Energy management for small portable systems

Numerous diverse and conflicting constraints burden the designer of small hand-held products. Aside from the customary restrictions on size and weight, these constraints include cost limitations, strict time schedules, battery-life goals measured in weeks instead of hours, and host computers that are (sometimes) overtaxed with the demands of power management.

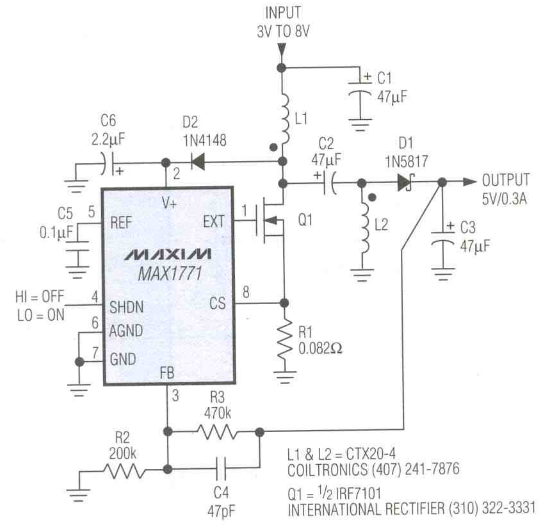
Because power requirements for hand-held applications vary widely with product use, no single "best" power source exists for these applications. A device used intermittently is more concerned with no-load quiescent current than with full-load efficiency, and so may operate satisfactorily with alkaline batteries. Cell phones, on the other hand, must contend with high peak loads and frequent use. This mode of operation emphasizes conversion efficiency over quiescent current, so cell phones are better served with a rechargeable battery.

In hand-held product design, size limitations often dictate the number of battery cells early in the process. This is frustrating to the electrical engineer, and a substantial constraint, since the number (and type) of cells allowed determines the operating-voltage range, which in turn strongly affects the cost and complexity of the power supply. High cell counts enable the use of linear regulators and simple circuitry at the cost of extra weight and limited efficiency. Low cell counts compel the use of a more costly switching regulator, but the low cost of the battery may justify this expense.

Four-cell designs

Four-cell batteries often provide an attractive compromise between weight and operating life. That number is particularly popular for alkaline batteries because they are commonly sold in multiples of four. Four-cell power for 5V circuitry presents a design challenge, however. As the battery discharges, the regulator must first step down, and then step up. This requirement precludes use of the simpler, one-function regulator topologies that can only step down, step up, or invert.

One effective solution to this problem is the SEPIC (single-ended primary inductance converter), in which



EFFICIENCY AT I_{LOAD}

INPUT VOLTAGE	10mA	100mA	200mA	300mA
3.5V	81%	83%	84%	84%
4.0V	82%	84%	84%	85%
5.0V	82%	84%	85%	86%
6.0V	82%	84%	86%	86%

Figure 1. This regulator topology supplies 5V for inputs ranging from 3V to 8V. The operation shifts smoothly between step-up and step-down conversion without steps or mode changes. During shutdown, the output turns off completely and sources no current.

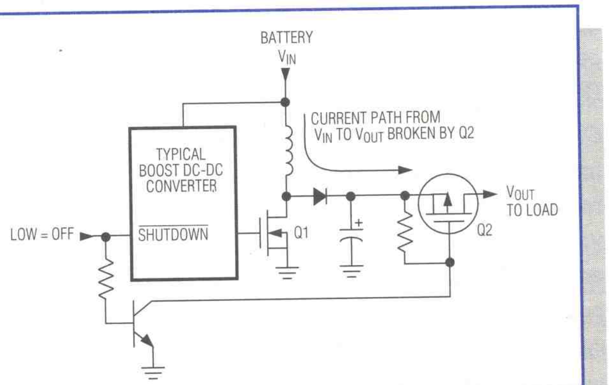


Figure 2. Typical dc-dc boost converters provide a current path from input to output, even when powered down. To interrupt this path, you must add a disconnect switch (Q2).

V_{OUT} is capacitively coupled to the switching circuitry (**Figure 1**). The absence of a transformer is one of several advantages this configuration has over flyback-transformer regulators and combination step-up/linear regulators.