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READERS SOLVE DESIGN PROBLEMS

Use an LM317 as 0 to 3V adjustable regulator

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Most engineers know that they can use an inexpensive, three-terminal adjustable regulator, such as Fairchild Semiconductor's (www.fairchildsemi.com) LM317, as an adjustable regulator to only some necessary value of voltage, such as 36 or 3V. This value cannot be less than 1.25V without employing other approaches, however. The devices' inner reference voltage is 1.25V, and their output voltage accordingly cannot be less than this value without potential bias (**Reference 1**). One way to solve this problem is to use a reference-voltage source based on two diodes (**Reference 2**). Although this approach is suitable for a 1.2 to 15V or higher-voltage regulator, it is not appropriate for an extra-low-voltage fixed- or adjustable-voltage regulator. The two 1N4001 diodes it employs do not provide the needed potential bias of 1.2V, and they have additional temperature instability of approximately 2.5 mV/K (**Reference 3**). Hence, additional temperature drifting of the output voltage is approximately 100 mV; it is more than 6% for a 1.5V output voltage and 10% for a 1V output voltage if you adjust the temperature to 20°C—a typical indoor situation. You can solve these problems by using a Fairchild Semiconductor LM185 or an Analog Devices (www.analog.com) AD589 adjustable-voltage-reference IC. These devices are expensive, however, and, in this case, they require not only additional zero adjustment but also matching. These adjustments at their reference voltages are 1.215 to 1.255V and 1.2 to 1.25V for the LM185 and AD589, respectively. Note that the reference voltage of the LM317 is 1.2 to 1.3V.

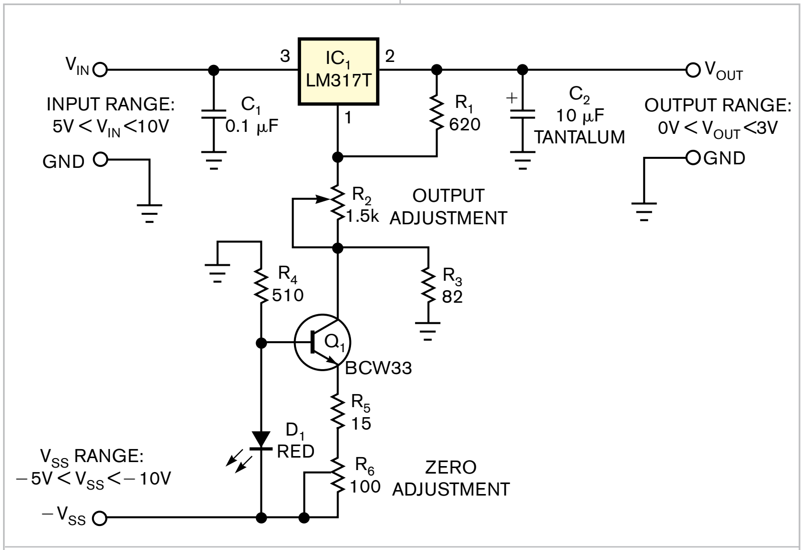

Figure 1 This circuit is an inexpensive approach using a simple 0 to 3V adjustable regulator.

Figure 1 shows an inexpensive approach using a simple 0 to 3V adjustable regulator. You implement the necessary potential bias using a simple temperature-stabilized constant-current source (**Reference 4**). You calculate this current source using the following **equation**: $I=(V_F-V_{EBO})/(R_5+R_6)$, where V_F is D_1's forward voltage of approximately 2V and V_{EBO} is Q_1's emitter-base voltage of approximately 0.68V. The current is approximately $1.32/(R_5+R_6)$. The constant-current source creates a bias voltage of approximately −1.25V on resistor R_3. You implement the zero adjustment using resistor R_6, which can change the current of the constant-current source. Resistor R_5 protects transistor Q_1. You can use D_1 as a light indicator. You can adjust the output voltage using resis-

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tor R_2. Calculate the output voltage as follows: $V_{OUT}=V_{REF}(1+R_2/R_1)-V_{R3}$, where V_{REF} is the reference voltage of IC_1 and V_{R3} is some compensative voltage of resistor R_3. You should establish this voltage to equal the reference voltage for its compensation. In this case, $V_{OUT}=V_{REF}(R_2/R_1)$. With R_2 having a value of 1.2 kΩ, this circuit found use as the equivalent of a typical battery with an output voltage of 1.56V for development projects.EDN

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[2] "LM350 3-Terminal 3A Positive Adjustable Voltage Regulator," Fairchild Semiconductor Corp, 2001, www.fairchildsemi.com/ds/LM/LM350.pdf.

