FREQUENCY ASSIGNMENTS

FOR 53 CHANNEL CATV SYSTEMS

DOC INTERIM REPORT

DOC-CR-CS-81-011

FREQUENCY ASSIGNMENTS

FOR 53 CHANNEL CATV SYSTEMS

DOC INTERIM REPORT

CABLESYSTEMS ENGINEERING

A DIVISION OF ROGERS CABLESYSTEMS INC.

AUTHOR: Philip L. Mambo

DATE: March 9, 1981

Government of Canada
Department of Communications

DOC CONTRACTOR REPORT DOC-CR-CS-81-011

DEPARTMENT OF COMMUNICATIONS - OTTAWA - CANADA

COMMUNICATION SYSTEMS RESEARCH AND DEVELOPMENT

TITLE: FREQUENCY ASSIGNMENTS FOR 53 CHANNEL CATV SYSTEMS - DOC INTERIM REPORT.

AUTHOR(S): PHILIP L. MAMBO

ISSUED BY CONTRACTOR AS REPORT NO: 81-03-01

CONTRACTOR: CABLESYSTEMS ENGINEERING

DEPARTMENT OF SUPPLY AND SERVICES CONTRACT NO: DSS ST. 36001-013347

DOC SCIENTIFIC AUTHORITY: DR. METKIN AKGUN

CLASSIFICATION: UNCLASSIFIED

DATE: MARCH 13, 1981

TABLE OF CONTENTS

TABLES

TABLES

FIGURES

EXEC. SUMMARY

EXECUTIVE SUMMARY

This report is in fulfilment to milestone (a) of the 400MHz DOC - Project (CE No. 342-9223). The report summarizes all the work of Phase I & II which has been done on the project to date. The purpose, objectives and the interim conclusions are clearly outlined in the report.

The thrust in the CATV industry has been directed towards designing fully functional 400MHz systems carrying 50 or more channels. Unfortunately at the present moment, most of the 400MHz CATV hardware available on the market are 300MHz components stretched to 400MHz. The performance of a network using such components deteriorates rapidly when loaded to 50 or more channels. To maintain our high system performance specifications, new techniques for designing 400MHz systems must be developed.

NEW DESIGN TECHNIQUES

There are two categories in the new design techniques; those based on headend and converters and the ones involving the cable network. The headend and converter techniques are:

i) those using standard frequency assignment systems with offsets in the super and hyper bands

ii) those using phaselock channeling assignments, and

iii) those utilizing suppressed carrier transmission.

The cable network techniques are:

- *i) those utilizing amplifiers with improved intermodulation specifications, and*
- *ii) those using split-band amplification.*

This project was commissioned to look into these new design techniques and relate their network performance improvement with noise and intermodulation distortion. In order to study, analyze, and give recommendations on the most economical design alternatives, several objectives were established.

PROJECT OBJECTIVES

The following objectives were set out:

1) *to mathematically model the CATV system to derive equations which can be used to predict the number and level of intermodulation products,*
2) *utilizing the equations derived in (1), to generate a computer program which predicts the number of beats and their relative level for any given frequency assignment,*
3) *to determine the dB improvement of different system configurations referenced to the standard frequency assignment,*
4) *to conduct amplifier and system measurements to provide the necessary data required in the computer program and to validate the computer predictions.*

To date a great percentage of these objectives have been accomplished.

CONCLUSIONS

The following conclusions can be drawn from the study:

1) the mathematical equations for calculating the intermodulation products in CATV systems have been derived,

2) three different amplifier data have been measured and characterized for use in the computer program,

3) an initial computer program with the capability of predicting the number of beats and their relative levels has been developed, and

4) the predicted data has been shown to be very close to the laboratory measurements.

INTRODUCTION

1.0 INTRODUCTION

Up to 1979, most of the CATV systems design and engineering techniques were based on 300MHz, 35 channels systems. Recently however, many programmers have been looking into systems with 50 or more channels. The thrust now has been shifted towards designing fully functional 400MHz systems with 50 or more channels. Cablesystems Engineering has been studying new techniques for designing 400MHz systems which meet our standard system specifications.

Due to the lack of 400MHz hardware, it has been difficult to quantitatively measure and establish levels of performance on future components. Most of the 400MHz amplifiers available in the market are using 300MHz chips in 400MHz applications. The use of 300MHz chips will result in increased deterioration of performance at 400MHz. These existing uncertainties have compelled many system engineers to opt for new design techniques to improve system performance when using 50 or more channels.

1.1 New Design Techniques

The new design techniques can be categorized into two parts, that is:those involving headends and converters, and the ones based on the cable network. The techniques involving headends and converters are:

1.1 (cont'd)

1) those using standard frequency assignments with offsets in the super and hyper bands,

2) those using phaselock channeling assignments such as, Harmonically Related Carriers (HRC), and Incrementally Related Carriers (IRC), and

3) those systems using suppressed carrier techniques.

The cable network techniques are:

1) those using amplifiers with improved intermodulation specifications, for instance, feed forward techniques, [6] and

2) those using split-band amplification techniques.

To aid CATV system engineers in designing optional and cost-effective networks carrying 50 or more channels, this project was initiated to study, analyze and give recommendations on the most economical alternatives.

1.2 Project Objectives

The objectives of this project are:

1) using the available mathematical techniques, model the CATV system, to produce equations which can be used to predict the number and level of second and third-order intermodulation products,

2) using the mathematical equations derived in (1) to generate a computer program which

1.2 (cont'd)

predicts the number of beats and the relative level for a given frequency assignment,

3) using the computer program developed in (2), to determine the dB improvement of different system configurations referenced to a standard frequency assignment system. This should include systems such as frequency offset, HRC, IRC, and suppressed carrier systems, and

4) to conduct laboratory measurements to provide all the necessary data required in the computer program and to validate the computer predictions.

THEOR. ANAL.

2.0 THEORETICAL ANALYSIS

This chapter examines the theoretical analysis required in developing the computer model for predicting the number of beats and the levels of nonlinear distortions in CATV systems. A mathematical model of the CATV nonlinear transmission media is developed, and its application to the design of CATV systems is examined, to determine the final equations for the computer model.

2.1 Historical Background

One of the major limitations in the design of CATV systems has been nonlinear distortion generated by intermodulation of the discrete frequency components. These distortions are formed by the nonlinearities in the CATV amplifiers. When the number of amplifiers and channels in a cascade system are increased, the nonlinear distortions (beats) add up very rapidly to form a cluster of beats centered around the discrete-frequencies. To better understand the nonlinear distortion in the CATV system, the major contributors to interference are defined.

In the standard frequency assignment systems, the major contributors to third-order distortion are the triple beat components and crossmodulation components. Triple beat components occur when three picture carriers beat together to form a distortion on another picture carrier. Most of the carriers in a standard system have slight

2.1 (cont'd)

frequency deviations due to local oscillator inaccuracies. As a result, the large number of spurious beats generated by the carriers can be assumed to be independent, and their distribution around the carriers approaches a normal density function. The peak of the normal density function is called "composite triple beat level". In CATV measurements, this level is referenced to the victim channel picture carrier and referred to as "composite triple beat ratio" (CBR). CBR is the major limiting factor in the design of standard systems.

The other third-order distortion in standard CATV systems, which was for a long time considered the design's limiting factor, is cross-modulation (XM). Cross-modulation occurs when the picture carrier of a victim channel beats with the picture carrier and the first video sideband of an interfering channel.

In the case of Incrementally Related Carrier (IRC) and Harmonically Related Carrier (HRC) systems, CBR is not necessarily the design's limiting factor. The triple beat components in these systems fall coherently on the picture carriers, and because there is no video information transmitted on these frequency components, the distortions are of less concern. However, the third-order spurious beats resulting from one video first sideband beating with two

2.1 (cont'd)

other picture carriers and falling on or close to a video first sideband of a victim channel are significant in IRC and HRC systems. The video signals in these systems are not all gen-locked because the off-air channels' syncs originate from different generators with different phase deviations. Therefore, the beats resulting from the video sidebands can be assumed to be independent, and their distribution around the video sidebands approach a normal density function. When these beats are referenced to their respective picture carriers, we call it composite triple video beat ratio (CVBR). In IRC and HRC systems, CVBR imposes a more stringent design limitation than CBR.

2.2 MATHEMATICAL MODEL

The CATV amplifiers have been designed with special care to ensure that the distortion due to the frequency dependent nonlinearities lies within an acceptable range. This acceptable range can be achieved by expressing the distortions in terms of the system parameters in which the amplifiers will operate, and then optimizing them.

It was easier to optimize the amplifier distortions when 12 channel systems were used. These amplifiers used narrow-band transistors which have negligible capacitive and inductive effects. This allowed the use of power series to express the input-output transfer characteristics of the amplifiers.

2.2 (cont'd)

However, the rapid increase in demand for more channel capacity by the CATV operators has compelled the amplifier manufacturers to upgrade the basic CATV amplifier to satisfy this new market. In order to upgrade the amplifiers, wide-band transistors must be used. The inductive and capacitive effects in these wide-band amplifiers are no longer negligible. The power series espansion needed to approximate the amplifier characteristics cannot be used for the wide-band amplifier, mainly because they no longer have zero-memory. A much better approximation can be achieved by using the Volterra series expansion.

The major contributors to non-linear distortions in the signal are the numerious discrete-frequency components in the CATV system. These frequency components intermodulate to form beats. The continuous video spectrum of the picture causes a random noise-like effect in the system. However, for system design purposes, this type of distortion is not as limiting a factor as the distortion produced by the discrete-frequency components (CBR,XM & CVBR). The mathematical model to be developed here will be one based on distortion from the discrete-frequency components.

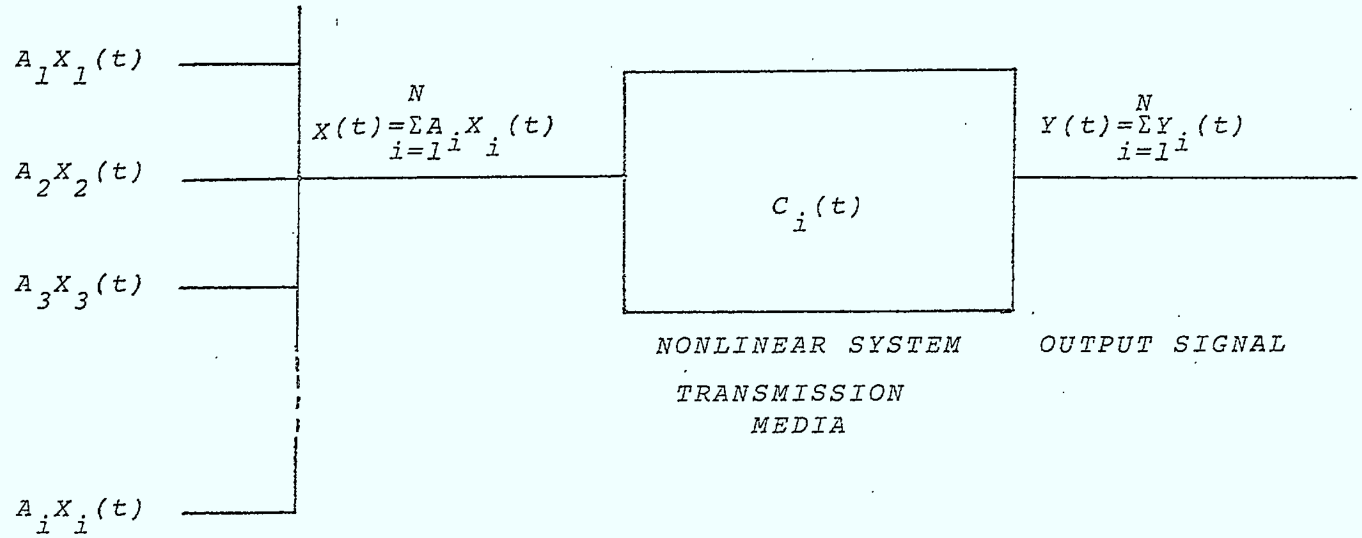


figure 1 - CATV SYSTEM MODEL

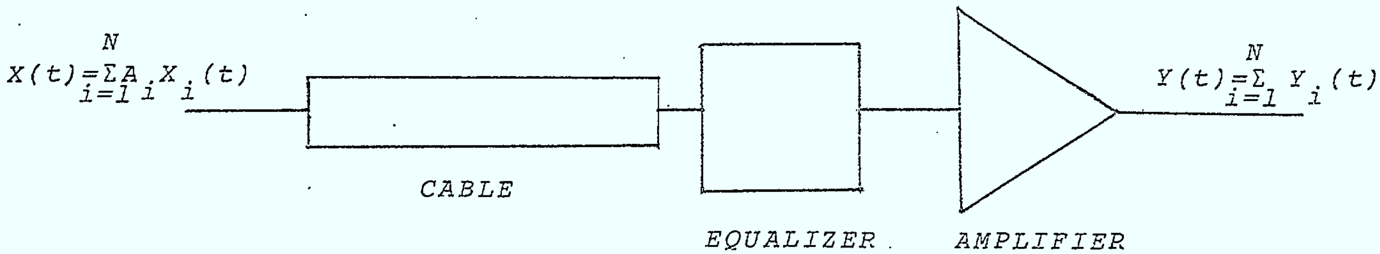


figure 2 - TYPICAL TRANSMISSION MEDIA ELEMENT

2.2.1 Distortion in Nonlinear CATV Systems

Assume that the nonlinear system in figure 1 is composed of cable, an equalizer and one amplifier as shown in figure 2. In this analysis assume that the CATV trunk system is designed so that the product of the amplifier gain , the cable and equalizer losses is unity. Also, the cable and equalizer are comprised of passive elements, and therefore, they do not contribute to any nonlinear distortion. In addition to these assumptions, assume that the transmission media is reasonably linear in phase-frequency relationship. In other words, there is no envelope delay distortion.

Since, the output signal $y(t)$ is dependent on the past history of the input signal, it can be represented by the Volterra series as follows:

$$y(t) = y_1(t) + y_2(t) + y_3(t) + y_4(t) + \text{---------} \; y_i(t) \qquad (1)$$

where

$$y_i(t) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \text{-----} \int Ci(\tau_1, \tau_2, \text{----} \tau_i) \; x(t-\tau_1) \; x(t-\tau_2) \text{---} \; x(t-\tau_i) \; d\tau_1 \; d\tau_2 \text{ --- } d\tau_i \qquad (2)$$

C_i - is a real-valued symmetric function of i real variables, and

$C_i(t_1, t_2, \text{---} t_i)$ - is a Volterra kernel.

2.2.1 (cont'd)

The system under analysis is assumed to be stable and the Fourier transform of the function $C_i(t_1,t_2,---,t_i)$ is given by:

$$C_i(f_1,f_2---f_i)= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}--\int_{-\infty}^{\infty} C_i(t_1,t_2, ---,t_i)\, exp(-j(W_i t_1 + W_2 t_2 + ---- W_i t_i)\, dt_1,dt_2, --- dt_i \quad (3)$$

The mathematical model will consider the first three terms of the Volterra series to be sufficient to describe the input/output transfer characteristics of the wide-band amplifier. Detailed discussion on the use of Volterra series can be found in [1-3]

The CATV input signals are complex in nature, and as such, they are very cumbersome to work with when determining the nonlinear distortion in terms of the system parameters. Because the limiting distortion in most CATV systems is caused by the intermodulation of the discrete-frequency components, it is reasonably accurate to consider the input signals to be composed of sinusoidal waveforms.

2.2.2 Single Amplifier Sinusoidal Response

Consider that the input signal to an amplifier is made up of individual composite video waveforms from different modulators. Assume that each modulator transmits an approximate sinusoidal waveform of amplitude A_i, frequency

2.2.2 (cont'd)

$W_i | 2\pi$, and phase ϕ_i. Unmodulated carrier signals only will be used in deriving the final equations. Nevertheless, the equations for the first video sidebands will be considered in the computer program. This approach can be taken since the position of the sidebands is known to be 15750Hz on either side of a picture carrier, and that its level differs from its picture carrier level by a constant. Thus, the input signal x(t) to the amplifier can be described as:

$$x(t) = \sum_{i=1}^{N} A_i \text{ Cos } (W_i t + \phi_i) \qquad (4)$$

where

$$1 \leqslant i \leqslant N$$

By substituting equation (4) into equation (2), the equations at the output of the amplifier can be determined by the first three terms of the Volterra series. These equations have been documented by several authors [3,4]. Nevertheless, the fundamental, second and third-order output equations of an amplifier can easily be derived from equations (2) and (3) and then reduced using the following identity:

$$\text{Cos } \beta = (e^{j\beta} + e^{-j\beta}) / 2 \qquad (5)$$

These equations have been derived and broken down into several categories as follows:

2.2.2 (cont'd)

<u>First Order Components:</u>

$$y_1(t) = \sum_{i=1}^{N} A_i \left| C_1(f_i) \right| Cos(W_i t + \phi_i + \theta_1) \qquad (6)$$

<u>Second Order Components:</u>

(i) DC Components

$$y_{2DC}(t) = \frac{1}{2} \sum_{i=1}^{N} A_i^2 \left| C_2(f_i - f_j) \right| Cos\theta_2 \qquad (7)$$

(ii) Second Harmonic Components

$$y_{2HC}(t) = \frac{1}{2} \sum_{i=1}^{N} A_i^2 \; C_2(f_i, f_i) \left| Cos(2W_i t + 2\phi_i + \theta_2) \right. \qquad (8)$$

(iii) Sum and Difference Components

$$y_{2SD}(t) = \sum_{i=2}^{N} \sum_{j=1}^{i-1} A_i A_j (\left| C_2(f_i, f_j) \right| Cos((W_i + W_j)t + \phi_i + \theta_j + \theta_2)$$

$$+ \left| C_2(f_i, -f_j) \right| Cos((W_i - W_j)t + \theta_i - \phi_j + \theta_2) \qquad (9)$$

Thus,

$$y_2(t) = y_{2DC}(t) + y_{2HC}(t) + y_{2SD}(t) \qquad (10)$$

<u>Third Order Components</u>

(i) Third Harmonic Components

$$y_{3HC}(t) = \frac{1}{4} \sum_{i=1}^{N} A_i^3 \left| C_3(f_i, f_i, f_i) \right. Cos(3W_i t + 3\phi_i + \theta_3 \qquad (11)$$

2.2.2 (cont'd)

(ii) Intermodulation Components

$$y_{3IC}(t) = \frac{3}{4} \sum_{i=1}^{N} \sum_{j=1}^{N} A_i \; A_j^2 \; \left| C_3(\pm f_i, f_j, f_j) \right| Cos((\pm W_i + 2W_j)t + (\pm\phi_i + 2\phi_j + \theta_3))$$

(12)

(iii) Triple Beat Components

$$y_{3TC}(t) = \frac{3}{2} \sum_{i=3}^{N} \sum_{j=2}^{i-2} \sum_{k=1}^{j-1} A_i A_j A_k \left| C_3(f_i, \pm f_j, \pm f_k) \right| Cos\,((W_i \pm W_j \pm W_k)t + (\phi_i \pm \phi_j \pm \phi_k) + \theta_3)$$

(13)

(iv) Self-Compression Components

$$y_{3SC}(t) = \frac{3}{4} \sum_{i=1}^{N} A_i^3 \left| C_3(f_i, f, -f_i) \right| Cos(W_i t + \phi_i + \theta_3)$$

(14)

(v) Cross-Compression Components

$$y_{3CC}(t) = \frac{3}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} A_i A_j^2 \left| C_3(f_i, f_j, -f_j) \right. Cos(W_i t + \phi_i + \theta_3)$$

(15)

Note that the phases θ_1, θ_2 and θ_3 are frequency-dependent and that they correspond to the phase angles of $C_1(f)$, $C_2(f_1, f_2)$ and $C_3(f_1, f_2, f_3)$ respectively.

The expression given in equations (6) to (15) can be used to calculate the power levels of the intermodulation products.

In order to calculate these products, the amplifier in use has to be characterized to obtain the values or expressions for $C_1(f_i)$, $C_2(f_i, \pm f_j)$ and $C_3(f_i, \pm f_j, \pm f_k)$. The transfer functions C_2 and C_3 depend on the forming frequencies, that is f_i, f_j & f_k. In other words, if the levels of C_2 and C_3 were measured using 2 or 3 discrete-frequencies respectively (f_i, f_j or f_i, f_j & f_k), they would be different. Therefore, for a large sample of f_i, f_j and f_k which form beats at one specific beat-frequency, we can define an average $\bar{C}_2$ and $\bar{C}_3$ with some associative standard deviations. The average $\bar{C}_2$ and $\bar{C}_3$ can then be regarded as single frequency-dependent on the beat-frequency f_b (see figure 3).

Where,

$$f_b \in (f_i, \pm f_j) \text{ for } i = 1, N : j = 1, N$$

and

$$f_b \in (f_i, \pm f_j, \pm f_k) \text{ for } i = 1, N : j = 1, N : k = 1, N \quad (16)$$

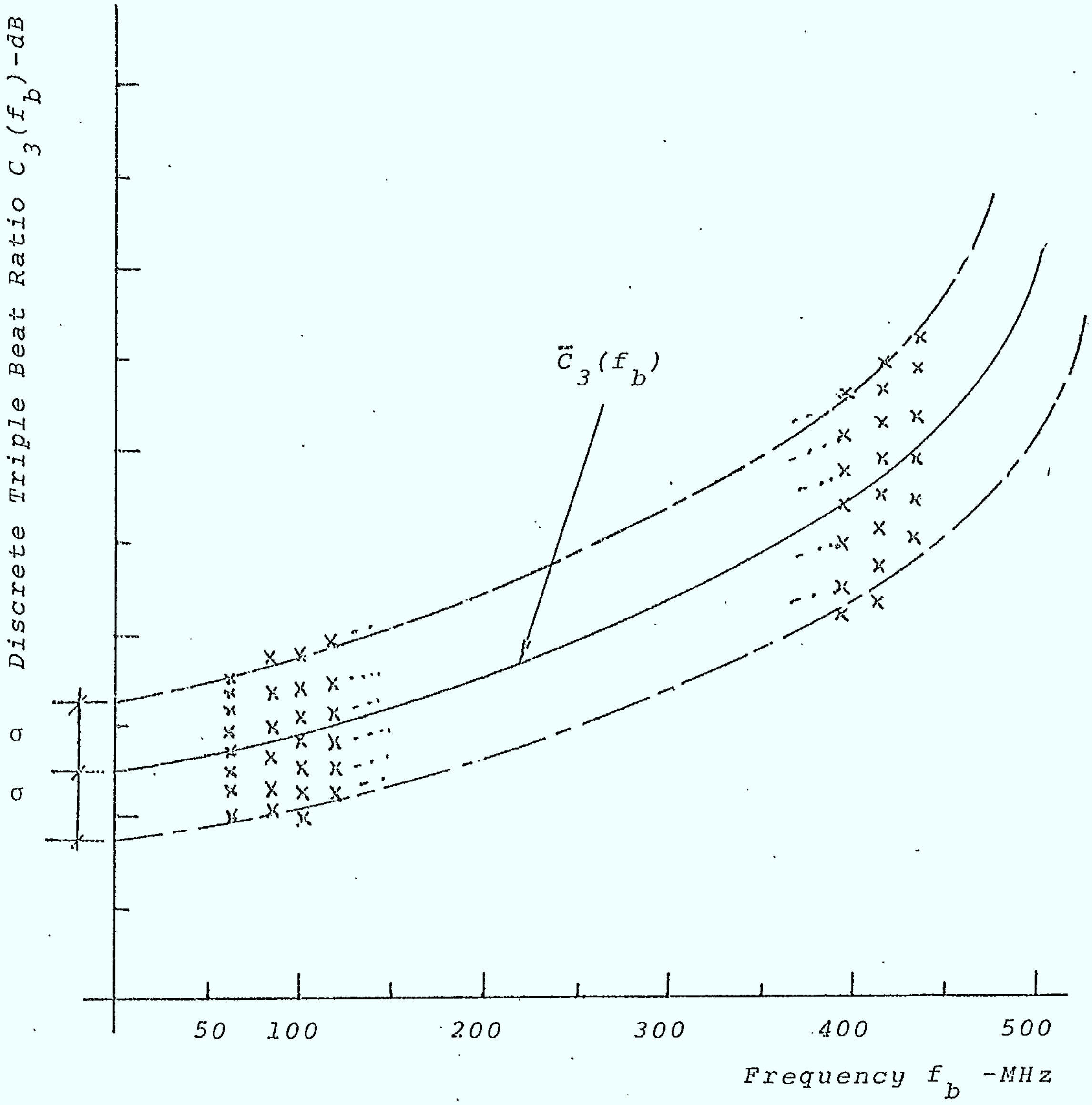


figure 3 - THIRD-ORDER TRANSFER FUNCTION $C_3(f_b)$ VS f_b

2.2.2 (cont'd)

The expression for figure 3 can be determined by measuring the amplifier's transfer functions $\bar{C}_2$ and $\bar{C}_3$. These are simply the second and third order discrete beats formed by passing two or three discrete-frequency components through the amplifier simultaneously. Thus, for a given amplifier's transfer characteristics, one can predict the individual beat levels. To determine the combined contribution of beat levels at any given beat frequency, we need to sum up all the individual beat levels. The type of addition we use in such a summation will depend on the kind of frequency-assignment system that has been analyzed.

