SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J1939-71 SEP2013

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Superseding J1939-71 MAY2011

(R) Vehicle Application Layer

RATIONALE

This SAE Recommended Practice has been updated to reflect a change in the publishing of the SLOT, SPN, and PGN definition details formerly in Appendix A through Appendix C. This technical content is now published in the J1939DA digital annex and Appendix A through Appendix C now directs the reader to J1939DA for this information.

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

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. The data parameters (SPNs) and messages (PGNs) previously published within this document are now published in SAE J1939DA. The reference figures and reference information for the SPNs and PGNs associated with the SAE J1939-71 document are published in this document. The data parameters (SPNs) and messages (PGNs) associated with this document are applicable to most SAE J1939 applications.

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 Publications

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 724-776-4970 (outside USA), www.sae.org.

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

SAE J1922 Powertrain Control Interface for Electronic Controls Used in Medium- and Heavy-Duty Diesel On-Highway Vehicle Applications

SAE J1939DA Digital Annex of Serial Control and Communications Heavy Duty Vehicle Network Data

SAE J1939 Serial Control and Communications Heavy Duty Vehicle Network

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

2.1.2 ISO Publications

Available from ANSI, 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

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. Other parameters consisting of 2 or more data bytes shall be transmitted least significant byte first.

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.

	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	¡	¢	£	¤	¥	¦	§	¨	©	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	ð	ñ	ò	ó	ô	õ	ö	÷	ø	ù	ú	û	ü	ý	þ	ÿ

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 - TRANSMITTED 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 4 294 967 294 $FFxxxxxx_{16}$	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

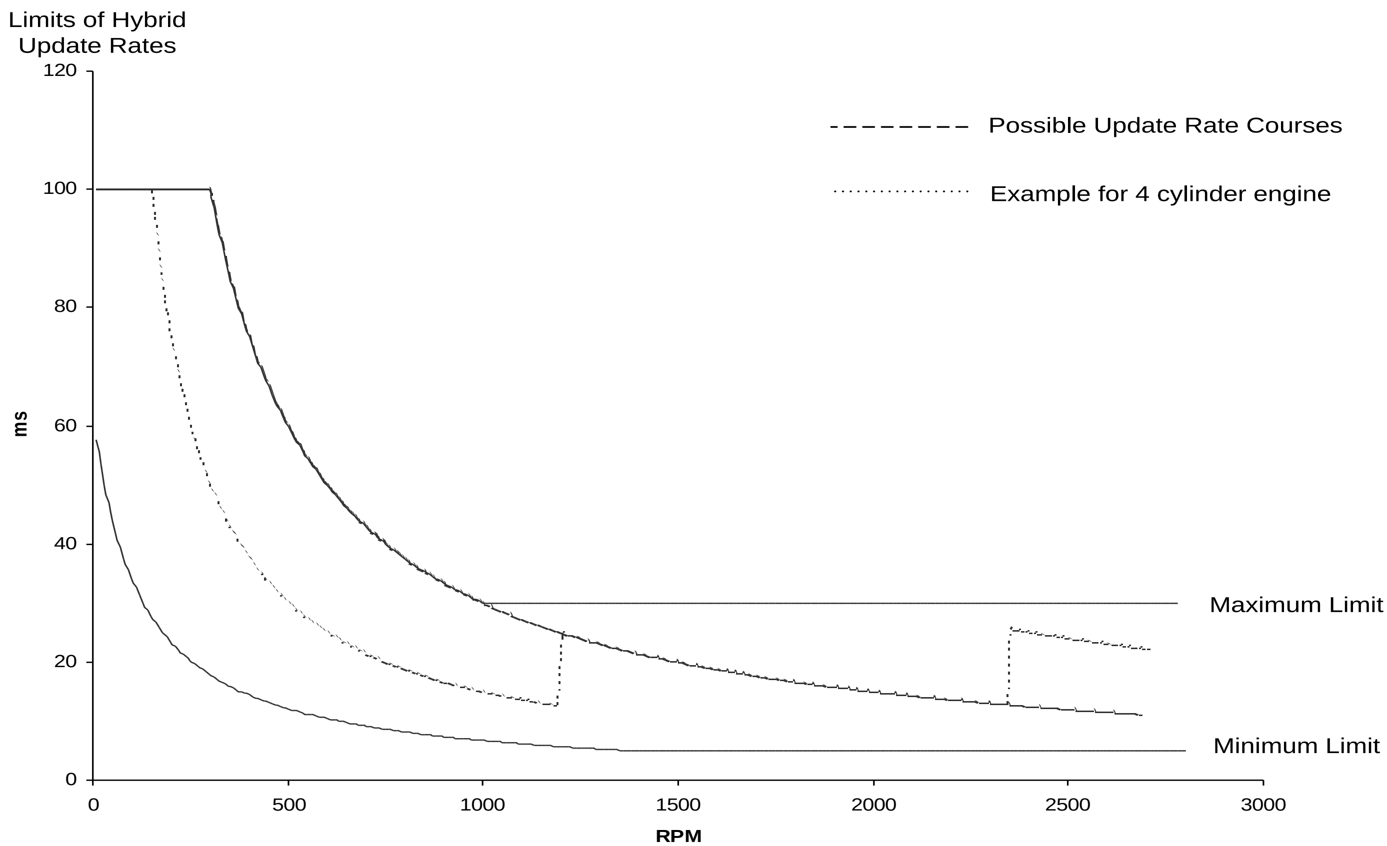


FIGURE 1 - LIMITS OF HYBRID UPDATE RATES

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.

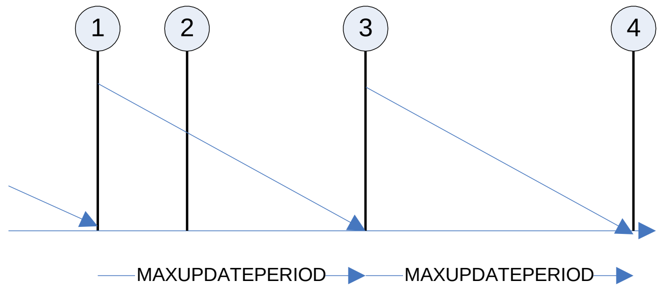


FIGURE 2 – ON-CHANGE IMPLEMENTATION OPTION 1

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.

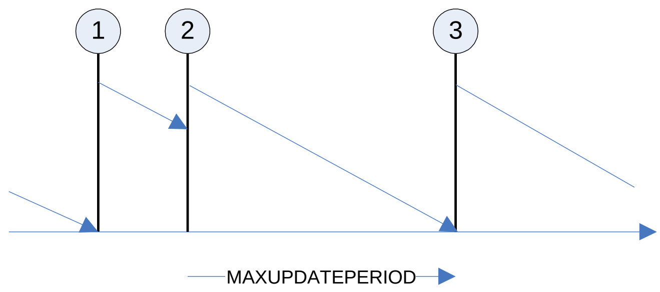


FIGURE 3 – ON-CHANGE IMPLEMENTATION OPTION 2

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 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 by used. While facing the engine from the 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. For a 12 cylinder "V" engine, the position furthest from the flywheel on the left bank will be identified as 1, followed by the position next closest to the flywheel on the left bank. 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).

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, 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).

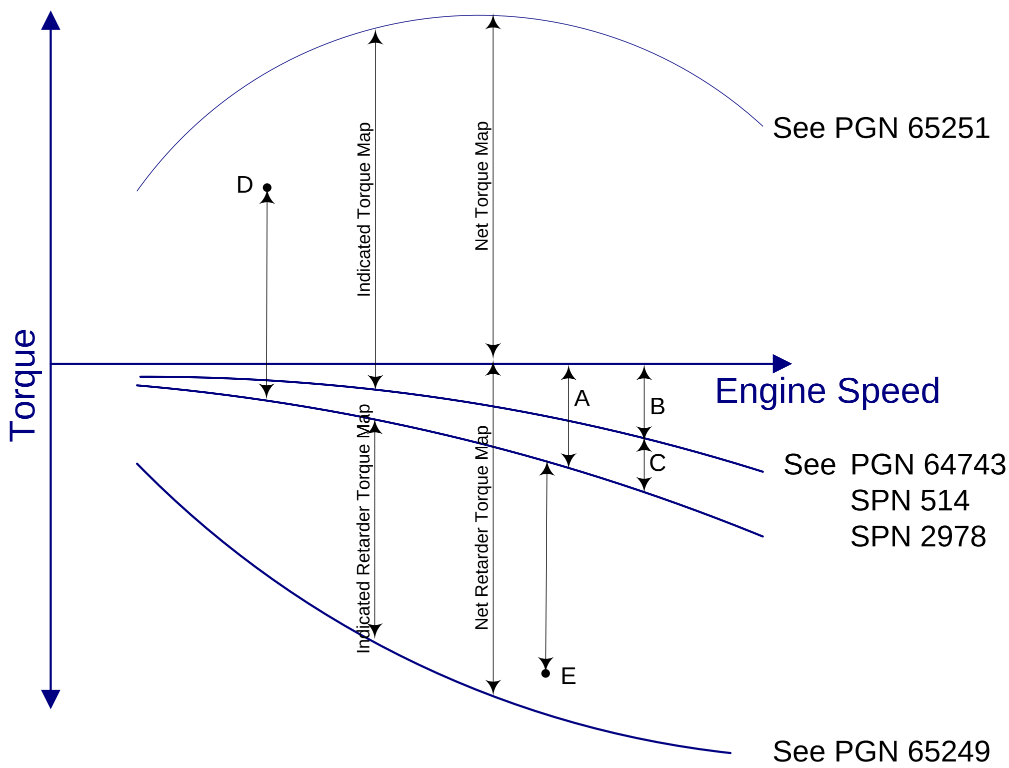


FIGURE 4 – TORQUE DEFINITIONS

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 parastic 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 support 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.)

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 configure 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 and 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 5 through Figure 9 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 7 through Figure 9. In Figure 7, 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 5 through Figure 9.

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 9. In Figure 9, 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 6, Figure 8 and Figure 9. In Figure 9, 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 5
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 6
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 7
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 8, Figure 9**

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 5 - 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 6 - 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 7 - 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 8 - 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 9 - 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 10 through Figure 13. 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 10
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 11, Figure 12

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 10
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 13
'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').*	

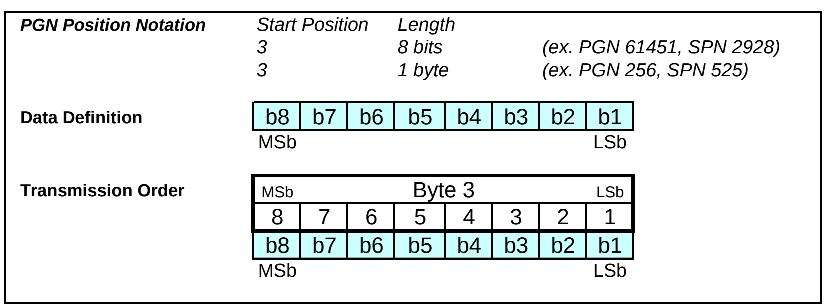


FIGURE 10 - SINGLE BYTE DATA PLACEMENT (NON-ALPHANUMERIC AND ALPHANUMERIC)

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 11 - 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 12 - 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 13 - 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 14 using an example PGN 12345. The top section of Figure 14 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 14 - UNSPECIFIED BITS EXAMPLE

6. NOTES

6.1 Marginal Indicia

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

D.1 SPN 16 – FUEL FILTER (SUCTION SIDE) DIFFERENTIAL PRESSURE

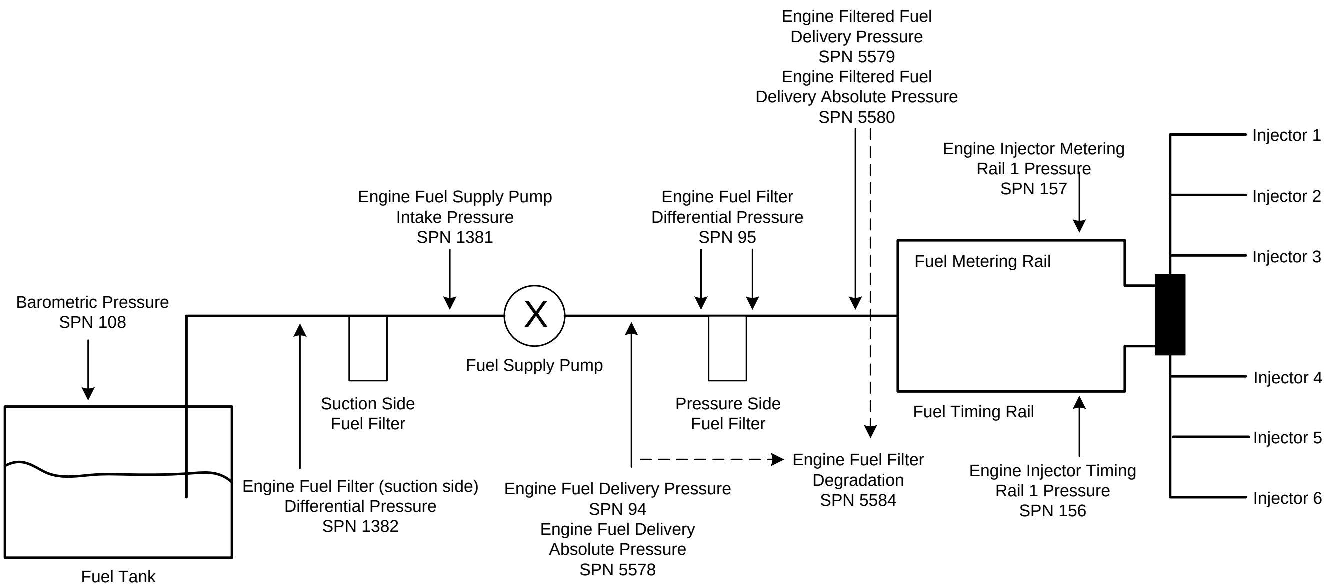


FIGURE SPN16_A - FUEL SYSTEM WITH RAILS

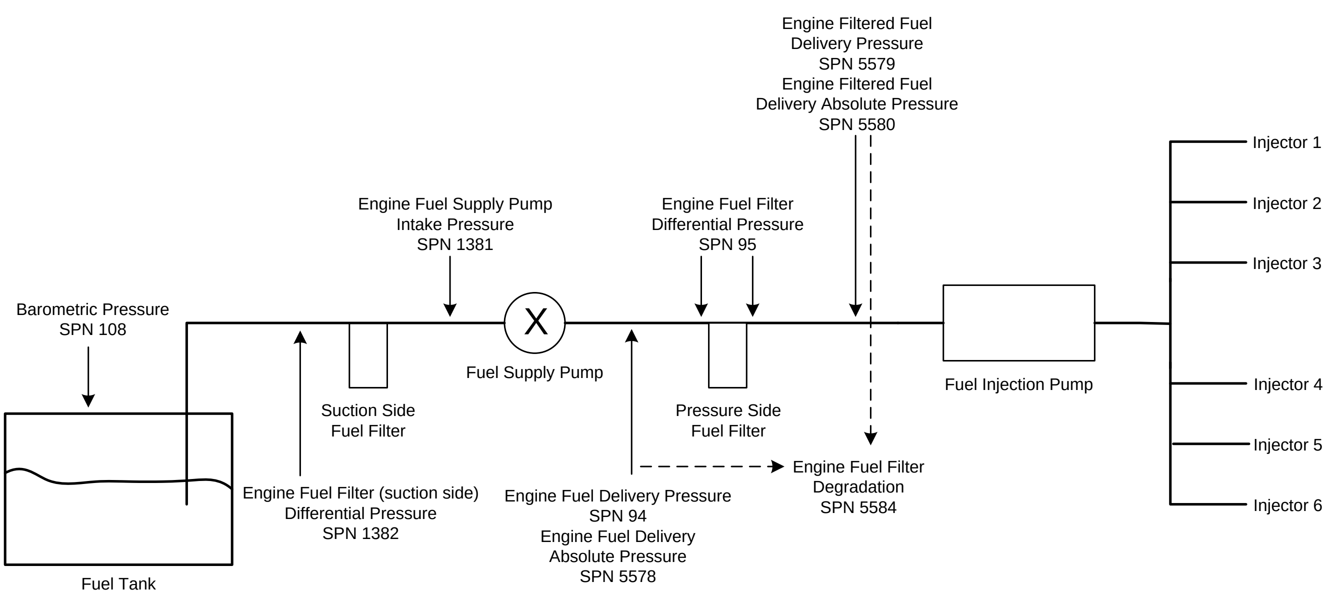


FIGURE SPN16_B - FUEL SYSTEM WITH PUMP

D.2 SPN 27 – EGR SYSTEM DIAGRAM

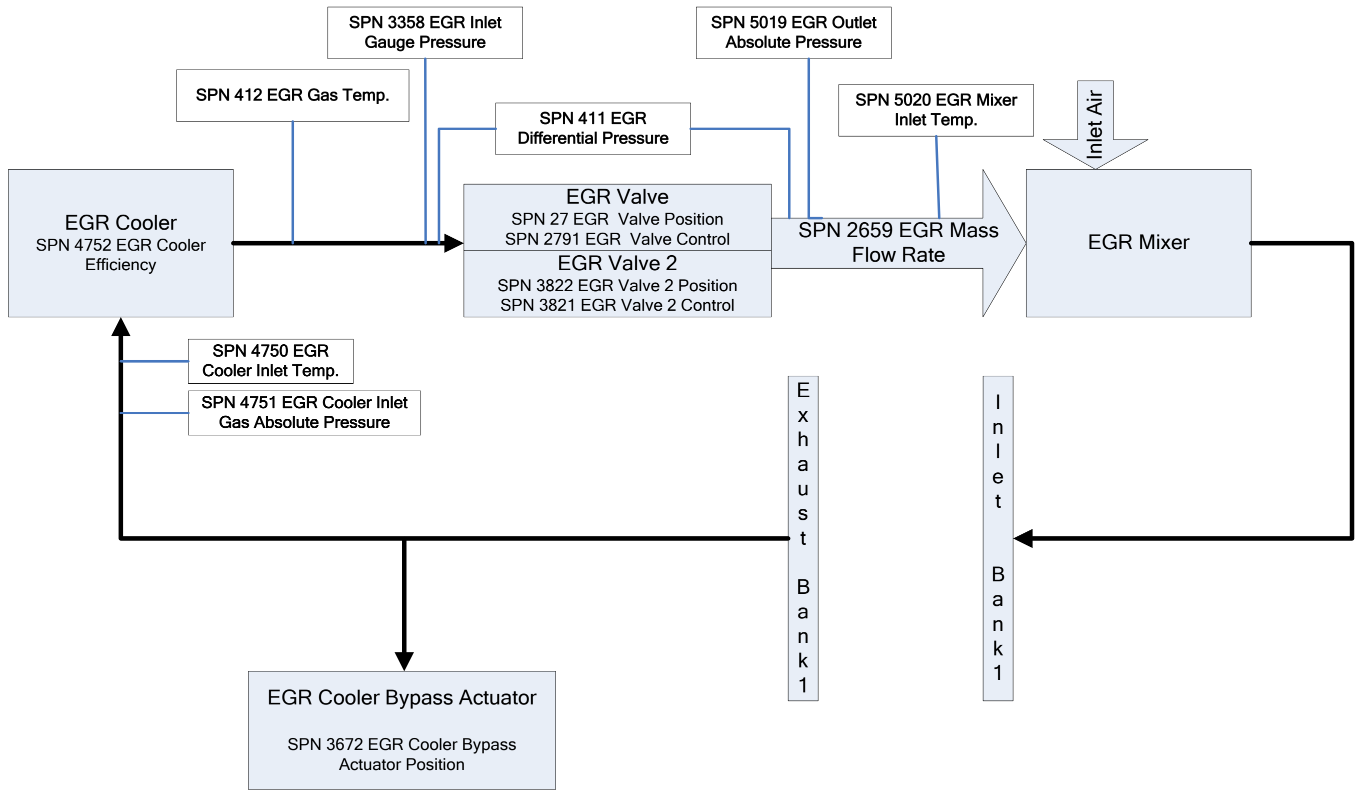


FIGURE SPN27_A – EGR SYSTEM

D.3 SPN 512 – DRIVER'S DEMAND ENGINE – PERCENT TORQUE

Figure SPN512_A and Figure SPN512_B show two typical torque calculations in an engine controller. On the left side of the figures there are single engine controller functions. The output torque signals of these functions are connected in the manner shown. The result is the actual engine percent torque which is realized by the engine.

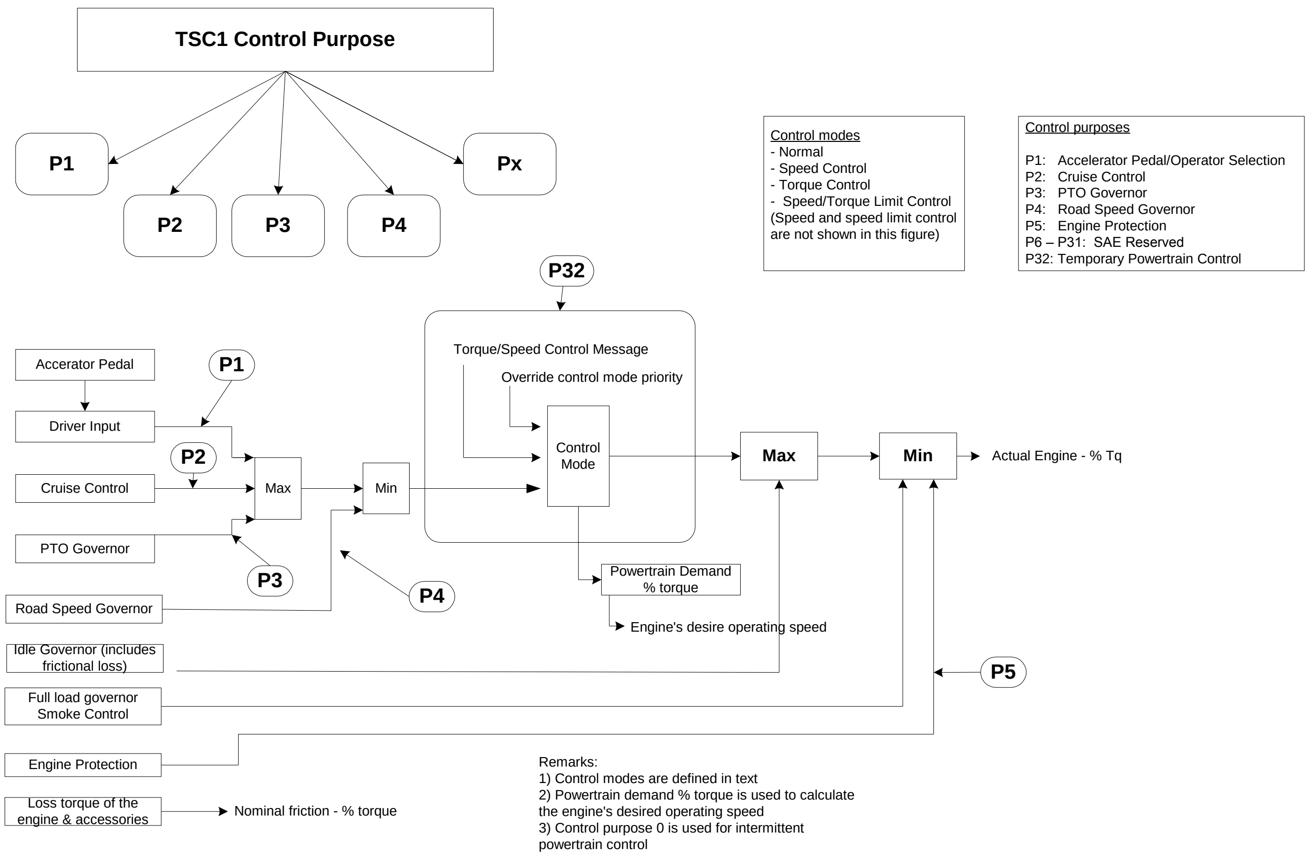


FIGURE SPN512_A - TORQUE COMMANDS AND CALCULATIONS WHEN A "MAXIMUM SELECTION FOR LOW IDLE" TECHNIQUE IS USED

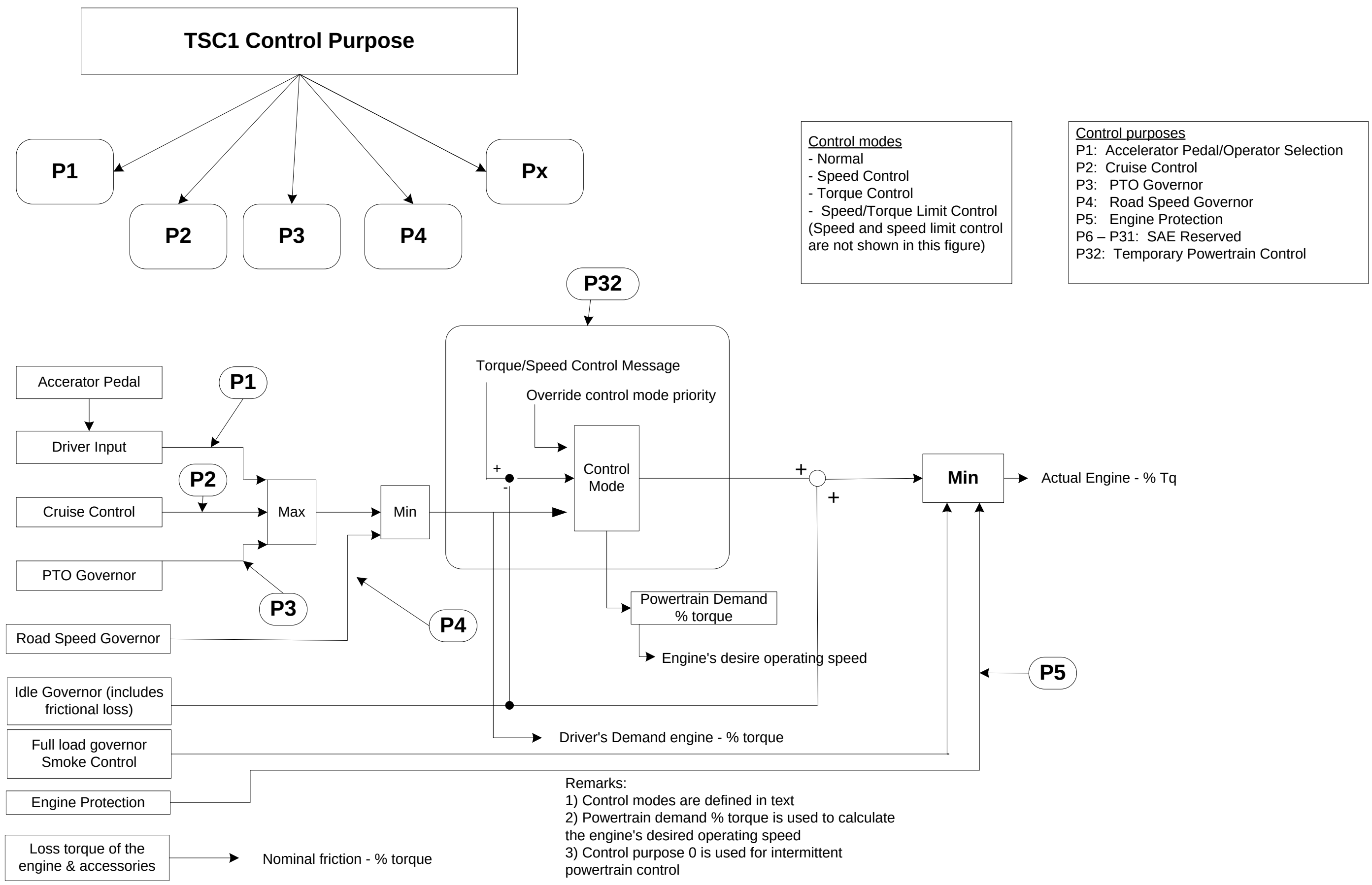


FIGURE SPN512_B - TORQUE COMMANDS AND CALCULATIONS WHEN A “SUMMATION WITH LOW IDLE” TECHNIQUE IS USED

On top of the figures, external torque commands (e.g., traction and transmission control) can control the engine. These commands can influence the engine torque by four control modes. Four engine internal signals are transmitted to the network:

a. Driver’s demand engine - percent torque

b. Actual engine - percent torque

c. Nominal friction - percent torque

d. Engine's desired operating speed

The difference between Figure SPN512_A and Figure SPN512_B is the connection of the idle governor output to the torque calculation. In Figure SPN512_A there is a maximum selection, while in Figure SPN512_B a summation is used. The summation method needs a subtraction point for each external command input because the starting point of an ASR or a shift operation should be the present actual engine - percent torque value. As the actual engine - percent torque signal contains the idle governor output and the external commands are compared with the driver’s demand engine - percent torque or the powertrain demand which don't contain the idle governor output, the external commands must be subtracted by the idle governor output to get the correct signals for comparison.

The advantage of the maximum selection (Figure SPN512_A) is that no other speed controller can work parallel to the idle governor. This allows for a better optimization of the different speed control loops. The advantage of the summation method (Figure SPN512_B) is that changes of the idle governor output influence the engine directly (no dead zones exist).

D.4 SPN 518 – ENGINE REQUESTED TORQUE/TORQUE LIMIT

When preparing to send a request to a retarder, the states of the Retarder Enable - Shift Assist Switch and the Retarder Enable - Brake Assist Switch must be checked by the requesting device to determine whether the request may be sent to the Retarder. Figure SPN518_A shows how those switches and other operator and network inputs are used to create the actual retarder operating point on a system-wide basis. The Retarder may or may not be the device reading the actual switches; even if it is, it will not accept or reject a request based on its knowledge of the switch states. Its function is to send the switch states via J1939 (in its ERC1 message) and it expects other J1939 nodes to honor those switch states by refraining from sending inappropriate commands.

Several elements affect the retarder besides the Requested Torque parameter in the TSC1 message. These elements are not looked at by the retarder itself, but are used by various other devices to determine if they may ask the retarder to be engaged. These are the Retarder Enable Shift Assist Switch, and the Retarder Enable Brake Assist Switch. The relationship between those switches and the retarder (as well as that between the operator and retarder) is described in Figure SPN518_A.

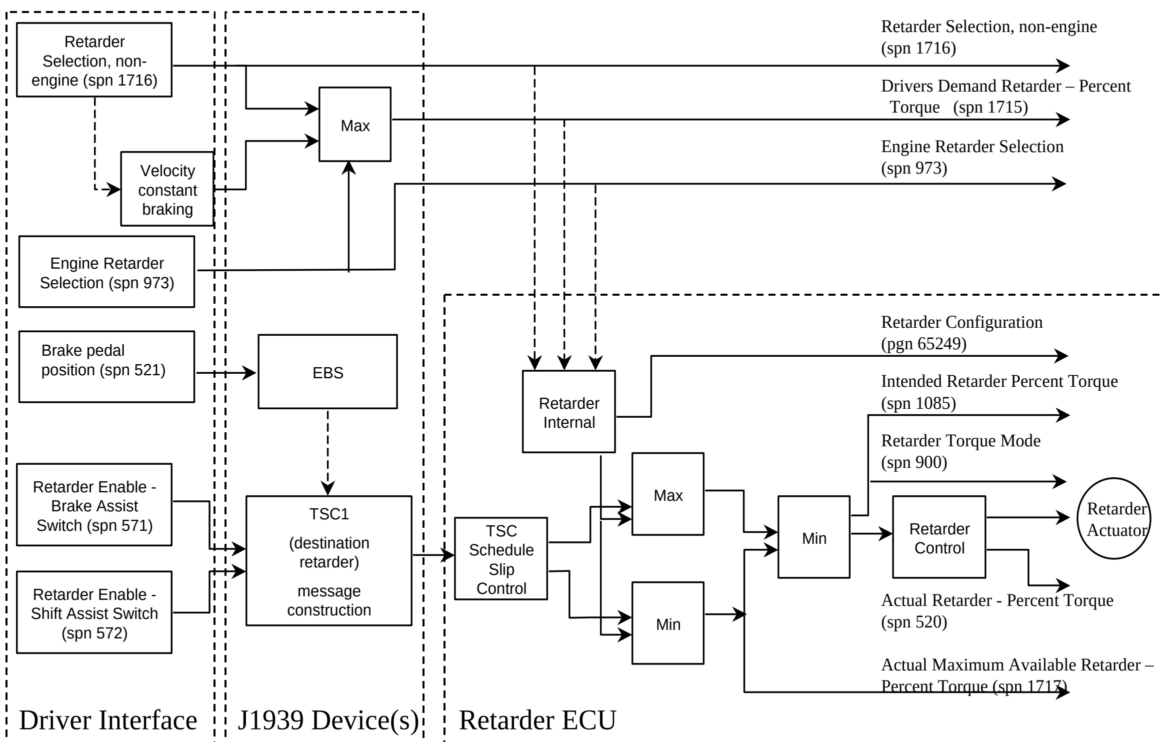


FIGURE SPN518_A - RELATIONSHIP BETWEEN OPERATOR/SWITCH INPUTS AND RETARDERS

Tables SPN518_A and SPN518_B identify many use cases. Each row is the summary of one or more uses. One of the primary communications provided by these tables is that the retarder can be activated by the J1939 TSC1 message, although the operator input is “off.”

