Keywords: single device, pulse-width modulation (PWM), waveform generator

APPLICATION NOTE 5718

Simple Solutions for a Single-Device Pulse-Width Modulation (PWM) Waveform Generator

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Abstract: Pulse-width modulation (PWM) generators are integrated in nearly every switching power device. The methods of implementing integrated PWM generators are well-known. This application note is prompted by a customer who asked for a single-device standalone analog PWM waveform generator.

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Pulse-width modulation (PWM) generators are integrated in nearly every switching power device. This article shows two methods for implementing a stand-alone analog PWM waveform generator. These designs can also be modified to make a dual-device PWM generator.

There are two ways to implement a single-device PWM waveform generator. One method uses an ICM7555 timer, while the other uses a MAX998 low-power comparator. We will look at each.

Method 1: Use a Low-Power Timer as a PWM Generator

In this method an ICM7555 timer is configured as in **Figure 1**.

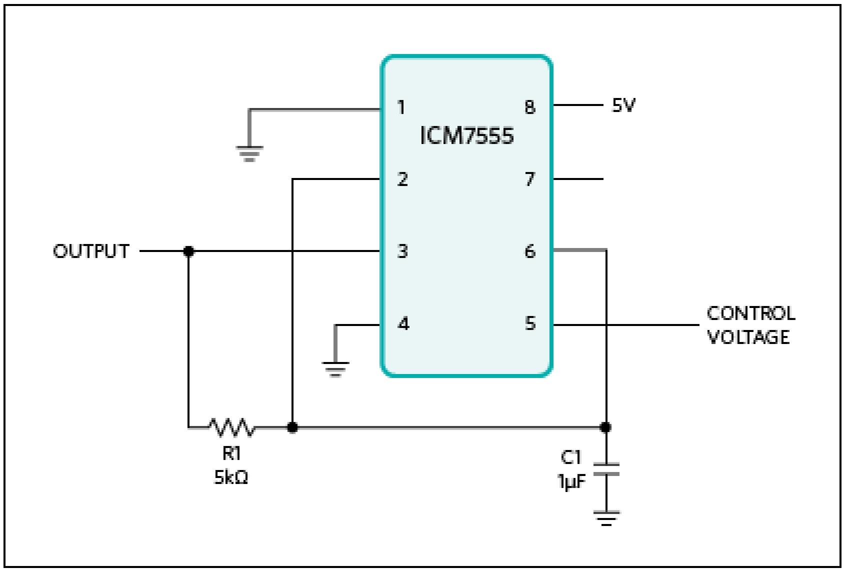

Figure 1. A PWM generator and timer for a single device.

In Figure 1 the pulse width of the output at Pin 3 is modulated by the control voltage ($V_{CONTROL}$) applied at Pin 5. Lab tests were done on the design with the power supply set at 5V. **Figures 2** through **5** show the PWM output at three different control voltages, 1V, 2V, and 4V. C1 is charged to $V_{CONTROL}$ by the supply voltage (V_{SUPPLY}) and discharged from $V_{CONTROL}/2$ to ground. When no external control voltage is applied, $V_{CONTROL}$ is at 2/3 of V_{SUPPLY}.

