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APPLICATION NOTE 5420

Total Harmonic Distortion (THD) Test Circuit Eliminates the Need for External Filters

By: Ken Mendez
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Abstract: This application note presents a total harmonic distortion (THD) test circuit that uses active noise amplification to eliminate the need for expensive and often ineffective external filters. The circuit also enables the measurement of THD at several orders of magnitude below the resolution of the test fixture being used.

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Measuring the low-frequency (below 100kHz) total harmonic distortion (THD) of cutting-edge amplifiers presents several problems. The most difficult issue arises when the amplifiers are designed with a THD rating that is much lower than most test equipment. This problem has typically forced engineers to design with expensive and generally ineffective external filters and to use high-end test fixtures.

There is an alternative approach. The test circuit in this design uses active noise amplification to eliminate the need for external filters. This approach allows the test engineer to measure THD at several orders of magnitude smaller than the resolution of the test fixture being used.

Current THD test circuits attempt to use passive amplification techniques to force the device under test (DUT) to correct itself. This approach can generate considerable error by terminating the distortion signal with small resistive loads. However, the preferred way to generate accurate data is to isolate the DUT and measure it using a high-impedance buffer. This method requires active amplification of the distortion at the amplifier's output. The circuit in **Figure 1** employs a secondary operational amplifier for the gain stage to enable active amplification.

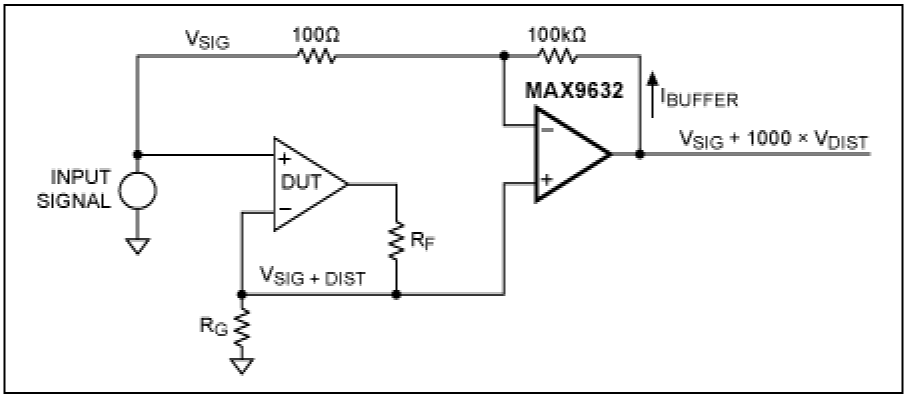

Figure 1. THD test circuit uses the MAX9632 wideband op amp.

A reliable signal source with a fairly low THD (at least -70dB) should be used for the input signal to the DUT. Most spectrum analyzer sources operate in this range. The input source will be distorted before it reaches the DUT, because the signal source is not perfect. Nonetheless, this distortion will be negligible if a low-THD source is used. The input signal is fed through the DUT, which distorts the signal.

The output from the DUT is now a combination of the input signal and the distortion from the DUT (SIG + DIST) multiplied by the gain of the setup. The DUT can be gained and loaded according to its specification in the data sheet. This signal at the DUT's negative terminal is SIG + DIST without the gain. This signal is connected to the positive input of the secondary amplifier.

The output signal of the circuit is calculated as:

$$I_{BUFFER} = \frac{V_{SIG} - V_{SIG + DIST}}{100\Omega}$$

$$V_{OUT} = I_{BUFFER} \times 100k\Omega + V_{SIG} = V_{DIST} \times 1000 + V_{SIG}$$

The secondary amp is set up in a large (1000V/V) gain. However, instead of terminating the gain setting resistor to ground, it is terminated to SIG. This allows amplification of the distortion (DIST), but not the input signal. Consequently, the DUT's output, when referenced to ground, is the original input signal plus the secondary gain times the output distortion of the DUT.

