COMPOSITE SECOND ORDER DISTORTION
AND
DISTRIBUTION SYSTEM PERFORMANCE

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ABSTRACT

Consistent throughout the evolutionary development of the electronic equipment, which is used in cable television distribution systems, has been the villan referred to as "The System Limiting Distortion". As system bandwidth has increased, the distortion form that has limited system performance has changed. Cross modulation controlled performance in the early years; composite triple beat ruled until recently; now that distribution system bandwidth has continued to expand composite second order distortion threatens to limit system design flexibility.

Therefore, the objectives of this paper are to provide an introduction and a comprehensive analysis of composite second order distortion. An in depth analysis as well as empirical measurement data are offered.

INTRODUCTION

As the number of channels carried by cable TV distribution systems has increased, it has been necessary to specify and control more of the distortion products generated by the CATV amplifier. Composite second order is the distortion product of most recent concern[1].

Second order beats are generated at sum and difference frequencies of the video carriers.

Except for channels 5 and 6, the video carriers for a standard IRC (incrementally related carriers) frequency assignment are given by:

$$f = 6m + 1.25 \text{ MHz}$$

where m is the appropriate integer for a particular channel.

Therefore, the sum beat of two channels is given by:

$$f_1 = 6m + 1.25$$
$$f_2 = 6n + 1.25$$
$$f_1 + f_2 = 6(m + n) + 2.50$$

The sum beat falls 1.25 MHz above the victim video carrier, which is a sensitive area of visible interference (Reference Figure 1). The difference beat falls 1.25 MHz below the video carrier at a frequency of negligible sensitivity.

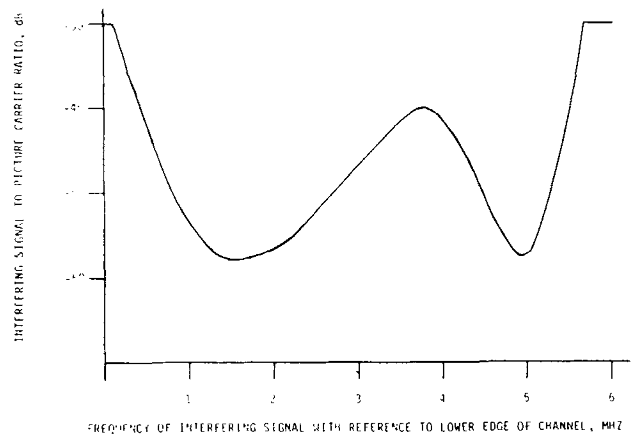
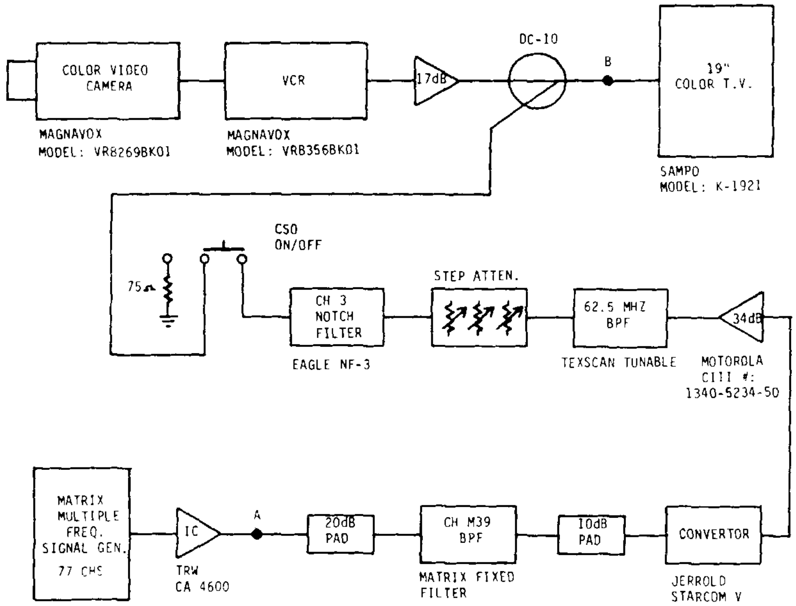


FIGURE 1. PERMISSIBLE LIMITS FOR INTERMODULATION AND OTHER UNDESIRED SINGLE-FREQUENCY SIGNALS

The largest number of sum beats falls on the highest channel and the number of sum beats on the highest channel increases rapidly as the number of channels increases. For a 52-channel, 400-MHz system the number of sum beats falling on the highest channel of 397.25 MHz is 16. For a 77-channel, 550-MHz system, the number of sum beats on the highest channel of 547.25 MHz increases to 29.

