T4-1

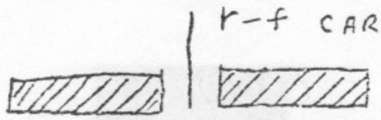
Power Distribution in an Amplitude Modulated Signal

by Angel M. Garcia

This analysis concerns itself with the distribution of power in the amplitude modulated (a.m.) signal which is characteristic to all stations operating in the standard broadcast band. It will, hopefully, explain the reason why, in many instances, the audio component of an a.m. signal is inaudible even though the carrier is present.

The amplitude modulated signal consists of a radio-frequency (r-f) carrier and a pair of sidebands symmetrically located on either side of the carrier. These sidebands are referred to as the lower and upper sidebands and are produced by the modulating signal (such as music, speech, tone, etc.). This means, of course, all of the intelligence being transmitted is contained in the sidebands. Figure 1 illustrates the sidebands produced by amplitude modulation.

FIG. 1



The power in an amplitude modulated wave is divided between the carrier and the sidebands. The carrier power is constant (except in cases of overmodulation) and so the sideband power is the difference between the carrier power and the total power in the modulated wave. When a carrier is modulated by a single sinusoidal tone, the total power output is found from the formula:

$$P_{MOD} = \left(1 + \frac{m^2}{2}\right) \times P_{CAR}$$

where: P_{mod} is the power in the modulated wave
m is the percentage of modulation
P_{car} is the power in the carrier

Assuming that a 500 watt carrier is modulated 100%, the power in the signal is:

$$\left(1 + \frac{(1)^2}{2}\right) \times 500 = 750 \text{ watts}$$

Of this total, 500 watts are in the carrier and 250 watts in the sidebands. The percentage of sideband power (250/750) = 33.3%. Of the 250 watts of sideband power, there are 125 watts in each sideband and the power content of each therefore is 16.6% of the total power output with 100% modulation. In essence, 66.6% of the power in an a.m. signal, modulated at 100%, is wasted in the r-f carrier which does not convey any intelligence!

Note that in using voice modulation, the greater portion of the audio frequency components will not modulate the carrier 100%, so that the power increase for voice modulation is much less than for single tone modulation. It is for this reason that stations conducting tests for DX purposes should be encouraged to modulate with a test tone.

The available sideband power takes a marked drop when the average percentage of modulation is well below 100%. This is shown by modulating the carrier only 50% when the carrier is 500 watts.

$$P_{MOD} = \left(1 + \frac{(.5)^2}{2}\right) \times 500 = 562.5 \text{ watts}$$

The total modulated power is now 562.5 watts. Since 500 watts exist in the carrier, only 62.5 watts of power remain in the sidebands. Since 62.5 watts is $\frac{1}{4}$ the value obtainable with 100% modulation, it is seen that reducing the modulation 50% causes a 75% reduction in the available sideband power! Since all of the intelligence being transmitted is contained in the sidebands, the desirability of a high percentage of modulation becomes evident.

I sincerely hope this article has been of interest to all and that it has answered some of the questions concerning a.m. signals which you may have had. Comments regarding this article are welcome. 73.

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