PTT 5151

ECHO/ADVANCED IMPAIRMENTS SIMULATOR

OPERATIONS MANUAL

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1.0 INTRODUCTION

The PTT 5151 Echo/Advanced Impairments Simulator is a general purpose, full featured, and user friendly test set that can be used with the PTT 5100 Telephone Line Simulator or in a stand-alone mode. This unit provides controlled telephone line impairments for use in engineering and manufacturing testing of data communications equipment. It is ideally suited for testing products such as full duplex echo canceling equipment (e.g. V.32 modems). Standard features include: independent selection of up to four echo signals (two near end and two far end), individual control of the delay and amplitude of each echo signal, control of the amplitude and envelope delay distortion encountered by the far end echoes, an extensive list of advanced impairments such as frequency offset, phase jitter, gain hits/ dropouts, nonlinear distortion, single frequency interference, listener echo, satellite delay, impulse noise, saving and recalling of user defined configurations for all Model 5151 parameters, manual front panel control, and both RS-232C and IEEE-488 remote programming.

A digital signal processing approach is used for implementation so that most of the test features are under software control. Consequently, many custom requirements can be met simply by changing the software programs.

The PTT 5151 is available in 3 configurations with the feature sets of each shown below. A factory installed option card is available to offer standalone operation, additive noise generation, and means to induce additional impairments externally when operating with the PTT 5100. All option card related documentation is contained in the PTT 5151 Option Card Operations Manual.

MODEL 5151-1
TALKER ECHOES
FREQUENCY OFFSET
SATELLITE DELAY
PHASE JITTER
NONLINEAR DISTORTION

MODEL 5151-2
ALL 5151-1 FEATURES PLUS
AMPLITUDE JITTER
GAIN HITS/DROPOUTS
IMPULSE NOISE
SINGLE FREQUENCY INTERFERENCE

MODEL 5151-3
ALL 5151-2 FEATURES PLUS
LISTENER ECHO
ECHO DISTORTION
RANDOM SELECTION FOR HITS AND IMPULSE NOISE
BAND LIMITED NOISE MODULATION SOURCE FOR
PHASE JITTER AND AMPLITUDE JITTER

2.0 SETUP PROCEDURE

2.1 5100 Companion Operation

The PTT 5151 can work in conjunction with a PTT 5100 of the proper revision level. To verify the revision level of the 5100, simultaneously press both scroll buttons. The LINE TYPE display will appear as shown below;

S-#.xx H-xx

S-#.xx reflects the software level while H-xx reflects the hardware level. For proper operation with the 5151, the 5100 software level must be 3.AA or higher. If the software version is not 3.AA or higher (1.xx or 2.xx), the 5100 must be factory modified to allow proper operation.

The 5100 will automatically detect the presence (or absence) of the 5151. Connecting the 5151 to an operating 5100 will cause the 5100 to change operating modes to incorporate the 5151 into the signal path. This process may provide undesirable transients, therefore, it is recommended the 5151 only be connected or disconnected with the 5100 powered off.

To operate the Model 5151 as a companion to the Model 5100, connect one end of the 40 conductor ribbon cable provided with the Model 5151 to the rear panel port labeled EXPANSION PORT. Connect the other end of the ribbon cable to the rear panel connector on the Model 5100 labeled EXPANSION PORT.

Connect the female end of the power cord provided with the Model 5151 to the receptacle labeled POWER IN. Connect the male end to an appropriate wall socket. Check to see that the rear panel voltage selector switch is set to match the available wall power (115 or 220 volts).

2.2 Standalone Operation

NOTE: The Model 5151 must be equipped with the factory installed option card to permit standalone operation.

Connect the female end of the power cord provided with the Model 5151 to the receptacle labeled POWER IN. Connect the male end to an appropriate wall socket. Check to see that the rear panel voltage selector switch is set to match the available wall power (115 or 220 volts). Once the unit is powered on, the GENERAL SETUP OPTIONS menu will be used to select standalone operation. Refer to the MENU CONFIGURATION and FRONT PANEL OPERATION sections for additional information.

3.0 POWER ON PROCEDURE

3.1 Power Up

The unit is powered on by the switch located on the upper left corner of the rear panel (viewed from the rear). Approximately one second after power is applied to the unit, the 5151 is restored to the configuration that was present when the unit was powered down.

3.2 LCD Contrast Adjustment

The contrast of the front panel LCD may be adjusted for optimum contrast under varying lighting conditions. The GENERAL SETUP OPTIONS menu allows for setting the LCD CONTRAST. Refer to the FRONT PANEL OPERATION section for additional information (Section 4.0).

3.3 Factory Reset Procedure

The 5151 can be initialized to a factory set status by using a "back door" power up procedure. CAUTION: This procedure will erase all previously saved parameters including the current front panel configuration. The procedure is:

1. Turn the power off.
2. Hold down the FAST button located on the front panel.
3. Turn on the power.
4. Release the FAST button.

4.0 FRONT PANEL OPERATION

The front panel of the Model 5151, as shown in Figure 1, is a functional block diagram of the signal flow paths within the unit. This yields a straightforward control philosophy that is both easy to understand and easy to operate. The use of a 2 row by 40 column Liquid Crystal Display (LCD) permits a menu driven approach to parameter selection and control.

Help is provided at each step of the MENU, SUBMENU, and VALUE selection process by flashing LEDs in the buttons that are active for the next operation.

4.1 Feature Selection, Value, and Numeric Description

The FEATURE SELECTION block contains select switches for MENU, SUBMENU, VALUE, and left and right SCROLL. Pressing the MENU button enables the SCROLL buttons and permits selection of major categories shown below;

ECHO ATTENUATION AND DELAY
ECHO DISTORTION
EXTERNAL PATH
FORWARD IMPAIRMENTS
CONFIGURATION STORAGE
GENERAL SETUP OPTIONS.

The second line of the LCD is used to provide user guidance. The MENU item being displayed will have additional features which can be accessed by pressing the SUBMENU switch and then using the SCROLL switches to select the the submenu item. For example, under ECHO ATTENUATION AND DELAY there are 5 items which can be selected as shown below;

FAR END ECHO
INTERMEDIATE ECHO A (FAR END)
INTERMEDIATE ECHO B (NEAR END)
NEAR END ECHO
LISTENER ECHO.

By scrolling to the desired submenu using the SCROLL buttons, the value of the selected parameter (e.g. FAR END ECHO) can be set by first pressing the VALUE select switch, then using the VALUE SCROLL buttons to scroll to the new value. By simultaneously pressing the FAST button in conjunction with one of the VALUE SCROLL buttons, the scroll speed is increased by approximately a factor of 10. The parameter value is updated each time the display changes while using the VALUE SCROLL buttons.

Example: Change the Near End Echo Delay from 0.0000 Seconds to 0.0005 Seconds.

1. Press the MENU button.
2. Use the left or right SCROLL button in the FEATURE SELECTION block to select ECHO ATTENUATION AND DELAY on the top line of the display.
3. Press the SUBMENU button.
4. Use the left or right SCROLL button in the FEATURE SELECTION block to select NEAR END ECHO on the top line of the display.
5. Press the VALUE button.
6. Use the left or right SCROLL button in the FEATURE SELECTION block to select the DELAY parameter (indicated by a flashing DELAY value)
7. Use the up SCROLL button in the VALUE SCROLL block to change the DELAY to 0.0005 seconds.

An alternative to using the VALUE SCROLL buttons is the direct value entry mode accessed with the NUMERIC button. A parameter value may be entered by pressing the NUMERIC button which transforms the front panel into a numeric keypad. Each front panel button has a numeric value identified above the button. The desired parameter value may then be entered directly by pressing the buttons corresponding to the desired numeric value. Once the value has been entered press the NUMERIC button again to toggle the front panel out of numeric mode. The VALUE CONTROL block may then be used to enter the value by pressing the ENTER button or cancel the entry by pressing the CANCEL button. The numeric entry mode offers a mechanism for making large instantaneous value changes, since the parameter value is not changed until the ENTER button is pressed.

Example: Change the Near End Echo Delay from 0.0000 Seconds to 0.0005 Seconds.

1. Press the MENU button.
2. Use the left or right SCROLL button in the FEATURE SELECTION block to select ECHO ATTENUATION AND DELAY on the top line of the display.
3. Press the SUBMENU button.
4. Use the left or right SCROLL button in the FEATURE SELECTION block to select NEAR END ECHO on the top line of the display.
5. Press the VALUE button.
6. Use the left or right SCROLL button in the FEATURE SELECTION block to select the DELAY parameter (indicated by a flashing DELAY value).
7. Press the NUMERIC button to enter numeric mode.

8. Press the CANCEL button (.).
9. Press the OFF/ON button (0).
10. Press the OFF/ON button (0).
11. Press the OFF/ON button (0).
12. Press the -> button (5).
13. Press the NUMERIC button to exit numeric mode.
14. Press the ENTER button.

Each impairment has ON/OFF capability and may be turned ON or OFF by using the OFF/ON switch in the VALUE CONTROL block. Turning an impairment OFF simply disables that impairment and does not alter the parameter values.

4.2 Status Description

The LCD display may be used to indicate the 5151 setup by pressing the STATUS button. The SCROLL buttons in the FEATURE SELECTION block may then be used to scroll through the available status screens.

Screen 1: Displays the settings for the 4 talker echoes.
Screen 2: Displays the settings of SATELLITE DELAY, FREQUENCY OFFSET, and PHASE JITTER.
Screen 3: Displays the settings of NONLINEAR DISTORTION.
Screen 4: Displays the settings of PHASE HITS
Screen 5: Displays the settings of AMPLITUDE JITTER
Screen 6: Displays the settings of IMPULSE NOISE and SINGLE FREQUENCY INTERFERENCE.
Screen 7: Displays the settings of GAIN HITS / DROPOUTS
Screen 8: Displays the settings of LISTENER ECHO and ECHO DISTORTION.

4.3 Front Panel Standby Mode

A front panel standby mode may be entered at any time by pressing the FEATURE SELECTION button associated with the present state. For example, pressing the SUBMENU button while displaying NEAR END ECHO will disable the SCROLL switches and extinguish all flashing LEDs. Pressing the STATUS button while in the Status mode will also initiate the standby condition. There is no change in the operating mode of the unit while in standby. Active impairments continue to operate; however, all flashing on the front panel is disabled.

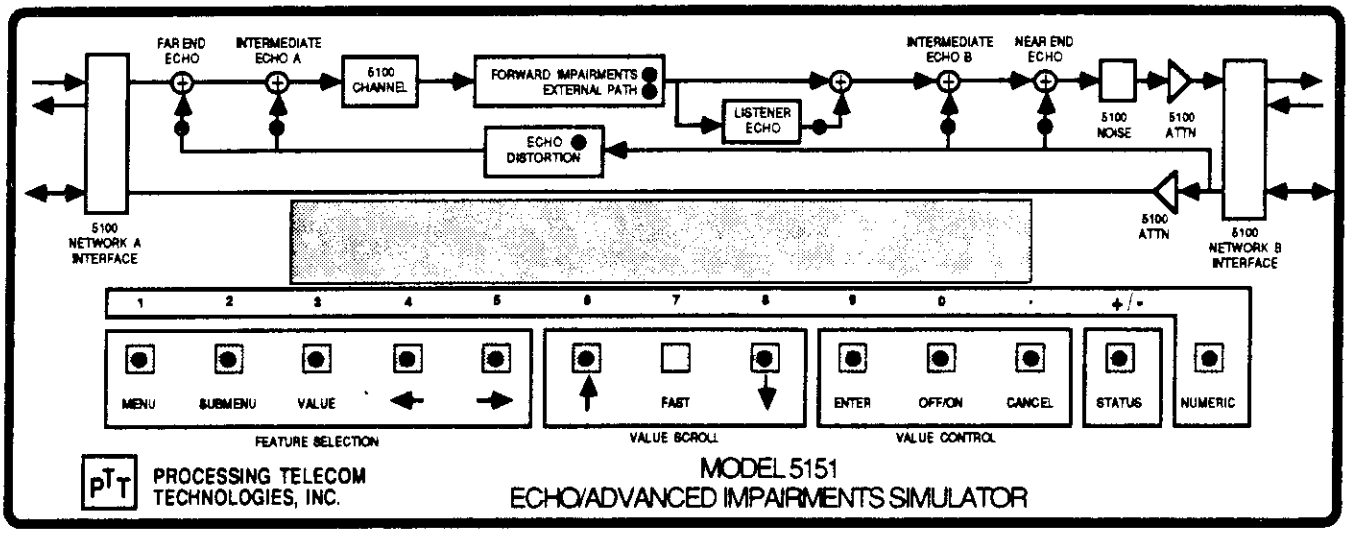
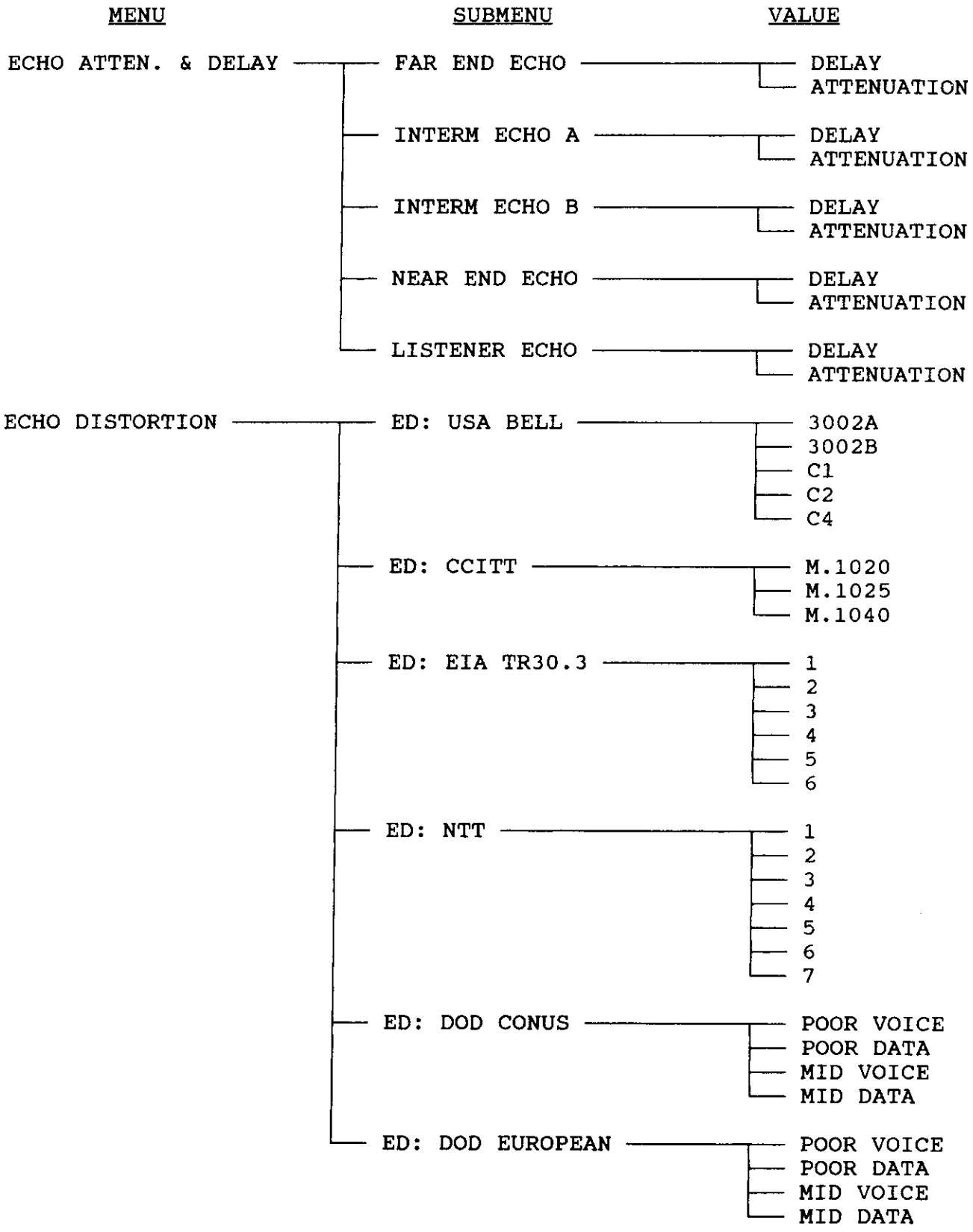
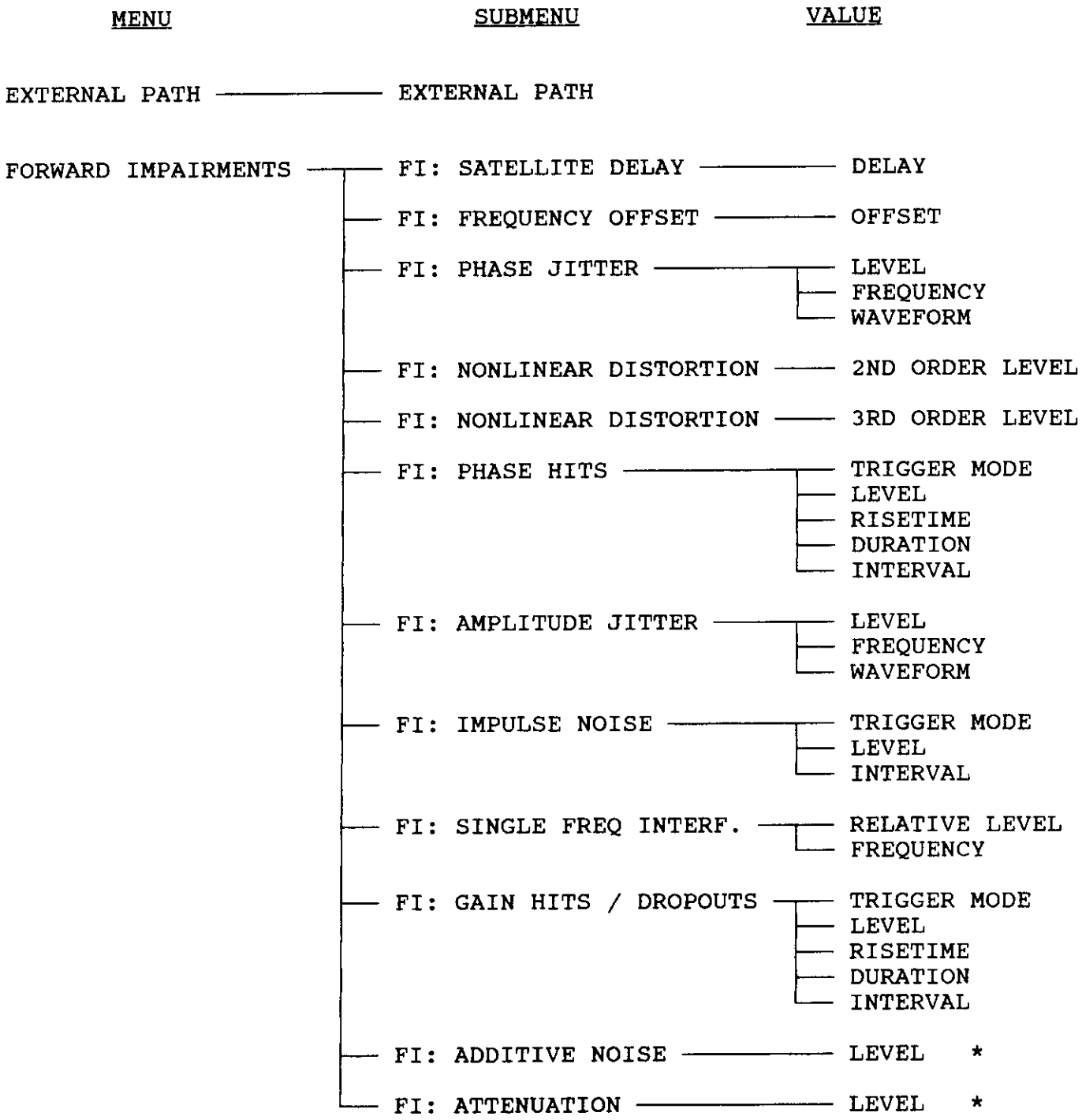


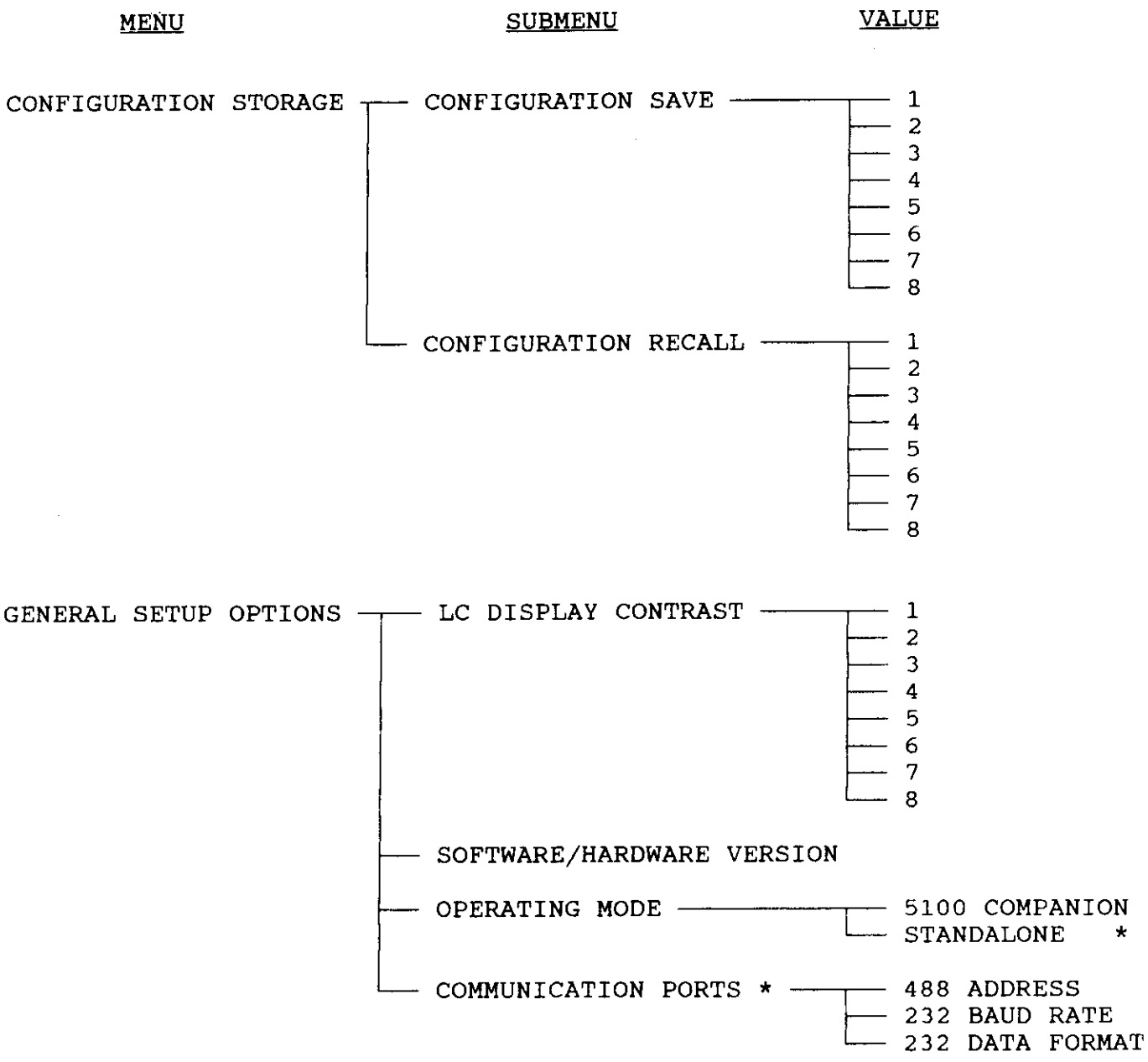
Figure 1: Echo/Advanced Impairments Simulator Front Panel Layout

5.0 MENU CONFIGURATION

The following tree diagram shows the structure of the 5151 menus.




MENU
SUBMENU
VALUE
EXTERNAL PATH
EXTERNAL PATH
FORWARD IMPAIRMENTS
FI: SATELLITE DELAY
DELAY
FI: FREQUENCY OFFSET
OFFSET
FI: PHASE JITTER
LEVEL
FREQUENCY
WAVEFORM
FI: NONLINEAR DISTORTION
2ND ORDER LEVEL
FI: NONLINEAR DISTORTION
3RD ORDER LEVEL
FI: PHASE HITS
TRIGGER MODE
LEVEL
RISETIME
DURATION
INTERVAL
FI: AMPLITUDE JITTER
LEVEL
FREQUENCY
WAVEFORM
FI: IMPULSE NOISE
TRIGGER MODE
LEVEL
INTERVAL
FI: SINGLE FREQ INTERF.
RELATIVE LEVEL
FREQUENCY
FI: GAIN HITS / DROPOUTS
TRIGGER MODE
LEVEL
RISETIME
DURATION
INTERVAL
FI: ADDITIVE NOISE
LEVEL *
FI: ATTENUATION
LEVEL *



* OPTION CARD REQUIRED

6.0 REAR PANEL CONNECTORS

The power entry module, power switch , 115/220 volt selector switch, PTT Serial Number Sticker, Expansion Port, Analog In and Analog Out connectors are all located on the rear panel of the 5151 as shown in Figure 2.

If the PTT 5151 has been equipped with a 5151 OPTION CARD, the rear panel will also include an IEEE-488 connector and an RS-232 connector.

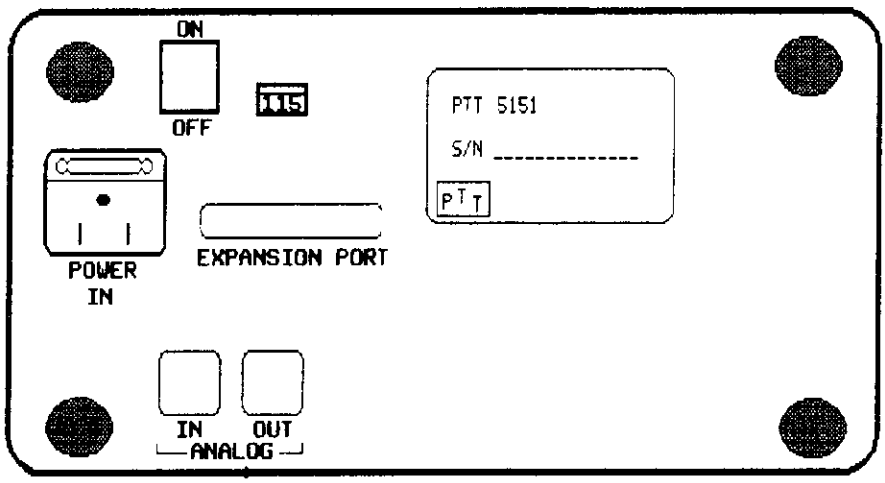


Figure 2: PTT 5151 Rear Panel

6.1 Expansion Port Connector

The Expansion Port connector is used to connect the 5151 to the PTT 5100 Telephone Line Simulator.

37 Pin Dual Row - TRW Part No. FC37ST

6.2 Analog In/Out Connectors

The Analog In/Out connectors are functional only with the 5151 OPTION CARD installed. The In port is used to connect signals into the Forward Path when operating in the standalone mode. These signals will pass through the Forward Impairments block and exit via the Analog Out connector. The reverse signal enters the Out connector and is used to create the 4 talker echoes while being passed out the In connector.

When used in conjunction with the PTT 5100 for EXTERNAL PATH inputs and outputs, the forward impairment path is broken and the signal is routed to the OUT connector. The signal may then pass through an additional impairment inducing device (such as the PTT 5721 PCM/ADPCM LINK SIMULATOR) and be returned via the IN connector. The signal is then reinjected into the forward path at the original point. It is recommended that gain not be added externally in this mode to avoid clipping in the 5151.

6.2.1 Signal Levels

Input — +3 dBm to −25 dBm

Output — 0 dBm to −55 dBm

6.2.2 Impedance Levels

The input and output impedances are 600 ohms resistive.

