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

Part 3:
Data link layer

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

Partie 3: Couche liaison de données

Contents

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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.

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.

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

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: Basic applications layer*

— *Part 8: Power train*

— *Part 9: Tractor ECU*

— *Part 10: Process data applications layer*

— *Part 11: Task controller and management information system data interchange*

Annexes A and B form an integral part of this part of ISO 11783. Annexes C and D are for information only.

Introduction

Parts 1 to 11 of ISO 11783 specify a communications system for agricultural equipment based on the CAN 2.0 B protocol. SAE J 1939 documents, on which parts of ISO 11783 are also 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.

The purpose of ISO 11783 is to provide an open interconnected system for on-board electronic systems. It is intended to enable electronic units 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 (manufacturers of CAN devices) throughout the world. For this purpose, the statement of the holder of this patent is registered with ISO. Information may be obtained from:

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

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

Part 3:
Data link layer

1 Scope

This part of ISO 11783 specifies a serial data network for control and communications on forestry or agricultural tractors, mounted, semi-mounted, towed or self-propelled implements. Its purpose is to standardize the method and format of data transfer between sensor, actuators, control elements, information storage and display units whether mounted or part of the tractor, or any implements. This part of ISO 11783 describes the CAN 29 Bit Identifier [5] Data Link Layer [6].

2 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, error control and flow control. The flow control is accomplished through a consistent message frame format.

3 Technical requirements

3.1 Message frame format

The message frame format shall conform to the CAN requirements. The CAN specification referenced throughout this document is CAN Specification version 2.0 B [5]. It should be noted that when there are differences between the above-mentioned CAN specification and ISO 11783, ISO 11783 is 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 network according to ISO 11783 requires that controller addressing be used to prevent multiple controllers from using the same CAN Identifier field. Many additional requirements are given in ISO 11783 that are not specified by CAN.

CAN 2.0 B specifies two message frame formats, Standard Frame and Extended Frame. "CAN 2.0 B compatibility" implies that messages of both format can potentially be present on a single network, by using certain bit codings which allow for the recognition of the different formats. 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 standard frame format messages are for proprietary use following the rules defined in this part of ISO 11783.

Therefore, controllers according to ISO 11783 must use the Extended Frame format. Standard Frame format messages can reside on the network, but only as described in this part of ISO 11783.

NOTE — Standard frame controllers do not respond to network management messages and will not be 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 differ between the CAN Standard and CAN Extended Frame messages. CAN

Standard Frame messages, shown in "A", contain 11 Identifier bits in the arbitration field and CAN Extended Frame messages, shown in "B", contain 29 Identifier bits in the arbitration field. ISO 11783 further defines the Identifier bits in the arbitration field of the CAN message frame formats. These definitions are given in table 1.

