Application Engineering Bulletin

Subject	This AEB is for the following applications:
Electronic Features	☐ **Automotive** ☒ **Industrial** ☐ **Power Generation**

Date September 2000	Page 1 of 34	AEB Number 15.40

Engine Models included: QSB, QSC, QSL9, QSM11, QSX15, QSK19, QST30, QSK45, QSK60

Fuel Systems included:

Introduction

The Electronic Features Technical Package was written to assist OEMs in understanding the Industrial Electronic Features. This technical package also includes the setup and limitations of the Generic Calibrations for each engine family and the Engine Monitoring System called CENSE.

Refer to the following other Industrial AEBs:

> **15.42   OEM Interfaces and Components**
>
> **15.43   Datalinks and Diagnostics**
>
> **15.44   Installation Recommendations**

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FEATURE DESCRIPTION

Section I: Governors

There are several types of governors available on the QUANTUM engines: Min/Max (automotive), All Speed (variable speed), Low Speed, High Speed, Intermediate Speed Control, and Auxiliary Speed.

1. All Speed (Variable Speed) Governor
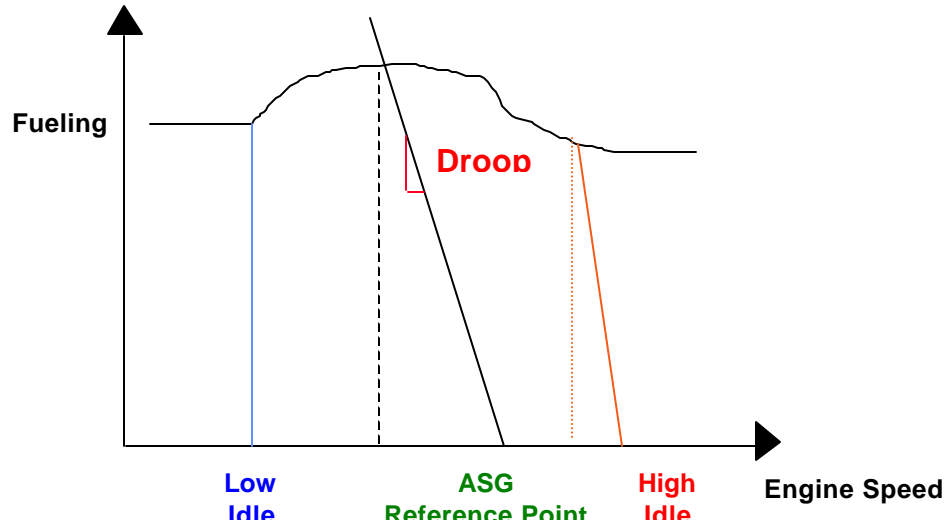
$$\text{Droop \%} = \frac{\text{no load speed - full load speed}}{\text{(full\_load\_speed)}} \times 100$$

All Speed Governor controls to an engine speed proportional to the throttle position. This governor has the ability to run isochronous (0% droop) or with droop. Droop is the change in engine speed with change in load. Droop can be defined independently at 0% throttle and 100% throttle; then interpolates in between that range.

2. Automotive Min/Max Governor
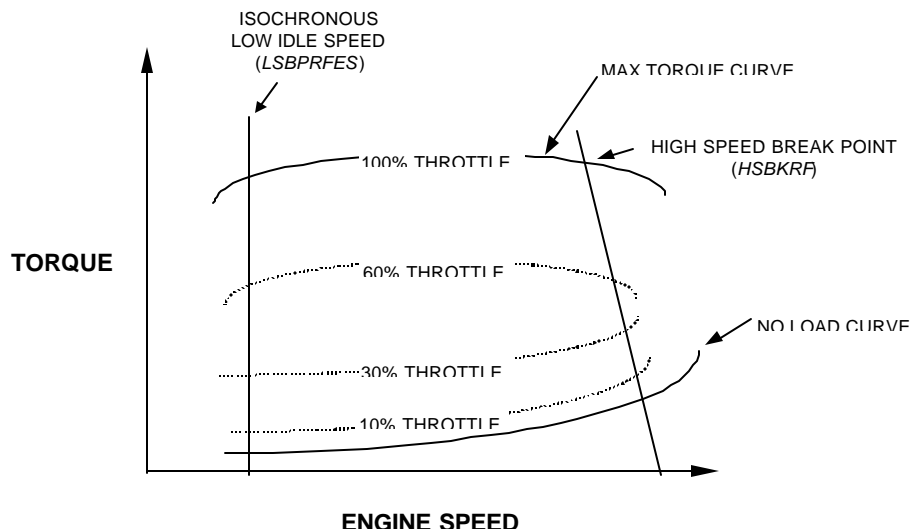
The Min/Max Governor produces engine torque proportional to throttle input. Engine speed is determined by the load and is bounded by the low speed governor and high-speed governor.

3. Auxiliary Speed Governor

The Auxiliary Speed Governor provides a means for the engine to be governed by something other than engine speed. Engine speed is controlled in order to maintain a given Auxiliary Speed input (speed or pressure) to the ECM. It is intended to control shafts or other similar mechanisms on the downstream side of the torque converter. The Auxiliary Speed Governor has two possible modes of operation, Speed Control and Pressure Control. This governor can be enabled or disabled via on/off switch. When you turn the switch off you go back to low idle and no longer have throttle control. The pressure/speed is set by the current throttle position at the time it is turned on. Load pressure/speed must be proportional to engine speed for the auxiliary governor to function.

Pressure Control

The Pressure Control Governor feature maintains a constant pump/compressor output for applications which require constant liquid/gas delivery pressures. Engine speed is controlled to maintain a constant fluid pressure, regardless of flow requirements, but constrained by the engine operating limits. The equipment operator is able to vary the command reference pressure as necessary with an adjustable throttle input.

Exceptions

QST30   not available

Speed Control

The Auxiliary Speed Governor controls engine speed in order to maintain a given Auxiliary Speed input to the ECM. This input is typically measured on the downstream side of the torque converter. The operator uses the throttle to adjust the Auxiliary reference speed of the Auxiliary Governor. There is no droop capability.

4. Hybrid Governor
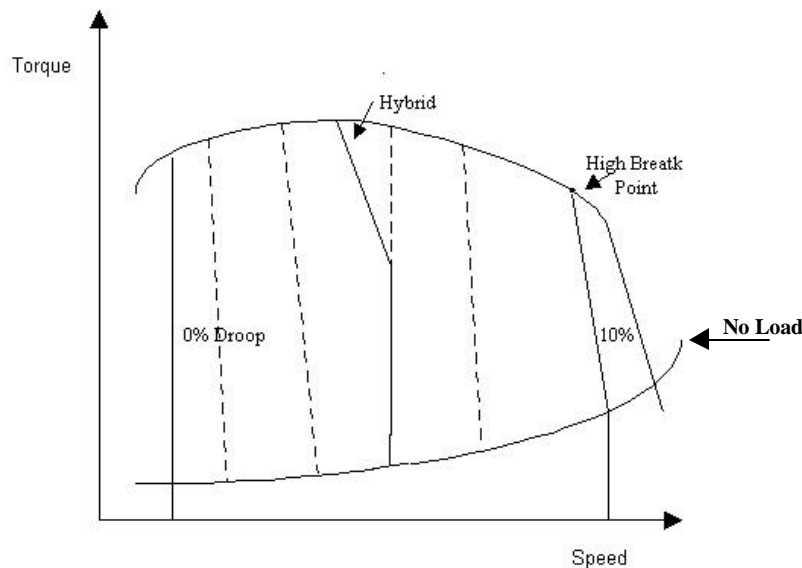
At low loads the hybrid governor runs isochronous and as the load exceeds a predetermined torque level engine speed starts drooping back. The hybrid governor allows part throttle torque rise when using the all speed governor.

Exceptions

QSK19/45/60   not available

5.   Cruise Control

Cruise Control has three modes: off, standby and active. The *off* position of the enable switch, disables cruise control. The *standby* mode occurs when the operator switches the cruise control on/off switch to the on position. The operator can then achieve the *active* mode, the accelerator pedal can be used to increase the speed beyond the cruise control set speed (up to the high idle engine governor speed or to the road speed governor limit). When the pedal is released, cruise control will remain active when vehicle speed reached the previously set speed.

Cruise Control is deactivated and returns to the *standby* mode in several ways; the brake pedal is depressed, the engine speed drops below 1000 (rpm), and on a manual transmission, the activation of the clutch switch.

To return to *active* mode, if cruise is in *standby* mode, the operator must enable either the set or the resume switch. Momentary enabling the set switch will establish a new set speed at the current vehicle speed. Momentary enabling of the resume switch will return cruise control to the previously established cruise speed.

While in the *active* mode, the coast feature of the set switch is used to decrease the vehicle speed and establish a new lower cruise speed. By holding the set switch closed, the vehicle speed decreases until the switch is released; the speed at release becomes the new set speed. One-mile-per-hour decrements can be achieved by bumping (briefly enabling) the set switch.

The accelerate feature of the resume switch, is used to increase the vehicle speed and establish a new higher cruise speed. By holding this switch closed, the vehicle speed increases until the switch is released; the speed at release becomes the new set speed. One-mile-per-hour increments can be achieved by bumping (briefly enabling) the resume switch.

Note: The cruise control feature can be multiplexed using J1939.

Exceptions

QSM11   not available

QSX15   not available

QSK19   not available

QST30   not available

QSK45   not available

QSK60   not available

6.   Road Speed Governor

The Road Speed Governor feature allows the owner to limit the maximum vehicle speed. A vehicle speed sensor is required for this feature.

Exceptions

QSM11   not available

QSX15   not available

QST30   not available

QSK19   not available

QSK45   not available

QSK60   not available

7. Intermediate Speed Control

The Intermediate Speed Control (ISC) is a fixed speed governor that can be activated by up to three switches. Inputs are labeled as ISC 1,2, & 3 in the Systems Wiring Diagram. In addition, a variable voltage input may be added to allow five more speeds (otherwise known as variable ISC). See table below. When activated by switch or potentiometer, the ISC feature governs engine speed to the corresponding preset speed depending on priority. The three preset speeds can be adjusted with an increment/decrement switch and are service tool adjustable but will not exceed the low or high idle governor engine speed limits. Only one droop setting is available for all ISC speeds. One of the switch inputs can, as an option, be used as a validation input (ISC3). In this case, ISC requests are not recognized unless the validation input is ON and the ISC switch input has transitioned from OFF to ON. If validation is selected only two ISC speeds can be achieved and the five variable ISC inputs will be disabled. User defined priority logic determines which ISC speed is in control with multiple active switch inputs. The priority logic also determines when throttle or ISC will control engine speed.

