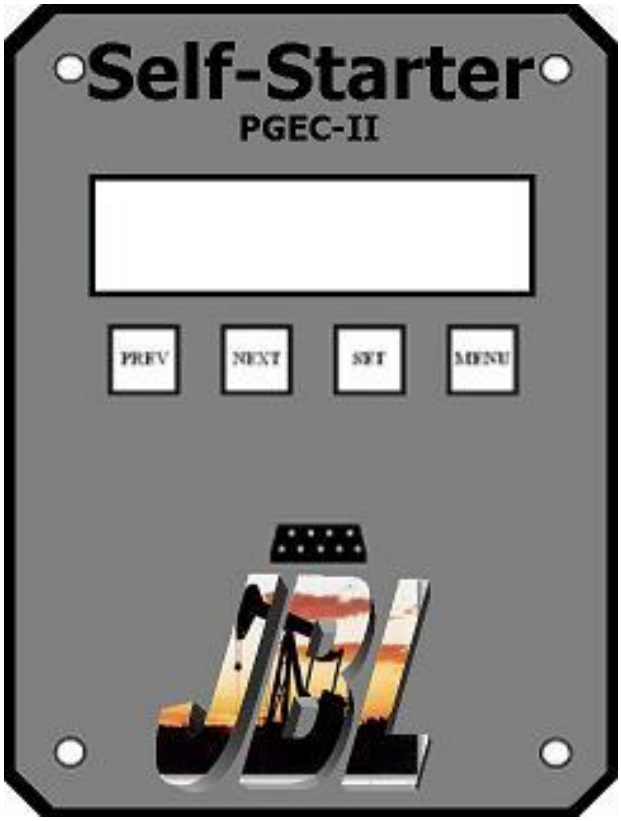
“Self Starter” Engine Controller



Owners Manual

010108

WARNING !!!

The PGEC II Auto Starter is designed to start the engine “Automatically”.

Before working on the engine or any components attached to or driven by the engine the power source (battery) should be disconnected.

It is recommended that a sign or notice of this warning be prominently displayed near the unit.

DESCRIPTION

The PGEC II Self Start Engine Controller gives the user an easy to install and operate, yet a full featured automatic engine starter.

The PGEC II operates on 12 Volts. It includes ignition, crank, and rest cycles, sensing of crank time, start up speed and start attempts.

The easy to read display reflects the current status of the controller and engine. Statistics such as engine run time, start ups, retries, fail times and others are easily accessible.

"Wet" or "dry" start and stop inputs provide the flexibility to use the controller for numerous applications or as a slave device of another controller.

The unit is MODBUS compatible to interface with most remote control or SCADA systems.

Four user interface buttons make for easy set up of run/off schedules as well as adjustable parameters such as over speed/under speed shutdown RPM.

FEATURES

- Small and lightweight
- Built in back-up battery
- Displays in English or Spanish
- Day and Date clock
- Adjustable starter disengage RPM
- Adjustable engine under speed shutdown RPM
- Adjustable engine over speed shutdown RPM
- Adjustable start attempts
- Adjustable starter run time
- Adjustable start up warning time
- Adjustable start retry delay
- Adjustable time delay for stop inputs.
- Adjustable engine warm up time
- Adjustable engine cool down time
- Adjustable MODBUS slave address
- Adjustable Serial Port Speed
- Adjustable Serial Port Format
- Adjustable Serial RTS On Delay
- Adjustable Serial RTS Off Delay

Adjustable Serial Obey CTS

SPECIFICATIONS

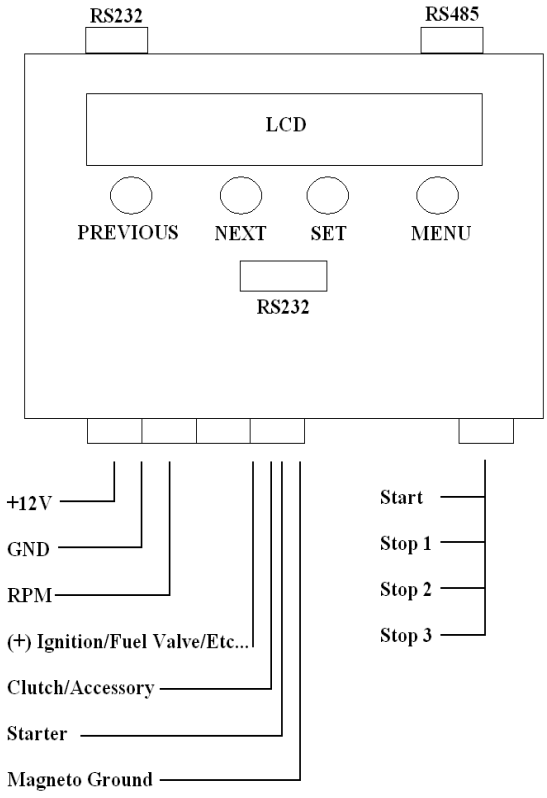
Power input – 12 VDC.
Engine-Speed Sensing Input
One "Start" and three "Stop" inputs (wet to 30 VDC or dry)
RS232 I/O and/or RS485 I/O

