Ample Power Company

EnerMatic System Controller Specifications

EnerMatic Controller

Introduction

The EnerMatic Controller is designed to manage an energy system including batteries, an engine, solar panels, and wind/hydro generators.

Electrical Isolation

There is electrical isolation between the engine related circuits and the other *energy* components. That is, the engine circuits and the energy circuits don't share a common ground. The alternator, though mounted on the engine, is part of the energy circuits and thus isolated from the engine.

This isolation is provided so that the battery and other energy circuits can be connected with a negative or positive ground. Land line telephone systems have historically used a positive ground because a negatively biased wire in the earth will suffer less from corrosion.

The *ground* of the EnerMatic Controller is always connected to the most negative point. That is, the -48V terminal in a historical telcom system.

There are two serial ports on the EnerMatic Controller, both of which are electrically isolated from the engine and the energy system.

Connectors

Connections to the EnerMatic Controller are made with watertight Molex connectors, (MX150L), or via #10-32 brass studs.

Engine System

12V Supply

A 12V supply is required, and the 12V starter battery is typically used. There are two 12V inputs, one for sensors and low current outputs, and one for high current outputs.

Engine Referenced High Current Outputs

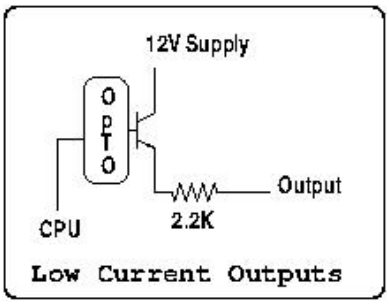
Engine Controls are asserted positively from the high current 12V supply via #10–32 brass studs.

Control Output	Current (Amps) Int./Cont.	Timing
Glow	90/45	Programmable
Crank	90/45	Programmable
Run	45/22	Programmable
Fuel	20/10	Programmable
H2O Pump	20/10	Programmable
Oil Pump	45/22	Programmable
Stop	90/20	Programmable
Fan	20/10	Programmable

Engine Referenced Low Current Outputs

- **SENDER POWER** . . . asserted to enable engine switches and senders. Approximately 0.2 Amps available for external use, over the sender requirements, however electrically noisy loads may affect engine senders.

All other engine referenced low current outputs shown below are of the form shown in the schematic below. As shown, an optical coupler is used to isolate the internal microcomputer from the 12V circuits. Drive current is approximately 0.005 A when the output is *asserted*. This is adequate to drive an LED or other control apparatus. Further isolation is required to interface to energy circuits that use a positive ground.



Outputs available are:

- **THROB** . . . periodic signal that indicates the processor is running. Can be used to drive an LED.
- **SOLAR** . . . asserted when solar charge control parameters are *true*.
- **WIND** . . . asserted when wind charge control parameters are *true*.
- **ERROR** . . . indicates that an error has occurred.
- **STATUS** . . . indicates autostart is enabled.
- **TOD** . . . asserted during a programmable daily interval.
- **TOD2** . . . asserted during a programmable daily interval.
- **PARALLEL** . . . asserted when programmable parameters for the energy battery voltage have been met.

Engine Referenced Inputs

- **EMERGENCY STOP** . . . contact closure to stop the engine immediately.
- **REMOTE** . . . contact closure to run/stop the engine.
- **IGN1** . . . positive signal to enable regulator without running engine.
- **IGN2** . . . positive signal to enable regulator without running engine.
- **H2OSW** . . . switch input for coolant over temperature, open equals hot.
- **H2O SENDER** . . . resistive coolant temperature sender.
- **OILSW** . . . switch input for oil pressure, open = low pressure.
- **OIL SENDER** . . . resistive sensor for oil pressure.
- **RPM** . . . flywheel gear tooth sensor for RPM measurement.
- **FUEL LEVEL** . . . resistive sensor for fuel level.
- **OIL LEVEL** . . . resistive sensor for oil level.
- **V3** . . . resistor divider for voltage measurement.
- **T1** . . . input for silicon temperature sender.
- **T2** . . . input for silicon temperature sender.
- **12V** . . . input for low current engine circuits.
- **12V PWR** . . . input for high current engine circuits.

Engine Instrumentation

Name	Type	Displayed	Resolution	Accuracy
Fuel Level	resistive sender	Percent Remaining	12 bits	per sender
Oil Level	resistive sender	Percent Remaining	12 bits	per sender
Oil Pressure	resistive sender	PSI	12 bits	per sender
Coolant Temperature	resistive sender	$^{\circ}C$	12 bits	per sender
Starter Battery Voltage	Resistor Divider(1)	Voltage	12 bits	0.1%
V3 Voltage	Resistor Divider(2)	Voltage	12 bits	0.1%
T1 Temperature	Silicon(3)	$^{\circ}C$	12 bits	2°C
T2 Temperature	Silicon(3)	$^{\circ}C$	12 bits	2°C

1. Starter Battery voltage is nominal 12 unless special order.
2. V3 voltage channel available for special applications.
3. T1 and T2 temperature channels available for special applications.