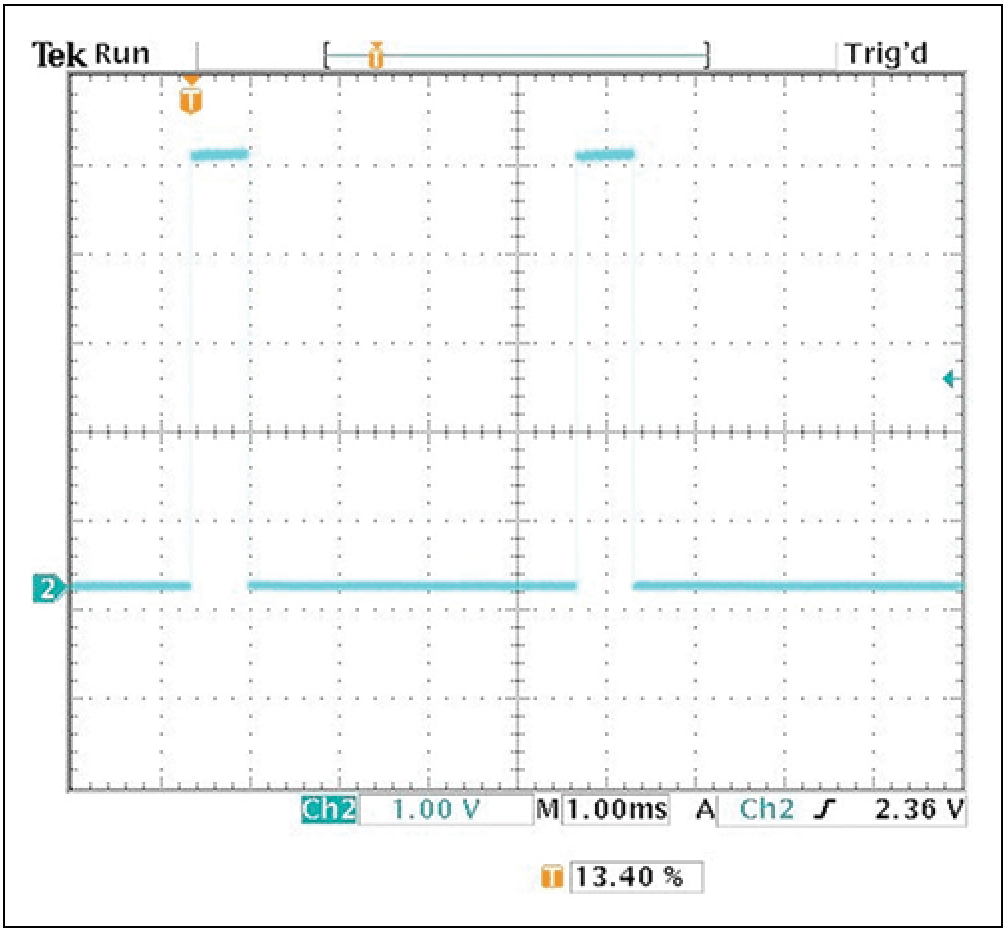

Figure 2. PWM output with control voltage = 1V.

