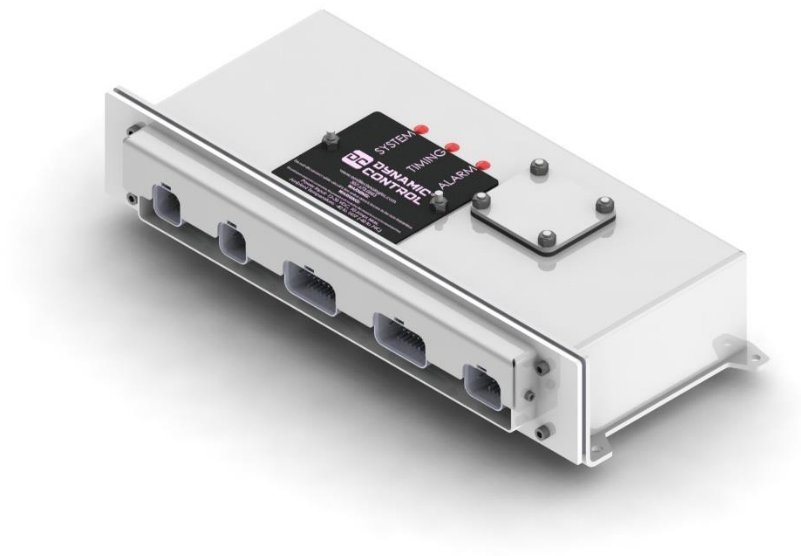


Dynamic Control ECU

Installation, Operation, Troubleshooting Manual

Document Date: 01 July 2021
Document Number: ECU_EXT01
Revision: 0.14

Contents

C1D2 Notice

This module must be installed in a C1D2-suitable enclosure that is IP54 rated or better, and protects the module from being accessed in normal operation without using a tool. The enclosure should suitably protect the equipment from deterioration that would affect its suitability for Class I, Division 2 locations. End device wiring outside of the enclosure must use methods suitable for Class 1, Division 2 hazardous locations and meet all local electrical codes.

<u>Standards</u>

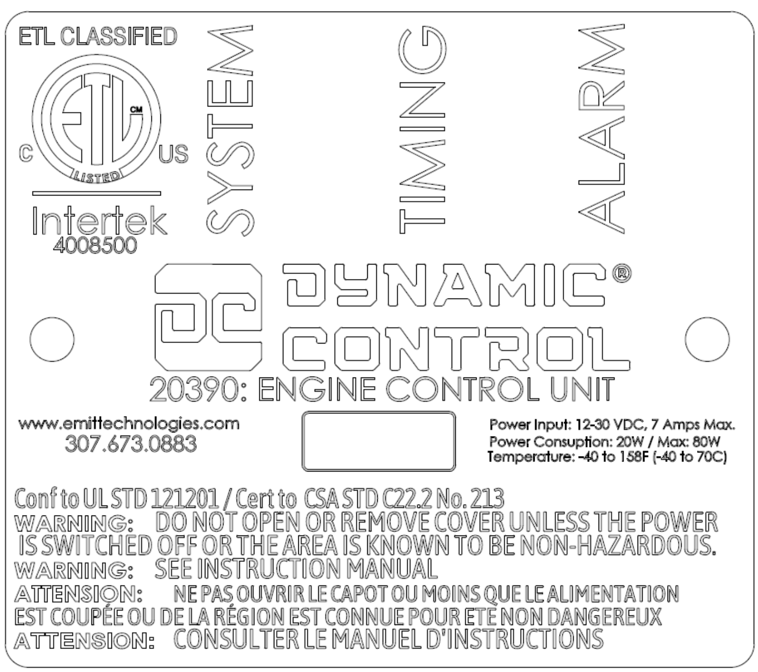
Nonincendive Electrical Equipment For Use In Class I And II, Division 2 And Class III, Divisions 1 And 2 Hazardous (Classified) Locations [ISA 12.12.01:2015]
Nonincendive Electrical Equipment For Use In Class I And II, Division 2 And Class III, Divisions 1 And 2 Hazardous (Classified) Locations [CSA C22.2#213:2016 Ed.2]

<u>Model</u>

EMIT Engine Control Unit 20390

For Use In: Class I Division 2, Groups A,B,C,D, T4
Ambient Temp: -40°C to +70°C
Input 12-30VDC

<u>External Label</u>



WARNING

IT IS IMPORTANT TO READ AND UNDERSTAND ALL THE INSTRUCTIONS AND WARNINGS LISTED IN THIS MANUAL BEFORE USING OR INSTALLING THE ETS SYSTEM.

FAILURE TO FOLLOW INSTALLATION INSTRUCTIONS MAY LEAD TO ENGINE DAMAGE AND PERSONAL INJURY TO OPERATORS OR NEARBY PERSONNEL.

EXPLOSION HAZARD - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS AREA IS KNOWN TO BE NON-HAZARDOUS.

DO NOT OPEN OR REMOVE COVER UNLESS THE POWER IS DE-ENERGIZED OR THE AREA IS KNOWN TO BE NON-HAZARDOUS.

EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS 1, DIVISION 2.

THE INSTALLER SHOULD BE FAMILIAR WITH AND OBSERVE ALL LOCAL, STATE, AND FEDERAL CODES.

Cet appareil convient pour une utilisation en Classe 1, Division 2, les emplacements Groupes A, B, C & D ou non classifiés.

ATTENTION

IL EST IMPORTANT DE LIRE ET COMPRENDRE TOUTES LES INSTRUCTIONS ET MISES EN GARDE CONTENUES DANS CE MANUEL AVENT D'UTILISER OU D'INSTALLER LE SYSTÈME.

LE NON-RESPECT DES INSTRUCTIONS D'INSTALLATION PEUT ENTAÎNER DES DOMMAGES AU MOTEUR ET DE BLESSURES POUR LES OPÉRATEURS OU LE PERSONNEL À PROXIMITÉ.

RISQUE D'EXPLOSION – NE PAS DÉBRANCHER LORSQUE LE CIRCUIT EST SOUS TENSION SAUF SI RÉGION EST CONNU POUR ÊTRE NON DANGEREUX.

NE PAS OUVRIR LE CAPOT OU MOINS QUE LE ALIMENTATION EST COUPÉE OU DE LA RÉGION EST CONNUE POUR ETRE NON DANGEREUX.

RISQUE D'EXPLOSION – SUBSTITUTION DE COMPOSANTS PEUT NUIRE À LA CONFORMITÉ CLASSE 1, DIVISION 2.

L'INSTALLATEUR DOIT CONNAÎTRE ET RESPECTER TOUTES LES RÉGLEMENTATIONS LOCALES, ÉTATIQUES ET FÉDÉRALES CODES.

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EMIT Technologies, Inc.
GPL Compliance Division
PO Box 6785
Sheridan, WY 82801

Please include a note asking for the “open source items for DCT” which identifies your shipping address and preferred method of shipment. EMIT Technologies will ship a CD or other storage media containing the open source license, the copyright notice, and the complete source code for any open source software program utilized in the product.

This offer is available to anyone in receipt of this information.

Hardware and System Overview

EMIT Dynamic Control is a modular solution engineered to meet the wide range of requirements found in air fuel ratio control, engine ignition, compliance monitoring, and compressor protection and control applications. The architecture of the system is based on a single user interface that is capable of operating and managing multiple modules, each with their own primary function. This configuration allows the system to be highly flexible in the approach necessary to solving issues found in typical and complex applications. Additionally, each module is capable of accepting a range of auxiliary inputs that can be used to further facilitate advanced operations for the most demanding scenarios.

The ECU (Engine Control Unit) is a single module that controls Air-Fuel ratio, ignition, throttle, and other aspects of engine operation. The ECU along with the touchscreen (DCT) and the Brain form a complete integrated engine and compressor control solution.

The ECU is designed for small horsepower engines that are single bank, richburn, and have 6 cylinders or less. For other engines, the individual Dynamic Control engine modules are used instead.

Document Organization

This document is organized in the following manner:

1. Overview
2. System installation and initial setup
3. System common connections and information
4. Individual system part details
    a. Speed Controller
    b. AFR
    c. Ignition
5. Appendices and other information

ECU Electrical Specifications

Power

- 12 – 30VDC power supply input range
- Typical power consumption: 20W
- Maximum power consumption: 80W

Environmental

- Temperature: -40°C to +70°C (-40°F to 158°F) T4
- Humidity: 5% - 90%, non-condensing

Communication

- Controller Area Network (CAN) network for communicating to touchscreen
- End devices:
    - Throttle body
    - Thermocouples (2)
    - Thermistors (2)
    - Pressure sensors (2)
    - Ignition coils (6)
    - Injectors (6)
    - Digital power valve
    - O2 sensors (2)
    - Knock sensors (2)
    - Speed/timing sensors (2)
    - Misc I/O – see connection information
- USB host for software updates (3)
- Status LEDs (3)

Enclosure Overview

- Exterior dimensions: 15.3” x 7.2” x 3.3”
- Mount hole spacing (4): 14.675” x 5.1”
- Mount holes: 0.266” (for ¼” bolts)

ECU Installation

The general installation order, described in more detail in subsequent sections, is:

1. Mount module on engine
2. Install ignition end devices
3. Install throttle/mixer, DPV, and route fuel system
4. Install other end devices
5. Route engine harnesses (2)
6. Run and terminate panel harness

Module Mounting

The ECU module is supplied with an appropriate mount bracket that matches the application engine. Some engine specific information is listed below.

Caterpillar ® 3306B, 3304B

Bracket will be mounted under exhaust manifold near the cooler side of the engine.

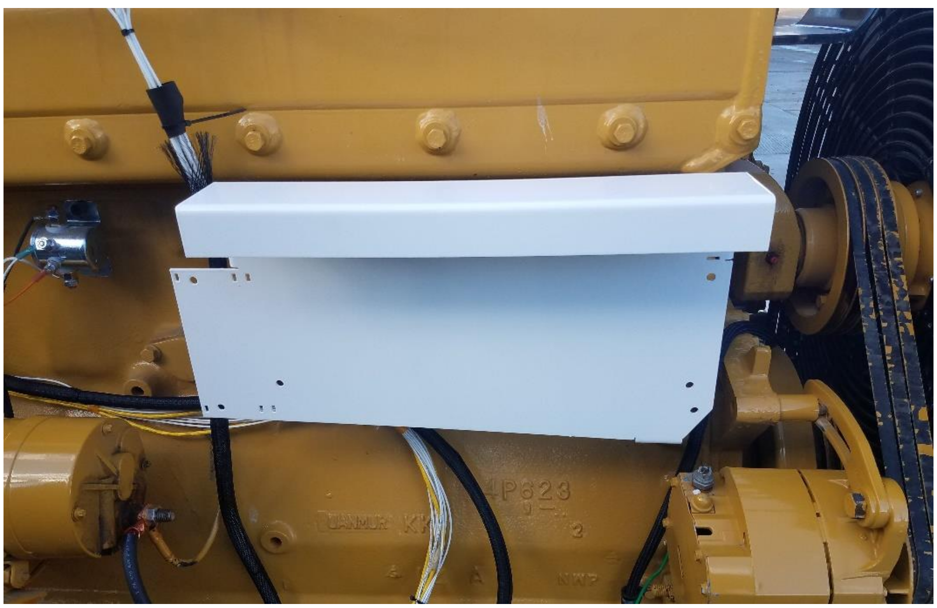


Figure 1. Bracket in location

The bracket will be attached to the engine with provided 5/16”-18 x ¾” bolts (14328).

Mounting module to bracket

Mount the module to the bracket on the supplied four mount locations using ¼”-20 bolts, washers, and lock nuts. Vibration dampeners (14340) should be between the module and the mount bracket.

End Device Installation

IGNITION COILS

An included ignition coil harness bracket is used to give the harness a secure mounting location and keep it from touching the exhaust manifold.

Place the harness bracket over the holes for the ignition coils, then mount the ignition coils on top of the manifold.

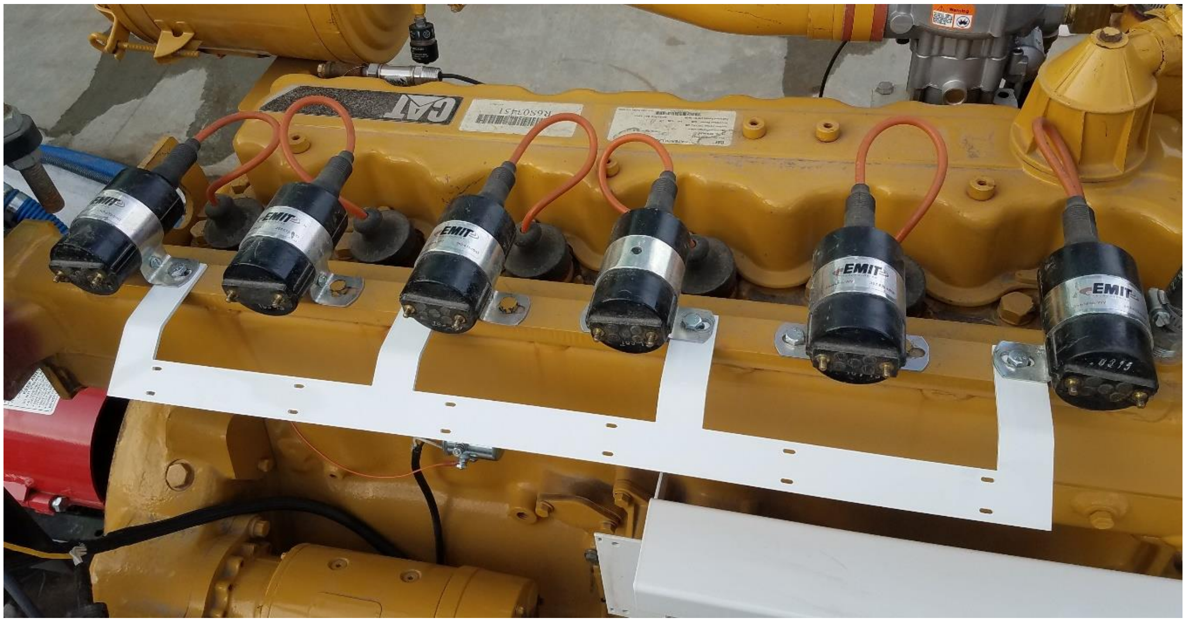


Figure 2. Coil harness bracket installed under coils

SPARK PLUGS

- Install the spark plugs provided in the kit.
  - The spark plugs should be gapped to 0.022".
  - Torque the spark plugs to 30 ft-lbs.

IGNITION PRIMARY WIRE – "COIL" HARNESS

The ECU module includes an ignition coil harness, to support up to 6 cylinders.

Carefully route the harness from the ECU enclosure to the *coil rail*.

- Secure the coil harness with P-clamps, where applicable.
- The common power lead within the coil harness is red and jumps from the (+) terminal of each coil
- The other leads within the coil harness go to negative terminals of each coil.
  - The wire ends will have labels for which cylinder and whether + or –
  - The coils will have a + and – stamped above the screw terminals
- After wiring the coils, secure the wiring using zip ties or P-clamps.
  - The coil harness is meant to be zip tied to the left side of the ECU mount bracket in order to keep the harness away from other harnesses

⚠	The ignition system uses negative-side, or low-side, switching to control the coils. The power lead is jumped to the (+) terminals for all coils, and the (-) leads are wired to the individual wires of the ignition harness.

Figure 3. Coil harness attached to bracket

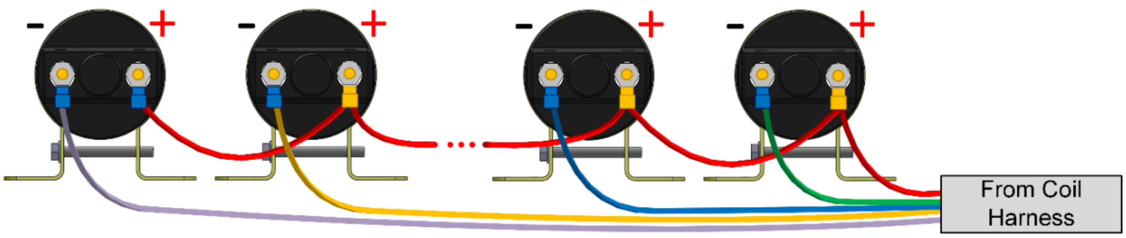


Figure 4. Ignition Coil Wiring Example (Wires will not be colored and instead will have a label)

Figure 5. Note ignition harness securely attached to mount bracket to keep it away from other harnesses.

IGNITION SECONDARY WIRES

- Apply a small amount of dielectric grease to both ends of the ignition secondary wires and install between the ignition coil and spark plug for each cylinder.
- When connecting secondary wires between the ignition coil and the spark plug, it is important to completely seat the connection on each end.
    - The connector should click, or pop, into place.
- The secondary wires should be positioned so they are kept approximately two inches from the chassis.

MIXER/THROTTLE BODY ASSEMBLY

The mixer/throttle body assembly is to be installed on the intake manifold of the engine using the bolts provided. Below are install notes:

- Torque 5/16” bolts to 13 ft-lbs

- Torque 3/8” bolts to 23 ft-lbs
- If more than one mounting orientation is possible with the kit provided, the mixer/throttle body assembly should be installed in the orientation which places the axis of the throttle shaft as close to horizontal as possible.
- Use only black pipe or brass fittings when plumbing the fuel line
    - Under no circumstances should galvanized fittings be used to install the fuel piping.
- Install the AFRC digital power valve as close to the mixer as possible.

⚠	Do not use galvanized fittings for fuel piping! The fuel will cause the galvanized coating to corrode and fall free which may cause engine damage.

💡	A rag may be placed in the intake port of the engine while scraping away the old intake gasket to prevent debris from falling into the intake manifold.

A more specific installation guide may be available for the specific engine, if so it will be provided by EMIT.

DIGITAL POWER VALVE

- Install the 0.75” Digital Power Valve (12014) as close to the inlet of the mixer as space will allow through either a 3/4” pipe elbow or 3/4" pipe nipple.
    - The pipe fitting size should match the piping size of the mixer gas inlet.
    - The valve might already be part of the mixer assembly
- Position the plug connection so that it is directly on top of the valve housing.

⚠	Do not over tighten the threads on female threaded valve body. The pipe could interfere with the actuating device of the valve.

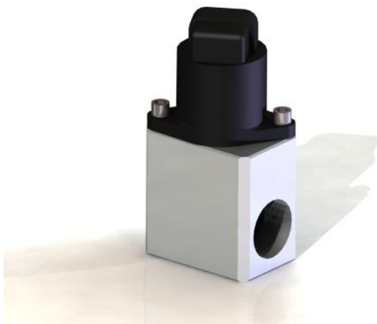


Figure 6. 3/4" NPT Inline Valve (12014)

MAGNETIC PICKUP

- Identify a *5/8"-18 threaded location* directly over the flywheel teeth and remove the placeholder cap, if necessary.
- Thread the magnetic pickup into the identified location until the sensor makes contact with the flywheel teeth.
- Rotate the magnetic pickup out 1/4 turn after making contact with the flywheel.
    - 1/4 turn will provide a gap of 0.013".
- Secure the position of the magnetic pickup using the jam nut on the sensor.

Flanged Hall Sensor (CAT ® 330XB Engines)

If the engine uses a flanged hall sensor, install the sensor on the front of the engine near the cooler drive. The sensor will come with a bracket to hold the sensor in place since the sensor flange is in the opposite direction of the engine mounting hole. Secure the sensor in place with the flange flat against the engine.

Threaded Hall Sensor (CAT ® 3406 and some other engines)

If the engine uses a 5/8" threaded hall sensor, install the sensor into the appropriate cam location. Screw until the sensor is all the way in, then back out two turns. Secure in place with the 5/8" jam nut.

AUX Pickup (other engines)

If either hall sensor is not appropriate for the engine, a magneto driven auxiliary pickup is used. Installing this part is detailed in the steps below.

1. Before powering off the engine and removing the existing magneto from the aux drive, crank the engine without starting and make a note of which direction the aux drive rotates.
   ENGINE ROTATES (Circle One): CW CCW
2. Set the engine to top dead center (TDC) compression.
3. Remove the existing magneto from the aux drive. Be sure to scrape off any existing gasket material that remains attached to the drive.
4. Remove the timing port plug from the Aux Pickup and rotate the Aux Pickup's white drive coupling until a mark indicating 0deg can be seen through the timing port.
5. Install the Aux Pickup with gasket and torque bolts to 33ft-lbs. Do not rotate the white drive coupling more than necessary when aligning with the engine's aux drive.
6. Use a flashlight to view the degree mark on the timing disc and make a note of the mark. Be sure to note whether an "A" or "B" is visible.
   TIMING DISC MARK: _____A OR _____B
    a. If no timing marks are present, do the following:
        i. Remove the Aux Pickup from the engine
        ii. If the gear ratio listed on the outer cover is 3:1, rotate the Aux Pickup's white drive coupling 1.5 turns, re-install, and use a

flashlight to make a note of the degree mark on the timing disc. Using thread sealant, reinstall the timing port plug.

iii. If the gear ratio listed on the outer cover is 2:1, rotate the Aux Pickup's white drive coupling 1 turn, re-install, and use a flashlight to make a note of the degree mark on the timing disc. Using thread sealant, reinstall the timing port plug.

