SAE J1939™DA Support Information

Red text in this release of the Information Report indicates changes approved thru May 2024 (2Q2024). This content supersedes the technical support documentation provided in Appendix D of SAE J1939™-71.

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

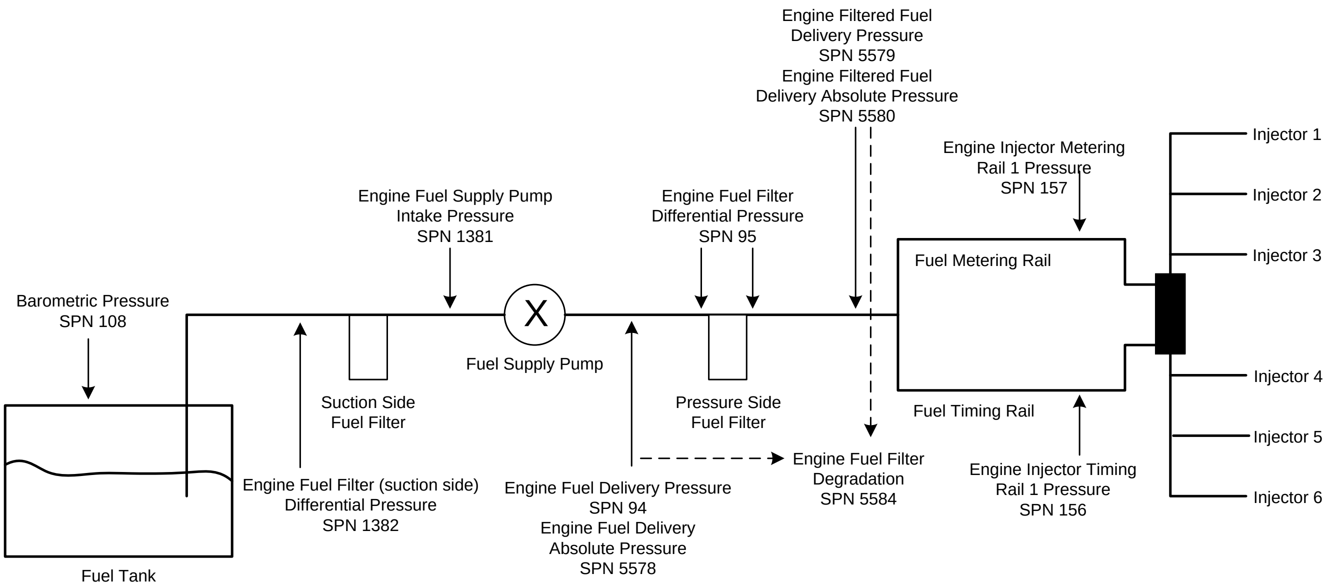


FIGURE SPN16_A - FUEL SYSTEM WITH RAILS

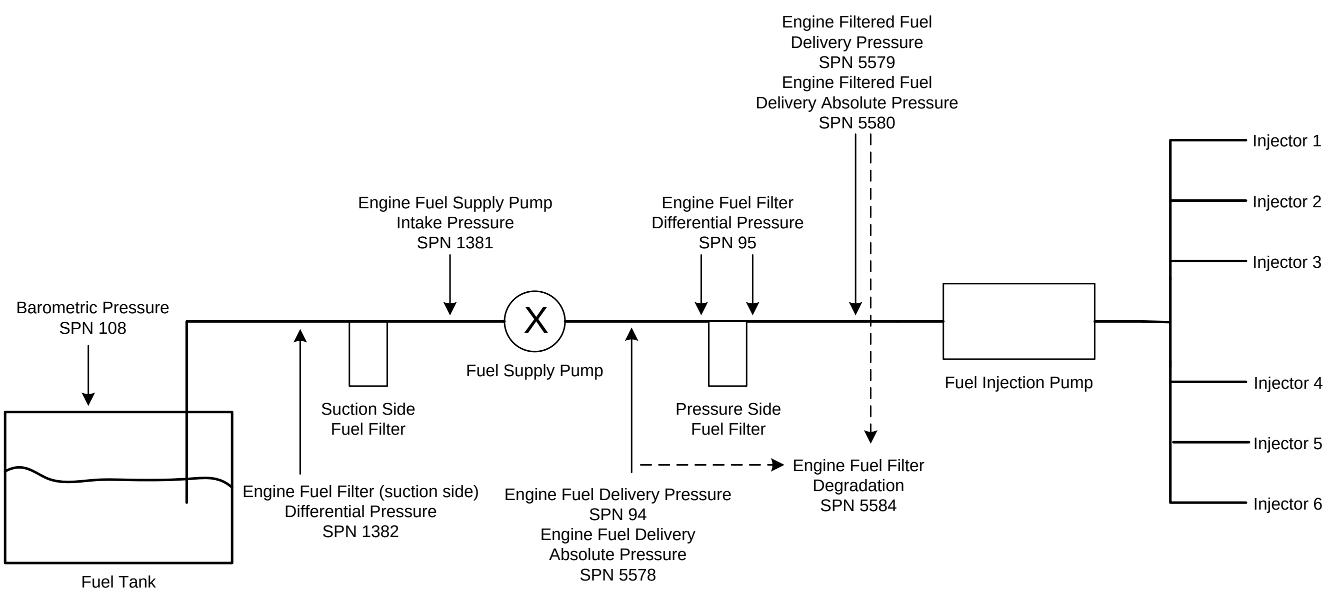


FIGURE SPN16_B - FUEL SYSTEM WITH PUMP

A.2 SPN 27 – EGR SYSTEM DIAGRAM

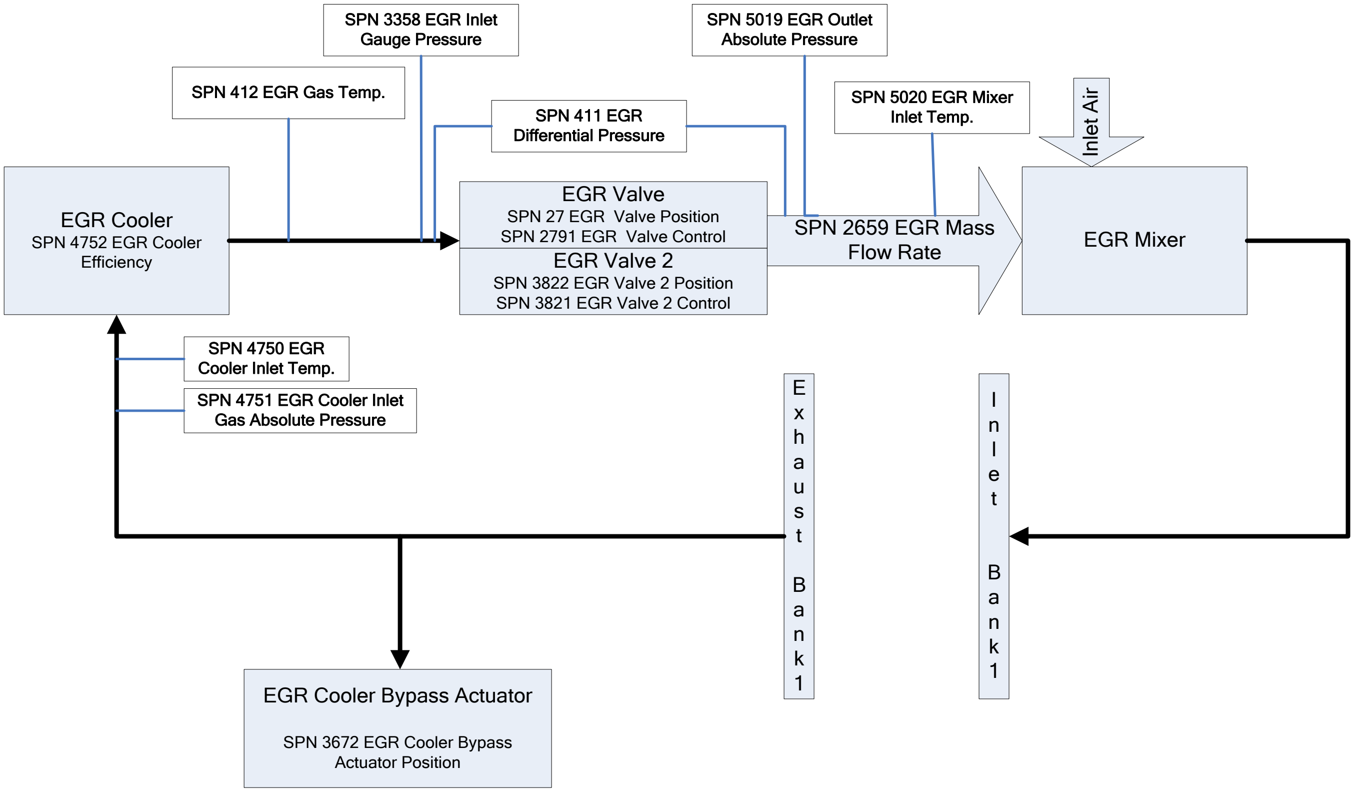


FIGURE SPN27_A – EGR SYSTEM

A.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.

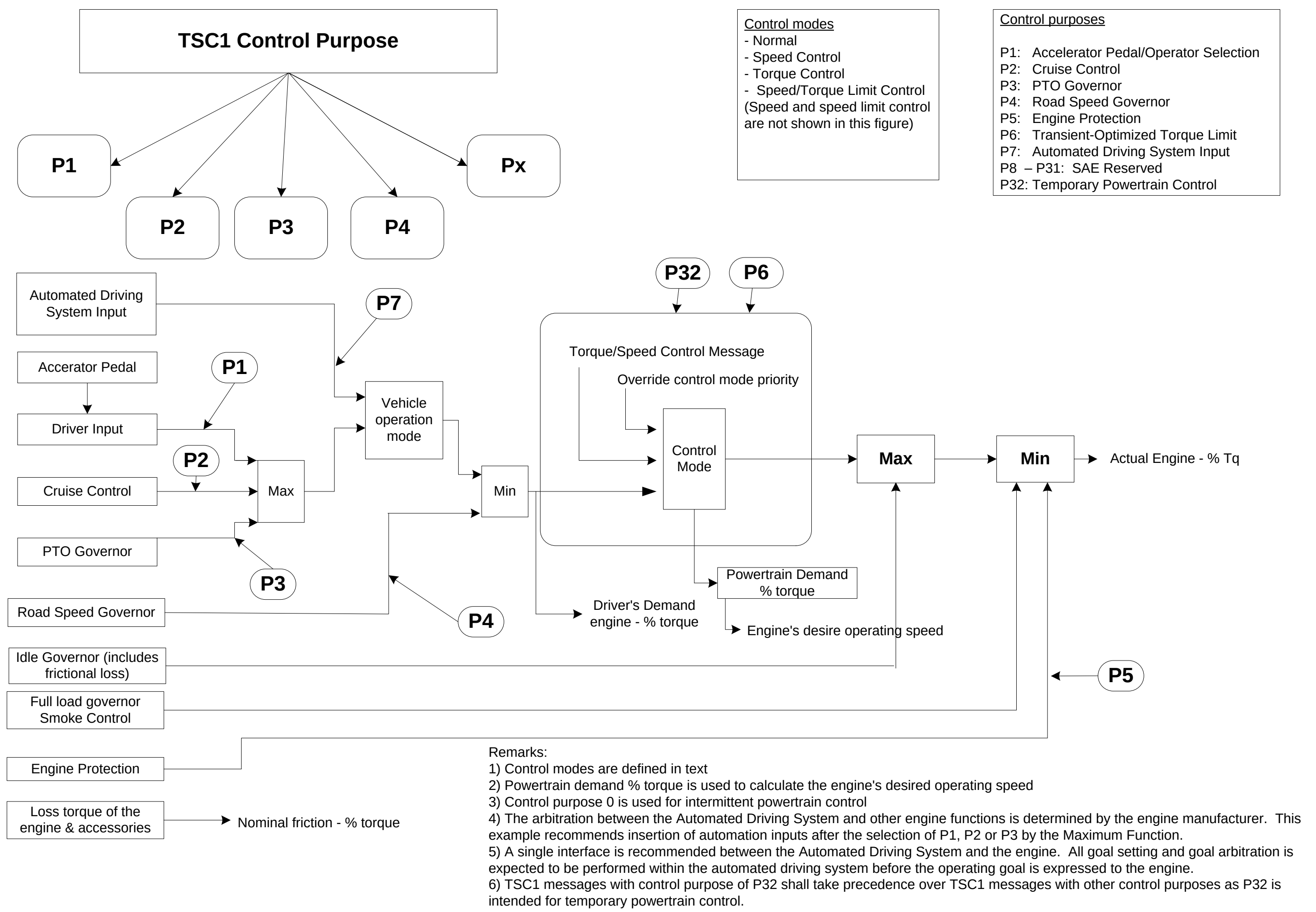


FIGURE SPN512_A - TORQUE COMMANDS AND CALCULATIONS WHEN A "MAXIMUM SELECTION FOR LOW IDLE" TECHNIQUE IS USED

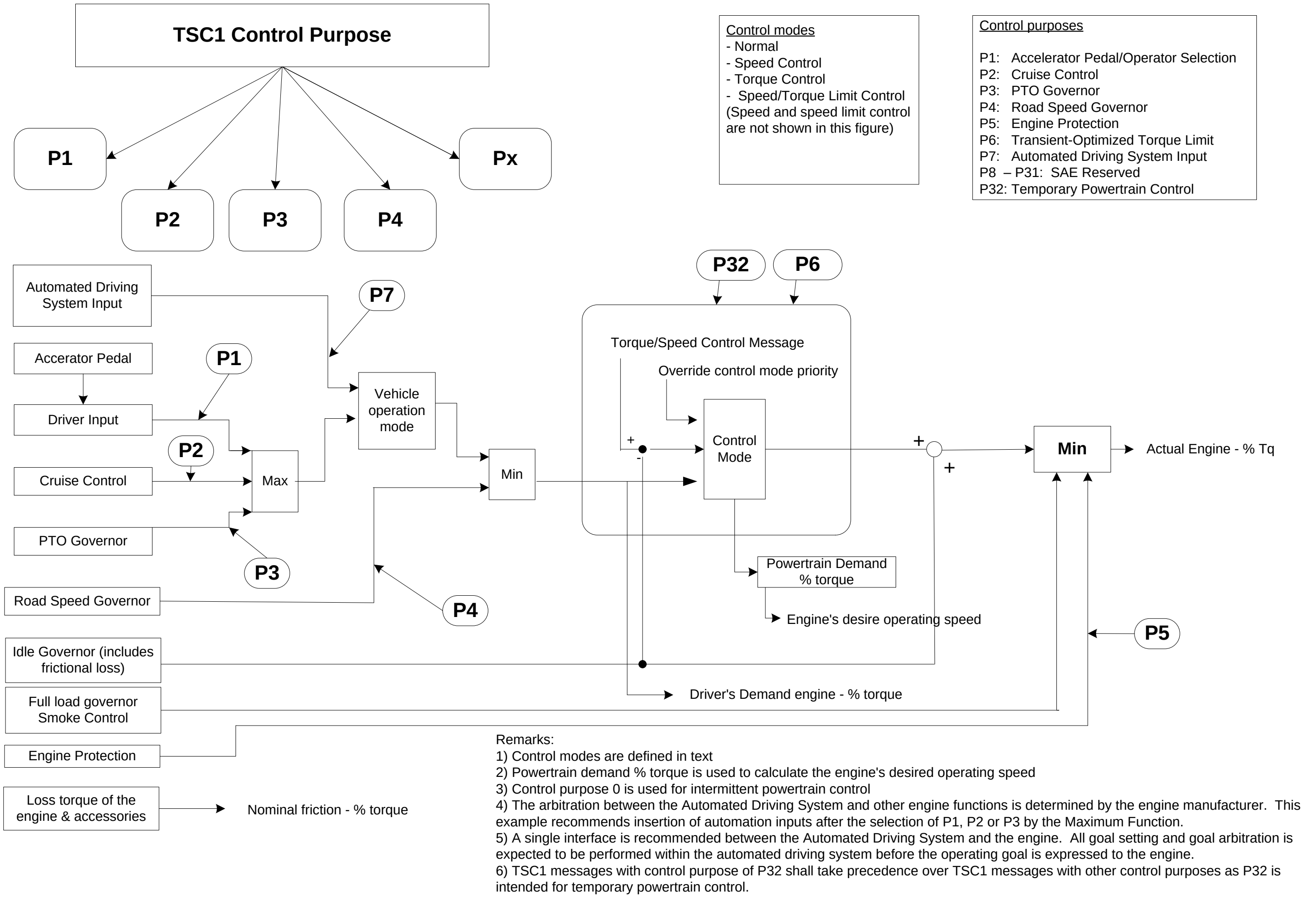


FIGURE SPN512_B - TORQUE COMMANDS AND CALCULATIONS WHEN A “SUMMATION WITH LOW IDLE” TECHNIQUE IS USED

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).

A.4 SPN 513 – TORQUE DEFINITIONS

Net Engine Brake Torque (Power)

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

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

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).

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.

Net Brake Torque (Engine Based Retarder)

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

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

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

Figure SPN513_A shows how some of the torque calculations are determined.

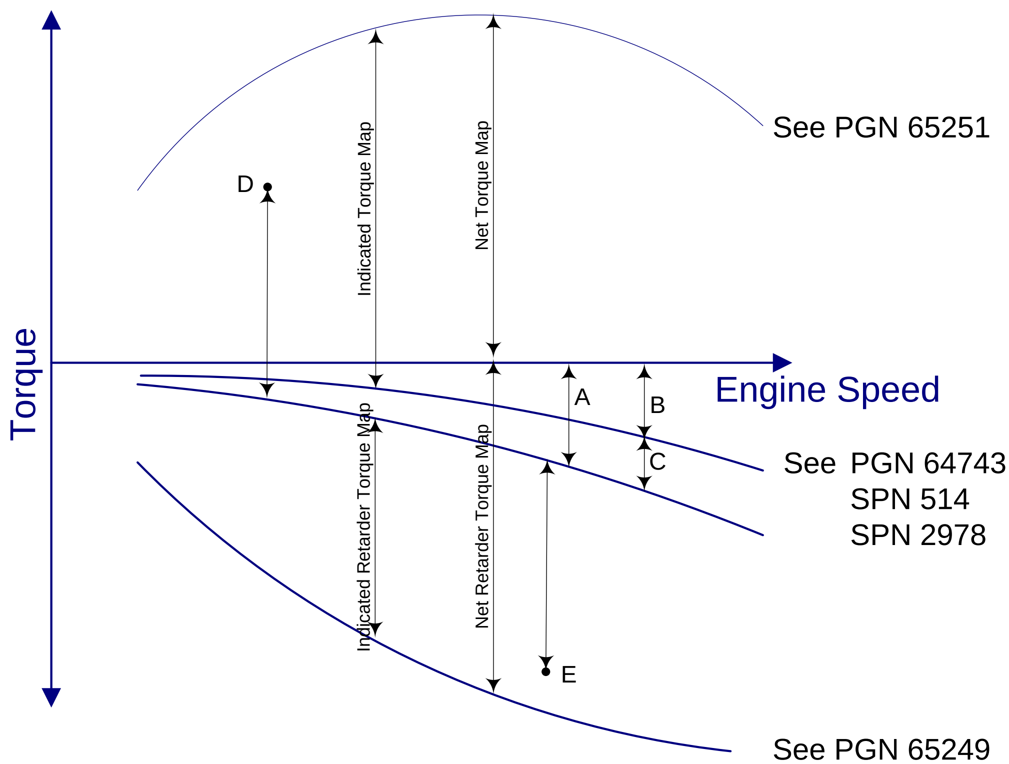


FIGURE SPN513_A – TORQUE DEFINITIONS

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

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

C. SPN 2978, Estimated Engine Parasitic Losses – Percent Torque. This torque curve is intended to demonstrate that the indicated retarder torque map does not change when Friction Torque 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, and 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).

Current Engine Percentage of Peak Torque

The ratio of actual engine percent torque (indicated) to the peak torque available at the rated peak torque engine speed, clipped to zero torque during engine braking.

This calculation should be performed by using the value for the Engine Indicated Torque divided by the output of SPN 1248 (Engine Peak Torque 1) for rating #1 or 1249 (Engine Peak Torque 2) for rating #2.

Adaption of Indicated Torque Parameters to Applications with Electric Motors

"Engine Indicated Torque" is defined to be the torque developed in the (engine) cylinders. Advances in hybrid and electric vehicles have motivated some manufacturers to consider how existing SAE J1939 indicated torque parameters can be adapted to these applications. SAE J1939 network nodes that are interested in the capability and/or current operating condition of the internal combustion engine need to be able to determine the net torque at the engine flywheel. Earlier sections in 5.2.1 describe how to use the existing indicated torque parameters to determine the net torque at the engine flywheel which is the output of the internal combustion engine.

For electric vehicles or series hybrid vehicles, the output of the power source is not the flywheel of an internal combustion engine, but the motor shaft of an electric motor. In these applications, Nominal Friction – Percent Torque (NFPT, SPN 514) will be transmitted by the controller application responsible for electric motor torque management (e.g., Powertrain Control Module (SA 90) or Power Systems Manager (SA 91)) as zero. Likewise the Friction Torque Map in the Engine Configuration 3 (EC3) message will use zero for NFPT. The equations described in this section still apply for devices that need to determine the torque at the output of the power source. For example, Actual Engine – Percent Torque (AEPT, SPN 513) will contain the net torque at the output of the motor shaft. Since NFPT is zero, the equations used by recipients will be functional as they will be subtracting 0 from AEPT to determine the net torque at the motor shaft. Those devices that transmit TSC1 messages to the power source will calculate the net torque command/limit using the same equations when interfacing with an electric power source as were used when interfacing with an internal combustion engine power source.

For parallel hybrid vehicles, the powertrain output is a combination of both the engine and motor. In these applications, NFPT will be transmitted by the controller application responsible for torque management as a summation of the friction torque in the powertrain. This would also apply to the Friction Torque Map in the EC3 message.

Note: Heavy Duty OBD regulatory requirements as well as Heavy Duty in-use emissions compliance testing requirements (e.g. US EPA and California ARB) rely on engines adhering to currently specified definitions for torque reporting. For that reason, in areas where such regulations may apply, the torque reported by the engine (SA 0) cannot be altered to include torque provided by other devices. Therefore, regardless of the chosen controller application responsible for torque management, the engine (SA 0) must always transmit torque parameters that are solely based on the engine and cannot be modified by electric motor related torque parameters.

Messages and parameters that may be used in applications with electric motors as described above include, but are not limited to:

PGN 0 – Torque/Speed Control 1
- All Parameters

PGN 61444 – Electronic Engine Controller 1
- SPN 4154 – Actual Engine - Percent Torque (Fractional)
- SPN 512 – Driver's Demand Engine - Percent Torque
- SPN 513 – Actual Engine - Percent Torque
- SPN 2432 – Engine Demand – Percent Torque

PGN 61443 – Electronic Engine Controller 2
- SPN 3357 – Actual Maximum Available Engine - Percent Torque

PGN 65247 – Electronic Engine Controller 3
- SPN 514 – Nominal Friction – Percent Torque

PGN 65251 – Engine Configuration 1
- Speed and Torque points for the Torque Map
- SPN 544 – Engine Reference Torque

PGN 64743 – Engine Configuration 3
- All Parameters

A.5 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.

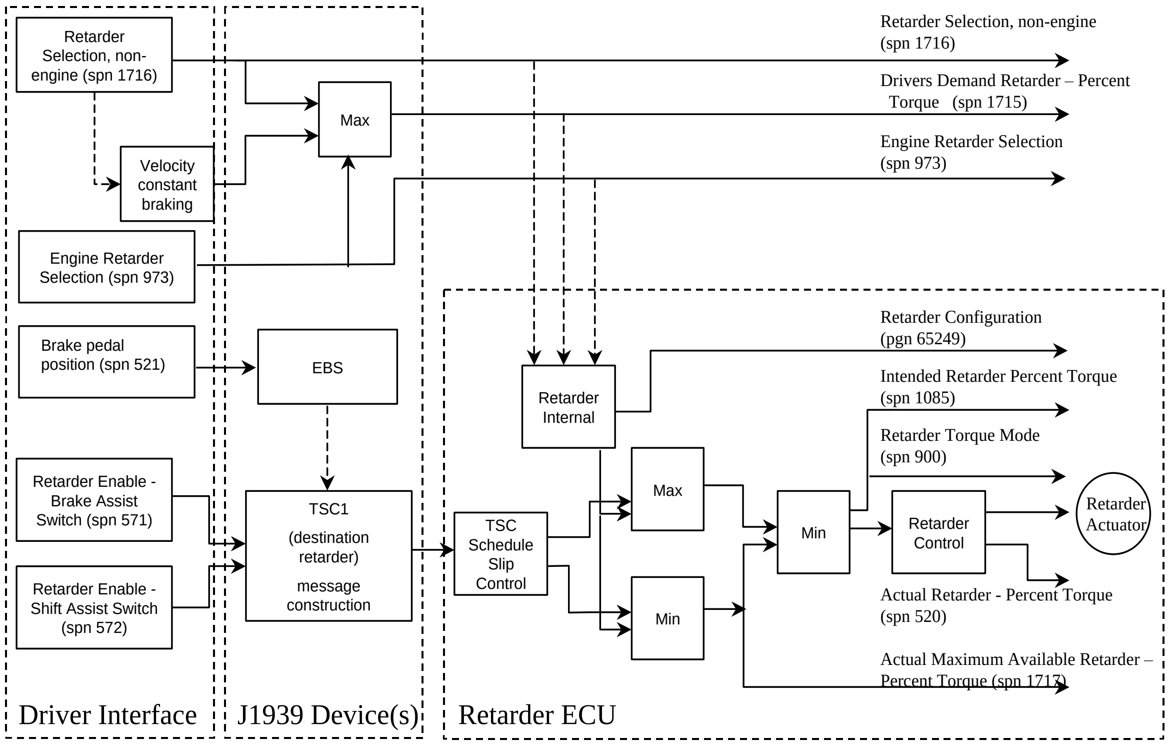


FIGURE SPN518_A - RELATIONSHIP BETWEEN OPERATOR/SWITCH INPUTS AND RETARDERS

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.

A.6 SPN 519 – DESIRED OPERATING SPEED ASYMMETRY ADJUSTMENT

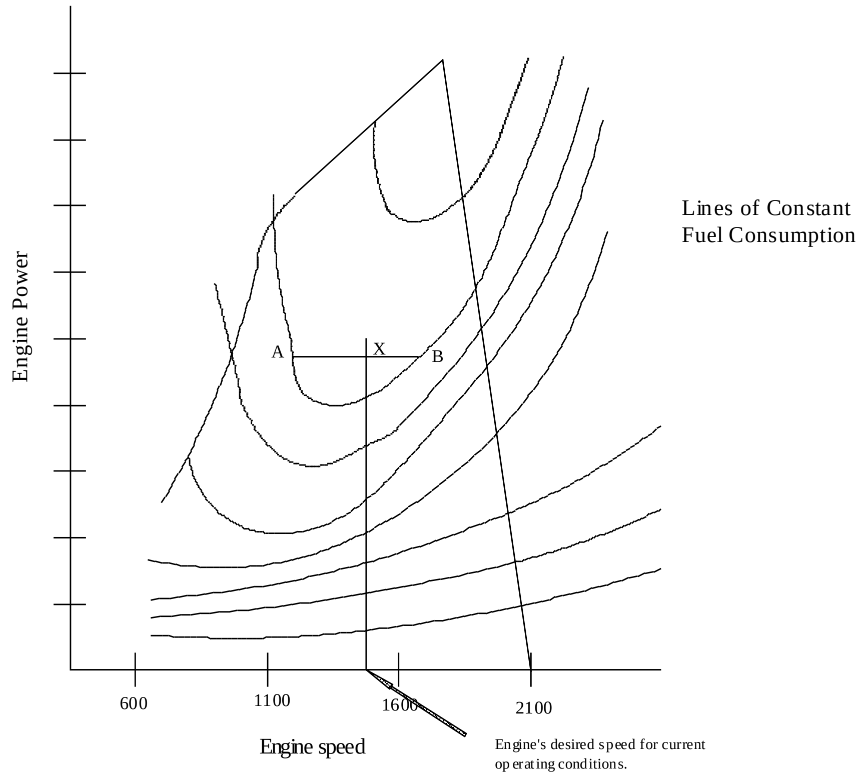


FIGURE SPN519_A - DESIRED OPERATING SPEED ASYMMETRY ADJUSTMENT

A.7 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.

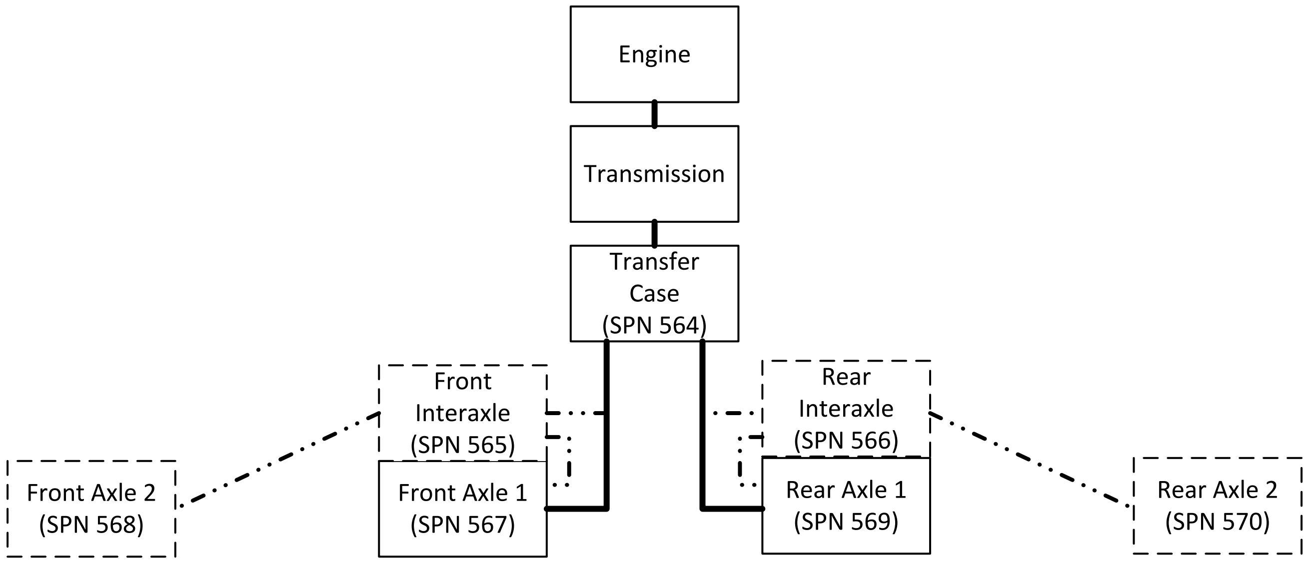
011b Decelerate - Used to indicate that the cruise control device is in the process of ramping down, or coasting, the operating speed.

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.

A.8 SPN 564 – DIFFERENTIAL LOCK POSITIONS

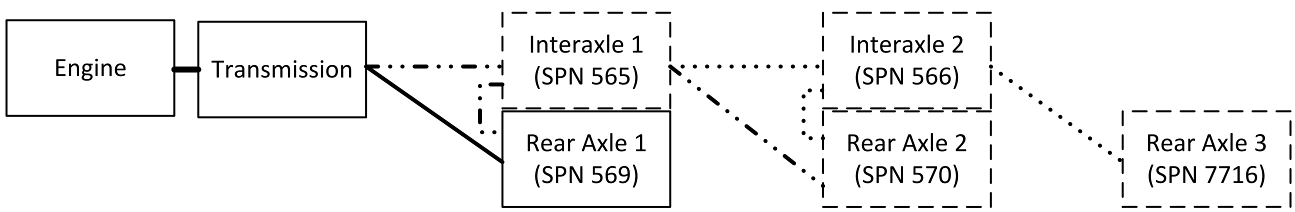


Legend:

Torque path for single drive axle

Torque path for tandem drive axle (front, rear, or both)

FIGURE SPN564_A - DIFFERENTIAL LOCK POSITIONS FOR SYSTEMS WITH FRONT AND REAR DRIVE AXLES



Legend:

Torque path for single drive axle

Torque path for tandem drive axle or front axle for tridem drive axle

Torque path for tridem drive axle – center and rear axle

FIGURE SPN564_B - DIFFERENTIAL LOCK POSITIONS FOR SYSTEMS WITH REAR DRIVE AXLES ONLY

A.9 SPN 574 – SHIFT IN PROCESS

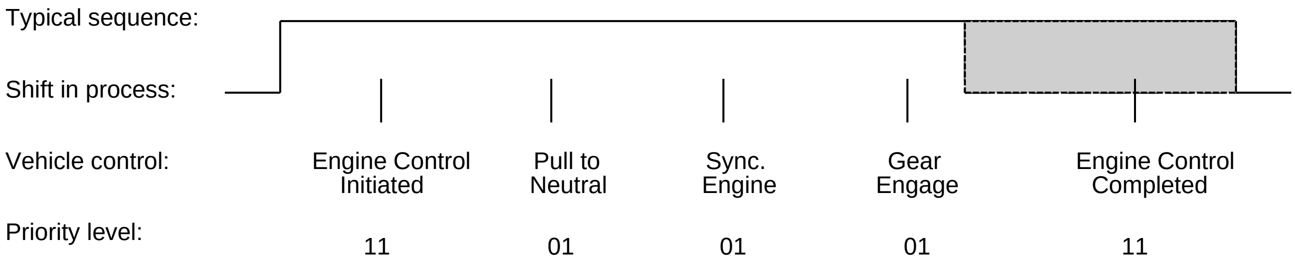


FIGURE SPN574_A - SHIFT IN PROCESS

A.10 SPN 590 – IDLE SHUTDOWN

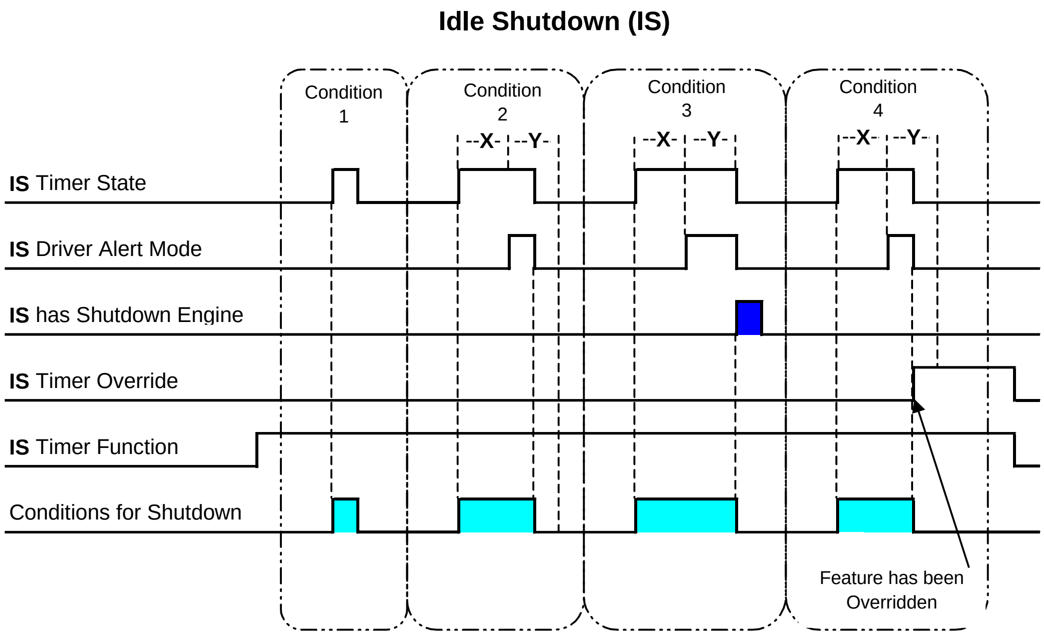


FIGURE SPN590_A - IDLE SHUTDOWN (IS)

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.

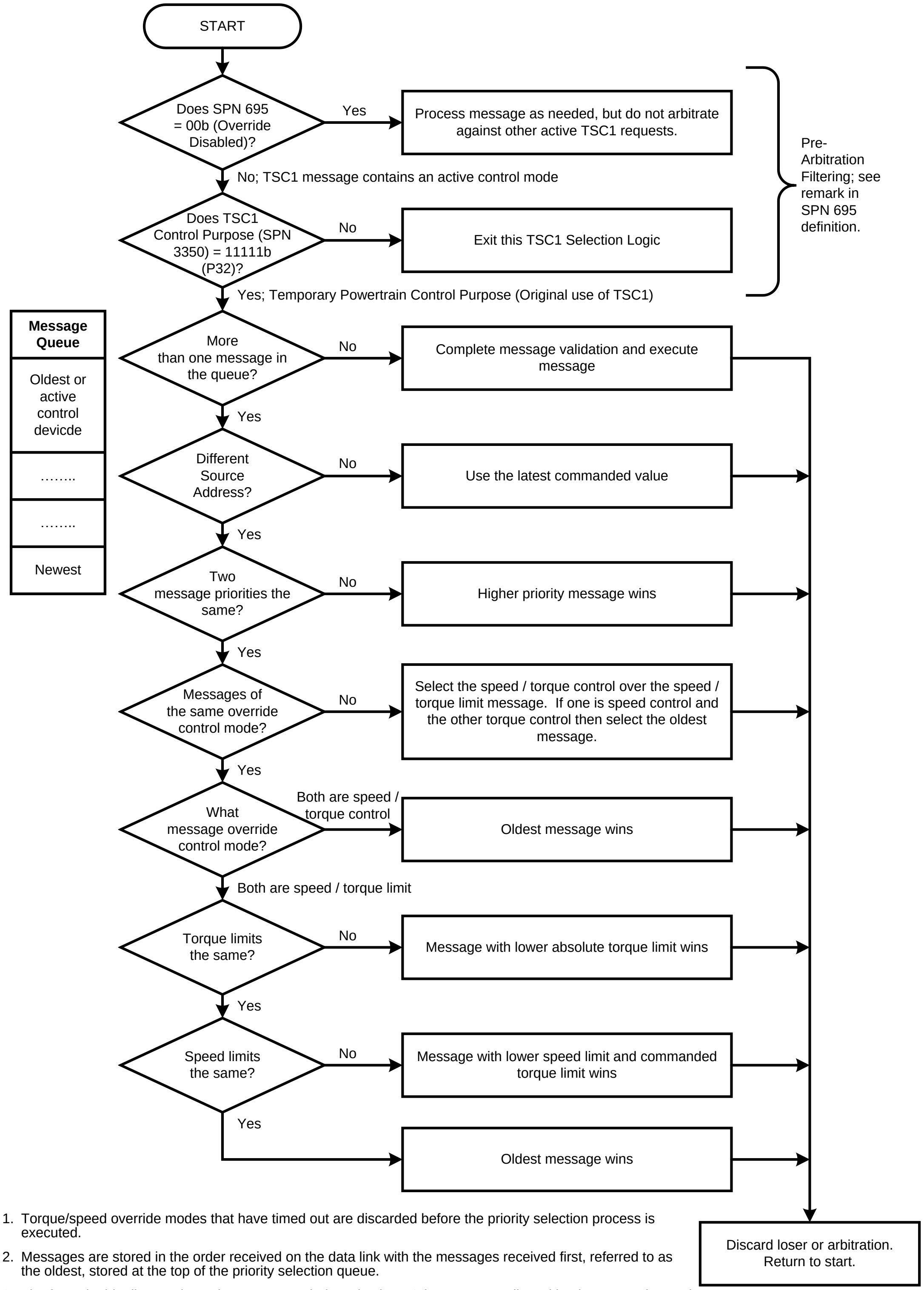
Condition 3 - When the IS Timer Override is inactive, then the IS has Shutdown Engine will be active after the "Y" time interval has expired.

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.

A.11 SPN 695 – ENGINE OVERRIDE CONTROL MODE



1. Torque/speed override modes that have timed out are discarded before the priority selection process is executed.
2. 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.
3. The focus in this diagram is on the message priority selection. Other message disposition issues are ignored in this context.

FIGURE SPN695_A - TORQUE/SPEED CONTROL PRIORITY SELECTION LOGIC

A.12 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.

A.13 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.

A.14 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	Transmission oil filter – transmission #1
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	High Pressure Gaseous Fuel Filter
53	High Pressure Fuel Storage Container
54	Engine Fuel Filter – Suction Side
55-60	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
73	Aftertreatment Diesel Exhaust Fluid Doser Cooldown Interrupt Count
74	Aftertreatment Diesel Exhaust Fluid Doser Purge Interrupt Count
75	Aftertreatment Diesel Exhaust Fluid Pump Filter
76	Aftertreatment 1 Diesel Particulate Filter
77	Aftertreatment 2 Diesel Particulate Filter
78-239	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

A.15 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	991
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
Aftertreatment Trip Diesel Exhaust Fluid	6563
Trip Drive Energy Economy	20875
Total Trip Energy Consumed	20876
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

A.16 SPN 1014 – TRIP AVERAGE ENGINE SPEED

The equation is as follows:

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

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

A.17 SPN 1085 – INTENDED RETARDER PERCENT TORQUE

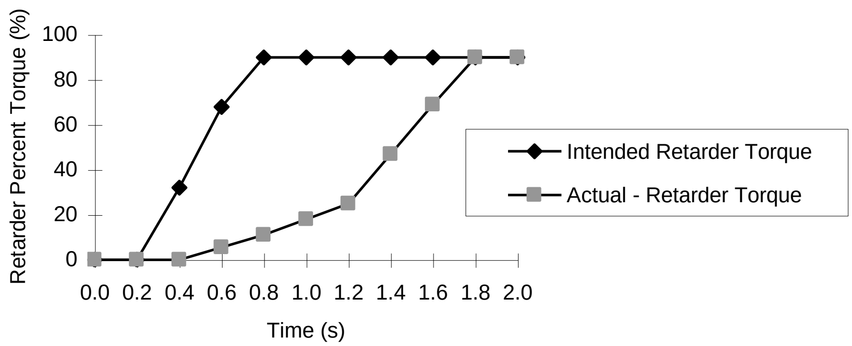


FIGURE SPN1085_A - INTENDED RETARDER PERCENT TORQUE

A.18 SPN 1107 – ENGINE PROTECTION SYSTEM TIMER STATE

Engine Protection System (EPS)

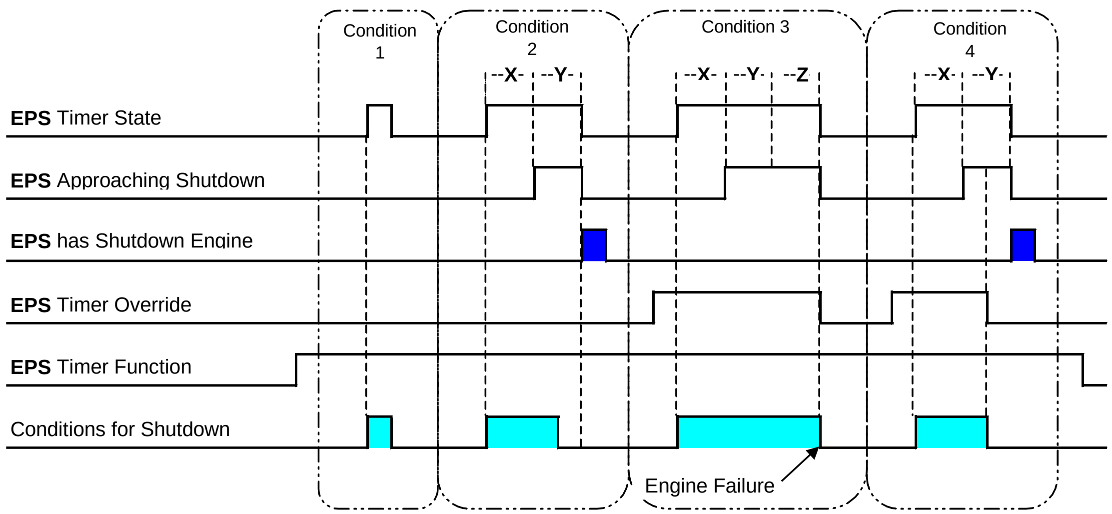


FIGURE SPN1107_A - ENGINE PROTECTION SYSTEM (EPS)

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.

A.19 SPN 1734 – NOMINAL LEVEL FRONT AXLE

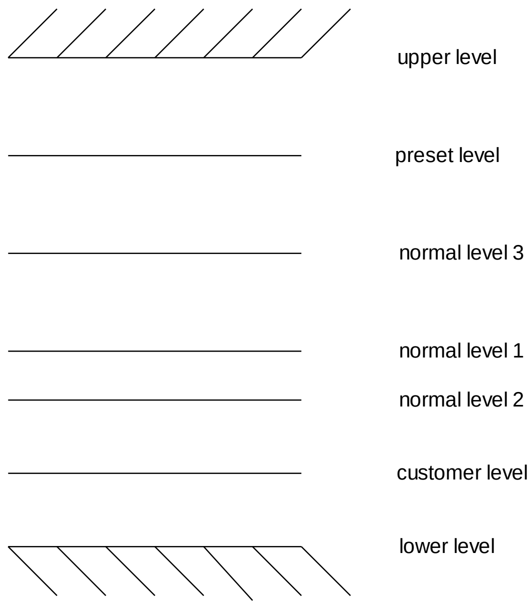


FIGURE SPN1734_A - EXAMPLE FOR NOMINAL LEVELS

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.

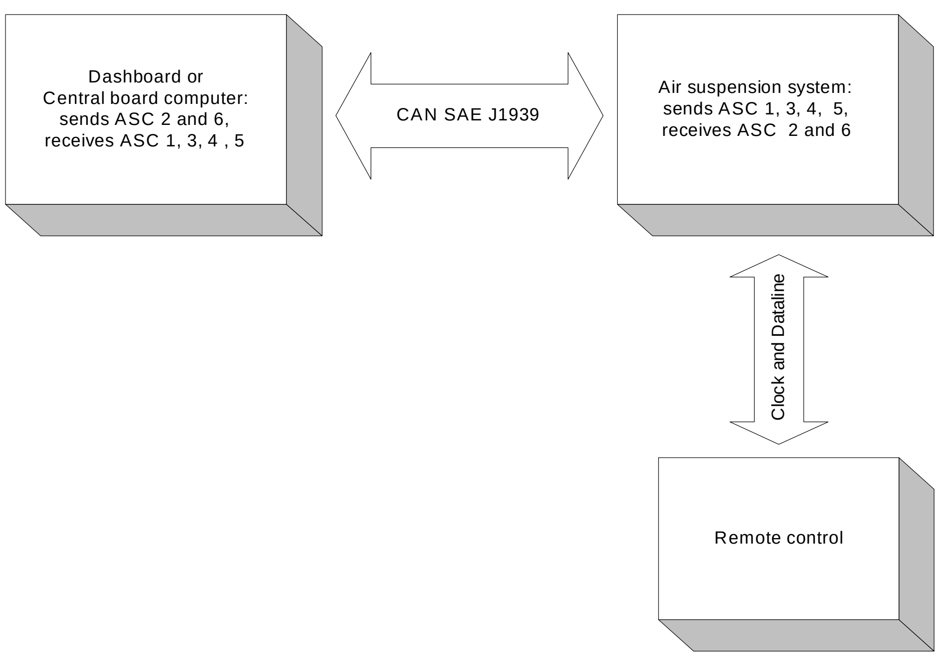
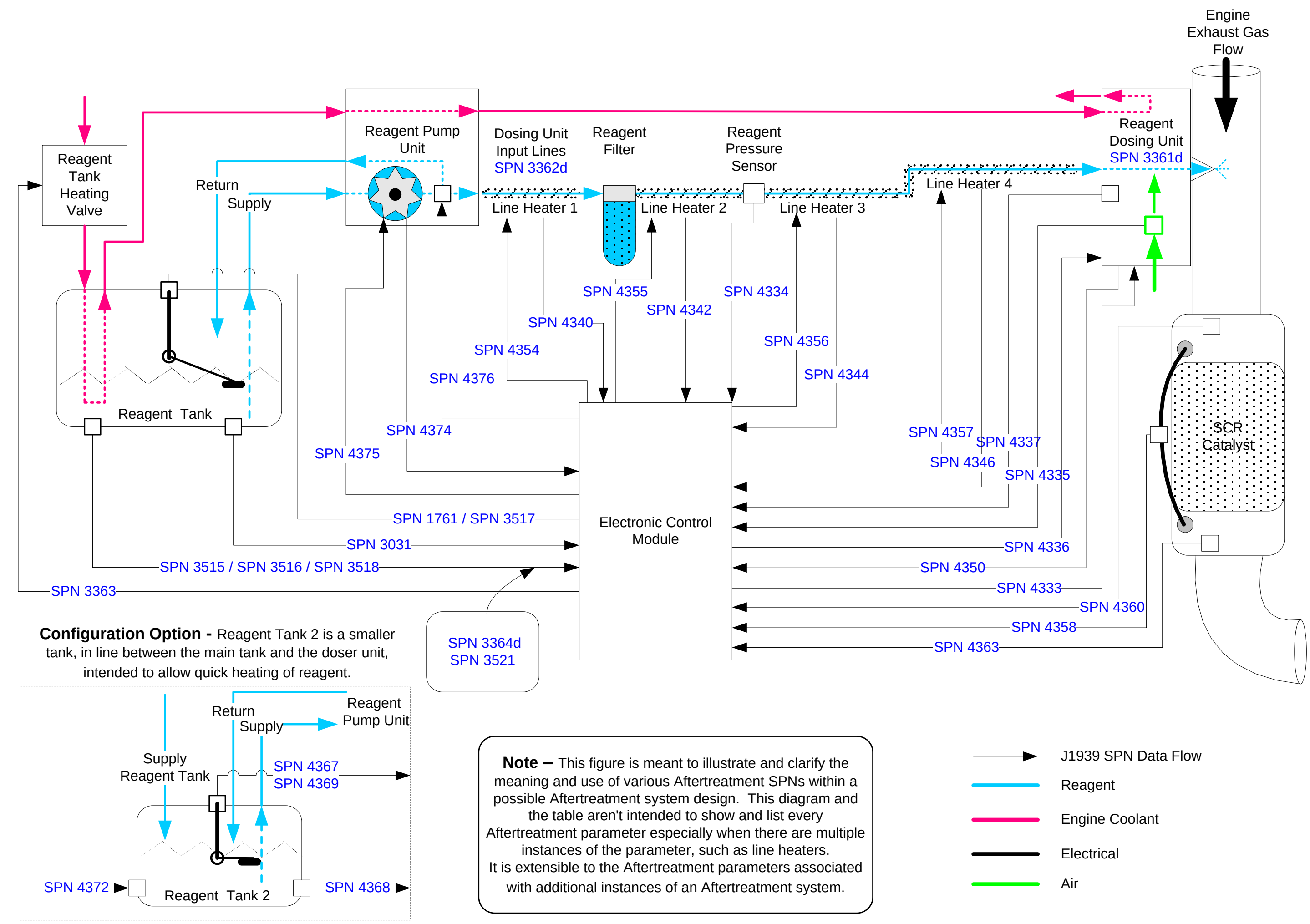


FIGURE SPN1734_B - POSSIBLE INTEGRATION OF ASC SYSTEM INTO VEHICLE NETWORK

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.

A.20 SPN 1761 – AFTERTREATMENT SYSTEM DIAGRAM



SPN	SPN Name	SPN	SPN Name
1761	Aftertreatment 1 Diesel Exhaust Fluid Tank Volume	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 1	4350	Aftertreatment 1 Diesel Exhaust Fluid Requested Quantity of Integrator
3362	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit 1 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	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 Quick Thaw Tank Volume
4333	Aftertreatment 1 Diesel Exhaust Fluid Actual Quantity of Integrator	4368	Aftertreatment 1 Diesel Exhaust Fluid Quick Thaw Temperature
4334	Aftertreatment 1 Diesel Exhaust Fluid Doser 1 Absolute Pressure	4369	Aftertreatment 1 Diesel Exhaust Fluid Quick Thaw Tank Level
4335	Aftertreatment 1 SCR Dosing Air Assist Absolute Pressure	4372	Aftertreatment 1 Diesel Exhaust Fluid Quick Thaw Heater
4336	Aftertreatment 1 SCR Dosing Air Assist Valve	4374	Aftertreatment 1 Diesel Exhaust Fluid Pump 1 Motor Speed
4337	Aftertreatment 1 Diesel Exhaust Fluid Doser 1 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 Dosing Unit 1 Diverter Valve
4342	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 2 State		

FIGURE SPN1761_A - EXAMPLE AFTERTREATMENT SYSTEM SCHEMATIC

A.21 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 optimal 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 is 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.

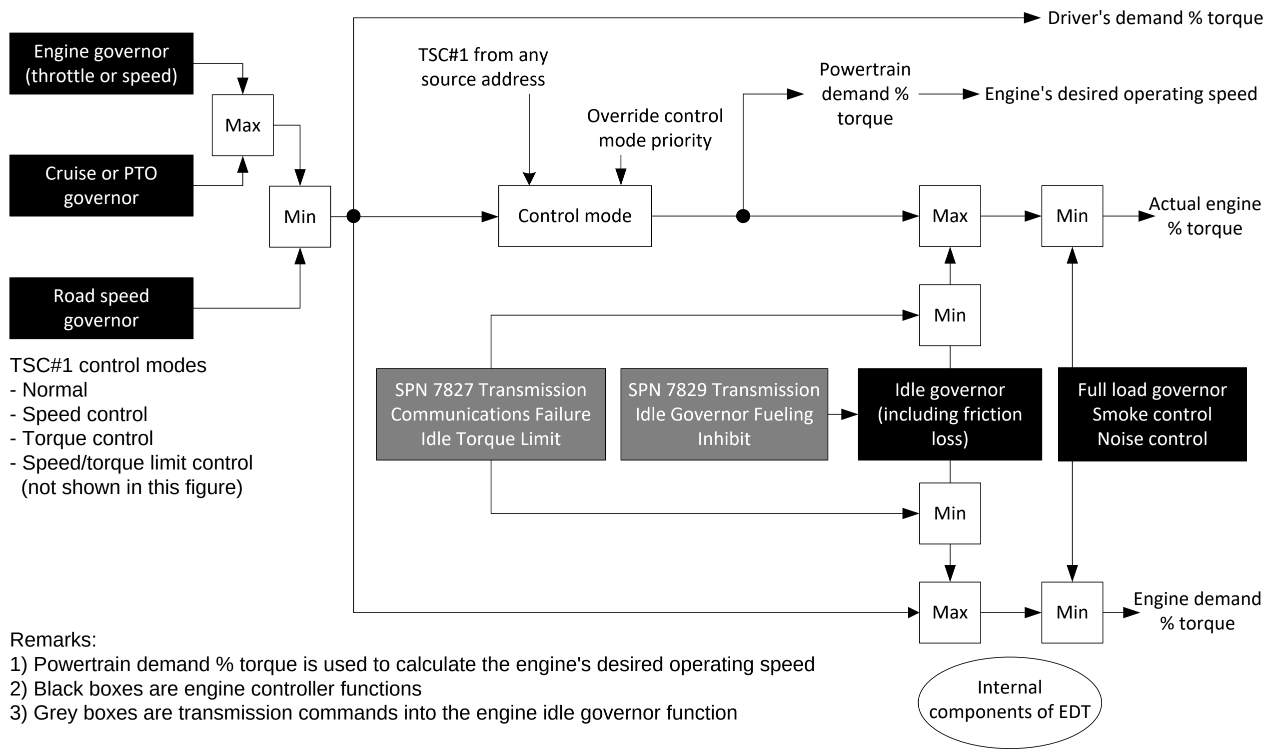


FIGURE SPN2432_A - TORQUE COMMANDS AND CALCULATIONS WHEN A “MAXIMUM LOW IDLE” TECHNIQUE IS USED

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.

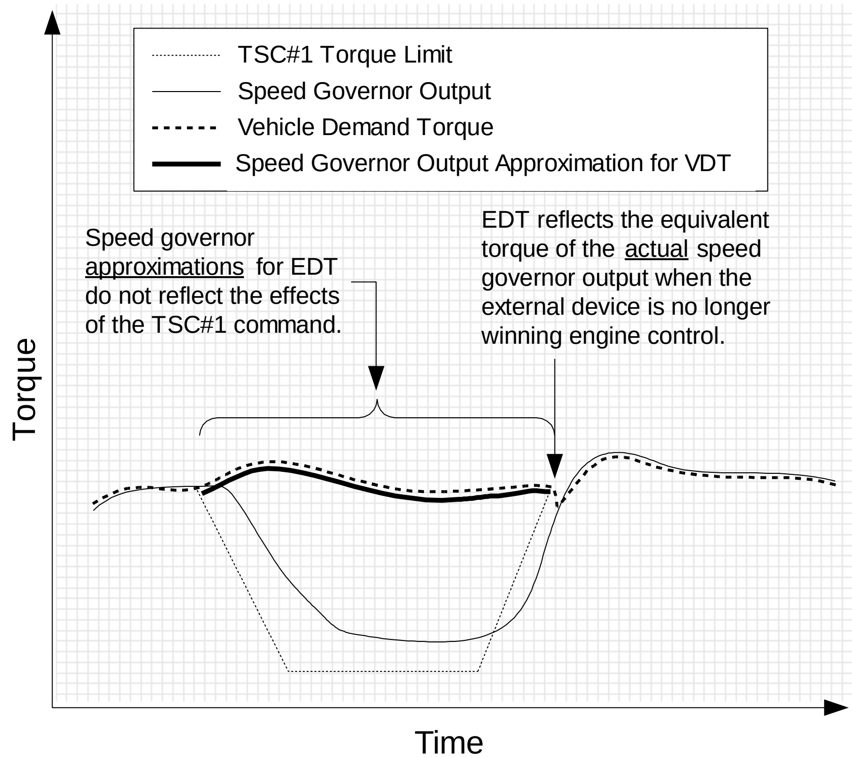


FIGURE SPN2432_B - EDT AND SPEED GOVERNOR OUTPUT RELATIONSHIP DURING A CONTROL SEQUENCE

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.

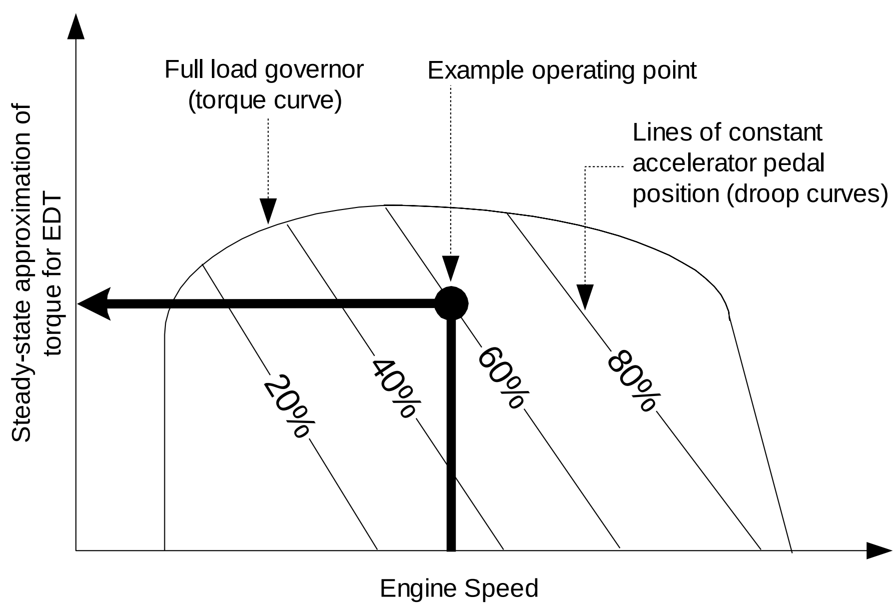


FIGURE SPN2432_C - FINDING EDT TORQUE APPROXIMATION FOR A SPEED GOVERNOR

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

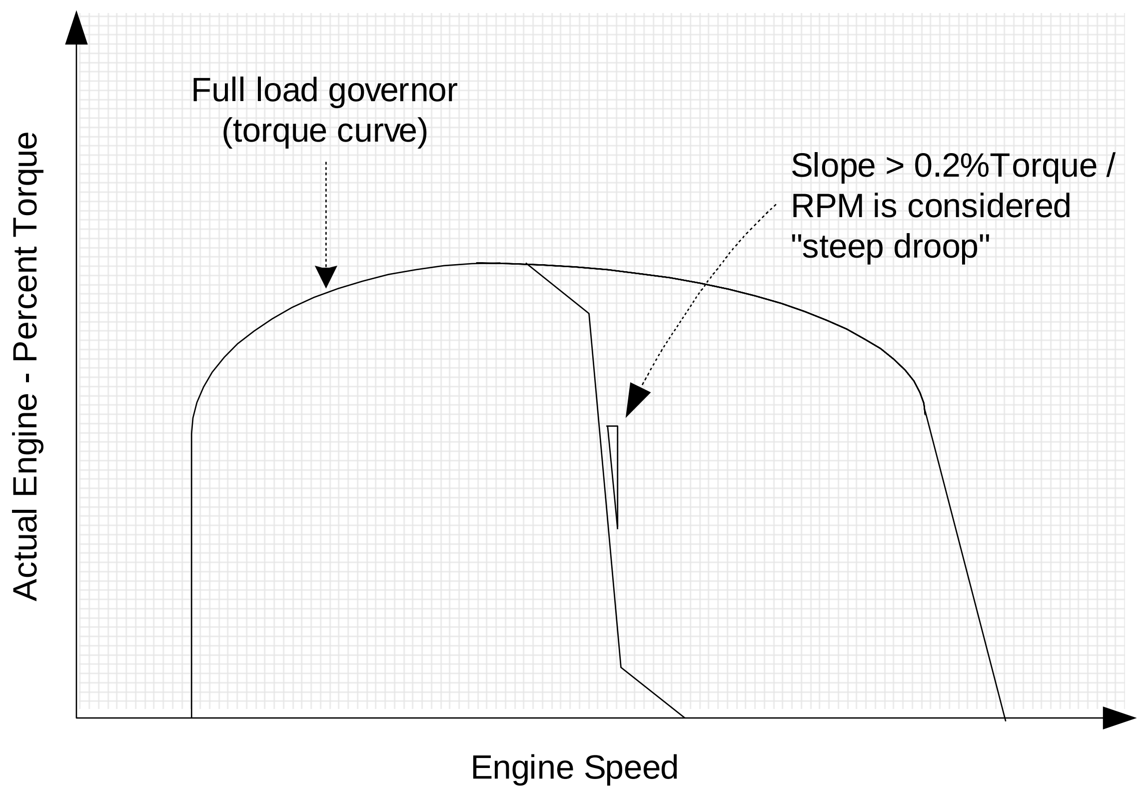


FIGURE SPN2432_D - EXAMPLE OF "STEEP DROOP" SPEED GOVERNOR

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.

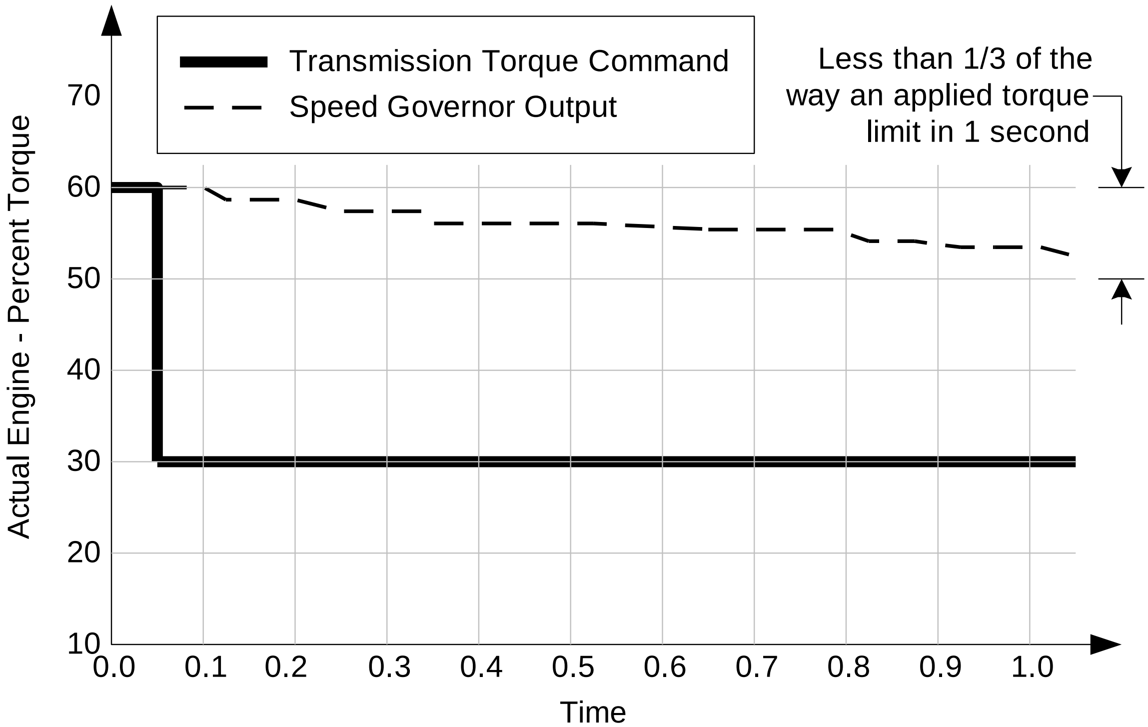


FIGURE SPN2432_E - EXAMPLE OF "SLOW TO RESPOND" SPEED GOVERNOR

A.22 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 :

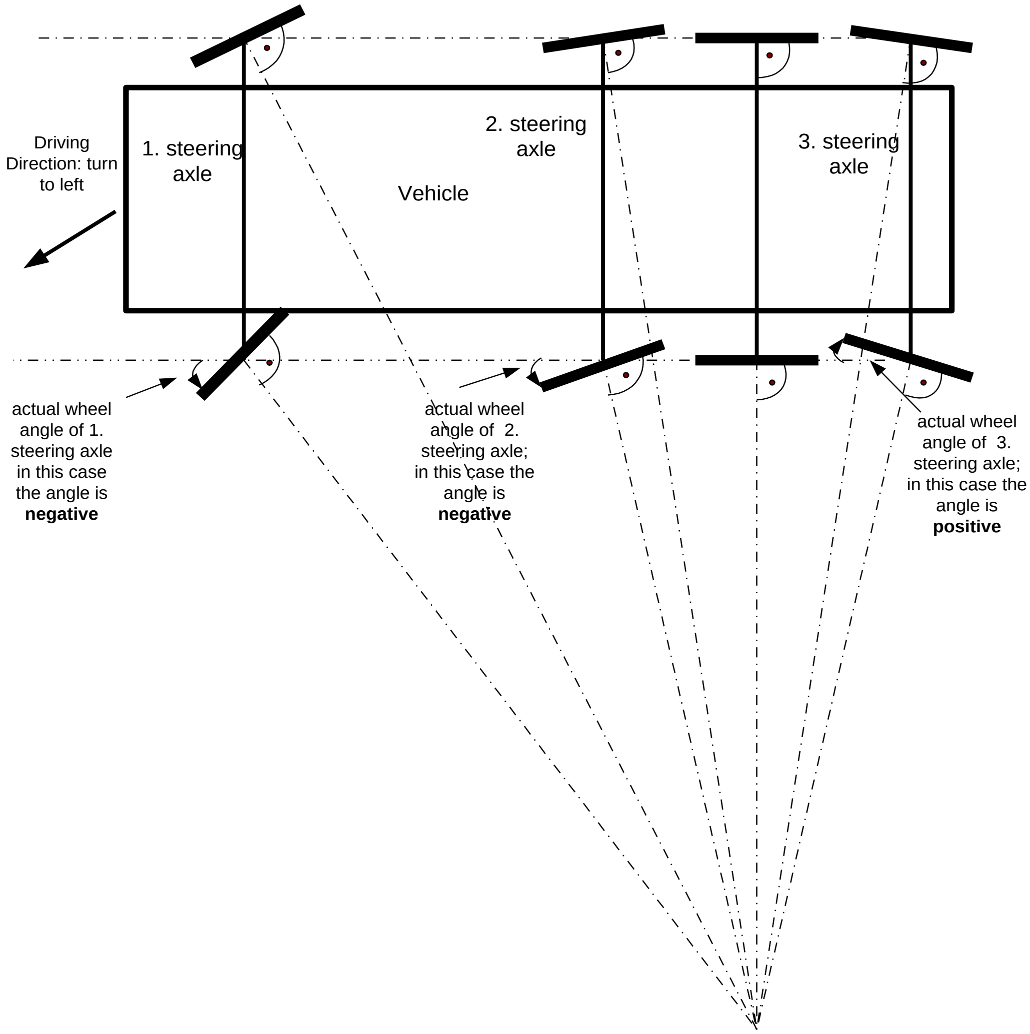


FIGURE SPN2927_A - STEERING AXLE ORIENTATION

A.23 SPN 3697 – DIESEL PARTICULATE FILTER LAMP COMMAND

	State of Regeneration Cycle	SAE J1939 Parameters: 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

A.24 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

A.25 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.

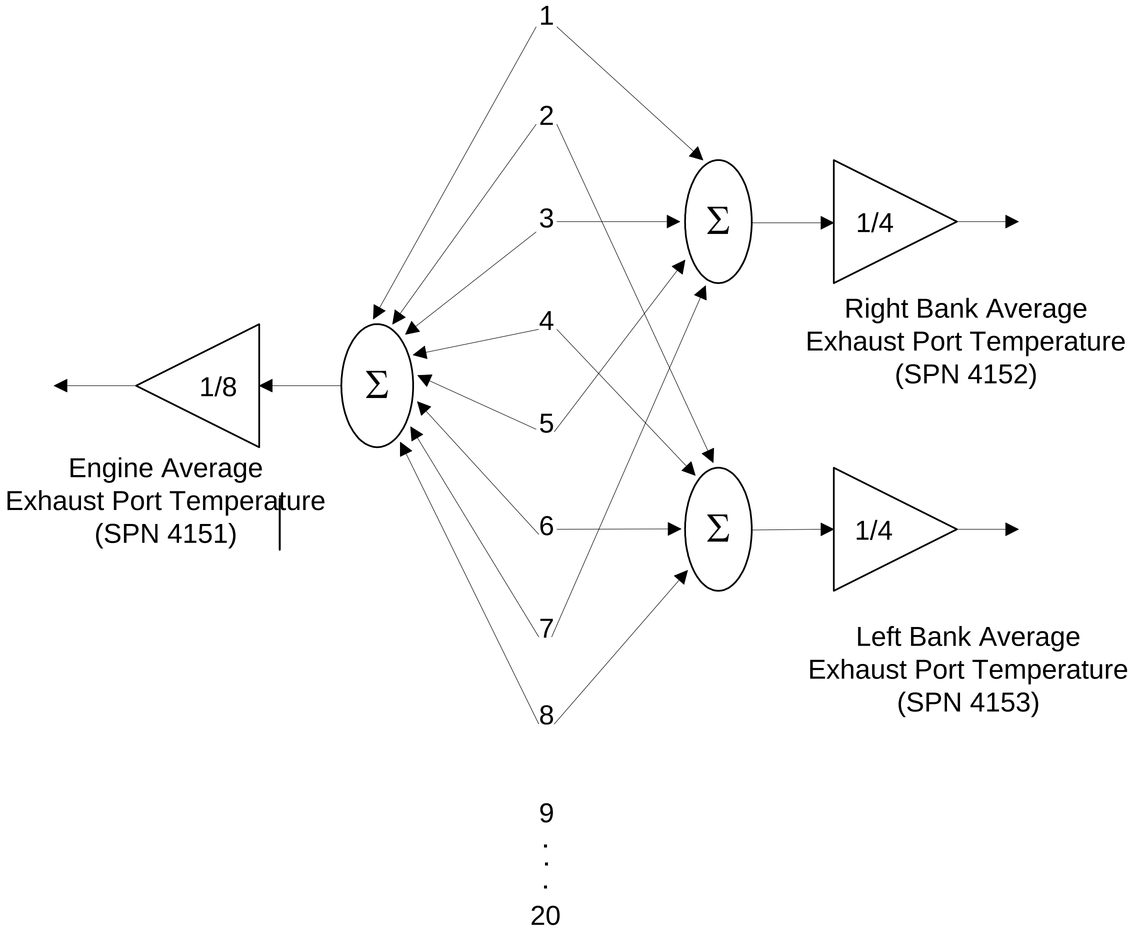


FIGURE SPN4151_A - ENGINE EXHAUST TEMPERATURE AVERAGING METHOD

A.26 SPN 5052 – CLUTCH/TORQUE CONVERTER INPUT SPEED

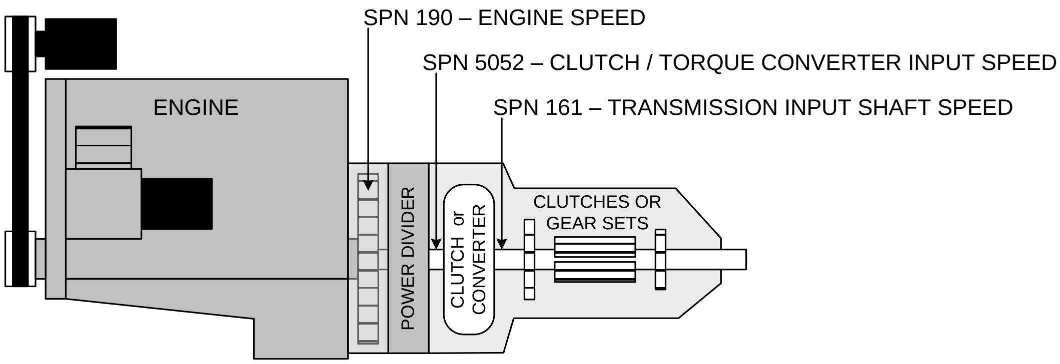


FIGURE SPN5052_A - POWER DIVIDER SCHEMATIC

A.27 SPN 5275 – PARK BRAKE ACTIVATION

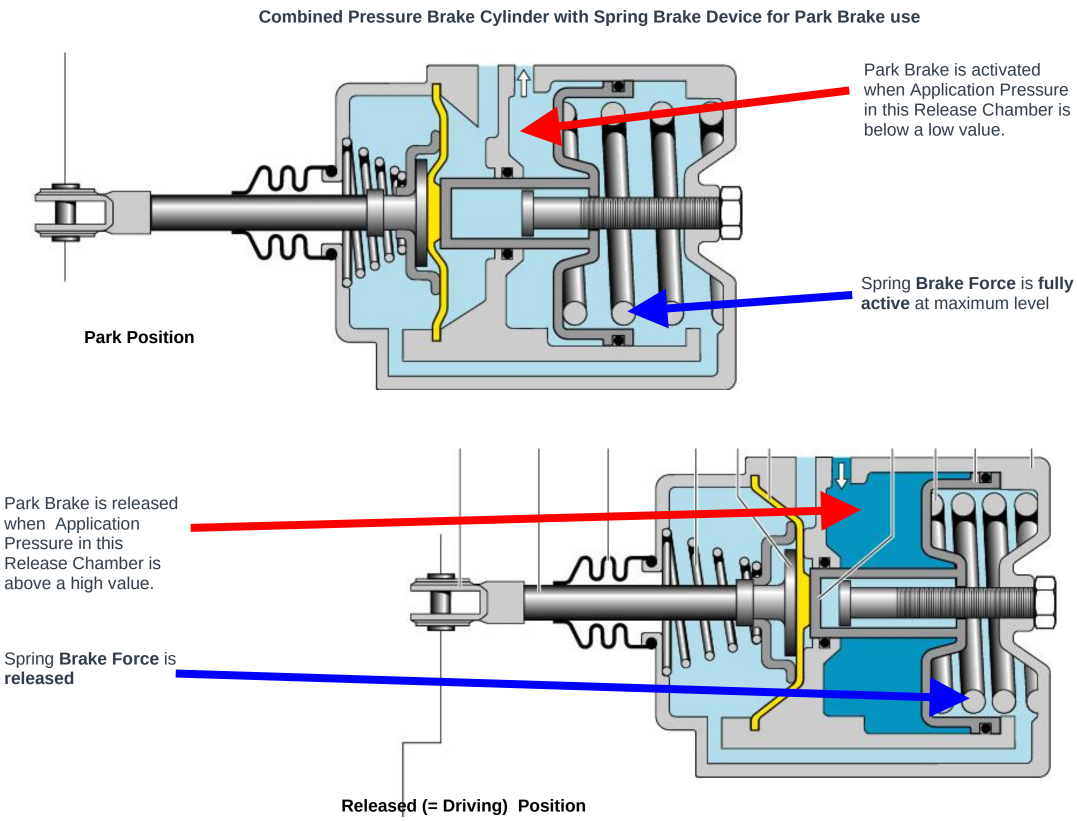


FIGURE SPN5275A - PARK BRAKE ACTIVATION

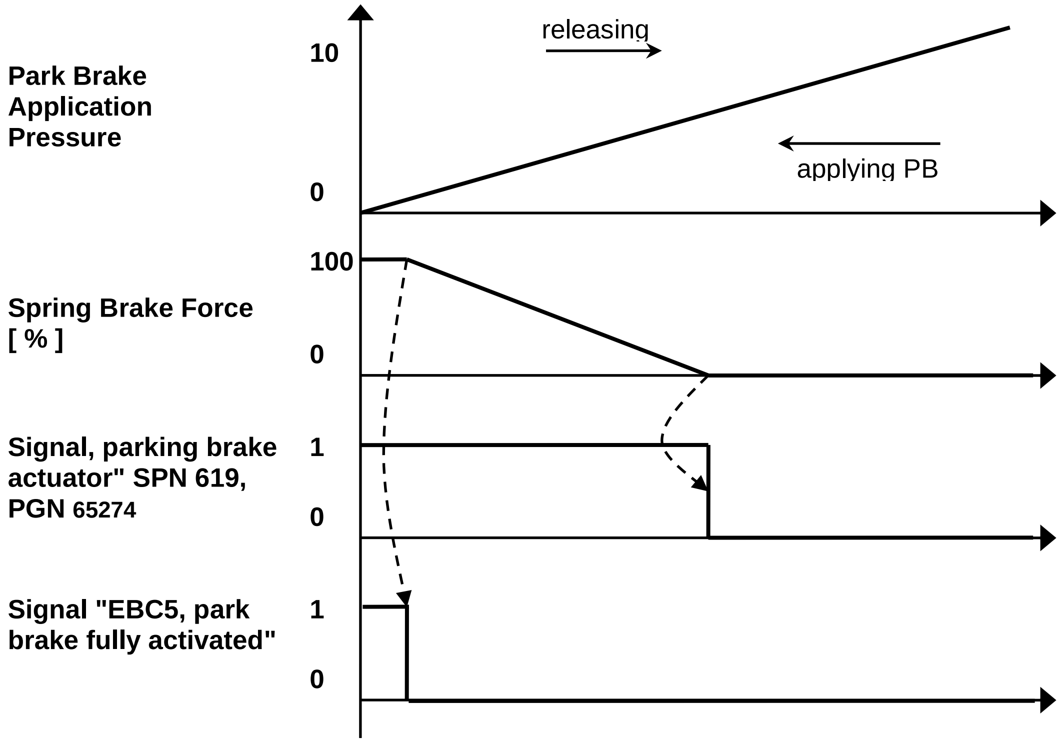


FIGURE SPN5275B - PARK BRAKE ACTIVATION STATES

A.28 SPN 5919 – HVESS VOLTAGE LEVEL

The table below identifies the SPNs that will be used in SAE J1939-73 DM24 to indicate the datastream that are provided to support the California Air Resources Board Heavy Duty Zero Emission Powertrain (ZEP) regulations as defined by Title 13 Section 1956.8. See also J1939-73 Table 1 and Table 2 to identify the datastream and diagnostic message support requirements for HD ZEPs.

