Dynamic Control

Installation, Operation, Troubleshooting Manual

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.

EMIT Technologies, Inc.

D.C.T. P/N: 20370 12-30V, 2A Class 1, Div. 2, Groups A, B, C, & D
T4 Amb. Temp. -40 to 149°F (-40 to 65°C)

Conforms to ANSI/ISA Std 12.12.01, Certified to CSA Std C22.2 No. 213

WARNING: DO NOT OPEN OR REMOVE COVER UNLESS THE POWER IS SWITCHED OFF OR THE AREA IS KNOWN TO BE NON-HAZARDOUS.

WARNING: SEE INSTRUCTION MANUAL

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

ATTENTION: CONSULTER LE MANUEL D'INSTRUCTIONS

ETL CLASSIFIED
C ETL LISTED US
Intertek
4008500

Standards

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]

Models

EMIT Total Solution, Includes EIM, EMD, AFRC Lite, AFRC Adv
For Use In: Class I Division 2, Groups A,B,C,D, T5
Ambient Temp: -40°C to +65°C

ICM2-8 and ICM2-16 Cylinder
For use in: Class I Division 2, Groups A, B, C, D, T4
Ambient Temp: -10°C to +70°C

ICM1-8 Cylinder (20270)
For use in: Class I Division 2, Groups A, B, C, D, T4
Ambient Temp: -40°C to +70°C

ICM1-16 Cylinder (20280)
For use in: Class I Division 2, Groups A, B, C, D, T4
Ambient Temp: -40°C to +70°C

Governor (20310)
For use in: Class I Division 2, Groups A, B, C, D, T4
Ambient Temp: -40°C to +65°C

Annunciator (20320)
For use in: Class I Division 2, Groups A, B, C, D, T4
Ambient Temp: -40°C to +65°C

Annunciator Expansion Module (20330)
For use in: Class I Division 2, Groups A, B, C, D, T4
Ambient Temp: -40°C to +65°C

EDT (20350)
For use in: Class I Division 2, Groups A, B, C, D, T4
Ambient Temp: -40°C to +65°C

LED Light Bar (14431-0004)
For use in: Class I Division 2, Groups A, B, C, D, T4
Ambient Temp: -40°C to +65°C

DCT (20370)
For use in: Class I, Division 2, Groups A, B, C, D, T4
Ambient Temp: -40°C to +65°C

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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.

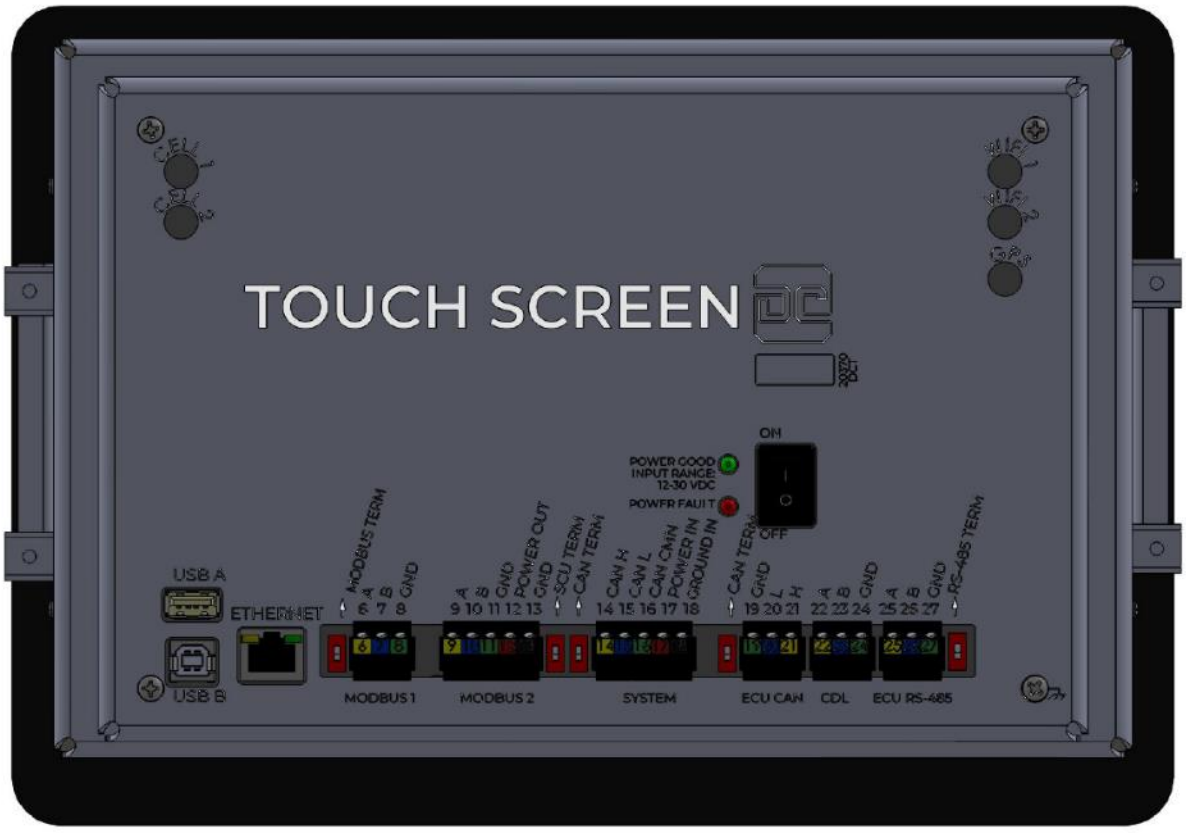
This offer is available to anyone in receipt of this information.

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 system is built around the Dynamic Control Touchscreen, which provides a 12” touchscreen display to present data and interact with any connected modules. Modules are connected to the touchscreen through a high-speed daisy-chain style configuration, and upon detection are automatically made available for operation within the display. The display also acts as the communication hub for the system providing access to datalog downloads through USB, remote data access through Ethernet and RS-485 connections, local WiFi Access, and cellular remote data access.

Touchscreen Connections



The connections available on the back of the touchscreen are shown in the diagram above, and include the following:

- SYSTEM: Main power and communications connector. Input voltage is 12-30v DC and should be fused to 2A
- MODBUS 1,2: Modbus ports for connection to SCADA system (RS-485). Can be configured for different baud rates.
- ECU CAN, CDL, ECU RS-485: Connection options to ECUs (Engine control units)
- ETHERNET: Ethernet port for Modbus/TCP
- USB A: USB Host port for downloading datalogs and other items to a thumb drive
- USB B: Manufacturing use only
- CELL 1,2: Connections for cell phone antenna(s) for remote data collection if activated. Cell 2 is only used in rare cases where signal strength is very low.
- WIFI 1,2: Connections to wifi antenna(s) for local viewing of runtime data on a cell phone
- GPS: Connection to GPS antenna

NOTE: The back connections should be protected from access in the panel by some tool-required latch.

Touchscreen Electrical Specifications

Power

- 12 – 30VDC power supply input range
- Typical power consumption: 11W (Low brightness) - 25W (Max brightness)
- Maximum power consumption: 30W

Environmental

- Temperature: -30°C to +85°C (-22°F to 185°F) T4
- Humidity: 5% - 90%, non-condensing

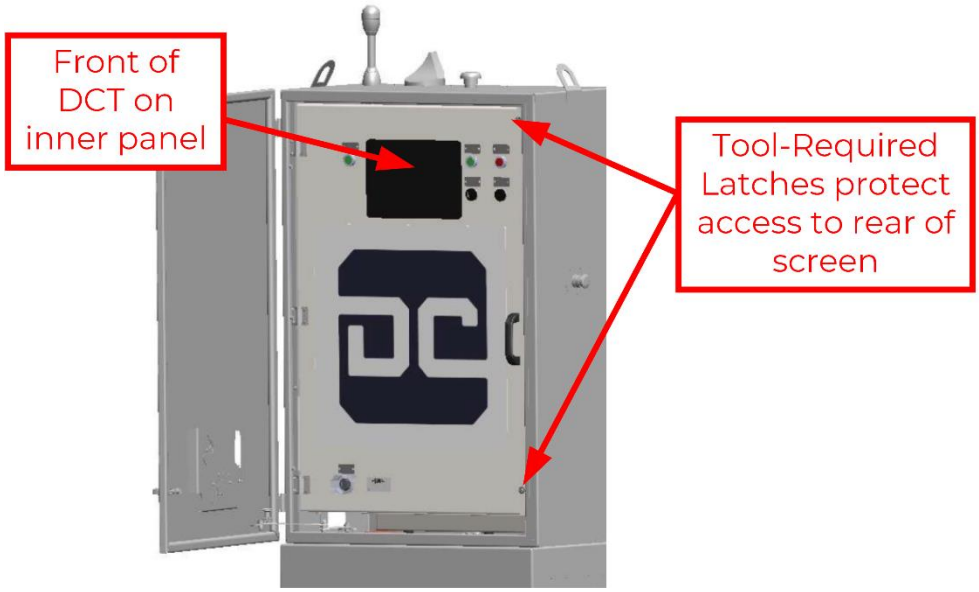
Communication

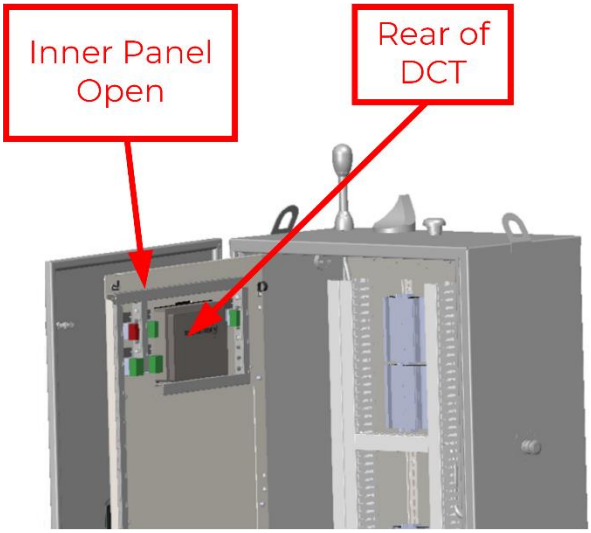
- Controller Area Network (CAN) network for access to additional EMIT modules
- USB host for datalog access and software updates
- RS-485 half-duplex MODBUS RTU (2)
- Ethernet port for Modbus/TCP access
- Wifi Antenna for local wireless access to unit information
- Cell module for remote data collection and callouts
- GPS for location service & accurate time

Touchscreen Mounting

The touchscreen should be completely enclosed in a IP54 or better enclosure to adequately protect it from environmental hazards. Additionally, when the enclosure is open, the back of the touchscreen (switches and connectors) should be protected from being accessible by some method that requires a tool to access.

Enclosure and access protection example shown below.





To mount, place gasket behind touchscreen then insert into inner panel cutout. While holding the touchscreen in the panel face, attach the mount clips on the back of the unit and finger tighten to keep the touchscreen in place. Finally, tighten the four clips to 6 lbf-in (0.68 N-m).

Dynamic Control Touchscreen Overview

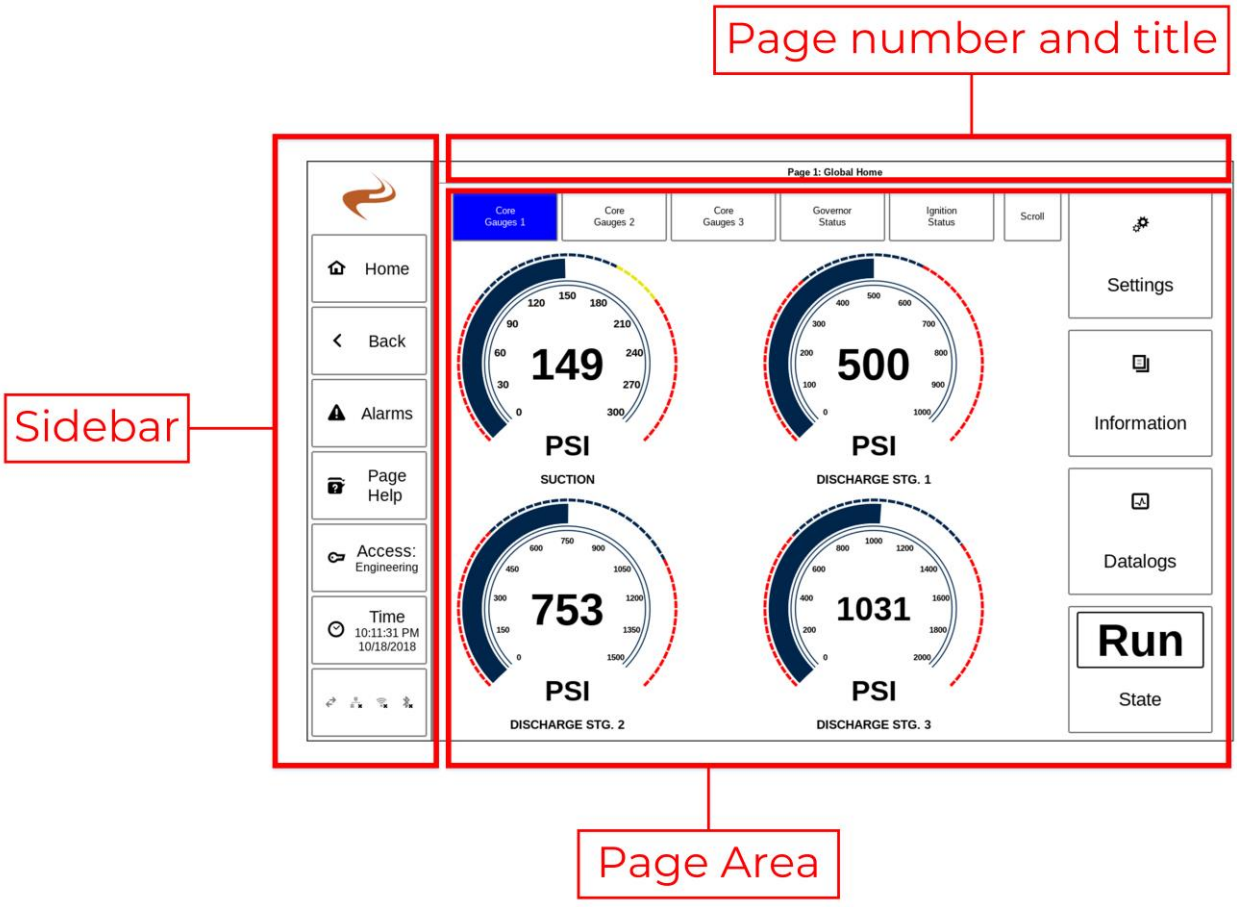
The EMIT Dynamic Control Touchscreen provides a 12” display and communication hub for any one module, or multiple modules, connected to the Controller Area Network (CAN) of the screen. Modules connected to the CAN port will automatically be displayed as ‘tabs’ on the system home screen of the display. Selecting any of the module buttons allows for current status of that module.

Other functions not directly related to module interaction include the system run signal trigger, security passwords and access, timer management, alarms, date and time, sensor data logging, and MODBUS communications.

The touchscreen is designed to be mounted directly into panel face.

User Interface Overview

An example of the home page is shown below.



Page Number and Title

The top of the page shows the page number and title of the page.

Sidebar

The sidebar is always present on the left side of the screen. The following buttons are in the sidebar:

- **Home:** Always returns to the system home screen. (Shown in the example)
- **Back:** Returns to the previous page
- **Alarms:** Views current active alarm events and old acknowledged alarm events. Additionally, logs of recent shutdowns can be viewed.
- **Page Help:** Will show a popup with help for the current page, if available.
- **Access:** Shows the current access level, and shows a keypad for entering a password. Higher access levels allow for more settings changes.
- **Time:** Shows the current time, and navigates to a screen for setting the time and viewing expired timers. If a timer is expired the icon will flash.
- **Connection Status:** Shows the status of the CAN, Wifi, Cell, and GPS signals. Selecting the button navigates to the connection information page.

Basic Navigation

The home page will show 'tabs' along the top for connected modules.[1] The Brain (core) module, if attached, can have multiple tabs.

Selecting a tab or swiping the central area will change between status slides for each module. For the Brain module gauges (e.g. Suction pressure, Oil Temperature) the gauge can be selected to see more information for that input.

The 'Settings' button on the Home page navigates to the settings menu to access settings for all modules.

The 'Datalogs' button will navigate to the datalog display page to view long term datalogs for any sensor.

The 'Information' button will navigate to the Information menu which leads to various informational items for different parts of the system.

The bottom-right button of the Home page will show the current Brain module state. Selecting the button will navigate to more status information for that module. This page will be discusses in a later section.

Access Levels

The active security access is displayed in the "Access:" button in the sidebar. To change the security access mode, select the "Access:" button and input the password of the desired security using the keypad. Available security levels include:

- Read-Only – Limited access to system features. No adjustments can be made.
- Setup – Access to most system features and settings.
- Engineering – Access to all system features including advanced adjustments.

[1] If the internal data translator (EDT) is disabled, its tab will not be shown.

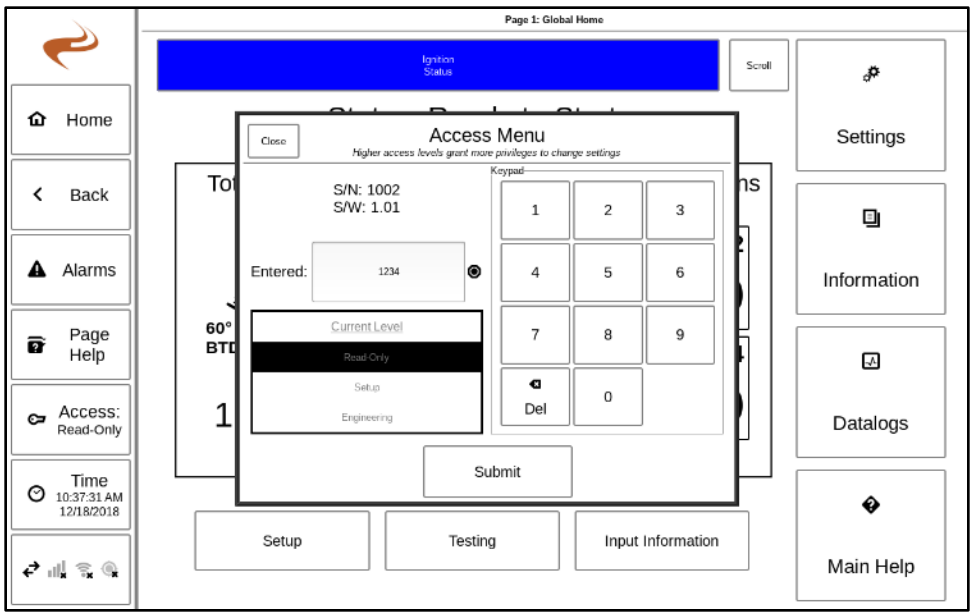


Figure 1. Access Menu Popup

When shipped, the passwords will be attached to a tag on the back of the unit. Type in the password in the dialog and select 'Submit' to enter the new level.

Optionally, a USB security key can be purchased that allows for the touchscreen to be changed to 'Security Key Required' mode. In this mode, the USB security key must be inserted to access engineering access level, while the Setup level will still be accessed with a normal password. The key itself is also used to set or clear the key required setting.

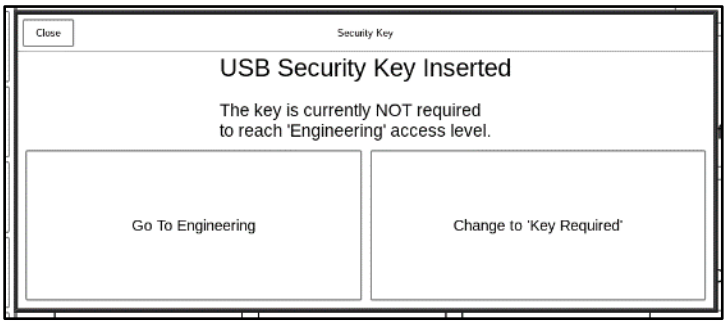
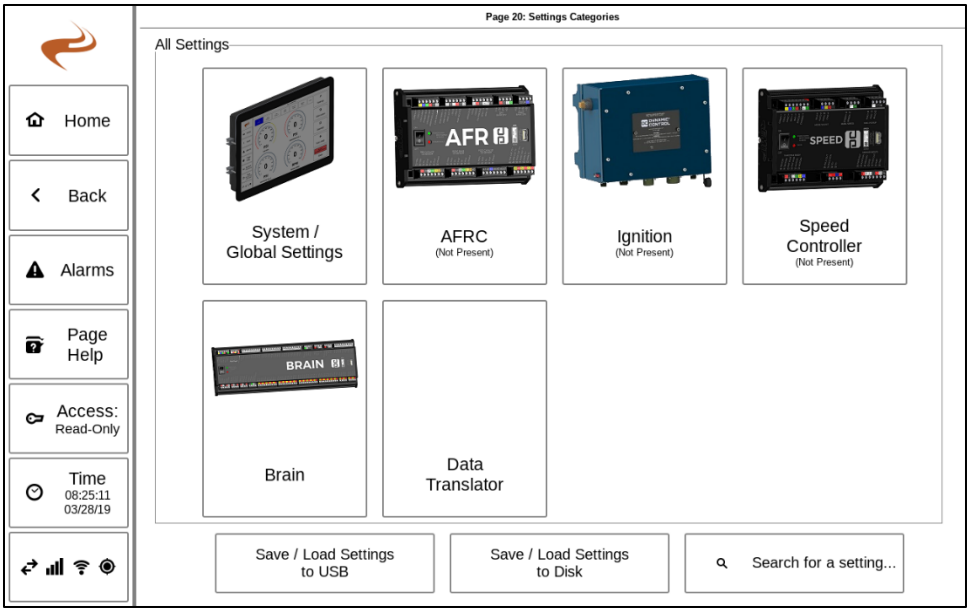


Figure 2. Dialog that pops up when key is inserted

If the system is in 'Key Required' mode, while the key is in the different levels can be accessed normally. With the key removed, the 'Engineering' password will not work.

Settings Navigation

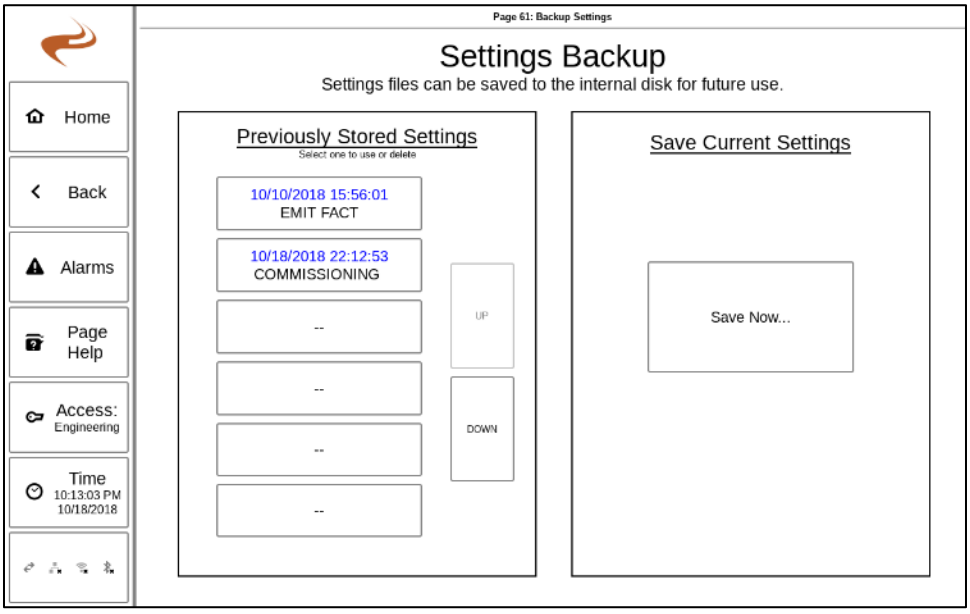
The 'Settings' button on the Home screen can be selected to navigate to the **Settings Categories** Menu, shown below.



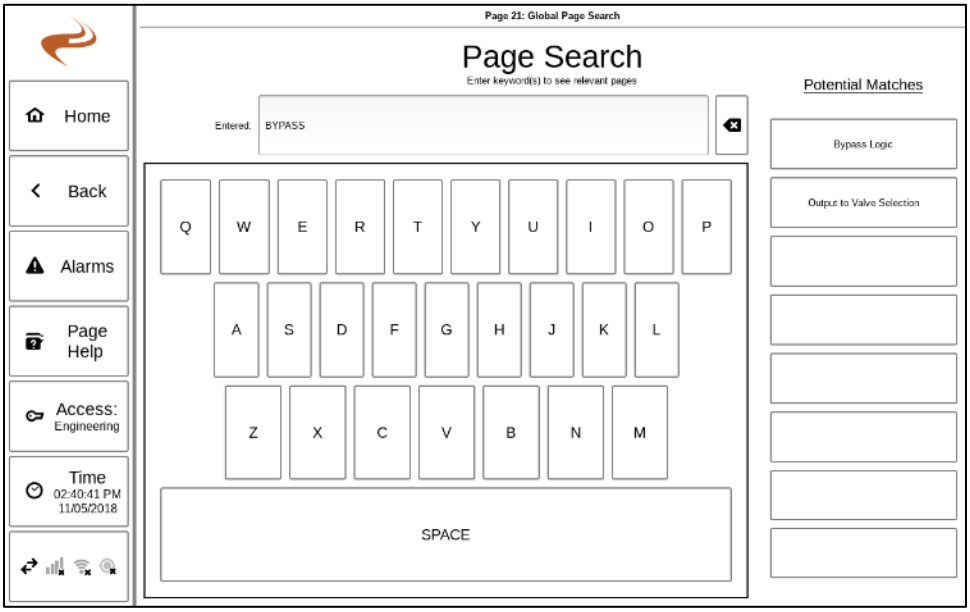
Each module is shown as a category, so selecting that module will navigate to the module settings menu. The 'System / Global Settings' button navigates to settings options that are not limited to one particular module. Options under that menu are covered in the next section.

The Settings Categories page also has three utility buttons:

- **Save / Load Settings to USB:** This page can be used to save and load settings off a flash drive for backup purposes or to use on another unit
- **Save / Load Settings to Disk:** This page can be used to make backups of unit settings at particular times, in case settings need to be rolled back in the future.



- **Search for a setting...:** Because there are many settings on the system, this page can be used to quickly find a setting instead of navigating through normal menus. Simply type a keyword or title of the setting and potential matches will appear on the right.



System / Global Settings

The System / Global Settings menu navigates to these setup pages

Software Update

This screen is used to update the touchscreen software. To use, insert a USB drive with the update file (ending in .tar), and select 'Start Update'. If there are more than one update file on the drive, a dialog will ask which one to use.

Display Settings

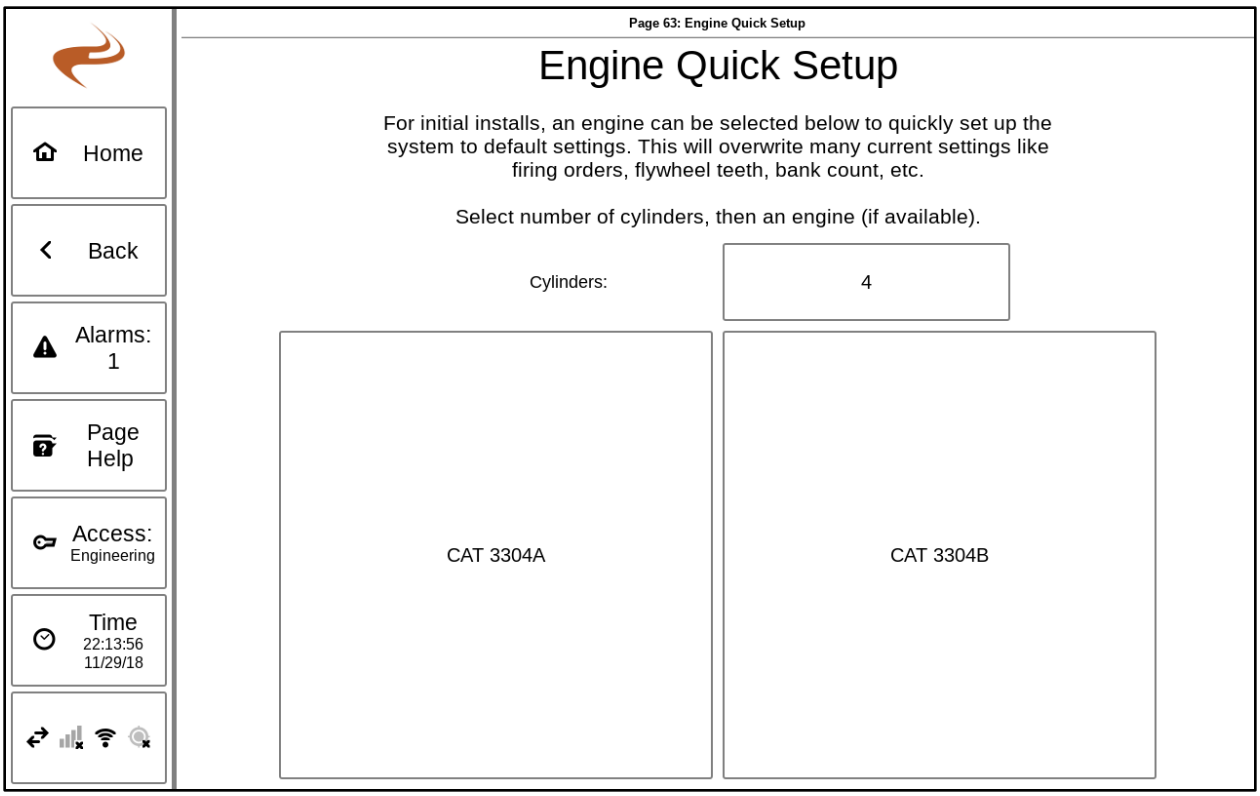
This screen is used to change the screen brightness. Note that higher brightness creates more heat.

Go to Page

This screen is used to jump to a specific page by the page number.

Engine Quick Setup

This screen is used to pre-fill many settings for the AFR, Speed controller, and Ignition with default settings for a particular engine. This will overwrite many settings for those modules, so it is intended to be used only on a new install.



To use, select the number of cylinders at the top of the screen, then select the engine in the list. The system will overwrite with default settings for that engine to the AFR, Ignition, and Speed controller.

Compressor Quick Setup

This wizard guides through the process of initially setting up the Brain module. This can be used on install to save time in entering settings.

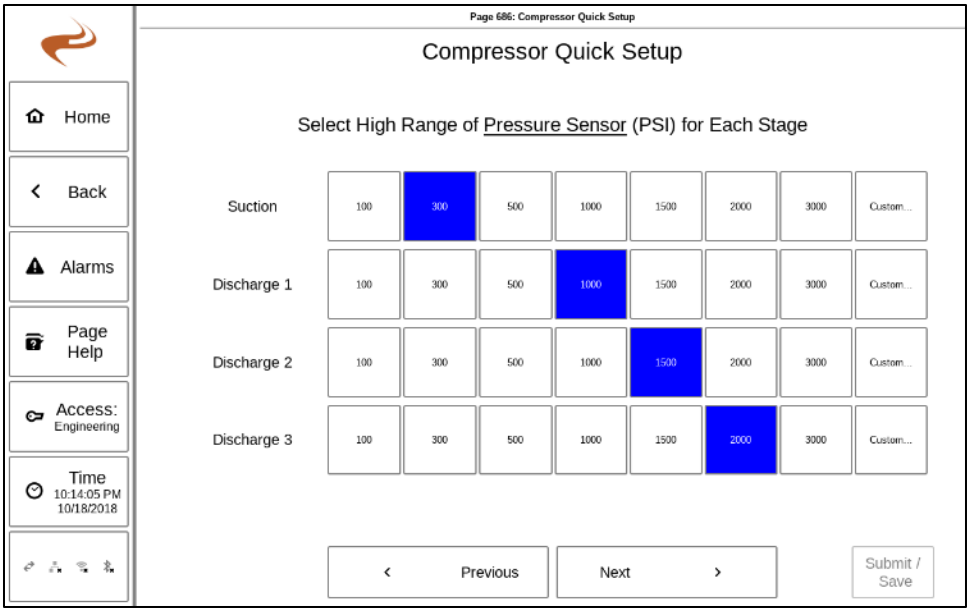


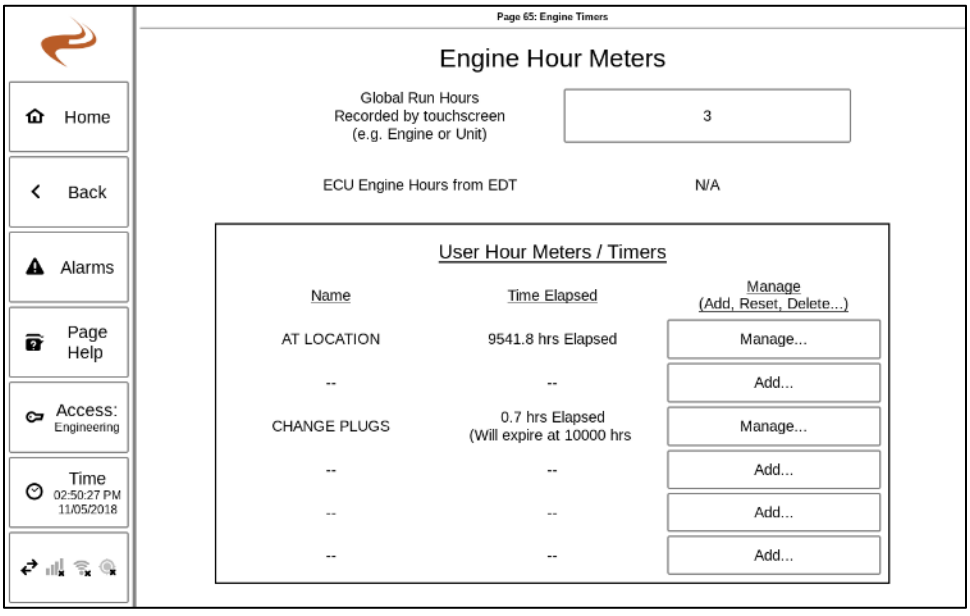
Figure 3. Compressor quick setup step 2

- Slide 1: Select the number of stages and cylinders for the compressor
- Slide 2: Select the high pressure sensor range for each process stage
- Slide 3: Select which other sensors are used
- Slide 4: Review and save if needed

The compressor quick setup will overwrite many Brain (Annunciator) settings with the new sensor settings. This is intended to be used only once on initial install.

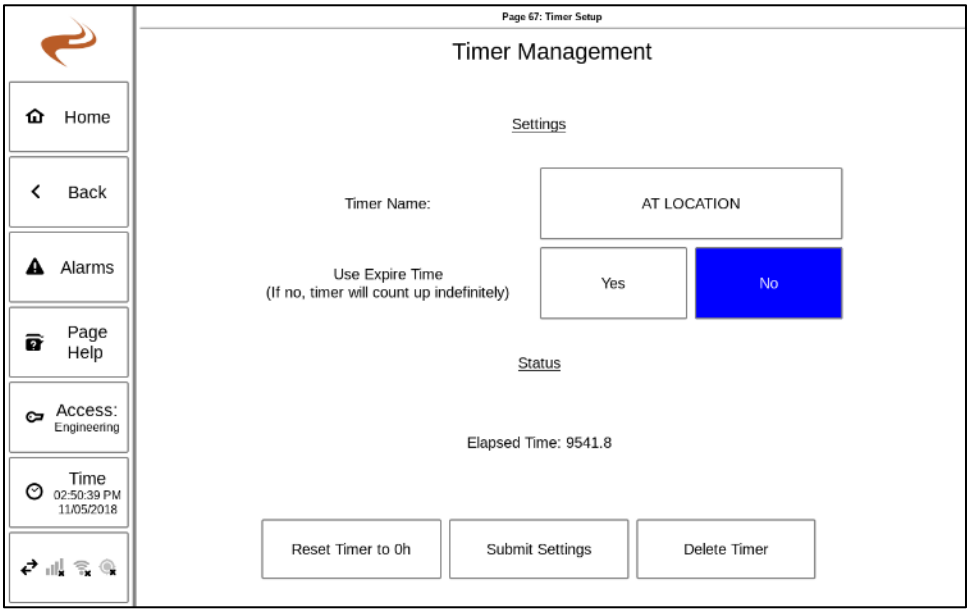
Engine Timers

This page is used to view the current run hours, and to add individual hour meters or timers. A screenshot of this page is shown below.



For the individual hour meters / timers, the timer can optionally be configured to have an expiration time. For timers without an expiration, the system will track the run hours indefinitely for that timer until reset. For example, there could be hour meters for time spent since last overhaul or since at the current site. For a timer with an expiration, the system will flash the Time icon when a timer expires. This can be used for maintenance events.

To add or manage a timer, select the box on the right side of the row. This will bring up the timer management screen.