In standard frequency-assignment systems the intermodulation products will add up on a power basis. For HRC and IRC systems, the intermodulation products are presumed theoretically to add up on a voltage basis.

2.3 Application to the Design of CATV Systems

Based on the previous statements, this type of distortion prediction becomes a very powerful tool in system design. In other words, given an amplifier, a system channel capacity, and a type of frequency assignment, one can predict the distribution of distortion in the system for various input level configurations. By using a computer to perform the predictions, answers can be obtained for system designs more rapidly and with reasonable accuracy.

2.3 (cont'd)

The relative level of intermodulation products in a CATV system can be calculated by using the following equations:

(a) For standard frequency-assignment systems:

(i) Second Order Products

$$B_2(f_b) = \bar{C}_2(f_b) + 10 \log (\# \text{ beats}) + 10 \log N + CF_L \quad (17)$$

(ii) Third-Order Products

$$B_3(f_b) = \bar{C}_3(f_b) + 10 \log (\# \text{ beats}) + 10 \log N + CF_L \quad (18)$$

$$B_3(f_b)^* = \bar{C}_3(f_b) + 10 \log (\# \text{ beats}) + 20 \log N + CF_L \quad (19)$$

* for beats falling on a picture carrier

(b) For HRC and IRC Systems

(i) Second-Order Products

$$B_2(f_b) = \bar{C}_2(f) + 20 \log (\# \text{ beats}) + 10 \log N + CF_L \quad (20)$$

(ii) Third-Order Products

$$B_3(f_b) = \bar{C}_3(f_b) + 20 \log (\# \text{ beats}) + 10 \log N + CF_L \quad (21)$$

2.3 (cont'd)

$$B_3(f_b)^* = \bar{C}_3(f_b) + 20 \log (\#\ beats) + 20 \log N + CF_L \quad (22)$$

* for beats falling on a picture carrier

Where,

$B_2(f_b)$, $B_3(f_b)$ - is the relative level (e.g. CBR for triple beat ratios)

$\bar{C}_2(f_b)$, $\bar{C}_3(f_b)$ - is the average transfer function value at a given beat frequency for a specified amplifier

\# beats - is the total number of beats falling at a given beat frequency

N - is the number of amplifiers in cascade

CF_L - is the design and $\bar{C}_2$ & $\bar{C}_3$ specification level correction factor

AMP. EVAL.

3.0 AMPLIFIER EVALUATIONS

Based on the mathematical developments from chapter 3, the transfer characteristics of different amplifiers can be measured. These transfer characteristics can be derived by measuring a reasonably large sample of second and third order discrete beats at different beat frequencies. Test procedures for measuring these types of CATV amplifier parameters have been developed and are well documented.

3.1 Second and Third Order Discrete Beats

The test set-up shown in Figure 4 is used for measuring the second and third order discrete beats and the composite beat ratios of any given CATV amplifier. It will be sufficient for our test purposes to measure one type of discrete beat using CW carriers on Dix-Hill generator. For example, the second-order discrete beats can be measured by turning on two discrete carriers on the Dix-Hill generator to form sum and difference products at a given beat-frequency. From this, the second harmonic discretes can be derived by applying the appropriate correction factor. The formation of second-order discrete beats is illustrated in example 1. Similarly, the third-order discrete beats can be measured by turning on three carrier frequencies which form a triple beat product at a beat-frequency. Thus, the third harmonic and the intermodulation discrete products can be determined by applying the required correction factor. The formation of third-order discrete beats is shown in example 2.

To obtain the amplifier's function, these discrete beats are measured at different beat-frequencies within the tested bandwidth. The measurements for this report were performed on 300 and 400 MHz amplifiers.

The second and third-order discrete beats were measured in the 54.00 - 408.00 MHz bandwidth. Several measurements of beat levels were recorded at each beat-frequency. Each beat-frequency was generated from different carrier frequencies with no repetition. All measurements were made using flat input level, and the amplifier in use was set for flat output gain with no slope. The input level and gain were set so that the second and third-order discrete beats could be measured on a spectrum analyzer, while ensuring that the amplifier was operating in the well-behaved range.

3.2 Measured Amplifier Data

Three different amplifier data measurements are included in this report, namely:

1) Starline 20/400 - 400 MHz trunk amplifier
2) Starline 300 - 300 MHz trunk amplifier
3) Scientific Atlanta 400 - 400 MHz line extender

The flatness response of the Starline 20/400 is shown in

Figure 5. The flatness from 50 - 420 MHz is ±0.25 dB. Table 3 shows the means and standard deviations of the discrete triple beat ratios for the Starline 20/400. A plot of the discrete triple beat ratios versus beat-frequencies is illustrated in Figure 6. Table 4 also shows the means and standard deviations of the discrete second-order beat ratios (sums and differences products) for Starline 20/400. A plot of the beat ratios versus beat-frequencies is given in Figure 7.

The flatness response of Starline 300 is shown in Figure 8. The flatness response from 50 - 330 MHz is ±.35 dB. The means and standard deviations of the discrete triple beat ratios are given in Table 5. A plot of the discrete triple beat ratios versus beat-frequencies is shown in Figure 9.

The flatness response from the Scientific Atlanta - 400 MHz line extender (LE) is ±1.5 dB from 50 - 350 MHz and rolls-off by 6 dB at 400 MHz. (See Figure 10) The means and standard deviations of the discrete triple beat ratios of the SA-400-LE are given in Table 6. A plot of the discrete triple beat ratios versus beat-frequencies is shown in Figure 11.

3.3 Data Analysis

Plots of the means (μ) and standard deviations (σ) of the discrete second and third-order beat ratios versus beat-frequencies for Starline 20/400, Starline 300 and SA-400 LE are given in Figures 6,7,9 and 11. A computer program was used to curve-fit a polynomial through the data points of Figures 6,7,9 and 11. The fitted function represents the $\bar{C}_2(f_b)$ and $\bar{C}_3(f_b)$ derived in chapter 2. Using least square fit the following equations were derived:

i) Starline 20/400

a) Second-order discrete beat ratio (sums and differences products)

$$\bar{C}_2(f_b) = -87.46 + 2.33 \times 10^{-1} f_b - 2 \times 10^{-3} f_b^2 + 7.35 \times 10^{-6} f_b^3 - 8.63 \times 10^{-9} f_b^4 - \quad (23)$$

At an output level = 47.75 dBmV

b) Third-order discrete beat ratio (Triple beat products)

$$\bar{C}_3(f_b) = -82.35 - 6.6 \times 10^{-2} f_b + 6.33 \times 10^{-4} f_b^2 - 1.85 \times 10^{-6} f_b^3 + 1.8 \times 10^{-9} f_b^4 - (24)$$

At an output level = 47.75 dBmV

ii) Starline 300 TR

Third-order discrete beat ratio (Triple beat products)

$$\bar{C}_3(f_b) = -90.28 + 1.9 \times 10^{-2} f_b + 4.8 \times 10^{-5} f_b^2 - (25)$$

At an output level = 46.75 dBmV

iii) Scientific Atlanta - 400 LE

Third-order discrete beat ratio (Triple beat products)

$$\bar{C}_3(f_b) = -76.95 - 1.31 \times 10^{-1} f_b + 8.6 \times 10^{-4} f_b^2 - 1.83 \times 10^{-6} f_b^3 + 1.37 \times 10^{-9} f_b^4 - (26)$$

At an output level = 48.0 dBmV

These equations represent the amplifier transfer characteristics. These equations will be used in the computer model to predict the intermodulation products for a CATV system which uses the same type of amplifiers as the ones characterized here. Since $\overline{C}_2(f_b)$ *and* $\overline{C}_3(f_b)$ *were the only unknown variables in equations 17 - 22, a computer program to predict* $B_2(f_b)$ *and* $B_3(f_b)$ *can now be written.*

DIAGRAMS

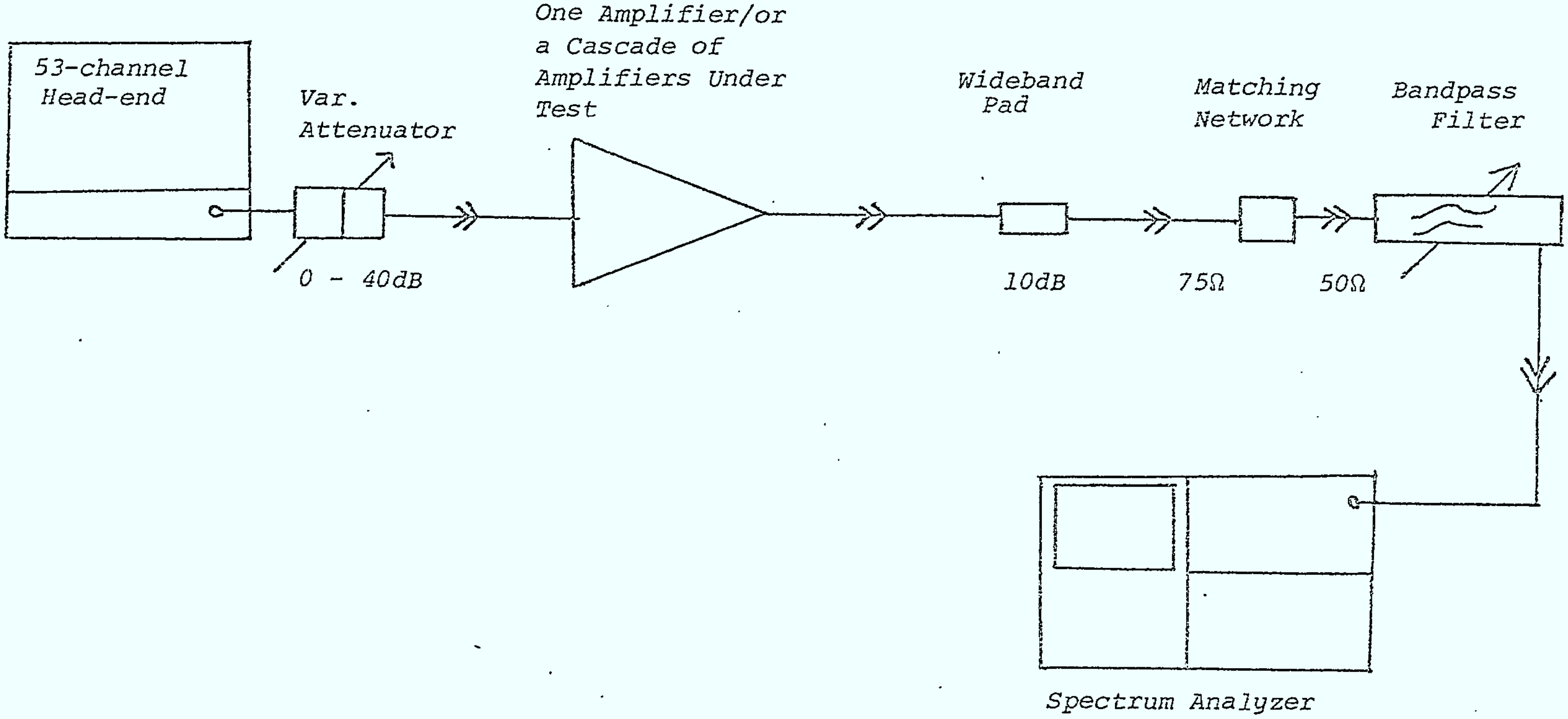


Figure 4 - Test Set-up for Measurement of Second, Third-Order Discrete and Composite Triple Beat Ratios.

Example 1

Formation of Second-Order Discrete Beats

The type of second order beats considered in this test are those of the form:

$$fb = f1 \pm f2$$

Where: fb - is the beat frequency

f1 & f2 - are picture carrier frequencies.

Table 1 - An example list of beat frequencies for discrete second-order products

An example of the beat frequencies for the discrete sencond-order beat ratios to be measured for this report are given below:

BEAT CHANNEL	BEAT FREQ. fb -MHz	f1 -MHz	f2 -MHz	Channel (f1)	Channel (f2)
2	54.00	121.25 181.25 295.25	67.25 127.25 241.25	A 8 W	4 B N
O	246.00	301.25 313.25 367.25	55.25 67.25 121.25	X Z M-9	2 4 A
W	294.00	349.25 361.25 355.25	55.25 67.25 61.25	M-6 M-8 M-7	2 4 3
M-14	398.50	121.25 169.25 193.25	277.25 229.25 205.25	A I 10	T L 12

Example 2

Formation of Third-Order Discrete Beats

Discrete third order beats of the triple beat type will be considered in this test. These are the beats formed by:

$$fb = f1 \pm f2 \pm f3$$

Where: fb - is the beat frequency

f1, f2 & f3 - are picture carrier frequencies.

Table 2 - An example list of beat frequencies for discrete third-order beat ratio

The following is an example of the frequencies required to form a triple beat:

BEAT CHANNEL	BEAT FREQ. fb-MHz	f1 MHz	f2 MHz	f3 MHz	CHANNEL (f1)	CHANNEL (f2)	CHANNEL (f3)
2	55.25	67.25 67.25 67.25	121.25 193.25 361.25	133.25 205.25 373.25	4 4 4	A 10 M-8	C 12 M-10
O	247.25	133.25 67.25 67.25	169.25 121.25 169.25	55.25 301.25 349.25	C 4 4	I A I	2 X M-6
W	295.25	121.25 55.25 169.25	229.25 145.25 193.25	55.25 385.25 67.25	A 2 I	L E 10	2 M-12 4
M-14	397.25	67.25 193.25 337.25	385.25 373.25 361.25	55.25 169.25 301.25	4 10 M-4	M-12 M-10 M-8	2 I X

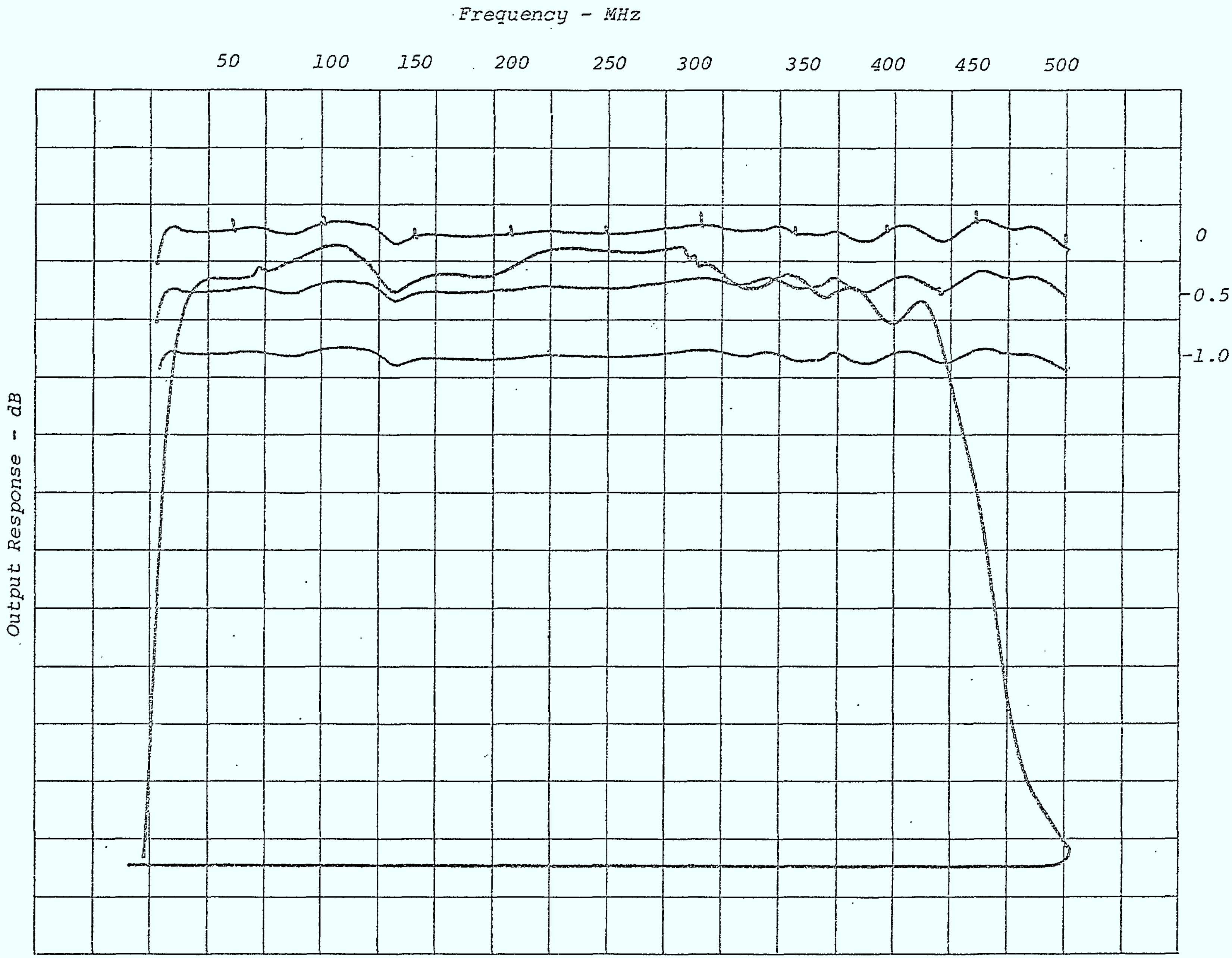


Figure 5-Frequency Response of Starline 20/400 Trunk Amplifier

DATE

BY P. Mambo &
A. Nancekivell

Table 3 - STARLINE 20/400MHz TRUNK AMPLIFIER

DISCRETE TRIPLE BEAT RATIO

SPECTRUM ANALYZER SETTINGS

BANDWIDTH: 3KHz

SCAN WIDTH: 20 KHz

SCAN TIME: 1 sec

VIDEO FILTER: 100 Hz

TEMPERATURE: 20°C
AMPLIFIER GAIN: 25.00

BEAT FREQUENCY - MHz	OUTPUT LEVEL - dBmV	DISCRETE BEAT PRODUCT RATIO - dB	
		MEAN	STD DEV
55.25	47.75	- 83.4	- 1.9
61.25		- 84.3	- 1.3
67.25		- 85.6	- 1.7
77.25		- 89.0	- 0.8
83.25		----	----
121.25	47.75	- 82.9	- 2.1
127.25		- 84.4	- 1.7
133.25		- 82.1	- 1.1
139.25		- 83.9	- 0.3
145.25		- 83.4	- 1.8
151.25		- 84.0	- 0.5
157.25	47.55	- 83.0	- 1.2
163.25		- 83.3	- 0.7
169.25		- 82.6	- 1.0
175.25		- 82.7	- 1.2
181.25		- 83.9	- 1.6
187.25		- 81.9	- 0.6
193.25		- 82.3	- 1.2
199.25	47.75	- 81.9	- 0.6
205.25		- 82.7	- 2.1
211.25		- 81.7	- 0.7
217.25		- 82.4	- 1.4
223.25		- 81.9	- 0.6
229.25		- 82.7	- 1.7
235.25		- 81.4	- 0.7
241.14		- 82.7	- 1.5
247.25		- 80.4	- 0.9
253.25	47.45	- 80.9	- 2.2
259.25		-80.6	- 1.2
265.25		- 82.1	- 2.0

BEAT FREQUENCY - MHz	OUTPUT LEVEL- - dBmV	DISCRETE BEAT PRODUCT RATIO - dB	
		MEAN	STD DEV
271.25		- 79.6	- 1.4
277.25		- 81.4	- 1.8
283.25		- 78.7	- 1.6
289.25		- 80.6	- 1.8
295.25	47.65	- 79.7	- 2.0
301.25		- 81.6	- 1.3
307.25		- 80.0	- 1.6
313.25		- 81.1	- 1.6
319.25		- 80.7	- 1.3
325.25	47.75	- 80.6	- 2.3
331.25		- 80.4	- 1.5
337.25		- 80.6	- 1.6
343.25		- 80.1	- 1.5
349.25		- 80.3	- 1.2
355.25		- 81.6	- 0.7
361.25	47.75	- 79.9	- 1.1
367.25		- 81.3	- 1.0
373.25		- 78.9	- 1.8
379.25		- 80.3	- 1.3
385.25		- 79.0	- 1.5
391.25		- 80.3	- 1.5
397.25		- 79.3	- 2.2
403.25	47.75	- 80.3	- 1.3

