SURFACE VEHICLE RECOMMENDED PRACTICE

J1939™-71 OCT2016

Issued 1994-08
Revised 2016-10

Superseding J1939-71 JUN2015

Vehicle Application Layer

RATIONALE

Clarifications have been made to the Table 1 Title and to sections 5.1.2 and 5.1.8.

FOREWARD

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 (SPNs) and messages (PGNs) that are relevant to most SAE J1939 applications. This document also defines the conventions and notations for data encoding and parameter placement in PGN data fields.

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 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. 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.

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 Vehicle Application Layer is the SAE J1939 reference document for the conventions and notations that specify parameter placement in PGN data fields, the conventions for ASCII parameters, and conventions for PGN transmission rates. This document previously contained the majority of the SAE J1939 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 (SPNs), messages (PGNs) and 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

General information regarding this series of recommended practices is found in SAE J1939. Unless otherwise specified, 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 - 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 J1939-73 Application Layer - Diagnostics

SAE J2012 Diagnostic Trouble Code Definitions

SAE J2403 Medium/Heavy-Duty E/E Systems Diagnosis Nomenclature

SAE J2403DA Digital Annex of Medium/Heavy-Duty E/E Systems Diagnosis Nomenclature

2.1.2 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

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

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

See SAE J1939 for terms and definitions that are not defined in this document.

4. ABBREVIATIONS

ACC	Adaptive Cruise Control or Autonomous Cruise Control
AEBS	Advanced Emergency Braking System
ATA	American Trucking Association
ATC	Automatic Traction Control
CTI	Central Tire Inflation
DPF	Diesel Particulate Filter
EBS	Electronic Braking System or Electronically-controlled Braking System
ECBS	Electronically-controlled Braking System
EGR	Exhaust Gas Recirculation
FMS	Fleet Management System
HMI	Human Machine Interface
Kp	Engine endspeed governor gain
NOx	Nitrogen Oxide
O2	Oxygen
PLC	Power Line Carrier
ROP	Roll Over Prevention
SCR	Selective Catalytic Reduction
VDC	Vehicle Dynamic (Stability) Control
VGT	Variable Geometry Turbocharger
VMRS	Vehicle Maintenance Reporting System

See SAE J1939 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 may be used by other nodes. It is recommended that the time between physical data acquisition of a signal and the transmission of the data should not exceed 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 Message Format

The message format of SAE J1939 uses the parameter group number as the label for a group of parameters. Each of the parameters within the group can be expressed in ASCII, as scaled data defined by the ranges described in 5.1.4, or as function states consisting of two or more bits. Alphanumeric data will be transmitted with the most significant byte first.

Most significant byte first for ASCII or alphanumeric data means the individual characters are positioned in the data field in left-to-right reading order of the ASCII string. The left most character of the ASCII string shall be positioned closest to the PGN in the CAN header and transmitted first, and the right most character of the ASCII string shall be positioned farthest from the PGN in the CAN header and transmitted last. For example, if the ASCII string is "The quick brown fox jumped over the lazy dog", then the ASCII character 'T' shall be positioned so it is transmitted first and the ASCII character 'g' shall be positioned so it is transmitted last.

Unless otherwise specified, alphanumeric characters will conform to the ISO Latin 1 ASCII character set as shown in section 5.1.3.

Parameters consisting of 2 or more data bytes shall be transmitted least significant byte first. Further description of bit placement within a message is described in section 5.4.3.

The type of data shall also be identified for each parameter. Data may be either status or measured. Status specifies the present state of a multi-state parameter or function as a result of action taken by the transmitting node. This action is the result of a calculation which uses local and/or network “measured” and/or “status” information. Note that specific confirmation of this action is not necessarily assured. For instance, the status may indicate that a solenoid has been activated, yet no measurement may have been taken to ensure the solenoid accomplished its function. Examples of status-type data are: engine brakes are enabled, PTO speed control is active, cruise control is active, the cruise control is in the “set” state of operation (as opposed to a measured indication that the “set” switch contacts are closed), fault codes, torque/speed control override modes, desired speed/speed limit, engine torque mode, engine's desired operating speed, engine's operating speed asymmetry adjustment, etc.

Measured data conveys the current value of a parameter as measured or observed by the transmitting node to determine the condition of the defined parameter. Examples of measured-type data are: boost pressure, ignition on/off, cruise set switch activated, maximum cruise speed, cruise set speed, engine speed, percent load at current speed, etc.

A device shall not receive SPN data from the network segment and retransmit that same SPN data using the same SPN 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 show below. Unless otherwise specified, only these 191 character values are permitted for ASCII parameters. The terminology 'ASCII characters' and 'printable ASCII characters' are used in J1939 to refer to this set of 191 graphic character values.

The remaining 65 characters 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 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 are the single hexidecimal digit representing the lower nibble of the single byte code for the character. Vertical boldface characters are the single hexidecimal digit representing the upper nibble of the single byte code for the character.

<table>
<tr><th></th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td>0</td><td colspan="16">-------------------- should not be displayed -----------------------</td></tr>
<tr><td>1</td><td colspan="16">-------------------- should not be displayed -----------------------</td></tr>
<tr><td>2</td><td>space</td><td>!</td><td>"</td><td>#</td><td>$</td><td>%</td><td>&</td><td>'</td><td>(</td><td>)</td><td>*</td><td>+</td><td>,</td><td>-</td><td>.</td><td>/</td></tr>
<tr><td>3</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>:</td><td>;</td><td><</td><td>=</td><td>></td><td>?</td></tr>
<tr><td>4</td><td>@</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td><td>G</td><td>H</td><td>I</td><td>J</td><td>K</td><td>L</td><td>M</td><td>N</td><td>O</td></tr>
<tr><td>5</td><td>P</td><td>Q</td><td>R</td><td>S</td><td>T</td><td>U</td><td>V</td><td>W</td><td>X</td><td>Y</td><td>Z</td><td>[</td><td>\</td><td>]</td><td>^</td><td>_</td></tr>
<tr><td>6</td><td>`</td><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td><td>f</td><td>g</td><td>h</td><td>i</td><td>j</td><td>k</td><td>l</td><td>m</td><td>n</td><td>o</td></tr>
<tr><td>7</td><td>p</td><td>q</td><td>r</td><td>s</td><td>t</td><td>u</td><td>v</td><td>w</td><td>x</td><td>y</td><td>z</td><td>{</td><td>|</td><td>}</td><td>~</td><td>nil</td></tr>
<tr><td>8</td><td colspan="16">-------------------- should not be displayed -----------------------</td></tr>
<tr><td>9</td><td colspan="16">-------------------- should not be displayed -----------------------</td></tr>
<tr><td>A</td><td>nil</td><td>¡</td><td>¢</td><td>£</td><td>¤</td><td>¥</td><td>|</td><td>§</td><td>¨</td><td>©</td><td>ª</td><td>«</td><td>¬</td><td>-</td><td>®</td><td>¯</td></tr>
<tr><td>B</td><td>°</td><td>±</td><td>²</td><td>³</td><td>´</td><td>µ</td><td>¶</td><td>·</td><td>¸</td><td>¹</td><td>º</td><td>»</td><td>¼</td><td>½</td><td>¾</td><td>¿</td></tr>
<tr><td>C</td><td>À</td><td>Á</td><td>Â</td><td>Ã</td><td>Ä</td><td>Å</td><td>Æ</td><td>Ç</td><td>È</td><td>É</td><td>Ê</td><td>Ë</td><td>Ì</td><td>Í</td><td>Î</td><td>Ï</td></tr>
<tr><td>D</td><td>Ð</td><td>Ñ</td><td>Ò</td><td>Ó</td><td>Ô</td><td>Õ</td><td>Ö</td><td>×</td><td>Ø</td><td>Ù</td><td>Ú</td><td>Û</td><td>Ü</td><td>Ý</td><td>Þ</td><td>ß</td></tr>
<tr><td>E</td><td>à</td><td>á</td><td>â</td><td>ã</td><td>ä</td><td>å</td><td>æ</td><td>ç</td><td>è</td><td>é</td><td>ê</td><td>ë</td><td>ì</td><td>í</td><td>î</td><td>ï</td></tr>
<tr><td>F</td><td>ð</td><td>ñ</td><td>ò</td><td>ó</td><td>ô</td><td>õ</td><td>ö</td><td>÷</td><td>ø</td><td>ù</td><td>ú</td><td>û</td><td>ü</td><td>ý</td><td>þ</td><td>ÿ</td></tr>
</table>

5.1.4 Parameter Ranges

Table 1 defines the ranges used to determine the validity of a transmitted signal. Table 2 defines the ranges used to denote the state of a discrete parameter and Table 3 defines the ranges used to denote the state of a control mode command. The values in the range “error indicator” provide 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 values in the range “not available” provide a means for a module to transmit a message which contains a parameter that is not available or not supported in that module. The values in the range “not requested” provide a means for a device to transmit a command message and identify those parameters where no response is expected from the receiving device.

