Bubba oscillator

The Bubba oscillator (Figure 9) is another phase-shift oscillator, but it takes advantage of the quad op amp package to yield some unique advantages. Four RC sections require 45° phase shift per section, so this oscillator has an excellent dϕ/dt to minimize frequency drift. The RC sections each contribute 45° phase shift, so taking outputs from alternate sections yields low-impedance quadrature outputs. When an output is taken from each op amp, the circuit delivers four 45° phase-shifted sine waves. The loop equation is:

$$A\beta = A\left(\frac{1}{RCs+1}\right)^4 \quad \textbf{(6)}$$

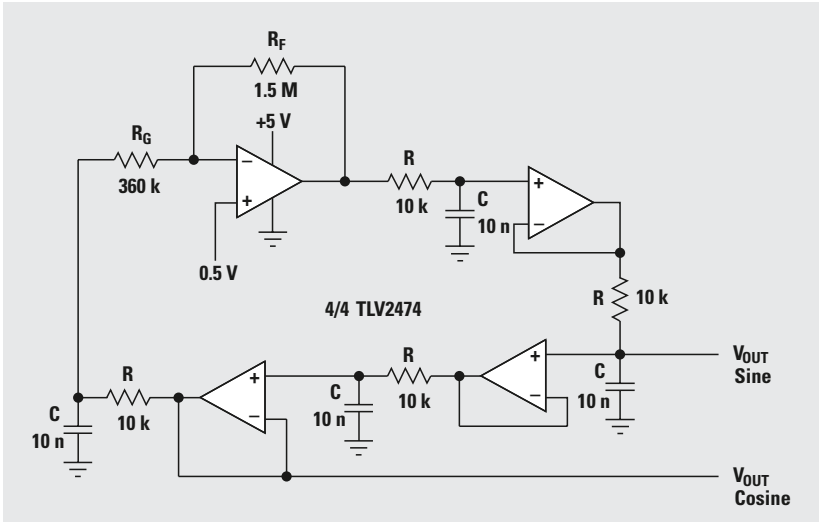
When ω = 1/RCs, Equation 6 reduces to Equations 7 and 8.

$$|\beta| = \left|\left(\frac{1}{1+j}\right)^4\right| = \frac{1}{\sqrt{2}^4} = \frac{1}{4} \quad \textbf{(7)}$$

$$\text{Phase} = \text{Tan}^{-1}\,1 = 45° \quad \textbf{(8)}$$

The gain, A, must equal 4 for oscillation to occur. The test circuit oscillated at 1.76 kHz rather than the ideal frequency 1.72 kHz when the gain was 4.17 rather than the ideal gain of 4. With low gain, A, and low bias current op amps, the gain setting resistor, R_G, does not load the last RC section thus insuring oscillator frequency accuracy. Very low-distortion sine waves can be obtained from the junction of R and R_G. When low-distortion sine waves are required at all outputs, the gain should be distributed between all the op amps. The non-inverting input of the gain op amp is biased at 0.5 V to set the quiescent output voltage at 2.5 V. Gain distribution requires biasing of the other op amps, but it has no effect on the oscillator frequency.

Figure 9. Bubba oscillator



Summary

Op amp oscillators are restricted to the lower end of the frequency spectrum because op amps do not have the required bandwidth to achieve low phase shift at high frequencies. The new current feedback op amps are very hard to use in oscillator circuits because they are sensitive to feedback capacitance. Voltage feedback op amps are limited to a few hundred kHz because they accumulate too much phase shift.

The Wien-bridge oscillator has few parts, and its frequency stability is good. Taming the distortion in a Wien-bridge oscillator is harder than getting the circuit to oscillate. The quadrature oscillator only requires two op amps, but it has high distortion. Phase-shift oscillators, especially the Bubba oscillator, have less distortion coupled with good frequency stability. The improved performance of the phase-shift oscillators comes at a cost of higher component count.

References

For more information related to this article, you can download an Acrobat Reader file at www-s.ti.com/sc/techlit/*litnumber* and replace *"litnumber"* with the **TI Lit. #** for the materials listed below.

Document Title	**TI Lit. #**
1. "Feedback Amplifier Analysis Tools"	.sloa017

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