The following SP numbers are used in J1939-73 DM24 to indicate support of groups of SPs. Each grouping is defined in the table following this list under the column header "Group". It may be that one or more controllers will report these SPNs in their DM24. If multiple controllers are to report DM24, each of these SPNs shall only be reported once across all controllers.

- SPN 5919 HVESS Voltage Level - Reported to indicate the system data stream parameters are supported.
- SPN 11052 HVESP1 Voltage Level - Reported to indicate pack 1 data stream parameters are supported.
- SPN 11168 HVESP2 Voltage Level - Reported to indicate pack 2 data stream parameters are supported.
- SPN 11284 HVESP3 Voltage Level - Reported to indicate pack 3 data stream parameters are supported.
- SPN 11400 HVESP4 Voltage Level - Reported to indicate pack 4 data stream parameters are supported.
- SPN 11516 HVESP5 Voltage Level - Reported to indicate pack 5 data stream parameters are supported.
- SPN 11632 HVESP6 Voltage Level - Reported to indicate pack 6 data stream parameters are supported.
- SPN 14062 HVESP7 Voltage Level - Reported to indicate pack 7 data stream parameters are supported.
- SPN 14205 HVESP8 Voltage Level - Reported to indicate pack 8 data stream parameters are supported.
- SPN 14348 HVESP9 Voltage Level - Reported to indicate pack 9 data stream parameters are supported.
- SPN 14491 HVESP10 Voltage Level - Reported to indicate pack 10 data stream parameters are supported.
- SPN 15294 HVESP11 Voltage Level - Reported to indicate pack 11 data stream parameters are supported.
- SPN 15436 HVESP12 Voltage Level - Reported to indicate pack 12 data stream parameters are supported.
- SPN 15578 HVESP13 Voltage Level - Reported to indicate pack 13 data stream parameters are supported.
- SPN 15720 HVESP14 Voltage Level - Reported to indicate pack 14 data stream parameters are supported.
- SPN 15862 HVESP15 Voltage Level - Reported to indicate pack 15 data stream parameters are supported.
- SPN 16004 HVESP16 Voltage Level - Reported to indicate pack 16 data stream parameters are supported.
- SPN 16146 HVESP17 Voltage Level - Reported to indicate pack 17 data stream parameters are supported.
- SPN 16288 HVESP18 Voltage Level - Reported to indicate pack 18 data stream parameters are supported.
- SPN 16430 HVESP19 Voltage Level - Reported to indicate pack 19 data stream parameters are supported.
- SPN 16572 HVESP20 Voltage Level - Reported to indicate pack 20 data stream parameters are supported.
- SPN 16714 HVESP21 Voltage Level - Reported to indicate pack 21 data stream parameters are supported.
- SPN 16856 HVESP22 Voltage Level - Reported to indicate pack 22 data stream parameters are supported.
- SPN 16998 HVESP23 Voltage Level - Reported to indicate pack 23 data stream parameters are supported.
- SPN 17140 HVESP24 Voltage Level - Reported to indicate pack 24 data stream parameters are supported.
- SPN 17282 HVESP25 Voltage Level - Reported to indicate pack 25 data stream parameters are supported.
- SPN 17424 HVESP26 Voltage Level - Reported to indicate pack 26 data stream parameters are supported.

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
0	5919	61584	High Voltage Energy Storage System Data 1	5919	HVESS Voltage Level
0	5919	61584	High Voltage Energy Storage System Data 1	5920	HVESS Current
0	5919	61589	High Voltage Energy Storage System Data 6	9119	HVESS Temperature
0	5919	61600	High Voltage Energy Storage System Data 7	8205	HVESS Discharge Energy Capacity
0	5919	64394	High Voltage Energy Storage System Data 11	13071	HVESS Actual Charge Rate
0	5919	64605	High Voltage Energy Storage System Configuration	8118	HVESS Recommended Minimum State Of Charge
0	5919	64605	High Voltage Energy Storage System Configuration	8119	HVESS Recommended Maximum State Of Charge
0	5919	64606	High Voltage Energy Storage System History	8121	HVESS State of Health
0	5919	64605	High Voltage Energy Storage System Configuration	15262	HVESS Nominal Rated Capacity
0	5919	64606	High Voltage Energy Storage System History	8211	HVESS Total Energy Throughput
0	5919	64606	High Voltage Energy Storage System History	13365	HVESS Total Lifetime Energy Input
0	5919	64606	High Voltage Energy Storage System History	13366	HVESS Total Lifetime Energy Output
1	11052	61841	High Voltage Energy Storage Pack 1 Data 1	11052	HVESP1 Voltage Level
1	11052	61841	High Voltage Energy Storage Pack 1 Data 1	11053	HVESP1 Current
1	11052	61846	High Voltage Energy Storage Pack 1 Data 6	11074	HVESP1 Temperature
1	11052	61848	High Voltage Energy Storage Pack 1 Data 7	11090	HVESP1 Discharge Energy Capacity
1	11052	61854	High Voltage Energy Storage Pack 1 Data 11	13065	HVESP1 Actual Charge Rate
1	11052	64346	High Voltage Energy Storage Pack 1 Configuration	11135	HVESP1 Recommended Minimum State Of Charge
1	11052	64346	High Voltage Energy Storage Pack 1 Configuration	11136	HVESP1 Recommended Maximum State Of Charge
1	11052	64345	High Voltage Energy Storage Pack 1 History	11141	HVESP1 State of Health

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
1	11052	64346	High Voltage Energy Storage Pack 1 Configuration	15261	HVESP1 Nominal Rated Capacity
1	11052	64345	High Voltage Energy Storage Pack 1 History	11143	HVESP1 Total Energy Throughput
1	11052	64345	High Voltage Energy Storage Pack 1 History	13367	HVESP1 Total Lifetime Energy Input
1	11052	64345	High Voltage Energy Storage Pack 1 History	13368	HVESP1 Total Lifetime Energy Output
2	11168	61856	High Voltage Energy Storage Pack 2 Data 1	11168	HVESP2 Voltage Level
2	11168	61856	High Voltage Energy Storage Pack 2 Data 1	11169	HVESP2 Current
2	11168	61861	High Voltage Energy Storage Pack 2 Data 6	11190	HVESP2 Temperature
2	11168	61863	High Voltage Energy Storage Pack 2 Data 7	11206	HVESP2 Discharge Energy Capacity
2	11168	61869	High Voltage Energy Storage Pack 2 Data 11	13066	HVESP2 Actual Charge Rate
2	11168	64344	High Voltage Energy Storage Pack 2 Configuration	11251	HVESP2 Recommended Minimum State Of Charge
2	11168	64344	High Voltage Energy Storage Pack 2 Configuration	11252	HVESP2 Recommended Maximum State Of Charge
2	11168	64343	High Voltage Energy Storage Pack 2 History	11257	HVESP2 State of Health
2	11168	64344	High Voltage Energy Storage Pack 2 Configuration	15260	HVESP2 Nominal Rated Capacity
2	11168	64343	High Voltage Energy Storage Pack 2 History	11259	HVESP2 Total Energy Throughput
2	11168	64343	High Voltage Energy Storage Pack 2 History	13369	HVESP2 Total Lifetime Energy Input
2	11168	64343	High Voltage Energy Storage Pack 2 History	13370	HVESP2 Total Lifetime Energy Output
3	11284	61871	High Voltage Energy Storage Pack 3 Data 1	11284	HVESP3 Voltage Level
3	11284	61871	High Voltage Energy Storage Pack 3 Data 1	11285	HVESP3 Current
3	11284	61876	High Voltage Energy Storage Pack 3 Data 6	11306	HVESP3 Temperature
3	11284	61878	High Voltage Energy Storage Pack 3 Data 7	11322	HVESP3 Discharge Energy Capacity
3	11284	61884	High Voltage Energy Storage Pack 3 Data 11	13067	HVESP3 Actual Charge Rate

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
3	11284	64342	High Voltage Energy Storage Pack 3 Configuration	11367	HVESP3 Recommended Minimum State Of Charge
3	11284	64342	High Voltage Energy Storage Pack 3 Configuration	11368	HVESP3 Recommended Maximum State Of Charge
3	11284	64341	High Voltage Energy Storage Pack 3 History	11373	HVESP3 State of Health
3	11284	64342	High Voltage Energy Storage Pack 3 Configuration	15259	HVESP3 Nominal Rated Capacity
3	11284	64341	High Voltage Energy Storage Pack 3 History	11375	HVESP3 Total Energy Throughput
3	11284	64341	High Voltage Energy Storage Pack 3 History	13371	HVESP3 Total Lifetime Energy Input
3	11284	64341	High Voltage Energy Storage Pack 3 History	13372	HVESP3 Total Lifetime Energy Output
4	11400	61886	High Voltage Energy Storage Pack 4 Data 1	11400	HVESP4 Voltage Level
4	11400	61886	High Voltage Energy Storage Pack 4 Data 1	11401	HVESP4 Current
4	11400	61891	High Voltage Energy Storage Pack 4 Data 6	11422	HVESP4 Temperature
4	11400	61893	High Voltage Energy Storage Pack 4 Data 7	11438	HVESP4 Discharge Energy Capacity
4	11400	61899	High Voltage Energy Storage Pack 4 Data 11	13068	HVESP4 Actual Charge Rate
4	11400	64340	High Voltage Energy Storage Pack 4 Configuration	11483	HVESP4 Recommended Minimum State Of Charge
4	11400	64340	High Voltage Energy Storage Pack 4 Configuration	11484	HVESP4 Recommended Maximum State Of Charge
4	11400	64339	High Voltage Energy Storage Pack 4 History	11489	HVESP4 State of Health
4	11400	64340	High Voltage Energy Storage Pack 4 Configuration	15258	HVESP4 Nominal Rated Capacity
4	11400	64339	High Voltage Energy Storage Pack 4 History	11491	HVESP4 Total Energy Throughput
4	11400	64339	High Voltage Energy Storage Pack 4 History	13373	HVESP4 Total Lifetime Energy Input
4	11400	64339	High Voltage Energy Storage Pack 4 History	13374	HVESP4 Total Lifetime Energy Output
5	11516	61901	High Voltage Energy Storage Pack 5 Data 1	11516	HVESP5 Voltage Level

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
5	11516	61901	High Voltage Energy Storage Pack 5 Data 1	11517	HVESP5 Current
5	11516	61906	High Voltage Energy Storage Pack 5 Data 6	11538	HVESP5 Temperature
5	11516	61908	High Voltage Energy Storage Pack 5 Data 7	11554	HVESP5 Discharge Energy Capacity
5	11516	61914	High Voltage Energy Storage Pack 5 Data 11	13069	HVESP5 Actual Charge Rate
5	11516	64338	High Voltage Energy Storage Pack 5 Configuration	11599	HVESP5 Recommended Minimum State Of Charge
5	11516	64338	High Voltage Energy Storage Pack 5 Configuration	11600	HVESP5 Recommended Maximum State Of Charge
5	11516	64337	High Voltage Energy Storage Pack 5 History	11605	HVESP5 State of Health
5	11516	64338	High Voltage Energy Storage Pack 5 Configuration	15257	HVESP5 Nominal Rated Capacity
5	11516	64337	High Voltage Energy Storage Pack 5 History	11607	HVESP5 Total Energy Throughput
5	11516	64337	High Voltage Energy Storage Pack 5 History	13375	HVESP5 Total Lifetime Energy Input
5	11516	64337	High Voltage Energy Storage Pack 5 History	13376	HVESP5 Total Lifetime Energy Output
6	11632	61916	High Voltage Energy Storage Pack 6 Data 1	11632	HVESP6 Voltage Level
6	11632	61916	High Voltage Energy Storage Pack 6 Data 1	11633	HVESP6 Current
6	11632	61921	High Voltage Energy Storage Pack 6 Data 6	11654	HVESP6 Temperature
6	11632	61923	High Voltage Energy Storage Pack 6 Data 7	11670	HVESP6 Discharge Energy Capacity
6	11632	61929	High Voltage Energy Storage Pack 6 Data 11	13070	HVESP6 Actual Charge Rate
6	11632	64336	High Voltage Energy Storage Pack 6 Configuration	11715	HVESP6 Recommended Minimum State Of Charge
6	11632	64336	High Voltage Energy Storage Pack 6 Configuration	11716	HVESP6 Recommended Maximum State Of Charge
6	11632	64335	High Voltage Energy Storage Pack 6 History	11721	HVESP6 State of Health
6	11632	64336	High Voltage Energy Storage Pack 6 Configuration	15256	HVESP6 Nominal Rated Capacity

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
6	11632	64335	High Voltage Energy Storage Pack 6 History	11723	HVESP6 Total Energy Throughput
6	11632	64335	High Voltage Energy Storage Pack 6 History	13377	HVESP6 Total Lifetime Energy Input
6	11632	64335	High Voltage Energy Storage Pack 6 History	13378	HVESP6 Total Lifetime Energy Output
7	14062	61973	High Voltage Energy Storage Pack 7 Data 1	14062	HVESP7 Voltage Level
7	14062	61973	High Voltage Energy Storage Pack 7 Data 1	14063	HVESP7 Current
7	14062	61978	High Voltage Energy Storage Pack 7 Data 6	14084	HVESP7 Temperature
7	14062	61980	High Voltage Energy Storage Pack 7 Data 7	14102	HVESP7 Discharge Energy Capacity
7	14062	61986	High Voltage Energy Storage Pack 7 Data 11	14162	HVESP7 Actual Charge Rate
7	14062	64177	High Voltage Energy Storage Pack 7 Configuration	14174	HVESP7 Recommended Minimum State Of Charge
7	14062	64177	High Voltage Energy Storage Pack 7 Configuration	14175	HVESP7 Recommended Maximum State Of Charge
7	14062	64178	High Voltage Energy Storage Pack 7 History	14163	HVESP7 State of Health
7	14062	64177	High Voltage Energy Storage Pack 7 Configuration	15255	HVESP7 Nominal Rated Capacity
7	14062	64178	High Voltage Energy Storage Pack 7 History	14165	HVESP7 Total Energy Throughput
7	14062	64178	High Voltage Energy Storage Pack 7 History	14167	HVESP7 Total Lifetime Energy Input
7	14062	64178	High Voltage Energy Storage Pack 7 History	14168	HVESP7 Total Lifetime Energy Output
8	14205	61988	High Voltage Energy Storage Pack 8 Data 1	14205	HVESP8 Voltage Level
8	14205	61988	High Voltage Energy Storage Pack 8 Data 1	14206	HVESP8 Current
8	14205	61993	High Voltage Energy Storage Pack 8 Data 6	14227	HVESP8 Temperature
8	14205	61995	High Voltage Energy Storage Pack 8 Data 7	14245	HVESP8 Discharge Energy Capacity
8	14205	62001	High Voltage Energy Storage Pack 8 Data 11	14305	HVESP8 Actual Charge Rate
8	14205	64175	High Voltage Energy Storage Pack 8 Configuration	14317	HVESP8 Recommended Minimum State Of Charge

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
8	14205	64175	High Voltage Energy Storage Pack 8 Configuration	14318	HVESP8 Recommended Maximum State Of Charge
8	14205	64176	High Voltage Energy Storage Pack 8 History	14306	HVESP8 State of Health
8	14205	64175	High Voltage Energy Storage Pack 8 Configuration	15254	HVESP8 Nominal Rated Capacity
8	14205	64176	High Voltage Energy Storage Pack 8 History	14308	HVESP8 Total Energy Throughput
8	14205	64176	High Voltage Energy Storage Pack 8 History	14310	HVESP8 Total Lifetime Energy Input
8	14205	64176	High Voltage Energy Storage Pack 8 History	14311	HVESP8 Total Lifetime Energy Output
9	14348	62003	High Voltage Energy Storage Pack 9 Data 1	14348	HVESP9 Voltage Level
9	14348	62003	High Voltage Energy Storage Pack 9 Data 1	14349	HVESP9 Current
9	14348	62008	High Voltage Energy Storage Pack 9 Data 6	14370	HVESP9 Temperature
9	14348	62010	High Voltage Energy Storage Pack 9 Data 7	14388	HVESP9 Discharge Energy Capacity
9	14348	62016	High Voltage Energy Storage Pack 9 Data 11	14448	HVESP9 Actual Charge Rate
9	14348	64173	High Voltage Energy Storage Pack 9 Configuration	14460	HVESP9 Recommended Minimum State Of Charge
9	14348	64173	High Voltage Energy Storage Pack 9 Configuration	14461	HVESP9 Recommended Maximum State Of Charge
9	14348	64174	High Voltage Energy Storage Pack 9 History	14449	HVESP9 State of Health
9	14348	64173	High Voltage Energy Storage Pack 9 Configuration	15253	HVESP9 Nominal Rated Capacity
9	14348	64174	High Voltage Energy Storage Pack 9 History	14451	HVESP9 Total Energy Throughput
9	14348	64174	High Voltage Energy Storage Pack 9 History	14453	HVESP9 Total Lifetime Energy Input
9	14348	64174	High Voltage Energy Storage Pack 9 History	14454	HVESP9 Total Lifetime Energy Output
10	14491	62018	High Voltage Energy Storage Pack 10 Data 1	14491	HVESP10 Voltage Level
10	14491	62018	High Voltage Energy Storage Pack 10 Data 1	14492	HVESP10 Current
10	14491	62023	High Voltage Energy Storage Pack 10 Data 6	14513	HVESP10 Temperature

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
10	14491	62025	High Voltage Energy Storage Pack 10 Data 7	14531	HVESP10 Discharge Energy Capacity
10	14491	62031	High Voltage Energy Storage Pack 10 Data 11	14591	HVESP10 Actual Charge Rate
10	14491	64171	High Voltage Energy Storage Pack 10 Configuration	14603	HVESP10 Recommended Minimum State Of Charge
10	14491	64171	High Voltage Energy Storage Pack 10 Configuration	14604	HVESP10 Recommended Maximum State Of Charge
10	14491	64172	High Voltage Energy Storage Pack 10 History	14592	HVESP10 State of Health
10	14491	64171	High Voltage Energy Storage Pack 10 Configuration	15252	HVESP10 Nominal Rated Capacity
10	14491	64172	High Voltage Energy Storage Pack 10 History	14594	HVESP10 Total Energy Throughput
10	14491	64172	High Voltage Energy Storage Pack 10 History	14596	HVESP10 Total Lifetime Energy Input
10	14491	64172	High Voltage Energy Storage Pack 10 History	14597	HVESP10 Total Lifetime Energy Output
11	15294	62034	High Voltage Energy Storage Pack 11 Data 1	15294	HVESP11 Voltage Level
11	15294	62034	High Voltage Energy Storage Pack 11 Data 1	15295	HVESP11 Current
11	15294	62039	High Voltage Energy Storage Pack 11 Data 6	15316	HVESP11 Temperature
11	15294	62041	High Voltage Energy Storage Pack 11 Data 7	15334	HVESP11 Discharge Energy Capacity
11	15294	62047	High Voltage Energy Storage Pack 11 Data 11	15394	HVESP11 Actual Charge Rate
11	15294	64133	High Voltage Energy Storage Pack 11 Configuration	15404	HVESP11 Recommended Minimum State Of Charge
11	15294	64133	High Voltage Energy Storage Pack 11 Configuration	15405	HVESP11 Recommended Maximum State Of Charge
11	15294	64132	High Voltage Energy Storage Pack 11 History	15395	HVESP11 State of Health
11	15294	64133	High Voltage Energy Storage Pack 11 Configuration	15410	HVESP11 Nominal Rated Capacity

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
11	15294	64132	High Voltage Energy Storage Pack 11 History	15397	HVESP11 Total Energy Throughput
11	15294	64132	High Voltage Energy Storage Pack 11 History	15399	HVESP11 Total Lifetime Energy Input
11	15294	64132	High Voltage Energy Storage Pack 11 History	15400	HVESP11 Total Lifetime Energy Output
12	15436	62049	High Voltage Energy Storage Pack 12 Data 1	15436	HVESP12 Voltage Level
12	15436	62049	High Voltage Energy Storage Pack 12 Data 1	15437	HVESP12 Current
12	15436	62054	High Voltage Energy Storage Pack 12 Data 6	15458	HVESP12 Temperature
12	15436	62056	High Voltage Energy Storage Pack 12 Data 7	15476	HVESP12 Discharge Energy Capacity
12	15436	62062	High Voltage Energy Storage Pack 12 Data 11	15536	HVESP12 Actual Charge Rate
12	15436	64135	High Voltage Energy Storage Pack 12 Configuration	15546	HVESP12 Recommended Minimum State Of Charge
12	15436	64135	High Voltage Energy Storage Pack 12 Configuration	15547	HVESP12 Recommended Maximum State Of Charge
12	15436	64134	High Voltage Energy Storage Pack 12 History	15537	HVESP12 State of Health
12	15436	64135	High Voltage Energy Storage Pack 12 Configuration	15552	HVESP12 Nominal Rated Capacity
12	15436	64134	High Voltage Energy Storage Pack 12 History	15539	HVESP12 Total Energy Throughput
12	15436	64134	High Voltage Energy Storage Pack 12 History	15541	HVESP12 Total Lifetime Energy Input
12	15436	64134	High Voltage Energy Storage Pack 12 History	15542	HVESP12 Total Lifetime Energy Output
13	15578	62064	High Voltage Energy Storage Pack 13 Data 1	15578	HVESP13 Voltage Level
13	15578	62064	High Voltage Energy Storage Pack 13 Data 1	15579	HVESP13 Current
13	15578	62069	High Voltage Energy Storage Pack 13 Data 6	15600	HVESP13 Temperature

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
13	15578	62071	High Voltage Energy Storage Pack 13 Data 7	15618	HVESP13 Discharge Energy Capacity
13	15578	62077	High Voltage Energy Storage Pack 13 Data 11	15678	HVESP13 Actual Charge Rate
13	15578	64137	High Voltage Energy Storage Pack 13 Configuration	15688	HVESP13 Recommended Minimum State Of Charge
13	15578	64137	High Voltage Energy Storage Pack 13 Configuration	15689	HVESP13 Recommended Maximum State Of Charge
13	15578	64136	High Voltage Energy Storage Pack 13 History	15679	HVESP13 State of Health
13	15578	64137	High Voltage Energy Storage Pack 13 Configuration	15694	HVESP13 Nominal Rated Capacity
13	15578	64136	High Voltage Energy Storage Pack 13 History	15681	HVESP13 Total Energy Throughput
13	15578	64136	High Voltage Energy Storage Pack 13 History	15683	HVESP13 Total Lifetime Energy Input
13	15578	64136	High Voltage Energy Storage Pack 13 History	15684	HVESP13 Total Lifetime Energy Output
14	15720	62079	High Voltage Energy Storage Pack 14 Data 1	15720	HVESP14 Voltage Level
14	15720	62079	High Voltage Energy Storage Pack 14 Data 1	15721	HVESP14 Current
14	15720	62084	High Voltage Energy Storage Pack 14 Data 6	15742	HVESP14 Temperature
14	15720	62086	High Voltage Energy Storage Pack 14 Data 7	15760	HVESP14 Discharge Energy Capacity
14	15720	62092	High Voltage Energy Storage Pack 14 Data 11	15820	HVESP14 Actual Charge Rate
14	15720	64139	High Voltage Energy Storage Pack 14 Configuration	15830	HVESP14 Recommended Minimum State Of Charge
14	15720	64139	High Voltage Energy Storage Pack 14 Configuration	15831	HVESP14 Recommended Maximum State Of Charge
14	15720	64138	High Voltage Energy Storage Pack 14 History	15821	HVESP14 State of Health
14	15720	64139	High Voltage Energy Storage Pack 14 Configuration	15836	HVESP14 Nominal Rated Capacity

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
14	15720	64138	High Voltage Energy Storage Pack 14 History	15823	HVESP14 Total Energy Throughput
14	15720	64138	High Voltage Energy Storage Pack 14 History	15825	HVESP14 Total Lifetime Energy Input
14	15720	64138	High Voltage Energy Storage Pack 14 History	15826	HVESP14 Total Lifetime Energy Output
15	15862	62094	High Voltage Energy Storage Pack 15 Data 1	15862	HVESP15 Voltage Level
15	15862	62094	High Voltage Energy Storage Pack 15 Data 1	15863	HVESP15 Current
15	15862	62099	High Voltage Energy Storage Pack 15 Data 6	15884	HVESP15 Temperature
15	15862	62101	High Voltage Energy Storage Pack 15 Data 7	15902	HVESP15 Discharge Energy Capacity
15	15862	62107	High Voltage Energy Storage Pack 15 Data 11	15962	HVESP15 Actual Charge Rate
15	15862	64141	High Voltage Energy Storage Pack 15 Configuration	15972	HVESP15 Recommended Minimum State Of Charge
15	15862	64141	High Voltage Energy Storage Pack 15 Configuration	15973	HVESP15 Recommended Maximum State Of Charge
15	15862	64140	High Voltage Energy Storage Pack 15 History	15963	HVESP15 State of Health
15	15862	64141	High Voltage Energy Storage Pack 15 Configuration	15978	HVESP15 Nominal Rated Capacity
15	15862	64140	High Voltage Energy Storage Pack 15 History	15965	HVESP15 Total Energy Throughput
15	15862	64140	High Voltage Energy Storage Pack 15 History	15967	HVESP15 Total Lifetime Energy Input
15	15862	64140	High Voltage Energy Storage Pack 15 History	15968	HVESP15 Total Lifetime Energy Output
16	16004	62109	High Voltage Energy Storage Pack 16 Data 1	16004	HVESP16 Voltage Level
16	16004	62109	High Voltage Energy Storage Pack 16 Data 1	16005	HVESP16 Current
16	16004	62114	High Voltage Energy Storage Pack 16 Data 6	16026	HVESP16 Temperature

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
16	16004	62116	High Voltage Energy Storage Pack 16 Data 7	16044	HVESP16 Discharge Energy Capacity
16	16004	62122	High Voltage Energy Storage Pack 16 Data 11	16104	HVESP16 Actual Charge Rate
16	16004	64143	High Voltage Energy Storage Pack 16 Configuration	16114	HVESP16 Recommended Minimum State Of Charge
16	16004	64143	High Voltage Energy Storage Pack 16 Configuration	16115	HVESP16 Recommended Maximum State Of Charge
16	16004	64142	High Voltage Energy Storage Pack 16 History	16105	HVESP16 State of Health
16	16004	64143	High Voltage Energy Storage Pack 16 Configuration	16120	HVESP16 Nominal Rated Capacity
16	16004	64142	High Voltage Energy Storage Pack 16 History	16107	HVESP16 Total Energy Throughput
16	16004	64142	High Voltage Energy Storage Pack 16 History	16109	HVESP16 Total Lifetime Energy Input
16	16004	64142	High Voltage Energy Storage Pack 16 History	16110	HVESP16 Total Lifetime Energy Output
17	16146	62124	High Voltage Energy Storage Pack 17 Data 1	16146	HVESP17 Voltage Level
17	16146	62124	High Voltage Energy Storage Pack 17 Data 1	16147	HVESP17 Current
17	16146	62129	High Voltage Energy Storage Pack 17 Data 6	16168	HVESP17 Temperature
17	16146	62131	High Voltage Energy Storage Pack 17 Data 7	16186	HVESP17 Discharge Energy Capacity
17	16146	62137	High Voltage Energy Storage Pack 17 Data 11	16246	HVESP17 Actual Charge Rate
17	16146	64145	High Voltage Energy Storage Pack 17 Configuration	16256	HVESP17 Recommended Minimum State Of Charge
17	16146	64145	High Voltage Energy Storage Pack 17 Configuration	16257	HVESP17 Recommended Maximum State Of Charge
17	16146	64144	High Voltage Energy Storage Pack 17 History	16247	HVESP17 State of Health
17	16146	64145	High Voltage Energy Storage Pack 17 Configuration	16262	HVESP17 Nominal Rated Capacity

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
17	16146	64144	High Voltage Energy Storage Pack 17 History	16249	HVESP17 Total Energy Throughput
17	16146	64144	High Voltage Energy Storage Pack 17 History	16251	HVESP17 Total Lifetime Energy Input
17	16146	64144	High Voltage Energy Storage Pack 17 History	16252	HVESP17 Total Lifetime Energy Output
18	16288	62139	High Voltage Energy Storage Pack 18 Data 1	16288	HVESP18 Voltage Level
18	16288	62139	High Voltage Energy Storage Pack 18 Data 1	16289	HVESP18 Current
18	16288	62144	High Voltage Energy Storage Pack 18 Data 6	16310	HVESP18 Temperature
18	16288	62146	High Voltage Energy Storage Pack 18 Data 7	16328	HVESP18 Discharge Energy Capacity
18	16288	62152	High Voltage Energy Storage Pack 18 Data 11	16388	HVESP18 Actual Charge Rate
18	16288	64147	High Voltage Energy Storage Pack 18 Configuration	16398	HVESP18 Recommended Minimum State Of Charge
18	16288	64147	High Voltage Energy Storage Pack 18 Configuration	16399	HVESP18 Recommended Maximum State Of Charge
18	16288	64146	High Voltage Energy Storage Pack 18 History	16389	HVESP18 State of Health
18	16288	64147	High Voltage Energy Storage Pack 18 Configuration	16404	HVESP18 Nominal Rated Capacity
18	16288	64146	High Voltage Energy Storage Pack 18 History	16391	HVESP18 Total Energy Throughput
18	16288	64146	High Voltage Energy Storage Pack 18 History	16393	HVESP18 Total Lifetime Energy Input
18	16288	64146	High Voltage Energy Storage Pack 18 History	16394	HVESP18 Total Lifetime Energy Output
19	16430	62154	High Voltage Energy Storage Pack 19 Data 1	16430	HVESP19 Voltage Level
19	16430	62154	High Voltage Energy Storage Pack 19 Data 1	16431	HVESP19 Current
19	16430	62159	High Voltage Energy Storage Pack 19 Data 6	16452	HVESP19 Temperature

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
19	16430	62161	High Voltage Energy Storage Pack 19 Data 7	16470	HVESP19 Discharge Energy Capacity
19	16430	62167	High Voltage Energy Storage Pack 19 Data 11	16530	HVESP19 Actual Charge Rate
19	16430	64149	High Voltage Energy Storage Pack 19 Configuration	16540	HVESP19 Recommended Minimum State Of Charge
19	16430	64149	High Voltage Energy Storage Pack 19 Configuration	16541	HVESP19 Recommended Maximum State Of Charge
19	16430	64148	High Voltage Energy Storage Pack 19 History	16531	HVESP19 State of Health
19	16430	64149	High Voltage Energy Storage Pack 19 Configuration	16546	HVESP19 Nominal Rated Capacity
19	16430	64148	High Voltage Energy Storage Pack 19 History	16533	HVESP19 Total Energy Throughput
19	16430	64148	High Voltage Energy Storage Pack 19 History	16535	HVESP19 Total Lifetime Energy Input
19	16430	64148	High Voltage Energy Storage Pack 19 History	16536	HVESP19 Total Lifetime Energy Output
20	16572	62169	High Voltage Energy Storage Pack 20 Data 1	16572	HVESP20 Voltage Level
20	16572	62169	High Voltage Energy Storage Pack 20 Data 1	16573	HVESP20 Current
20	16572	62174	High Voltage Energy Storage Pack 20 Data 6	16594	HVESP20 Temperature
20	16572	62176	High Voltage Energy Storage Pack 20 Data 7	16612	HVESP20 Discharge Energy Capacity
20	16572	62182	High Voltage Energy Storage Pack 20 Data 11	16672	HVESP20 Actual Charge Rate
20	16572	64151	High Voltage Energy Storage Pack 20 Configuration	16682	HVESP20 Recommended Minimum State Of Charge
20	16572	64151	High Voltage Energy Storage Pack 20 Configuration	16683	HVESP20 Recommended Maximum State Of Charge
20	16572	64150	High Voltage Energy Storage Pack 20 History	16673	HVESP20 State of Health
20	16572	64151	High Voltage Energy Storage Pack 20 Configuration	16688	HVESP20 Nominal Rated Capacity

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
20	16572	64150	High Voltage Energy Storage Pack 20 History	16675	HVESP20 Total Energy Throughput
20	16572	64150	High Voltage Energy Storage Pack 20 History	16677	HVESP20 Total Lifetime Energy Input
20	16572	64150	High Voltage Energy Storage Pack 20 History	16678	HVESP20 Total Lifetime Energy Output
21	16714	62184	High Voltage Energy Storage Pack 21 Data 1	16714	HVESP21 Voltage Level
21	16714	62184	High Voltage Energy Storage Pack 21 Data 1	16715	HVESP21 Current
21	16714	62189	High Voltage Energy Storage Pack 21 Data 6	16736	HVESP21 Temperature
21	16714	62191	High Voltage Energy Storage Pack 21 Data 7	16754	HVESP21 Discharge Energy Capacity
21	16714	62197	High Voltage Energy Storage Pack 21 Data 11	16814	HVESP21 Actual Charge Rate
21	16714	64153	High Voltage Energy Storage Pack 21 Configuration	16824	HVESP21 Recommended Minimum State Of Charge
21	16714	64153	High Voltage Energy Storage Pack 21 Configuration	16825	HVESP21 Recommended Maximum State Of Charge
21	16714	64152	High Voltage Energy Storage Pack 21 History	16815	HVESP21 State of Health
21	16714	64153	High Voltage Energy Storage Pack 21 Configuration	16830	HVESP21 Nominal Rated Capacity
21	16714	64152	High Voltage Energy Storage Pack 21 History	16817	HVESP21 Total Energy Throughput
21	16714	64152	High Voltage Energy Storage Pack 21 History	16819	HVESP21 Total Lifetime Energy Input
21	16714	64152	High Voltage Energy Storage Pack 21 History	16820	HVESP21 Total Lifetime Energy Output
22	16856	62199	High Voltage Energy Storage Pack 22 Data 1	16856	HVESP22 Voltage Level
22	16856	62199	High Voltage Energy Storage Pack 22 Data 1	16857	HVESP22 Current
22	16856	62204	High Voltage Energy Storage Pack 22 Data 6	16878	HVESP22 Temperature

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
22	16856	62206	High Voltage Energy Storage Pack 22 Data 7	16896	HVESP22 Discharge Energy Capacity
22	16856	62212	High Voltage Energy Storage Pack 22 Data 11	16956	HVESP22 Actual Charge Rate
22	16856	64155	High Voltage Energy Storage Pack 22 Configuration	16966	HVESP22 Recommended Minimum State Of Charge
22	16856	64155	High Voltage Energy Storage Pack 22 Configuration	16967	HVESP22 Recommended Maximum State Of Charge
22	16856	64154	High Voltage Energy Storage Pack 22 History	16957	HVESP22 State of Health
22	16856	64155	High Voltage Energy Storage Pack 22 Configuration	16972	HVESP22 Nominal Rated Capacity
22	16856	64154	High Voltage Energy Storage Pack 22 History	16959	HVESP22 Total Energy Throughput
22	16856	64154	High Voltage Energy Storage Pack 22 History	16961	HVESP22 Total Lifetime Energy Input
22	16856	64154	High Voltage Energy Storage Pack 22 History	16962	HVESP22 Total Lifetime Energy Output
23	16998	62214	High Voltage Energy Storage Pack 23 Data 1	16998	HVESP23 Voltage Level
23	16998	62214	High Voltage Energy Storage Pack 23 Data 1	16999	HVESP23 Current
23	16998	62219	High Voltage Energy Storage Pack 23 Data 6	17020	HVESP23 Temperature
23	16998	62221	High Voltage Energy Storage Pack 23 Data 7	17038	HVESP23 Discharge Energy Capacity
23	16998	62227	High Voltage Energy Storage Pack 23 Data 11	17098	HVESP23 Actual Charge Rate
23	16998	64157	High Voltage Energy Storage Pack 23 Configuration	17108	HVESP23 Recommended Minimum State Of Charge
23	16998	64157	High Voltage Energy Storage Pack 23 Configuration	17109	HVESP23 Recommended Maximum State Of Charge
23	16998	64156	High Voltage Energy Storage Pack 23 History	17099	HVESP23 State of Health
23	16998	64157	High Voltage Energy Storage Pack 23 Configuration	17114	HVESP23 Nominal Rated Capacity

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
23	16998	64156	High Voltage Energy Storage Pack 23 History	17101	HVESP23 Total Energy Throughput
23	16998	64156	High Voltage Energy Storage Pack 23 History	17103	HVESP23 Total Lifetime Energy Input
23	16998	64156	High Voltage Energy Storage Pack 23 History	17104	HVESP23 Total Lifetime Energy Output
24	17140	62229	High Voltage Energy Storage Pack 24 Data 1	17140	HVESP24 Voltage Level
24	17140	62229	High Voltage Energy Storage Pack 24 Data 1	17141	HVESP24 Current
24	17140	62234	High Voltage Energy Storage Pack 24 Data 6	17162	HVESP24 Temperature
24	17140	62236	High Voltage Energy Storage Pack 24 Data 7	17180	HVESP24 Discharge Energy Capacity
24	17140	62242	High Voltage Energy Storage Pack 24 Data 11	17240	HVESP24 Actual Charge Rate
24	17140	64159	High Voltage Energy Storage Pack 24 Configuration	17250	HVESP24 Recommended Minimum State Of Charge
24	17140	64159	High Voltage Energy Storage Pack 24 Configuration	17251	HVESP24 Recommended Maximum State Of Charge
24	17140	64158	High Voltage Energy Storage Pack 24 History	17241	HVESP24 State of Health
24	17140	64159	High Voltage Energy Storage Pack 24 Configuration	17256	HVESP24 Nominal Rated Capacity
24	17140	64158	High Voltage Energy Storage Pack 24 History	17243	HVESP24 Total Energy Throughput
24	17140	64158	High Voltage Energy Storage Pack 24 History	17245	HVESP24 Total Lifetime Energy Input
24	17140	64158	High Voltage Energy Storage Pack 24 History	17246	HVESP24 Total Lifetime Energy Output
25	17282	62244	High Voltage Energy Storage Pack 25 Data 1	17282	HVESP25 Voltage Level
25	17282	62244	High Voltage Energy Storage Pack 25 Data 1	17283	HVESP25 Current
25	17282	62249	High Voltage Energy Storage Pack 25 Data 6	17304	HVESP25 Temperature

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
25	17282	62251	High Voltage Energy Storage Pack 25 Data 7	17322	HVESP25 Discharge Energy Capacity
25	17282	62257	High Voltage Energy Storage Pack 25 Data 11	17382	HVESP25 Actual Charge Rate
25	17282	64161	High Voltage Energy Storage Pack 25 Configuration	17392	HVESP25 Recommended Minimum State Of Charge
25	17282	64161	High Voltage Energy Storage Pack 25 Configuration	17393	HVESP25 Recommended Maximum State Of Charge
25	17282	64160	High Voltage Energy Storage Pack 25 History	17383	HVESP25 State of Health
25	17282	64161	High Voltage Energy Storage Pack 25 Configuration	17398	HVESP25 Nominal Rated Capacity
25	17282	64160	High Voltage Energy Storage Pack 25 History	17385	HVESP25 Total Energy Throughput
25	17282	64160	High Voltage Energy Storage Pack 25 History	17387	HVESP25 Total Lifetime Energy Input
25	17282	64160	High Voltage Energy Storage Pack 25 History	17388	HVESP25 Total Lifetime Energy Output
26	17424	62259	High Voltage Energy Storage Pack 26 Data 1	17424	HVESP26 Voltage Level
26	17424	62259	High Voltage Energy Storage Pack 26 Data 1	17425	HVESP26 Current
26	17424	62264	High Voltage Energy Storage Pack 26 Data 6	17446	HVESP26 Temperature
26	17424	62266	High Voltage Energy Storage Pack 26 Data 7	17464	HVESP26 Discharge Energy Capacity
26	17424	62272	High Voltage Energy Storage Pack 26 Data 11	17524	HVESP26 Actual Charge Rate
26	17424	64163	High Voltage Energy Storage Pack 26 Configuration	17534	HVESP26 Recommended Minimum State Of Charge
26	17424	64163	High Voltage Energy Storage Pack 26 Configuration	17535	HVESP26 Recommended Maximum State Of Charge
26	17424	64162	High Voltage Energy Storage Pack 26 History	17525	HVESP26 State of Health
26	17424	64163	High Voltage Energy Storage Pack 26 Configuration	17540	HVESP26 Nominal Rated Capacity

Group 0 to 26	DM24 Indicator	PGN	PG Label	SPN	SP Label
26	17424	64162	High Voltage Energy Storage Pack 26 History	17527	HVESP26 Total Energy Throughput
26	17424	64162	High Voltage Energy Storage Pack 26 History	17529	HVESP26 Total Lifetime Energy Input
26	17424	64162	High Voltage Energy Storage Pack 26 History	17530	HVESP26 Total Lifetime Energy Output

A.29 SPN 5920 – CURRENT FLOW DIRECTIONS FOR A HYBRID SYSTEM

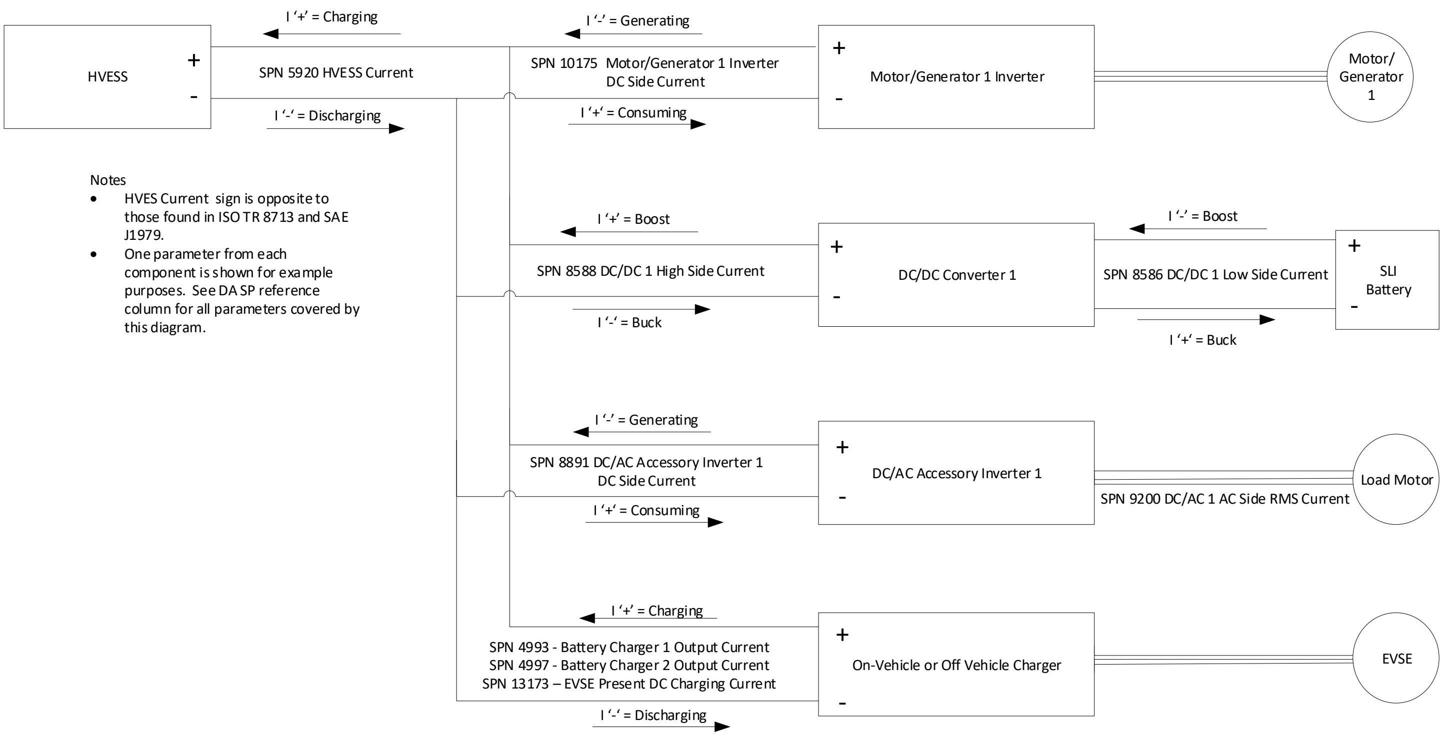


FIGURE SPN5920A - CURRENT FLOW DIRECTIONS FOR A SYSTEM WITH TWO MOTOR/GENERATORS, AND ONE DC/DC, DC/AC, AND HVES

A.30 SPN 6810 – HYBRID SYSTEM OBD RELATED DTC STATUS

Devices supporting SPN 6810 shall adhere to the following concepts of operation:

Hybrid System Behaviors

1. The hybrid system shall continuously broadcast an SPN 6810 value of 00b in applications where the hybrid system does not fall under OBD regulation.

2. In applications where SPN 6810 is used to satisfy OBD regulations, the hybrid system shall broadcast an SPN 6810 value of 01b when one or more Emission-Related MIL-On Diagnostic Trouble Codes are present and 00b when no Emission-Related MIL-On Diagnostic Trouble Codes are present.

3. In applications where SPN 6810 is used to satisfy OBD regulations, the hybrid system shall monitor a periodic broadcast message (“heartbeat”) from the engine (e.g. EEC1, EEC2, DM1, etc.) for communication integrity, and detect loss of engine communication if the heartbeat is not received within a timeout period.

4. When a value of 01b is being broadcast, or loss of communication with the engine is detected as defined above, the hybrid system shall activate a “hybrid warning indicator” (lamp, etc. used to notify personnel) such that the vehicle operator / service technician is aware a hybrid fault exists.

5. When a hybrid DTC has caused a 00b to 01b transition to occur, and that hybrid DTC subsequently self-clears, the hybrid system shall continue to activate the “hybrid warning indicator” (e.g. using SPN 5872 - Hybrid System Warning Indicator) until such a time as SPN 6810 / FMI 31 no longer appears in the engine’s DM1 broadcast. Note: The SPN 6810 parameter broadcast by the hybrid system cannot be used to directly control the “hybrid warning indicator”.

6. In applications where SPN 6810 is used to satisfy OBD regulations, the hybrid system shall never attempt to directly activate the MIL. In this case, DM1 broadcasts from the hybrid system shall always have SPN 1213 Malfunction Indicator Lamp Status set to 11b (i.e. Not Available).

   Optionally, if the hybrid system OBD fault manager can provide the MIL state for the hybrid system, then it may broadcast 00b (i.e. Lamp Off) or 01b (i.e. Lamp On) in its DM1 MIL (SPN 1213). In this case, the DM1 MIL (SPN 1213) from the hybrid only conveys the MIL status of the hybrid system. The engine’s DM1 MIL (SPN 1213) reflects the hybrid system’s SPN 6810 (per statement 2 from the Engine Behaviors below) in addition to the engine’s own Emission-Related MIL-On DTCs.

   In either case, the engine controller is not required to read the hybrid system’s DM1.

   Note 1: The optional DM1 MIL (SPN 1213) support by the hybrid system is intended to reduce SAE J1939-84 test errors on hybrid vehicles, as J1939-84 test sequence development did not consider SPN 6810-based OBD implementations.

   Note 2: If the hybrid system supports DM1 MIL (SPN 1213), the hybrid system shall report MIL (SPN 1213) in other supported J1939-73 Diagnostic Messages.

7. When the hybrid system is repaired, the service tool used to clear hybrid system DTCs shall issue a global DM11 request such that both engine and hybrid system OBD-related DTC content is reset simultaneously.

Engine Behaviors

1. In applications where SPN 6810 is used to satisfy OBD regulations, the engine shall receive SPN 6810 from the hybrid system.

2. When an SPN 6810 value of 01b is received, the engine shall activate the MIL, log a hybrid specific Emission-Related MIL-On Diagnostic Trouble Code, and capture “freeze frame” data as specified per OBD regulation. The

engine shall reference SPN 6810 FMI 31 in any relevant J1939 diagnostic communication (e.g. DM1, DM12, DM25 and DM28 messages).

3. Once the engine has set its hybrid specific DTC (SPN 6810/FMI 31), the engine shall only deactivate its hybrid specific DTC and its associated MIL after three sequential driving cycles where SPN 6810 has remained at a value of 00b.

4. In applications where SPN 6810 is used to satisfy OBD regulations, the engine shall monitor SPN 6810 for communication integrity and detect loss of hybrid system communication if SPN 6810 is not received for a period of more than 5 seconds (5X the PGN 64706 broadcast rate).

5. When the engine detects a loss of communication with the hybrid system as defined above, the engine shall set DTC SPN 6810/FMI 9 to highlight the communication issue. If DTC SPN 6810/FMI 31 is active when communication loss is detected, the engine shall also continue to indicate SPN 6810/FMI 31 as active.

6. When an SPN 6810 value of 11b is received, the engine shall set DTC SPN 6810/FMI 11 to indicate an improper hybrid system configuration.

7. The engine shall clear the Hybrid specific DTC (SPN 6810/FMI 31) when the appropriate Clear message is received from the SCAN tool.

8. The engine shall delay setting a new SPN 6810 DTC for 5 seconds after a global DM11 is requested to allow time for the hybrid system to clear its diagnostic data.

A.31 SPN 7548 – HYBRID SYSTEM PARAMETERS

Advances in Electric Vehicles (EVs) have motivated some manufacturers to consider how existing SAE J1939 Hybrid System parameters can be adapted for use in EV applications.

Many Hybrid System parameters exist in SAE J1939. At the time these parameters were created, most manufacturers were not developing EVs or components for EVs. Since then, development of EVs has gained momentum and standardization of EV interfaces is needed.

The existing Hybrid System parameters shall be used for comparable parameters in an EV system. Requests for new SAE J1939 parameters for EV interfaces will only be approved when a distinction between an EV and Hybrid System interface is required for a given vehicle application.

A.32 SPN 7579 – ELEVATED ENGINE SPEED ALLOWED SWITCH

Aftertreatment Regeneration Allow Truth table						
Switch States (0 = Not Active, 1 = Active)				Regeneration allowed for given engine speed		
Aftertreatment Regeneration Force Switch (SPN 3696)	Aftertreatment Regeneration Inhibit Switch (SPN 3695)	Elevated Engine Speed Allowed Switch (SPN 7579)	Aftertreatment Regeneration Engine Speed Allowed Switch (SPN 7580)	Engine Speed is less than the minimum regeneration speed	Engine speed is less than the engine speed requested by the control system, but greater than the minimum Regeneration Speed	Engine Speed is greater than the engine speed required to perform a regeneration
0	0	0	0	No	No	No
0	0	0	1	No	No	Yes
0	0	1	0	Yes (Note 1)	Yes	No (Note 2)
0	0	1	1	Yes (Note 1)	Yes	Yes
0	1	0	0	No	No	No
0	1	0	1	No	No	No
0	1	1	0	No	No	No
0	1	1	1	No	No	No
1	0	0	0	No	No	Yes
1	0	0	1	No	Yes	Yes
1	0	1	0	Yes (Note 1)	Yes	Yes
1	0	1	1	Yes (Note 1)	Yes	Yes
1	1	0	0	No	No	No
1	1	0	1	No	No	No
1	1	1	0	No	No	No
1	1	1	1	No	No	No
Notes						
Note 1: For engine speed less than minimum allowed aftertreatement regeneration speed, the engine speed will be automatically elevated to the engine speed determined by the control system in order to perform the regeneration.						
Note 2: For the case where SPN 7579 is active and SPN 7580 is inactive, a regeneration will only be allowed when the engine is idling or at low engine speed.						

FIGURE SPN7579_A - AFTERTREATMENT REGENERATION ALLOW TRUTH TABLE

A.33 SPN 7895 – STORED ENERGY SOURCE LEVEL

In a Diesel-Electric Hybrid, the HVESS Fast Update State of Charge (SPN 5921) and the Hybrid Battery Remaining Charge (SPN 5464) represents the entire range (0 to 100%) of the SOC. The Stored Energy Source Level (SPN 7895) is the current percentage of the high voltage energy storage useable capacity. A battery manufacturer may define the useable capacity to be between an SOC of S1 (e.g. 30%) and S2 (e.g. 70%). In this case, the Stored Energy Source Level would be indicated as 0% for an SOC of S1 or lower and 100% for an SOC of S2 or higher.

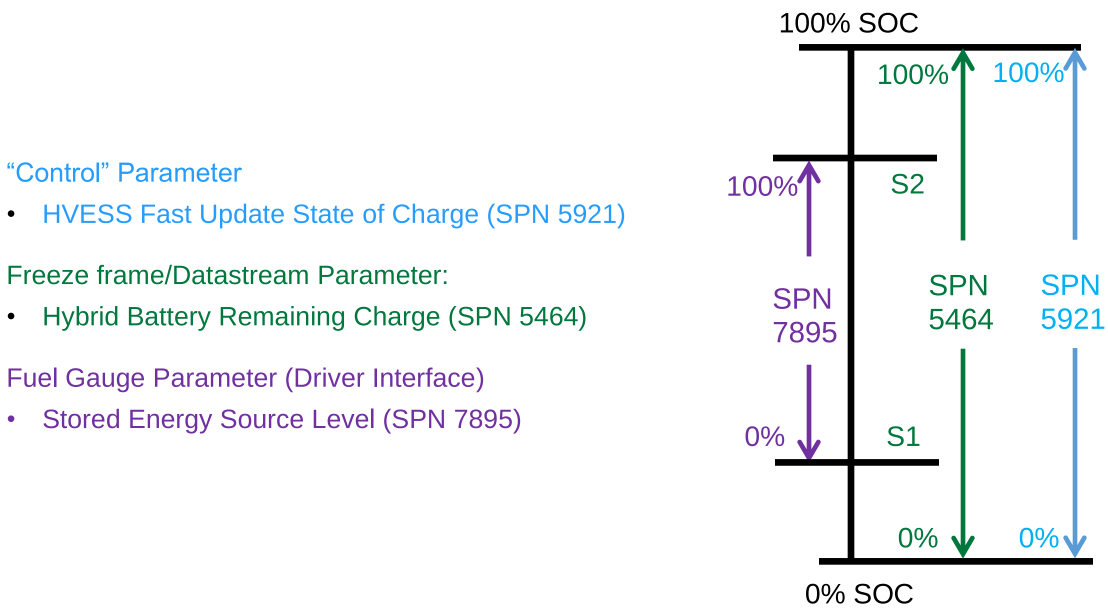


FIGURE SPN7895_A - STORED ENERGY SOURCE LEVEL VERSUS STATE OF CHARGE (SOC)

A.34 SPN 8412 – HVES CONTROL

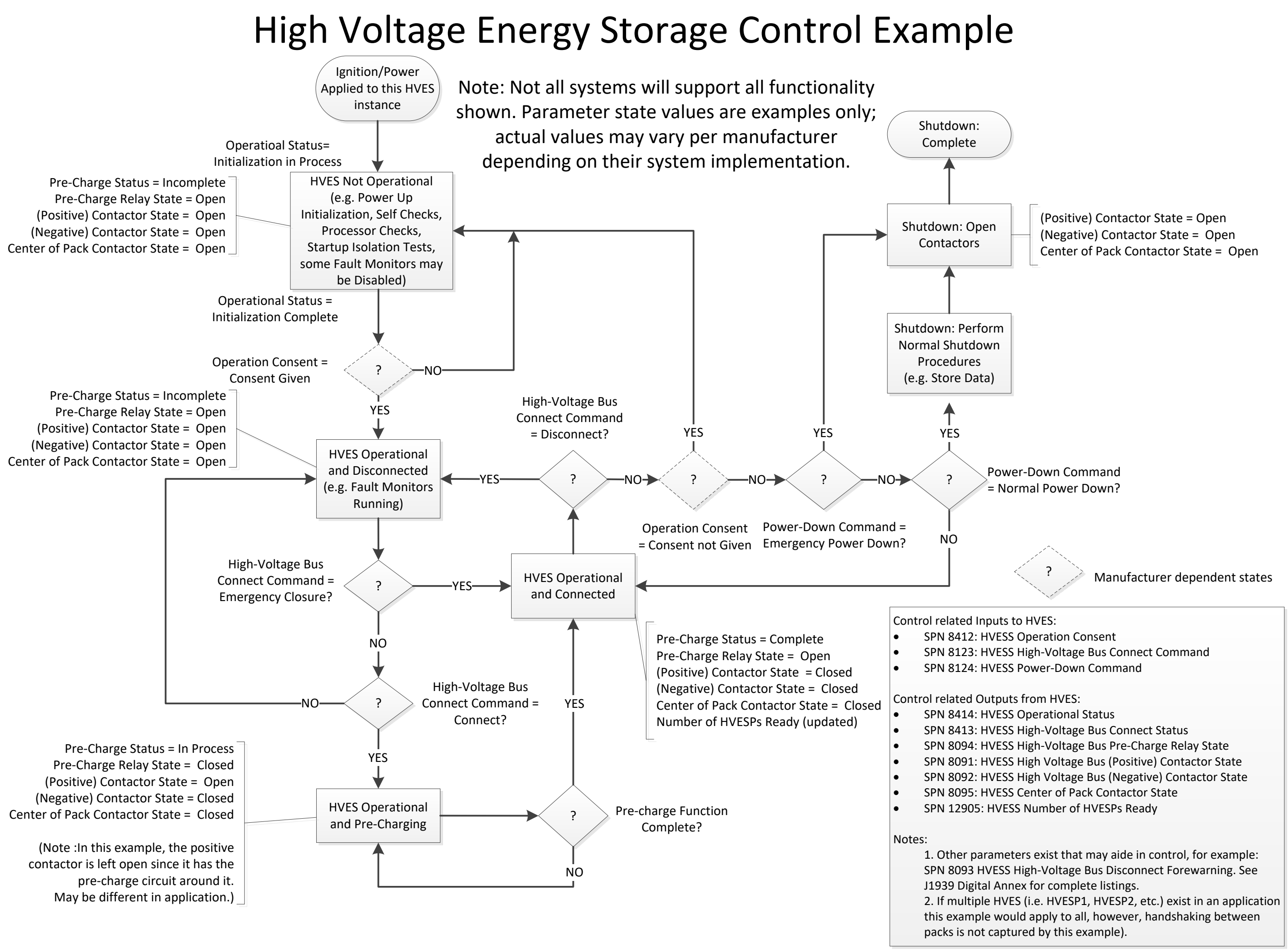


FIGURE SPN8412_A – HIGH VOLTAGE ENERGY STORAGE CONTROL EXAMPLE

A.35 SPN 9122 – HVES PACK VOLTAGE/CURRENT/TEMPERATURE DEFINITION NOTE EXPLANATION

The examples below represent hypothetical battery packs to define how the enumeration at the end of the Suspect Parameter Name may be used. The intent is to make it clear that the enumeration for these Suspect Parameters may be used to indicate a module or multiple instances within the modules or the pack.

1. In example 1 there are 12 temperature sensors and each are designated to a unique cell. So the SPNs used might be for pack 1 temperature 1 to 12.

2. However in example 2, the design could be done in a way that a temperature sensor is used to measure a temperature that does not allow the specific cell to be pinpointed but allows you to know down to one of two modules that have an issue with Module 1 or Module 2 temperature sensor 1. In example 2, the SPNs used for diagnostics could be pack 1 temperature 1 to 8 even though there are 12 cells.

3. In example 3, the temperature sensors are again shared but in this approach they allow a module to be pinpointed based on a temperature issue. Here the SPNs used would be for Pack 1 temperature sensors 1 to 9 even though there are 12 cells.

Therefore, in example 1, T4 is Module 1, in example 2, T4 is Module 1 or Module 2, and in example 3, T4 is Module 2.

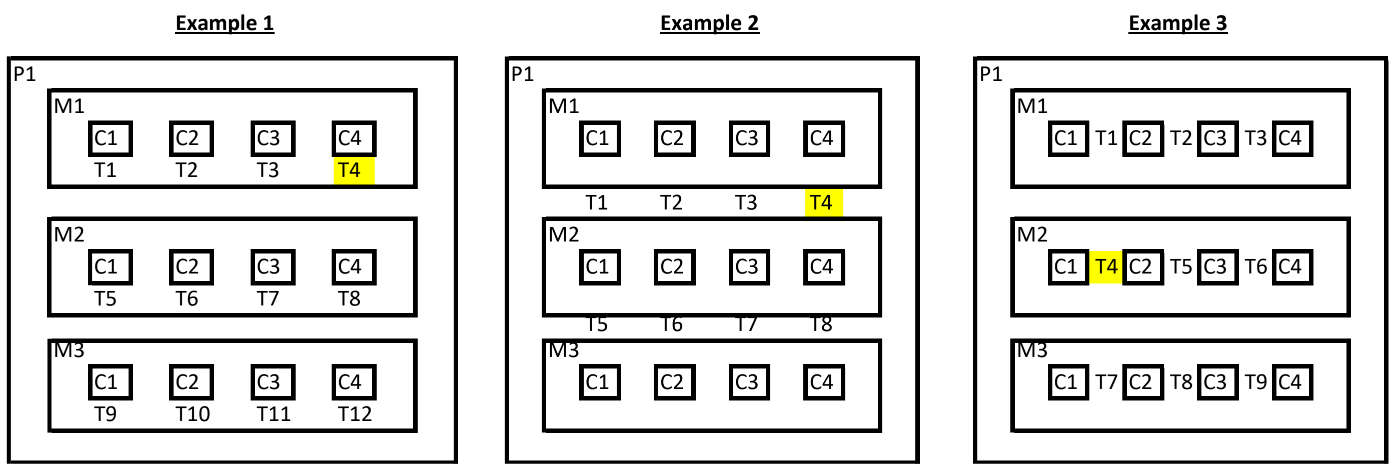
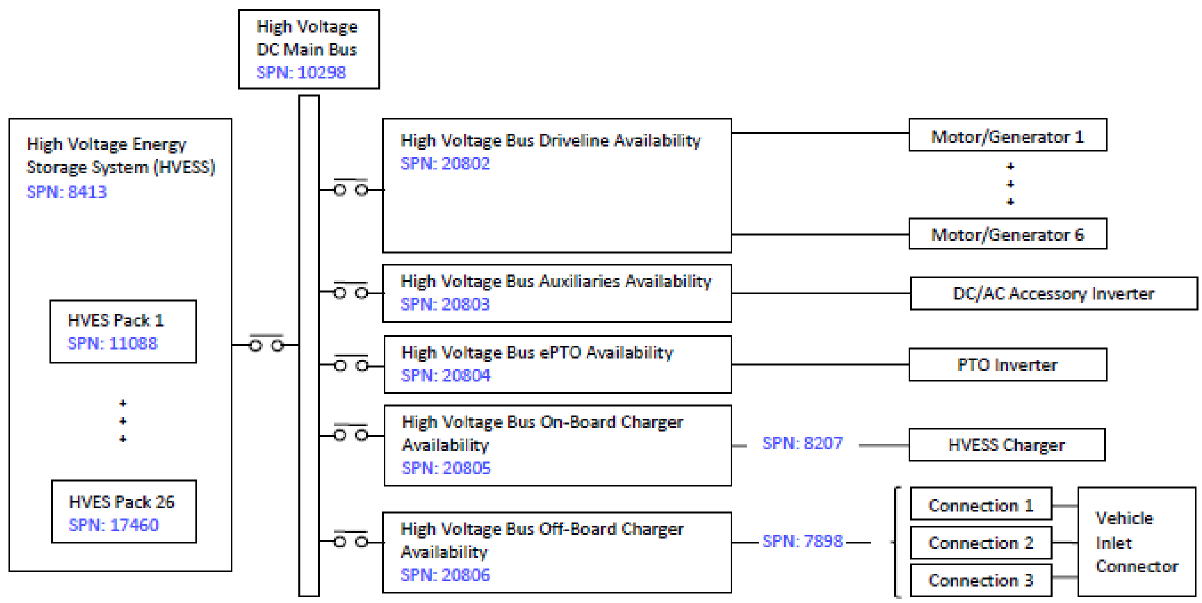


FIGURE SPN9122_A – EXAMPLES OF BATTERY PACK ENUMERATION

A.36 SPN 10298 – HIGH VOLTAGE DC BUS AVAILABILITY



SPN	PG	SP Name
11088	HVESP1S1	HVESP1 High-Voltage Bus Connection Status
11204	HVESP1S2	HVESP2 High-Voltage Bus Connection Status
11320	HVESP1S3	HVESP3 High-Voltage Bus Connection Status
11436	HVESP1S4	HVESP4 High-Voltage Bus Connection Status
11552	HVESP1S5	HVESP5 High-Voltage Bus Connection Status
11668	HVESP1S6	HVESP6 High-Voltage Bus Connection Status
14098	HVESP1S7	HVESP7 High-Voltage Bus Connection Status
14241	HVESP1S8	HVESP8 High-Voltage Bus Connection Status
14384	HVESP1S9	HVESP9 High-Voltage Bus Connection Status
14527	HVESP1S10	HVESP10 High-Voltage Bus Connection Status
15330	HVESP1S11	HVESP11 High-Voltage Bus Connection Status
15472	HVESP1S12	HVESP12 High-Voltage Bus Connection Status
15614	HVESP1S13	HVESP13 High-Voltage Bus Connection Status
15756	HVESP1S14	HVESP14 High-Voltage Bus Connection Status
15898	HVESP1S15	HVESP15 High-Voltage Bus Connection Status
16040	HVESP1S16	HVESP16 High-Voltage Bus Connection Status
16182	HVESP1S17	HVESP17 High-Voltage Bus Connection Status
16324	HVESP1S18	HVESP18 High-Voltage Bus Connection Status

SPN	PG	SP Name
16466	HVESP1S19	HVESP19 High-Voltage Bus Connection Status
16608	HVESP1S20	HVESP20 High-Voltage Bus Connection Status
16750	HVESP1S21	HVESP21 High-Voltage Bus Connection Status
16892	HVESP1S22	HVESP22 High-Voltage Bus Connection Status
17034	HVESP1S23	HVESP23 High-Voltage Bus Connection Status
17176	HVESP1S24	HVESP24 High-Voltage Bus Connection Status
17318	HVESP1S25	HVESP25 High-Voltage Bus Connection Status
17460	HVESP1S26	HVESP26 High-Voltage Bus Connection Status
8413	HVESSS1	HVESS High-Voltage Bus Connection Status
10298	HVBI	High Voltage DC Bus Availability
20802	HVBI	High Voltage Bus Driveline Availability
20803	HVBI	High Voltage Bus Auxiliaries Availability
20804	HVBI	High Voltage Bus ePTO Availability
20805	HVBI	High Voltage Bus On-Board Charger Availability
10806	HVBI	High Voltage Bus Off-Board Charger Availability
8207	HVESSS1	HVESS Internal Charger Status
7898	HSS1	External Energy Source Connection Status

FIGURE SPN10298_A – HIGH VOLTAGE DC BUS AVAILABILITY

A.37 SPN 12861 – ELECTRIC VEHICLE CHARGING SYSTEM

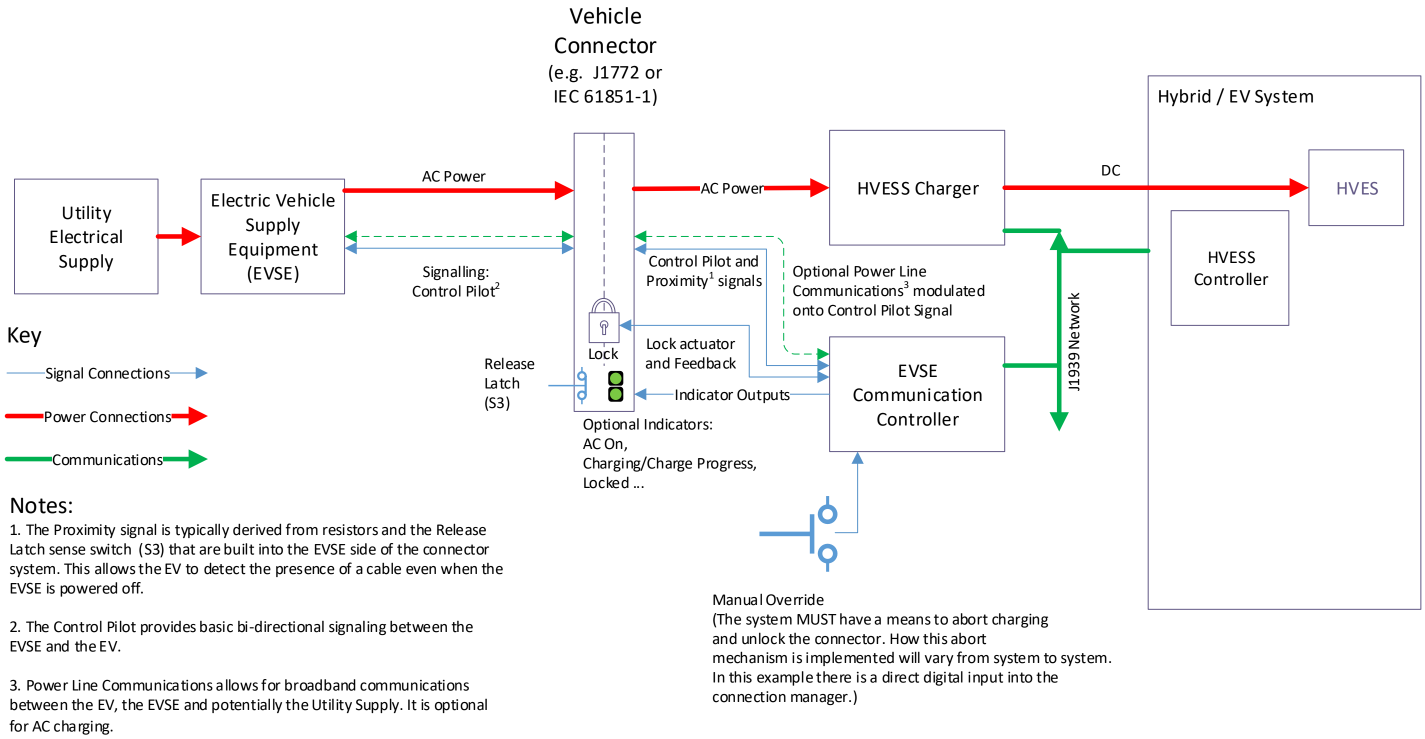


FIGURE SPN12861_A – EXAMPLE AC CHARGING SYSTEM CONFIGURATION

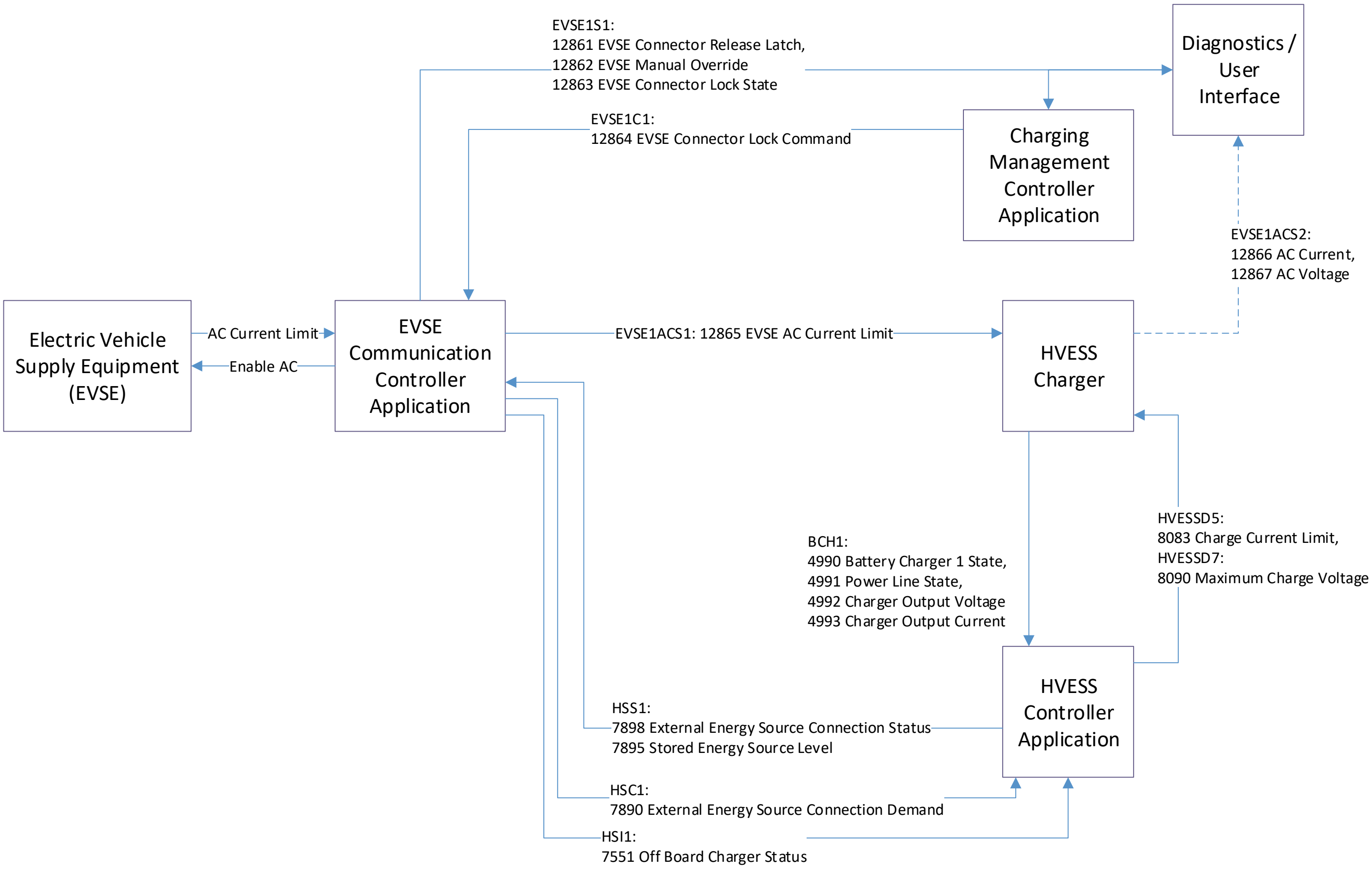
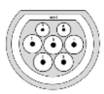


FIGURE SPN12861_B – EXAMPLE AC CHARGER MESSAGE USAGE

A.38 SPN 12865 – ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE) INFORMATION

			EVSE 1 AC Status 1 PGN 61243				EVSE 1 AC Supply Voltage PGN 64196			
			EVSE AC RMS Current Limits				EVSE AC RMS Voltage			
		CP-Type	L1 SPN 12865	L2 SPN 13003	L3 SPN 13004	Neutral SPN 13005	Line – N SPN 13006	Line-Line SPN 13007	Frequency SPN 13008	
Single Phase AC E.g. IEC 62196 Type 1, J1772 	J1772 AC Level 1 120V	PWM	6-16 A	FFFF	FFFF	FFFF	FFFF	FFFF	FF	
	J1772 AC Level 2 208 – 240V	PWM	6-80 A	FFFF	FFFF	FFFF	FFFF	FFFF	FF	
1-3 Phase AC E.g. IEC 62196 Type 2, J3068 	J3068 AC_6 <250 V L-N	PWM	6-63 A	FFFF	FFFF	FFFF	FFFF	FFFF	FF	
	J3068 AC_6 US Single Phase	LIN	<70 A	0	0	Same as L1	120V	FFFF	60Hz	
	J3068 AC_6 US Split Phase	LIN	<63 A	< 63A	0	Same as L1	120V	240V	60Hz	
	J3068 AC_6 US 3 Phase	LIN	<63 A	< 63A	< 63 A	< 63 A	120V	208V	60Hz	
	J3068 AC_6 US 3 Phase Balanced	LIN	<63 A	< 63A	< 63A	0 A	120V	208V	60Hz	
	IEC 62196 Type 2 EU 3 Phase	LIN	<63 A	< 63A	< 63A	< 63A	240V	415V	50Hz	
	IEC 62196 Type 2 EU 415V 3 Phase	PWM	12, 20, 32 or 63 A	FFFF	FFFF	FFFF	FFFF	FFFF	FF	

References:
SAE J1772 Oct 2017: SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler
SAE J3068 Apr 2018: Electric Vehicle Power Transfer System Using a Three-Phase Capable Coupler
IEC-62196-2 2016: Plugs, socket-outlets, vehicle connectors and vehicle inlets –Conductive charging of electric vehicles

FIGURE SPN12865_A – EXAMPLE EVSE AC STATUS AND SUPPLY VOLTAGE PG USAGE

A.39 SPN 13030 – EXAMPLES FOR ONE BYTE CRC CALCULATIONS (LEGACY METHOD), CRC IN BYTE 8

Many Parameter Groups (PGs) use an AUTOSAR CRC8, for these checksums the order of bytes is relevant. There are Parameter Groups using different checksum algorithms, those are not covered in this document.

