MOSFET shunt regulator substitutes for series regulator

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YOU WOULD NORMALLY use a series linear regulator or a dc/dc converter to obtain 3V dc from a higher supply. However, when breadboarding a concept, you may be able to use a shunt regulator, especially if a series regulator of the correct voltage is unavailable. The MOSFET in **Figure 1** can replace a zener diode in a shunt regulator and provide lower output impedance than a zener diode.

The MOSFET is self-biased by connecting its drain to its source. The difference between the input voltage and the gate-to-source threshold voltage, V_{GS}, sets the current. The IRF521 in this example has a threshold voltage of 2 to 4V at 250 μA. The upper curve of **Figure 2** shows that the IRF521 achieves a gate-to-source voltage of 3V at a current of about 200 μA. MOSFETs can vary from device to device, but the typical MOSFET has a threshold at approximately the mean between the maximum and the minimum limits.

The lower curve in **Figure 2** is the output impedance, which you obtain from the upper curve by differentiating the upper curve. Although the output impedance, R_{OUT}, is near 800Ω at a current of 100 μA, it rapidly drops to less than 6Ω at 50 mA. Because you operate the MOSFET at or near threshold, its on-resistance spec doesn't apply, and the output impedance of this circuit is far higher than you would expect from the on-resistance. However, in general, the lower the on-resistance, the lower the output impedance at a specific current near threshold.

This circuit may require that R_2 and C_1 stop the oscillation in the MOSFET. Add a filter capacitor to the output to minimize the effect of load transients. Connecting a large filter capacitor from the gate to the source with short leads eliminates the need for R_2. You can use other

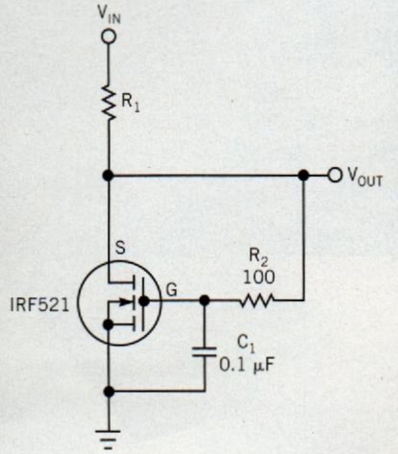

Figure 1 A MOSFET configured to replace a zener diode of a shunt regulator provides lower impedance than a diode-based implementation.

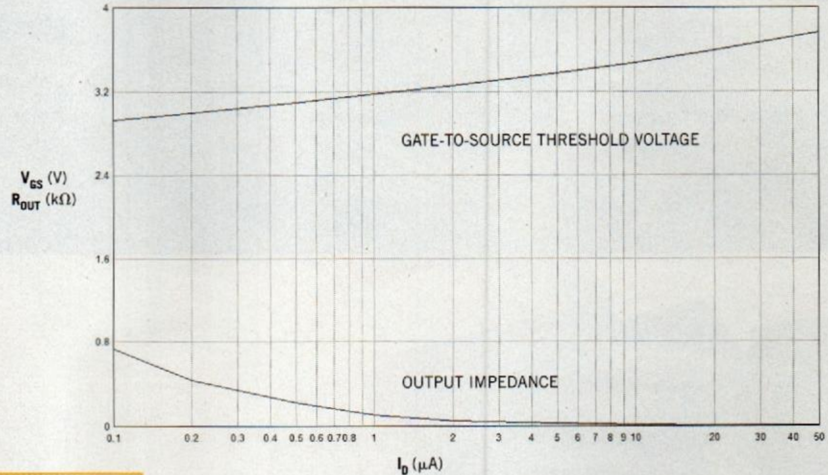

Figure 2 A plot of key parameters—gate-to-source voltage and output impedance—versus drain current shows smoothness of variation over two and one-half decades.

MOSFET families and other voltages if necessary.

Although you may be unable to get the exact output voltage you need at the current you prefer, many devices tolerate wide variations in operating voltage. For instance, many 3.3V-dc microcontrollers can operate as low as 2.5V dc and as high as 3.6V dc. Note that operating a MOSFET near its threshold causes a large negative-temperature coefficient of the gate-to-source voltage. This circuit has significant change in output voltage over a wide temperature range; it is suitable for only limited temperature ranges.□

Zener test circuit serves as dc source

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This Design Idea describes a versatile test circuit for zener diodes after yet another misread zener diode had infiltrated the ranks of 1N4148 diodes assembled on a pc board. As a bonus, the circuit can serve as a moderate-voltage, power-limited adjustable dc source. Although conventional multimeters' resistance ranges typically apply enough voltage to forward-bias most diodes, few can drive a zener diode into reverse conduction. **Figure 1a** shows a simple variable-frequency dc/dc step-up converter whose output voltage depends on the device under test's breakdown voltage.

Upon power application, Pin 3 of IC_1 (one section of a 74HC132 quad dual-input Schmitt-trigger NAND gate) goes to logic one and switches on Q_1, an N-channel logic-level power MOSFET. Current flows through Q_1 and R_6 and stores energy in inductor L_1's magnetic field. Zener diode D_1 limits the voltage at IC_1's Pin 1 to 4.7V. Simultaneously, diode

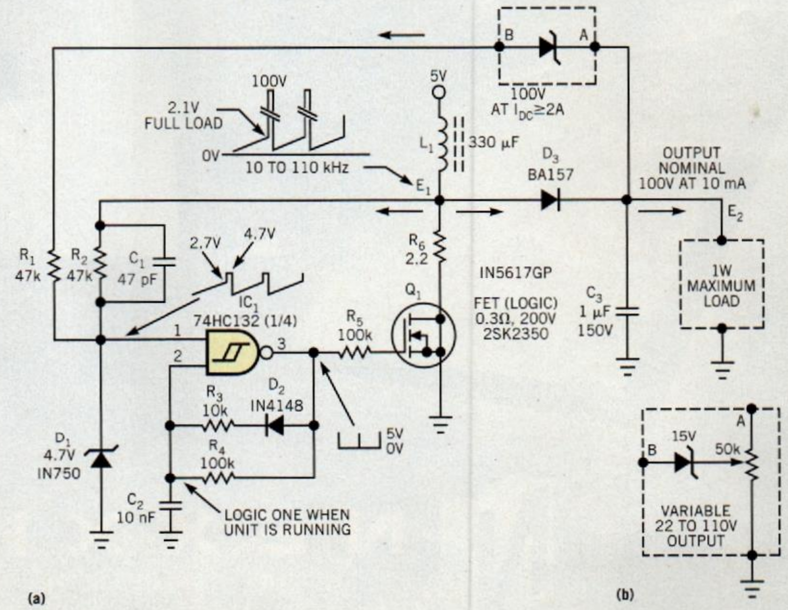

Figure 1 The output voltage of a simple variable-frequency dc/dc step-up converter depends on the device under test's breakdown voltage (a). To use the circuit as a variable medium-voltage power supply, replace the device under test with a network (b).