

design ideas

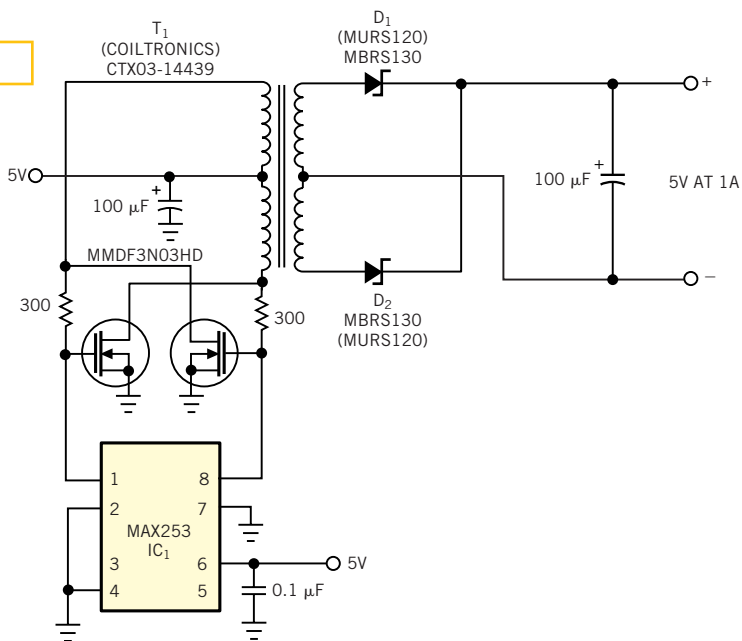
Edited by Bill Travis and Anne Watson Swager

Push-pull driver provides isolated 5V at 1A

Ron Young, Maxim Integrated Products, Sunnyvale, CA

THE CIRCUIT IN **Figure 1** converts a regulated 5V input to an isolated 5V output with 1A current-output capability. IC₁, a push-pull transformer driver, powers a pair of cross-coupled power MOSFETs in a flip-flop-like configuration. In turn, the MOSFETs toggle the primary winding of a forward transformer. The transformer's secondary output, after rectification and filtering, provides the isolated 5V supply. Because the output voltage is unregulated, its voltage tolerance depends on the input-voltage range and the range of load current. With Schottky rectifiers, such as the MBR5130 for D₁ and D₂, the circuit delivers 5V ± 10% at 700 to 1000 mA from a 5V ± 5% input with 80% efficiency (**Figure 2**). Using ultrafast-recovery silicon rectifiers, such as the MURS120, the circuit delivers 5V ± 10% at 200 to 500 mA from a 5V ± 5% input, with 77% efficiency. (DI #2502)

Figure 1



A simple circuit produces a 5V, 1A isolated output from a 5V regulated input.

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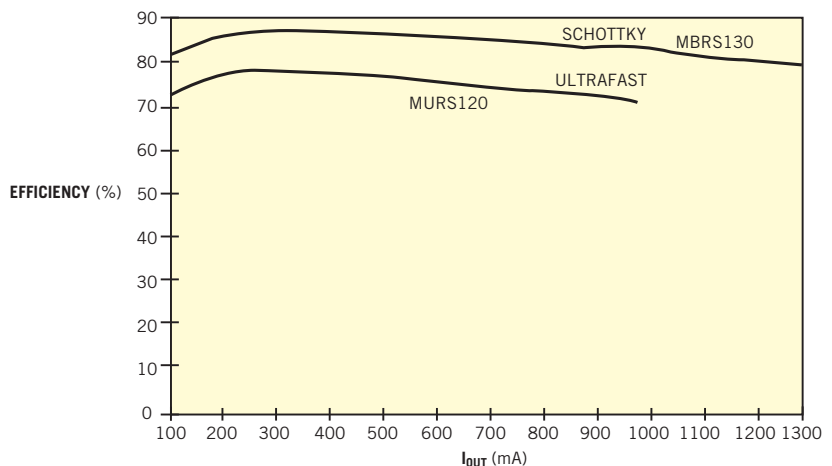


Figure 2

The efficiency of the circuit in Figure 1 depends directly on the forward drops of the output rectifiers.

