NO. UMTA-MA-06-0031-73,X

ELECTROMAGNETIC ENVIRONMENT MEASUREMENTS OF PRT SYSTEMS AT "TRANSPO®72" VOLUME X MONOCAB SYSTEM

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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 each system operating individually.

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 and to assess the effect of each system on the power line with all other PRT systems turned off.

The measurements obtained during this test will be used for a comparison with data obtained with no PRT systems operating and with all four PRT systems operating simultaneously.

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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.

POWER LINE CONDUCTED NOISE MEASUREMENTS

MONOCAB SYSTEM - TRANSPO® '72

1. INTRODUCTION

This technical report presents the data obtained in the performance of tests for power line conducted noise at the personal rapid transit (PRT) system of MONOCAB at TRANSPO® '72, Dulles Airport, Washington, D. C. This report covers one of the four tests defined under Item 5 of Contract DOT-TSC-375, and as performed by National Scientific Laboratories.

Item 5 calls for the performance of conducted noise measurements on PRT ac power lines in the frequency range from dc to at least 10 KHz, with one PRT system on. The objective of the test was to gather operational data for each of the PRT systems. Such data will enable characterization of the noise increase attributable to system operations, when considered in comparison with the ambient data collected and documented* previously by NSL.

The measurements reported in this document were made during the forenoon of July 27, 1972.

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* Technical Report, Item 4, Ambient Power Line Conducted Noise Survey, PRT Systems, March 1972, Contract No. DOT-TSC-375, Department of Transportation, Transportation Systems Center, 55 Broadway, Cambridge, Massachusetts 02142.

2. METHOD OF MEASUREMENT

2.1 Instruments

All measurements were made using test set-ups and instruments as nearly identical as possible to those used during ambient testing. 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. A Hewlett Packard Model 3005B X-Y Plotter was driven from the receiver.

Some observations were made at frequencies above 50 kHz through the use of a Hewlett Packard Model 8552/8553A spectrum analyzer. Data was recorded photographically with a Hewlett Packard Model 198A oscilloscope camera. The analyzer is an extremely versatile instrument in that it has numerous frequency scan and bandwidth settings throughout the frequency spectrum of a few cycles up to 100 MHz.

Signals were obtained from the power lines 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.

2.2 Power Line Arrangement

The power provided to the PRT site via an underground feeder is 480 v.a.c., three phase (Ø). These feeder lines enter commercial switchgear in the MONOCAB building and are coded as follows:

Phase	Color Code
A	Black
B	Red
C	Blue
Neutral	White

The current probe was attached at the point where the feeders enter the switchgear which is the same point as used when making the ambient tests described in report Item 4.

2.3 Measurement Technique

Each of the four power conductors were tested by scanning two frequency ranges, d.c. to 1 kHz using 5 Hz bandwidth, and 1 kHz to 50 kHz using a 50 Hz bandwidth. Two recordings have been made for each frequency range, on each of the four power lines. The scanning time per recording averaged four to six minutes.

These recordings are reproduced in the Appendix as the upper half of pages A-2 through A-17. The recordings are presented in order of phase rather than the order in which they

were produced. The dB scale refers to the level at the instrument input connector. Note that in some of the charts there are two scales indicated--the upside down letter "Y" located somewhere along the bottom line of the chart indicates the point of switchover from the scale on the left side to the scale on the right side.

3. INTERPRETATION OF DATA

The amplitude/frequency charts produced during the tests are reproduced in the upper half of each page of Appendix A-2 through A-17. The lower chart on each page is a plot of approximately one level in each major frequency division of the chart directly above it. Peaks were selected whenever available. A correction factor for the current probe (current probe amplitude response is non-linear with frequency) has been included in the levels plotted in the lower chart.

In the upper chart, noise peaks recorded in the top major amplitude division are out of the calibrated range of the instrumentation system. Thus, the levels plotted for peaks that enter the upper division are plotted as having an amplitude of the highest level indicated numerically on the chart for that particular frequency.

Notations are written on the charts which denote vehicle movements occuring simultaneously with a noise peak. For the most part, the notations refer to a vehicle leaving the station, and vehicle acceleration after coming out of the southeast turn of the guideway.

On Page A-18 are oscillograms of tests No. 247 and 248. They are oscillograms of spectrum analyzer displays to the 210 kHz frequency regions when observing signals on the neutral power line. This is the frequency at which the Control Computer and Vehicle communicate. The upper oscillogram shows a frequency scan of the spectrum when centered at 210 kHz, and scanning at 5 kHz/div.

The two lower oscillograms show time domain of events occurring at 210 kHz. The narrow spikes are power rectified switching, the two groups of wider pulses are two data words consisting of two pulses each. Each pulse contains numerous smaller segments. The bottom oscillogram is an expansion to get a closer look at the segments in the word pulses.

4. TIME LOG

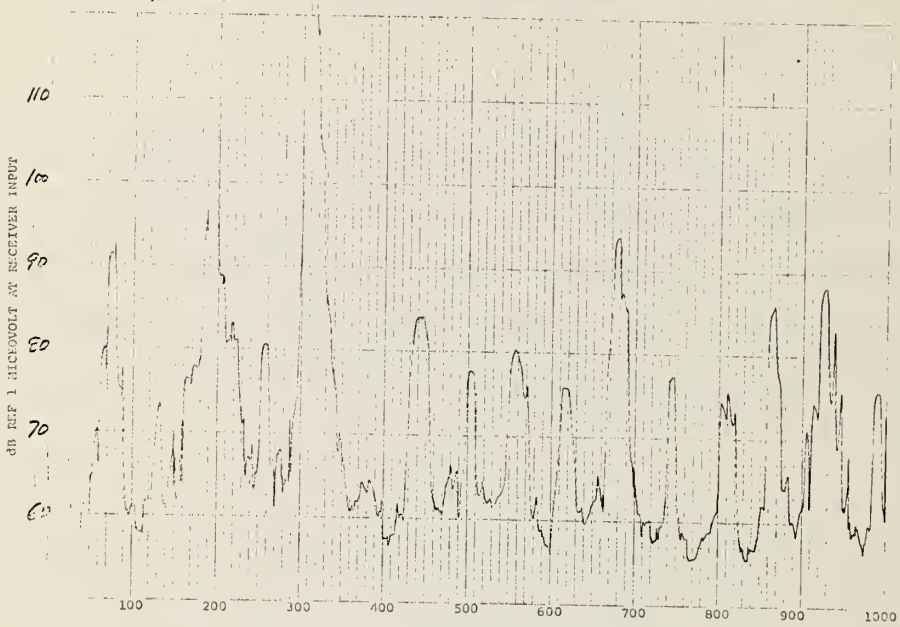
MONOCAB had two vehicles running during the test period -- 0800 to 1200 noon. The log was hand written in pencil and did not reproduce well. An NSL typed copy of the log is contained on page A-19.

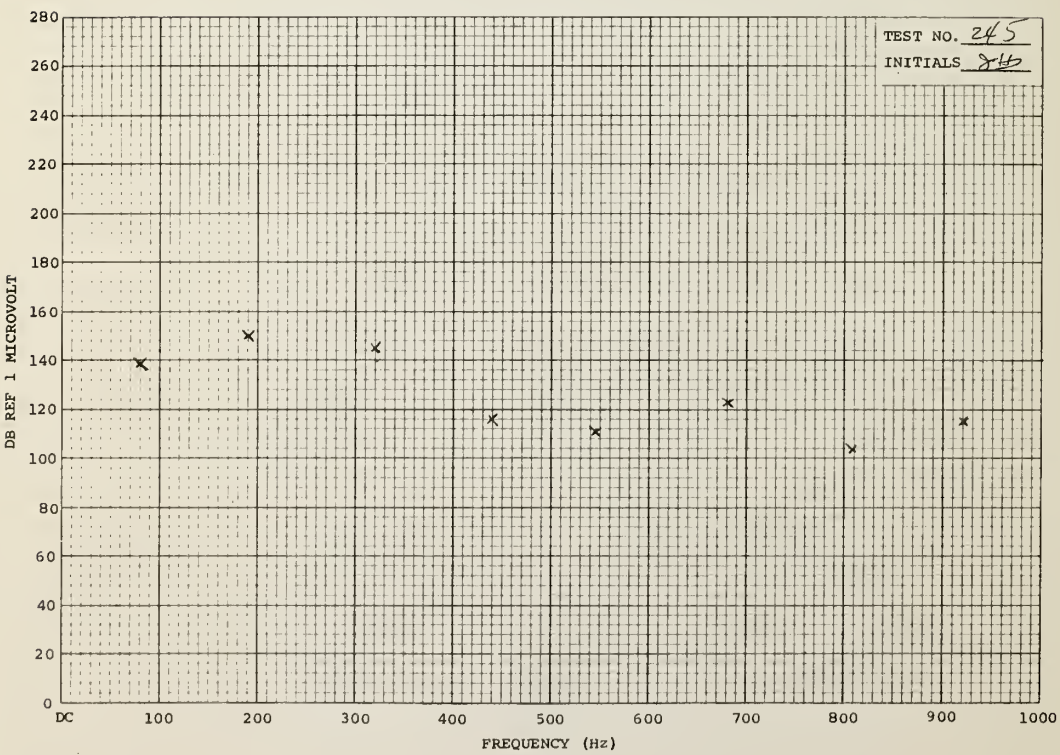
APPENDIX A

POWER LINE CONDUCTION MEASUREMENTS DATA

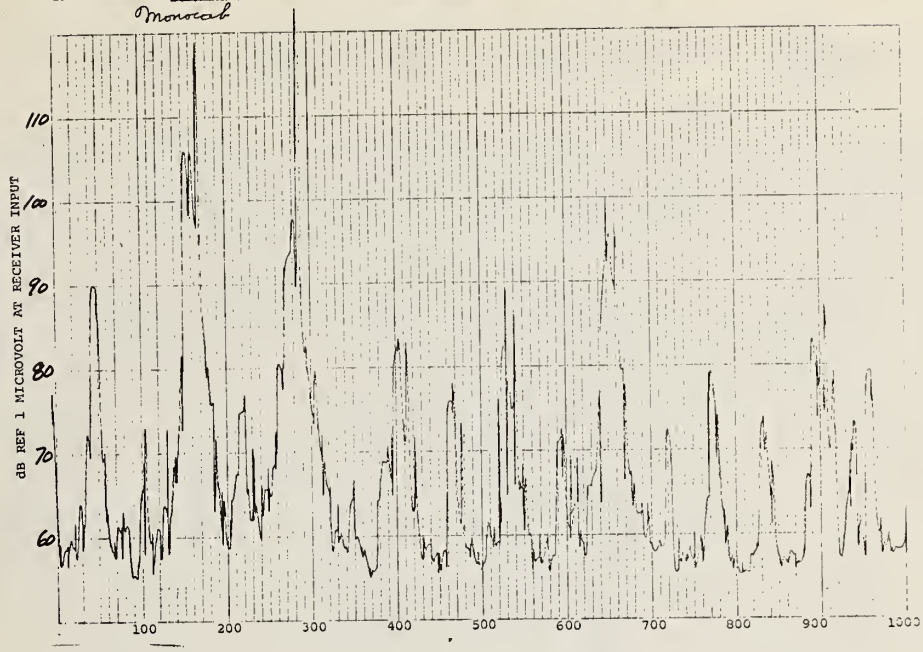
Contains data charts for test No. 237 through 246, and oscillograms No. 247 and 248. The charts are presented in order of phase; A, B, C, Neutral--for ease of analysis, rather than in numerical order as the tests were performed. The oscillograms are on the last page.