[3] Schenk, C, and Ulrich Tietze, *Halbleiter-Schaltungstechik*, Springer-Verlag Berlin Heidelberg, 2002, ISBN: 3540428496.

[4] Rentyuk, Vladimir, "The Simple Temperature-Stabilized Constant-Current Source," *Electronics World*, November 2006.

Alarm monitors rotational speed of dc motor

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You can use the circuit in **Figure 1** to monitor the rotating speed of a dc fan motor and sound an alarm if the motor stalls. One potential application of the circuit is monitoring the CPU-fan speed in a PC in which overheating the CPU can ruin the whole system. A PC BIOS (basic input/output system) often has a limited capability for monitoring the speed of CPU or chassis fans during boot-up. Moreover, if you enable the CPU-fan-protection function of BIOS today, you can have a problem with it tomorrow: If the fan's starting acceleration slows down, the BIOS powers down the PC at the beginning of the boot sequence, not allowing you to go into BIOS settings to correct the situation. So, the manual often advises you to disable this fan function. The circuit in **Figure 1** shows how to implement continuous monitoring and sound an alarm and automatically power off the system if a fan problem occurs.

The impulses on R_1, arising from commutation in the fan's brushless motor, start up the Schmitt trigger, Q_1/Q_2, which controls transistor switch Q_3, commutating the sense pin of the fan's motherboard connector; the frequency of commutation is proportional to the rotation speed. Optionally, the output of the trigger resets the timer with two time-out periods; the expiration of the first time-out activates the alarm buzzer.

After the second time-out, transistor Q_5 powers down the PC with or without the relay switch. The relay switching is more consistent, is less prone to interference, and is preferable when the distance between this circuit and the power-switch connector on the motherboard exceeds 20 to 30 cm. You must connect the collector of Q_5 or the contacts of the relay in parallel with the power-switch button. The alarm circuit comprises Q_4 and a three-terminal piezoelectric buzzer.EDN

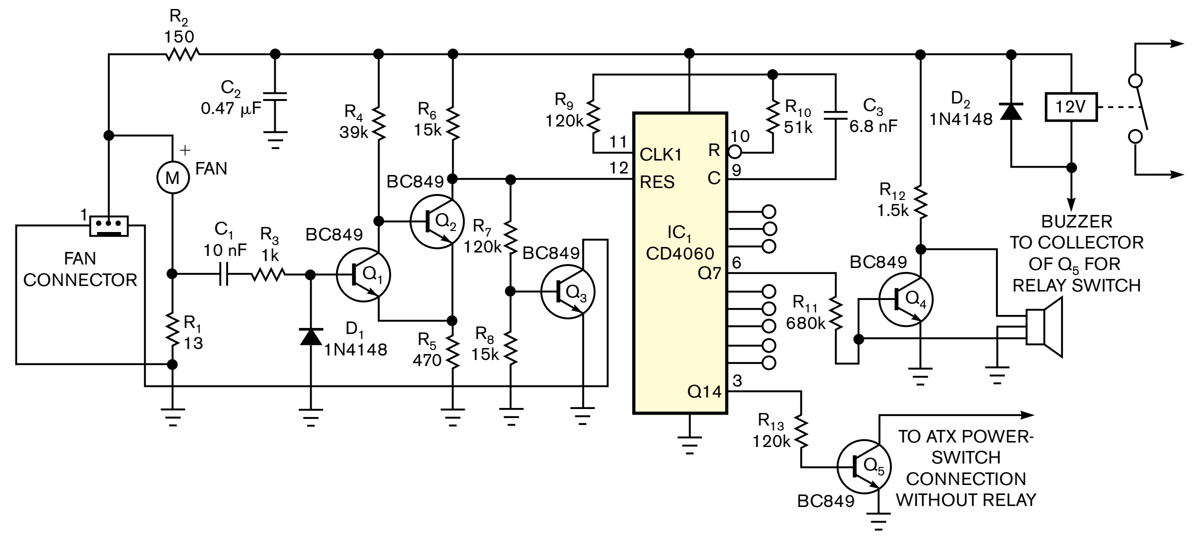


Figure 1 This circuit provides an optional audible alarm after a time-out when a brushless-dc fan motor slows down. Then, after a second time-out, the circuit powers down the PC.