6.2.3 Connector Specifications

AMP 520250−2 RJ−11

6.2.4 IN Connector Operation

PIN #	NAME	STANDALONE FUNCTION	EXTERNAL PATH FUNCTION
1	NOT USED		
2	MI (BLACK)	Reverse Path Output	
3	RING (RED)	Forward Path Input	Output from External Impairments (5151 input)
4	TIP (GREEN)	Forward Path Input	Output from External Impairments (5151 input)
5	MIC (YELLOW)	Reverse Path Output	
6	NOT USED		

6.2.5 OUT Connector Function

PIN #	NAME	STANDALONE FUNCTION	EXTERNAL PATH FUNCTION
1	NOT USED		
2	MI (BLACK)	Forward Path Output	Input to External Impairments (5151 output)
3	RING (RED)	Reverse Path Input	
4	TIP (GREEN)	Reverse Path Input	
5	MIC (YELLOW)	Forward Path Output	Input to External Impairments (5151 output)
6	NOT USED		

6.3 RS-232C Connector

The RS-232C connector is only present on units equipped with the 5151 OPTION CARD. This connector allows the interface of a dumb terminal or a computer and permits remote control of the 5151 system parameters in standalone mode. When used with the PTT 5100, the control commands are relayed through the 5100 RS-232C interface port, eliminating the need for an additional port on the 5151.

Connector on Rear Panel: RS-232 BERG 68232-025

PIN #	CKT	DIRECTION	FUNCTION
2	BA	FROM DTE	TD Transmit Data
3	BB	TO DTE	RD Receive Data
5	CB	TO DTE	CTS Clear To Send
6	CC	*	DSR Data Set Ready
7	AB		Signal Ground
8	CF	*	CD Data Carrier Detect
20	CD	FROM DTE	DTR Data Terminal Ready

ALL OTHER PINS ARE NOT USED

* Pulled high through 3.3K to +12 VDC in the 5151.

6.4 IEEE-488 Connector

The IEEE-488 connector is only present on units equipped with the 5151 OPTION CARD. This connector allows the interface of a IEEE-488 bus (GPIB) and permits remote control of the 5151 system parameters in the standalone mode. When used with the PTT 5100, the control commands are relayed through the 5100 IEEE-488 interface port, eliminating the need for an additional port on the 5151. The pin definitions and functionality are specified in ANSI/IEEE Std 488-1978 and IEEE Std 728-1982. Refer to Appendix A for additional details.

Connector on Panel: IEEE 488	BERG 68519-001
	AMPH 57-92245-12

6.5 Fuse Replacement Procedure

The 5151 fuses the AC power to protect the unit from current surges or other potentially hazardous conditions. To replace the fuse, follow the procedure outlined below;

1. Remove the power cord from the rear panel power entry module.
2. Using a small screwdriver, remove the fuse holder from the power entry module.
3. Replace the damaged fuse with a 5 X 20 mm 1A 250V Fast Blow fuse.

7.0 IMPAIRMENTS

7.1 IMPAIRMENT DESCRIPTIONS

7.1.1 Linear Distortion

Linear amplitude and envelope delay distortion available in echo signal path as shown in line model graphs of Appendix B.

7.1.2 Nonlinear Distortion

Second and Third order nonlinear distortion adjustable over a range of -20 to -60 dB relative level with a resolution of 0.5 dB. Calibrated according to the IEEE 743-1984 four tone test.

7.1.3 Frequency Offset

Available over the range of +/- 20 Hz at a resolution of 0.001 Hz. Amplitude modulation is less than one percent.

7.1.4 Phase Hits

Uniform, single, or pseudo-random hits as described in Figure 7.1. The parameter bounds are automatically set using the equations shown below;

D - Duration
I - Interval
R - Risetime

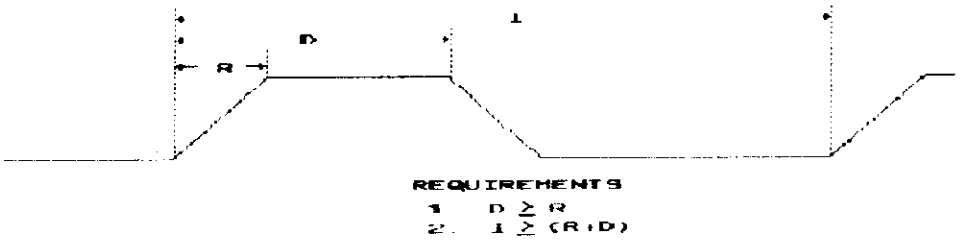


Figure 7.1 Amplitude and Phase Hits Waveform Description.

7.1.5 Phase Jitter

Level ranges from 0 to 360 degrees, frequency ranges from 0 to 360 Hz, with sinusoidal, square wave, half-wave rectified, full-wave rectified, and bandlimited noise modulation sources available.

7.1.6 Gain Hits/Dropouts

Uniform, single, or pseudo-random hits as described in figure 7.1. Total RMS output power should not be set to exceed 0 dBm during the hit.

7.1.7 Amplitude Jitter

Level ranges from 0 to 99 percent, frequency ranges from 0 to 360 Hz., with sinusoidal, square wave, half-wave rectified, full-wave rectified, and bandlimited noise modulation sources available.

7.1.8 Single Frequency Interference

Amplitude programmable from 0 to -50 dB relative to outut signal level, at a frequency range of 200 to 3300 Hz.

7.1.9 Impulse Noise

Amplitude programmable from 30 to 100 dBrn with an interval range from 0.1 to 600 seconds. Standard impulse defined by IEEE 743-1984. Single, uniform, or pseudo-random trigger sources available.

7.1.10 White Noise

Signal-to-Noise Ratio programmable from 0 to 40 dB. SNR is true RMS power to noise power in a 300-3300 Hz band. Noise level is subject to an absolute minimum noise level of -80 dBm.

7.1.11 Talker Echoes

Four independent talker echoes (two near end and two far end) with independent amplitude adjustable from 3 to 40 dB attenuation relative to input signal, and independent delay adjustable from 0.1 to 1600 ms.

7.1.12 Listener Echoes

Amplitude adjustable from 3 to 40 dB attenuation relative to input signal, delay adjustable from 0.1 to 1600 ms.

7.1.13 Satellite Delay

Bulk delay programmable from 0.1 to 1600 ms.

7.2 IMPAIRMENT SPECIFICATIONS

#	IMPAIRMENT	PARAMETER	RANGE	RESOLUTION	ACCURACY	COMMENTS
1	LINEAR DISTORTION	AMPLITUDE/EDD DISTORTION	-	-	-	SEE APPENDIX B FOR LINE MODELS
2	NONLINEAR DISTORTION	2nd ORDER RELATIVE LEVEL	-20 to -60 dB	0.5 dB	+/- 0.5 dB	LEVELS RELATIVE TO SIGNAL CALIBRATED ACCORDING TO 4 TONE TEST IEEE 743-1984.
		3rd ORDER RELATIVE LEVEL	-20 to -60 dB	0.5 dB	+/- 0.5 dB	
3	FREQUENCY OFFSET	FREQUENCY OFFSET	-20 to +20 Hz	0.001 Hz	+/- 0.01% +/-0.0005 Hz	A.M. < 1%
4	PHASE HITS	LEVEL	0 - 180 DEG	0.1 DEG	+/-0.05 DEG	
		RISETIME	0.2 - 1000 ms	0.1 ms	+/-0.1 ms	
		DURATION	0.0003 - 30 sec	0.0001 sec	+/-0.01% +/-0.1 ms	UNIFORM, SINGLE, OR PSEUDO-RANDOM
		INTERVAL	0.1 - 600 sec	0.1 sec	+/-0.1 sec	
5	PHASE JITTER	LEVEL	0 - 360 DEG	0.1 DEG	+/-0.05 DEG	WAVEFORM SELECTIONS: SINUSOID, FULL-WAVE OR HALF-WAVE RECTIFIED SINUSOID, SQUARE WAVE, AND BANDLIMITED NOISE.
		FREQUENCY	0 - 360 Hz	0.1 Hz	+/-0.05 Hz	
		WAVEFORMS	-	-	-	
6	GAIN HITS/ DROPOUTS	LEVEL	-25 to +7 dB	0.1 dB	+/-0.05 dB	NOTE: TOTAL RMS OUTPUT POWER SHOULD NOT BE SET TO EXCEED 0 dBm DURING GAIN HIT.
		RISETIME	0.2 - 1000 ms	0.1 ms	+/-0.1 ms	
		DURATION	0.0003 - 30 sec	0.0001 sec	+/-0.01% +/-0.1ms	UNIFORM, SINGLE, OR PSEUDO-RANDOM
		INTERVAL	0.1 - 600 sec	0.1 sec	+/-0.1ms	
7	AMPLITUDE JITTER	LEVEL	0 - 99%	0.1%	+/-0.05%	WAVEFORM SELECTIONS: SINUSOID, FULL-WAVE OR HALF-WAVE RECTIFIED SINUSOID, SQUARE WAVE, AND BANDLIMITED NOISE.
		FREQUENCY	0 - 360 Hz	0.1 Hz	+/-0.05 Hz	
		WAVEFORMS	-	-	-	
8	SINGLE FREQUENCY INTERFERENCE	RELATIVE LEVEL	0 to -50 dB	0.5 dB	+/-0.5 dB	LEVEL CALIBRATED RELATIVE TO SIGNAL
		FREQUENCY	200 - 3300 Hz	1 Hz	+/-0.5 Hz	

Table A: PTT 5151 Impairment Specifications

#	IMPAIRMENT	PARAMETER	RANGE	RESOLUTION	ACCURACY	COMMENTS
9	IMPULSE NOISE	LEVEL	30-100 dBrn	0.5 dB	+/-0.5 dB	LEVEL CALIBRATION IS C-NOTCHED. STD IMPULSE OF IEEE 743-1984 IS USED
		INTERVAL	0.1-600 sec	0.1 sec	+/-0.01% +/-0.1 sec	UNIFORM, SINGLE, OR PSEUDO-RANDOM
10	WHITE NOISE	SNR (SEE NOTE 1)	0-40 dB SUBJECT TO NOISE >= -80 dBm	0.5 dB	+/-0.5 dB +/-1.0 dB	FOR NOISE >=-60 dBm FOR NOISE < -60 dBm
		BANDWIDTH	-3 dB @ 5 KHz	-	-	ROLL-OFF IS 12 db/OCTAVE
11	TALKER ECHOES	ATTENUATION (SEE NOTE 2)	3 - 40 dB	0.1 dB	+/-0.2 dB	THERE ARE 4 INDEPENDENT TALKER ECHOES: NEAR, FAR INTERMEDIATE A, AND
		DELAY (SEE NOTE 3)	0.1 - 1600.0 ms	0.1 ms	+/-0.01% +/-0.1 ms	INTERMEDIATE B. SEE MANUAL FOR ROUTING.
		AMPLITUDE/EDD DISTORTION	-	-	-	SEE MANUAL FOR LINE MODELS
12	LISTENER ECHO	ATTENUATION	3 - 40 dB	0.1 dB	+/-0.1 dB	LEVEL CALIBRATED RELATIVE TO SIGNAL
		DELAY	0.1 - 1600.0 ms	0.1 ms	+/-0.01% +/-0.1 ms	
13	SATELLITE DELAY	DELAY (SEE NOTE 4)	0.1 - 1600.0 ms	0.1 ms	+/-0.01% +/-0.1 ms	

NOTE 1: SNR IS TRUE RMS SIGNAL OUTPUT POWER TO NOISE POWER IN 300-3300 Hz BAND.

NOTE 2: ATTENUATION IS CALIBRATED TO THE POINT OF INJECTION INTO FORWARD PATH: FAR END AND INTERMEDIATE A ECHOES HAVE ADDITIONAL FORWARD PATH ATTENUATION.

NOTE 3: DELAY IS CALIBRATED TO THE POINT OF INJECTION INTO THE FORWARD PATH. FAR END AND INTERMEDIATE A ECHOES HAVE ADDITIONAL FORWARD PATH DELAY AND/OR SATELLITE DELAY.

NOTE 4: TOTAL DELAY IS SUM OF SATELLITE DELAY AND ADDITIONAL DELAYS ASSOCIATED WITH LINE MODELS.

Table A: PTT 5151 Impairment Specifications (cont.)

8.0 SPECIFICATIONS

8.1 Physical

DIMENSION: 6" x 12" x 12"

WEIGHT: 12 lbs.

8.2 Environmental

Operating Temperature: 0 to 50 degrees C

Storage Temperature: -40 to 85 degrees C

Humidity: 10% to 90% non-condensing

8.3 Power

115 VAC +/- 10% , 50-60 Hz
(Switchable to 220 VAC +/- 10%)

Fuse: 1A 250V Fast Blow
5 X 20 mm

9.0 WARRANTY

Processing Telecom Technologies, Inc. warrants each Model 5151 against defects in material and workmanship for a period of one year from the date the Model 5151 was shipped to the customer. If at any time during the warranty period, the Model 5151 should malfunction, PTT will repair or, at PTT's option, replace the unit free of charge.

The remedies listed herein are the user's sole and exclusive remedies. PTT shall not be liable for any indirect, direct, incidental, or consequential damages. Owner must return the unit to the factory, shipping prepaid, insured and packaged to best commercial standard for electronic equipment. PTT will pay shipping charges for delivery on return. Customer is responsible for mode and cost of shipment to PTT.

Warranty does not apply if the unit has been damaged by accident, misuse or as a result of service or modification by other than PTT personnel. The warranty registration card, shipped with the equipment, must be completed and returned to PTT to validate this warranty.

When returning a 5151 for warranty work, a return material authorization (RMA) number must be obtained from customer service at the address/phone number below.

Customer Service Manager
Processing Telecom Technologies, Inc.
6767 Madison Pike #296
Huntsville, AL 35806 Telephone: 205/837-7880

APPENDIX A

IEEE-488/RS-232C REMOTE CONTROL INSTRUCTIONS

A.1 COMMUNICATION PORT SETUP

A.1.1 PTT 5100 Companion Operation

A.1.1.1 IEEE-488 Address

In 5100 Companion Mode, the 5151 receives remote commands via the expansion port connector. Commands are relayed through the PTT 5100. Therefore, the PTT 5100 is the only device connected to the IEEE-488 bus. Refer to the PTT 5100 manual for setting the bus address for the device pair.

A.1.1.2 RS-232C Configuration

In 5100 Companion Mode, the 5151 receives remote commands via the expansion port connector. Commands are relayed through the PTT 5100. Therefore, the PTT 5100 is the only device connected to the RS-232C controller. Refer to the PTT 5100 manual for instructions on how to setup the 5100's RS-232C port.

A.1.2 Standalone Operation

A.1.2.1 IEEE-488 Address

In the standalone mode, the IEEE-488 address is set using the front panel LCD. The GENERAL SETUP OPTIONS menu contains an entry for setting up the COMMUNICATION PORTS. Once this menu has been selected, the VALUE SCROLL buttons may be used to change the address.

A.1.2.2 RS-232C Configuration

In the standalone mode, the RS-232C setup is configured using the front panel LCD. The GENERAL SETUP OPTIONS menu contains an entry for setting up the COMMUNICATION PORTS. Once this menu has been selected, the VALUE SCROLL buttons may be used to change the baud rate and data format. The data format is constrained to be any combination of data bits, parity bits, and stop bits that results in a 10 bit per character data format.

A.1.3 Command Format

All commands sent to the 5151 using either the IEEE-488 or RS-232C control ports must be terminated with a Carriage Return (CR). A line feed character (LF) after the carriage return is optional. Blanks preceding and following the actual command are allowed, but blanks "embedded" in the command are not allowed. The Backspace key can be used to backspace over previous entries and re-enter the information. An entire line can be deleted using a Ctrl X (^X) key sequence.

Responses from the 5151 are terminated with carriage return and line feed character. For the IEEE-488, the EOI line is asserted when sending the line feed character.

A.2 REMOTE CONTROL COMMAND CONVENTION

The 5151 can be configured from the IEEE-488 or RS-232 ports according to the commands summarized below. The following conventions are followed when interpreting the commands:

Xx,Yx - Primary and Secondary Arguments

[] - Optional arguments, if omitted the 5151 will return the present argument parameter value(s).

The 5151 will re-configure the hardware according to the command given and then will respond as follows:

OK	The command has been accepted and implemented
ERR x	Error message (See Command Response Table)

*****IMPORTANT*****

The command arguments must be sent to the 5151 in exactly the form shown in the command summary. Otherwise, an invalid argument response will be returned.

A.3 5151-1 COMMANDS

A.3.1 FAR END ECHO (FEE)

COMMAND	SUMMARY	
FEE[,X1]	Description:	Activate/Deactivate FEE
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
FEE	Response:	5151 will respond with either an ON or OFF code.
FEEA[,X1]	Description:	Set Far End Echo Attenuation
	Arguments:	X1 = Attenuation (03.0 ≤ X1 ≤40.0 dB) Step Size: 0.1 dB
	Response:	OK or ERR code
FEEA	Response:	5151 will respond with present argument value
FEED[,X1]	Description:	Set Far End Echo Delay
	Arguments:	X1 = Delay (0.0000 ≤ X1 ≤ 1.6000 Sec.) Step Size: 0.0001 Sec.
	Response:	OK or ERR code
FEED	Response:	5151 will respond with present argument value

A.3.2 INTERMEDIATE ECHO A (IEA)

COMMAND	SUMMARY	
IEA[,X1]	Description:	Activate/Deactivate IEA
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
IEA	Response:	5151 will respond with either an ON or OFF code.
IEAA[,X1]	Description:	Set Intermediate Echo A Attenuation
	Arguments:	X1 = Attenuation (03.0 ≤ X1 ≤ 40.0 dB) Step Size: 0.1 dB
	Response:	OK or ERR code
IEAA	Response:	5151 will respond with present argument value
IEAD[,X1]	Description:	Set Intermediate Echo A Delay
	Arguments:	X1 = Delay (0.0000 ≤ X1 ≤ 1.6000 Sec.) Step Size: 0.0001 Sec
	Response:	OK or ERR code
IEAD	Response:	5151 will respond with present argument value

A.3.3 INTERMEDIATE ECHO B (IEB)

COMMAND	SUMMARY	
IEB,X1]	Description:	Activate/Deactivate IEB
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
IEB	Response:	5151 will respond with either an ON or OFF code.
IEBA[,X1]	Description:	Set Intermediate Echo B Attenuation
	Arguments:	X1 = Attenuation (03.0 ≤ X1 ≤ 40.0 dB) Step Size: 0.1 dB
	Response:	OK or ERR code
IEBA	Response:	5151 will respond with present argument value.
IEBD[,X1]	Description:	Set Intermediate Echo B Delay
	Arguments:	X1 = Delay (0.0000 ≤ X1 ≤ 1.6000 Sec.) Step Size: 0.0001 Sec
	Response:	OK or ERR code
IEBD	Response:	5151 will respond with present argument value.

A.3.4 NEAR END ECHO (NEE)

COMMAND	SUMMARY	
NEE[,X1]	Description:	Activate/Deactivate NEE
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
NEE	Response:	5151 will respond with either an ON or OFF code.
NEEA[,X1]	Description:	Set Near End Echo Attenuation
	Arguments:	X1 = Attenuation (03.0 ≤ X1 ≤ 40.0 dB) Step Size: 0.1 dB
	Response:	OK or ERR code
NEEA	Response:	5151 will respond with present argument value.
NEED[,X1]	Description:	Set Near End Echo Delay
	Arguments:	X1 = Delay (0.0000 ≤ X1 ≤ 1.6000 Sec.) Step Size: 0.0001 Sec
	Response:	OK or ERR code
NEED	Response:	5151 will respond with present argument value.

A.3.5 FORWARD IMPAIRMENT SATELLITE DELAY (FISD)

COMMAND	SUMMARY	
FISD[,X1]	Description:	Set Forward Impairment Satellite Delay
	Arguments:	X1 = Delay = OFF = ON (0.0000 ≤ X1 ≤ 1.6000 sec.) Step Size: 0.0001 Sec
	Response:	OK or ERR code
FISD	Response:	5151 will respond with either an ON or OFF plus the present argument value.

A.3.6 FORWARD IMPAIRMENT FREQUENCY OFFSET (FIFO)

COMMAND	SUMMARY	
FIFO[,X1]	Description:	Set Forward Impairment Frequency Offset
	Arguments:	X1 = Offset = OFF = ON (−20.000 ≤ X1 ≤ +20.000 Hz) Step Size: 0.001 Hz
	Response:	OK or ERR code
FIFO	Response:	5151 will respond with either an ON or OFF plus the present argument value.

A.3.7 FORWARD IMPAIRMENT PHASE JITTER (FIPJ)

COMMAND	SUMMARY	
FIPJ[,X1]	Description:	Activate/Deactivate FIPJ
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
FIPJ	Response:	5151 will respond with either an ON or OFF code.
FIPJL[,X1]	Description:	Set Forward Impairment Phase Jitter Level
	Arguments:	X1 = Amplitude (000.0 ≤ X1 ≤ 360.0 Degrees) Step Size: 0.1 Degrees
	Response:	OK or ERR code
FIPJL	Response:	5151 will respond with present argument value.
FIPJF[,X1]	Description:	Set Forward Impairment Phase Jitter Frequency
	Arguments:	X1 = Frequency (000.0 ≤ X1 ≤ 360.0 Hz) Step Size: 0.1 Hz
	Response:	OK or ERR code
FIPJF	Response:	5151 will respond with present argument value.

COMMAND	SUMMARY	
FIPJW[,X1]	Description:	Set Forward Impairment Phase Jitter Waveform type
	Arguments:	X1 = Waveform SINUSOID (Sine Wave) FW RECT (Full Wave Rectified sine) HW RECT (Half Wave Rectified Sine) SQUARE (Square Wave) BL NOISE (Band Limited # Pseudo-Random Noise)
# 5151-3 ONLY		
	Response:	OK or ERR code
FIPJW	Response:	5151 will respond with present argument value.

A.3.8 FORWARD IMPAIRMENT NONLINEAR DISTORTION 2ND ORDER (FIND2)

COMMAND	SUMMARY	
FIND2[,X1]	Description:	Set Forward Impairment Nonlinear Distortion 2nd Order level
	Arguments:	X1 = Level = ON = OFF (20.0 ≤ X1 ≤ 60.0 dB) Step Size: 0.5 dB
	Response:	OK or ERR code
FIND2	Response:	5151 will respond with ON or OFF plus the present argument value.

A.3.9 FORWARD IMPAIRMENT NONLINEAR DISTORTION 3RD ORDER (FIND3)

COMMAND	SUMMARY	
FIND3[,X1]	Description:	Set Forward Impairment Nonlinear Distortion 3nd Order level
	Arguments:	X1 = Level = ON = OFF (20.0 ≤ X1 ≤ 60.0 dB) Step Size: 0.5 dB
	Response:	OK or ERR code
FIND3	Response:	5151 will respond with ON or OFF plus the present argument value.

A.3.10 CONFIGURATION SAVE (CSAVE)

COMMAND	SUMMARY	
CSAVE[,X1]	Description:	Save the current state of the 5151 in the selected address.
	Arguments:	X1 = Address to SAVE state Range: 1 – 8
	Response:	OK or ERR code

A.3.11 CONFIGURATION RECALL (CRCL)

COMMAND	SUMMARY	
CRCL[,X1]	Description:	Recall stored PTT 5151 setup and restore unit to recalled state.
	Arguments:	X1 = Address of stored setup Range: 1 – 8
	Response:	OK or ERR code

A.4 5151-2 ADDITIONAL COMMANDS

A.4.1 FORWARD IMPAIRMENT PHASE HITS (FIPH)

COMMAND	SUMMARY	
FIPH[,X1]	Description:	Activate/Deactivate FIPH
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
FIPH	Response:	5151 will respond with either an ON or OFF code.
FIPHL[,X1]	Description:	Set Forward Impairment Phase Hits Level.
	Arguments:	X1 = Level 000.0 ≤ X1 ≤ 180.0 Degrees) Step Size: 0.1 Degrees
	Response:	OK or ERR code
FIPHL	Response:	5151 will respond with present argument value.
FIPHR[,X1]	Description:	Set Forward Impairment Phase Hits Risetime.
	Arguments:	X1 = Risetime (0000.2 ≤ X1 ≤ 1000.0 mSec.) Step Size: 0.0001 Sec. (See FIPHD and FIPHI for restrictions)
	Response:	OK or ERR code
FIPHR	Response:	5151 will respond with present argument value.

COMMAND	SUMMARY	
FIPHD[,X1]	Description:	Set Forward Impairment Phase Hits Duration.
	Arguments:	X1 = Duration (00.0010 ≤ X1 ≤ 30.0000 Sec.) Step Size: 0.0001 Sec. (Duration must exceed Risetime). See FIPHI, also.
	Response:	OK or ERR code
FIPHD	Response:	5151 will respond with present argument value.
FIPHI[,X1]	Description:	Set Forward Impairment Phase Hits Interval.
	Arguments:	X1 = Interval (000.1 ≤ X1 ≤ 600.0 Sec.) Step Size: 0.1 Sec. (Interval must exceed Risetime plus Duration).
	Response:	OK or ERR code
FIPHI	Response:	5151 will respond with present argument value.
FIPHT[,X1]	Description:	Set Forward Impairment Phase Hits Interval Trigger
	Arguments:	X1 = Trigger Mechanism UNI (Uniform) SGL (Single) RAN (Pseudo-Random) #
FIPHT	Response:	5151 will respond with present argument value.

- 5151-3 Only

A.4.2 FORWARD IMPAIRMENT AMPLITUDE JITTER (FIAJ)

COMMAND	SUMMARY	
FIAJ[,X1]	Description:	Activate/Deactivate FIAJ
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
FIAJ	Response:	5151 will respond with either an ON or OFF code.
FIAJL[,X1]	Description:	Set Forward Impairment Amplitude Jitter Level
	Arguments:	X1 = Level (00.0 ≤ X1 ≤ 99.0 Percent) Step Size: 0.1 Percent
	Response:	OK or ERR code
FIAJL	Response:	5151 will respond with present argument value.
FIAJF[,X1]	Description:	Set Forward Impairment Amplitude Jitter Frequency
	Arguments:	X1 = Frequency (000.0 ≤ X1 ≤ 360.0 Hz) Step Size: 0.1 Hz
	Response:	OK or ERR code
FIAJF	Response:	5151 will respond with present argument value.

COMMAND	SUMMARY	
FIAJW[,X1]	Description:	Set Forward Impairment Amplitude Jitter Waveform Type
	Arguments:	X1 = Waveform SINUSOID (Sine Wave) FW RECT (Full Wave Rectified sine) HW RECT (Half Wave Rectified Sine) SQUARE (Square Wave) BL NOISE (Band Limited # Pseudo-Random Noise)
FIAJW	Response:	5151 will respond with present argument value.

5151-3 ONLY

A.4.3 FORWARD IMPAIRMENT IMPULSE NOISE (FIIN)

COMMAND	SUMMARY	
FIIN[,X1]	Description:	Activate/Deactivate FIIN
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
FIIN	Response:	5151 will respond with either an ON or OFF code.
FIINL[,X1]	Description:	Set Forward Impairment Impulse Noise Level
	Arguments:	X1 = Level (030.0 ≤ X1 ≤ 100.0 dBrn) Step Size: 0.5 dBrn
	Response:	OK or ERR code
FIINL	Response:	5151 will respond with present argument value.
FIINI[,X1]	Description:	Set Forward Impairment Impulse Noise Interval
	Arguments:	X1 = Interval (000.1 ≤ X1 ≤ 600.0 Sec.) Step Size: 0.1 Sec.
	Response:	OK or ERR code
FIINI	Response:	5151 will respond with present argument value.

COMMAND	SUMMARY	
FIINT[,X1]	Description:	Set Forward Impairment Impulse Noise Interval Trigger
	Arguments:	X1 = Trigger Mechanism UNI (Uniform) SGL (Single) RAN (Pseudo-Random) #
FIINT	Response:	5151 will respond with present argument value.

- 5151-3 Only

A.4.4 FORWARD IMPAIRMENT SINGLE FREQUENCY INTERFERENCE (FISFI)

COMMAND	SUMMARY	
FISFI[,X1]	Description:	Activate/Deactivate FISFI
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
FISFI	Response:	5151 will respond with either an ON or OFF code.
FISFIL[,X1]	Description:	Set Forward Impairment Single Frequency Interference Level
	Arguments:	X1 = Relative Level (00.0 ≤ X1 ≤ 50.0 -dB) Step Size: 0.5 dB
	Response:	OK or ERR code
FISFIL	Response:	5151 will respond with present argument value.
FISFIF[,X1]	Description:	Set Forward Impairment Single Frequency Interference Frequency
	Arguments:	X1 = Frequency (0200 ≤ X1 ≤ 3300 Hz.) Step Size: 1.0 Hz
	Response:	OK or ERR code
FISFIF	Response:	5151 will respond with present argument value.

