



OS-TSCI

TSC Industrial Panel User Manual

OPERATOR'S MANUAL

Marine Generators | Marine Diesel Engines | Land-Based Generators



NORTHERN LIGHTS





— CALIFORNIA —
Proposition 65 Warning:

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

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OPERATOR'S MANUAL

OS-TSCI User Manual

Read this operator's manual thoroughly before starting to operate your equipment.

This manual contains information you will need to run and service your new unit.

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Proprietary Information

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1 Specifications

Testing Specifications

Specification	Rating
Electrical Transients	SAE1113-11
Thermal Shock and Cycling	SAE1455
Vibration Profiles	SAE1455
Electric Static Discharge	SAE1113-13

Physical Specifications

Specification	Rating
Operating Temperature	-40 to +158°F (-40 to +70°C)
LCD Viewing Temperature	-4 to +158°F (-20 to +70°C)
Weight	0,83lb (0.38kg)
Dimensions	4.17" x 6.50" x 1.38" (10.59cm x 16.51cm x 3.51cm)

Electrical Specifications

Specification	Rating
Operating Voltage	5.5 ~ 36VDC
Standby Current	60mA @ 12V 38mA @ 24V
Switched Inputs	+Battery, Ground, Open
Switched Outputs	+Battery @ 1A Max
Low Resistance Sensors	0 ~ 750Ω
High Resistance Sensors	0 ~ 7,500Ω
Universal Sensors	0 ~ 750Ω, 0 ~ 7,500Ω, 0 ~ 5VDC, 4 ~ 20mA
Magnetic Pickup	10 ~ 10,000Hz at 1 ~ 50VAC
AC Voltage (Line-To-Line)	50 ~ 575VAC True RMS, Accuracy: 1% Full Scale
AC Current	0 ~ 5A (Current Transformer), Accuracy: 1% Full Scale
Communications	SAE J1939 (Tier II, III, IV) Isolated RS485 (Slave Modbus RTU)

1.1 Introduction

The TOUGH series controllers are designed to provide complete control, protection, AC metering, and engine instrumentation for both standard and electronic engines. Your S-TSCI Panel has been configured by Northern Lights to work with your genset. However, if you require custom configurations, the programming can be modified using either the front panel buttons or PC configuration software. See Appendix for information. TOUGH series controllers are ideally suited for severe duty applications where reliability is critical.

Features and Functions:

- SAE J1939 CAN Bus Protocol
- RPM via J1939, Magnetic Pickup, or Generator
- Autostart on low battery and other sensors
- Trim feature for AC monitoring and sensors
- Maintenance counter
- Exerciser Clock
- 150 Event Log
- Conformally coated for protection against moisture
- Gasket for water ingress protection IP65
- Passcode protected
- Automatic shutdowns and warnings
- Manual and Remote start
- Pre-heat and many other configurable timers
- Accepts common senders (VDO, Datcon)

1.1 Introduction (Continued)

Available Displays:

- Engine Temperature
- Oil Pressure
- Fuel Level
- Engine Speed
- AC Metering
- Battery Voltage
- Real Time Clock
- Engine Hours
- Time to Maintenance
- Text
- Custom Senders
- Warnings and Failures

1.2 This Manual

This manual is divided into three sections:

1. Hardware Installation
2. Operation / Configuration
3. Advanced Configuration

1.3 Receiving, Handling & Storage

Receiving:

Every effort is made to ensure that your S-TSC gen-set controller arrives at its destination undamaged and ready for installation. The packaging is designed to protect the S-TSC internal components as well as the enclosure. Care should be taken to protect the equipment from impact at all times. Do not remove the protective packaging until the equipment is at the installation site and ready to be installed.

When the S-TSC reaches its destination, the customer should inspect the shipping box and controller for any signs of damage that may have occurred during transportation. Any damage should be reported to a Northern Lights representative after a thorough inspection has been completed.

A shipping label affixed to the shipping box includes a variety of product and shipping information, such as items and Customer numbers. Make certain that this information matches your order information.

Handling:

As previously mentioned, each S-TSC gen-set controller is packaged in its own individual box. Do not discard the packing material until the controller is ready for installation. Protect the equipment from impact at all times and do not carelessly stack. Once the controller is at the installation site and ready to be installed, the packaging material may be removed.

Storage:

Although well packaged, this equipment is not suitable for outdoor storage. S-TSC is to be stored indoors for any period of time, it should be stored with its protective packaging in place. Protect the controller at all times from excessive moisture, dirty conditions, corrosive conditions, and other contaminants. It is strongly recommended that the package-protected equipment be stored in a climate-controlled environment of -20 to 65°C (-4 to 149°F), with a relative humidity of 80% or less. Do not stack other equipment on top of the stored controllers.

2 Installation

Generator systems contain high voltage circuitry and precautions to protect against it should be taken. Failing to power down and lock out equipment can cause damage, injury or death.

! WARNING *Wiring of this controller should be performed by qualified electricians only.*

The following general electrical safety precaution should be followed:

- Do a thorough inspection of the area before performing any maintenance.
- Keep fluids away from electrical equipment.
- Unplug connectors by pulling on the plug and not the cord.
- Use fuses where appropriate.
- Ensure all equipment is properly grounded.
- Provide support to wires to prevent stress on terminals.

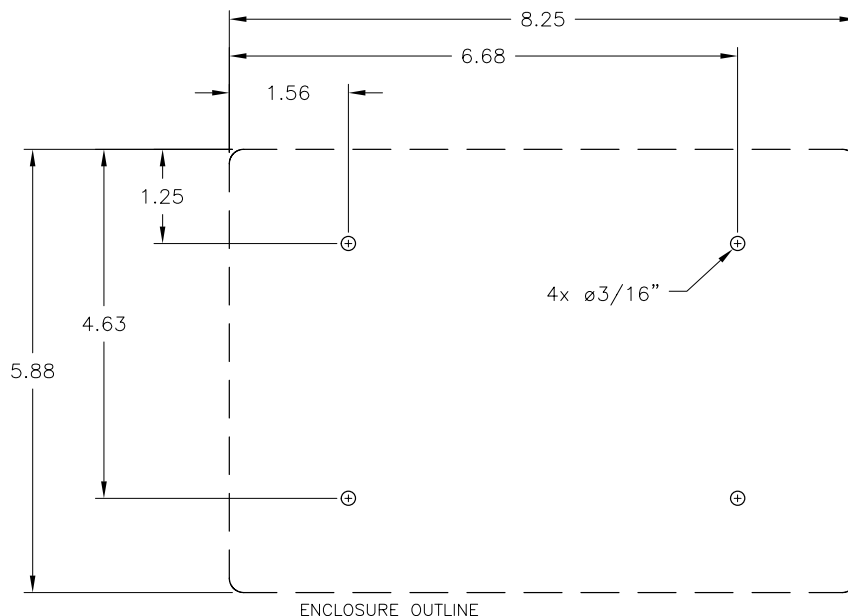
To ensure proper and safe operation, caution must be taken at the installation site to make sure it is free from excessive moisture, fluctuating temperature, dust and corrosive materials.

Choose a mounting surface with the least amount of vibration, within reach of the cables connecting the unit to the generator set. There are two ways to mount the local (or remote) control panel.

Surface Mounting

The rear wall of the S-TSC enclosure has four, 3/16" diameter holes for mounting to a flat surface.

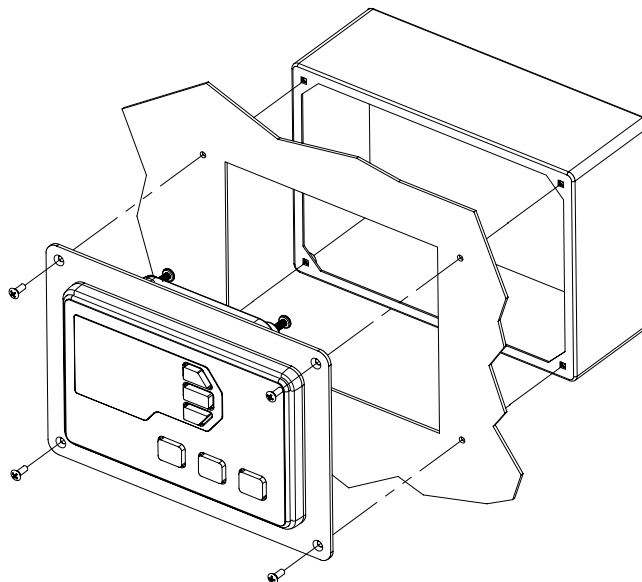
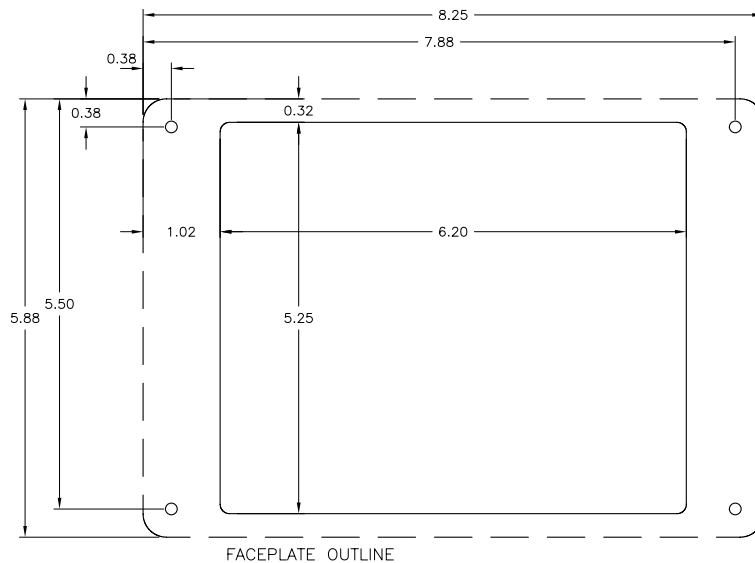
1. Choose a suitable location based on the criteria above, with adequate space for the S-TSC enclosure.
2. Using the dimensions below, drill pilot or through holes for the enclosure, depending on your mounting method.
3. Remove the four screws holding the S-TSC faceplate to the enclosure.
4. If desired, the connectors to the back of the S-TSC controller can be (carefully!) removed for enclosure installation. They will only plug in to the correct receptacles.
5. Secure the enclosure to the mounting surface.
6. Plug in the panel connectors if necessary, and secure the faceplate to the enclosure with the original screws.



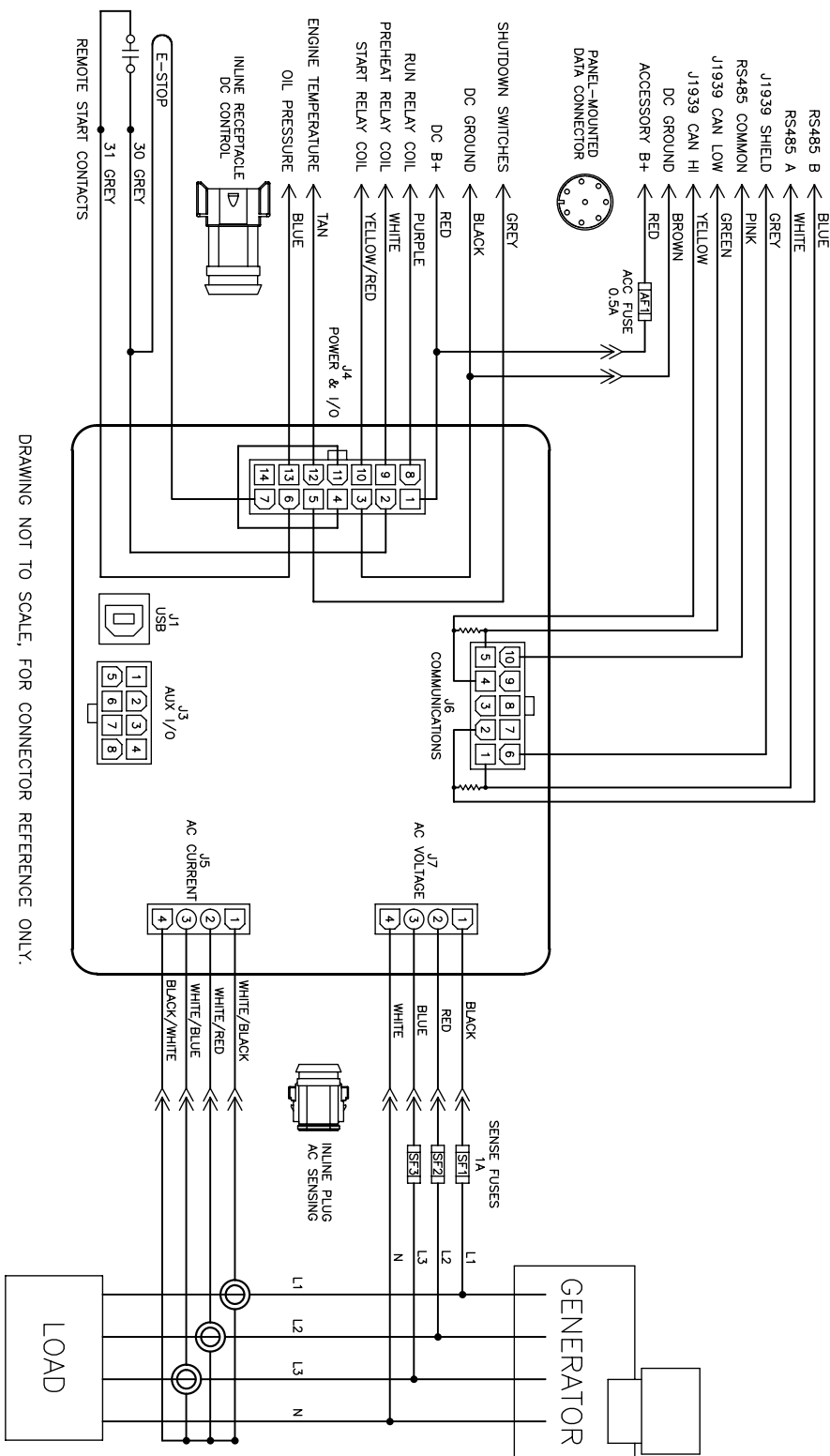
Flush Mounting

If low profile mounting is desired, the S-TSC faceplate and enclosure can be mounted on opposite sides of an existing panel.

1. Choose a suitable location based on the criteria above, with adequate area for the S-TSC faceplate and adequate depth behind the panel for the enclosure body.
2. Drill four mounting holes and create a rectangular cutout in your panel to the dimensions shown below.
3. Remove the four screws holding the S-TSC faceplate to the enclosure.
4. If desired, the connectors to the back of the S-TSC controller can be (carefully!) removed for enclosure installation. They will only plug in to the correct receptacles.
5. Place the controller and faceplate on the front surface of your panel. Insert one of the faceplate screws in a mounting hole to maintain location if necessary.
6. Bring the enclosure close to the rear side of the panel, and plug the connectors into the back of the S-TSC.
7. Secure the enclosure to the rear of your panel by inserting the faceplate screws through the faceplate, through the holes in your panel, and threading into the enclosure.



2.1 Typical Wiring Diagram



DRAWING NOT TO SCALE, FOR CONNECTOR REFERENCE ONLY.

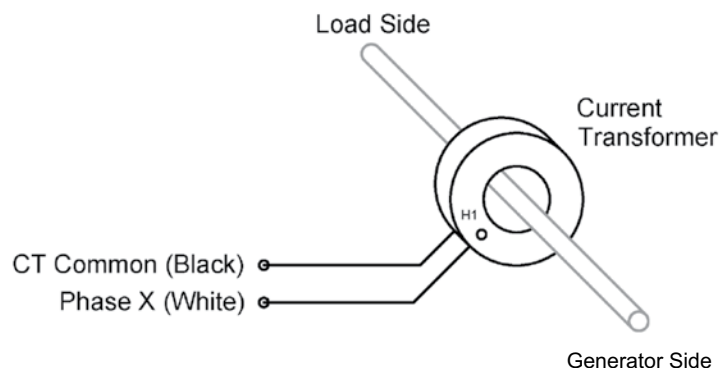
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2.2 Electrical Installation

Wiring required for S-TSC controllers is installed by Northern Lights, and your controller has been configured for and tested with your generator set at the factory. Minimal installation, if any, is required.

Control Connections

1. Plug the smaller rectangular connectors together between the S-TSC panel and the generator set. These connectors provide AC sensing signals. **UNDER NO CIRCUMSTANCES** is the generator set to be run with these connectors disconnected. Dangerous voltages could result.
2. Plug the larger rectangular connectors together between the S-TSC panel and the generator set. These connectors interface the S-TSC controller to the generator set's DC logic relays.
3. A single set of AC and DC extension harnesses may be used to locate the S-TSC further from the generator set. **ONLY ONE SET OF EXTENSIONS MAY BE USED.** Use of additional extensions will cause errors in the AC sensing circuits. If a longer run is required, a remote S-TSC must be used in conjunction with the local panel.
4. Whenever possible, the factory will install the current transformers on the fixed output leads of the generator. If the current transformers are installed, the load lines may be connected to the generator output terminals, and no further installation is necessary. If the current transformers are **NOT** already installed and are loose in the junction box, the installation leads will need to be run through them when the electrical installation of the generator is completed. All of the CTs must face the same direction, and the side marked "H1" must face the generator as shown in the diagram below. Do not make more than one pass through the CT, or disturb any other generator winding wires.
5. When making AC output connections in the junction box, you may have noticed that one of the relay bases is empty. **DO NOT** insert a relay in this base. If your generator set came with a loose relay, it is a spare and can be set aside.



