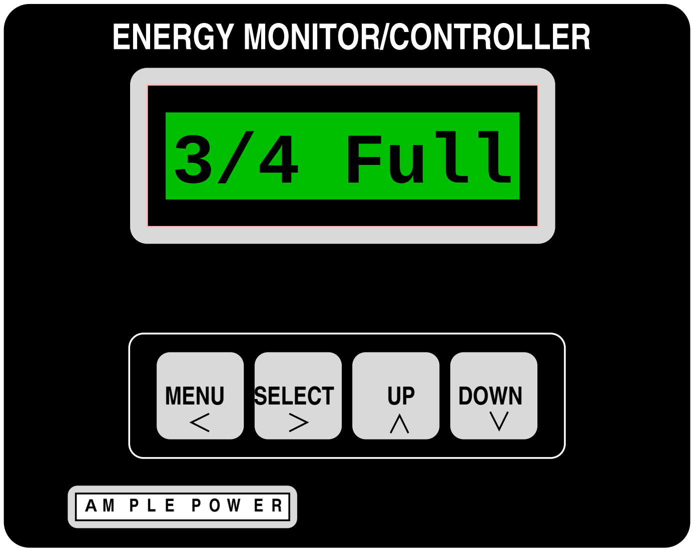
Energy Monitor/Controller 2001

Installation and Operating Instructions

EMON2001–H1, EMON2001-H1A June 14, 2001



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Introduction

The Energy Monitor/Controller 2001, EMON for short, is designed to completely monitor one house battery bank and one engine starter bank. It provides the resolution and accuracy necessary to eliminate battery discharge problems and its selectable alarms will keep you informed of abnormal conditions before they become dangerous.

The Energy Monitor is made in two versions: the H1, a one house bank unit with an auxiliary current sensing input and the H1A, a one house bank unit with an Alternator Current Sensor input. The H1 requires an option shunt to measure auxiliary current, while the H1A requires an optional Alternator Current Sensor to measure alternator current.

Alarms for abnormal conditions can be individually enabled or disabled, and the alarm setpoints can be programmed as desired. Alarm values and their activation controls are kept in non–volatile memory.

Interfaces are available to control external solar and wind generator relays, to start/stop a generator, and signal an external alarm circuit such as a horn or pager input.

A computer interface is provided to allow data gathering.

The Emon operates on 12 or 24 Volts, and input channels can be a mix of 12 and 24 Volts.

Measurements

The Emon measures voltage for two batteries, battery current, battery temperature, and either auxiliary current, (H1), or alternator current, (H1A). Note: Auxiliary current is measured with a shunt in the negative lead of the auxiliary charge source, while alternator current in measured in the positive lead. The auxiliary shunt can be used in the negative lead of an alternator that has a floating ground.

Full scale voltage is 39.99 Volts with a resolution of 0.01V. Battery current is measured to 399.9 Amps, with 0.1A resolution.

Auxiliary and alternator channels measure 199.9 Amps full scale with 0.1 Amp resolution. Full scale to 400 Amps can be accommodated on special order.

Voltage and Current Analog References

The Emon generates a voltage and current analog reference that can be used by an external charger to control the charge setpoint and the current limit. The voltage reference is temperature compensated. The voltage reference is 1/10 of the expected battery voltage for 12 Volt systems, and 1/20 for 24 Volts.

Note: Analog references are high impedance and must not be loaded with a resistance less than 100 Kohms.

Solar/Regulator Controller Signal

A digital signal is provided which interfaces to external solar/wind controllers and the Next Step or Smart Alternator Regulators. This signal instructs the controllers and regulators to stay in the absorption state until the battery is full. Note that the same signal is used from multiple solar/wind controllers as well as alternator regulators. It is a voltage signal that swings both positive, (asserted), and negative, (inactive). It must not be loaded with more than 0.003 Amps.

Activation setpoints for the control signal are programmable.

Generator Start/Stop Signal

A digital signal is provided which can be used to tell a generator to start or stop. The signal is asserted whenever battery capacity falls below a programmable setpoint, and it remains asserted until capacity is restored to a second programmable setpoint. For example the signal can be programmed to be asserted when capacity falls below 50% and stay asserted until capacity recovers to 90%.

The start/stop signal is pulled to ground with a small signal NPN transistor. An external relay may be required to interface it to a generator controller. No more than 0.050 Amps may be sunk by the transistor.

Alarm Signal

An external alarm signal is provided which is asserted whenever an abnormal condition is detected. Note: Abnormal condition setpoints are programmable, and alarms can be individually enabled or disabled.

The alarm signal is pulled to ground with a small signal NPN transistor. An external relay may be required to interface it to an external circuit. No more than 0.050 Amps may be sunk by the transistor.

Accuracy and Usability

The Energy Monitor can be very accurate and highly functional when it is installed and configured properly. Failure to configure the unit for your system particulars will not allow it to provide the accuracy and functionality expected. Accuracy is dependent on several parameters and conditions and an understanding of these is necessary before the performance of the unit is fully apparent.

