FM BROADCAST MEASUREMENTS USING THE SPECTRUM ANALYZER

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Cover photo courtesy of KPAM, AM and FM, Portland, Oregon

I. Introduction: The Stereophonic Spectrum

This application note explains how to use and interpret spectrum analysis of the **fm** stereo system.

The **fm** system approved for use by the FCC in the U. S. uses a complex modulation system to achieve a compatible mono/stereo system of broadcasting. In a simple monaural system, the **fm** channel is frequency modulated ± 75 kHz with the audio information. To achieve a compatible system, when stereo is transmitted, the same monaural (left plus right channel combined) remains in the 0 to 15 kHz position of the transmitted frequency spectrum. This monaural signal, however, cannot be modulated ± 75 kHz, since it would occupy the total frequency spectrum available for an **fm** station. Instead, the monaural signal is modulated only 45%, average. The second component of a stereo transmission is the pilot carrier at 19 kHz. This 19 kHz pilot carrier modulates the **fm** channel 8 to 10%. On a monaural station receiver, the pilot would not be heard at 19 kHz, since it is beyond the normal human hearing limit. In an **fm** stereo receiver, the pilot carrier signals that the transmission is stereo (sometimes lighting an indicator). The third part of the stereo transmission is the sub-channel which is a double sideband suppressed carrier signal (DSSC). This subcarrier is a left-subtracted-from-right (L-R) signal, which, when fed through a matrix with the monaural main channel in the receiver, forms the individual left and right channels. The 38 kHz channel is transmitted without a carrier (suppressed carrier). The 38 kHz carrier is obtained in the receiver from the 19 kHz pilot and reinserted on the sub-channel prior to detection. The sub-channel is modulated 45%, so that the total modulation for an **fm** stereo station is main channel 45%, pilot carrier 10%, and sub-channel 45%. The total is 100%. The only other possible signal in the modern station is an SCA usually used for background music. This is an extra audio channel carried at 67 kHz and is generally modulated 10% in a stereo station. Since the total modulation cannot be over 100%, stereo stations with an SCA reduce the main and sub-channel modulations to 40% each.

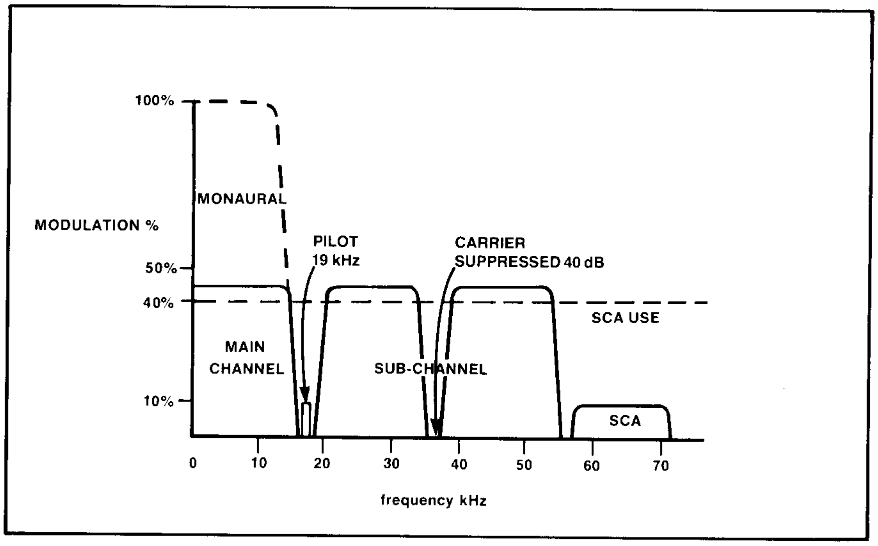


Fig. 1. The Composite **Fm** Stereo Spectrum

This combination then gives main channel 40%, pilot 10%, sub-channel 40%, and SCA 10%. The total is 100%. An audio spectrum analyzer can be used to show all these components and their relative levels and interactions. The signals can be checked at the composite output of the stereo generator. The theoretical channel occupancy is shown in *figure 1.*

A theoretical diagram of an **fm** stereo generator is shown in *figure 2.* Both the left and right channels are pre-emphasized just as a normal monaural signal would be. Then the left and right signals are both added and subtracted in a matrix. The channels added (L+R) form a monaural signal. This is the main channel. The subtracted channels (L-R) are modulated on a 38 kHz carrier, to form the sub-channel. Since a balanced modulator is used, the carrier at 38 kHz will be suppressed, leaving only the modulated audio information. The 38 kHz oscillator is divided by 2 to make the 19 kHz pilot. The three signals: main channel, sub-channel, and pilot are combined in the proper ratios (45, 45, 10%) forming the composite output.

