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ELECTROMAGNETIC ENVIRONMENT MEASUREMENTS
OF PRT SYSTEMS AT "TRANSPO⁷²"
VOLUME VII

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JANUARY 1974

FINAL REPORT

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16. Abstract This report covers the measurements of the broadband conducted noise present on the A.C. power lines feeding the Personalized Rapid Transit (PRT) systems at Dulles Airport with all four systems off. The purpose of the measurement effort was to evaluate the electrical environment existing on each of the PRT "hot" and neutral A.C. power lines prior to the installation and operation of any of the systems. These data will provide a baseline for use in establishing the relative increase in EMI levels associated with PRT system operation. Data obtained under this effort will enable an evaluation of whether or not existing or potential EMI levels might effect the normal operation of the PRT systems. Such interference could conceivably contribute to breakdown, malfunctions, or safety problems associated with the automated equipment utilized by the PRT systems in performing normal functions.					
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PREFACE

The work described in this report was performed as part of a test program conducted to evaluate the Safety and Performance characteristics of the four Personalized Rapid Transit Systems (PRT) on display at Transpo[®] 72. Sponsored by the U.S. Department of Transportation, Transpo[®] 72 was the first United States International Transportation Exposition and was intended to demonstrate to the general public new technologies in transportation.

The PRT demonstration program was the responsibility of the Urban Mass Transportation Administration (UMTA) and was conducted to provide detailed engineering test data in addition to providing mature candidates for an Urban demonstration.

AMBIENT POWER LINE CONDUCTED NOISE SURVEY
PRT SYSTEMS - TRANSPO® '72

1. INTRODUCTION

This technical report details results obtained in measurements of ambient power line conducted noise at each of the four personal rapid transit (PRT) sites at TRANSPO® '72, at Dulles Airport, Washington, D.C. This test program was performed for DOT, Transportation Systems Center (TSC), by National Scientific Laboratories, pursuant to Item 4 of the Contract No. DOT-TSC-375, and the approved test procedures submitted on February 24, 1972. This item called for the performance of conducted noise measurements on PRT a.c. power lines in the frequency range from d.c. to at least 10 kHz, with all PRT systems off.

The objective of the test program was establishment of a base line for use in interpreting data taken at a later date with the PRT systems operating. Such data would enable characterization of the noise increase attributable to system operation.

The measurements described in this report were made at various times, as indicated, during the period of 25-29 February

1972. Much of the data were taken in the evening hours to preclude contamination by noise originating from construction tools, such as arc welders, drills, impact tools, and other electromechanical machinery.

2. METHOD OF MEASUREMENT

2.1 Equipment

All of the power-line conducted measurements were performed using a Fairchild Model EMC-10 Interference Analyzer. This device is a battery-operated calibrated RFI/EMI meter, which, when operated as a narrowband tunable device, covers the frequency range of d.c. to 50 kHz. The receiver has an internal calibration source and incorporates a meter circuit of such design that signal levels are expressed in decibels on a linear scale. In addition, the receiver incorporates circuitry providing buffered voltage outputs in proportion to meter indication and tuned frequency. This feature permits the receiver to be used with an X-Y Plotter.

To permit rapid taking of data, a Hewlett Packard Model 3005B X-Y Plotter was operated from the receiver.

Signals were obtained from the power line by means of a Fairchild Model PCL-10 Current Probe. This device is a clamp-on current transformer which provides an output voltage in proportion to the current on the conductor which passes through its aperture. This probe has a specified transfer-admittance characteristic which is a function of frequency.

The overall test configuration utilized is illustrated in Figure 1. A.C. power needed to operate the X-Y Plotter was obtained from a 12 volt automotive battery by means of an inverter.

2.2 Measurement Technique

The TRANSPO® PRT sites are each provided 15 kv, 3 ϕ , Y-connected power from a commercial feeder. This power is applied to a step-down transformer multiple transformer to obtain 480V, 3 ϕ power. This secondary power passes through government switchgear and thence by underground feeder to the commercial switchgear located at a given PRT site. The specifics of each site are delineated in Table 1.

TABLE 1

Site Power Feeder Specifics

<u>Site</u>	<u>Type of Power</u>	Parallel no. of feeders	Color Code			
			<u>ea. phase</u>	<u>OA</u>	<u>OB</u>	<u>OC</u> <u>Neutral</u>
TTI	480v, 3 ϕ , Y-connected	2	Orange	Brown	Yellow	Non Coded
FORD	480v, 3 ϕ , Grounded Corner Delta	3	Orange	Brown	Yellow	None Grounded
Dashevayor	480v, 3 ϕ , Y-connected	1	Orange	Brown	Yellow	Non Coded
		(NSL code)	(4)	(3)	(1)	(2)
Monocab	480v, 3 ϕ , Y-connected	1	Black	Red	Blue	White

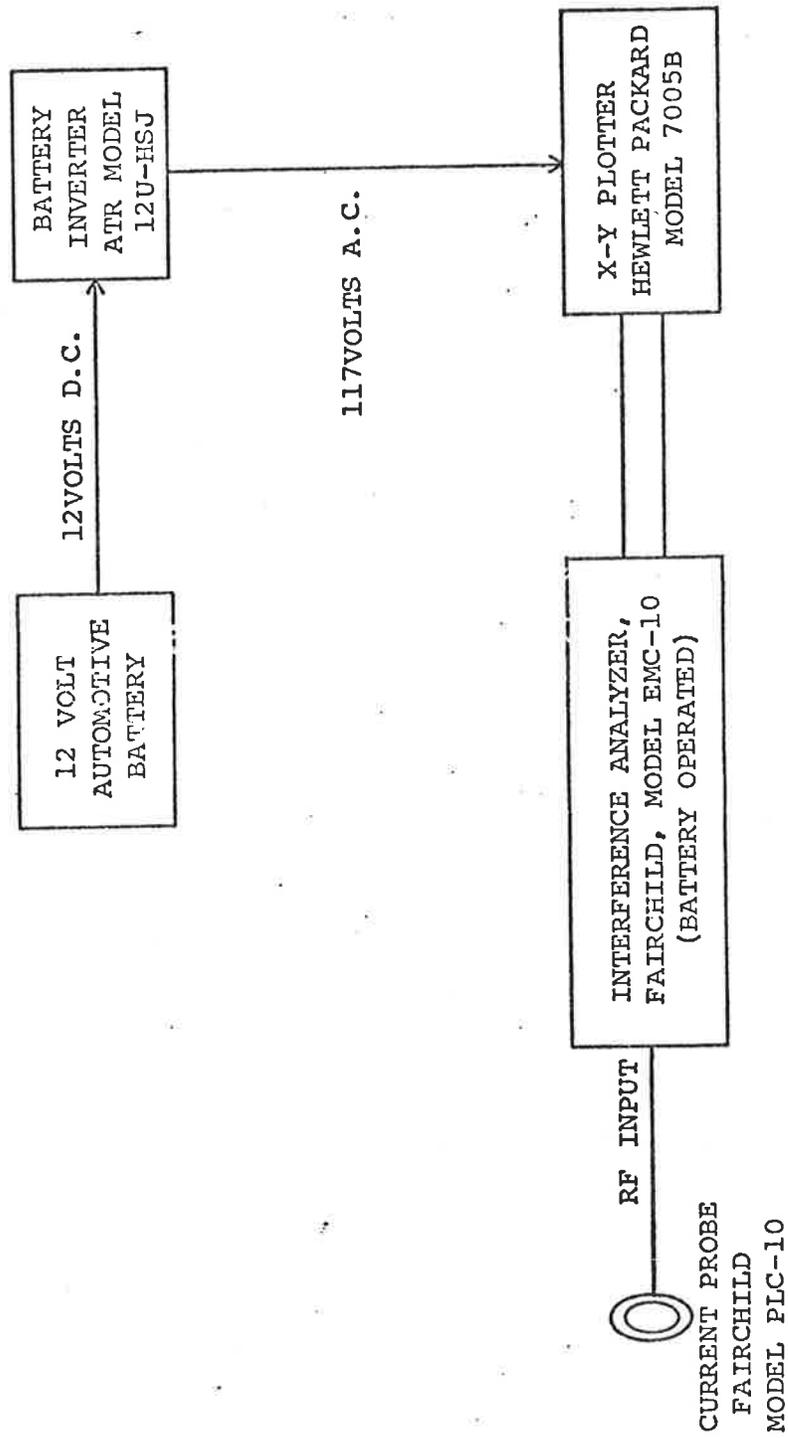


FIGURE 1. TEST SETUP-CONDUCTED EMISSION TESTS.

Power line measurements were performed at the feeder input lines in the commercial switchgear at each site. It was determined that access was considerably easier at this point rather than in the government switchgear, where insufficient clearance was available. It was possible to identify the conductors associated with each phase by color code at each site except Dashevayor, where the layout of the switchgear precluded this. At Dashevayor, therefore, the three phases and neutral were identified by Dashevayor personnel and the feeders were marked using a numeric code.

Each line was tested by scanning through two frequency ranges, 10 Hz to 1 KHz, and 1 KHz to 50 KHz. In the former, a 5 Hz bandwidth was used, while in the latter range, a 50 Hz bandwidth was used.

Where two or more parallel feeders were installed per phase, only one of the feeders was tested. It was assumed that, at least where ambient tests were concerned, the noise level on each parallel feeder would be the same, since both feeders have the same installation method and routing.

3. INTERPRETATION OF RESULTS

3.1 General

The data obtained during the ambient power line conducted noise survey are presented in appendix A. This appendix is organized in such a manner that the data taken at a given site are grouped together. At some sites, data were taken on more than

one date. Where this is the case, the earlier data are presented first and are followed by the data taken at the later date. Results obtained on a given date are organized by conductor, in alphabetical phase order, followed by neutral.

In general, there are two data sheets per phase, corresponding to the two different test-frequency ranges.

Each data sheet portrays a single frequency scan of the indicated conductor. Two graphs are illustrated. The upper graph is a facsimile of the graph produced by the X-Y Plotter (quick-look), and indicates noise at the receiver input as a function of frequency. The amplitude scale of this graph is expressed in terms of decibels referenced to $1 \mu\text{v}$ at the receiver input.

The lower graph expresses the amplitude of the signal on the power line as a function of frequency. The amplitude scale of this graph is expressed in decibels referenced to $1 \mu\text{v}$ on a power line having an assumed impedance of 50 ohms. This assumption is a matter of convention and has no basis in theory. The lower graph is produced by adding a conversion factor to the result portrayed in the upper graph. The conversion factor added is a function of frequency and is numerically equal to the transfer admittance of the current probe expressed in decibels referenced to 1 mho, plus 34 decibels to compensate for the assumed 50 ohm line impedance.

3.2 Monocab Site

The results obtained at the Monocab site are illustrated on pages A-2 to A-9 inclusive. Monocab tests were performed at approximately 7:30 to 8:30 p.m. on the evening of 28 February 1972, the timing being chosen to avoid data contamination by arc welding devices. The data obtained include noise contributed by lighting and an uninterruptible power supply. The latter incorporates rectifiers and a battery charger. Since all of this equipment represents part of the normal operation of Monocab when no vehicle is running, the data are deemed to represent a valid ambient for use in comparative purposes. The high content of 120 Hz harmonics in the data is undoubtedly due to rectifiers in the power supply mentioned above.

3.3 Dashevayor Site

The results obtained at the Dashevayor site are illustrated on pages A-10 to A-17 inclusive. Dashevayor tests were performed between the hours of 10:30 a.m. and 11:30 a.m. on the morning of February 25, 1972. The data obtained include some noise contributed by SCR dimmers, apparently used in the lighting system. An occasional impulse is seen in some of the graphs, e.g. page A-17. These impulses are due to the occasional use of power tools, and as such, are time domain phenomenon, and are not regarded as being

part of the ambient. Since the amount of contamination from these sources is evidently very low, the data obtained are regarded as being a valid ambient.

3.4 Ford Site

The results obtained at the Ford site are illustrated on pages A-18 to A-29 inclusive. Ford tests were conducted from 2:15 to 3:15 p.m. on the afternoon of February 25, 1972, and from 4:30 to 5:30 p.m. on the evening of February 29, 1972. The data obtained on 25 February (A-18 through A-22) revealed severe and substantial interference from power tools. Such tools, consisting of drills and impact wrenches, were observed to be in operation at times coincident with the contaminating disturbances. The scanning time of the graphs is rather slow, being of the order of two minutes.

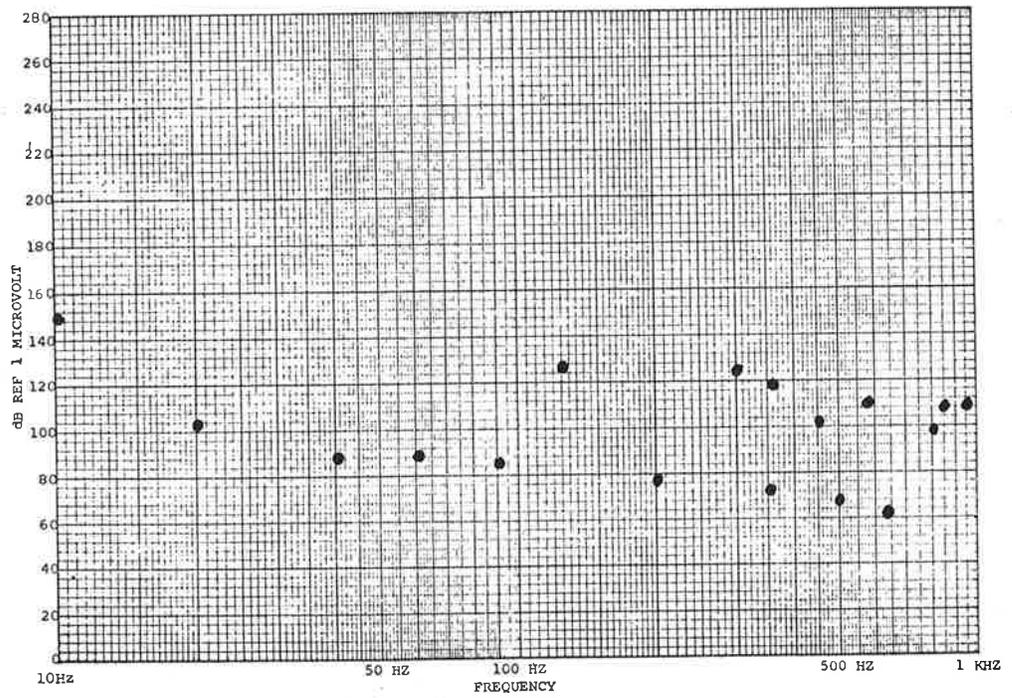
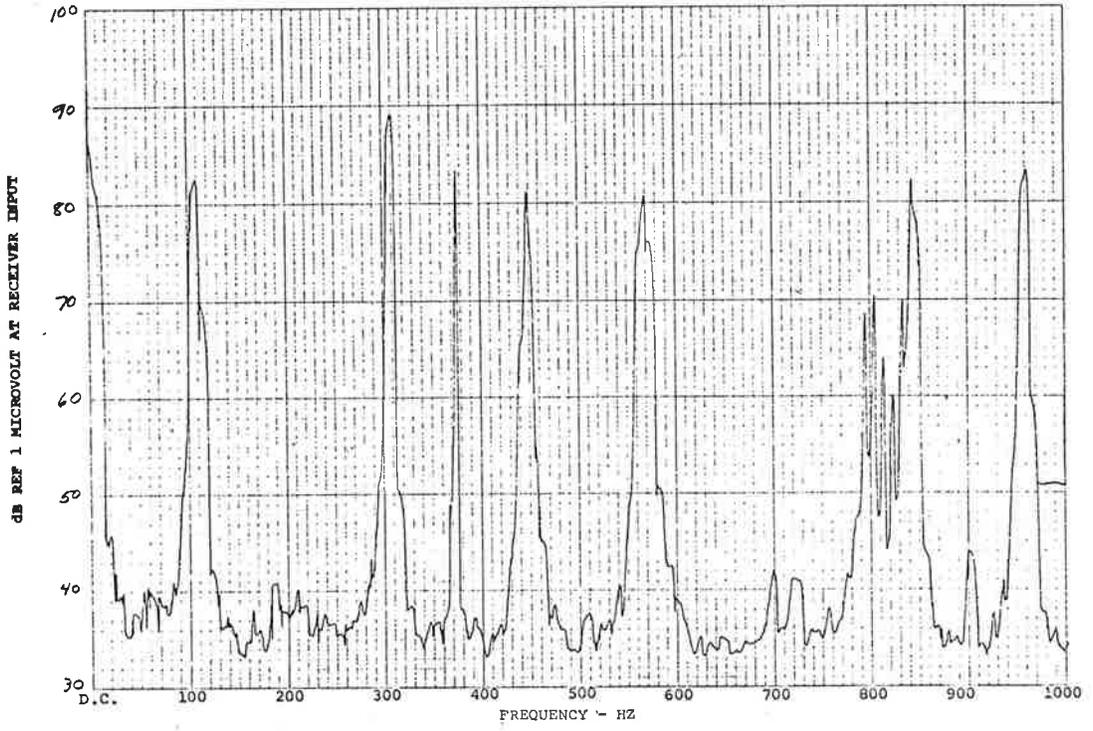
Data contamination forced a repeat measurement on the evening of 29 February. These measurements (A-23 to A-29) reveal little transient contamination by power tools. Lighting systems and some electronic test equipment were in operation at the time of measurement. Since this equipment represents part of the normal post-construction operation of the site, the data were deemed to constitute a valid ambient.

3.5 Transportation Technology, Incorporated Site

The results obtained at the Transportation Technology, Incorporated (TTI) site are illustrated on pages A-29 to A-38 inclusive. The data were obtained during the hours of 1:30 p.m. to 2:15 p.m. on the afternoon of February 25, 1972, and the hours of approximately 5 p.m. and 6 p.m. on 28 February 1972. The earlier tests (A-29 to A-30) revealed severe and almost continuous contamination by power tools. Accordingly, TTI was scheduled for an evening test effort. The results of this test effort (A31-A38) show ambient with no contamination from any source. In fact, no lighting or other systems were in use at TTI at the time of the test. The data are accordingly deemed to be a valid ambient.

APPENDIX A
POWER LINE AMBIENT
TEST
DATA

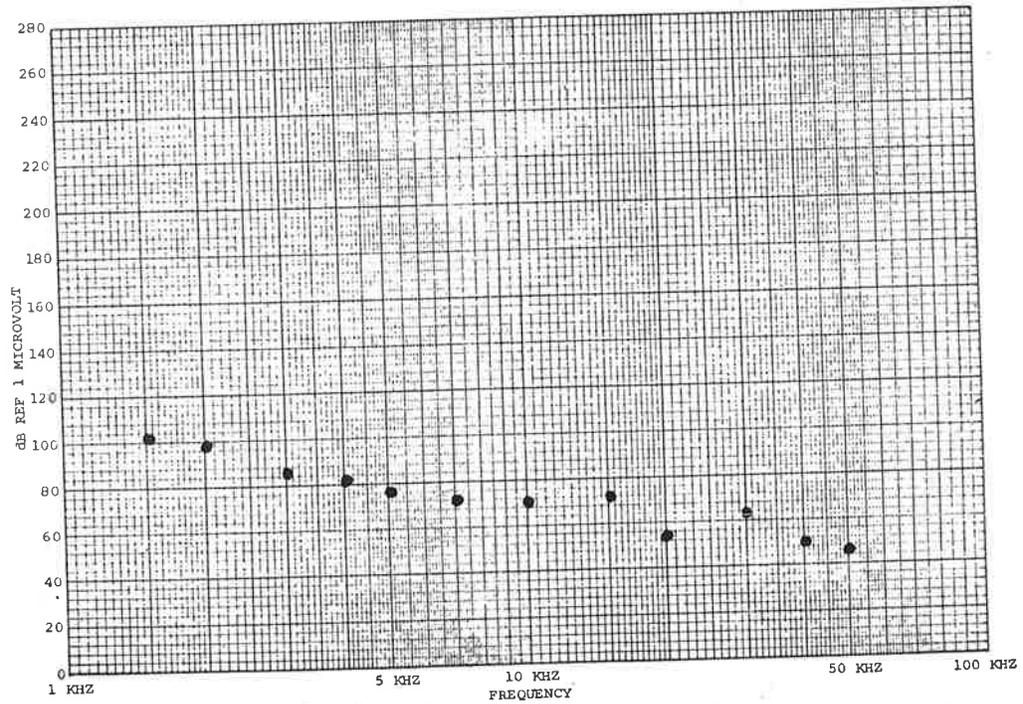
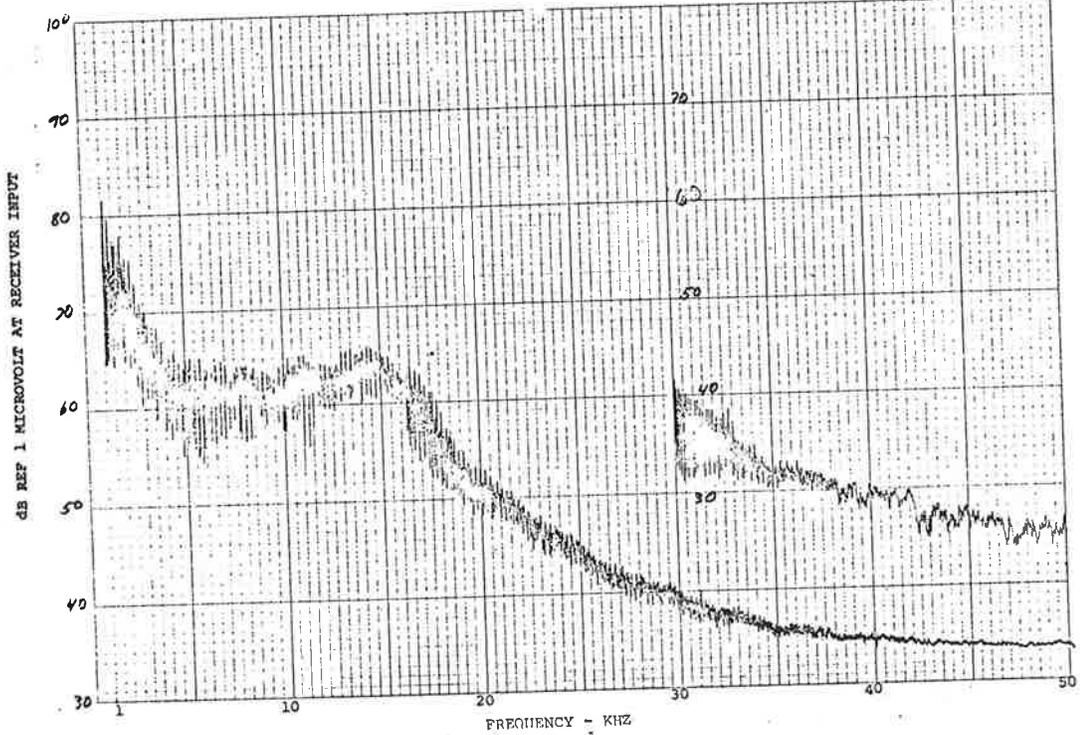
TEST NO. 25 TEST TYPE PLC OA BANDWIDTH 5Hz
 TEST SPECIMEN MONOCAB TEST EQUIP. ERC-10 DATE 28 FEB 72



