



INTERFACE STANDARD

Name	J1939 Multiplexing of Inputs and Outputs	Engineering Specification Number
Identifier	Interface Standard	IS-1377-9804
		April 19, 1999

1. Introduction

This document contains the interface information necessary to multiplex vehicle cab information with the engine Electronic Control Unit (ECU) using the SAE J1939 data link. Table 1 lists the SAE J1939 functions supported by Cummins for multiplexing and it indicates whether the Vehicle ECU transmits or receives the information

The document does not attempt to explain the detailed operation of individual functions in the engine ECU, such as cruise control. Cummins provides an Electronic Subsystem Technical Package for each electronic engine that does explain the operation of individual functions. Refer to the Applications Engineering Bulletin (AEB) number TBD as an example.

2. Vehicle ECU Calibration

The Vehicle ECU and the engine ECU must be calibrated properly to allow multiplexing of data via the J1939 data link verses the hard wire input. Each parameter that is to be multiplexed in the vehicle ECU must be calibrated for acceptance in the engine ECU.

The recommended procedure to insure correct programming of the vehicle ECU and the engine ECU is to first determine the parameters that are supported by the Vehicle ECU. (e.g. remote throttle). If the vehicle does not support the parameter then the ECU calibration requires that the parameter feature be turned off and multiplexing for that parameter be turned off.

If the vehicle ECU does support the parameter then the ECU calibration requires the parameter feature be turned on and then a determination as to whether or not the parameter is supported as a hard wired feature or a multiplexed feature. In most cases, following this sequence will allow the vehicle and engine ECU's to log a configuration fault for one having a parameter multiplexed and the other not.

Refer to the appropriate AEB section "OEM Programming" for detailed information on calibrating the engine ECU. Refer to section 10 for diagnostic actions taken for configuration errors.

n Parameters

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Table 1.1 lists parameters related to those required for multiplexing, but are not needed to implement the features described in this document. However, the OEM may have other uses for these parameters so they are described here.

TABLE 1 - J1939 PARAMETERS SUPPORTED FOR MULTIPLEXING I/O

Parameter	PGN	SPN	Vehicle ECU Transmit/Receive	Section
Pneumatic Control Pressure (Wet Tank Pressure)	65,198	46	Receive/Transmit	7.4
Accelerator Pedal Position	61,443	91	Transmit	4.0
Water In Fuel Indicator	65,279	97	Receive	5.0
Accel Pedal Low Idle Switch	61,443	558	Transmit	4.0
Driver Alert Mode	65,252	594	Receive	5.0
Cruise Control Active	65,265	595	Receive	8.1
Cruise Control Enable Switch	65,265	596	Transmit	3.0
Brake Switch	65,265	597	Transmit	3.0,8.3
Clutch Switch	65,265	598	Transmit	3.0,8.4
Cruise Control Set Switch	65,265	599	Transmit	3.0,8.2
Cruise Control Resume Switch	65,265	601	Transmit	3.0,8.2
Red Stop Lamp Status	65,226	623	Receive	5.0
Amber Warning Lamp Status	65,226	624	Receive	5.0
Oil Change Required	65,216	914	Receive	5.0
Engine Test mode Switch	65,265	966	Transmit	3.0
Idle Decrement	65,265	967	Transmit	3.0
Idle Increment	65,265	968	Transmit	3.0
Remote Accelerator Switch	61,441	969	Transmit	3.0
Auxiliary Shutdown Switch	61,441	970	Transmit	3.0
Engine Derate Switch	61,441	971	Transmit	3.0
Accelerator Interlock Switch	61,441	972	Transmit	3.0
Engine Retarder Selection	61,441	973	Transmit	6.0
Remote Accelerator	61,443	974	Transmit	4.2
Estimated Percent Fan Speed	65,213	975	Receive	7.2
Remote PTO Preprogrammed Speed Control Switch	65,264	979	Transmit	3.0
PTO Enable Switch	65,264	980	Transmit	3.0,8.1
PTO Resume Switch	65,264	982	Transmit	3.0,8.2
PTO Set Switch	65,264	984	Transmit	3.0,8.2
A/C High Pressure Fan Switch	65,252	985	Transmit	3.0,7.3
Requested Percent Fan Speed	57,344	986	Transmit	7.1
Protect Lamp Status	65,226	987	Receive	5.0
Wait To Start Lamp	65,252	1081	Receive	5.0
Engine Protection System Approaching Shutdown	65,252	1109	Receive	5.0
Malfunction Indicator Lamp	65,226	1213	Receive	5.4

le 1.1 Other Information Parameters for OEM Use

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Cruise Control Set Speed	65,265	86	Receive	-
Percent Load at Current Speed	61,443	92	Receive	-
Actual Retarder-Percent Torque	61,440	520	Receive	-
Cruise Control State	65,265	527	Receive	-
Retarder Torque Mode	61,440	899	Receive	-
PTO/Remote PTO State	65,265	976	Receive	-
Fan Drive State	65,213	977	Receive	-

3. Digital Signal Conditioning

3.1 Overview

The digital signal conditioning will define the debounce and transmission time for all digital switches. Figure 3.0 is a representation of multiplexing the switches verses non-multiplexing the switches. Below are the list of the switches that can be multiplexed.

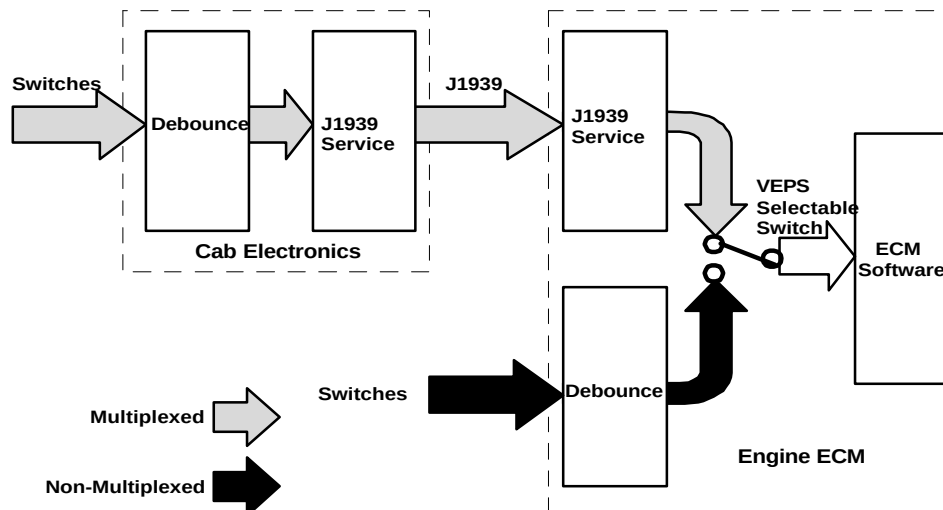


Figure 3.0 Mutlplexing Switches





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<u>Parameter</u>	<u>PGN</u>	<u>SPN</u>
Accel Pedal Low Idle Switch	61,443	558
Cruise Enable	65,265	596
Brake	65,265	597
Clutch	65,265	598
Cruise Set	65,265	599
Cruise Resume	65,265	601
Engine Test Mode	65,265	966
Idle Decrement	65,265	967
Idle Increment	65,265	968
Remote Accelerator	61,441	969
Auxiliary Shutdown	61,441	970
Engine Derate	61,441	971
Accelerator Interlock	61,441	972
Remote PTO Preprogrammed Speed Control	65,264	979
PTO Enable	65,264	980
PTO Resume	65,264	982
PTO Set	65,264	984
A/C High Pressure Fan Switch	65,252	985

3.2 General System Requirements

Each switch SPN above is broadcast from the vehicle ECU if it is multiplexed. Each of the above switches shall be debounced to eliminate false reading. Each input shall be read a minimum of three times over a period of 60 +/- 10 milliseconds. Each read shall be at least 10 milliseconds apart from the last read value. If the state remains the same for each of the reads over the 60 millisecond period, the state of the switch shall be changed. If the switch is asserted a '01' shall be transmitted to the engine ECU. If the switch is not asserted a '00' shall be transmitted to the engine ECU. See also the special conditions for cruise control below.

