Low-cost LCD-bias generator uses main microcontroller as control IC

Tom Hughes - November 26, 2009

LCD circuits often require a –10V voltage at 2 to 15 mA to bias a graphics-LCD-driver IC. You can usually accomplish this task with an external charge-pump IC, such as Maxim's ICL7660, but that approach adds cost to the design. Instead, you can control a buck-boost switch-mode regulator using the same microcontroller that sends data to the LCD. In addition, you can sequence the power rails under software control, as some types of LCD controllers require.

The circuit includes IC_1, an Atmel Attiny15 microcontroller (Figure 1), which provides regulation with 200-mV-p-p ripple at a 30-mA load current when supplying –10V. Listing 1 lets you download the source code, which uses only 4.8% of the total CPU time to achieve the stated regulation, even with a relatively low-speed clock frequency of 1.6 MHz.

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To minimize CPU time, the software uses the 8-bit on-chip PWM (pulse-width modulator) to drive Q_1. With the on-chip ADC in free-running mode, the microcontroller generates a hardware interrupt with a period of 7.69 kHz. The interrupts have one drawback: If they stop, the circuit can go out of regulation. Thus, you must take care when using interrupts with long processing times. The Attiny15 uses an on-chip, 16× PLL (phase-locked loop) to drive the PWM timer. You can achieve a PWM carrier frequency of 100 kHz, which allows the use of a relatively low-capacitance filter capacitor, C_1.

Two constants in the source code let you alter the bias voltage of the circuit's output voltage. These constants employ basic buck-boost-converter theory (Reference 1). The following **equation** defines the maximum 8-bit constant, or threshold, that the ADC reads on the chip: $51.2\times\{V_{CC}-[(V_{CC}-V_{MAX})/(R_4+R_5)]R_5\}$, where V_{MAX} is the maximum desired output voltage and V_{CC} is the supply voltage. To achieve optimum operation, increase the PWM signal's duty cycle when you need higher voltages. Use the following **equation** to determine the 8-bit PWM's value: $255-V_{OUT}/(V_{OUT}-V_{IN})\times255$, where V_{OUT} and V_{IN} are the output and input voltages, respectively. In practice, however, if you keep the current at less than 2 mA, this requirement is less important.

The circuit can deliver currents that Q_1's collector current predominantly delivers. This current is the peak output current that the circuit can safely deliver. The following **equation** calculates the current: $I_{OUTMAX}=(V_{IN}\times0.08)/V_{OUT}$, where I_{OUTMAX} is the maximum output current. If your design needs higher current, then substitute a BC327 for Q_1. Additionally, the inductor should have a maximum rms (root-mean-square) current value of at least twice the peak output current and preferably be a low-ESR (equivalent-series-resistance) type to maximize circuit efficiency.

Reference

1. Hart, Daniel W, *Introduction to Power Electronics*, First Edition, pg 202, Prentice Hall, Oct 25, 1996, ISBN-10: 0023511826, ISBN-13: 978-0023511820.