7. Save the information noted in the steps above for startup later.

OXYGEN SENSORS

The ECU requires two oxygen sensors: one pre-catalyst and one post-catalyst.

For the pre-catalyst O2 sensor:

- The mounting location should be as close to the engine exhaust manifold as possible.
- The sensor location chosen should allow for easy access.
- The location chosen should not subject the exterior shell of the sensor to an ambient air temperature greater than 350°F.
- Do not mount vertical/above exhaust as the heat rise may damage harness.
- Do not mount directly below exhaust as condensation may damage sensor element.

For the post-catalyst O2 sensor:

- Install to either the outlet nipple of the catalyst housing or in the tailpipe.
  - If installing in the tailpipe, the sensor should be installed at least 16" from the exit of the tailpipe.
  - The post-catalyst oxygen sensor requires the "necked" or "throttled" flow found in the outlet nipple or tailpipe. It will not function properly if installed in the main body of the housing.
- If no 18mm port is available, an 18mm weldment will need to be installed (Item 13020).

THERMOCOUPLES

The ECU requires two type-k thermocouples: one pre-catalyst and one post-catalyst.

- Install the 1/2" NPT compression fittings pre- and post-catalyst as close to the catalyst as possible.
- Insert the thermocouple probes into the compression fittings and tighten the fittings to secure the thermocouples in place.

EXHAUST HARNESS

Once the oxygen sensors and catalyst thermocouples are installed, the exhaust harness can be routed. This harness comes in a variety of lengths depending on the catalyst location.

- Plug the ECU end of the harness into the rightmost (14 pin) ecu connector. Route the harness to the catalyst and secure the harness appropriately in-between. Leave a drip loop near the ECU to prevent water from pooling against the ECU connector.
- Plug in the pre-catalyst sensors into the inner connectors of the harness and plug the post-catalyst sensors into the end connectors of the harness
- Secure the harness so that it is not against the catalyst to prevent heat damage to the connectors.

⚠	The harness sleeving near the catalyst sensors is rated to high temperature, but the (black) sleeving on the long length of the harness is not. Keep the black sleeved section of the harness away from the exhaust.

THERMISTORS

There are two ECU thermistors – engine oil temperature and engine coolant temperature. They are supplied with ¼" NPT adapters.

- Install both sensors on the appropriate location on the engine. If only ½" NPT ports are available, use a ½" to ¼" NPT adapter busing.
- Yellow thread tape is recommended on the oil temp sensor, or appropriate pipe thread sealant

MANIFOLD PRESSURE SENSOR

Install the manifold pressure sensor on the intake manifold in an appropriate ¼" NPT port. If a port is not available, there may be one on the throttle assembly flange. The harness is sized such that the sensor should be near the throttle assembly.

OIL PRESSURE SENSOR

Install the oil pressure sensor in an available ¼" NPT port on the engine. The harness is sized such that the sensor should be installed near the flywheel.

STARTER SOLENOID

Attach a master solenoid (magnetic switch) to drive the main starter solenoid. The engine harness to be installed later will have a ring terminal that drives high to contact the switch. Wire the other side of the switch input to ground, and wire the two output switches to drive the main solenoid.

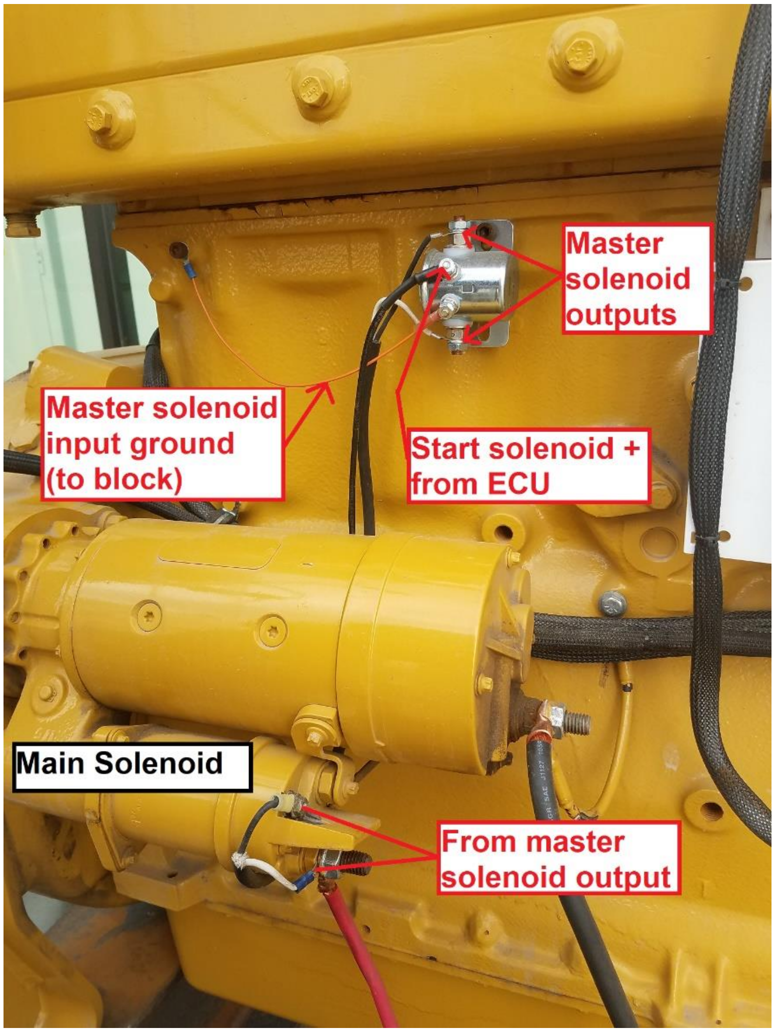


Figure 7. Example starter wiring

Engine Harness Installation

The main engine harness goes from the white 23 pin ECU connector to most sensors on the engine. Route the harness by plugging into the ECU and running the harness around the flywheel side of the engine to the applicable end devices. Once end devices have been connected, use p-clamps on at least 5 points of the harness to keep it secure and prevent vibration.

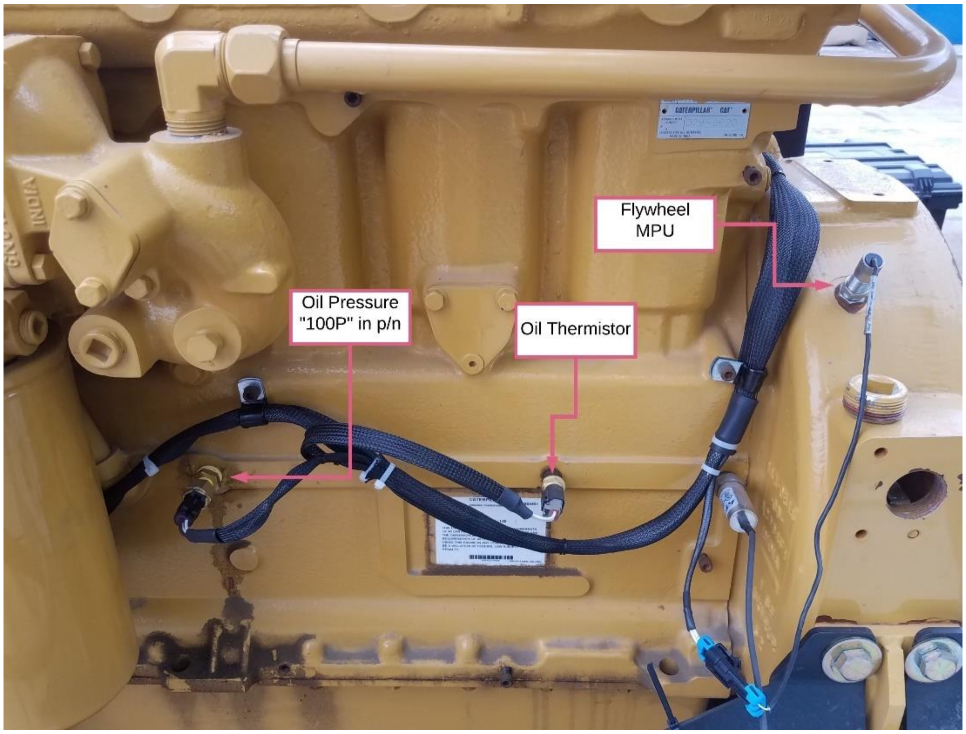


Figure 8. 3300b example on oil filter side

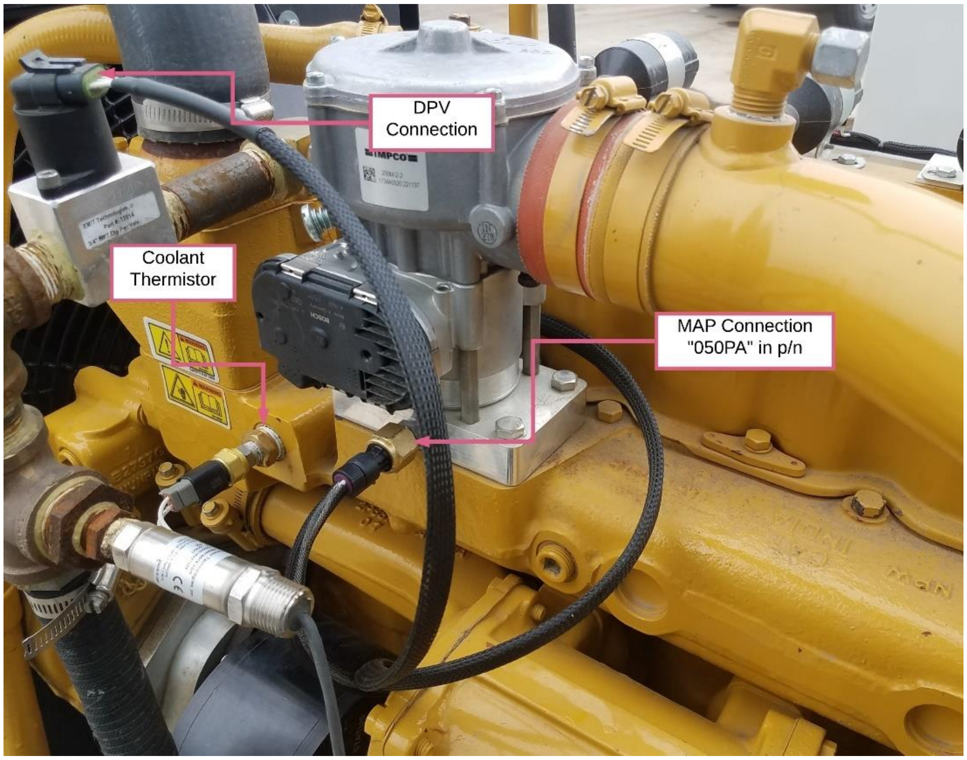
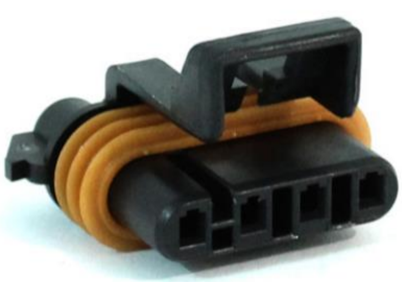


Figure 9. Fuel system area example, 3300 NA

Connector Identification

The harness will be engine-specific because of differences in sensor locations. The wire label near the plug will indicate the sensor the plug is intended to connect to. A reference blow shows the plug types. Pin numberings of the main plug can be seen in a later section.

Image (Some colors may vary)	Plug Type	Sensor(s)	EMIT P/Ns
	2 pin metri-pack 150	• Flywheel Magnetic pickup	Body 15556 Wire Seal 15046 Terminal 15029 Clip 15555

	2 pin Deutsch DT	• Oil temp thermistor • Coolant temp thermistor (usually coolant temp is the farther sensor along the harness)	Body 15127-0001 Lock 15127-0002 Terminal 15555-0002
	3 pin metri-pack 150.2	• Oil pressure sensor • Manifold pressure sensor (usually manifold pressure is the further sensor along the harness)	Body 15557-0006 Terminal 15555-0007
	3 pin metri-pack 150.2 flat	• Hall sensor (3300B engines)	Body 15557-0001 Terminal 15555-0001
	4 pin metri-pack 150	• Oxygen sensors (2) (post catalyst O2 is always the further sensor along the harness) • Threaded hall sensor (3406 engine)	Body 15027 Wire Seal 15046 Terminal 15029 Clip 15030 Boot 15026

	4 pin metripack 150 (pull)	• DPV sensor	Body 15024 Terminal 15025 Boot 15023
	4 pin 3106 MIL connector (14S)	• AUX Pickup (some engines)	15115-0001
	Amphenol MQS 6 pin	• Throttle body connector	Body 15127 Wire Seal 15129 Terminal 15128

	Ring terminal	• Coil harness • Starter solenoid (+)	15560
	Ampseal 8-pin white	ECU Coil connector	Body 15104-0005 Terminal 15555-0008
	Ampseal 8-pin black	ECU injection connector	Body TBD Terminal 15555-0008
	Ampseal 23-pin white	ECU main engine harness connector	Body 15104-0003 Terminal 15555-0008

	Ampseal 23-pin black	ECU panel harness connector	Body 15104-0004 Terminal 15555-0008
	Ampseal 14-pin black	ECU Exhaust connector	Body 15104-0006 Terminal 15555-0008

Panel Connection Notes

The panel harness will be routed directly to the panel and each wire will land on terminal blocks called out in the panel drawing. All BATT+ and BATT- connections should be landed for optimal power distribution. The analog ground signals (two) will land on normal ground as well.

Generic I/O

The ECU has two generic digital inputs, two generic analog inputs, and one generic analog output. These will be used in future updates for various selectable options.

Shutdown Input

The shutdown input is used to stop the engine when grounded. If using an EMIT annunciator (Brain), this input is not needed because run status is shared digitally.

Alarm Output

The alarm output closes to ground when the system is shut down on a fault. This is not needed with an EMIT panel because this information is shared digitally.

Fuel Switch Output

The fuel switch output closes to ground to energize a fuel valve. This output can be wired directly to the (-) terminal of a fuel valve, with the (+) terminal of the fuel valve connected to power. For larger fuel valves, adding a relay is recommended.

ECU Initial Setup and Startup

Powering

1. Connect battery power and turn on the panel
2. Verify that all modules are powered and appear on the touchscreen.
    a. Select "Information" -> "Software Versions" to view attached modules. The ECU will show up as three rows.

Initial Setup

For most engines, the fastest method of setup is the 'Engine Quick Setup' on the DCT under 'Settings' -> 'System / Global Settings' -> 'Engine Quick Setup'. On this screen the engine can be selected and the defaults for most engine settings will be filled. More detailed setup instructions are in later sections relating to each module.

Other Settings Verifications

Outside of engine quick setup, these settings should be reviewed:

1. Ignition Dwell Time: "Settings" -> "Ignition" -> "Engineering Setup". Recommended starting dwell time is 1.5 ms for 24V systems and 4.5 ms for 12V systems.
2. High temp limits: "Settings" -> "ECU Common Settings". Check the high oil temp shutdown and high coolant temp shutdown and set to engine manufacturer recommended values.
3. Panel kills: If not previously configured, select each Brain gauge and set kill levels as needed.
4. If using an AUX pickup:
    a. Input the degree mark noted on the timing disc during installation into the calibration offset. Use the table below to determine whether the offset should be negative or positive.

	Clockwise Rotation	Counterclockwise Rotation
Timing Disc "A" Side	Positive (+)	Negative (-)
Timing Disc "B" Side	Negative (-)	Positive (+)

Ignition and Speed Tests

1. From the Ignition home page, select "Testing" followed by "Engine Off Testing". For each cylinder:
    a. Select the cylinder to start a spark test
    b. Check the correct cylinder is sparking by disconnecting the coil and checking with a multimeter from A to B on the rail side.
2. If autostart is enabled, it may be useful to disable autostart until this section is complete
3. From the ignition home page, select 'Input Information'
4. Without fuel, crank the engine briefly and verify that the first two boxes turn green.

   a. If either the hall or MPU show 'not moving', the sensor may need to be screwed in slightly.
5. Navigate to the Speed home page
6. Once again, crank briefly and verify that the speed module sees RPM. The throttle motor should go from closed to crank position.
7. While cranking, check the timing on the reference cylinder. If it doesn't match displayed timing, calibrate on the page "Settings" -> "Ignition" -> "Calibration".

ENGINE STARTUP

1. Set the speed switch to idle
2. Select 'Reset' then 'Start'. The pre lube cycle should run (if used), followed by the crank cycle.
3. Watch the speed status and the ignition input status pages if the engine has trouble starting
4. Once the engine is running, verify timing with a timing light.
   a. If the timing light does not match the displayed timing, adjust the offset at "Settings" – "Ignition" – "Calibration"
   b. This is a one-time calibration, once they match it will be calibrated for all timing ranges.
5. Check the AFRC home page and verify that the O2 sensors are reading (once the thermocouples are reading and load delay ends). Once controlling, verify that the DPV is able to affect the O2 reading, and the reading reaches the target.
   a. If not controlling properly, first verify the DPV is working by changing to 'Manual' mode and moving up and down. This should make the O2 reading richer (open) or leaner (close).
   b. If the DPV is working but reaches a limit (full open or closed) without meeting the target, adjust the fuel pressure at the regulator.
6. Verify there are no misfires on each cylinder by selecting the spark durations on the ignition home screen.
7. The engine is ready to load.

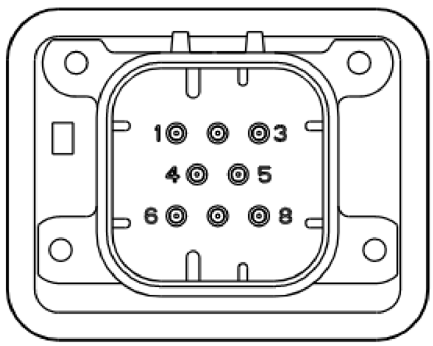
ECU Common Connections and Settings

Most functionality of the ECU is broken into one of three parts – speed controller, AFR, or Ignition. These three parts are detailed in subsequent sections. Some other information is relevant to the entire system, which is covered in this section.

Enclosure Connections

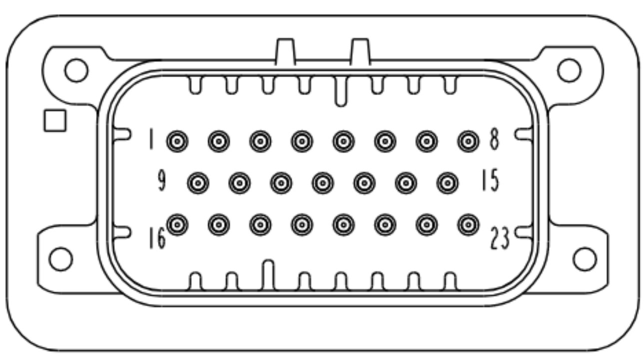
The ECU module has five connections, which are (from left to right) Ignition, Injection, Main Engine, Panel, and Exhaust. The plugs are keyed and colored so that same size plugs cannot be plugged into each other. Pin numberings for each are shown below.

Ignition Connector- 8 Pins



PIN	CONNECTION
1	Coil 1 -
2	Coil 2 -
3	Coil 3 -
4	Coil +
5	Shield
6	Coil 4 -
7	Coil 5 -
8	Coil 6 -

Main Engine Connector – 23 Pins



Note: Numbers in parentheses under "Connection" below are the destination plug pin label.

PIN	CONNECTION
1	Oil Thermistor + (1)
2	Oil Thermistor – (2)
3	Throttle + (4)
4	Throttle – (1)
5	Throttle position 1 (6)
6	Throttle position 2 (5)
7	MPU TDC+ / Hall (*)
8	MPU TDC- (*)
9	Coolant Thermistor + (1)
10	Coolant Thermistor – (2)
11	DPV A (A)
12	DPV D (D)
13	Solenoid +
14	Throttle pot ground (*)
15	Shield (*)
16	Oil Pressure Sig (C)
17	Manifold pressure Sig (C)
18	12V Power for hall (*)
19	DPV B (B)
20	DPV C (C)
21	Motor pot 5V (*)
22	Flywheel MPU + (A)
23	Flywheel MPU – (B)

*These connections at the sensor vary numbering by engine or branch to multiple locations. See engine harness drawing.

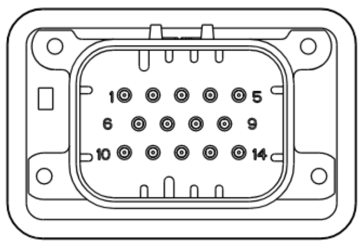
Panel Connector – 23 pins

(Physical pin layout same as 23 pin connector above)

PIN	CONNECTION
1	CAN H
2	CAN L
3	CAN GND
4	Shutdown input
5	Alarm output
6	Fuel relay (low drive)
7	Digital In 2
8	Digital in 1
9	Battery -
10	Battery -
11	Battery -

12	(Reserved)
13	12V Sensor power
14	Analog ground
15	Analog ground
16	Battery +
17	Battery +
18	Battery +
19	(Reserved)
20	(Reserved)
21	Analog out 1
22	Analog in 2
23	Analog in 1

Exhaust Connection – 14 pin



PIN	CONNECTION
1	Knock L
2	Precat TC + (Yellow)
3	Precat TC – (Red)
4	Postcat TC + (Yellow)
5	Postcat TC – (Red)
6	Precat O2 Htr – (C)
7	Postcat O2 Htr – (C)
8	Precat O2 Vs (B)
9	Postcat O2 Vs (B)
10	Knock R
11	Precat O2 Htr + (D)
12	Postcat O2 Htr + (D)
13	Precat O2 Vref (A)
14	Postcat O2 Vref (A)

Software Updates

Software updates must be performed with the engine off. The three co processors are updated separately.