Amp–hours remaining, percent remaining and the ‘gauge’ messages are all based on the same arithmetic process. If one is not correct, then none will be correct. In subsequent paragraphs, the term Amp-hours remaining also means percent remaining and the gauge display.

Amp–hours remaining is dependent on the capacity, or ‘size’ of the battery bank. Capacity is programmed under the Size ? prompt. For best result, don’t accept manufacturer’s claims of battery capacity ... many capacity claims are simply not true. For best accuracy, perform a capacity test. Capacity tests should be done once a year.

Amp–hours remaining is also dependent on Peukert’s exponent. This value is programmed by the user. The only way that a valid exponent can be programmed is to first determine the exponent by two capacity tests.

When charging, Amp–hours depends on charge efficiency. During charge, an efficiency factor is arithmetically applied to charge current, reducing the actual current to its effective value. If charge efficiency is inaccurate, the state-of-charge information grows inaccurate with every charge.

Charge efficiency can be manually programmed by the user, or it can be calculated automatically. In most circumstances, the microcomputer can best determine recharge efficiency.

Before the microcomputer computes charge efficiency, three conditions must be met. First, the unit must be programmed to compute charge efficiency automatically. Secondly, the batteries must reach a full charge as defined by the FULL V and FULL I parameters. Finally, there must have been a prior discharge of the batteries of at least 50% of capacity. This discharge need not be the last discharge cycle ... it may have occurred at any time in the past since the last time a full charge occurred.

Periodically discharge below 50% and fully recharge. Without a periodic full charge, Amp-hours consumed and remaining continue to grow in error until the displays are meaningless. Be sure to periodically charge to the programmed full criteria, and periodically discharge below 50% of capacity.

The steps to accuracy are:

- Accurate programming of battery capacity;
- Accurate programming of Peukert's exponent;
- Selecting automatic determination of charge efficiency;
- Periodic discharge below 50% and then;
- Periodic charge to the full criteria.

Once these steps have been understood and performed, the Energy Monitor will provide unequaled accuracy regarding battery state of charge.

Determining Peukert's Exponent

The Emon reports Amp–hours consumed as the product of Amps and time. Amp–hours consumed is not a good indicator or Amp–hours remaining because the faster the rate of discharge, the less total Amp–hours are available.

Back in 1897, a battery researcher by the name of Peukert published an equation that allows the calculation of available capacity at any discharge current. His equation, still valid today, states:

$$I^n t = C$$

In Peukert's equation, *C* is a constant, namely the capacity of the battery. The letter *I* denotes the discharge current in Amps. The exponent *n* is related to battery construction, and is also a constant for any given battery. The letter *t* represents the time of discharge. Exponent *n* varies from more than one to about 2. Exponent *n* can be calculated by knowing the capacity obtained at any two discharge currents. That is, if we first discharge a battery at 5 Amps, and later at 20 Amps, and calculate the Ah obtained for each discharge, then the exponent *n* can be calculated from the equation below.

$$n = \frac{log t_2 - log t_1}{log I_1 - log I_2}$$

In the equation above, t_1 is the hours of discharge at the current I_1. The second discharge is t_2 and I_2.

The discharge procedure to determine the exponent is to first start with a fully charged battery. Discharge it at a convenient rate which is below your normal discharge rate, perhaps 5-8 Amps. When the voltage falls to 10.5 Volts, note the Amp-hours consumed and the length of time that the discharge took. Calculate the average Amps by dividing the Amp-hours consumed by the length of the discharge. For instance, assume that the discharge lasted for 49.5 hours and Amp-hours consumed was 300. Doing the division yields an average Amps of 6.06. This completes all the data needed for half of the above equation.

Charge the battery fully and repeat the discharge for the second data set. This time, however, discharge at a rate which is higher than your normal usage, perhaps that expected on an overnight passage. By making the discharge tests on either side of normal usage, you'll develop an exponent that is very accurate for the range which includes normal use. Once the two discharges have been done and Peukert's exponent calculated, program it into the Emon and enjoy the satisfaction of knowing Amp-hours remaining very accurately. The Emon is initialized at the factory with an exponent of 1.125. This is a convenient mid-range value. Large battery banks will have a lower exponent, while small banks will be higher. While this exponent may be close to your bank(s), we urge you to perform the discharge tests and be precise.

Interpreting Display Data

Data, which includes such elements as Battery 2 voltage, Amp–hours consumed and Battery 1 temperature are presented with a leading identifier, the value of the data, and a trailing identifier. The leading identifier describes what is being displayed, while the trailing identifier shows the units of the value.

For instance, a leading identifier of 1 with a trailing identifier of V means that the value is Battery 1 Volts.

Some of the displays, such as Life Amp–hours are too long to include the leading and trailing identifiers . . . pressing the Menu key will show the prompt which identifies the data.