Figure 6- STARLINE 20/400 -TR - DISCRETE TRIBLE BEAT RATIO

OUTPUT LEVEL: 47.75 dBmV / GAIN: 25.0 dB / TEMP.: 20 DEG. C

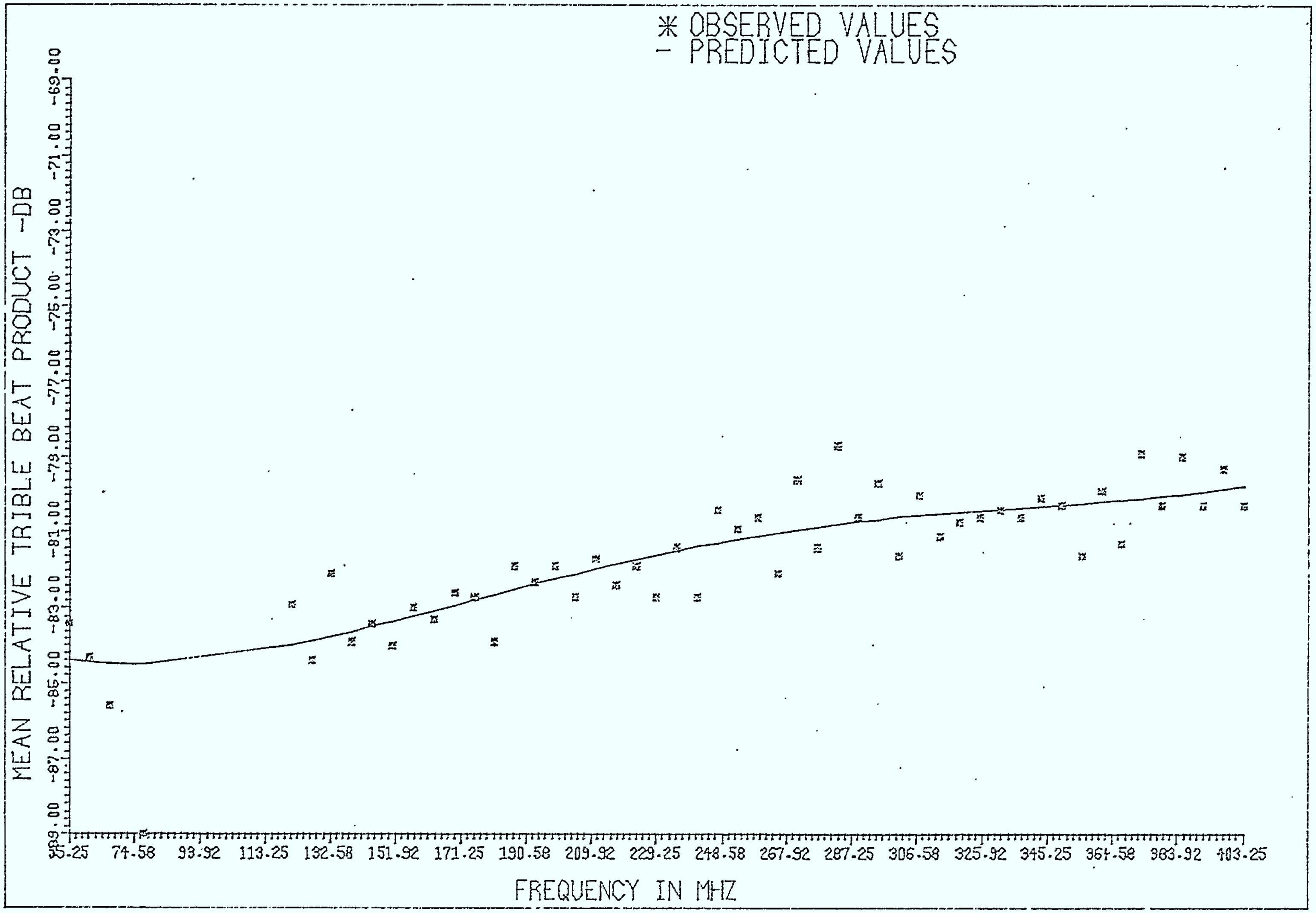


Table 4 - STARLINE 20/400 MHz TRUNK AMPLIFIER

DISCRETE - 2ND-ORDER PRODUCTS

SPECTRUM ANALYZER SETTINGS:

BANDWIDTH: 3KHz

SCAN WIDTH: 20KHz/DIV

SCAN TIME: 1 SEC/DIV

VIDEO FITTER: 100Hz

Temperature: 20°C
Amplifier gain: 25.00 dB

BEAT FREQ. - MHz	OUTPUT LEVEL	DISCRETE BEAT PRODUCT RATIO - dB 2nd Sum & Differences	
54.00	48.75	- 82.0	- 0.
60.00		- 78.9	- 2.2
66.00		- 78.0	- 1.0
72.00		- 76.7	- 0.7
78,00		- 78.5	- 0.5
84.00		-76.9	- 1.0
120.00		- 78.0	- 0.5
126.00		- 77.5	- 0.5
132.00		- 77.0	- 0.8
138.00		- 78.0	- 1.0
144.00		- 77.3	- 1.0
150.00		- 78.0	- 0.0
156.00		- 77.1	- 0.6
162.00		- 77.0	- 1.0
168.00		- 76.6	- 0.9
174.00		- 77.5	- 0.5
180.00		- 76.1	- 1.0
186.00		- 77.5	- 1.5
192.00		- 75.4	- 0.7
198.00		- 77.0	- 0.0
204.00		- 75.1	- 1.1
210.00		- 74.5	- 0.5
216.00		- 74.3	- 0.7
222.00		- 75.0	- 1.0
228.00		- 75.0	- 0.9
234.00		- 74.3	- 0.5
240.00		- 73.0	- 0.7
246.00		- 72.3	- 0.5
252.00		- 72.7	- 0.5
258.00		- 71.7	- 0.5

BEAT FREQUENCY - MHz	OUTPUT LEVEL - dBmV	DISCRETE BEAT PRODUCT RATIO dB	
264.00		- 70.7	- 0.5
270.00		- 71.3	- 0.5
276.00		- 70.7	- 0.5
282.00		- 71.7	- 0.5
288.00		- 71.0	- 0.8
294.00		- 71.0	- 0.8
300.00		- 70.7	- 0.5
306.00		- 70.3	- 0.5
312.00		- 69.0	- 0.0
318.00		- 67.7	- 0.5
324.00		- 66.7	- 0.5
330.00		- 66.7	- 0.5
336.00		- 65.3	- 0.5
342.00		- 63.5	- 0.5
348.00		- 63.0	- 0.0
356.50		- 64.3	- 0.5
362.50		- 65.8	- 0.7
368.50		- 64.0	- 0.8
374.50		- 65.6	- 0.5
380.50		- 65.7	- 1.2
386.50		-65.4	- 1.4
393.50		- 65.7	- 0.5
398.50		- 63.7	- 1.5
404.50		- 64.3	- 0.5

Figure 7-STARLINE 20/400 - DISCRETE 2ND SUM & DIFF. BEAT RATIO

OUTPUT LEVEL: 48.75 dBmV / GAIN: 25.0 dB / TEMP.: 20 DEG. C

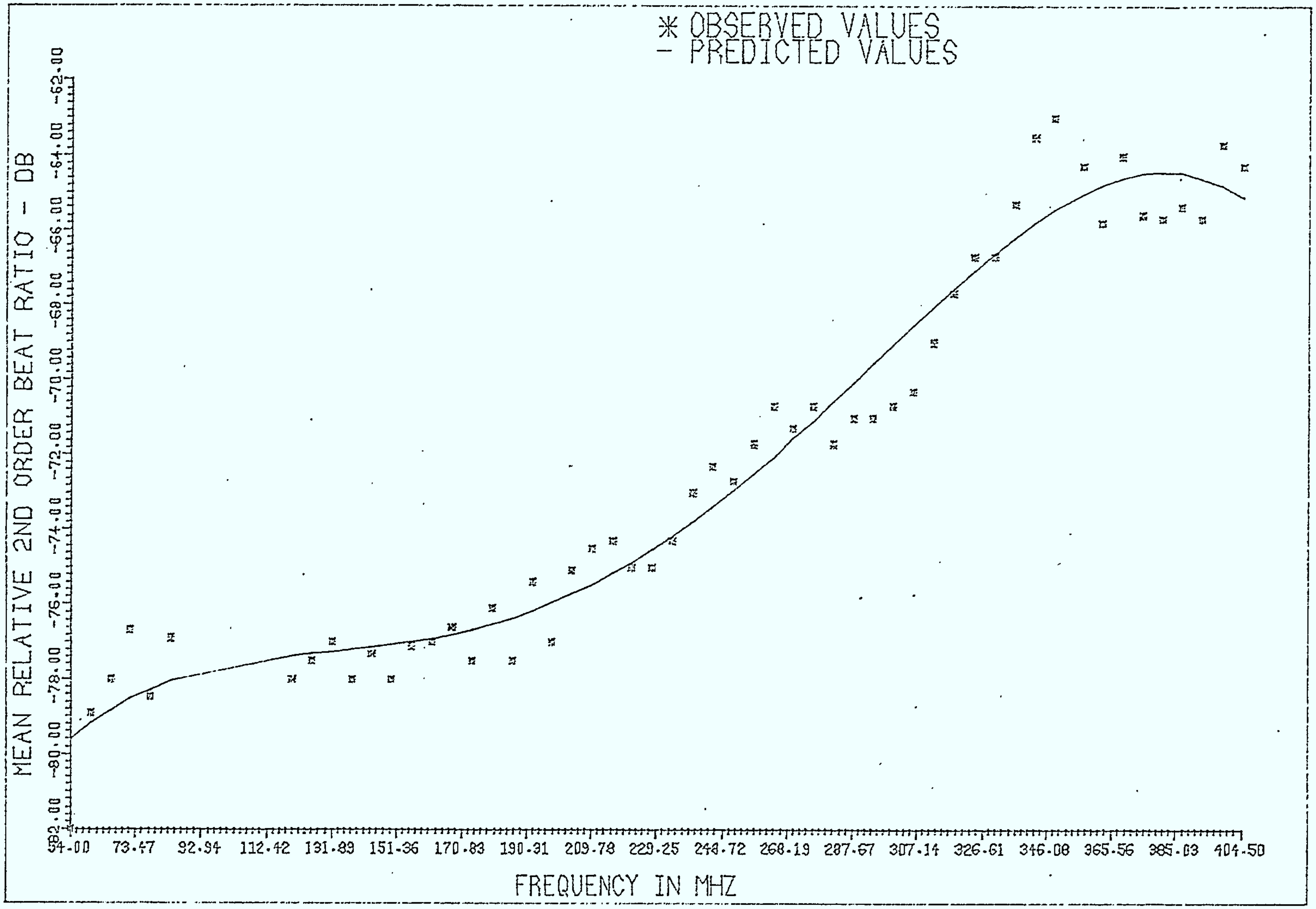


Figure 8 -Frequency Response of Starline 300 Trunk Amplifiers with Diplex Filters

DATE

BY P. Mambo & A. Nancekivell

Table 5 - Jerrold Starline - 300 Trunk Amplifier

Discrete Trible Beat Ratio - TBR

Spectrum Analyzer Settings:

BANDWIDTH: 3 KHz

SCAN WIDTH: 20 KHz/DIV

SCAN TIME: 1 SEC/DIV

VIDEO FILTER: 10 Hz

Temperature: 20° C

Amplifier Gain: 22.0 dB

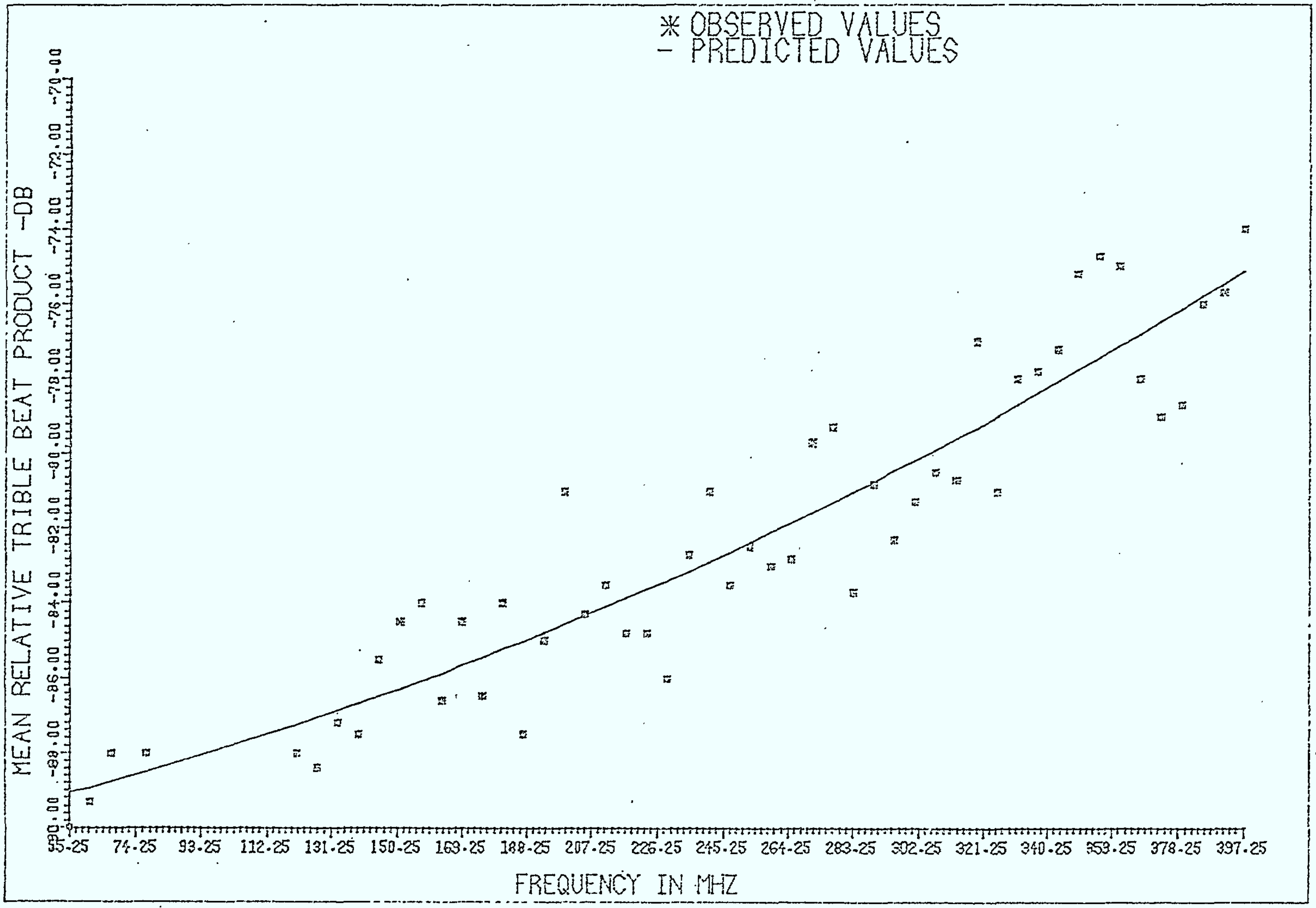
BEAT FREQUENCY - MHz	OUTPUT LEVEL - dBmV	DISCRETE TRIPLE BEAT RATIO - dB	
		MEAN	STD DEV.
55.25	46.15	-90.0	0.0
61.25		-89.3	.9
67.25		-88.0	2.0
77.25		-88.0	.8
83.25		---	---
121.25		-88.0	2.8
127.25		-88.4	1.7
133.25		-87.2	2.4
139.25		-87.5	2.6
145.25		-85.5	0.5
151.25		-84.5	2.5
157.25		-84.0	2.0
163.25		-86.6	2.3
169.25		-84.5	1.5
175.25		-86.5	1.5
181.25		-84.0	3.3
187.25		-87.5	2.5
193.25		-85.0	0.0
199.25		-81.0	2.0
205.25		-84.3	2.6
211.25	46.95	-83.5	2.5
217.25		-84.8	5.0
223.25		-84.8	4.8
229.25		-86.0	4.0
235.25		-82.7	2.5
241.25		-81.6	2.4
247.25		-83.5	3.2
253.25		-82.5	3.1

. . . /2

BEAT FREQUENCY - MHz	OUTPUT LEVEL - dBmV	DISCRETE TRIPLE BEAT RATIO - dB	
		MEAN	STD DEV.
259.25		-83.0	3.6
265.25		-82.8	3.8
271.25		-79.7	2.4
277.25		-79.3	2.6
283.25		-83.7	4.1
289.25		-80.8	1.5
295.25	46.75	-82.3	3.3
301.25		-81.3	3.6
307.25		-80.5	3.3
313.25		-80.7	4.5
319.25		-77.0	0.0
325.25		-81.0	0.0
331.25		-78.0	1.6
337.25		-77.8	0.8
343.25	46.75	-77.2	1.2
349.25		-75.2	1.0
355.25		-74.7	0.9
361.25		-75.0	1.0
367.25		-78.0	2.0
373.25		-79.0	3.0
379.25		-78.7	3.4
385.25		-76.0	2.8
391.25		-75.7	2.1
397.25		-74.0	0.0
403.25			

Figure 9-STARLINE-300 TRUNK AMPLIFIER - DISCRETE TRIBLE BEAT RATIO

OUTPUT LEVEL: 46.75 dBmV / GAIN: 22.0 dB / TEMP.: 20 DEG. C



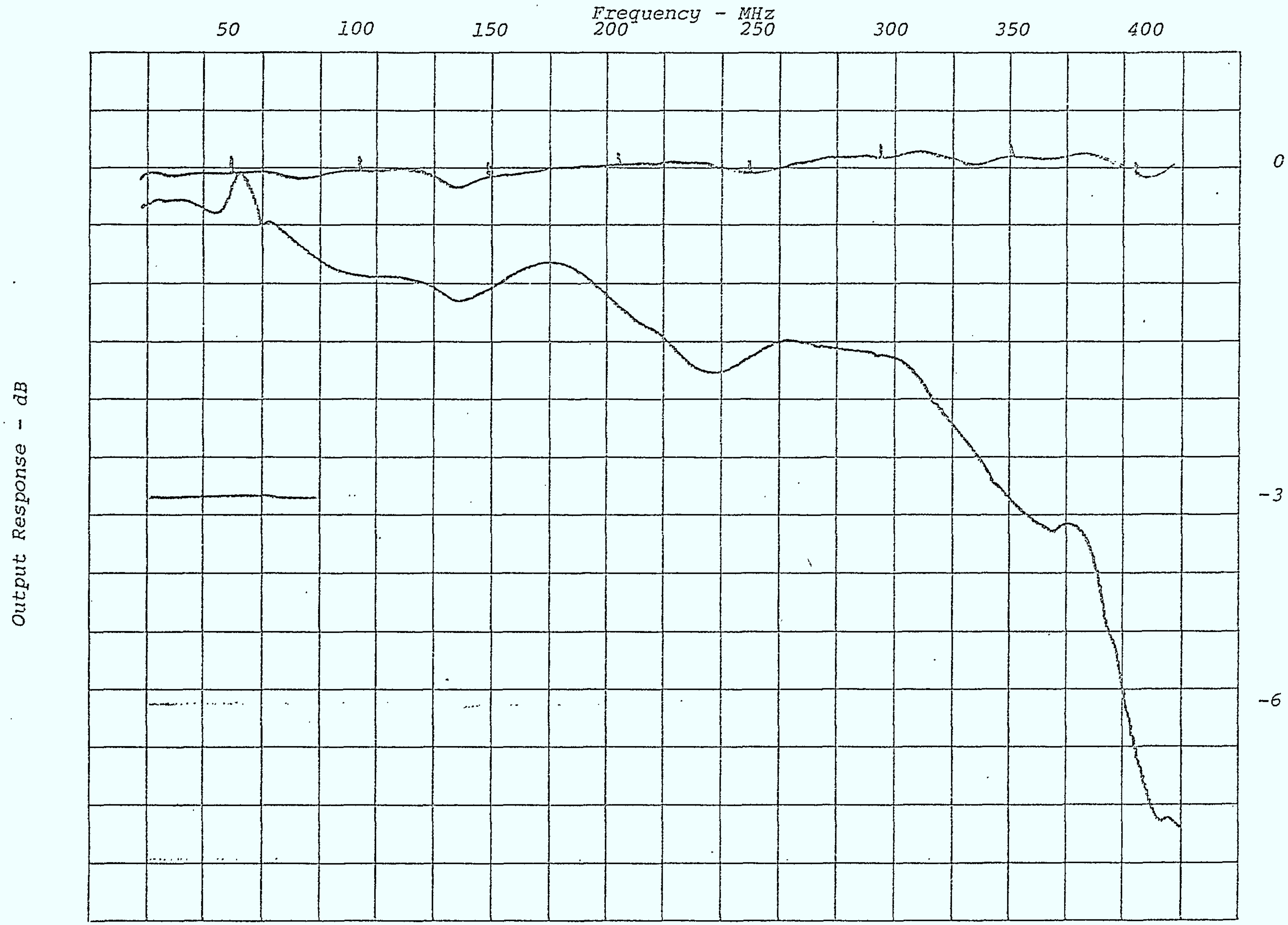


Figure 10 - Frequency Response of SA - 400 MHz - Line Extender Amplifier

DATE

BY P. Mambo & A. Nancekivell

Table 6-S. A. - 400 MHz - Line Extender Amplifier

Trible Beat Product Ratio - TBR - Discrete Beat

Spectrum Analyzer Settings:

Bandwidth: 3.0 KHz
Scan Width: 20 KHz
Scan Time: 1 Sec.
Video Filter: 100 Hz.

Amplifier Gain: 30.6 dB

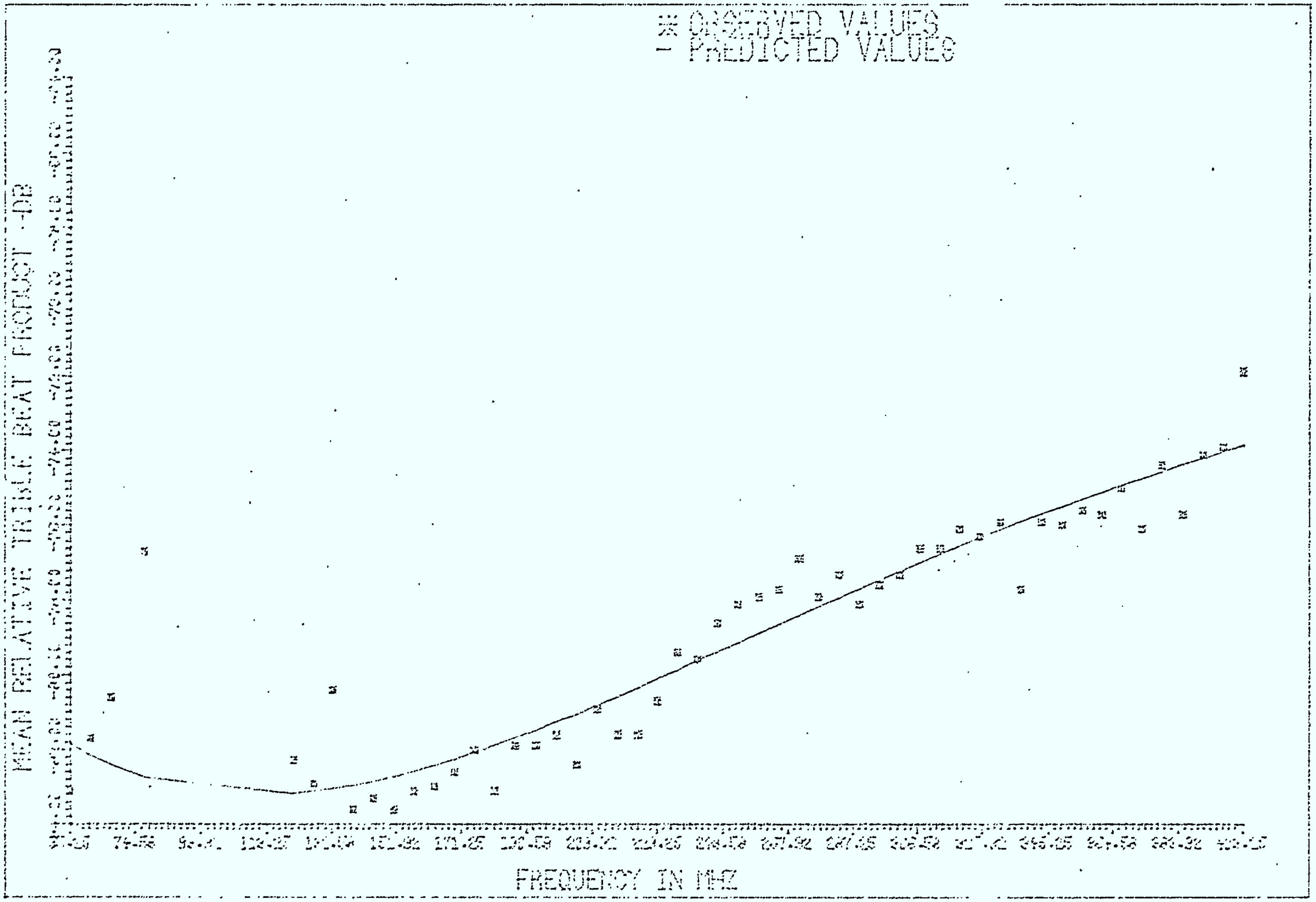
BEAT FREQUENCY -MHz	OUTPUT LEVEL -dBmV	DISCRETE TRIBLE - TBR - dB MEAN	BEAT RATIO STD - DEV
55.25	49.15	-83.1	0.8
61.25		-81.7	0.9
67.25		-80.6	1.0
77.25		-76.7	0.5
83.25		-	-
721.25	49.15	-82.3	1.2
727.25		-82.9	0.6
133.25		-80.4	1.2
139.25		-83.6	0.5
145.25		-83.3	0.9
151.25		-83.6	0.5
157.25		-83.1	0.6
163.25		-83.0	0.8
169.25	47.55	-82.6	0.7
175.25		-82.1	0.6
181.25		-83.1	1.0
187.25		-81.9	1.0
193.25		-81.9	0.3
199.25	47.75	-81.6	0.9
205.25		-82.4	0.7
211.25		-80.9	0.8
217.25		-81.6	0.7
223.25		-81.6	0.7
229.25		-80.7	0.7
235.25		-79.4	1.0
241.25	47.75	-79.6	0.5
247.25		-78.6	0.7
253.25		-78.1	0.6
259.25		-77.9	0.8
265.25		-77.7	0.5
271.25	46.95	-76.9	0.8
277.25		-77.9	0.8
283.25		-77.3	1.0
289.25		-78.1	1.4
295.25	48.25	-77.6	0.5
301.25		-77.3	1.0
307.25		-76.6	0.5
313.25	47.85	-76.6	0.5
319.25		-76.1	1.0

Cont'd.