TEST NO. 245 TEST TYPE PLC BANDWIDTH 5 Hz 1041
TEST SPECIMEN ΦA TEST EQUIP. EMC-10 DATE 7-27-72
Monorail

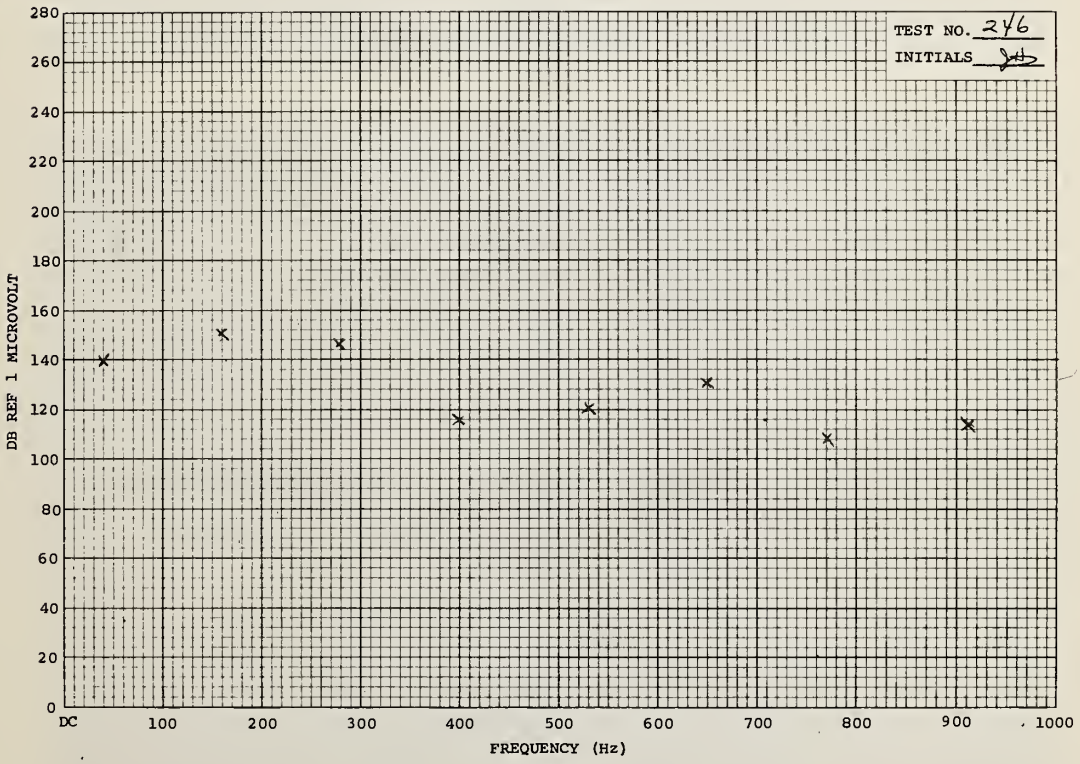




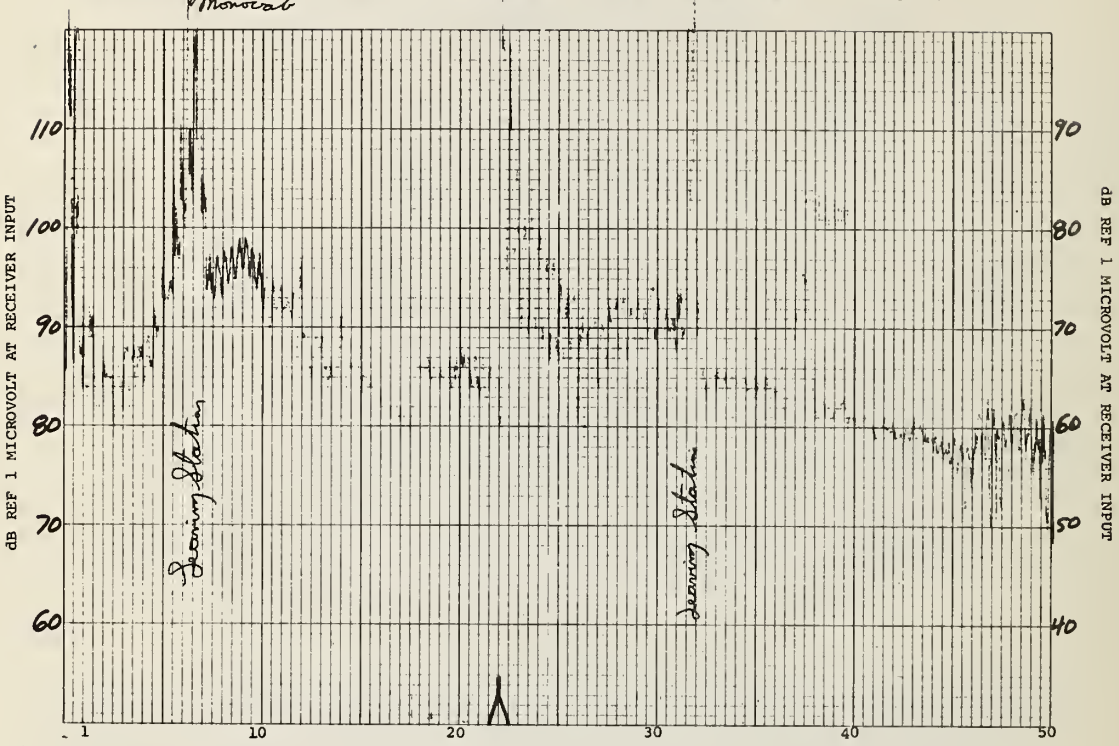
TEST NO. 246
TEST SPECIMEN ΦA Monocab
TEST TYPE PLC
TEST EQUIP. EMC-10
BANDWIDTH 5Hz
DATE 7-27-72
1044