TABLE SPN518_A - PRIMARY RETARDER – BEFORE TRANSMISSION
(COMPRESSION RELEASE ENGINE RETARDER)

Operator Inputs				Outputs	
J1939 Inputs[1] (TSC1)	**Cruise Control[2]**	**Accel Pedal[3]**	**Torque Request Via "Retarder Selection, Engine"[4]**	**May Retarder Provide Brake Torque?**	**Retarder Torque Mode (base 2)**
T	Any	Any	Any	No	0000
R	Any	Any	Any	Yes	> 0001
NTR	Any	T	Any	No	0000
NTR	R	ZR	R	Yes	> 0001
NTR	R	ZR	ZR	Yes	0010
NTR	NTR	ZR	R[5]	Yes[5]	0001
NTR	NTR	ZR	ZR	No	0000
ZR	Any	Any	Any	No	0000

Key:

T = request positive Torque

R = request Retarder torque

NTR = No Torque Request

ZR = Zero torque Requested by retarder

Any = This value has no bearing whether or not the Retarder is available. The retarder will NOT be available because some other entity is requesting positive torque.

Footnotes:

1. Note that the TSC1 inputs will override Operator Torque Selection. The J1939 devices that generate the TSC1 messages will assure that the Retarder Enable Brake Assist Switch and Retarder Enable Shift Assist Switch are enabled as appropriate before commanding the Retarder to engage. See parameters SPN 571 and 572 for descriptions of these switches. Also, for the purposes of this table, it is assumed that if the TSC1, Destination Retarder message is requesting Retarder Torque, no other TSC1, Destination Engine messages are requesting engine fueling. That arbitration is beyond the scope of this section.

2. This refers to the torque requested by the cruise control, and does not refer to the cruise switches. Cruise control is defined to be on and engaged in this column. The cruise control should not request retarder torque unless the Retarder Enable - Brake Assist Switch is enabled.

3. The Accelerator Pedal is inherently incapable of requesting negative torque. It may have no particular torque demands, or it may request some engine fueling, which prevents the retarder from engaging. Consequently, the chart is complete even though no rows exist for the AP to request retarder torque.

4. The Operator Torque Request is incapable of requesting positive torque. The table is complete without the Operator Torque Request asking for positive Engine Torque

5. This description assumes no other switch (such as brake pedal depressed) is needed in order for the operator torque request to initiate retarder braking. Other implementation specific rules would apply if such a catalyst were needed.

Table SPN518_B shows the relationship between various inputs and an after engine retarder.

The biggest difference between this type of retarder and an engine brake is that the exhaust brake may be engaged while the engine is still being fueled. Also, if cruise control is communicating with the retarder, it would do so using the TSC1 message.

Consequently, columns for accelerator pedal input and cruise control input would only serve to confuse the issue of retarder availability in Table SPN518_B.

TABLE SPN518_B - PRIMARY RETARDER – AFTER ENGINE (EXHAUST BRAKE, HYDRAULIC RETARDER)

Operator Inputs		**Outputs**	
J1939 Inputs[1] (TSC1)	**Torque Request Via operator torque request[2]**	**May Retarder Provide Brake Torque?**	**Retarder Torque Mode (base 2)**
R	R	Yes	> 0001
R	ZR	Yes	> 0001
NTR	R[3]	Yes[3]	0001
NTR	ZR	No	0000
ZR	Any	No	0000

Key:

R = request Retarder torque - some amount of braking torque is requested of the retarder.

ZR = Zero Retarder request - Zero percent torque is requested of the retarder

NTR = No retarder Torque Request - No request is being made of the retarder one way or another.

Any = This value has no bearing whether or not the retarder is available. In fact, because of what some other entity is requesting, the retarder will NOT be available.

Footnotes:

1. Note that the TSC1 inputs will override Operator Torque Selection. The J1939 devices that generate the TSC1 messages will assure that the Retarder Enable Brake Assist Switch and Retarder Enable Shift Assist Switch are enabled before commanding the Retarder to engage. Also, for the purposes of this table, it is assumed that if the TSC1, Destination Retarder message is requesting Retarder Torque, no other TSC1, Destination Engine messages are requesting engine fueling. That arbitration is beyond the scope of this section.

2. The Operator Torque Request is incapable of requesting positive torque. The table is complete without the Operator Torque Request asking for positive Engine Torque

3. This description assumes no other switch (such as brake pedal depressed) is needed in order for the operator torque request to initiate retarder braking. Other implementation specific rules would apply if such a requirement were needed.

D.5 SPN 519 – DESIRED OPERATING SPEED ASYMMETRY ADJUSTMENT

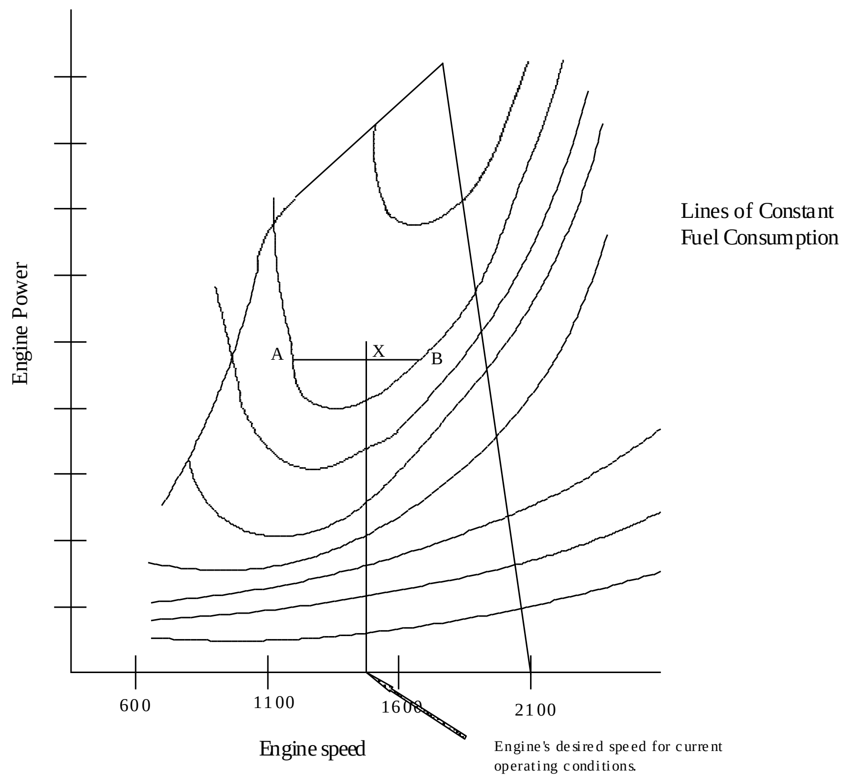


FIGURE SPN519_A - DESIRED OPERATING SPEED ASYMMETRY ADJUSTMENT

D.6 SPN 527 – CRUISE CONTROL STATES

TABLE SPN527_A - CRUISE CONTROL STATES

Bit States	Cruise Control State
000	Off/Disabled
001	Hold
010	Accelerate
011	Decelerate/Coast
100	Resume
101	Set
110	Accelerator override
111	Not available

State Descriptions:

000b Off/Disabled - Used to indicate that the cruise control device is off or on standby. Note that the cruise control system switch does not necessarily have to be off to be in this mode.

001b Hold - Used to indicate that the cruise control device is active and currently maintaining a captured operating speed.

010b Accelerate - Used to indicate that the cruise control device is in the process of ramping up the operating speed.

011b Decelerate - Used to indicate that the cruise control device is in the process of ramping down, or coasting, the operating speed.

100b Resume - Used to indicate that the cruise control device is in the process of resuming the operating speed to a previously captured value.

101b Set - Used to indicate that the cruise control device is establishing the current vehicle speed as the operating speed (captured value).

110b Accelerator Override - Used to indicate that the cruise control device is active but not currently maintaining the captured operating speed.

D.7 SPN 564 – DIFFERENTIAL LOCK POSITIONS

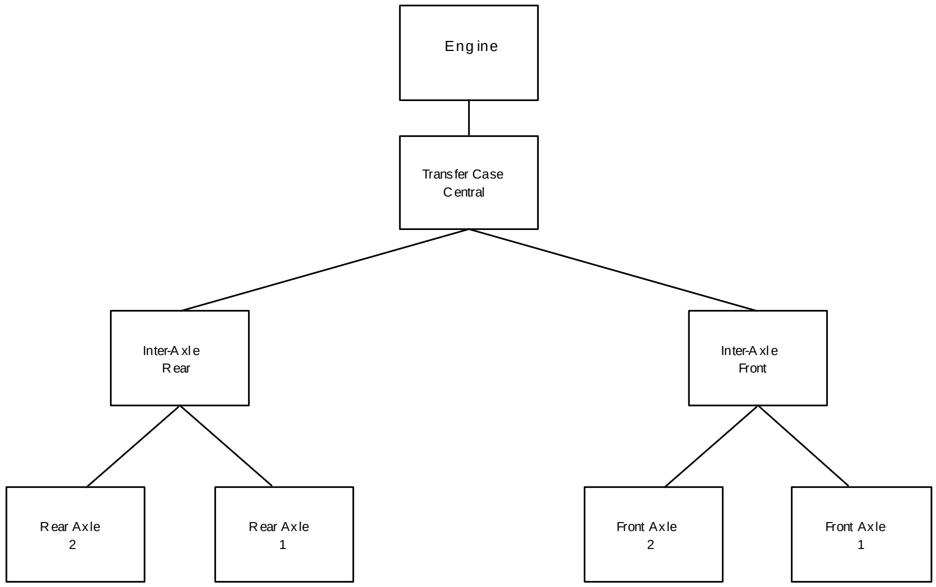


FIGURE SPN564_A - DIFFERENTIAL LOCK POSITIONS

D.8 SPN 574 – SHIFT IN PROCESS

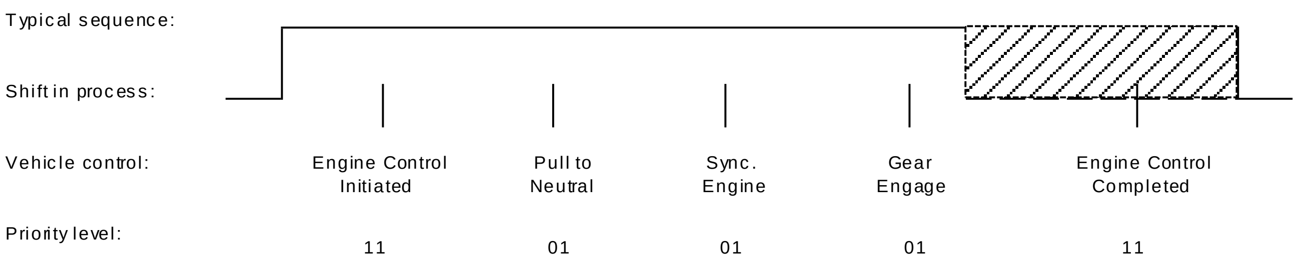


FIGURE SPN574_A - SHIFT IN PROCESS

D.9 SPN 590 – IDLE SHUTDOWN

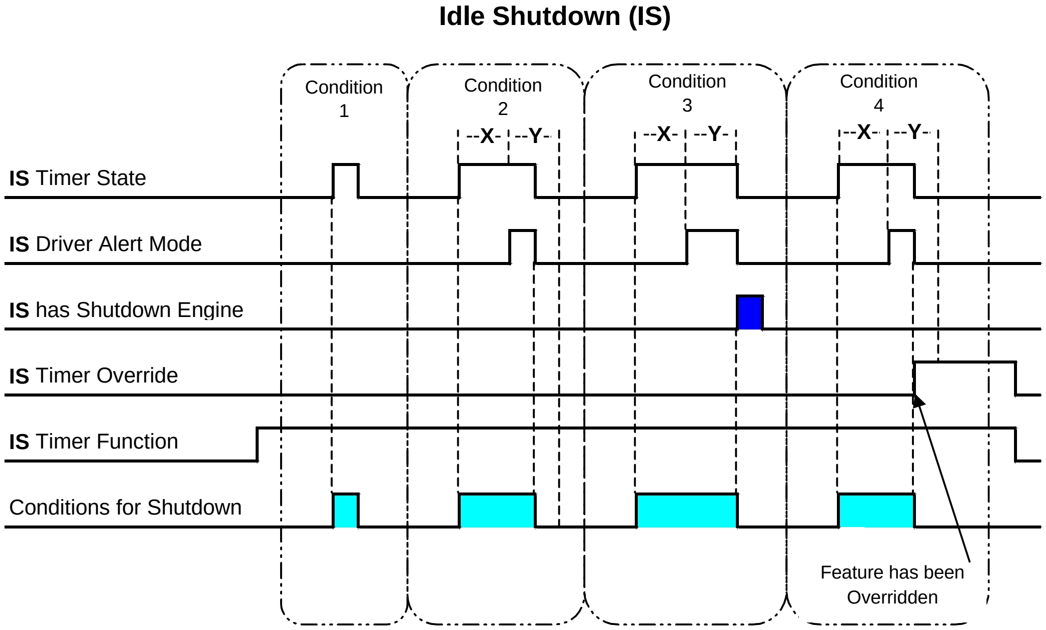


FIGURE SPN590_A - IDLE SHUTDOWN (IS)

Condition 1 - When the IS Timer Override is inactive, the IS Timer State will become inactive if the conditions for shutdown no longer exist before the “X” time interval has expired or IS Driver Alert Mode is activated.

Condition 2 - When the IS Timer Override is inactive, the IS Timer State will become inactive if the conditions for shutdown no longer exist before the IS Driver Alert Mode “Y” time interval has expired.

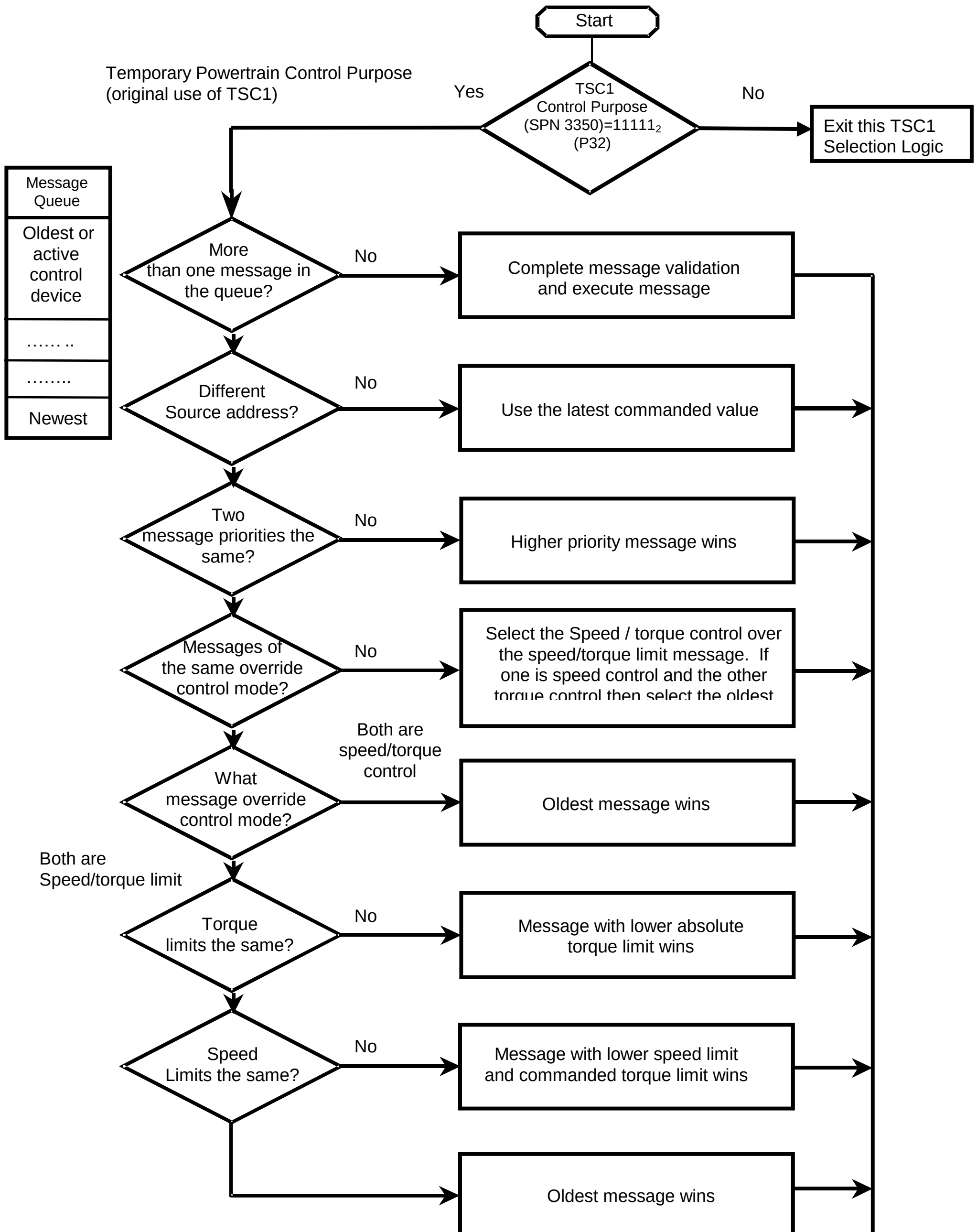
Condition 3 - When the IS Timer Override is inactive, then the IS has Shutdown Engine will be active after the “Y” time interval has expired.

Condition 4 - When the IS Timer Override is active during the “Y” time interval, then the IS feature shall be overridden and will no longer be available until the system has been re-initated.

NOTE: 0 State – Inactive, disabled in calibration, or conditions for idle shutdown do not exist.

1 State – Active, enabled in calibration, or conditions for idle shutdown do exist.

D.10 SPN 695 – ENGINE OVERRIDE CONTROL MODE



- Torque/speed override modes that have timed out are discarded before the priority selection process is executed.
- Messages are stored in the order received on the data link with the messages received first, referred to as the oldest, stored at the top of the priority selection queue.
- The focus in this diagram is on the message priority selection. Other message disposition issued are ignored in this context.

FIGURE SPN695_A - TORQUE/SPEED CONTROL PRIORITY SELECTION LOGIC

D.11 SPN 899 – ENGINE/RETARDER TORQUE MODES

TABLE SPN899_A - ENGINE/RETARDER TORQUE MODES

Bit States	Engine/Retarder Torque Mode
0000	Low idle governor/no request (default mode)
0001	Accelerator pedal/operator selection
0010	Cruise control
0011	PTO governor
0100	Road speed governor
0101	ASR control
0110	Transmission control
0111	ABS control
1000	Torque limiting
1001	High speed governor
1010	Braking system
1011	Remote accelerator
1100	Service procedure
1101	not defined
1110	Other
1111	Not available

State Descriptions:

0000b Low Idle Governor/No request (Default mode) - This mode is active if the accelerator pedal (not necessarily the torque output of the driver input, see Figure SPN512_A and Figure SPN512_B) is zero. This is the default mode. At low speed, the low idle governor may be active while at higher speed, it is zero.

0001b Accelerator Pedal - This mode is active if the accelerator pedal position is active (being followed). This mode is active for the retarder if it is turned on by the operator. Note that it may be disabled by the accelerator pedal or clutch switches (operator selection).

0010b Cruise Control - This mode is active if cruise control is active and greater than the accelerator pedal request.

0011b PTO Governor - This mode is active if the PTO governor is active.

0100b Road Speed Governing - Indicates that road speed governing is active and limiting torque.

0101b ASR Control - Indicates that the ASR command is active (Speed, Torque, or Speed/Torque Limit Control).

0110b Transmission Control - Indicates that the transmission command is active (Speed, Torque, or Speed/Torque Limit Control).

0111b ABS Control - Indicates that the ABS is controlling torque.

1000b Torque Limiting - This mode is active if the demanded or commanded engine torque is limited by internal logic due to full load, smoke and/or emissions control, engine protection and/or other factors. A reduced torque limit may be necessary for engine protection if the engine temperature is too high or a sensor fails (speed, timing, or boost pressure), as examples.

1001b High Speed Governor - This mode is active if the engine is controlled by the high speed governor due to normal operation.

1010b Brake System (Electronic) - This indicates that the brake pedal is controlling the torque. Note that this may include enabling of the retarder when the brake pedal is depressed (touched).

Note that if there is a request to the retarder but operating conditions do not allow braking, this situation will be reflected by the Percent Retarder Torque = 0 when broadcast.

1011b Remote Accelerator - This mode is active if the remote accelerator is controlling engine speed.

1100b Service procedure - This mode is active if the engine is operating in a specific service mode. For example, fuel injection may be disabled to allow a service procedure to crank the engine without fuel injection occurring.

1110b Other - Torque control by a type of device which is different than those defined in states 0000b to 1100b.

D.12 SPN 901 – RETARDER TYPE

TABLE SPN901_A - RETARDER TYPES

Bit States	Retarder Type
0000	Electric/Magnetic
0001	Hydraulic
0010	Cooled Friction
0011	Compression Release (Engine retarder)
0100	Exhaust
0101-1101	Not defined
1110	Other
1111	Not available

Electric/Magnetic Retarder - The electric/magnetic retarder functions by creating eddy currents generated in a conductive armature when placed in a variable magnetic field. Currently, electric retarders have a stator on which field coils are mounted. The rotors, mounted on both sides of the drive shaft, are ribbed for heat dissipation. In order to brake the vehicle, voltage is applied to the field coils which generate a magnetic field inducing eddy currents in the rotors as they pass through the field. Magnetic retarders use a permanent magnet to generate the eddy currents. Braking-torque is dependent on stator excitation and on the air gap between the rotor and the stator.

Hydraulic Retarder - The hydraulic retarder is a hydrodynamic coupling device. Two impellers which face each other, a rotor and a stator, are filled with oil. When the rotor, which is connected to the vehicle drive shaft rotates, it drives the oil in the direction of rotation. The mechanical energy produced by the rotor is converted into kinetic energy in the operating fluid. Hydrodynamic coupling between the rotor and stator converts the kinetic energy into heat and the rotor is retarded. This retardation effect is transmitted to the drive shaft and the vehicle is retarded.

Cooled Friction Brake - The cooled friction brake uses air or hydraulic fluid to dissipate heat from the friction surface of the service brake. By controlling the friction surface temperature, retarding torque is improved, along with a reduced rate of wear.

Compression Release Engine Retarder - The compression release engine retarder converts a power-producing diesel engine into a power-absorbing retarding mechanism by opening the exhaust valve near the top dead center in the engine compression cycle. No positive power will be produced, since the compressed air mass is released. The vehicle is retarded as it must provide energy to compress the cylinder air charge and subsequently to return the piston to the bottom position.

Exhaust Brake - The exhaust brake restricts the escape of the exhaust gas from the exhaust manifold. Each succeeding exhaust stroke builds up a back pressure in the manifold which exerts a retarding effect to the pistons during the exhaust stroke. The engine turns against this back pressure creating a braking effect to the vehicle.

Auxiliary Retarder - Fans, air conditioners, or any power-absorbing device in the vehicle can also function as retarders as they impose parasitic loading on the engine or vehicle.

D.13 SPN 911 – SERVICE COMPONENT IDENTIFICATION

TABLE SPN911_A - SERVICE COMPONENT IDENTIFICATION

	Identification	Component
	0	Service check for entire vehicle
	1	Brake lining; left front axle
	2	Brake lining; right front axle
	3	Brake lining; left rear axle
	4	Brake lining; right rear axle
	5	Clutch lining
	6-10	Not defined
	11	Brake lining; left rear axle #2
	12	Brake lining; right rear axle #2
	13	Brake lining; left rear axle #3
	14	Brake lining; right rear axle #3
	15	Brake lining: general
	16	Regulated general check for entire vehicle
	17	Brake system special check
	18	In-between check
	19	Check trip recorder
	20	Check exhaust gas
	21	Check vehicle speed limiter
	22-29	Not defined
	30	Engine coolant change
	31	Engine coolant filter change
	32	Engine oil—engine #1
	33	Engine oil—engine #2
	34	Not defined
	35	Steering oil
	36	Not defined
	37	Transmission oil—transmission #1
	38	Transmission oil—transmission #2
	39	Not defined
	40	Intermediate transmission oil
	41	Not defined
	42	Front axle oil
	43	Rear axle oil
	44-47	Not defined
	48	Tires
	49	Engine air filter
	50	Engine oil filter
	51	Engine Fuel Filter
	52-60	Not defined
	61	Tachograph
	62	Driver card #1
	63	Driver card #2
	64-70	Not defined
	71	Diesel Particulate Filter 1 Ash
	72	Diesel Particulate Filter 2 Ash
(R)	73	Aftertreatment Diesel Exhaust Fluid Doser Cooldown Interrupt Count
(R)	74	Aftertreatment Diesel Exhaust Fluid Doser Purge Interrupt Count
	75-239	Not defined
	240-249	Manufacturer specific
	250-251	Reserved
	252	Reset all components
	253	No action to be taken
	254	Error
	255	Component identification not available

D.14 SPN 988 – TRIP GROUP 1

TABLE SPN988_A - TRIP GROUP 1

	Parameter	SPN
	Trip distance	244
	Trip fuel	182
	High resolution trip distance	918
	Trip compression brake distance	990
	Trip service brake applications	993
	Trip maximum engine speed	1013
	Trip average engine speed	1014
	Trip drive average load factor	1015
	Trip average fuel rate	1029
	Trip average fuel rate (Gaseous)	1031
	Aftertreatment 1 Trip Fuel Used	3733
	Aftertreatment 1 Trip Active Regeneration Time	3734
	Aftertreatment 1 Trip Disabled Time	3735
	Aftertreatment 1 Trip Number of Active Regenerations	3736
	Aftertreatment 1 Trip Passive Regeneration Time	3737
	Aftertreatment 1 Trip Number of Passive Regenerations	3738
	Aftertreatment 1 Trip Number of Active Regeneration Inhibit Requests	3739
	Aftertreatment 1 Trip Number of Active Regeneration Manual Requests	3740
	Aftertreatment 2 Trip Fuel Used	3741
	Aftertreatment 2 Trip Active Regeneration Time	3742
	Aftertreatment 2 Trip Disabled Time	3743
	Aftertreatment 2 Trip Number of Active Regenerations	3744
	Aftertreatment 2 Trip Passive Regeneration Time	3745
	Aftertreatment 2 Trip Number of Passive Regenerations	3746
	Aftertreatment 2 Trip Number of Active Regeneration Inhibit Requests	3747
	Aftertreatment 2 Trip Number of Active Regeneration Manual Requests	3748
(R)	Aftertreatment Trip Diesel Exhaust Fluid	6563
	Parameter Group	**PGN**
	Aftertreatment 2 Trip Information	64888
	Aftertreatment 1 Trip Information	64889
	Trip time information #2	65200
	Trip time information #1	65204
	Trip shutdown information	65205
	Trip vehicle speed/cruise distance information	65206
	Trip fuel information (Gaseous)	65208
	Trip fuel information	65209
	Trip distance information	65210
	Trip fan information	65211

D.15 SPN 1014 – TRIP AVERAGE ENGINE SPEED

The equation is as follows:

$$Trip\_average\_engine\_speed = \frac{\sum_{i=0}^{N} RPM(i)}{N+1} \qquad \text{(Eq.SPN1014\_A)}$$

where:

RPM is the engine speed at sample i, N is the number of samples of engine speed and is proportional to the current trip elapsed time

D.16 SPN 1085 – INTENDED RETARDER PERCENT TORQUE

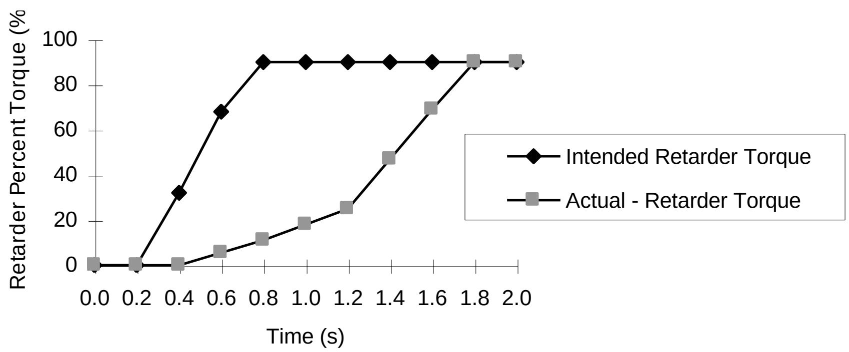


FIGURE SPN1085_A - INTENDED RETARDER PERCENT TORQUE

D.17 SPN 1107 – ENGINE PROTECTION SYSTEM TIMER STATE

Engine Protection System (EPS)

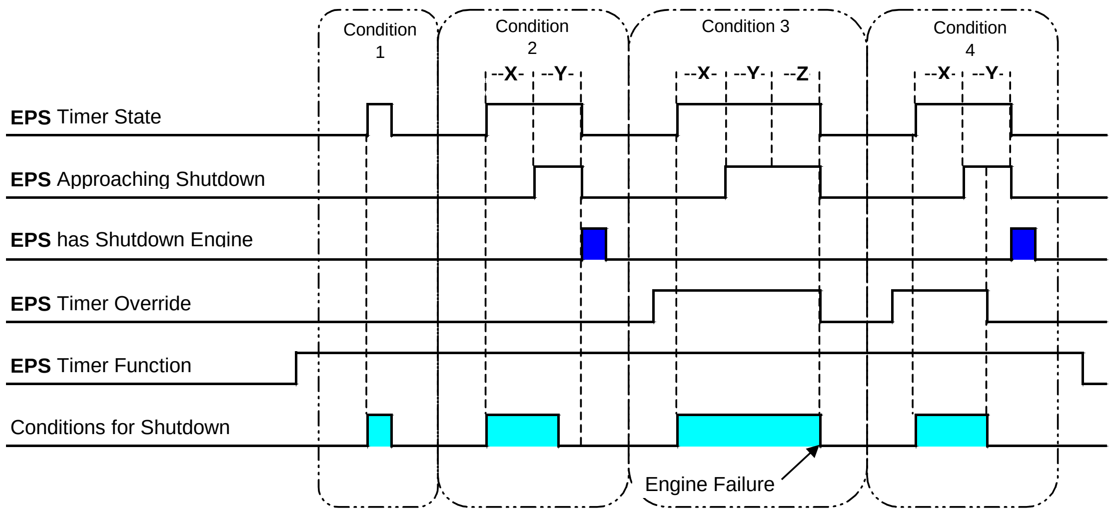


FIGURE SPN1107_A - ENGINE PROTECTION SYSTEM (EPS)

Condition 1 – When the EPS Timer Override is inactive, the EPS Timer State will become inactive if the conditions for shutdown no longer exist before the "X" time interval has expired or EPS Approaching Shutdown is activated.