Therefore the total time from the point of first reading an input switch until it is debounced and ready to be transmitted to the engine ECU shall be a maximum of 70 milliseconds. This is illustrated in figure 2.2.



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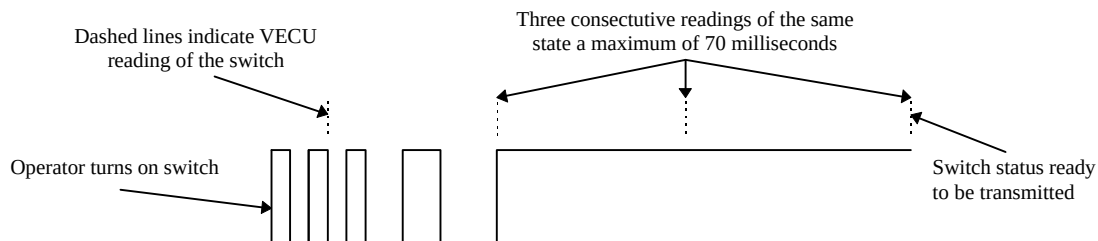
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Figure 3.2 Switch Debounce



4.0 Accelerator and Remote Accelerator

4.1 Accelerator

This section will define the requirements for multiplexing the accelerator signal. Figure 4.0 is a representation of multiplexing with and without the accelerator. The accelerator signal PGN sent to the engine ECU shall conform to FMVSS124. The signal is assumed to be idle validated under non-error conditions. This requires both the accelerator and the idle switch to be multiplexed or both to be non multiplexed.

<u>Parameter</u>	<u>PGN</u>	<u>SPN</u>
Accelerator	61,443	91
Accelerator Pedal Low Idle Switch	61,443	558

Please note that for improved accelerator response, the vehicle ECU must transmit the accelerator pedal value before validation with the switches occurs. Time must be allowed for the idle validation switches to reach the transition point where they are guaranteed to transition and be debounced before validating the agreement between the switch and the accelerator. This may result in the accelerator being non zero when the idle switch is still indicating idle. Also, a 0 % throttle signal must be transmitted for SPN 91 if the engine is to be at idle, since the engine controller operates from the accelerator parameter (SPN 91) if it is valid regardless of the state of the Idle switch. Also note that based on preliminary FMEA results, SPN 91 and 558 should be made available from the same source.



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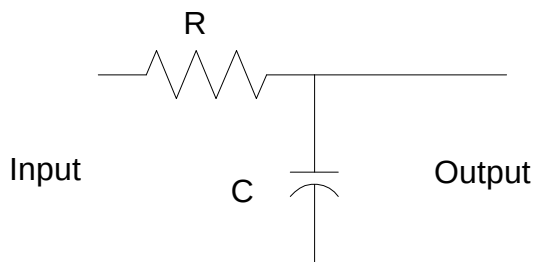
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4.1.1 General signal conditioning requirements

Processor based controls with analog inputs to A/D converters require filtering in some form for noise or to meet requirements of the hold time of the A/D converter. This generally places some requirement for a low pass filter in hardware. Most units typically have a software filtering scheme as well. In order to maintain good system response time these filters need to be carefully selected to minimize the delay imposed by the filters.

It is recommended that the hardware low pass filter have a cut off frequency between 20 - 50 Hz and the software filter have a cut off frequency of 6 - 15 Hz. The sampling rate for the filter should be between 10 and 20 mS to minimize the delays. We recommend 10mS.

The hardware filter is a simple RC lowpass filter of the form:



Low Pass Filter

And the software filter is a simple first order filter in the following form:

$$\text{Output} = \text{Input} + (\text{Output}_{\text{previous}} - \text{Input}) * \text{Filter Constant}$$

Where the filter constant is $e^{-t/T}$, and T is $R*C$. For a unity gain filter, the constant must be between 0 and 1. Where a zero makes the filter transparent to the system and a 1 will fix the input to its initial value.

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4.1.2 Accelerator Error Conditions

The different accelerator position and accelerator pedal low idle switch conditions for normal and error conditions are shown in table 4.1.2 with the action taken by the engine ECU for each case.

The FMEA results of the multiplexed approach versus the non-multiplexed approach indicate that a failure mode is generated in the multiplexed approach that was not existent in the non multiplexed approach. This failure mode occurs as a result of a loss in communication via the data link, and would prevent operation of the engine above idle speed. The cause of the communication loss could be due to a variety of situations (e.g. loss of power to VECU). By the addition of a hard wire connection between the throttle pedal off idle switch and the engine ECU the ability to limp home via two throttle operating conditions can be obtained. This connection is recommended to allow usage of this limp home feature.

4.1.2.1 Clearing of Accelerator Error Conditions

Clearing of error conditions typically occurs when normal function resumes for a specified time period. However, in the case of the accelerator with an accelerator position error, it is recommended that the accelerator error conditions not be cleared until a valid idle condition occurs. In this way, the clearing of an error condition will not create a sudden acceleration, as it would if the error clears with the accelerator in an off idle position.



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Table 4.1.2 Engine ECU Actions For Received Accelerator Pedal and Switch Conditions