Circuit programs Atmel AVR μ Cs

Guo-Yin Xu, XuMicro, Houston, TX

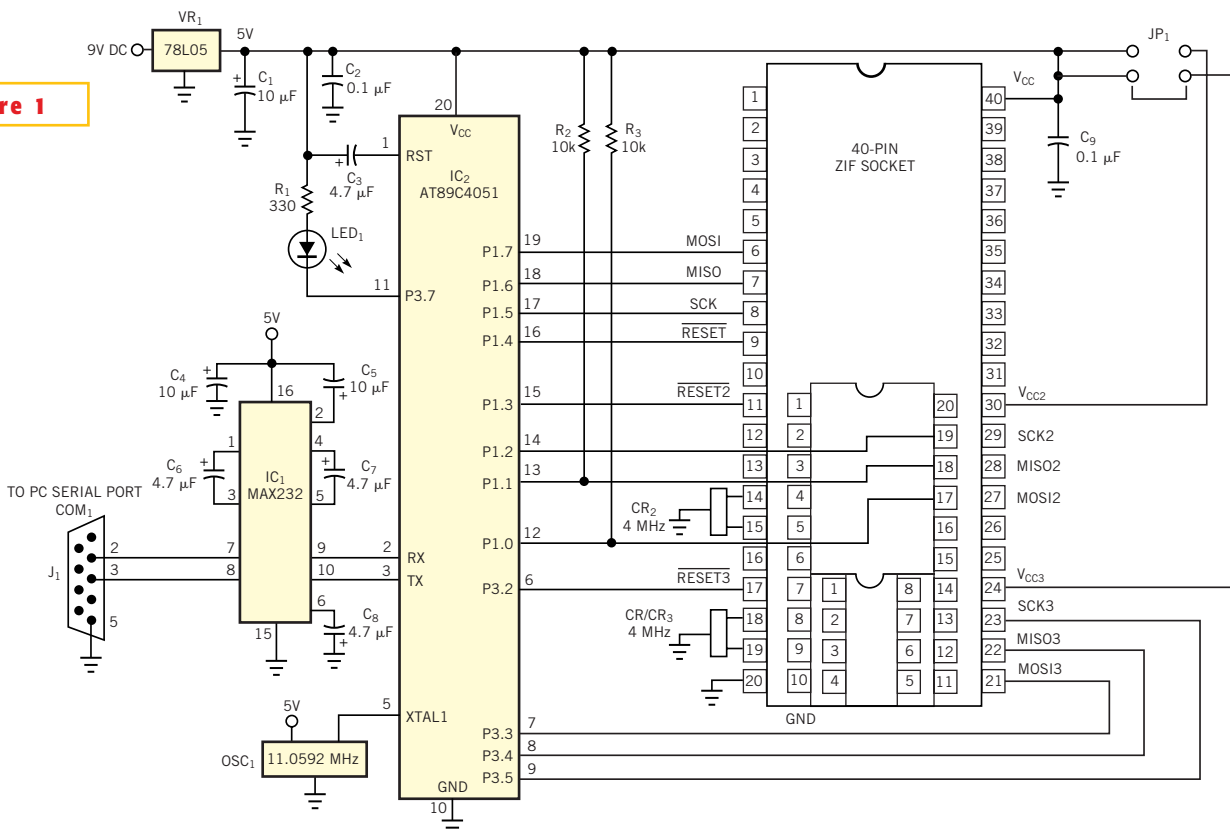
ATMEL AVR μ Cs feature an enhanced RISC architecture that purportedly offer the highest MIPS-per-milliwatt capability in the 8-bit μ C market. **Figure 1** shows an easy-to-build AVR μ C-programming circuit that can program the 40-pin AT90S4414/8515, the 20-pin AT90S1200/2313, and the eight-pin AT90S2323/2343. The programmer uses only three chips. It connects to the host PC's serial port via a MAX232 RS-232 transceiver, IC₁. Power comes from a 9V wall cube and the 78L05 linear regulator, VR₁. The AT89C4051 μ C (IC₂) works with the 11.0592-MHz oscillator, and controls all programming tasks. LED₁ indicates the programmer's status. The circuit exploits the fact that all AVR μ Cs

have a built-in SPI (serial-peripheral-interface) port that you can use to effect serial programming. The SPI port uses only the system-clock (SCK), master-output/slave-input (MOSI), and master-input/slave-output (MISO) pins. The AVR data book requires that, to place a μ C in serial-programming mode, you must first pull the Reset and SCK pins low (**Reference 1**). Then, the μ C must execute a programming-enable instruction before it can execute any program of erase instructions.

Hence, you need four pins to control the programming of a μ C. For instance, the control signals from the AT89C4051 port pins P1.4 to P1.7 are for 40-pin μ Cs, the signals from P1.0 to P1.3 are for 20-

pin μ Cs, and the signals from P3.2 to P3.5 are for eight-pin μ Cs. Note that you need pullup resistors for the AT89C4051 port pins P1.0 and P1.1, because these pins normally serve as analog-signal-input lines. Jumper JP₁ controls the 5V power supply for 20- and eight-pin μ Cs. You should remove the jumper when programming 40-pin μ Cs, which use a hard-wired connection to the 5V power. The circuit uses two 4-MHz ceramic resonators: CR₂ for 20-pin μ Cs, and CR/CR₃ for 40- or eight-pin μ Cs. Because the wires for the resonators should be as short as possible, the circuit uses no switching or jumping mechanisms. Instead, it uses one more resonator, CR₂, that's hard-wired to pins 4 and 5 of the

Figure 1



Exploit the power of Atmel's AVR μ Cs, using this easy-to-build programmer.