Please ensure that the “SPN reference” column of the SP implemented references this Appendix D section before implementing. There are SPs with CRC definitions that no longer use this legacy format and instead include the PS (i.e., Destination Address) in the CRC calculation (See SPN 14456 – Examples For One Byte CRC Calculations, CRC in Byte 8). There are new SPs with CRCs that use this new format defined in the SAE J1939DA_202301 publication or later.

The CRC is defined as follows:

- Length: 8 bits
- Polynomial: x^8+x^5+x^3+x^2+x+1 (97h)
- Initial Value: FFh
- Input Data Reflection: Not reflected
- Result Data Reflection: Not reflected
- XOR value: FFh

The CRC algorithm is defined in AUTOSAR (AUTOSAR_SWS_CRCLibrary.pdf) as CRC8H2F() function.

- CRC = CRC8H2F (Data Byte 1, Data Byte 2, Data Byte 3, Data Byte 4, Data Byte 5, Data Byte 6, Data Byte 7, Source Address byte, PGN LSB, PGN second byte, PGN MSB)

For PGs of PDU Format 1 PGN LSB is 00h.

Difference to AUTOSAR E2E profile 2:

The CRC8H2F() function is also used for AUTOSAR E2E profile 2, however the CRCs in these SAE J1939 PGs are not E2E profile 2 CRCs.

In AUTOSAR E2E profile 2 a Data ID Byte (not transmitted) is included as additional virtual Data Byte.

In SAE J1939 CRCs instead of the virtual Data Byte parts of the CAN ID are included in CRC calculation, in addition, in some PGs the CRC is not in the first byte as it is specified in AUTOSAR E2E profile 2.

In the following 2 examples for CRC calculation are presented:

- Example 1: PG HVESP1C1, PDU Format 1, CRC in Byte 8 (counting from Byte 1 to Byte 8)
- Example 2: PG HVESP1S1, PDU Format 2, CRC in Byte 8

Example 1:

- Parameter Group HVESP1C1
- PGN = 10752d or 2A00h, Default Priority is 3.
- CRC is placed in Byte 8

CRC processing order
-------------------->
CRC8H2F (DB1, DB2, DB3, DB4, DB5, DB6, DB7, SA, PS, PF, PGN MSB)

The data bytes are processed from left to right.

- DBx = Data Byte n(1..7) of the Message, DB1 is the first transmitted Data Byte
- SA = Source Address
- PS = PGN LSB
- PF = PDU Format (Middle Byte of PGN)
- PGN MSB = High Byte of PGN consisting of Data Page (DP) Bit and Extended Data Page (EDP) Bit

For a CAN Message sent from Source Address 12h to Destination Address 23h CAN ID is 0C2A2312h for priority 3.

Since the priority is not part of the PGN, it will not be taken into account for the CRC calculation. Therefore, the PGN MSB is 00h, not 0Ch.

Note: some manufacturers using PDU format 1 messages may have used the Destination Address as the PGN LSB instead of the J1939-21 defined 00h, in this case this example will not work. It is the responsibility of the manufacturer using this approach to validate their solution.

- DB1 = 11h,
- DB2 = 22h,
- DB3 = 33h,
- DB4 = 44h,
- DB5 = 55h,
- DB6 = 66h,
- DB7 = 77h,
- Source Address byte = 12h,
- PGN LSB = 00h,
- PGN second byte = 2Ah,
- PGN MSB (Data Page bit and Extended Data Page bit) = 00h

ID						Data Payload							
Priority	EDP	DP	PF	PS (DA)	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	2Ah	23h**	12h	11h	22h	33h	44h	55h	66h	77h	X

CRC = CRC8H2F (11h, 22h, 33h, 44h, 55h, 66h, 77h, 12h, 00h, 2Ah, 00h**) = CEh

Changing DB1 = 22h, DB2 = 11h:

ID						Data Payload							
Priority	EDP	DP	PF	PS (DA)	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	2Ah	23h**	12h	22h	11h	33h	44h	55h	66h	77h	X

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 77h, 12h, 00h, 2Ah,00h**) = 04h

Changing DB7 = 00h:

ID						Data Payload							
Priority	EDP	DP	PF	PS (DA)	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	2Ah	23h**	12h	22h	11h	33h	44h	55h	66h	00h	X

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 00h, 12h, 00h, 2Ah, 00h**) = 67h

Changing Source Address to 02h:

ID						Data Payload							
Priority	EDP	DP	PF	PS (DA)	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	2Ah	23h**	02h	22h	11h	33h	44h	55h	66h	00h	X

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 00h, 02h, 00h, 2Ah, 00h**) = 11h

Changing Destination Address to 24h:

ID						Data Payload							
Priority	EDP	DP	PF	PS (DA)	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	2Ah	24h**	02h	22h	11h	33h	44h	55h	66h	00h	X

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 00h, 02h, 00h, 2Ah, 00h**) = 11h

**Note: The destination address (DA) in the CAN ID is not used in PDU format 1 PG's, therefore, the PGN LSB is 00h in the CRC calculation.

Example 2:

- Parameter Group HVESP1S1
- PGN = 61847= F197h Default Priority 3
- The CRC is placed in Byte 8

CRC processing order
------------------->
CRC8H2F (DB1, DB2, DB3, DB4, DB5, DB6, DB7, SA, PGN LSB, PF, PGN MSB)

The data bytes are processed from left to right.

- DBx = Data Byte n(1..7) of the Message, DB1 is the first transmitted Data Byte
- SA = Source Address
- PS = PGN LSB
- PF = PDU Format (Middle Byte of PGN)
- PGN MSB = High Byte of PGN consisting of Data Page (DP) Bit and Extended Data Page (EDP) Bit

For a CAN Message sent from Source Address 11h, PGN is PDU2 Format, therefore there is no Destination Address:
CAN ID is 0CF19711h for Priority 3

Since the priority is not part of the PGN, it will not be taken into account for the CRC calculation.

- DB1 = 62h
- DB2 = 12h
- DB3 = 34h
- DB4 = 56h
- DB5 = 78h
- DB6 = 9Ah
- DB7 = BCh
- SA = 11h
- PGN LSB = 97h (Group Extension for PDU2 Format)
- PGN Mid Byte = PF = F1h
- PGN MSB = 00h (For Extended Data Page and Data Page = 0 this value is 0)

ID						Data Payload							
Priority	EDP	DP	PF	PS (GE)	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	F1h	97h	11h	62h	12h	34h	56h	78h	9Ah	BCh	X

CRC = CRC8H2F (62h, 12h, 34h, 56h, 78h, 9Ah, BCh, 11h, 97h, F1h, 00h) = A7h

Changing Value of DB1 to 63h:

ID						Data Payload							
Priority	EDP	DP	PF	PS (GE)	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	F1h	97h	11h	63h	12h	34h	56h	78h	9Ah	BCh	X

CRC = CRC8H2F (63h, 12h, 34h, 56h, 78h, 9Ah, BCh, 11h, 97h, F1h, 00h) = 81h

Exchanging values for DB2 and DB3:

ID						Data Payload							
Priority	EDP	DP	PF	PS (GE)	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	F1h	97h	11h	63h	34h	12h	56h	78h	9Ah	BCh	X

CRC = CRC8H2F (63h, 34h, 12h, 56h, 78h, 9Ah, BCh, 11h, 97h, F1h, 00h) = B1h

Changing Source Address to 32h:

ID						Data Payload							
Priority	EDP	DP	PF	PS (GE)	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	F1h	97h	32h	63h	34h	12h	56h	78h	9Ah	BCh	X

CRC = CRC8H2F (63h, 34h, 12h, 56h, 78h, 9Ah, BCh, 32h, 97h, F1h, 00h) = ADh

A.40 SPN 13167 – EXAMPLES FOR ONE BYTE CRC CALCULATIONS (LEGACY METHOD), CRC IN BYTE 1

Many Parameter Groups (PGs) use an AUTOSAR CRC8, for these checksums the order of bytes is relevant. There are Parameter Groups using different checksum algorithms, those are not covered in this document.

Please ensure that the “SPN reference” column of the SP implemented references this Appendix D section before implementing. There are SPs with CRC definitions that no longer use this legacy format and instead include the PS (i.e., Destination Address) in the CRC calculation (See SPN 22679 – Examples For One Byte CRC Calculations, CRC in Byte 1). There are new SPs with CRCs that use this new format defined in the SAE J1939DA_202301 publication or later.

The CRC is defined as follows:

- Length: 8 bits
- Polynomial: x^8+x^5+x^3+x^2+x+1 (97h)
- Initial Value: FFh
- Input Data Reflection: Not reflected
- Result Data Reflection: Not reflected
- XOR value: FFh

The CRC algorithm is defined in AUTOSAR (AUTOSAR_SWS_CRCLibrary.pdf) as CRC8H2F() function.

- CRC = CRC8H2F (Data Byte 2, Data Byte 3, Data Byte 4, Data Byte 5, Data Byte 6, Data Byte 7, Data Byte 8, Source Address byte, PGN LSB, PGN second byte, PGN MSB)

For PGs of PDU Format 1 PGN LSB is 00h.

<u>Difference to AUTOSAR E2E profile 2:</u>

The CRC8H2F() function is also used for AUTOSAR E2E profile 2, however the CRCs in these SAE J1939 PGs are not E2E profile 2 CRCs.

In AUTOSAR E2E profile 2 a Data ID Byte (not transmitted) is included as additional virtual Data Byte.

In SAE J1939 CRCs instead of the virtual Data Byte parts of the CAN ID are included in CRC calculation, in addition, in some PGs the CRC is not in the first byte as it is specified in AUTOSAR E2E profile 2.

In the following two examples for CRC calculation are presented:

- Example 1: PG MG1IC, PDU Format 1, CRC in Byte 1 (counting from Byte 1 to Byte 8)
- Example 2: PG PC1IC1, PDU Format 2, CRC in Byte 1

Example 1:

- Parameter Group MG1IC
- PGN = 9728 = 2600h Default Priority 3.
- CRC is placed in Byte 1.

CRC processing order
-------------------->
CRC8H2F (DB2, DB3, DB4, DB5, DB6, DB7, DB8, SA, PS, PF, PG MSB)

The data bytes are processed from left to right.

- DBx = Data Byte n(2..8) of the Message, DB2 is the second transmitted Data Byte since the CRC is in the first Data Byte
- SA = Source Address
- PS = PGN LSB
- PF = PDU Format (Middle Byte of PGN)
- PGN MSB = High Byte of PGN consisting of Data Page (DP) Bit and Extended Data Page (EDP) Bit

For a CAN Message sent from Source Address 22h to Destination Address 11h CAN ID is 0C261122h for Priority 3.

Since the priority is not part of the PGN, it will not be taken into account for the CRC calculation.
Therefore, the PGN MSB is 00h, not 0Ch.

Note: some manufacturers using PDU format 1 messages may have used the Destination Address as the PGN LSB instead of the SAE J1939-21 defined 00h, in this case this example will not work. It is the responsibility of the manufacturer using this approach to validate their solution.

- DB2 = 62h
- DB3 = 12h
- DB4 = 34h
- DB5 = 56h
- DB6 = 78h
- DB7 = 9Ah
- DB8 = BCh
- SA = 22h
- PGN LSB = 00h
- PGN Second byte = PF = 26h
- PGN MSB = 00h (For Extended Data Page and Data Page = 0 this value is 00h)

ID						Data Payload							
Priority	EDP	DP	PF	PS (DA)	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	26h	11h**	22h	X	62h	12h	34h	56h	78h	9Ah	BC

CRC = CRC8H2F (62h, 12h, 34h, 56h, 78h, 9Ah, BCh, 22h, 00h, 26h, 00h) = BDh

Changing Sequence Counter from 2 to 3 (lower nibble of DB2):

ID						Data Payload							
Priority	EDP	DP	PF	PS (DA)	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	26h	11h**	22h	X	63h	12h	34h	56h	78h	9Ah	BC

CRC = CRC8H2F (63h, 12h, 34h, 56h, 78h, 9Ah, BCh, 22h, 00h, 26h, 00h) = 9Bh

Exchanging values for DB3 and DB4:

ID						Data Payload							
Priority	EDP	DP	PF	PS (DA)	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	26h	11h**	22h	X	63h	34h	12h	56h	78h	9Ah	BC

CRC = CRC8H2F (63h, 34h, 12h, 56h, 78h, 9Ah, BCh, 22h, 00h, 26h, 00h) = ABh

Changing Source Address to 32h:

ID						Data Payload							
Priority	EDP	DP	PF	PS (DA)	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	26h	11h**	32h	X	63h	34h	12h	56h	78h	9Ah	BC

CRC = CRC8H2F (63h, 34h, 12h, 56h, 78h, 9Ah, BCh, 32h, 00h, 26h, 00h) = DDh

Changing Destination Address to 41h:

ID						Data Payload							
Priority	EDP	DP	PF	PS (DA)	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	26h	41h**	32h	X	63h	34h	12h	56h	78h	9Ah	BC

CRC = CRC8H2F (63h, 34h, 12h, 56h, 78h, 9Ah, BCh, 32h, 00h, 26h, 00h**) = DDh

**Note: The destination address (DA) in the CAN ID is not used in PDU format 1 PG's, therefore, the PGN LSB is 00h in the CRC calculation.

Example 2:

- Parameter Group PC1IC1
- PGN = 61551 = F06Fh Default Priority 3
- The CRC is placed in Byte 1

CRC processing order
-------------------->
CRC8H2F (DB2, DB3, DB4, DB5, DB6, DB7, DB8, SA, PS, PF, PG MSB)

The data bytes are processed from left to right.

- DBx = Data Byte n(2..8) of the Message, DB2 is the second transmitted Data Byte since the CRC is in the first Data Byte
- SA = Source Address
- PS = PGN LSB
- PF = PDU Format (Middle Byte of PGN)
- PGN MSB = High Byte of PGN consisting of Data Page (DP) Bit and Extended Data Page (EDP) Bit

For a CAN Message sent from Source Address 11h, PG is PDU2 Format, therefore there is no Destination Address: CAN ID is 0CF06F11h for Priority 3

Since the priority is not part of the PGN, it will not be taken into account for the CRC calculation.

Therefore, the PG MSB is 00h, not 0Ch.

- DB2 = 62h
- DB3 = 12h
- DB4 = 34h
- DB5 = 56h
- DB6 = 78h
- DB7 = 9Ah
- DB8 = BCh
- SA = 11h
- PGN LSB = 6Fh Group Extension (GE) for PDU2 Format
- PGN Second byte = PF = F0h
- PGN MSB = 00h (For Extended Data Page and Data Page = 0 this value is 0)

ID						Data Payload							
Priority	EDP	DP	PF	PS (GE)	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	F0h	6Fh	11h	X	62h	12h	34h	56h	78h	9Ah	BCh

CRC = CRC8H2F (62h, 12h, 34h, 56h, 78h, 9Ah, BCh, 11h, 6Fh, F0h, 00h) = 0Dh

Changing Sequence Counter from 2 to 3 (lower nibble of DB2):

ID						Data Payload							
Priority	EDP	DP	PF	PS (GE)	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	F0h	6Fh	11h	X	63h	12h	34h	56h	78h	9Ah	BCh

CRC = CRC8H2F (63h, 12h, 34h, 56h, 78h, 9Ah, BCh, 11h, 6Fh, F0h, 00h) = 2Bh

Exchanging values for DB3 and DB4:

ID						Data Payload							
Priority	EDP	DP	PF	PS (GE)	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	F0h	6Fh	11h	X	63h	34h	12h	56h	78h	9Ah	BCh

CRC = CRC8H2F (63h, 34h, 12h, 56h, 78h, 9Ah, BCh, 11h, 6Fh, F0h, 00h) = 1Bh

Changing Source Address to 32h:

ID						Data Payload							
Priority	EDP	DP	PF	PS (GE)	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	F0h	6Fh	32h	X	63h	34h	12h	56h	78h	9Ah	BCh

CRC = CRC8H2F (63h, 34h, 12h, 56h, 78h, 9Ah, BCh, 32h, 6Fh, F0h, 00h) = 07h

A.41 SPN 14456 – EXAMPLES FOR ONE BYTE CRC CALCULATIONS, CRC IN BYTE 8

Many Parameter Groups (PGs) use an AUTOSAR CRC8, for these checksums the order of bytes is relevant. There are Parameter Groups using different checksum algorithms, those are not covered in this document.

Please ensure that the “SPN reference” column of the SP implemented references this Appendix D section before implementing. There are SPs with a CRC that use a legacy format (see SPN 13030 – For One Byte CRC Calculations (Legacy Method), CRC in Byte 8).

The CRC is defined as follows:
- Length: 8 bits
- Polynomial: x^8+x^5+x^3+x^2+x+1 (97h)
- Initial Value: FFh
- Input Data Reflection: Not reflected
- Result Data Reflection: Not reflected
- XOR value: FFh

The CRC algorithm is defined in AUTOSAR (AUTOSAR_SWS_CRCLibrary.pdf) as CRC8H2F() function.

- CRC = CRC8H2F (Data Byte 1, Data Byte 2, Data Byte 3, Data Byte 4, Data Byte 5, Data Byte 6, Data Byte 7, Source Address byte, Byte X, PGN second byte, PGN MSB)

For PDU1, Byte X is the PS (i.e., Destination Address)
For PDU2, Byte X is the PGN LSB.

<u>Difference to AUTOSAR E2E profile 2:</u>

The CRC8H2F() function is also used for AUTOSAR E2E profile 2, however the CRCs in these J1939 PGs are not E2E profile 2 CRCs.

In AUTOSAR E2E profile 2 a Data ID Byte (not transmitted) is included as additional virtual Data Byte.

In J1939 CRCs instead of the virtual Data Byte parts of the CAN ID are included in CRC calculation, in addition, in some PGs the CRC is not in the first byte as it is specified in AUTOSAR E2E profile 2.

The following examples for CRC calculation are presented:
- Example 1: PG ADSC3, PDU Format 2, CRC in Byte 8 (counting from Byte 1 to Byte 8)
- Example 2: PG EAMC, PDU Format 1, CRC in Byte 8 (counting from Byte 1 to Byte 8)

Example 1:
- Parameter Group ADSC3
- PGN = 64079d or FA4Fh, Default Priority is 6.
- CRC is placed in Byte 8

CRC processing order
-------------------->
CRC8H2F (DB1, DB2, DB3, DB4, DB5, DB6, DB7, SA, Byte X, PGN Second Byte, PGN MSB)

The data bytes are processed from left to right.

- DBx = Data Byte n (1..7) of the Message, DB1 is the first transmitted Data Byte
- SA = Source Address
- Byte X = PGN LSB (because PG is PDU 2)

For a CAN Message sent from Source Address 12h to Destination Address 23h CAN ID is 18FA4F12h for priority 6.

Since the priority is not part of the PGN, it will not be considered in the CRC calculation. Therefore, the PGN MSB is 00h, not 18h.

- DB1 = 11h,
- DB2 = 22h,
- DB3 = 33h,
- DB4 = 44h,
- DB5 = 55h,
- DB6 = 66h,
- DB7 = 77h,
- Source Address byte = 12h,
- Byte X (BX) = 4Fh (PGN LSB)
- PGN second byte (B2) = FAh
- PGN MSB (Data Page bit and Extended Data Page bit) = 00h

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
6	0	0	FAh	4Fh	12h	11h	22h	33h	44h	55h	66h	77h	*D3h*

CRC = CRC8H2F (11h, 22h, 33h, 44h, 55h, 66h, 77h, 12h, 4Fh, FAh, 00h) = *D3h*

Changing DB1 = 22h, DB2 = 11h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	FAh	4Fh	12h	22h	11h	33h	44h	55h	66h	77h	*19h*

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 77h, 12h, 4Fh, FAh, 00h) = *19h*

Changing DB7 = 00h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	FAh	4Fh	12h	22h	11h	33h	44h	55h	66h	00h	*7Ah*

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 00h, 12h, 4Fh, FAh, 00h) = *7Ah*

Changing Source Address to 02h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	FAh	4Fh	02h	22h	11h	33h	44h	55h	66h	00h	*0Ch*

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 00h, 02h, 4Fh, FAh, 00h) = *0Ch*

Example 2:

- Parameter Group EAMC
- PGN = 32000d or 7000h, Default Priority is 6.
- CRC is placed in Byte 8

CRC processing order
-------------------->
CRC8H2F (DB1, DB2, DB3, DB4, DB5, DB6, DB7, SA, Byte X, PGN Second Byte, PGN MSB)

The data bytes are processed from left to right.

- DBx = Data Byte n (1..7) of the Message, DB1 is the first transmitted Data Byte
- SA = Source Address
- Byte X = PGN LSB (because PG is PDU 2)

For a CAN Message sent from Source Address 12h to Destination Address 23h CAN ID is 187D2312h for priority 6.

Since the priority is not part of the PGN, it will not be considered in the CRC calculation. Therefore, the PGN MSB is 00h, not 18h.

- DB1 = 11h,
- DB2 = 22h,
- DB3 = 33h,
- DB4 = 44h,
- DB5 = 55h,
- DB6 = 66h,
- DB7 = 77h,
- Source Address byte = 12h,
- Byte X (BX) = 23h (PGN LSB)
- PGN second byte (B2) = 7Dh
- PGN MSB (Data Page bit and Extended Data Page bit) = 00h

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
6	0	0	7Dh	23h	12h	11h	22h	33h	44h	55h	66h	77h	*43h*

CRC = CRC8H2F (11h, 22h, 33h, 44h, 55h, 66h, 77h, 12h, 23h, 7Dh, 00h) = *43h*

Changing DB1 = 22h, DB2 = 11h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	7Dh	23h	12h	22h	11h	33h	44h	55h	66h	77h	*89h*

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 77h, 12h, 23h, 7Dh, 00h) = *89h*

Changing DB7 = 00h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	7Dh	23h	12h	22h	11h	33h	44h	55h	66h	00h	*EAh*

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 00h, 12h, 23h, 7Dh, 00h) = *EAh*

Changing Source Address to 02h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	7Dh	23h	02h	22h	11h	33h	44h	55h	66h	00h	*9Ch*

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 00h, 02h, 23h, 7Dh, 00h) = *9Ch*

Changing Destination Address to 34h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	DB1	DB2	DB3	DB4	DB5	DB6	DB7	CRC
3	0	0	7Dh	34h	02h	22h	11h	33h	44h	55h	66h	00h	*56h*

CRC = CRC8H2F (22h, 11h, 33h, 44h, 55h, 66h, 00h, 02h, 34h, 7Dh, 00h) = *56h*

A.42 SPN 21252 OR SPN 23374 – TRANSMISSION AUTO-NEUTRAL AUTO-RETURN INTERFACE

November 2023 – PGN 7168 (TC3) and its parameters have been obsoleted and superseded by PGN 16896 (TC4). New parameters SPN 23373 and SPN 23374 are equivalent to the obsoleted parameters:

Parameter	Obsoleted SPN	Superseding SPN
Transmission Auto-Neutral (Auto-Return) Enable Switch	21251	23373
Transmission Auto-Neutral (Auto-Return) Request	21252	23374

Neutral Entry Criteria
Prior to sending SPN 23374 [Transmission Auto-Neutral (Auto-Return) Request] = 01b [Request to shift to (or maintain) Auto-Neutral state], the sender should verify that their own Neutral entry criteria (if any) are satisfied. The transmission will initiate a shift to Neutral when all of the following conditions are met:

1. SPN 23373 [Transmission Auto-Neutral (Auto-Return) Enable Switch] indicates 01b [Enabled].
2. An SPN 23374 [Transmission Auto-Neutral (Auto-Return) Request] value of 01b is received.
3. The shift selector is in a Non-Neutral position.
4. All other transmission manufacturer-specific criteria are satisfied (e.g. vehicle is stopped).

Return-to-Range Criteria
Prior to sending SPN 23374 [Transmission Auto-Neutral (Auto-Return) Request] = 10b [Request to shift from Auto-Neutral state to previous direction], the sender should verify that their own return-to-range criteria (if any) are satisfied. The transmission will initiate a shift from Neutral back to the previous direction under the following conditions:

1. SPN 23373 [Transmission Auto-Neutral (Auto-Return) Enable Switch] continues to indicate 01b [Enabled].
2. An SPN 23374 [Transmission Auto-Neutral (Auto-Return) Request] value of 10b is received.
3. All other transmission manufacturer-specific criteria are satisfied (e.g. engine speed is acceptable).

Auto-Neutral Function Abort
The transmission may abort the Auto-Neutral function in the event the operator makes a direction request via the shift selector.

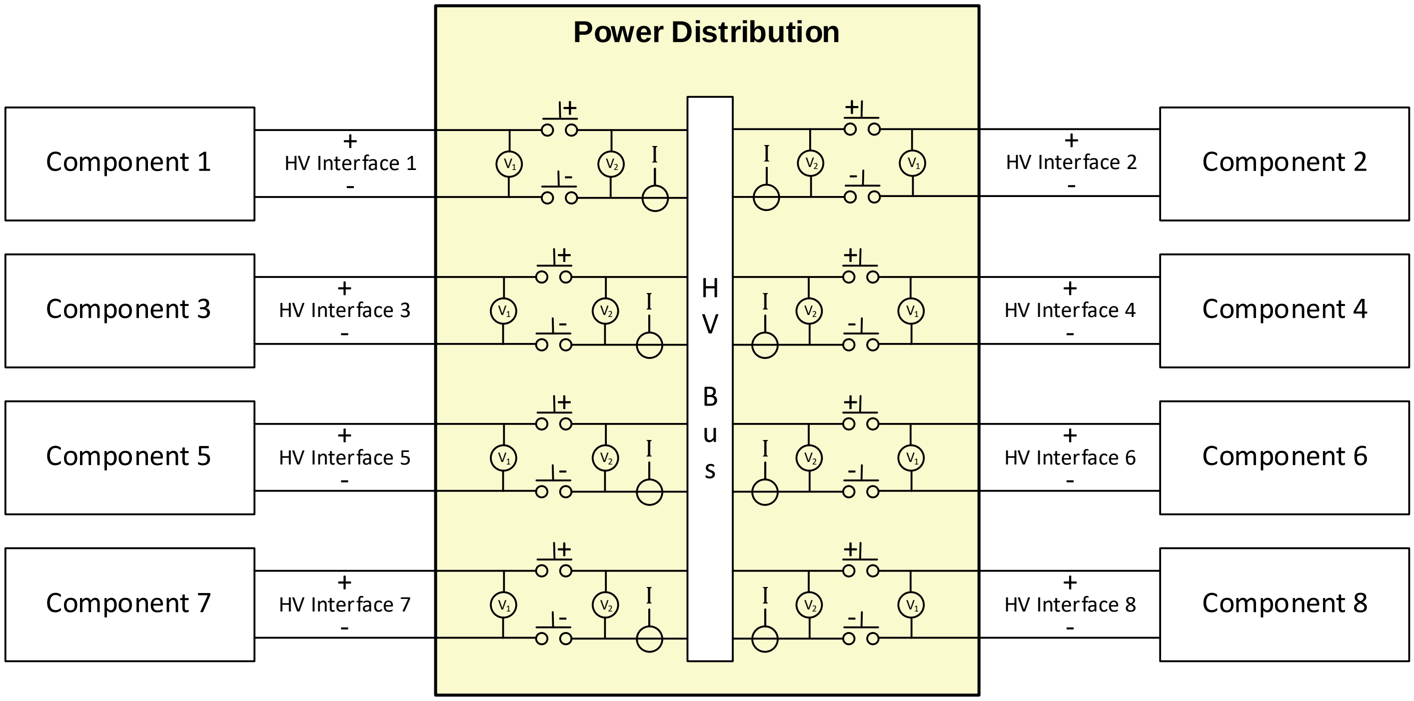
The exact shift selector input or sequence required to abort the Auto-Neutral function will be transmission manufacturer specific. In applications where transmission direction is accomplished through a mechanical linkage, the shift selector will need to be physically moved in order to abort the Auto-Neutral function.

The transmission may opt to honor the operator shift selector input only when this parameter is set to state 00b [No request to shift to Auto-Neutral state], or it may opt to do so for any/all other states. If honored for states other than 00b, this parameter must return to 00b before the transmission will honor another request to enter the Auto-Neutral state.

Inhibit or Abort Recovery
During the course of an Auto-Neutral (Auto-Return) operating sequence, the transmission may report via SPN 21254 [Transmission Auto-Neutral (Auto-Return) Function State] that the operating sequence has been aborted or disabled by the operator [0000b – Function Aborted or Disabled], or that it is unable to satisfy a request [0011b – Function Request Inhibited].

In such cases, the transmission may require the requestor to cycle SPN 23373 [Transmission Auto-Neutral (Auto-Return) Enable Switch] through the 00b [Disable] state and/or SPN 23374 [Transmission Auto-Neutral (Auto-Return) Request] through a 00b [No request] state before it will take any further action with the Auto-Neutral function.

A.43 SPN 21523 – HIGH VOLTAGE INTERFACE FOR DIAGNOSTIC SPNS



Notes:

1. See SPN 10298 Appendix D figure for HV DC Bus Availability parameters.
2. The High Voltage Bus Interface order and design is Manufacturer Specific.
3. Examples of components: Motor/Generator Inverter 1, 2, etc.; DC/DC Converter 1, 2, etc.; DC/AC Accessory Inverter 1, 2, etc.; DC Charger Plug, ePTO.
4. The table of SPNs below are only for the first instance of HV Bus Interface (1). All other HV Bus Interface instances can be found by searching for SP Names of similar format (e.g., HV Bus Interface 2, HV Bus Interface 3). Note that some SPNs are currently diagnostic-only, while others are parameters.

Reference	Diagnostic SPN	Parametric SPN	Name (Only first instance shown for example)
I	21528	--	High-Voltage Bus Interface 1 Current
V2	21529	--	High-Voltage Bus Interface 1 HV Bus Side Voltage
V1	21530	--	High-Voltage Bus Interface 1 Connected Device Side Voltage
+	--	21531	High-Voltage Bus Interface 1 Positive Contactor State
-	--	21532	High-Voltage Bus Interface 1 Negative Contactor State
Controller	21523	--	High-Voltage Bus Interface 1 Controller

FIGURE SPN21523_A – EXAMPLE USAGE FOR HIGH VOLTAGE INTERFACE SPNS

A.44 SPN 21699 – HIGH VOLTAGE INTERLOCK (HVIL)

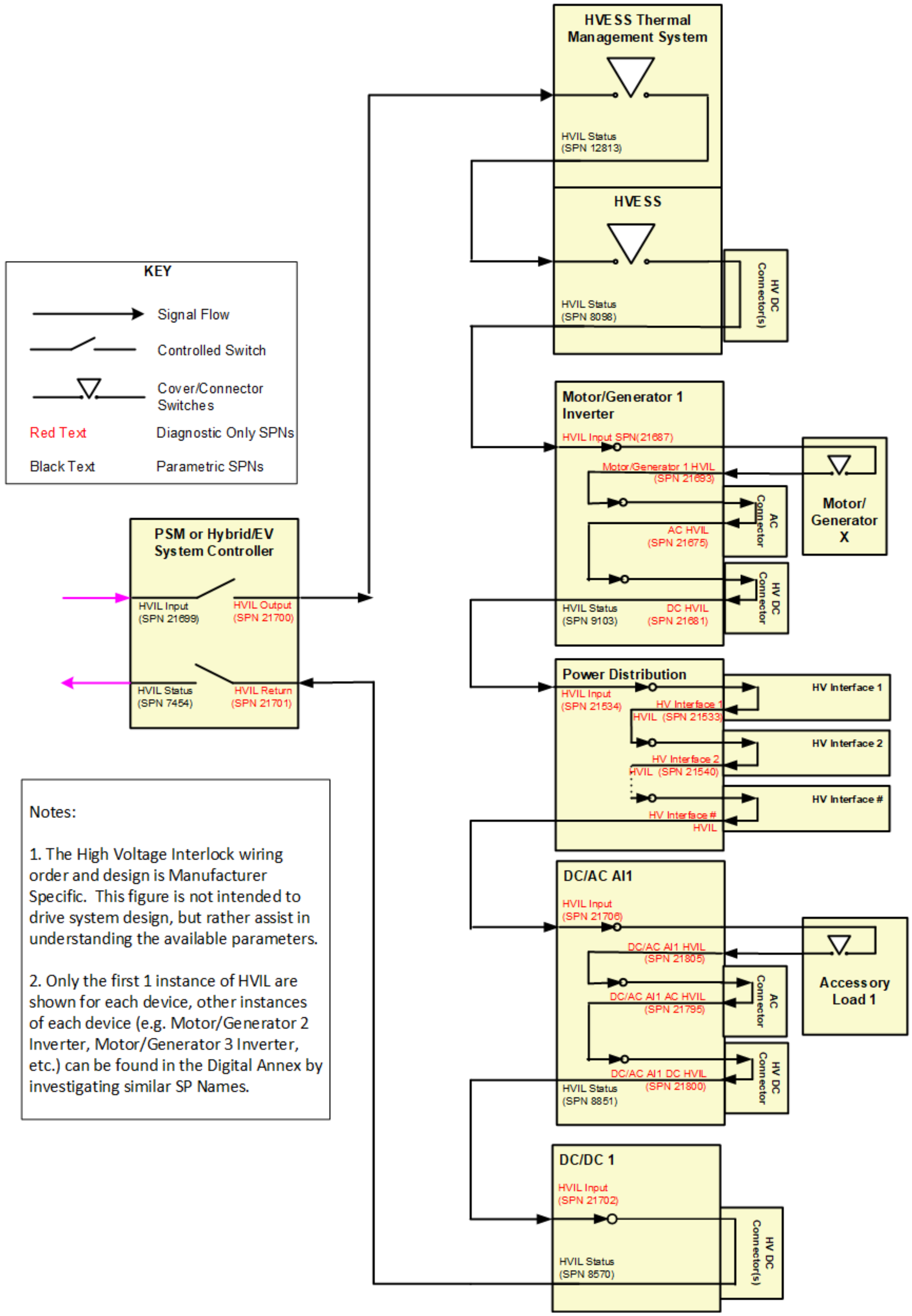


FIGURE SPN21699_A – EXAMPLE USAGE FOR HIGH VOLTAGE INTERLOCK (HVIL) PARAMETERS AND DIAGNOSTIC SPNS

A.45 SPN 22128 – EXTERNAL ACC ACCELERATION REQUEST CRC

This two-byte signal field is reserved to support the use of an in-frame data integrity CRC.

When a CRC is correctly implemented as part of a Functional Safety process (ISO 26262) it can provide protection against the effects of faults within the communication link.

This two-byte signal field CRC is based on the AUTOSAR Profile 5 as defined in AUTOSAR Document 428
It is intended that this PG can be directly processed by an AUTOSAR 4.x based ECU.

The CRC is 16 bits with polynomial in format 0x1021 (CRC-16-CCITT-FALSE)

Polynomial representation: x16+x12+x5+1
Initial value: 0xFFFF
Input data reflected: No
Result data reflected: Yes
XOR value: 0x0000
Check: 0x29B1
Magic check: 0x0000

Example of CRC calculation for AUTOSAR profile 5. This CRC profile is defined in AUTOSAR Document, Specification of CRC Routines – ID 016. The AUTOSAR document shall always be considered the reference.

This example is for informational purposes only.

AUTOSAR Profile 5 is defined in AUTOSAR Document, Specification of SW-C End-to-End Communication Protection Library – ID 428.
Profile 5 is defined as 16 bits, polynomial in normal form 0x1021 (AUTOSAR notation).
This CRC is implemented with the CRC16 routine based on CCITT-FALSE CRC16 standard.
The polynomial in normal format is, x16 + x12 + x5 + 1

Example:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	*Data ID*
E2E CRC		Counter	Data 1	Data 2	Data 3	Data 4	Data 5	*Data ID*
9C88h		CCh	55h	AAh	55h	FFh	FFh	000Fh

For more AUTOSAR Profile 5 CRC calculation examples, see Specification of CRC Routines – ID 016.

Reference Documents

AUTOSAR – Specification of CRC Routines, ID 016
https://www.autosar.org/fileadmin/user_upload/standards/classic/4-3/AUTOSAR_SWS_CRCLibrary.pdf

AUTOSAR – Specification of SW-C End-to-End Protection Library, ID 428
https://www.autosar.org/fileadmin/user_upload/standards/classic/4-3/AUTOSAR_SWS_E2ELibrary.pdf

AUTOSAR – Requirements on E2E Communication Protection, ID 651
https://www.autosar.org/fileadmin/user_upload/standards/classic/4-3/AUTOSAR_SRS_E2E.pdf

WIKIPEDIA – Cyclic
https://en.wikipedia.org/wiki/Cyclic_redundancy_check

A.46 SPN 22633 – TRAILER TYPES

Additional information for trailer descriptions used in SPN 22633 - Trailer Type and included in byte instance(s) “g” in PGN 64035. This Describes the axle topology of a given trailer segment. These types of trailers are taken from ISO7641 and ISO13052.

FIGURE SPN22633_A – SEMI (E.G., TRADITIONAL 5TH WHEEL TRAILER WITH A KINGPIN)

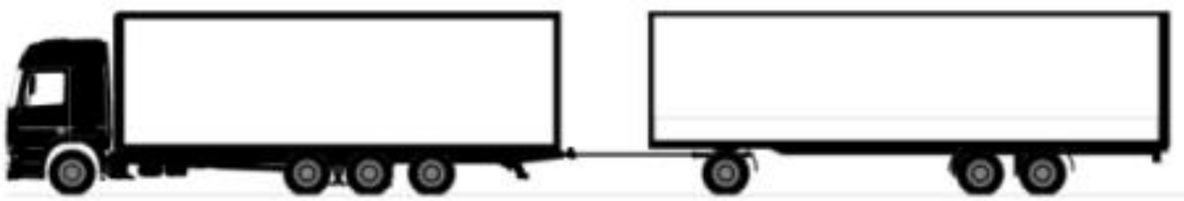


FIGURE SPN22633_B – FULL (TRAILER HAS PERMANENTLY ATTACHED STEER AXLE)

FIGURE SPN22633_C – DOLLY (GOES UNDER A 5TH WHEEL)

FIGURE SPN22633_D – DRAWBAR (TRAILER HOOKED TO VEHICLE WITH TRADITIONAL HITCH; NO KINGPIN)

FIGURE SPN22633_E – CENTER AXLE TRAILER

A.47 SPN 22679 – EXAMPLES FOR ONE BYTE CRC CALCULATIONS, CRC IN BYTE 1

Many Parameter Groups (PGs) use an AUTOSAR CRC8, for these checksums the order of bytes is relevant. There are Parameter Groups using different checksum algorithms, those are not covered in this document.

Please ensure that the "SPN reference" column of the SP implemented references this Appendix D section before implementing. There are SPs with a CRC that use a legacy format (see SPN 13167 – For One Byte CRC Calculations (Legacy Method), CRC in Byte 1).

The CRC is defined as follows:

- Length: 8 bits
- Polynomial: x^8+x^5+x^3+x^2+x+1 (97h)
- Initial Value: FFh
- Input Data Reflection: Not reflected
- Result Data Reflection: Not reflected
- XOR value: FFh

The CRC algorithm is defined in AUTOSAR (AUTOSAR_SWS_CRCLibrary.pdf) as CRC8H2F() function.

- CRC = CRC8H2F (Data Byte 2, Data Byte 3, Data Byte 4, Data Byte 5, Data Byte 6, Data Byte 7, Data Byte 8, Source Address byte, Byte X, PGN second byte, PGN MSB)

For PDU1, Byte X is the PS (i.e., Destination Address)
For PDU2, Byte X is the PGN LSB.

<u>Difference to AUTOSAR E2E profile 2:</u>

The CRC8H2F() function is also used for AUTOSAR E2E profile 2, however the CRCs in these J1939 PGs are not E2E profile 2 CRCs.

In AUTOSAR E2E profile 2 a Data ID Byte (not transmitted) is included as additional virtual Data Byte.

In J1939 CRCs instead of the virtual Data Byte parts of the CAN ID are included in CRC calculation, in addition, in some PGs the CRC is not in the first byte as it is specified in AUTOSAR E2E profile 2.

In the following examples, CRC calculations are presented:

- Example 1: PG BCH1C1, PDU Format 1, CRC in Byte 1 (counting from Byte 1 to Byte 8)
- Example 2: PG FCSOS, PDU Format 2, CRC in Byte 1 (counting from Byte 1 to Byte 8)

Example 1:

- Parameter Group BCH1C1
- PGN = 14848d = 3A00h Default Priority 6.
- CRC is placed in Byte 1.

CRC processing order
------------------->
CRC8H2F (DB2, DB3, DB4, DB5, DB6, DB7, DB8, SA, Byte X, PGN Second Byte, PGN MSB)

The data bytes are processed from left to right.

- DBx = Data Byte n (2..8) of the Message, DB2 is the second transmitted Data Byte since the CRC is in the first Data Byte
- SA = Source Address
- Byte X = Destination Address (because PG is PDU1)

For a CAN Message sent from Source Address 22h to Destination Address 11h CAN ID is 183A1122h for Priority 6.

Since the priority is not part of the PGN, it will not be considered in the CRC calculation.

Therefore, the PGN MSB is 00h, not 18h.

- DB2 = 62h
- DB3 = 12h
- DB4 = 34h
- DB5 = 56h
- DB6 = 78h
- DB7 = 9Ah
- DB8 = BCh
- Source Address Byte = 22h,
- Byte X (BX) = 11h (Destination Address),
- PGN Second byte (B2) = 3Ah,
- PGN MSB = 00h (For Extended Data Page and Data Page = 0 this value is 00h)

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
6	0	0	3Ah	11h	22h	*26h*	62h	12h	34h	56h	78h	9Ah	BC

CRC = CRC8H2F (62h, 12h, 34h, 56h, 78h, 9Ah, BCh, 22h, 11h, 3Ah, 00h) = *26h*

Changing Sequence Counter from 2 to 3 (lower nibble of DB2):

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
6	0	0	3Ah	11h	22h	*00h*	63h	12h	34h	56h	78h	9Ah	BC

CRC = CRC8H2F (63h, 12h, 34h, 56h, 78h, 9Ah, BCh, 22h, 11h, 3Ah, 00h) = *00h*

Exchanging values for DB3 and DB4:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
6	0	0	3Ah	11h	22h	*30h*	63h	34h	12h	56h	78h	9Ah	BC

CRC = CRC8H2F (63h, 34h, 12h, 56h, 78h, 9Ah, BCh, 22h, 11h, 3Ah, 00h) = *30h*

Changing Source Address to 32h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
6	0	0	3Ah	11h	32h	*46h*	63h	34h	12h	56h	78h	9Ah	BC

CRC = CRC8H2F (63h, 34h, 12h, 56h, 78h, 9Ah, BCh, 32h, 11h, 3Ah, 00h) = *46h*

Changing Destination Address to 41h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
6	0	0	3A	41h	32h	*57h*	63h	34h	12h	56h	78h	9Ah	BC

CRC = CRC8H2F (63h, 34h, 12h, 56h, 78h, 9Ah, BCh, 32h, 41h, 3Ah, 00h) = *57h*

Example 2:

- Parameter Group FCSOS
- PGN = 62327d or F377h, Default Priority is 6.
- CRC is placed in Byte 1

CRC processing order
-------------------->
CRC8H2F (DB2, DB3, DB4, DB5, DB6, DB7, DB8 Byte X, PGN Second Byte, PGN MSB)

The data bytes are processed from left to right.

- DBx = Data Byte n(2..8) of the Message, DB2 is the second transmitted Data Byte since the CRC is in the first Data Byte
- SA = Source Address
- Byte X = PGN LSB (because PG is PDU 2)

For a CAN Message sent from Source Address 12h CAN ID is 18F37712h for priority 6.

Since the priority is not part of the PGN, it will not be considered in the CRC calculation. Therefore, the PGN MSB is 00h, not 18h.

- DB2 = 62h
- DB3 = 12h
- DB4 = 34h
- DB5 = 56h
- DB6 = 78h
- DB7 = 9Ah
- DB8 = BCh
- Source Address = 12h
- Byte X (BX) = 77h (PGN LSB)
- PGN Second byte (B2) = F3h
- PGN MSB = 00h (For Extended Data Page and Data Page = 0 this value is 00h)

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	CRC
6	0	0	F3h	77h	12h	*79h*	62h	12h	34h	56h	78h	9Ah	BCh

CRC = CRC8H2F (62h, 12h, 34h, 56h, 78h, 9Ah, BCh, 12h, 77h, F3h, 00h) = *79h*

Changing Sequence Counter from 2 to 3 (lower nibble of DB2):

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	F3h	77h	12h	*5Fh*	63h	12h	34h	56h	78h	9Ah	BCh

CRC = CRC8H2F (63h, 12h, 34h, 56h, 78h, 9Ah, BCh, 12h, 77h, F3h, 00h) = *5Fh*

Changing DB8 = 00h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	F3h	77h	12h	*20h*	63h	12h	34h	56h	78h	9Ah	00h

CRC = CRC8H2F (63h, 12h, 34h, 56h, 78h, 9Ah, 00h, 12h, 77h, F3h, 00h) = *20h*

Changing Source Address to 02h:

ID						Data Payload							
Priority	EDP	DP	B2	BX	SA	CRC	DB2	DB3	DB4	DB5	DB6	DB7	DB8
3	0	0	F3h	77h	02h	*56h*	63h	12h	34h	56h	78h	00h	00h

CRC = CRC8H2F (63h, 12h, 34h, 56h, 78h, 9Ah, 00h, 02h, 77h, F3h, 00h) = *56h*

A.48 SPN 22943 – MOTOR/GENERATOR THERMAL CAPABILITY USED

This explanation applies to all Motor/Generator instances, but is shown as an example for Motor/Generator 1.

SPN [22943] Motor/Generator 1 Thermal Capability Used and SPN [22945] Motor/Generator 1 Inverter Thermal Capability Used are indicators of the motor/generator and inverter power capability in relation to thermal conditions. The calculation method must be defined by the manufacturer.

SPN [22944] Motor/Generator 1 Thermal Capability Limit and SPN [22946] Motor/Generator 1 Inverter Thermal Capability Limit are a manufacturer defined thermal thresholds beyond which product life may be reduced.

The figure below shows an example of how these parameters may be configured. The SPN [22943] Motor/Generator 1 Thermal Capability Used and SPN [22945] Motor/Generator 1 Inverter Thermal Capability Used ranges from 0% to 100 %. Full Performance is allowed up to SPN [22946] Motor/Generator 1 Thermal Capability Limit and SPN [22946] Motor/Generator 1 Inverter Thermal Capability Limit. Above SPN [22946] Motor/Generator 1 Thermal Capability Limit and SPN [22946] Motor/Generator 1 Inverter Thermal Capability Limit the device is operating above its specified operation range. This may lead to a reduction of component life. Possible measures to prevent a life reduction could be derating its output. Reaching 100 % may affect an emergency shutoff to prevent component damage depending on manufacturer specific design.

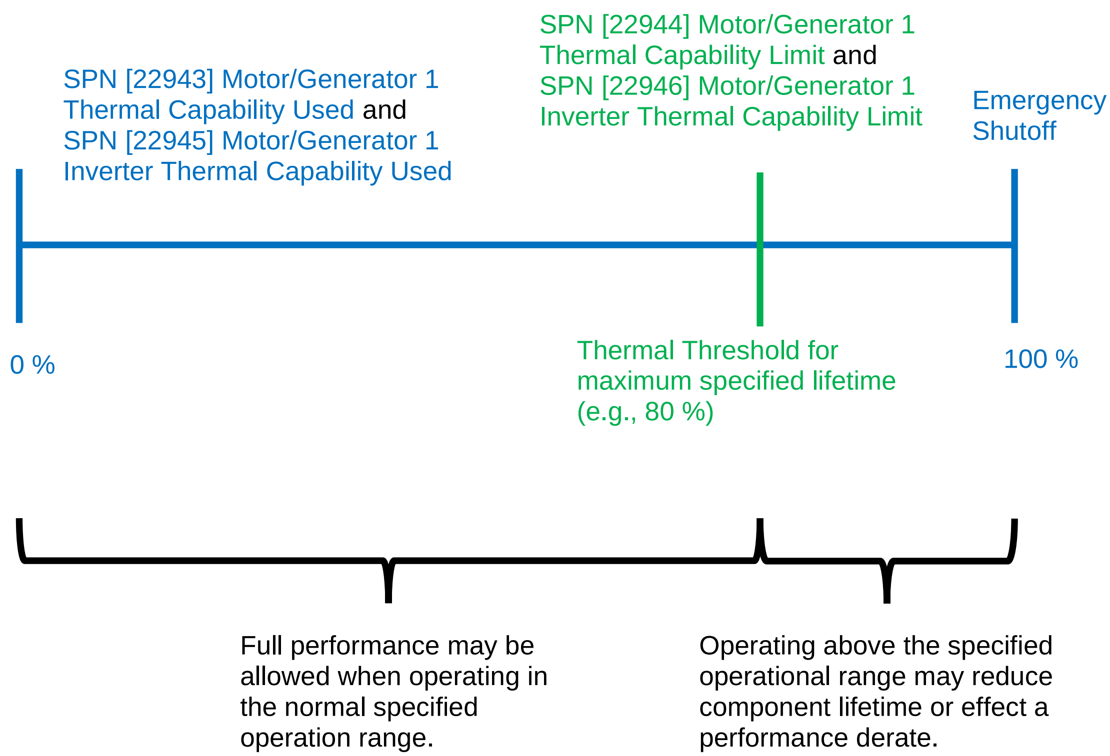


FIGURE SPN22943_A – THERMAL CAPABILITY USED

A.49 SPN 23164 – FUEL CELL SYSTEM ACTUAL MINIMUM AVAILABLE NET POWER

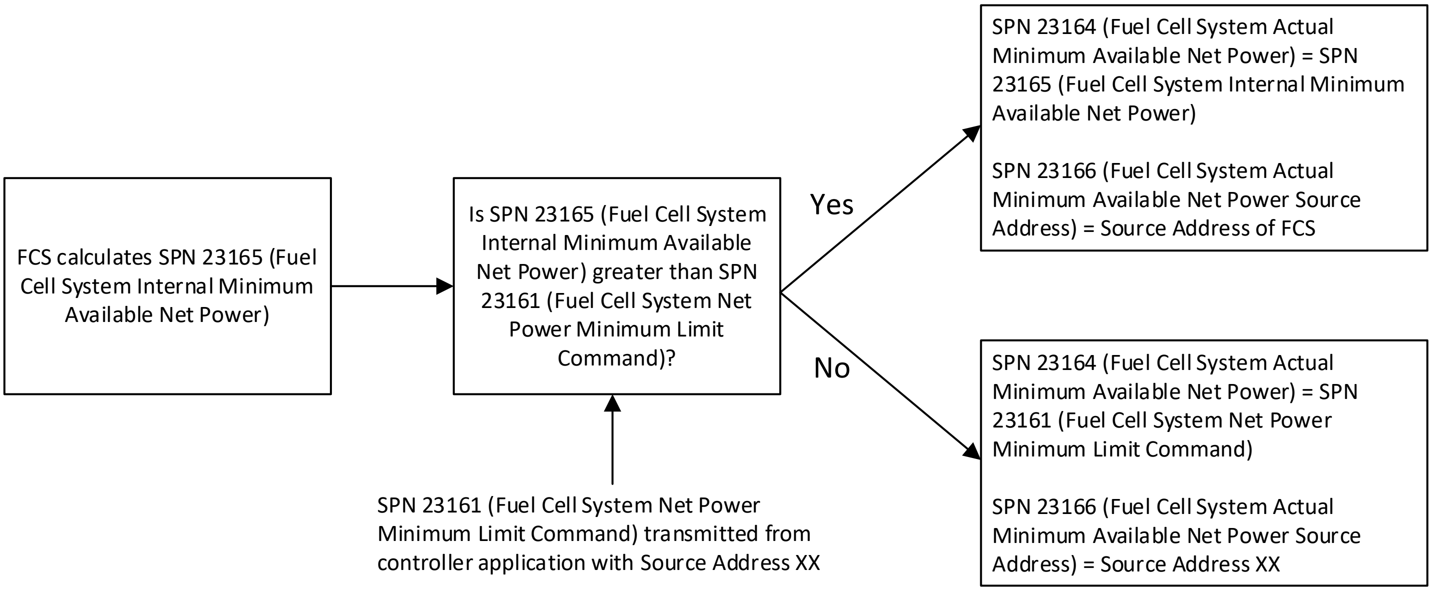


FIGURE SPN23164_A – FUEL CELL SYSTEM ACTUAL MINIMUM AVAILABLE NET POWER

A.50 SPN 23169 – FUEL CELL SYSTEM ACTUAL MAXIMUM AVAILABLE NET POWER

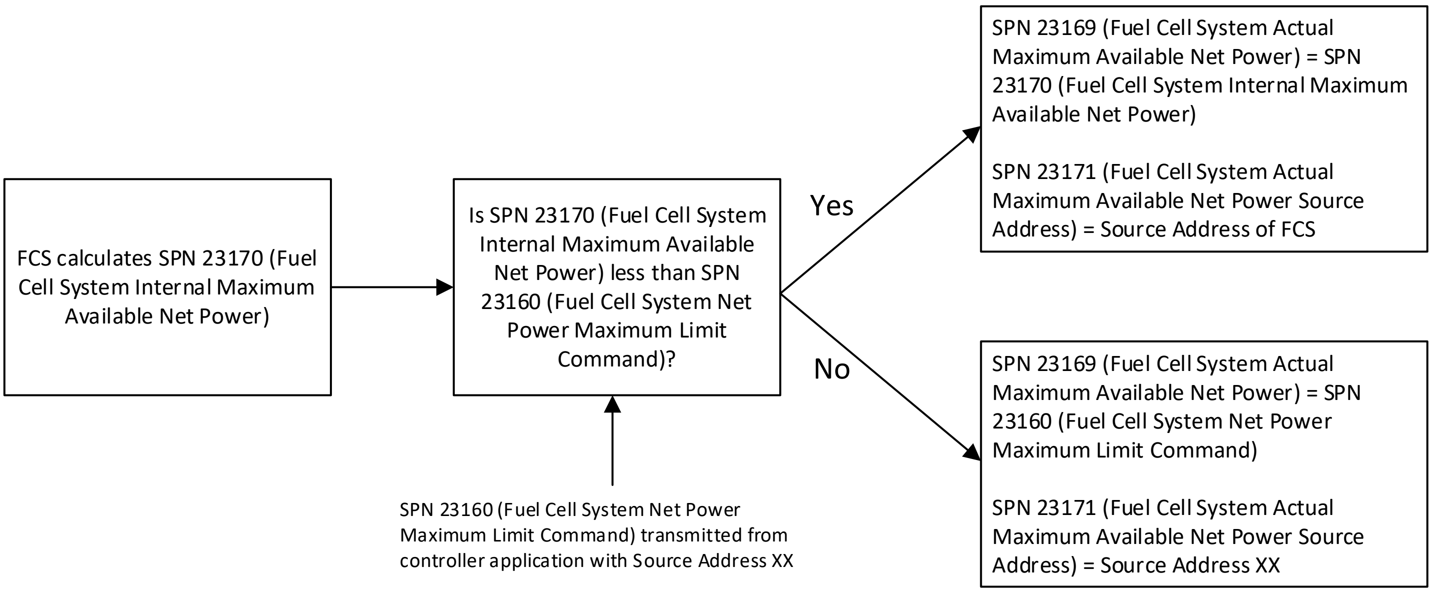


FIGURE SPN23169_A – FUEL CELL SYSTEM ACTUAL MAXIMUM AVAILABLE NET POWER

A.51 SPN 23178 – FUEL CELL SYSTEM ACTUAL MINIMUM AVAILABLE NET CURRENT

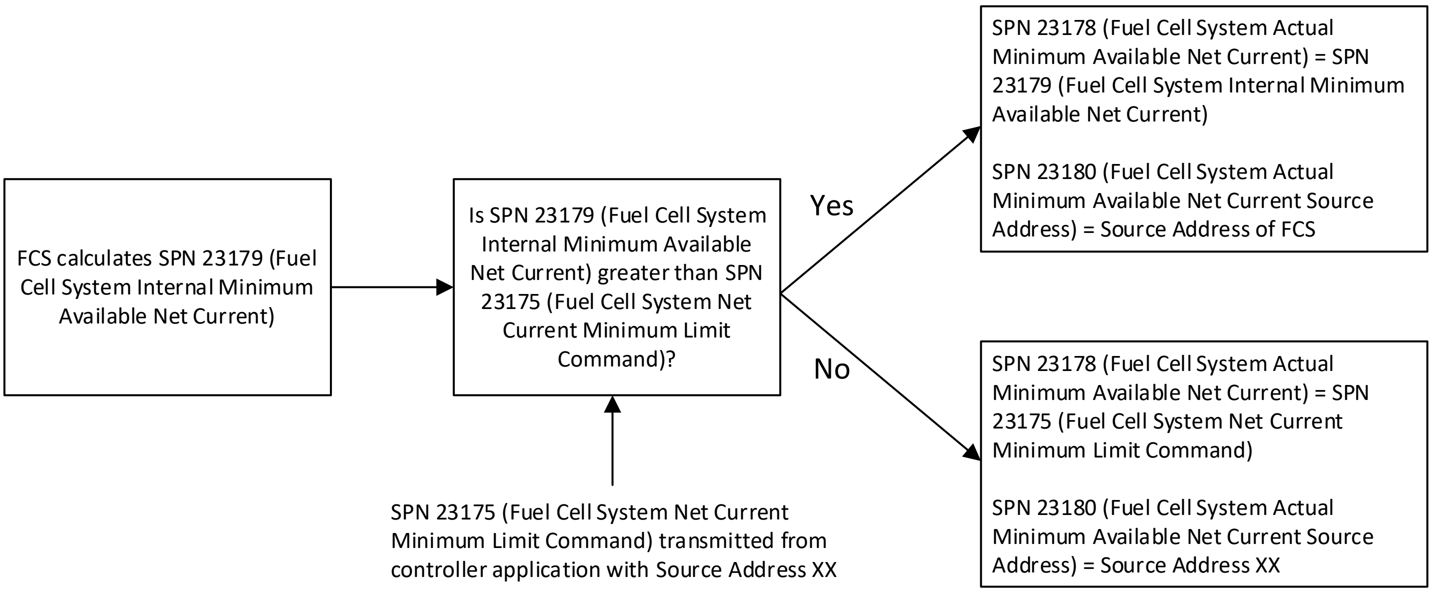


FIGURE SPN23178_A – FUEL CELL SYSTEM ACTUAL MINIMUM AVAILABLE NET CURRENT

A.52 SPN 23183 – FUEL CELL SYSTEM ACTUAL MAXIMUM AVAILABLE NET CURRENT

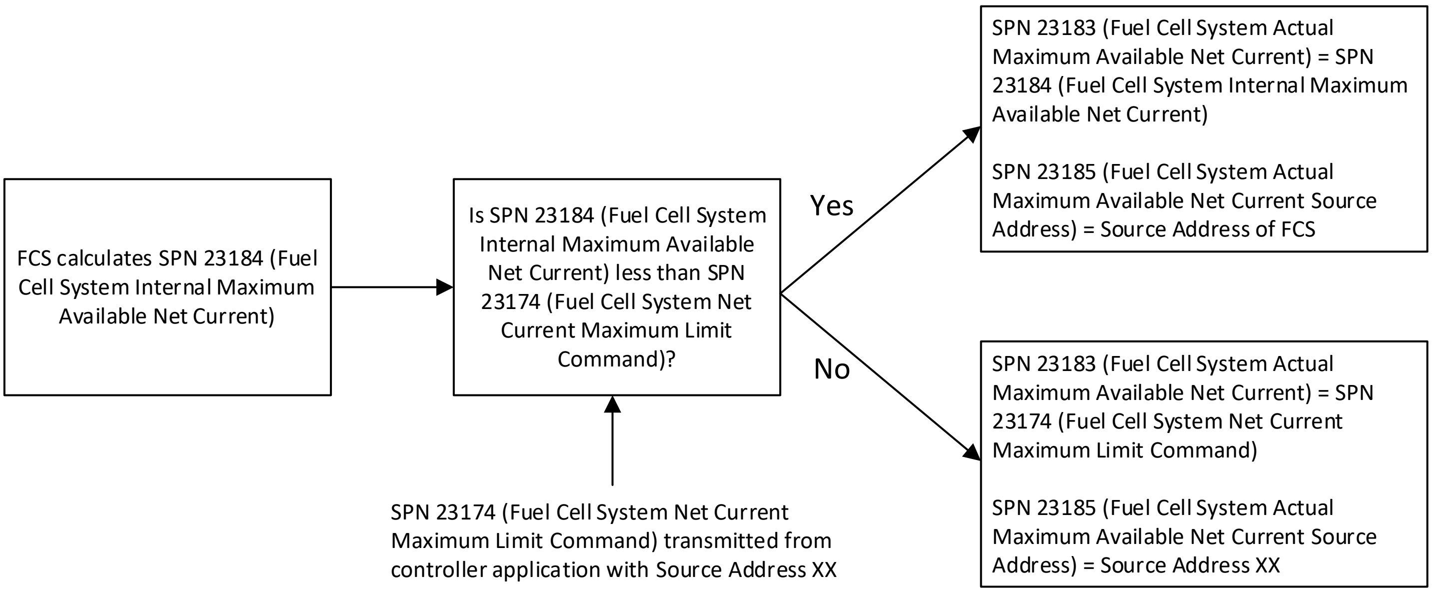


FIGURE SPN23183_A – FUEL CELL SYSTEM ACTUAL MAXIMUM AVAILABLE NET CURRENT

A.53 SPN 23196 – FUEL CELL SYSTEM OPERATION STATE

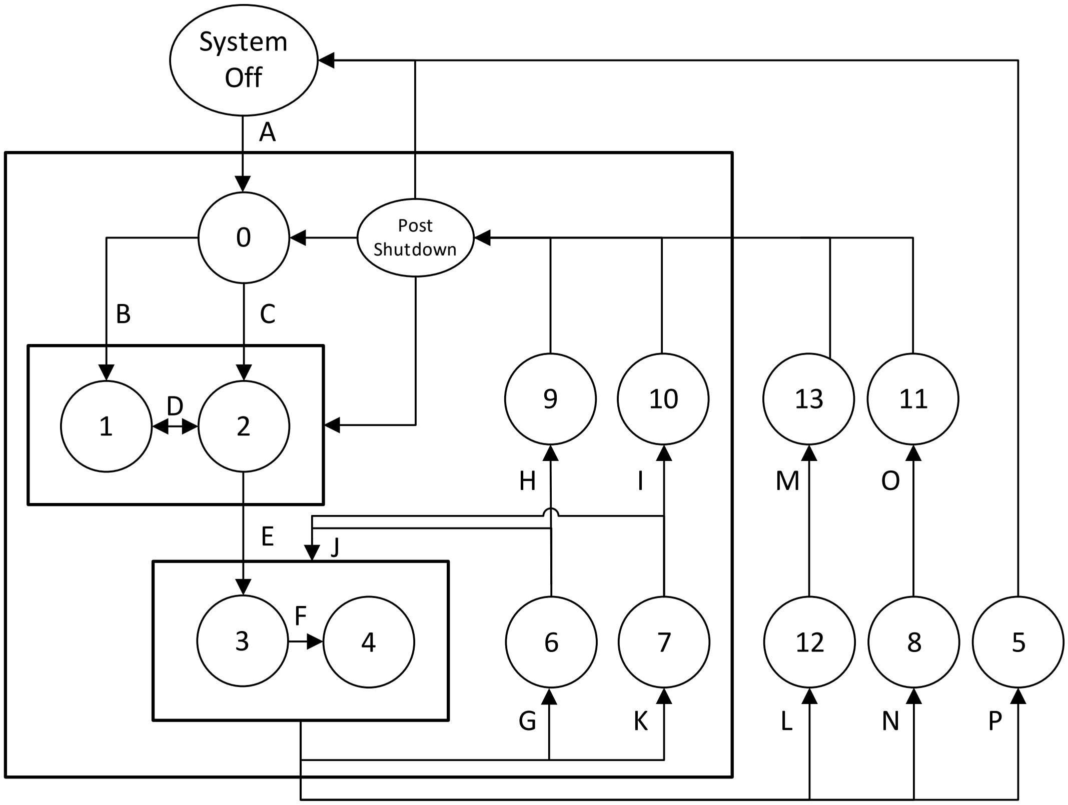


FIGURE SPN23196_A – STATE DIAGRAM FOR FUEL CELL SYSTEM OPERATION STATE

States:

0: System self-check (e.g., checking configuration, external accessory evaluation, etc.)
1: Low voltage standby.
2: High voltage standby.
3: Starting up (e.g., activate coolant pump, enable hydrogen supply, enable air compressor, etc.)
4: Operating.
5: FCS is shutting down due to operator.
6: FCS is shutting down due to (FCS low priority shutdown command).
7: FCS is shutting down due to (FCS medium priority shutdown command).
8: FCS is shutting down due to (FCS high priority shutdown command).
9: FCS has shut down due to (FCS low priority shutdown command).
10: FCS has shut down due to (FCS medium priority shutdown command).
11: FCS has shut down due to (FCS high priority shutdown command).
12: FCS is shutting down due to a faulted condition internal to the FCS.
13: FCS is in a shutdown state due to a faulted condition internal to the FCS.
Post Shutdown: It is up to manufacturers to determine the next state after a shutdown. It could be System Off, System self-check, or Standby.

State Transitions:

A: Operator applies power to the system (e.g., key switch transitions to ON).
B: After initialization, FCS is isolated from the vehicle high voltage bus.
C: After initialization, FCS is connected to vehicle high voltage bus.

D: Transition between LV Standby and HV Standby. (It may be determined due to vehicle high voltage supply state, FCS active command, or the logic of FCS controller.)

E: FCS has received Fuel Cell System State Command = FCS active command (3).

F: FCS has completed Starting up process successfully.

G: FCS has received Fuel Cell System State Command = FCS low priority shutdown command (4).

H: FCS has completed low priority shutdown.

I: FCS has completed medium priority shutdown.

J: Low and medium priority shutdowns could be interrupted and transition to Operating instead of shutting down.

K: FCS has received Fuel Cell System State Command = FCS medium priority shutdown command (5).

L: FCS has started shutdown due to fault condition internal to the FCS.

M: FCS has completed shutdown due to fault condition internal to the FCS.

N: FCS has received Fuel Cell System State Command = FCS high priority shutdown command (6).

O: FCS has completed high priority shutdown.

P: Operator power down (e.g., key switch transitions to OFF).

A.54 PGN 1024 – EXTERNAL BRAKE REQUEST

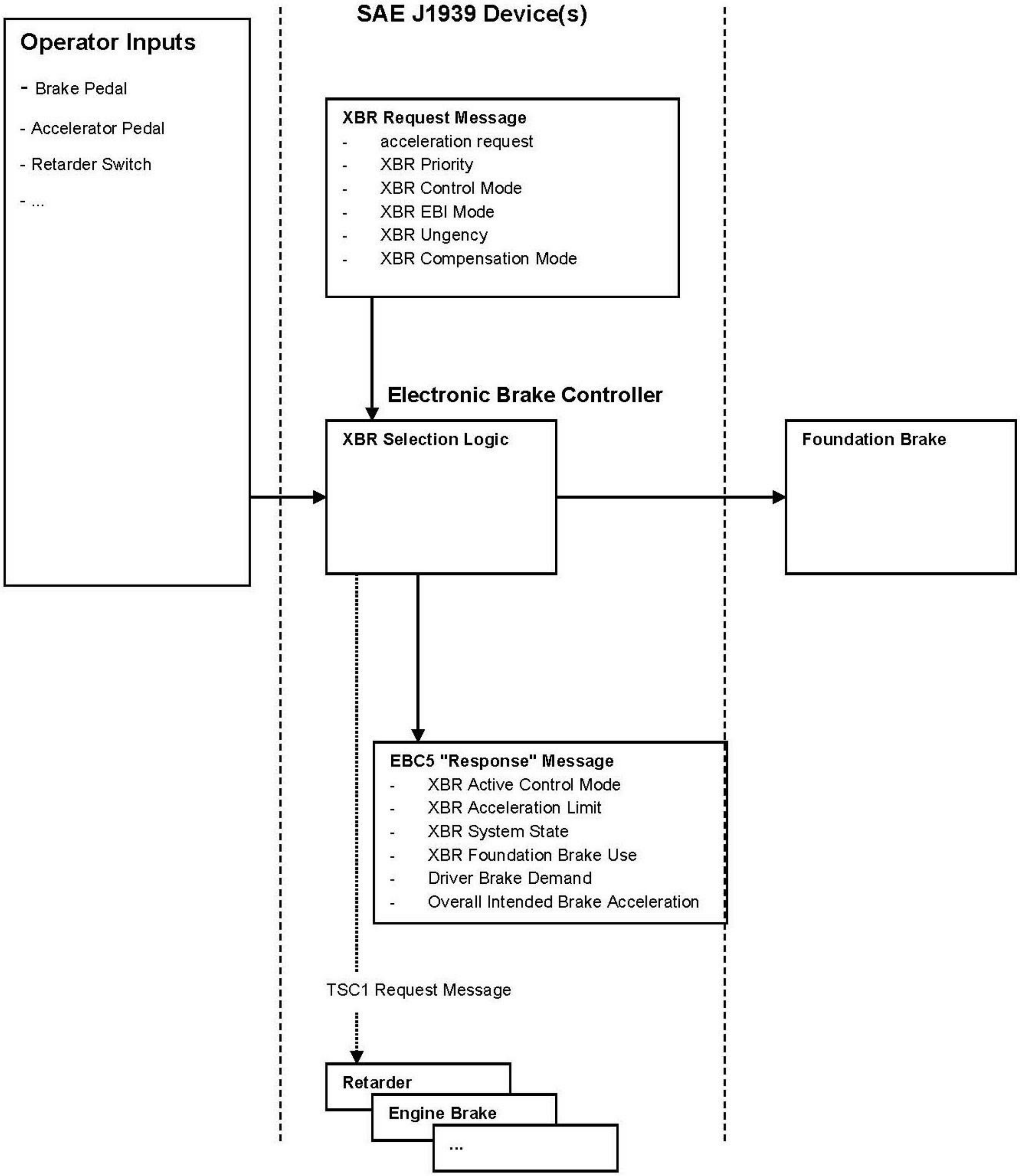
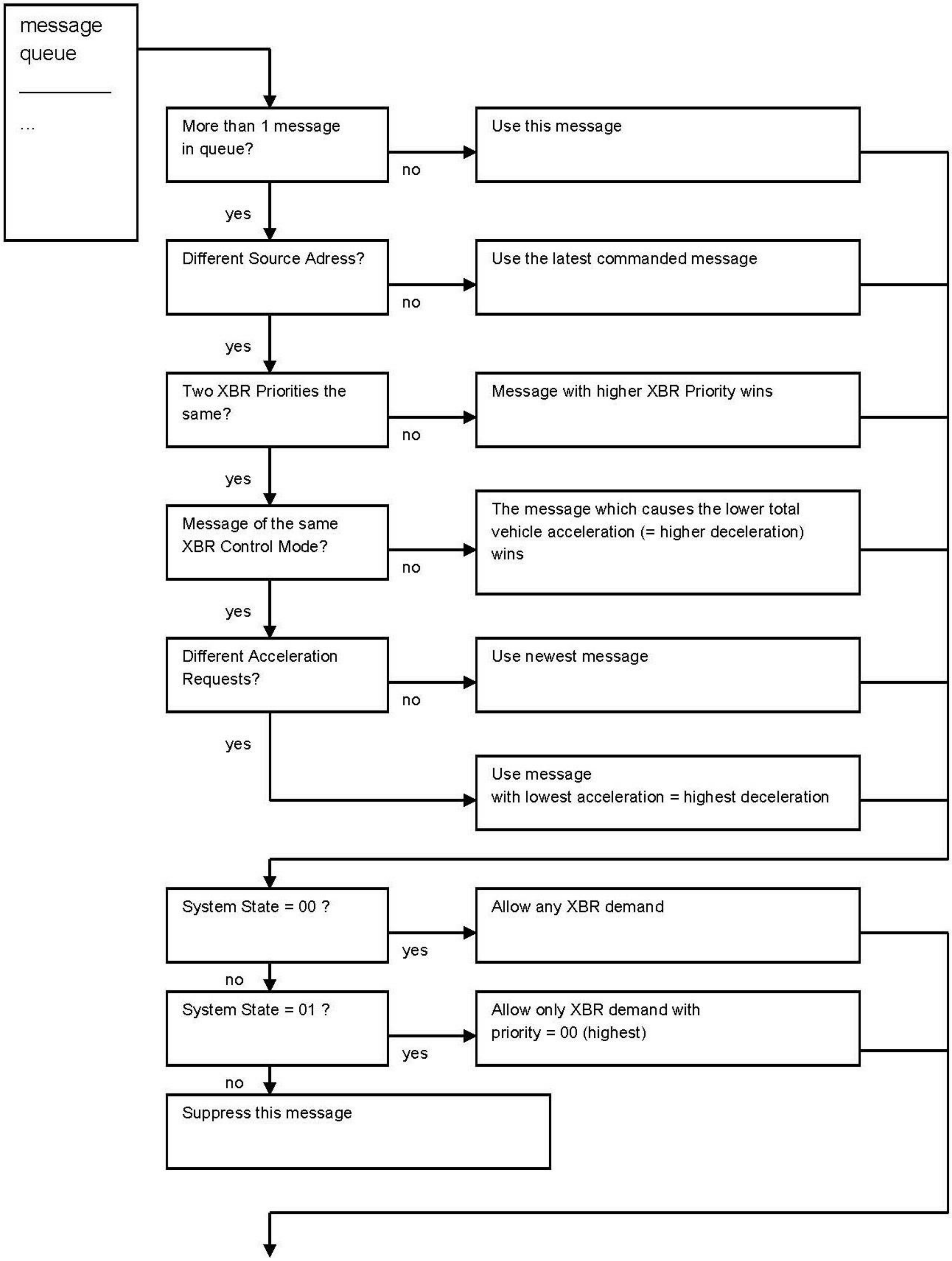


FIGURE PGN1024_A - DATA FLOW DIAGRAM FOR EXTERNAL BRAKE REQUEST



(CONTINUED ON NEXT PAGE)

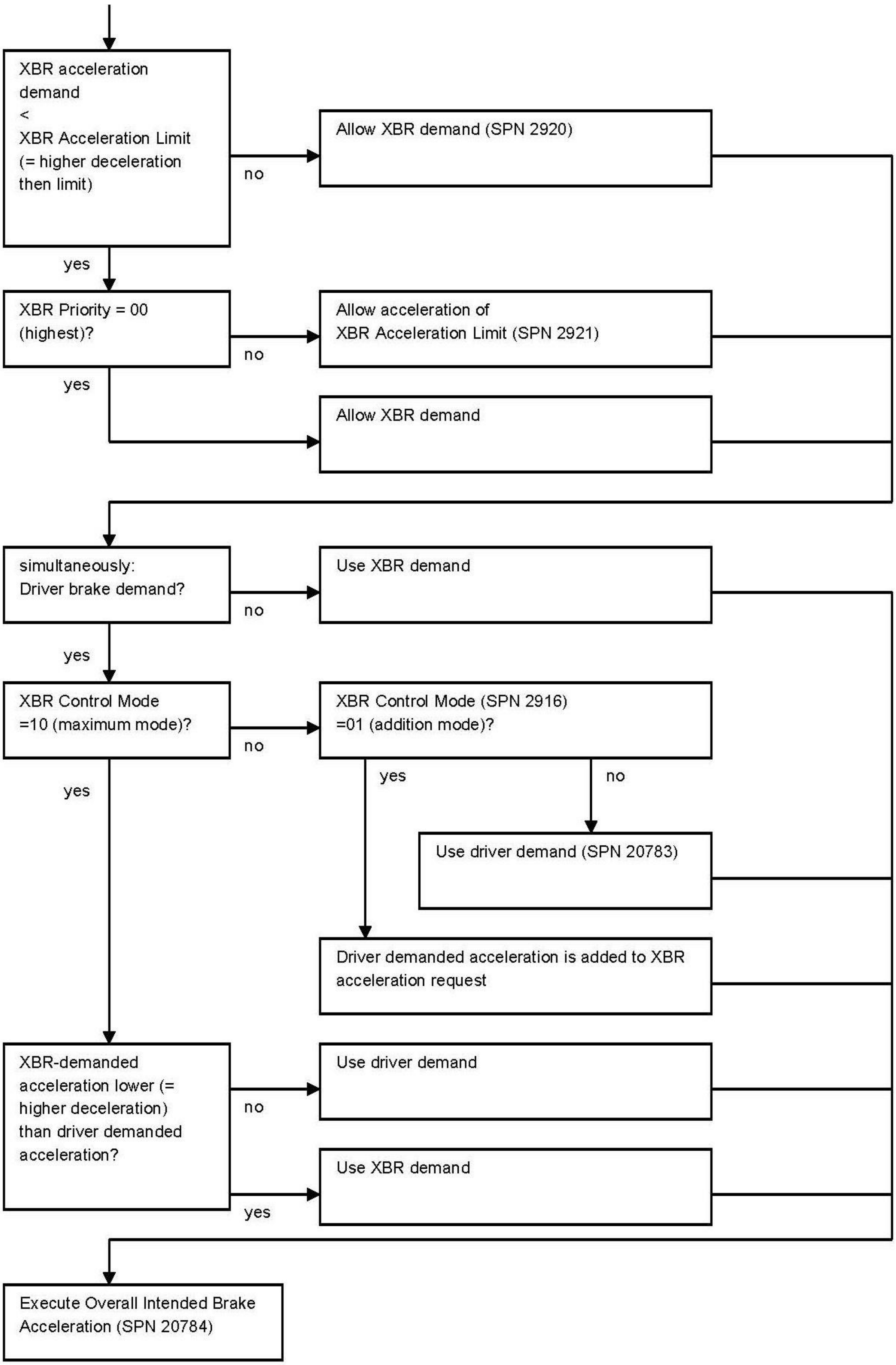


FIGURE PGN1024_B - XBR PRIORITY SELECTION LOGIC

A.55 PGN 2560 – CRUISE CONTROL/VEHICLE SPEED 2

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)	Cruise Control Set Command (SPN 9843)	Action by Cruise Control Device	Cruise Control System Command State (SPN 5	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)	Source Address of Controlling Device for Setting Cruise Control (SPN 9843)
00	don't care	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	0xFE
01	Operator selection	Operator selection	Operator selection	Operator selection	00	don't care	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	0xFE
01	don't care	don't care	don't care	don't care	01	don't care	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	0xFE
01	00	00	00	00	01 → 00[1]	don't care	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	0xFE
01	don't care	don't care	don't care	don't care	00	01	don't care	don't care	Cruise control is not active. Cruise control set speed is retained	010	Off (000)	Off (00)	0xFE	SA of Device	0xFE
01	00	00	00	00	00	01 → 00[2]	don't care	don't care	Cruise control is not active. Cruise control set speed is retained	010	Off (000)	Off (00)	0xFE	0xFE	0xFE
01	00	00	00	00	00	01 → 00[4]	00 → 01[4]	00	If a previous set speed exists, then cruise control will become active.	011[3]	Resume (100)	On (01)	0xFE	0xFE	0xFE
01	00	00	00	00	00	00	01	00	If a previous set speed exists, then cruise control will become active.	011[3]	Resume (100)	On (01)	0xFE	0xFE	0xFE
01	00	00	00	00	00	00	01	00	If a previous set speed does not exist, then cruise control will not become active.	100	Off (000)	Off (00)	0xFE	0xFE	0xFE
01	00	00	00	00	00	00	00	01	Cruise Control becomes active and the cruise control set speed is set to the current vehicle speed	101[5]	Set (101)	On (01)	0xFE	0xFE	SA of Device

[1] The values in the Outputs 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 to activate cruise control is the Cruise Control Set Switch or the Cruise Control Set Command.