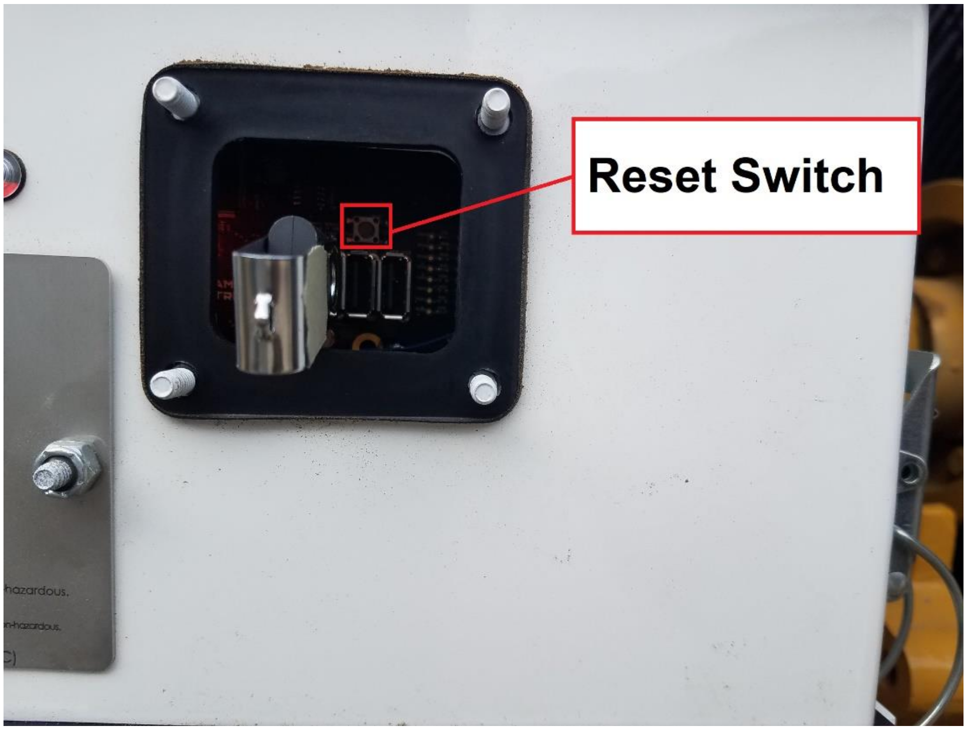


Figure 10. Update cover open with USB inserted in ignition port.

1. Place the update hex file or files on a USB drive that is formatted FAT.
    a. Speed controller updates will start with "Gov…"
    b. Ignition updates will start with "IIC…"
    c. AFR updates will be called "AFRC_ADV.hex"
2. Open the small cover on the front of the ECU
3. Insert the drive into the appropriate USB port
    a. From left to right, the ports are Ignition, Speed, AFRC
4. Press the reset switch above the USB ports
5. Wait about 20 seconds for the update to complete
6. Remove USB drive
7. Re-attach cover securely to prevent leaks

⚠	Do not over tighten the nuts on the cover or the studs could break off

The update can be checked on the page "Information" -> "Software Versions" of the DCT to verify the new version has uploaded.

ECU Common Settings

Most settings for the ECU are under the relevant controller section (Ignition, AFR, Speed). Some are common to the ECU globally under "Settings" -> "ECU Common Settings".

- Cooldown time on normal stop: This specifies an amount of time the unit will cool down when the 'stop' button is pressed. After this amount of time, the engine will stop. Note: Faults always shut down the engine immediately.
- High oil temp shutdown: This value specifies the high alarm for engine oil temperature
- High coolant temp shutdown: This value specifies the high alarm for engine coolant temperature
- Oil Pressure Sensor High Scale (PSI): This specifies the upper scaling of the oil pressure sensor in PSI Gauge. For example, the default 0-100 PSI sensor will be set to "100". If alternate sensors are used, the value can be set here.
- Manifold Pressure Sensor High Scale (PSIA): This specifies the upper scaling of the manifold pressure sensor, in PSI *absolute* units. For example, a 0-50 PSIA sensor will be set to "50" here. A -30" – 30 PSI sensor will be set to 44.7 here.

ECU Speed Controller

The speed control system of the ECU is an electronic speed control system for natural gas engines. The speed control part of the ECU consists of two main components: the control circuitry and an electronic throttle body. The throttle body / mixer assembly comes in a variety of sizes for different engines, and mounts directly between the intake piping and intake manifold.

The speed controller works by monitoring the speed of the engine by reading a magnetic pickup (MPU) over the flywheel teeth. If the engine is running too slow or fast for the current control RPM, the throttle position is adjusted according to a PID control algorithm. The control speed is determined by a variety of conditions. First, the user can select through a panel switch one of three operating modes. They are "Idle," "Manual," or "Auto" speed control mode. In Idle mode, the ECU will hold the engine to an idle speed. In Manual mode, the user can increase or decrease the engine RPM, starting from the engine's current speed, by using the "Speed+ / Speed-" switch on the panel. In Auto mode, the system control behavior will be determined in setup control mode, which may be configured to hold a fixed run speed or control to a certain compressor pressure.

Pressure control under Auto mode can either control to suction pressure or discharge pressure. In suction control mode, the speed decreases as suction pressure drops and increases as the pressure rises. This is intended for wells or situations where the intake pressure varies but the downstream system can handle the discharge pressure changes. In discharge control mode, by contrast, the engine will increase speed if discharge pressure is too low, and lower speed if discharge pressure is too high. This aims to keep the discharge pressure constant.

MODES OF OPERATION

The user can select through the panel's mode switch either "Idle," "Manual," or "Auto" (Run) mode for the speed controller. Additionally, Auto mode can be setup to function in various ways. A description of each control mode is provided below.

IDLE

When the panel's mode switch is in Idle, the ECU will hold the engine at the user-specified idle speed. This speed is specified during initial setup, described in a later section.

MANUAL

When the panel's mode switch is in Manual, the ECU will hold at a fixed manual speed. Whenever the switch is switched to Manual, the manual speed will start at whatever speed the engine is currently operating at and from there, the user can use the panel's speed switch to increase or decrease the speed. This mode is intended to be used only temporarily.

💡	If the mode switch is in Manual when the engine is started, the manual speed will start at the idle speed.

💡	If the mode switch is not at Manual, then the "Speed+ / Speed-" speed switch will have no effect.

AUTO

The Auto setting is used for normal run operation of the engine. The behavior of the Auto setting can currently be set to one of three ways, described below.

AUTO – CONTROL TO FIXED SPEED

For a fixed speed setpoint, the ECU will hold the engine at a specified run speed. This run speed can be adjusted in setup.

AUTO – CONTROL TO SUCTION PRESSURE

For a suction pressure setpoint, the engine will increase speed when the suction pressure is too high and decrease speed when the suction pressure is too low. The user specifies some range that the engine should not deviate from during the Auto operation. This mode is useful for cases where the incoming pressure varies, such as a low-producing well. Decreasing the RPM when the pressure drops gives the supply a chance to replenish. This can result considerable fuel savings and reduction of engine wear by eliminating wasted work by the engine.

AUTO – CONTROL TO DISCHARGE PRESSURE

For a discharge pressure setpoint, the engine will increase speed when the discharge pressure is too low and decrease speed when the discharge pressure is too high. Overall, this keeps the discharge at a constant rate. This mode can be used when the supply pressure is unconstrained, but the outgoing pressure is desired to be constant.

💡	When switching between operating modes (Idle, Manual, or Auto), the ECU will ramp more slowly than it would during normal operation.

USER INTERFACE

SPEED CONTROLLER HOME SCREEN

The **Speed Home** slide shows an overview of the ECU speed controller operation. The current status is shown at the top of this screen.

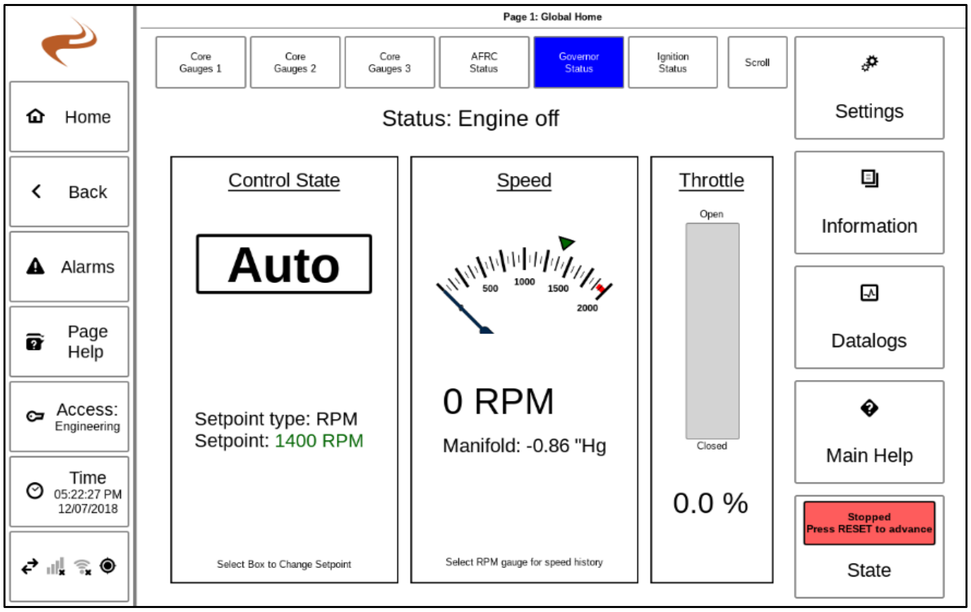


Figure 11. Speed Controller Home Slide

The left section of the home screen shows the control state, with the inner box in the left section showing the state of the panel's mode switch – Idle, Manual, or Auto. The current control settings are shown in the lower part of this section.

The middle section of the home screen shows the current speed. There are several additional markers on the speed gauge. The green marker or markers show the auto operating speed or speed range. A blue marker, if present, shows the temporary speed setpoint – either idle speed or manual speed. Red bars show the over- and underspeed alarm ranges. Under the gauge, the manifold pressure is shown if a sensor is present. The speed gauge can be selected to go to the speed graph screen, which shows a graph of the last two minutes of the speed setpoint and actual speed.

The right section on the home screen shows the current throttle position, which ranges from 0-100%, with 100% being fully open.

SENSOR STATUS

The **Speed Controller Sensors** screen shows the current status of sensors related to speed control. This screen is found by navigating to 'Information' -> 'Speed'. The screen shows the RPM, throttle position, and battery voltage. Also shown are the pressure inputs, if attached.

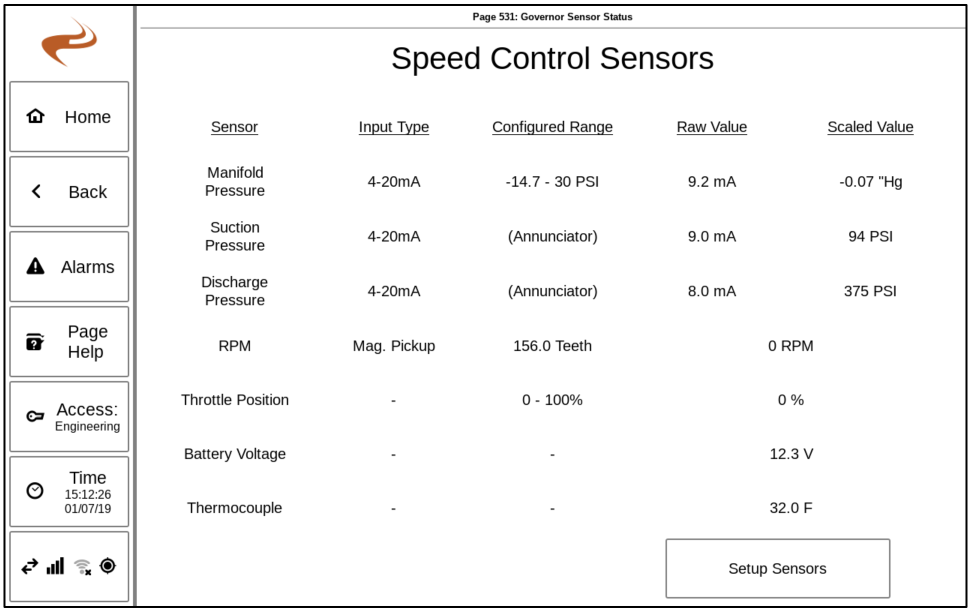


Figure 12. Speed Controller Sensor Status Screen

SPEED CONTROLLER SETUP

After initial install, or when settings changes are needed, the speed controller setup screens are used. The setup screens are accessed by selecting 'Settings' -> 'Speed Controller'. An access level of *Setup* or higher is needed to access these screens.

The main setup is under 'Main Setup Wizard' of this menu.

STEP 1: ENGINE SETTINGS

Step 1 of setup specifies the basic engine settings. These are the number of flywheel teeth, the idle speed for when the panel switch is in "Idle", and the speed alarm values. After initial setup, these settings are not commonly changed.

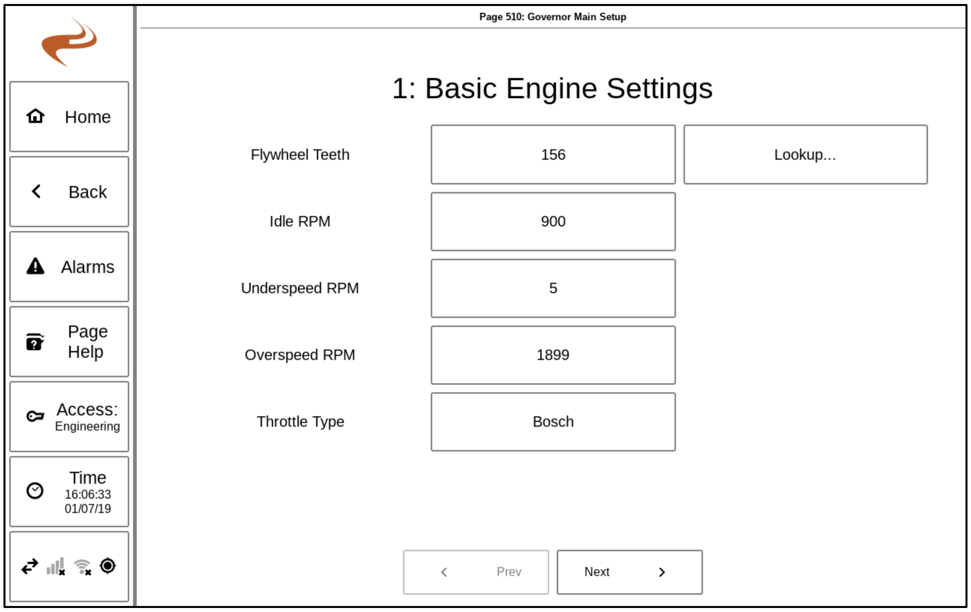
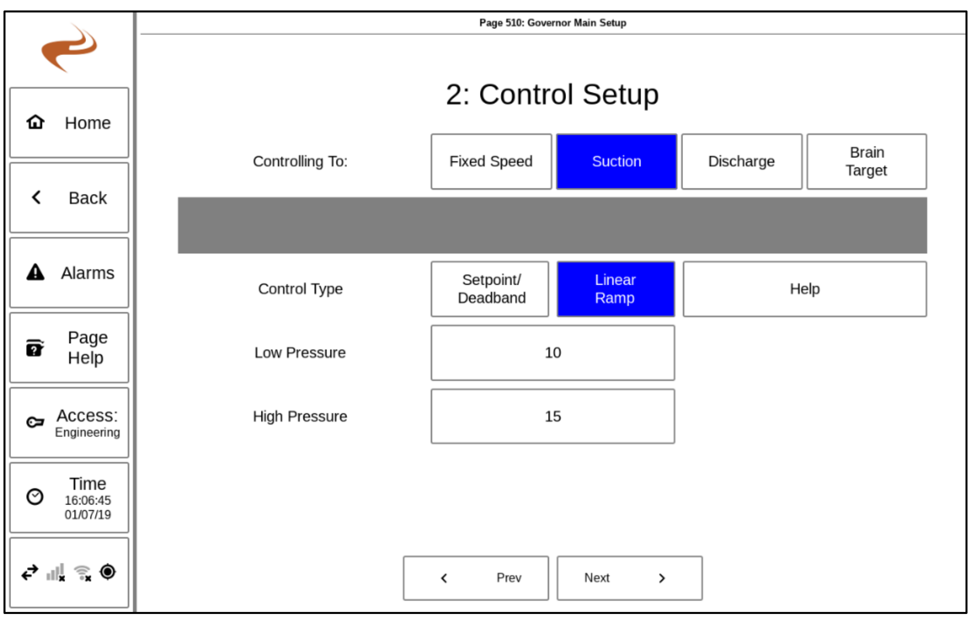


Figure 13. Setup Step 1

If an underspeed alarm is not needed, it can be set to “0”. The speed alarm will always shut down the engine regardless of the control mode or condition. If an RPM setpoint higher than the overspeed alarm is specified, the setting will be allowed, but once the engine hits the overspeed value it will be shut down.

STEP 2: CONTROL SELECTION

In step 2 of setup, the setpoint type and value are specified. For the fixed speed control type, the setpoint is an engine RPM. For suction or discharge control, the setpoint is a PSI value.



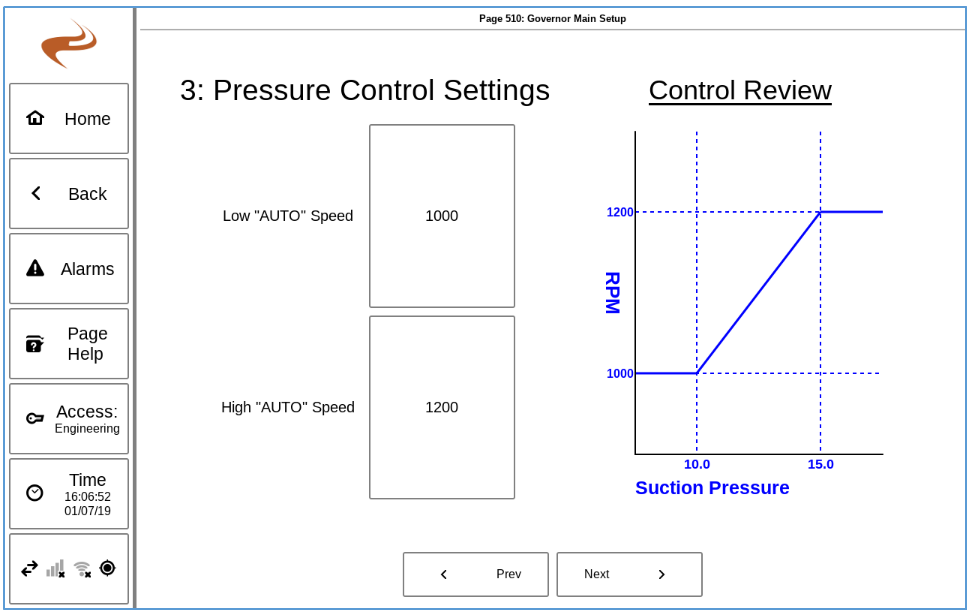
For Suction or Discharge control, the control type can be 'Setpoint / Deadband' or 'Linear Ramp'. In Setpoint/Deadband mode, the PSI target setpoint and deadband are specified, and the system will speed up or slow down if outside this range. For example, if the Setpoint is 35 PSI and deadband 1, then the speed will change when below 34 or above 26. For Linear Ramp mode, a low and high setpoint will be specified and the target will be interpolated linearly between these two points.

A final option is 'Brain Target'. This option allows the rest of speed control setup to be setup under the Brain speed control setup. This might be used if a sensor is wired to the Brain and is needed for speed control.

If fixed speed control is selected, the setup will skip to **Setup Review** after this step.

STEP 3: PRESSURE CONTROL SETTINGS

If using a pressure control mode (suction or discharge), step 3 will specify some additional settings.



The High and Low Auto RPM specify the operating range of the engine while controlling to the specified pressure. The ECU will not let the engine out of this range, even if the pressure is still too low or high. This is separate from the over- and underspeed alarms mentioned earlier, which specify the absolute min and max speed for the engine.

For 'Setpoint / Deadband' mode, a setting will also be available for Speed Change Rate. This rate determines how fast the ECU will ramp up or down the RPM when in a pressure control mode. A lower value will result in less tight control, but more stable operation because the engine will ramp more slowly.

	Generally, for suction control the response rate can be lower, since a well changes pressure so slowly. For discharge control, the response rate is usually higher.

SETUP SUMMARY

The setup summary page shows a summary of all the selected settings. If the page looks correct, the "Submit" button can be pressed to send the settings to the ECU. If this is the first setup, the sensor settings should be reviewed.

