Battery Monitor Hardware Circuit Description

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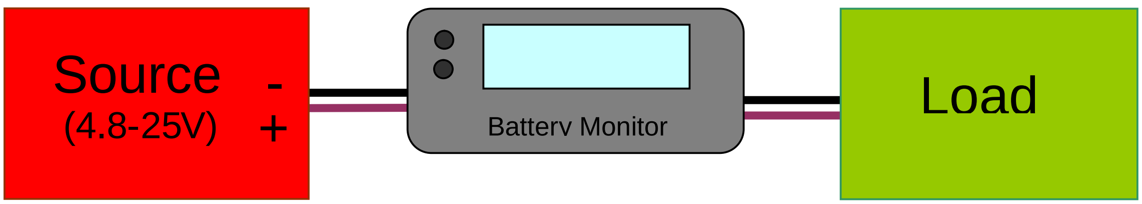
Overview

For most applications BatteryMonitor is connected in series between a source (battery) and load and uses a low value sense resistor in the negative lead to measure current. A load is connected to BatteryMonitor's negative Load lead (Sense Hi). Current flows from the load through the units' sense resistor to the Source negative lead (Sense Lo) then to source's negative terminal. The positive lead is connected directly from the source through the unit to the load. The positive lead is tapped inside the unit to provide bias for the BatteryMonitor circuitry (Vcc) and is also used to measure the source voltage.



Hardware Functional Blocks

Battery Monitor contains eight hardware blocks shown in figure1.

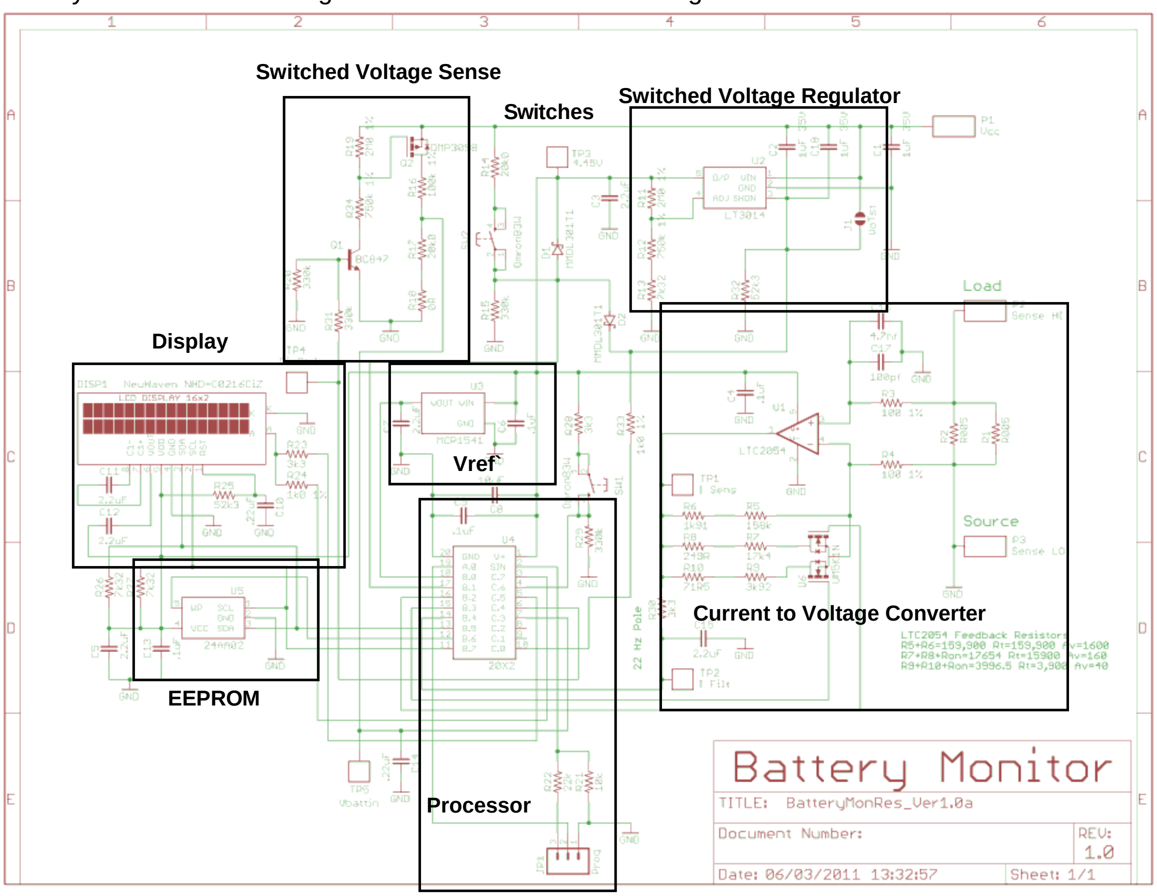


Figure 1 Battery Monitor Functional Blocks

Battery monitor uses a 2.5 milliohm resistor in the ground lead between Sense LO (Source) and Sense Hi (LOAD) to sense load current. The positive supply lead Vcc runs through Battery Monitor and directly connects the source to the load. Supply current for battery monitor is drawn from the source though the Vcc and returned to the source through the source lead (Sense LO point). As a result Battery Monitor does not measure its own bias current