A.4.5 FORWARD IMPAIRMENT GAIN HITS (FIGH)

COMMAND	SUMMARY	
FIGH[,X1]	Description:	Activate/Deactivate FIGH
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
FIGH	Response:	5151 will respond with either an ON or OFF code.
FIGHL[,X1]	Description:	Set Forward Impairment Gain Hits Level.
	Arguments:	X1 = Level (−25.0 ≤ X1 ≤ +07.0 dB) Step Size: 0.1 dB
	Response:	OK or ERR code
FIGHL	Response:	5151 will respond with present argument value.
FIGHR[,X1]	Description:	Set Forward Impairment Gain Hits Risetime.
	Arguments:	X1 = Risetime (0000.2 ≤ X1 ≤ 1000.0 mSec.) Step Size: 0.0001 Sec. (See FIGHD and FIGHI for restrictions)
	Response:	OK or ERR code
FIGHR	Response:	5151 will respond with present argument value.

COMMAND	SUMMARY	
FIGHD[,X1]	Description:	Set Forward Impairment Gain Hits Duration.
	Arguments:	X1 = Duration (00.0010 ≤ X1 ≤ 30.0000 Sec.) Step Size: 0.0001 Sec. (Duration must exceed Risetime). See FIGHI, also.
	Response:	OK or ERR code
FIGHD	Response:	5151 will respond with present argument value.
FIGHI[,X1]	Description:	Set Forward Impairment Gain Hits Interval.
	Arguments:	X1 = Interval (000.1 ≤ X1 ≤ 600.0 Sec.) Step Size: 0.1 Sec. (Interval must exceed Risetime plus Duration).
	Response:	OK or ERR code
FIGHI	Response:	5151 will respond with present argument value.
FIGHT[,X1]	Description:	Set Forward Impairment Gain Hits Interval Trigger
	Arguments:	X1 = Trigger Mechanism UNI (Uniform) SGL (Single) RAN (Pseudo-Random) #
FIGHT	Response:	5151 will respond with present argument value.

– 5151-3 Only

A.5 5151-3 ADDITIONAL COMMANDS

A.5.1 LISTENER ECHO (LE)

COMMAND	SUMMARY	
LE [,X1]	Description:	Activate/Deactivate LE
	Arguments:	X1 = OFF = ON
	Response:	OK or ERR code
LE	Response:	5151 will respond with either an ON or OFF code.
LEA[,X1]	Description:	Set Listener Echo Attenuation
	Arguments:	X1 = Attenuation (03.0 ≤ X1 ≤ 40.0 dB) Step Size: 0.1 dB
	Response:	OK or ERR code
LEA	Response:	5151 will respond with present argument value
LED[,X1]	Description:	Set Listener Echo Delay
	Arguments:	X1 = Delay (0.0000 ≤ X1 ≤ 1.6000 sec.) Step Size: 0.0001 Sec
	Response:	OK or ERR code
LED	Response:	5151 will respond with present argument value

A.5.2 ECHO DISTORTION (ED)

COMMAND	SUMMARY	
ED[,X1]	Description:	Set Envelope and Amplitude Distortion seen by Far End and Intermediate Echo A
	Arguments:	X1 = Line Type 3002A,3002B,C1,C2,C4 M1020,M1025,M1040 TR30-1,TR30-2,TR30-3 TR30-4,TR30-5,TR30-6 NTT-1,NTT-2,NTT-3 NTT-4,NTT-5,NTT-6,NTT-7 CONUS-PV CONUS-MV CONUS-PD CONUS-MD EURO-PV EURO-MV EURO-PD EURO-MD OFF
	Response:	OK or ERR code
ED	Response:	PTT 5151 will respond with present argument value.

See Appendix B for Amplitude and Group Delay Curves

A.6 COMMAND REFERENCE LIST

FEE	– Far End Echo ON/OFF
FEEA	– Far End Echo Amplitude
FEED	– Far End Echo Delay
IEA	– Intermediate Echo A ON/OFF
IEAA	– Intermediate Echo A Amplitude
IEAD	– Intermediate Echo A Delay
IEB	– Intermediate Echo B ON/OFF
IEBA	– Intermediate Echo B Amplitude
IEBD	– Intermediate Echo B Delay
NEE	– Near End Echo ON/OFF
NEEA	– Near End Echo Amplitude
NEED	– Near End Echo Delay
LE	– Listener Echo ON/OFF
LEA	– Listener Echo Amplitude
LED	– Listener Echo Delay
FISD	– Forward Impairment Satellite Delay
FIFO	– Forward Impairment Frequency Offset
FIPJ	– Forward Impairment Phase Jitter ON/OFF
FIPJL	– Forward Impairment Phase Jitter Level
FIPJF	– Forward Impairment Phase Jitter Frequency
FIPJW	– Forward Impairment Phase Jitter Waveform
FIND2	– Forward Impairment Nonlinear Distortion 2nd
FIND3	– Forward Impairment Nonlinear Distortion 3rd
FIPH	– Forward Impairment Phase Hits ON/OFF
FIPHL	– Forward Impairment Phase Hits Level
FIPHR	– Forward Impairment Phase Hits Risetime
FIPHD	– Forward Impairment Phase Hits Duration
FIPHI	– Forward Impairment Phase Hits Interval
FIPHT	– Forward Impairment Phase Hits Interval Trigger
FIAJ	– Forward Impairment Amplitude Jitter ON/OFF
FIAJL	– Forward Impairment Amplitude Jitter Level
FIAJF	– Forward Impairment Amplitude Jitter Frequency
FIAJW	– Forward Impairment Amplitude Jitter Waveform
FIIN	– Forward Impairment Impulse Noise ON/OFF
FIINL	– Forward Impairment Impulse Noise Level
FIINI	– Forward Impairment Impulse Noise Interval
FIINT	– Forward Impairment Impulse Noise Interval Trigger
FISFI	– Forward Impairment Single Freq. Interf. ON/OFF
FISFIL	– Forward Impairment Single Freq. Interf. Level
FISFIF	– Forward Impairment Single Freq. Interf. Freq.
FIGH	– Forward Impairment Gain Hits ON/OFF
FIGHL	– Forward Impairment Gain Hits Level
FIGHR	– Forward Impairment Gain Hits Risetime
FIGHD	– Forward Impairment Gain Hits Duration
FIGHI	– Forward Impairment Gain Hits Interval
FIGHT	– Forward Impairment Gain Hits Interval Trigger
ED	– Echo Distortion
CSAVE	– Configuration Save
CRCL	– Configuration Recall

A.7 ERROR MESSAGES

COMMAND RESPONSE
ERROR MESSAGES ERR x

x	DESCRIPTION
1	INVALID ARGUMENT
2	MISSING ARGUMENT
3	ARGUMENT OUT OF RANGE
4	INVALID COMMAND
5	INVALID MODE
6	END OF LINE BUFFER (NO COMMAND FOUND)
7	5151 NOT ON LINE

Table A.1

1. Argument was incorrectly entered—possibly a missing comma.

2. 5151 expects an argument after this command.

3. Argument not within range of acceptable values as specified in the command summary.

4. Command either typed incorrectly or not supported by this model 5151.

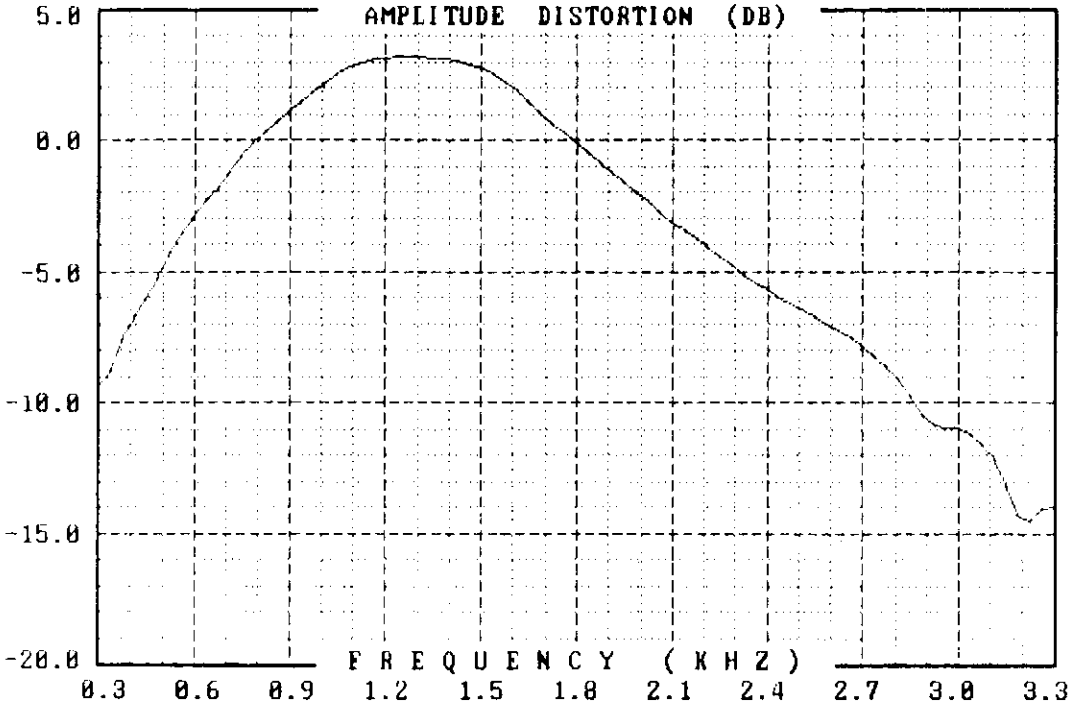
5. This response is received when controller attempts to execute a command not acceptable to the current mode of operation.

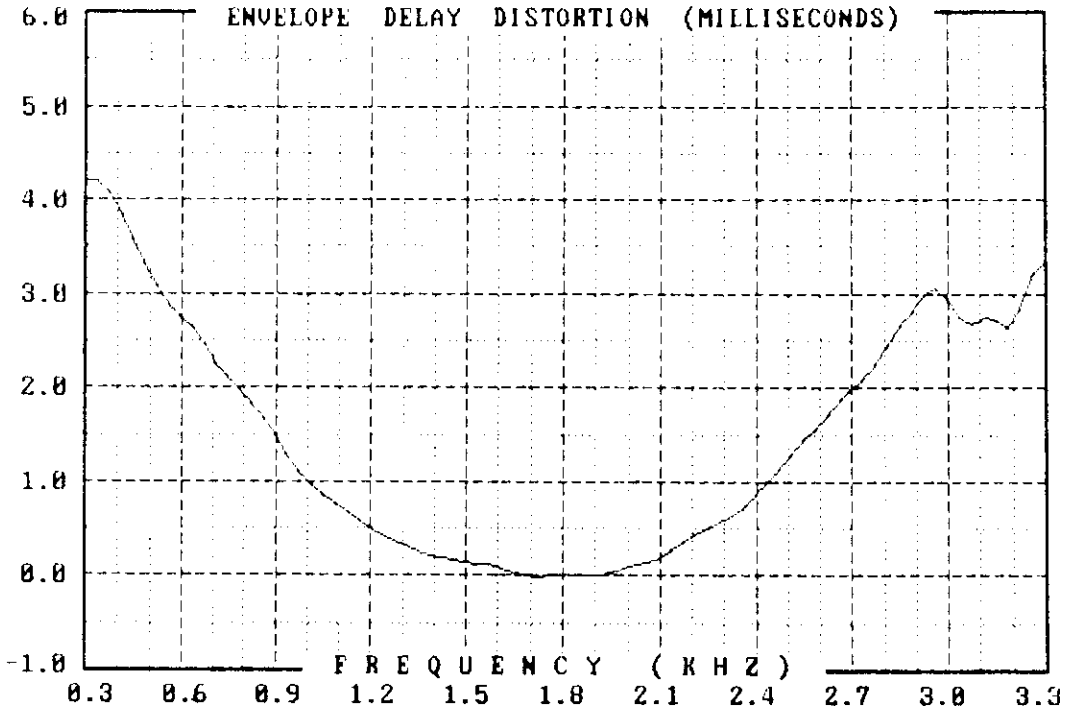
6. Data received from external controller did not contain valid command before end of buffer was reached.

7. Command received by the PTT 5100, intended for the PTT 5151, which is presently disconnected or powered off.

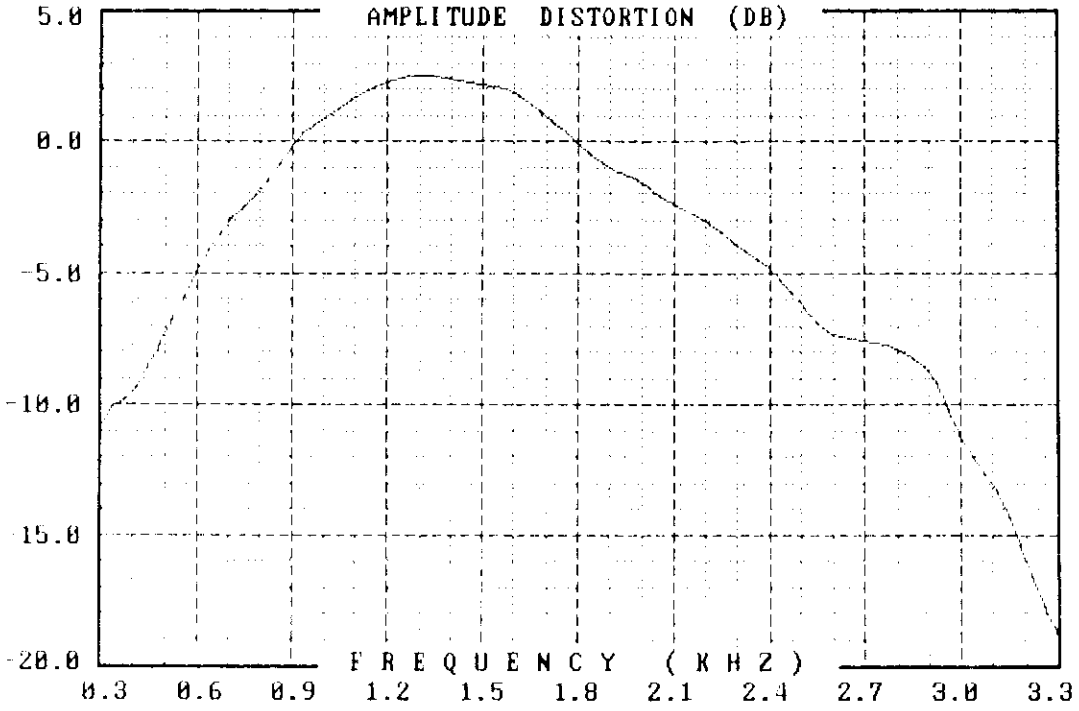
APPENDIX B

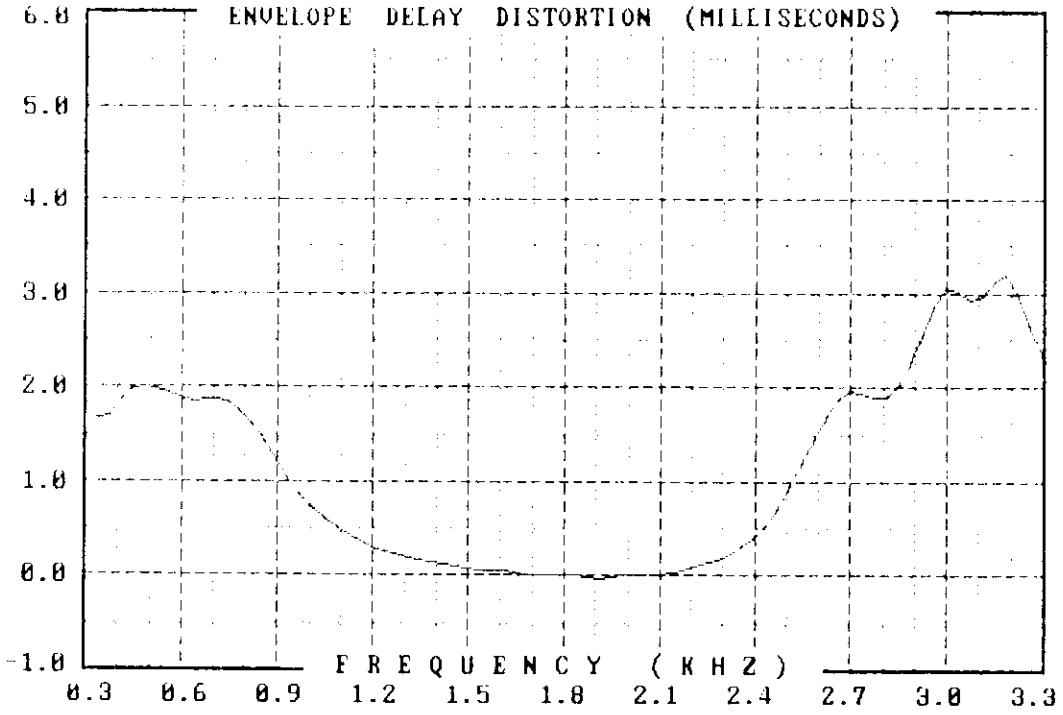
ECHO DISTORTION AMPLITUDE AND GROUP DELAY CURVES


AMPLITUDE DISTORTION (DB)
5.0
0.0
-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

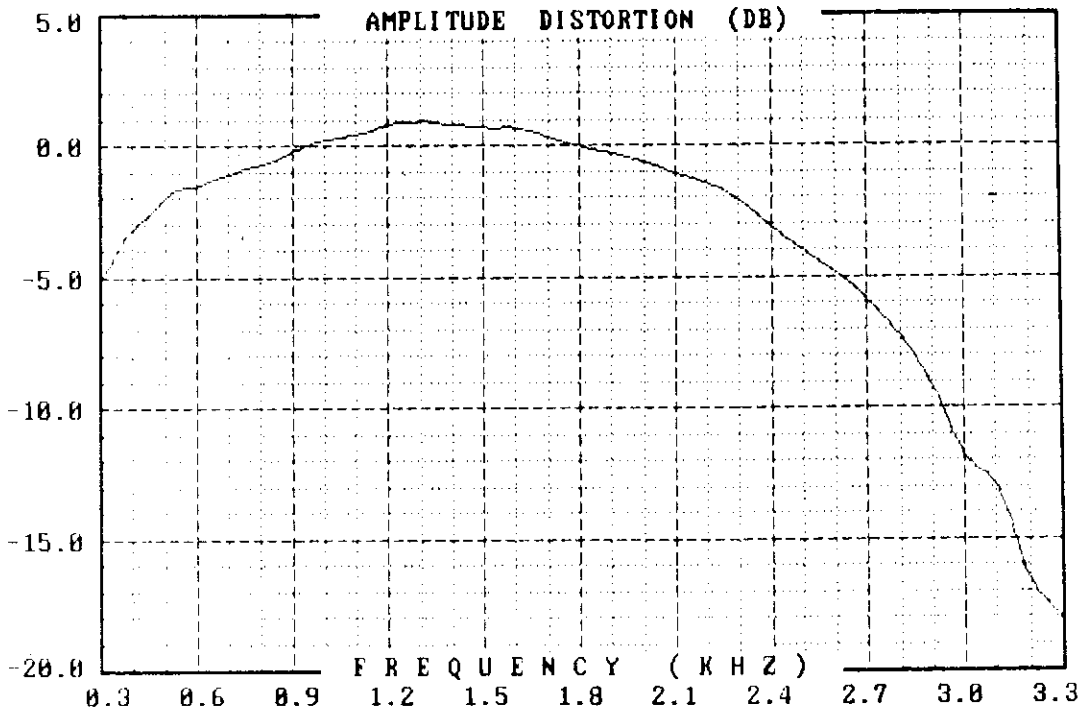

ENVELOPE DELAY DISTORTION (MILLISECONDS)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

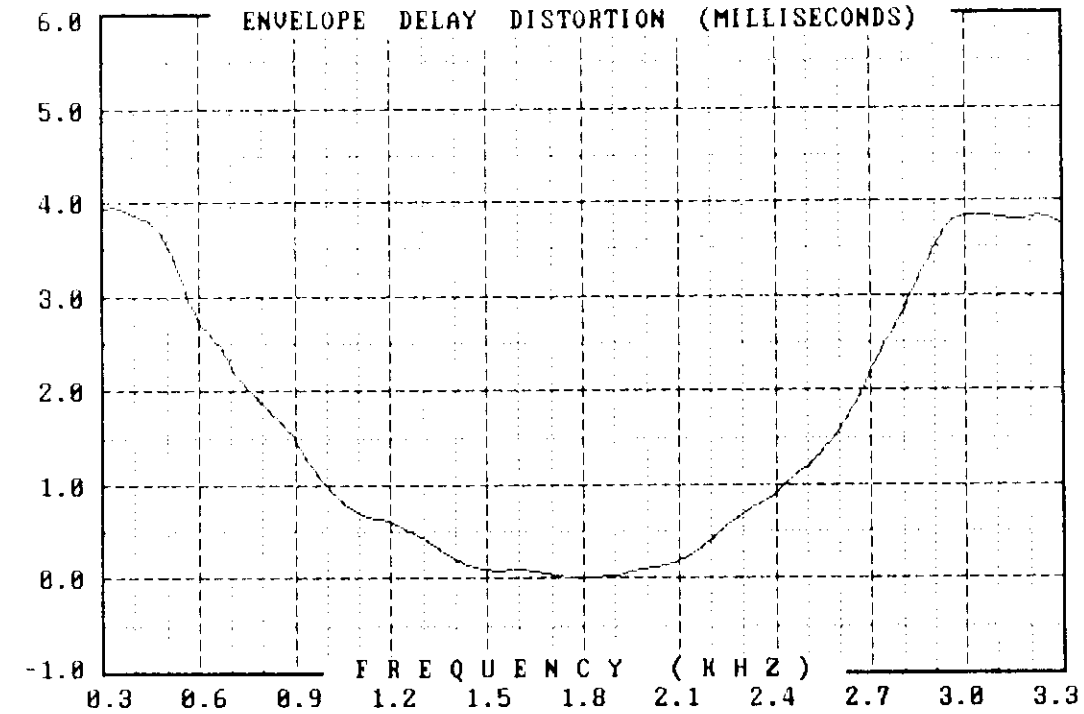
3002 - MODEL A


AMPLITUDE DISTORTION (DB)
5.0
0.0
-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

3002 - MODEL B


AMPLITUDE DISTORTION (DB)
5.0
0.0
-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

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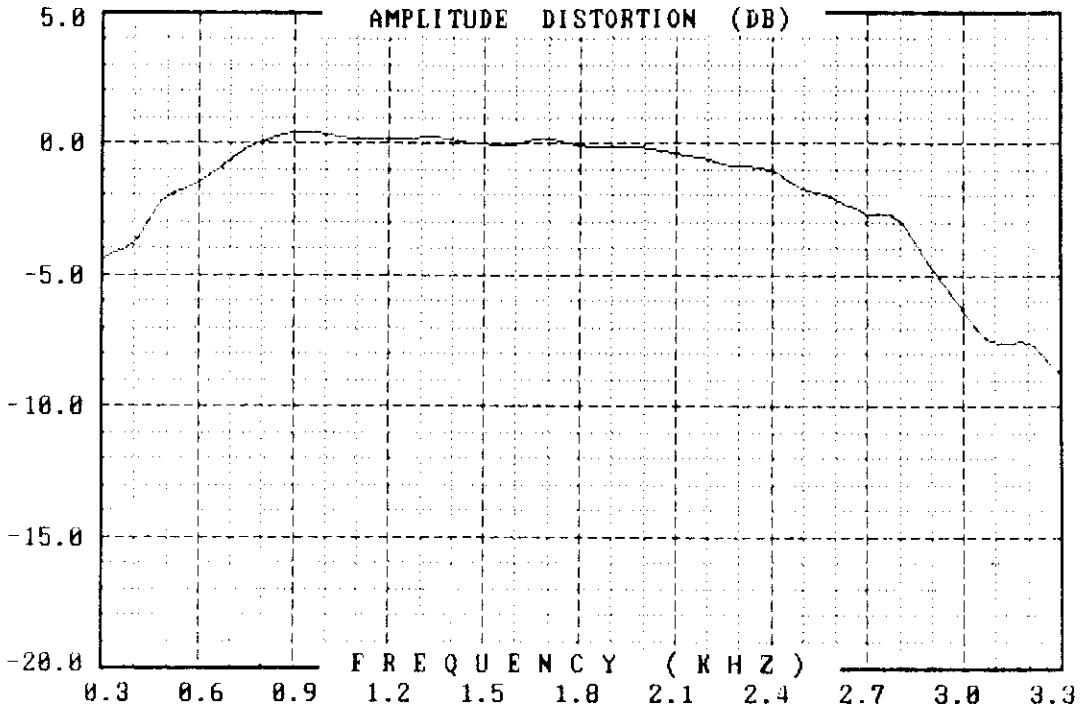
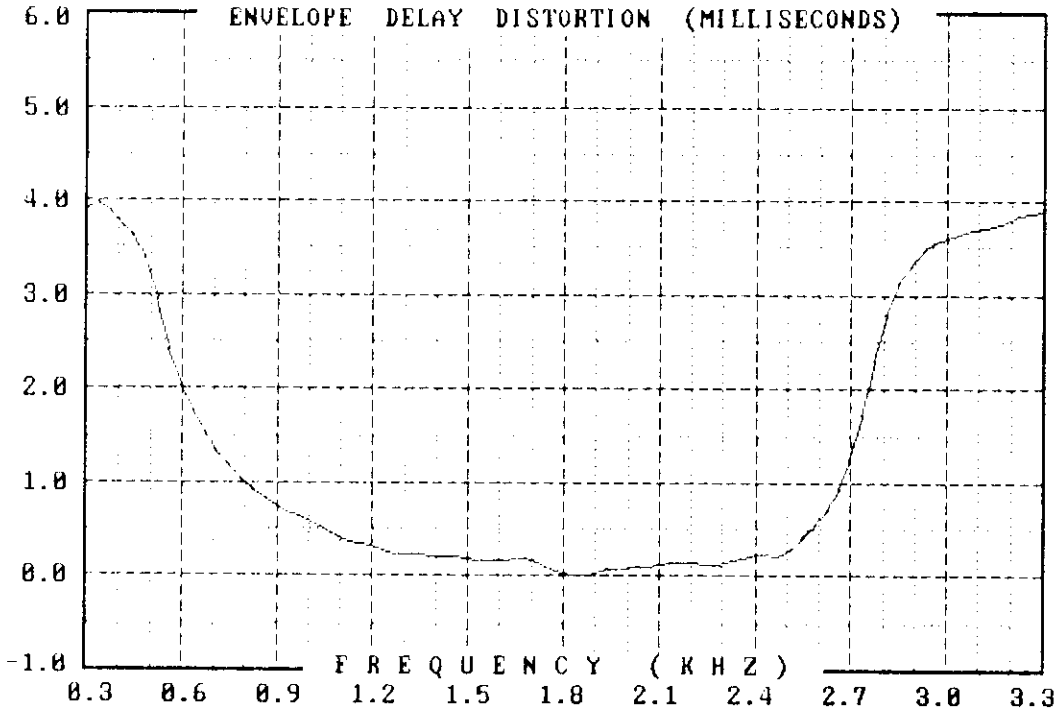
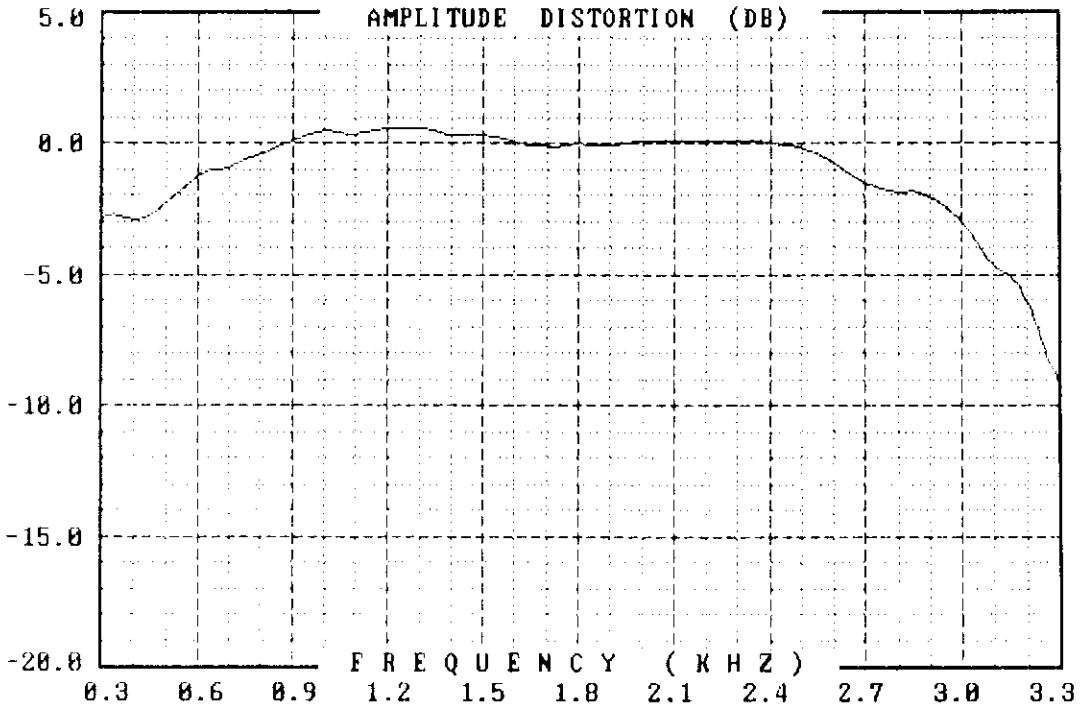

