes the following. A connection is considered closed

   1) when the originating controller sends the last data transfer packet,

   2) when the receiving controller

      i) receives the last data transfer packet, or

      ii) has a T1 connection timeout.

b) Connection closure for Request to Send/Clear to Send messages includes the following. A connection is considered closed

   1) when the originating controller

      i) receives the TP.CM_EndOfMsgACK at the completion of the data transfer for the entire PGN,

ii) sends a Connection Abort for any reason (e.g. due to a T3 or T4 timeout), or

iii) receives a Connection Abort,

2) when the receiving controller

i) sends the TP.CM_EndOfMsgACK at the completion of the data transfer for the entire PGN

ii) receives a Connection Abort, or

iii) sends a Connection Abort for any reason (including stopping the session early if desired, for a T1 or T2 connection timeout, etc.).

5.10.4 Transport protocol — Connection management messages

5.10.4.1 Connection management message definition

This type of message is used to initiate and close connections and also to control flow. Transport protocol provides the following five transport protocol 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 format of this message is shown below in the Parameter Group definition for Transport Protocol — Connection Management.

Parameter group name:	TRANSPORT PROTOCOL — CONNECTION MANAGEMENT (TP.CM)
Definition:	Used for the transfer of parameter groups with 9 B or more of data. A definition of each specific message defined as part of the transport protocol is contained in the following clauses.
Transmission repetition rate:	per the PGN to be transferred
Data length:	8 B
Data page:	0
PF:	236
PS:	DA
Default priority:	7
Parameter group number:	60 416 ($00EC00_{16}$)

Data ranges for parameters used by this group function:

Control byte:	0 to 15, 18, 20 to 31, 33 to 254 reserved for assignment in a future International Standard
Total message size, bytes:	9 to 1 785 (2 B), 0 to 8 and 1 786 to 65 535 not allowed
Total number of packets:	1 to 255 (1 B), zero not allowed
Maximum number of packets:	2 to 255 (1 B), zero and 1 not allowed
Number of packets that can be sent:	0 to 255 (1 B)
Next packet number to be sent:	1 to 255 (1 B), zero not allowed
Sequence number:	1 to 255 (1 B), zero not allowed

Connection Mode Request To Send (TP.CM_RTS): destination-specific

Byte:	1	Control byte = 16, Destination Specific Request_To_Send (RTS)
Bytes:	2 to 3	Total message size, number of bytes
Byte:	4	Total number of packets
Byte:	5	Maximum number of packets that can be sent in response to one CTS. FF_{16} indicates that no limit exists for the originating controller

Byte:	6	PGN of requested information (8 LSB of parameter group number, Bit 8 MSB)
Byte:	7	PGN of requested information (second byte of parameter group number, Bit 8 MSB)
Byte:	8	PGN of requested information (8 MSB of parameter group number, Bit 8 MSB)

Connection Mode Clear To Send (TP.CM_CTS): destination-specific

Byte:	1	Control byte = 17, Destination Specific Clear_To_Send (CTS)
Byte:	2	Number of packets that can be sent. This value shall be no larger than the value in Byte 5 of the RTS message
Byte:	3	Next packet number to be sent
Bytes:	4 to 5	Reserved for assignment in a future International Standard, these bytes shall be sent as FF_{16}
Bytes:	6 to 8	PGN of packeted message

End of Message Acknowledgement (TP.CM_EndofMsgACK): destination-specific

Byte:	1	Control byte = 19, End_of_Message Acknowledge
Bytes:	2 to 3	Total message size, number of bytes
Byte:	4	Total number of packets
Byte:	5	Reserved for assignment in a future International Standard, this byte shall be sent as FF_{16}
Bytes:	6 to 8	PGN of packeted message

Connection Abort (TP.Conn_Abort): destination-specific

Byte:	1	Control byte = 255, Connection Abort
Byte:	2	Connection Abort reason
Bytes:	3 to 5	Reserved for assignment in a future International Standard, these bytes shall be sent as FF_{16}
Bytes:	6 to 8	PGN of packeted message

Broadcast Announce Message (TP.CM_BAM): global destination

Byte:	1	Control byte = 32, Broadcast Announce Message
Bytes:	2 to 3	Total Message Size, number of bytes
Byte:	4	Total number of packets
Byte:	5	Reserved for assignment in a future International Standard, this byte should be sent as FF_{16}
Bytes:	6 to 8	Parameter Group Number of packeted message