Data Connections

The circular connector on the bottom of the S-TSC enclosure provides power and data to an S-TSC remote panel, or RS485 interface device. If one of these accessories was ordered, connect the associated extension cable to this connector, and the other end to the remote panel or network interface.

Remote Start Contact Connection

The S-TSC(I) panel includes a small harness pigtail including two wires with butt splice connectors installed. These can be connected to set of dry contacts to allow other equipment to start and stop the generator. With the controller in AUTO, close the contacts to run the generator, and open them to stop the generator.

The other wire loop is for an emergency stop switch connection. See the "Emergency Stop Wiring" section for details.

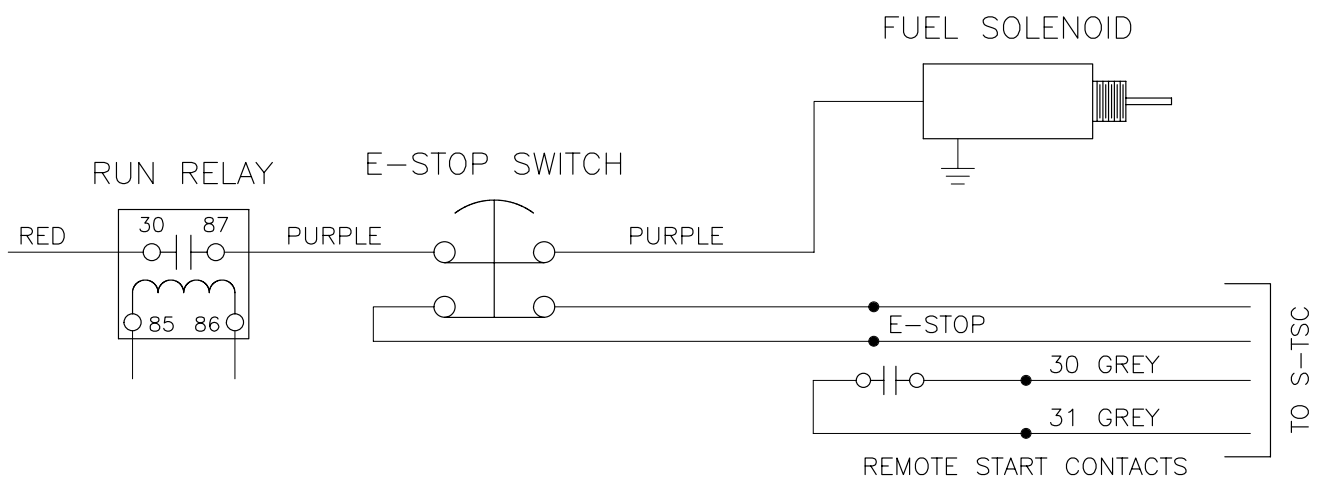
Refer also to the electrical drawings that were supplied with your unit for further information.

2.3 Emergency Stop Wiring

If an Emergency Stop function is required, it is mandatory to install an external mushroom style switch wired in series with the switched ignition supply to the engine to ensure reliable and immediate shutdown upon activation. This circuit is the purple wire running from the 87 (center-rear) terminal of the Run Relay to the fuel solenoid and alternator. Refer to your generator set's specific DC wiring diagram for more information.

The remote start harness pigtail includes an E-Stop wire loop, which can be cut and spliced into an additional set of contacts on the E-Stop switch. This will signal the E-Stop to the S-TSC and record the action in the event log. Connecting only this circuit is NOT adequate for proper emergency stop function.

Shown below is a typical wiring diagram of a normally closed, double-pole single-throw switch used to activate the S-TSC E-Stop input and cut power to the fuel solenoid.





Note! Before starting the generator set, make sure that the AVR circuit breakers are in the closed (up) position.

Running the Generator

With the generator set fully installed, connected to the starting battery and ready to run, the S-TSC will power on and the LCD display will show the status of the generator.

Manual Run: Press the Run button. The controller will enter preheat mode for ten seconds, and then engage the starter. The starter will crank for a maximum of ten seconds. If the generator fails to start in that time, the controller will repeat the preheat/crank cycle for a total of five times. If the generator still fails to start after the fifth attempt, the S-TSC will display a failure message and return to stopped mode.

Press the Stop button to stop the generator.

Auto or Remote Start: From Off mode, press the Auto button to place the S-TSC into autostart mode. The generator set can then be run by

- Pressing the Run button on the local or remote panel
- Closing the remote start contacts
- Sending a run command via RS485

Likewise, the generator can be stopped by pressing the Stop button on the local or remote panel, opening the remote start contacts, or sending the stop command via RS485.

Pressing the Stop button at the local panel will also revert the S-TSC from Auto to Off mode.



Warning! Placing the S-TSC in Off mode is not an adequate method of disabling the generator for service. The starting battery cables MUST be disconnected before attempting to adjust or service the generator set.

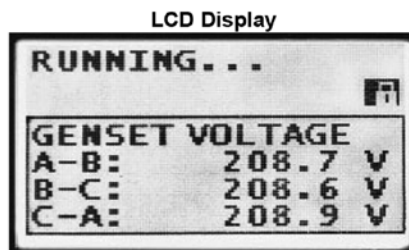
When the generator is running, the S-TSC display will scroll through AC electrical and engine information. Refer to the tables below for further information about display and control functions.

Warnings and Failures

The S-TSC is programmed with a number of warnings and shutdowns (failures). These include high engine temperature, low oil pressure, overspeed, underspeed, and other parameters specific to your generator. When a warning threshold is reached, a warning message will show on the display and be added to the event log. The generator will continue to run, and if the problem is remedied, the warning will turn off. If a failure threshold is exceeded, the generator will shut down. The failure will be displayed on the screen and recorded in the event log.

As a backup to the oil pressure and coolant temperature shutdowns based on engine sensor readings, Northern Lights generators include fixed-value shutdown switches. If the low oil pressure or high coolant temperature switch is tripped (or high exhaust elbow temperature on models so equipped), the failure message will display "NLI Shutdown."

3 Using the Controller (Continued)



Using the Menu System

Task	Description
Entering Menu	When in the OFF mode, press the enter button to bring up the menu.
Navigating Menu	Once in the menu, use the up and down arrows to navigate. Pressing enter will move you into that menu.
Change a Setting	Scroll to the desired value and press enter to select. A check mark should now be beside that item. Press enter again to save the setting and return to the previous screen.
Scroll Parameters	When in Auto or Running mode, pressing the up and down arrows will scroll through the parameters pages.
Lock Screen	When in Auto or Running mode, you can lock the screen onto a certain parameter page by pressing enter. You can unlock the screen by pressing enter again.
Events History	Once in the menu, select Events History to view the most recent controller event. Use the up and down arrows to navigate to other events. The controller can store up to 150 events. If more than 150 events occur, the oldest event is deleted to make room for the next event.

Front Panel Items

Item	Name	Description
	Off Button	Used for turning off the engine or exiting out of Auto mode. This is not intended to function as an Emergency Stop as there are conditions in which it will not shutdown the engine. See the OFF Button Function section for more information
	Auto Button	Used for placing the controller into Auto mode. Once in Auto the controller waits for a start command to be received.
	Run Button	Used to start the engine manually. Must use the Off button to shutdown the engine if started from front panel.
	Up Button	Used for moving around in the menu, changing a settings value, or changing the currently displayed parameter page.
	Enter Button	Used for entering the menu system, accepting settings, or locking the LCD screen when viewing parameters.
	Down Button	Used for moving around in the menu, changing a settings value, or changing the currently displayed parameter page.
	Generator LED	Green = Engine running with no issues Amber = Engine running with warnings Red = Engine shutdown on failure

3.1 Troubleshooting

If you are having issues with your controller, please refer to the table below for a solution before contacting technical support.

Issue	Solution
Engine starts but the crank output does not turn off	The controller is not receiving a speed signal. 1. Verify the Sensors -> Engine Speed -> Signal Source setting is set correctly. 2. Verify the Timers -> Engine Logic -> RPM Disconnect setting is set correctly. 3. Ensure the correct wiring to the controller. For magnetic pickup, Speed Sensing A and B terminals are used. For generator voltage, the AC voltage connections are used.
Sender always displayed its lowest or highest value	The sender could either be open (not connected) or shorted to ground. Verify your connections and ensure the correct sender table is loaded.
Engine cranks, controller shows "Locked Rotor" failure and stops cranking.	Controller is not receiving AC output to measure speed. 1. Confirm that AVR circuit breakers are ON 2. Field may need to be flashed.

3.2 Modes, Starting and Stopping

The following table describes the different operating modes of the controller:

Modes

Mode / State	Description
OFF	When in the OFF mode, the engine cannot be remotely started.
Auto	When in the Auto mode, the engine waits to receive a start command.
Running	When engine is Running, the controller monitors engine parameters and waits to receive a stop command.
Failure	When a failure occurs, the controller shuts down the engine and displays reason for failure. The unit must be reset using the front panel OFF button with the exception of Modbus.
Menu	When in the menu you can change settings and view the events history.

The following table describes the different methods in which a controller can start. The controller *must* be in the AUTO mode in order to start for all methods with the exception of Manual Run.

Starting Methods

Methods	Description
Manual Run	Pressing the Run button will start the engine. You must press the OFF button to shutdown the engine.
Start / Stop Switched Input	When this input is active the engine will start. When the input becomes inactive the engine will shutdown.
Modbus Start	When a certain command is sent to the controller over Modbus the engine will start. See the Modbus Reference Manual for more information.

The following starting methods are available through user programming; See Appendix A.

Starting Methods

Methods	Description
Momentary Switched Inputs	Switched inputs Momentary Start and Momentary Stop can be used for starting and stopping of the engine. Unlike other inputs, they only have to be activated for a short period of time.
Battery Recharge	When the battery voltage drops below a certain level the engine will start and run for a predetermined amount of time.
Exerciser	When the scheduled exerciser interval occurs the engine will start and run for a predetermined amount of time.



WARNING

WARNING: See the Using Cooldown Mode section for more information on how it affects starting and stopping.

Appendix A: Special Programming

A.1 Custom Inputs and Programming

Your Northern Lights Tough Series controller has been programmed by the factory and tested with your generator set to provide optimum performance and protection. Altering the programming is not recommended. However, some applications may require additional controls. This section provides information on programming auxiliary inputs and outputs on the S-TSC.

To connect to the auxiliary inputs and outputs on connector J3, you will need a Molex 39-01-2080 8-position connector body, and 39-00-0039 female crimp terminals. These are available from many electronic component suppliers. J3 terminal assignments are as follows:

J3-1	Switched Input D	J3-5	Switched Output F
J3-2	Switched Input E	J3-6	N/C
J3-3	Switched Output D	J3-7	Sensor Ground
J3-4	Switched Output E	J3-8	Sensor Input D

A.2 Terminal Descriptions

Main Connector (J4)

Terminal	Name	Description
J4-1	+Battery	Provides power to the controller from the battery
J4-2	+Battery	Provides power to the controller from the battery
J4-3	Ground	Provides ground return for the controller
J4-4	Ground	Provides ground return for the controller
J4-5	Switched Input A	Configurable to detect +Battery, Ground, or Open
J4-6	Switched Input B	Configurable to detect +Battery, Ground, or Open
J4-7	Switched Input C	Configurable to detect +Battery, Ground, or Open
J4-8	Switched Output A	Outputs +Battery voltage when active (Max Current: 1A)
J4-9	Switched Output C	Outputs +Battery voltage when active (Max Current: 1A)
J4-10	Switched Output B	Outputs +Battery voltage when active (Max Current: 1A)
J4-11	Sensor Ground	Provides ground return for 2-wire sensors.
J4-12	Sensor Input A	High impedance sensor input (0 - 7,500Ω)
J4-13	Sensor Input B	Low impedance sensor input (0 - 750Ω)
J4-14	Sensor Input C	Universal sensor input (0 - 750Ω, 0 - 7,500Ω, 0 - 5VDC, 4 - 20mA) See Universal Sensor section for more information.

A.2 Terminal Descriptions (Continued)

Expansion Connector (J3)

Terminal	Name	Description
J3-1	Switched Input D	Configurable to detect +Battery, Ground, or Open
J3-2	Switched Input E	Configurable to detect +Battery, Ground, or Open
J3-3	Switched Output D	Outputs +Battery voltage when active (Max Current: 1A)
J3-4	Switched Output E	Outputs +Battery voltage when active (Max Current: 1A)
J3-5	Switched Output F	Outputs +Battery voltage when active (Max Current: 1A)
J3-6	Sensor 5V	Provides 5V for electronics sensors.
J3-7	Sensor Ground	Provides ground return for 2-wire sensors.
J3-8	Sensor Input D	Universal sensor input (0 - 750Ω, 0 - 7,500Ω, 0 - 5VDC, 4 - 20mA) See Universal Sensor section for more information.

Communications Connector (J6)

Terminal	Name	Description
J6-1	RS485-A	Communications line for Modbus (RS485)
J6-2	RS485-B	Communications line for Modbus (RS485)
J6-3	No Connection	No Connection
J6-4	CAN-L	Communications line for CAN Bus (J1939)
J6-5	CAN-H	Communications line for CAN Bus (J1939)
J6-6	CAN-Shield	Connect the shield of the twisted pair cable to this terminal.
J6-7	Speed Sensing A	Connect to a magnetic pickup, tachometer, or a flywheel alternator. Not polarity sensitive and not required if using AC voltage terminals for speed sensing.
J6-8	Speed Sensing B	Connect to a magnetic pickup, tachometer, or a flywheel alternator. Not polarity sensitive and not required if using AC voltage terminals for speed sensing.
J6-9	No Connection	No Connection
J6-10	RS485-Common	Common line for Modbus (RS485)

Generator AC Voltage (J7)

Terminal	Name	Description
J7-1	Phase A	Connect to Phase A of the generator.
J7-2	Phase B	Connect to Phase B of the generator.
J7-3	Phase C	Connect to Phase C of the generator.
J7-4	Neutral	Connect to neutral.

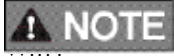
Generator AC Current (J5)

Terminal	Name	Description
J5-1	Phase A	Connect to current transformer for Phase A of the generator.
J5-2	Phase B	Connect to current transformer for Phase B of the generator.
J5-3	Phase C	Connect to current transformer for Phase C of the generator.
J5-4	CT Common	Connect to the commons of the current transformers.

A.3 Universal Sensor

Universal Sensors have the ability to be configured to detect different sender types (0 - 750Ω, 0 - 7,500Ω, 0 - 5VDC, 4 - 20mA).

The examples shown below are advanced applications of the universal sensor.

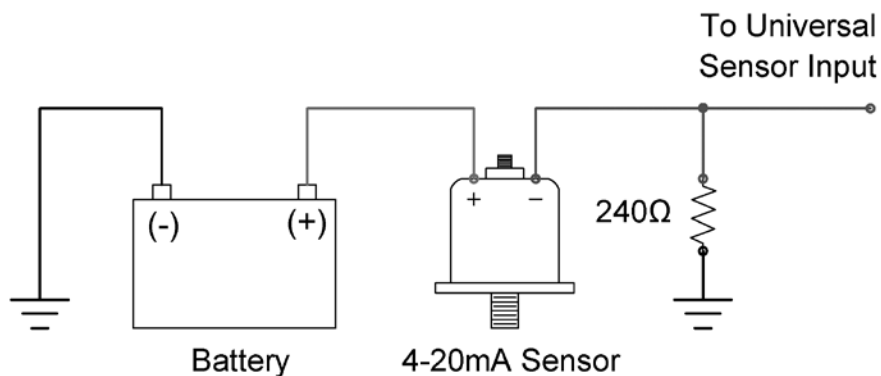


NOTE: Custom Sender tables are required for the universal sender to work

these examples. See the Custom Sender Table section for more information.

Example #1: The following example shows the correct way for wiring a 4-20mA sensor. The 240Ω resistor is required to change the 4-20mA current into a 0-5V voltage level that the controller can understand.

4-20mA Wiring Example



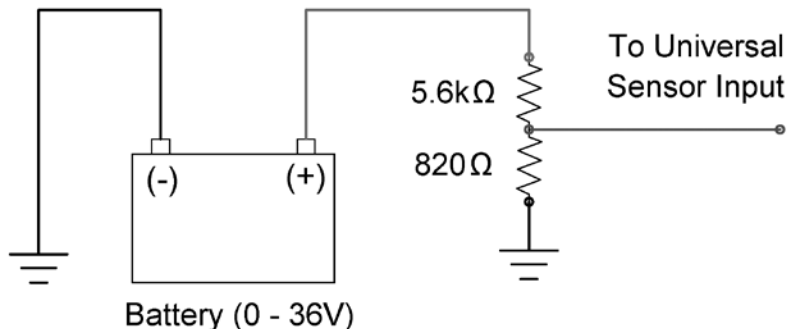
Example #2: Sometimes it is required to measure voltages outside the 0-5V range allowed by the controller. To do this you must use a voltage divider with appropriate scaling resistors. The equation to calculate the resistor values is as follows:

$$V_{out} = \left(\frac{R1}{R1 + R2} \right) \times V_{in}$$

$V_{out} = 5V$
 $V_{in} = \text{Maximum Voltage to Read}$
 $R1 = \text{Common Resistor Value} > 10k\Omega$
 $R2 = \text{Calculated Resistor Value (Select closest common resistor value)}$

The following diagram shows the typical wiring of a voltage divider. The resistors values have been selected to allow the controller to read up to 36V from an external battery bank.