Switched voltage regulator

An LT3014 low quiescent current, low drop out regulator provides a constant 4.45V output. R11, R12, and R13 set the output voltage. C1 and C3 insure stability. The LT3014 is shutdown when the SHDN pin is low (less than 0.25V). When the normally open pushbutton Sw2 is open and the processor is not powered, R32 keeps the regulator in the shutdown state. The PICAXE processor's C.0 output is set high to keep the regulator on. The time constant between the parallel combination of C2 plus C18 and R32 insures that at initial power-on, the regulator is held on long enough for the processor's C.0 output to activate and hold the $\overline{SHDN}$ pin high. R33 protects the processors output pin while allowing sufficient drive to maintain the regulator state. Sw2 can also be used to turn the unit on. When Sw2 is pushed its contacts close and the LT3014 $\overline{SHDN}$ pin is taken high by R14 though D2 The voltage on the $\overline{SHDN}$ pin is sustained once the processor boots. J1 is used for initial tests during construction. It's shorted to hold $\overline{SHDN}$ high keeping the regulator on. J1 must be open for normal processor controlled operation.

Vref

A MCP1541 4.096V 1% precision voltage reference provides the positive voltage reference for the PICAXE 20X2 A/D converters. This voltage produces an A/D reading of 4mV per bit using a 10 bit (1024 level) A-D converter. A supply voltage independent 4mV per bit A/D step is very convenient for a calculation intensive application like Battery Monitor.

Switched Voltage Sense

A six to one voltage divider is constructed from R16 and R17- R18. Q2 a low Ron P-channel MOSFET connects the voltage divider to the source voltage without altering the divider ratio. Q1 enables control of Q2 from the 5V PICAXE processor regardless of source voltage. Q2 is turned off when the unit powers off or during hibernation to insure the total supply current drain in these modes is minimized.

EEPROM

A 128 byte I2C 24AA02 EEPROM stores calibration data, device variables, and user selected options. This device enables resumption of same state operation at power-up. Write protect is controlled by the PICAXE 20X2 B.6 output. This device is always write protected. The WP pin is held high by the processor B.6 output except when the processor is actively changing content. C5 filters the supply during high current multiple byte writes.

Processor

A PICAXE 20X2 in a 20 pin small outline package is BatteryMonitor's central processor. This device has a frequency programmable internal clock trimmed to better than 1% accuracy, 4k bytes of program memory, 256 bytes of EEPROM, 128 bytes of scratchpad and 128 bytes of special function RAM. The processor contains a 10bit A-D converter which is used to measure source voltage and load current. The converter's positive reference is connected to the external 4.096V MCP1541 voltage reference. This device also features an I2C interface used to communicate with both the display and an external EEPROM. An interrupt driven timer is also employed to collect battery use. Flexible I/0 is capable of driving up to 10mA so is used for a variety of housekeeping functions which include directly driving the display backlight.

Display

Battery monitor uses a Newhaven 2 line x 16 character I2C LCD display with backlight. R25 and C10 hold the display's reset pin low at initial power-up to insure reset. C11 and C12 are used to control internal biases. R23 and R24 driven by the processor set the back light level. These two pins enable four backlight levels. When the display backlight is set off both C.5 and C.7 processor pins are set low. When the display backlight level is set to low, output C.5 is set high and C.7 set as an input sending about 0.5mA through R23. When the backlight level is set to medium, C.5 is set as an input and C.7 is set high sending about 1.5mA through R24. When the backlight level is set high both C.5 and C.7 are set high causing about 2mA of current to flow through R23 and R24 into the backlight.

Current to Voltage Converter

A 2.5 milliohm sense resistor (R1 in parallel with R2) is used to sense current flow from source to load. The voltage drop across the resistor at 40A is 100mV and results in 4 Watts power dissipation. Each milliamp produces 2.5uV across the sense resistor, so care in layout is needed along with a good amplifier to achieve low current accuracy. A LTC2054 low quiescent current rail to rail input and output chopper stabilized op-amp is configured as a non inverting amplifier with variable gain. R3 and R4 are the input sense resistors. The negative input resistor R4 is tied to ground at Sense LO, the Source connection. R3 feeds the non-inverting input from Sense HI, the load connection, while C16 and C17 provide a measure of RF bypass. R5 and R6 create a gain of 1600 which provides an output of 4mV/mA or 1mA per bit to the A/D input of the 20X2. R30 and C15 form a single pole low pass filter with a corner frequency of twenty two hertz to reduce noise to the A/D converter input. The amplifiers gain is switched to 160 or 40 by U1 a dual N channel MOSFET. The MOSFET is controlled by the processor and is placed in the feedback loop on the virtual earth side of the feedback resistors to insure the switch does not impact the amplifiers dynamic range. A gain of 160 is created by R7 and R8 in parallel with R5 and R6 to produce an output of 400uV/mA or 10mA per bit. When a gain of 160 is selected, the processor turns output B.2 high and B.3 low. A gain of 40 is created by R9 and R10 in parallel with R5 and R6. This produces an output of 100uV/mA or 40mA per bit by setting B.3 high and B.2 low.

Function Switches

Sw1 and Sw2 are normally off push button switches. Sw1 is connected to the processor C.6 input and Sw2 is connected B.1. Sw2 is used for two purposes. Besides function selection it is also used to turn Battery Monitor on. When Sw2 is pressed it draws current from the source through R14 increasing the voltage on the LT3014 SHDN pin through D2. This turns the regulator on which in turn powers the processor. The processor C.0 output is driven high by software to hold the switching regulator on. When the push button is released D2 becomes reversed biased and the input voltage to the processor's B.1 input falls to ground. Schottky diode D1 clamps the B.1 input to Vcc.