Analog switch converts 555 timer into pulse-width modulator

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This Design Idea describes a new approach to producing a variable-duty-cycle waveform from a 555-based free-running oscillator. The circuit's wide modulation range, highly linear control over a wide range of duty-cycle values, and excellent linearity make it ideal for PWM (pulse-width-modulation)-based control applications. **Figure 1** shows the basic circuit, which works as follows: When IC_1's output goes high, switch S_1 closes, and IC_1's internal discharge, switch S_2, opens. Capacitor C_1 charges through R_1 and R_2. When IC_1's output goes low, S_1 opens, and S_2 closes, discharging C_1 through R_2 and R_3.

The generic configuration works well for producing a fixed-value duty cycle.

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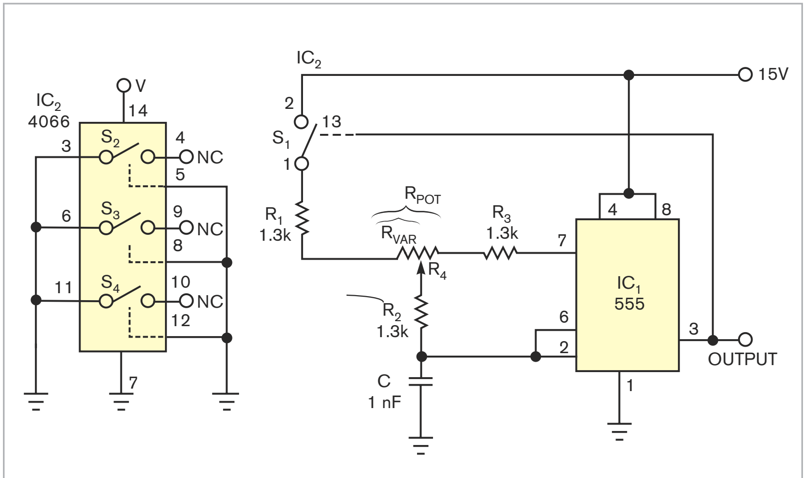

Figure 2 Add a potentiometer, R_4, to produce an output pulse that has a manually variable duty cycle.

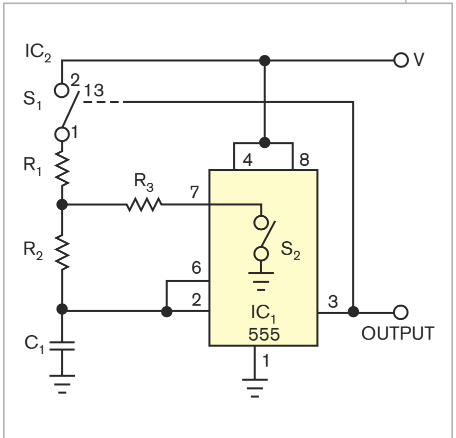

Figure 1 An external analog switch and a 555 timer provide a free-running oscillator with a fixed duty cycle.

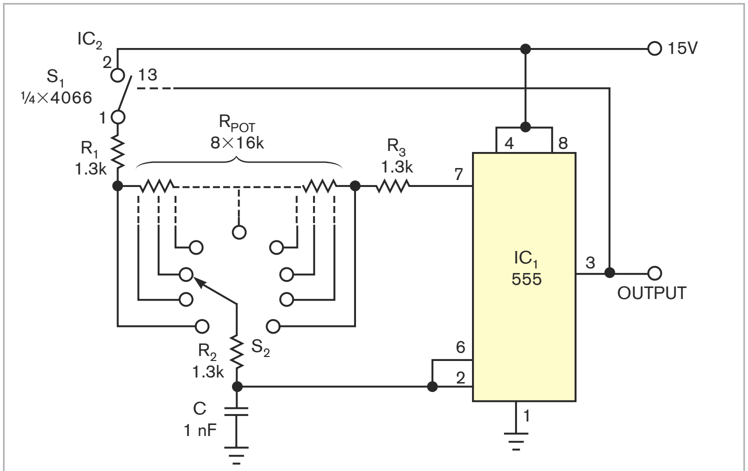

Figure 3 To obtain fixed-duty-cycle values for linearity evaluation, you can replace the potentiometer with a rotary switch and a series-connected string of precision resistors.

To obtain a continuously variable duty cycle, **Figure 2** shows how to connect potentiometer R_4 to the common junction of R_1, R_2, and R_3. The output waveform's duty cycle, D_TC, follows the equation: $D_TC=(R_1+R_2+R_{VAR})/(R_1+2R_2+R_3+R_{POT})$, where R_{POT} is the potentiometer's end-to-end resistance, and R_{VAR} is the fraction of R_{POT} between the rotor and R_1. As the equation shows, D_TC depends linearly on R_{VAR}. Switch S_1 comprises one section of a 4066 CMOS quad bilateral SPST switch, IC_2.

You can use the circuit in **Figure 3** to evaluate duty-cycle linearity. A rotary switch and a tapped series string of 16-kΩ resistors provide a 10-kHz signal with nine discrete, equally spaced duty-cycle values ranging from 2 to 98%. For accurate results, use a 5½-digit multimeter to match the values of resistors R_4 through R_{11} and a Tektronix 3012 oscilloscope or equivalent to gather D_TC data.

Microsoft's (www.microsoft.com) Excel-spreadsheet software includes a linearity analysis that returns the following trend line for the duty-cycle measurements: $D_TC=0.7565\times R_{VAR}+2.1548$; $R^2=1$. The value of 1 for R^2 as Excel calculates shows that the transfer function is perfectly linear. Switch S_1's on-resistance and particularly its leakage current slightly affect the D_TC-versus-R_{VAR} equation's slope and intercept, but the equation remains strictly linear. Using only one of IC_2's four switches eliminates leakage effects and crosstalk that would occur if other circuits used the remaining switches. In addition, using moderately low values for the resistor network further reduces leakage-current effects on circuit performance. EDN