

PROJECT OF THE MONTH

A Digitally Programmable VMOS Variable Resistor

By Forrest M. Mims

MICROPROCESSORS and computers can be readily interfaced to power switching devices like SCRs, triacs and VMOS FETs. But of all these on/off switching devices, the VMOS FET is the only one that can also be used in a variable resistor mode. This is done by varying the voltage (V_{GS}) at the gate of the transistor, which in turn controls, in a nearly linear fashion, the resistance of the transistor's drain-source channel.

A digital-to-analog converter provides a convenient means for allowing a computer to generate a variable voltage. Figure 1 shows a very simple, low-cost, 4-bit D/A converter that applies (under digital control) a variable voltage to the gate of a VMOS FET.

The D/A converter is made from an R-2R resistor ladder network and two op amps. Of course, a single-chip D/A converter such as the DAC801 can be used to provide higher resolution (8 bits or 256 voltage levels) as well as better accuracy.

How It Works. The D/A conversion is accomplished by the resistor ladder network. When all inputs are low, the network output is 0 V. When all inputs are high, the output is nearly +V. Intermediate binary inputs provide directly proportional output voltages.

The first 741 op amp buffers, inverts, and gives dual polarity to the output from the ladder network. The second 741 provides a means of adjusting the baseline of the output voltage (above, below, or at ground). This is achieved by adjusting R_{11} , which permits the output voltage applied to the gate of Q_1 to be set to any point.

Testing the Circuit. Interfacing the circuit in Fig. 1 to the computer's data bus is best accomplished by interposing buffers between the data bus and the D/A converter.

If you want to test the circuit *without* a computer, the nibble generator circuit in Fig. 2 provides a convenient source of a stepped, automatically recycled binary count (0000 to 1111 and repeat). The count is controlled by R_1 . Capacitor C_1 can be increased to a few tens of microfarads for much slower count rates.

When the circuit in Fig. 1 is connected to a data bus or nibble generator that provides a repetitive series of ascending binary counts, you can test Q_1 's opera-

tion. Just connect a small lamp (with a rating equal to the power supply) at R_L . When R_{11} is properly adjusted, the lamp will respond to an ascending count by gradually brightening. It will then suddenly turn off and again begin to brighten as the cycle repeats.

Be sure to connect a voltmeter to pin 6 of the second 741 while performing the lamp test. You can then monitor V_{GS} while adjusting R_{11} . For best results, slow the count rate when you are making voltage readings.

Going Further. This circuit has many interesting applications. For example, Q_1 can be used as the frequency control resistor for a 555 tone generator circuit. Use the basic 555 clock circuit in Fig. 2, but omit R_1 and connect Q_1 's drain to +V. Connect its source through a 50-kilohm trimmer resistor to pin 7 of the 555. Reduce C_1 's value to 0.01 μ F. Connect a small speaker through a 200-ohm resistor from pin 3 of the 555 to +V. Adjusting R_{11} , the tone generator trimmer, and R_1 of the clock will provide a repetitive series of stepped frequency tones.

For more information about using VMOS FETs as variable resistors, see this month's "Experimenter's Corner." Also, refer to application notes published by the various VMOS FET manufacturers. \diamond

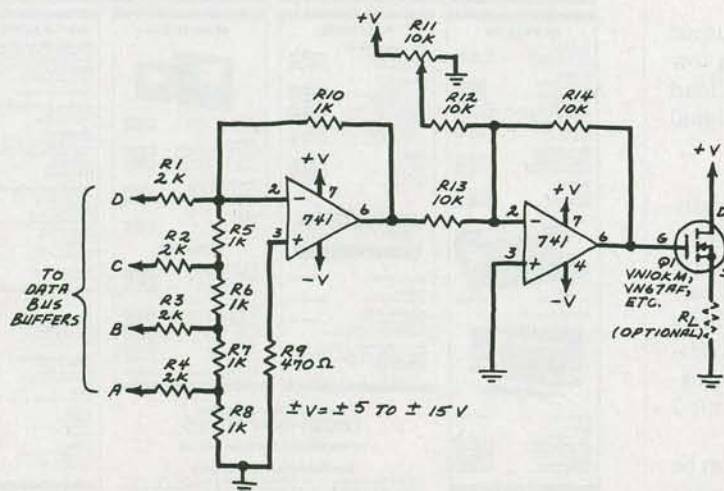


Fig. 1. Digitally programmable VMOS variable resistor.

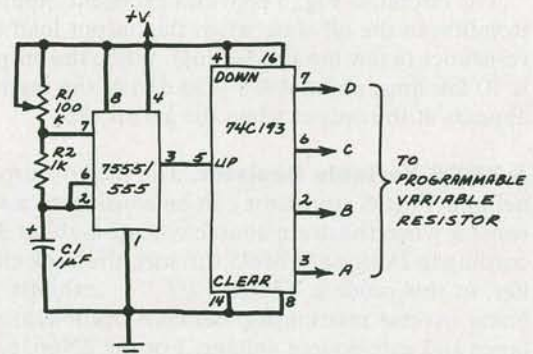


Fig. 2. Nibble generator for testing programmable variable resistor.