AMPLITUDE DISTORTION (DB)
5.0
0.0
-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3

C - 2


AMPLITUDE DISTORTION (DB)
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-10.0
-15.0
-20.0
FREQUENCY (KHZ)
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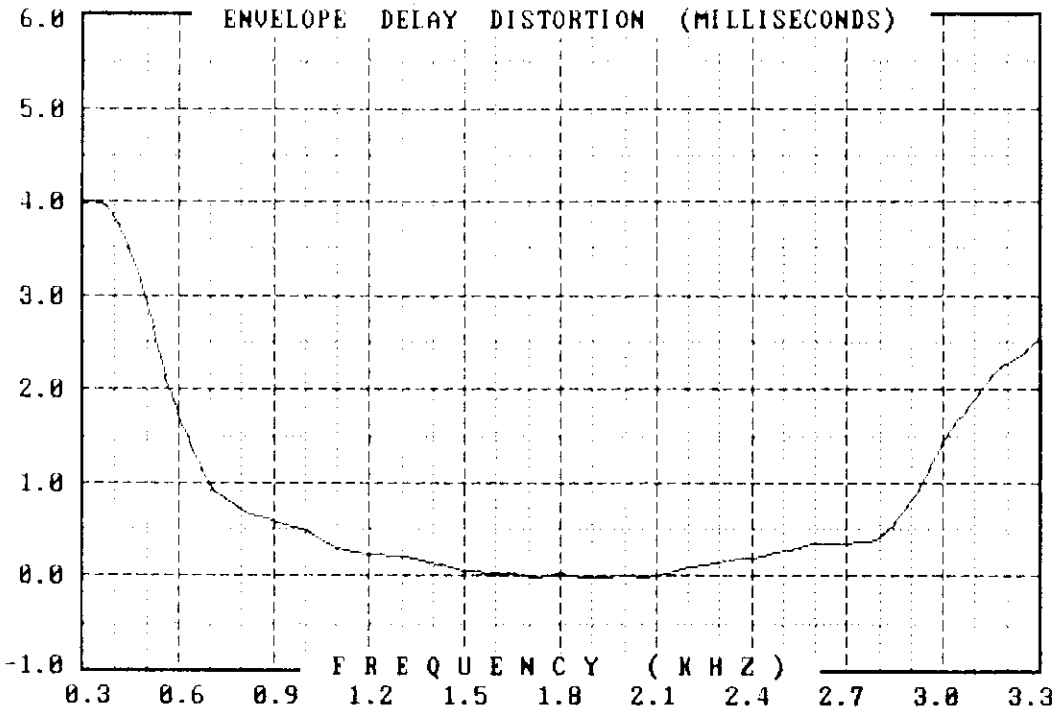
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
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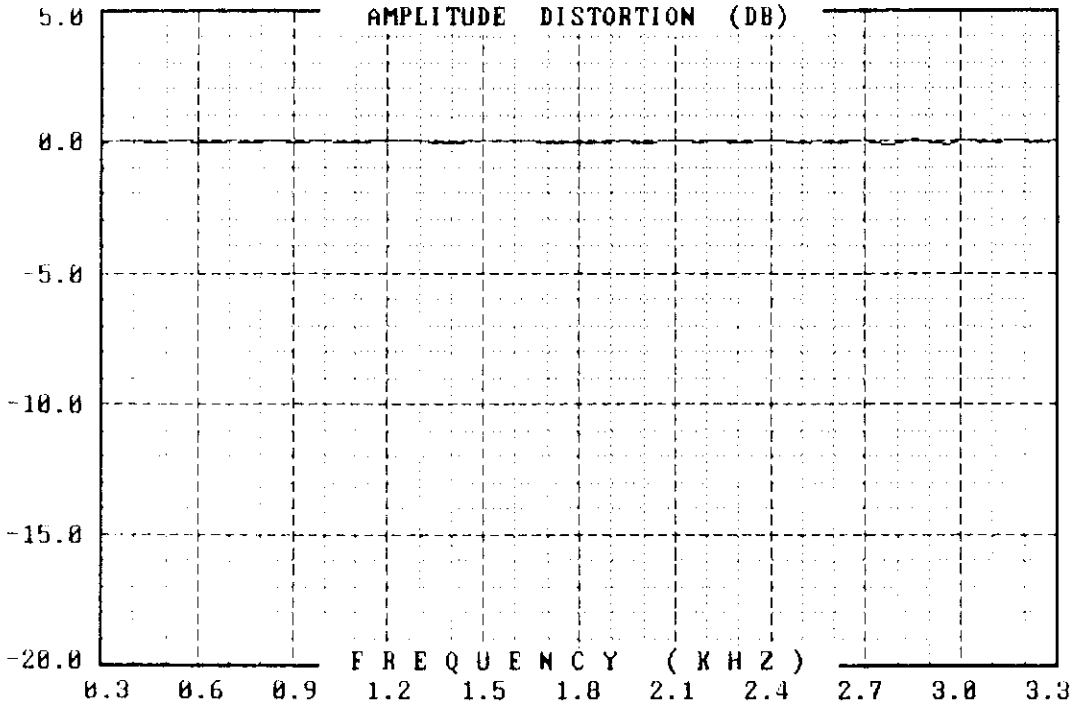
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


AMPLITUDE DISTORTION (DB)
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-5.0
-10.0
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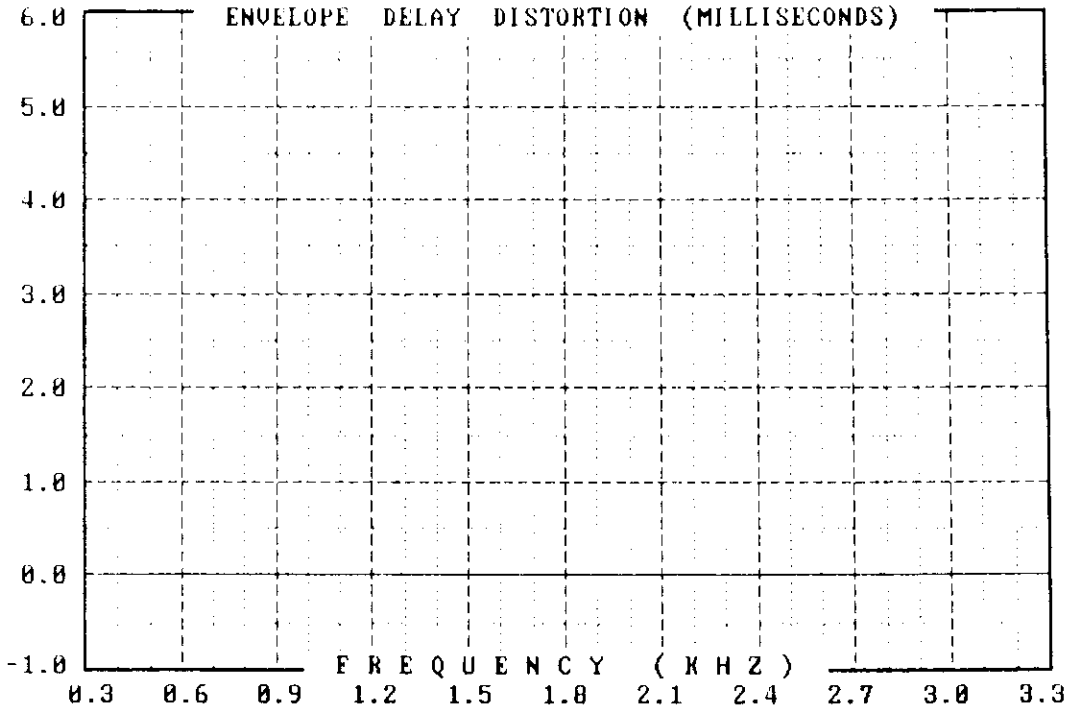
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
6.0
5.0
4.0
3.0
2.0
1.0
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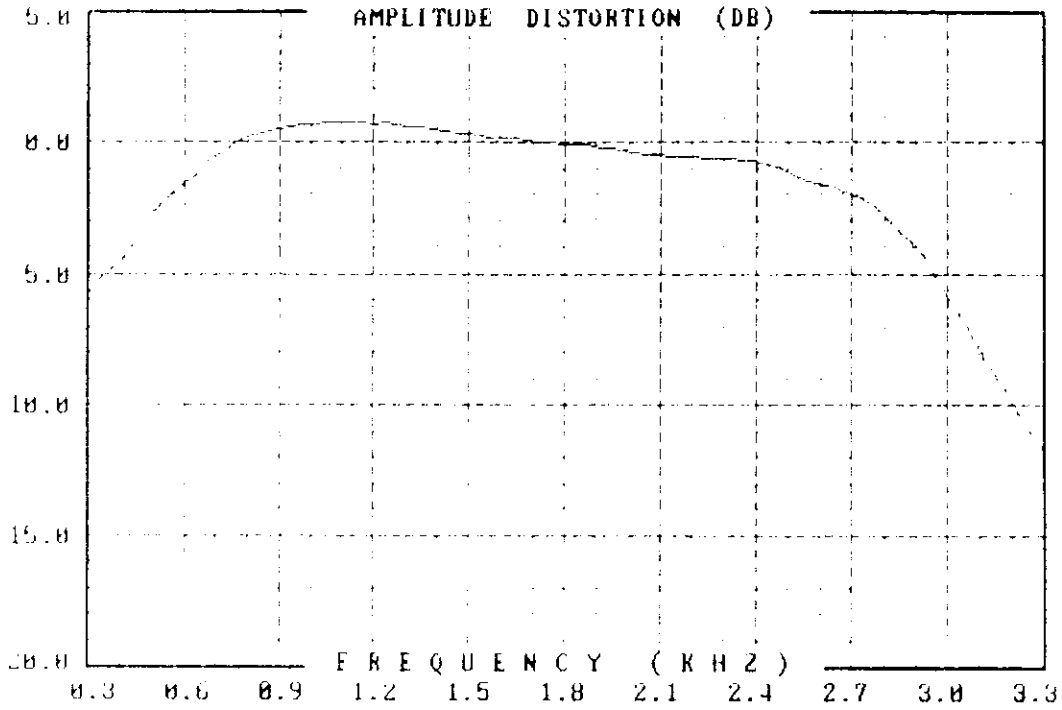
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3

FLAT


AMPLITUDE DISTORTION (DB)
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5.0
10.0
15.0
20.0
FREQUENCY (KHZ)
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0.9
1.2
1.5
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2.1
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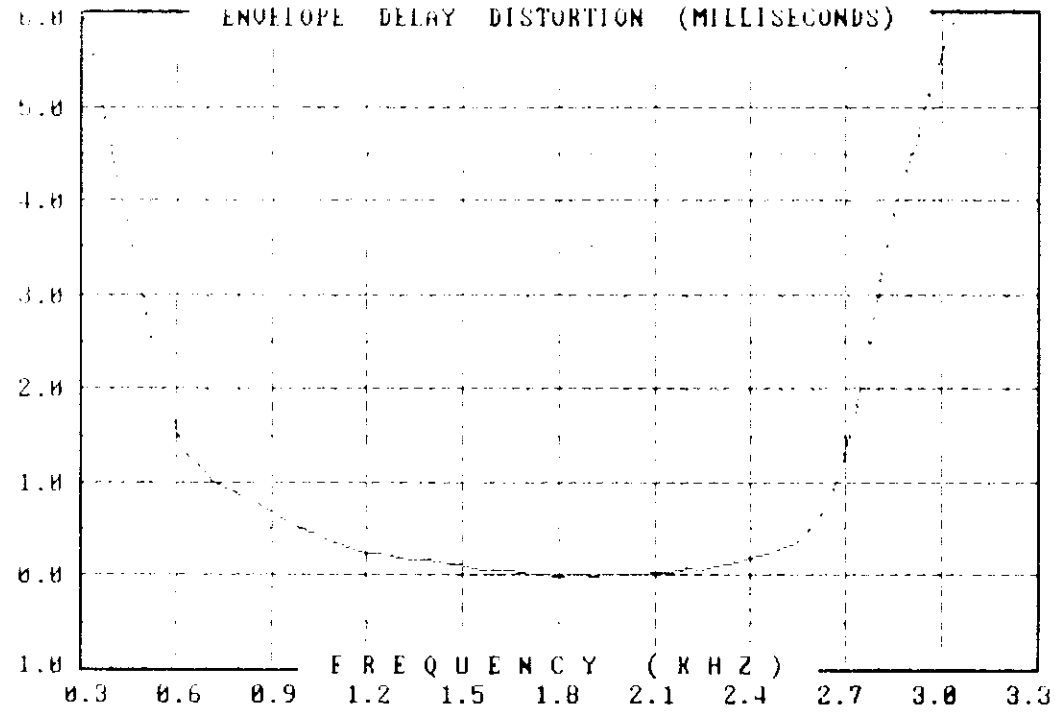
ENVELOPE DELAY DISTORTION (MILLISECONDS)
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4.0
3.0
2.0
1.0
0.0
1.0
FREQUENCY (KHZ)
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1.8
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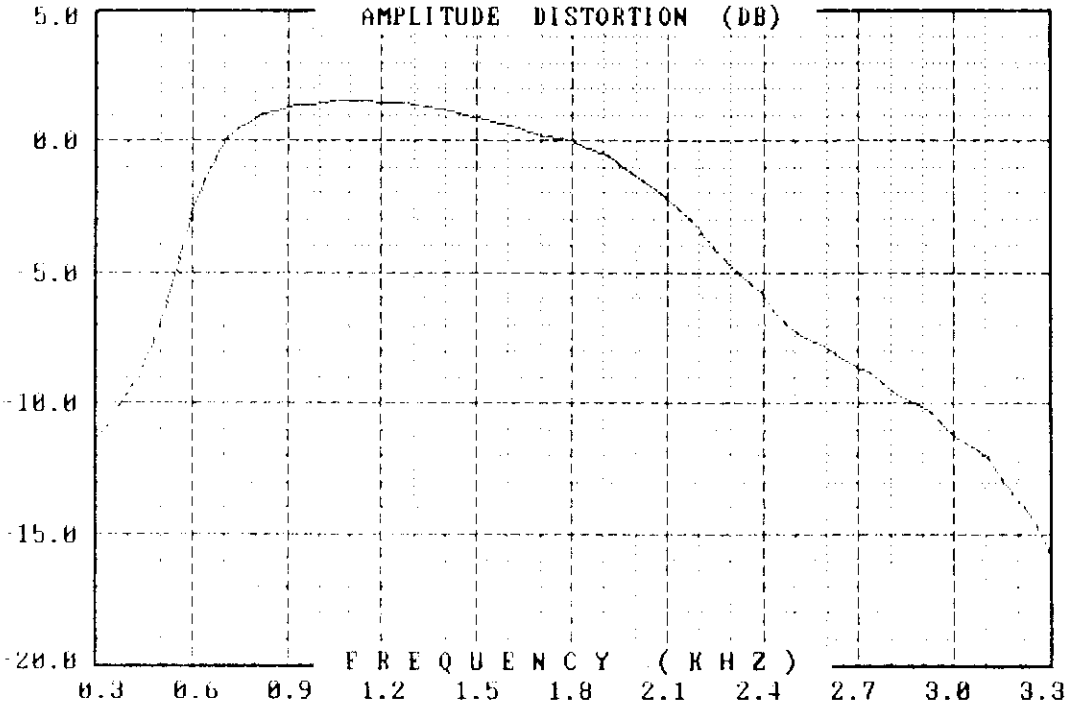
2.4
2.7
3.0
3.3

M.1020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-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
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0.9
1.2
1.5
1.8
2.1
2.4
2.7
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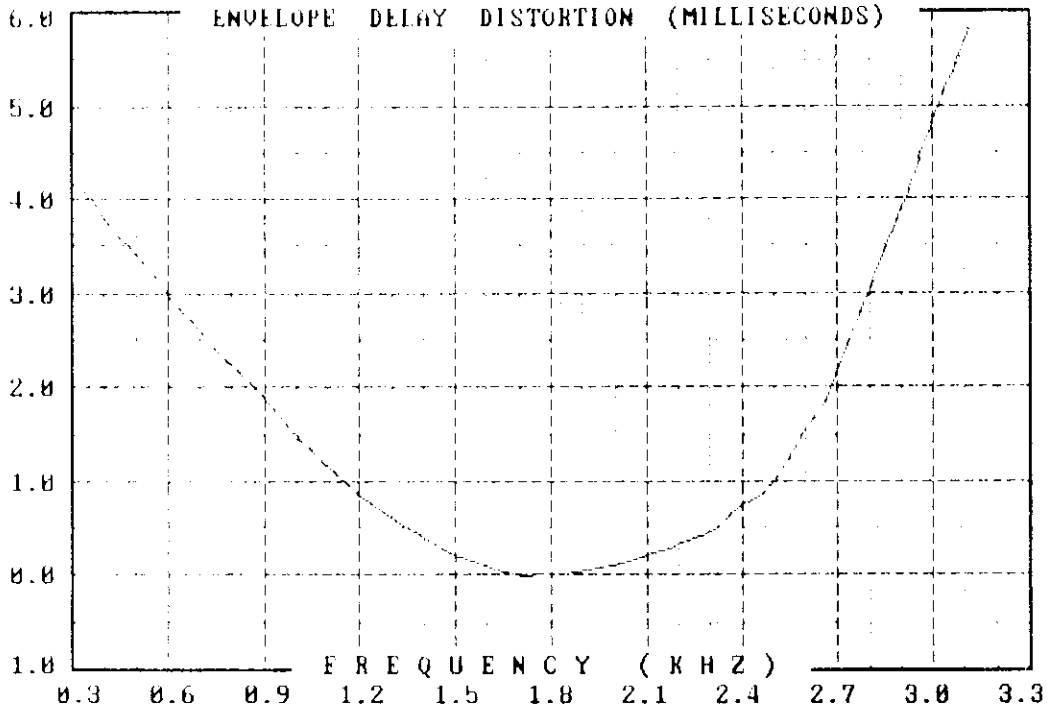
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
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4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
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1.2
1.5
1.8
2.1
2.4
2.7
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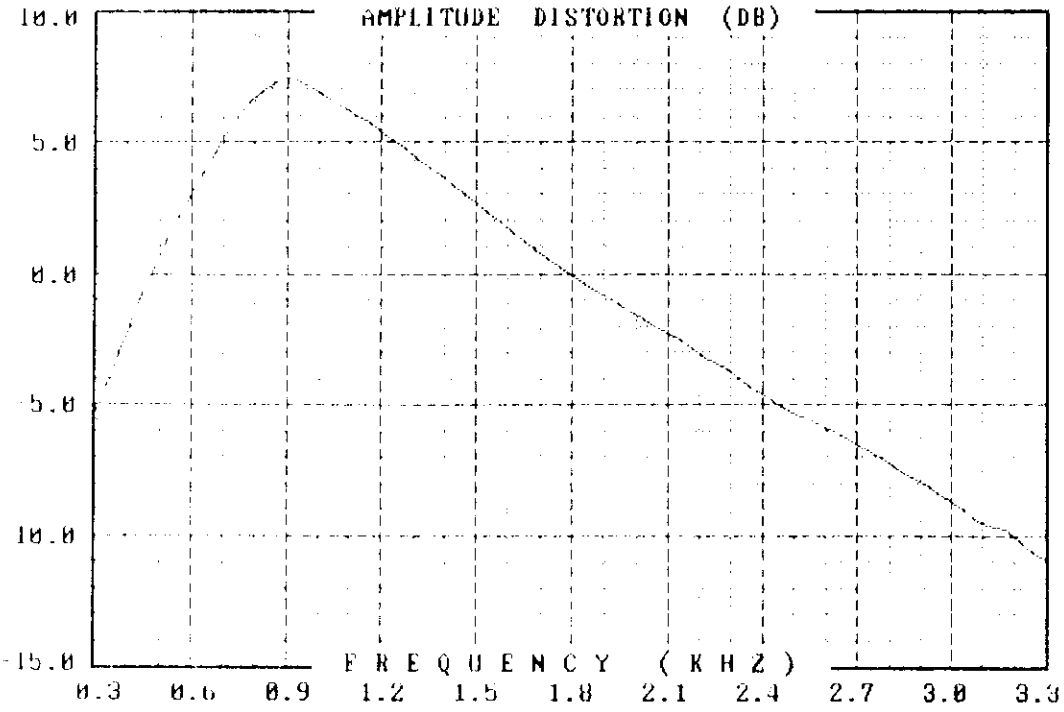
3.3

M.1025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0.0
-5.0
-10.0
-15.0
FREQUENCY (KHZ)
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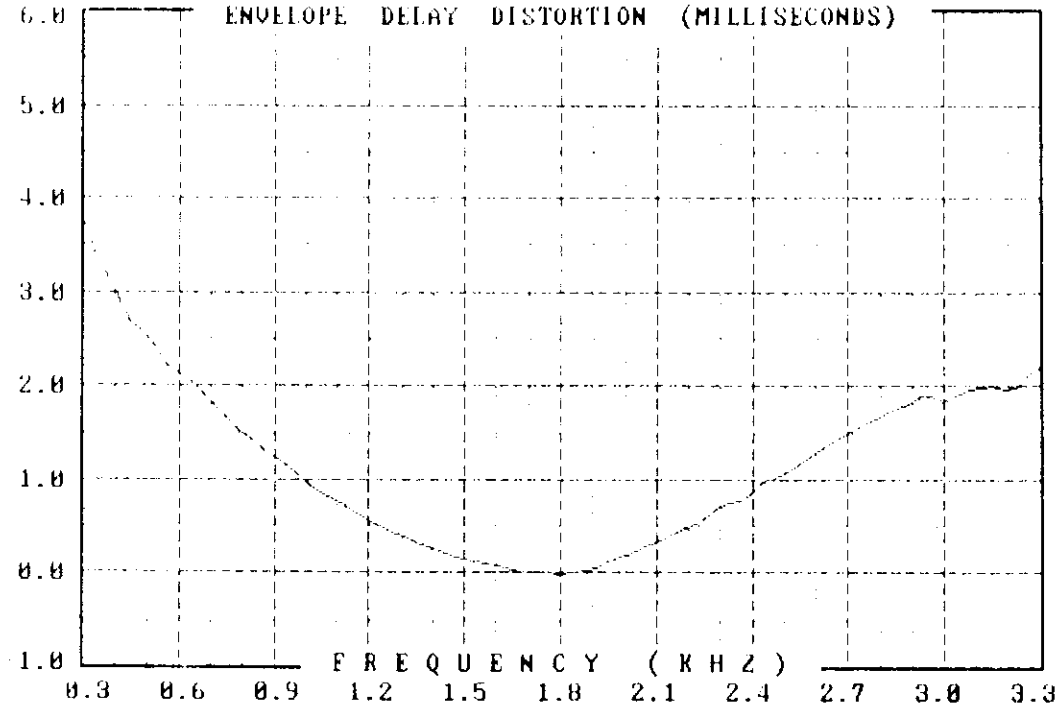
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
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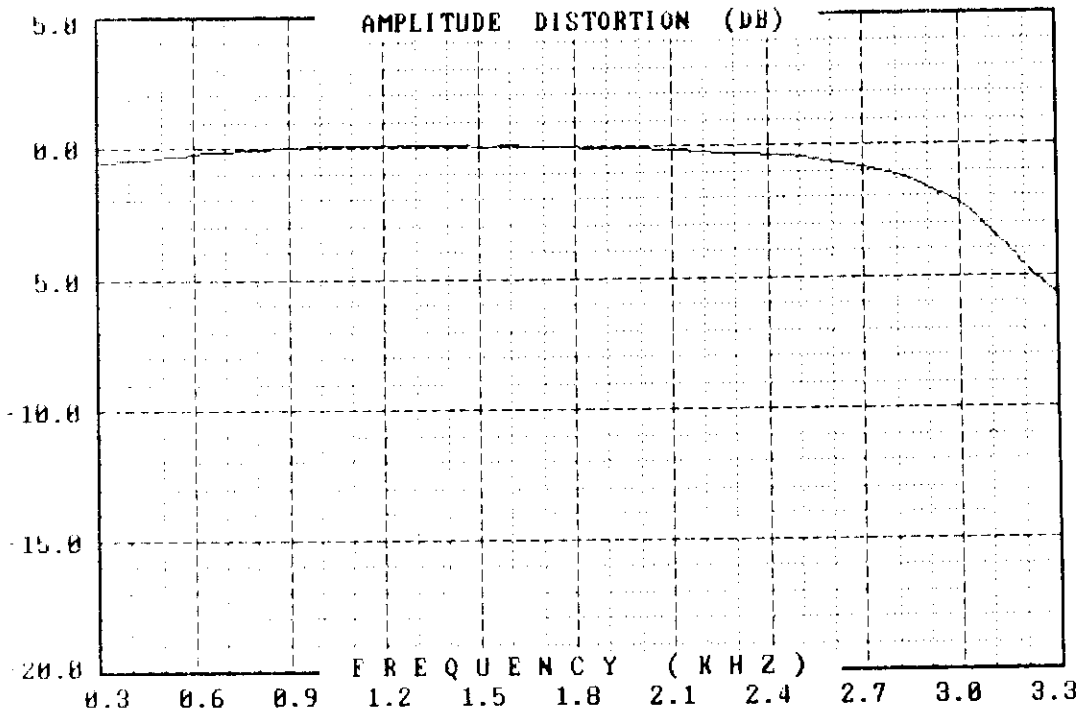
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