VEHICLE ECU INPUTS		VECU J1939 MESSAGE COMMUNICATED		ENGINE ECU ACTIONS	
Accelerator Pedal Position	Accelerator Pedal Low Idle Switch	Accelerator Pedal Position SPN Data	Accelerator Pedal Low Idle Switch SPN	Engine ECU Action Taken	Engine ECU Diagnostic Fault
Normal	Normal	Normal ¹	Normal ⁴	Normal	No Fault
Don't Care	Don't Care	Normal ¹	Not Available or Reserved Condition ⁵	Go to Idle	Set both switch and accelerator to default state as shown in table 11.1 and log a Configuration Fault
Don't Care	Don't Care	Not Available or Reserved Condition ²	Normal ⁴	Go to Idle	Set both switch and accelerator to default state as shown in table 11.1 and log a Configuration Fault
Don't Care	Don't Care	Not Available or Reserved Condition ²	Not Available or Reserved Condition ⁵	Go to Idle	Set both switch and accelerator to default state as shown in table 11.1 and log a Configuration Fault
Don't Care	Don't Care	PGN Time-out	PGN Time-out	Limp home using hard wire	Set accelerator to default state as shown in table 11.1 and log a PGN timeout Fault
Out of range	Normal	Error Condition ³	Normal ⁴	Limp home using Accelerator Pedal Low Idle Switch over the data link	Set accelerator to default state as shown in table 11.1 and log a J1939 Accelerator Fault
Specific Conditions when using a form C switch for Idle Validation					
Normal	Switches indicate Not at Idle and Not at Off Idle simultaneously	Normal ¹	Error Condition ⁶	Normal	Set switch to default state as shown in table 11.1 and log a J1939 Accelerator Fault
Normal	Switches indicate at Idle and at Off Idle simultaneously	Error Condition ³	Error Condition ⁶	Go to Idle	Set both switch and accelerator to default state as shown in table 11.1 and log a 1939 Accelerator Fault
In-range	Reading complimentary states but disagree with the accelerator pedal	Error Condition ³	Error Condition ⁶	Go to Idle	Set both switch and accelerator to default state as shown in table 11.1 and log a 1939 Accelerator Fault
Specific Conditions when using a Single Contact Idle Validation Switch					
In Idle position	Low Idle Switch in off idle position	Normal ¹	Error Condition ⁶	Normal	Set switch to default state as shown in table 11.1 and log a J1939 Accelerator Fault
In off Idle position	Low Idle Switch in idle position	Error Condition ³	Error Condition ⁶	Go to Idle	Set both switch and accelerator to default state as shown in table 11.1 and log a 1939 Accelerator Fault

SAE J1939 Accelerator Pedal Position States: ¹ Normal = 0-FAH; ² Not Available or Reserved Status = FB-FDH, FFH; ³ Error Condition = FEH, out of range high or low

SAE J1939 Accelerator Pedal Low Idle Switch States: ⁴ Normal = 00, 01; ⁵ Not Available or Not Installed = 11; ⁶ Error Condition = 10





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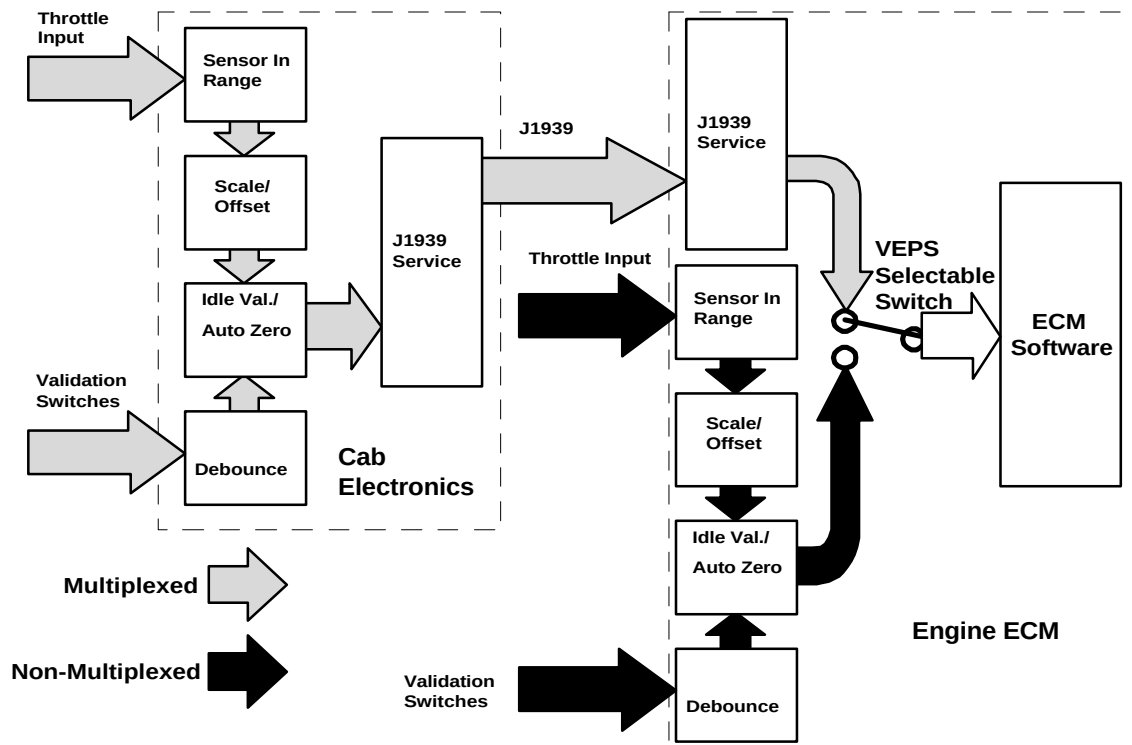


Figure 4.0 Multiplexing The Accelerator

4.2 Remote Accelerator

This section will define the requirements for multiplexing the remote accelerator. When the Remote Accelerator Switch is set to 'on' the Remote Accelerator is enabled.

Parameter	PGN	SPN
Remote Accelerator Switch	61,441	969
Remote Accelerator	61,443	974



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4.2.2 Remote Accelerator Conditions

The different remote accelerator position and remote accelerator switch conditions for normal and error conditions are shown in table 4.2.2 with the action taken by the engine ECU for each case.



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Table 4.2.2 Engine ECU Actions For Received Accelerator Pedal and Switch Conditions

Remote Accelerator Position	Remote Accelerator Enable Switch	Engine ECU Action Taken	Engine ECU Diagnostic Fault Action
Normal ¹	Enabled ⁴	Normal Remote Accelerator Position operation	No Fault
Normal ¹	Error Condition ⁶	Use Primary Accelerator Position parameter	Set both to default state as shown in table 11.1 and log a J1939 Remote Accelerator Fault
Error Condition ³	Enabled ⁴	Go to idle	Set remote accelerator to default state as shown in table 11.1 and log a J1939 Remote Accelerator Fault
Normal ¹	Not Available or Reserved Condition ⁵	Use Primary Accelerator Position parameter	Set both to default state as shown in table 11.1 and log a Configuration Fault
Not Available or Reserved Condition ²	Enabled ⁴	Go to idle	Set remote accelerator to default state as shown in table 11.1 and log a Configuration Fault
PGN time-out	Enabled ⁴	Go to idle	Set remote accelerator to default state as shown in table 11.1 and log a PGN Time-out Fault
Normal ¹	PGN time-out	Use Primary Accelerator Position parameter	Set both to default state as shown in table 11.1 and log a PGN Time-out Fault
PGN time-out	PGN time-out	Go to idle	Set both inputs to default state as shown in table 11.1 and log a PGN Time-out Fault
Error Condition ³	Error Condition ⁶	Use Primary Accelerator Position parameter	Set both inputs to default state as shown in table 11.1 and log a J1939 Remote Accelerator Fault
Not Available or Reserved Condition ²	Not Available or Reserved Condition ⁵	Use Primary Accelerator Position parameter	Set both inputs to default state as shown in table 11.1 and log a Configuration Fault
Don't Care	Not Enabled ⁷	Use Primary Accelerator Position parameter	No Fault

SAE J1939 Remote Accelerator Position States:

¹ Normal = 0-FAH; ² Not Available or Reserved Status = FB-FDH, FFH;

³ Error Condition = FEH, out of range high or low

SAE J1939 Remote Accelerator Enable Switch States:

⁴ Enabled = 01; ⁵ Not Available or Reserved Status = 11

.0; ⁷ Not Enabled = 00



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5.0 Lamp Outputs and Operator Warning

This section will define the requirements for multiplexing the lamp outputs and warning the operator of engine or vehicle operating conditions. This can be done either with the lamps or a text display but in either case the operator should be given sufficient warning of vehicle operating conditions.