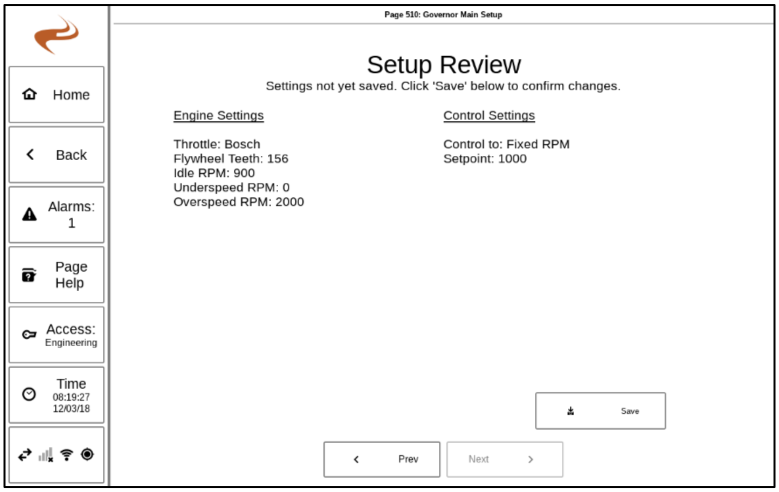


Figure 14. Setup Summary

OTHER SPEED SETUP PAGES

ALARM SETUP

The **Alarm Setup** page specifies alarms for RPM and pressure sensors. An access level of *Setup* or higher is needed to see this screen.

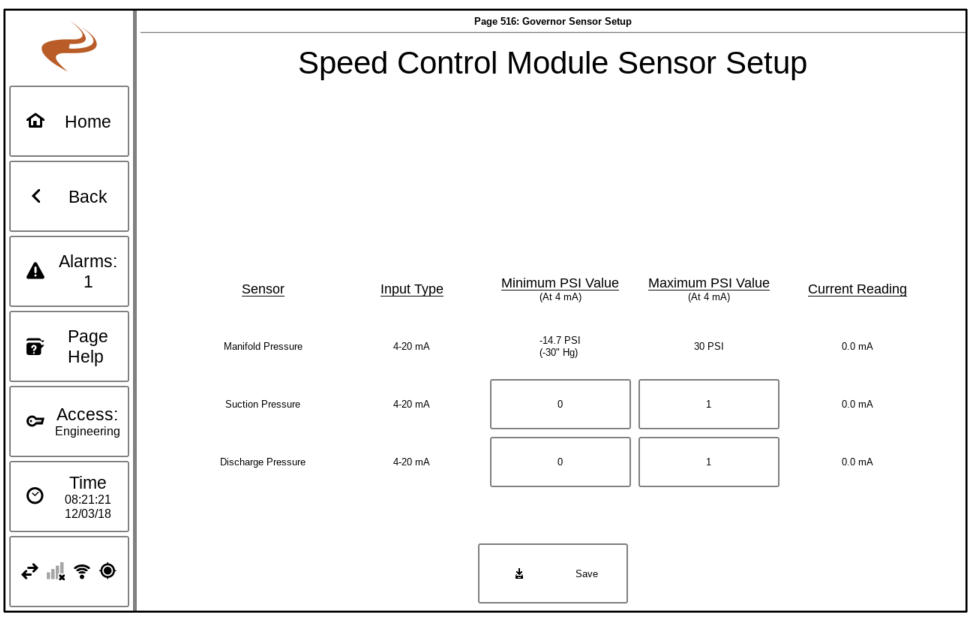


Figure 15. Speed Control Alarm Setup

The RPM alarm values duplicate the settings from setup step 1. These specify the low and high shutdown values for the engine. If an underspeed is not needed, it can be set to 0.

SENSOR SETUP

For Suction and Discharge sensors, the setup will be through the Brain module. The current readings will be shared digitally to the ECU for speed control.

ADVANCED SETUP PAGE

The **Speed Control Advanced Setup** page contains advanced settings for speed operation. An access level of *Engineering* is needed to use this page. A description of each setting is listed below.

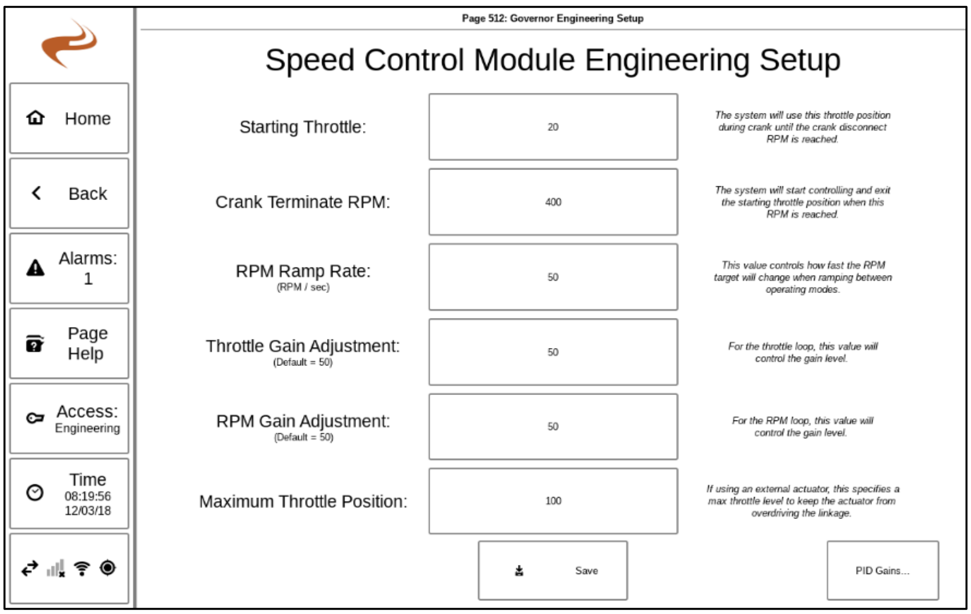


Figure 16. Speed Controller Advanced Setup

<u>Starting Throttle:</u> This is the throttle position that is held when the engine is cranking. If an engine is hard to start, this could be increased. If an engine starts but overshoots the idle rpm, this could be decreased.

When the engine is not turning, the throttle is kept closed. The ECU only opens the throttle when it detects flywheel movement.

<u>Crank Terminate RPM:</u> This is the value which the ECU uses to determine if the engine is done cranking. It would not likely need to be changed unless an engine cranks very quickly.

<u>RPM Ramp Rate:</u> This value determines how fast the RPM will change when changing between modes (Auto/Idle/Manual). It does not affect how fast the throttle changes when a mode is not changing.

<u>Throttle gain adjustment</u>: This value scales the gains for the throttle control loop. It is recommended to keep at 50 unless EMIT recommends otherwise.

<u>RPM gain adjustment:</u> This value, which can range from 1-100% with a default of 50%, scales the control gains for the throttle. A higher value will result in faster response but possibly more instability. A lower value will result in slower response but more stability.

<u>Maximum throttle position:</u> This value can be used to stop the throttle from going past a certain position. If using a –PD type Heinzmann actuator, this can be used to keep the system from over-driving the throttle past where the mechanical stop is.

THROTTLE CALIBRATION

The **Throttle Calibration** page can be used to re-calibrate the throttle body. This moves the throttle through its full range of motion and saves the values for the endpoints and what effort is required to move the throttle.

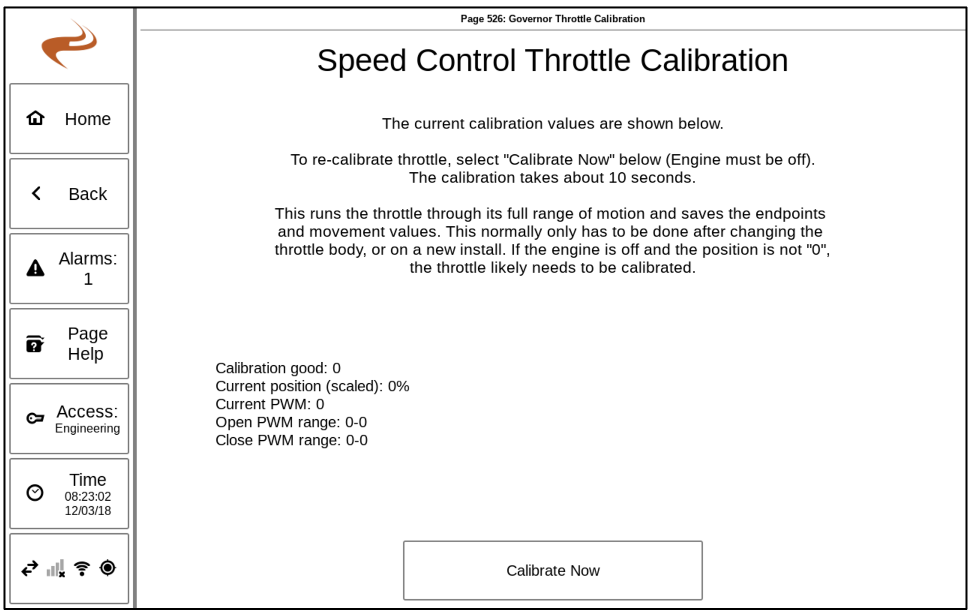


Figure 17. Throttle Calibration

The throttle will usually only need to be recalibrated if the throttle is changed. It could also help to recalibrate it if it seems the calibration is bad, such as if the throttle does not show "0%" with the engine is off.

To calibrate, make sure the engine is off and click the "Calibrate Now" button. Wait for about 20 seconds for the calibration to complete.

IDLE HOLD SETUP

The Idle Hold setup page can be used to specify a condition where the engine will not leave Idle speed until a certain temperature is reached.

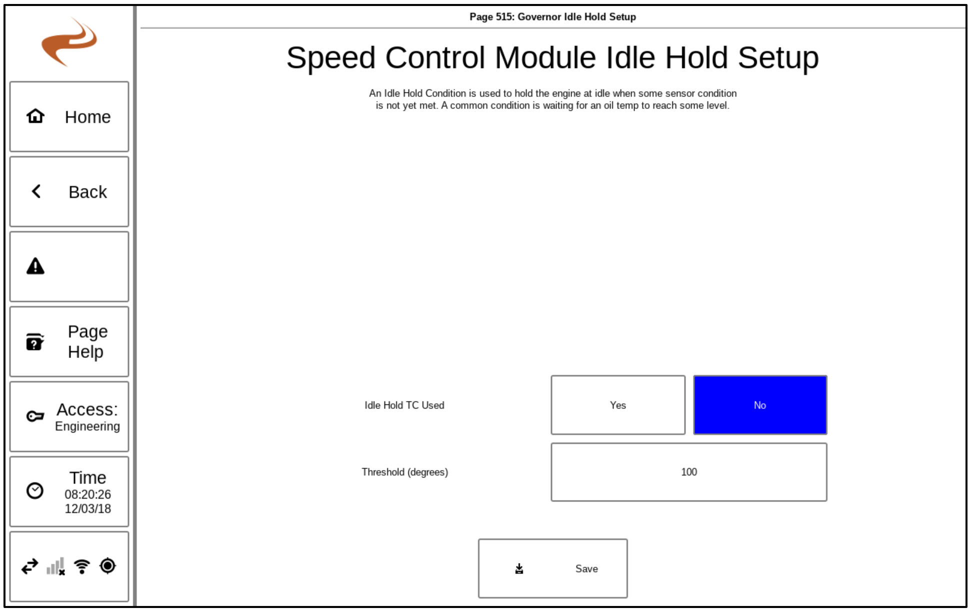


Figure 18. Speed Controller Idle Hold Setup

For the ECU the idle hold sensor will always be engine oil temperature. If an EMIT Brain module is present, the idle hold function in the Brain can alternately be used if a different sensor is needed for idle hold. Either the speed controller or Brain idle hold page can be used, but only one or the other – if both are enabled it can cause confusion.

To use the idle hold, select 'Yes' for Idle Hold Used, and specify a threshold in degrees. Until the oil temperature goes past the threshold, the speed cannot go higher than idle for any reason.

SPEED CONTROLLER ALARMS

There are two types of ECU speed control alarms – system-generated and user-specified. The user-specified alarms are set up and detailed in the above section "Alarms Setup."

System-generated alarms are for problems with the ECU speed control system itself. These appear as subcodes under alarm code GOV007. The description on the alarm page gives information on what caused the alarm. Possible alarms are the following:

- "NVM Write Failure" / "NVM data write failure" – these likely indicate a problem with the circuit board.
- "Unknown Reset" – The reset condition was not known.
- "Throttle feedback error" – The throttle feedback was lost, or the difference between the two feedback lines were too great. Verify the throttle is connected and wired properly. If this error happens repeatedly, the throttle may need to be replaced.

ECU AFR

OVERVIEW

The ECU integrated air/fuel ratio controller (AFRC) is designed to control turbocharged or naturally aspirated carbureted stationary natural gas or propane engines. The ECU AFR controls rich-burn only. The system is equipped to control an engine in single-setpoint mode or Auto Control algorithm, which determines the target automatically.

Use of the AFRC controller with an appropriate catalytic converter can result in dramatic reductions in exhaust gas pollutants, particularly Oxides of Nitrogen (NOx), Carbon Monoxide (CO), and Hydrocarbons (HC). Rich-burn NSCR catalytic converters require a constant oxygen content of less than 0.5% from the engine in order to work effectively – the AFRC provides the control needed to maintain that constant oxygen concentration. In lean burn applications, the use of the AFRC with an oxidation catalyst can result in dramatic reductions in exhaust gas pollutants of Carbon Monoxide (CO), Hydrocarbons (HC) and Volatile Organic Compounds (VOC).

The air fuel ratio of the engine is maintained by setting the appropriate oxygen sensor target setpoint that corresponds with the desired emissions reduction. The controller automatically targets and maintains the setpoint by adjusting the valve position which allows or restricts the amount gas streamed into the mixer which then richens or leans the engine. The valve is moved and stabilized using a finely-tuned Proportional Integral Derivative (PID) control loop that automatically adjusts the correct valve position quickly with little overshoot or error. In addition to “Setpoint” control type, the AFRC offers optional “Auto Control” configuration that can efficiently find and maintain the optimum target setpoint automatically for maximum emissions reduction. No setpoint adjustment or multi-setpoint mapping is required.

USER INTERFACE

The **AFRC Home** screen provides all the necessary information and functionality to select the target setpoint, adjust the valve, enable/disable control, and access additional setup features. This slide will be added to the home page slide list when the AFRC is detected by the touchscreen.

The left side of the screen will show gauges for oxygen reading, valve position, and catalyst temperatures. A security mode of *Setup* or *Engineering* is required to make any adjustments or changes to this screen.

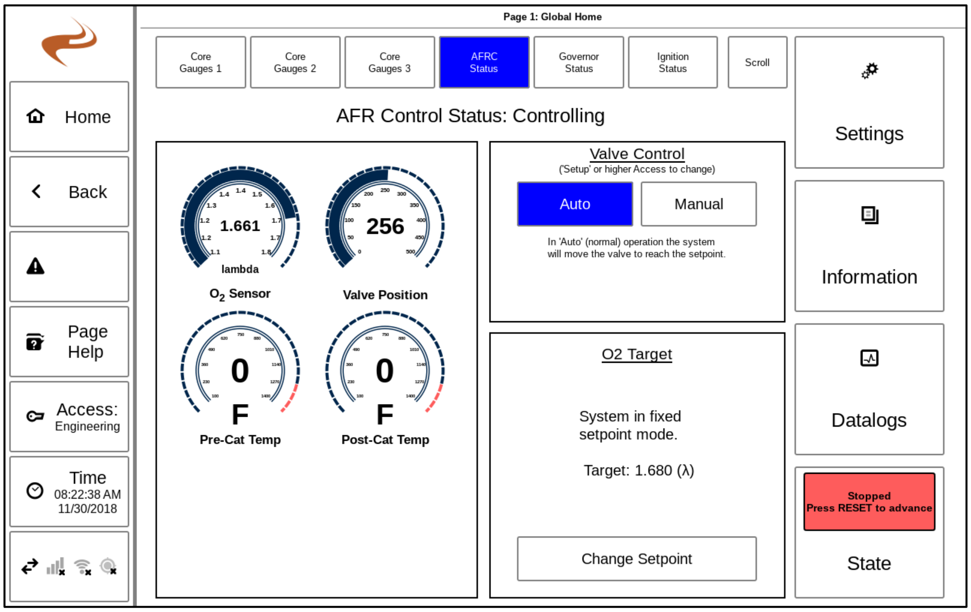


Figure 19. AFRC Home Screen Shown In “Setpoint” Mode, Single Bank

VALVE CONTROL TOGGLE BUTTON (“Auto” AND “Manual”)

In normal operation, the ‘Auto’ option should be selected, meaning that the AFRC will adjust the valve position to meet the target. If ‘Manual’ is selected, the valve position will not move until a user specifies a new position. The ‘Manual’ mode may be useful in some troubleshooting scenarios. Also while in ‘Manual’ mode, an option to home the valve is shown, which will calibrate the valve to the ‘Home’ (starting) position. The AFRC always automatically homes the valves every time the engine stops.

TARGET BOX

If in setpoint mode and in a high enough access level, a button will be available to change the setpoint(s). Selecting this button allows a new setpoint to be entered.

If in ‘Autocontrol’ mode, there will not be a button to change the setpoint because the system determines the setpoint automatically.

CONTROL STATUS

The status of the controller is displayed to the top of the slide. The statuses are as follows:

- “No Run Signal” – No run signal is present or detected
- “Heater Warmup” – Run signal has been detected and the sensor heater is warming up to the operational temperature
- “Ready” – Sensor heater is warm and ready but control has not been enabled
- “Control Enabled, in Load Delay” – The load delay, defined on the **Engineering Setup** screen, is counting down before taking control
    - Default load delay is 30 seconds
- “Attempting to Control” – Valve is actively adjusting to meet the desired target setpoint
- “Controlling” – The target setpoint has been met and control is stable
- “AutoControl is Active” – “Auto Control” control mode is currently engaged an operational
- “Failed Lean – System is unable to maintain control and air fuel mixture is lean
- “Failed Rich” – System is unable to maintain control and air fuel mixture is rich
- “Invalid Readings” – Sensor values are outside the expected range
- “Heater Failure” – Sensor heater failed to warm up
- “AutoControl Startup State” – The AutoControl is in its startup state
- "Pre or Post Cat Over Temp" – One of the catalyst temperature readings are out of range
- "Waiting for exhaust to warm up" – The AFRCA is waiting for the exhaust to reach a minimum operating temperature (before moving to load delay)

GAUGES

The “O2” gauges display the oxygen sensor readings in real time. Narrowband sensors show richer values towards the top and leaner values towards the bottom. The graphs are labeled accordingly based on the sensor being used. Orange markers indicate the target setpoint of the bank.

The “Valve” gauges display the full range of the valve, 0 to 499, for each bank with the top being all the way open (499), and the bottom being all the way closed (0). An orange bar over the valve bar graph(s) show the current home position(s). (AFRC software versions above 1444)

The “Catalyst Temperature” gauges display the real-time readings for the pre-catalyst and post-catalyst thermocouples. Red areas indicate temperature alarm values configured.

AFRC SETUP AND CONFIGURATION

ENGINE CONDITION

For proper AFRC operation, it is critical that the engine be in good operational status. Verify the following before running the AFRC:

- Valves are adjusted to factory specification
- Spark plugs are properly gapped and in good condition
- Cylinders have good compression
- Mixers are in good condition and regulator fuel pressure is set to factory specification
- Fuel connections are secure and leak-free
- Ignition system functioning correctly and timing set appropriately for fuel composition

> If the controller is operating at near the valve limit, or is at the valve limit and still not controlling well, the fuel pressure likely needs to be adjusted.

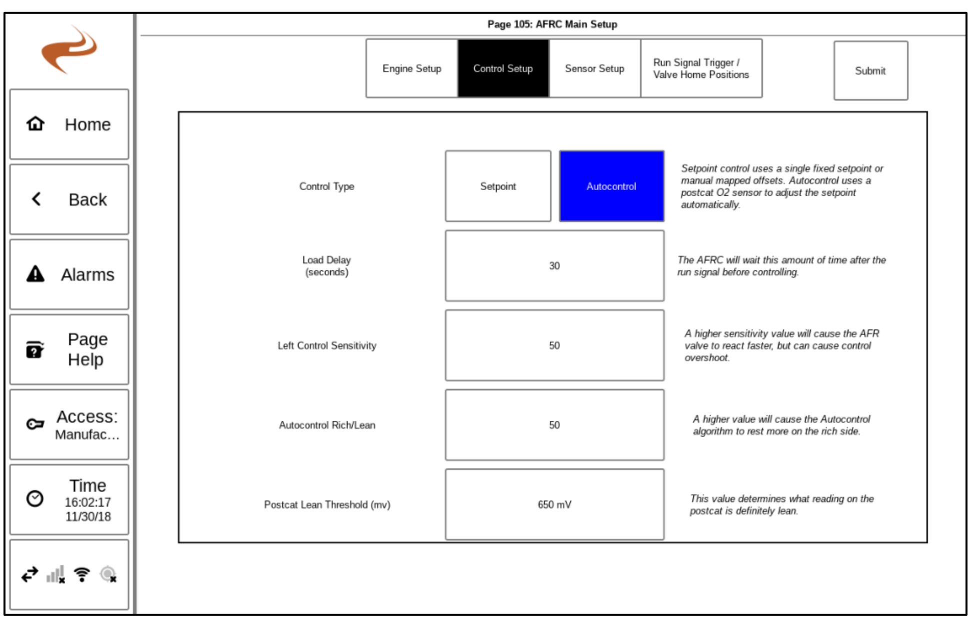
MAIN SETUP

The main AFRC setup is accessed by selecting 'Settings' -> 'AFRC' -> 'Main Settings'. This is the primary area for setup of control and sensors. This setup is organized into four slides.

