Installation Guide

Electronic Fuel Injection (EFI)
+
Electronic Throttle Control (ETC)

Document Updates

Date	Page #	Changes Made	Name/Position
05/08/2023	14, 16	Electrical protection, CAN speeds	Brian Brunelli

Table of Contents

ECM

Throttle Body

Manifold Absolut Pressure Sensor Passage

Electronic Throttle Actuator

Intake Air Temp. Sensor

ECM Connector

NOTE: all components listed above are included in the ETC throttle body assembly. These components are not individually serviceable and would require the whole assembly to be replaced in the event of a service repair being required by an individual component failure.

ETC System Description

What is electronic throttle control?

- A throttle body is traditionally controlled through mechanical linkages connected to a mechanically sprung governor control system. Electronic throttle control (ETC) now uses the ECU to control the throttle body electronically rather than mechanically. Many functions are associated with an engine's throttle body and mechanical governor system. ETC now uses a control module that offers the same functions electronically to improve engine performance, starting performance, speed control, load response and more.

What is an electronic governor?

- Electronic governor (E-Gov) systems are often incorrectly used to describe electronic throttle control. Electronic governing is a function that is controlled by the ETC system that involves engine speed, load response and stability control. Other functions and benefits of ETC would fall outside of the E-Gov feature.

How does engine performance change?

- The use of ETC can improve the amount of usable power being produced by the engine due to the reduction in governor droop. The engine's response to load acceptance can also be improved and reduce the impact of speed overshoot or undershoot.

-

- **Direct Throttle (WOT) horsepower curve** – this is identified by the blue dotted power curve in Figure 1. Peak horsepower occurs at maximum engine operating speed noted by the orange arrow in Figure 1.

- **Mechanically controlled throttle body system** – this is identified by the solid red line in Figure 1. Peak horsepower occurs where the governor droop meets the power curve and is noted by the red arrow in Figure 1. A shallow droop curve slope and rolling transition to the power curve limit the overall performance and response of the mechanical system.

- **Electronically controlled throttle body system** – This is identified by the black dashed line in Figure 1. Peak horsepower occurs where the ETC's governor calibration transitions to the power curve and is identified by the green arrow in Figure 1. The governor calibration allows for a much tighter droop curve slope which translates into higher peak power availability. The steeper slope and quicker transition to the power curve also provide quicker and more stable load acceptance. The green dashed area on Figure 1 represents the additional "usable" power the ETC will offer over a traditional mechanical controlled system.
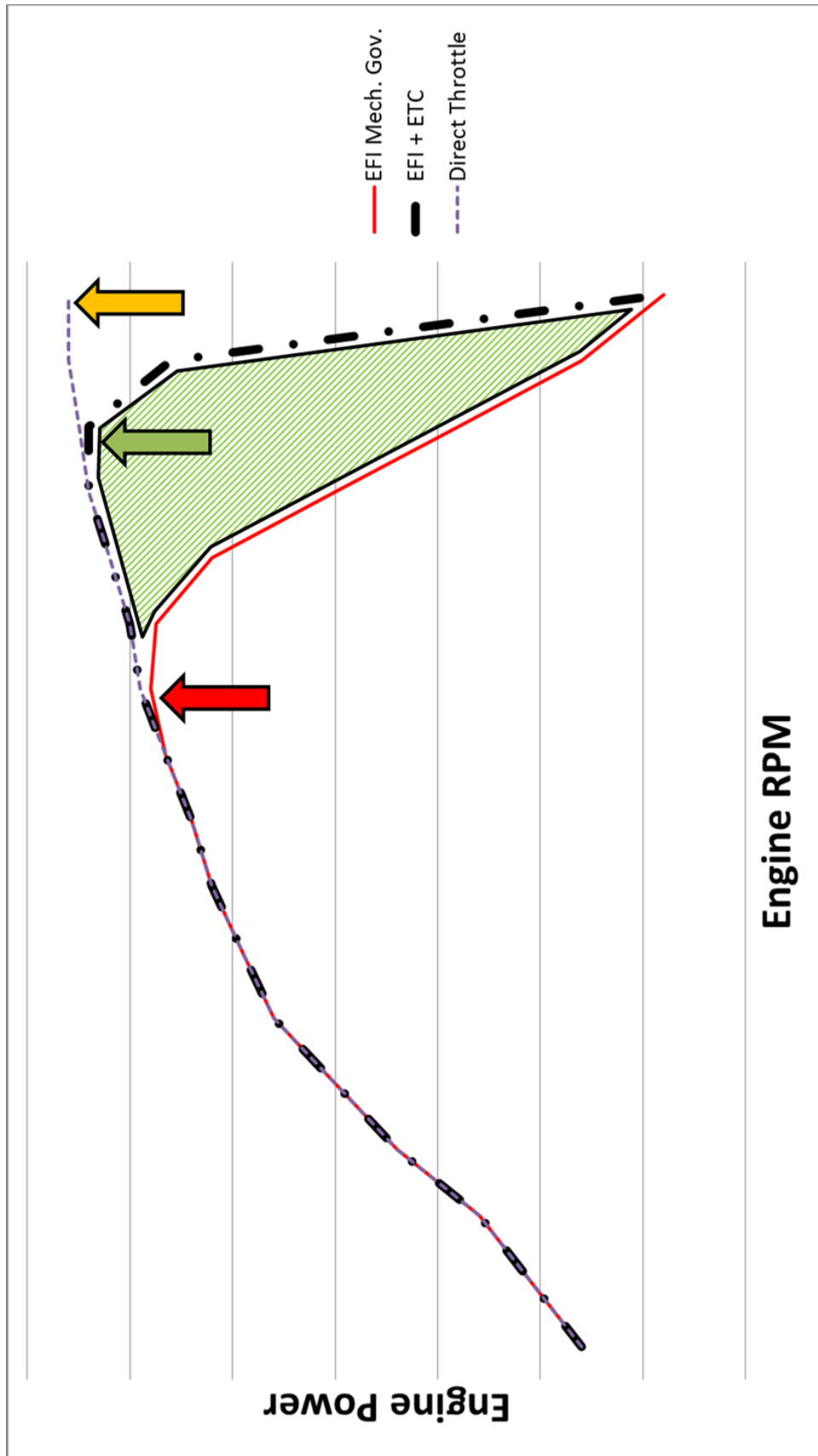
Figure 1: Direct Throttle vs. Mech. Gov. Droop vs. ETC Droop

Operating Temperature Compensation

Ignition Timing vs. Cylinder Head Temperatures – based on the measured cylinder head temperatures the desired ignition timing can continuously change to improve engine operating. The calibration strategy begins to retard timing as cylinder head temperature trends warmer.

Overheat Strategy – This will not begin to control the engine until cylinder head temperatures have exceeded 180 deg. C. Once the overheat strategy has been triggered there are throttle angle, ignition timing and air/fuel ratio compensations employed to reduce engine power output and cool the engine.