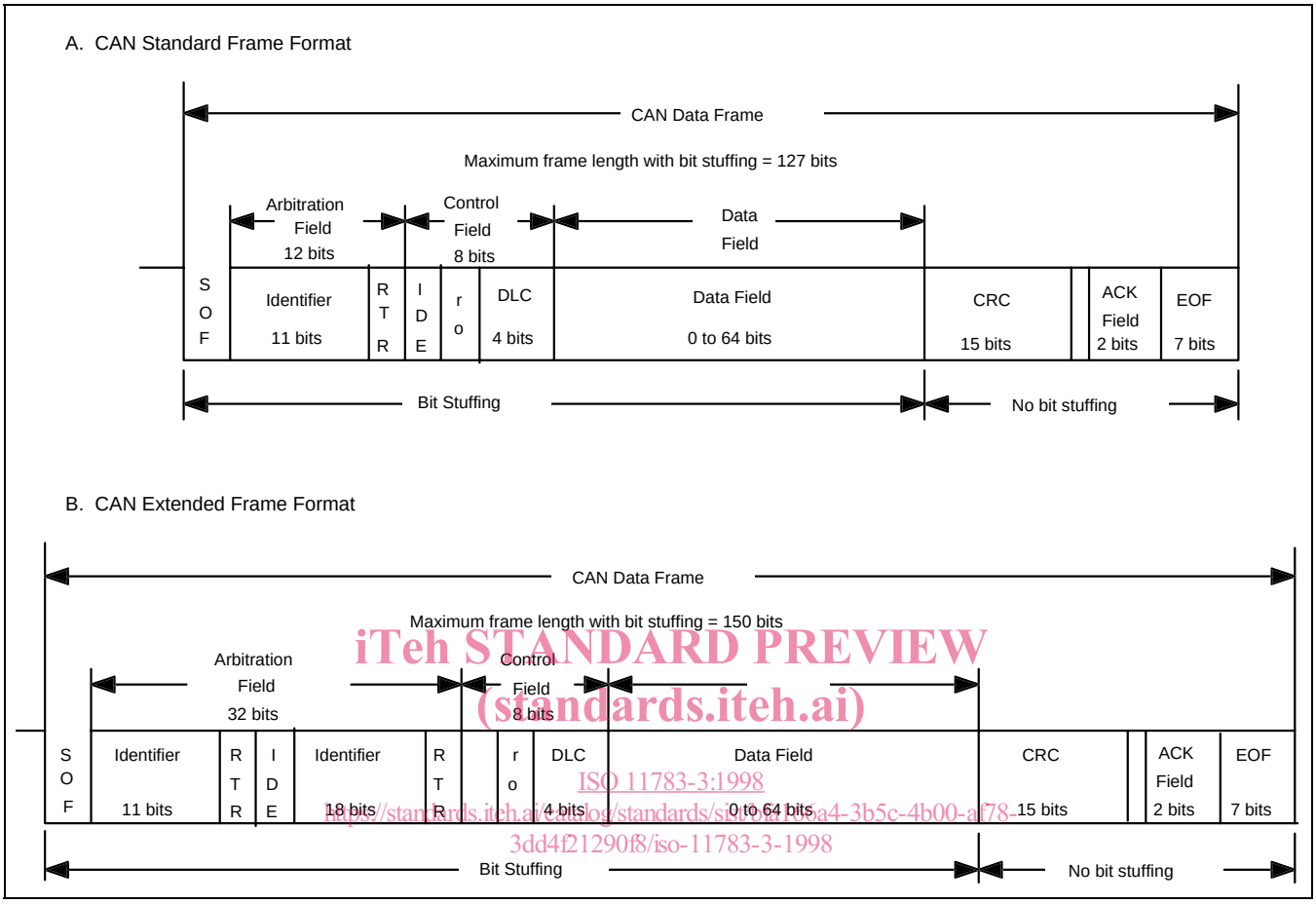


Figure 1 — CAN Data Frames

3.1.1 Message frame format according to ISO 11783 (CAN 2.0 B Extended Frame Format)

The CAN extended frame message, as shown in figure 1, encompasses a single Protocol Data Unit (PDU). PDUs consists of seven pre-defined fields. These fields are assimilated from information provided by the application layer. They are Priority, Reserved, Data Page, PDU Format, PDU Specific (which can be a destination address, Group Extension, or proprietary), Source Address and Data Fields. They 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 should be recognised that some Parameter Group definitions require more than one CAN data frame to send their information. Table 1 shows the arbitration and control fields of the 29 bit identifier for CAN, 29 bit identifier for ISO 11783, 11 bit identifier for CAN, and the 11 bit identifier for ISO 11783. A complete definition for each of the bit field assignments according to ISO 11783 is given in 3.3.

3.1.2 Parameter Group Number (PGN)

The Parameter Group Number is determined from the following constituent components: Reserved bit, Data Page bit, PDU Format Field (8 bits), and Group Extension Field (8 bits). These 18 bits are used to establish the 24 bit PGN. Whenever it is necessary to identify a Parameter Group in the data-field of a CAN data frame, it is expressed in 24 bits with the most significant bits set to zero. See table 2 for an illustration of PGNs, their corresponding bits and their conversion to a decimal number.

The procedure for the bit fields to be converted to Parameter Group Numbers is as follows. If the PDU Format (PF) value is less than 240 ($F0_{16}$), then the lower byte of the PGN is set to zero.

NOTE — Not all 131 072 combinations (2^{17}) are available to be assigned as PGNs. Only a total of 8 670 combinations are available for assignment (calculated as: 2 pages × [240 + (16 × 256)] = 8 670, using the conventions specified in this part of ISO 11783).