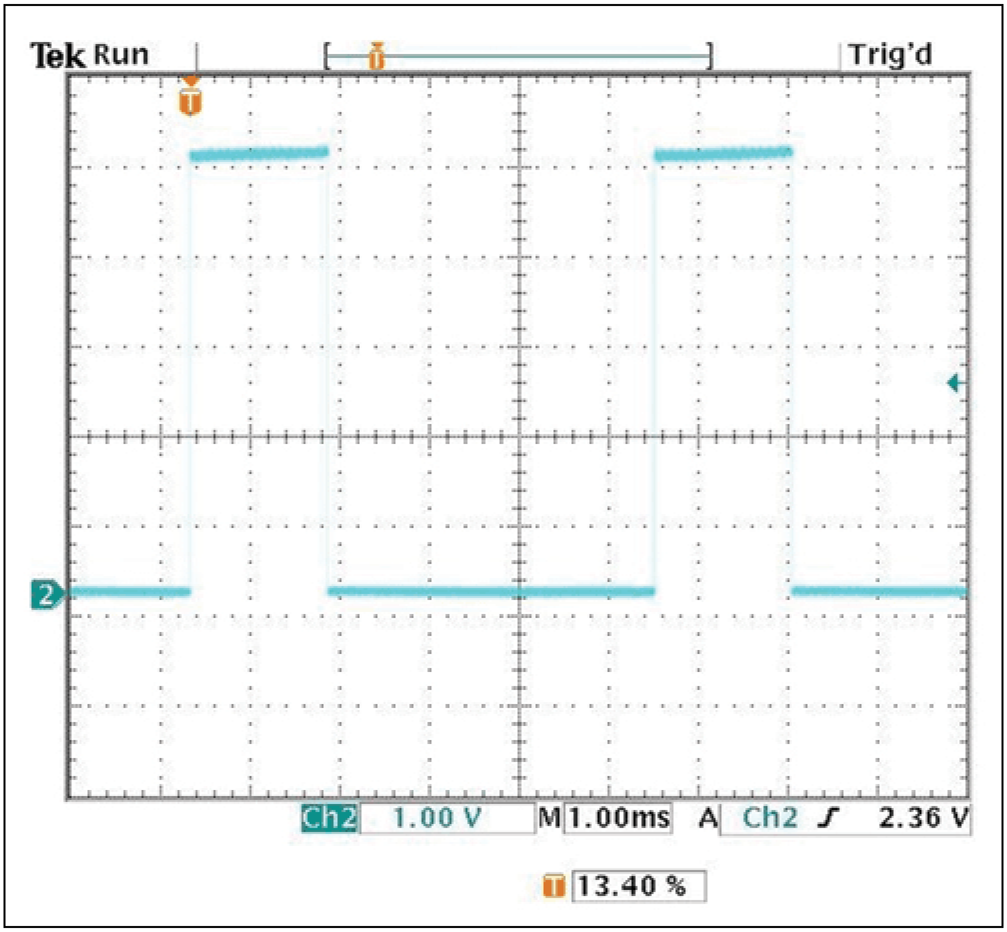

Figure 3. PWM output with control voltage = 2V.

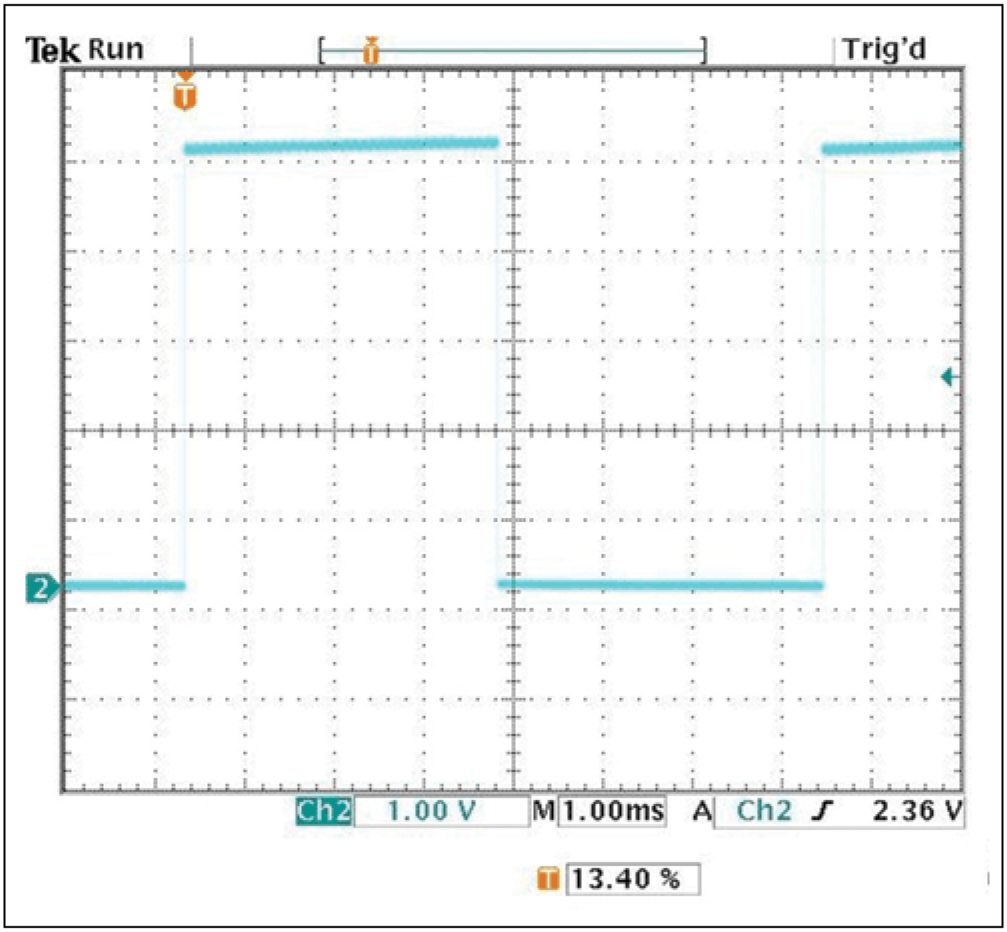

Figure 4. PWM output with no control voltage.