RRR Etn

TEST NO. 32 TEST TYPE PLC φA BANDWIDTH 50Hz
 TEST SPECIMEN CONDOSAB TEST EQUIP. ENG-10 DATE 28 FEB 72

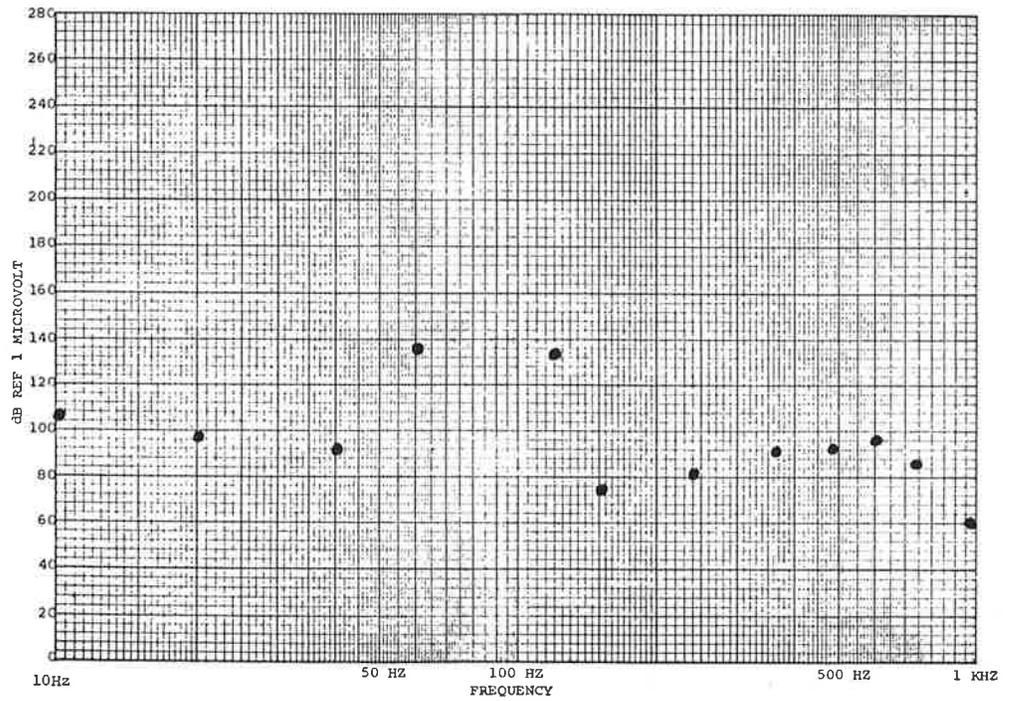
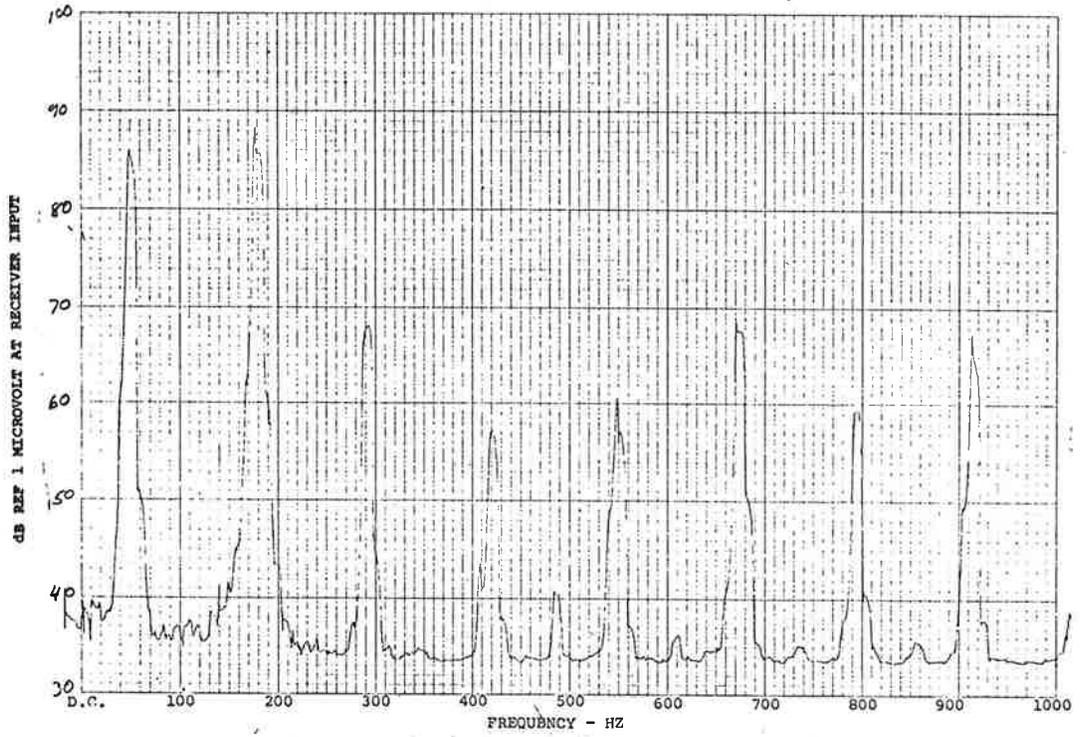
NOTE - TO PA 2 2510 Pwr. Supply ON DURING ALL PLC TESTS



A-3

RBR cuh

TEST NO. 26 TEST TYPE PLC FB BANDWIDTH 5 Hz
 TEST SPECIMEN NONBLAB TEST EQUIP. RNC-10 DATE 28 FEB 72



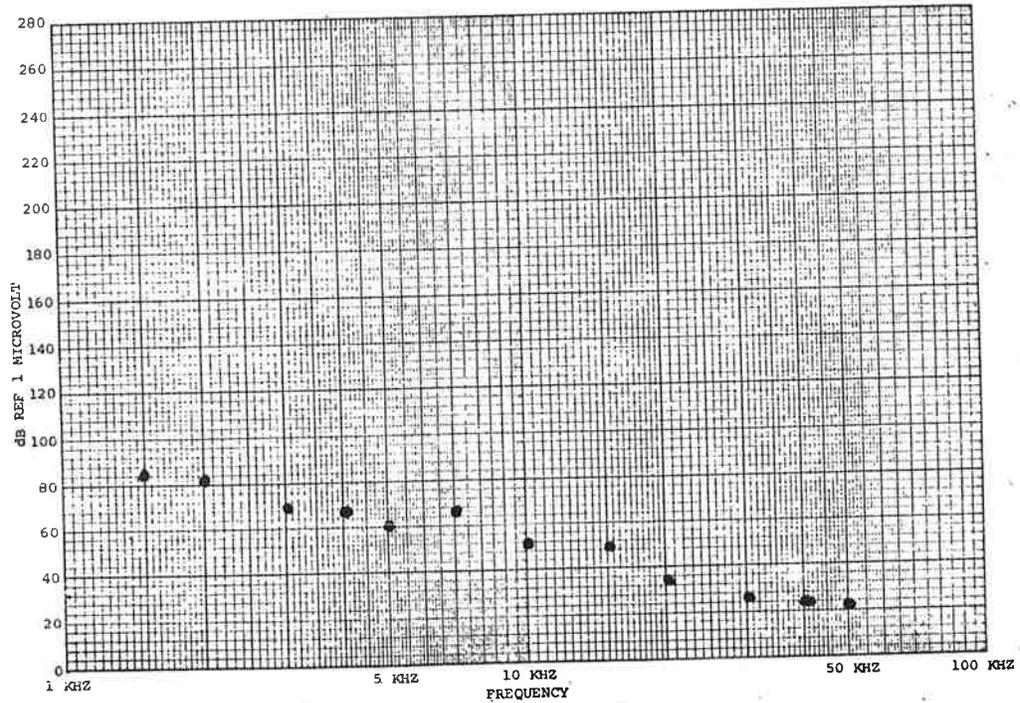
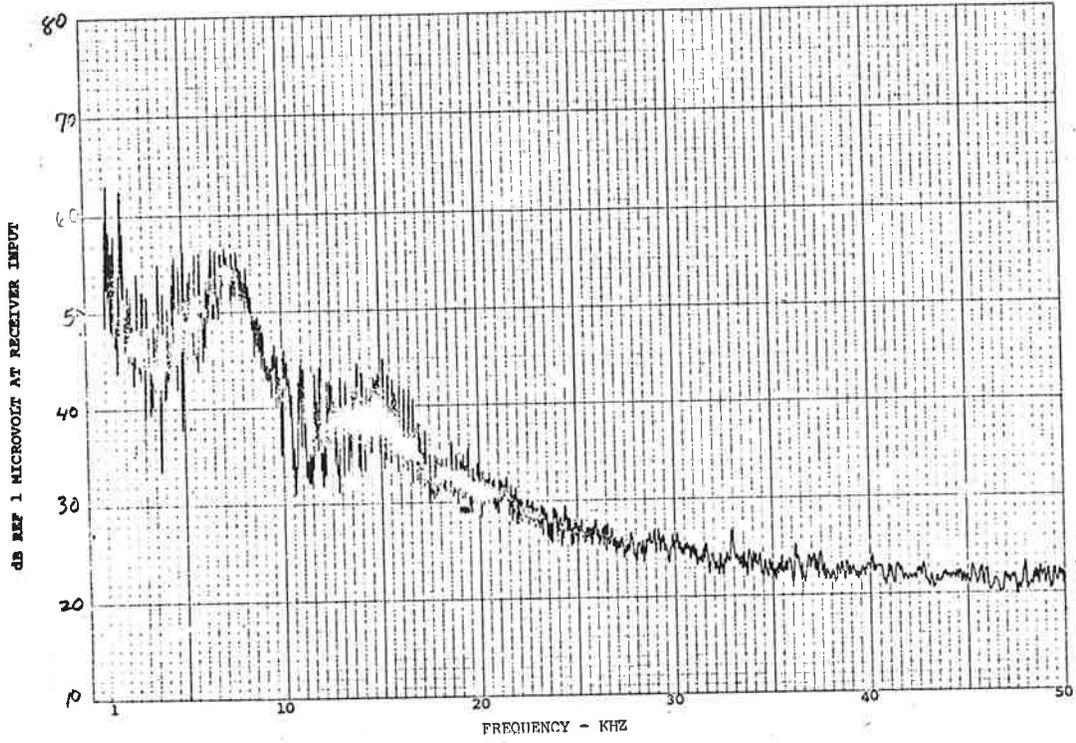
A-4

ROR EVZ

TEST NO. 31
TEST SPECIMEN 120406A

TEST TYPE PLC DB
TEST EQUIP. EMC-10

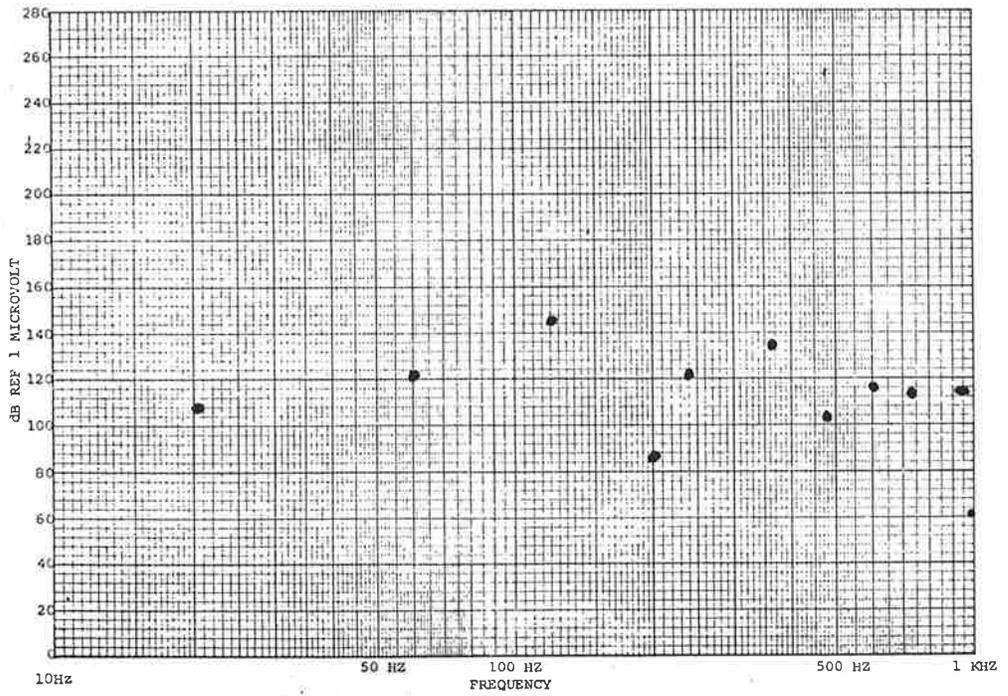
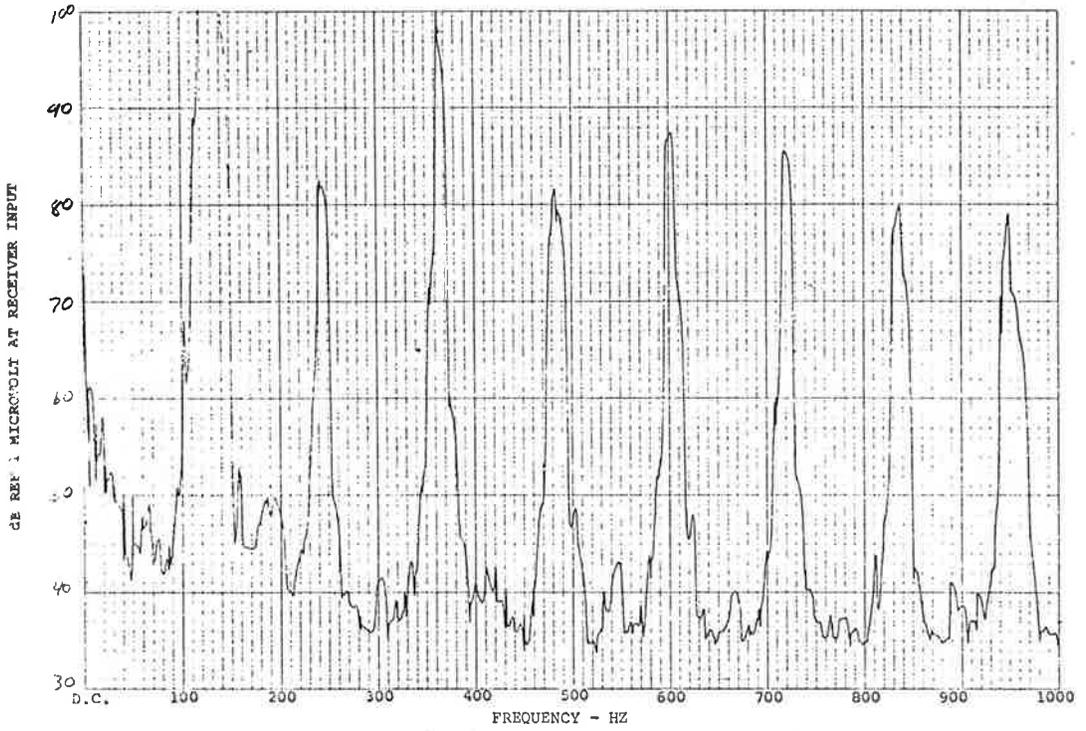
BANDWIDTH 50 Hz
DATE 28 Feb 72



A-5

RBR 002

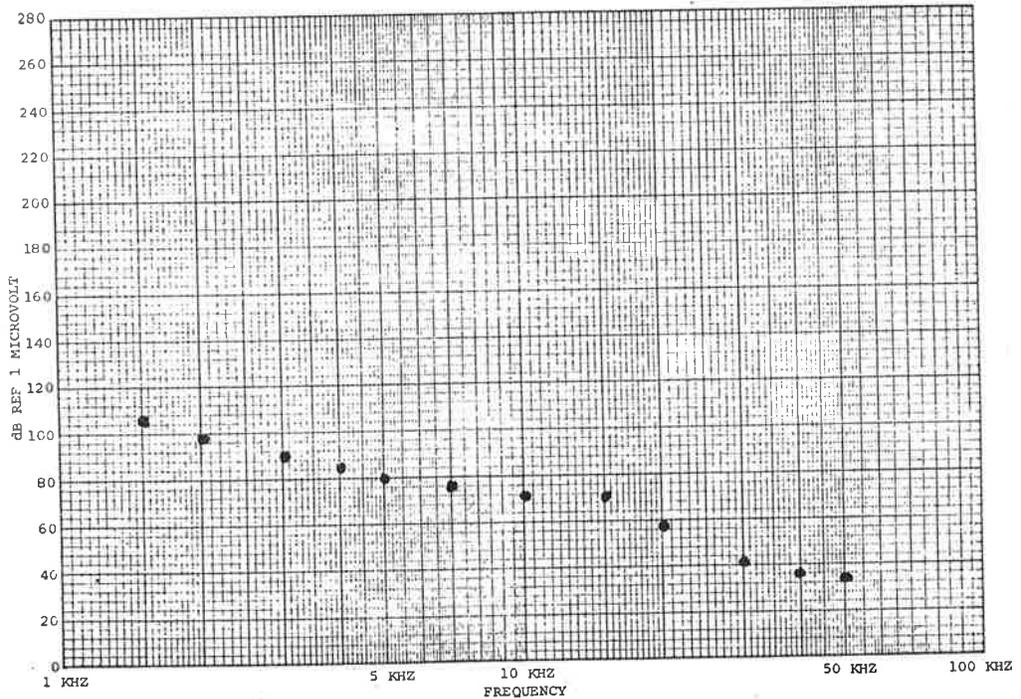
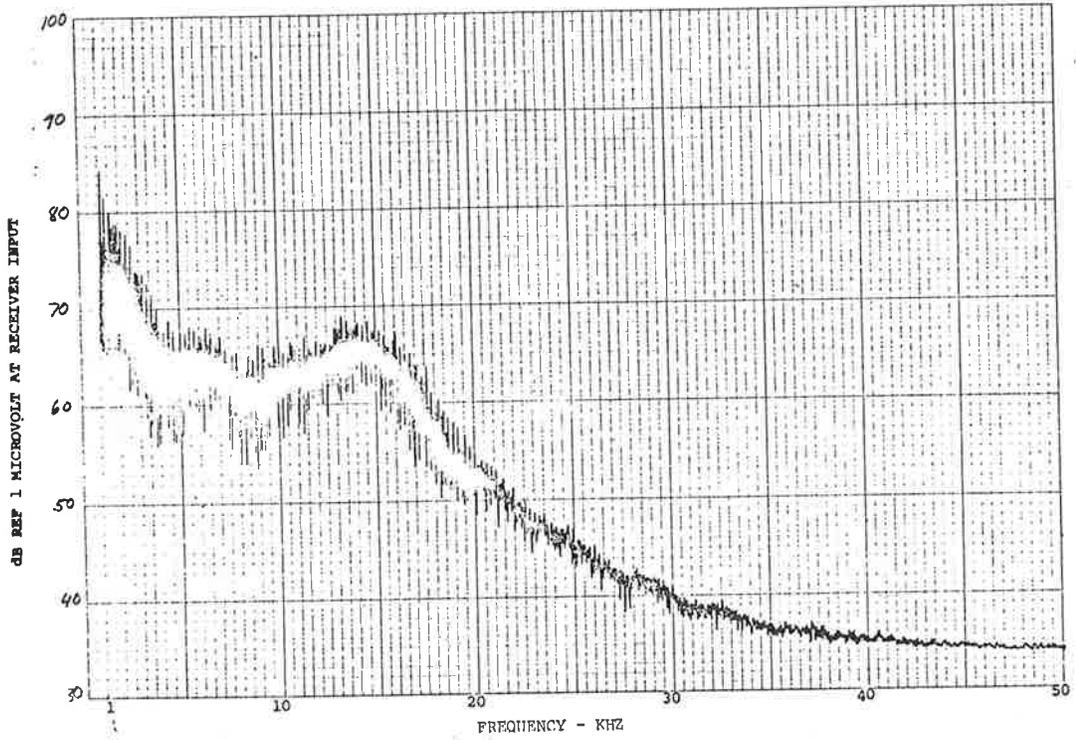
TEST NO. 27 TEST TYPE PLC DC BANDWIDTH 5HZ
 TEST SPECIMEN 13ND2AR TEST EQUIP. GTC-10 DATE 28 FEB 72



A-6

RBR 202

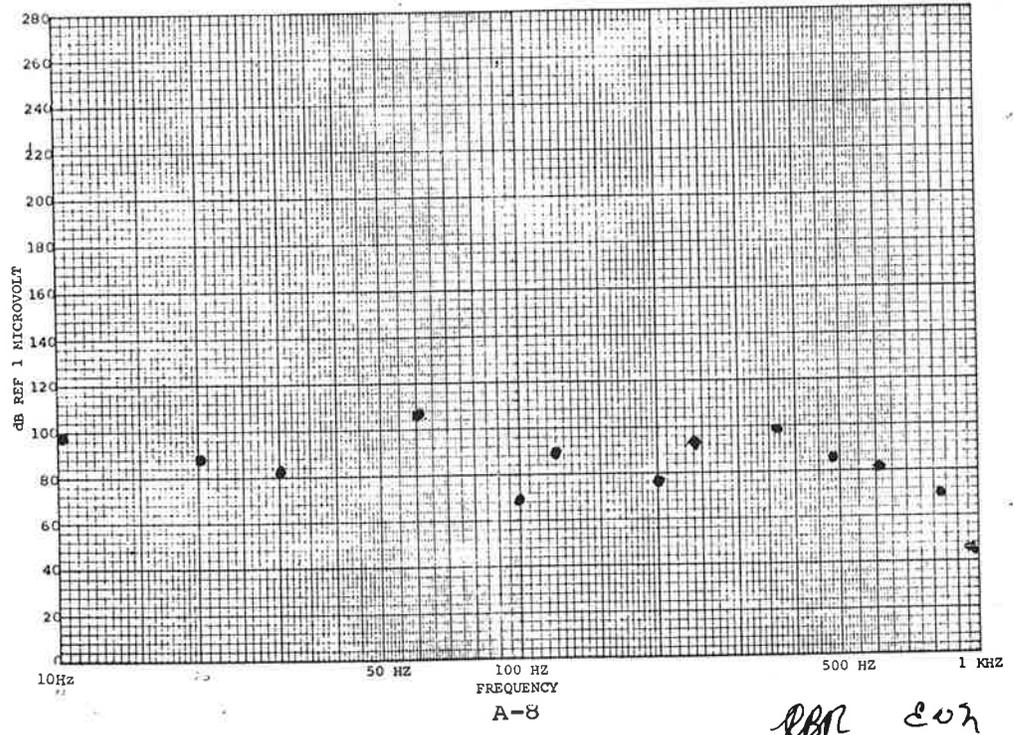
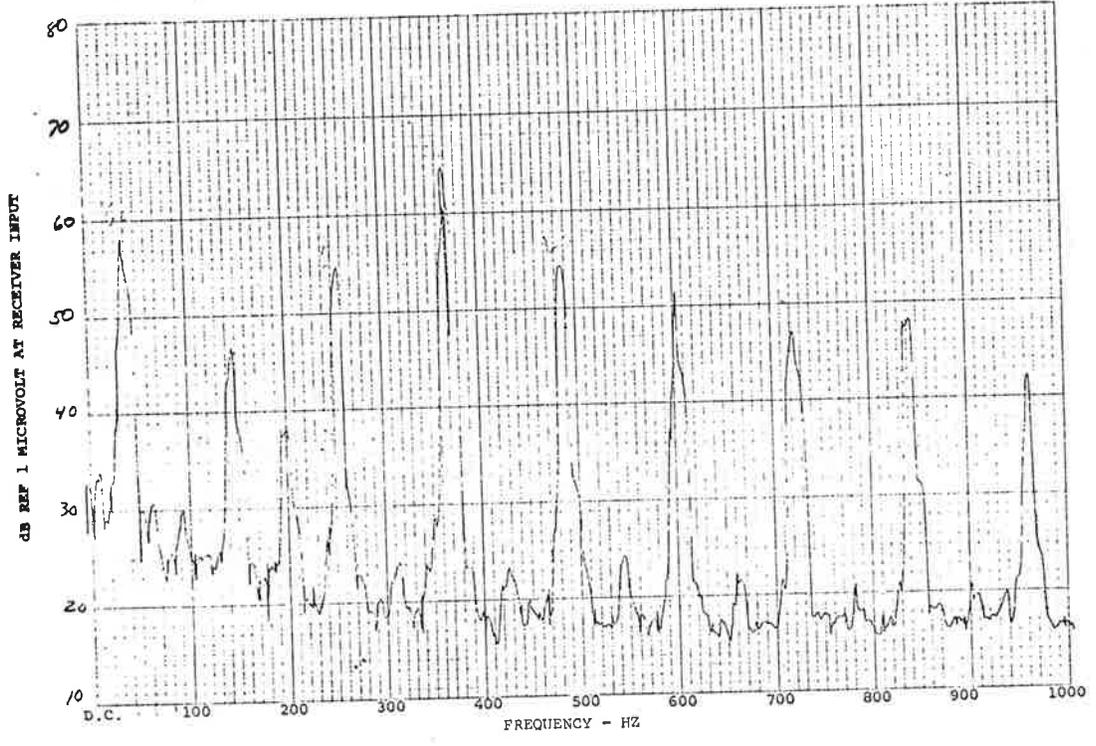
TEST NO. 30 TEST TYPE PLC DC BANDWIDTH 50 Hz
 TEST SPECIMEN HONGSAA TEST EQUIP. EMC-10 DATE 22 FEB 72