325.25		-76.3	1.0
331.25		-75.9	0.6
337.25		-77.7	1.0
343.25	47.35	-75.9	0.6
349.25		-76.0	0.5
355.25		-75.6	0.9
361.25		-75.7	0.7
367.25		-75.0	1.3
373.25	46.25	-76.1	1.0
379.25		-74.4	1.3
385.25		-75.7	0.5
391.25		-74.1	1.2
397.25	43.05	-73.9	0.8
403.25	41.25	-71.9	0.8

Figure 11- SA-400 MHz LINE EXTENDER – DISCRETE TRIBLE BEAT RATIO

OUTPUT LEVEL: 48.0 dBmV / GAIN: 30.6 dB / TEMP.: 20 DEG. C



COMP. MODEL

4.0 COMPUTER MODEL

The main purpose of the computer model is to aid CATV system designers in predicting the composite beat ratio (CBR) and composite video beat ratio (CVBR) for different network configurations. It was demonstrated in chapter 2 that equations 17-22 are sufficient to predict the CBR of any given network configuration. However, two of the amplifier transfer functions defined in equations 17-22, $\bar{C}_2(f_b)$ and $\bar{C}_3(f_b)$ had to be determined first. This was accomplished in chapter 3.

Since every unknown in equations 17 to 22 has been defined or detemined, we can now define a computer model to accomplish our goal of predicting CBR and CVBR for different network configurations.

The computer model defined in this report took the following two points into consideration:

(i) simple input data requirements, and

(ii) useful output data generation

For versatility and computational efficiency, the Fortran-IV Language will be used.

4.1 Computer Model Topology

Since we are dealing with repetitive iterations, the computer model topology was arranged to achieve:

4.1 (cont'd)

(i) time effeciency,

(ii) cost effectiveness,

(iii) easy user interaction, and

(iv) useful output data presentation.

The computer model topology is shown in figure 12. Basically there are two programs, namely:

(i) - The Beat and Level Program, and

(ii) - The Graphical Program

The Beat and Level Program predicts the number of beats generated at each beat-frequency and predicts the corresponding CBR for a given network configuration. All the output data is stored in internally generated output files for later use. The data in the output files can be printed out or used in the Graphical Program to produce a graphical presentation of beat versus frequency and CBR versus frequency. Of course, to obtain any kind of output data at all one has to define the network being analyzed. This is done in the input files.

4.2 Beat and Level Program

The Beat and Level Program is the main program in the computer model. This program generates the different beats in a given network configuration and determines the corresponding CBR. The program has been structured so that the CPU time is minimized to reduce computation costs when high capacity channel systems are analyzed. The structure utilized is shown in the flowchart of figure 13.

4.2 (cont'd)

First, all the arrays and constants in the program are initialized automatically whenever the program is evoked. The second-order products are calculated next, in the following order:

1) - Second Harmonic products, and

2) - Sums and differences products.

The third-order products are calculated in the following order:

1) - Third Harmonic products,

2) - Intermodulation products, and

3) - Triple beat products.

The data generated at every beat-frequency is stored in arrays. A detailed explanation of the Beat and Level Program will not be given in this report as the final version is still in review. However, in the final project report, the program details will be provided. The input/output formats are explained in the following sections.

4.2.1 <u>Input Data Format</u>

For efficiency and cost reduction, the input data file is created before the main program is evoked. When the main program is evoked, an input file-name is requested. This name should be the actual filename containing the input data for the network under analysis.

4.2.1 (cont'd)

The input data format is shown in figure 14. The input data uses the fortran-IV free-format.

FILENAME EXT

<table>
<tr><td colspan="5">IFR, IVR, ICA, NL, NA, XM, XG,</td></tr>
<tr><td>F(1),</td><td>A(1),</td><td>XS(1),</td><td>IVD(1),</td><td></td></tr>
<tr><td>F(2),</td><td>A(2),</td><td>SX(2),</td><td>IVD(2),</td><td></td></tr>
<tr><td>F(3),</td><td>A(3),</td><td>XS(3),</td><td>IVD(3),</td><td></td></tr>
<tr><td>F(NL)</td><td>A(NL)</td><td>XS(NL)</td><td>IVD(NL)</td><td></td></tr>
</table>

Figure 14 - Input Data Format

The symbols in the input data files represent the following:

4.2.1 (cont'd)

IFR - When IFR = 1, it symbolizes that the network being analyzed is HRC or IRC. When IFR ≠ 1, the network under analysis is the standard frequency assignment system.

IVR - When IVR = 1, it means all the video sources in the HRC, or IRC system are gen-locked. If IVR ≠ 1, the video sources are not all gen-locked.

ICA - Takes the values, ICA = 1,2,3, -----N, where: 1,2,3, -----N - represents the type of amplifier being used in the network.

NL - Represents the total number of discrete frequency components in the system to be analyzed.

NA - Total number of cascade amplifiers in a given section.

XM - The modulation index, usually equals to .875 for CATV systems.

XG - The actual gain for which the amplifier is set.

F(i) - An array of the input discrete frequency components.

4.2.1 (cont'd)

A(i) - An array of the corresponding discrete input levels.

XS(i) - An array of the corresponding amount of input level supression.

IVD(i) - If the system being analyzed is HRC or IRC and IVD(i) = 1, then the carrier-frequency component is locked to the 6MHz comb. If IVD(i) ≠ 1, the oscillator is free-running.

4.2.2 <u>Output Data Format</u>

The data generated during run time are stored in arrays and at the end of computation time written into the output files. There are two sets of output files. The first set is for printed output purposes, and the second set is for the graphical program. In each output set there are CBR, and CVBR data. The output file format is shown in figure 15.

The output data generated is rearranged in increasing order from channel 2 to M15. In the final version of the program a sort routine will be included to sort the output data and to printout the worst channel.

4.3 Graphical Program

The graphical program is a secondary program in the computer model which presents the output data in a plot form. The input data to the graphical program is a modified version of the output data from the Beat and Level program.

The program uses a digital plotter to plot the number of beats and the CBR at the discrete beat-frequency components. The corresponding W-curve levels are plotted on the CBR versus frequency curves for comparison purposes.

4.4 Sample Results

The initial versions of the Beat and Level, and the Graphical Programs have been completed. The final version of the Beat and Level Program has been coded, but it must be debugged and tested. The initial versions of the computer programs have been tested.

The input data for a standard 12 channel system is shown in table 7. Starline 300 trunk amplifier was used for this analysis. The printed output data is given in tables 8 and 9. The graphical presentation of the output data is shown in figures 17-19. It should be noted that these results are based on the initial version of the computer program, and as such some parts of the proposed format may be lacking.

4.4 (cont'd)

Table 8 shows that there are no second-order products as would be expected for a 12 channel system. The worst case channel is 11 with a CBR of -79.34 at 30dBmV output level and a cascade of 20 amplifiers. The number of third-order beats at this channel is 21.

The accuracy of the computer prediction was also tested using the Starline 300 trunk amplifier. 35 channel CBR measurements on the Starline 300 were performed in the laboratory, and these are shown in Appendix A. Using the computer program, the CBR at the same gain, cascade and output level as the laboratory measurements was predicted. The computer predictions are shown in Appendix B. The accuracy of the computer predictions is approximately ± 1.5dB. This is quite acceptable since the amplifier transfer function, $\overline{C}_3(f_b)$, which was used in the computer program had a standard deviation of ± 2.0dB.

DIAGRAMS

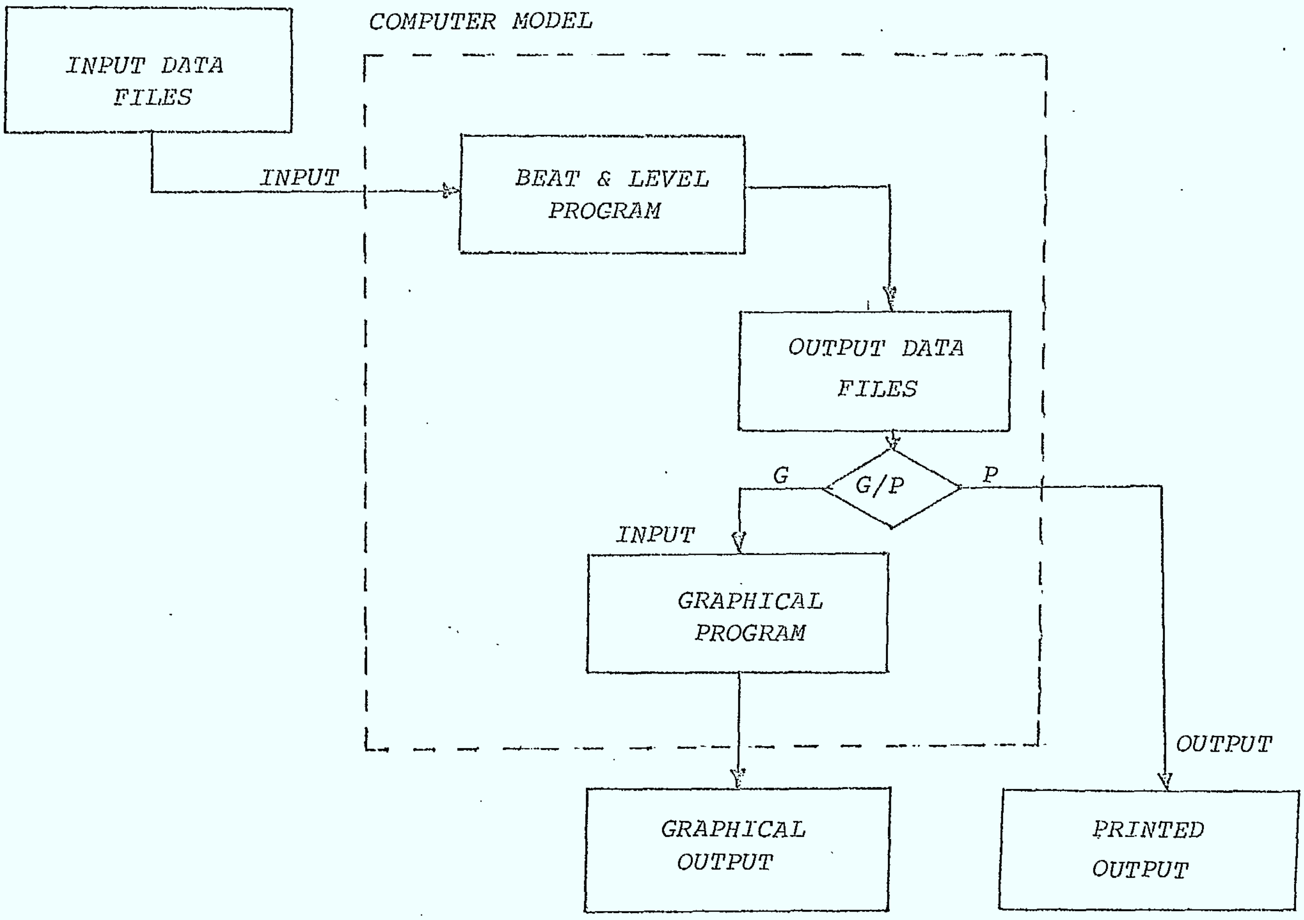


figure 12 - COMPUTER MODEL TOPOLOGY

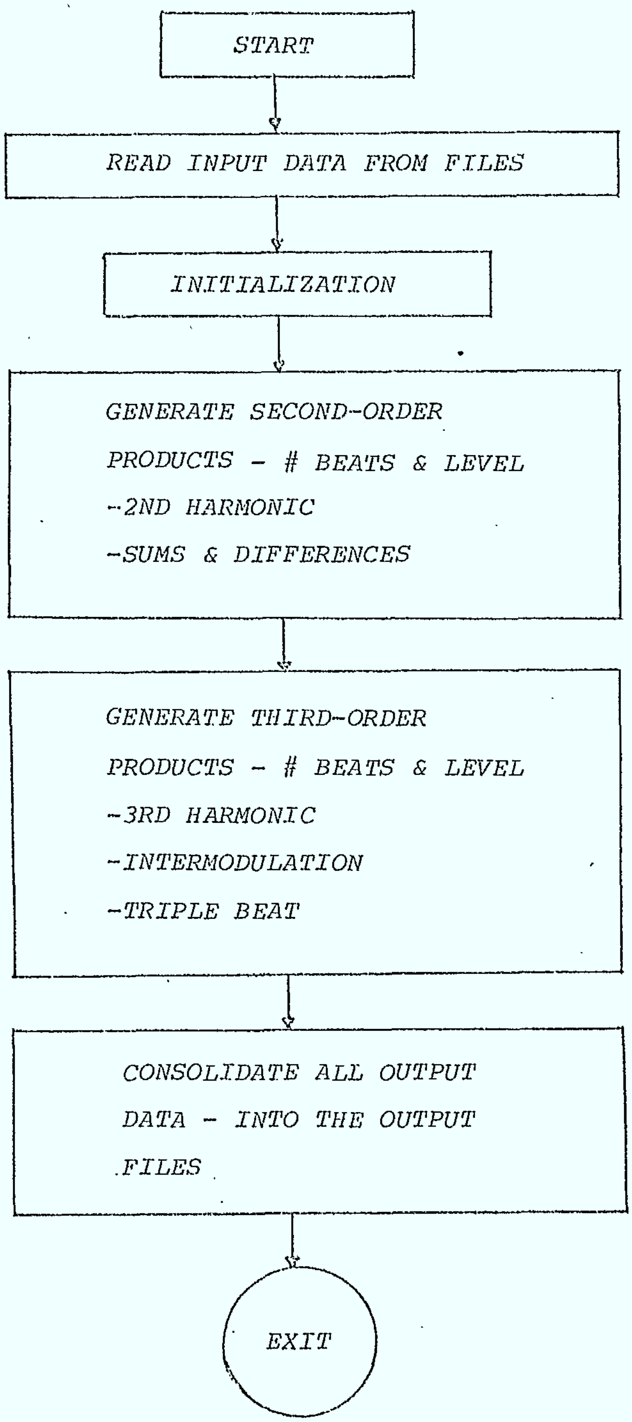


figure 13 - BEAT AND LEVEL PROGRAM FLOWCHART

FILENAME . EXT

(1) BEAT FREQUENCY -MHz	(2) 2ND ORDER		(3) 3RD ORDER		(4) 2ND & 3RD ORDER PRODUCTS		(5) W-CURVE RATIO -dB	(4)-(5) DIFFERENCE BETWEEN PRODUCTS & W-CURVE -dB
	# OF BEATS	RATIO -dB	# OF BEATS	RATIO -dB	# OF BEATS	RATIO -dB		
54.00	39	- 82.47	0	-150.00	39	- 82.47	-30.00	-52.47
54.75	0	-150.00	55	-102.45	55	-102.45	-48.00	-54.45
55.25	0	-150.00	435	- 93.62	435	- 93.62	-56.00	-37.62
56.00	2	- 95.22	0	-150.00	2	- 95.22	-56.00	-39.22
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
397.25	0	-150.00	589	- 87.76	589	- 87.76	-56.00	-31.76
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

figure 15 - OUTPUT FILE FORMAT

Table 7 - Input File

```
2,1,12,20,.875,20
55.25,10.0,0,61.25,10.,0,67.25,10.,0,77.25,10.,0,83.25,10.,0,175.25,10.
,0,181.25,10,0,187.25,10.,0,193.25,10.,0,199.25,10.0,0,205.25,10.,0,
211.25,10.0,0
```

(A)

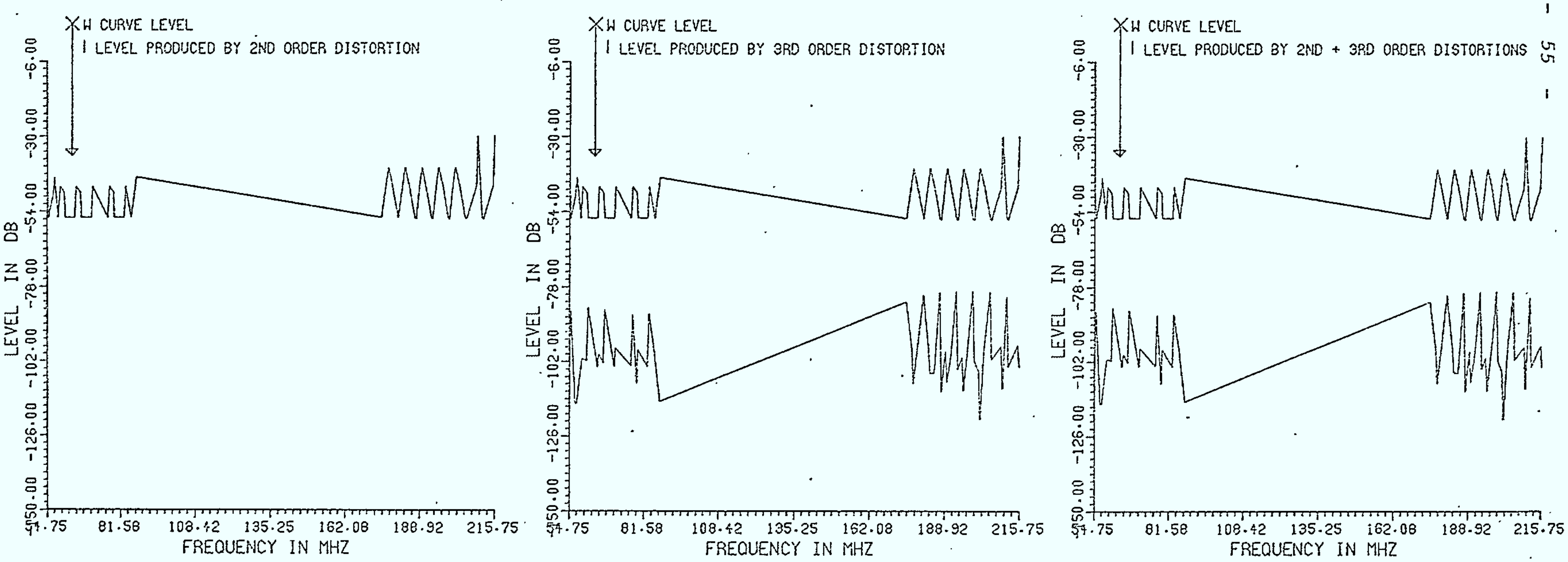
- *Unsuppressed Carrier - 12 Channels*
- *Jerrold Starline - 300TR*
- *CASCADE - 20 Amplifiers*
- *Gain: 20dB*
- *Input Level -10dBmV*