Slide 1: Engine Setup

For the ECU AFRC, the setup must be single bank, richburn, and narrowband sensor. Because of this, slide 1 is not used.

Slide 2: Control setup

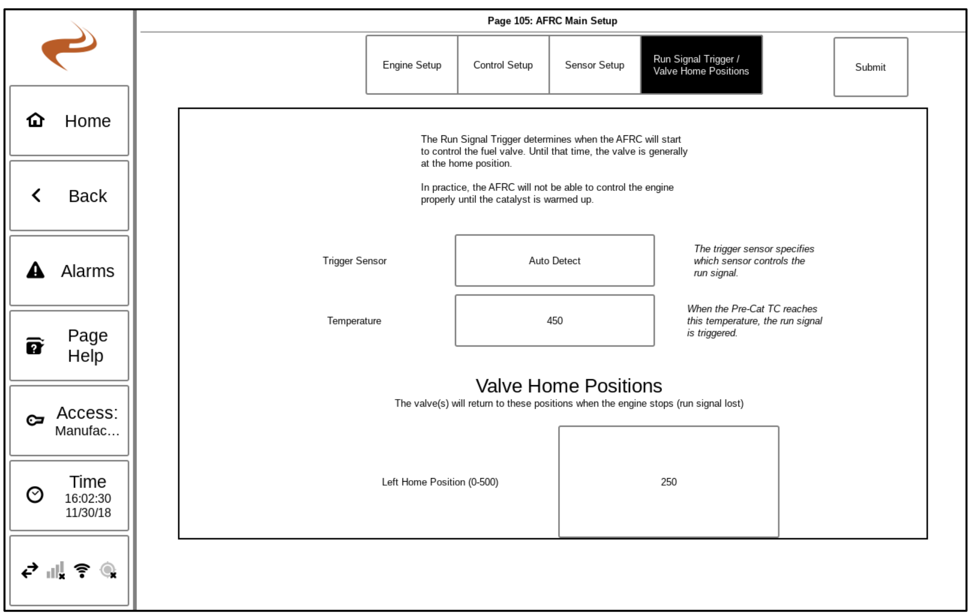


- Control Type: Setpoint control will use only pre-catalyst O2 sensor(s) and one setpoint, while Autocontrol will also use a post-catalyst sensor to automatically adjust the precat setpoint as conditions change
- Load Delay: The load delay is the amount of time after the ‘run signal’ is met before beginning to control. For some engines, it may be helpful to allow more time (using this value) for the engine to stabilize before starting control.
- Left/Right bank sensitivity: This value determines how quickly the valve will move to meet the O2 setpoint.
- Autocontrol rich/lean: When in autocontrol mode, this value helps trim the system operation to better match the catalyst. Increasing the value will make the control target more lean.
- Postcat lean threshold: This value does not often need to be changed, but determines when the postcat is considered lean. If during autocontrol the system keeps drifting rich, this value should be reduced.

Slide 3: Sensor Setup

This slide is not used for the ECU.

Slide 4: Run Signal Trigger and Valve Home Position(s)



<u>Run Signal Trigger</u>

The run signal trigger determines the threshold which the AFRC will use to determine that the engine is running and control should start. Typically, catalyst temperature is used because before the catalyst is warmed up the control won’t work properly. Select a trigger sensor to be used for the run signal trigger. If applicable, enter the temperature threshold in the second box.

<u>Valve Home Positions</u>

The valve home positions can be entered here. By default, the home position will be in the center of travel (250 steps). If another value is desired, it can be entered here. The home position will be used for startup and until the run signal is met and control begins.

ALARM SETUP

Up to eight (8) custom alarms can be configured on the AFRC to display within the **Alarms** screen (or to trigger an engine shutdown).

Configuring alarms is done on the **Alarm Setup** screen (Setup -> AFRC -> Alarms Setup) through the following parameters:

- Sensor – Input or condition to be monitored
    - Only enabled sensors are available for selection
- Min – Minimum trigger value (optional)
- Max – Maximum trigger value (optional)
- Duration – Time, in seconds, for the sensor reading to either be below the minimum trigger value or above the maximum trigger value to become active
- Action – Action to take when alarm becomes active
    - Warning – Displays the alarm within the **Alarms** screen and flashes the "Alarms" button on the footer of the display
    - Shutdown – Shuts down the engine, displays the alarm within the **Alarms** screen, and flashes the "Alarms" button on the footer of the display

It is optional to select both "Min" and "Max" values, but at least one must be selected for sensor monitoring alarms. Selecting both values is available for monitoring a condition within a window, if desired.

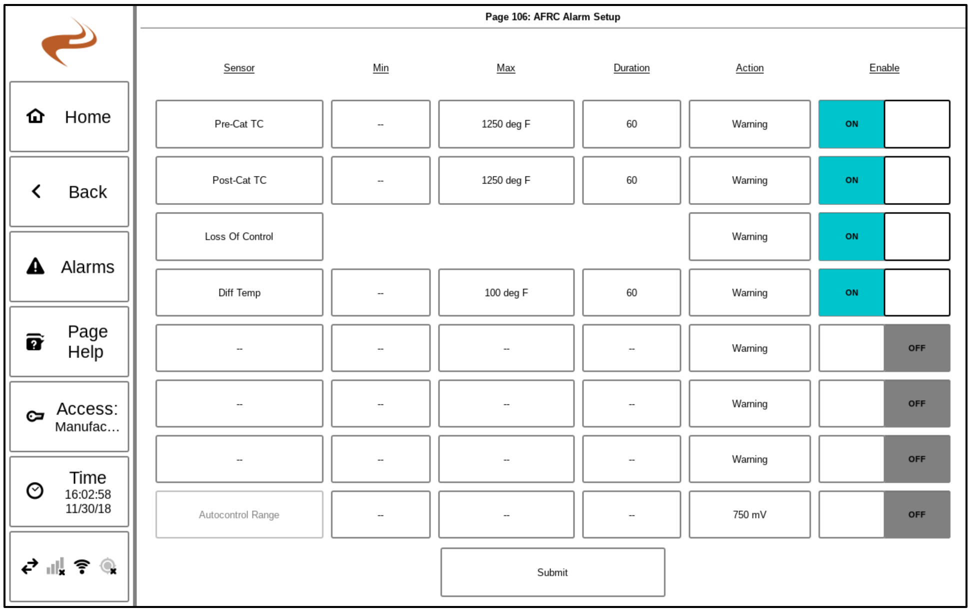


Figure 20. Alarm Setup Screen

Upon selecting the necessary information, the alarm is enabled by toggling the "Enable" slide at the end of the row.

	Modifying an existing alarm requires the "Enable" toggle box to be toggled back on to take effect.

	A sensor can be placed in two alarm rows. For example, a PostCat TC alarm could be configured to shutdown at 1250, and generate a warning at 1000.

AutoControl Range Alarm

If AutoControl is used, the final alarm in the **Alarms Setup** screen is the "AutoControl Range" alarm. This alarm can be used to fall back from "AutoControl" to "Setpoint" mode in the event the Post Catalyst O2 sensor milliVolt reading is pushed outside the set range, which can indicate the sensor is failing.

On a trigger of the alarm condition, the AFRC will go into "Setpoint" mode with a target setpoint valve defined by the alarm. The default is "777". To change the fallback setpoint value, select the "Setpoint: 777" button within the alarm row.

This event will trigger an alarm, AFR062 (min trigger) or AFR063 (max trigger), on the **Alarms** screen. This alarm must be reset in order to switch back from "Setpoint" mode to "AutoControl" mode. A security access level of *Setup* or *Engineering* is required to reset the alarm.

CONTROLLING THE ENGINE

RUNNING THE ENGINE

Detecting the Run Signal

With the engine running, the AFRC will detect the engine operation through the sensor trigger defined within the **Run Signal Trigger**. If a valid run signal is recognized, the black text in the header next to the "Home" button will display "Eng: Run".

Sensor Warm Up

Upon detecting the system run signal, the bank status within the control box will display "Heater Warmup" indicating the sensors have been started. After the sensor heaters are warmed, the AFRC will be ready to control. When the AFRC is ready, and in "Manual" control mode, the bank status will display "Ready" and will wait until the control mode is transitioned from "Manual" to "Auto". A security level of *Setup* or *Engineering* is required to toggle the control mode.

If the AFRC is already in "Auto" mode, it will start the process for initializing control.

Load Delay

Once the sensor is warm and in "Auto" mode, the AFRC will go into a load delay. By default, the load delay waits 30 seconds before the controller starts to move the valve.

If an AFRC Advanced is used and "Auto Control" is enabled, the controller not transition to delay mode until the pre-catalyst or post-catalyst thermocouple read a light off temperature of 550 degrees F.

Starting Control

When starting control, the bank status will update to "Attempting To Control". The valve will automatically adjust to try and match the actual O2 reading with the desired target setpoint. As the valve finds the position that's meets the target and is stable, the status will update to "Controlling".

Optimizing the Target Setpoint

The oxygen target setpoint "Target" should be set to optimize catalyst performance. This should be conducted while the engine is at a normal operating temperature and under normal loading. An exhaust gas analyzer should be used to reach optimum performance.

If "Auto Control" is enabled, no target setpoint adjustment is necessary.

External Dynamic and "600" Series Manual Valve Adjustment

If an external dynamic or 600 series valve is in use and the desired oxygen sensor target setpoint cannot be reached, then the valve will need manual adjustments. These valves contain an external "load" screw, which must be rotated to make adjustments.

STOPPING THE ENGINE

The engine may be stopped at any time. The AFRC will detect the engine has stopped based on the trigger selected on the **Run Signal Trigger** setting. When using thermocouples as the run indicator ("AFRC Pre-Cat TC" or "EMD Pre-Cat TC"), the controller will detect the engine has stopped after the pre-catalyst thermocouple drops below the trigger point (450°F by default). When using an oil pressure switch ("AFRC Oil Pressure" or "EMD Oil Pressure"), AFRC RPM, or Ignition State, the controller will immediately detect the engine has been shut down.

After the controller detects a shutdown, the digital power valve will fully open and then move to the startup position. This digital power valve cycle is repeated once after each engine shutdown to maintain calibration of the digital power valve position.

ECU IGNITION

OVERVIEW

The ECU Ignition is an electronically controlled ignition system that features highly accurate and reliable spark control and monitoring capabilities through the use of transistorized inductive technology. The ignition on the ECU supports up to 6 cyilnders. The ignition uses a variety of input options to determine the position of an engine, allowing it to be used on a wide range of applications. The ignition is appropriate for rich-burn or lean-burn combustion and naturally-aspirated or turbo-charged engines fueled by natural gas or propane.

The ECU utilizes transistorized inductive technology to build and transfer energy for spark initialization and control. By using the latest transistor technology, a high speed digital signal processor, and high-energy coils for inductive ignition, the ECU achieves precise and accurate control of a long duration spark that burns beyond that of a capacitive discharge system. The longer spark duration provides reliable combustion of the air/fuel mixture and performs particularly well for poorly mixed air/fuel mixtures, poor quality fuels, and lean air/fuel mixtures. Other benefits of inductive discharge systems include superior misfire performance, higher energy transfer efficiency to the spark, and reduced electromagnetic interference.

Capacitive discharge ignition systems have a higher peak spark voltage, but due to the corresponding short spark duration does not definitely translate to improved combustion. To overcome this, some capacitive systems need to spark multiple times to ensure the mixture is combusted if the original sparks did not ignite or only partially ignited the mixture. Multiple sparks reduce the ability to control peak cylinder pressure and unnecessarily wear coils, wires, and spark plugs. With the longer spark duration of the ECU, one spark provides sufficient energy to ignite the mixture.

For the ignition, the timing input can be sourced from different locations on the engine depending on the application. In wasted spark mode, the ignition utilizes two magnetic pickups: one for flywheel teeth and one for flywheel index to indicate top dead center of the reference cylinder. By using only two magnetic pickups, no additional sensors are needed for the camshaft timing, which is generally more difficult to access for installation. Alternatively, the ignition can use one magnetic pickup on the flywheel teeth and one hall sensor on the TDC of the camshaft to fire only on compression stroke. Lastly, the ignition can have the timing source from a camshaft timing disk, which has a timing mark for each cylinder, and an additional mark for the cylinder that is the reference cylinder.

Configuration, ignition status, timing adjustment, and diagnostic tools are all presented through the Dynamic Control Touchscreen. The touchscreen allows the ignition to be fully accessible and utilized without the need for a PC connection, external software, or any chips or keys.

Timing control is designed to automatically advance and retard based on changes to RPM and, optionally, load while also being quickly adjusted manually. Accuracy of the timing is based on engine RPM and is reduced as RPM increases. As an example, timing is accurate within +/-0.090 degrees at 1500 RPM and +/-0.180 degrees at the maximum RPM of 3000. Timing ignition adjustment limited to a range of 5 degrees BTDC and 60 degrees BTDC.

Diagnostic, testing, and control features for the ignition include a range of tools. Conditions for all cylinders can be displayed simultaneously for visual comparison. Various aspects of spark conditions can be setup to provide warnings for potential issues. The ignition can also trigger a warning or shutdown for poor spark performance, such as short spark duration or high misfire count. Other features include verification of timing inputs, verification of coil and harness wiring, top dead center input calibration, compression testing mode, adjustable fuel relay control, adjustable ignition start control, adjustable dwell time, and secondary spark waveform graphing.

USER INTERFACE

The **Ignition Home** slide of the global home page provides all the necessary information and functionality to quickly observe the system state and access additional diagnostic and setup features. The top of the screen provides the overall status of the ignition system. The timing box below displays the active timing, and the timing display can be clicked to make adjustments. The center box shows RPM. The right box shows spark durations. Links at the bottom go to pages for setup, testing, and input information. A security mode of *Setup* or *Engineering* is required to access any of the setup features.

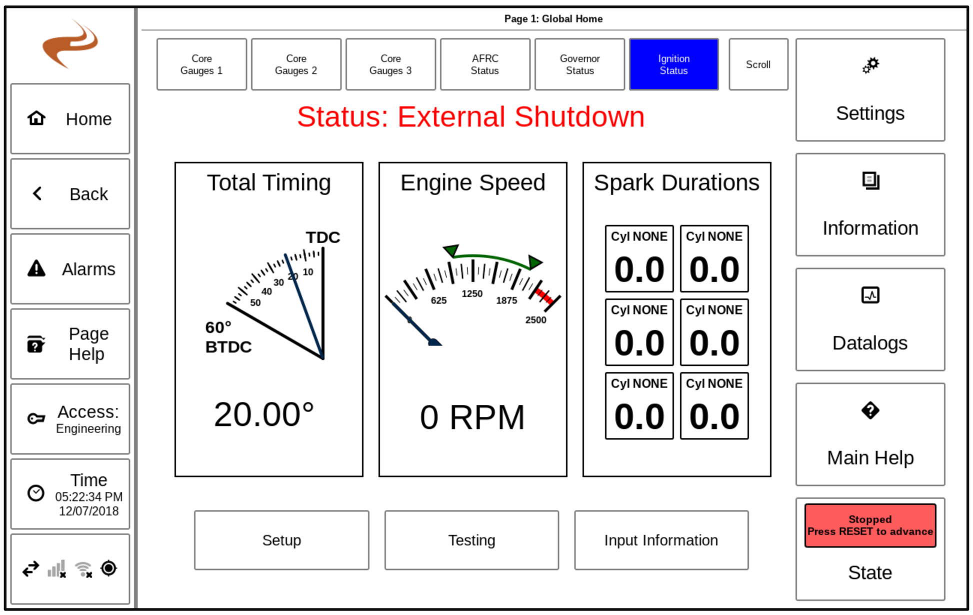


Figure 21. Ignition Home Screen

STATUS

Displays the current status of the ignition system. Possible statuses include:

- "Configuration/Setup Required" – Configuration and setup have not been completed
- "Ready to Start" – The ignition system is waiting for timing inputs from the engine
- "Engine Operation Detected" – Timing inputs have been detected and the ignition is preparing to start
- "Ignition Started" – Ignition is firing, but the engine is not yet at full running speed
- "Engine Running" – The engine and ignition are running properly
- "Engine Running with Warnings" – The engine is running, but warnings are present
- "Ignition Stopped – Critical Alarm" – The engine has been stopped due to a critical alarm

    - The alarm must be acknowledged in the **Alarms** screen in order to re-start the ignition
- "External Shutdown" – The shutdown input is grounded
- "Compression Test Mode" – The ignition is locked out and will not start during cranking
- "Firing Order Test Mode" – The ignition is firing desired coils with the engine off to verify wiring and operation
- "Bad Configuration" – There is a setup or configuration issue

TIMING BOX

The timing box on the **Ignition Home** screen displays the active total timing. The timing display can be clicked to go to a larger timing display screen to see the three timing components of total timing- rpm advance, load advance, and base timing. The base timing can be adjusted here as well. Values displayed on this secondary screen are:

- "Total Timing" – Current and active timing of the ignition system
    - Sum of the "Base Timing", "RPM Advance", and "Load Advance" timing values
- "Base Timing" – User adjustable fixed timing
    - Adjusted through the "Advance Base Timing" and "Retard Base Timing" buttons
    - Increments are +/- 0.25°
- "RPM Advance" – Amount of timing advance added to the total timing for changes in RPM
    - RPM advance timing is configured during the setup process
- "Load Advance" – Amount of timing advance or retard added to the total timing for changes in manifold pressure
    - Load advance timing is optional and requires a manifold pressure transducer for operation
    - Timing is typically retarded for increases in load or manifold pressure
- "Mapped Advance" – If using a pre-built map, this is the system calculated timing combination of RPM and load advance.

💡	Timing advance refers to increasing timing BTDC. Timing retard refers to decreasing the timing BTDC.

💡	Ignition timing is typically advanced for increases in RPM and retarded for increases to load.

SPARK DURATIONS

The right side of the Ignition Home screen shows the current spark durations. If not relatively steady and similar values, this could indicate a problem with a plug or coil.

Selecting this graph will go to the **Cylinder Information** screen.

VISUAL TOOLS

RPM Display

- Displays tachometer showing RPM and associated settings
- Bar above tachometer shows RPM advance range
- Red bar on the right indicated RPM overspeed value
- Red range on the left shows RPM underspeed range

Timing Display

- Displays an angular bar graph showing the current total timing
- Timing is the sum of "Base Advance", "RPM Advance", and "Load Advance" (if equipped), or the sum of "Mapped Advance" and "Base Advance" if using a map
- Selecting the graph navigates to the **Timing Graph** screen where the graph is displayed in greater detail with the current settings
- The base timing can be adjusted on this page in *Setup* or *Engineering* access modes

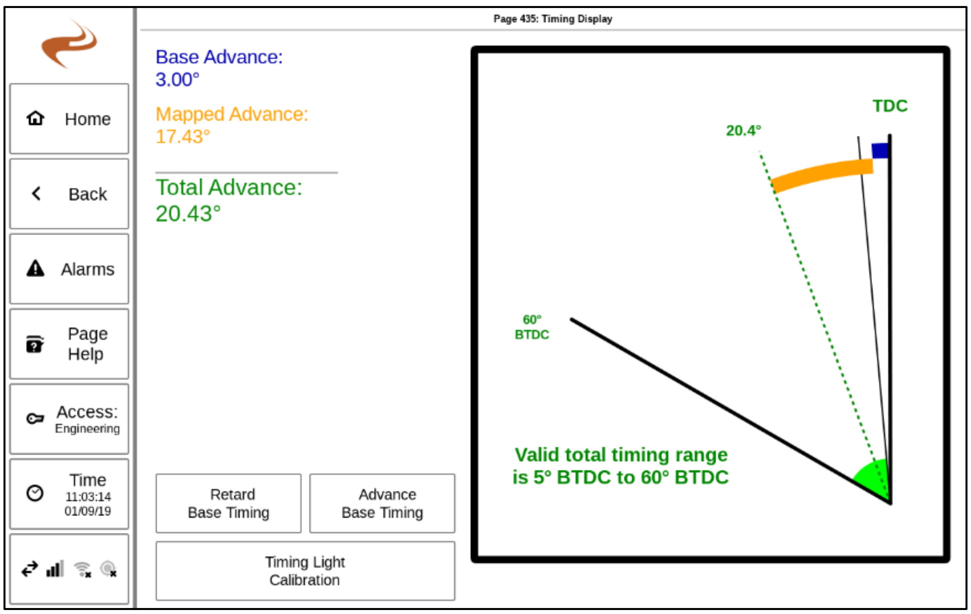


Figure 22. Timing Graph Showing Timing Calculation

IGNITION MAIN SETUP

After installation is completed, the ECU ignition must be configured prior to operation. To configure, navigate to the **Ignition Setup** screen, by selecting 'Settings' on the home screen, followed by 'Ignition' -> 'Main Setup'. Security access of *Engineering* is required.

💡	If this is a first-time install, the 'Engine Quick Setup' under 'System Settings' can be used instead of the Ignition Main Setup. This will fill in all the default settings for a particular engine.