If a component failure prevents the transmission of valid data for a parameter, the error indicator as described in Tables 1 and 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 should not be used. The data should be transmitted using the appropriate minimum or maximum parameter value.

5.1.5 Assignment of Ranges to New Parameters

This section is intended to define a set of recommended SLOTs (Scaling, Limit, Offset, and Transfer Function) which can be used when parameters are added to J1939. This permits data consistency to be maintained as much as possible between parameters of a given type (temperature, pressure, speed, etc.). Each SLOT is intended to provide a range and resolution suitable for most parameters within a given type. When necessary, a different scaling factor or offset can be used. All SLOTs should be based on a power of 2 scaling from another SLOT. This will minimize the math required for any internal scaling and reduce the opportunity for misinterpreted values. Offsets should be selected preferably on the following basis:

a. Offset = 0, or

b. Offset = 50% (equal ± range)

Appendix A defines the recommended SLOTs to be used when ranges are assigned to new parameters.

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

Table 1 - Logical signal ranges

Range Name	1 byte	2 bytes	4 bytes	ASCII
Valid Signal	0 to 250 00_{16} to FA_{16}	0 to 64 255 0000_{16} to $FAFF_{16}$	0 to 4 211 081 215 00000000_{16} to $FAFFFFFF_{16}$	1 to 254 01_{16} to FE_{16}
Parameter specific indicator	251 FB_{16}	64 256 to 64 511 $FB00_{16}$ to $FBFF_{16}$	4 211 081 216 to 4 227 858 431 $FBxxxxxx_{16}$	none
Reserved range for future indicator bits	252 to 253 FC_{16} to FD_{16}	64 512 to 65 023 $FC00_{16}$ to $FDFF_{16}$	4 227 858 432 to 4 261 412 863 $FC000000_{16}$ to $FDFFFFFF_{16}$	none
Error indicator	254 FE_{16}	65 024 to 65 279 $FExx_{16}$	4 261 412 864 to 4 278 190 079 $FExxxxxx_{16}$	0 00_{16}
Not available or not requested	255 FF_{16}	65 280 to 65 535 $FFxx_{16}$	4 278 190 080 to 4 294 967 295 $FFxxxxxx_{16}$	255 FF_{16}

Table 2 - Transmitted values for discrete parameters (measured)

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

Table 3 - Transmitted values for control commands (status)

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

5.1.6 Adding Parameters to Groups

Several of the Parameter Groups contain bytes that are not defined and may be replaced with new parameters as appropriate. 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 for additional definitions and abbreviations for instructions for adding new parameters to parameter groups and for requesting new parameter group numbers.

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 transmission repetition rates defined in SAE J1939/71 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 parameters may be calculated and/or updated based on engine crank angle rather than at a specific time interval. When this is the case the reference to a specific update rate is not accurate because this time will 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 1). 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 1

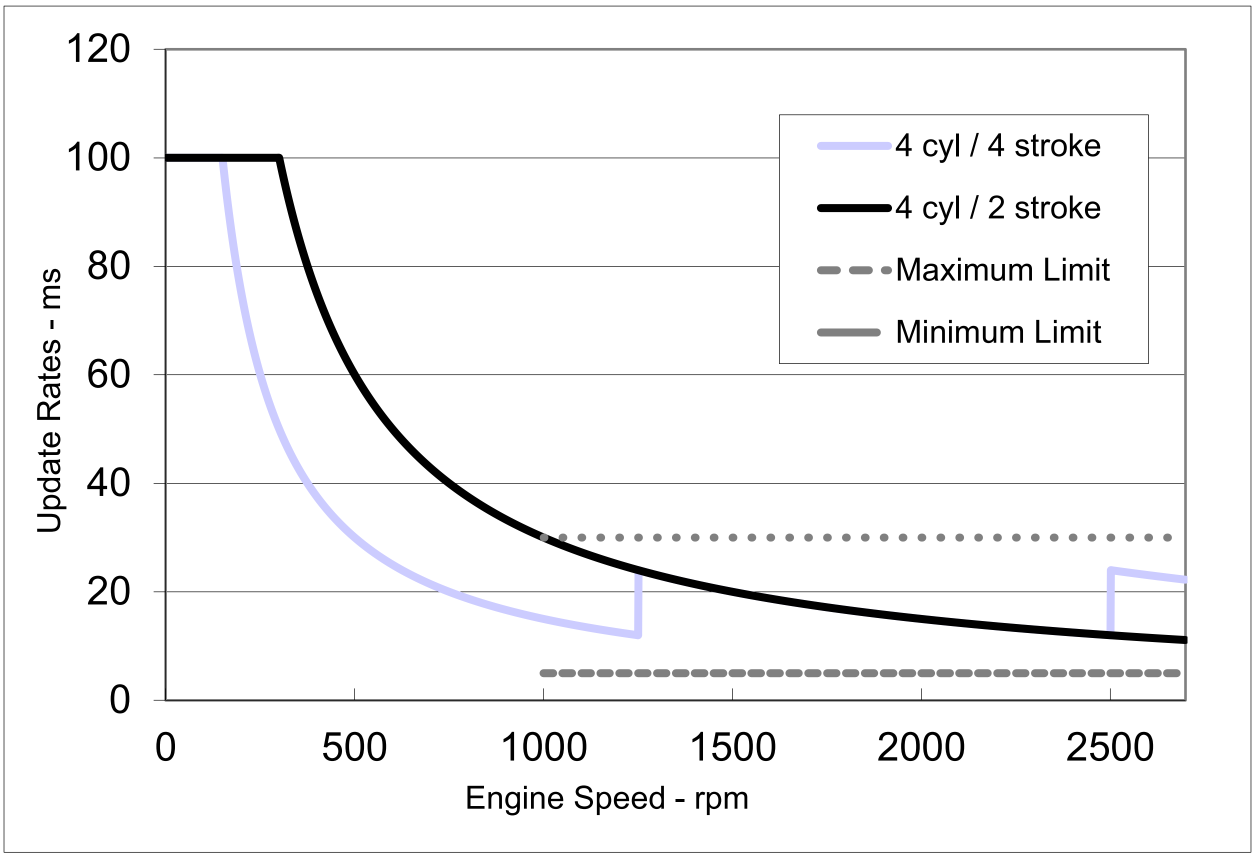

Figure 1 - Limits of hybrid update rates

5.1.7.3 Transmission Repetition Rate for On-change Messages

Some periodic messages contain information 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 a significant period of time for the next periodic update window.

Messages contain information that 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.

Transmission repetition rate definition for these messages takes the form of:

Every MAXUPDATEPERIOD and on CHANGECRITERA but no faster than every MINUPDATEPERIOD

Where:

- CHANGECRITERIA is the criterion that prompts an immediate broadcast of a new message.
- MAXUPDATEPERIOD is the maximum period of the message. When CHANGECRITERIA is not satisfied, this is the preferred period of the message.
- MINUPDATEPERIOD is the minimum period of the message. If CHANGECRITERIA indicates the message should be broadcast more often, the period must be equal to MINUPDATEPERIOD. This does not apply to the first message after a periodic broadcast.

Two acceptable implementations are illustrated below. In each illustration, the horizontal line represents time, the vertical bars topped with a numbered circle represent messages, and the diagonal line represents a timer that counts down to zero, which triggers the transmission of the next periodic message. In both illustrations, all messages are triggered by MAXUPDATEPERIOD except for message 2, which is triggered by CHANGECRITERIA.

Figure 2 shows the method where CHANGECRITERA results in extra messages that do not change the timing of the subsequent periodic messages. In this illustration, message 2 is triggered by CHANGECRITERIA, but since the countdown timer is not reset, message 3 is then broadcast after MAXUPDATEPERIOD elapses since message 1.

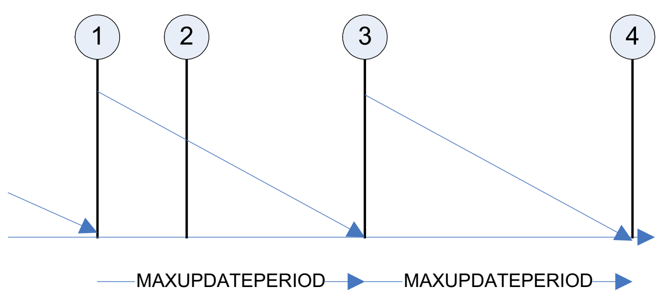

Figure 2 – On-change implementation option 1

Figure 3 shows the method where the message period is controlled by the last broadcast message. In this method, message 2 resets the timer, forcing message 3 to occur at a later time than if CHANGECRITERIA had not been satisfied. This implementation results in a lower average bus loading, as illustrated by the lack of message 4 in the same overall time as shown in the previous illustration.