0-36V Wiring Example



The following section relates to settings that can be changed to alter the way the controller performs its functions. Read and review these sections carefully to ensure your settings are set correctly for your engine.

A.4.1 Operator Setup

The following settings are used to change the way the user interacts with the controller. They are not password protected and can be changed by anyone from the front panel.

Name	Range	Description
Lamp Test	Function	Performs a lamp test on the LED's when selected.
Display -> LCD Reverse	Function	Reverses the white and black pixels when selected.
Display -> LCD Contrast	5 ~ 95%	Changes the contrast of the LCD.
Display -> Page Scroll	1 ~ 10 seconds	Amount of time between each auto scroll of the parameter pages.
Display -> Message Pop-Up	1 ~ 10 seconds	Amount of time each message is displayed on the screen before displaying next message in buffer.
Display -> DPF/DEF Display Time	0 ~ 10 seconds	See the J1939 Reference Manual for more information.
Display -> LCD Backlight Timeout	10 ~ 600 seconds	Amount of time the LCD Backlight stays on after button activity stops.
Date / Time -> Date Change	1 ~ 31 days 1 ~ 12 months 2000 ~ 2099 years	Sets the date.
Date / Time -> Time Change	0 ~ 23 hours 0 ~ 59 minutes 0 ~ 59 seconds	Sets the time.
Date / Time -> Daylight Savings	Enable ~ Disable	Turns Daylight Savings Time on or off.
Units -> Temperature Unit	°F or °C	Selects the units in which temperature is displayed.
Units -> Pressure Unit	PSI or kPa	Selects the units in which oil pressure is displayed.
Run from OFF	Enable ~ Disable	When enabled, allows user to start engine using the run button while in the OFF mode. When disabled the controller must be placed in AUTO mode before the run button can start the engine.

A.4.2 Switched Inputs

The controller has switched inputs which when activated, cause the controller to perform a function.

Settings

Name	Range	Description
Functions	List - See Below	The function that the switched input performs when active.
Active Modes	List - See Below	Determines under which operating conditions the switched input can be active. Multiple selections are allowed.
Trigger	List - See Below	The state of the input that determines if it is active or inactive.

Functions

Name	Active Mode	Description
Disabled	N/A	Input is disabled and has no function.
Start / Stop	Auto, Running	Starts the engine when active, stops the engine when deactivated. WARNING: The Triggers are different from the regular triggers for this function. See the Start / Stop (Momentary Function) section for more information.
Emergency Stop	Global	Shutdowns the engine when active and displays 'Emergency Stop.'
Idle Mode	Running	Controller ignores under speed, voltage and frequency warnings and failures when active. If using J1939, the controller will broadcast TSC1 as the Idle Speed parameter found in the Engine Speed section.
Voltage Select 1	Auto	Used for changing the systems voltage configuration. See Voltage Select for more information.
Voltage Select 2	Auto	Used for changing the systems voltage configuration. See Voltage Select for more information.
Battery Charger Fault	Global	Controller displays 'Charger Fault' warning when active.
Momentary Start	Auto	Starts the engine when momentarily active (Approximately 2 seconds).
Momentary Stop	Running	Stops the engine when momentarily active (Approximately 2 seconds).
Configurable Warning 1	Configurable	Controller displays a warning with configurable text when active. The DYNAGEN Configurator must be used to change the text.
Configurable Warning 2	Configurable	Controller displays a warning with configurable text when active. The DYNAGEN Configurator must be used to change the text.
Configurable Failure 1	Configurable	Controller displays a warning with configurable text and shutdowns engine when active.
Configurable Failure 2	Configurable	Controller displays a warning with configurable text and shutdowns engine when active.
Configurable Failure 3	Configurable	Controller displays a warning with configurable text and shutdowns engine when active.
Air Pressure Failure	Cranking	Controller displays 'Air Pressure Failure' and shutdowns engine when active.
Hydraulic Pressure Failure	Cranking	Controller displays 'Hydraulic Pressure Failure' and shutdowns engine when active.
Low Oil Pressure Warning	Running	Controller displays 'Oil Pressure Warning' when active.
Low Coolant Level Failure	Global	Controller displays 'Coolant Level Failure' and shutdowns engine when active.
High Fuel Warning	Global	Controller displays 'High Fuel Level' warning when active.
Lamp Test	Global	Controller performs lamp test when active.
Fuel In Basin	Global	Controller displays 'Fuel In Basin' warning when active.
Battle Mode	Running	Controller ignores all warnings and failures when active. If a failure occurs during Battle Mode it is 'latched' and the engine will shutdown on failure.

		when the controller leaves Battle Mode.
Start Inhibit	Auto	Controller ignores all start commands and engine cannot start when active. Once Start Inhibit becomes inactive starting is enabled again. If the engine is running, activating this input will shutdown the engine.
Primary RPM / 60Hz - Secondary RPM / 50Hz Select	Auto	Used for changing between Primary and Secondary RPM for an engine or 50Hz / 60Hz for a generator. See RPM / Frequency Select for more information.
Preheat Signal	Cranking	When the Preheat Mode setting in the Engine Logic menu is set to Switched Input. It uses this input to determine to control the preheat time.

Active Modes

Name	Description
Disable	Input cannot be triggered.
Global	Input can be triggered at any time.
OFF Mode	Input can be triggered while in the OFF mode.
AUTO Mode	Input can be triggered while in the AUTO mode.
Running	Input can be triggered after a start command is received until shutdown.
Cranking	Input can be triggered during cranking.
After Cranking	Input can be triggered after engine has started until shutdown.
Cooldown	Input can be triggered while cooldown timer is active.



NOTE: More than one Active Mode can be selected.

Triggers

Name	Description
Close +BAT	Input is active when +Battery is present at the terminal.
Close GND	Input is active when Ground is present at the terminal.
Close +BAT/GND	Input is active when either +Battery or Ground is present at the terminal.
Open	Input is active when neither +Battery or Ground is present at the terminal.



NOTE: When running wires over long distances (100+), it is recommended to use +BATTERY as the trigger method.

A.4.3 Configurable Inputs

These inputs are used to create custom warnings and failures. Using the Software Configurator you can change the text that is displayed when the warning or failure occurs. If you select one of these inputs without changing the text it will default to 'Config Warn X' and 'Config Fail X.'

There are also timers associated with which can be found in the menu under Timers -> Trigger Delays. These timers change the amount of time the input has to be active before the controller registers the warning or failure.



NOTE: If the switched input becomes inactive before the trigger delay time expires, the warning or failure will not occur.

Example: The user wants a pump to turn on 30 seconds after a high water level switch is tripped and remain on until the level switch turns off.

The level switch is connected to Switched Input C and closes to ground when the water level is too high. The words 'Water Pumping' are also required to be displayed on the controllers LCD screen. The pump is connected to a slave relay which is controlled by Switched Output D on the controller.

Relevant Settings

Setting	Value
Switched Input C -> Function	Configurable Warning 1
Switched Input C -> Active Mode	Global
Switched Input C -> Trigger	Close GND
Configurable Warning 1 Custom Text	Water Pumping
Switched Output D -> Warnings	Configurable Warning 1

4.4.4 Start / Stop (Momentary Function)

When a switched input is configured to Start / Stop, the trigger modes have different meanings than other inputs. The following table describes the trigger mode functionality.

Trigger	Description
Close to +Battery	Input active when +Battery is applied.
Close to Ground	Input active when ground is applied.
Close to +Battery / Ground	Input active when +Battery or ground is applied for approximately 2 seconds then deactivated.
Open	Input active when neither +Battery or ground is applied for approximately 2 seconds then deactivated.

The reason for changing these trigger mode is to allow the user to wire a single push button to be used for both starting and stopping the engine. Holding the button for too long will cause the engine to shutdown immediately after starting and vice versa.

The controller has switched outputs that are turned on under certain conditions to perform a function. The outputs turn on to +Battery voltage to drive the load when active. The following items are the available functions for switched outputs.

WARNING

WARNING: Switched outputs have a floating voltage of approximately 8V when off. If using the outputs for digital logic, it will be necessary to put a pull down resistor (1kΩ) from the output to ground to ensure a low logic level when output is off.

Event Functions

Name	Active Mode	Description
Pull Coil	Cranking	See Pull and Hold Coil section for more information.
LCD Backlight	Global	Active when LCD Backlight is active.
Voltage Regulator	Running	Active when engine is starting/running and is not in Idle Mode.
Energize to Stop	ETS Timer	Active during Energize to Stop timer.
Fuel	Cranking, Running	Active during cranking and running to supply fuel to engine.
Crank	Cranking	Active during cranking to start the engine.
Glowplug	Preheat, Midheat, Postheat	Active during the Preheat, Midheat and Postheat timers.
Not In Auto	Off	Active when the controller is in the OFF mode.
Idle Mode	Idle Mode	Active when Idle Mode switched input is active.
Warmup	Warmup Timer	Active after Warmup timer has expired to apply load to engine.
Cooldown	Cooldown Timer	Active when Cooldown timer is active.
Engine Running	Cranking, Running	Active when engine is cranking or running.
Exercising	Exercise Timer	Active during the engine exercising cycle.
Battery Recharge	Battery Recharge Timer	Active during the battery recharge cycle.
Maintenance Required	Global	Active when Maintenance timer has expired.
Low Battery During Cranking	Cranking	Active when Low Battery During Cranking warning is displayed.
Auxiliary Sensor 1	Auxiliary Settings Dependent	Active dependent upon settings in the Auxiliary sensor section.
Auxiliary Sensor 2	Auxiliary Settings Dependent	Active dependent upon settings in the Auxiliary sensor section.
Auxiliary Sensor 3	Auxiliary Settings Dependent	Active dependent upon settings in the Auxiliary sensor section.
Auxiliary Sensor 4	Auxiliary Settings Dependent	Active dependent upon settings in the Auxiliary sensor section.
System Ready	Auto	Active when controller is in Auto mode and no warnings or failures are present.
Delay to Start	Delay to Start Timer	Active when the Delay to Start timer is active.
Battle Mode	Battle Mode	Active when Battle Mode switched input is active.
Force Regeneration	User Controlled	When user triggers a Force Regeneration, output is active for 20 seconds then switches off.
Regeneration Inhibit	User Controlled	When user triggers a Regeneration Inhibit, output is active for 20 seconds then switches off.
Common Failure	Any Failure	Active when any failure occurs.
RPM Increment	Running	Output is used to trigger inputs on an ECM to control speed. See Front Panel Speed Control section for more information.
RPM Decrement	Running	Output is used to trigger inputs on an ECM to control speed. See Front Panel Speed Control section for more information.

A.5 Switched Outputs (Continued)

Warning Functions

Functions			
Low Engine Temperature	High Engine Temperature	Low Oil Pressure	Under Speed
Over Speed	Low Fuel Level	High Fuel Level	Low Battery Voltage
High Battery Voltage	Under Frequency	Over Frequency	AC Under Voltage
AC Over Voltage	Over Current	Fuel In Basin	Battery Charger Fault
Configurable Warning 1	Configurable Warning 2	Auxiliary Sensor 1	Auxiliary Sensor 2
Auxiliary Sensor 3	Auxiliary Sensor 4	---	---

Failure Functions

Functions			
Overcrank	Engine Failed to Stop	DM1 Stop Lamp	High Engine Temperature
Low Oil Pressure	Low Fuel Level	Under Speed	Over Speed
Low Battery Voltage	High Battery Voltage	Low Coolant Level	Low Air Pressure
Low Hydraulic Pressure	Under Frequency	Over Frequency	AC Under Voltage
AC Over Voltage	Over Current	ECM Communication Failure	Configurable Failure 1
Configurable Failure 2	Auxiliary Sensor 1	Auxiliary Sensor 2	Auxiliary Sensor 3
Auxiliary Sensor 4	---	---	---

A.5.1 Group Outputs

Group functions are designed so that multiple output functions can be bundled together and assigned to a single switched output pin. The definition of a group output is as follows:

-When any of the functions in a group is active (OR logic), the assigned switched output will be active.

Group Functions

Name	Active Mode	Description
Group #1	Group Dependent	Must be set from Configurator software.
Group #2	Group Dependent	Must be set from Configurator software.
Group #3	Group Dependent	Must be set from Configurator software.
Group #4	Group Dependent	Must be set from Configurator software.

Example: Low AC Frequency, High AC Frequency are bundled in 'Group #1' and assigned to Switched Output D. This output is connected to an external indicator lamp labeled 'AC Frequency Warnings.' This allows one output to indicate there is a warning with the AC frequency. The following table shows the output state based on the warnings status.

Low AC Frequency Warning	High AC Frequency Warning	Switched Output State
Inactive	Inactive	OFF
Inactive	Active	ON
Active	Inactive	ON
Active	Active	ON

A.6 Sensors

The controller has sensor ports which can be connected to a variety of different sensor types (Temperature, Pressure, Level, etc). See the Terminal Descriptions section for more information on which terminals your sensor is compatible with (Low Ω , High Ω , 0-5V or 4-20mA). Most sensors are used to monitor for warnings and failures but the Auxiliary sensors can be used to perform special functions (Example: Starting engine on low temperature).

A.6.1 Engine Temperature

The following settings are used to configure how the controller reads and interprets data from the engine temperature sender.

Name	Range	Description
Signal Source	Sensor Port X J1939 Bus	The source from which the sensor data is attained.
Sensor Type	Sender Table X Close = Warning Open = Warning Close = Failure Open = Failure	Select one of the pre-configured sender tables or one of the switch functions. A custom table can also be created using the Northern Lights Configurator. Close = Ground Open = Open Circuit
Trim Offset	-50.0 ~ 50.0°F	Calibrate a sensor by using the offset to correct errors.
Setpoints -> Bypass Time	0 ~ 90 seconds	Amount of time to bypass warnings and failures after engine has started.
Setpoints -> Low Warning	32 ~ 200°F	Reading at which a warning occurs.
Setpoints -> High Warning	50 ~ 300°F	Reading at which a warning occurs.
Setpoints -> High Failure	50 ~ 300°F	Reading at which a failure occurs.

A.6.2 Oil Pressure

The following settings are used to configure how the controller reads and interprets data from the oil pressure sender.

Name	Range	Description
Signal Source	Sensor Port X J1939 Bus	The source from which the sensor data is attained.
Sensor Type	Sender Table X Close = Warning Open = Warning Close = Failure Open = Failure	Select one of the pre-configured sender tables or one of the switch functions. A custom table can also be created using the Northern Lights Configurator. Close = Ground Open = Open Circuit
Trim Offset	-50.0 ~ 50.0 PSI	Calibrate a sensor by using the offset to correct errors.
Setpoints -> Bypass Time	0 ~ 90 seconds	Amount of time to bypass warnings and failures after engine has started.
Setpoints -> Low Warning	0.1 ~ 99.0 PSI	Reading at which a warning occurs.
Setpoints -> Low Failure	0.1 ~ 99.0 PSI	Reading at which a failure occurs.

A.6.3 Fuel Level

The following settings are used to configure how the controller reads and interprets data from the fuel level sender.

Name	Range	Description
Signal Source	Sensor Port X	The source from which the sensor data is attained.
Sensor Type	Sender Table X Close = Warning Open = Warning Close = Failure Open = Failure	Select one of the pre-configured sender tables or one of the switch functions. A custom table can also be created using the Northern Lights Configurator. Close = Ground Open = Open Circuit
Trim Offset	-50.0 ~ 50.0%	Calibrate a sensor by using the offset to correct errors.
Setpoints -> Bypass Time	0 ~ 90 seconds	Amount of time to bypass warnings and failures after engine has started.
Setpoints -> Low Warning	1 ~ 90%	Reading at which a warning occurs.
Setpoints -> Low Failure	1 ~ 90%	Reading at which a failure occurs.
Setpoints -> High Warning	1 ~ 125%	Reading at which a warning occurs.

A.6.4 Engine Speed

The following settings are used to configure how the controller reads and interprets speed sensing data.

