CATTRON™

DYNAGEN™

PRO-Series™
PRO TG/TE600A

User Manual

CONNECT. CONTROL. PROTECT.

Revision History

VERSION	DATE	NOTES
4.2.0	06/2021	Updated to reflect that Oil Pressure and J1939 display only in Run Mode. Changed Programmable Switched Input “More Than” time to 3600 seconds. Removed Remote Inputs from Switched Outputs-User Logic. Noted that Programmable Switch Input Stop 1 only works when Switched Input Start 1 is running; this is also true for Switched Input Start/Stop 2. Added note that “Common Warning” signal available in Group Logic and Advanced Logic is only activated for programmable warnings (programmable switched inputs and aux sensors 1-10). Added Oil Temperature in J1939 section.
A	10/2021	Document rebranded and contact information updated.
B	09/2022	Added French Translations for all DANGER/WARNING/CAUTION statements per UL Requirements.

Contents

1 Introduction

1.1 Overview

The TOUGH Series PRO controller is the next generation of DynaGen's tried and true engine control solutions. TOUGH Series controllers are designed to provide complete control, protection, AC metering and engine instrumentation for both standard and electronic engines. The module is easily configured using either the front panel buttons or our RapidCore™ Configurator Software.

TOUGH Series controllers are ideally suited for severe duty and variable speed applications where reliability is critical, such as mobile/stationary generators, irrigation pumps, sewage lift stations, and so on.

1.1.1 Features and Functions

- Five-Year Warranty protection
- SAE J1939 CANbus Protocol
- RPM via J1939, Magnetic Pickup or Generator
- Speed control offset for electronic engines
- AutoStart on low battery and other sensors
- Trim feature for AC monitoring and sensors
- Maintenance counter
- Exerciser Clock
- 160 Event Log
- IP67 (sealed against water ingress)
- Four threaded mounting holes with screws for simple installation
- Passcode protected
- Automatic shutdowns and warnings
- Manual and remote start options
- Momentary Start/Stop inputs
- Pre-heat and many other configurable timers
- Accepts common senders (VDO, Datcon, S&W)
- Custom senders configurable with RapidCore Configurator Software

1.1.2 Displays

- Engine Temperature
- Oil Pressure
- Fuel Level
- J1939 DTCs + Custom Text
- J1939 Parameters

- Engine Speed
- AC Metering
- Battery Voltage
- Custom Senders
- Auxiliary Sensors
- Real Time Clock
- Engine Hours
- Time to Maintenance
- Warnings and Failures

2 Specifications

The TOUGH Series PRO controller was rigorously tested to ensure durability, reliability and functionality. With the operator and equipment in mind, precautions were taken in the design process to ensure minimization of unavoidable risks associated with both environmental and operational hazards.

The following specifications are a brief summary of the general functionality and the standards to which the controller has been tested. For complete details on the testing performed, please contact Cattron at www.cattron.com/contact.

2.1 Testing Specification

DC Transients:

- Meets SAE J1113 Pulse 1(B/C)
- Meets SAE J1113 Pulse 2A
- Meets SAE J1113 Pulse 2B
- Meets SAE J1113 Pulse 3A and 3B
- Meets SAE J1113 Pulse 4
- Meets SAE J1113 Pulse 5A

ESD SAE J1113:

- Direct Discharge (Powered) - Meets SAE J1113-13, Figure B1, Severity Level 4
- Direct Discharge (Un-Powered) - Meets SAE J1113-13, Figure B1, Severity Level 4
- Air Gap Discharge (Powered) - Meets SAE J1113-13, Figure B1, Severity Level 4
- Air Gap Discharge (Un-Powered) - Meets SAE J1113-13, Figure B1, Severity Level 4

Environmental:

- Thermal Cycling (SAE J1455)

Mechanical (SAE J1455):

- Impact UL
- Harness Swing SAE J1455
- Unpackaged Drop SAE J1455, UL

Vibration Exceeds the SAE J1455 Profile:

- Sine on random, 20 G_{rms}, Range: 30 Hz - 2000 Hz

2.2 Battery Supply

Parameter	Specification
Range	5.5 VDC - 38 VDC
Cranking Dropout to 0 VDC	50 ms
Reverse Battery Protection	Yes
Power Consumption	0.92 W (0% backlight) - 1.8 W (100% backlight)

2.3 Display

Parameter	Specification
Number of Buttons	11
Backlight	Yes
Operating Temperature (with backlight)	-40 to +185 °F (-40 to +70 °C)

2.4 I/O

Parameter	Specification
Switched Inputs	
Number of Switched Inputs	12
Software Configurable	Yes – Switch to GND, Switch to VBAT, Switch Open and Switch Close
Minimum Trigger Delay	<100 ms
Analog Inputs	
Number of Analog Inputs	10
Software Configurable	Yes – 0-5 VDC, 4-20 mA, Resistive sensor
Transient Protection	Up to 60 VDC
Starter Battery Measurement	Yes
Accuracy	+/-2%
AC Voltage Inputs	
Number of Inputs	3 Voltage Inputs + Neutral
Sensing	Able to sense 3-phase with and without a neutral
Maximum Voltage	600 V_{RMS}
Accuracy	1% Full Scale (600 V)

Parameter	Specification
Configurations	Single-phase 2 and 3 wire Three-phase 3 and 4 wire Delta 4 wire
AC Current	
Number of Inputs	3 Line Current Inputs + CT Common
CT Type	5 A Secondary
Accuracy	2% Full Scale
Switched Outputs	
Number of Switched Outputs	10
Type	High Side Switches
Maximum Current per Channel	1 A
Logic Level Drive Capable	Yes

2.5 Speed Sensing

Options	Specification
J1939 Bus	Protocol over CAN for Electronic Engines
Magnetic Pickup	50-15000 Hz
Generator Voltage	600 VAC MAX, 5-500 Hz
Tachometer	5-400 Hz

2.6 Communications Ports

Parameter	Specification
CANbus	
Number of Ports	1
Software Configurable Internal Resistor	Yes – 120 Ω
RS485	
Number of Ports	1
Software Configurable Internal Resistor	Yes – 120 Ω
USB	
Number of Ports	1

2.7 Mechanical

Parameter	Specification
Dimensions	7.52” (191 mm) x 5.20” (132 mm)
Cut-out Size	6.18” (157 mm) x 3.78” (96 mm)
Sealed Enclosure	Yes – IP67
Sealed to Panel	Yes – IP67
Connectors	2 x 35 Pin AMPSEAL

2.8 Other Features and Specifications

Parameter	Specification
Real Time Clock	Yes – with 5 year backup battery
Protected 5 V Supply Output	Yes – 400 mA
Custom Branding	Yes – Gasket color and custom label under LCD
Operating Temperature	-40 to +185 °F (-40 to +70 °C)

3 Installation

Generator systems contain high voltage circuitry, and precautions should be taken to protect against electrical shock. 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 AND TECHNICIANS ONLY.

	**AVERTISSEMENT** LE CÂBLAGE DE CE CONTRÔLEUR NE DOIT ÊTRE EFFECTUÉ QUE PAR DES ÉLECTRICIENS ET TECHNICIENS QUALIFIÉS.

	**CAUTION** HIGH VOLTAGE MAY BE PRESENT AT THE CONTROLLER.

	**ATTENTION** UNE HAUTE TENSION PEUT ETRE PRESENTE AU NIVEAU DU CONTROLEUR.

The following general electrical safety precautions 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 on the cord
- Use fuses where appropriate
- Ensure all equipment is properly grounded
- Provide support to wires to prevent stress on terminals

	**CAUTION** 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.

	**ATTENTION** POUR GARANTIR UN FONCTIONNEMENT CORRECT ET SUR, IL FAUT PRENDRE DES PRECAUTIONS SUR LE SITE D'INSTALLATION POUR S'ASSURER QU'IL SOIT EXEMPT D'HUMIDITE EXCESSIVE, DE FLUCTUATIONS DE TEMPERATURE, DE POUSSIERE, ET DE MATERIAUX CORROSIFS.

Choose a mounting surface with the least amount of vibration, from 1/16” (1.6 mm) to 1/4” (6.35 mm) thick. The mounting surface should not be any more than 1/4” (6.35 mm) thick.

The following steps outline the mounting procedure:

1. Choose a suitable mounting location based on the criteria above.
2. Create a rectangular cut-out in the panel measuring 3.78” (96 mm) high and 6.18” (157 mm) wide. Drill holes around this cut-out corresponding to the 6-32 UNC threaded mounting screw holes in the rectangular 105 mm x 170 mm pattern on the controller, as shown in Figure 1.
3. Place the controller into the panel cut-out so that the LCD screen and buttons are facing out.
4. Place the mounting screws into the designated holes in the controller and tighten until firmly in place against the panel. Do not over-tighten. The recommended torque is 5 in-lb.
5. The maximum length of screw is 7/16”.

Figure 1 illustrates the dimensions and an application example of the mounting cut-out for the TOUGH Series PRO.

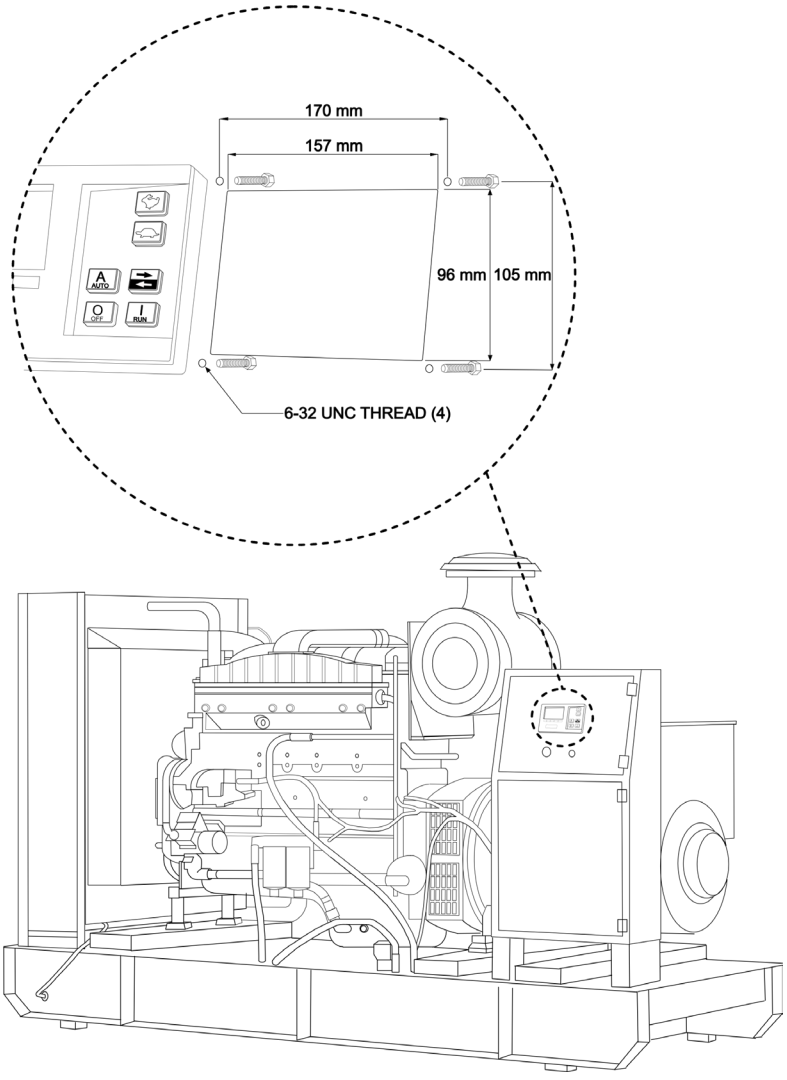

Figure 1: Mounting Cut-Out

3.1 General Wiring Notes

The following important wiring guidelines should be followed:

- Use a minimum of 18 AWG wire for all connections
- Battery Positive and Battery Negative connections on the controller should be run directly to the positive and negative terminals on the battery to prevent voltage drops from negatively impacting the controller
- Limit the wire length to 60 ft (18.3 m) to any I/O on the controller (e.g., Switched Input, Switched Outputs, AC Sensing and Analog Inputs)
- It is good practice to run the AC voltage sensing wiring to the controller in a separate conduit from the AC current sensing wiring – if the AC voltage is especially noisy (e.g., variable frequency drives), then they MUST be run separately

The TOUGH Series PRO contains a TVS to protect the I/O and internals from a transient on the main battery (the battery from which the controller is powered). If you have I/O connected to other batteries or power supplies, those I/O must contain their own voltage transient protection. Otherwise, the I/O and/or controller can be damaged if the transient exceeds the maximum rated voltage of the I/O. A device that provides this kind of protection is known as a TVS or a varistor.

- Fusing:
  - A fuse should be placed in line with the battery positive wire going to the controller power; a 10 A fuse is suggested
  - The AC Voltage A, B and C lines should be fused near the source of AC voltage with a 1 A fuse
- For noisy environments, some guidelines are as follows:
  - Replace speed sensing wires with twisted pair from the sensor to the controller
  - Consider using isolated sensors (i.e., two terminal) and use twisted pair wiring to connect from the engine to the controller

When possible, the following enclosure guidelines should be followed:

- It is recommended that vibration mounts be used

See Figure 5 for an illustration of a typical wiring configuration. This is a guide only; individual applications will differ.

The controller dimensions are shown in Figure 2.

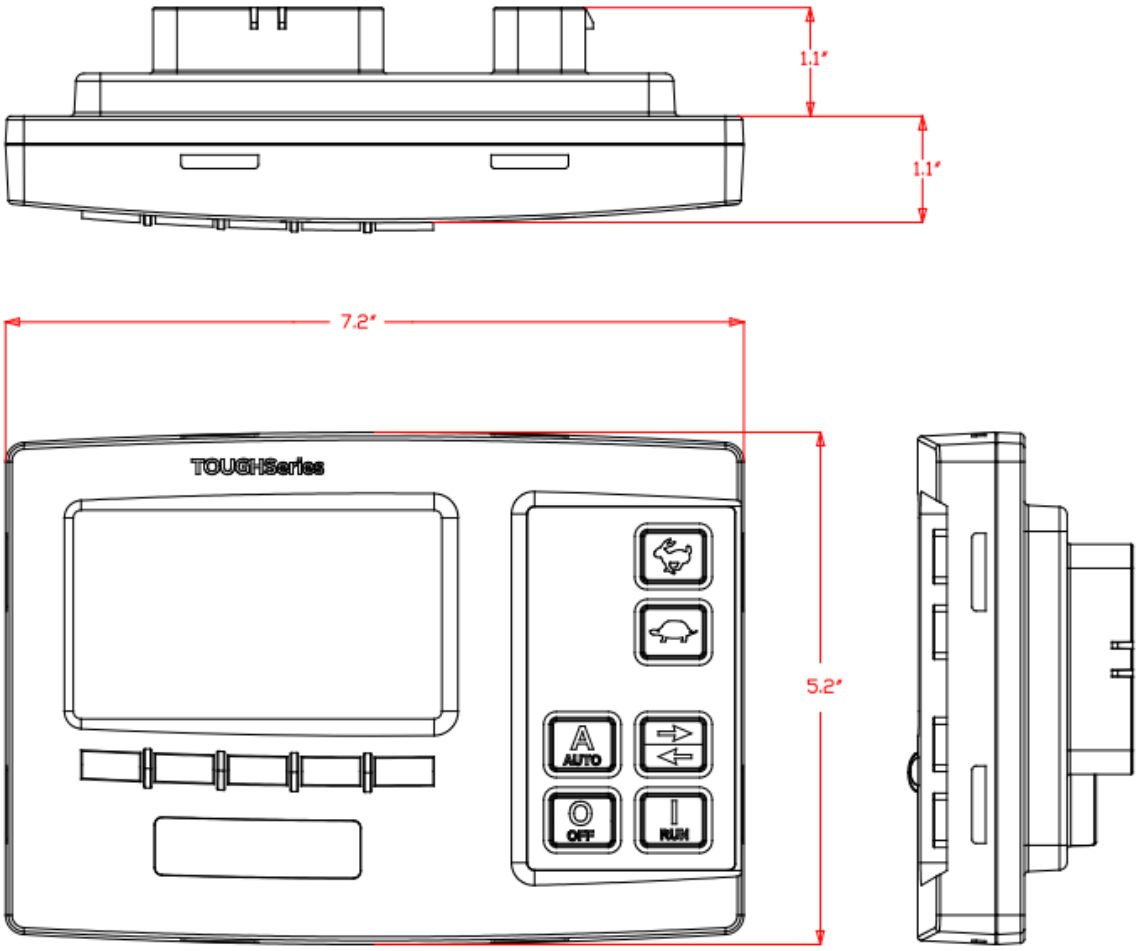

Figure 2: Controller Dimensions

3.2 Terminal Descriptions

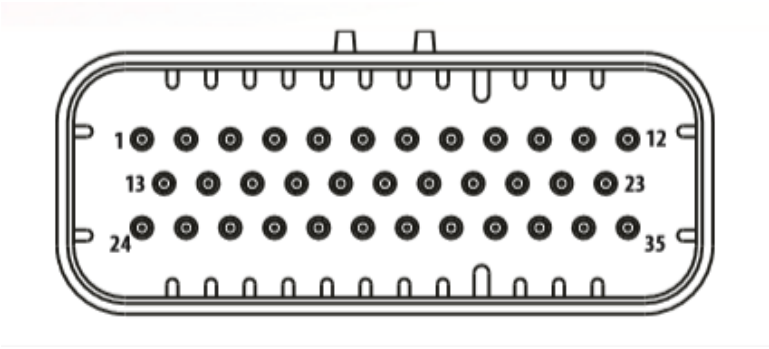

Figure 3: Main Connector – J1 (AMPSEAL 35-pin)

Terminal	Name	Description
J1-1	Battery Positive	Provides power to the controller from the battery
J1-2	Battery Positive	Provides power to the controller from the battery
J1-3	Switched Output 1	High side switch. Outputs +Battery voltage when active (1 A)
J1-4	Switched Output 3	High side switch. Outputs +Battery voltage when active (1 A)
J1-5	Switched Output 2	High side switch. Outputs +Battery voltage when active (1 A)
J1-6	Switched Input 1	Configurable digital tri-stating input. Logic high range from 3 VDC - V_{BAT}, logic low range from 0-3 VDC
J1-7	Switched Input 2	Configurable digital tri-stating input. Logic high range from 3 VDC - V_{BAT}, logic low range from 0-3 VDC
J1-8	Switched Input 6	Configurable digital tri-stating input. Logic high range from 3 VDC - V_{BAT}, logic low range from 0-3 VDC
J1-9	Sensor Input 1	High Impedance sensor input (0-7.5 kΩ, 0-5 VDC, 4-20 mA)
J1-10	Sensor Input 2	High Impedance sensor input (0-7.5 kΩ, 0-5 VDC, 4-20 mA)
J1-11	CANL	Communications line for CANbus (J1939), with internal software selectable 120 Ω
J1-12	CANH	Communications line for CANbus (J1939), with internal software selectable 120 Ω
J1-13	No Connection	N/A
J1-14	Switched Output 4	High side switch. Outputs +Battery voltage when active (1 A)
J1-15	Switched Output 5	High side switch. Outputs +Battery voltage when active (1 A)
J1-16	Switched Output 7	High side switch. Outputs +Battery voltage when active (1 A)

Terminal	Name	Description
J1-17	Switched Input 5	Configurable digital tri-stating input. Logic high range from 3 VDC - V_{BAT}, logic low range from 0-3 VDC
J1-18	Switched Input 3	Configurable digital tri-stating input. Logic high range from 3 VDC - V_{BAT}, logic low range from 0-3 VDC
J1-19	Sensor Input 3	Low Impedance sensor input (0-750 Ω, 0-5 VDC, 4-20 mA)
J1-20	Sensor Input 4	Low Impedance sensor input (0-750 Ω, 0-5 VDC, 4-20 mA)
J1-21	Sensor Input 5	High Impedance sensor input (0-7.5 kΩ, 0-5 VDC, 4-20 mA)
J1-22	Sensor Input 6	High Impedance sensor input (0-7.5 kΩ, 0-5 VDC, 4-20 mA)
J1-23	Sensor Input 7	High Impedance sensor input (0-7.5 kΩ, 0-5 VDC, 4-20 mA)
J1-24	Ground	Battery negative. Provides a path to ground for the controller
J1-25	Ground	Battery negative. Provides a path to ground for the controller
J1-26	Switched Output 8	High side switch. Outputs +Battery voltage when active (1 A)
J1-27	Switched Output 6	High side switch. Outputs +Battery voltage when active (1 A)
J1-28	Switched Input 4	Configurable digital tri-stating input. Logic high range from 3 VDC - V_{BAT}, logic low range from 0-3 VDC
J1-29	Switched Input 9	Configurable digital tri-stating input. Logic high range from $3V_{DC}$ - V_{BAT}, logic low range from 0-3 VDC
J1-30	Switched Input 8	Configurable digital tri-stating input. Logic high range from $3V_{DC}$ - V_{BAT}, logic low range from 0-3 VDC
J1-31	Switched Input 7	Configurable digital tri-stating input. Logic high range from $3V_{DC}$ - V_{BAT}, logic low range from 0-3 VDC
J1-32	Sensor Input 8	High Impedance sensor input (0-7.5 kΩ, 0-5 VDC, 4-20 mA)
J1-33	Sensor Input 9	Low Impedance sensor input (0-750 Ω, 0-5 VDC, 4-20 mA)
J1-34	Speed Input 1	Connect to a magnetic pickup, tachometer or a flywheel alternator. Not polarity sensitive and not required if using AC voltage terminals for speed sensing. One side of the magnetic pickup also must be connected to ground in addition to the controller.
J1-35	Speed Input 2	Connect to a magnetic pickup, tachometer or a flywheel alternator. Not polarity sensitive and not required if using AC voltage terminals for speed sensing. One side of the magnetic pickup also must be connected to ground in addition to the controller.