20-pin μC pins 14 and 15 of the ZIF socket. This connection does not disturb the programming of 40-pin μC s.

In addition to the hardware in **Figure 1**, the programmer also needs associated software. A binary file, AVR.P1.BIN, holds the finished AVR-programmer software, burned into the AT89C4051 μC by using an 8X51 EPROM/flash μC programmer (**Reference 2**). A DOS file, AVR.P1.EXE,

contains the host-PC communication program. You can download these routines from *EDN's* Web site, www.edn-mag.com. Click on "Search Databases" and then enter the Software Center to download the file for Design Idea #2504. (DI #2504)

REFERENCES

1. "8-bit RISC Microcontrollers Data

Book," Atmel Corp, August 1999.

2. Xu, Guo-Yin, "8X51 EPROM/flash microcontroller programmer," *Circuit Cellar Magazine*, April 1998.

TO VOTE FOR THIS DESIGN,
CIRCLE NO. 367

Circuit adds latch-off current limit to regulator

Craig Varga, Linear Technology Corp, Milpitas, CA

IN MANY APPLICATIONS, forcing a high-current power supply to latch off if a sustained fault condition exists can minimize the likelihood of damage to the pc-board traces and the power devices in the supply. Pulse-width-modulation (PWM)-control circuits provide no latch-off feature, but the circuit in **Figure 1** does. The circuit is based on IC₁, an LTC1430 PWM controller. The current-limiting feature of the IC operates by sensing the voltage across the high-side MOSFET and compares it with a threshold voltage developed across R₃. If an overcurrent condition exists, an internal current source starts to discharge the

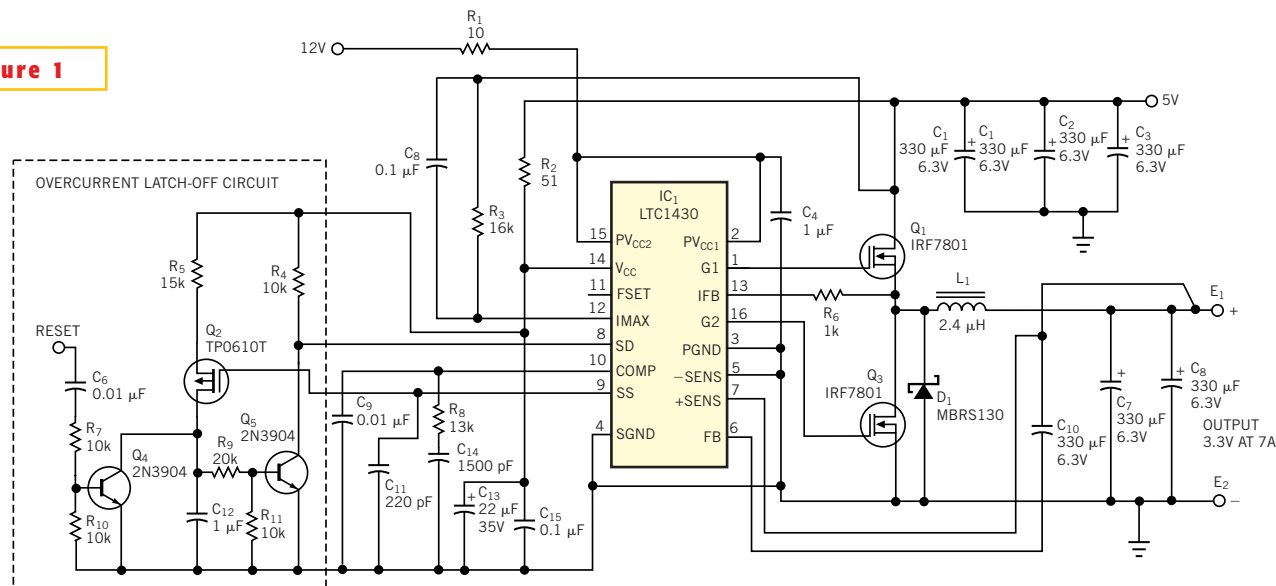
soft-start capacitor, C₉. At this point, the latch-off circuit begins to take over. When the voltage across C₉ decreases to a couple of volts below V_{CC}, Q₂ turns on and begins to source current, charging C₁₂.