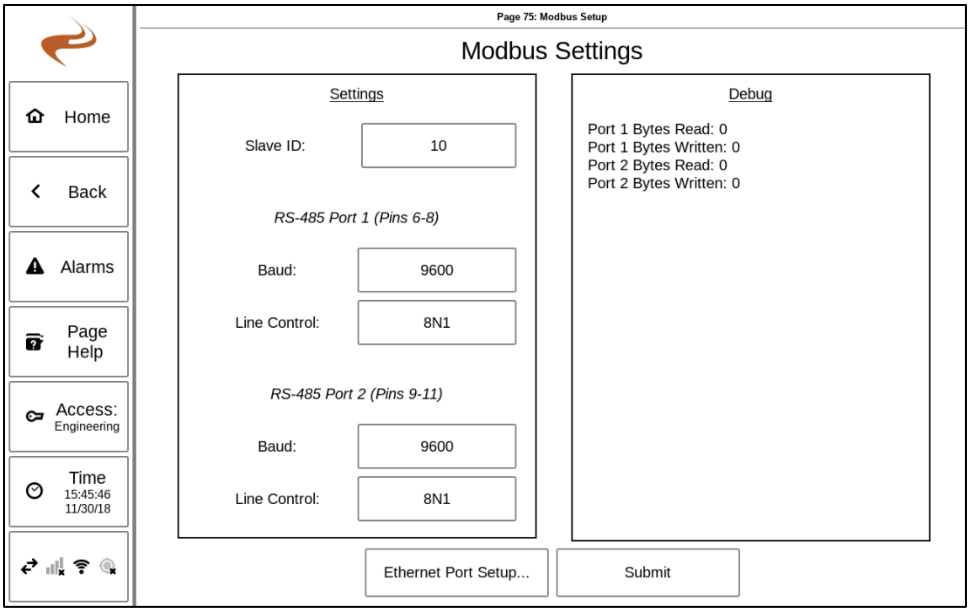
On this screen, enter a name for the timer and select whether it has an expire time. If it does expire, enter the expiration time. Also on this page a timer can be reset (to 0 hours) or deleted.

Modbus Setup

The Dynamic Control Touchscreen features two RS-485 Modbus RTU ports, along with an Ethernet port for Modbus/TCP. These can be used to gather data into a remote SCADA system.

For the RS-485 bus, the wiring should be in a 'daisy chain' arrangement, where all devices on the bus are on one chain of the same connection. The two devices on each end will be *terminated* with a resistor – in the case of the DCT, there is a switch next to the RS-485 plug to choose if terminated or not terminated.

The Modbus setup page is shown below.



Slave ID: There is one slave ID for the system. Set this value so that it matches where the SCADA is attempting to pull data, and make sure no other device on the bus has the same ID.

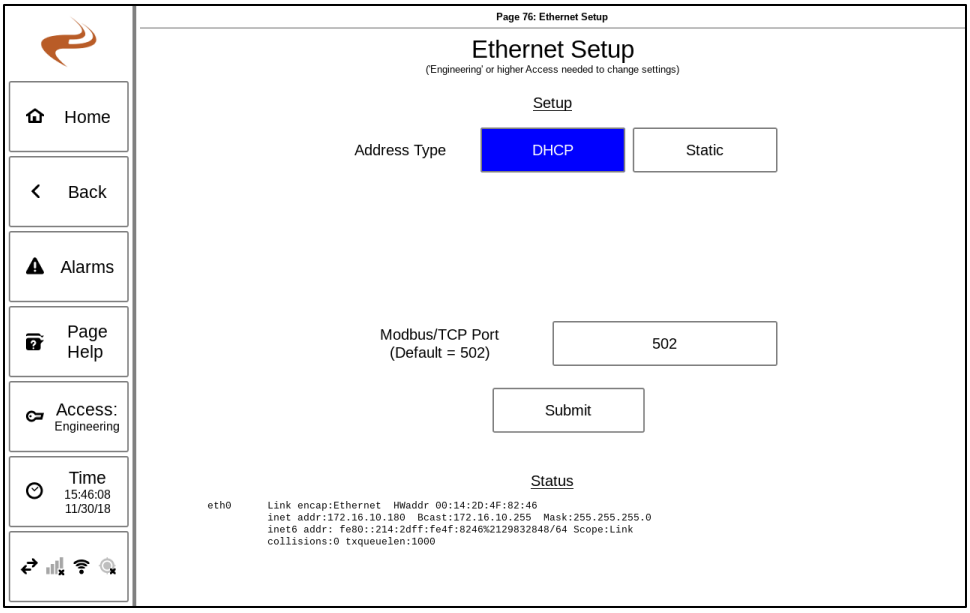
Port Settings: Each port can be configured to have individual baud rates and line control modes. Each will still target the same ID though.

For information on available registers and scaling, see a separate document "Dynamic Control Touchscreen Modbus".

Ethernet Setup

The Ethernet setup page is used to setup the IP address settings of the Ethernet port. Select DHCP to automatically get an address, or Static to manually specify an address. The Modbus TCP port number can also be specified on this page.

After changing an address, it is a good idea to wait about 1 minute then cycle power on the screen to make sure that the new settings are used properly.



Note: If using the 192.168.0.xxx subnet, be sure to change the WiFi IP address, mentioned below.

Change Setup Password

This page can be used to change the 'Setup' password.

Telematics Settings

This section is used to setup the telematics and callout targets. For more information, see later section "Dynamic Control Touchscreen Telematics".

Format USB Drive

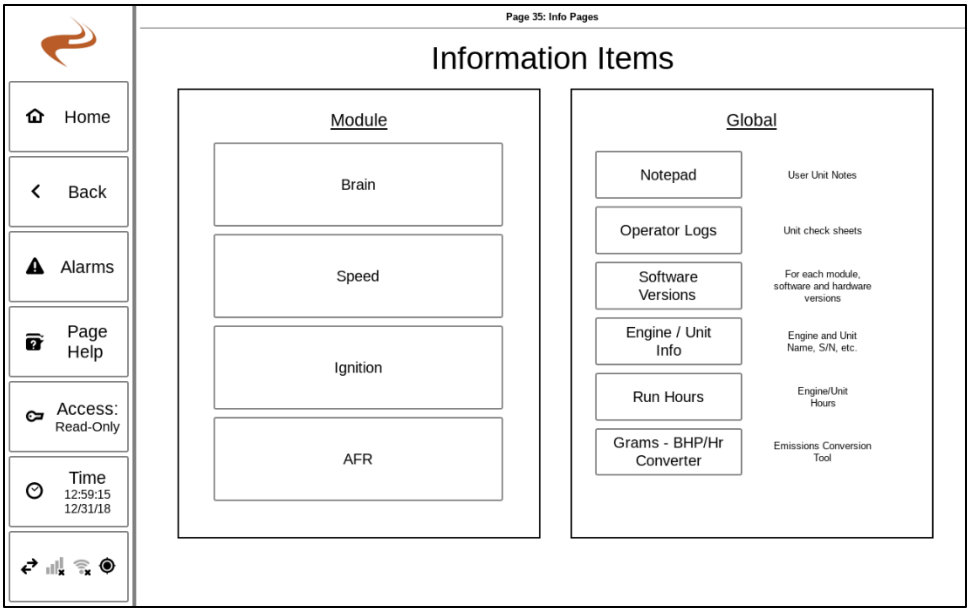
This tool can be used to format a USB drive to ensure it can be used with EMIT modules. This will delete all files from the drive in the process.

WiFi Setup

The WiFi setup is used to change the IP address used by the WiFi port, which is needed if you need to set the wired ethernet port to 192.168.0.xxx . In this case, simply change the WiFi IP to some other subnet, e.g. 192.168.4.1 .

Information Menu

The 'Information' button on the home page can be selected to go to the Information Menu, which links to some global and module-specific information items.



For each of the modules (Brain, Speed, Ignition, AFR) selecting that item goes to a sub-menu (if applicable) of information items for that module. These module information menus are discussed in the appropriate module section of this document. The global items are listed below.

Notepad

The notepad page is used to add user notes for the unit. Notes that might be helpful are emissions testing results, unit adjustments, maintenance events, etc. To add a note, select 'Add' and type a note. The notes can be downloaded when a USB drive is inserted and the screen is in 'Engineering' access level.

Operator Logs

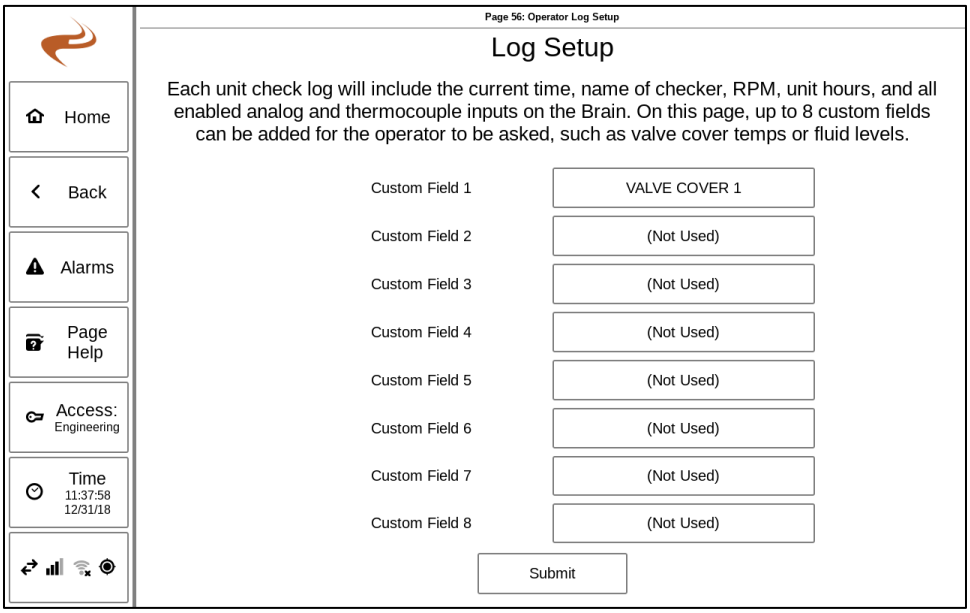
The 'Operator Logs' section of the touchscreen can be used to store unit check sheets. When a log event is added, the unit will save for that date/time:

- Name of person performing check
- All enabled analog input levels, alarm limits, and time of last alarm change
- All enabled thermocouples, alarm limits, and time of last alarm change
- Unit hours
- Engine Speed
- Other custom fields, if needed

The set of all logs can then be downloaded as needed.

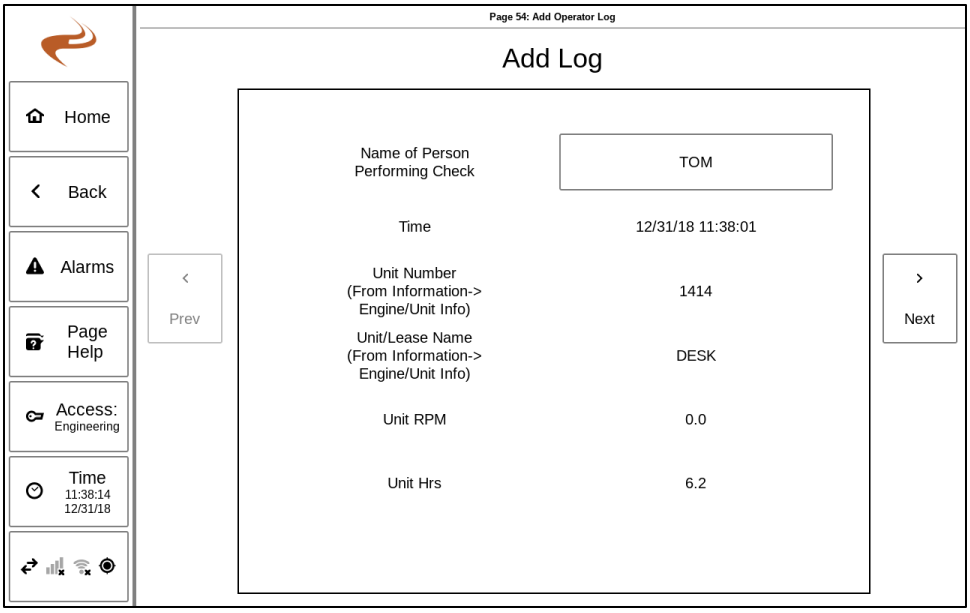
Configuring use of operator logs

To configure the logs, select 'Information' -> 'Operator Logs' -> 'Setup Log Content'. Most items the logs capture are built in, but custom items can be added to this list.

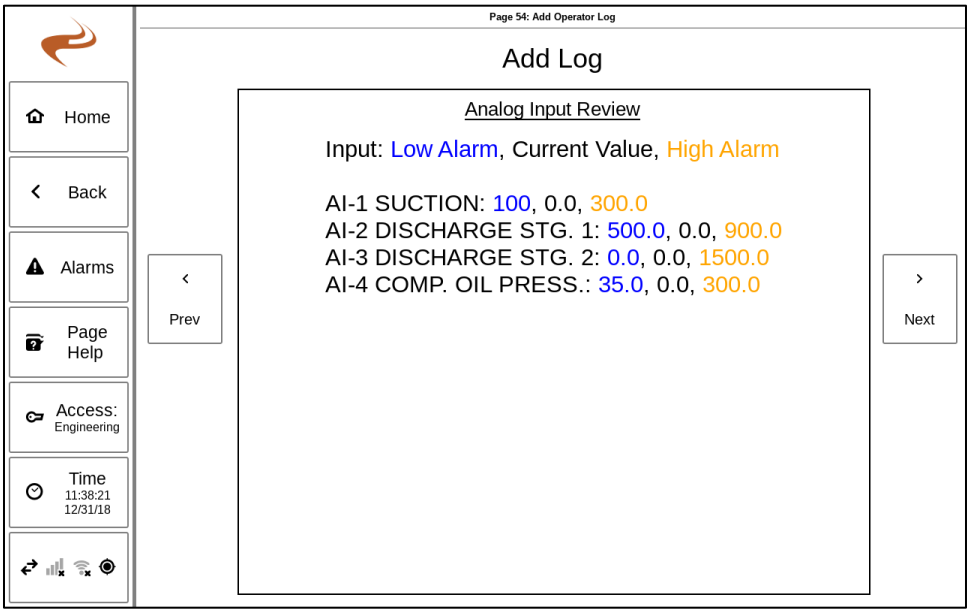


Adding a log event

To add a log, the person performing the check will navigate to 'Information' -> 'Operator Logs' -> 'Add...'. This will lead to a wizard that will go through the steps below.

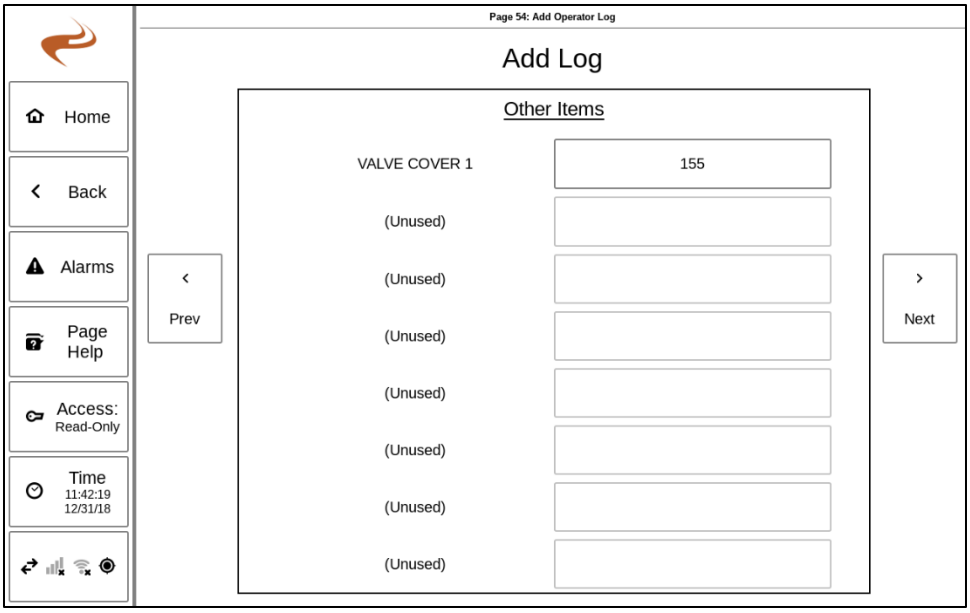


Step 1: The technician will enter their name and verify the time, unit number / name, RPM, and hours.



Step 2: The technician will verify the current analog input readings and alarms

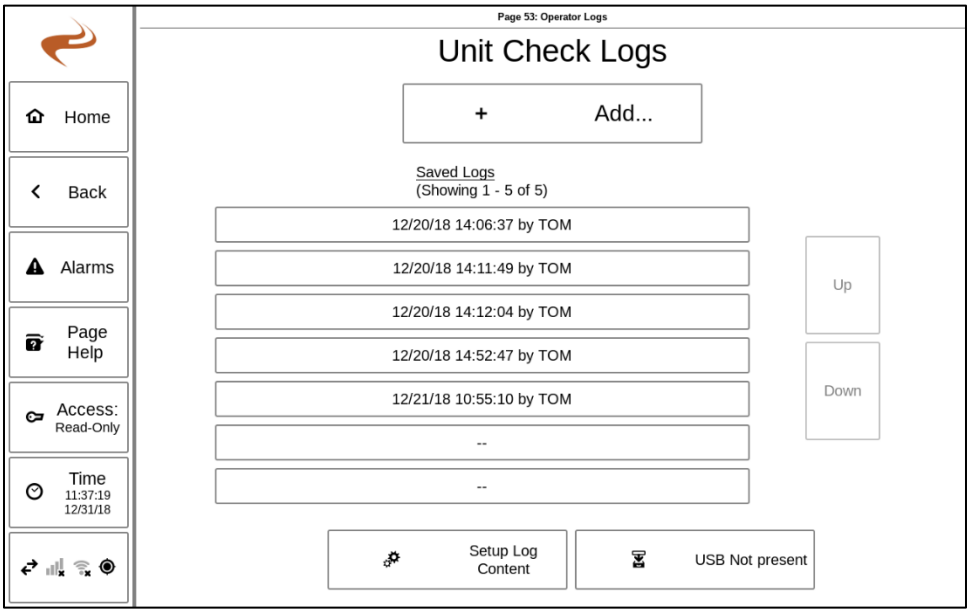
Step 3: The technician will verify the current thermocouple input readings and alarms. The screen appears very similar to the step 2 screen.



Step 4: The technician will enter any of the custom fields that were set up for that unit. In the example above, the only custom question is 'VALVE COVER 1' (temperature).

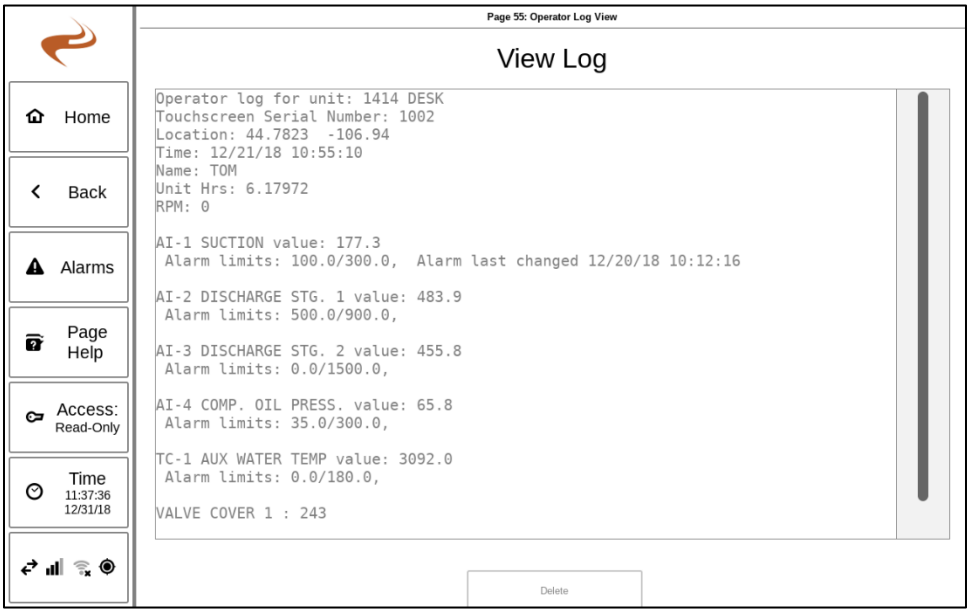
Step 5: Select 'Submit' to save.

Previously submitted logs will be displayed on the unit check log landing page, shown below.



Viewing Logs

From the unit check logs menu shown above, select a log event to see the data from that log event. Use the scroll bar on the right to view the entire log.



Downloading Logs

The list of logged events can be downloaded to view on a computer. There are two options for downloading a log:

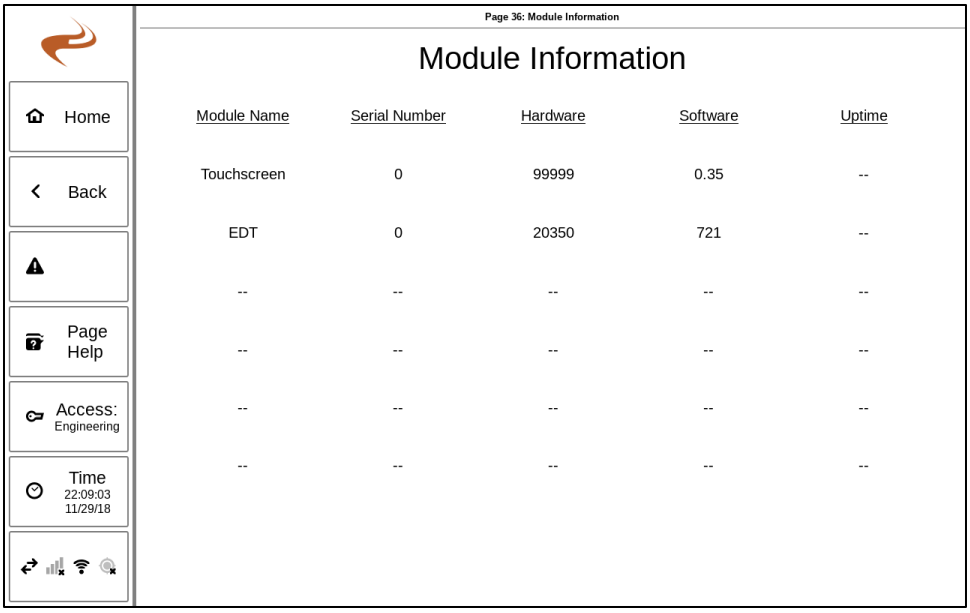
- Text Files: Save each log event as an individual text file. All the files will be copied to the drive, one per event.
- Single Table: Save a table of all the logged events, to view in Excel® or similar program. Each row is an individual event.

	A	B	C	D	E	F	G	H	I	
1	Operator logs for unit: 1414 DESK									
2	Location: 44.7824 -106.94									
3	Generated: 12/31/18 11:42:35									
4										
5	time_stamp	operator_name	unit_hours	rpm	AI-1 SUCTION value	AI-1 SUCTION low alarm	AI-1 SUCTION high alarm	AI-1 SUCTION alarm last changed	AI-2 DISCHARGE STG. 1 value	AI-2 low
6	12/20/2018 14:06	TOM	6.17972	0	177.225	100	300	12/20/2018 10:12	582.5	
7	12/20/2018 14:11	TOM	6.17972	0	177.2	100	300	12/20/2018 10:12	582.5	
8	12/20/2018 14:12	TOM	6.17972	0	177.3	100	300	12/20/2018 10:12	582.5	
9	12/20/2018 14:52	TOM	6.17972	0	177.2	100	300	12/20/2018 10:12	582.5	
10	12/21/2018 10:55	TOM	6.17972	0	177.3	100	300	12/20/2018 10:12	483.9	

Figure 4. Example of part of the downloaded table

Software Versions

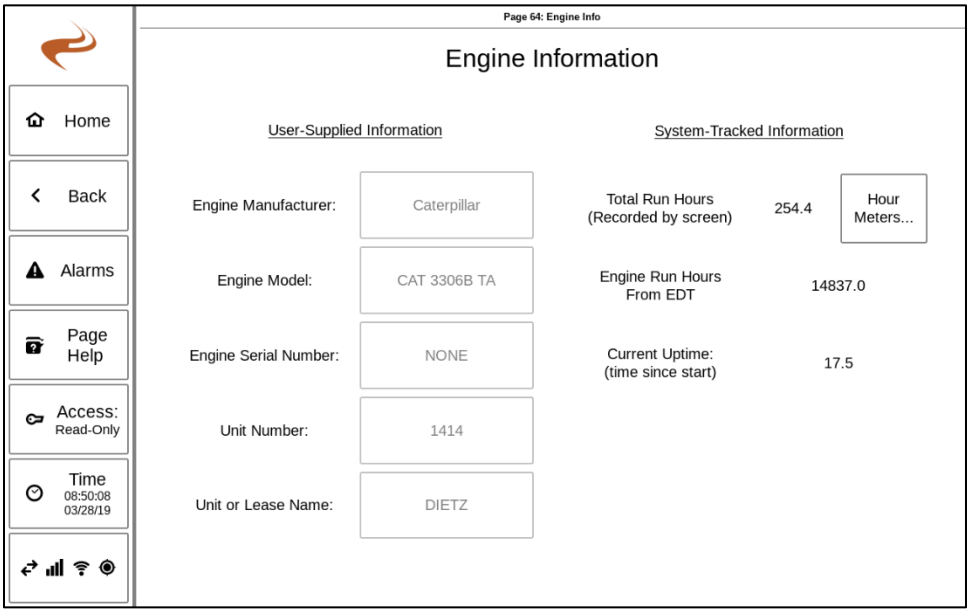
This page shows the software version and serial number of attached modules (including the DCT and the internal data translator). The page can be used to verify that software updates have been completed.



Note that the EDT (Data Translator) is built into the touchscreen but will show up as a separate row in this table since it can be updated separately.

Engine / Unit Info

This page is used to enter the engine make/model/serial number, the unit number, and the unit or lease name. This information is appended to some logs for convenience. The unit and engine hours are also shown.

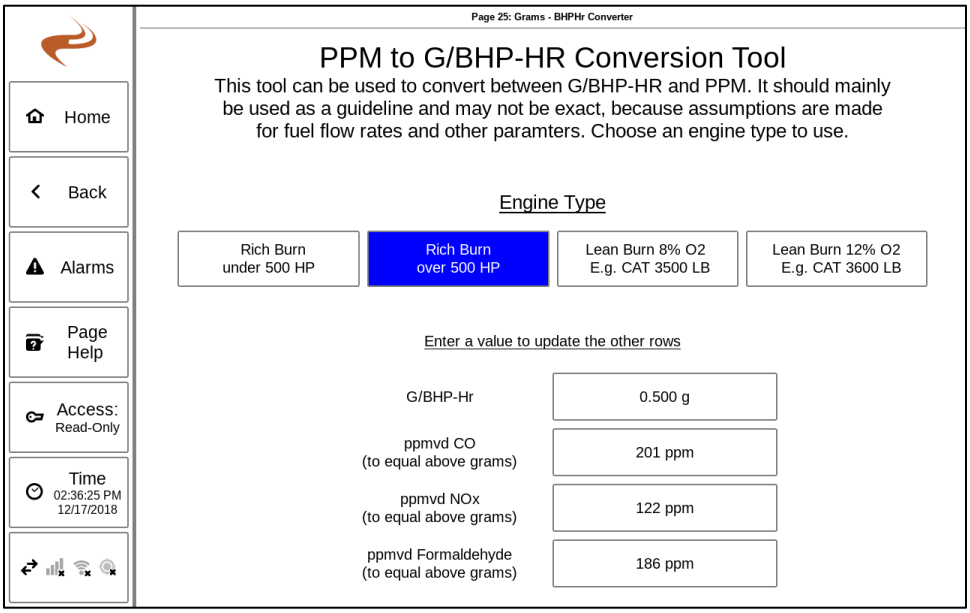


Run Hours

This links to the Engine Hour Meters page, discussed in the previous section, Engine Timers.

Grams – BHP/Hr Converter

This is a convenience tool for converting ppm of some pollutants to grams per brake horsepower hour. To use, select the engine type then enter an item in one of the four boxes to fill in the remaining boxes with the calculated values to match.



Other Global Pages

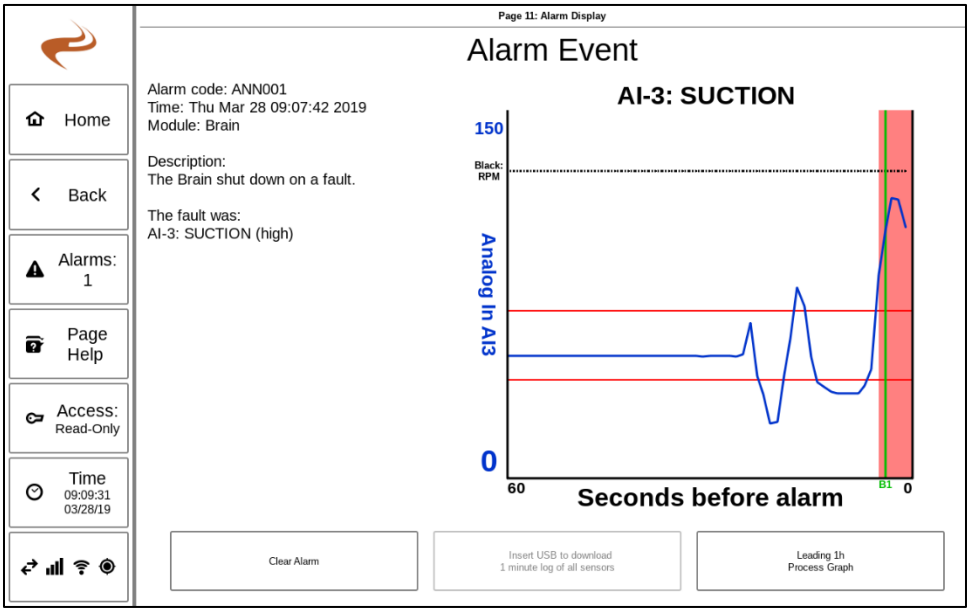
Alarms

The touchscreen and associated modules are capable of identifying a wide range possible alarm conditions.

Active alarms will cause the “Alarms” button in the sidebar of the display to show the number of current alarms and flash the text. Selecting this button will navigate to the **Alarms** screen that displays the current alarms with their associated date/time stamp, alarm code, description, and action taken.

Figure 5. Active Alarms page- Reached by pressing 'Alarms' on sidebar

Selecting the “View” button of the associated active alarm navigates to the **Alarm Display** screen. This screen displays the alarm in additional detail and provides the option to clear the alarm by pressing the “Reset Alarm” button. If a USB drive is inserted, a one-minute log of all sensors leading up to the alarm can be downloaded to be viewed on a personal computer. Once an alarm event is cleared, this log is lost, except for the recent shutdown logs discussed below.

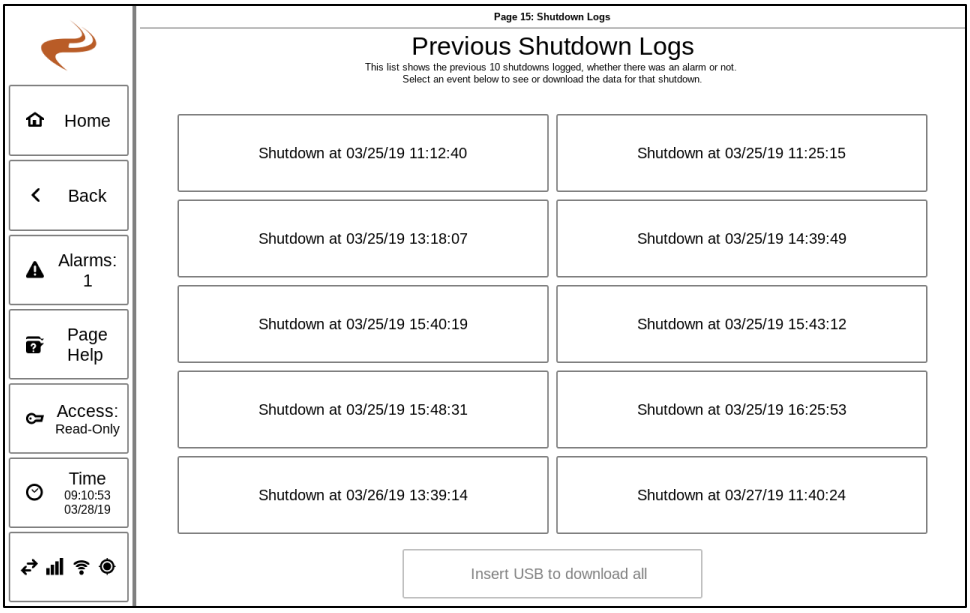


On the Alarm Display page, the graph itself can be selected to view other sensors at the time of alarm. The ‘Show All’ selection on the sensor selection will specify whether or not sensors should be hidden that are disabled or not relevant.

Figure 6. Selecting another sensor to graph on the alarm display

Shutdown Logs

From the Alarms screen, the button 'Recent Shutdown Logs' can be selected to see sensor datalogs of the one minute leading up to the previous ten shutdowns. These 10 logs will be created whether the system shut down on a fault or any other stop condition. These logs can be viewed and downloaded similar to alarm logs.

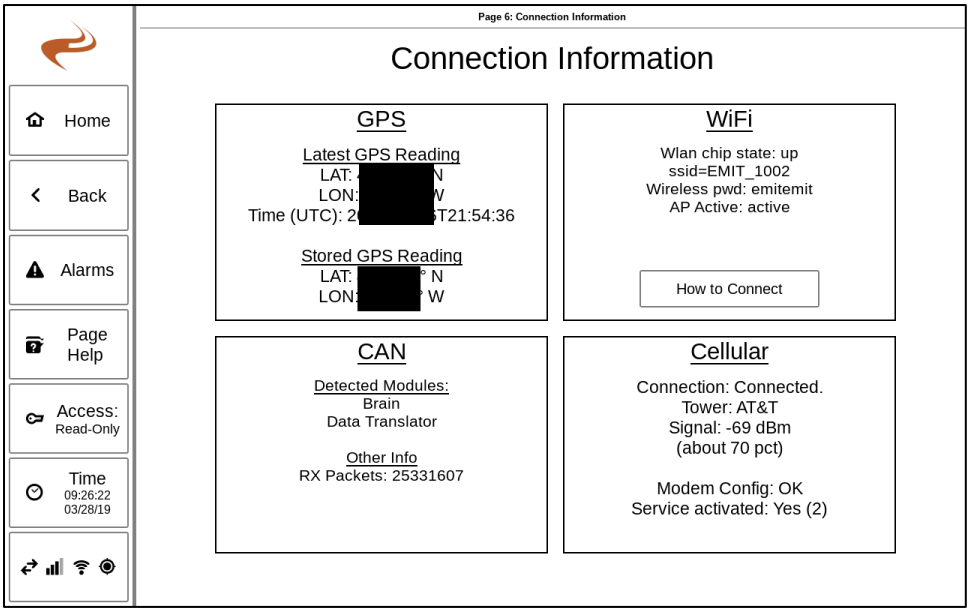


The shutdown logs are useful for:

1. If an alarm was cleared (which deletes the normal alarm sensor file) but later it is still desired to look at the sensor data of the minute before the shutdown. Since the last 10 shutdown logs are always retained, the event data can still be viewed after the alarm is cleared.
2. If the engine was shut down with a normal stop but the data leading up to shutdown still is desired.

Connection Status Screen

The connection status screen is reached by selecting the bottom left button of the sidebar. This page shows the status of the CAN, WiFi, Cell, and GPS connections.

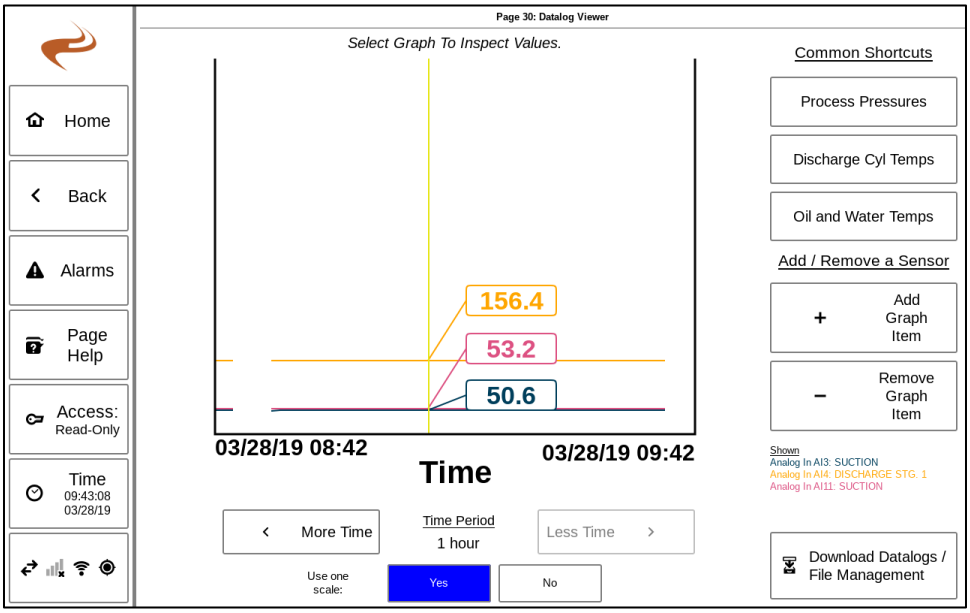


Connection information seen is the following:

- **GPS:** This box shows the current GPS reading, and the last reading stored. The system will only store the reading occasionally and when the reading is valid, to prevent using a faulty reading when needed. The GPS information is added to some logs and reports, and used for telematics.
- **WiFi:** The WiFi box shows the current access point name and password. Connecting to the WiFi is discussed a later section.
- **CAN:** This box will show detected modules and how many packets are received. The packets should always be going up if the CAN port is working, since the internal data translator will always be sending some information. If a module is not detected that should be on the panel, check the power and CAN connections for that module, and check that the CAN termination switches are terminated on modules at the end of the chan and unterminated on modules in the middle.
- **Cellular**: This box shows cell connection information. The current cell tower and signal is shown if connected. The system will find the strongest connection and can connect to a variety of providers. The last line shows if the service is actually activated – this is a step performed by EMIT remotely when telematics service is enabled as part of a plan.