There are three modes of operation with respect to the throttle. In the first mode, the throttle has control over the ISC speed so the ISC speed acts as a Low Speed Governor. In the second mode, the throttle has control under the ISC speed so the ISC speed acts as a High Speed Governor. In the third mode, when ISC is activated there is not any throttle control at all.

| Default Variable ISC Voltage Values ||
Speed	Voltage
1	0-1V
2	1V-2V
3	2V-3V
4	3V-4V
5	4V-5V

Section II: Engine Performance

8. Alternate Droop

Figure 1-1 Alternate Droop Selection

Figure 1-2 Alternate Droop Switch Configuration
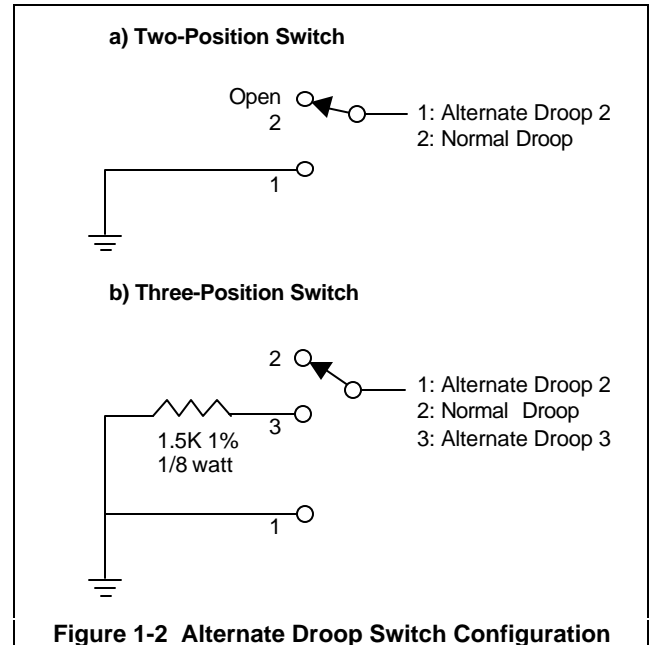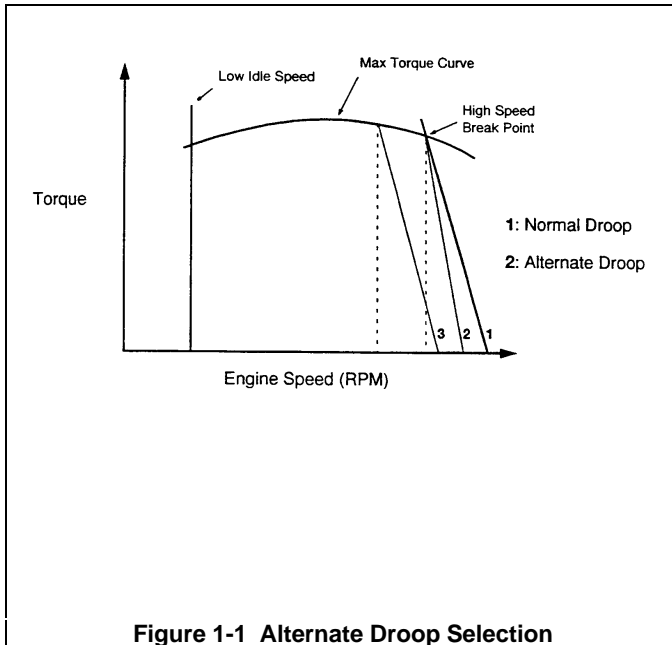
The switched Droop/Breakpoint feature allows the droop characteristics to be changed for both the High Speed Governor and All Speed Governor and is expressed as a percentage. A two-position switch or a three-position switch can be used depending on whether the OEM need one or two alternate droop settings.

The Switched Droop/Breakpoint feature also provides, depending on OEM requirements, the ability to select up to 3 droop settings by way of an OEM supplied switch. Each droop setting provides the ability to select the breakpoint speed and droop percent for the HSG and droop percent for the All Speed governor. The breakpoint speed determines at what position on the engine torque curve the HSG will start to limit engine torque output. The selection of the Alternate Droop feature is optional.

Exceptions

QSM11   only use 2-position switch

QSX15   only use 2- position switch

QSK19   switch (config showing in fig 1-3)

QST30   switch (config showing in fig 1-3)

QSK45   switch (config showing in fig 1-3)

QSK60   switch (config showing in fig 1-3)

Figure 1-3 Alternate Droop Switch Configuration for QSK19, QST30, QSK45, QSK60
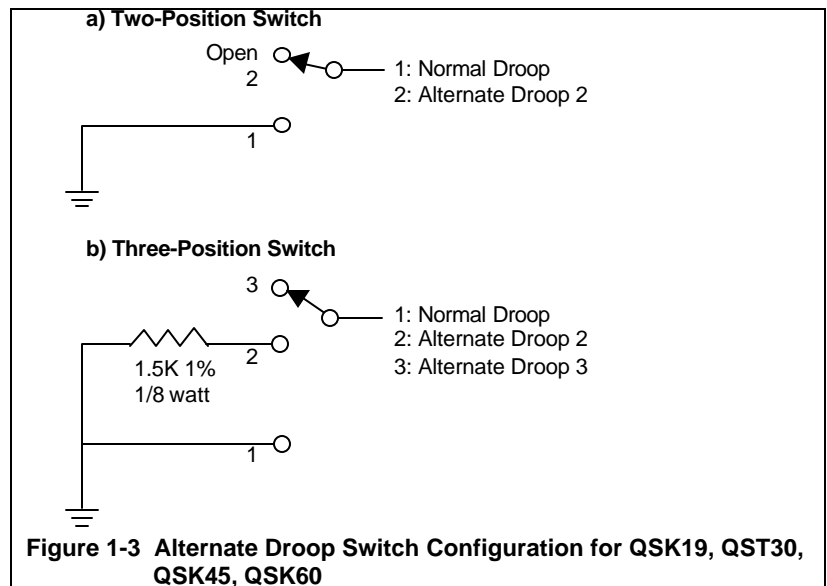
9. Alternate Torque Curve

At times it is desirable to limit the engine torque output to protect the equipment, transmission, or change the functional characteristics of the equipment during a particular operating mode.

The Alternate Torque Curve feature allows the OEM to switch between the 100% throttle torque curve and up to two derated torque curves. The ability to select each additional derated torque curve is provided by way of an OEM supplied switch. The OEM may use either a two-position switch or a three-position switch for this feature. The shape of the Alternate Torque Curves 1 and 2 has to be specified by the customer.

Figure 1-4 Alternate Torque Curve
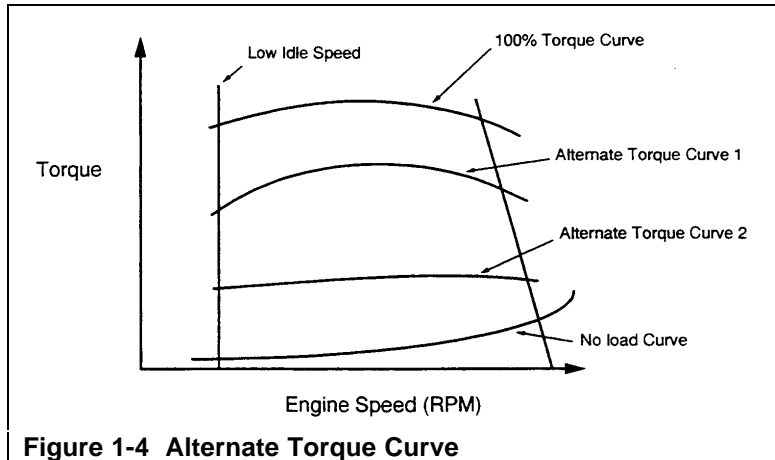
The switch position provides one of three possible inputs to the torque curve selection input of the ECM. See switch configuration in Figure 1-5.

Figure 1-5 Switches Configuration
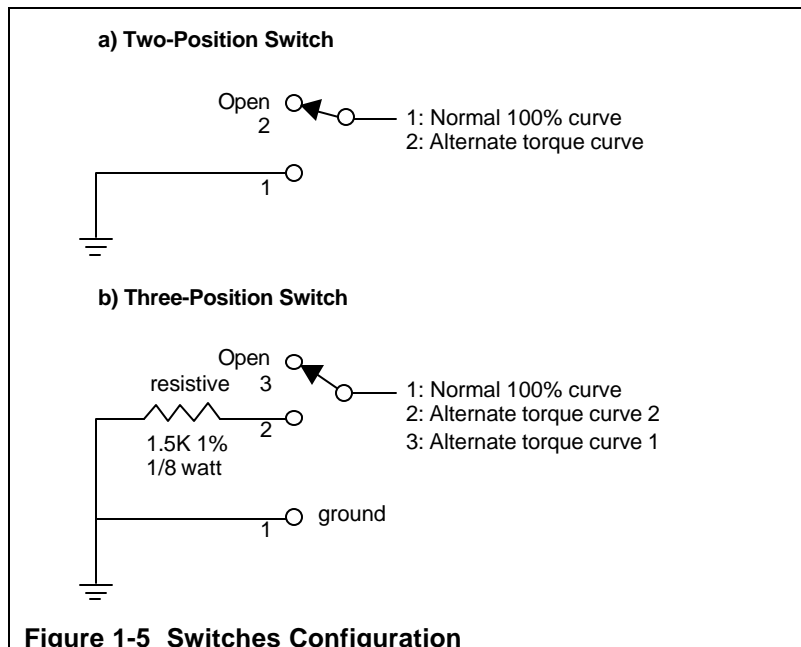
Alternate Torque Fueling Selection (Two-Position Switch Option)

Two-Position Switch	
Ground	**Open**
100% Curve	Alt. TQ Curve 1
Alt TQ Curve 1	100% Curve

*

Alternate Torque Fueling Selection (Three-Position Switch Option)

Three-Position Switch		
Ground	**Resistive**	**Open**
100% Curve	Alt TQ Curve 2	Alt TQ Curve 1
Alt TQ Curve 1	Alt TQ Curve 2	100% Curve

*

* Denotes standard setup

Exceptions

QSM11   switches different in Figure 1-6.

QSX15   switches different in Figure 1-6.

Torque Curve Select Switch Curve**	Alternate Torque Select Switch 2	Requested
GND	GND	100% normal curve
Open	Open	Torque Curve 2
GND	Open	Torque Curve 1
Open	GND	Torque Curve 2

Figure 1.6 QSM11 / QSX15 Switch Configuration

** The requested curves shown are with Torque Curve Option = 2

Exceptions

QST30 Only one alternate torque, therefore, you can only use 2-position switch Boost Power

10. Boost Power

Boost Power will provide the operator with enhanced torque/power for fraction of the operating period. The ECM will monitor engine speed, intake manifold temperature, and coolant temperature to determine if boost power can be activated. If boost power is activated, the engine will switch to the enhanced torque power rating for a limited period of time.
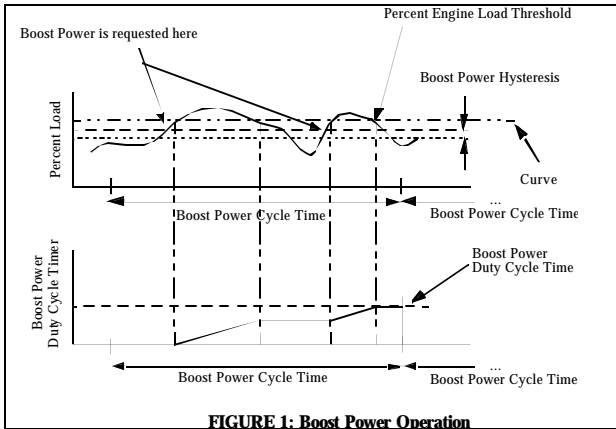
Figure 1-7 Boost Power Operation

Switched: Boost power is activated by a manual operated switch

Automatic: Based on calibratible % torque threshold

Cool Down Timer is the timer where after boost timer period has expired (used up all available time for boost power), the boost power feature is disengaged for the time specified in the cool down timer.

