EDN -- 11.10.94 Oscillator keeps THD below 1 ppm

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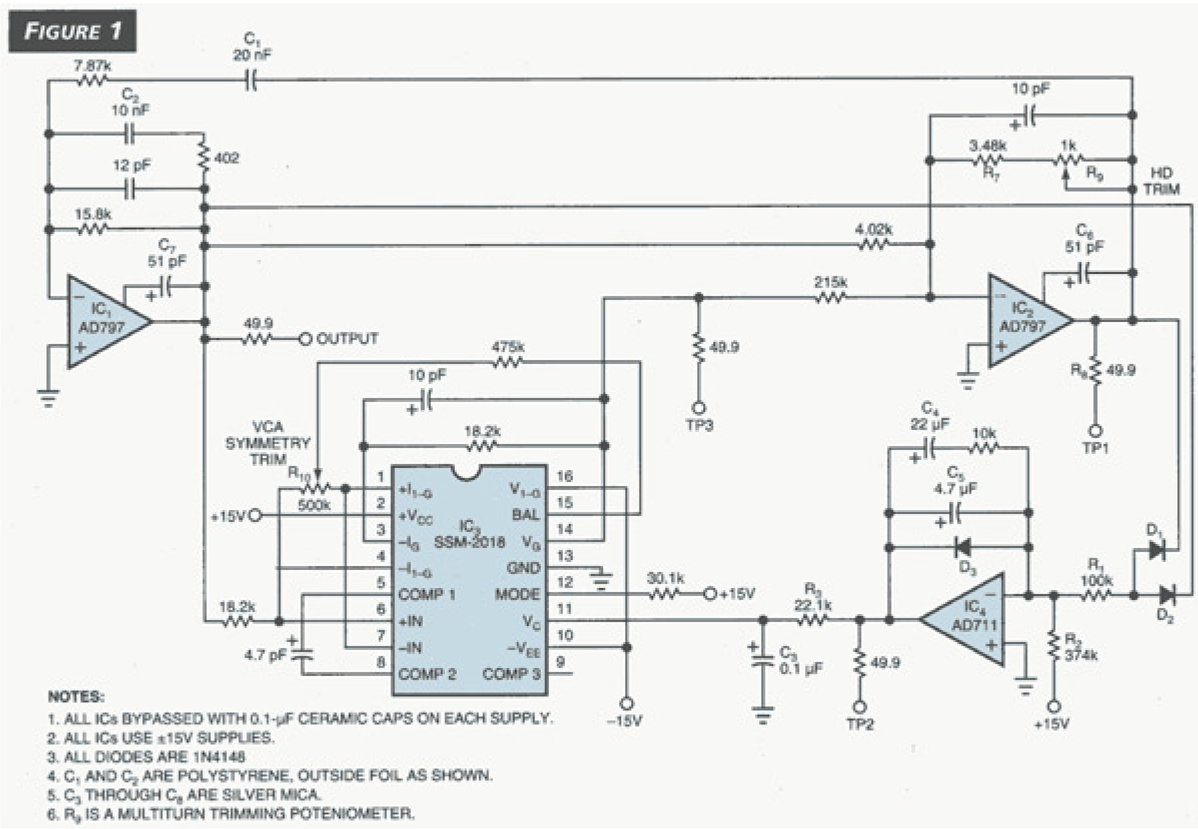
The Wien-bridge sine-wave oscillator uses a light bulb to stabilize its amplitude. The circuit in **Fig 1** doesn't have a light bulb; it sports several enhancements that lower its distortion and generate a test signal pure enough for testing modern op amps and high-resolution A/D converters.