SUBJECTIVE PERCEPTION OF COMPOSITE SECOND ORDER

In order to gain insight into the amount of composite second order (CSO) that can be subjectively tolerated, the test set-up diagrammed in Figure 2 was used. The camera was focused on the scene shown in Figure 3. Figures 4 and 5 show a close-up of this scene without CSO and with CSO, which was generated using a hybrid IC driven by a 77-channel Matrix using CW carriers. Channel M39 (547.25 MHz) was extracted using a bandpass filter and converted to Channel 3, the same as the output channel of the camera/VCR. A step attenuator provided relative adjustment of the CSO level. The notch filter eliminates the Channel 3 video carrier from the converter while passing the CSO beat. A Hewlett-Packard Model 8568B Spectrum Analyzer was used to measure the peak video carrier level and the CSO amplitude. A resolution bandwidth of 30 KHz and a video bandwidth of 10 Hz were used to measure the CSO amplitude, the same as recommended by the NCTA for measuring composite triple beat[2],



A: M39 (547.25 MHZ) OUTPUT LEVEL 44dBmV CSO-46dB

B: CARRIER WITH VIDEO 36dBmV CSO-47dB (STEP ATTEN @ 0dB)

FIGURE 2. CSO INTERFERENCE TEST SETUP BLOCK DIAGRAM

The results of the test are given in Table 1. The level of barely perceptible CSO ranged from -52 dB to -63 dB, with an average value of -59 dB. Because CW carriers were used to generate the CSO, the results represent an unrealistic worst case condition, i.e. video modulation on only one channel and standby carriers on all other channels.

An IRC headend was not available for evaluating CSO generated from carriers modulated with video from multiple sources. However, an estimate can be made of the improvement using modulated carriers. The average rf level of a modulated carrier is about 6 dB below the sync peak level. With CW carriers, each 6 dB lower than normal (except for the victim channel level, which remains unchanged), the CSO relative to the victim channel would be reduced by 12 dB[3]. As it is probably unrealistically optimistic with actual video to expect a 12-dB reduction in CSO, the author has chosen one-half, or 6 dB, as a reasonable reduction in CSO that could be expected using modulated carriers as compared to CW carriers.

Therefore, for the average viewer of Table 1, the CSO could be -53 dB (-59 + 6) when measured using CW carriers. This number is the same as that recommended by the NCTA for composite triple beat. (2) It may be somewhat on the conservative side as one would expect less visual sensitivity to a beat 1.25 MHz above the video carrier as compared to a beat falling on the video carrier. (Refer to Figure 1).

OBSERVER	BARELY PERCEPTIBLE CSO (dB)
#1	-57
#2	-58
#3	-60
#4	-52
#5	-54
#6	-59
#7	-59
#8	-63
#9	-62
#10	-62
#11	-63
#12	-61

AVERAGE: -59.2dB

TABLE 1. CSO SUBJECTIVE TEST RESULTS

CASCADE TEST RESULTS

Composite second order has been measured on a cascades of 16 550-MHz trunk amplifiers, using the Model XFTA-26/550 Trunk Amplifier. The XFTA-26/550 uses a conventional pre-amp driving a TRW FF224 post-amp. Operational gain is 26 dB.

The overall trunk amplifier CSO is determined predominantly by the pre-amp performance. A PHI 5517-21 is used as the pre-amp with CSO specified as -60 dB maximum for 77 channels at a 44 dBmV flat output. Cascade results are as follows:

Amplifier Model	No. in Cascade	Output Level (dBmV)	Tilt (dB)	Worst Case CSO (dB) @-25°F	@70°F	@134°F
XFTA-26/550	16	39	6	-64.5	-64	-64

FIGURE 3. PICTURE ON WHICH CAMERA WAS FOCUSED

FIGURE 4. CLOSE-UP OF SPACE SHUTTLE PICTURE

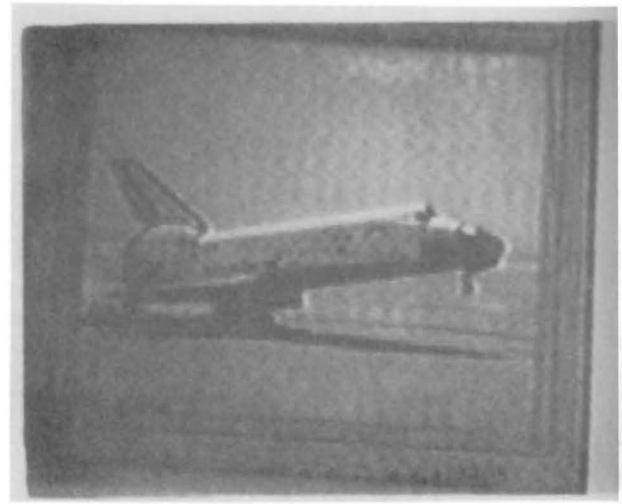


FIGURE 5. SAME AS ABOVE, EXCEPT WITH -47 DB OF CSO

The worst case reading of -64 dB occurred on the highest channel. This worst case reading is well below the -53 dB barely perceptible limit, allowing for further derating from cascade extension, bridger, and line extenders. CSO derating appeared to follow a 10 log N curve.

CONCLUSIONS

Composite second order distortion can indeed be a factor that can limit cascade performance on 550-MHz, 77-channel systems. However, by specifying hybrid IC CSO performance, this distortion product can be contained at a comfortable level.

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