Cycle Time is the total amount of time to be considered in one cycle. This value must be greater than the boost power duty cycle time.

Boost Power Duty Cycle Time is the time within the boost power cycle time which application can run at higher power.

Torque Threshold is the threshold the torque must be greater than to enable the automatic boost power. Values under this level will not be considered requests for boost power mode.

IMT Threshold is the temperature threshold where Boost Power is automatically cancelled if the intake manifold temperature exceeds this value.

RPM Threshold is the threshold that the engine speed must be greater than to engage the boost power feature.

Coolant Threshold is the temperature threshold where Boost Power is cancelled if the coolant temperature exceeds this value.

Exceptions

QSM11   Automatic Boost Power only

QSX15   Automatic Boost Power only

QST30   not available

QSK19   not available

QSK45   not available

QSK60   not available

11.   Switched Alternate Idle Speed

The switch alternate idle feature allows the operator to switch the low idle speed between 2 values, "Normal Idle and "Alternate Idle, depending on switch position. There is no adjusting the alternate idle speed through the use of INC/DEC switch. This feature can be configured to require a normal idle to alternate idle switch transition to go to alternate idle at start-up.

12.   Low Idle Speed Adjust

The low Idle Speed Adjust feature allows the operator to adjust the low idle set speed within a calibratible range. Each time the INC/DEC switch is incremented/decrement, the speed is increased/decreased by a calibratible step size. A save option can be enabled which would allow the idle speed to remain at the adjusted value after a key cycle has been performed. If the save option is not enabled, then the speed will return to the original low idle speed after a key cycle has been performed.

13. Low Idle Shutdown

The Idler Timer Shutdown feature increases fuel economy. When enabled, this function will automatically shut an engine off after a period of engine idling time an inactivity from the operator. The ECM will monitor the coolant temperature, commanded fuel, and the engine speed for an idle condition. The amount of time the ECM will allow an idle condition until engine shutdown is programmable via the user selectable. The engine can be restarted by cycling the key switch.

Exceptions

QSM11   In addition to shutting the engine down you can drive a relay to indicate the engine has been shutdown due to the low idle shutdown timer.

QSX15   In addition to shutting the engine down you can drive a relay to indicate the engine has been shutdown due to the low idle shutdown timer.

QST30   not available

14. Low Speed Governor Droop

Droop is available on the low speed governor when configured the engine will idle above the low idle speed and droop back to the low idle speed when load is applied.

Exceptions

QSB   not available

QSC   not available

QSL9   not available

QSM11   not available

QSX15   not available

15. Transmission Synchronization

The Transmission Speed Synchronization Control feature allows the Commanded Throttle value to be adjusted when an application changes gear shifts position. This would protect the engine, transmission and drive train assemblies during a transmission gear change and prevent "shift shock".

The input frequency signal may then either decrease or increase the commanded throttle value as needed by the application. The Frequency Throttle Linearization Table determines the relationship between the input frequency signal and the Signed Sampled Frequency Throttle value.

Exceptions

QSB   not available

QSC   not available

QSL9   not available

QSK19   not available

QST30   not available

QSK45   not available

QSK60   not available

Section III: Electronic Accelerator (Throttles)

Since engine speed in a QUANTUM system is commanded by an electrical signal rather than the position of a mechanical linkage, several options exist for throttle operation.

There are five types of throttles: Linear, Switched, Frequency, J1939 Multiplexing, and remote.

16. Linear Accelerator (Throttle)

Applications requiring continuous engine response from low idle through rated engine speed should use a throttle position sensor. Whether hand or foot operated, this device measures the physical displacement of the throttle and converts it into an electrical signal. The ECM is designed to accept a signal of varying voltage which is proportional to throttle angular position. The throttle signal varies from 0 to 100% of throttle range.

Idle Validation provides a secondary input to the ECM to provide fault detection and permit limp home capability.

Limp Home: In some applications, it is highly desired to provide the ability to continue equipment operation after a throttle failure occurs. When the throttle failure is present the idle validation switches are used to determine if the throttle is in the on idle or the off idle position. The engine will ramp to a predetermined fueling value when the throttle is in the off idle position. The Throttle Limp Home feature provides this capability in the case of some throttle failures. These throttle failures are any out of range throttle conditions. Idle Validation (IVS) is needed to use the Throttle Limp Home feature.

Industrial Throttle Default: The Industrial Throttle Default feature determines the default throttle values to be used when certain throttle system errors become active. The Throttle value will default to one of 2 calibratible values, depending on an out of range high or low fault. When enabled, the Industrial Throttle Default feature replaces the Throttle Limp Home feature.

Exception

QST30   Has only one throttle default valve

17. Switched Accelerators (Throttle)

Applications requiring just two discrete operating points (100% and 0%) for engine speed can be implemented using a switch throttle. Each switch setting is a referenced engine, speed is then translated into an appropriate fueling control actuator command to maintain each programmed engine speed.

If you need increment decrement capability you must use the Intermediate Speed Control feature. Throttle diagnostic is not available with switched throttle.

18. Frequency Accelerators (Throttle)

The Frequency Throttle feature converts a filtered throttle frequency input into a requested throttle percentage. The frequency signal must conform to the standards set forth in Cummins Engineering Standard #14118 (See Appendix B of this document. There is only one out of range value error.

19. J1939 Multiplexing Accelerators (Throttle)

The J1939 Multiplex throttle uses a J1939 datalink message (PGN 61443 Accelerator Pedal Position) to set the requested throttle percentage without requiring a throttle to be physically wired to the ECM.

Multiplexing is sending or receiving of input and output control commands using J1939 datalink instead of individual hard wires.

20.   Remote Accelerators (Throttle)

The Remote Throttle is an additional A/D throttle input for use in applications where a secondary control of the engine is required. The Remote Throttle includes an enable pin (input) to activate the remote input and ignore the Primary Throttle input. Unlike the Primary Throttle, idle validation (IVS) is not available with the Remote Throttle feature.

Remote throttle can be either a linear or switched throttle. There are five modes of interaction between the primary and remote throttle which are switched with interlock, switched without interlock, deceleration throttle, minimum wins and maximum wins. There is only one out of range value error.

Switched with Interlock – a switch is used to select between the primary and remote throttle. The interlock inhibits the transition from the primary to the remote throttle or the remote to the primary throttle until the selected throttle input is below the commanded throttle.

Switched without Interlock – a switch is used to select between the primary and remote throttle. The transition occurs immediately.

Deceleration Throttle - The remote throttle value is subtracted from the primary throttle value to give the commanded throttle value. This allows for improved equipment operation due to the ability to maneuver without changing primary throttle position

Exceptions

QST30   Does not support decelerate throttle

Minimum Wins – The minimum value between the primary and the secondary throttle is used as the commanded throttle.

Maximum Wins – The maximum value between the primary and the secondary throttle is used as the commanded throttle.

Section IV: Cold Start Aid

21. Grid Heater (Intake Air Heater)

The Intake Air Heater feature is used to aid in starting during cold temperatures. The intake air heater will energize and de-energize a grid heater and the wait-to-start lamp. When the keyswitch is turned on, the intake manifold temperature sensor is read; and based on the value, the grid heaters will be turned on for a given period of time. The amount of time the grid heater is activated is a function of the intake manifold temperature (or alternately a default value) at key on.

There are two phases of intake air heat operation: preheat (after key-on and before cranking) and post-heat (just after a successful engine start).

During cranking, the intake air heater is turned off to allow maximum current to be used by the starter. The post-heat phase starts after successful engine start and the grid heaters are cycled on a schedule based on the intake manifold temperature at key on. The post-heat cycle can operate for several minutes on very cold days before the grid heaters are de-energized

Exceptions

QSK19   not available

QST30   there is not post heat

QSK45   not available

QSK60   not available

22. Coolant Temperature Based Alternate Low Idle

The purpose of the coolant temperature based alternate low idle feature is to allow low idle speed, within calibrated limits, to be adjusted to higher value while the engine is warming up. This feature allows low idle governor reference speed to be adjusted to a higher set point, allowing the engine to warm up at a faster rate. When enabled and the coolant temperature is below the calibrated cold idle temperature, the idle reference speed shall be set equal to a cold idle reference speed, which is normally higher than the base low idle speed. This will force the engine to idle at a higher idle set point, thereby aiding to warm up the engine faster.

After a calibratible cold idle time has elapsed, the idle reference speed is ramped down at a calibratible rate to the initial reference speed that was present before the cold idle reference became active.

Exceptions

QSC   not available

QSL9   not available

23. Ether Injection Control

The Controlled Ether Injection feature provides a method to automatically inject ether into the intake manifold dependent upon engine speed and coolant temperature. The feature is intended to improve cold starting performance and reduce white smoke emissions. Controlling the ether injection solenoid will also require significantly less power than grid heaters that some engine systems use today to improve starting. There are two types of ether injection systems supported by this feature.

The first type of ether injection system is measured shot system. When engine speed and system temperatures indicate that it is appropriate to inject ether, a solenoid output will be pulsed on and off. This will provide a measured shot of ether each time the sequence is completed.

The second type of ether injection system is the "constant ON" system. Ether is injected by constantly energizing the ether solenoid. The constantly energized system uses an orifice to meter the amount of ether injected.

Exceptions

QSB   not available

QSC   not available

QSL9   not available

QSM11   not available

QSX15   not available

QST30   not available

24.   Pilot Injection

Pilot Injection is used in the QSC and QSL9 CAPS fuel system to ensure that the engine is properly warmed-up using engine coolant temperature and intake manifold temperature for its input to control activation. If both sensor readings measure less than 70 degrees Fahrenheit, Pilot Injection will be active and control engine idle rpm until the engine coolant temperature reaches set temperature or an elapse time of 3 minutes. When this is achieved, Pilot Injection will ramp the engine speed at 18 rpm/sec. to the low idle governor setting. Throttle position can be used during Pilot Injection and will disable the feature when rpm reaches approximately 850 rpm or greater. Therefore, Pilot Injection will re-engage if the engine rpm returns to the 850 rpm limit or less while Pilot Injection is enabled.

Note: It is recommended to allow Pilot Injection to run its full cycle prior to using throttle control, especially during extreme cold temperatures. This will prevent poor engine stability.

