



SURFACE VEHICLE RECOMMENDED PRACTICE

J1939™-71

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Vehicle Application Layer

RATIONALE

Section 4 (Abbreviations) and 5.2.1.1 (Torque Parameter Definitions) have been moved to SAE J1939DA. These changes are identified in this revision. Improvements have been made to properly describe Suspect Parameters (SP) and Parameter Groups (PG). PG data descriptions were updated to match SAE J1939-22 terminology. Other label descriptions and diagrams were updated to match their use in SAE J1939DA.

A Table of Contents was added and various references updated to support the Table of Contents.

FOREWORD

The SAE J1939 communications network is defined using a collection of individual SAE J1939 documents based upon the layers of the Open System Interconnect (OSI) model for computer communications architecture. The SAE J1939-71 document defines the majority of the OSI application layer data parameters (SPs) and messages (PGs) that are relevant to most SAE J1939 applications. This document also defines the conventions and notations for data encoding and parameter placement in PG data.

The SAE J1939 communications network is a high-speed ISO 11898-1 CAN-based communications network that supports real-time closed loop control functions, simple information exchanges, and diagnostic data exchanges between electronic control units (ECUs) physically distributed throughout the vehicle.

The physical layer aspects of SAE J1939 reflect its design goal for use in heavy-duty environments. Horizontally integrated vehicles involve the integration of different combinations of loose package components, such as engines and transmissions that are sourced from many different component suppliers. The SAE J1939 common communication architecture strives to offer an open interconnect system that allows the ECUs associated with different component manufacturers to communicate with each other.

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1. SCOPE

The SAE J1939 communications network is developed for use in heavy-duty environments and suitable for horizontally integrated vehicle industries. The SAE J1939 communications network is applicable for light-duty, medium-duty, and heavy-duty vehicles used on-road or off-road, and for appropriate stationary applications which use vehicle derived components (e.g., generator sets). Vehicles of interest include, but are not limited to, on-highway and off-highway trucks and their trailers, construction equipment, and agricultural equipment and implements.

SAE J1939-71 is the SAE J1939 reference document for the conventions and notations used to specify the parameter (SP) placement in PG data, the conventions for ASCII parameters, and conventions for PG transmission rates. This document previously contained the majority of the SAE J1939 OSI application layer data parameters and messages for information exchange between the ECU applications connected to the SAE J1939 communications network. It also contained reference figures and reference information. The data parameters (SPs), messages (PGs), reference figures, and information previously published within this document are now published in SAE J1939DA.

There are several SAE J1939-7X documents that collectively define all of the SAE J1939 application layer data parameters and messages. Diagnostic services and some industry-specific data parameters and messages are documented within other SAE J1939-7X application layer documents. An ECU may simultaneously use and support data parameters and messages from multiple SAE J1939-7X application layer documents.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 SAE Publications

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

SAE J824	Engine Rotation and Cylinder Numbering
SAE J1349	Engine Power Test Code - Spark Ignition and Compression Ignition - As Installed Net Power Rating
SAE J1843	Accelerator Pedal Position Sensor for Use with Electronic Controls in Medium- and Heavy-Duty Vehicle Applications - Truck and Bus
SAE J1922	Powertrain Control Interface for Electronic Controls Used in Medium- and Heavy-Duty Diesel On-Highway Vehicle Applications
SAE J1939DA	J1939 Digital Annex
SAE J1939	Serial Control and Communications Heavy-Duty Vehicle Network - Top Level Document
SAE J1939-21	Data Link Layer
SAE J1939-22	CAN FD Data Link Layer
SAE J1939-73	Application Layer - Diagnostics
SAE J2012	Diagnostic Trouble Code Definitions
SAE J2403DA	Digital Annex of Medium/Heavy-Duty E/E Systems Diagnosis Nomenclature
SAE J2403	Medium/Heavy-Duty E/E Systems Diagnosis Nomenclature

2.1.2 ISO Publications

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

ISO 2575 Road Vehicles - Symbols for Controls, Indicators, and Tell-Tales

ISO 6429 Information Technology - Control Functions for Coded Character Sets

ISO 8859-1 Information Processing - 8-Bit Single-Byte Coded Graphic Character Sets - Part 1: Latin Alphabet No. 1

2.1.3 Other Publications

Patent EP000001386774B1, "Control Apparatus for Brakes of a Commercial Vehicle," Held by Knorr-Bremse Systeme, Germany, Date 8/1/2003, included with permission from the patent holder.

