Twin-T power oscillators work as dc-biased ac sources

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AC test equipment often needs a low-distortion signal source to excite the device under test. The common practice is to use a signal generator to produce a low-distortion reference, which you feed to a power amplifier to drive the device under test. This Design Idea suggests a less cumbersome alternative.

Figure 1 shows an oscillator that generates a low-distortion sinusoidal signal with power-driving capability. The power oscillator consists of two major parts: a twin-T network and a high-power low-dropout regulator. The twin-T network has two T-type filters in parallel: one lowpass filter and one highpass filter. The twin-T network is highly frequency-selective as a notch filter. The low-dropout regulator amplifies the signal and drives the load. The regulator in this circuit incorporates a current-reference voltage-follower architecture. It is unity gain from the Set to the Out pins, and the current reference is a precision 10-μA current source. The R_{SET} resistor on the Set pin programs the output-dc level. By connecting a twin-T network between the Out and the Set pins, the resulting notch filter attenuates both high- and low-frequency content, allowing the center frequency to freely pass through. The resistors and capacitors program the center frequency, f_0: $f_0=1/(2\pi RC)$.

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Small-signal analysis of the twin-T network indicates that the gain is maximum at the center frequency. The twin-T oscillator's maximum gain increases from one to 1.1 when the K factor increases from two to five (**Fig-**

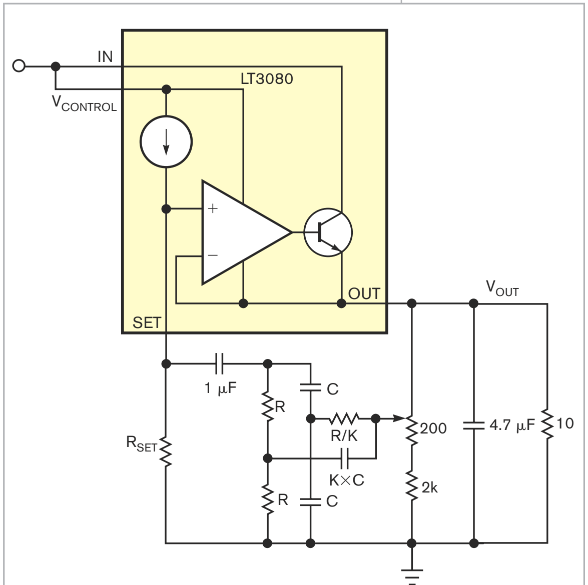

Figure 1 This oscillator generates a low-distortion sinusoidal signal with power-driving ability.

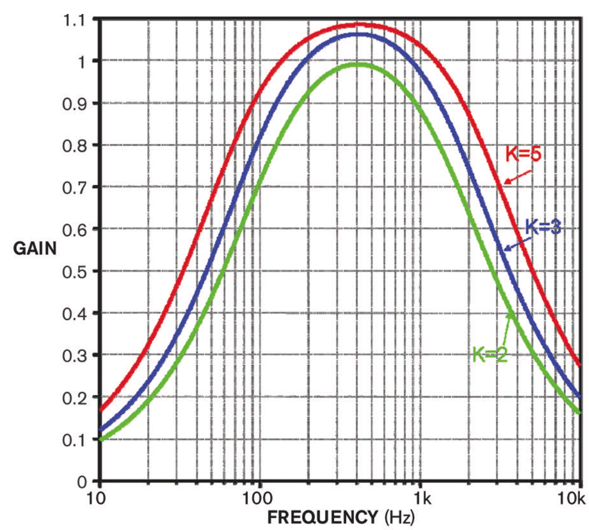

Figure 2 The twin-T network's gain changes with the value of K from Figure 1.