Exceptions

QSB   not available

QSM11   not available

QSX15   not available

QSK19   not available

QST30   not available

QSK45   not available

QSK60   not available

Section V: Engine Control

25. Dedicated PWM Output

The Dedicated PWM Output feature allows the OEM to create an analog signal (pulse width modulated) whose duty cycle is proportional to either engine speed, engine torque, or throttle percent. The intended use of the analog signal is to control an engine or transmission that relies on an analog signal input. The PWM duty cycle is clamped between 5% and 95%; the signal frequency is 64 Hz with an amplitude battery voltage.

% PWM	Speed rpm	Torque % *	Throttle %
5	0	0	0
95	0 fueling speed **	100	100

* Percent of 100% torque curve at current speed

** 0 fueling speed is described below

Fueling Speed
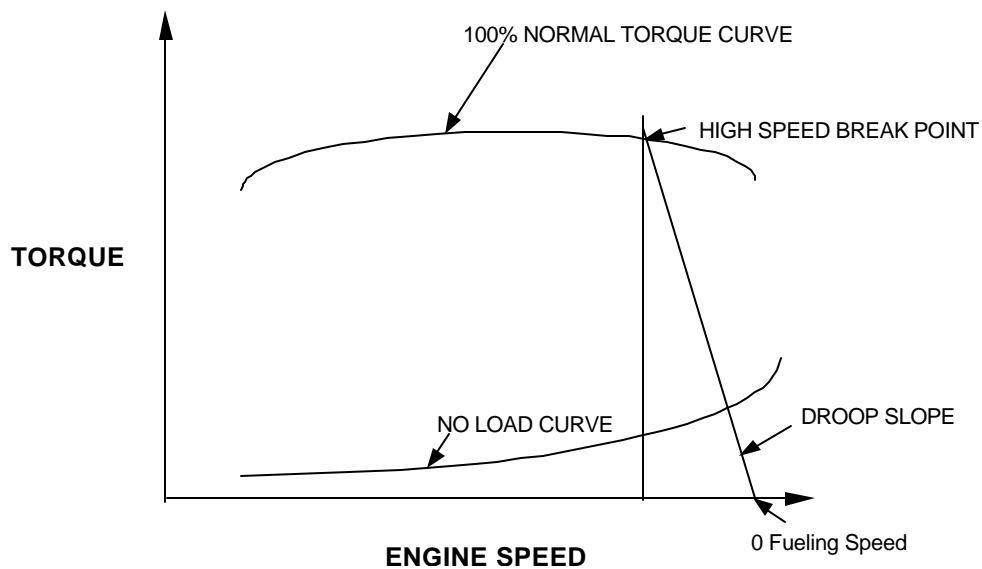
Exceptions

QSM11   default is 65 HZ

QSX15   default is 65 HZ

QSK19   default is 16 HZ when using electronic fan clutch control

QSK45   default is 16 HZ when using electronic fan clutch control

QSK60   default is 16 HZ when using electronic fan clutch control

26. Dual Outputs Based on Sensed Parameters

Dual outputs based on sensed parameters provide up to two independent switched outputs for OEM use. The state of each switched output can be determined by different inputs to the ECM depending on the engine. The ECM can provide different outputs to OEM devices if any of the inputs are above or below calibrated thresholds. Each switched output is independent of the other with respect to control parameter input and threshold settings.

The ECM can determine the state of the switched outputs based on the following possible inputs (either one or both switched outputs can use the same inputs)

Each of these inputs can have a specified threshold and threshold type (over or under). Each of the switched outputs can be calibrated to either on or off after a threshold is passed. Also, each output can be calibrated to change states if any one or all thresholds are passed.

Engine Platform Configurations

	QSB	QSC	QSL9	QSM11	QSX15	QSK19	QST30	QSK45	QSK60
Engine Speed	X	X	X	X	X	X	X	X	X
Commanded Fueling	X	X	X	X	X	X	X	X	X
Boost Pressure	X	X	X	X	X	X	X	X	X
Auxiliary Speed Input	X	X	X	X	X	X	X	X	X
Battery Voltage	X	X	X						
Oil Pressure	X	X	X	X	X	X	X	X	X
Coolant Temp	X	X	X	X	X	X	X	X	X
Commanded Throttle (%)	X	X	X	X	X	X		X	X
Intermediate Speed Control Status (off or active)	X	X	X	X	X	X	X	X	X
OEM Temperature				X	X	X		X	X
OEM Pressure	X	X	X	X	X	X		X	X
OEM Supplied Switch (open or ground)	X	X	X			X		X	X
Intake Manifold Temperature	X	X	X				X		
JCOMM Torque	X	X	X						
Coolant Pressure							X		
Fuel Temp		X	X						
OEM Sensor (Remote Throttle %)						X		X	X

27. Duty Cycle Monitor

The Duty Cycle Monitor feature allows INSITE to access data that tracks the time spent on different operating regions based on an engine speed versus torque relationship. The feature will use two short term 500 hour blocks of data that can be reset using INSITE. When both 500 hour blocks are filled, the instantaneous load factor calculation will continue to be calculated and broadcast, but this data will not be stored in the short term data stores. A long term hour map will be used to store long term data. This data cannot be cleared by INSITE. Both short and long term regions will be cleared on a recalibration.

Duty Cycle Map
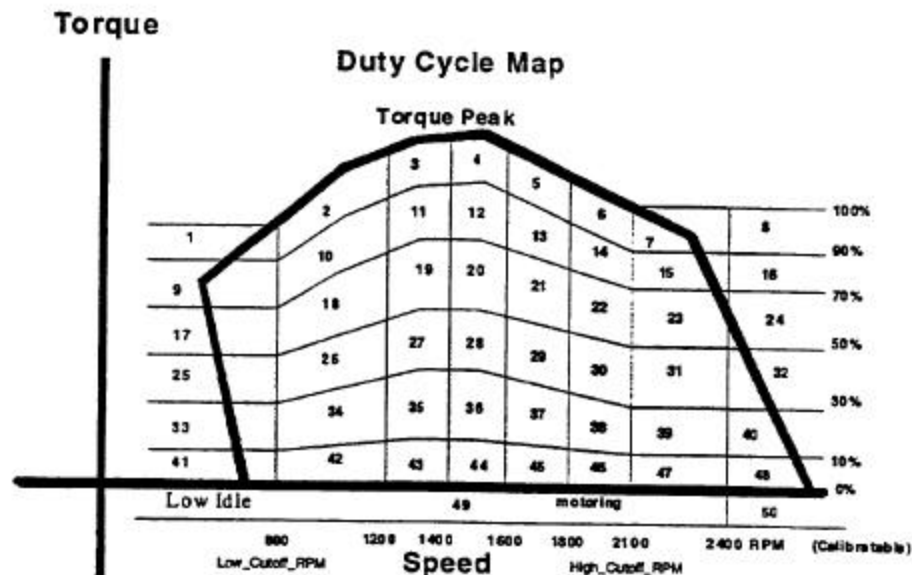
28. Exhaust Brake Control

The Exhaust Brake provides additional braking power using engine exhaust to slow the vehicle when commanded. At higher RPM's optimum braking power is achieved due to higher exhaust volumes. The exhaust Brake has shared control between the ECM and the operator, which can be enabled or disabled via an On/Off switch found on the cab interface panel. Exhaust Brake Control is compatible with exhaust brake systems available in the industry. The table below shows the conditions when Exhaust Brake is active.

Active Exhaust Brake	
Function	Condition
Exhaust Brake On/Off Switch	On
Cruise Control	Inactive
ISC	Inactive
Transmission Clutch Pedal	Released
Throttle Position	0%
Engine RPM	>1000

Exceptions

QSM11   not available

QSX15   not available

QSK19   not available

QST30   not available

QSK45   not available

QSK60   not available

29. Electronic Fan Clutch Control

The Electronic Fan Clutch feature provides a Pulse Width Modulated (PWM) signal to control a variable speed fan clutch based on the need provided by sensor inputs and an input from the local data link. Sensor input values are translated into PWM requests. The goals of this feature are to reduce fuel consumption by minimizing fan on time and lengthen belt life by reducing belt hop and slippage. The standard frequency is 64 Hz. The fan clutch can be controlled by the following parameters in the table below.

Engine Platform Configurations

Fan Clutch parameters	QSB	QSC	QSM11	QSX15	QST30	QSK45/60
Engine Brake	X	X				
Fuel Temperature						X
Intake Manifold Temperature	X	X	X	X	X	X
Coolant Temperature	X	X	X	X	X	X
Air Condition Pressure Switch			X	X		
OEM Pressure	X	X	X	X		X
OEM Temperature			X	X		X
Fan Clutch Switch	X	X	X	X	X	X

Exceptions

QSK19   Default is not available

QSK45   Default frequency is 16 HZ

QSK60   Default frequency is 16 HZ

30.   Speed Signal to Tachometer

The ECM outputs an engine rpm signal that is compatible with ATA/TMC Recommended Practice RP-123. The tachometer connections can be accommodated in the cab by way of the OEM harness. The tachometer signal is at 50% duty cycle and the pulses per engine revolution can be changed via Cummins calibration. The pulses per engine rev is set/defaulted to 12. Twelve pulses are generated for every crankshaft revolution, for an output frequency of rpm = 5 x F.

Tachometer Signal

T1 = RISE TIME; MAX 10% OF T3
T2 = DECAY TIME = 200 mS MAXIMUM
T3 = PULSE WIDTH = 250 mS MINIMUM
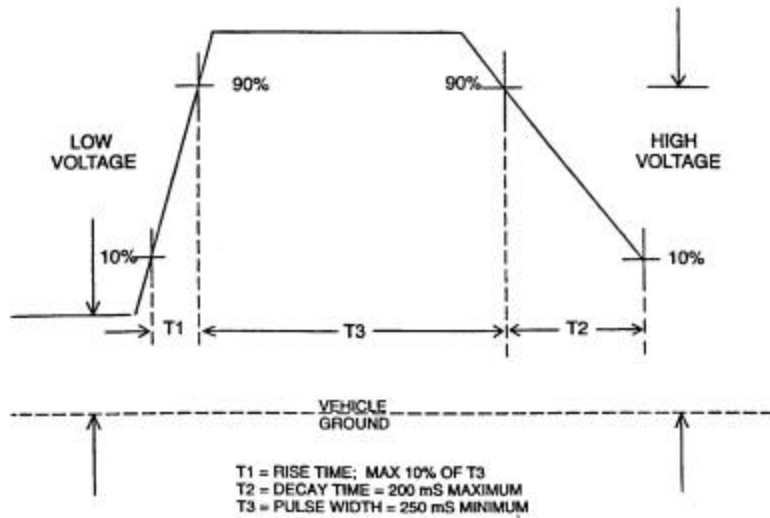
Section VI: Engine Protection

This feature monitors critical engine operating conditions (examples: Coolant temperature, Oil pressure, intake manifold temperature, Coolant level). When an operating condition is outside of calibrated limits a derate results. All calibrations with the exception of fire truck and fire pumps are equipped with the engine protection feature that derates the engine if an engine protection value is out of range.