RELAYS
Power output – 12V/10A
Magneto ground
Ignition power
Starter
Clutch / Accessory
Piezo Alarm (105 dB)

Shipping Weight:
3lbs

Shipping Dimensions:
9-1/2” x 7” x 5”

Typical Wiring Diagram



Functional Description

Electrical Connections

Note: This section describes the electrical connections of the printed circuit board.

There are four physical connectors on the PCB, they are labeled J1, J2, J3 and J4 and function as follows.

J1 – DB9 female, configured as a RS232 DCE. Use a straight-though cable to connect to your laptop's serial port.
J2 – 8 Socket Main power and control connector. Battery, ground, relay outputs and RPM sensing connections to engine.
J3 – 8 Socket contact inputs for START, STOP_1, STOP_2 and STOP_3 inputs.
J4 – Primary serial interfaces, RS232 and RS485 interfaces attach though this connector.

WARNING: Reversing J2 and J3 connectors will result in permanent damage to circuit board!

Wiring Diagram for Enclosure Outlets

J1 - Front Panel DB9 DCE RS232 Interface

The front panel serial interface is a standard RS-232 port with full handshaking. Signal levels are nominal +/-12V with basic protection provided by a MAX222 line driver. Asserting the DSR signal into this port causes internal logic to disable the other internal ports of the engine controller (on J4) and activate the front port. This design feature allows local communication to take place even if the device is connected to another communication network or radio system
(see firmware and operational documentation for details on communications parameters)

J1 Pinout	
1	unused
2	Transmit Data
3	Receive Data
4	Data Set Ready
5	Signal Ground
6	Data Terminal Ready
7	Clear To Send
8	Request To Send
9	unused

J2 - Engine Interface Connector

The J2 connector provides all interface signals for the wire bundle to the engine as well as power to the controller board. All signals on J2 are heavily protected and filtered.

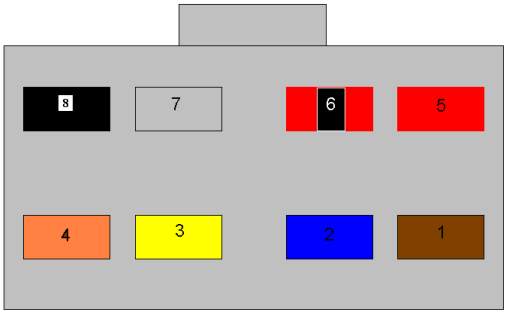
Battery power is supplied to the board via pin 2 of the connector. The board is designed to operate from a 12V source. Protection circuitry clamps spikes or surges above 28V and will cause fuse F1 to blow if the input voltage exceeds 28V for an extended period of time.

The RPM sense pin is a heavily protected input designed to accept a pulse signal from the engine ignition system. Although able to accept large spikes and noise without damage, this input depends on external circuitry to pre-filter ignition spikes into a measurable square-wave signal. External circuitry will consist of a resistor divider network, a filtering capacitor, and a snubbing diode for most applications, but will need to be tailored for each new ignition system architecture. Note that the pre-filter network should generally impose no more than a 20K-ohm load to any ignition system. At the current time, a pre-filter or "dongle" is used on Kohler CH series and all Wisconsin (including Continental TM27) engines. Kohler CA 12, Kubota, and GM engines do not require a dongle

The Clutch, Starter, and Ignition Power signals are simply Battery power (+BAT) switched through relay contacts. Although the contacts themselves are rated to switch up to 10A, the installer should assure that the sum total current draw through all three outputs is less than 10A continuous. This can be done using secondary relays.

J2 Connector - 8 Socket from PCBX to Engine

8 Socket Connector



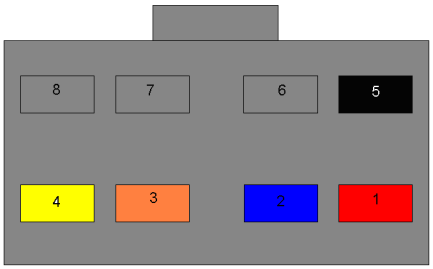
J2 Pinout	
1	Clutch
2	Starter
3	Ignition Power
4	Magneto Ground
5	+BAT (12V)
6	- BAT (GND)
7	Unused
8	RPM Sense

J3 - External Signal Input Connector

The J3 connector has four highly-filtered input pins whose logic is interpreted by the controller's software. Each of the inputs is pulled up to a TRUE condition (+5VDC) via a 10K resistor so that they are compatible with a dry-contact or pushbutton interface. The signal is then fed through a current limiting 100k resistor and snubbing diode so that the interface will also function with an externally driven signal up to 30VDC.