ETC Cold Start Strategy

One key feature of ETC is the improved cold start capabilities. If the engine cylinder head temperature is below a calibrated set point then additional engine speed will be commanded. This is done in an effort to improve cold engine stability and decrease the engine warm up time. Once the engine has met the necessary criteria the ECM will exit the cold start strategy and command idle at the base engine speed. Please note the engine will not exceed the maximum calibrated RPM for high speed. The cold start strategy only applies additional RPM at or near low idle.
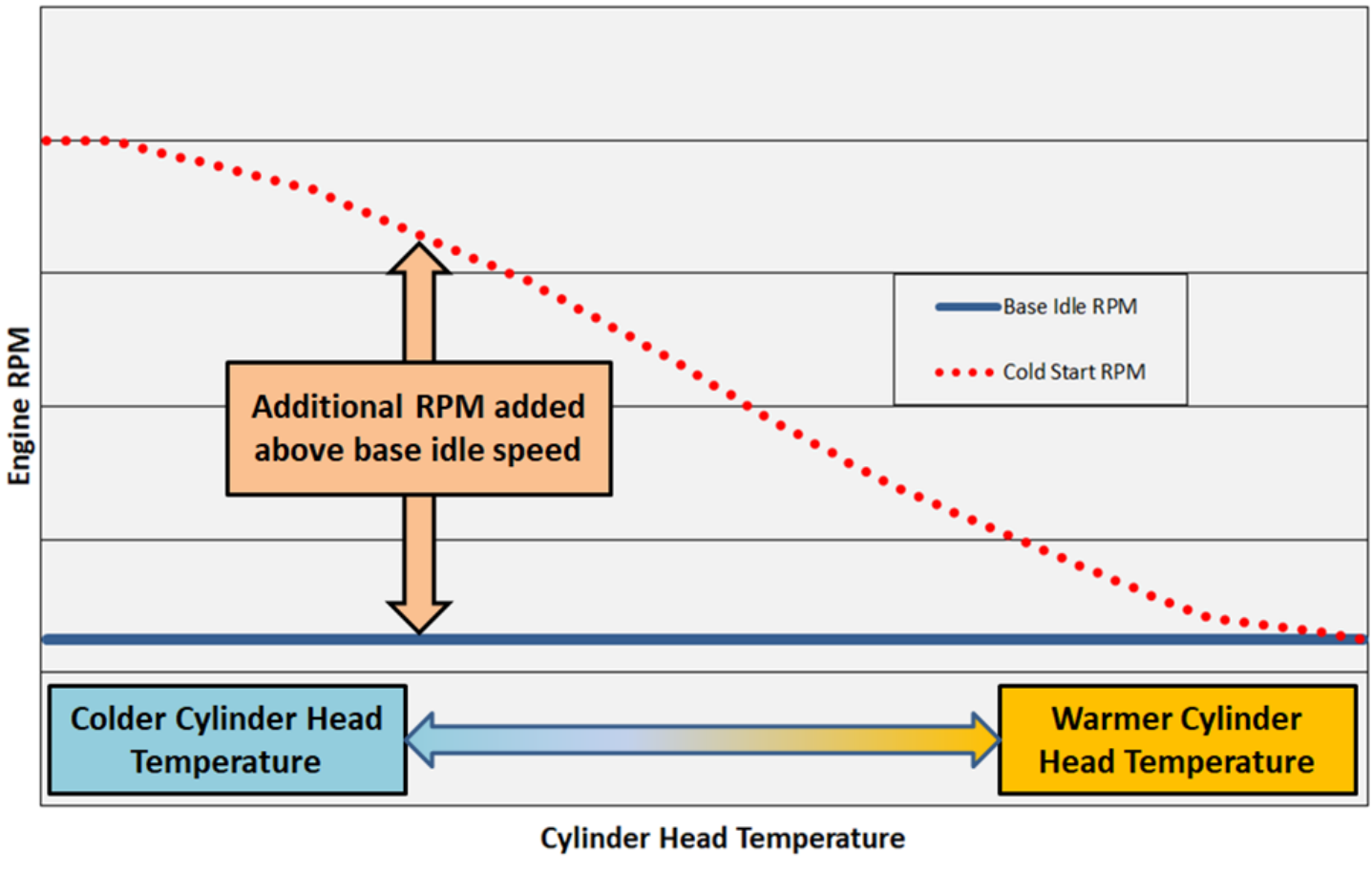
Understanding ETC Governor Overshoot and Undershoot

A governor system is in equilibrium when the engine speed output equals the target engine speed to complete the chore being performed by the application. When the target speed to complete the chore has changed the engine governor must change the engine speed output to accommodate the increase or decrease in target speed. (See Figure 2)

- **Overshoot** occurs when the engine governor responds rapidly and engine speed will momentarily exceed the target speed and fail to achieve equilibrium. The engine speed can have multiple recovery oscillations to achieve equilibrium depending on the ETC calibration parameters.

- **Undershoot** can occur due to slow response time or as a response to overshoot.
    - Slow response undershoot occurs when the engine fails to meet equilibrium quick enough. This type of undershoot is defined by the time the engine speed is below the target engine speed beyond the ideal stabilization point.
    - Fast response undershoot happens after engine speed has first seen an overshoot condition. The engine will respond to overshoot by quickly reducing engine speed lower than the target speed. The engine speed can have multiple recovery oscillations to achieve equilibrium depending on the ETC calibration parameters.

- An **ideal stabilization point** is the best response possible to complete the chore while providing the application operator with a satisfying physical and audible experience. ETC response time can vary with the amount of overshoot, undershoot and speed oscillations being calibrated to operator preferences in an effort to achieve a balance between performance and comfort.
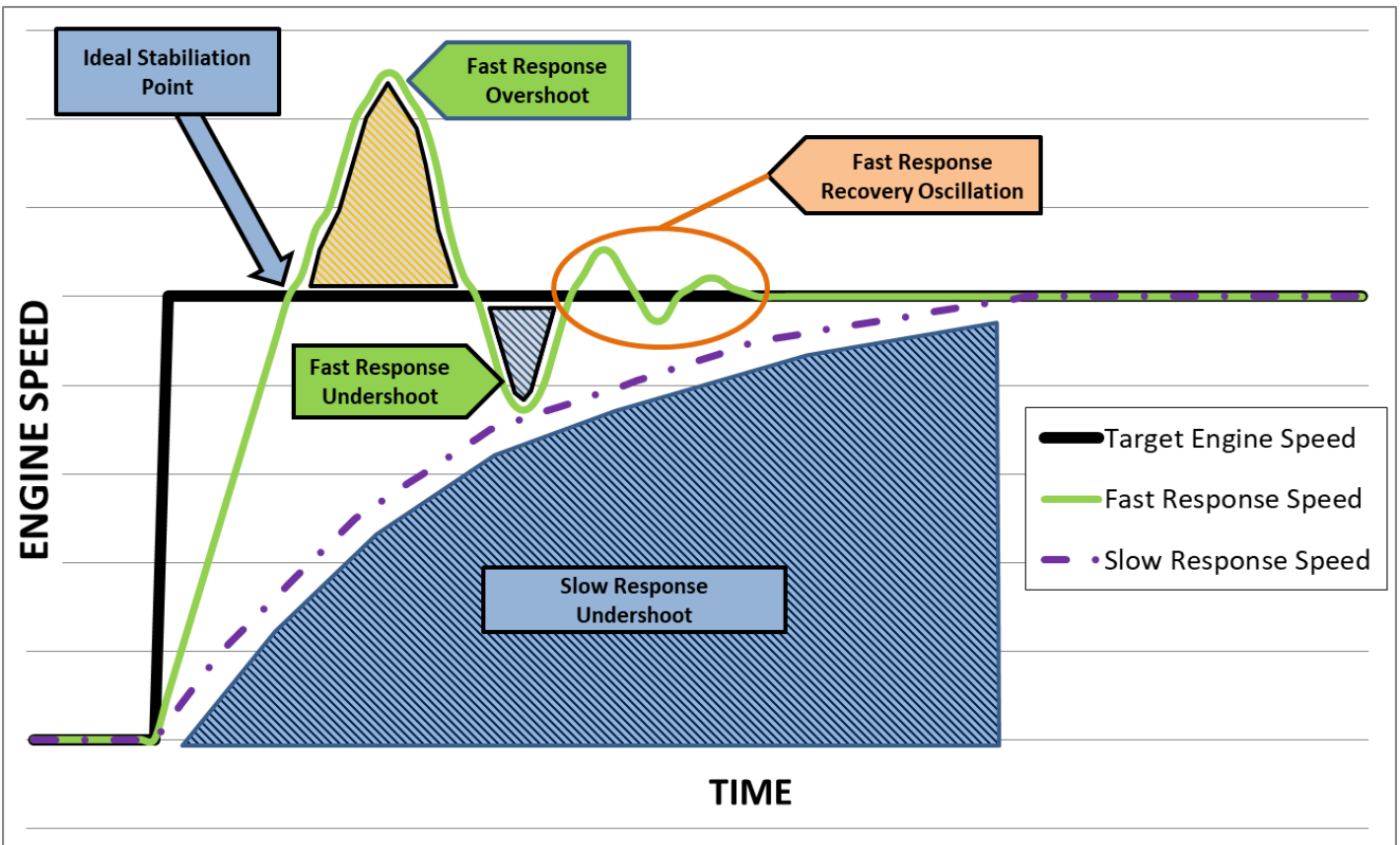
Customer Resources

Application Drawings
- 40hp Big Block Vertical = 61G801-0000-16
- 40hp Big Block Horizontal = 61G201-0000-16
- 27hp Commercial Series = 8664Y

Troubleshooting Guide – Service Part Number = XX

EFI Diagnostic Tool – Service Part Number = 19636


Figure 4: EFI+ETC compatible diagnostic tool

Electrical System

ECM Detail
- Normal Operating Voltage = 14 volts
- Operational Voltage Range = 8-16 volts
- Current Demand = ~3 amps