A-7

RRR 202

TEST NO. 28 TEST TYPE AC-NAV BANDWIDTH 5 Hz
 TEST SPECIMEN 170N06AA TEST EQUIP. ENC-10 DATE 20 FEB 73



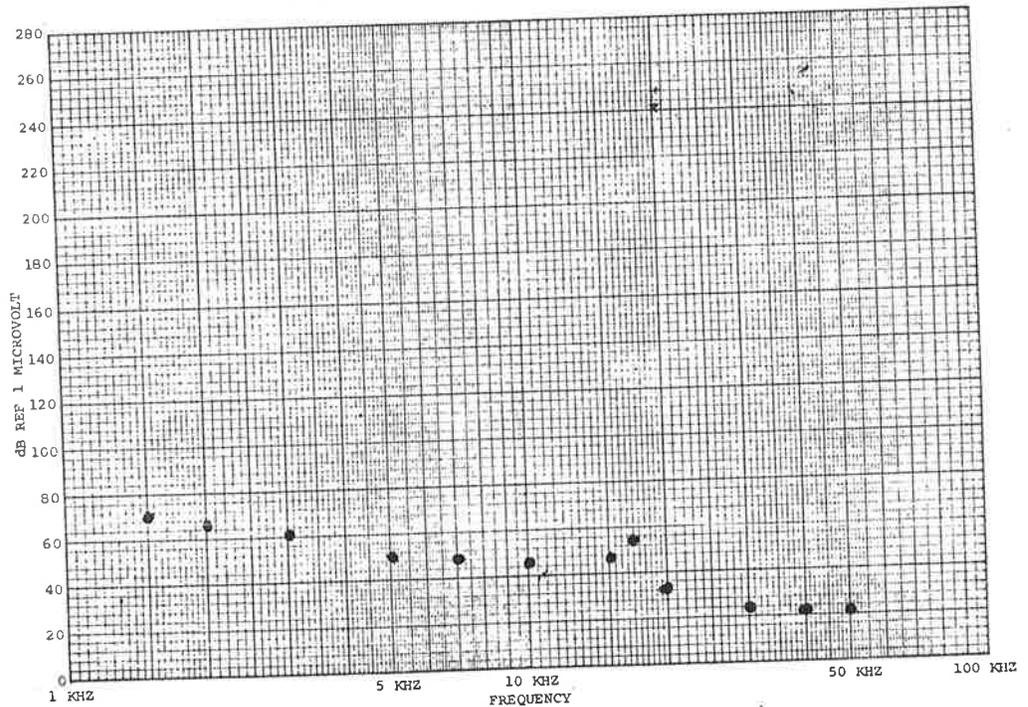
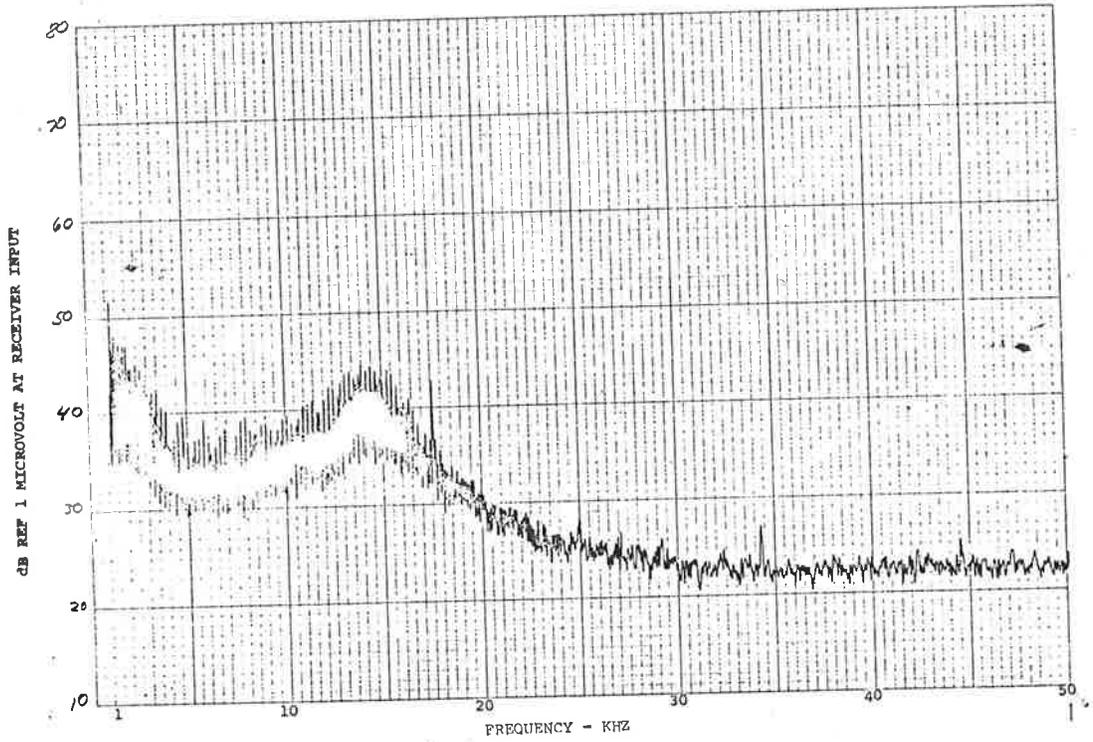
A-8

RBR 207

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TEST SPECIMEN PONDOLAB

TEST TYPE PLC-NEW
TEST EQUIP. ENG-10

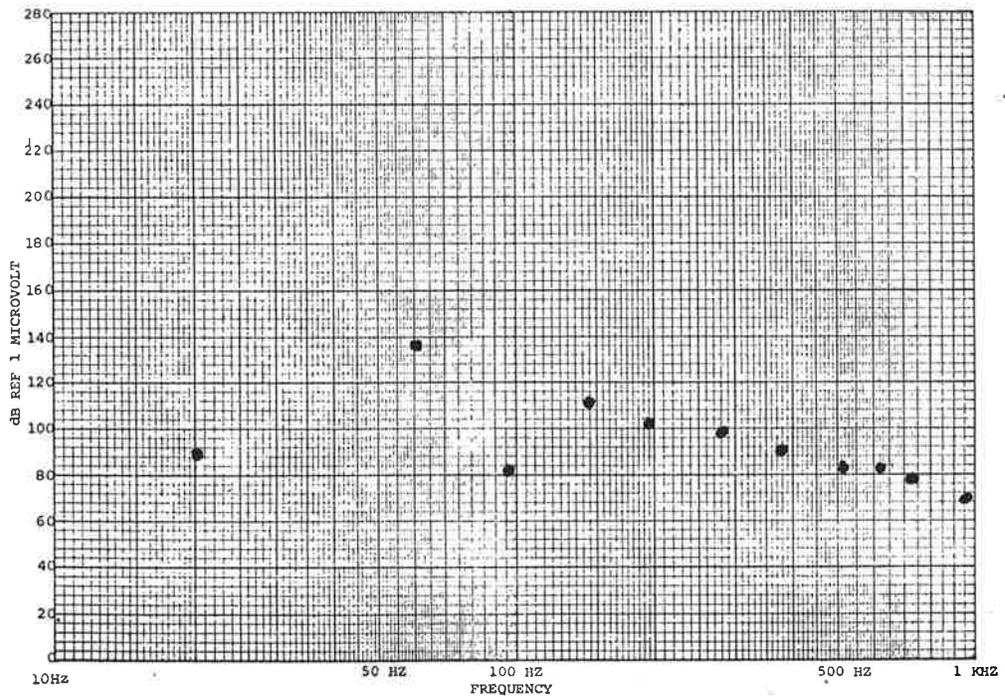
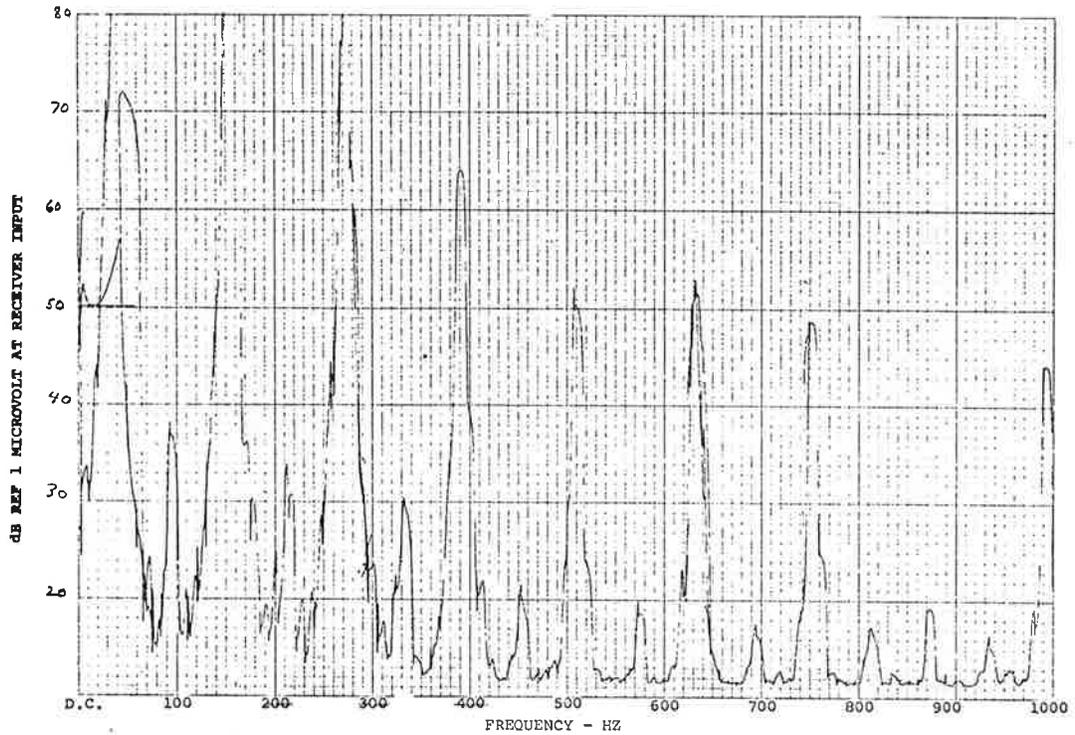
BANDWIDTH 50 Hz
DATE 28 FEB 72



A-9

RBR 202

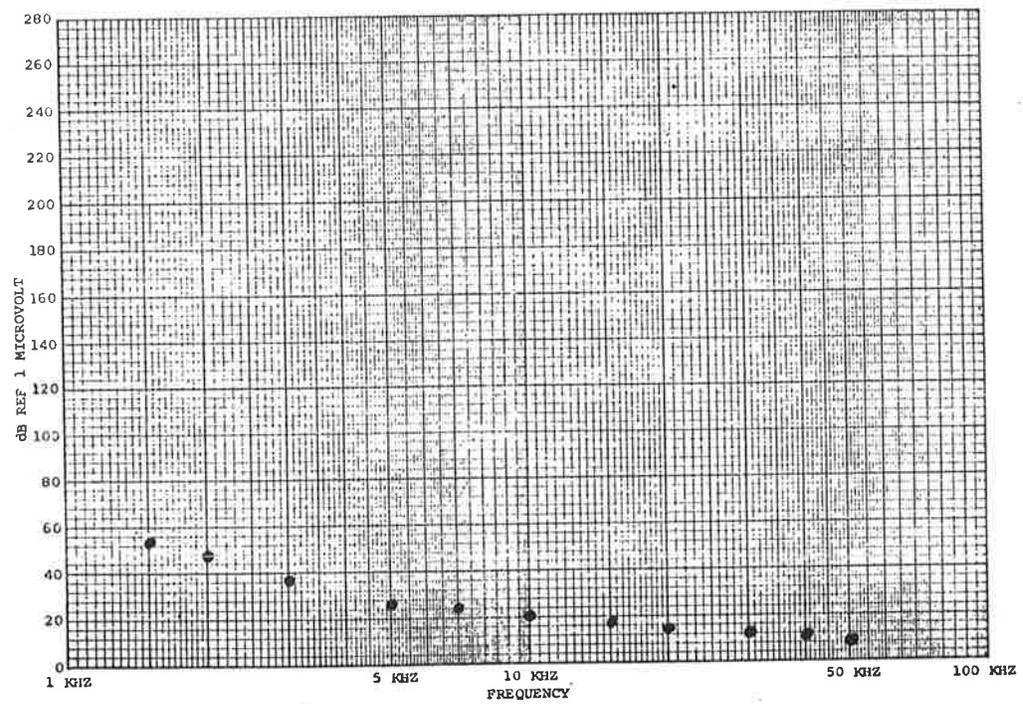
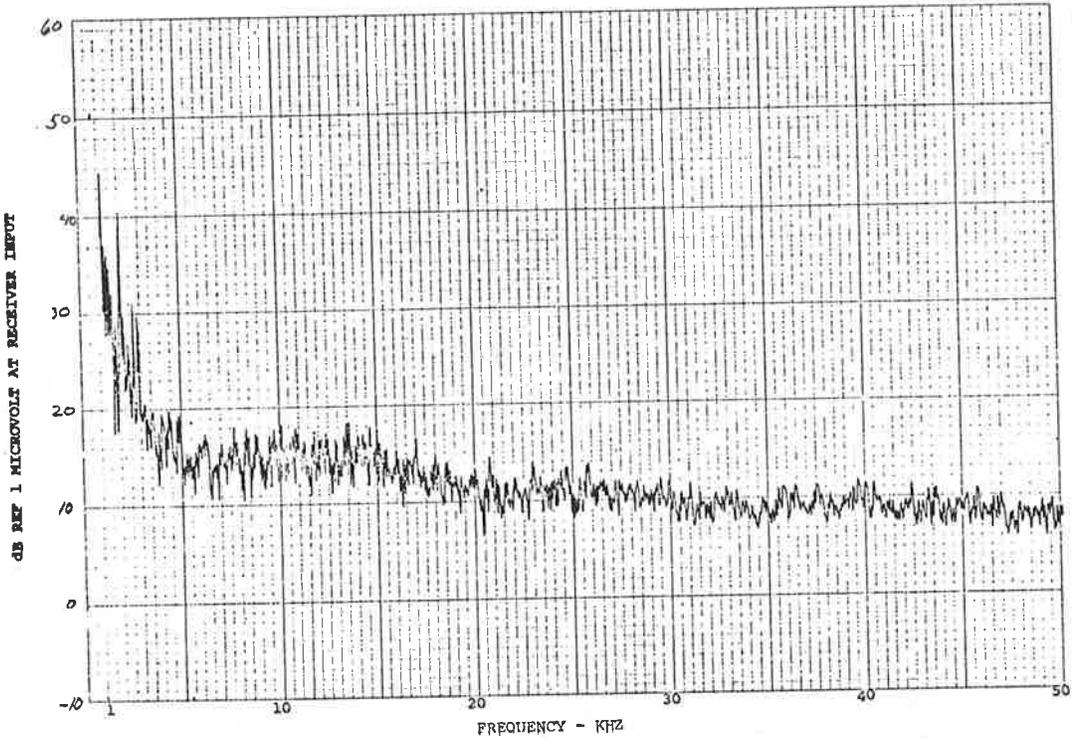
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A-10

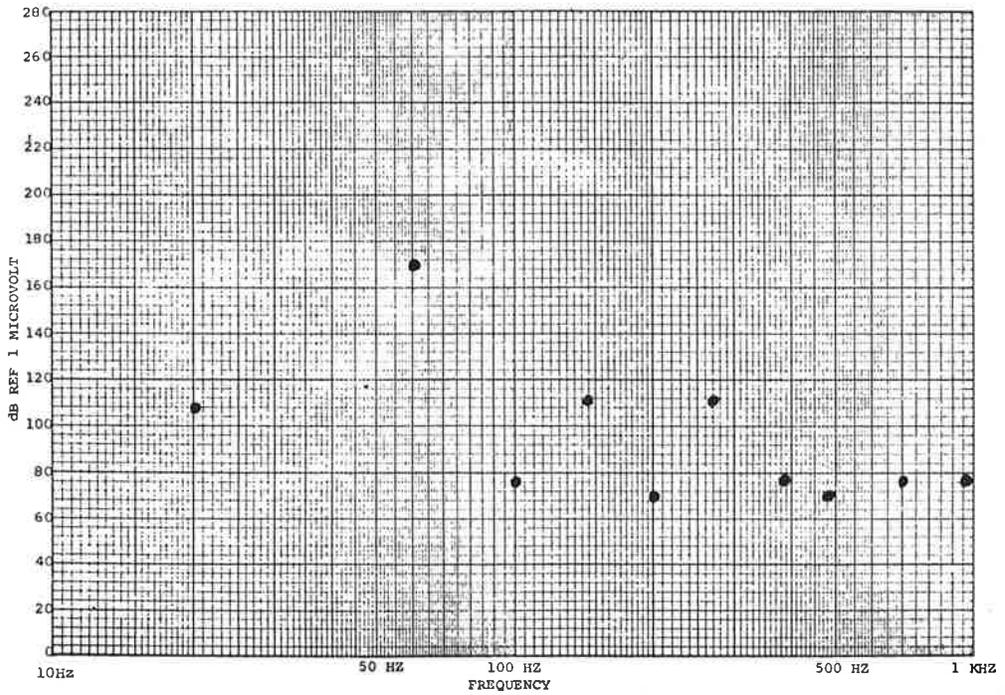
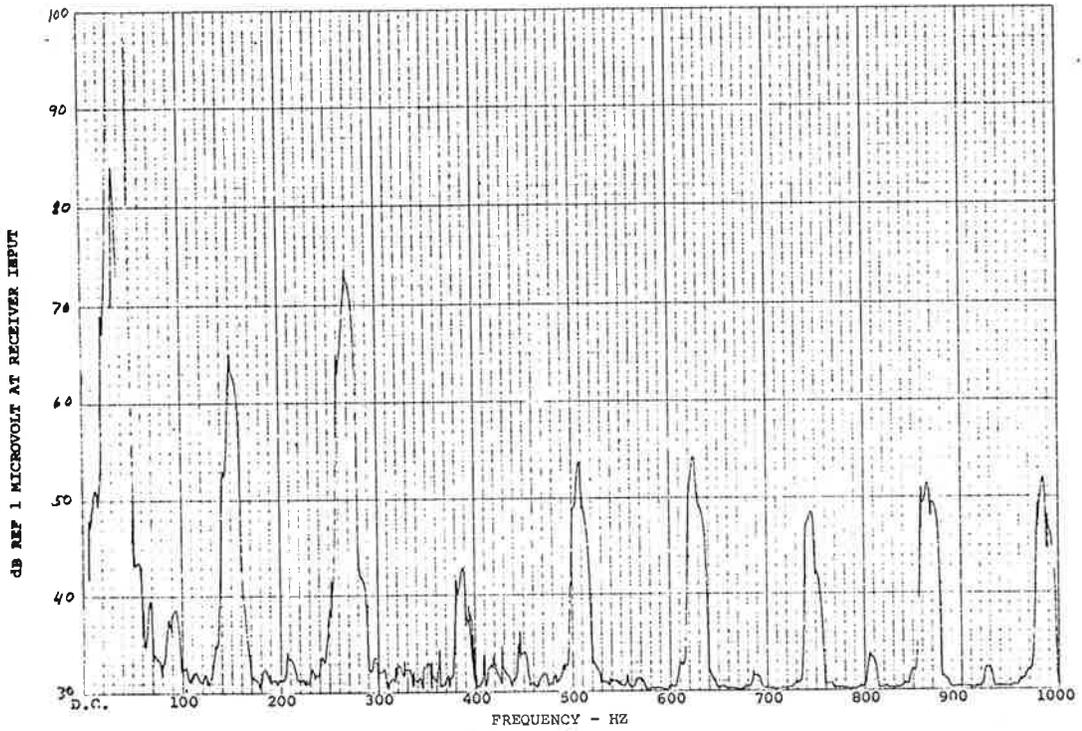
RAR *COH*

TEST NO. 6 TEST TYPE PLC & A LINE 4 BANDWIDTH 50 Hz
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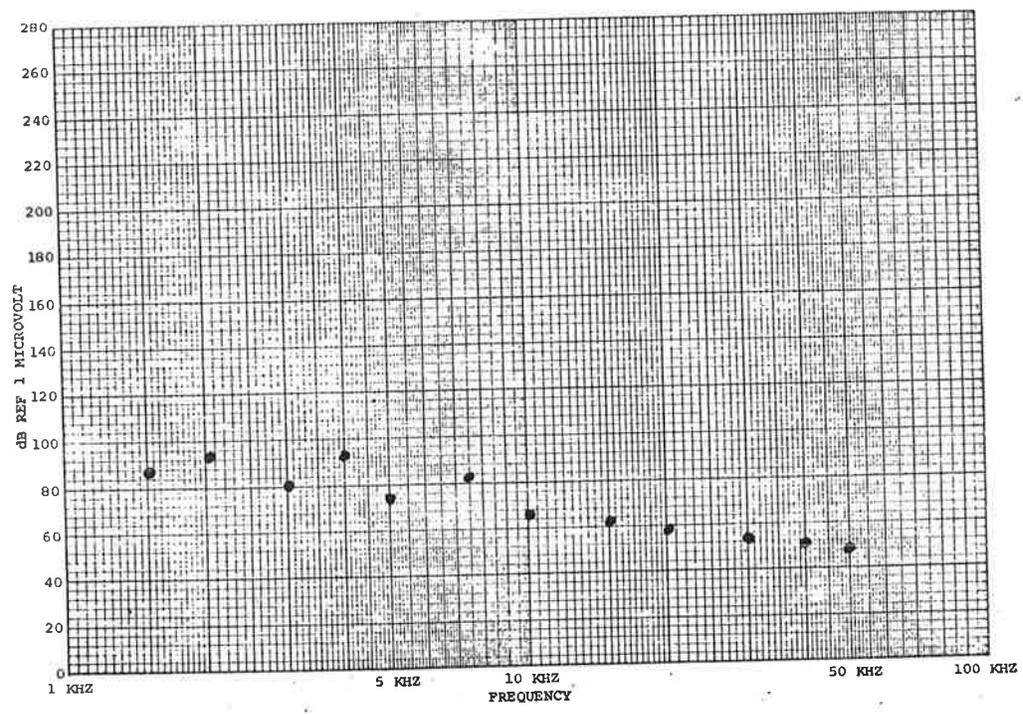
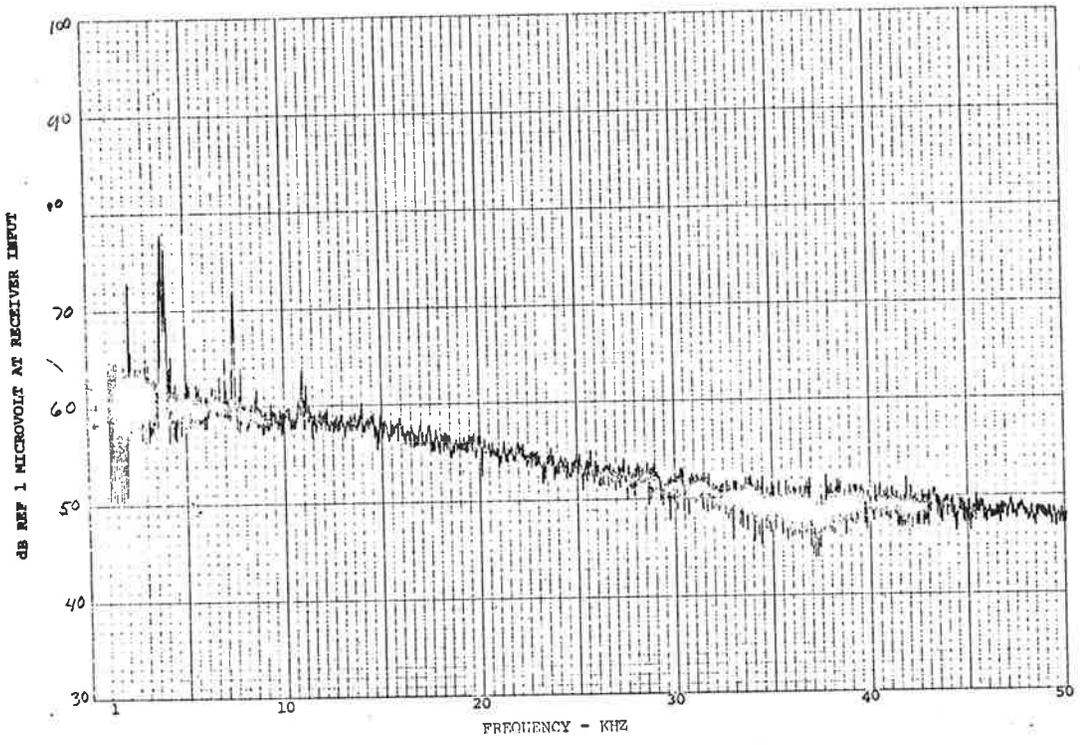


RRR 802

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 TEST SPECIMEN 02545402 TEST EQUIP. ENC-10 DATE 25 Feb 72
 120