J3 Connector – 8 Socket from PCBX to start/stop inputs

8 Socket Connector



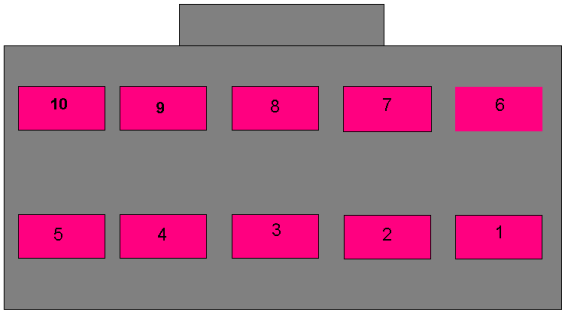
J3 Pinout	
NOTE: input is considered asserted when pulled low (i.e., connected to GND)	
1	Start
2	Stop #1
3	Stop #2
4	Stop #3
5	GND
6	Unused
7	Unused

J4 - Multi-purpose Communication Port

J4 contains the interface for the two SCADA communications port options. The engine controller board only has a single internal serial port, but has three interface possibilities to it. By default, the RS485 port terminated on J4 is active. If an RS232 device is connected to J4, the RS485 port is disabled and the RS232 port becomes active. Connecting a device to the front panel RS232 port (J1) overrides both ports on J4 until it is disconnected.

NOTE: The RS485 port is fully terminated by default via resistor R24. Resistors R25 and R26 provide a nominal differential bias to minimize noise and the possibility of an invalid port condition if the port is not used. If the engine controller is used in a multi-slave RS485 network application, these three resistors should be disabled from all but the last unit on the bus. This can be accomplished by simply cutting one leg of each resistor. For maximum bus length applications, the RS485 master should also be properly terminated to match the wire impedance.

J4 – 10 Socket Connector



J4 Pinout	
1	RS485 Non-Inverting
2	RS485 Inverting
3	RS232 Transmit Data
4	RS232 Receive Data
5	RS232 Request To Send
6	RS232 Clear To Send
7	RS232 Data Terminal Ready
8	RS232 Data Set Ready
9	RS232 Signal Ground
10	unused

J5 - Expansion Board Header

This expansion header is provided to facilitate future hardware additions to the motor controller. The microprocessor SPI bus (see Microchip PIC technical documentation) along with three TTL device enable lines (under software control) is presented on the expansion header. Additionally, a regulated +5VDC supply is provided. Should an add-on board require substantial current, the unregulated +12V battery voltage is also provided.

J5 Pinout	
1	Regulated +5VDC
2	Unregulated Vbat (+12)
3	SCLK
4	SDO
5	SDI
6	unused
7	Enable #1
8	Enable #2
9	Enable #3
10	GND

User Interface

The user interface is in the form of a 2 line by 24 character LCD display, four front panel pushbuttons and one pushbutton on the back of the PCB. The four front panel pushbuttons are (left to right): Previous, Next, Set and Menu. Previous and Next have varying effects depending on the currently selected function, but they generally go to the previous (or next) item or decrement (or increment) a value. Set generally selects an action, begins an adjustment, etc. Menu always returns you to the top most menu screen.

