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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

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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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D-70442 Stuttgart-Feuerbach
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);

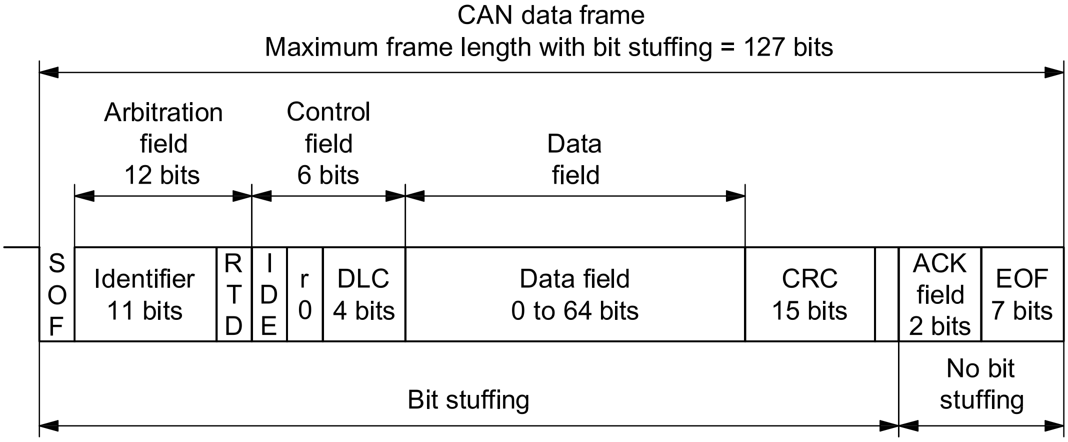
— PDU Format (PF),

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

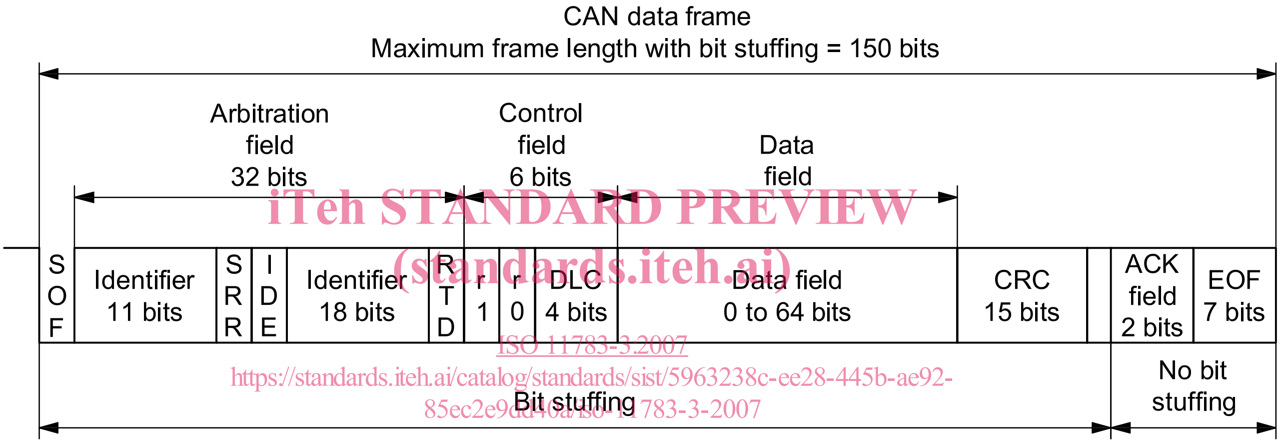
— Source Address (SA);

— 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.