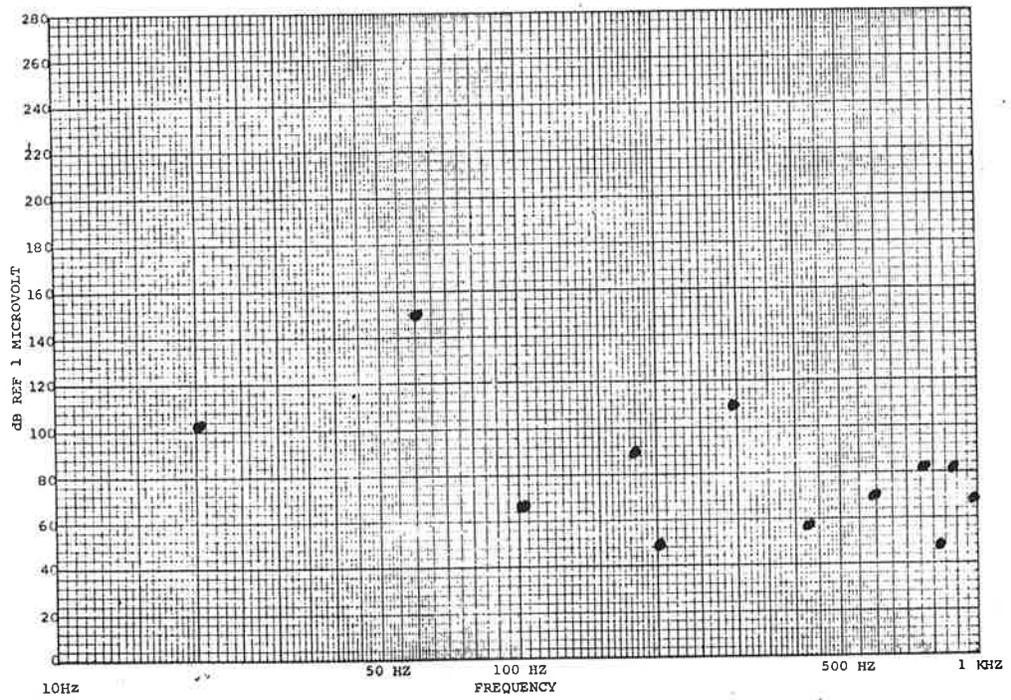
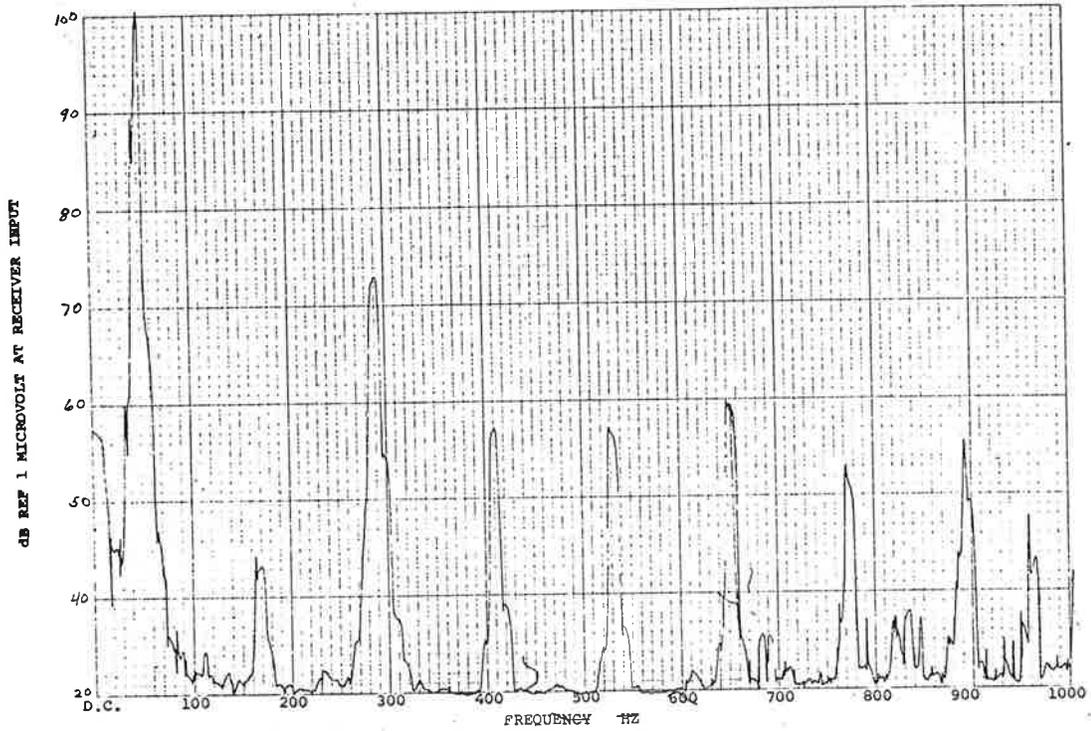


TEST NO. 8 TEST TYPE PLC OF LINE 3 BANDWIDTH 50 Hz
 TEST SPECIMEN DAING VAYOR TEST EQUIP. ETL-10 DATE 25 FEB 72

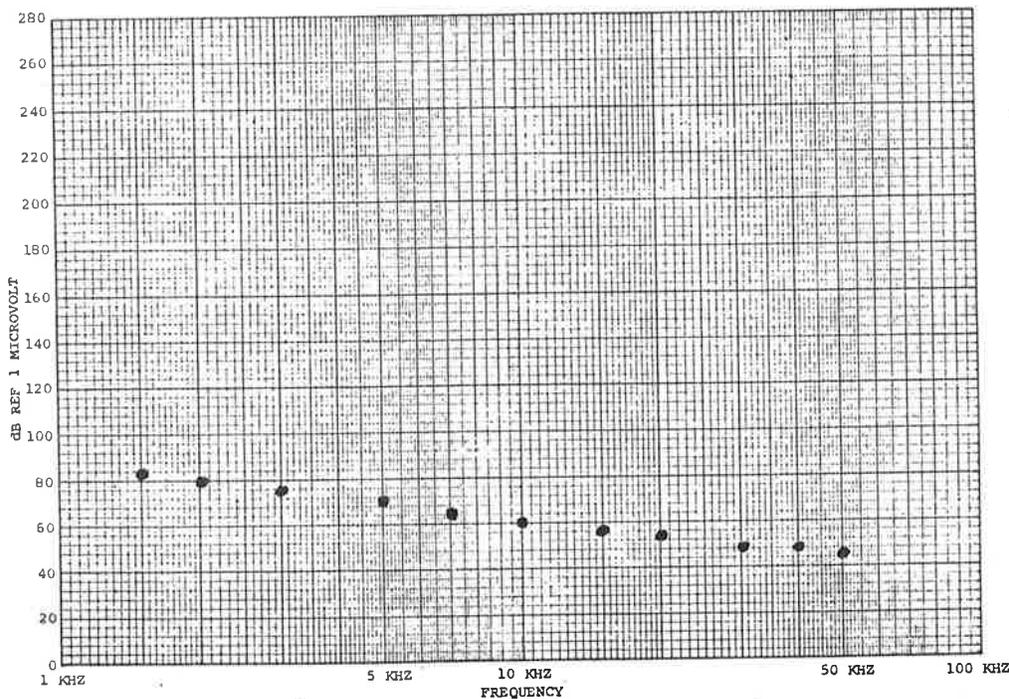
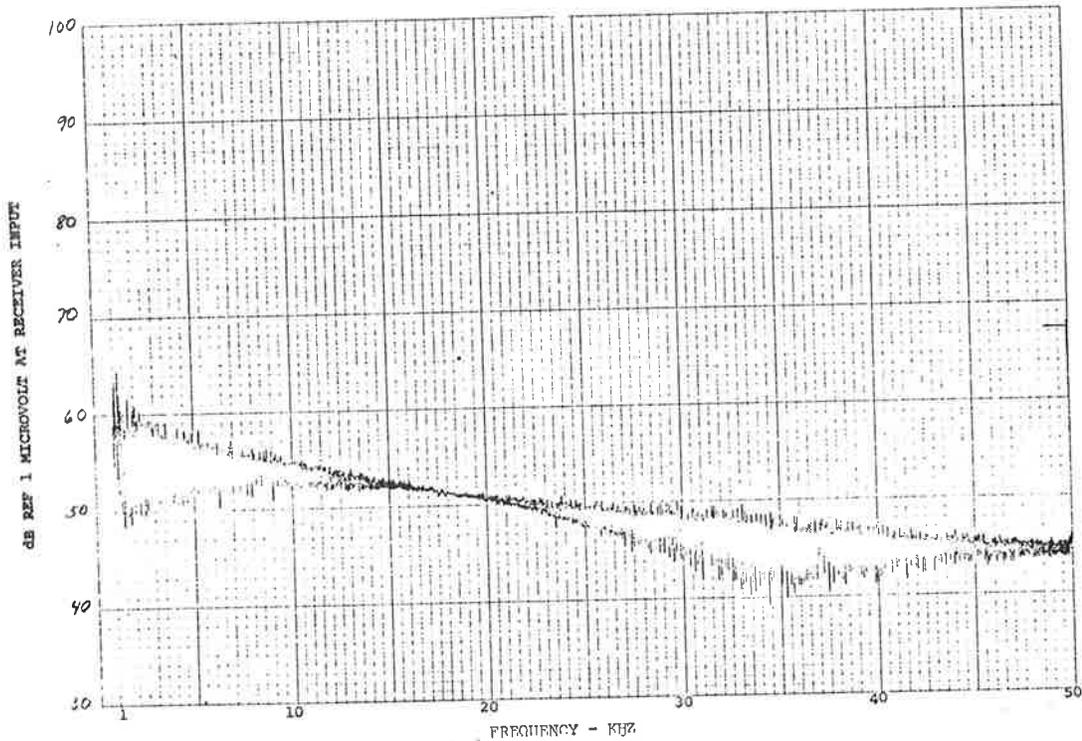


RR COZ

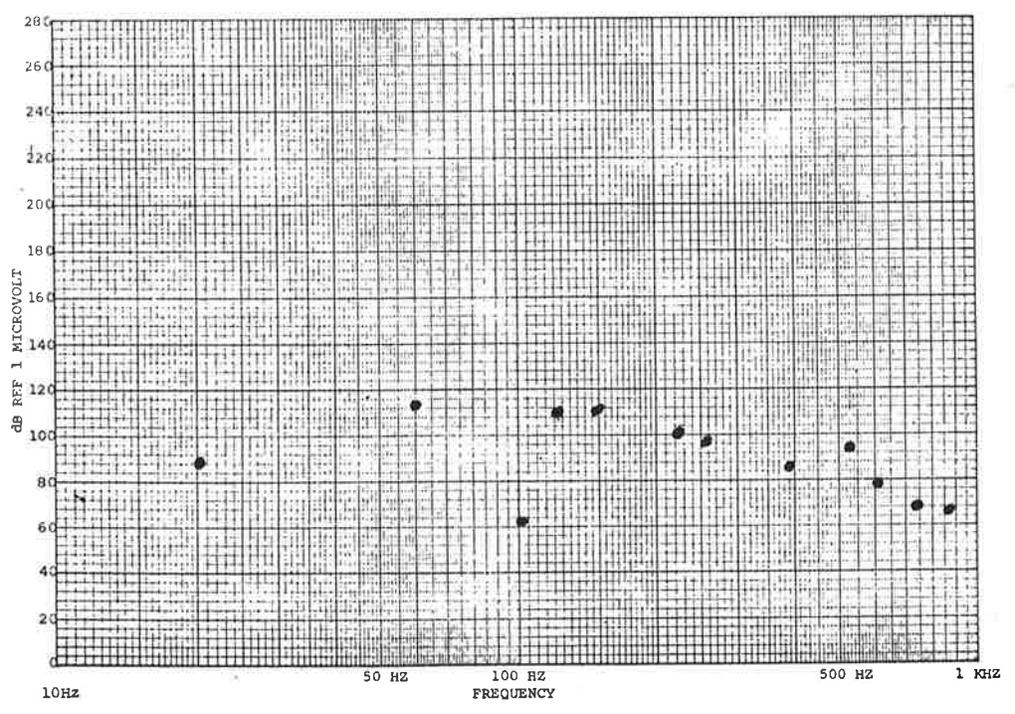
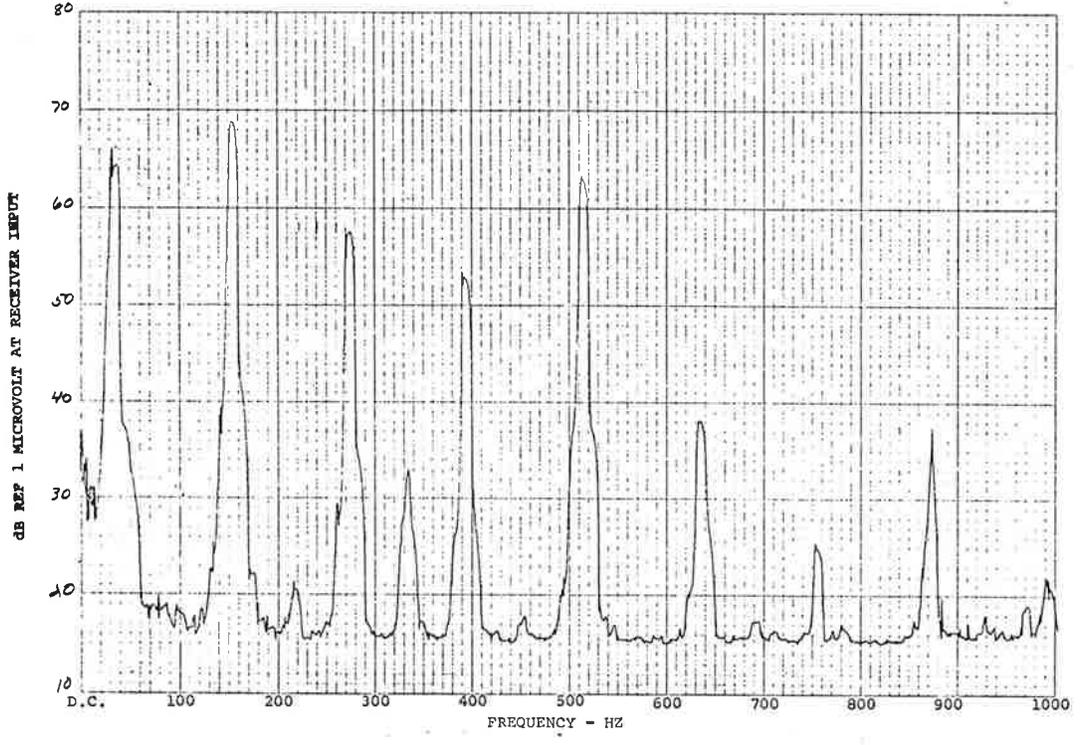
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 TEST SPECIMEN CATHENOXOR TEST EQUIP. EM-10 DATE 25 FEB 77



TEST NO. 7 TEST TYPE Acoustic Loss BANDWIDTH 5000
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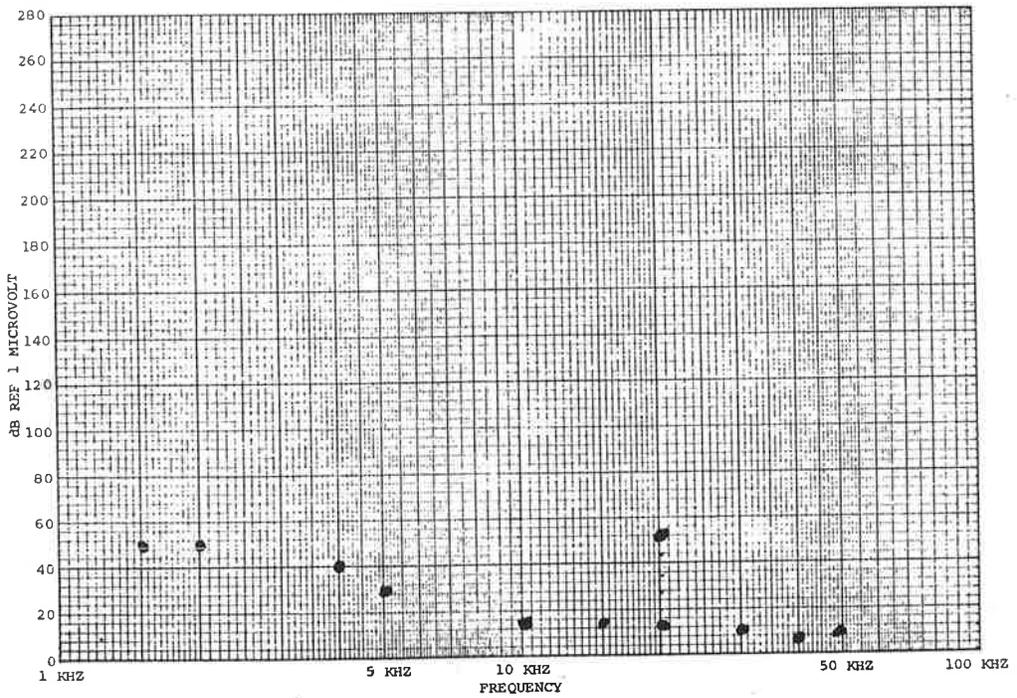
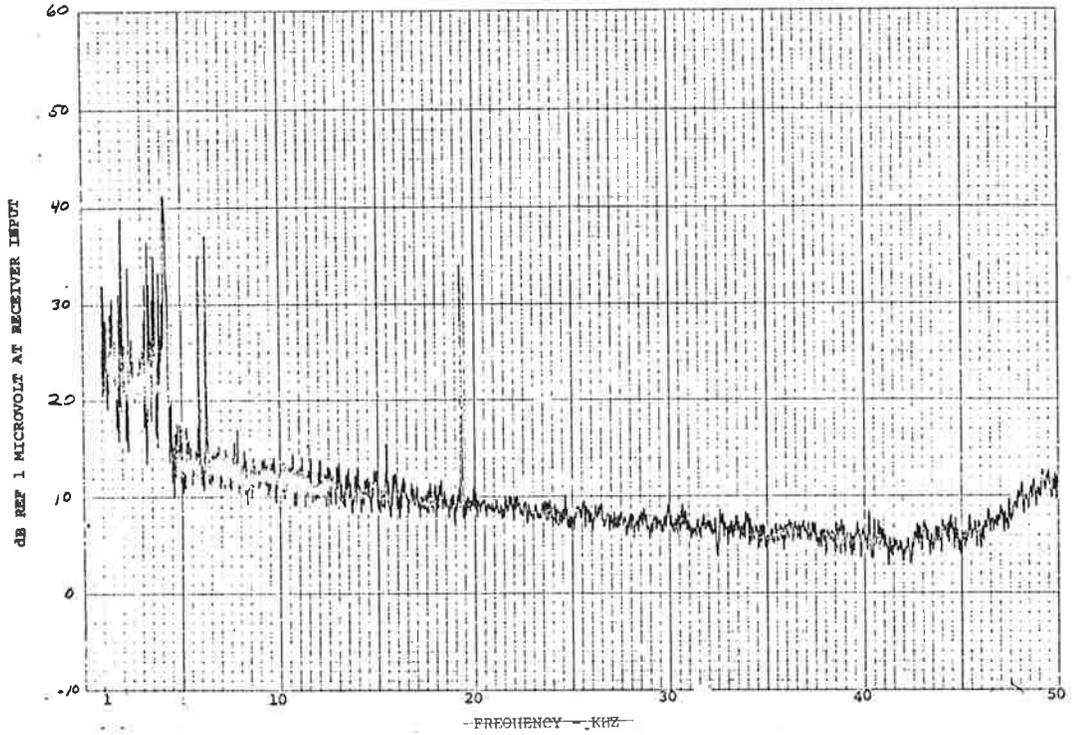


TEST NO. 4 TEST TYPE PLC No. 1/1/52 BANDWIDTH 5Hz
 TEST SPECIMEN DATMEVAYOR TEST EQUIP. EMG-10 DATE 25 FEB 77



RRR 862

TEST NO. 5 TEST TYPE W/C MEAS. LINE 2 BANDWIDTH 20 Hz
 TEST SPECIMEN WASHEVATOR TEST EQUIP. ENC-10 DATE 25 Feb 73

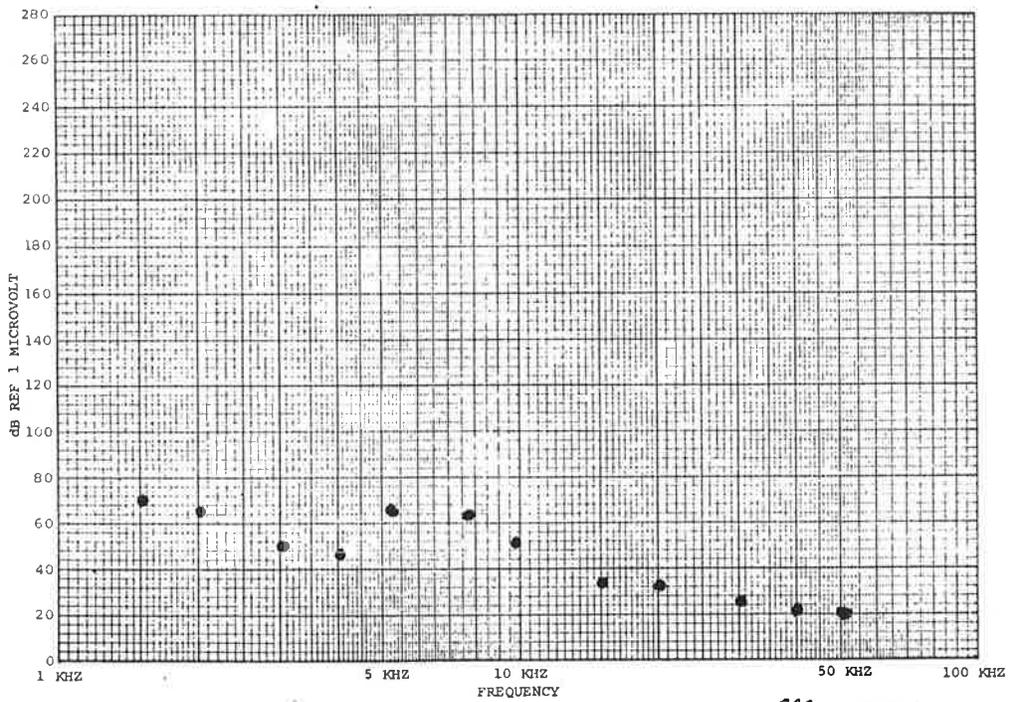
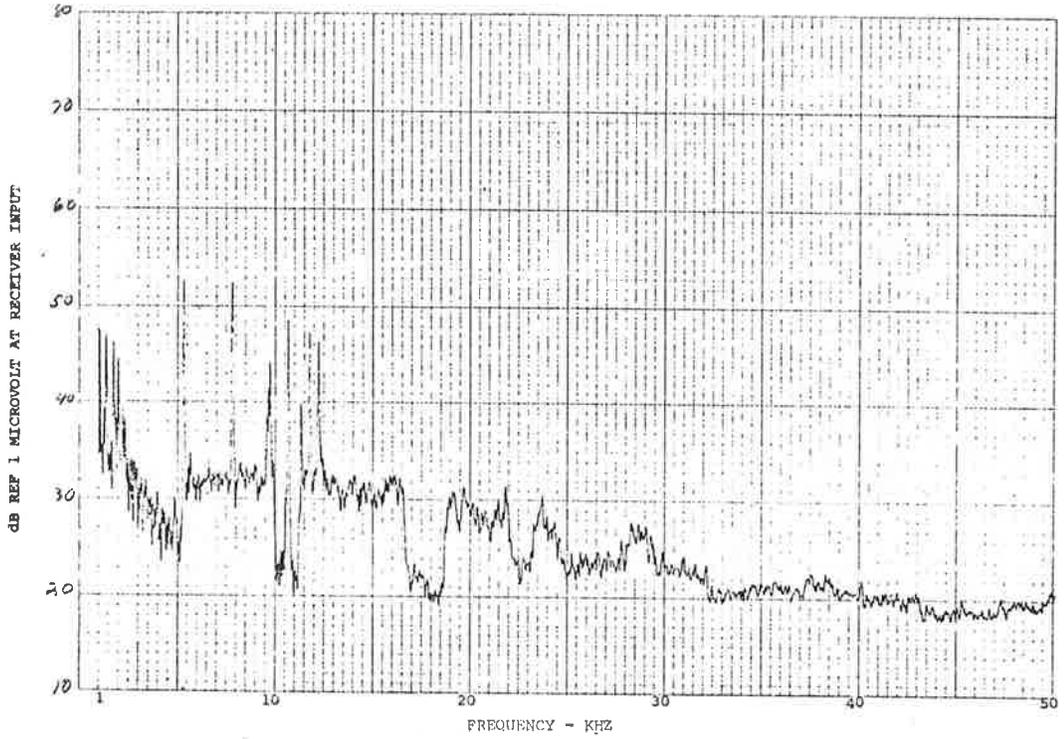