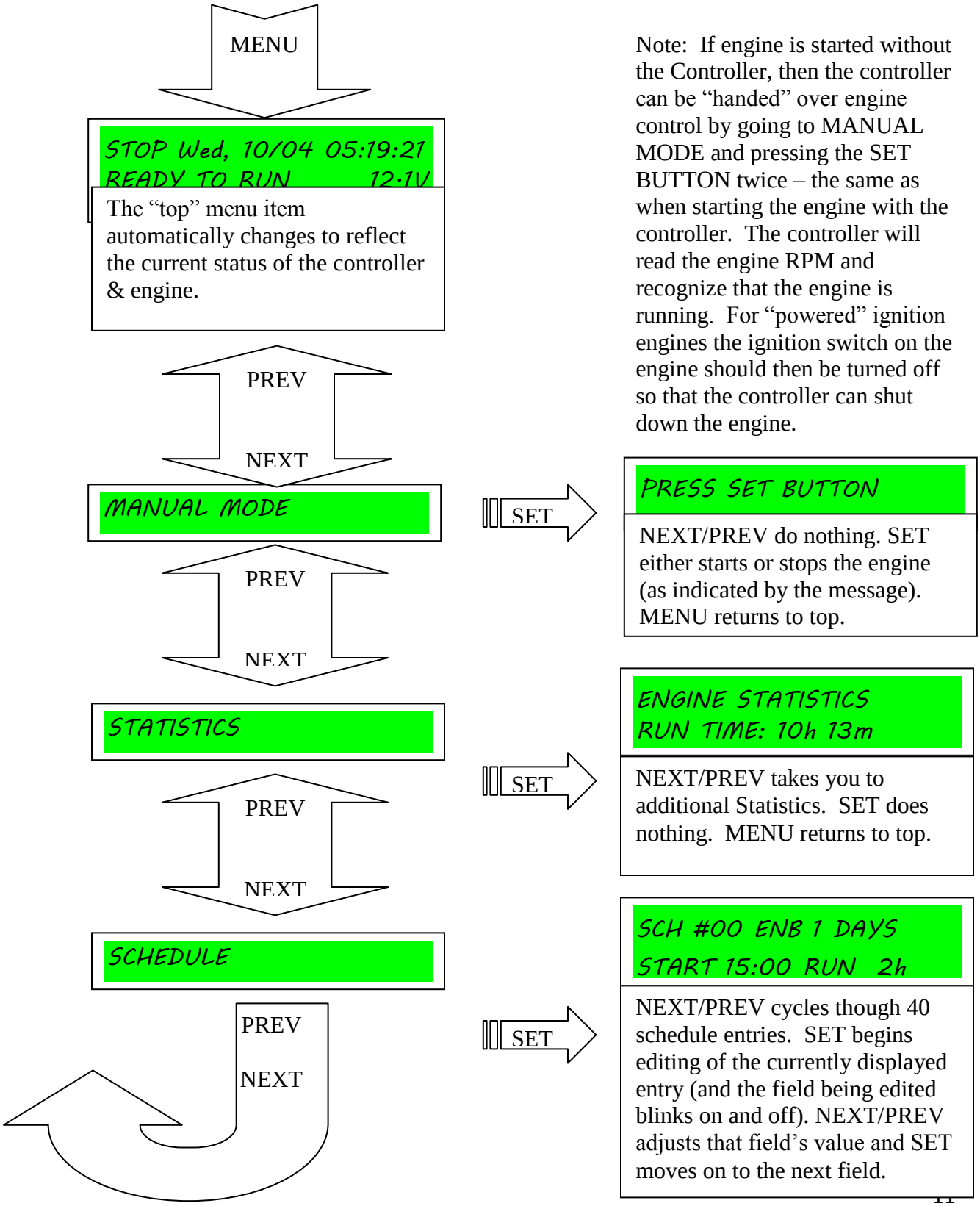
MODBUS Support

The controller fully supports the MODBUS RTU protocol over both RS485 and RS232. RS232 is supported both on the front panel via a DB9 connector and via the J4 connector on the component side of the circuit board.