Table 8 - Output File - CBR

STANDARD 12 CHANNEL CARRIER BEATS

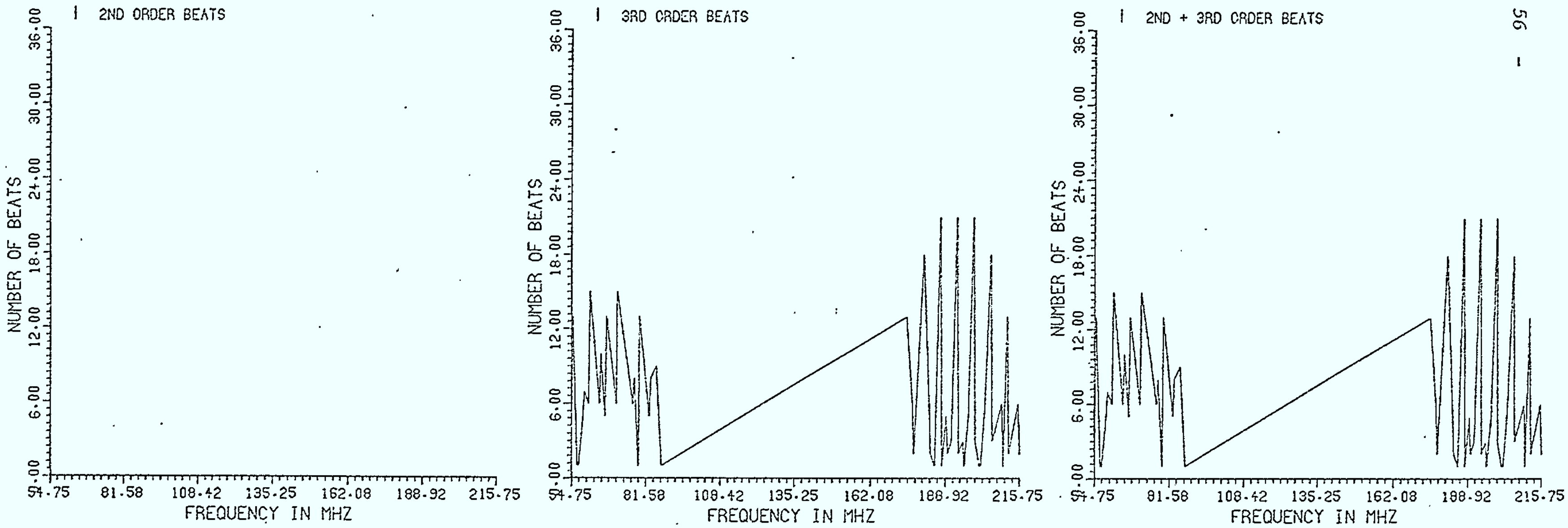
FREQUENCY	# 2ND ORD	LEVEL-DB	# 3RD ORD	LEVEL-DB	TOTAL # BEATS	TOTAL LEVEL-DB
51.75	0	-150.00	6	-101.80	6	-101.80
55.25	0	-150.00	13	-85.68	13	-85.68
56.75	0	-150.00	1	-115.54	1	-115.54
57.25	0	-150.00	1	-115.52	1	-115.52
58.75	0	-150.00	5	-104.04	5	-104.04
59.25	0	-150.00	7	-101.02	7	-101.02
60.75	0	-150.00	6	-101.66	6	-101.66
61.25	0	-150.00	15	-84.65	15	-84.65
64.75	0	-150.00	6	-103.59	6	-103.59
65.25	0	-150.00	10	-99.33	10	-99.33
66.75	0	-150.00	5	-102.30	5	-102.30
67.25	0	-150.00	13	-85.38	13	-85.38
70.75	0	-150.00	6	-103.44	6	-103.44
71.25	0	-150.00	15	-97.63	15	-97.63
76.75	0	-150.00	6	-103.28	6	-103.28
77.25	0	-150.00	8	-86.97	8	-86.97
78.75	0	-150.00	1	-108.98	1	-108.98
79.25	0	-150.00	13	-98.08	13	-98.08
82.75	0	-150.00	5	-103.43	5	-103.43
83.25	0	-150.00	8	-86.81	8	-86.81
85.25	0	-150.00	9	-99.26	9	-99.26
87.25	0	-150.00	1	-114.75	1	-114.75
175.25	0	-150.00	13	-82.64	13	-82.64
177.25	0	-150.00	6	-98.11	6	-98.11
177.75	0	-150.00	2	-108.87	2	-108.87
181.25	0	-150.00	18	-80.56	18	-80.56
183.25	0	-150.00	6	-97.89	6	-97.89
183.75	0	-150.00	2	-105.54	2	-105.54
185.25	0	-150.00	1	-105.60	1	-105.60
187.25	0	-150.00	21	-79.79	21	-79.79
187.75	0	-150.00	1	-111.51	1	-111.51
189.25	0	-150.00	5	-98.47	5	-98.47
189.75	0	-150.00	2	-108.43	2	-108.43
191.25	0	-150.00	3	-100.61	3	-100.61
193.25	0	-150.00	21	-79.39	21	-79.39
193.75	0	-150.00	2	-104.31	2	-104.31
195.25	0	-150.00	3	-100.46	3	-100.46
195.75	0	-150.00	1	-111.21	1	-111.21
197.25	0	-150.00	5	-98.16	5	-98.16
199.25	0	-150.00	21	-79.34	21	-79.34
199.75	0	-150.00	3	-101.54	3	-101.54
201.25	0	-150.00	1	-105.00	1	-105.00
201.75	0	-150.00	1	-120.48	1	-120.48
203.25	0	-150.00	6	-97.14	6	-97.14
205.25	0	-150.00	18	-79.66	18	-79.66
205.75	0	-150.00	3	-101.30	3	-101.30
209.25	0	-150.00	6	-96.91	6	-96.91
209.75	0	-150.00	1	-110.67	1	-110.67
211.25	0	-150.00	13	-81.29	13	-81.29
211.75	0	-150.00	2	-103.62	2	-103.62
215.25	0	-150.00	6	-96.67	6	-96.67
215.75	0	-150.00	2	-103.46	2	-103.46

Figure 16 - STANDARD 12 CHANNEL CARRIER BEATS



DISTORTION LEVEL IN DB VS. FREQUENCY

Figure 17 - STANDARD 12 CHANNEL CARRIER BEATS



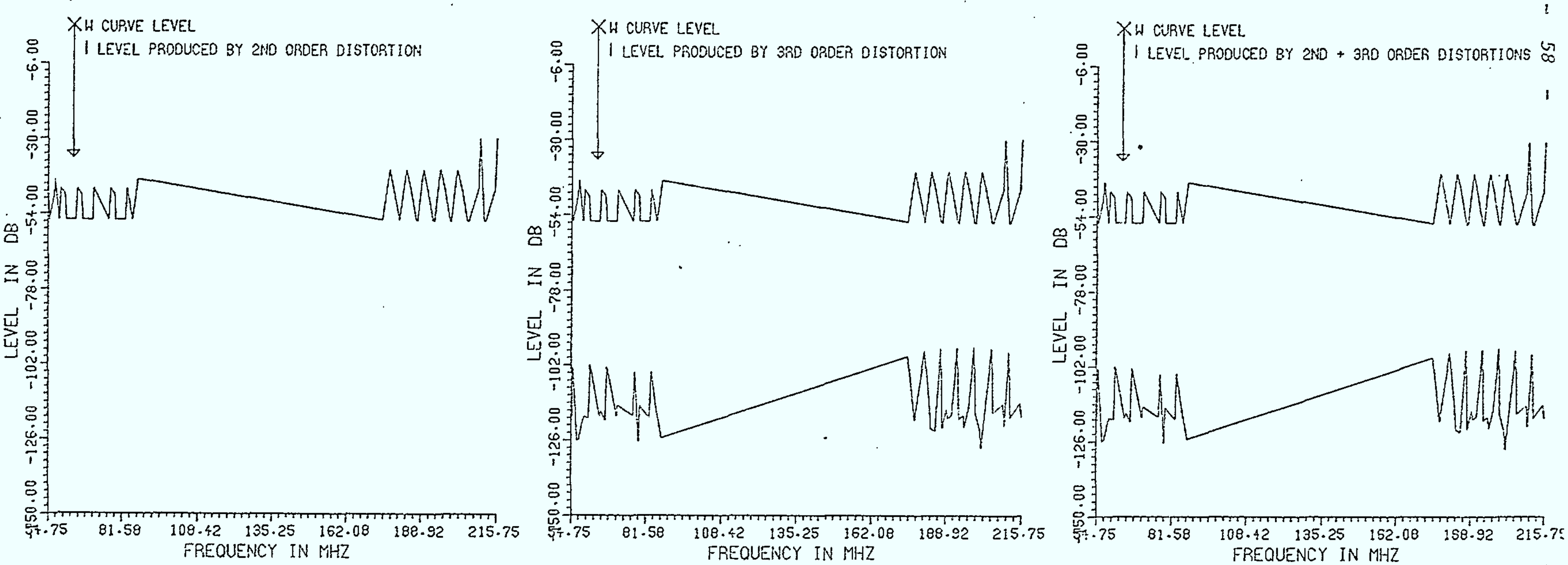
NUMBER OF BEATS VS. FREQUENCY

Table 9 - Output File - CVBR

STANDARD 12 CHANNEL VIDEO BEATS

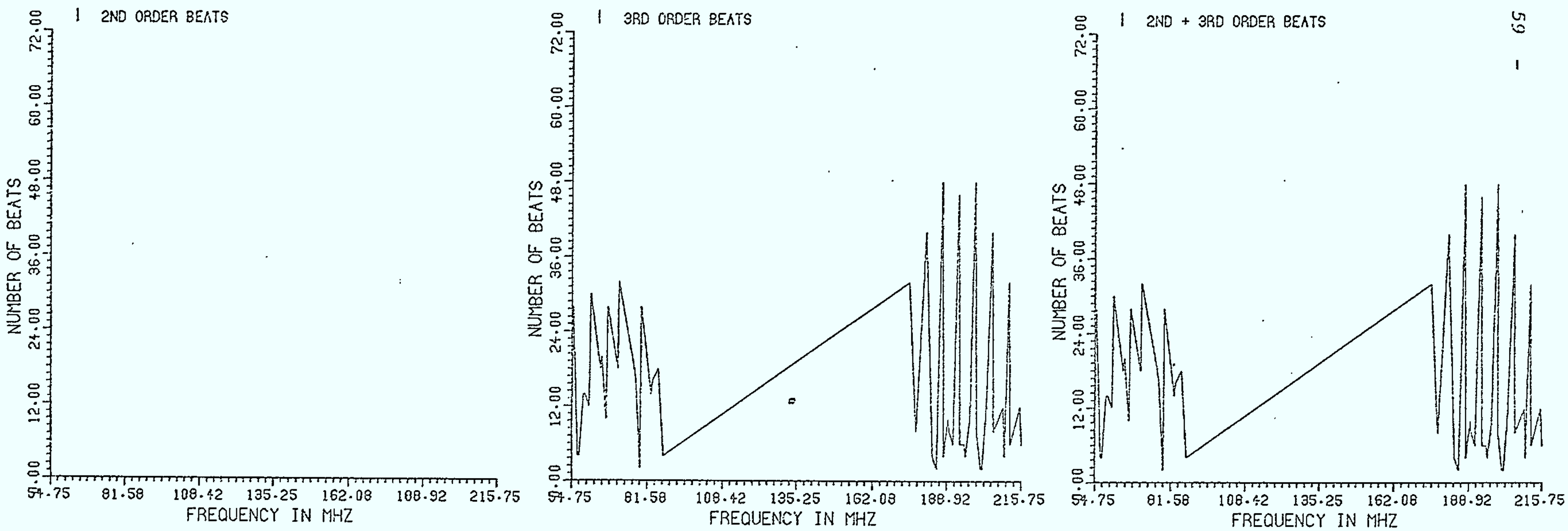
FREQUENCY	# 2ND ORD	LEVEL-DB	# 3RD ORD	LEVEL-DB	TOTAL # BEATS	TOTAL LEVEL-DB
54.75	0	-150.00	12	-119.16	12	-119.16
55.25	0	-150.00	28	-102.70	28	-102.70
56.75	0	-150.00	4	-125.96	4	-125.95
57.25	0	-150.00	4	-125.95	4	-125.93
58.75	0	-150.00	14	-119.46	14	-119.46
59.25	0	-150.00	14	-118.38	14	-118.38
60.75	0	-150.00	12	-119.02	12	-119.01
61.25	0	-150.00	30	-102.01	30	-102.01
64.75	0	-150.00	18	-118.42	18	-118.42
65.25	0	-150.00	20	-116.69	20	-116.68
66.75	0	-150.00	10	-119.66	10	-119.65
67.25	0	-150.00	28	-102.41	28	-102.41
70.75	0	-150.00	18	-118.27	18	-118.27
71.25	0	-150.00	32	-114.70	32	-114.70
76.75	0	-150.00	18	-118.12	18	-118.11
77.25	0	-150.00	16	-104.33	16	-104.33
78.75	0	-150.00	2	-126.34	2	-126.32
79.25	0	-150.00	28	-115.10	28	-115.10
82.75	0	-150.00	14	-118.84	14	-118.84
83.25	0	-150.00	16	-104.17	16	-104.17
85.25	0	-150.00	18	-116.62	18	-116.62
87.25	0	-150.00	4	-125.17	4	-125.16
175.25	0	-150.00	32	-98.94	32	-98.94
177.25	0	-150.00	12	-115.47	12	-115.47
177.75	0	-150.00	8	-119.29	8	-119.29
181.25	0	-150.00	40	-97.43	40	-97.43
183.25	0	-150.00	12	-115.25	12	-115.25
183.75	0	-150.00	4	-122.05	4	-122.05
185.25	0	-150.00	2	-122.96	2	-122.95
187.25	0	-150.00	48	-96.51	48	-96.51
187.75	0	-150.00	4	-121.94	4	-121.93
189.25	0	-150.00	10	-115.82	10	-115.82
189.75	0	-150.00	8	-118.85	8	-118.85
191.25	0	-150.00	6	-117.97	6	-117.97
193.25	0	-150.00	46	-96.33	46	-96.33
193.75	0	-150.00	6	-119.14	6	-119.14
195.25	0	-150.00	6	-117.82	6	-117.82
195.75	0	-150.00	4	-121.64	4	-121.63
197.25	0	-150.00	10	-115.52	10	-115.52
199.25	0	-150.00	48	-96.06	48	-96.06
199.75	0	-150.00	8	-117.31	8	-117.31
201.25	0	-150.00	2	-122.36	2	-122.35
201.75	0	-150.00	2	-128.38	2	-128.35
203.25	0	-150.00	12	-114.50	12	-114.50
205.25	0	-150.00	40	-96.53	40	-96.53
205.75	0	-150.00	8	-117.08	8	-117.08
209.25	0	-150.00	12	-114.27	12	-114.27
209.75	0	-150.00	4	-121.10	4	-121.09
211.25	0	-150.00	32	-97.59	32	-97.59
211.75	0	-150.00	6	-118.45	6	-118.45
215.25	0	-150.00	12	-114.03	12	-114.03
215.75	0	-150.00	6	-118.29	6	-118.29

Figure 18 - STANDARD 12 CHANNEL VIDEO BEATS



DISTORTION LEVEL IN DB VS. FREQUENCY

Figure 19 - STANDARD 12 CHANNEL VIDEO BEATS



NUMBER OF BEATS VS. FREQUENCY

CONCLUSIONS

5.0 CONCLUSIONS

The introduction of this report outlined the main objectives of this study. The report has clearly indicated that a greater percentage of these objectives has been fulfilled. Undoubtedly, by the time we issue the final report, all the set objectives will have been realized. The results obtained so far in this project are extremely useful and powerful for CATV system design. The initial computer program has been used to predict system specifications for different network configurations. The answers obtained so far have been quite accurate.

The conclusions from this study can be summarized as follows:

1) *the expressions for calculating second and third order products in CATV systems have been derived and broken down into simple parts for easy application in computer programs.*
2) *Three different amplifiers have been characterized in terms of the transfer functions derived in (1).*
3) *Using the expressions derived in (1) and the amplifier characteristic functions determined in (2), a computer program has been written which predicts the number of beats and their relative level in a given CATV system network configuration.*

5.0 (cont'd)

4) The predicted data has been shown to be very close to the measurements made in the laboratory.

REFERENCES

[1] E. Bredrosian and S.O. Rice, "The output properties of Volterra Systems (nonlinear systems with memory) driven by harmonic and Gaussian inputs", Proc. IEEE, Vol. 59, pp. 1688-1707, December, 1971.

[2] D.A. George, "Continuous nonlinear systems". Research Lab. of Electronics, Mass. Inst. Technology, Cambridge, Tech. Rep. 355, July 22, 1959.

[3] K.Y. Chang, "Intermodulation noise and products due to frequency-dependent nonlinearities in CATV systems", IEEE Transactions on Comm., vol. com-23, no. 1, pp. 142-155, January, 1975.

[4] A. Prochazka, "Cascading of distortion in CATV trunk line", IEEE Transactions on Broadcasting, vol. BC-20, no. 2, June, 1974.

[5] A. Prochazka, "Multichannel cross modulation in CATV Amplifier", IEEE Transactions on Broadcasting, vol. BC-20, no. 3, Semptember, 1974.

[6] R.G. Meyer, R. Eschenbach and W.M. Edgerley, "A wide-band feedforward amplifier", IEEE Journal of Solid-State Circuits, vol. SC-9, no. 6, December, 1974.

APPENDIX A

APPENDIX A

Laboratory Measurements

The composite triple Beat Ratios (CBR) for 35 and 53 channel systems are presented in this Appendix. These measurements were performed using CW carriers on a Dix-Hill Generator. The input into the amplifiers was flat with no slope. The flatness response of the Starline 300 and Starline 20/400 trunk amplifiers is ± .35 and ±.25dB respectively for the frequency range of 50-330MHz and of 50-420MHz. The flatness response of the SA-400 line extender is ±1.5dB for the frequency range of 50-350MHz and rolls off by 6dB at 400MHz.

The following amplifier results are presented:

1) Starline 20/400 - trunk amplifier

2) Starline 300 - trunk amplifier

3) SA-400 - line extender

STARLINE 20/400 - TRUNK AMPLIFIER

COMPOSITE TRIPLE BEAT RATIO - CBR

SPECTRUM ANALYZER SETTINGS:

BANDWIDTH: 30 KHz

SCAN WIDTH: 100 KHz / DIV

SCAN TIME: 0.1 SEC / DIV

VIDEO FILTER: 100 Hz

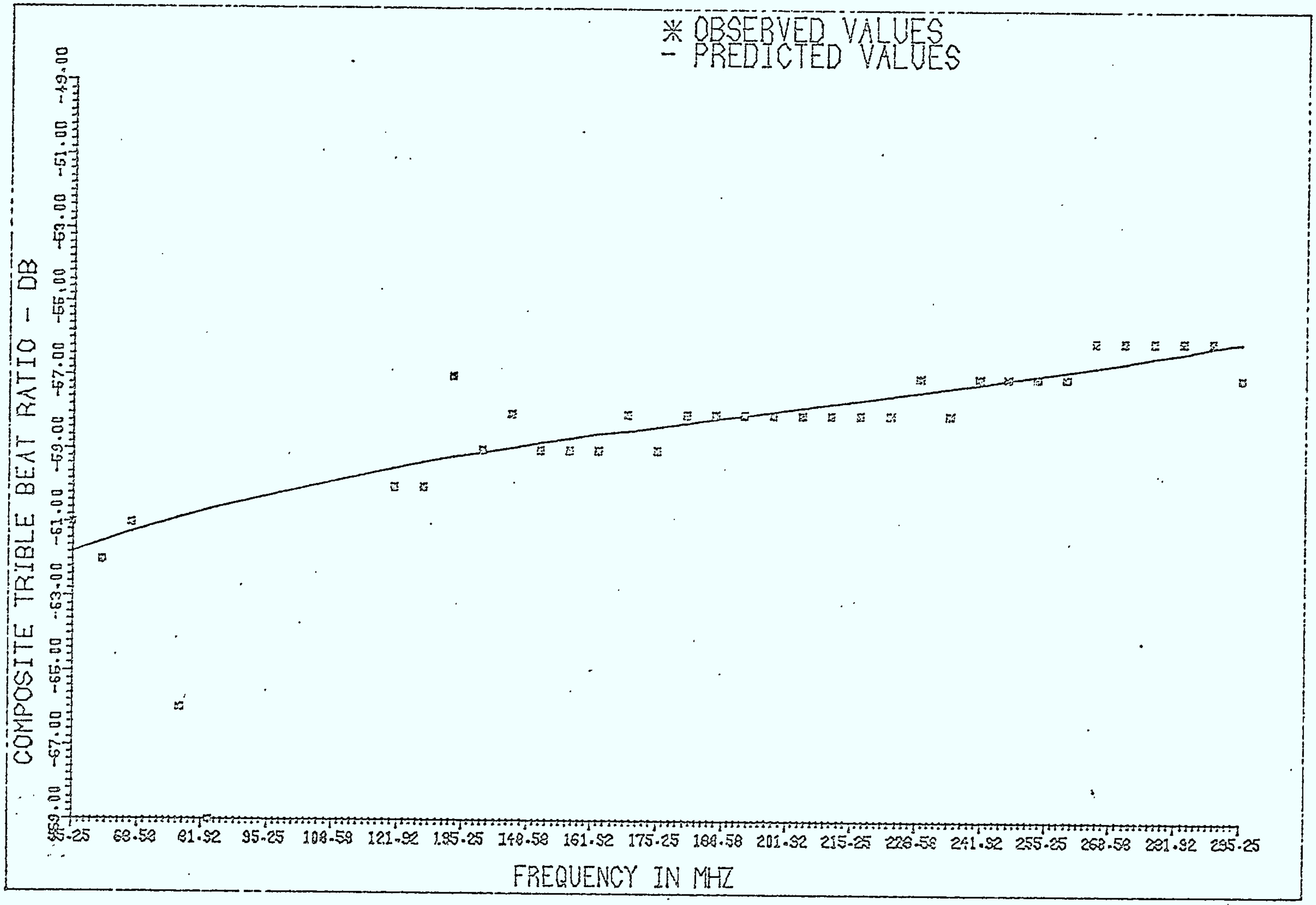
Temperature: 20°C
Amplifier Gain: 25.0 dB

BEAT FREQ. - MHz	OUTPUT LEVEL - dBmV	35 CHANNEL - CBR dB	53 CHANNEL - CBR dB
55.25	48.75	- 61.0	- 58.0
61.25		- 62.0	- 58.0
67.25		- 61.0	- 58.0
77.25		- 66.0	- 64.0
83.25		- 69.0	- 68.0
121.25		- 60.0	- 56.0
127.25		- 60.0	- 56.0
133.25		- 57.0	- 53.0
139.25		- 59.0	- 56.0
145.25		- 58.0	- 55.0
151.25		- 59.0	- 55.0
157.25		- 59.0	- 55.0
163.25		- 59.0	- 54.0
169.25		- 58.0	- 54.0
175.25		- 59.0	- 53.0
181.25		- 58.0	- 54.0
187.25		- 58.0	- 53.0
193.25		- 58.0	- 52.0
199.25		- 58.0	- 52.0
205.25		- 58.0	- 52.0
211.25		- 58.0	- 51.0
217.25		- 58.0	- 51.0
223.25		- 58.0	- 51.0
229.25		- 57.0	- 50.0
235.25		- 58.0	- 50.0
241.25		- 57.0	- 50.0
247.25		- 57.0	- 50.0
253. 25		- 57.0	- 50.0
259.25		- 57.0	- 49.0
265.25		- 56.0	- 49.0
271.25		- 56.0	- 48.0

BEAT FREQ. - MHz .	OUTPUT LEVEL - dBmV	35 CHANNEL - CBR dB	53 CHANNEL - CBR dB
277.25		- 56.0	- 48.0
283.25		- 56.0	- 48.0
289.25		- 56.0	- 48.0
295.25		- 57.0	- 48.0
301.25			- 49.0
307.25			- 49.0
313.25			- 50.0
319.25			- 49.0
325.25			- 49.0
331.25			- 48.0
337.25			- 48.00
343.25			- 49.0
349.25			- 50.0
355.25			- 50.0
361.25			- 49.0
367.25			- 49.0
373.25			- 49.0
379.25			- 48.0
385.25			- 47.0
391.25			- 47.0
397.25			- 47.0
403.25			- 47.0