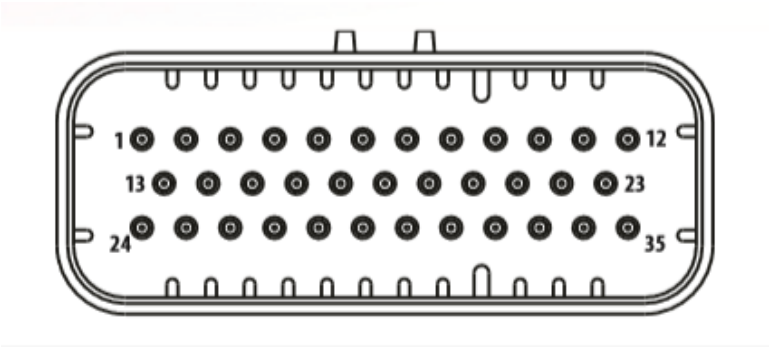

Figure 4: Auxiliary Connector – J2 (AMPSEAL 35-pin)

Terminal	Name	Description
J2-1	RS485 Positive (B)	Inverting communications line for Modbus (RS485)
J2-2	RS485 Negative (A)	Non-inverting communications line for Modbus (RS485)
J2-3	RS485 Common	Modbus Ground
J2-4	No connection	N/A
J2-5	No connection	N/A
J2-6	No connection	N/A
J2-7	Sensor Input 10	Low Impedance sensor input (0-750 Ω, 0-5 VDC, 4-20 mA)
J2-8	No connection	N/A
J2-9	AC Neutral	AC neutral input
J2-10	AC Voltage Phase A	AC Voltage Phase A input
J2-11	AC Voltage Phase B	AC Voltage Phase B input
J2-12	AC Voltage Phase C	AC Voltage Phase C input
J2-13	Switched Output 9	High side switch. Outputs +Battery voltage when active (500 mA)
J2-14	Switched Output 10	High side switch. Outputs +Battery voltage when active (500 mA)
J2-15	Switched Input 10	Configurable digital tri-stating input. Logic high range from 3 VDC - V_{BAT}, logic low range from 0-3 VDC
J2-16	Switched Input 11	Configurable digital tri-stating input. Logic high range from 3VDC - V_{BAT}, logic low range from 0-3 VDC
J2-17	Switched Input 12	Configurable digital tri-stating input. Logic high range from 3VDC - V_{BAT}, logic low range from 0-3 VDC
J2-18	No connection	N/A
J2-19	No connection	N/A

Terminal	Name	Description
J2-20	No connection	N/A
J2-21	No connection	N/A
J2-22	No connection	N/A
J2-23	No connection	N/A
J2-24	No connection	N/A
J2-25	USB D-	USB D- input
J2-26	USB D+	USB D+ input
J2-27	USB Ground	USB ground (internally connected to Battery Negative)
J2-28	5V Protected Output	5 V protected output
J2-29	Ground	Battery negative. Provides a path to ground for the controller
J2-30	No connection	N/A
J2-31	CT Common	CT common input
J2-32	CT Common	CT common input
J2-33	AC Current Phase A	AC current Phase A input
J2-34	AC Current Phase B	AC current Phase B input
J2-35	AC Current Phase C	AC current Phase C input

4 Typical Wiring

Figure 5 represents a typical wiring scenario for the TOUGH Series PRO controller. The following considerations apply.

4.1 Speed Sensing

- Use pins J1-34 and J1-35 for engine speed inputs 1 and 2, respectively
- Input is to be used for a magnetic pickup (MPU) sensor, alternator or tachometer output
- Speed sensing wires are not required when using the AC Voltage wiring harness
- The polarity of the inputs does not matter
- Use twisted pair shielded cable; leave one side of shield unterminated
- If using an MPU:
  - A shielded MPU is recommended
  - One side of the magnetic pickup also must be connected to ground in addition to the controller

4.2 CANbus (J1939) and Modbus (RS485) Connections

- A 120 Ω impedance twisted pair cable is required
  - Examples are Belden 9841 (single twisted pair) and Belden 7895A (two twisted pair)
- RS485 requires an extra wire or twisted pair in the cable for RS485 common
- To prevent noise from affecting controller operations, bring the shielded cable within at least 6 inches of the terminal; closer to 3 inches is recommended
- Terminate the bus on each end with a 120 Ω resistor. For the controller side, the internal resistor can be used instead by enabling it in the RapidCore Configurator Software or the front panel menu
- Ground the shield on one end; leave the other end unconnected

4.3 AC Current (CTs)

- If current readings are unstable, attempt to connect the Current Transformer (CT) Commons to ground, ensuring the connecting wire is as short as possible

4.4 Sensors and I/O

- If using non-isolated (one-wire) sensors, connect sensor common to battery negative. Make connection at the same point the main ground connection is made
- If sensor readings are unstable, it may be necessary to provide a dedicated ground path from the ground node of an individual sensor to the controller ground
- Ensure correct relay selection for system, i.e., 12 V coils for a 12 V system, and 24 V coils for a 24 V system

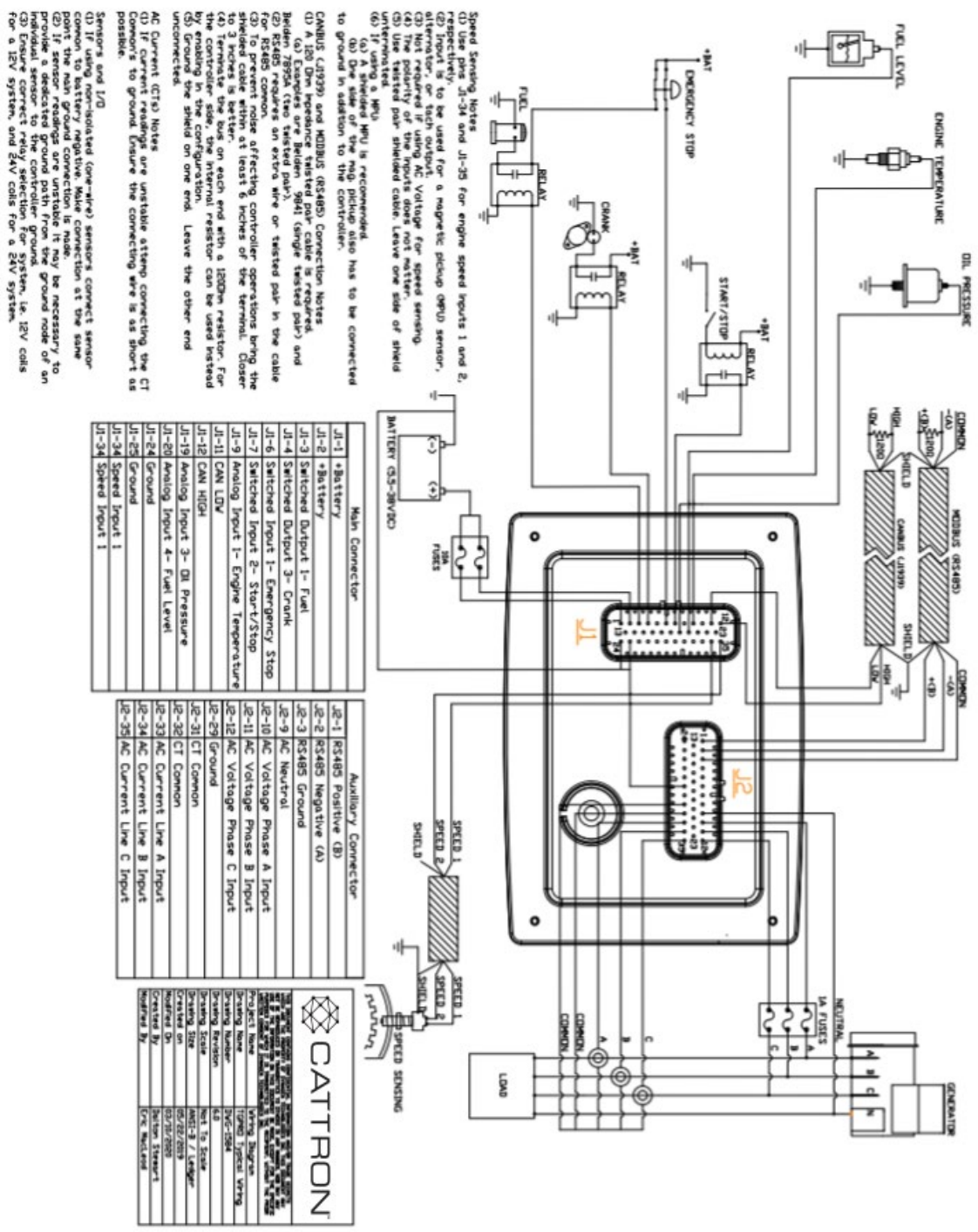

Figure 5: Typical Wiring Diagram

4.5 Wiring Considerations

The following sections are meant to describe certain wiring configurations and are for illustrative purposes only. Not all applications are the same. Please ensure that you modify these examples to fit your unique system requirements.

4.6 Emergency Stop Wiring

If Emergency Stop functionality is required, it should be an external mushroom-style switch wired in series with the fuel or ignition supply to ensure reliable and immediate shutdown upon activation.

Figure 6 shows is an example wiring diagram of a double pole, single throw switch being used to activate the e-stop input and cut power to the fuel solenoid. In this configuration, the e-stop is activated when there is an open circuit to the switched input, and it is inactive when the input detects battery positive voltage.

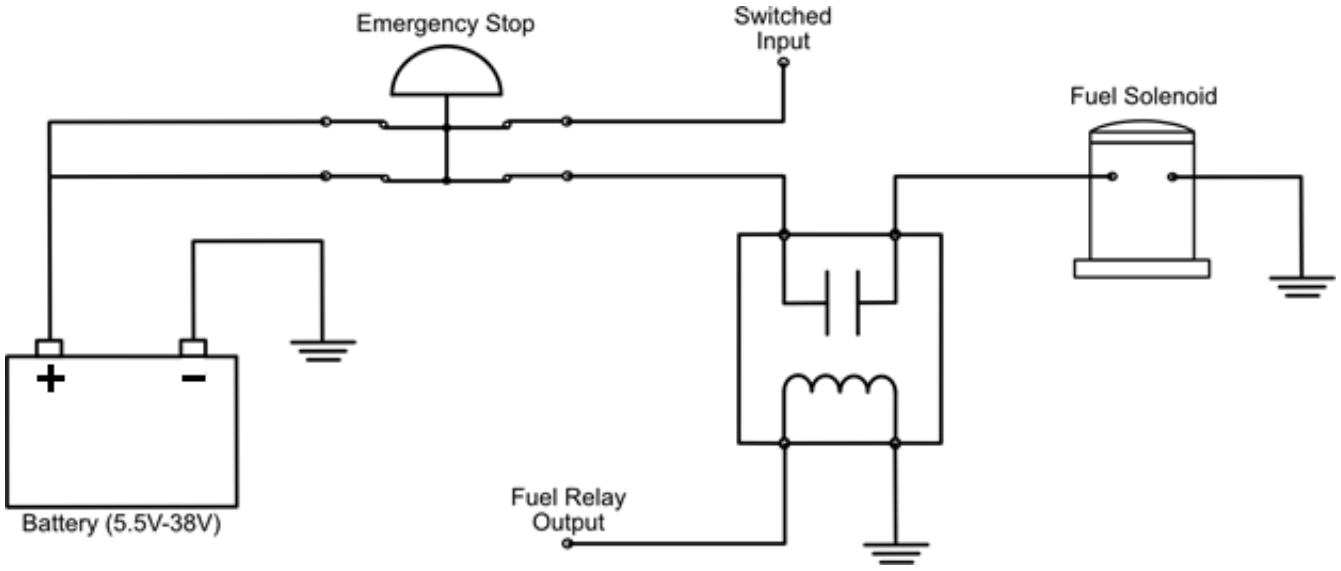

Figure 6: Emergency Stop Wiring Diagram

4.7 Auxiliary Sensors

Auxiliary Sensors can be configured for different sensor types (0-750 Ω, 0-7500 Ω, 0-5 VDC, 4-20 mA).

Auxiliary Sensors 3, 4, 9 and 10 are low impedance senders (0-750 Ω).

Auxiliary Sensors 1, 2, 5, 6, 7 and 8 are high impedance senders (0-7500 Ω).

Note: Custom Sender tables are required for the auxiliary sender to work with these examples. See the Auxiliary Sensors section for more information on Custom Sender Tables.

Example: Sometimes it is required to measure voltages outside the 0-5 V 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:

$V_{OUT} = (R1/(R1+R2)) \times V_{IN}$ Where: V_{OUT} = 5 V

V_{IN} = Maximum Voltage to Read

R1 = Common Resistor Value > 10 kΩ

R2 = Calculated Resistor Value (select closest common resistor value)

Figure 7 shows the typical wiring of a voltage divider. The resistors' values have been selected to allow the controller to read up to 36 V from an external battery bank.

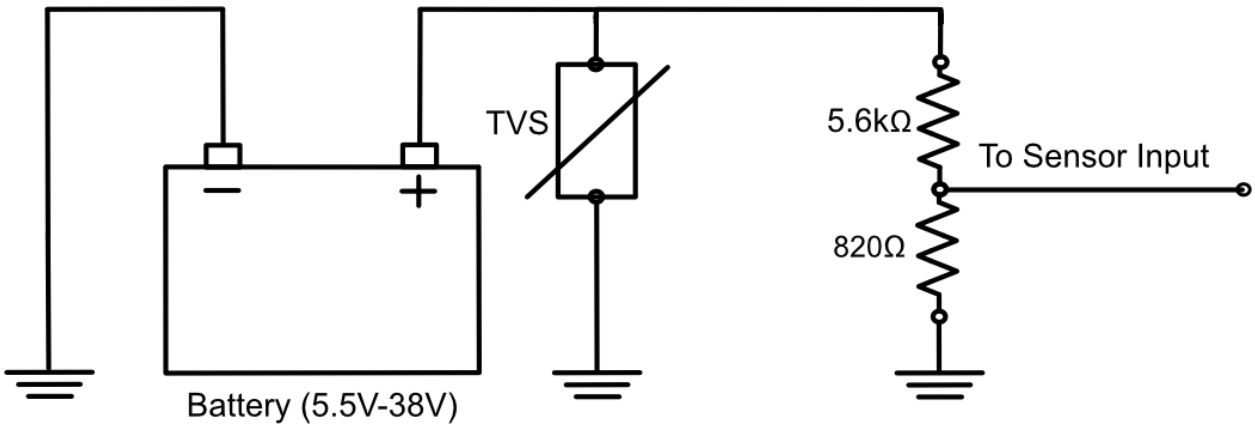

Figure 7: Universal Sensor Wiring Example

⚠	**CAUTION**
	A TVS (I.E., VARISTOR) IS REQUIRED IF THE BATTERY IS DIFFERENT THAN THE BATTERY FROM WHICH THE CONTROLLER IS POWERED. IN THIS CASE, THE CONTROLLER'S TVS CANNOT PROTECT THE SENSOR INPUT FROM TRANSIENTS.

⚠	**ATTENTION**
	UN TVS (VARISTANCE) EST NECESSAIRE SI LA BATTERIE EST DIFFERENTE DE CELLE QUI ALIMENTE LE CONTROLEUR. DANS CE CAS, LE TVS DU CONTROLEUR NE PEUT PAS PROTEGER L'ENTREE CAPTEUR CONTRE LES TRANSITOIRES.

4.8 CANbus Wiring

The following table outlines some items that must be taken into consideration when connecting to a CANbus engine.

Consideration	Description
Bus Termination	Each end of the bus must be terminated from CAN H to CAN L with 120 Ω +/- 10 Ω resistors. The resistor must be able to handle at least 400 mW of power dissipation. With the TOUGH Series PRO, this can be accomplished with an external resistor termination at the controller, or by simply enabling the internal resistor in the menu, as follows: Menu > Advanced Setting > Communications > J1939 CANbus – Internal 120 Ω Resistor > Enable
Cable Selection	A twisted pair 120 Ω impedance cable is required for communications. For better protection, a shielded twisted pair cable is recommended. Examples include the following: • Belden 9841 - Shielded cable with one twisted pair, 24 AWG • Belden 7895A - Shielded cable with two twisted pair, 20 AWG For short runs of 5 ft or less, regular 18 AWG wiring can often be run.
Shielding	If using a shielded cable, the shield must be connected to ground on one end of the bus only. This prevents loss of data from electromagnetic interference.
Termination at the Controller	The twisted pair cable must terminate no farther than six inches from the controller's CAN (J1939) connector. Three inches is ideal.

For detailed information about J1939 settings and functions, please use the J1939 Reference Manual. The manual can be found at www.cattron.com.

Typical communications writing is shown in Figure 8.

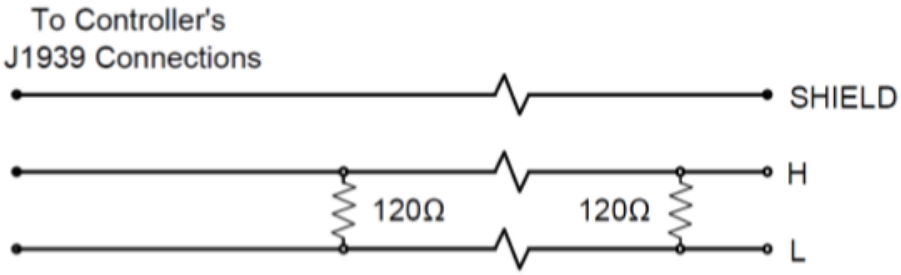

Figure 8: Communications Wiring

4.9 Modbus Wiring

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

Consideration	Description
Bus Termination	Each end of the bus must be terminated from A to B with 120 Ω +/- 10 Ω resistors. The resistor must be able to handle at least 400 mW of power dissipation. With the TOUGH Series PRO, this can be accomplished with an external resistor termination at the controller, or by simply enabling the internal resistor in the menu, as follows: Menu > Advanced Setting > Communications > Modbus Network > Modbus Internal 120 Ω Resistor > Enable
Cable Selection	Shielded twisted pair 120 Ω impedance cable is required for communications. Shield drain wire is NOT to be used for the RS485 common. The cable must have one twisted pair for A and B and a separate wire or twisted pair for the common. An example is Belden 7895A, a two twisted pair, 20 AWG, where the second pair can be used for the RS485 common.
Distance (Power and Ground)	If running power and ground from the battery of your system to a remote device, use the following guidelines for the gauge of the power and ground wires. • Up to 450 ft (137.2 m) – 22AWG • Up to 700 ft (213.4 m) – 20AWG • Up to 1125 ft (342.9 m) – 18AWG • Up to 1800 ft (548.6 m) – 16AWG • Up to 2800 ft (853.4 m) – 14AWG
Termination at the Controller	The above cable must terminate no farther than six inches from the controller's RS485 (Modbus) connector. Three inches is ideal.

For detailed information about the Modbus registers and their interpretations, please use the Modbus Reference Manual. The manual can be found at www.cattron.com.