[2] The values in the Outputs 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, (3) Cruise Control Resume Command, or (4) Cruise Control Set 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.

[5] Cruise Control System Command State will change to the appropriate value when Cruise Control States is no longer equal to Set (101).

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

A.56 PGN 18944 – MULTIPLE CHARGING SOURCES

Prior to J1939DA_202211, J1939 provided support for charging a vehicle's battery pack from an off board EVSE that supported either Single Phase AC, Three Phase AC, or DC charging.

There was limited support for multiple connection points on the vehicle and only one port was allowed to actively supply power at a time.

There are scenarios where a vehicle may want to have charging sources, with potentially more than one active at the same time. Some examples are given below.

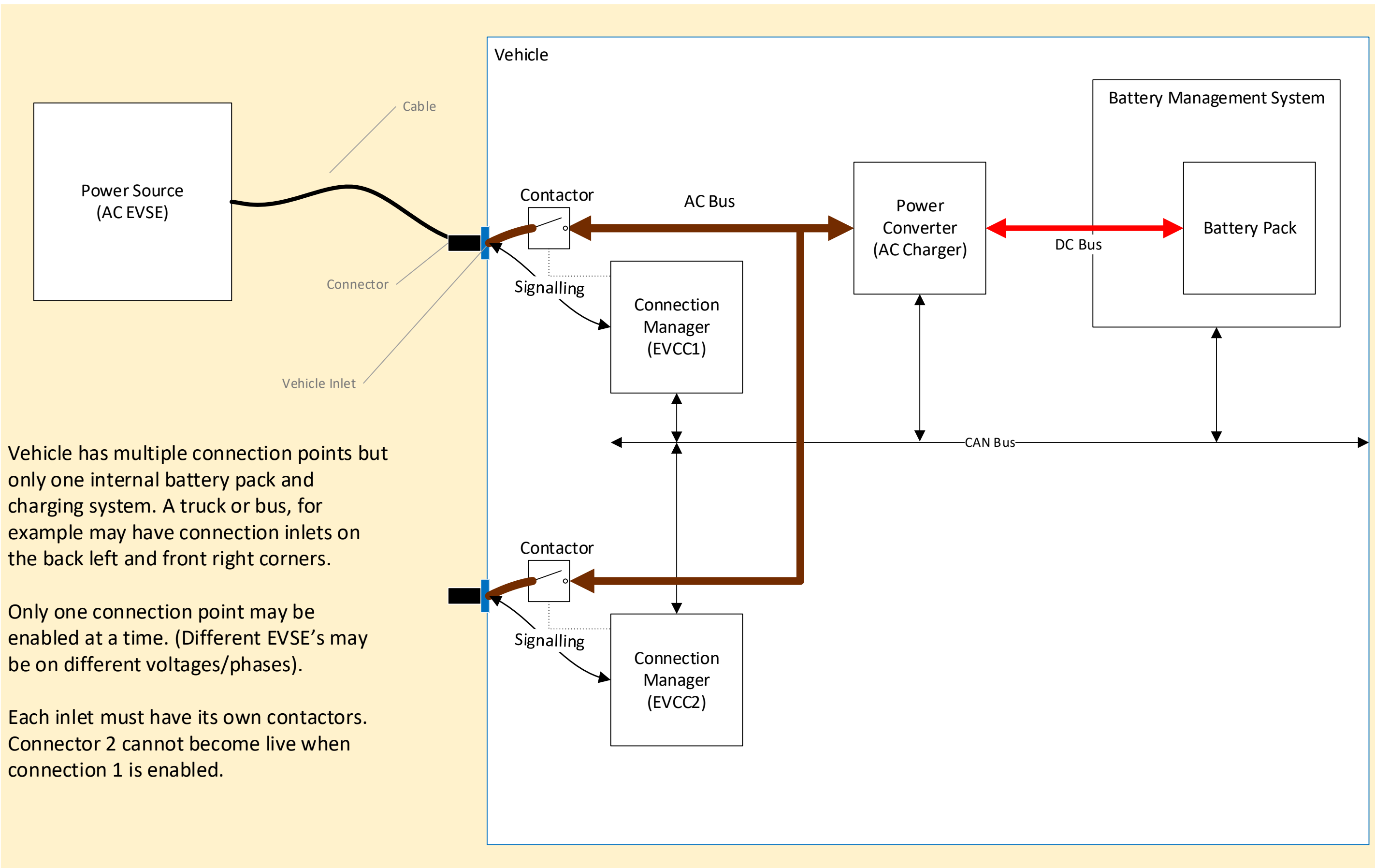


FIGURE PGN18944_A - EXAMPLE 1 - MULTIPLE AC CHARGING INLETS – 1 INTERNAL DC BUS

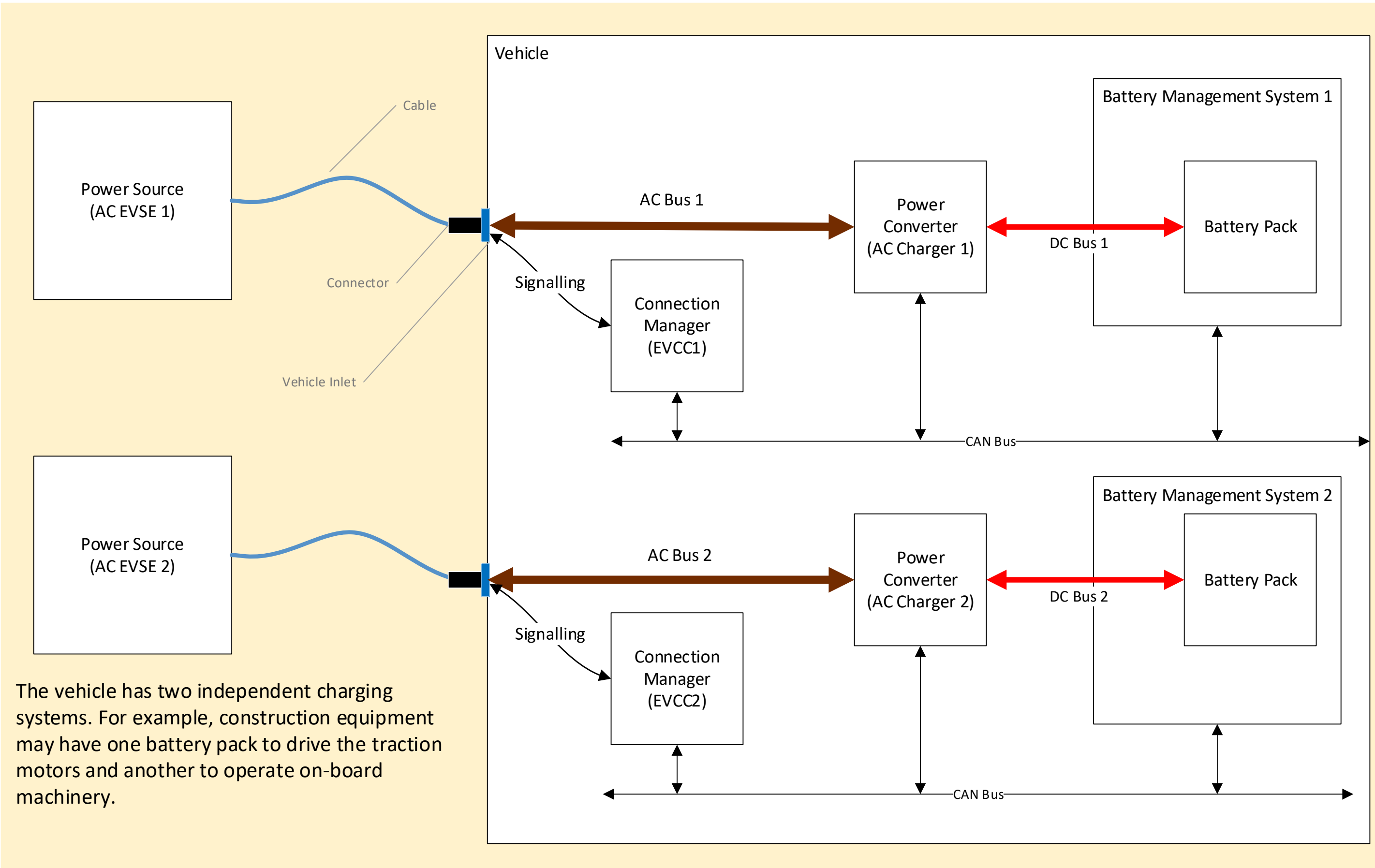


FIGURE PGN18944_B - EXAMPLE 2 - MULTIPLE AC CHARGING INLETS – SEPARATE INTERNAL DC BUSSES

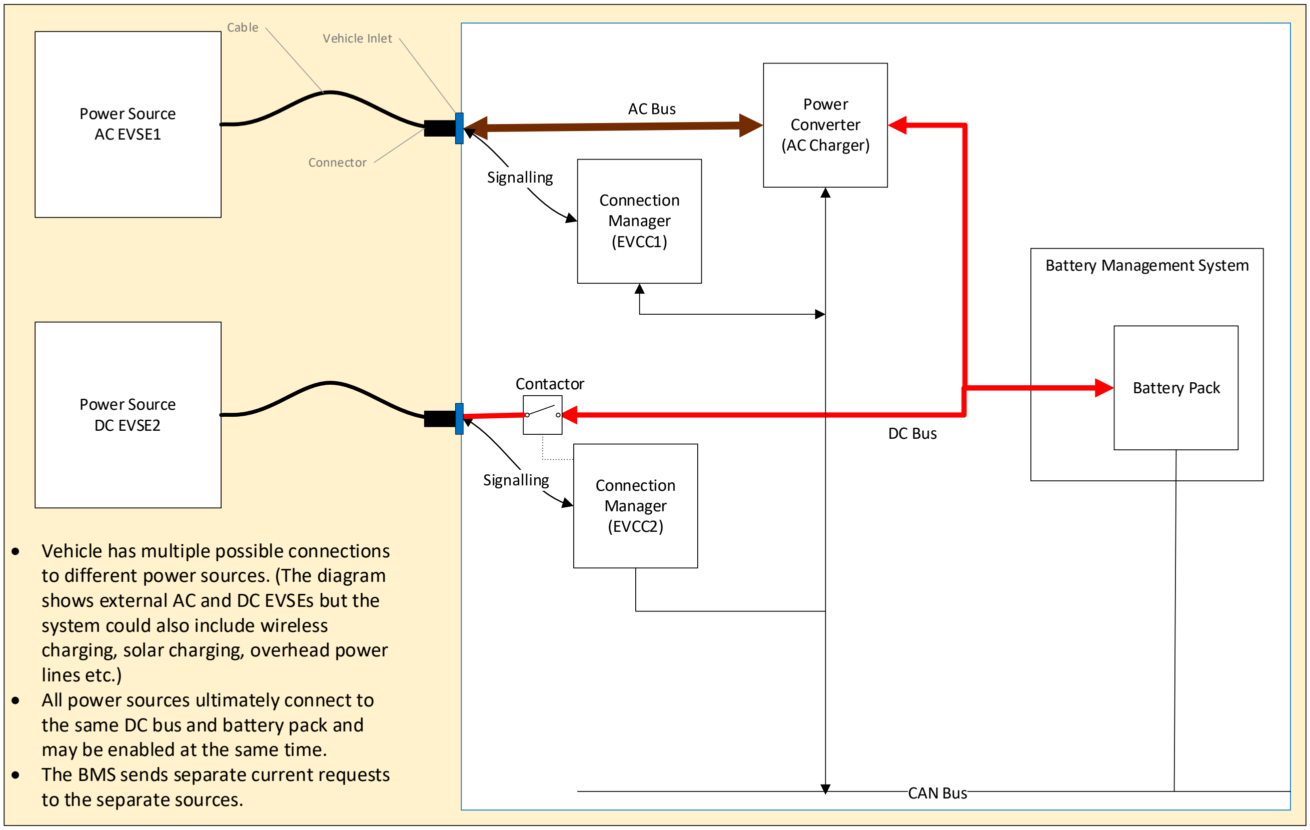


FIGURE PGN18944_C - EXAMPLE 3 - MULTIPLE ACTIVE SOURCES CONNECTED TO SAME DC BUS

Many existing charging/EVSE related PGs were PDU2 format and can only be broadcast on the J1939 bus. This limited them to supporting a single instance of EVSE or charger. It is difficult to re-use these without breaking backwards compatibility. When implementing a system that supports multiple active charging sources the following points need to be considered:

- Each instance of a device (EVCC / Charger) shall have a unique Function/ECU Instance when they claim their address. This implies their location on the vehicle and which other devices they are physically connected to.
- The instance of a device is identified by the source address of its PGs.
- Critical, high rate, commands to a device use PDU1 format PGs which allow a destination address to be specified. (e.g., BCH1C1, BCH2C1, EVSEC1, EVMCDCLIM1, EVMCDCS1)
- Informational PGs, sent at low speed or on request, that need directing to a specific device instance may use PDU2 format PGs that have an Extended ID byte. The Extended ID byte for a device will have the same numeric value as its SA. (e.g., EVMCDCLIM2, EVMCDCCIP). This tells the recipient if the data contained is intended for them.
- Where a PG has a defined message rate then this applies separately to each instance of the PG. See Figure PGN18944_D.
- If a device supports multiple instances of an On-Request PG. Then the instance returned is determined by the requestor's source address or, in the case of RQST2, the request's Extended ID byte. See PGN18944_E.

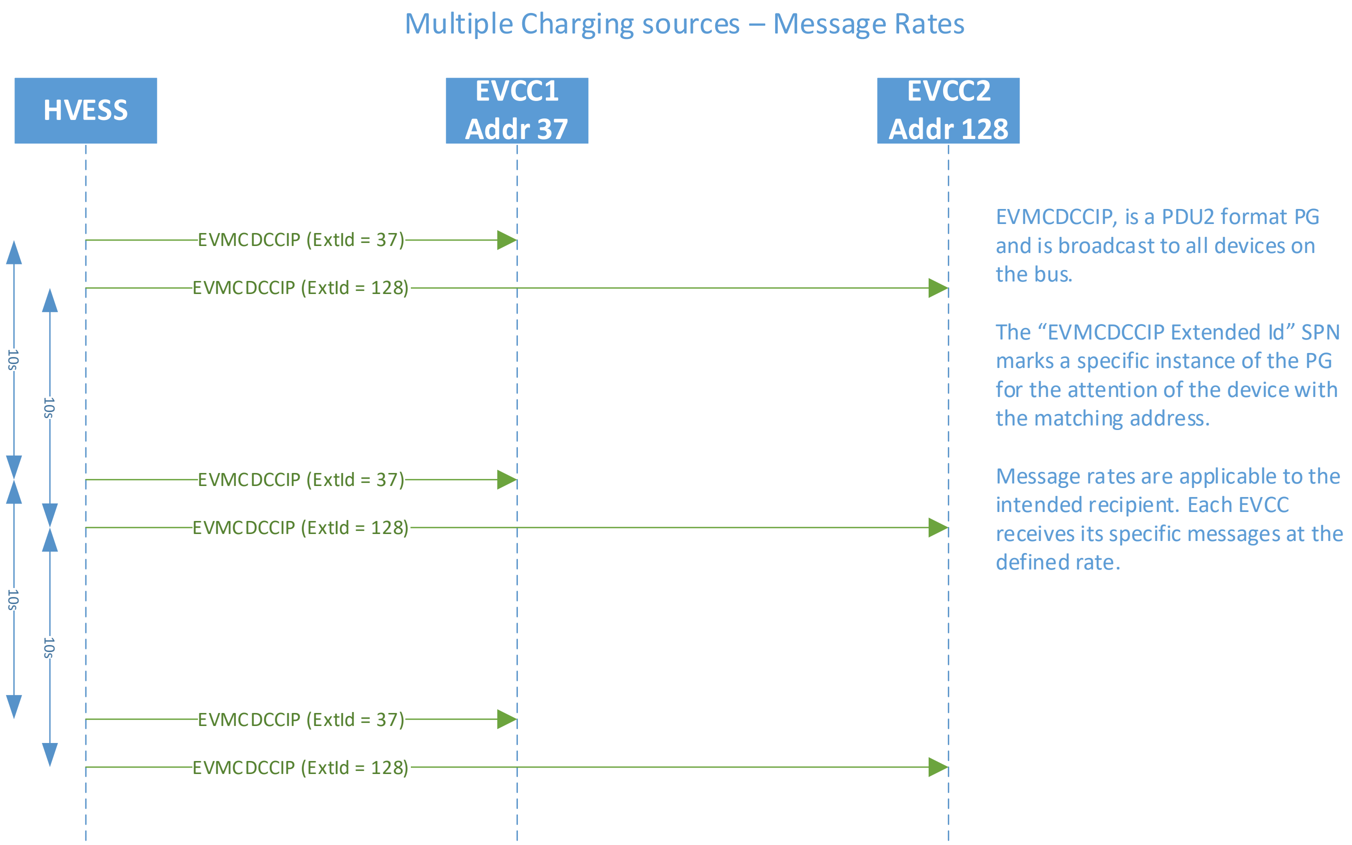


FIGURE PGN18944_D - MESSAGE RATE FOR MULTI-INSTANCE PGS

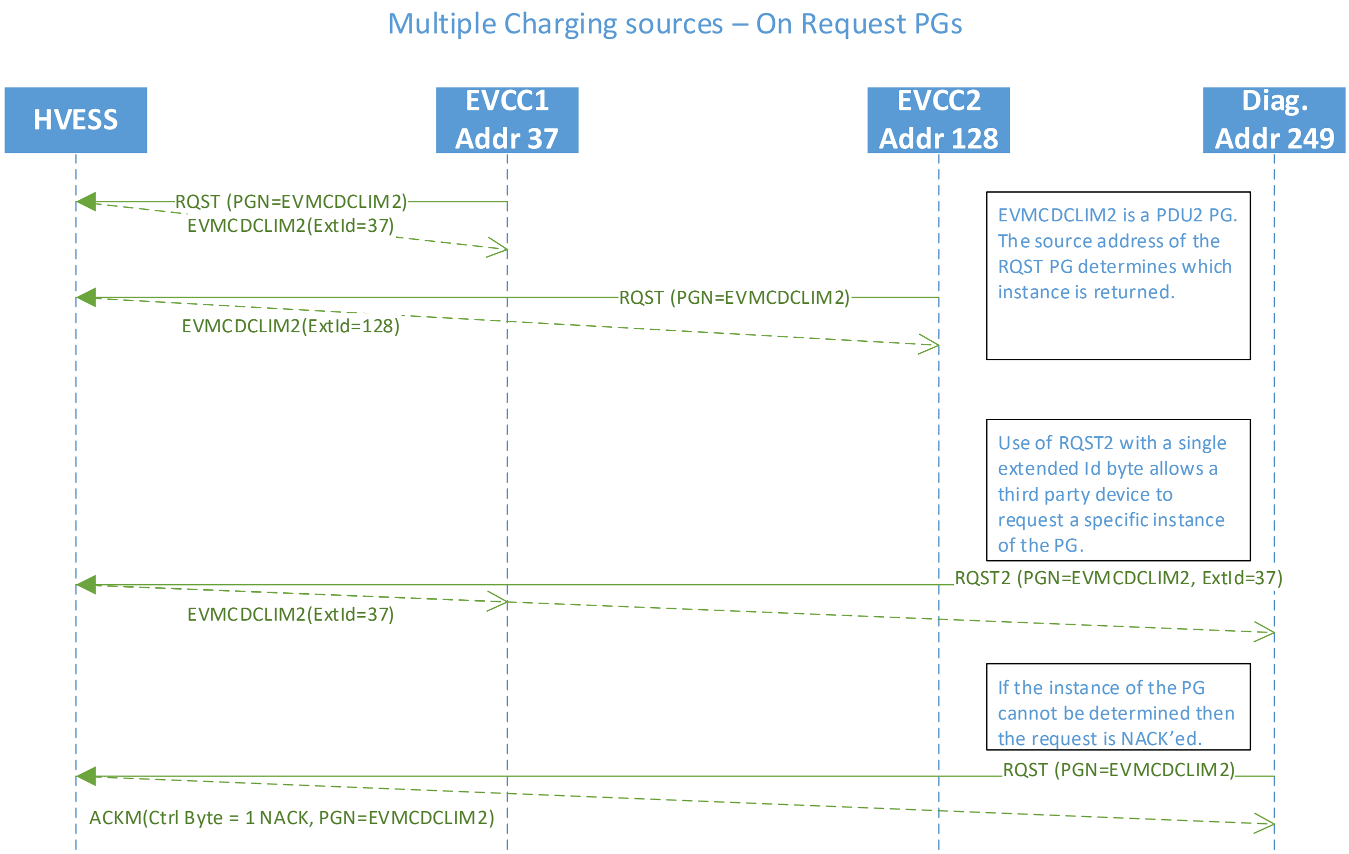


FIGURE PGN18944_E - REQUESTING MULTI-INSTANCE PGS

A.57 PGN 20992 – MANUFACTURER-DEFINED DATA TRANSFER

DATA TRANSFER MESSAGE INTENTION

The Data Transfer messages (PGN DDT, PGN WDT and PGN MDT) are for use by an intermediary (e.g. a telematics device) to regularly retrieve one or more proprietary data sets from a transmitting control module for the stated reporting interval (e.g. Daily, Weekly or Monthly). These data sets can then be forwarded to the transmitter manufacturer cloud or data repository. Prior to the Data Transfer messages, intermediaries had to implement multiple unique proprietary PGNs to retrieve proprietary data.

Data Transfer messages are not intended to convey real-time operational data nor pre-defined standard J1939 data. They are intended to convey data accumulated and packaged internally by the transmitter, such as configuration or duty cycle data. Since the transmitting control module has native knowledge of its own operating data, it can generate high resolution data summaries much more efficiently than sending out large quantities of raw data to be reduced elsewhere. Transferring large quantities of raw data to an intermediary device wastes network bandwidth and pushing this raw data to the cloud wastes cellular bandwidth and increases data transfer cost.

DATA TRANSFER MESSAGE CONTENT

The Data Transfer messages allow a transmitter to use one PGN to broadcast multiple sets of proprietary data when the update interval is reached. For example, a transmitter might broadcast (or be requested to broadcast) 5 proprietary data sets on a weekly basis, with each data set contained in an instance of the Weekly Data Transfer message. The 5 instances form a “broadcast series”. The broadcast series messages would be spaced apart per the transmit rate requirements.

All Data Transfer messages have the same structure, with the following content:

<Interval> Message Instance (e.g. Daily Message Instance)
<Interval> Message Instances Remaining
<Interval> Data Manufacturer ID
<Interval> Data Set ID
<Interval> Data

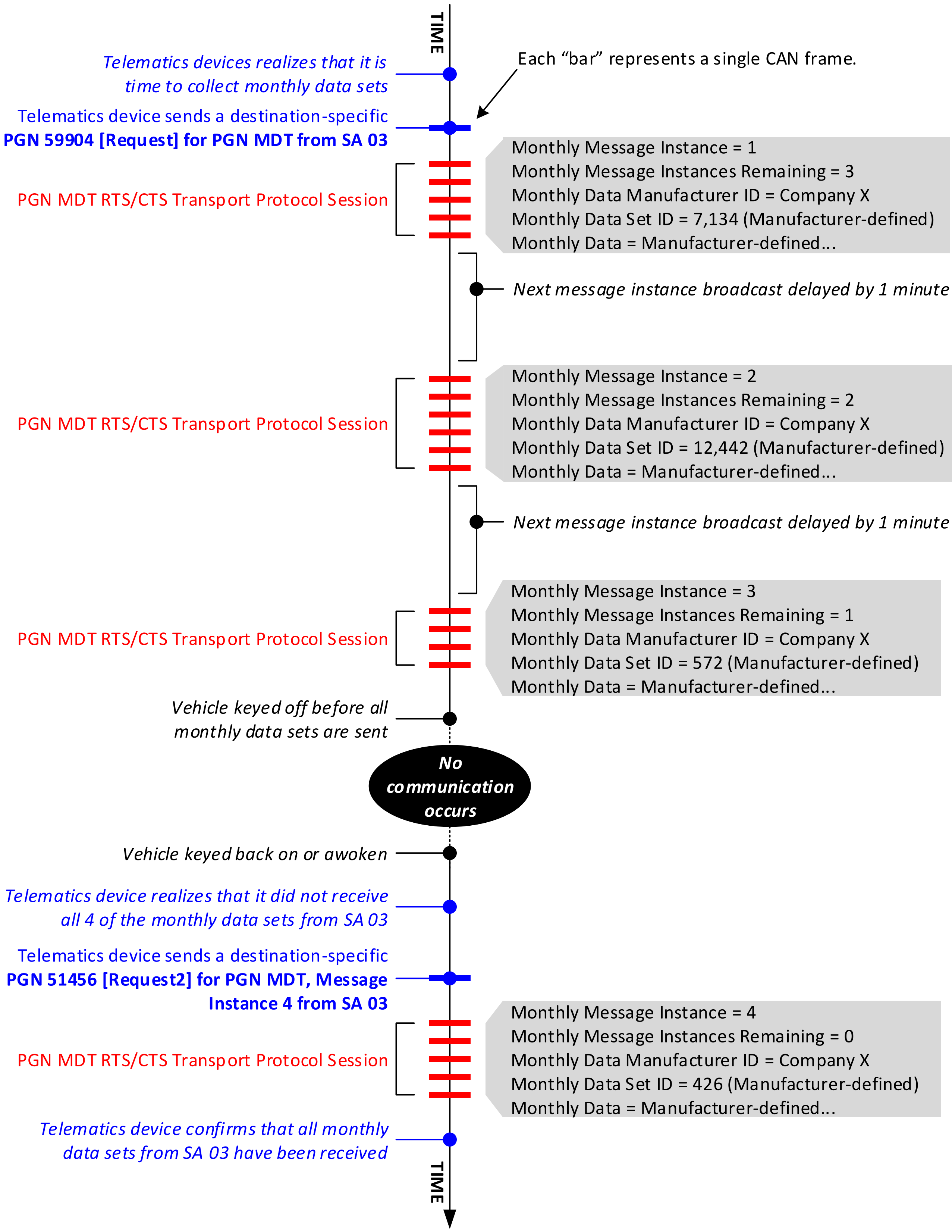
…where <Interval> is Daily, Weekly or Monthly.

The Message Instance, Message Instances Remaining and Data Manufacturer ID parameters are most relevant to the intermediary. The instance parameters allow the intermediary to determine what message instance is being sent or has been received, and whether or not all message instances have been received. The Data Manufacturer ID tells the intermediary whose cloud or data repository is the final destination for the data.

The Data Set ID and Data fields are only relevant to the transmitter manufacturer. The Data Set ID parameter allows the manufacturer to interpret the subsequent data content in a given message instance. Transmitters may elect to encrypt their data with no impact to the intermediary. Decryption would occur in the transmitter manufacturer cloud, so the intermediary is not involved in the encryption / decryption process.

EXAMPLE OF A MONTHLY DATA TRANSFER BROADCAST SERIES

In this example, the intermediary sends a single PGN 59904 Request to start the broadcast series, and then issues a PGN 51456 Request2 to obtain the one instance it didn't get due to vehicle power being interrupted:



RETRIEVING DATA TRANSFER MESSAGE INSTANCES

There are several ways an intermediary can obtain a full set of Data Transfer message instances from a supporting transmitter. One or more of these methods may be used to optimize bandwidth use and overall processing:

1. **Listen for unsolicited Data Transfer messages from the transmitter.**

   If the transmitter supports broadcast of a Data Transfer message, and it has its own internal clock or method to determine actual time, it may choose to broadcast its Data Transfer message instances when it determines the reporting interval has arrived. A transmitter might independently determine, for example, that today is Friday and it is time to send out its Weekly Data Transfer broadcast series.

   Note that broadcasts would need to occur when both the transmitter and intermediary are known to be powered up, such as during normal vehicle operation or "after hours" where a wake-up event is involved.

   The transmitter would either to use the BAM transport protocol for each message instance, or it would need to know the destination controller address in order to establish a CTS/RTS session for each message instance. Each message instance in the broadcast series would be spaced apart per the applicable Data Transfer message definition.

2. **Send one PGN 59904 [Request] to initiate transmitter broadcast of all its Data Transfer instances.**

   An intermediary sends out one request for a specific Data Transfer PGN, and the targeted transmitter broadcast its series of message instances for that Data Transfer PGN.

3. **Send one PGN 51456 [Request2] for each Data Transfer instance supported by the transmitter.**

   With this method the intermediary must request individual message instances of a Data Transfer PGN. This gives the intermediary more control over the retrieval process. For example, the intermediary can pace message instance reception or request message instances that were missed or interrupted. See below for Request2 implementation requirements.

Note: When Request or Request2 messages are used to retrieve Data Transfer messages, use of destination-specific requests is advised in order to regulate the amount of data received. Global requests may result in more responses than the intermediary device can handle.

UNDERSTANDING DATA TRANSFER MESSAGE SUPPORT

There are at least three ways an intermediary can determine support of a given Data Transfer PG:

1. **Issue a PGN 59904 [Request] for PGN DTS [Data Transfer Support].** If no Data Transfer PGs are supported, the transmitter will respond with a NACK. If one or more Data Transfer PGs are supported, parameters for those PGs will have values greater than zero. If a Data Transfer PG is not supported, parameters for that PG are populated with zeroes.

2. **Issue a destination-specific PGN 59904 [Request] for a given Data Transfer PGN.** If the destination controller application does not support the Data Transfer PG, it will respond with a NACK.

3. **Issue a destination-specific PGN 51456 [Request2] for the first instance of a given Data Transfer PGN.** If the destination controller application does not support the Data Transfer PG, it will respond with a NACK.

The Data Transfer Support PG also provides information on message buffering and overall memory requirements for each Data Transfer PG.

HOW TO KNOW WHEN ALL DATA TRANSFER MESSAGE INSTANCES HAVE BEEN RECEIVED

Each Data Transfer PG contains a Message Instance and a Message Instances Remaining parameter. When retrieving message instances via a single PGN 59904 [Request], the receiver can monitor the transfer progress through these parameters. The total number of message instances to expect can be found by adding the Message Instance and Message Instances Remaining parameter values.

An intermediary can also request PGN DTS [Data Transfer Support] and look at the Total Message Instances parameters. These allow a receiver to understand how many message instances to expect before any Data Transfer PGN request is issued.

DEALING WITH INTERRUPTIONS

When PGN 59905 [Request] is used to initiate transmitter broadcast of its message instances, it is very possible that the broadcast series gets interrupted before completion. For example, a vehicle could be powered down when only 3 of the 7 message instances of the broadcast series have been received.

In this case there are several options to recover the rest of the series. A very simplistic approach would be to re-issue the single Request message at the next power up and just start the entire broadcast series over again. A more optimized approach would be to track the message instance number as the Data Transfer messages are received, and then issue a Request2 for each message instance that was not received.

Interrupts to a given message broadcast are handled via normal Transport Protocol recovery methods.

REQUIREMENTS FOR ISSUING PGN 51456 [REQUEST2]

To request broadcast of a single specific Data Transfer message instance, PGN 51456 [Request2] content must be set as follows:

Bytes 1-3:	Requested PGN; set to the appropriate Data Transfer PGN.
Byte 4, bits 8-6:	Reserved; set to 111b.
Byte 4, bits 5-3:	Control Indicating Extended Identifier Type; set to 010b [2-Byte Extended Identifier].
Byte 4, bits 2-1:	Use Transfer PGN for Response; set to 00b [No]. Note: Transfer [XFER] PGN 51712 should not be confused with the Data Transfer PGNs DDT, WDT and MDT; it has a completely separate purpose unrelated to the Data Transfer PGs.
Byte 5 – Byte 6:	Set equal to the Message Instance number desired. Byte 5 is the least significant byte, and Byte 6 is the most significant byte.
Byte 7:	Unused; set to FFh.
Byte 8:	Reserved; set to FFh.

REQUIREMENTS FOR RESPONDING TO PGN 59904 [REQUEST] AND PGN 51456 [REQUEST2]

1. If PGN 59904 [Request] is received for a Data Transfer PGN, and the requested Data Transfer PG is supported, the responder shall transmit all Data Instances of said PGN.

2. If PGN 51456 [Request2] is received, and the requested Data Transfer PG and Message Instance are supported, the responder shall transmit said Message Instance of said PGN.

3. If PGN 51456 [Request2] is received, and the requested Data Transfer PG or Message Instance is not supported, the responder shall NACK the request.

A.58 PGN 22272 – MOTOR/GENERATOR 1 INVERTER CONTROL

Background:

The inverter provides several control modes. In some of them, it might be necessary to use a PID controller to accomplish the setpoint (see FIGURE PGN 22272_A). Running the PID controller in the inverter instead of an external controlling application has the advantage that the controller loop works fast, thus highly dynamic systems can be controlled.
A PID controller can be parameterized by factors Kp, Ki and Kd.

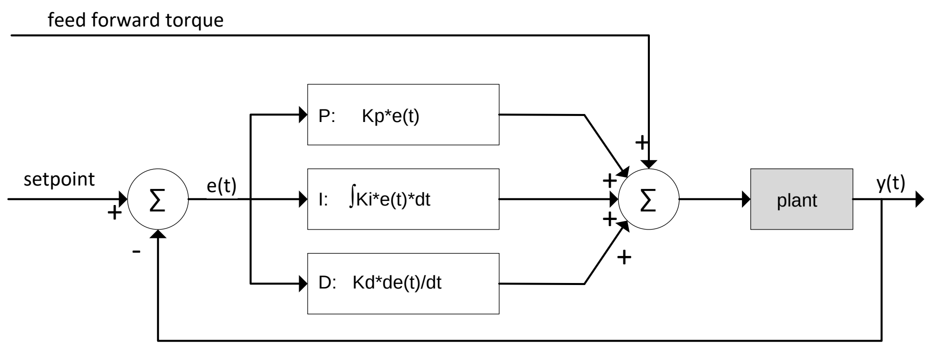


FIGURE PGN22272_A – PID CONTROLLER DIAGRAM

The following describes the SPNs which contain Kp, Ki and Kd for a PID controller within the inverter. Advantages of such remote parameterization are:

- The inverter’s behavior can be optimized for an application by the user.
- The inverter’s behavior can be changed during runtime for adapting to changing operational conditions.

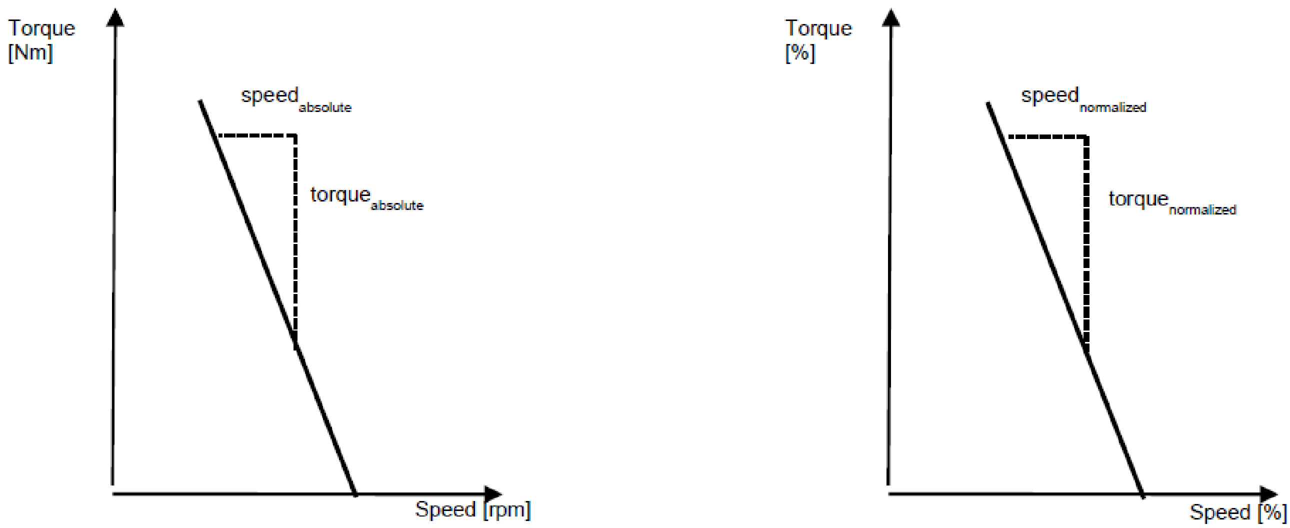
SP description:

The interfaces for inverter control are defined as percentage values, ref. PGN 9728 [Motor/Generator 1 Inverter Control]. This is handled by using “reference values”, ref. e.g. PGN 64373 [Motor/Generator 1 Inverter Reference 1].
The SPs for Kp, Ki and Kd are also defined as percentage values. This chapter explains how to interpret them.

Note: “Absolute” means engineering units and “normalized” means a percentage. Absolute indicates engineering units such as Nm and RPM. Ki and Kd are referenced to time in seconds.

Example: speed controller:

Diagrams for absolute … … and normalized scales :



$$Kp_{absolute} = \frac{torque_{absolute}}{speed_{absolute}} \text{ [Nm/rpm]} \qquad Kp_{normalized} = \frac{torque_{normalized}}{speed_{normalized}} \text{ [\%/\%]}$$

FIGURE PGN22272_B – TORQUE/SPEED DIAGRAMS IN ENGINEERING AND PERCENTAGE VALUES

Formula for conversion from normalized to absolute torque (Nm) and speed (RPM):

$$torque_{absolute} = torque_{normalized} \times reference\_value_{torque}$$

$$speed_{absolute} = speed_{normalized} \times reference\_value_{speed}$$

Combination of the above formulae to derive the conversion from $Kp_{normalized}$ [%/%] to $Kp_{absolute}$ [Nm/rpm]:

$$Kp_{absolute} = \frac{torque_{absolute}}{speed_{absolute}} = \frac{torque_{normalized} \times reference\_value_{torque}}{\underbrace{speed_{normalized}}_{Kp_{normalized}} \times reference\_value_{speed}} = Kp_{normalized} \times \frac{reference\_value_{torque}}{reference\_value_{speed}}$$

Therefore, in a similar way Ki and Kd are defined as:

For Ki : conversion from $Ki_{normalized}$ [%/(%*sec)] to $Ki_{absolute}$: Nm/(rpm*sec):

$$Ki_{absolute} = Ki_{normalized} \times \frac{reference\_value_{torque}}{reference\_value_{speed}}$$

For Kd : conversion from $Kd_{normalized}$ [%/(%/sec)] to $Kd_{absolute}$: Nm/(rpm/sec):

$$Kd_{absolute} = Kd_{normalized} \times \frac{reference\_value_{torque}}{reference\_value_{speed}}$$

If SPN 11762 [Motor/Generator 1 Inverter PID Control Normalized Integral Gain] is received with a special value, then the integrator value of the PID controller is reset dependent on this value. The choices are:

- FB00h: The integrator value is held at 0 Nm until a new value of Ki is received in the operational range (i.e. 0 to FAFFh).
- FB01h: The integrator value is set to 0 Nm and directly afterwards, the calculation of the integral value continues with the last valid Ki value which was received before the reset.

Dependency on SPN 11760 [Motor/Generator 1 Inverter PID Control Applicable Mode]:

Generally, Kp is defined as the amount of torque that may be set depending on the amount of control error: Kp = (output / control error). The controlled value (i.e. speed, voltage, current, or power) depends on the mode defined in SPN 11760 [Motor/Generator 1 Inverter PID Control Applicable Mode].

Therefore, the conversion between $Kp_{normalized}$ and $Kp_{absolute}$ depends on the mode as follows:

PID Control Applicable Mode = 0 (Speed Control Mode) :

$Kp_{absolute}$ = $Kp_{normalized}$ * (SPN 10170 [Reference Torque] / SPN 10171 [Reference Speed]) .
Physical units: $Kp_{absolute}$ [Nm/rpm] , $Kp_{normalized}$ [%/%]

PID Control Applicable Mode = 1 (DC Side Voltage Control Mode) :

$Kp_{absolute}$ = $Kp_{normalized}$ * (SPN 10170 [Reference Torque] / SPN 10203 [Reference Voltage]) .
Physical units: $Kp_{absolute}$ [Nm/V] , $Kp_{normalized}$ [%/%]

PID Control Applicable Mode = 2 (DC Side Current Control Mode):

$Kp_{absolute}$ = $Kp_{normalized}$ * (SPN 10170 [Reference Torque] / SPN 10202 [Reference Current]) .
Physical units: $Kp_{absolute}$ [Nm/A] , $Kp_{normalized}$ [%/%]

PID Control Applicable Mode = 3 (DC Side Power Control Mode) :

$Kp_{absolute}$ = $Kp_{normalized}$ * (SPN 10170 [Reference Torque] / SPN 10172 [Reference Power]) .
Physical units: $Kp_{absolute}$ [Nm/kW] , $Kp_{normalized}$ [%/%]

PID Control Applicable Mode = 4 (Mechanical Power Control Mode) :

$Kp_{absolute}$ = $Kp_{normalized}$ * (SPN 10170 [Reference Torque] / SPN 10172 [Reference Power]) .
Physical units: $Kp_{absolute}$ [Nm/kW] , $Kp_{normalized}$ [%/%]

For Ki and Kd, the reference values used for conversion from normalized to absolute values are the same and the conversion is performed in a similar way.

Examples:

Example for usage of $Kp_{normalized}$:

Desired control mode: Speed Control
$reference\_value_{torque}$ = 200 Nm
$reference\_value_{speed}$ = 12000 rpm
desired $Kp_{absolute}$: 0.5 Nm/rpm

➔ $Kp_{normalized}$ = $Kp_{absolute}$ * $reference\_value_{speed}$ / $reference\_value_{torque}$
= 0.5 Nm/rpm * 12000 rpm / 200 Nm
= 30 [%/%]

Example for usage of $Ki_{normalized}$:

Desired control mode: DC Side Voltage Control Mode
$reference\_value_{torque}$ = 200 Nm
$reference\_value_{voltage}$ = 500 V
desired $Ki_{absolute}$: 50 Nm/(V*sec)

➔ $Ki_{normalized}$ = $Ki_{absolute}$ * $reference\_value_{voltage}$ / $reference\_value_{torque}$
= 50 Nm/(V*sec) * 500 V / 200 Nm
= 125 [%/(%*sec)]

Example for usage of $Kd_{normalized}$:

Desired control mode: Mechanical Power Control Mode
$reference\_value_{torque}$ = 200 Nm
$reference\_value_{power}$ = 100 kW
desired $Kd_{absolute}$: 10 Nm/(kW/sec)

➔ $Kd_{normalized}$ = $Kd_{absolute}$ * $reference\_value_{voltage}$ / $reference\_value_{torque}$
= 10 Nm/(V*sec) * 100 kW / 200 Nm
= 5 [%/(%*sec)]

A.59 PGN 26624 – ON BOARD PROGRAMMING

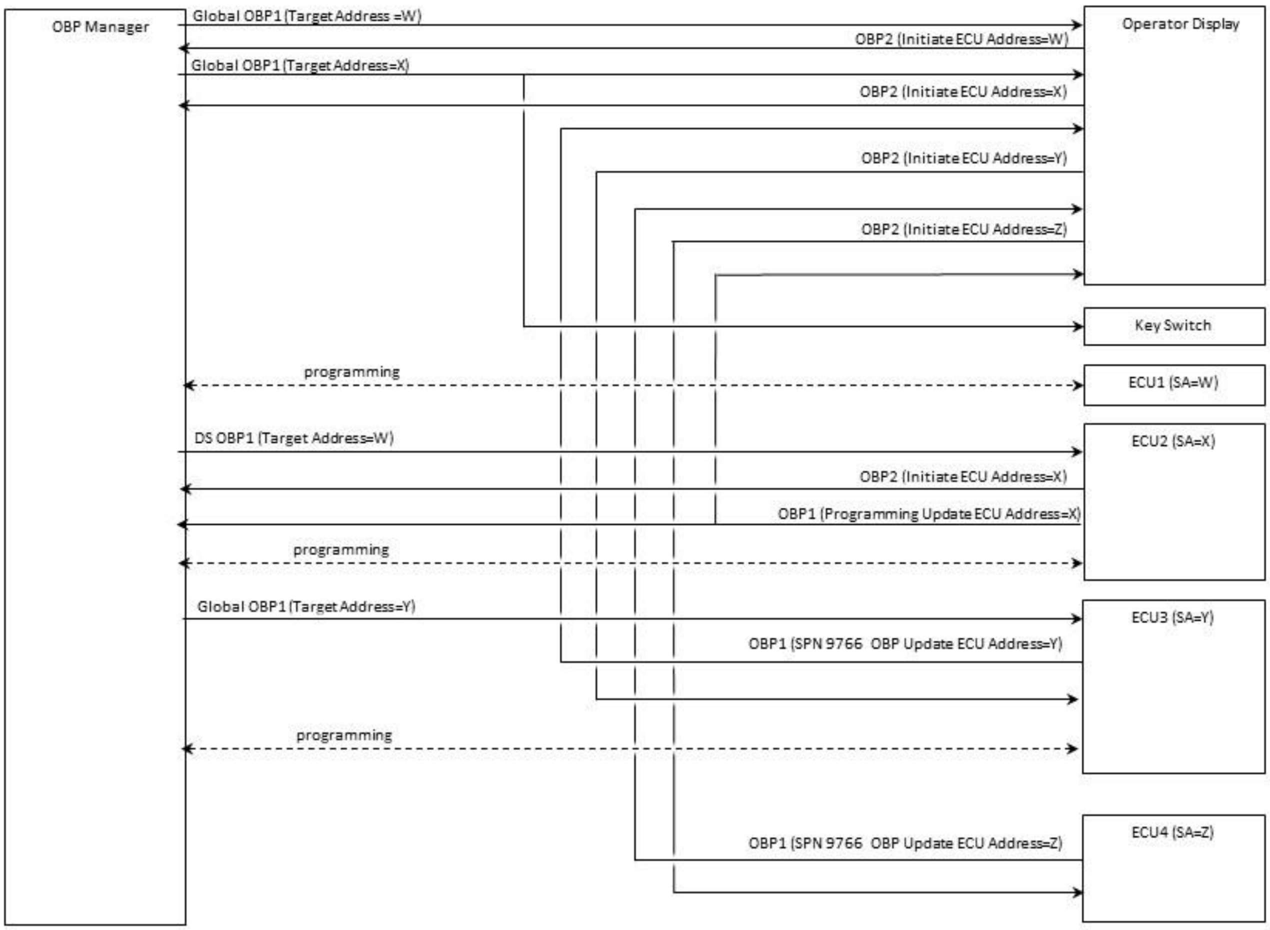
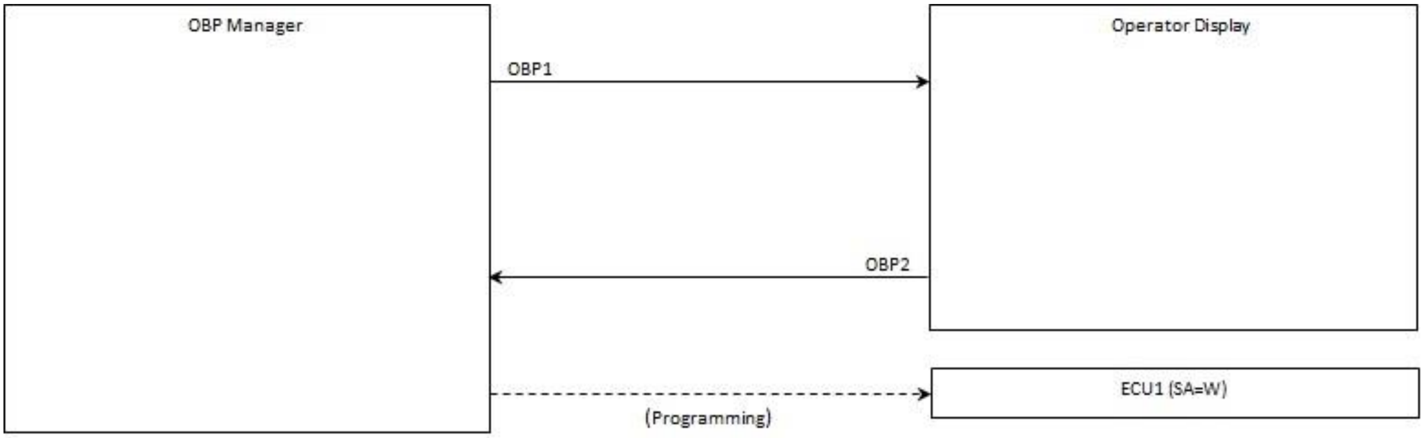


FIGURE PGN26624_A – ON BOARD PROGRAMMING (OBP) STRUCTURE



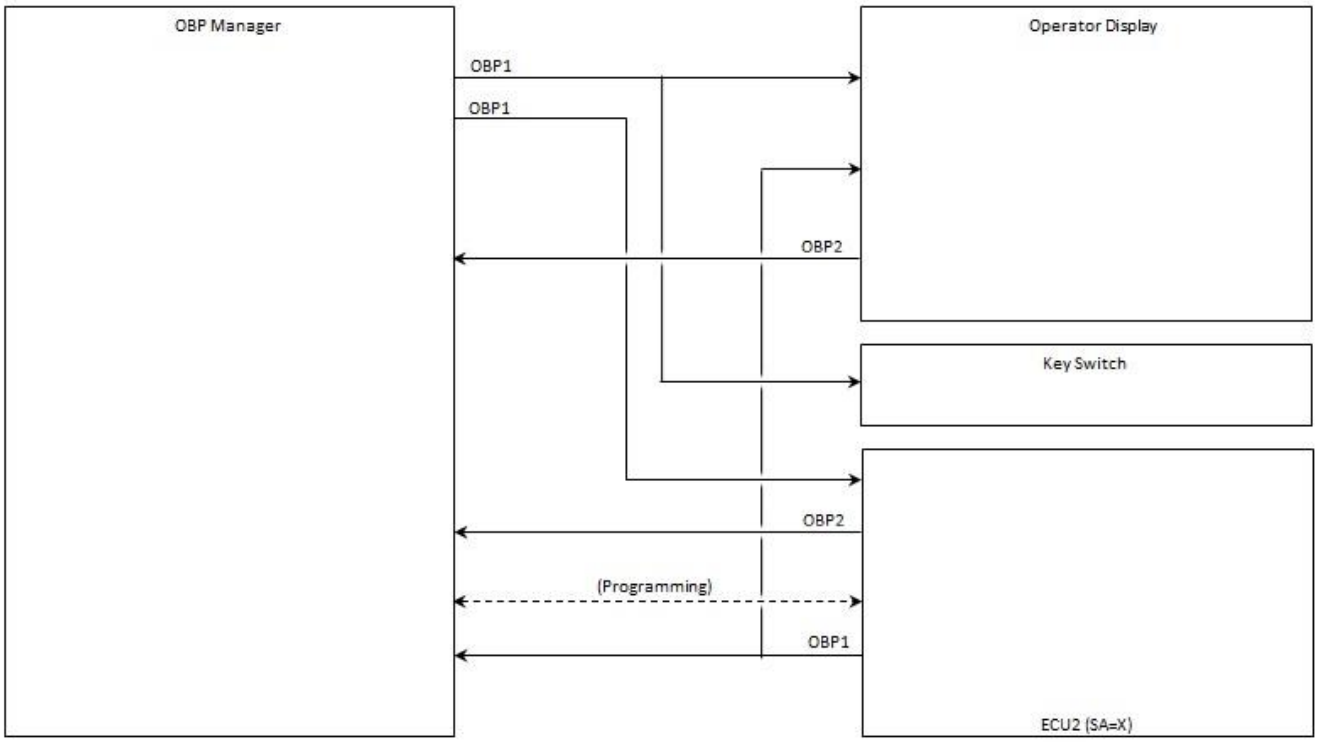
Scenario 1: Normal programming

1. OBP Manager indicates that an update is available for ECU with target SA.
2. Operator takes action to satisfy required interlocks as indicated
3. Operator is requested to keep the ignition key on (if required, OBP Key Switch Request = 01.)
4. Operator initiates programming.
5. OBP Manager continually updates the display with progress. (On Vehicle Programming Status = In process/Installing.)
6. OBP Manager indicates programming success and ignition is no longer required. (On Vehicle Programming Status = Software Up to Date.)

Scenario 2: Programming unsuccessful

1. OBP Manager indicates that an update is available.
2. Operator takes action to satisfy required interlocks as indicated
3. Operator is requested to keep the ignition key on (if required, OBP Key Switch Request = 01.)
4. Operator initiates programming.
5. OBP Manager continually updates the display with progress. (On Vehicle Programming Status = In process/Installing.)
6. Operator presses a cancel button or interlock becomes active. (OBP Programming Initiate Inhibit set or OBP Manager monitored interlock state changes.)
7. OBP Manager indicates programming failed and ignition is no longer required. (On Vehicle Programming Status = Unsuccessful.)

FIGURE PGN26624_B – EXAMPLE CONFIGURATION 1 – “DUMB” ECU



Scenario 1: Normal programming

1. OBP Manager indicates that an update is available. (DS OBP1 to ECU2)
2. ECU checks internal readiness and replies with On Vehicle Programming Initiate Request = 01.
3. OBP Manager (optionally) indicates to operator that update is available.
4. Operator initiates programming.
5. Ignition bus is requested to be energized for duration. (OBP Key Switch Request = 01.)
6. OBP Manager continually updates the display with progress
7. OBP Manager indicates programming success and ignition is no longer required.

Scenario 2: ECU declines programming

1. OBP Manager indicates that an update is available. (DS OBP1 to ECU2)
2. ECU checks internal readiness and replies with On Vehicle Programming Initiate Inhibit = 01.
3. ECU (optionally) sends OBP1 with interlock statuses.
4. OBP Manager indicates programming failed and ignition is no longer required. (On Vehicle Programming Status = Declined or aborted by target device.)
5. Operator Display (optionally) shows that ECU2 declined a programming request.

FIGURE PGN26624_C – EXAMPLE CONFIGURATION 2 – ECU SMART ENOUGH TO “VOTE” + SMART IGNITION SWITCH

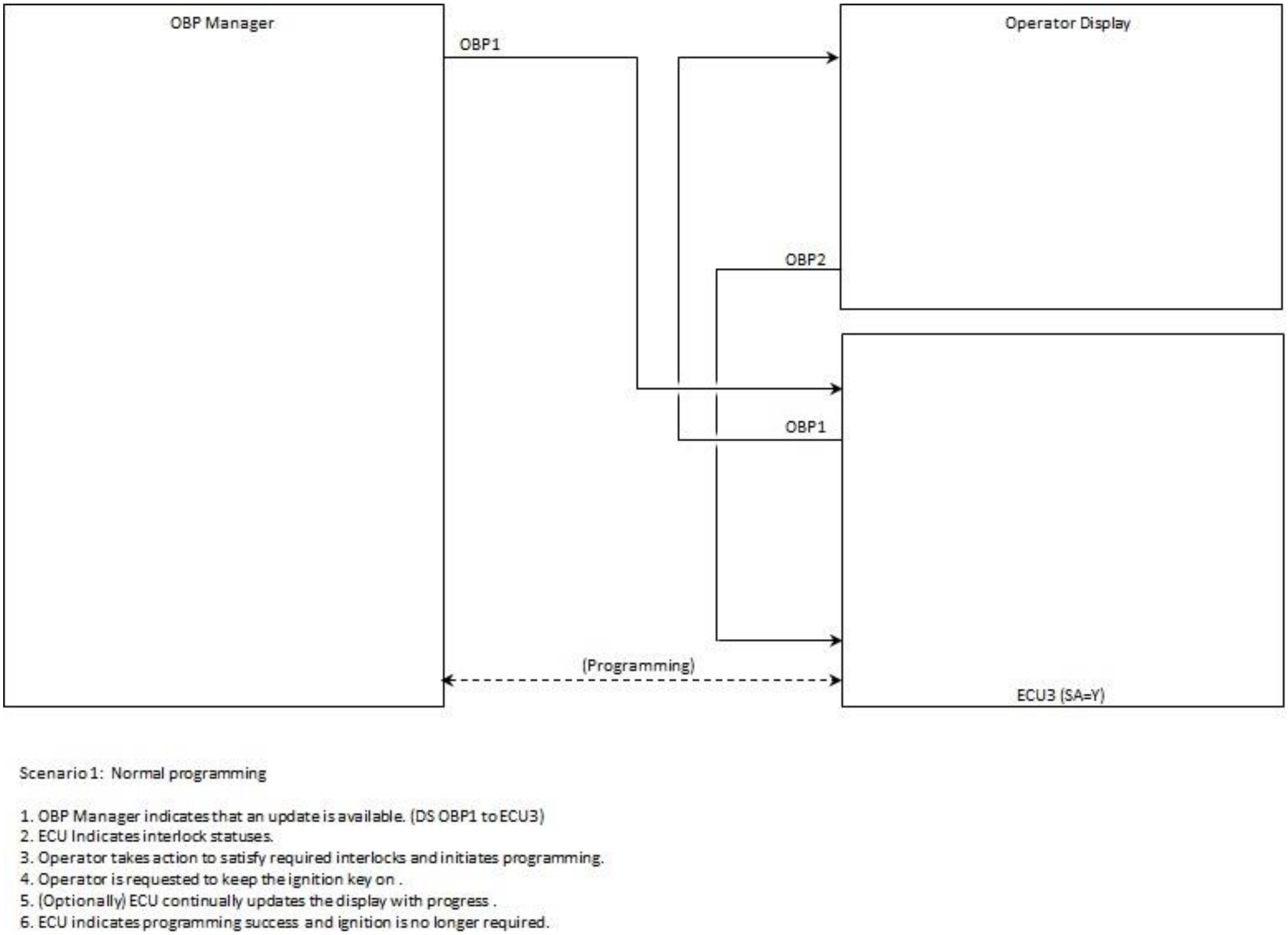


FIGURE PGN26624_D – EXAMPLE CONFIGURATION 3 – ECU MANAGES PROGRAMMING WITH NOTIFICATION FROM OBP MANAGER

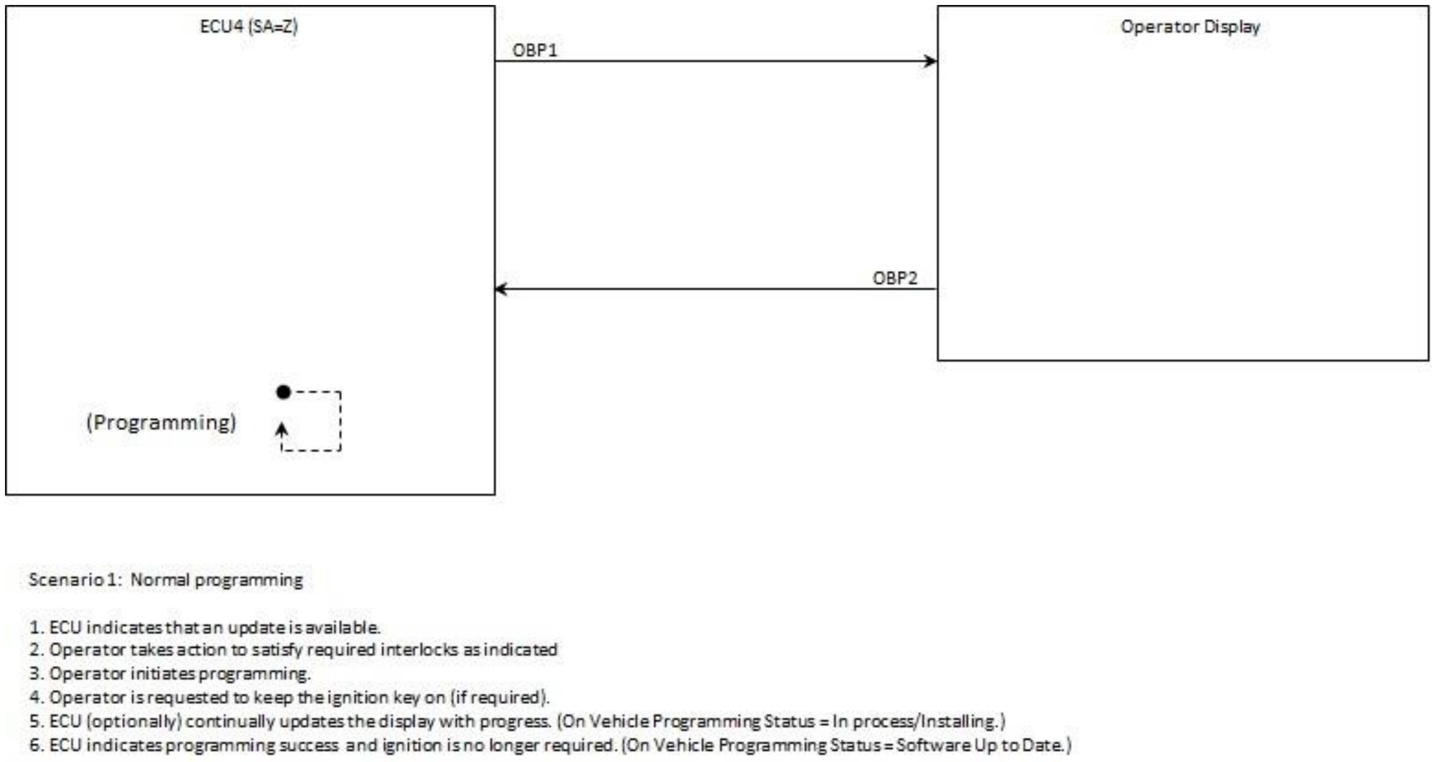


FIGURE PGN26624_E – EXAMPLE CONFIGURATION 4 – ECU DOES ENTIRELY OWN PROGRAMMING

A.60 PGN 28160 – CONFIGURABLE RECEIVE SPS COMMAND

Description of Operation for PGN 28160 and PGN 64462:

1. A Configurable ECU can have the receive capability of one or more if its ports modified by another ECU using PGN 28160. The Configurable ECU will have a list of predetermined SPs that can have their receive capability modified.
2. The solution is designed to support having only one device perform the receive configuration for any one Configurable ECU. PGN 64462 is a PDU2 type (broadcast) message so there is no ability to transmit the response directly to the device that issued PGN 28160.
3. Manufacturers may restrict processing PGN 28160 from only one device on one communication port to eliminate conflicting commands.
4. Applications should exercise caution when using the '0' (Current Port) value, making sure there is no possibility of a gateway or other network interconnect device retransmitting PGN 28160 and PGN 64462 messages between other networks.
5. A device can use PGN 28160 to modify the receive behavior of Configurable Receive SPs on a specific ECU communication port of a Configurable ECU.
6. A Configurable ECU may be able to support reception of a given SP simultaneously from multiple ports; refer to ECU manufacturer documentation for capabilities and details. If an SP can be received from more than one port, multiple instances of PGN 28160 [Configurable Receive SPs Command] must be used to configure reception from each individual port. A unique set of message content a, b, c, d, and e (refer to the description of PGN 64462) is required to specify each port. If a Configurable SP can only be received on one port, the configurable ECU will act on the last PGN 28160 received. When use of multiple ports is requested, multiple instances of PGN 64462 [Configurable Receive SPs Status] will be necessary to convey the status of the Configurable SP on each port.
7. When an ECU is capable of being configured to receive a specific Configurable SN on only one of its ports at any time and the ECU accepts a Configuration Request to enable receiving that SP on a different port, then the ECU is permitted to automatically change the original port's Receive Status from 'Enable' to 'Pending to be disabled'. When an ECU is capable of being configured to receive a specific Configurable SP on multiple ports at the same time and the ECU accepts a Configuration Request to enable receiving that SP on another port, then the ECU is permitted to leave the Receive Status unchanged for any other ports. If the user's intention is to configure the ECU so that SP is only received on the newly configured port, then the user might be required to send a separate Configuration Request to that ECU to disable receiving that SP on the original port.
8. A Configurable ECU may be able to support reception of a Configurable SP simultaneously from multiple source addresses; refer to ECU manufacturer documentation for capabilities and details. If an SP can be received from more than one source address, a single instance of PGN 28160 [Configurable Receive SPs Command] can be used to configure reception from each source address. Message content c, d and e (refer to the description of PGN 28160) can be repeated for each source address instance. If an SP can only be received from one source address, the configurable ECU will act on the last SPN 8841 [Commanded Receive SP Source Address] received in PGN 28160. When reception from multiple source addresses is specified or in use, a single instance of PGN 64462 [Configurable Receive SPs Status] may have multiple entries (sets of c, d, e, and f) for a given SP in order to reflect the status related to each source address.
9. A Configurable ECU shall not apply the requested receive behavior changes until a significant trigger (e.g., system reset, key switch cycle, etc.). The intent is to make sure that the Configurable ECU can make appropriate adjustments, such as enabling timeout diagnostics.
10. A change that has been requested during a given power cycle is considered pending as it has not been applied yet, but will be applied after the significant trigger (e.g., system reset, key switch cycle, etc.) has occurred.
11. Any device may issue PGN 28160 with SPN 8838 set to 0 (Request Port Receive Status) to the Configurable ECU at any time to obtain the current status of the Configurable ECU’s receive configuration.

A.61 PGN 28298 – CONFIGURABLE TRANSMIT PGS COMMAND

Description of Operation for PGN 28928 and PGN 64471:

1. A ‘Configurable ECU’ can have the transmit capability of one or more if its ports modified by another ECU using PGN 28928. The Configurable ECU will have a list of predetermined PGNs that can have their transmit capability modified.
2. The solution is designed to support having only one device perform the transmit configuration for any one Configurable ECU. PGN 64471 is a PDU2 type (broadcast) message so there is no ability to transmit the response directly to the device that issued PGN 28928.
3. Manufacturers may restrict processing PGN 28928 from only one device on one communication port to eliminate conflicting commands.
4. Applications should exercise caution when using the '0' (Current Port) value, making sure there is no possibility of a gateway or other network interconnect device retransmitting PGN 28928 and PGN 64471 between other networks.
5. A device can use PGN 28928 to modify the transmit behavior of 'Configurable Transmit' PGNs on a specific ECU communication port of a Configurable ECU.
6. Transmit capability of a PG is considered to be enabled and disabled independently on each communication port of a Configurable ECU. (i.e., Enabling a PG for transmit on port 1 shall not automatically alter the transmit status of that same PG on port 2. The commanding device must issue commands to enable and disable the transmit state for each individual communication port.)
7. A Configurable ECU shall not apply the requested transmit behavior changes until a significant trigger (e.g., system reset, key switch cycle, etc.). The intent is to make sure that all affected ECUs communicating with the Configurable ECU can make appropriate adjustments, such as disabling timeout diagnostics.
8. A change that has been requested during a given power cycle is considered pending as it has not been applied yet, but will be applied after the significant trigger (e.g., system reset, key switch cycle, etc.) has occurred.
9. Any device may issue PGN 28928 with SPN 8596 set to 0 (Request Port Transmit Status) to the Configurable ECU at any time to obtain the current status of the Configurable ECU’s transmit configuration.

A.62 PGN 39680 – PROPRIETARY MESSAGING INFORMATION

This PG 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.

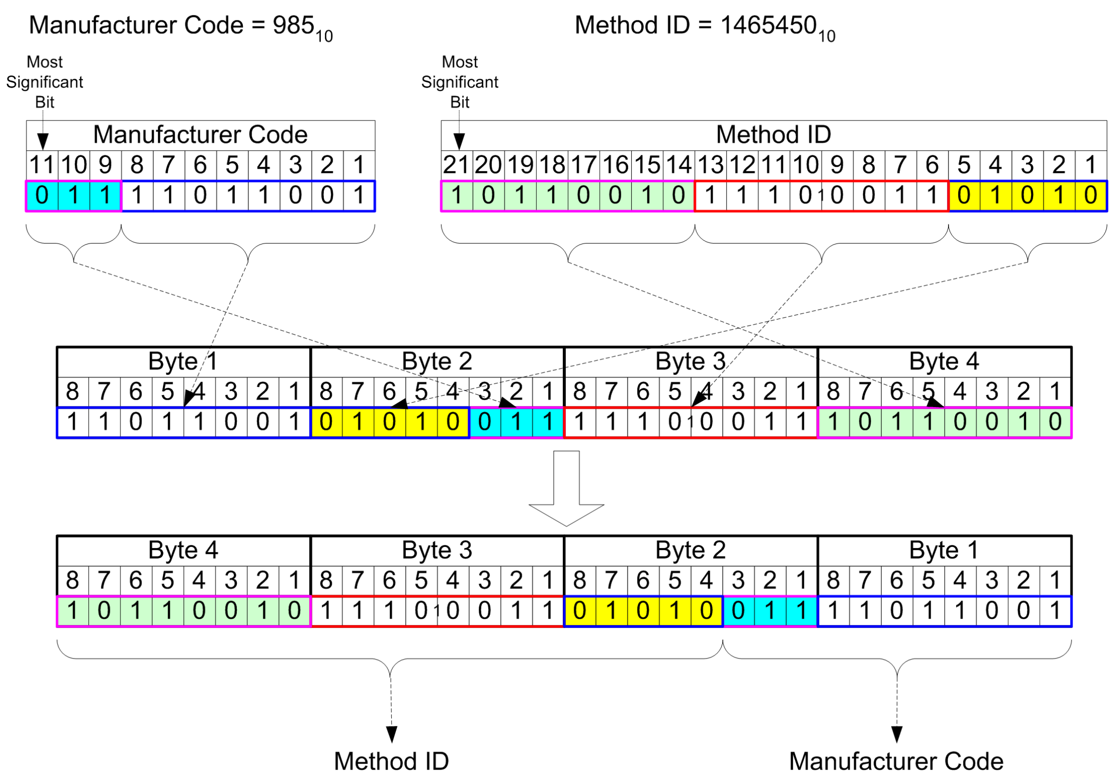


FIGURE PGN39680_A - PLACEMENT OF MANUFACTURER CODE AND METHOD ID DATA

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.

A.63 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.

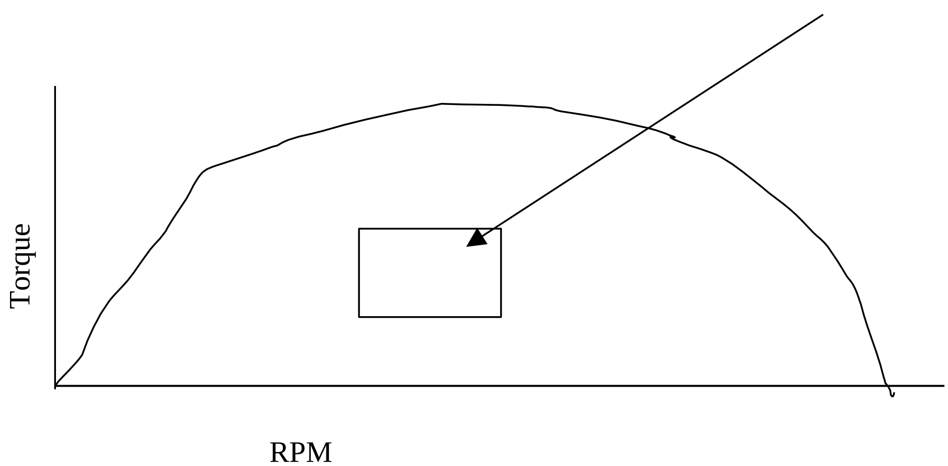


FIGURE PGN52992_A – EXAMPLE TORQUE CURVE WITH TORQUE/SPEED WINDOW

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.

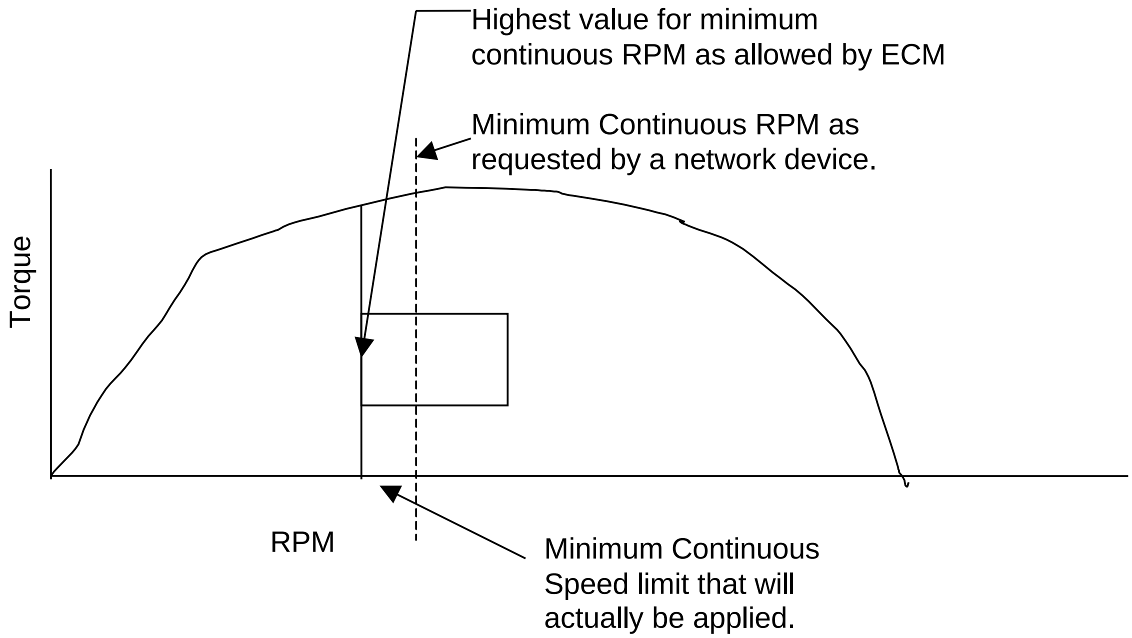


FIGURE PGN52992_B – EXAMPLE TORQUE CURVE WITH SPEED LIMIT APPLIED

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.