Operating the User Interface

The Emon is very easy to use after a short trial period. An eight character display and four keypads permit menu traversal, adjustment of setpoints, selection of options, and viewing of data.

All menus are circular with a varying number of prompts. By using the Up and Down keys, all menu prompts in a given circle can be seen. Prompts end in a question mark. When presented with a prompt, the Select key can be used to go to the menu or data display behind the prompt. You might think of the Select key as a Yes key to the questions asked by the prompt.

At any prompt, the Menu key can be used to escape to a higher menu. It is also used to abort data entry. You might think of the Menu key as an Escape key. It's the safest key to actuate when in doubt.

The top–most menu, which is presented whenever power is applied to the Emon, begins with the prompt *Start ?*. By actuating the Select key the next item in the top–most menu will appear.

Besides prompts, which are always terminated with a ? mark, there are data display, value adjustments, and option selections. The operations of the keypads have slightly different meanings depending on what is being displayed.

When viewing data, the Up or the Down key will move to the prompt for the preceding or next data display in the menu. As with prompts, the Menu key will escape to a higher level menu. The Select key merely refreshes the present data display, which is automatically updated once a second anyway.

Options are selected by using the Up and Down keys to set True, (Up), or False, (Down). The True or False refers to the question asked by the prompt. Once an option has been set to the desired state, the Select key is used to save the option in non–volatile memory. To escape changing an option, the Menu key can be used to exit the selection leaving the previously selected option in memory.

When an option is Selected, the next option in the menu is presented with its prompt.

Adjusting values uses the Up and Down keys to increment or decrement the displayed value. Holding the Up or Down key will make the increments or decrements greater the longer the key is held down. Once a value has been entered, the Select key will lock it into non-volatile memory. To escape setting a value, use the Menu key.

Sometimes when depressing a key for a long period to get a large change in the value, the display will fall behind and may display partial information or perhaps be blank. Releasing the key will allow the display to catch up.

Before reading the subsequent sections regarding menus, it's suggested to install and wire the Emon so that the keypad and display can be used.

Top–Most 'Start' Menu

- Start ? . . . . start by using the Select key

The Start menu is a menu of a single element. Pushing the Up or Down key just moves around this circular menu like all the rest of the menus. There isn't a higher level menu, so the Menu key has no where to go but to the Start menu.

Since the Menu key always escapes to a higher menu offering, pushing that key repeatedly will eventually reach the Start ? prompt. The Menu key doesn't set any values, so it's always safe to push the Menu key until the Start ? prompt is displayed.

Main Menu

- Scroll ? . . . . sequentially shows data in the 'scroll list'
- View ? . . . . select data to be displayed
- Program? . . . . set options, alarms, setpoint values
- Reset ? . . . . clear accumlated Amp–hours and other data
- Kwikeys? . . . . operate in four key 'data' mode

The data that is presented when Scroll is active depends on the selections made under the Programming Menu. When scrolling, data is presented continuously. This is done with a descripter followed by a value. If you want to stop at a particular place, depress the Select key when the descripter is shown. The value for that descripter will then be continuously updated until the Select key is depressed to resume scrolling.

Selecting on the View ? prompt descends to the View Menu. Here you can choose the data to be displayed an item at a time.

Selecting on the Program ? prompt opens up the Program Menu where you can customize the operation of the Emon to suit your specific requirements.

Selecting on the Reset Menu enables you to clear accumulated data, such as Trip Amp–hours or Life Amp–hours. (A description of these is presented later.)

Selecting on the Kwikeys ? prompt drops you into an alternate use of the keypads. In the Kwikeys mode, the four keys are used to select a subset of the data available under the View Menu. The data behind the keys is:

- Menu . . . . B1 Volts – Battery 1 is the house battery bank
- Select . . . . B1 Amps – house battery current, minus is discharge
- Up . . . . Amp–hours consumed from the house bank
- Down . . . . B1 state–of–charge in English (3/4 Full)

Escaping the Kwikeys mode is done by actuating any one key five times in a row rapidly.

View Menu

The View Menu is used to select data to be displayed continuously until a different selection is made. Data to be viewed is grouped according to the source of the data . . . that is house bank, starter bank, and auxiliary/alternator channel.

Choices under the View Menu are:

- B1 . . . . data for B1, the house battery bank
- B2 . . . . data for B2, the starter battery bank
- Aux Ch/(Alt Ch) . . . . data for the auxiliary/alternator channel

View/B1 Menu

Under the B1 selection of the View Menu is all the measured and computed data for the house bank.

