THE MEASURE AND PERCEPTIBILITY OF COMPOSITE TRIPLE BEAT

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ABSTRACT

This paper describes the result of a study done under field conditions as to the measure and perceptibility of composite triple beat. Two interesting conclusions are drawn: (1) the threshold of perceptibility under field conditions particularly with regard to Pay Television signals and their contents occurs at a ratio of 57 db carrier to composite triple beat; (2) measurements of the composite triple beat near system generated thermal noise, such as those conducted on the trunk lines, require special consideration and techniques to insure their accuracy.

THE PERCEPTIBILITY OF THE BEAT

Existing work by Arnold and others has established the threshold of the visibility of the composite triple beat to be at/or near 54 db. This can be repeated under the conditions described by the various authors. It is also widely recognized that with any channel loading above 25 the composite triple beat becomes the predominant distortion to be recognized. Pay television has brought a much heavier channel loading to many systems previously not burdened by the composite triple beat buildup that full loading would otherwise generate, and perhaps more interestingly the program content of the pay television signal (or signals) is of a type that does not carry as high an average picture level as broadcast television. Broadcast television is often thought to carry an average picture level in the 50% or higher range while the movies that make up the bulk of pay television program material are thought to have an average picture level of something near 40%.

In addition, the propensity of the subscriber to judge the quality of the pay television channel very harshly is increased because it is one for which he pays a good deal more money than the other channels carried on the system.

For these reasons it especially is important to minimize the perceptibility of the composite triple beat of these premium channels. The beat is composed, as has been recorded by the other work referenced, of many discrete carriers that when added together closely approximate a burst of random noise centered within 30 KHz of the carrier frequency. The beats manifest themselves on a television receiver screen as striations of a duration up to one or more horizontal lines occurring on a random basis. On any fairly broadband detector (approximating a television set), they can be observed to be momentary pulsations that appear above thermal noise by some 4 to 6 db (depending on the cascade depth and noise buildup). Of course this is the property which makes them visible above thermal noise on the television sets.

The traditional manner of measure in order to exclude other distortions is to observe a 30 KHz slot whose center is the carrier frequency, with heavy filtering in order to determine the approximate RMS value of the buildup, referenced to the carrier amplitude. It is in this measurement described that 54 db or greater is the necessary separation from carrier reference for the beats not to be perceptible. These conditions however, were determined with a carrier modulated to 87.5% with a video signal essentially noise free, such as a color bar generator or other test pattern. Under the condition in which the modulation depth is only 40% the apparent ratio of signal to interference to the display device is reduced by approximately 3 db. The perceptibility for these channels occurs at -57db.

Perceptibility is difficult to gauge and establish, but using the same trained observers, there has been correlation in five separate tests with five types of equipment for generation and measurement on five types of amplifier equipment that this effect can be emperically observed, and that the threshold of perceptibility for composite triple beat under conditions such as on a pay television signals of 40 to 35% modulation is 57 db. This depth modulation was chosen to approximate the level of grey scale information most observed for significant portions of the programming.

It is widely recognized that the CW tests are more harsh than the real world signal carriage conditions would bring about. It is also realized that the design to the threshold of the perceptibility arrived in this fashion leaves some headroom for operational variance, of the same order as to design for the threshold of perceptibility of synchronous cross modulation. For pay television work this design figure should be 57 db in order for the pay signals at their lower depth modulation not to be impaired by the effects of composite triple beat.

MEASUREMENT

It is quite important in many cases to measure the composite triple beat buildup on the trunk line in order that judgements may be made about equipment performance; also, judgements may be made on the basis of these measurements about the extension of the trunk line; and also trouble shooting techniques are often applied where composite triple beat is measured at various points on the trunk line. It is characteristic of present day amplifiers for the composite triple beat generated at any appreciable cascade depths to be at a level hardly discernable above thermal noise under the conditions of its measure.

It is recognized and is published in the various literature associated with measurement techniques of this nature that measurements near noise may be subject to a correction factor. It is important to note here that the thermal noise generated by the system may lie 10 to 15 db above the noise floor of the spectrum analyzer where other uncertainties do exist. There is a correction factor often applied which was generated both empirically and supported by some analytical work by a manufacturer of test instrumentation. This work assumes that composite triple beat will closely approximate a CW source. Empirical observations will show, however, that composite triple beat will closely approximate a random noise source, and will add as two power sources on a power basis. Measurements made near noise are subject to the correction factor shown in Table I and it is obtained analytically from a 10 log power addition where the resultant display is the sum of the noise floor and the distortion signal. Also given in the table are the various empirical observations that lend credence to the validity of the assumptions. The test arrangement is shown in Figure 1. The data in the table have been observed to hold for three types of spectrum analyzers in common usage in our industry.

Again, the correction is only applicable in cases where the trunk thermal noise is the limiting factor and the beat near the noise must be measured. In the feeder lines, the level of the beat is significantly above the noise and the necessary correction is negligible.

CONCLUSIONS

Threshold of perceptibility for the typical program content carried on a premium television signal should be thought of to be 57 db, and is different than the 54 db established in previous observations for test signals (of high luminous and chrominance content) modulated at 87%. Given that pay television signals are subject to closer scrutiny and more harsh judgement by the subscribers and that the current prices of a db of distribution level is thought to be at or near $50.00 per system mile for most designs today, the increase in the composite triple beat specification to 57 db for a system that is intended realistically to operate under a 35 channel loading condition should be considered and compared to the cost of service calls that may otherwise be generated.

In order to measure the composite triple beat generated by the trunk near the thermal noise generated by the trunk, an appropriate correction factor must be used for the combination of the two sources and their resultant within the instrumentation to be accounted for.

ACKNOWLEDGEMENTS

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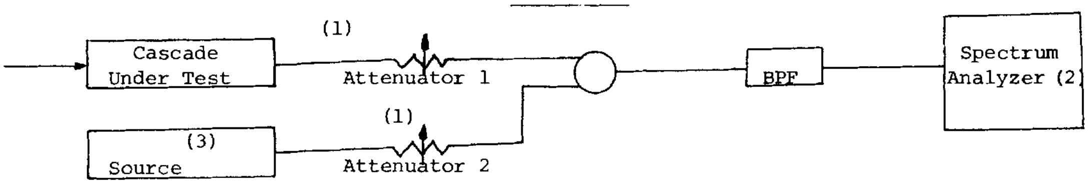
TABLE I

EXPECTED & MEASURED CORRECTION

FACTORS FOR CTB MEASUREMENTS

Spectrum Analyzer Display; db Above Thermal Noise	Correction Factor, db Expected (10 log)	Measured, CW	Measured, CTB	Measured Random Noise	Measured R. A. Kreiger
1	6.8	3.5	6	6	6
2	4.3	2.5	5	4	5
3	3.0	1.5	3	3	3.9
4	2.2	1.0	2.5	2	3
5	1.6	0.5	1	1.5	2.3
6	1.2		1	1	1.7

FIGURE 1



Procedure: Attenuator 1 was adjusted for a system noise floor $\geq$ 15 db above the noise floor of the spectrum analyzer (and about 60 db lower than standard signal level). The level of the source was varied from 20 db above the noise to that point at which the signal could not be discerned on the analyzer display. The difference between the calibrated attenuator and the reading of the display was recorded as the correction factor.

(1) Laboratory quality attenuator

(2) Calibrated to manufacturer's specifications. Controls were adjusted for typical CTB measurement; 30 KHZ IF with noise averaging filters in.

(3) One of the three:
   1) Random noise
   2) CW signal
   3) CTB signal generated from a distribution amplifier, (but without components outside 30 KHZ from carrier frequency).