After a time interval depending on the values of R₅ and C₁₂, Q₅ turns off and pulls the shutdown pin low, thereby turning off the controller. Because this action internally grounds the soft-start pin (to allow a normal soft-start cycle at turn-on), the circuit remains latched in the off state. You can initiate a reset by applying a fast logic high to the reset line. C₆ and C₇ provide a differential pulse to the base of Q₄, which discharges C₁₂, allowing the

regulator to restart. If you don't need the reset function, you can eliminate C₆, R₇, R₁₀, and Q₄. You can then initiate a restart by recycling the 5V input power. The only timing requirement is that the latch-off delay be greater than the soft-start rise time at turn-on. Otherwise, the regulator can never start. You can modify the circuit to work with any other controller, such as the LTC1553, having the soft-start function. (DI #2503)

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Figure 1



You can add a latch-off current-limiting feature to a simple pulse-width-modulation controller by adding a few external components.

Dual power supply delivers 8A with no heat sinks

John Seago, Linear Technology Corp, Milpitas, CA

THE CIRCUIT IN Figure 1 is a high-current dual supply that provides 5 and 3.3V at currents as high as 8A. The circuit uses a fixed-frequency, two-output, current-mode synchronous-buck-controller, IC₁, to regulate both 5 and 3.3V outputs. The circuit uses separate regulator circuits for each output voltage. However, both circuits are identical except for the lower feedback resistors, R₄ and R₇, which determine the 5 and 3.3V output voltages, respectively.

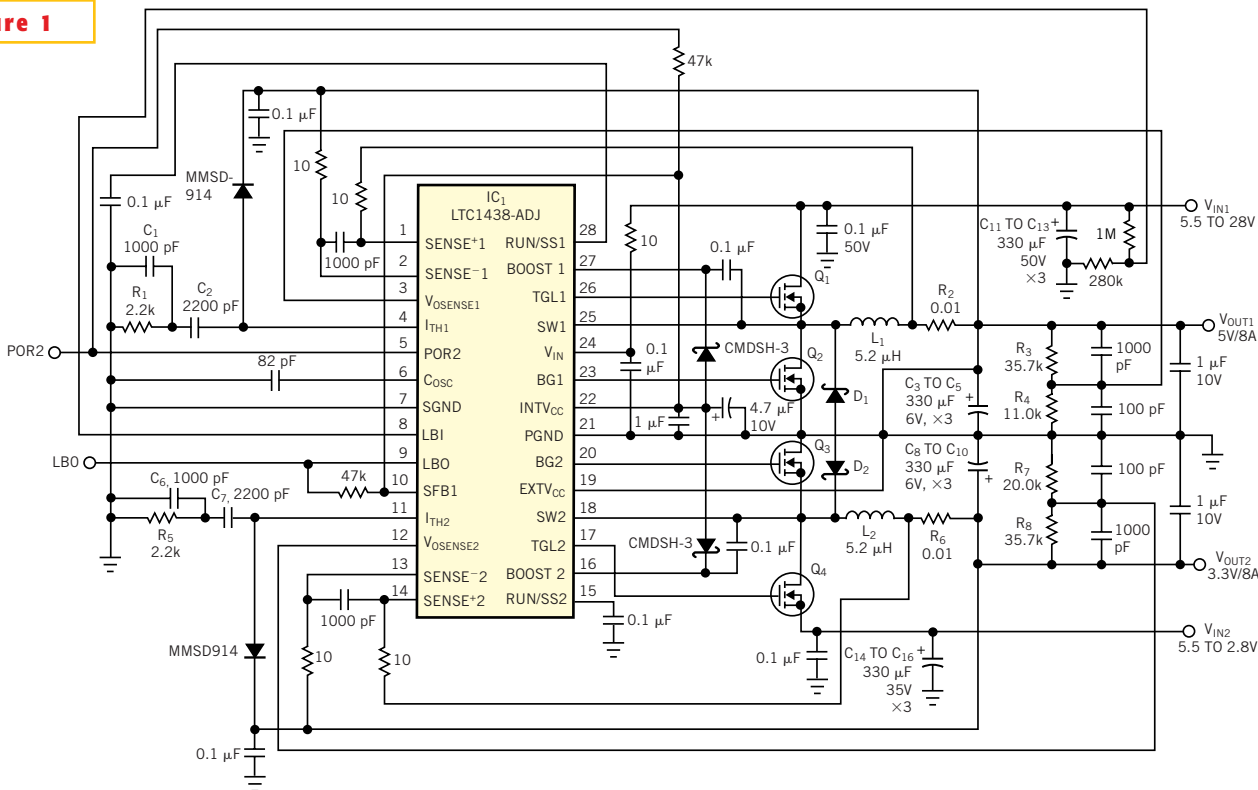
IC₁ regulates the 5V output, V_{OUT1}, by

