ANAND BASAWAPATNA
Director, Operations and Marketing
Pronghorn Solutions

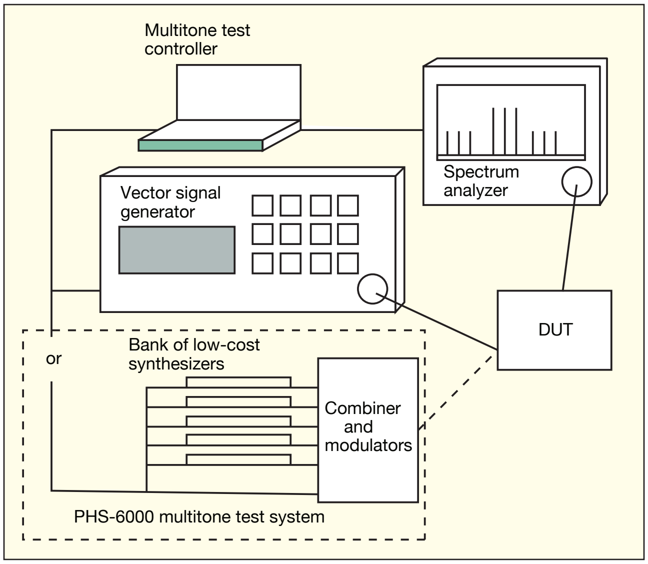
GANESH R. BASAWAPATNA
Chief Technical Officer

P.O. Box 3316, Englewood, CO 80155; (720) 808-9832,
e-mail: sales@pronghorn-solutions.com, www.pronghorn-solutions.com.

Create Cost-Effective Multitone Test Signals

Generating the multiple-tone signals needed for system and component linearity testing does not require a full-sized rack of high-priced RF/microwave instrumentation.

MODERN APPETITES for increased information from wireless devices has driven the complexity of communications modulation formats, as well as the complexity of the signal sources needed to test those communications systems. Advanced modulation formats often cannot tolerate linearity shortcomings of components in those systems, often visible as unwanted intermodulation distortion (IMD). Testing active and some passive components for susceptibility to IMD usually requires multitone test signals, which can be expensive. Fortunately, a host of new, compact, signal generators have made it easier to create the signals needed for multitone RF/microwave testing.

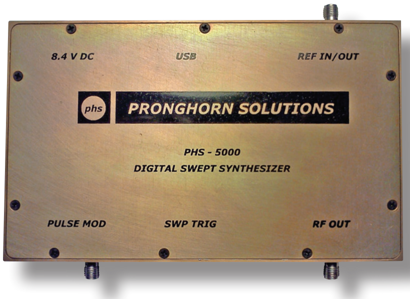


1. Two possible approaches for producing multitone test signals are the vector signal generator and multiple modular frequency synthesizers.

Multitone testing **(Fig. 1)** is usually required in every terrestrial and satellite-communications (satcom) application. Multitone test signals are created by combining two or more single-frequency signals according to a frequency plan. For broadband component testing, multitone signals may cover an octave or more and may be performed with fixed test tones or on a swept-frequency basis. When considering different options for generating multitone test signals, it can be helpful to understand how they can differ and how to compare different multitone signal sources. First and foremost, multitone test signals must be high quality, with well-behaved spectral characteristics in terms of harmonics, spurious, and phase noise. For example, the relative phase between different tones can influence the IMD produced by a device under test (DUT). When a DUT, such as a high-gain amplifier, is known to have this sensitivity to test-signal phase, the resulting IMD may need to be measured not only as a function of frequency spacing between the tones but also by the phase differences between tones. Amplitude differences between the tones can also affect measured IMD results, so that signal sources for multitone testing should be stable in terms of frequency, phase, and amplitude.

The two traditional methods for generating multitone signals are vector signal generators (VSGs) and multiple combined signal generators. These are shown in **Fig. 1**, where either acts as the input to the DUT and the output is monitored on a spectrum analyzer. Multitone test signals are traditionally produced by combining the outputs of separate test sources; depending upon the cost of each source, however, this can be an expensive solution. Multitone test signals can be represented as time functions of multiple sinusoidal signals. In the case of n sinusoidal signals with associated voltages of V_1, V_2, V_3 to V_4, the total voltage waveform, $V_i(t)$ as a periodic function of time can be written as:

$$V_i(t) = V_1 \sin(\omega_i t) + \varphi_i + V_2 \sin(\omega_2 t) + \varphi_2 + V_3 \sin(\omega_3 t) + \varphi_3 + V_n \sin(\omega_n t) + \varphi_n$$



2. By adding modular synthesized sources, multitone test signals of any required complexity can be created by adding more sources.

where:
ω_1, ω_2, ω_3, and ω_n are the frequencies ($2\pi f$) and φ_1, φ_2, φ_3, and φ_n, are the phases of the n signals. The combined multitone signal is fed to the input of the DUT, with its outputs monitored on a spectrum analyzer as shown in **Fig. 1**, and the results are fed back to the controller for analysis.

VSGs produce multitone signals by modulating a single synthesized carrier frequency with a complex waveform to create the desired multitone output. But the approach has its limitations: a VSG that can create two tones as much as 80 MHz apart can only create as many as 16 tones that are each 5 MHz apart. And if the VSG provides +10-dBm output power, the most power per tone for an eight-tone test signal will be less than +2 dBm. The capability to control individual signal phases and amplitudes with a VSG is also limited.

3. Battery-powered multitone signal sources can simplify on-site testing.

Fortunately, with cost-effective programmable broadband synthesizers such as the PHS-5000 from Pronghorn Solutions (www.pronghorn-solutions.com; **Fig. 2**), it is now possible to create practical multitone test signals. At a fraction of the cost of a VSG—with each synthesizer measuring only 6 x 3 x 0.5 in., weighing less than 1.5 lbs, and consuming less than 5 W power, and with IVI and other standard programmability functions—the multiple synthesizer multitone method overcomes the limitations of the VSG approach.

To select a multitone test source, it is necessary to specify the number of tones required, the frequency range of each tone, the power range and level accuracy of each tone, the frequency accuracy and spectral purity, any phase adjustment requirements, and any modulation requirements. Small size, light weight, and low power consumption are often important, especially for on-site applications where battery operation is often desirable.

This "new generation" of low-cost signal generators can be combined for multitone testing, and including compact, battery-powered units such as the PHS-4000 signal generator. This handheld signal source **(Fig. 3)** offers a fundamental frequency range of 150 MHz to 9 GHz that can be extended to 50 MHz to 18 GHz. Multiple PHS-4000 generators can be combined for multitone testing, and each unit runs about four hours on a rechargeable battery for on-site testing. MWRF