THREE-TONE NONLINEARITY TESTING - THE INTERMODULATION COEFFICIENT, M

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In many cases single tone and two-tone testing of nonlinear devices yield sufficient information for the systems designer. Additional diagnostics can be obtained from three-tone testing.

Test frequencies A, B, C will provide dominant intermodulation (IM) products of the type A-B+C. A particularly useful choice of three frequencies is to fix two of the frequencies (A and C) at the edges of the frequency band and sweep the third frequency with all input amplitudes held equal. The variation in level of the A-B+C type product, as frequency B is swept, gives diagnostic information useful in modelling the device.

A third order IM coefficient may be defined (in dB notation)

$$M_{A-B+C} = P_{A-B+C} - (P_A+P_B+P_C)$$

where P_x is the measured output power in dBm at frequency x. For a third order device M_{A-B+C} is a constant. A plot of M_{A-B+C} versus P_A will show the dynamic range over which the third order power series approximation is valid. Deviations from a constant coefficient value are more noticeable than deviations from a prescribed slope from the output IM power versus input power plot (as in the intercept point measurement).

Other useful benefits of the three-tone test exist. The three-tone amplitude distribution is a better approximation to a Gaussian load than a smaller number of tones. Also, the A-B+C type product is 6 dB higher than the 2A-B type third order products and, for a noise like frequency spectrum, the ratio of the number of A-B+C type products to the number of 2A-B products is $\frac{1}{2}(N-2)$ (where N is the number of tones); therefore, the A-B+C type product is the dominant IM noise for a noise like signal. Device characteristics determined by measuring 2A-B only could thus be misleading.

Noise Loading of FM Systems
The Noise-Power-Ratio (NPR) and Customer Requirements

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Amplitude and phase non-linearities in multichannel FM transmission systems must be closely controlled to avoid excessive intermodulation noise in the derived message channels. Though parameters may be measured individually, their combined effect on distortion performance is most directly measured by applying a standard test signal to the FM system which closely simulates the working multichannel baseband signal. For high capacity systems, this baseband signal is closely approximated by a band of Gaussian (white) noise, band-limited at the same frequencies as the working baseband.

In multichannel telephony, both the number of trunks in use at any given moment and the rms power contributed by each busy trunk have a statistical variation. For this reason, the 'standard' white noise test signal is arranged to have a flat power density spectrum whose total rms power will be exceeded by the actual multichannel signal for only a small percentage of the time. The generally accepted test signal powers for different capacity systems are given. Distortion performance of the FM system is then evaluated by inserting a number of slots or 'dark' bands at several frequencies across the spectrum of the white noise test signal. A noise receiver, tuned to one of these slots and connected to the output of the FM system, encounters similar distortion conditions as would an idle message channel in a group of occupied channels.

This distortion performance is often measured as a Noise Power Ratio, the ratio between the noise power observed in the narrow band noise receiver with and without the transmitting slot filter. Direct conversion of this ratio into conventional noise performance units is easily made.

The main type of transmission non-linearity causing a poor NPR performance can usually be determined from the slot position showing the greatest degradation. In addition, the system's vulnerability to overload modulation can easily be determined by increasing the standard test signal power by fixed steps until the NPR shows a rapid deterioration.