M.1040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-5.0
-10.0
-15.0
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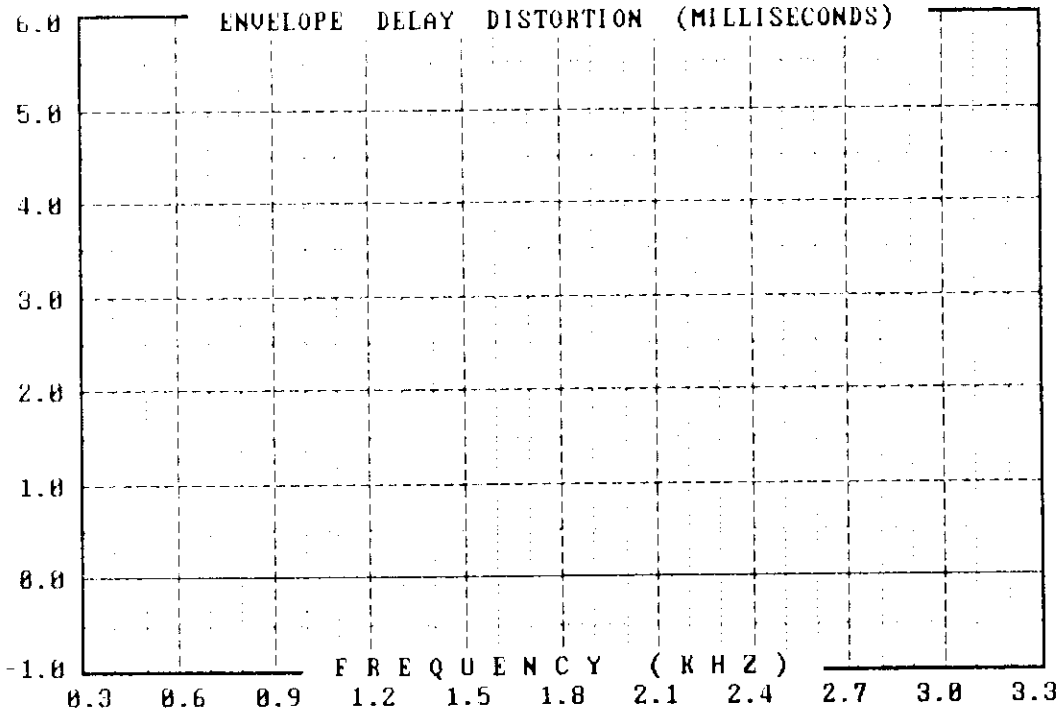
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3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4.0
3.0
2.0
1.0
0.0
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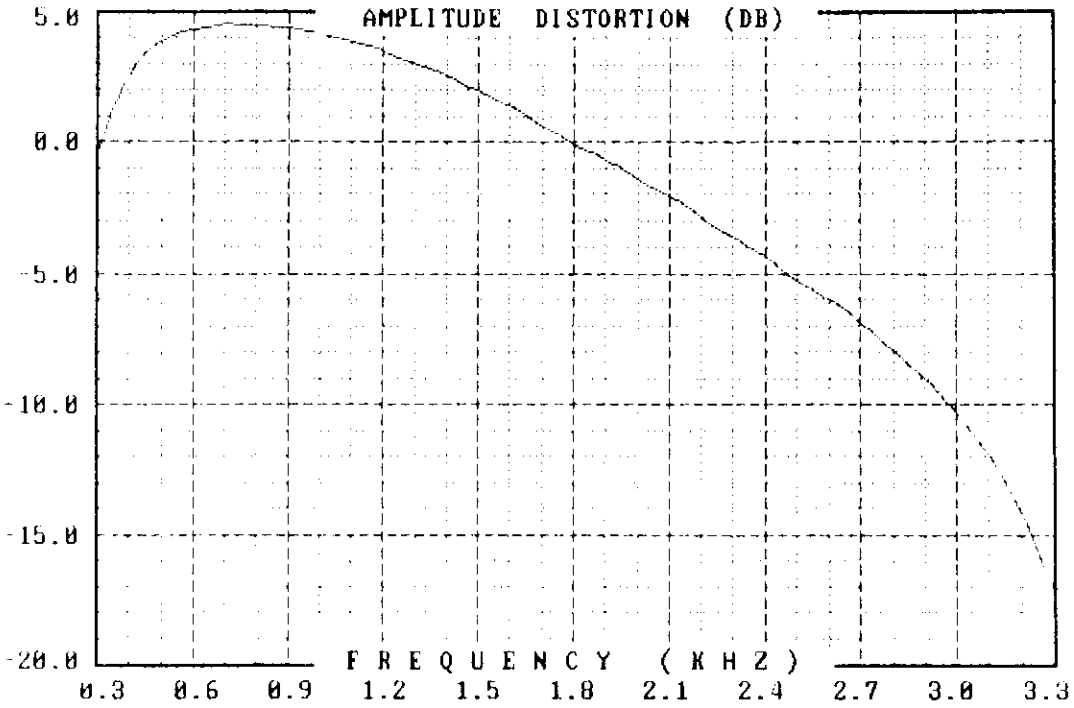
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3

TR30.3 - 1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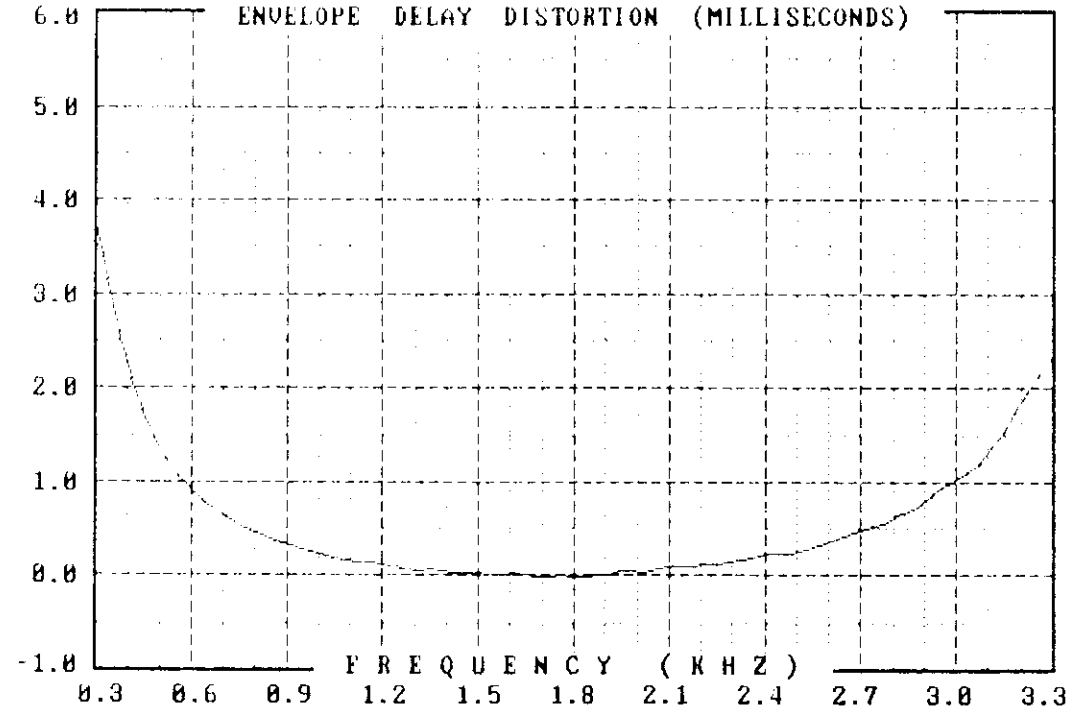
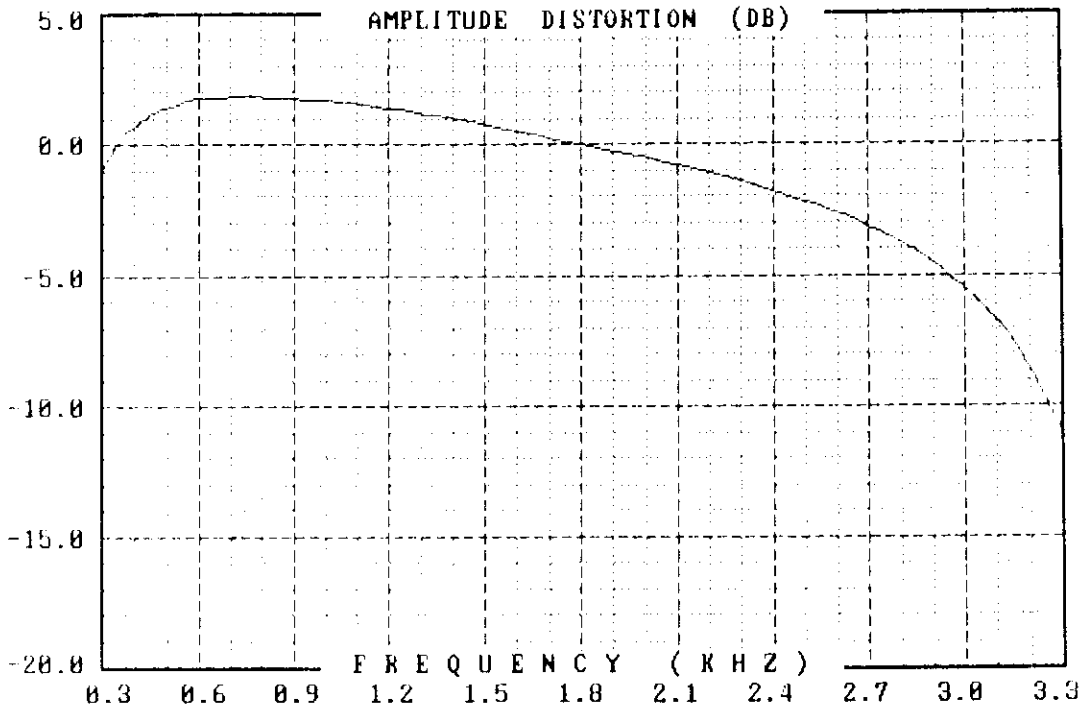
0.0
-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3

TR30.3 - 2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0.0
-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
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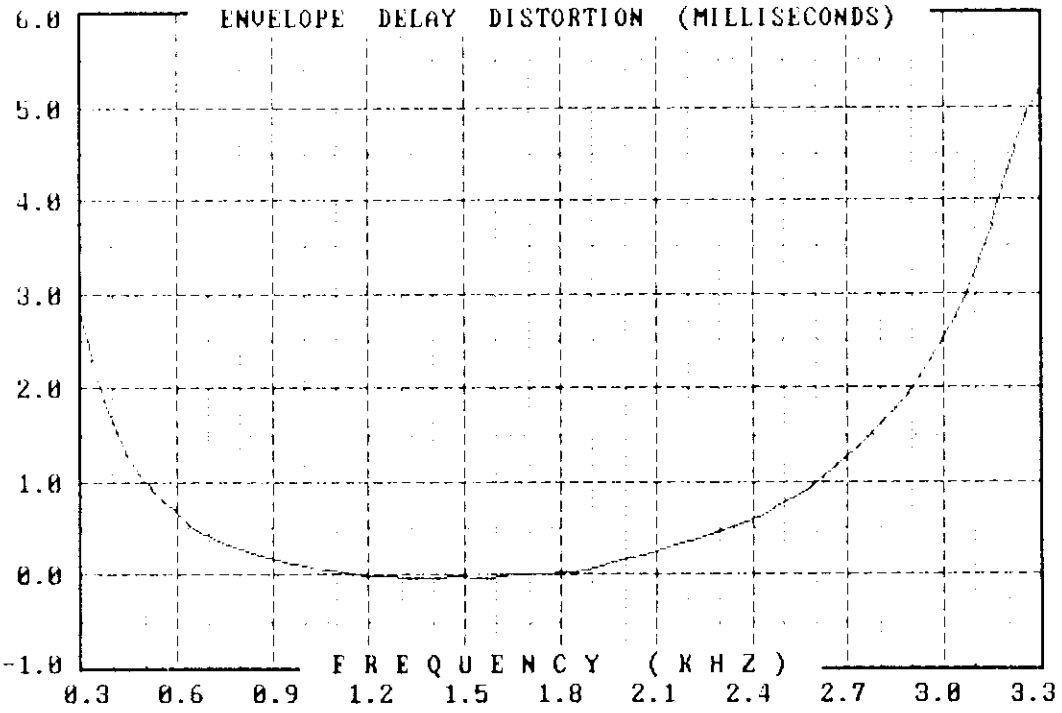
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
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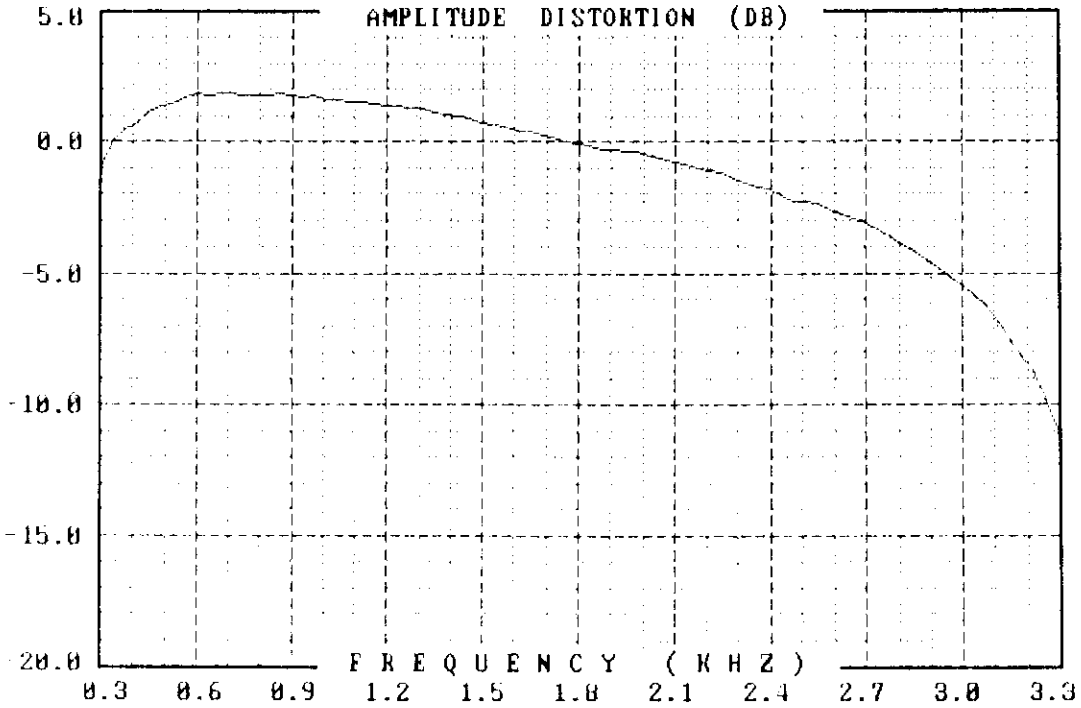
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

TR30.3 - 3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-10.0
-15.0
-20.0
FREQUENCY (KHZ)
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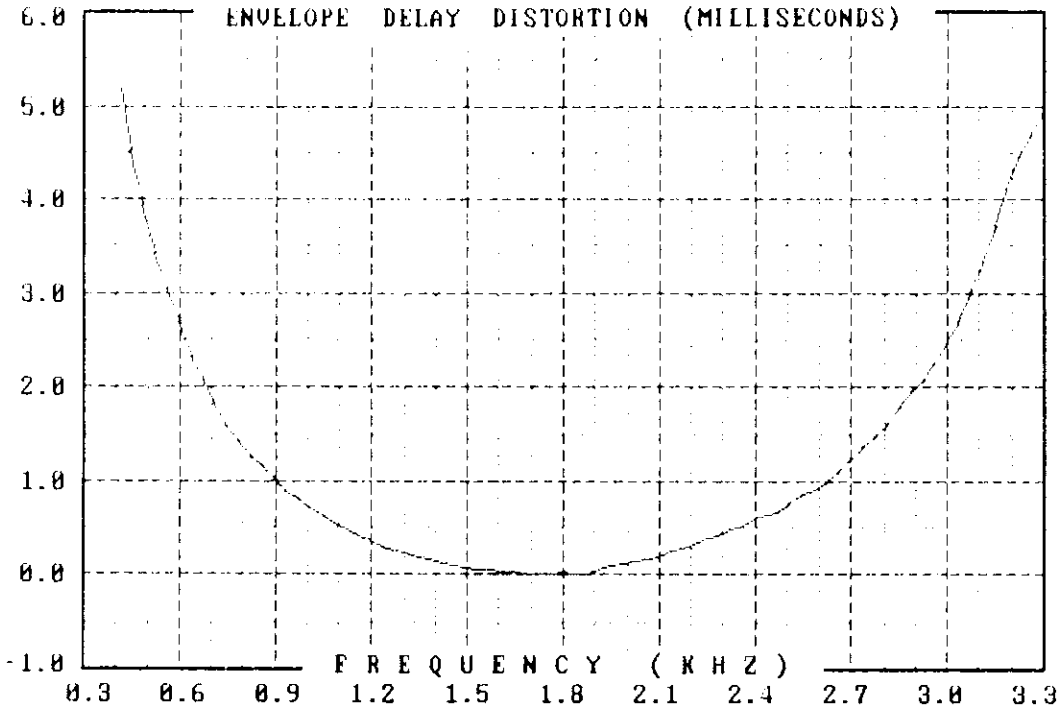
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
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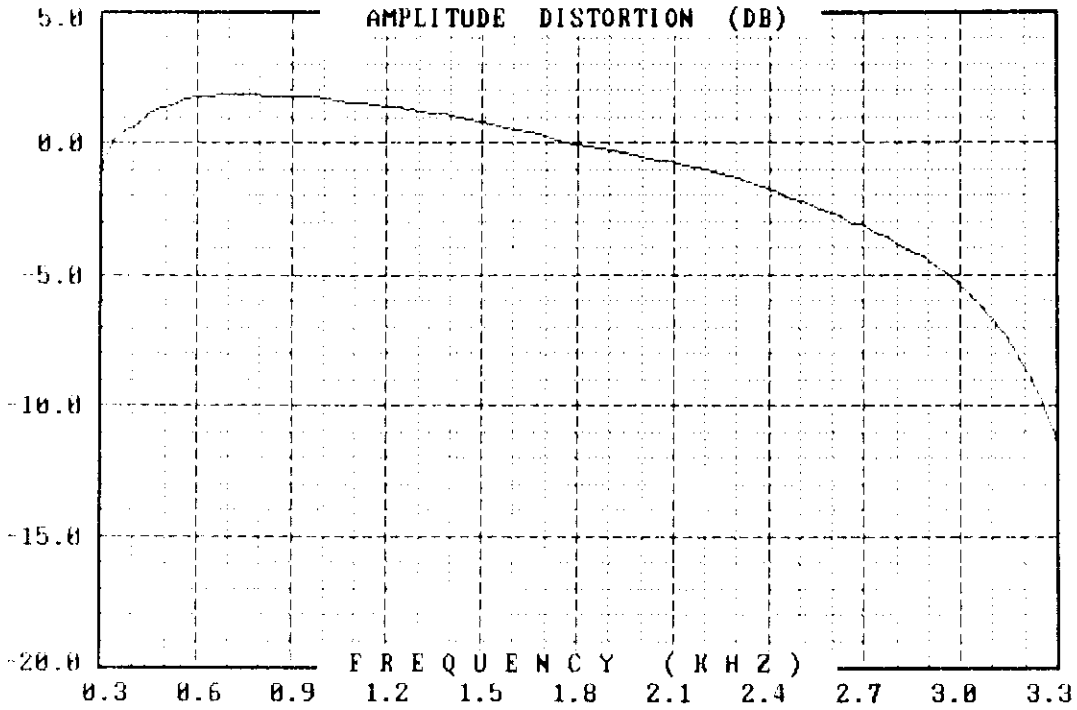
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

TR30.3 - 4


AMPLITUDE DISTORTION (DB)
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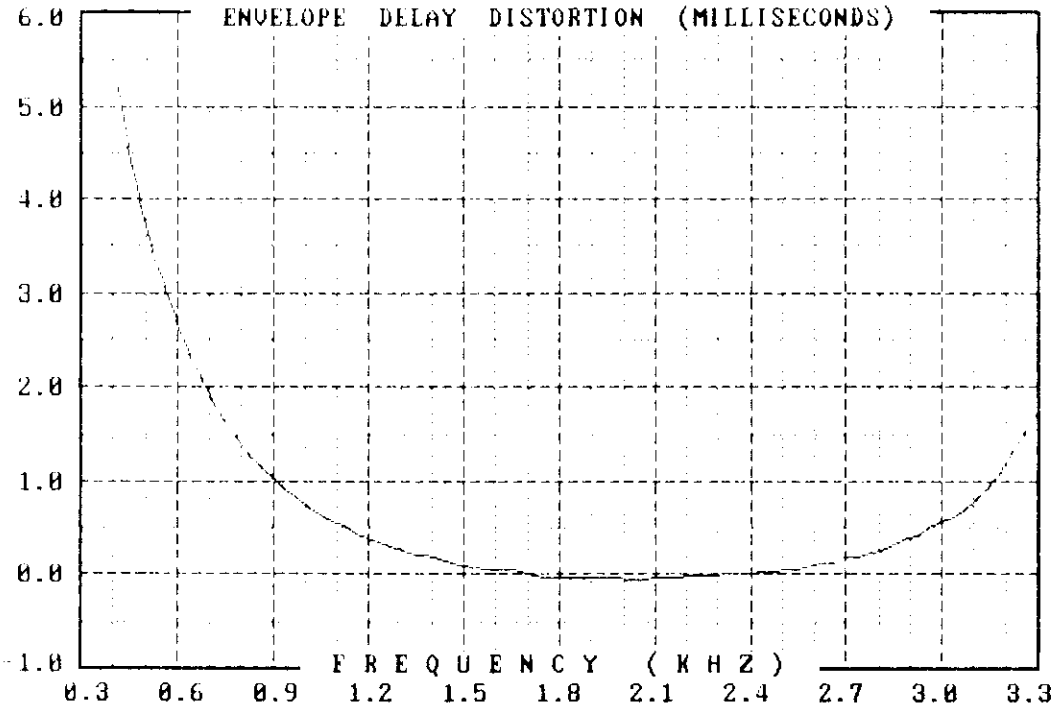
-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
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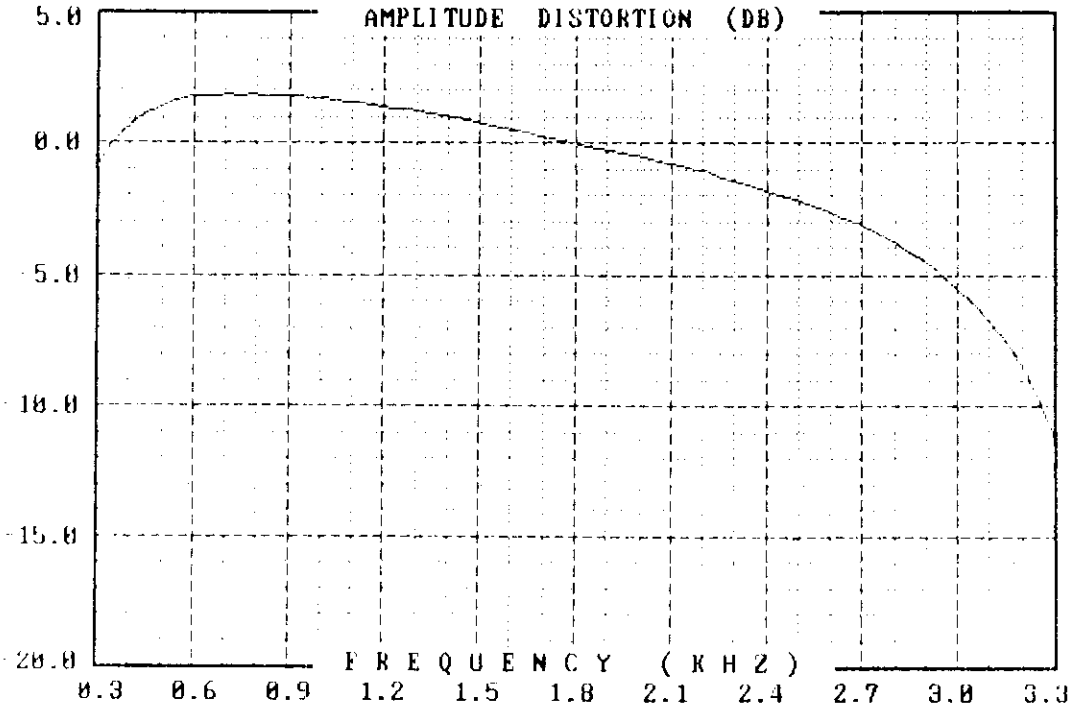
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3

TR30.3 - 5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-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
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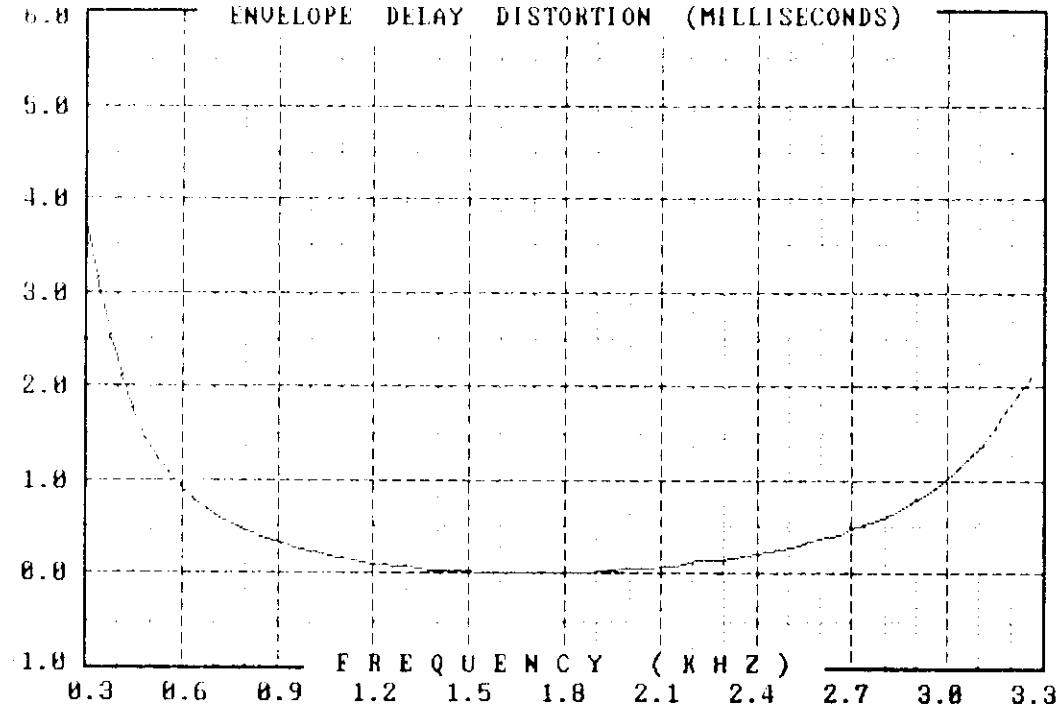
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
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4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
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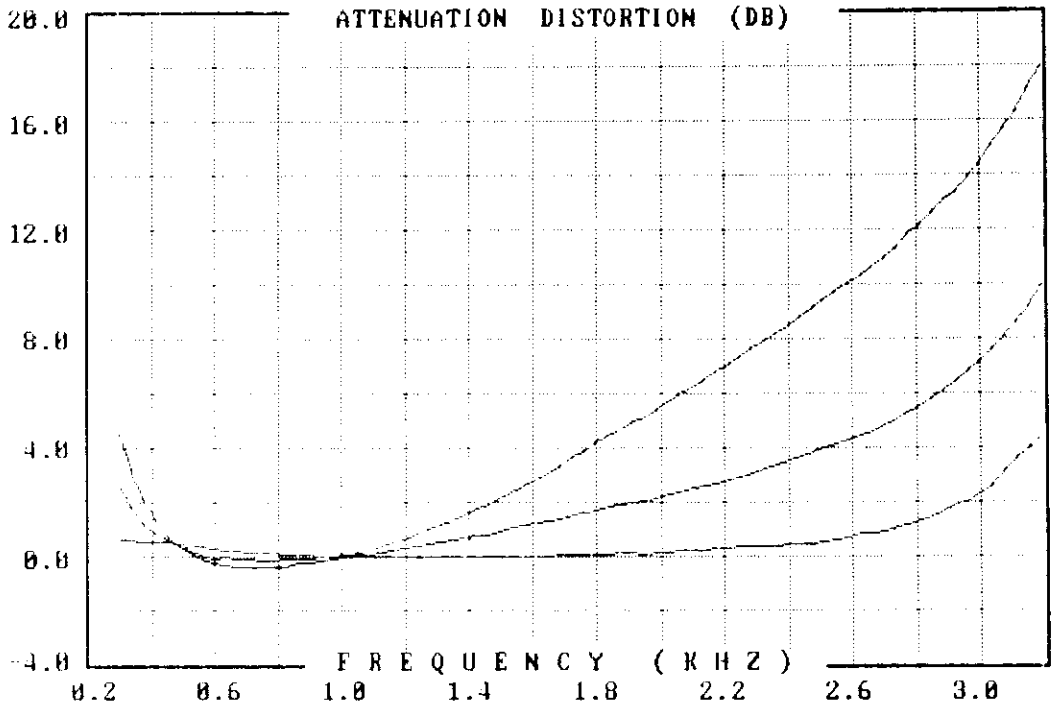
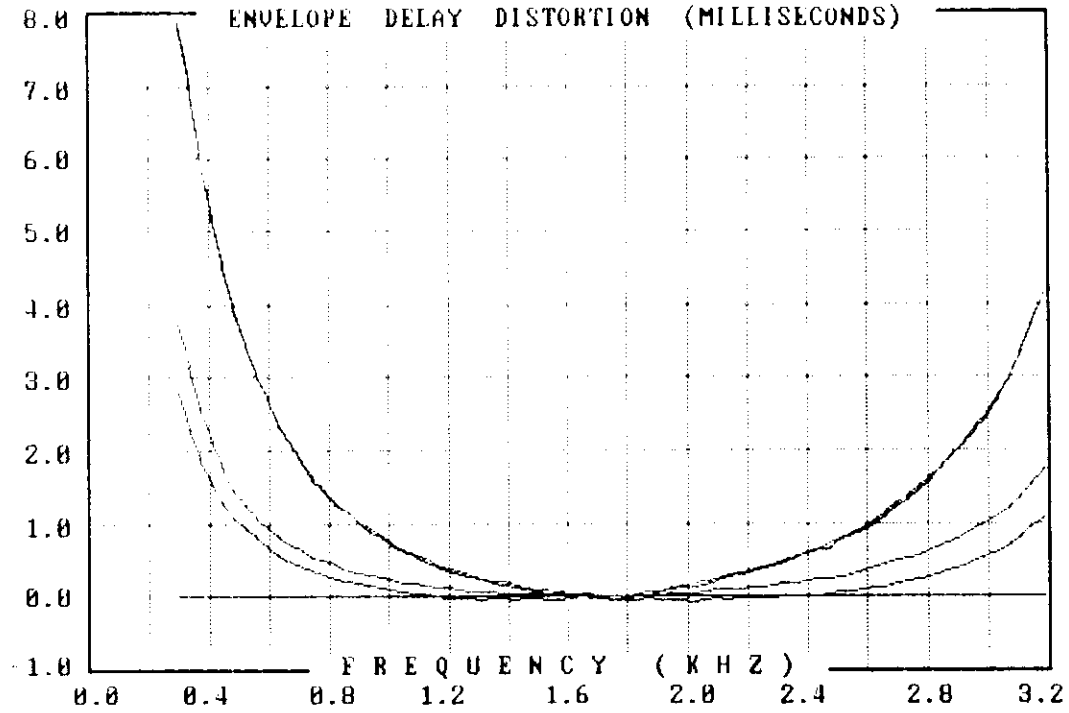
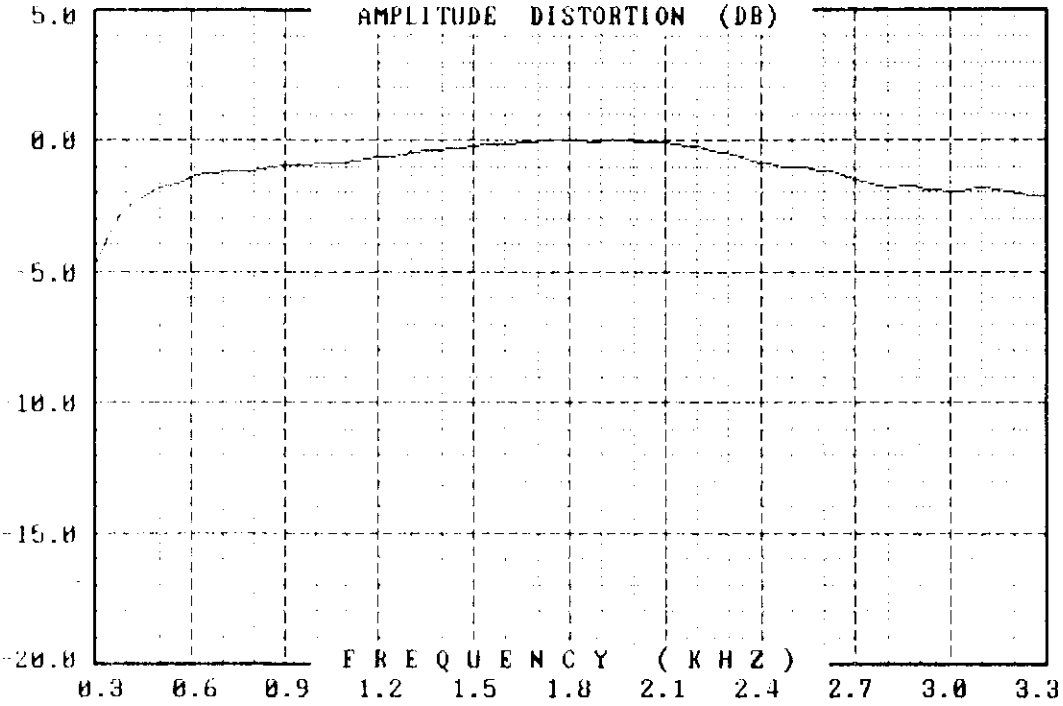
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3