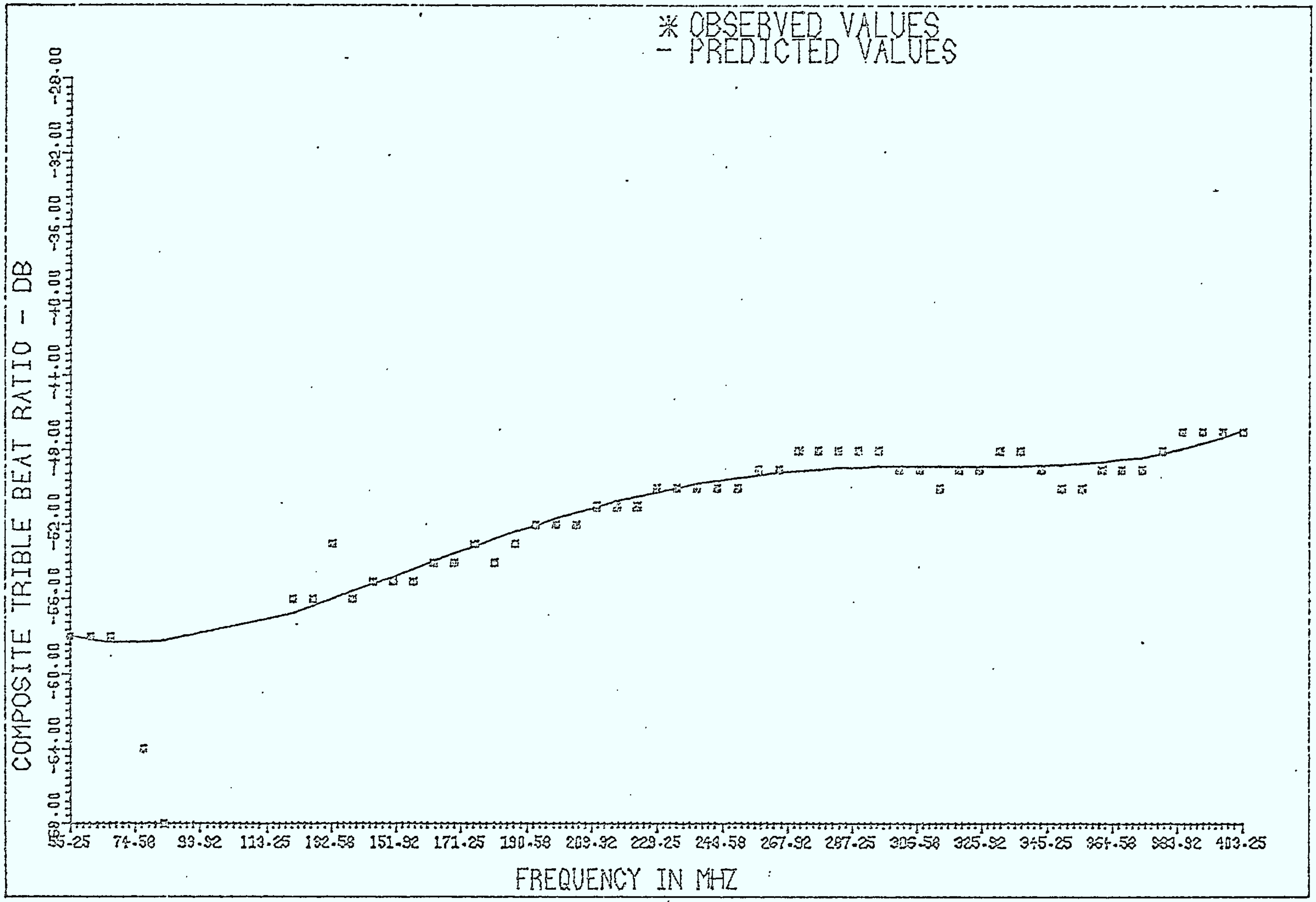
STARLINE 20/400 - TR - 35 CHANNEL CBR

OUTPUT LEVEL: 48.75 dBmV / GAIN: 25.0 dB / TEMP.: 20 DEG. C



STARLINE 20/400 – TR – 53 CHANNEL CBR

OUTPUT LEVEL: 48.75 dBmV / GAIN: 25.0 dB / TEMP.: 20 DEG. C



Jerrold Starline - 300 Trunk Amplifier

Composite Triple Beat Ratio - CBR

Spectrum Analyzer Settings:

BANDWIDTH: 30 KHz

SCAN WIDTH: 100 KHz/DIV

SCAN TIME: 0.1 SEC/DIV

VIDEO FILTER: 100 Hz

TEMPERATURE: 20° C

AMPLIFIER GAIN: 22.0 dB

BEAT FREQUENCY - MHz	OUTPUT LEVEL - dBmV	35 CHANNEL CBR - dB	53 CHANNEL CBR - dB
55.25	46.15	- 71.0	- 65.0
61.25		- 71.0	- 65.0
67.25		- 69.0	- 63.0
77.25		- 76.0	- 72.0
83.25		- 77.0	- 73.0
121.25		- 67.0	- 60.0
127.25		- 67.0	- 59.0
133.25		- 66.0	- 59.0
139.25		- 65.0	- 58.0
145.25		- 65.0	- 58.0
151.25		- 65.0	- 57.0
157.25	46.75	- 65.0	- 58.0
163.25		- 66.0	- 58.0
169.25		- 65.0	- 57.0
175.25		- 65.0	- 57.0
181.25		- 64.0	- 56.0
187.25		- 64.0	- 56.0
193.25		- 63.0	- 55.0
199.25		- 63.0	- 55.0
205.25		- 62.0	- 55.0
211.25	46.95	- 62.0	- 54.0
217.25		- 61.0	- 53.0
223.25		- 60.0	- 52.0
229.25		- 61.0	- 53.0
235.75		- 61.0	- 52.0

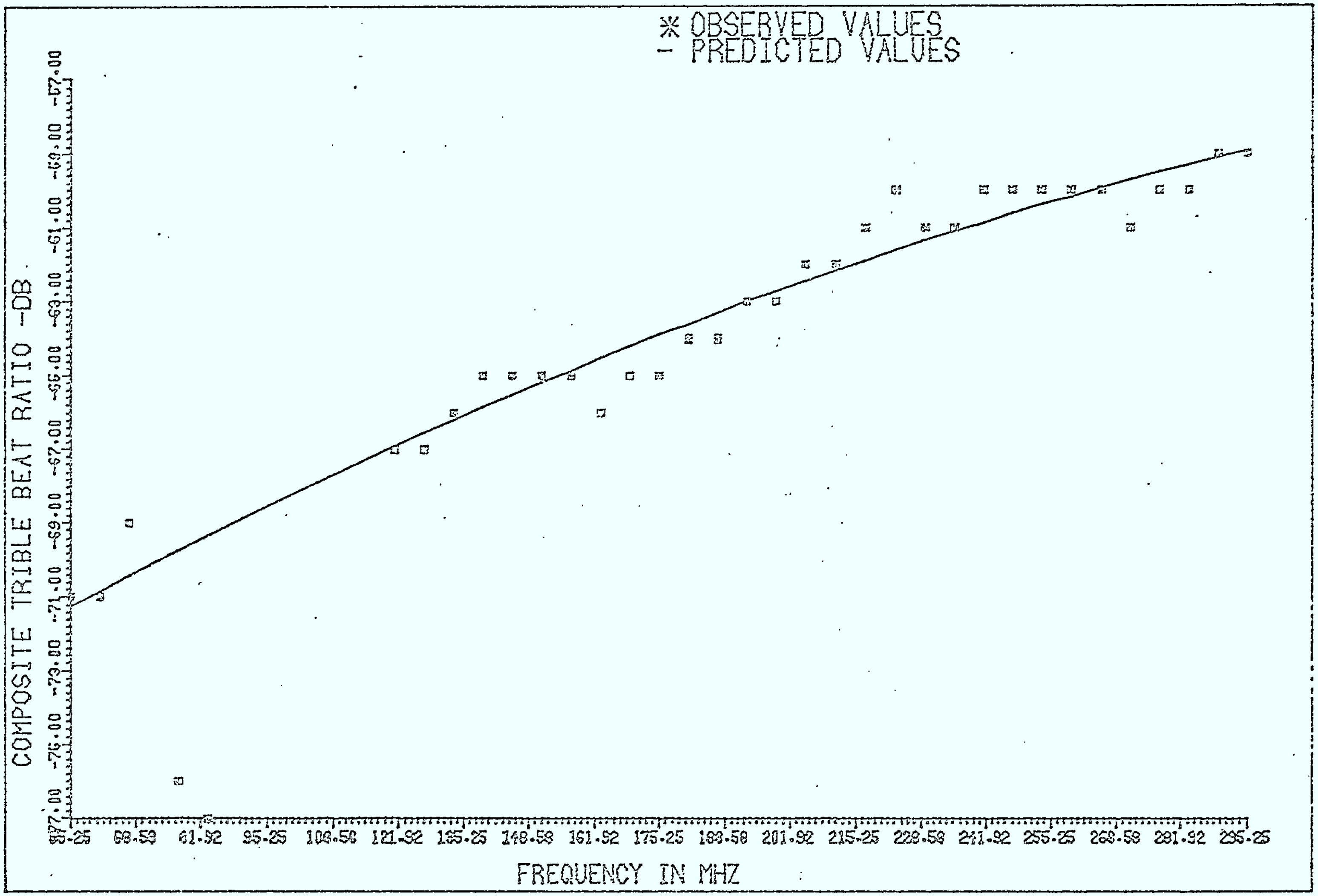
. . ./2

Jerrold Starline - 300 Trunk Amplifier

BEAT FREQUENCY - MHz	OUTPUT LEVEL - dBmV	35 CHANNEL CBR - dB	53 CHANNEL CBR - dB
241.25		- 60.0	- 51.0
247.25		- 60.0	- 51.0
253.25		- 60.0	- 51.0
259.25		- 60.0	- 51.0
265.25		- 60.0	- 51.0
271.25		- 61.0	- 51.0
277.25		- 60.0	- 50.0
283.25		- 60.0	- 51.0
289.25		- 59.0	- 49.0
295.25	46.75	- 59.0	- 49.0
301.25			- 49.0
307.25			- 50.0
313.25			- 50.0
319.25			- 49.0
325.75			- 49.0
331.25			- 49.0
337.25			- 49.0
343.25	46.75		- 48.0
349.25			- 46.0
355.25			- 47.0
361.25			- 48.0
367.25			- 47.0
373.25			- 46.0
379.25			- 47.0
385.25			- 45.0
391.25			- 46.0
397.25			- 46.0
403.25	41.55		- 46.0

STARLINE-300 TRUNK AMPLIFIER - 35 CHANNEL CBR

OUTPUT LEVEL: 46.75 dBmV/GAIN: 22.0 dB / TEMP.: 20 DEG. C



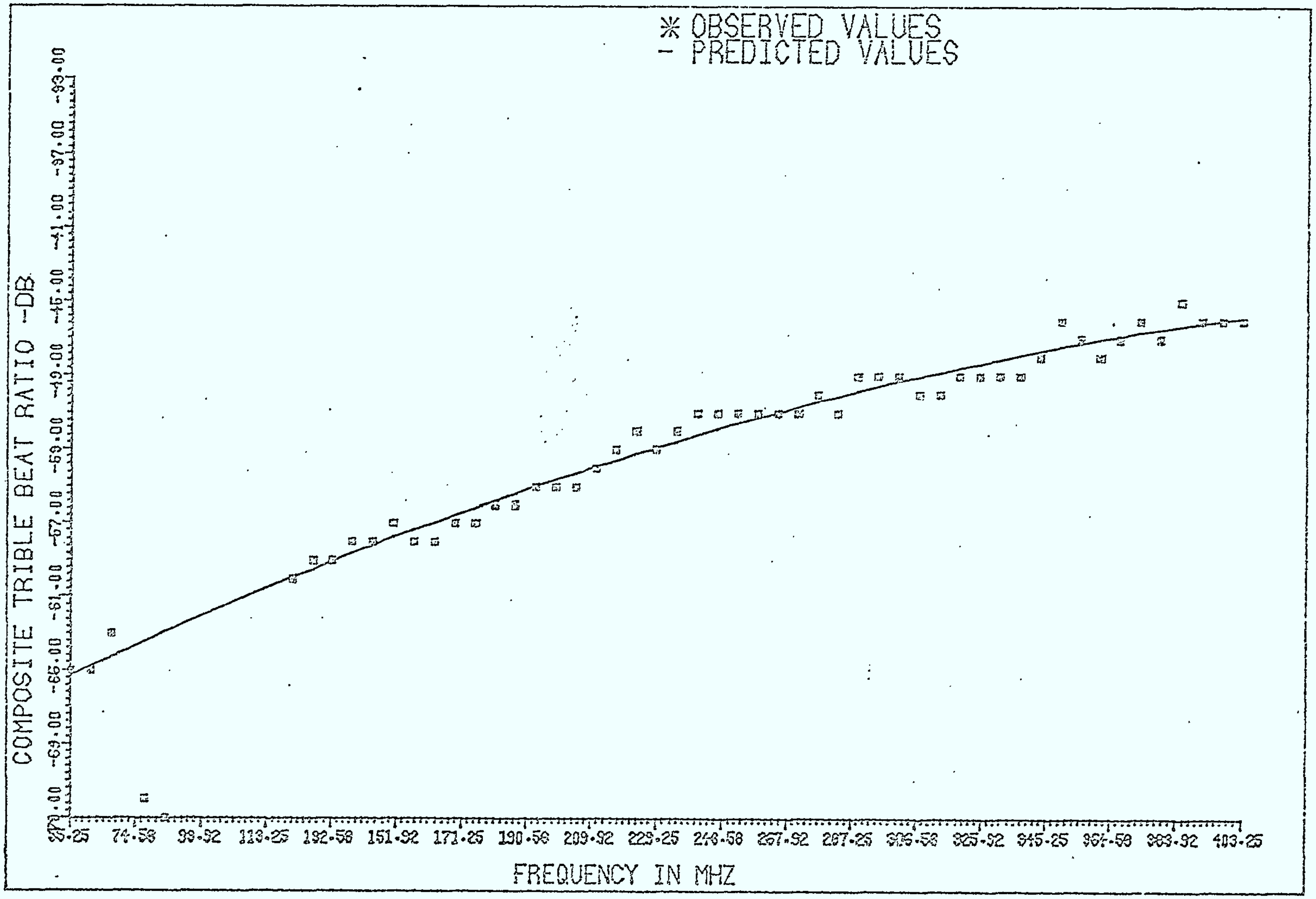
- 70 -

cablesystems engineering

BROADBAND COMMUNICATION ENGINEERS

STARLINE-300 TRUNK AMPLIFIER - 53 CHANNEL CBR

OUTPUT LEVEL: 46.75 dBmV / GAIN: 22.0 dB / TEMP.: 20 DEG.. C



S.A. - LE - 400 MHz.
- 6dB roll-off @ M-15

RIPPLE

Composite Triple Beat
B.W. = 30 KHz, Scan width = 100 KHz, Scan Time = 1 Sec.
Video Filter - 100 Hz.
Attn: 18, Gain: 30.6 dB

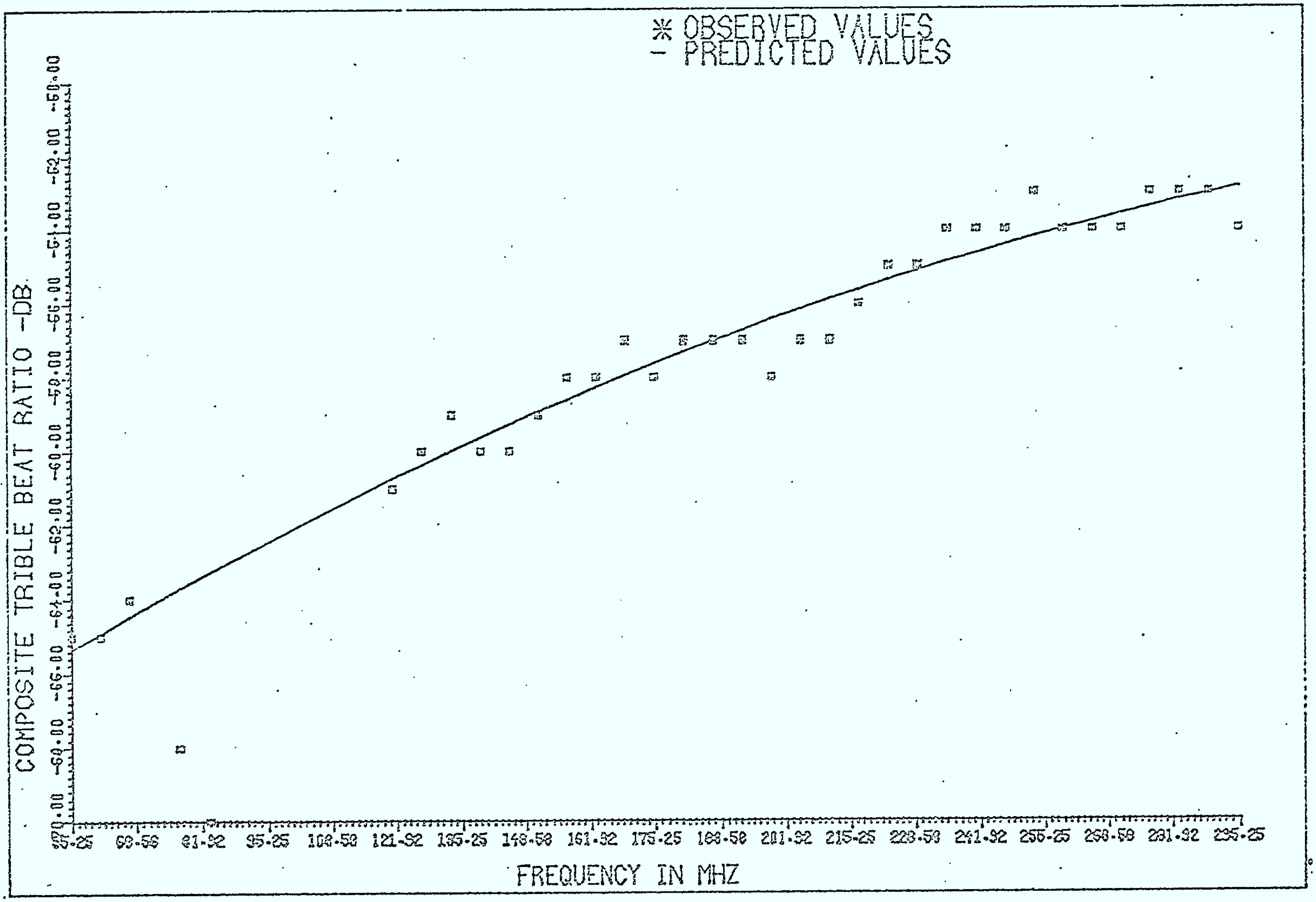
BEAT FREQ. MHz.	OUTPUT LEVEL dBmV	CTB - 35 CH.	CTB - 52 CH.
55.25	50.75	-65	-60
61.25		-65	-60
67.25		-64	-59
77.25		-68	-65
83.25		-70	-66
121.25		-61	-56
127.25		-60	-55
133.25		-59	-55
139.25		-60	-56
145.25		-60	-56
151.25		-59	-55
157.25	49.95	-58	-54
163.25		-58	-54
169.25		-57	-53
175.25		-58	-54
181.25		-57	-53
187.25		-57	-52
193.25		-57	-52
199.25	49.75	-58	-53
205.25		-57	-52
211.25	50.25	-57	-53
217.25		-56	-51
223.25		-55	-50
229.25		-55	-50
235.25		-54	-50
241.25		-54	-50
247.25		-54	-49
253.25		-53	-49
259.25		-54	-49
265.25	48.95	-54	-49
271.25		-54	-48
277.25		-53	-48
283.25		-53	-48
289.25		-53	-48
295.25		-54	-48
301.25		-54	-48
307.25		-54	-48
313.25		-53	-47
319.25		-53	-47
325.25		-54	-47
331.25		-54	-47
337.25		-54	-48
343.25		-55	-48
349.25		-55	-47

Cont'd.

355.25		-54	-47
361.25		-54	-47
367.25		-54	-47
373.25	47.75	-55	-46
379.25		-54	-45
385.25		-54	-45
391.25	46.75	-54	-45
397.25		-54	-44
403.25	44.95	-53	-44

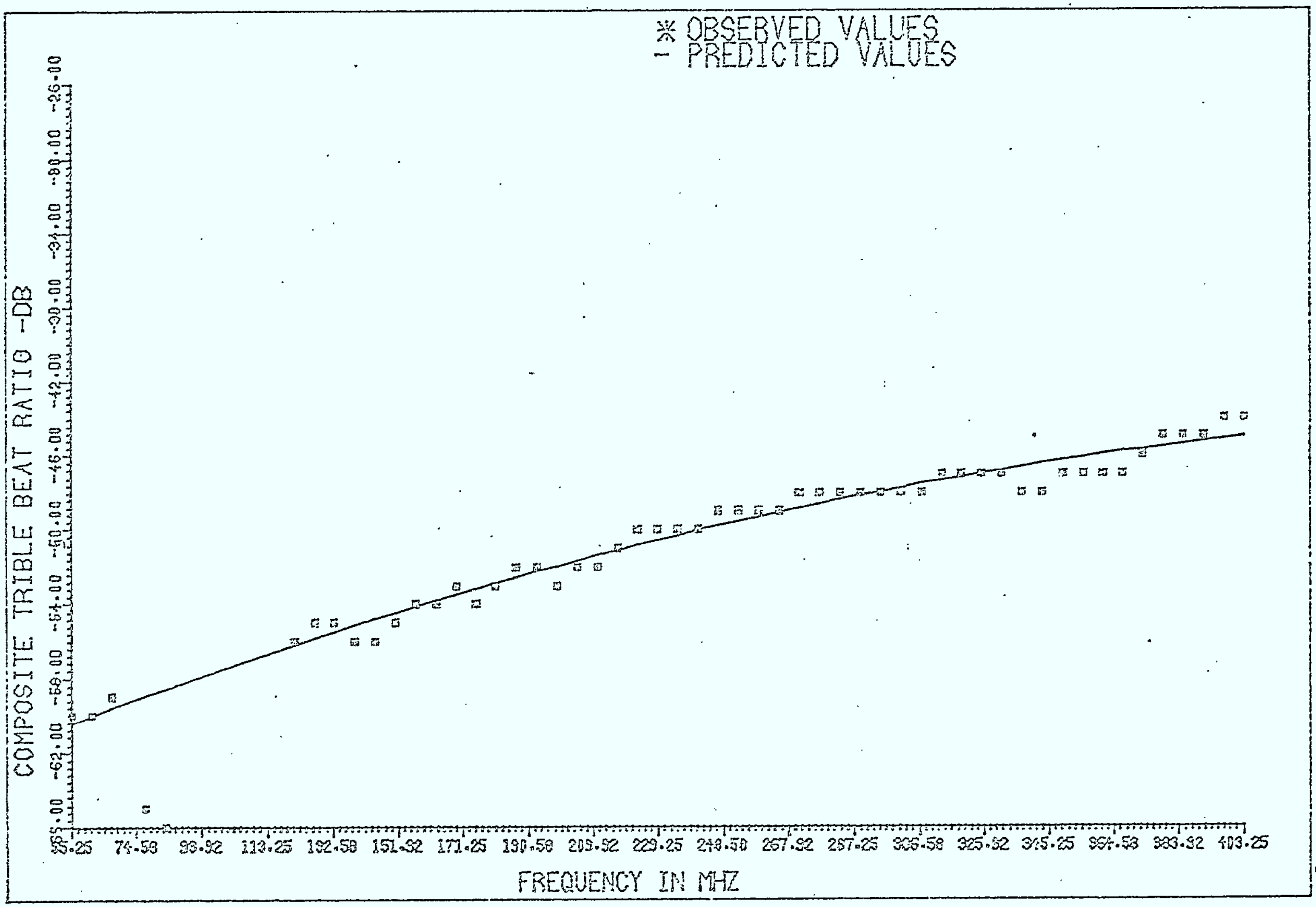
SA-400 MHz LINE EXTENDER - 35 CHANNEL CBR