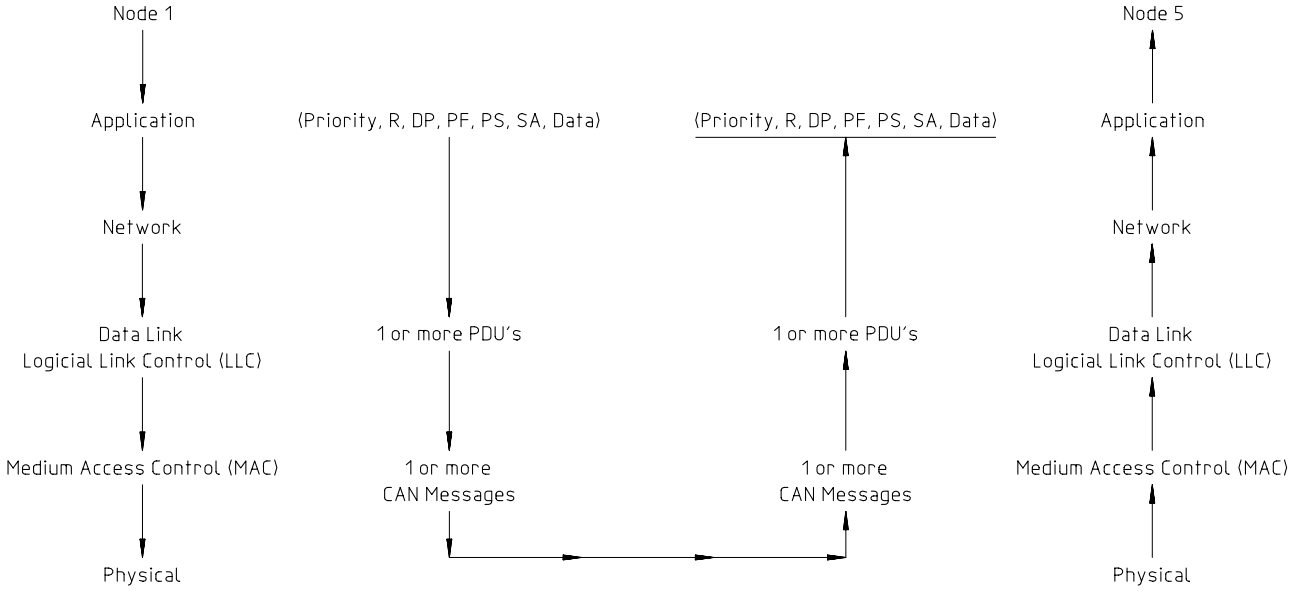
Table 1 — Mapping of ISO 11783 into CAN's Arbitration and Control fields

Bit No.	29 bit identifiers		11 bit identifiers	
	CAN	ISO 11783	CAN	ISO 11783[1)]
1	SOF	SOF*)	SOF	SOF*)
2	ID 28	P 3	ID 11	P 3
3	ID 27	P 2	ID 10	P 2
4	ID 26	P 1	ID 9	P 1
5	ID 25	R 1	ID 8	SA 8
6	ID 24	DP	ID 7	SA 7
7	ID 23	PF 8	ID 6	SA 6
8	ID 22	PF 7	ID 5	SA 5
9	ID 21	PF 6	ID 4	SA 4
10	ID 20	PF 5	ID 3	SA 3
11	ID 19	PF 4	ID 2	SA 2
12	ID 18	PF 3	ID 1	SA 1
13	SRR (r)	SRR*)	RTR (x)	RTR*)
14	IDE (r)	IDE*)	IDE (d)	IDE*)
15	ID 17	PF 2	R 0	R 0*)
16	ID 16	PF 1	DLC 4	DLC 4
17	ID 15	PS 8	DLC 3	DLC 3
18	ID 14	PS 7	DLC 2	DLC 2
19	ID 13	PS 6	DLC 1	DLC 1
20	ID 12	PS 5		
21	ID 11	PS 4		
22	ID 10	PS 3		
23	ID 9	PS 2		
24	ID 8	PS 1		
26	ID 6	SA 7		
27	ID 5	SA 6		
28	ID 4	SA 5		
29	ID 3	SA 4		
30	ID 2	SA 3		
31	ID 1	SA 2		
32	ID 0	SA 1		
33	RTR (x)	RTR*)		
34	r 1	r 1*)		
35	r 0	r 0*)		
36	DLC 4	DLC 4		
37	DLC 3	DLC 3		
38	DLC 2	DLC 2		
39	DLC 1	DLC 1		

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

*) CAN Defined Bit, Unchanged in ISO 11783.

1) Required format of proprietary 11 bit identifiers.



Key

PF	PDU Format
R	Reserved
DP	Data Page
SA	Source Address
PS	PDU Specific

Figure 2 — Application of OSI Model according to ISO 11783

3.1.3 ISO 11783 support of CAN 2.0 B Standard Frame Format messages

It is recognised that controllers on the ISO 11783-specified network may support the CAN Standard Frame (11 bit identifier) message format. Though these are not compatible with the message structure according to ISO 11783, a minimum level of definition is given to accommodate the co-existence of the two formats. This minimum definition allows controllers that use this format to avoid interfering with other controllers. CAN Standard Frame Format messages are defined as being proprietary. As shown in table 1, the 11 bit Identifier field is parsed as follows: the three most significant bits are used as priority bits, the eight least significant bits identify the source address of the PDU. Priority bits are described in 3.3.1. The source address is defined in the Source Address Table [2] or is determined by the procedures outlined in the part of ISO 11783 which deals with network management [3].