Advanced Driver Assistance Systems Interface Specifications (ADASIS), adasis.ertico.com.

3. DEFINITIONS

Refer to SAE J1939 (Top Level) document for terms and definitions that are not defined in this document.

4. ABBREVIATIONS

The list of abbreviations used in this document have been moved to SAE J1939DA.

Refer to SAE J1939 (Top Level) Document for additional abbreviations that may be used in this document.

5. TECHNICAL REQUIREMENTS

The application layer provides a means for application processes to access the OSI environment. This layer contains management functions and generally useful mechanisms to support applications.

5.1 General Guidelines

5.1.1 Signal Characterization

It is the intent of the SAE J1939 network to provide current data and signals from a source so that it can be used by other nodes. It is recommended that the time between physical data acquisition of data for a Suspect Parameter and the transmission of that data in a Parameter Group should be no more than two times the repetition rate defined for the data. Additional constraints may be defined for certain parameters (see also 5.1.7.2).

5.1.2 PG Data Format

SAE J1939 uses the Parameter Group Number (PGN) as the numeric identifier for a defined group of parameters, called a Parameter Group (PG). A PG definition in SAE J1939 defines a structured data object, called PG data, for the data for the group of parameters. For SAE J1939 defined PGs, the "PG length" property of a PG defines the size constraints of the PG data structure and the PG definition specifies the placement of SP data in the PG data structure. The PG definition identifies each parameter (SP) with the group and the position of the parameter's data within the structured data object. Parameter data positions are specified by byte and bit position in the data object using one-based indexing for both byte and bit. Using a left-to-right model, byte 1 is the leftmost byte, byte 2 follows to the right, and so on. Bit 1 is the lowest order bit in a byte and bit 8 is the highest order bit in a byte. Parameter position notations are described in detail in 5.4.2.

An SP definition in SAE J1939 specifies how to encode the engineering data within the PG data. The SLOT (Scaling, Length, Offset, Transfer function) associated with the parameter defines the conversion between the engineering value (real world) and the encoded value (PG data presentation). For the majority of the SAE J1939 parameters, data is expressed as ASCII, as scaled data defined by the ranges described in 5.1.4, or as discrete value states. Parameter definitions are described in detail in 5.2.

Alphanumeric (ASCII) data is ordered with the most significant byte first in the PG data. Most significant byte first for ASCII or alphanumeric data means the individual characters are positioned in the PG data in left-to-right reading order of the ASCII string. The left most character of the ASCII string shall be positioned in the lowest ordered byte of the PG data bytes occupied by the parameter data, and the right most character of the ASCII string shall be positioned in the highest ordered byte of the PG data bytes occupied by the parameter data. For example, if the ASCII string is "The quick brown fox jumped over the lazy dog" and the PG definition indicates the parameter data is to start at byte 1 in the PG data, then the ASCII character "T" shall be positioned in byte 1 of the PG data and the ASCII character "g" shall be positioned in byte 44 of the PG data.

Unless otherwise specified, alphanumeric characters conform to the ISO Latin 1 ASCII character set as described in Figure 1.

Parameters consisting of two or more data bytes are transmitted least significant byte first. Further description of bit placement within a message is described in 5.4.2.

A device shall not receive SP data from the network segment and retransmit that same SP data using the same SP back onto the same network segment.

5.1.3 ISO Latin 1 Character Set

There are 191 graphic characters of the ISO 8859-1 Latin 1 Character set shown in Figure 1. Unless otherwise specified, only these 191 character values are permitted for ASCII parameters. The terminology "ASCII characters" and "printable ASCII characters" are used in SAE J1939 to refer to this set of 191 graphic character values.

The remaining 65 character values (0 through 31 and 127 through 159) are control functions. According to ISO 8859-1, these character values are defined in ISO 6429. The terminology "ASCII control characters" and "non-printable ASCII characters" are used in SAE J1939 to refer to this set of 65 character values. As specified in ISO 6429, the character value 0 (zero) is the "NULL" character.