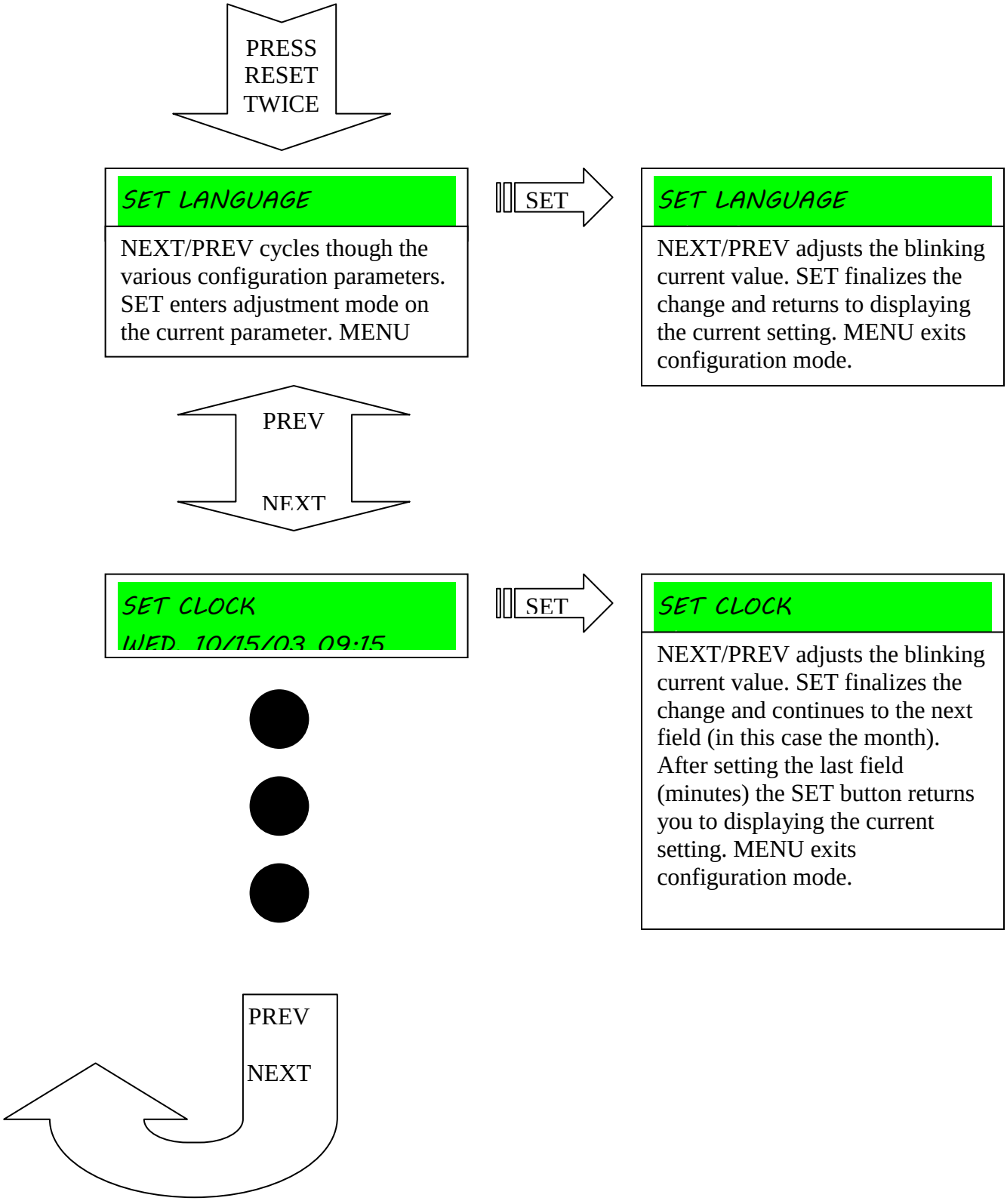
Note: Which of the serial interfaces is active is based on the state of the DTR signal provided to the controller from external devices connected to either the front or rear RS232 ports. If no DTR signal is present at either RS232 port, then the RS485 interface is active. If a DTR signal is present at the rear panel RS232 port, then and none is present at the front panel RS232 port, then the rear RS232 port is active. If there is a DTR signal present at the front panel RS232 port, then it is active and the others are disabled.

Operational Walk-through

Upon power up the controller begins scanning its schedule of run times while also monitoring the serial communications port for incoming MODBUS messages and accepting input from the front panel user interface.
Refer to the Quick Reference Card's depiction of the user interface.



Note: If engine is started without the Controller, then the controller can be "handed" over engine control by going to MANUAL MODE and pressing the SET BUTTON twice – the same as when starting the engine with the controller. The controller will read the engine RPM and recognize that the engine is running. For "powered" ignition engines the ignition switch on the engine should then be turned off so that the controller can shut down the engine.


PRESS
RESET
TWICE
SET LANGUAGE
NEXT/PREV cycles though the various configuration parameters. SET enters adjustment mode on the current parameter. MENU
SET
SET LANGUAGE
NEXT/PREV adjusts the blinking current value. SET finalizes the change and returns to displaying the current setting. MENU exits configuration mode.
PREV
NEXT
SET CLOCK
WED 10/15/03 09:15
SET
SET CLOCK
NEXT/PREV adjusts the blinking current value. SET finalizes the change and continues to the next field (in this case the month). After setting the last field (minutes) the SET button returns you to displaying the current setting. MENU exits configuration mode.
PREV
NEXT

Initially the controller will power up and display the top menu item, where it will show that the engine is in STOP state. Using the Previous and Next buttons, you can move between the main areas of the user interface, the initial top menu, the Manual Mode menu, the Statistics menu and the Schedule menu. Pressing the Set button at any of these items will take you to sub-menus that are specific to each area.

The **Manual Mode** menu is a simple one. If the engine is currently in STOP state, you will presented the opportunity to press the Set button to start the engine which will then continue until either a manual stop - **not a scheduled stop** or a MODBUS stop is signaled. If the engine was in RUN state, you will be presented the opportunity to press the Set button to stop the engine.