When the lamps are controlled by the vehicle ECU each of the lamp outputs shall be activated/deactivated within 100 milliseconds after receiving the status from the data link. The engine ECU, where appropriate, will send the following status parameters to the vehicle ECU. Figure 5.0 is a representation of multiplexing with and without the lamp drivers.

<u>Parameter</u>	<u>PGN</u>	<u>SPN</u>
Water in fuel indicator	65,279	97
Driver Alert Mode	65,252	594
Red Stop Lamp	65,226	623
Amber Warning Lamp	65,226	624
Oil Change Required	65,216	914
Protect Lamp	65,226	987
Wait to Start	65,252	1081
Engine Protection System Approaching Shutdown	65,252	1109
Malfunction Indicator Lamp	65,226	1213

5.1 Power up Lamp Flash Sequence

There are two recommended options for the power up lamp sequence. The first option is for those installations where it is still possible to cross wires from the controlling device to the lamp. An illustration is shown in figure 5.1. The second option is for the installations that no longer require verification of crossed wires.



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Option 1:

1. turn all lamps on for 2.0 seconds as soon as possible after the key switch is turned on
2. turn off the first lamp and delay for 0.5 seconds
3. turn off the second lamp and delay for 0.5 seconds
4. turn off the next lamp and delay for 0.5 seconds
5. continue the sequence above until all lamps are off at which time the lamps remain off for 1.0 seconds before any other action is taken.

Key ON power up delay x sec	all lamps on 2.0 sec	first lamp off 0.5 sec	Second lamp off 0.5 sec	Nth lamp off 0.5 sec	all lamps off 1.0 sec	continue non-power up lamp display
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Figure 5.1 Option 1 Powerup Lamp Sequence

Option 2:

1. turn all lamps on for 2.0 seconds as soon as possible after the key switch is turned on
2. turn all lamps off for 1.0 seconds before any other action is taken.

In some applications it may be acceptable for the vehicle ECU to customize the application of the lamps.

If the vehicle is not equipped with a text or graphics display and the red and amber lamps are to be used to flash fault code information, refer to section 9 for details.

5.2 Oil Change Required Lamp Sequence

indicates the oil change interval has expired either the text or graphics need to change oil or the lamps can be flashed to indicate this to the

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operator. It should be noted that PGN 65,216, which contains the oil change required SPN is not broadcast on a regular basis, but is a requested parameter. The recommended approach on flashing the lamps is to indicate this condition when the key switch is turned on and begin flashing the protect lamp immediately after the initial power up lamp sequence is complete. It is recommended that the lamp be flashed in the following pattern:

Power up Flash sequence is complete	Wait for 5 sec	Turn lamp on .3 sec	Turn lamp off .3 sec	Turn lamp on .3 sec	Turn lamp off .3 sec	Turn lamp on .3 sec	Turn lamp off .9 sec	Repeat flash cycle 5 times
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Figure 5.2 Oil Change Required Lamp Sequence

5.3 Driver Alert Mode and Engine Protection System Approaching Shutdown Lamp Sequence

If the engine is about to shutdown due to an Idle shutdown feature as indicated by the Driver Alert Mode SPN, the amber Warning Lamp should be flashed to warn the operator. If the engine is about to shutdown due to an engine protection feature as indicated by the Engine Protection System Approaching Shutdown SPN, the red Stop Engine lamp should be flashed to warn the operator. The lamp should repeatedly flash from the time the message is received until the shutdown takes place and the associated SPN indicates an off condition. Typically, the warning is issued 30 seconds before a shutdown occurs. Recommended flash timing is .3 seconds on followed by .3 seconds off and repeated for the duration of the flash cycle.

5.4 Malfunction Indicator Lamp

The Malfunction Indicator Lamp message indicates that a failure has occurred in the engine which has an effect on emissions. In markets or applications where this lamp is required, this message can be used to communicate the information.



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5.5 Maintenance Lamp

The maintenance lamp is to be illuminated whenever the Protect Lamp is indicated. This is a relatively new lamp defined at Cummins to indicate that operator maintenance should be performed at the most convenient opportunity. The faults which will cause the illumination of this lamp are defined in the serial communications document.

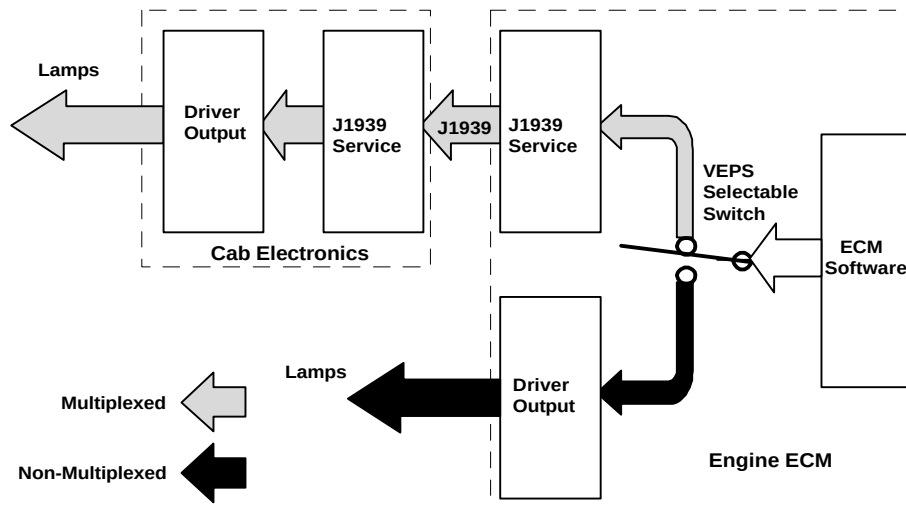


Figure 5.0 Multiplexing Lamps

6.0 Engine Brake

This section will define the requirements for multiplexing the engine brake inputs. Figure 6.0 is a representation of multiplexing with or without engine brake. As defined by J1939, the engine brake parameter is a percent of desired braking level. The vehicle ECU shall send the following parameter to activate/deactivate the engine brake.

Parameter	PGN	SPN
Engine Retarder Selection	61,441	973

Automatic engine brake mode is available in the engine ECU in cruise control (refer to the AEB for further details). In this mode the automatic engine brake operation percentage of braking applied is limited to the maximum Engine Brake Selection percentage transmitted to



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The actual number of engine brake cylinders activated will be based on a number of conditions of the vehicle and engine as determined by the engine ECU. Refer to the AEB for further information about the operation of the engine brake.