SUMMARY FOR TR30.3 IN ORIGINAL SPECIFICATION FORMAT


AMPLITUDE DISTORTION (DB)
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-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
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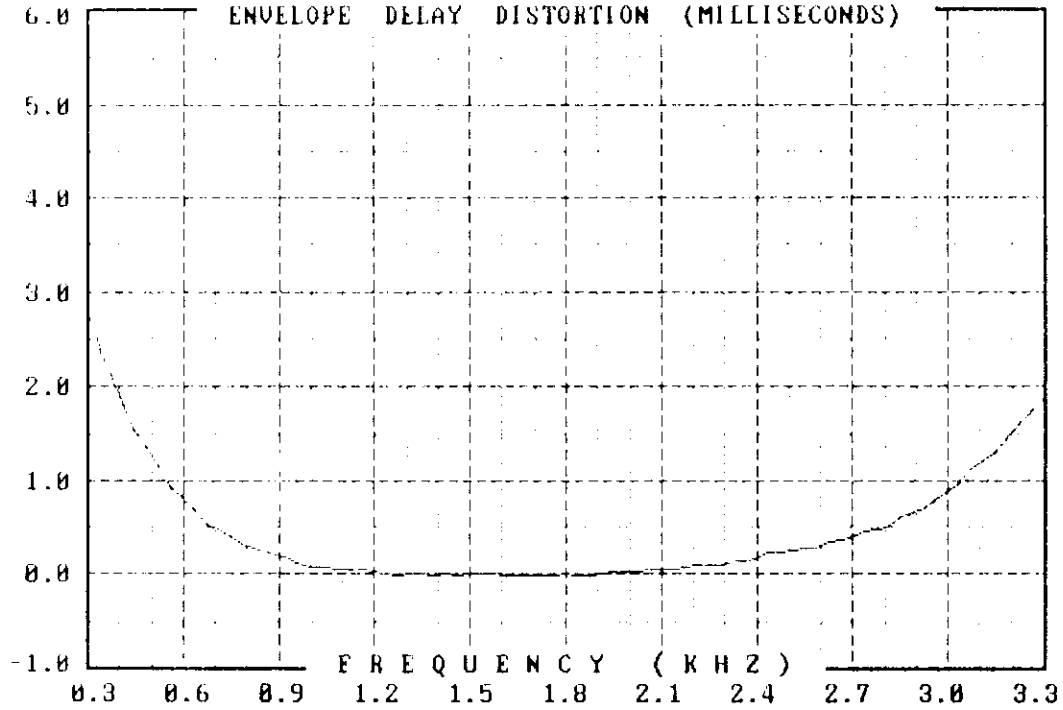
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
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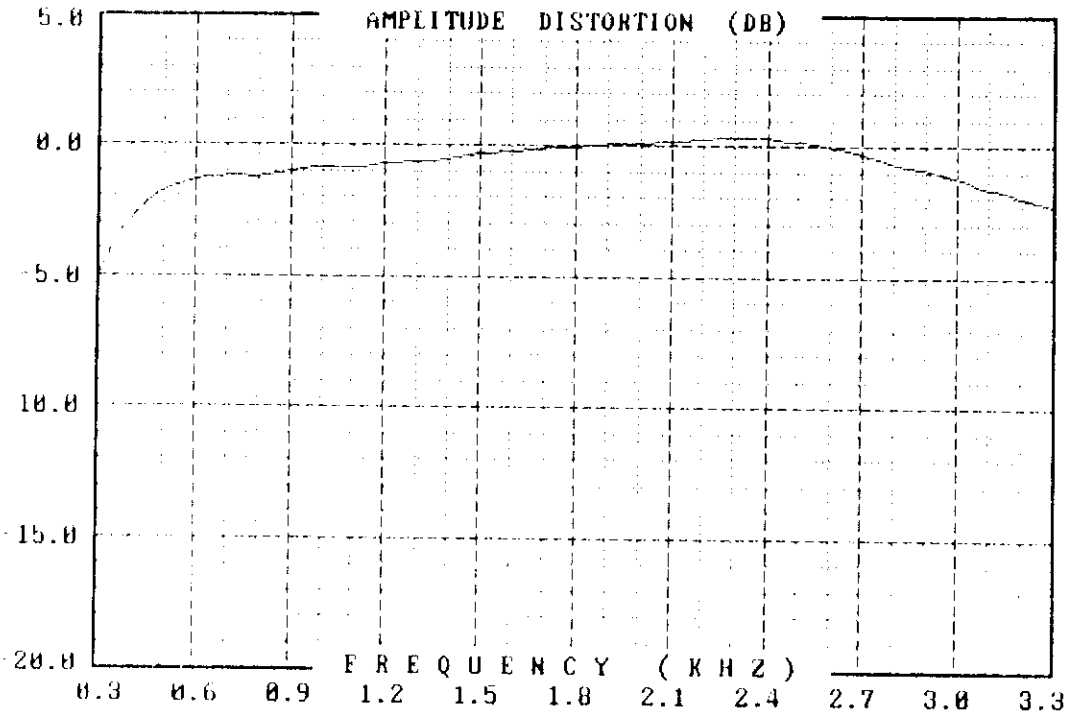
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

NTT - 1


AMPLITUDE DISTORTION (DB)
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-5.0
-10.0
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-20.0
FREQUENCY (KHZ)
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0.9
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1.5
1.8
2.1
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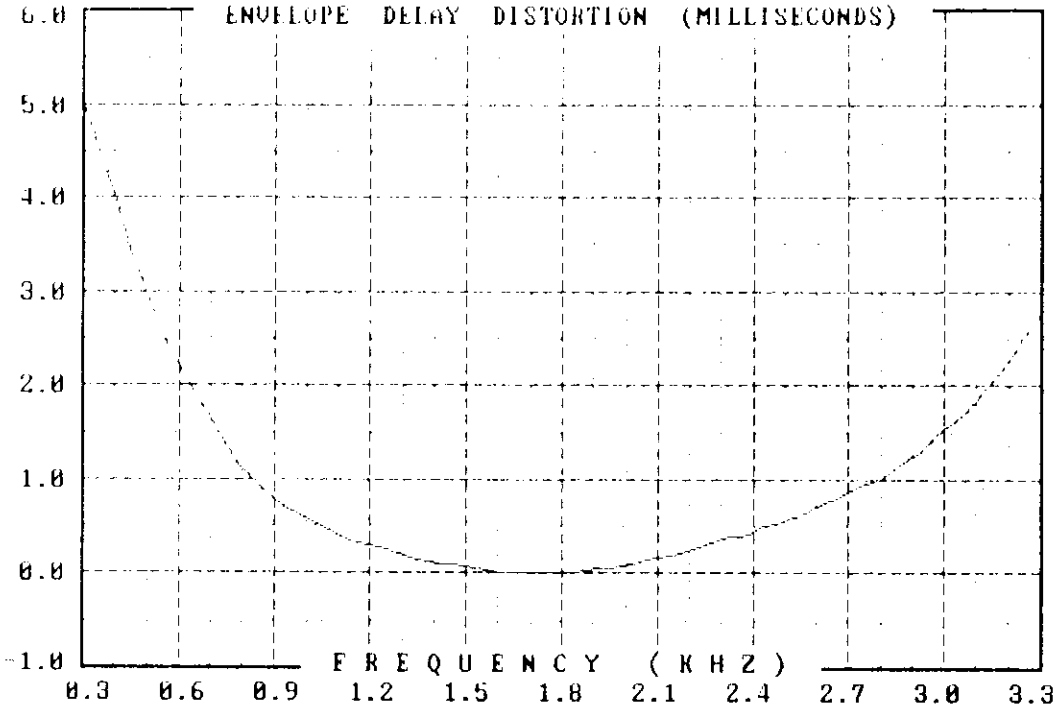
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
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4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
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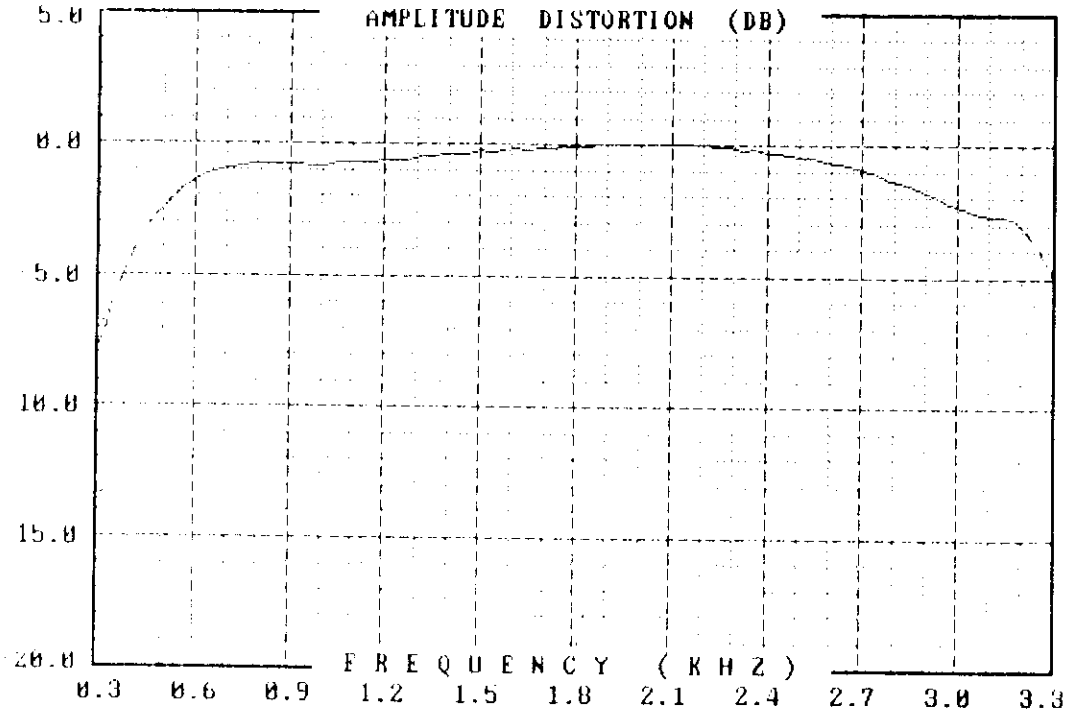
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

NTT - 2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5.0
10.0
15.0
20.0
FREQUENCY (KHZ)
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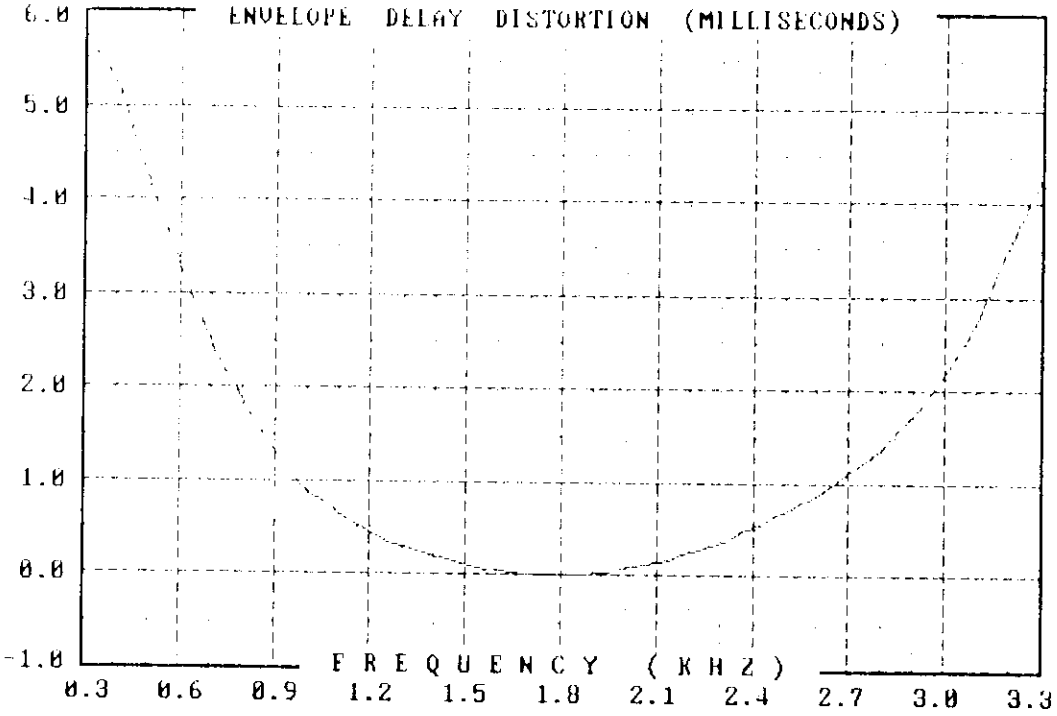
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
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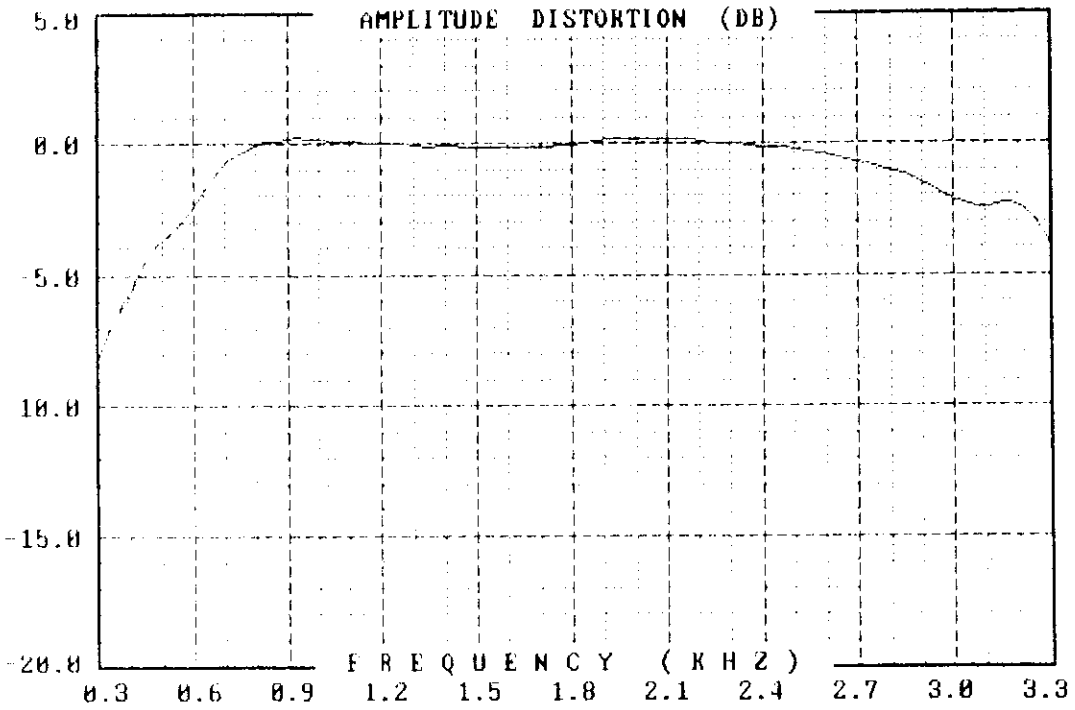
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

NTT - 3


AMPLITUDE DISTORTION (DB)
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-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
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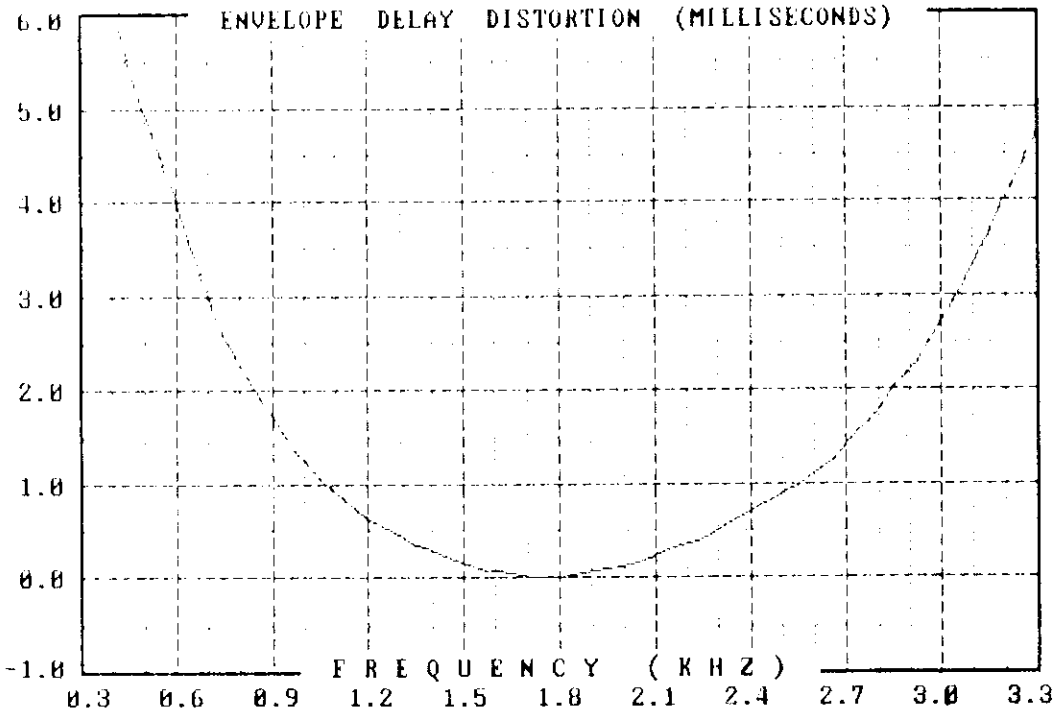
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
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4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
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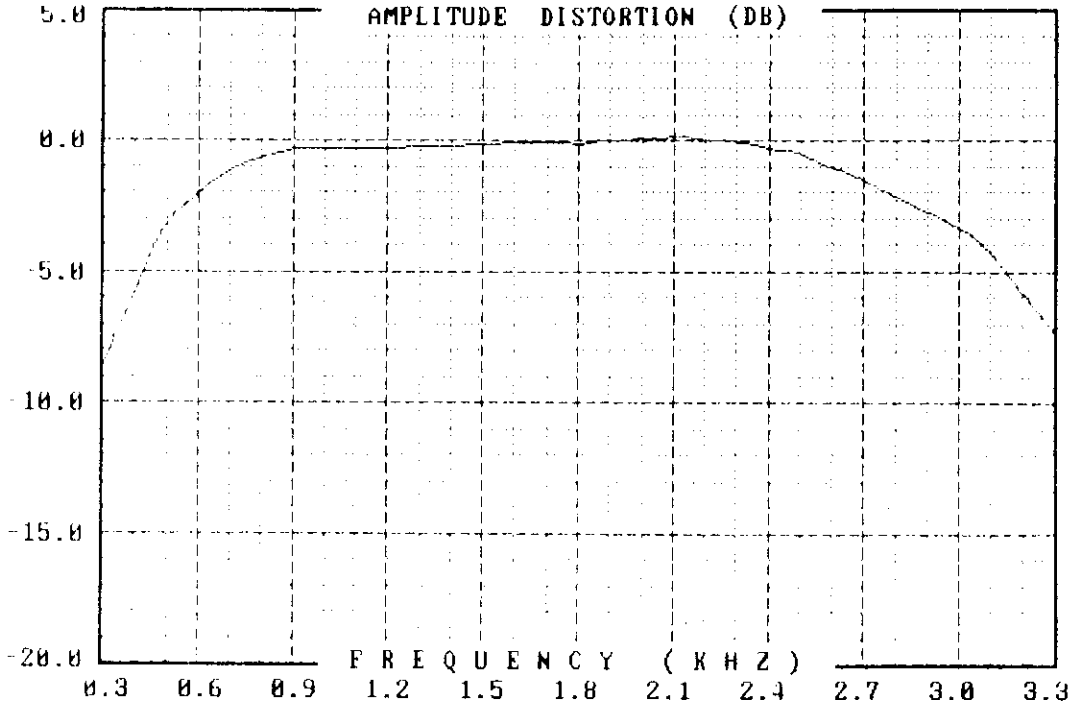
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3

NTT - 4


AMPLITUDE DISTORTION (DB)
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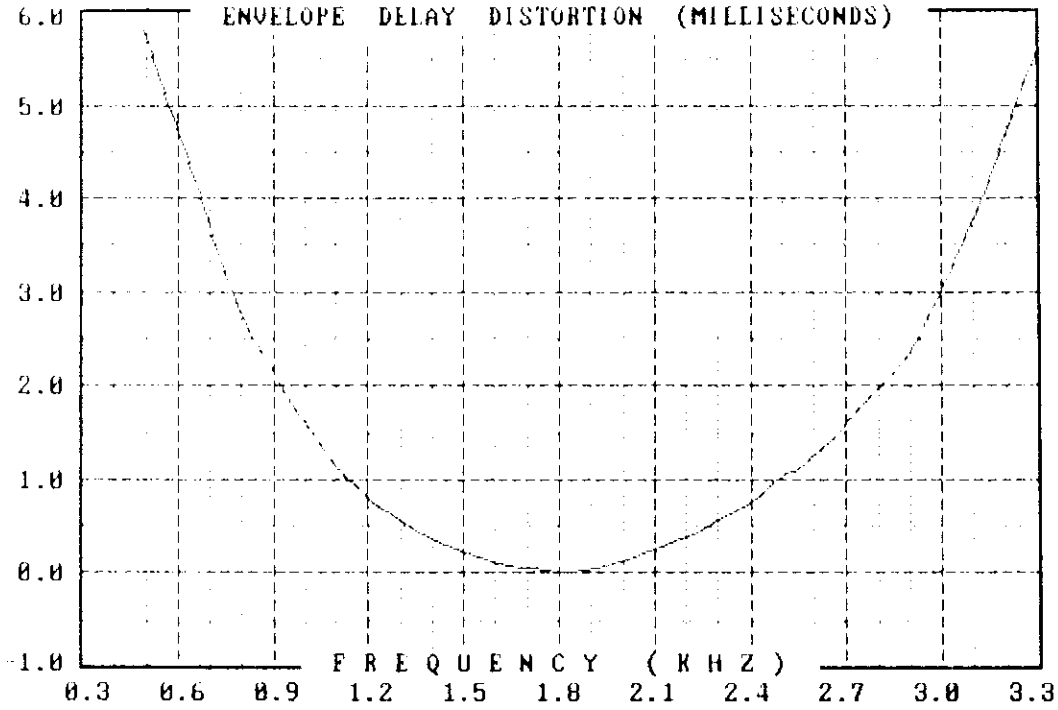
0.0
-5.0
-10.0
-15.0
-20.0
FREQUENCY (KHZ)
0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3.0 3.3