5.10.4.2 Connection Mode Request To Send (TP.CM_RTS)

The TP.CM_RTS message informs a controller that another controller on the network wishes to open a virtual connection with it. The TP.CM_RTS is a message with the SA field set to that of the originating controller, DA set to that of the intended receiving controller of a large message, and the remaining fields set appropriately for the PGN being sent. Byte 5 of this message allows the originating controller to limit the receiving controller's number of packets specified in the Clear To Send message (see Figures B.4 and B.5). When the receiving controller complies with this limit, it ensures that the originating controller can always retransmit packets that, for whatever reason, the receiving controller has not received. If multiple RTS are received from the same SA for the same PGN, then the most recent RTS shall be acted on and the previous RTS abandoned. No abort message shall be sent for the abandoned RTS in this specific case. TP.CM_RTS is only transmitted by the originating controller.

5.10.4.3 Connection Mode Clear To Send (PT.CM_CTS)

The TP.CM_CTS message is used to respond to the Request To Send message. It informs the peer controller that it is ready for a certain amount of large message data. The amount of large message data cleared to send shall not be greater than Byte 5 of the originating controller TP.CM_RTS message. If multiple CTS are received after a connection is already established, then the connection shall be aborted. When the originating controller aborts the connection, it shall send the Connection Abort message. The receiving controller shall not send the next CTS until it has received the last data packet from the previous CTS or has timed out. If a CTS is received while a connection is not established, it shall be ignored. CTS 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 originating controller of a large message transmission can use Byte 5 of the TP.CM_RTS message as a way to ensure the possibility of retransmission of a packet within the last set of packets cleared to send. TP.CM_CTS is only transmitted by the receiving controller.

5.10.4.4 End of Message Acknowledgement (TP.CM_EndofMsgACK)

The TP.CM_EndofMsgACK message is passed from the receiving controller of a large message to its originating controller, indicating that the entire message was received and reassembled correctly. The receiving controller can keep the connection open after the last Data Transfer of the session by not immediately sending the TP.CM_EndOfMsgACK. This allows the receiving controller to have a packet resent if necessary. If an End of Message Acknowledgment is received by the originating controller prior to the final Data Transfer, then the originating controller ignores it. One End of Message Acknowledgment is sent to inform the originating controller that the large message transfer has been received and assembled correctly. TP.CM_EndOfMsgACK is only transmitted by the receiving controller.

5.10.4.5 Connection Abort (TP.Conn_Abort)

The TP.Conn_Abort message is used by either controller 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 a Connection Mode Request To Send message, a controller shall determine if there are sufficient resources available to deal with the message for which this connection is sought — for example, if the controller has to acquire memory from the system heap and cannot claim enough to accept the entire message, or a controller is simply too occupied doing other tasks to expend processor cycles handling a large message. In these cases, a Connection Abort message may be sent, even though the connection has not been established. This may be done in order to allow the originating controller to attempt another virtual connection without first having to wait for a timeout to occur

When, for any reason, either the originating or receiving controller decides to close out a connection prior to completing the data transfer, including a timeout, it shall send a Connection Abort message with the appropriate Connection Abort reason. See Table 8 for the list of Connection Abort reasons.

The originating controller (i.e. the RTS controller) shall immediately stop transmitting after the reception of the Connection Abort message by the CAN protocol controller. 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 Connection Abort message, all related data packets received shall be ignored. TP.Conn_Abort is transmitted by the originating controller or the receiving controller.

Table 8 — Connection Abort reasons

Value	Description
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
4–250	Reserved for assignment in a future International Standard
251–255	According to ISO 11783-7 and ISO 11783-8 definitions.

5.10.4.6 Broadcast Announce Message (TP.CM_BAM)

The TP.CM_BAM is used to inform all the controllers 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 the transmission of the TP.CM.BAM message, Data Transport messages are sent containing the “packetized” broadcast data.

TP.CM.BAM is only transmitted by the originating controller.

5.10.5 Transport Protocol — Data Transfer messages (TP.DT)

The TP.DT message is used to communicate the data associated with a parameter group. The TP.DT message is an individual packet of a multi-packet message transfer. For example, if a large message had to be divided into five packets in order to be communicated then there would be five TP.DT messages. (See Annex B for examples of TP.DT messages in use.) The format of this message is shown in the following parameter group definition.

TP.DT is only transmitted by the originating controller.