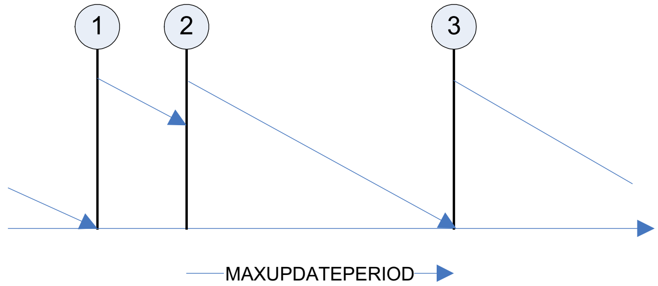

Figure 3 – On-change implementation option 2

This message definition was created after many “on change” messages were published. As a result, the implementation of those messages may vary from the description in this section. This section is intended to provide uniformity of future implementations of “on change” messages.

After July 2010, new implementations of “on change” messages are expected to conform to this recommended practice. Many existing implementations prior to that date comply with this definition and no change is required.

While this section describes the preferred implementation, existing implementations prior to July 2010 are grandfathered, and may have an alternate acceptable definition.

5.1.7.4 Transmission Repetition Rate for Messages Used in Diagnostic Applications

If the PGN is transmitted on a control network where there may be consumers using the message for control functions, then the documented standard PGN transmission rate must be used.

However, in an OEM integrated vehicle system, the vehicle system designer may have a SAE J1939 network where the PGN data will not be required for control functions, and the PGN data is only required for non control (or informational only) functions, such as user interface display or diagnostic tools. In such an OEM integrated vehicle system, it is permissible to use a system specific, extended transmission rate for periodic PGNs. The responsibility falls on the vehicle system designer of the OEM vehicle system to make sure all involved ECUs are function appropriately with the system specific, extended rate.

The extended transmission rate may be up to 5 times slower than the defined rate.

5.1.8 Naming Convention for Engine Parameters

When there are multiple instances of the same parameter on the same component (i.e., exhaust ports), the following naming convention will be used. While facing the engine flywheel housing, left bank (LB) parameters are assigned prior to the right bank (RB) parameters. Front parameters are assigned prior to the rear or back parameters (with the rear/back being the end containing the flywheel housing. For a six cylinder in-line engine, the position furthest from the flywheel will be identified as 1, the position next closest to the flywheel will be identified as 2, etc. For a 12 cylinder “V” engine, the position furthest from the flywheel on the left bank will be identified as 1, the position furthest from the flywheel on the right bank will be identified as 2, followed by the position next closest to the flywheel on the left bank. See SAE J824. When only one parameter is required or available, the parameter denoted as number 1 should be used. (i.e., an engine having only one turbocharger would use Turbocharger 1 Compressor Inlet Temperature when broadcasting the temperature).

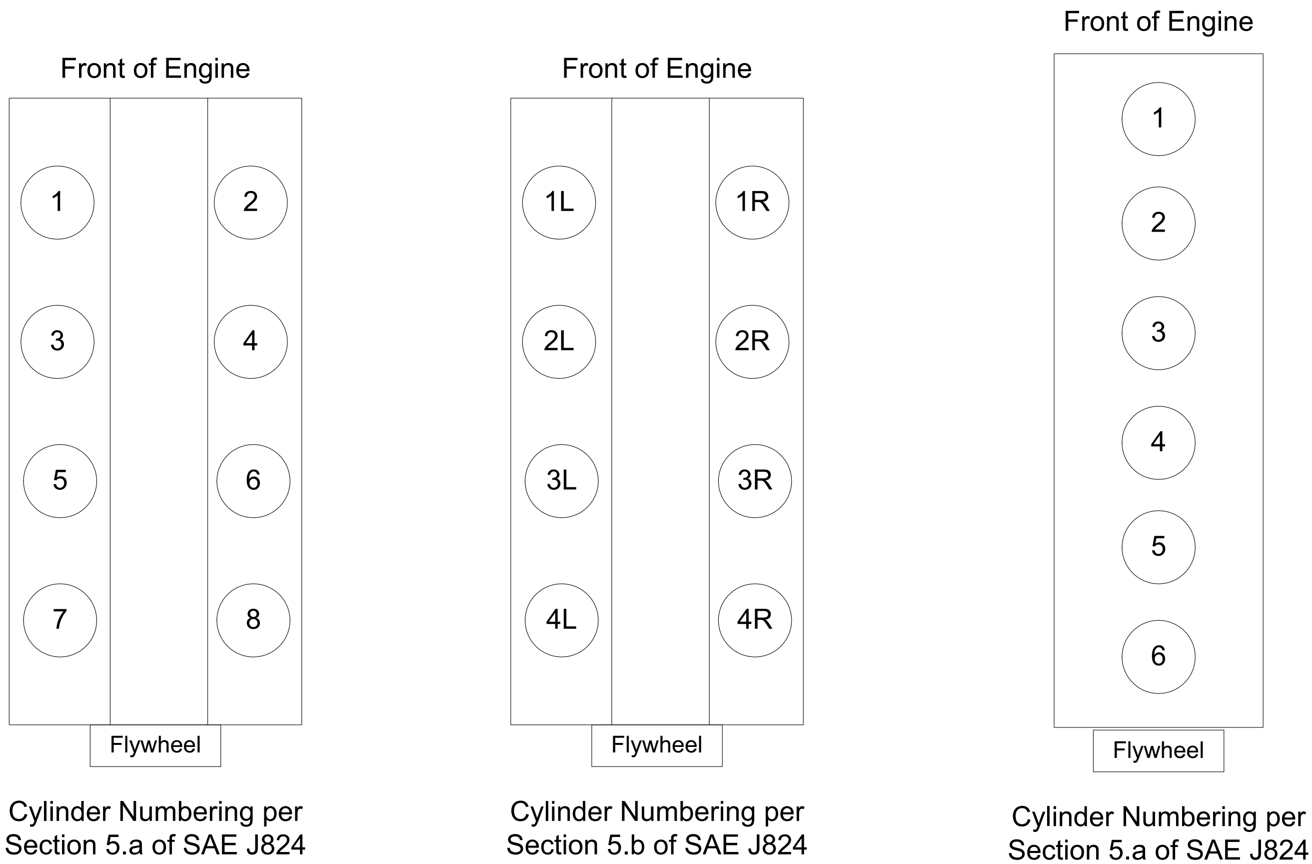

Figure 4 - Cylinder numbering per SAE J824

5.2 Parameter Definitions

This section provides a description of each parameter used in the SAE J1939 network. The description includes data length, data type, resolution, range, and a tag (label) for reference.

After power on, a node should internally set the “availability bits” of received parameters as not available and operate with default values until valid data is received. When transmitting, undefined bytes should be sent as 255 (FF_{16}) and undefined bits should be sent as 1.

5.2.1 Control Parameters

5.2.1.1 Net Engine Brake Torque (Power)

The measured torque (or power output) of a “fully equipped” engine. A fully equipped engine is an engine equipped with accessories necessary to perform its intended service. This includes, but is not restricted to, the basic engine, including fuel, oil, and cooling pumps, plus intake air system, exhaust system, cooling system, alternator, and starter, emissions, and noise control. Accessories which are not necessary for the operation of the engine, but may be engine mounted, are not considered part of a fully equipped engine. These items include, but are not restricted to, power steering pump systems, vacuum pumps, and compressor systems for air conditioning, brakes, and suspensions. When these accessories are integral with the engine, the torque/power absorbed in an unloaded condition may be determined and added to the net engine brake torque. (Refer to SAE J1349.)

Net engine brake torque is calculated by subtracting friction torque from indicated torque for the purposes of this document.

5.2.1.1 Engine Friction Torque

The torque required to drive the engine alone as “fully equipped.”

Engine friction torque is equal to the sum of Nominal Friction - Percent Torque (SPN 514) and Estimated Engine Parasitic Losses - Percent Torque (SPN 2978). Nominal Friction - Percent Torque (SPN 514) includes Estimated Pumping - Percent Torque (SPN 5398).

5.2.1.2 Engine Indicated Torque

Engine indicated torque is the torque developed in the cylinders. It is defined as the sum of the net engine brake torque and engine friction torque.

5.2.1.3 Net Brake Torque (Engine Based Retarder)

Net brake torque of the retarder is calculated by subtracting engine friction torque from engine indicated torque. For example, the net retarder torque would be calculated as 'Actual Retarder Percent Torque' minus 'Nominal Friction Percent Torque' minus 'Estimated Parasitic Losses Percent Torque' (if supported).

Net brake torque of the retarder is calculated by subtracting engine friction torque from engine indicated torque. For example, the net retarder torque would be calculated as:

Net Retarder Torque = Actual Retarder Percent Torque – Nominal Friction Percent Torque – Estimated Parasitic Losses Percent Torque

Figure 5 shows how some of the torque calculations are determined.