4.10 ECM Wiring

It is common practice to use the fuel output to trigger the ECM key input to enable the ECM before cranking. Figure 9 shows an example of wiring this configuration. For some ECMs to function, they must be powered/enabled for a certain period before cranking to allow time for the ECM to boot up. There are two ways to provide this time:

- Set a preheat time or increase the preheat time to allow a longer time for the ECM to boot up before cranking; the fuel output turns on at the start of preheat
- Enable the Auto Power ECM setting in the Communications > CANbus (J1939) menu, which will cause the fuel output to turn on in Auto Mode and stay on

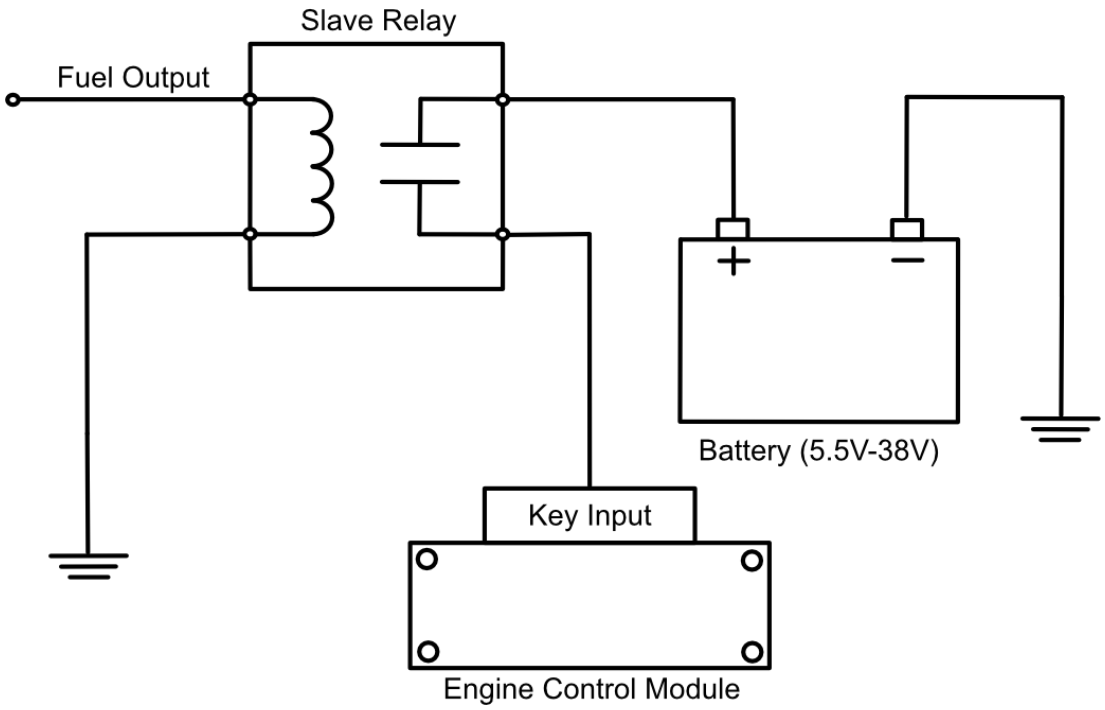

Figure 9: ECM Wiring

4.11 Current Transformers

When wiring current transformers (CTs) into the system, you must follow these considerations:

- The maximum amperage allowed on the secondary winding is 5 A. An X:5A ratio CT should be used where X is the maximum primary winding amperage rating (e.g., 200 A)
- The CT power rating should be a minimum of 1 V·A
- The CT of each phase must be facing the same direction, as shown in Figure 10
- The CT Common connection must be connected to the black wire on each CT
- The wires from the CTs to the controller should be as short as possible
- It is recommended to use twisted pairs of wire
- The CT wires should be run in a separate conduit from the AC voltage wires

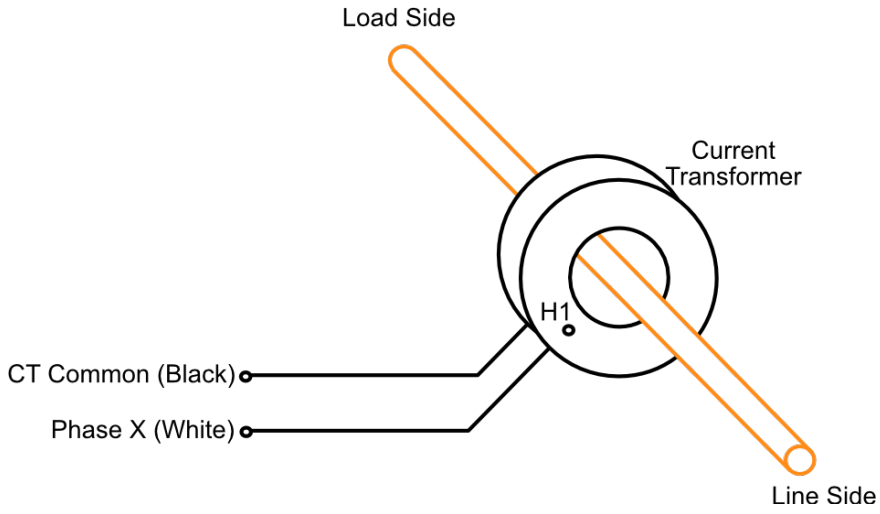

Figure 10: CT Wiring

⚠	**CAUTION**
	IF READINGS ARE UNSTABLE WITH THE CONFIGURATION SHOWN IN FIGURE 10, ATTEMPT TO CONNECT THE CT COMMON'S BLACK WIRE TO THE NEGATIVE TERMINAL OF THE BATTERY. ENSURE THE CONNECTING WIRE IS AS SHORT AS POSSIBLE.

⚠	**ATTENTION**
	SI LES MESURES SONT INSTABLES AVEC LA CONFIGURATION INDIQUEE EN FIGURE 10, ESSAYEZ DE CONNECTER LE FIL NOIR COMMON (COMMUN) DU CT (TRANSFORMATEUR DE COURANT) A LA BORNE NEGATIVE DE LA BATTERIE. ASSUREZ-VOUS QUE LE FIL DE CONNEXION SOIT AUSSI COURT QUE POSSIBLE.

5 Using the Controller

The TOUGH Series PRO controller's LCD display is the primary source of information from the controller. It allows the user to view and monitor the status of sensors and other engine peripherals. This automotive-grade display adheres to the TOUGH Series rugged standards by maintaining functionality to -20 °C throughout use and -40 °C with the backlight active.

Figure 11 illustrates the controls used to navigate and change the on-screen information and subsequently use the controller.

5.1 Front Panel and Buttons

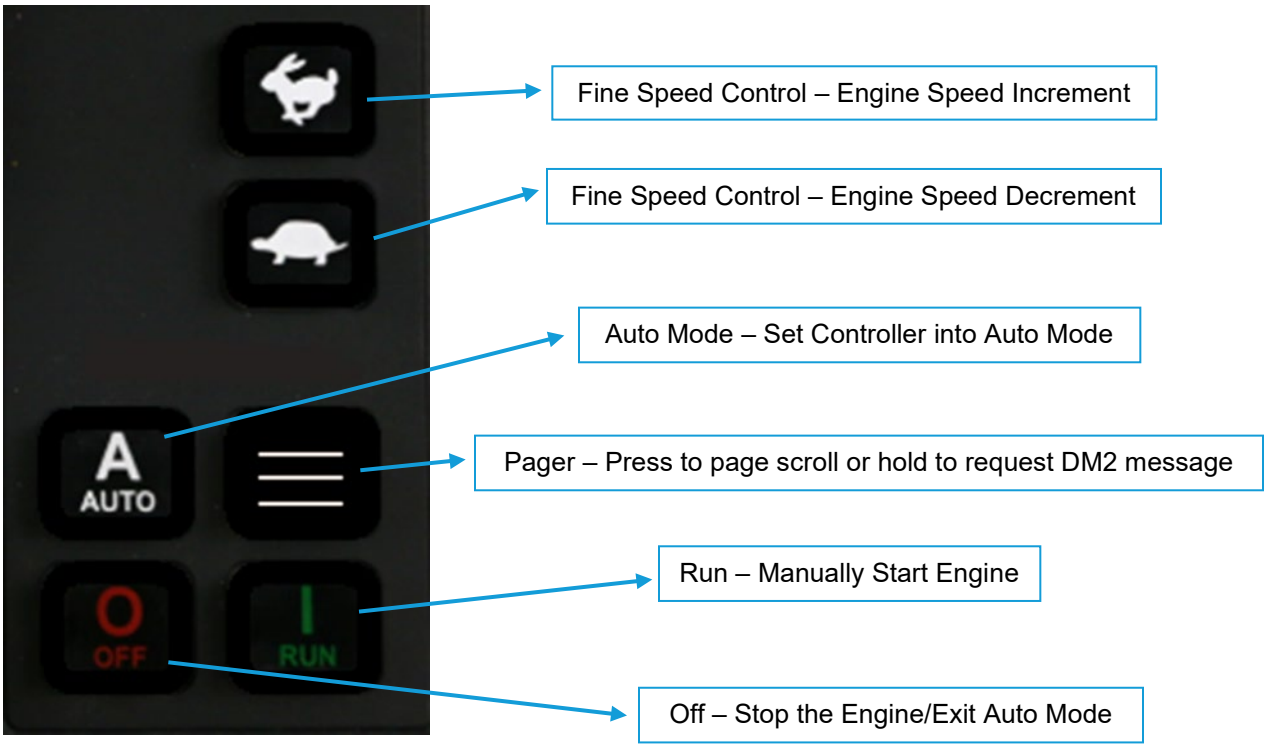

Figure 11: Controller Button Descriptions

5.2 Using the Menu System

5.2.1 Navigation/Input:

The user is able to navigate the interface by using the five buttons located directly below the LCD screen. The buttons themselves do not have any description. A small row at the bottom of the LCD screen describes each button's function.

Figure 12 shows the default button descriptions.

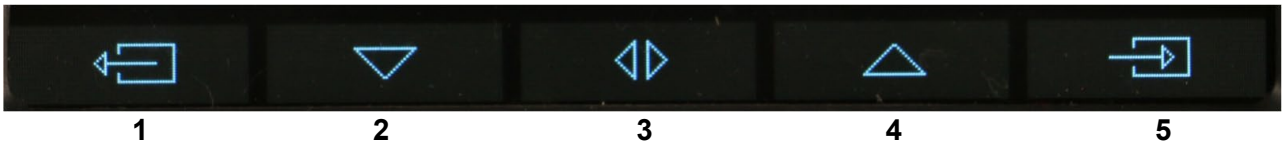

Figure 12: LCD Screen Button Descriptions

1. Back – Allows the user to return to the previous screen/acts as a cancel button in the menu. Allows the user to view the DM1 list.
2. Navigational Down – Allows the user to scroll down.
3. Menu/Navigational – In Off Mode, it allows the user to enter the menu system. In each setting it will scroll to the next setting. In Run Mode, it allows the user to change the display page on the left side of the controller screen.
4. Navigational Up – Allows the user to scroll up.
5. Select – Allows the user to confirm selection/enter sub menus.

The following table describes the menu structure and selections at the front panel of the controller. All of the settings and configuration options can be observed in depth in the Configuration section of this manual.

Option	Subheadings	Description
System Information	About This Device	This option provides easy access to information regarding: • Hardware • Firmware • Model • Serial Number • User ID • Settings Name • Engine Hour • Hours to Service
	Events History	Provides access to a log of controller events and notifications.

Option	Subheadings	Description
Operator Setup	Page Scroll Message Delay LCD Backlight Backlight Timeout OFF Start Pressure Unit Temperature Unit Fluid Level Unit Fluid Rate Unit Date* Time* Daylight Savings	Allows configuration of basic parameters. Examples of units, measurement, and time.
Advanced Setting	Time and Scheduler Engine Speed Common Sensors Sensor Inputs Genset AC Signals Communications Switched Input Switched Output Miscellaneous	Allows configuration of advanced parameters. See the Configuration section for more information.
Programmable Logic	Remote Start/Stop Switch Inputs Events Advanced Logic 1 Advanced Logic 2 Advanced Logic 3 Advanced Logic 4	Allows configuration of application specific parameters. See the Configuration section for more information.

*** Only available via front panel access**

The TOUGH Series PRO is a generic engine controller that will adapt to various engine applications. Each application will have its own configuration, with easy access to generic settings under the centralized “Programmable Logic” and “Advanced Settings” items. Configuring the device requires choosing generic engine settings in correlation with choosing application specific settings.

For example, navigating to the “Programmable Logic” item and pressing the Menu/Navigational will open the corresponding menu, under which the operator can proceed to select Remote Start/Stop, Switched Input Events, and Advanced Logic 1-4.

When selecting these menu options, a pass code prompt will ask the user to input a four-digit pass code. Scroll up and down to select a digit between 0 and 9 and press the Select button to confirm each digit. Press the Back button to return to the previous menu. **The default passcode is 0000.** This is illustrated in Figure 13.

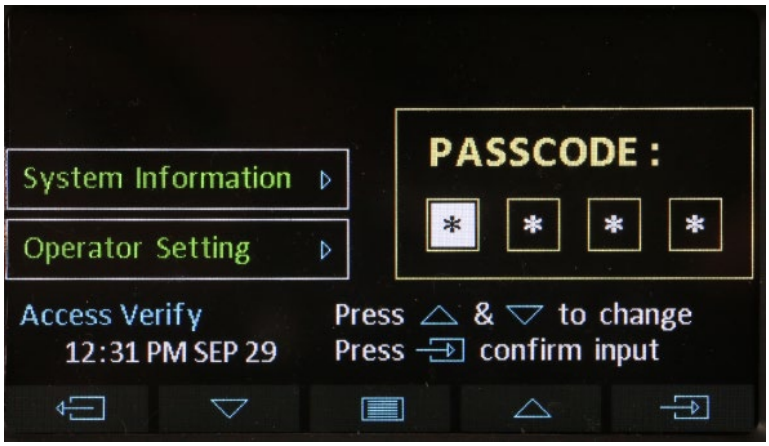

Figure 13: Passcode

If the user enters an incorrect pass code three consecutive times, the menu will be inaccessible for 10 minutes, although the controller can still operate with the settings as they were prior to the incorrect pass code attempts.

Figure 14 shows the controller in Auto Mode at the home screen.

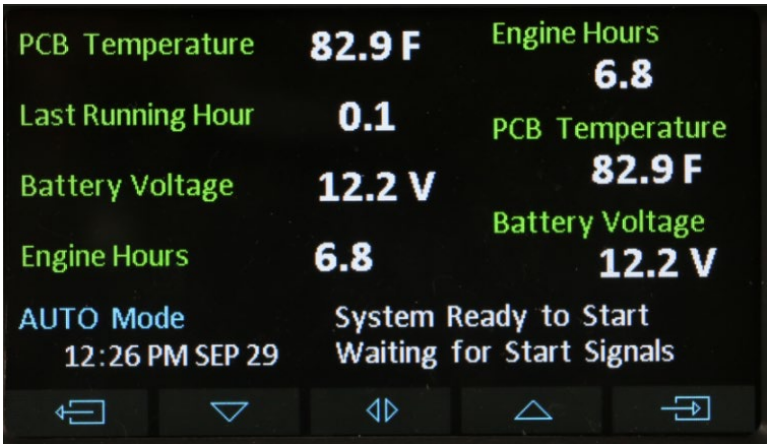

Figure 14: Home Screen

5.3 Modes, Starting and Stopping

The controller operates using modes that dictate, and are dictated by, engine behavior in order to communicate status and conditions.

The following table describes the operating modes of the controller:

Mode/State	Description
OFF	When in Off Mode, the user can access the menu mode.
Auto	When in Auto Mode, the engine waits to receive a start command or manual start.
Running	When in Running Mode, the controller monitors engine parameters and waits to receive a stop command or manual stop.
Failure	When in Failure Mode, the controller shuts the engine down and displays the reason for failure. The unit must be reset using the front panel OFF button.
Menu	When in Menu Mode, settings can be changed and the Events History may be viewed.

Unless using the Manual Run or Run from OFF settings to start the controller, the controller must be in Auto Mode in order to start an engine. The following table describes the different methods for starting an engine using a controller.

Methods	Description
Manual Run	Pressing the Run button will start the engine. You must press the OFF button to shut down the engine.
Start/Stop Switched Input	When this input is active the engine will start. When the input becomes inactive the engine will shut down. Pressing OFF will also cause a shut down.
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.
Key Switch Start Input	If this input is active in Auto or Off Mode, the engine will start. The engine will continue to run if the switched input is inactive.
Battery Recharge	When the battery voltage drops below the chosen voltage, the engine will start and run for a predetermined amount of time. It is necessary to be in AUTO for battery recharge to start.
Exerciser	When the scheduled exerciser interval occurs, the engine will start and run for a predetermined amount of time. It is necessary to be in AUTO for the exerciser to start.
Weekly Scheduler	When a scheduled event occurs, the engine will start and run for a predetermined amount of time. It is necessary to be in AUTO for the weekly scheduler to start.
Auxiliary Sensors	When a properly configured Auxiliary Sensor falls below/rises above a certain point, the engine will start as determined by the Auxiliary Sensors -> Mode Select settings.
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; it can be found at www.cattron.com.

Methods	Description
J1939 Start	Start/Stop commands are sent through the J1939 CANbus; for example, from the TR100 or a remote telemetry device. The controller will display either "J1939 Run" or "J1939 Remote" as the reason for starting.
ECM Power On	This is not a starting mode like the others. In Auto Mode, if the Auto button is held for 3 seconds, the fuel output is turned on for 1 hour. "ECM Power On" will be displayed on the screen. Pressing and holding Auto again within the hour will refresh for another hour. This feature can be used to turn on or activate equipment powered by the fuel output. Often this is used by a tech to power the ECM on an electronic engine so that a diagnostic tool can obtain information from the ECM.

	**WARNING**
	SEE THE USING COOLDOWN MODE SECTION FOR MORE INFORMATION ON HOW IT AFFECTS STARTING AND STOPPING.

	**AVERTISSEMENT**
	VOIR LA SECTION USING COOLDOWN MODE (UTILISATION DU MODE REFROIDISSEMENT) POUR PLUS D'INFORMATIONS SUR LA FAÇON DONT CELA PEUT AFFECTER LE DÉMARRAGE ET L'ARRÊT.

5.4 Cranking Behavior

Crank disconnect is monitored throughout cranking. If the controller is programmed to use CAN J1939 or a magnetic pickup, the controller will also monitor AC Voltage Phase A line for frequency as a backup or secondary means of crank disconnect.

The oil pressure is not used as a means of crank disconnect.

5.5 Using Warmup Mode

Warmup Mode is used to protect the engine from heating up too quickly.

After successful cranking, the engine delays this amount of time before turning on the Warmup output. This allows the engine to warm up before applying any load to it. The output will turn off when the controller enters the Cooldown Delay.

5.6 Using Cooldown Mode

When configured to use Cooldown Mode (see the Engine Timer 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 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 shut down.

The following is an example of how the cooldown functionality works; this process is also shown in Figure 15.

1. Remote Start contacts close.
2. Engine starts and is in 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 shut down.
7. Engine can now only be shut down by using the OFF button or Emergency Stop input.

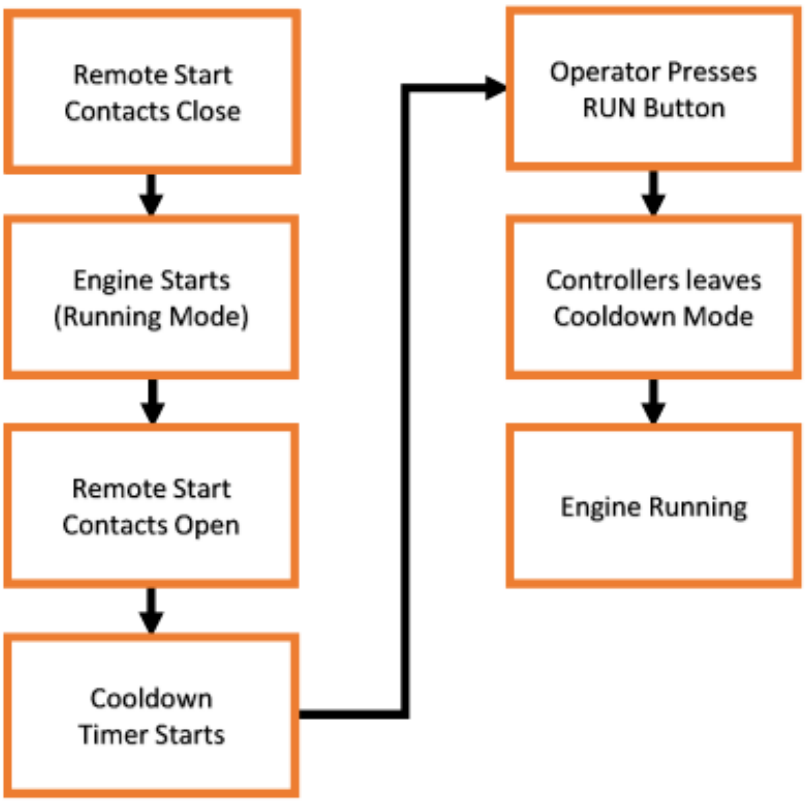

Figure 15: Cooldown Functionality

The flowchart in Figure 16 depicts the process followed by the controller during a typical “Active State.”