Name	Range	Description
Signal Source	J1939 Bus Mag Pickup Genset Voltage	The source from which the sensor data is attained.
Speed Settings -> Rated RPM	500 ~ 4000	Speed at which the engine runs under normal operating conditions. Warning and failure setpoints are calculated from this setting.
Speed Settings -> Idle RPM	300 ~ 2000	Speed at which the engine runs when it is idling.
Speed Settings -> Tooth Count	1 ~ 600	Number of teeth on the flywheel (Mag Pickup only).
Setpoints -> Low Warning	50 ~ 99%	Reading at which a warning occurs.
Setpoints -> Low Failure	50 ~ 99%	Reading at which a failure occurs.
Setpoints -> High Warning	101 ~ 150%	Reading at which a warning occurs.
Setpoints -> High Failure	101 ~ 150%	Reading at which a failure occurs.
Front Panel Speed Control Settings	N/A	See Front Panel Speed Control section for more information on these settings.
RPM Switch -> Secondary RPM / 50Hz	500 ~ 4000	The Rated RPM when the Secondary RPM / 50Hz is selected. See RPM / Frequency Select section for more information.



NOTE: When using J1939 or Genset Signal as a signal source, connections to the speed sensing terminals are not required.



WARNING: Switched outputs have a floating voltage of approximately 8V when off. If using the outputs for digital logic, it will be necessary to put a pull down resistor (1kΩ) from the output to ground to ensure a low logic level when output is off.

A.6.5 Battery Level

The following settings are used to configure how the controller reads and interprets the battery voltage level.

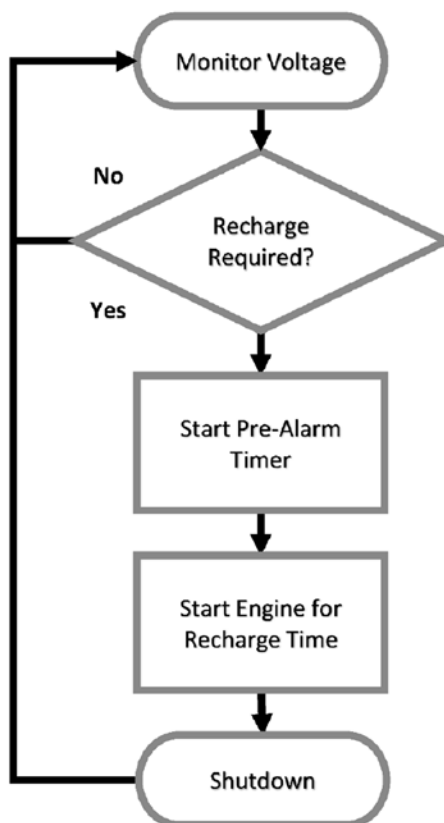
Name	Range	Description
Battery Recharge	Enable ~ Disable	Enables or disables the ability to have the engine start on low battery voltage in order to charge it.
Recharge Setup -> Level	6.0 - 30.0V	Voltage level at which the controller starts the engine to recharge the battery.
Recharge Setup -> Pre-Alarm	1 ~ 20 minutes	Amount of time to display a warning before starting the engine.
Recharge Setup -> Duration	10 ~ 900 minutes	Amount of time to run the engine.
Setpoints -> Low Warning	6.0 ~ 24.0V	Reading at which a warning occurs.
Setpoints -> Low Failure	6.0 ~ 24.0V	Reading at which a failure occurs.
Setpoints -> High Warning	12.0 ~ 32.0V	Reading at which a warning occurs.
Setpoints -> High Failure	12.0 ~ 32.0V	Reading at which a failure occurs.
Crank Low Batt	6.0 ~ 24.0V	Screen displays a 'Low Voltage During Cranking' warning if voltage dips below this level during cranking.



NOTE

NOTE: When the engine is running, the battery voltage will equal the alternator charging voltage. The actual open circuit battery voltage may be lower than displayed.

Battery Recharge Sequence



A.6.6 Auxiliary

The Auxiliary sensors on the controller are used for performing functions based on sensor readings. There are 2 different ways in which the auxiliary sensors can be utilized:

Scenario #1 - Custom Sensors

Use the auxiliary sensors to create custom sensors (Current, Voltage, etc.) that are not supported by the controller by default (Engine Temperature, Oil Pressure, Fuel Level).

Scenario #2 - Add-On Functionality

Double up the auxiliary sensor onto the same Sensor Port that is currently being used by one of the other sensors (Engine temperature, Oil pressure, Fuel level). This allows you to use the special functions (Start on Low, Output on High, etc.) in conjunction with those sensors.



NOTE

NOTE: You must set the auxiliary sensor port and sender table to the same values as the other sensor.

Name	Range	Description
Signal Source	Sensor Port X	The source from which the sensor data is attained.
Display	Enable ~ Disable	Determines if the sensors value is displayed on the screen when the engine is running.
Active Modes	Disable Global Not In Auto Auto State Running Cranking After Cranking Cooldown	Determines under which operating conditions the Auxiliary Sensor is monitored. Multiple selections are allowed. Refer to the Switched Inputs section for more information on the Active Modes.
Mode Select	Fault Monitor Output on Low Output on High Start on Low Start on High	Determines how the controller responds to the readings of the auxiliary sensor. Refer to the examples in the following pages for more information on how each mode functions.
Trim Offset	-50.0 ~ 50.0 units	Calibrate a sensor by using the offset to correct errors.
Mode Settings -> Bypass Time	0 ~ 90 seconds	Amount of time to bypass warnings and failures after engine has started.
Mode Settings -> Active Time ¹	1 ~ 600 minutes	The amount of time to turn on the auxiliary switched output or engine before turning off.
Mode Settings -> Start Level ¹	Sender Table Dependent	The level at which the auxiliary switched output or engine turns on.
Mode Settings -> Stop Level ¹	Sender Table Dependent	The level at which the auxiliary switched output or engine turns off.
Setpoints -> Low Warning	Sender Table Dependent	Reading at which a warning occurs.
Setpoints -> Low Failure	Sender Table Dependent	Reading at which a failure occurs.
Setpoints -> High Warning	Sender Table Dependent	Reading at which a warning occurs.
Setpoints -> High Failure	Sender Table Dependent	Reading at which a failure occurs.

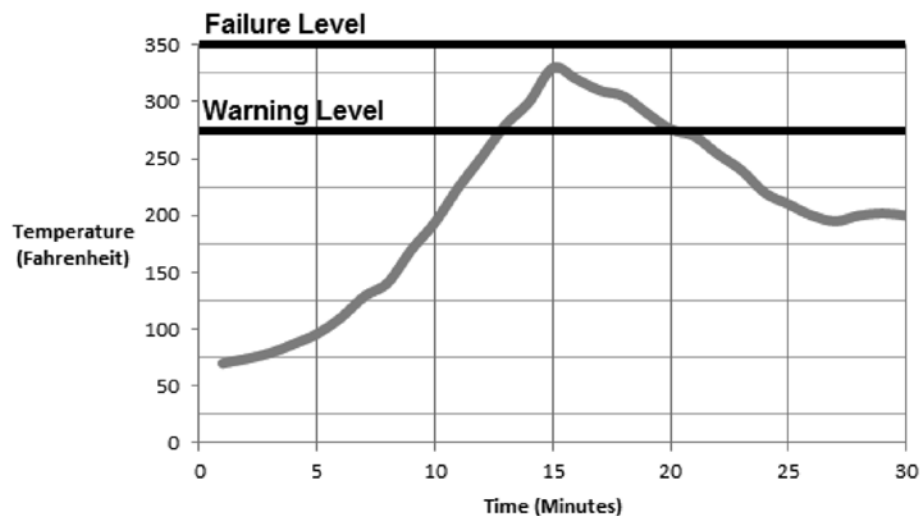
¹ Refer to the sections below for more information on how these settings affect the auxiliary sensors.

A.6.6.1 Fault Monitor Example

In this example, a sensor is monitoring the temperature of an engine block. If the temperature rises above 275°F a warning message is displayed. If the temperature rises above 350°F the engine shuts down and a failure message is displayed.

Relevant Settings

Setting	Value
Signal Source	Same as Engine Temperature
Display	Disable (If enabled, controller will display Engine Temperature twice)
Sensor Type	Same as Engine Temperature
Sender Table Name	Engine Temp.
Active Range	Running
Mode Select	Fault Monitor
Setpoints -> Low Warning	Disabled
Setpoints -> Low Failure	Disabled
Setpoints -> High Warning	275°F
Setpoints -> High Failure	350°F



The chart above shows the connection between engine temperature and time. At approximately 13 minutes run time the temperature rises above the 275°F warning threshold so a warning is displayed. The engine continues to run because it does not reach the 350°F failure threshold. At 20 minutes run time the temperatures falls below the warning threshold and the warning disappears.

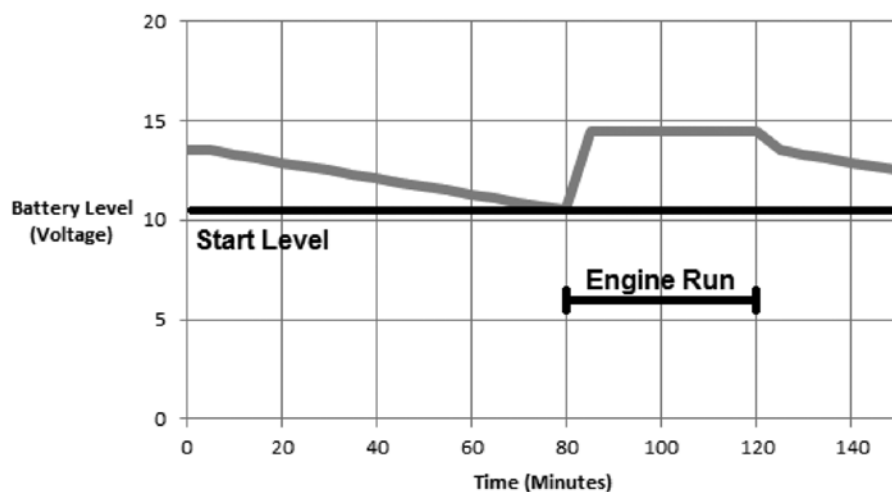
A.6.6.2 Start on Low / High Example

In this example, a sensor is monitoring the voltage of an external battery bank. If the voltage falls below 10.5V, the engine will start and run for 40 minutes to charge the battery.

Relevant Settings

Setting	Value
Signal Source	Sensor Port X
Display	Enable
Sensor Type	Custom
Sender Table Name	Battery Bank
Active Range	N/A (These ranges are fixed for Start on Low / High)
Mode Select	Start on Low
Mode Settings -> Active Time	40 minutes
Mode Settings -> Start Level	10.5V
Mode Settings -> Stop Level ¹	Disabled

¹ Stop Level is disabled because when the engine is running, the battery voltage will equal the alternator charging voltage. Having this disabled will force the engine to run for the entire duration of the active time.



The chart above shows the connection between a battery bank and time. At approximately 80 minutes time the voltage falls below the 10.5V start threshold causing the engine to start. The engine runs for the 40 minutes active time regardless of the voltage reading and the shuts down.

A.6.6.3 Output on Low / High Example

In this example, a sensor is monitoring the temperature of an engine. If the temperature rises above 325°F a fan will turn on to cool the engine. Once the temperature drops to below 200°F the fan will turn off.

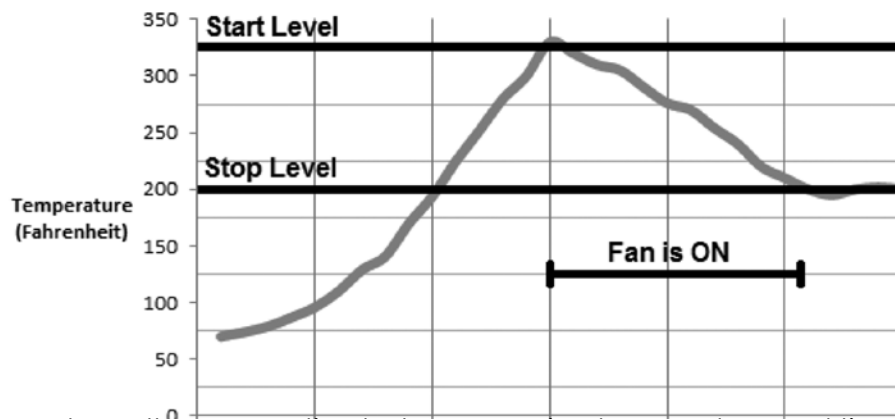
Relevant Settings (Auxiliary Sensor)

Setting	Value
Signal Source	Same as Engine Temperature
Display	Disable (If enabled, controller will display Engine Temperature twice)
Sensor Type	Same as Engine Temperature
Sender Table Name	Engine Temp.
Active Range	Global
Mode Select	Output on High
Mode Settings -> Active Time ¹	Disabled
Mode Settings -> Start Level	325°F
Mode Settings -> Stop Level	200°F

¹ Active time is disabled because the fan needs to stay on indefinitely or until 200°F is reached.

Relevant Settings (Switched Outputs)

Setting	Value
Switched Output X	Auxiliary Sensor X (Choose based on which Auxiliary Sensor is being used)



The chart above shows the connection between engine temperature and time. At approximately 10 minutes run time the temperature rises above the 325°F start threshold and the fan turns on. The fan continues to run as the temperature declines. When the temperature falls below the 200°F stop threshold the fan turns off.

A.6.7 Custom Sender Tables

Custom Sensor Tables are created using the Software Configurator when using a sensor that is not supported by Northern Lights. The configurator has the ability to create these custom tables so that the controller can properly read the sensor data.



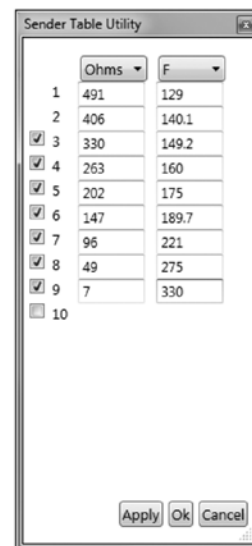
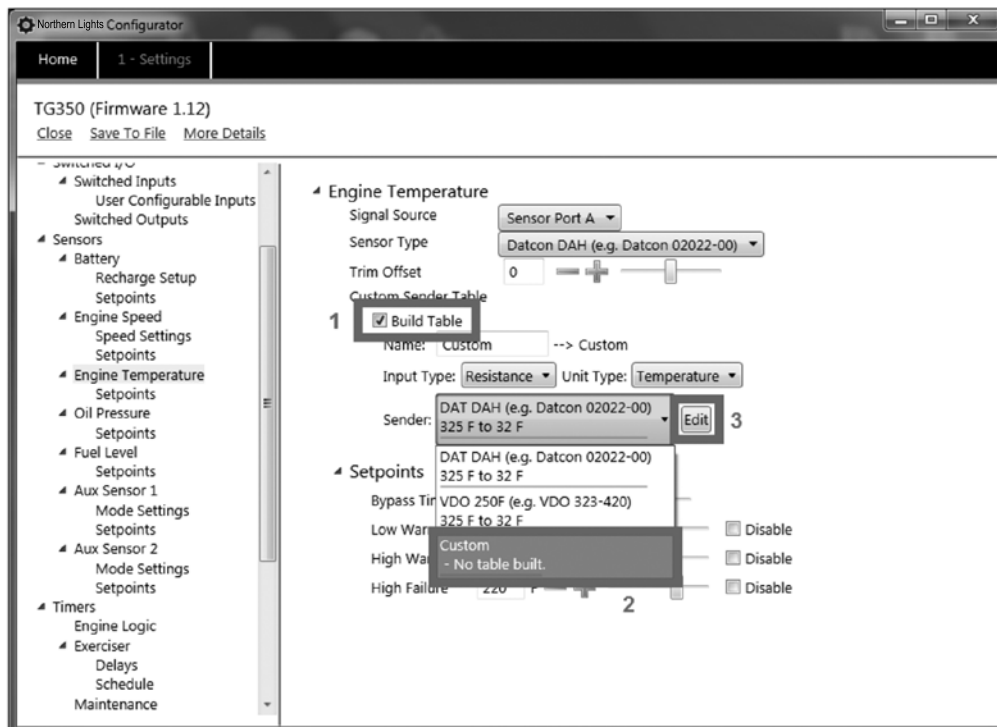
NOTE

NOTE: Custom sender tables can only be created when using the configurator.

Parameter	Description
Name	The label that will be displayed in the controller (Engine Temp, Oil Pressure, etc.)
Input Type	Choose resistance, voltage or current based on the sensor type. Use the Terminal Descriptions section to determine if your sender is compatible with a sensor port.
Unit Type	Choose temperature, pressure, voltage, current or percentage based on the sensor. This defines what unit of measurement will be displayed on the front panel (F, PSI, V, A, %).

The following steps are an example of how to create a custom sensor table:

1. Navigate to the sensor input that will be using your custom sensor table.
2. Select a Name, Input Type and Unit Type for the controller (Definitions in table above).
3. Click the check box next to 'Build Table' (Image Step 1).
4. From the 'Sender' drop down menu, select 'Custom' (Image Step 2).
5. Click the 'Edit' button next to the drop down menu (Image Step 3).
6. Enter the sensor values. Once entered, click Apply then OK.



The controller has an internal clock which is used not only to keep time, but to make sure certain events happen at the correct times. The following sections are used to configure settings associated with timing functions.



NOTE: The controller has an on-board backup battery to keep time even when main power is not supplied to the unit. This battery has an un-powered (no main power) lifetime of approximately five years.

A.7.1 Engine Logic

The following settings determine how the controller starts and stops the engine. It gives the user the functionality to add delays and timers to the sequences. Most of the settings have a switched output associated with them that must be set in the Switched Outputs settings.