Datalogs

The system will store a log of all sensor data for each module on the internal disk. This data is logged once per minute and retained in a rolling fashion for around one month. These logs can be viewed or downloaded through the 'Datalogs' section, accessed by hitting the 'Datalogs' button on the home page.



The 'Common Shortcuts' on the top right will automatically graph some common items when selected. To graph any sensor, select 'Add Graph Item', which brings up

a list of all sensors that can be graphed. Select one to add it to the graph. The current sensors graphed are shown in the bottom right.

The graph itself can be selected to add a cursor that shows the exact value of the datalines at that point in time, as seen on the screenshot above. The time period on the bottom of the page can be increased or decreased to change the amount of time the graph is showing.

The 'Use one scale' button on the bottom toggles whether all the datalines are graphed together or separately. Using one scale makes it easier to compare values, but may not make good use of the vertical space. Turning it off allows each line to be graphed independently, which makes seeing trends easier but removes the ability to directly compare sensor values against one another.

Downloading Datalogs

All datalogs can be downloaded or deleted at the **Datalog File Management** page. This page is reached by selecting 'Download Datalogs / File Management' on the Datalog display page. Insert a USB drive and select "Download All" to download all logs to the disk to be viewed on a computer.

Main Help

The **Main Help** system is reached from the main page by selecting the "Main Help" button. This page features overviews and troubleshooting trees for the Dynamic Control system.

Select **Overviews** to go to overviews for each module, or select **Troubleshooting** to go to troubleshooting trees. The troubleshooting trees are organized by module and can be used to troubleshoot some common issues.

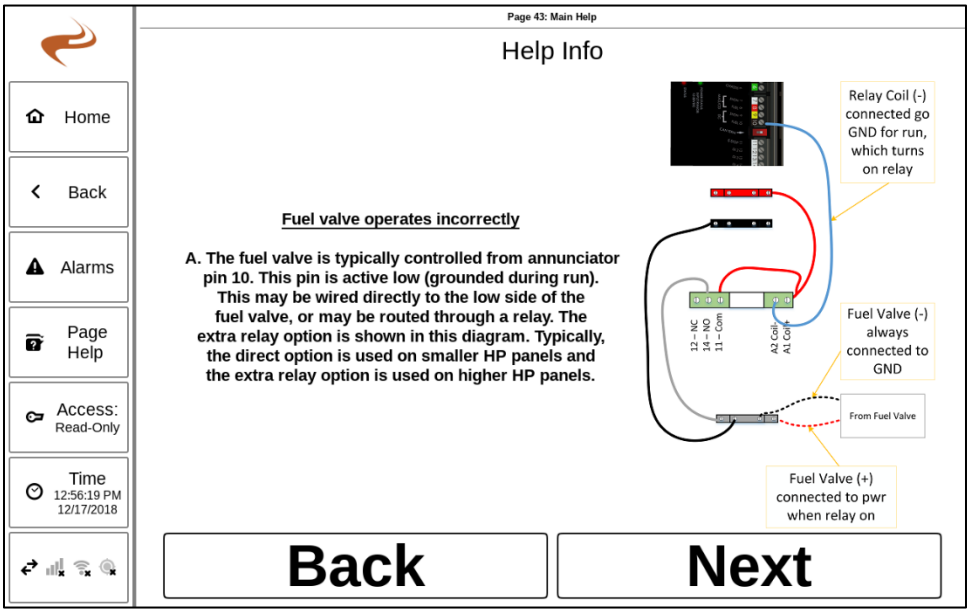


Figure 7. Troubleshooting tree example page

As previously mentioned, separately from this main help page are the individual page helps, which can be seen by selecting 'Page Help' on any page.

WiFi Connection

The Control Touchscreen features a local WiFi connection that can be connected to with a phone to view current runtime information. This allows viewing sensor data from around the site.

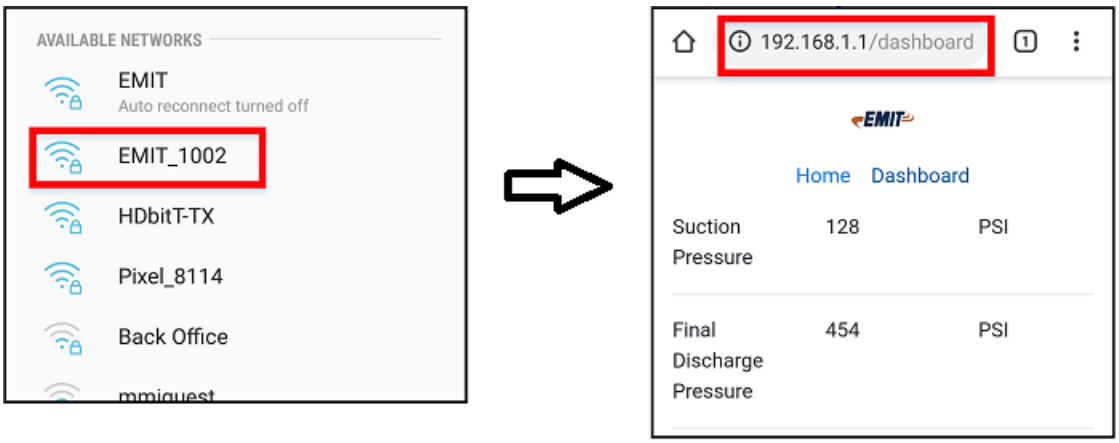
How to Connect

1. On your phone, check under WiFi connections for an access point named "EMIT_XXXX", where XXXX is the serial number of the touchscreen.

2. Select the connection, and for the password enter "emitemit" (all lowercase). It is recommended to turn auto reconnect off.

3. On your phone browser, enter "192.168.1.1" into the navigation bar. It should pull up the page shown below, where "Dashboard" can be selected to see current unit data. If it does not connect, try entering "http://192.168.1.1" into the navigation bar of the browser.

Note: The address will be different if the WiFi IP address was changed, this is shown under "System Settings" -> "Wifi Setup"



Touchscreen Telematics

The Dynamic Control Touchscreen has an integrated cell modem with the ability to send run data and shutdown callout information to remote EMIT servers for distribution to registered individuals.

Description of Service

When the unit goes from running to not running, the DCT will send a message to a central server detailing the cause of the shutdown. The DCT uses built-in input information to determine the cause of shutdown, so no setup of shutdown codes is required. The sever then send out texts, emails, and voice calls to enabled targets detailing the unit and cause of shutdown. If the shutdown cause was engine run status from the ADEM®, the CAT code will be reported as well if available.

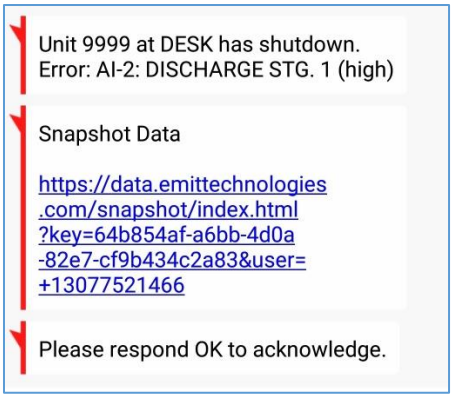


Figure 8. Example text message

The list of callout targets is tied to each individual unit. This list is stored on a central server, but can be edited on the DCT itself, which will communicate with the server. Alternately, callout lists can be sent to EMIT to be manually entered on the server if needed.

If a cell number is configured to have call and text alerts, the server will send a callout text first. If the text is acknowledged, the call will not be used. If the call is not acknowledged in a few minutes, the voice call will go out to the number.

The DCT will also send a group of standard runtime data that consists of common engine and compressor data (e.g. speed, stage pressures and temps, oil temps, etc.) every 15 minutes. This will be stored on the server for export as needed. Once again, no setup is needed because the DCT can determine the sources of all relevant information.

A link to a plot of runtime data available for the time leading up to the shutdown event is sent with the text or email. The link allows access to the previous day of stored data for the unit and potentially a 60 second snapshot of 1 second data related to the shutdown. The snapshot data is omitted if the sensor causing the shutdown does not have recorded data.

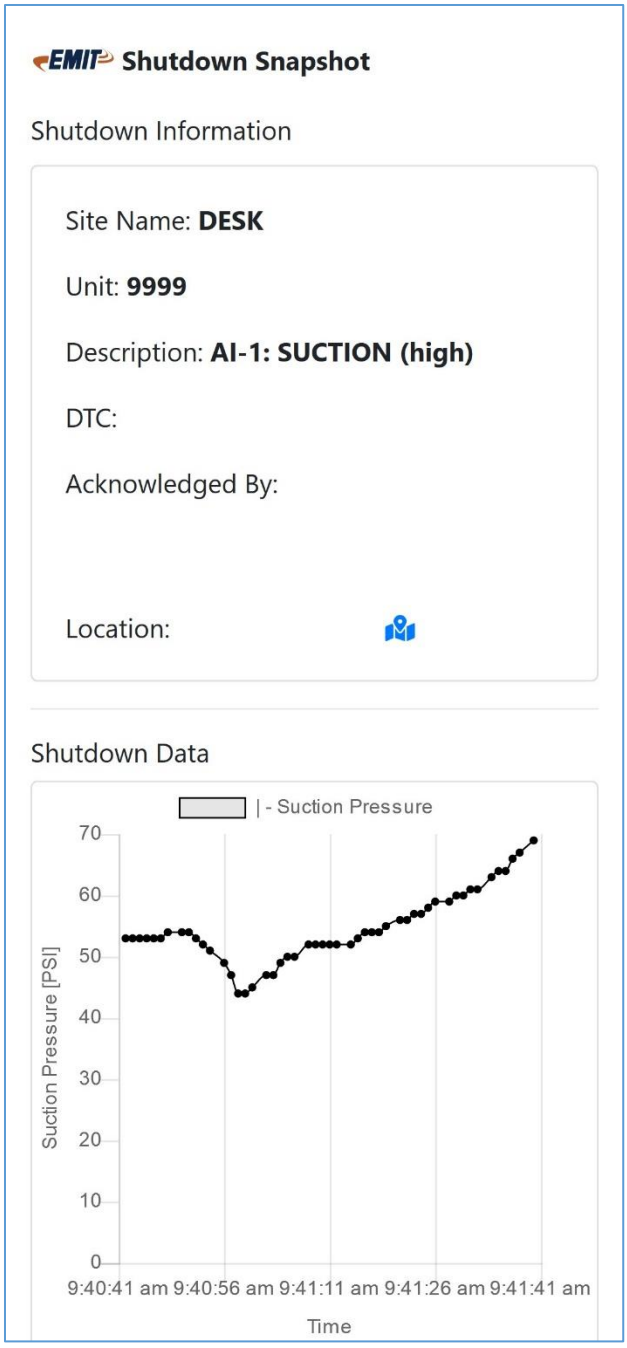


Figure 2. Example shutdown snapshot

The 'Zoom' and 'Sensors' buttons under the graph can be used to select other sensors and time periods to graph. The link next to 'location' can be selected to get a map of the location for convenience.

Wiring

The back of the DCT has two SMA connections for cell antenna(s), labeled CELL 1 and CELL 2. An antenna suitable for LTE bands should be connected to CELL 1. In areas with very poor coverage, an additional antenna can be connected to CELL 2.

Connection Status

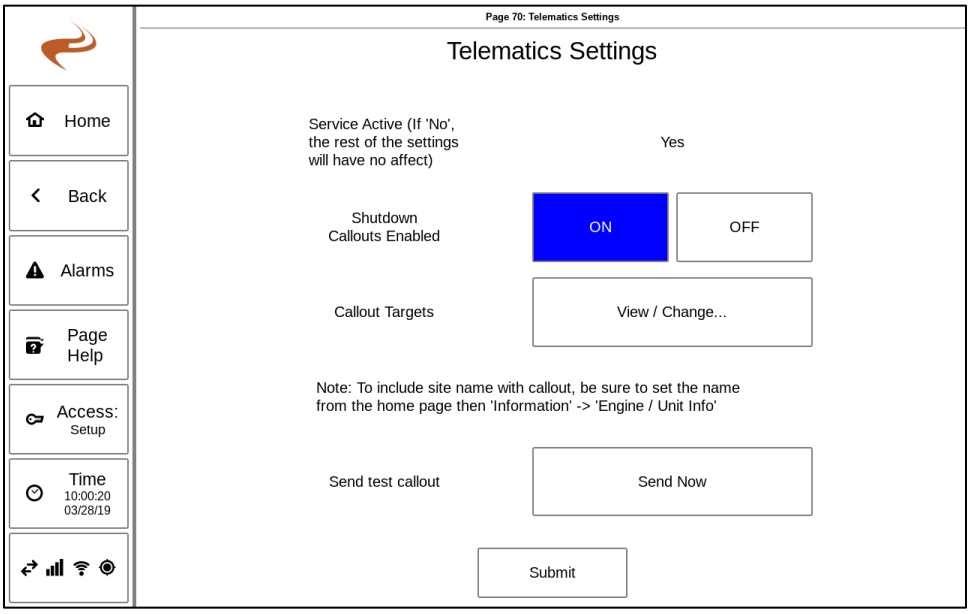
The connection status page, described in a previous section, can be reached by pressing the lower left button on the sidebar. It will show if the Cell modem is connected, the signal level, and the service level.

Activation of Callout Service

In order for the DCT to send callout information, the service has to be active. Contact EMIT to enable the service, and be sure to note the DCT serial number before contacting. Contact at telematics@emittechnologies.com , or call 307-673-0883 and ask for telematics support. Required information will be DCT serial number and unit number.

Telematics Settings

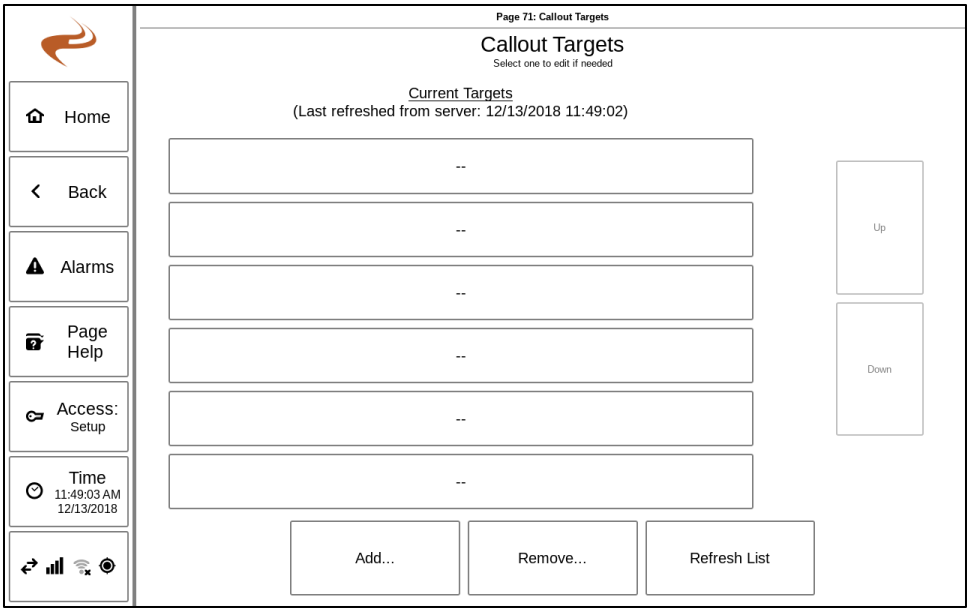
To adjust telematics settings, go to 'Setup' -> 'System Settings' -> 'Telematics Settings'. This page is shown below.



Shutdown callouts can be disabled on this page if desired. To adjust callout targets, select the 'Callout Targets' button. The 'Send test callout' can be used to verify that the targets are working properly. Note that a test callout will not work if the callouts are disabled or the service is not active.

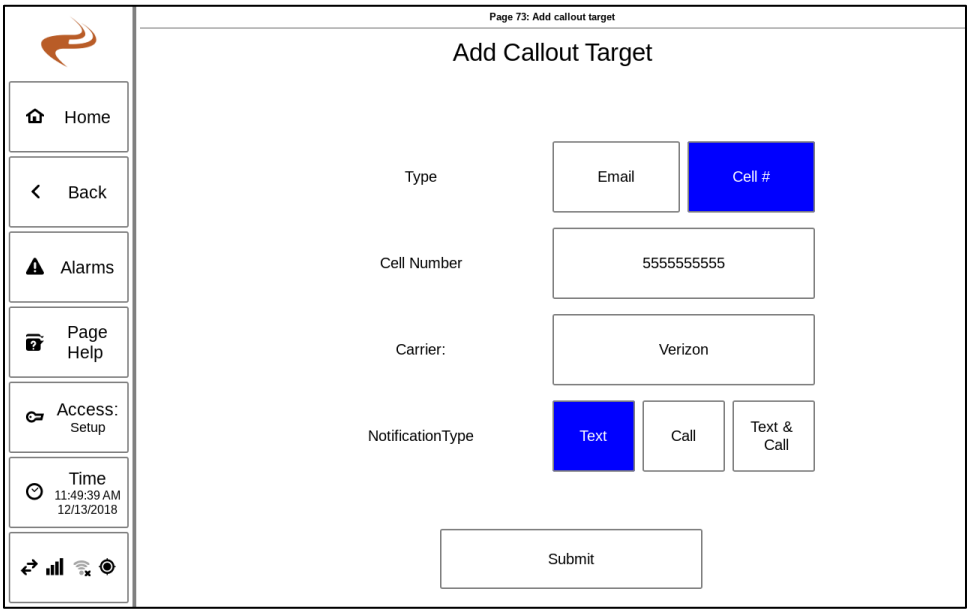
Callout Targets Page

This page is used to add/remove current callout targets, and adjust the voice settings for each target. A callout target can be an email or a cell phone number.



The callout targets are stored on a remote server. When 'Refresh List' is pressed, the touchscreen will request the latest list of callout targets from the server. This usually takes around 10 seconds. If the list doesn't show up, try refreshing again in case the message was lost.

To add a target, select 'Add...'.

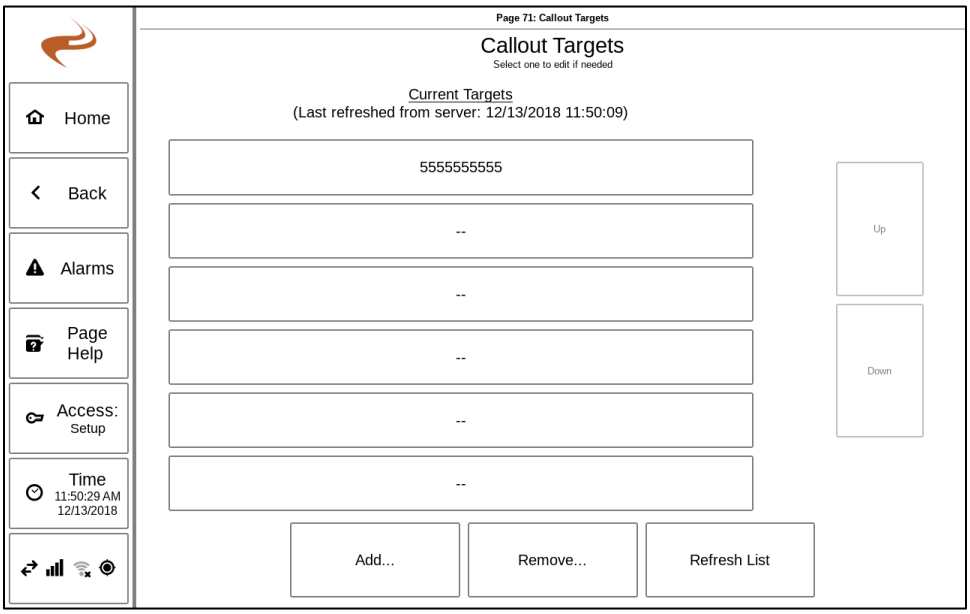


On this page, enter:

- **Type**: Select Email or Cell # for the target type
- **Cell Number** or **Email Address:** Enter the target in box 2
- **Carrier:** If the target is a Cell #, select your carrier

- **Notification Type**: For Cell #, select Text, Call, or Both for the notification type

After selecting 'Submit', the screen will return to the callout list. Wait about 10 seconds then refresh the page to confirm the server received the message.



After a target has been added, you can later select the button to edit the target (e.g change the callout type). Also, the 'Remove...' button can be selected to choose a target to remove from the list.

Troubleshooting

The main area to check communication status is the connection information page, which is reached by pressing the lower left button on any screen. Information about the cell connection is in the "Cell" box.

The following messages may be seen for the connection:

- "No response from modem": This indicates that the modem itself or the script that communicates between the modem and the DCT program has failed. If this message persists for a few minutes, try restarting. If it still won't go away, it could be a problem with the modem itself (either hardware failure or a misconfiguration).
- "Connection: No connection": This indicates that the modem is responding properly, but there is no connection to a tower. Sometimes it may take several minutes to get a connection. If still there is no connection, it could be because of antenna wiring, the SIM card isn't activated (by EMIT), or there is not enough signal strength. We have spec'd directional antennas that can be mounted in a higher location (pole or platform) that may help (item numbers TBD).

- "Connection: Connected": The modem is connected to a tower, and it will show the signal strength and current carrier.

If the status is not showing "Connection: Connected", then there is a problem between the unit and the tower. This could be because of one of the problems listed in each bullet point above for the other two items.

If the status is showing 'Connected', check as well that the "Service Activated" is showing 'Yes'. This has to be activated from the server end (by EMIT) while the screen is running.

If the service is activated and connected but callouts are not going out, verify that 'Callouts Enabled' is set to 'Yes' on the telematics setup page.

Data Collection

Normal data collection begins when a unit is activated at customer request, and consists of 15-minute data points of sensor information and warning related information. The collection and usage of this information is governed by the telematics contract, our privacy policy, and our terms of service.

When a unit is not activated EMIT may still collect very minimal information including but not limited to location and software version in order to improve our services. This minimal collection can be disabled by request to telematics@emittechnologies.com, or by disconnecting the cellular antenna.

BRAIN (ANNUNCIATOR)

Overview

The Dynamic Control Brain (Annunciator) is a digital system designed for monitoring, protecting, and controlling natural gas engines and compressor equipment. The system works by monitoring a variety of inputs and shutting down the engine if an input crosses user-defined shutdown conditions. Additionally, the system monitors, displays, and datalogs the inputs for later user review. The system also contains analog and digital outputs for controlling various processes in the compression system.

All setup and status information is available through the Dynamic Control Touchscreens. This same display can be used for interfacing with other DC modules, such as the Air Fuel Ratio Controller (AFRC) or ignition. The Brain can work in tandem with other ETS modules, if present, in various scenarios, or can act as a standalone annunciator.

This document covers the installation of the annunciator, the basic setup, advanced setups, and other testing and usage guides.

INPUT TYPES

The following inputs are available on the module:

- Digital Inputs: Can be normally opened or normally closed, and are closed to ground on a faulted or unfaulted condition.
- Analog Inputs: Can be configured to accept 4-20mA, 0-5V and 1-5V sensors. Most commonly used for pressure sensors, though any sensor of the above type can be used.
- Thermocouples: Can be configured to Type K or Type J and monitors temperatures on the system.
- Magnetic Pick Up: Used to monitor the speed of the engine or compressor.

FAULT TYPES

Input Class

Each input will belong to a certain input class, which determines if an input is *armed*. If an input is armed it will fault if it reaches a fault condition. If it is not armed, the input will not fault regardless of the reading. The following are the input classes and their arming condition.

- Class ESD: The input is always armed, even in test mode. For all other input classes, the input will not be armed in test mode regardless of class.
- Class A: The input is always armed (Except test mode).
- Class B1: The input will start unarmed after a ‘reset’ button press, and becomes armed after the B1 timer expires.

- Class B2: The input will start unarmed after a 'reset' button press, and becomes armed after the B2 timer expires. Generally, the B2 timer is intended to be the shorter B timer.
- Class C: The input will start unarmed after a 'reset' button press, and will become armed after it first becomes clear (unfaulted). There is also an optional global C timer to arm all C inputs after a specified time

Alarm Action

Each input will also have an alarm action, which determines what happens when an input is armed and faulted.

- Shutdown: The engine will be shut down. The first input to fault causing the shutdown will be saved for user review.
- Warning: The warning lamp will be illuminated and the state changed to "Running with warnings"
- No Action: Nothing will happen when an input faults. However, the input is still enabled to be viewed in the system. This can be useful during testing and for inputs that may be used in the future, such as "Site Shutdown".
- Disabled: The input is totally disabled

Additional Alarm Warning

Up to 8 inputs can also have a secondary warning, which will cause an alarm event to be added to the alarm screen when certain criteria is met. This can be added regardless of the other action of the input (except disabled).

USER INTERFACE OVERVIEW

GENERAL OVERVIEW

The system has two normal sources of user input- the display and the panel switches. The general operating states and how the panel switches affect the state are as follows.

With the Brain in the "Stopped" state, pressing the panel RESET button will reset the annunciator. This will cause the annunciator to go to the "Run" state on small engines, or move to “Standby”. If not in the stopped state, pressing RESET will only restart the B timers. Any “A” input faults will cause the system to immediately stop and return to “Faulted” state. If using autostart or an ECU with autostart, after any pre/post lube or other startup conditions are met the annunciator will display “Ready to Start”.

Pressing the panel STOP button will cause the annunciator to go to the "Stopped" state. If an auto-cooldown is used, pressing STOP will cause the unit to cool down for a time period. Pressing the E-Stop will always stop the unit immediately.

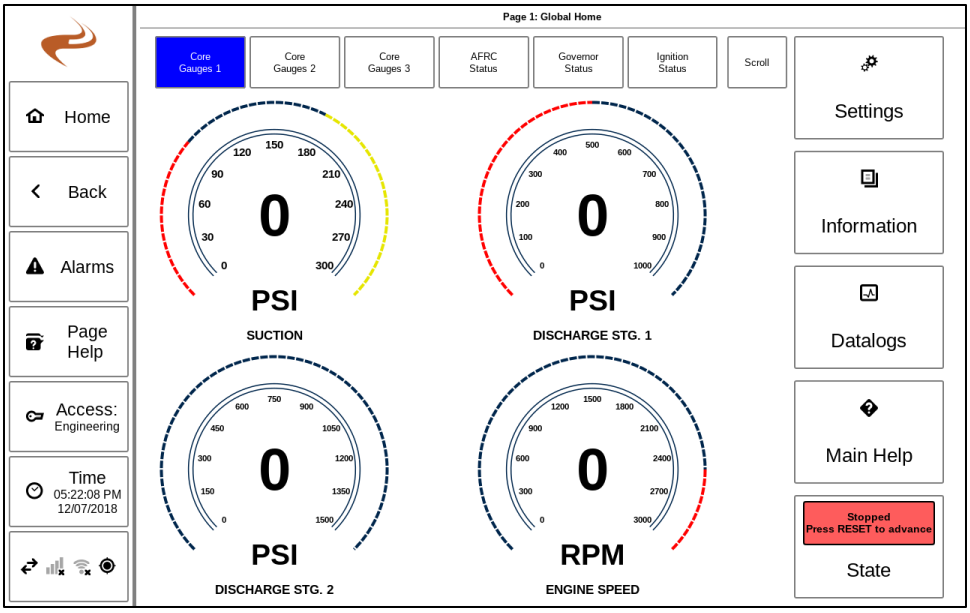
If using an ADEM® system on the engine, pressing panel RESET will go to “Standby” state. In this state, the ADEM alarms can be cleared. Once ready so start, the panel START button can be pressed to begin the start sequence.

If autostart is not used then holding the START button will run the starter, if the annunciator is in a run state.

The next section covers some of the main screens of the Brain.

HOME SCREEN

The **Brain Home** slides are 1-5 slides on the global home page showing overview of the system status and the readings of some select sensors.



RUN STATUS

The bottom-right button of the home screen is the Run Status (State) box. The area in the top of this region will show the current run state of the system- running, stopped, or another state. Selecting this button will go to the Core Status page, discussed in a later section.

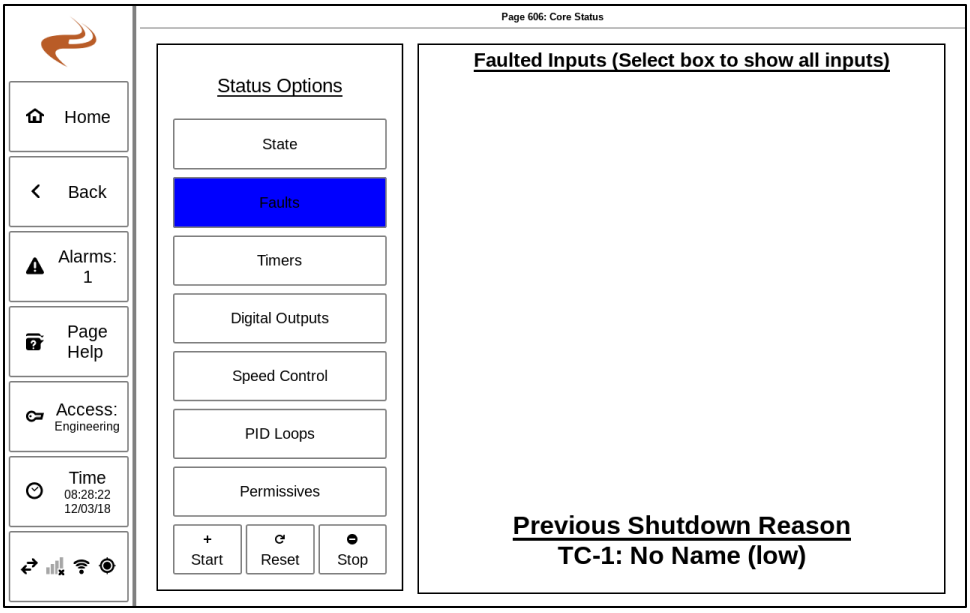
GAUGES

The main section of the brain home slides contain sets of gauges. Up to nine gauges can be shown on each slide, and up to five slides can be shown. The gauges shown can be changed in the **Gauge Selection Screen**, described later. If four or less gauges are configured for a page, the gauges will be scaled larger.

Each gauge shows the name of the input at the bottom and the current reading of the input in the center. If configured, warning bars will be shown on the top and/or bottom and will be colored red for shutdown inputs, yellow for warning inputs, and gray for no-action inputs. Selecting a gauge will navigate to the **Individual Input Statistics** for that input.

INPUTS AND TIMERS STATUS

Selecting the “State” box from the home screen navigates to the **Inputs and Timers Status**.



Select different categories on the left of the screen to see the status of that category.

Options are:

- State: Shows current run state and related information
- Faults: Shows which inputs are currently faulted. Selecting this box will show a list of all sensors, which can be useful for testing.
- Timers: Shows status of various timers, including the B timer and load delay timer. The B timer can be manually armed on this slide.
- Digital Outputs: Shows current state of each digital ouptut (on or off)
- Speed Control: Shows the mode and current target of the speed control output (if used)
- PID Loops: Shows the state of the PID control loops. Each loop can be selected for more status information.
- Permissives: Shows status of various permissives

The Start/Reset/Stop buttons on this page mirror the functionality of the physical panel buttons.

INDIVIDUAL INPUT STATUS/STATISTICS

Selecting a gauge on the home screen will navigate to the **Individual Input Statistics** screen for that input. This page can also be accessed from “Settings” -> “Brain” -> “Input Status” for inputs that do not have a gauge configured.

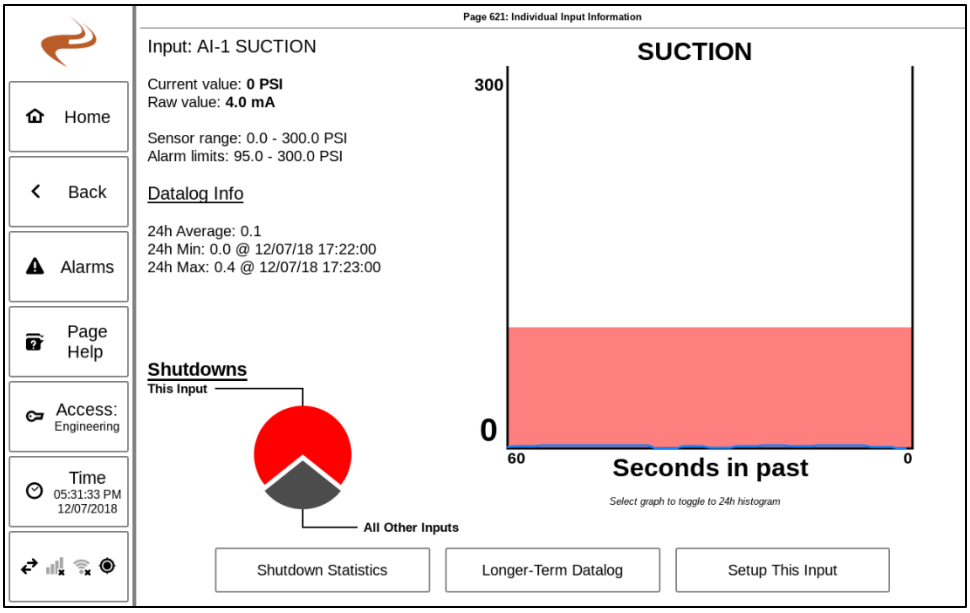


Figure 9. Individual input statistics and status

The left side of the screen shows the current reading and information from the datalog. The bottom-left area shows what percentage of shutdowns were caused by this input.

The right side of the screen shows the previous minute of sensor data, graphed in real time. If an alarm or warning limit is configured, shaded bars will be shown for the limits. Selecting the graph will toggle to a histogram of values for the previous day.

The bottom of the screen has links to go to the **Datalog View** screen ("Longer-Term Datalog") with that input selected, to see sensor data for a longer period- up to one month. The other button goes to the individual sensor setup page for that input, with the target page dependent on sensor type.

BRAIN SETUP AND CONFIGURATION

OVERVIEW

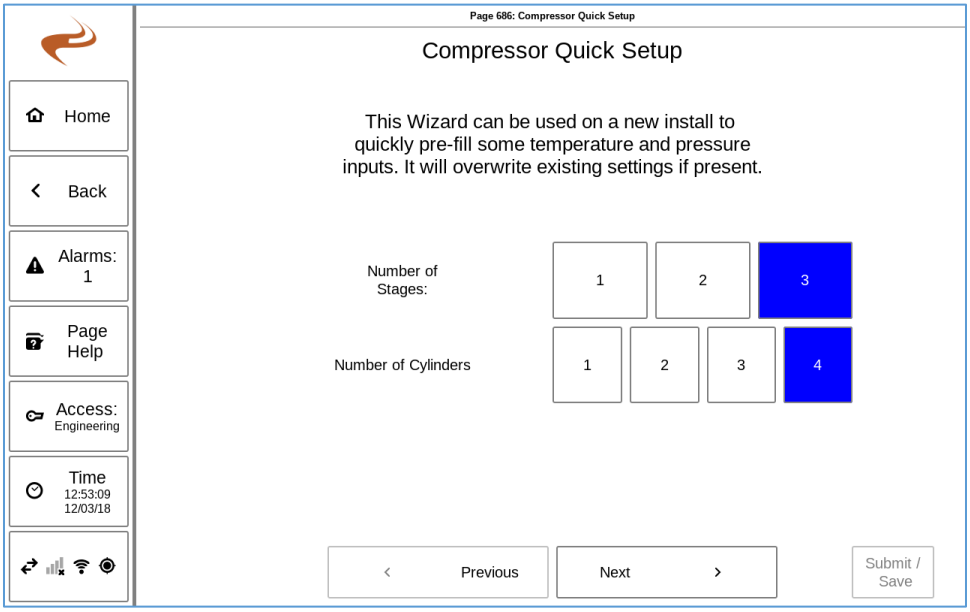
There are many Brain setup screens, all accessed through the **Brain Setup Pages** screen and its subpages, reached by selecting the "Settings" -> "Brain" from the home screen**.**

Subsequent sections of this part of the manual will describe the setup of individual parts of the system. The bulk of the setup items are under the subpage "Inputs Setup" or "Outputs Setup". As previously mentioned, the "Search" function on the main "Settings" page can be useful for finding a setup page.

