Shunt regulator speeds power supply's start-up

Michael O'Loughlin, Texas Instruments, Nashua, NH

In certain applications, design requirements may call upon a system's switched-mode power supply to more promptly deliver its output than would the garden-variety power supply. **Figure 1** shows such a supply's bootstrap, or start-up, circuit. In a switched-mode power supply's PFC (power-factor-corrected) preregulator, the circuit's PWM (pulse-width modulator), IC_1, draws its normal operating power from auxiliary winding L_1, wound on boost inductor L_2's magnetic core and diode D_1.

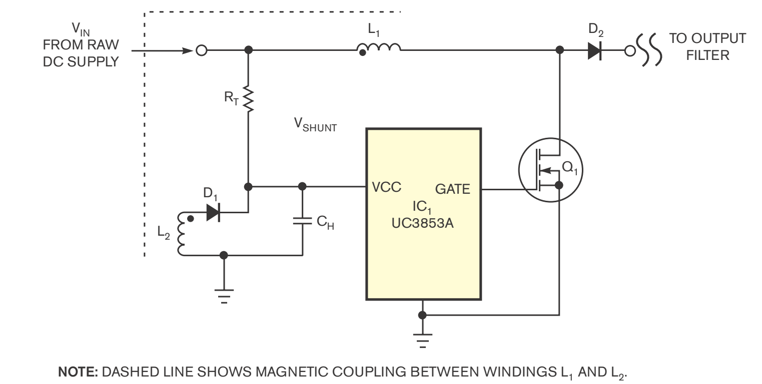

Figure 1 In a conventional switched-mode power supply's bootstrap circuit, trickle-charge resistor R_T and capacitor C_H supply start-up power to the pulse-width modulator and controller, IC_1.

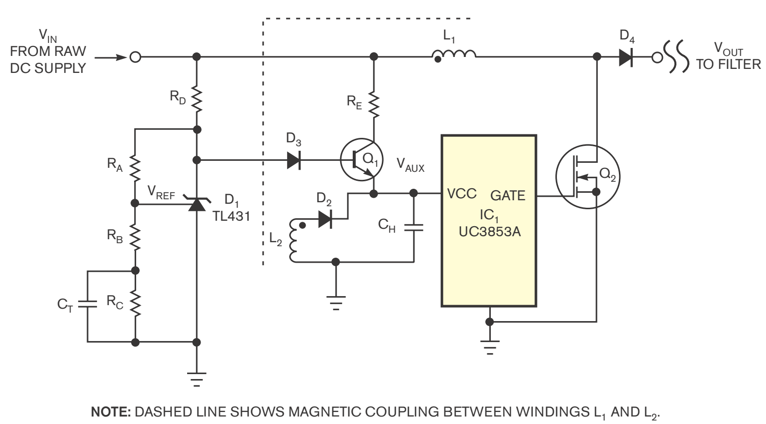

Figure 2 In this augmented bootstrap circuit, transistor Q_1 delivers a robust initial pulse of current to capacitor C_H, ensuring faster start-up and power delivery.

DIs Inside

Resistor R_T and capacitor C_H form a trickle-charge circuit that supplies power for bootstrapping IC_1 into normal operation. In conventional designs, R_T comprises a high resistance that delivers just enough current to overcome the standby current and supply a trickle charge to holdup capacitor C_H, which stores enough energy to power the PWM circuit until the power converter begins operation. Under normal circumstances, the circuit's slow start-up response poses no problems.

When faster power-on response becomes important, you can reduce the bootstrap time by reconfiguring the start-up shunt regulator (**Figure 2**). Capacitor C_T; shunt-regulator IC D_1, a TL431; diode D_3; transistor Q_1; and resistors R_A through R_D form the bootstrap circuit. At power application, capacitor C_T holds no charge, and the series-pass regulator that Q_1 and D_1 form determines the voltage at the PWM's power input, V_{AUX}.

At turn-on, the V_{AUX} voltage reaches its peak voltage, V_{AUX_PEAK}, which the ratio of resistors R_A and R_B determines.

Capacitor C_T and resistor R_C conserve energy by setting the bootstrap circuit's turn-off time and voltage. Resistor R_D supplies bias current to D_1, the TL431 shunt-regulator IC, and resistor R_E keeps transistor Q_1 within its safe operating area by limiting its collector current.