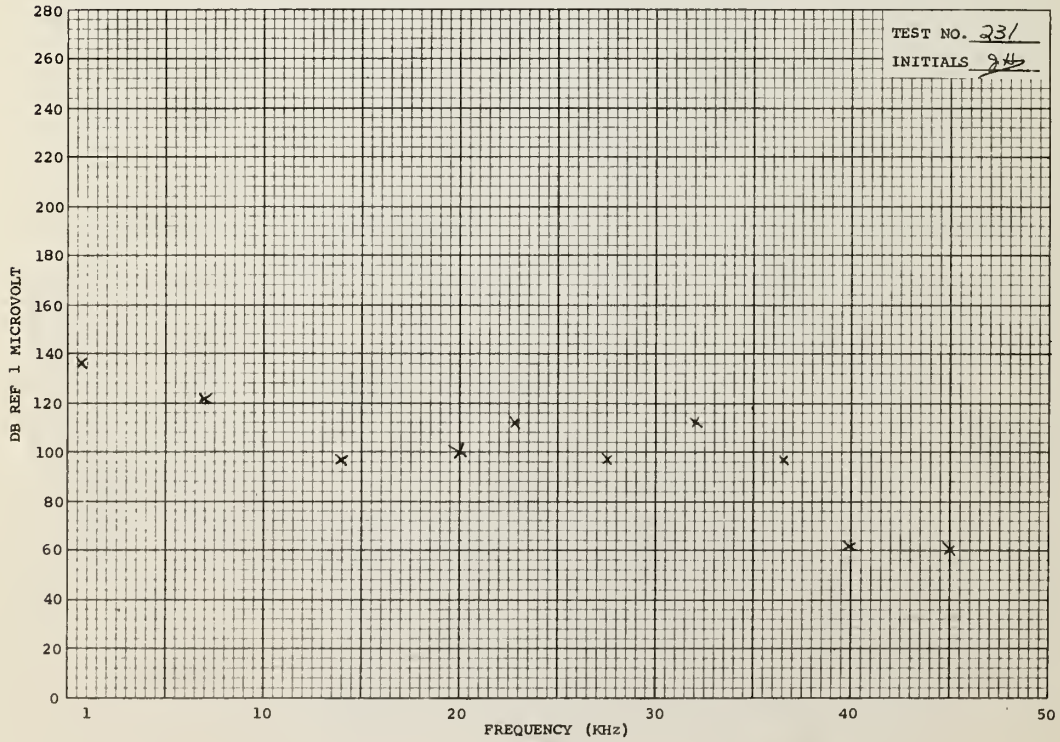


TEST NO. 246
INITIALS

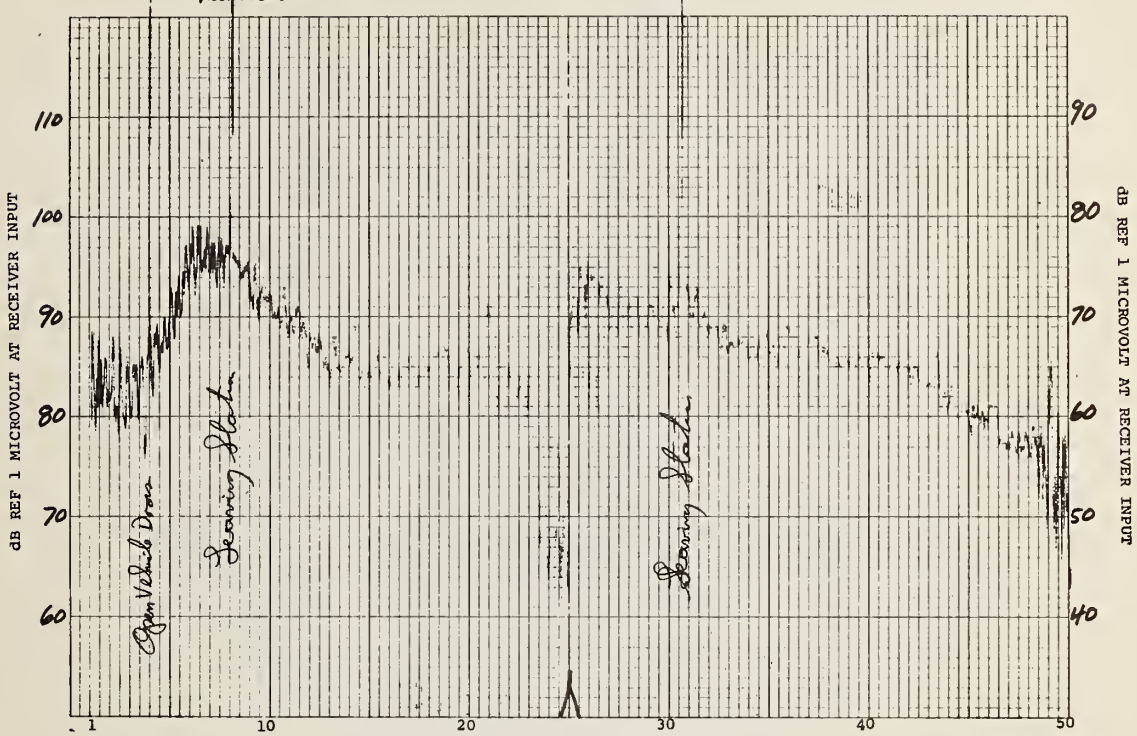


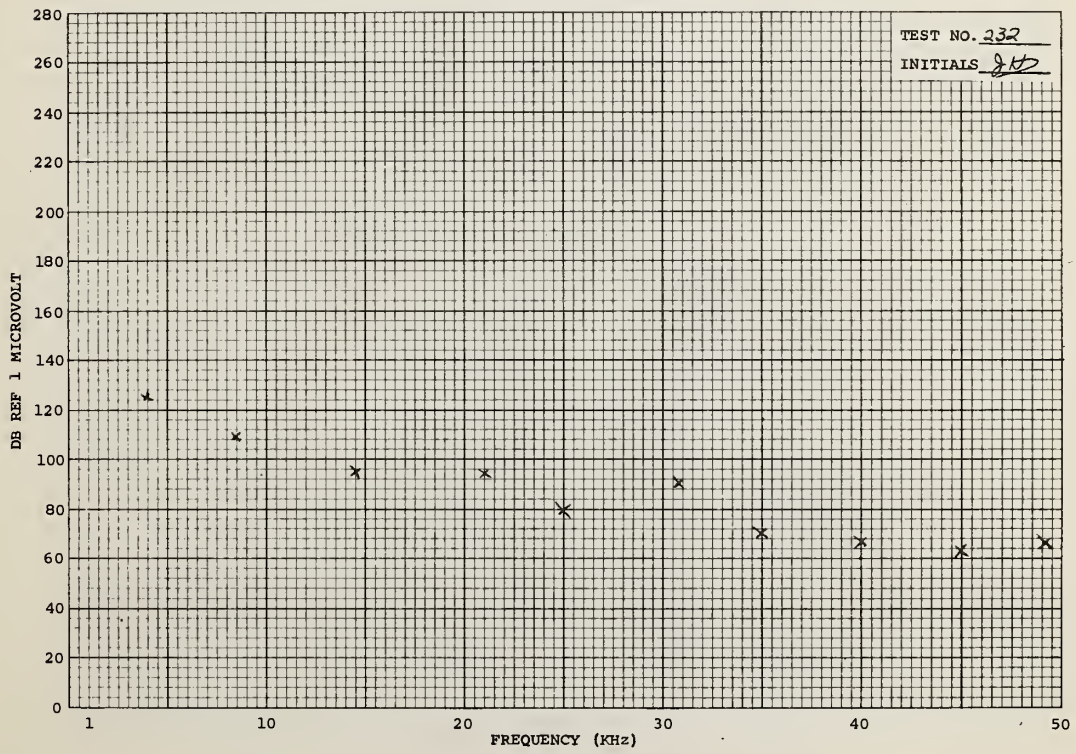
TEST NO. 231 TEST TYPE PLC BANDWIDTH 50 Hz 0824
TEST SPECIMEN ØA DATE 7-27-72
Monaural
EMC-10

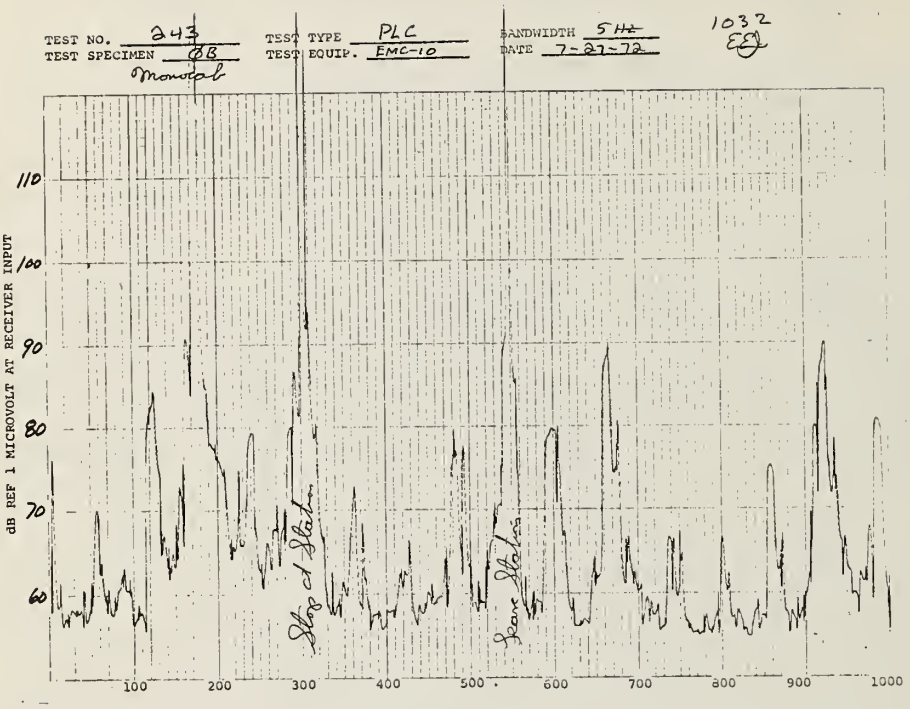


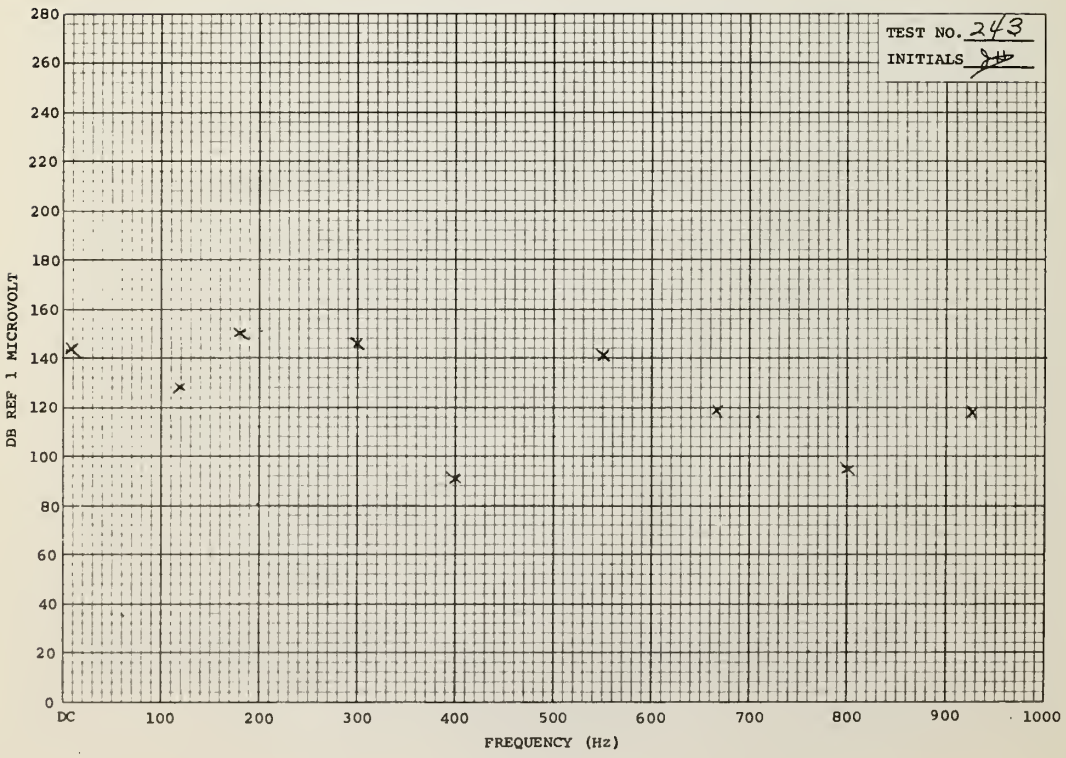


TEST NO. 232 TEST TYPE PLC BANDWIDTH 50Hz 0830
TEST SPECIMEN ØA TEST EQUIP. EMC-10 DATE 7-27-72
Monocab

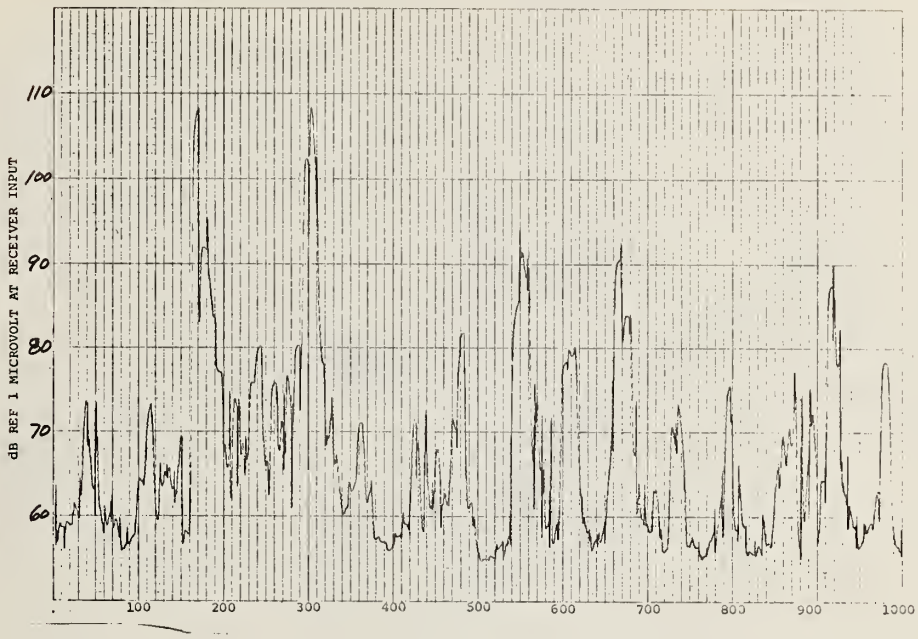


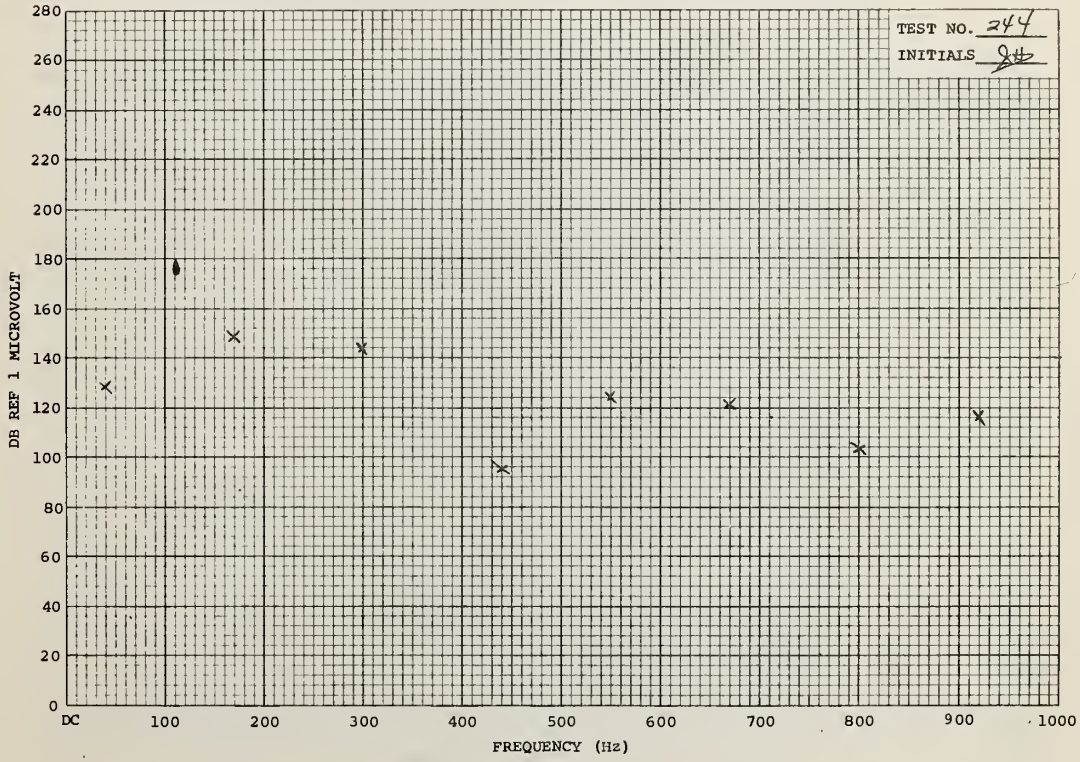



TEST NO. 243
TEST SPECIMEN QB
Monotab
TEST TYPE PLC
TEST EQUIP. EMC-10
BANDWIDTH 5Hz
DATE 7-27-72
1032
EGJ
dB REF 1 MICROVOLT AT RECEIVER INPUT
110
100
90
80
70
60
100
200
300
400
500
600
700
800
900
1000
Slop'd Flat
Slop'd Flat