In operation, the ECM monitors engine-operating conditions while the engine is running. If one of the critical operating conditions exceeds the engine protection limit as defined in the calibration a derate will occur and a warning lamp is illuminated. The severity of the derate will vary according to which engine operating condition has exceeded its engine protection limit. Also, the severity of the derate may vary in relation to the severity of the event (Example: IMT slightly above a thresholds for a short period of the time will result in a mild derate compared to intake manifold temp over a threshold or for a longer time). If the condition persists and engine protection shutdown is enabled, the stop lamp will flash to warn the driver of an impending shutdown event and the engine will shutdown.

Completing a Failure Mode and Effects Analysis (FMEA) is required to enable shutdowns.

Standard Engine Platform Configurations

Standard Engine Protection Derate	QSC/QSB QSL9	QSM11 QSX15	QSK19	QSKV45 QSKV60	QST30
Coolant Temperature Torque Derate	X	X	X	X	X
Intake Manifold Temperature Torque Derate	X	X	X	X	X
Oil Temperature Torque Derate		X	X	X	
Oil Pressure Torque Derate	X	X	X	X	X
Oil Pressure Speed Derate	X	X	X	X	X
Coolant Level Torque Derate	X	X	X	X	X
Fuel Temperature Speed Derate				X	
Crankcase (Blowby) Pressure Torque Derate				X	
Oil Level Monitor				X	
Coolant Pressure Torque Derate				X	

Note: QSKV45/60 only has oil temp torque derate with Cense

31.   Engine Protection - OEM Pressure and Temperature Input

The OEM pressure sensor and OEM temperature sensor can be utilized to activated the engine protection feature. Certain customer specific information is needed to activate this functionality. Reference OEM interfaces AEB to define the sensor input parameters.

- Speed and/or fuel derate

- Time or severity derate

- Derate threshold values

- Shutdown threshold values (if required)

Exceptions

QSB   OEM temperature is not supported

QSC   OEM temperature is not supported

QSL9   OEM temperature is not supported

QSM11   OEM temperature is not supported

QSX15   OEM temperature is not supported

32. Engine Protection - Overspeed

The overspeed Protection feature monitors the engine speed and shuts off fuel to the engine if an overspeed condition is detected.   Once an overspeed condition is detected, the fuel shutoff valve closes, thereby preventing fuel flow to the engine. A fault will be logged and the ECM shall record and store engine data when the fault occurs. The fuel shutoff valve reopens when the engine speed drops below a secondary engine speed threshold. The engine speed at which an overspeed condition is detected depends on the application.

Exceptions

QSM11   It commands 0 fueling once the initial overspeed limit is exceeded if engine speed continues to increase past secondary overspeed limit then the fuel shutoff valve is closed.

QSX15   It commands 0 fueling once the initial overspeed limit is exceeded if engine speed continues to increase past secondary overspeed limit then the fuel shutoff valve is closed.

33. Engine Warm-up Protection - Max RPM and Max Torque

It is desirable to limit engine speed and torque following start-up until sufficient oil pressure is available to the engine components. Failure to do so may damage key engine parts - particularly the turbocharger. When enabled, and in the absence of active oil pressure or oil pressure sensor faults, the feature limits torque and/or speed until sufficient oil pressure is observed

34. Water in Fuel Warning

The Water-in-Fuel (WIF) sensor is installed at the bottom of the fuel filters. The ECM turns on the WIF lamp (maintenance lamp) when water covers the sensor in the filter. When the WIF lamp (maintenance lamp) is illuminated the vehicle driver/maintainer should release the water from the fuel filter with the drain provided at the base of the filter. Once the water has been drained and only fuel covers the WIF sensor, the ECM will turn off the maintenance lamp.

Note: The Water-in-Fuel lamp function is strongly encouraged even through it can be multiplexed into the maintenance lamp which will eliminate the need for the WIF lamp indicator in the dash.

WIF warning capability can be maintained by routing a wire from the ECM OEM connector WIF lamp signal to the maintenance lamp in parallel with the wire from ECM OEM connector that runs to the maintenance warning lamp. Wiring in this way allows for consistent lamp performance at the vehicle user interface as the new lamp strategy is introduced. This is left as an option to the OEM.

Exceptions

QSB   A dedicated WIF lamp is available. The water in fuel lamp function is strongly encouraged though the WIF lamp can be multiplexed into the maintenance lamp, which will eliminate the need for the WIF lamp indicator in the dash

QSC   A dedicated WIF lamp is available. The water in fuel lamp function is strongly encouraged though the WIF lamp can be multiplexed into the maintenance lamp, which will eliminate the need for the WIF lamp indicator in the dash

QSL9   A dedicated WIF lamp is available. The water in fuel lamp function is strongly encouraged though the WIF lamp can be multiplexed into the maintenance lamp, which will eliminate the need for the WIF lamp indicator in the dash.

QSK19   not available

QSK45   not available

QSK60   not available

35. Altitude Derate

The Altitude Derate feature is intended to prevent damage to the engine when the operator is running application at higher altitudes, it does so by derating the engine to slow the turbocharger by way of effecting full load fueling value based upon engine speed and ambient air pressure.

Exceptions

QSB   not available

36. Throttle Activated Diagnostic Switch

The Throttle Activated Diagnostics feature eliminates the need for a dash mounted diagnostic switch by providing a simple sequence of throttle movements that activate the diagnostic mode. This diagnostic mode displays active fault codes in a sequence of flashing lamps. When the engine is not running and the keyswitch is turned on, a sequence of throttle movements shall activate the diagnostic mode. The sequence of throttle movements can be defined as follows: The throttle must quickly be cycled three times in order to define the throttle as a diagnostic switch. A successful throttle cycle is defined as each time the throttle passes a calibratible upper and lower threshold. Every successive throttle cycle will lead to the next fault code in the same manner as if an increment switch was activated. The increment/decrement switch can still be used to Navigate to the next or previous fault code, but in case these switches are not available, a throttle cycle will only increment to the next fault.

Section VII: Miscellaneous Features

37. Load Bias

The Load Bias generates an output to provide closed loop control on engine load. The signal output can be an analog output, PWM output, or transmitted via the J1939 datalink. The signal indicated overloading, underloading, and "optimal" loading of the engine.

Load Bias is important because of the ability to get optimal engine performance by utilizing all available engine horsepower despite varying auxiliary loads.

Note: The alternate torque curve feature can not be used with Load Bias. Also all speed governor (ASG) must be the selected throttle control.

Exceptions

QSM11   not available

QSX15   not available

QSB   not available

QSC   not available

QSL9   not available

QST30   not available

38. Multiple Unit Synchronization

The Multiple Unit Synchronization feature allows two or more engines to be controlled by a single throttle input. One engine is configured as the Master engine, all other engines should be configured as Slaves. There are three applications of Multiple Unit Synchronization: Hard (series) coupled, Soft (parallel) coupled, and Soft coupled Marine.
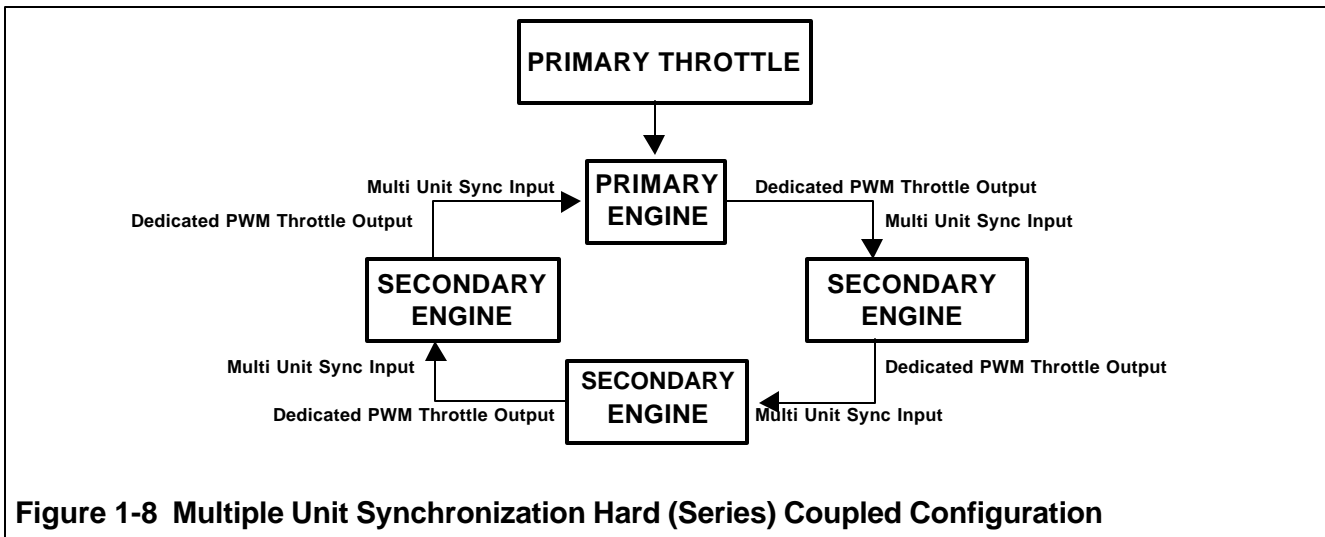
Hard (Series) Coupled Application

In the Hard (series) coupled application, the engine configuration is determined in the calibration. This feature utilizes the Dedicated PWM Output feature to generate a throttle output duty cycle on the Primary engine from Commanded Throttle input. This signal is sent to the Secondary engine(s) and read on the VSS input circuit. The Primary engine shall be configured to run in an isochronous state. The Secondary engine(s) shall be configured to run with droop, at a slightly higher set speed than the Primary engine. The Primary engine shall interpret and send the throttle value to the first Secondary engine. This engine reads the input value, then sends the value to the next engine in the chain, until ending as feedback into the Primary engine. The feedback duty cycle to the Primary engine is compared with the output duty cycle from the Primary engine; if this comparison is outside of a calibratible range, a fault condition will exist and the engines will be shut down.

In the Hard (series) coupled configuration, the engine speed will be consistent; however, loading would not be consistent for varying engine speeds. All of the keyswitches should be wired together to insure the engines are started at the same time. This will insure the engines will synchronize together instead of having one engine drag the others. The engines are wired in series. If one engine stops, the remaining engines will stop.

Each engine should have its own fuel level sensor if the engines run from separate fuel tanks. Should one engine run out of fuel, all the engines will shutdown.

The maximum number of engines that can be used in the Hard (series) coupled configuration is 11.

Figure 1-8 Multiple Unit Synchronization Hard (Series) Coupled Configuration

Soft (Parallel) Coupled Application

In the Soft (parallel) coupled application, the engine configuration is determined in the calibration. This feature utilizes the Dedicated PWM Output feature to generate a throttle output duty cycle on the Primary engine from Commanded Throttle input. This signal is sent to the Secondary engine(s) and read on the VSS input circuit.