STEP 1: Engine Setup

Step 1 of the setup process involves identifying engine parameters and position input types.

- "Cylinder Count" – Number of cylinders of the engine
- "Cam Angles" – If the engine has even Cam angles (each cylinder to cylinder angle gap between TDC is the same), select "Normal". Otherwise, select "Asymmetrical" and enter the first and second angle. Most engines are normal.
- "Flywheel Tooth Count" – Number of teeth on the flywheel for one revolution

⚠	If there are any teeth missing or broken on the flywheel, the original tooth count should be entered. The ECU will compensate for the missing teeth automatically.

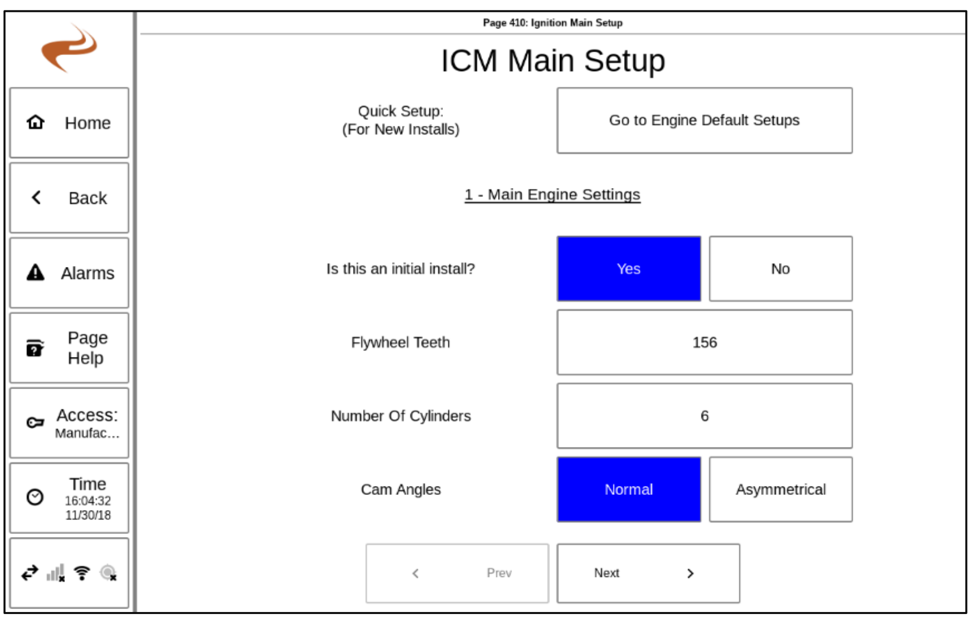
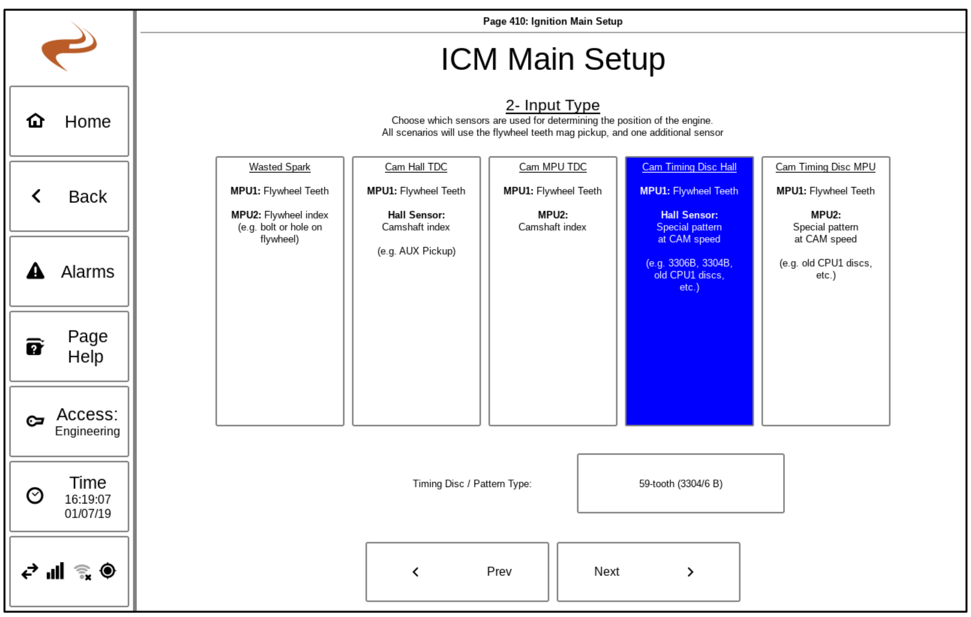


Figure 23. Step 1: Engine Setup

STEP 2: Input Selection

This page is used to select the type of position inputs used. There will always be a flywheel teeth MPU, and the second input can be a MPU or Hall effect sensor. Options are:

- "Wasted Spark" will fire ignition on both the compression and exhaust strokes. The second sensor will be a MPU on flywheel TDC.
- "Cam Hall TDC" will utilize a Hall effect sensor to indicate the TDC of the compression stroke of the reference cylinder, and does not use a flywheel TDC
- "Cam MPU TDC" will use a magnetic pickup on the cam to indicate TDC of the compression stroke.
- "Cam Timing Disc Hall"- will use a hall effect sensor on a cam timing disk to sense the camshaft position. This timing disk can have different layouts. One layout type is one mark (gap or magnet) for the TDC of each cylinder, and one extra mark to indicate the reference cylinder. Another layout type is a 60 tooth disc with one tooth missing. This mode is often used if a digital ignition was already installed.
- "Cam Timing Disc MPU"- this mode is the same as Cam Timing Disc Hall, but uses a mag pickup instead of hall sensor



If one of the timing disc options are used, a box will appear to ask for the disc type.

STEP 3: Cylinder Firing Order

Step 3 is used to define the engine firing order for the number of cylinders defined in Step 1. Select each cylinder and enter the firing order. The firing order can usually be found on the engine block. Some presets are available for common engines, if applicable select a preset to fill in the order.

If needed, cylinders can be appended with “L” and “R” letters for left and right banks. If utilizing the “L” and “R” designations, all cylinders should include either an “L” or an “R”.

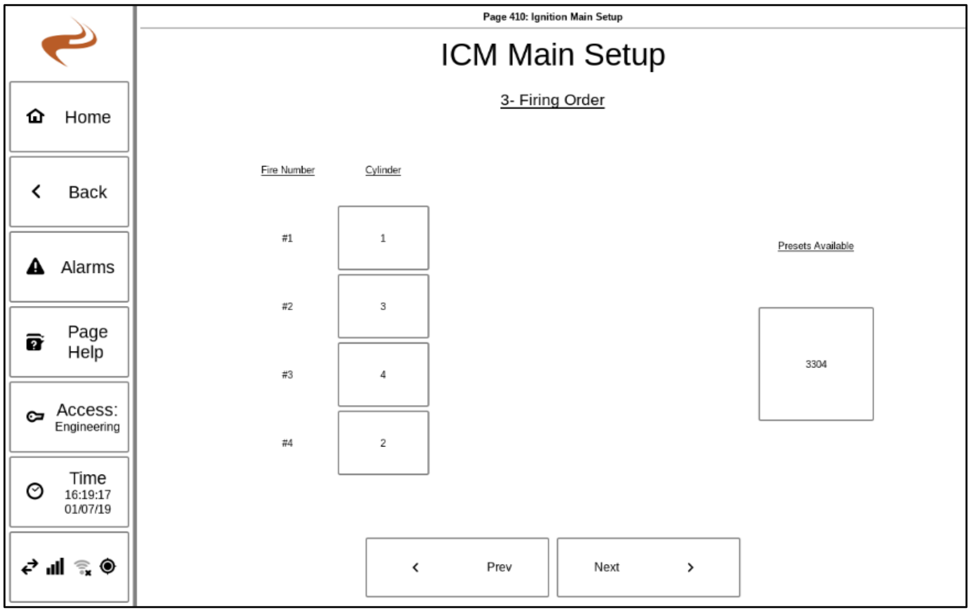
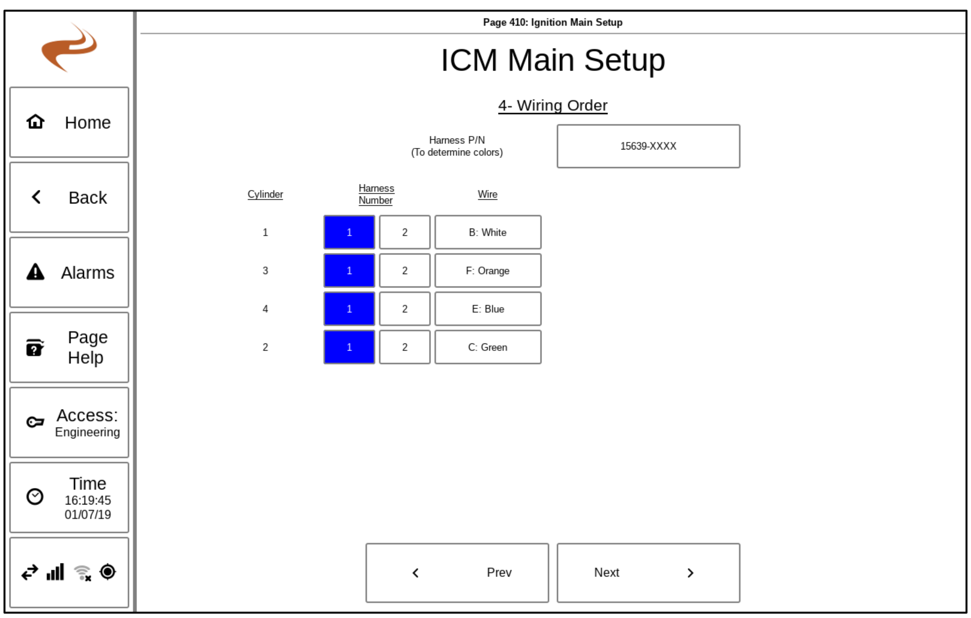


Figure 24. Step 3: Cylinder Firing Order

STEP 4: Harness Identification

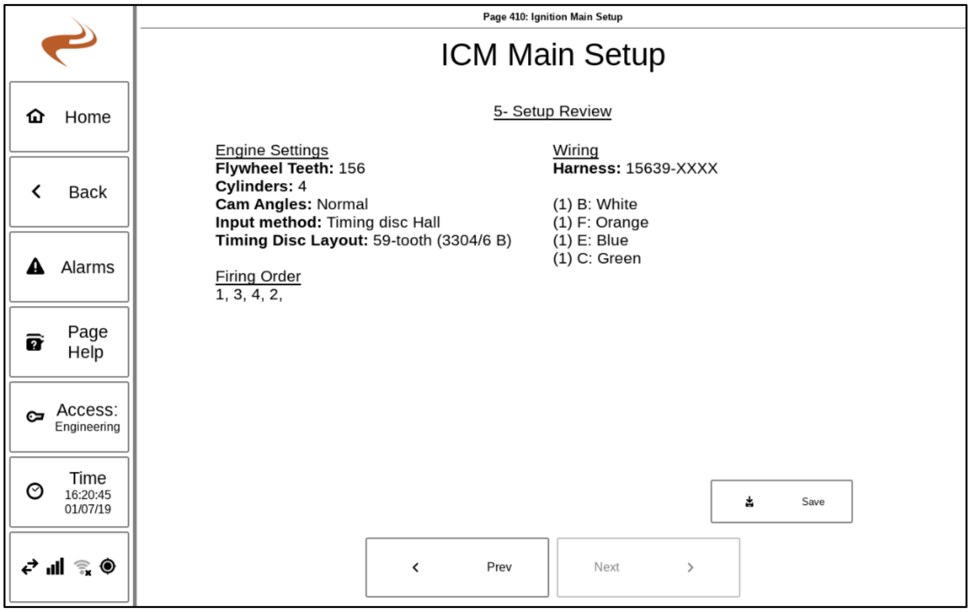
Step 4 is used to identify harness connected to the system.



For the ECU in almost all cases cylinder 1 will go to wire A, cylinder 2 to wire B, and so on. The default setup selected on step 3 should fill in the proper order.

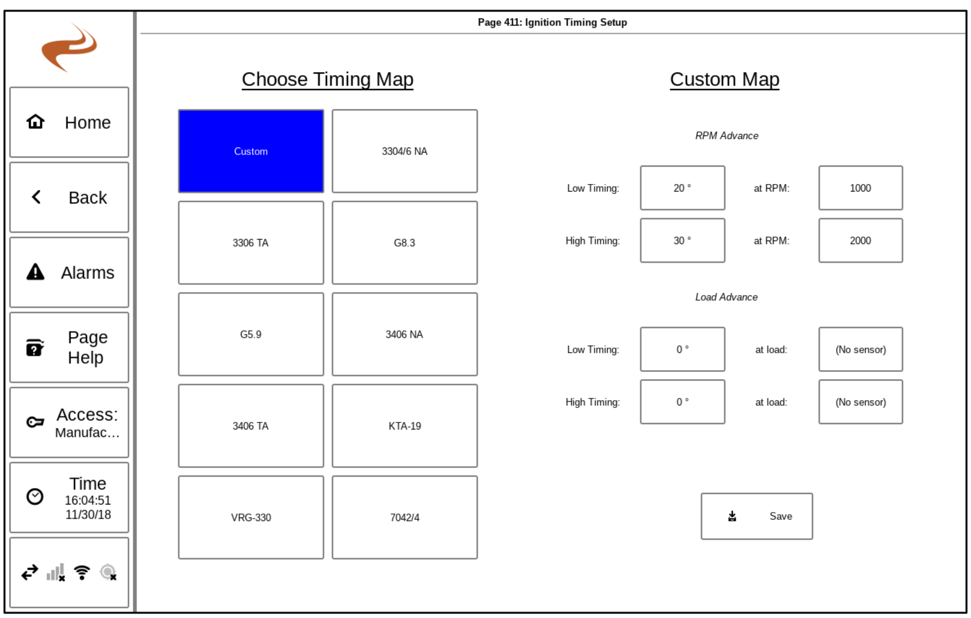
STEP 5: Review

After reviewing the setup, select 'Submit' to save.



TIMING SETUP

After completing main setup, the timing setup should be selected. This is found at 'Settings' -> 'Ignition' -> 'Timing Setup'.



After "Map Type" any built-in maps will be listed, along with "Custom". Built-in maps are preconfigured timing maps for a particular engine that will adjust the timing for speed and load changes, and have been specifically setup for that engine. If a built-in map is not available, the "Custom" map type can be selected for user-selected timing ranges.

CUSTOM TIMING

The timing and RPM information entered under "Custom" map type will allow the timing to be automatically adjusted based on user-configured changes to RPM.

To set the RPM advance, timing must be specified for a low RPM value and a high RPM value.

- For the low RPM timing:
  - Set the low RPM value to the RPM during cranking or at the lower range of operating RPM, whichever is desired
  - Set the timing the ignition should be running at that specific RPM
- For the high RPM timing
  - Set the high RPM value to the maximum operational RPM
  - Set the timing the ignition should be running at that specific RPM

The timing will automatically be interpolated between the two specified RPM values. If the RPMs exceed the two RPMs provided, the timing will be clipped respectively.

Similarly, a custom load advance can be specified by entering a low timing / load pair and high timing / load pair. The ignition will add both RPM and load advance to base timing for the total timing. A typical load advance setup may have 0 degrees advance at low load and -5 degrees advance at high load.

BASE TIMING

Base Timing is a manual timing adjustment that is fixed. The purpose of Base Timing is to allow the operator to quickly advance or retard the timing in small increments without having to modify the RPM Advance or Load Advance settings.

If desired, the Load Advance can be disabled and the RPM Advance can be setup to not change timing which would allow for a fully manual timing setup.

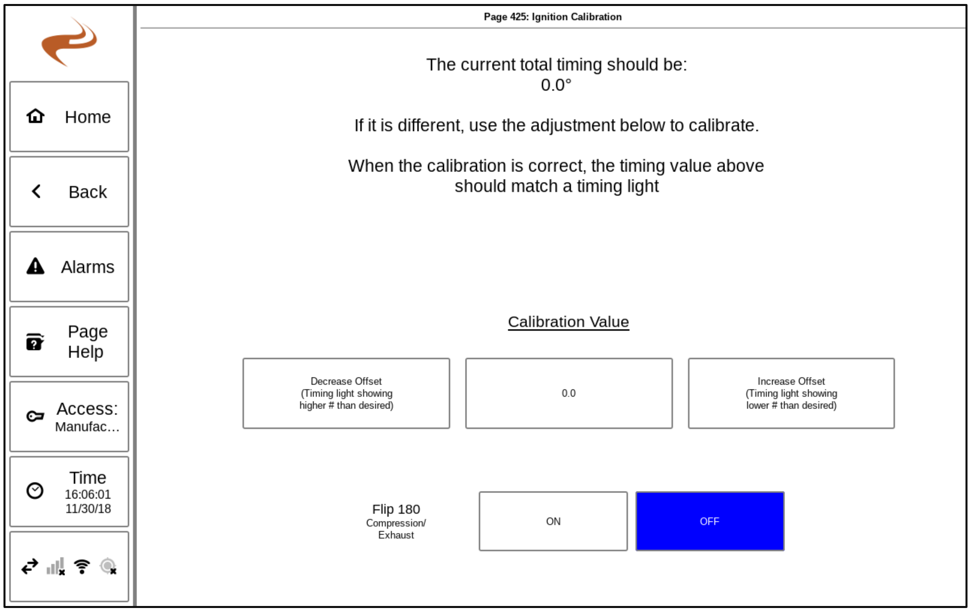
Base Timing can be positive (timing advance) or negative (timing retard). Base Timing adjustments increment in 0.25° steps. Base timing is adjusted on the Timing Display page, which is accessed by clicking on the small timing graph on the Ignition Home screen.

⚠	If a prebuilt timing map is selected in ignition setup, the base timing will start at 0 degrees. The base timing can still be adjusted to raise or lower the timing. If in a prebuilt timing mode, it is not recommended to have base timing outside the range +/- 5 degrees.

TIMING CALIBRATION

After initial install, the calibration screen can be used to match the actual timing observed on a timing light with what is displayed on the screen. This helps correct for offsets in the input trigger with actual TDC.

The timing calibration screen is found at 'Settings' -> 'Ignition' -> 'Calibration'.



The current total timing is shown at the top of the page. While using a timing light, select 'decrease offset' and 'increase offset' to change the offset value until the light matches the displayed total timing. Once the timing light matches the current timing, the signal is calibrated, and should match for all changes in timing.

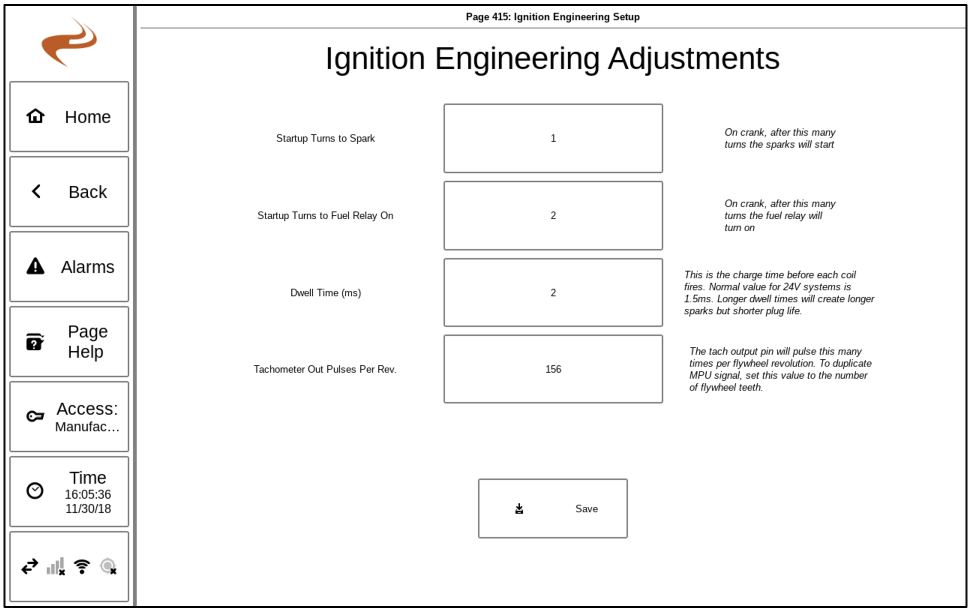
When doing an initial calibration of the engine, it can be useful to set RPM advance to be constant so that the timing does not move around while calibrating, e.g. to 20 degrees fixed.

If using a timing disc, the TDC of the disc may have been installed as the fire location (advanced). In this case the calibration value will end up being fairly high, e.g. +30 degrees. Once calibrated, this shouldn't cause any issue.

If the trigger was installed BTDC, the offset will be negative. If the trigger was installed ATDC, the offset will be positive.

ENGINEERING SETUP

The Engineering Setup page for the ignition is used to change some advanced settings for the Ignition. This page is found at 'Settings' -> 'Ignition' -> 'Engineering Setup'.