Connector / Terminal Detail
- Engine Connector = Molex 033482-8601
- Application Connector = Molex 033472-1606
- ETC wiring harness now includes sealed connectors or anti-capillary wires where sealed connectors weren't utilized.
- Hand crimp tool - 64016-0133
   - 033012-2002 (20-18ga) (Right Reel Payoff)
   - 033012-3002 (20-18ga) (Left Reel Payoff)
   - 033012-2001 (16-14ga) (Right Reel Payoff)
   - 033012-3001 (16-14ga) (Left Reel Payoff)
   - 34345-0001 Cavity Plug
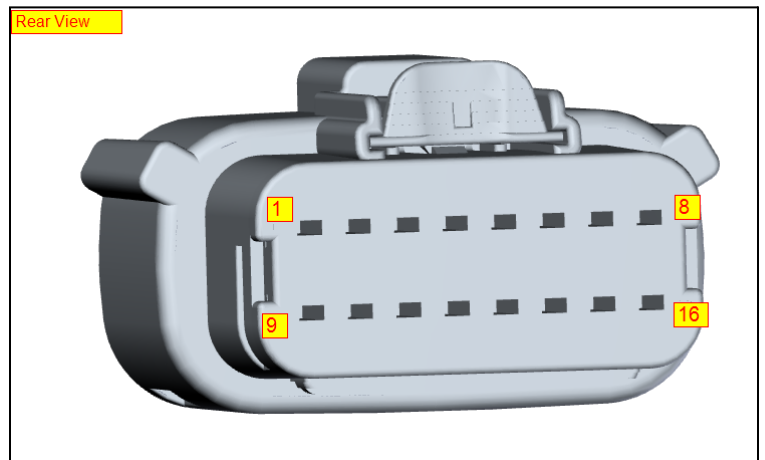
COMMERCIAL SERIES OPT. 1 - ENGINE CONNECTOR (80081461)

1	2	3	4	5	6	7	8
-	CAN HIGH	SENSOR GROUND	ANALOG THROTTLE INPUT	5V SENSOR POWER	INTERLOCK	IGNITION POWER	EFI POWER
REGULATOR	CAN LOW	BRAKE	-	MIL	TACH OUTPUT	-	-
9	10	11	12	13	14	15	16

COMMERCIAL SERIES OPT. 2 - ENGINE CONNECTOR (80081462)

1	2	3	4	5	6	7	8
-	CAN HIGH	SENSOR GROUND	ANALOG THROTTLE INPUT	5V SENSOR POWER	INTERLOCK	IGNITION POWER	EFI POWER
-	CAN LOW	BRAKE	-	MIL	TACH OUTPUT	STARTER SOLENOID	-
9	10	11	12	13	14	15	16

BIG BLOCK - ENGINE CONNECTOR (80081737)

1	2	3	4	5	6	7	8
-	CAN HIGH	SENSOR GROUND	ANALOG THROTTLE INPUT	5V SENSOR POWER	INTERLOCK	IGNITION POWER	EFI POWER
-	CAN LOW	BRAKE	-	MIL	TACH OUTPUT	STARTER SOLENOID	-
9	10	11	12	13	14	15	16

Recommended Pin Connection Details

Pin 1 = Open / Not Used

Pin 2 = CAN High – See details in the *CAN Control* section of *ETC Engine Speed Control Strategies* below.

Pin 3 = Analog Sensor Ground – See details in the *Analog Control* section of *ETC Engine Speed Control Strategies* below.

Pin 4 = Analog Sensor Output – See details in the *Analog Control* section of *ETC Engine Speed Control Strategies* below.

Pin 5 = Analog Sensor Power – See details in the *Analog Control* section of *ETC Engine Speed Control Strategies* below.

Pin 6 = Interlock – active low input used by application to command engine shut down.
- Grounded = engine shut down.
- Open = engine running.

- Details = input has an internal 1.62kΩ Pull-Up Resistor with series diode.

Pin 7 = Ignition Power – Apply battery voltage to this pin to turn on engine ECM.
- Battery voltage is applied to this input to turn the ECU on so the engine can be started.

Pin 8 = Battery / EFI Power – Used to power EFI system from application.
- This connection will be connected to battery positive (+) terminal.
- This must be unswitched.

Pin 9 = Harness dependent – Regulator OR Open / Not Used – Can be used to charge the battery if from voltage regulator if populated in the connector.
- This connection will be connected to battery positive (+) terminal.
- This connection can be used to test the charging system.

Pin 10 = CAN Low – See details in the *CAN Control* section of *ETC Engine Speed Control Strategies* below.

Pin 11 = Brake Switch – Programmable input used by the application to change engine operation.
- Active with low circuit.
- Test stand should ground this pin during test and look for status change on the CANBUS.
- Switch configurable in software.
- This input has an internal 432Ω Pull-Up Resistor with series diode.

Pin 12 = Open / Not Used

Pin 13 = MIL – This pin is connected to ground when an engine fault is active.
- Maximum sink current = 1A.
- Recommended customer supply current limiting resistor if LED is used.
- Recommended to connect to ignition power.

Pin 14 = Tach Output – this output is used to drive a tachometer.
- One pulse is created per one engine crankshaft revolution.
- Tach signal is 0 to 12 volts.
- This output has an internal 1.62kΩ Pull-Up Resistor.
- Max output power at 12.5V = 7.7mA.
- Max sinking current is 50mA.

Pin 15 = Harness dependent – Starter Solenoid OR Open / Not Used – Can be used to pass a start signal from the vehicle harness through the engine connector to the starter solenoid.
- This is a low current circuit connected to battery positive (+) to trigger the starter solenoid.

Pin 16 = Open / Not Used

N/C - 1
CAN_H - 2
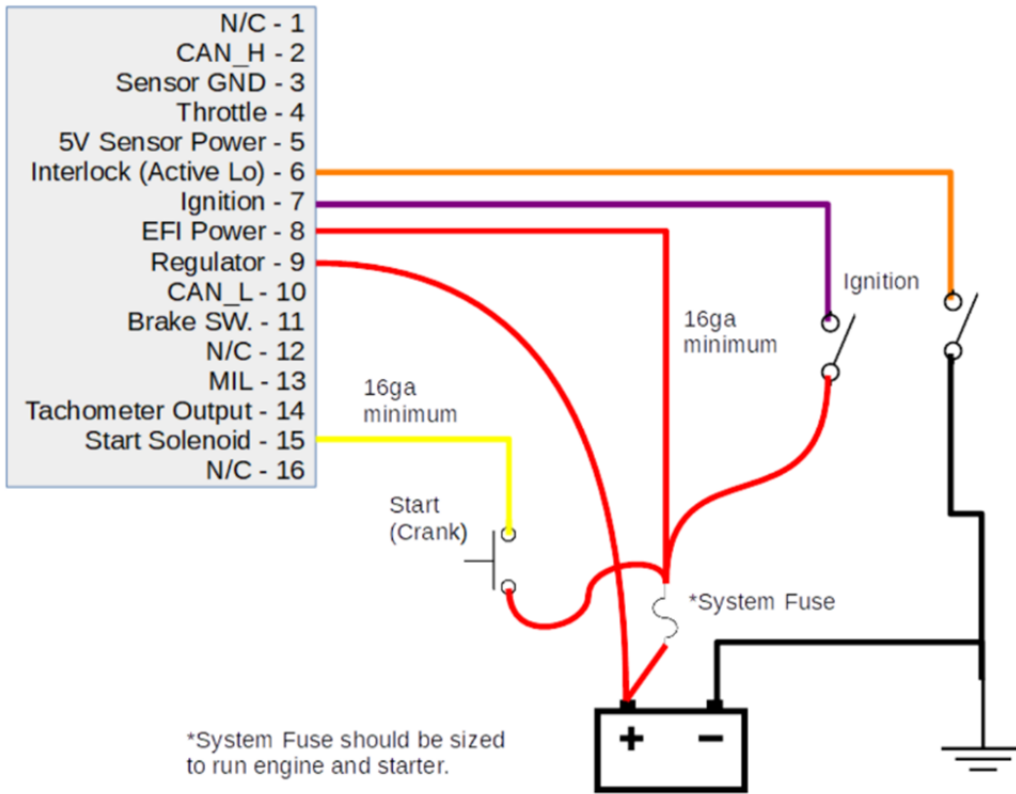Sensor GND - 3
Throttle - 4
5V Sensor Power - 5
Interlock (Active Lo) - 6
Ignition - 7
EFI Power - 8
Regulator - 9
CAN_L - 10
Brake SW. - 11
N/C - 12
MIL - 13
Tachometer Output - 14
Start Solenoid - 15
N/C - 16

Ignition

16ga
minimum

16ga
minimum

Start
(Crank)

*System Fuse

*System Fuse should be sized
to run engine and starter.