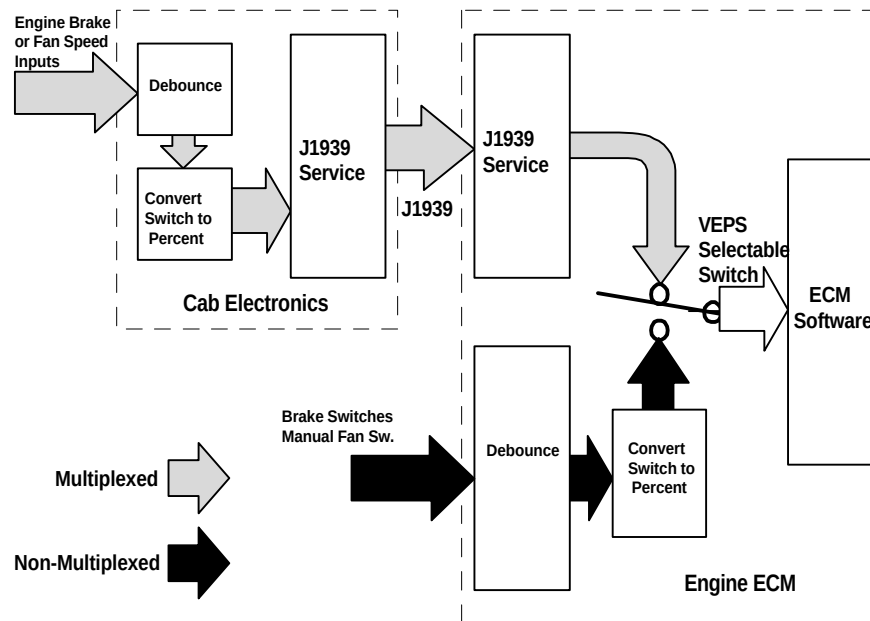


Figure 6.0 Multiplexing Engine Retarder and Fan Speed



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7.0 Auxiliary Controls

7.1 Requested Percent Fan Speed

This section will define the requirements for multiplexing the auxiliary inputs. Figure 6.0 is a representation of multiplexing with or without fan control. As defined by J1939, the fan speed parameter is a percent of desired fan speed requested by the operator. The vehicle ECU shall send or receive the following parameters to activate/deactivate the fan. Air compressor control in the future will require the pneumatic control pressure parameter.

<u>Parameter</u>	<u>PGN</u>	<u>SPN</u>
Pneumatic Control Pressure (Wet Tank Pressure)	65,198	46
A/C High Pressure Fan Switch	65,252	985
Requested Percent Fan Speed	57,344	986

The fan will be activated by the engine ECU based on a number of conditions of the vehicle (e.g. high side refrigerant pressure input), as well as the engine (e.g. coolant temperature) and type of fan in use. When the engine is running, the fan speed will always be set to the highest fan speed requested by either the requested percent fan speed input or the fan speed as determined by the engine ECU. Refer to the AEB for further information about the operation of the fan.

7.2 Estimated Percent Fan Speed

The estimated percent fan speed broadcast from the engine ECU will be dependent on vehicle and engine operating conditions and the type of fan being controlled.

7.3 A/C High Pressure Fan Switch

The A/C High Pressure Fan Switch will need to be read by the vehicle ECU and broadcast on J1939 for use by other devices. The engine ECU algorithm will modify the fan speed based on the status of the A/C High Pressure Fan Switch.



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7.4 Pneumatic Control Pressure

A future parameter in the ECM will be the Pneumatic control pressure which may be read by the engine ECU or VECU and broadcast on J1939 for use by other devices.

8.0 Cruise Control & PTO

8.1 Cruise Control & PTO Active

Cruise Control Active or PTO Active will be set to “on” and broadcast by the engine ECU once the engine ECU has received the Cruise Control Enable SPN or PTO Enable SPN set to “on” from the vehicle ECU. Similarly the Cruise Control Active or PTO Active will be set to “off” and broadcast by the engine ECU once the engine ECU has received the Cruise Control Enable SPN or PTO Enable SPN set to “off” from the vehicle ECU.

8.2 Cruise Control and PTO Set and Resume

The engine ECU will determine if either the cruise control or PTO mode is active. Therefore, the vehicle ECU shall set both the Cruise switch SPN number as well as the PTO switch SPN number as required. For example, if the cab set switch is depressed, both the Cruise SPN set switch and the PTO SPN set switch will be set to indicate on. Similarly, if the cab resume switch is depressed, both the Cruise SPN resume switch and the PTO SPN resume switch will be set to indicate on.

The engine ECU will not respond to the Cruise control Accelerate Switch SPN 602, Coast Switch SPN 600, PTO Accelerate Switch SPN or the PTO Coast Switch SPN parameters. The engine ECU will determine if PTO or cruise are in accelerate or coast modes are entered when the Set or Resume SPN remains “on” for a minimum of 500 milliseconds and cruise mode has already been activated. The engine ECU can be programmed for either Set/Coast, Resume/Accel or Set/Accel, Resume/Coast modes. Refer to the appropriate AEB for further information on the operation of cruise control and setting of the desired mode.



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8.3 Brake Switch

The brake switch shall indicate not asserted '00' when released and asserted '01' when depressed.

8.4 Clutch Switch

The clutch pedal switch shall indicate not asserted '00' when the clutch pedal is released and asserted '01' when the clutch pedal is depressed. For more information see the appropriate technical package.

9.0 Switch sequencing and switch sharing

By monitoring a sequence of switch closure and opening events, the engine ECU can then determine to activate or reset certain functions or features. A table showing these switch sequences is shown in Table 9.0.

The OEM may have similar scenarios in which certain switches are shared to activate certain modes of operation in the vehicle ECU. It is the responsibility of both parties to make sure that the switch sequencing patterns and feature activation are not misinterpreted by the various ECU's. In the future, special messages from the vehicle ECU will be the preferred method of enabling or resetting these features.



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TABLE 9.0 Switch Sequencing and Sharing

SW1 - On/Off Cruise Control Switch (PGN 65,265) or On/Off PTO Switch¹ (PGN 65,264)

SW2 - Set/Coast Cruise Control Switch (PGN 65,265) or Set/Coast PTO Switch¹ (PGN 65,264)

SW3 - Resume/Accelerate Cruise Control Switch (PGN 65,265) or Resume/Accelerate PTO Switch¹ (PGN 65,264)

SW4 - Engine Test Mode Switch (PGN 65,265).

SW5 - Idle Increment Switch (PGN 65,265).

SW6 - Idle Decrement Switch (PGN 65,265).

speed, e.g. 30 MPH.

SW7 - Brake Switch (PGN 65,265)

SW8 - AP Low Idle Switch (PGN 61,433)

AP - Accelerator Pedal (AP) Position (PGN 61,443)

SW9 - Remote PTO Preprogrammed Speed Control Switch (RPTO PProg SCS) (PGN 65,264)

SW10 - Alternate Torque Select Switch

SW11 - Torque Curve Select

CC Mode - When the CC is enabled and active.