controlling the duty cycle of the top MOSFET for V_{OUT1}, Q₁, so that average input voltage to the buck inductor, L₁, is equal to the output voltage. The buck inductor and output capacitors C₃ to C₅—three 330-μF capacitors in parallel—integrate and filter the energy pulses from Q₁ to generate the dc output. After Q₁ turns off, the bottom MOSFET for V_{OUT1}, Q₂, turns on to conduct inductor current to the load. To avoid shoot-through current, a short dead time occurs before each MOSFET turns on. During this dead

time, inductor current flows through the commutating diode, D₁, to the load. Feedback resistors R₃ and R₄ connect IC₁'s internal error amplifier to the output. Loop-compensation components R₁, C₁, and C₂ control the frequency response of the error amplifier. The internal current comparator senses inductor current by the voltage developed across the current-sense resistor, R₂.

The 3.3V regulator, which produces V_{OUT2}, functions exactly like the 5V regulator. Q₃ and Q₄ are the top and bottom

Figure 1



- NOTES:**
 C₁₁ TO C₁₃, C₁₄ TO C₁₆=SANYO 35CV330GX.
 C₃ TO C₅, C₈ TO C₁₀=KEMET T495X337M006AS.
 D₁, D₂=MOTOROLA MBRD835L.
 L₁, L₂=PULSE ENGINEERING PE-53700.
 Q₁, Q₄=SILICONIX SUD50N03-10.
 Q₂, Q₃=SILICONIX SI4420DY.
 R₂, R₆=IRC LRF2512-01-R010-J.

A single IC regulates both 5 and 3.3V outputs; each output delivers 8A.

MOSFETs, respectively, and L_2 is the buck inductor. D_2 is the commutating diode. Feedback resistors R_7 and R_8 connect the error amplifier to the output. R_5 , C_6 , and C_7 are the loop-compensation components, and R_6 is the sense resistor. C_8 , C_9 , and C_{10} make up the output capacitor.

The circuit in **Figure 1** has some features that add versatility. The low-battery comparator in IC_1 flags a low-input-voltage condition. Normally, the LBO pin is

high but goes low when the input voltage is low. IC_1 includes a complete power-on-reset circuit. At startup, the POR2 pin is low. This pin goes high 65,536 oscillator cycles after Channel 2's output voltage reaches 95% of its programmed value. The POR2 pin goes low if the output voltage falls 7.5% from nominal. Each output has a RUN/SS pin that provides output-voltage delay, output-current soft-start, and on/off control. The value

of the capacitor connected to the RUN/SS pin determines the output voltage delay and the inductor-current ramp time, both at a rate of 0.5 sec/ μ F. Pulling a RUN/SS pin low turns off that output voltage. Pulling both RUN/SS pins low shuts down IC_1 , turns off all internal circuitry, and limits the input current to 16 μ A. (DI #2494)

TO VOTE FOR THIS DESIGN,
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Power switch provides soft start

John Haase, Colorado State University, Fort Collins, CO

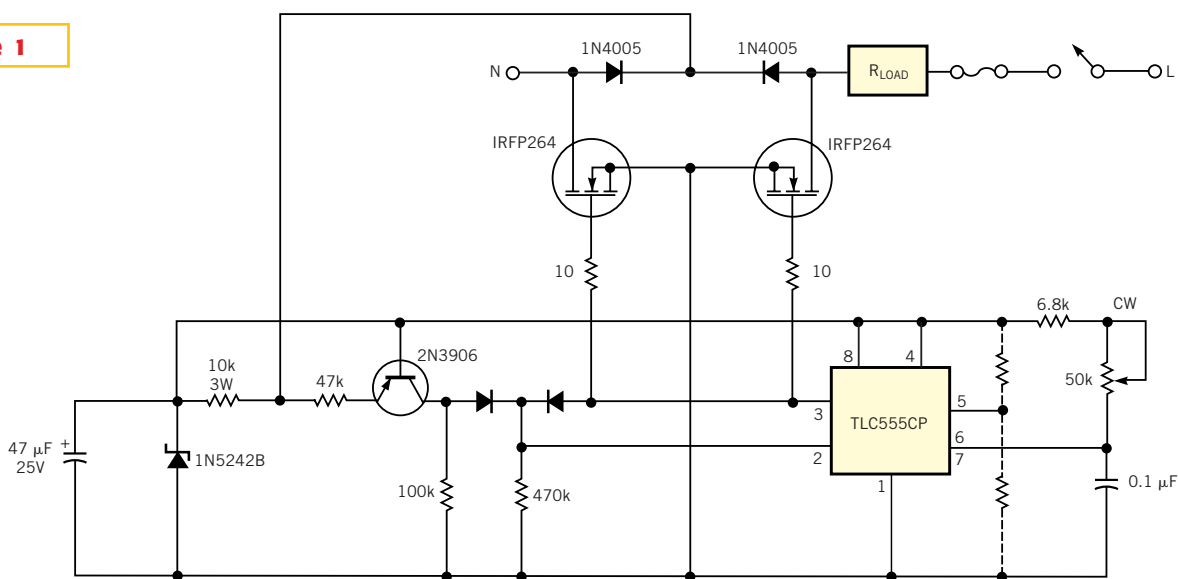
IN THE CIRCUIT IN **Figure 1**, series-connected MOSFETs turn on the line voltage near the zero-crossing point and off when the 555-timer delay lapses. That delay ranges from 1 to 7 msec. The MOSFETs' body diodes and the 1N4005 diodes form a full-wave bridge rectifier that provides a floating 12V-dc level via the 10-k Ω , 3W resistor. The bridge simultaneously delivers the crossing signal