- Gauge ? . . . . the state–of–charge in English, (3/4 Full)
- Volts ? . . . . the present voltage on B1, the house bank
- Amps ? . . . . the present current through B1, minus is discharge
- Temp ? . . . . the present temperature of B1
- Ah Con ? . . . . . . Amp–hours consumed since Full, minus is overcharge
- Ah Rem ? . . . . Amp–hours remaining in the house bank
- %Remain ? . . . . Ah remaining expressed as a percent of capacity
- Time ? . . . . time remaining at present discharge rate
- Trip Ah ? . . . . an Ah accumulator analogous to a trip odometer
- Life Ah ? . . . . an Ah accumulator for long term acquisition
- kWh ? . . . . kilo–Watt–hours used in the last discharge
- kWh Tot ? . . . . a long term accumulation of kWh consumed
- Effic . . . . the present recharge Amp–hour efficiency
- T Size ? . . . . battery capacity adjusted for temperature

Note: The time remaining is based on the present discharge rate and present state–of–charge as well as a programmble parameter which represents the end point for the time calculation. See the 'End %RM ?' prompt under programming. When the battery is not being discharged, the Time display shows 'No Cons', for no consumption.

The Trip Ah is useful to measure the Ah consumption for specific events, say a weekend or week of use. Life Ah is best used to measure how many Amp–hours a set of batteries provided over their useful life.

View/B2 Menu

- Volts . . . . the voltage of B2 the starter bank

View/Aux Ch/(Alt Ch) Menu

- Amps . . . . the present current from the Aux/(Alt) device
- Life Ah . . . . the accumulated Amp–hours from the Aux/(Alt) device

Program Menu

- Charger . . . . modes and references for Ample Power chargers
- Cntrlr . modes and setpoints for solar/regulator and generator start/stop
- B1 . . . . enable/disable alarms; setpoints; capacity; limits; values
- B2 . . . . enable/disable alarms; alarm setpoints; calibrate
- Aux Ch/(Alt Ch) . . . . calibrate
- Back Lt . . . . operational mode, brightness, turn off delay
- Contrst . . . . LCD contrast setpoint; when in doubt go Down
- Scroll . . . . select data items for 'scroll list'
- Baud . . . . select Baud rate for computer interface
- Fahren . . . . choose fahrenheit or celsius temperature display
- Effauto . . . . choose automatic or manual charge efficiency

Program/Charger Menu

Under the Charger Menu, the operating mode and setpoint values can be selected which control the analog voltage and current references. These references can be used on the first generation Ample Power Smart Chargers, the Smart Alternator Regulator, V2, and the new Power Supply/Charger units. The Next Step Regulator and Smart Alternator Regulator, V3 do not use the analog references, but use a digital control signal instead.

- Op Mode ? . . . . automatic multi–step or fixed setpoint operation
- Values . . . . adjust the voltages for the various setpoints

Using the Op Mode Menu the references can be applied in a multi–step manner, or fixed at a particular setpoint. Selecting True for any given op–mode sets the others to False.

The Values Menu permits setting the voltages used for the various multi–step setpoints.

Program/Charger/Op Mode Menu

- Auto . . . . . automatic multi–step operation; recommended
- Gas . . . . . lock voltage to the ‘gas voltage’ setpoint
- Absorb . . . . . lock voltage to the ‘absorption voltage’ setpoint
- Float . . . . . lock voltage to the ‘float voltage’ setpoint
- Equaliz . . . . . perform battery equalization

Program/Charger/Values Menu

- Gas . . . . . set the ‘gas voltage’ setpoint
- Absorb . . . . . set the ‘absorption voltage’ setpoint
- Float . . . . . set the ‘float voltage’ setpoint
- Equaliz . . . . . set the ‘equalization’ voltage
- Amps . . . . . adjust the Amps analog reference
- Minutes . . . . . set the maximum equalization minutes
- Calibrt . . . . . adjust voltage reference for charger

The Calibrt function is used to adjust the voltage reference so that battery voltage precisely matches the setpoint value. This is usually not necessary unless extreme accuracy is desired.

Program/Cntrlr Menu

- B1 Full ? . . . . . solar/regulator controller negates on ‘full’ or voltage
- Volt Lo ? . . . . . connect voltage for solar/regulator controller
- Volt Hi ? . . . . . disconnect voltage for solar/regulator controller
- Tmp Cmp ? . . . . . True/False . . . temperature compensate setpoints
- SOC Lo ? . . . . . generator Start state–of–charge setpoint
- SOC Hi ? . . . . . generator Stop state–of–charge setpoint

The controller signal is used for solar and wind generator control and also used with the Next Step and Smart Alternator Regulator, V3. The signal will be asserted when the voltage falls below the Volt Lo setpoint. If B1 Full is marked True, then the controller signal will be negated only when the batteries are full. Alternatively, the signal can be negated when the voltage exceeds the Volt Hi setpoint. This mode is selected by making B1 Full ? False.

Program/B1 Menu

The Program/B1 Menu is used to choose options and adjust setpoints for the house bank.