NOTE: Setting a timers value to 0 seconds will disable the timer. Example: If Delay to Start is set to 0 seconds, the controller will not perform a Delay to Start when starting the engine.

Name	Range	Description
Delay to Start	0 ~ 90 seconds	Amount of time to delay the starting of the engine after receiving a command to start.
Delay to Start on Manual Run	Enable ~ Disable	Determines if the the Delay to Start timer is used when the front panel RUN button is used to start the engine.
Preheat Mode	Preheat Timer Switched Input J1939	Determines which method controls when the glowplug output should be enabled. See the Preheat Mode section for more information.
Preheat Time	0 ~ 90 seconds	Amount of time the <u>Glowplug output</u> is active before cranking the engine. Used on diesel engines to warm the engine before cranking.
Crank Time	3 ~ 30 seconds	Amount of time the <u>Crank output</u> is active before going to crank rest. This timer immediately expires upon successful cranking.
Midheat Time	0 ~ 90 seconds	Keeps <u>Glowplug output</u> turned on while cranking but not during crank rest. Output will turn off upon cranking failure, crank success or midheat time expiration.
Crank Rest Time	1 ~ 90 seconds	Amount of time to delay between each attempt to start the engine.
Crank Attempts	1 ~ 20	Number of attempts to start the engine before going to a overcrank failure.
Fuel Crank Rest	Fuel ON Fuel OFF	Determines if the fuel output stays on during the crank rest time.
RPM Disconnect	100 ~ 2000 RPM	Speed at which controller determines the engine has started successfully and turns off the <u>Crank output</u> .
Postheat Time	0 ~ 90 seconds	Amount of time the <u>Glowplug output</u> remains on after crank success and the engine is running.
Restart on False Start	Enable ~ Disable	Determines if the controller will monitor for false starts and attempt a restart. Controller will only attempt restarting the engine as many times as determined by Crank Attempts.
False Restart Detect Time	5 ~ 30 seconds	Amount of time after successful cranking to monitor for a false restart. If this time expires and the engines stalls out the controller will not attempt a restart.
Auto Idle	Enable ~ Disable	Determines if the controller will automatically enter Idle Mode during the Warmup and Cooldown delays.
Warmup Time	0 ~ 600 seconds	After successful cranking, engine delays this amount of time before turning on the <u>Warmup output</u> . This allows the engine to warmup before applying any load to it. The output will turn off when the controller enters the Cooldown Delay.

A.7.1 Engine Logic (Continued)

OFF Button Function	Cooldown Shutdown Force Cooldown	The function the OFF button on the front panel performs while engine is running. See the OFF Button Function section for more information.
Cooldown Delay	0 ~ 600 seconds	Amount of time to cooldown the engine after a stop command has been received. During this time the <u>Warmup output</u> turns off and the <u>Cooldown output</u> turns on. If another start command is received during cooldown, the controller will return to running mode.
Energize to Stop Duration	0 ~ 30 seconds	Amount of time the <u>Energize to Stop output</u> is on after the engine has shutdown. If controller still detects speed (RPM) after this time expires, it goes to a 'Failed to Stop' failure. Time must be greater than 0 seconds for the Energize to Stop function to work.

A.7.1.1 Preheat Mode

The controller has the ability to control the length of the preheat time through 3 different methods. The table below describes each method:

Mode	Description
Preheat Timer	This mode uses the Preheat Timer setting in the Engine Logic menu.
Switched Input	This mode uses a switched input set to Preheat Signal.



NOTE: During preheat the Glowplug switched output is on.

A.7.1.2 OFF Button Function

The OFF button on the front panel of the controller can be configured to function in 3 different ways while the engine is running.

The table below describes each of these functions:

Function	Description
Cooldown	This function causes the controller to go into cooldown. Pressing the OFF button again will cause the engine to shutdown.
Shutdown	This function bypasses Cooldown and causes the engine to shutdown.
Force Cooldown	This function causes the controller to go into cooldown. Pressing the OFF button will have no affect as the controller is forcing the engine to perform a full cooldown.



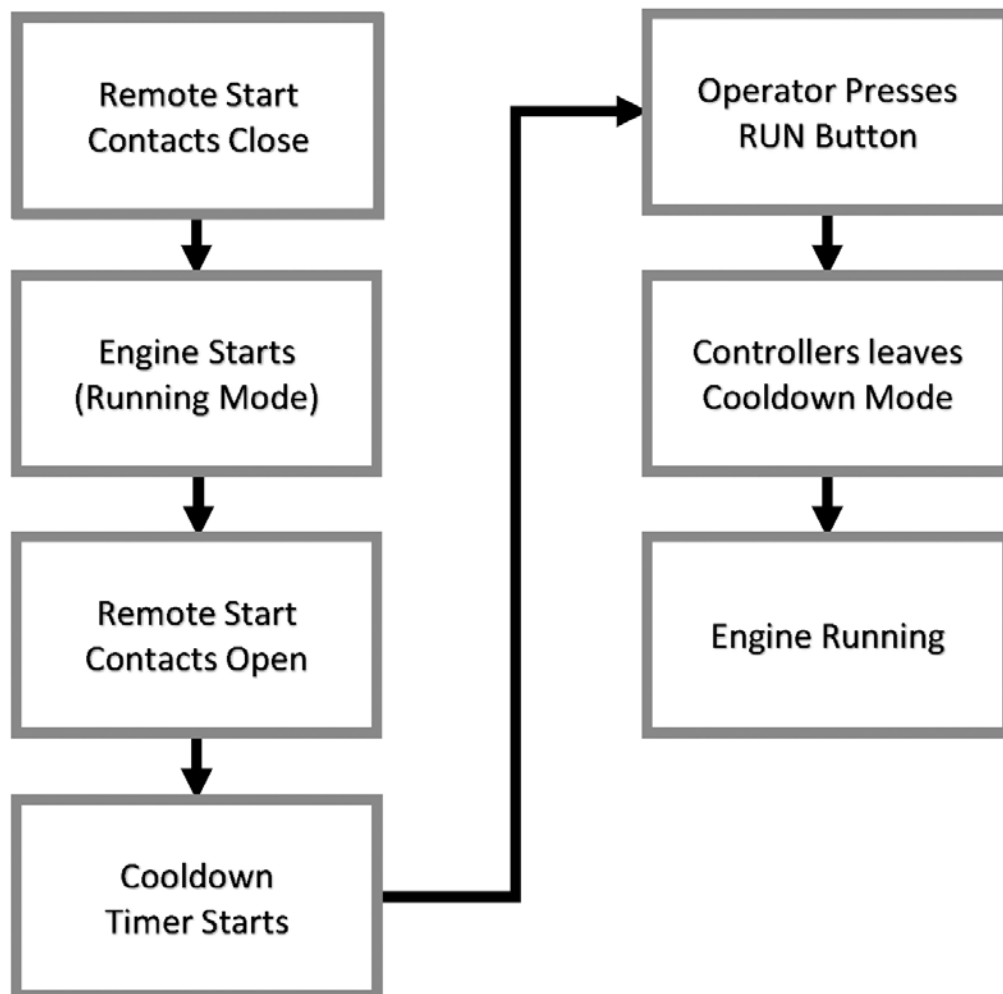
WARNING: If the controller receives a command to start while in Cooldown, it will leave the Cooldown mode and go back to Running mode.

When the controller is configured to have a cooldown period (See Engine Logic section) for the engine, there is some special functionality that must be considered.

The cooldown period is special in that during this time, it will accept a Start Command. This means that if the engine is cooling down and a start command is received, the controller will be placed back into a running mode and will not shutdown.

Example: The following is an example of how the cooldown functionality works.

1. Remote Start contacts close
2. Engine starts and is in the running mode
3. Remote Start contacts open
4. Engine starts cooldown period
5. User presses RUN button on the front panel
6. Engine moves back into running mode and does not shutdown
7. Engine can now only be shutdown by the OFF button or Emergency Stop input



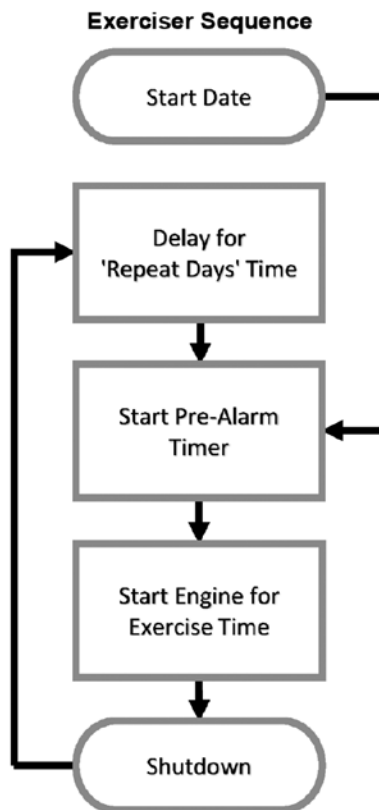
A.9 Exerciser

The Exerciser function is used start and run the engine periodically. This is commonly used to make sure problems with the engine do not arise from sitting idle for too long. The following settings configure the Exerciser function

Name	Range	Description
Enable	Enable ~ Disable	Determines if the engine is automatically exercised periodically.
Delays -> Pre-Alarm	1 ~ 20 minutes	Amount of time to display a warning before starting the engine.
Delays -> Run Time	10 ~ 1500 minutes	Amount of time to run the engine.
Schedule -> Start Date	1 ~ 31	The initial day of the month to run the exerciser.
Schedule -> Start Hour	0 ~ 23	The initial hour of the day to run the exerciser.
Schedule -> Repeat Days	1 ~ 28 days	Number of days between each exerciser cycle.

When configuring the Start Date and Hour, you must select a time in the future in which to run the initial exerciser sequence.

After the initial sequence, the exerciser runs at an interval determined by 'Repeat Days.'



The controller has the ability to count down the time between scheduled maintenance by a technician. Once maintenance is required, the controller will alert the operator via the LCD screen and a switched output (if enabled) wired to a lamp / horn / buzzer. The following settings are used to configure the maintenance timer.

Name	Range	Description
Reset Counter	Enable ~ Disable	Once the maintenance count interval expires, use this setting to reset the time and turn off the switched output (if enabled).
Enable Counter	Enable ~ Disable	Determines the number of hours between required maintenance. A switched output can be configured to turn on once the count interval expires.
Counter Interval	10 ~ 9990 hours	Enables or disables the maintenance function.

To find out the amount of time until next maintenance, follow these menu steps:

Main Menu -> Device Info. -> Maintenance

Maintenance counter is disabled if '----' is displayed. A negative number indicates the amount of time since maintenance timer expired.

A.11 AC Monitor

The following sections are use to configure settings associated with AC monitoring.

A.11.1 Generator Voltage

The following settings are used to configure how the controller responds to voltage measurements.

Name	Range	Description
Voltage Source	Disable 2-Wire Single 3-Wire Single 3-Wire 3-Phase 4-Wire 3-Phase 4-Wire Delta Auto Selection	The wiring configuration of the generator. Selecting Auto Selection will use the <u>Voltage Select</u> inputs to determine which wiring configuration is implemented and displayed.
Scaling Factor	0.500 ~ 2.500	Scaling factor at which the voltage is read into the controller. See below for more information.
Nominal Volts	50 ~ 800Vac	Voltage at which the generators runs at when operating under normal running conditions.
Auto Nominal -> 1-Phase 3-Wire	50 ~ 800Vac	Nominal Volts when using the <u>Voltage Select</u> inputs.
Auto Nominal -> 3-Phase (1)	50 ~ 800Vac	Nominal Volts when using the Voltage Select inputs.
Auto Nominal -> 3-Phase (2)	50 ~ 800Vac	Nominal Volts when using the Voltage Select inputs.
Auto Nominal -> 3-Phase (3)	50 ~ 800Vac	Nominal Volts when using the Voltage Select inputs.
Auto Ratios -> 1-Phase 3-Wire	0.500 ~ 2.500	Scaling Factor when using the <u>Voltage Select</u> inputs.
Auto Ratios -> 3-Phase (1)	0.500 ~ 2.500	Scaling Factor when using the Voltage Select inputs.
Auto Ratios -> 3-Phase (2)	0.500 ~ 2.500	Scaling Factor when using the Voltage Select inputs.
Auto Ratios -> 3-Phase (3)	0.500 ~ 2.500	Scaling Factor when using the Voltage Select inputs.
Auto Single	A-C Phase A-B Phase	For 1-Phase 3-Wire when using the Voltage Select inputs, this determines which phases the voltage is read from.
V Setpoints -> Low Warning	50 ~ 99%	Reading at which a warning occurs.
V Setpoints -> Low Failure	50 ~ 99%	Reading at which a failure occurs.
V Setpoints -> High Warning	101 ~ 150%	Reading at which a warning occurs.
V Setpoints -> High Failure	101 ~ 150%	Reading at which a failure occurs.

Application Note: Scaling Factor

The scaling factor setting can be used to calibrate the AC voltage if there are discrepancies between the reading and the actual value. It can also be used if transformers are used to step up / down the voltage. The scaling factor applies to all phases in a system.

Example: The voltage source is a 3-Wire 3-Phase system with a nominal voltage of 208V. The controller is reading 206.3V but a calibrated multimeter gives 208.3V. Use the formula below to determine the scaling factor.

1. Scaling Factor = Multimeter Reading / Controller Reading
2. Scaling Factor = 208.4V / 206.3V
3. Scaling Factor = 1.010

A.11.2 Generator Frequency

The following settings are used to configure how the controller responds to frequency measurements.

Name	Range	Description
Frequency Source	Nominal 50Hz Nominal 60Hz Auto Selection	The wiring configuration of the generator. Selecting Auto Selection will use the Frequency Select input to determine which frequency is used.
Hz Setpoints -> Low Warning	50 ~ 99%	Reading at which a warning occurs.
Hz Setpoints -> Low Failure	50 ~ 99%	Reading at which a failure occurs.
Hz Setpoints -> High Warning	101 ~ 150%	Reading at which a warning occurs.
Hz Setpoints -> High Failure	101 ~ 150%	Reading at which a failure occurs.

A.11.3 Generator Current

The following settings are used to configure how the controller responds to current measurements.

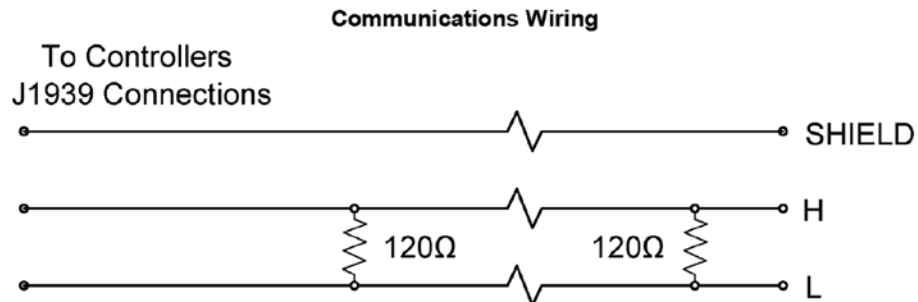
Name	Range	Description
Current Source	Enable ~ Disable	Enables or disables current metering.
Turns Ratio	5 ~ 5000A : 5A	The turns ratio of the current transformers.
Scaling Factor	0.500 ~ 1.250	Scaling factor at which the voltage is read into the controller. See below for more information.
Volt Sel Inputs -> 1-Phase 3-Wire	5 ~ 5000A : 5A	Rated Amps when using the Voltage Select inputs.
Volt Sel Inputs -> 3-Phase (1)	5 ~ 5000A : 5A	Rated Amps when using the Voltage Select inputs.
Volt Sel Inputs -> 3-Phase (2)	5 ~ 5000A : 5A	Rated Amps when using the Voltage Select inputs.
Volt Sel Inputs -> 3-Phase (3)	5 ~ 5000A : 5A	Rated Amps when using the Voltage Select inputs.
Volt Sel Ratios -> 1-Phase 3-Wire	0.500 ~ 2.250	Scaling Factor when using the Voltage Select inputs.
Volt Sel Ratios -> 3-Phase (1)	0.500 ~ 2.250	Scaling Factor when using the Voltage Select inputs.
Volt Sel Ratios -> 3-Phase (2)	0.500 ~ 2.250	Scaling Factor when using the Voltage Select inputs.
Volt Sel Ratios -> 3-Phase (3)	0.500 ~ 2.250	Scaling Factor when using the Voltage Select inputs.
Setpoints -> Rated Amps	5 ~ 5000A	Maximum current draw the generator can provide when operating under normal running conditions.
Setpoints -> High Warning	1 ~ 125%	Reading at which a warning occurs. Percentages based off the Rated Amps value.
Setpoints -> High Failure	1 ~ 125%	Reading at which a failure occurs. Percentages based off the Rated Amps value.

Appendix B: J1939 Communications

B.1 CAN Bus Wiring

The following table outlines some items that must be taken into consideration when using the CAN bus output.