The **Statistics Mode** menu allows you to step though, using the Previous and Next buttons, various statistics that the controller maintains:

Engine Run Time
Startups
Start Retries
Start Failures
WDT Resets (Watch Dog Timer – internal)
MCLR Resets (Master Clear – external)
Power On Resets

The **Schedule mode** allows you to adjust the run schedule, using up to 40 entries that have fields for Enabling (ENB) or Disabling (DIS) each schedule, setting the number of days between repeating the schedule (ie – 1 runs the schedule every day. 2 runs the schedule every other day. Etc…), setting the time of day (military time) the engine is to start and the amount of time (hours and minutes) the engine is to run before shutting itself off. Pressing Set on any of them causes the selected entry be adjusted, one field at a time by use of the Previous and Next buttons to decrement or increment the currently blinking field. The Set button moves to the next adjustable field and so on until you've adjusted all the fields and are returned automatically (indicated by no blinking field) to review the changes you made. You can then continue using Previous and Next to move to the next schedule entry you'd like to adjust. **In order for the controller to stop the engine while operating in the schedule mode the engine must be started by the controller in the schedule mode.**

Note: The Menu button will return you to the top menu of the user interface at any time.

A completely separate section of the user interface, the **Configuration mode**, is accessed by pressing the **Reset button on the back of the printed circuit board** twice in pretty rapid succession (the second press must come before the controller "welcome/version" screen disappears). After accessing this menu, you can change all the Configuration Parameters in the controller. The configuration menu uses the same navigation methods

as the rest of the user interface, so Previous, Next and Set work as before.
Menu has the additional effect of exiting the configuration mode such that you have to use the Reset button to get back into configuration mode if desired.

Configuration Parameters:

Set Language {English | Spanish}
Sets the language that will be used on the front panel user interface.

Set Clock
Set the current time of day. Uses a 24-hour clock format.

Set Starter Disengage RPM
During the startup process the starter will be disengaged once the engine reaches this RPM. This is normally set between 500 to 700 RPM. *Version 1.3and later – Previously after the starter was engaged, the controller watched for the RPM to climb above the threshold to disengage the starter and that was considered "started". Now, the starter is disengaged after reaching that threshold, but the engine is not declared "successfully started" unless it runs to the end of the warm up time without the RPM falling to zero. If the RPM falls to zero, a restart attempt is begun after the restart attempt delay and repeats until the maximum restart attempts have been spent.*

Set Engine Under-speed Shutdown RPM
After the engine is running, if the RPM falls below this speed 9normally set at least 300 rpm above starter disengage rpm), the engine will be shutdown and the controller will lockout displaying the message "Under-speed Shutdown – Field Service Required". The field service tech must press the rear panel reset button to restart the controller after correcting the problem (out of fuel, excessive load due to - ?, etc.). *Version 1.2and later – Enforcement of underspeed does not occur until 30 seconds after the warm up time has expired.*

Set Engine Over-speed Shutdown RPM
After the engine is running, if the RPM exceeds this speed (normally set at least 500 rpm above maximum engine speed), the engine will be shutdown and the controller will lockout displaying the message "Over-speed Shutdown – Field Service Required". The field service tech must press the rear panel reset button to restart the controller after correcting the problem (loss of load due to - ?, governor failure, etc.)

Set RPM Sense Divider
The RPM sensing is based on the possibility that the slowest ignition pulse rate will come from a single cylinder four-stroke engine, which will fire once for every two revolutions. A setting of '1' for this parameter will accommodate such an engine. This number, therefore, represents the number of ignition firings for every two engine revolutions. *Version 1.4 and later – The RPM sense divider will accept a number up to 255.*

Previously 16 was the maximum number. **For Most Honda and Kohler engines set on "2". For GM 3.0 set on "3". For Kubota set on "10".**

Set Start Attempts
This is the number of attempts that will be made upon a single start command to start the engine. If the engine fails to start after this number of attempts, the controller will lockout displaying the message "Engine Failed To Start – Field Service Required". The field service tech must press the rear panel reset button to restart the controller after correcting the problem. *Version 1.3 and later – Previously after the starter was engaged, the controller watched for the RPM to climb above the threshold to disengage the starter and that was considered "started". Now, the starter is disengaged after reaching that threshold, but the engine is not declared "successfully started" unless it runs to the end of the warm up time without the RPM falling to zero. If the RPM falls to zero, a restart attempt is begun after the restart attempt delay and repeats until the maximum restart attempts have been spent.*

Set Max Starter Run Time
This the maximum time the starter motor will be run during a single start attempt. If the engine fails to start in this time, the controller will retry until the Start Attempts are exhausted.

Set Startup Warning Time
The controller is equipped with a 105dB piezo buzzer which sounds for this period of time at the beginning of each start attempt.

Set Start Retry Delay
If a start attempt fails, the controller will wait this amount of time before trying again. This is used in conjunction with Start Attempts to control the start retry behavior.

Set Warm Up Time
When a START is signaled this time period is then used to allow the engine to warm up before the clutch is engaged. *Version 1.2and later – Enforcement of underspeed does not occur until 30 seconds after the warm up time has expired. Version 1.7 – If engine stall after starting during the Warm Up Time, then engine will be considered to have Failed to Start –See Start Attempts.*

Set Cool Down Time
When a STOP is signaled, the clutch is immediately disengaged and this time period is then used to allow the engine to cool before it is shutdown.