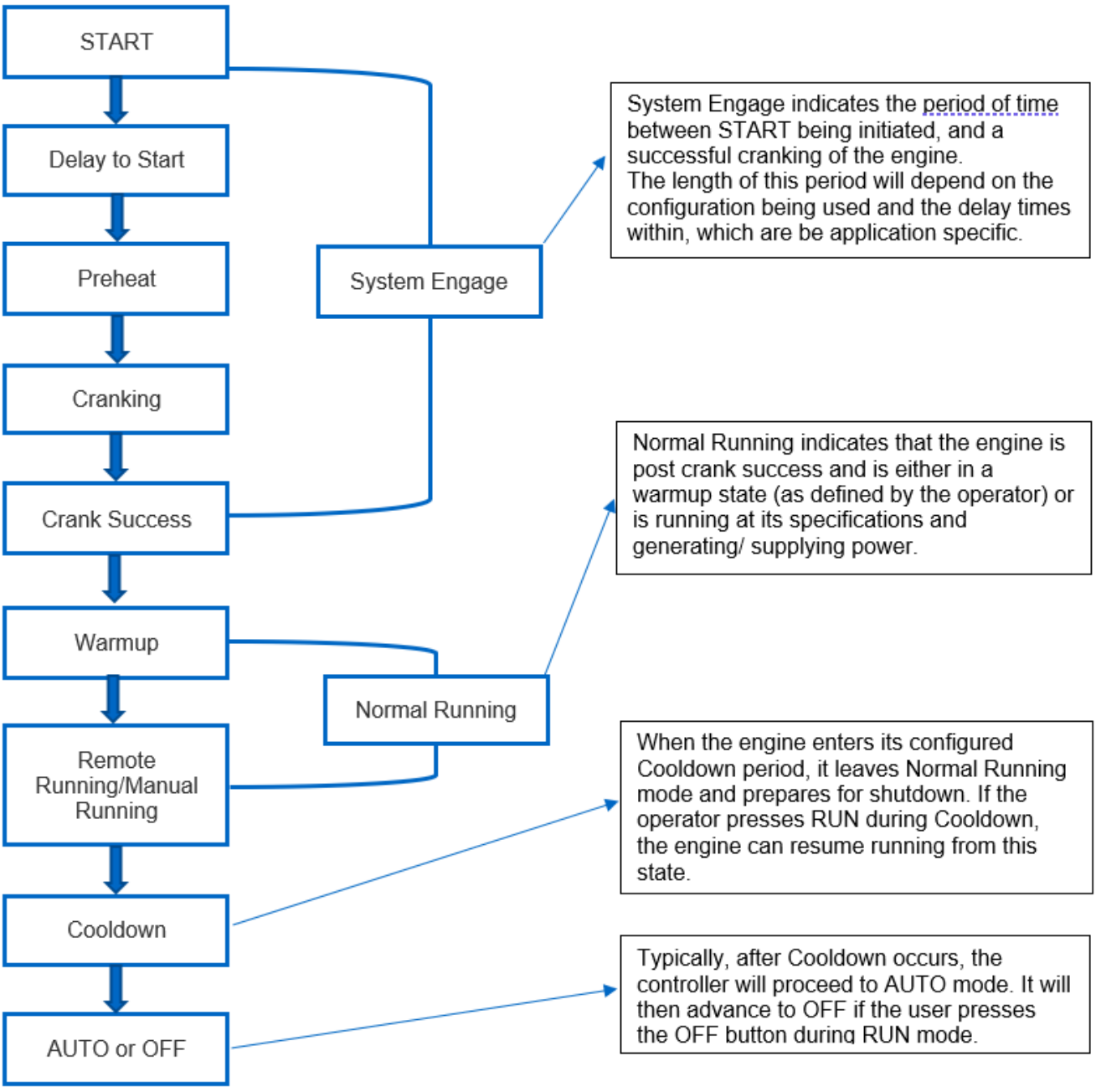

Figure 16: Flow of Active State

6 Configuration

6.1 Options

6.1.1 Load Factory Defaults

In RapidCore, select the “start” button found under the Load Factory Defaults heading. This will result in the settings file for the unit being reconfigured to the default settings.

6.1.2 Controller Password

If the checkbox is selected to Enable Password via the RapidCore Configurator Software, the operator must enter the front panel password when using the configuration software to read and store settings as well as to update the firmware.

Under this heading there is a drop box selection labeled Number of Password Tries. This allows the operator to customize the number of attempts for entering the password.

6.1.3 User ID & Settings Name

When storing settings from the RapidCore Configurator Software, a custom name can be entered to allow users to determine the settings that are stored in the controller. This custom name, called “Configuration Name” (ID in the controller) is found under Options in the settings tab of the configuration software. The name can be up to 12 characters long.

There is no controller menu to set this ID. The Configuration Name can be viewed on the controller as follows: Off Mode > System Information > About This Device.

6.2 Events History

Every time a significant event occurs, the time and date as well as a description of the event is placed as an entry in the Events History. Examples of events include the following: 'Controller Power On', 'System Enter Cooldown' or 'Engine Fail to Stop.'

To view the Events History, follow these steps:

1. Place the controller in Off Mode.
2. Press the down button to select System Information, then press Enter.
3. Select Events History, then press Enter.
4. Press the Up or Down buttons to browse through the events.
5. Press the Back button (first button on the left below the LCD) to exit out of the Events History.

From this menu you can scroll through up to 160 events using the up and down arrows. Keep in mind that the events are recorded in order, so Event 1 is the most recent event and Event 160 is the oldest event.

6.3 Operator Setup

Setting	Range	Description
Page Scroll Delay	1-10 s (default is 3 s)	Amount of time between each auto scroll of the parameter pages.
Message Delay	1-10 s (default is 2 s)	Amount of time each message is displayed on the screen before displaying next message in the buffer.
LCD Brightness	5-100% (default is 50%)	Level of LCD brightness for visibility in different conditions.
Backlight Timeout	10-600 s (default is 600 s) Disable	Amount of time the LCD Backlight stays on after button activity stops.
Start from Off Mode	Enable (default) Disable	When enabled, allows a user to start the 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.
Pressure Unit	PSI (default) kPa	Selects the oil pressure display format.
Temperature Unit	Fahrenheit (default) Celsius	Selects the temperature unit display format.
Fluid Level Unit	Feet (default) Meters	Selects the fluid level display format.
Fluid Rate Unit	GPH LPH (default)	Selects the fluid rate display format.
Daylight Savings	Enable (default) Disable	Turns Daylight Savings Time on or off. This applies to North America only. Disable for other locations.

7 Display Configuration

Setting Name	Options	Description
Default Main Display	Speed (default) Four Line Page 1 (Run Page 1) Four Line Page 2 (Run Page 2) Four Line Page 3 (Run Page 3) Four Line Page 4 (Run Page 4) Voltage Current Voltage and Current Single Phase 3-Wire Volts and Amps Single Phase 2-Wire Volts and Amps	Customizable lines for default main display page.
User Screens	**Big Screen** – Speed Four Line Page 1 (Run Page 1) Four Line Page 2 (Run Page 2) Four Line Page 3 (Run Page 3) Four Line Page 4 (Run Page 4) Voltage Current Voltage and Current Single Phase 3-Wire Volts and Amps Single Phase 2-Wire Volts and Amps **Right Screen** – Line 1, Line 2 and Line 3	Customizable lines for User Screens. Access by pressing front panel pager button. Default state does not have user screens defined.
Auto Display Page Line 1 Auto Display Page Line 2 Auto Display Page Line 3 Auto Display Page Line 4	Engine Temperature Fuel Level Oil Pressure Battery Voltage (default Line 3) Engine Hours (default Line 4) Engine Speed Auxiliary Sensor 1 Auxiliary Sensor 2 Auxiliary Sensor 3 Auxiliary Sensor 4 Auxiliary Sensor 5 Auxiliary Sensor 6 Auxiliary Sensor 7 Auxiliary Sensor 8 Auxiliary Sensor 9	Four customizable lines for Auto Mode page display.

Setting Name	Options	Description
	Auxiliary Sensor 10 PCB Temperature (default Line 1) Last Run Time (default Line 2)	
Run Page 1 – Line 1 Run Page 1 – Line 2 Run Page 1 – Line 3 Run Page 1 – Line 4 Run Page 2 – Line 1 Run Page 2 – Line 2 Run Page 2 – Line 3 Run Page 2 – Line 4 Run Page 3 – Line 1 Run Page 3 – Line 2 Run Page 3 – Line 3 Run Page 3 – Line 4 Run Page 4 – Line 1 Run Page 4 – Line 2 Run Page 4 – Line 3 Run Page 4 – Line 4	Blank Line (default for all lines of Run Pages 2-4) Engine Temperature (default Run Page 1 – Line 2) Fuel Level Oil Pressure Engine Frequency Battery Voltage (default Run Page 1 – Line 3) Engine Hours (default Run Page 1 – Line 1) Current Run Time Engine Speed (default Run Page 1 – Line 4) AC Voltage – Phase A AC Voltage – Phase B AC Voltage – Phase C AC Current – Phase A AC Current – Phase B AC Current – Phase C Auxiliary Sensor 1 Auxiliary Sensor 2 Auxiliary Sensor 3 Auxiliary Sensor 4 Auxiliary Sensor 5 Auxiliary Sensor 6 Auxiliary Sensor 7 Auxiliary Sensor 8 Auxiliary Sensor 9 Auxiliary Sensor 10 PCB Temperature Last Run Time J1939 Oil Temperature J1939 DPF Soot Load J1939 DPF Ash Load J1939 Time Since Last Regeneration J1939 Exhaust Gas Temperature J1939 DEF Tank Level J1939 DEF Tank Temperature J1939 Engine Torque J1939 DPF Gas Temperature	(Configurable using RapidCore Configurator Software only) Four of the Run Mode scrolling pages can be customized. Up to four parameters (lines) per page can be shown. If “Blank Line” is set for two consecutive lines, then those two lines are removed and all subsequent lines are moved up. If only one page is desired, then set all lines to “Blank Line” and that page will not be shown.

Setting Name	Options	Description
	J1939 Engine Load J1939 Ambient Air Temperature J1939 Engine Fuel Rate AC Apparent Power AC Real Power AC Reactive Power AC Power Factor	

7.1 Quick Menu – Generic Start/Stop Page

The quick menu is an Auxiliary Sensor Start/Stop threshold that is configurable through the front panel without entering the main menu. The user must use the RapidCore Configurator Software to select the Auxiliary Sensor that will control the Start/Stop threshold for the quick menu.

Setting	Range	Description
Quick Menu	Disable (default) Enable	Determines access to the quick menu through the front panel of the controller.
Auxiliary Sensor	Auxiliary Sensors 1-10 (default Auxiliary Sensor 5)	Selection for the Auxiliary Sensor to control the Start/Stop threshold.
Title	Custom Text (default Quick Menu)	User defined name for quick menu.
Item Label 1	Custom Text (default Aux 5 Start)	User defined name for Auxiliary Start.
Item Label 2	Custom Text (default Aux 5 Stop)	User defined name for Auxiliary Stop.
Menu Timeout	Disable 1-60000 s (default 180 s)	Configurable time that the quick menu page will stay open if the operator does not manually exit.

Figure 17 illustrates what the operator will see after enabling the quick menu.

1. Enable Quick Menu in RapidCore; store the settings to the controller.
2. Press the Auto button to enter Auto state.
3. Press the Menu/Navigational button to open the Quick Menu, the center button below the LCD.

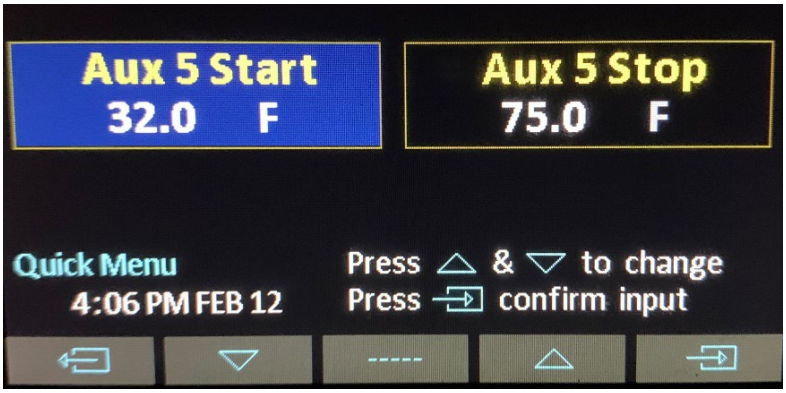

Figure 17: Quick Menu

8 Programmable Logic

8.1 Programmable Switched Input

The controller has configurable switched inputs used to create a custom Start/Stop, as well as warnings and failures.

Setting	Range	Description
Switched Input Start	Name: Custom Text (default) If switched input on: Disable (default) Port 1-12 Is Equal to: Battery Positive (default) Ground Battery Positive/Ground Open For more than: 0.1-3600 s (default 3 s) Run Duration: 0-900 min (default 60 min)	User configurable engine start control based on logic relating to switched input parameters and comparison.
Switched Input Active/Stop	Name: Custom Text (default) If switched input on: Disable (default) Port 1-12 Is Equal to: Battery Positive (default) Ground Battery Positive/Ground Open For more than: 0.1-3600 s (default 3 s) Trigger: Disable (default) Shut Down Start Inhibit Hold Cooldown ***See text below table for trigger explanations. ***	User configurable engine stop control based on logic relating to switched input parameters and comparison. If Switched Input Stop 1 is programmed to perform a Shutdown, it will only function correctly when Start Input 1 is in Run Duration. This also applies to Switched Input Start/Stop 2, with respect to matching numbers. Switched Input Active/Stop 3 will only perform a Start Inhibit or Hold Cooldown. It will NOT perform a Shutdown.

Setting	Range	Description
Switched Inputs Events	Name: Custom Text (default) If switched input on: Disable (default) Port 1-12 Is Equal to: Battery Positive (default) Ground Battery Positive/Ground Open For more than: 0.1 - 3600 s (default 3 s) Trigger Event: Disable (default) Warning Failure Trigger Signal: Disable (default) Events 1-8 Bypass Delay: 1 - 90 s (default 5 s) Event Active State: OFF State AUTO State System Engage Warmup Normal Running Cooldown	User configurable system events control based on logic relating to switched input parameters and comparison.

* **Start Inhibit:** If active and the controller is in Off or Auto Mode, it will prevent the engine from starting. If active and the controller is in the Engage, Running or Cooldown states, the controller will shut down and enter Auto Mode, bypassing the cooldown state.

* **Hold Cooldown:** If active while in the Cooldown state, the controller will not shutdown under normal operation. Activating Start Inhibit, emergency stop, or a failure will cause the engine to stop.

8.2 Programmable Advanced Logic

The controller has configurable advanced logic which is used to set a trigger signal on/off. The logic is triggered by various applications.

Setting	Range	Description
Name	Custom Text (default)	User defined name for logic function.
Trigger Signal	Disable (default) Events 1-8	Selection for event that logic function is triggered upon. The state of the input determining if it is active or inactive.
Active Time	Disable (default) 1-900 min	Configurable time for logic function to be active.

Setting	Range	Description
Active Recover	1-900 min (default 450 min)	Configurable time for recovery after logic function completes Active Time, before reactivation.
Conditions	If Parameter: Disable (default) Engine RPM Battery Voltage J1939 Torque % J1939 Ambient Temp Phase A Current Fluid Level Engine Temp Auxiliary Sensor 1 Auxiliary Sensor 2 Auxiliary Sensor 3 Auxiliary Sensor 4 Auxiliary Sensor 5 Auxiliary Sensor 6 Auxiliary Sensor 7 Auxiliary Sensor 8 Auxiliary Sensor 9 Auxiliary Sensor 10 Is: Greater Than Less Than (default) Constant: 0.1-4000 s (default 100 s) For more than: 0.1-60 s (default 5 s) Then Set Signal: On Off (default)	These configurable sections contain the settings defining the conditions necessary to be met in order to activate the logic function in question. Four conditions can be added to one Advanced Logic. Conditions offer a less than/ greater than comparison, while Logic Active Conditions offers the use of True and False conditions. Two logic conditions can be added to one Advanced Logic. Without an OFF logic condition, the condition will always stay on until the unit is turned off, and that is assuming that the control running state excludes the AUTO or OFF states; otherwise, it will simply remain on all the time.
Logic Active Conditions	If: Disable (default) Fuel Crank Pull Coil Energize to Stop After Warmup Voltage Regulator Idle Battle Mode Low Battery During Crank Off Mode Auto Mode	

Setting	Range	Description
	Delay to Start	
	Preheat	
	Warmup	
	Cooldown	
	Normal Running	
	Exerciser	
	Battery Recharge	
	Auto Idle	
	Dummy Load	
	Genset Disable	
	AC Breaker Trip	
	TSC1 Inc Speed	
	TSC1 Dec Speed	
	Force Regeneration	
	Regen Inhibit	
	DEF Pump	
	Transducer Power	
	Common Warning*	
	System OK	*Common Warning signal is only activated for programmable warnings (Programmable Switched Inputs and Aux Sensors 1-10)
	Not in Auto	
	Events 1-8	
	Common OR 1-4	
	Common AND 1-4	
	Aux Sensor 1-10 Low Warning	
	Aux Sensor 1-10 High Warning	
	Aux Sensor 1-10 Low Failure	
	Aux Sensor 1-10 High Failure	
	Aux Sensor 1-10 Trigger	
	Remote Inputs 1-8	
Is: False		
	True (default)	
Then Set Signal: On		
	Off (default)	

Setting	Range	Description
Control Running State	OFF State AUTO State System Engage Warmup Normal Running Cooldown Shutdown Failure	Used to define under which states a given function can occur.

9 Switched Inputs

The controller has configurable switched inputs which enable the controller to perform a function when activated.

Name	Active Mode	Description
Disabled	N/A	Input is disabled and has no function.
Start/Stop	Auto Running Cooldown	Starts the engine when active and stops the engine when deactivated. Must be in AUTO to start.
Emergency Stop	Global	When active, shuts down the engine, displays Emergency Stop, and prevents the controller from leaving the Off Mode. When the engine is in Run Mode and Emergency Stop input is active, the controller will bypass Cooldown and will proceed directly to ETS Shutdown.  **CAUTION** THIS SHOULD ONLY BE USED FOR THE EMERGENCY STOP INDICATION ON THE CONTROLLER. THE INSTALLER MUST PROVIDE AN INDEPENDENT MEANS TO SHUT DOWN THE ENGINE FROM THE EMERGENCY STOP BUTTON SUCH AS CUTTING OFF FUEL. SEE THE TYPICAL WIRING DIAGRAMS IN FIGURE 5 AND FIGURE 6 FOR EXAMPLES ON HOW TO WIRE THE EMERGENCY STOP.  **ATTENTION** CELA NE DOIT ETRE UTILISE QUE POUR LE VOYANT D'ARRET D'URGENCE SUR LE CONTROLEUR. L'INSTALLATEUR DOIT PREVOIR UN MOYEN INDEPENDANT D'ARRETER LE MOTEUR A PARTIR DU BOUTON D'ARRET D'URGENCE, PAR EXEMPLE EN COUPANT LE CARBURANT. VOIR LES SCHEMAS DE CABLAGE TYPES EN FIGURE 5 ET FIGURE 6 POUR DES EXEMPLES DE CABLAGE DE L'ARRET D'URGENCE.
Idle Mode	Running	See the Idle section under Engine Timer Logic for more information.
AC Select 1 and 2	Auto	Used for changing the system AC voltage configuration. See the AC Voltage Select section for more information.
AUTO Engine System (Frequency Select)	Auto	Used for changing between Primary and Secondary RPM for an engine or 50 Hz / 60 Hz for a generator. See the RPM / Frequency Select section for more information.
Battery Charger Fault	Global	Controller displays ‘Charger Fault’ warning when active.

Name	Active Mode	Description
Key Switch Start	OFF Auto Cooldown	Used to start the engine with a Key Switch wired to a switched input.
Momentary Start	Auto and Cooldown	Starts or stops the engine when momentarily active for at least 2 seconds. These inputs allow the user to wire separate inputs for Start and Stop or to use a push button instead of a toggle switch.
Momentary Stop	Running	Momentary Stop will only stop the controller when the reason for start was “Momentary Start.” It will not stop if the front panel run button was used to start the engine.
Low Air Pressure	Cranking	Controller displays ‘Low Air Pressure’ and shuts down engine when active.
Low Hydraulic Pressure	Cranking	Controller displays ‘Hydraulic Pressure Failure’ and shuts down engine when active.
Low Oil Pressure	Running	Controller displays ‘Oil Pressure Warning’ when active.
Low Coolant Level	Global	Controller displays ‘Low Coolant Level’ and shuts down engine when active.
High Fuel Level	Global	Controller displays ‘High Fuel Level’ warning when active.
Fuel in Basin	Global	Controller displays ‘Fuel in Basin’ warning when active.
Battle Mode	After Cranking	Controller ignores all warnings and failures when active. Displays ‘Battle Running’ when active. If a failure occurs during Battle Mode, it is ‘latched’ and the engine will shut down on failure when the controller leaves Battle Mode.
Start Inhibit	Global	Controller ignores all Start commands and the engine cannot start when active. Once Start Inhibit becomes inactive, starting is enabled again. If the engine is running, activating this input will shut down the engine.
Speed Increment	Auto Running	Allows the operator to increment the engine speed.
Speed Decrement	Auto Running	Allows the operator to decrement the engine speed.
Remote Reset	Global	Allows the controller to be reset from a Failure Mode. • Momentary action for 3-5 seconds in Failure Mode will place the controller in Off Mode • Momentary action for 3-5 seconds in Off Mode will place the controller in Auto Mode • Momentary action for 3-5 seconds in Run Mode will place the controller in Auto Mode. Cooldown is skipped.

Name	Active Mode	Description
ECM Preheat (ECM Preheat Signal)	Cranking (during the Preheat countdown only)	Controls preheating using a switched input. See Switched Input in the Preheat Mode section.