OUTPUT LEVEL: 48.0 dBmV / GAIN: 30.6 dB / TEMP.: 20 DEG. C



SA-400 MHz LINE EXTENDER - 53 CHANNEL CBR

OUTPUT LEVEL: 48.0 dBmV / GAIN: 30.6 dB / TEMP.: 20 DEG. C



APPENDIX B

APPENDIX B

Computer Predictions

The composite triple beat ratio (CBR) computer predictions for 35 channel system is presented in this Appendix. These predictions were performed using Starline 300 transfer function and running the amplifier at the same output level as was done in the laboratory measurements. In general the accuracy of these predictions in comparison to the laboratory measurements is ± 1.5dB. It should be noted however, that the amplifier transfer function ($C_3(f_b)$) had a standard deviation of ± 2.0dB. Thus the computer prediction is within this window.

```
2,1,35,1,.875,22
55.25,24.75,0,61.25,24.75,0,67.25,24.75,0,77.25,24.75,0,83.25,24.75,0,
121.25,24.75,0,127.25,24.75,0,133.25,24.75,0,139.25,24.75,0,145.25,24.75,0,
151.25,24.75,0,157.25,24.75,0,163.25,24.75,0,169.25,24.75,0,175.25,24.75,0,
181.25,24.75,0,187.25,24.75,0,193.25,24.75,0,199.25,24.75,0,205.25,24.75,0,
211.25,24.75,0,217.25,24.75,0,223.25,24.75,0,229.25,24.75,0,235.25,24.75,0,
241.25,24.75,0,247.25,24.75,0,253.25,24.75,0,259.25,24.75,0,265.25,24.75,0,
271.25,24.75,0,277.25,24.75,0,283.25,24.75,0,289.25,24.75,0,295.25,24.75,0,
```

(C) - Laboratory Measurement Check

- *Jerrold Starline-300TR*
- *35-Channels-Unsuppressed*
- *Cascade - 1 Amplifier*
- *Gain - 22dB*
- *Input Level: 24.75dBmV*

STANDARD 35 CHANNEL CARRIER BEATS

FREQUENCY	# 2ND ORD	LEVEL-DB	# 3RD ORD	LEVEL-DB	TOTAL # BEATS	TOTAL LEVEL-DB
54.00	22	-65.09	0	-150.00	22	-65.09
54.75	0	-150.00	21	-75.87	21	-75.87
55.25	0	-150.00	159	-67.30	159	-67.30
56.00	2	-75.46	0	-150.00	2	-75.46
56.75	0	-150.00	3	-87.28	3	-87.28
57.25	0	-150.00	1	-95.03	1	-95.03
58.75	0	-150.00	36	-73.71	36	-73.71
59.25	0	-150.00	53	-71.74	53	-71.74
60.00	22	-64.94	0	-150.00	22	-64.94
60.75	0	-150.00	19	-76.16	19	-76.16
61.25	0	-150.00	171	-66.80	171	-66.80
62.00	2	-75.31	0	-150.00	2	-75.31
62.75	0	-150.00	3	-87.13	3	-87.13
64.75	0	-150.00	33	-73.97	33	-73.97
65.25	0	-150.00	56	-71.35	56	-71.35
66.00	22	-64.79	0	-150.00	22	-64.79
66.75	0	-150.00	17	-76.49	17	-76.49
67.25	0	-150.00	180	-66.45	180	-66.45
68.00	2	-75.16	0	-150.00	2	-75.16
68.75	0	-150.00	3	-86.98	3	-86.98
70.75	0	-150.00	30	-74.26	30	-74.26
71.25	0	-150.00	61	-70.88	61	-70.88
76.75	0	-150.00	27	-74.60	27	-74.60
77.25	0	-150.00	31	-73.61	31	-73.61
78.00	20	-64.90	0	-150.00	20	-64.90
78.75	0	-150.00	13	-77.35	13	-77.35
79.25	0	-150.00	226	-65.12	226	-65.12
80.00	2	-74.84	0	-150.00	2	-74.84
80.75	0	-150.00	3	-86.66	3	-86.66
82.75	0	-150.00	24	-75.00	24	-75.00
83.25	0	-150.00	31	-73.45	31	-73.45
84.00	19	-64.96	0	-150.00	19	-64.96
84.75	0	-150.00	11	-77.91	11	-77.91
85.25	0	-150.00	234	-64.79	234	-64.79
86.00	2	-74.68	0	-150.00	2	-74.68
86.75	0	-150.00	3	-86.50	3	-86.50
87.25	0	-150.00	1	-94.26	1	-94.26
120.00	13	-65.57	0	-150.00	13	-65.57
120.75	0	-150.00	6	-79.50	6	-79.50
121.25	0	-150.00	274	-63.06	274	-63.06
122.00	2	-73.64	0	-150.00	2	-73.64
122.50	2	-75.66	0	-150.00	2	-75.66
122.75	0	-150.00	3	-85.46	3	-85.46
123.25	0	-150.00	6	-79.43	6	-79.43
124.75	0	-150.00	6	-81.42	6	-81.42
125.25	0	-150.00	45	-70.62	45	-70.62
126.00	12	-65.73	0	-150.00	12	-65.73
126.75	0	-150.00	6	-79.32	6	-79.32
127.25	0	-150.00	288	-62.65	288	-62.65
128.00	2	-73.45	0	-150.00	2	-73.45
128.50	1	-76.45	0	-150.00	1	-76.45
128.75	0	-150.00	3	-85.27	3	-85.27
129.25	0	-150.00	6	-79.24	6	-79.24
130.75	0	-150.00	6	-81.23	6	-81.23
131.25	0	-150.00	44	-70.52	44	-70.52
132.00	11	-65.92	0	-150.00	11	-65.92
132.50	1	-76.32	0	-150.00	1	-76.32
132.75	0	-150.00	6	-79.13	6	-79.13

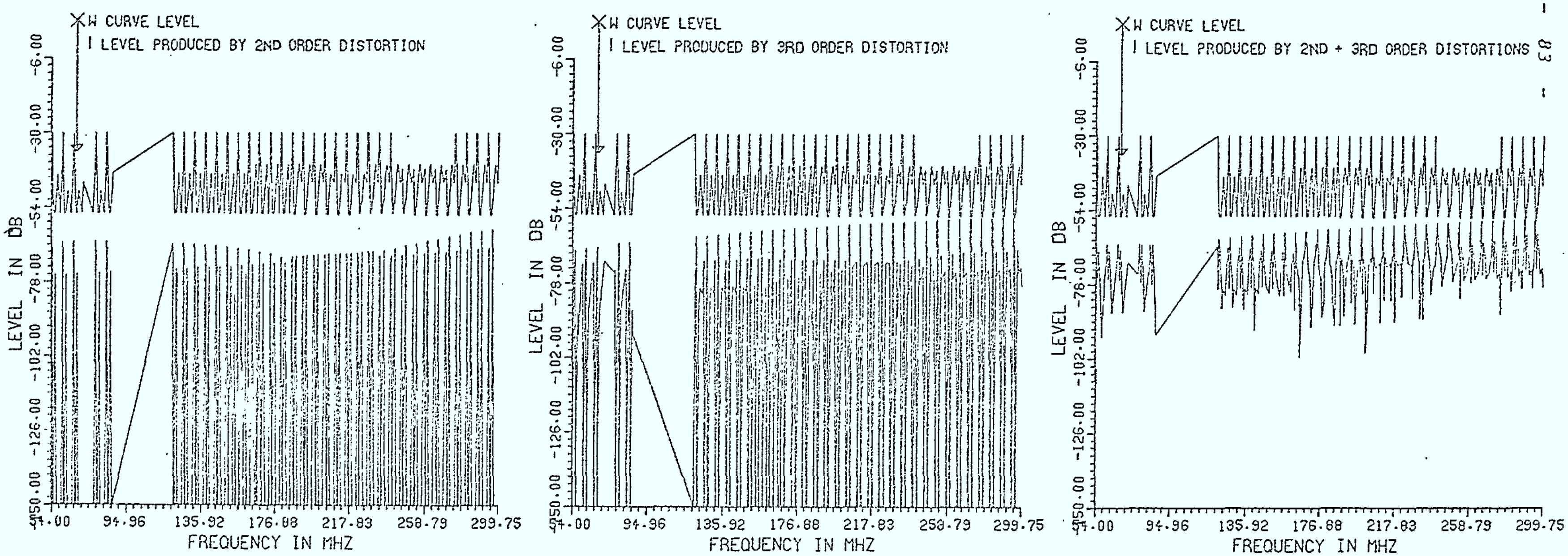
133,25	0	-150,00	299	-62,29	299	-62,29
134,00	2	-73,26	0	-150,00	2	-73,26
134,50	1	-82,26	0	-150,00	1	-82,26
134,75	0	-150,00	2	-85,87	2	-85,87
135,25	0	-150,00	6	-79,05	6	-79,05
136,75	0	-150,00	6	-81,04	6	-81,04
137,25	0	-150,00	44	-70,33	44	-70,33
138,00	10	-66,14	0	-150,00	10	-66,14
138,50	2	-73,12	0	-150,00	2	-73,12
138,75	0	-150,00	6	-78,94	6	-78,94
139,25	0	-150,00	308	-61,97	308	-61,97
140,00	2	-73,07	0	-150,00	2	-73,07
140,75	0	-150,00	1	-92,65	1	-92,65
141,25	0	-150,00	6	-78,86	6	-78,86
142,75	0	-150,00	6	-80,85	6	-80,85
143,25	0	-150,00	44	-70,14	44	-70,14
144,00	9	-66,41	0	-150,00	9	-66,41
144,50	2	-72,92	0	-150,00	2	-72,92
144,75	0	-150,00	6	-78,74	6	-78,74
145,25	0	-150,00	316	-61,66	316	-61,66
146,00	2	-72,87	0	-150,00	2	-72,87
147,25	0	-150,00	6	-78,66	6	-78,66
148,75	0	-150,00	6	-80,65	6	-80,65
149,25	0	-150,00	43	-70,04	43	-70,04
150,00	8	-66,72	0	-150,00	8	-66,72
150,50	1	-75,73	0	-150,00	1	-75,73
150,75	0	-150,00	5	-79,34	5	-79,34
151,25	0	-150,00	323	-61,36	323	-61,36
152,00	2	-72,67	0	-150,00	2	-72,67
153,25	0	-150,00	6	-78,46	6	-78,45
154,50	1	-81,60	0	-150,00	1	-81,60
154,75	0	-150,00	6	-80,45	6	-80,45
155,25	0	-150,00	41	-70,05	41	-70,05
156,00	7	-67,10	0	-150,00	7	-67,10
156,75	0	-150,00	3	-81,35	3	-81,35
157,25	0	-150,00	329	-61,07	329	-61,07
158,00	2	-72,47	0	-150,00	2	-72,47
159,25	0	-150,00	7	-78,08	7	-78,08
160,50	1	-75,39	0	-150,00	1	-75,39
160,75	0	-150,00	6	-80,24	6	-80,24
161,25	0	-150,00	39	-70,06	39	-70,06
162,00	6	-67,56	0	-150,00	6	-67,56
162,75	0	-150,00	1	-85,92	1	-85,92
163,25	0	-150,00	334	-60,80	334	-60,80
164,00	2	-72,26	0	-150,00	2	-72,26
165,25	0	-150,00	8	-77,23	8	-77,23
165,75	0	-150,00	1	-101,31	1	-101,31
166,50	1	-81,19	0	-150,00	1	-81,19
166,75	0	-150,00	5	-80,33	5	-80,33
167,25	0	-150,00	37	-70,08	37	-70,08
168,00	5	-68,14	0	-150,00	5	-68,14
169,25	0	-150,00	338	-60,54	339	-60,54
170,00	2	-72,05	0	-150,00	2	-72,05
171,25	0	-150,00	9	-76,45	9	-76,45
171,75	0	-150,00	1	-91,60	1	-91,60
172,75	0	-150,00	4	-81,58	4	-81,58
173,25	0	-150,00	35	-70,11	35	-70,11
174,00	4	-68,90	0	-150,00	4	-68,90
175,25	0	-150,00	342	-60,28	342	-60,28

176,00	2	-71,84	0	-150,00	2	-71,84
176,50	1	-74,83	0	-150,00	1	-74,83
177,25	0	-150,00	10	-75,74	10	-75,74
177,75	0	-150,00	2	-88,38	2	-88,38
178,75	0	-150,00	2	-84,38	2	-84,38
179,25	0	-150,00	33	-70,15	33	-70,15
180,00	3	-69,93	0	-150,00	3	-69,93
181,25	0	-150,00	345	-60,02	345	-60,02
182,00	2	-71,62	0	-150,00	2	-71,62
182,50	2	-71,60	0	-150,00	2	-71,60
183,25	0	-150,00	11	-75,08	11	-75,08
183,75	0	-150,00	2	-85,05	2	-85,05
184,75	0	-150,00	1	-91,13	1	-91,13
185,25	0	-150,00	31	-70,20	31	-70,20
186,00	3	-69,71	0	-150,00	3	-69,71
187,25	0	-150,00	348	-59,78	348	-59,78
187,75	0	-150,00	1	-91,02	1	-91,02
188,00	2	-71,40	0	-150,00	2	-71,40
188,50	3	-69,62	0	-150,00	3	-69,62
189,25	0	-150,00	12	-74,45	12	-74,45
189,75	0	-150,00	2	-87,94	2	-87,94
191,25	0	-150,00	29	-70,27	29	-70,27
192,00	3	-69,49	0	-150,00	3	-69,49
193,25	0	-150,00	349	-59,53	349	-59,53
193,75	0	-150,00	2	-83,82	2	-83,82
194,00	2	-71,18	0	-150,00	2	-71,18
194,50	3	-69,40	0	-150,00	3	-69,40
195,25	0	-150,00	13	-73,86	13	-73,86
195,75	0	-150,00	1	-90,72	1	-90,72
197,25	0	-150,00	27	-70,35	27	-70,35
198,00	3	-69,26	0	-150,00	3	-69,26
198,50	1	-74,02	0	-150,00	1	-74,02
199,25	0	-150,00	350	-59,30	350	-59,30
199,75	0	-150,00	3	-81,05	3	-81,05
200,00	2	-70,95	0	-150,00	2	-70,95
200,50	3	-69,17	0	-150,00	3	-69,17
201,25	0	-150,00	14	-73,29	14	-73,29
201,75	0	-150,00	1	-99,99	1	-99,99
203,25	0	-150,00	25	-70,46	25	-70,46
204,00	3	-69,04	0	-150,00	3	-69,04
204,50	2	-70,78	0	-150,00	2	-70,78
205,25	0	-150,00	349	-59,07	349	-59,07
205,75	0	-150,00	3	-80,81	3	-80,81
206,00	2	-70,72	0	-150,00	2	-70,72
206,50	3	-68,94	0	-150,00	3	-68,94
207,25	0	-150,00	15	-72,74	15	-72,74
209,25	0	-150,00	23	-70,59	23	-70,59
209,75	0	-150,00	1	-90,18	1	-90,18
210,00	3	-68,80	0	-150,00	3	-68,80
210,50	2	-70,54	0	-150,00	2	-70,54
211,25	0	-150,00	348	-58,86	348	-58,86
211,75	0	-150,00	2	-83,13	2	-83,13
212,00	2	-70,48	0	-150,00	2	-70,48
212,50	3	-68,70	0	-150,00	3	-68,70
213,25	0	-150,00	16	-72,21	16	-72,21
215,25	0	-150,00	21	-70,74	21	-70,74
215,75	0	-150,00	2	-82,97	2	-82,97
216,00	3	-68,57	0	-150,00	3	-68,57
216,50	2	-70,31	0	-150,00	2	-70,31
217,25	0	-150,00	345	-58,65	345	-58,65

217,75	0	-150,00	1	-89,87	1	-89,87
218,00	1	-73,26	0	-150,00	1	-73,26
218,50	3	-68,47	0	-150,00	3	-68,47
219,25	0	-150,00	17	-71,70	17	-71,70
221,25	0	-150,00	19	-70,94	19	-70,94
221,75	0	-150,00	3	-81,94	3	-81,94
222,00	3	-68,33	0	-150,00	3	-68,33
222,50	2	-70,07	0	-150,00	2	-70,07
223,25	0	-150,00	342	-58,46	342	-58,46
224,50	3	-68,22	0	-150,00	3	-68,22
225,25	0	-150,00	18	-71,20	18	-71,20
227,25	0	-150,00	17	-71,18	17	-71,18
227,75	0	-150,00	2	-82,49	2	-82,49
228,00	3	-68,08	0	-150,00	3	-68,08
228,50	2	-69,82	0	-150,00	2	-69,82
229,25	0	-150,00	337	-58,27	337	-58,27
230,50	3	-67,98	0	-150,00	3	-67,98
231,25	0	-150,00	19	-70,71	19	-70,71
231,75	0	-150,00	2	-88,84	2	-88,84
233,25	0	-150,00	15	-71,48	15	-71,48
233,75	0	-150,00	1	-89,22	1	-89,22
234,00	2	-69,60	0	-150,00	2	-69,60
234,50	2	-69,57	0	-150,00	2	-69,57
235,25	0	-150,00	332	-58,10	332	-58,10
236,50	3	-67,73	0	-150,00	3	-67,73
237,25	0	-150,00	20	-70,23	20	-70,23
237,75	0	-150,00	3	-81,28	3	-81,28
239,25	0	-150,00	13	-71,85	13	-71,85
240,00	1	-72,36	0	-150,00	1	-72,36
240,50	2	-69,32	0	-150,00	2	-69,32
241,25	0	-150,00	326	-57,92	326	-57,92
242,50	4	-67,13	0	-150,00	4	-67,13
243,25	0	-150,00	21	-69,75	21	-69,75
243,75	0	-150,00	5	-78,40	5	-78,40
245,25	0	-150,00	11	-72,32	11	-72,32
246,50	2	-69,07	0	-150,00	2	-69,07
247,25	0	-150,00	321	-57,75	321	-57,75
248,50	4	-65,97	0	-150,00	4	-65,97
249,25	0	-150,00	22	-69,29	22	-69,29
249,75	0	-150,00	6	-77,06	6	-77,06
251,25	0	-150,00	9	-72,93	9	-72,93
252,50	2	-68,81	0	-150,00	2	-68,81
253,25	0	-150,00	315	-57,56	315	-57,56
253,75	0	-150,00	1	-82,37	1	-82,37
254,50	5	-65,45	0	-150,00	5	-65,45
255,25	0	-150,00	23	-68,83	23	-68,83
255,75	0	-150,00	6	-76,54	6	-76,54
257,25	0	-150,00	7	-73,76	7	-73,76
258,50	2	-68,55	0	-150,00	2	-68,55
259,25	0	-150,00	309	-57,40	309	-57,40
259,75	0	-150,00	3	-77,33	3	-77,33
260,50	5	-64,48	0	-150,00	5	-64,48
261,25	0	-150,00	24	-68,38	24	-68,38
261,75	0	-150,00	6	-76,27	6	-76,27
263,25	0	-150,00	6	-74,17	6	-74,17
264,50	2	-68,29	0	-150,00	2	-68,29
265,25	0	-150,00	301	-57,24	301	-57,24
265,75	0	-150,00	5	-74,85	5	-74,85
266,50	6	-64,00	0	-150,00	6	-64,00
267,25	0	-150,00	25	-67,93	25	-67,93

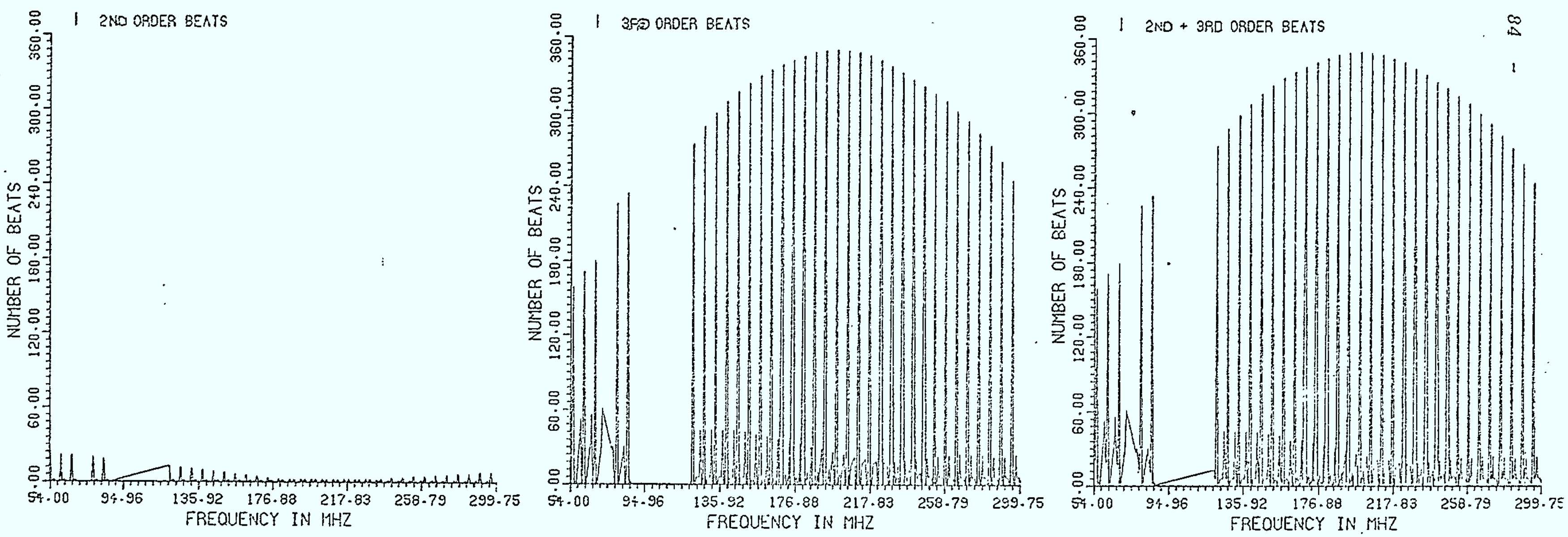
267.75	0	-150.00	6	-76.01	6	-76.01
269.25	0	-150.00	6	-73.90	6	-73.90
270.50	2	-68.02	0	-150.00	2	-68.02
271.25	0	-150.00	293	-57.11	293	-57.11
271.75	0	-150.00	6	-73.79	6	-73.79
272.50	6	-63.15	0	-150.00	6	-63.15
273.25	0	-150.00	25	-67.66	25	-67.66
273.75	0	-150.00	6	-75.74	6	-75.74
275.25	0	-150.00	6	-73.63	6	-73.63
275.75	0	-150.00	1	-87.39	1	-87.39
276.50	2	-67.75	0	-150.00	2	-67.75
277.25	0	-150.00	283	-56.98	283	-56.98
277.75	0	-150.00	6	-73.52	6	-73.52
278.50	7	-62.71	0	-150.00	7	-62.71
279.25	0	-150.00	24	-67.57	24	-67.57
279.75	0	-150.00	6	-75.46	6	-75.46
281.25	0	-150.00	6	-73.36	6	-73.36
281.75	0	-150.00	2	-80.14	2	-80.14
282.50	2	-67.47	0	-150.00	2	-67.47
283.25	0	-150.00	273	-56.88	273	-56.88
283.75	0	-150.00	6	-73.24	6	-73.24
284.50	7	-61.94	0	-150.00	7	-61.94
285.25	0	-150.00	23	-67.48	23	-67.48
285.75	0	-150.00	6	-75.19	6	-75.19
287.25	0	-150.00	6	-73.08	6	-73.08
287.75	0	-150.00	3	-79.07	3	-79.07
288.50	2	-67.19	0	-150.00	2	-67.19
289.25	0	-150.00	260	-56.81	260	-56.81
289.75	0	-150.00	6	-72.96	6	-72.96
290.50	8	-61.51	0	-150.00	8	-61.51
291.25	0	-150.00	23	-67.20	23	-67.20
291.75	0	-150.00	6	-74.91	6	-74.91
293.25	0	-150.00	6	-72.80	6	-72.80
293.75	0	-150.00	3	-78.79	3	-78.79
294.50	2	-66.91	0	-150.00	2	-66.91
295.25	0	-150.00	245	-56.81	245	-56.81
295.75	0	-150.00	6	-72.68	6	-72.68
296.50	8	-60.80	0	-150.00	8	-60.80
297.25	0	-150.00	24	-66.73	24	-66.73
297.75	0	-150.00	7	-74.34	7	-74.34
299.25	0	-150.00	6	-72.51	6	-72.51
299.75	0	-150.00	3	-78.50	3	-78.50