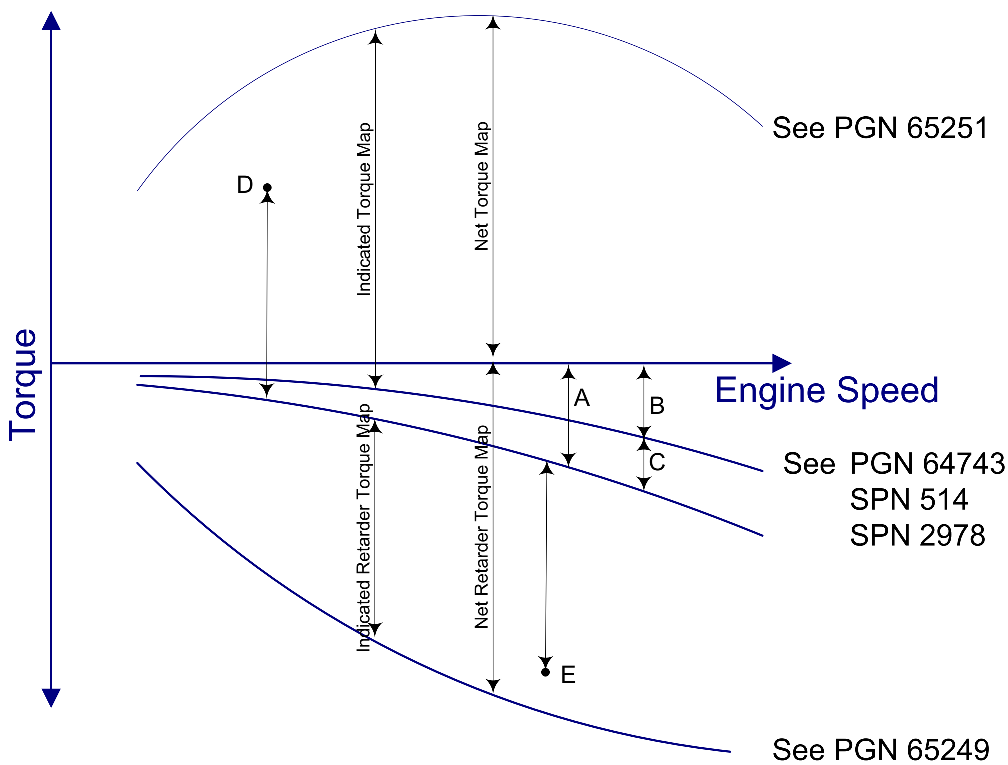

Figure 5 – Torque definitions

A. Friction Torque Curve (includes the effects of SPN 2978, i.e., SPN 2978 is equal to 0xFB when transmitted by the engine). Since this includes the parasitic losses, this is not defined by SAE J1939 and it is not the friction torque map defined in the EC3 message.

B. Friction Torque Map in the EC3 message (does not include the effects of SPN 2978, i.e., SPN 2978 is supported by the engine)

C. SPN 2978, Estimated Engine Parasitic Losses – Percent Torque. This torque curve is intended to demonstrate that the indicated retarder torque map does not change when Friction Torque, as defined in Section 5.2.1.2, changes. Examples of why this might change include, but are not limited to, the fan changing state or a change in engine temperature. The torque curve depicted by adding C to B is not defined by SAE J1939 if SPN 2978 is supported by the engine.

D. Typical value of Actual Engine – Percent Torque (SPN 513). The intent of this point is to illustrate the relationship of this parameter to the friction torque curve. The value at Point D includes the torque necessary to overcome the parasitic losses. If Point D is at the torque curve, then final torque will be reduced by the amount of the parasitic loss at that engine speed (curve C). Other parameters that have the same relationship to the friction torque curve are Engine Demand – Percent Torque (SPN 2432), Driver's Demand Engine – Percent Torque (SPN 512), and Actual Maximum Available Engine – Percent Torque (SPN 3357).

E. Typical value of Actual Retarder – Percent Torque (SPN 520). The intent of this point is to illustrate the relationship of this parameter to the friction torque curve. Other parameters that have the same relationship to the friction torque curve are Intended Retarder Percent Torque (SPN 1085), Drivers Demand Retarder – Percent Torque (SPN 1715), and Actual Maximum Available Retarder – Percent Torque (SPN 1717).

NOTE 1: The purposes of A, B, & C are to:

(1) Refer to an instantaneous point along the torque curve, although the value of friction torque along these curves at different engine speeds may not be known.

(2) Illustrate the frictional effects when SPN 2978 is supported or not.

(3) Illustrate how the frictional effects are used to determine net torque.

NOTE 2: Although SPN 514 and SPN 2978 are shown in the graph as having negative values, typical values for these parameters are positive because they are defined to be loss torque.

NOTE 3: This figure applies to engine based retarders only (compression release and/or exhaust).

5.2.2 ASCII Parameters

This section describes the standard practices for ASCII data parameters. SAE J1939 has three (3) standard ASCII SLOT Types for different data length designation techniques, which are summarized in Table 4. Some of the ASCII SLOT Types use a delimiter technique for data length designation which may reduce the ASCII characters available for parameter data. The ASCII SLOT Types are discussed individually in more detail in the sections 5.2.2.1, 5.2.2.4, and 5.2.2.5.

The SLOT Table in Appendix A may have multiple ASCII SLOTs for the same ASCII SLOT Type to accommodate different maximum bytes allowed. The numerical designator in the ASCII SLOT Name reflects the maximum bytes allowed for an ASCII SLOT. For example, the ASCII SLOT 'SAEatad0200' has a maximum length of 200 bytes while the ASCII SLOT 'SAEatad0025' has a maximum length of 25 bytes.

Table 4 - Summary of ASCII slot Types

ASCII SLOT Type	Description	Data Length Indication	Delimiter Character included in Data Length?	Any Characters not allowed within the Data?	Required to fill Data to a specific length?
Fixed Length ASCII	The Data length is a fixed or constant number of bytes	Fixed number of bytes of data	No. The length indicates required data space for parameter data.	No. All of the ASCII characters may be used in the Data	Yes, must provide data in all of the required number of bytes
Character Delimited, Variable Length ASCII	The Data length may vary within defined limits and a specific ASCII character is placed following the Data to indicate the end of the parameter data	Length indicated by the delimiter character (always required).	No. The length indicates allowed data space for parameter data.	Yes. The delimiter character is not allowed within the parameter data, since it will be interpreted as the delimiter	No, unless the ASCII data SPN definition has a minimum data length of 1 or more characters
Byte Count Delimited, Variable Length ASCII	The Data length may vary within defined limits and a separate data parameter (SPN) within the PGN data field specifies the byte length of the ASCII Data	Separate SPN that specifies the ASCII data byte length	No. The length indicates allowed data space for parameter data.	No. All of the ASCII characters may be used in the Data	No, unless the ASCII data SPN definition has a minimum data length of 1 or more characters

5.2.2.1 ASCII Characters

The character values for ASCII Characters are specified in Section 5.1.3 of J1939-71. By default, only the printable ASCII characters are allowed in the data for ASCII parameters. The ASCII control characters, or non-printable ASCII characters, are not allowed in the data for an ASCII parameter, unless the ASCII parameter definition explicitly states otherwise. SPN 162 and SPN 163 are examples of ASCII parameters with explicit statements allowing the use of ASCII control characters in the parameter data.

5.2.2.2 ASCII Byte Order

The standard practice for the ordering of data bytes for ASCII data parameters is defined in Section 5.1.2 of J1939-71.

5.2.2.3 ASCII SLOT Type - Fixed Length ASCII

The Fixed Length ASCII SLOT Type defines an ASCII data parameter with a fixed, or non-varying, number of ASCII characters in the data field. All ASCII characters are available for use in the SPN data with this type of ASCII SLOT.

Some examples of SPNs using a fixed length ASCII SLOT Type are SPNs 162, 3620, and 4254.

5.2.2.3.1 SPN Data Definition for Fixed Length ASCII

An SPN using a fixed length ASCII SLOT Type has the following data definition characteristics:

- The 'Resolution' property indicates "ASCII"
- The 'Data Length' property is a fixed byte length, such as "5 bytes"

All ASCII characters are available for use in the ASCII data with this type of ASCII SLOT.

The 'Data Length' property defines the required byte length of the data for this SPN. If it is possible to have actual SPN data that is shorter than the required data length, then the SPN data definition should specify the acceptable ASCII character(s) for an application to use to fill or pad the remaining data bytes. The definition should indicate if there is a standard for preference for inserting the pad or fill characters before or after the actual SPN data.

5.2.2.3.2 PGN Data Field Details for Fixed Length ASCII Parameters

Within the PGN data field, the specified number of bytes of data is required in the data field position for the fixed length ASCII data SPN, whether the source application supports the SPN or not.