In the Soft (parallel) coupled application, the primary engine interprets and sends the throttle value to all Secondary engines. The engines are wired in parallel. In the Soft (parallel) coupled application, both engines shall be capable of running in an isochronous state. This allows the engines to have similar speeds. The Primary engine should be started before or at the same time as the Secondary engine(s) to insure a throttle signal is present before the Secondary engine(s) try to read it. The engines are wired in parallel. If one engine stops, the others remain running.

Each engine should have its own fuel sensor if the engines run from separate fuel tanks. Should one engine run out of fuel, only the engine out of fuel will shutdown. If a Multi Unit Sync error exists on one of the Secondary engines, this engine will run at a calibratible default throttle percent; there is no shutdown option in the Soft (parallel) coupled configuration.

The output signal from the Primary engine is generated on the PWM Out pin of the OEM harness. This output is then the input signal for the Secondary engine, which is input on the VSS input pin of the OEM harness. Five (5) Volts must be applied to the VSS return pin on both Primary and Secondary engines: (5V) should be tied to Pin M (VSS return) on each engine. All the engines should be grounded to the same point. A special OEM harness will be required for the Multi Unit Sync application.

Figure 1-9 Multi Unit Synchronization Soft (Parallel) Coupled Configuration
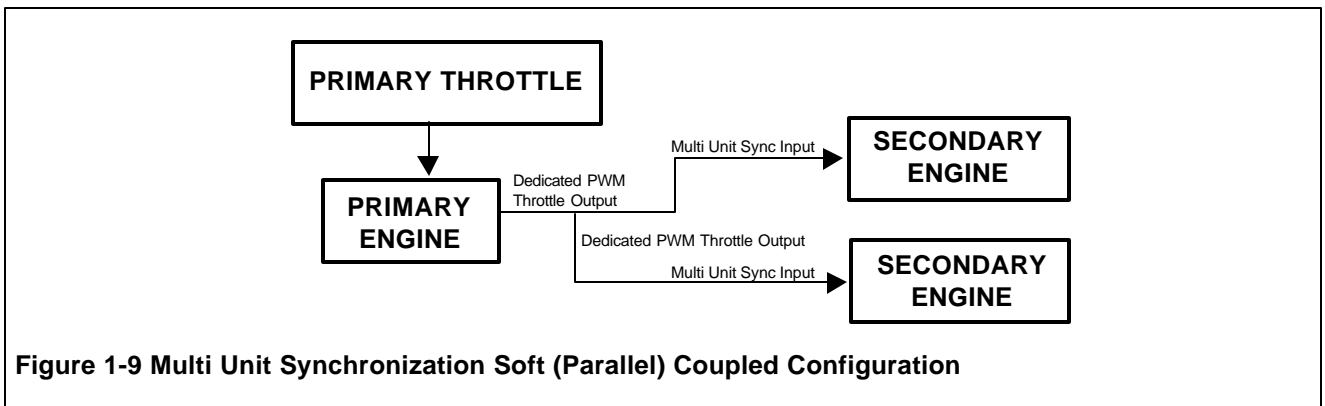
Datalink Coupled Application

For Datalink coupled application, the engine configuration is determined via the appropriate switch settings. The J1939 datalink is used to communicate the throttle position from the Primary engine to the Secondary engine(s).

In the datalink coupled application, the primary engine interprets and sends the throttle value to all Secondary engines. The engines are wired in parallel. In the Datalink coupled application, both engines shall be capable of running in an isochronous state. This allows the engines to have similar speeds. The Primary engine should be started before or at the same time as the Secondary engine(s) to insure a throttle signal is present before the Secondary engine(s) try to read it. The engines are wired in parallel. If one engine stops, the others remain running.

Each engine should have its own fuel sensor if the engines run from separate fuel tanks. Should one engine run out of fuel, only the engine out of fuel will shutdown. If a Multi Unit Sync error exists on one of the Secondary engines, this engine will run at a calibratible default throttle percent; there is no shutdown option in the Datalink coupled configuration.

The maximum number of engines that can be used in the Datalink coupled configuration is 6.

MUS SWITCH #3	MUS SWITCH #2	MUS SWITCH #1	DESCRIPTION
inactive	inactive	inactive	Error Condition
inactive	inactive	active	Master
inactive	active	inactive	Slave 1
inactive	active	active	Slave 2
active	inactive	inactive	Slave 3
active	inactive	active	Slave 4
active	active	inactive	Slave 5
active	active	active	Error Condition

Figure 1-9 Datalink Coupled Switch Settings
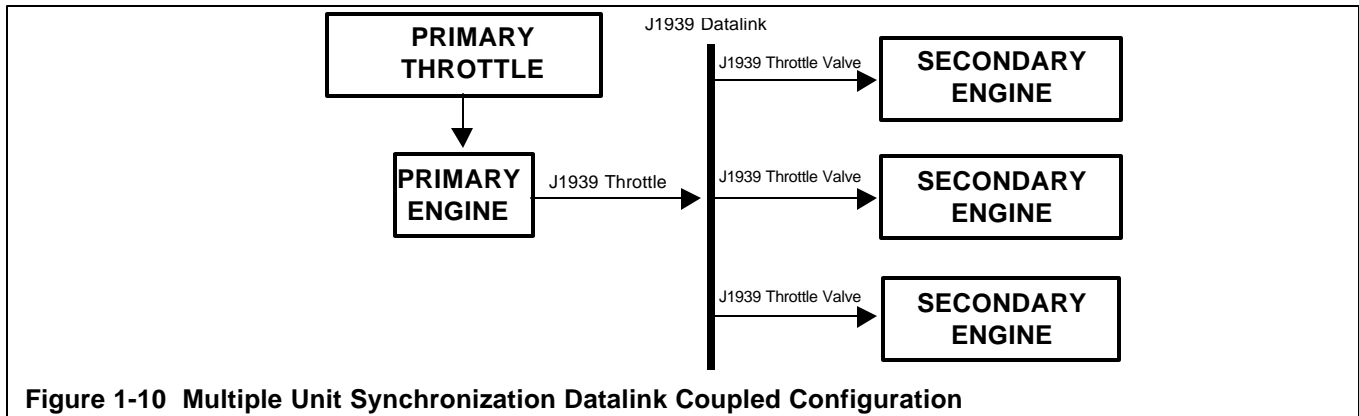
Figure 1-10 Multiple Unit Synchronization Datalink Coupled Configuration

Exceptions

QSB   not available

QSC   not available

QSL9   not available

QSM11   Only datalink coupled applications supported

QSX15   Only datalink coupled applications supported

QSK19   Only datalink coupled applications supported

QST30   not available

QSK45   Only datalink coupled applications supported

QSK60   Only datalink coupled applications supported

Section VIII: Engine Maintenance/Monitoring Features

39. Maintenance Monitor

The Maintenance Monitor (Oil Change Monitor) feature provides a method of monitoring the oil change interval of an industrial engine and signaling the operator when an oil change is needed.

The maintenance Monitor counts the hours of engine operation and subtracts this from the oil change interval time. The Maintenance Monitor feature also allows for extended oil change intervals when the customer is using such products as Premium Blue 2000. Programming tools can be used to display the percent of the current interval that has been consumed.

When a certain calibratible percentage of the oil change interval time has been used, the MAINTENANCE lamp is flashed at key on and a warning flag is set. The Maintenance Monitor can be reset using service tools or a manual method as follows:

Maintenance Monitor Manual Reset with the Diagnostic Test Switch

1. Keyswitch ON with engine shutdown

2. Diagnostic Test Switch ON for > 3 seconds then OFF

3. Diagnostic Test Switch ON twice more briefly < 3 seconds each on OFF and after

4. Diagnostic Test Switch ON for > 3 seconds then OFF

5. The warning lamp will flash 3 quick flashes signifying a successful request

6. The manual reset sequence must be completed within a maximum of 30 seconds

40. Oil Level Monitor - Low

The Oil Level Monitor feature provides information about the oil level to both the operator and the ECM features which require this information. The Oil Level Monitor feature accomplishes this by interpreting an A/D input for the engine oil level and a switch input for the remote oil reservoir. It will tell the operator when to add oil, providing an oil level check without shutting down the engine. During the low oil level condition, the yellow (warning) lamp will be illuminated. It will also provide data to the Centinel and Engine Protection features regarding the existence of a very low engine oil level. During the very low oil level condition, the Centinel feature will be shutoff and the Engine Protection feature will be used.

Exceptions

QSB   not available

QSC   not available

QSL9   not available

QSK19   not available

QSM11   not available

QSX15   not available

QST30   not available

41. Trip Information - Fuel Consumption Rate Log

The fuel Consumption Rate Log feature allows INSITE to access data that tracks instantaneous fuel economy and fuel rate over a 40 hour time span in increments of one hour. It also tracks a non-resettable running average of fuel consumption rate over the lifetime of the engine. This feature can be used to enter warranty information related to fuel consumption, to trouble-shoot customer issues regarding poor fuel economy, and to verify engine performance during field test or for gathering data. This feature can also be used by an operator or customer to monitor, track and possibly improve performance of the machine.

42. Centinel (Continuous Oil Replacement System)

The Centinel feature is an electro mechanical system that will extend service intervals, increase engine uptime and reduce oil filter disposal through continuous oil change. As a result, the customer's operation costs will be reduced. The Centinel feature injects engine crankcase oil into the fuel system where is eventually burned in the combustion process. The amount of engine oil directed into the fuel system is controlled based on fuel usage.

The Centinel feature provides for the extension or elimination of oil change via two options (depending on market and customer preference).

Option 1 utilizes a remote reservoir. Based upon fuel usage, a controlled amount of engine crankcase oil is released into the fuel system via a fuel return line. The fuel and crankcase oil are further mixed in the vehicle's fuel tank. A corresponding amount of oil is added back into the engine lube oil system from the remote reservoir. The remote reservoir is assumed to be kept at a temperature such that oil will flow.

Option 2 is to burn oil only without a remote reservoir. For systems not using a remote reservoir, the lube oil will be replenished during the daily lube system check or at the time of re-fueling. The oil mixing and subsequent burning of the used oil will remain the same as Option 1 with the exception of the oil replenishment procedure.

Exceptions

QSB   not available

QSC   not available

QSL9   not available

QSM11   not available

QSX15   not available

QST30   not available

43. Hot Shutdown Monitor

The Hot Shutdown Monitor feature monitors the engine condition and records the occurrence of an engine hot shutdown. The operator/customer will be informed via a fault code (no fault lamp illumination). Cummins service would then be able to track the data to discuss with the operator/customer when engine damage (i.e. turbocharger damage, exhaust manifold damage, etc.) is occurring due to frequent or repeat hot shutdowns.

