DESIGN NOTES

# SOT-23 1kHz to 30MHz Oscillator with Single Resistor Frequency Set – Design Note 262

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The LTC®1799 resistor-programmed oscillator eliminates the hassle in designing an accurate square-wave frequency reference. A single resistor (R_{SET}) connected between the power supply and an input pin (SET) programs the frequency of a master oscillator to a value between 100kHz and 30MHz. An internal clock divider is programmed using a three-state input pin (DIV) to divide the master oscillator frequency by 1, 10 or 100 before driving the output. This extends the lower limit to 1kHz for a total range of 1kHz to 30MHz. The output frequency is linearly related to R_{SET}, as defined by the frequency-setting equation:

$$ f_{OSC} = 10\text{MHz} \bullet \left(\frac{10\text{k}\Omega}{N \bullet R_{SET}} \right), N = \begin{cases} 100, & \text{DIV} = V^+ \\ 10, & \text{DIV} = \text{Open} \\ 1, & \text{DIV} = \text{GND} \end{cases} $$

This simple and accurate relationship is achieved with a proprietary design that linearizes the resistance-to-frequency conversion, eliminating errors such as oscillator propagation delay.

Tiny Circuit, Big Performance

As shown in Figure 1, a complete oscillator requires only an LTC1799, a frequency-setting resistor and a bypass capacitor. The circuit's small component count and the LTC1799's diminutive SOT-23 package add up to big savings in PCB space when compared to oscillators built from crystals, ceramic resonators, 555 timers or discrete components.
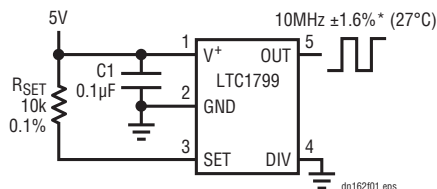
*INCLUDING ERROR CONTRIBUTION FROM RESISTOR

Figure 1. Complete Oscillator Solution

You don't pay a performance penalty for this miniaturization. The LTC1799 has a guaranteed frequency accuracy of ±1.5% (±0.5% typical) at room temperature. This spec applies over the entire 2.7V to 5.5V supply range, made possible by the stingy 0.05%/V typical drift over supply voltage.

The accuracy remains tight over temperature as well. The LTC1799C has a typical temperature drift of ±0.004%/°C, with guaranteed accuracy of ±2% over 0°C to 70°C (LTC1799I guaranteed accuracy is ±2.5% over −40°C to 85°C). Figure 2 shows the frequency output of the circuit in Figure 1 over the industrial temperature range for three typical parts.
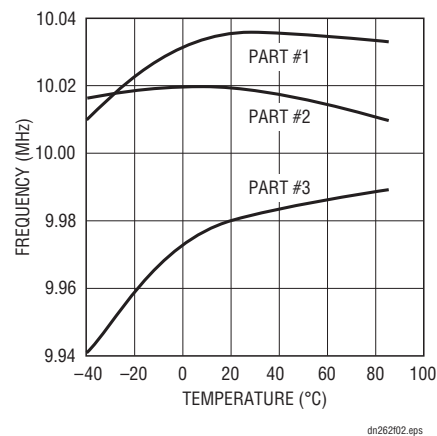
Figure 2. Frequency vs Temperature for Figure 1's Circuit

Due to its low sensitivity to supply and temperature variation, the LTC1799 has abilities that no other oscillator can match. Replacing R_{SET} with a potentiometer allows the output frequency to be "tuned" after the circuit is completed. Once set, the LTC1799 will accurately maintain the desired frequency over all operating conditions. Crystals and ceramic resonators cannot be adjusted in this manner; 555 timers and other RC oscillators do not have this level of stability.

Fast Start-Up Time

One common problem designers encounter with crystal oscillators is the long start-up time before the circuit is oscillating at its final frequency. At MHz frequencies, this start-up time is typically 10ms. At frequencies below 100kHz, a crystal oscillator may take up to a second to start up. The LTC1799 takes less than 1ms to settle within 1% of any frequency between 5kHz and 30MHz.