DRR 207

TEST NO. 11
TEST SPECIMEN F2RP

TEST TYPE PII 5A
TEST EQUIP. ENG-10

BANDWIDTH 50 MHz
DATE 25 FEB 72

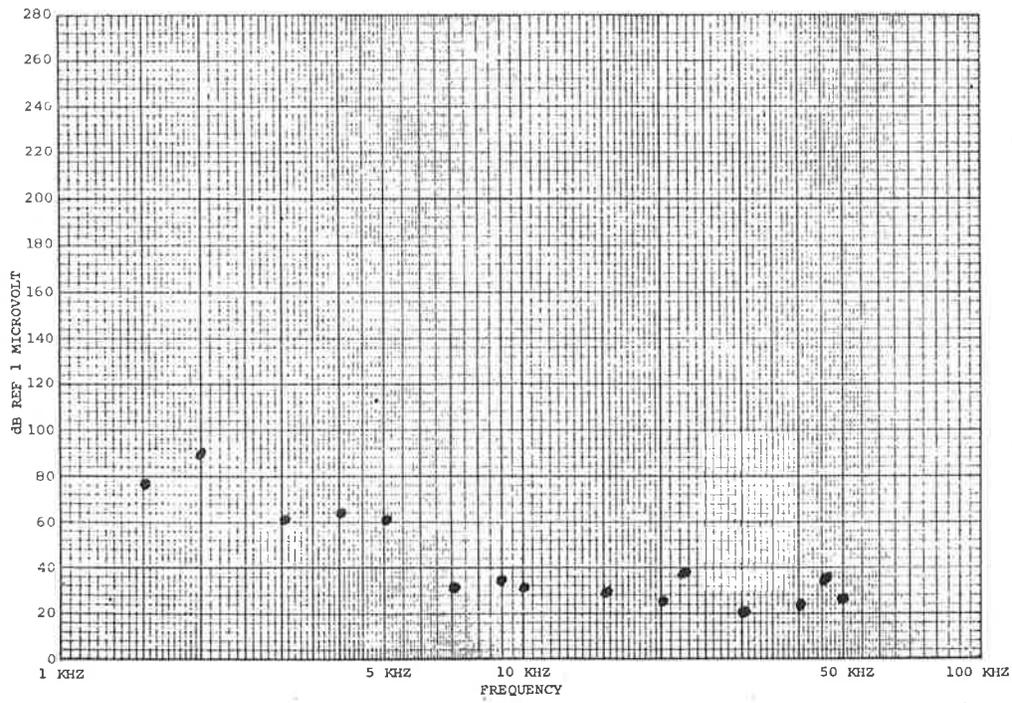
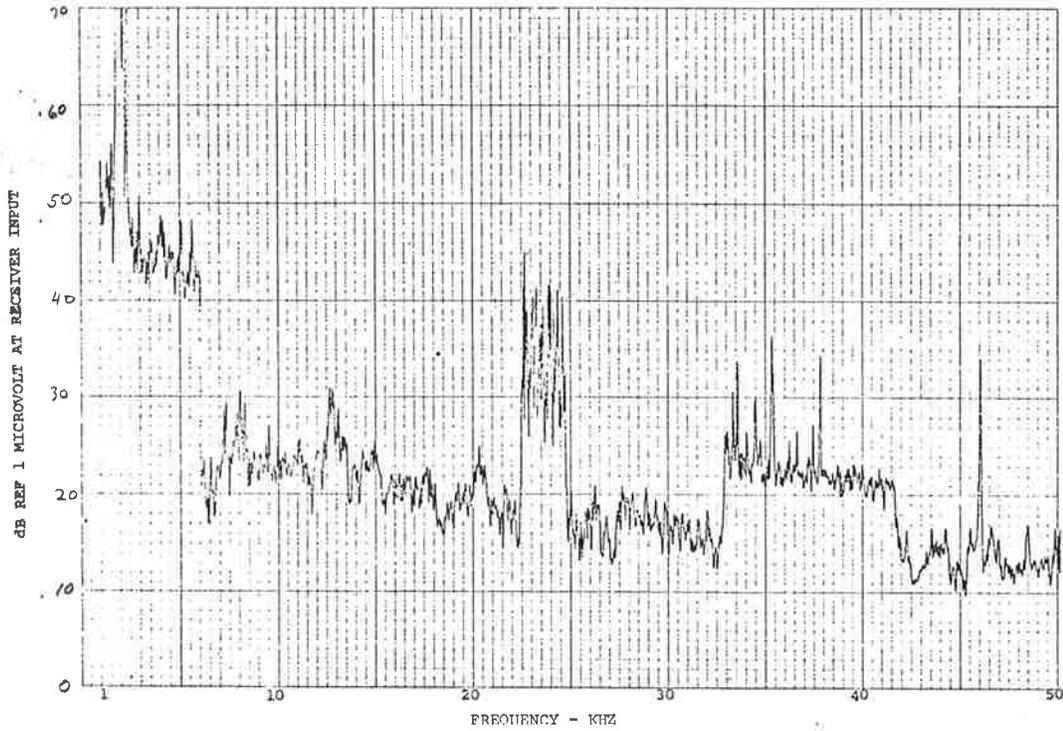


PER CVH

TEST NO.
TEST SPECIMEN 1180

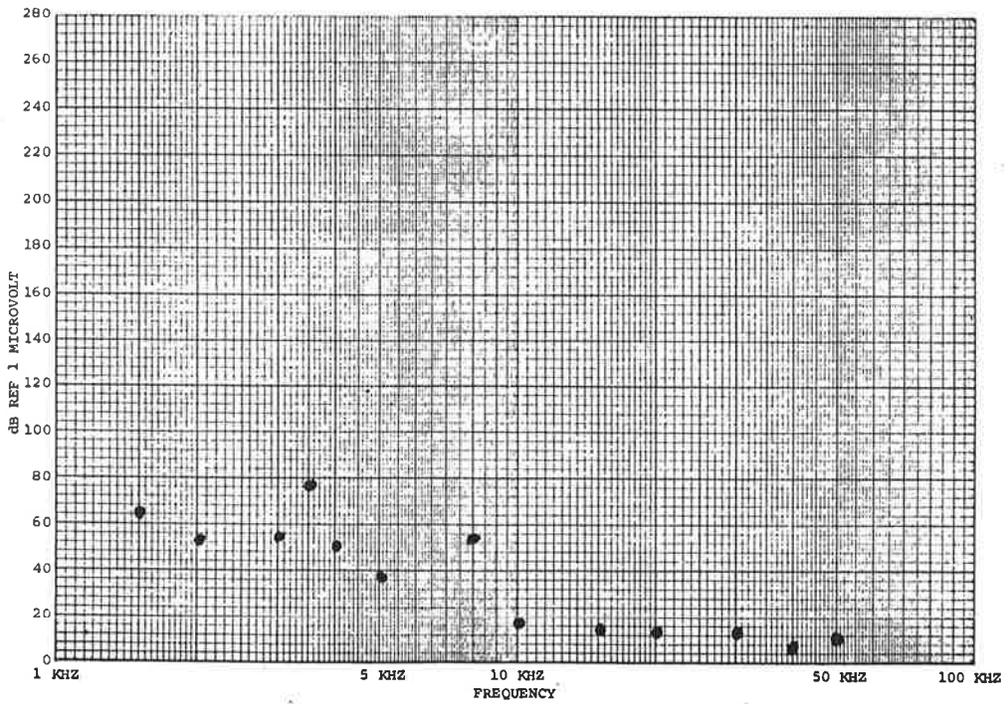
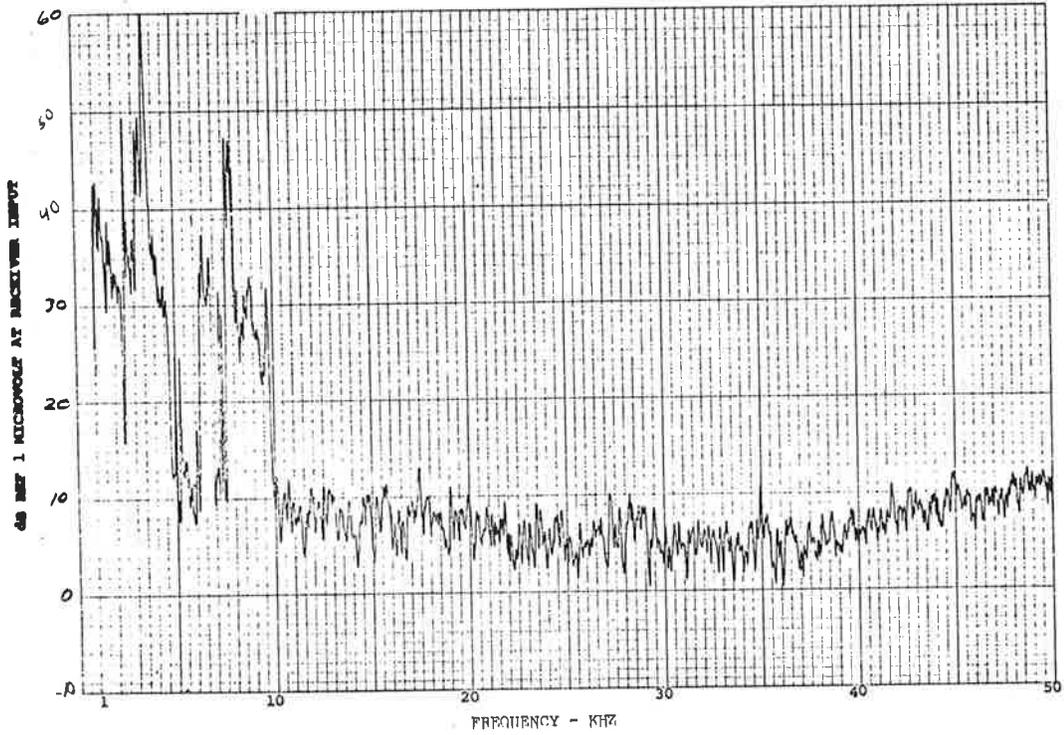
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TEST EQUIP. ETC-10

BANDWIDTH 50 Hz
DATE 25 Feb 72



PRR cuh

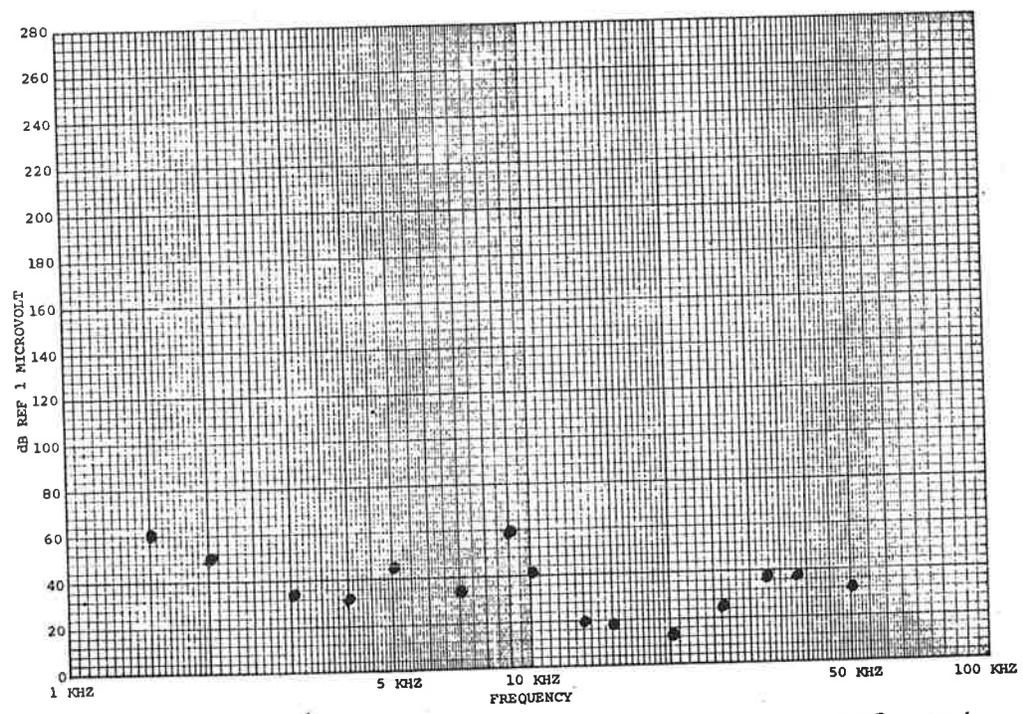
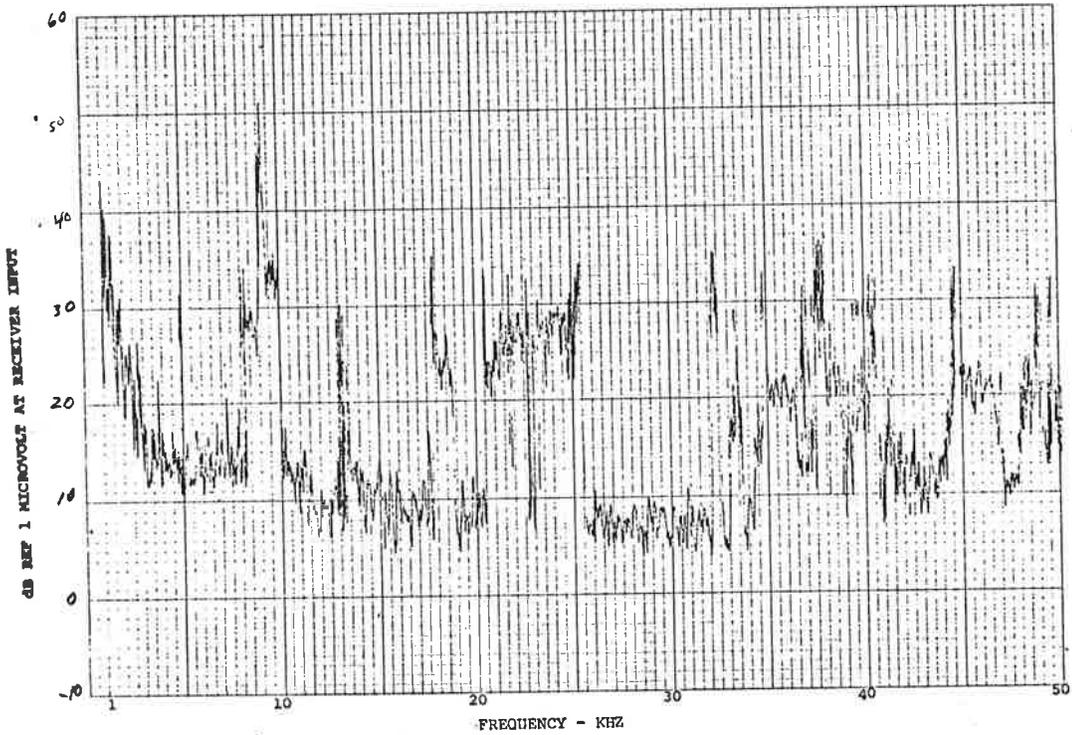
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 TEST SPECIMEN 560 TEST EQUIP. EAC-10 DATE 25 FEB 77



A-20

ROR CVN

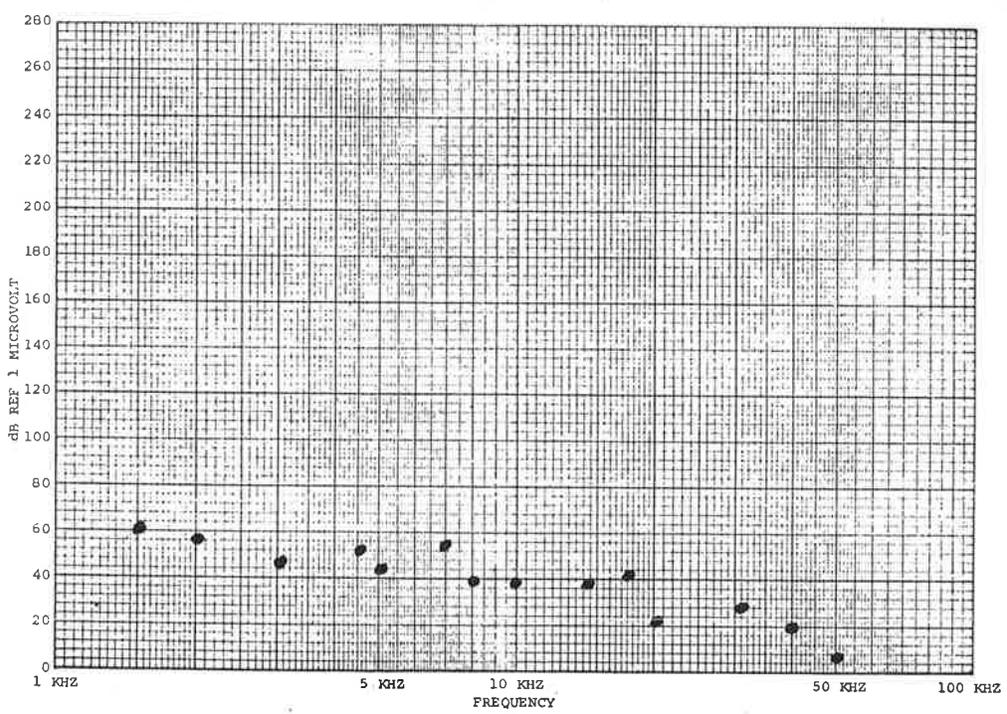
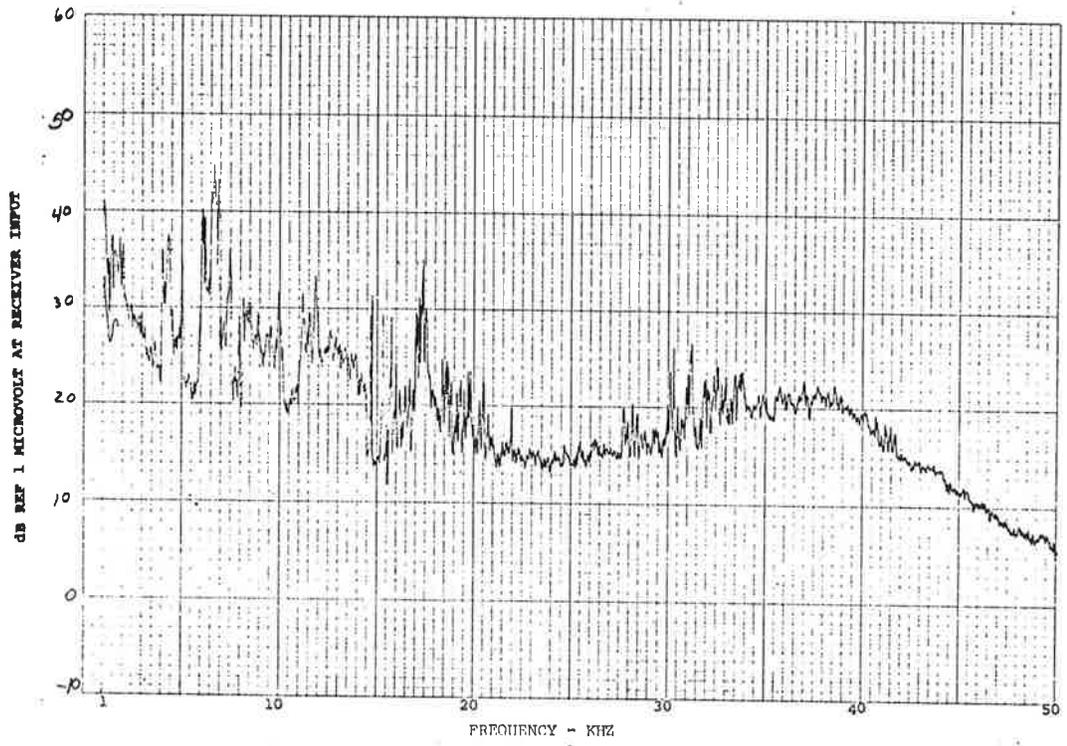
TEST NO. 111 TEST TYPE PLC (P. 1.311) BANDWIDTH 50 Hz
 TEST SPECIMEN FeP TEST EQUIP. KTC-10 DATE 25 FEB 72



A-21

TOR con n

TEST NO. 15 TEST TYPE PLC & C (GRD) BANDWIDTH 50 Hz
 TEST SPECIMEN FOLD TEST EQUIP. 5725-10 DATE 25 FEB 77

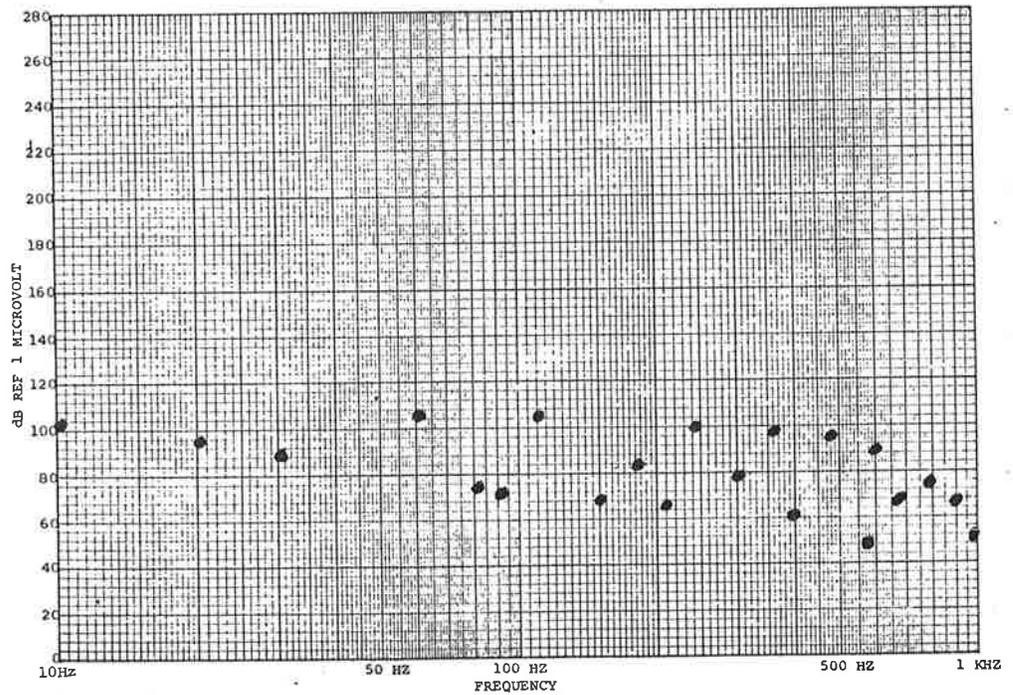
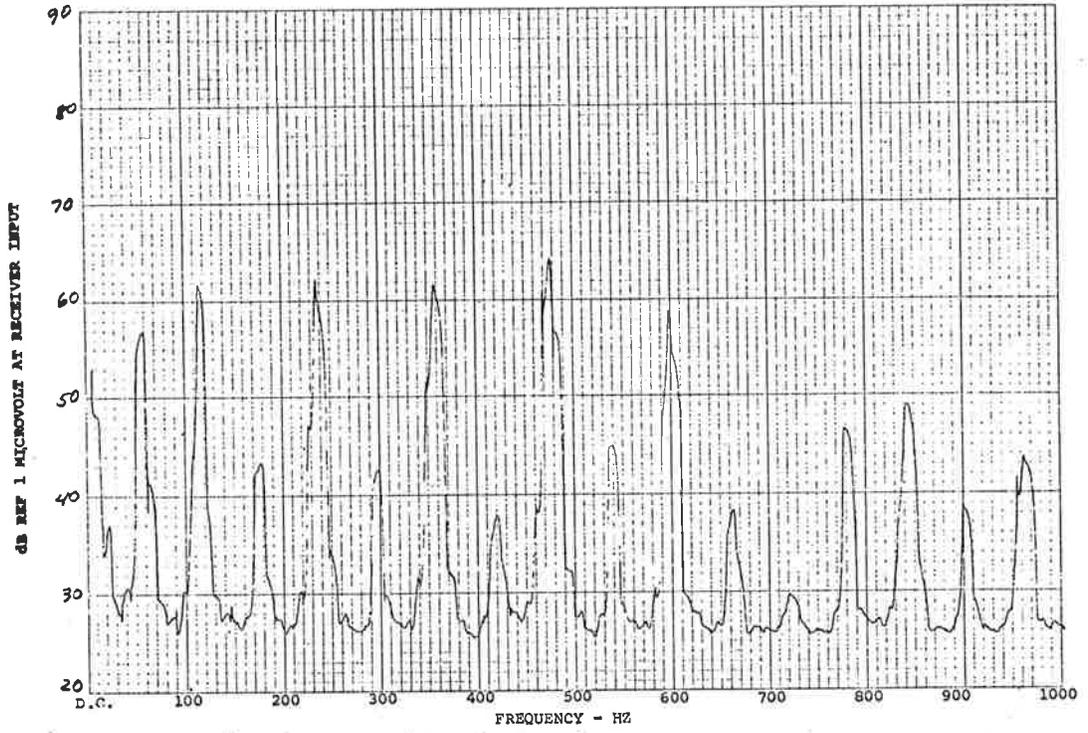