Consideration	Description
Bus Termination	Each end of the bus must be terminated from H to L with 120 Ω resistors. Tough Series local and remote panels have terminating resistors built in. Connection to third-party devices such as NMEA converters may require a terminating resistor at the end of the bus opposite the panel.
Cable Selection	A J1939 twisted pair 120 ² cable is required for communications. Possible options are: 1. Belden 9841 - One twisted pair, 24AWG 2. Belden 7895A - Two twisted pair, 20AWG, second pair can be used for power
Shielding	When using a Belden style cable, the shield must be grounded on one end of the bus. This prevents loss of data from electromagnetic interference.



B.2 Reference

This section details the J1939 PGNs and SPNs supported by the TSC controller. This section details the J1939 support. Specifically the PGN and SPNs the controller supports.

General J1939 notes:

- (1) 0xFF indicates that a parameter is not available.
- (2) The least significant byte (LSB) is always the first.

List of PGNs

PGN #	Name	Short Name	Rate (ms)	Priority	Description
65021 (0xFDFD)	Generator Phase C Basic AC Quantities	GPCAC	100	3	Transmits AC Frequency, AC Voltage, and AC RMS Current for Phase A.
65024 (0xFE00)	Generator Phase B Basic AC Quantities	GPBAC	100	3	Transmits AC Frequency, AC Voltage, and AC RMS Current for Phase B. The controller does not support phase B frequency.
65027 (0xFE03)	Generator Phase A Basic AC Quantities	GPAAC	100	3	Transmits AC Frequency, AC Voltage, and AC RMS Current for Phase C. The controller does not support phase C frequency.
65030 (0xFE06)	Generator Average Basic AC Quantities	GAAC	100	3	Average of phase A, B, and C for Line-Line, Line-Neutral, AC Frequency, and AC RMS current.
59904 (0xEA00)	PGN Request	RQST	N/A	6	This is used by the controller to request engine hours from the ECM.
61444 (0xF004)	Electronic Engine Controller 1	EEC1	100	3	Used to broadcast or receive engine speed. For receiving ECM must be at address 0. Controller can also broadcast engine speed.
65253 (0xFEE5)	Engine Hours, Revolutions	HOUR S	N/A	6	Used to receive or broadcast engine hours. Requested by controller every 1s. Broadcast (if enabled) by controller every 5s.
65262 (0xFEEE)	Engine Temperature 1	ET1	100 0	6	Used to receive or broadcast engine temperature. For receiving ECM must be at address 0.
65263 (0xFEEF)	Engine Fluid Level/ Pressure 1	EFL/P1	500	6	Used to receive or broadcast oil pressure from ECM. For receiving ECM must be at address 0.
65271 (0xFE7F)	Vehicle Electrical Power 1	VEP1	100 0	6	Used to broadcast battery voltage.
65276 (0xFEFC)	Dash Display	DD	100 0	6	Used to broadcast fuel level.

Engine SPNs

Parameter Name	SPN	Range	Conversion/ Unit	PGN	PGN Byte/ Bit Location	Description
Fuel Level 1	96	0 to 100%	Gain = 0.4 %/bit Offset = 0	65276 (0xFEFC)	Byte 2	Used for broadcasting of fuel level.
Engine Oil Pressure	100	0 to 1000kPa	Gain = 4kPa/bit Offset = 0	65263 (0xFEEF)	Byte 4	Used to broadcast or receive oil pressure.
Engine Coolant Temperature	110	-40 to 210 °C	Gain = 1degC/ bit Offset = -40	65262 (FEEE)	Byte 1	Used to broadcast or receive engine temperature. Controller is limited to 0°C for failure set-point purposes.
Battery Potential / Power Input 1	168	0 to 3212.75 V	Gain = 0.05V/bit Offset = 0	65271 (0xFE7F)	Bytes 5 and 6	Used for broadcasting of battery voltage.
Engine Speed	190	0 to 8,031.875 rpm	Gain = 0.125rpm/bit Offset = 0	61444 (0xF004)	Bytes 4 and 5	Used to broadcast or receive engine speed. Controller is limited to 6000rpm.
Engine Total Hours of Operation	247	0 to 210,554,060.75 hr	Gain = 0.05hr/ bit Offset = 0	65253 (0xFEE5)	Bytes 1 to 4	Used to broadcast or receive engine hours.

B.3 Standard

Generator SPNs

Parameter Name	SPN	Range	Conversion/ Unit	PGN	PGN Byte/ Bit Location	Description
Generator Average AC Frequency	2436	0 to 501.992 1875 Hz	Gain = 1/128 Hz/bit Offset = 0	65030 (0xFE06)	Bytes 5 and 6	Broadcast by controller.
Generator Phase A AC Frequency	2437	0 to 501.992 1875 Hz	Gain = 1/128Hz/ bit Offset = 0	65027 (0xFE03)	Bytes 5 and 6	Broadcast by controller.
Generator Average Line-Line AC RMS Voltage	2440	0 to 64 255 Volts	Gain = 1 V/bit Offset = 0	65030 (0xFE06)	Bytes 1 and 2	Broadcast by controller.
Generator Phase AB Line-Line AC RMS Voltage	2441	0 to 64 255 V	Gain = 1V/bit Offset = 0	65027 (0xFE03)	Bytes 1 and 2	Broadcast by controller.
Generator Phase BC Line-Line AC RMS Voltage	2442	0 to 64 255 Volts	Gain = 1V/bit Offset = 0	65024 (0xFE00)	Bytes 1 and 2	Broadcast by controller.
Generator Phase CA Line-Line AC RMS Voltage	2443	0 to 64 255 Volts	Gain = 1V/bit Offset = 0	65021 (0xFDFD)	Bytes 1 and 2	Broadcast by controller.
Generator Average Line-Neutral AC RMS Voltage	2444	0 to 64 255 Volts	Gain = 1V/bit Offset = 0	65030 (0xFE06)	Bytes 3 and 4	Broadcast by controller.
Generator Phase A Line-Neutral AC RMS Voltage	2445	0 to 64 255 Volts	Gain = 1V/bit Offset = 0	65027 (0xFE03)	Bytes 3 and 4	Broadcast by controller.
Generator Phase B Line-Neutral AC RMS Voltage	2446	0 to 64 255 Volts	Gain = 1V/bit Offset = 0	65024 (0xFE00)	Bytes 3 and 4	Broadcast by controller.
Generator Phase C Line-Neutral AC RMS Voltage	2447	0 to 64 255 Volts	Gain = 1V/bit Offset = 0	65021 (0xFDFD)	Bytes 3 and 4	Broadcast by controller.
Generator Average AC RMS Current	2448	0 to 64 255 Amps	Gain = 1A/bit Offset = 0	65030 (0xFE06)	Bytes 7 and 8	Broadcast by controller.
Generator Phase A AC RMS Current	2449	0 to 64 255 A	Gain = 1A/bit Offset = 0	65027 (0xFE03)	Bytes 7 and 8	Broadcast by controller.
Generator Phase B AC RMS Current	2450	0 to 64 255 A	Gain = 1A/bit Offset = 0	65024 (0xFE00)	Bytes 7 and 8	Broadcast by controller.
Generator Phase C AC RMS Current	2451	0 to 64 255 A	Gain = 1A/bit Offset = 0	65021 (0xFDFD)	Bytes 7 and 8	Broadcast by controller.

B.4 Proprietary

PGN #	Name	Short Name	Rate	Priority	Description
65450 (0xFFAA)	Dynagen 1	N/A	200	6	Broadcasting of internal controller parameters useful to a remote panel.
65451 (0xFFAB)	Dynagen 2: Aux Sensor	N/A	200	6	Broadcasting of the auxiliary sensors 1 to 4. Units or custom text are not broadcast.

Dynagen 1 PGN

Parameter Name	SPN	Range	Gain/ Offset	PGN	PGN Byte/ Bit Location	Description
Controller State	52020 0	0 = Others 1 = Failure 2 = OFF 3 = AUTO 4 = Cooldown 5 = Shutdown 6 = Running	Gain = 1 Offset = 0	65450 (0xFFAA)	Bits 0 to 3 of Byte 1	

Pressure Unit	52020 1	0 = kPa 1 = PSI		65450 (0xFFFA)	Bit 7 of Byte 1	
Temperature Unit	52020 2	0 = Fahrenheit 1 = Celsius		65450 (0xFFFA)	Bit 6 of Byte 1	
Failure State	52020 3	0 = OK 1 = Warning 2 = Failure 3 = Double Failure	Gain = 1 Offset = 0	65450 (0xFFFA)	Bits 4 and 5 of Byte 1	
Warning/Failure ID	52020 4	0 = Failed To Stop 2 = Load Imbalance 3 = (Reserved) 4 = Over Current 6 = High Engine Temperature 7 = Low Oil Pressure 8 = Under Speed 9 = Over Speed 11 = Low Battery 13 = Over Crank 14 = Over Voltage 15 = Under Voltage 16 = (reserved) 17 = Regen Needed 20 = High Battery 22 = Under Frequency 23 = Over Frequency 255 = (none)	Gain = 1 Offset = 0	65450 (0xFFFA)	Byte 2	
First Line Display ID	52020 5	0 = (empty) 1 = Auto State 2 = Not In Auto 3 = Menu Setting 4 = Start Engine 5 = (reserved) 6 = Preheating 7 = J1939 Remote 8 = Speed Valid 9 = Dly To Stat... 10 = Preheating... 11 = Cranking... 12 = Warm-up... 13 = Crank Rest 14 = Running... 15 = Cooldown 16 = Shutdown... 17 = Idle Running... 18 = System Failed 19 = Emergency ... 20 = Speed Detect ... 21 = Idle Cool ... 22 = Remote Run ... 23 = Manual Run ... 24 = Modbus Run ... 25 = Charging ... 32 = Switch Run ... 33 = Cranking ... 34 = Idle Speed ...	Gain = 1 Offset = 0	65450 (0xFFFA)	Byte 3	

B.4 Proprietary

Second Line Display ID	52020 6	0 = (empty) 1 = (scroll lock symbol) 2 = Waiting To Start 3 = Enter To Reset 4 = Warning 5 = Crank Failed 6 = No System Comm 7 = Low Batt InCrank 11 = Engine Started 12 = Lock Screen 15 = Under Voltage 18 = Under Speed 19 = Over Speed 20 = Over Voltage 21 = High Engine Temp 22 = Low Oil Pressure 29 = False Restart 30 = Remote Start 31 = Modbus Start 35 = (auxiliary sensor 1 text) 36 = Not Registered 37 = (auxiliary sensor 2 text) 38 = Under Speed 39 = Rotor Locked 41 = Low Battery 42 = High Battery 44 = (reserved) 45 = (reserved) 46 = (reserved) 47 = Emergency Stop 49 = Under Frequency 50 = Over Frequency 51 = Emergency Stop 52 = Manual Stop 53 = Remote Stop 54 = Modbus Shutdown 57 = (config warn 1 input text) 58 = (config warn 2 input text) 59 = Sensor Start 60 = Sensor Shutdown 61 = Switch Start 62 = Switch Stop 65 = Over Current 66 = (start inhibit text) 67 = (auxiliary sensor 3 text) 68 = (auxiliary sensor 4 text) 77 = Load Imbalance 78 = Start Inhibit	Gain = 1 Offset = 0	65450 (0xFFFA)	Byte 4	
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B.4 Proprietary

AC Group Display	52020 7	17 (0x11) = single phase 2 wire with current 1 (0x01) = single phase 2 wire without current 18 (0x12) = 3 wire single phase A-B with current 2 (0x02) = 3 wire single phase A-B without current 146 (0x92) = 3 wire single phase A-C with current 130 (0x82) = 3 wire single phase A-C without current 19 (0x13) = 3-wire 3-phase with current 3 (0x03) = 3-wire 3-phase without current 20 (0x14) = 4-wire 3-phase with current 4 (0x04) = 4-wire 3-phase without current 21 (0x15) = 4-wire Delta 3-phase with current 5 (0x05) = 4-wire Delta 3-phase without current	Gain = 1 Offset = 0	65450 (0xFFA A)	Byte 6	The voltage and current configuration.
Current Run Time	52020 8	0 to 6500.0 hr. Display limited to 999.9 hours.	Units: hours Gain = 0.1 Offset = 0	65450 (0xFFA A)	Bytes 7 and 8	The amount of time the controller has been running since the last start.

B.5 Aux Sensor

Parameter Name		Range	Gain/Offset	PGN	PGN Byte/Bit Location	Description
Auxiliary Sensor 1	52022 0	0 to 6553.5	Gain = 0.1 Offset = 0	65451 (0xFFA B)	Bytes 1 and 2	0xFFFF = parameter disabled or not available. Units are not transmitted over J1939.
Auxiliary Sensor 2	52022 1	0 to 6553.5	Gain = 0.1 Offset = 0	65451 (0xFFA B)	Bytes 3 and 4	0xFFFF = parameter disabled or not available. Units are not transmitted over J1939.
Auxiliary Sensor 3	52022 2	0 to 6553.5	Gain = 0.1 Offset = 0	65451 (0xFFA B)	Bytes 5 and 6	0xFFFF = parameter disabled or not available. Units are not transmitted over J1939.
Auxiliary Sensor 4	52022 3	0 to 6553.5	Gain = 0.1 Offset = 0	65451 (0xFFA B)	Bytes 7 and 8	0xFFFF = parameter disabled or not available. Units are not transmitted over J1939.

B.6 TR100 Control PGNs

A remote must use the request PGN (RQST, 59904 or 0xEA00) to send start, stop, and forced stop commands to the controller. The PGN # sent as part of the request PGN is the command. The address of the remote must be 234.

- (1) Send request for PGN 40000 to the controller to trigger a start (if controller is in AUTO mode).
- (2) Send request for PGN 40011 to the controller to trigger a stop (if controller is in RUN mode).
- (3) Request request for PGN 40044 to the controller to trigger a forced stop (if controller is in RUN mode).

Note: this is not in the J1939 standard. This is a proprietary extension of the request PGN in the standard.

B.7 Dynagen DM1

The controller can broadcast it's warnings and failures over J1939.

It deviates from the J1939 standard in the following ways:

- (1) It sends only one DTC at a time even when multiple trouble codes are active. It alternates
between DTCs every 3s.
- (2) It always sends an SPN of 40179 for warnings and a SPN of 40181 for failures.
- (3) The FMI does not indicate the failure mode. The FMI indicates the specific active warning or
failure.

B.8 Warnings

FMI	Description
1	High Engine Temperature
2	Low Oil Pressure
3	Under Speed
4	Over Speed
7	Low Battery Voltage
8	High Battery Voltage
9	Under AC Frequency
10	Over AC Frequency
11	AC Under Voltage
12	AC Over Voltage Battery
14	Over Current Warning
16	Switched Input Configurable Warning 1
17	Switched Input Configurable Warning 2
18	Auxiliary Sensor 1
19	Auxiliary Sensor 2
20	Auxiliary Sensor 3
21	Auxiliary Sensor 4
22	Load Imbalance
23	Remote Start Inhibit
24 - 31	(Reserved)

FMI	Description
0	Overcrank
1	Engine Failed to Stop
3	High Engine Temperature
4	Low Oil Pressure
6	Under Speed
7	Over Speed
8	Low Battery Voltage
9	High Battery Voltage
13	Under Frequency
14	Over Frequency
15	AC Under Voltage
16	AC Over Voltage
18	Switched Input Configurable Failure 1
19	Switched Input Configurable Failure 2
20	Auxiliary Sensor 1
21	Auxiliary Sensor 2
22	Auxiliary Sensor 3
23	Auxiliary Sensor 4
24	Over Current
25	Switched Input Configurable Failure 3
26	Load Imbalance

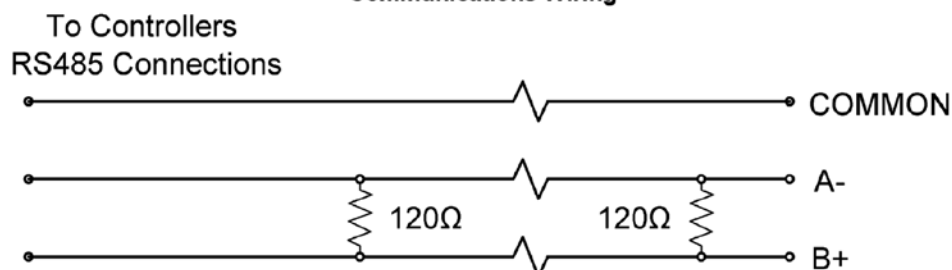
Appendix C: RS485 Communications

C.1 Modbus Settings and Wiring

The following table outlines some items that must be taken into consideration when connecting up a Modbus system.

Consideration	Description
Bus Termination	Each end of the bus must be terminated from H to L with 120 Ω resistors. Tough Series local panels and optional NLI RS485 output cables have terminating resistors built in.
Cable Selection	RS485 twisted pair 120 Ω cables are required for communications: <ol style="list-style-type: none"> 1. Belden 9841 - One twisted pair, 24AWG, the shield of this cable must be used for Modbus common. 2. Belden 7895A - Two twisted pair, 20AWG, second pair can be used for power
Distance (Power and Ground)	If running power and ground from the battery of your system to another device, use the following guidelines for the gauge of the power and ground wires: <ol style="list-style-type: none"> 1. Up to 450ft - 22AWG 2. Up to 700ft - 20AWG 3. Up to 1125ft - 18AWG 4. Up to 1800ft - 16AWG 5. Up to 2800ft - 14AWG

Communications Wiring



C.1 Modbus Settings and Wiring (Continued)

Settings and Information

The following settings/information are associated with Modbus and can be configured using the PC Configurator or from the front panel.