to 2N2906 common-base comparator. When the emitter current approaches zero, the collector voltage falls to 4V and triggers the delay timer, initiating gate drive to the switches. Positive-going pin 3 of the 555 also removes the trigger threshold by coupling to the diode OR gate. Because the circuit generates the 12V operating voltage only during off-time, the limit for maximum delay is ap-

proximately 7 msec. You trim the delay by selecting a resistance value from Pin 5 to raise (pins 5 to 8) or lower (pins 5 to 1) the upper comparator threshold at Pin 6. Thus, load power is from 0 to 90% of maximum (600W). You must use a heat sink for the power MOSFETs. (DI #2506).

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Figure 1



NOTE: $V_{L,N}=115V$ AC AT 60 Hz.

This smart switch provides a small initial current for loads with a normally high inrush current.

Circuit eliminates PC echoes

Hans Kroboth, EEC, Nesconset, NY

LONG-DISTANCE-TELEPHONE services available via the Internet often require the PC user to wear headphones of a headset to prevent echo caused by the microphone's picking up the loudspeaker outputs. The circuit in **Figure 1** eliminates the echo while using the existing PC microphone and speakers for a comfortable conversation. The interface is between a standard electret condenser microphone and the microphone input of the PC. The loudspeaker output of the PC serves to mute the microphone input. R_1 and R_2 provide biasing for both the electret microphone and the Q_1 emitter follower. Q_2 , a p-channel FET, acts as a switch that opens with the application of a gate voltage greater than

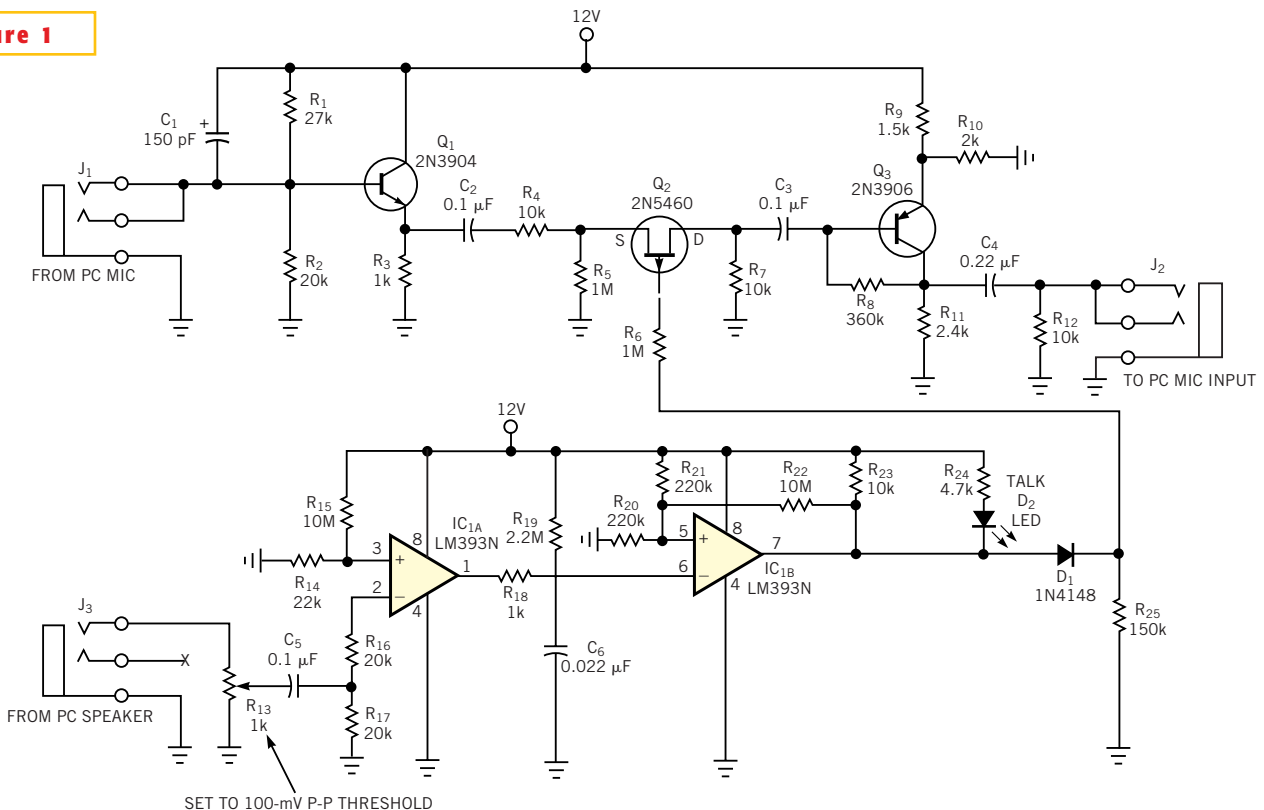
6V and closes with a gate voltage of 0V. Q_3 compensates for the switching-circuit losses and buffers the output. R_9 and R_{10} provide an appropriate input impedance to Q_3 and limit the output to 5V p-p, thus preventing any possible damage to the PC's microphone input.