Parameter group name:	TRANSPORT PROTOCOL — DATA TRANSFER (TP.DT)
Definition:	Used for the transfer of data associated with Parameter Groups that have more than 8 B of data.
Transmission repetition rate:	per the PGN to be transferred
Data length:	8 B
Data page:	0
PF:	235
PS:	DA [global (DA = 255) for TP.CM.BAM data transfers; global not allowed for RTS/CTS data transfers]
Default priority:	7 (Priority used regardless of the PGN being transported)
Parameter group number:	60 160 ($00EB00_{16}$)

Data ranges for parameters used by this message type:

Sequence Number:		1 to 255 (1 B)
Byte:	1	Sequence Number
Bytes:	2 to 8	“Packetized” data (7 B)

The last packet of a multi-packet parameter group can require less than 8 B. The extra bytes shall be filled with FF_{16}.

5.10.6 Connection constraints

5.10.6.1 General

If a controller cannot handle another session, then it should reject the connection initiations that are pursued by other controllers. 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 Connection Abort. This allows the device desiring a connection to move on to a new connection without having to wait for a timeout.

5.10.6.2 Number and type of connections a controller shall support

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

Only one multi-packet BAM (i.e. global destination) can be sent from an originating controller at a given time. This is because TP.DT does not contain the actual PGN or a connection identifier. However, receiving controllers shall recognize that multiple multi-packet messages can be received, interspersed with one another, from different originating controllers (i.e. source addresses).

A controller shall also be able to support one RTS/CTS session and one BAM session concurrently from the same SA. Therefore, the receiving controller shall use the destination address of the two transport protocol messages to keep them properly separated. One of the transport protocol messages has a global and the other a specific DA. The DA shall be used to distinguish the difference between the two because the TP.DT contains neither the actual PGN nor a connection identifier.

Regardless of whether a controller can support multiple simultaneous transport protocol sessions (RTS/CTS and/or BAM), it shall ensure that TP.DT messages from the same SA but having different DA can be differentiated. Receiving controllers shall use the DA and SA to keep the data for the messages correct.

5.10.6.3 Intended transport protocol use

Transport Protocol has been developed to provide a mechanism for transferring PGN with nine or more data bytes (see 5.2.8.2). A PGN defined as multi-packet capable having less than nine data bytes to transfer in a specific instance shall be sent in a single CAN data frame with the DLC set to 8 (see 5.2.8.1).

5.10.6.4 Concurrent PGN reception

It is possible that specific parameter groups can be sent in a non-transport-protocol form when they are less than or equal to 8 B, and then also be sent in transport protocol form when they are greater than 8 B. It is possible for these two forms of the same PG to be sent concurrently.

NOTE A non-transport-protocol form of a PGN is not considered to be a session, so its being sent does not close out the transport protocol form of the same PGN.

5.11 PDU processing requirements

Processing of the PDU requires the following of specific procedures. The suggested sequence for interpreting PDU is described in Annex A. Annex C shows example ISO 11783 message types and PDU formats being used.

Controllers shall be able to process data link messages 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 messages, each controller shall be able to process the messages fast enough not to lose messages due to their back-to-back nature. Processing the messages fast enough does not mean that a message has to be immediately generated, but that a new message shall not overrun the previous messages.

5.12 Application notes

5.12.1 High data rates

Data that is to be updated at a high rate and that 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 cancelled if the information that is getting ready to be requested is received prior to the request being sent. That is, if the information is received 50 ms prior to request scheduling, then the request should not be issued. Parameter groups should not be requested if they are recommended to be broadcast. Exceptions can arise when the recommended broadcast time exceeds a special case need.

5.12.3 Controller response time and timeout defaults

All controllers, when required to provide a response, shall do so within 0,20 s (T_r). All controllers expecting a response shall wait at least 1,25 s (T3) 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, a 20 ms response can be expected for high-speed control messages. Reordering of any buffered messages can be necessary to reach a faster response. There is no restriction on minimum response time.

Time between packets of a multi-packet message directed to a specific destination is 0 ms to 200 ms. This means that back-to-back messages can occur and they can contain the same identifier. The CTS mechanism can be used to assure a given time spacing between packets (flow control). The required time interval between packets of a multi-packet broadcast message is 50 ms to 200 ms. A minimum time of 50 ms ensures the receiving controller has time to pull the message from the CAN hardware. The receiving controller shall use a timeout (i.e. T1) of 250 ms. This provides a timeout that is greater than the maximum transmit spacing of 200 ms.