Horizontal boldface characters in Figure 1 are the hexadecimal digit representing the lower nibble of the single byte code for the character. Vertical boldface characters in Figure 1 are the hexadecimal digit representing the upper nibble of the single byte code for the character. For example, the byte code for the capital letter "J" character is 4Ah.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	----- should not be displayed -----															
1	----- should not be displayed -----															
2	space	!	"	#	\$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{		}	~	nil
8	----- should not be displayed -----															
9	----- should not be displayed -----															
A	nil	ı	¢	£	¤	¥	¦	§	¨	©	ª	«	¬	-	®	¯
B	°	±	²	³	´	µ	¶	·	¸	¹	º	»	¼	½	¾	¿
C	À	Á	Â	Ã	Ä	Å	Æ	Ç	È	É	Ê	Ë	Ì	Í	Î	Ï
D	Ð	Ñ	Ò	Ó	Ô	Õ	Ö	×	Ø	Ù	Ú	Û	Ü	Ý	Þ	ß
E	à	á	â	ã	ä	å	æ	ç	è	é	ê	ë	ì	í	î	ï
F		ö	ñ	ò	ó	ô	õ	ö	÷	ø	ù	ú	û	ü	ý	ÿ

Figure 1 - ISO 8859-1 Latin 1 character set

5.1.4 Parameter Ranges

For SAE J1939 defined parameters, the range of possible encoded values may be partitioned into one or more ranges, namely a range for valid parameter data, a range for parameter data error indicators, a range for parameter support indicators, and ranges for parameter-specific/future data use. The encoded value partitioning for a parameter (SP) is derived from the SLOT specified for the parameter. The number of partitioned ranges and the value size of the partitioned ranges are a function of the data bit length and the parameter type.

Encoded values are the data presentation form used for communicating parameter data in the PG data. The SLOT defined for a parameter (SP) specifies the transfer function for converting between the engineering data value and the encoded data value.

Table 1 defines the standard partitioned encoded value ranges used for numeric value data, i.e., data where a linear equation is used to translate between engineering value and the encoded value. Table 2 defines the standard partitioned encoded value ranges used for “measured” state value (discrete) data, and Table 3 defines the standard partitioned encoded value ranges used for “status” state value (control) data.

The “error indicator” value range provides a means for a module to immediately indicate that valid parametric data is not currently available due to some type of error in the sensor, sub-system, or module.

The “not available” value range provides a means to indicate valid data for a parameter that is not available or a parameter is not supported by the sending device. The “not requested” and “don’t care/take no action” value ranges provide a means to indicate when valid data is not provided for a command parameter where no direct action is being specified by the sending device.

If a component failure prevents the transmission of valid data for a parameter, the error indicator as described in Table 1 and Table 2 should be used in place of that parameter’s data. However, if the measured or calculated data has yielded a value that is valid yet exceeds the defined parameter range, the error indicator shall not be used. The data shall be transmitted using the appropriate minimum or maximum parameter value.

The “operational range” for a parameter includes the valid signal range as well as any parameter-specific indicators that have been defined.

Some parameters use the entire encoded values range for valid parameter data and, therefore, have no means to indicate a data error or “not available.” This is generally limited to ASCII data parameters, counters data that wraps around once the limit is achieved, CRC calculations, manufacturer ID, a Parameter Group Number (PGN), a Suspect Parameter Number (SPN), failure mode indicator (FMI), and some bit-mapped parameters.

Table 1 - Logical signal ranges

Parameter Size	Valid Signal	Parameter-Specific Indicator	Reserved Range for Future Indicator Bits
4 bits	0h to Ah	Bh	Ch to Dh
8 bits	0h to FAh	FBh	FCh to FDh
10 bits	0h to 3FAh	3FBh	3FCh to 3FDh
12 bits	0h to FAFh	FB0h to FBFh	FC0h to FDFh
16 bits	0h to FAFFh	FB00h to FBFFh	FC00h to FDFFh
20 bits	0h to FAFFFh	FB000h to FBFFFh	FC000h to FDFFFh
24 bits	0h to FAFFFFh	FB0000h to FBFFFFh	FC0000h to FDFFFFh
28 bits	0h to FAFFFFFFh	FB00000h to FBFFFFFFh	FC00000h to FDFFFFFFh
32 bits	0h to FAFFFFFFFh	FB000000h to FBFFFFFFFh	FC000000h to FDFFFFFFFh

Parameter Size	Error Indicator	Not Available or Not Requested
4 bits	Eh	Fh
8 bits	FEh	FFh
10 bits	3FEh	3FFh
12 bits	FE0h to FEFh	FF0h to FFFh
16 bits	FE00h to FEFFh	FF00h to FFFFh
20 bits	FE000h to FEFFFh	FF000h to FFFFFh
24 bits	FE0000h to FEFFFFh	FF0000h to FFFFFFFh
28 bits	FE00000h to FEFFFFFFh	FF00000h to FFFFFFFFh
32 bits	FE000000h to FEFFFFFFFh	FF000000h to FFFFFFFFh

