400 MHz CATV SYSTEM PERFORMANCE STUDIES

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ABSTRACT

Composite triple beat measurements of various trunk cascade lengths operating to 400 MHz with fifty-two channel loading are compared to various trunk cascade lengths operating to 300 MHz with thirty-five channel loading. The performance of distribution amplifiers is similarly compared. A system model from which these measurements were obtained is described and the calculated performance based on specifications is compared to actual performance. The improvement to subjective picture quality when using phase lock techniques is discussed. Cross-Modulation and Second Order Beat distortions are not addressed by this article.

INTRODUCTION

The primary objective of this paper is to give the end user of 400 MHz active system components some insight into the actual performance degradation when expanding from 35 to 52 channel loading. It seems meaningful that this subject be addressed due to the skepticism that has been expressed with regard to expanded channel operation. As more 400 MHz data becomes available to the industry, an improved confidence level will be shared. Toward this end, the distortion characteristic of Composite Triple Beat will be treated herein. To facilitate the study of composite triple beat behavior, a system model was designed and constructed.

SYSTEM MODEL

The system configuration for the evaluation, based on performance specifications, was divided into three segments, such that equal distortion contribution would result from: 16 trunk amplifiers; one bridger amplifier; and two line extenders operating at 300 MHz or 400 MHz.

Figure 1 summarizes the resulting operating levels that were chosen, and the distortions that would result in a 300 MHz system with 35-channel loading.

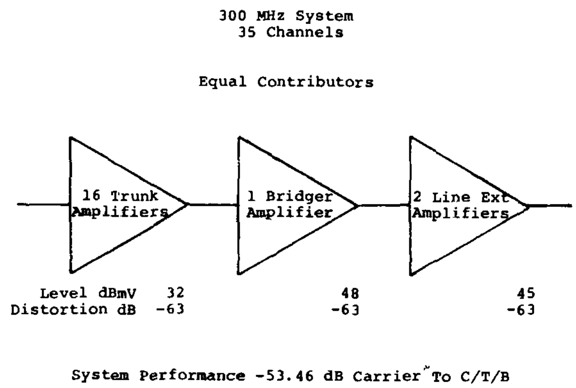

Figure 1

The relative distortion level of -53 dB, which is the recommended minimum level as indicated in the NCTA standard of "Good Engineering Practices for Measurements on Cable TV Systems", was chosen as a reference.

Figure 2 indicates the relative distortion level that would result based on specifications when seventeen channels are added to the system model as introduced in the previous figure.

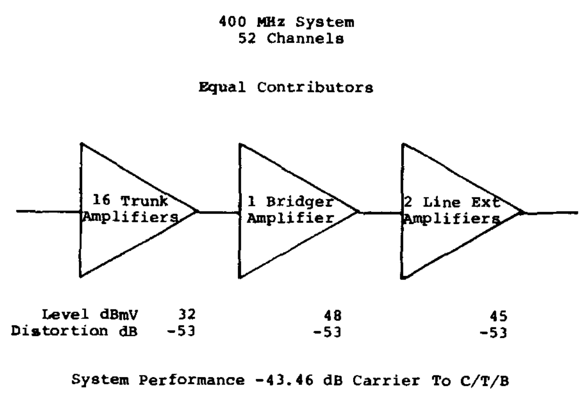

Figure 2

The barely perceptible point for composite triple beat distortion has been established at a relative distortion level of -51 dB. Therefore, the resultant relative distortion level of -43 dB would be unacceptable in terms of subjective picture quality unless a technique such as coherent carriers is utilized.

DATA FORMAT

Two of the 35 channels were characterized to represent thirty-five channel performance. Channel 11, because mathematically it has the maximum number of beats that fall around the carrier and channel 35 which represents worst case performance based on previously accumulated data. Similarly, channel 28 and channel 50 were selected to represent 52 channel performance. NOTE: 43 channel data is also included on all graphs.