Condition 2 – When the EPS Timer Override is inactive and conditions for shutdown exist during the "Y" time interval, then the Engine will shutdown, even though shutdown conditions subside before the "Y" time interval has expired.

Condition 3 – When the EPS Timer Override is active, then the EPS feature shall be overridden allowing for an engine failure when the "Z" time interval has expired.

Condition 4 – When the EPS Timer Override is active and then allowed to go inactive during the "Y" time interval, the response by the EPS shall be the same as condition 2. The time intervals for "X" and "Y" shall always start when conditions for shutdown first commence regardless whether the EPS Timer Override is enabled or not.

NOTE: 0 State – Inactive, disabled in calibration, or conditions for Engine Protection do not exist.

1 State – Active, enabled in calibration, or conditions for Engine Protection do exist.

D.18 SPN 1734 – NOMINAL LEVEL FRONT AXLE

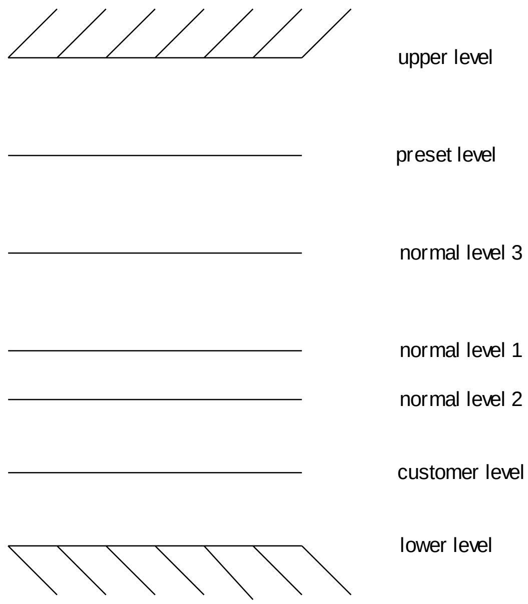


FIGURE SPN1734_A - EXAMPLE FOR NOMINAL LEVELS

If the vehicle height, to be controlled by the Air Suspension Controller (ASC), is not within the tolerances of the defined nominal levels, the nominal level is set to not specified.

The defined vehicle heights can be activated via the ASC2 (PGN: 53760) message or via a remote control (see figure SPN1734_B). The remote control is an external unit to operate the suspension system.

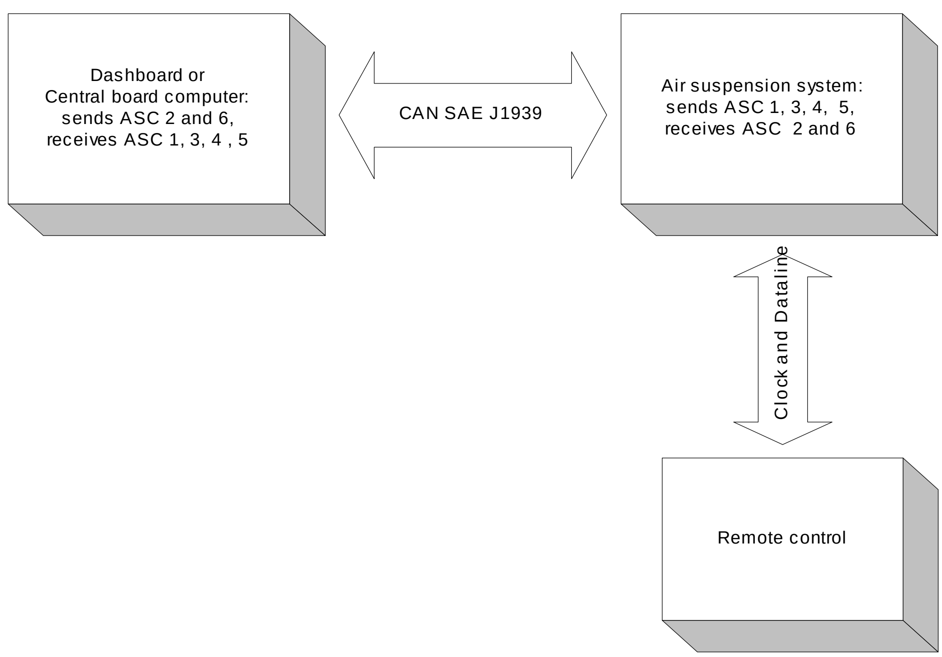
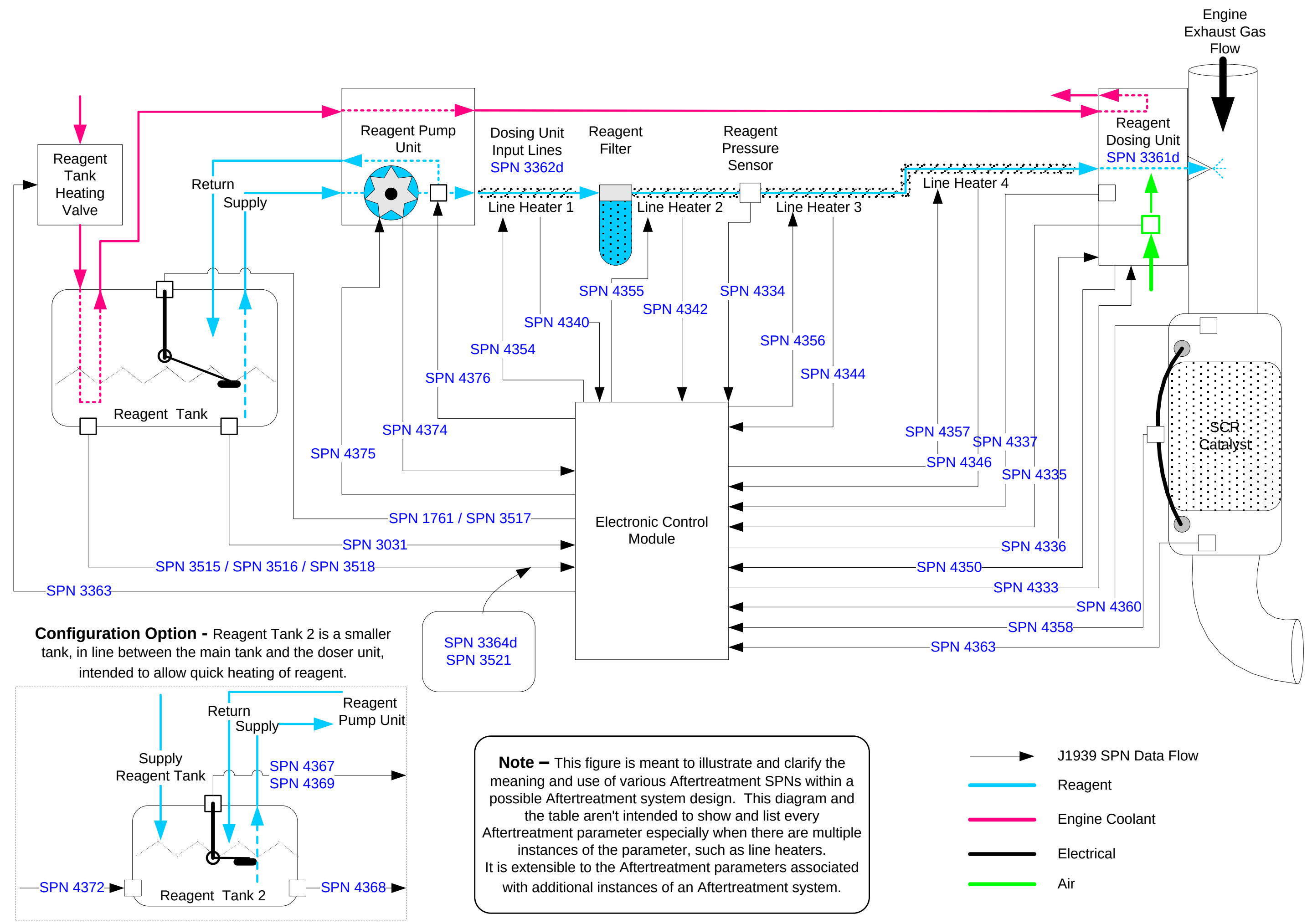


FIGURE SPN1734_B - POSSIBLE INTEGRATION OF ASC SYSTEM INTO VEHICLE NETWORK

An example: The nominal level is the normal level 1. Via remote control a new nominal level (for instance upper level) is requested. The nominal level is then set to upper level and during the height modification the ASC is indicating that the actual level is below nominal level until the upper level is reached.

D.19 SPN 1761 – AFTER TREATMENT SYSTEM DIAGRAM



SPN	SPN Name	SPN	SPN Name
1761	Aftertreatment 1 Diesel Exhaust Fluid Tank Level	4344	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 3 State
3031	Aftertreatment 1 Diesel Exhaust Fluid Tank Temperature	4346	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 4 State
3361	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit	4350	Aftertreatment 1 Diesel Exhaust Fluid Requested Quantity of Integrator
3362	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit Input Lines	4354	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 1
3363	Aftertreatment 1 Diesel Exhaust Fluid Tank Heater	4355	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 2
3364	Aftertreatment 1 Diesel Exhaust Fluid Tank Quality	4356	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 3
3515	Aftertreatment 1 Diesel Exhaust Fluid Temperature 2	4357	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 4
3516	Aftertreatment 1 Diesel Exhaust Fluid Concentration	4358	Aftertreatment 1 SCR Differential Pressure
3517	Aftertreatment 1 Diesel Exhaust Fluid Tank Level 2	4360	Aftertreatment 1 SCR Intake Temperature
3518	Aftertreatment 1 Diesel Exhaust Fluid Conductivity	4363	Aftertreatment 1 SCR Outlet Temperature
3521	Aftertreatment 1 Diesel Exhaust Fluid Property	4367	Aftertreatment 1 Diesel Exhaust Fluid Tank 2 Level
4333	Aftertreatment 1 Diesel Exhaust Fluid Actual Quantity of Integrator	4368	Aftertreatment 1 Diesel Exhaust Fluid Tank 2 Temperature
4334	Aftertreatment 1 Diesel Exhaust Fluid Doser Absolute Pressure	4369	Aftertreatment 1 Diesel Exhaust Fluid Tank 2 Level 2
4335	Aftertreatment 1 SCR Dosing Air Assist Absolute Pressure	4372	Aftertreatment 1 Diesel Exhaust Fluid Tank 2 Heater
4336	Aftertreatment 1 SCR Dosing Air Assist Valve	4374	Aftertreatment 1 Diesel Exhaust Fluid Pump Motor Speed
4337	Aftertreatment 1 Diesel Exhaust Fluid Dosing Temperature	4375	Aftertreatment 1 Diesel Exhaust Fluid Pump Drive Percentage
4340	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 1 State	4376	Aftertreatment 1 Diesel Exhaust Fluid Return Valve
4342	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 2 State		

FIGURE SPN1761 - EXAMPLE AFTERTREATMENT SYSTEM SCHEMATIC

D.20 SPN 2432 – ENGINE DEMAND - PERCENT TORQUE

Background:

During periods of TSC#1 engine control, other devices on the J1939 network may wish to know where the engine wants to go once it is released from TSC#1 control. In order for option transitions of driveline torque between different devices, it becomes necessary to understand the *engine's* desired torque for all phases of a TSC#1 control sequence.

Driver's Demand Engine – Percent Torque (SPN 512) provides a partial prediction of the torque the engine wishes to produce after a TSC#1 command is removed. Included in Driver's Demand Torque are external requestors to the powertrain such as accelerator pedal, cruise control, and road speed limit governors. However, *excluded* from DDT are (1) dynamic commands within the powertrain such as smoke control, noise control, and low and high speed engine governing, and (2) external TSC#1 commands to the engine such as those generated by traction control, unless SPN 3350 in the received TSC1 message is equal to P1 (Accelerator Pedal / Operator Selection), P2 (Cruise Control), P3 (PTO Governor), or P4 (Road Speed Governor). Since those control purposes originate from the driver, they shall be included in the calculation of DDT.

For a controller to properly determine the engine's desired output torque during a TSC#1 sequence, it needs knowledge of the torque being scheduled by all active controls within the engine. Since DDT excludes many of these active controllers from its calculation, it cannot be used to accurately predict the desired output torque. The effects of the external TSC#1 commands can be approximated by other devices by means of monitoring TSC#1 messages to the engine; however the effects of the engine's internal dynamic commands are completely unknown and cannot be estimated.

Actual Engine – Percent Torque (SPN 513) provides a window to the engine's desired torque output when no TSC#1 commands are actively controlling the engine. However, when the engine is responding to TSC#1 commands, the Actual Engine – Percent Torque parameter is no longer indicative of the torque that the engine will produce once those TSC#1 commands are removed.

In simplest terms, Engine Demand – Percent Torque (or "EDT") contains the engine's internal dynamic commands that are excluded from the Driver's Demand Engine – Percent Torque definition, including smoke control, noise control, and low and high speed governing. With this additional piece of information, devices on the network that are controlling the engine via TSC#1 messages can determine the torque direction of the engine once the current TSC#1 command is relinquished.

It is important to note that the Engine Demand – Percent Torque parameter is used as information. The addition of the EDT parameter should in no way cause a change to the engine's actual torque command architecture.

EDT Calculation:

When no devices are controlling the engine via TSC#1 messages, the value of EDT is equal to the Actual Engine – Percent Torque parameter. When the engine <u>is</u> being controlled via a TSC#1 message, it is necessary for the engine controller to calculate what its' target torque *would be* if there were no external commands being received. This "runner up" in engine control will come from internal dynamic engine commands.

In the calculation of Actual Engine – Percent Torque, the output of the engine's idle governor must be considered, along with the impact of the engine's full load governor, smoke controls and other internal limiting logic. In the determination of the Engine Demand Torque parameter, these same engine logic components are needed, as indicated in Figure SPN 2432_A. However, there is a significant difference: These components only affect the Actual Engine – Percent Torque parameter determination if they are the component *actively* controlling the engine. In EDT, any of these components will be used to calculate EDT if they are the *"runner up"* for engine control. Even though these components may lose in the engine's internal control arbitration, the engine output torque that they would produce if in command needs to be found to determine EDT.

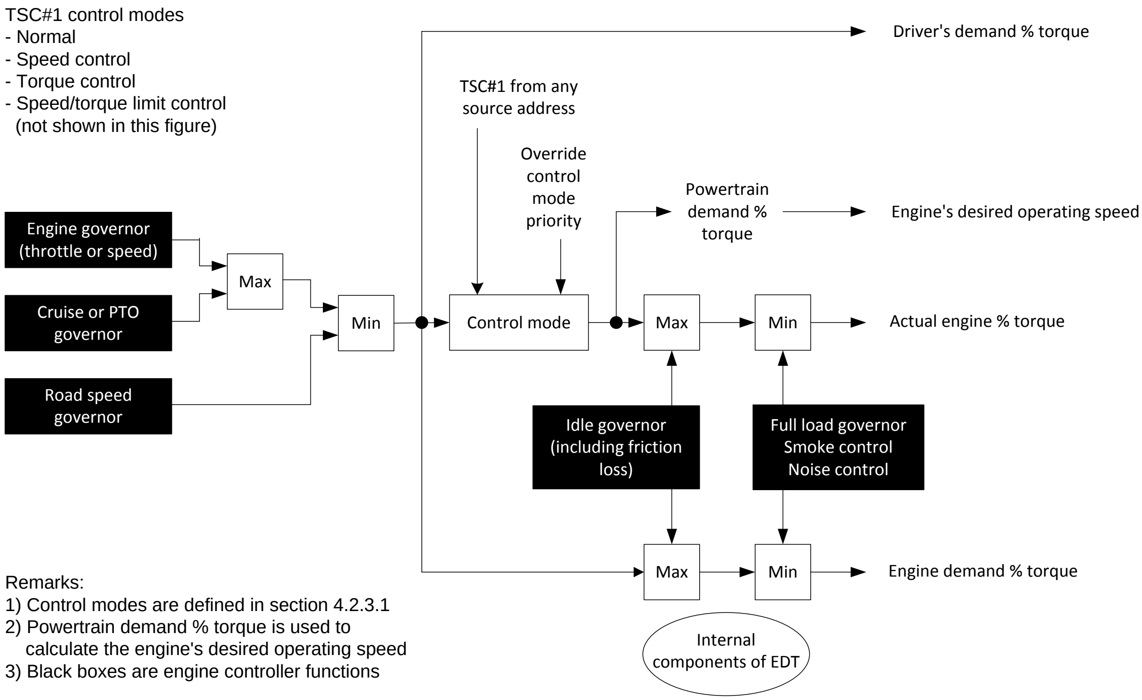


FIGURE SPN2432_A - TORQUE COMMANDS AND CALCULATIONS WHEN A “MAXIMUM LOW IDLE” TECHNIQUE IS USED

If speed governors are involved in determining these components of the EDT calculation, any of the following 3 special cases may need to be addressed:

Special Case #1: Speed Governors

If the engine governor referenced in Figure SPN2432_A is a speed-based governor instead of a throttle table arrangement, a new challenge is presented in determining EDT. Since the speed governor output is directly influenced by the TSC#1 command in control (for example, integrator anti-windup logic), the speed governor’s output during TSC#1 commands cannot be used to calculate EDT.

Instead, an *approximation* of the speed governor output without the effects of any TSC#1 commands is required for use in the EDT calculation. “Approximation” refers to removing the effects of integrator terms and any other dynamic components that result from the controlling TSC#1 commands. All elements affecting the speed governor reference should be included before the reference is translated into terms of torque.

All control algorithms with dynamic elements (e.g., speed governors) that execute during TSC#1 commands need to have their outputs replaced by “steady-state” approximations for use in the EDT calculation. Again note that these approximations are for use only in the EDT calculation; the actual engine control logic remains unchanged.

Figure SPN2432_B illustrates EDT and speed governor output during a typical control sequence. The output of the speed governor may tend to lag the engine’s torque trace during and after the TSC#1 command sequence. Note however that the TSC#1’s influence is not factored into EDT; only when the command sequence ends or is no longer winning in terms of engine control arbitration do the dynamic effects of the speed governor(s) appear in the EDT signal.

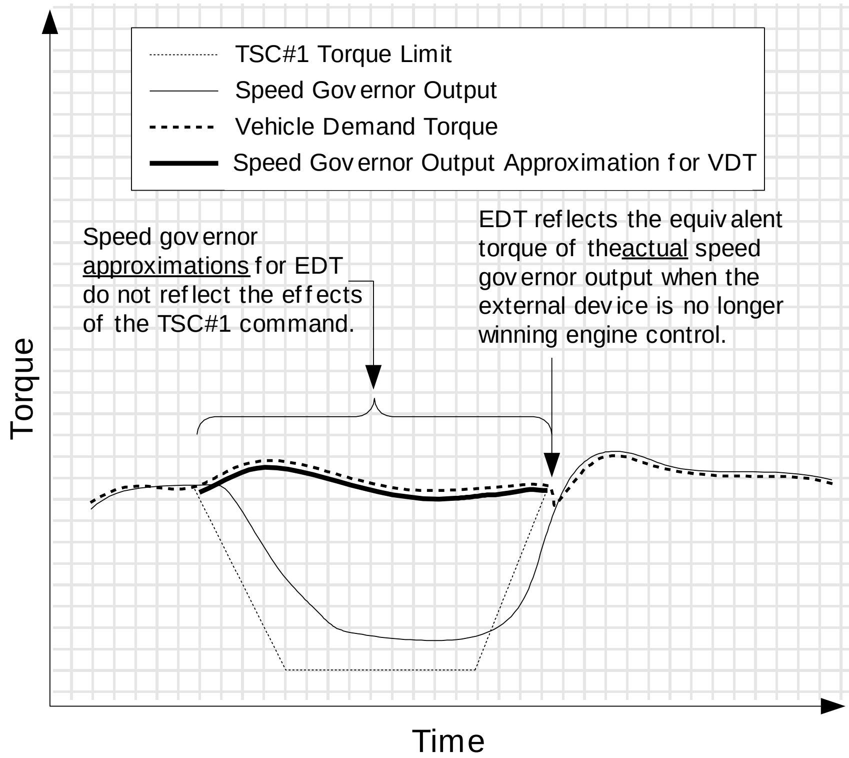


FIGURE SPN2432_B - EDT AND SPEED GOVERNOR OUTPUT RELATIONSHIP DURING A CONTROL SEQUENCE

One method of converting the speed governor reference to torque is shown in Figure SPN2432_C. The inputs of current engine speed, accelerator pedal position and the shape of the governor droop curves can be used to find the equivalent torque output of the governor. A lookup table or calculation could be used.

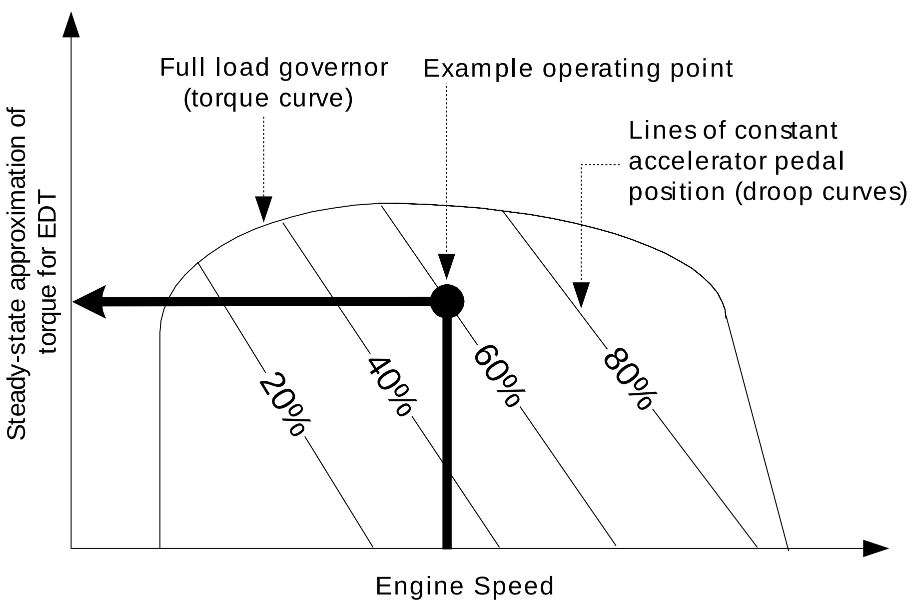


FIGURE SPN2432_C - FINDING EDT TORQUE APPROXIMATION FOR A SPEED GOVERNOR

Special Case #2: “Steep” or zero droop speed governors

Using a steady-state approximation with a “steep” or zero droop speed governor can cause large EDT changes over small speed changes. For example, if a cruise control governor has a zero droop and the vehicle speed is just below the cruise set speed, the steady-state torque approximation using the method described previously is very large. If vehicle speed increases a small amount to above the cruise set speed, the steady-state torque approximation becomes very small or zero.

As a result, a more accurate steady-state torque approximation is needed when steep droop governors are involved. A steep droop speed governor is defined as having a droop slope greater than 0.2% actual torque per rpm as seen below in Figure SPN2432_D.

The following method can be used to determine a steady-state torque approximation for steep or zero droop governors with fast responding integrator anti-windup / integrator resetting:

Upon a TSC#1 message actively controlling engine torque, save the last value of torque commanded by the speed governor (τ_{SGo}) and the last value of speed governor error (ε_{SGo}).

During this control sequence, calculate speed governor error (ε_{SGi})

Calculate an estimated torque for EDT determination use: $\tau_{SGestimated} = \tau_{SGo} + Kp_{SG} * (\varepsilon_{SGo-} \varepsilon_{SGi})$

where Kp_{SG} is the speed governor proportional gain

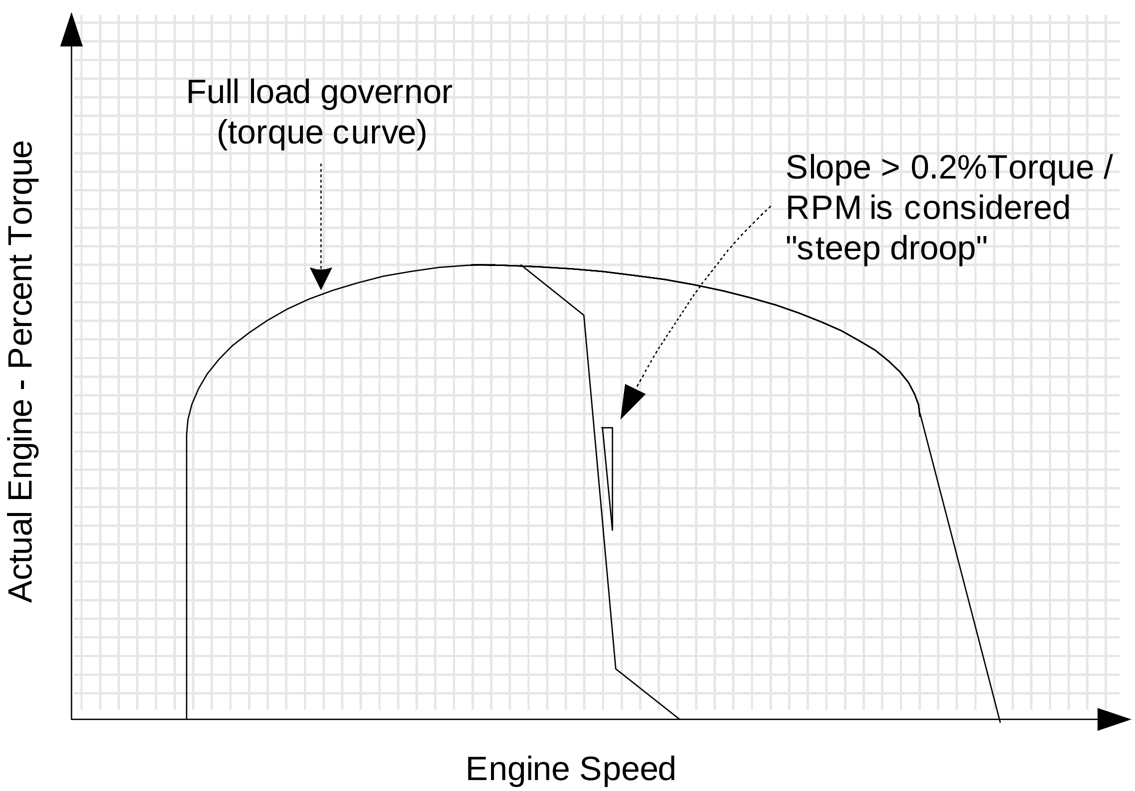


FIGURE SPN2432_D - EXAMPLE OF "STEEP DROOP" SPEED GOVERNOR

Special Case #3: “Slow Response” Speed Governors

If the speed governor dynamic elements are slow to respond to a 1 second torque derate, then the speed governor can simply be executed during the TSC#1 event and the output used directly in determining EDT. This is an alternative for a speed governor which does not contain an integrator, or if the integrator anti-windup logic is slow to respond. A guideline for “slow response” is that the governor output after 1 second of torque limiting has only moved 1/3 of the way to the limit, as shown for example in Figure SPN2432_E.

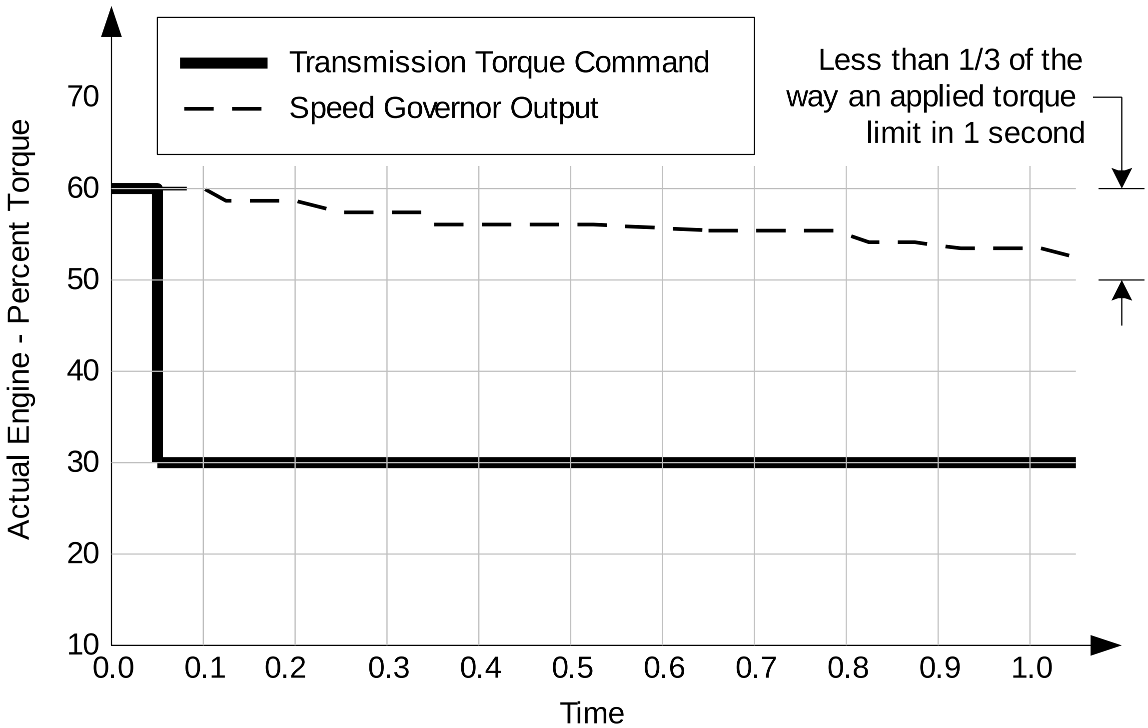


FIGURE SPN2432_E - EXAMPLE OF “SLOW TO RESPOND” SPEED GOVERNOR

D.21 SPN 2927 - ACTUAL INNER WHEEL STEERING ANGLE

Following sketch shows an example for the actual inward wheel angles of the steering axles in the requested PGN :

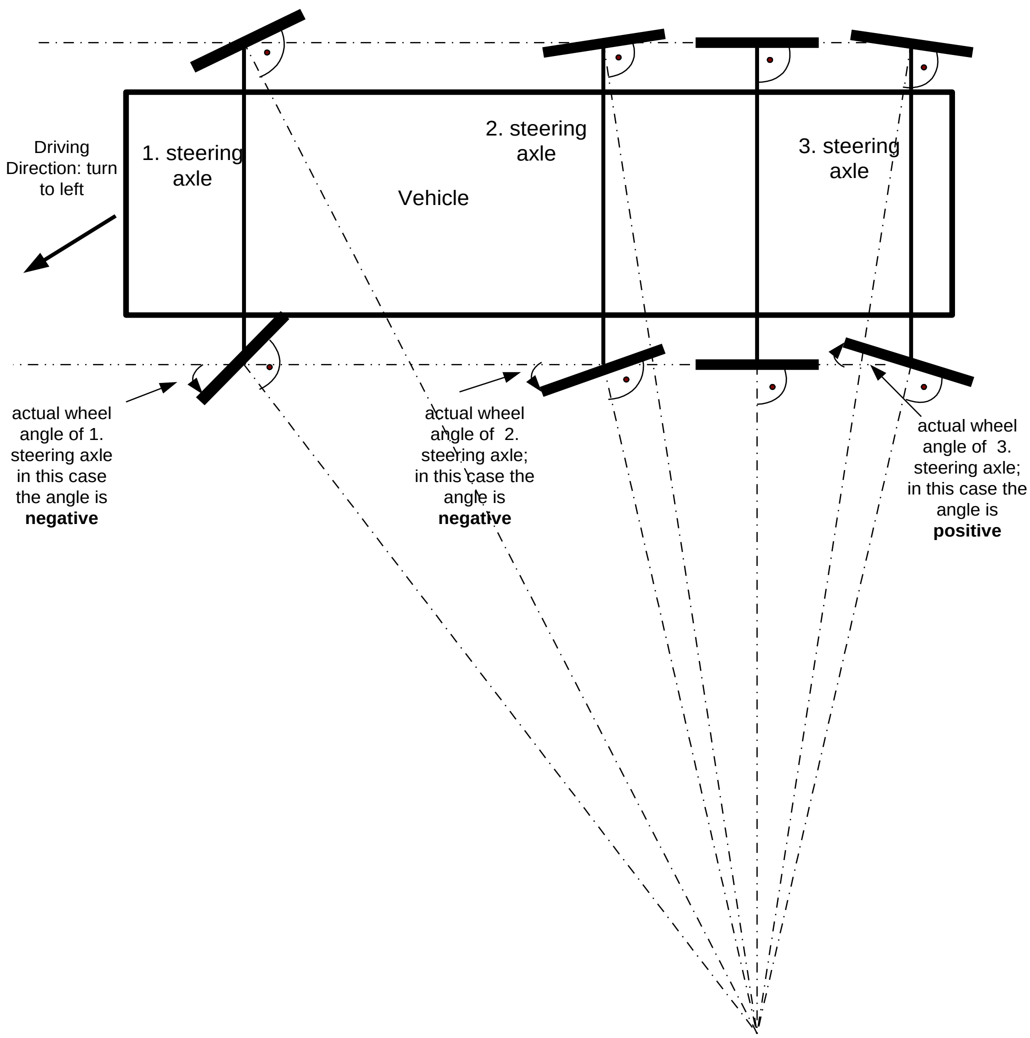


FIGURE SPN2927_A - STEERING AXLE ORIENTATION

D.22 SPN 3697 – DIESEL PARTICULATE FILTER LAMP COMMAND

		SAE J1939 Parameters					
	State of Regeneration Cycle	SPN 3697 - Diesel Particulate Filter Lamp Command	SPN 3698 - Exhaust System High Temperature Lamp Command[1]	SPN 3703 - Diesel Particulate Filter Active Regeneration Inhibited Due to Inhibit Switch	SPN 3700 - Diesel Particulate Filter Active Regeneration Status	SPN 3701 - Diesel Particulate Filter Status	DM1 Message
1	Regeneration not needed	000	000	00	00	000	Per active DTCs
2	Regeneration needed – Request Level	001	000	00	10	001	Per active DTCs
3	Regeneration needed – Warning Level	100	000	00	10	010	Per active DTCs
4	Regeneration needed - Service Level	100	000	00	10	011	Per active DTCs. Amber Lamp shall be on with active DTC indicating regeneration level.
5	Regeneration needed – Stop Level	100	000	00	10	011	Per active DTCs. Red Lamp shall be on with active DTC indicating regeneration level.
6	Manual Regeneration Request Acknowledge	Per Filter Status - lamp will reflect actual level of DPF fill.	000	00	At transition. Change to 01 following switch input.	Per appropriate regeneration needed level	Per active DTCs
7	Regeneration active with exhaust temperature above a threshold	Per Filter Status - lamp will reflect actual level of DPF fill.	001	00	01	Per appropriate regeneration needed level	Per active DTCs
8	Regeneration active with exhaust temperature below a threshold	Per Filter Status - lamp will reflect actual level of DPF fill.	000	00	01	Per appropriate regeneration needed level	Per active DTCs
9	Regeneration Inhibit Acknowledge	Per Filter Status - lamp will reflect actual level of DPF fill.	Per exhaust temperature.	At transition. From 00 to 01 following switch input.	The following is for information only during this state: If SPN 3700 is equal to 01, then it will change from 01 to the appropriate state following switch input. If it is not equal to 01, then value remains the same.	Per appropriate regeneration needed level	Per active DTCs

The diesel particulate filter (DPF) thresholds used in the explanations below are relative to each other in the following manner: Request Level < Warning Level < Service Level < Stop Level

1. Regeneration not needed: Amount of particulate matter in DPF is below the request level threshold.
2. Regeneration needed - Request Level: Amount of particulate matter in DPF has exceeded request level threshold, but has not exceeded the warning level threshold.
3. Regeneration needed - Warning Level: Amount of particulate matter in DPF has exceeded warning level threshold, but has not exceeded the service level threshold.
4. Regeneration needed - Service Level: Amount of particulate matter in DPF has exceeded service level threshold, but has not exceeded the stop level threshold.
5. Regeneration needed - Stop Level: Amount of particulate matter in DPF has exceeded stop level threshold.
6. Manual Regeneration Request Acknowledge: When the operator sets the SPN 3696 Diesel Particulate Filter Regeneration Force Switch to 01, then SPN 3700 will indicate that regeneration is active.
7. Regeneration active with exhaust temperature above a threshold: Needs no explanation.
8. Regeneration active with exhaust temperature below a threshold: Needs no explanation.
9. Regeneration Inhibit Acknowledge: If the operator has activated the Diesel Particulate Filter Regeneration Inhibit Switch (SPN 3695), then another device on the network can detect this event by monitoring SPN 3703 to change from 00 to 01.