COMRPESSOR QUICK SETUP

If the system is being configured for the first time, the compressor quick setup can be used to quickly add some basic inputs. To use, navigate to 'Settings' -> 'System / Global Settings' -> 'Compressor Quick Setup'.

Note: the quick setup will overwrite some existing settings.



On the first page, select the number of stages and cylinders for the compressor.

On the next step, select the pressure ranges for the sensors on each stage.

On the third step, select which additional sensors are used.

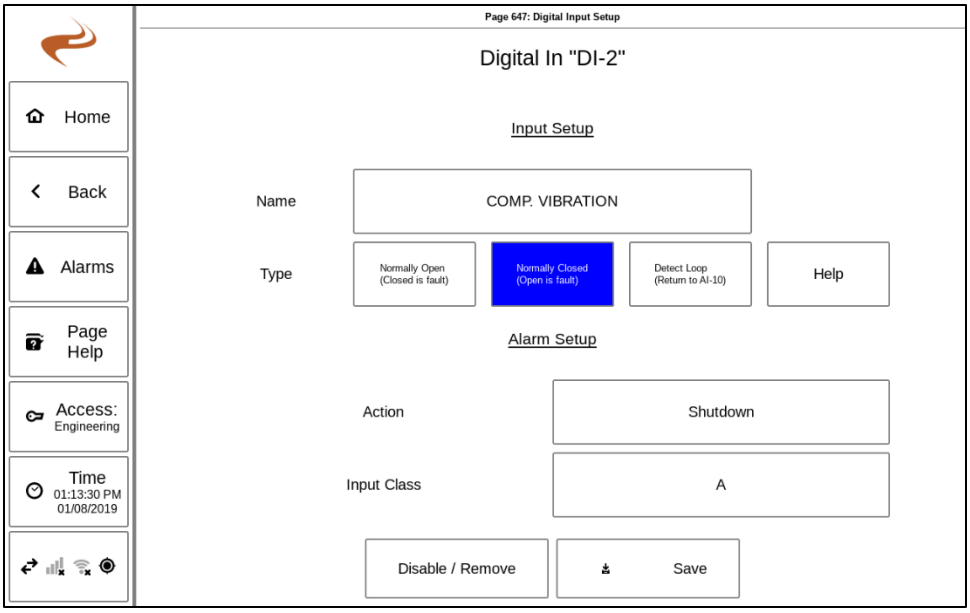
Finally, select 'Submit' on the review page. The quick setup will fill in the inputs specified and add some default gauges. Other inputs will still need to be added, but this will provide a quick starting point.

BASIC INPUT SETUPS

The basic four types of inputs (Analog, Digital, Thermocouple, and Magnetic Pickup) are setup through "Setup", "Brain", then "Inputs Setup". The "Inputs Setup" page lists all types of inputs, and selecting one type will bring up a list of inputs that can be configured. Details on the setup items of each type of input is listed below.

Digital Inputs

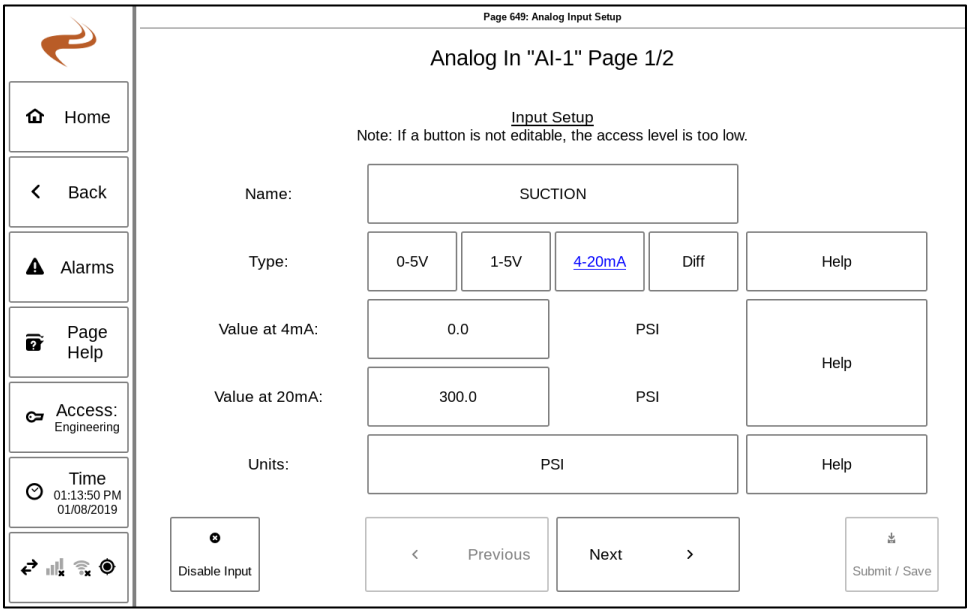
- **Name**: Choose or type in a name for the input
- **Type**: Choose normally open or normally closed, based on the sensor type. A third option, "Detect Loop", is described in a later section.
- **Alarm action and class**: Choose as needed based on the descriptions in the overview section



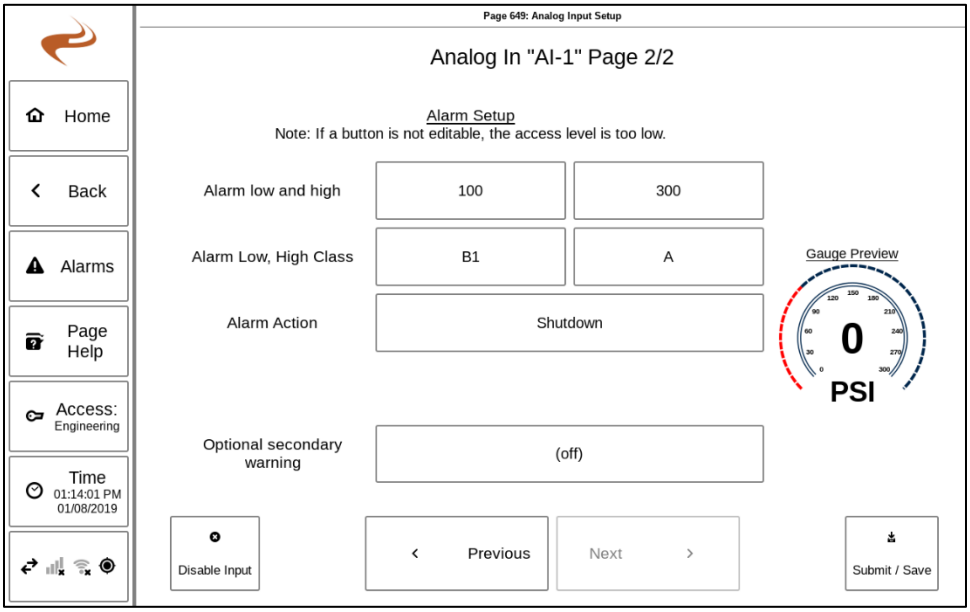
Analog Inputs

- **Name**: Choose or type in a name for the input
- **Type**: Choose 0-5V, 1-5V, or 4-20mA based on the sensor type
- **Value at (low) and (high)**: Enter the full range of the sensor. This should be printed on the sensor itself or can be found in the sensor documentation.
- **Units**: Enter the unit of the sensor for when displaying the value

	If an EMIT governor is on the system and pressure-based speed control is used, the suction/discharge sensors on the Brain must use the units “PSI” or “KPA”.

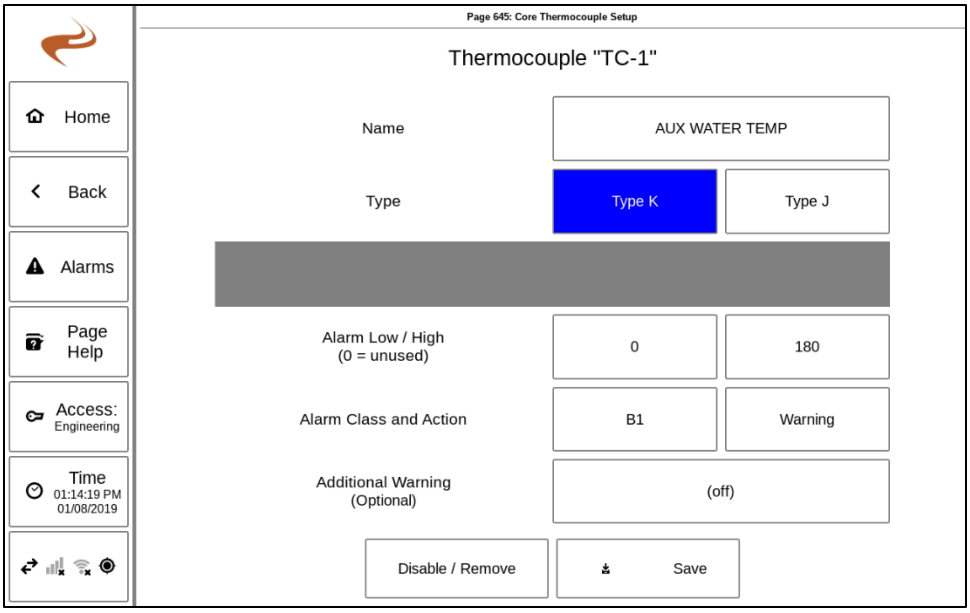


- **Alarm low and high**: Enter the low and high alarm for the sensor. If either the low or high is not needed, it can be put at the limit or out of range of the sensor to keep it from ever faulting.
- **Alarm action and class**: Choose as needed based on the descriptions in the overview section
- **Optional secondary warning**: If an extra warning is desired, it can be added here.



Thermocouples

- **Name**: Choose or type in a name for the input
- **Type**: Choose Type K or Type J based on the thermocouple type
- **Alarm low/ high**: Choose the low and high alarms if required. An unneeded limit can be set to zero to be disabled.
- **Alarm action and class**: Choose as needed based on the descriptions in the overview section
- **Optional secondary warning**: If an extra warning is desired, it can be added here.



Magnetic Pickup

- **Number of flywheel teeth**: Enter the number of teeth expected on the MPU.
  - Note: If an RPM reading is available to another EMIT module (e.g. Governor), this can be set to “0” because the Brain module can collect the RPM over the communications bus instead of measuring the RPM itself.
- **Low/high alarm values**: Enter limits as required. The low limit can be set to ”0” if not needed.

Input Voltage

An alarm can be added to the input voltage to trigger a warning or shutdown if the voltage is out of range. This page is accessed from “Input Setups” -> “Input Voltage”. The options are shown below.

- **Alarm when below / above**: Enter a low and high voltage alarm. Either or both can be “0” for unused.
- **Duration to be above / below before alarm (s)**: Enter seconds of duration before creating alarm
- **Alarm class / action**: Enter the class and action for the alarm, if used
- **Battery Saver Shutdown**: Separate from the input voltage alarm, a time can be added here which will trigger an output after the unit is not running for the specified time. For example, if this is set to 60 minutes, then after 60 continuous minutes of the engine not running, the “Battery Saver” output will be activated. This output is intended to be wired to a latching relay to turn off some or all panel items. The actual assignment of the output is under “Output to Function Assignment”, discussed later.

INDIVIDUAL CYLINDER TEMPERATURES

In some applications, each cylinder on the engine will have a thermocouple. The system has a special setup for this case to help make the configuration easier.

On the setup page for the list of thermocouples, there is a button labeled “Cylinder Temperatures…”. This links to a page asking for the number of cylinder temperatures needed, and the labeling scheme. If cylinder temperatures are needed, set the number of cylinders to a value other than zero.

The second page of the cylinder temperature setup is the same as for a normal thermocouple, but sets up all the cylinder temperature inputs at once. Each cylinder temperature will share the same type, range, alarms, and alarm action. After hitting “Submit” the values and cylinder temperature names will be copied to the first block of thermocouple inputs.

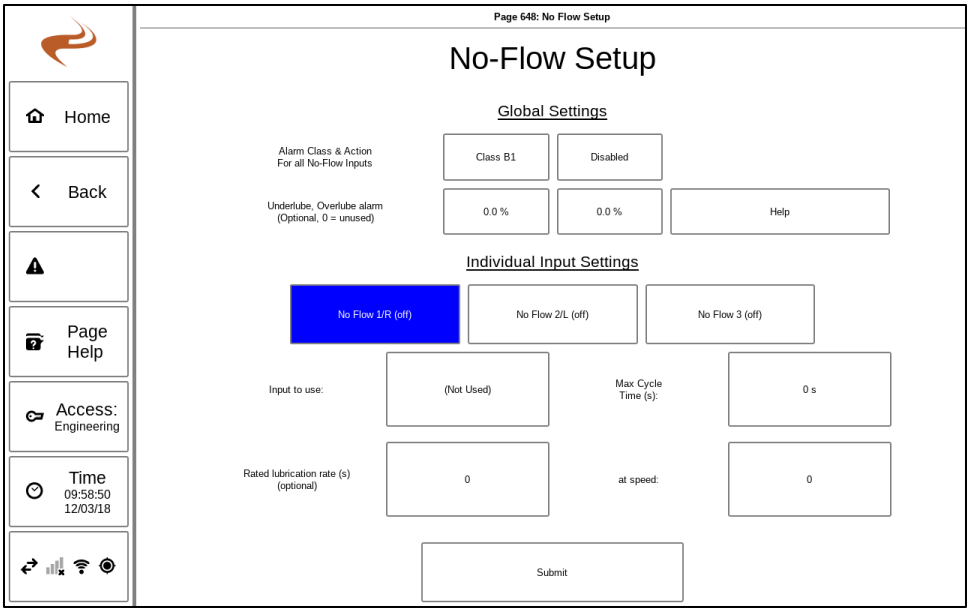
If using individual cylinder temperatures, one of the home page gauge sets can be configured to show the cylinder temperatures in a bar graph, as shown below. The configuring of the home page gauges is covered in the section CHANGING HOME PAGE GAUGES.

NO FLOW MONITORING

Up to three of the digital inputs can be used for No-Flow monitoring by connecting to a proximity switch on a lubrication divider block. This function monitors the lubrication rate of distribution blocks and shuts down the engine if a lubrication system fails. The system can also monitor the average lubrication rate to determine if the system is running above or below the proper rate over time.

This setup is accessed under the main Brain setup, then “Inputs Setup”, followed by “No-Flow Monitoring”.

	If using an external no-flow monitor (E.g. proflow), this section isn’t needed. Instead the input will be set up as a normal digital input named “NO FLOW”.



The top part of the No-Flow setup page are the global settings. The top line is the class and action for the alarm on all no-flow inputs. This is usually a class B1 Shutdown. The second line is the over/underlube alarm. This will be described below.

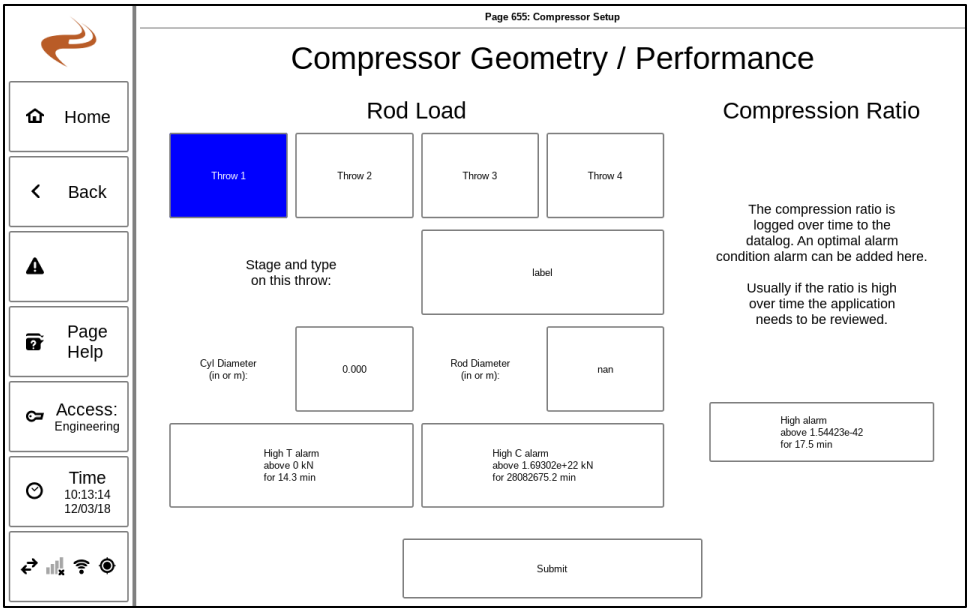
The bottom part of the screen has setups for each individual No-Flow input, of which up to three can be configured. For each, a digital input must be selected along with a max cycle time. That digital input is then wired to the proximity switch for the given divider block. If the maximum cycle time passes without the proximity switch activating (showing lubricant is distributed), then the input will fault.

Below these settings is an optional specification of the rated lubrication rate. This specifies the manufacturers rated lubrication time at a specified speed. This rate will be well below the “Max Cycle Time” shutdown because of the variance in lubrication rates. If a rate and rated speed are specified, the system will log the lubrication rate over time as a percentage of the rated rate. For example, if the specification is 10 seconds at 1000rpm, then either 10s at 1000rpm or 20s at 2000 rpm are considered at 100% rate. If the cycle time is less, the system is lubricating too quickly, if more, too slowly.

Over time, if the lubrication system runs slow (under the normal rate), it can prematurely wear compressor parts. If, over time, the lubrication system runs fast it will waste lubricant. The datalog can be reviewed to see how close the system is running against its target rate. The Overlube and Underlube alarm can be specified at the top of the page to shut down the engine if a lube rate is out of the specified range.

COMPRESSOR GEOMETRY SETUP

Optionally, the compressor geometry can be set up under the main system setup, then “Inputs Setup”, then “Compressor Geometry / Performance”.



On the left side of the page, the piston sizes can be entered to enable rod load monitoring. For each throw of the compressor enter a cylinder diameter and rod diameter for the compressor piston. If valid, the system will measure the rod load of each throw over time, in lbf, during tension and compression. High rod loads or unbalanced loads can lead to premature wear or failure of compressor parts. A high alarm can be added to each throw to shut down the engine if a load is exceeded for that stage.

The tension and compression load for each throw will also be added to the normal datalog to be trended over time if desired.

The right side of the page allows an alarm to be added for exceeding a compression ratio. Each stage's compressor ratio will automatically be logged, and an alarm can be added here to shut down the engine if a stage exceeds the given ratio. Generally a ratio above around 4.5 indicates a design issue with the application.

CLASS B/C TIMERS SETUP

The length of the B and global C timer can be adjusted on the **Class B/C Timer Setup** Page. This page can be found by navigating to "Timers Setup" -> "Class B/C Timer Lengths". Both B timers will count down from any RESET button press, and when they reach zero will arm the inputs of that class. Generally, the B2 timer should be the shorter timer, intended for items that should clear during the very initial startup of the engine.

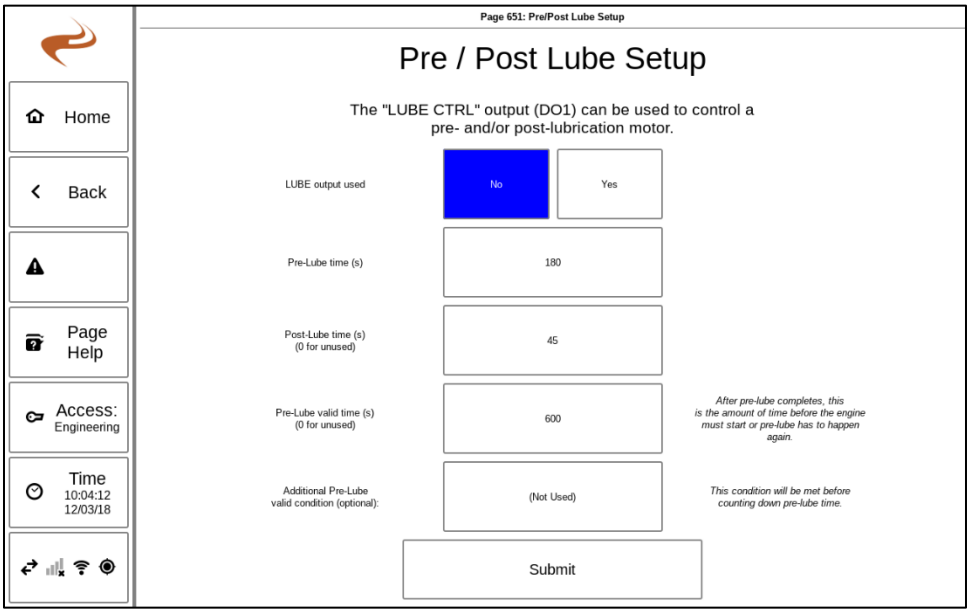
The maximum C time can be optionally entered on this page, or set to 0 if not used. If used, this timer will count down from the RESET button press, and when it expires will globally arm all C inputs, even if they have not cleared yet. This prevents a C contact from never arming before the operator leaves the site.

PRELUBE/POSTLUBE SETUP

A Pre/Post lubrication system can be driven from the Brain module by enabling it through the **Pre/Post Lube Setup** Page. This page can be accessed from the main setup by selecting “Outputs Setup”, then “Pre/Post Lube Setup”.

On the Pre/Postlube setup page, the Prelube and Postlube time can be specified. These are the times that the lube output (digital out 1) will run before starting the engine and after it shuts down. Also on this page is the Pre-Lube Valid timer, which is the amount of time after completing pre-lube that the engine can be started or restarted before having to complete the prelube process again.

Optionally, a prelube valid condition can be added. This condition must be met before prelube will be considered complete. If the prelube time finishes and the condition isn’t met, the lube will continue until the condition is met. This condition can be based on any input and threshold.



SHUTDOWN SETUP

The **Shutdown Setup** can be accessed from the main setup by selecting “Outputs Setup” followed by “Shutdown Pins”. On this page, the type of fuel valve and ignition can be selected to show a diagram for how to wire to the shutdown pins block of the Brain (Pins 7-10). Note that this does not actually change the functionality of the pins, it only is for viewing the correct wiring.

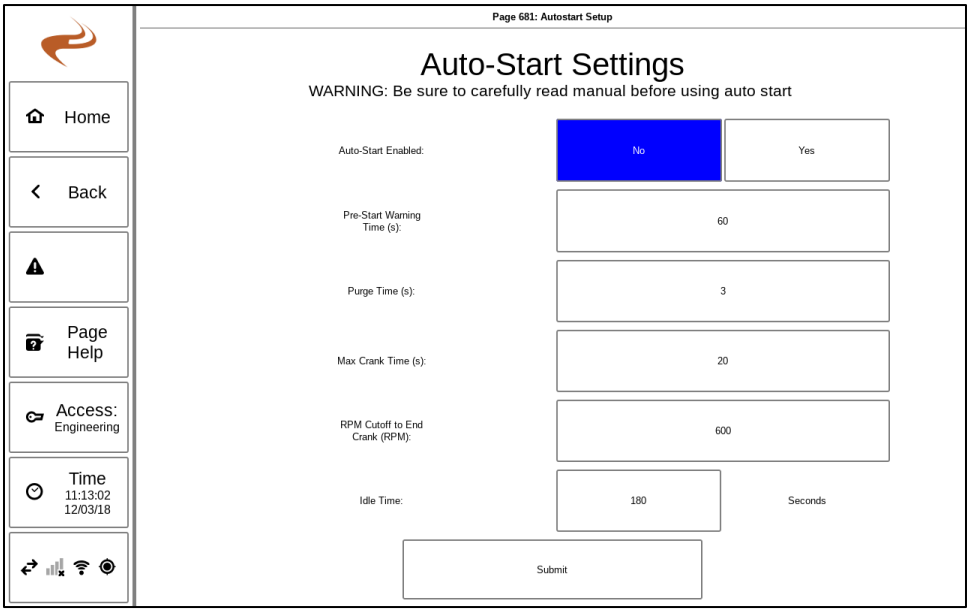
On the lower part of the screen, the stage 2 shutdown timer can be altered. This timer specifies the amount of time after the fuel valve is latched close to keep the ignition running. For a latching fuel valve, this MUST be at least 1 second. For DC fuel valves, this time is optional, but 2-3 seconds is recommended to allow the ignition to burn off excess gas before being disabled.

If using a DC latch-shut fuel valve, the final box can be used to assign a digital output to be on during shutdown delay. This output will be used to latch shut the valve.

AUTO-START SETUP

If using EMIT engine controls, the Brain can be used to autostart the engine. During autostart, the system will actuate the STARTER output (digital out 2) and activate the fuel valve, and crank until the engine reaches a cutoff speed. The Brain will then communicate with the (EMIT) Governor to idle for a specified amount of time, then ramp to the Auto governor operating condition. If not using an EMIT governor, the autostart function cannot be used, but autostart might still be enabled through an external ECU, such as the CAT ADEM.

The **Autostart Setup** Page is accessed from the main setup page by selecting "Outputs Setup" then "Auto-Start".



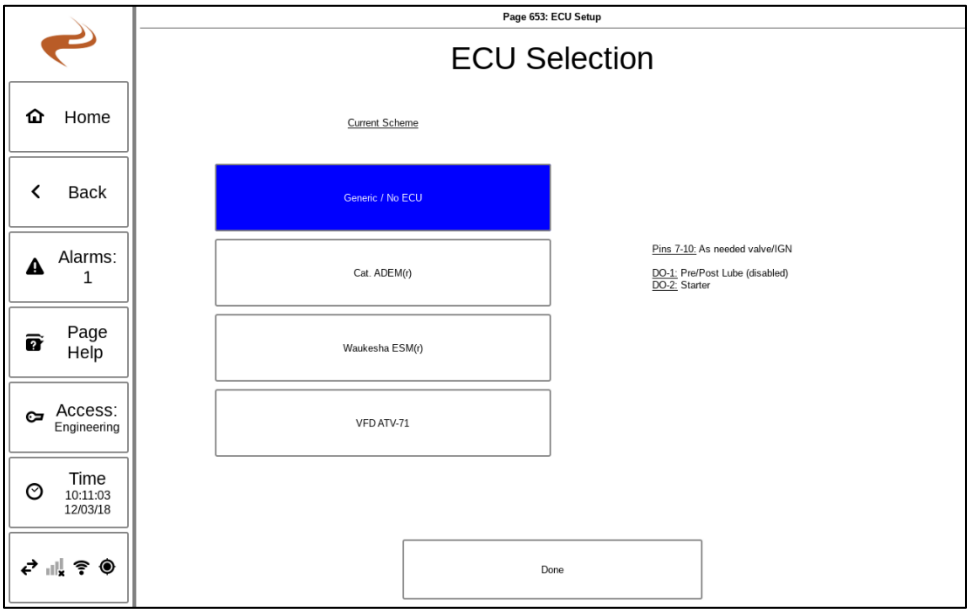
The first autostart setting is the Pre-Start Warning Time. This is the amount of time the system will activate a siren and/or beacon to warn any personnel of an impending autostart. The next setting is the purge time, which is the amount of time the engine will crank without fuel. The Max Crank Time specifies the maximum amount of time the START output should crank the engine, and if the engine does not start in this time the system will fault out. The RPM cutoff specifies what speed the engine is considered started and cranking should stop.

The second autostart setup page specifies the idle time, which is the amount of time to idle the engine before ramping to full speed. Note that if an idle permissive condition is enabled on the governor it will also have to be met before ramping to full speed. Finally, the user is asked whether autoload of the compressor is used, and if so, will navigate next to autoload setup.

ECU Setup

The ECU Selection specifies the general way the Brain outputs are integrated into the engine. The system can either control the starter and ignition directly, or can be configured to control through an external ECU: either a Caterpillar ADEM or a Waukesha ESM.

The **Output Scheme Setup** page can be accessed from the main setup menu "Outputs Setup" then "ECU Setup".



On this page the output type can be selected. On the right side of the page the output connections will be summarized to assist with wiring.

⚠	If an external ECU is selected, the Brain will use digital in 27 as the status input. If another function is enabled on the input, it will be overwritten.

Some output schemes will show additional options at the bottom of the page specific to that scheme.

For ADEM®:

- ADEM Max Startup Wait Time(s): This value specifies how long the system will wait for the engine to start after supplying a start signal to the ADEM. Typically, 1 or 2 minutes are needed for engine pre-lube. Only after the engine actually starts will the B timers start counting down.
- RPM Cutoff to consider as running: When this RPM is reached, the system will advance the start sequence

For ESM®:

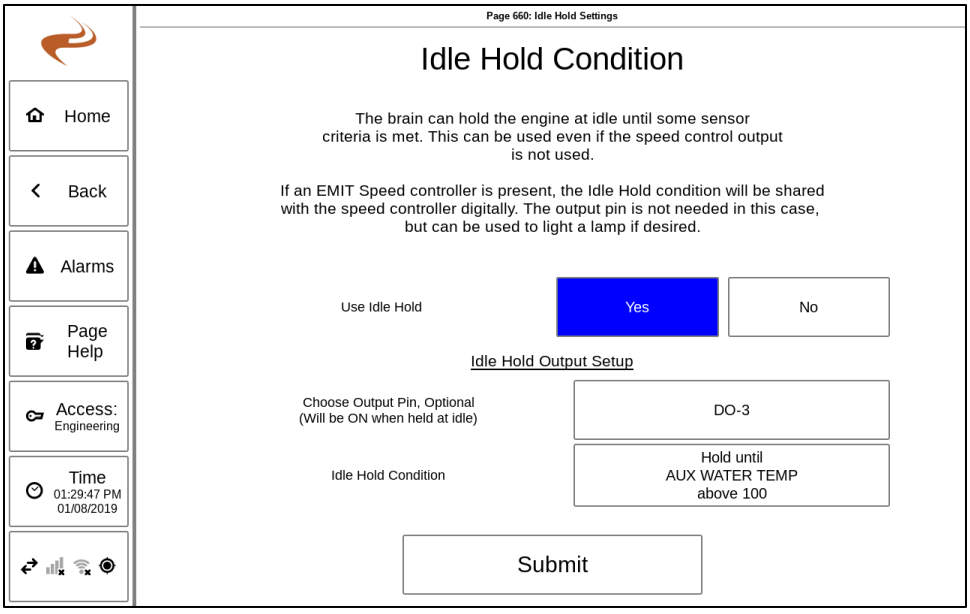
- ESM Max Startup Wait Time(s): This value specifies how long the system will wait for the engine to start after supplying a start signal to the ESM.

SPEED CONTROL OUTPUT

If an EMIT governor is not used on the engine, the Brain can control speed through an analog output connected to the ECU or another governor that uses an analog input to control the speed setpoint. Whether or not the speed output is used, an idle permissive condition can also be added to control a digital output to hold the engine at idle. Each of these two functions will be covered separately below.

Idle Hold Setup

The **Idle Hold Setup** page is accessed from "Outputs Setup" -> "Idle Hold Settings".

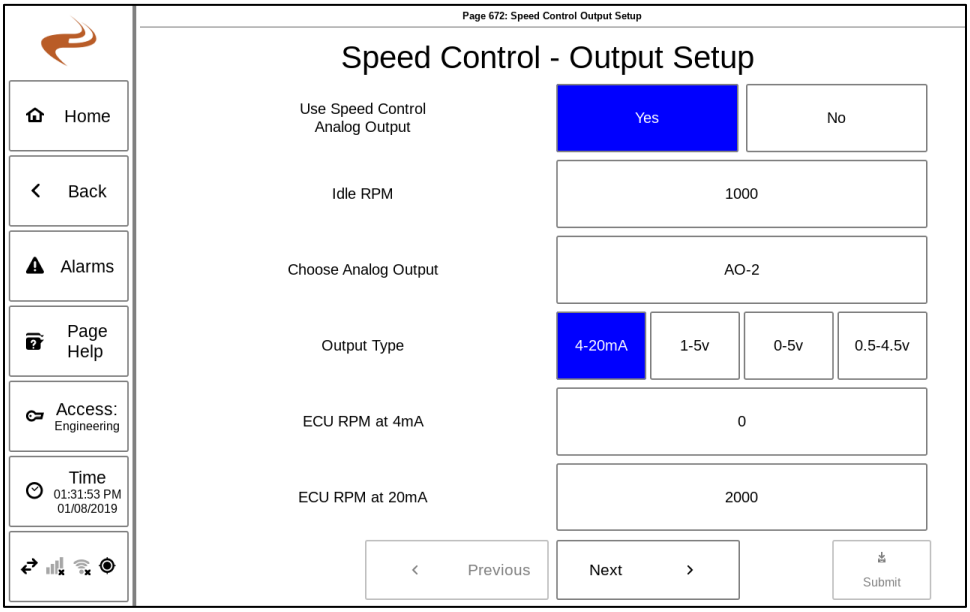


The idle hold condition is an optional condition that will keep the engine at idle until some criteria is met. Usually, this is a lubricant temperature reaching a certain point. While the condition is not met, a selected digital output is on. This digital output can be wired to an ECU input that holds the engine at idle, or to a relay that sends the fixed idle speed voltage into a remote speed input of an ECU or governor. The output can also be wired to an indicator on the panel. The idle hold can be used whether or not the speed control output is used. If the speed control analog output is used, that output will also be at a fixed idle speed during idle hold.

To specify an idle hold condition, select "Yes" for using idle hold. Under idle hold setup, select the button to pick an available digital output to turn on when idle hold is active. Select the second button to select an idle hold condition. For the condition, pick any input, then a threshold value and whether the hold should continue until the input is above or below that value.

Speed Output Setup Part 1

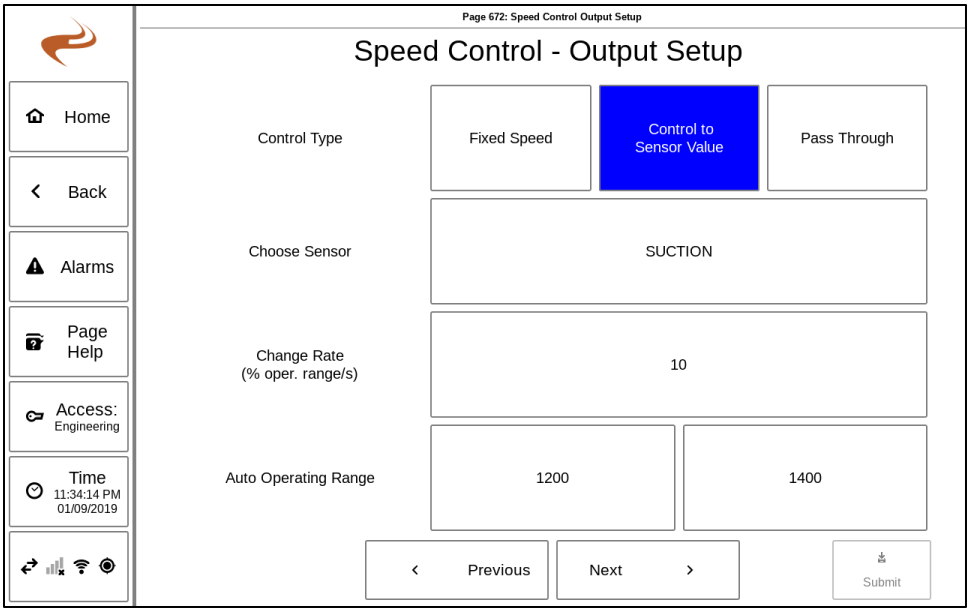
As mentioned above, one analog output can be used to output a target engine speed to another speed controller or engine control unit. This configuration is accessed from “Outputs Setup” -> “Speed Control Output Setup”. The first page of setup is shown below.



Options on this page include:

- **Using Analog Speed Control Output:** Select “Yes” to continue with setup, or “No” to disable.
- **Idle RPM:** This speed will be sent to the speed controller when “Idle” is selected. If an idle contact is also used, this setting will likely have no affect.
- **Output Type**: This specifies the analog output type to use. This should match what the ECU is expecting as an input.
- **ECU RPM at LOW/HIGH**: This value should match what the ECU is expecting the low and high analog value to represent

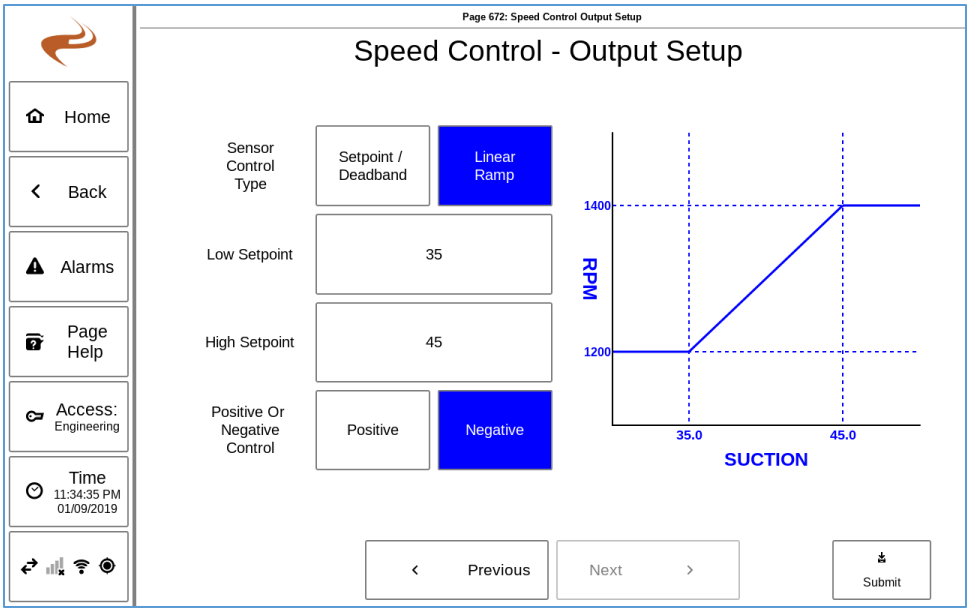
The next step of speed control control setup configures the actual control settings for the speed.