10 Switched Outputs

The controller is equipped with switched outputs that can be configured to activate under certain conditions. When activated, the switched outputs are switched to battery voltage to drive the associated loads when active. The following items are the available functions for switched outputs.

Engine Control		
Setting	***Active Mode***	***Description***
Fuel	Cranking Running	Active during cranking and running to supply fuel to engine.
Crank	Cranking	Active during cranking to start the engine.
Pull Coil	Cranking	For pull and hold fuel systems, activate for two seconds before the fuel Switched Output activates at engine start. The fuel Switched Output acts as a hold.
ETS Shutdown	ETS Timer	Active during Energize to Stop timer.
After Warmup	Running	Active following warmup period.
Voltage Regulator	Running	Active when engine is starting/running and is not in Idle Mode.
System in Idle	Idle Mode	Active when Idle Mode switched input is active.
System in Battle	Battle Mode	Active when Battle Mode switched input is active.
Programmable Output	Global	Active when selected event is active.
System Running		
Setting	***Active Mode***	***Description***
System in OFF / System Not in Auto	Off Mode, Failure Mode	Active when the controller is in Off Mode and Failure Mode.
System in Auto / System OK	Auto Mode, Running	Active when the controller is in Auto Mode and Run Mode. This output will stay on until a warning or failure occurs.
Delay to Start	Delay to Start Timer	Active when the Delay to Start timer is active.
System in Preheat	Preheat	Active when system is in Preheat condition.
System in Warmup	Warmup Timer	Active when system is in Warmup condition.
System in Cooldown	Cooldown Timer	Active when system is in Cooldown condition.
Normal Run	Running	Active when system is in Normal Running conditions.
Exerciser Run	Exercise Timer	Active during the engine exercising cycle.
Low Battery Recharging Run	Battery Recharge Timer	Active during the Battery Recharge cycle.

Engine Control		
Maintenance Required	Global	Active when Maintenance timer has expired. If the timer has expired when the controller is in the Run Mode, the output does not turn on until the controller enters the OFF or Auto Mode. See the Engine Maintenance Schedule section.

10.1 Switched Output – Warnings

Warnings, and consequently failures, occur when certain parameters (fuel level, oil pressure, etc.) are outside of specified limits. These settings can be configured and observed using the front panel or the RapidCore Configurator Software.

All warnings and failures are recorded in the Events History section of the menu.

Warning	Enabled Condition(s)	Description
DTC Received Warning	DTC Received enabled (Add selection in Switched Outputs and enable desired Port).	Active when controller receives a DM1 from the ECM.
Charger Fault Warning	Battery Charger Fault enabled (Add selection in Switched Inputs and enable desired Port).	Displays a warning when a Battery Charger Fault is detected.
Fuel in Basin Warning	Fuel in Basin enabled (Add selection in Switched Inputs and enable desired Port).	Displays a warning that there is fuel in the basin.
High AC Current Warning	AC Current signal (Enable and define thresholds under Genset AC Signals).	Displays a warning that the AC Current level is too high, according to the pre-defined thresholds.
Load Imbalance Warning	Load Imbalance Warning enabled (Add selection in Switched Inputs and enable desired Port). See the Load Imbalance section. AC Current feature.	Generator load imbalance between AC line currents. Excessive AC current on one or more of the three phases.
Low Oil Pressure Warning	Oil Pressure sensor signal (Enable and define thresholds under Sensors > Oil Pressure > Setpoints).	Displays a warning that the Oil Pressure is too low.
Low Engine Temperature	Engine Temperature sensor signal (Enable and define thresholds under Sensors > Engine Temperature > Setpoints).	Displays a warning that the Engine Temperature is too low. This is often used to indicate a malfunction of the engine block heater in stationary generator applications.

Warning	Enabled Condition(s)	Description
High Engine Temperature	Engine Temperature sensor signal (Enable and define thresholds under Sensors > Engine Temperature > Setpoints).	Displays a warning that the Engine Temperature is too high.
Low Fuel Level Warning	Fuel Level sensor signal (Enable and define thresholds under Sensors > Fuel Level > Setpoints).	Displays a warning that the Fuel Level is too low.
High Fuel Level Warning	Fuel Level sensor signal (Enable and define thresholds under Sensors > Fuel Level > Setpoints).	High Fuel Level warning. This is often used to indicate an over fueling condition where fuel could be overflowing from the fuel tank.
Low Battery Warning	Battery sensor signal (Enable and define thresholds under Sensors > Battery > Setpoints).	Displays a warning that the battery level is too low, according to pre-defined thresholds.
High Battery Warning	Battery sensor signal (Enable and define thresholds under Sensors > Battery > Setpoints).	Displays a warning that the battery level is too high, according to pre-defined thresholds.
Low Engine Speed Warning	Engine speed signal (Enable and define thresholds under Engine Speed).	Displays a warning that the Engine Speed level is too low, according to pre-defined thresholds.
High Engine Speed Warning	Engine speed signal (Enable and define thresholds under Engine Speed).	Displays a warning that the Engine Speed level is too high, according to pre-defined thresholds.
Low Frequency Warning	Frequency signal (Enable and define thresholds under Genset AC Signal).	Displays a warning that the AC frequency level is too low, according to pre-defined thresholds.
High Frequency Warning	Frequency signal (Enable and define thresholds under Genset AC Signal).	Displays a warning that the AC frequency level is too high, according to pre-defined thresholds.
Low AC Voltage Warning	AC Voltage signal (Enable and define thresholds under Genset AC Signal).	Displays a warning that the AC Voltage level is too low, according to pre-defined thresholds.
High AC Voltage Warning	AC Voltage signal (Enable and define thresholds under Genset AC Signal).	Displays a warning that the AC Voltage level is too high, according to pre-defined thresholds.

10.2 Switched Output – Failures

Failures are conditions that cause the controller to shutdown to prevent damage to the engine or generator, or harm to the operators. These are conditions that can be enabled or disabled when the operator configures the various settings in the controller.

Figure 18 illustrates what the operator will see from a failure state.

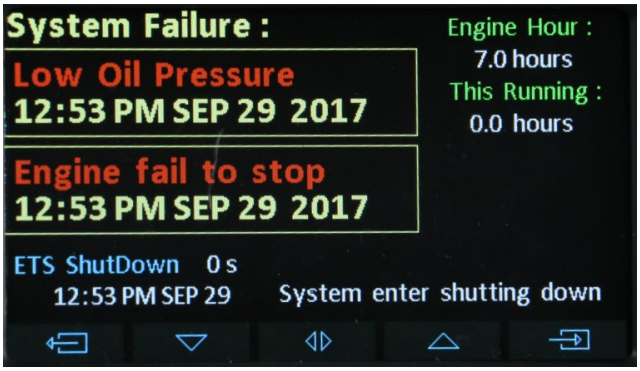

Figure 18: Failure State

The following table describes notable failures:

Failure Name	Enabled Conditions	Description
Over Crank Failure	Failure based on the monitoring of engine cranking as defined by the operator under the Engine Logic and Switched Outputs sections.	Once crank time and attempts have been exceeded, controller will enter a failure state.
DM1 Stop Lamp Failure	Failure based on a DM1 Stop Lamp active signal via J1939.	When the controller receives the appropriate J1939 signal for DM1 Lamp status, a failure occurs.
Failure to Stop	Engine Speed feature. Disabled when ETS On Duration is set to 0 seconds; otherwise, it is enabled. ETS should be set to at least 2 to 3 seconds; otherwise, this failure may not occur.	After ETS countdown is finished, if the speed was greater than 50 RPM for the previous 2 seconds, then the controller triggers this failure.
High AC Current Failure	Failure based on the monitoring of AC Genset Current (Enable and define under Genset Current > Setpoints).	AC Overcurrent failure condition.
Load Imbalance Failure	See the Load Imbalance section. AC Current feature.	Generator load imbalance. Excessive AC current on one or more of the three phases.
Exception Failure	Configured to be displayed in the Switched Outputs section.	When the controller encounters an unhandled exception or lockup (watchdog triggered), it will reset and enter the Failure Mode as an exception fault. Essentially, this is an indication of an internally generated failure due to a bug.
Loss of ECM Failure	Enabled if loss of ECM communication is enabled. J1939 feature; refer to the J1939 CANbus section.	Enabled if the controller has not received messages from the ECM for 6 seconds.

Failure Name	Enabled Conditions	Description
Common Failure	Configured to be displayed in the Switched Outputs section.	Used to indicate a general failure externally. Triggered on any failure.
Low Coolant Failure	Low Coolant Level enabled (Add selection in Switched Inputs and enable desired Port).	Low Coolant Level failure condition.
Low Air Pressure Failure	Switched input set to “Low Air Pressure Failure” function and triggered if switched input is active. See Switched Inputs.	Application specific.
Low Hydraulic Pressure Failure	Low Hydraulic Pressure enabled (Add selection in Switched Inputs and enable desired Port).	Refers to Low Hydraulic pressure usually. Application specific.
High Engine Temperature Failure	Engine Temperature sensor signal (Enable and define thresholds under Sensors > Engine Temperature > Setpoints).	High Engine Temperature failure condition.
Low Fuel Level Failure	Fuel Level sensor signal (Enable and define thresholds under Sensors > Fuel Level > Setpoints).	Low Fuel Level failure condition.
Low Oil Pressure Failure	Oil Pressure sensor signal (Enable and define thresholds under Sensors > Oil Pressure > Setpoints).	Low Oil Pressure failure condition.
Low Battery Voltage Failure	Battery sensor signal (Enable and define under Sensors > Battery > Setpoints).	Low Battery failure condition.
High Battery Voltage Failure	Battery sensor signal (Enable and define under Sensors > Battery > Setpoints).	High Battery failure condition.
Low Speed Failure	Speed sensor signal (Enable and define thresholds under Sensors > Engine Speed > Speed Settings and Setpoints).	Under Speed failure condition.
High Speed Failure	Speed sensor signal (Enable and define thresholds under Sensors > Engine Speed > Speed Settings and Setpoints).	Over Speed failure condition.
Low Frequency Failure	Failure based on the monitoring of AC Genset Frequency (Enable and define under Genset Frequency > Setpoints).	Under Frequency failure condition.
High Frequency Failure	Failure based on the monitoring of AC Genset Frequency (Enable and define under Genset Frequency > Setpoints).	Over Frequency failure condition.
Low AC Voltage Failure	Failure based on the monitoring of AC Genset Voltage (Enable and define under Genset Voltage > Setpoints).	AC Under Voltage failure condition.

Failure Name	Enabled Conditions	Description
High AC Voltage Failure	Failure based on the monitoring of AC Genset Voltage (Enable and define under Genset Voltage > Setpoints).	AC Over Voltage failure condition.

10.3 Switched Output – Other Functions

Other Functions	Condition	Description
Automatic Idle	Warmup, Cooldown	Active when the Warmup or Cooldown Idle is active. See Warmup Idle and Idle Cooldown in the Engine Timer Logic section. This does to react to the Idle switched input.
Dummy Load	Running	Output is controlled by the dummy load feature.
Genset Disable	Global	Disables the generator during a stationary Regen on Kubota engines (see Aftertreatment in the J1939 User Manual) or also during an engine IDLE condition from the IDLE switched input. Automatic idle is ignored. If the generator voltage is not below the under voltage setpoint in 10 seconds, the controller will shut down the engine on “Generator Disable Failure.”
Current Breaker Trip	Running	Output is controlled by the Over Current Failure or IDMT features and by the Load Imbalance feature.
TSC1 Speed Increment	Running	The controller communicates with the ECM of an electronic engine to adjust its speed by broadcasting the TSC1 command. Refer to the J1939 Reference Manual for more information; it can be found at www.cattron.com.
TSC1 Speed Decrement	Running	
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.
DEF Fluid Pump	Running	Active when DEF Fluid Level falls below the DEF Low Level and stays active until the level rises above the DEF High Level. See the J1939 CANbus section for more information.
Transducer Power	Global	This is the “Start” and “Stop” transducer setting.

User Defined Signals	Condition	Description
Defined Event 1-8	Global	Application specific; the operator defines the event as a trigger signal during customizing various Switched Input Events.

User Defined Signals	Condition	Description
Auxiliary Sensor 1-10 Trigger	Global	Application specific; the operator selects a trigger signal after customizing the Auxiliary Sensor Trigger.
Virtual Auxiliary Sensor 1-5 Trigger	Global	Application specific; the operator selects a trigger signal after customizing the Virtual Auxiliary Sensor Trigger.

Logic Defined Signals	Condition	Description
OR Signal 1-4	Global	Common events defined by logic assigned to engine conditions.
AND Signal 1-4	Global	

*Common AND Signal: All events must be active for the Switched Output to respond and indicate activity.

*Common OR Signal: Either one of the events, NOT all, must be active for the Switched Output to respond.

10.4 Programmable Output

The Programmable Output is a Switched Output that is configurable for certain applications.

Setting	Active Mode	Description
Low Battery During Cranking	Cranking	Active when low battery voltage threshold is met during cranking.
Fuel Type	Global	Active when Fuel Type 2 is selected.

11 Engine Speed

Use the following settings' configurations to allow the controller to read and interpret speed sensing data.

Setting	Range	Description
System	50 Hz 60 Hz (default) Auto Selection	Used for changing between Primary and Secondary RPM for an engine or 50 Hz / 60 Hz for a generator.
Signal Source	J1939 Bus Magnetic Pickup Generator Voltage (default) TACH Signal	Source selection for the engine speed signal: J1939 – Engine speed is obtained over the engine CAN communication bus. Genset Voltage – The AC Voltage connector phase A is used for engine speed. Magnetic Pickup/TACH Signal – A magnetic pickup, alternator output, function generator, tachometer or the distributor signal can be used to sense speed. Must use J1 pins 34 and 35. If using a distributer, a filter is often required. Contact Cattron at www.cattron.com for more information on using a distributor signal.

11.1 Speed Settings

Use the following settings' configurations to allow the controller to read and interpret RPM and flywheel teeth.

Setting	Range	Description
Rated RPM	500-4000 RPM (default 1800 RPM)	Speed at which the engine runs under normal operating conditions. Warning and failure setpoints are calculated from this setting.
Idle RPM	500-4000 RPM (default 900 RPM)	Speed at which the engine runs when it is idling.
Tooth Count	0.1-600 (default 110)	Applies when Signal Source is set to Magnetic Pickup or TACH Signal. Number of teeth on the flywheel. If the number of teeth is unknown, the following formula can be used. A multimeter must be used to measure the AC frequency in Hertz (f below) from the magnetic pickup. The speed in RPM (v below) must be known. Tooth Count = (f * 60) / v When selecting TACH signal, convert the number of teeth according to the distributor poles.

11.2 Engine Speed Setpoints

Use the following settings' configurations to select the desired speed warnings and failures. This will prevent possible damage to the engine or generator.

Setting	Range	Description
Under Speed Warning	500-4000 RPM (default 1700 RPM)	Reading at which a warning occurs.
Under Speed Failure	500-4000 RPM (default 1600 RPM)	Reading at which a failure occurs.
Over Speed Warning	500-4000 RPM (default 1900 RPM)	Reading at which a warning occurs.
Over Speed Failure	500-4000 RPM (default 2000 RPM)	A over speed failure is triggered if the speed is above this threshold for 4 seconds.

11.3 ECM Speed Control Modes

11.3.1 Manual Start

When the user starts the engine from the front panel run button or key switch start input, the controller will refer to the settings defined under this profile.

Setting	Range	Description
Initial RPM Set	Rated Speed (default) Idle Speed Aux Speed Auto Ramping	The speed profile or set point to which the controller will go upon start-up. • Rated Speed: The controller will go to the set rated speed. • Idle Speed: The controller will go to the set idle speed. • Aux Speed: The controller will look at the designated Aux sensor as outlined in TSC1 speed settings (default is Aux 1) and go to whatever speed it is presently reading from that Aux sensor if it is set up. • Auto Ramping: Upon start-up the unit will go through the defined ramping profile as set in Auto Ramping Setup.

Setting	Range	Description
RPM Adjust Source	Disable (default) Local Remote Both Loop Aux	The RPM can be adjusted when selected by the following options. • Local: User can increase/decrease speed from front panel rabbit/turtle buttons. • Remote: User can use switched inputs, Modbus for remote speed control. • Both: User can use both front panel and remote speed inputs for speed control. • Loop: Speed will automatically adjust based on the settings defined in closed loop control. • Aux: Speed control will be based on the desired Aux input (default is Aux 1). Users must be aware of the position/output signal of their throttle control device upon start-up.
Limit Modes	Min/Max Speed (default) Speed Bias (+/-)	The speed control RPM thresholds. • Min/Max Speed: As defined in the MAX and MIN RPM settings under TSC1 Speed Settings. • Speed Bias: As defined in the Speed Bias settings under TSC1 and the Rated RPM under Speed Settings.

11.3.2 Remote Start

When the user starts the engine from a remote start contact or AutoStart condition. The parameters defining this control profile are the same as those defining Manual Start.

Setting	Range	Description
Initial RPM Set	Rated Speed (Default) Idle Speed Aux Speed Auto Ramping	The speed profile or set point the controller will go to upon start-up. • Rated Speed: The controller will go to the set rated speed. • Idle Speed: The controller will go to the set idle speed. • Aux Speed: The controller will look at the designated Aux sensor as outlined in TSC1 speed settings (default is Aux 1) and go to whatever speed it is presently reading from that Aux sensor if it is set up. • Auto Ramping: Upon start-up the unit will go through the defined ramping profile as set in AUTO Ramping Setup.

Setting	Range	Description
RPM Adjust Source	Disable (Default) Local Remote Both Loop Aux	The RPM can be adjusted when selected by the following. • Local: User can increase/decrease speed from front panel rabbit/turtle buttons. • Remote: User can use switched inputs, Modbus, or J1939 for remote speed control. • Both: User can use both front panel and remote speed inputs for speed control. • Loop: Speed will automatically adjust based on the settings defined in closed loop control. • Aux: Speed control will be based on the desired Aux input (default aux 1) *Users must be aware of the position/output signal of their throttle control device upon start-up.*
Limit Modes	Min/Max Speed (Default) Speed Bias (+/-)	The speed control RPM thresholds. • Min/Max Speed: As defined in the MAX and MIN RPM settings under TSC1 Speed Settings. • Speed Bias: As defined in the Speed Bias settings under TSC1 and the Rated RPM under Speed Settings.

11.3.3 TSC1 Speed Settings

The settings below affect Torque Speed Control and the J1939 message, as well as the active actuator position. TSC1 can be monitored by using a software compatible with J1939 communication.

Setting	Range	Description
Aux Speed	Aux 1-10 (default Aux 1)	Auxiliary sensor selection. Only active when selected as RPM Adjustment Source and/or Initial RPM set in ECM Speed Control Modes > Remote or Manual Start.
Speed Bias (+/-)	5-600 RPM (default 100 RPM)	The minimum or maximum RPM that the engine speed can be adjusted around the rated RPM. Example: Rated RPM is 1800 and Speed Bias is 150. The minimum RPM will be 1650 and maximum RPM will be 1950. Only valid when the correct limit method is chosen.
Bump Speed	1-500 RPM (default 300 RPM)	The RPM change per increment/decrement request signal.
RPM/Sec	10-300 RPM/s (default 200 RPM/s)	Refer to the J1939 Reference Manual for information about this setting; it can be found at www.cattron.com.

Setting	Range	Description
MIN RPM	500-4000 RPM (default 600 RPM)	The minimum RPM that can be set using speed control. Only valid when the correct Limit Method is chosen.
MAX RPM	500-4000 RPM (default 4000 RPM)	The maximum RPM that can be set using speed control. Only valid when the correct Limit Method is chosen.

11.3.4 Auto Ramping Setup

Use the following settings' configurations to allow the controller to read and interpret Auto Ramping Setup. It is only active when selected under Initial RPM Set in ECM Speed Control Modes > Remote or Manual Start.

Setting	Range	Description
Ramping Goal	500-4000 RPM (default 1800 RPM)	Defines the final RPM that the engine will be ramping to reach.
Intermediate	500-4000 RPM (default 1200 RPM)	Defines the intermediate RPM that the engine will reach before continuing to the goal.
Idle to Intermediate Time	1-300 s (default 60 s)	Defines the amount of time that the engine will take to ramp from the idle speed to the intermediate speed.
Intermediate Time	1-300 s (default 100 s)	Defines the amount of time that the engine will remain at the intermediate speed during ramping.
Intermediate to Goal Time	1-300 s (default 100 s)	Defines the amount of time that the engine will take to ramp from the intermediate speed to the goal speed.
Goal to Idle Time	1-300 s (default 60 s)	Defines the amount of time that the engine will take to ramp from the goal speed back to the idle speed.

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

Note: Speed is monitored at the start of cranking. If there is speed detected above the crank disconnect setting, then cranking and idle are skipped. The speed is not monitored during delay-to-start or preheat as this provides some degree of protection against false signals due to noise. The fuel input is turned on at the start of preheat and often powers external equipment that can cause noise.

11.3.5 Front Panel Speed Control

The operator is able to adjust the speed of the engine by using the controller's front panel. This section describes the methods available for implementing speed control, the settings and parameters to be used, and the necessary instructions allowing the operator to control the speed.