In an actual **fm** facility, a slightly different type of stereo generator is used which produces the same result as the theoretical generator by using a switching technique. After pre-emphasis, a simple

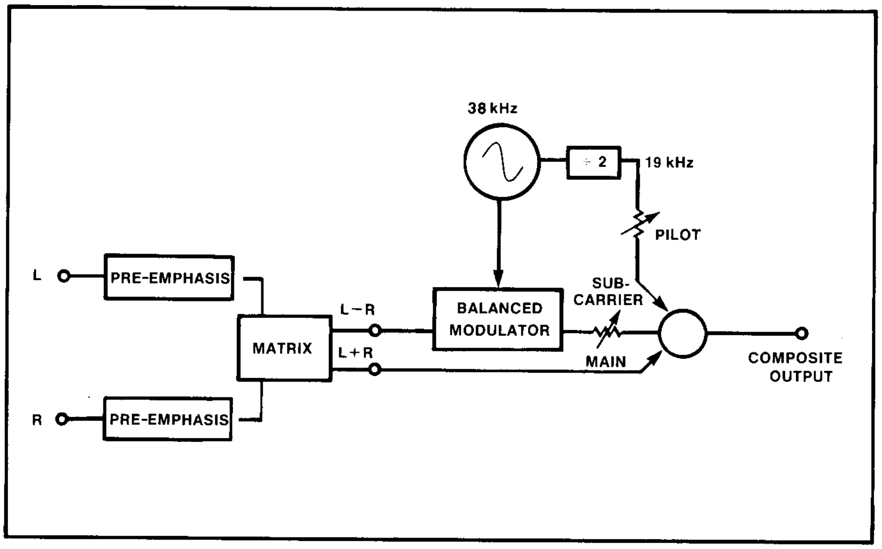
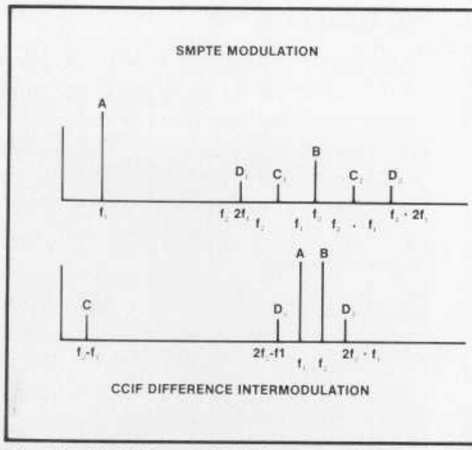


Fig. 2. Block Diagram of Theoretical **Fm** Stereo Generator



DISTORTION		COMMONLY USED FREQUENCIES
2nd	3rd	
$\frac{C_1 + C_2}{B}$	$\frac{D_1 + D_2}{B}$	60 Hz-5000 Hz 60 Hz-6000 Hz 60 Hz-7000 Hz (IHFM)
$\frac{C}{A+B}$	$\frac{D_1}{A+B}$	4000 Hz-5000 Hz 6000 Hz-7000 Hz 1200 Hz-1400 Hz

Fig. 57. SMPTE and CCIF Intermodulation Test Standards

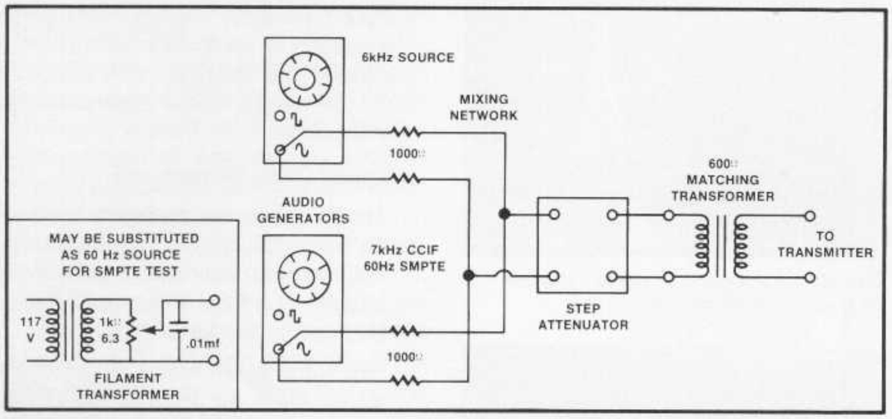


Fig. 58. Two-tone Source for Intermodulation Tests

shown in *figure 59,* then converting to percentage using the chart in *figure 23.*