RBR d07

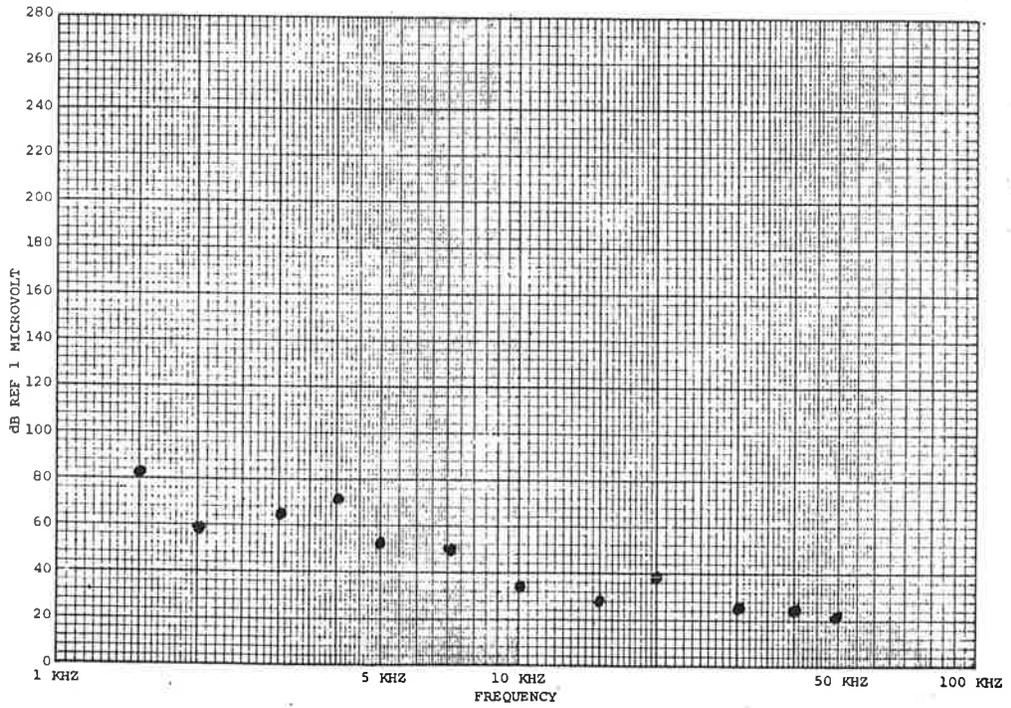
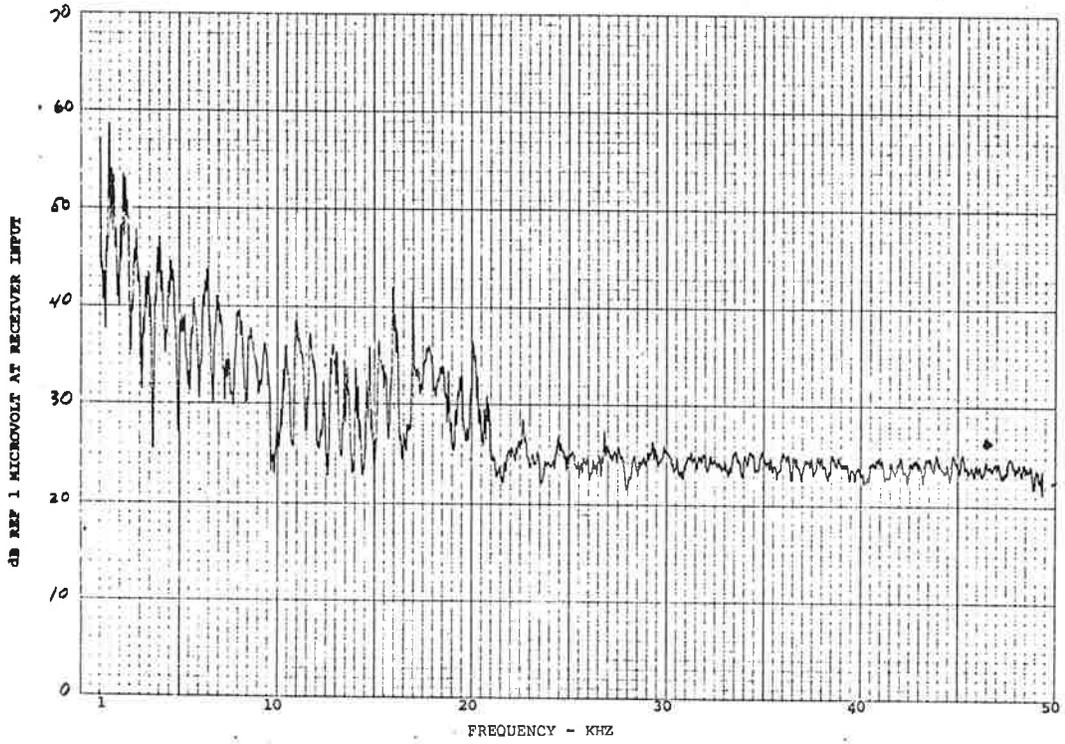
TEST NO. 38
TEST SPECIMEN FOLD

TEST TYPE PLC & PA
TEST EQUIP. 876-10

BANDWIDTH 5 Hz
DATE 29 FEB 72

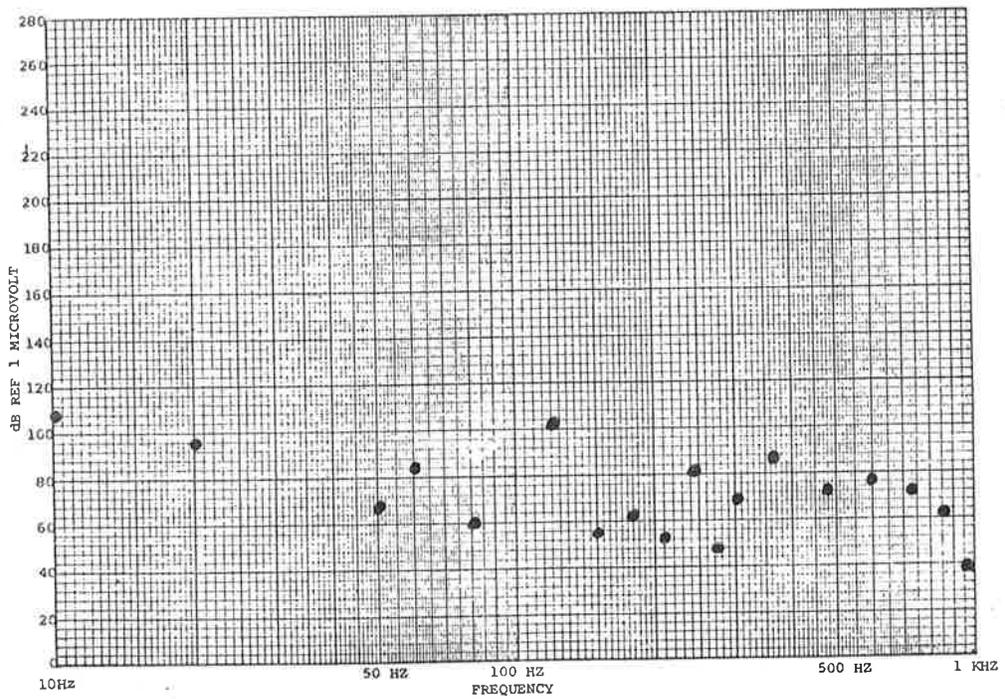
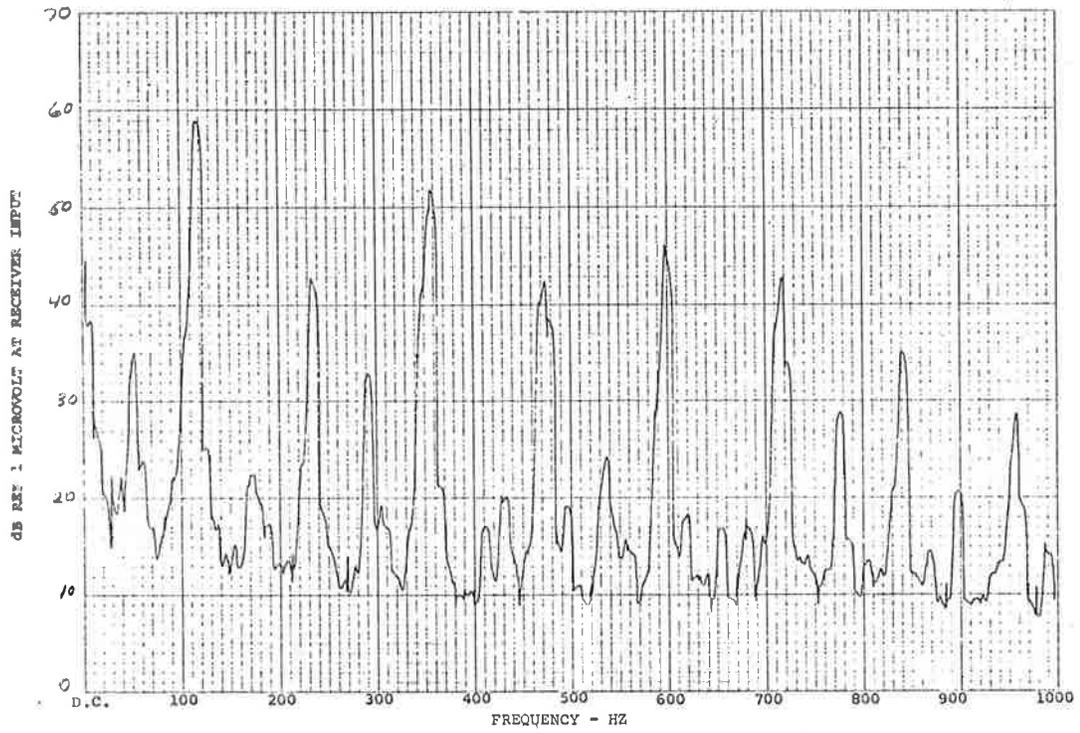


TEST NO. 33 TEST TYPE PLC PA BANDWIDTH 50 Hz
 TEST SPECIMEN FORD TEST EQUIP. 276-10 DATE 29 FEB 72



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TEST NO. 37 TEST TYPE PLC 30 BANDWIDTH 5 Hz
 TEST SPECIMEN FORD TEST EQUIP. 676-10 DATE 12-1-72

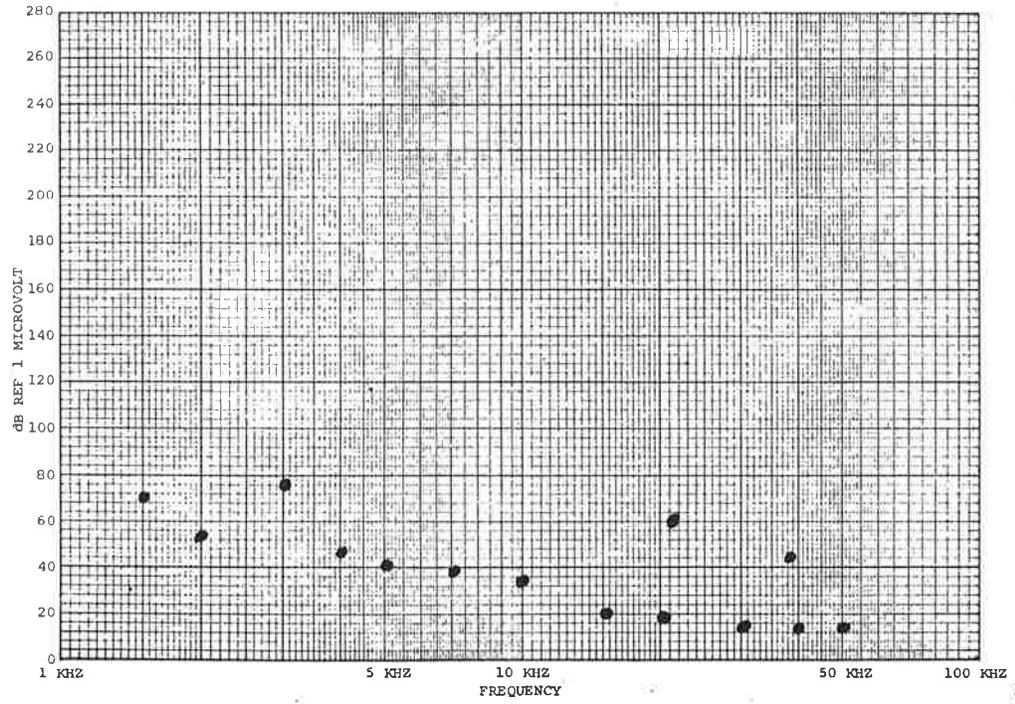
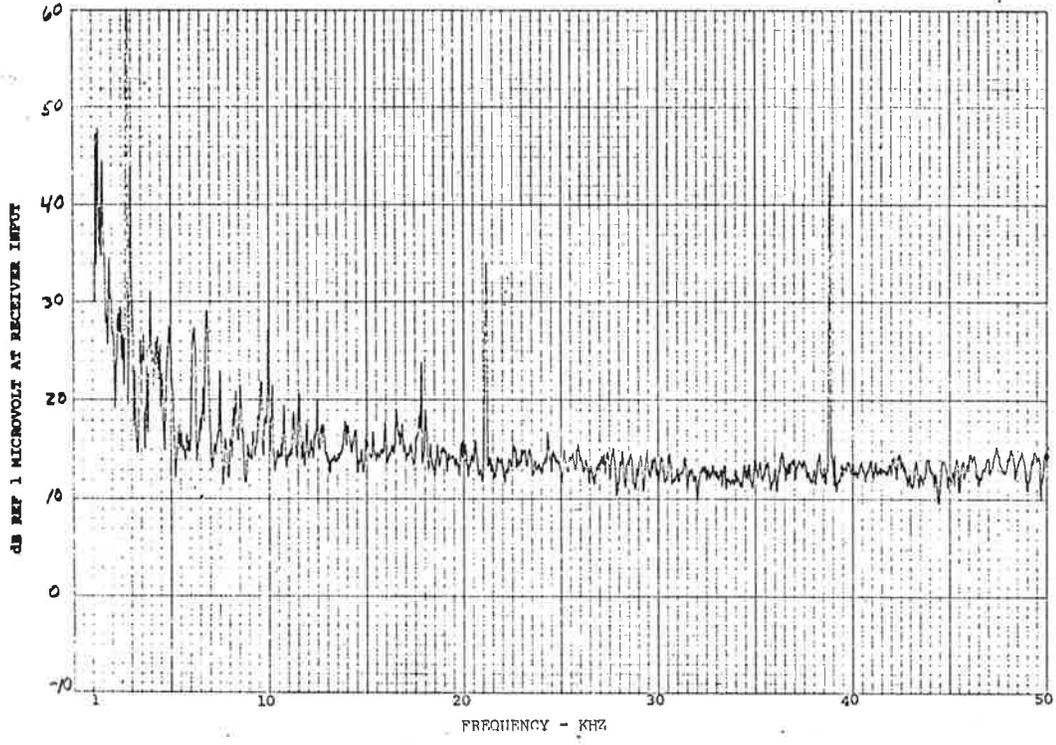


RRR 867

TEST NO. 34
TEST SPECIMEN FR10

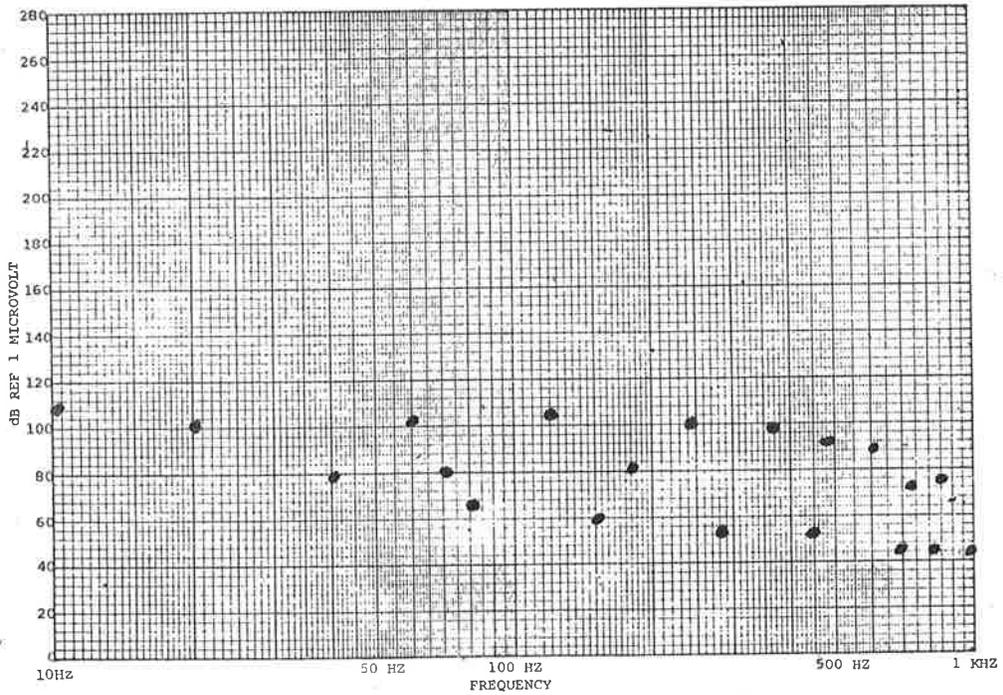
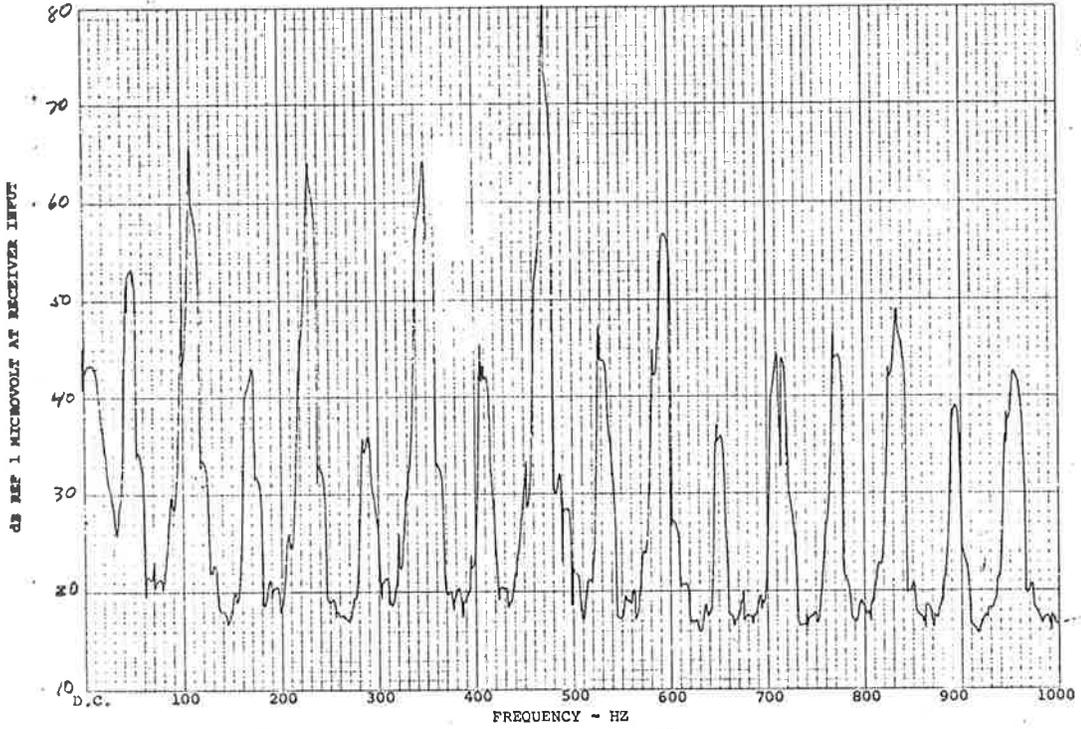
TEST TYPE PLC & B
TEST EQUIP. B76-10

BANDWIDTH 50 Hz
DATE 29 Feb 72



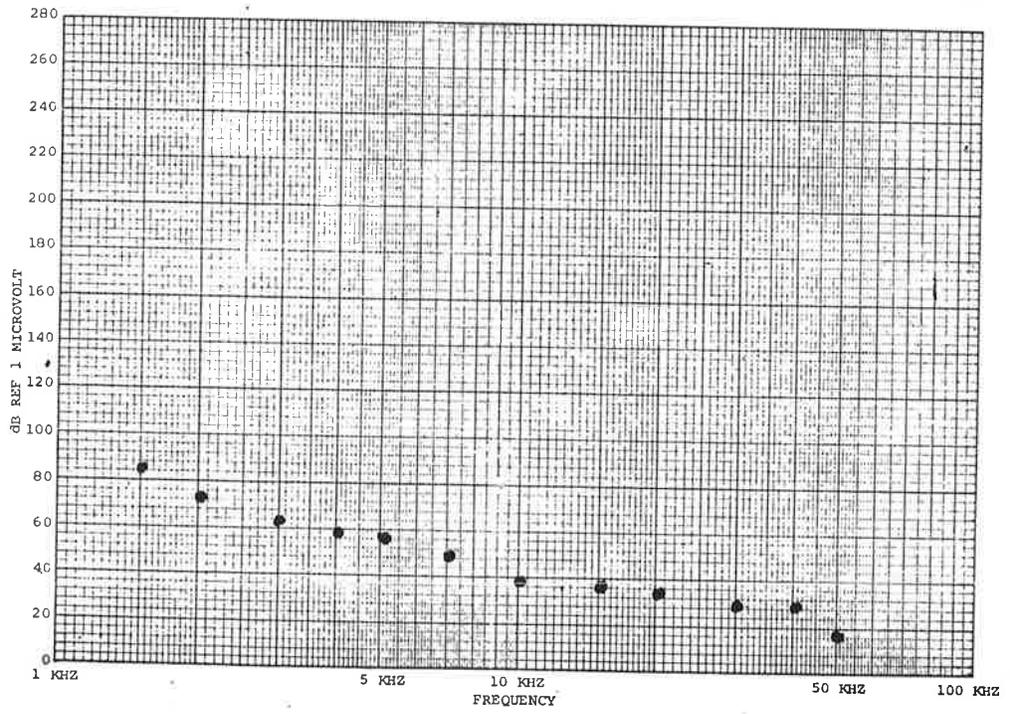
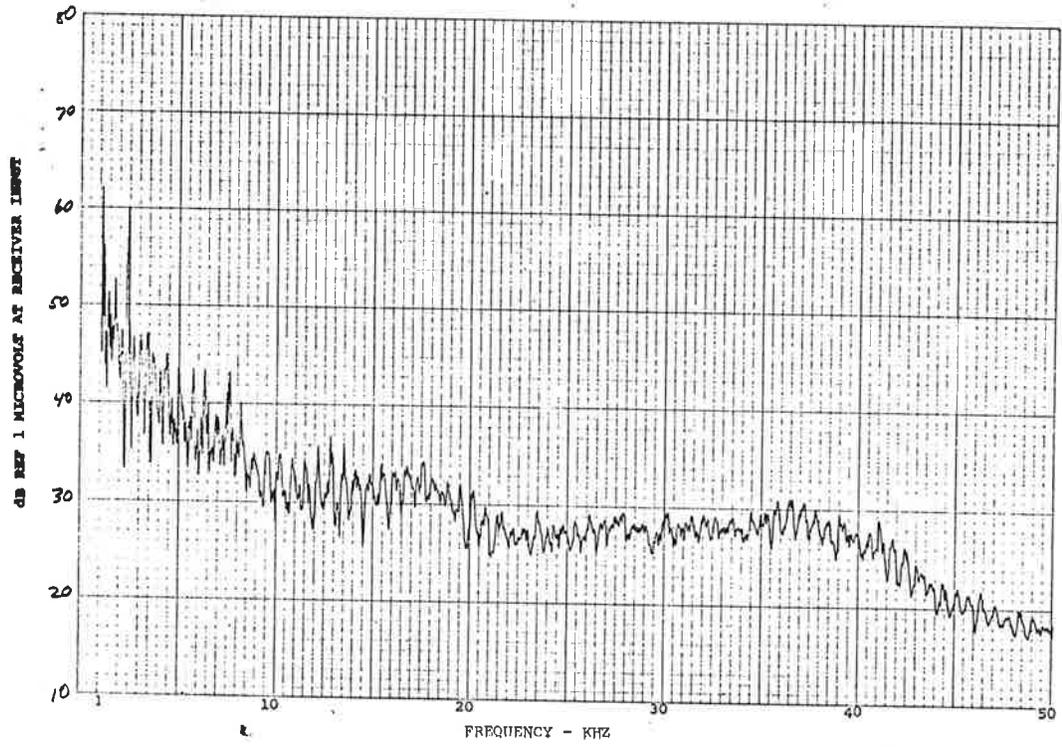
RRR 042

TEST NO. 36 TEST TYPE PLC PC GPD BANDWIDTH 5 Hz
 TEST SPECIMEN F020 TEST EQUIP. SMC-10 DATE 29 Feb 72



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TEST NO. 35 TEST TYPE PLC PC GRD BANDWIDTH 50 Hz
 TEST SPECIMEN FORD TEST EQUIP. GTC-10 DATE 29 FEB 72