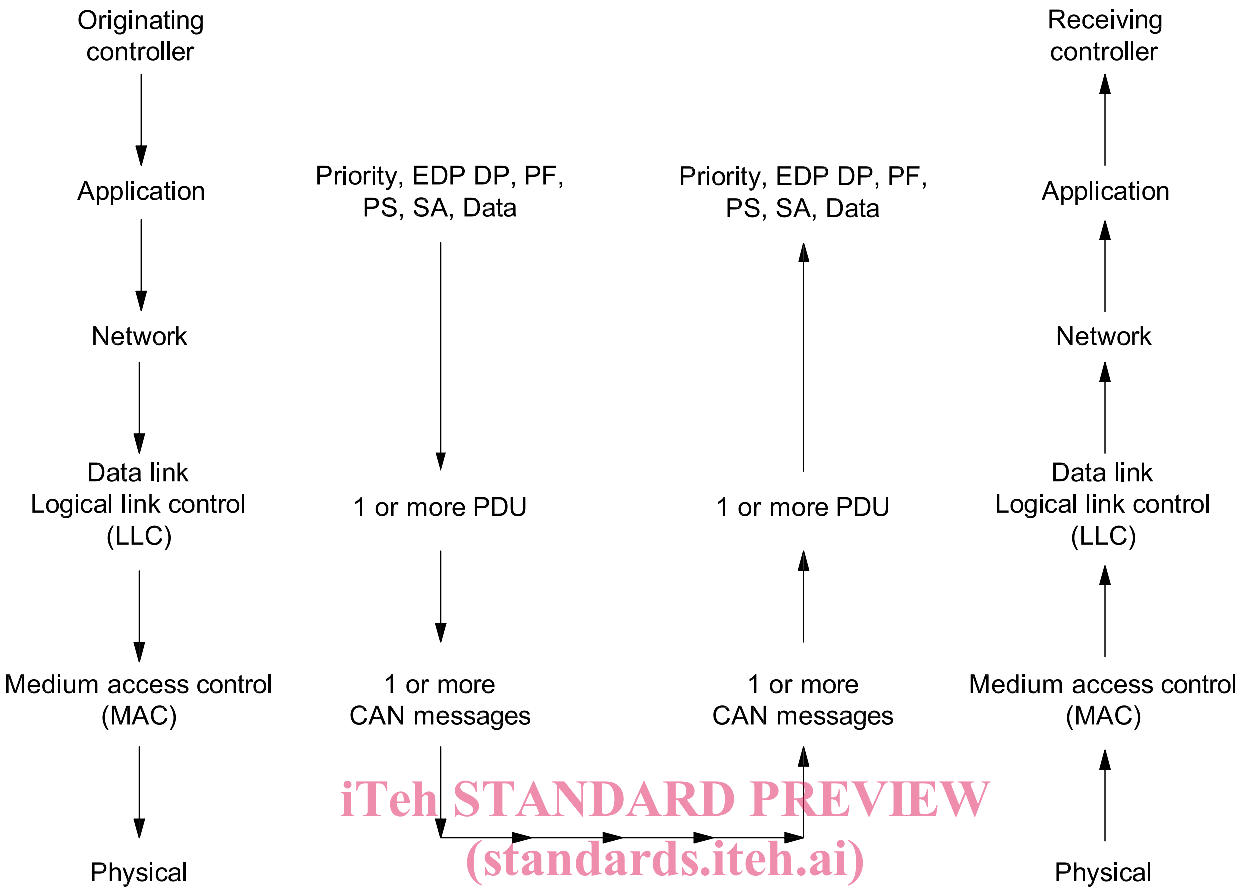


Figure 2 — Application of OSI model according to ISO 11783

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.

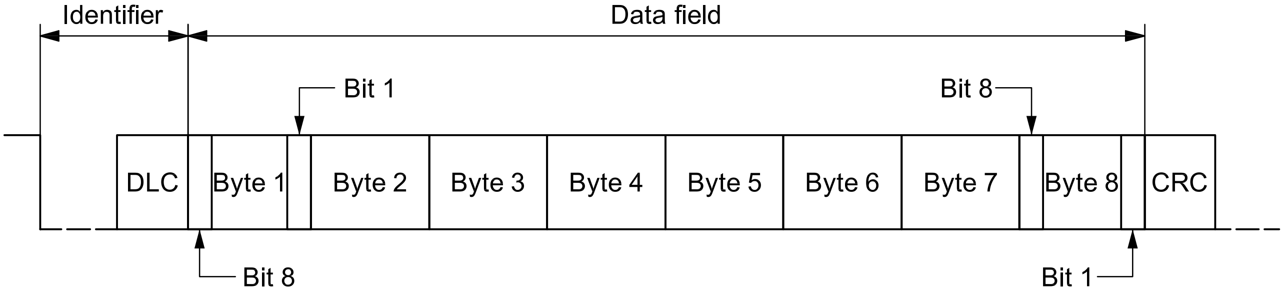


Figure 3 — CAN data field

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.