Sender Data

Sender	Low Ohms	High Ohms
Fuel Level	240 empty	33 full
Oil Level	240 empty	33 full
Oil Pressure	10 at 0 PSI	188 at 80 PSI
Coolant Temperature	264 at 93°C	22 at 121°C
Oil Switch	open	closed
Coolant Switch	closed	open
Silicon Temperature	2.98V at 25°C	$\pm$10millivolt per °C

Energy System

Energy System Referenced Inputs

- **B1 VOLTS** . . . voltage of the energy battery.
- **AUXV** . . . another voltage input for special applications.
- **SOLAR SHUNT** . . . shunt input to measure solar current.
- **WIND SHUNT** . . . shunt input to measure wind generator current.
- **ALT SHUNT** . . . shunt input to measure alternator current.
- **BAT SHUNT** . . . shunt input to measure energy battery current current.
- **B1T** . . . input for battery temperature sensor.
- **FLD VOLTS** . . . voltage on the alternator field.
- **B+** . . . main power for the Energy System circuits.

Energy System Instrumentation

Name	Type	Polarity	Resolution	Accuracy
Battery Amps	50 mV shunt(1)	Charge/Discharge	12 bits	0.15%
Alternator Amps	50 mV shunt(1)	Charge	10 bits	0.3%
Solar Panel Amps	50 mV shunt(1)	Charge	10 bits	0.3%
Wind Generator Amps	50 mV shunt(1)	Charge	10 bits	0.3%
Battery Temperature	Silicon	Positive/Negative	10 bits	2°C
Battery Voltage	Resistor Divider(2)	Positive/Negative	10 bits	0.15%
Field Voltage	Resistor Divider(2)	Positive/Negative	10 bits	0.15%
Auxiliary Voltage	Resistor Divider(3)	Positive/Negative	10 bits	0.15%

1.Full scale Amps for a shunt is programmable via the User Interface Menus.
2. System Voltage selection is factory set at 12, 24, 32, 36, or 48 Volts.
3. Auxiliary Voltage available for special applications.

Engine Start Methods

The engine will not start when ever the *emergency stop* input is asserted.

The engine can be automatically started by a variety of user enabled and programmed conditions. Multiple enabled conditions can be programmed and the engine will start when the first condition is met.

- **HEURISTIC** . . . conditions based on Ample Power battery management expertise.
- **VOLTS & TIME** . . . voltage less than a programmable setpoint for a time greater than a programmed amount.
- **CURRENT & TIME** . . . discharge greater than a programmable setpoint for a time greater than a programmed amount.
- **AMP–HOURS CONSUMED** . . . after a programmed quantity of Amp–hours has been consumed by discharge.
- **REMOTE** . . . when the remote input is asserted.

Engine Controls Start Timing

The Enermatic asserts outputs with timing parameters pre–programmed by the user. The sequence timing for start can be programmed to change the order but is usually as shown below:

1. **Assert Run** . . . turn on external gear and/or throttle solenoid.
2. **Assert Senders** . . . turn on engine sensors.
3. **Assert Fuel(1)** . . . turn on fuel pump for programmable period or continuously.
4. **Assert Glow** . . . activate glow plugs for programmable period.
5. **Assert Crank** . . . activate starter for programmable period, (maximum) or until engine starts.
6. **Assert Water Pump(2)** . . . activate water pump, (if used).
7. **Assert Fan(3)** . . . activate electric fan, (if used).
8. **Assert Regulator** . . . activate alternator regulator. (allow for engine warm up.)

1. Fuel pump can be operated at start up for a programmable time, typically used to prime the mechanical pump, or the fuel pump can be operated continuouly, sometimes used to *polish* the diesel fuel while the engine is running.
2. Water pump can be used to pump coolant through an external heat exchanger.
3. Fan can be used for engine cooling, or other application.

Engine Stop Methods

The engine will stop when ever the *emergency stop* input is asserted.

The engine can be automatically stopped by a variety of user enabled and programmed conditions. Multiple enabled conditions can be programmed and the engine will stop when the first condition is met.

- **HEURISTIC** . . . conditions based on Ample Power battery management expertise.
- **VOLTS & TIME** . . . voltage greater than a programmable setpoint for a time greater than a programmed amount.
- **VOLTS & AMPS & TIME** . . . voltage greater than a programmable setpoint with battery current below a programmed setpoint and for a time greater than a programmed amount.
- **BATTERY FULL** . . . when the programmable battery full criteria is met.
- **LOW ALT AMPS** . . . when alternator current falls below a programmed amount.
- **REMOTE** . . . when the remote input is negated, if started with the remote input.
- **LOW OIL PRESSURE** . . . when the low oil pressure switch opens.
- **HIGH ENGINE TEMPERATURE** . . . when the engine coolant switch opens.