In order to provide a logical progression, it was decided to initially treat the trunk cascade, the bridger amplifier and the line extender cascade as separate units, and then finally to evaluate the three components together as a transportation and a distribution system.

TRUNK CASCADE ANALYSIS

Data accumulated during the system study confirmed that composite triple beat distortion increases as a function of frequency and is graphically illustrated in Figure 3.

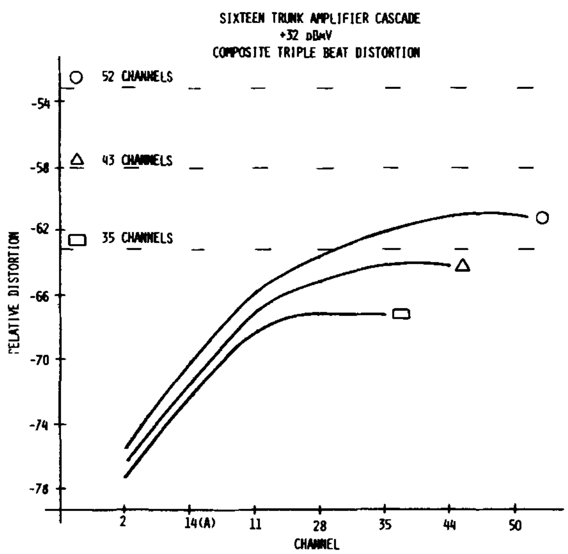

Figure 3

The horizontal lines that are contained in this graph and subsequent graphs indicate the present Jerrold specification limits. They are included for reference purposes only.

The data contained in Figure 4 provides a basis for numerical comparison of a trunk cascade performance using the worst case channel for each of the loading conditions indicated. It should be kept in mind while making comparisons that no attempt was made to select amplifiers with equal distortion contributions as individual units. However, due to the fact that both channel loads were applied to the same cascade, the true value of this information can be realized by comparing the distortion degradation that resulted as a function of channel load. By comparing thirty-five channel data from the cascade locations listed, it can be determined that a 20 LOG N degradation applies (ie: 20 log 16 = 24 dB). Making the same comparison for 52-channel loading suggests a cascade degradation of less than 20 LOG N.

TRUNK AMPLIFIER BEHAVIOR

OUTPUT LEVEL +dBmV	35 CHANNEL CASCADE 1	4	16	52 CHANNEL CASCADE 1	4	16
32			67.0 (63)			61.0 (53)
34			62.5			56.0
36		69.0	58.0		59.5	52.5
38		65.0	54.0		55.5	48.0
40	74.5	60.0	50.0	64.0	52.0	43.5
42	69.0	56.0	46.5	59.5	48.5	39.0
44	65.5	52.0		55.0	45.0	
46	61.5			51.5		
48	57.0			47.5		

(Spec 47dBmV for -57dB) (Spec 47dBmV for -47dB)

Figure 4

BRIDGER AMPLIFIER ANALYSIS

The performance of a bridger amplifier operating as a single unit with various channel loads can be determined by referring to Figure 5.

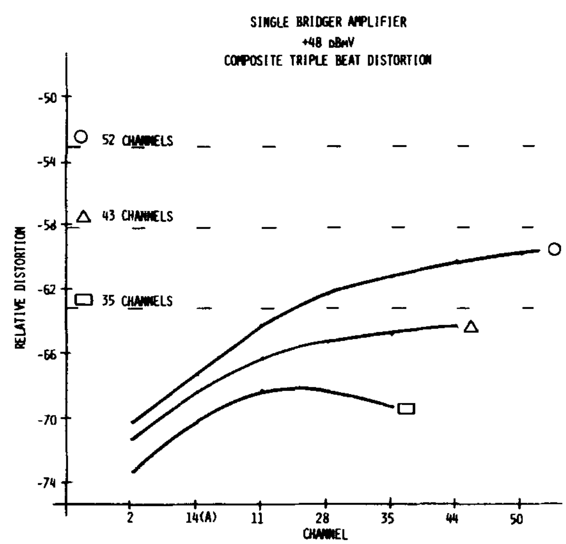

Figure 5

The bridger amplifier was operated with 6 and 8 dB slope for 35 and 52 channel loading respectively. Sloped operation is utilized to maximize the output capability of distribution amplifiers and to minimize tap level variation across the frequency spectrum. It is significant to note that the margin of distortion remains relatively constant regardless of channel loading.