The actual values of all thresholds referenced above are defined by the manufacturer.

Note [1]: In addition to the above table, the exhaust system high temperature lamp can be set due to high exhaust temperatures that are independent of a regeneration cycle.

FIGURE SPN3697_A - DIESEL PARTICULATE FILTER LAMP COMMAND

D.23 SPN 3785 – TRACTOR BRAKE STROKE SYSTEM

The brake stroke system has essentially two inputs:

1) Sensor at each actuator that allows the determination of 3 regions of stroke (Fully Returned, Normal Stroke Range, or Overstroke Range)

2) A sensor to detect the use of the brake pedal (similar to Stop Light Switch)

The ECU then determines the brake stroke status as follows:

		Brake Pedal	
		OFF	ON
Stroke Sensor	**RETURNED**	OK	Non-functional
	NORMAL	Dragging	OK
	OVERSTROKE	Dragging	Overstroke

FIGURE SPN3785_A - TRACTOR BRAKE STROKE DEFINITIONS

D.24 SPN 4151 – ENGINE EXHAUST TEMPERATURE AVERAGE

Up to 3 different exhaust port temperature averages will be computed. These three averages include the left bank average exhaust port temperature, the right bank average exhaust port temperature and the engine average exhaust port temperature. The example below illustrates how these averages would be computed for a V8 engine configuration. Inline engines would utilize SPN 4151 for Engine Average Exhaust Temperature.

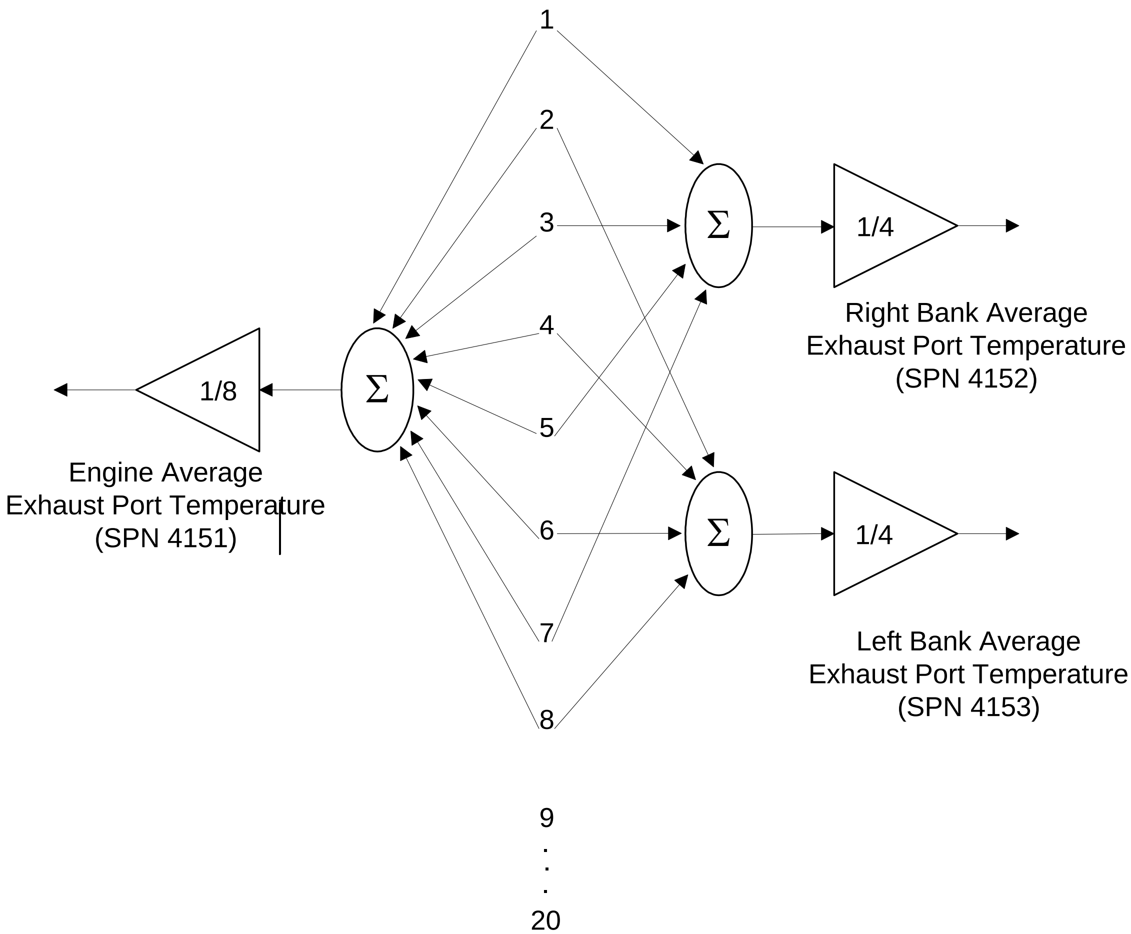


FIGURE SPN4151_A - ENGINE EXHAUST TEMPERATURE AVERAGING METHOD

D.25 SPN 5052 – CLUTCH/TORQUE CONVERTER INPUT SPEED

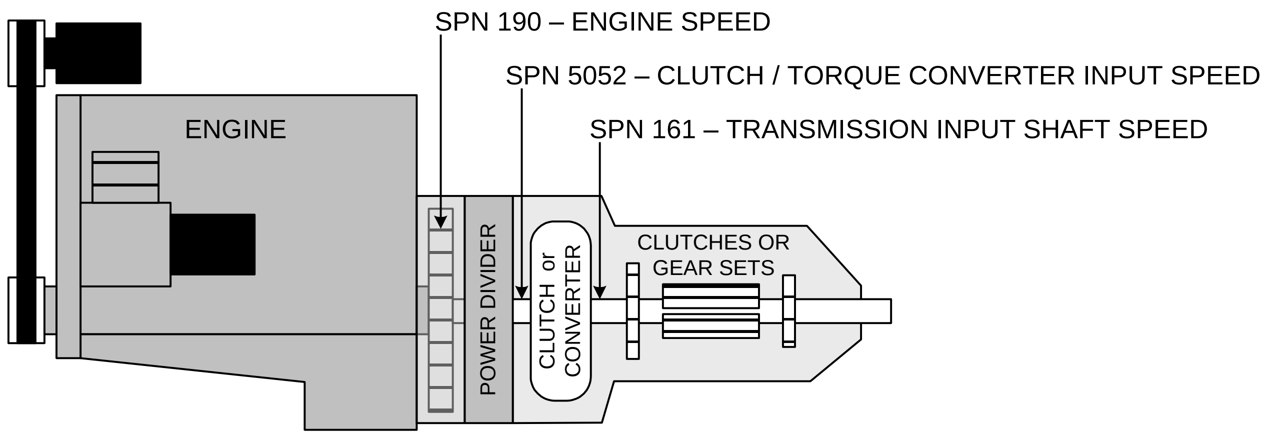


FIGURE SPN5052_A - POWER DIVIDER SCHEMATIC

D.26 SPN 5275 – PARK BRAKE ACTIVATION

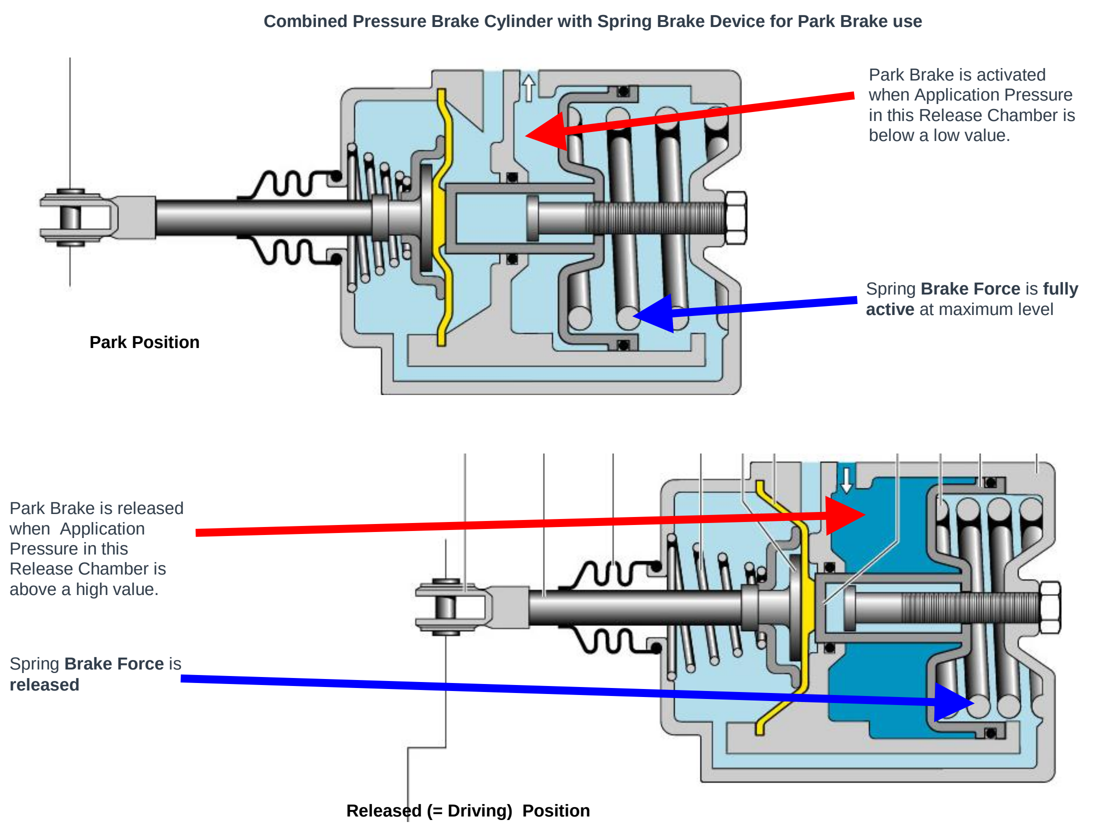


FIGURE SPN_5275A - PARK BRAKE ACTIVATION

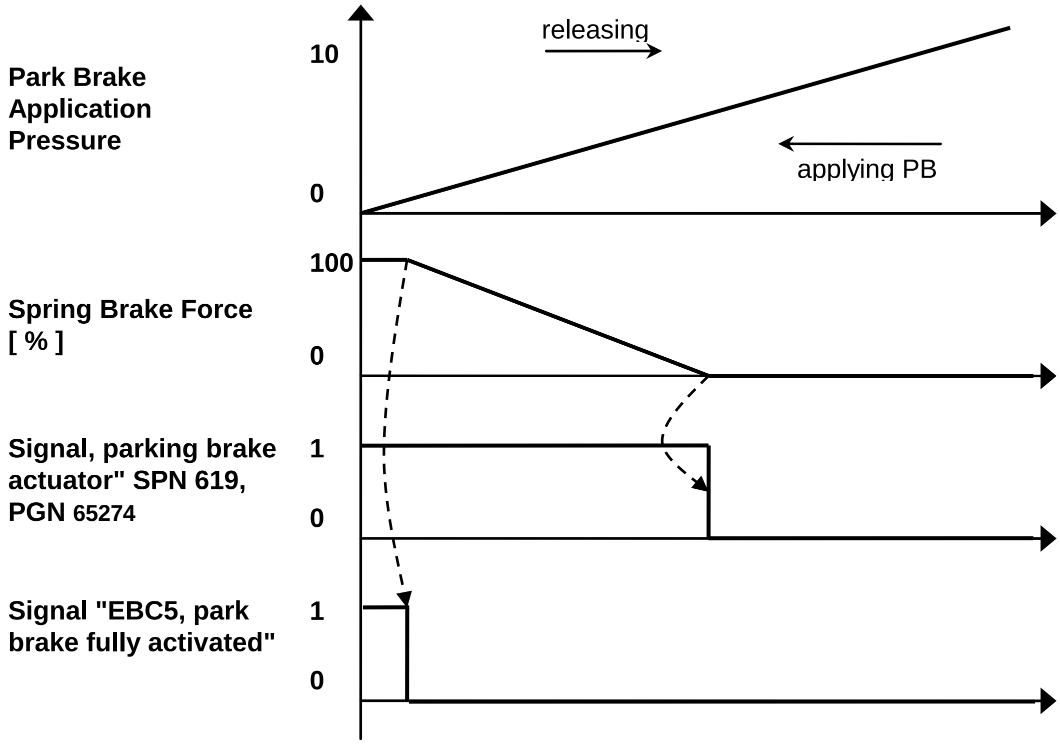


FIGURE SPN_5275B - PARK BRAKE ACTIVATION STATES

D.27 PGN 1024 – EXTERNAL BRAKE REQUEST

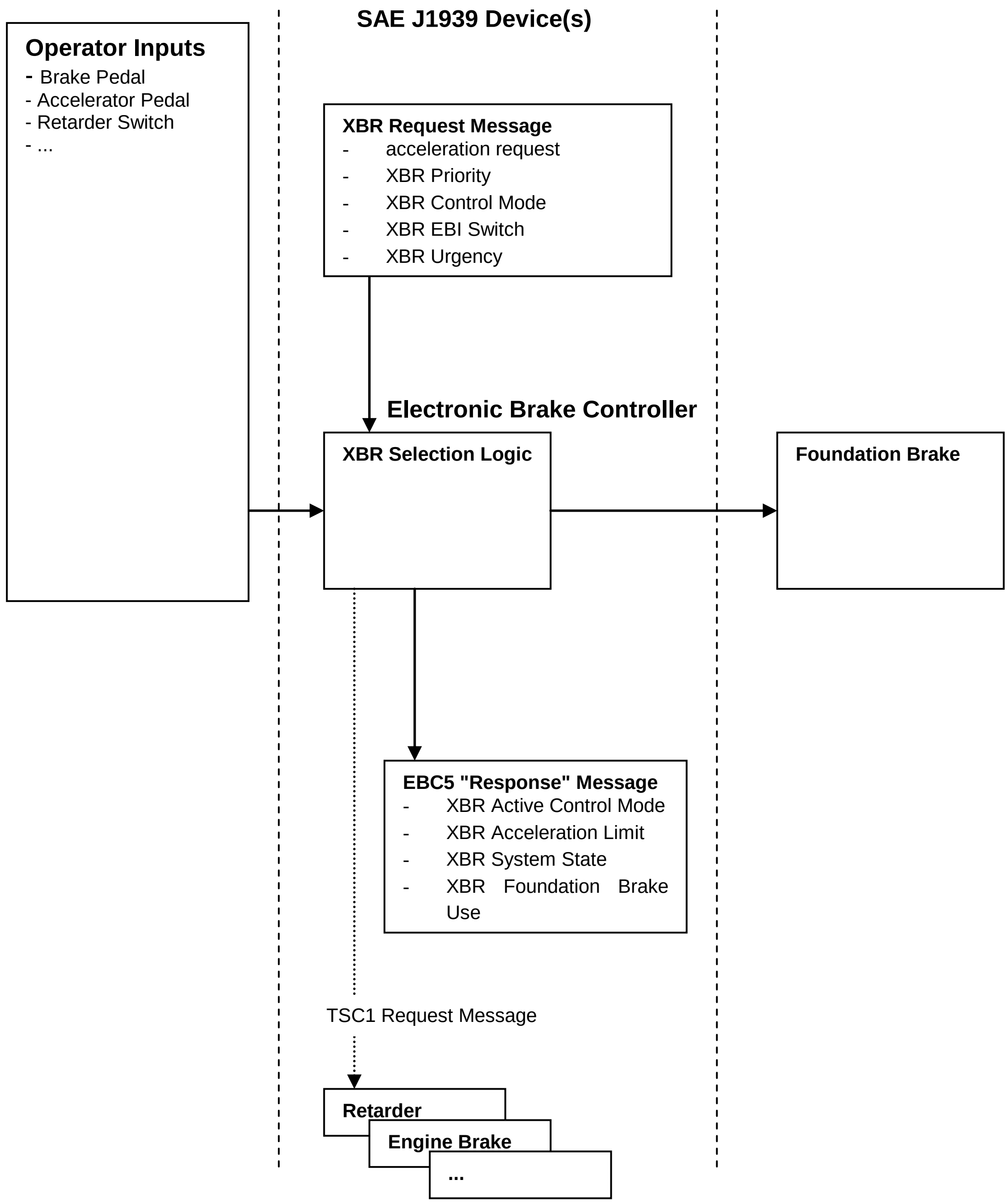
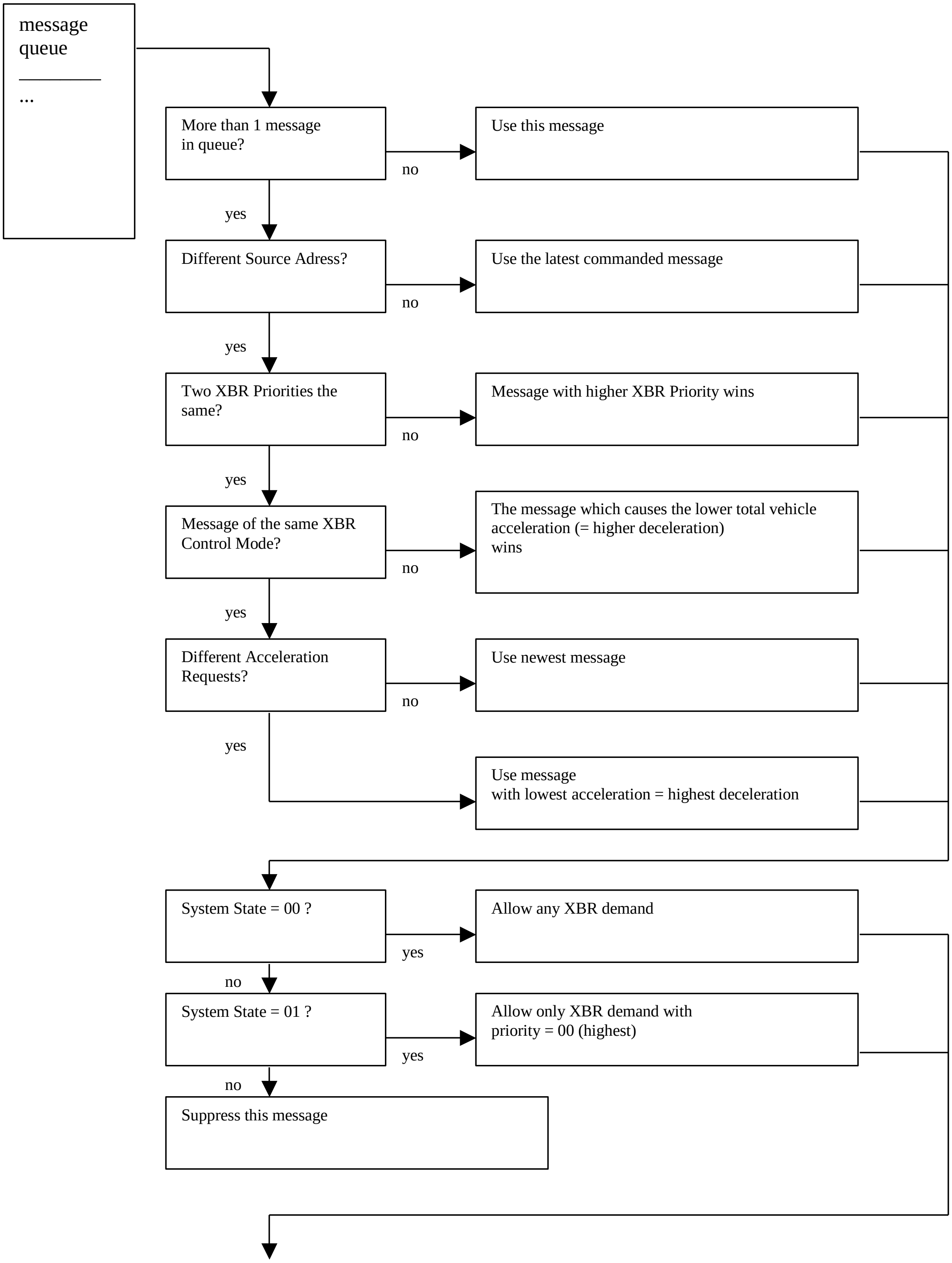


FIGURE PGN1024_A - DATA FLOW DIAGRAM FOR EXTERNAL BRAKE REQUEST



(CONTINUED ON NEXT PAGE)

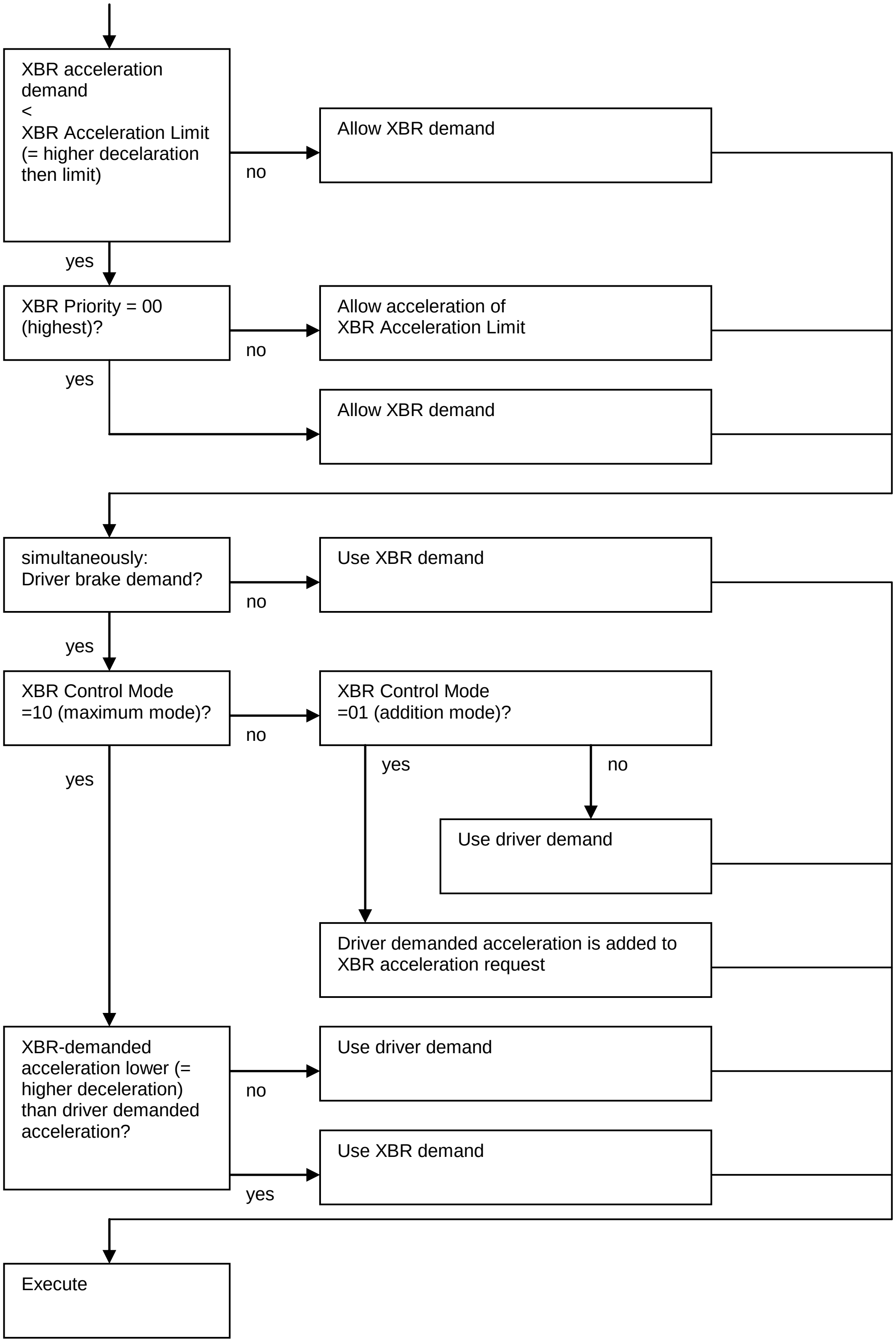


FIGURE PGN1024_B - XBR PRIORITY SELECTION LOGIC

D.28 PGN 2560 – CRUISE CONTROL/VEHICLE SPEED

Inputs								Outputs					
Cruise Control Enable Switch (SPN 596)	Cruise Control Resume Switch (SPN 601)	Cruise Control Set Switch (SPN 599)	Cruise Control Coast Switch (SPN 600)	Cruise Control Accel Switch (SPN 602)	Cruise Control Disable Command (SPN 5603)	Cruise Control Pause Command (SPN 5605)	Cruise Control Resume Command (SPN 5604)	Action by Cruise Control Device	Cruise Control System Command State (SPN 5607)	Cruise Control States (SPN 527)	Cruise Control Active (SPN 595)	Source Address of Controlling Device for Disabling Cruise Control (SPN 5608)	Source Address of Controlling Device for Pausing Cruise Control (SPN 5609)
00	don't care	don't care	don't care	don't care	don't care	don't care	don't care	Cruise control is disabled.	000	Off (000)	Off (00)	0xFE	0xFE
01	Operator selection	Operator selection	Operator selection	Operator selection	00	don't care	don't care	Cruise Control Device shall execute the operator's request.	000	Based on operator selection	Based on operator selection	0xFE	0xFE
01	don't care	don't care	don't care	don't care	01	don't care	don't care	Cruise control is not active. Cruise control set speed is not retained.	001	Off (000)	Off (00)	SA of Device	0xFE
01	00	00	00	00	01 → 00[1]	don't care	don't care	Cruise control is not active. Cruise control set speed is not retained.	001	Off (000)	Off (00)	0xFE	0xFE
01	don't care	don't care	don't care	don't care	00	01	don't care	Cruise control is not active. Cruise control set speed is retained	010	Off (000)	Off (00)	0xFE	SA of Device
01	00	00	00	00	00	01 → 00[2]	don't care	Cruise control is not active. Cruise control set speed is retained	010	Off (000)	Off (00)	0xFE	0xFE
01	00	00	00	00	00	01 → 00[4]	00 → 01[4]	If a previous set speed exists, then cruise control will become active.	011[3]	Resume (100)	On (01)	0xFE	0xFE
01	00	00	00	00	00	00	01	If a previous set speed exists, then cruise control will become active.	011[3]	Resume (100)	On (01)	0xFE	0xFE
01	00	00	00	00	00	00	01	If a previous set speed does not exist, then cruise control will not become active.	100	Off (000)	Off (00)	0xFE	0xFE

[1] The values in the Output columns apply to the transition and after the transition until a valid command is received. If Cruise Control Disable Command has been used to disable cruise control, then a valid command is the Cruise Control Set Switch can be used to activate cruise control.

[2] The values in the Output columns apply to the transition and after the transition until a valid command is received. If Cruise Control Pause Command has been used to disable cruise control, then a valid command to activate cruise control is (1) the Cruise Control Resume Switch, (2) the Cruise Control Set Switch, or (3) Cruise Control Resume Command.

[3] Cruise Control System Command State will change to the appropriate value when Cruise Control States is no longer equal to Resume (100).

[4] Information in this row indicates that Cruise Control Pause Command and Cruise Control Resume Command can transition in the same message and still achieve the desired cruise control resume functionality.