Figure 6: Recommended Wiring

N/C - 1
CAN_H - 2
Sensor GND - 3
Throttle - 4
5V Sensor Power - 5
Interlock (Active Lo) - 6
Ignition - 7
EFI Power - 8
Regulator - 9
CAN_L - 10
Brake SW. - 11
N/C - 12
MIL - 13
Tachometer Output - 14
Start Solenoid - 15
N/C - 16

MIL

Brake
Switch

*System Fuse

Tachometer
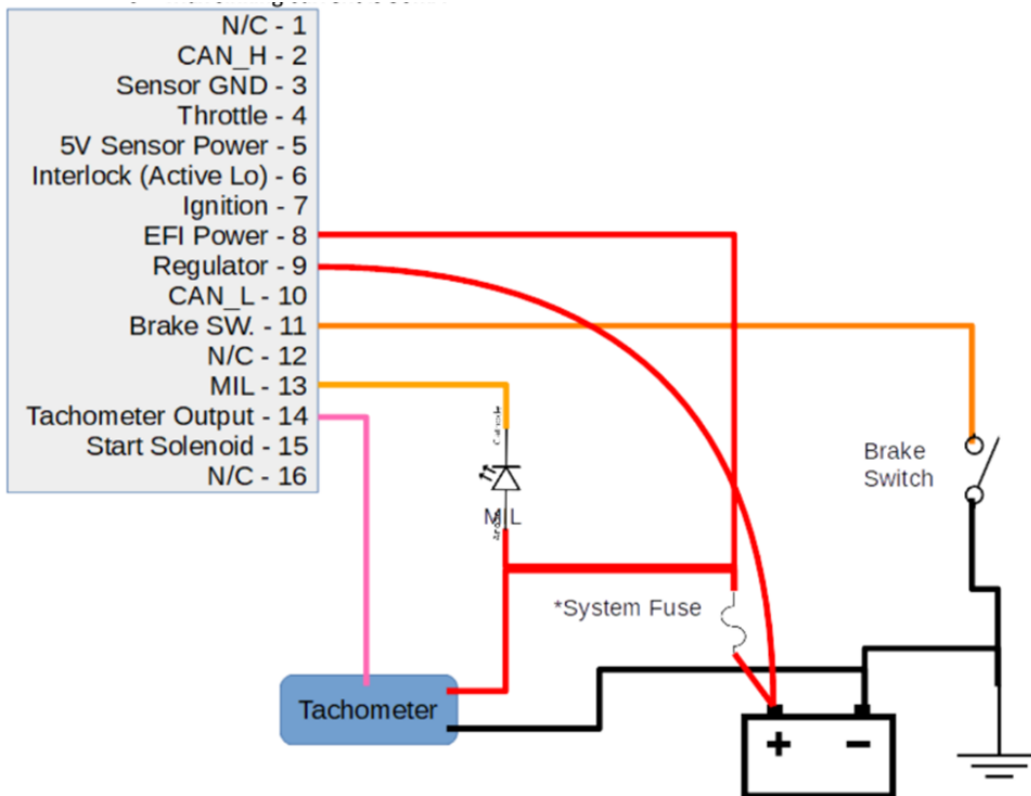
Figure 7: Recommended Wiring (Continued)

12

Alternator Systems

Briggs & Stratton
20 Amp Regulated Alternator Output
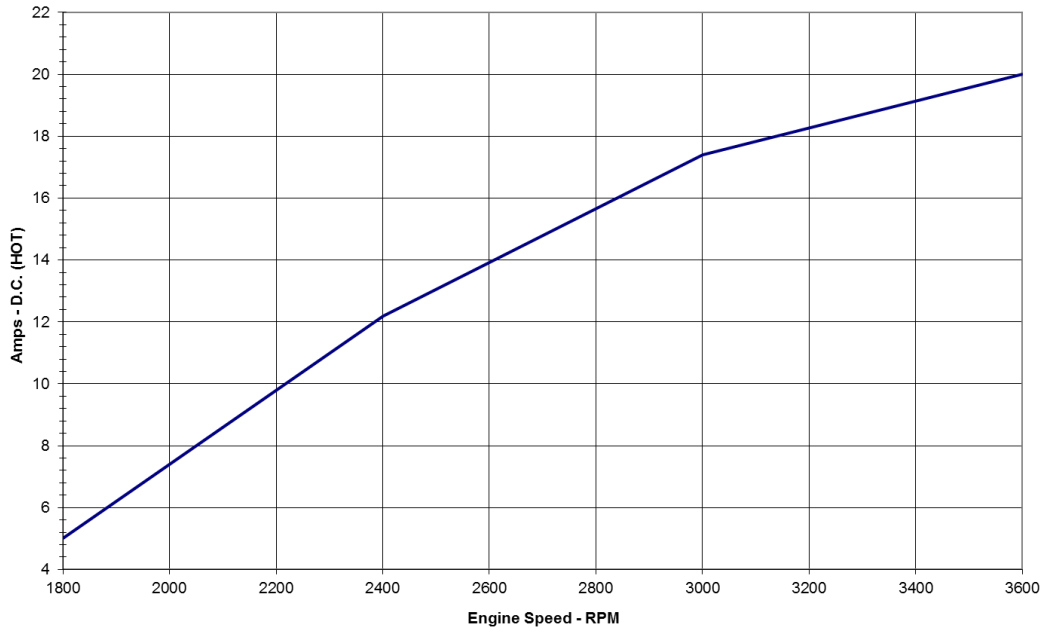
Figure 8: 20 amp alternator curve

20/ 50 Amp Alternator (Cold)
(1.63mm wire, 039 magnets)
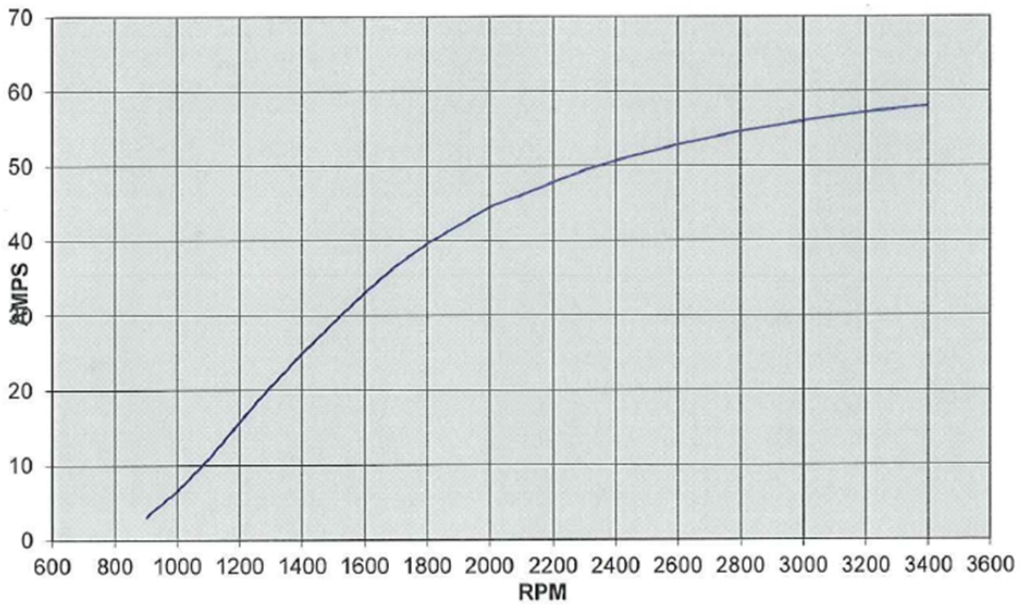
Figure 9: 20/50 amp alternator curve

Electrical protection:

- Electric clutch manufacturers recommend that a 24 volt zener diode be placed across the power and ground lead near the clutch to reduce voltage spikes upon clutch disengagement. Diode part 5100781 may be used.
- EFI electronics are very sensitive to voltage and current spikes.
    - Batteries must not become disconnected from system during operation of engine.
    - Some Lithium Ion starting batteries contain special electronics that disconnect the charge system when the battery determines it no longer needs charge. Verify that the style of lithium battery used does not create this situation.
- Wiring should be protected from heat sources and sharp edges. The length of wire used should be sufficient to prevent stressing wires and connections.