The control type can be either “Fixed Speed”, “Control to Sensor Value”, or “Pass Through”. If fixed speed is used, the only other setting needed is the speed setpoint. In this case, the system will simply output a fixed analog value to keep the speed at this point. For “Pass Through”, the Brain simply passes an analog input to the output. If controlling to a sensor value, more settings are available, which are outlined below.

- Choose Sensor: Select this button to choose the sensor the speed is controlling around. If this sensor is too low or high the speed will be adjusted. Most commonly this will be suction or final discharge pressure.
- Change Rate: The change rate defines the percentage of the operating range that the rpm will swing in one second. For example, if set to 50% then it will take two seconds to ramp from the low to the high range if required. Setting to a lower value will slow down the control.
- Auto Operating Range: This defines the operating RPM range for the speed output. If the output reaches one of these limits and the sensor is still out of setpoint range, the RPM will be clamped to this value. These limits keep the engine from going too fast or slow when trying to meet the setpoint.

If the control type is “Control to Sensor Value”, a third page will be shown next.



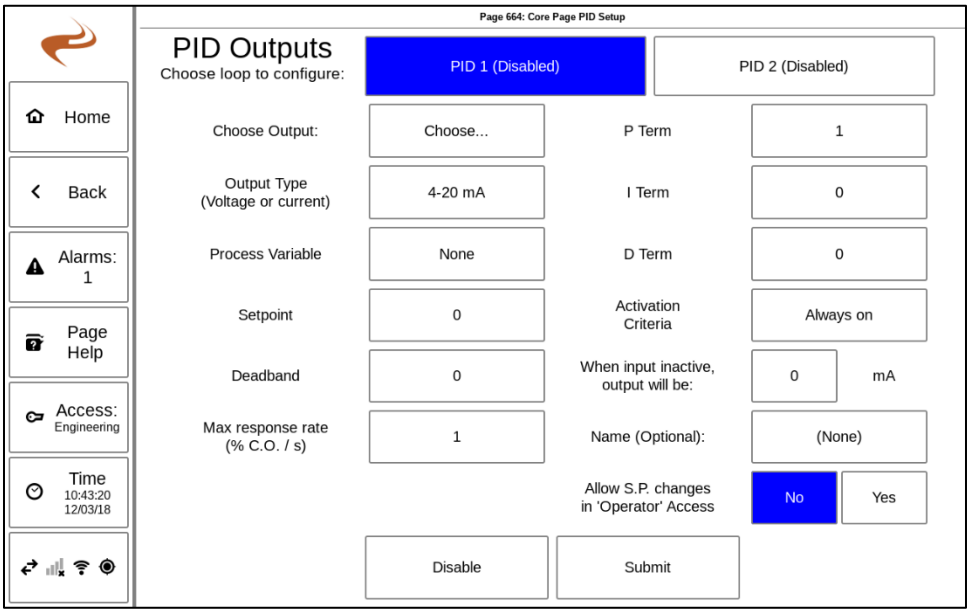
- Control Type: This can be set to either “Setpoint / Deadband” or “Linear Ramp”. For Setpoint/Deadband, a target value will be specified along with a deadband- if the sensor value is outside this range the speed target will change. In Linear Ramp mode, the speed target will be linearly interpolated between the low and high sensor value / RPM pairs.
- (If in Setpoint Mode) Setpoint: This is the target value for the sensor chosen. For some types of sensors, such as discharge or manifold, this setpoint should be held fairly close. For some, such as suction, the speed will spend a lot of time near the limits and the setpoint is more of a cross-over point when the sensor goes from high/low or low/high.
- (If in Setpoint Mode) Deadband: The deadband defines a region around the setpoint where the speed will not change.
- (If in Linear Ramp Mode) Low Setpoint / High Setpoint: This specifies the low and high sensor reading that corresponds to the low and high RPM.
- Positive or Negative Control: This setting controls the direction the speed will change to meet the target setpoint. For *positive* control, increasing the RPM will increase the sensor, such as manifold or discharge pressure. For *negative* control, increasing the RPM will decrease the sensor, such as suction pressure.

After reviewing the entered settings, select “Submit” to save.

CUSTOM PID OUTPUTS

The Brain supports up to four custom PID analog outputs. These outputs can be used to control a variety of processes and controls. A PID output can be configured on the **PID Setup** Screen by navigating from the main setup to “Outputs Setup” then “Custom PID”.

Only experienced personnel should adjust PID settings



To configure a PID output, select one of the available PID loops at the top of the screen. Each setting is outlined below. When complete, select “Submit” to save, or “Disable” to disable that PID loop.

- Choose Output: Select this button to choose the analog output to use. All available analog outputs will be listed to select.
- Output Type: Choose 4-20mA, 1-5V, or 0-5V based on what equipment is driven
- Process Variable: Choose the process variable. This is the variable that will react to changes in the output.
- Setpoint: Choose the target setpoint for the process variable.
- Deadband: Choose a deadband for the setpoint. Within this deadband around the setpoint, the output will not be changed
- Max response rate: The max response rate is the percentage of the output range that will be changed in one second when the controller is moving at its fastest rate. This clips the change in controller output after the loop calculates the value.
- P,I,D term: These are the actual Kp,Ki,Kd constants
- Activation Criteria: Select this button to choose when the loop should be active.
- Inactive state: Enter what the output should be when the controller is not active

PID Status and Auto / Manual Control

Under the "Faults / Outputs Status page" described in a previous section, there is a "PID" category to see the status of all loops.

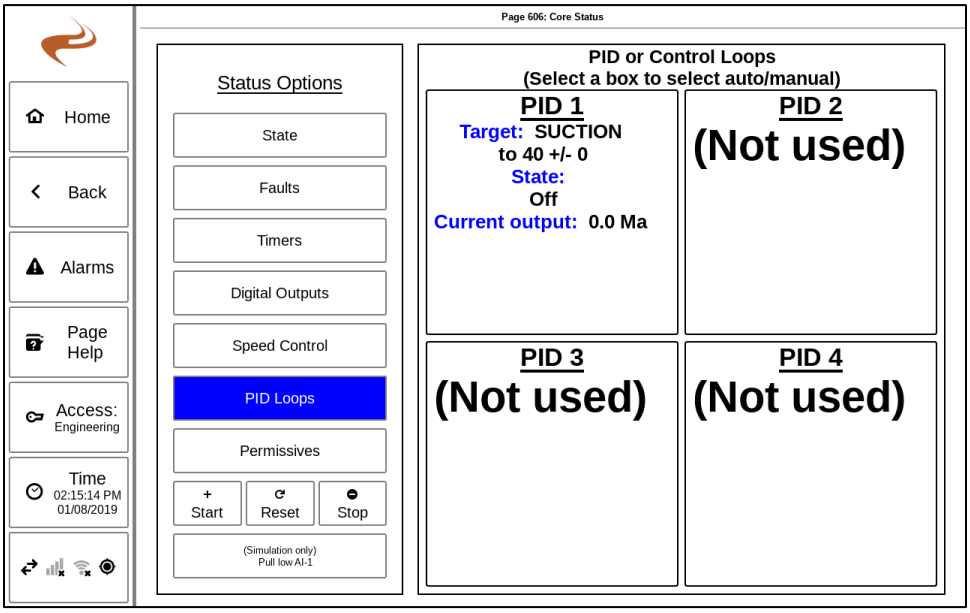


Figure 10. Status page at 'PID' category

Selecting a loop will navigate to the PID Status Page for that single loop, shown below.

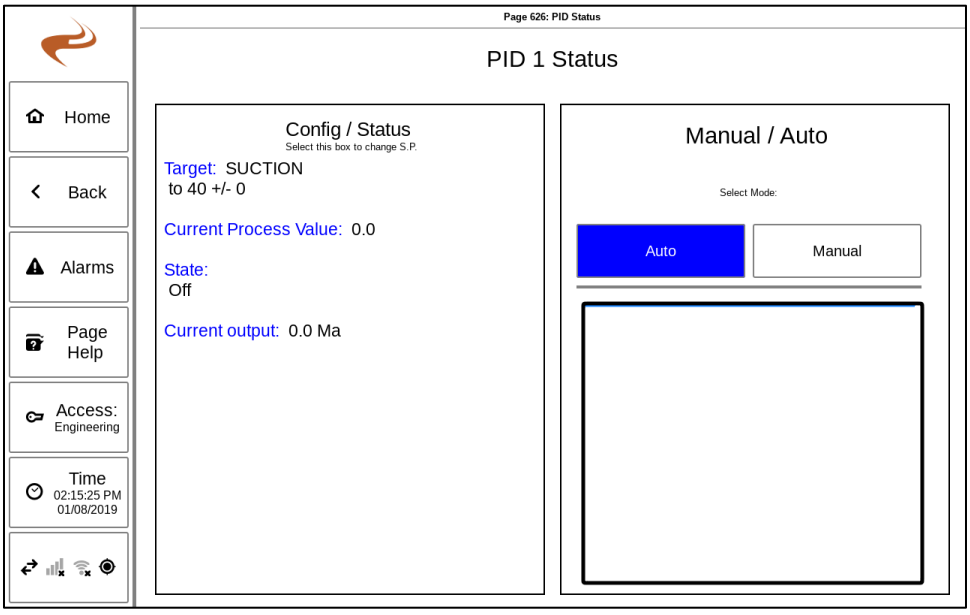


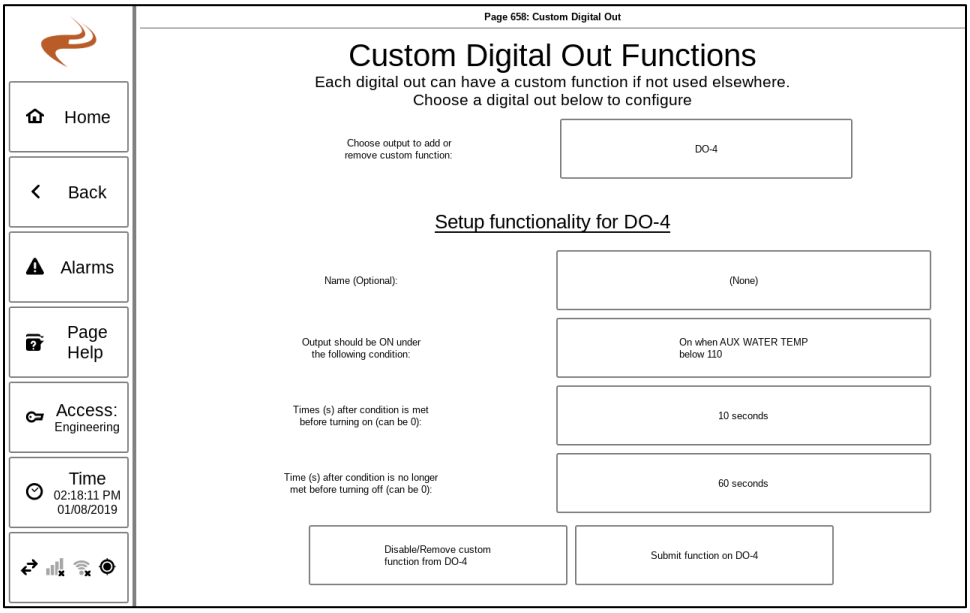
Figure 11. Single PID Status Page

On this page, the mode "Auto" or "Manual" can be selected if the access level is 'setup' or higher. In manual, the box on the right side of the page will show the manual setting, and can be selected to change the output.

CUSTOM DIGITAL OUTPUTS

The Brain has the ability to turn the digital outputs on and off based on a user-defined sensor condition. Any digital out that is not in use by another function can have a custom function associated with it.

The custom digital out function is configured by selecting "Outputs Setup", then "Custom Digital Outs".



Select the top button of the page to select an output to configure. Only outputs that have no function or already have a custom digital out can be selected.

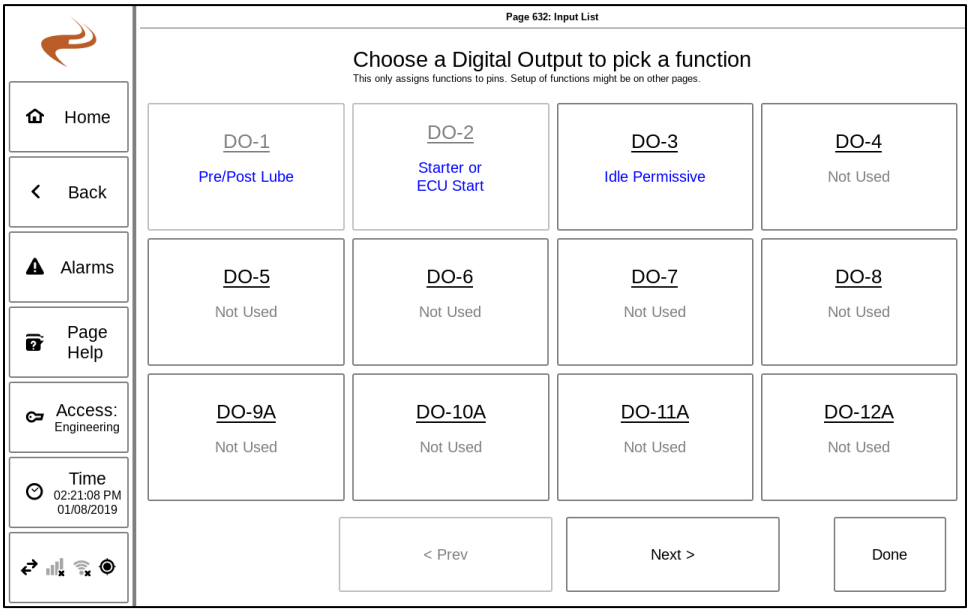
For a given output, select the top button of the lower section to define a condition when the output should be on. This can be any condition dependent on other inputs. Also available is a delay before/after the sensor condition is true/false for the output to activate or deactivate.

In the example shown above, when the Aux Water Temperature is below 110 degrees for 10 solid seconds, Digital Out 4 will turn on. Once the temperature is above 110 degrees for 60 solid seconds, the output will turn off.

For Brain versions above 1350, a row for ‘Deadband (optional)’ is shown. This can be used to specify a deadband in which the output will not change. For example, if the sensor criteria is “output will be on when Suction is above 50 PSI”, and the deadband is 5, then the output will go from off to on when suction rises above 55 PSI. Subsequently, the output will go from on to off when the suction falls below 45 PSI.

DIGITAL OUTPUT TO FUNCTION SETUP

The **Digital Output to Function Assignment** Page can be used to assign digital outputs to a specific function.



To assign a function to an output, first choose the output. The screen will bring up a list of available functions for that pin. Choose a function to assign it to that pin.

Some functions (such as idle permissive, pre lube permissive lamp, etc.) will have an option on their own setup page for assigning a pin to a function, in which case this page will not be needed. For some functions (such as battery saver output), this page is the only place to assign that function to a pin. Additionally, there may be cases where it is desirable to have two digital outs share the same function to help with wiring.

	Digital out 1 and 2 are fixed to LUBE PUMP and STARTER OR ECU START, respectively, and cannot be changed.

A list of possible options and what they do is shown below.

Function	Description
LUBE	Powered on when the Pre/Post lube should be active
START	Powered when the start output is active. For Non-ECU modes, this runs a starter. For an ECU, this may be on the entire run time as a run signal to the ECU, depending on ECU type.
IDLE	Powered on during idle hold or idle switch selection
PRELUBE PERMISSIVE	Powered on when the prelube permissive is not yet met. Can be used for a lamp

WARNING LT	Duplicates the warning (yellow) segment of the light tower
SIREN	Duplicates the siren signal of the light tower
RED LT	Duplicates the red segment of the light tower
GREEN LT	Duplicates the green segment of the light tower
SHUTDOWN ACTIVE	Powered on during the 'shutdown delay' state
SUCTION	Suction block valve
DISCHARGE	Discharge block valve
BYPASS	Bypass valve
BLOWDOWN	Blowdown valve
BATT SAVER	Battery saver active. Should be wired to kill the panel.
FAULT	Powered when in the faulted state
WARNING	Powered on when a warning is active
ADEM DER	Driven Equipment Ready logic to go the ADEM. Powered on when the system is clearing the ECU to start the unit.
FUEL VALVE	Duplicates the logic of pin 10 of the module. Powered on during normal run to allow for a fuel block valve.
START GAS SUPPLY	Start gas block valve
SPEED AUTO	Powered on when the speed is in the auto state
HOT START	Powered on when the engine is off but not faulted, for hot start

CHANGING HOME PAGE GAUGES

The gauges on the home screen can be changed to show the most relevant sensors. Up to nine gauges can be shown at a time, and up to five “sets” of gauges can be enabled, which causes more tabs to appear on the home page. If four or less gauges are shown, they will be scaled larger. It is allowed to show the same sensor on multiple pages if desired. To change the gauges shown, the **Home Page Gauge Selection** page is used, which is reached from the main setup by selecting “Gauges Setup”.

Note: Previous to v1.05, only four pages were available.

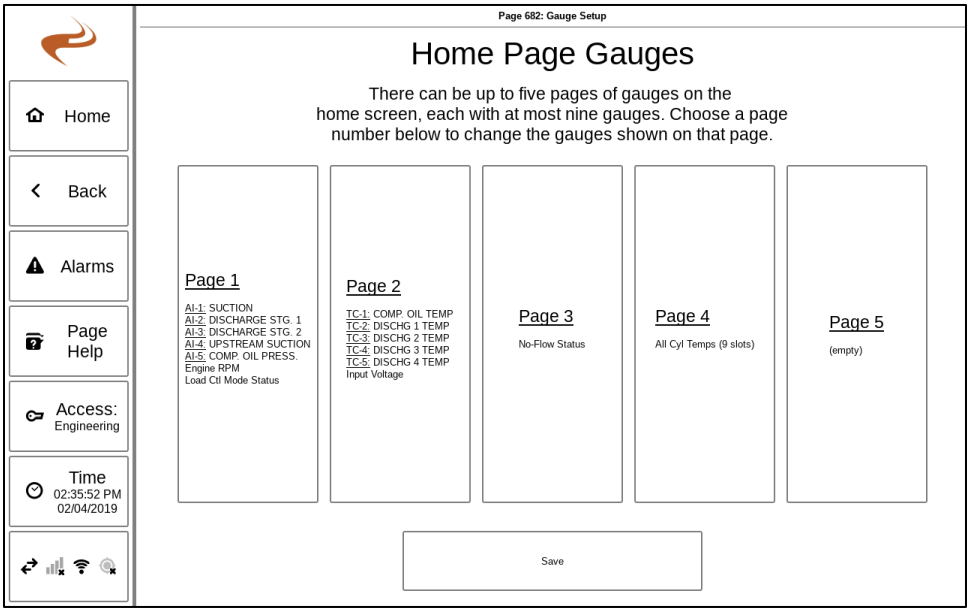


Figure 12. Home Page Gauge Selection Overview

The main gauge selection page shows an overview of the available sets of home page gauges. If a page set doesn’t have any items selected, that tab will be hidden. Selecting one of the four sets (pages) will bring up the **All Sensors Selection** screen to select the gauges for that page.

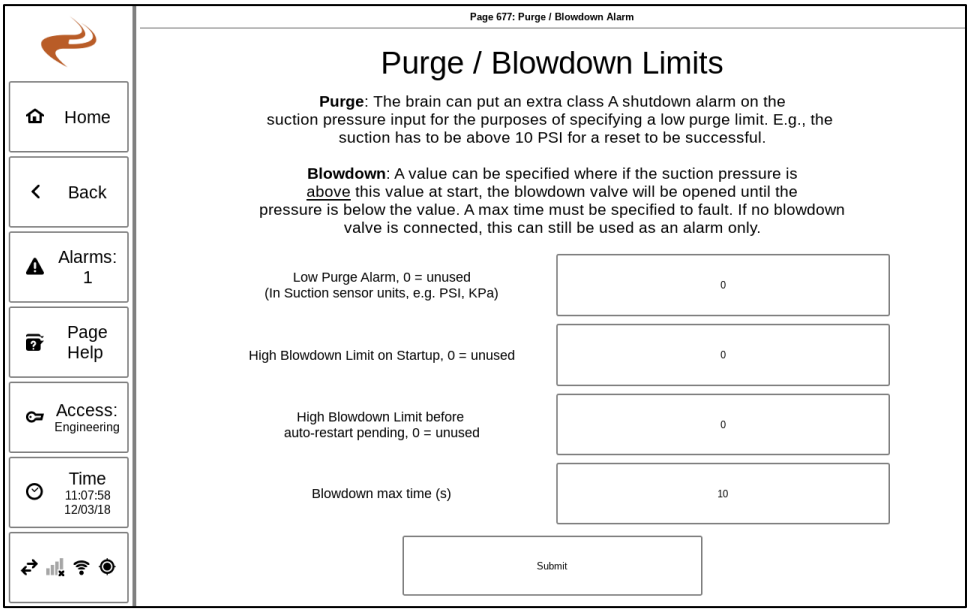
The buttons at the top of the sensor select page can change the displayed items between Analog Inputs, Thermocouples, and Other items. On a given group of items, the items highlighted in blue are currently selected. Selecting a blue item will unhighlight it and remove it from the gauge set. Selecting an item in black will highlight it and add it to the gauge set. When finished, click “Done” to return to the previous page. If more than nine items are enabled for that set, an error will be shown and some must be de-selected.

Some items under the ‘other’ category are related to control statuses, such as no flow status.

When complete on the main selection page, click “Save”.

PURGE / BLOWDOWN ALARM

The Purge/blowdown limit setup page sets the startup suction pressure limits for alarm and control purposes.

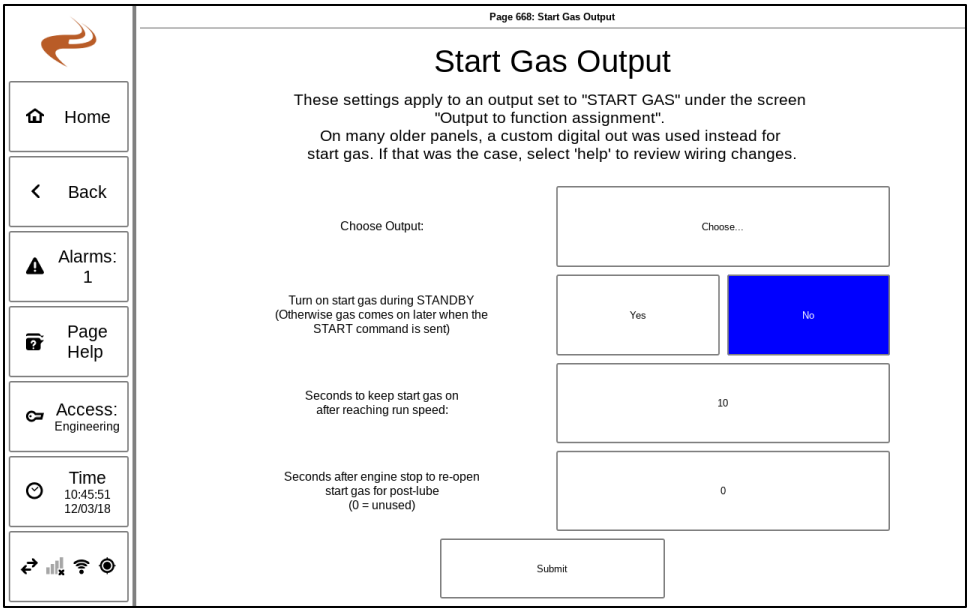


The settings on this page are:

- **Low Purge Alarm:** This value specifies the minimum suction permissive to start or run the system. During normal startup and run states, the suction can never go below this value.
    - If using the purge sequence, this also specifies the minimum pressure below which the purge will be performed automatically
- **High Blowdown limit on Startup**: If specified, this specifies the maximum suction pressure at startup above which a blowdown will be automatically performed. For the blowdown to actually happen, a blowdown valve has to be assigned on the output to valves selection page.
- **High blowdown limit before auto restart pending**: If this value is specified, then a blowdown will also be performed right after shutdown if the shutdown will result in an auto restart. This gives time for the pressure to stabilize before the next startup.
- **Blowdown max time (s)**: This specifies the maximum amount of time to blow down a unit, if the pressure isn't below the limit in this time the sequence faults. This can catch a valve malfunctioning.

START GAS LOGIC

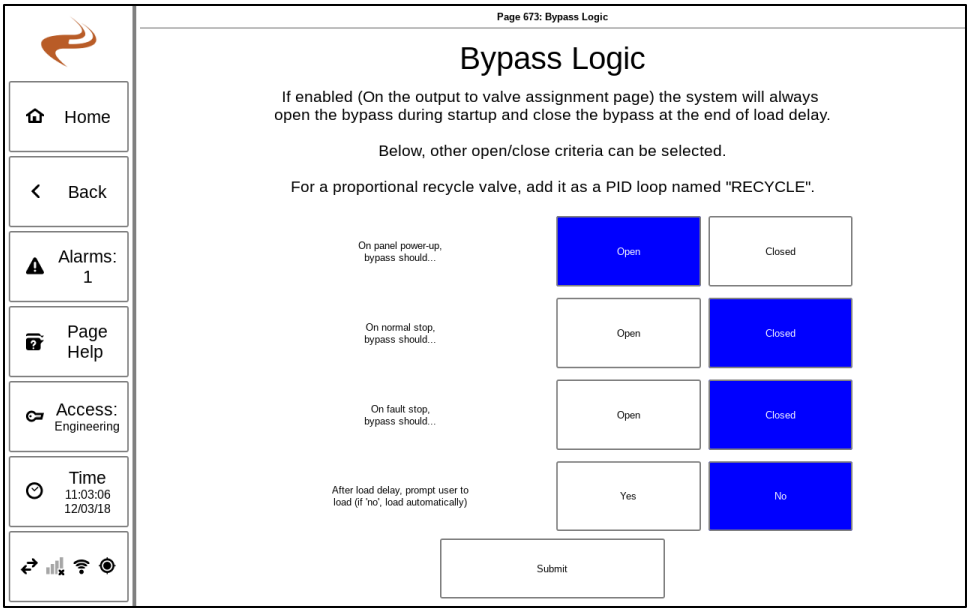
If a start gas block valve is used, a digital output can be selected to drive the valve. The output will come on right before starting the unit, and will turn off once running. A few aspects of the control can be adjusted on the Start Gas setup page, which is reached from "Outputs Setup" -> "Start Gas Output".



- **Turn Gas On during STANDBY:** This causes the start gas block valve to come on during standby instead of when the START command is sent to the ECU. Having the valve come on early may be needed if it is slow.
- **Seconds to keep start gas on after run speed:** After a run RPM is detected, the start gas valve will be left on for this amount of time
- **Seconds after stop to re-open:** If the pre/post lube pump is supplied from past the start gas block valve, this value can be set to some value to allow the supply to come on after stop for post lube purposes.

BYPASS LOGIC

A digital output can be assigned to drive a bypass valve. The normal function of the output is to open the bypass during startup then close the bypass when load delay ends, thus loading the engine. Some other settings can be adjusted on the Bypass Logic setup screen, reached from “Outputs Setup” -> “Bypass Logic”.

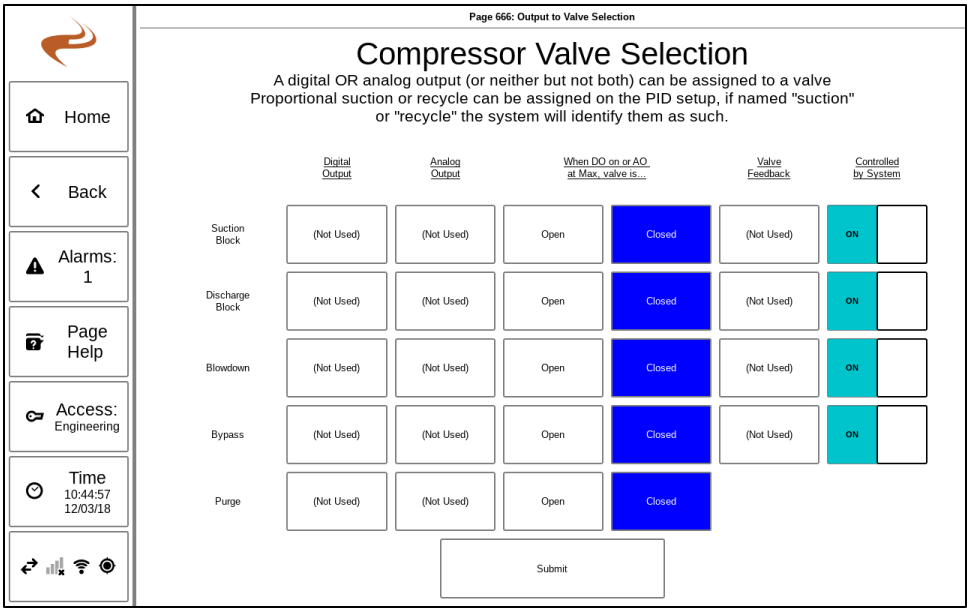


The first three options specify whether the valve should be open or closed on power up, normal stop, and fault stop. In any case, the valve will open during pre-lube if not already open.

The final option specifies if the valve should load automatically or by user confirmation. If set to ‘No, the valve will close after load delay. If set to ‘Yes’, when ready to load the user will be asked if the load can complete. When the user verifies the selection, the valve closes.

OUTPUTS TO VALVES SELECTION

The outputs to valves selection page is used to set up valves that are controlled by the system. The page can be found under “Outputs Setup” -> “Output to Valve Selection”.



Note that this page is only used for valves that do not have a PID loop. For suction and recycle valves that also need a PID loop, those should be set up as normal PID outputs with the names “SUCTION” and “RECYCLE”. The system will see the names and control the function during startup. In this case the row for suction and/or bypass on the page above will still say “(Not Used)” for both digital and analog output.

For each valve used (other than as noted in the previous paragraph), select a digital OR analog output that will drive the valve. Then, select whether the output being at max scale or turned on means the valve is open or closed.

If using valve feedback (digital or analog), select the button for that row and enter the inputs.

If ‘Controlled By System’ is set to ON (default), the valve will be controlled as the run sequence requires. If set to ‘No’, then the valve can be manually turned on/off by the user by selecting the valve status gauge, if added under gauges selection.

SCREW COMPRESSOR LOADING

Overview

A screw compressor is a type of compressor that uses rotating 'screws' that continuously rotate and force air from larger to smaller air pockets. A capacity (or load) slide valve controls how much air is bypassed around the compressor, thus directly controlling load. Some compressors also have a "Vi" slider, which controls the ratio of air volume in the compressor from beginning to end of the load cycle. The system can control the capacity slider, and optionally the Vi slider as well.

Screw compressor sliders are moved by energizing air solenoids that, while energized, force the slider to move one direction or another. Each slider will have two solenoids- one for each direction. If the system is only controlling the load slider,

then two outputs and solenoids are used (load/unload). If the system is also controlling the Vi slider, then two additional outputs will be required for four total.

Optionally, the slider(s) may have a feedback sensor that gives the position of the slider as a 4-20 mA reading. The actual reading at each end stop is within the 4-20 range, but not necessarily 4 or 20 mA. This can be calibrated as described in the feedback section below.

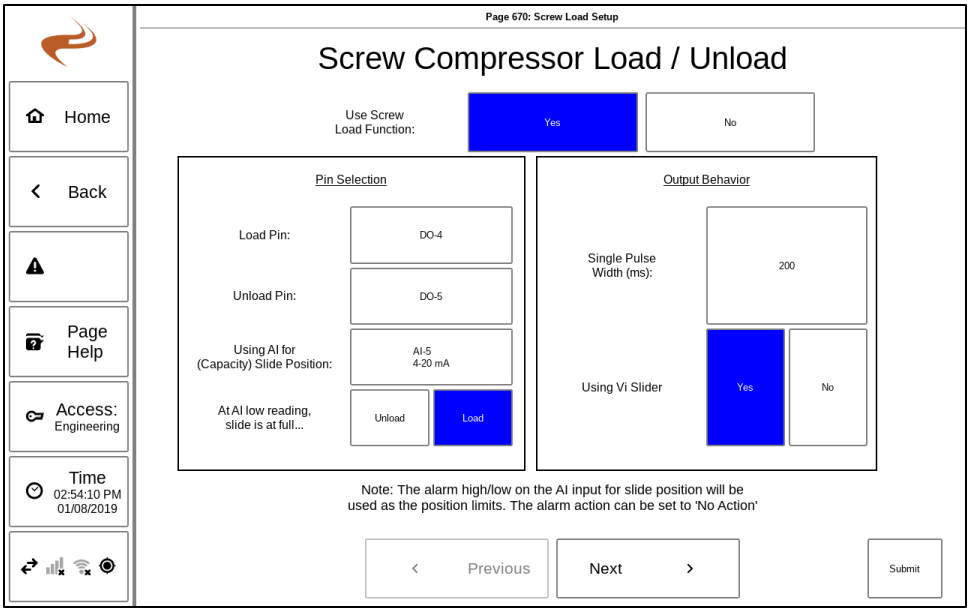
The Brain has the ability to load and unload a screw compressor based on sensor conditions. One - Four sensors can be used to control this loading. The sequence of operations is as follows:

1. The system enters normal engine running state with the screw loading in 'auto', OR after previously running in 'manual' the 'auto' mode is selected
2. A load delay counts down
3. The system enters normal load / unload loop:
    a. If one or more sensors call for unload, the screw will be unloaded
    b. If the primary sensor calls for load and the other sensors are in deadband, the screw will be loaded
    c. Otherwise, the screw will not change
    d. Once enough pulses in a row have been sent, the system will stop trying to move the load valve

The primary (first) sensor is the main sensor that controls loading and unloading. Which sensor is used will depend on field requirements. For example, if the unit can run fully loaded, then the primary load sensor can be manifold pressure, with other secondary sensors only for unloading in unsafe operating conditions (e.g. low suction). As another example, if a certain suction pressure needs to be maintained then the primary load sensor will be suction, and other secondary sensors can be used to trigger other minor unload conditions.

Setup

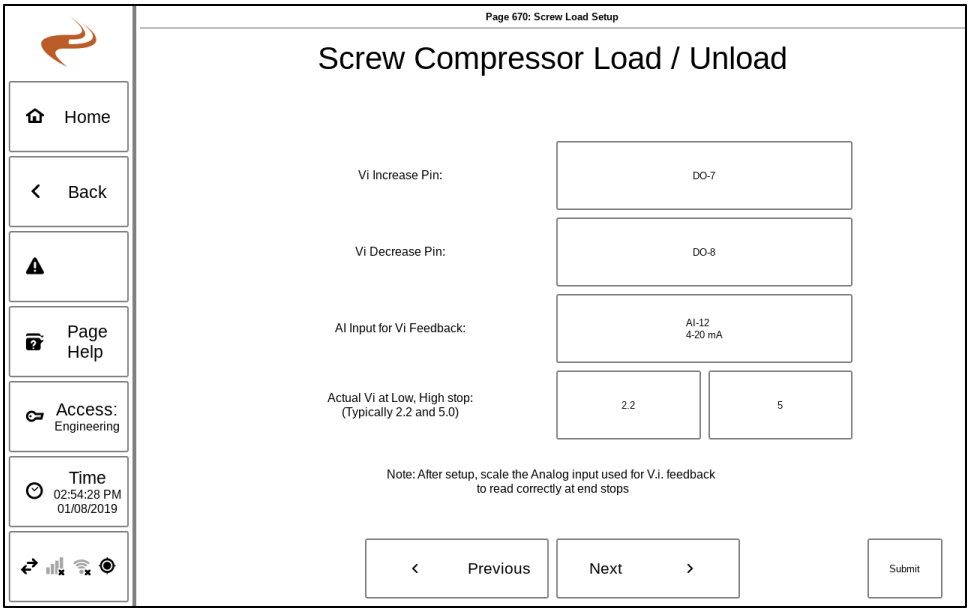
The screw load setup is reached from the main Brain Setup by selecting "Outputs Setup" -> "Screw Loading". The setup consists of two or three pages.