Maximum forward delay time within a bridge is 50 ms. The total number of bridges is equal to 10 (i.e. one tractor + five trailers + four dollies = 10 bridges). Therefore, the total network delay is 500 ms in one direction.

Number of request retries is equal to two (three requests total), this applies to the situation where the CTS is used to request the retransmission of data packet(s).

The margin for timeouts is 50 ms.

Figures B.1 and B.3 show the timing requirements identified. In Figure B.1 the time numbers are computed assuming the worst case number of bridges, that is, 10 bridges. The timeout numbers for receiving controllers are identified as a time value while originating controller requirements are specified as a less than or equal to time value.

NOTE An originating controller has transmitter and receiving requirements and a receiving controller has transmitter and receiving requirements.

5.12.4 Required responses

A response is required for a global request from all controllers that use the requested parameter group, even the requestor. Acknowledgements are not allowed for global requests.

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

5.12.5 Transmission of PGN to specific or global destinations

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

5.12.6 CTS number of packet recommendation

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

Annex A
(informative)

ISO 11783 PDU processing — Typical receive routine

RECEIVE INTERRUPT:

NOTE 1 When a message is received by the microprocessor via the CAN IC, several tests are performed in order to parse it and determine if and where it should be stored. The three priority bits are used only for bus arbitration and are therefore not needed (used) by the receiving controller.

NOTE 2 A given controller can have more than one address if it performs multiple functions.

```
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                                              ; PDU2 Format
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
```

Annex B
(informative)

Transport protocol transfer sequences — Examples of connection mode data transfer

Under normal circumstances, the flow model for data transfer follows that shown in Figure B.1. The originating controller sends the TP.CM_RTS indicating that there are 23 B in the packet message, which will be transferred in four packets. The PGN for the data in the transfer is 65 259, component identification.

The receiving controller replies with a TP.CM_CTS indication that it is ready to process two packets, beginning with packet 1.

The originating controller passes the first two packets across the network using TP.DT. The receiving controller then issues a TP.CM_CTS indicating that it wants to hold the connection open but cannot receive any packets at that moment. A maximum of 500 ms later it is required to send another TP.CM_CTS message to hold the connection. In this example, it sends another TP.CM_CTS indicating that it can take two more packets, beginning with packet 3. Once packets 3 and 4 have been transferred, the receiving controller transmits a TP.EndOfMsgACK message indicating that all the packets expected were transmitted and that the connection is now considered closed. Note that packet 4 contains 2 B of valid data, bytes 22 and 23, the remaining data characters in this packet are transmitted as 255 (FF_{16}), data not available, such that the message is 8 B in length.

Message transfer in the event of an error on the link is shown in Figure B.2. The TP.CM_RTS is transferred and responded to properly, then data is lost during the data transfer phase.

In this situation, the request to send is sent in the same manner as the earlier example. The first two packets are transferred, but packet two fails checksum, or was considered in error by the receiving controller. The receiving controller then transfers a TP.CM_CTS indicating that it wants a single packet and that the packet is packet 2. The originating controller complies, transferring packet 2. The receiving controller then passes a CTS indicating it wants two packets, starting with packet 3. This TP.CM_CTS is the acknowledgement that packets 1 and 2 were received correctly. Once the last packet is received correctly, the receiving controller passes a TP.EndOf MsgACK signalling that the entire message has been correctly received.

In the situation shown in Figure B.3, a controller indicates to the network that it is about to transfer a multi-packet message utilizing the services of the transport protocol. In this example, PGN 65 260, tractor identification is being broadcast to the network. The originating controller first transmits a TP.CM_BAM, followed by the data packets. No acknowledgement is performed by any of the receiving controllers.

In Figure B.4, the originating controller uses the Maximum Number of Packets parameter to limit the number of packets the receiving controller requests to be transferred. In this example, both controllers support the Maximum Number of Packets parameter.

Figure B.5 illustrates the situation where the originating controller supports the RTS parameter, Maximum Number of Packets, but the receiving controller does not. In this situation, the originating controller shall comply with the receiving controller’s CTS limits. In this example, the originating controller would have to send seven data transfer packets, even though it preferred to send only five at a time.

CAUTION — In this example, if the receiving controller were to send a CTS for packet 1 after the data transfer of packet 7, it is possible that the originating controller would have to recompute the information and, therefore, the second transmission of packet 1 could contain different data from the original packet 1, depending on the kind of data the PGN contained. For instance, PGN 65 227 has dynamic data and might cause packet 1 to be different while a PGN such as 65 242 has static data and would not cause packet 1 to be different on its second data transfer.