Add charging status to simple lithium-ion charger

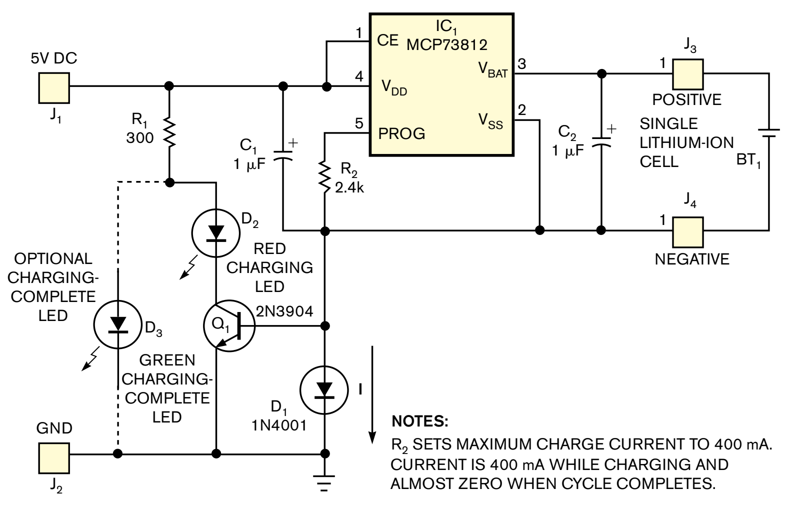
Peter T Miller, Applied Inspirations, Bethlehem, CT

Like other simple, single-cell lithium-ion battery chargers, Microchip's (www.microchip.com) MCP73812 provides no means of indicating the charging status. You can remedy this situation by adding four components (**Figure 1**). Add one more LED, and you also get a charging-complete indication. This two-LED configuration has the added benefit that one of the LEDs is always on, providing an indication that the charger is powered.

While the cell is in the constant-current charging mode, 401 mA flows through the 1N4001 diode, D_1. The additional 1 mA is the supply current of the control chip. Because the 1N4001 conducts before the base-emitter junction of Q_1, it prevents Q_1 from turning on until the forward voltage across it reaches about 450 mV. Q_1 then starts to conduct and turns on D_2, a red LED that indicates charging. Because the forward-voltage drop for a green LED is typically higher than that of a red LED—2.1 versus 1.7V—the voltage across D_2 and Q_1 is less than the turn-on voltage of the green LED, D_3, and it remains off.

For the last part of the charging cycle, the controller switches to constant-voltage mode. As the cell voltage gets closer to this 4.2V terminal voltage, the current through D_1 drops, and at 15 to 40 mA, both LEDs illuminate.

Tests measured this range for several 2N3904 transistors. Testing with 2N4401s gave a lower range of 4 to 18 mA. When the current drops below about 15 mA, Q_1 turns off D_2. The voltage across D_3 now rises above its forward-voltage threshold, and the green charging-completed LED lights.EDN



NOTES:
R_2 SETS MAXIMUM CHARGE CURRENT TO 400 mA.
CURRENT IS 400 mA WHILE CHARGING AND ALMOST ZERO WHEN CYCLE COMPLETES.

Figure 1 Adding a few components to a lithium-ion cell charger provides an indication of charging status.

555 timer drives multiple LEDs from one NiMH cell

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Using a CMOS 555 timer and a single NPN transistor, you can drive as many as seven LEDs using a minimal amount of voltage and power from a single NiMH (nickel-metal-hydride) AA cell. The circuit works by creating much higher-voltage pulses than the voltage for powering the circuit by pulsing a high-Q power inductor. The circuit