- Alarm ? . . . . . enable/disable alarms for B1
- Volts ? . . . . . calibrate full scale and zero for B1 voltage
- Hi Alrm ? . . . . . set the high voltage alarm setpoint
- Lo Alrm ? . . . . . set the low voltage alarm setpoint
- Amps ? . . . . . calibrate full scale and zero for B1 current
- End %RM ? set the ending % remaining for time remaining calculation
- B1C Lo ? . . . . . set the % remaining for capacity low alarm
- Hi Amps ? . . . . . set the Amps value for the high Amps alarm
- Tempcal ? . . . . . calibrate the temperature sensor
- Tmp Lim ? . . . . . set the temperature for the high temperature alarm
- Size ? . . . . . enter the Amp-hour capacity at the 20 hour rate
- Peukert ? . . . . . enter Peukert’s exponent for rate of discharge effects
- Effic ? . . . . . enter manual recharge efficiency
- Full V ? . . . . . set the voltage required to achieve a full condition
- Full A ? . . . . . set the Amps required to achieve a full condition

Full V and Full A settings are critical to proper operation. These parameters are used to detect when a full charge is achieved. For a full charge to occur, the battery voltage must be greater than the Full V setting, and the battery current must be less than the Full A setting.

The Full V setpoint should be set at slightly less than what the battery charger or alternator regulator delivers as a maximum. That is, 14.1 Volts is appropriate for a charger known to deliver 14.4 Volts.

The Full A setpoint should be set at about 5% of battery capacity in Amp–hours. That is, for 100 Ah of capacity, the Full A setpoint would be 5.0 Amps.

Failure to set Full V and Full A values appropropriately for the charge sources and the battery capacity will result is poor or meaningless Amp–hour computations.

An accurate Peukert’s exponent is crucial to computing Amp–hours remaining, especially under high current loads. The book *Wiring 12 Volts for Ample Power* explains Peukert’s exponent and how to derive it by two complete battery discharges.

Time remaining is calculated from the preset state–of–charge, using the present discharge current to the percent remaining set under the End %R ? prompt.

Program/B1/Alarm Menu

This menu is used to enable or disable individual alarms by setting them True, (enabled) or False, (disabled).

- B1V Hi ? . . . . . high voltage alarm for B1
- B1V Lo ? . . . . . low votage alarm for B1
- B1T Hi ? . . . . . high temperature alarm for B1
- B1 50% ? . . . . . alarm at 50% capacity for B1
- B1 20% ? . . . . . alarm at 20% capacity remaining for B1
- B1C Lo ? . . . . . alarm at programmable capacity setpoint for B1
- B1 Full ? . . . . . alarm when B1 reaches full
- Hi Amps ? . . . . . alarm if the high Amps setpoint is exceeded

Program/B1/Volts Menu

This menu permits calibration full scale and zero for the B1 voltage channel.

- Zero ? . . . . . adjust to read 0.0 with no input on B1V terminal
- Calibrt ? . . . . . calibrate full scale reading against known reference

Program/B1/Amps Menu

This menu permits calibration full scale and zero for the B1 current channel.

- Zero ? . . . . . adjust to read 0.0 with no input on B1 Amps terminals
- Calibrt ? . . . . . calibrate full scale reading against known reference

Program/B2 Menu

This menu is similiar to the B1 menu, but with fewer values to program. Refer to the prompts for B1 for an explanation of their meanings.

Program/Back Lt Menu

The Back Lt menu is used to control the LCD backlight intensity, and the mode of operation. The backlight can operate in the auto mode where it goes off when the keypad has been inactive for a prescribed delay time. In this mode the display will reactivate when any key is depressed. The backlight can also be on or off continuously. Since the backlight can take 4–6 times the energy draw of the Emon itself, operating in the auto mode is recommended.

- Delay ? . . . . seconds to delay after last key activation before turning off
- Bright ? . . . . . controls backlight intensity
- Op Mode ? . . . . . select Auto or On/Off

Program/Back Lt/Op Mode Menu

- Auto ? . . . . . operate automatically if True; False let On/Off work
- On ? . . . . . if Auto is False, On=True means backlight on, False off

Program/Scroll Menu

This menu selects the data that will be displayed when the Emon is scrolling. A data element is put into the scroll list when it is marked True. Any element marked False is omitted.

- B1 Volt ? . . . . . battery 1 voltage measurement
- B1 Amps ? . . . . . battery 1 current measurement, minus for discharge
- Time ? . . . . . time remaining to the End %RM
- B1 Temp ? . . . . . battery 1 temperature
- B1 Con ? . . . . . battery 1 Amp–hours consumed
- B1 Rem ? . . . . . battery 1 Amp–hours remaining
- B1 %RM . . . . . battery 1 percent remaining relative to capacity
- B1 Gaug ? . . . . . battery 1 state–of–charge in English
- B1 Trip ? . . . . . Amp–hours accumulated in the Trip odometer
- B2 Volt ? . . . . . battery 2 voltage measurement
- AX Amps ? . . . . . Amps measured at the Aux/(Alt) channel

Program/Reset Menu

The Reset Menu is used to clear accumulators and restore settings to default conditions. All the resets except the Factory ? reset start and finish the reset action when the Select key is actuated.