Note: The table above is intended to demonstrate that a request to disable cruise control shall have priority over another type of request. A request to disable cruise control includes one of the following: Cruise Control Enable Switch in the OFF position, a Cruise Control Disable Command received as 01, or a Cruise Control Pause Command received as 01.

FIGURE PGN2560_A - RELATIONSHIP BETWEEN CRUISE CONTROL COMMAND PARAMETERS

D.29 PGN 39680 – PROPRIETARY MESSAGING INFORMATION

This PGN allows an ECU to report basic information about its data methods for the PropA, PropA2, and PropB messages for ECUs to determine proprietary messaging compatibility. Once proprietary messaging compatibility is determined through this PGN, then those ECUs could rely upon messages within that compatible proprietary space to negotiate more specific details of compatibility, such as the set of messages specifically supported and the data dictionary details. An accurate assessment of the proprietary messaging compatibility between ECUs in a network is vital to avoiding system operational hazards resulting from improper interpretation of proprietary messages.

Using the J1939 Proprietary Messages (PropA, PropA2, and PropB) for communications between ECUs in a system requires ECUs to determine which, if any, of the other ECUs support and use the same data methods (i.e. data dictionary, ID assignments, data field structures, etc). Presently, the only SAE J1939 standardized data available to ECUs for determining such proprietary messaging compatibility is the Manufacturer Code parameter in the J1939 NAME reported in the address claim message. This information is marginally sufficient for ECUs to limit proprietary messaging use with peer ECUs of the same Manufacturer Code. However, this information is not sufficient when proprietary messaging is needed between ECUs with different Manufacturer Codes.

Using proprietary messages to communicate between ECUs from different manufacturers requires design time negotiations between manufacturers to establish the data dictionary, message IDs, etc. Often only a small range of message IDs are sectioned off for these interactions and the rest of the proprietary space in each ECU is the native proprietary language of that manufacturer. When using the PropA and PropA2 messages, an ECU can restrict to only those sent specifically to its address and validate the Manufacturer Code and other NAME elements of the Source Address before applying the negotiated methods. However, it is possible that the negotiated language for the sectioned off IDs is applicable by each manufacturer for those specific components, and such space may have different language rules for other components or similar components on other systems. When using the PropB messages, an ECU can only cross reference the Manufacturer Code and other NAME elements of the Source Address. However, it is not possible to determine how the message source has encoded the message or if the source even intended for the ECU to use the message. Consequently, the J1939 NAME is not really sufficient for determining any compatibility for the PropA, PropA2, and PropB messages.

NOTES

The data field consists of zero or more Proprietary Method data structures. Each Proprietary Method data structure consists of a Manufacturer Code parameter and a Method ID parameter. The J1939 Manufacturer Code values (J1939 Table B10) shall serve as the enumeration standard for the Manufacturer Code. The Method ID parameter is a 21-bit value defined and set by the manufacturer.

Each Proprietary Method structure allow an ECU to essentially say "This ECU supports Manufacturer X's Proprietary Method '123' ". Since the message supports the ability to report multiple Proprietary Methods, this structure allows an ECU to essentially say:

"This ECU supports
Manufacturer X's proprietary method '123'
Manufacturer X's proprietary method '456'
Manufacturer Y's proprietary method '321' "

In the above example, Manufacturer X method 123 (X-123) might be for PropA messaging and may have a set of the rules for discovering further PropA proprietary details. Those ECUs with X-123 knowledge will be able to perform the discovery and possibly initiate messaging conversations using the X-123 methods. The Manufacturer X method 456 (X-456) might be for PropA2 messaging and may have a set of the rules for discovering further PropA2 proprietary details. Similarly, those ECUs with X-456 knowledge will be able to perform the discovery and possibly initiate messaging conversations using the X-456 methods. Finally, an ECU could limit acceptance and interpretation of proprietary messages only to those ECUs that indicate specific Proprietary Methods. When establishing proprietary messaging between ECUs with different manufacturer codes, the parties can establish the Proprietary Method ID which indicates the use of the that specific negotiated messaging.

A destination specific message is requested to allow an ECU to customize its message response for the requesting device.

This is a standardized mechanism for an ECU to report a listing of the manufacturer specific (i.e. proprietary) methods it supports when using the PropA, PropA2, and PropB PGNs. The ability to support multiple manufacturer proprietary methods allows manufacturers to collaborate on application specific communication needs that are not of interest to the SAE Truck & Bus Control and Communication Committee. The process of selecting a specific method for ECUs that list multiple mutually exclusive methods is intended to be defined by the manufacturer and therefore not within the scope of this PGN.

NOTE: The placement of the Manufacturer Code and Method ID bits into the 4-byte space is illustrated in Figure PGN39680_A.

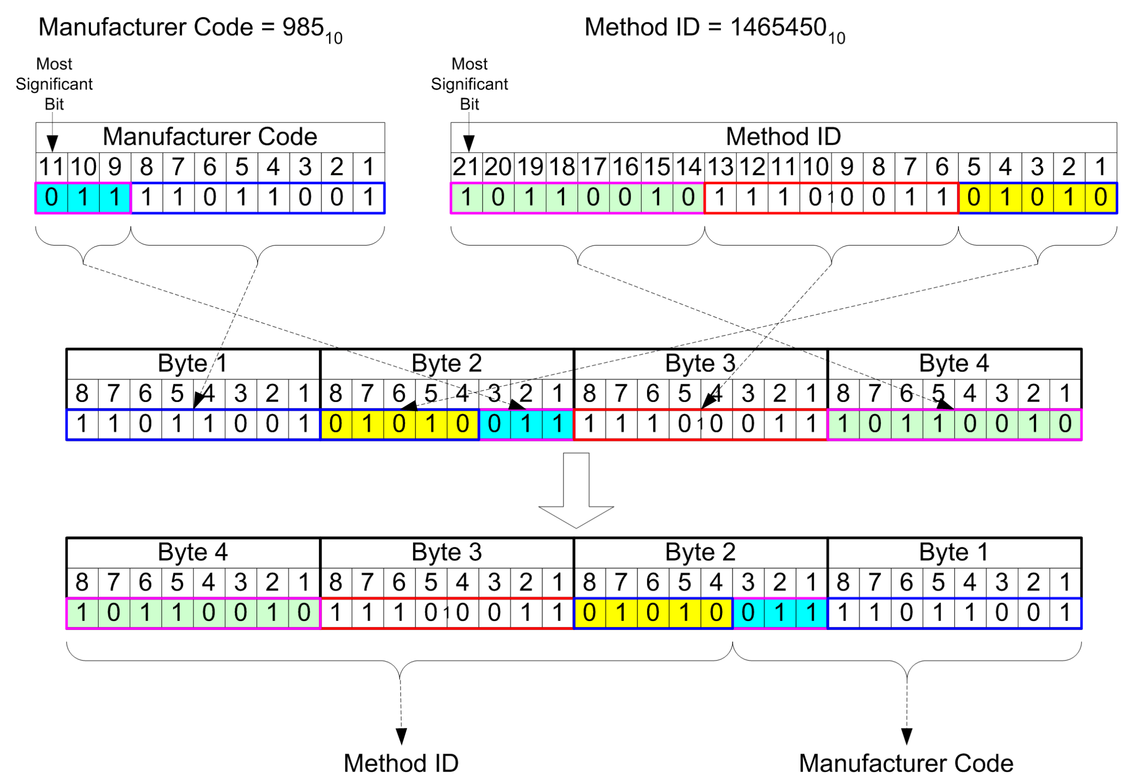


FIGURE PGN39680_A - PLACEMENT OF MANUFACTURER CODE AND METHOD ID DATA

EXAMPLE 1: The following illustrates the message format for when there are more than one proprietary method to report.

Given:

a = Manufacturer Code

b = Method ID

Message form is as follows: a,b,a,b,a,b,a,b, ...etc. In this example, the transport protocol of SAE J1939-21 has to be used to send the information because it requires more than 8 data bytes. Actually any time there is more than two methods to report, the services of the transport protocol have to be used.

D.30 PGN 52992 – CONTINUOUS TORQUE & SPEED LIMIT REQUEST

The TSC1 message allows J1939 network devices to temporarily control engine and retarder speed and torque. This approach allows engine (and retarder) speed to be controlled by one device for a limited period of time. This may need to happen for brief emergency conditions (as requested by an anti-lock braking system for example) or in order to synchronize engine speed with some other device such as a transmission in order to allow a shift. Conflicting speed and torque requests from different devices are resolved by a predefined arbitration scheme.

Not every torque or speed need is satisfactorily addressed by this plan, however. Occasionally a network device may wish to impose longer lasting limits on speed and torque. For instance, as long as a transmission is in third gear, it may not be able to withstand all the torque the engine (or retarder) can produce. Or, an auxiliary device such as a pump may only operate correctly if engine speed and torque are kept within some fairly limited range *but not necessarily at one precise speed/torque!* In these cases, the network device does not need to command the precise speed or torque, but does have a legitimate desire to keep it within some boundary for an extended period of time. The TSC1 message doesn't provide this ability.

How: The ECM and retarder controller(s) first must define a "window" within the torque map. The window should be chosen carefully, and shouldn't be any larger than necessary. Any requests for continuous limits that attempt to intrude on this window will succeed only in setting limits at the very threshold of the window. For example, if the ECM declares that minimum continuous torque limits must be less than 900 lb-ft, and some device attempts to set a minimum continuous torque of 1000 lb-ft, the actual applied continuous limit will be 900 lb-ft (thus 900 lb-ft is the *minimum continuous* torque). When this limit is applied, the engine will always produce at least 900 lb-ft of torque. Similarly, if the engine declares that minimum continuous engine speed cannot be more than 1100 RPM, any attempts at setting a minimum continuous engine speed of over 1100 RPM will result in a minimum continuous engine speed of 1100 RPM. That is, the engine has declared beforehand that it will *always* be able to operate at least at 1100 RPM.

Periodically, the ECM and retarder controller(s) will transmit the dimensions of this window, as well as what actual continuous limits have been applied. This allows the engine to adjust the size and shape of the "window" to allow for derates and provides feedback to the various devices requesting continuous torque and/or speed limits.

The following figure shows an example torque curve with a "window" inside.

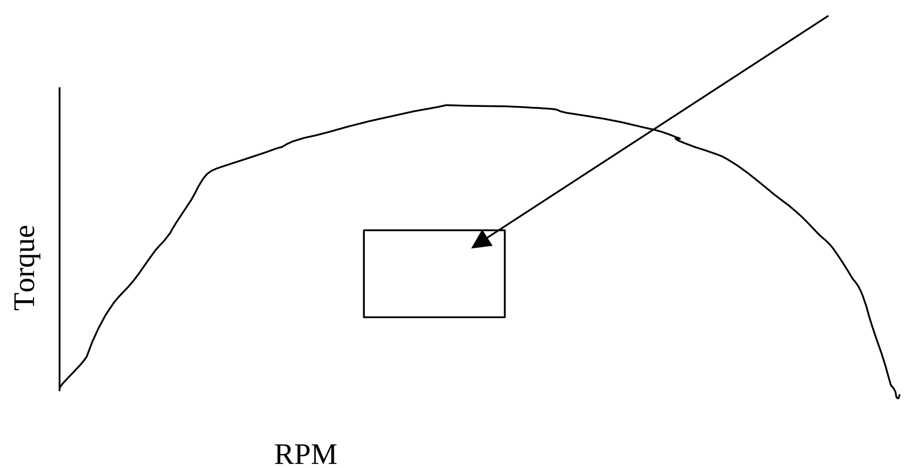


FIGURE PGN52992_A

The following figure shows how the ECM will treat requests that are outside of the bounds set by the "window." Note that the ECM has declared a "maximum allowable minimum" and a "minimum allowable maximum" for both speed and torque. These limits form a sort of rectangular "window" within the torque. The engine **must** be free to operate within this window; no continuous limits will be accepted that would intrude on it. In the diagram, some network device has ignored those values and attempted to set a minimum continuous speed higher than allowed. Remember, a minimum continuous speed means that the engine must always maintain an RPM of that value or greater. The ECM cannot accept the requested limit, so it applies a continuous limit as close as possible: right at the boundary set by "maximum value allowed for minimum continuous speed." Requests for Minimum Continuous Speed and Max/Min continuous torque are handled the same way.

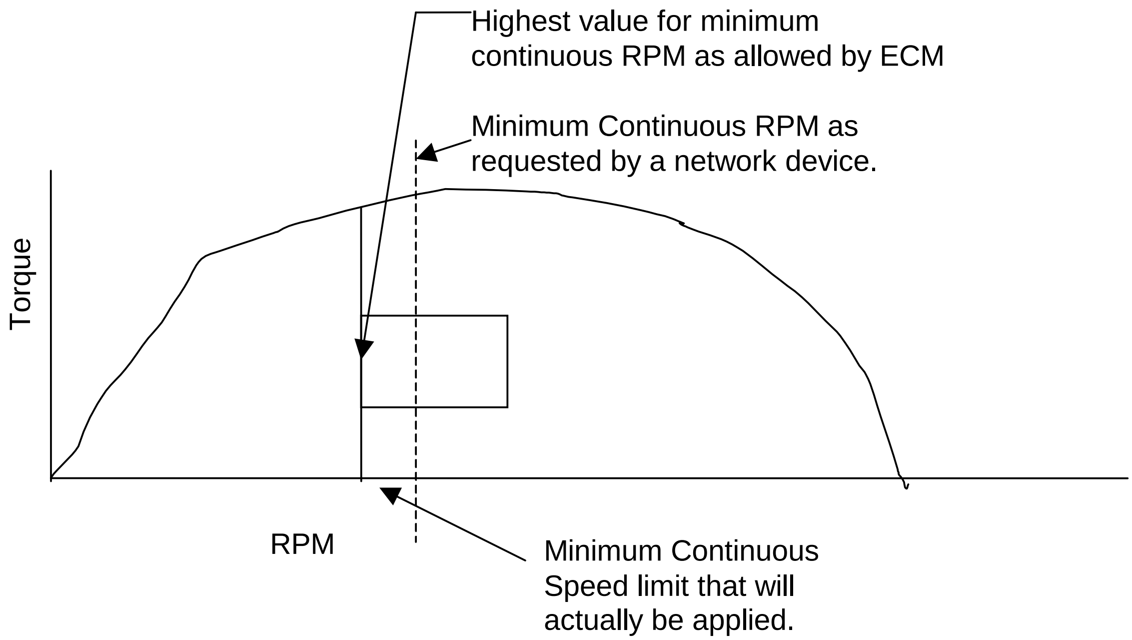


FIGURE PGN52992_B

Things get a little more complicated when a retarder is included. Fortunately, only the engine compression brake retarder has any real relationship to the engine's torque map. Because other retarders may work against the engine, only the compression brake is generally controlled by the same ECU. For this reason, we must give it more careful attention.

The following figure illustrates one of the problems. Suppose continuous limits have been applied to the engine and retarder as indicated by the rectangular boxes within the torque maps. If the engine is prohibited from allowing torque to decrease below ***x***, how can the retarder be engaged? An engine compression brake retarder needs zero fueling for the engine in order to engage. The simple answer is that if there is a minimum continuous torque limit applied to the engine, the retarder will not be engaged.

How does the reverse case behave? If the retarder is of a type other than engine compression brake, it may work against the engine and continuously produce a negative torque. Engine compression brake retarders must not send out a list of acceptable limits that would allow such conundrums. In practical terms, this means that engine compression brake retarders must set their Maximum Continuous Torque limit (think of it as MINIMUM continuous BRAKING torque limit) to zero in order for the retarder to ever be engaged. Similarly, the continuous limits as actually applied to the engine must allow zero torque if the retarder is to be engaged.