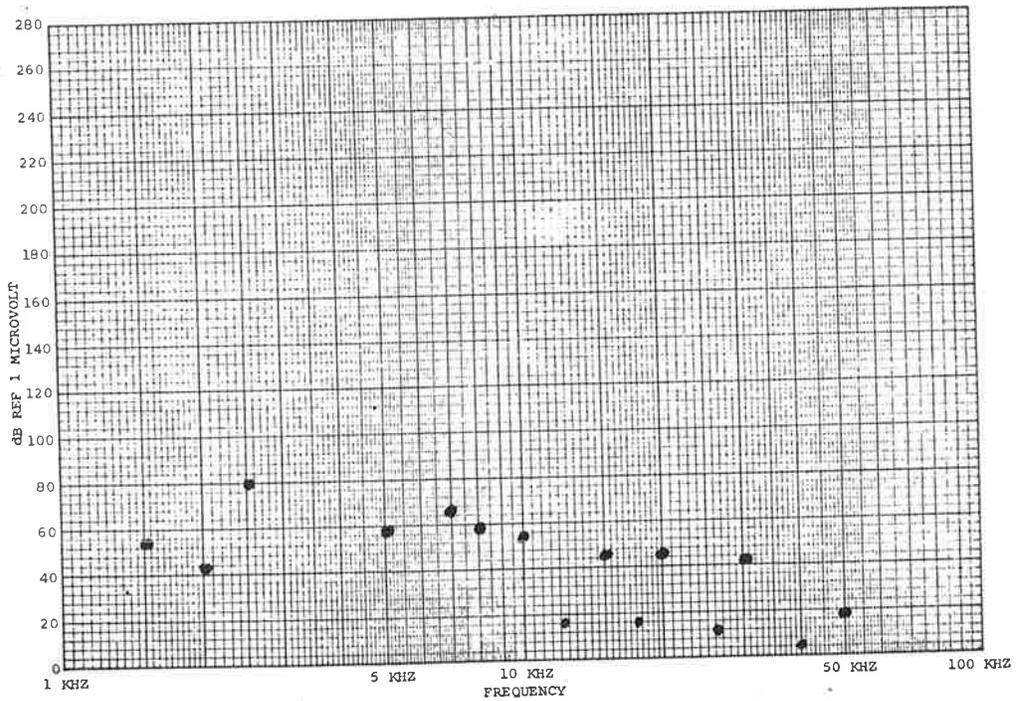
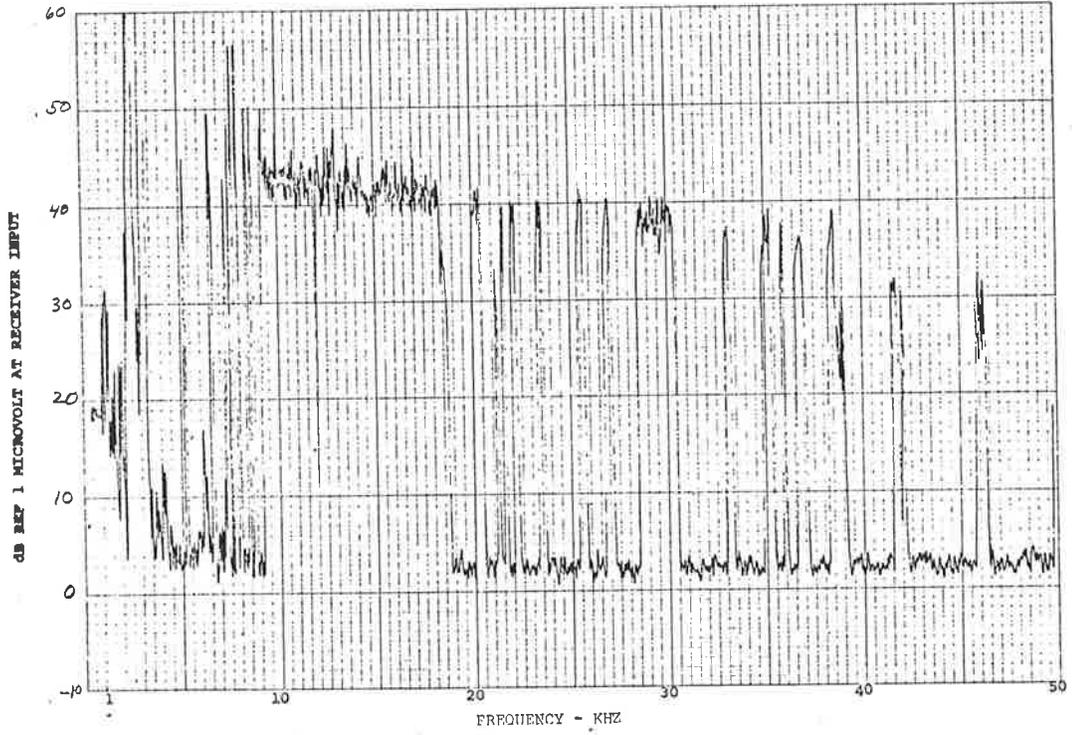


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TEST NO. 9
TEST SPECIMEN TT1

TEST TYPE PLC 9A
TEST EQUIP. RAC-10

BANDWIDTH 50 Hz
DATE 25 FEB 73

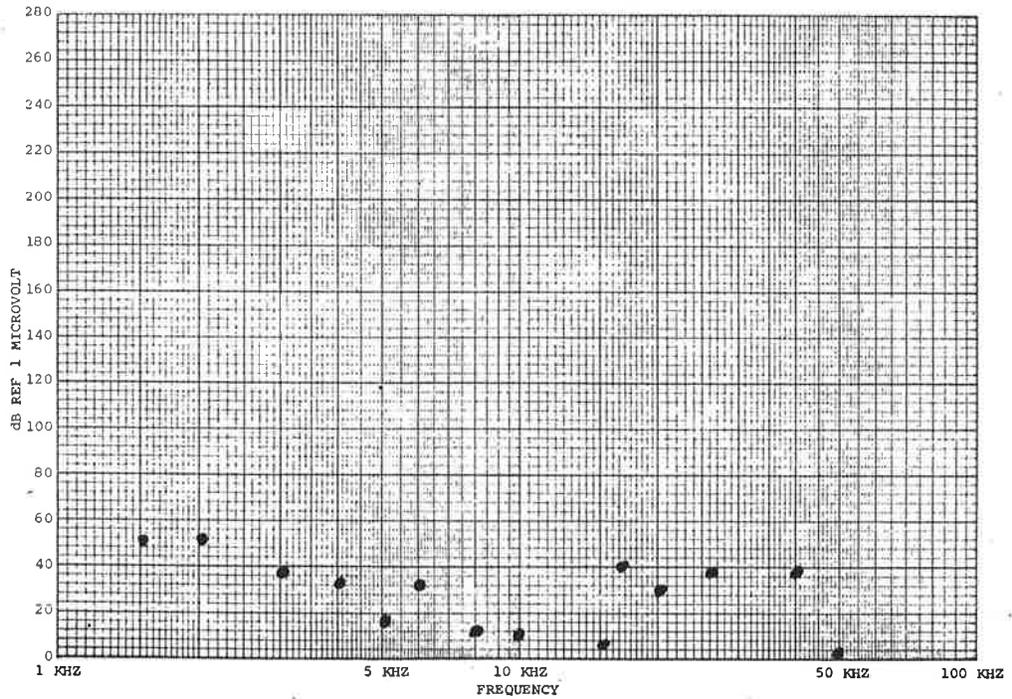
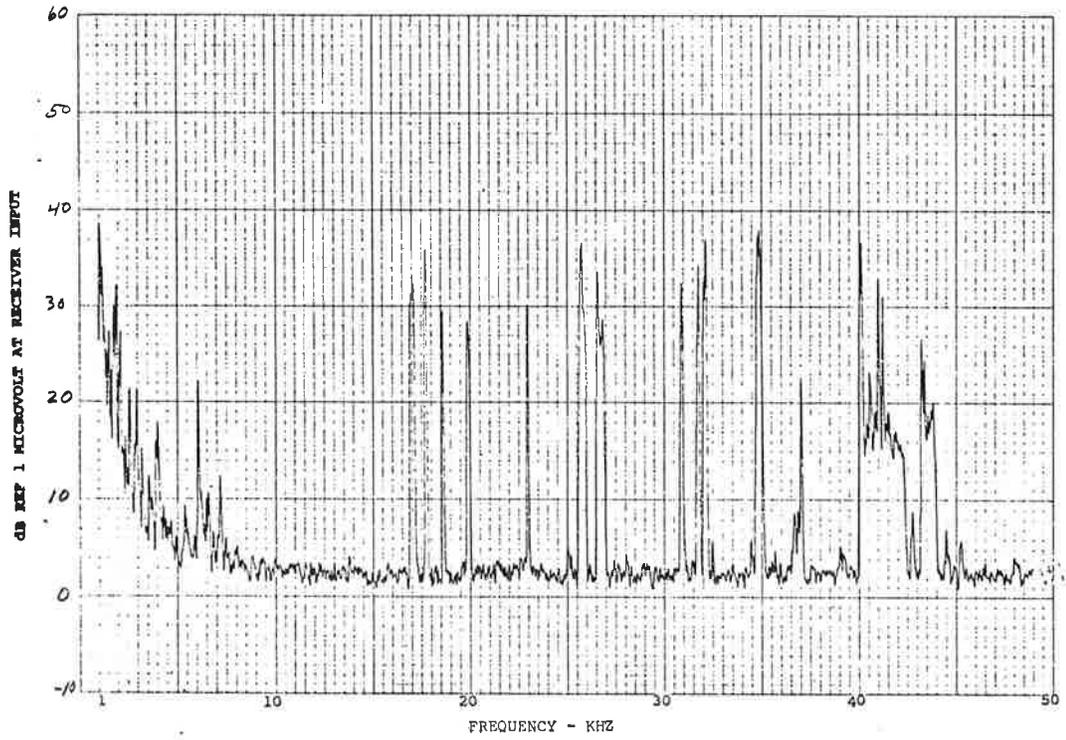


RAC-10

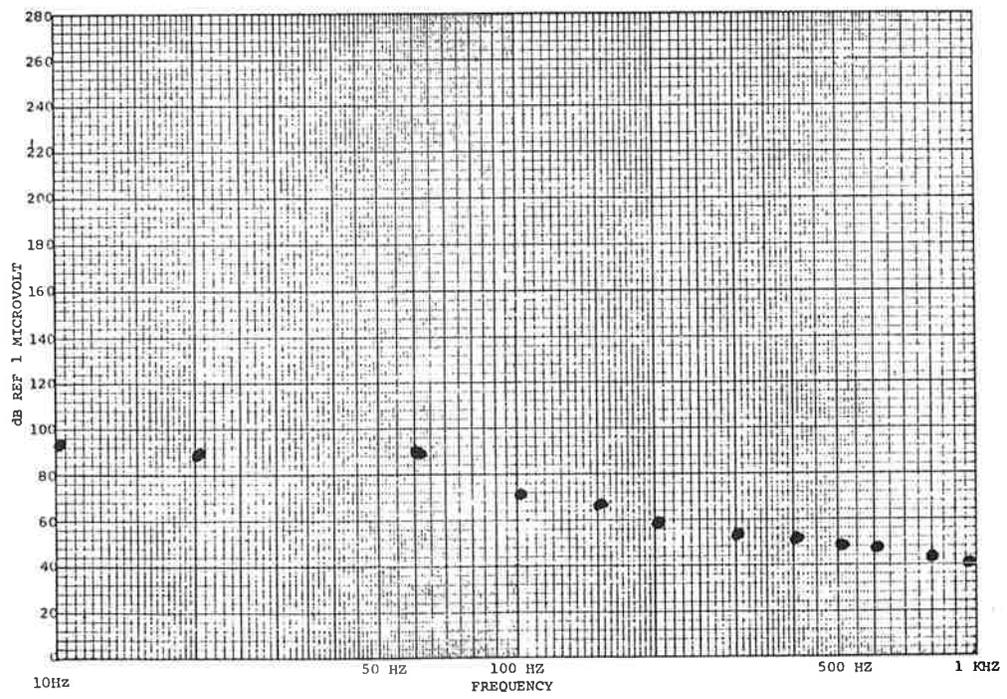
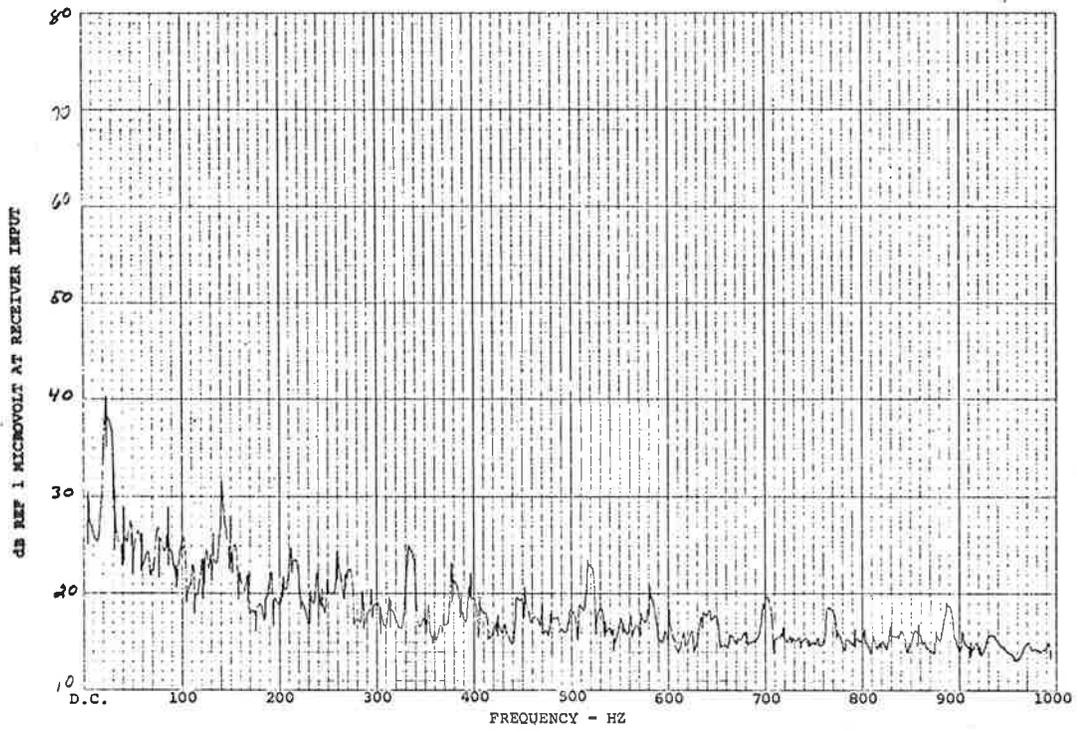
TEST NO. 17
TEST SPECIMEN III

TEST TYPE Fig. 4B
TEST EQUIP. ENC-10

BANDWIDTH 50 Hz
DATE 25 Nov 72

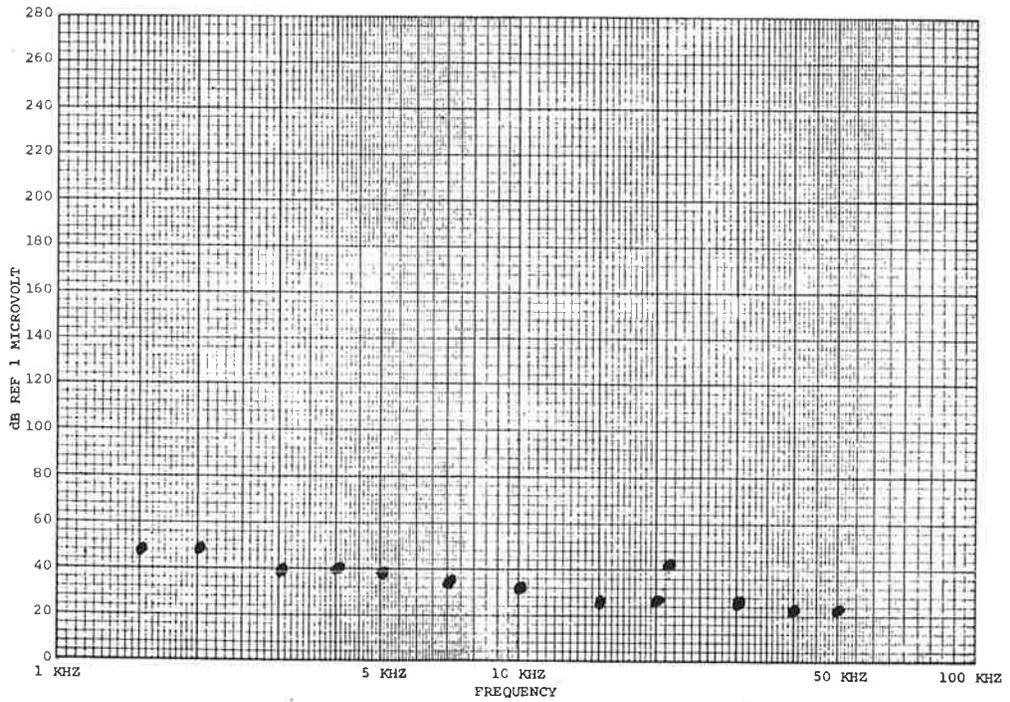
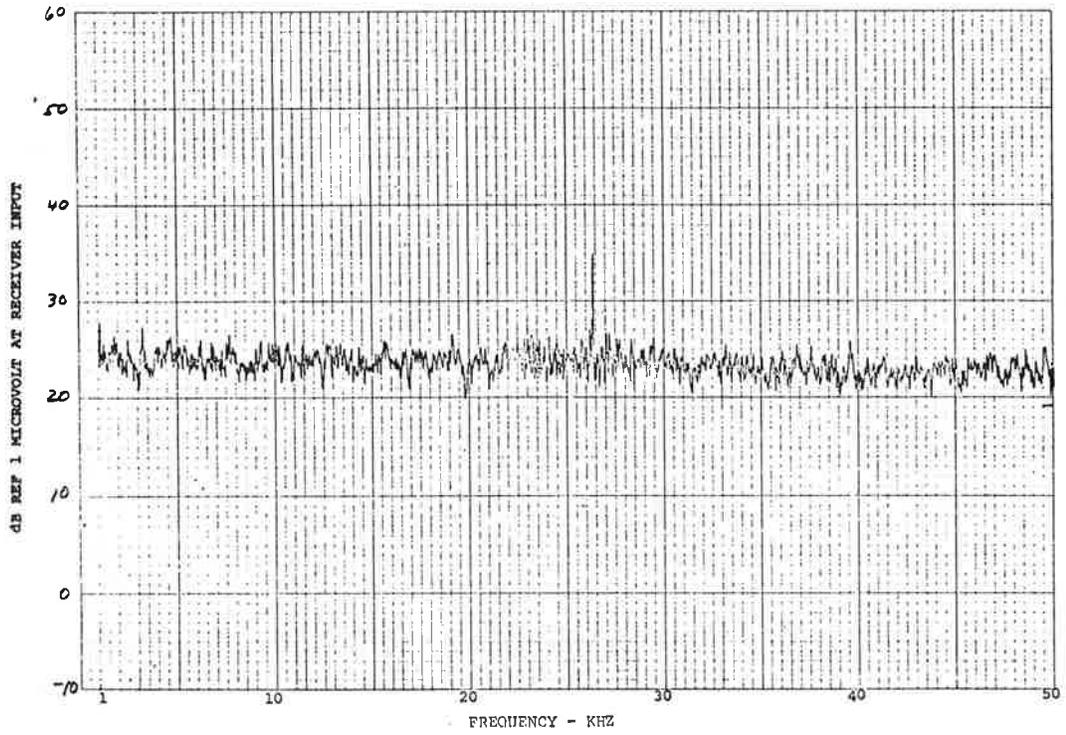


TEST NO. 17 TEST TYPE PLC PA BANDWIDTH 5 Hz
 TEST SPECIMEN 1 TEST EQUIP. E76-10 DATE 28 FEB 72



RBR euh

TEST NO. 22 TEST TYPE PLC & A BANDWIDTH 50 Hz
 TEST SPECIMEN 471 TEST EQUIP. ENG-10 DATE 28 FEB 78

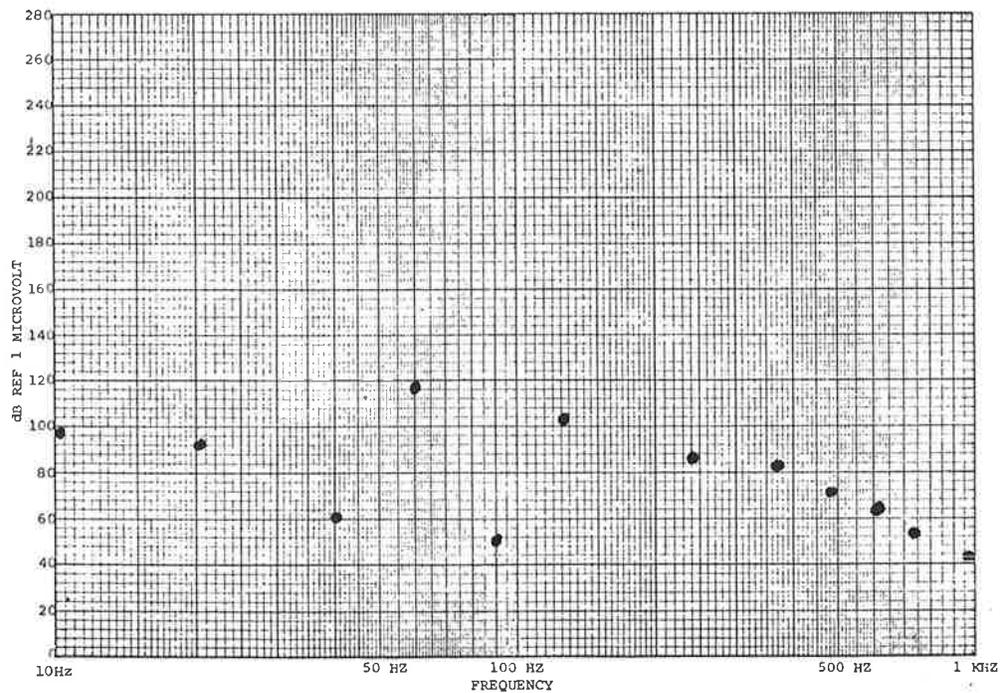
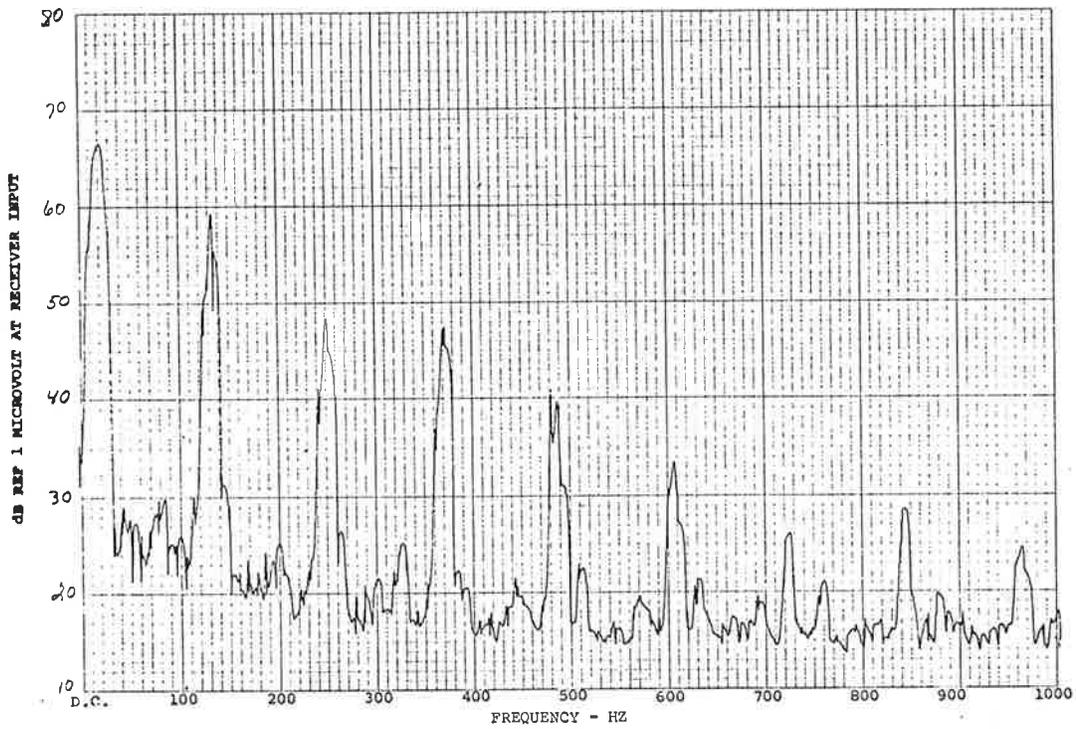