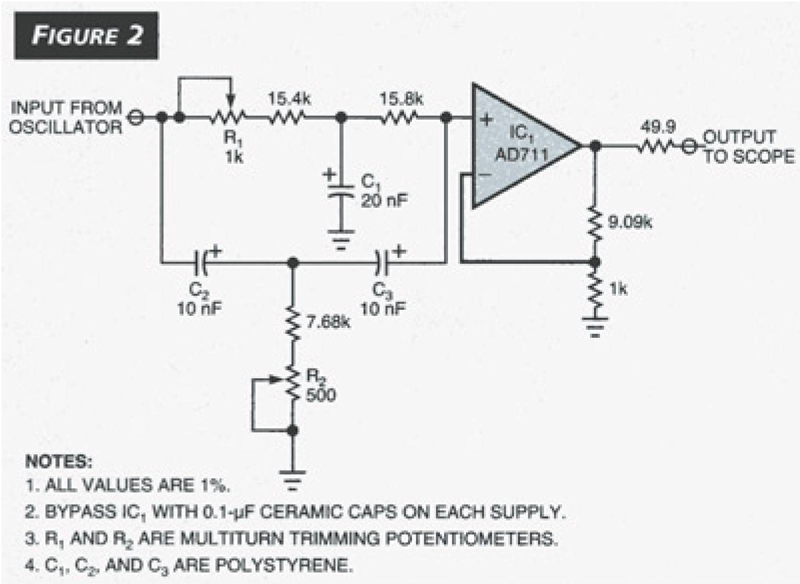
This Wien-bridge sine-wave oscillator sports several enhancements that lower its distortion and generate a test signal pure enough for testing modern op amps and high-resolution A/D converters.

IC_1 and associated components form the Wien-bridge and function as a bandpass filter. IC_1's output goes to the voltage-controlled amplifier (VCA), IC_3. IC_3 acts as a "smart resistor" whose value the circuit continuously adjusts via IC_4. IC_2 adds the outputs of IC_1 and the VCA and feeds the result into the bridge. These two op-amp inverters eliminate any common-mode signal that might limit performance.

The circuit's AGC loop begins with diodes D_1 and D_2. These diodes half-wave rectify the outputs of IC_1 and IC_2. These outputs are 180° out of phase; so IC_4 sees a full-wave rectified signal through R_1

that is proportional to the output signal's amplitude.

Integrator IC_4 compares the average value of the rectified current to a constant current through R_2. Any imbalance in these currents causes IC_4 to output a correction signal, changing the gain of VCA IC_3. The VCA's gain adjusts the oscillation's amplitude until IC_4's input currents are equal. R_3 and C_3 further filter the correction signal to remove harmonic components that would manifest themselves as distortion at the circuit's output. D_3 minimizes damage to C_4 and C_7 in the event of reverse polarization.



Because the large ratio of output signal to distortion and noise floor makes verifying the performance of the circuit in Fig 1 difficult, you need this tunable, buffered-output, twin-T filter, which reduces the fundamental (1 kHz) in the output by 70 dB.

The ac performance of C_1 and C_2 is critical to this design. I recommend polystyrene or polypropylene film types; and make sure you connect the outside plate as **Fig 1** indicates. Mylar capacitors can degrade the circuit's performance by 6 dB. C_5 and C_6 are peculiar to IC_1 and IC_2. They eliminate distortion arising from V_{BE} nonlinearities in the op amps' output stages.

The large ratio of output signal to distortion and noise floor makes verifying the performance of this circuit with standard test equipment difficult. Therefore, I used the tunable, buffered-output, twin-T filter in **Fig 2** to reduce the fundamental (1 kHz) in the output by 70 dB. Spectral analysis of the filter's output permits calculation of THD.

When properly tuned, the filter reduces the second and third harmonics by about 10 and 5 dB, respectively. Harmonic-distortion calculations must take this reduction into account. Harmonic-distortion calculations must factor in the gain of IC_1 (**Fig 2**). Be sure to use the same high-performance capacitors used for C_1 and C_2 in **Fig 1** for C_1, C_2, and C_3 in **Fig 2**.

To tune the filter:

- Adjust R_9 so that R_7 shorts to R_8.
- Monitor TP3 on an oscilloscope and adjust R_{27} for a visually undistorted sine wave.
- Using the filter, adjust R_{10} for a minimum second-harmonic distortion at TP3.

Note: You may need to make small adjustments to R_9 for successful power up. (DI #1617)