- Factory ? . . . . . set all programmable parameters to factory defaults
- B1 Trip ? . . . . . clear the B1 Trip Ah accumulator
- B1 Life ? . . . . . clear the B1 Life Ah accumulator
- B1 ? . . . . . clear Trip and Life, and internal data, make full
- kWh Tot ? . . . . . clear the KwH total accumulator
- Aux Ch ? . . . . . clear the Life Ah counter
- Cntrlr ? . . . . . negate the solar/regulator signal and restart logic
- Gen Set ? . . . . . negate the generator Start/Stop signal and restart logic

Factory reset should only be done if a clean starting point to reconfigure is necessary. This will reset all the calibration constants along with all the other programmable values. Don't do a factory reset if you have special calibration constants set for the shunts.

By design, executing a factory reset is difficult. After Selecting on the prompt, the display shows three zeroes. The objective is to get 911 to replace the three zeroes. Actuate the Down key to get a 900 showing. Actuate Select to save that value and then actuate Up to get 910 showing. Now actuate Up again to show 911. Pressing the final Select will do the reset. You can always escape by pressing Menu at any time.

Mounting the Energy Monitor

The EMON II has been designed for the marine environment with the expectation that high humidity is normal and occasional splashes may be encountered. The main housing is packaged so that in theory, it is completely waterproof.

Signals exit the chassis via a waterproof cable and terminate on a free standing terminal block. Theory and practice are not always the same, so don't mount the unit where it will be repeatedly splashed or ever submerged. Often it is convenient to mount the unit in a companionway where it is readily available to persons at the helm and below. This is permissible if the companionway is normally protected with a dodger.

The display in the Emon has a fairly wide viewing angle, but don't mount it where it can only be seen at oblique angles.

Signal Names and Functions

NOTE: There are two terminal blocks with the Emon, TB1, and TB2. TB1 refers to the 16–pin terminal block and TB2 refers to the 6–pin terminal block.

Orient the terminal blocks so that Pin 1 is at the top.

- **TB1–1, Vref**, (*optional*) . . . analog voltage reference for external chargers.
- **TB1–2, Iref**, (*optional*) . . . analog current reference for external chargers.
- **TB1–3, B2 Volts**, (*optional*) . . . starter battery voltage.
- **TB1–4**, (*optional*) . . . alternator current sensor or auxiliary shunt.
- **TB1–5, Aux Dev**, (*optional*) . . . auxiliary shunt.
- **TB1–6, T+(RED)**, (*recommended*) . . . this input indicates the temperature of the house battery.
- **TB1–7, B1 Volts**, (***required***) . . . this input must have a connection to the house bank.
- **TB1–8, B1SHG**, (***required***) . . . battery 1, shunt ground side.
- **TB1–9, REFG**, (***required - connect this wire first***) . . . the reference ground for the Emon. All battery voltages are referenced to this connection.
- **TB1–10, GND**, (***required***) . . . the power ground for the Emon.
- **TB1–11, B+**, (***required***) . . . this is the main power feed from the house bank,
- **TB1–12, ELGND**, (***required***) . . . the backlight ground for the Emon.
- **TB1–13, Alarm**, (*optional*) . . . alarm signal.
- **TB1–14, B1SHD**, (***required***) . . . battery 1, shunt battery side.
- **TB1–15, Chassis GND**, (***required***) . . . the chassis ground for the Emon.
- **TB1–16, Chassis GND**, (***required***) . . . the shield ground for the Emon.
- **TB2–1, Slr**, (*optional*) . . . solar/regulator control signal.
- **TB2–2, SGnd**, (*optional*) . . . signal ground for computer connection.
- **TB2–3, Rx**, (*optional*) . . . serial communications receive from computer.
- **TB2–4, Tx**, (*optional*) . . . serial communications transmit to computer.
- **TB2–5, Start/Stop**, (*optional*) . . . generator start/stop.
- **TB2–6, Shield**, (*recommended*) . . . shield for the serial communications cable.

Wiring Information

• **Use pre–tinned wire ::** Over time, corrosion attacks even the best connections. The use of pre–tinned wire will delay the onset of corrosion and is worth the slight price differential.

• **Wire Size ::** Wire gauge callouts on the drawings is only for reference. Always consult a wire table to determine what size is appropriate for your specific system. A wire table can be found in *The Ample Power Primer*, which can be ordered from an Ample Power dealer, or downloaded from the Ample Power website, http://www.amplepower.com.

• **Wire Ground First ::** Wire TB1-9, TB1-12, and TB1-16 first. Use separate wires as shown on the diagram . . . combining any of these wires may reduce accuracy and stability.

