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INTERMODULATION DISTORTION

There are 2 kinds of intermodulation distortion, first, amplitude, wherein a component of one frequency amplitude-modulates a component of another frequency, and Doppler distortion in which one component causes a frequency modulation of another component. Usually amplitude modulation distortion but not Doppler distortion would be produced by an amplifier; both may be produced by a speaker or a tape machine.

To evaluate the audible effect of a small amount of Doppler distortion -- alone, with amplitude modulation, a recording was made on a tape machine to whose capstan a sleeve had been added, the sleeve being very carefully machined to be 0.0014 inch eccentric in an outside diameter of 0.280 inch, so the peak-to-peak flutter would be one percent, the peak flutter 0.5 percent, and the RMS flutter 0.35 percent.

At a recorded frequency of 1046 cycles and a capstan (flutter) frequency of 10 cps, the result was a rapid tremolo, not particularly irritating. At 20 cps flutter rate, the sound became irritating. By re-recording at half speed, both frequencies were doubled and the 2092 cycle tone being fluttered at 40 cps became extremely irritating, even though the RMS flutter still was only 0.35 percent.

In testing speakers, it was found the amplitude modulation distortion always exceeded the frequency modulation distortion. The latter may be computed from the frequency and amplitude of the component with the large excursion. Computed values

in the order of 1% have been found, which according to the tape experiment should have been irritating. But since the amplitude modulation was even greater (and the Doppler distortion certainly not less than calculated), it is understandable why the degree of irritation was greater than expected.

One way to separate good speakers from bad is to use two oscillators --- or a recorded tape of 2 frequencies, and feed both into the speaker. The 2 frequencies must be chosen so they will both be radiated by the same speaker unit. Thus if there is a crossover at say 1,000 cycles to a midrange speaker, and the woofer is the unit to be tested, both frequencies must be below 1,000 cycles.

We used a tape with frequencies of 36.7 and 367 cycles, 43.6 and 436 cycles, 49.0 and 490 cycles, in each case the higher frequency having an amplitude (voltage or current) of 0.25 the value of the lower frequency, care being taken that the distortion level of the tape machine was not exceeded. (Note; if the Volume Indicator is a rectifier type instrument, it reads average values and the average value of the sum of 2 such sine waves would be only slightly (about 3%) greater than that of the bass tone, but the instantaneous peak is 25 percent higher or 2 db higher. In a tape machine which will produce appreciable distortion above "zero level" it is important to make the recording at minus 2 db indicated. It is well to use a cathode ray oscilloscope while making the recording.

The use of such a tape or similar 2-tone source will reveal quite a lot of faults in speakers and indicate (by

comparison) some of the exaggerations in other claims such as frequency response.

A contemporary direct radiator speaker, advertised as "flat to 30 cycles", was compared to a corner-horn back-loaded speaker known to be down 10 db at 50 cycles. On program material containing extended heavy bass, such as a theater organ, the 50 cycle speaker was evidently producing much deeper fundamentals than the direct radiator. Yet the diaphragm was barely moving. The diaphragm of the direct radiator, pumping through some 1/4 or 1/2 inch excursion, was producing severe "muddyness" in the middle tonal range.

The point to be made is that both types of distortion are not merely audible, they are irritating even at levels of one percent. There isn't much use in spending big sums for amplifiers with 0.1% harmonic distortion and 0.4% modulation distortion when the speaker modulation distortion levels are 10 or 100 times as high. And the sooner the general public becomes aware that these high distortions are inherent to direct radiator speakers which are being overdriven the sooner the advertising for "zero distortion", "2 decibel response" and other things impossible of attainment will be read properly with tongue in cheek.

It seems to me that freedom from distortion should be a first consideration, and frequency response second. If either has to be sacrificed, let it be bass response. This has been my attitude since 1940, and the performance of the new "long-throw" forced-bass speakers makes me all the more convinced of its truth.

This is by no means a condemnation of direct radiator speakers which remain the economical means of reproducing sound. But it is a condemnation of claims of low distortion when the cone is moving through large excursions and velocities. One maker of direct radiator speakers whom I admire for his honesty states that he aims to limit cone excursion to 1/8 inch even though his speakers are of the high-compliance type. The modulation distortion at 1/8 inch excursion will be about 1/16 as great as for a 1/2 inch excursion.

This does not condemn the high-compliance driver, either. The longer the region of linear motion and the more compliant the suspension, the more linear the whole system can be made. The lower the amplitude distortion, the lower the amplitude modulation distortion, down to the irreducible minimum of distortion produced by the velocity of the air itself.

But regardless of how perfectly the cone may move to produce a distortion free single frequency output, the modulation distortion is always with us; it is a function of a moving sheet of air rather than a fault of a speaker. It remains even for a "perfect" speaker. The remedy is reduction of air velocity, not in higher compliance, longer capable motion, or acoustico-electric feedback. To reiterate, the Doppler distortion, at least, is a function of a moving sheet of air, not a fault of a speaker driver system.