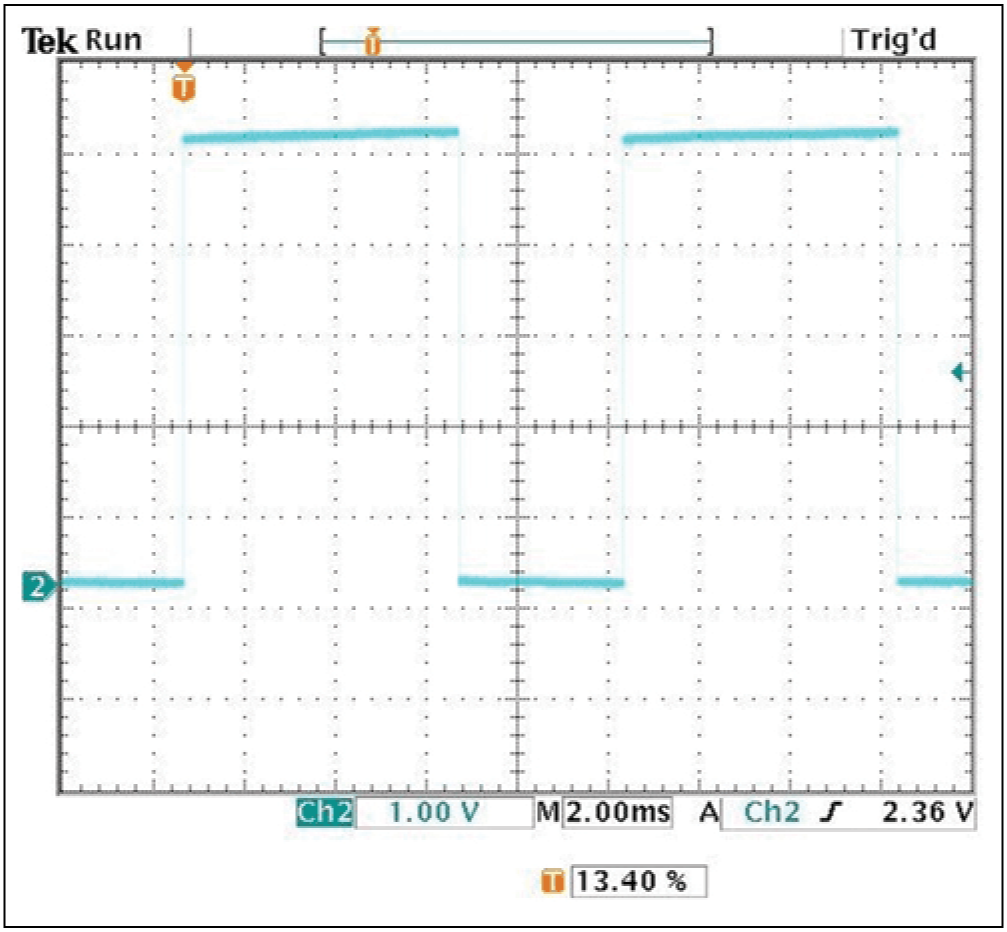

Figure 5. PWM output with control voltage = 4V.

The data illustrate how the control voltage applied at Pin 5 changes the threshold voltage of the two internal comparators. Without the applied control voltage (Figure 4), the device sets the charging and discharging of C1 at 1/3 and 2/3 of the supply voltage. This is equidistant from the supply voltage and ground, thus effecting a 50% duty cycle. The different control voltages change the charging time for C1 to reach $V_{CONTROL}$ and the discharging time for C1 to discharge to $V_{CONTROL}/2$. This process alters the pulse width of the output waveform.