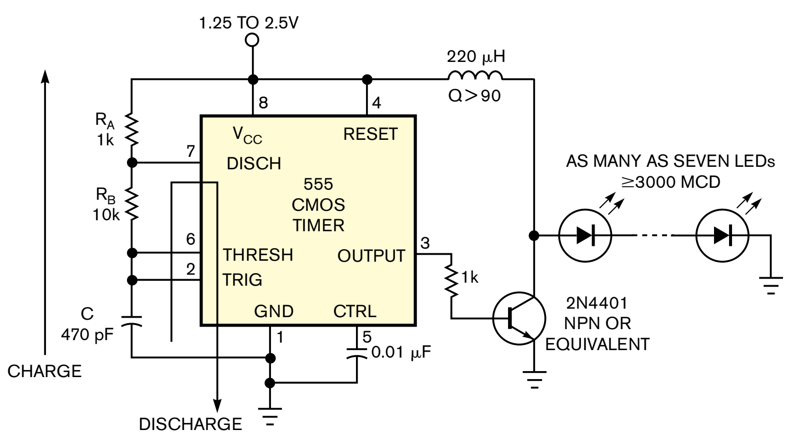

Figure 1 Using a CMOS 555 timer configured as a switching power supply, you can drive seven high-brightness LEDs from a single 1.25V cell.

creates voltage pulses of 23V using a 1.25V NiMH cell with seven connected LEDs.

The circuit uses a CMOS timer because it functions on low voltages—in this case, as low as 1V. A single white LED rated at 9300 mcd maintains its brilliance down to this low voltage. The circuit works for 192 hours using a 2000-mAHr-rated NiMH cell. The output of the timer is a 4.5-µsec pulse repeating at a 222-kHz rate. Although you can use the circuit to power any LED, it works best using high-brightness, high-power LEDs rated at 3000 mcd or higher. Obviously, the higher the millicandela rating, the brighter the LED will appear.

You can connect the LEDs in parallel if their forward voltages match; otherwise, the LED with the lowest forward voltage will dim out the other LEDs. Using the parallel connection, all LEDs will glow with equal brightness if their forward voltages match. Adding LEDs does not increase the current drawn from the battery but reduces the brilliance of all of the connected LEDs.

The advantage of connecting the LEDs in series—which is possible because of the high pulse voltage they produce—is equal brilliance of all LEDs, regardless of their individual forward-voltage drops and millicandela ratings. Each additional LED decreases additional voltage and lowers the resulting current into the series string of LEDs, lowering their brilliance. Using seven LEDs with a single 1.25V cell draws a current of only 8 mA. By adding a 1.25V cell to the power input, the LEDs become so brilliant that it is difficult to look at them. With a 2.5V supply, the peak voltage pulses increase to 70V with no connected LEDs. With the LEDs connected, the output voltage peaks at 25V. Current draw at 2.5V is 20 mA. **EDN**

Microcontroller inputs parallel data using one pin

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Inputting multiple bits of information using a single entry pin of a microcontroller without the complexity of UARTs can prove useful. Such a scheme could allow scanning of a keyboard, mode switches, or any relatively slowly changing digital data. **Reference 1** details a technique for outputting signals with a single pin. The data from switch bank S_1 first presents itself to IC_3, a 74HC165 parallel-to-serial converter from NXP Semiconductors (www.nxp.com, **Figure 1**). Loading the data into the shift register requires a pulse on the PL line (Pin 1). Line CK accomplishes this pulse by sending as output a long pulse on the microcontroller-pin line. R_2 and C_2 introduce a delay, and, once the pulse exceeds that delay, the PL line goes low, and the data loads.

After the PL signal rises, shorter pulses on the microcontroller's I/O port generate pulses at the shift register's clock input, CP, but not at the PL input. The duration of these clock pulses must be long enough to exceed delay R_1C_1 but not R_2C_2. These clock

