PROJECT OF THE MONTH

By Forrest M. Mims

Controller for Small DC Motors

SMALL dc motors that operate in both forward and reverse directions are used in many kinds of devices such as tape recorders, toy cars, and card readers. The rotational direction of these motors is reversed by means of a dpdt switch connected as shown in Fig. 1. Also shown is a pictorial view of the switch contacts wired for forward-reverse directional control.

Many applications require that the rotational direction of a small motor be controlled by a low-level logic signal rather than a mechanical switch. This is readily accomplished by substituting transistors for the switches in Fig. 1. Bipolar transistors can be used, but VMOS power transistors are a better choice since they can be readily interfaced with TTL, LS and CMOS logic.

A Solid-State Motor Reverser. Figure 2 shows one way to substitute VMOS FETs in the circuit of Fig. 1. Two gates in a CMOS 4011 quad NAND gate provide the steering logic necessary to switch the appropriate VMOS FETs on and off.

In operation, when the input is low, *Q1* and *Q2* are switched on, and *Q3* and *Q4* are switched off. This applies a positive polarity to the A terminal of the motor, and the motor rotates in a corresponding direction. When the input is high, *Q3* and *Q4* are switched on, and *Q1* and *Q2* are switched off. This reverses the polarity of the voltage applied to the motor and causes it to reverse its direction of rotation.

An interesting feature of the circuit is that, in a low-noise environment, directional control can be implemented by making the input high or low momentarily and then allowing it to float. The motor will stop and reverse direction even *after* a momentary change in the input level has taken place. Of course the input should not be allowed to float in a noisy environment since the CMOS gate may switch in response to spurious signals.

Adding a Speed Control. Figure 3 shows how the circuit in Fig. 2 can be expanded to include adjustable rotational speed. A bonus feature of the expanded circuit is that the two unused gates in the 4011 are connected as a free-running oscillator—no additional chips are required.

The pulse-repetition rate of the oscillator is governed by *R2* and *C1*. VMOS FET *Q5* is connected as a solid-state switch that applies power to the motor-reverser circuit under control of the oscillator.

The oscillator has a fixed duty cycle of about 50 percent. In other words, the duration of each output pulse is about equal to the time between pulses. When the oscillation frequency is high, the pulses are narrow and the motor turns slowly. When the oscillation frequency is low, the pulses are wide and the motor turns more rapidly.

When the pulses are too wide (a few hundred or more milliseconds), the motor pulsates and may even operate in a start-stop mode. When the pulses are too narrow (50 to 100 microseconds), the motor will cease operation and may emit a high-pitched tone. Different motors may behave in different ways as the pulse train is altered.

Operating Tips. The circuit in Fig. 3 is designed for use with low-voltage, low-power hobby motors such as those in model cars and robots.

Though I used VN67 VMOS FETS (available from Siliconix distributors and Radio Shack stores), most other types will work. But be sure the motor's current drain doesn't exceed the ratings for the VMOS FETs, and use heat sinks if necessary. You can parallel VMOS FETs to obtain a lower *on* resistance and more efficient operation.

Finally, remember that this circuit uses MOS semiconductors. Be sure to follow appropriate handling precautions to avoid causing damage to either the 4011 or any of the transistors. If your circuit fails to operate properly, one of the gates in the 4011 or one of the VMOS FETs may be defective. ◇

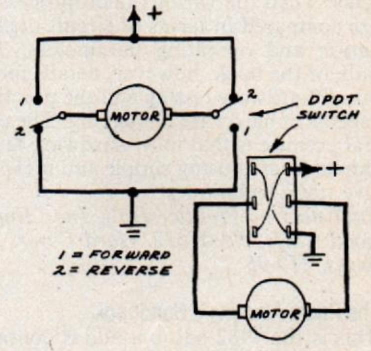

Fig. 1. (Above right.) A mechanical switch motor reverser.

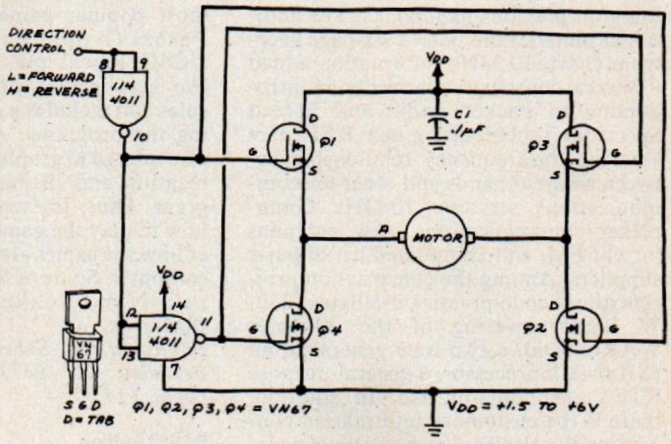

Fig. 2. (Right) A solid-state motor reverser circuit.

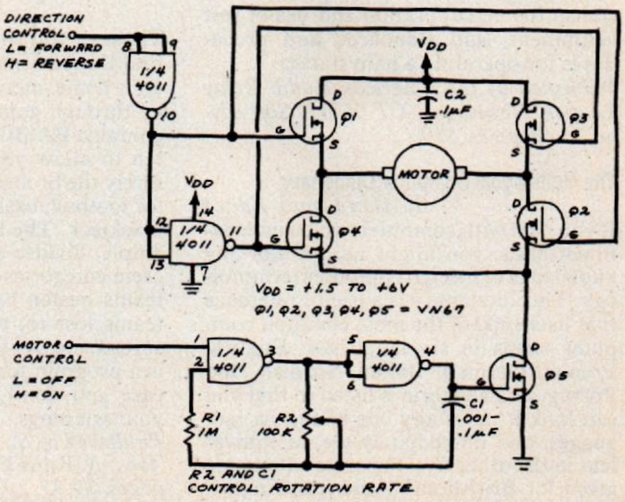

Fig. 3. Small motor direction and speed controller.