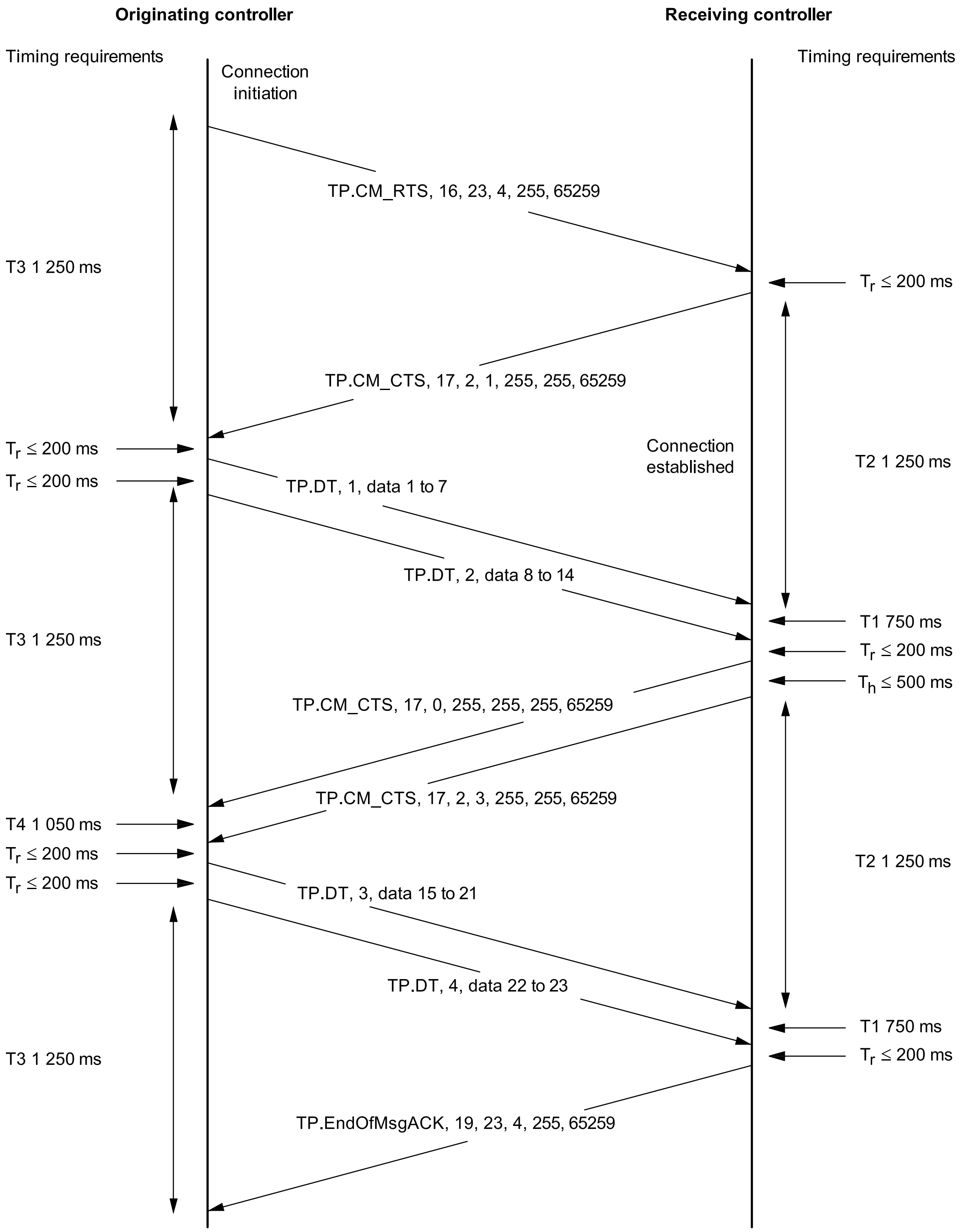


Figure B.1 — Data transfer without error

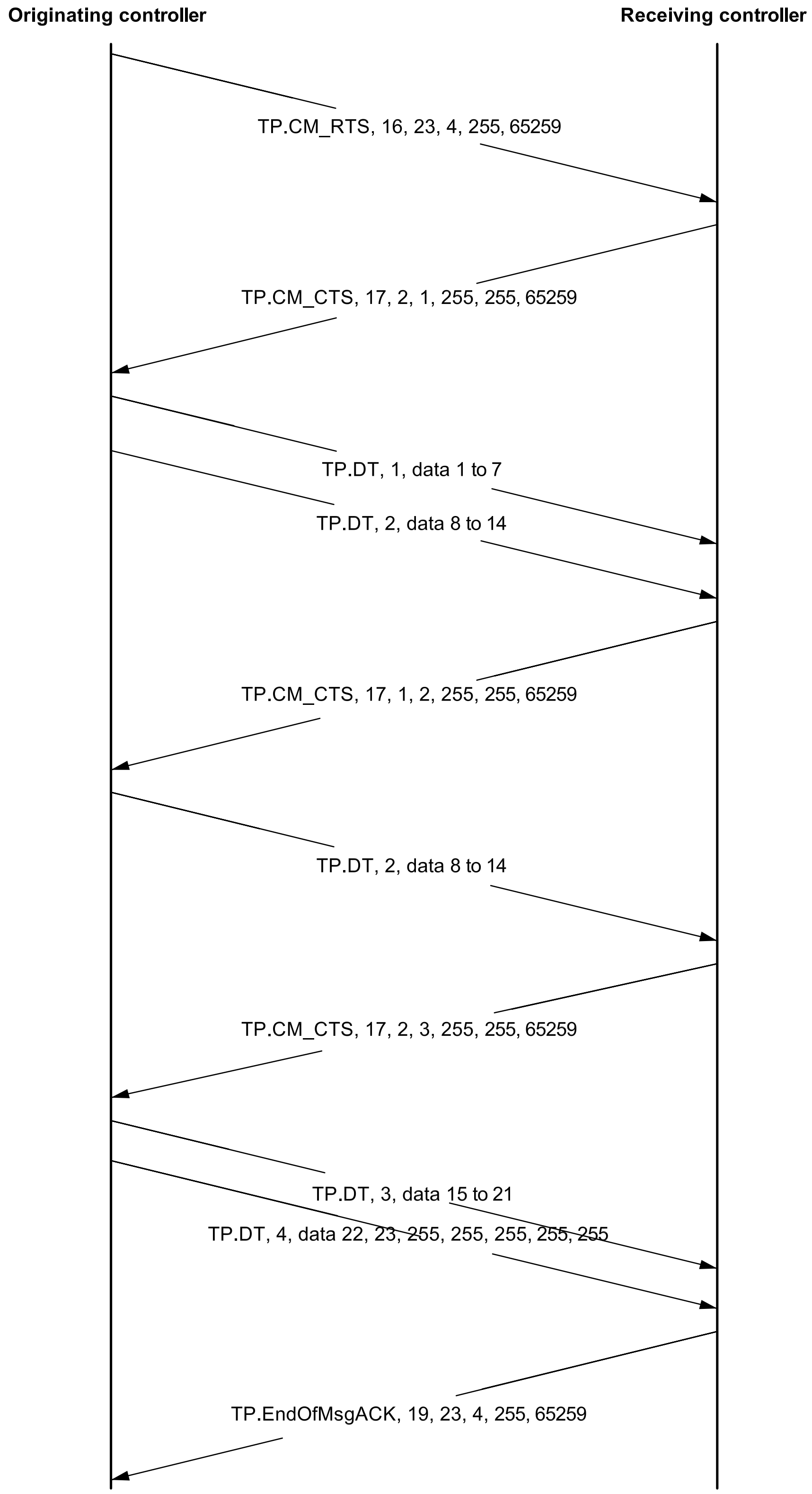


Figure B.2 — Data transfer with error

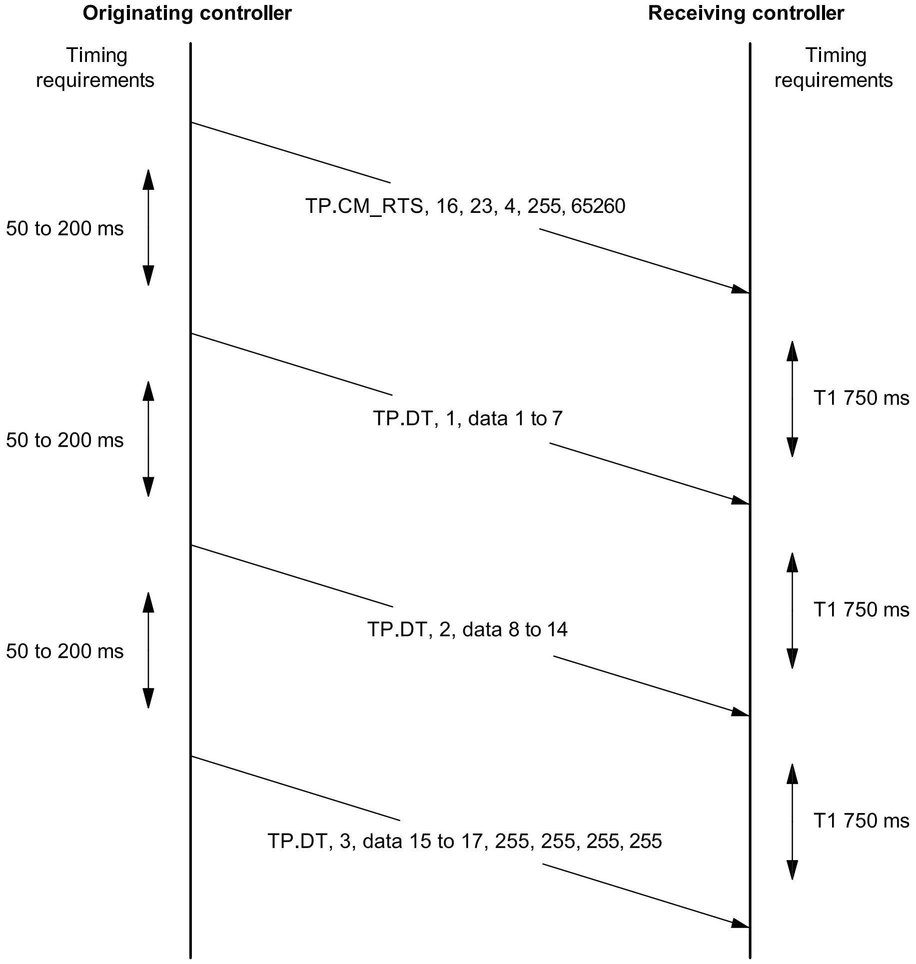


Figure B.3 — Broadcast data transfer

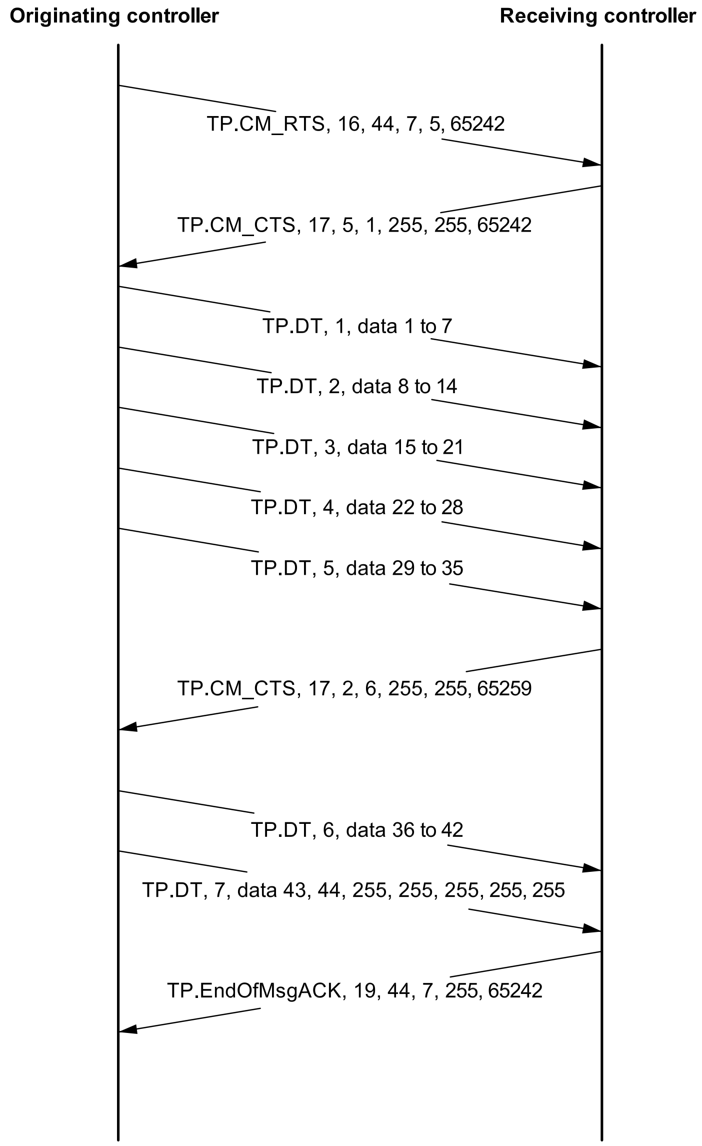


Figure B.4 — Data transfer utilizing RTS maximum number of packets capability

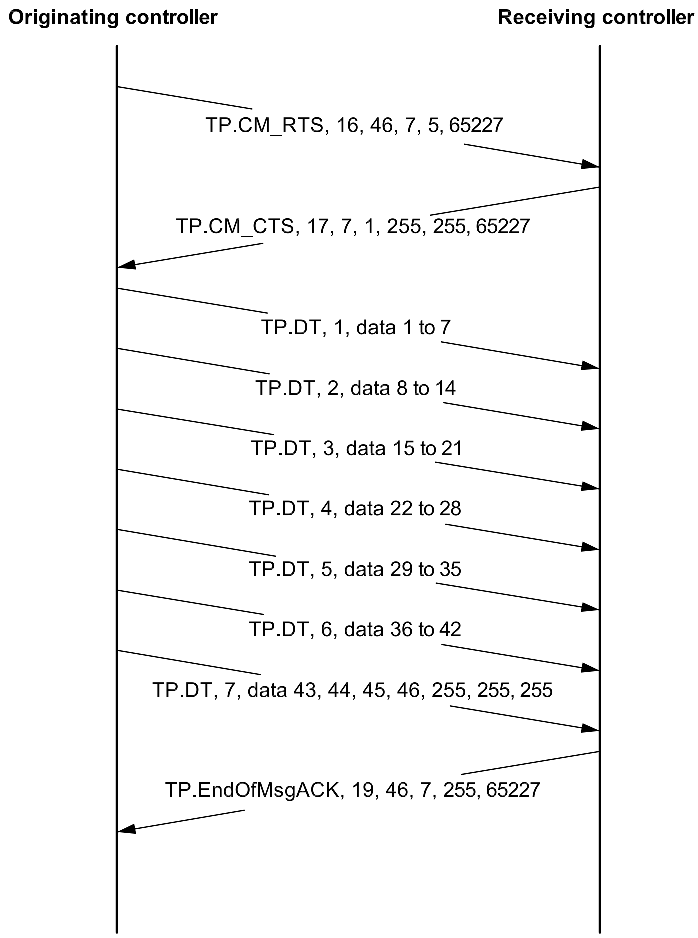


Figure B.5 — Data transfer not able to utilize RTS maximum number of packets capability

Annex C
(informative)

Communication mode examples