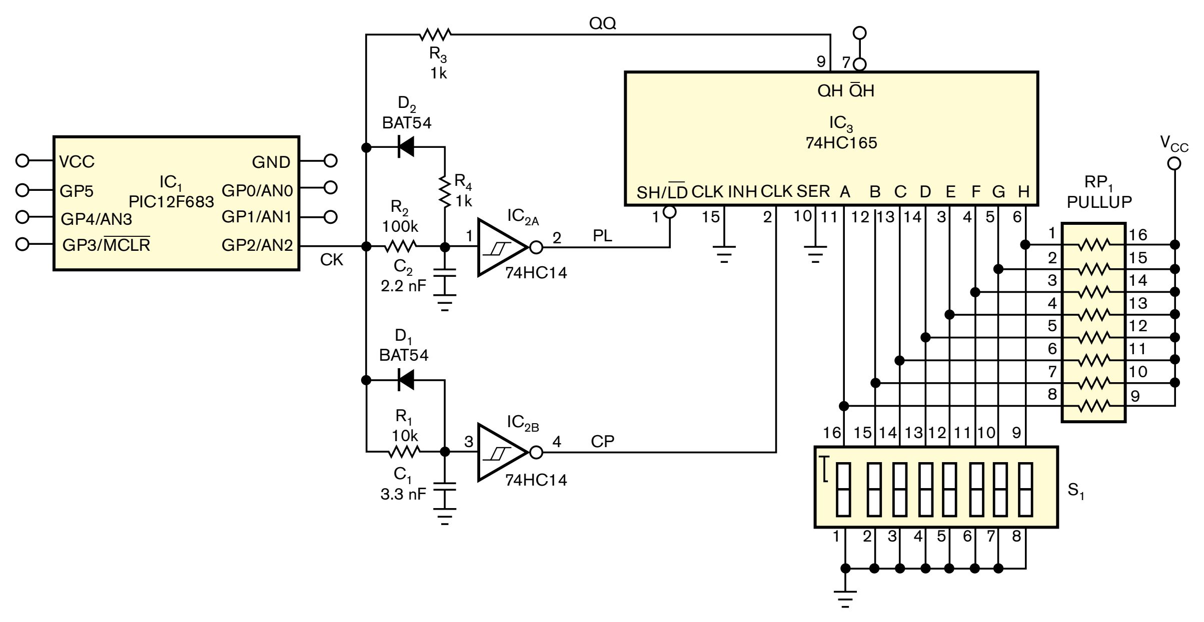

Figure 1 Careful adjustment of the RC time constants allows a microcontroller to input a serial-data stream using a single I/O pin.

pulses shift the data so that the 8 bits appear in sequence at the shift-register output, QQ.

If the microcontroller's data direction briefly changes to input with high impedance, this shift-register data dominates because of the relative values of R_1, R_2, and R_3, with R_3 being a much lower value. The high-impedance state must exist only for a time less than the R_1C_1 time constant (**Figure 2**). The microcontroller now reads the single bit of data. The action of three differing periods generates three functions: load, clock, and data read. The time the microcontrollers need to change port direction, read the pin data, and reset the pin's direction to output determines the timing. For example, a 1-µsec microcontroller requires 10 µsec.

To avoid spurious CP pulses, this time constant must be less than $0.33R_1C_1$, so R_1C_1 could be 30 µsec and R_2C_2 could be 200 µsec. These settings would allow a complete 8-bit read in about 1 msec. To achieve faster operation, replace the RC delays with a precision retriggerable monostable multivibrator, such as NXP's 74HC123, and logic gates. You can expand the scheme with more shift registers to read dozens of signals.

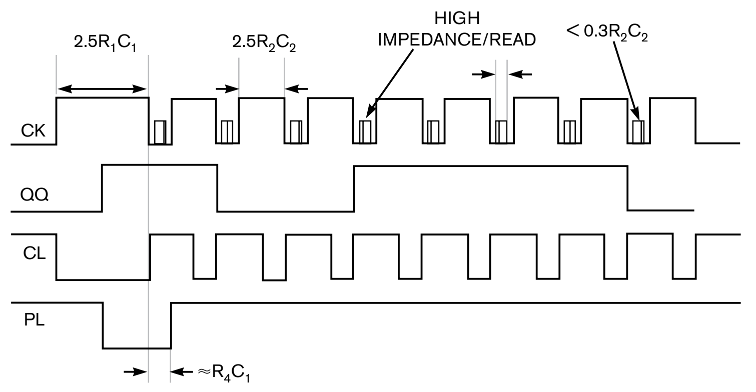

Figure 2 The high-impedance state must exist only for a time less than the R_1C_1 time constant.

Note that internal logic in the 74HC165 shift register prevents the CP signal from shifting data when LD is active. Resistor R_4 ensures the correct sequencing of LD and CP. Diodes D_1 and D_2 quickly discharge the capacitors to "reset" the delay function of R_1C_1 and R_2C_2. EDN

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1 Niven, Rex, "RC lowpass filter expands microcomputer's output port," *EDN*, June 21, 2007, pg 74, www.edn.com/article/CA6451248.