The first page is used to setup the following options:

- Use Screw Load Function: Select "Yes" to use
- Load Pin / Unload Pin: Select each box to pick a digital output to use for screw loading and unloading. These pins will be used to pulse the actuator each direction.
- Using AI for slide position: If the slide (capacity) position has a feedback, select the analog input here. Also select when the reading is low (e.g. 4 mA) the slide is at load or unload position.
- Single pulse width (ms): The width of one pulse. The longer the pulse, the more the slider will move for each loop cycle.
- Max Pulses: This specifies the number of pulses it takes to go from full open to full closed. This is only needed if not using AI for slide position.
- Using Vi Slider: If using a Vi slider that is controlled by the system, select 'Yes' here

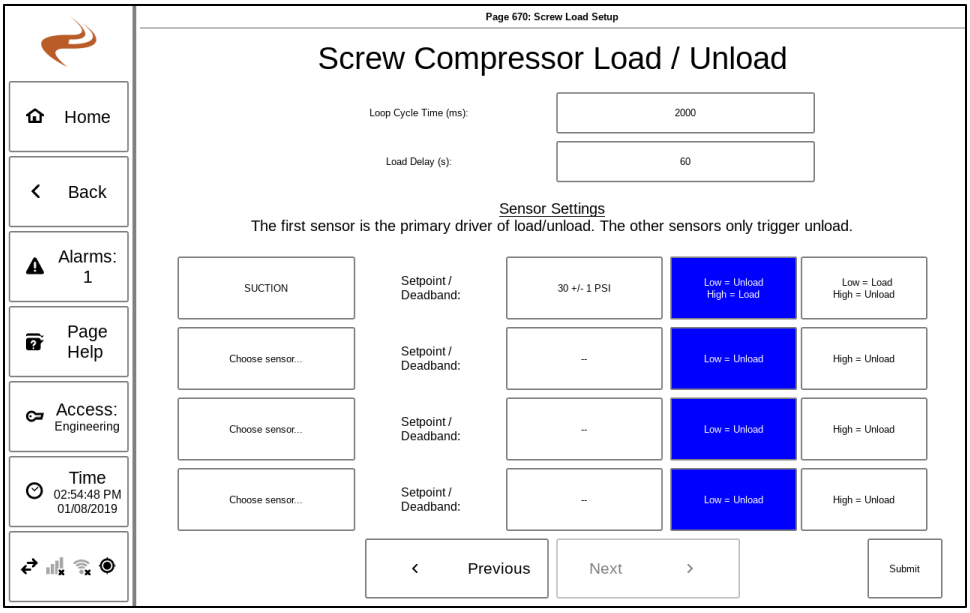
Vi Setup (below) is only used if "Using Vi Slider" was set to "Yes" on step 1.



For Vi setup, all values here must be set. The setup items on this page are:

- Vi Increase Pin: Select to assign a digital output to control the Vi Increase solenoid
- Vi Decrease Pin: Select to assign a digital output to control the Vi Decrease solenoid
- Ai Input for Vi Feedback: Select the Analog input where the 4-20mA feedback from the slider is attached.
- Actual Vi at Low, High stop: Enter the values for the min and max Vi of the compressor.

The final part of screw compressor load setup is shown below:



This page sets up actual control behavior. There are two global settings:

- Loop cycle time: This specifies the cycle time of the loop. A pulse will be sent this often while loading or unloading.
- Load delay: This specifies the amount of time after reaching BOTH running state and the load control selection in 'auto' when control will begin

The lower half of the page is for sensor settings. Up to four sensors can be selected, and at least one must be used.

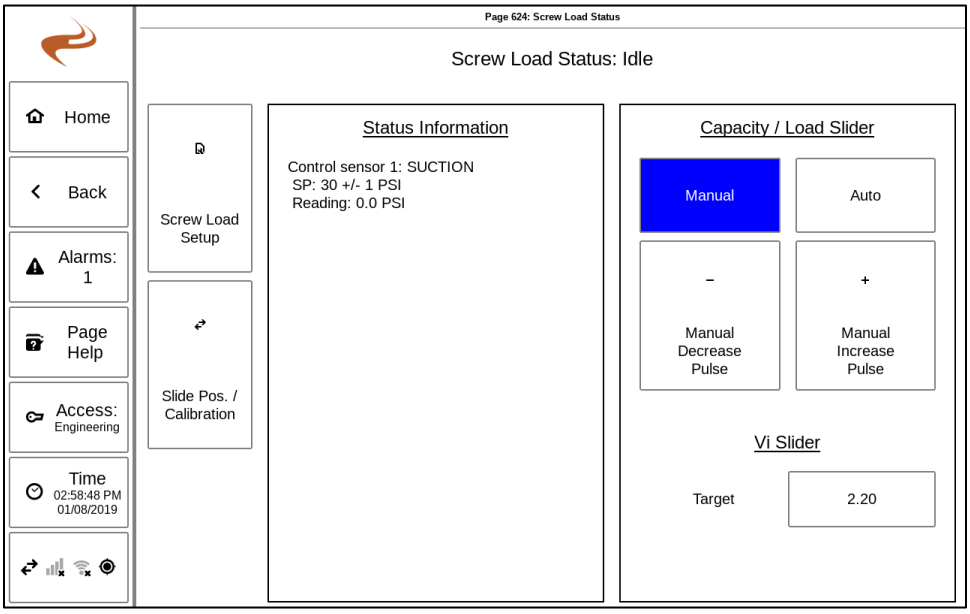
The first sensor is the **primary** driver. If the other two sensors are in deadband or are not calling for unload, and the first sensor wants to load, the unit will load. If **any** sensor calls for unload, the unit will unload. The setting "Sensor Low = LOAD" vs "Sensor Low = UNLOAD" controls how an out of deadband reading is interpreted. If set to "Sensor Low = LOAD", then when the sensor reading is below the setpoint, it is considered a condition where the engine should be loaded. With this same setting, when the sensor is high (above the setpoint + deadband), the unit should be unloaded.

Note: If the manifold pressure is physically wired to a governor, ignition, or AFRC, the sensor can be used as a control option under the 'other' category. If the manifold pressure sensor is physically wired to the Brain, the sensor can be selected on the "Analog Inputs" category.

Screw Load Status

Once screw loading is enabled, the status information can be added to the home page in the place of a gauge. Gauge selection is under "Gauges Setup. In the gauge selection dialog, the option "Screw Load Status" appears under the list for "other" items. Select this to add the status to a gauge set.

The screw load status box (gauge) can be selected to go to the screw load status page shown below.

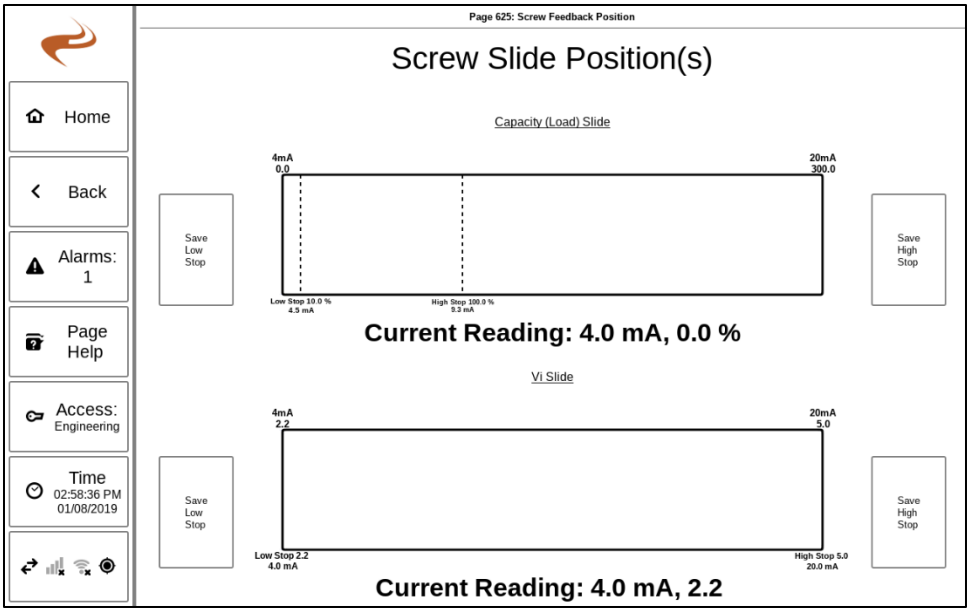


The screw load status page can be used to show the current status of the screw loading. On this page the load type can be switch between 'manual' and 'auto'. When in 'Manual', the user can manually send increase and decrease pulses. When in 'Auto' the system will load and unload the screw normally (after entering run and expiring the load delay). Note that pushing 'Manual Increase/Decrease Pulse' only causes a single pulse, and many pulses are required to move the slider very far.

If Vi is used, the target button will be shown on this page. The button can be selected to select a new Vi value. When the unit is running at the control mode is 'Auto', the system will pulse the Vi increase/decrease solenoids to move the Vi slider to the target value.

Analog slide feedback

Selecting the button "Slide Pos. / Calibration" on the screw status page will bring up the screw slide position page, shown below.



This page can be used to view the current position reading of the slider(s), and set the end stop. Each slider will show the current reading in both mA and scaled units. Note that the scaled unit reading won't be correct until the end stops are calibrated. To calibrate the end stops, move the sliders to their end stops either with the unit running or by using air connections when the unit is off. If in 'Engineering' access level, the 'Save XXX Stop' buttons can be used to save the current position of a slider as an end stop. This will cause the 4mA/20mA scaling values to be adjusted so that the readings show up correctly.

After calibrating, the capacity slide feedback input should be configured to add alarm limits to tell the Brain when to stop moving the slider. The system will stop loading or unloading when the input is alarmed (though the alarm action can be no action). For a common example, if the capacity slide is properly calibrated then the alarm limits for that input might be set to 15% and 95%, so that the capacity slider will stop pulsing right before the end stop. The alarm limits can be adjusted if different load ranges are desired, though this won't be common.

Example:

- Analog in 5 used for slide feedback
- Alarm Low: 20%
- Alarm High: 80 %
- Alarm Action: No Action

In the above setup, the system will load or unload the slide until the control is in deadband, or the slide reaches the edge of the range 20% - 80%, at which time the slide cannot move any further.

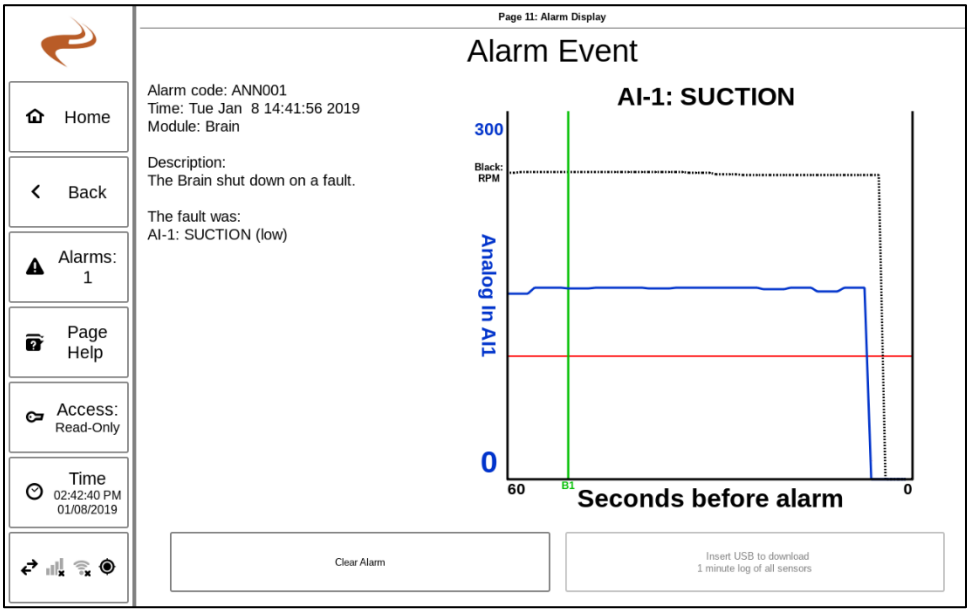
Control without feedback

If not using Analog Input for feedback, the system will pulse open or closed about the number of pulses specified as 'max pulses from open to closed'. Since there is no position feedback, the system will assume the slide is at the end position after that number of open or close pulses has been sent. Every 30 minutes the system will reset its assumed position in case the slide is drifting, and will start pulsing again.

OTHER BRAIN TOOLS AND INFORMATION

FAULTS

When an input faults, the Brain will shut down the engine and move to “Faulted” state and the touchsreen will generate an alarm event. On the home screen, the state will show as faulted and the input that faulted will be listed. Selecting the alarm event on the alarms screen will bring up the alarm event. The alarm event will list the faulted input and show the previous 60 seconds of sensor data for the faulted sensor as a graph.



Selecting the graph will allow a different sensor to be graphed, to examine what other inputs were doing around the time of shutdown.

Inserting a USB drive enables a button to download a datalog of all the sensors for the minute before the fault.

NO-FLOW STATUS

The status of the no flow inputs is available on the **No-Flow Input Status** screen. This page is reached from the main setup by selecting “Inputs Status” followed by “No-Flow Monitoring”.

The no-flow input of interest can be selected at the top of the screen. The first values shown are the time since the last cycle and the previous cycle time. This can be

useful to see the cycles as they happen, to make sure the input is cycling correctly at startup.

The next set of data are the averages. The first value is the average of the last 10 cycles. The next value is the average over the previous day.

Near the bottom is the total number of cycles since reset. This value can be used to calculate the total amount of lubricant used, or to monitor the life of the proximity switch. To reset this value if in *Engineering* or higher access mode, click “Reset Total Cycles”.

ROD LOAD AND COMPRESSION RATIO STATUS

The **Compressor Geometry / Performance Status** screen can be used to see the current and historical values of the rod loads and compression ratios, if the compressor geometry was configured. This page is accessed from the main setup by selecting “Inputs Status” followed by “Compressor Geometry / Performance”.

The left side of the screen shows the rod load status, for each stage that has the piston size configured. The first pair of values is the current rod load in tension and compression. The second value is the average for each over the last day. The last two values are the peak loads over the last day, and the time.

The right side of the screen shows the current and average compression ratio for each stage with a discharge sensor enabled.

TESTING MODE

The Brain can be used in a test mode with or without the engine running using the **\ Testing Mode** screen. This page is accessed from the main setup by selecting “Testing Mode”.

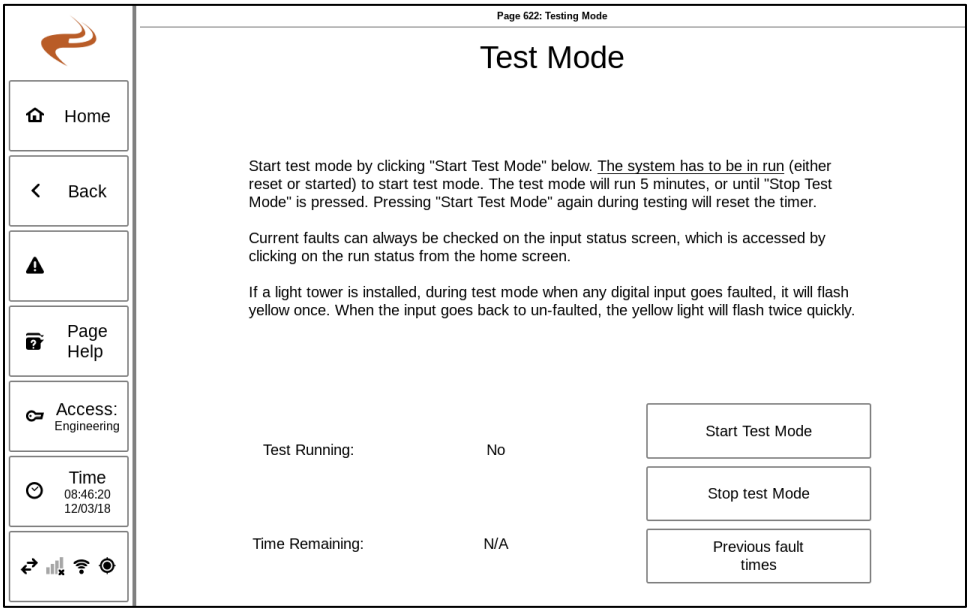


Figure 13. Test Mode Screen

On the page the testing mode can be started or stopped. When started, the test mode will run for 5 minutes, or until it is stopped. During testing mode the Brain will not shut down the engine for any A, B, or C class faults. The faults will still be shown on the **Inputs and Timers Status** page to verify the shutdown is normally operational. Any ESD class inputs will still cause the engine to be shut down when faulted.

Select “Start Test Mode” to begin the 5-minute timer, or restart the timer. Select “Stop Test Mode” to end test mode.

The “Previous fault times” button can be selected to go to the **Previous Fault Times** screen, which shows the last time every input was faulted. The previous fault time will be shown for the last time the input was faulted for any reason, whether in test mode or not. This screen can be used to see if all inputs have been tested or are working recently.

If a light tower is installed (or a lamp is connected to the LT YEL segment output), during test mode when any digital input goes from not faulted -> faulted, the tower will flash yellow once. When a digital input goes faulted -> not faulted, the light tower will flash twice.

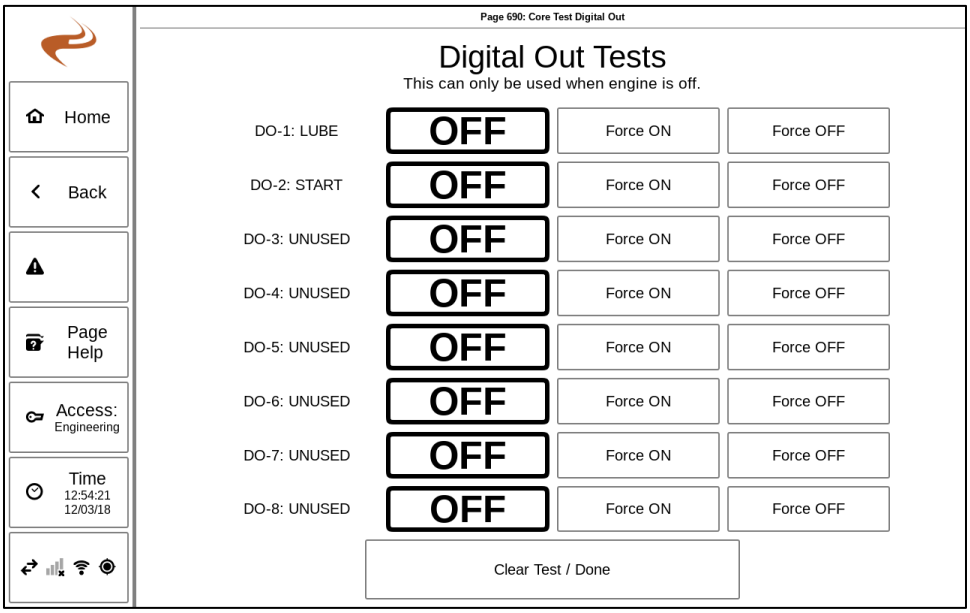
COOLDOWN MODE

The Brain has a manual cooldown mode that is accessed on the **Cooldown Mode** screen. This screen is reached from the main Brain setup menu button “Cooldown Mode”.

On this page, select “Start Cooldown” to start a 5-minute cooldown timer. While this timer is active, the process pressure (Suction and discharge stages) will be changed to a ‘warning’ so that the compressor can be unloaded.

Digital Out Test Screen

The digital out test screen is used to test the digital outputs (especially during install).



The screen is reached from the main Brain menu by selecting "Output Status / Testing" -> "Digital Out Testing".

To use this page, the Brain must be in a stopped state. Select "Force ON" or "Force OFF" to force an output to that level for testing.

Select "Clear Test / Done" to remove all forced commands and return the outputs to their normal state. (Note: Some outputs will still be normally on when the system is stopped, such as hot start).

If "RESET" or "STOP" is ever pressed on the panel, all forced output states will be cleared immediately.

Load Delay

The system can be configured to enter a load delay after startup. If an 'idle hold' (Warmup) condition is configured, the load delay will begin counting down as soon as the idle hold permissive is met. Otherwise, the load delay will count down when the unit enters full running state.

The load delay timer can be setup under “Timers Setup"->"Load Delay Timer".

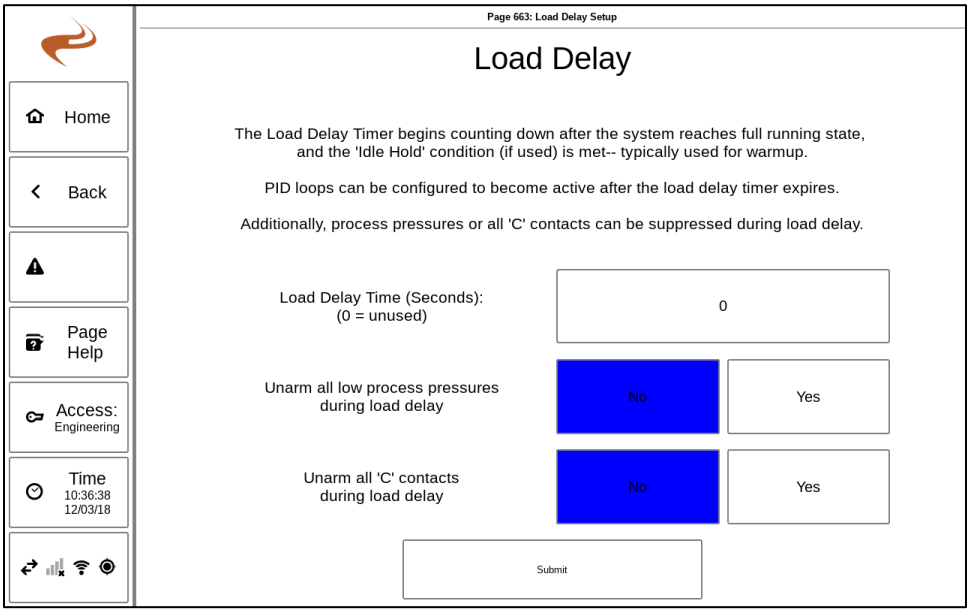


Figure 14. Load Delay Setup

If a load delay is desired, enter the number of seconds the delay should last.

Additionally, there are two options at the bottom of the page.

- **Unarm all low process pressures during load delay:** If set to "Yes", then during load delay all low process pressure kills will be unarmed (e.g. Low Suction, Low Discharges). These will arm normally after the load delay expires. These inputs will still have normal operation before load delay (warmup), so the B timer should be long enough to cover the warmup period, or the low process pressures should be C contacts.
- **Unarm all 'C' contacts during Load Delay**: If set to "Yes", then during load delay all C contacts will be considered unarmed and clear. After load delay expires the C contacts will revert to normal operation, with the inputs considered previously unarmed (i.e., if the input is in low range at end of load delay it will arm when it first clears after load delay ends).

BRAIN + EXPANSION MODULE

The Brain+ expansion module is an additional module available from EMIT that expands the amount of inputs and outputs available for the Brain. The expansion module adds 12 thermocouples, 8 analog inputs, 6 digital outputs, and 2 analog outputs.

CONFIGURING EXPANSION I/O

If the expansion module is present on the communications bus along with a Brain, there will still be only slides for the normal Brain on the home page. Under the input setups, however, the available inputs will be expanded by the amount available on the expansion module. The inputs and outputs show up as if the Brain itself simply has more I/O, and the expanded I/O can be configured in the same way as any other I/O.

The inputs on the expansion module begin at the next available index, and are appended with “A” or “B”, depending on the CAN ADDR switch on the expansion module.

EXPANSION MODULE FUNCTIONALITY

The inputs and outputs on the expansion module will function the same as on the Brain- the inputs can be set up for any class and action, and if configured as a shutdown will shut down the engine when faulted. The additional inputs will also show up in the datalog list to view for datalogging.

Once the expansion module appears on the communication bus, the system will expect it to be present indefinitely until the panel is powered off. If the expansion module ever goes from present to not present, because of hardware or power failure, the system will fault out with the shutdown code "Expansion module no longer present" to make sure no items under protection of the Expansion module are left unprotected

Data Translator

The ECU Data Translator (or EMIT Data Translator) is a module for translating engine information from a non-EMIT system into the EMIT ETS system. It allows for more standard system integration between units, and allows for datalogging and viewing engine information from an ECU on the DCT. All remote (Modbus) access to the site can then be done only through the Touchscreen, simplifying setup.

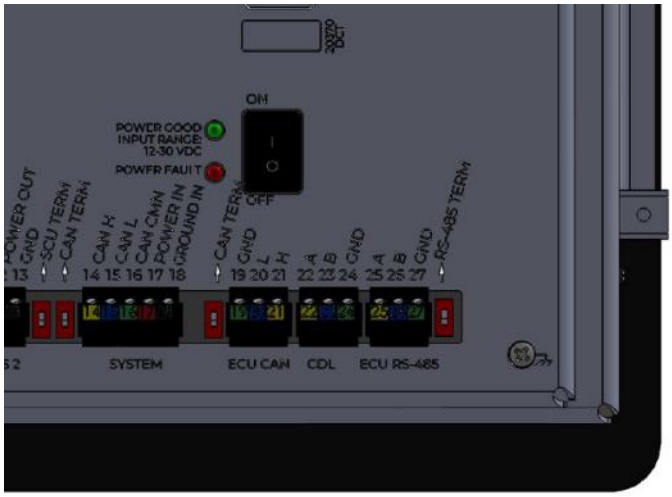
Previously, the EDT was a stand-along module, but its functionality has now been built into the touchscreen.

Features include:

- Allows a standard interface (DCT) for remote modbus access for all unit types- engine control from EMIT, ADEM, ESM, or Schneider VFD
    - If EMIT Brain is present, both compressor and engine data will be available from the DCT to simplify SCADA setup
- Brings ADEM or ESM data into the touchscreen for the user on site to view
- Datalogs all ECU sensors in standard datalogs
    - Data can be graphed or downloaded for the previous month like other logs
- Shutdowns will have engine sensor data in the logs to align with compressor data
- Plug-and-play- no setup of data tables is required. There are very few settings and the system can be up and running in minutes.

WIRING

There are three data translator ports on the back of the DCT, of which one or two will be used on a given engine.



The following table shows which plugs will be used on which ECUs.

	ADEM 3	ADEM 4	ATV71 VFD	ESM
"ECU CAN" 19,20,21	X	X		
"CDL" 22,23,24	X			
"ECU RS-485" 25,26,27			X	X

ADEM WIRING

For an ADEM 4, run a cable from the "ECU CAN" port to the "CAN H/L/SHLD" of the ADEM control panel. Typically, the CANH is Yellow and the CANL is Green in the CAT panel. The terminal block number of the ADEM CAN wires vary by engine- see the engine schematic if unsure. Typically an EMIT wire bundle for the panel will include wires that go from the appropriate terminal block that connects to ECU CAN to the ADEM CAN terminal block.

For an ADEM 3, there will be two connections required. Run the first connection from the "ECU CAN" port to the "CAN H/L/SHLD" of the ADEM control panel. Typically, the CANH is Yellow and the CANL is Green in the CAT panel. Run the second cable from the "CDL" port to the "CDL+/-" connections in the ADEM panel. (Note: CDL A on the DCT is CDL+ on the ADEM, and CDL B is CDL –). Typically, CDL+ is pink and CDL- is purple in the CAT panel. The terminal block numbers in the CAT panel for the CAN and CDL wires vary by engine- see the engine schematic if unsure.

ESM Wiring

If using the system to connect to an ESM, run a harness from the "ECU RS-485" terminal block on the DCT or panel to the "RS 485A-" and "RS 485B+" wires (#1305 and #1306) on the ESM customer interface harness.

ATV71 VFD Wiring

Since the VFD uses Modbus, it will connect to the system in the same way as the ESM above, using the ECU RS-485 port. On the main ATV box there is an RJ-45 (Ethernet-like) connector for Modbus and CAN. The following are used in this scenario:

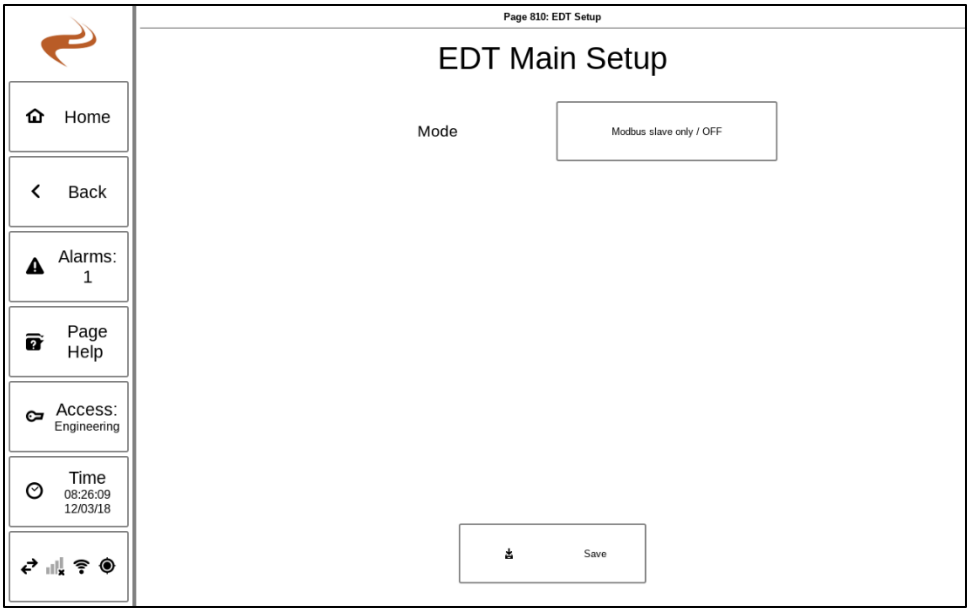
VFD Pinout (RJ-45)

- 4- RS485-B
- 5- RS485-A
- 8- Gnd (if needed)

On most Ethernet cables, this corresponds to 4 = Blue, 5 = Blue/White, 8 = Brown.

Setup

The EDT setup is generally simple because there are not many settings. The setup is accessed from the home page "Settings" -> "Data Translator".



ADEM SETUP

From the “Mode” box, select ADEM 3/4 for the mode and hit Submit. No other settings are required.

Note: The mode “ADEM (Send Requests)” is generally not used, this mode differs in that it actually sends requests for data values to the ADEM. In the normal mode the EDT only listens for data, which is generally sufficient because the ADEM panel is requesting data values. The “ADEM (Send Requests)” mode would only be used if there was no CAT panel.

ESM SETUP

From the mode box, select ESM mode. Fill in the port settings and the Modbus ID of the target ESM. If this information is not known, it can be found by connecting to the ESM with the Waukesha ESP software. After confirming the settings, select “Submit”.

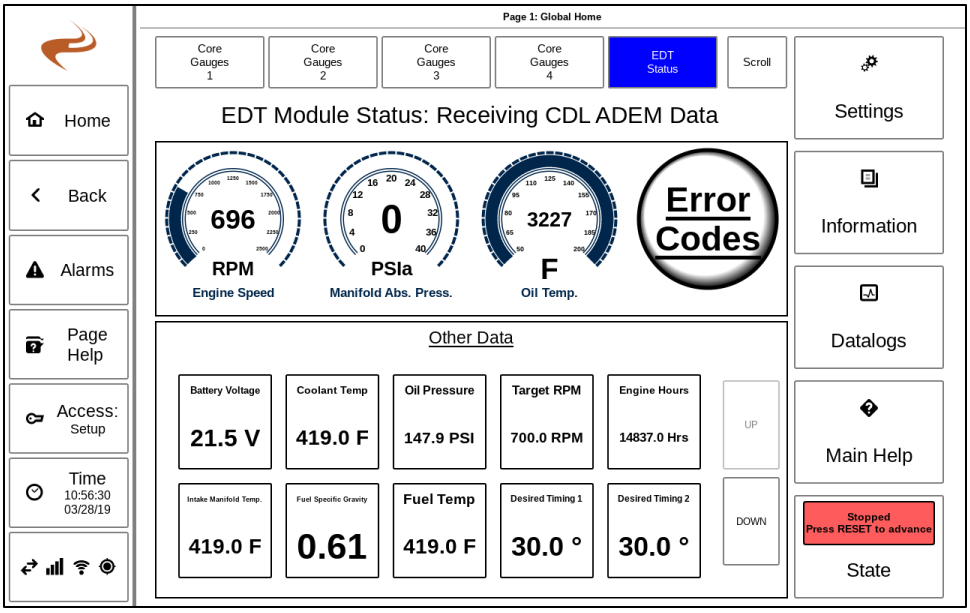
VFD SETUP

From the mode box, select “VFD ATV71”. Fill in the port settings and the Modbus ID of the VFD, which can be found from the VFD panel. By default, the VFD Modbus ID is set to 0 on the VFD panel, which has to be changed to another value for the Modbus to be activated.

EDT Home Screen

The EDT Home Screen is one of the slides available on the home page. The slide will only be shown as available if the mode setup is set to something other than “Off”.

The EDT Home Screen shows current data received from the ECU. Any data detected will be automatically populated into this screen. The status on the top of the page will show if data is being received and on which port.



DATALOGGING

Most ECU data shown on the EDT home screen is logged to the normal datalogs. To view these logs, select “Datalogging” on the home screen.

When graphing from the datalog, only items relevant to the current ECU will be shown.

To download the datalogs, select “Download Datalogs” on the datalogging screen, insert a USB drive, and follow the instructions on that screen. The datalog can be opened in Excel® or a similar program. A column will be present for all possible EDT sensors, so for any given engine application some of the columns will not be available and will be blank. For example, a single bank engine won’t log right bank items.

MODBUS

All data collected by the EDT can also be accessed over the Modbus ports.

See the document “Dynamic Control Touchscreen Modbus” to find the EDT Modbus registers. The EDT Modbus table contains all possible values that the EDT can collect. Some values will not be available on all engines- for example, the Waukesha WKI value will not be present on Caterpillar systems. Some other values will be available on all engines, such as engine speed. If a value is not available, the register value will be 65,535 (0xFFFF).

Separately, there is a unified Modbus data table shown in the Modbus tables document. This data table has a subset of the engine data, but is in the same place and address for all systems, which makes setting up SCADA systems to multiple varied units easier. It might be preferred in some cases to use this register set instead of the normal EDT register set, though many values are only available on the full EDT register set. For example, register 42006 is engine oil pressure. The DCT will

fill this register with the proper data whether it comes from the Brain, an EDT connected to a Waukesha, or an EDT connected to a Caterpillar. In either case the end user doesn't have to worry about how the system is laid out- the register will always contain the proper data if it is available.

Speed Controller (Governor)

The EMIT Speed (Governor) module is an electronic speed control system for stationary carbureted natural gas engines. The Governor system consists of two main components: the control board and an electronic throttle body. The control board is intended to be mounted in a panel or external enclosure. 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 Governor 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 Governor 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 Governor 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 Governor. 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 Governor will hold the engine at the user-specified idle speed. This speed is specified during governor setup, described in a later section.

MANUAL

When the panel’s mode switch is in Manual, the Governor 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 Governor in 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 Governor will hold the engine at a specified run speed. This run speed can be adjusted in governor 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 Governor 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 Governor will ramp more slowly than it would during normal operation.

	When switching between operating modes (Idle, Manual, or Auto), the Governor will not actually change control modes until the switch stops changing for two seconds.

USER INTERFACE

GOVERNOR HOME SCREEN

The **Governor Home** slide shows an overview of governor operation. The current status is shown at the top of this screen.

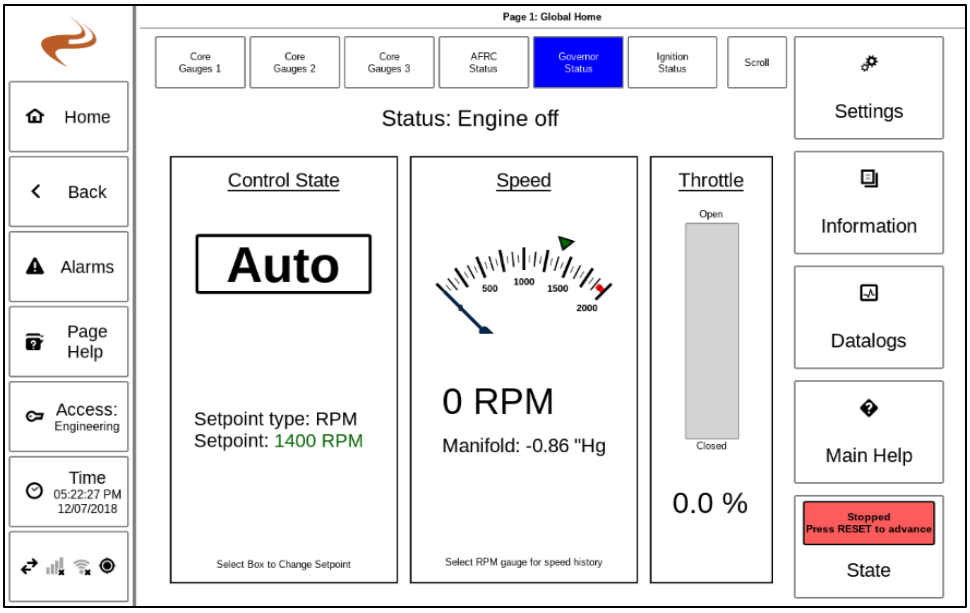


Figure 15. Governor Home Slide

The left section of the governor 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 governor 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.