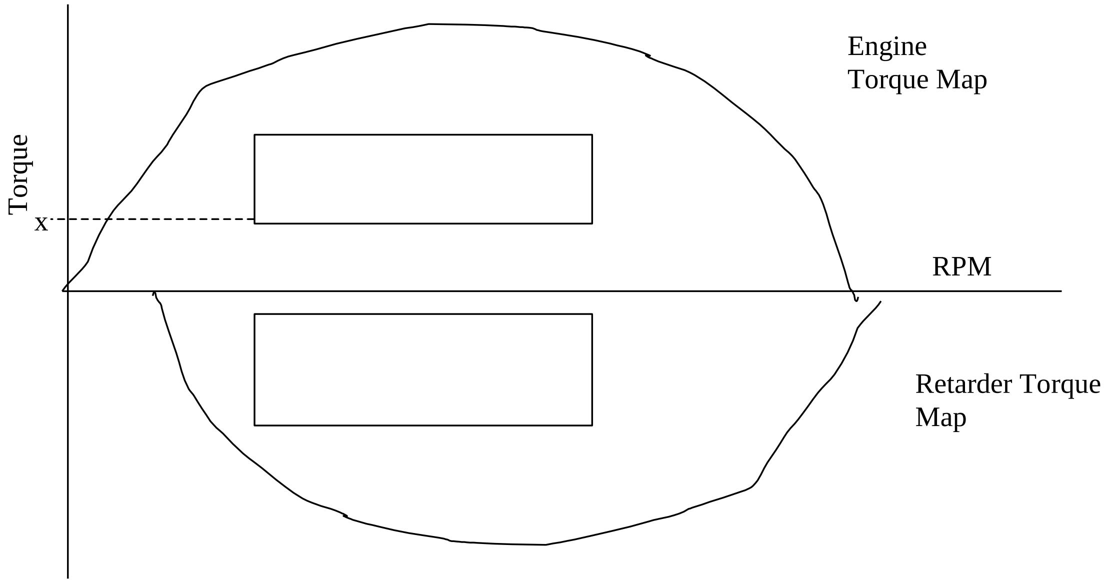


FIGURE PGN52992_C – EXAMPLE TORQUE CURVE FOR RETARDER LIMITING

A.64 PGN 56320 – ANTI-THEFT STATUS

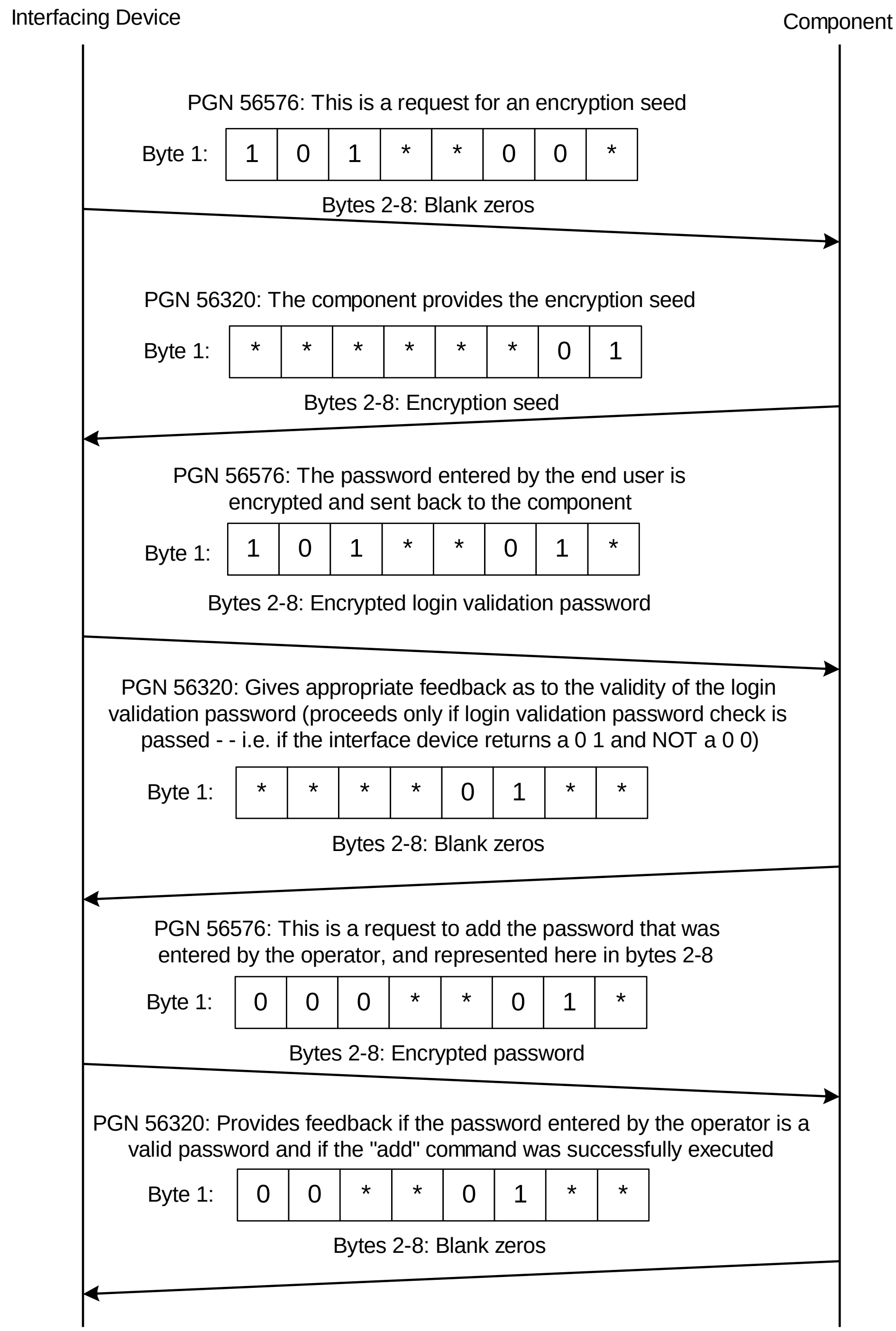


FIGURE PGN56320_A - OPERATOR DESIRES TO ADD A PASSWORD TO THE COMPONENT'S PASSWORD STRUCTURE

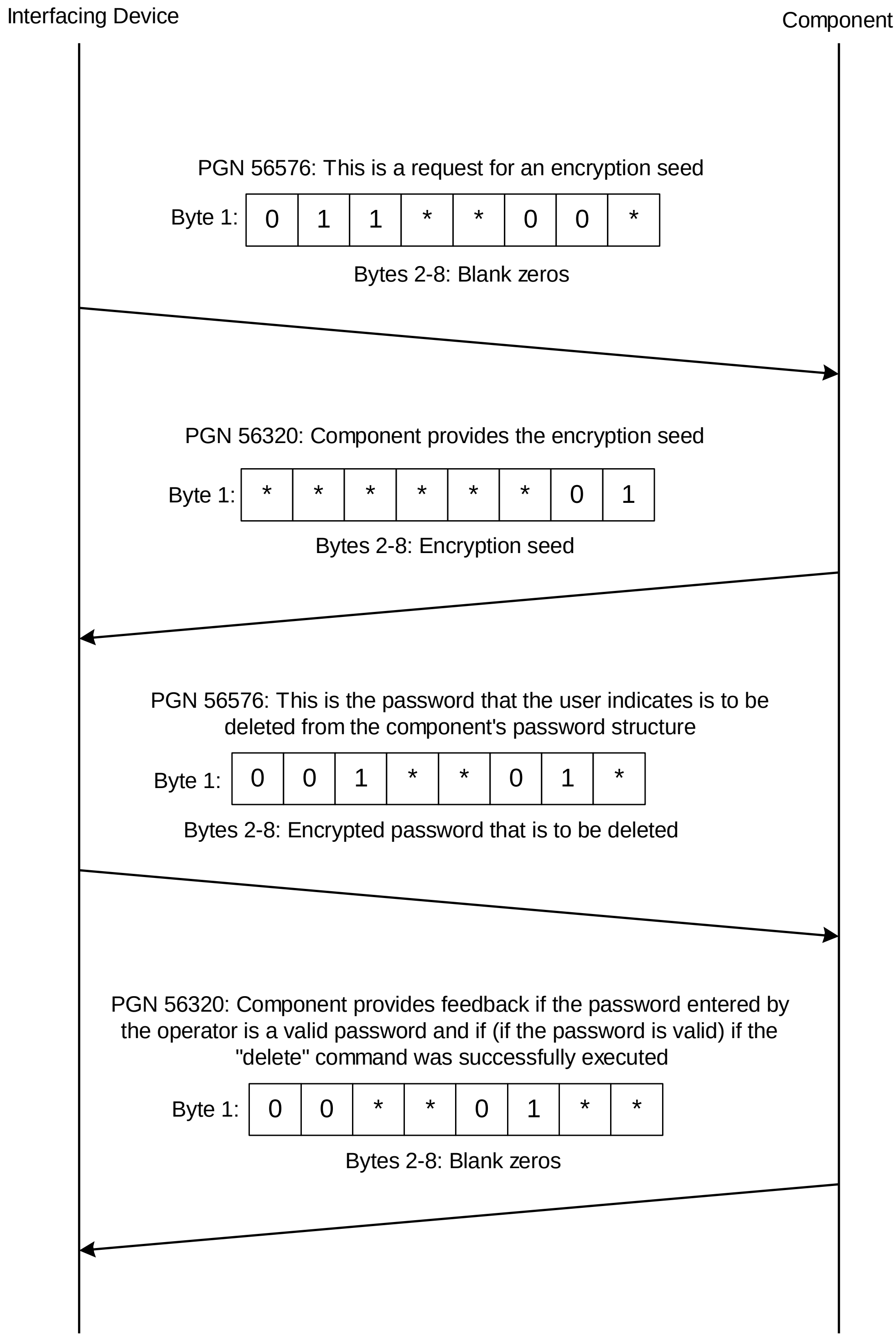


FIGURE PGN56320_B - OPERATOR DESIRES TO DELETE A PASSWORD FROM THE COMPONENT'S PASSWORD STRUCTURE

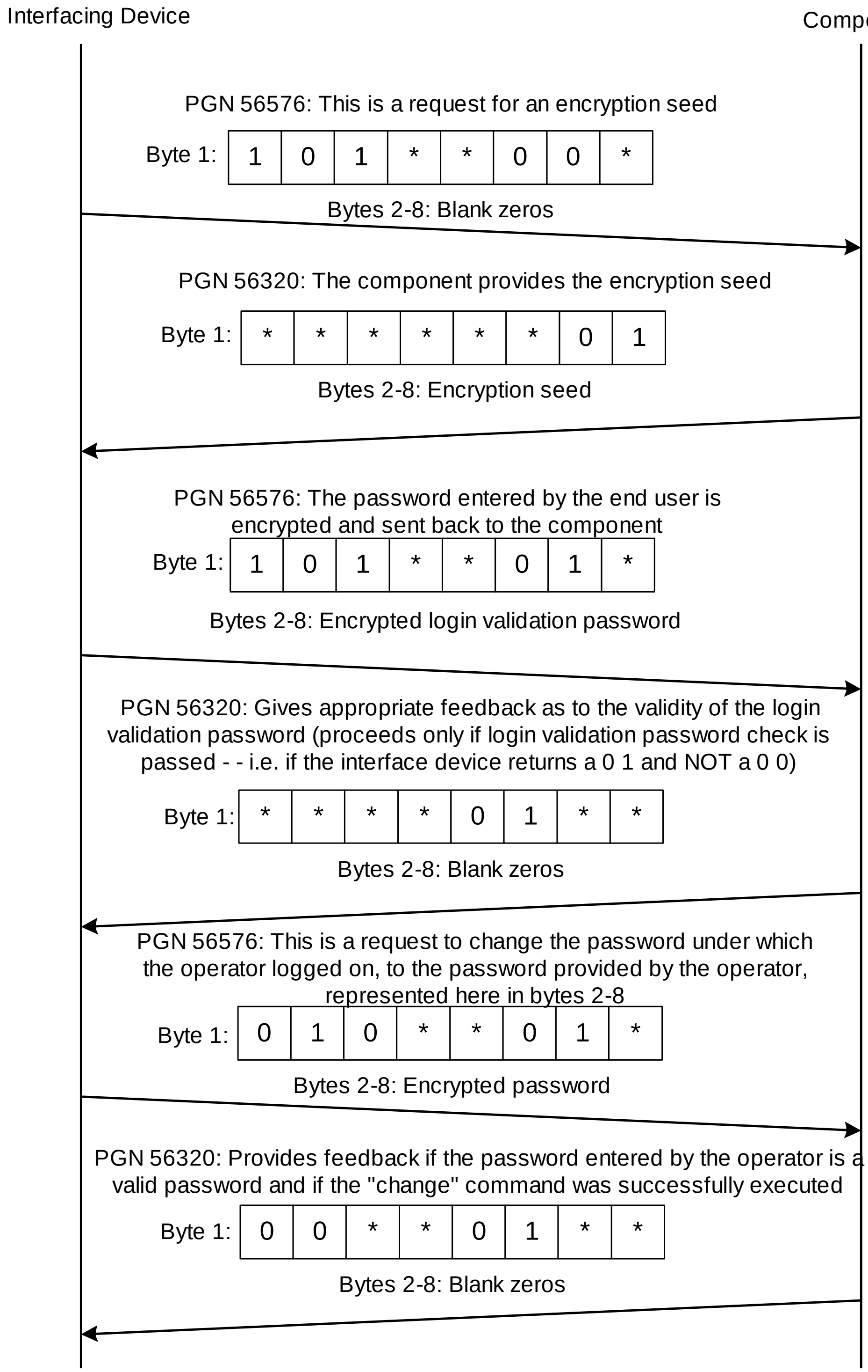


FIGURE PGN56320_C - OPERATOR DESIRES TO CHANGE A PASSWORD WITHIN THECOMPONENT'S PASSWORD STRUCTURE

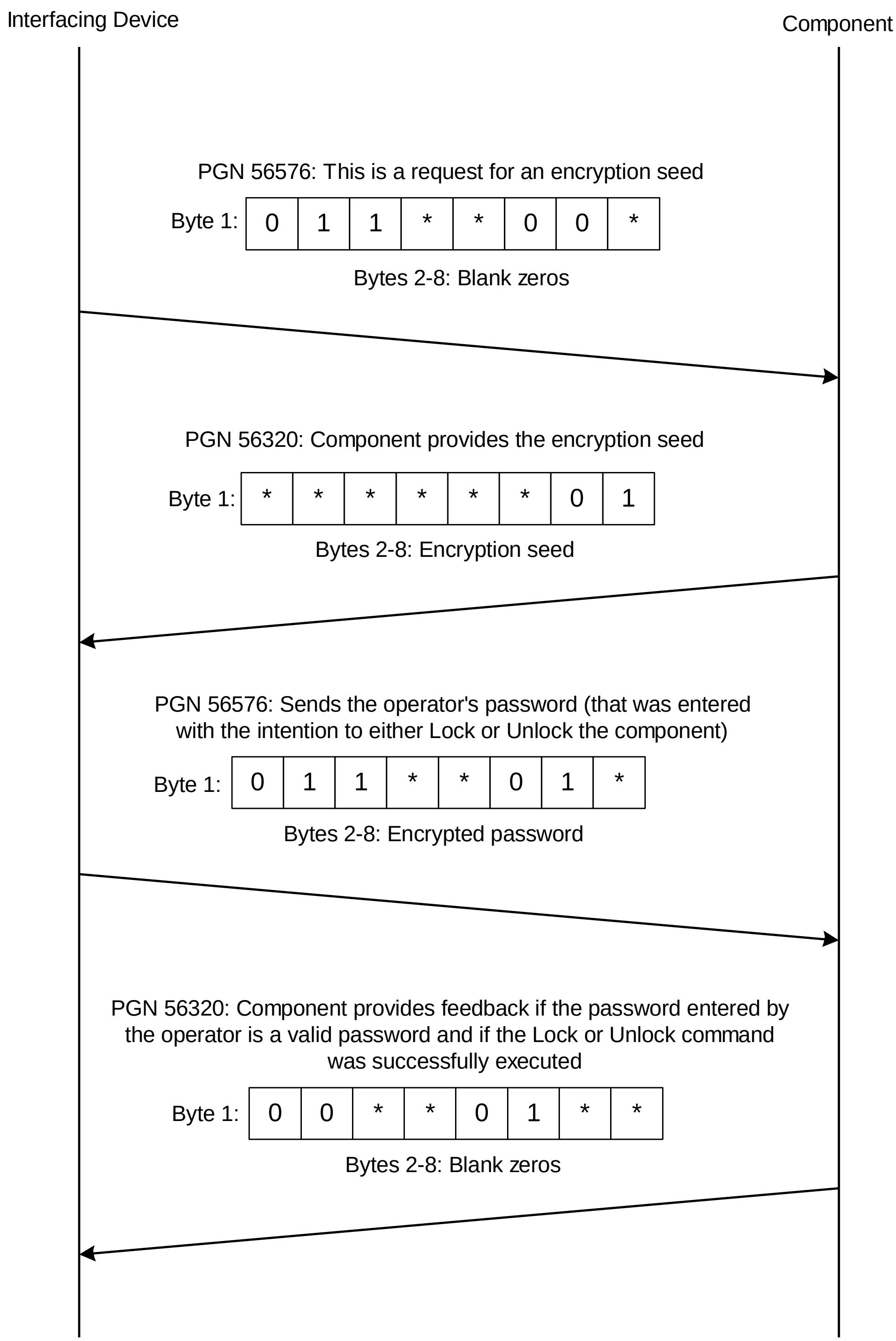


FIGURE PGN56320_D - OPERATOR DESIRES TO LOCK OR UNLOCK THE COMPONENT

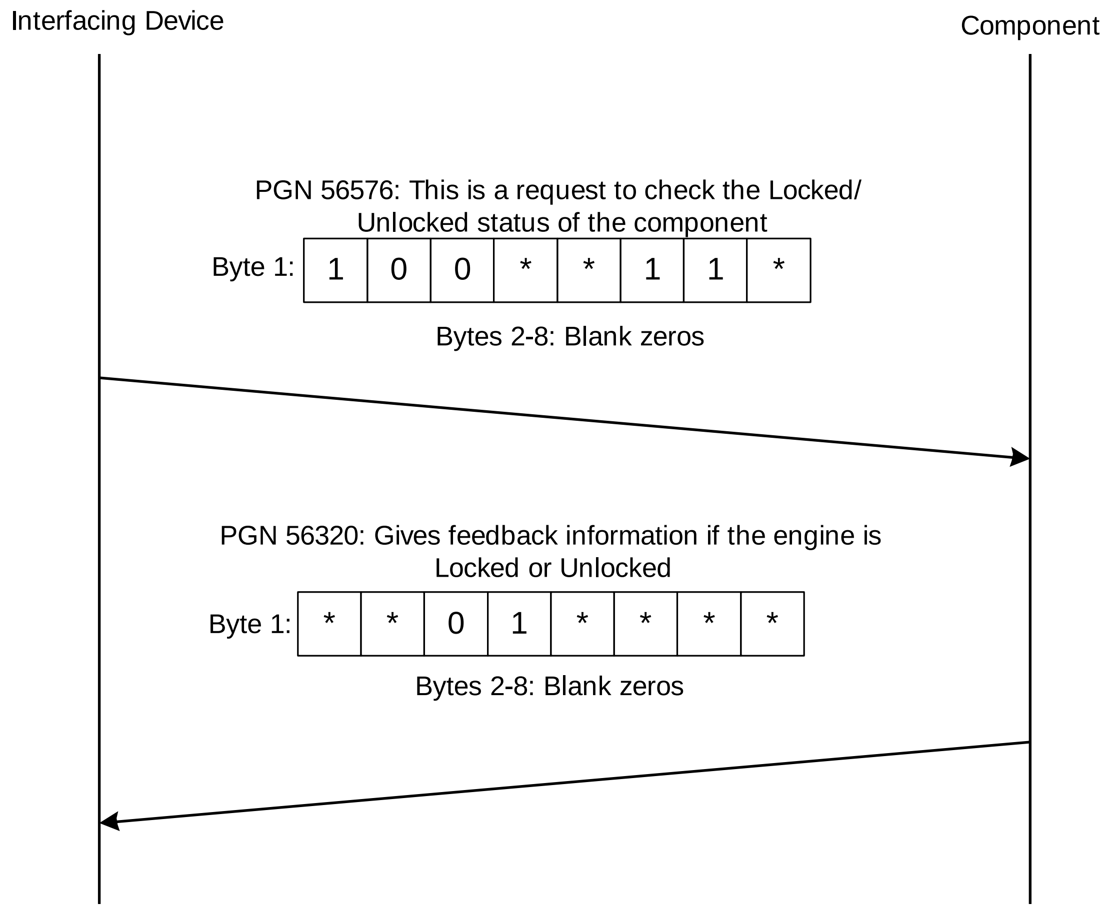


FIGURE PGN56320_E - CHECKING STATUS OF THE COMPONENT

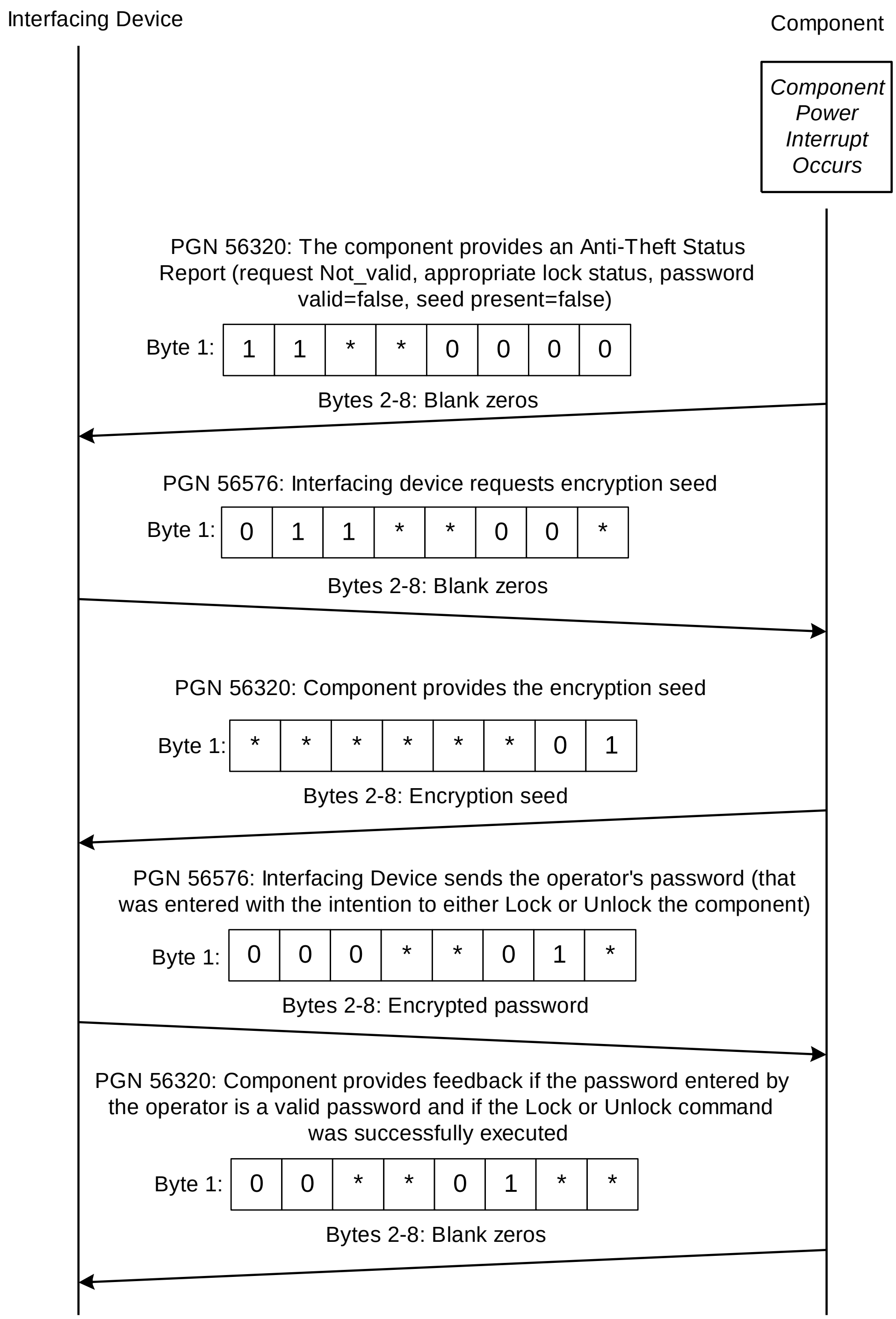


FIGURE PGN56320_F - ABNORMAL COMPONENT POWER INTERRUPTION (INTERFACING DEVICE POWER IS NOT INTERRUPTED)

A.65 PGN 61459 – SLOPE SENSOR INFORMATION

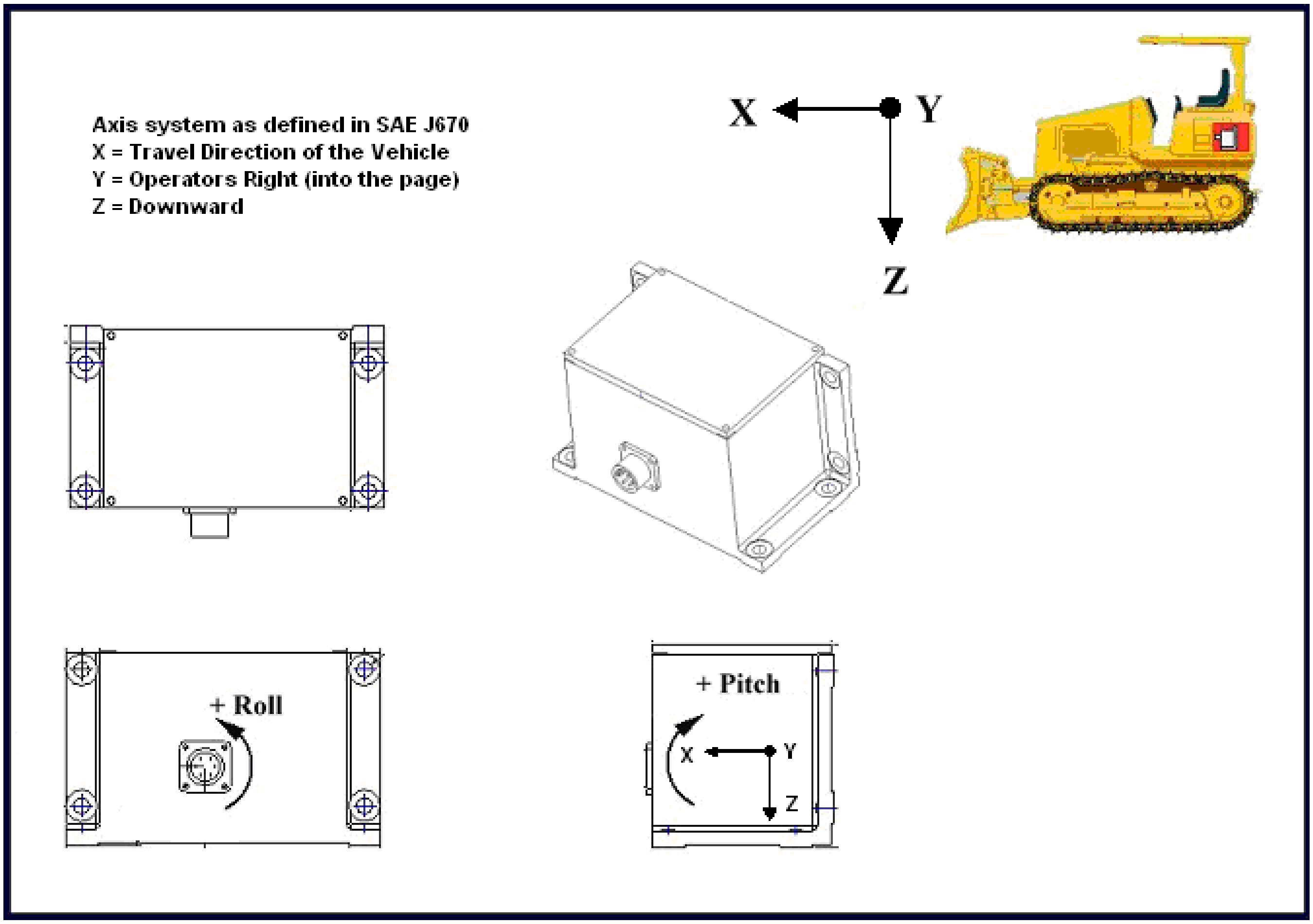


FIGURE PGN61459_A - SLOPE SENSOR ORIENTATIONS

A.66 PGN 61466 – ENGINE THROTTLE / FUEL ACTUATOR CONTROL COMMAND

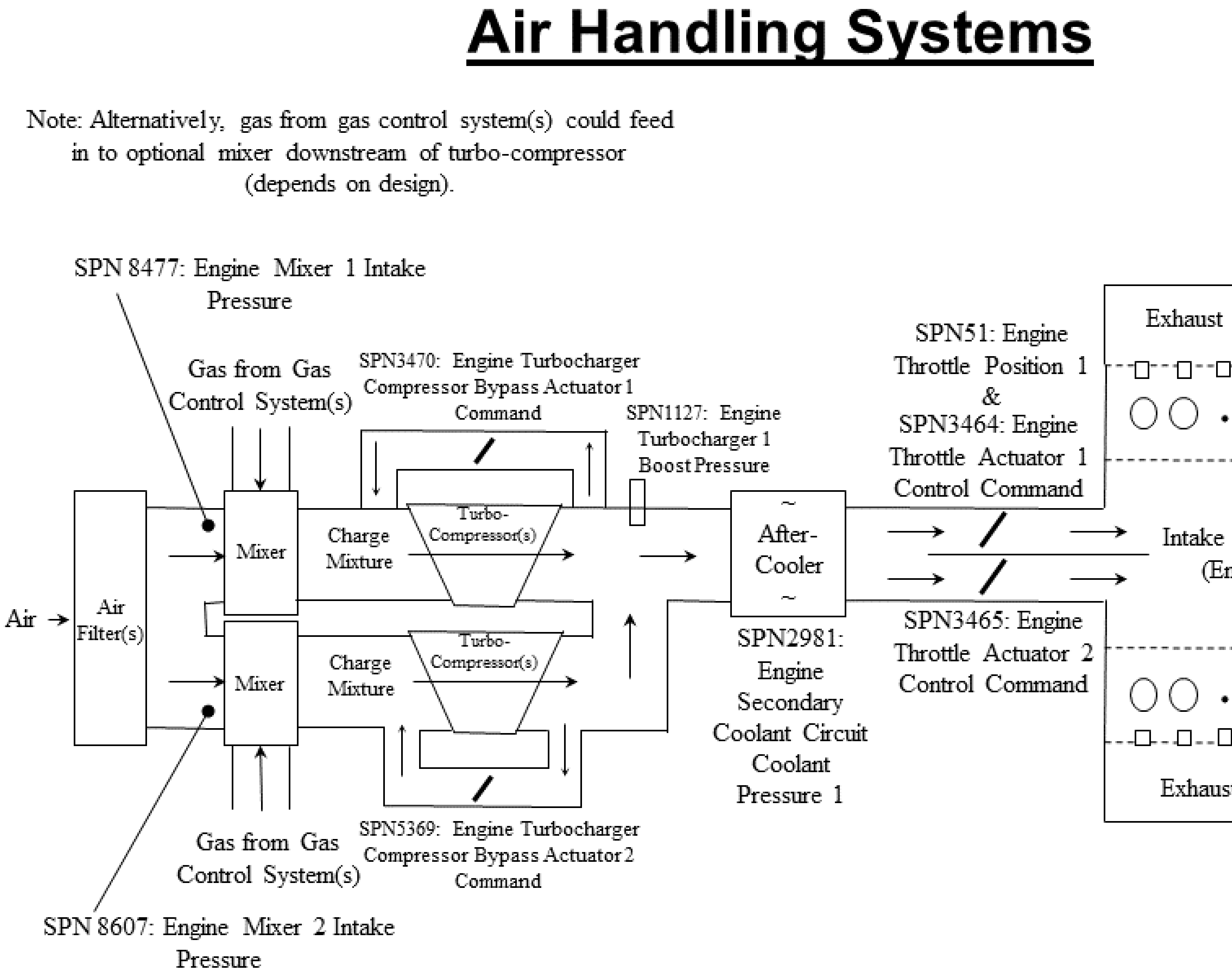


FIGURE PGN61466_A – AIR HANDLING SYSTEMS

A.67 PGN 61486 – ENGINE TURBOCHARGER CONTROL

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

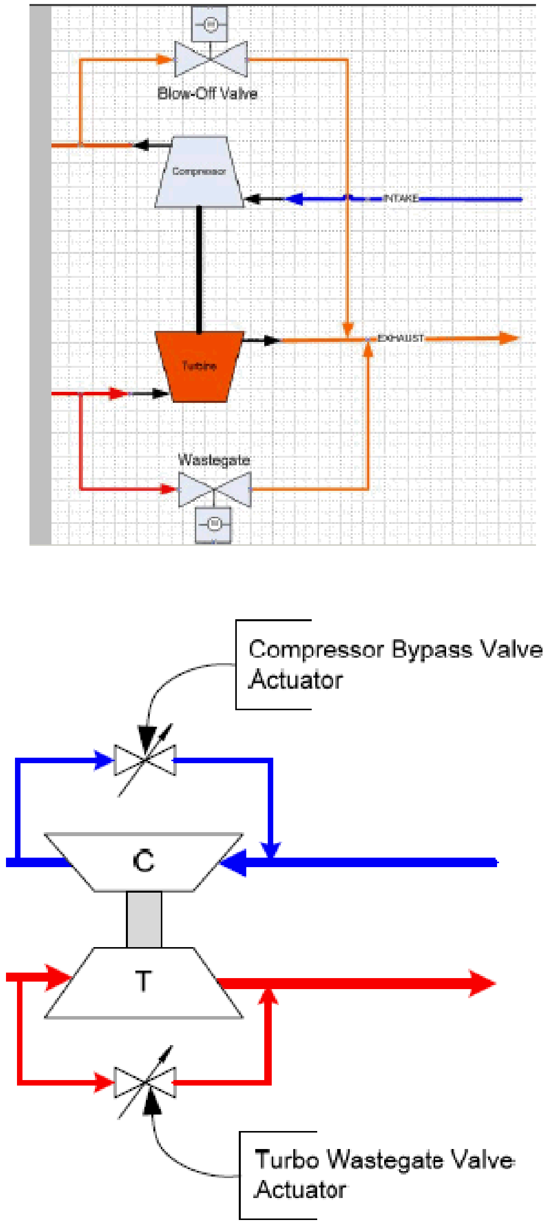


FIGURE PGN61486_A – ENGINE TURBOCHARGER CONTROL

A.68 PGN 61654 – DC/AC ACCESSORY INVERTER 1 COMMAND

Heavy Duty hybrid vehicles typically have several larger accessories that are used including air conditioning, air compressor for braking systems, and a power steering pump. These larger loads may be powered using a DC/AC Accessory Inverter operating at a fixed frequency (230Vac three-phase inverter) output or using a variable frequency motor control for dynamic control. Since these electrified accessory loads do not require highly dynamic control, a Volts/Hz algorithm may be commonly used where the inverter varies the frequency in a linear fashion with voltage to control the motor driving the various accessories. The figure below provides one example of how several PGNs may be used to control an Electrified Accessory System used in a Hybrid Vehicle.

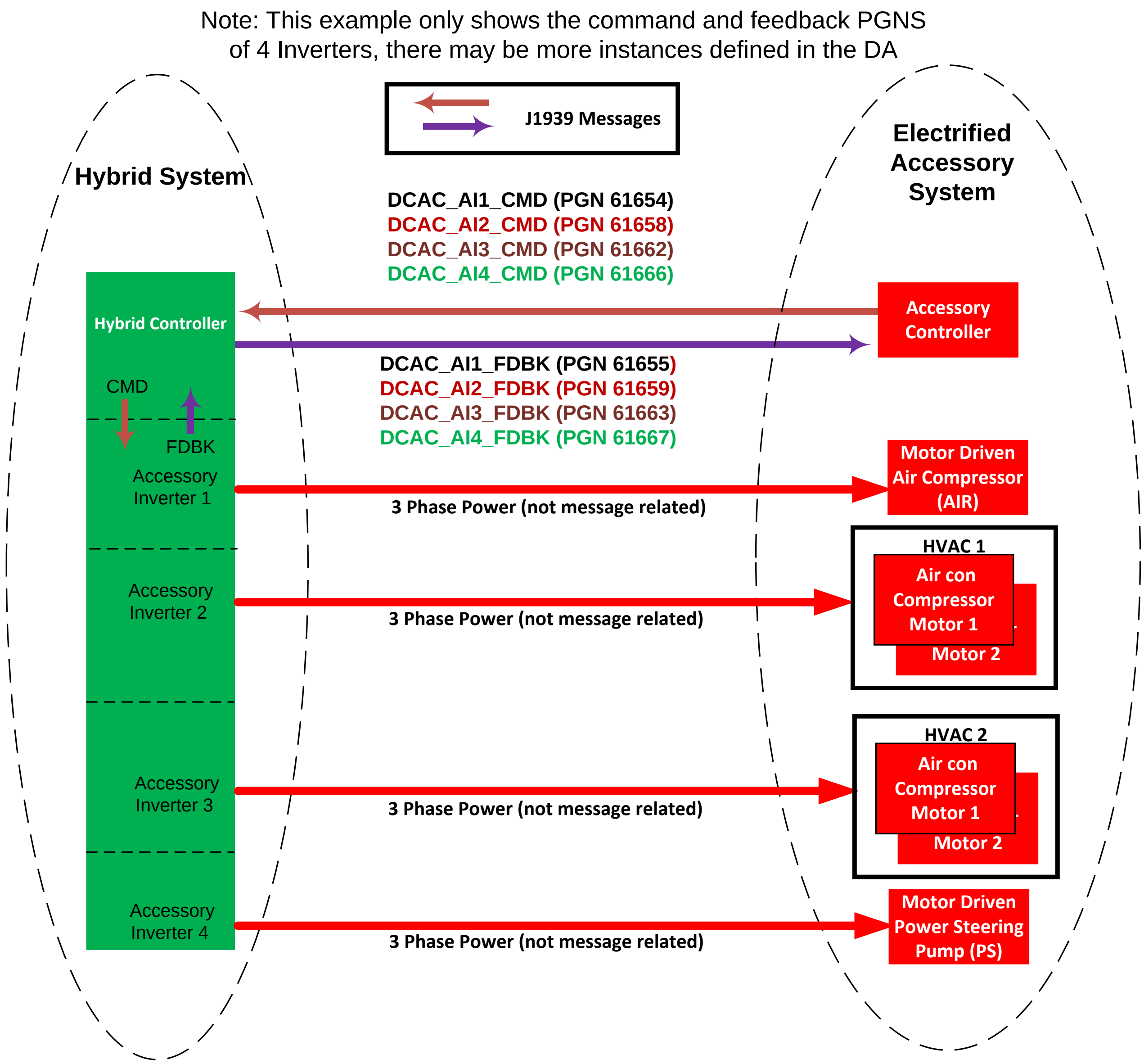


FIGURE PGN61654_A - ENERGY CONSUMER VARIABLE FREQUENCY CONTROL EXAMPLE

A.69 PGN 61677 – ENGINE START PARAMETERS

PGNs 61677 and 61685 define parameters for use during the engine start process. This appendix describes a method for devices to consent to and request an engine start using the above PGNs. The main goal is a flexible solution that can be applied to various vehicle configurations including traditional starter setups, vehicles with automatic start/stop systems, vehicles with hybrid systems with or without a traditional starter, etc. Other goals are minimal impact to the vehicle configuration, minimal number of PGs/SPs, minimal number of affected components, minimum system complexity, etc.

While not explicitly labeled in each parameter name, PGNs 61677 and 61685 are intended for applications with a single engine. If expansion to a second engine becomes necessary, a second set of parameters may be requested and the parameter names contained in PGNs 61677 and 61685 may be amended to specify “Engine 1”.

An operator-requested engine start is a start that is initiated directly by the operator (i.e. via the key switch).

An automatic engine start is one that is initiated by a vehicle system without direct operator interaction (i.e. as part of engine off at stop operation, etc.)

The engine start mechanism described in this appendix uses two global PGNs. PGN 61685 (ENGSA) is used for all signals from the arbitrator and PGN 61677 (ENGSC) is used for all other signals. Request and consent are generic signals, not directed to a specific destination, while all signals related to a particular starter controller are specific to that starter instance. This allows for minimal configuration requirements of requesting and consenting devices. Configuration is only needed for the arbitrator and the starter controllers.

Both messages are broadcast at a rate of once every 20 ms, unless the sender receives a broadcast rate signal from the arbitrator that instructs it to lower the rate. The slower rate is once every 250 ms or on change but no faster than 20 ms. When a device has a need to increase the broadcast rate temporarily, it may ignore the instructions from the arbitrator and broadcast at the 20 ms rate. This may be useful, for example, when a requester wants to abort an engine start and wants to ensure that a single missed message does not significantly delay the abort.

A 4 bit message counter and 8 bit checksum in the Engine Start Control message are used to detect data integrity issues.

Separate starter feedback parameters for starter 1 and starter 2 are necessary because distinction by source address may not be possible in applications where both starter controllers are contained in the same control module. These signals are intended to be used by the arbitrator. Existing SPN 1675 may be used to convey additional details regarding the starter state.

It is the responsibility of the system integrator to ensure that at least one controller prevents starter engagement when the engine is already running. This interlock may be part of the starter controller or another device that sends “No Consent” to both, automatic and operator-requested starts while the engine is running.

The logical devices are defined as follows:

Starter Controller – This device contains the driver circuit to actuate the starter. Examples are engine control units, body control modules, or hybrid control modules. The starter controller receives a dedicated starter command from the arbitrator. When this signal is true, the controller actuates the engine starter until the signal becomes false or an internal reason causes it to stop (for example, thermal or electrical considerations, timeout, etc). The system integrator configures the starter controller to accept the command signal from the arbitrator’s source address and designates the starter instance (starter 1 or starter 2). A vehicle configuration may contain multiple instances of a starter controller, each dedicated to a particular starter. The starter controllers send a feedback signal to the arbitrator to convey their current state.

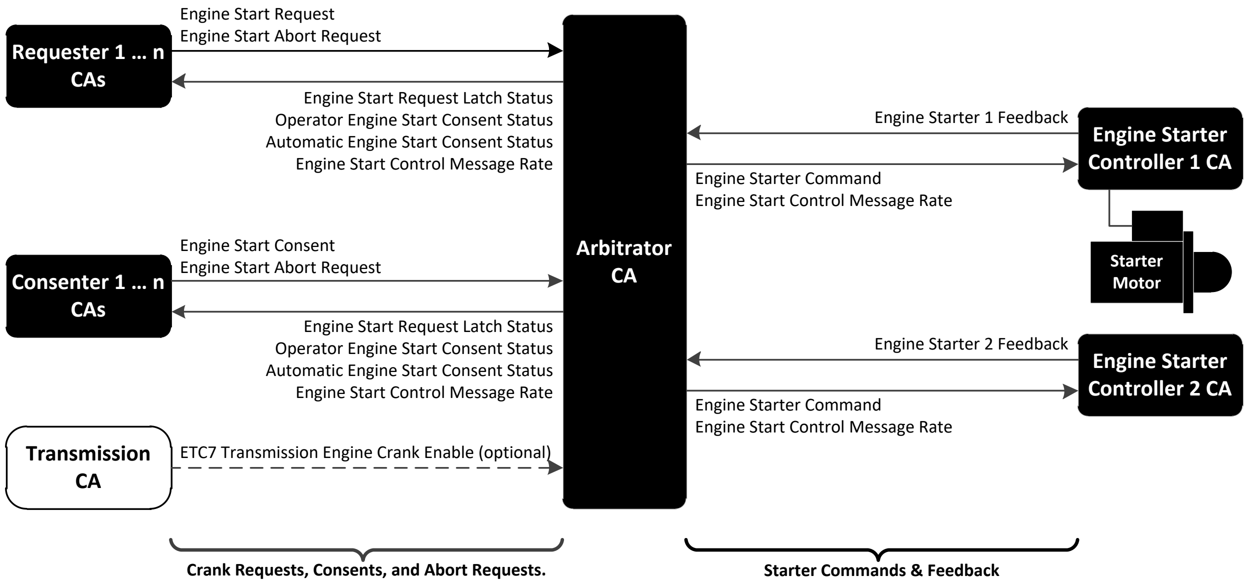
Requester – This device requests engine starts. Examples are a body controller that is connected to the ignition key switch or a start/stop controller that manages automatic engine starts. The requester sends the start request until the arbitrator indicates that the request is latched (SPN 7754). Before issuing a start request, the requester may monitor Operator Engine Start Consent Summary (SPN 7755) and Automatic Engine Start Consent Summary (SPN 7756) to determine if the request would be honored. However, the requester shall issue its request even if consent currently is not given. This allows consenters to see the requester’s intent to start the engine. Some consenters may be able to prepare for, and eventually provide positive consent when a start request is pending.

Consenter – This device consents to engine starts. It can allow or prevent the engine from starting. Examples are transmission control modules or a body control module connected to a hood switch. A consenter that desires to cancel an ongoing engine start to which it had previously consented may abort the start by sending Engine Start Abort Request (SPN 7747). An Engine Start Consent value of “No Consent” does not abort an ongoing start. It can only prevent a start before it is initiated. This is necessary so that a consenter that comes back online after dropping out due to low voltage during cranking does not abort the ongoing start when it sends “No Consent” while it determines its state.

Arbitrator – This device receives consent and request signals and commands engine starts via one of the available starter controllers. The system integrator configures the arbitrator to require consent for operator-requested and automatic starts from certain source addresses and to accept start requests from certain source addresses. Legacy signal ETC7 Transmission Engine Crank Enable (SPN 2900) may be considered by the arbitrator as another consent signal. When the arbitrator receives a valid engine start request, it latches the request signal and starts to process the required consent signals. The arbitrator may wait for a period of time (defined by the system integrator) to receive all required consent signals and for those signals to indicate positive consent. Once consent is confirmed, the arbitrator chooses a starter instance (how the starter instance is determined is defined by the system integrator) and sends the starter command to the starter controller. If consent cannot be established within the allowed period of time, the arbitrator un-latches the start request and returns to a wait state where it waits for the next start request. While the start request is latched, the arbitrator listens for abort requests. When an abort request is received, the arbitrator un-latches the start request, cancels any active starter command, and returns to the wait state until a new request is received. If an abort request and a start request are received at the same time, the abort request overrules the start request. The latching mechanism is necessary to ensure that an engine start does not abort when requesters or consenters drop out due to a temporary voltage drop. In case of a traditional key switch input the system designer may desire that the engine only crank while the key is held in the start position. This can be achieved by sending an abort request from the key switch controller when the switch transitions out of the start position. The arbitrator provides overall consent status signals for automatic and operator-requested starts based on consent signals it receives from consenters. It also sends its request latch status and a broadcast rate signal that allows other devices to switch to a slower broadcast rate at times when engine start control is not required.

Consenters, requesters, starter controllers, and the arbitrator may be contained in the same logical controller. For example, a hybrid control module may request starts, consent to start requests from other devices, command the starter(s) and arbitrate requests and consents from other devices. Such controllers shall broadcast their internal request, consent, and starter command signals so that other devices on the network may see the internal decisions.

The engine start mechanism defined in this appendix may be used in conjunction with the engine stop mechanism defined in ESR/EEC13.



Notes:

- Message use is by Controller Application (CA). A given physical controller may encompass multiple CAs, e.g. a single body controller might be an Engine Starter Controller CA, Requester CA, and a Consenter CA.
- All participants broadcast the global ENGSA and/or ENGSC message depending on their role; receiving CAs use the parameters applicable to their roles.
- All parameters shown from the arbitrator are in the ENGSA message, all other parameters are in ENGSC messages unless designated otherwise.
- All participants receive the Engine Start Control Message Rate parameter from the arbitrator to allow the variable characteristics of the ENGSA/ENGSC message broadcast rate.

FIGURE PGN61677_A – ENGINE START CONCEPT OVERVIEW

This table shows which role broadcasts which signal.

Signal	Sender	Receiver
Engine Start Request	Requester(s)	Arbitrator
Engine Start Consent	Consenter(s)	Arbitrator
Engine Starter Command	Arbitrator	Starter Controllers 1 & 2
Engine Start Control Message Rate	Arbitrator	All ENGSC senders
Engine Start Abort Request	Requester(s), Consenter(s)	Arbitrator
Engine Start Request Latch Status	Arbitrator	Requester(s), Consenter(s)
Engine Starter 1 Feedback	Starter Controller 1	Arbitrator
Engine Starter 2 Feedback	Starter Controller 2	Arbitrator
Operator Engine Start Consent Summary	Arbitrator	Requester(s)
Automatic Engine Start Consent Summary	Arbitrator	Requester(s)
Engine Start Control Message Counter	All ENGSC senders	All ENGSC senders
Engine Start Control Checksum	All ENGSC senders	All ENGSC senders
Engine Start Arbitrator Message Counter	Arbitrator	All ENGSC senders
Engine Start Arbitrator Checksum	Arbitrator	All ENGSC senders

FIGURE PGN61677_B – ENGINE START BROADCAST ROLES TABLE

A.70 PGN 61686 – ADAPTIVE DRIVER ASSISTANCE SYSTEMS INTERFACE SPECIFICATION 1

The Advanced Driver Assistance Systems Interface Specification (ADASIS) defines parameters that describe the upcoming vehicle's environment, including the attributes about the current roadway, intersections, and roads that deviate from the intersections. ADASIS was developed by the ADASIS global standardization forum, which is a forum coordinated by ERTICO - ITS Europe (http://www.ertico.com/adasisforum).

Refer to ADASIS for specific message and parameter definitions.

ADASIS defines seven different types of messages. Manufacturers have the option of using a unique CAN ID for each message or using one CAN ID for all messages. If one CAN ID is used (full multiplexed implementation), then a parameter within the data field of the message indicates the type of message transmitted. SAE J1939 supports a full multiplexed implementation or a partial multiplexed implementation, but it does not support an implementation where each message has a unique CAN ID.

For a full multiplexed implementation, the ADASIS1 message (PGN 61686) shall be used to transmit all ADASIS messages.

For a partial multiplexed implementation, the ADASIS1 message (PGN 61686) can be used for the following ADASIS messages:

System Specific
POSITION
SEGMENT
STUB
META-DATA

The ADASIS2 message (PGN 61687) can only be used in a partial multiplexed implementation and is intended for the PROFILE SHORT ADASIS message.

The ADASIS3 message (PGN 61688) can only be used in a partial multiplexed implementation and is intended for the PROFILE LONG ADASIS message.

A.71 PGN 61714 – DC/DC CONVERTER DIAGRAM

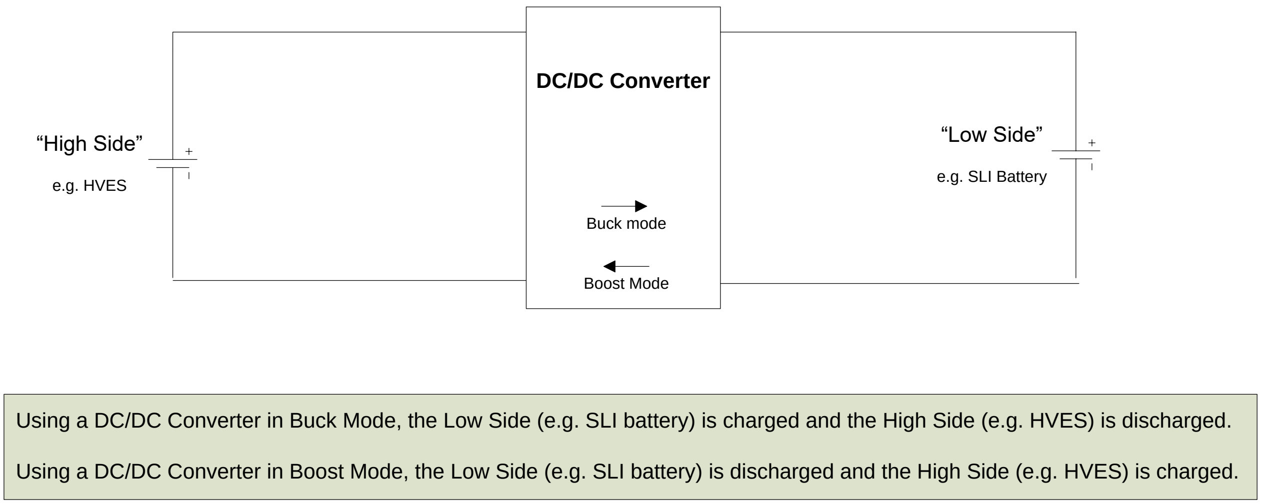


FIGURE PGN61714_A – DC/DC CONVERTER DIAGRAM

A.72 PGN 61839 – IMPOSTOR PG ALERT

An “impostor” is defined as a network component (ECU) broadcasting messages using a source address *that has already been claimed and in use by another existing network component.* The impostor communication could be the result of a malicious attack meant to affect vehicle operation, the addition of a poorly integrated aftermarket network device, or simply a network configuration issue. In any case, communication from a legitimate sender to its receiver(s) does not occur as intended. Unexpected communication occurs.

The impostor detection and reporting method described here was developed as a simple “entry-level” Intrusion Detection System (IDS). It detects a known existing attack vector, as well as the addition of non-malicious aftermarket devices that are not integrated properly with the vehicle network. The method described has relatively low overhead and can be performed by individual ECUs as needed.

IMPOSTOR DETECTION

The logic used to detect an impostor is manufacturer specific and not specified by SAE. However, the following illustrates one possible implementation: A legitimate ECU listens for messages containing its Source Address, and then compares the PGN and data field content of those messages against the PGN and data field content of legitimate messages that it has recently sent. A received message is from an impostor if its content fails to match that of the same message last sent by the legitimate ECU.

In this manner a legitimate ECU can detect impostor instances of PGs. In addition, the legitimate ECU can also easily listen for PGs whose transmit it does not support.

IMPOSTOR REPORTING

Once an impostor message has been detected, the Impostor PG Alert (IPGA) message (PGN 61839) allows the legitimate ECU to inform other network devices and/or service personnel of the situation.

A unique impostor PGN instance is defined by the combination of impostor source address, destination address and PGN value. The same unique impostor PGN instance may be used in multiple attack events. For example, each time an impostor transmits a series of TSC1 commands from SA 03 to DA 00, each series would be considered as an attack event. If an impostor continuously transmits a periodic message during a key cycle, that would be considered as one long attack event. Since the IPGA structure only contains information on one impostor PGN instance, multiple IPGA broadcast instances are needed to convey multiple unique impostor PGN instances.

An IPGA message is broadcast each time an attack event is detected, and then sent at a slower update for the rest of the key cycle. SAE J1939DA SPN 10840 [Impostor PGN Event Detection Counter] explains how to sense the beginning and end of an attack event. If a legitimate sender has detected no attack events in the current key cycle, the IPGA message would only be sent on request. Note the IPGA broadcast content is only for the current key switch cycle; all parameters, including the counter, are reset at the beginning of each key switch cycle.

While a legitimate sender may monitor and report impostors for any PG, such activity is likely most important for command-and-control messages such as TSC1 or TC1.

RESPONSE TO DETECTING AN IMPOSTOR

The sender, receiver and system reactions to an impostor alert are not specified by SAE; reactions are left to their discretion. However, example reactions might include:

- Reporting a DTC
- Changing to a different mode of operation
- Ignoring the questionable message and reacting as if its reception has been lost

LIMITATIONS

The impostor detection and IPGA reporting method discussed here has both advantages and disadvantages. The main advantages are that (1) detection implementation is relatively simple and compact, and is well suited for classical CAN applications, and (2) this method can often be supported by existing controllers not capable of more complex security measures such as fully authenticated communication.

However, this method is certainly not a comprehensive security mechanism. For example, it cannot combat (1) Man-in-the-Middle attacks, where a device physically blocks or intercepts and modifies legitimate communication, nor can it combat (2) Denial of Service (DoS) attacks from the impersonating device. It cannot definitively authenticate a given message.

Furthermore, IPGA broadcasts are a *reactionary measure* to an attack. It takes time to detect an impostor, broadcast an IPGA message, and for any receivers to respond to the alert. As such, this mechanism *alone* cannot prevent receivers from responding to a least some number of impostor messages. However, in some applications it may be possible for a receiver to filter incoming messages (i.e. don't react to any one single instance of a message) to provide time for impostor detection, reporting and response to occur. If nothing else, the IPGA can prevent longer term attacks from going completely undetected.

It is also realized that *the impostor itself* could send out IPGA messages (PGN 61389) and potentially cause restricted vehicle operation depending on how vehicle systems are designed to respond to IPGA messages. In this case, however, the impostor is effectively telling the rest of the network that it is doing something it shouldn't be.

A.73 PGN 63973 – OPERATOR INDUCEMENT VEHICLE SPEED INFORMATION

This section contains an example of how the SPs in the Operator Inducement Vehicle Speed Information PG will be set when a vehicle speed derate is applied. Consider the table below is the desired vehicle speed derate table:

Hours of non-idle engine operation	Maximum speed (km/hr)
0	88.515
6	80.467
12	72.421
45	64.375
70	56.328
90	40.234

FIGURE PGN63973_A – VEHICLE SPEED DERATE TABLE

Given the above information, the SPs in the Operator Inducement Vehicle Speed Information PG will be set as in the table below when the vehicle speed derate became active. SPN 23381 Operator Inducement Time to Next Vehicle Speed Derate would pause decrementing when the engine is idle.

Duration of non-idle engine operation since Operator Inducement Vehicle Speed Derate became active (See FIGURE PGN63973_A)	SPN 23380 Operator Inducement Vehicle Speed Derate	SPN 23381 Operator Inducement Next Vehicle Speed Derate	SPN 23382 Operator Inducement Time to Next Vehicle Speed Derate	SPN 23383 Operator Inducement Vehicle Speed Derate SPN	SPN 23384 Operator Inducement Vehicle Speed Derate FMI	SPN 23385 Operator Inducement Vehicle Speed Derate Reason Code
Vehicle Speed Derate due to Operator Inducement is not active	FBh	FBh	FB00h	0	0	0
6 hours	88.515	80.467	21600 sec → 0 sec	3517	1	1
12 hours	80.467	72.421	21600 sec → 0 sec	3517	1	1
45 hours	72.421	64.375	118000 sec → 0 sec	3517	1	1
70 hours	64.375	56.328	90000 sec → 0 sec	3517	1	1
90 hours	56.328	40.234	72000 sec → 0 sec	3517	1	1
After 90 hours of non-idle engine operation after vehicle speed derate inducement first applied.	40.234	FCh	FC00h	3517	1	1

FIGURE PGN63973_B – EXAMPLE OF BROADCAST SPS IN THE OPERATOR INDUCEMENT VEHICLE SPEED INFORMATION PG

A.74 PGN 63978 – SAE J2012 3-BYTE DTC DISPLAY

Intended to convey basic SAE J2012 3-byte DTC information for on-board or service tool displays. However, this message can also be used to convey SAE J2012 2-byte DTCs; in these cases the 3rd byte (Failure Type) is set to "00". Data byte arrangement:

A $B1_1$ $B2_1$ $B3_1$ $B4_1$ $B5_1$ C_1 $D1_1$ $D2_1$ E_1 $B1_X$ $B2_X$ $B3_X$ $B4_X$ $B5_X$ C_X $D1_X$ $D2_X$ E_X . . .

…where:

Data Byte	Definition
A	Number of J2012 3-byte DTCs
$B1_X$	1st Base Code Character of DTC x
$B2_X$	2nd Base Code Character of DTC x
$B3_X$	3rd Base Code Character of DTC x
$B4_X$	4th Base Code Character of DTC x
$B5_X$	5th Base Code Character of DTC x
C_X	Byte value of 45 (ASCII "-" Delimiter)
$D1_X$	1st Failure Type Byte (FTB) Character of DTC x
$D2_X$	2nd Failure Type Byte (FTB) Character of DTC x
E_X	Bit 8: J2012 3-byte DTC Status Bits 7-1: J2012 3-byte DTC Occurrence Count

If PGN 63978 is requested and a supporting device has no J2012 3-byte DTCs to report, PGN 63978 shall be sent as a single frame message with the first data byte (*Number of J2012 3-Byte DTCs*) set to zero. When one or more J2012 3-byte DTCs are indicated then PGN 63978 must be sent via Transport Protocol.

EXAMPLE – A device conveying (1) 9 counts of an active P1482 base code with a Circuit Intermittent FTB and (2) 4 counts of an inactive U0100 base code with no FTB information (2-byte DTC) would populate the data bytes as follows:

Data Byte:	1	2	3	4	5	6	7	8	9	10
Decimal	2	80	49	52	56	50	45	49	70	137
ASCII:	--	'P'	'1'	'4'	'8'	'2'	'-'	'1'	'F'	--

Data Byte:	11	12	13	14	15	16	17	18	19
Decimal	85	48	49	48	48	45	48	48	4
ASCII:	'U'	'0'	'1'	'0'	'0'	'-'	'0'	'0'	--

A.75 PGN 63979 – HIGH VOLTAGE ENERGY STORAGE SYSTEM

Example of Single Pack System with Internal Circuits (HVESS SPNs)

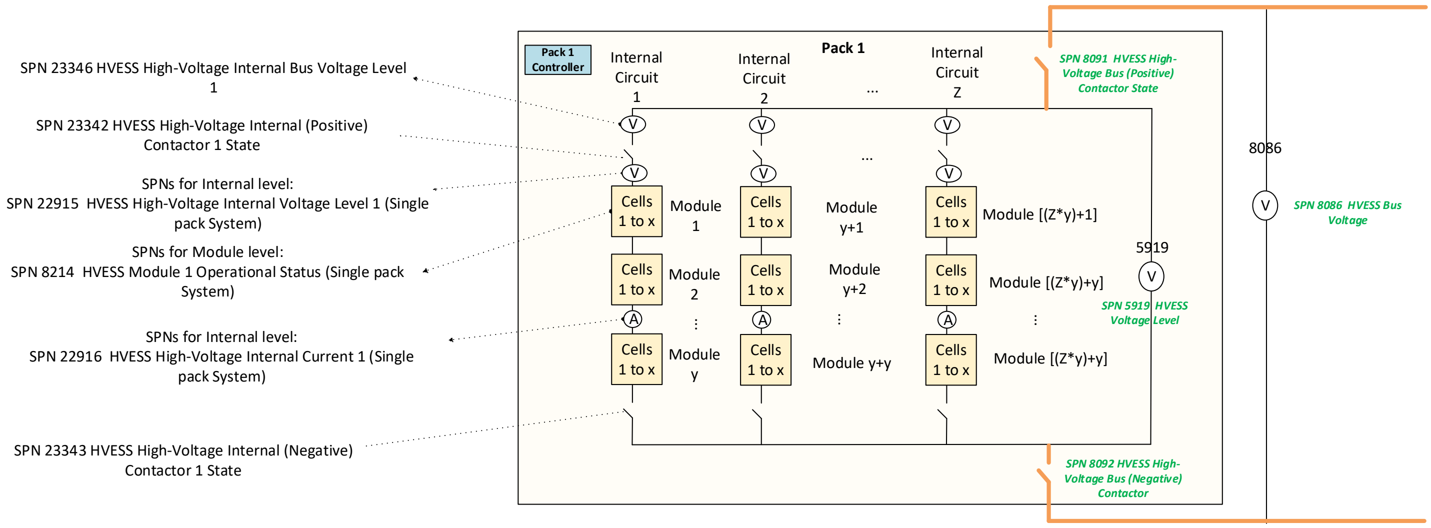


FIGURE PGN63979_A – EXAMPLE OF SINGLE PACK SYSTEM WITH INTERNAL CIRCUITS

A.76 PGN 63998 – APPLICATION PROGRAMMING INTERFACE (API) NEGOTIATION

Parameter Groups APISUP (PGN 63998) and APISEL (PGN 17920) allow two J1939 devices to enumerate at runtime which charging services the other supports and to select which service/services are to be used.

The initial use case for these PGs is for the SAE J3271 Megawatt Charging Standard (MCS) where the EV and EVSE connect at runtime on a peer-to-peer CAN subnet. When the two systems connect, they need to establish that they are communicating with a compatible system and then select which version of the charging API is to be used.

The APISUP and APISEL PGs supports all the functionality currently in the ISO 15118-2 2016, ISO 15118-20 2022, SAE J2847-2 April 2015 PLC *supportedAppProtocolReq* and *supportedAppProtocolRes* messages.

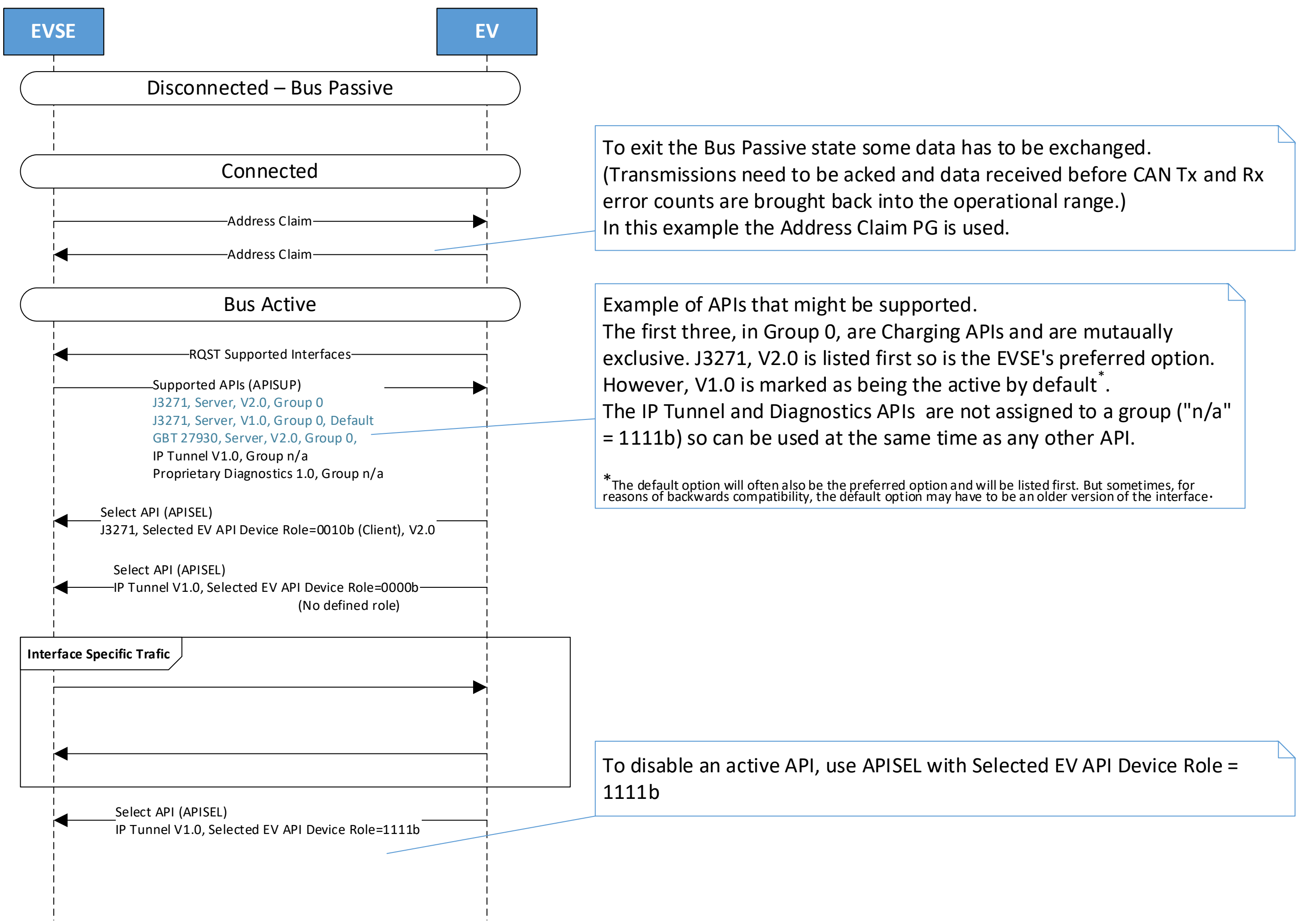


FIGURE PGN63998_A – EXAMPLE USAGE

If the EVSE only supports a single version of a single API the Parameter Group APISUP is sent as a single 8-byte message. If multiple APIs are supported then APISUP is sent using the TP or BAM protocol, where fields a through i are repeated for each API. The overall message length will be a multiple of 8-bytes. Fields that are not a multiple of 8-bits are allocated according to J1939-71 Feb 2020 Section 5.4.6.

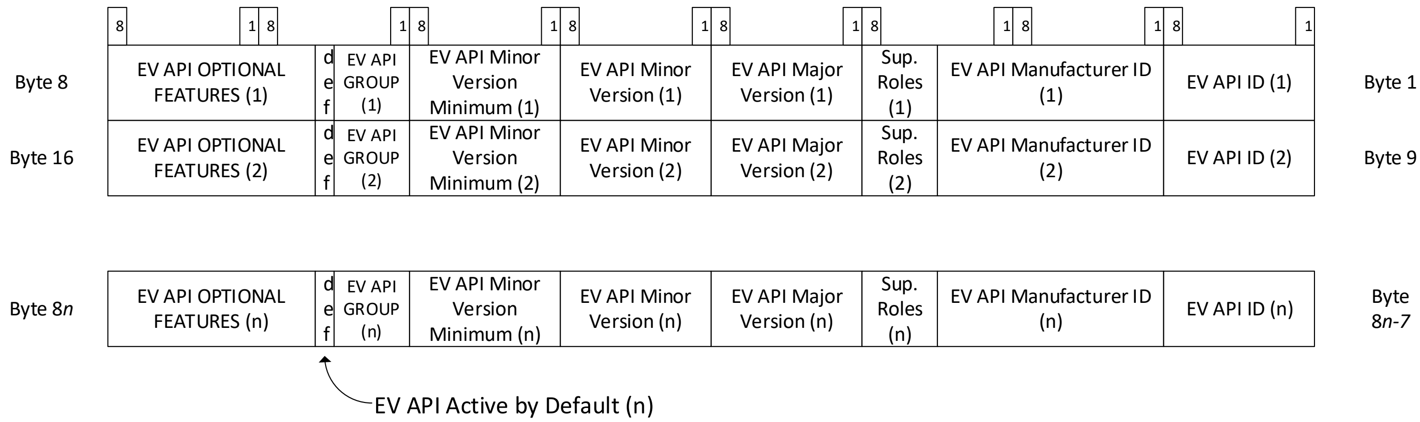


FIGURE PGN63998_B – APISUP SPN MAP

API Versions

An API has major and minor version numbers. A change in the major version indicates that the API may not be backwards compatible. Therefore, for example, EVSE Charging API version 2.0 may not be useable with an EV that only supports Charging API 1.0.

Where API versions only differ by a minor version then backwards compatibility can be assumed. An EV that supports API version 1.2 can work with an EVSE that only supports version 1.0. Any features added in versions 1.1 and 1.2 are considered non-essential.

The minor API version will be updated if the API specification documentation is updated, and the changes are confined to:

- Clarifications to the intended behavior
- Tightening of conformance tests
- Addition of new, but non-essential, PGs and SPs

If a device claims support for version 1.2 of an API it also implies that it supports version 1.1 and 1.0 of the API **and** has been tested with devices that only support the earlier versions.

Sometimes, where the earlier versions of the API specification were perhaps ambiguous or had insufficient conformance testing, then a device may wish to exclude the earlier versions. In this case, SPN 23219 (EV API Minor Version Minimum) will be set to a non-zero value.

For Example, and EVSE claims to Support API version 1.2 with the EV API Minor Version Minimum set to 1. This means it is prepared to interoperate with EVs that support API versions 1.1 and 1.2 but not 1.0.

Standard and Proprietary APIs

When an API is listed as having an SPN 23215 (EV API Manufacturer ID) of 0 then this is a standard API and SPN 23214 (EV API ID) value is allocated by SAE and listed in the SAE J1939 DA.

When the API has a non-zero SPN 23215 (EV API Manufacturer ID) then the API is proprietary to the manufacturer and they allocate the allowed EV API ID values and maintain the necessary API specifications. For instance, an EVSE/EV manufacturer may define a proprietary diagnostic API to assist in the testing and debugging of their equipment. The use of a proprietary charging APIs may also be used during the development and field trials of new versions of a standard charging API.

A.77 PGN 64007 – VEHICLE SPEED PROFILE

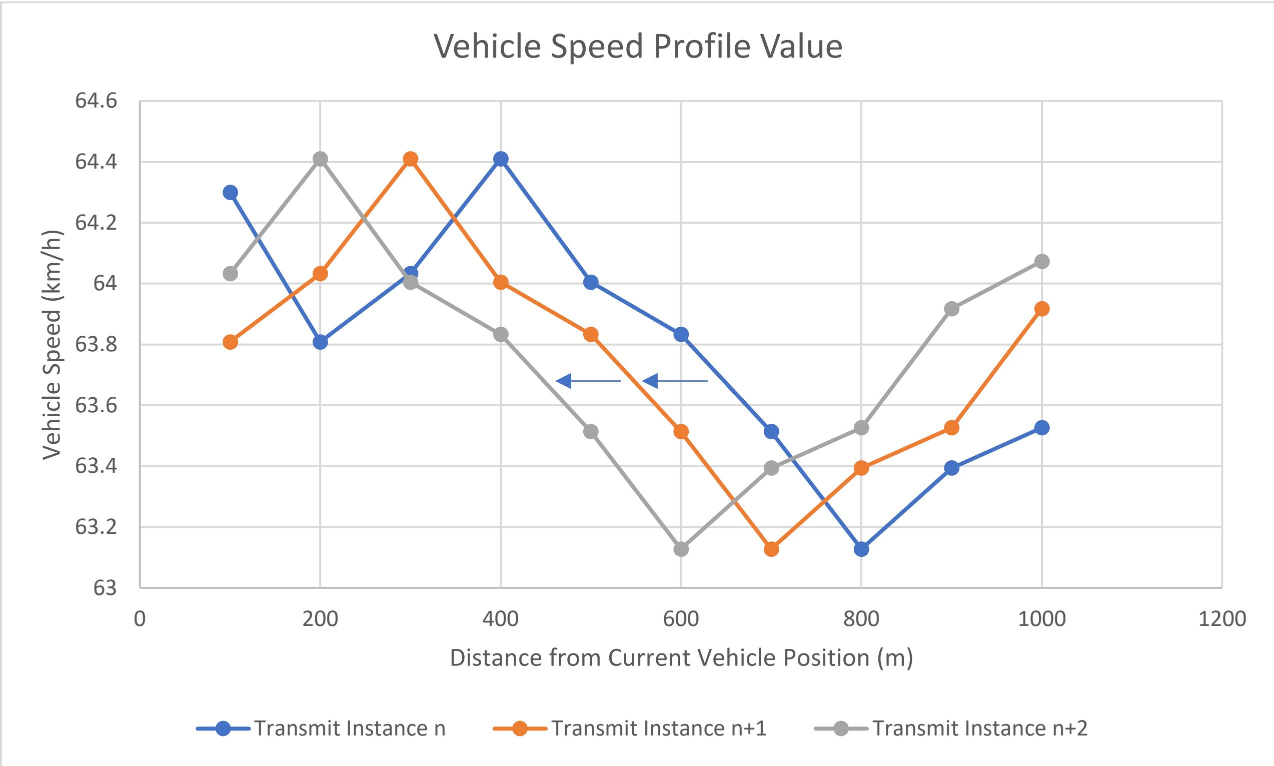


FIGURE PGN64007_A – VEHICLE SPEED PROFILE EXAMPLE

Example for PGN 64007 (Vehicle Speed Profile).

1. SPN 23073 (VSP Number of Points) is equal to 10.
2. SPN 23074 (VSP Point Distance) is equal to 100 m.
3. The Vehicle Velocity Profile message with "Transmit Instance n+1" data points is transmitted at the moment the vehicle has travelled 100 meters after transmitting the message with "Transmit Instance n" data points. The velocity points in "Transmit Instance n" from 200 to 1000 are shifted so they are now points 100 to 900 in "Transmit Instance n+1". The point at 1000 m in "Transmit Instance n+1" is a new data point.
4. The Vehicle Velocity Profile message with "Transmit Instance n+2" data points is transmitted at the moment the vehicle has travelled 100 meters after transmitting the message with "Transmit Instance n+1" data points. The velocity points in "Transmit Instance n+1" from 200 to 1000 are shifted so they are now points 100 to 900 in "Transmit Instance n+2". The point at 1000 m in "Transmit Instance n+2" is a new data point.
5. This example shows that the upcoming VSP speed values don't change as the vehicle travels forward, but the VSP speed values previously transmitted could be updated in each subsequent broadcast. This is why the entire speed profile is transmitted each time.

A.78 PGN 64018 – MOTOR/GENERATOR LOCATION EXTENDED EXAMPLES

Example 1 - Generator on Series hybrid truck tractor, or bus.

Axle Instance: 0000b: No Axle
Motor/Generator Location: 0000b: No MG (Motor/Generator) connected
Motor/Generator Identification: Depends on which MG is the generator (use states 0001b through 0110b)
Motor/Generator Rotation Versus Vehicle Direction: 1100b = Direction of motor/generator rotation is not related to vehicle direction (e.g., series hybrid, genset)
Vehicle Segment: Pick the segment that the motor is located
Trailer Type: Pick the type of segment that the generator is located on.
Motor/Generator Source Address: Provide the source address.

Example 2 - Truck 6x4 with no trailer, Steer Axle is not driven

MG1 is on the first driven axle. No gearbox
MG2 is on the second driven axle. No gearbox

Number of Axle Instances Being Reported: 3
Axle Instance: 0001b: Axle 1
Motor/Generator Location: 0000b: No MG connected
Motor/Generator Identification: 1111b: Not Applicable
Motor/Generator Rotation Versus Vehicle Direction: 1111b: Not Applicable
Vehicle Segment: 0000b: Truck
Trailer Type: 0000b: Not applicable: segment is not a trailer
Motor/Generator Source Address: FFh: parameter is not supported

Axle Instance: 0010b: Axle 2
Motor/Generator Location: 0011b: Left and Right Sides – MG impacts both wheel ends.
Motor/Generator Identification: 0001b: Motor/Generator 1
Motor/Generator Rotation Versus Vehicle Direction: 0000b = Positive Speed propels the vehicle forward
Vehicle Segment: 0000b: Truck
Trailer Type: 0000b: Not applicable: segment is not a trailer
Motor/Generator Source Address: FFh: Provide the source address.