Setting	Description
Front Panel Speed Control using J1939 TSC1	The controller can instruct the ECM of an electronic engine to adjust its speed by broadcasting the TSC1 command. Refer to the J1939 Reference Manual for more information; it can be found at www.cattron.com.
Front Panel Speed Control using Switched Outputs *Advanced Setting > Switch Output > Other Functions > Press Menu button until TSC1 Speed Increment/decrement settings appear.*	The controller can instruct the ECM of an electronic engine to adjust its speed by using the TSC1 speed increment/ decrement switched outputs on the controller, set to RPM increment and RPM decrement to interface with digital inputs on the ECM. When the speed is changed, the corresponding switched output will be on for one second each time increment or decrement is pressed. This function also has Electronic Governor systems with increment/ decrement contacts such as the Woodward L series Governors. See the remainder of this section for more information.
Aux Speed Control	The auxiliary sensor is used to determine setpoint speed. The speed is adjusted with the TSC1 J1939 command. Refer to the J1939 Reference Manual for more information; it can be found at www.cattron.com.
Speed Increment/Decrement Front Panel Buttons (Rabbit/Turtle)	The controller features a speed increment button and a speed decrement button, with industry standard rabbit and turtle symbols, respectively. *To Configure via the controller, enter Engine Speed > System Speed Mode > Manual Start.*

11.4 Closed Loop Control

The Process Control feature has two different control methods: Maintain In and Maintain Out. The Maintain In option maintains a reservoir level by controlling the flow of fluid into the reservoir. The Maintain Out option maintains a reservoir level by controlling the flow of fluid from the reservoir. It does this by regulating the speed of the engine over the J1939 CANbus.

The controller reads the sensor value from selected Auxiliary Sensor input, compares the input value set-point, and then, based on an algorithm, increments or decrements the speed (RPM) by an amount proportional to the difference between the setpoint and actual level to maintain the desired set-point outside of the deadband area. Control pauses inside the deadband area. If the sensor input goes beyond a minimum or maximum value, the RPM will be maintained at a minimum or maximum value.

The algorithm is a logic type control with a deadband and a minimum/maximum saturation. The user sets the aggressiveness of the control with the Gain setting and the response time of the control with the Delay setting.

Setting	Range	Description
Control Type	Disable (default) Maintain In Maintain Out	Maintain In controls the level when pumping fluid into a reservoir. Maintain Out controls the level while pumping fluid out of the reservoir.
Signal Source	Auxiliary Sensor 1-10 (default Auxiliary Sensor 1)	The Auxiliary Sensor Input function that is providing feedback on the reservoir level.
Delay	0.1-30 s (default 5 s)	The sampling time of the control algorithm.
Gain	1-30 (default 19)	The amount to increment or decrement the RPM proportional to the sensed value outside of the deadband.

Setpoints	Range	Description
Maintain In	1-900 (default 300)	The level set-point to attempt to maintain. Only applies if System is set to In-Keep.
Maintain Out	1-900 (default 500)	The level set-point to attempt to maintain. Only applies if System is set to Out-Keep.
High Deadband	1-30 (default 3)	The high limit of the deadband.
Low Deadband	1-30 (default 3)	The low limit of the deadband.

Thresholds	Range	Description
High Limit	1- 900 (default 700)	The high saturation. The maximum level at which the RPM control is fixed.
Low Limit	1-900 (default 100)	The low saturation. The minimum level at which the RPM control is fixed.
Max Limit RPM	500-4000 RPM (default 3200 RPM)	The fixed RPM that should be used when the level rises above the High Limit.
Low Limit RPM	500-4000 RPM (default 1000 RPM)	The fixed RPM that should be used when the level falls below the Low Limit.

12 Sensors

The TOUGH Series PRO has 10 sensor inputs which can be connected to a variety of different sensors/switches depending on the input. See the Terminal Descriptions section for more information regarding the sensor types supported.

To configure the behavior of these sensor inputs, the user assigns the sensor input to one of the following:

- Engine Temperature
- Oil Pressure
- Fuel Level
- Auxiliary Sensor 1 – 10

The Engine Temperature, Oil Pressure, and Fuel Level functions are fixed in functionality but assigned by the operator. The Auxiliary sensors can be configured to perform specific shutdowns or special functions (Example: Starting engine on low temperature).

12.1 System Battery

Use the following settings' configurations to allow the controller to read and interpret the battery voltage level. Figure 19 illustrates the logic flow for the recharge functionality.

Setting	Range	Description
AutoStart Level	Disable (default) 5-50 V	Voltage level at which the controller starts the engine to recharge the battery.
Recharge Pre-Alarm	1-30 min (default 5 min)	Amount of time to display a warning before starting the engine.
Recharge Run Duration	10-900 min (default 30 min)	Amount of time to run the engine.
Setpoints		
Setting	**Range**	**Description**
Low Warning	Disable 5-50 V (default 9 V)	Reading at which a warning occurs.
Low Failure	Disable 5-50 V (default 8 V)	Reading at which a failure occurs.
High Warning	Disable 5-50 V (default 27 V)	Reading at which a warning occurs.
High Failure	Disable 5-50 V (default 28 V)	Reading at which a failure occurs.
Low Battery During Cranking	5-50 V (default 9 V)	Screen displays a 'Low Voltage During Cranking' warning if voltage drops below this level during cranking.

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.

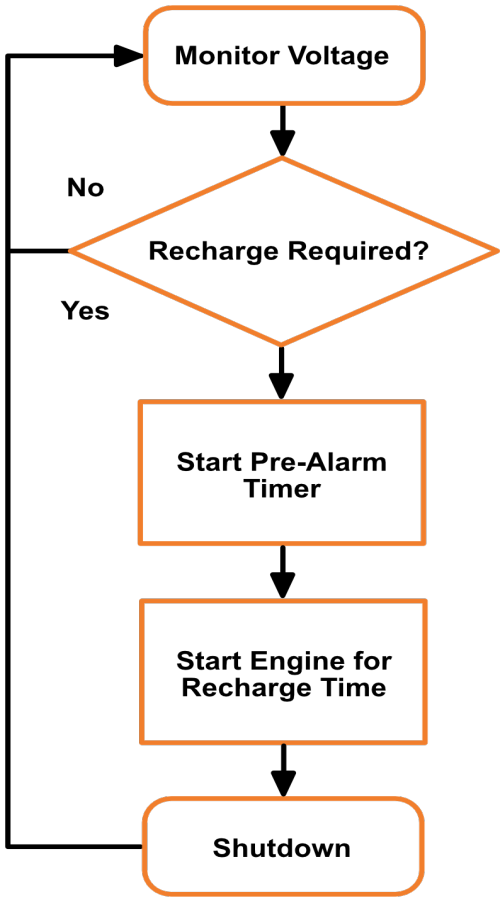

Figure 19: Battery Recharge Functionality

12.2 Engine Temperature

Use the following settings' configurations to allow the controller to read and interpret data from the engine temperature sensor or switch.

Setting	Range	Description
Signal Source	Sensor Input 1 (default) Disable Sensor Input 1-10 J1939 Bus*	The sensor input pin where the engine temperature switch or sender is attached. *Engine temperature is obtained from the engine controller (ECM) using the CANbus communication port and J1939 protocol.

Setting	Range	Description
Sensor Type	DAT DAH* (default) VDO 250F* Custom sender**	Select the sender that is connected to the Signal Source above. If using a switch, select the action that should occur when the switch is active. *These are preprogrammed into the controller and cannot be changed. • DAT DAH supports all Datcon type DAH (high range) temperature sensors such as 02022-00 • VDO 250F supports the VDO 323-420 or equivalent temperature sensor **A custom table can be created using the RapidCore Configurator Software. The text (custom sender) will be replaced with the custom text you choose when creating the sender.
Trim Offset	-50.0 ~ 50.0 °F (default 0 °F)	Calibrate a sensor by using the offset to correct errors. Only applies if Sensor Type has been set to a sender.
Engine Temp. Custom Sender Table	Name: Custom Text Input Type: Resistance Voltage 4-20 mA Unit Type: Temperature Sender: Custom Table	Custom Sender configuration options. The user can create a sender table that applies to the application.
Setpoints		
Setting	**Range**	**Description**
Bypass Time	1-30 s (default 10 s)	Amount of time to bypass warnings and failures after engine has started.
Low Warning	Disabled 5 ~ 399 °F (default 50 °F) (-15 ~ 204 °C)	Reading at which a “Low Engine Temp” warning occurs. Displays 'Low Engine Temp' on the screen. Only applies if Sensor Type has been set to a sender. Monitored globally including OFF and AUTO.
High Warning	Disabled 5 ~ 399 °F (default 200 °F) (-15 ~ 204 °C)	Reading at which a “High Engine Temp” warning occurs. Only applies if Sensor Type has been set to a sender. Only monitored in the Run Mode.
High Failure	Disabled 5 ~ 399 °F (default 220 °F) (-15 ~ 204 °C)	Reading at which a “High Engine Temp” failure occurs. Only applies if Sensor Type has been set to a sender. Only monitored in the Run Mode.

12.3 Oil Pressure

Use the following settings' configurations to allow the controller to read and interpret data from the oil pressure sensor or switch.

Setting	Range	Description
Signal Source	Sensor Input 3 (default) Disable Sensor Input 1-10 J1939 Bus*	The sensor input pin where the oil pressure switch or sender is attached. *Oil pressure is obtained from the engine controller (ECM) using the CANbus communication port and J1939 protocol. *When Oil Pressure is signaled by J1939, it will only show the value when in Run Mode. If in Auto or Off Mode, it will display N/A.
Sensor Type	DAT 100P/R240* (default) VDO 150P/R180* Custom sender**	Select the sender that is connected to the Signal Source above. If using a switch, select the action that should occur when the switch is active. *These are preprogrammed into the controller and cannot be changed. • DAT 100P/R240 supports the Stewart - Warner 279B-F and Datcon 2505-00 sender tables • VDO 150P/R180 supports the VDO 360-004 oil pressure sender **A custom table created using the RapidCore Configurator Software. The text (custom sender) will be replaced with the custom text you choose when creating the sender.
Trim Offset	-50.0 ~ 50.0 psi (default 0 psi) (-344.7 ~ 344.7 kPa)	Calibrate a sensor by using the offset to correct errors. Only applies if Sensor Type has been set to a sender.
Oil Pressure Custom Sender	Name: Custom Text Input Type: Resistance Voltage 4-20 mA Unit Type: Pressure Sender: Custom Table	Custom Sender configuration options. The user can create a sender table that applies to the application.
Setpoints		
Setting	**Range**	**Description**
Bypass Time	1-30 s (default 10 s)	Amount of time to bypass warnings and failures after engine has started.

Setting	Range	Description
Low Warning	Disabled 1-699.9 psi (default 20 psi) (7-4826.3301 kPa)	Reading at which a “Low Oil Pressure” warning occurs. Only applies if Sensor Type has been set to a sender.
Low Failure	Disabled 1-699.9 psi (default 15 psi) (7-4826.3301 kPa)	Reading at which a “Low Oil Pressure” failure occurs. Only applies if Sensor Type has been set to a sender.

12.4 Fuel Level

Use the following settings’ configurations to allow the controller to read and interpret data from the fuel level sensor.

Setting	Range	Description
Signal Source	Sensor Input 4 (default) Disable Sensor Input 1-10	The sensor input pin where the fuel level switch or sender is attached.
Sensor Type	DAT R/33-240* (default) VDO R/0-180* Custom sender**	Select the sender that is connected to the Signal Source above. If using a switch, select the action that should occur when the switch is active. *These are preprogrammed into the controller and cannot be changed. • DAT R33-240 supports a DATCON fuel level sensor of the range 33 - 180 Ω • VDO R/0-180 supports a VDO fuel level sensor of the range 0 - 180 Ω **A custom table created using the RapidCore Configurator Software. The text (custom sender) will be replaced with the custom text you choose when creating the sender.
Trim Offset	-50.0 ~ 50.0% (default 0%)	Calibrate a sensor by using the offset to correct errors. Only applies if Sensor Type has been set to a sender.
Fuel Level Custom Sender	Name: Custom Text Input Type: Resistance Voltage 4-20 mA Unit Type: Level Sender: Custom Table	Custom Sender configuration options. The user can create a sender table that applies to the application.

Setting	Range	Description
Setpoints		
Bypass Time	1-30 s (default 10 s)	Amount of time to bypass warnings and failures after engine has started.
Low Warning	Disabled 1-100% (default 20%)	Reading at which a “Low Fuel Level” warning occurs. Only applies if Sensor Type has been set to a sender. Only monitored in the Run Mode.
Low Failure	Disabled 1-100% (default 15%)	Reading at which a “Low Fuel Level” failure occurs. Only applies if Sensor Type has been set to a sender. Only monitored in the Run Mode.
High Warning	Disabled 1-100% (default 96%)	Reading at which a “High Fuel Level” warning occurs. Displays ‘High Fuel Level’ on the screen. Only applies if Sensor Type has been set to a sender. Monitored globally including OFF and AUTO.

12.5 Auxiliary Sensors

The TOUGH Series PRO has 10 auxiliary sensor inputs that are used for supporting custom sensors and triggering actions based on the sensor values.

You must use the RapidCore Configurator Software to program a custom sender table to the controller for the auxiliary sensor(s) that will be used. Otherwise, an undefined sensor will appear in the front panel menu system. Once a sender table is programmed to the controller, all the other settings can be adjusted from the front panel of the controller.

Scroll through each Auxiliary Configuration by pressing the menu/navigational button below the LCD.

Setting	Range	Description
Display	Disable (default) Hidden Auto Engage Running	Determines when the sensor’s value is displayed on the screen, during either Auto Mode, Engage or Running.
Name	Custom Text	Defines the sensor name to be displayed.
Sender Table Type	Custom Table (default) Datcon DAH VDO 250F Datcon 100P/R240 VDO 150P/R180	The sender resistance/value curve must be programmed from the RapidCore Configurator Software even if the port is being overloaded. This tells the controller how to interpret the signal from the port. No front panel configuration is allowed

Setting	Range	Description
	Datcon R/33-240 VDO R/0-180 TF1 115F/R240 TF2 231F/R240 TP1 200P/R240 TP2 100P/R240	until the sender curve is programmed to the controller.
Trim Offset	-500 ~ 500 units (default 0) The units depend on the unit type of the programmed sender table (°F, psi, %, V, A)	This displays a fixed offset to the actual sensor reading. The operator can calibrate a sensor by using the offset to correct errors.
Bypass Time	0.1-30 s (default 5 s)	The period of time a sensor will be ignored after entering the active state, according to the configured sensor.
Auxiliary Sensor Custom Sender	Name: Custom Text Input Type: Resistance Voltage 4-20 mA Unit Type: Temperature Level Pressure Voltage Current Length Speed Sender: Custom Table	Custom Sender configuration options. The user can create a sender table that applies to the application.

Auxiliary Sensor Configuration

Setting	Range	Description
Start Configuration	Name: Custom Text Is: Greater Than Less Than (default) Constant: Disable (default) 0.1-6000 More Than: 0.1-3600 s (default 3 s) Run Duration: 1-900 min (default 60 min)	User configurable engine start control based on logic relating to sensor parameters and comparison. “More than” is the period of time that a sensor is greater than or less than a given set point for it to trigger a Start command. “More Than” time will not begin until the Auxiliary Sensor “Bypass Time” has completed.

Setting	Range	Description
Stop Configuration	Name: Custom Text Is: Greater Than Less Than (default) Constant: Disable (default) 0.1-6000 More Than: 0.1-3600s (default 3 s)	User configurable engine stop control based on logic relating to sensor parameters and comparison. “More than” is the period of time that a sensor is greater than or less than a given set point for it to trigger a Stop command. “More Than” time will not begin until the Auxiliary Sensor “Bypass Time” has completed.
Warning Configuration	Warning Delay: 0.1-3600 s (default 3 s) Low Warning Name: Custom Text Value: Disable (default) 0.1-6000 High Warning Name: Custom Text Value: Disable (default) 0.1-6000 Active Modes: Off Auto Engage Running Cooldown Shutdown	User configurable warning based on the logic relating to sensor parameters and comparison. Warning Delay is the period of time a sensor must be active before the configured warning is activated. The Warning Delay time will not begin until the Auxiliary Sensor “Bypass Time” has completed. Active Modes refer to the engine states in which the configured warning condition can occur.
Failure Configuration	Failure Delay: 0.1-3600 s (default 3 s) Low Failure Name: Custom Text Value: Disable (default) 0.1-6000 High Failure Name: Custom Text Value: Disable (default) 0.1-6000 Active Modes: Off Auto Engage Running Cooldown Shutdown Failure	User configurable failure based on the logic relating to sensor parameters and comparison. Failure Delay is the period of time a sensor must be active before the configured failure is activated. The Failure Delay time will not begin until the Auxiliary Sensor “Bypass Time” has completed. Active Modes refer to the engine states in which the configured failure condition can occur.

Setting	Range	Description
Trigger Configuration	Name: Custom Text If: Greater Than Less Than (default) Constant: Disable (default) 0.1-6000 More Than: 0.1-3600 s (default 3 s) Hysteresis: Disable (default) 0.1-6000 *Special: Inhibit Start Hold Cooldown Active Modes: Off Auto Engage Running Cooldown Shutdown	User configurable trigger based on the logic relating to sensor parameters and comparison. “More than” is the period of time that a sensor is greater than or less than a given set point for it to trigger the “Special” or signal command. “More Than” time will not begin until the Auxiliary Sensor “Bypass Time” has completed. Hysteresis value is a delta from the constant. For example, if configured to trigger if less than 100.0 with a hysteresis value of 25, the trigger would occur at 99.9; and clear at 125.1.

* **Inhibit Start:** If active and the controller is in Off or Auto Mode, it will prevent the engine from starting. If Active and the controller is in the Engage, Running or Cooldown states, the controller will shut down and enter Auto Mode bypassing the Cooldown state.

* **Hold Cooldown:** If active while in the Cooldown state, the controller will not shutdown under normal operation. Activating start inhibit, emergency stop, or a failure will cause the engine to stop.

12.5.1 Temperature Fault Monitoring Example

In this example, a sensor is monitoring the temperature of an engine block. After the Auxiliary Sensor is programmed in the TOUGH Series PRO unit, the user can choose either an Auxiliary warning or failure. The Auxiliary Configuration allows the user the option to program the warning or failure for greater than or less than applications. The Auxiliary Trigger Signal 1-10 can be selected as well for the indication using a switched output.

Figure 20 shows the connection between engine temperature and time. At approximately 13 minutes run time, the temperature rises above the 275 °F warning threshold, activating the warning display. The engine will continue to run because it has not reached the 350 °F failure threshold. At 20 minutes run time, the temperature falls below the warning threshold, and the warning disappears. The failure will not be activated until the temperature reaches above 350 °F.

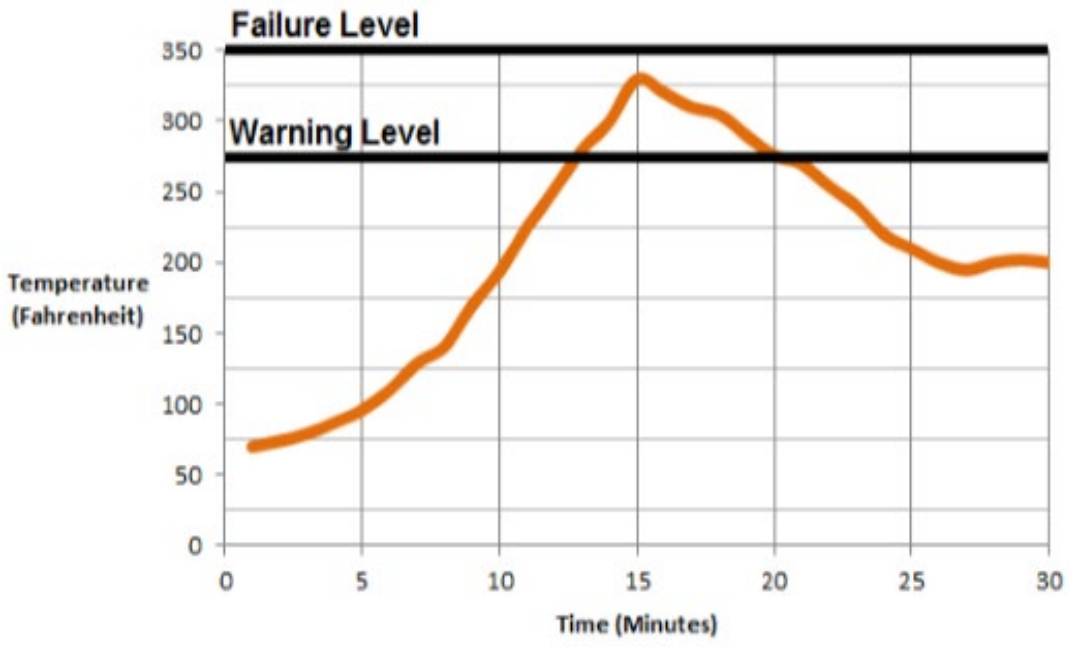

Figure 20: Engine Temperature Warnings and Failures

12.6 Virtual Auxiliary Sensors

The TOUGH Series PRO has five virtual auxiliary sensor inputs that are assigned to auxiliary sensors for triggering actions. The Virtual Auxiliary Sensor value is based on the assigned Auxiliary Sensor value.