Set Stop_1 Delay Time
When using a switch closure to stop the engine, a delay time before the controller recognizes the stop input can be set up to 255 seconds. The controller will start counting as soon as the Startup Warning Time begins. *Version 1.7 A switch closure must be*

maintained for 5 seconds to stop the engine (this is designed to prevent "false" shutdowns. The engine will stop after any "cool down time period" and annotate in display that reason is Stop_1. The engine will restart upon receiving a start signal.

Set Stop_2 Delay Time
Delay time works the same as Stop_1. *Version 1.7 – When a stop signal/switch closure is maintained for 5 seconds, the engine will shut down immediately ignoring any cool down time. This is termed a "hard stop" and will require a "reset" of the controller before any further action (including restart).*

Set Stop_3Delay Time
Works same as Stop_2.

Set MODBUS Slave Address
This the MODBUS Slave Address, it can range from 1-247.

Set Serial Port Speed {1200, 2400, 9600, 19200, 38400, 57600, 115200}
This is the port speed (baud rate) of the controller's serial port. The factory default is 1200 baud in accordance with the MODBUS specification requirements.

Set Serial Data Format {8 E 1, 8 N 2, 8 O 1, 8 N 1}
This is the data format for the controller's serial port. The factory default is 8 bits, Even parity and 1 stop bit. The setting for 8 bits, no parity and 1 stop bit is in violation of the MODBUS standard, but is provided as it is commonly used in practice.

Set Serial RTS On Delay
This parameter causes a delay between the time the controller asserts the RTS RS-232 signal and begins sending data.

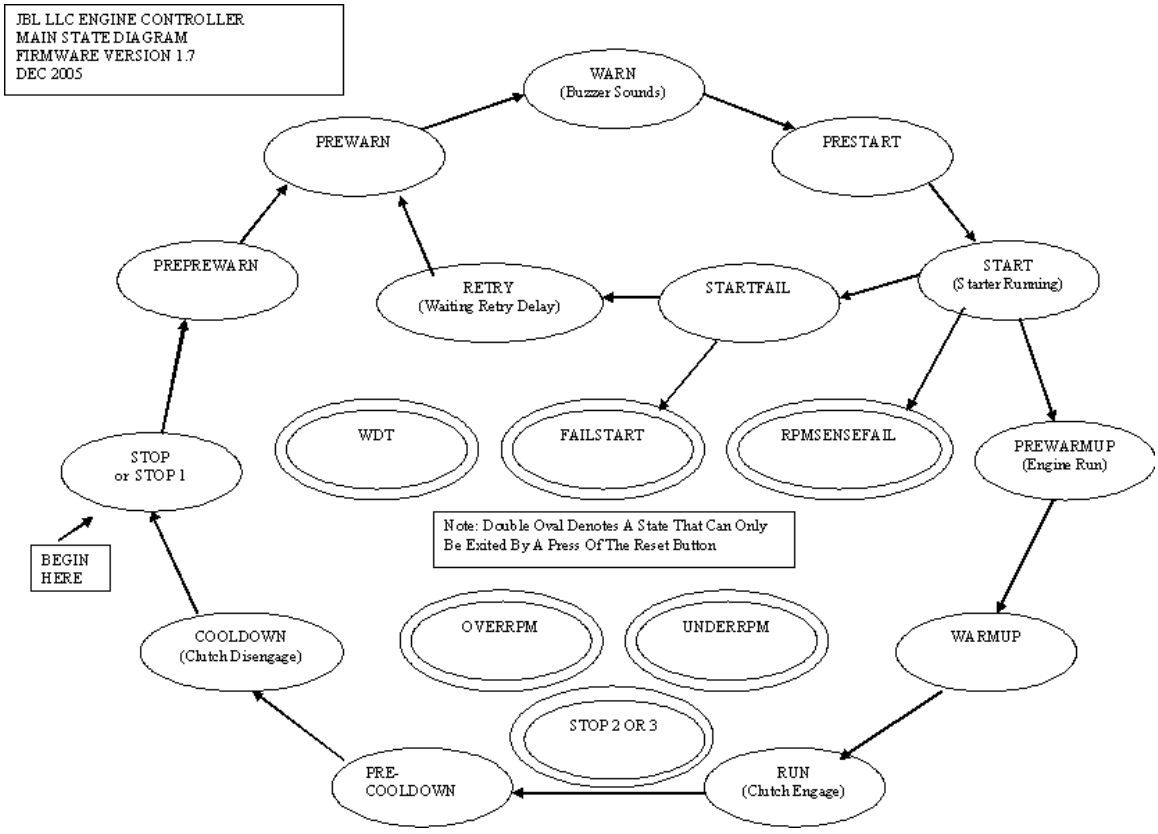
Set Serial RTS Off Delay
This parameter causes a delay between the time the controller sends the last data of a packet and lowering the RTS RS-232 signal.