ENVELOPE DELAY DISTORTION (MILLISECONDS)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
FREQUENCY (KHZ)
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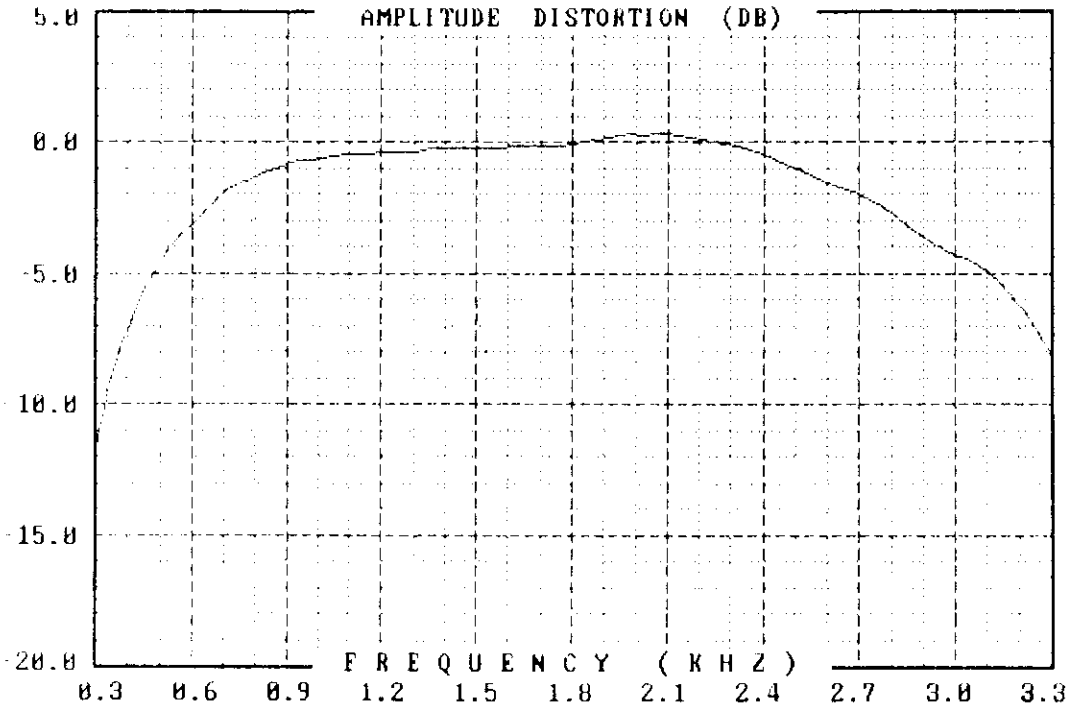
NTT - 5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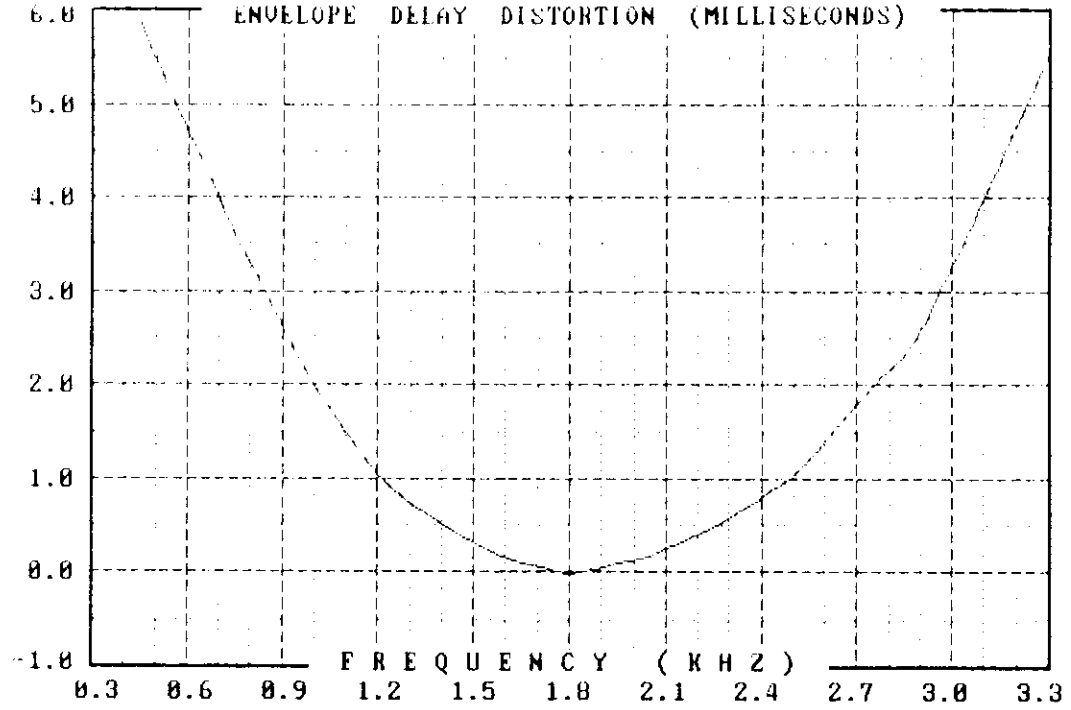
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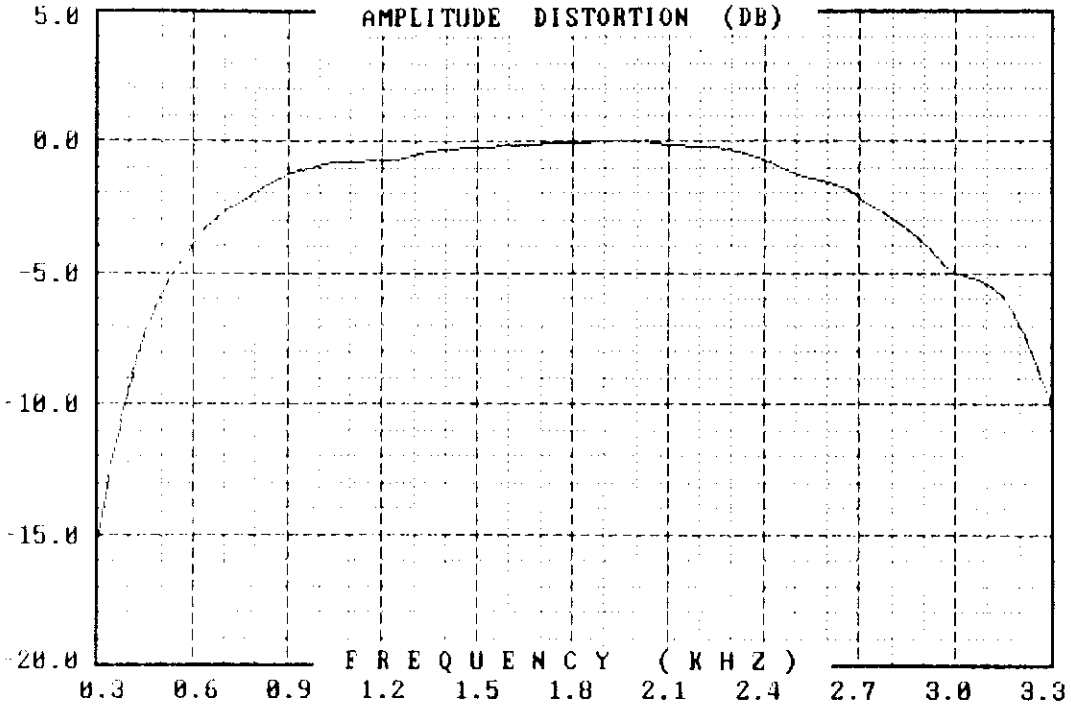
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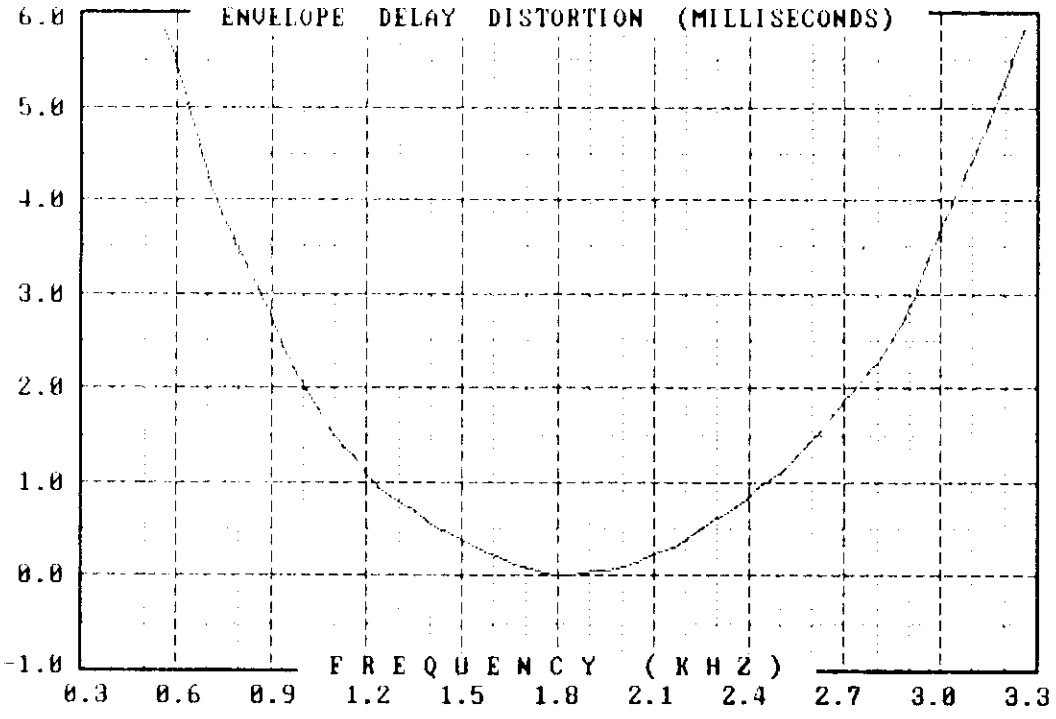
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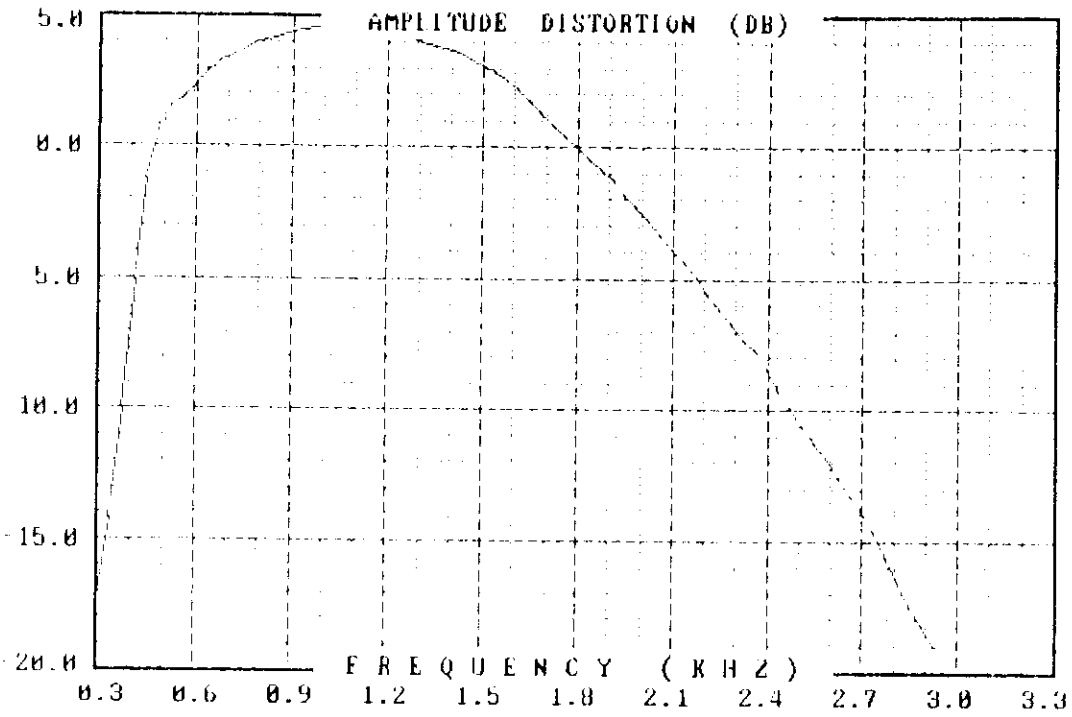
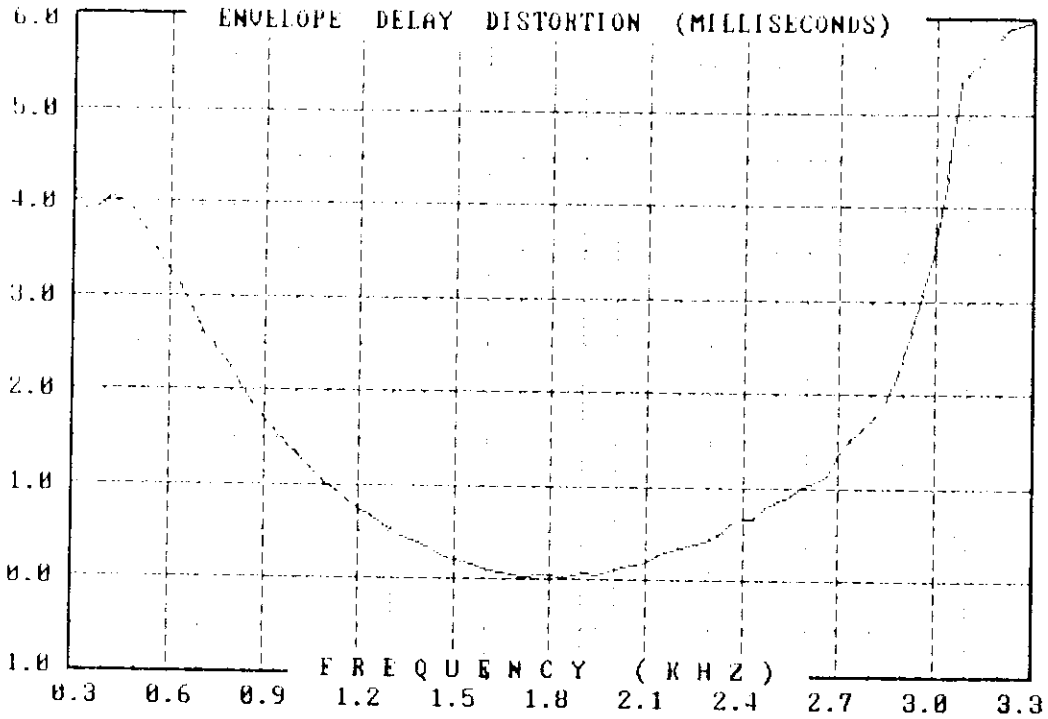
NTT - 7





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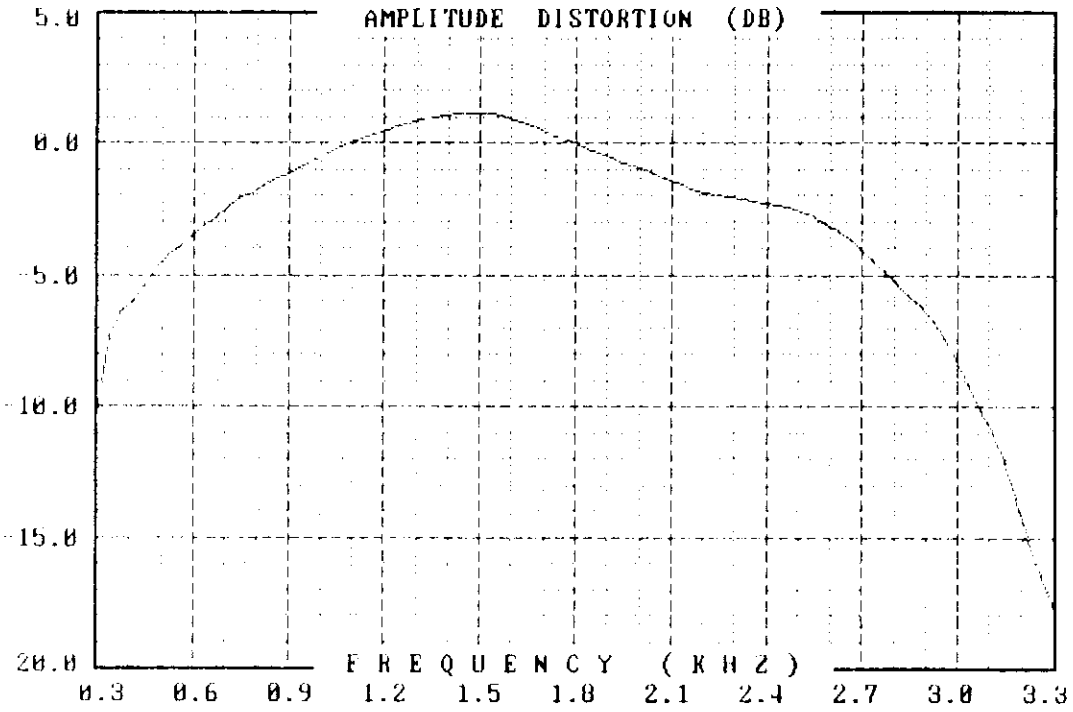

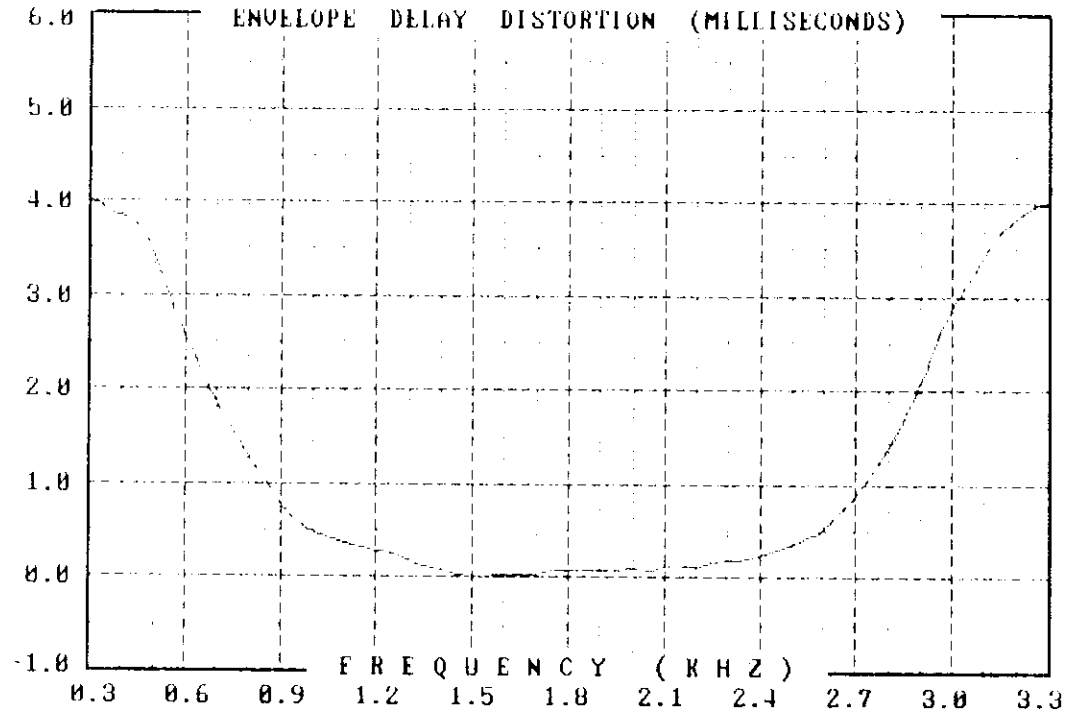

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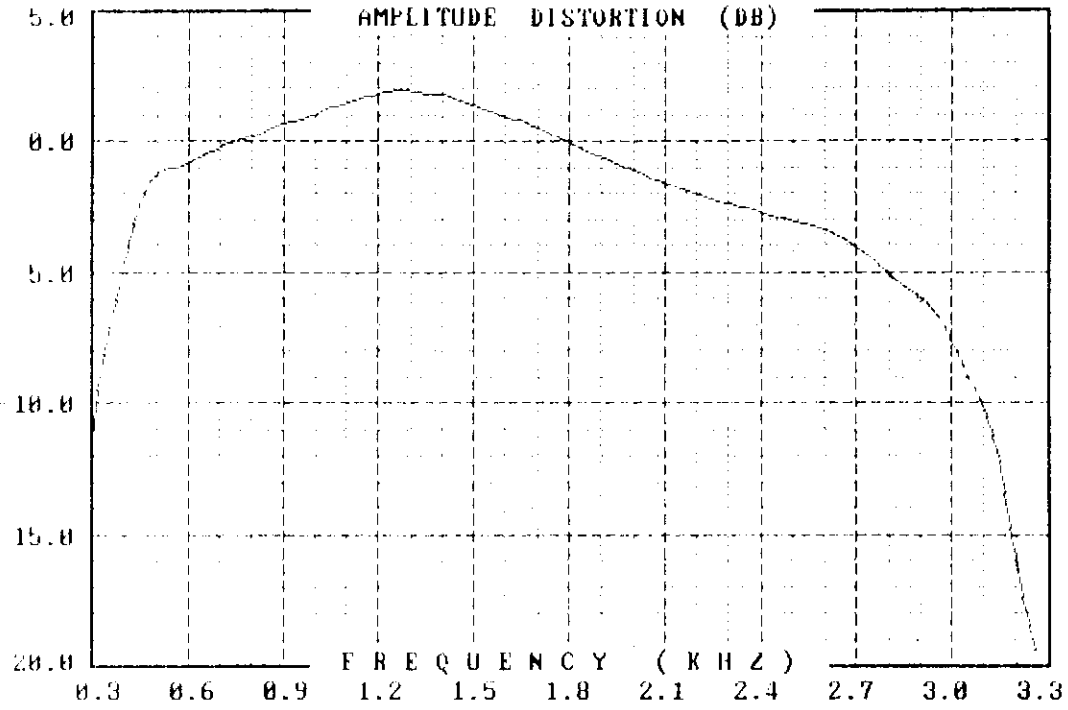

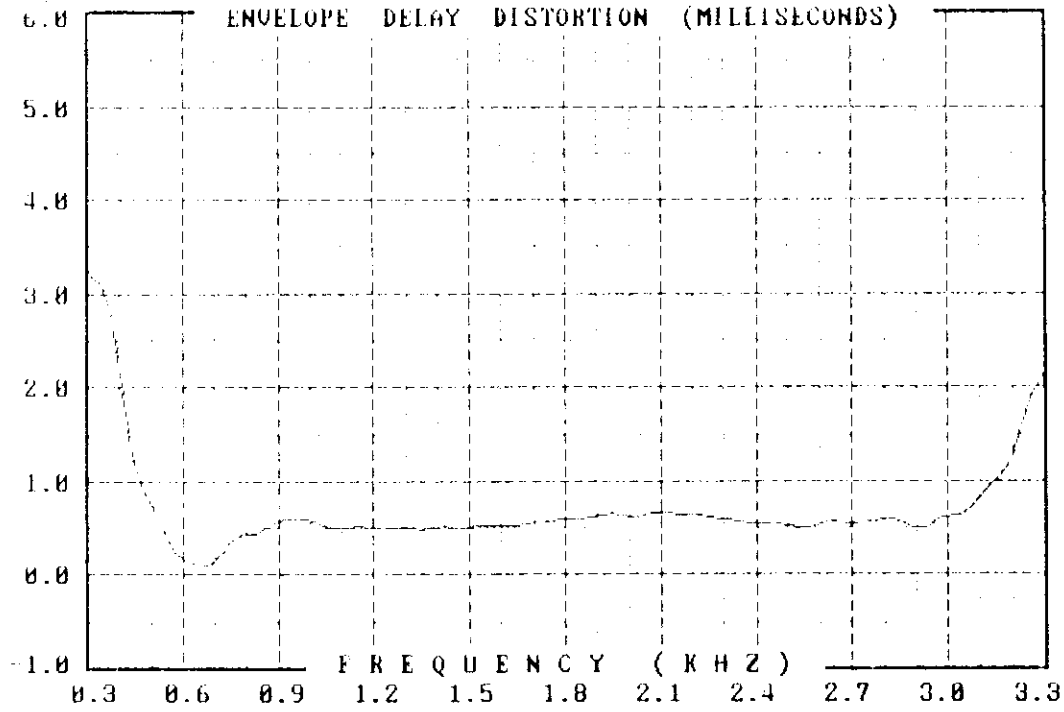

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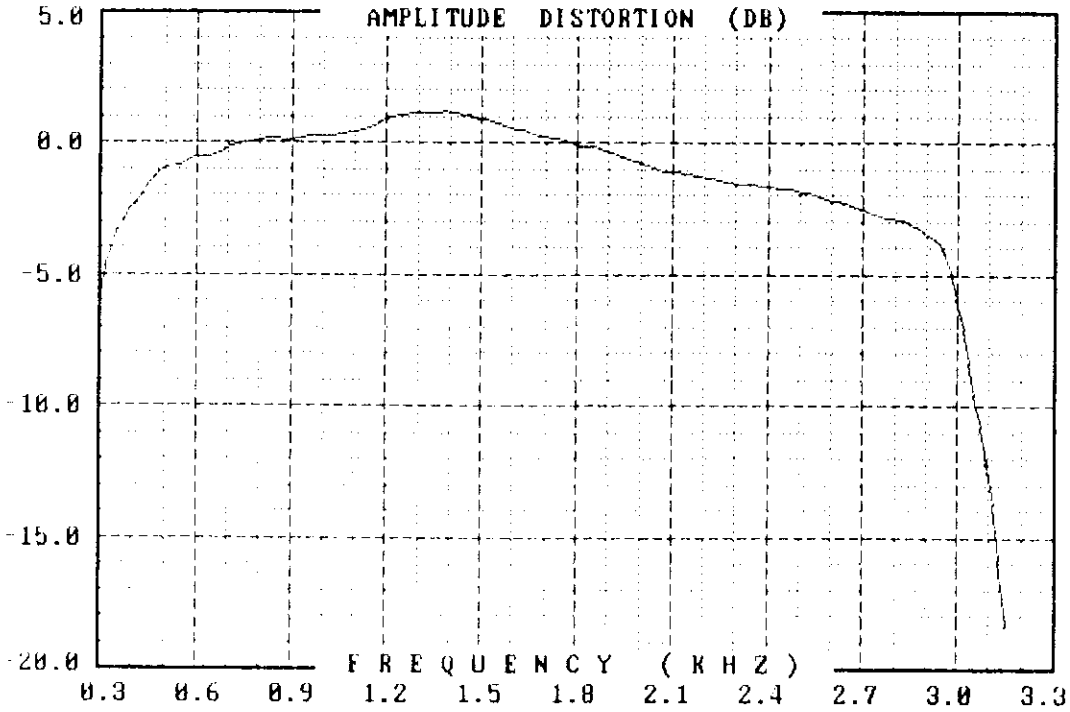

