

Buck-converter Charger also Provides System Power

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Many systems require long time operation during periods of power loss. Often a Lead Acid battery (gel or wet-cell) is found to be the best solution because of the high capacity and relative low cost. The battery is charged during normal operation, and used to power the system during power loss. These systems require a circuit to charge the battery as well as regulate voltage for the system Vcc. In these systems one must provide a current limited voltage to the battery for charging, while developing system Vcc in both the charge or discharge condition.

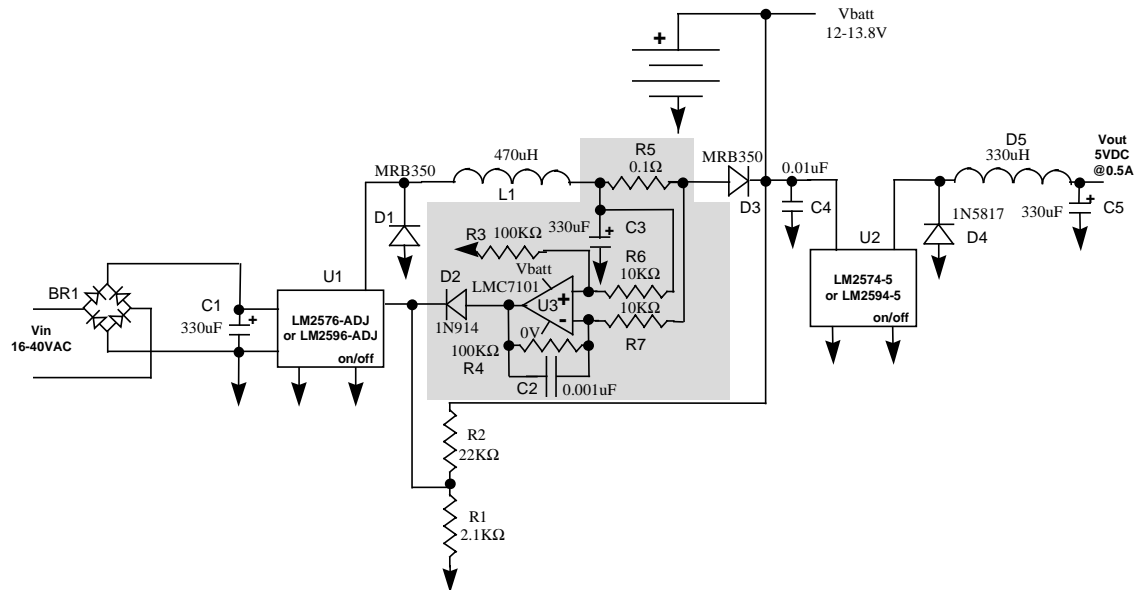
Many older designs would utilize inefficient linear regulators to provide these functions. These designs require a large heat sink for regulating the battery voltage to the system Vcc (typically 5V).

One may utilize switching regulator technology to provide a much more efficient design at about the same relative cost as a linear regulator design. Many of these designs utilize low voltage AC power that is usually provided by a low cost wall transformer. Because of the switching technology utilized in this design, one could accommodate a wide input voltage range and thus may be used for power line voltages from 100V to 240V without any circuit changes.

One of the best approaches to the design is a current limited voltage source that sources current into the battery until the battery voltage reaches a voltage setpoint. The charger then operates in a constant voltage mode, supplying the current required to maintain the voltage.

Most lead acid batteries have a voltage setpoint of 13.8V at 25°C. The current limit is set depending on the exact battery and charge time requirement.

The design shown in Figure 1 employs two Simple Switcher Buck converters from National Semiconductor. The first regulator U1 is an LM2576 or LM2596 Simple Switcher used to efficiently step down the unregulated input voltage from the output of the rectifier. This buck converter generates the input voltage for the battery while also providing voltage to the second regulator. Both buck regulators may utilize either a slower 52 kHz converter or a higher frequency device marked respectively. The higher frequency devices employ added features such as sync input and soft-start. The second regulator U2, is a small DIP or SO LM2574 or LM2594 capable of providing up to 0.5A system Vcc. One must consider the system current requirements when setting the current limit value of the charger. The current limit value set by the gain of U3 must be increased by the current required to supply power to the system.



