APPLICATION NOTE 5718

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

By: Budge Ing
Oct 25, 2013

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.

A similar version of this article appears on EDN, September 25, 2013.

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.
In Figure 1 the pulse width of the output at Pin 3 is modulated by the control voltage (V\text{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\text{CONTROL} by the supply voltage (V\text{SUPPLY}) and discharged from V\text{CONTROL}/2 to ground. When no external control voltage is applied, V\text{CONTROL} is at 2/3 of V\text{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:

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

The discharging time is expressed as:

$$-\frac{t}{RC} = \ln 0.5$$

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.

![Diagram of PWM generator and comparator](image)

*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.
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:

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

The discharging time is expressed as:

\[-t/RC = \ln \left(1 - \frac{V_{CONTROL}/(V_{SUPPLY} + V_{CONTROL})}{}\right)\]

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

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<td>Low-Power, General-Purpose Timer</td>
<td>Free Samples</td>
</tr>
<tr>
<td>MAX998</td>
<td>Single/Dual/Quad, SOT23, Single-Supply, High-Speed, Low-Power Comparators</td>
<td>Free Samples</td>
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APPLICATION NOTE 5718, AN5718, AN 5718, APP5718, Appnote5718, Appnote 5718
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