The charging time is expressed as:

$$-t/RC = \ln [1 – (V_{CONTROL}/(2V_{SUPPLY} - V_{CONTROL}))]$$

The discharging time is expressed as:

$$-t/RC = \ln 0.5$$

where R = R1 and C = C1.

Method 2: A PWM Generator with Comparator

In this method a MAX998 comparator is configured as in **Figure 6**.

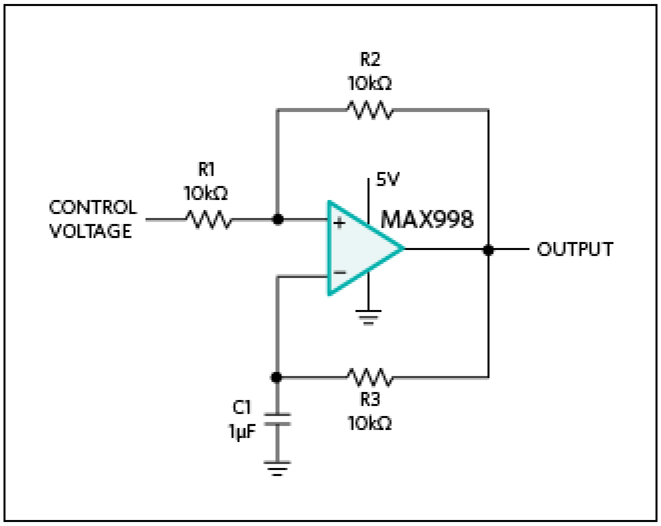

Figure 6. A PWM generator and comparator.

The pulse width of the output is modulated by the control voltage applied at R1. Lab tests were done with the power supply set at 5V. **Figures 7** through **9** show the PWM output of three different control voltages, 1V, 2V, and 3V.