ISO 11783 only specifies a full strategy for standardized communications using the extended frame format. Hardware conforming to CAN 2.0 A specification must not be used on the network, since these versions of hardware do not allow the Extended Frame messages to be communicated.

3.2 Protocol Data Unit (PDU)

The Applications and/or Network Layer provides 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 key to each CAN Data Frame that is sent. The protocol data unit (PDU) according to ISO 11783 shall consist of seven fields. These fields are Priority, Reserved, Data Page, PDU Format, PDU Specific (which can be a destination address, Group Extension or proprietary), Source Address and Data. These fields are then 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 — It should be recognised that some Parameter Group Number definitions will require more than one CAN data frame to send the corresponding data.

Some of the CAN Data Frame fields have been 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. They include the SOF, SRR, IDE, RTR, parts of the control field, CRC field, ACK field and the EOF field. These fields are defined by the CAN protocol definition and were not modified for ISO 11783. The seven PDU fields are illustrated in figure 3. Each of the fields within the PDU are defined in 3.2.1 to 3.2.7.

Table 2 — Parameter Group Number (PGN) examples

PGN constituent components					**PGN**		**Number of assignable PGs**	**Cumulative number of PGs**	**ISO or manufacturer assigned**
PGN (msb) Byte 1			PGN Byte 2	PGN Byte 3	DEC	HEX			
Bits8-3	R Bit 2	DP Bit 1	PF	PS					
0	0	0	0	0	0	00000	—	—	ISO
0	0	0	238	0	60928	00EE00	239	239	—
0	0	0	239	0	61184	00EF00	1	240	Manufacturer
0	0	0	240	0	61440	00F000	—	—	ISO
0	0	0	254	255	65279	00FEFF	3 840	4 080	—
0	0	0	255	0	65280	00FF00	—	—	Manufacturer
0	0	0	255	255	65535	00FFFF	256	4 336	—
0	0	1	0	0	65536	010000	—	—	ISO
0	0	1	239	0	126720	01EF00	240	4 576	—
0	0	1	240	0	126976	01F000	—	—	ISO
							096	8 672	—

	Priority,	R,	DP,	PF,	PS,	SA,	Data Field
No. of Bits	..3...,	.1.,	.1.,	...8...,	...8...,	...8...,	...64...

Key:
R Reserved
DP Data Page
PF PDU Format
PS PDU Specific
SA Source Address

Figure 3 — Protocol Data Unit (PDU)

3.2.1 Priority (P)

Priority bits are used to optimize message latency for transmission onto the bus only. They should be globally masked off by the receiver (ignored). The priority of any message can be set from highest, 0 (00_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 PGNs values are assigned and bus traffic changes. A recommended priority is assigned to each PGN when it is added to the application layer documents.

3.2.2 Reserved bit (R)

This bit is currently reserved for use in a future International Standard. This reserved bit should not be confused with the CAN reserved bits. All messages should set the ISO-specified reserved bit to ZERO on transmit. Future definitions might possibly be expanding the PDU Format field, defining new PDU formats, expanding the Priority field, or increasing the address space.

3.2.3 Data Page (DP)

The data page bit sets an auxiliary page of Parameter Group descriptions. Assignment of all Parameter Group Numbers available in page zero are complete (filled) before the page one assignments are made (see 3.9 which discusses PGN Assignments).

3.2.4 PDU Format (PF)

The PDU Format is an 8-bit field that determines the PDU format and is one of the fields used to determine the Parameter Group Number assigned to the CAN data field. Parameter Group Numbers are used to identify or label commands, data, some requests, acknowledgements and negative-acknowledgements. Parameter Group Numbers identify or label information that may require one or more CAN data frames to communicate the information. If there is more information than will fit in 8 data bytes, a multi-packet message needs to be sent. A Parameter Group Number can represent one or more parameters, where a parameter is a piece of data such as engine rotations per minute. Even though a Parameter Group Number label can be used for one parameter, it is recommended that multiple parameters be grouped so that all 8 bytes of the data field are used.

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

3.2.5 PDU Specific (PS)

The PDU Specific field is an 8-bit field and its definition depends on the PDU format. Depending on the PDU format, it can be a Destination Address or a Group Extension. See table 3.

Table 3 — Definition of a PDU Specific field

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

3.2.5.1 Destination Address (DA)

This 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.