Axle Instance: 0011b: Axle 3
Motor/Generator Location: 0011b: Left and Right Sides – MG impacts both wheel ends.
Motor/Generator Identification: 0010b: Motor/Generator 2
Motor/Generator Rotation Versus Vehicle Direction: 0000b = Positive Speed propels the vehicle forward
Vehicle Segment: 0000b: Truck
Trailer Type: 0000b: Not applicable: segment is not a trailer
Motor/Generator Source Address: FFh: Provide the source address.

Example 3 - Bus with 4 hub motors, Steer Axle is not driven

MG1 is on the first driven axle on the left side
MG2 is on the first driven axle on the right side
MG3 is on the second driven axle on the left side
MG4 is on the second driven axle on the right side

Number of Axle Instances Being Reported: 3
Axle Instance: 0001b: Axle 1
Motor/Generator Location: 0000b: No MG connected
Motor/Generator Identification: 1111b: Not Applicable
Motor/Generator Rotation Versus Vehicle Direction: 1111b: Not Applicable
Vehicle Segment: 0000b: Bus
Trailer Type: 0000b: Not applicable: segment is not a trailer
Motor/Generator Source Address: FFh: parameter is not supported

Axle Instance: 0010b: Axle 2
Motor/Generator Location: 0001b: Left Side - MG located on the left side of the axle when facing forward in the driver's seat.
Motor/Generator Identification: 0001b: Motor/Generator 1
Motor/Generator Rotation Versus Vehicle Direction: 0000b: Positive Speed propels the vehicle forward
Vehicle Segment: 0000b: Bus
Trailer Type: 0000b: Not applicable: segment is not a trailer
Motor/Generator Source Address: FFh: Provide the source address.

Axle Instance: 0010b: Axle 2
Motor/Generator Location: 0010b: Right Side- MG located on the right side of the axle when facing forward in the driver's seat
Motor/Generator Identification: 0010b: Motor/Generator 2
Motor/Generator Rotation Versus Vehicle Direction: 0001b: Negative Speed propels the vehicle forward
Vehicle Segment: 0000b: Bus
Trailer Type: 0000b: Not applicable: segment is not a trailer
Motor/Generator Source Address: FFh: Provide the source address.

Axle Instance: 0011b: Axle 3
Motor/Generator Location: 0001b: Left Side - MG located on the left side of the axle when facing forward in the driver's seat.
Motor/Generator Identification: 0011b: Motor/Generator 3
Motor/Generator Rotation Versus Vehicle Direction: 0000b: Positive Speed propels the vehicle forward
Vehicle Segment: 0000b: Bus
Trailer Type: 0000b: Not applicable: segment is not a trailer
Motor/Generator Source Address: FFh: Provide the source address.

Axle Instance: 0011b: Axle 3
Motor/Generator Location: 0010b: Right Side- MG located on the right side of the axle when facing forward in the driver's seat
Motor/Generator Identification: 0100b: Motor/Generator 4
Motor/Generator Rotation Versus Vehicle Direction: 0001b: Negative Speed propels the vehicle forward
Vehicle Segment: 0000b: Bus
Trailer Type: 0000b: Not applicable: segment is not a trailer

A.79 PGN 64019 – COLD START EMISSIONS REDUCTION STRATEGY (CSCRS)

PGNs 64019 (Cold Start Emissions Reduction Strategy Current Operating Cycle Data) and PGN 64020 (Cold Start Emissions Reduction Strategy Average Data) define 20 SPs that provide the data required to meet 13 CCR 1971.1 (h)(5.9). The following notes explain the content of these 20 SPs, and highlight key provisions in the (h)(5.9) for reset and storage of the data. Following the notes, notional equations are provided to refine the definitions provided in (h)(5.9.2). The (h)(5.9) text was published 22 November 2022. For complete information refer to (h)(5.9). Text in italics quotes the regulation as published.

CSERS DM24 Support.

Engines that support CSERS Data shall only provide SPN 22227 in their DM24 response.

CSERS Data Storage Provisions. See (h)(5.9.5)(A).

The OBD system shall store each number (for (h)(5.9.2)(A)-(J)) within 10 seconds after all counters in section (h)(5.9.2) have stopped tracking in each driving cycle.

CSERS Data Reset conditions. See (h)(5.9.5)(A).

Each number shall be reset to zero only when a non-volatile memory reset occurs (e.g., reprogramming event). ***Numbers may not be reset to zero under any other circumstances including when a scan tool (generic or enhanced) command to clear fault codes or reset KAM is received.***

CSERS Pause conditions for tracking. See (h)(5.9.6)

The OBD system shall pause tracking of all parameters listed in section (h)(5.9.2) above within 10 seconds if a malfunction of a component used as an input to any of the parameters or a CSERS malfunction described in section (e)(11.2.2) or (e)(11.2.3) has been detected and the MIL is commanded on for that malfunction. When the malfunction is no longer detected and the MIL is no longer commanded on, tracking of all parameters in section (h)(5.9.2) shall resume within 10 seconds.

CSERS Data Calculation Definitions

(h)(5.9.1) For purposes of section (h)(5.9), the following terms shall be defined as follows:

(A) "Catalyst cold start tracking temperature threshold" is defined as when the SCR catalyst temperature that is directly measured or estimated for purposes of enabling DEF dosing reaches 180 degrees Celsius.

T_{CTT} = Catalyst temperature threshold (180 degrees Celsius) T_o = Ambient Temperature (at engine start)

(B) "FTP catalyst cold start tracking time" is defined as the time from engine start until the catalyst cold start tracking temperature threshold is achieved on an FTP test. For an engine family with multiple power ratings, manufacturers may request Executive Officer approval for proposing a representative FTP catalyst cold start tracking time for the engine family. The Executive Officer shall approve the request upon determining that, based on manufacturer-submitted data and/or information, the representative time represents the FTP catalyst cold start tracking time on the majority of the power ratings in the field.

t_{CTT} = definite integral from T_o to T_{CTT} of dt

t_{CTT_FTP} = definite integral from T_o to T_{CTT} of dt, for a cold FTP in a 1065 test cell.

*(C) "Engine output energy", in units of Joules (J) or Watts (W)*s, is defined by integrating brake engine power output over time, with:*
"Brake engine power output" = 2π x (Brake engine torque) x (Engine RPM)/60 in units of W, and
"Brake engine torque" = (engine reference torque) x [(indicated torque) – (friction torque)].

T_{brake} = (engine reference torque) x [(indicated torque (%)) – (friction torque (%))].

EOE = definite integral from 0 to t of (2π * T_{brake} * N / 60) * dt

Note: The formula only works for torque in percent of reference torque.
Net Brake Engine Torque and EOE under no load conditions are effectively zero.
Vehicle launches before T_{CTT} will be needed to see significant energy accumulation.

(D) "Specified FTP engine output energy" is defined as the accumulated engine output energy measured from engine start until the catalyst cold start tracking temperature threshold is achieved on an FTP test. For an engine family with multiple power ratings, manufacturers may request Executive Officer approval for proposing a representative specified FTP engine output energy for the engine family. The Executive Officer shall approve the request upon determining that, based on manufacturer-submitted data and/or information, the representative energy represents the specific FTP engine output energy on the majority of the power ratings in the field.

Spec. FTP EOE = definite integral from 0 to t_{CTT_FTP} of (2π * T_{brake} * N / 60) * dt

For cold FTP in a 1065 test cell.

(E) "Pre-SCR heat energy" is defined as the heat energy flow prior to the SCR over time, with:
"Heat energy flow prior to the SCR" = [heat capacity of exhaust gas (Cp)] x [exhaust mass flow ($m_{exhaust}$)] x (temperature difference between SCR inlet and ambient) /1000.

T_{SCR_Inlet} = SCR Inlet Temperature T_o = Ambient Temperature (at engine start)

dQ = [heat capacity of exhaust gas (Cp)] x [exhaust mass flow ($m_{exhaust}$)] x (|temperature difference between T_{SCR_Inlet} and T_o|) /1000.

Q_{Pre_SCR} = definite integral from 0 to t of dQ * dt

Note: Absolute value addresses ambient temperature rise after a cold soak.

(h)(5.9.2) For 20 percent of 2026, 50 percent of 2027, and 100 percent of 2028 and subsequent model year diesel engines, manufacturers shall implement software algorithms to individually track and report in a standardized format the following parameters. During driving cycles where the CSERS monitoring conditions (as defined in section (c)) are met at engine start, each parameter shall start tracking from engine start until the conditions described below for each parameter are met:

SPN 22227 - (5.9.2)(A) Heat energy release tracker #1 (kiloJoules (kJ)): track pre-SCR heat energy (in units of kJ) until the FTP catalyst cold start tracking time is achieved.

CSERS HER_1 = definite integral from 0 to t_{CTT_FTP} of dQ * dt

SPN 22228 - (5.9.2)(B) Heat energy release tracker #2 (kJ): track pre-SCR heat energy until the specified FTP engine output energy is achieved.

CSERS HER_2 = definite integral from 0 to $t_{Spec.\ FTP\ EOE}$ of dQ * dt

$t_{Spec.\ FTP\ EOE}$ = definite integral from 0 to Spec. FTP EOE of dt.

```
SUM_FTP_EOE := 0;
SUM_Q_SCR_INLET := 0;

While SUM_FTP_EOE <= CAL_SPEC_FTP_EOE DO;
SUM_FTP_EOE := SUM_FTP_EOE + (2π * Tbrake * N / 60) * delta-t;
SUM_Q_SCR_INLET := SUM_Q_SCR_INLET + [[heat capacity of exhaust gas (Cp)] x [exhaust mass flow (mexhaust)]
      x ( | temperature difference between TSCR_Inlet and To | ) /1000] * delta-t;
END DO;
```

SPN 22229 - (*5.9.2)(C) Heat energy release tracker #3 (kJ): track pre-SCR heat energy until catalyst cold start tracking temperature threshold is achieved.*

CSERS HER_3 = definite integral from T_0 to T_{CTT} of dQ * dt

SPN 22230 - *(5.9.2)(D) Engine output energy tracker #1 (kJ): track engine output energy until the FTP catalyst cold start tracking time is achieved*.

CSERS EOE_1 = definite integral from T_0 to t_{CTT_FTP} of (2π * T_{brake} * N / 60) * dt

SPN 22231 - *(5.9.2)(E) Engine output energy tracker #2 (kJ): track engine output energy until the catalyst cold start tracking light-off temperature threshold is achieved.*

CSERS EOE_2 = definite integral from T_0 to T_{CCT} of (2π * T_{brake} * N / 60) * dt

SPN 22232 - *(5.9.2)(F) EGR mass flow tracker #1 (kilograms (kg)): track EGR mass flow until the FTP catalyst cold start tracking time is achieved*.

CSERS EGR $Mass_1$ = definite integral from 0 to t_{CTT_FTP} of m_{EGR} * dt

SPN 22233 - *(5.9.2)(G) EGR mass flow tracker #2 (kg): track EGR mass flow until the specified FTP engine output energy is achieved.*

CSERS EGR $Mass_2$ = definite integral from 0 to Spec. FTP EOE of m_{EGR} * dt

SPN 22234 - *(5.9.2)(H) EGR mass flow tracker #3 (kg): track EGR mass flow until the on-road catalyst cold start tracking temperature threshold is achieved.*

CSERS EGR $Mass_3$ = definite integral from T_0 to T_{CTT} of m_{EGR} * dt

SPN 22235 - *(5.9.2)(I) Timer #1 engine energy output accumulated time (seconds): track time until the specified FTP engine output energy is achieved.*

CSERS TFTP = definite integral from 0 to Spec. FTP EOE of dt

SPN 22236 - *(5.9.2)(J) Timer #2 catalyst cold start tracking accumulated time Light-Off Timer (seconds): track time until the catalyst cold start tracking temperature threshold is achieved.*

CSERS TLO = definite integral from T_0 to T_{CCT} of dt

SPNs 22237-22246 - CSERS EWMA Calculation. See (h)(5.9.3)(B).

Historical data, using an exponentially weighted moving average (EWMA) equation with lambda (λ) = 0.2 for calculation of the historical data, with the EWMA equation as follows:
*EWMA(t) = (1-λ)*EWMA(t-1) + λ*Y(t) (for t = 1, 2, ..., n), where*
EWMA(t) is the weighted mean of historical data (the current weighted moving average),
EWMA(t-1) is the weighted mean of historical data calculated one event prior to time t,
Y(t) is the observation at time t,
n is the number of measurements, and
λ is a constant that determines the degree of weighting/filtering for the EWMA calculation.

Or, CSERS WMA_X^+ = CSERS WMA_X^- * (1 - λ) + X * λ … for each of the 10 defined values (here X) in (h)(5.9.2)

The OBD II system shall store each number (for (h)(5.9.3(B)) within 600 seconds after the end of a driving cycle.

A.80 PGN 64051 – MULTI-COLOR INDICATOR LAMPS

Examples where PGN 64051 can be used:

1. RC and Autonomy Application: PGN 64051 can be used to indicate various modes of operation.
2. Police Vehicles: PGN 64051 can be used to flash colors on police vehicles.
3. Traffic Control: PGN 64051 can be used to turn on and off colors in traffic signal lights.

Other examples include vehicle turn signal lights, mining applications (use to indicate warning levels), etc.

This command PGN will have 10 time slots. Each time slot could be 100 ms or 50 ms or 200 ms depends on the operating frequency. If the frequency is 1 Hz, then each timeslot will be 100 ms. That means one message will carry a 1 second flashing pattern. In the same way, if the operating frequency is 0.5 Hz then each time slot will become 200 ms. That means one message will carry 2 seconds of flashing pattern information. If the operating frequency is 2 Hz, then each time slot will be 5 0ms. That means one message will carry a 500 ms flashing pattern.

In these examples there will be one lamp and inside the lamp there are 4 LEDs. One for Color 1, one for Color 2, one for Color 3, and one for Color 4. In each time slot, the message will contain information about each LED activation.

These are some of the example patterns.

Example Pattern 1:

In this example the operating frequency is 1 Hz. As a result, each slot will be 100 ms. Total message will be a 1 second flashing pattern.

Color 1: Blue
Color 2: Red
Color 3: Yellow
Color 4: Violet
Brightness: 100%
Frequency: 1 Hz (1 second)

Data:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
03 (03h)	01 (01h)	02 (02h)	04 (04h)	01 (01h)	48 (30h)	100 (64h)	04 (04h)

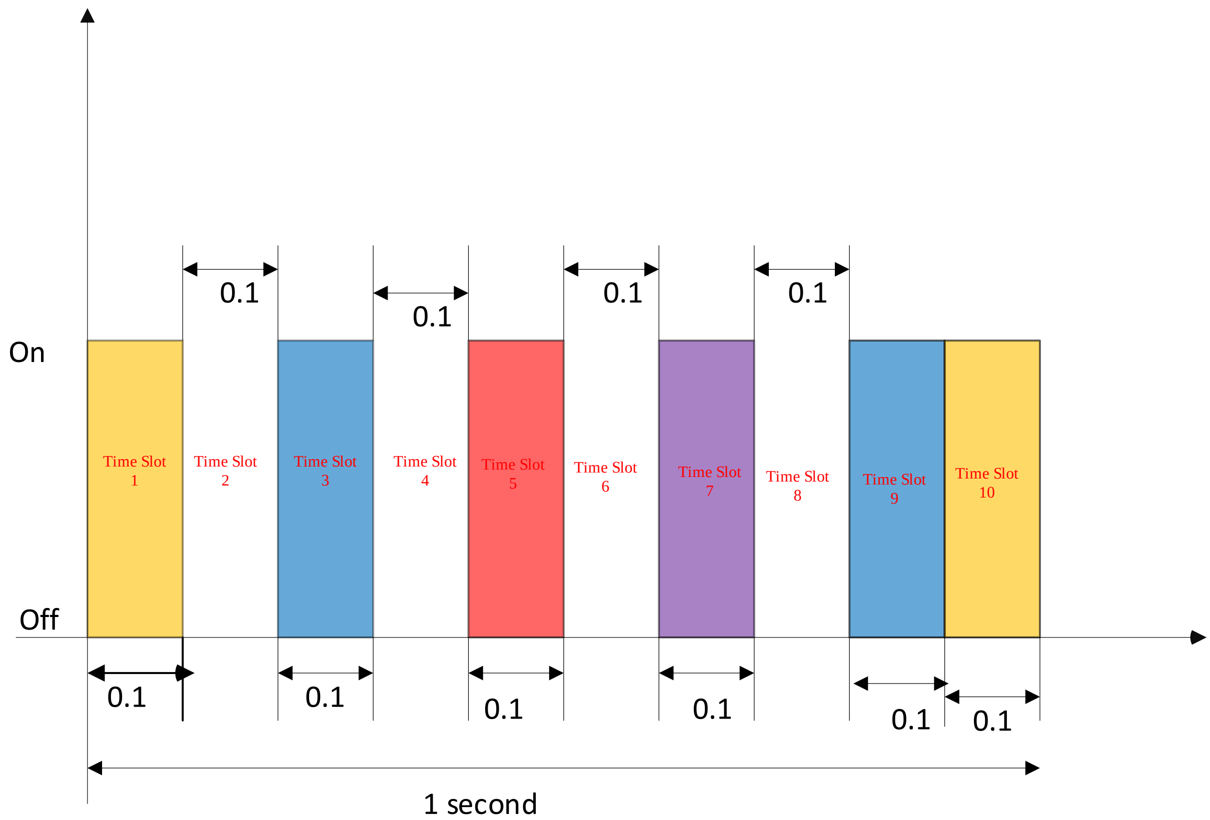


FIGURE PGN64051_A – EXAMPLE PATTERN 1

Example Pattern 2:

In this example the operating frequency is 0.5 Hz. As a result, each slot will be 200 ms. Total message will be a 2 second flashing pattern.

Color 1: Blue
Color 2: Red
Color 3: Yellow
Color 4: Green
Brightness: 100%
Frequency: 0.5 Hz (2 seconds)

Data:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
17 (11h)	49 (31h)	51 (33h)	51 (33h)	51 (33h)	48 (30h)	100 (64h)	00 (00h)

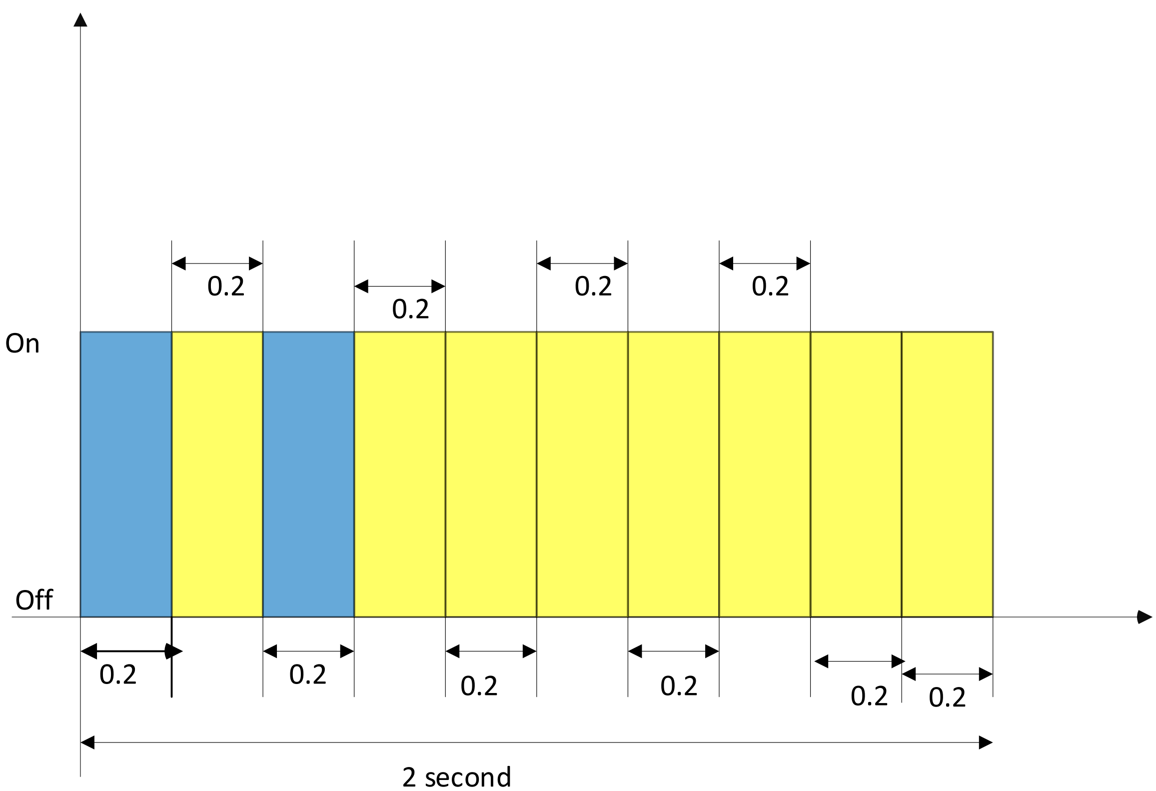


FIGURE PGN64051_B – EXAMPLE PATTERN 2

Example Pattern 3:

In this example the operating frequency is 2 Hz. As a result, each slot will be 200 ms. The message will be a 0.5 second flashing pattern.

Color 1: Blue
Color 2: Red
Color 3: Yellow
Color 4: Green
Brightness: 100%
Frequency: 2 Hz (0.5 second)

Data:

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
49 (31h)	49 (31h)	51 (33h)	51 (33h)	51 (33h)	48 (30h)	100 (64h)	08 (08h)

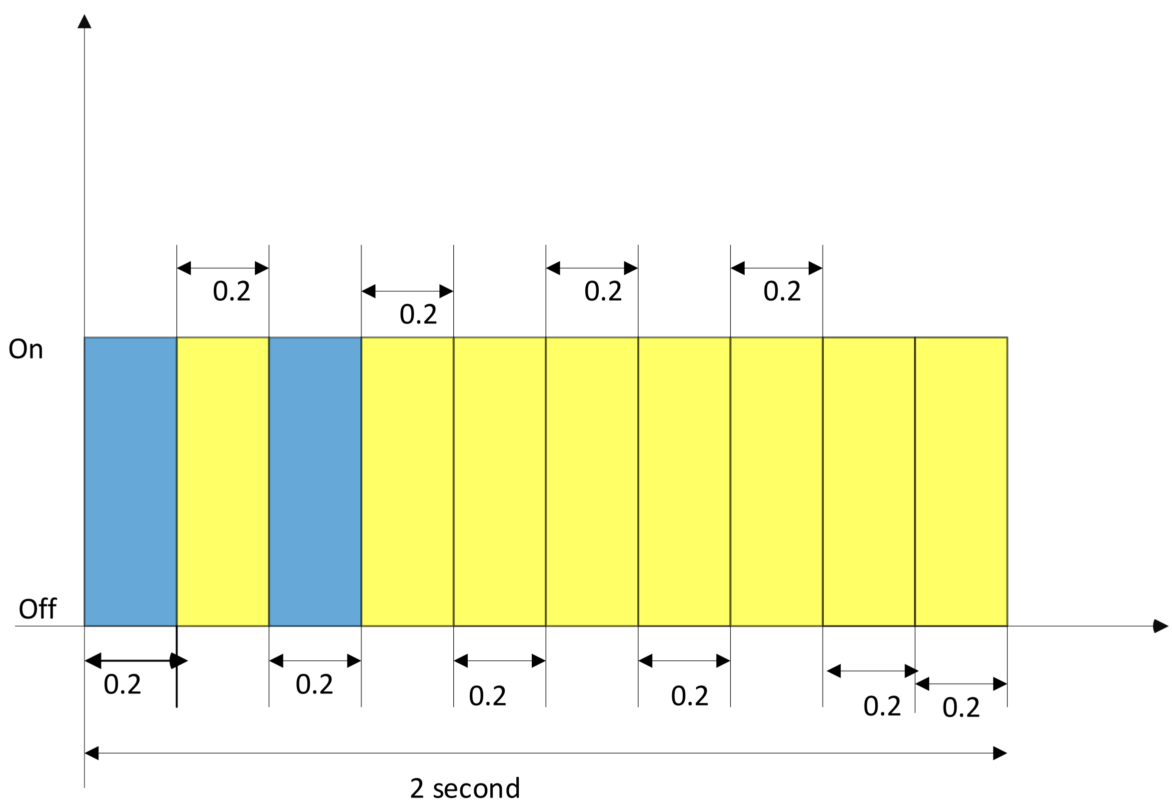


FIGURE PGN64051_C – EXAMPLE PATTERN 3

A.81 PGN 64180 – DC CHARGING SYSTEM

The following diagrams illustrate the usage of J1939 Parameter Groups associated with communications with an off-board DC Charging station (EVSE).

FIGURE PGN64180_A shows a block diagram for the system. Communications from the EV to the EVSE uses a Power Line Communications (PLC) protocol.

On the vehicle the Electric Vehicle Communications Controller (EVCC) manages the digital PLC communications as well as the analogue signals associated with the physical connection.

The vehicle's Inlet Contactors are further illustrated in
FIGURE PGN64180_B.

This example is for a "full featured" system which uses all elements of the PLC protocol, with the vehicle (EV) taking full control of the connection to the EVSE.

FIGURE PGN64180_C summarizes the PGs used in DC charging, indicating the source and recipients.

FIGURE PGN64180_D through
FIGURE PGN64180_O are UML message sequence charts that illustrate how data in PLC messages relates to data in J1939 PGs. The figures have a stage number (e.g 4a/b, 5a/b etc.). These numbers refer to different stages of the operation sequence as defined by J2847-2 April 2015 (Sections 5.4 and 5.5) and J1772 Oct 2017 (Sections F 1.8 and F 1.9).

The following general notes apply to these diagrams:

- Familiarity is assumed with the following documents:
- J1772 Oct 2017
    - Covers EV DC Charging (and AC charging). In particular sections:
        - F 1.8 Normal Startup Sequence
        - F 1.9 Normal Shutdown Sequence
- J2847-2 April 2015
    - Covers the PLC communications between the Electric Vehicle (EV) and the off-board DC Charging station (EVSE). Sections 5.4 and 5.5 summarize the messages exchanged, indicating the mandatory and optional elements.
    - In the diagrams,
    - FIGURE PGN64180_D through
    - FIGURE PGN64180_O, mandatory PLC items are denoted by 'M' and optional items by 'O'. PLC items prefixed by '+' are compound items where the internal items are not detailed. Items prefixed by '-' are fully expanded to show internal detail.
- PLC and J1939 messaging are asynchronous from each other – a J1939 PG will not directly trigger a PLC message and vice-versa. The purpose of the diagrams is to illustrate how SP values in J1939 PGs are mapped to corresponding elements in the PLC requests/responses.
- Many J1939 PGs are sent with defined transmission rates. The diagrams only show J1939 messages where they are: a) relevant to the current operation and b) carry values that have changed.
    - Cyclic PGs are shown in blue in the diagrams.
- Some PGs, EVSE1DCS1 for example, have multiple SPs. Not all of these SPs may be relevant to the current operation. For simplicity, unimportant SPs may not be shown.

- J1939 PGs have defined transmission rates but there is no implicit synchronization between different PGs. If one PG is used to send a command and another used to receive a response or acknowledgement, there will be an inherent race condition between those PGs. If a device sends a “command” PG, the next “response” PG it receives may not be the response to that command. It could still contain the response to the previous command.
- EV Ready. Many PLC messages sent from the EVCC to the EVSE contain a DC_EVStatus element which contains the EVReady flag. For systems with a Control Pilot signal the *EVReady* flag reflects the state of the Control Pilot and is set to TRUE only for J1772 Control Pilot states ‘C’ or ‘D’.
- Existing J1939 systems only support charging (AC or DC) from a single source/connection at a time. SPN 7898 in PG HSS1 is used to control the Control Pilot’s transition to/from States ‘C’/’D’.
- Provision has been made in PG EVDCS1 for SPN 21085, EV Ready. This SP is for future use on systems that support multiple active power sources. For current systems that use SPN 7898 to switch the Control Pilot state SPN 21085, EV Ready, in EVDCS1 shall be set to Not Available.
- Error handling / fault recovery is not covered in these diagrams. Please see J1772 section F 1.9.1.

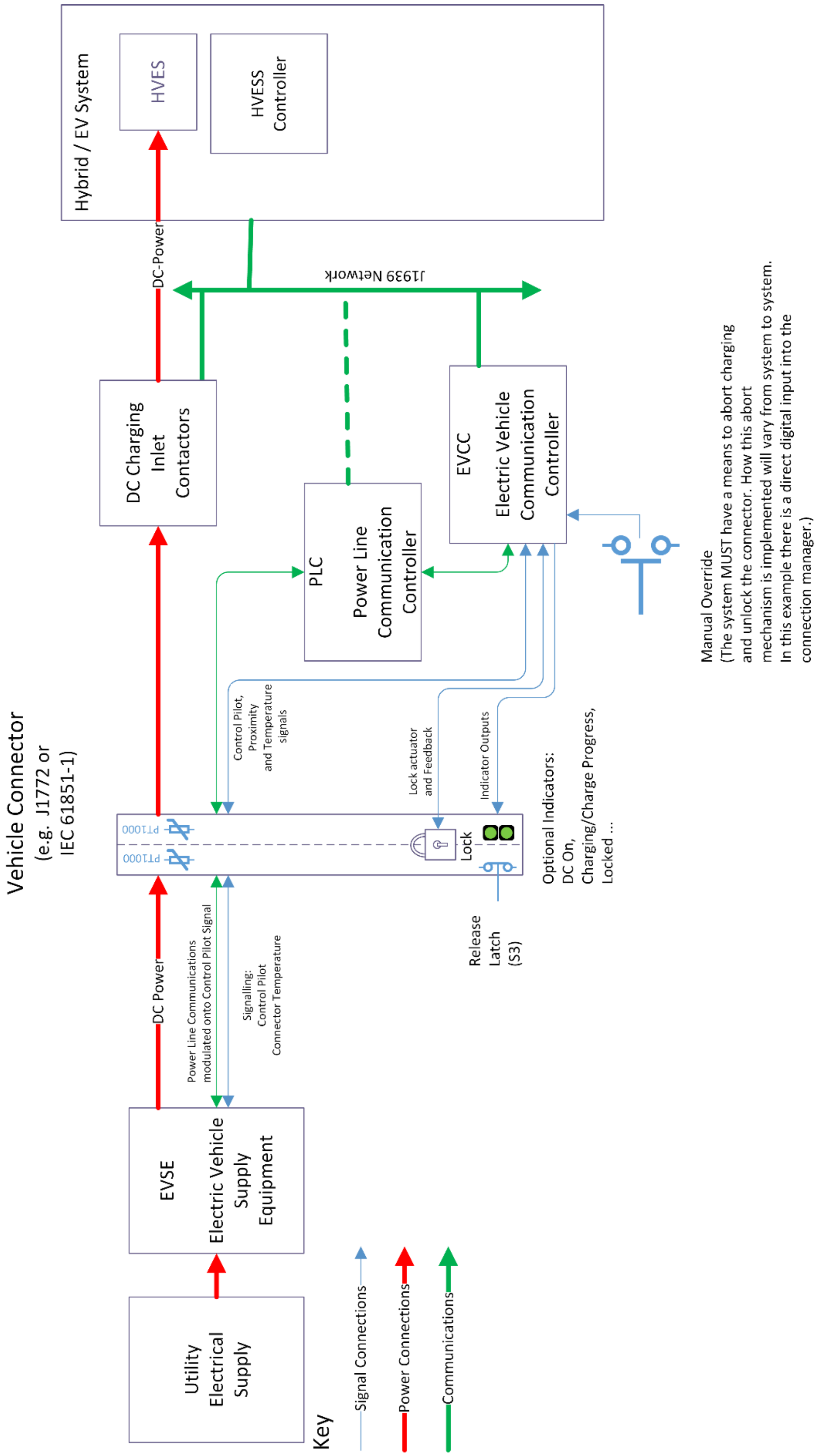
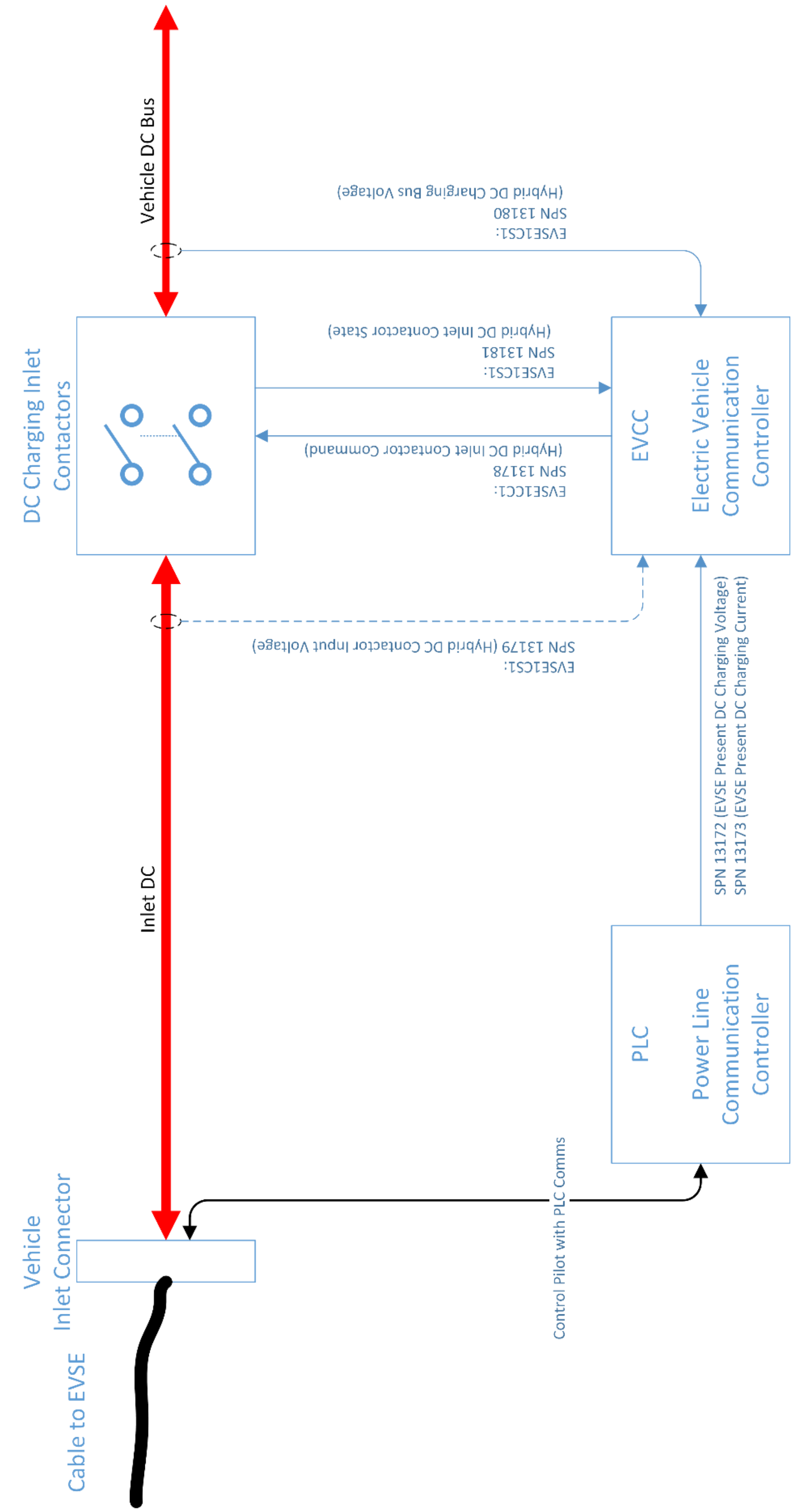


FIGURE PGN64180_A - EXAMPLE DC CHARGING BLOCK DIAGRAM



Notes:
Refer to J1772 / J2847 for detailed requirements.
In this example, the PLC Modem, EVCC, and the Inlet contactors are shown as separate entities communicating over the CAN bus. In an actual system one or more of these functions may be contained within the same ECU, in which case some SPNs will become internal signals and may only be made available on the CAN bus for diagnostic purposes.

FIGURE PGN64180_B - INLET CONTACTORS

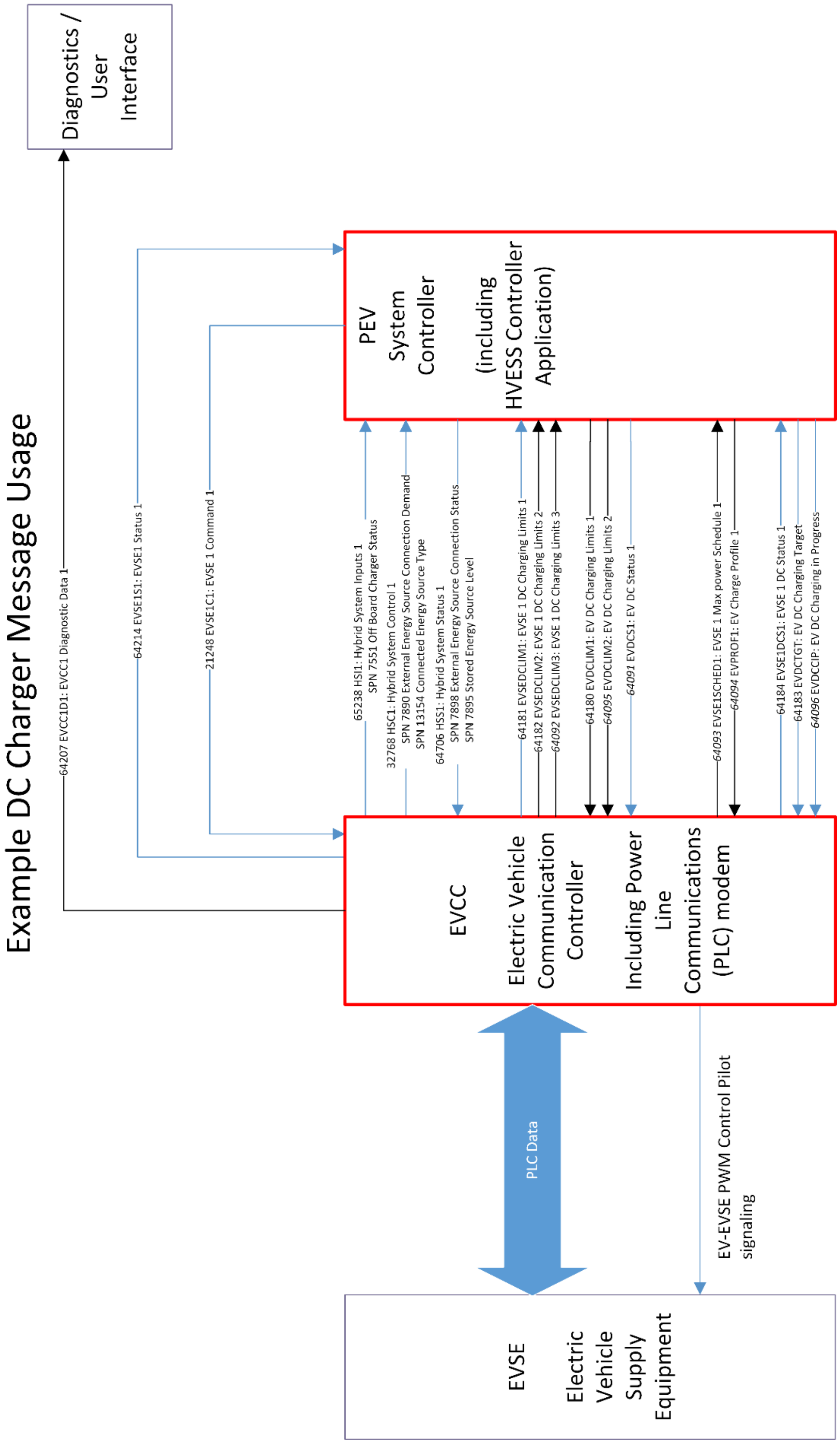


FIGURE PGN64180_C - MESSAGE FLOW

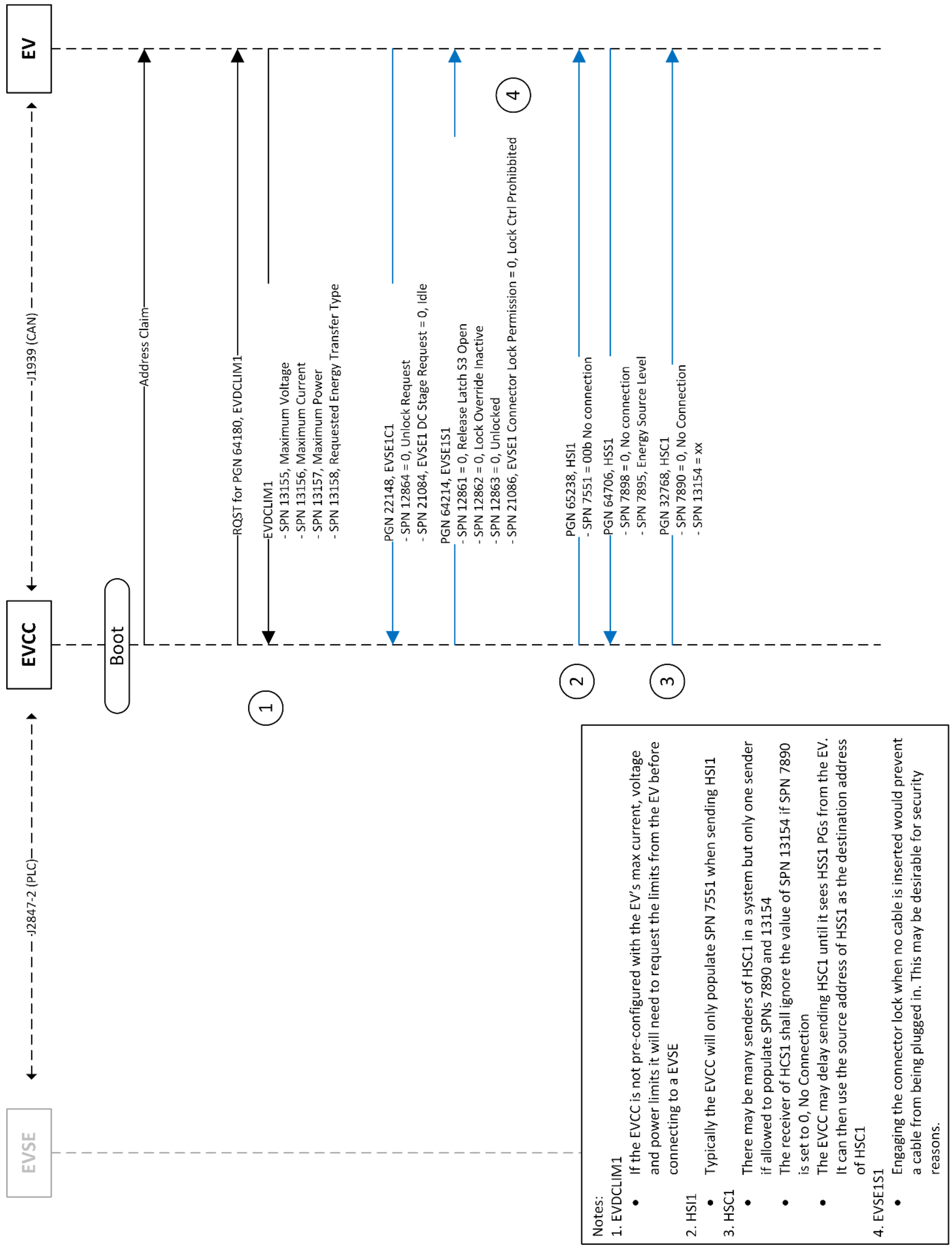


FIGURE PGN64180_D - SYSTEM BOOT

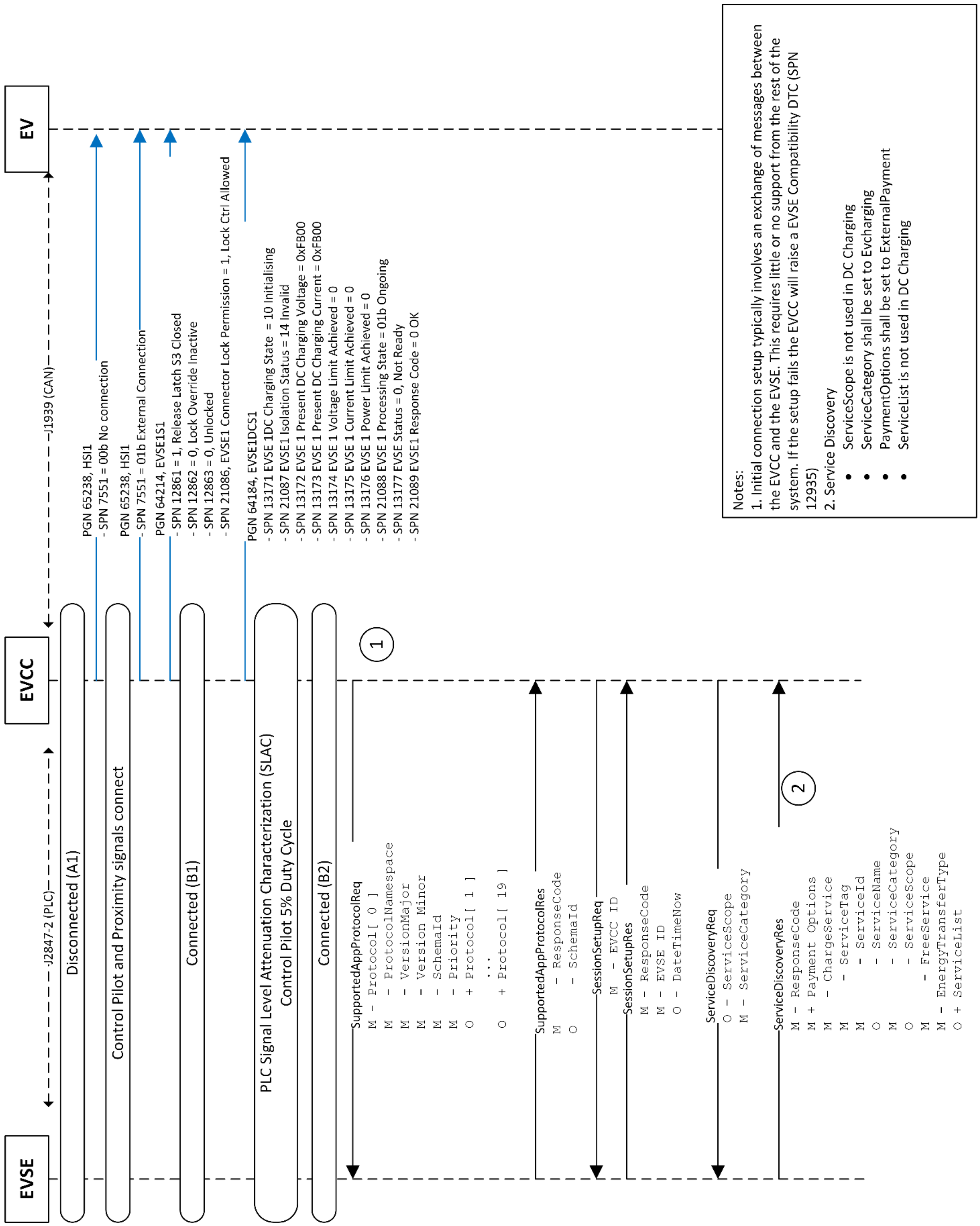


FIGURE PGN64180_E - EVSE-CONNECT-1, STAGE 0-2A/B

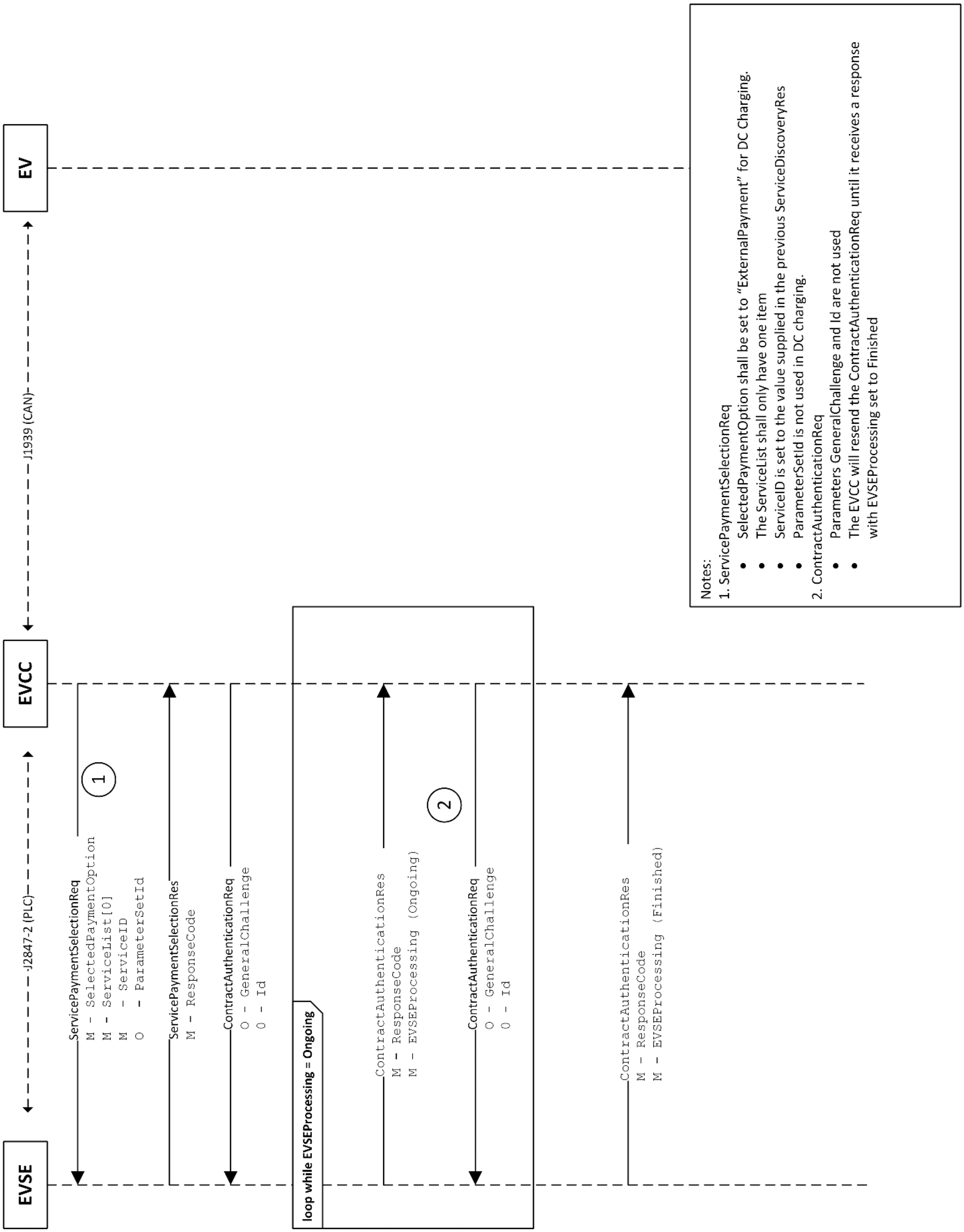


FIGURE PGN64180_F - EVSE-CONNECT-2, STAGES XA/B YA/B

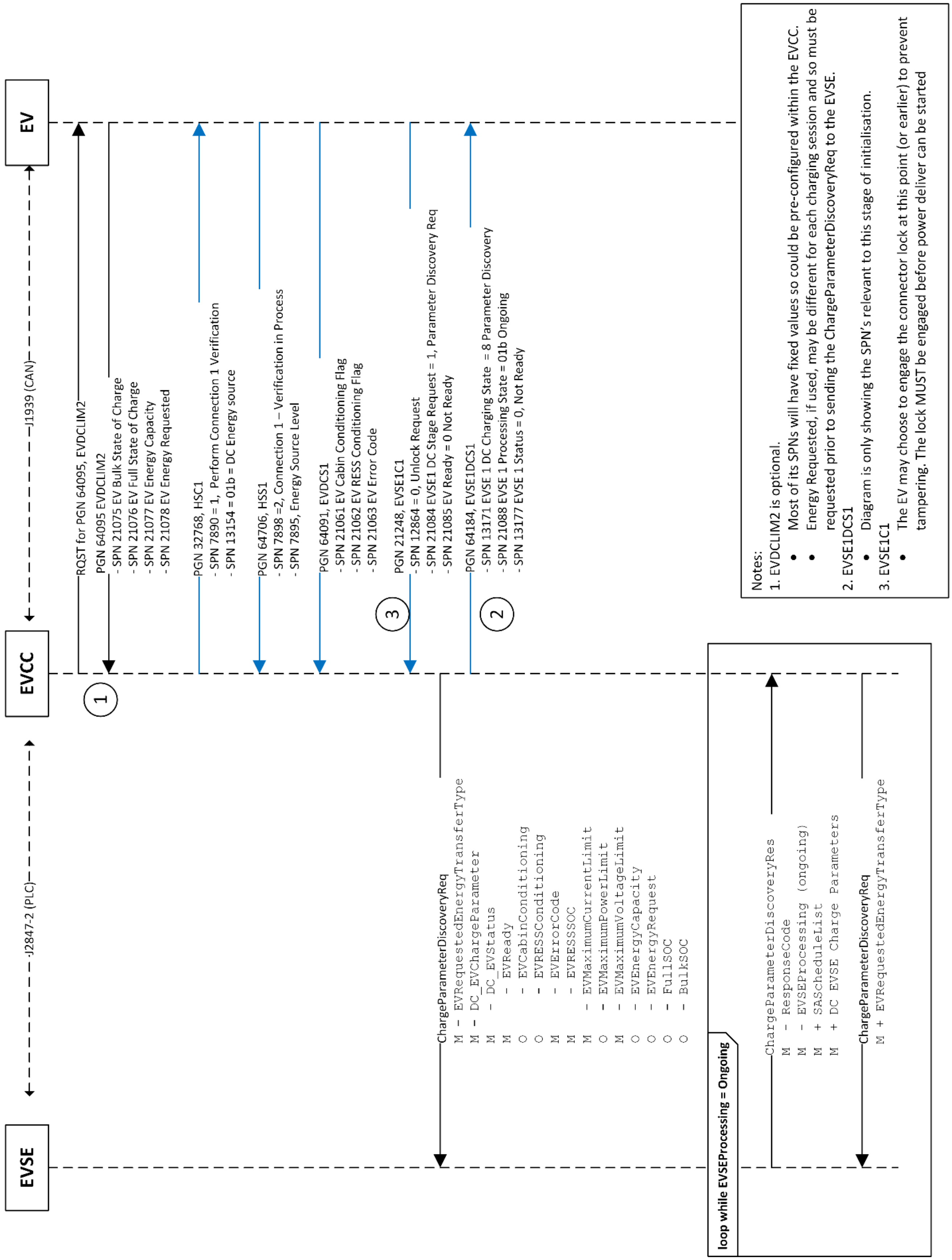
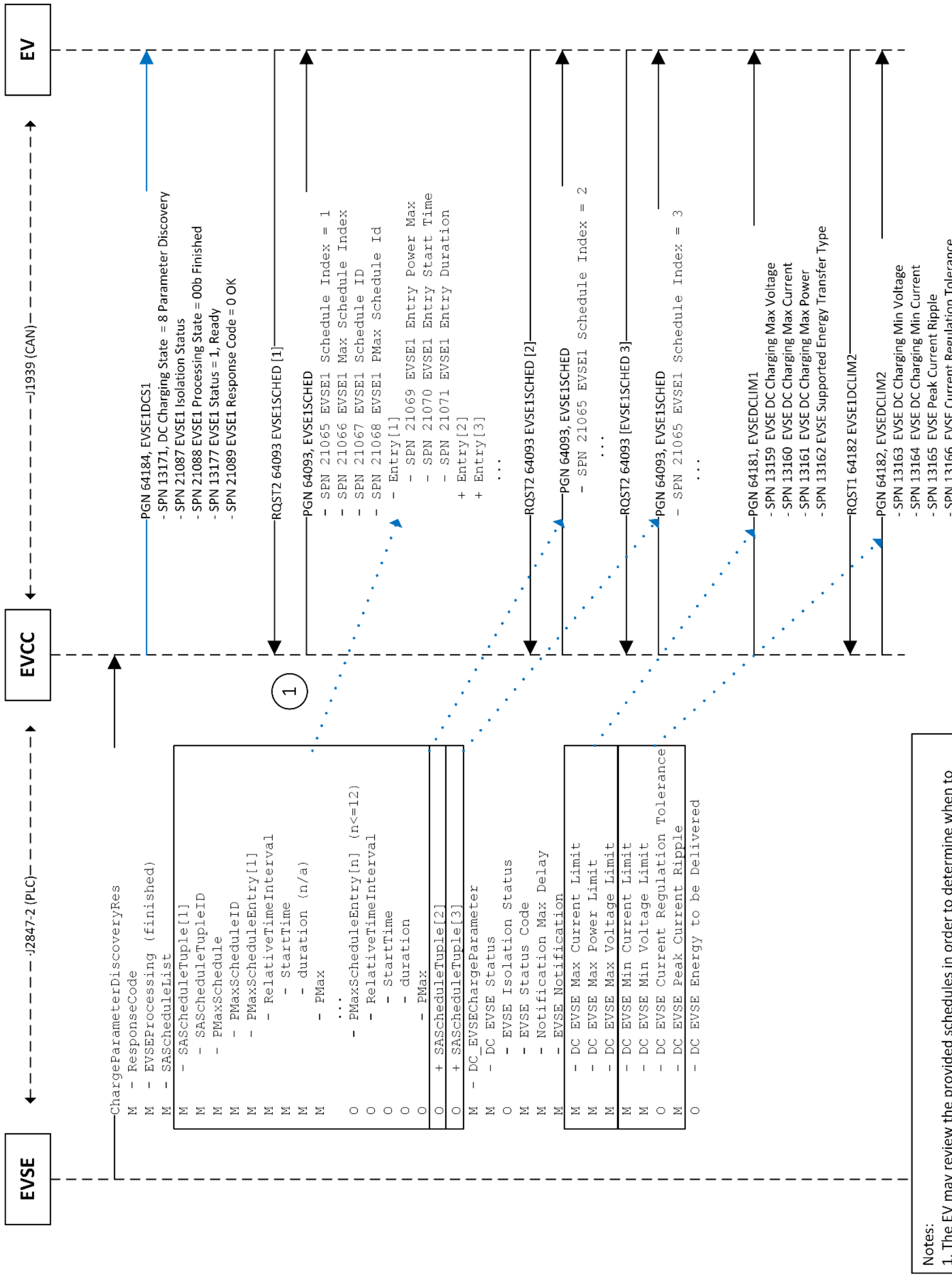


FIGURE PGN64180_G - CHARGE PARAMETERS-1, STAGE 3A/B



Notes:
1. The EV may review the provided schedules in order to determine when to start the actual charge cycle.

FIGURE PGN64180_H - CHARGE PARAMETERS-2, STAGE 3A/B

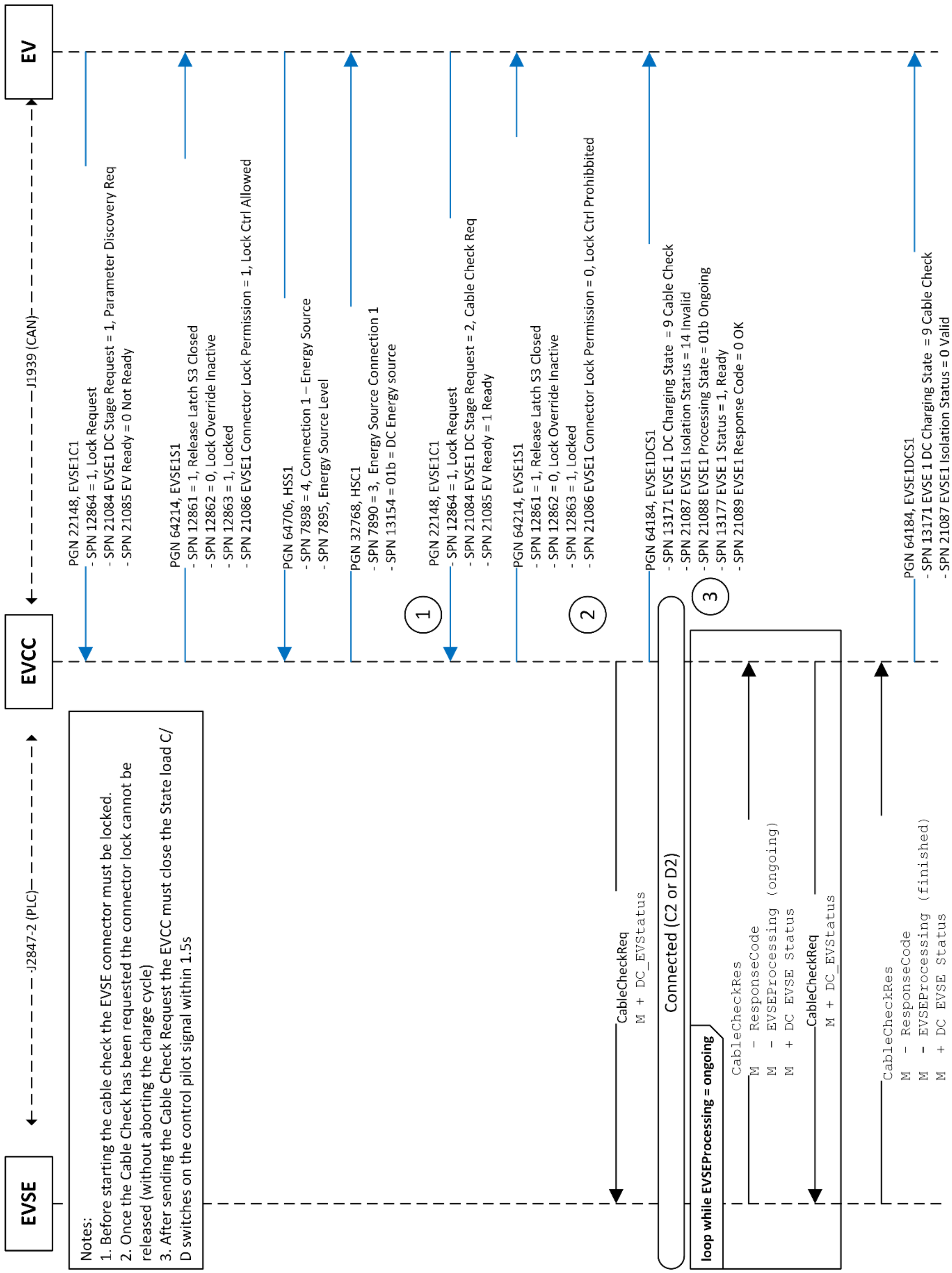


FIGURE PGN64180_I - CABLE CHECK, STAGE 4A/B

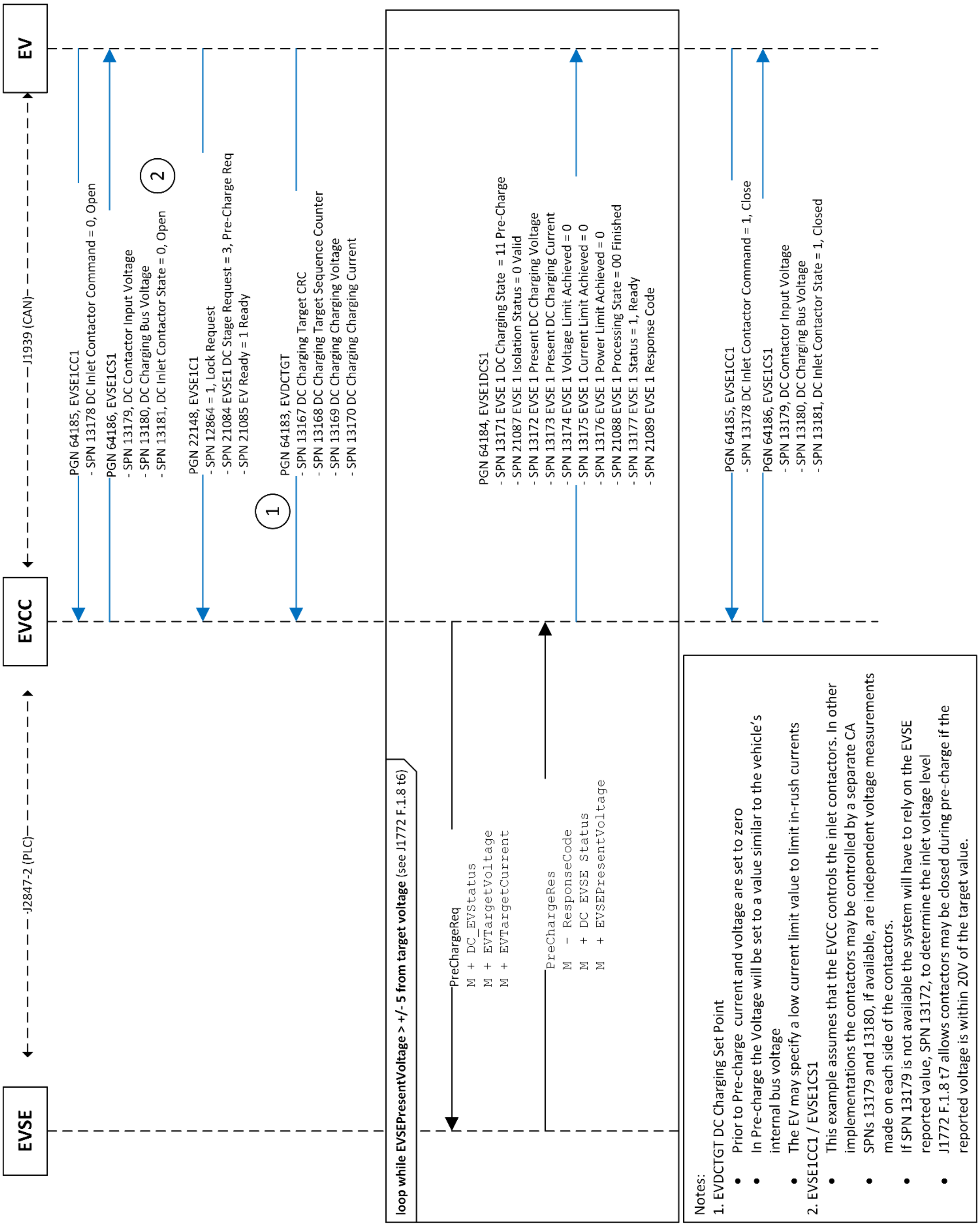


FIGURE PGN64180_J - PRE-CHARGE, STAGE 5A/B

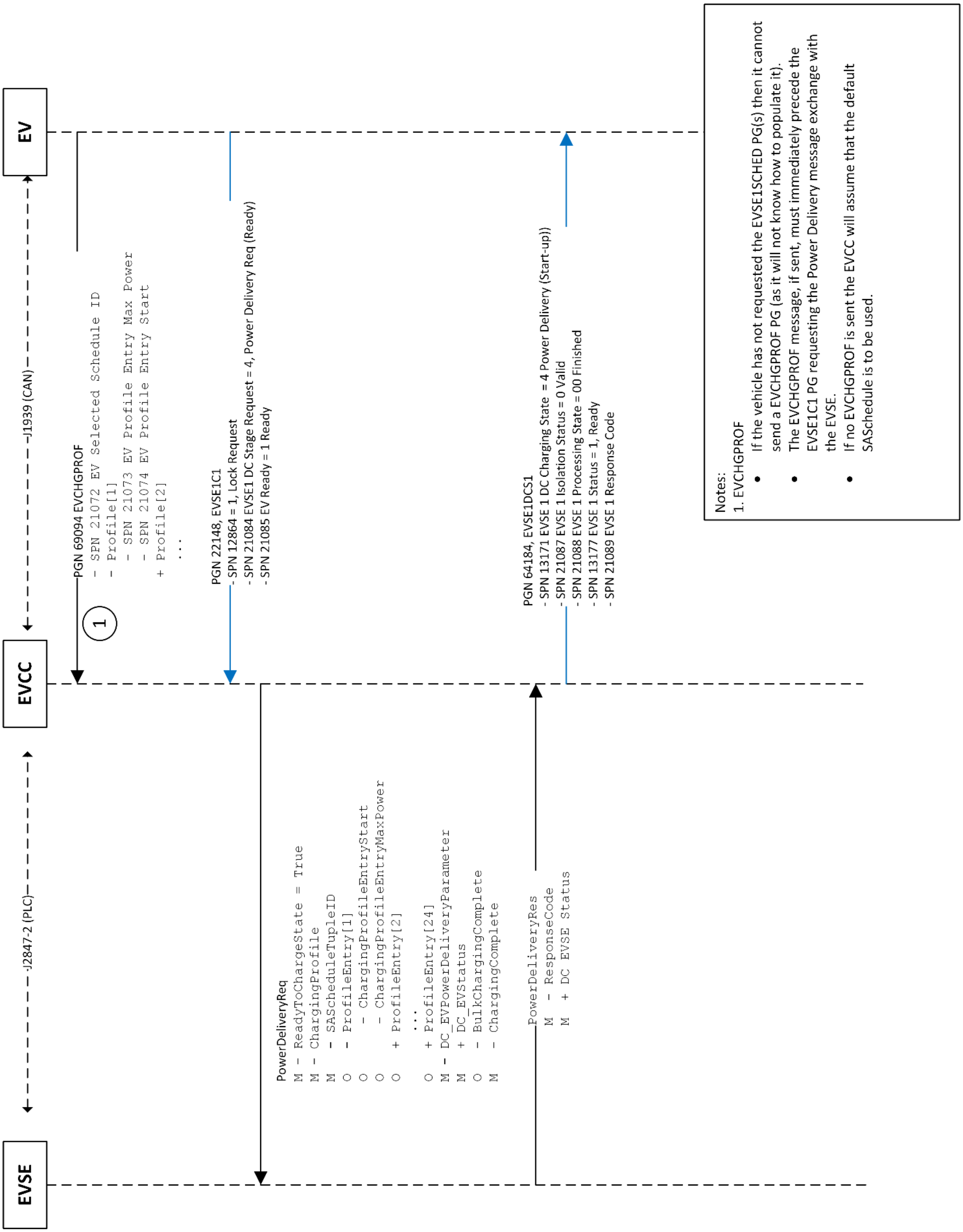
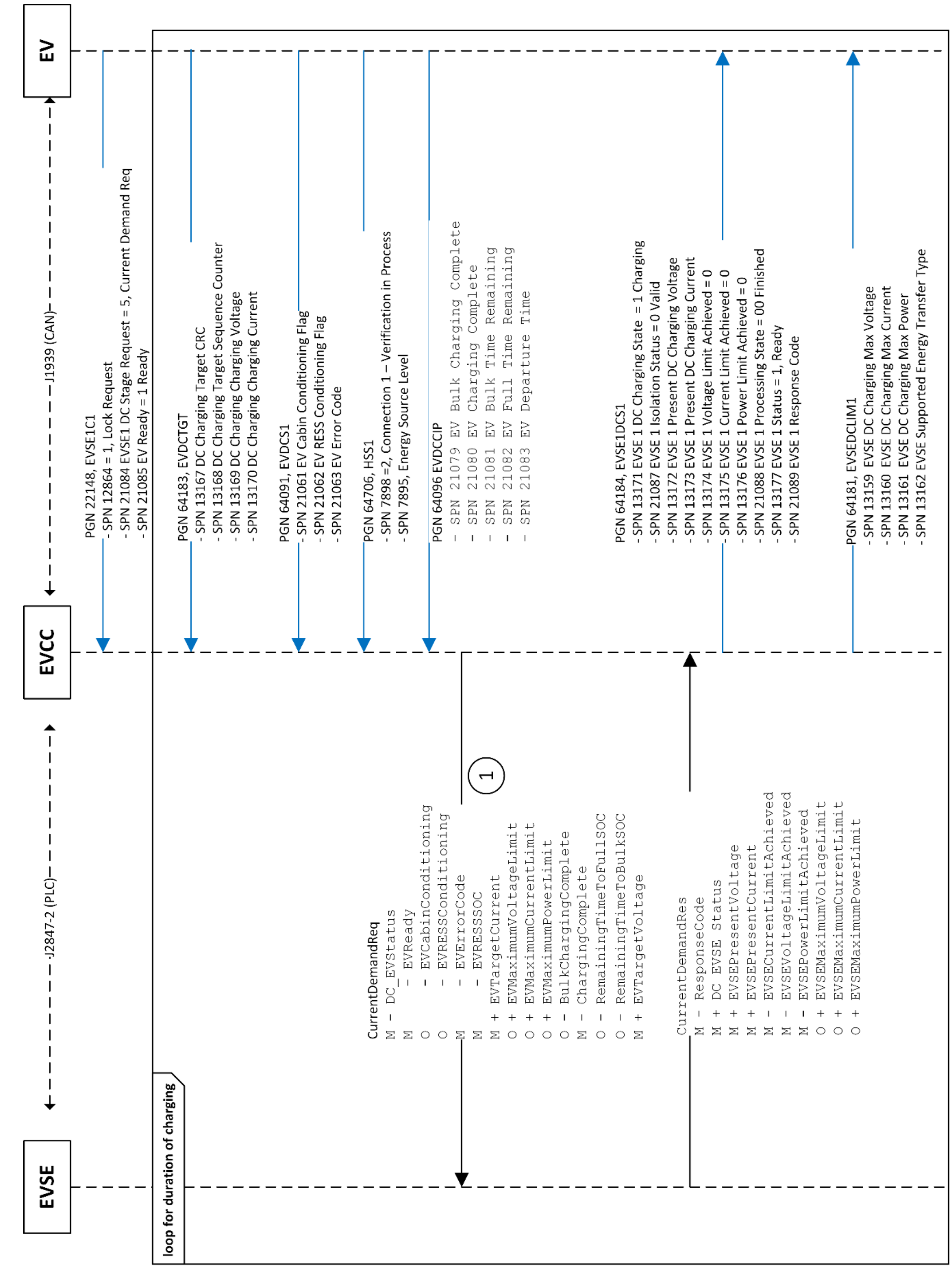


FIGURE PGN64180_K - POWER DELIVERY START-UP, STAGE 6A/B



Notes:
1. DC_EV_Status – EVRESSSOC is poulated using the value in HSS1, SPN 7895

FIGURE PGN64180_L - CURRENT DEMAND, STAGE 7A/B

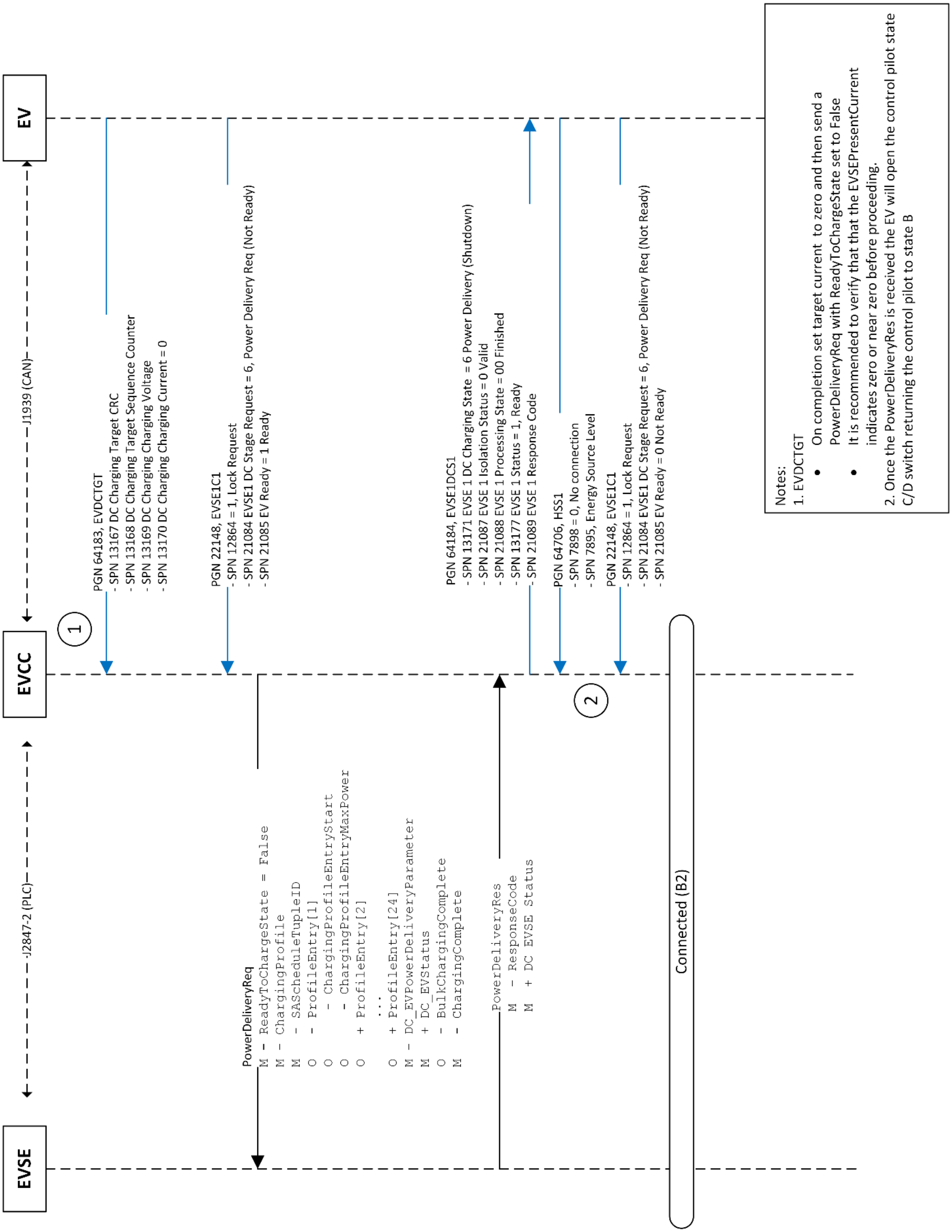


FIGURE PGN64180_M - POWER DELIVERY SHUTDOWN, STAGE 8A/B

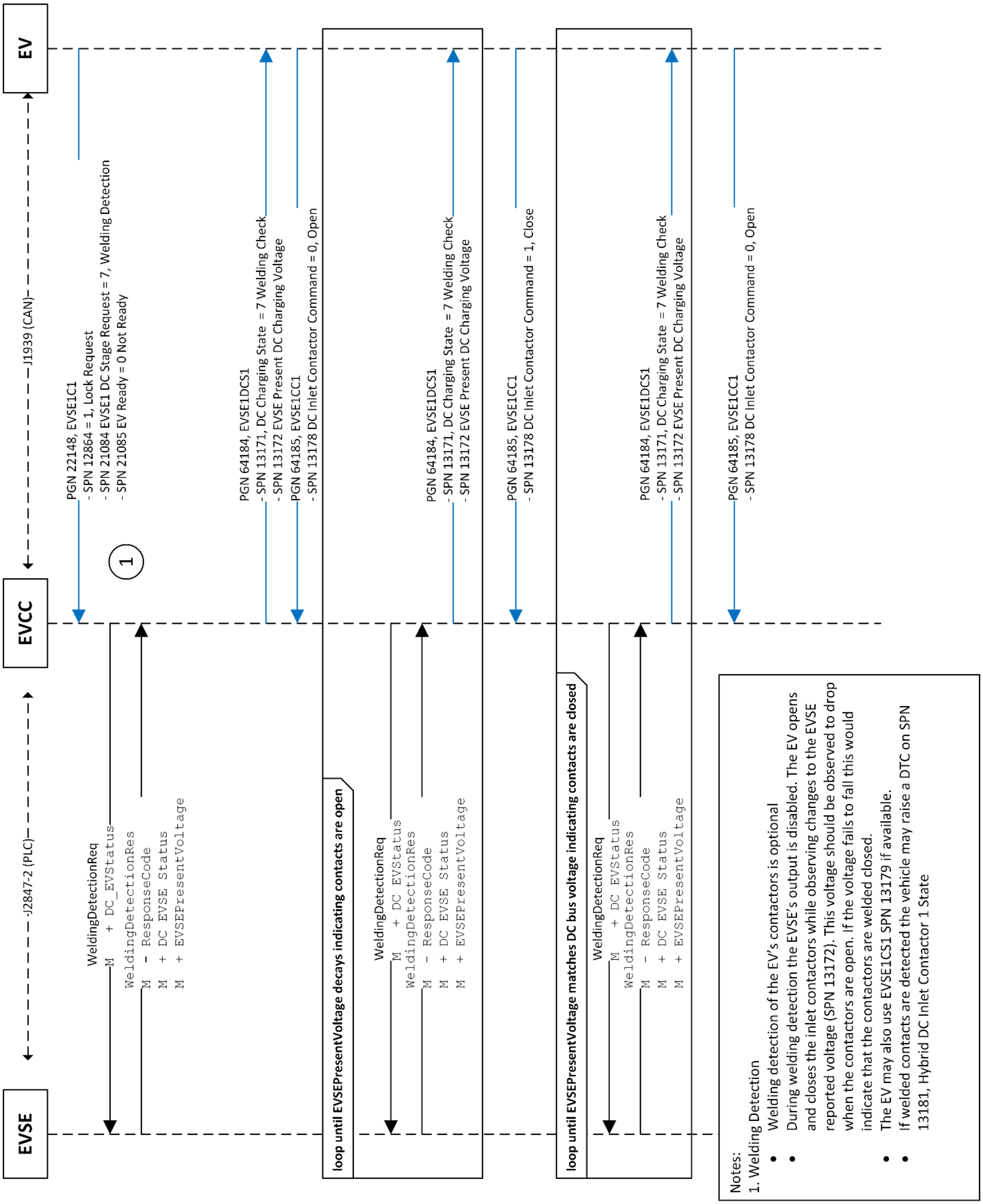


FIGURE PGN64180_N - WELDING DETECTION, STAGE 9A/B

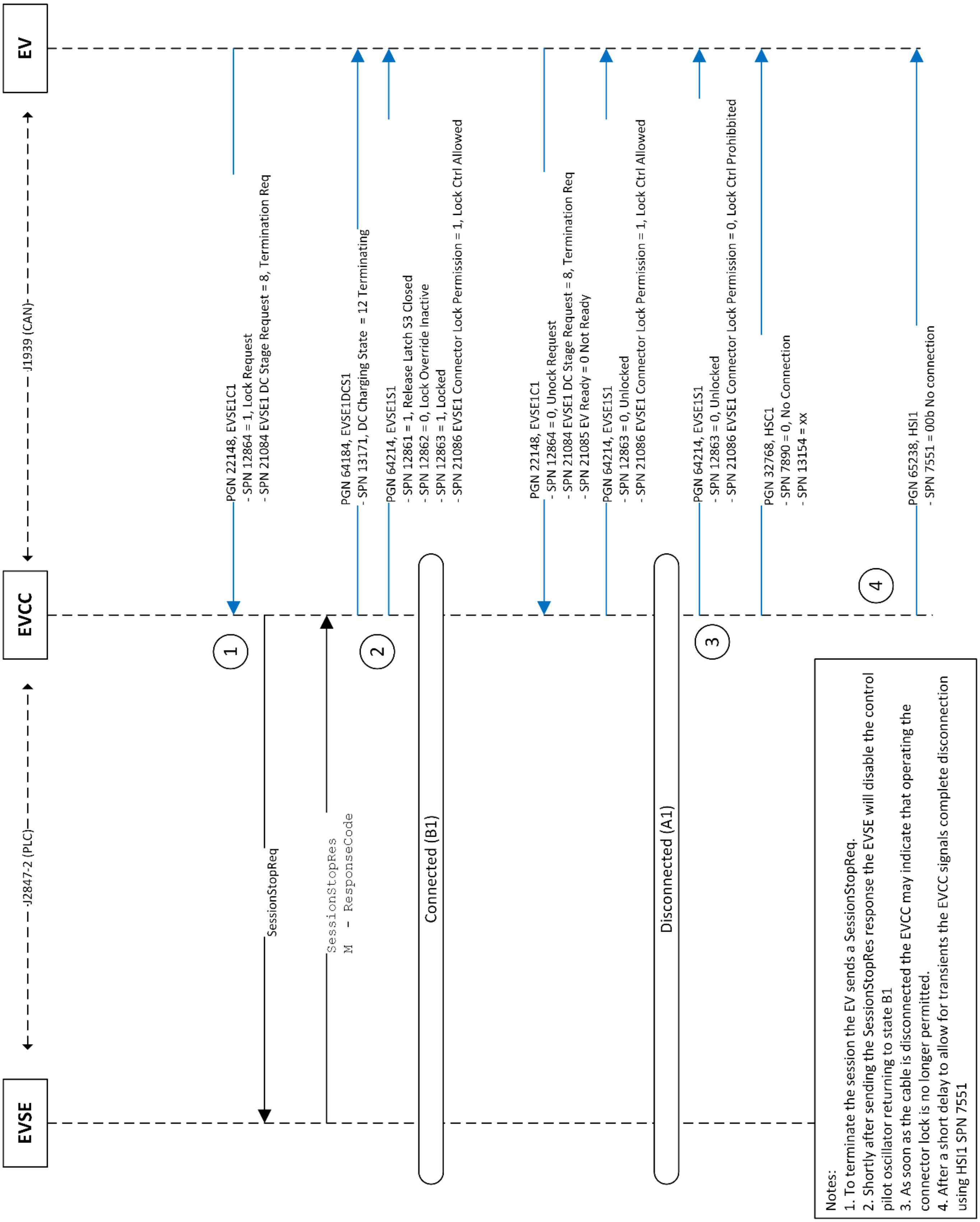


FIGURE PGN64180_O - SESSION STOP, STAGE 10A/B

A.82 PGN 64241 – GREEN HOUSE GAS [GHG] TRACKING FOR HYBRID AND EV DRIVETRAINS

PGs 64241, 64242, 64243, 64244, 64245, 64246 track Green House Gas [GHG] and electrical grid related parameters for Hybrid and EV drivetrains as identified in draft 13 CCR 1971.1 (h)(5). Time shall be accumulated while the vehicle is capable of movement, that is, when the [hybrid or electric] powertrain is capable of movement. Vehicles that do not incorporate electric drives in either a battery electric or a hybrid electric configuration are not required to support these PGs.