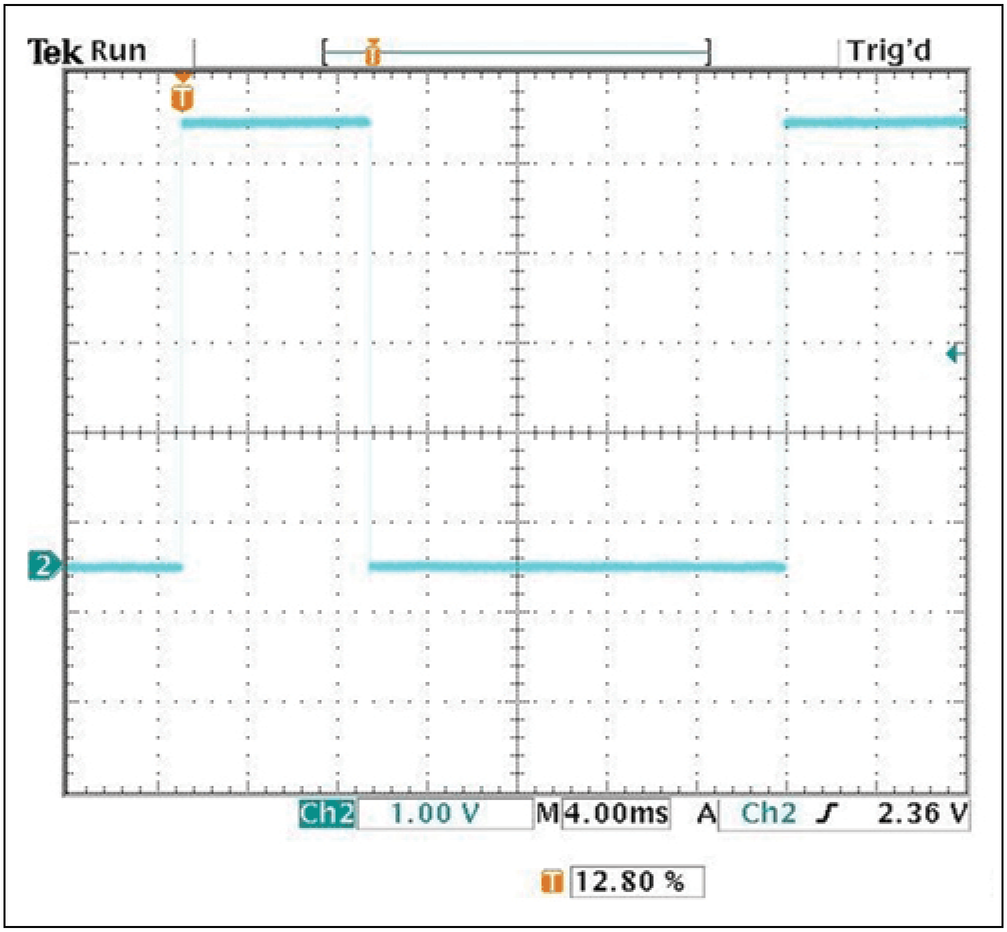

Figure 7. PWM output with control voltage = 1V.

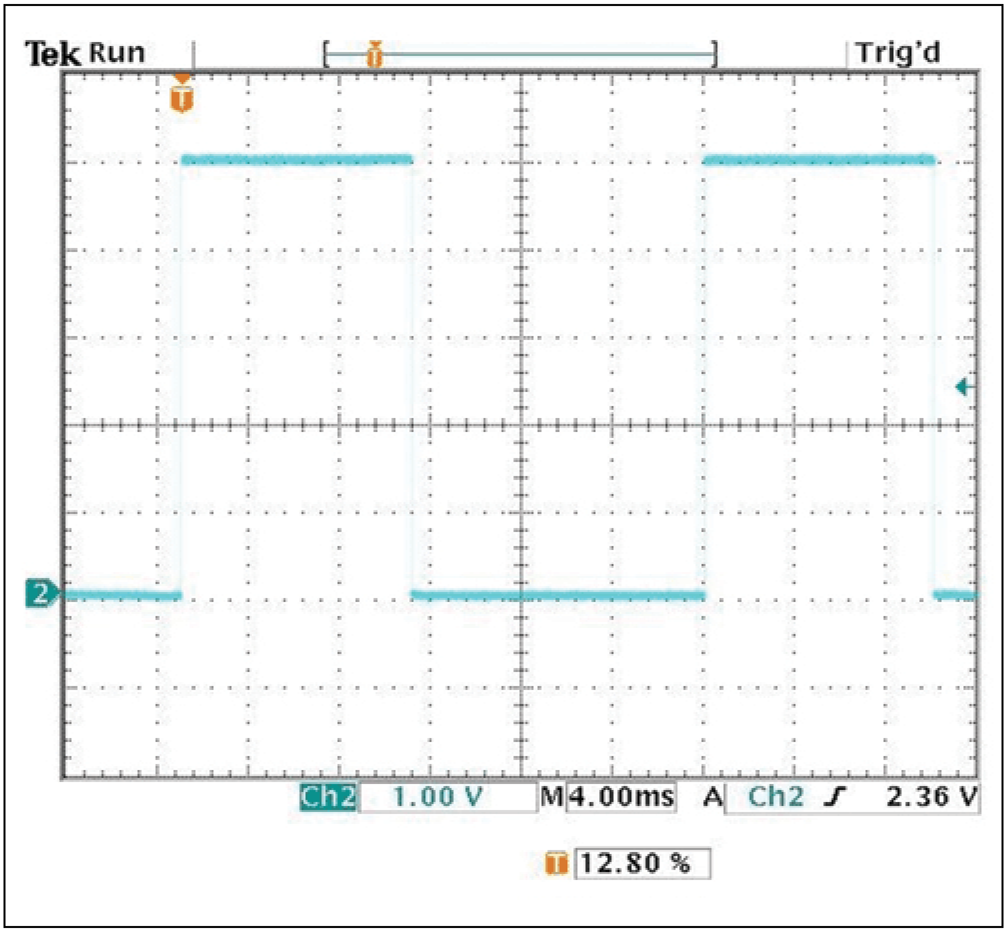

Figure 8. PWM output with control voltage = 2V.