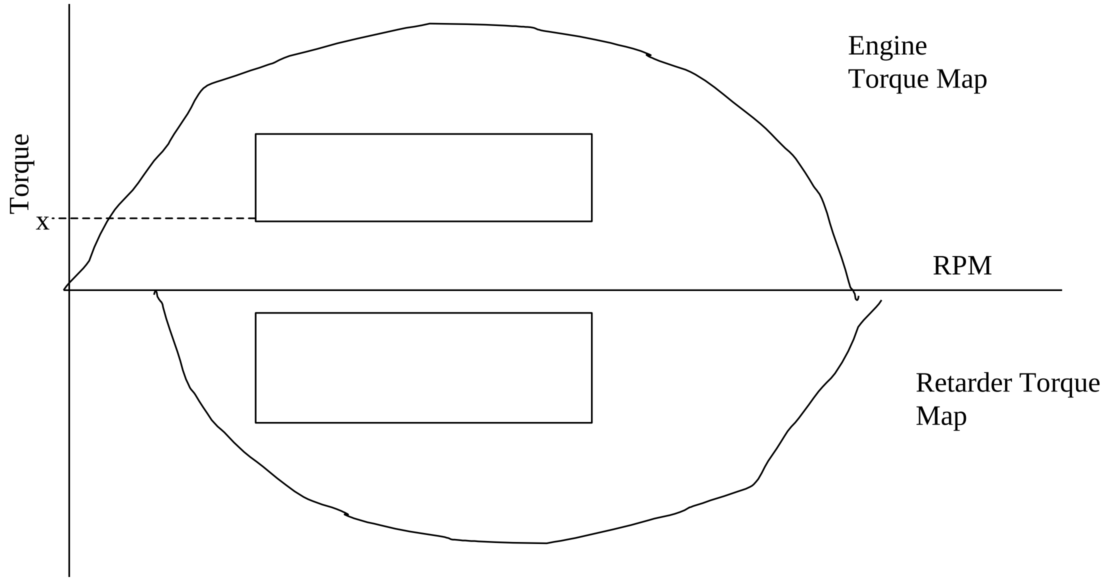


FIGURE PGN52992_C

D.31 PGN 56320 – ANTI-THEFT STATUS

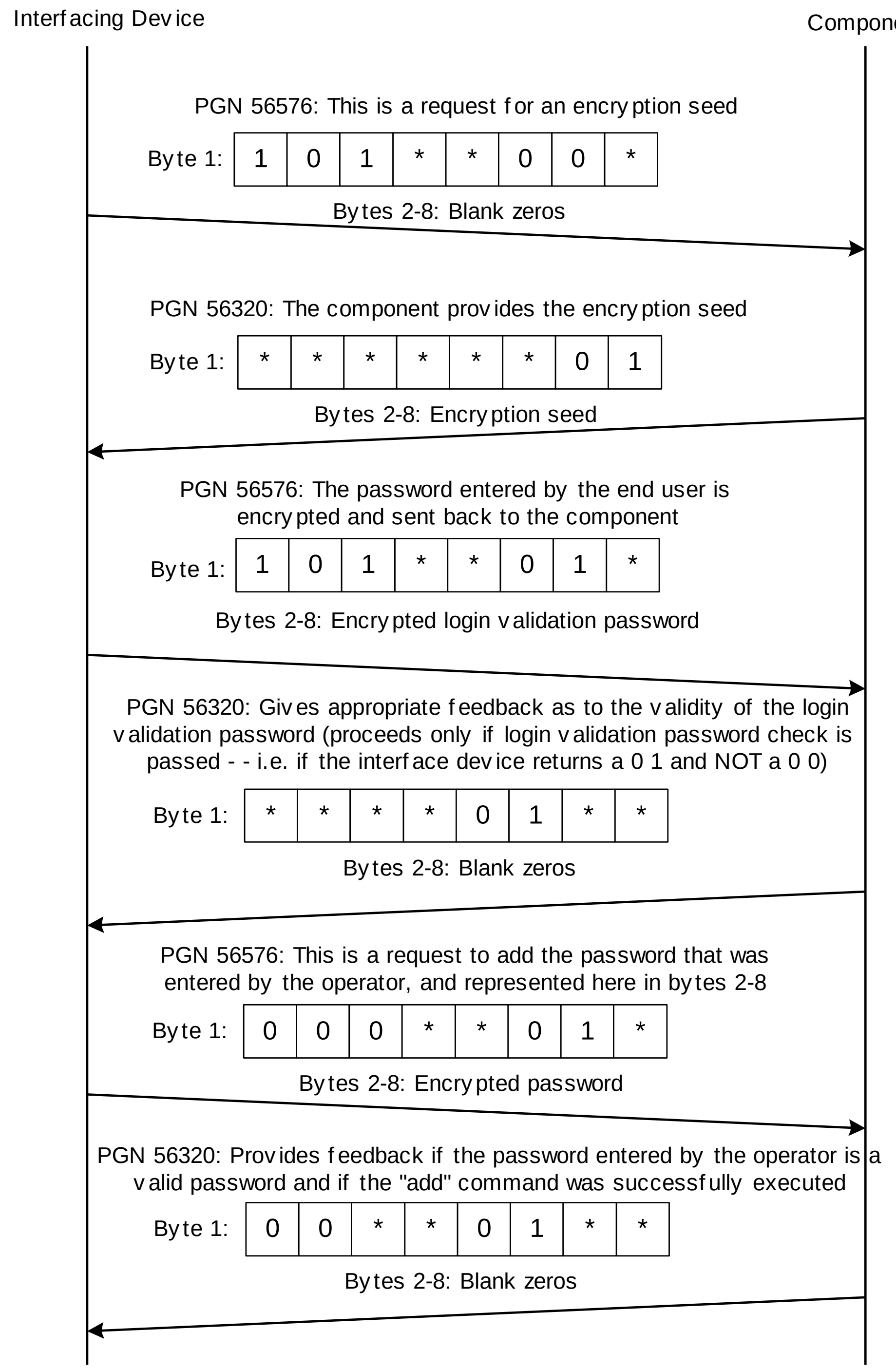


FIGURE PGN56320_A - OPERATOR DESIRES TO ADD A PASSWORD TO THE COMPONENT'S PASSWORD STRUCTURE

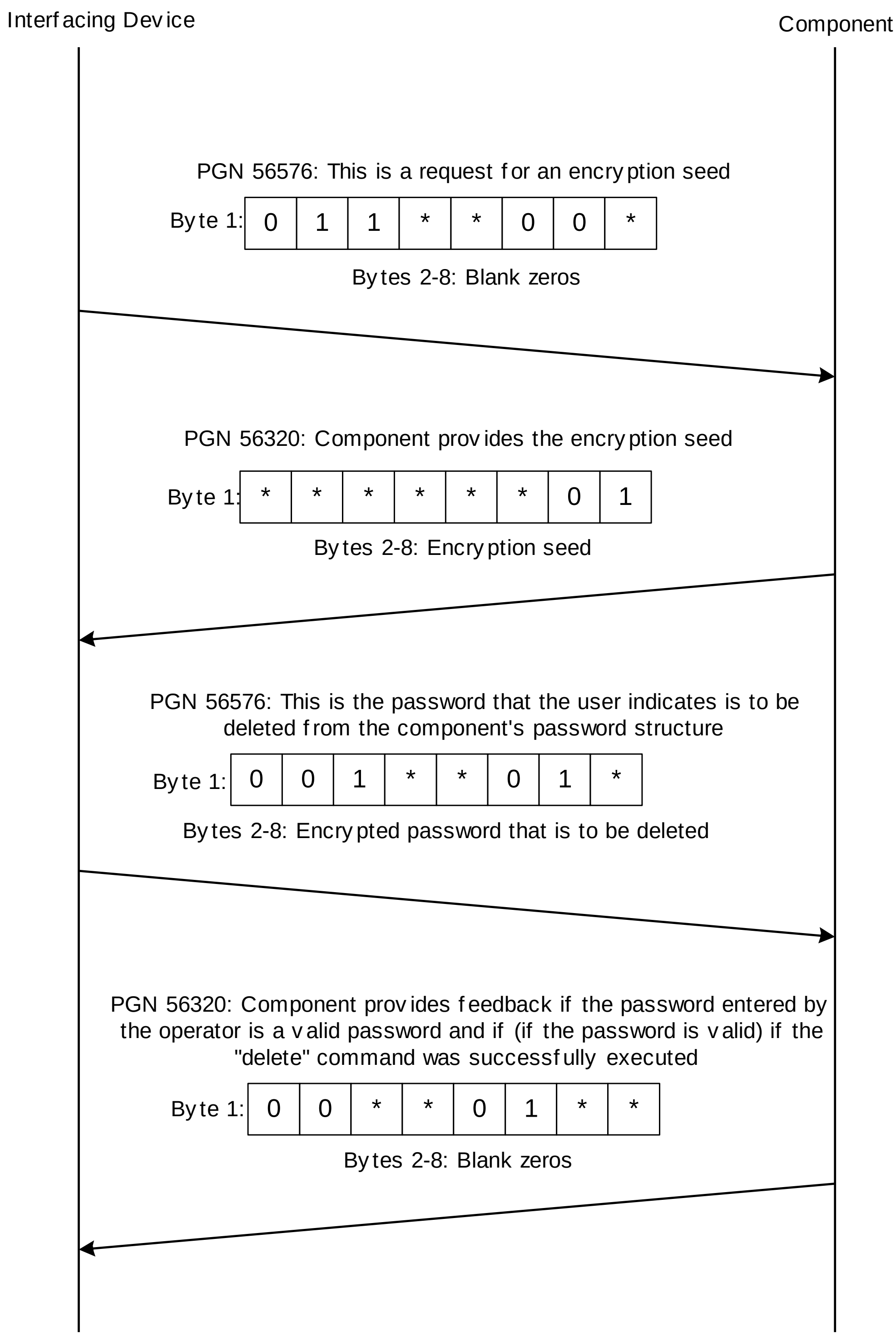


FIGURE PGN56320_B - OPERATOR DESIRES TO DELETE A PASSWORD FROM THE COMPONENT'S PASSWORD STRUCTURE

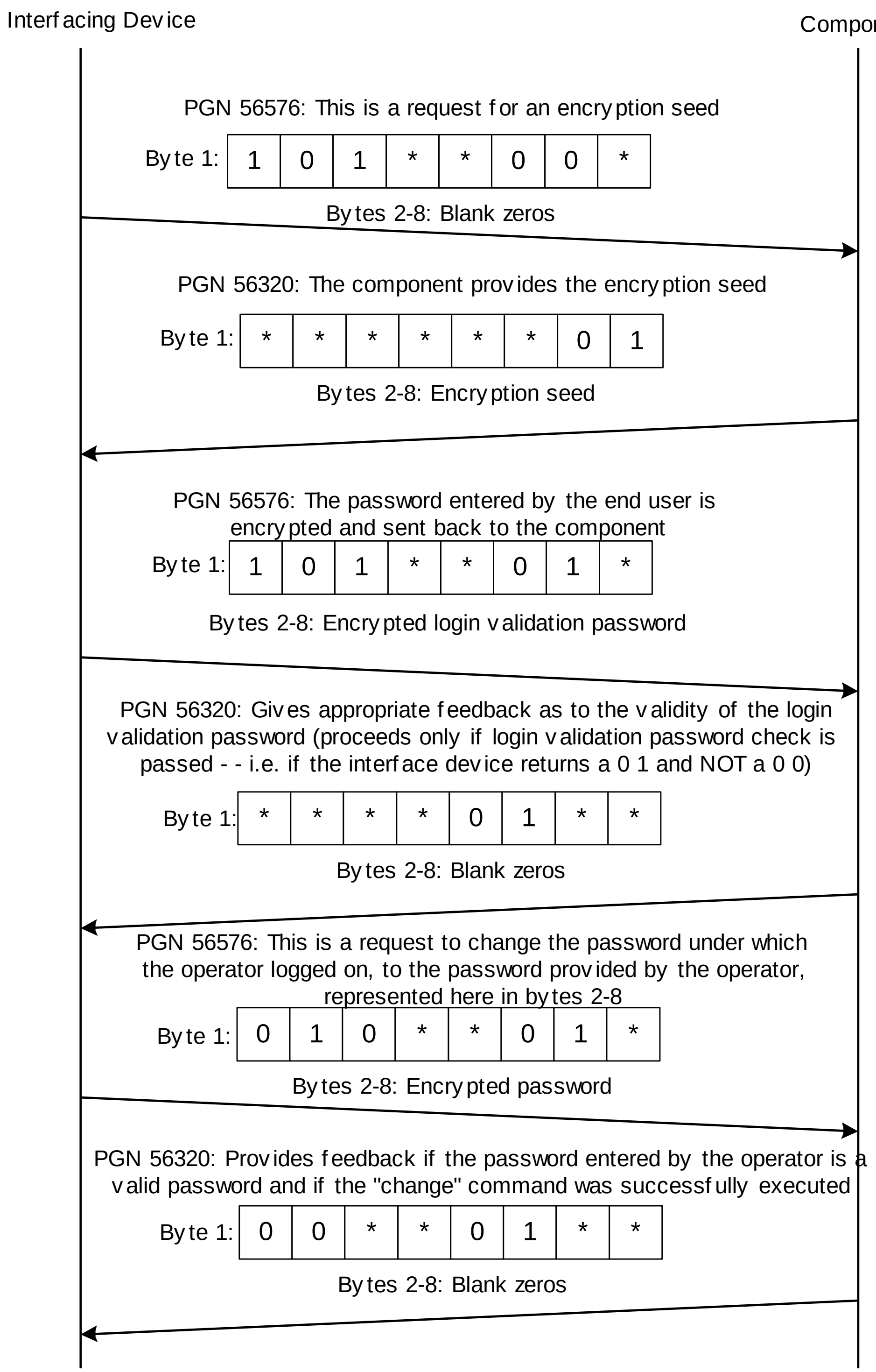


FIGURE PGN56320_C - OPERATOR DESIRES TO CHANGE A PASSWORD WITHIN THECOMPONENT'S PASSWORD STRUCTURE

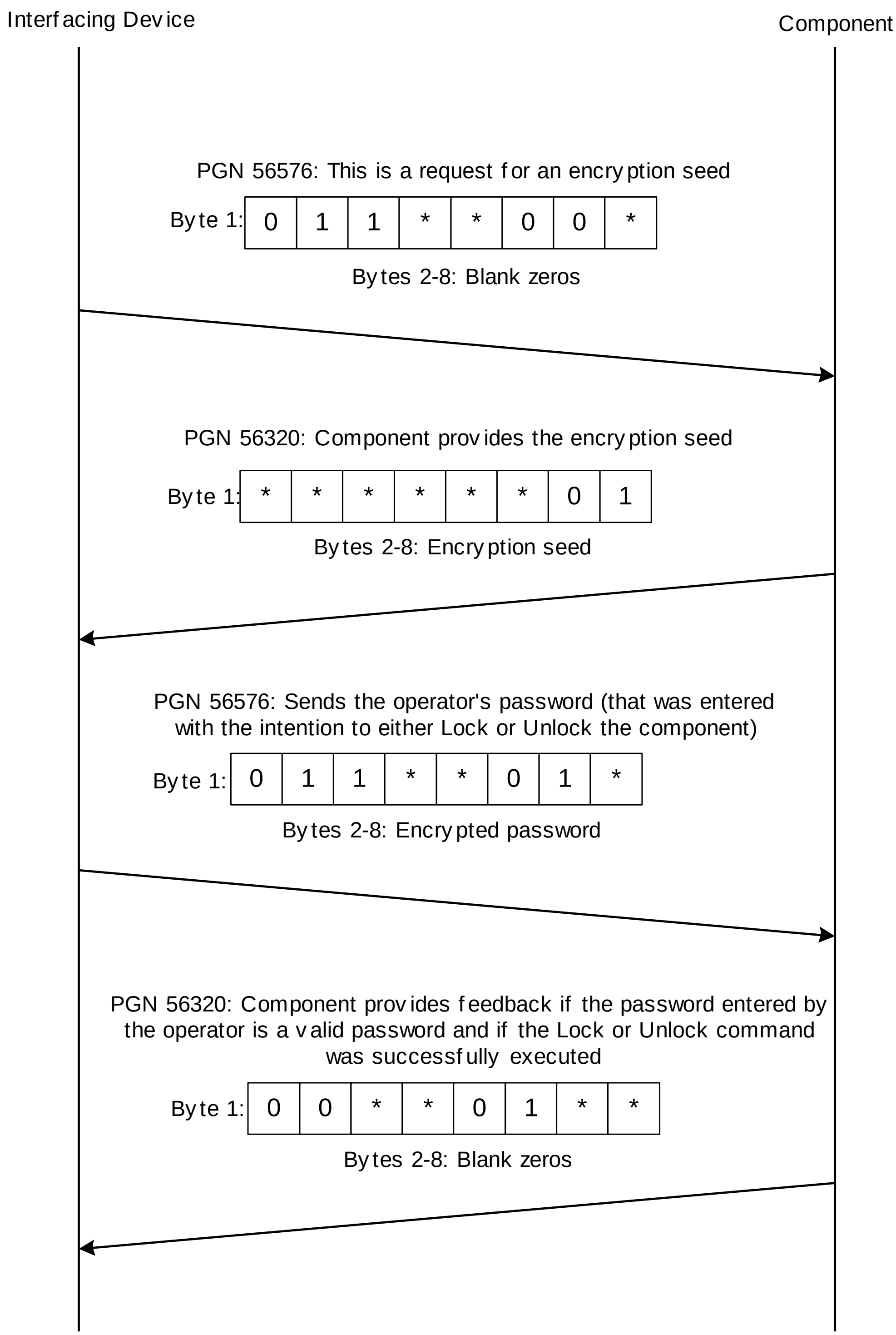


FIGURE PGN56320_D - OPERATOR DESIRES TO LOCK OR UNLOCK THE COMPONENT

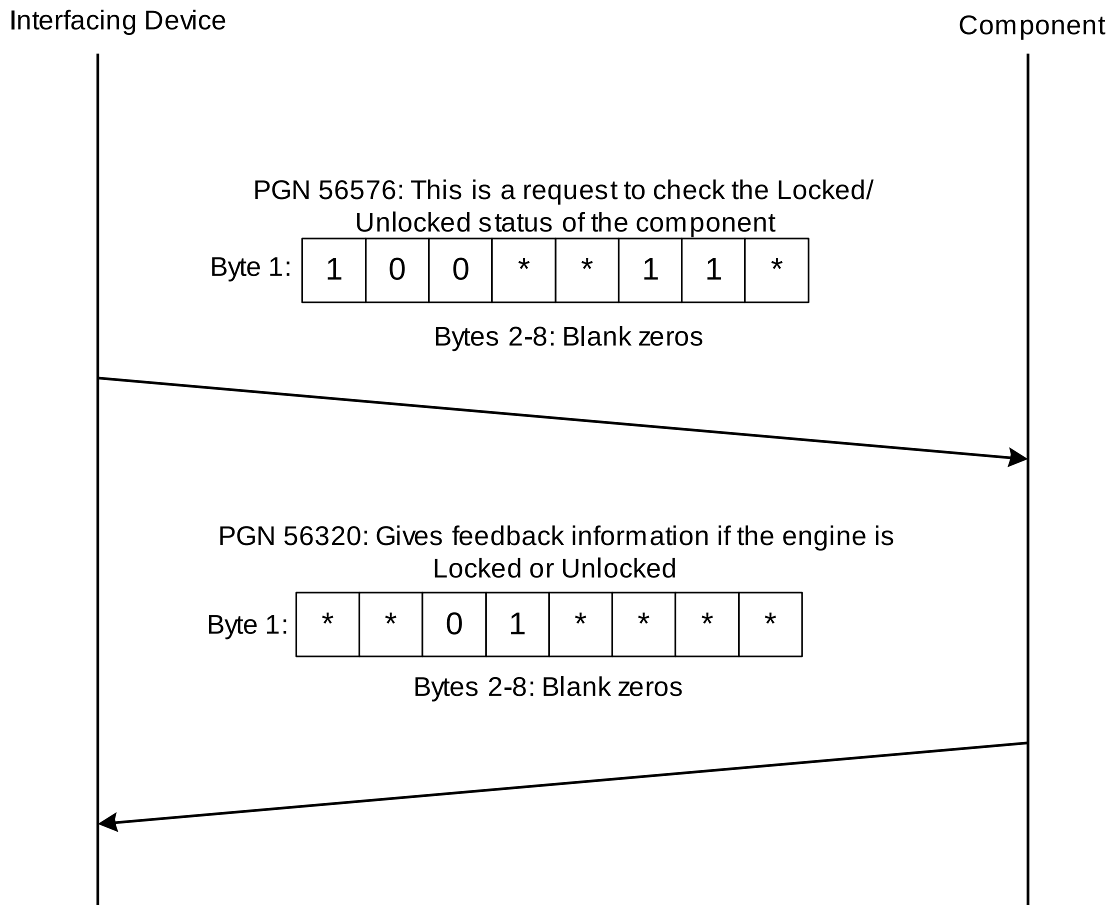


FIGURE PGN56320_E - CHECKING STATUS OF THE COMPONENT

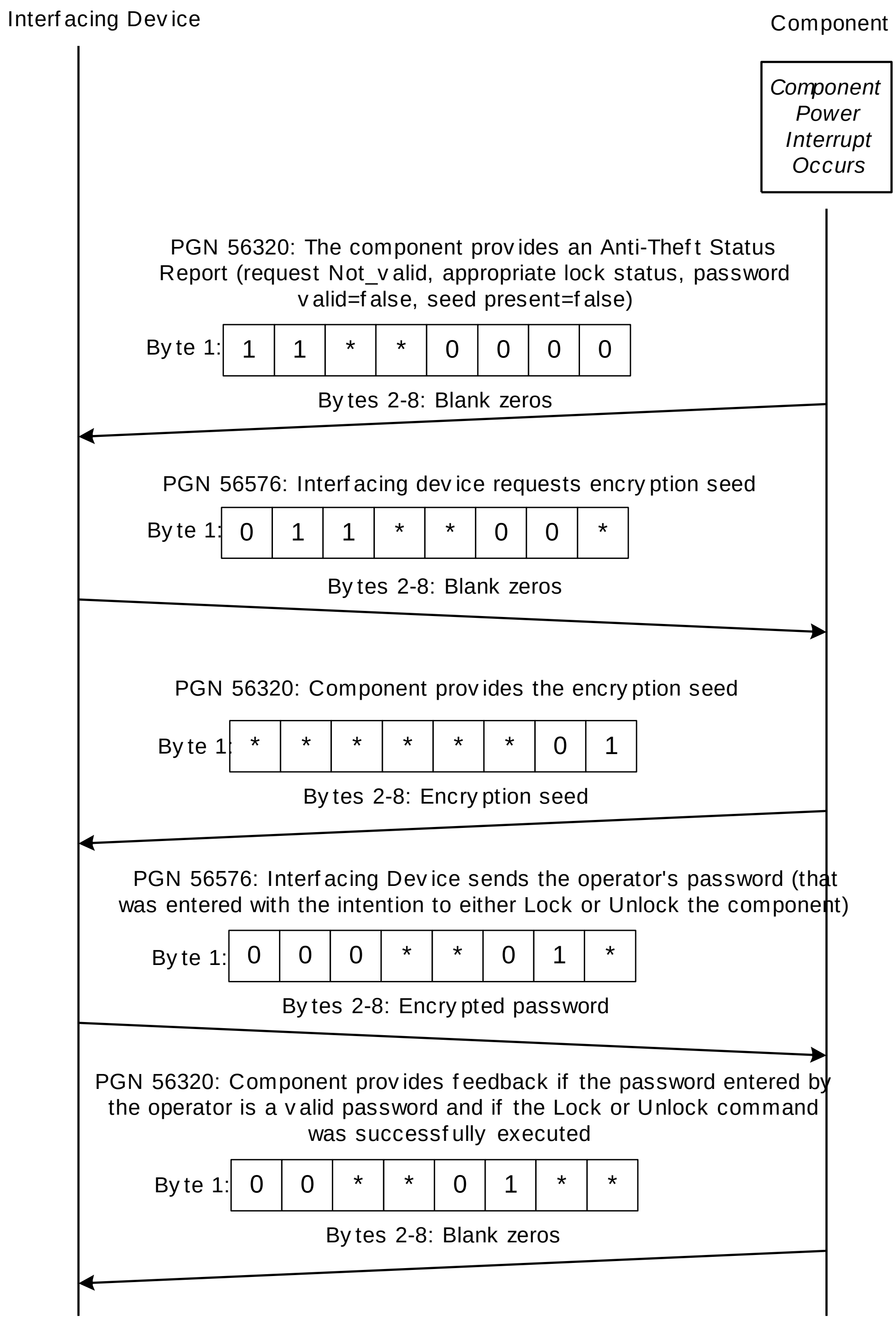


FIGURE PGN56320_F - ABNORMAL COMPONENT POWER INTERRUPTION (INTERFACING DEVICE POWER IS NOT INTERRUPTED)

D.32 PGN 61459 – SLOPE SENSOR INFORMATION

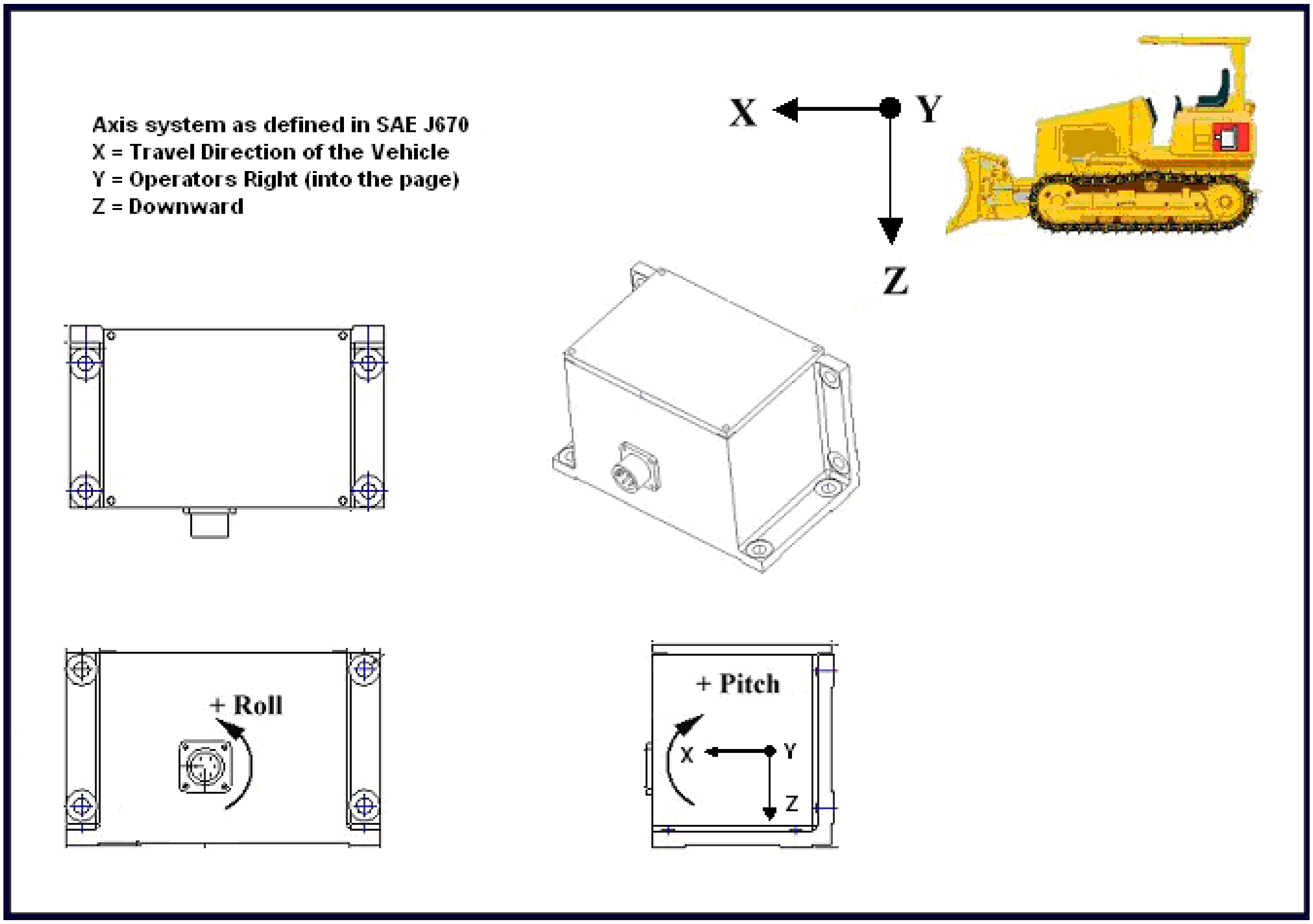


FIGURE PGN61459_A - SLOPE SENSOR ORIENTATIONS

D.33 PGN 61466 – ENGINE THROTTLE / FUEL ACTUATOR CONTROL COMMAND

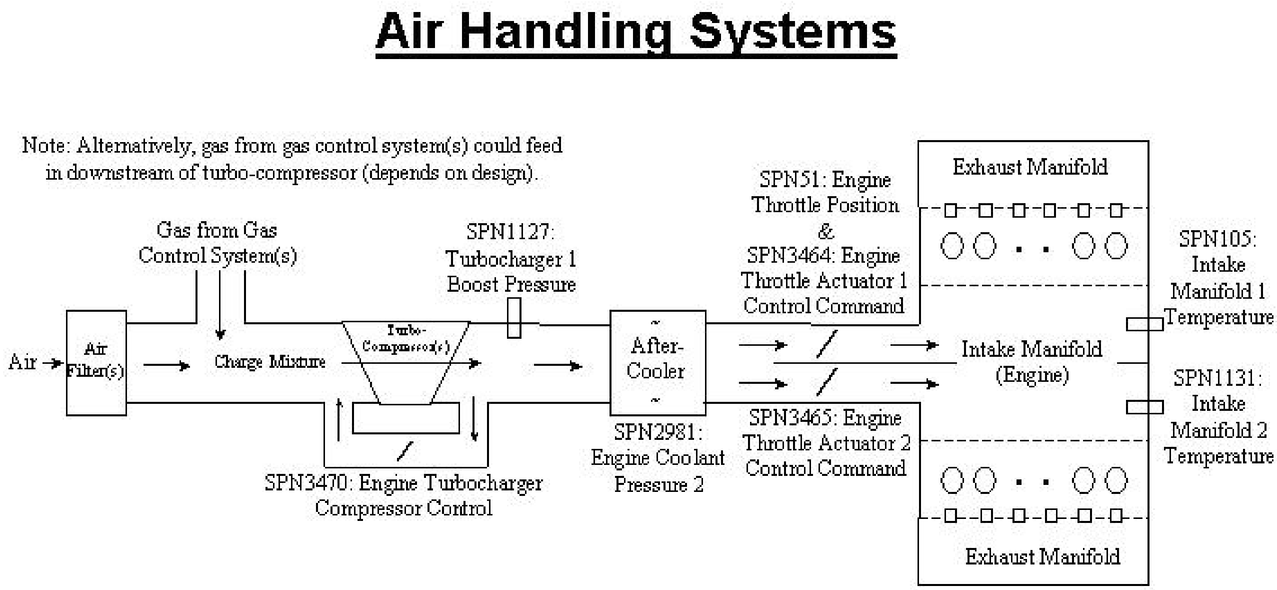


FIGURE PGN61466_A – AIR HANDLING SYSTEMS

D.34 PGN 61486 – ENGINE TURBOCHARGER CONTROL

Block diagrams showing the functionality of Blow-off, Compressor Bypass and wastegate valves.

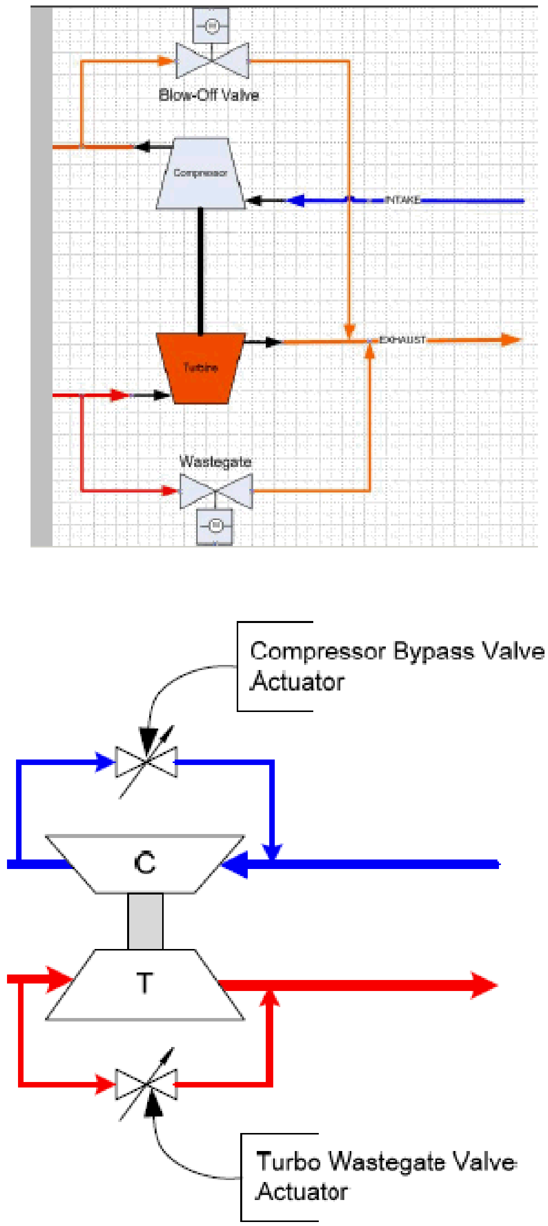


FIGURE PGN61486_A – ENGINE TURBOCHARGER CONTROL

D.35 PGN 64719 – NOX SENSOR SELF-DIAGNOSIS REQUEST

Some NOx sensors support a self-diagnosis mode. Once this self-diagnosis is initiated, it can take several seconds to execute. During this self-diagnostic period, normal data is not available. See FIGURE PGN64719_A for a typical timing schedule for NOx Sensor. Contact the sensor manufacturer for more details.

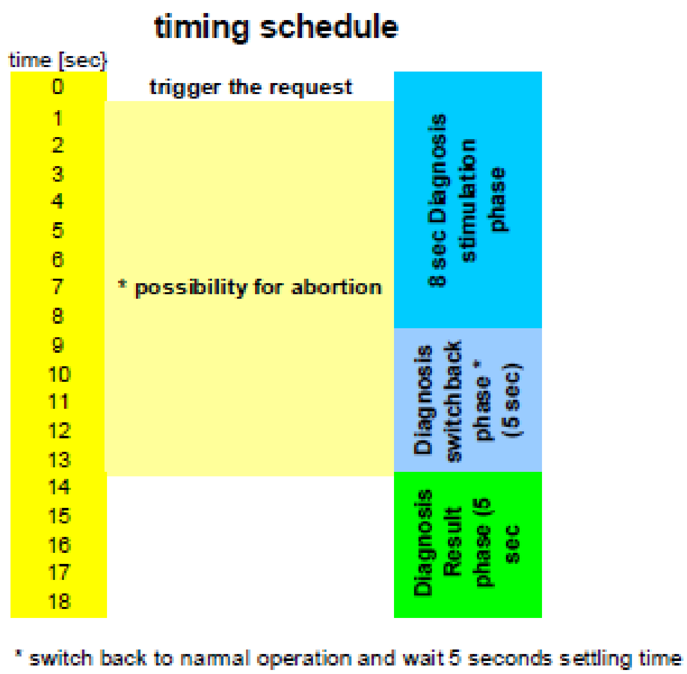


FIGURE PGN64719_A – TIMING SCHEDULE FOR NOX SENSOR SELF-DIAGNOSIS

D.36 PGN 64730 – DIESEL PARTICULATE FILTER SOOT SENSOR MEASUREMENT

The DPF Soot Loading Sensor (aka Soot Sensor) consists of a pair of antennae mounted across the DPF filter. The sensor operates by applying a signal on one antenna and measures the attenuation of the signal on the other antenna. The sensor can vary the frequency characteristics of the applied signal, thereby providing the ability to do frequency spectrum analysis of the DPF filter. The requested command and data messages provide the ability for another ECU within the system to request the attenuation measurements for 4 specific frequencies at any point in time.

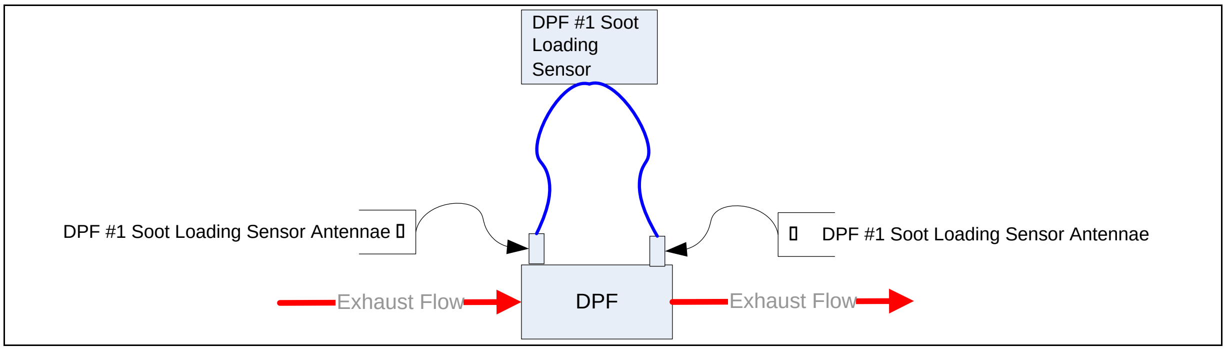


FIGURE PGN64730_A - SOOT LOADING SENSOR ANTENNAE LOCATIONS

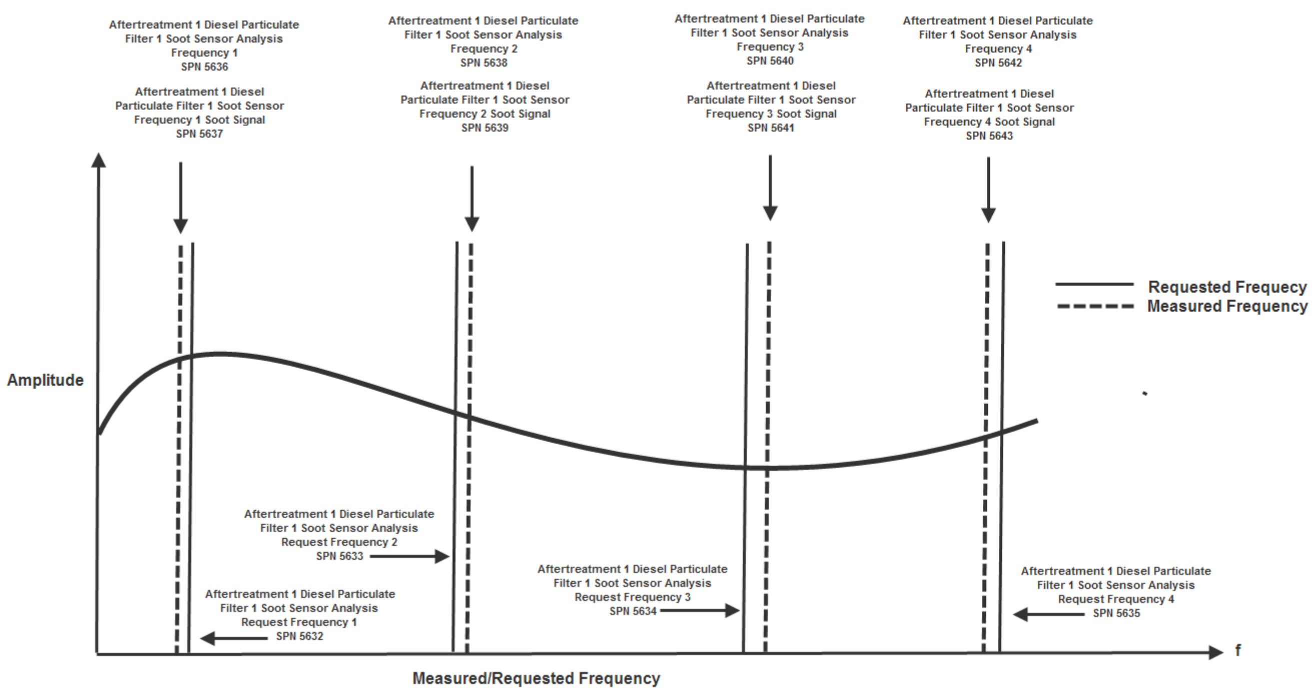


FIGURE PGN64730_B – SOOT LOADING SENSOR MEASUREMENT LOCATIONS

D.37 PGN 64739 - ENGINE EXHAUST BRAKE CONTROL

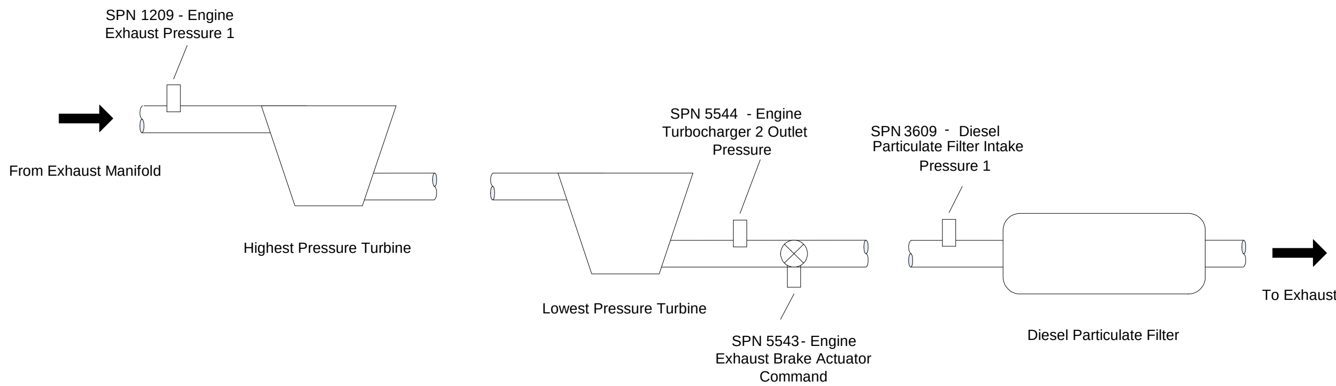


FIGURE 64739_A - ENGINE EXHAUST BRAKE CONTROL SIGNALS

D.38 PGN 64839 – TRANSMISSION MODE LABELS

Conveys ASCII ‘labels’ for each of the manufacturer-specified TC1 Transmission Mode ’x’ / ETC7 Transmission Mode Indicator ‘x’ pairs. Intended for use with on-board or service tool displays. There are up to 8 fields (for Transmission Mode 1 through Transmission Mode 8), and each is separated by an ASCII asterisk delimiter “*”. It is not necessary to include all fields; however, the delimiter is always required.

Data byte arrangement $a_1 \ldots a_x$ * $a_1 \ldots b_x$ * $c_1 \ldots c_x$ * $d_1 \ldots d_x$ * $e_1 \ldots e_x$ * $f_1 \ldots f_x$ * $g_1 \ldots g_x$ * $h_1 \ldots h_x$

…where, if applicable:

$a_1 \rightarrow a_x$	Transmission Mode Label, for Transmission Mode 1
ASCII *	Delimiter
$b_1 \rightarrow b_x$	Transmission Mode Label, for Transmission Mode 2
ASCII *	Delimiter
$c_1 \rightarrow c_x$	Transmission Mode Label, for Transmission Mode 3
ASCII *	Delimiter
$d_1 \rightarrow d_x$	Transmission Mode Label, for Transmission Mode 4
ASCII *	Delimiter
$e_1 \rightarrow e_x$	Transmission Mode Label, for Transmission Mode 5
ASCII *	Delimiter
$f_1 \rightarrow f_x$	Transmission Mode Label, for Transmission Mode 6
ASCII *	Delimiter
$g_1 \rightarrow g_x$	Transmission Mode Label, for Transmission Mode 7
ASCII *	Delimiter
$h_1 \rightarrow h_x$	Transmission Mode Label, for Transmission Mode 8

EXAMPLE: Delimiter use when label support varies:

aaaaaaaa*bbbbbbbbbbb******

*bbbbbbbb******

*bbbbbbbb**dddd****

EXAMPLE: A transmission supporting a 'NORMAL' operating mode in Transmission Mode 1, and a 'PLOW' mode in Transmission Mode 2 might send:

Data Byte:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Decimal	78	79	82	77	65	76	42	80	76	79	87	42	42	42	42	42	42
ASCII:	'N'	'O'	'R'	'M'	'A'	'L'	'*'	'P'	'L'	'O'	'W'	'*'	'*'	'*'	'*'	'*'	'*'

D.39 PGN 64906 – SAE J2012 DTC DISPLAY

Conveys basic SAE J2012 DTC information for on-board or service tool displays.

Data byte arrangement: A $B1_1$ $B2_1$ $B3_1$ $B4_1$ $B5_1$ C_1 $B1_X$ $B2_X$ $B3_X$ $B4_X$ $B5_X$ C_X . . .

…where:

Data Byte	Definition
A	Number of J2012 DTCs
$B1_X$	1st Character of J2012 DTC x
$B2_X$	2nd Character of J2012 DTC x
$B3_X$	3rd Character of J2012 DTC x
$B4_X$	4th Character of J2012 DTC x
$B5_X$	5th Character of J2012 DTC x
C_X	Bit 8: J2012 DTC Status
	Bits 7-1: J2012 DTC Occurrence Count

If PGN 64906 is requested and a supporting device has no active or inactive J2012 DTCs, PGN 64906 shall be sent as a single frame message with the first data byte (*Number of J2012 DTCs*) set to zero. When two or more J2012 DTCs are indicated, PGN 64906 must be sent via Transport Protocol (See J1939-21).

EXAMPLE: A device conveying (1) an active P1482 with 9 counts and (2) an inactive U0100 with 4 counts would populate the data bytes as follows:

Data Byte:	1	2	3	4	5	6	7	8	9	10	11	12	13
Decimal	2	80	49	52	56	50	137	85	48	49	48	48	4
ASCII:	--	'P'	'1'	'4'	'8'	'2'	--	'U'	'0'	'1'	'0'	'0'	--

D.40 PGN 64912 – ADVERTISED ENGINE TORQUE CURVE

This map conveys the advertised torque curve for the engine, as typically seen on specification sheets available from most engine manufacturers. The collection conditions for the data conveyed are indicated by SPN 3558 – AETC Data Collection Standard.

This map does not contain dynamic elements, and does not change during engine operation. For engines capable of dynamically switching between torque curves or ratings during operation, this map contains values for the highest (most powerful) rating. This map is not intended for use in real time engine control, but merely to indicate what engine rating is installed in the vehicle.

Data points on the curve are in order from left to right, and, at a minimum, must span from the lowest rpm where peak torque can be produced to the high speed governor breakpoint. SPN 3559 – Number of AETC Data Points indicates the number of data points being sent. A minimum of 5 points must be supported, with up to 15 available as needed to properly convey the shape of the torque curve. As illustrated below, speed values need not be evenly incremented.