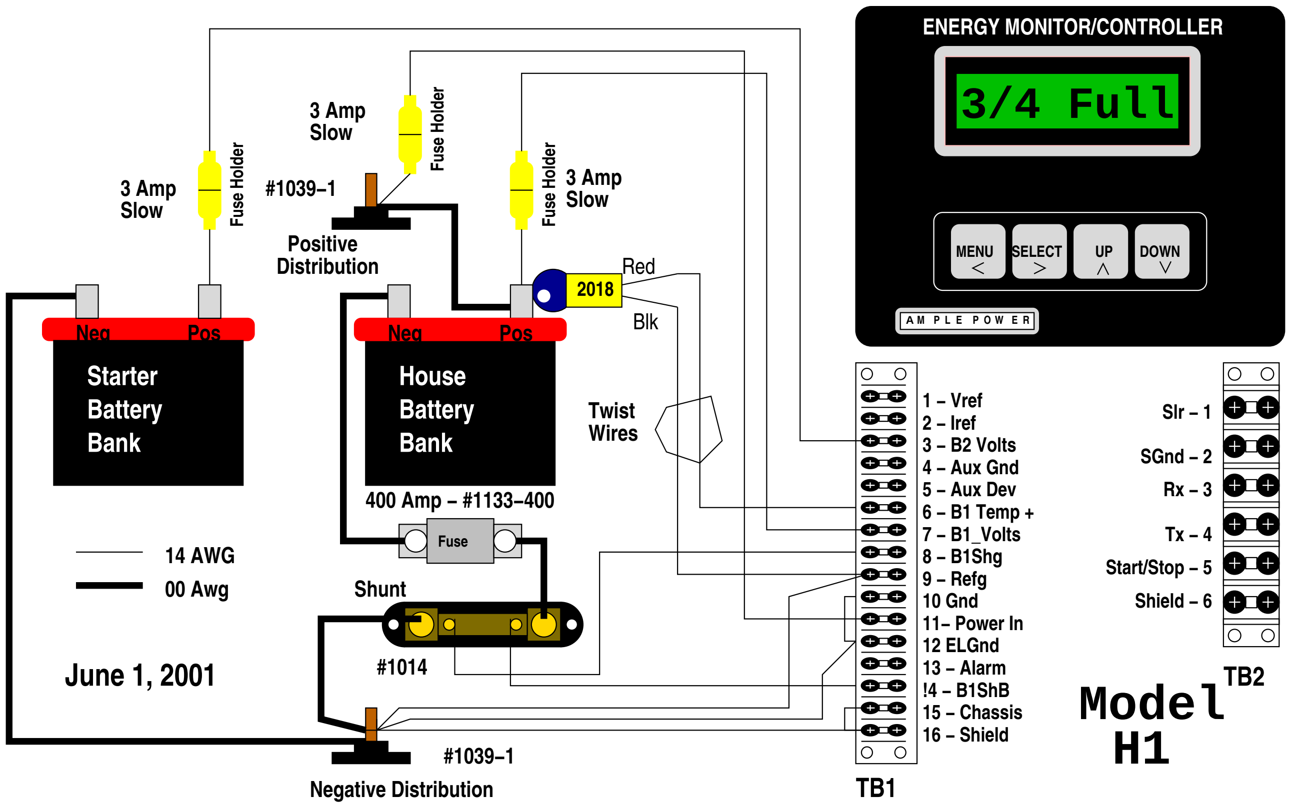
• **Twist Temperature Sensor Wires ::** Using a twisted pair for temperature sensor wiring is recommended. Two wires can be twisted by chucking one end of them in a drill motor and securing the other end of the wires. Stretch thewires taut and operate the drill motor slowly.

• **Twisted, Shielded Pair ::** Always use a twisted, shielded pair for the shunt sense wires. Terminate the shield lead at the shunt.