GOVERNOR SENSOR STATUS

The **Governor Sensors** screen shows the current status of sensors connected to the Governor. 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. The scaling of the pressure sensors can be specified on the **Sensor Setup** screen, discussed later.

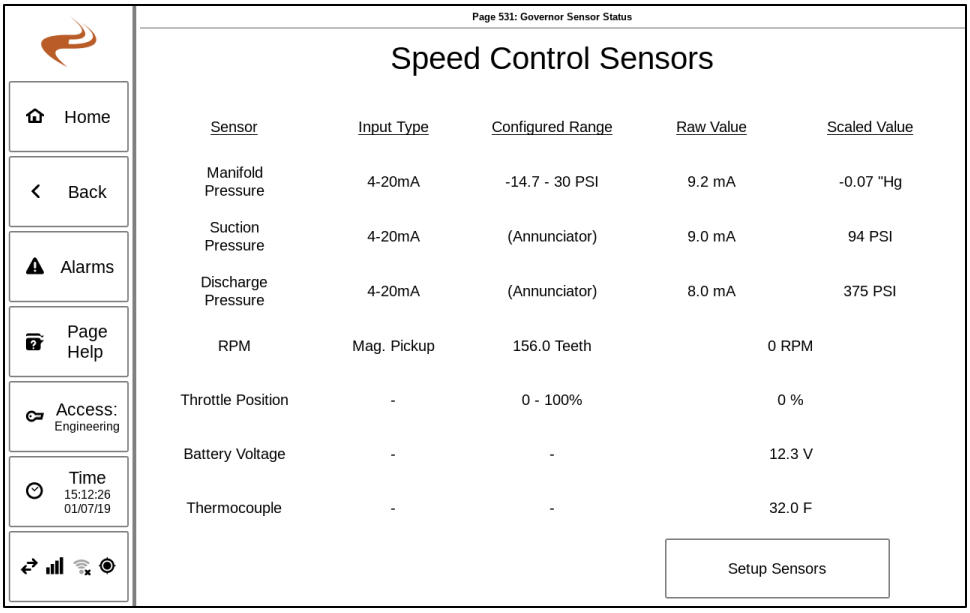


Figure 16. Governor Sensor Status Screen

GOVERNOR SETUP

After initial install, or when settings changes are needed, the Governor 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 governor 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.

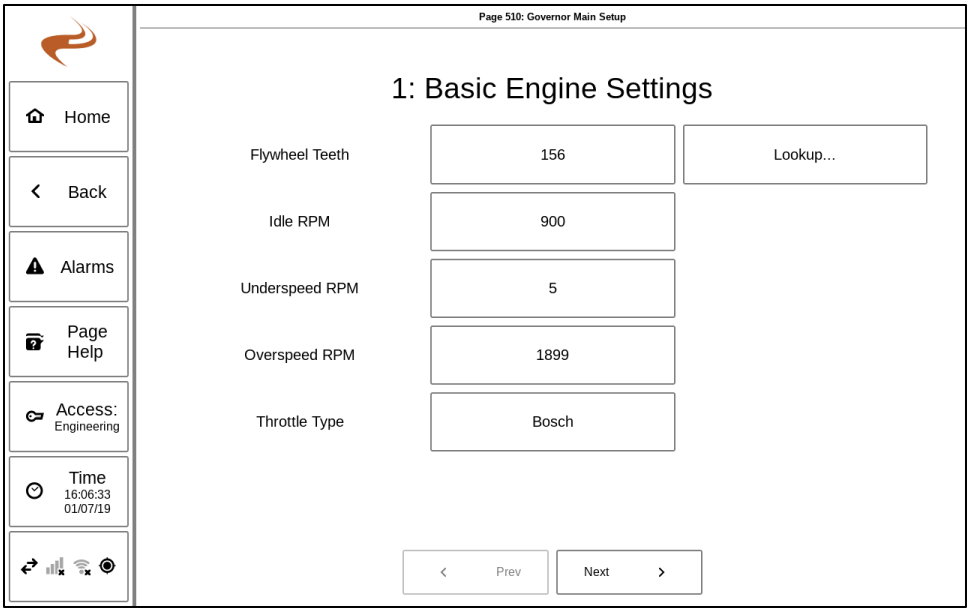
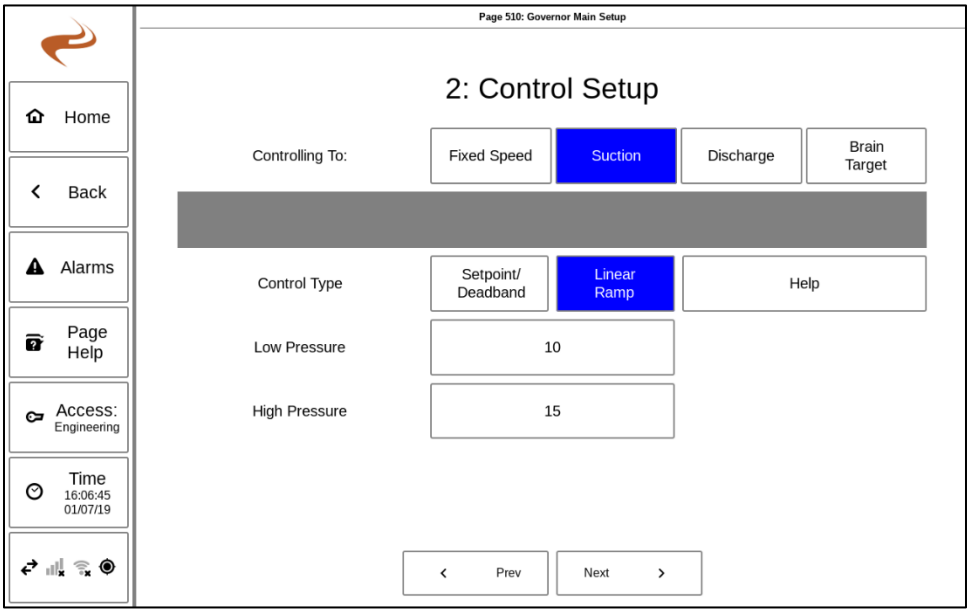


Figure 17. Setup Step 1

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 the governor 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.



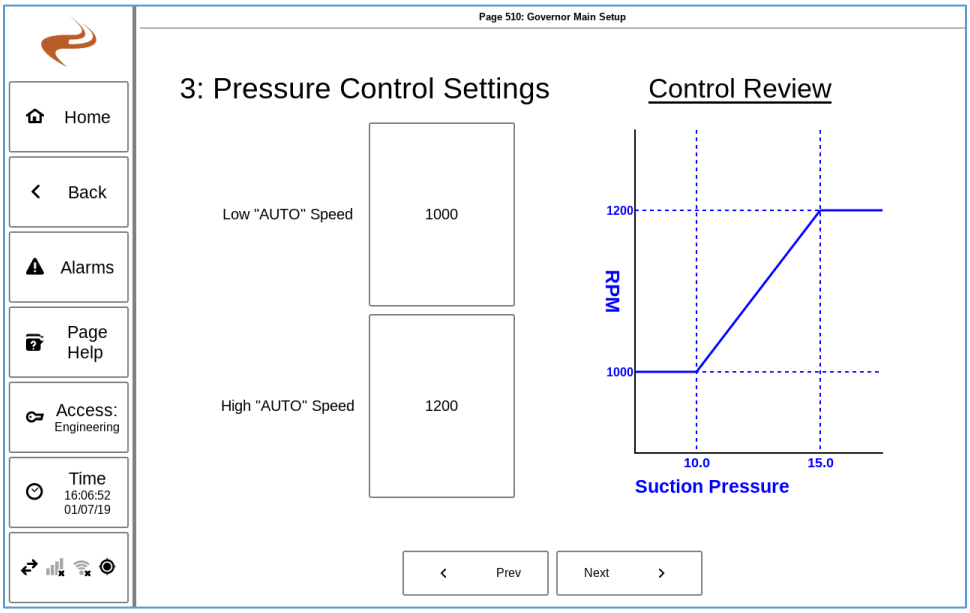
For Suction or Discharge control, the control type can be 'Setpoint / Deadband' or 'Linear Ramp'. In Setpoint/Deadband mode, the PSI target setpoint and deadband are specified, and the system will speed up or slow down if outside this range. For example, if the Setpoint is 35 PSI and deadband 1, then 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 **Governor 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 Governor 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 Governor 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 for the Governor. If the page looks correct, the “Submit” button can be pressed to send the settings to the Governor. If this is the first setup, the sensor settings should be reviewed.

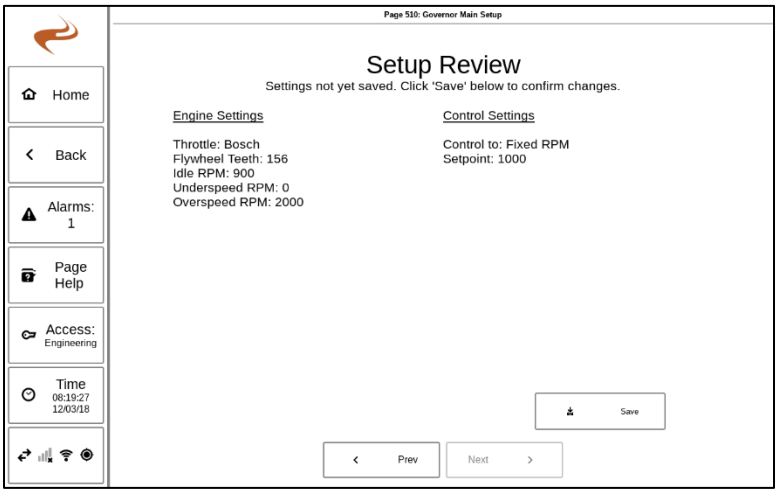


Figure 18. Setup Summary

OTHER SPEED SETUP PAGES

GOVERNOR 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.

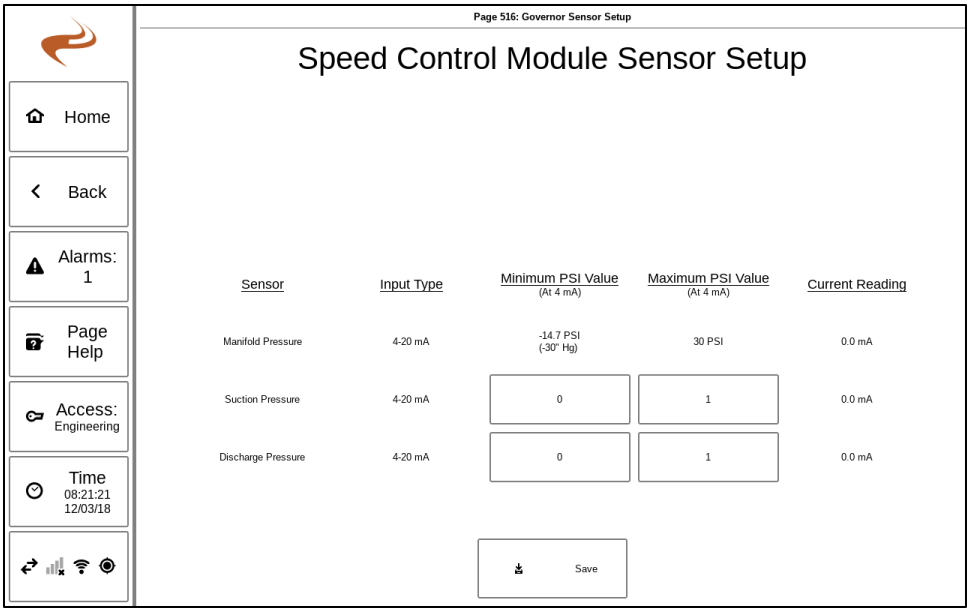


Figure 19. Governor Alarm Setup

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.

Each of the pressure inputs can have an alarm set up for it. To enable an alarm, click the enable "X" on that row, which will allow the parameters for that sensor to be changed. A low alarm, high alarm, and duration can be specified. If the sensor is outside the operating range for longer than the duration, an alarm will be triggered. If the action selected under "Action" is "Warning," then triggering the alarm only adds the event to the **Alarms** screen. If the action is "Shutdown," then the engine will be shut down in addition to adding the event to the alarm screen.

	If a "Shutdown" alarm is needed, the alarm relay on the Governor circuit board should be connected to an annunciator panel. During a shutdown the relay is closed to kill the engine. Additionally, the Governor will close the throttle, but this does not guarantee an engine kill.

SENSOR SETUP

The **Sensor Setup** page specifies the pressure sensor settings. An access level of *Setup* or higher is needed to see this screen.

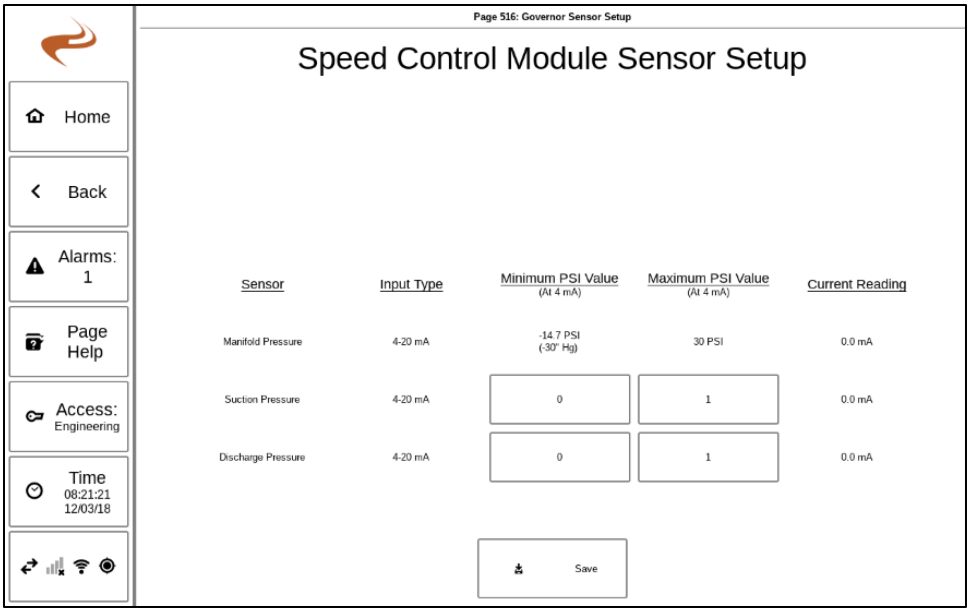


Figure 20. Governor Sensor Setup

For each sensor used, specify the low and high PSI value that corresponds to the input that causes an output of 4mA and 20mA respectively. This information can be found stamped on the sensor itself.

	If not using a pressure control mode one or both pressure sensors can still be installed for display and datalogging.

ADVANCED SETUP PAGE

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

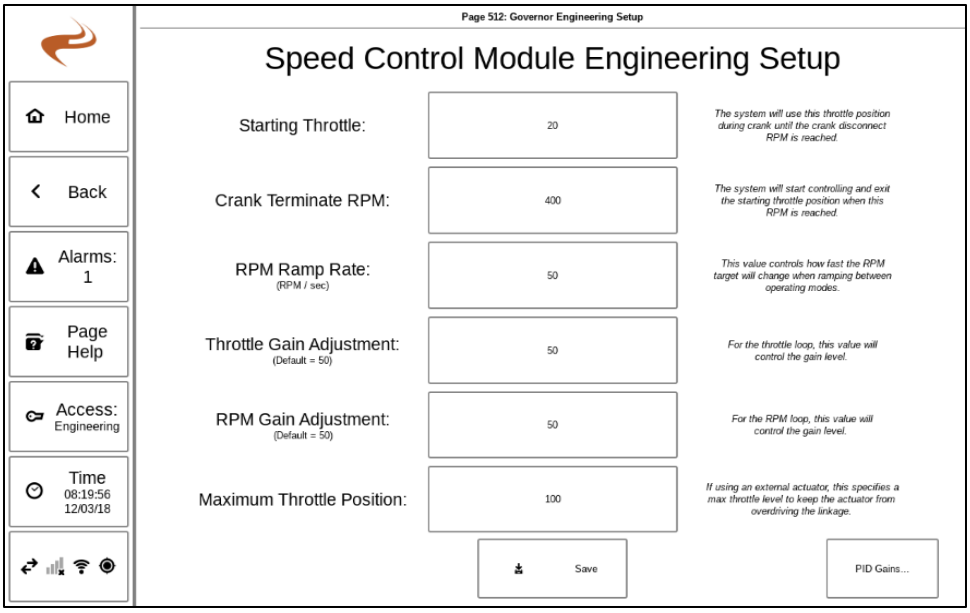


Figure 21. Governor Advanced Setup

Starting Throttle: 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 Governor only opens the throttle when it detects flywheel movement.

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

RPM Ramp Rate: 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.

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

RPM gain adjustment: 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.

Maximum throttle position: 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 **Governor 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 also what effort is required to move the throttle.

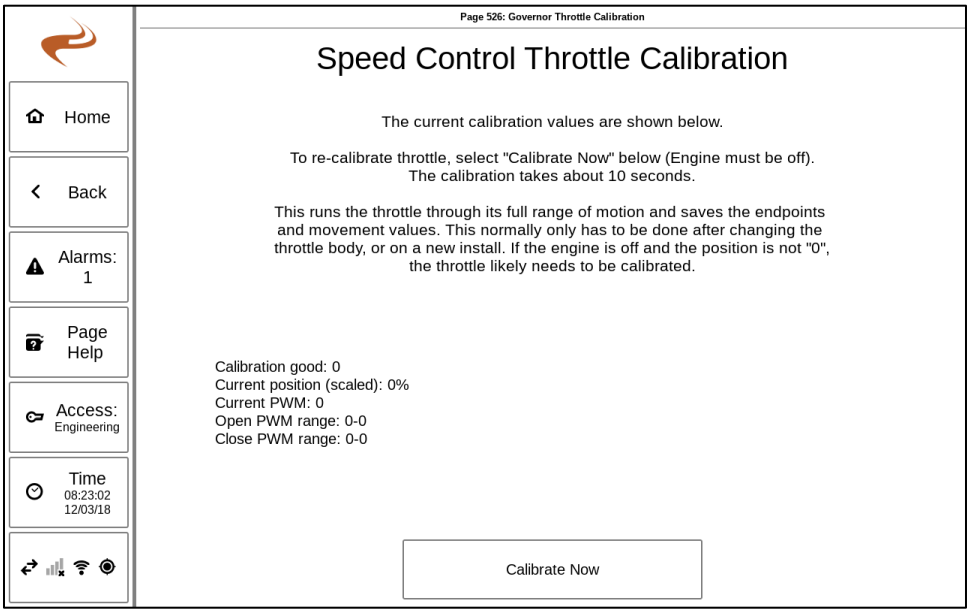


Figure 22. Throttle Calibration

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 governor will not leave Idle speed until a certain temperature is reached.

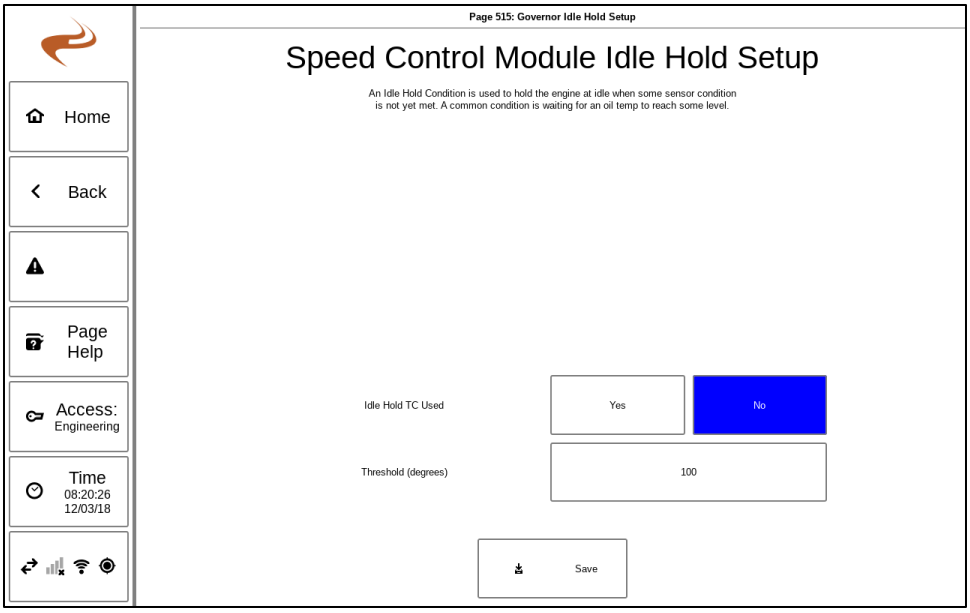


Figure 23. Speed Controller Idle Hold Setup

Note that this page is only used if a thermocouple is directly wired to the speed controller module. If an EMIT Brain module is present, it is likely that using the idle hold condition in the Brain makes more sense- it will share the condition digitally with the speed controller module.

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

SPEED CONTROLLER OVERRIDE CONDITION

Overview

In some cases, it is useful to have the governor go to full speed during a pressure-control mode to anticipate an upcoming load change. The governor auto override allows for this.

In general, starting the override mode causes the governor to enter full speed for a given time period (e.g. 3 minutes). Once this time period expires, the governor returns to normal control mode.

The timer will start and count down regardless of control mode, but if the governor is not running in "Auto", the override timer will have no effect.

Methods of triggering

The override mode can be triggered one of these ways:

Modbus command: A write to modbus register 45107 at the governor address will cause the governor to start the override timer with the written value, in seconds. For example, if '60' is written to modbus register 45107, the governor will go to high 'auto' RPM for 60 seconds.

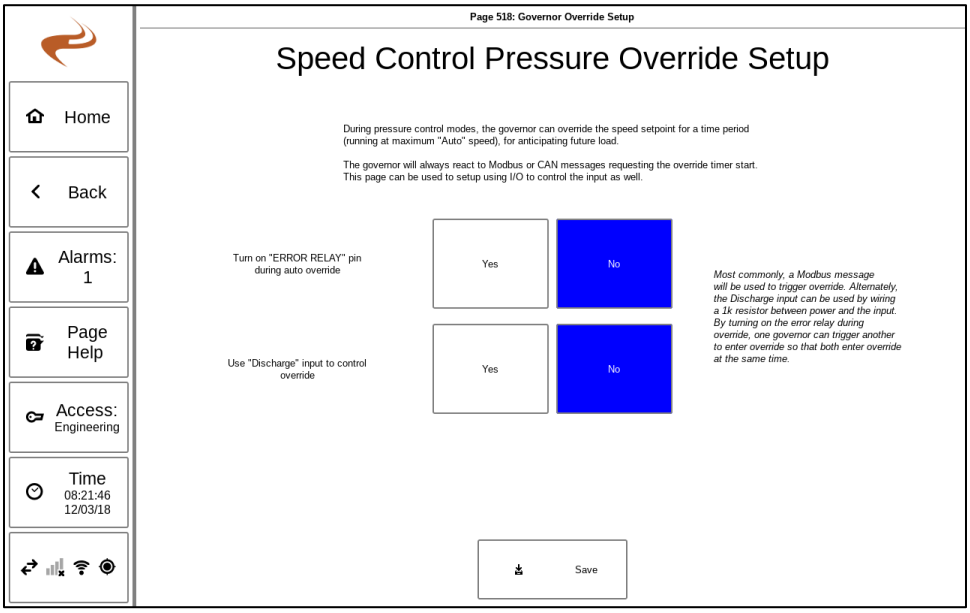
CAN command: A command might come to the governor from another module triggering the override. This is set up from the module used.

'Discharge' input: The discharge pressure input can be configured to be used as the trigger to control the override mode. This is discussed in more detail below.

More than one of the above can be used at a time. For example, if the 'discharge' input is used to trigger an override period, a modbus command will still be accepted and will become the new timer value.

Override Setup Page

The override setup page is accessed from the speed controller setup menu, then "Override Condition Setup". The page is shown below.



The setting "Turn on 'Error Relay' output during override", if enabled, will cause the governor error relay to be on (closed to ground) whenever the override is active. This can be used to drive a lamp or to chain to another governor so that one master governor controls override on multiple units.

The next three options are related to the 'discharge' input trigger. This is discussed in the next section.

Discharge input setup

The discharge input can be used to trigger the governor override. This can work in one of two ways

Signal at discharge starts timer: In this mode, "Use Discharge input to control override" is set to YES, and "Hold override while discharge input active" is set to NO. In this configuration, when the discharge input becomes active (more than 6 mA) the 'default discharge time' starts counting down for the override period. For example, if setup as shown in the above screenshot, when the discharge input goes

from below 6mA to above 6mA the governor will go to override mode (full speed) for three minutes, then the timer expires and the speed returns to normal.

Hold override while discharge active: In this mode, both "Use Discharge input to control override" and "Hold override while discharge input active" are set to YES. This causes the governor to constantly override (go full speed) while the discharge input is above 6mA. As soon as the input goes below 6mA, the override ends. This is the only use of override mode where there is no timer involved.

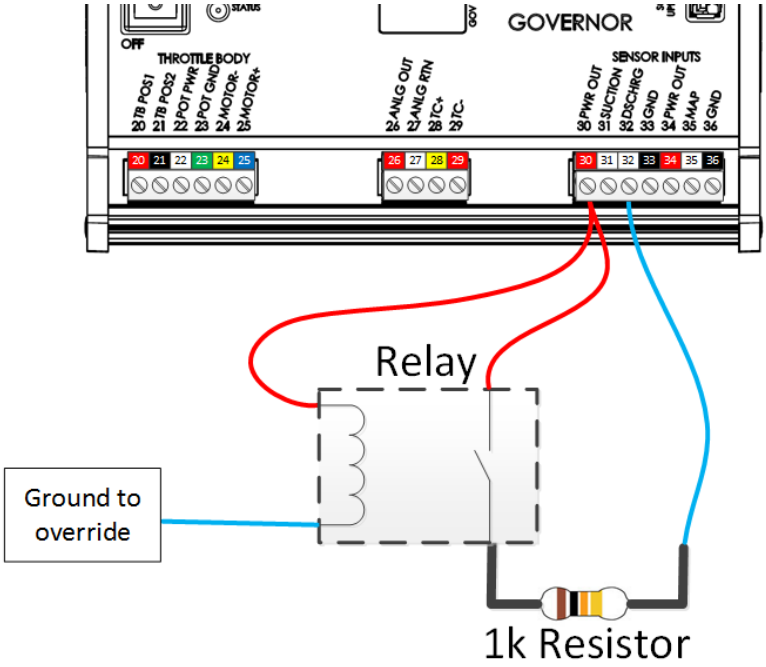
Note: If discharge input is used for triggering override, it will always show up as "0" in the datalog and on the sensors screen to prevent false recordings.

Wiring

One method for wiring the discharge input to be above 6mA is the following:

- Wire one end of a normally-open relay contact to the "+12V OUT" on the governor
- Wire the other end to a 1kOhm resistor
- Wire the other end of the resistor to the discharge input
- Wire the coil side of the relay to any control source

In this way, when the relay turns on, the discharge input becomes active. This example is shown below.



GOVERNOR ALARMS

There are two types of governor alarms – system-generated and user-specified. The user-specified alarms are set up and detailed in the above section “Governor Alarms Setup.”

System-generated alarms are for problems with the Governor 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.

AFRC

OVERVIEW

The EMIT air/fuel ratio controller (AFRC) is available in two offerings: the AFRC single-bank narrowband, and AFRC Dual bank narrow/wideband model. Both controllers are designed to control turbocharged or naturally aspirated carbureted stationary natural gas or propane engines. The dual bank model can control either rich-burn or lean-burn applications, while the single bank model controls rich-burn only. The AFRC 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 for single bank or dual bank rich burn engines 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. If on a dual-bank engine both bank's valve positions and oxygen readings will be shown. Otherwise, only one of each gauges is shown. A security mode of *Setup* or *Engineering* is required to make any adjustments or changes to this screen.

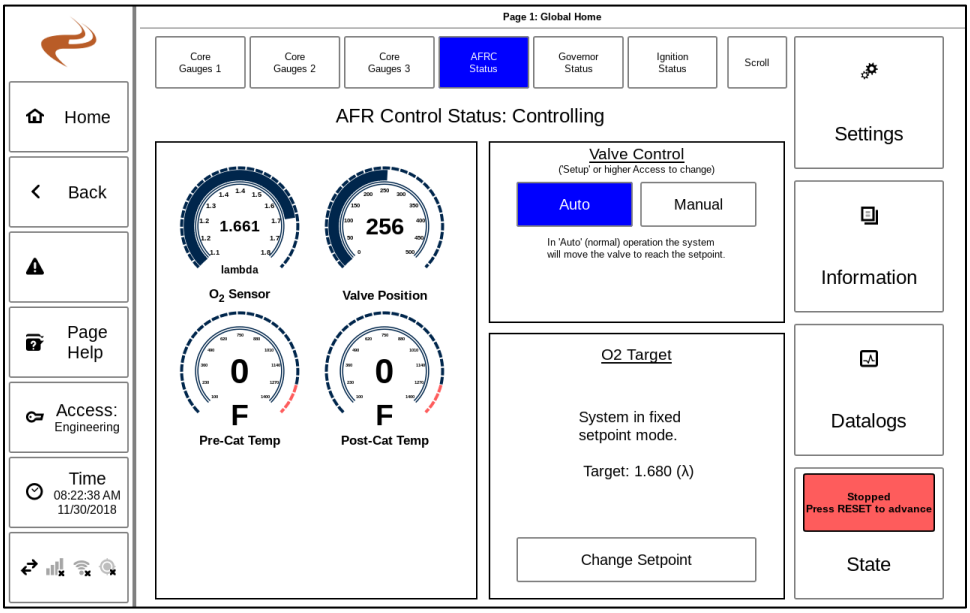


Figure 24. AFRC Home Screen Shown In "Setpoint" Mode, Single Bank

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. Wideband sensors show richer values towards the bottom and leaner values towards the top. 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. Dual bank configurations will show two "O2" gauges, one for each bank, while a single bank configuration will only show a single gauge. 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:

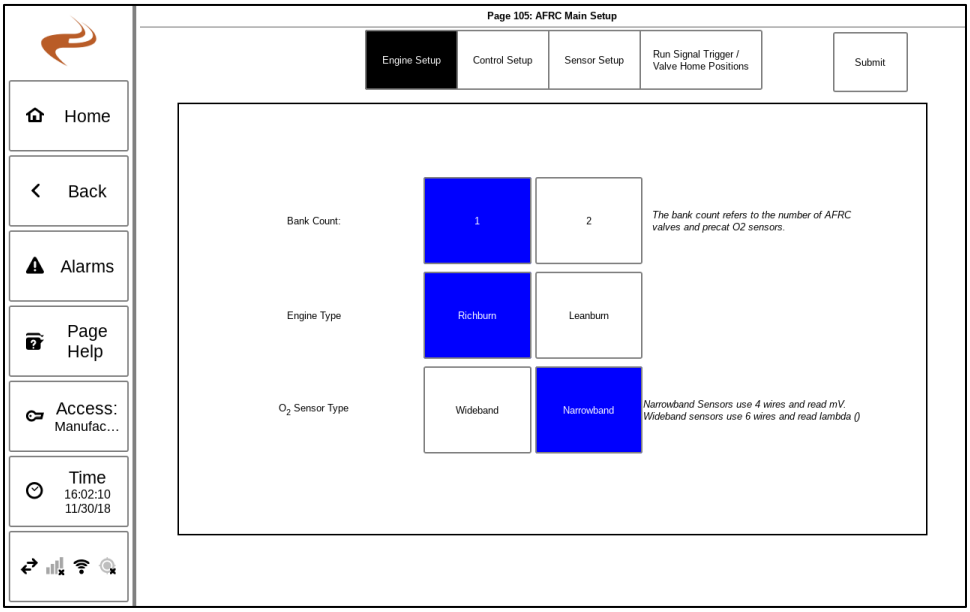
- Valves are adjusted to factory specification
- Spark plugs are properly gapped and in good condition
- Cylinders have good compression
- Mixers are in good condition and regulator fuel pressure is set to factory specification
- Fuel connections are secure and leak-free
- Ignition system functioning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

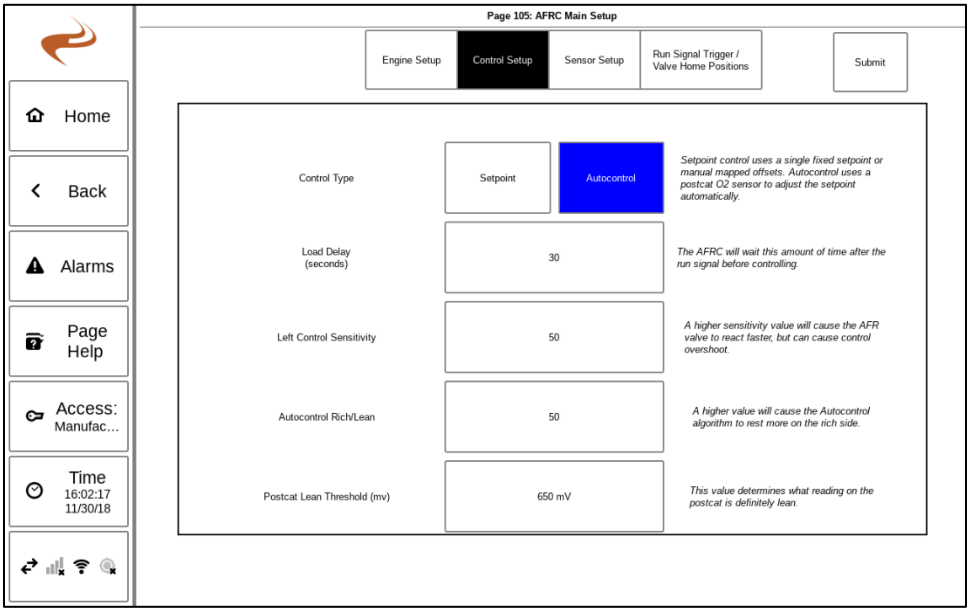
Slide 1: Engine Setup



- Bank count: This refers to the number of DPVs that need to be controlled. Note that some two bank engines have one fuel system, so the bank count would be '1' for those engines.

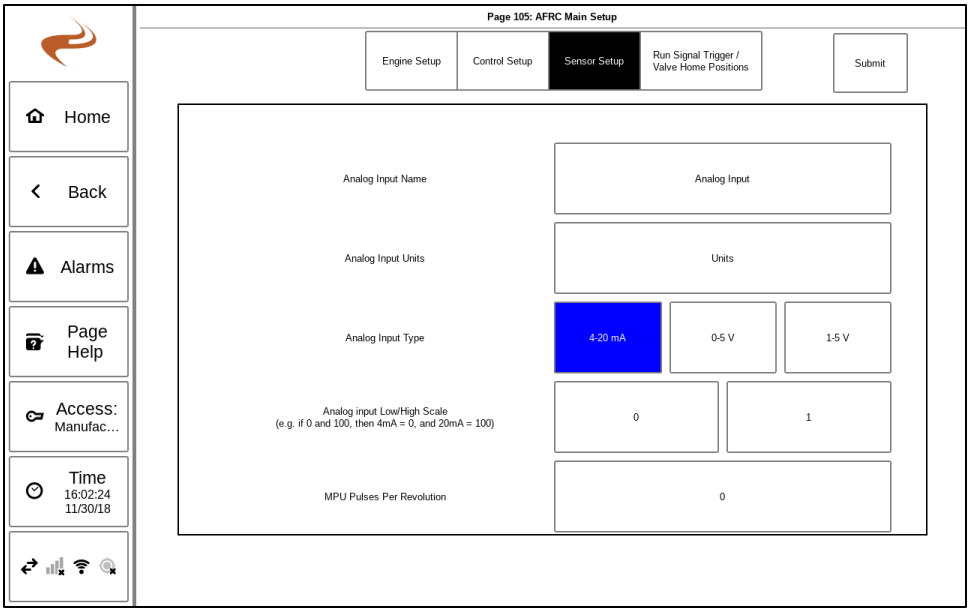
- Engine Type: Select rich burn or lean burn
- O2 Sensor type: Select the sensor type. A narrowband sensor has 4 wires and a wideband sensor has 6 wires. Note that a lean burn engine must use a wideband sensor

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.