PTO Mode - When the CC is enabled and the Vehicle Speed is less than the calibrated

Engine Idle Mode - Engine speed is at Idle with Vehicle Speed = 0.

Engine Stop Mode - Engine RPM is zero

Integrated Idle Management System (**IIMS**)

PreProgrammed (**PProg**).



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Switch Functionality for Features	Hardwired Into ECM	Engine Mode & Conditions required to Achieve Switch Functionality for that Feature	J1939 Mux'ed Parameters
Cruise Control (CC) 1.) Enable/Disable 2.) Set Vehicle Speed 3.) Resume Vehicle Speed <i>Bump Up/Down Vehicle Set Speed ²</i> <i>Ramp Up/Down Vehicle Set Speed ²</i>	 1.) SW1 2.) SW1, SW2 3.) SW1, SW3 <i>SW1, SW2, SW3</i> <i>SW1, SW2, SW3</i>	 1.) SW1 ON while in CC mode. 2.) SW1 ON and Tap SW2 while NOT in CC mode. 3.) SW1 ON and Tap SW3 when NOT in CC mode. <i>SW1 ON and Tap SW2 or SW3 while IN CC mode.</i> <i>SW1 ON and Hold SW2 or SW3 >0.5sec while IN CC mode.</i>	 1.) CC Enable Switch 2.) CC Enable Switch CC Set Switch 3.) CC Enable Switch CC Resume Switch <i>CC Enable Switch</i> <i>CC Set Switch</i> <i>CC Resume Switch</i> <i>CC Enable Switch</i> <i>CC Set Switch</i> <i>CC Resume Switch</i>
Diagnostic Fault Code Flashout 1.) Bump Up/Down using Idle Increment or Decrement Switches 3 <i>Bump Up/Down using CC Switches 2</i> 2.) Bump Up using Accelerator Pedal (AP)	 1.) SW4, SW5, SW6 <i>SW1, SW2, SW3</i> 2.) AP	 1.) SW4 ON and Tap SW5 or SW6 while IN Engine Stop Mode. <i>SW1 OFF and Tap SW2 or SW3 while IN Engine Stop mode.</i> 2.) Step1 - Fully depress AP and release . Repeat 2 more times for e.g. <5sec. Step2 - Fully depress AP and release to increment fault codes flash out.	 1.) Engine Test Mode Switch Idle Increment Switch Idle Decrement Switch <i>CC Enable Switch</i> <i>CC Set Switch</i> <i>CC Resume Switch</i> 2.) Accelerator Pedal (AP)



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Switch Functionality for Features	Hardwired Into ECM	Engine Mode & Conditions required to Achieve Switch Functionality for that Feature	J1939 Mux'ed Parameters
Idle Engine Speed Adjustment 1.) Bump Up/Down using Idle Increment or Decrement Switches 3 <i>Bump Up/Down using CC Switches 2</i>	1.) SW5, SW6 SW1, SW2, SW3	1.) Tap SW5 or SW6 while IN Engine Idle Mode. <i>SW1 OFF and Tap SW2 or SW3 while IN Engine Idle mode.</i>	1.) Idle Increment Switch Idle Decrement Switch CC Enable Switch CC Set Switch CC Resume Switch
Power Takeoff (PTO) 1.) Enable/Disable <i>Set PProg Engine Speed 1</i> <i>Ramp Up/Down PProg Engine Speed 1 2</i> <i>Set PProg Engine Speed 2</i> <i>Ramp Up/Down PProg Engine Speed 2 2</i> <i>Set PProg Engine Speed 8</i> <i>Ramp Up/Down PProg Engine Speed 8 2</i>	1.) SW1 SW1, SW2 SW1, SW2, SW3 SW1, SW3 SW1, SW2, SW3 SW1, SW2, SW3 SW1, SW2, SW3	1.) SW1 ON while IN PTO mode. <i>SW1 ON and Tap SW2 while IN PTO mode.</i> <i>SW1 ON and Hold SW2 or SW3 >0.5sec while IN PTO mode and in speed 1.</i> <i>SW1 ON and Tap SW3 while IN PTO mode.</i> <i>SW1 ON and Hold SW2 or SW3 >0.5sec while IN PTO mode and in speed 2.</i> <i>SW1 ON and Tap both SW2 and SW3 at same time while IN PTO mode.</i> <i>SW1 ON and Hold SW2 or SW3 >0.5sec while IN PTO mode and in speed 8.</i>	1.) PTO Enable Switch PTO Enable Switch PTO Set Switch PTO Enable Switch PTO Set Switch PTO Resume Switch PTO Enable Switch PTO Resume Switch PTO Enable Switch PTO Set Switch PTO Resume Switch PTO Enable Switch PTO Set Switch PTO Resume Switch PTO Enable Switch PTO Set Switch PTO Resume Switch

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Switch Functionality for Features	Hardwired Into ECM	Engine Mode & Conditions required to Achieve Switch Functionality for that Feature	J1939 Mux'ed Parameters
Remote Power Takeoff (RPTO)			
1.) Set PProg RPTO Engine Speed 3 <i>Set PProg RPTO Engine Speed 4</i>	1.) SW9 SW9	1.) SW9 ON >0.5sec while IN PTO mode. <i>Step1 SW9 ON then OFF then ON <0.5sec while IN PTO mode.</i> <i>Step2 Repeat step 1.</i> <i>Step1 SW9 ON then OFF then ON <0.5sec while IN PTO mode.</i> <i>Step2 Repeat step 1 two more times.</i> <i>Step1 SW9 ON then OFF then ON <0.5sec while IN PTO mode.</i> <i>Step2 Repeat step 1 three more times.</i> <i>Step1 SW9 ON then OFF then ON <0.5sec while IN PTO mode.</i> <i>Step2 Repeat step 1 four more times.</i>	1.) RPTO PProg SCS <i>RPTO PProg SCS</i>
<i>Set PProg RPTO Engine Speed 5</i>	SW9		<i>RPTO PProg SCS</i>
<i>Set PProg RPTO Engine Speed 6</i>	SW9		<i>RPTO PProg SCS</i>
<i>Set PProg RPTO Engine Speed 7</i>	SW9		<i>RPTO PProg SCS</i>
Alternate Power Takeoff (APTO)			
1.) Enable/Disable <i>Set PProg Engine Speed 1</i>	1.) SW1 SW1, SW2	1.) SW1 ON while IN PTO mode. <i>SW1 ON and Tap SW2 while IN PTO mode.</i>	1.) PTO Enable Switch <i>PTO Enable Switch</i> <i>PTO Set Switch</i> <i>PTO Enable Switch</i> <i>PTO Set Switch</i> <i>PTO Resume Switch</i> <i>PTO Enable Switch</i> <i>PTO Resume Switch</i> <i>PTO Enable Switch</i> <i>PTO Set Switch</i> <i>PTO Resume Switch</i>
<i>Ramp Up/Down PProg Engine Speed 1 2</i>	SW1, SW2, SW3	<i>SW1 ON and Hold SW2 or SW3 >0.5sec while IN PTO mode and in speed 1.</i> Note: To switch from PProg Engine Speed 1 and 2, you must FIRST toggle SW1 (SW1 OFF then ON) before the 2nd PProg Engine Speed may be obtained.	
<i>Set PProg Engine Speed 2</i>	SW1, SW3	<i>SW1 ON and Tap SW3 while IN PTO mode.</i>	
<i>Ramp Up/Down PProg Engine Speed 2 2</i>	SW1, SW2, SW3	<i>SW1 ON and Hold SW2 or SW3 >0.5sec while IN PTO mode and in speed 2.</i>	
IIMS			
	1.) SW1	1.) SW1 ON , interlocks in safe position, 0 Vehicle Speed while IN Engine Idle mode.	1.) CC Enable Switch