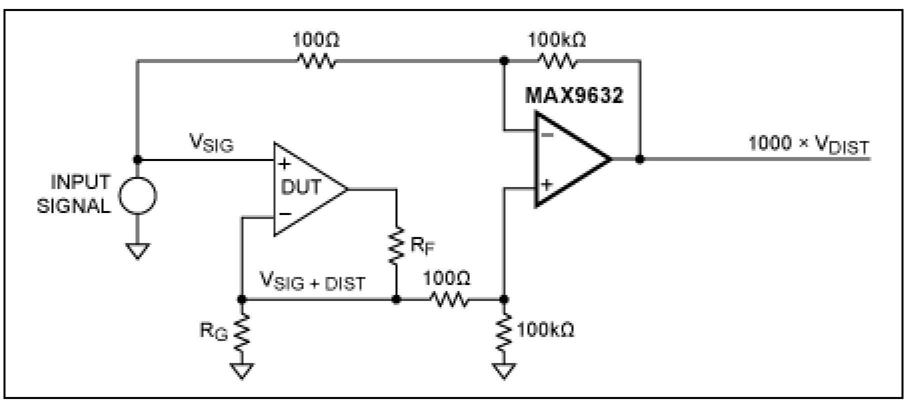

Figure 2. This THD circuit uses a differential output to eliminate the principal harmonic.

If a direct measurement of the harmonics is desired, a differential amplifier configuration on the buffer amplifier will eliminate a large amount of the principal input signal (**Figure 2**). Some amount of the signal will still reach the output because of the buffer amplifier circuit's CMRR, however, that signal will be reduced so that it does not affect the measurement of the amplified distortion.

The output of the differential circuit is calculated using superposition:

$$V_{OUT\_TOTAL} = V_{OUT\_SIG} + V_{OUT\_SIG + DIST}$$

$$V_{OUT\_SIG} = -V_{SIG} \times \frac{100k\Omega}{100\Omega}$$

$$V_{OUT\_SIG + DIST} = \left[V_{SIG + DIST} \times \frac{100k\Omega}{100\Omega + 100k\Omega}\right]\left(1 + \frac{100k\Omega}{100\Omega}\right) = V_{SIG + DIST} \times \frac{100k\Omega}{100\Omega}$$

$$V_{OUT\_TOTAL} = V_{SIG + DIST} \times \frac{100k\Omega}{100\Omega} - V_{SIG} \times \frac{100k\Omega}{100\Omega} = V_{DIST} \times 1000$$

The circuit in Figure 2 makes any minor distortion on the input signal irrelevant, because it is measuring the difference between the output and input of the DUT. Any distortion on the input is removed from the secondary gain stage. Any signal taken from the IC is done using a high-impedance input to a buffer amplifier. This circuit also offers an added benefit: it can set up the DUT in any noninverting configuration and is easily edited to accommodate inverting conditions (**Figure 3**).

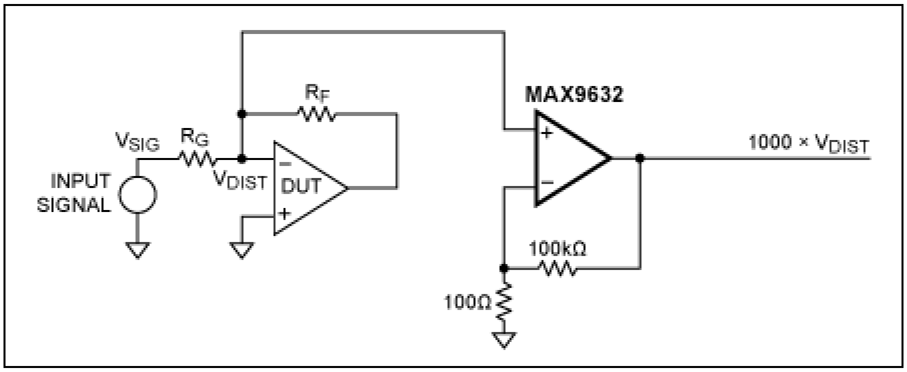

Figure 3.The THD circuit in an inverting configuration.

Related Parts		
MAX9632	36V, Precision, Low-Noise, Wide-Band Amplifier	Free Samples

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