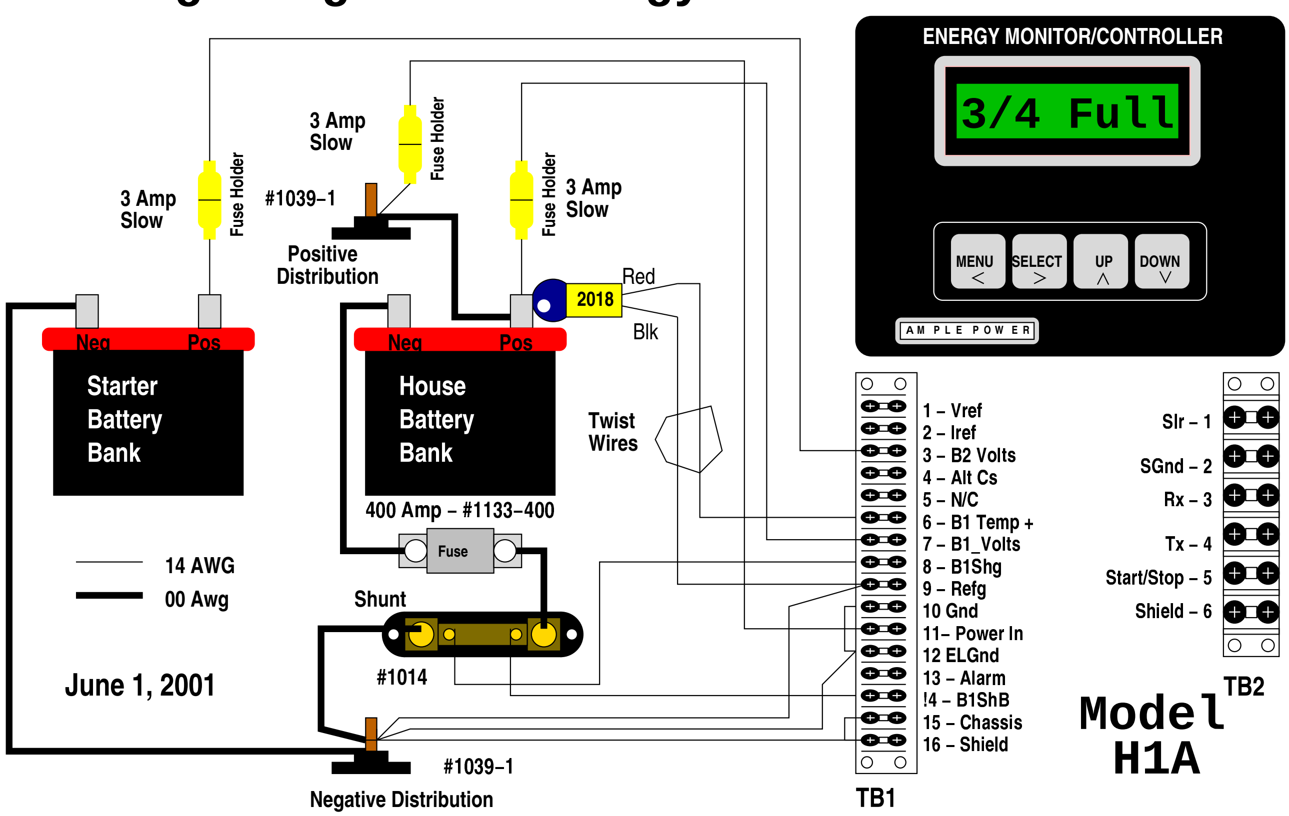
• **Fuse at the Batteries ::** Fuses are designed to prevent meltdown of wiring. To be effective, they must be located close to the power, whether that is battery positive, or positive distribution.

• **Prevent Chafe ::** Avoid running wires near metal objects, if possible. Always secure wires so that they cannot chafe with vibration.

Wiring Diagrams



SS **Wiring Diagram – Energy Monitor/Controller**



SS **Wiring Diagram – Energy Monitor/Controller**

Troubleshooting Information

• **Temperature versus Sensor Voltage ::** A faulty temperature sensor can produce erroneous readings for Amp–hours remaining, and incorrectly compensate charger setpoints. Be sure to check the temperature display when readings appear inconsistent. The temperaure probe is designed to produce 2.98 Volts at $77^\circ F$, ($25^\circ C$). The sensor voltage increases or decreases 0.01 Volts for every degree C change in temperature.

• **Fuse Corrosion ::** The voltage sense wires for B1 and B2 conduct very low current. Without the backlight on, the power input wire also conducts quite low current. The in–line fuses that connect these wires may corrode sufficiently to disrupt circuit function. Visual inspection may not show much corrosion.

• **Is the unit dead, or just the display? ::** If the processor is operating, then there will be voltage on TB1-1, representing 1/10th of the expected charge voltage . . . 1.35 to 1.45 Volts. A higher or lower voltage indicates that the processor is not operating.

• **Unit is dead ::** If the unit is dead, and there is no voltage on TB1-1, then there probably isn't power on TB1-11.

• **Be Prepared to Help Yourself ::** Before contacting support, use a voltmeter to take readings on all the pins of both TB1 and TB2. These readings will enable support personnel to assist you.

Be able to describe the problem. The hardware and software for the Emon is complex, and there are many facets of its operation. Without specific details regarding the problem, support will not be able to help.

• **Field Replacement ::** The cables that exit the Emon are sealed with watertight bushings. These do not unplug. To replace a unit after installation, remove the system wires from TB1 and TB2. Do not remove the wires on these terminal blocks that go into the Emon housing.

Installation and Warranty Support

For questions regarding installation, operation, or warranty service contact PowerTap, Inc. who is the authorized warranty service agent for all Ample Power products. Their phone number is **206-789-4743**, and their fax is **206-789-9003**.

Email support is available from support@amplepower.com. See also the following websites for more troubleshooting suggestions.

http://www.amplepower.com
http://www.pwrtap.com