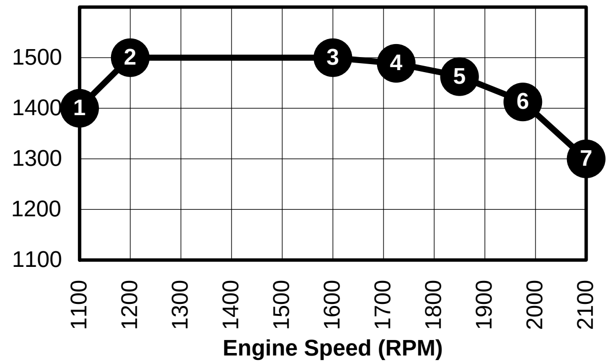


FIGURE PGN64912_A - ADVERTISED ENGINE TORQUE CURVE

D.41 PGN 64932 – PTO DRIVE ENGAGEMENT

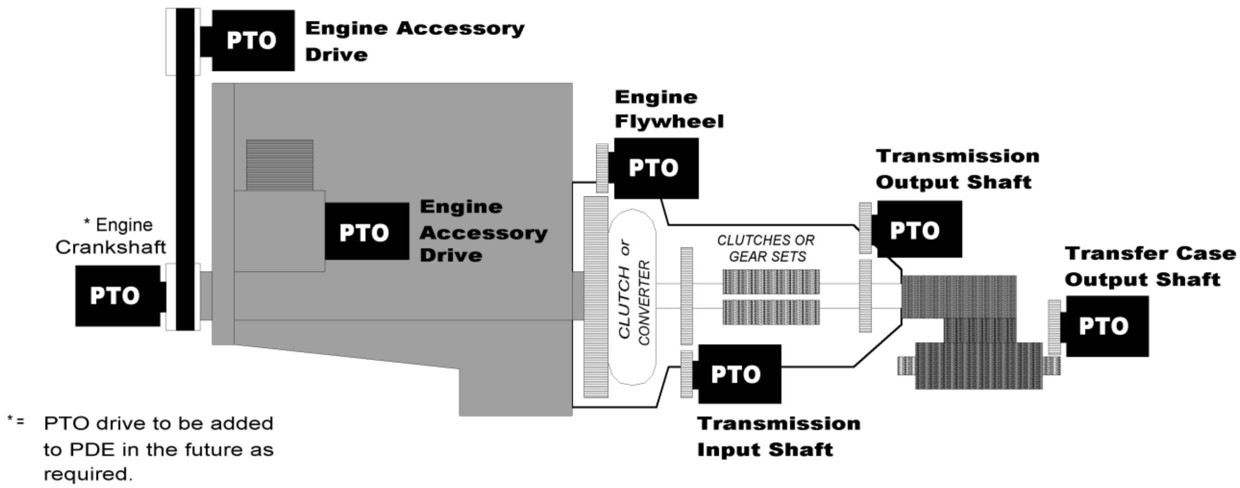


FIGURE PGN64932_A - PTO DRIVE ENGAGEMENT LOCATIONS

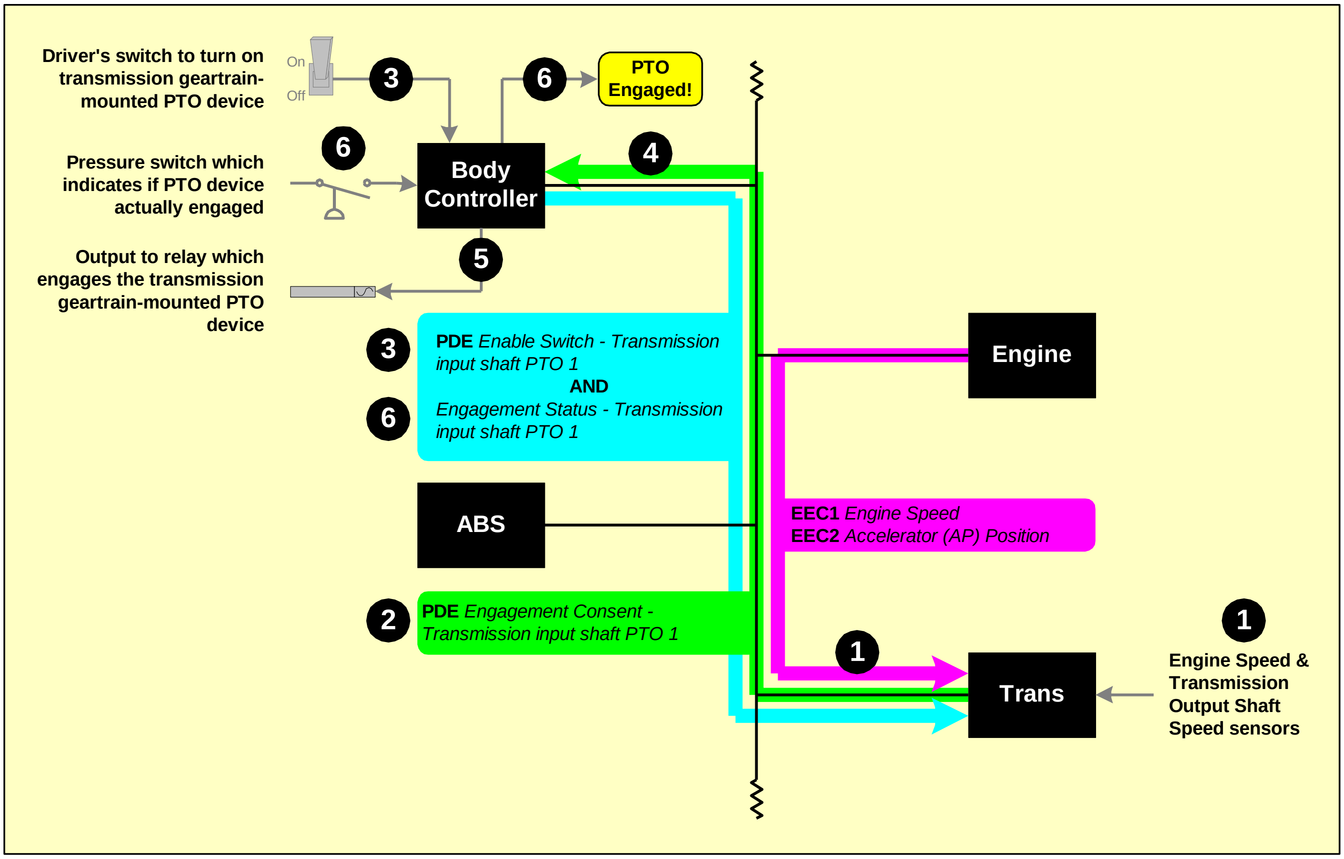


FIGURE PGN64932_B - VEHICLE OEM CONTROLLER INTERFACES WITH ALL PTO WIRING

More ideal from an OEM standpoint, as they no longer need any specialized PTO wiring for different makes of transmissions.

1. The transmission continually monitors the conditions it requires before its PTO drive can be engaged. This may include internal sensors as well as data collected from the network, such as accelerator pedal position.
2. Regardless of whether the operator has requested PTO engagement, the ‘engagement consent’ status is continually broadcast by the transmission.
3. The operator turns on the cab switch to activate the PTO device mounted on the transmission. The Body Controller reflects this switch status in its PDE message broadcast; the transmission or other devices on the network may choose to use this information in their control logic.
4. Among its conditions and inputs required before engaged the PTO drive, the Body Controller checks the ‘consent’ status broadcast from the transmission.
5. If conditions are acceptable, the Body Controller power the circuit to engage the PTO mounted on the transmission.
6. The Body Controller monitors the progress of the physical PTO engagement, and reflects this in its PDE broadcast so that other on the network may use the information.
7. The Body Controller continues to monitor the transmissions ‘consent’ broadcast, and disengages the PTO if at any time the transmission rescinds its consent.

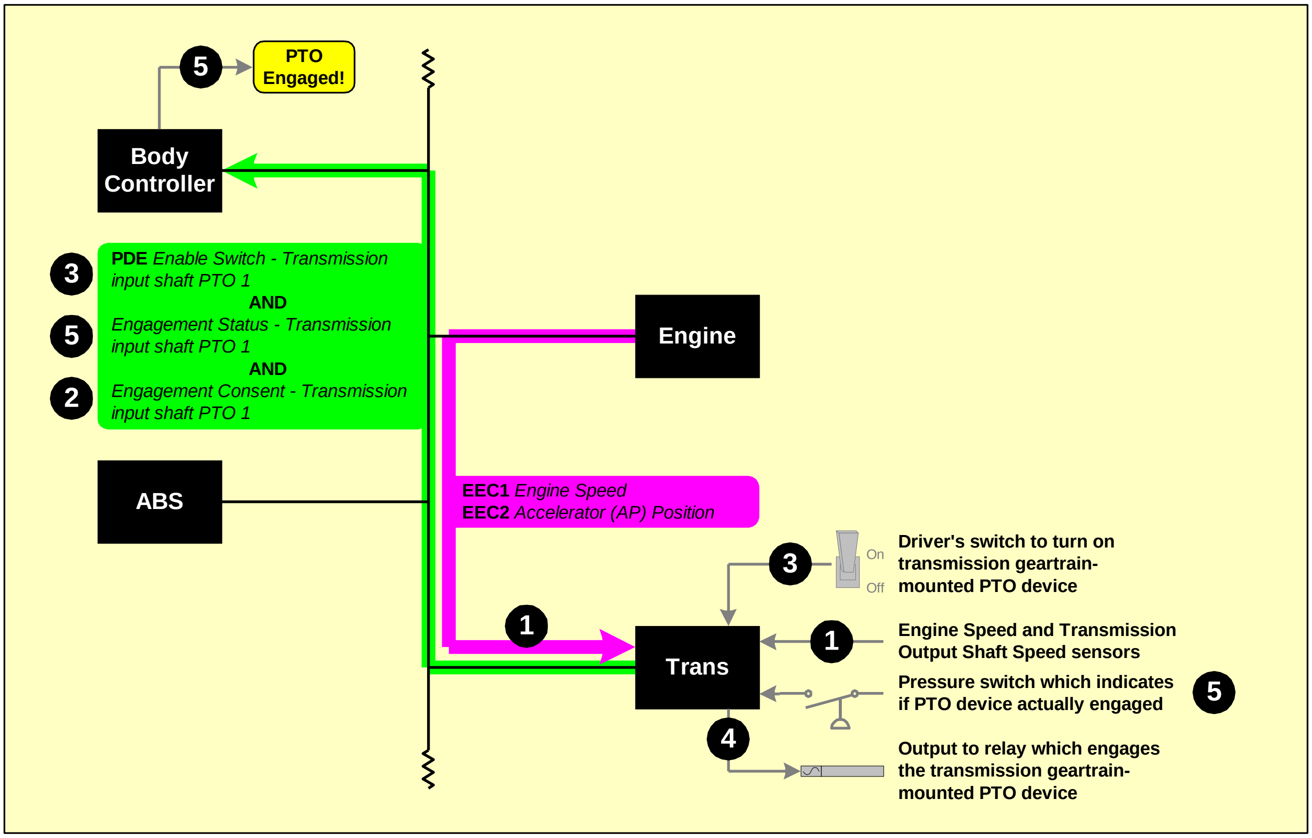


FIGURE PGN64932_C – COMPONENT DRIVING PTO INTERFACES WITH ALL PTO WIRING

This arrangement might be better suited for small OEMs who would rather not deal with figuring out the PTO wiring.

The key point is that the PTO Engagement message structure would adapt to either configuration. Note that the Body Controller broadcasts no new messages; only the transmission sends the PDE message.

1. The transmission continually monitors the conditions it requires before its PTO drive can be engaged. This may include internal sensors as well as data collected from the network, such as accelerator pedal position.
2. Regardless of whether the operator has requested PTO engagement, the ‘engagement consent’ status is continually broadcast by the transmission.
3. The operator turns on the cab switch to activate the PTO device mounted on the transmission. The Transmission Controller reflects this switch status in its PDE message broadcast; the Body Controller or other devices on the network may choose to use this information in their control logic.
4. If conditions are acceptable, the Transmission Controller power the circuit to engage the PTO mounted on the transmission.
5. The Transmission Controller monitors the progress of the physical PTO engagement, and reflects this in its PDE broadcast so that other on the network may use the information.

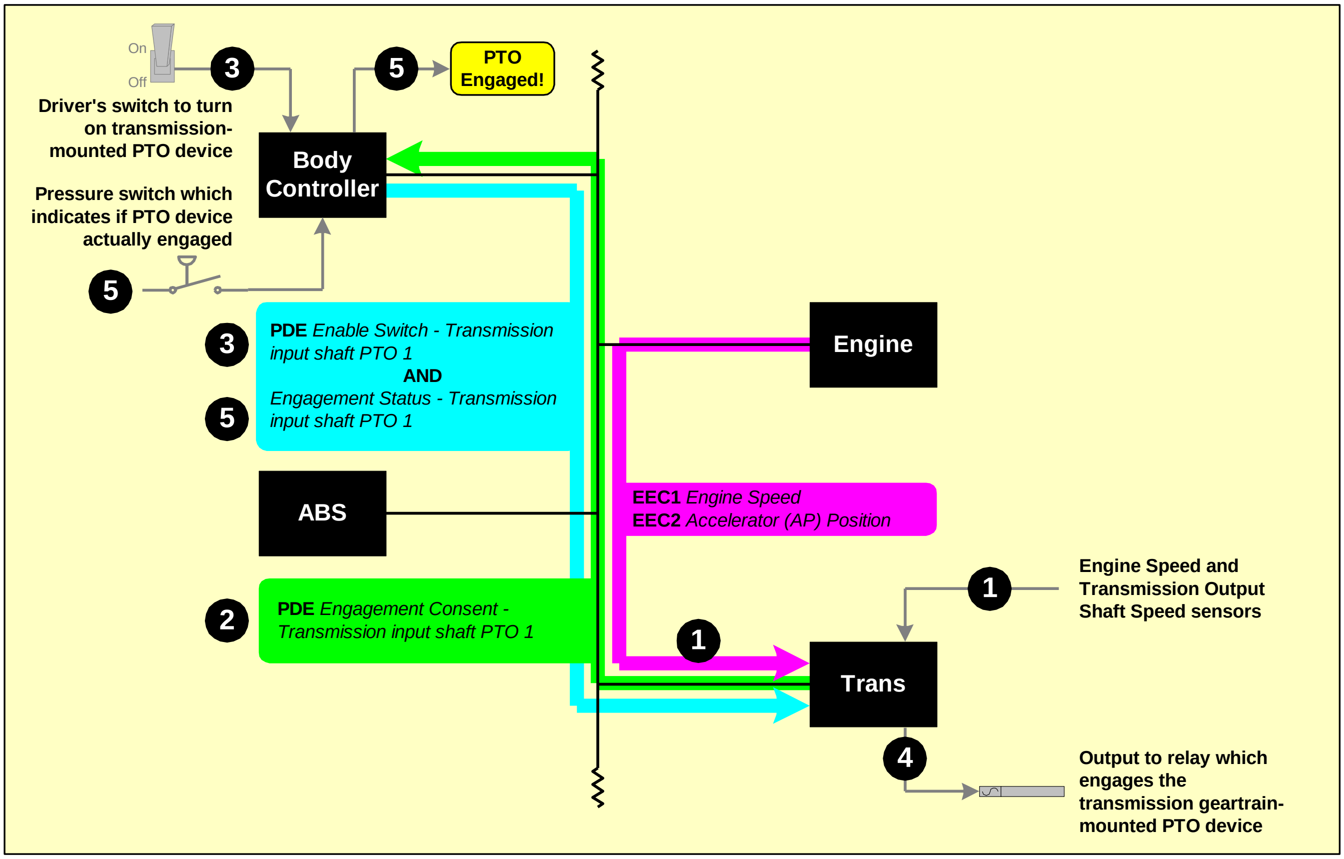


FIGURE PGN64932_D – DISTRIBUTED PTO INTERFACES WIRING

This arrangement is shown to illustrate the flexibility of the PDE messaging.

The various inputs are distributed among two or three controllers that are part of the PTO engagement system.

1. The transmission continually monitors the conditions it requires before its PTO drive can be engaged. This may include internal sensors as well as data collected from the network, such as throttle position.
2. Regardless of whether the operator has requested PTO engagement, the ‘engagement consent’ status is continually broadcast by the transmission.
3. The operator turns on the cab switch to activate the PTO device mounted on the transmission. The Body Controller reflects this switch status in its PDE message broadcast; the Transmission Controller receives this input.
4. If conditions are acceptable, the Transmission Controller power the circuit to engage the PTO mounted on the transmission.
5. The Body Controller monitors the progress of the physical PTO engagement, and reflects this in its PDE broadcast so that other on the network may use the information.

D.42 PGN 64938 – ENGINE FLUID, LEVEL AND PRESSURE 4

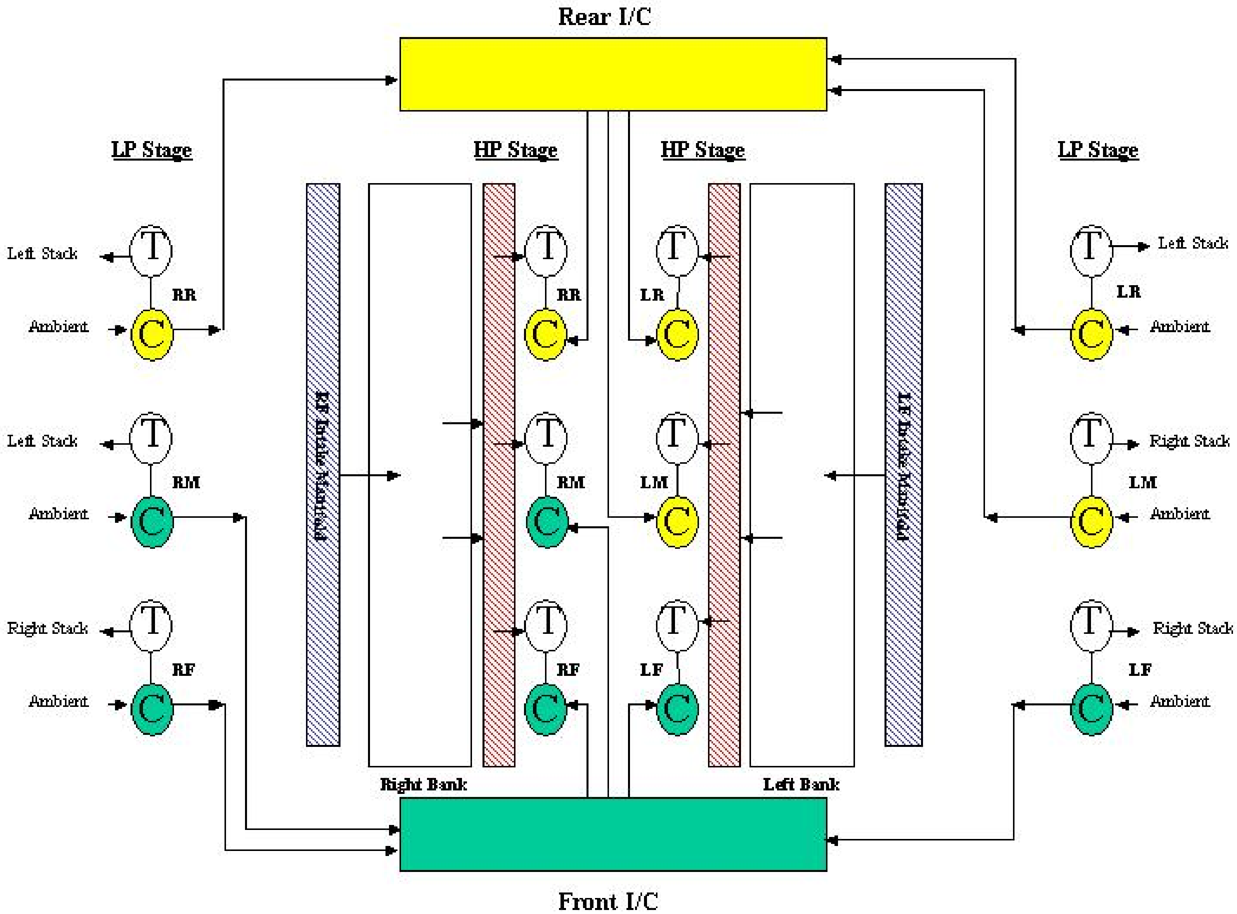


FIGURE PGN64938_A - ENGINE CHARGE AIR COOLER PRESSURES

D.43 PGN 64948 – AFTERTREATMENT SYSTEMS

The diagram illustrates an aftertreatment configuration that consists of a Warm Up Diesel Oxidation Catalyst, a Diesel Oxidation Catalyst, and a Diesel Particulate Filter. An optional component is displayed within the dashed lines.

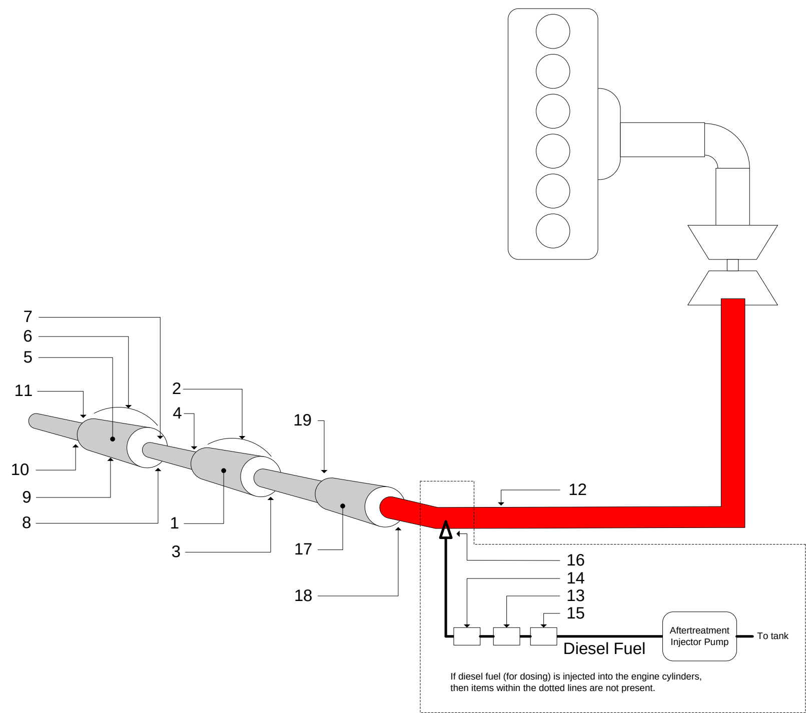


FIGURE PGN64948_A - CONFIGURATION SHOWING WARM UP DIESEL OXIDATION CATALYST, DIESEL OXIDATION CATALYST, AND DIESEL PARTICULATE FILTER

Numerical Identifer in FIGURE PGN64948_A	**Parameter Name**	**Example: J1939 SPN**
1	Aftertreatment Diesel Oxidation Catalyst	5018
2	Aftertreatment Diesel Oxidation Catalyst Differential Pressure	4767
3	Aftertreatment Diesel Oxidation Catalyst Intake Temperature	4765
4	Aftertreatment Diesel Oxidation Catalyst Outlet Temperature	4766
5	Aftertreatment Diesel Particulate Filter	3936
6	Aftertreatment Diesel Particulate Filter Differential Pressure	3251
7	Aftertreatment Diesel Particulate Filter Intake Pressure	3609
8	Aftertreatment Diesel Particulate Filter Intake Temperature	3242
9	Aftertreatment Diesel Particulate Filter Intermediate Gas Temperature	3250
10	Aftertreatment Diesel Particulate Filter Outlet Pressure	3610
11	Aftertreatment Diesel Particulate Filter Outlet Temperature	3246
12	Aftertreatment 1 Exhaust Gas Temperature 1	3241
13	Aftertreatment Fuel Drain Actuator	4097
14	Aftertreatment Fuel Pressure	3480
15	Aftertreatment Fuel Shutoff Valve	3482
16	Aftertreatment Hydrocarbon Doser	3556
17	Aftertreatment Warm Up Diesel Oxidation Catalyst	4791
18	Aftertreatment Warm Up Diesel Oxidation Catalyst Intake Temperature	4809
19	Aftertreatment Warm Up Diesel Oxidation Catalyst Outlet Temperature	4810

D.44 PGN 64966 – COLD START AIDS

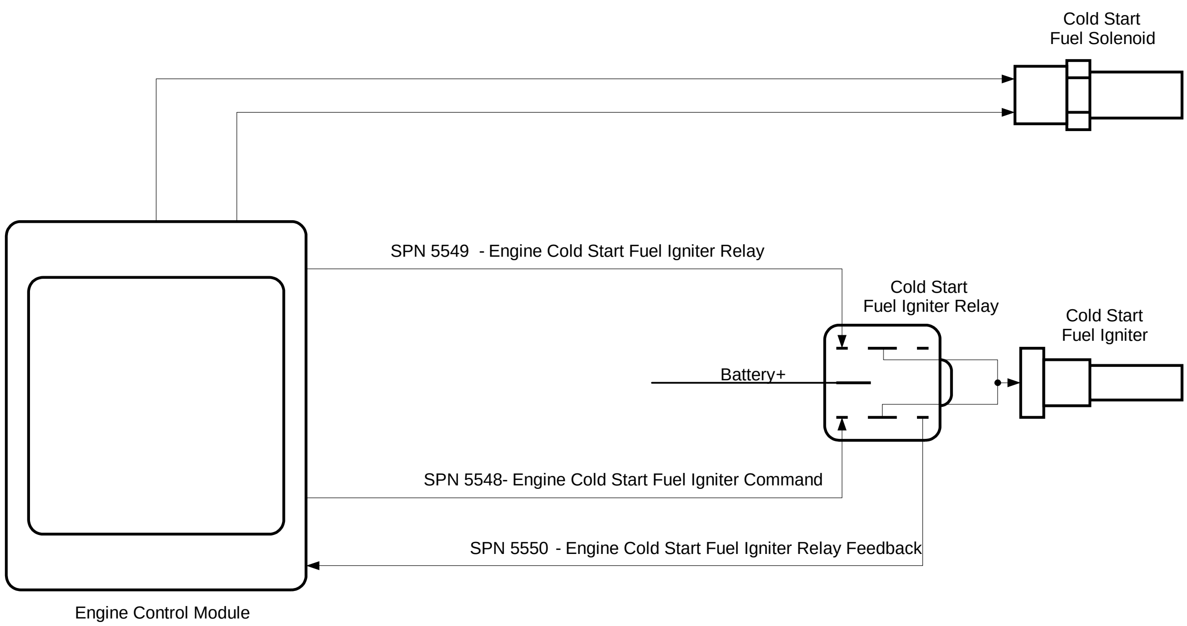
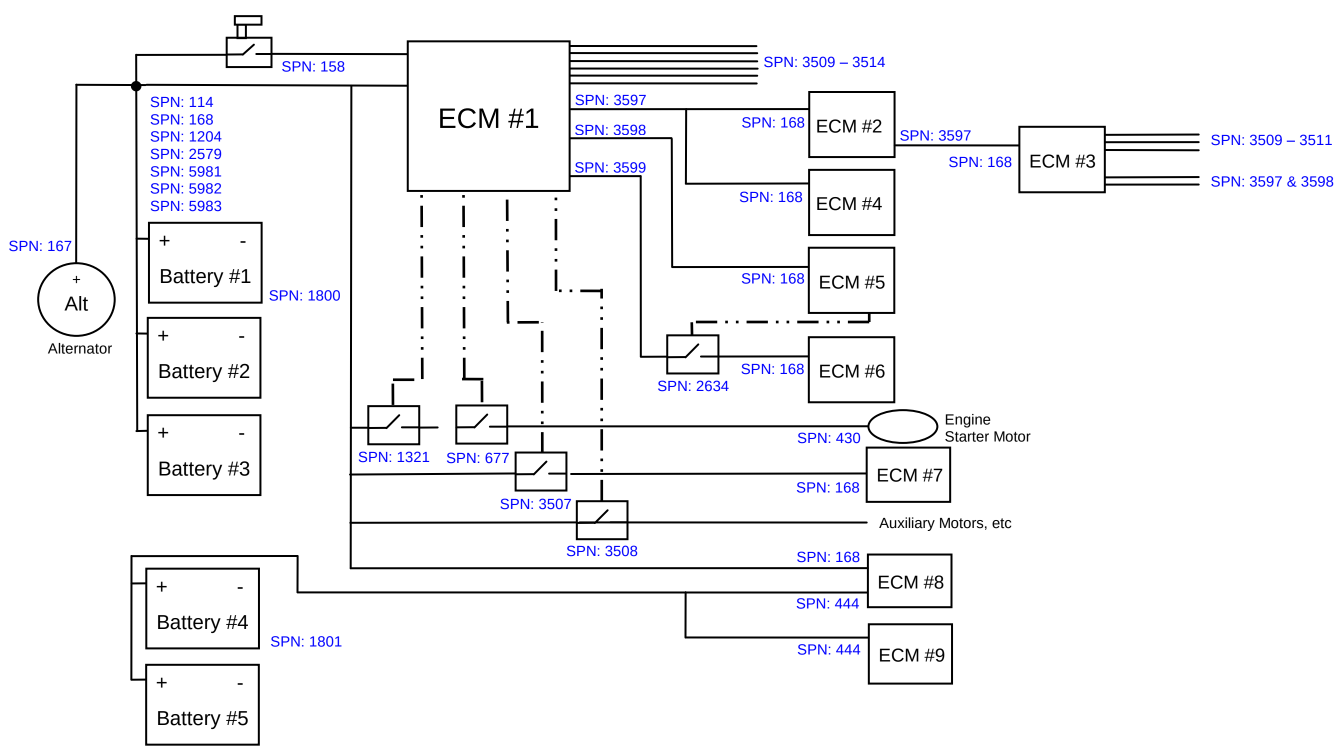


FIGURE 64966_A - COLD START AID SIGNALS

D.45 PGN 65104 – BATTERY INFORMATION



Note: The ECMs shown in this diagram could represent an ECM, or any intelligent device that is capable of diagnostics.