PGN	PG Label	PG Acronym
64241	PSA Times Lifetime Hours	PSATL
64242	PSA Times Stored 100 Hours	PSATS
64243	PSA Times Active 100 Hours	PSATA
64244	Hybrid Charge Depleting or Increasing Operation Lifetime Hours	HCDIOL
64245	Hybrid Charge Depleting or Increasing Operation Stored 100 Hours	HCDIOS
64246	Hybrid Charge Depleting or Increasing Operation Active 100 Hours	HCDIOA

Data is accumulated in three time frame works. The active 100 hour data accumulates data until 100 hours of Powertrain System Active (PSA) time has elapsed. The active 100 hour data is reset to zero after 100 PSA hours have elapsed and the data has been transferred into the Stored 100 hour data. The lifetime data is collected for the life of the vehicle. Data may be reset when the [hybrid/electric] system controller is updated with new software. Addends to the arrays must be estimated each second. These addends shall be correlated with each other in time.

Idle conditions are defined as v <= 1.6 km/h. Urban vehicle speeds are defined as 1.6 km/h <= v <= 60 km/h. The threshold value of 1.6 km/h may be implemented such that all vehicle speeds that are detected as 0 km/h using existing vehicle speed measurement technology may be considered to meet the idle threshold. It is not proposed or intended that new vehicle speed technology must be employed to accurately discriminate vehicle speeds between 0 and 5 km/h.

When GHG Tracking for Hybrid (including plugin capable) vehicles is supported there are two SPs that may be required to be reported in DM24 for datastream as described in SAE J1939-73:

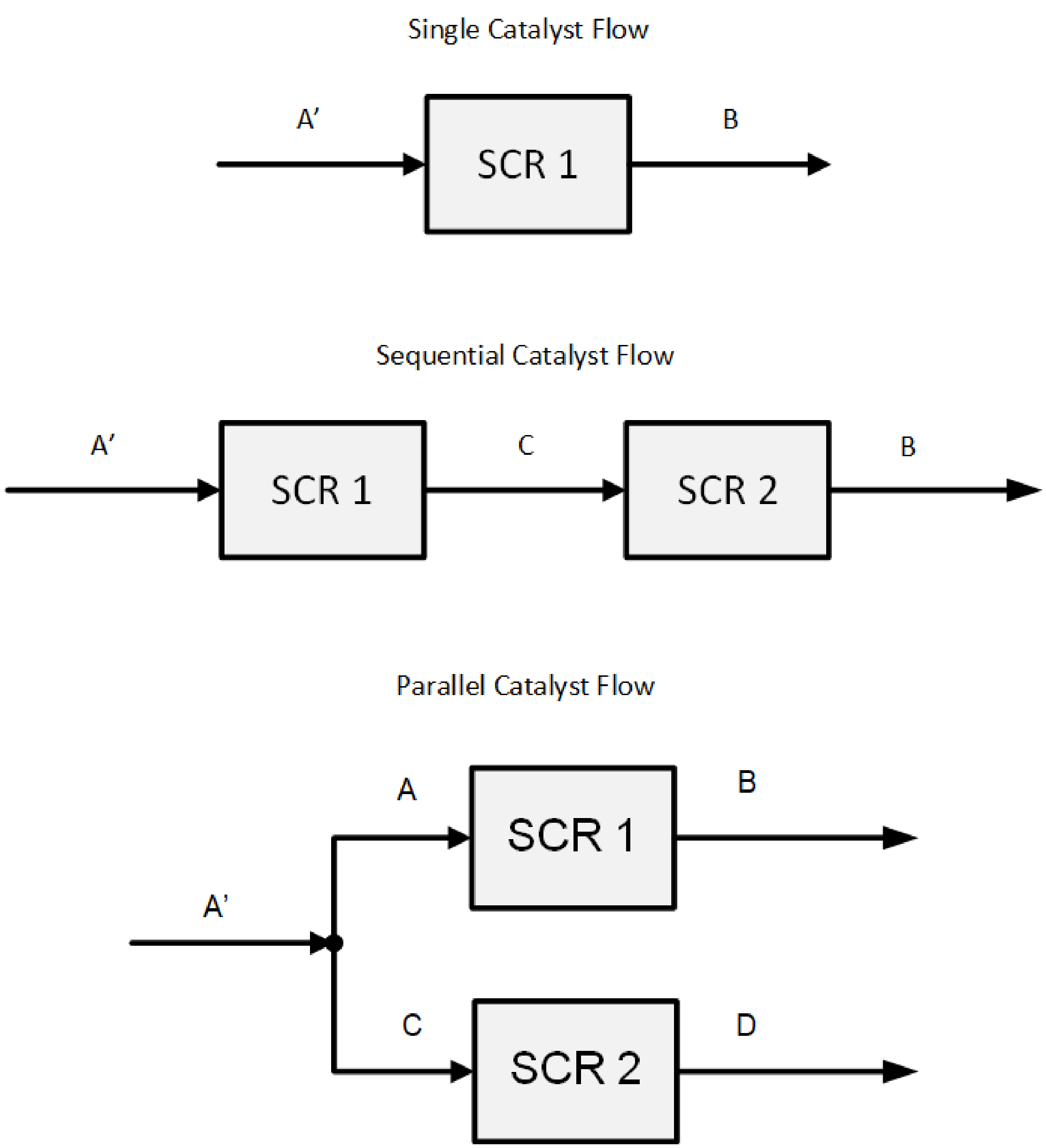
1. SPN 12797 (Hybrid Lifetime Propulsion System Active Time)
    - Indicates when the PSA related parameters are supported
2. SPN 12783 (Hybrid Lifetime Distance Traveled in Charge Depleting Operation with Engine off),
    - Indicates when the Hybrid Plugin related parameters are supported

It may be that one OBD controller will report SPN 12797 in DM24 and another OBD controller report SPN 12783 in a separate DM24. Or, one OBD controller may report both SPN 12797 and SPN 12783 in a single DM24 to indicate it provides all of the messages identified above.

A.83 PGN 64249 – AFTERTREATMENT 1 SCR NOX MASS AND NH3 STORAGE

PGN 64249 and PGN 64250 define NOx Mass and Ammonia Storage parameters for multiple aftertreatment configurations. A single catalyst, and two configurations of dual catalysts are accommodated by these messages. The figure below shows the use of the four NOx Mass SPs for the varied configurations. The inlet and outlet flows of the SCR catalysts are labeled with letters from the legend that match the SP to the inlet or outlet. PGN 64250 provides the overall view of engine out NOx and tailpipe NOx for both the single SCR and tandem SCR (with sequential flow) configurations. For the parallel configuration SPNs 12751 and 12755 must be summed to provide the total NOx flow.

These same figures are also used to organize SP conventions for NOx Concentration, Oxygen Concentration, Corrected NOx, DEF Dosing Quantity and SCR Catalyst Operating Mode. Both 3000 series and 7000 series SPs for NOx Concentration and Oxygen Concentration are shown in the legend to reflect all the available PGs. Location C provides expected SPs at the inlet of the second catalyst of a sequential flow configuration. Locations A and C also provide conventions for DEF dosing quantities and DEF dosing command SPs. New implementations with two SCR catalysts should provide two DEF dosing modes. *The new DEF dosing mode SP* is defined at location C for the second SCR catalyst.



NOx Mass: (location, SP)

A:	SP 12750 Aftertreatment 1 SCR 1 Engine Exhaust NOX Mass (Parallel Flow Inlet NOx)
A':	SP 12750 Aftertreatment 1 SCR 1 Engine Exhaust NOX Mass (Only Engine Outlet NOx Mass Measurement)
B:	SP 12751 Aftertreatment 1 SCR 1 Tailpipe NOX Mass (System Out NOx – Preferred / Parallel Flow SCR 1 Outlet)
C:	SP 12754 Aftertreatment 1 SCR 2 Intake NOX Mass (Sequential Flow SCR 1 Outlet NOx / Parallel Flow SCR 2 Inlet NOx)
D:	SP 12755 Aftertreatment 1 SCR 2 Outlet NOX Mass (Parallel Flow SCR 2 Tailpipe NOx)

NOx Concentration, 3000 series: (location, SP)

A:	SP 3216 Engine Exhaust 1 NOx 1 (Parallel Flow SCR 1 Inlet NOx PPM)
A':	SP 3216 Engine Exhaust 1 NOx 1 (Only Engine Outlet NOx PPM Measurement)
B:	SP 3226 Aftertreatment 1 Outlet NOx 1 (System Out NOx PPM / Parallel Flow SCR 1 Outlet NOx PPM)
C:	SP 3255 Engine Exhaust 2 NOx 1 (Sequential Flow SCR 2 Intake NOx PPM / Parallel Flow SCR 2 Inlet NOx PPM)
D:	SP 3265 Aftertreatment 2 Outlet NOx 1 (Parallel Flow SCR 2 Outlet/Tailpipe NOx PPM)

NOx Concentration, 7000 series: (location, SP)

A:	SP 7649 Engine Exhaust 1 NOx 2 (Parallel Flow SCR 1 Inlet NOx PPM)
A':	SP 7649 Engine Exhaust 1 NOx 2 (Only Engine Outlet NOx PPM Measurement)
B:	SP 7660 Aftertreatment 1 Outlet NOx 2 (System Out NOx PPM / Parallel Flow SCR 1 Outlet NOx PPM)
C:	SP 7671 Engine Exhaust 2 NOx 2 (Sequential Flow SCR 2 Intake NOx PPM / Parallel Flow SCR 2 Inlet NOx PPM)
D:	SP 7682 Aftertreatment 2 Outlet NOx 2 (Parallel Flow SCR 2 Outlet/Tailpipe NOx PPM)

Corrected NOx Concentration: (location, SP)

A:	SP 7353 Engine Exhaust 1 Corrected NOx (Parallel Flow SCR 1 Inlet Corrected NOx PPM)
A':	SP 7353 Engine Exhaust 1 Corrected NOx (Only Engine Outlet Corrected NOx PPM Estimate)
B:	SP 7351 Aftertreatment 1 Outlet Corrected NOx (System Out Corrected NOx PPM / Parallel Flow SCR 1 Corrected Outlet NOx PPM)
C:	SP 7354 Engine Exhaust 2 Corrected NOx (Sequential Flow SCR 2 Intake Corrected NOx PPM / Parallel Flow SCR 2 Intake Corrected NOx PPM)
D:	SP 7352 Aftertreatment 2 Outlet Corrected NOx (Parallel Flow SCR 2 Outlet/Tailpipe Corrected NOx PPM)

Oxygen Concentration, 3000 series: (location, SP)

A:	SP 3217 Engine Exhaust 1 Percent Oxygen 1 (Parallel Flow SCR 1 Inlet 1 O2 PPM)
A':	SP 3217 Engine Exhaust 1 Percent Oxygen 1 (Only Engine Outlet O2 PPM Measurement)
B:	SP 3226 Aftertreatment 1 Outlet NOx 1 (System Out O2 PPM)
C:	SP 3256 Engine Exhaust 2 Percent Oxygen 1 (Sequential Flow SCR 2 Intake O2 PPM / Parallel Flow SCR 2 Inlet O2 PPM)
D:	SP 3265 Aftertreatment 2 Outlet NOx 1 (Parallel Flow SCR 2 Outlet/Tailpipe NOx PPM)

Oxygen Concentration, 7000 series: (location, SP)

A:	SP 7650 Aftertreatment 1 Intake Percent Oxygen 2 (Parallel Flow SCR 1 Inlet 1 O2 PPM)
A':	SP 7650 Aftertreatment 1 Intake Percent Oxygen 2 (Only Engine Outlet O2 PPM Measurement)
B:	SP 7660 Aftertreatment 1 Outlet NOx 2 (System Out O2 PPM)
C:	SP 7672 Aftertreatment 2 Intake Percent Oxygen 2 (Sequential Flow SCR 2 Intake O2 PPM / Parallel Flow SCR 2 Inlet O2 PPM)
D:	SP 7682 Aftertreatment 2 Outlet NOx 2 (Parallel Flow SCR 2 Outlet/Tailpipe NOx PPM)

A.84 PGN 64252 – GREEN HOUSE GAS [GHG] TRACKING

PGs 64252, 64253, and 65245 provide data related to the fuel efficiency of the vehicle. The collected data is reported under three time frames. The active 100 hour data accumulates data until 100 hours of Powertrain System Active (PSA) time has elapsed. Vehicles that do not provide an electric drive shall use engine runtime instead of Powertrain system active time. The active 100 hour data is reset to zero after 100 PSA hours have elapsed and the data has been transferred into the Stored 100 hour data. The lifetime data is collected for the life of the vehicle. Displayed data should be no more than 10 seconds old when its broadcast is initiated.

PGN	PG Label	PG Acronym
64252	GHG Tracking Lifetime Array Data	GHGTL
64253	GHG Tracking Stored 100 Hour Array Data	GHGTS
64254	GHG Tracking Active 100 Hour Array Data	GHGTA

When GHG Tracking is supported only one SP, SPN 12730 (GHG Tracking Lifetime Engine Run Time) shall be reported in DM24 for datastream report as described in SAE J1939-73. Waste Heat Recovery Time and Distance is provided in the active technology messages to save space in the GHG tracking messages.

Positive Kinetic Energy (PKE) Ratio Calculations

The PKE ratio is a vehicle use metric that captures mission specific profiles of vehicle acceleration. The formula for the PKE ratio is shown below. The GHG tracking messages display the numerator separately from the denominator. Each second, the difference in vehicle speed (given in km/h) is checked with the vehicle speed from the prior second. When the vehicle has accelerated (V2 > V1), the difference between the squared velocities is added to the numerator. The denominator is the indefinite integral for the path length. The indefinite integral is the vehicle distance traveled under all circumstances, this distance is reported in the GHG tracking messages separately from numerator.

$$\text{PKE Ratio} = \frac{\Sigma\,(v_2^{\,2} - v_1^{\,2}) \text{ where } v_2 > v_1}{\int dS \text{ for all } v}$$

Example calculations for the PKE ratio are illustrated in the table below. Unlike the table, extrapolation of the vehicle speed into distance traveled over the second is not recommended. Existing means for estimating distance (shown here as dS), that do not extrapolate from vehicle speed are preferred for the estimation of the PKE denominator. The ratio is not reported – only the numerator and denominator are reported.

Example Second by Second PKE Ratio Calculation

Time (ms)	***(1) V2 km***	***(2) V1 km***	***(3) V2^2***	***(4) V1^2***	***(5) = (3)-(4) V2^2-V1^2 | V2>V1 (km/h)^2***	***(6) = ((2)+(1)) /2/3600 dS***	***(7) = Σ (5) Σ Delta V^2 PKE Numerator***	***(8) = Σ (6) Σ dS PKE Denominator***	***(9) = (7) / (8) Second by Second PKE Ratio***
6477068	16	29	256	841	FALSE	0.00625	92707	57.77944	1604.498
6478066	11	16	121	256	FALSE	0.00375	92707	57.78319	1604.394
6479065	12	11	144	121	23	0.003194444	92730	57.78639	1604.703
6480067	15	12	225	144	81	0.00375	92811	57.79014	1606.001
6481065	19	15	361	225	136	0.004722222	92947	57.79486	1608.223
6482160	24	19	576	361	215	0.005972222	93162	57.80083	1611.776
6483065	29	24	841	576	265	0.007361111	93427	57.80819	1616.155
6484065	37	29	1369	841	528	0.009166667	93955	57.81736	1625.031
6485065	39	37	1521	1369	152	0.010555556	94107	57.82792	1627.363
6486068	41	39	1681	1521	160	0.011111111	94267	57.83903	1629.816
6487065	41	41	1681	1681	FALSE	0.011388889	94267	57.85042	1629.496
6488065	41	41	1681	1681	FALSE	0.011388889	94267	57.86181	1629.175

GHG Parameter Notes

SPN	SP Name	SP Description and Notes
12730	GHG Tracking Lifetime Engine Run Time	Accumulated engine run time over the lifetime of the vehicle for GHG Tracking. *Note: Calculation methods used for SPN 247 may be extended to support SPN 12730, which is subject to the pause conditions given in (h)(5.7.5). PSA time is to be used for xEVs.*
12731	GHG Tracking Lifetime Vehicle Distance	Accumulated vehicle distance over the lifetime of the vehicle for GHG Tracking. *Note: Calculation methods used for SPN 245 may be extended to support SPN 12731, which is subject to the pause conditions given in (h)(5.7.5). SPN 12731 provides the denominator for the PKE ratio.*
12732	GHG Tracking Lifetime Vehicle Fuel Consumption	Accumulated vehicle fuel consumption over the lifetime of the vehicle for GHG Tracking. *Note: Calculation methods used for SPN 250 may be extended to support SPN 12732, provided that the data combines both engine power and aftertreatment dosing fuel use,subject to the pause conditions given in (h)(5.7.5).*
12733	GHG Tracking Lifetime Engine Fuel Consumption	Accumulated engine fuel consumption over the lifetime of the vehicle for GHG Tracking. *Note: Data used for SPN 12733 must not include fuel that was used for aftertreatment dosing. Like SPN 12732, calculation methods for SPN 250 may be extended for SPN 12732, subject to the pause conditions given in (h)(5.7.5).*
12734	GHG Tracking Lifetime Engine Output Energy	Accumulated engine output energy over the lifetime of the vehicle for GHG Tracking. *See NOx Binning message notes for Engine Output Energy Calculations.*
12735	GHG Tracking Lifetime Positive Kinetic Energy Numerator	Accumulated positive kinetic energy numerator (as delta-V-squared) over the lifetime of the vehicle for GHG Tracking. The PKE Denominator is provided by GHG Tracking Lifetime Vehicle Distance *SPN 12731*. *See PKE calculation notes above.*
12736	GHG Tracking Lifetime Urban Speed Run Time	Accumulated time at urban vehicle speeds over the lifetime of the vehicle for GHG Tracking. *Urban vehicle speeds are (1.6 km/h < v < 60 km/h).*
12737	GHG Tracking Lifetime Idle Run Time	Accumulated engine run time under idle conditions over the lifetime of the vehicle for GHG Tracking. *Note: Calculation methods used for SPN 235 may be extended to support SPN 12737, which is subject to the pause conditions given in (h)(5.7.5). Idle vehicle speeds are less than or equal to 1.6 km/n (v <= 1.6 km/h).*
12738	GHG Tracking Lifetime Engine Idle Fuel Consumption	Accumulated fuel consumption under idle conditions over the lifetime of the vehicle for GHG Tracking. *Note: Calculation methods used for SPN 246 may be extended to support SPN 12738, which is subject to the pause conditions given in (h)(5.7.5).*
12739	GHG Tracking Lifetime Engine Power Take Off Run Time	Accumulated engine runtime under power take off [PTO] governor control over the lifetime of the vehicle for GHG Tracking. *Note: Calculation methods used for SPN 248 may be extended to support SPN 12739 which is subject to the pause conditions given in (h)(5.7.5).*
12740	GHG Tracking Lifetime Engine Power Take Off Fuel Consumption	Accumulated fuel consumption under power take off [PTO] governor control over the lifetime of the vehicle for GHG Tracking. Note: *Calculation methods used for SPN 1028 may be extended to support SPN 12740, which is subject to the pause conditions given in (h)(5.7.5).*
12741	GHG Tracking Lifetime Automatic Engine Shutdown Technology Activation Count	Accumulated activation counts of the automatic engine [idle] shutdown (AES) system over the lifetime of the vehicle for GHG Tracking. *Note: This count shall not include engine shutdowns that result from the vehicle being stopped at a traffic light.*

The same data sources used for the lifetime data shall also be used for the Active 100 hour and Stored 100 hour data.

Addends to the arrays must be estimated each second. These addends shall be correlated with each other in time. When both NOx Binning data and GHG Tracking data addends are estimated the addends for NOx Binning shall be correlated with the addends for GHG Tracking.

Idle conditions are defined as v <= 1.6 km/h. Urban vehicle speeds are defined as 1.6 km/h <= v <= 60 km/h. The threshold value of 1.6 km/h may be implemented such that all vehicle speeds that are detected as 0 km/h using existing vehicle speed measurement technology may be considered to meet the idle threshold. It is not proposed or intended that new vehicle speed technology must be employed to more accurately discriminate vehicle speeds between 0 and 5 km/h.

GHG Tracking Pause Conditions from (h)(5.7.5)

GHG Tracking pause conditions separate GHG data values from traditional HD engine data collection for engine hours, fuel used, vehicle distance and others. When GHG data accumulation is paused, the traditional data collection processes continues to provide vehicle owners and operators with access to the data they use in their operations.

The pause conditions for GHG Tracking in (h)(5.7.5) state:
(h)(5.7.5) The OBD system shall pause tracking of all parameters listed in sections (h)(5.4), (5.5), and (5.6) within 10 seconds if any of the conditions in sections (h)(5.7.5)(A) through (C) below occur. When the condition no longer occurs (e.g., the engine stop lamp is not commanded on), tracking of all parameters in sections (h)(5.4), (5.5), and (5.6) shall resume within 10 seconds:
(A) A malfunction of any component used to determine vehicle speed has been detected and the MIL is commanded on for that malfunction;
(B) A NOx sensor malfunction has been detected and the MIL is commanded on for that malfunction; or
(C) The engine stop lamp (if equipped) is commanded on.
(h)(5.7.6) The manufacturer may request Executive Officer approval to pause tracking of all parameters listed in sections (h)(5.4), (5.5), and (5.6) if a malfunction occurs that is not covered under sections (h)(5.7.5)(A) through (C) above (e.g., a light is commanded on for vehicles with no engine stop lamps such that the driver is likely to stop the vehicle, the odometer is lost, a malfunction of any component used as a primary input to the exhaust gas flow model occurs). The Executive Officer shall approve the request upon determining based on manufacturer submitted data and/or engineering evaluation that the malfunction will significantly affect the accuracy of the parameter values specified under section (h)(5.3.1).
These conditions mirror the pause conditions for NOx Binning in (h)(5.3.6).

Liquid Fuel Adjustment Factoring for Gaseous Fuels and other Alternative Fuels

Vehicles employing gaseous fuels whether compressed or liquified or other alternative fuel shall scale the fuel consumed into a diesel fuel equivalent by using Carbon mass fraction of the alternative fuel divided by the Carbon mass fraction of certified diesel fuel multiplied by volume per kg of certified diesel fuel at 20-25 degrees Celsius.

A.85 PGN 64255 – GREEN HOUSE GAS [GHG] ACTIVE TECHNOLOGY TRACKING

Active technology utilization for minimizing fuel use is provided as defined in PGNs 64255, 64256, and 64257. The utilization is tracked as time and distance in three time frames. The active 100 hour time frame accumulates time and distance for a duration of up to 100 hours. These times and distances are stored as the stored 100 hour display when 100 hours has elapsed and the active 100 hours and distances are reset to zeros. The Lifetime active technology tracking message tracks the utilization time and distance for the full life of the vehicle. Addends to the arrays must be estimated each second. Displayed data for active 100 hour and lifetime messages should be no more than 10 seconds old when its broadcast is initiated.

Lifetime tracking is limited to the life of the engine block or engine ECM. Data values may be reset to zero when new software is installed in the engine ECM. Utilization time shall be tracked with the vehicle in motion. Utilization time shall include those seconds where the engine is not powering the driveline in a hybrid vehicle.

PGN	PG Label	PG Acronym
64255	Green House Gas Stored 100 Hour Active Technology Tracking	GHGTTS
64256	Green House Gas Active 100 Hour Active Technology Tracking	GHGTTA
64257	Green House Gas Lifetime Active Technology Tracking	GHGTTL

When GHG Active Technology Tracking is supported only one SP, SPN 12691 [GHG Tracking Lifetime Active Technology Index], shall be reported in DM24 for datastream support as described in SAE J1939-73. Waste Heat Recovery Time and Distance is provided in the active technology messages to save space in the GHG tracking messages.

Iterative PG Structure

A common, iterative SP strategy is used for each of these three messages. Three SP types which labeled as a, b, and c are used repeatedly in each of the three PGs above.

a	GHG Tracking - Active Technology Index	SPs 12691, 12694, and 12697
b	GHG Tracking - Active Technology Time	SPs 12692, 12695, and 12698
c	GHG Tracking - Technology Vehicle Distance	SPs 12693, 12696, and 12699

Each of the SPNs a, b, and c are repeated in the display message for each active technology that is tracked. SPN a (SPNs 12691, 12694, and 12697) defines the index number for technology. A supported index number shall appear in each of the displays for PGNs 64255, 64256, and 64257. SPN b provides the time accumulated while the active technology is deployed to reduce fuel consumption. SPN c provides the distance accumulated while the active technology is deployed. Example messages are shown below.

SPs 12691, 12694, and 12697: Common Active Technology Key Table for SPN a

The index numbers allowed for SPN a in each active technology tracking PG are described in the table below.

Standardized GHG Active Technology Enumeration	Manufacturer Defined GHG Active Technology Enumeration
0, SAE/ISO Reserved	243, Manufacturer Defined Active Technology 8
1, [Engine Controlled] Waste Heat Recovery	244, Manufacturer Defined Active Technology 7
2, Cylinder Deactivation	245, Manufacturer Defined Active Technology 6
3, [Engine Controlled] Active Aerodynamics	246, Manufacturer Defined Active Technology 5
4, [Engine Participating] Intelligent Control	247, Manufacturer Defined Active Technology 4
5, [Engine Controlled] Vehicle Speed Limiting Technology	248, Manufacturer Defined Active Technology 3
6, [Engine Controlled] Predictive Cruise Control	249, Manufacturer Defined Active Technology 2
7, [Engine Controlled] Auto Neutral	250 (FAh), Manufacturer Defined Active Technology 1
8-242, SAE/ISO Reserved	251-255, SAE/ISO Reserved

Note: 251-255 (FBh, FCh, FDh, FEh and FFh) shall not be used as they convey special values according to SAE J1939-71.

Note: Additional Standardized GHG Active Technology Enumerations may be assigned starting at the lowest value in the SAE/ISO Reserved range. Additional Manufacturer Defined GHG Active Technology Enumerations may be assigned starting at the highest value in the SAE/ISO Reserved range.

Example GHG Active Technology Message Structures

The message structure examples below show how SPNs a, b, and c are repeated to create the iterative structure. The lifetime active technology tracking uses 4 byte accumulators. SPs 12691, 12692, and 12693 are repeated sequentially to provide data for multiple active technologies. The active technology that is tracked is identified with the label for the technology in SPN a that precedes the time in SPN b and distance in SPN c.

PGN 64257 Green House Gas Lifetime Active Technology Tracking Example Message Structure

Start Position	End Position	Length	Parameter Name	SPN
1		1 byte	GHG Lifetime Technology Index	a. SPN 12691
2	5	4 byte	GHG Lifetime Technology Time	b. SPN 12692
6	9	4 byte	GHG Lifetime Technology Distance	c. SPN 12693
10		1 byte	GHG Lifetime Technology Index	a. (2nd technology listed)
11	14	4 byte	GHG Lifetime Technology Time	b. (2nd technology listed)
15	18	4 byte	GHG Lifetime Technology Distance	c. (2nd technology listed)
…				
(n-1) * 9 + 1		1 byte	GHG Lifetime Technology Index	a. (nth technology listed)
(n-1) * 9 + 2	(n-1) * 9 + 5	4 byte	GHG Lifetime Technology Time	b. (nth technology listed)
(n-1) * 9 + 6	(n-1) * 9 + 9	4 byte	GHG Lifetime Technology Distance	c. (nth technology listed)

PGN 64255 Green House Gas Stored 100 Hour Active Technology Tracking Example Message Structure
PGN 64256 Green House Gas Active 100 Hour Active Technology Tracking Example Message Structure

PGN 24255 and PGN 24256 share the same structure example because both use identical 2 byte time and distance representations.

Start Position	End Position	Length	Parameter Name	SPN
1		1 byte	GHG Active Technology Index	a. SPN 12694 / 12697
2	3	2 bytes	GHG Active Technology Time	b. SPN 12695 / 12698
4	5	2 bytes	GHG Active Technology Distance	c. SPN 12696 / 12699
6		1 byte	GHG Active Technology Index	a. (2nd technology listed)
7	8	2 bytes	GHG Active Technology Time	b. (2nd technology listed)
9	10	2 bytes	GHG Active Technology Distance	c. (2nd technology listed)
…				
(n-1) * 5 + 1		1 byte	GHG Active Technology Index	a. (nth technology listed)
(n-1) * 5 + 2	(n-1) * 5 + 3	2 bytes	GHG Active Technology Time	b. (nth technology listed)
(n-1) * 5 + 4	(n-1) * 5 + 5	2 bytes	GHG Active Technology Distance	c. (nth technology listed)

A.86 PGN 64258 – NOX BINNING

CARB's REAL program demands the summation of NOx emissions over the lifetime of the vehicle. The requirements of the REAL program are described in 13 CCR 1971.1 (h)(5). Fuel consumption, engine hours, vehicle distance, and engine output energy are all summed in addition to engine out and tailpipe NOx. Data is allocated across a total of 17 bins. The definitions for these bins is provided by the table below. Additional guidelines are provided for the estimation of data items and identification of operating conditions. When NOx Binning messages are supported, only one SPN, SPN 12675 [NOx Tracking Engine Activity Lifetime Fuel Consumption Bin 1 (Total)], shall be reported in DM24 for datastream support as described in SAE J1939-73.

PGN	PG Label	PG Acronym
64258	NOx Tracking Engine Activity Lifetime Fuel Consumption Bins	NTFCEA
64259	NOx Tracking Engine Activity Lifetime Engine Run Time Bins	NTEHEA
64260	NOx Tracking Engine Activity Lifetime Vehicle Distance Bins	NTVMEA
64261	NOx Tracking Engine Activity Lifetime Engine Output Energy Bins	NTEEEA
64262	NOx Tracking Valid NOx Lifetime Fuel Consumption Bins	NTFCV
64263	NOx Tracking Valid NOx Lifetime Engine Run Time Bins	NTEHV
64264	NOx Tracking Valid NOx Lifetime Vehicle Distance Bins	NTVMV
64265	NOx Tracking Valid NOx Lifetime Engine Output Energy Bins	NTEEV
64266	NOx Tracking Valid NOx Lifetime Engine Out NOx Mass Bins	NTENV
64267	NOx Tracking Valid NOx Lifetime System Out NOx Mass Bins	NTSNV
64268	NOx Tracking Stored 100 Hour Fuel Consumption Bins	NTFCS
64269	NOx Tracking Stored 100 Hour Engine Run Time Bins	NTEHS
64270	NOx Tracking Stored 100 Hour Vehicle Distance Bins	NTVMS
64271	NOx Tracking Stored 100 Hour Engine Output Energy Bins	NTEES
64272	NOx Tracking Stored 100 Hour Engine Out NOx Mass Bins	NTENS
64273	NOx Tracking Stored 100 Hour System Out NOx Mass Bins	NTSNS
64274	NOx Tracking Active 100 Hour Fuel Consumption Bins	NTFCA
64275	NOx Tracking Active 100 Hour Engine Run Time Bins	NTEHA
64276	NOx Tracking Active 100 Hour Vehicle Distance Bins	NTVMA
64277	NOx Tracking Active 100 Hour Engine Output Energy Bins	NTEEA
64278	NOx Tracking Active 100 Hour Engine Out NOx Mass Bins	NTENA
64279	NOx Tracking Active 100 Hour System Out NOx Mass Bins	NTSNA

Each of these PGs provides 17 bins to categorize Fuel Consumption, Engine Hours, Vehicle Distance, Engine Output Energy, and NOx mass. The bin definitions for the NOx binning arrays is shown in the table below. When the conditions in the top row and left most column are met, the indicated field contains the index number that is to be used for all parameters estimated during the one second sampling period.

NOx Bin Definitions from draft 13 CCR 1971.1

Vehicle Speed / Engine Power	**0 kph**	**> 0 – 16 kph**	**>16 – 40 kph**	**>40 – 64 kph**	**>64 kph**
kW% > 50% Rated	Bin 2, [one bin for all power levels at 0 kph]	Bin 11	Bin 12	Bin 13	Bin 14
25% Rated < kW% <= 50% Rated		Bin 7	Bin 8	Bin 9	Bin 10
kW% <= 25% Rated		Bin 3	Bin 4	Bin 5	Bin 6
All, [MIL Off]	Bin 1 is the sum of bins 2 through 14				
All, NTE Conditions Met	Bin 15, All NTE Conditions are met as described in 40 CFR 86.1370. This subtotal is kept independently of Bins 1 – 14, 16				
All, Engine Commanding Active DPF Regen	Bin 16, Active PM Filter Regeneration is being commanded (e.g. the HC doser is being (was recently) used to ignite the Carbon Black in the DPF).				
All, MIL On	***Bin 17, MIL On Bin. Bins 1-16 are used only with the MIL off.***				

Notes:

1. Bin 17 is the only bin that shall be used when the MIL is on. Bins 1-16 are only used when the MIL is off.
2. When the MIL is off, each sample is added to Bin 1.
3. The sample shall also be added to one of bins 2 through 14 based on vehicle speed and engine power output.
4. Each sample shall also be added to bin 15 when all the NTE conditions given in 40 CFR 86.1370 have been met. Specific content from section 1370 is provided below..
5. Each sample shall also be added to bin 16 if the ECM is commanding (conducting) an active DPF regeneration.
6. Use of Bins 15 and 16 are not specifically defined to be mutually exclusive events.
7. The engine output energy estimate for one second shall be divided by SPN 166 Engine Rated Power to determine the engine power percent.
8. One second data addends are added to three sets of bins, lifetime, engine activity, and active 100 hour when NOx sensors are active. Only the engine activity bins are used when one or more NOx sensors are inactive
9. Additional criteria are defined in 13 CCR 1971.1 for the suspension of data binning altogether.
10. The threshold vehicle speed value of 1.6 km/h may be implemented such that all vehicle speeds that are detected as 0 km/h using existing vehicle speed measurement technology may be considered to meet the idle threshold. It is not proposed or intended that new vehicle speed technology must be employed to accurately discriminate vehicle speeds between 0 and 5 km/h.

NOx Binning Pause Conditions from (h)(5.3.6)

(h)(5.3.6) Pause conditions for tracking:

(A) Except for malfunctions described in section (h)(5.3.6)(B) below, the OBD system shall continue tracking all parameters listed in section (h)(5.3.1) if a malfunction has been detected and the MIL is commanded on. Within 10 seconds of the MIL being commanded on, tracked data shall only be stored in Bin 17 as described in section (h)(5.3.3)(H) and storage of data in all other bins (Bins 1-16) shall be paused. When the malfunction is no longer detected and the MIL is no longer commanded on, tracking of all parameters in section (h)(5.3.1) shall resume in Bins 1-16 and shall pause in Bin 17 within 10 seconds.

(B) The OBD system shall pause tracking of all parameters listed in section (h)(5.3.1) within 10 seconds if any of the conditions in sections (h)(5.3.6)(B)(i) through (iii) below occur. When the condition no longer occurs (e.g., the engine stop lamp is not commanded on), tracking of all parameters in section (h)(5.3.1) shall resume within 10 seconds:
(i) A malfunction of any component used to determine vehicle speed has been detected and the MIL is commanded on for that malfunction;
(ii) A NOx sensor malfunction has been detected and the MIL is commanded on for that malfunction;
(iii) The engine stop lamp (if equipped) is commanded on.

(C) The manufacturer may request Executive Officer approval to pause tracking of all parameters listed in section (h)(5.3.1) if a malfunction occurs that is not covered under sections (h)(5.3.6)(B)(i) through (iii) above (e.g., a light is commanded on for vehicles with no engine stop lamps such that the driver is likely to stop the vehicle, the odometer is lost, a malfunction of any component used as a primary input to the exhaust gas flow model occurs). The Executive Officer shall approve the request upon determining based on manufacturer submitted data and/or engineering evaluation that the malfunction will significantly affect the accuracy of the parameter values specified under section (h)(5.3.1).

Binning Criteria

The REAL program given in draft (h)(5.3) requires the collection of six parameters based on vehicle operating conditions.

(A) NOx mass – engine out (g);
(B) NOx mass – tailpipe (g);
(C) Engine output energy (EOE) (kWh);
(D) Distance traveled (km);
(E) Engine run time (hours);
(F) Vehicle fuel consumption (liters)

Key operating condition provisions are reviewed below for the collection of these six parameters. Each parameter shall be estimated for a common one second window, and then added to bins that are determined by operating conditions in the table above.

MIL On Status and Other Failure Conditions

Data is binned only into Bin 17 when the MIL is illuminated. Data shall be diverted into bin 17 within 10 seconds of the illumination of the MIL. The use of bins 1-16 shall be restored within 10 seconds of the MIL being extinguished. Data shall be stored in bin 17 unless there is some other disqualifying failure.

Certain failures to vehicle speed measurement, NOx Sensors, exhaust mass flow estimation stop the collection of binning data altogether, including engine activity arrays. Data collection is also halted when the engine stop lamp is illuminated. A complete description of all possible failures for all known engine component architectures is beyond the scope of this explanation. Fault tree analyses of sensor system designs and parameter estimation may be needed and compared to the regulation text to determine all possible causes to stop data collection.

Draft (h)(5.3.1) Parameter	**Example Potential Failures**
(A) NOx mass – engine out (g)	Engine Out NOx PPM Failure … MAF Sensor Failure (which may impact estimated exhaust mass air flow).
(B) NOx mass – tailpipe (g)	Tailpipe NOx PPM Failure MAF Sensor Failure (which may impact estimated exhaust mass air flow).
(C) Engine output energy (EOE) (kWh)	Fuel system quantity and/or timing failure could impact estimated torque samples – This impacts bin selection too.
(D) Distance traveled (km)	Vehicle Speed Sensor Failures e.g. VSS open circuit. All data must not be sent into bin1. *The inability to estimate vehicle speed must stop data collection; the MIL must be illuminated when data collection is stopped.*
(E) Engine run time (hours)	Failures for engine run time (i.e. the microprocessor clock or the microprocessor power feed)) are failures that would disable the microcontroller all together … or prevent the injection of fuel altogether)
(F) Vehicle fuel consumption (liters)	Fuel system quantity failure would potentially disable fuel accumulation … if the engine continues to run.

NOx Sensor Status

The status of the NOx sensors determines which series of bins that data will be accumulated within. If all NOx sensors are providing valid NOx concentration data (in ppm), then the data is accumulated in the bins displayed by the following PGs (PGs 64258 -- 64279). [Of course, accumulation is absent any failure condition that preempts the collection of data].

PGN	PG Label	PG Acronym
64258	NOx Tracking Engine Activity Lifetime Fuel Consumption Bins	NTFCEA
64259	NOx Tracking Engine Activity Lifetime Engine Run Time Bins	NTEHEA
64260	NOx Tracking Engine Activity Lifetime Vehicle Distance Bins	NTVMEA
64261	NOx Tracking Engine Activity Lifetime Engine Output Energy Bins	NTEEEA
64262	NOx Tracking Valid NOx Lifetime Fuel Consumption Bins	NTFCV
64263	NOx Tracking Valid NOx Lifetime Engine Run Time Bins	NTEHV
64264	NOx Tracking Valid NOx Lifetime Vehicle Distance Bins	NTVMV
64265	NOx Tracking Valid NOx Lifetime Engine Output Energy Bins	NTEEV
64266	NOx Tracking Valid NOx Lifetime Engine Out NOx Mass Bins	NTENV
64267	NOx Tracking Valid NOx Lifetime System Out NOx Mass Bins	NTSNV
64274	NOx Tracking Active 100 Hour Fuel Consumption Bins	NTFCA
64275	NOx Tracking Active 100 Hour Engine Run Time Bins	NTEHA
64276	NOx Tracking Active 100 Hour Vehicle Distance Bins	NTVMA
64277	NOx Tracking Active 100 Hour Engine Output Energy Bins	NTEEA
64278	NOx Tracking Active 100 Hour Engine Out NOx Mass Bins	NTENA
64279	NOx Tracking Active 100 Hour System Out NOx Mass Bins	NTSNA

If the NOx sensors have not failed, but one or more of the sensors is inactive, then only the engine activity bins represented by the following PGs (64258, 64259, 64260, and 64261) are used to collect data.

PGN	PG Label	PG Acronym
64258	NOx Tracking Engine Activity Lifetime Fuel Consumption Bins	NTFCEA
64259	NOx Tracking Engine Activity Lifetime Engine Run Time Bins	NTEHEA
64260	NOx Tracking Engine Activity Lifetime Vehicle Distance Bins	NTVMEA
64261	NOx Tracking Engine Activity Lifetime Engine Output Energy Bins	NTEEEA

The Stored 100 Hour bins represented by the PGs below only display the data collected from the prior 100 hour period. They remain fixed until the 100 hour activity period has expired, when they refreshed with the data just collected for the past 100 hours.

PGN	PG Label	PG Acronym
64268	NOx Tracking Stored 100 Hour Fuel Consumption Bins	NTFCS
64269	NOx Tracking Stored 100 Hour Engine Run Time Bins	NTEHS
64270	NOx Tracking Stored 100 Hour Vehicle Distance Bins	NTVMS
64271	NOx Tracking Stored 100 Hour Engine Output Energy Bins	NTEES
64272	NOx Tracking Stored 100 Hour Engine Out NOx Mass Bins	NTENS
64273	NOx Tracking Stored 100 Hour System Out NOx Mass Bins	NTSNS

NOx sensor stability data is represented by SPs 3230 and 3220. The following expression assumes that neither sensor has failed and the MIL is off.

SPN 3230 Aftertreatment 1 Outlet NOx 1 Reading Stable == 01 AND
SPN 3220 Engine Exhaust 1 NOx 1 Reading Stable == 01

DPF Regen Status

Data is collected into bin 16 only when the DPF is being actively regenerated. SPN 3700, Active Regen Status will display 01b when a regen has been demanded and/or commanded.

NTE Status

The Not To Exceed or NTE conditions used for the Supplemental Emissions Test (SET) are described by US Federal regulations including 40 CFR 86.1370. Key aspects of the Federal regulations that determine NTE conditions are summarized below. Data is summed into bin 15 only when all the following conditions are met.

SPN 4127 NTE Zone Control Area &&
NTE SPN 108 Barometric Pressure >= 82.5 kPa &&
NTE Exhaust Temp (not) too Cold &&
NTE IMT MAP Threshold Temp. Status &&
NTE ECT MAP Threshold Temp. Status &&
NTE Engine Power Above Threshold

Provided the engine speed (N) and engine load (estimated using torque (Tq)) lie within the following operating envelope.

[N >= (nlo + 0.15 * (nhi – nlo))] && [(Indicated Tq – Friction Tq) ÷ (Peak Tq (net)) >= 0.3]

The value provided by this particular expression is recommended to be used as the value for SPN 4127 NTE Zone Control Area in DM34 and describes the first condition. Nhi and nlo are defined in 40 CFR 86.1360.

nhi = High speed as determined by calculating 70% of the maximum power. The highest engine speed where this power value occurs on the power curve is defined as nhi.
nlo = Low speed as determined by calculating 50% of the maximum power. The lowest engine speed where this power value occurs on the power curve is defined as nlo.

Note that the maximum power may be as defined in SPN 166.

NTE Exhaust Temp (not) too Cold &&

The exhaust temperature for the SCR outlet must exceed 250 degrees C. This measurement is often displayed in SPN 4363, Aftertreatment 1 SCR Outlet Temperature.

NTE IMT MAP Threshold Temp. Status &&

The Intake manifold temperature, or IMT, (in Fahrenheit) must exceed the quotient of sum of the Intake manifold absolute pressure (in atmospheres) and the constant 7.75 and the divisor of 0.0875. See 40 CFR 86.1370(f)(1)(i).

IMT > (P + 7.75) / 0.0875

This equation is derived by solving the following equation for IMT and setting the inequality. P + 7.75 = 0.0875 * IMT. SPN 105 provides an available estimate for IMT. SPN 3563 provides an estimate for intake maniford absolute pressure (often referred to as MAP or IMP).

NTE ECT MAP Threshold Temp. Status &&

The engine coolant temperature, or ECT, (in Fahrenheit) must exceed the quotient of sum of the Intake manifold absolute pressure (in atmospheres) and the constant 9.8889 and the divisor of 0.0778. See 40 CFR 86.1370(f)(1)(ii).

ECT > (P + 9.8889) / 0.0778

This equation is derived by solving the following equation for IMT and setting the inequality. P = 0.0778 * ECT – 9.8889. SPN 110 provides one of the available estimates for engine coolant temperature.

NTE SPN 108 Barometric Pressure >= 82.5 kPa &&

NTE rules only apply when the vehicle altitude is at or below 5 500 ft., as defined in 40 CFR 86-007-11 (a)(4)(ii)). CARB directs that this shall be represented by a barometric pressure at or below 82.5 kPa.

NTE Engine Power Above Threshold

Finally, NTE data is only collected when the engine power output is at least 30 percent of the engine rated power. SPN 166 advertises the rated power of the engine and provides the denominator for the estimated engine output energy over the one second sample period. The estimation of Engine Output Energy is described below.

[(Engine Output Energy this Second (kW)) / SPN 166 Rated Power (kW)] >= 30 %

Cold Temperature Criteria Conversion to Celsius and Pascals

The Intake Manifold Temperature and Engine Coolant Temperature conditions in the Federal regulations are expressed in relationships that use technical units that are expressed in Atmospheres and Fahrenheit. The following shows a transformation of these into kPa and Celsius. Implementors are encouraged to use these derived relationships and minimize product variation across industry. P is intake manifold pressure.

Intake Manifold Temperature Criteria

P + 7.75 = 0.0875 * IMT	[Relationship as given in CFR]
IMT <= (P + 7.75) / 0.0875	[Solve for IMT]
IMT <= (P/100 +7.75) / 875/10000	[100 kpa = 1 Bar / Convert to kPa]]
IMT <= ((P/100 +775/100) * 10000/875	
IMT <= 100 * (P+775) / 875	[For IMT in Celsius and MAP in kPa]
IMT in C <= (100 * (P+775) / 875) – 32) * 5/9	[(F-32)*5/9 = C / Convert to Celsius]
IMT in C * 9/5 <= (100 * (P+775) / 875) – 32)	
IMT in C * 9/5 <= (100 * (P+775) / 875) – 28000 / 875)	
IMT in C * 9/5 <= (100 * P / 875 + 77500 / 875 – 28000 / 875)	
IMT in C * 9/5 <= (100 * P / 875 + 49500 / 875)	
IMT in C * 9 <= (100 * P / 175 + 49500 / 175)	
IMT in C <= (100 * P / 1575 + 49500 / 1575)	
IMT <= 100 * P / 1575 + 31.4286	[For IMT in Celsius and MAP in kPa]

Engine Coolant Temperature Criteria

ECT * 0.0778 <= P + 9.8889	[Relationship as given in CFR Set inequality and solve for ECT]
ECT * 7 / 90 <= (P + 9.8889)	[7/90 = 0.0777777778]
ECT * 7 / 90 <= (P/100 + 9.8889)	[100 kPa = 1 bar]
ECT * 7 / 90 * 100 <= (P/100 + 9.8889) * 100	
ECT * 70 / 9 <= (P + 988.89)	
ECT <= 9 / 70 * (P + 988.89)	[ECT in F and Pressure in kPa]
9 / 5 * ECT + 32 <= 9 / 70 * (P + 988.89)	[F = 9/5 C +32 Convert Celsius data to F]
9 / 5 * ECT <= 9 / 70 * (P + 988.89) - 32	
ECT <= (5 / 9) * ((9 / 70) * (P + 988.89) - 32)	
ECT <= (5 / 70) * (P + 988.89) - (5 / 9) * 32)	
ECT <= (1 / 14) * (P + 988.89) - (160 / 9)	
14 * ECT <= (P + 988.89) – 14 * (160 / 9)	
14 * ECT <= (P + 988.89) – 248.89	
14 * ECT <= (P + 988.89 – 248.89)	
14 * ECT <= (P + 740)	
ECT <= (P + 740) / 14	[For ECT in Celsius and MAP in kPa]

NOx Binning Parameter Estimation

The following discussion provides guidelines for the estimation of selected parameters. The estimates comprise the addends for the NOx Binning arrays, which must be estimated each second. Displayed data should be no more than 10 seconds old when its broadcast is initiated. The same data estimates should be used for NOx Binning and GHG addends. There is no need to estimate these parameters more than once. Not all parameter estimates have been defined as available SPNs. Parameter estimates that are defined as SPs are noted below. CARB does not expect visibility to other data not listed in these messages or in the regulation.

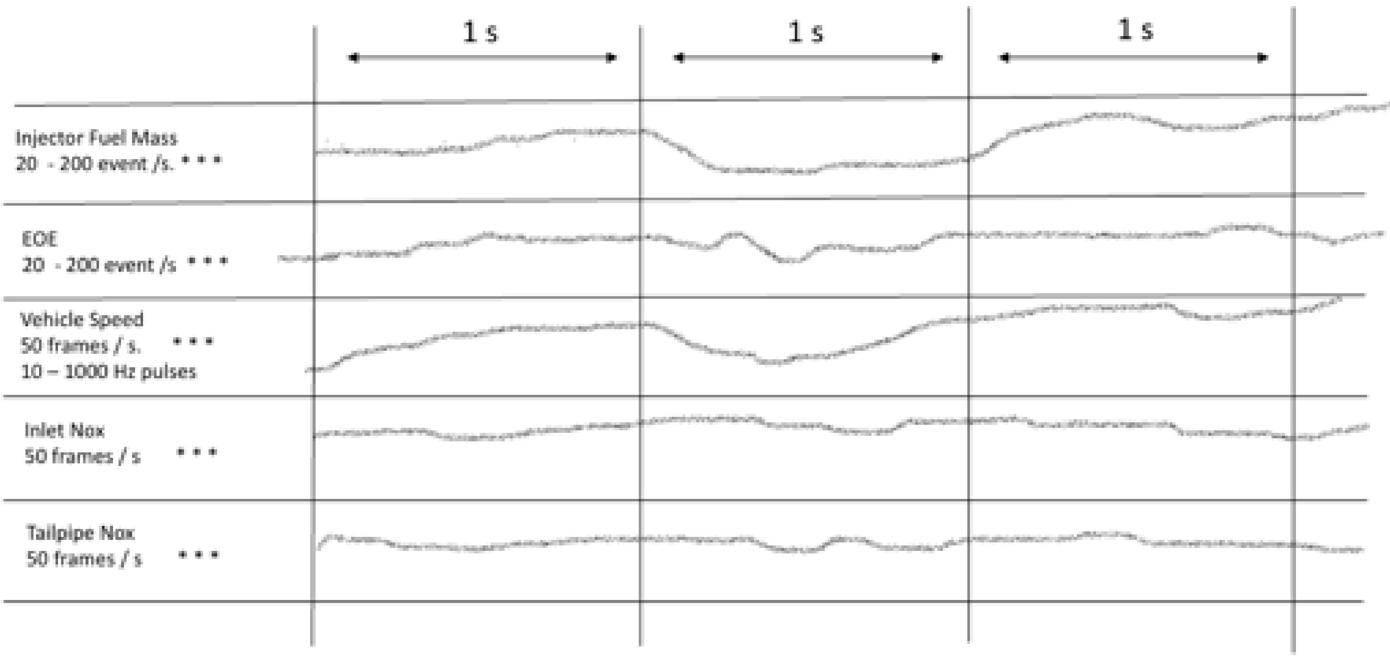


FIGURE PGN64258_A – NOX BINNING DATA FRAMEWORK

Figure PGN64258_A depicts a notional framework for the collection of NOx Binning data. Multiplexed NOx sensors provide 50 data frames per second. In contrast, fuel injection and the torque created are event driven; determined by degrees before top dead center. Vehicle speed and vehicle distance are found in multiple configurations. In some cases vehicle speed is multiplexed from another ECU that counts pulses — in other cases the ECM counts pulses based on tire revs per mile (or km). NOx mass, and engine output energy are inferred from NOx concentrations, exhaust mass flow, engine speed, and fuel quantities.

For each one second interval like those shown in the figure, estimates of NOx mass, Fuel Consumption, EOE, Vehicle distance, plus 1 second of time must be summed into two or more bins, bin 1 (the total bin) and one of bin 2 – 14. When NTE conditions are met, the summed signal data is additionally summed into the NTE bin. The disparate time frames of the signals challenge the creation of a cohesive, correlated summary of engine operation for the one second interval.

It is insufficient to select a single instant within each one second interval and use the signal value present to represent the interval. Poorly structured sampling regimens can interject systematic biases into the one second summary. Fuel injection quantities are known to exhibit wide shot to shot variation, which is reflected in instantaneous torque values. Variation in NOx concentration signals are sensitive to sampling frequency. Where signal data is multiplexed, implementers must account for the “jitter” when one CAN message frame is delayed at from the end of a particular one second interval into the beginning of the next interval.

The variety among the signals is anticipated to be reflected in disparate sampling frequencies, each of which must support the cohesive one second operating summary. In some cases, all available samples will be used for some signals to create the sum used in the one second summary.

NOx Mass Estimation

The estimation of engine out NOx and tailpipe NOx mass use the same conversion method, based on SPN 7353, Corrected Inlet NOx (ppm) and SPN 7351 Corrected Outlet NOx (ppm). The corrected NOx concentration in parts per million is multiplied by the estimated exhaust mass flow (kg/h) and multiplied by 0.001588. The constant 0.001588 includes the ratio of the NOx molecular weight and the standard molecular weight of air, which estimates the average molecular weight of the exhaust stream.

NOx (g/s) = 0.001588 * NOx (ppm) * Exhaust Flow (kg/h) / 3600

This equation is scaled for exhaust flows that are expressed in g/s dividing the Exhaust Flow (kg/h) by 3600. Calculations based on an estimated Exhaust Flow scaled in (g/s) would omit the division by 3600 and adjust the constant.

NOx (g/s) = 1.588 * NOx (ppm) * Exhaust Flow (g/s) / 10^6

Low concentrations of NOx will result in data that would be expressed in micrograms. Averaged estimates for NOx ppm over the one second window are recommended to avoid presenting outliers as nominal estimates. Note that the estimate of exhaust flow may be time sensitive, especially with respect to the NOx sensor locations. To obtain representative NOx mass estimates, the exhaust flow estimates may be matched to respective delays from the turbocharger outlet to the SCR inlet NOx sensor and earlier in time to the SCR outlet NOx sensor, The data shall be displayed in SPN 12750 Aftertreatment 1 Engine Exhaust Mass Flow and SPN 12751 Aftertreatment 1 SCR 1 Tailpipe NOx Mass Flow.

Implementations that periodically sample NOx concentration are recommended to use sampling frequencies above 6 Hz. Sampling frequencies at 6 Hz and below can result in estimates with excess errors.

Fuel Use Estimation

Diesel engine fuel (mass) used may be estimated as the sum of the mg/stroke of diesel fuel injected into the engine's cylinders over the one second sample period. This sum is then divided by 1000 to scale the sum as grams. Fuel used to operate the intake air heater, aftertreatment system or diesel-fired furnace shall not be included in the sum. This data may be used to provide values for SPN 6893 PEMS engine fuel mass rate or SPN 5833 Engine Fuel Mass Flow rate.

A conversion factor shall be applied to estimate volumetric fuel use. This may be more effective for larger sums of fuel mass over longer periods than one second.

Engine Output Energy Estimation

Engine output energy (EOE) is estimated as the sum of the torque samples / divided by the number of samples (this second) * engine speed (r/minute) * 104.725

EOE = Σ (T/n) * N * 104.725

P = T ω
P = T * 2 π N/60
P = T * N / 9.5488 (kW)
1/9.5488 * 1000 = 104.7252 (W)

This definition of Engine Output Energy will be divided by SPN 166 Rated Engine Power as part of the NTE bin (bin 16) selection.

A.87 PGN 64553 – FORWARD LANE IMAGE

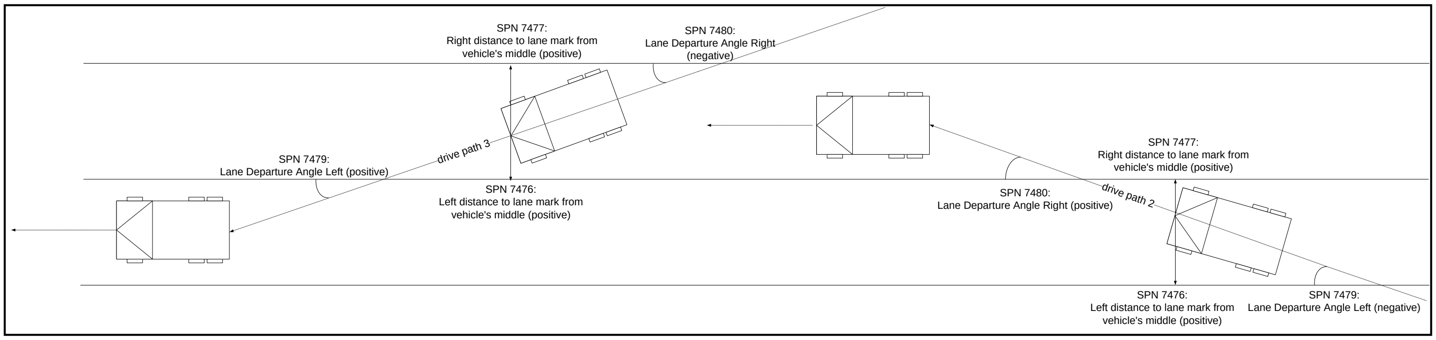


FIGURE PGN64553_A - DEPARTURE ANGLE

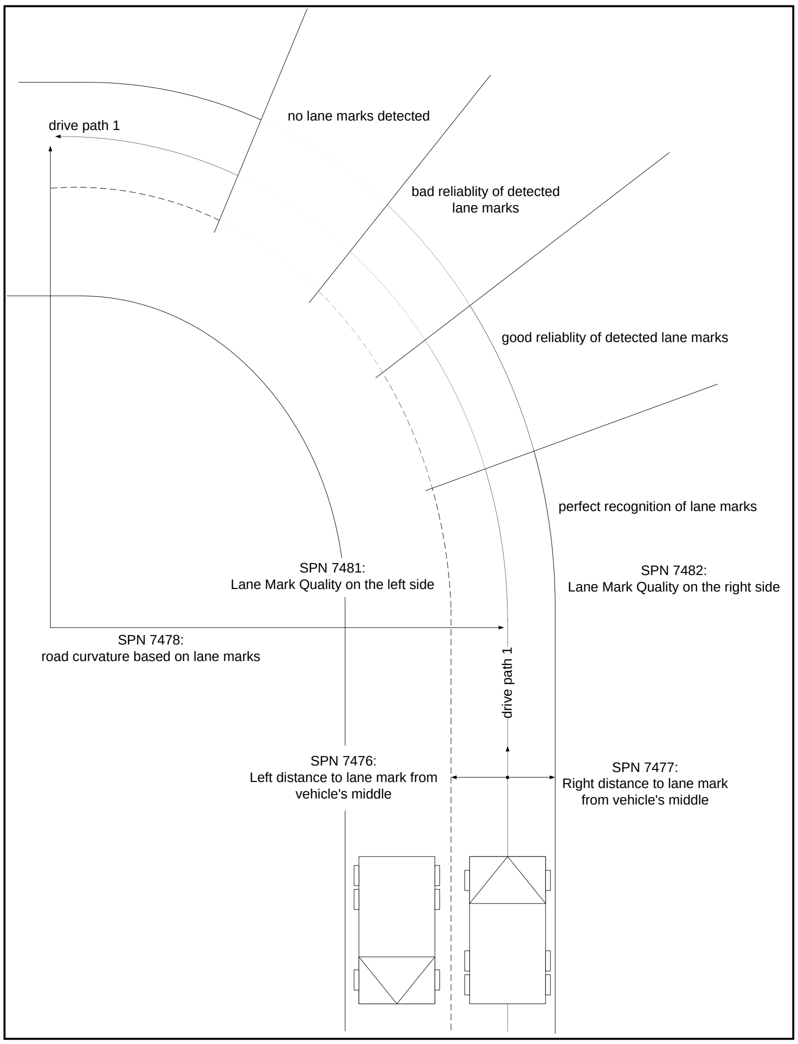


FIGURE PGN64553_B - QUALITY CURVATURE DISTANCE

A.88 PGN 64618 – SYSTEM IDENTIFICATION

Where different systems connect at run-time this PG is used to exchange ID information. For the case of an EV connecting to an EVSE there are a number of different ID formats depending on the communications protocol in use.

SPN 23067 (System ID Type)	Role	Format	Not Available	Notes
0	EVSE	ISO-15118-2 (Annex H 2016)	“ZZ00000”	7-37 ASCII characters forming a * delimited set of strings. E.g. “FR*A23*E45B*78C”
1	EVSE	ISO-15118-20	“ZZ00000”	7-255 Characters that match requirements of IEC 63119-2
2	EVSE	J2847-2	“00”	1-32 characters. The string's contents is defined in DIN SPEC 91286. Only characters '0' to '9' and '*' are allowed. e.g. "49*89*6360".
3	EVCC	ISO-15118-2		EVCC's 6 byte MAC address encoded as 12 ASCII hex characters '0'-'9','A'-'F'
4	EVCC	ISO-15118-20		20 to 255 ASCII characters A-Z,a-z,0-9 as detailed in ISO-15118-20 Appendix C.5

When requesting the PG then the ID of the local system can be requested using RQST or RQST2 with a single Extended ID byte set to 00h.

To request the System ID of the *n*th connected device then use RQST2 with a single Extended ID byte set to *n*.

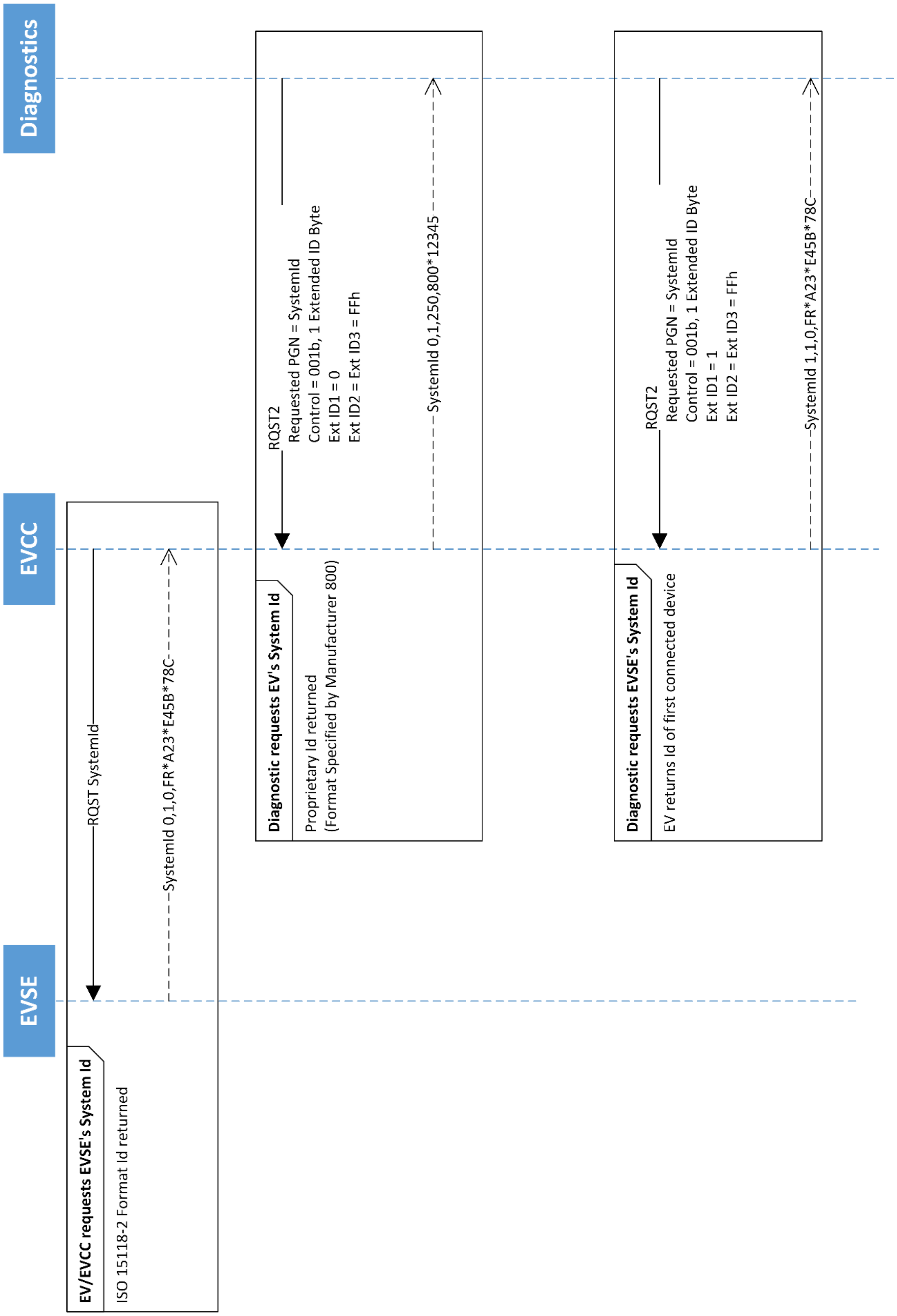


FIGURE PGN64618_A – EXAMPLE USAGE OF SYSTEM IDENTIFICATION

A.89 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.

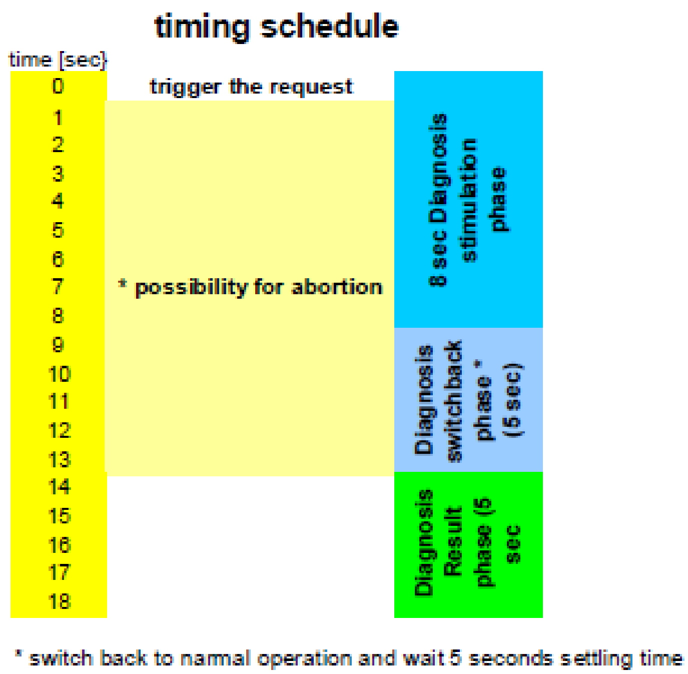


FIGURE PGN64719_A – TIMING SCHEDULE FOR NOX SENSOR SELF-DIAGNOSIS

A.90 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.