The data for a subsequent parameter shall immediately follow the required number of data bytes.

If the source application is reporting data for the SPN, then the source application must fill each of the data bytes for the SPN. If the actual SPN data is shorter than the required data length, then the source application is required to fill any remaining data bytes. The remaining data bytes shall be filled according to the SPN definition. If the SPN definition does not specified the data fill method, then the application shall fill the remaining bytes as appropriate for the data content.

If the source application does not support the SPN, then the source application is still required to fill each of the SPN data bytes with the "not available" value.

5.2.2.4 ASCII SLOT Type - Character Delimited, Variable Length ASCII

The Character Delimited, Variable Length ASCII SLOT Type defines an ASCII data parameter with a varying number of ASCII characters in the data field, and uses a specific ASCII character (delimiter) to indicate the end of the ASCII text for the parameter. All ASCII characters except for the delimiter character are permitted in the SPN data with this type of ASCII SLOT. The delimiter character is not permitted in the SPN data because it will be interpreted as the end of data indicator.

The delimiter character is not considered part of the data for the parameter. Consequently, the delimiter character is not included in the Data Length maximum byte length value in the SLOT definition. The delimiter is a mechanism within the PGN data content to denote the end of the parameter data for the variable length ASCII parameter. However, this fundamental perspective should not be seen as restricting how the parameter data is handled internally by an application.

Some examples of SPNs using a character delimited, variable length ASCII SLOT Types are SPNs 237 and 2902.

5.2.2.4.1 SPN Data Definition for Character Delimited, Variable Length ASCII

An SPN using a Character Delimited, Variable Length ASCII SLOT Type has the following data definition characteristics:

- The 'Resolution' property indicates "ASCII"
- The 'Data Length' property indicates a variable length, such as "Variable - up to 200 characters"
- The 'Data Length' property indicates the delimiter character, such as "followed by an '*' delimiter"

All ASCII characters, except for the delimiter character, are available for use in the SPN data with this type of ASCII SLOT. The delimiter character is not permitted in the SPN data for this type of ASCII SLOT because it will be interpreted as the end of data indicator. The asterisk (*) character is the standard delimiter character for J1939 parameters of this SLOT type. There is a SLOT type that uses the NULL character (value 0) as the delimiter character. The SLOT type with a NULL delimiter character is appropriate when there is a need to have the asterisk character available as a valid data character rather than a delimiter.

The 'Data Length' property defines the maximum length available for the ASCII data for the SPN. There is no minimum data length required for the data, unless the Data Length property explicitly states otherwise. The delimiter character is not included in the maximum data length value in the 'Data Length' property. The delimiter character is specified within the SLOT definition and SPN definition because it places a restriction on the allowed ASCII characters for the SPN data. It is included in the 'Data Length' property since this property appears in the PGN definition content.

The delimiter character is not considered part of the data for the parameter. This delimiter character perspective is not meant to restrict how the parameter data is handled internally by an application. An application may choose to include the delimiter as part of the parameter data within its memory storage; or alternately, an application may choose to add the delimiter as the parameter data is placed into the PGN data structure and to remove the delimiter as the parameter data is extracted from the PGN data structure and place into memory/storage. This fundamental perspective about the delimiter not being part of the parameter data is important when the SPN data is exchanged through means other than the PGN, such as through Memory Access Protocol with SPN spatial addressing. Since the delimiter character is not part of the parameter data, then the delimiter character shall not be included when exchanged through other means. For Memory Access Protocol, the content of the DM16 Binary Data Transfer PGN shall not include the delimiter character.

5.2.2.4.2 PGN Data Field Details for Character Delimited, Variable Length ASCII

Within the PGN data field, the maximum data length defines the maximum number of bytes available for the ASCII data for this SPN in the data field position. The designated delimiter character shall immediately follow the last valid byte of ASCII data for the SPN in the PGN data field. The maximum data length does not define the required number of bytes for the data. A source application should not fill or pad the ASCII data for this type of SPN just to occupy the maximum length allowed. The delimiter character denotes the end of the data for the ASCII data SPN and indicates the starting position for a subsequent parameter. The delimiter is a mechanism within the PGN data content to denote the end of the parameter data for the variable length ASCII parameter.

The data for a subsequent parameter shall immediately follow the delimiter character.

The delimiter character is always required after a delimited variable length ASCII data field within the PGN data field, including situations when

- the delimited variable length ASCII parameter is not supported by the source application
- the delimited variable length ASCII parameter is the only parameter in the data field
- the delimited variable length ASCII parameter data is zero (0) bytes or characters in length
- the delimited variable length ASCII parameter is the last parameter in the PGN data field
- the delimited variable length ASCII parameter data uses the maximum data length available for the SPN

It is not necessary to include ASCII text for a delimited Variable Length ASCII parameter; however, the delimiter is always required. In other words, it is acceptable to transmit zero-length ASCII text for a variable length ASCII parameter as long as the delimiter character is included in the PGN data.

The asterisk (*) character is the standard delimiter character for J1939 parameters of this SLOT type. There is a SLOT type that uses the NULL character (Hex value 0) as the delimiter character. The SLOT type with a NULL delimiter character is appropriate when there is a need to have the asterisk character available as a valid data character rather than a delimiter.

Several examples are provided below to illustrate the PGN data field content for several situations. For these examples the letters 'a' through 'e' represent the data for 5 consecutive variable length ASCII parameters (asterisk * delimited) within the PGN data field.

Example 1:	Data provided for each parameter	aaaa*bbb*c*dddd*eee*
Example 2:	Data only for parameters 'a' and 'b'	aaaaaaaa*bbbbbbbbbbb****
Example 3:	Data only for parameter 'a' and 'd'	*bbbbbbbb**ddddd**
Example 4:	Data only for parameter 'e'	****eeeeee*

5.2.2.5 ASCII SLOT Type - Byte Count Delimited, Variable Length ASCII

The Byte Count Delimited, Variable Length ASCII SLOT Type defines an ASCII data parameter (SPN) with a varying number of ASCII characters in the data field, and relies upon a separate parameter (SPN) to report the ASCII data parameter byte length. The ASCII data SPN and the separate ASCII data byte length SPN must be transmitted in the same PGN, since it is possible for the length of the ASCII data to vary from one instance of the SPN data to another instance of the SPN data. All ASCII characters are permitted in the SPN data with this type of ASCII SLOT.

Special design considerations must be recognized by any application that is the source of a PGN with an SPN of the this ASCII SLOT type. One design consideration involves maintaining synchronization between the value for the associated Number of Bytes SPN and the length of the ASCII data SPN. Another design consideration involves the value reported for the Data Length SPN value if the ASCII parameter is not available or supported by the source.

Some examples of SPNs using a byte count delimited, variable length ASCII SLOT Type are SPNs 509 and 3075. SPN 509 is the ASCII data SPN and SPN 3070 reports the byte length of SPN 509. Similarly, SPN 3075 is the ASCII data SPN and SPN 3072 reports the byte length of SPN 3075.

5.2.2.5.1 SPN Data Definition for Byte Count Delimited, Variable Length ASCII

An SPN using a Variable Length ASCII with Byte Count Parameter SLOT data type has the following data definition characteristics:

- The 'Resolution' property indicates "ASCII"
- The 'Data Length' property indicates a variable length, such as "Variable - up to 100 characters"
- The 'Data Length' property does not specify a delimiter character
- The Description Notes identify the Number of Bytes SPN that reports the ASCII data byte length

All ASCII characters are available for use in the ASCII data with this type of ASCII SLOT.

The 'Data Length' property defines the maximum length available for the ASCII data for the SPN. There is no minimum data length required for the ASCII data, unless the Data Length property explicitly states otherwise. A source application should not fill or pad the ASCII data for this type of SPN just to occupy the maximum length allowed.

5.2.2.5.2 PGN Data Field Details for Byte Count Delimited, Variable Length ASCII

Within the PGN data field, the maximum data length defines the maximum number of bytes available for the ASCII data for this SPN in the data field position. The maximum data length does not define the required number of bytes for the data. A source application should not fill or pad the ASCII data for this type of SPN just to occupy the maximum length allowed.

The Number of Bytes SPN shall be positioned somewhere before the ASCII data SPN within the PGN data field to enable recipient applications to determine the end of the data for the ASCII data SPN. The source application must make sure the value in the Number of Bytes SPN is correct for the length of the instance of ASCII data SPN. The Number of Bytes SPN denotes the end of the ASCII data SPN and indicates the starting position for a subsequent parameter. The Number of Bytes SPN is the mechanism within the PGN data content to denote the end of the data for the variable length ASCII parameter.

The data for a subsequent parameter shall immediately follow the specified number of bytes after the starting byte position for the ASCII data SPN.

