Switched-capacitor regulator provides gain

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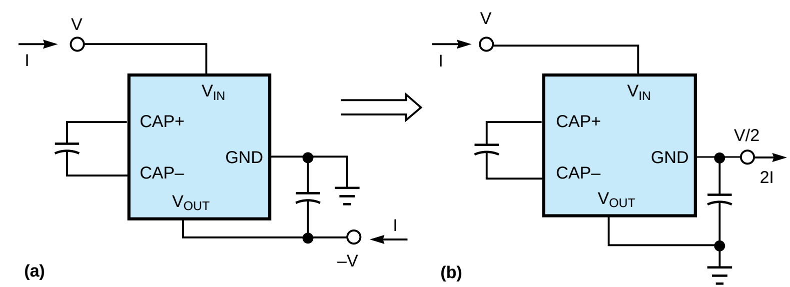
Linear voltage regulators become inefficient when the input voltage is much higher than the regulated output. The circuit in **Figure 1** dramatically increases efficiency when the input voltage is more than twice the desired output; for example, using 12V to obtain a regulated 3.3 or 5V. You usually use a switched-capacitor voltage inverter to generate a negative supply voltage from a positive input voltage. The negative-supply current is equal to the current drawn from the input. By swapping the roles of the ground and output pins, the inverter in **Figure 1** divides the input voltage by two. It also doubles the current from the input to the output, thereby providing much better efficiency than does a linear regulator.

Figure 2 illustrates the circuit's operation. An internal oscillator alternately closes and opens four switches. In the first half-cycle, switches 1 and 2 close, and current flows from the input to the output, charging C_1. In the second half-cycle, switches 3 and 4 close, discharging C_1 into the output. The current delivered to the output is continuous and equal to twice the average input current. Because the current is continuous, the output-voltage ripple is low. Note that you do not need to match C_1 and C_{OUT}, because their voltages equalize on each cycle.

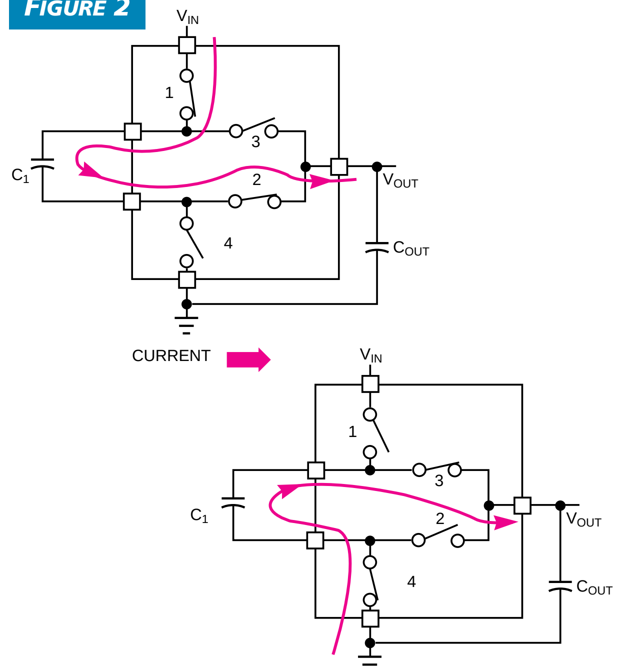
Figure 3 shows the actual circuit. IC_1, an LT1054 switched-capacitor voltage converter and regulator, modulates the

Figure 1



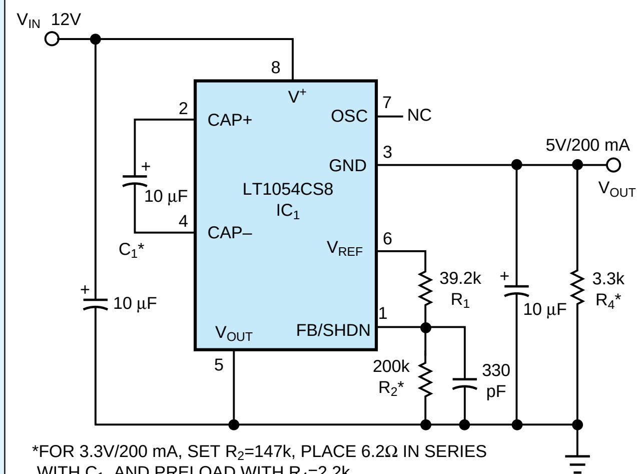
Rewiring a switched-capacitor inverter for step-down regulation results in a current gain of 2.

FIGURE 2



This switched-capacitor regulator doubles the current from the input to the output, thus increasing efficiency and eliminating the need for a heat sink.

FIGURE 3



*FOR 3.3V/200 mA, SET R_2=147k, PLACE 6.2Ω IN SERIES WITH C_1, AND PRELOAD WITH R_4=2.2k.

The LT1054's internal switches alternately charge and discharge C_1, thereby delivering a continuous current to the output.

current (through switch 1 of **Figure 2**) to regulate the output. A servo loop keeps the potential at the FB pin equal to the potential at the GND pin. The circuit can deliver 200 mA at 5V from an input of 11.2 to 13V. Typical efficiency is 74%, compared with 42% for a linear regulator. More important, dissipation decreases from 1.4W for a linear regulator to 0.35W, a figure that IC_1's eight-pin, surface-mount package can easily handle. For a 200-mA, 3.3V output, the circuit is 49% efficient, compared with a linear regulator's 27%, with power dissipation reduced from 1.8 to 0.7W. A 6.2Ω resistor in series with C_1 shares the dissipated power with the LT1054; the circuit needs no heat sink. (DI #2168)

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Precision current sink costs less than $20

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If you often need a simple active load (constant-current sink), you can benefit from the simple circuit in **Figure 1**. The need often arises to measure the life of a battery or other power device under constant-load conditions. The easy-to-build and inexpensive circuit in **Figure 1** is a handy addition to your arsenal of test fixtures. You can build the circuit for less than $20. The most expensive parts are the vernier knob and the multiturn potentiometer. You can build the active load into a miniature enclosure with banana-jack connectors. The vernier control allows you to directly set current from 1 mA to 1A by simply dialing the desired set current. Without the vernier and multiturn potentiometer, you could build the circuit for less than $10, but you then lose the advantage of a calibrated, stand-alone test box.

The circuit is a precision current sink with typical current regulation of better than 0.5% for a 3 to 40V compliance voltage. R_4 is a sensing resistor; its voltage drop servos the input voltage to IC_{1A}. The wiper of the vernier potentiometer sets the input voltage, discounting any amplifier offset errors. The offset could be as high as 2 mV in a run-of-the-mill LM10, translating to a 2-mA error between the set current and the current flowing in R_4. The reference amplifier, IC_{1B}, is a gain-of-5 stage that provides a 1.00V reference on the high side of the current-setting potentiometer. The voltage-to-current transfer function is thus 1A/1V. You can change the transfer function to fit your needs.