GENERIC CALIBRATIONS

Feature Setup and Limitations

	QSB/QSC/QSL9	QSM11/QSX15	QSK19	QST30	Comments
Throttle Options					
Primary Throttle	Morse Hand Throttle	Morse Hand Throttle	Morse Hand Throttle	Williams Foot Throttle	All platforms defaulted to a linear throttle
Primary Throttle Idle Valid	Disabled	Disabled	Disabled	Enabled	The idle valid switch can only be enabled/disabled on QSB/C/9
Tool Adjustable	Yes	No	No	No	
Throttle OOR Default Value	Low Idle	Low Idle	High Idle	Low Idle	Engine default speed with no throttle
Remote Throttle	Disabled	Linear	Switch Throttle	Linear	Remote throttle does not offer throttle diagnostics
Tool Adjustable	Yes	Yes	No	No	
Low Idle Speed	750 RPM	750 RPM	750 RPM	750 RPM	Low idle speed tool adjustable: Speed range dependent on engine platform
Tool Adjustable	Yes	Yes	Yes	Yes	
Governor Details					
Low Idle Droop	0%	0%	0%	0%	Standard value for all platforms
Low Speed Inc/Dec (saved at key-off)	Yes 700-900 RPM	Yes 700-900 RPM	Yes 650-1200 RPM	Yes 700-900 RPM	Inc/Dec value will be saved at key-off
Throttle Control	All Speed Gov	All Speed Gov	All Speed Gov	All Speed Gov	
High Speed Gov. Breakpoint					High Idle Speed is rating specific. Tool adjustable for gov breakpoint and isochronous cut-off speed.
Tool Adjustable	Yes	Yes	Yes	No	
High Idle Droop	7%	7%	7%	7%	Standard value for all platforms. High idle droop = All speed droop
Tool Adjustable	Yes	Yes	Yes	No	
All Speed Governor Droop	7%	7%	7%	7%	Standard value for all platforms
Features					
Intermediate Speed Control (saved at key-off)	Qty 3	Qty 3	Qty 2 ISC2 not avail.	Qty 2 ISC2 not avail.	Speeds set to (1800/1600/1400 rpm) 0% droop. See INC/DEC
Tool adjustment	Yes	Yes	Yes	Yes	
Alternate Droop	0%	0%	0%	0%	Breakpoint speed and droop are tool adjustable for one alternate value
Tool Adjustable	Yes	Yes	Yes	Bkpnt speed	
Dedicated PWM Output	Enabled	Enabled	Enabled	Enabled	Configured for percent torque
Elec Fan Clutch Control-PWM	Disabled	Disabled	Disabled	Disabled	
Tool Adjustable	No	No	No	No	
Dual Outputs	Enabled Output #2	Enabled Output #2	Enabled Output #1	Enabled Output #1	Output is configured to support a starter lock-out
Engine Warm-up Protection	Enabled	Enabled	Enabled	Enabled	Torque limitation on oil pressure also set as a default. Adj as On/Off
Tool Adjustable	Yes	Yes	Yes	Yes	
Coolant Level Switch	Enabled	Enabled	Enabled	Enabled	Shorting plug is required to disable feature
Water in Fuel Sensor	Standard	Enabled QSX15 Disabled QSM11	N/A	N/A	
Tool Adjustable		Yes			
Oil Change Monitor	Disabled	Disabled	Disabled	Disabled	Can be enabled and interval hours set with service tool
Tool Adjustable	Yes	Yes	Yes	Yes	
Standard Engine Protection	Enabled	Enabled	Enabled	Enabled	Engine shutdowns are disabled and are not configurable

There are not any generic calibrations for the QSK45/60 engines

CENSE Engine Montoring System - QST30, QSK45, QSK60

Figure 2-1 CENSE System Capabilities - INFORM
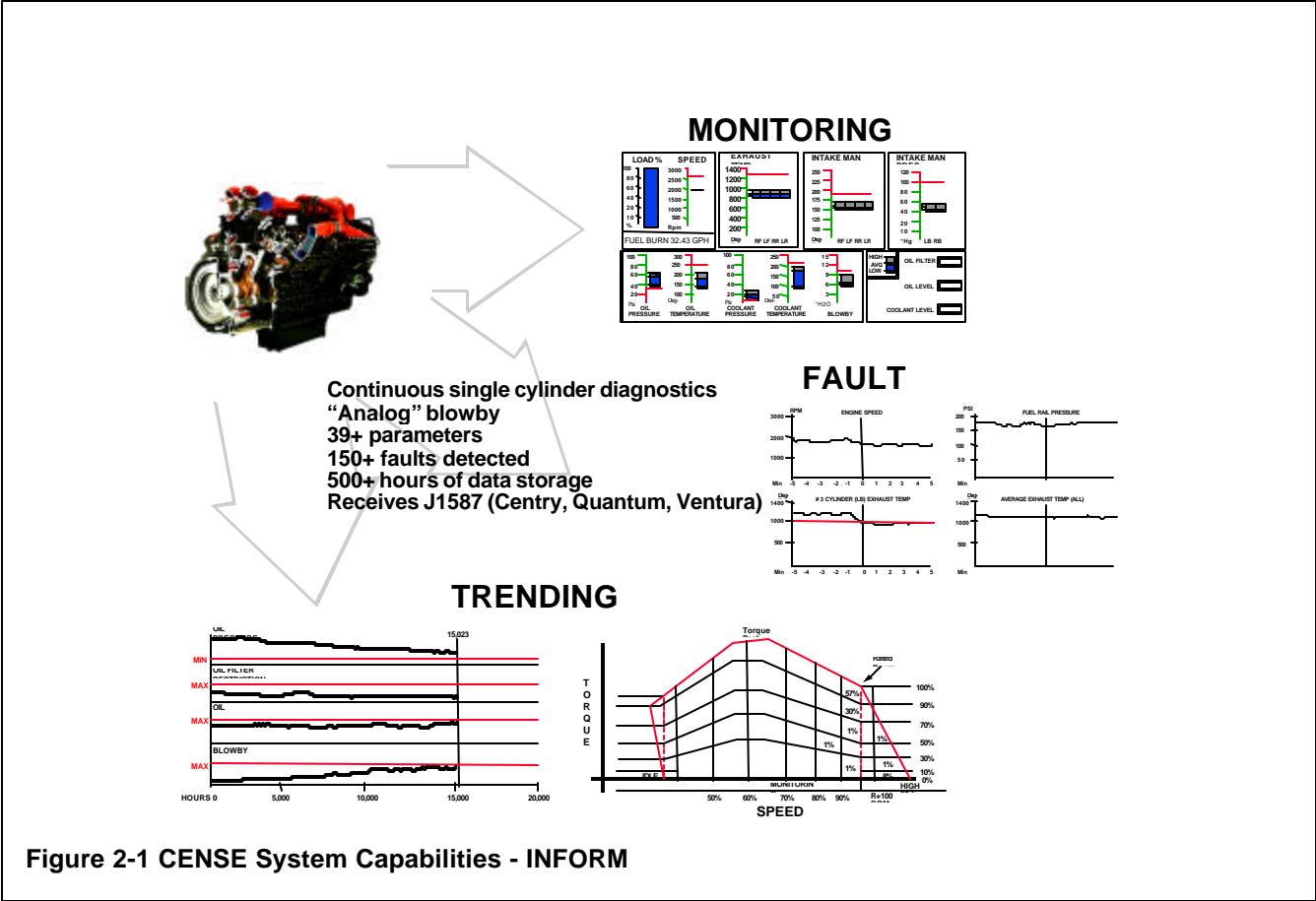
The CENSE single cylinder diagnostics approach uses exhaust port temperatures to determine the amount of power loss or gain in any cylinder with respect to other cylinders. This allows the CENSE to perform dynamic single cylinder diagnostics at any operating point (e.g. with vehicle on the go under a heavy load) rather than as a static measurement at idle. The focus of CENSE is to move to non-intrusive, continuous diagnostics, without requiring down-time for shop analysis.

Figure 2-1 shows some additional CENSE capabilities. CENSE has engine hour clocks that record engine hours since rebuild and hours at idle. The CENSE system also records the number of engine starts, and the start and stop times for each run, providing run duration and stopped duration. In addition, the CENSE includes a real time clock, so all data is local date and time stamped.
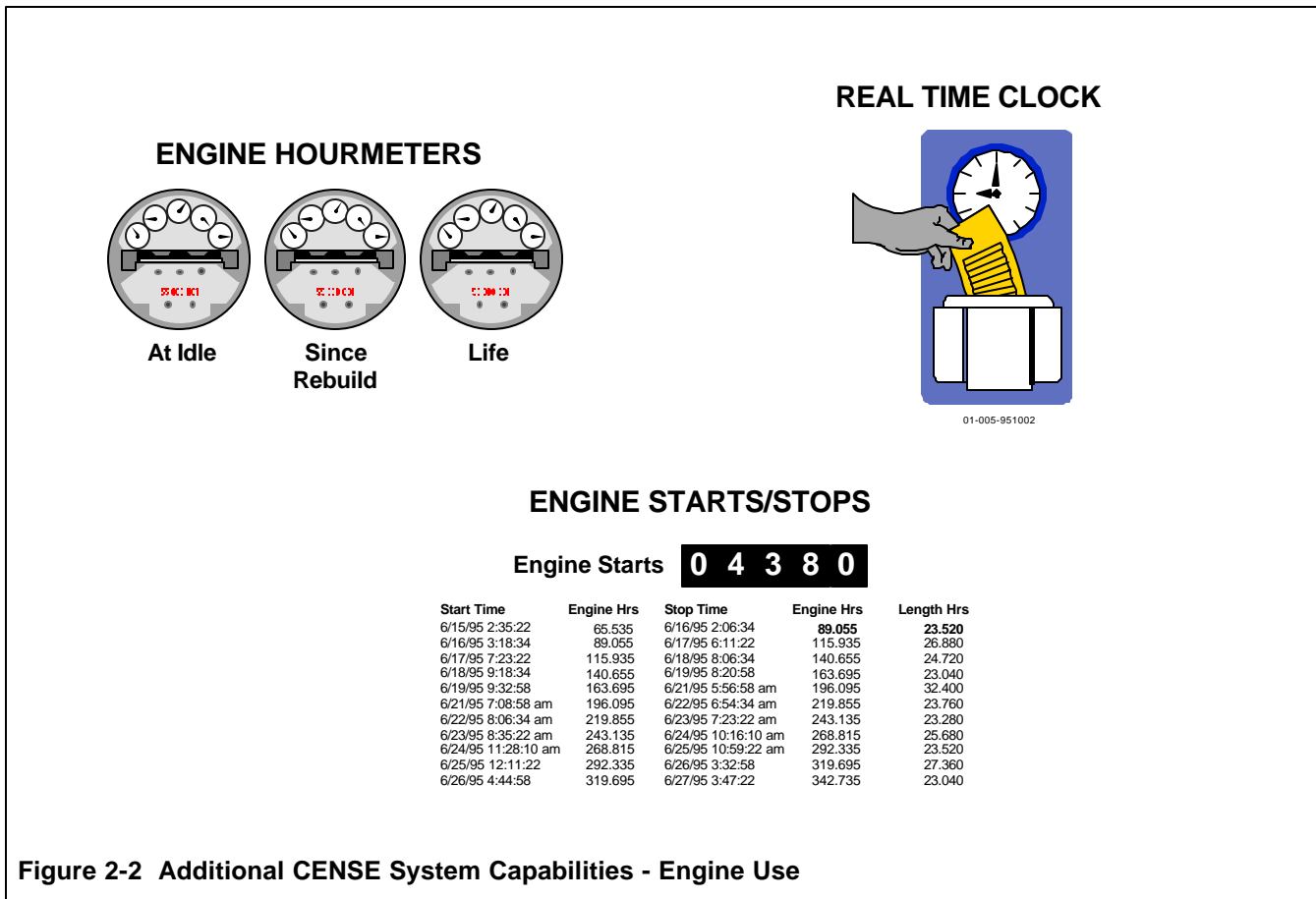
ENGINE HOURMETERS