To design the circuit, begin by selecting resistors R_A and R_B to establish the peak charging voltage, as the following equation shows:

$$\frac{V_{REF}}{R_B}=\frac{V_{AUX\_PEAK}+V_{D3}+V_{BE}-V_{REF}}{R_A+R_B},$$

where V_{REF} represents the TL431's internal reference voltage. Next, select resistor R_C to reduce the shunt-regulated voltage below the nominal V_{AUX} voltage, $V_{VAUX\_NOMINAL}$, which the auxiliary winding supplies:

$$RC_T=\frac{V_{REF}\times R_A+(V_{REF}-V_{AUX\_NOMINAL})R_B}{V_{AUX\_NOMINAL}-V_{REF}-1V}.$$

Choose capacitor C_T's value to set the bootstrap time, T_{BOOT}, as follows:

$$C_T=\frac{2\times T_{BOOT}}{R_C}.$$

As in **Figure 1**, diode D_2 and auxiliary winding L_2 provide normal operating power to IC_1. EDN

Build a USB-based GPIB controller

Boštjan Gla ar, Marko Jankovec, and Marko Topic,
Laboratory of Semiconductor Devices, Ljubljana, Slovenia

Contemporary research laboratories include a variety of instruments that connect using any of several interface methods to a PC for automating procedures and collecting data. Although different communication interfaces exist, the GPIB (general-purpose-interface bus) still enjoys wide popularity. The host PC must include a suitable GPIB controller—an internal interface card or an external device. Newer PC designs are phasing out traditional internal buses, such as PCI, ISA, and EISA, in favor of other standards, so using an external controller offers a more appropriate approach because external I/O ports, such as RS-232 and USB, tend to maintain backward compatibility.

This Design Idea covers the development of a GPIB controller, which turned out to be easier and cheaper than commercially available alternatives. The design uses easy-to-obtain components with a total component cost of approximately $50. For comparison, a commercial controller costs at least 10 times more: $500 to $1000. The USB 2.0-compliant controller, an external device, draws its operating power from the bus and provides plug-and-play operation and high-speed data transfer. In addition, a USB-controller design extends its applications to notebooks and other computers that lack available I/O slots. The controller resides on a double-sided pc board and fits into a 123×30×70-mm enclosure (**Figure 1**). To simplify controller use, the design uses National Instruments' (www.ni.com) LabView graphical programming language to develop the appropriate driver.

The design uses the FT245BM USB-controller IC from Future Technology Devices International Ltd (www.ftdichip.com), which features an 8-bit parallel connection to the host microcontroller and a virtual-communications port to the PC-interface side. The circuit operates at a full speed of 12 Mbps. Targeting use in GPIB applications, the 75160 and 75161 ICs drive GPIB I/O lines. An Atmel (www.atmel.com) AVR AT90S8515 microcontroller provides firmware-resident sequence control and in-circuit-programmable flash memory that simplifies firmware design and upgrades. The USB also can supply 5V of power at as much as 500 mA, which eliminates the requirement for an external power supply. The controller also supports the required low-power mode to reduce consumption to less than 1 mA.

The designers used the Protel (www.altium.com) schematic-capture and pc-board-layout software to design the circuit. They used a milling machine to produce the prototype pc board and partially assembled the board with a manual SMD placer. You can also use a commercial prototype pc-board-fabrication service to prepare a double-sided pc board with plated through holes and manually assemble the circuit. **Figure 2** shows an internal view, and **Figure 3** shows the completely assembled controller, which is easy and fast to build.

The controller communicates with the host computer through a logical serial interface that enables use of the

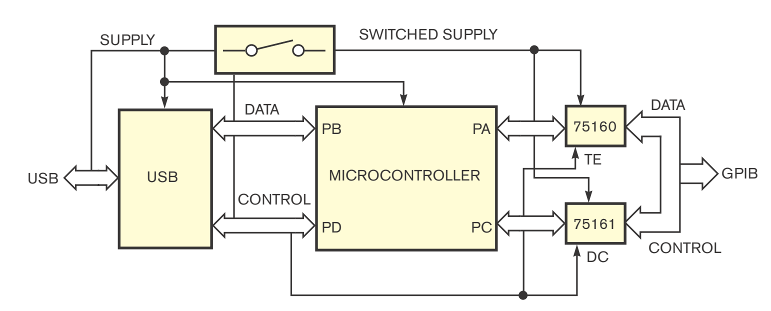

Figure 1 This USB-based GPIB controller requires only four ICs.