Name	Description	Range / Values
Device Address	The device address of the controller.	1 ~ 247
Baud Rate (BPS)	The speed at which the controller (slave) communicates with the master.	9600, 19200, 38400, 57400
Communication Protocol	The controller always communicates in Modbus RTU.	Modbus RTU (Fixed)
Slave / Master Configuration	The controller is always the slave and must be queried by the master.	Slave (Fixed)

Wiring Considerations

The following table outlines some items that must be taken into consideration when connecting up a Modbus system.

C.2 Modbus Version 2

C.2.2 Quick Register Reference

The following section is used as a quick reference to find out information about a register. To find more information about that register and how to interpret it, click on the register name or go to the Detailed Register Information section of the manual.

C.2.2.1 Remote Control Registers

Name	Description	Write Single Register	Value
Enable System	Places the controller in AUTO mode	40098	0x5BA4
Disable System	Places the controller in OFF mode	40098	0x5DA2
Start Engine	Starts the engine	40098	0x9768
Stop Engine	Stops the engine	40098	0x57A8

C.2.2.2 System Status Registers

Name	Register	Units / Format	Range	Resolution	Not Available	Bit Format
System State	40168	List	N/A	N/A	N/A	16 bit unsigned
Running State	40169	List	N/A	N/A	N/A	16 bit unsigned
Event Bit Map 1	40183 ~ 40184	List	N/A	N/A	N/A	32 bit unsigned
Event Bit Map 2	40185 ~ 40186	List	N/A	N/A	N/A	32 bit unsigned
Fault Bit Map	40181 ~ 40182	List	N/A	N/A	N/A	32 bit unsigned
Warning Bit Map	40179 ~ 40180	List	N/A	N/A	N/A	32 bit unsigned
Active Event	40170	List	N/A	N/A	N/A	16 bit unsigned
Active Fault	40171	List	N/A	N/A	N/A	16 bit unsigned

C.2.2.3 AC Sensing Registers

Name	Register	Units / Format	Range	Resolution	Not Available	Bit Format
AC Voltage Configuration	40162	List	N/A	N/A	N/A	16 bit unsigned
Generator Frequency	40154	Hz	0 ~ 1000	0.1	N/A	16 bit unsigned
Generator Voltage	40156 ~ 40158	Vrms	0 ~ 10000	0.1	N/A	16 bit unsigned
Generator Current	40159 ~ 40161	Arms	0 ~ 10000	0.1	N/A	16 bit unsigned
Mains Voltage ¹	40159 ~ 40161	Vrms	0 ~ 10000	0.1	N/A	16 bit unsigned

¹ This is currently not supported. Reserved for future use.

C.2.2.4 Sensor Registers

Name	Register	Units / Format	Range	Resolution	Not Available	Bit Format
Engine Temperature	40151	°F	0 ~ 10000	0.1	0xFFFF	16 bit unsigned
Oil Pressure	40152	PSI	0 ~ 10000	0.1	0xFFFF	16 bit unsigned
Fuel Level	40153	%	0 ~ 1000	0.1	0xFFFF	16 bit unsigned
Engine Speed	40150	RPM	0 ~ 50000	0.1	0xFFFF	16 bit unsigned
Battery Voltage	40155	Vdc	0 ~ 400	0.1	N/A	16 bit unsigned
Aux Sensor 1	40172	Sender Table Dependent	Sender Table Dependent	0.1	0xFFFF	16 bit unsigned
Aux Sensor 2	40173	Sender Table Dependent	Sender Table Dependent	0.1	0xFFFF	16 bit unsigned
Aux Sensor 3	40195	Sender Table Dependent	Sender Table Dependent	0.1	0xFFFF	16 bit unsigned
Aux Sensor 4	40196	Sender Table Dependent	Sender Table Dependent	0.1	0xFFFF	16 bit unsigned
Auxiliary Units	40189	List	N/A	N/A	N/A	16 bit unsigned
Internal Temperature ¹	40165	0.1	-400 ~ 2000	0.1	0xFFFF	16 bit signed

¹ Only available on controllers with the heater option.

C.2.2.5 Timer Registers

Name	Register	Units / Format	Range	Resolution	Not Available	Bit Format
Engine Run Hours	40163	Hours	0 ~ 60000	0.1	N/A	16 bit unsigned
Total Engine Hours	40187 ~ 40188	Hours	0 ~ 10000000	0.1	N/A	32 bit unsigned
Maintenance Counter	40164	Hours	-30000 ~ 9990	1	-0x767D	16 bit signed

C.2.2.6 Switched I/O Registers

Name	Register	Units / Format	Range	Resolution	Not Available	Bit Format
Switched Inputs	40166	List	N/A	N/A	N/A	16 bit unsigned
Switched Outputs	40167	List	N/A	N/A	N/A	16 bit unsigned

C.2.2.7 Controller Information Registers

Name	Register	Units / Format	Range	Resolution	Not Available	Bit Format
Serial Number	40193 ~ 40194	N/A	0 ~ 999999	N/A	N/A	32 bit unsigned
Hardware Version	40178	x.xx	0 ~ 999	0.01	N/A	16 bit unsigned
Firmware Version	40177	Note ¹	Note ¹	N/A	N/A	16 bit unsigned

¹ See Detailed Register Information for interpretation of values.

C.2.2.8 Events History Registers

Write Registers

Name	Description	Write Single Register	Value
Read Previous Event	Read Previous Event	40130	0x6C93
Read Next Event	Read Next Event	40130	0x639C

Read Registers

Name	Register	Units / Format	Range	Resolution	Not Available	Bit Format
Log Type	40131	N/A	N/A	N/A	N/A	16 bit unsigned
Log Minute	40132	N/A	1 ~ 59	1	N/A	16 bit unsigned
Log Hour	40133	N/A	1 ~ 23	1	N/A	16 bit unsigned
Log Date	40134	N/A	1 ~ 31	1	N/A	16 bit unsigned
Log Month	40135	N/A	1 ~ 12	1	N/A	16 bit unsigned
DTC Code	40136 ~ 40137	N/A	N/A	N/A	N/A	32 bit unsigned
Log Number	40138	N/A	1 ~ 150	1	N/A	16 bit unsigned
Total Logs	40139	N/A	1 ~ 150	1	N/A	16 bit unsigned

C.3 Detailed Register Information

The following section is used as a detailed reference to find out information about a register. If you have any further questions about the functionality of the register, please contact Northern Lights for more information.

C.3.1 System Status

The following registers are associated with the status of the system.

C.3.1.1 System State

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40168	List	N/A	N/A	N/A	16 bit unsigned

Interpretation: This register is interpreted by comparing the read value to the table below.

Value	Name	Description
0x0090	Menu	Controller is in the menu system
0x0093	Off	Controller is in the off mode
0x0096	Auto	Controller is in the auto mode
0x0099	Failure	Controller is in the failure mode
0x009C	Running	Controller is in the running mode

Example: A reading of 0x009C indicates that the controller is currently running.

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40169	List	N/A	N/A	N/A	16 bit unsigned

Interpretation: This 16 bit register is separated into two bytes. The low byte indicates the current running state of the controller and the high byte indicates the method in which the controller had started. Use the tables below to determine the controllers running state.

Low Byte

Value	Name	Description
0x00	No Running Mode	Controller is not in any running state
0x01	Delay to Start	Controller is delaying to start
0x02	Preheat	Controller is preheating engine
0x03	Cranking	Controller is cranking engine
0x04	Crank Rest	Controller is resting before next crank
0x05	Crank Success	Controller has successfully started engine
0x06	Reserved	Reserved
0x07	Warmup	Controller is warming up engine before applying load
0x08	Running	Controller is in a normal running state
0x09	Cooldown	Controller is cooling down engine before shutting down
0x0A	Shutdown	Controller has shut down the engine
0x0B	Failure	Controller has shut down the engine due to a fault

High Byte

Value	Name	Description
0x20	Remote	Controller was started from 'Start / Stop' switched input
0x21	Manual	Controller was started from the front panel button
0x22	Modbus	Controller was started by Modbus command
0x23	Battery Recharge	Controller was started to recharge batteries
0x24	Exerciser	Controller was started from the exerciser clock
0x25	Auxiliary Sensor 1	Controller was started based on Auxiliary Sensor 1 reading
0x26	Auxiliary Sensor 2	Controller was started based on Auxiliary Sensor 2 reading
0x27	Loss of Mains	Controller was started due to loss of mains voltage
0x28	Momentary Switch	Controller was started from 'Momentary' switched input
0x29	Auxiliary Sensor 3	Controller was started based on Auxiliary Sensor 3 reading
0x2A	Auxiliary Sensor 4	Controller was started based on Auxiliary Sensor 4 reading

Example: A reading of 0x2108 indicates the controller was started from the front panel button and is currently in a normal running state.

C.3.1.3 Event Bit Map 1

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40183 ~ 40184	List	N/A	N/A	N/A	32 bit unsigned

Interpretation: This register is separated into individual bits to indicate an event. A bit can be either 0 (inactive) or 1 (active). The majority of the items listed below have a Switched Output that can be assigned to them. The bit will still become active even if there is no switched output associated with that event.

Bit	Name	Description
0	Not In Auto	Bit is on due to controller not being in auto mode
1	Idle Mode	Bit is on due to controller being in idle mode
2	Battle Mode	Bit is on due to controller being in battle mode
3	System OK	Bit is on due to controller being free of warnings and failures
4	Glowplug	Bit is on due to 'Preheat' timer
5	Warmup	Bit is on due to 'Warmup' timer
6	Cooldown	Bit is on due to 'Cooldown' timer
7	Engine Running	Bit is on due to engine running
8	Exerciser	Bit is on due to engine exercise
9	Battery Recharge	Bit is on due to battery recharge
10	Maintenance Required	Bit is on due to 'Maintenance Counter' timer expiring
11	Low Battery During Cranking	Bit is on due to 'Low Battery Voltage During Cranking'
12	Auxiliary Sensor 1	Bit is on due to Auxiliary Sensor 1 reading
13	Auxiliary Sensor 2	Bit is on due to Auxiliary Sensor 2 reading
14	Auxiliary Sensor 3	Bit is on due to Auxiliary Sensor 3 reading
15	Auxiliary Sensor 4	Bit is on due to Auxiliary Sensor 4 reading
16	Delay to Start	Bit is on due to 'Delay to Start' timer
17	Reserved	Reserved
18	Reserved	Reserved
19 ~ 23	Reserved	Reserved
24	Fuel	Bit is on due to fuel output enabled
25	Crank	Bit is on due to crank output enabled
26	Genset Break ¹	Bit is on due to transferring to generator position
27	Mains Break ¹	Bit is on due to transferring to mains position
28	Pull Coil	Bit is on due to pull coil being enabled
29	LCD Backlight	Bit is on due to the LCD backlight being on
30	Voltage Regulator	Bit is on when controller is not in idle mode
31	Energize to Stop	Bit is on due to Energize to Stop timer

¹ This is currently not supported. Reserved for future use.

Example: A reading of 0010 0001 0000 0000 0000 0000 1000 1000 has the following bits active: 3, 7, 24, 29.

Looking at the bits in the table will tell us the following things:

1. Controller is free from warnings and failures
2. Controller is currently running
3. Fuel output is currently on
4. Backlight is currently on

C.3.1.4 Event Bit Map 2

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40185 ~ 40186	List	N/A	N/A	N/A	32 bit unsigned

Interpretation: This register is separated into individual bits to indicate an event. A bit can be either 0 (inactive) or 1 (active). The majority of the items listed below have a Switched Output that can be assigned to them. The bit will still become active even if there is no switched output associated with that event.

Bit	Name	Description
0	Group Output 1	Bit is on due to output set to Group Output 1 is active
1	Group Output 2	Bit is on due to output set to Group Output 2 is active
2	Group Output 3	Bit is on due to output set to Group Output 3 is active
3	Group Output 4	Bit is on due to output set to Group Output 4 is active
4	Reserved	Reserved
5	Reserved	Reserved
6	Reserved	Reserved
7	Genset Disable	Bit is on due to the Genset being disabled
8	Dummy Load ON	Bit is on due to Dummy Load being enabled
9 ~ 11	Reserved	Reserved
12	Glowplug	Bit is on due to preheat input or ECM preheat being active
13	Common Fault	Bit is on due to a any fault occurring
14	Temperature Unit	Reserved - Fixed to Fahrenheit
15	Pressure Unit	Reserved - Fixed to PSI
16	Overcrank Warning	Bit is on due to controller failing to crank engine on first attempt
17	Invalid Setting Warning	Bit is on due to an invalid setting being stored in the controller
18	Emergency Input	Bit is on due to Emergency Stop input being active
19	EPS Load is On	Bit is on due to current readings being at least 5% of the rated current setting

Example: A reading of 0010 0001 0000 0000 0000 0000 1000 1000 has the following bits active: 3, 7, 24, 29.

Looking at the bits in the table will tell us the following things:

1. Controller is free from warnings and failures
2. Controller is currently running
3. Fuel output is currently on
4. Backlight is currently on

C.3.1.5 Fault Bit Map

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40181 ~ 40182	List	N/A	N/A	N/A	32 bit unsigned

Interpretation: This register is separated into individual bits to indicate a fault. A bit can be either 0 (inactive) or 1 (active). Use the table below to determine the fault.

Bit	Name	Description
0	Overcrank	Fault due to max attempts at cranking without starting
1	Engine Failed to Stop	Fault due to engine speed not being 0 RPM at shutdown
3	High Engine Temperature	Fault due to high engine temperature
4	Low Oil Pressure	Fault due to low oil pressure
5	Low Fuel Level	Fault due to low fuel level
6	Under Speed	Fault due to low engine speed
7	Over Speed	Fault due to high engine speed
8	Low Battery Voltage	Fault due to low battery voltage
9	High Battery Voltage	Fault due to high battery voltage
10	Low Coolant Level	Fault due to low coolant level
13	Under Frequency	Fault due to low AC frequency
14	Over Frequency	Fault due to high AC frequency
15	AC Under Voltage	Fault due to low AC voltage
16	AC Over Voltage	Fault due to high AC voltage
17	ECM Communication	Fault due to loss of communications with ECM
	Failure ¹	
18	Configurable Failure 1	Fault due to Configurable Fail Input 1 being active
19	Configurable Failure 2	Fault due to Configurable Fail Input 2 being active
20	Auxiliary Sensor 1	Fault due to low / high reading on Auxiliary Sensor 1
21	Auxiliary Sensor 2	Fault due to low / high reading on Auxiliary Sensor 2
22	Auxiliary Sensor 3	Fault due to low / high reading on Auxiliary Sensor 3
23	Auxiliary Sensor 4	Fault due to low / high reading on Auxiliary Sensor 4
24	Over Current	Fault due to high current reading
25	Configurable Failure 3	Fault due to Configurable Fail Input 3 being active
26 ~ 31	Reserved	Reserved

¹ These items are only applicable when using the CAN protocol to communicate with an ECM.

Example: A reading of 0000 0000 0000 0000 1000 0000 0000 0000 indicates that the controller shutdown due to low AC voltage from the generator.

C.3.1.6 Warning Bit Map

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40179 ~ 40180	List	N/A	N/A	N/A	32 bit unsigned

Interpretation: This register is separated into individual bits to indicate a fault. A bit can be either 0 (inactive) or 1 (active). Use the table below to determine the fault.

Bit	Name	Description
0	Low Engine Temperature	Warning due to low engine temperature
1	High Engine Temperature	Warning due to high engine temperature
2	Low Oil Pressure	Warning due to low oil pressure
3	Under Speed	Warning due to low engine speed
4	Over Speed	Warning due to high engine speed
5	Low Fuel Level	Warning due to low fuel level
6	High Fuel Level	Warning due to high fuel level
7	Low Battery Voltage	Warning due to low battery voltage
8	High Battery Voltage	Warning due to high battery voltage
9	Under Frequency	Warning due to low AC frequency
10	Over Frequency	Warning due to high AC frequency
11	AC Under Voltage	Warning due to low AC voltage
12	AC Over Voltage	Warning due to high AC voltage
13	Battery Charger Fault	Warning due to battery charger fault
14	Over Current	Warning due to high AC current
15	Fuel In Basin	Warning due to fuel being in the catch basin
16	Configurable Warning 1	Warning due to Configurable Warn Input 1 being active
17	Configurable Warning 2	Warning due to Configurable Warn Input 2 being active
18	Auxiliary Sensor 1	Warning due to low / high reading on Auxiliary Sensor 1
19	Auxiliary Sensor 2	Warning due to low / high reading on Auxiliary Sensor 2
20	Auxiliary Sensor 3	Warning due to low / high reading on Auxiliary Sensor 3
21	Auxiliary Sensor 4	Warning due to low / high reading on Auxiliary Sensor 4
22 ~ 31	Reserved	Reserved

¹ These items are only applicable when using the CAN protocol to communicate with an ECM.