Example of a Virtual Auxiliary Sensor:

- Virtual Sensor 1 is sourced to Auxiliary Sensor 1
- The warning, failure and trigger values for Virtual Sensor 1 are triggered through the Auxiliary Sensor 1 value

Setting	Range	Description
Virtual Auxiliary Sensor	Source: Disable (default) Auxiliary Sensor 1-10 Bypass Time: 0.1-30 s (default 5 s)	The auxiliary sensor selected will determine the base value for the virtual sensor.
Warning Configuration	Warning Delay: 0.1-3600s (default 3 s) Low Warning Name: Custom Text Low Warning Value: Disable (default) 0.1-6000 High Warning Name: Custom Text High Warning Value: Disable (default) 0.1-6000	User configurable warning. The warning is activated when the assigned auxiliary sensor value drops below/exceeds the configurable value for the virtual sensor. Warning Delay is the period of time a sensor must be active before the configured warning is activated. The Warning Delay time will not begin until the Auxiliary Sensor “Bypass Time” has completed.

Setting	Range	Description
	Active Modes: Off Auto Engage Running Cooldown Shutdown	Active Modes refer to the engine states in which the configured warning condition can occur.
Failure Configuration	Failure Delay: 0.1-3600s Low Failure Name: Custom Text Value: Disable (default) 0.1-6000 High Failure Name: Custom Text Value: Disable (default) 0.1-6000 Active Modes: Off Auto Engage Running Cooldown Shutdown Failure	User configurable failure. The failure is activated when the assigned auxiliary sensor value drops below/exceeds the configurable value for the virtual sensor. Failure Delay is the period of time a sensor must be active before the configured failure is activated. The Failure Delay time will not begin until the Auxiliary Sensor “Bypass Time” has completed. Active Modes refer to the engine states in which the configured failure condition can occur.
Trigger Configuration	If: Greater Than Less Than Constant: Disable (default) 0.1-6000 More Than: Disable (default) 0.1-3600 s Hysteresis: Disable (default) 0.1-6000 *Special: Inhibit Start Hold Cooldown Active Modes: Off Auto Engage Running Cooldown Shutdown	User configurable trigger. The trigger is activated when the assigned auxiliary sensor value drops below/exceeds the configurable value for the virtual sensor. “More than” is the period of time that a sensor is greater than or less than a given set point for it to trigger the “Special” or signal command. “More Than” time will not begin until the Auxiliary Sensor “Bypass Time” has completed.

* **Inhibit Start:** If active and the controller is in Off or Auto Mode, it will prevent the engine from starting. If Active and the controller is in the Engage, Running or Cooldown states, the controller will shut down and enter Auto Mode bypassing the Cooldown state.

* **Hold Cooldown:** If active while in the Cooldown state, the controller will not shutdown under normal operation. Activating start inhibit, emergency stop, or a failure will cause the engine to stop.

13 Timers & Scheduler

The controller has an internal clock which is used not only to keep time, but to ensure programed 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 unpowered (no main power) lifetime of approximately five years.

13.1 Engine Timer 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.

Setting	Range	Description
Delay to Start	Disable 1-90 s (default 6 s)	Amount of time to delay the starting of the engine after receiving a command to start.
Delay to Start on Manual Run	Enable (default) Disable	Determines if the Delay to Start timer is used when the front panel RUN button is used to start the engine.
Preheat Signal Source	Preheat Timer (default) Switched Input J1939	Determines the method used to control enabling the glow plug output. See the Preheat Mode section for more information.
Preheat Time	Disable 1-1200 s (default 8 s)	Amount of time the glow plug output is active before cranking the engine. Used on diesel engines to warm the engine before cranking.
Midheat Time	Disable (default) 1-90 s	Keeps glow plug output turned on while cranking but not during crank rest. Output will turn off upon crank failure, crank success or midheat time expiration.
Postheat Time	Disable (default) 1-90 s	Amount of time the glow plug output remains on after crank success and the engine is running.
Crank Time	3-30 s (default 3 s)	Amount of time the Crank output is active before going to crank rest. This timer immediately expires upon successful cranking.
Crank Rest Time	3-60 s (default 5 s)	Amount of time to delay between each attempt to start the engine.
Crank Attempts	1-12 (default 3)	Number of attempts to start the engine before going to an over crank failure.

Setting	Range	Description
Fuel ON While Resting	Fuel ON (default) Fuel OFF	Determines if the fuel output stays on during the crank rest time.
Crank Success RPM	100-2000 RPM (default 660 RPM)	Speed at which controller determines the engine has started successfully and turns off the Crank output.
False Start Restart	Enable Disable (default)	Enable false start (engine stall) detection. 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 Detect Time	3-30 s (default 10 s)	If False Start Reset is enabled, it will also enable this feature. It is the amount of time after crank success to monitor for a false start.
Stall Detection	Enable (default) Disable	When enabled, the controller detects when the engine is stalling. A message will appear on the controller indicating a stalling state.
Warmup Time	Disable 1-1200 s (default 30 s)	After successful cranking, the engine delays this amount of time before turning on the Warmup output. This allows the engine to warm up before applying any load to it. The output will turn off when the controller enters the Cooldown Delay.
OFF Key Function	Cooldown (default) Shutdown Force Cooldown	The function the OFF key on the front panel performs while the engine is running. See the OFF Key Function section for more information.
Cooldown Time	Disable 5-6000 s (default 30 s)	Amount of time to cool down the engine after a stop command has been received. During this time, the Warmup output turns off and the Cooldown output turns on. If another start command is received during cool down, the controller will return to Running mode.
Energize to Stop Duration	Disable 3-300 s (default 3 s)	Amount of time the Energize to Stop output is on after the engine has shut down. 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.

Setting	Range	Description
Failed to Stop	Disable 100-1000 RPM (default 500 RPM)	RPM over which the controller will consider the engine to have failed to stop.
Warmup Idle	Disable (default) Warmup Timer Oil Temperature Engine Temperature	Configurable parameter for Warmup Idle. The Warmup Idle is used to run the engine at a reduced speed at engine start. Can be configured to idle for a set period of time, based on achieving a target oil temperature or engine temperature in order to warm up the engine as desired by the operator.
Idle Settings		
Setting	**Range**	**Description**
Idle Limit	1-10 s (default 10 s)	Idle time limit (for use with Oil Temperature or Engine Temperature warmup conditions).
Idle Low Setpoint Temperature	10-399 °F (default 32 °F)	Low temperature threshold for Warmup Idle parameters (for use with Oil Temperature or Engine Temperature warmup conditions).
Idle High Setpoint Temperature	10-399 °F (default 50 °F)	High temperature threshold for Warmup Idle parameters (for use with Oil Temperature or Engine Temperature warmup conditions).
Idle Cooldown	Enable Disable (default)	Idle during Cooldown conditions.
Start/Stop Switch Input Inhibit	Enable Disable (default)	Prevent the remote start switch input from starting the engine when the idle switch is active.
Aux Start Idle Inhibit	Enable Disable (default)	Prevent the auxiliary start switch input from starting the engine when the idle switch is active.
Switch Start Idle Inhibit	Enable Disable (default)	Prevent the start switch on a switched input from starting the engine when the idle switch is active.

13.1.1 Idle

The TOUGH Series PRO ignores under speed, voltage, and frequency warnings and failures when Idle is active. If using J1939, the controller will broadcast TSC1 as the Idle Speed parameter found in the Engine Speed section.

This section explains the general idle functionality.

There are three ways to use idle:

- Warmup Idle - Automatically enter the Idle Mode during warmup for a period of time before going to rated speed. See Warmup Idle in the Engine Timer Logic section
- Cooldown Idle - Idle automatically during cool down
- Idle Switched Input - Idle whenever this switched input is active. See the Idle Mode function under Switched Inputs

If the engine is in the Idle Mode because of the Warmup Idle feature, the remote start (start/stop) and auxiliary sensors AutoStart will still start the engine.

This prevents starting when the Idle switch is active in the Auto Mode. This will also shut down the engine if the idle switched input is activated when the controller is in the delay-to-start, preheat, cranking, and crank reset states. The main purpose is to prevent a remote start if the idle switch was accidentally left on.

13.1.2 Preheat Mode

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

Mode	Description
Preheat Timer	This mode uses the Preheat Time setting in the Engine Logic menu.
Switched Input	This mode uses a switched input set to 'ECM Preheat' to determine when to exit preheat. The preheat time (in the Engine Logic menu) must be set to a minimum of 5 seconds for this input to work. If the switched input is or becomes active when the preheat timer is counting down, the controller displays 'ECM Preheating' on the screen after the preheat counter has finished its countdown. Cranking begins when the 'ECM Preheat' switched input is no longer active.
J1939	This mode uses commands sent from the ECM over J1939 to decide when to exit preheat.

13.1.3 OFF Key Function

The OFF button on the front panel of the controller can be configured to function in three different ways while the engine is running. This can be done using the "OFF Key Function" dropdown menu in the Engine Timer Logic menu of the RapidCore Configurator Software. The table below describes each of these functions.

Function	Description
Cooldown	This function causes the controller to go into cooldown. Pressing the OFF button for the second time will cause the engine to shut down.
Shutdown	This function bypasses Cooldown and causes the engine to shut down.
Force Cooldown	This function causes the controller to activate the cooldown process. Pressing the OFF button will have no effect as the controller is forcing the engine to perform a full cooldown.

⚠	**WARNING** IF THE CONTROLLER RECEIVES A COMMAND TO START FROM THE REMOTE START, FRONT PANEL RUN BUTTON, CANBUS OR MODBUS, OR AUX START WHILE IN COOLDOWN, IT WILL LEAVE THE COOLDOWN MODE AND GO BACK TO RUNNING MODE.

⚠	**AVERTISSEMENT** SI LE CONTROLEUR REÇOIT UNE COMMANDE DE DEMARRAGE A PARTIR DE LA COMMANDE DE DEMARRAGE A DISTANCE, OU DU BOUTON RUN (MARCHE) DU PANNEAU DE COMMANDE ALORS QU'IL EST EN MODE COOLDOWN (REFROIDISSEMENT), IL QUITTERA LE MODE COOLDOWN (REFROIDISSEMENT) ET REVIENDRA AU MODE RUNNING (MARCHE).

13.2 Schedulers

13.2.1 Exercise Scheduler

The Exerciser function is used to start and run the engine periodically. When waiting for the Exercise Scheduler to start, the controller MUST be in Auto Mode. The settings in the following table configure the Exerciser function. Figure 21 illustrates this functionality.

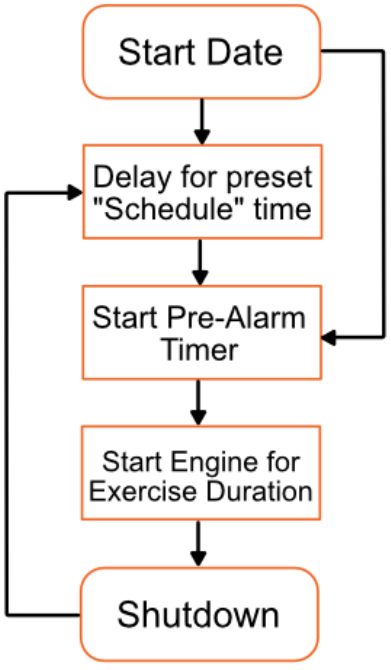

Figure 21: Exerciser Functionality

Setting	Range	Description
Start Time	12:00 AM - 11:45 PM	Start Time for exerciser function.
Pre-alarm	1-20 minutes	Amount of time to display a warning before starting the engine.
Duration	15 minutes - 15 hours	Amount of time to run the engine.
Stop Time	12:00 AM - 11:45 PM	Stop Time for exerciser function.
Schedule: Daily/Weekly	Sunday-Saturday	Configurable frequency of exerciser. Number of days/weeks between each exerciser cycle. This setting is applied to all subsequent exerciser starts after the first start.
Repeat Days	0-90 days	Number of days at which the schedule is repeated.
Start Date		Configurable calendar Start Date for exerciser runs.

If the controller is in the Off Mode, if the emergency stop is activated, or if the Start Inhibit is active, then the exerciser will not run. The event “Bypass Exerciser” will be logged in the Events History and the exerciser will run again at the next scheduled time as determined by the “Repeat Days” setting.

13.2.2 Week Scheduler

The weekly scheduler allows multiple unique weekly exercise times to be created.

Setting	Range	Description
Start Time	12:00 AM - 11:45 PM	Time when the exercise should start on a given day. At the selected time, a one-minute pre-alarm is displayed on the LCD screen. The controller starts after this one-minute period.
Duration	15 minutes - 15 hours	Duration of exercise run. Will auto-fill if Stop Time is selected first.
Stop Time	12:00 AM - 11:45 PM	Time when the exercise should stop on a given day. Will auto-fill if duration is selected first.
Daily/Weekly	Sunday-Saturday	The day of the week on which the exercise will take place.

It is recommended that you use the RapidCore Configurator Software to enter the times as this provides a much more convenient interface, especially if daily exercise times are wanted.

13.2.3 Engine Maintenance Schedule

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

Setting	Range	Description
Enable Counter	Enable Disable (default)	Enables or disables the maintenance function. Accessible through the front panel access.
Count Interval	10-9000 hr (default 1000 hr)	Determines the number of hours between required maintenance. A switched output can be configured to turn on once the count interval expires. Accessible through the front panel access.
Long Term Run	Enable Disable (default)	Allows the operator to configure their system to use Long Term Run if it applies for the application. Accessible through the RapidCore Configurator Software.
Run Duration	1-5000 hr (default 60 hr)	The amount of time to run before shutting down. Accessible through the RapidCore Configurator Software.

The Long Term Run counter can be used to shut down the controller after a very long period of time. This is useful for remote primary power applications where the user wants to divide run time between two generators, or when a finite run time is desired without the need for an operator to return for shutdown. When the countdown expires, the controller will shut down.

To determine the amount of time until the next scheduled maintenance, follow these menu steps:

Advanced Setting > Time and Scheduler > Engine Maintenance > Counter Hour

To reset the counter, follow these menu steps:

Advanced Setting > Time and Scheduler > Engine Maintenance > Reset Counter

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

14 AC Monitoring

The controller has the ability to monitor AC Voltage, Current, and Power from a generator. The following sections are used to configure settings associated with AC Monitoring.

14.1 Genset Voltage

14.1.1 Voltage Setpoints

The following settings are used to configure the controller's responses to Voltage measurements.

Setting	Range	Description
Voltage Source	Disable (default) 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. Disable will disable AC Voltage and AC Frequency sensing and display. 2-Wire Single: One 120 VAC L-N. Use phase A. 3-Wire Single: 120/240 VAC systems. Use phases A-B or A-C. 3-Wire 3-Phase: Three phase Delta without a ground. 4-Wire 3-Phase: Three phase Wye system. Center tap ground. 4-Wire Delta: Delta with a ground. The high leg is phase B. For example, if A-N and C-N read 120 VAC, then B-N will read 208 VAC. Auto Selection will use the Voltage Select switched inputs to determine the wiring configuration. This setting also enables the AC Frequency monitoring and display.
Scaling Factor	0.500-2.500	The gain to apply to the AC voltage that is read at the controller. See below for more information.
Nominal Volts	50-800 VAC*	Generator voltage output when operating under normal running conditions.

Auto Nominal	Range	Description
Auto Nominal: 1-Phase 3-Wire	50-800 VAC*	Nominal Volts when using the Voltage Select inputs.
Auto Nominal: 3-Phase (1)	50-800 VAC*	
Auto Nominal: 3-Phase (2)	50-800 VAC*	
Auto Nominal: 3-Phase (3)	50-800 VAC*	

CAUTION

* 800 VAC APPLIES TO SOFTWARE LOGIC ONLY. DO NOT EXCEED 600 VAC ON THE AC VOLTAGE TERMINALS INCLUDING DURING OVER VOLTAGE WARNING AND FAILURE CONDITIONS.

	ATTENTION
	* 800 VCA NE S'APPLIQUE QU'A LA LOGIQUE LOGICIELLE. NE DEPASSEZ PAS 600 VCA SUR LES BORNES DE TENSION CA, Y COMPRIS EN SITUATION D'AVERTISSEMENT DE SURTENSION OU DE DEFAILLANCE.

Auto Scaling Factor	Range	Description
Auto Scaling: 1-Phase 3-Wire	0.500-2.500	Scaling Factor when using the Voltage Select inputs.
Auto Scaling: 3-Phase (1)	0.500-2.500	
Auto Scaling: 3-Phase (2)	0.500-2.500	
Auto Scaling: 3-Phase (3)	0.500-2.500	
Single Phase Voltage Sensing	A-C Phase A-B Phase	Configuration setting for 2-wire or 3-wire single phase voltage sensing.

Voltage Setpoints	Range	Description
AC Under Voltage Warning	Disable 20-99% (default 90%)	Voltage level at which a low voltage warning occurs.
AC Under Voltage Failure	Disable 20-99% (default 85%)	Voltage level at which a low voltage failure occurs.
AC Over Voltage Warning	Disable 101-150% (default 110%)	Voltage level at which a high voltage warning occurs.
AC Over Voltage Failure	Disable 101-150% (default 115%)	Voltage level at which a high voltage failure occurs.

Application Note: 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 208 VAC. The controller is reading 206.3 VAC but a calibrated multimeter gives 208.3 VAC. Use the formula below to determine the scaling factor.

Scaling Factor = Multimeter Reading / Controller Reading

Therefore, Scaling Factor = 208.3 VAC / 206.3 VAC

Scaling Factor = 1.010

14.1.2 AC Voltage Select

The controller has the ability to automatically change its AC sensing (voltage and current) and display the configuration through the use of switched inputs. When using Voltage Select, the controller will continue to monitor the inputs for 10 seconds after crank success. Once that time expires, the controller will then display the selected voltage configuration.

The following must be set:

- Two of the available switched inputs (Applications Settings > Switched Inputs > Add > AC Select 1 and 2) must be set to the Volt Select 1 and Volt Select 2 functions
- Genset AC Signals > Genset Voltage > Voltage Source must be set to Auto Selection

The table below shows the relationship between the switched inputs status and the voltage configuration.

AC Voltage Select 1 Input	AC Voltage Select 2 Input	Voltage Configuration
Inactive	Inactive	3-Wire Single Phase
Active	Inactive	3-Phase (1)
Inactive	Active	3-Phase (2)
Active	Active	3-Phase (3)

The settings shown below must be set. All except “Single Phase Voltage Sensing” are menus that contain four settings corresponding to the Volt Select 1 / Volt Select 2 inputs shown in the table above.

Setting	AC Select 2 Input
Genset Voltage > Single Phase Voltage Sensing	Only applies when voltage source is set to 1-Phase 3-Wire. This determines which phases the single phase voltage is read from: A-C or A-B.
Genset Voltage > Auto Nominal	These settings corresponds to the “Nominal Volts” setting under the Genset AC Signals > Genset Voltage menu.
Genset Voltage > Auto Scaling Factor	These settings corresponds to the “Scaling Factor” setting under the Genset AC Signals > Genset Voltage menu.
Genset Current > Auto Rated	These settings corresponds to the “Rated Amps” setting under the Genset AC Signals > Genset Current menu.
Genset Current > Auto Scaling Factor	These settings corresponds to the “Scaling Factor” setting under the Genset AC Signals > Genset Current menu.

14.1.3 Frequency Setpoints

Generator AC frequency display on the controller is enabled when the Voltage Source is NOT set to Disable.

The following settings are used to configure the controller’s responses to Frequency measurements.

Setting	Range	Description
Under Frequency Warning	Disable 20-99% (default 90%)	Frequency level at which a low frequency warning occurs.

Setting	Range	Description
Under Frequency Failure	Disable 20-99% (default 85%)	Frequency level at which a low frequency failure occurs.
Over Frequency Warning	Disable 101-150% (default 110%)	Frequency level at which a high frequency warning occurs.
Over Frequency Failure	Disable 101-150% (default 115%)	Frequency level at which a high frequency failure occurs.

14.1.3.1 RPM / Frequency Select

The controller has the ability to change between Primary RPM / 60 Hz and Secondary RPM / 50 Hz through the use of a switched input called Auto Engine System (Frequency Select).

The following settings must be set in order for this feature to function:

- Switched Inputs > “Add” > Auto Engine System (Frequency Select). The switched input is only monitored before a start signal has been received. Once a start signal has been received, changing the status of the switched input will have no effect
- Engine Speed > System > Auto Selection
- Engine Speed > Auto RPM Nominal > Primary RPM or 60 Hz
- Engine Speed > Auto RPM Nominal > Secondary RPM or 50 Hz

The table below shows the correspondence between the switched input status and the RPM / Frequency.

Switched Input	Speed / Frequency
Inactive	Primary RPM / 60 Hz
Active	Secondary RPM / 50 Hz

14.2 Genset Current

The following settings are used to configure the controller’s responses to Current measurements.