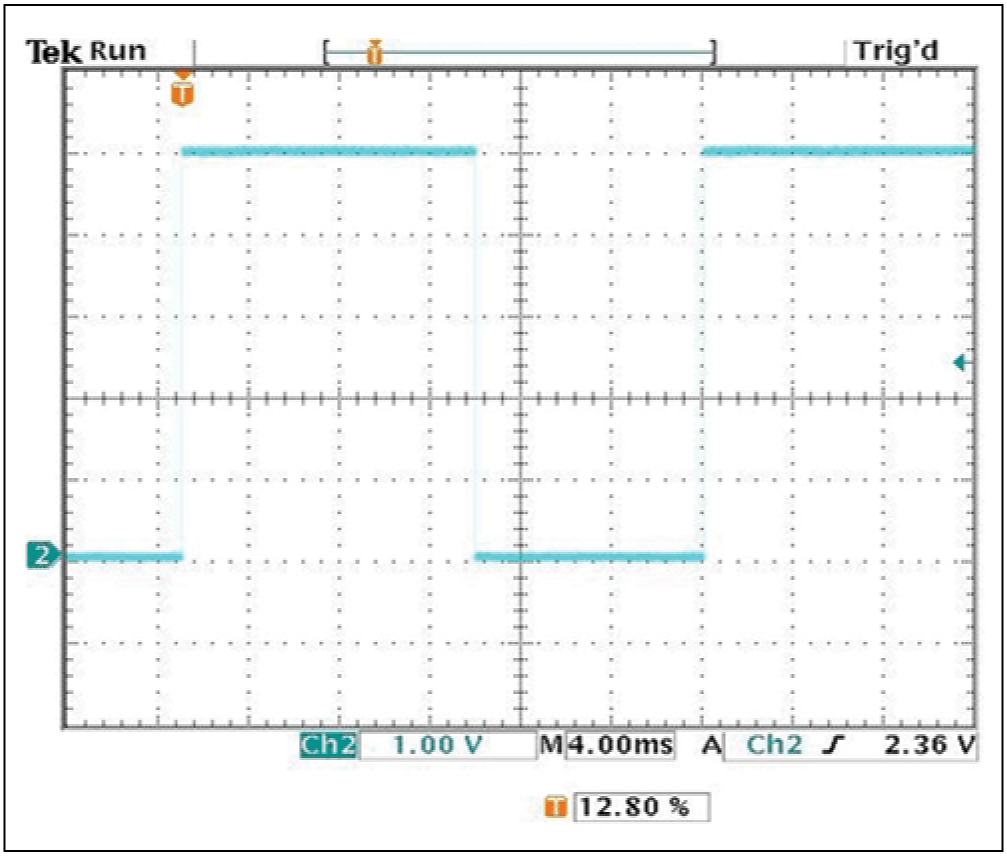

Figure 9. PWM output with control voltage = 3V.

The control voltage applied to the MAX998 sets the threshold voltages at which charging and discharging occur. The upper threshold voltage is $(V_{SUPPLY} - V_{CONTROL})/2 + V_{CONTROL}$ and the lower threshold voltage is $V_{CONTROL}/2$.

The charging time is expressed as:

$$-t/RC = \ln [1 - (V_{SUPPLY}/(2 \times V_{SUPPLY}) - V_{CONTROL}))]$$

The discharging time is expressed as:

$$-t/RC = \ln [1 - (V_{CONTROL}/(V_{SUPPLY} + V_{CONTROL})$$

where R = R1 and C = C1.

Modifications for a Dual-Device PWM Generator

It is important to note that the control voltage also changes the frequency in both circuit methods. Thus, an additional comparator to the circuits of Method 1 and Method 2 transforms each into a fixed-frequency, dual-device PWM generator.

For Method 1, feed the sawtooth signal at Pin 6 into an input of the second comparator. A voltage applied at the second comparator's input sets the duty cycle of the fixed-frequency output. Similarly for Method 2, feed the sawtooth signal at the MAX998's negative input into the input of the second comparator. A voltage applied at the second comparator's input sets the duty cycle of the fixed-frequency output.

Related Parts		
ICM7555	Low-Power, General-Purpose Timer	Free Samples
MAX998	Single/Dual/Quad, SOT23, Single-Supply, High-Speed, Low-Power Comparators	Free Samples

More Information
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