Engine Controls Stop Timing

The Enermatic asserts outputs with timing parameters pre–programmed by the user. The sequence timing for stop can be programmed to change the order but is usually as shown below:

1. **Negate Regulator** . . . turn off load on engine for cool down.
2. **Assert Stop(1)** . . . activate stop solenoid for programmable time period, (if used).
3. **Negate Run** . . . turn off external gear and/or throttle solenoid.
4. **Negate Senders** . . . turn off engine senders.

1. Some engines use a separate solenoid that must be actuated to stop the engine.

Alternator Regulation

The alternator is regulated with a multi–step regimen that uses battery temperature to compensate the regulated voltage. There are user programmable setpoints to accomodate different battery types.

Power generated by the alternator can be limited by the regulator according to user programmable configuration.

Communications

Two RS-232 serial ports are provided. Serial ports are isolated from both engine and energy circuits, allowing use of a standard laptop PC with positive grounded batteries.

Port #	Protocol	Method	Baud Rate
1	VT100	Terminal Menu	38,400
2	Remote Access	External Computer	38,400

Data Logging Memory – 512 kBytes

Data logging memory is supplied via data flash chips soldered onto the printed circuit. Data flash chips are like those used in SD cards. Storage of 512 kBytes is available to log user selectable data sets.

Logged data can be saved to a file on a PC by using Port 1 of the communication ports or via Port 2 if the external computer is capable.

Power Consumption

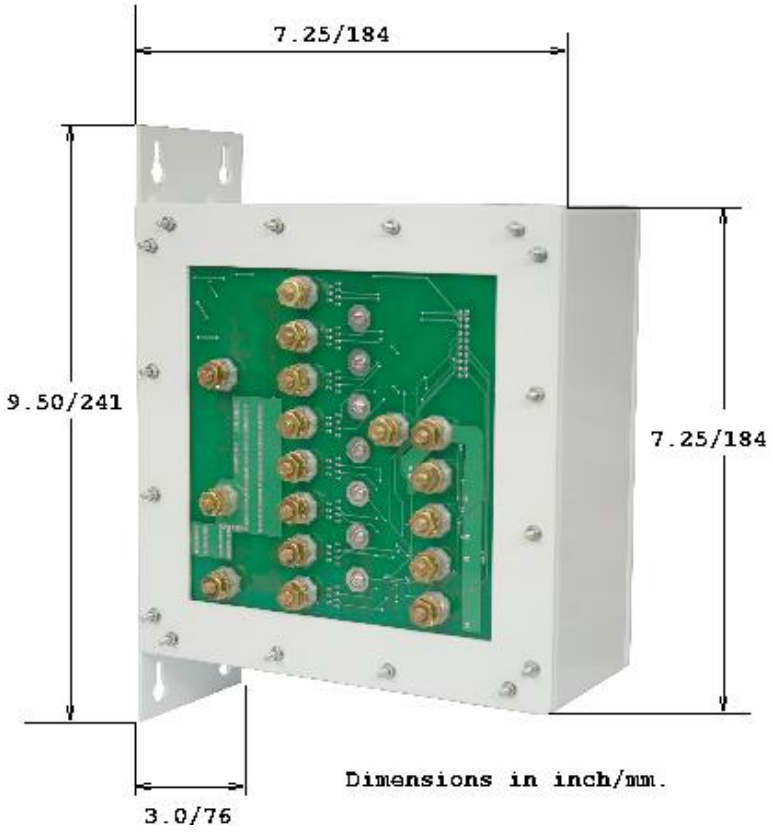
Power Source	Engine Running Watts	Engine Not Running Watts
Engine System	1(1)	0.05(2)
Energy System	0.75	0.5

1. Not counting throttle solenoid, fuel pump, water pump, and fan loads.
2. Internal engine circuits are de-powered when engine is not running.

Dimensions and Packaging

The EnerMatic Controller is packaged in a watertight, powdered coated, aluminum enclosure suitable for mounting in harsh environments such a ocean buoys, engine compartments, and industrial settings.

Low current signals use Molex MX150L connectors. High current connections are made via #10–32 studs that have been floated in clear epoxy to make a robust seal.



Weight: Aproximately 3 pounds, (1.5 kg).

Standard Accessories

The following items below are included with the EnerMatic Controller. Shunts with different ratings may be substituted when requested at the time of order.

1. **Battery Shunt** rated 400 Amps at 0.05 Volts.
2. **Alternator Shunt** rated 400 Amps at 0.05 Volts.
3. **Temperature Sensor** for the Energy Battery.
4. **Hardware** for the #10–32 studs.
5. **Cable End Mates** for the Molex connectors.
6. **Pins** required for mating connectors/
7. **Crip Tool** for the Molex pins.

Optional Accessories

Optional accessories include:

1. **Solar Panel Shunt** . . . specify rating.
2. **Wind Generator Shunt** . . . specify rating.
3. **Temperature Sensors** for auxiliary temperature sensing.