5.3 Parameter Group Definitions

Parameter Groups (PGNs) for use on the SAE J1939 network may be found in Appendix C. All undefined bits are to be transmitted with a value of "1." All undefined bits should be received as "don't care" (either masked out or ignored). This permits them to be defined and used in the future without causing any incompatibilities.

Messages that are requesting control over the receiving device (TSC1, TC1) are transmitted at high rate only during the time when the control is active, but may be optionally sent at a slow rate as a "heartbeat." For TSC1, it is expected that the transmitting device indicate to the receiving device that it no longer requests control by sending at least one broadcast with the override control modes set to 00. In the absence of continued broadcasts from a requesting module, the receiving device shall default to its normal mode after two update periods.

The size of the CAN data field is 8 bytes. Parameter groups that are 0-8 data bytes in length use the services of the Data Link layer (Refer to SAE J1939-21). Parameter groups that exceed 8 data bytes or parameter group definitions that are variable in length and may exceed 8 data bytes shall utilize the services of the Transport Protocol. (Refer to SAE J1939-21.) Network nodes that receive multipacket messages must anticipate that the received message size may vary due to a possible assignment of new SPNs to a given message.

5.4 Application Notes

5.4.1 Parameters with Multiple Sources

Each parameter received by a node for control purposes shall be configurable by the system integrator to identify the primary source of the data, as well as the secondary source, if applicable. It is to be expected that the system integrator configures each receiving device on a network identically. A secondary source of data is defined to be a device on the network that measures the data independently of the primary source of that data.

5.4.2 Conventions for Parameter Placement Notation and Unspecified Bits in Message Definitions

This section explains the various notations used by J1939 documents to specify the position of parameter data within the PGN data field and illustrates the bit placement associated with the notations. This section also explains how to deal with the unspecified bits in the data field definition. The information in this section is intended to aid the reader in determining the proper placement of parameter data based upon the Start Position and Length attributes specified in the PGN definition. The information in this section is also intended to serve as a guide for how to properly define the Start Position attribute to define the placement of parameter data in a PGN.

5.4.3 Terminology for Parameter Placement

5.4.3.1 Parameter Data Length Classification Terminology

Three different classifications of parameters have been defined for the purposes of discussing parameter placement. The classifications are based upon the parameter data length. The three classifications are fractional byte length, integer byte length, and variable byte length. The 'Start Position' notation is explained according to each of the parameter data length classifications.

Fractional Byte Length: Term used to classify a parameter with a fixed data length where the data length is not an integer number of bytes. A parameter with a data length of 2 bits, a parameter with a data length of 5 bits, and a parameter with a data length of 10 bits are examples of fractional byte length parameters.

Integer Byte Length: Term used to classify a parameter with a fixed data length where the data length is an integer number of bytes. A parameter with a data length of 1 byte, a parameter with a data length of 2 bytes, and a parameter with a data length of 8 bits are examples of integer byte length parameters.

Variable Byte Length: Term used to classify a parameter with a variable data length that is an integer number of bytes. A parameter with a data length of "Variable - up to 200 characters" is an example of a variable byte length parameter. Alphanumeric or textual data parameters are the primary examples of variable byte length parameters.

5.4.3.2 Start Position Terminology

The following terms are used throughout the parameter placement to describe the 'Start Position' notation style.

Fixed: Term used to describe a 'Start Position' notation that defines an absolute or fixed position for the placement of the parameter data in the data field. Some examples of fixed start position notations are '3', '5.4', '1-2', and '1.7-2',

Equation: Term used to describe a 'Start Position' notation that defines the placement of the parameter data using an equation rather than an absolute position. Equation start position notations are appropriate when the parameter data length is variable, when the PGN data field has multiple variable length parameters, or when there are fixed length parameters after variable length parameters in the data field. Some examples of equation start position notations are '14-n', '2 to n', '5 to A', and 'A+1 to B'.

Field: Term used to describe a 'Start Position' notation that defines the placement of the parameter data in terms of its relative sequence in the data field rather than with an absolute position or equation. Field start position notations are appropriate when the PGN data field has multiple consecutive variable length parameters in the data field or the parameter is repeated in the data field. The placement order of fields follows the alphabetical sequence of the start positions. Some examples of field start position notations are 'a' 'b', and 'c'.

5.4.3.3 Start Position Diagrams

Illustrations are included for many of the parameter placement notation styles to help clarify the parameter placement practices and the transmission order of the data over the J1939 data link. These illustrations include one or more of the following diagrams.

Data Definition: The Data diagram serves to illustrate the parameter data bits for the example data, shown where the data bits go highest order bit to lowest order significant bit in a left to right manner. Individual bits are identified with a 'b' followed by a number. The 'b' is the abbreviation for 'bit' and the number denotes the significance order of the bit, where bits with lower significance have a lower number value. This diagram serves as a convenient way of discussing bit placement for the J1939 data order practices. In the ASCII examples, the 'b' identifier may be preceded by a 'c' plus a number to designate the character instance.

Placement: The Placement diagram illustrates the placement of the parameter bits using a common view of data in memory, where the bytes go most significant to least significant in a left to right manner and the bits within a byte go highest order to lowest order in a left to right manner. This diagram serves as a convenient way of discussing bit placement for the J1939 data order practices.

Transmission Order: The Transmission Order diagram illustrates the parameter data bits in the order they are transmitted over the J1939 data link. As specified in J1939-21 Section 5.1.1, the data is transmitted in increasing byte order (i.e. byte 1, byte 2, byte 3, etc.) with the bits within a byte transmitted highest order bit first (i.e. bit 8, bit 7, bit 6, etc.).

5.4.4 Guidelines for Parameter Placement

The following guidelines provide the basis for the parameter data placement conventions. These guidelines and the conventional parameter placement methods should be applied when defining the placement of parameters in PGNs.

1. Parameters with less than 8 bits should reside within a byte boundary

2. Parameters with more than 8 bits should either start or stop on a whole byte boundary

3. Only parameters with more than 8 bits should span a byte boundary

4. ASCII parameters, variable length parameters, and parameters with repeating data fields should start and stop on whole byte boundaries

5. Byte ordering rules are specified in 5.1.2 Message Format.

5.4.5 Start Position Notation and Parameter Placement

The 'Start Position' specified for a parameter in the PGN definition and the 'Length' attribute of the parameter describes the placement of the parameter data into the PGN data field. Generally, the 'Start Position' notation reflects the bit position for the lowest order bit of the parameter data within the byte. When the parameter data is confined to a single byte, then the 'Start Position' consists of one numerical value declaring the position for the lowest order bit of the parameter data. When the parameter data spans one or more byte boundaries, then the 'Start Position' consists of two numerical values; each declaring the position for the lowest order bit of the parameter data in the lowest and highest order bytes. For numerical start position notation, the integer value identifies the byte and the decimal value identifies the bit position (1 to 8, with 1 as the lowest order bit) within the byte. When the start position value does not include a decimal value, then the parameter data consumes the entire byte.

The 'Start Position' notation has several formats to accommodate the different parameter data length types and the different parameter placement needs. For the purposes of parameter placement discussion, parameter data length is classified as fractional byte length (2 bits, 4 bits, 10 bits, etc.), integer byte length (1 byte, 2 byte, etc.), and variable byte length. Each of these parameter length classifications have different requirements when it comes to specifying the position data field position of the data. This section explains the 'Start Position' notation according to each of the parameter data length classifications.

5.4.6 Start Position Notation for Fractional Byte Length Parameters

Fractional byte length parameters are parameters with a data length that is not an integer number of bytes, e.g., 2 bits, 5 bits, 10 bits, etc. The information in Table 5 presents the 'Start Position' notations used with fractional byte length parameters and explains the respective parameter placement. Figure 6 through Figure 10 show examples of these 'Start Position' notations and illustrate the parameter placement.

The following guidelines explain how to determine data placement from the 'Start Position' and 'Length' attributes for a parameter with Fractional Byte Length data.

1. In the Start Position notation, the number before the decimal point identifies the byte and the number after the decimal point identifies the bit position within that byte.

2. If the data length is less than 1 byte and all data bits are within the same byte, then the Start Position consists of one numerical value.

3. If the data length is larger than 1 byte or the data spans a byte boundary, then the Start Position consists of two numerical values separated by a comma or dash. The number before the comma or dash is the first position designation and the number after the comma or dash is the second position designation.

4. If a position designation in the Start Position does not have a decimal value, then the start bit is at bit 1 (one) in that byte. For example, a position designation of '2' is equivalent to the position designation '2.1'. This abbreviated style is only used when the data occupies the whole byte. In Table 5, a designation of "R" is equivalent to the designation "R.1", and a designation of "S" is equivalent to the designation "S.1". This is illustrated in Figure 8 through Figure 10. In Figure 8, the second position designation is '2', so the lowest order data bit placed into byte 2 will be positioned at bit 1.