Options on this page are:

- Startup turns to Spark: This setting sets the number of crank revolutions before enabling the ignition. Additional crank revolutions may be necessary to purge the cylinders of fuel when running in wasted spark mode. On slow-cranking engines it may be desirable to increase this value a few turns so that the ignition timing is more accurately resolved by the time the coils are enabled.
- Startup turns to fuel on: The fuel relay adjustment setting sets the number of crank revolutions before toggling the fuel relay. This setting can be used to turn on fuel before or after ignition coils have been started. Note that this only affects the ignition fuel relay, not the Brain fuel relay.
- Dwell Time (ms): Dwell time is the period of time the ignition coil is charged prior to firing the spark. Dwell times have a direct effect on spark energy and component life. Longer dwell times can provide additional energy to the spark resulting in hotter and longer spark. If the dwell time is excessive, the ignition coil and the spark plug will have a significantly reduced life span. Low dwell times will extend component life but will result in a lower-energy spark. Primary current and spark durations should be monitored when adjusting dwell time. It is recommended that dwell time does not exceed 2.5ms for a 24V battery system and 6.0ms for a 12V battery system.

	Turbo-charged engines and engines with poor quality fuels may require higher dwell times.

ALARM SETUP

The system presents ignition diagnostics in the form of visual tools, user-defined alarms and warnings, and a quick-view for active faults.

Adjustable alarms and faults are available on the **Ignition Alarms** screen. Alarm thresholds on this screen can be configured at any time to trigger fault conditions for the events listed below.

When an alarm occurs, the “Alarms” button in the sidebar of the display will flash the “Alarm” text and display the current number of alarms. To clear the alarm, the “Reset Alarm” button must be selected from the **Alarm View** screen. The overspeed, underspeed, and critical timing error alarms will shut down the engine. The other diagnostic trigger values will cause an alarm but the engine will stay running.

To enable or disable a diagnostic trigger, select ON or OFF on the relevant row. Note that “Overspeed RPM” cannot be disabled.

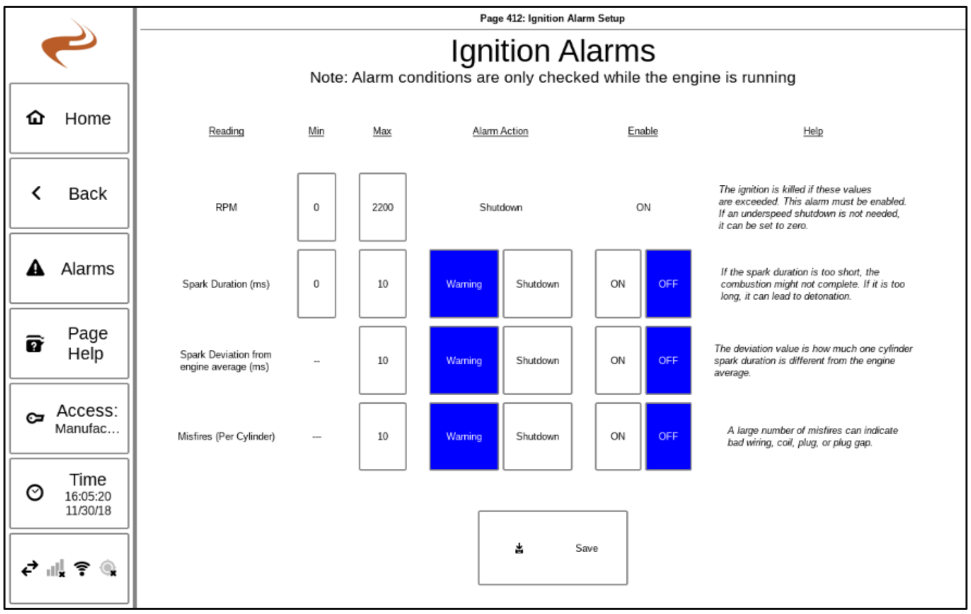


Figure 25. Ignition Alarms Screen

RPM Overspeed

- “RPM Overspeed” is the setpoint value for a high RPM shutdown
- This value is configured during the ignition setup process but can be updated at any moment
- The maximum RPM overspeed setpoint is 3000 RPM

RPM Underspeed

- “RPM Underspeed” is the setpoint value for a low RPM shutdown
- Alarm is only engaged after a startup grace period expires
    - Startup grace period is adjustable up to 20 minutes

Spark Duration

- A spark duration warning can be configured by defining the “Maximum Spark Duration” and “Minimum Spark Duration” values
- Valid ranges for spark duration are between 0.5 and 20 ms

- A spark duration fault provides a warning and does not shutdown the ignition

Spark Deviation from Engine Average

- The spark deviation warning is intended to identify any cylinder or ignition component issues by comparing the individual spark duration with the engine average duration
- Valid ranges for spark duration deviation are between 0.1 and 10 ms
- A spark deviation fault provides a warning and does not shutdown the ignition

Maximum Cylinder Misfires

- If a cylinder's spark plug is detected to have not sparked properly a misfire count for that cylinder will be incremented
- The Maximum Cylinder Misfires value gives a threshold value past which an alarm will be triggered
- The misfire alarm will show a list of cylinders that are over the threshold value

Critical Timing Error – Missing Index

- If the crank TDC index signal has not been detect for 2.0 seconds while the engine is running, the ignition will shutdown and display the fault in the Alarms screen
- Potential causes of this fault include:
    - TDC magnetic pickup installed too far from the trigger bolt to detect
    - Excessive oil and metal shavings on the pole of the TDC magnetic pickup
    - Improper wiring of the TDC magnetic pickup or hall sensor
    - Intermittent connection to the hall sensor

Shutdown Alarms

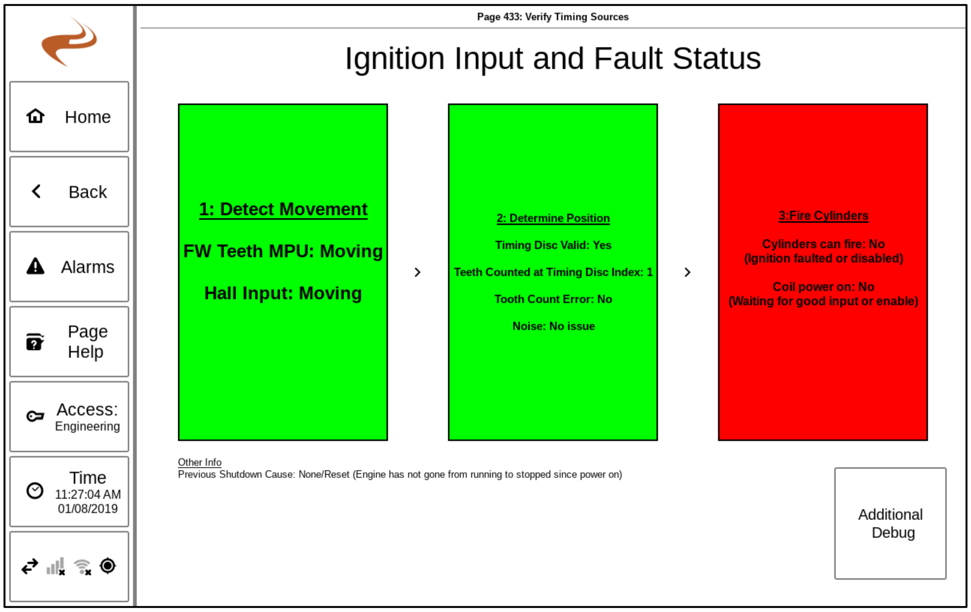
The Ignition has a variety of shutdown diagnostic alarms that are always enabled. After a shutdown, the touchscreen will evaluate the conditions of the ignition before and after the engine stopping. If an unusual or problematic condition exists, it will trigger an alarm under code ICM007, and will provide additional information to the user as to what might have contributed to the shutdown.

IGNITION TESTING TOOLS

The testing tools described in this section are available from the **Ignition Testing Menu** screen. This menu is reached from the Ignition home page by selecting 'Testing', or from the global Information menu by selecting 'Ignition'. Security access of *Setup* or *Engineering* is required for some screens.

Input Information Screen

The Input Information Screen is used to see what the Ignition is detecting from the position inputs.



The first box will show if either or both of the two inputs are seen to be moving. If one is not during crank, it indicates a wiring or sensor problem.

The second box shows if the ignition can determine the position correctly. If it is not able to, it could be because of noise on the inputs, loose connections, or an incorrect configuration.

The final box shows if the cylinders are firing and if there are no misfires.

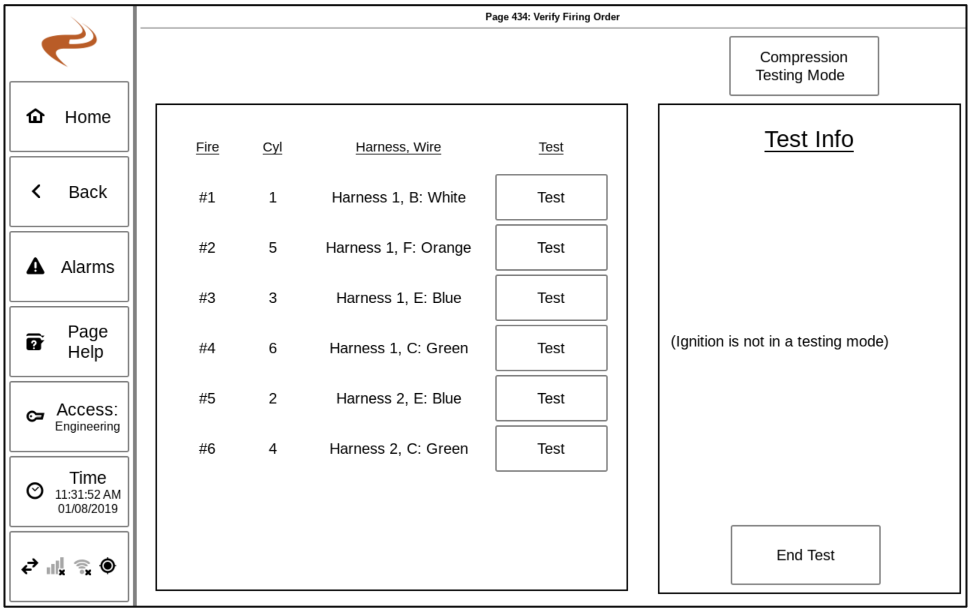
The 'additional debug' button can be selected to show the input counts of the inputs. This can be helpful when debugging connections.

At the bottom of the screen, "Previous Shutdown Cause" – Displays the reason for the previous ignition shutdown

- "None/Reset (Engine has not gone from running to stopped since power on)" – The engine has not shutdown since the ignition has been powered on
- "Generic stall (ignition was firing when engine died)" – Engine stalled while the ignition was firing
- "User disabled" – The ignition was killed by selecting the "Shutdown Engine" button from the "System Menu" screen
- "External disable (shutdown line was pulled low)" – Ignition is disabled from the annunciator
- "Critical alarm shutdown (e.g. overspeed/underspeed)" – An overspeed or underspeed event occurred
- "Critical timing fault- timing signals were too poor to continue firing" – The magnetic pickup or Hall sensor signal lost integrity
- "Generic stall low RPM (ignition was firing when engine died)" - Engine stalled while the ignition was firing

ENGINE OFF TESTING

The **Engine Off Testing** screen is used to test ignition component operation and wiring when the engine is off. In this mode you can enter Compression Testing Mode, and can run wiring and firing order tests.



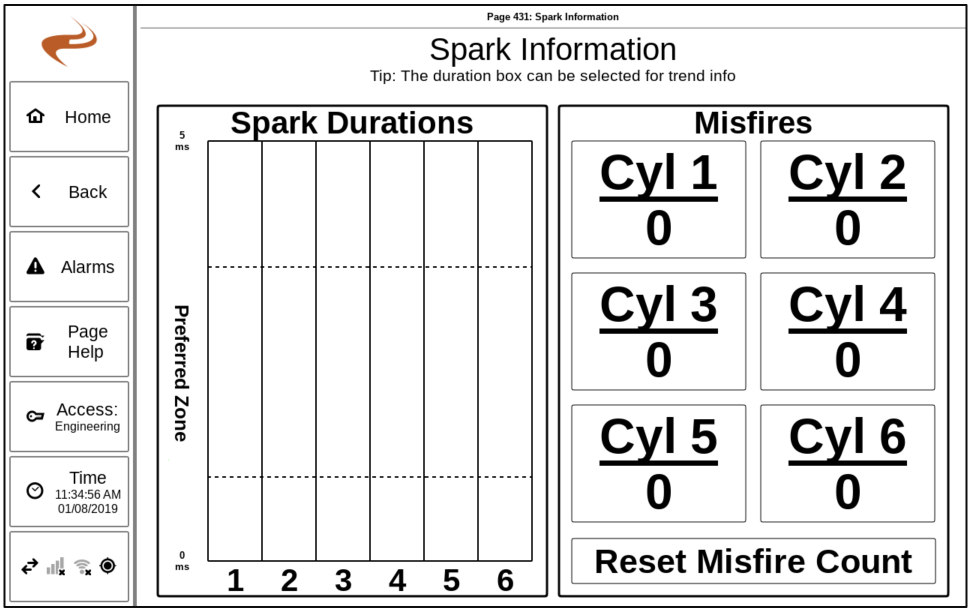
The left box can be used to select an individual cylinder to test sparking to verify wiring. To test a cylinder, select 'Test' next to that cylinder. When testing is active, the ignition coil under test will fire continuously. To check the component health or activity, use a spark checker tool or observe the spark information on the right side of the screen. To end the test, select the "End Test" button.

The text labels for the cylinders will illuminate blue while under test. On the **Ignition Home** screen, the status will display "Firing Order Test Mode".

The 'Compression Testing Mode' button can be selected when there are no individual cylinder tests taking place. This locks out the ignition system so that the user can crank the engine for a compression test without the coils firing. Click 'End Test' to exit this mode.

SPARK INFORMATION

The **Spark Information** screen presents ignition information in bar graph form and provides access to additional individual cylinder information. This page can be accessed by selecting 'Spark Information' from the Ignition Testing Menu, or by selecting the right box on the Ignition Home Page.



The left side of the screen will show a bar graph with the spark duration of each cylinder. Ideally, all cylinders will be relatively similar and within the preferred zone. The right side of the screen will show accumulated misfire counts.

Factors leading to shorter spark duration are:

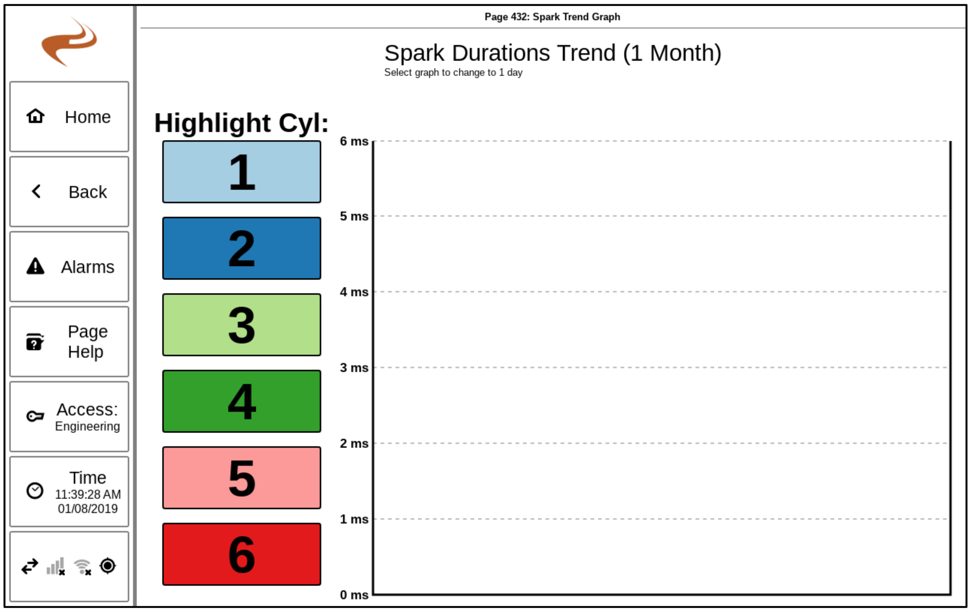
- Larger spark gaps
- Higher cylinder compression
- Bad wiring connections
- Old or fouled plugs
- Lower dwell times

Factors leading to longer spark duration:

- Smaller spark gaps
- Low cylinder compression
- Higher dwell times

If spark durations are too short, the combustion will not start well (or not at all). If spark durations are too long, engine knocking can occur from overly-hot plugs, and spark plug life will be shorter.

The left side of the screen can be selected to show the spark durations trend screen.

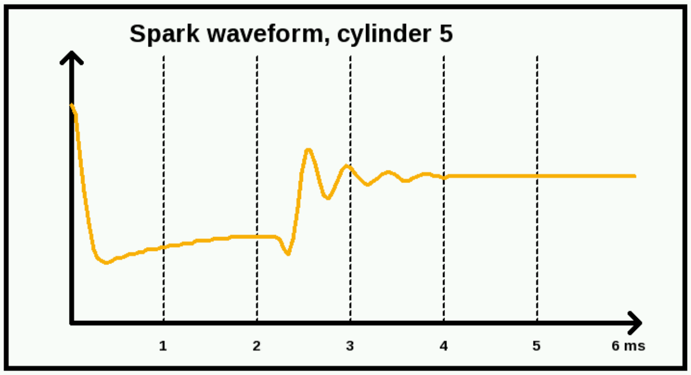


The spark tend screen will show the spark durations over the last month (if data is available). This can be used to see if durations are dropping off (from old plugs) or if one cylinder is unusually high or low.

SPARK GRAPHING

The **Spark Graph** screen is accessed by selecting the "Spark Graphing" button from the Ignition Testing Menu.

To graph a spark waveform, select the cylinder to capture and press the "Capture Spark" button. A healthy spark should be drawn as shown below. Unhealthy sparks will be abnormally short/long or have intermittent jogs within the low duration of the spark.



SINGLE CLINDER DROPOUT TEST

The ignition has the ability to run briefly without firing a single cylinder. This can be used to verify that each cylinder is supplying a similar amount of power to the engine.

⚠	Running without firing one cylinder sends unburnt fuel to the catalyst, which is hard on the element. Cylinder dropout tests should only be run briefly, with plenty of time between tests running normally to make sure unburnt fuel is purged out of the system. The test should be used with a moderate load, if the load is too high the engine will probably stall.

The single cylinder dropout test screen is found by navigating from the ignition home page to " Testing", then "Single Cylinder Dropout Test".

Manual Test

Once the engine is running, a manual test can be used by clicking 'Manual Drop One Cylinder'. A dialog will be shown to choose a cylinder, after which the engine will run without firing that cylinder for about 5 seconds. After the test the average RPM and manifold pressure during the test will be shown.

During the test, selecting 'Stop Test' will abort the test.

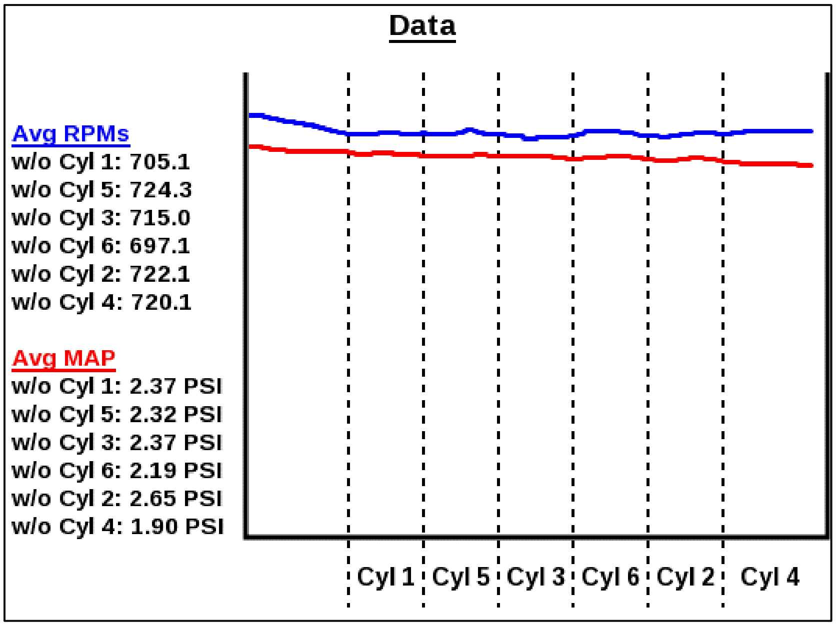
Auto Test

The ignition will perform the following sequence during this test:

- The speed will be commanded to hold a fixed throttle position, followed by a short delay
- Each cylinder will be dropped out for about 4 seconds each
- At the end of the test, the speed and ignition will return to normal operation

During the test, the test can be stopped by selecting 'Stop Test'. Also, if the engine stops during the test it will be aborted.

After the test, a graph of the RPM and MAP during the test will be shown. This makes comparing cylinder power easy.



Since the throttle is fixed during the test, the RPMs will change based on how much power is lost as each cylinder is dropped. If one cylinder in particular has a higher engine speed during its dropped period, this means that the cylinder was doing less work than the average of the others. This could be due to poor combustion (plug, ignition, etc.) or poor compression (valves, etc.).

DEBUG LOG

The Debug log, accessed from the Testing Menu -> “Debug Log”, is used by EMIT to see recent input information.