IC_1 , which acts as low-level retriggerable monostable multivibrator, controls the Q_2 FET switch. Loudspeaker voltage levels as low as 15 mV from the PC cause comparator IC_{1A} 's open-collector output to discharge C_6 via R_{18} . The falling voltage of C_6 , passing the threshold of comparator IC_{1B} , produces a high output that turns off Q_2 . Any input from the PC's loudspeaker output discharges C_6 . The absence of an input allows C_6 to charge

within approximately 40 msec to the IC_{1B} threshold, producing a low-level output and turning on Q_2 . LED D_2 lights whenever no loudspeaker output is present, and the microphone input to the PC becomes enabled. D_1 reduces the Q_2 gate voltage to 0V when the IC_{1B} output saturates. You should set R_1 such that approximately a 100-mV p-p microphone input just triggers IC_1 , as indicated by the LED's extinguishing. This level prevents any noise from the PC's loudspeaker output from falsely triggering the monostable multivibrator. (DI #2508).

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Figure 1



Eliminate annoying echoes from loudspeaker-microphone feedback by using this simple circuit.

Clamping circuit dissipates minimal power

Carlisle Dolland, Allied Signal Aerospace, Torrance, CA

THE CIRCUIT IN **Figure 1** is a quasi-linear regulator. It functions as a source follower for input voltages greater than a preset level, determined by VR_3 . For input voltages lower than the preset level, the pass element, Q_2 , operates as a saturated switch. The circuit comprises an oscillator, a charge pump, and a linear regulator. The linear regulator, consisting of Q_1 , R_1 , VR_1 , and R_2 , drives a charge pump comprising C_2 , D_2 , D_3 , and C_3 . The charge pump generates a voltage equal to the output of the linear regulator for input voltages greater than the breakdown

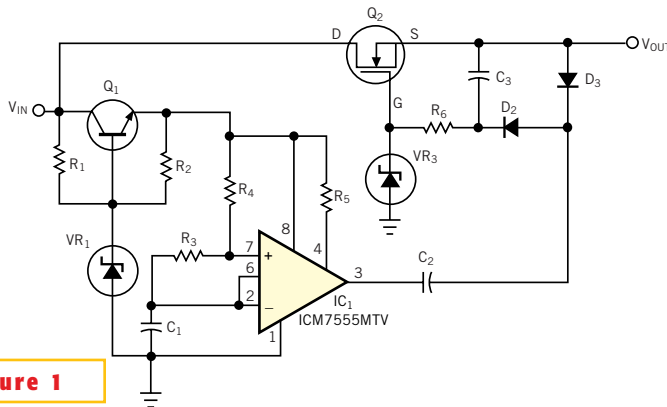


Figure 1

This circuit clamps transient voltages and dissipates minimal power.

voltage of VR_3 . For input voltages lower than VR_3 's breakdown voltage, the output voltage is $V_{OUT} = V_{IN} - I_{OUT} \times (R_{ON} \text{ of } Q_2)$.