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Switch Functionality for Features	Hardwired Into ECM	Engine Mode & Conditions required to Achieve Switch Functionality for that Feature	J1939 Mux'ed Parameters
Top-2 Gears 1.) Enable/Disable <i>Freezes State of Transmission</i>	1.) SW1 <i>SW1</i>	1.) SW1 ON enables Top-2 while either IN or NOT in Top-2. <i>SW1 OFF while IN Top-2.</i>	1.) CC Enable Switch <i>CC Enable Switch</i>
Max Road Speed Governor (RSG) 1.) Bump Up/Down 2 2.) Ramp Up/Down 2	1.) SW1, SW2, SW3 2.) SW1, SW2, SW3	1.) SW1 OFF and Tap SW2 or SW3 while NOT in Engine Idle Mode. 2.) SW1 OFF and Hold SW2 or SW3 >0.5sec while NOT in Engine Idle Mode.	1.) CC Enable Switch CC Set Switch CC Resume Switch 2.) CC Enable Switch CC Set Switch CC Resume Switch
Tire Wear Monitor 1.) Enable Reset	1.) SW1, SW7, SW8	1.) Step1 - SW1 OFF while in Engine Stop Mode. Step2 - Then turn SW1 ON , SW7 ON , SW8 OFF by depressing the AP.	1.) CC Enable Switch Brake Switch AP Low Idle Switch



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Switch Functionality for Features	Hardwired Into ECM	Engine Mode & Conditions required to Achieve Switch Functionality for that Feature	J1939 Mux'ed Parameters
Fuel Inlet Restriction Monitor (FIRM) 1.) Enable Reset for the FIRM	1.) SW7, AP	1.) Step1 - Fully depress AP and Hold . While holding AP, depress and release SW7. twice, then release the AP while in Engine Stop Mode. Step2 - Repeat step 1. Complete steps 1 & 2 within 20sec.	1.) Brake Switch Accelerator Pedal (AP)
User Activated Datalogger 1.) Enable Datalogger for Snapshot	1.) SW4	1.) SW4 OFF then ON when engine is NOT in Engine Stop Mode to capture 1 Snapshot. Cycle SW4 from ON to OFF then ON to capture 2nd Snapshot. All attempts to capture any other Snapshots will simply overwrite the 2nd Snapshot.	1.) Engine Test Mode Switch
AUTOMOTIVE Oil Change Monitor (OCM) 1.) Enable Reset for Automotive using Accelerator Pedal (AP) and Brake	1.) AP, SW7	1.) Step1 - Fully depress AP and Hold . While holding AP, depress and release SW7 brake three times then release the AP while in Engine Stop Mode. Step2 - Repeat step 1. Complete steps 1 & 2 within e.g. 15sec.	1.) Accelerator Pedal (AP) Brake Switch
INDUSTRIAL Oil Change Monitor			



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Switch Functionality for Features	Hardwired Into ECM	Engine Mode & Conditions required to Achieve Switch Functionality for that Feature	J1939 Mux'ed Parameters
1.) Enable Reset for Industrial using Accelerator Pedal (AP)	1.) AP	1.) Step1 - Fully depress AP for e.g. >3sec, then release while in Engine Stop Mode. Step2 - Fully depress AP and release for e.g. <3sec. Perform twice more. Step3 - Fully depress AP for e.g. >3sec. Complete all 3 steps within e.g. 30sec.	1.) Accelerator Pedal (AP)
2.) Enable Reset for Industrial using Engine Test Mode Switch 4	2.) SW4	2.) Step1 - SW4 ON and Hold for e.g. >3sec, then turn OFF while in Engine Stop Mode. Step2 - then cycle ON and OFF twice more for e.g.<3sec. Step3 - then turn ON and Hold for e.g. >3sec. Complete all 3 steps within 20sec.	2.) Engine Test Mode Switch
INDUSTRIAL Ether Change Monitor			
1.) Enable Reset using Engine Test Mode Switch	1.) SW4	1.) Step1 - SW4 ON and Hold for e.g. >5sec, then turn OFF for e.g.>5sec while in Engine Stop Mode. Step2 - SW4 ON and Hold for e.g. >5sec. Complete steps 1 & 2 within e.g. 30sec.	1.) Engine Test Mode Switch
2.) Enable Reset using Accelerator Pedal (AP)	2.) AP	2.) Step1 - Fully depress AP for e.g. >5sec, then release for e.g.>5sec while in Engine Stop Mode. Step2 - Fully depress AP for e.g. >5sec. Complete steps 1 & 2 within e.g. 30sec.	2.) Accelerator Pedal (AP)
INDUSTRIAL Throttle Rescale			
1.) Alternate Torque Select Switch	1.) SW10	1.) SW10 OFF or ON (discrete input) Depends upon Trims and Calibrations.	1.) <i>Not Currently Available</i>
2.) Torque Curve Select	2.) SW11	2.) SW11 LOW, MID, HIGH (analog input) Depends upon Trims and Calibrations.	2.) <i>Not Currently Available</i>

¹ The On/Off Resume/Accelerate PTO Switches may be hardwired if the CC Feature is being multiplexed, otherwise must be sent on datalink if the PTO feature is multiplexed.

² This switch is trimmable allowing for the direction to be changed to “up or down” via the Set_Accel_Switch_Select.

³ The Inc Dec Separate Switch_Select must be set to TRUE in order to use Increment and Decrement switches instead of the CC Switches.
Diagnostic Test Switch is only made available for installations without an Accelerator Pedal.



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Note: The key switch is ON for all of the above features.



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10.0 Diagnostics and Service

10.1 Fault Code Support

The vehicle ECU shall perform multiplexing system diagnostics and self diagnostics where possible. All fault messages shall be J1939 publicly defined in order to maximize serviceability of the engine/vehicle ECU interface.

For applications that do not have a text or graphics display the fault code information may be flashed to the driver from the engine ECU when the engine test mode switch is enabled for applications where the lamps are not multiplexed. When the lamps are multiplexed by the vehicle ECU the vehicle ECU can read the SAE J1939 Diagnostic Message 1 (DM1) and flash the fault information on the lamps as specified for each Cummins fault code. A complete list of Cummins fault codes and flash sequences is contained in the Serial Communications section of the engine technical package.

10.2 Disable of Broadcast for ECU Service

The engine ECU and vehicle ECU shall implement the SAE J1939 Stop/Start Broadcast PGN 57088 to allow disabling of broadcasts during service and ECU programming procedures.