ROR *cu*

TEST NO. 16
TEST SPECIMEN TT1

TEST TYPE PLC dB
TEST EQUIP. ENC-10

BANDWIDTH 5 Hz
DATE 28 FEB 71

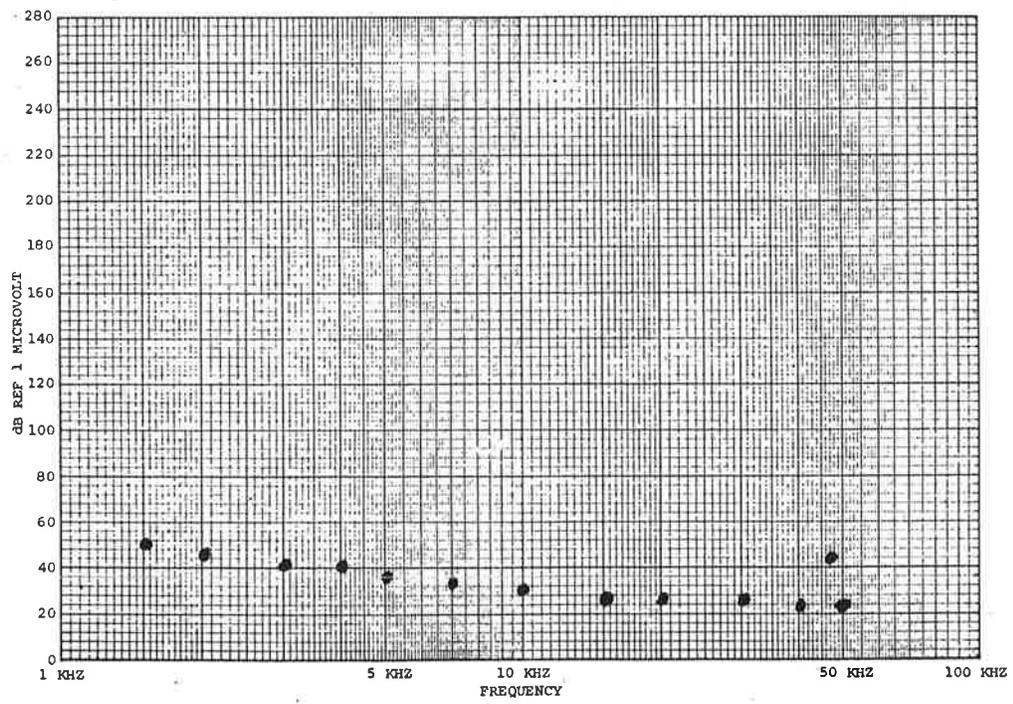
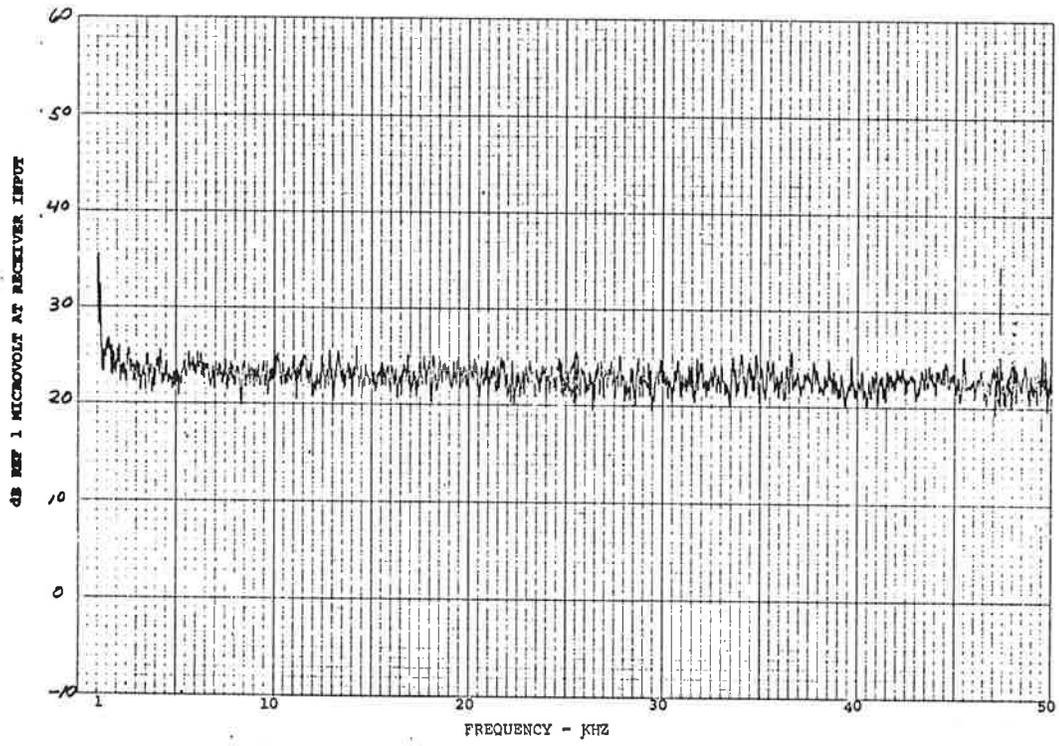


RBR euh

TEST NO. 23
TEST SPECIMEN 77

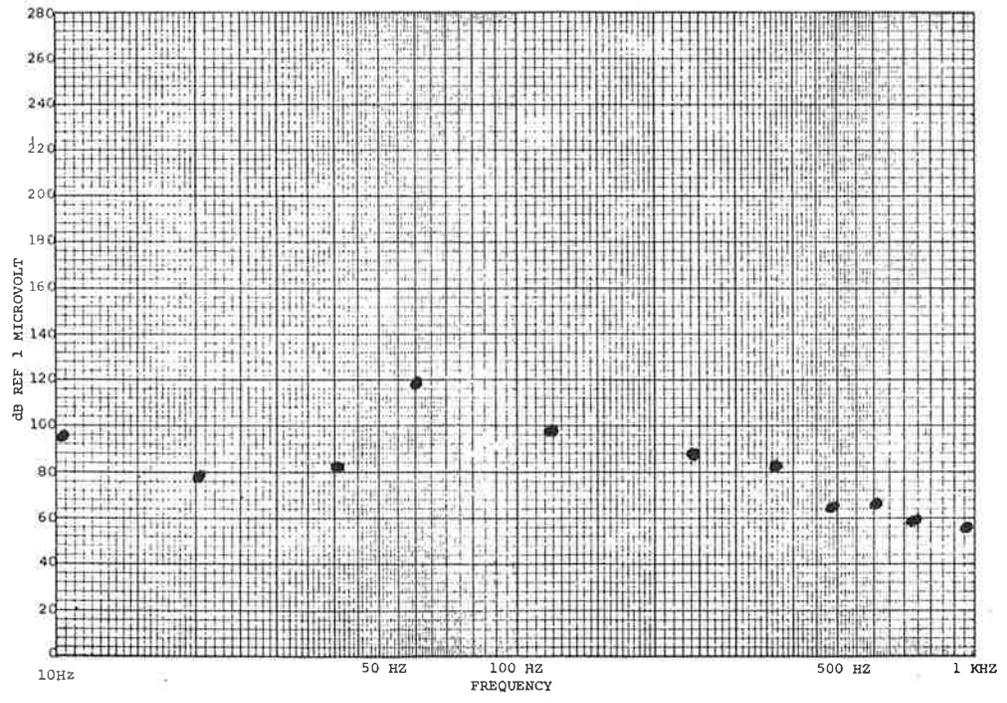
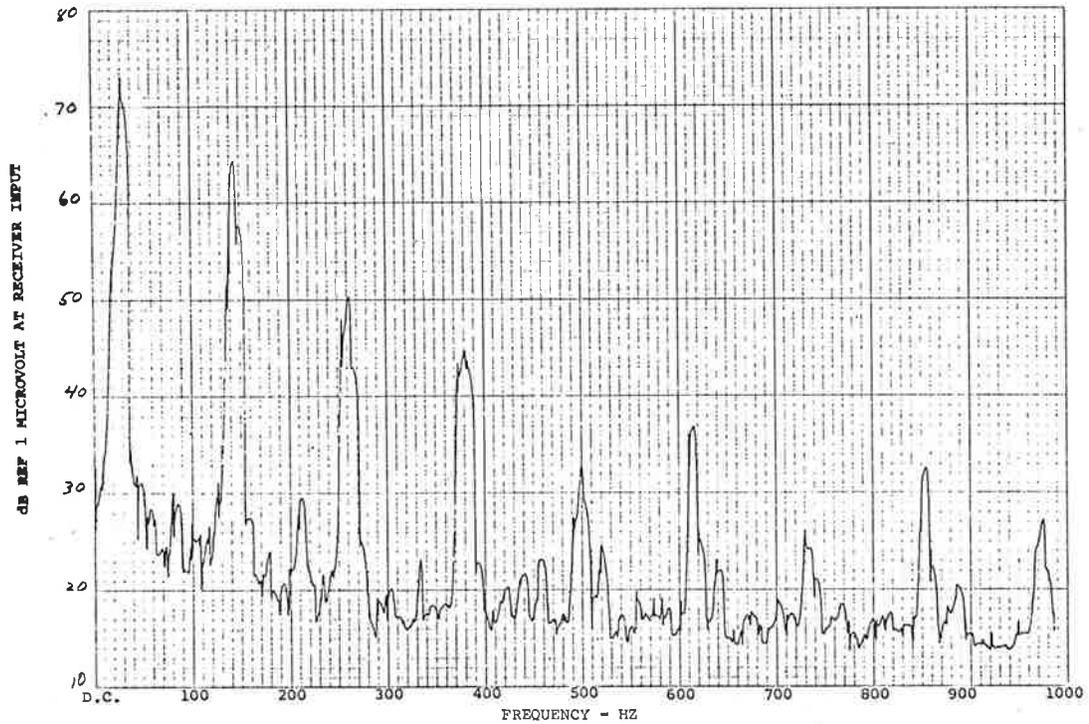
TEST TYPE P.L. A.F.
TEST EQUIP. ENC-10

BANDWIDTH 50 Hz
DATE 28 FEB 78



RBR *807*

TEST NO. 18 TEST TYPE PLC ΦC BANDWIDTH 5 Hz
 TEST SPECIMEN TT1 TEST EQUIP. 57E-10 DATE 28 FEB 72

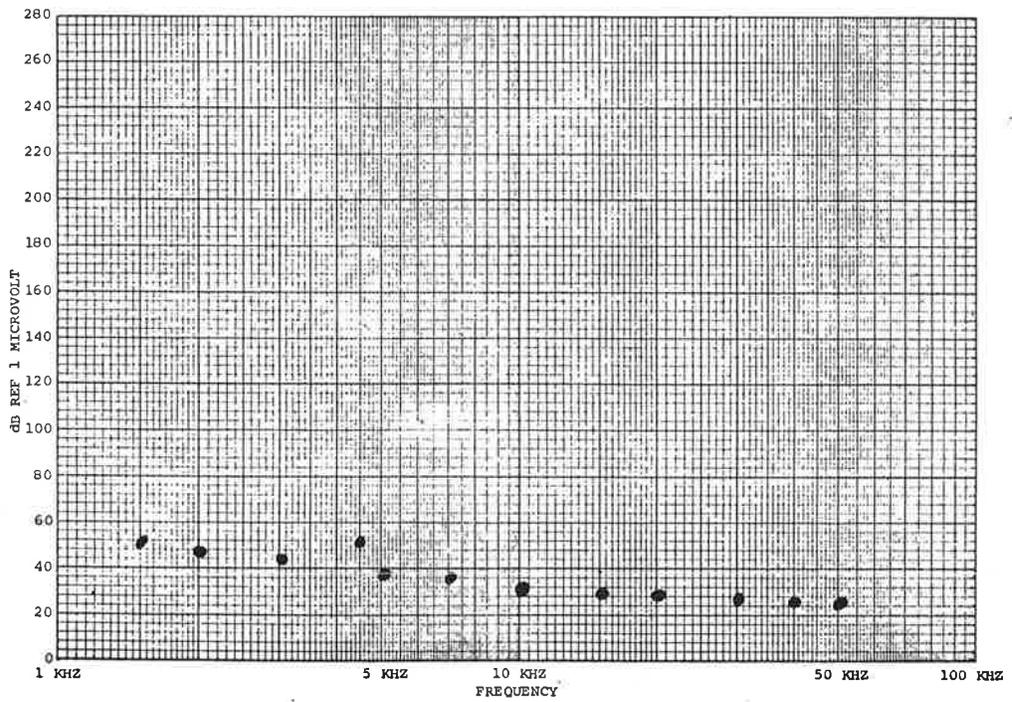
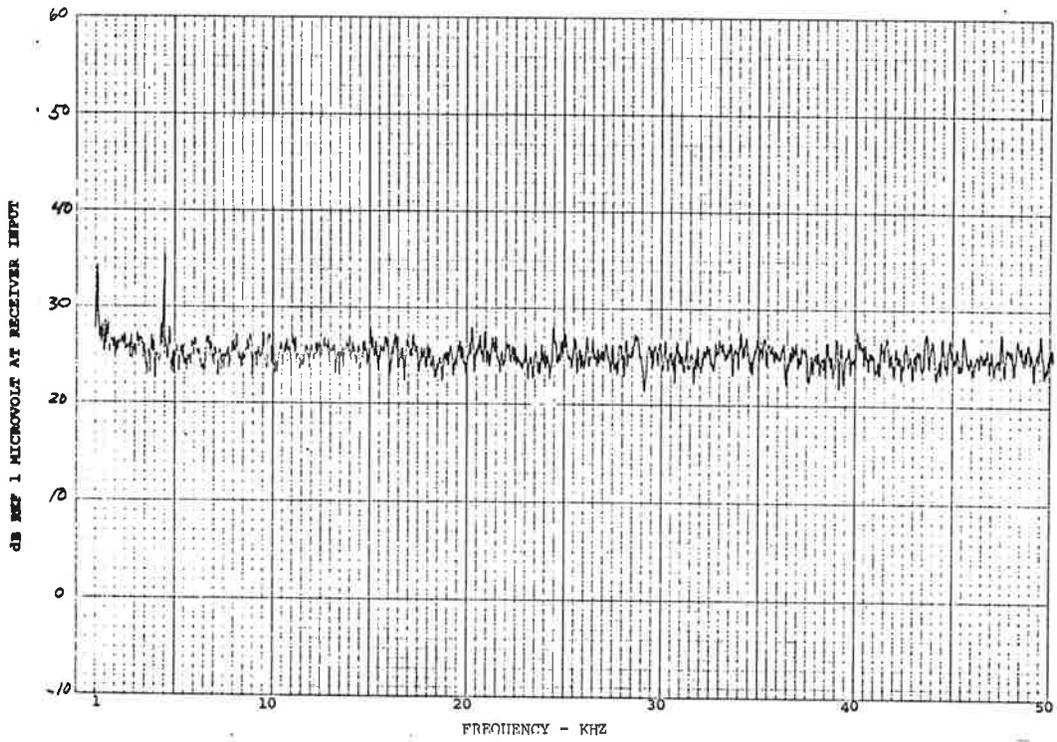


RBR *sun*

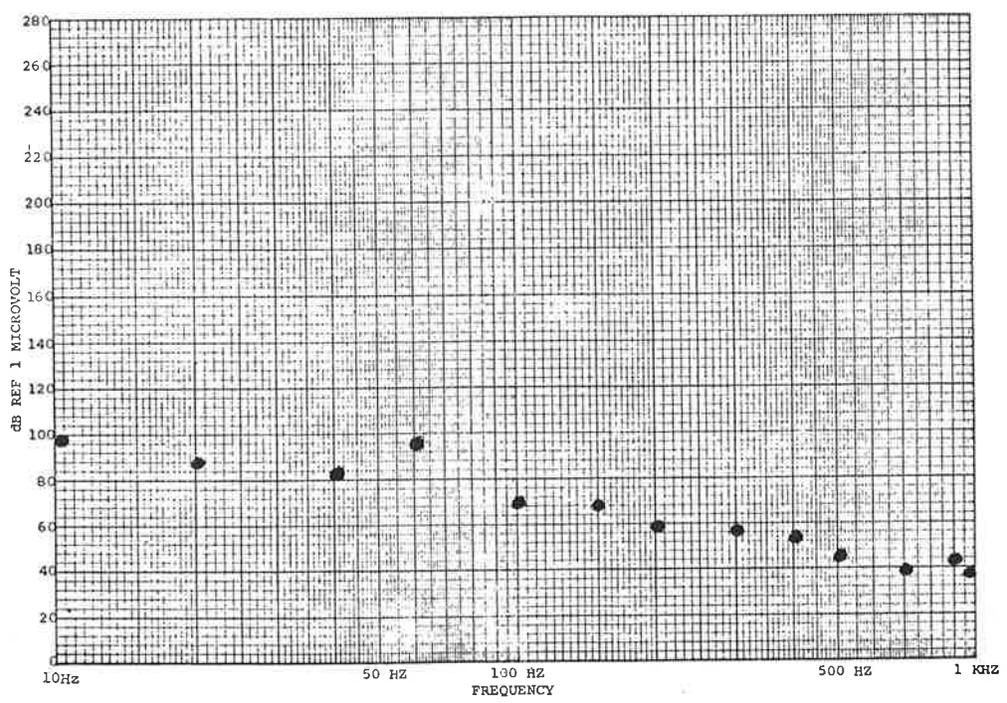
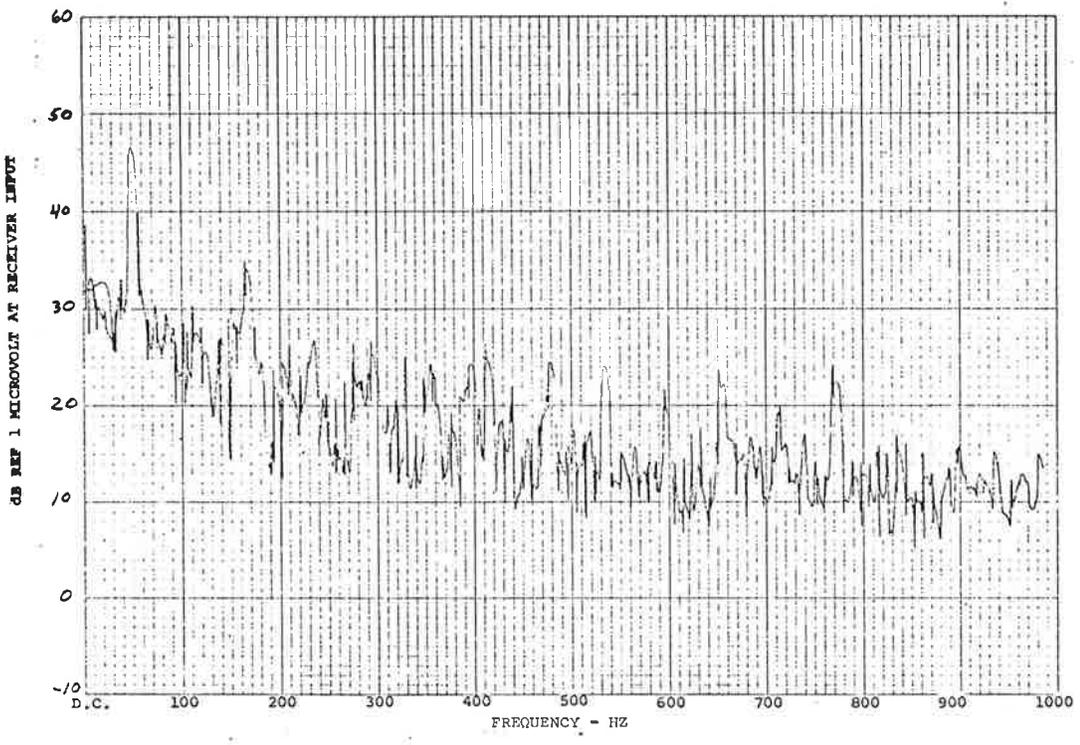
TEST NO. 21
TEST SPECIMEN TT1

TEST TYPE PLC PC
TEST EQUIP. EMC-10

BANDWIDTH 50 Hz
DATE 28 FEB 72

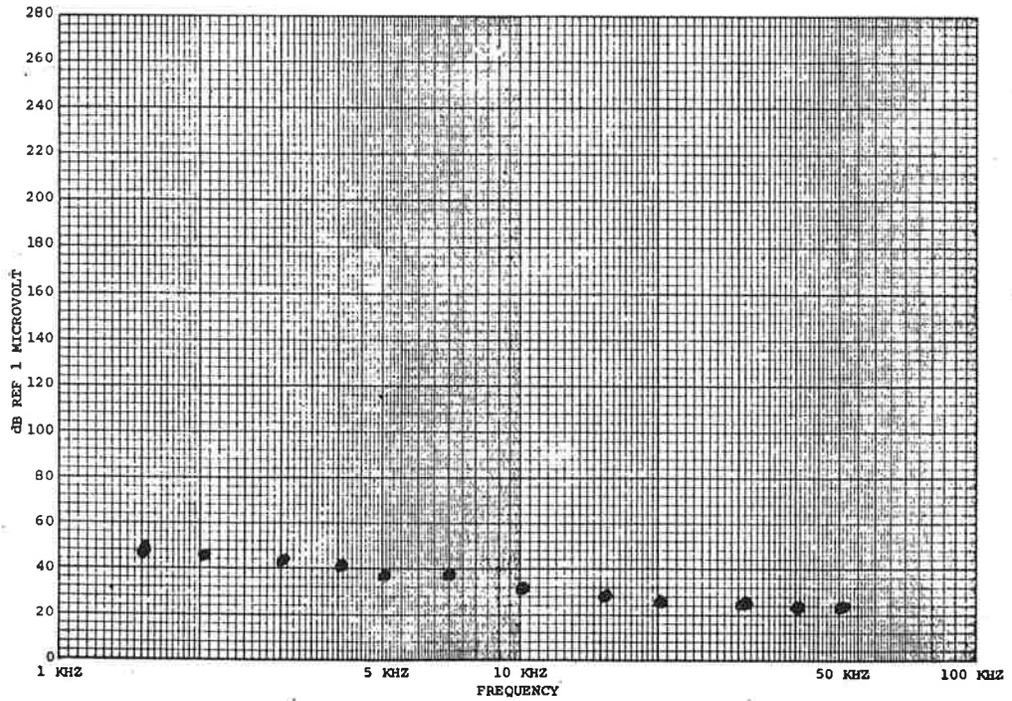
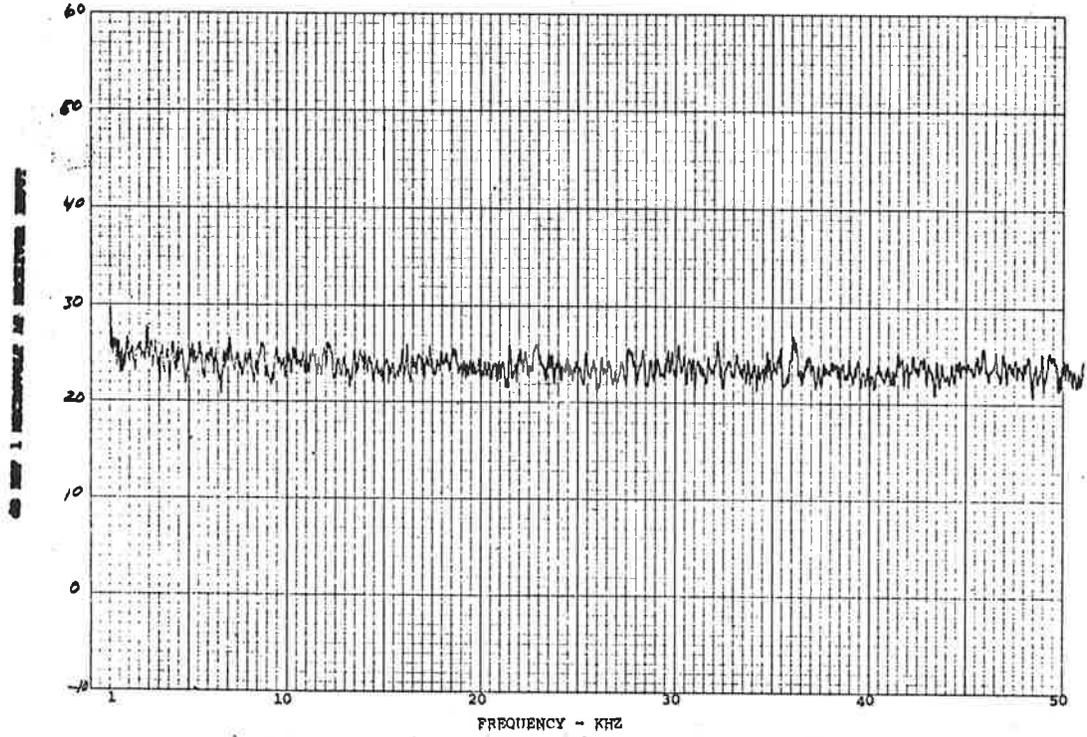


TEST NO. 17 TEST TYPE PLC-NEU BANDWIDTH 5 Hz
 TEST SPECIMEN III TEST EQUIP. ENG-10 DATE 20 FEB 73



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TEST NO. 20 TEST TYPE PLC NEU BANDWIDTH 50 Hz
 TEST SPECIMEN 771 TEST EQUIP. 87C-10 DATE 28 FEB 71



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