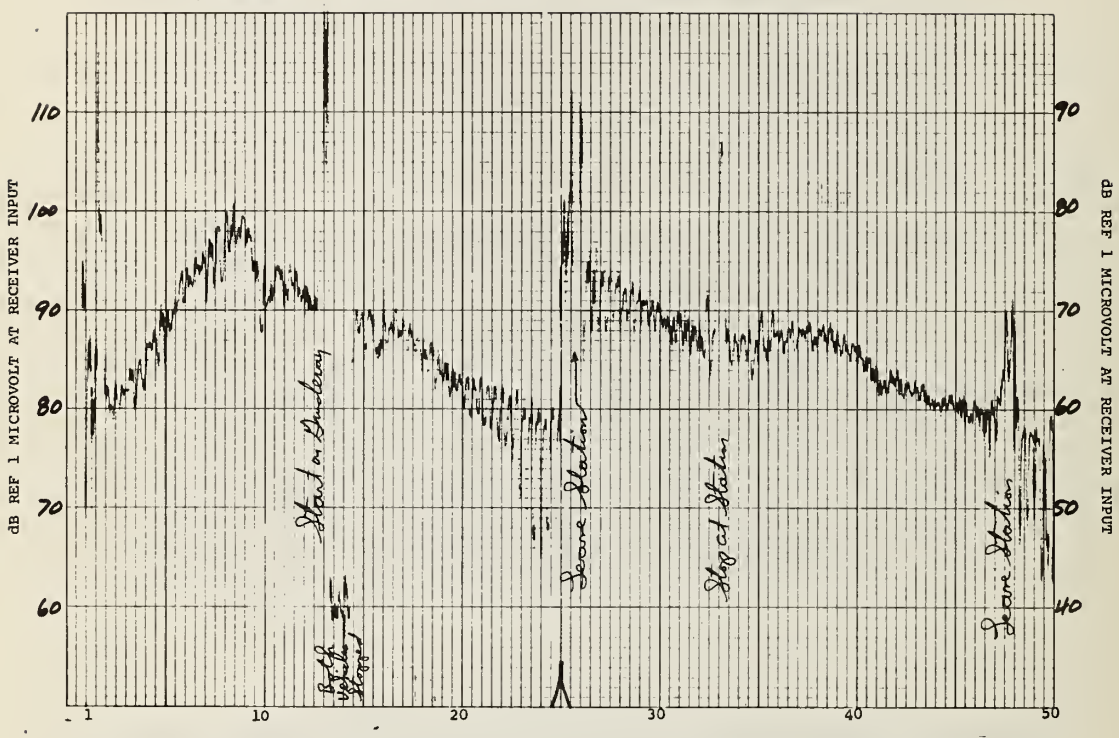

TEST NO. 243
INITIALS JH
DB REF 1 MICROVOLT
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
DC
100
200
300
400
500
600
700
800
900
1000
FREQUENCY (Hz)

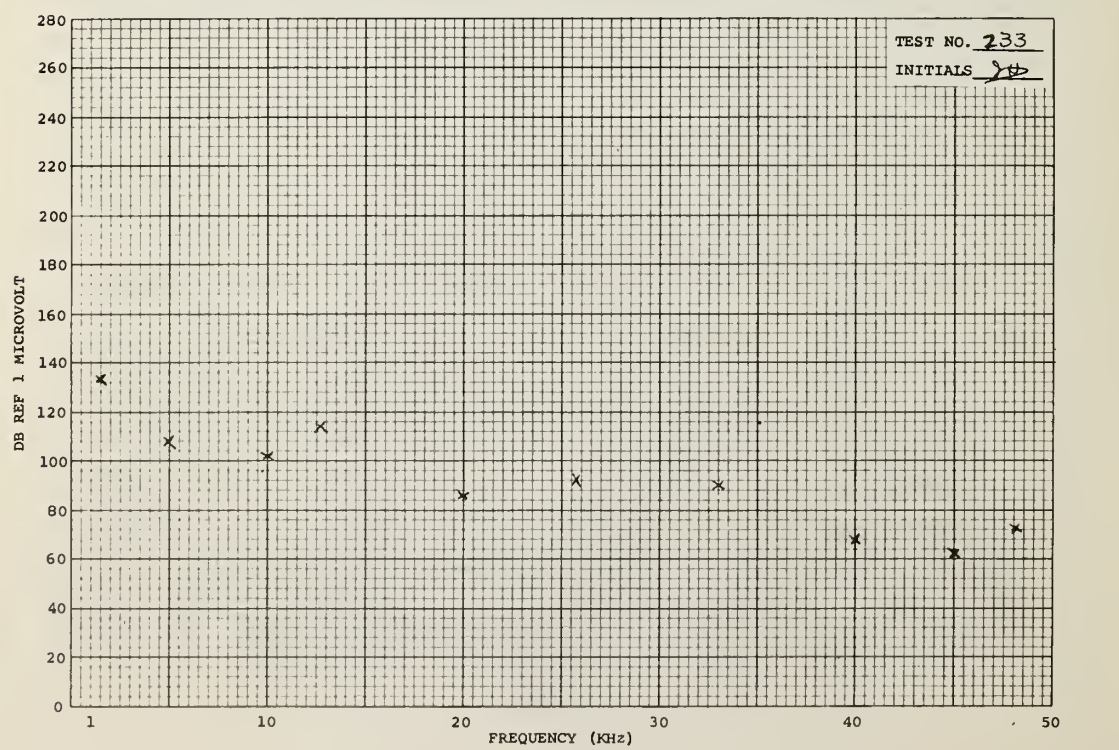
TEST NO. 244 TEST TYPE PLC BANDWIDTH 5 Hz 1036
TEST SPECIMEN ØB TEST EQUIP. EMC-10 DATE 7-27-72 EEJ
Monocab