The tabular data in Figure 6, as well as the graph in Figure 5, indicate the distortion degradation that occurs when seventeen additional channels are added.

BRIDGER AMPLIFIER BEHAVIOR

OUTPUT LEVEL +dBmV	35 CHS 6 dB SLOPE CH 11	CH 35	52 CHS 8 dB SLOPE CH 28	CH 50
46	72.0	73.5	67.0	65.0
48	68.0	69.0 (63)	62.0	59.5 (53)
50	63.0	65.0	57.0	53.5
52	59.0	61.5	52.0	48.0
	(Spec 51 dBmV for -57 dB)		(Spec 51 dBmV for -47 dB)	

Figure 6

LINE EXTENDER CASCADE ANALYSIS

Line extender performance with added channel loading tends to resemble that of the bridger amplifier. Refer to Figures 7 and 8. Note that when comparing the tabular data contained in Figure 8, that channel 28 was the worst case channel for thirty-five channel loading as indicated in Figure 7.

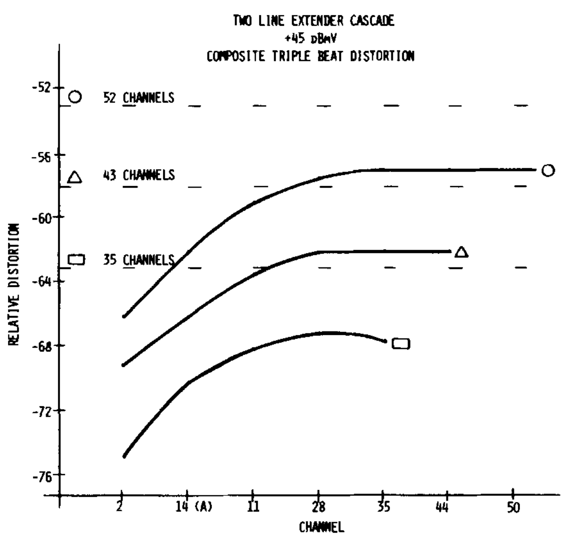

Figure 7

COMPLETE SYSTEM ANALYSIS

The cumulative distortion that was measured after the component parts were connected together to form a typical system is contained in Figure 9.

TWO LINE EXTENDERS IN CASCADE

MEASURED BEHAVIOR

OUTPUT LEVEL +dBmV	35 CHS 6 dB SLOPE CH 11	CH 35	52 CHS 8 dB SLOPE CH 28	CH 50
43	71.0	71.5	61.0	60.0
45	68.0	67.5 (63)	57.5	57.0 (53)
47	63.0	63.5	53.0	52.5
49	59.0	59.0	49.5	48.0
51	54.5	54.5	44.0	45.0
	(Spec 48dBmV for -57dB)		(Spec 48dBmV for -47dB)	