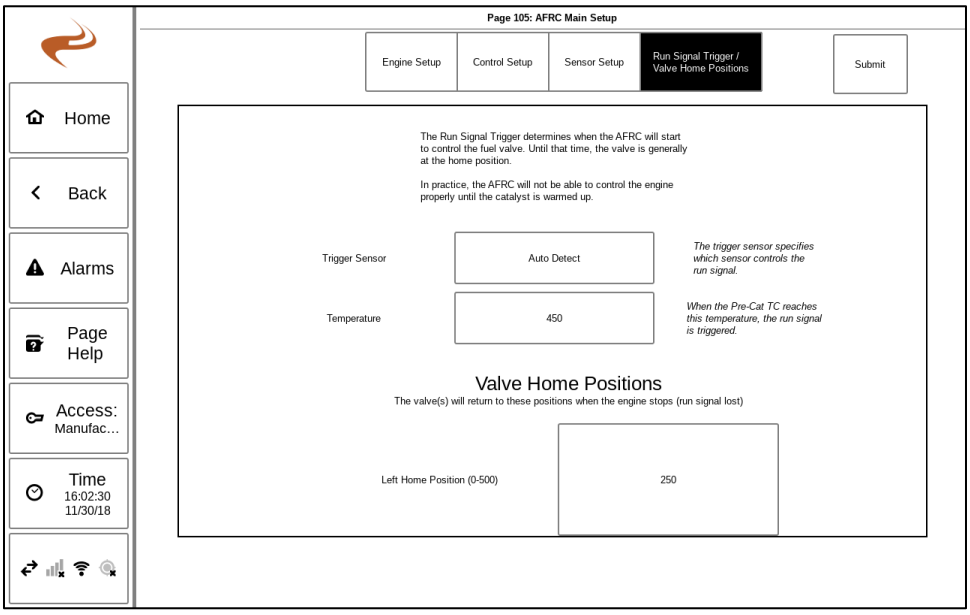
Slide 3: Sensor Setup



If using the analog input, the name, units, type, and scaling can be set here. The input can be used for any generic analog sensor, most typically catalyst differential pressure.

The last line specifies the MPU pulses per revolution for the RPM reading. If RPM information is available elsewhere in the system already (e.g. through EDT or Ignition), then the AFRC doesn't need an MPU.

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



Run Signal Trigger

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.

Valve Home Positions

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 external alarm though the error relay (terminal 6).

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 – Closes the error relay (terminal 6), 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.

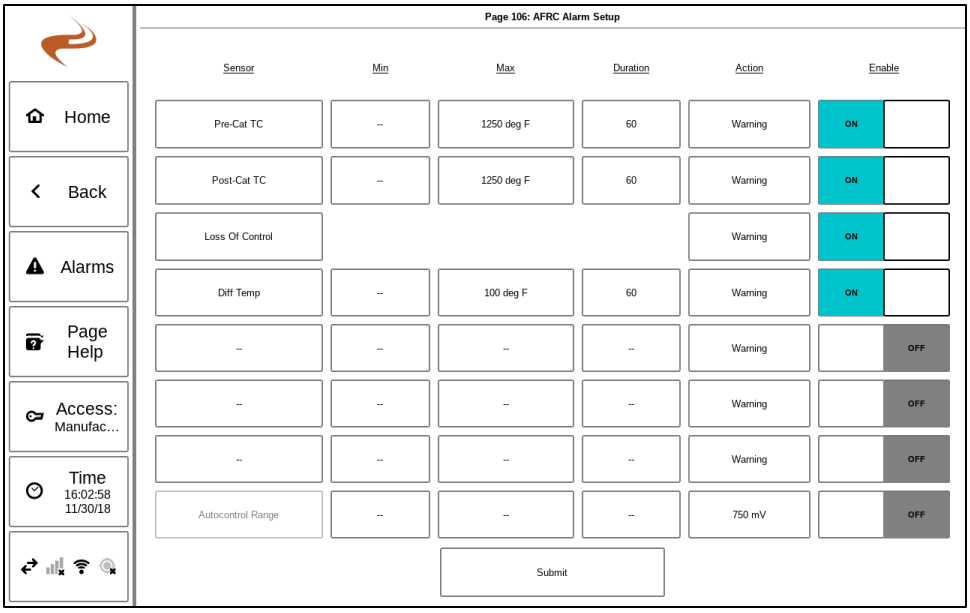


Figure 25. Alarm Setup Screen

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.

IGNITION CONTROLLER MODULE (ICM)

OVERVIEW

The EMIT Ignition Controller Module (ICM) 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 ICM is available in two versions with a maximum of 8 or 16 cylinders. The ICM 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 ICM 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 ICM 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 ICM, 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 ICM1 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 ICM 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 ICM include a range of tools. Conditions for up to eight cylinders at a time can be displayed simultaneously for visual comparison. Various aspects of spark conditions can be setup to provide warnings for potential issues. For engine protection, the ICM offers overspeed and underspeed shutdowns. The ICM 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.

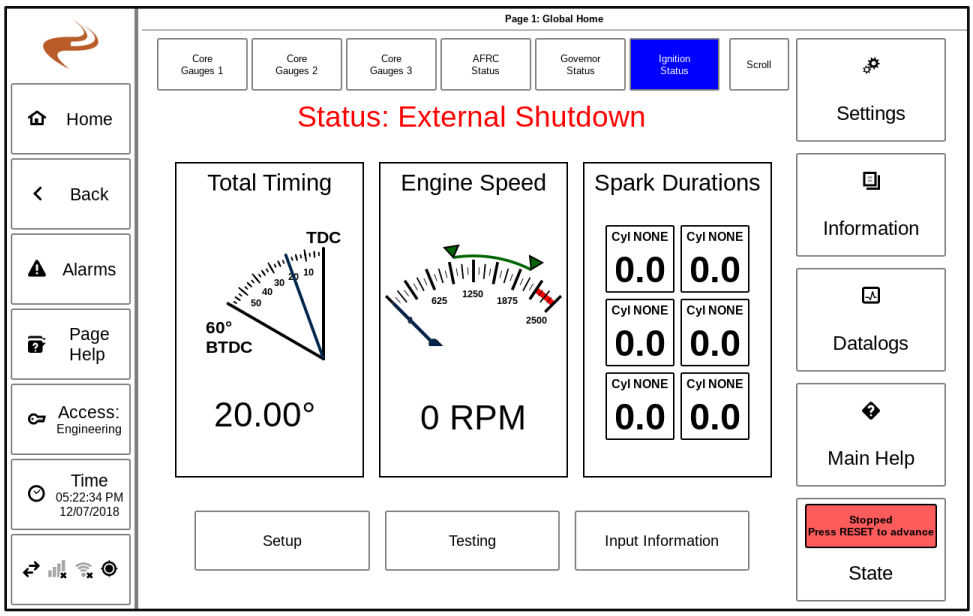


Figure 26. Ignition Home Screen

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

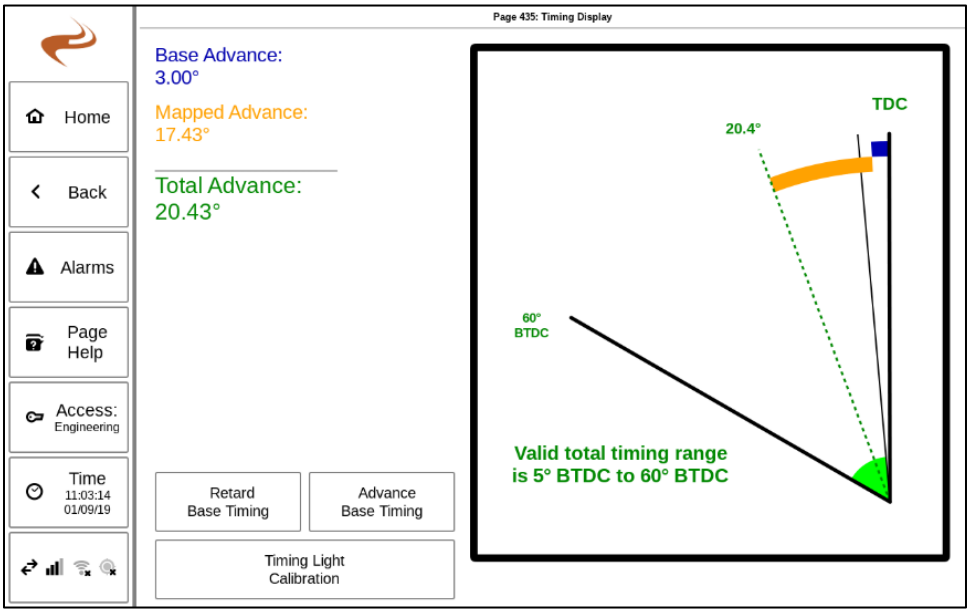


Figure 27. Timing Graph Showing Timing Calculation

IGNITION MAIN SETUP

After installation is completed, the ICM 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. Some examples of asymmetrical engines are
- "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 ICM will compensate for the missing teeth automatically.

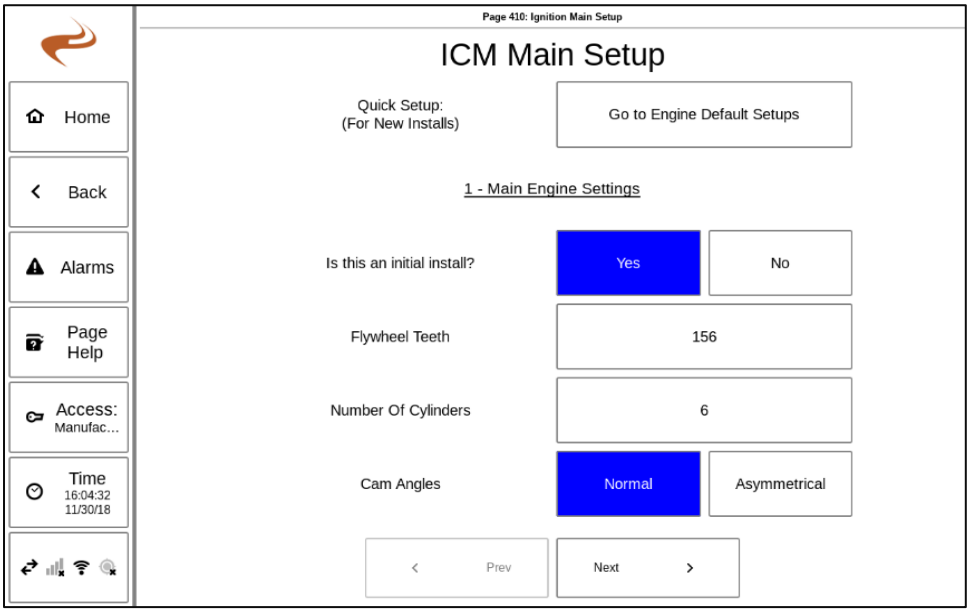
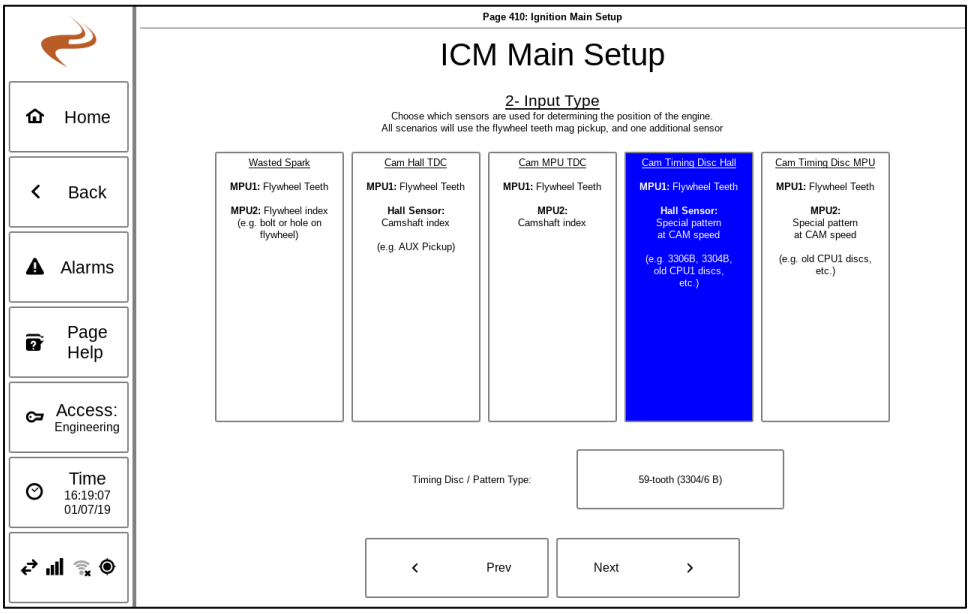


Figure 28. Step 1: Engine Setup

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”.

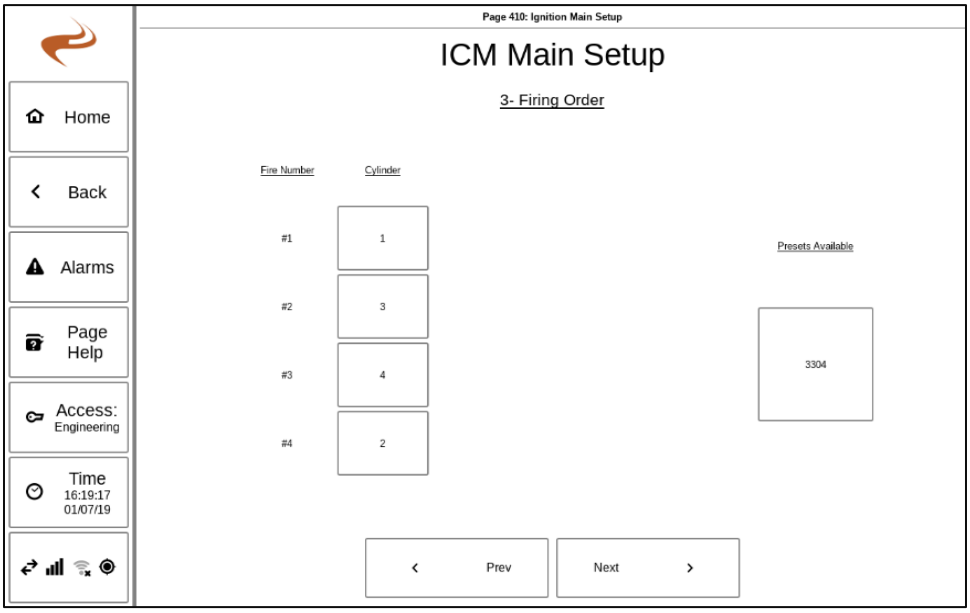
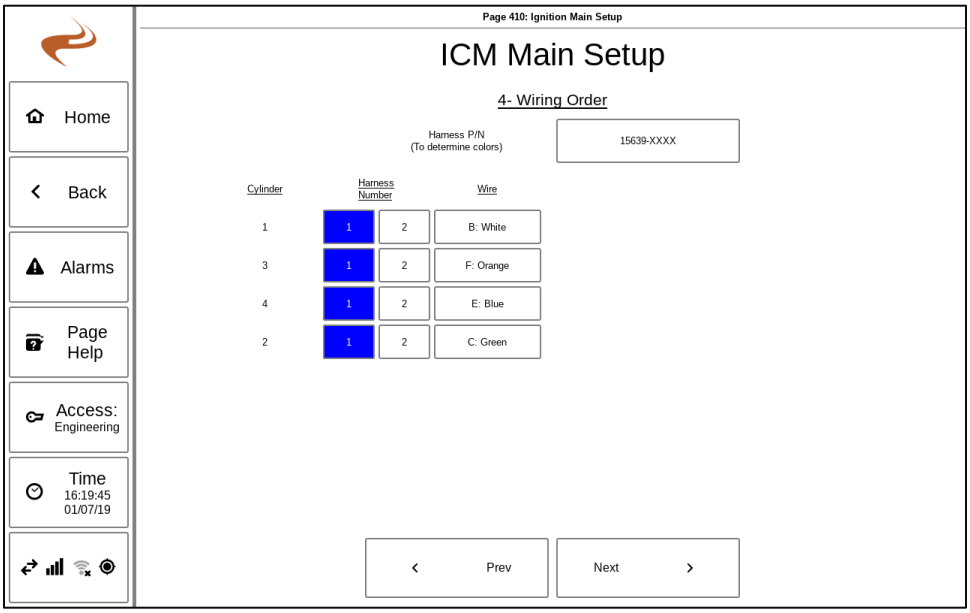


Figure 29. Step 3: Cylinder Firing Order

STEP 4: Harness Identification

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

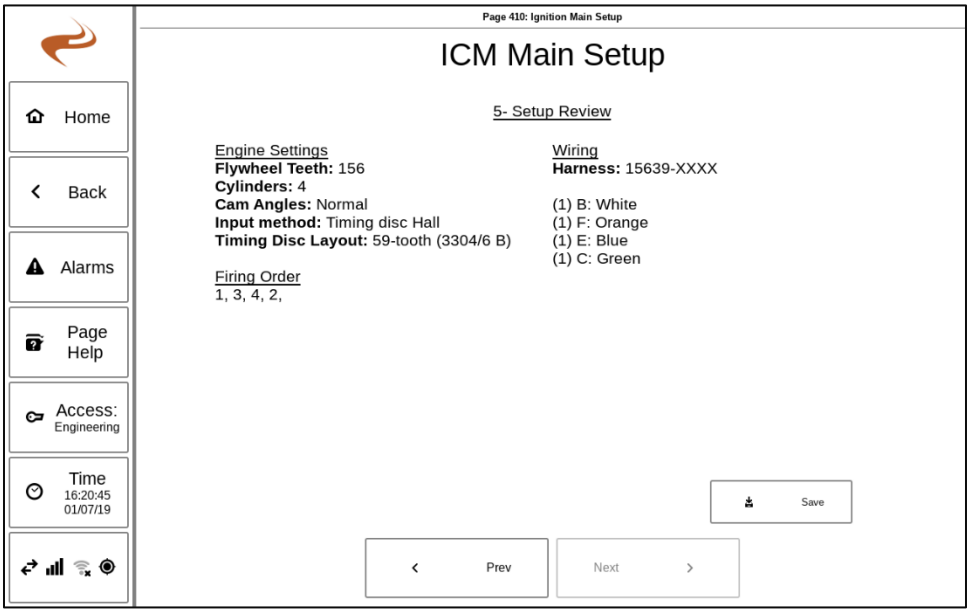


Use the “Harness P/N” box to select the harness part number (to determine the color order). The part number can be found on the tag attached to the coil harness.

Next, assign the color going to each cylinder using the ‘wire’ box.

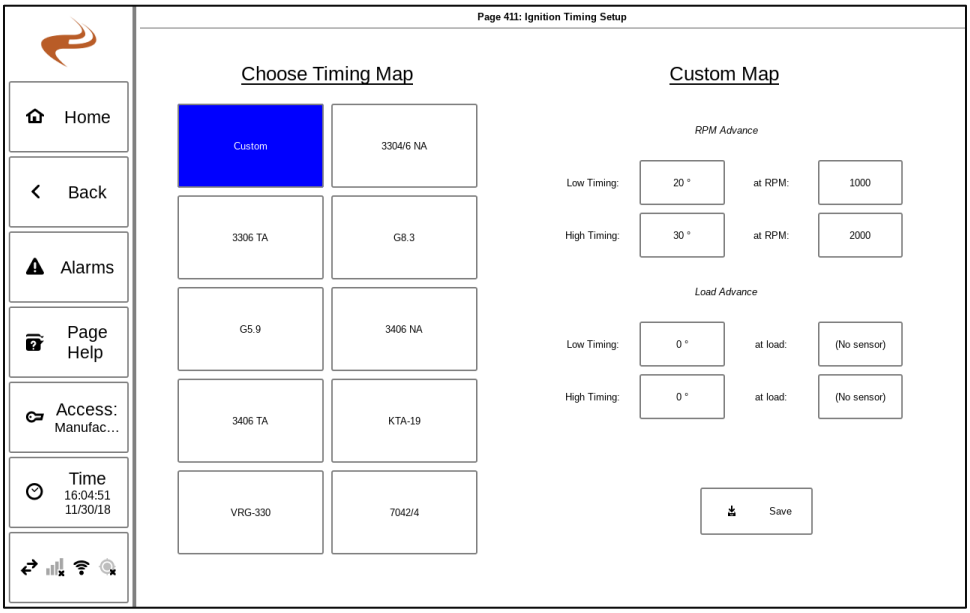
STEP 5: Review

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.

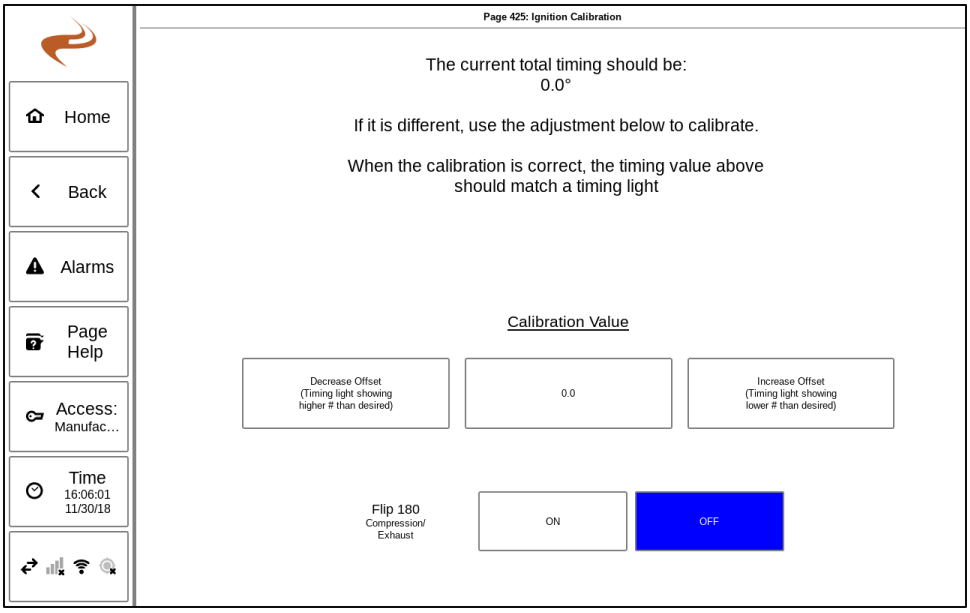
Base Timing can be positive (timing advance) or negative (timing retard). Base Timing adjustments increment in 0.25° steps. Base timing is adjusted on the Timing Display page, which is accessed by clicking on the small timing graph on the Ignition Home screen.

⚠	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.

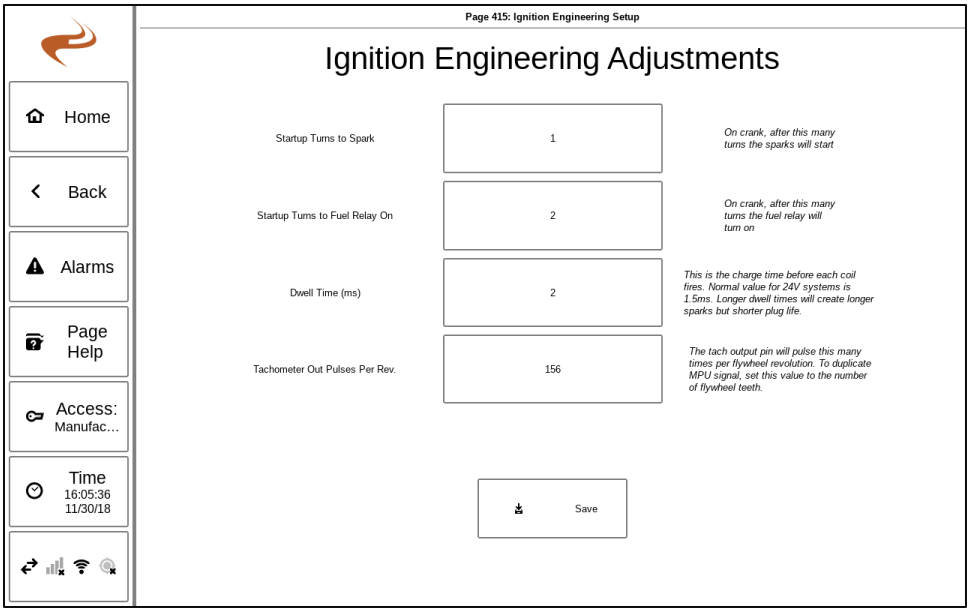
	When doing an initial calibration of the engine, it can be useful to set RPM advance to be constant so that the timing does not move around while calibrating, e.g. to 20 degrees fixed.

	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.

- Tachometer Out Pulses Per Rev: This setting is used to set the number of pulses per revolution for the Tachometer Output pin on the ICM. This can be used to display RPMs on other devices. Press the button to change the number of pulses on the tach output for every flywheel revolution.

⚠	If connecting the tachometer output to the MPU input of the EMIT Speed Controller (Governor), set the tach pulses per rev. to the number of flywheel teeth.

ALARM SETUP

The ICM 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.

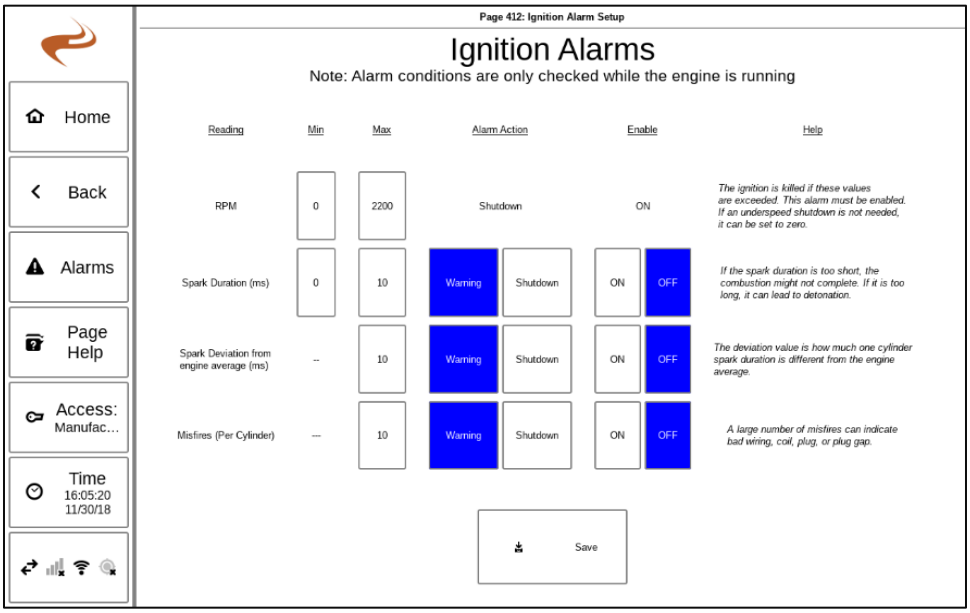


Figure 30. Ignition Alarms Screen

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

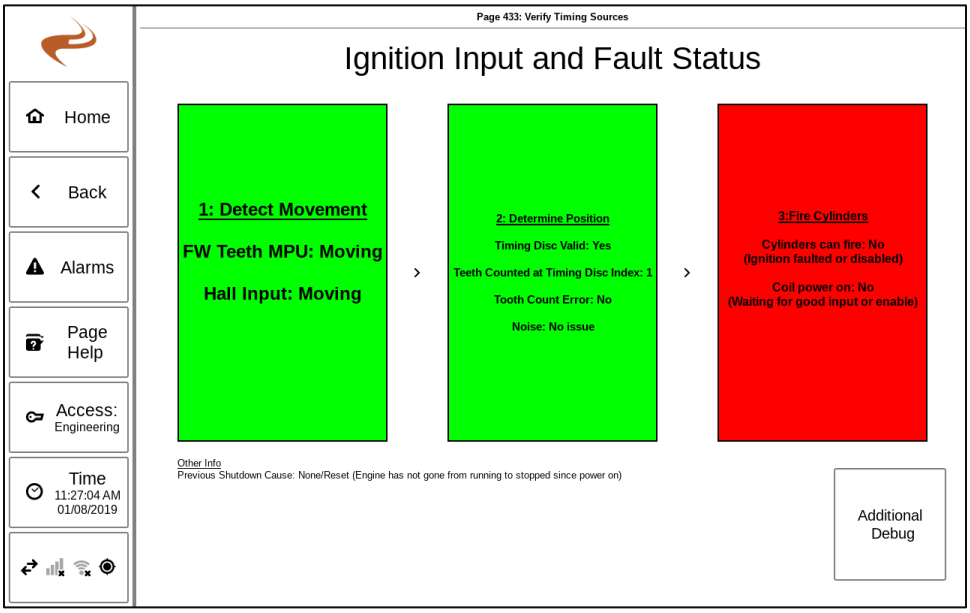
The Ignition has a variety of shutdown diagnostic alarms that are always enabled. After a shutdown, the touchscreen will evaluate the conditions of the ignition before and after the engine stopping. If an unusual or problematic condition exists, it will trigger an alarm under code ICM007, and will provide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

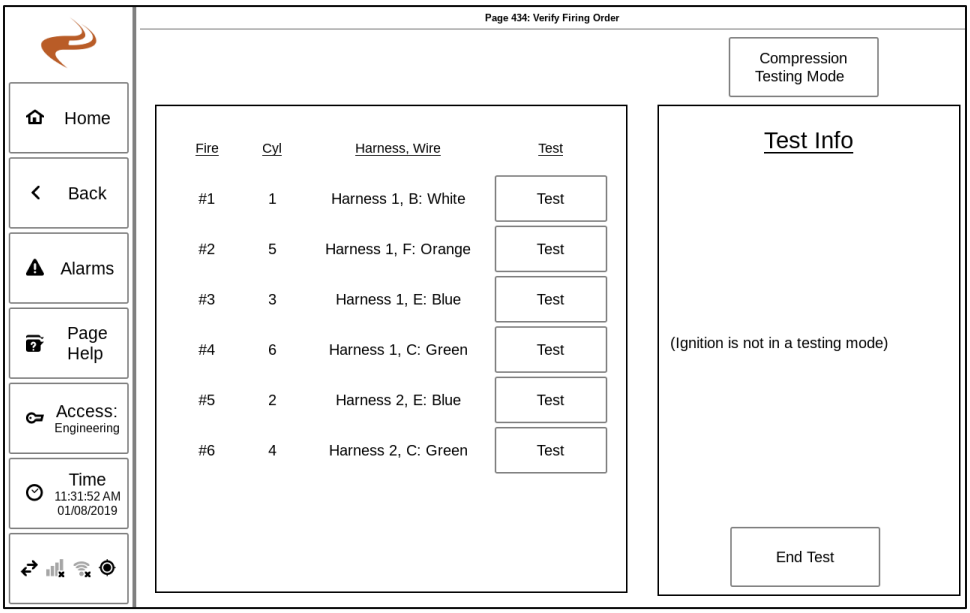
At the bottom of the screen, "Previous Shutdown Cause" – Displays the reason for the previous ignition shutdown

- "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.



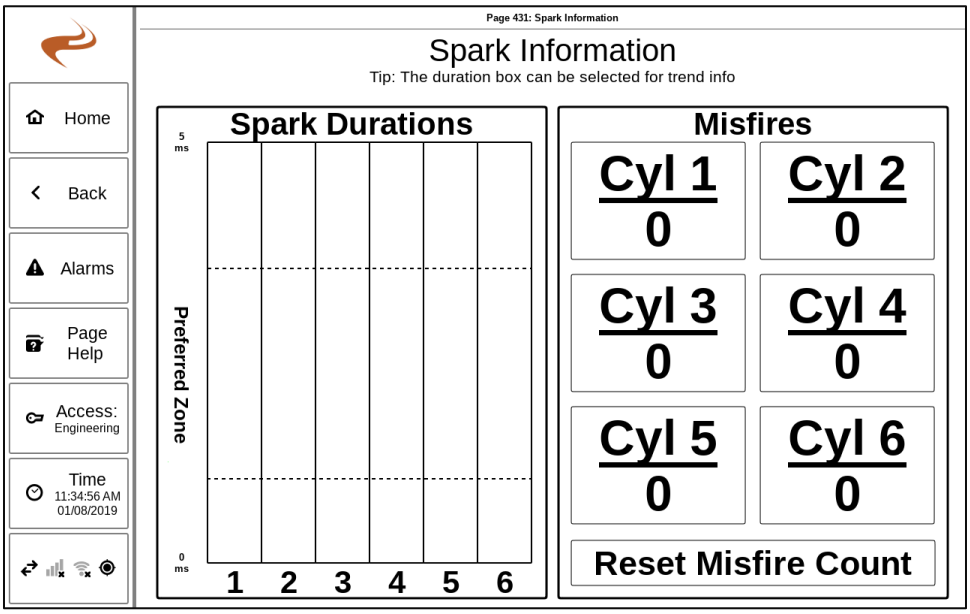
The left box can be used to select an individual cylinder to test sparking to verify wiring. To test a cylinder, select 'Test' next to that cylinder. When testing is active, the ignition coil under test will fire continuously. To check the component health or activity, use a spark checker tool or observe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

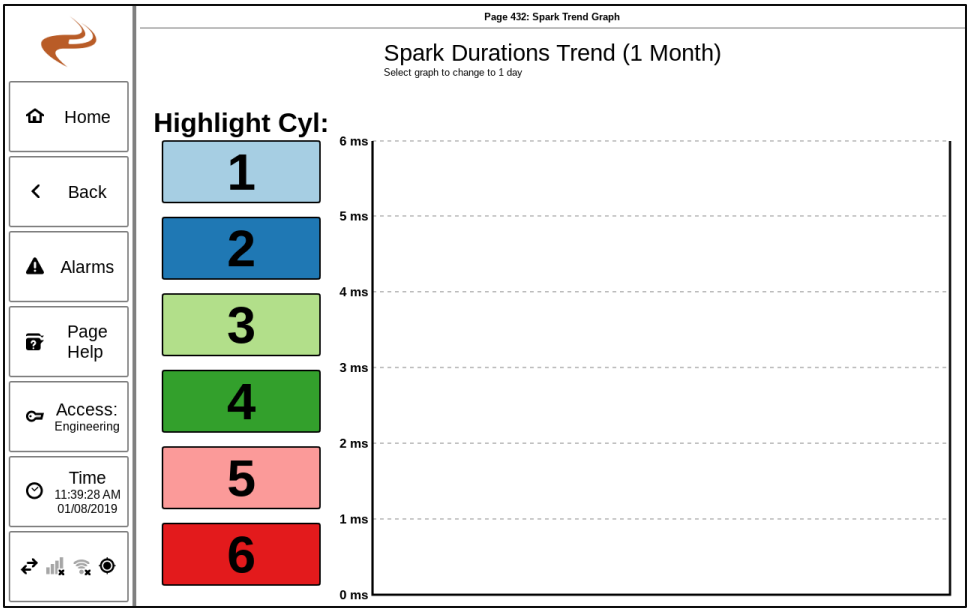
- Larger spark gaps
- Higher cylinder compression
- Bad wiring connections
- Old or fouled plugs
- Lower dwell times

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.

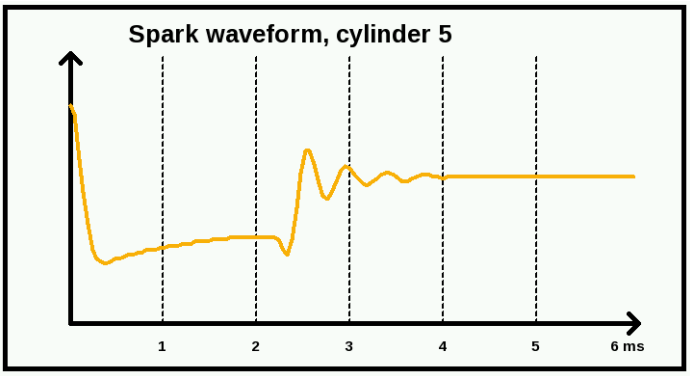


The spark tend screen will show the spark durations over the last month (if data is available). This can be used to see if durations are dropping off (from old plugs) or if one cylinder is unusually high or low.

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.

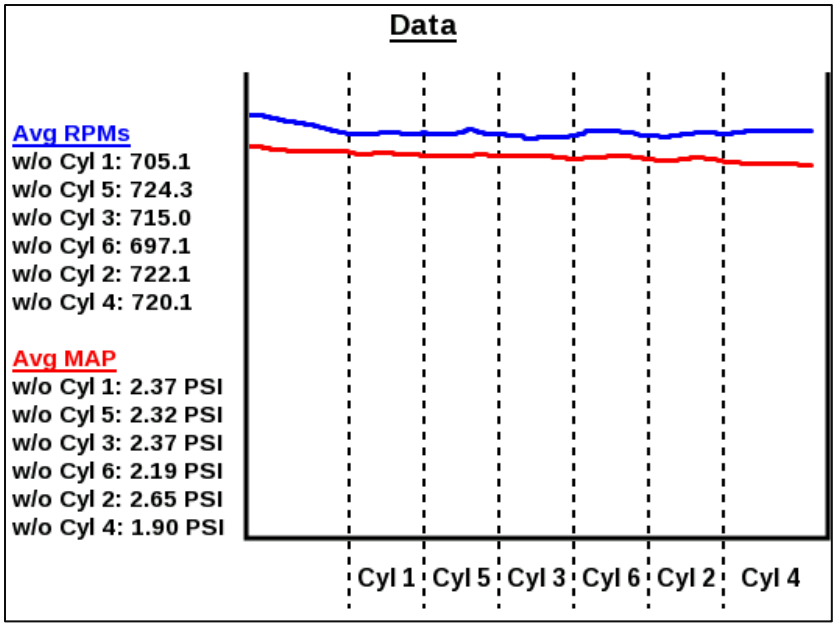
Auto Test

If an EMIT governor is present on the engine, the 'Auto' test can be used. The ignition will perform the following sequence during this test:

- The governor 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 governor 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. (Note: A MAP sensor can be connected to the ignition, governor, or AFRC to get MAP information). 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.

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Version 2, June 1991

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