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Analog switch lowers relay power consumption

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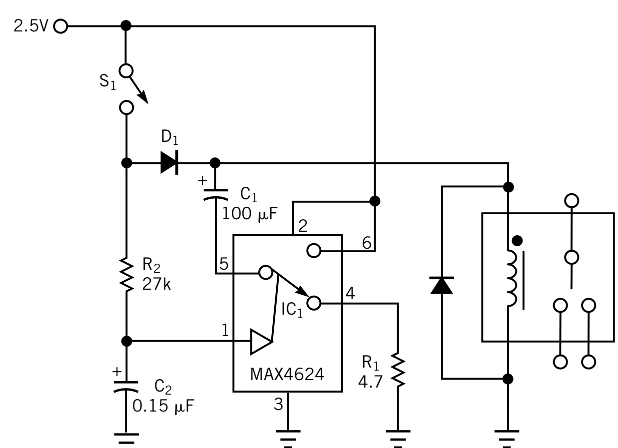
Designers often use relays as electrically controlled switches. Unlike transistors, their switch contacts are electrically isolated from the control input. However, the power dissipation in a relay coil may render the device unattractive in battery-powered applications. You can lower this dissipation by adding an analog switch that allows the relay to operate at a lower voltage (**Figure 1**). The power that a relay consumes equals V^2/R_{COIL}. The circuit lowers this dissipation after actuation by applying less than the normal 5V operating voltage. Note that the voltage required to turn a relay on the pickup voltage is greater than the pickup voltage required to keep in on the dropout voltage. The relay in **Figure 1** has a 3.5V pickup voltage and a 1.5V dropout voltage. The circuit allows the relay to operate from an intermediate supply voltage of 2.5V. **Table 1** compares the relay's power dissipation with the fixed operating voltages applied and with the circuit in **Figure 1** in place.

Figure 1



By using an analog switch, you can reduce a relay's power consumption.

TABLE 1—RELAY POWER DISSIPATION

Voltage (V)	Current (mA)	Total power dissipation (mW)
5 (normal operating voltage)	90	450
3.5 (pickup voltage)	63	221
2.5 (circuit of Figure 1)	45	112

When you close S_1, current flows in the relay coil, and C_1 and C_2 begin to charge. The relay remains inactive because the supply voltage is lower than the pickup voltage. The RC time constants are such that C_1 charges almost completely before the voltage across C_2 reaches the logic threshold of the analog switch. When C_2 reaches that threshold, the analog switch connects C_1 in series with the 2.5V supply and the relay coil. This action turns the relay on by boosting the voltage across its coil to 5V, which is twice the supply voltage. As C_1 discharges through the coil, the coil voltage drops back to 2.5V minus the drop across D_1, but the relay remains on because its coil voltage is above the relay's 1.5V dropout voltage. Component values for this circuit depend on the relay characteristics and the supply voltage. The value of R_1, which protects the analog switch from the initial current surge through C_1, should be low enough to allow C_1 to charge rapidly but high enough to prevent the surge current from exceeding the peak current specified for the analog switch.

IC_1's peak current is 400 mA, and the peak surge current is $I_{PEAK}=(V_{IN}-V_{D1})/(R_1+R_{ON})$, where R_{ON} is the on-resistance of the analog switch (typically 1.2Ω). The value of C_1 depends on the relay characteristics and on the difference between V_{IN} and the relay's pickup voltage. Relays that need more turn-on energy need larger values of C_1. You select the values for R_2 and C_2 to allow C_1 to charge almost completely before C_2's voltage reaches the threshold of the analog switch. In this example, the time constant R_2C_2 is approximately seven times $(R_1+R_{ON})C_1$. Larger R_2C_2 values increase the delay between switch closure and relay activation.

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