System Troubleshooting

Input Issues

RPM Reads "0" when cranking

MPU Wiring information:

The mag pickup has a two wire metri-pack connector that attaches to the main engine harness. These two wires run to the ECU 23 pin white plug, pins 22 and 23. The order of the pins on a mag pickup do not matter.

A. Unplug the MPU and use a multimeter to measure AC Volts across the two MPU wires while cranking. It should show around 2-10V AC. If less is shown, then one of the following may be the cause:
    a. The MPU is bad
    b. The connection to the plug is bad
    c. The engine is cranking too slowly to generate proper voltage
    d. A stronger MPU is needed
    e. The MPU is not close enough to the flywheel (typically should be ¼ to ½ turn out)
B. If test (A) passes, check the resistance of the mag pickup. It should be around xxx ohms.
C. Plug the mag pickup back in and unplug the white 23 pin plug at the ecu. Measure the resistance between pins 22-23, it should match the value from test (B). If not, the harness has a connection issue.
D. If test C passes, verify that the ignition and speed controller software are up to date.
E. If the software is up to date and no other issue has been found, it is most likely a ECU hardware issue.

MPU reads more than 0, but is not correct

If the MPU is reading a faulty RPM, verify the following

A. Make sure the flywheel teeth setting is correct
B. Verify that all connections are secure at the MPU plug and where wires land at the ECU
C. The MPU may not be screwed in far enough. Verify it is within ½ to ¼ turn of the flywheel.
D. The MPU harness may be picking up noise. Make sure it is routed away from noise sources, and the drain wire is connected to ground.

The throttle position does not show around 0% position when the engine is off

A. The throttle may need to be re-calibrated. Navigate to Settings -> Speed -> 'Setup' -> 'Throttle Calibration' and hit 'calibrate now'.
B. If (A) does not fix the issue, see if the position appears to change at all while the calibration is taking place, if not, go to 'Throttle not moving' below
    a. If the position is moving but the calibration still does not complete successfully, go to 'throttle feedback problems' below

Throttle feedback problems

The Bosch throttle bodies use four feedback lines and two power lines. General wire connection:

- ECU (23-PIN white connector) PIN 4 -> Throttle PIN 1
- ECU PIN 3 -> Throttle PIN 4
- ECU PIN 6 -> Throttle PIN 5
- ECU PIN 5 -> Throttle PIN 6
- ECU PIN 21 -> Splice -> Throttle PIN 3
- ECU PIN 14 -> Splice ->Throttle PIN 2

A. Unplug the throttle body and check the voltage at pin 3 of the harness to the block. It should be around 5v.
   a. If the voltage is not 5v, unplug the two pressure sensors and check again. If this fixes it, a pressure sensor has an issue.
   b. If the voltage is still not 5v, unplug the 23 pin white connector at the ECU and check the voltage of pin 21 to ground. If not 5v, there is a board issue or the software is not up to date.
   c. If the voltage appears at the ECU but not the 6-pin throttle connector, there is a harness issue.

B. Pin 2 of the throttle connector on the harness should show continuity to the block (under 2 ohms). If not, it indicates a harness issue.

C. Plug the throttle back in and unplug the 23-pin white connector on the ECU. Both pin 5 OR 6 measured resistance to ground should show in the range 500 ohms – 1.2k ohms. If much lower or higher it could indicate a harness break or throttle issue.

D. If all above tests pass, it indicates most likely a board issue or a bad throttle body.

Speed controller does not switch Idle/Auto/Manual mode

A. The speed switches are wired to the Brain (annunciator). Check the brain setup under “outputs setup” -> “Speed control output to ECU” and make sure “Send switch positions to ECU” is set to Yes.

B. The governor may be in idle hold because of warmup. The actual switch position detected by the brain module can be seen by selecting the “Brain State” from the home page, “faults” category, then selecting the right box. The “Manual” and “Auto” switch should light as the switch is cycled. If not, check the brain speed setting mentioned in “A”, make sure software is up to date, and check the switch wiring. Each of the two mode switches close to ground.

Speed controller is not reporting suction / discharge pressure correctly

If the Brain is connected to the normal pressure sensors, it should be sharing the suction and *final* discharge stage values to the governor. If it does not:

A. Make sure the built-in names for the stages are used on the annunciator so that the system knows how to sort out the input. E.g. choose 'Suction' for first stage suction instead of using a custom name like 'First stage suction'.
B. Make sure the module firmwares are relatively up to date.
C. Make sure the brain input setup uses 'PSI' or 'Kpa' for units on the pressure sensors

Ignition general input checking

On the ICM home slide, the 'Input Information' box can be selected to view the position input information. While cranking, both the flywheel teeth input and the index input (either another MPU or the hall sensor) should be shown as moving. Also, the "Additional Debug" button can be checked on this page both before and after cranking to see if the "Input Counts" have increased.

Hall sensor not moving

If the input information screen shows the hall sensor not moving, or the alarm "Hall Disconnect" is thrown when using a hall sensor, then the board is not seeing the hall sensor at all. Typical system wiring:

<u>330xB engine hall sensor:</u>

- ECU (23 pin white connector) Pin 7 -> Hall connector C
- ECU Pin 15 -> Hall connector B
- ECU Pin 18 -> Hall connector A

<u>Threaded hall sensor:</u>

- ECU (23 pin white connector) Pin 7 -> Hall connector B (WHT)
- ECU Pin 15 -> Hall connector C (BLK)
- ECU Pin 18 -> Hall connector D (RED)

<u>Aux pickup:</u>

- ECU (23 pin white connector) Pin 7 -> Round connector B (WHT)
- ECU Pin 15 -> Round connector A (BLK)
- ECU Pin 18 -> Round connector D (RED)

A. With ICM powered, unplug the hall sensor at the engine (or aux pickup) and verify the following on the **harness** end:
    a. 330xB hall sensor:
        i. Pin A- DC V to ground should be 12 V
        ii. Pin B- Resistance to ground should be < 1 ohm
        iii. Pin C- DC V to ground should be 5 V
    b. Aux pickup connector
        i. Pin A- Resistance to ground should be < 1 ohm
        ii. Pin B- DC V to ground should be 5 V
        iii. Pin D- DC V to ground should be 12 V

c. Threaded hall sensor with 4-pin weatherpak (checking on weatherpak):
    i. Pin B- DC V to ground should be 5 V
    ii. Pin C- Resistance to ground should be < 1 ohm
    iii. Pin D- DC V to ground should be 12 V

B. If any of the tests in (A) fail, there is wiring or connection issues in the harness or box.
C. If (A) passes, jump a wire from ground to the pin on the connector that is listed as "DC V to ground should be 5 V" in (A). For each time grounding that pin, the hall sensor input counts on the input status screen should increase. (Note: The input count dialog aka 'Additional Debug' has to be closed and re-opened to update the input counts).
    a. If this does not work, there is a connection problem between the end of the harness and the ignition board, or a problem with the ECU board itself.
D. If (C) passes, remove the hall sensor and move a magnet to see if the input counts increase. For the aux pickup, plug back in and spin the engine or remove and spin the input shaft manually.
    a. If this fails, the hall sensor itself may be bad

Shutdown pin input not working / Ignition is not in "External Shutdown" when engine is off

A. Normally, the shutdown state is shared from the Brain to the Ignition without using the shutdown wire. Turn off the Brain and disconnect the shutdown wire (ECU panel harness "SHUTDN"). Cycle power on the ECU, and the state should be "Ready to start". If not, it is likely a board issue or a harness disconnect to the panel plug pin 4.
B. As the shutdown pin is connected and disconnected from ground, the state should switch between 'externally disabled' and 'ready to start'. If not, it is a board issue. Note: If the state is 'configuration required' then the board should be configured first.
C. If (B) passes, turn on the Brain. As the state changes from stopped to running, the ignition state should switch from externally disabled to ready to start. If not, the Brain may be out of date.

Hall sensor or TDC index moving, but erratic or not resolving correctly

A. Verify that the ignition setup is correct. The inputs shown as active in step 1 of ignition setup should be the same as the sensors on the engine.
B. Verify that all the connections are well established (see wiring info in "Hall sensor not moving" above)
C. Route the hall harness as far away from the coil harness and other noise sources as possible
D. If using the flange mounted hall sensor, make sure that the sensor is well seated against the engine.

Narrowband O2 reading is 0 or otherwise incorrect

A. Note that the O2 reading will not show up until the run signal is met, under AFRC “Setup” -> “Run Signal Trigger”
B. If the AFRC is displaying the O2 reading in units of lambda (λ), the sensor type setting is incorrect. Go to the AFRC setup and change the O2 type to Narrowband.
C. With the AFRC plug disconnected (at the sensor), the AFRC screen should show an O2 reading of around 450-550 Mv. If not (assuming the run signal is met), the board may be damaged.
D. If (C) passes, check with a multimeter on the loose harness going back to the panel that V DC from pin “B” to any ground is around 0.45-0.55 volts. If it is not, the harness itself is miswired or not landed correctly.
E. If (D) passes but the reading is still zero when plugged in, then the O2 sensor itself is damaged, or the O2 reading is truly very lean
F. If the sensor is consistently low (lean), the sensor may be at its lifetime

Thermocouple reading incorrect

A. If the TC reading is consistently low only with the engine running, the thermocouple may be picking up noise. Check that the wires are routed away from noise sources.
B. Unplug the TC and ground the harness end connector between +/-. The temperature should be near ambient. If not, there is a harness or board issue.
    a. Leaving the jump in place, if the 14-pin ECU connector is removed, there should be continuity on the harness end between 2/3 for precat or 4/5 for postcat (depending on where the jump was placed). If not, then the harness has a break.
C. Verify the polarity of the TC wires are correct. If backwards, the TC will read from ambient *down* instead of ambient *up*.

Output Issues

Module does not show up on DCT home page

A. If only one module is missing, make sure that the software is updated on that module.
B. Make sure the CAN wiring on the panel harness is landed correctly and routed to the next module (typically Brain).
C. Verify the CAN termination switches in the panel are set correctly according to schematic. In most cases, the screen should be terminated and each other module within the panel unterminated.
D. Verify the power light is on the ECU, if not , check the power wiring.

Throttle not moving

A. Unplug the throttle body connector at the throttle body, and check the voltage between pins 1 and 4 on the harness. When someone hits ‘Calibrate Now’ on the governor calibration screen, for a couple seconds there should be around +/- 12V between the two pins. If not, the board likely has an issue or there is a harness break.
B. To check for a harness break, plug the throttle back in and unplug the white 23 pin conector on the ECU. Check the resistance between pins 3 and 4 on the connector, it should show around 2-5 ohms. If much higher, it indicates a likely harness issue.
C. If the above passes, it is most likely a bad throttle body.

One or more coils do not fire

A. If no coils fire, first verify on the input status screen that the ignition is even trying to fire. If not, troubleshoot the inputs using the above sections
B. Make sure the ICM status shows ‘Ready to Start’ before starting the crank
C. Using the Ignition “Setup and Testing” -> “Engine Off Diagnostics and Testing” each cylinder can be tested with the engine off. During each test, every coil positive pin should be energized with battery voltage, but only the coil under test will have its negative pin grounded out during fire.
    a. If the ICM shows the test in progress but there is no voltage at the positive pins, there is a connection issue in the harness or ECU plug.
    b. If the ICM shows the test in progress but the pin is not firing, try a few other coils. The negative wire may be mixed up with another coil.
    c. Swapping a coil/secondary/plug with a neighboring cylinder may reveal a bad part

Coils fire in test, but when cranking engine one or more do not fire

A. Make sure the input status shows that the tooth count is good. If the index input is incorrect some coils may be prevented from firing
B. Make sure the dwell time is set long enough to fire the plugs while the cylinders are compressed. A good starting point is 1.5ms for 24 v engines and 4ms for 12v engines.

C. Check to see if any secondary leads appear to be arcing out. The voltage demand in compression will be higher than during engine off testing, and misfires will be more likely.

Ignition resets during operation or throws reset code

A. Verify that there are good ground connections directly to the skid. If needed, run a chassis wire from the ECU to the engine block.
B. Occasionally the ICM will reset on shutdown when all the coils are shut off, after the engine shuts down for another reason.

DPV does not move or may not be moving

A. With the engine off, unplug the ECU 23-pin white plug and check the resistance from pins 11-12 on the harness, then 19-20 on the harness. Each pair should be around 50 ohms. If not, it is a harness issue, or less likely a bad DPV.
B. With the engine running, run the DPV in manual on the screen open and closed, and see if the O2 reading shifts. If so, the DPV is operating. If closing the valve causes the engine to go *rich*, then some of the wiring is swapped and the valve is operating backwards.
C. If (A) passes but the DPV is definitely not moving, the board itself may be bad

Control issues

RPM is erratic

A. Navigate to speed controller “Setup” -> “Engineering Setup”. Try adjusting the “Throttle gain setting” up and down (especially up). If this does not have an effect, return to “50”. Similarly try increasing or decreasing the “RPM gain adjustment”. In general, increasing the RPM gains will cause faster response but potentially lower overshoot. Lowering the RPM gains leads to slower response but less overshoot.
B. Verify that fuel pressure and AFR are relatively steady
C. Make sure there is not an active alarm for throttle feedback error. If there is, recalibrate the throttle with the engine off.
D. If the throttle body has been in use for a long time, the gear may have enough wear in it that the throttle plate has too much slack

Engine will not start

A. While cranking, verify that RPM is showing up. If it is not, go to section above “RPM Reads ‘0’ when cranking”
B. If (A) is ok, verify that the throttle goes to an open position during cranking. If not, go to “Throttle not moving” above.
C. If (B) is ok, the starting throttle may need to be adjusted. This is under governor “Setup” -> “Engineering Setup”.

Spark durations are abnormally low on one or more cylinders

A. Spark plug could be fouled or the gap too wide

B. The dwell time may not be set high enough for the compression of the engine
C. The fuel mixture may be overly lean

Spark durations are abnormally high on one or more cylinders

A. The spark plug gap could be too narrow
B. The secondary circuit could be grounded out or misfiring. Replace the secondary lead if needed.
C. The compression on the cylinder may be low
D. The dwell time may be set too high

Ignition displays “Bad Configuration”

A. Update to the latest ignition version to make sure any bad config values are cleared out
B. Make sure there aren’t two cylinders firing the same pin

Timing light shows a timing that does not match what is displayed on the screen

A. Use the Ignition “setup” -> “Timing Calibration” screen to calibrate the timing.

Ignition displays “Bad peak count” fault and/or has erratic timing

A. See the debug steps above under “Hall sensor or TDC index moving, but erratic or not resolving correctly”
B. If the flywheel has any broken teeth, make sure that the configuration is set to the *original* number of flywheel teeth
C. Make sure the flywheel is relatively clean of debris

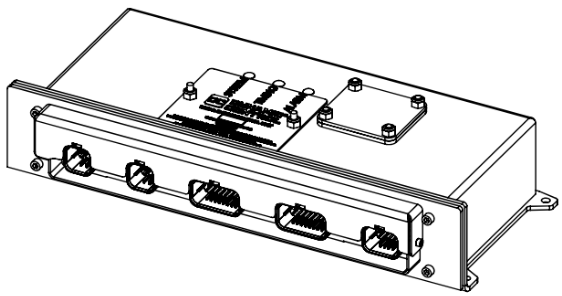
DPV limit stays at/near maximum, or AFRC throws “loss of control” alarm

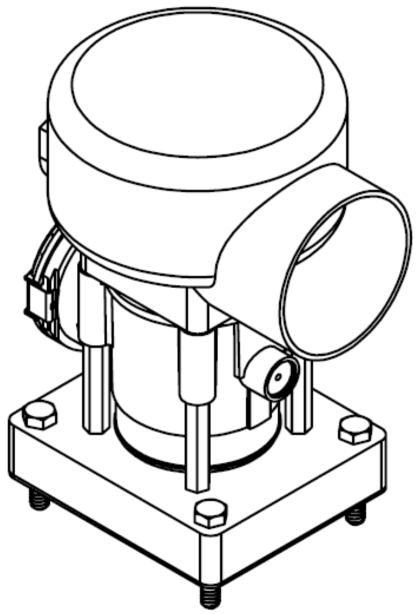
A. Adjust the fuel pressure to get the valve more in the center of the range
B. Verify in manual mode that the DPV is moving in the correct direction

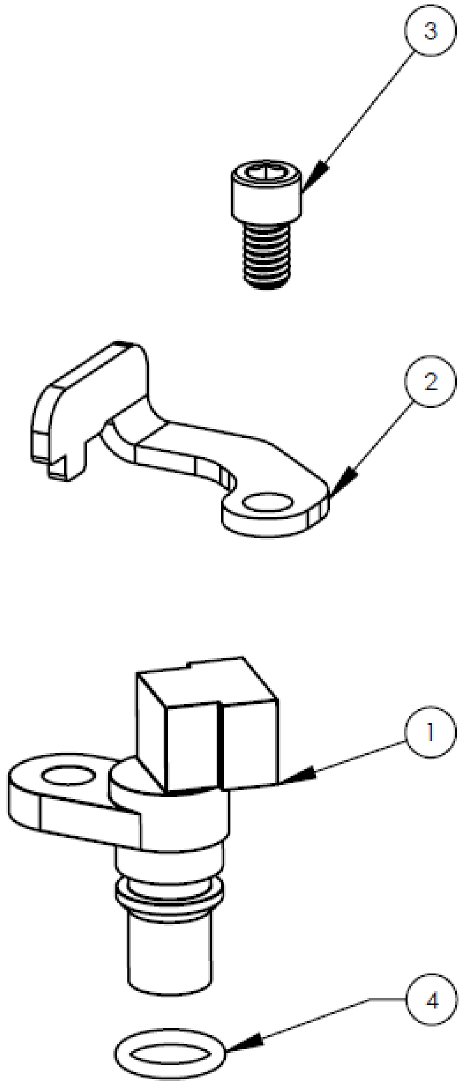
In ‘Autocontrol’ mode, the AFRC tends to rest very rich

A. Lower the ‘postcat lean threshold’ 50-100 points
B. Adjust rich/lean setting up

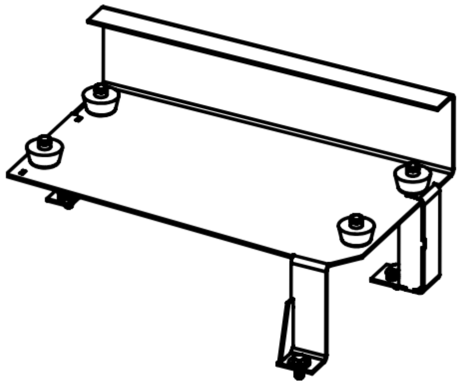
Appendix A: Part Identification

Image	Part description	EMIT item number
	ECU Assembly	20390
	ECU Coil harness, 6cyl	15657-0001
	ECU Panel harness	15656-0001
	ECU Main Engine Harness, CAT 330xB	15655-0001
	ECU Exhaust Harness, manifold mount catalyst	15658-0001
	Thermistor probe (coolant and oil temperature)	13255-0001
	Thermocouple assembly 3' (pre/post cat)	13062-0001)

	Throttle/Mixer Assembly 3306 TA	17011-2002
	Ignition Coil, standard	14330-0001
	Spark plug 14mmx19mm	14331-0001
	Spark plug wire, 330x	14332-0001
	Mag pickup assembly	13211

	Hall effect sensor and bracket for 330xB	13240-0002
	Coil harness bracket 330x	64595-0133
	Oxygen sensor weldment	13020

	Manifold pressure sensor, 0-50 psi absolute	13063
	Oxygen sensor, narrowband	13009
	Oil pressure sensor, 0-100 PSIg	13064
	¼ MNPT x 1/8 FNPT bushing	17115-0019
	¾" inline DPV	12014

	ECU Mount Kit, 330xB	20393-0001

Appendix B. Software License Agreement

This License Agreement ("Agreement") is a binding contract between EMIT Technologies, Inc., a Wyoming corporation ("EMIT" or "Licensor"), and you ("User or Licensee"). Your acceptance of the terms of this Agreement shall be deemed effective immediately upon your receipt of the Dynamic Control Touchscreen (the "Equipment") on which EMIT's proprietary and confidential software (the "Software") has been installed. If you do not accept the terms of this Agreement, you must return the Equipment and Software to EMIT and refund or credit will be issued to you.

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- In consideration of the matters described above, and of the mutual benefits and obligations set forth in this Agreement, the parties agree as follows:

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10. SEVERABILITY. If any substantial or essential provision of this Agreement is held to be invalid or unenforceable in any jurisdiction, the parties agree to negotiate an appropriate change or amendment to this Agreement as to such jurisdiction. If any provision of this Agreement is held to be invalid or unenforceable in any jurisdiction and the provision is not substantial or essential to the Agreement, the Agreement shall be continued in that jurisdiction as if the invalid or unenforceable provision was not included.

11. ENTIRE AGREEMENT. This Agreement constitutes the entire Agreement between the parties. Any prior understanding or representation of any kind preceding the date of this Agreement shall not be binding on either party except to the extent incorporated in this Agreement.

12. MODIFICATION OF AGREEMENT. Any modification of this Agreement or additional obligation assumed by either party in connection with the relationship established through this Agreement shall be binding only if evidenced in writing, and signed by an authorized representative of Licensor and Licensee.

13. GOVERNING LAW. This Agreement shall be governed by, construed, and enforced in accordance with the laws of Wyoming.

Appendix C. GNU General Public License

Version 2, June 1991

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