CAN Communication Capability

The EFI+ETC system implemented on these engines uses a Controller Area Network (CAN) communication strategy. This opens many doors to equipment manufactures for controlling and monitoring the engine state during operation.
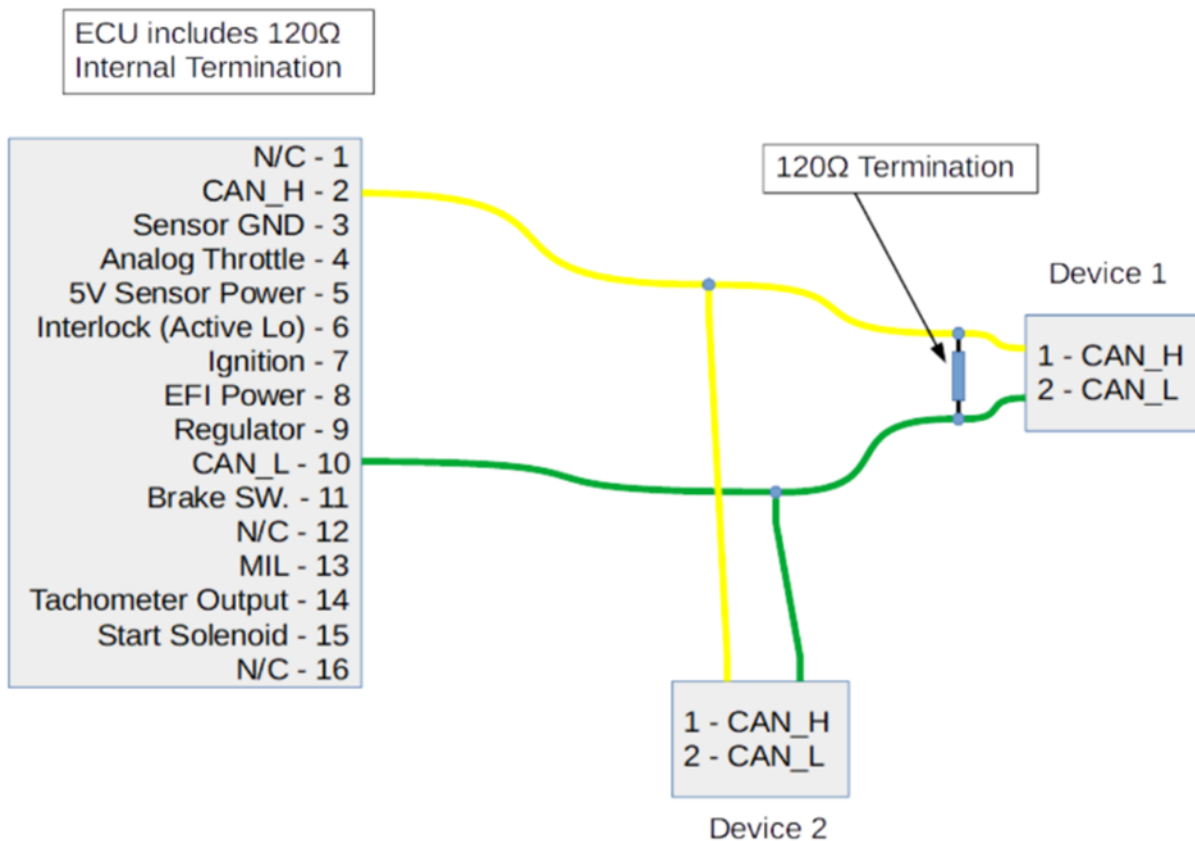
Figure 10: CAN Wiring

CANBUS Details

- CAN specification = SAE J1939
    - Baud Rate = 250 Kbit/s
    - Appendix A: PGN & SPN list sent by ECM (Broadcast)
    - Appendix B: PGN & SPN list received by ECM (Respond to)

- Recommend 1.5 twists per inch for CAN wires
- Throttle body includes a terminating resistor. It is recommended that remote CAN connections include terminating resistors.
    - A maximum of (2) terminating resistors are allowed in the system. Having more terminating resistors in the system can disrupt the CANBUS signal.
    - It is recommended that the terminating resistors are placed at either end of the signal. Briggs included at throttle body and OEM included at controller.
- Control engine speed – see details below

ETC Engine Speed Control Strategies

Analog Control – 5 volt sensor power and sensor ground can be used with customer supplied hall-effect throttle sensor input to control engine speed. Analog control is established using engine connector pins 3, 4 and 5 as shown below. This method allows for an infinite sweep of engine speeds to mimic a cable throttle seen on mechanically governed engines.
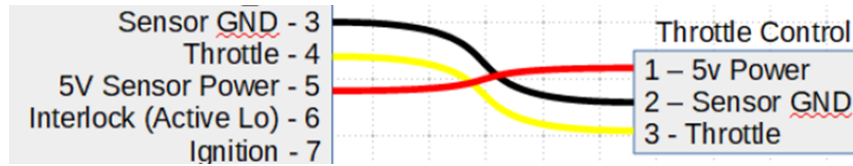
Figure 11: Analog controller wiring

Electrical Characteristics
- Input has an internal 10 kΩ pull-p resistor
- 5V sensor power can source a maximum current of 50mA
- Throttle input accepts 0-5V
  - 0.0 to 0.1 Volts – Diagnostic/Fault Low Voltage Region – ECM commands Idle
  - 0.1 to 1.0 Volts – Deadband
  - 1.0 to 4.0 Volts – Linear Region
  - 1.0 Volts – Idle (Speed Calibration Dependent)
  - 4.0 Volts – High Speed – No Load (Calibration Dependent)
  - 4.0 to 4.9 Volts - Deadband
  - 4.9 to 5.0 Volts – Diagnostic/Fault High Voltage Region – ECM commands Idle
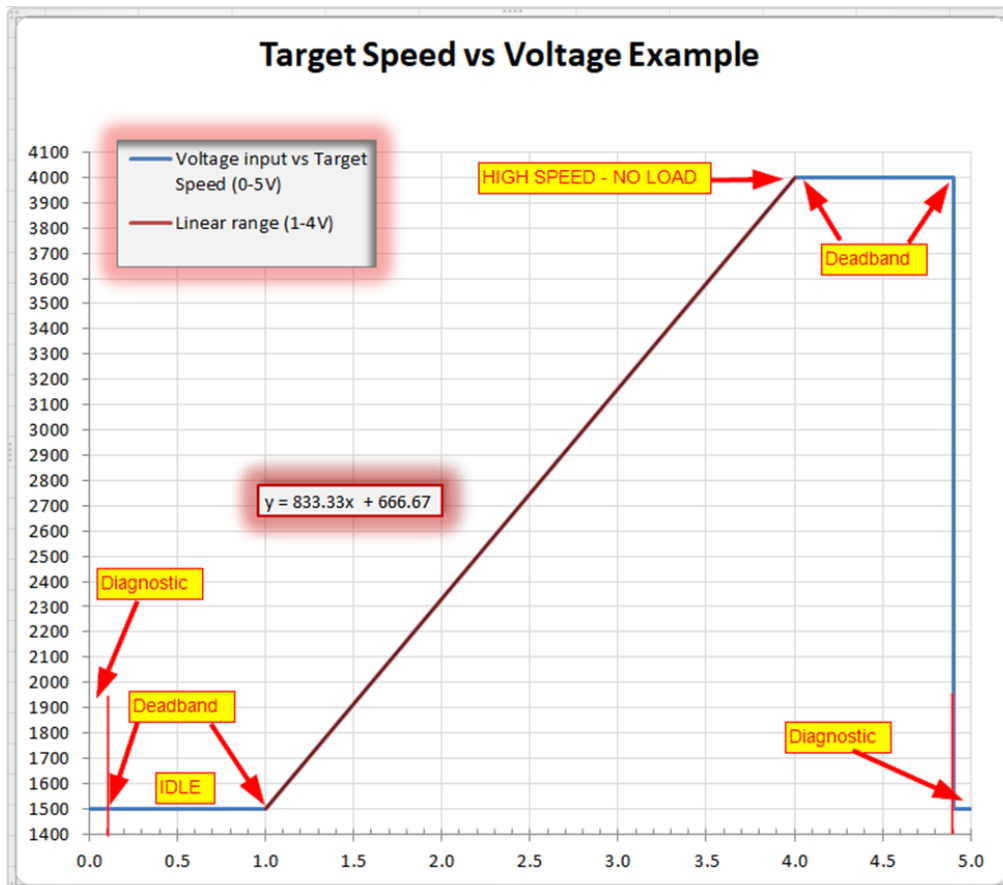
CAN Control – a customer supplied CAN capable controller can be used to communicate engine speed commands to the engine ECM. (NOTE: CAN commanded cranking/starting is not available.)

** Customer must submit controller spec. to assure compatibility with B&S J1939 CAN based ECM**

CAN Controlled Engine Speed Options and Limits
- The equipment manufacture will set the operating range of the engine for their specific application within the boundaries available with CAN speed control.
    o   Minimum Low Speed = 1200 rpm
    o   Maximum High Speed = 4000 rpm (3800 rpm on the 33 hp)
- CAN speed control messaging details – in order for OEMs to control speed through the CANBUS they will need to utilize the Torque/Speed Control #1 (TSC1) PGN. Please see the PGN details below for controlling engine speed.
    o   TSC1 recommended update rate = 20 msec.

3.5.2   PGN 0 – Torque/Speed Control #1

Engine speed can be set with this PGN. Minimum SPNs needed for engine speed control include: 898, 3349, 4206, and 4207.