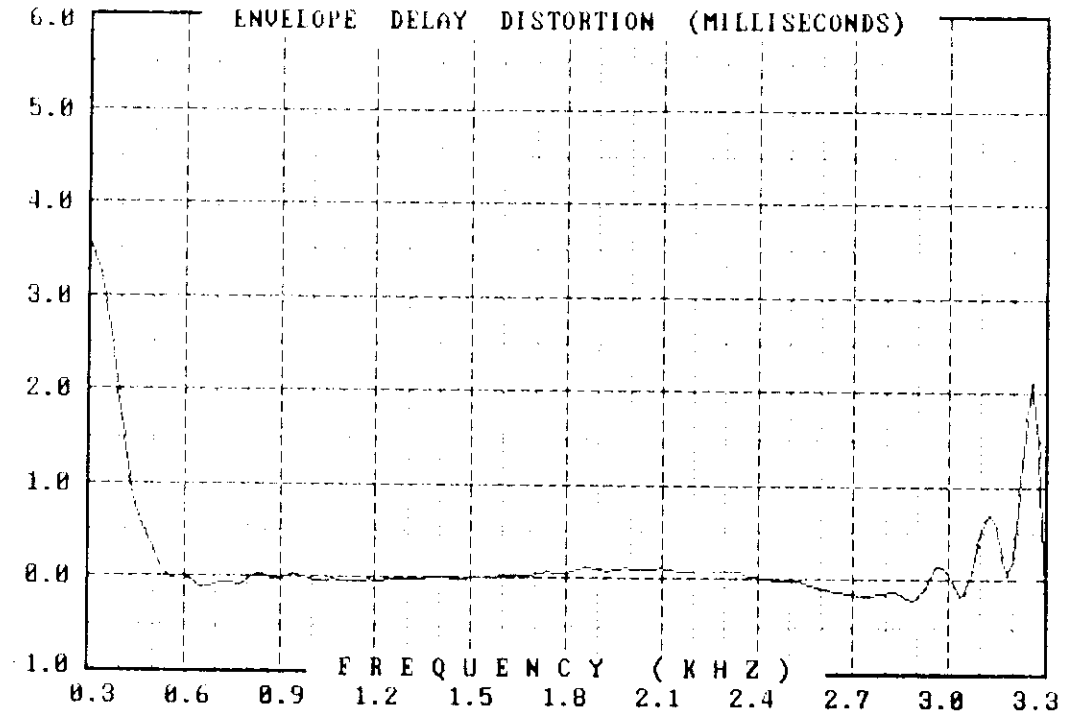

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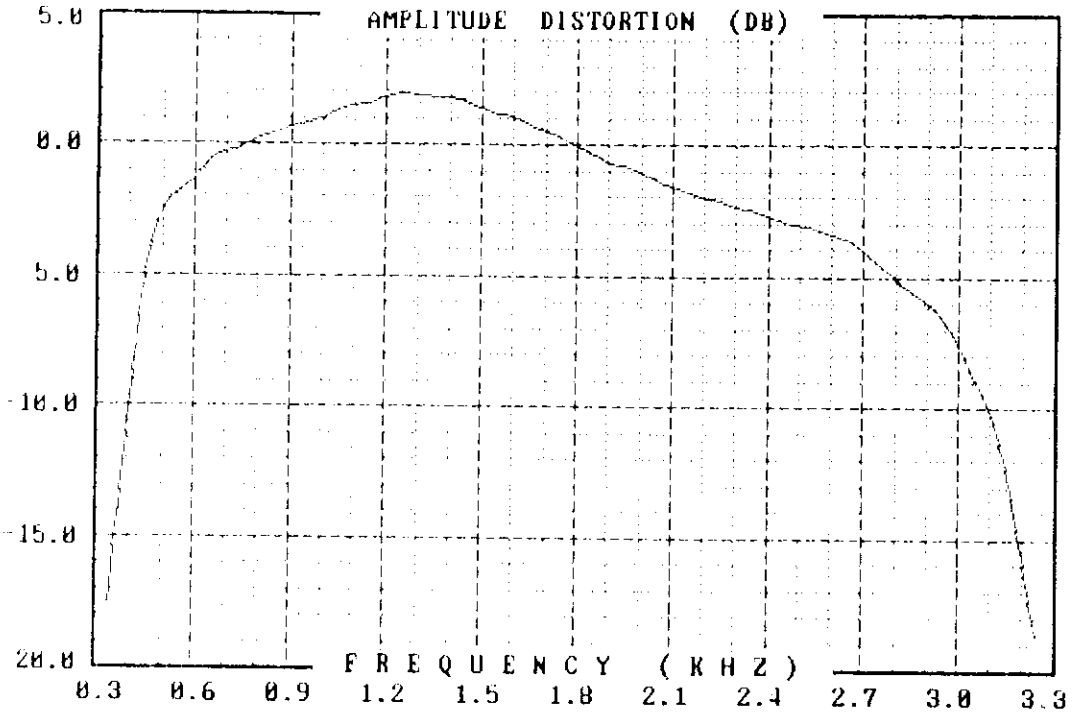

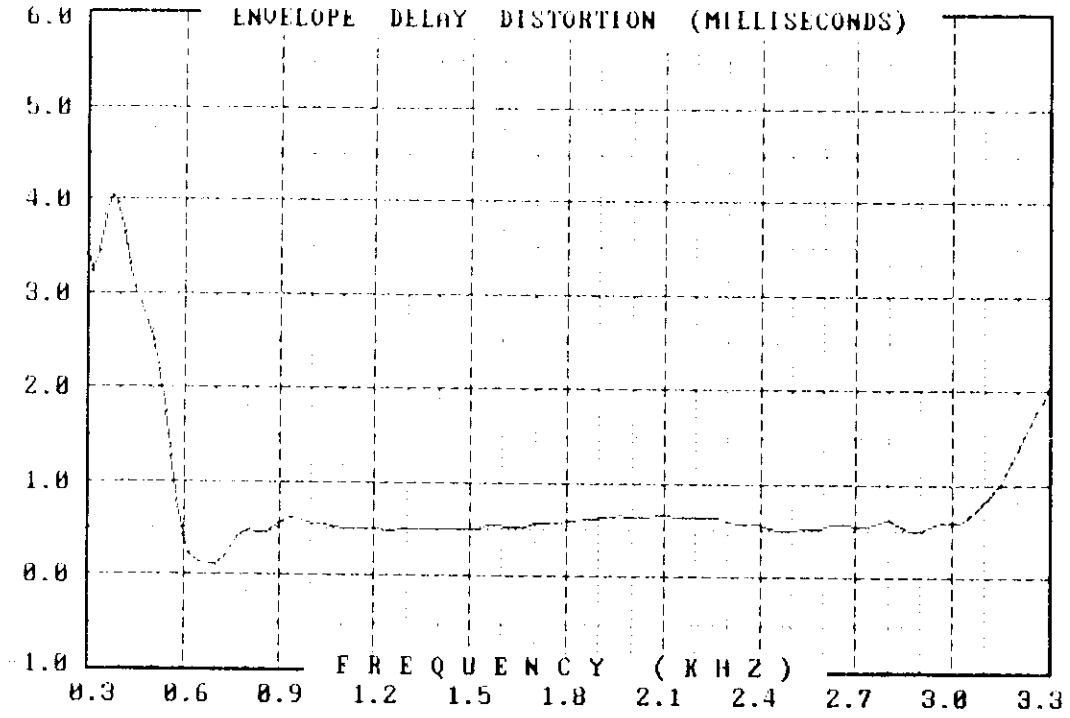

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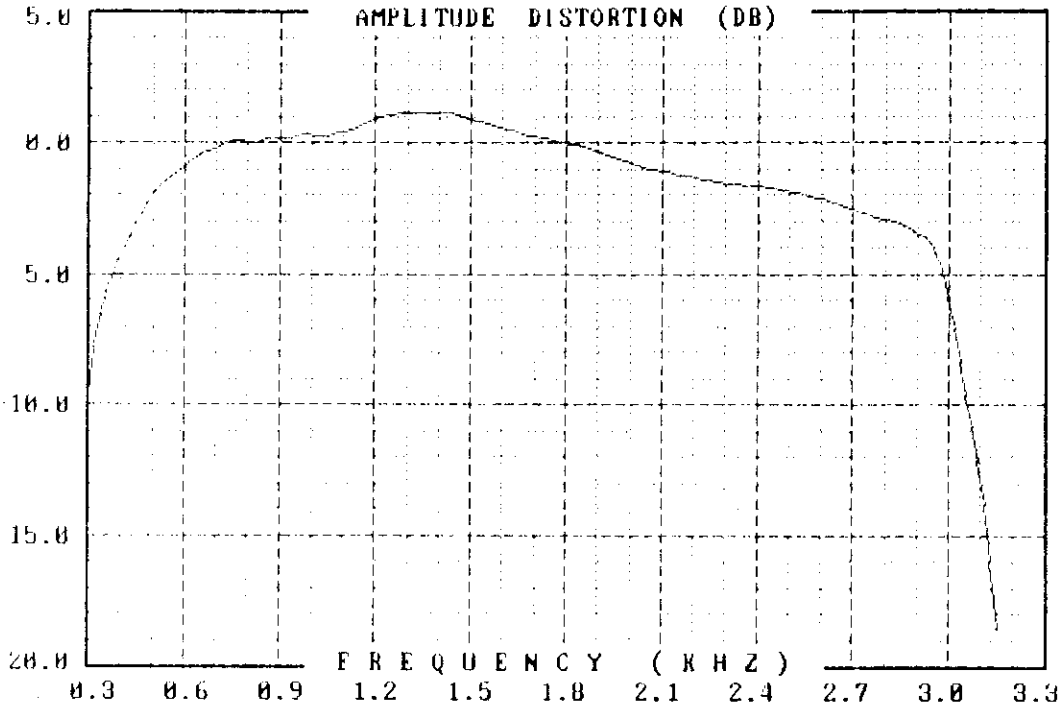

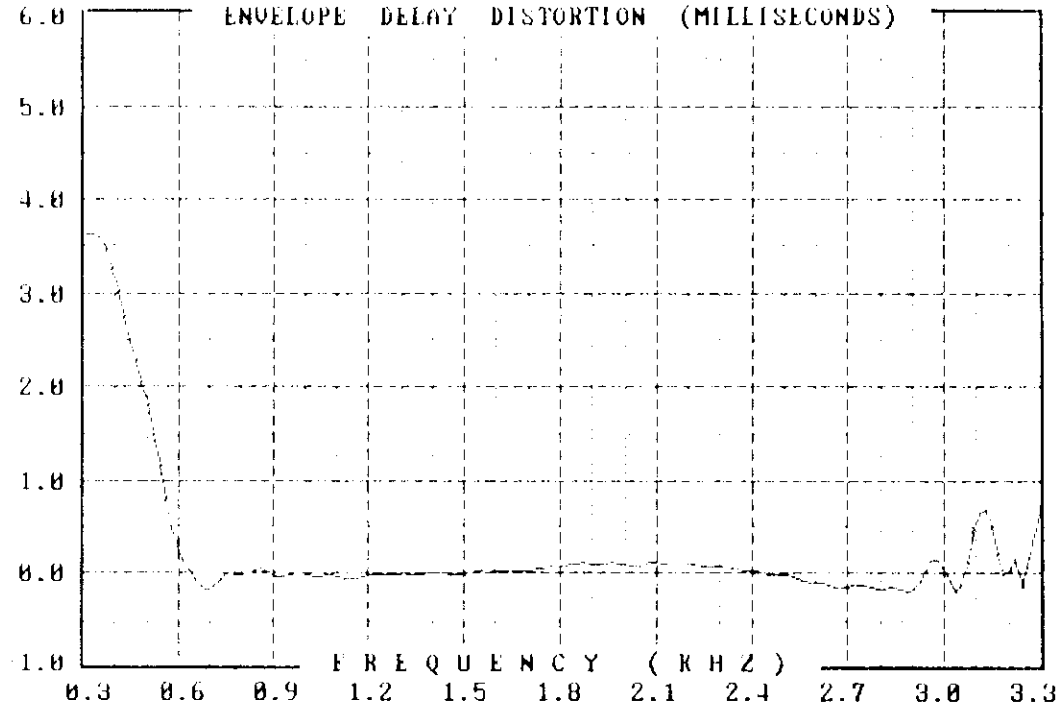

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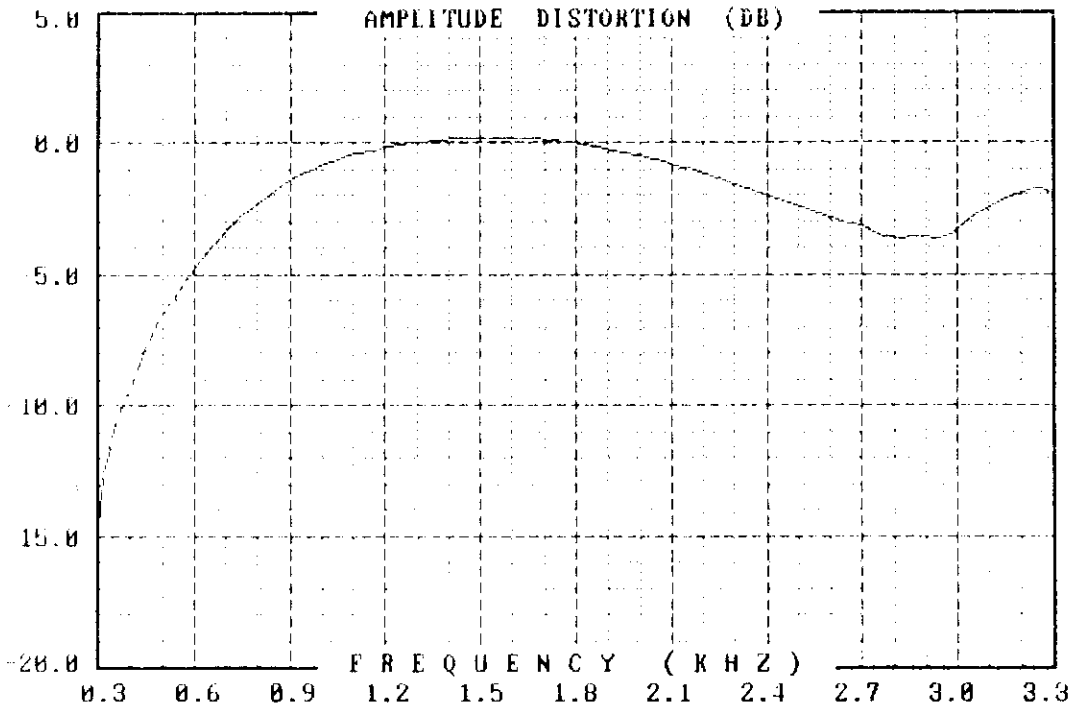

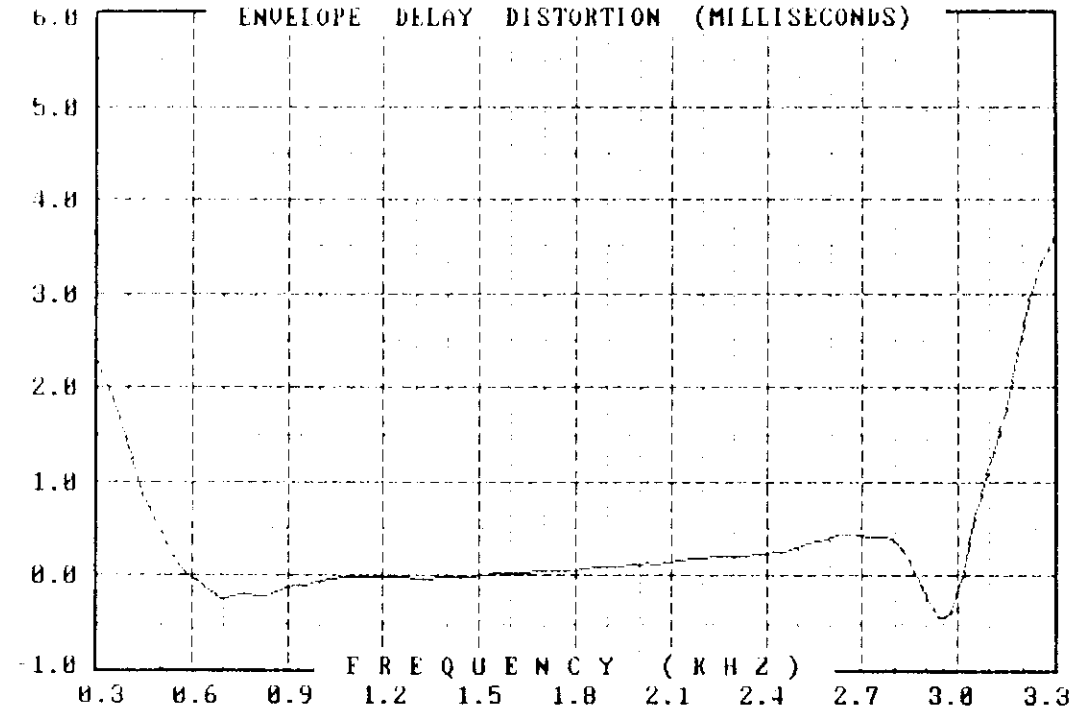

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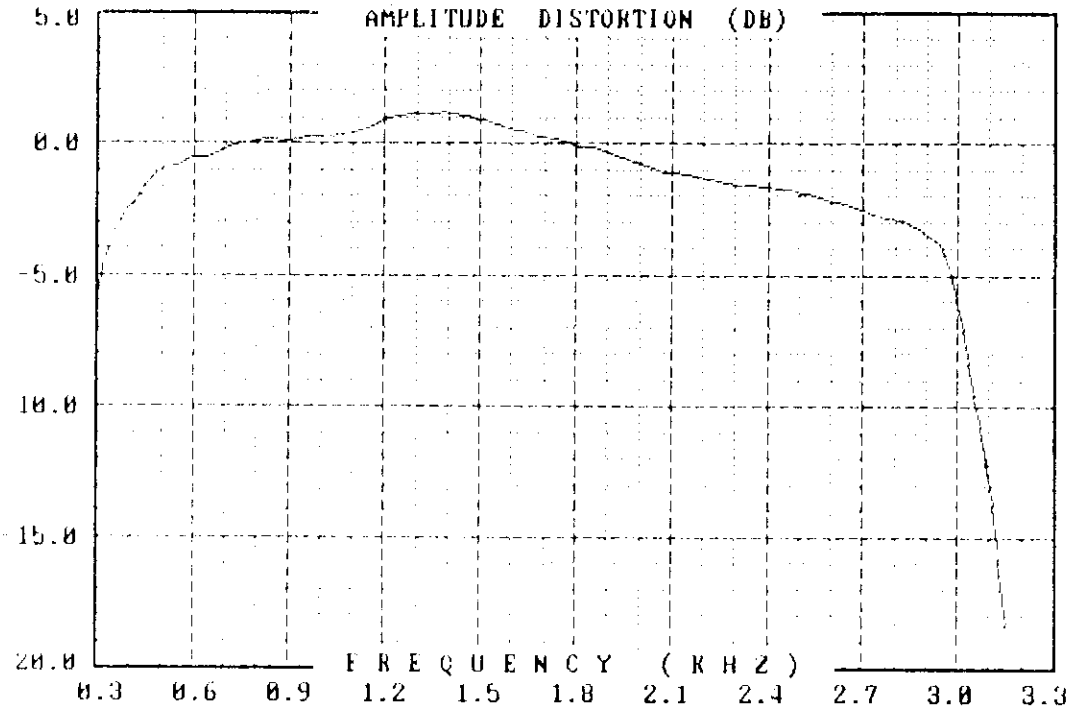

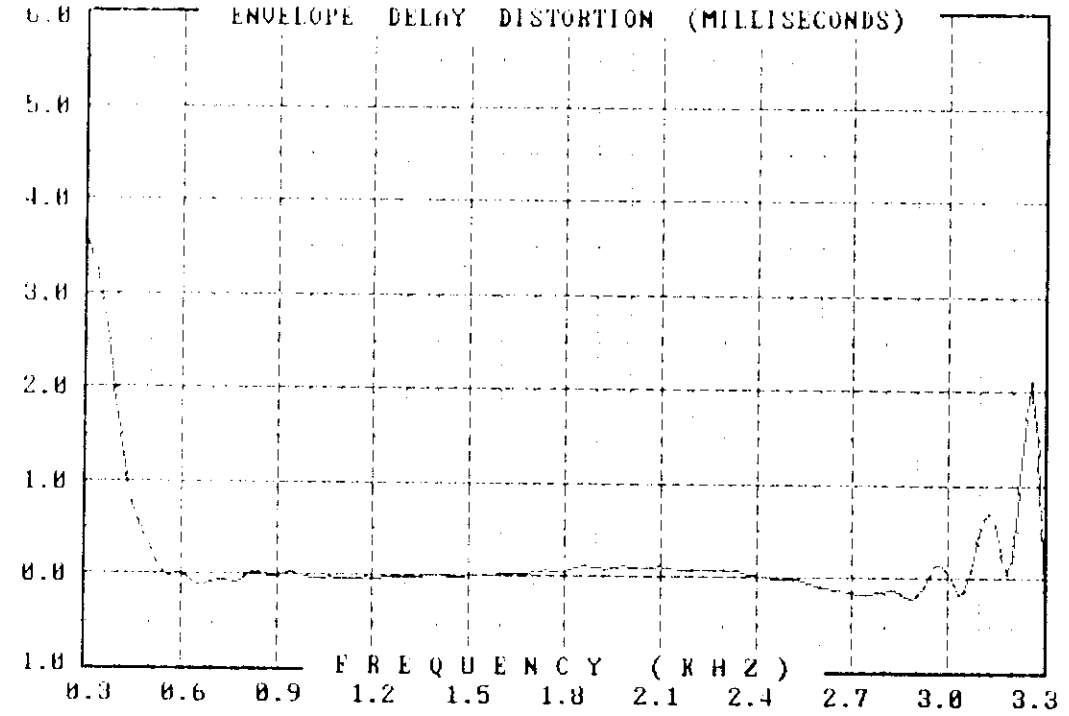

EUROPEAN MID DATA

APPENDIX C

APPLICATION NOTES

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**************************************************
**************************************************
***  PTT 5151 ECHO/ADVANCED IMPAIRMENTS SIMULATOR ***
***        APPLICATION NOTE 5151-01  12/7/87      ***
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<<< TELEPHONE NETWORK ECHOES AND SIMULATION WITH THE PTT 5151 >>>

I. THE ECHO PROBLEM

It has long been recognized that the telephone network induces echoes on the signals passed through it. Historically, echo suppressers have been used to reduce or eliminate the annoying sound of echoes from voice traffic. Until recently, modems using only a single pair of wires for data traffic were either half duplex or used split band techniques so that data in each direction was carried on an essentially non-interfering basis. Modems have typically generated tones when necessary to disable the echo suppressers in the network in order to speed up line "turnaround" in half duplex modems. Now, however, a new approach to full duplex transmission on two wires has become possible through the latest digital signal processing techniques. With these methods, messages occupying the same frequency band are transmitted simultaneously in both directions on a single pair of wires. In this approach, each modem receiver must cancel its own transmitted signal from the line in order to obtain the signal to be received from the other modem. This technique is commonly referred to as echo-canceling.

The transmitting modem generates a signal which is partially eliminated from the received signal path with a hybrid circuit used by the modem to interface to the two-wire line. However, the effectiveness of the hybrid is critically related to the impedance match assumed between the modem and the telephone line. With a perfect 600 ohm resistive load, the hybrid may suppress the transmitted signal by 30 or 40 dB from the receiver path; but in practice the lines encountered are neither 600 ohms exactly nor purely resistive. Actually, the impedance is a function of frequency so that a simple hybrid circuit designed for a a single frequency or a single impedance cannot hope to cancel the transmitted signal very effectively. Rejection of the transmit signal may be as little as 10 dB in many cases and even less occasionally. The residual transmit signal that remains in the receiver path is called an echo, since it is a received replica of the transmitted signal. In the new generation of echo-canceling modems where the received signal occupies the same frequency band as the echo, the undesired echo cannot be eliminated by filtering, as it was in older split band techniques. Special echo canceling techniques are used to take the transmitted signal, process it as required, and subtract it from the received path.

At each point in the network where a conversion from two wires to four wires (or the reverse) occurs, there will be echoes generated. The size of the echo depends upon the quality of the conversion circuit and the impedances involved. Traditionally there have been two echoes of major concern to modem designers. These were the near end echoes generated at the local modem and (perhaps) at the local telephone office and the far end echoes generated at the remote telephone office and (perhaps) at the remote modem. Now, however, with the break-up of the Bell system and the advent of many different long distance carriers, the scenario has changed. Now a signal may undergo additional conversions from four-wire to two-wire and back again at intermediate points in the signal path. Therefore, it is now likely that a modem receiver will need to contend with not only near end and far end echoes, but also with intermediate echoes.

Normally it is expected that as echoes are induced farther and farther away, they will undergo more line attenuation and will be weaker. But this is not necessarily true, since an echo originating from a weaker transmitted signal may encounter a more severe impedance mismatch and thus be stronger than a nearer echo generated by a better impedance match. It is generally expected that a far end echo will at least be somewhat weaker than the desired signal transmitted from the far end, since the signal will undergo some attenuation in reaching the far end and it will encounter the same attenuation on the return path as the desired signal. Therefore, the person designing, testing, or evaluating an echo canceling modem, such as a V.32 modem, should consider the possibility of near end echoes (perhaps as strong as 10 dB below the transmitter or even stronger), of far end echoes (probably at levels almost as strong as the received signal, perhaps 6 dB down), and additionally the very real possibility of intermediate echoes somewhere in between.

The delays encountered on echoes can vary from almost no delay for the near end echoes up to a second or more for echoes induced in calls routed through satellite circuits. Therefore, a wide range of echo delays should be considered. Finally, it should be remembered that the echo signals will undergo distortion and other line impairments as they pass through the network. In general, it is not enough to adjust the scaling and delay of the transmitted signal to obtain an echo replica and subtract it at the receiver to cancel the echo. The near end echo will normally encounter very little distortion, since it passes through so little of the network. However, far end echoes will encounter severe impairments, because (by definition) these echoes traverse a long path through the network. In fact, the far end echo path is generally more severe than that encountered by the desired signal because it must pass through the network once to reach the far end and then pass back through again, along with the desired far end signal, to reach the modem where it originated as a transmitted signal.

A modem design intended to properly cope with a far end echo (or with an intermediate echo originating deep within the network) should account for the fact that the echo may undergo a "worst case" line distortion on the transmit path and a second "worst case" line distortion on the receive path. This echo may additionally encounter other impairments. Frequency offset is of significant concern because, if it is present, it must be tracked by the receiver echo canceling process in order to accomplish any echo cancellation at all. There are arguments made that in the U.S. telephone system, frequency offset in the transmit path are canceled in the received path so that no net offset is seen on far end echoes. It is also true that many people are skeptical that this is always true, and frequency offset tracking in echo canceling modems is a real concern in both the technical literature and in the modem industry. It seems likely that frequency offset must be considered in a robust design. Additionally, other impairments such as phase jitter, nonlinear distortion, etc., will also be encountered and are of some concern. The dominant corruption of the echoes, however, is generally considered to be linear distortion (amplitude and envelope delay characteristics) and frequency offset.

In summary, the echo canceling modem design should be prepared to deal with multiple echoes. In addition to near and far end echoes, there may be intermediate echoes. Delays on the echoes may range from almost zero to over one second. Additionally, a robust design must deal with severe line characteristics; quite possibly far echoes or intermediate echoes near the far end may encounter two cascaded "worst case" lines. Finally frequency offset must be considered, along with other possibly less significant impairments.

II. The PTT 5151 ECHO SIMULATION CAPABILITIES

The PTT 5151 (used with the PTT 5100 Telephone Line Simulator) is designed to offer the modem designer, evaluator, or user the capability to simulate the full range of echoes that are encountered in the telephone network. It features four adjustable echo paths: near end, far end, and two intermediate echoes. The user can independently control the delay and attenuation in each path. Delays are adjustable up to 1.6 seconds in steps of 104 microseconds, and attenuations are adjustable up to 40 dB. Each echo can, of course, be turned on or off. Two echoes can be added to the receive signal path after the normal line impairments. These echoes are normally used to model near end echo and an intermediate echo point near to the local modem. Two additional echoes are added to the signal at the far end and are processed through the entire receive signal path along with the usual signal transmitted from the far end. These echoes are normally used to model the far end echo and an intermediate echo near to the far end.

In addition to the attenuation and delay functions, other impairments are available to fully model echoes encountered on the telephone network. Frequency offset of up to +/-20 Hz is included in the forward signal path, so that this important phenomenon can be induced in both the far end echo and one intermediate echo. The more advanced versions of the PTT 5151 also provide the capability to pass these two echoes through a wide range of amplitude and envelope delay distortion models in the reverse path. These distorted echoes are then added to the forward signal and passed through the forward line model impairments. This means that these echoes can be distorted by an independent line model as they travel to the far end, in addition to the distortion and impairments encountered on the return path, just as in the real telephone network. Additionally, other impairments can be induced in the forward channel so that they affect the echo as well as the received signal. These include satellite delay, phase jitter and amplitude jitter, harmonic distortion, phase and amplitude hits, impulse noise, and single frequency interference.

Another impairment often encountered on the telephone networks is listener echo. This phenomenon occurs when the desired received signal is partially reflected at the receiver into the transmit path and then is reflected at some later point back into the received path. This impairment is not unique to echo canceling modems, but is a degradation that can affect all modems. Since this echo can be considered as a linear distortion of the received signal path, it tends to be controlled by a modem with an adaptive equalizer, if the equalizer is long enough to span the time delay of the listener echo. Listener echo is present to some degree in all telephone networks, but has been found to be especially troubling on some networks outside the U.S. system. The more advanced versions of the PTT 5151 offer modeling of listener echo, so that its effect on modem performance can be studied. Options also include an external analog path, so that the user can include any additional equipment or impairments into the signal path if this is desired.

The PTT 5151, used in conjunction with the PTT 5100 Telephone Line Simulator, is the most full-featured echo simulator on the market. It offers highly realistic modeling of the echoes likely to be encountered in the telephone network. All the important features needed to critically test echo performance of modems or other voiceband telephone equipment are present. In addition to detailed modeling of multiple echoes, it provides all the advanced system impairments needed for complete evaluation of any modem. The unit provides a front panel block diagram of the system model as well as a menu-driven selection scheme for the echoes and advanced impairments, insuring the unit is extremely easy to use.