Table 2 - Transmitted values for discrete parameters (measured)

Range Name	Transmitted Value
Disabled (off, passive, etc.)	00b
Enabled (on, active, etc.)	01b
Error indicator	10b
Not available or not installed	11b

Table 3 - Transmitted values for control commands (status)

Range Name	Transmitted Value
Command to disable function (turn off, etc.)	00b
Command to enable function (turn on, etc.)	01b
Reserved	10b
Don't care/take no action (leave function as is)	11b

5.1.5 Assignment of Ranges to New Parameters

SAE J1939 defines a set of recommended SLOTS (Scaling, Length, Offset, and Transfer function) used with parameters added to SAE J1939. When a new SAE J1939 parameter is being defined, the data encoding and encoded value range partitions for the new parameter are specified by the SLOT selected for the parameter. This permits data consistency to be maintained as much as possible between parameters of a given type (temperature, pressure, speed, etc.). Each SLOT provides a valid data range and scaling suitable for most parameters within a given type. When necessary, a new SLOT may be created with a different scaling factor, length, or offset. All SLOTS should be based on a power of two, scaling from another SLOT. This will minimize the math required for any internal scaling and reduce the opportunity for misinterpreted values. Preferably, offsets should be selected on the following basis:

- a. Offset = 0, or
- b. Offset = 50% (equal $\pm$ range)

Unless otherwise specified, all pressure SLOTS are measured as gage pressure.

5.1.6 Adding Parameters to Parameter Groups

When a new data parameter is defined for SAE J1939, the parameter must be assigned to a Parameter Group. A new parameter may be added to unassigned bits in an existing PG, appended to the end of an existing multipacket PG, or added to a new PG. If existing Parameter Group definitions do not permit the inclusion of a new parameter, a new Parameter Group may be defined. Refer to SAE J1939 (Top Level) document for instructions for adding new parameters to Parameter Groups and for requesting to create new Parameter Groups.

In general, parameters should be grouped into Parameter Groups as follows:

- a. By function (oil, coolant, fuel, etc.) and not by type (temperature, pressure, speed, etc.)
- b. With similar update rates (to minimize unnecessary overhead)
- c. By common subsystem (the device likely to measure and send data)

5.1.7 Transmission Repetition Rates (Update Rates)

5.1.7.1 Definition of Transmission Repetition Rate

All Parameter Group transmission repetition rates defined in SAE J1939DA are nominal rates. The actual transmission repetition rate on the network should be at this rate plus/minus the “typical” jitter which occurs in microcontroller-based systems. The average rate should be the nominal value.

5.1.7.2 Transmission Repetition Rate for Engine Speed and Directly Associated Data (Crank Angle or Time-Based Update Rates)

Some Parameter Groups contain parameters that may be calculated, measured, and/or updated based on engine crank angle rather than at a specific time interval. When this is the case, the specification of a fixed update rate for the PG is not accurate because the update rate needs to change based on the speed of the engine. The primary goal is to minimize the latency associated with sampling, calculating, and transmitting the data without overburdening the network. There are many approaches to sampling the data to be converted and sent over the network. The two preferred approaches are: (a) time-based sampling, calculating, and transmission; and (b) a hybrid time-based and engine crank angle-based sampling, calculating, and transmission, where the number of crank angle degrees between updates is modified based on the current operating speed in order to maintain an update rate within an acceptable range (see Figure 2). Because there are multiple ways to acquire and transmit data onto the network, the following guidelines have been defined for the engine speed and directly associated data.

1. At speeds above 500 rpm, the time from sampling to message transmission shall not exceed 12 ms. Systems that acquire engine speed information via period measurement inherently have less time delay at higher speeds. Above 1000 rpm, for instance, the time from sampling to message transmission shall range from 5 to 30 ms. Less time is required because the period measurement takes less time at higher speeds. How much time is saved depends on the number of crank angle degrees used to perform the period measurement.
2. "Normal" update rates:
 - a. Time-based updates will occur every 20 ms.
 - b. Hybrid time-based and engine crank angle-based updates are shown in Figure 2.