STD 35 CHANNEL CARRIER BEATS LAB MST



DISTORTION LEVEL IN DB VS. FREQUENCY

STD 35 CHANNEL CARRIER BEATS LAB MST



NUMBER OF BEATS VS. FREQUENCY

STANDARD 35 CHANNEL VIDEO BEATS

FREQUENCY	# 2ND ORD	LEVEL-DB	# 3RD ORD	LEVEL-DB	TOTAL # BEATS	TOTAL LEVEL-DB
54.00	44	-65.09	0	-150.00	44	-82.45
54.75	0	-150.00	42	-93.23	42	-93.23
55.25	0	-150.00	340	-84.36	340	-84.36
56.00	4	-75.40	0	-150.00	4	-92.82
56.75	0	-150.00	10	-100.99	10	-100.99
57.25	0	-150.00	4	-105.46	4	-105.46
58.75	0	-150.00	78	-90.71	78	-90.71
59.25	0	-150.00	106	-89.10	106	-89.10
60.00	44	-64.94	0	-150.00	44	-82.30
60.75	0	-150.00	38	-93.52	38	-93.52
61.25	0	-150.00	362	-83.91	362	-83.91
62.00	4	-75.31	0	-150.00	4	-92.67
62.75	0	-150.00	10	-100.84	10	-100.84
64.75	0	-150.00	72	-90.93	72	-90.93
65.25	0	-150.00	112	-88.71	112	-88.71
66.00	44	-64.79	0	-150.00	44	-82.15
66.75	0	-150.00	34	-93.85	34	-93.85
67.25	0	-150.00	384	-83.52	384	-83.52
68.00	4	-75.16	0	-150.00	4	-92.52
68.75	0	-150.00	10	-100.69	10	-100.69
70.75	0	-150.00	66	-91.18	66	-91.18
71.25	0	-150.00	124	-88.17	124	-88.17
76.75	0	-150.00	60	-91.47	60	-91.47
77.25	0	-150.00	62	-90.97	62	-90.97
78.00	40	-64.90	0	-150.00	40	-82.26
78.75	0	-150.00	26	-94.71	26	-94.71
79.25	0	-150.00	478	-82.23	478	-82.23
80.00	4	-74.84	0	-150.00	4	-92.20
80.75	0	-150.00	10	-100.38	10	-100.38
82.75	0	-150.00	54	-91.81	54	-91.81
83.25	0	-150.00	62	-90.81	62	-90.81
84.00	38	-64.96	0	-150.00	38	-82.32
84.75	0	-150.00	22	-95.27	22	-95.27
85.25	0	-150.00	492	-81.93	492	-81.93
86.00	4	-74.68	0	-150.00	4	-92.04
86.75	0	-150.00	10	-100.22	10	-100.22
87.25	0	-150.00	4	-104.68	4	-104.68
120.00	26	-65.57	0	-150.00	26	-82.93
120.75	0	-150.00	12	-96.86	12	-96.86
121.25	0	-150.00	576	-80.20	576	-80.20
122.00	4	-73.64	0	-150.00	4	-91.00
122.50	4	-75.66	0	-150.00	4	-90.98
122.75	0	-150.00	10	-99.17	10	-99.17
123.25	0	-150.00	12	-96.79	12	-96.79
124.75	0	-150.00	18	-96.25	18	-96.25
125.25	0	-150.00	90	-87.97	90	-87.97
126.00	24	-65.73	0	-150.00	24	-83.09
126.75	0	-150.00	12	-96.68	12	-96.68
127.25	0	-150.00	604	-79.80	604	-79.80
128.00	4	-73.45	0	-150.00	4	-90.81
128.50	2	-76.45	0	-150.00	2	-93.81
128.75	0	-150.00	10	-98.98	10	-98.98
129.25	0	-150.00	12	-96.60	12	-96.60
130.75	0	-150.00	18	-96.06	18	-96.06
131.25	0	-150.00	88	-87.88	88	-87.88
132.00	22	-65.92	0	-150.00	22	-83.28
132.50	2	-76.32	0	-150.00	2	-93.68
132.75	0	-150.00	12	-96.49	12	-96.49

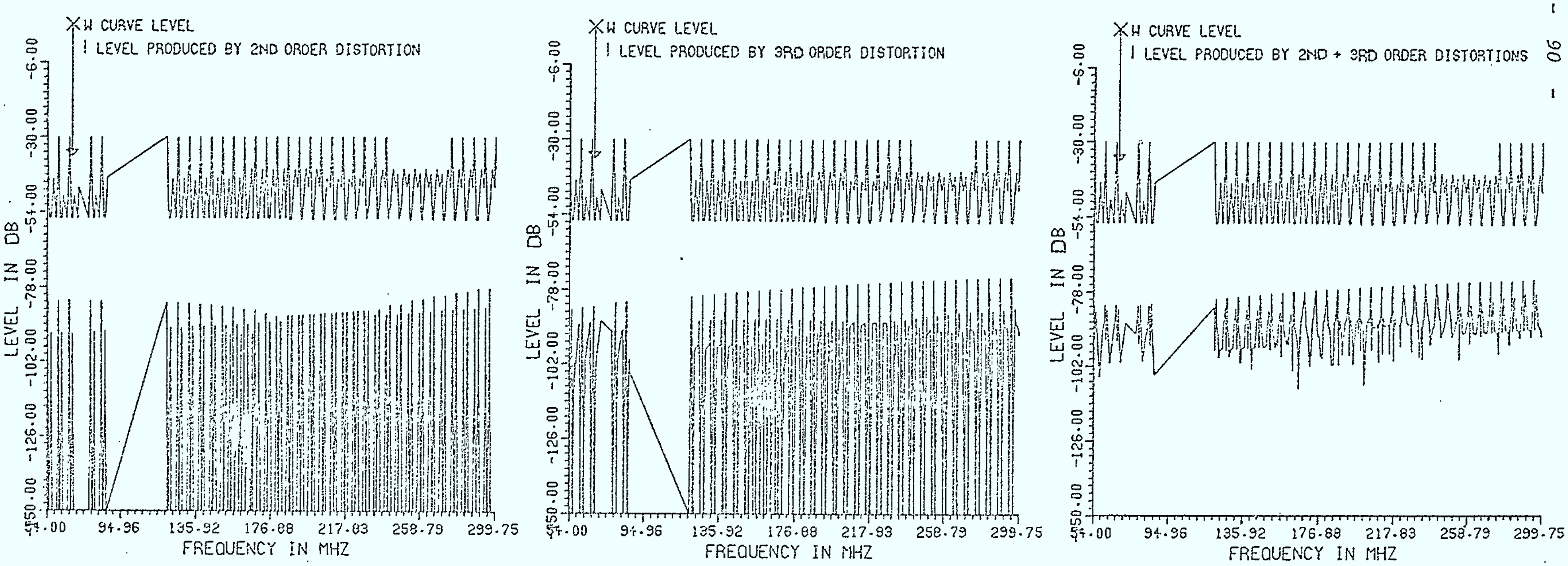
133,25	0	-150,00	626	-79,45	626	-79,45
134,00	4	-73,26	0	-150,00	4	-90,62
134,50	2	-82,26	0	-150,00	2	-93,62
134,75	0	-150,00	6	-100,71	6	-100,71
135,25	0	-150,00	12	-96,41	12	-96,41
136,75	0	-150,00	18	-95,87	18	-95,87
137,25	0	-150,00	88	-87,69	88	-87,69
138,00	20	-66,14	0	-150,00	20	-83,50
138,50	4	-73,12	0	-150,00	4	-90,48
138,75	0	-150,00	12	-96,30	12	-96,30
139,25	0	-150,00	644	-79,13	644	-79,13
140,00	4	-73,07	0	-150,00	4	-90,43
140,75	0	-150,00	4	-103,08	4	-103,08
141,25	0	-150,00	12	-96,22	12	-96,22
142,75	0	-150,00	18	-95,68	18	-95,68
143,25	0	-150,00	88	-87,50	88	-87,50
144,00	18	-66,41	0	-150,00	18	-83,77
144,50	4	-72,92	0	-150,00	4	-90,28
144,75	0	-150,00	12	-96,10	12	-96,10
145,25	0	-150,00	660	-78,82	660	-78,82
146,00	4	-72,87	0	-150,00	4	-90,23
147,25	0	-150,00	12	-96,02	12	-96,02
148,75	0	-150,00	18	-95,48	18	-95,48
149,25	0	-150,00	86	-87,40	86	-87,40
150,00	16	-66,72	0	-150,00	16	-84,08
150,50	2	-75,73	0	-150,00	2	-93,09
150,75	0	-150,00	10	-96,70	10	-96,70
151,25	0	-150,00	674	-78,53	674	-78,53
152,00	4	-72,67	0	-150,00	4	-90,03
153,25	0	-150,00	12	-95,82	12	-95,82
154,50	2	-81,60	0	-150,00	2	-92,96
154,75	0	-150,00	18	-95,28	18	-95,28
155,25	0	-150,00	82	-87,41	82	-87,41
156,00	14	-67,10	0	-150,00	14	-84,46
156,75	0	-150,00	6	-98,71	6	-98,71
157,25	0	-150,00	686	-78,25	686	-78,25
158,00	4	-72,47	0	-150,00	4	-89,83
159,25	0	-150,00	16	-94,80	16	-94,80
160,50	2	-75,39	0	-150,00	2	-92,75
160,75	0	-150,00	18	-95,07	18	-95,07
161,25	0	-150,00	78	-87,42	78	-87,42
162,00	12	-67,56	0	-150,00	12	-84,92
162,75	0	-150,00	2	-103,28	2	-103,28
163,25	0	-150,00	696	-77,98	696	-77,98
164,00	4	-72,26	0	-150,00	4	-89,62
165,25	0	-150,00	18	-94,03	18	-94,03
165,75	0	-150,00	2	-109,21	2	-109,21
166,50	2	-81,19	0	-150,00	2	-92,55
166,75	0	-150,00	14	-95,75	14	-95,75
167,25	0	-150,00	74	-87,44	74	-87,44
168,00	10	-68,14	0	-150,00	10	-95,50
169,25	0	-150,00	704	-77,72	704	-77,72
170,00	4	-72,05	0	-150,00	4	-89,41
171,25	0	-150,00	20	-93,32	20	-93,32
171,75	0	-150,00	4	-102,03	4	-102,03
172,75	0	-150,00	12	-96,41	12	-96,41
173,25	0	-150,00	70	-87,47	70	-87,47
174,00	8	-68,90	0	-150,00	8	-86,26

175,25	0	-150,00	714	-77,45	714	-77,45
176,00	4	-71,84	0	-150,00	4	-89,20
176,50	2	-74,83	0	-150,00	2	-92,19
177,25	0	-150,00	22	-92,66	22	-92,66
177,75	0	-150,00	8	-98,80	8	-98,80
178,75	0	-150,00	6	-99,21	6	-99,21
179,25	0	-150,00	66	-87,51	66	-87,51
180,00	6	-69,93	0	-150,00	6	-87,29
181,25	0	-150,00	720	-77,20	720	-77,20
182,00	4	-71,62	0	-150,00	4	-88,98
182,50	4	-71,60	0	-150,00	4	-88,96
183,25	0	-150,00	24	-92,04	24	-92,04
183,75	0	-150,00	4	-101,56	4	-101,56
184,75	0	-150,00	4	-101,56	4	-101,56
185,25	0	-150,00	62	-87,56	62	-87,56
186,00	6	-69,71	0	-150,00	6	-87,07
187,25	0	-150,00	728	-76,94	728	-76,94
187,75	0	-150,00	4	-101,45	4	-101,45
188,00	4	-71,40	0	-150,00	4	-88,76
188,50	6	-69,62	0	-150,00	6	-86,98
189,25	0	-150,00	26	-91,45	26	-91,45
189,75	0	-150,00	8	-98,36	8	-98,36
191,25	0	-150,00	58	-87,63	58	-87,63
192,00	6	-69,49	0	-150,00	6	-86,85
193,25	0	-150,00	728	-76,70	728	-76,70
193,75	0	-150,00	6	-98,65	6	-98,65
194,00	4	-71,18	0	-150,00	4	-88,54
194,50	6	-69,40	0	-150,00	6	-86,76
195,25	0	-150,00	28	-90,88	28	-90,88
195,75	0	-150,00	4	-101,15	4	-101,15
197,25	0	-150,00	54	-87,71	54	-87,71
198,00	6	-69,26	0	-150,00	6	-86,62
198,50	2	-74,02	0	-150,00	2	-91,38
199,25	0	-150,00	732	-76,46	732	-76,46
199,75	0	-150,00	8	-96,82	8	-96,82
200,00	4	-70,95	0	-150,00	4	-88,31
200,50	6	-69,17	0	-150,00	6	-86,53
201,25	0	-150,00	30	-90,34	30	-90,34
201,75	0	-150,00	2	-107,89	2	-107,89
203,25	0	-150,00	50	-87,82	50	-87,82
204,00	6	-69,04	0	-150,00	6	-86,40
204,50	4	-70,78	0	-150,00	4	-88,14
205,25	0	-150,00	728	-76,25	728	-76,25
205,75	0	-150,00	8	-96,59	8	-96,59
206,00	4	-70,72	0	-150,00	4	-88,08
206,50	6	-68,94	0	-150,00	6	-86,30
207,25	0	-150,00	32	-89,81	32	-89,81
209,25	0	-150,00	46	-87,95	46	-87,95
209,75	0	-150,00	4	-100,61	4	-100,61
210,00	6	-68,80	0	-150,00	6	-86,16
210,50	4	-70,54	0	-150,00	4	-87,90
211,25	0	-150,00	728	-76,02	728	-76,02
211,75	0	-150,00	6	-97,96	6	-97,96
212,00	4	-70,48	0	-150,00	4	-87,84
212,50	6	-68,70	0	-150,00	6	-86,06
213,25	0	-150,00	34	-89,30	34	-89,30
215,25	0	-150,00	42	-88,10	42	-88,10
215,75	0	-150,00	6	-97,80	6	-97,80
216,00	6	-68,57	0	-150,00	6	-85,93
216,50	4	-70,31	0	-150,00	4	-87,67

217,25	0	-150,00	720	-75,82	720	-75,82
217,75	0	-150,00	4	-100,29	4	-100,29
218,00	2	-73,26	0	-150,00	2	-90,62
218,50	6	-68,47	0	-150,00	6	-85,83
219,25	0	-150,00	36	-88,80	36	-88,80
221,25	0	-150,00	38	-88,30	38	-88,30
221,75	0	-150,00	10	-95,65	10	-95,65
222,00	6	-68,33	0	-150,00	6	-85,68
222,50	4	-70,07	0	-150,00	4	-87,43
223,25	0	-150,00	716	-75,62	716	-75,62
224,50	6	-68,22	0	-150,00	6	-85,58
225,25	0	-150,00	38	-88,31	38	-88,31
227,25	0	-150,00	34	-88,54	34	-88,54
227,75	0	-150,00	6	-97,32	6	-97,32
228,00	6	-68,08	0	-150,00	6	-85,44
228,50	4	-69,82	0	-150,00	4	-87,18
229,25	0	-150,00	704	-75,44	704	-75,44
230,50	6	-67,98	0	-150,00	6	-85,34
231,25	0	-150,00	40	-87,84	40	-87,84
231,75	0	-150,00	6	-98,93	6	-98,93
233,25	0	-150,00	30	-88,84	30	-88,84
233,75	0	-150,00	4	-99,64	4	-99,64
234,00	4	-69,60	0	-150,00	4	-86,96
234,50	4	-69,57	0	-150,00	4	-86,93
235,25	0	-150,00	696	-75,25	696	-75,25
236,50	6	-67,73	0	-150,00	6	-85,09
237,25	0	-150,00	42	-87,37	42	-87,37
237,75	0	-150,00	10	-94,99	10	-94,99
239,25	0	-150,00	26	-89,21	26	-89,21
240,00	2	-72,36	0	-150,00	2	-89,72
240,50	4	-69,32	0	-150,00	4	-86,68
241,25	0	-150,00	682	-75,08	682	-75,08
242,50	8	-67,13	0	-150,00	8	-83,59
243,25	0	-150,00	44	-86,91	44	-86,91
243,75	0	-150,00	16	-92,58	16	-92,58
245,25	0	-150,00	22	-89,68	22	-89,68
246,50	4	-69,07	0	-150,00	4	-86,43
247,25	0	-150,00	674	-74,89	674	-74,89
248,50	8	-65,97	0	-150,00	8	-83,33
249,25	0	-150,00	46	-86,45	46	-86,45
249,75	0	-150,00	16	-92,32	16	-92,32
251,25	0	-150,00	18	-90,29	18	-90,29
252,50	4	-68,81	0	-150,00	4	-86,17
253,25	0	-150,00	660	-74,72	660	-74,72
253,75	0	-150,00	2	-99,73	2	-99,73
254,50	10	-65,45	0	-150,00	10	-82,11
255,25	0	-150,00	48	-86,00	48	-86,00
255,75	0	-150,00	18	-91,37	18	-91,37
257,25	0	-150,00	14	-91,12	14	-91,12
258,50	4	-68,55	0	-150,00	4	-85,91
259,25	0	-150,00	650	-74,53	650	-74,53
259,75	0	-150,00	6	-94,69	6	-94,69
260,50	10	-64,48	0	-150,00	10	-81,84
261,25	0	-150,00	50	-85,55	50	-85,55
261,75	0	-150,00	18	-91,10	18	-91,10
263,25	0	-150,00	12	-91,53	12	-91,53
264,50	4	-68,29	0	-150,00	4	-85,65
265,25	0	-150,00	632	-74,39	632	-74,39
265,75	0	-150,00	10	-92,21	10	-92,21

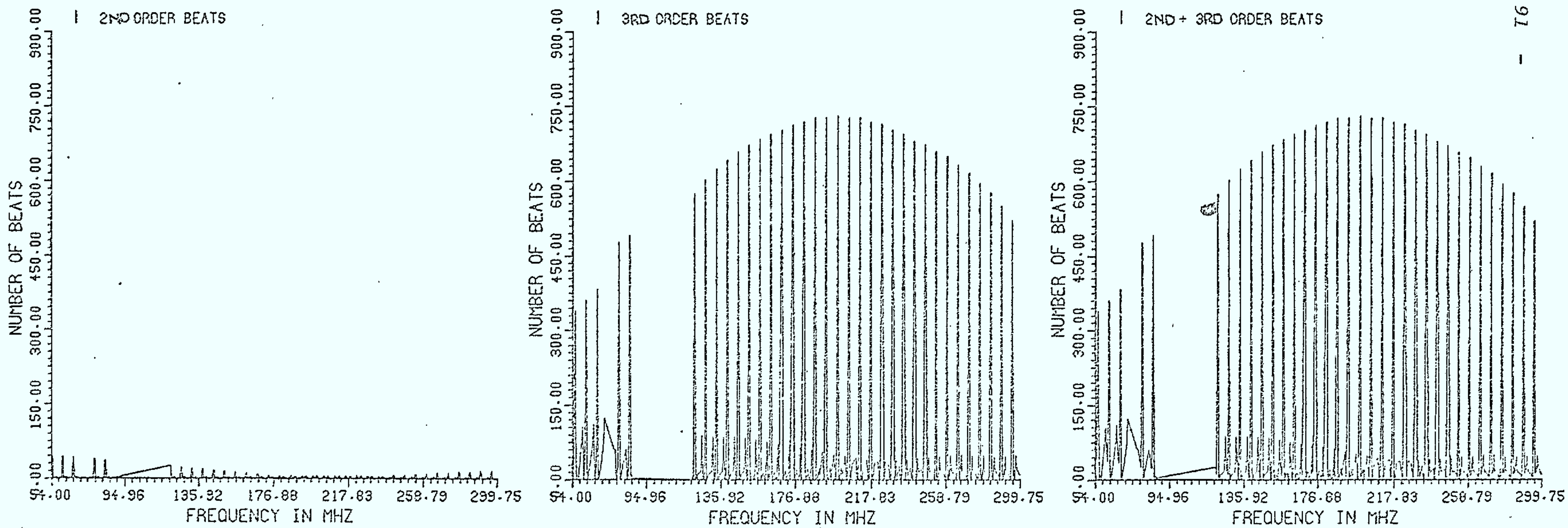
266,50	12	-64.00	0	-150,00	12	-80,79
267,25	0	-150.00	52	-85,11	52	-85,11
267,75	0	-150,00	18	-90,84	18	-90,84
269,25	0	-150,00	12	-91,26	12	-91,26
270,50	4	-68,02	0	-150,00	4	-85,38
271,25	0	-150.00	618	-74,23	618	-74,23
271,75	0	-150,00	12	-91,15	12	-91,15
272,50	12	-63,10	0	-150,00	12	-80,52
273,25	0	-150,00	52	-84,84	52	-84,84
273,75	0	-150.00	18	-90,57	18	-90,57
275,25	0	-150,00	12	-90,99	12	-90,99
275,75	0	-150.00	4	-97,82	4	-97,82
276,50	4	-67,75	0	-150,00	4	-85,11
277,25	0	-150.00	596	-74,11	596	-74,11
277,75	0	-150,00	12	-90,88	12	-90,88
278,50	14	-62,71	0	-150,00	14	-79,57
279,25	0	-150,00	50	-84,75	50	-84,75
279,75	0	-150,00	18	-90,29	18	-90,29
281,25	0	-150,00	12	-90,72	12	-90,72
281,75	0	-150,00	6	-94,97	6	-94,97
282,50	4	-67,47	0	-150,00	4	-84,83
283,25	0	-150,00	578	-73,98	578	-73,98
283,75	0	-150,00	12	-90,60	12	-90,60
284,50	14	-61,94	0	-150,00	14	-79,30
285,25	0	-150,00	48	-84,65	48	-84,65
285,75	0	-150,00	18	-90,02	18	-90,02
287,25	0	-150,00	12	-90,44	12	-90,44
287,75	0	-150,00	10	-92,78	10	-92,78
288,50	4	-67,19	0	-150,00	4	-84,55
289,25	0	-150,00	550	-73,92	550	-73,92
289,75	0	-150,00	12	-90,32	12	-90,32
290,50	16	-61,51	0	-150,00	16	-78,44
291,25	0	-150,00	48	-84,37	48	-84,37
291,75	0	-150,00	18	-89,74	18	-89,74
293,25	0	-150,00	12	-90,16	12	-90,16
293,75	0	-150,00	10	-92,50	10	-92,50
294,50	4	-66,91	0	-150,00	4	-84,27
295,25	0	-150,00	522	-73,89	522	-73,89
295,75	0	-150,00	12	-90,04	12	-90,04
296,50	16	-60,80	0	-150,00	16	-78,16
297,25	0	-150,00	50	-83,91	50	-83,91
297,75	0	-150,00	22	-88,72	22	-88,72
299,25	0	-150,00	12	-89,87	12	-89,87
299,75	0	-150,00	10	-92,22	10	-92,22

STD 35 CHANNEL VIDEO BEATS LAB MST



DISTORTION LEVEL IN DB VS. FREQUENCY

STD 35 CHANNEL VIDEO BEATS LAB MST



NUMBER OF BEATS VS. FREQUENCY