For input voltages that exceed VR_3 's breakdown voltage by approximately 3V, R_6 and VR_3 dissipate the energy the charge pump supplies. In this mode, the circuit functions as a source follower, and the output voltage is approximately 3V lower than VR_3 's breakdown voltage. The circuit dissipates minimal power. During transients, the load current determines the dissipation in Q_2 . (DI #2499)

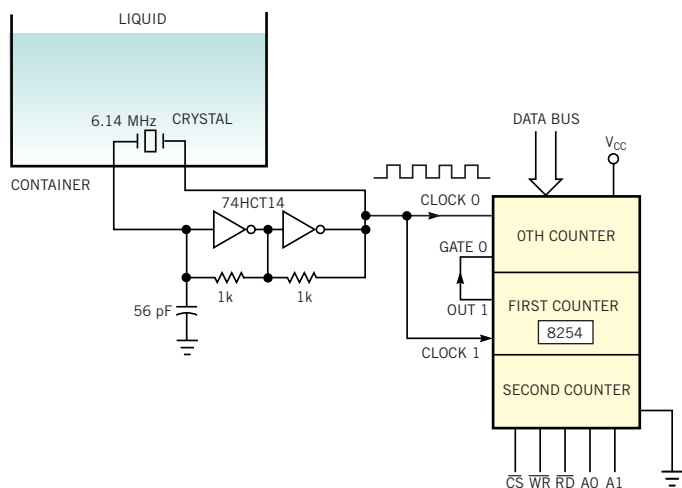
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Piezo crystal monitors liquid level

J Jayapandian, IGCAR, Tamil Nadu, India

THE SIMPLE AND INEXPENSIVE circuit in **Figure 1** monitors the liquid level in a container. The piezo crystal, carefully mounted at the bottom surface of the container, receives its activation from the 74HCT14 hex Schmitt trigger. The crystal generates stable clock pulses according to its specification (for example, 6.14 MHz) when it is in free air. The crystal-based clock drives the 0th counter in an 8254 programmable-counter/timer chip, programmed in Mode 0 as an event counter. The first counter of the 8254, programmed in Mode 1 as a retriggerable one-shot whose time period is 1 sec, controls the gate of the 0th counter. The first counter allows the 0th counter to count for a period of 1 sec. The counts in the air medium serve as a reference. Depending on the height of the liquid level, the pressure acting on the surface of the crystal increases, thereby reducing reference-crystal clock frequency. The variation in clock frequency with respect to the air-

Figure 1



By measuring frequency shifts, this circuit provides a measure of liquid level.

medium reference gives you the height of the liquid level. (DI # 2507)

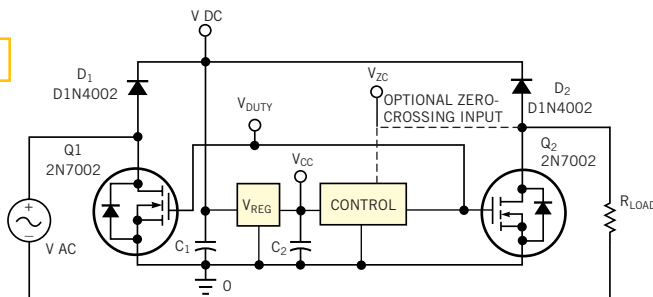
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Switch intelligently controls current

Jim Hartmann, Silent Knight LLC, Maple Grove, MN

THE CIRCUIT IN **Figure 1** can intelligently control ac or dc current when connected in series with a load. The circuit “steals” its power by turning off the load at a low duty cycle. The switch uses the MOSFETs’ parasitic body diode to its advantage. While the MOSFETs are off, the body diodes, along with D_1 and D_2 , serve as two legs of a diode bridge. Current flows through the load and the bridge, charging C_1 to the peak ac or dc voltage. The relatively small control-block supply current continues to flow through the load when the load is turned off. The circuit has low insertion loss because of the MOSFET’s bidirectional nature. The control block connects power to the load by turning MOSFETs Q_1 and Q_2 on. On alternating cycles, either Q_1 or Q_2 becomes reverse-biased, but current does not flow through the body diode because the MOSFET can conduct in either direction. The insertion loss is equivalent to the loss in two times

Figure 1



With a control circuit of your choice, you can obtain intelligent control of ac or dc current.

the MOSFET’s on-resistance.

While the load is turned on, the control block draws current from C_1 . The circuit must periodically recharge C_1 by briefly turning off the load. You can allow the duty cycle to go as high as 99.99% with a high-current load and a micro-power control circuit. The maximum duty cycle is approximately $I_{LOAD} / (I_{CONTROL} + I_{LOAD})$. For example, with a 1A load and a control-circuit current of 1 mA, the

maximum duty cycle is 99.9%. By choosing MOSFETs and diodes with higher current ratings, you can adapt the circuit to control high-power loads. Many applications are possible—lamp dimmers and thermostats, for example. The controller can optionally synchronize to the ac zero-crossing point as shown. (DI # 2505)

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