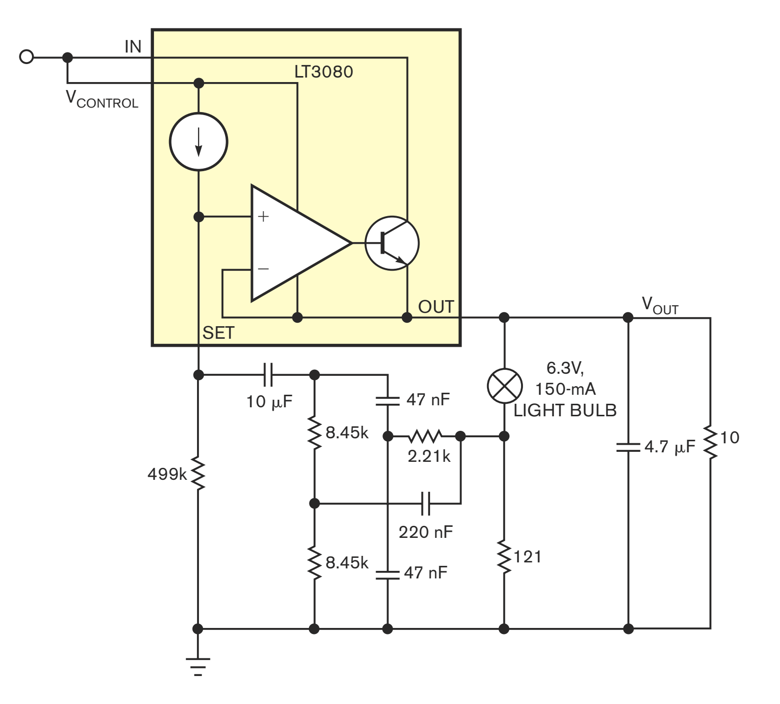

Figure 3 To automatically control the gain, you can replace the potentiometer with a light bulb.

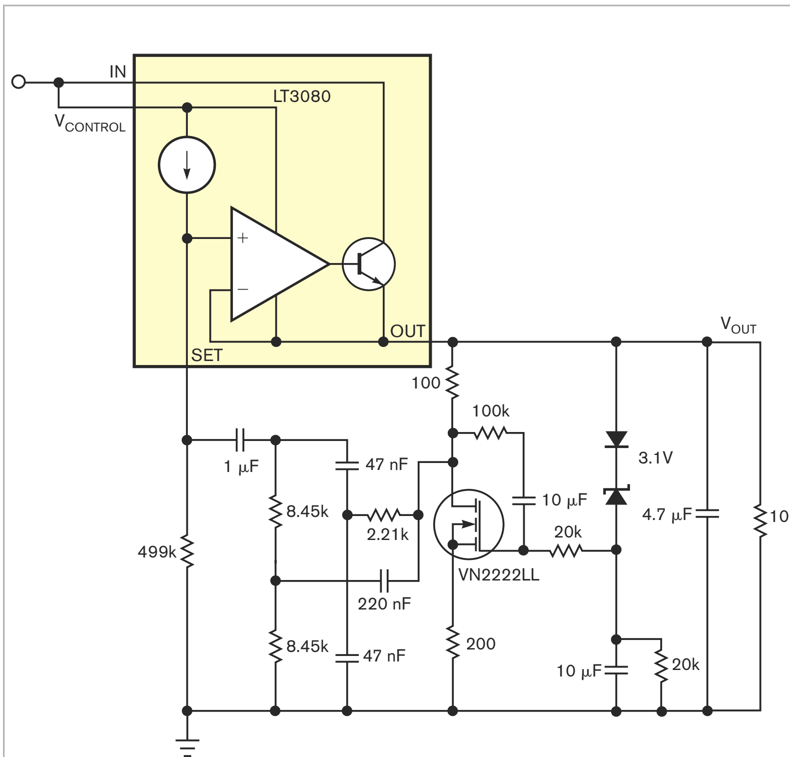

Figure 4 You can automatically control the gain by replacing the potentiometer with a variable-resistance MOSFET.

ure 2). The maximum gain decreases when the K factor is larger than five. Therefore, select a K factor of three to five for a gain larger than unity gain. The loop gain must be unity to maintain a steady oscillation. Thus, you need a potentiometer to tune the loop gain to control the oscillation amplitude.

The twin-T oscillator can drive inductive, capacitive, or resistive loads. The low-dropout regulator's current limit, which is 1.1A for the Linear Technology (www.linear.com) LT3080, is the only limit on the oscillator's drive capability. The load characteristics limit the maximum programmable frequency. For example, a 10Ω resistive load with a 4.7-µF output capacitor causes a 7% THD (total harmonic distortion) at a frequency higher than 8 kHz, although THD is 0.1% at 400 Hz in the circuit of **Figure 3**. The twin-T oscillator has the same performance in line and load regulation as the LT3080. It also works in a wide temperature range.