At Idle   Since Rebuild   Life

REAL TIME CLOCK

01-005-951002

ENGINE STARTS/STOPS

Engine Starts `0 4 3 8 0`

Start Time	Engine Hrs	Stop Time	Engine Hrs	Length Hrs
6/15/95 2:35:22	65.535	6/16/95 2:06:34	**89.055**	**23.520**
6/16/95 3:18:34	89.055	6/17/95 6:11:22	115.935	26.880
6/17/95 7:23:22	115.935	6/18/95 8:06:34	140.655	24.720
6/18/95 9:18:34	140.655	6/19/95 8:20:58	163.695	23.040
6/19/95 9:32:58	163.695	6/21/95 5:56:58 am	196.095	32.400
6/21/95 7:08:58 am	196.095	6/22/95 6:54:34 am	219.855	23.760
6/22/95 8:06:34 am	219.855	6/23/95 7:23:22 am	243.135	23.280
6/23/95 8:35:22 am	243.135	6/24/95 10:16:10 am	268.815	25.680
6/24/95 11:28:10 am	268.815	6/25/95 10:59:22 am	292.335	23.520
6/25/95 12:11:22	292.335	6/26/95 3:32:58	319.695	27.360
6/26/95 4:44:58	319.695	6/27/95 3:47:22	342.735	23.040

Figure 2-2 Additional CENSE System Capabilities - Engine Use

Figure 2-2 shows the CENSE capabilities to communicate fault information real-time. The CENSE system is compatible with Dispatch Systems such as Modular Mining providing fault and sensor data real-time to mine site operations managers. In addition, CENSE includes drivers for three operator panel lamps indicating different fault severity levels. CENSE can communicate to other J1939 devices.

MODULAR MINING DISPATCH SYSTEM

OPERATOR INDICATOR LAMPS

Figure 2-3 Additional CENSE System Capabilities - Fault Communication
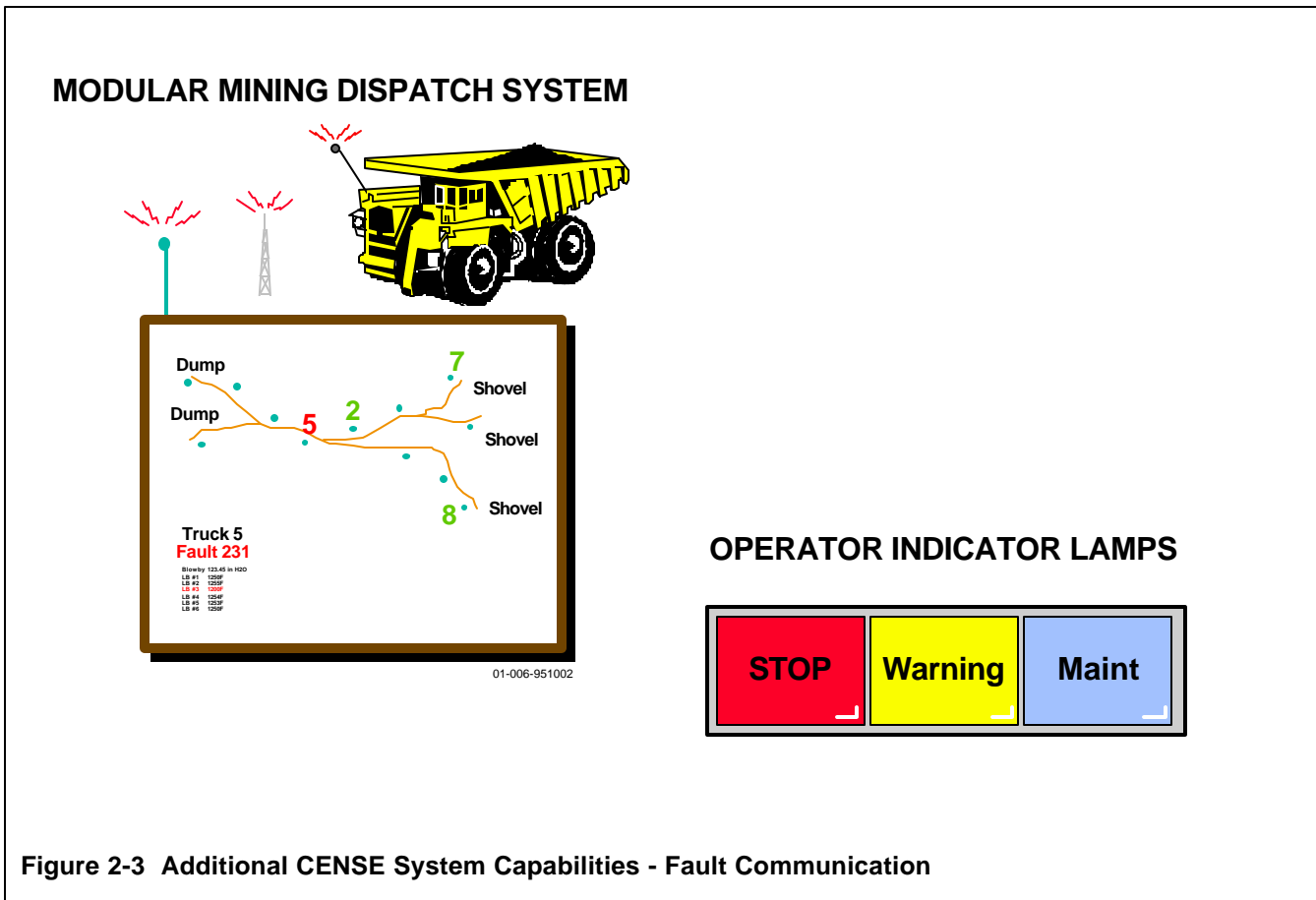
1.   CENSE Operational States

Five states govern the operation of the CENSE system:
- Key switch on, engine not cranking or running
- Key switch on, engine cranking
- Key switch on, engine running
- Key switch on, after engine cranking or running
- Key switch off

Key Switch on, Engine Not Cranking or Running - With the key switch on, and the engine not cranking or running, the electronic module performs diagnostic and status operations. Initially the CENSE indicator lamps will illuminate for approximately 1-2 seconds to indicate the CENSE has been powered on and the lamps are working properly, and then they will turn off. If all lamps remain on, this indicates that the CENSE module has failed and requires servicing.

The CENSE will begin reading the inputs from the CENSE engine sensors. If connected up to an electronic engine controller, the CENSE module will read parameter information from the ECM. The CENSE system performs diagnostics such as checking for low oil level.

If there are active faults, the CENSE yellow lamp (for faults detected only by the CENSE ECM) or red lamp (for faults detected by the fuel control ECM) will flash in a sequence of pulses to indicate each specific fault code that is active. After displaying all active fault codes, the lamp will pause, and then start over from the beginning. This will continue until the key switch is turned off or the engine begins cranking. Further discussion of diagnostic operations is found in the Diagnostics section.

When the module is powered up, the CENSE system communicates over the RS422 datalink, providing the automatic RF transmission of engine fault status, engine parameter data to remote locations (like central dispatch offices).

During this state the module service datalink is active and can be accessed by the Cummins' INSITE service tool.

Key switch on, engine cranking - When the engine is cranking, the module is performing additional diagnostic and status operations. An active fault causes one of the three indicator lamps to illuminate and remain on; which lamp is on depends on the severity of the fault. If all lamps are on, this indicates the CENSE module has failed and service is required.

Key switch on, engine running - When the engine is running, the full CENSE diagnostics begin. Engine protection and operation engine diagnostics begin, including single cylinder and crankcase pressure diagnostics. Fault recording and datalogging occur when faults are detected. Trend data is taken during this state. Engine hourmeters record engine running, engine rebuild, and engine idle hours in this state.

During the engine running state the module service datalink is active and can be accessed by the Cummins' INSITE service tool.

Key switch on, after engine cranking or running - When the engine is stops cranking or running and the key switch is left on, the module is performing additional diagnostic and status operations. An active fault causes one of the three indicator lamps to illuminate and remain on; which lamp is on depends on the severity of the fault.

Engine data recorded during the engine run is stored in non-volatile memory.
During this state the module service datalink is active and can be accessed by the Cummins' INSITE service tool.

Key switch off - When the engine is stops cranking or running and the key switch is turned off, the indicator lamps turn off and the module finishes diagnostics and data collection. The CENSE system stores engine data recorded during the engine run into non-volatile memory. After all fault data has been stored, the module powers itself down.

2. CENSE Onboard Diagnostics

Engine Protection Diagnostics - Engine protection diagnostics are a standard feature of the CENSE system. When the keyswitch is turned on, and the engine is running, the CENSE system provides continuous onboard engine diagnostics; it monitors key engine parameters during engine operation and logs diagnostic faults when an over or under normal operating range condition occurs.

Operator Stimulus - The CENSE module provides a red lamp output from the electronic module to the cab or dash to alert the driver of an out-of-range condition. This electronic module output is similar in its electrical connection and characteristics to the other operator indicator lamps. A lighted red lamp indicates a major engine problem and the vehicle should be stopped as soon as safely possible. For added safety, it is possible to connect this lamp output to a switch which disables propel thus removing the load from the engine. The electronic module also keeps an electronic datalog of the fault occurrence.

Onboard Engine Performance Diagnostics - When the keyswitch is turned on and the engine is cranking or running, the CENSE system provides continuous onboard engine performance diagnostics.

In addition to the engine protection diagnostics mentioned above, the CENSE system also has a built-in diagnostic capability which alerts the operator of a system problem while the engine is running by illuminating an indicator lamp. The warning (yellow) lamp, when lighted, warns the operator of an active engine performance fault. The vehicle should be serviced to solve the problem but the situation is not considered an emergency.

The following engine mounted sensors are used by the CENSE diagnostics: engine speed, fuel rail pressure, oil pressure, oil temperature, oil level, coolant pressure, coolant temperature, crankcase pressure, ambient air pressure, turbo compressor inlet air temperature, intake manifold temperature, intake manifold pressure, and exhaust port temperature. The radiator coolant level sensor is mounted in the radiator top tank and must be supplied by the OEM.

The electronic module also communicates the fault occurrence over the RS-422 and J1939. (Note that the RS-422 datalink can be used with the Modular Mining Dispatch System.)
The electronic module also keeps an electronic datalog of the fault occurrence.