Setting	Range	Description
Current Source	Enable Disable (default)	Enables or disables current metering.
CT Turns Ratio (X:5A)	5-5000 A:5 A (default 100 A)	The turns ratio of the current transformers.
Scaling Factor	0.50-2.5 (default 1)	Scaling factor at which the voltage is read into the controller. See below for more information.

Setting	Range	Description
Rated Amps	5-5000 AAC (default 100 AAC)	Maximum current the generator can provide when operating under normal running conditions.

Auto Rated Amps	Range	Description
Single Phase 3-Wire	5-5000 AAC (default 100 AAC)	Rated Current for Single Phase Three Wire. Selected when Volt Select 1 and Volt Select 2 are inactive.
Three Phase (1)	5-5000 AAC (default 100 AAC)	Rated Current for Three Phase Four Wire. Selected when Volt Select 1 is inactive and Volt Select 2 is active.
Three Phase (2)	5-5000 AAC (default 100 AAC)	Rated Current for Three Phase Four Wire. Selected when Volt Select 1 is active and Volt Select 2 is inactive.
Three Phase (3)	5-5000 AAC (default 100 AAC)	Rated Current for Three Phase Four Wire. Selected when Volt Select 1 and Volt Select 2 are active.

Auto Scaling Factor	Range	Description
Single Phase 3-Wire	0.500-2.250 (default 1)	Gain for Single Phase Three Wire. Selected when Volt Select 1 and Volt Select 2 are inactive.
Three Phase (1)	0.500-2.250 (default 1)	Rated gain for Three Phase Four Wire. Selected when Volt Select 1 is inactive and Volt Select 2 is active.
Three Phase (2)	0.500-2.250 (default 1)	Rated gain for Three Phase Four Wire. Selected when Volt Select 1 is active and Volt Select 2 inactive.
Three Phase (3)	0.500-2.250 (default 1)	Rated gain for Three Phase Four Wire. Selected when Volt Select 1 and Volt Select 2 are active.

14.2.1 Protections

14.2.1.1 Basic Alarms

The controller can give a warning and/or shutdown when an Over Current is detected by using the following setting:

- Genset AC Signals > Protections > Basic Alarms

If IDMT is enabled, then it overrides the High Failure shutdown, but the warning is still active.

Setting	Range	Description
Breaker Trip Failure	Disable (default) Enable	Shuts down the generator if the generator circuit breaker fails to trip. If the Breaker Trip switched output is active (due to IDMT or Load Imbalance), and if after 10 seconds the measured generator current is still above 10% of the Rated Current, the generator will shut down.
Over Current Warning	Disable 1-200%* (default 110%)	Reading at which a warning occurs.
Over Current Failure	Disable 1-200%* (default 115%)	Reading at which a failure occurs.

* Percentages are based on the Rated Amps setting. The warning and failure setpoints apply to each phase separately and not to the sum of the phases.

14.2.1.2 Dummy Load

The dummy load feature can be enabled to prevent wet stacking by using the following setting:

- Genset AC Signals > Genset Current > Dummy Load

Name	Range	Description
Bypass	Disabled 1-120 s (default 5 s)	The amount of time to delay before applying the dummy load.
Load On	Disabled (default) 1-200 AAC	The threshold below which the dummy load is applied. There is a 4 second debounce time. The bypass time must expire before the load is applied. All phases must drop below this threshold to trigger dummy load.
Load Off	Disabled (default) 1-200 AAC	The threshold above which the dummy load is removed. Dummy load is turned off if one phase rises above this threshold.

Using the RapidCore Configurator Software, program the Dummy Load to a Switched Output in the Switched Output Settings.

These settings turn on the Dummy Load Switched Output to control an external load. This ensures minimum load on the engine to prevent unburned fuel passing on into the exhaust system (i.e., wet stacking).

14.2.1.3 IDMT

IDMT sets an inverse time trip curve for Over Current by using the following setting:

- Genset AC Signals > Genset Current > IDMT Settings

When set, this overrides the Over Current Failure.

Name	Range	Description
IDMT Mode	Disable (Default) Breaker Trip Shutdown Trip	Disable: Disables the IMDT feature. Breaker Trip: If IDMT is active, the Breaker Trip switched output is activated to switch off the main generator breaker. This is a latching feature. The operator must press the up and down keys to reset the feature. Shutdown Trip: Shuts down the engine.
Time Dial Setting	0.1-30 (default 0.3)	Sets the slope of the IDMT curve. This controls the sensitivity of the trip to Over Current.
Reset Time	0-600 s (default 200 s)	How long the current must drop and stay below the rated current to reset the IDMT.

The equation for the IDMT is given as:

$$(t_r)_m = \frac{TDS * 13.5}{\frac{I}{I_S} - 1}$$

where

TDS is the time dial setting

I_S is the Rated Current (A)

I is the actual current measured by the controller (A)

$(t_r)_m$ is the trip time (seconds)

For example, with a Rated Current of 100 A and a TDS of 0.1, the IDMT will trigger in:

0.15 seconds if the actual generator current is 1000 A

1.35 seconds if the actual generator current is 200 A

6.75 seconds if the actual generator current is 120 A

14.2.1.4 Load Imbalance Settings

Load imbalance provides protection against differences in phase currents by using the following setting:

- Genset AC Signals > Protections > Load Imbalance Settings

Name	Range	Description
Load Imbalance Mode	Disable (default) Breaker Trip Shutdown Trip	Disable: Disables the Load Imbalance feature. Breaker Trip: If Load Imbalance is active, the Breaker Trip switched output is activated to switch off the main generator breaker. This is a latching feature. The operator must press the up and down keys to reset the latch. Shutdown Trip: Shuts down the engine.
Load Imbalance %	1-100% (default 10%)	The percentage of rated current that any phase must exceed the other phases by to trigger a load imbalance.
Load Imbalance Delay	0-600 s (default 10 s)	The length of time to allow an imbalance before triggering (trip, shutdown).

The load imbalance formula is given as:

For three-phase:

$$\max\{|I_A - I_B|, |I_A - I_C|, |I_B - I_C|\} > \text{Rated Amps} \times \text{Phase Imbalance Threshold (\%)}$$

For single-phase:

$$|I_1 - I_2| > \text{Rated Amps} \times \text{Phase Imbalance Threshold (\%)}$$

where

I_A, I_B, I_C, I_1, and I_2 are the actual currents measured by the controller

Note: Phase Imbalance is the same as load imbalance.

14.3 Genset Power

The user can enable or disable the display of Genset Power. Each Power measurement will display on the controller for monitoring. Once Genset Power is enabled and the controller is in Run Mode, it will display the following: Apparent Power (kV·A), Real Power (kW), Reactive Power (kVAR), and Power Factor.

Typical Power Equations:

* Most generators are rated for a power factor of 0.8 *

$$\mathbf{W} = \text{V x A x Power Factor}$$

$$\mathbf{kVAR} = \text{V x Reactive Amps (capacitive and inductive load)}$$

$$\mathbf{VA} = \text{V x A (resistive load)}$$

$$\mathbf{PF} = \text{kW / kVA}$$

14.3.1 Power Setpoints

The following settings are used to configure the controller's responses to Power measurements.

Setting	Range	Description
Right Display	Enable Disable (default)	Enables or Disables AC Power metering.
Rated Power	1-5000 kW (default 10 kW)	Amount of Rated Power the generator or engine will produce.

Power Overload	Range	Description
High Power Warning	Disable 1-125% (default 101%)	Power percentage at which a High Power Warning occurs.
High Power Failure	Disable 1-125% (default 105%)	Power percentage at which a High Power Failure occurs.

Before setting the Rated Power (kW) on the controller, observe the Rated Power with respect to the generator specifications.

14.3.2 Current Transformers Involving Power Factor

14.3.2.1 CT Polarity

Be cautious when observing the correct polarity of the CTs. Incorrect positioning of the CT will cause negative kW readings when the generator is providing power. To test the position of the CT, run the generator, but not in parallel with any other supply. Load the generator to 10-15% of the generator rating. Make certain that the controller shows positive kW for all three phase readings.

14.3.2.2 CT Phasing

⚠	**CAUTION**
	TAKE CAUTION THAT THE CTS ARE CONNECTED TO THE CORRECT PHASES. INCORRECT CONNECTION OF PHASES WILL RESULT IN INCORRECT POWER FACTOR MEASUREMENTS. THIS WILL CAUSE INCORRECT WATTAGE VALUES.

	**ATTENTION** VEILLEZ A CE QUE LES TC (TRANSFORMATEURS DE COURANT) SOIENT CONNECTES AUX BONNES PHASES. UNE CONNEXION INCORRECTE DES PHASES ENTRAINERA DES MESURES INCORRECTES DU FACTEUR DE PUISSANCE. CELA ENTRAÎNERA DES VALEURS DE PUISSANCE EN WATTS INCORRECTES.

15 Communications

The TOUGH Series PRO has the ability to communicate with other systems over communication buses. The following sections relate to settings associated with communications.

15.1 J1939 CANbus

For detailed information about J1939 settings and functions, please use the J1939 Reference Manual, which can be found at www.cattron.com.

Setting	Range	Description
J1939 Bus		
Internal 120 Ω enable	Enable Disable (default)	Allows the use of an internal terminating resistor for J1939 communications lines.
ECM Communication Failure	Enable Disable (default)	If no CAN messages are received for more than 6 seconds, the controller shuts down the engine.
Controller Address	Default (default) 1-251	Allows selection of the controller address. Default is 108.
Auto Mode Fuel ON	Disable (default) 5-60 s	When enabled, the fuel relay is enabled in Auto Mode so that the ECM is already booted up and initialized before the user decides to start the engine. When the engine shuts down, the controller waits for the time specified before turning on the fuel relay. This prevents unwanted start-ups due to the engine not being completely shut down.
Manual Fuel On (Hold AUTO) ECM Power	Disable (default) 5-60 min	When activated, the user can press and hold the AUTO button for 3 seconds to turn the fuel output (ignition) signal on for the specified time period while the controller is in Auto Mode without running the engine.
Broadcast Over J1939		
Warnings and Failures	Enable Disable (default)	Enable condition to broadcast parameter over J1939. All settings must be enabled to utilize remote monitoring and control products such as the TL3600 (RemoteIQ™) or local remote TR100 devices, as well as other third party J1939 monitoring devices.
AC Sensing	Enable Disable (default)	
Fuel Level	Enable Disable (default)	
Battery Voltage	Enable Disable (default)	
Engine Speed	Enable Disable (default)	

Setting	Range	Description
Engine Temperature	Enable Disable (default)	
Oil Pressure	Enable Disable (default)	
Engine Hours	Enable Disable (default)	
AC Power	Enable Disable (default)	
ECM Module	Generic J1939 John Deere JDEC Volvo EMS/EMS2 Cummins CM850 Yanmar ECO Detroit Diesel Volvo EMS2B Isuzu T4F GM PSI eControl Kubota T4F Scania S8 T4F Doosan G2 Deutz EMR3/4 JCB Power Hatz E1	Choose one of the compatible ECM modules from the list. The user should consult their local engine distributor to find out if Generic J1939 can be used, as well as if a specific implementation is needed for the engine.
ECM Special Settings	*This section will populate with ECM model with specific special settings, if necessary.*	
Cummins PGN	Enable Disable	Enables or disables the broadcasting of PGNs required by Cummins engines.
EMS2B Frequency Select	Primary Secondary	For Volvo EMS2B Engine Control Modules only.
EMS2B Accelerator	40.0-60.0%	For Volvo EMS2B Engine Control Modules only.
Diagnostic Trouble Code		
DTC Display	Not Allowed (default) All Enable (Global) Running Only	Defines when DTC messages will be displayed to the user.
Log Active DM1	Enable Disable (default)	Enables or disables the storing of active faults (DM1).

Setting	Range	Description
Allow Read DM2	Enable Disable (default)	Enables or disables the ability to request stored fault codes from the ECM (DM2).
DTC Conversion	Version 1 Version 2 Version 3 (default)	Select the SPN conversion method.
DM1 Stop Lamp	Disable (default) Enable	Enables/disables the DM1 Stop Lamp.
Custom J1939-DM1 Messages	SPN: 0-524287 FMI: 0-31 SPN Text: User Defined	Specifies custom messages as required by application.
DTC Ignore List	SPN: 0-524287 FMI: 0-31	Specifies which DTCs to ignore.
Aftertreatment		
Aftertreatment Enable	Disable (default) DPF DEF/SCR	These settings configure the Diesel Particulate Filter (DPF) regeneration control and monitoring functionality. These settings pertain to engines with aftertreatment systems, either Diesel Particulate Filter (DPF) or Diesel Exhaust Fluid/Select Catalytic Reduction (DEF/SCR), via user configured related settings and display options.
Aftertreatment Display Page Enable (Configuration Software only)	Disable Enable (default)	
Aftertreatment Mode	Inhibit Auto (default) Last Running	
Soot % Display	Enable Disable (default)	
Ash % Display	Enable Disable (default)	
Exhaust Temperature Display	Enable Disable (default)	
DPF Gas Temperature Display	Enable Disable (default)	
DEF/SCR Tank Level Display	Enable Disable (default)	
DEF/SCR Fluid Temperature	Enable Disable (default)	
Password	Enable Disable (default)	

Setting	Range	Description
Custom Priority/Address PGN List	Priority: 0-7 PGN: 0-65535 Source Address 0-255	Select a Custom Priority, PGN, and Source Address through the RapidCore Configurator Software.
Actual Engine % Torque	Enable Disable (default)	Enables the display of the Actual Engine % Torque parameter from the bus. This is not available for all ECMs.
Percent Engine Load	Enable Disable (default)	Enables the display of the Percent Engine Load parameter from the bus. This is not available for all ECMs.
Air Intake Temperature	Enable Disable (default)	Enables the display of the Ambient Air Temperature parameter from the bus. This is not available for all ECMs.
Engine Fuel Rate	Enable Disable (default)	Enables the display of the Engine Fuel Rate parameter from the bus. This is not available for all ECMs.
Oil Temperature	Enable Disable (default)	Enables the display of Oil Temperature parameter from the bus. This is not available for all ECMs.

15.2 Modbus (RS485)

The Modbus functionality on the controller provides interface ability to PLCs, SCADA and building management systems.

For detailed information about the Modbus registers and their interpretations, please use the Modbus Reference Manual, which can be found at www.cattron.com.

Setting	Range / Values	Description
Internal 120 Ω enable	Enable Disable (default)	Allows the use of an internal terminating resistor for RS485 communications lines.
Modbus Enable	Enable (default) Disable	Enables or disables the use of Modbus communications.
Device Address	1-247 (default 1)	The device address of the controller.
Baud Rate (BPS)	9600 (default) 19200 38400 57400	The speed at which the controller (slave) communicates with the master.

15.3 Remote Inputs

The controller has eight Remote Inputs. The operator can write to the controller through Modbus communication which will trigger designated switched outputs.

Setting	Range	Description
Remote Input 1 – 8	Label: Remote Input 1-8 Output Port: Disable (default) Port 1-10 Active Modes: Off Auto Engage Running Cooldown Shutdown Failure	User selectable remote input communication based on the assigned switched output and controller state. 8 Remote Input ports, where 2 bits indicate the status of the port: 00 = Not Active/No Action 01 = Activated by another source/No Action 10 = Set Inactive 11 = Set Active Default location: 40133

Remote Input 1: Bit 0-1

Remote Input 2: Bit 2-3

Remote Input 3: Bit 4-5

Remote Input 4: Bit 6-7

Remote Input 5: Bit 8-9

Remote Input 6: Bit 10-11

Remote Input 7: Bit 12-13

Remote Input 8: Bit 14-15

16 Miscellaneous

16.1 Password

The default password to change settings is “0000”. The Password menu is used to create a password for entering System Settings, as follows:

- Miscellaneous > Password

Setting	Range	Description
Bypass	Disable (default) Enable	If enabled, a password is not required to change settings.
Timeout	10-120 min (default 10 min)	How long after the password is entered before the user is required to enter it again. The timeout is implemented as a simple countdown timer. The following apply: • If the bypass time is changed, this new bypass time will not be loaded until the countdown timer has expired and the user enters the password. • The countdown timer is stored in non-volatile memory and is “paused” when the controller is powered off. The counter will resume when the controller is powered on again. • Any button press in the menu will reset the timer.
Passcode	0000-9999 (default = 0000)	The four numeric digits that make up the password.

16.2 Thomson Actuator

The Thomson Actuator can be used for automatic speed control on mechanical engines, with full control through the TOUGH Series PRO Controller, as follows:

- Miscellaneous > Thomson Actuator

Use the following settings configuration to calibrate the Thomson Actuator.

Setting	Range	Description
Actuator Enable	Disable (default) Enable	Enables full control of the Actuator to complete calibration.
Tracking	10-50 RPM (default 30 RPM)	The RPM on the Tracking Range allows the engine to proceed over and under the desired RPM. If the load increases or decreases the RPM past the Tracking Range value, the actuator is calibrated to guide the engine RPM back to the desired RPM in the Tracking Range.

Setting	Range	Description
Calibration Active*	Disable (default) 1000-3000	The Calibration Active number is programmed specifically for the Actuator. This will enable the Actuator Calibration, allowing the controller to possess full control over the Thomson Actuator. The Calibration number is **2039.**
Manual Adjust*	0% - 100% (default 100%)	Setting a value to the Manual Adjust will precisely guide the actuator to the desired location before start-up. The maximum distance that the actuator can extend is 100%. Reducing the percent downward by the value of one will cause the Actuator to decline in exact decrements.
Idle Position*	5% or 95% (default 95%)	The Idle position percentage is the miniature amount of the Actuator stroke that is locked and cannot proceed below or above the specific percentage. If the Actuator is pushing, then the Idle Position should be set to 5%. The Actuator stroke will not go below 5%. If the Actuator is pulling, then the Idle Position should be set to 95%. The Actuator Stroke will not go above 95%.

*Calibration Active, Manual Adjust, and Idle Position are only accessible through the settings in the controller. These three settings are not accessible through the RapidCore Configurator Software.

*Adjust the throttle cable so that when the Actuator stroke is set to 5% or 95%, it approximately gives the user the Idle speed.

Follow the steps below to complete the Actuator Calibration Run:

- Exit menu settings > Enter Auto Mode > Press the Run button to begin the Calibration Run

* A message will appear on the controller screen saying “Actuator Calibration… Wait for Position Adjust”

- Press the “Pager” button directly to the right of the Auto button, refer to Figure 11 (Controller Button Descriptions)

* Once that is complete “Calibration All Done!” message will appear on the screen of the controller.

- Press the Off button to return to Off Mode

16.3 Fuel Select

The Fuel Select is an operator facing option which allows the user to configure two fuel types.

Setting	Range	Description
Fuel Type	Enable: Fuel 1 (default) Fuel 2	When Fuel 2 is selected, it will activate the assigned switched output. When Fuel 1 is selected, it does not activate the switched output; this gives the user the ability to acknowledge which fuel type is selected.

Setting	Range	Description
Fuel Indication	Disable (default) Enable	This allows the user to enable or disable the fuel type indication message. When enabled, the indication message will appear on the screen of the controller.
Remote Set Fuel	Disable (default) Enable	Not available.
Fuel 1 Text	Custom Text (default)	The user can select the desired name for Fuel Type 1.
Fuel 2 Text	Custom Text (default)	The user can select the desired name for Fuel Type 2.

Refer to Switched Outputs > Programmable Output for more information on programming the Fuel Type Switched Output.

17 Troubleshooting

If you are having issues with your controller, please refer to the table below for a solution before contacting Cattron at www.cattron.com.

⚠	**CAUTION**
	ALWAYS CHECK THE CATTRON WEBSITE FOR THE LATEST SOFTWARE, FIRMWARE AND USER MANUALS.

⚠	**ATTENTION**
	CONSULTEZ TOUJOURS LE SITE WEB DE CATTRON POUR OBTENIR LES DERNIERS LOGICIELS, MICROLOGICIELS, ET MANUELS D'UTILISATION.

Issue	Solution
Engine starts but the crank output does not turn off	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.
Sensor always displays its lowest or highest value	The sensor could either be open (not connected) or shorted to ground. Verify your connections and ensure the correct sender table is loaded.
High Engine Temperature Trip	Issue: Engine Temperature is inaccurate or shifting frequently on non-isolated (signal terminal) senders. Solution: Check that the ground from the negative of the battery to the sensor is in good condition. If needed, run a wire (or use the sensor ground on the controller) to the sensor body. Do not rely on the engine chassis. Solution: Consider twisted pair wiring to reduce/eliminate the effects of electrical noise.
Cannot communicate via CANbus	Doublecheck addressing using the PGN list in the J1939 Reference manual, which can be found at www.cattron.com.
Cannot communicate via Modbus	Doublecheck the Modbus command being used to communicate with the controller and the registers that are being read and written using the Modbus Reference manual. Also ensure that the bus is terminated with 120 Ω resistors. The Modbus Reference manual can be found at www.cattron.com.

18 Technical Support

For remote and communication control systems support, parts and repair, or technical support, visit us online at: www.cattron.com/contact.

Cattron Wireless Automation and Control Solutions Support
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