To automatically tune the gain, you can replace the potentiometer with a light bulb (**Figure 3**) or a voltage-modulated resistive MOSFET (**Figure 4**). The light bulb's resistance increases with the oscillation amplitude due to a self-heating effect, so it servos the loop gain to maintain the oscillation. In **Figure 4**, by detecting the peak voltage using a zener diode, the MOSFET resistance decreases when the oscillation amplitude is high. The loop gain also decreases to maintain the oscillation.

Figure 5 shows the test waveform of the twin-T oscillator using a light bulb. The output is tuned to a 4V-p-p voltage with 5V-dc bias voltage (**Figure 6**). The twin-T oscillator has a 400-Hz frequency and 0.1% THD. The most significant harmonic contribution is from the second harmonic at less than 4 mV p-p. **Figure 6** shows the test waveform of the twin-T oscillator using the MOSFET. The THD is 1% with a 40-mV-p-p second harmonic.

Start-up is another important aspect of the oscillator. Both circuits exhibit no low-frequency swing, which is common to other types of oscillators. The waveforms in **figures 7** and **8** exhibit little overshoot. The oscilla-

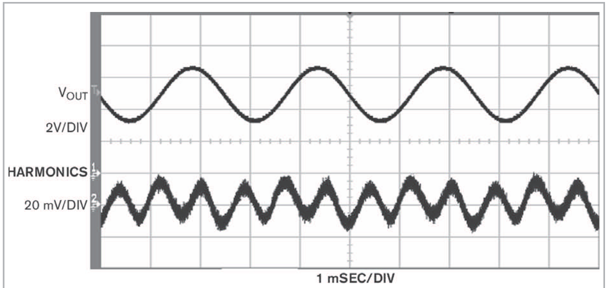

Figure 5 The test waveform for the oscillator in Figure 3 shows low distortion at a THD of 0.1%.

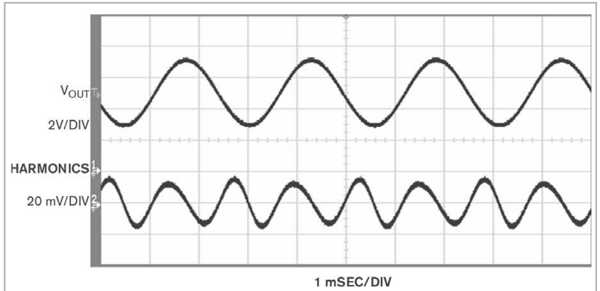

Figure 6 The test waveform for the oscillator in Figure 4 shows low distortion with a THD of 1%.

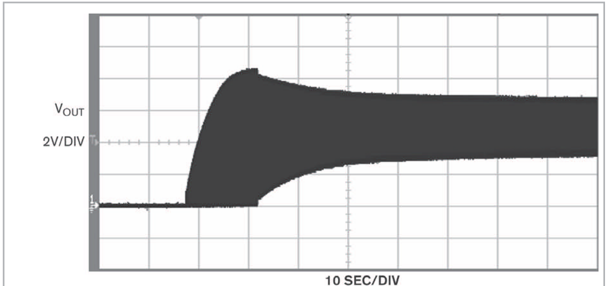

Figure 7 The waveform for the circuit in Figure 3 shows a slow start-up of the light-bulb oscillator.

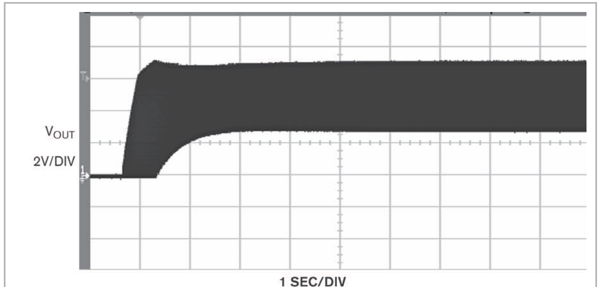

Figure 8 The waveform for the circuit in Figure 4 shows a quick start-up of the MOSFET oscillator.

tor using the MOSFET stabilizes faster than the one using the light bulb because the light bulb has a long thermal constant due to the heating effect. You can use the simple circuit as a dc-biased ac source in applications requiring low distortion and power-driving capability.EDN

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