Set Serial Obey CTS
This parameter determines if the controller obeys CTS flow control.

Modular Description

State Machines

The controller's firmware is governed by a series of finite state machines. The main state machine controls high level functionality such as the current mode (Run/Stop) and the paths to move between these two major states (Warm-up, Cool-down, etc.). The main state machine diagram will assist you in understanding the source code.



MODBUS message processing is controlled by an additional state machine which follows the official MODBUS protocol specification closely.

Real Time Clock

The Dallas Semiconductor DS1306 Real Time Clock chip is used for three purposes in this design. First, it provides a reliable and accurate clock that is more stable that would have been possible with a firmware clock. Second it provides a programmable periodic interrupt that is used by the firmware as a signal to check the schedule for events and do other housekeeping chores. Third, as the clock is battery backed up and has a small quantity of RAM memory, it was the perfect place to store all the statistics (which are frequently updated and thus not ideal for EEPROM storage). The battery being built into the controller has a life expectancy of about 7 years, upon failure the controller will no longer maintain its clock or statistical data during power downs. Replacing the battery requires soldering skills, but the decision not to socket the battery or otherwise make it

"user replaceable" was made solely because of reliability issues. Corrosion of the battery connection would result in erratic behavior.

EEPROM Usage

The Microchip 25LC256 EEPROM is used to store configuration parameters, the schedule and all multilingual message text. The layout of this memory is encoded into the main microcontroller, so doing things like adding additional languages will actually require reprogramming the microcontroller in addition to reprogramming this EEPROM.

MODBUS Protocol Handler

The MODBUS Protocol Handler is a very literal implementation of the specification. It has been extensively tested with the very common Wonderware InTouch HMI software.

Serial I/O – RS232 & RS485

The controller has three serial drivers for interconnection convenience, but in fact only has one serial port into the microcontroller. Which of the three serial drivers (front panel RS232, DB9 connector), back of circuit board RS232 or back of circuit board RS485 is in use is determined as follows.

Front DTR State	Rear DTR State	Active Port
Asserted (<= 0v)	Don't Care	Front RS232
Deasserted (> 0v)	Asserted (<= 0v)	Rear RS232
Deasserted (> 0v)	Deasserted (> 0v)	Rear RS485

The effect of this is to allow a SCADA system connection on either the RS485 or RS232 ports on the rear of the board and allow a field service tech to connect a laptop to the front RS232 port (thus interrupting the connection to the SCADA system) and allow the field service tech to perform local MODBUS interactions (such as reading the log data).

Battery Voltage Monitor

The battery voltage (nominally a 12v wet cell type) is continuously monitored and reported at appropriate times on the LCD display. This information is also available via MODBUS (see the MODBUS register map tables).

LCD Display

The LCD display is a 2 line by 24 character reflective display with a very wide viewing angle. There is a contrast control adjustment available on the back of the circuit board, a small potentiometer (R10) can be adjusted with a small screwdriver. This should rarely be necessary after initial adjustment and any required adjustment will likely be due to ambient temperature changes.

User Interface Pushbuttons

There are five pushbutton switches on the controller. The four on the front panel are labeled, left to write: Previous, Next, Set and Menu. The pushbutton on the back of the circuit board is to initiate a Reset (single press) or enter Configuration mode (double

press). More information on the use of the buttons is given in the **Operational Walk-through.**

Warning Horn

The pre-start warning tone (500mS duration pulses at 1 second intervals for the time specified in the "Warning Time" configuration parameter is provided by a 105dB piezo buzzer located on the back of the back of the circuit board.

Output Relays

Four output relays provide +12v switched power for the ignition, starter and clutch and provide a switched path to ground for the magneto ground/engine kill function.

Discrete Input Contacts

Four discrete input contacts are provided on connector J3. One input is denoted "START" and shorting this to ground will signal a start condition to the controller. The other three inputs are denoted "STOP_1", "STOP_2" and "STOP_3" and shorting any of these three to ground will signal a stop condition to the controller. Holding any of the STOP contacts at ground will prevent any kind of start activity.

RPM Sensing

RPM sensing is achieved by presenting nearly any reasonably "clean" wave form on the RPM Sense line of the J2 connector. External filtering and conditioning is expected in the cable assembly as near to the target engine as possible to reduce the high voltage emissions entering the controller.

Power Supply

Power to the controller is expected to be a 12v wet cell battery and power input to the controller is protected against reverse polarity and over voltage. The board is over current protected by a 15 amp ATC style automotive fuse.