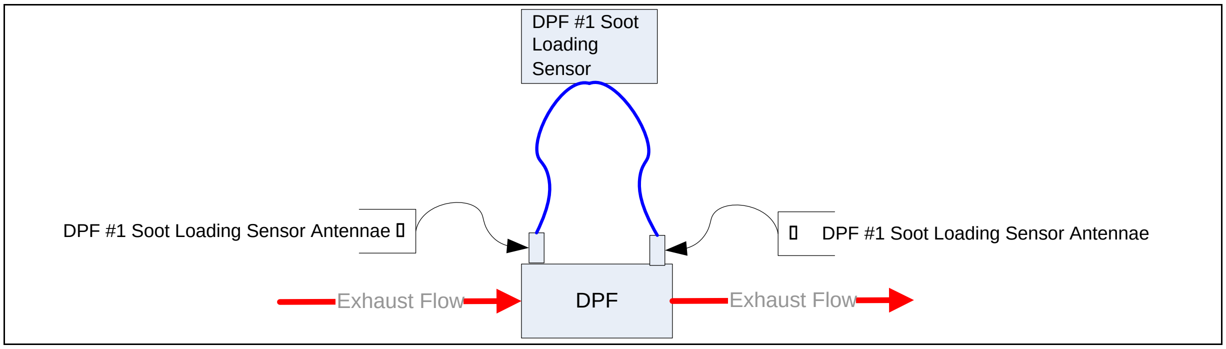


FIGURE PGN64730_A - SOOT LOADING SENSOR ANTENNAE LOCATIONS

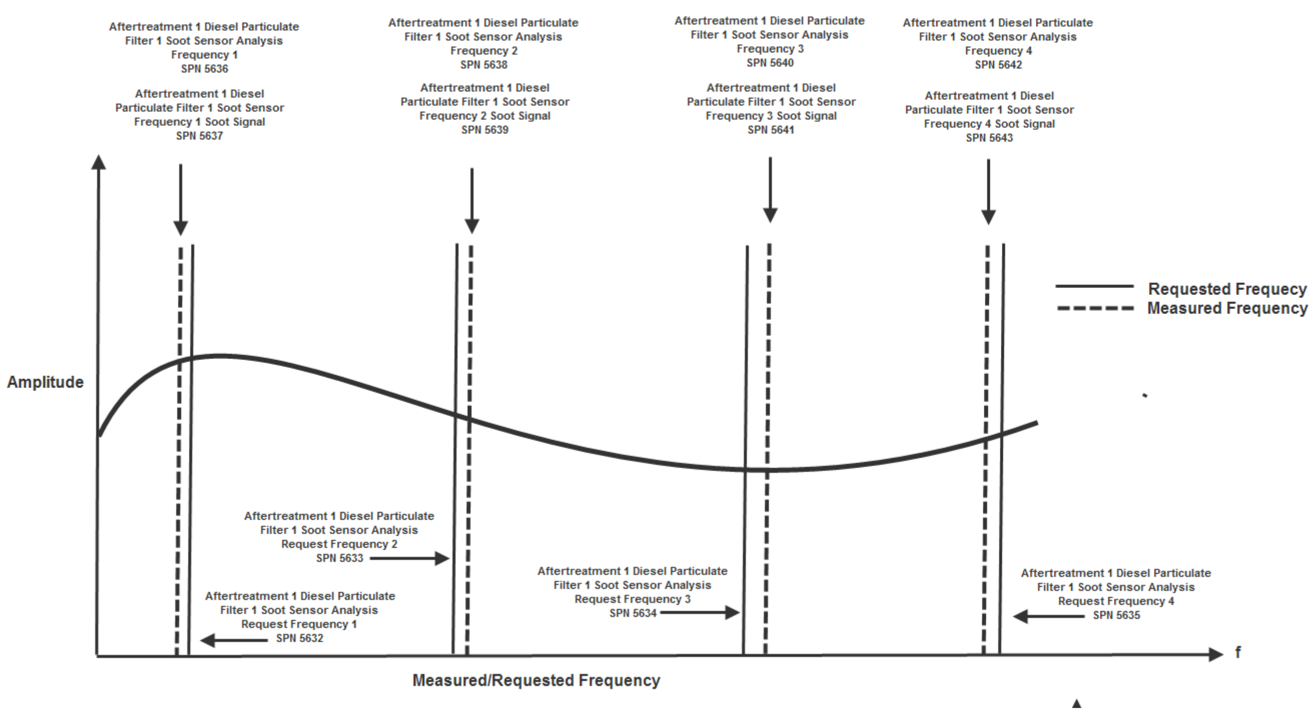


FIGURE PGN64730_B – SOOT LOADING SENSOR MEASUREMENT LOCATIONS

A.91 PGN 64739 – ENGINE EXHAUST BRAKE CONTROL

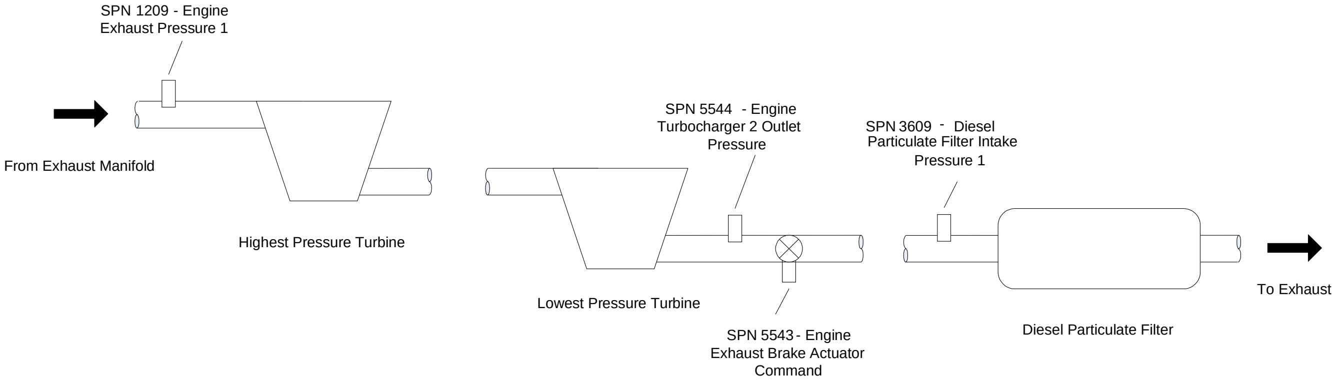


FIGURE PGN64739_A - ENGINE EXHAUST BRAKE CONTROL SIGNALS

A.92 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'	'*'	'*'	'*'	'*'	'*'	'*'

A.93 PGN 64872 – GROSS COMBINATION VEHICLE WEIGHT

The Transmission Repetition Rate of PGN 64872, Gross Combination Vehicle Weight, is once every ten seconds or on request. The sender also has the option of transmitting on significant change, as defined by the sender.

An ECU requesting this message will get it virtually immediately; the scale will then broadcast it ten seconds later and every ten seconds thereafter, barring any additional request.

As an example, consider a scale broadcasting Gross Combination Vehicle Weight, receiving a request for this message:

Seconds	**Weight broadcast**
10.00	Gross Combination Vehicle Weight
20.00	Gross Combination Vehicle Weight
30.00	Gross Combination Vehicle Weight
40.00	Gross Combination Vehicle Weight
50.00	Gross Combination Vehicle Weight
55.00	Another device requests Gross Combination Vehicle Weight
55.01	Gross Combination Vehicle Weight
65.01	Gross Combination Vehicle Weight
75.01	Gross Combination Vehicle Weight
85.01	Gross Combination Vehicle Weight

The change in timing will be similar if the sender exercises the option of transmitting on significant change, but no more often than once per second:

Seconds	**Weight broadcast**
10.00	Gross Combination Vehicle Weight
20.00	Gross Combination Vehicle Weight
22.30	Gross Combination Vehicle Weight, following significant change to GCVW
25.80	Gross Combination Vehicle Weight, following another significant change to GCVW
35.80	Gross Combination Vehicle Weight

A.94 PGN 64874 – AXLE GROUP WEIGHT

The Transmission Repetition Rate of the available set of Axle Group Weight messages broadcast via PGN 64874, Axle Group Weight, is once every ten seconds or on request. Thus, a scale weighing each of a vehicle's three axle groups will broadcast the set of all three axle group weights every ten seconds, with individual messages broadcast within 200ms intervals.

An ECU requesting this message will get it for the available set of axle group weights, beginning immediately. The next transmission of the set will occur ten seconds later, barring any additional request.

As an example, consider a scale broadcasting axle group weights for Steer, Drive, Trailer, receiving a request for Axle Group Weight:

Seconds	**Weight broadcast**
1.00	Steer
1.20	Drive
1.40	Trailer
11.00	Steer
11.20	Drive
11.30	Another device requests Axle Group Weight
11.31	Steer
11.51	Drive
11.71	Trailer
21.71	Steer

A.95 PGN 64906 – SAE J2012 DTC DISPLAY

Note: New applications are recommended to support PGN 63978 (SAE J2012 3-Byte DTC Display), as it has the ability to convey J2012 2-byte or 3-Byte DTCs.

PGN 64906 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’ --

A.96 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.

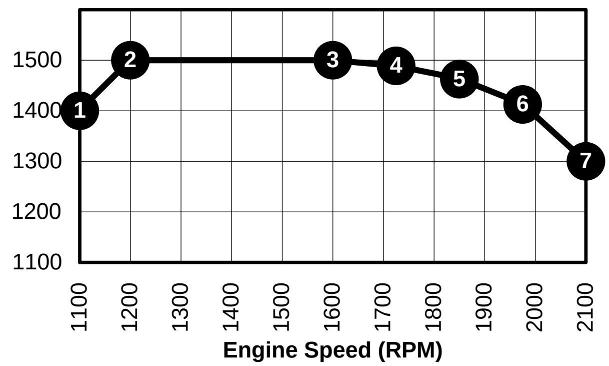


FIGURE PGN64912_A - ADVERTISED ENGINE TORQUE CURVE

A.97 PGN 64932 – PTO DRIVE ENGAGEMENT

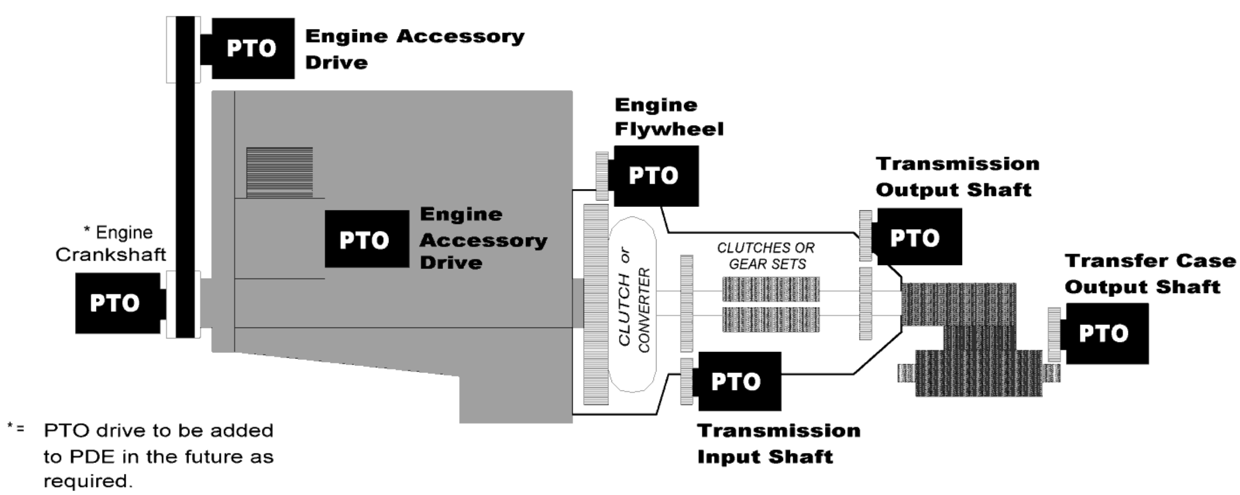


FIGURE PGN64932_A - PTO DRIVE ENGAGEMENT LOCATIONS

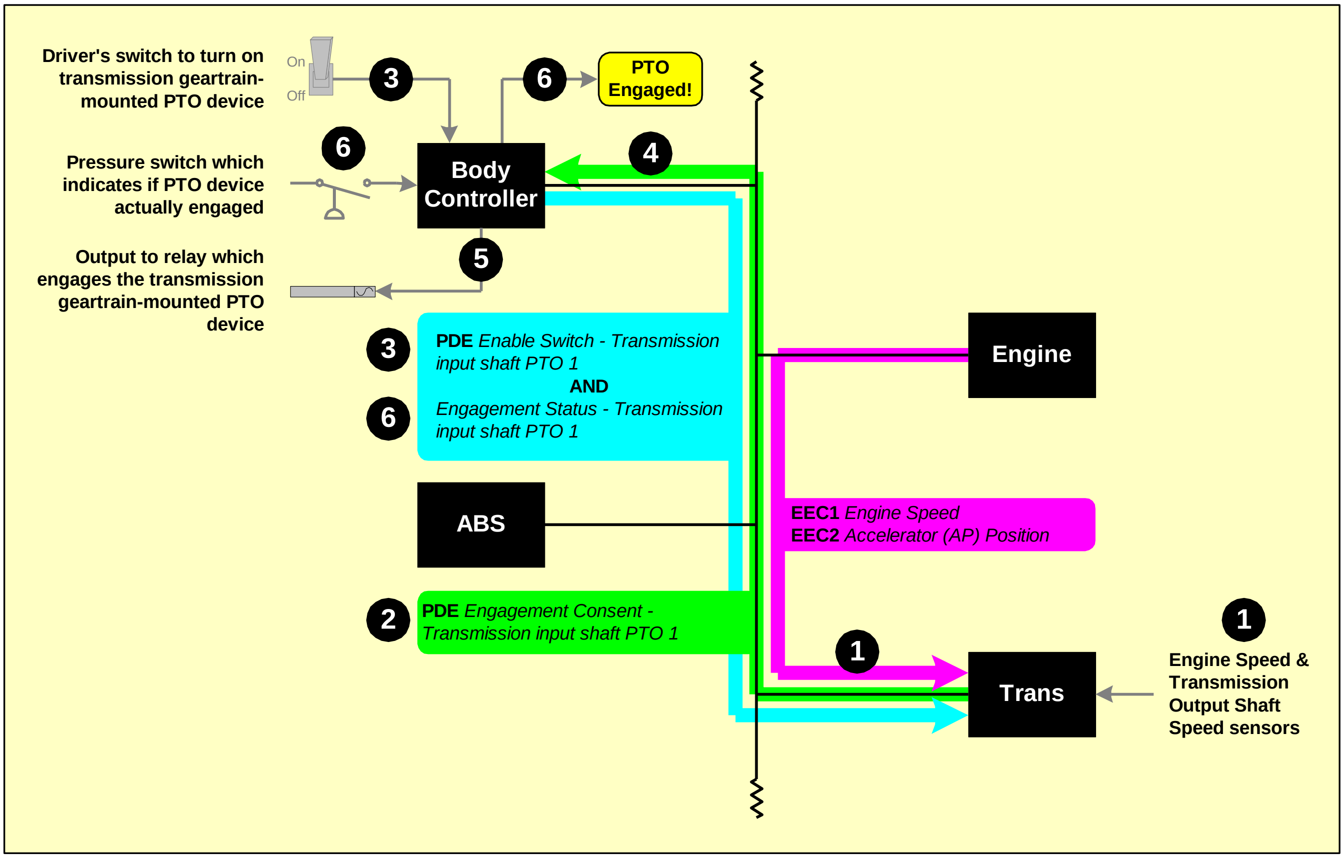


FIGURE PGN64932_B - VEHICLE OEM CONTROLLER INTERFACES WITH ALL PTO WIRING

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.

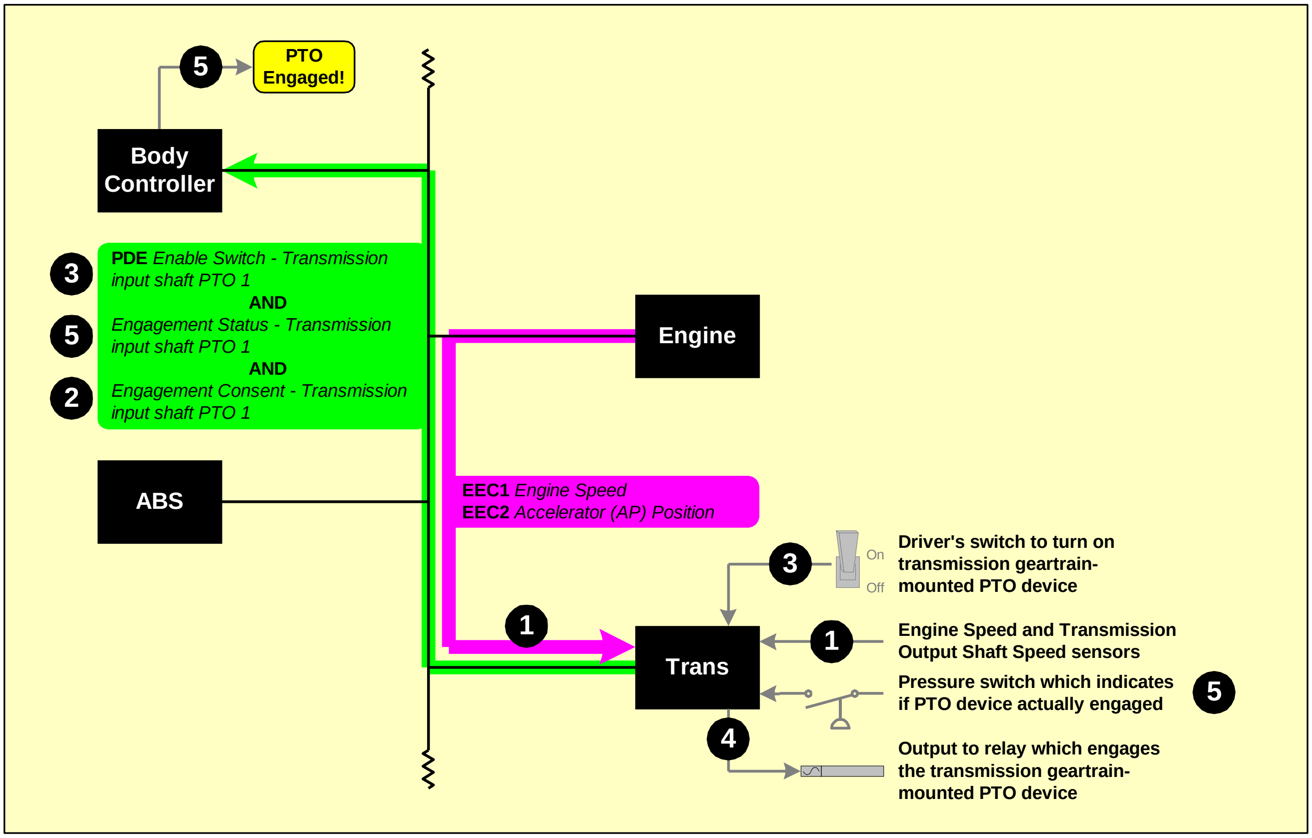


FIGURE PGN64932_C – COMPONENT DRIVING PTO INTERFACES WITH ALL PTO WIRING

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.

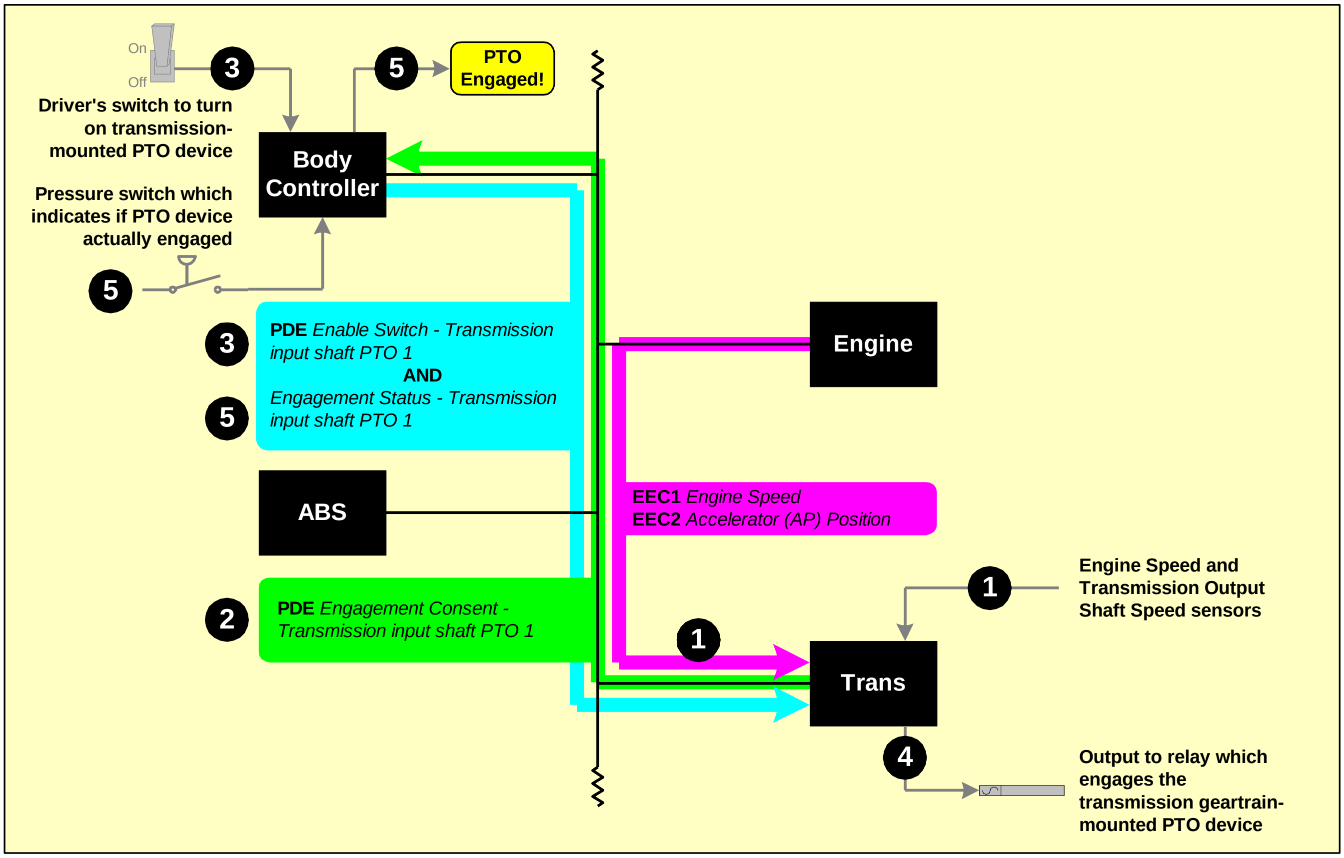


FIGURE PGN64932_D – DISTRIBUTED PTO INTERFACES WIRING

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.

A.98 PGN 64938 – ENGINE FLUID, LEVEL AND PRESSURE 4

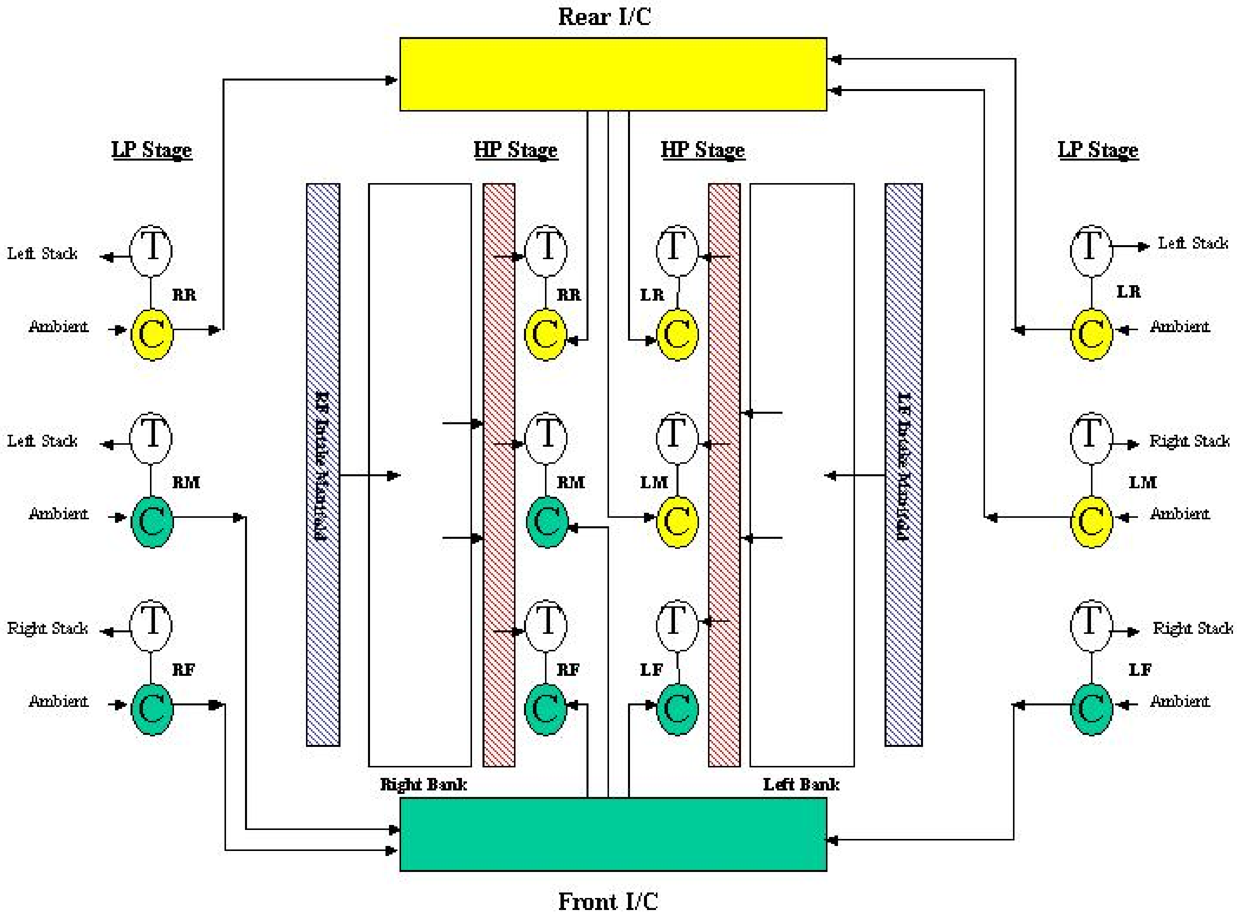


FIGURE PGN64938_A - ENGINE CHARGE AIR COOLER PRESSURES

A.99 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.

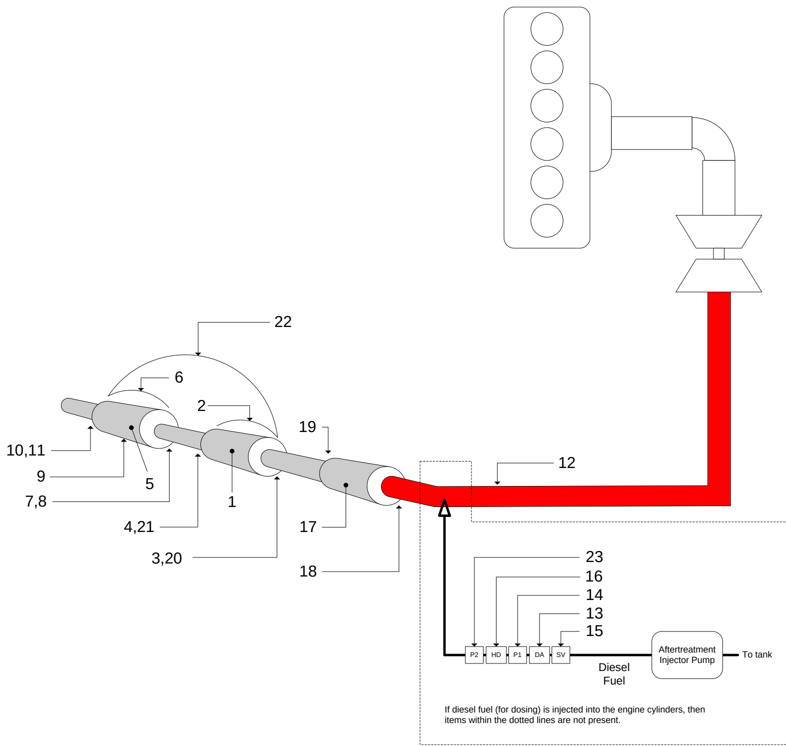


FIGURE PGN64948_A - CONFIGURATION SHOWING WARM UP DIESEL OXIDATION CATALYST, DIESEL OXIDATION CATALYST, AND DIESEL PARTICULATE FILTER

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
20	Aftertreatment Diesel Oxidation Catalyst Intake Pressure	8160
21	Aftertreatment Diesel Oxidation Catalyst Outlet Pressure	8161
22	Aftertreatment DOC Inlet to DPF Outlet Delta Pressure	8162
23	Aftertreatment Fuel Pressure 2	4077

Exhaust Gas Temperature SPs for Otto Cycle Engines

The exhaust gas temperature PGs shown below have a dual purpose to support either a Diesel aftertreatment system or an Otto-cycle aftertreatment system. Accordingly, Figure PGN64948_A must be interpreted differently for a three-way catalyst behind an Otto-cycle engine. In SAE J1979DA, exhaust temperatures 1, 2 and 3 are expected to be sequentially assigned with exhaust temperature 1 being the closest to the engine exhaust manifold.

In the example below the Diesel Oxidation Catalyst (DOC), DOC Warmup Catalyst (figure item 17) and Diesel Particulate Filter (DPF) in Figure PGN64948_A would be replaced by representative Otto Cycle aftertreatment system components like a three-way catalyst and pre-catalyst. When SI engines support the SAE J1939 PGs for exhaust temperatures, mapping the SPs like that shown in the table below will match the expected practice in SAE J1979DA.

Location Relative to FIGURE PGN64948_A	Engine Exhaust Temperature Parameter	SPN	PGN
12	Aftertreatment 1 Exhaust Temperature 1	3241	64948
3	Aftertreatment 1 Exhaust Temperature 2	3249	64946
8	Aftertreatment 1 Exhaust Temperature 3	3245	64947

A.100 PGN 64966 – COLD START AIDS

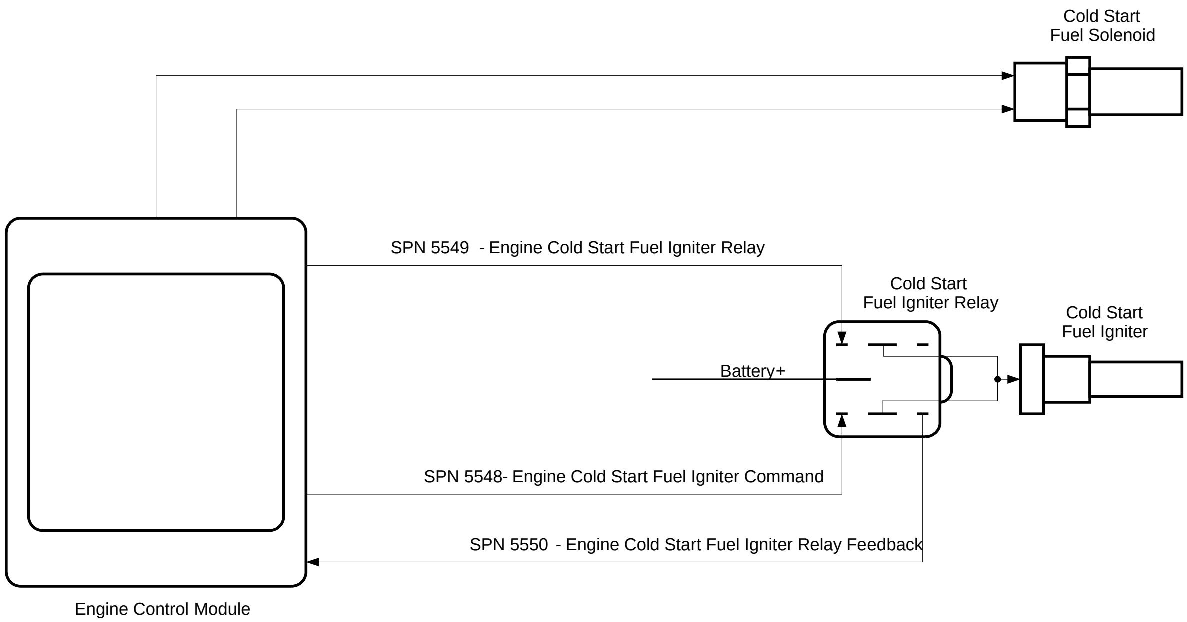


FIGURE PGN64966_A - COLD START AID SIGNALS

A.101 PGN 64999 – GENERATOR AND UTILITY SYNCHRONIZATION PARAMETERS

The SPs and PGs discussed here are predominantly associated with monitoring and control of generators and driven equipment in electric power generation and industrial applications.

The synchronization SPs and PGs are organized according to synchronization of bus #1 to a generator set or utility. These PGs contain parameters that would be generated by, or perhaps used by, a synchronizer or sync check relay to connect the generator set or utility to bus #1. These parameters include AC phase difference, voltage match, frequency match, phase match, in sync, and dead bus flag. The SPs and PGs for Synchronization parameters for bus #1 to the Utility and the generator are summarized in Tables PGN64999_A and PGN64999_B.

TABLE PGN64999_A - SPN SUMMARY FOR SYNCHRONIZATION PARAMETERS

Synchronization Quantities	Reference Type	Bus #1 to Utility	Bus #1 to Generator	Stationary Inverter to Bus
Frequency Match	SPN	2533	2528	9808
Voltage Match	SPN	2532	2527	9809
Phase Match	SPN	2531	2526	9807
Phase Difference	SPN	2517	2516	9811
Utility in Sync	SPN	2534	2529	9810
Dead Bus	SPN	2535	2530	9806

TABLE PGN64999_B - PGN SUMMARY FOR SYNCHRONIZATION PARAMETERS

Synchronization Quantities	Reference Type	Bus #1 to Utility	Bus #1 to Generator	Stationary Inverter to Bus
Frequency Match	PGN	64999	65000	61764
Voltage Match	PGN	64999	65000	61764
Phase Match	PGN	64999	65000	61764
Phase Difference	PGN	64999	65000	61764
Utility in Sync	PGN	64999	65000	61764
Dead Bus	PGN	64999	65000	61764

A.101.1 AC PHASE DIFFERENCE

AC phase difference represents the phase difference between the bus #1 and utility or generator voltages. The voltages tested may be line-line or line-neutral, and may be based on a single phase or a combination of two or more phases. This is up to the control generating the data. The phase difference is a signed angle ranging from -180 to +180 degrees. A resolution of 0.1 degree is adequate.

A.101.2 DEAD BUS

Dead bus flag indicates whether the synchronizer or sync check relay has determined that the bus is dead for the purpose of connecting the utility to the bus. When standby generator sets are brought online in response to a utility failure, the first generator set to connect to the bus must connect to a dead bus without synchronizing. Subsequent generator sets may synchronize to the first online generator set. A dead bus is typically indicated by a bus voltage less than a programmed threshold, but a more sophisticated method may be used. (The dead bus threshold used for bus #1/utility synchronization may be different than that used for bus #1/generator synchronization.) The voltages tested may be line-line or line-neutral, and may be based on a single phase or a combination of two or more phases. This is up to the control generating the flag.

A.102 PGN 65003 – GENERATOR AND UTILITY BUS PARAMETERS

The SPs and PGs discussed here are predominantly associated with monitoring and control of generators and driven equipment in electric power generation and industrial applications.

The bus SPs and PGs describe the voltage and some other parameters on the bus, which is a point where multiple generator sets and utilities can be paralleled together to drive a load. All bus PGs are called "bus #1..." to allow for multiple busses in a system. It is expected that future PGs for other busses would be identical to the bus #1 PGs. The SPs and PGs for bus parameters are summarized in Table PGN65003_A and PGN65003_B.

TABLE PGN65003_A - SPN SUMMARY FOR BUS #1 PARAMETERS

Bus #1 AC Quantities	Reference Type	Phase A	Phase B	Phase C	Average
Line-to-Line AC rms Voltage	SPN	2509	2510	2511	2508
Line-to-Neutral AC rms Voltage	SPN	2513	2514	2515	2512
AC Frequency	SPN	2505	2506	2507	2504

TABLE PGN65003_B - PGN SUMMARY FOR BUS #1 PARAMETERS

Bus #1 AC Quantities	Reference Type	Phase A	Phase B	Phase C	Average
Line-to-Line AC rms Voltage	PGN	65003	65002	65001	65004
Line-to-Neutral AC rms Voltage	PGN	65003	65002	65001	65004
AC Frequency	PGN	65003	65002	65001	65004

Multiple gensets, loads, and possibly a utility may be connected to a bus at any time. Ignoring resistive losses, the voltage and frequency will be constant at all points on the bus. The current and power, on the other hand, will vary depending on where the sensing is done. Consider the example of two gensets G1 and G2, and one load L. Suppose they are connected on the bus in the configuration G1 ---- L ---- G2, so L is between the gensets. If the bus current is sensed between G1 and L, it will show the current and power delivered by G1. If the bus current is sensed between G2 and L, it will show the current and power delivered by G2. These two quantities may be completely different. For this reason, bus #1 current is not included in the bus #1 basic AC quantities, and no bus #1 power PGNs are currently defined.

A.103 PGN 65026 – GENERATOR AND UTILITY PARAMETERS

The SPs and PGs are for information predominantly associated with monitoring and control generators and driven equipment in electric power generation and industrial applications.

The generator and utility related SPs and PGs are organized according to total and per-phase related parameter quantities. The generator PGs describe the generator output: voltage, current, frequency, and power. The utility PGs describe the input from a utility: voltage, current, frequency, and power. In a three-phase power system, the voltage, current, and power can be measured independently for each phase (labeled phase A, phase B, and phase C). These per-phase values can then be combined to form total (or average, or overall) quantities. For some generator configurations, the per-phase values are not meaningful, and the total quantities are the only values available. Frequency parameter information is in per-phase PGs in order to keep symmetry with the total PGs, and to support independent frequency measurements on the individual phases. The SPs and PGs for generator and utility parameters are summarized in Tables PGN65026_A through PGN65026_D.

TABLE PGN65026_A - SPN SUMMARY FOR GENERATOR AND INVERTER PARAMETERS

Generator AC Quantities	Reference Type	Phase A	Phase B	Phase C	Total	Average	Request	Stationary Inverter
Real Power	SPN	2453	2454	2455	2452	-	-	9801
Apparent Power	SPN	2461	2462	2463	2460	-	-	9802
Reactive Power	SPN	2457	2458	2459	2456	-	3383	9798
Power Factor	SPN	2465	2466	2467	2464	-	3384	9799
Power Factor Lagging	SPN	2519	2520	2521	2518	-	3385	9800
Line-to-Line AC rms Voltage	SPN	2441	2442	2443	-	2440	3386	9794
Line-to-Neutral AC rms Voltage	SPN	2445	2446	2447	-	2444	-	9795
AC rms Current	SPN	2449	2450	2451	-	2448	-	9797
AC Frequency	SPN	2437	2438	2439	-	2436	-	9796
kWh Import	SPN	-	-	-	2469	-	-	-
kWh Export	SPN	-	-	-	2468	-	-	-

TABLE PGN65026_B - PGN SUMMARY FOR GENERATOR AND INVERTER PARAMETERS

Generator AC Quantities	Reference Type	Phase A	Phase B	Phase C	Total	Average	Request	Stationary Inverter
Real Power	PGN	65026	65023	65020	65029	-	-	61762
Apparent Power	PGN	65026	65023	65020	65029	-	-	61762
Reactive Power	PGN	65025	65022	65019	65028	-	61461	61761
Power Factor	PGN	65025	65022	65019	65028	-	61461	61761
Power Factor Lagging	PGN	65025	65022	65019	65028	-	61461	61761
Line-to-Line AC rms Voltage	PGN	65027	65024	65021	-	65030	61468	61760
Line-to-Neutral AC rms Voltage	PGN	65027	65024	65021	-	65030	-	61760
AC rms Current	PGN	65027	65024	65021	-	65030	-	61760
AC Frequency	PGN	65027	65024	65021	-	65030	-	61760
kWh Import	PGN	-	-	-	65018	-	-	-
kWh Export	PGN	-	-	-	65018	-	-	-

TABLE PGN65026_C - SPN SUMMARY FOR UTILITY PARAMETERS

Utility AC Quantities	Reference Type	Phase A	Phase B	Phase C	Total	Average
Real Power	SPN	2487	2488	2489	2486	-
Apparent Power	SPN	2495	2496	2497	2494	-
Reactive Power	SPN	2491	2492	2493	2490	-
Power Factor	SPN	2499	2500	2501	2498	-
Power Factor Lagging	SPN	2523	2524	2525	2522	-
Line-to-Line AC rms Voltage	SPN	2475	2476	2477	-	2474
Line-to-Neutral AC rms Voltage	SPN	2479	2480	2481	-	2478
AC rms Current	SPN	2483	2484	2485	-	2482
AC Frequency	SPN	2471	2472	2473	-	2470
kWh Import	SPN	-	-	-	2503	-
kWh Export	SPN	-	-	-	2502	-

TABLE PGN65026_D - PGN SUMMARY FOR UTILITY PARAMETERS

Utility AC Quantities	Reference Type	Phase A	Phase B	Phase C	Total	Average
Real Power	PGN	65013	65010	65007	65016	-
Apparent Power	PGN	65013	65010	65007	65016	-
Reactive Power	PGN	65012	65009	65006	65015	-
Power Factor	PGN	65012	65009	65006	65015	-
Power Factor Lagging	PGN	65012	65009	65006	65015	-
Line-to-Line AC rms Voltage	PGN	65014	65011	65008	-	65017
Line-to-Neutral AC rms Voltage	PGN	65014	65011	65008	-	65017
AC rms Current	PGN	65014	65011	65008	-	65017
AC Frequency	PGN	65014	65011	65008	-	65017
kWh Import	PGN	-	-	-	65005	-
kWh Export	PGN	-	-	-	65005	-

A.103.1 AC APPARENT POWER

The power quantity that is the product of a circuit's voltage and current, without reference to phase angle. While apparent power is an unsigned quantity, the same range and resolution shoul be use for AC apparent power and AC Real Power. Apparent power is an unsigned quantity, but there is no benefit in having a larger range for apparent power than for real power.

A.103.2 AC FREQUENCY

Measured AC frequency is an unsigned quantity. Common nominal frequencies in use worldwide for generator sets are 50 Hz, 60 Hz, and 400 Hz. The minimum resolution for display and control is 0.1 Hz.

When AC frequency is used to report frequency difference, such as might be used by a synchronizer, then a signed quantity is required.

A.103.3 AC KILOWATT-HOUR

AC kilowatt-hour measures the total energy output of a generator set, or the total import/export energy of a utility incomer. AC kilowatt-hour could be considered a signed quantity, since reverse power would subtract (or, for a utility incomer, import and export power would cancel each other). In practice, if there is a significant amount of power flowing in either direction at different times, the "positive" and "negative" flow should be accumulated separately. A utility might charge a different rate for “imported” power than it pays for “exported” power. Therefore, it is desirable to treat this as an unsigned quantity, and to accumulate positive and negative kW separately.

For a generator set, the range should be sufficient to accumulate the output of a 10 MW generator set operating continuously at 80% capacity for 100000 hours: 800000 MWH. (For a utility incomer, the range must be somewhat higher.)

A.103.4 AC POWER FACTOR

AC power factor measures the ratio of real power to apparent power, sometimes approximated as the cosine of the angle between voltage and current for a single phase. The range is -1.0 to +1.0. Negative values indicate reverse power flow. A value of 1.0 indicates that all of the power flow is real power delivered to the load (i.e., a purely resistive load). A value of 0.0 indicates that no real power is delivered to the load (i.e., a purely reactive load).

Power factor can be leading (a capacitive load) or lagging (an inductive load). This is not indicated by the sign of the power factor, but by a separate flag.

A.103.5 AC REACTIVE POWER

In a normally operating system, the reactive power will be less than half the real power. In order to allow for fault conditions, it is desirable to have the same range for reactive power as for real power. Reactive power is a signed quantity, like real power.

A.103.6 AC REAL POWER

AC real power must be signed since power may flow in both directions. The range for reverse power does not need to be as large as the range for positive power for a generator set, but this quantity might also be used to measure power imported from a utility. In this case, a negative value for real power indicates power delivered (sold) to the utility, and might equal the total capacity of the generator sets.

A "large" diesel or gas generator set might have a capacity of around 10 MW (about 13000 HP). Assuming it is desired to measure the power output of up to 20 generator sets paralleled together, the total capacity will be around 200 MW. The required resolution for a small (20 kW) generator set is approximately 0.1 kW = 100 W.

A.103.7 AC rms CURRENT

The maximum size breaker commonly available for generator sets is 6500 A. It is desirable to provide a 10X allowance for fault current measurement, which results in a desired range of 0 to 65000 A.

A.103.8 AC rms VOLTAGE

The maximum voltage likely to be measured by a generator set monitoring device is 33 kV (the UK heavy distribution voltage). Utility voltage may be much higher, but will be stepped down for paralleling with generator sets.

A.103.9 TOTAL AC ENERGY

Total AC energy is the total energy exported or imported by the generator set or utility.

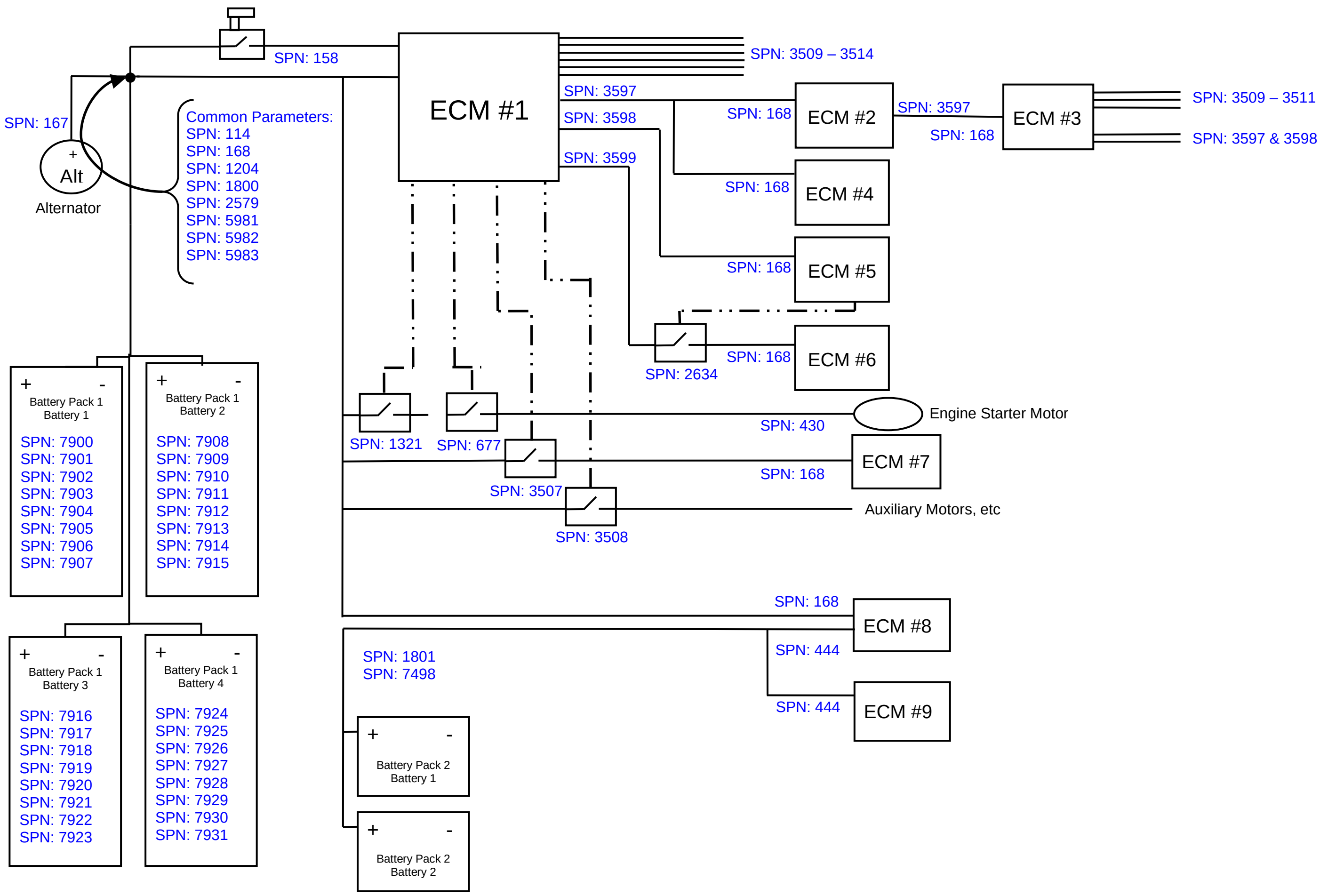
For generator sets, exported energy is energy delivered to the load (the normal situation). Imported energy is energy taken from the load or bus (reverse power, an abnormal and potentially damaging situation).

For utilities, exported energy is energy delivered by the generator set to the utility. Imported energy is energy delivered by the utility to the load. Unlike the case with generator sets, both exported and imported energy are normal for a utility.

A.103.10 UTILITY INCOMER

Any source of power that is present for which the user is not responsible for the generation of that power. This is typically the local utility or power company, but could be other power sources, such as the power coming from a system at a separate building.

A.104 PGN 65104 – BATTERY INFORMATION



Note 1: The ECMs shown in this diagram could represent an ECM, or any intelligent device that is capable of diagnostics.
Note 2: If a battery pack consists of a single battery, then the common parameters should be used.
Note 3: Last updated 2/2017. There are controller specific SPNs assigned that are not in this figure. e.g. HVES Ignition Voltage SPN 8087

FIGURE PGN65104_A - BATTERY INFORMATION

SPN	SPN Name	SPN	SPN Name
114	SLI Battery 1 Net Current	7900	SLI Battery Pack 1 Battery 1 Net Current
115	Alternator Current	7901	SLI Battery Pack 1 Battery 1 Temperature
158	Key Switch Battery Potential	7902	SLI Battery Pack 1 Battery 1 Voltage
167	Charging System Potential (Voltage)	7903	SLI Battery Pack 1 Battery 1 State of Charge
168	Battery Potential / Power Input 1	7904	SLI Battery Pack 1 Battery 1 Capacity
430	Engine Starter Solenoid Voltage	7905	SLI Battery Pack 1 Battery 1 Health
444	Battery Potential / Power Input 2	7906	SLI Battery Pack 1 Battery 1 Predicted Minimum Cranking Voltage
677	Engine Starter Motor Relay	7907	SLI Battery Pack 1 Sensor 1 Initialization Status
7712	Battery Potential / Power Input 3	7908	SLI Battery Pack 1 Battery 2 Net Current
7713	Battery Potential / Power Input 4	7909	SLI Battery Pack 1 Battery 2 Temperature
1204	Electrical Load	7910	SLI Battery Pack 1 Battery 2 Voltage
1321	Engine Starter Solenoid Lockout Relay Driver Circuit	7911	SLI Battery Pack 1 Battery 2 State of Charge
1795	Alternator Current (High Range/Resolution)	7912	SLI Battery Pack 1 Battery 2 Capacity
1800	SLI Battery 1 Temperature	7913	SLI Battery Pack 1 Battery 2 Health
1801	SLI Battery 2 Temperature	7914	SLI Battery Pack 1 Battery 2 Predicted Minimum Cranking Voltage
2579	SLI Battery 1 Net Current (High Range/Resolution)	7915	SLI Battery Pack 1 Sensor 2 Initialization Status
2634	Power Relay	7916	SLI Battery Pack 1 Battery 3 Net Current
3507	TECU ECU_PWR relay	7917	SLI Battery Pack 1 Battery 3 Temperature
3508	TECU PWR Relay	7918	SLI Battery Pack 1 Battery 3 Voltage
3509	Sensor supply voltage 1	7919	SLI Battery Pack 1 Battery 3 State of Charge
3510	Sensor supply voltage 2	7920	SLI Battery Pack 1 Battery 3 Capacity
3511	Sensor supply voltage 3	7921	SLI Battery Pack 1 Battery 3 Health
3512	Sensor supply voltage 4	7922	SLI Battery Pack 1 Battery 3 Predicted Minimum Cranking Voltage
3513	Sensor supply voltage 5	7923	SLI Battery Pack 1 Sensor 3 Initialization Status
3514	Sensor supply voltage 6	7924	SLI Battery Pack 1 Battery 4 Net Current
3597	ECU Power Output Supply Voltage #1	7925	SLI Battery Pack 1 Battery 4 Temperature
3598	ECU Power Output Supply Voltage #2	7926	SLI Battery Pack 1 Battery 4 Voltage
3599	ECU Power Output Supply Voltage #3	7927	SLI Battery Pack 1 Battery 4 State of Charge
5981	SLI Battery Pack State of Charge	7928	SLI Battery Pack 1 Battery 4 Capacity
5982	SLI Battery Pack Capacity	7929	SLI Battery Pack 1 Battery 4 Health
5983	SLI Battery Pack Health	7930	SLI Battery Pack 1 Battery 4 Predicted Minimum Cranking Voltage
7498	SLI Battery 2 Net Current	7931	SLI Battery Pack 1 Sensor 4 Initialization Status

FIGURE PGN65104_B - BATTERY INFORMATION LEGEND

A.105 PGN 65135 – ADAPTIVE CRUISE CONTROL

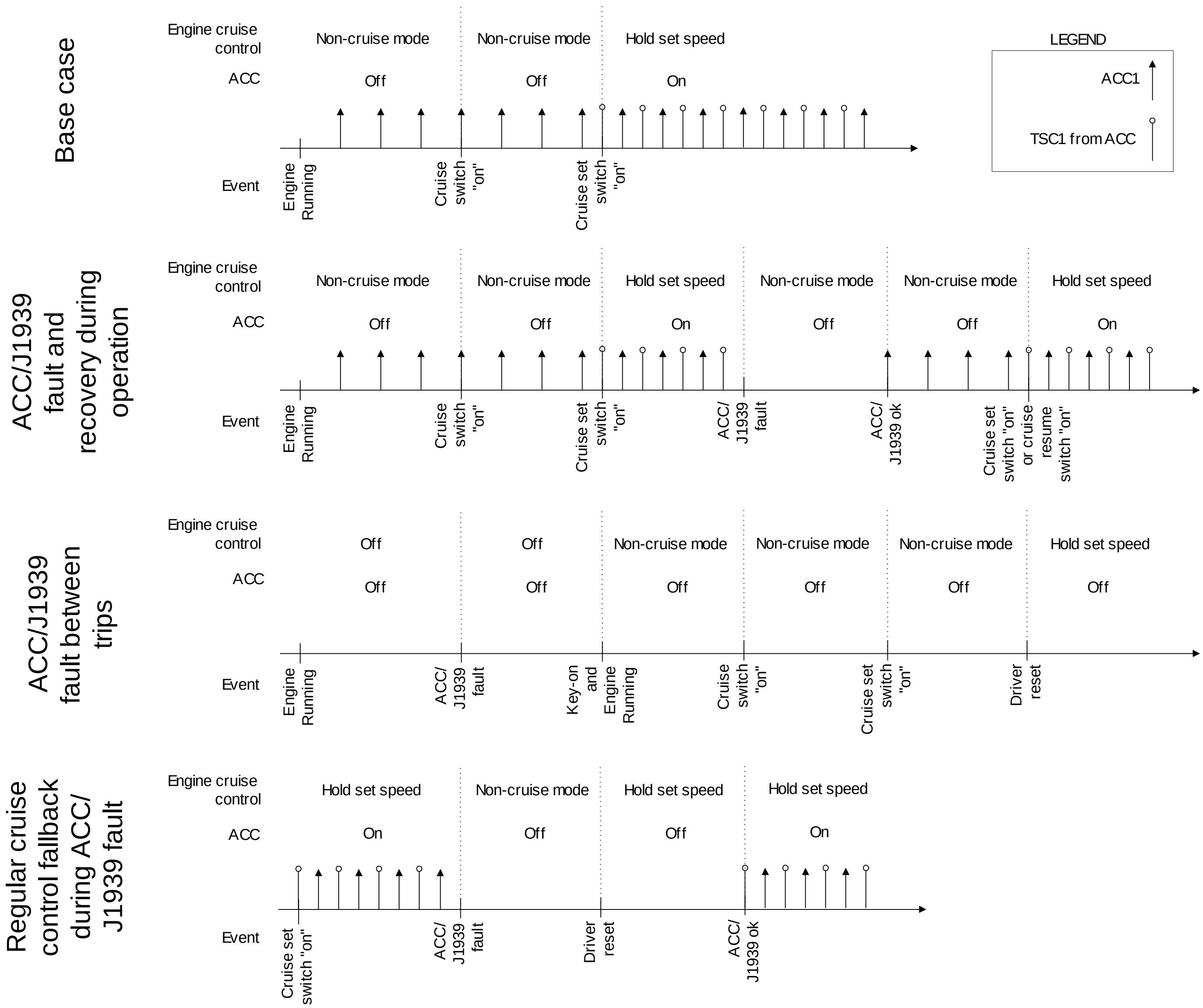


FIGURE PGN65135_A – ADAPTIVE CRUISE CONTROL TIMING DIAGRAM

A.106 PGN 65163 – GASEOUS FUEL PRESSURE

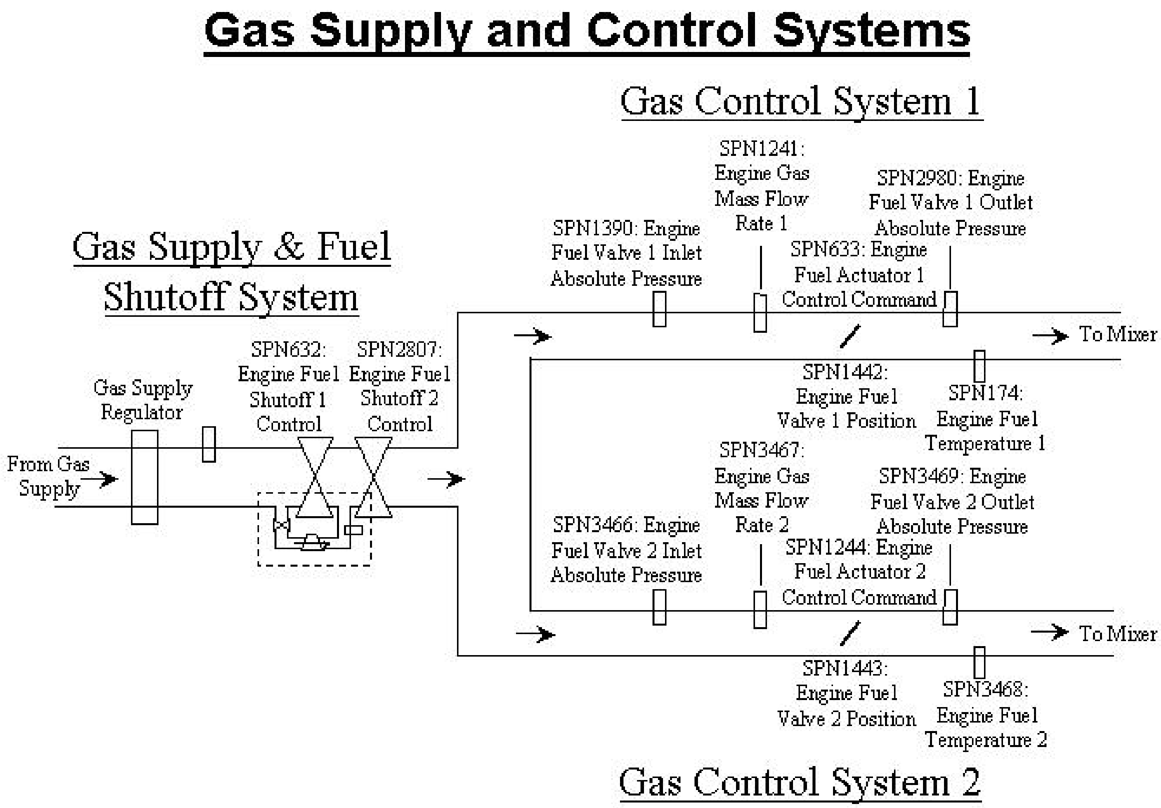


FIGURE PGN65163_A - GAS SUPPLY AND CONTROL SYSTEMS

A.107 PGN 65190 – TURBOCHARGER INFORMATION

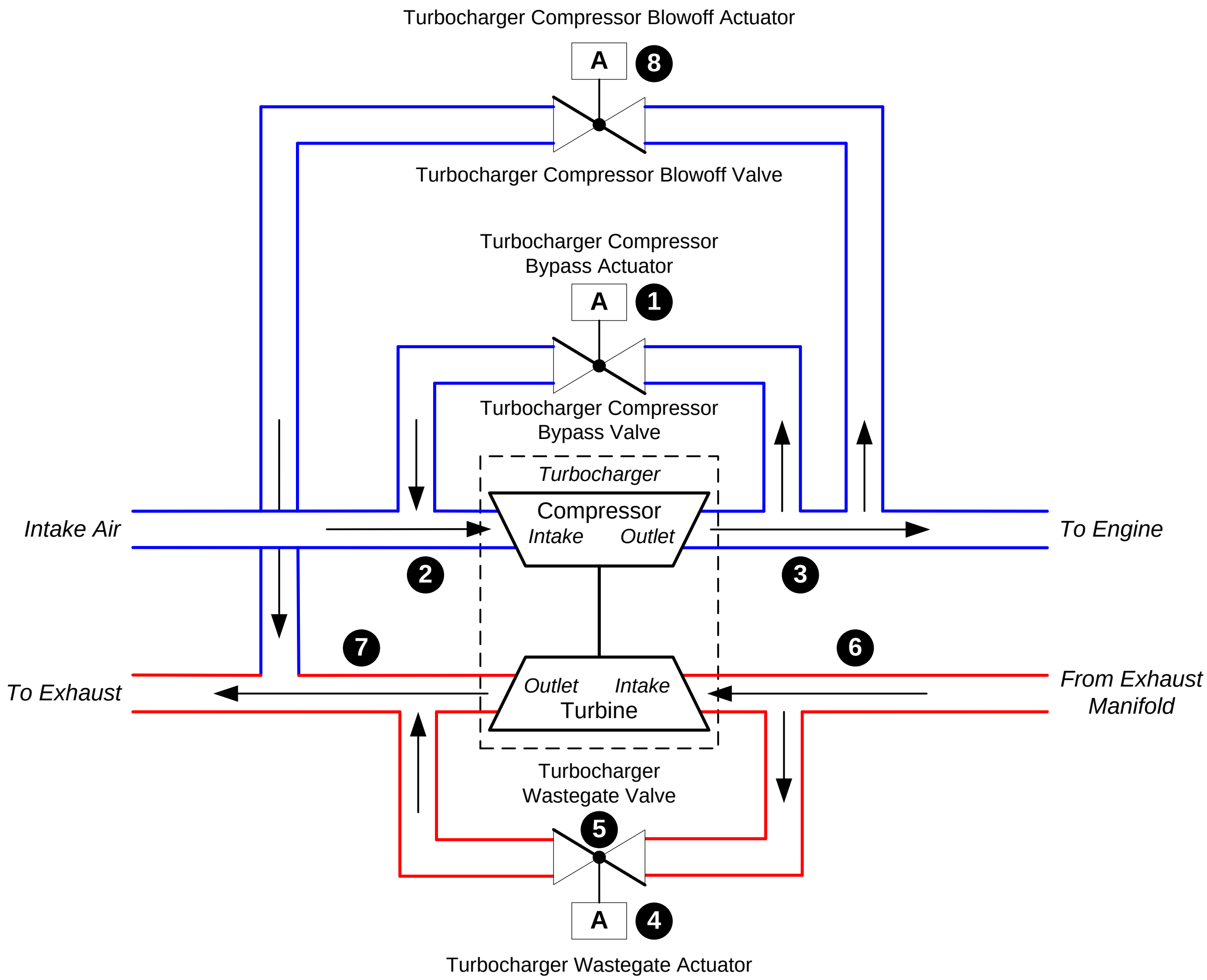


FIGURE PGN65190_A – TYPICAL TURBOCHARGER SYSTEM

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

A.108 PGN 65249 – RETARDER CONFIGURATION

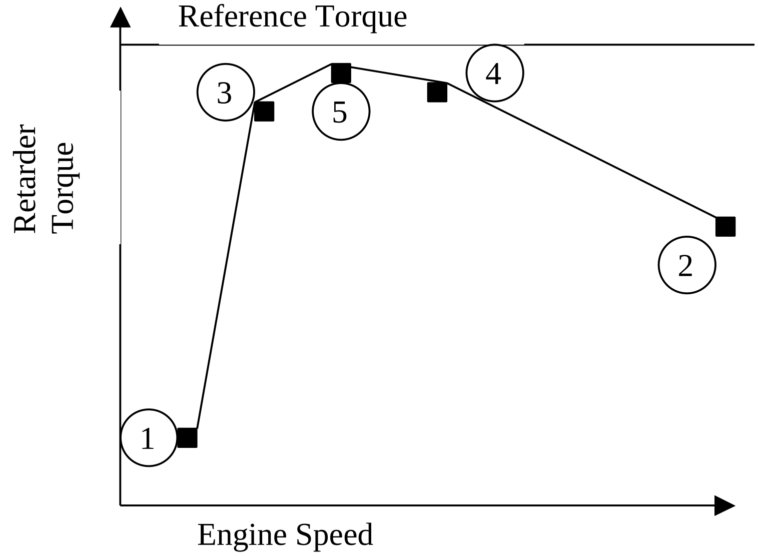


FIGURE PGN65249_A - TYPICAL HYDRAULIC RETARDER TORQUE CURVE

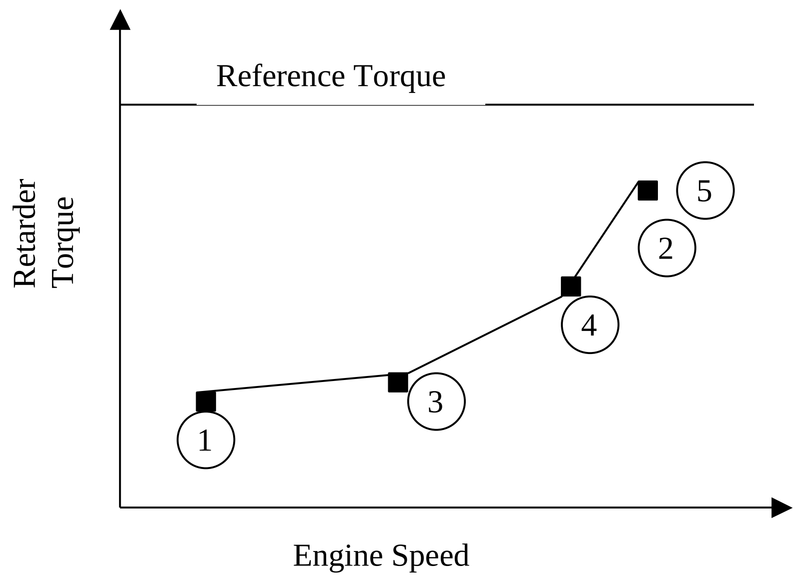


FIGURE PGN65249_B - TYPICAL ENGINE COMPRESSION BRAKE TORQUE CURVE

A.109 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.

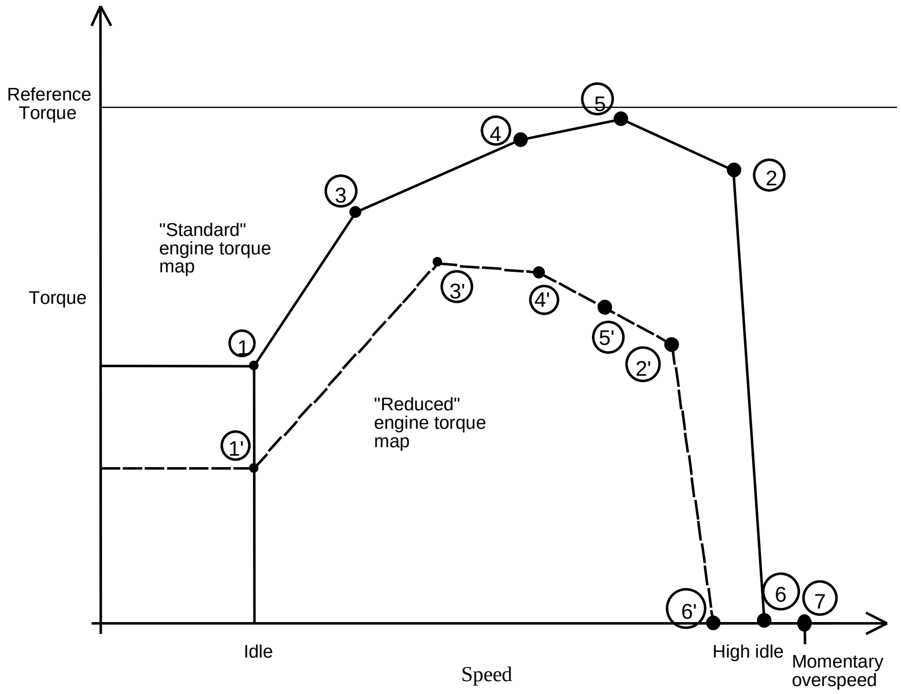


FIGURE PGN65251_A - ENGINE CONFIGURATION MAP - MODE 1

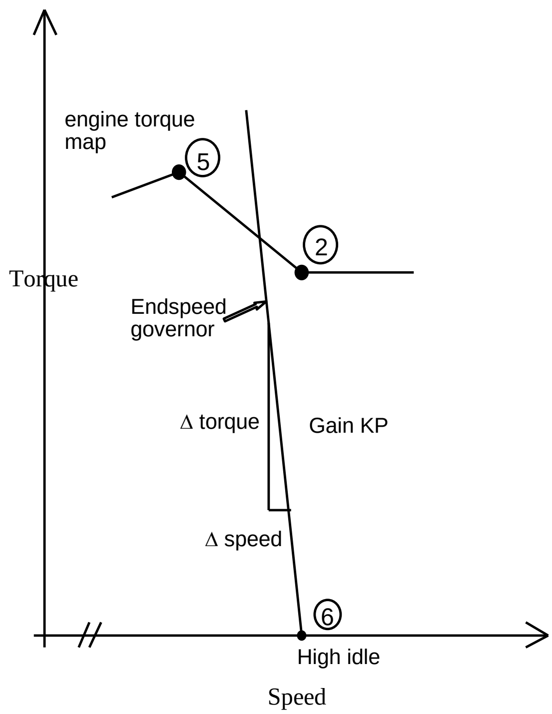


FIGURE PGN65251_B - ENGINE CONFIGURATION MAP - MODE 2

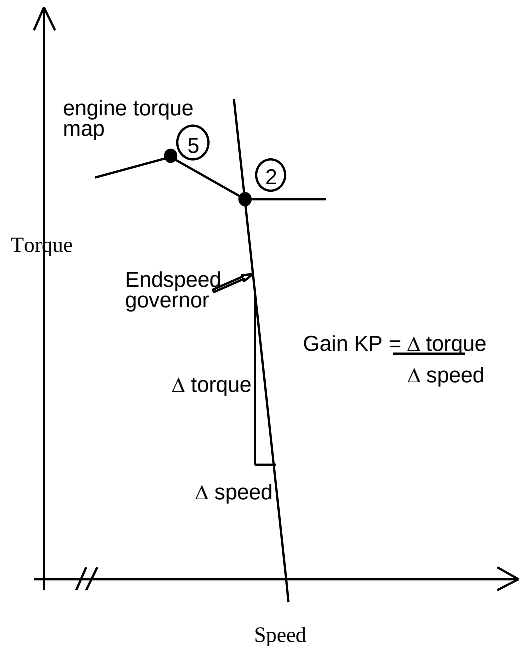


FIGURE PGN65251_C - ENGINE CONFIGURATION MAP - MODE 3

A.110 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.

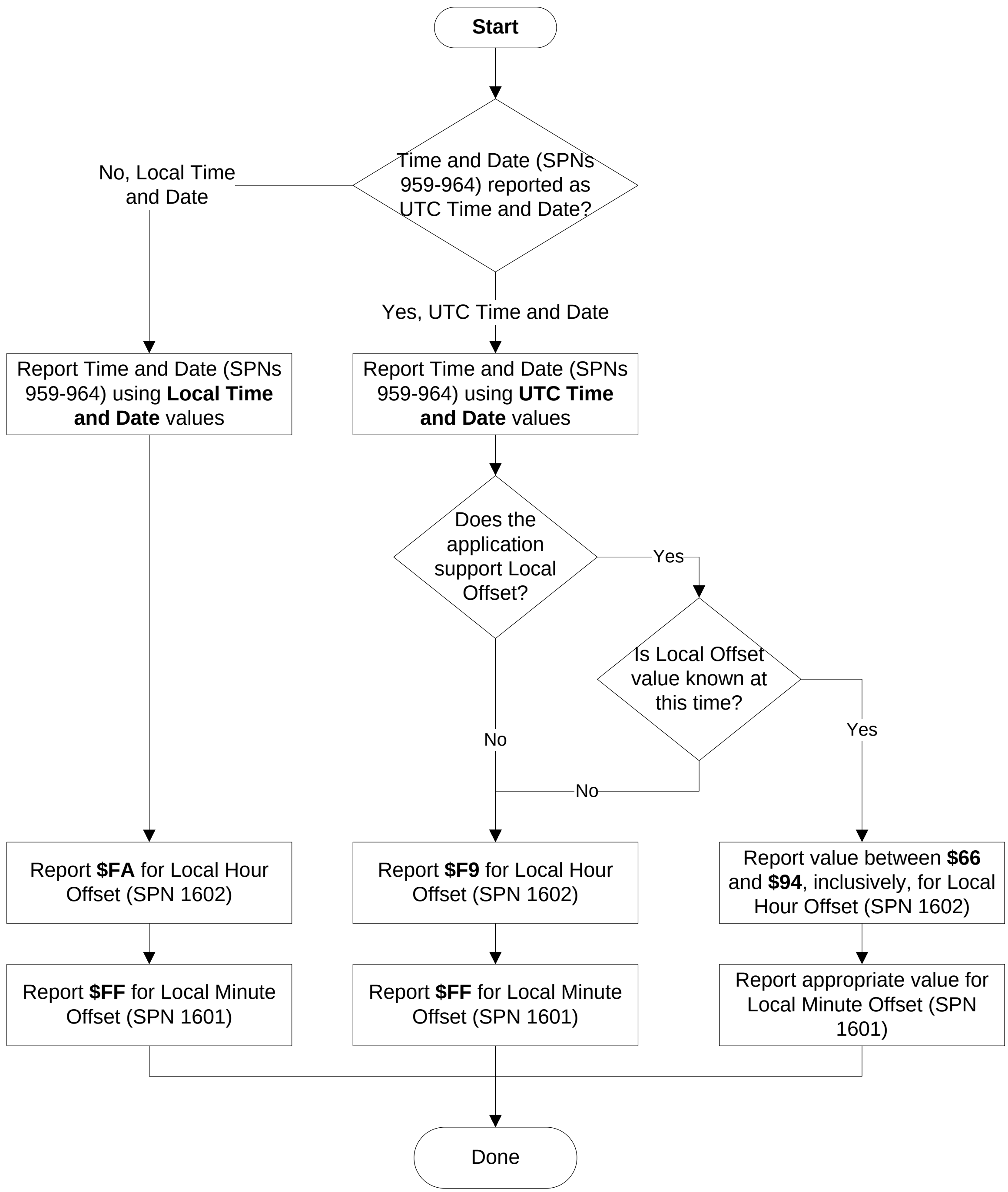


FIGURE PGN65254_A - FLOW CHART FOR REPORTING TIME AND DATE AND LOCAL HOUR OFFSET

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).

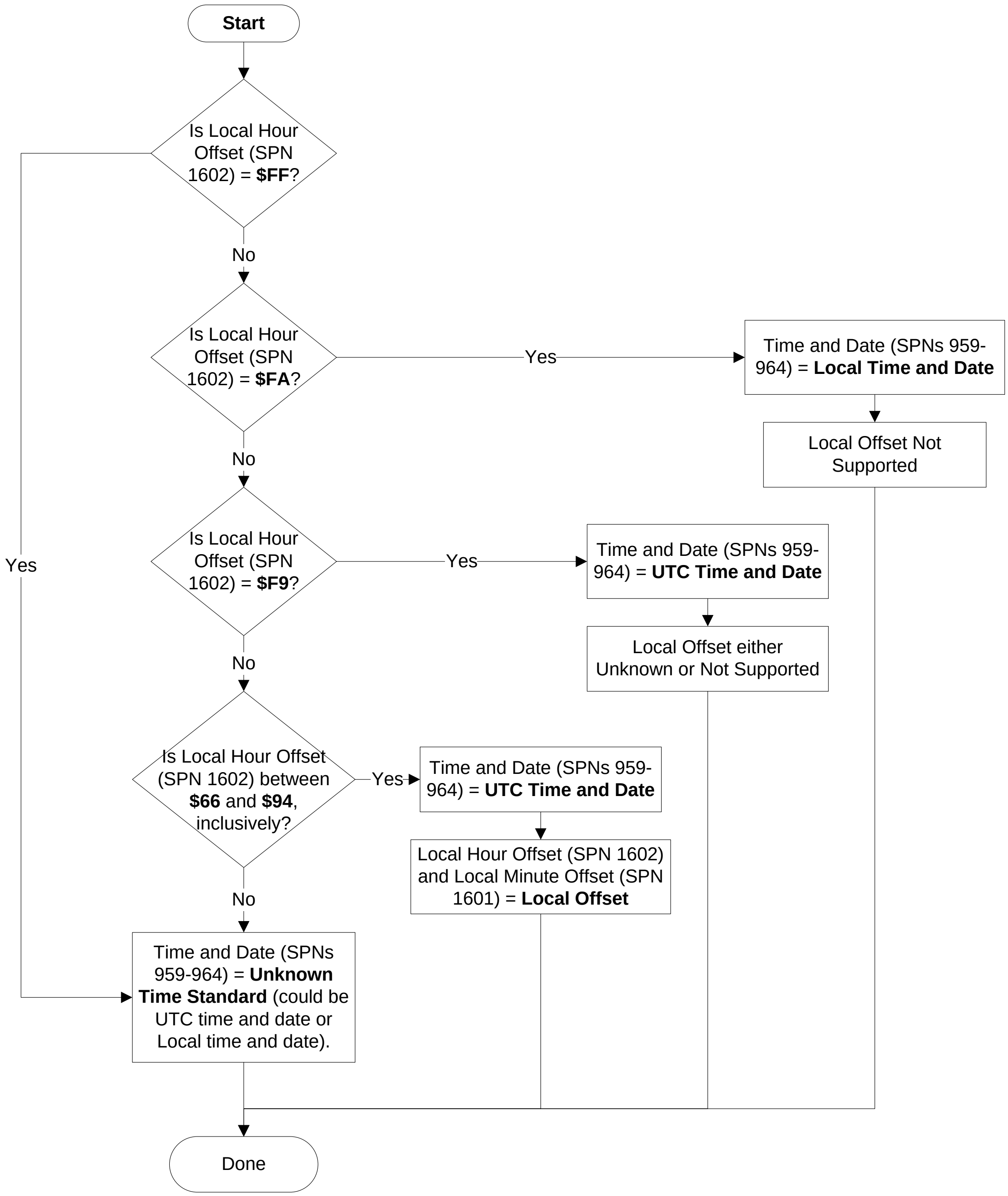


FIGURE PGN65254_B - FLOW CHART FOR INTERPRETING TIME AND DATE AND LOCAL HOUR OFFSET