Part of the PGN	Value	Remarks
Transmission Repetition Rate	Control Purpose Dependent – Maximum 10 ms	
Data Length	8 bytes	
Extended Data Page	0	
Data Page	0	
PDU Format	0	
PDU Specific	218	
Default Priority	3	
Parameter Group Number	0 (0x000000)	

Figure 13: TSC1 PGN Detail

Start Position	Length	Parameter Name	SPN	Remarks
1.1	2 bits	Engine Override Control Mode	695	
1.3	2 bits	Engine Requested Speed Control Conditions	696	
1.5	2 bits	Override Control Mode Priority	897	
2 – 3	2 bytes	Engine Requested Speed/Speed Limit	898	
4	1 byte	Engine Requested Torque/Torque Limit	518	
5.1	3 bits	TSC1 Transmission Rate	3349	
5.4	5 bits	TSC1 Control Purpose	3350	
6.1	4 bits	Engine Requested Torque – High Resolution	4191	
8.1	4 bits	Message Counter	4206	
8.5	4 bits	Message Checksum	4207	

Figure 14: TSC1 SPN Detail

Exhaust System

Maximum backpressure limits are engine dependent. Consult Application Engineering / PAC
OEM supplied mufflers must be reviewed for back pressure compliance

Mounting Boss Dimensions

Mounting Boss: M12 x 1.25 – 6G Threads

Major Diameter: 12.388 – 12.028 mm

Minor Diameter: 10.940 – 10.675 mm

Pitch Diameter: 11.396 – 11.216 mm

Material: Ferritic Stainless Steel or equivalent

Thread Quality: Threads must be free of burrs, voids, or other imperfections which would interfere with proper installation or removal of the sensor.

Boss Thickness: 7.0 – 7.4 mm

Sealing Surface Roughness: 3.2 RMS

Leakage: less than 5scc per min @ 3psi on fresh application
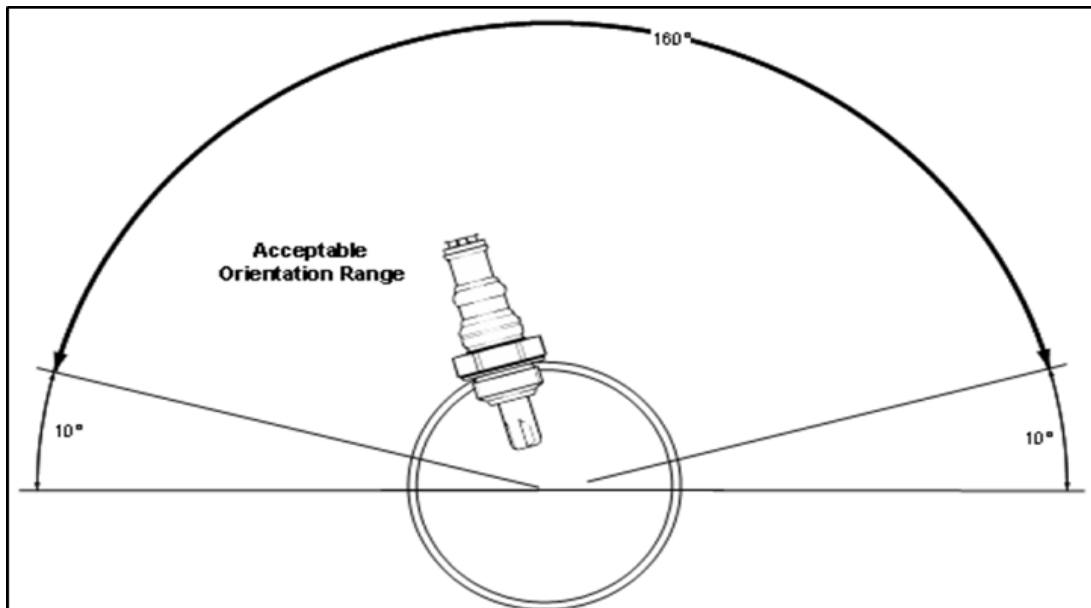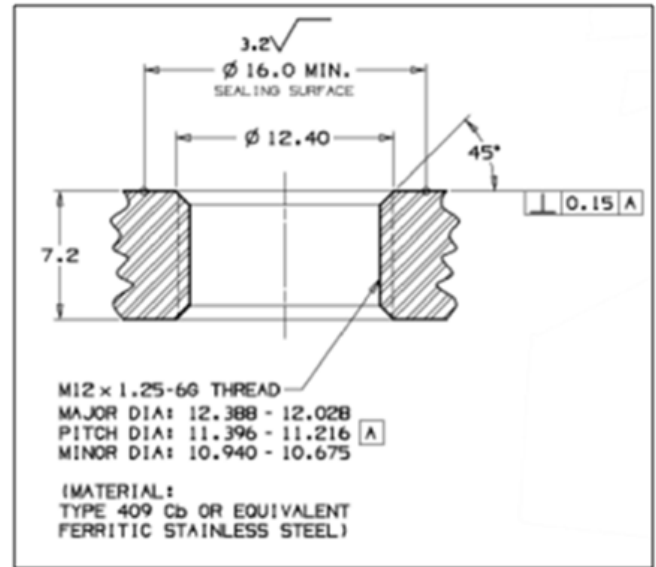
Figure 16: Acceptable O2 sensor orientation

- O2 sensors must be placed in the first chamber where cylinder 1 and 2 exhaust gases are combined. The sensor must also be placed as far from the exhaust outlet as possible.
- O2 sensors must be installed dry. **DO NOT USE LUBRICANT OR ANTI-SIEZE ON THREADS**.

Fuel System

Lift Pump
- Operating voltage range = 8.5-16V
- Max operating current = 1.5A
- Lift height maximum: 18 inches (dry pump) ● Output pressure is 2.5 to 3.3 psi (17-23kPa) at 0 delivery.
- Runs for 2 seconds upon turning the key "on". (If the key switch is cycled from on-off-on the pump will not run unless the key switch is off for 10 seconds).

High Pressure Module
- Max operating current = 2A
- Pressure output to injectors = 38-43 PSI

Fuel Filter - 30 micron installed on the engine. Filter fuel before the lift pump.

<u>**Appendix A**</u>

	Send by Electronic Module (Broadcast)			
Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
☒	Electronic Engine Controller 1	EEC1	61444 (0x00F004)	☐ 899: Engine Torque Mode ☐ 4154: Percent Torque – Demand ☐ 512: Drivers Demand Engine - % torque ☐ 513: Actual Engine - % torque ☒ 190: Engine Speed ☒ 1483: Source address control device ☐ 1675: Engine Starter Mode ☐ 2432: Engine Demand - % torque
☒	Electronic Engine Controller 2	EEC2	61443 (0x00F004)	☐ 558: Accelerator Pedal 1 Low Idle Switch ☐ 559: Accelerator Pedal Kickdown Switch ☐ 1437: Road Speed Limit Status ☐ 1437: Road Speed Limit Status ☐ 2970: Accelerator Pedal 2 Low Idle Switch ☐ 91: Accelerator Pedal Position 1 ☒ 92: Engine Percent Load at Current Speed ☐ 974: Remote Accelerator Pedal Position ☐ 29: Accelerator Pedal Position 2 ☐ 2979: Vehicle Acceleration Rate Limit Status ☐ 5021: Momentary Engine Maximum Power Enable Feedback ☐ 5399: DPF Thermal Management Active ☐ 5400: SCR Thermal Management Active ☐ 3357: Actual Maximum Available Engine - Percent Torque ☐ 5398: Estimated Pumping - Percent Torque
☒	Engine Operation Information	EOI	64914 (0x00FD92)	☒ 3543 - Engine Operating State ☐ 4082 - Fuel Pump Primer Control ☐ 6385 - Engine Starter Motor Relay Control ☐ 3544 - Time Remaining in Engine Operating State ☐ 3608 - Engine Fuel Shutoff Vent Control ☐ 632 - Engine Fuel Shutoff 1 Control ☐ 2807 - Engine Fuel Shutoff 2 Control ☐ 3601 - Engine Fuel Shutoff Valve Leak Test Control ☐ 3589 - Engine Oil Priming Pump Control ☐ 3602 - Engine Oil Pre-heater Control

Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
				☐ 3603 - Engine Electrical System Power Conservation Control ☐ 3604 - Engine Pre-Heater Control ☐ 3605 - Engine Coolant Pump Control ☐ 3606 - Engine Controlled Shutdown Request ☒ 3607 - Engine Emergency (Immediate) Shutdown Indication ☐ 6884 - Engine Cold Ambient Elevated Idle Status ☐ 6807 - Engine Desired Torque Request ☐ 3644 - Engine Derate Request
☒	Engine Temperature 1	ET1	65262 (0x00FEEE)	☒ 110: Engine Coolant Temperature ☐ 174: Engine Fuel Temperature 1 ☐ 175: Engine Oil Temperature 1 ☐ 176: Engine Turbocharger Oil Temperature ☐ 52: Engine Intercooler Temperature ☐ 1134: Engine Intercooler Thermostat Opening
☐	Engine Temperature 2	ET2	65188 (0x00FEA4)	☐ 1135: Engine Oil Temperature 2 ☐ 1136: Engine ECU Temperature ☐ 411: Engine Exhaust Gas Recirculation 1 Differential Pressure ☐ 412: Engine Exhaust Gas Recirculation 1 Temperature
☒	Inlet/Exhaust Conditions	IC1	65270 (0x00FEF6)	☐ 81: Engine Diesel Particulate Filter Intake Pressure ☒ 102: Engine Intake Manifold #1 Pressure ☒ 105: Engine Intake Manifold 1 Temperature ☒ 106: Engine Air Intake Pressure ☐ 107: Engine Air Filter 1 Differential Pressure ☐ 173: Engine Exhaust Gas Temperature ☐ 112: Engine Coolant Filter Differential Pressure
☒	Vehicle Electrical Power 1	VEP1	65271 (0x00FEF7)	☐ 114: Net Battery Current ☐ 115: Alternator Current ☐ 167: Charging System Potential (Voltage) ☒ 168: Battery Potential / Power Input 1 ☒ 158: Key Switch Battery Potential
☒	Engine Fuel Valve Duration Cmd	EGFVDC1	61540 (0x00F064)	☒ 6658: Engine Gaseous Fuel Valve 1 Duration Command

Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
				☒ 6659: Engine Gaseous Fuel Valve 2 Duration Command ☐ 6660: Engine Gaseous Fuel Valve 3 Duration Command ☐ 6661: Engine Gaseous Fuel Valve 4 Duration Command
☐	Ignition Timing #1	IT1	65154 (0x00FE82)	☐ 1413: Engine Cylinder #1 Ignition Timing ☐ 1414: Engine Cylinder #2 Ignition Timing ☐ 1415: Engine Cylinder #3 Ignition Timing ☐ 1416: Engine Cylinder #4 Ignition Timing
☒	Fuel Economy	LFE1	65266 (0x00FEF2)	☐ 183: Engine Fuel Rate ☐ 184: Engine Instantaneous Fuel Economy ☐ 185: Engine Average Fuel Economy ☒ 51: Engine Throttle Valve 1 Position ☐ 3673: Engine Throttle Valve 2 Position
☐	Engine Spark Misfire Rate 1	ESMR1	64675 (0x00FCA3)	☐ 6270: Engine Spark Plug 1 Misfire Rate ☐ 6271: Engine Spark Plug 2 Misfire Rate ☐ 6272: Engine Spark Plug 3 Misfire Rate ☐ 6273: Engine Spark Plug 4 Misfire Rate ☐ 6274: Engine Spark Plug 5 Misfire Rate ☐ 6275: Engine Spark Plug 6 Misfire Rate ☐ 6276: Engine Spark Plug 7 Misfire Rate ☐ 6277: Engine Spark Plug 8 Misfire Rate
☒	Engine Fluid Level/Pressure 1	EFL/P1	65263 (0x00FEEF)	☐ 94: Engine Fuel Delivery Pressure ☐ 22: Engine Extended Crankcase Blow-by Pressure ☐ 98: Engine Oil Level ☒ 100: Engine Oil Pressure (if an oil pressure switch is used, define nominal and minimum detected pressures) ☐ 101: Engine Crankcase Pressure ☐ 109: Engine Coolant Pressure ☐ 111: Engine Coolant Level
☒	Vehicle Identification	VI	65260 (0x00FEEC)	☒ 237: Vehicle Identification Number (ASCII data)

The table header "Send by Electronic Module (Broadcast)" spans across all columns.

23

Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
☒	Three Letter Acronym TLA	TLA	65289 (0x00FF09)	☒ 0: Three Letter Acronym manufacturer specific (ASCII data)
☒	Acknowledgment	ACKM	59392 (0x00E800)	☐ 2541: Control Byte ☐ 2542: Group Function Value ☐ 3290: Address Detail ☐ 2543: PGN of requested info
☒	ECU Identification Information	ECUID	64965 (0x00FDC5)	☒ 2901: ECU Part Number ☒ 2902: ECU Serial Number ☒ 2903: ECU Location ☒ 2904: ECU Type ☒ 4304: ECU Manufacturer Name
☒	Software Identification	SOFTID	65242 (0x00FEDA)	☒ 965: Number of Software Identification Fields ☒ 234: Software Identification
☒	Engine Hours, Revolutions	HOURS	65253 (0x00FEE5)	☒ 247: Engine Total Hours of Operation ☐ 249: Engine Total Revolutions
☒	Engine Configuration 1	EC1	65251 (0x00FEE3)	☐ 188: Engine Speed at Idle, Point 1 (Engine Configuration) ☐ 539: Engine Percent Torque at Idle, Point 1 (Engine Configuration) ☐ 528: Engine Speed at Point 2 (Engine Configuration) ☐ 540: Engine Percent Torque at Point 2 (Engine Configuration) ☐ 529: Engine Speed at Point 3 (Engine Configuration) ☐ 541: Engine Percent Torque at Point 3 (Engine Configuration) ☐ 530 Engine Speed at Point 4 (Engine Configuration) ☐ 542: Engine Percent Torque at Point 4 (Engine Configuration) ☐ 531: Engine Speed at Point 5 (Engine Configuration) ☐ 543: Engine Percent Torque at Point 5 (Engine Configuration) ☐ 532: Engine Speed at High Idle, Point 6 (Engine Configuration)

				Send by Electronic Module (Broadcast)
Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
				☐ 545: Engine Gain (Kp) of the Endspeed Governor (Engine Configuration)
				☐ 544: Engine Reference Torque (Engine Configuration)
				☐ 533: Engine Maximum Momentary Override Speed, Point 7 (Engine Configuration)
				☐ 534: Engine Maximum Momentary Override Time Limit (Engine Configuration)
				☐ 535: Engine Requested Speed Control Range Lower Limit (Engine Configuration)
				☐ 536: Engine Requested Speed Control Range Upper Limit (Engine Configuration)
				☐ 537: Engine Requested Torque Control Range Lower Limit (Engine Configuration)
				☐ 538: Engine Requested Torque Control Range Upper Limit (Engine Configuration)
				☐ 1712: Engine Extended Range Requested Speed Control Range Upper Limit (Engine configuration)
				☐ 1794: Engine Moment of Inertia
				☐ 1846: Engine Default Torque Limit
				☒ 3344: Support Variable Rate TSC1 Message
				☒ 3345: Support TSC1 Control Purpose Group 1
				☒ 3346: Support TSC1 Control Purpose Group 2
				☐ 3347: Support TSC1 Control Purpose Group 3
				☐ 3348: Support TSC1 Control Purpose Group 4
☒	Fuel Economy (Liquid)	LFE1	65266 (0x00FEF2)	☒ 183 - Engine Fuel Rate ☐ 184 - Engine Instantaneous Fuel Economy ☐ 185 - Engine Average Fuel Economy ☒ 51 - Engine Throttle Valve 1 Position 1 ☐ 3673 - Engine Throttle Valve 2 Position ☐ 541: Engine Percent Torque at Point 3 (Engine Configuration)
☒	Ambient Conditions	AMB	65269 (0xFEF5)	☒ 108 - Barometric Pressure ☐ 170 - Cab Interior Temperature ☐ 171 - Ambient Air Temperature ☒ 172 - Engine Intake 1 Air Temperature

Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
				☐ 79 - Road Surface Temperature
☒	Engine Throttle / Fuel Actuator Control Command	TFAC	61466 (0xF01A)	☒ 3464 - Engine Throttle Actuator 1 Control Command ☐ 3465 - Engine Throttle Actuator 2 Control Command ☒ 633 - Engine Fuel Actuator 1 Control Command ☒ 1244 - Engine Fuel Actuator 2 Control Command
☒	Ignition Timing #6	IT6	65159 (0xFE87)	☒ 1433 - Engine Desired Ignition Timing 1 ☒ 1434 - Engine Desired Ignition Timing 2 ☐ 1435 - Engine Desired Ignition Timing 3 ☒ 1436 - Engine Actual Ignition Timing
☒	Engine Exhaust Bank 1 O2 Fuel Trim	O2FT1	64841 (0xFD49)	☒ 4237 - Long-term Fuel Trim - Bank 1 ☒ 4236 - Short-term Fuel Trim - Bank 1 ☒ 4240 - Engine Exhaust Bank 1 O2 Sensor Closed Loop Operation
☒	Engine Gas Flow Rate	EGF1	61450 (0x00F00A)	☐ 2659 - Engine Exhaust Gas Recirculation 1 Mass Flow Rate ☒ 132 - Engine Intake Air Mass Flow Rate ☐ 5257 - Engine Exhaust Gas Recirculation 2 Mass Flow Rate
☒	Air Fuel Ratio	AFR	64658 (0x00FC92)	☐ 6575 - Engine Main Chamber Air Fuel Ratio ☒ 6576 - Engine Main Chamber Desired Air Fuel Ratio ☐ 6577 - Engine Prechamber Air Fuel Ratio ☐ 6578 - Engine Prechamber Desired Air Fuel Ratio
☒	Trip Time Information 2	TTI2	65200 (0x00FEB0)	☐ 1034 - Total time accumulated while the engine is in the cruise hold state, excluding time in accelerator override, since the last trip reset. ☐ 1035 - Total time accumulated while the engine is in the PTO or remote PTO governor hold state since the last trip reset. ☒ 1036 - Total time accumulated while the engine speed is greater than zero since the last trip reset. Note that time with the ignition switch on but engine speed at zero is not included. ☐ 1037 - Total time accumulated while the engine speed is greater than zero, both the PTO and remote PTO governors are inactive, and the vehicle speed is less than 2 km/h, since the last trip reset. ☐ 1038 - Total time that the air compressor is on and compressing air since the last trip reset.