The LTC1799 is immune to vibration and acceleration forces, another problem that plagues crystal oscillators. And its 1mA typical supply current (2.4mA max at 10MHz, 5V supply) is very efficient when compared to the 10mA to 30mA many crystal oscillators consume.

Two-Step Design Process

The LTC1799 combines infinite frequency selectivity (limited only by resistor selection) with incredible ease-of-use. The external resistor R_{SET} determines the frequency of the master oscillator within a 100kHz to 30MHz range. The three-state DIV pin determines whether the master oscillator signal is passed directly to the output, or first divided by 10 or 100. The design process is simple:

1. Use Table 1 to determine the proper divider setting.

Table 1. Frequency Range vs Divider Setting

DIVIDER SETTING	DIV (Pin 4) CONNECTION	FREQUENCY RANGE
÷1 ($N = 1$)	GND (Pin 2)	>500kHz*
÷10 ($N = 10$)	Floating	50kHz to 1MHz
÷100 ($N = 100$)	VCC (Pin 1)	≤100kHz

* At frequencies above 10MHz ($R_{SET} < 10k$), the LTC1799 may suffer reduced accuracy on supplies less than 4V.

2. With N known, calculate the best value for R_{SET} using the equation:

$$R_{SET} = 10k \cdot \left(\frac{10MHz}{N \cdot f_{OSC}} \right)$$

It's that simple! Of course, since the LTC1799 converts resistance into frequency, any errors in the value of R_{SET} (due to resistor tolerance or nonideal choice of resistor value) reduce the frequency accuracy. Therefore, 1% or 0.1% resistors are recommended for best performance.

Application: Temperature-to-Frequency Converter

The most straightforward application for the LTC1799 is as a constant-frequency reference. But its resistance-to-frequency conversion architecture allows for a variety of applications. Figure 3 shows a temperature-to-frequency converter that is built by simply replacing R_{SET} with a thermistor. The YSI 44011 has a resistance of 100k at 25°C, 333k at 0°C and 16.3k at 70°C, a span that fits nicely into the LTC1799's permitted range for R_{SET}. With its low tempco and high linearity, the LTC1799 adds less than 0.5°C of error over the commercial temperature range. Figure 4 plots the output frequency vs temperature.
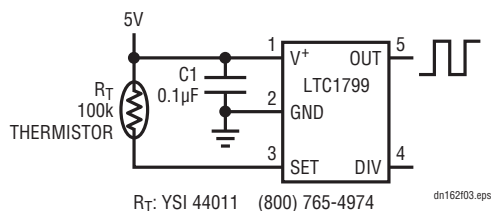

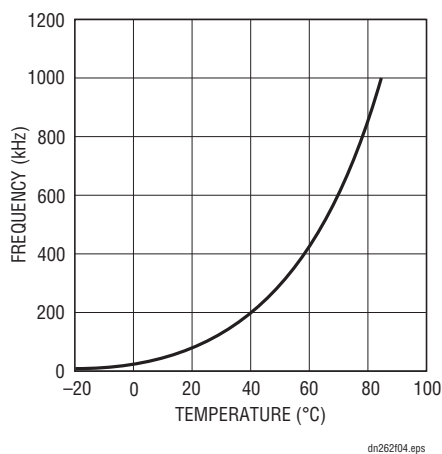**Figure 3. Temperature-to-Frequency Converter**

Figure 4. Output Frequency vs Temperature for Figure 3's Circuit

Conclusion

The LTC1799 is a tiny, accurate, easy-to-use oscillator that is programmed by a single resistor. With a typical accuracy of better than 0.5% and low temperature and supply sensitivity, the LTC1799's performance approaches that of crystal oscillators and ceramic resonators and yet requires far less PCB space. The resistance-to-frequency conversion architecture allows infinite resolution and design simplicity. The result is a square-wave oscillator with an unprecedented combination of ease-of-use and precision in a tiny SOT-23 package.

For applications help,
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