Example: A reading of 0000 0000 0000 0000 1000 0000 0000 0000 indicates that the controller shutdown due to low AC voltage from the generator.

C.3.1.7 Active Event

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40170	List	List	List	N/A	16 bit unsigned

Interpretation: This register is based on what the controllers LCD is currently displaying on the screen. Once a new message is displayed this register will update accordingly. It is recommended to use the Events, Faults and Warning Bit Maps. If use of this register is still desired, contact Northern Lights directly.

C.3.1.8 Active Fault

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40171	List	N/A	N/A	N/A	16 bit unsigned

Interpretation: This register is based on what fault the controllers LCD is currently displaying on the screen. Once a new message is displayed this register will update accordingly. It is recommended to use the Events, Faults and Warning Bit Maps. If use of this register is still desired, contact Northern Lights directly.

C.4 AC Sensing

The following registers are associated with AC sensing and monitoring.

C.4.1 AC Voltage Configuration

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40162	List	N/A	N/A	N/A	16 bit unsigned

Interpretation: This 16 bit register is separated into two bytes. The low byte indicates the AC configuration of the generator and the high byte indicates the AC configuration mains power. Both bytes can use the table below to determine their respective configuration.

Value	Name	Description
0x0000	Disabled	Controller has AC sensing disabled
0x0001	2-Wire Single Phase	Controller is sensing 2-Wire Single Phase voltage
0x0002	3-Wire Single Phase	Controller is sensing 3-Wire Single Phase voltage
0x0003	3-Wire Three Phase	Controller is sensing 3-Wire Three Phase voltage
0x0004	4-Wire Three Phase	Controller is sensing 4-Wire Three Phase voltage
0x0005	4-Wire Delta	Controller is sensing 4-Wire Delta voltage

Example: A reading of 0x0202 indicates that both the generator and mains voltages are 3-Wire Single Phase systems.

C.4.2 Generator Frequency

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40154	Hertz	0 ~ 1000	0.1	N/A	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Example: A reading of 598 can be interpreted as 59.8Hz.

C.4.3 Generator Voltage

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40156 ~ 40158	Vrms	0 ~ 10000	0.1	N/A	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

The readings will change based on which AC Voltage Configuration is selected. The following table indicates the what each register is reading based on the configuration:

Configuration	Register A	Register B	Register C
2-Wire Single Phase	Line A-N	N/A	N/A
3-Wire Single Phase	Line A-N	Line B-N	Line A-B
3-Wire Three Phase	Line A-B	Line B-C	Line C-A
4-Wire Three Phase	Line A-B	Line B-C	Line C-A
4-Wire Delta	Line A-B	Line B-C	Line C-A (High Leg)

Example: A reading of 2073 can be interpreted as 207.3Vrms

C.4.4 Generator Current

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40159 ~ 40161	Arms	0 ~ 10000	0.1	N/A	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Example: A reading of 894 can be interpreted as 89.4Arms.

C.5 Sensors

The following registers are associated with the readings of sensors.

C.5.1 Engine Temperature

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40151	°F	0 ~ 10000	0.1	0xFFFF	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Example: A decimal reading of 2154 can be interpreted as 215.4°F.

C.5.2 Oil Pressure

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40152	PSI	0 ~ 1000	0.1	0xFFFF	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Example: A decimal reading of 404 can be interpreted as 40.4PSI.

C.5.3 Fuel Level

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40153	%	0 ~ 1000	0.1	0xFFFF	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Example: A decimal reading of 898 can be interpreted as 89.8%.

C.5.4 Engine Speed

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40150	RPM	0 ~ 62500	0.1	0xFFFF	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Example: A decimal reading of 17985 can be interpreted as 1798.5RPM.

C.5.5 Battery Voltage

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40155	Vdc	0 ~ 400	0.1	N/A	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Example: A decimal reading of 135 can be interpreted as 13.5Vdc.

C.5.6 Auxiliary Sensor 1

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40172	Auxiliary Units Dependent	Auxiliary Units Dependent	0.1	0xFFFF	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Note: This registers units, range and resolution are all dependent upon the sender table that has been programmed to the controller. To determine these values, you must read the Auxiliary Sensor Units register.

Example: See other sensor examples.

C.5.7 Auxiliary Sensor 2

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40173	Auxiliary Units Dependent	Auxiliary Units Dependent	0.1	0xFFFF	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Note: This registers units, range and resolution are all dependent upon the sender table that has been programmed to the controller. To determine these values, you must read the Auxiliary Sensor Units register.

Example: See other sensor examples.

C.5.8 Auxiliary Sensor 3

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40195	Auxiliary Units Dependent	Auxiliary Units Dependent	0.1	0xFFFF	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Note: This registers units, range and resolution are all dependent upon the sender table that has been programmed to the controller. To determine these values, you must read the Auxiliary Sensor Units register.

Example: See other sensor examples.

C.5.9 Auxiliary Sensor 4

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40196	Auxiliary Units Dependent	Auxiliary Units Dependent	0.1	0xFFFF	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Note: This registers units, range and resolution are all dependent upon the sender table that has been programmed to the controller. To determine these values, you must read the Auxiliary Sensor Units register.

Example: See other sensor examples.

C.5.10 Auxiliary Sensor Units

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40189	List	N/A	N/A	N/A	16 bit unsigned

Interpretation: This 16 bit register is separated into 4 sections, one for each of the Auxiliary Sensors. Use the tables below to determine the units, range and resolution.

Bits	Name
0 ~ 3	Auxiliary Sensor 1
3 ~ 7	Auxiliary Sensor 2
8 ~ 11	Auxiliary Sensor 3
12 ~ 15	Auxiliary Sensor 4

Value	Name	Units	Range	Resolution
0xF	Disabled	N/A	N/A	N/A
0x0	Temperature	°F	320 ~ 9999	0.1
0x1	Level	%	10 ~ 1250	0.1
0x2	Pressure	PSI	10 ~ 60000	0.1
0x3	Voltage	V	0 ~ 1000	0.1
0x4	Current	A	1 ~ 999	0.1

Example: A hexadecimal reading of 0xF012 gives the following information:

1. Auxiliary Sensor 1 is configured for Pressure.
2. Auxiliary Sensor 2 is configured for Level.
3. Auxiliary Sensor 3 is configured for Temperature.
4. Auxiliary Sensor 4 is configured for Disabled.

C.5.11 Internal Temperature

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40165	°F	-400 ~ 2000	0.1	0xFFFF	16 bit signed

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Example: A decimal reading of 905 can be interpreted as 90.5°F.

C.6 Timers

The following registers are associated with the timers of the system.

C.6.1 Engine Run Hours

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40163	Hours	0 ~ 60000	0.1	N/A	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Note: This register only updates every 6 minutes as readings are done in 1/10ths of an hour.

Example: A decimal reading 104 can be interpreted as 10.4 hours

C.6.2 Total Engine Hours

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40187 ~ 40188	Hours	0 ~ 10000000	0.1	N/A	32 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers.

Note: This register only updates every 6 minutes as readings are done in 1/10ths of an hour.

Example: A decimal reading 1004 can be interpreted as 100.4 hours

C.6.3 Maintenance Counter

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40164	Hours	-30000 ~ 9990	1	-0x767D	16 bit signed

Interpretation: The register is meant to be read as a decimal number. The right digit is the decimal point. All digits to the left of it are the whole numbers. A negative number indicates the amount of hours since maintenance counter has expired.

Note: This register only updates every 6 minutes as readings are done in 1/10ths of an hour.

C.7 Switched I/O

The following registers are associated with the status of the inputs and outputs.

C.7.1 Switched Inputs

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40166	List	N/A	N/A	N/A	16 bit unsigned

Interpretation: This 16 bit register is separated into two bytes. The low byte indicates whether the corresponding input is low (ground) or high (+battery). The high byte indicates if that corresponding input is active or inactive. Each byte is broken down as follows:

Bit	7	6	5	4	3	2	1	0
Input	N/A	N/A	N/A	Input E	Input D	Input C	Input B	Input A

Example: A binary reading of 0000 0111 0000 0101 can give us the following information:

1. Input A is high and active
2. Input B is low and active
3. Input C is high and active
4. All other inputs are open

C.7.2 Switched Outputs

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40166	List	N/A	N/A	N/A	16 bit unsigned

Interpretation: This 16 bit register only utilizes the low byte. Each bit corresponds to a switched output and indicates if it is active or inactive. The byte is broken down as follows:

Bit	7	6	5	4	3	2	1	0
Input	N/A	N/A	Output F	Output E	Output D	Output C	Output B	Output A

Example: A binary reading of 0000 0000 0000 0101 can give us the following information:

1. Switched Output A is active
2. Switched Output C is active
3. All other outputs are off

C.8 Controller Information

The following registers are associated with information related to the controller.

C.8.1 Serial Number

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40193 ~ 40194	N/A	N/A	1	N/A	32 bit unsigned

Interpretation: The register is meant to be read as a decimal number.

Example: A decimal reading of 10256 can be interpreted as 10256.

C.8.2 Hardware Version

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40178	N/A	0 ~ 999	0.01	N/A	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. The two right digits are the decimal point. All digits to the left of it are the whole numbers.

Example: A decimal reading of 122 can be interpreted as V1.22.

C.8.3 Firmware Version

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40177	N/A	N/A	N/A	N/A	16 bit unsigned

Interpretation: This 16 bit register is separated into two sections. Use the table below to determine the Firmware Version and the beta number.

Bits	Name
0 ~ 5	Beta Number
6 ~ 15	Firmware Version

With the firmware version, the two right digits of the decimal number are the decimal points. All digits to the left of it are the whole numbers. The beta is a whole number.

Example: A hexadecimal reading of 0x1E81 can be interpreted as follows:

1. The beta bits can be read as decimal 1 which is 01.
2. The firmware version bits can be read as decimal 122 which is 1.22
3. Combining both numbers give you Firmware Version 1.22.01.

C.9 Events History

The following registers are associated with the Events History log.

C9.1 Log Control

Use the following commands to change the currently viewed event:

Name	Description	Write Single Register	Value
Read Previous Event	Read Previous Event	40130	0x6C93
Read Next Event	Read Next Event	40130	0x639C

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40131	N/A	N/A	1	N/A	16 bit unsigned

Interpretation:

Value	Name	Type
0x00DE	Empty	No Log Returned
0x00E9	DTC	DTC Log Returned
0x00A0	Configurable Warning 1	User Defined Text
0x00A1	Configurable Warning 2	User Defined Text
0x00A4	Auxiliary Sensor 1 Warning	User Defined Text
0x00A5	Auxiliary Sensor 2 Warning	User Defined Text
0x00A6	Auxiliary Sensor 3 Warning	User Defined Text
0x00A7	Auxiliary Sensor 4 Warning	User Defined Text
0x00B4	Auxiliary Sensor 1 Event	User Defined Text
0x00B5	Auxiliary Sensor 2 Event	User Defined Text
0x00B6	Auxiliary Sensor 3 Event	User Defined Text
0x00B7	Auxiliary Sensor 4 Event	User Defined Text
0x00B8	Start Inhibit	User Defined Text
0x00C2	Configurable Failure 1	User Defined Text
0x00C3	Configurable Failure 2	User Defined Text
0x00C4	Auxiliary Sensor 1 Failure	User Defined Text
0x00C5	Auxiliary Sensor 2 Failure	User Defined Text
0x00C6	Auxiliary Sensor 3 Failure	User Defined Text
0x00C7	Auxiliary Sensor 4 Failure	User Defined Text
0x00C8	Reserved	User Defined Text
0x00C9	Configurable Failure 3	User Defined Text
0x8000	Power ON	Event
0x8001	Auto Enabled	Event
0x8002	Off Enabled	Event
0x8003	Manual Start	Event
0x8004	Start Cooldown	Event
0x8005	Remote Start	Event
0x8006	Remote Stop	Event
0x8007	Emergency Stop	Event
0x8008	Start Charging	Event
0x8009	Stop Charging	Event
0x800A	Service Required	Event
0x800B	Reset Defaults	Event
0x800C	Service Complete	Event
0x800D	Exerciser Bypass	Event
0x800E	Start Exercise	Event
0x800F	Stop Exercise	Event
0x8010	Log Cleared	Event
0x8011	Modbus Start	Event
0x8012	Modbus Stop	Event

C.9.2 Log Type (Continued)

0x8013	System Recovery	Event
0x8014	Engine Started	Event
0x8015	Reserved	Event
0x8016	Idle Speed	Event
0x8017	Normal Speed	Event
0x8018	Auxiliary Sensor 1 Run	Event
0x8019	Auxiliary Sensor 2 Run	Event
0x801A	Auxiliary Sensor 1 Stop	Event
0x801B	Auxiliary Sensor 2 Stop	Event
0x801C	Mains Failed	Event
0x801D	Mains Return	Event
0x801E	Switch Start	Event
0x801F	Switch Stop	Event
0x8020	Regen Inhibited	Event
0x8023	Auxiliary Sensor 3 Run	Event
0x8024	Auxiliary Sensor 4 Run	Event
0x8025	Auxiliary Sensor 3 Stop	Event
0x8026	Auxiliary Sensor 4 Stop	Event
0xC000	Crank Failed	Warning
0xC001	Low Battery During Cranking	Warning
0xC002	Charger Fault	Warning
0xC003	High Fuel Level	Warning
0xC004	Low AC Voltage	Warning
0xC005	Under Speed	Warning
0xC006	Over Speed	Warning
0xC007	High Engine Temperature	Warning
0xC008	Low Oil Pressure	Warning
0xC009	Low Fuel Level	Warning
0xC00A	False Restart	Warning
0xC00B	Reserved	Warning
0xC00C	High Current	Warning
0xC00D	Fuel In Basin	Warning
0xC00E	Low Battery Voltage	Warning
0xC00F	High Battery Voltage	Warning
0xC010	Low Engine Temperature	Warning
0xC011	Battle Mode	Warning
0xC012	Low Frequency	Warning
0xC013	High Frequency	Warning
0xC014	Invalid Setting	Warning
0xC015	High AC Voltage	Warning
0xF000	Failed to Stop	Failure
0xF001	Reserved	Failure
0xF002	Reserved	Failure
0xF003	Reserved	Failure
0xF004	High Current	Failure
0xF005	ECM Shutdown	Failure

C.9.2 Log Type (Continued)

0xF006	High Engine Temperature	Failure
0xF007	Low Oil Pressure	Failure
0xF008	Under Speed	Failure
0xF009	Over Speed	Failure
0xF00A	Low Fuel Level	Failure
0xF00B	Low Battery Voltage	Failure
0xF00C	Low Coolant Level	Failure
0xF00D	Cranking Failed	Failure
0xF00E	High AC Voltage	Failure
0xF00F	Low AC Voltage	Failure
0xF011	Reserved	Failure
0xF014	High Battery Voltage	Failure
0xF015	ECM Communication Failure	Failure
0xF016	Low AC Frequency	Failure
0xF017	High AC Frequency	Failure

Example: A reading of 0xF00A indicates that the current log item was due to 'Low Fuel Level.'

C.9.3 Log Time

Log Minute

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40132	N/A	0 ~ 59	1	N/A	16 bit unsigned

Log Hours

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40133	N/A	0 ~ 23	1	N/A	16 bit unsigned

Log Date

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40134	N/A	1 ~ 31	1	N/A	16 bit unsigned

Log Month

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40135	N/A	1 ~ 12	1	N/A	16 bit unsigned

Interpretation: All these registers are meant to be read in a decimal format.

Example: A log reading with the following register values can be interpreted as July 4th, 12:01a.m.

1. 40132 = 0x0001
2. 40133 = 0x0000
3. 40134 = 0x0004
4. 40135 = 0x0007

C.9.4 Log DTC Code

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40136 ~ 40137 ¹	List	N/A	N/A	N/A	32 bit unsigned

¹ Register only valid if the Log Type register is DTC (0x00E9).

Interpretation: This 32 bit register is separated into 4 sections. Use the tables below to determine the SPN, OC, FMI and CM of the DTC code for the current log.

Bits	Name
0 ~ 18	Suspect Parameter Number (SPN)
19 ~ 25	Occurrence (OC)
26 ~ 30	Failure Mode Identifier (FMI)
31	Connection Management (CM)

Example: A hexadecimal reading of 0x0C10006E can be interpreted as follows:

1. The SPN bits can be read as decimal 110 which is Engine Coolant Temperature.
2. The OC bits can be read as decimal 2 occurrences
3. The FMI bits can be read as decimal 3 which is Above Normal.
4. The CM bit can be read as decimal 0 which is Version 4.

Note: You must have access to J1939 specifications to interpret all the data appropriately.

C.9.5 Log Number

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40138	N/A	1 ~ 150	1	N/A	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. It indicates what the number of the currently viewed log is.

Example: A decimal reading of 7 can be interpreted as the 7th log out of the Total Logs.

C.9.6 Total Logs

Default Register	Units / Format	Range	Resolution	Not Available	Bit Format
40139	N/A	1 ~ 150	1	N/A	16 bit unsigned

Interpretation: The register is meant to be read as a decimal number. It indicates how many logs there are in the Events History.

Example: A decimal reading of 96 can be interpreted as a total of 96 logs.



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