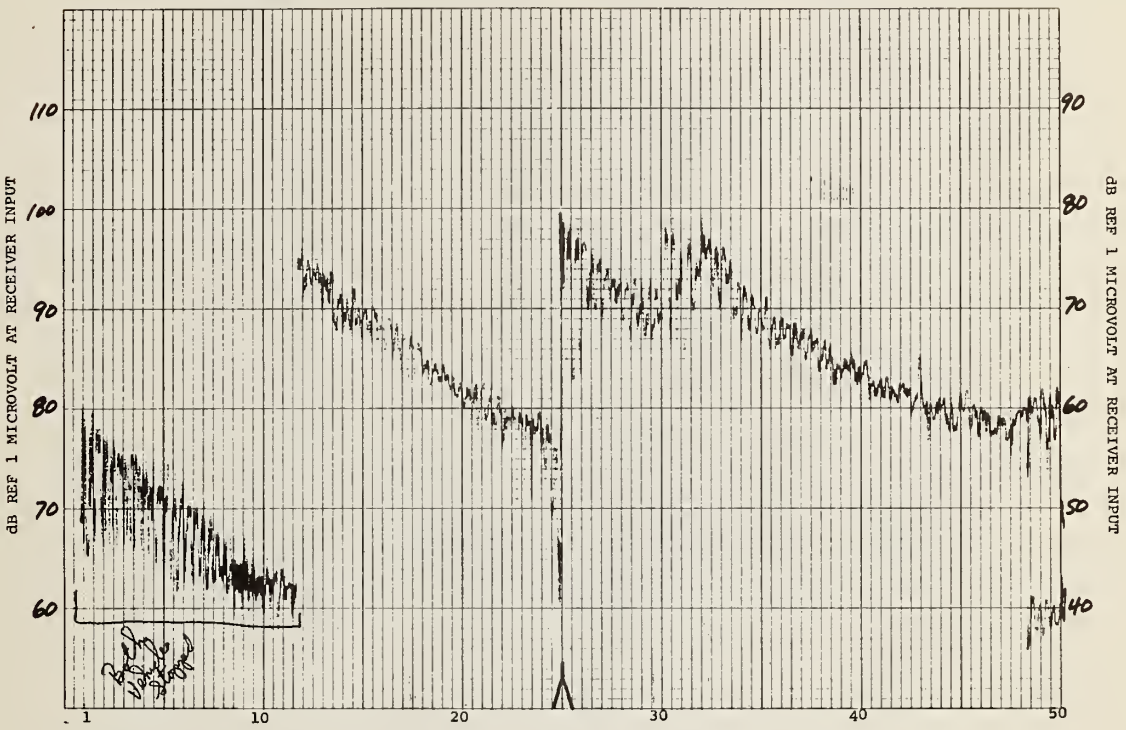


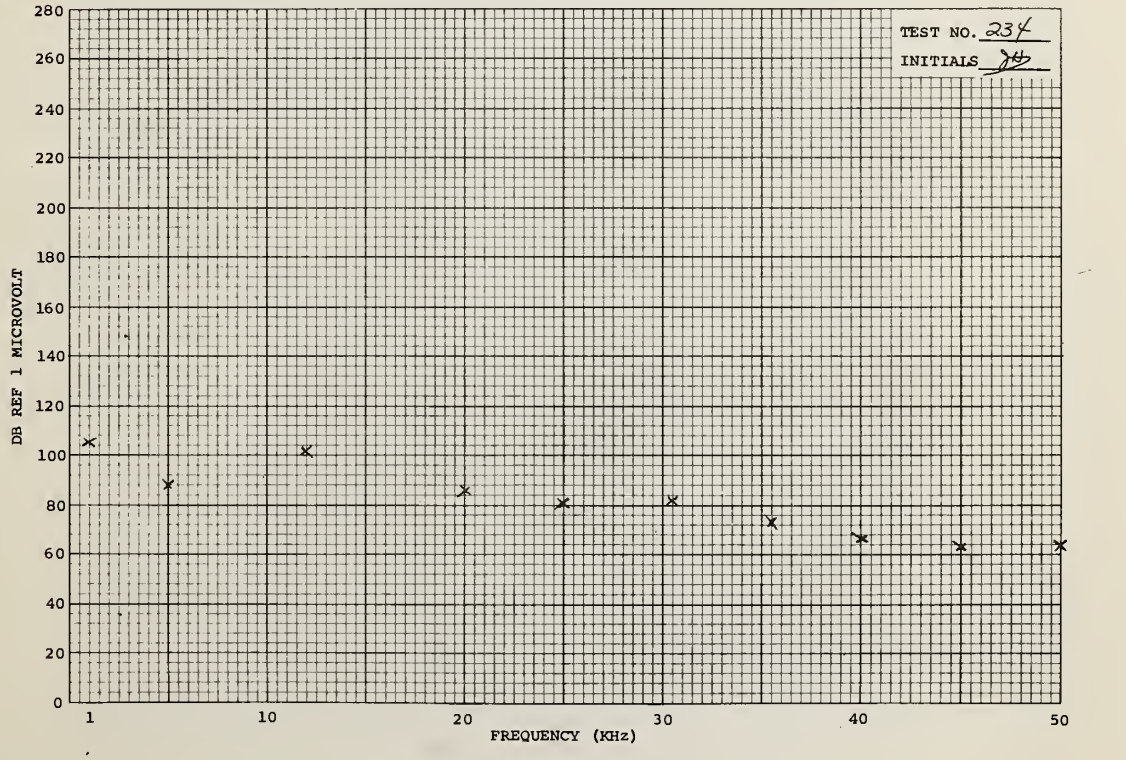
TEST NO. 233 | TEST TYPE PLC | BANDWIDTH 50Hz | 0835 EDJ
TEST SPECIMEN ϕB Monocal | TEST EQUIP. EMC-10 | DATE 7-27-72



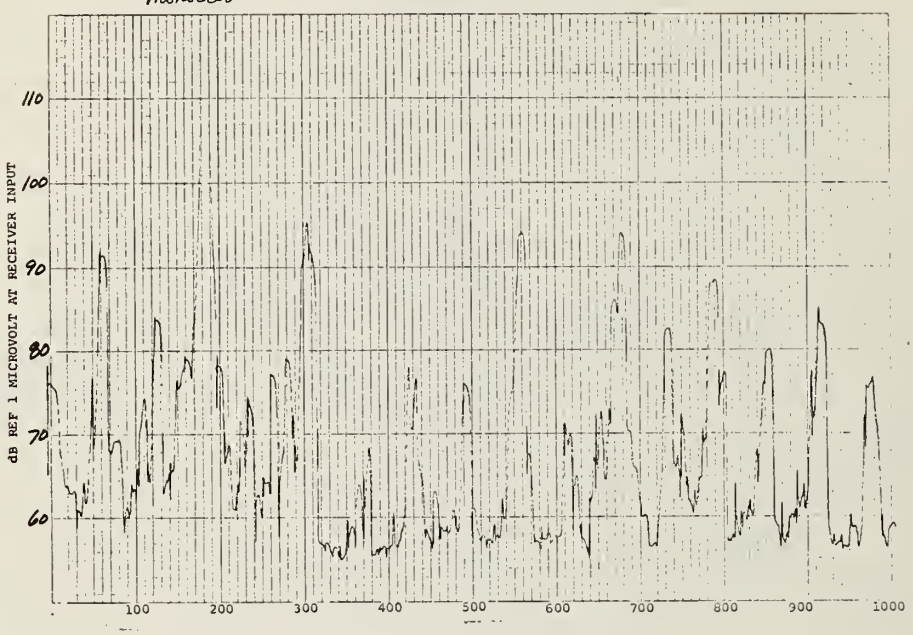


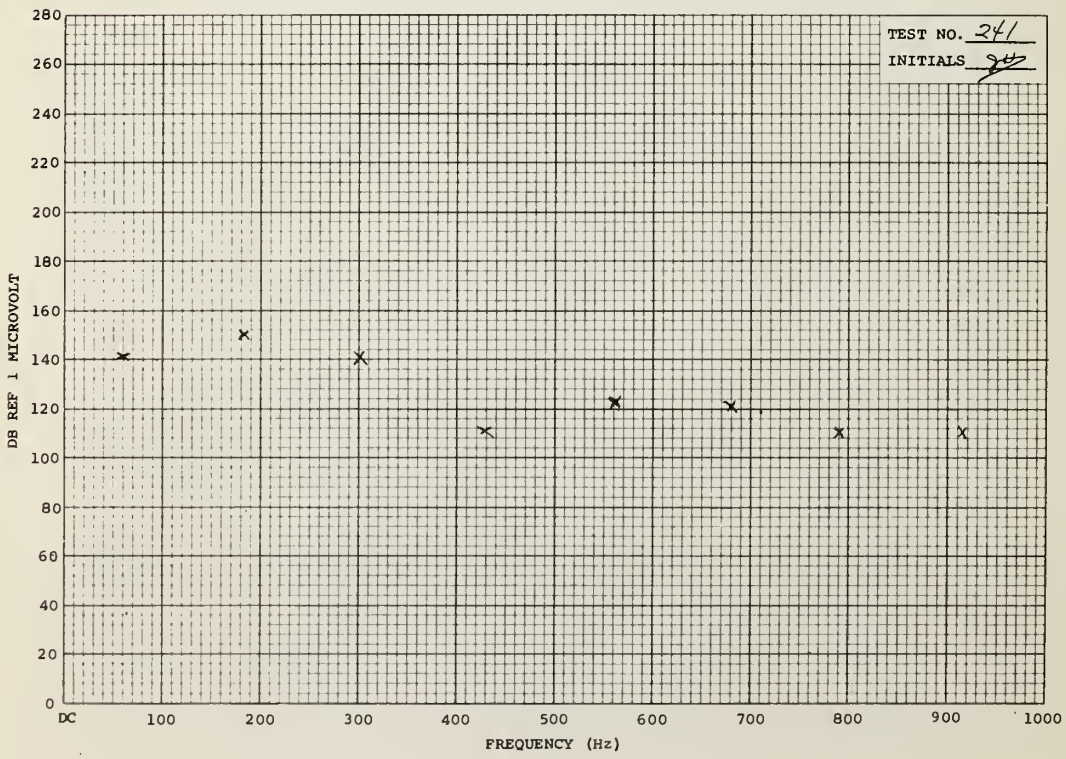
TEST NO. 234 TEST TYPE PLC BANDWIDTH 50Hz 0842
TEST SPECIMEN ØB TEST EQUIP. EMC-10 DATE 7-27-72
Monocal





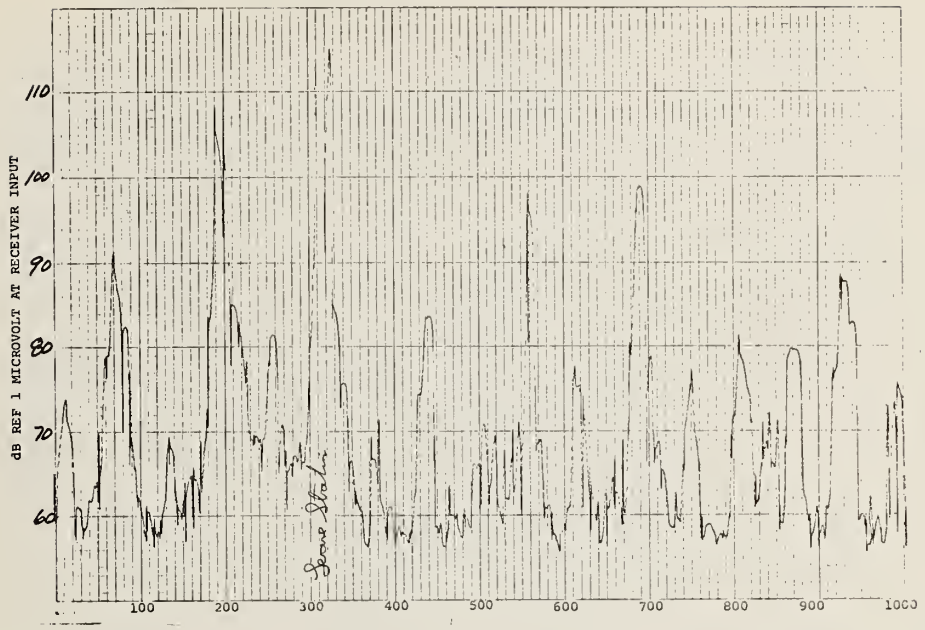
TEST NO. 241 TEST TYPE PLC BANDWIDTH 5 Hz 1020
TEST SPECIMEN ØC DATE 7-27-72
Monocal TEST EQUIP. EMC-10