Figure 8

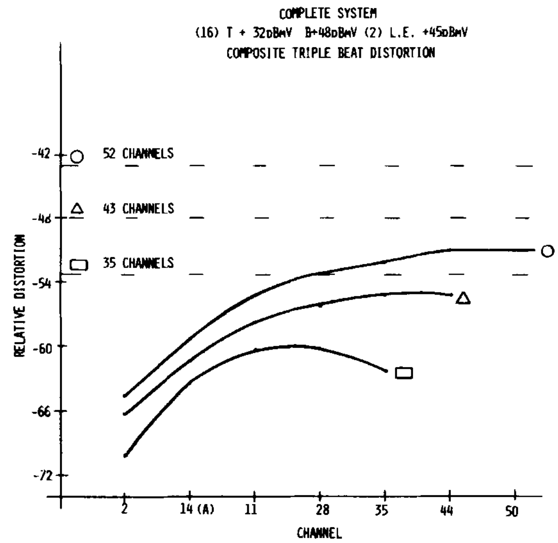

Figure 9

Upon inspection of the distortion data accumulated for each of the elements of the system model on a per amplifier basis at specification level, one can conclude that the degradation in composite triple beat performance by expanding from 35 to 52 channel loading was 10, 9.5 and 10.5 dB for trunk, bridger and line extenders respectively, or approximately 10 dB. This degradation is a result of additional beat accumulation associated with 52 channel operation and loss of amplifier performance as a function of frequency. The data also reveals that the trunk as a cascade of amplifiers only degraded by 6 dB under 52 channel loading at +32 dBmV, instead of the anticipated 10 dB. The bridger and line extender cascade degraded as expected.

In order to investigate the contribution of the trunk distortion to the overall system distortion, it was decided to increase the trunk operating level in two dB increments while maintaining the bridger and line extender output levels constant.

The results of this experiment are tabulated in Figure 10. It is worthwhile to realize that as the trunk level was increased, the thirty-five channel system distortion specification was reached with the trunk operating at +36 dBmV. The fifty-two channel system specification was not reached until the trunk was operating at +38 dBmV.

SYSTEM BEHAVIOR

SYSTEM COMPONENT LEVELS +dBmV			300 MHz 35 CHS		400 MHz 52 CHS	
16 TR +	BR +	2 LE	CH 11	CH 35	CH 28	CH 50
32	48	45	60.0	62.0 (53)	53.0	51.0 (43)
34	48	45	56.5	58.0	50.0	48.0
36	48	45	53.5	54.0	48.5	46.5
38	48	45	50.0	50.5	46.0	43.5

Figure 10

ADVANTAGES OF PHASE LOCK

The recommendation that coherent carrier schemes could be used to reduce perceptible distortion, thus, allowing a significant increase in the number of channels to serve the same geographic area formerly limited to thirty-five channel distribution, is viewed as a "gimmick" by some individuals. Coherent carrier schemes are not new and have been used for many years to improve system margin and/or system reach. If coherent carrier schemes are truly a "gimmick" used to improve the subjective picture quality of a television channel, then push-pull amplifiers, which reduce the effect of second order distortion, must also be classified as a "gimmick".

Subjective evaluations of picture quality that resulted from the system model carrying thirty-five and fifty-two channels have been made in the laboratory. Tests were conducted using both the coherent and non-coherent modes. A group of trained observers established the point of barely perceptible distortion on the channel exhibiting the most distortion. Test results indicated that a system of either thirty-five or fifty-two channels can be operated 5 dBmV higher when coherent carrier schemes are applied to a non-coherent system. A fifty-two channel system using coherent carriers has the same or a slightly better "barely perceptible" reference as the identical non-coherent system carrying thirty-five channels.

SUMMARY

A system model was designed and constructed to evaluate composite triple beat behavior in systems operating to 300 and 400 MHz. Comparing earlier 300 MHz system data to this data verified that no degradation in 300 MHz system performance was introduced when utilizing 400 MHz amplifiers over previously available 300 MHz amplifiers. The behavior of a 35 channel 300 MHz system complied with the 20 LOG N degradation formula. The degradation in trunk behavior of a 52 channel 400 MHz system was less than 20 LOG N. The distortion margin of the bridger and the line extenders, when comparing specification vs. measured performance, remains relatively constant regardless of channel loading. The improved performance of the trunk cascade in 52 channel 400 MHz systems could be utilized to improve the carrier to noise ratio of the system. A system of either 35 or 52 channels can be operated 5 dBmV higher when coherent carrier schemes are applied to a non-coherent system. A 52-channel system using coherent carriers has the same, or a slightly better "barely perceptible" reference as the identical non-coherent system carrying 35 channels.