3.2.5.2 Group Extension (GE)

The Group Extension field, in conjunction with the four least significant bits of the PDU Format field, provide for 4 096 Parameter Groups per data page. These 4 096 Parameter Groups are only available using the Group Extension Format PDU. In addition, 240 Parameter Groups are provided in each data page for use only in the Destination Specific Format PDU. In total, 8 672 Parameter Groups are available to be defined using the two data pages currently available.

NOTE — When the four most significant bits of the PDU Format field are set it indicates that the PS field is a Group Extension.

The total number of Parameter Group labels available can be calculated as follows:

$$[240 + (16 \times 256)] \times 2 = 8\ 672$$

where

240 = number of PDU Format field values available per data page (i.e. PDU1 Format);

16 = PDU Format values per Group Extension value (i.e. PDU2 Format only);

256 = number of possible Group Extension values (i.e. PDU2 Format only);

2 = number of Data Page states (both PDU Formats).

3.2.6 Source Address (SA)

The Source Address field is 8 bits long. There shall only be one controller on the network with a given source address. Therefore, the source address field assures that the CAN identifier is unique, as required by CAN. Address management and allocation and procedures to prevent duplication of source addresses are defined in a future International Standard [3].

3.2.7 Data Field

3.2.7.1 Data from 0 to 8 bytes

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 can be used. It is generally recommended that eight bytes be allocated or reserved for all Parameter Group Number assignments which are likely to expand in the future. This provides a means to add parameters easily and not be incompatible with previous revisions which only define part of the data field. Once the number of bytes of data associated with a Parameter Group Number is specified, it cannot be changed (nor can it become multi-packet, unless originally defined as multi-packet). It is important to note that a given group function (see 3.4.5) must 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.

3.2.7.2 Data from 9 to 1785 bytes

When 9 to 1785 data bytes are needed to express a given Parameter Group, the communication of this data is done in multiple CAN Data Frames. Thus the term "multi-packet" is used to describe this type of Parameter Group Number. The ”Transport Protocol Function” is used when more than one CAN data frame is required to send a particular Parameter Group. The "Transport Protocol Function’s 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 3.10).

All CAN data frames associated with a particular multi-packet response are required to 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 or a fixed number of packets. The Parameter Group Number 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 send exceeds eight.

3.3 Protocol Data Unit (PDU) formats

The available PDU formats are illustrated in figure 4. Two PDU formats are defined; PDU1 Format (PS = Destination Address) and PDU2 Format (PS = Group Extension). The PDU1 Format allows for direction of the CAN Data Frame to a specific destination address (controller). The PDU2 Format can only communicate CAN Data Frames that are not destination-specific. The creation of two separate PDU formats was established in order to provide more possible Parameter Group Number combinations while still providing for destination-specific communications. Proprietary Parameter Group definitions have been assigned so that both PDU formats are available for proprietary communications. A standardized method was established for proprietary communications to prevent possible conflicts in identifier usage.

The definition of two proprietary Parameter Group Numbers was established which allows both PDU1 and PDU2 Formats to be used. The interpretation of the proprietary information will vary by manufacturer. For example, engine manufacturer "A's" proprietary communications will likely be different from engine manufacturer "B's" even though they both use the same source address.

3.3.1 PDU1 Format

The PDU1 format allows for applicable Parameter Groups to be sent to either a specific or global destination(s). The PDU Specific (PS) field contains a destination address (DA). PDU1 Format messages can be requested or sent as unsolicited messages.

PDU1 Format messages are determined by the PDU Format (PF) field. When the PDU Format field value is 0 to 239 the message is PDU1 Format. The Format of the PDU1 message is illustrated in figure 4.

Parameter Groups requiring a destination (PDU1) and minimal latency start at PF = 0 and increment toward x (or x1) (see table 5).

Parameter Groups requiring a destination where latency is not critical will start at PF = 239 and decrement toward x (or x1) (see table 5).

A PF equal to 239 (reserved bit = 0 and data page bit = 0) is assigned for proprietary use. In this case the PDU Specific (PS) field is a destination address (see 3.4.5). The PGN for Proprietary A is 61184.

PDU 1

	Priority,	R,	DP,	PF,	PS(DA),	SA,	Data Field
No. of Bits	...3...,	.1.,	.1.,	...8...,	...8...,	...8...,	...64...

PDU 2

	Priority,	R,	DP,	PF,	PS(GE),	SA,	Data Field
No. of Bits	...3...,	.1.,	.1.,	...8...,	...8...,	...8...,	...64...

Key:

R	Reserved
DP	Data Page
PF	PDU Format
PS	PDU Specific
DA	Destination Address
GE	Group Extension
SA	Source Address

Figure 4 — Available PDU Formats