This example shows how an engine would typically perform the following actions.

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 the example for item 4, below.

2A GLOBAL REQUEST

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

3 COMMAND

For some commands, it can be desirable to receive a specific acknowledgement 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 below uses “CF” as the command which is 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 (PGN) in the data field. If the Parameter Group Number in a COMMAND or REQUEST is not recognized by the destination (addressed controller), 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 233.

EXAMPLES

		PF	PS(DA)	SA	DATA
1	BROADCAST	254	235(GE)	000	236 912
2	SPECIFIC REQUEST	234	000(DA)	003	PGN 65 259
1	RESPONSE	254	235(GE)	000	236 912
or					
4	NACK	232	255(DA)	000	01,255,255,255,255,PGN 65 239
2A	GLOBAL REQUEST	234	233(DA)	003	PGN 65 259
1	RESPONSE	254	233(GE)	000	236 912
3	COMMAND	CF	000(DA)	240	
1	ACK	232	255(DA)	000	00,255,255,255,255,PGN for CF
or					
4	NACK	232	255(DA)	000	01,255,255,255,255,PGN for CF
or	OTHER [2]				

2) Commands shall always have a mechanism for confirming whether 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.

Bibliography

[1] CAN Specification Version 2.0 Part B, Robert Bosch GmbH, September 1991

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[3] ISO 15765-3, *Road vehicles — Diagnostics on Controller Area Networks (CAN) — Part 3: Implementation of unified diagnostic services (UDS on CAN)*

[4] IEC 60027-2, *Letter symbols to be used in electrical technology — Part 2: Telecommunications and electronics*

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