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MATRIX TECHNICAL NOTES

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PM TO AM CONVERSION OF DISTORTION PRODUCTS BY SLOPE DETECTION IN TV RECEIVERS

One of the distortion products generated during the transmission of signals through amplifiers is PM (phase modulation) of the carrier. It is the result of the reactances, usually associated with the transistors, being modulated by the signals. This results is additional intermodulation products that are at exactly the same frequency and just as important as the amplitude intermodulation products. In some cases the phase intermodulation products will add or subtract from the amplitude intermodulation products. When measuring discrete second order distortion products, sometimes the sum and difference products have different amplitudes. This can be the result of a frequency response that is not flat or phase intermodulation products that add to or subtract from the amplitude intermodulation products.

Crossmodulation presents a different situation in that the phase intermodulation products appear as pairs of sidebands spaced +/- 15.75 KHz from the signal carrier and fall in the measurement band. The amplitude intermodulation (crossmodulation) and phase intermodulation products are at exactly the same frequency. When displayed on a spectrum analyzer, amplitude intermodulation and phase intermodulation sidebands appear to be identical. Under ideal conditions, phase intermodulation sidebands in pairs, as in the crossmodulation case, do not produce amplitude intermodulation components.

Although TV receivers use an AM video detector and to a great extent are immune to phase intermodulations, some of the phase intermodulations are converted to amplitude intermodulations by the slope of the IF response, which was designed to accept a vestigial sideband signal.

The following is an analysis of the degree of PM to AM conversion within the TV receiver.

For small modulation indexes the following function accurately describes an amplitude modulated signal. (Ref. 1)

$$f_c(t) = \cos\omega_c t + \frac{m}{2}[\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t\ ]$$

And a phase modulated signal can be described by the following function.

$$f_c(t) = \cos\omega_c t + \frac{\beta}{2}[\cos(\omega_c + \omega_m)t - \cos(\omega_c - \omega_m)t\ ]$$

Where $f_c(t) = \text{Function}$

$t = \text{Time}$

$m = \text{AM modulation index}$

$\beta = \text{PM modulation index}$

$\omega_c = \text{Angular frequency, carrier}$

$\omega_c = \text{Angular frequency, modulation}$

The normalized gain of the IF response of a TV receiver slopes from 1 to 0 over a band of -/+ 0.75 MHz from the carrier, with less gain at the higher frequencies.
The gain-frequency slope can be written as.

$$\frac{\Delta \mathrm{G}}{\Delta\omega} = \frac{(0-1)}{(2\pi)(1.5\mathrm{MHz})}$$

For a frequency offset of 15.750 KHz, the change in gain is.

$$\Delta G = \frac{(-1)(2\pi)(15.75\mathrm{KHz})}{(2\pi)(1.5\mathrm{MHz})} = -0.0105$$

This says that the higher sideband frequency is less by a gain change of 0.0105 and the lower sideband frequency is greater by a gain change of 0.0105.

Starting with the function for PM modulation and looking at only the sideband frequencies including the small gain changes we may write.

$$\{[\cos(\omega_c + \omega_m)t - 0.0105\cos(\omega_c + \omega_m)t] - [\cos(\omega_c - \omega_m)t + 0.0105\cos(\omega_c - \omega_m)t]\}$$

and

$$\{[\cos(\omega_c + \omega_m)t - \cos(\omega_c - \omega_m)t] - 0.0105[\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t]\}$$

We recognize

$[\cos(\omega_c + \omega_m)t - \cos(\omega_c - \omega_m)t]$ as the sidebands of a PM signal

and

$-0.0105[\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t]$ as the sidebands of an AM signal

The relative magnitude of the AM sidebands to the PM sidebands is 0.0105 or –39.6 dB.

This indicates that a pure PM signal would have to be almost 40 dB stronger than an AM signal for equal effects on a TV receiver.

REFERENCES

(1) Schwartz, Mischa, Information Transmission Modulation and Noise, Mcgraw-Hill Book Company Inc., 1959, Pages 118,119.