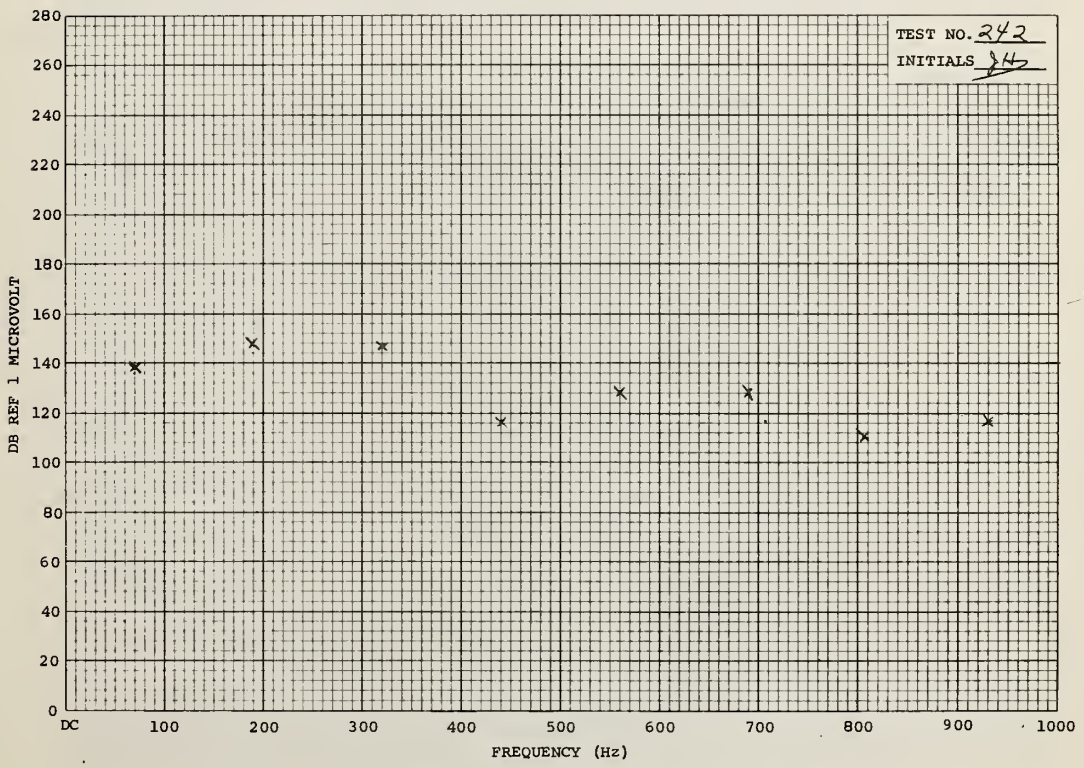




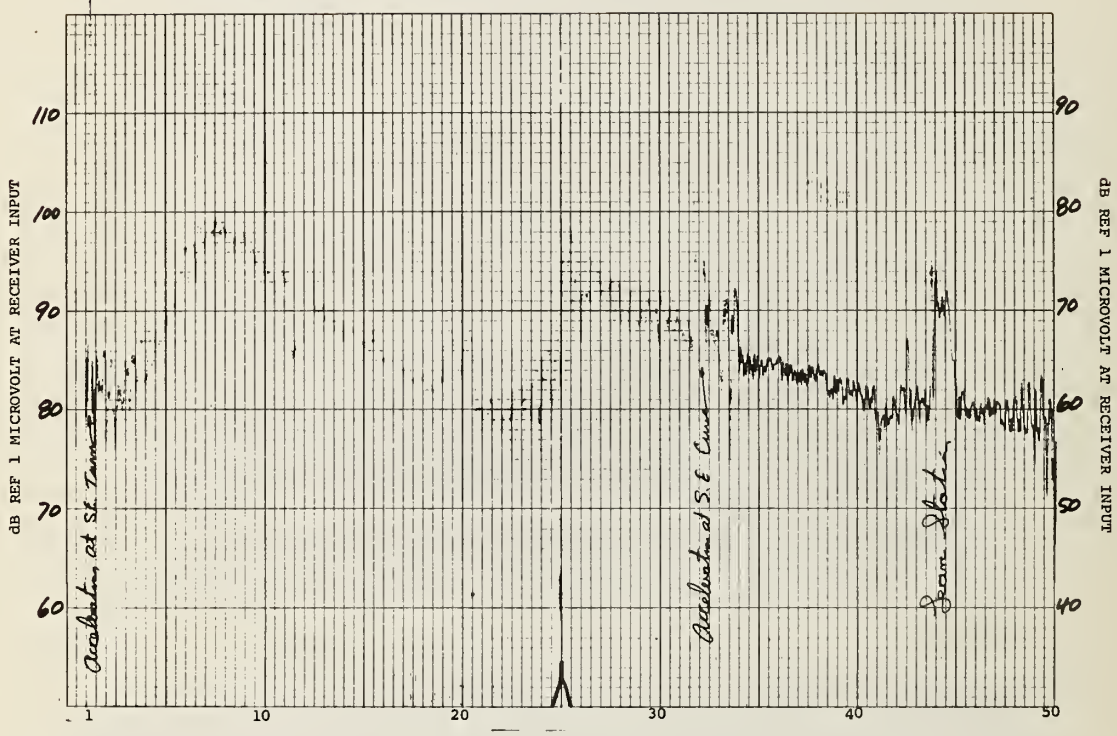
TEST NO. 242 TEST TYPE PLC BANDWIDTH 5 Hz
TEST SPECIMEN PC Monorail TEST EQUIP. EMC-10 DATE 7-27-72

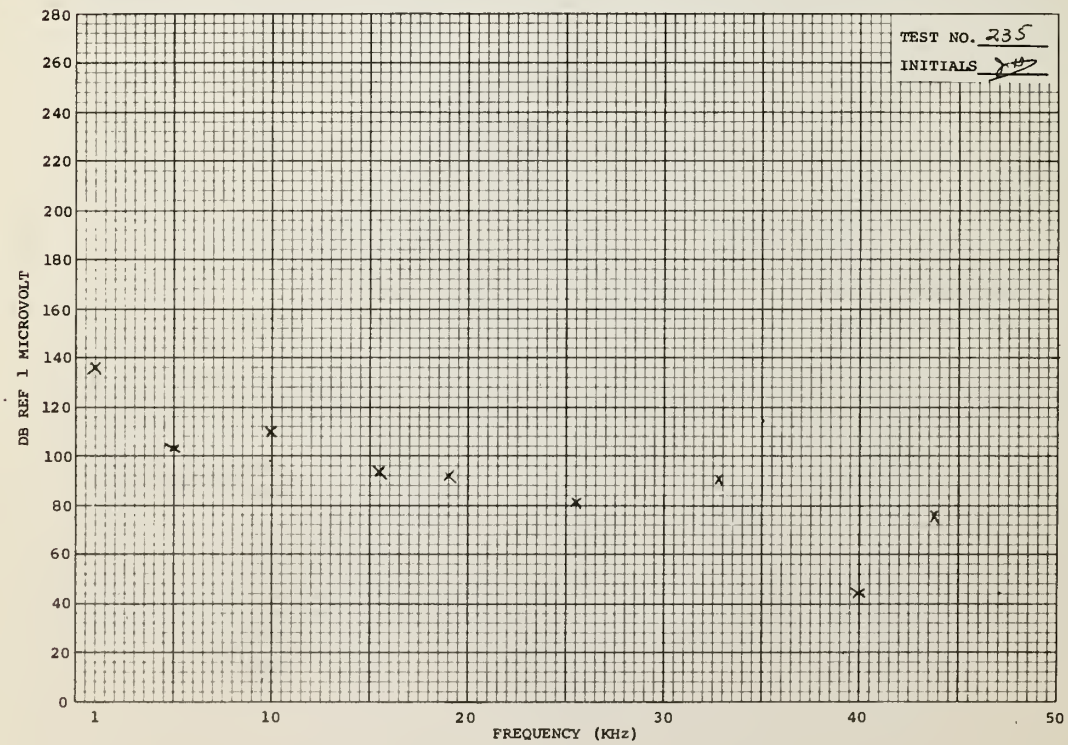
1028 EST



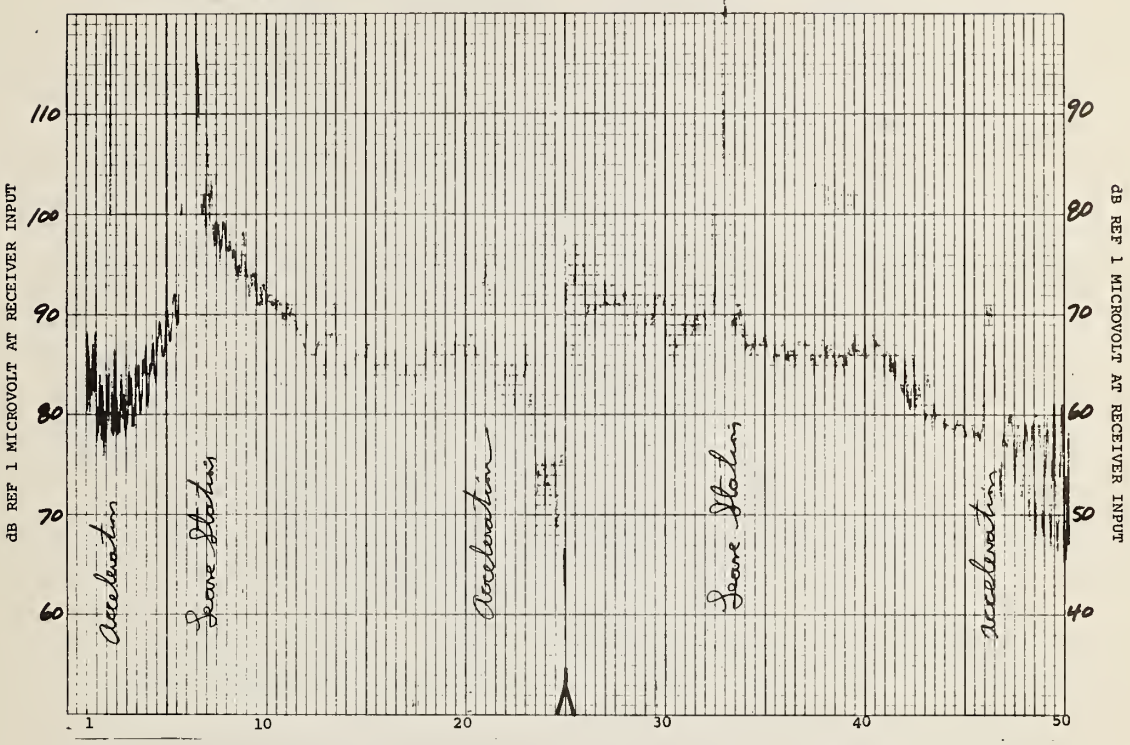


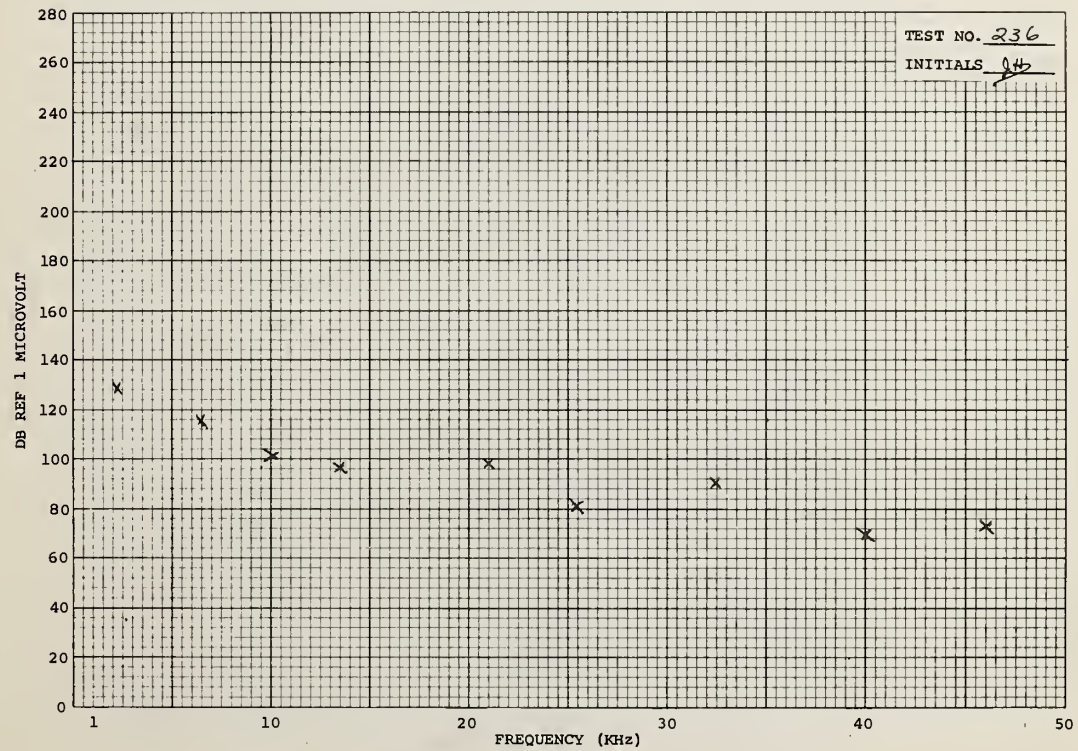
TEST NO. 235 TEST TYPE PLC BANDWIDTH 50Hz 0855
TEST SPECIMEN ϕC TEST EQUIP. EMC-10 DATE 7-27-72
Monrad