5. For fractional byte length data, the least significant data bit is always positioned at the first position designation, and each next higher order data bit is placed into the next higher order data field bit position. In Table 5, "R.x" represents the first position designation, so the least significant bit of the data is placed at bit 'x' of byte 'R', the next higher order bit of the data is placed at bit 'x+1' of byte 'R', etc. This is illustrated in Figure 6 through Figure 10.

6. When higher order data bit placement reaches a byte boundary and the next higher data field byte is an intermediate byte between the bytes specified in the first and second position designations, then the next higher order data bit is placed at bit 1 of the next higher order data field byte and additional higher order data bits are placed in next higher order fashion from that point. This is illustrated in Figure 10. In Figure 10, the Start Position notation identifies byte 6 in the first position designation and byte 8 in the second position designation, so byte 7 is an intermediate byte. When bit placement reaches byte 7, the next higher order data bit (bit 'b9'), is place at bit 1 of byte 7 and the next higher order data bits are placed into byte 7 in next higher order fashion from that point.

7. When higher order data bit placement reaches a byte boundary and the next higher data field byte is the byte identified in the second position designation in the Start Position, then the number after the decimal in the second position designation indicates the bit position in that byte where the next higher order data bit is placed in the byte and any remaining higher order data bits are to be placed in next higher order fashion from that point. In Table 5, "S.w" represents the second position designation, so when data bit placement reaches byte 'S' of the data field, the next higher order bit of the data is placed at bit 'w' of byte 'S', the next higher order bit of data after that is place at bit 'w+1' of byte 'S', etc. This is illustrated in Figure 7, Figure 9 and Figure 10. In Figure 10, the second position designation is '8.6'. When bit placement gets to byte 8, then next higher order data bit, bit 'b17', is placed at bit 6 of byte 8 and the last two bits, 'b18' and 'b19', are placed at bit 7 and bit 8 of byte 8, respectively.

Table 5 - Start position notation for fractional byte length parameters

R.x	Y bits (Y less than 8)	Fixed position of the data within a byte boundary for a fractional byte length parameter with less than 8 bits. The parameter occupies 'Y' number of bits of byte 'R' with the least significant bit of the parameter data at bit 'x' in byte 'R' and the most significant bit of the parameter data is at bit ('x' + ('Y'-1)) in byte 'R'.	***Figure 6***
R.x-S.w	Y bits (Y less than 8)	Fixed position of the data across a byte boundary for a fractional byte length parameter with less than 8 bits. The parameter occupies the most significant bits of byte 'R' from bit 'x' to bit 8 and the remaining number of data bits start from bit 'w' in byte 'S'. The least significant bit of the parameter data is placed at bit 'x' in byte 'R'.	***Figure 7***
R.x-S	Y bits (Y greater than 8)	Fixed position of a fractional byte length parameter with more than 8 bits where the data crosses a byte boundary and stops on a whole byte. The parameter occupies the most significant bits of byte 'R' from bit 'x' to bit 8 plus all whole bytes up to 'S'.	***Figure 8***
R-S.w	Y bits (Y greater than 8)	Fixed position of a fractional byte length parameter with more than 8 bits where the data crosses a byte boundary and starts on a whole byte. The parameter occupies all whole bytes from 'R' up to 'S' and the remaining modulo-8 number of bits starting from bit 'w' in byte 'S'.	***Figure 9***, Figure 10**

PGN Position Notation *Start Position 5.4* *Length 5 bits* *(ex. PGN 0, SPN 3350)*

Data Definition

b5	b4	b3	b2	b1
MSb				LSb

Placement

MSb	Byte 5						LSb
8	7	6	5	4	3	2	1
b5	b4	b3	b2	b1			
MSb				LSb			

Transmission Order

MSb	Byte 5						LSb
8	7	6	5	4	3	2	1
b5	b4	b3	b2	b1			
MSb				LSb			

Figure 6 - Fractional byte (less than 1 byte) within byte boundary

PGN Position Notation *Start Position 7.6-8.1* *Length 5 bits* *(ex. PGN 64943, SPN 3287)*

Data Definition

b5	b4	b3	b2	b1
MSb				LSb

Placement

MSb	Byte 8						LSb	MSb	Byte 7						LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
						b5	b4	b3	b2	b1					
						MSb				LSb					

Transmission Order

MSb	Byte 7						LSb	MSb	Byte 8						LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
b3	b2	b1												b5	b4
		LSb												MSb	

Figure 7 - Fractional byte (less than 1 byte) across byte boundary

PGN Position Notation *Start Position 1.7-2* *Length 10 bits* *(ex. PGN 64982, SPN 2660)*

Data Definition

b10	b9	b8	b7	b6	b5	b4	b3	b2	b1
MSb									LSb

Placement

MSb	Byte 2						LSb	MSb	Byte 1						LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
b10	b9	b8	b7	b6	b5	b4	b3	b2	b1						
MSb									LSb						

Transmission Order

MSb	Byte 1						LSb	MSb	Byte 2						LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
b2	b1							b10	b9	b8	b7	b6	b5	b4	b3
	LSb							MSb							

Figure 8 - Fractional byte (larger than 1 byte) ending on byte boundary

PGN Position Notation *Start Position* *6-7.1* *Length* *12 bits* *(ex. PGN 64955, SPN 3169)*

Data Definition

b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1
MSb											LSb

Placement

MSb	Byte 7						LSb	MSb	Byte 6						LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
				b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1
				MSb											LSb

Transmission Order

MSb	Byte 6						LSb	MSb	Byte 7						LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
b8	b7	b6	b5	b4	b3	b2	b1					b12	b11	b10	b9
							LSb					MSb			

Figure 9 - Fractional byte (larger than 1 byte) starting on byte boundary

PGN Position Notation Start Position 6-8.6 Length 19 bits (ex. PGN 49920, SPN 3036)

Data Definition

b19	b18	b17	b16	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1
MSb																		LSb

Placement

MSb	Byte 8						LSb	MSb	Byte 7						LSb	MSb	Byte 6						LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
b19	b18	b17						b16	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1
MSb																							LSb

Transmission Order

MSb	Byte 6						LSb	MSb	Byte 7						LSb	MSb	Byte 8						LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
b8	b7	b6	b5	b4	b3	b2	b1	b16	b15	b14	b13	b12	b11	b10	b9	b19	b18	b17					
							LSb									MSb							

**** Note**: This placement method is used in the various Diagnostics Messages in J1939-73 when passing the SPN number in the data field. The use of this fractional byte placement model should be limited to passing the SPN number in the DMx messages.

Figure 10 - Fractional byte (larger than 1 byte) starting on byte boundary

5.4.7 Start Position Notation for Integer Byte Length Parameters

The information in Table 6 and Table 7 presents 'Start Position' notations used with parameters with integer byte length. Examples of these 'Start Position' notations are illustrated in Figure 11 through Figure 14. Integer byte length parameters are parameters with a fixed data length in whole bytes, e.g., 1 byte, 2 bytes, 4 bytes, 16 bits, etc. The placement of the data bytes for integer byte length parameters larger than 1 byte depends upon whether the parameter is non-alphanumeric (e.g., scaled data or state list) or alphanumeric. As noted in 5.1.2 Message Format, the placement or ordering of the data bytes for multiple byte parameters differs between alphanumeric and all other data types. The parameter definition must be referenced to determine if the parameter is non-alphanumeric or alphanumeric data.

Table 6 - Start position notation for integer byte length parameters (non-alphanumeric)

Start Position	Length	Interpretation	Example Illustration
R	1 byte or 8 bits	Fixed position of a one byte data parameter within a whole byte. The parameter occupies the entire byte 'R'.	Figure 11
R-S R, S R	Y bytes or 16 bits	Fixed position of a multiple byte data. Since this parameter is non-alphanumeric data (based upon parameter definition), the data is positioned so the Least Significant Byte is transmitted first, per 5.1.2. The parameter occupies 'Y' number of bytes from byte 'R' through byte 'S'.	Figure 12, Figure 13

Table 7 - Start position notation for integer byte length parameters (alphanumeric)

Start Position	Length	Interpretation	Example Illustration
R	1 byte or 8 bits	Fixed position of a one byte data parameter within a whole byte. The parameter occupies the entire byte 'R'.	Figure 11
R-S	Y bytes	Fixed position of a multiple byte data. Since this parameter is alphanumeric data (based upon parameter definition), the data is positioned so the Most Significant Byte is transmitted first, per 5.1.2. The parameter occupies 'Y' number of bytes from byte 'R' through byte 'S'.	Figure 14
'n'	Y bytes	Field position of a multiple bye data. Since this parameter is alphanumeric data (based upon parameter definition), the data is positioned so the Most Significant Byte is transmitted first, per 5.1.2. The parameter occupies 'Y' number of bytes from the point that the field starts (i.e. in the first byte following the previous field). Example (PGN 64912, SPN 3560 and 3561) Start Position Length a 2 bytes (SPN 3560) b 2 bytes (SPN 3561) *The structure of these two parameters repeats in the data field. The 2 bytes of data for SPN 3561 (field 'b') is placed in the 2 bytes following the last byte of SPN 3560 (field 'a').*	