				Send by Electronic Module (Broadcast)
Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
☒	ECU History	EH	65201 (0x00FEB1)	☐ 1032 - Total ECU Distance ☒ 1033 - Total ECU Run Time
☒	Engine Speed Sensor Information 1	ESSI1	61473 (0x00F021)	☐ 4201 - The engine speed as measured by speed sensor 1. ☐ 723 - The engine speed as measured by speed sensor 2. ☐ 4202 - The engine speed as measured by speed sensor 3. ☐ 4205 - This is the timing pattern status of the engine speed sensor signal for sensor 3 ☐ 4204 - This is the timing pattern status of the engine speed sensor signal for sensor 2 ☒ 4203 - This is the timing pattern status of the engine speed sensor signal for sensor 1
☒	DM1 Active Diagnostic Trouble Codes	DM1	65226 (0x00FECA)	☒ 987: Protect Lamp Status ☒ 624: Amber Warning Lamp Status ☒ 623: Red Stop Lamp Status ☐ 1213: Flash Amber Warning Lamp ☐ 3041: Flash Protect Lamp ☐ 3038: Flash Malfunction Indicator Lamp ☐ 3039: Flash Red Stop Lamp ☐ 3040: Flash Amber Warning Lamp ☐ 3041: Flash Protect Lamp ☒ 1214: SPN ☒ 1215: FMI ☒ 1216: Occurrence Count ☐ 1706: SPN Conversion Method
☒	DM2 Previously Active Codes	DM2	65227 (0x00FECB)	☒ Same as DM1
☒	DM4 Freeze Frame Parameters	DM4	65229 (0x00FECD)	☒ 1217: Freeze Frame Length ☒ 1214: SPN ☒ 1215: FMI ☒ 1216: Occurrence Count ☐ 1706: SPN Conversion Method ☒ 899: Engine Torque Mode ☒ 102: Engine Intake Manifold #1 pressure ☒ 190: Engine Speed

				Send by Electronic Module (Broadcast)
Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
				☒ 92: Engine Percent Load at Current Speed ☒ 110: Engine Cylinder Head Temperature ☐ 84: Wheel-Based Vehicle Speed ☒ 105: Intake Air Temperature ☒ 51: Absolute Throttle Position ☒ 158: Control Module Voltage ☒ 1413: Ignition Timing Advance for #1 Cylinder
☒	DM8 Test Results for Non-Continuously Monitored Systems	DM8	65232 (0x00FED0)	☒ 1225: Test Type/Component Identifier ☒ 1226: Test Value ☒ 1227: Test Limit Maximum ☒ 1228: Test Limit Minimum
☒	DM15 Memory Access Response	DM15	55296 (0x00D800)	☒ 1649: Length/Number Allowed ☒ 1646: Memory Access State/Status ☒ 1648: Error Indicator/EDC Parameter ☒ 1647: EDCP Extension ☒ 1599: Seed
☒	DM16 Binary Data Transfer	DM16	55040 (0x00D700)	☒ 1650: Number of Occurrences of Raw Binary Data ☒ 1651: Raw Binary Data
☒	Transport Protocol – Connection Management (TP.CM)	TP.CM	60416 (0x00EC00)	
☒	Transport Protocol – Data Transfer (TP.DT)	TP.DT	60160 (0x00EB00)	

Appendix B

Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
Received by Electronic Module (Respond to)			
☒	Request PGN		59904 (0x00EA00)	☒ 2540: Parameter Group Number being requested
☒	Torque/Speed Control #1	TSC1	0 (0x000000)	☒ 695: Engine Override Control Mode ☒ 696: Engine Requested Speed Control Conditions ☒ 897: Override Control Mode Priority ☒ 898: Engine Requested Speed/Speed Limit ☒ 518: Engine Requested Torque/Torque Limit ☒ 3349: TSC1 Transmission Rate ☒ 3350: TSC1 Control Purpose ☒ 4191: Engine Requested Torque – High Resolution ☒ 4206: Message Counter ☒ 4207: Message Checksum
☐	Off-Highway Engine Control Selection	OHECS	64971 (0x00FDCB)	☐ 2284: Engine Auxiliary Governor Switch ☐ 1377: Engine Synchronization Switch ☐ 2883: Engine Alternate Low Idle Switch ☐ 2882: Engine Alternate Rating Select ☐ 2881: Engine Alternate Droop Accelerator 1 Select ☐ 2879: Engine Alternate Droop Accelerator 2 Select ☐ 2886: Engine Alternate Droop Remote Accelerator Select ☐ 2885: Engine Alternate Droop Auxiliary Input Select ☐ 8608: Engine Operating Mode Command
☒	Cruise Control Vehicle Speed 1	CCVS1	65265 (0x00FEF1)	☐ 69: Two Speed Axle Switch ☐ 70: Parking Brake Switch ☐ 1633: Cruise Control Pause Switch ☐ 3807: Park Brake Release Inhibit Request ☐ 84: Wheel-Based Vehicle Speed ☐ 595: Cruise Control Active ☐ 596: Cruise Control Enable Switch ☐ 597: Brake Switch ☐ 598: Clutch Switch

Received by Electronic Module (Respond to)				
Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
				☐ 599: Cruise Control Set Switch ☐ 600: Cruise Control Coast (Decelerate) Switch ☐ 601: Cruise Control Resume Switch ☐ 602: Cruise Control Accelerate Switch ☐ 86: Cruise Control Set Speed ☒ 976: PTO Governor State ☐ 527: Cruise Control States ☐ 968: Engine Idle Increment Switch ☐ 967: Engine Idle Decrement Switch ☐ 966: Engine Test Mode Switch ☐ 1237: Engine Shutdown Override Switch
☒	DM3 Diagnostic Data Clear/Reset of Previously Active DTCs	DM3	65228 (0x00FECC)	
☒	DM4 Freeze Frame Parameters	DM4	65229 (0x00FECD)	☒ 1217: Freeze Frame Length ☒ 1214: SPN ☒ 1215: FMI ☒ 1706: SPN Conversion Method ☒ 1216: Occurrence Count ☒ 899: Engine Torque Mode ☒ 102: Engine Intake Manifold #1 Pressure ☒ 190: Engine Speed ☒ 92: Engine % Load ☒ 110: Engine Coolant Temperature ☐ 86: Vehicle Speed ☒ Manufacturer Specific Info (See Appendix B for selection)
☐	DM5 Diagnostic Readiness	DM5	65230 (0x00FECE)	☐ 1218: Active Trouble Codes ☐ 1219: Previously Active Diagnostic Trouble Codes ☐ 1220: OBD Compliance ☐ 1221: Continuously Monitored Systems Support/Status ☐ 1222: Non-continuously Monitored Systems Support ☐ 1223: Non-continuously Monitored Systems Status

Received by Electronic Module (Respond to)				
Selection	PGN Name	PGN Short Name	PGN Short Name	SPN Selection
☒	DM7 Command Non-Continuously Monitored Test	DM7	58112 (0x00E300)	☒1224: Test Identifier ☒4148: SPN ☒4149: FMI
☒	DM11 Diagnostic Data Clear/Reset For Active DTCs	DM11	65235 (0x00FED3)	
☒	DM13 Start/Stop Broadcast	DM13	57088 (0x00DF00)	☐1230: Current Data Link ☐608: J1587 ☐622: J1922 ☐639: SAE J1939 Network #1, Primary vehicle network ☐1231: SAE J1939 Network #2 ☐1232: ISO 9141 ☐1233: J1850 ☐1234: Other, Manufacture Specified Port ☐1235: SAE J1939 Network #3 ☐1236: Hold Signal ☐2618: Suspend Signal ☐2619: Suspend Duration
☒	DM14 Memory Access Request	DM14	55552 (0x00D900)	☐1640: Length/Number Requested ☐1641: Pointer Type ☐1642: Command ☐1644: Pointer ☐1643: Pointer Extension ☐1645: Key/User_Level

DRAFT – 5/8/2023
Glossary

ECM – Engine Control Module
CAN – Controller Area Network
EFI – Electronic Fuel Injections
ETC – Electronic Throttle Control
MAP – Manifold Absolute Pressure
IAT – Intake Air Temperature
MIL – Malfunction Indicator Lamp