10.3 Cab Accessible Service Link

A standard cab accessible service stub shall exist. The stub shall follow the SAE J1939 diagnostic connector recommendation (9-pin Deutsch). It shall be located in the data link wiring harness between the vehicle ECU and the engine compartment bulkhead connector.



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11. Loss of J1939 Communication and Error Management

The engine ECU does, and the vehicle ECU should continually verify the receipt and accuracy of messages that are being received on the J1939 data link. There are separate error modes for PGN error and SPN errors and the actions for each are covered below. In order to prevent erroneous communication errors due to start up delay differences between communicating modules it is recommended that all modules be powered up simultaneously. This will typically require all modules to be powered from the same keyswitch source. It is also recommended that a TBD delay be added before logging data link communication errors to prevent erroneous errors from being logged at startup. Currently, the engine ECU has a 10-second delay after power up, before communication errors are logged.

11.1 PGN Time Out

If a PGN from a source is not received within five times the broadcast rate, the SPN supported by that PGN source should be set to the default safest state in the receiving ECU. Refer to table 11.1 for the Default State for a PGN time-out error condition. The engine ECU will log a PGN timeout fault for any PGN time-out. It is recommended that the vehicle ECU log a PGN time-out fault for any PGN time-out.

11.2 SPN Error Conditions

Depending on the type (analog or switch), an SPN can be received in two or three different states other than the normal parameter condition. These states are an Error state, Not Available, and SAE Reserved. If an individual SPN is received by either ECU in one of these states or conditions and the SPN has been calibrated to be multiplexed in the receiving ECU, the SPN shall be set to the corresponding default state in the receiving ECU as shown in table 11.1.

In addition the engine ECU will log a fault for several of these conditions. The engine ECU will log a configuration fault if either the Not Available or SAE Reserved states are received for any SPN that is multiplexed (see table 1). The engine ECU will also log an individual fault if the Accelerator Pedal Position (SPN 91) or the Remote Accelerator (SPN 974) is set to the Error state condition, see section 4.0.

DEFAULT MODES FOR DATA LINK BROADCAST ERRORS

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Parameter	PGN	SPN	VECU Default Mode	ECU Default Mode
Pneumatic Control Pressure (Wet Tank Pressure)	65,198	46	zero	-
Cruise Control Set Speed	65,265	86	zero	-
Accelerator Pedal Position	61,443	91	-	zero
Percent Load at Current Speed	61,443	92	zero	-
Water In Fuel Indicator	65,279	97	Off	-
Actual Retarder-Percent Torque	61,440	520	zero	-
Cruise Control State	65,265	527	Off/Disabled	-
Accel Pedal Low Idle Switch	61,443	558	-	Low idle
Driver Alert Mode	65,252	594	Warning lamp on	-
Cruise Control Active	65,265	595	Cruise control switched off	-
Cruise Control Enable Switch	65,265	596	-	Disabled
Brake Switch	65,265	597	-	Engaged
Clutch Switch	65,265	598	-	Engaged
Cruise Control Set Switch	65,265	599	-	Not set
Cruise Control Resume Switch	65,265	601	-	Not resume
Red Stop Lamp Status	65,226	623	Lamp off	-
Amber Warning Lamp Status	65,226	624	Lamp on	-
Retarder Torque Mode	61,440	899	No request	-
Oil Change Required	65,216	914	Warning lamp on	-
Engine Test mode Switch	65,265	966	-	Off
Idle Decrement	65,265	967	-	Not set
Idle Increment	65,265	968	-	Not set
Remote Accelerator Switch	61,441	969	-	Not set
Auxiliary Shutdown Switch	61,441	970	-	Not set
Engine Derate Switch	61,441	971	-	Not set
Accelerator Interlock Switch	61,441	972	-	Not set
Engine Retarder Selection	61,441	973	-	Not set
Remote Accelerator	61,443	974	-	zero
Estimated Percent Fan Speed	65,213	975	zero	-
PTO/Remote PTO State	65,265	976	Off/Disabled	-
Fan Drive State	65,213	977	Fan Off	-
Remote PTO Preprogrammed Speed Control Switch	65,264	979	-	Not set
PTO Enable Switch	65,264	980	-	Disabled
PTO Resume Switch	65,264	982	-	Not resume
PTO Set Switch	65,264	984	-	Not set
A/C High Pressure Fan Switch	65,252	985	Not set	-
Requested Percent Fan Speed	65,213	986	-	Zero
Protect Lamp Status	65,226	987	Lamp off	-
Wait To Start Lamp	65,252	1081	Lamp off	-
Engine Protections System Approaching Shutdown	65,252	1109	Warning lamp on	-
Malfunction Lamp	65,226	1213	Warning lamp on	-

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Table 11.2 Engine ECU Diagnostic Actions For Received Abnormal Conditions

Received State	ECU Action
Not Available or SAE Reserved State	Set to the default state as shown in table 11.1 and log a configuration fault.
Error State	¹ Set to default state as shown in table 11.1.

¹ - See section 4.0 for additional Accelerator and Remote Accelerator faults.

11.3 Input Voltage operating requirements

The operating voltage range of the VECU should correspond to the operating voltage range of the EECU. If the VECU should stop operating during abnormal voltage conditions, such as battery load dump, intermittent connections, or inductive load switching, erratic throttle performance and the logging of faults can occur. Duration of inductive load switching faults can be up to 10 mS and load dump conditions can last up to 480 mS. The EECU is designed to operate continuously over the 9-32 volt range and during transient conditions of load dump, inductive load switching, and starter motor engagement. To minimize problems during engine cranking fault logging of J1939 messages in the engine ECU will not occur during cranking but will resume 10 seconds after cranking stops.

12.0 Failure Mode and Effects Analysis

Hardware configurations greatly effect the failure mode and effects analysis for a given input or output. For this reason the choice of normally closed or normally open switches and grounding type switch inputs or high side type switch inputs are best determined through an FMEA. Recommendations for various switch types in previous ECU's using the non-multiplexed approach will generally be acceptable if the ECU hardware configuration is the same. An application specific FMEA needs to be performed on any new ECU hardware in order to make sure the failure conditions will not result in unacceptable performance or behavior.



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INTERFACE STANDARD

Name	J1939 Multiplexing of Inputs and Outputs	Engineering Specification Number
Identifier	Interface Standard	IS-1377-9804
		April 19, 1999

REVISION HISTORY

REV 1. Changed Accel Ped low Idle switch SPN, added SPN's for several TBD's. Added a new section 9 on switch sequencing and renumbered the sections and tables that followed. Corrected Pneumatic Control pressure SPN. Changed brake and clutch switch defaults in Table 11.1 to engaged. Deleted Paragraph 12. Corrected superscripts in Table 4.1.2 Corrected Wait to Start SPN. Added Malfunction Indicator Lamp information in Par. 5.4, to table in Par. 5.0 and to table 1. Revised Par. 10.1 wording around Engine test switch function. Par. 5.3 Changed description of lamp to be flashed to correspond to the appropriate shutdown condition. Corrected several typos. Reordered all tables by ascending SPN number. Added Section 5.5 Maintenance Lamp.

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REV 2. Added Para. 4.1.2.1 Clearing of Accelerator error conditions. Clarified wording in Table 4.1.2.

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