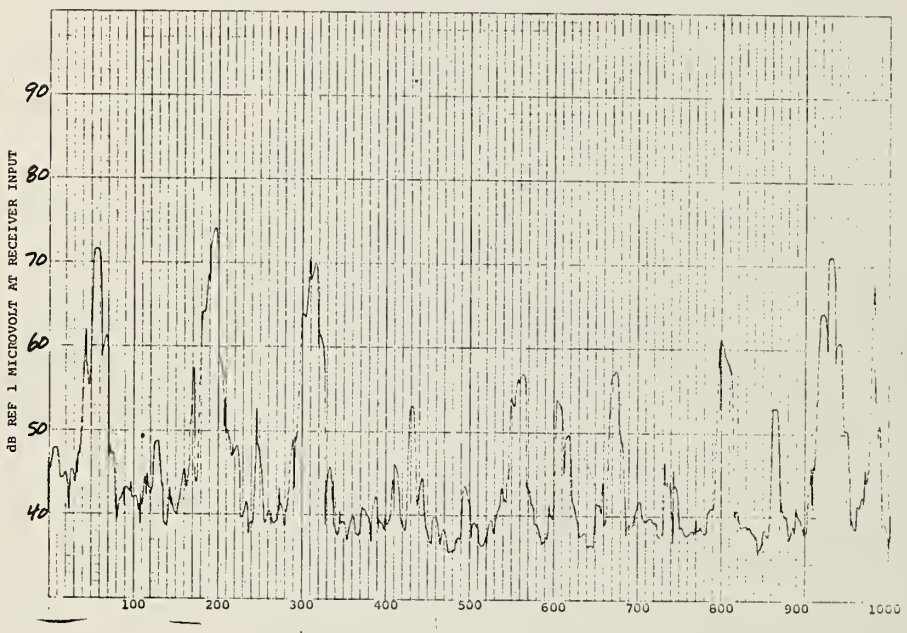


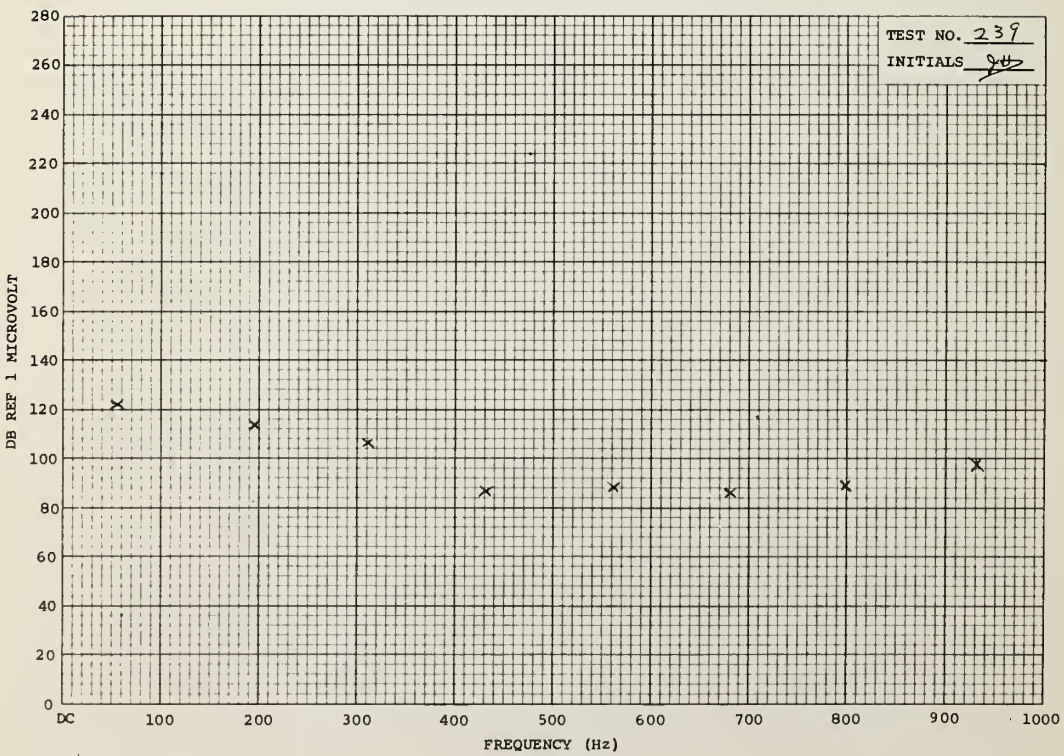
TEST NO. 236 TEST TYPE PLC BANDWIDTH 50Hz 0901
TEST SPECIMEN ØC TEST EQUIP. EMC-1e DATE 7-27-72
Monorab



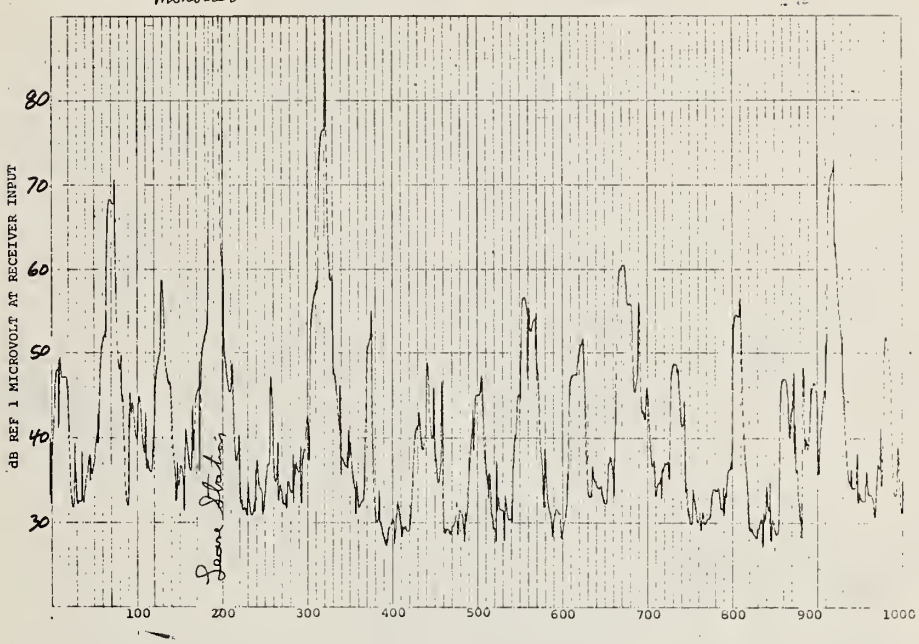


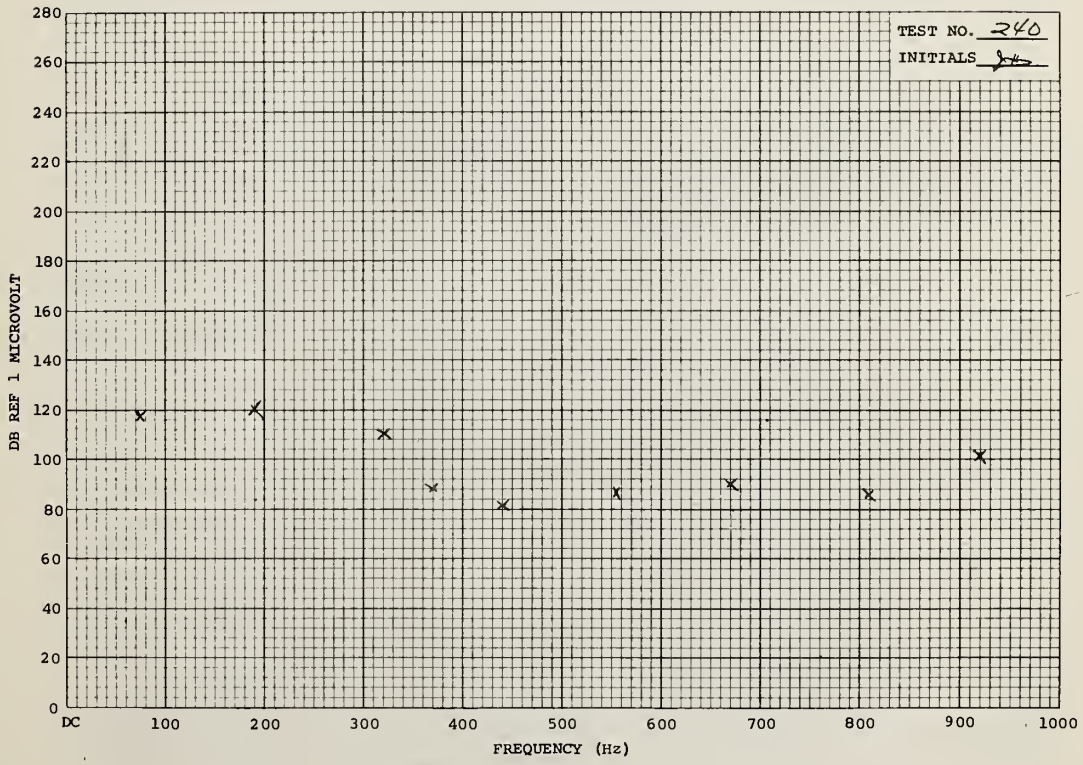
TEST NO. 239 TEST TYPE PLC BANDWIDTH 5 Hz 1012
TEST SPECIMEN Differential Monaural TEST EQUIP. EMC-10 DATE 7-27-72 EJ