PGN Position Notation *Start Position* *Length*
3 *8 bits* *(ex. PGN 61451, SPN 2928)*
3 *1 byte* *(ex. PGN 256, SPN 525)*

Data Definition

b8	b7	b6	b5	b4	b3	b2	b1
MSb							LSb

Transmission Order

MSb			Byte 3				LSb
8	7	6	5	4	3	2	1
b8	b7	b6	b5	b4	b3	b2	b1
MSb							LSb

Figure 11 - Single byte data placement (non-alphanumeric and alphanumeric)

PGN Position Notation *Start Position* *Length*
3 *2 bytes* *(ex. PGN 61454, SPN 3217)*
3-4 *2 bytes* *(ex. PGN 61450, SPN 132)*
3,4 *2 bytes* *(ex. PGN 64957, SPN 3085)*

Data Definition

b16	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1
MSb															LSb

Transmission Order

MSb			Byte 3				LSb	MSb			Byte 4				LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
b8	b7	b6	b5	b4	b3	b2	b1	b16	b15	b14	b13	b12	b11	b10	b9
							LSb	MSb							

Figure 12 - Multiple byte placement (non-alphanumeric data)

PGN Position Notation

Start Position	*Length*	
1-4	*4 bytes*	*(ex. PGN 65199, SPN 1039)*
01-04	*4 bytes*	*(ex. PGN 65211, SPN 994)*

Data Definition

b32	b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1
MSb																															LSb

Transmission Order

MSb	Byte 1						LSb	MSb	Byte 2						LSb	MSb	Byte 3						LSb	MSb	Byte 4						LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
b8	b7	b6	b5	b4	b3	b2	b1	b16	b15	b14	b13	b12	b11	b10	b9	b24	b23	b22	b21	b20	b19	b18	b17	b32	b31	b30	b29	b28	b27	b26	b25
							LSb																	MSb							

Figure 13 - Multiple byte placement (non-alphanumeric data)

PGN Position Notation

Start Position	*Length*	
5-6	*2 bytes*	*(ex. PGN 61445, SPN 162 - ASCII)*

Data Definition

ASCII Character 1								ASCII Character 2							
c1b8	c1b7	c1b6	c1b5	c1b4	c1b3	c1b2	c1b1	c2b8	c2b7	c2b6	c2b5	c2b4	c2b3	c2b2	c2b1
MSb							LSb	MSb							LSb

Transmission Order

MSb	Byte 5						LSb	MSb	Byte 6						LSb
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
c1b8	c1b7	c1b6	c1b5	c1b4	c1b3	c1b2	c1b1	c2b8	c2b7	c2b6	c2b5	c2b4	c2b3	c2b2	c2b1
MSb							LSb	MSb							LSb

Figure 14 - Multiple byte placement (alphanumeric data)

5.4.8 Start Position Notation for Variable Length Parameters

The information in Table 8 present 'start position' notations used with variable length parameters. Alphanumeric or textual data parameters are the primary examples of variable byte length parameters. The 'starting position' is typically denoted using letters and equations to explain the position of the content within the message data field.

Table 8 - Start position notation for variable length parameters

Start Position	Length	Interpretation
R-'N'	Variable – up to Y characters ("*" delimited)	The parameter starts at byte 'R' and continues through some variable number of bytes where the end is denoted by an asterisk character in the data stream. The length of the parameter does not include the "*" delimiter. Example (PGN 65242, SPN 234) Start Position Length 2-N Variable - up to 200 characters ("*" delimited) *Parameter starts at byte 2 and continues up to the asterisk character (at byte 203 at the highest).*
R to 'N' 'N'+1 to 'P'	Variable – up to Y characters Variable – up to Y characters	Equations define the starting position of two consecutive variable length parameters. The first parameter starts at byte 'R' and continues through some variable number of bytes. And the second parameter starts at the first byte last character of the first parameter and continues through some variable number of bytes. Example (PGN 64958, SPNs 3074 and 3075) Start Position Length 2 1 byte (Number of bytes in SPN 3074) 3 1 byte (Number of bytes in SPN 3075) 5 to A Variable - up to 100 characters (SPN 3074) A+1 to B Variable - up to 100 characters (SPN 3075) *First variable length parameter starts at byte 5 and continues through the number of bytes specified in Byte 2. The second variable length parameter starts at first byte after SPN 3074 data and continues through the number of bytes specified in Byte 3.*
'n'	Variable – up to Y characters ("*" delimited)	Field position of a variable length data parameter. The parameter is the nth ordered field. The parameter occupies the first data byte following the previous parameter and continues some variable number of bytes where the end is denoted by an asterisk character in the data stream. The length of the parameter does not include the "*" delimiter. Example (PGN 64965, SPN 2903) Start Position Length c Variable - up to 200 characters ("*" delimited) *Parameter is the 3rd field and continues up to the asterisk delimiter character (201 bytes beyond start of 3rd field at the highest). The starting byte number depends upon the length of the data before this field.*

5.4.9 Unspecified Bits in the PGN Data Field Definition

Unspecified bits are the bits within the PGN data field byte length that are not assigned to a parameter or are not used by the data for the collection of parameters (SPNs) in the PGN. In the J1939 PGN definitions, the unspecified bits are typically not shown or explicitly identified in the PGN definition.

The 'Data Length' property of the PGN definition specifies the minimum and maximum byte length of the data field for the PGN. The transmitted data field must be at least the minimum length specified by the 'Data Length' property for the PGN, and all unspecified bit within the transmitted data field must be filled with a value of one (1). This standard makes it possible to assign unspecified bits to parameters at some future time.

5.4.9.1 Unspecified Bits - Illustrated Example

An example of unspecified bits is provided in Figure 15 using an example PGN 12345. The top section of Figure 15 shows the PGN Data Length and PGN content definition for the PGN. There are 36 Unspecified Bits in the PGN definition in this example. The unspecified bits are bit 5 to bit 8 of byte 2 (4 bits total) and all bits in byte 4 through byte 8 (32 bits total).

The PGN definition indicates SPN_1 is a 1 byte parameter with a data start position at byte 1. Since SPN_1 occupies all the bits in byte 1, there are no unspecified bits in byte 1. Next, the PGN definition indicates SPN_2 is a 4 bit parameter with a starting position of '2.1' which means the data for SPN_2 occupies bit 1 to bit 4 of byte 2. The next parameter in the PGN definition has a starting position in byte 3, which means bit 5 through bit 8 of byte 2 are Unspecified Bits. The third parameter in the PGN definition indicates SPN_3 is a 2 byte parameter with a data start position of '3- 4'. Since SPN_3 occupies all the bits in bytes 3 and 4, there are no unspecified bits in byte 3 or byte 4. Finally, the PGN 'Data Length' property indicates the PGN has a message data field length of 8 bytes, but the PGN definition only lists parameter content through byte 4. All of the bits in byte 5 through byte 8 are Unspecified Bits. When transmitted, the message data field for this PGN must be 8 bytes in length, as specified by the PGN Data Length property. The 36 Unspecified Bits must be filled each with a one (1), and the other 28 bits for the data for SPNs SPN_1, SPN_2, and SPN_3 must be filled appropriately.

PGN 12345 **Example J1939 PGN Message**
Data Length: 8

Start Position	**Length**	**Parameter Name**	**SPN**
1	1 byte	Example Parameter 1	SPN_1
2.1	4 bits	Example Parameter 2	SPN_2
3-4	2 bytes	Example Parameter 3	SPN_3

MSb Byte 1 LSb								MSb Byte 2 LSb								MSb Byte 3 LSb								MSb Byte 4 LSb							
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
b8	b7	b6	b5	b4	b3	b2	b1	1	1	1	1	b4	b3	b2	b1	b8	b7	b6	b5	b4	b3	b2	b1	b16	b15	b14	b13	b12	b11	b10	b9
SPN_1								Unspecified Bits				SPN_2				SPN_3															

MSb Byte 5 LSb								MSb Byte 6 LSb								MSb Byte 7 LSb								MSb Byte 8 LSb							
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Unspecified Bits																															

Figure 15 - Unspecified bits example

6. NOTES

6.1 Revision Indicator

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

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

APPENDIX A

SLOTS

See J1939DA for current listing of SLOTS

APPENDIX B

SPNS

See J1939DA for current listing of SPNs

APPENDIX C

PGNS

See J1939DA for current listing of SPNS mapped to PGNs

APPENDIX D

SUPPORTING INFORMATION

See J1939DA for supporting information and figures.