FIGURE PGN65104_A - BATTERY INFORMATION

SPN	SPN Name	SPN	SPN Name
114	Net Battery Current	3507	TECU ECU_PWR relay
115	Alternator Current	3508	TECU PWR Relay
158	Keyswitch Battery Potential	3509	Sensor supply voltage 1
167	Charging System Potential (Voltage)	3510	Sensor supply voltage 2
168	Battery Potential / Power Input 1	3511	Sensor supply voltage 3
430	Engine Starter Solenoid Voltage	3512	Sensor supply voltage 4
444	Battery Potential / Power Input 2	3513	Sensor supply voltage 5
677	Engine Starter Motor Relay	3514	Sensor supply voltage 6
1204	Electrical Load	3597	ECU Power Output Supply Voltage #1
1321	Engine Starter Solenoid Lockout Relay Driver Circuit	3598	ECU Power Output Supply Voltage #2
1795	Alternator Current (High Range/Resolution)	3599	ECU Power Output Supply Voltage #3
1800	Battery 1 Temperature	5981	Battery Pack State of Charge
1801	Battery 2 Temperature	5982	Battery Pack Capacity
2579	Net Battery Current (High Range/Resolution)	5983	Battery Pack Health
2634	Power Relay		

FIGURE PGN65104_B - BATTERY INFORMATION LEGEND

D.46 PGN 65135 – ADAPTIVE CRUISE CONTROL

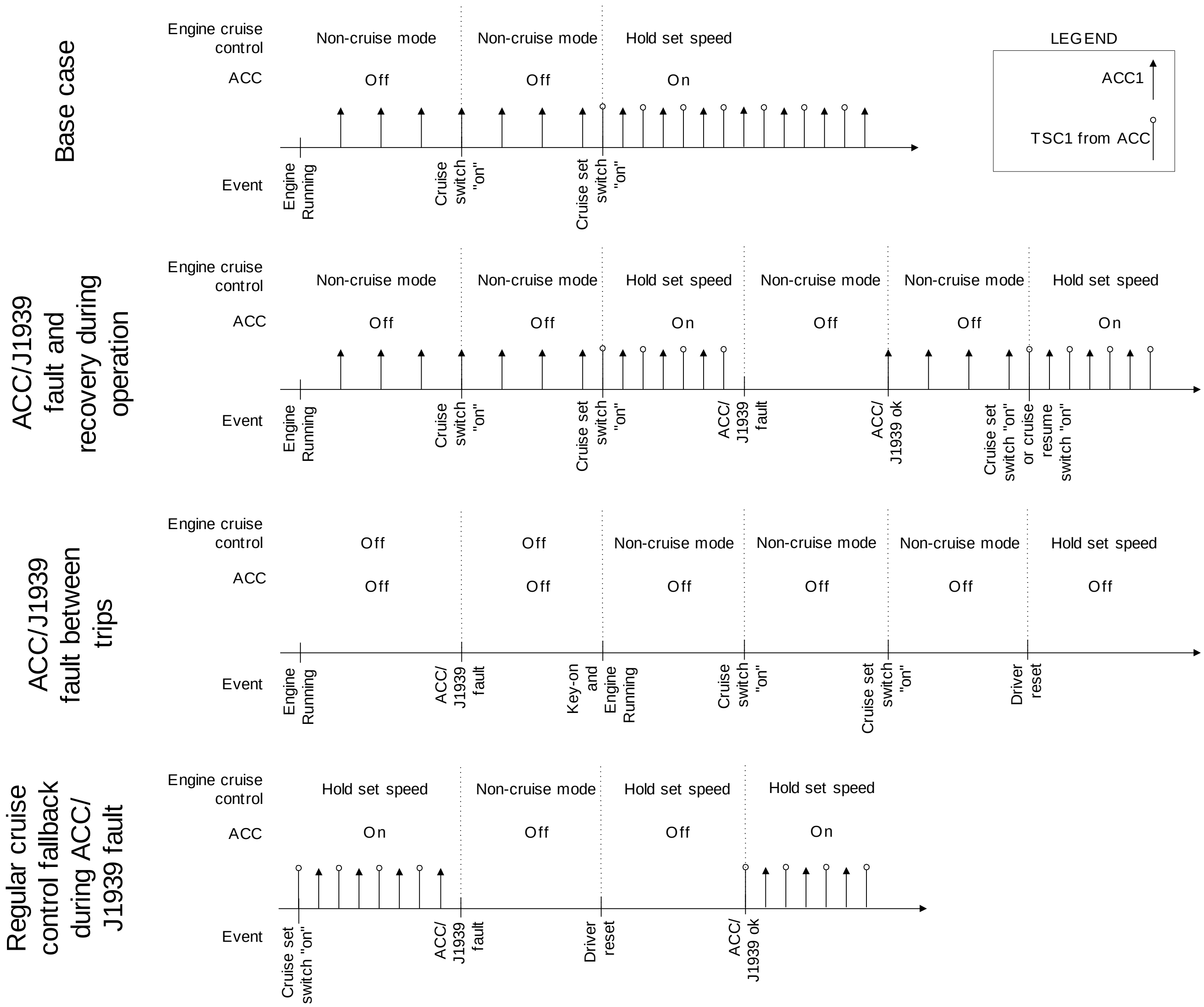


FIGURE PGN65135_A – ADAPTIVE CRUISE CONTROL TIMING DIAGRAM

D.47 PGN 65163 – GASEOUS FUEL PRESSURE

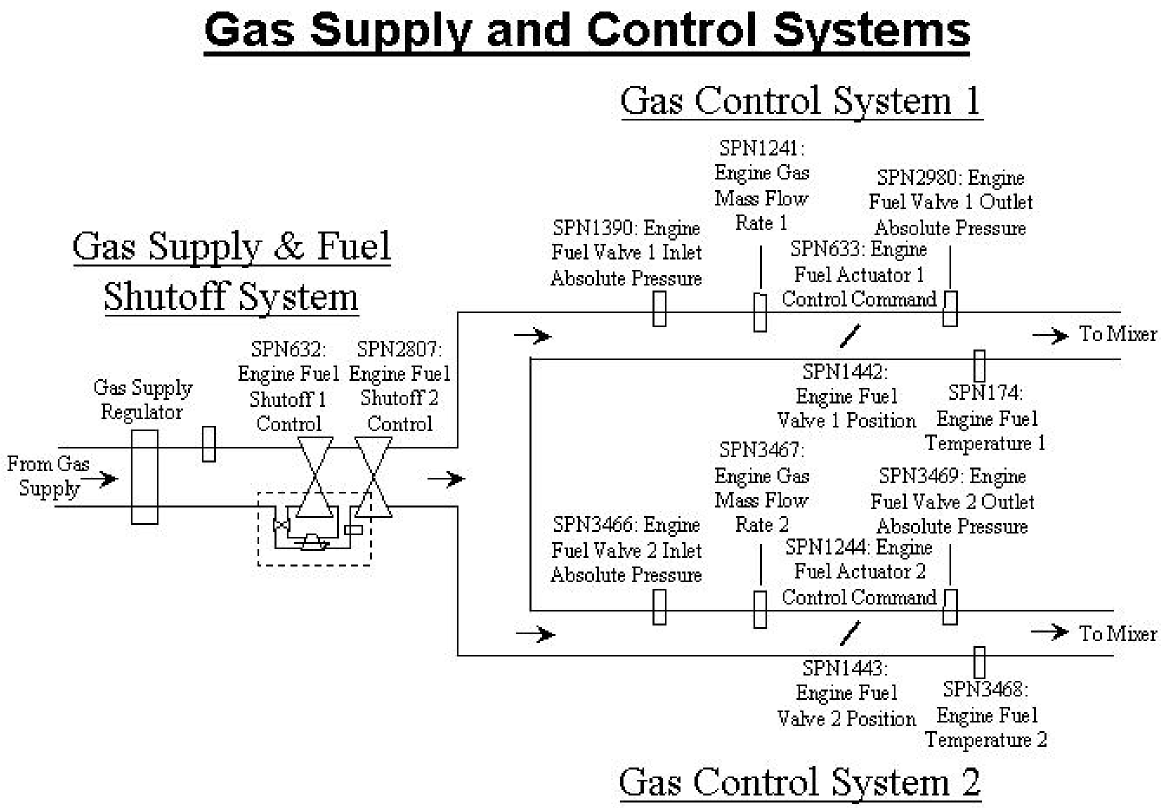


FIGURE PGN65163_A - GAS SUPPLY AND CONTROL SYSTEMS

D.48 PGN 65190 – TURBOCHARGER INFORMATION

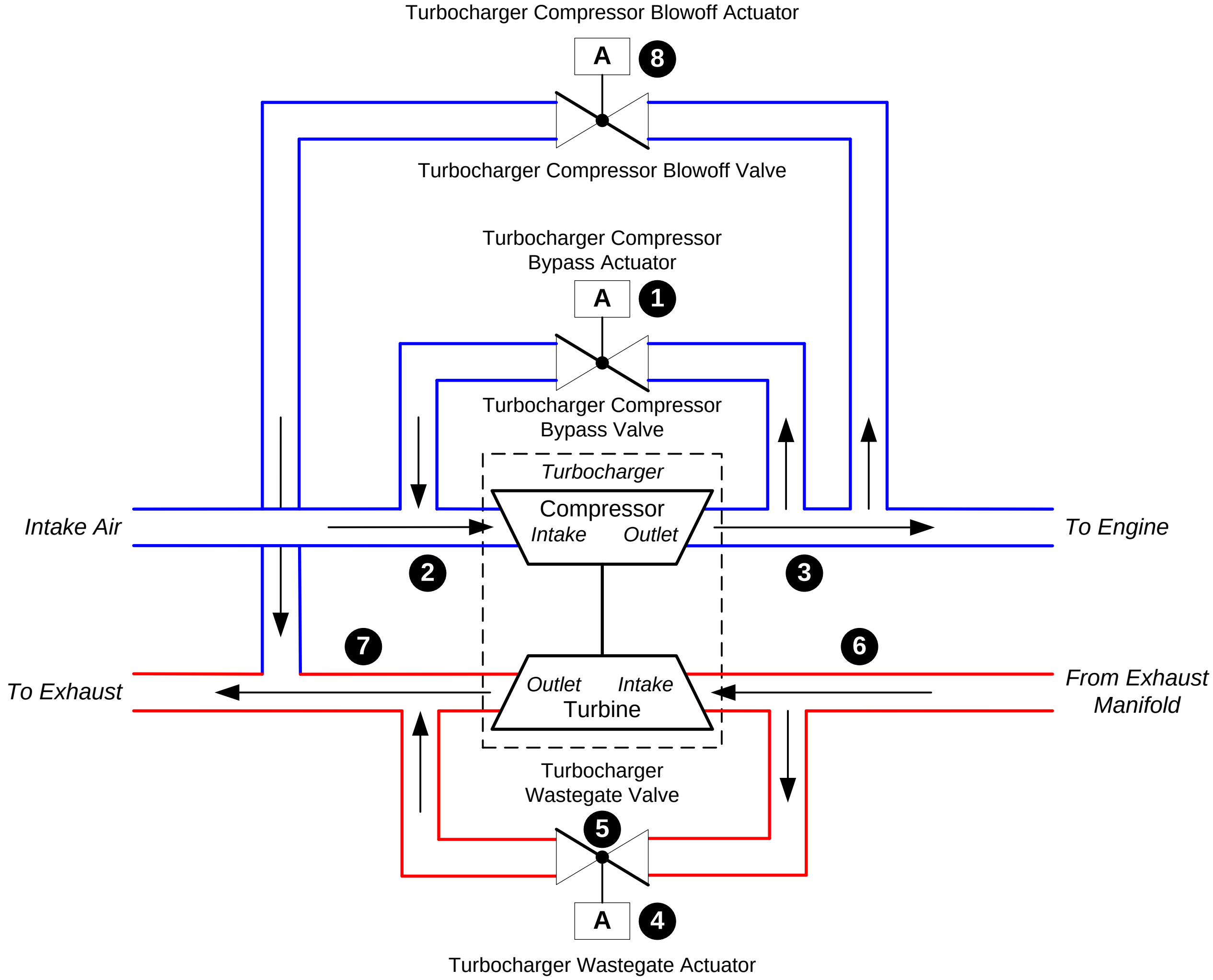


FIGURE PGN65190_A: TYPICAL TURBOCHARGER SYSTEM

SPN	Name	Location
1127	Engine Turbocharger 1 Boost Pressure	3
1128	Engine Turbocharger 2 Boost Pressure	3
1129	Engine Turbocharger 3 Boost Pressure	3
1130	Engine Turbocharger 4 Boost Pressure	3
1172	Engine Turbocharger 1 Compressor Intake Temperature	2
1173	Engine Turbocharger 2 Compressor Intake Temperature	2
1174	Engine Turbocharger 3 Compressor Intake Temperature	2
1175	Engine Turbocharger 4 Compressor Intake Temperature	2
1176	Engine Turbocharger 1 Compressor Intake Pressure	2
1177	Engine Turbocharger 2 Compressor Intake Pressure	2
1178	Engine Turbocharger 3 Compressor Intake Pressure	2
1179	Engine Turbocharger 4 Compressor Intake Pressure	2
1180	Engine Turbocharger 1 Turbine Intake Temperature	6
1181	Engine Turbocharger 2 Turbine Intake Temperature	6
1182	Engine Turbocharger 3 Turbine Intake Temperature	6
1183	Engine Turbocharger 4 Turbine Intake Temperature	6
1184	Engine Turbocharger 1 Turbine Outlet Temperature	7
1185	Engine Turbocharger 2 Turbine Outlet Temperature	7
1186	Engine Turbocharger 3 Turbine Outlet Temperature	7
1187	Engine Turbocharger 4 Turbine Outlet Temperature	7
1188	Engine Turbocharger Wastegate Actuator 1 Position	4
1189	Engine Turbocharger Wastegate Actuator 2 Position	4
1190	Engine Turbocharger Wastegate Actuator 3 Position	4
1191	Engine Turbocharger Wastegate Actuator 4 Position	4
1192	Engine Turbocharger Wastegate Actuator Control Air Pressure	4
1693	Engine Turbocharger Wastegate Valve Position	5
2629	Engine Turbocharger 1 Compressor Outlet Temperature	3
2799	Engine Turbocharger 2 Compressor Outlet Temperature	3
2800	Engine Turbocharger 3 Compressor Outlet Temperature	3
2801	Engine Turbocharger 4 Compressor Outlet Temperature	3
3470	Engine Turbocharger Compressor Bypass Actuator 1 Command	1
3675	Engine Turbocharger Compressor Bypass Actuator 1 Position	1
5367	Engine Turbocharger Compressor Bypass Actuator 1 Preliminary FMI	1
5368	Engine Turbocharger Compressor Bypass Actuator 1 Temperature Status	1
5369	Engine Turbocharger Compressor Bypass Actuator 2 command	1
5371	Engine Turbocharger Wastegate Actuator 1 Preliminary FMI	4

SPN	Name	Location
5371	Engine Turbocharger Wastegate Actuator 1 Preliminary FMI	4
5372	Engine Turbocharger Wastegate Actuator 1 Temperature Status	4
5384	Engine Turbocharger Wastegate Actuator 2 Preliminary FMI	4
5385	Engine Turbocharger Wastegate Actuator 2 Temperature Status	4
5386	Engine Turbocharger Wastegate Actuator 1 Command	4
5387	Engine Turbocharger Wastegate Actuator 2 Command	4
5388	Engine Turbocharger Compressor Bypass Actuator 2 Position	1
5390	Engine Turbocharger compressor Bypass Actuator 2 Preliminary FMI	1
5391	Engine Turbocharger Compressor Bypass Actuator 2 Temperature Status	1
5401	Engine Turbocharger Turbine Bypass Actuator	4
5420	Engine Turbocharger Compressor Bypass Actuator 1	1
5421	Engine Turbocharger 1 Wastegate Actuator 1	4
5449	Engine Turbocharger Compressor Bypass Actuator 1 Operation Status	1
5450	Engine Turbocharger Compressor Bypass Actuator 2 Operation Status	1
5451	Engine Turbocharger Wastegate Actuator 1 Operation Status	4
5452	Engine Turbocharger Wastegate Actuator 2 Operation Status	4
5483	Engine Turbocharger 1 Turbine Bypass Actuator 1 Position	4
5541	Engine Turbocharger 1 Turbine Outlet Pressure	7
5544	Engine Turbocharger 2 Turbine Outlet Pressure	7
5787	Engine Turbocharger Wastegate Actuator 2 Temperature	4
5788	Engine Turbocharger Wastegate Actuator 1 Temperature	4
5791	Engine Turbocharger Compressor Bypass Actuator 1 Temperature	1
5792	Engine Turbocharger Compressor Bypass Actuator 2 Temperature	1
6201	Engine Turbocharger 1 Compressor Blowoff Actuator Command	8
6294	Engine Turbocharger 1 Wastegate Actuator 2	4
6295	Engine Turbocharger 2 Wastegate Actuator 1	4
6296	Engine Turbocharger 2 Wastegate Actuator 2	4
6297	Engine Turbocharger 3 Wastegate Actuator 1	4
6298	Engine Turbocharger 3 Wastegate Actuator 2	4
6299	Engine Turbocharger 4 Wastegate Actuator 1	4
6300	Engine Turbocharger 4 Wastegate Actuator 2	4
6311	Turbocharger Compressor Blowoff Actuator Preliminary FMI	8
6312	Turbocharger Compressor Blowoff Actuator Temperature Status	8
6313	Turbocharger Compressor Blowoff Actuator Temperature	8
6315	Turbocharger Compressor Blowoff Actuator Position	8
6316	Turbocharger Compressor Blowoff Actuator Operation Status	8

FIGURE PGN65190_B: TYPICAL TURBOCHARGER SYSTEM LEGEND

D.49 PGN 65249 – RETARDER INFORMATION

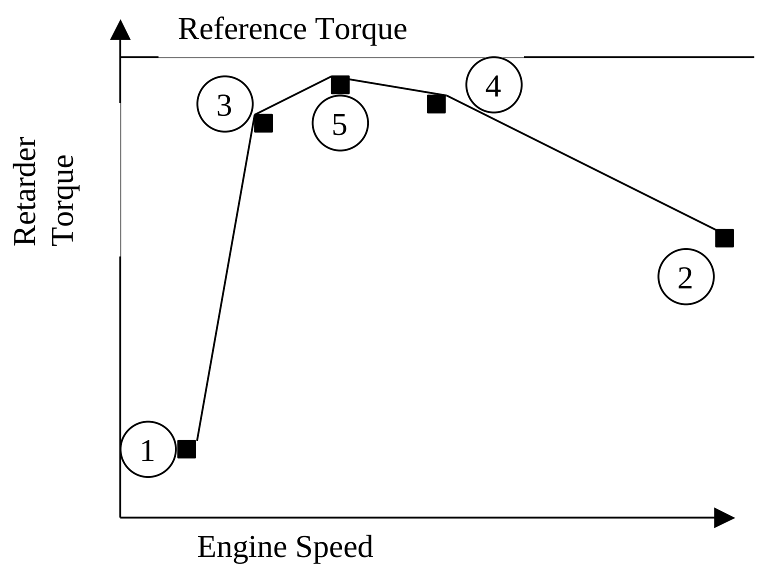


FIGURE PGN65249_A - TYPICAL HYDRAULIC RETARDER TORQUE CURVE

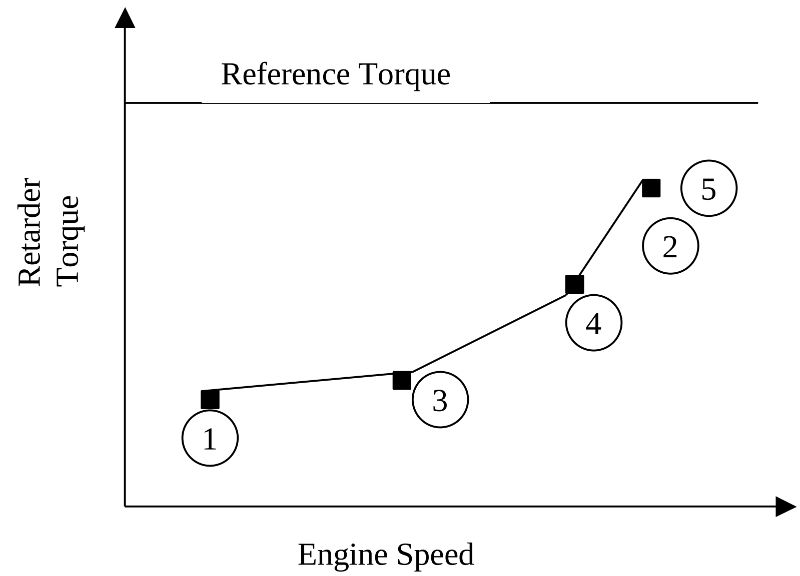


FIGURE PGN65249_B - TYPICAL ENGINE COMPRESSION BRAKE TORQUE CURVE

D.50 PGN 65251 – ENGINE CONFIGURATION 1

TABLE PGN65251_A - ENGINE CONFIGURATION CHARACTERISTIC MODES

Mode	Torque/Speed Point 2	Governor Gain KP	High Idle Speed
1	Available	Not available	Available
2	Not Available	Available	Available
3	Available	Available	Not available

The following points are shown in Figures PGN65251_A, PGN65251_B, and PGN65251_C.

Point 1 (required): Torque/speed point at idle

Point 2 (required): Mode 1 & 3: Torque/speed point at which the high speed governor becomes active

Mode 2: Normal torque/speed point

Point 3,4,5 (required): Torque/speed points between points 1 and 2 to permit linear interpolation over the entire torque range. It is required that one of these points indicate the peak torque point for the current engine torque map.

Point 6 (mode dependent): Mode 1 & 2: High idle speed (torque = 0)

Mode 3: Not available (point is defined by the endspeed governor where torque = 0)

Point 7 (optional): Maximum momentary engine override speed (torque = 0)

Reference engine torque: Engine torque in Nm.

This parameter is the reference value of 100% for all defined indicated engine torque parameters. It is only defined once and doesn't change if a different engine torque map becomes valid.

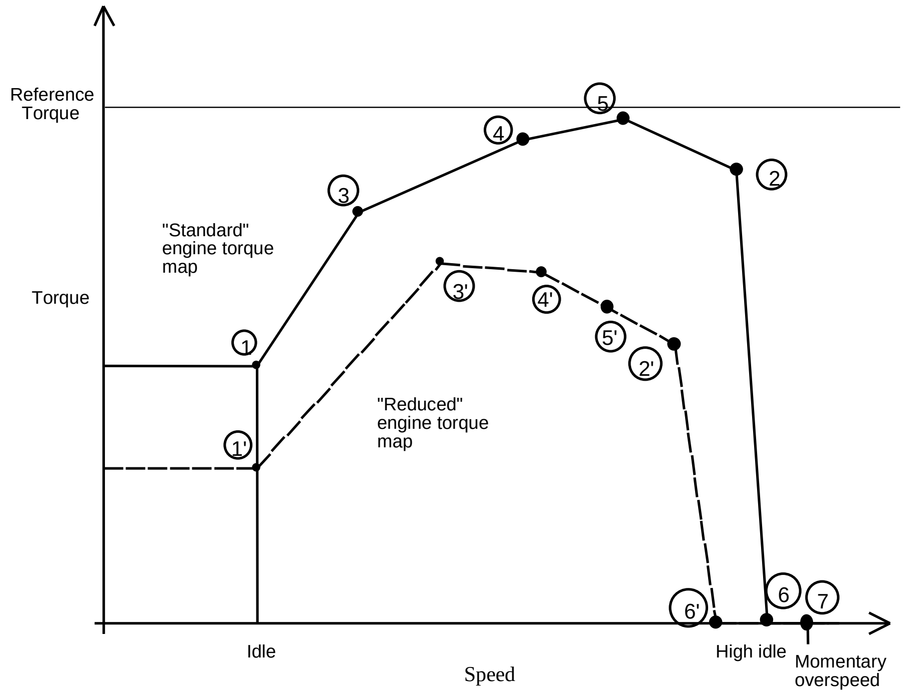


FIGURE PGN65251_A - ENGINE CONFIGURATION MAP-MODE 1

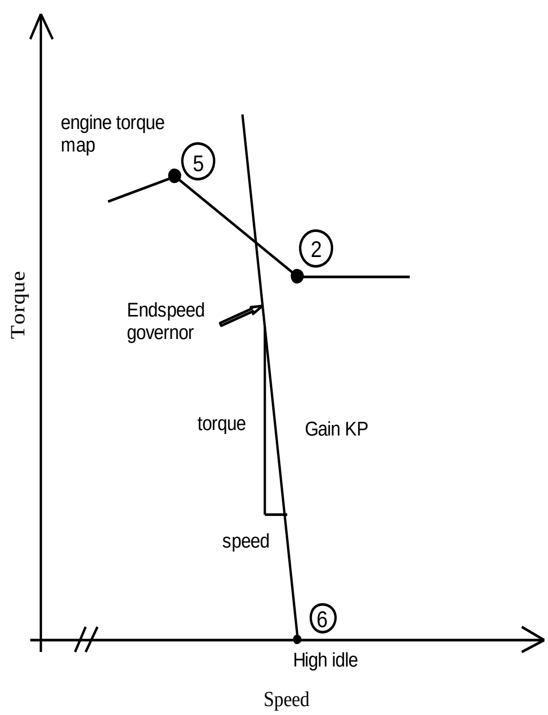


FIGURE PGN65251_B - ENGINE CONFIGURATION MAP-MODE 2

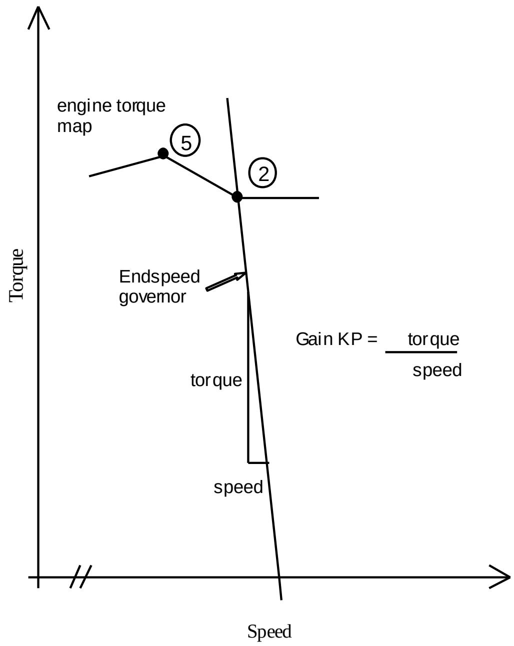


FIGURE PGN65251_C - ENGINE CONFIGURATION MAP-MODE 3

D.51 PGN 65254 – TIME/DATE BROADCAST

Decision Tree for Reporting Time and Date and Local Hour Offset

The flow chart shows the correct values to report for the Time and Date (SPNs 959-964) and Local Hour Offset (SPN 1602), depending upon the Time Standard (UTC or Local Time) used for SPNs 959-964 data and support of Local Offset.

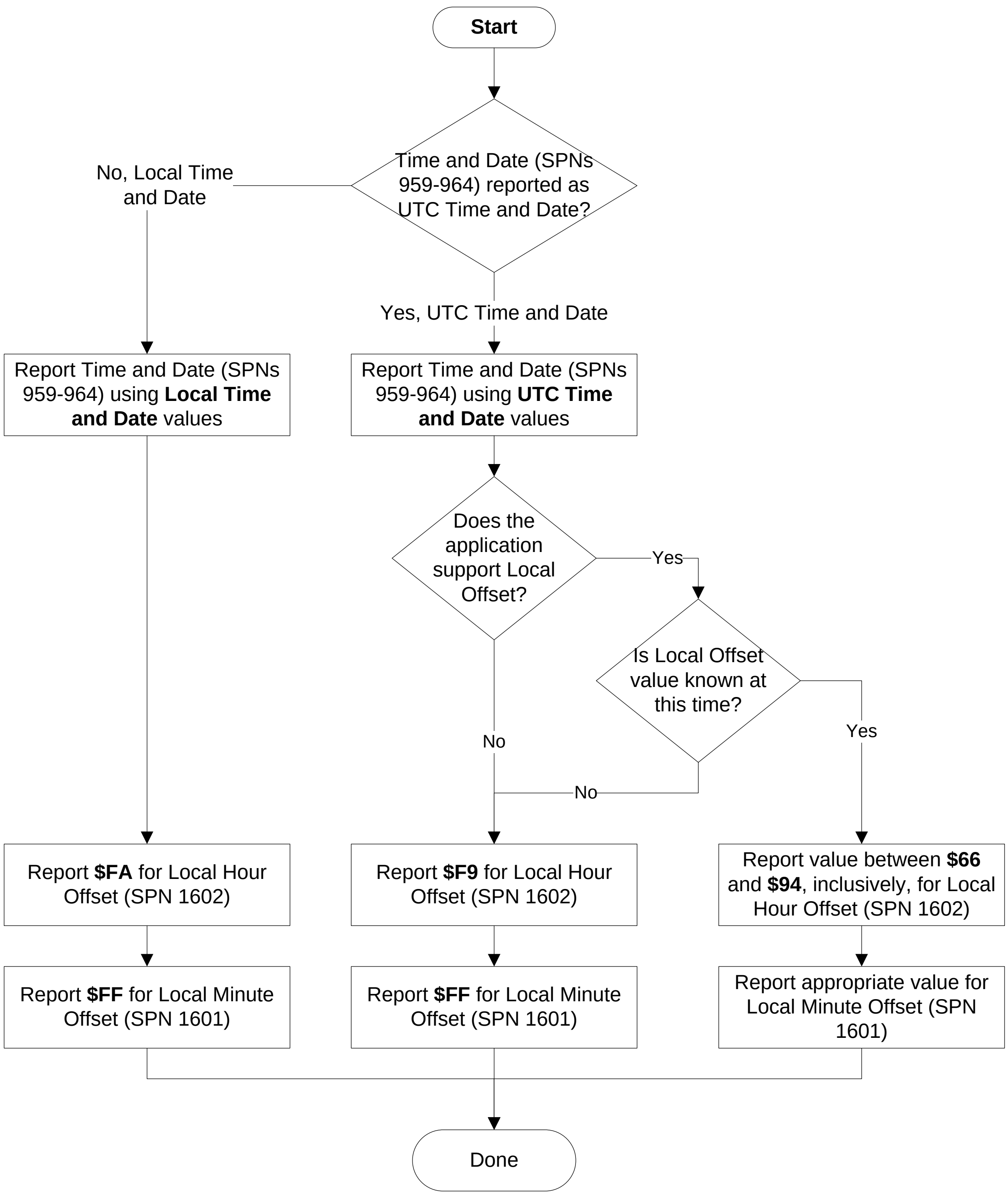


FIGURE 65254_A - FLOW CHART FOR REPORTING TIME AND DATE AND LOCAL HOUR OFFSET

Flow Chart for Interpreting Time and Date and Local Hour Offset

The flow chart shows how to determine the Time Standard (UTC or Local Time) used for SPNs 959-964 data and Local Offset support based upon the value reported for the Local Hour Offset (SPN 1602).

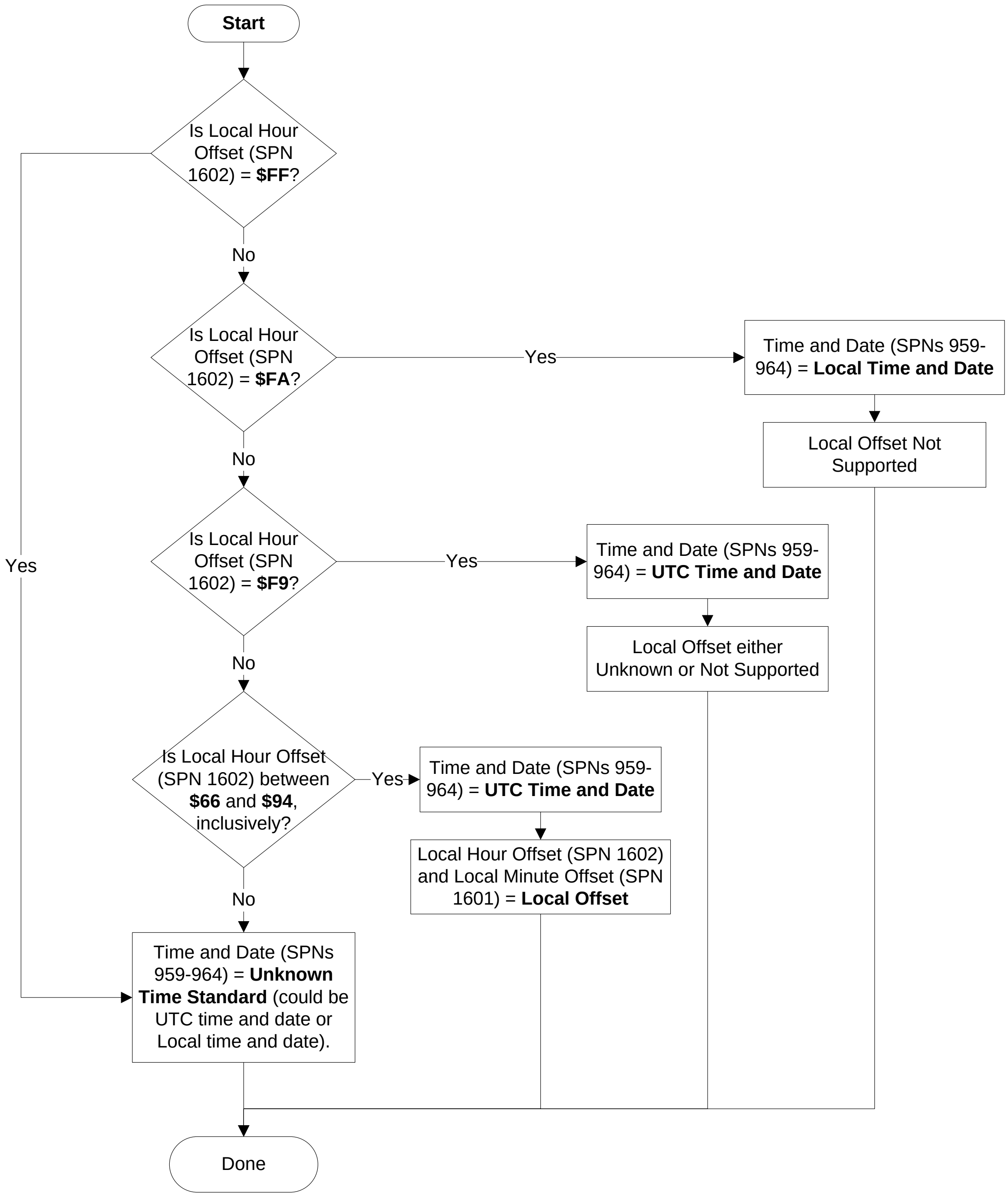


FIGURE 65254_B - FLOW CHART FOR INTERPRETING TIME AND DATE AND LOCAL HOUR OFFSET