The first regulator provides the charge voltage setpoint with current regulation while the second regulator provides the system Vcc

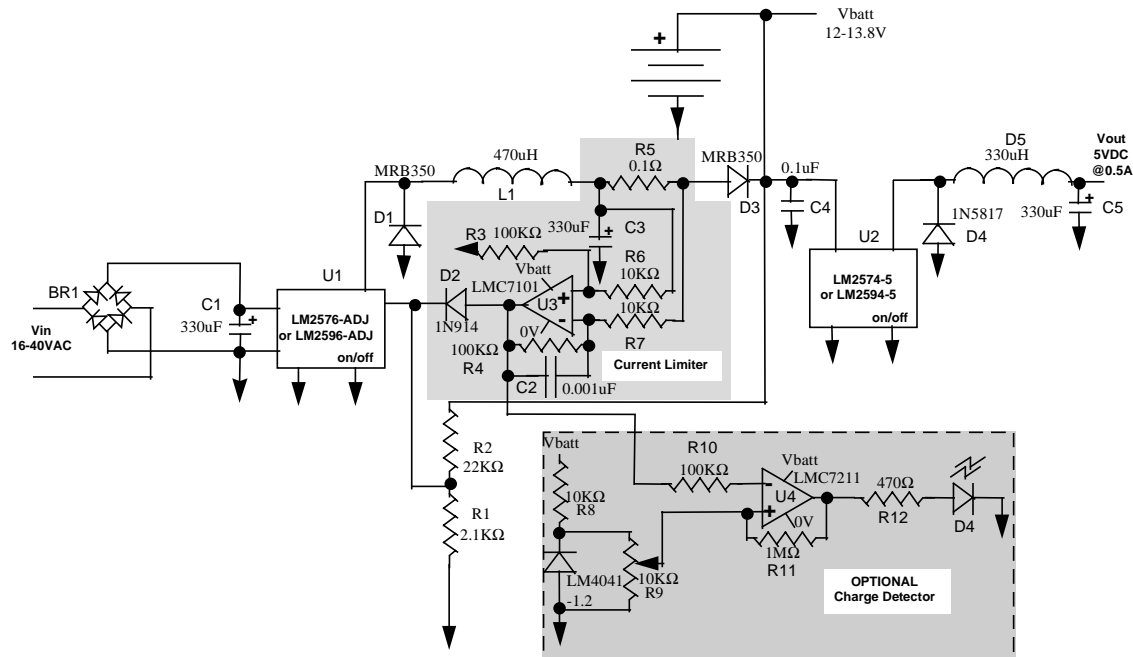
FIGURE 1.

U1 is regulated at the Battery charge voltage with the feedback network R1/R2. These resistors are chosen by $V_{out} = 1.23(1 + R2/R1)$. The diode D3 provides current switching between U1 and the battery during power loss.

The shaded area is used to measure and regulate the current flow into the battery during battery charge. The circuit utilizes a shunt resistor to measure the current to the battery, and amplifies it via the amplifier U3. The LMC7101 shown for U3 is a National Semiconductor CMOS OP-Amp that provides an output voltage inversely proportional to current. The LMC7101 provides a BW of 1 MHz and is available in a very small SOT23 package. Other Op-Amps such as the National LMC6482 will also do the job, and are available in standard DIP and SO packages.

With the gain of 10 provided by the Op-Amp, the diode D2 will forward bias and pull up the feedback voltage when the output current is about 1.6A ($V_{ref} + \text{diode drop}$). During normal voltage regulation the diode is reverse biased.

The second regulator U2 is used to provide 5V to the system. This buck regulator efficiently provides system power when the input is at its highest voltage of about 13.8V or at the lower voltage that will be generated when U1 is current limiting .



An additional SOT23 comparator and voltage reference provides a battery charge indication.
FIGURE 2.

Some systems may need an indication of charge complete. In a system that utilizes a microcontroller with on chip A/D (such as the National COP8ACC), one could connect the output of U3 into the input of the A/D, and read the charge current directly. Depending of the voltage reference used for the A/D, and accuracy needed, one may need to add another Op-Amp stage prior to the A/D. Figure 2 shows the circuit with an added SOT23 voltage comparator. The output of the current amplifier U2 is compared to the voltage set by the potentiometer R9. This voltage can be set to represent the current flow that takes place at the end of charge.

Simple Switcher designs can be analyzed and verified by utilizing a software package called “Switchers Made Simple” from National Semiconductor. By splitting the design into two buck voltage regulators, one may utilize the software to obtain component values with vendor part numbers, junction temperatures, stability, and lots more design information.

The software package is available free of charge by calling National at 1-800-272-9959 or through the Web site at www.national.com.