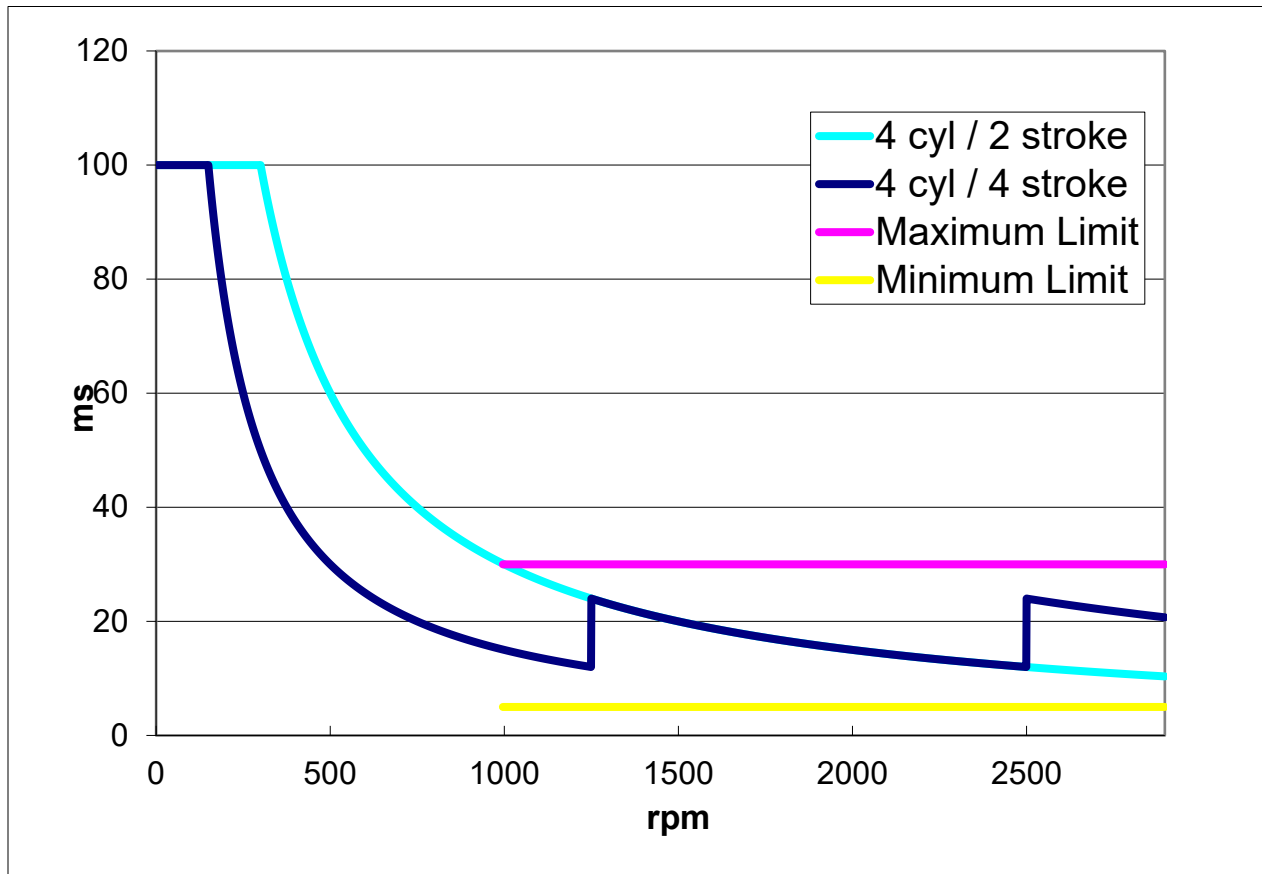


Figure 2 - Limits of hybrid update rates

5.1.7.3 Transmission Repetition Rate for On-Change Parameter Groups

There are some periodic Parameter Groups that contain parameter data that is of particular interest when a state change occurs. For example, it is desirable to immediately broadcast a change in the engine configuration rather than waiting for the next periodic update window. In some situations, it is possible these parameters may change states at a very high rate. A rapidly changing state is not useful to consumers of this information, and unnecessarily increases bus loading. An example of this would be a switch state in a cab message.

For such Parameter Groups, the PGs are defined with a transmission repetition rate in the form of:

Every MAXUPDATEPERIOD and on CHANGECRITERIA, but no faster than every MINUPDATEPERIOD