6. Intermodulation distortion using the CCIF method is performed by noting the dB down of the generated 1 kHz sidebands as shown in *figure 60,* then converting to percentage. The single carrier at 1 kHz is the 2nd order difference beat and the sidebands centered around the 6 and 7 kHz tones are the 3rd order components.

D. Intermodulation Testing of the Transmitter/Generator Combination

Some specialized tests have been devised to evaluate the **im** performance of the **fm** transmitter and the stereo generator. The ability of the stereo generator to produce clean modulation components without intermodulation is only one requirement. The bandpass of the transmitter and the linearity of the modulation oscillator both contribute to the **im** performance. Typically most stereo systems will pass signals with intermodulation down at least 40 dB. A few companies now offer systems with intermods suppressed at least 60 dB.

One of the simplest ways to evaluate intermod performance is to use three test combinations of a 7 kHz tone. The 7 kHz modulates the transmitter through the stereo generator as a *left* only, then a *left plus right* and finally as a *left minus right* signal. A variation of this test is to use a 60 Hz and 7 kHz tone in combination, with the 60 Hz 12 dB greater than the 7 kHz. Many intermod products will be formed that correspond to second and third order components. If linearity adjustments are provided in the modulation oscillator, adjustments will sometimes improve the performance. Retuning the transmitter can also improve performance. As part of the intermod test, the components in the 67 kHz SCA area should be noted since they will determine the crosstalk performance. In some transmitters, intermods should be measured out to 500 kHz since many transmitters will pass higher frequency intermods, causing the occupied bandwidth to be out of tolerance.

Figures 61 through *64* show a typical transmitter intermod test sequence.

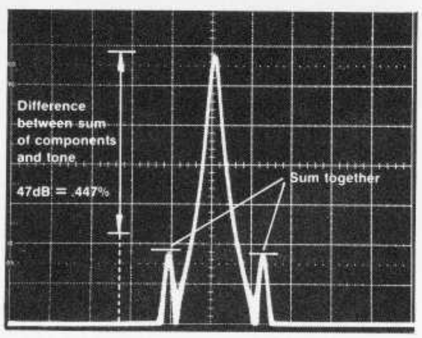


Fig. 59. Measurement Using the SMPTE Standard

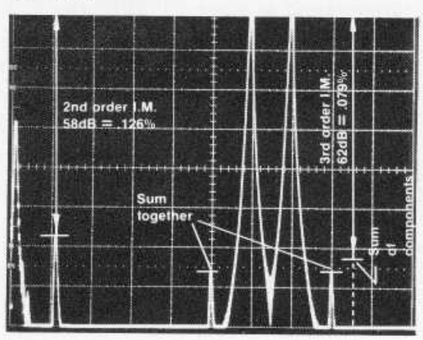


Fig. 60. Measurement Using the CCIF Standard

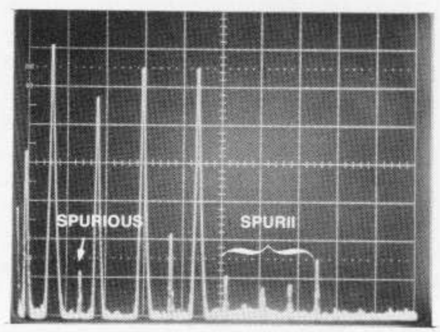


Fig. 61. 7 kHz Left Channel **Im** Test

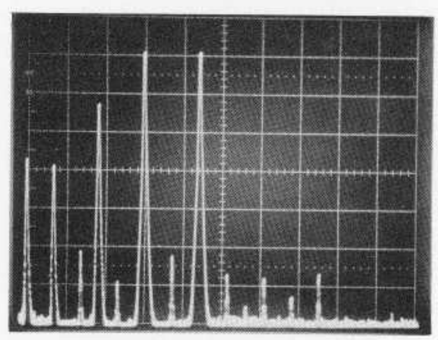


Fig. 62. 7 kHz L Minus R **Im** Test