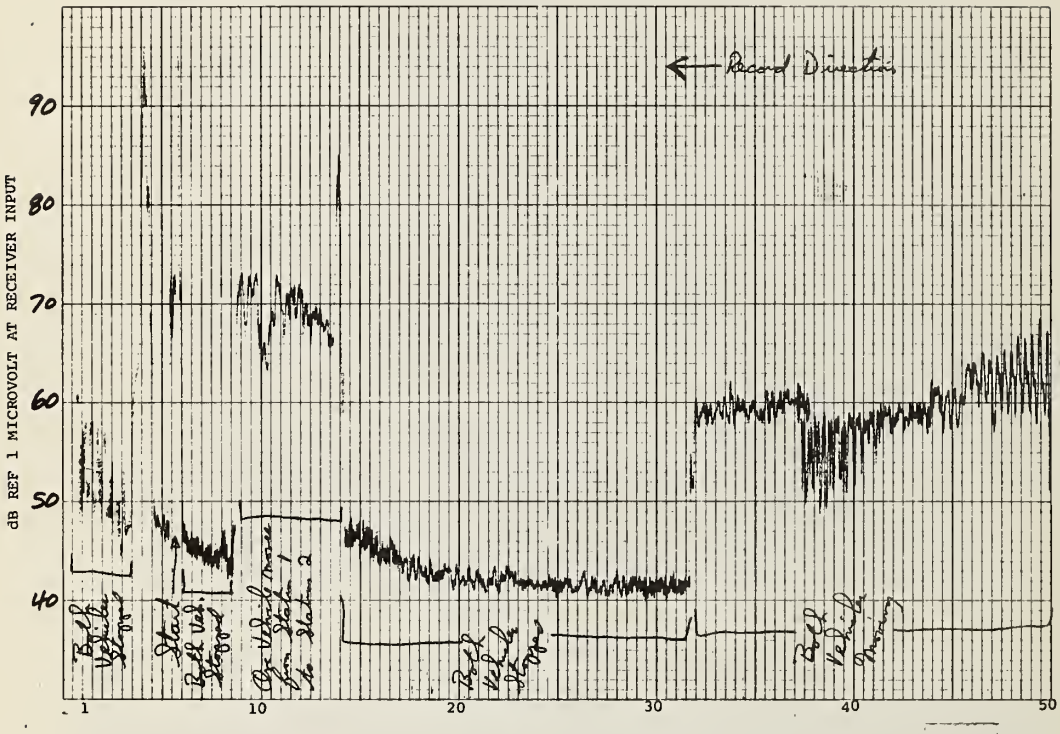


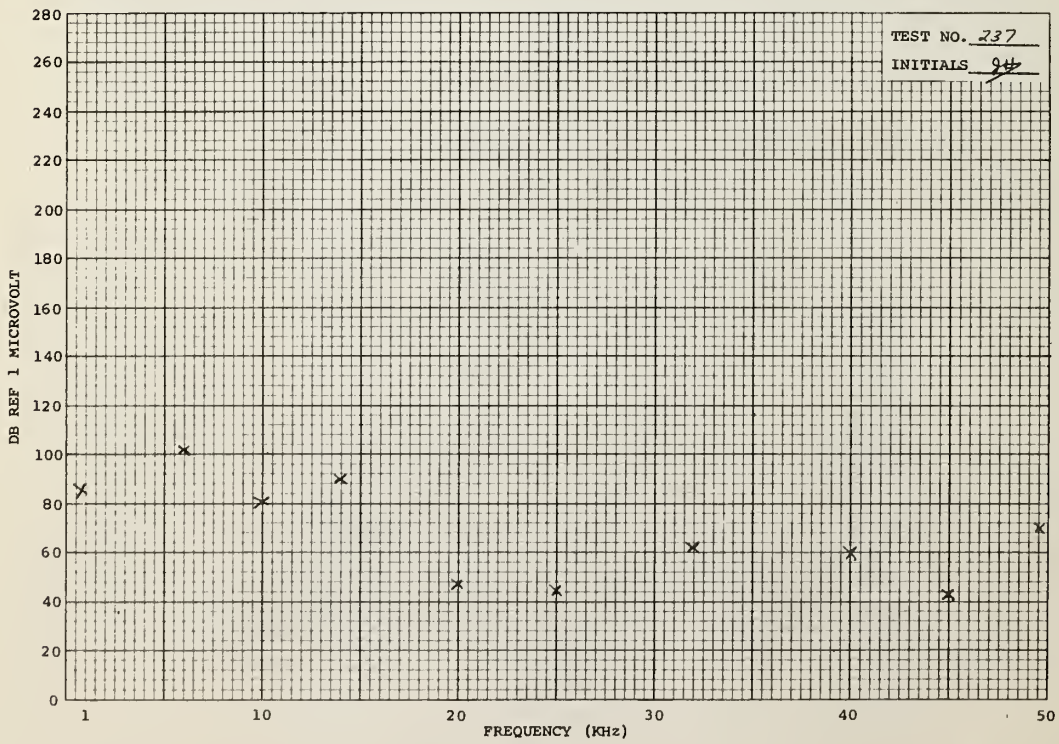
TEST NO. 240 TEST TYPE PLC BANDWIDTH 5Hz 1015
TEST SPECIMEN Neutral Monocab TEST EQUIP. EMC-10 DATE 7-27-72 EEJ



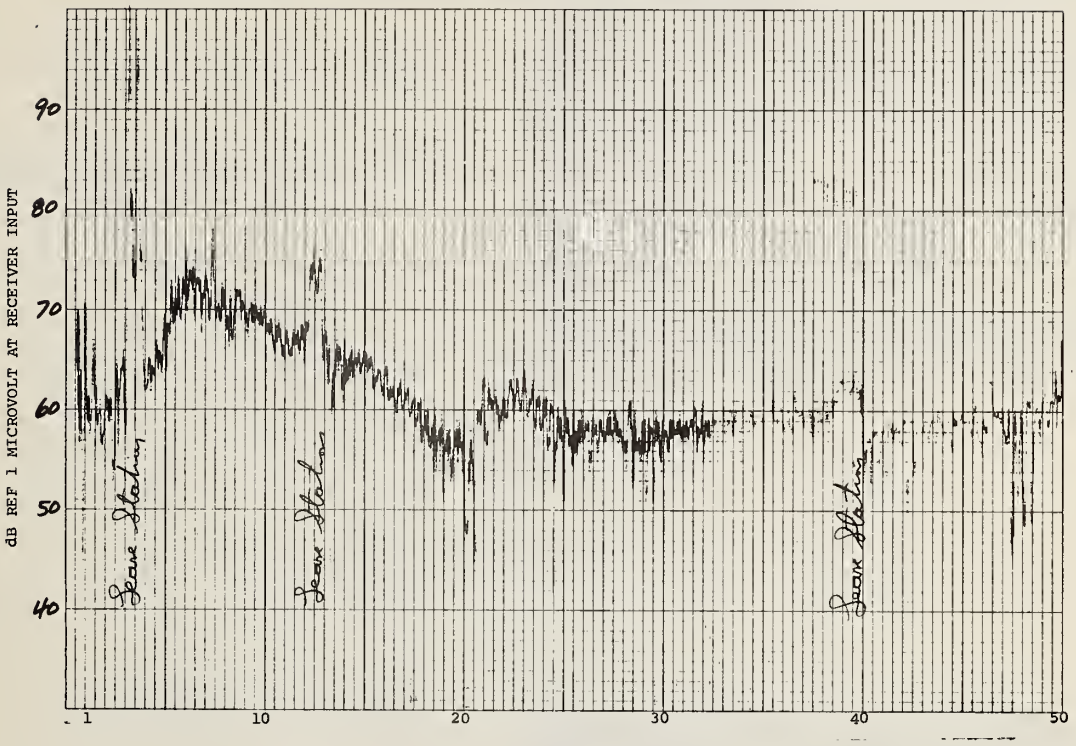


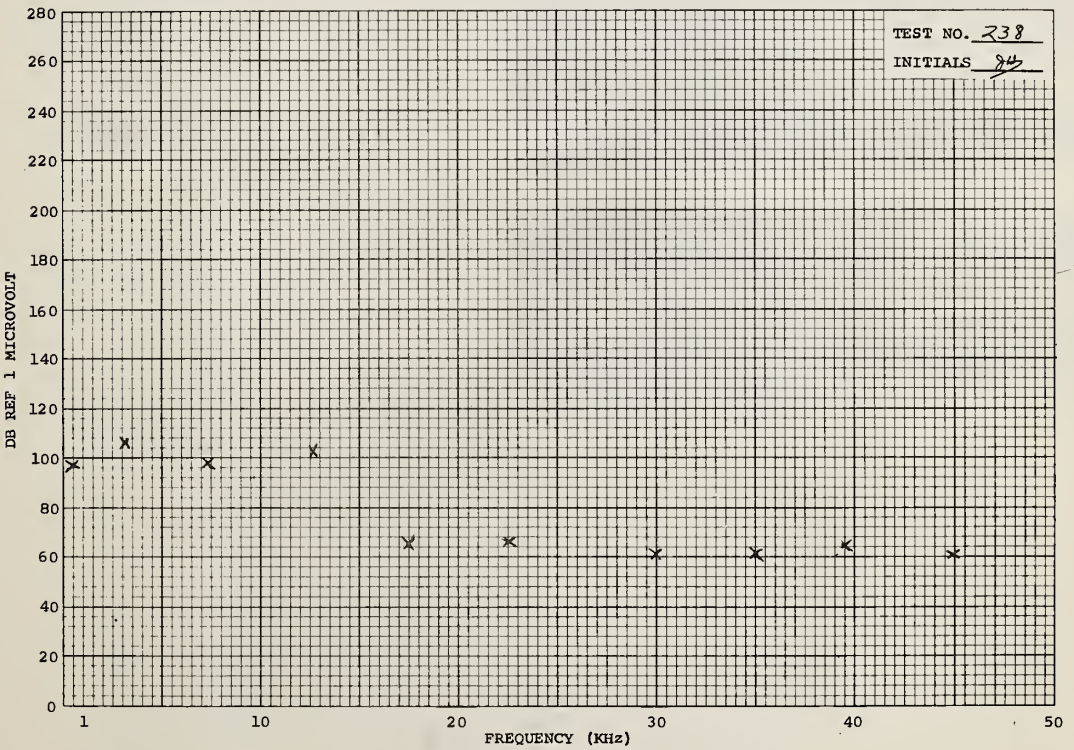
TEST NO. 237 TEST TYPE PLC BANDWIDTH 50Hz 0907
TEST SPECIMEN Neutral TEST EQUIP. EMC-10 DATE 7-27-72
Monocal

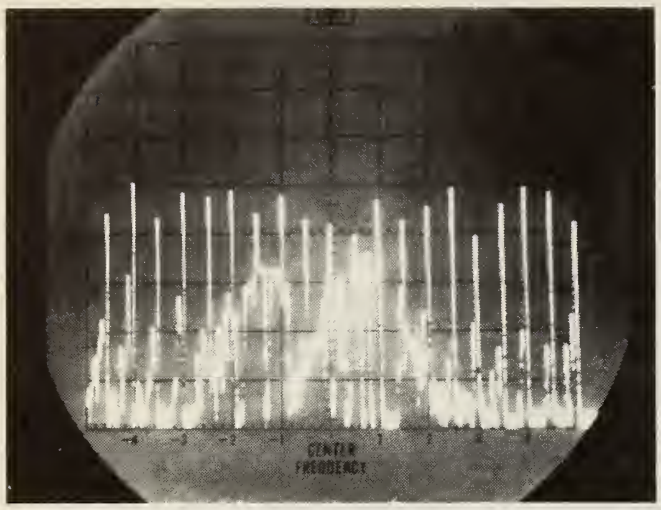




TEST NO. 238 TEST TYPE PLC BANDWIDTH 50Hz 0920
TEST SPECIMEN Ventral Monocab TEST EQUIP. EMC-10 DATE 7-27-72 EST







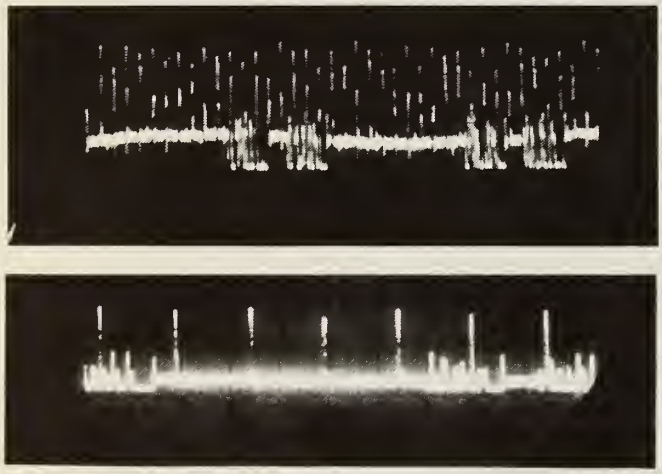
f_c

210KHz

Test No. 247 & 248
Neutral Power Line

Freq. Scan = 5 kHz/Div.
Sweep Rate = 5 msec/Div.

Amplitude: Center Gradicule Line is 104 dBμV/MHz (10 dB/Div.)



Conduction Signals at 210 kHz (No Freq. Sweep)

Time Between word groups is approximately 50 msec.

Lower recording is an expansion of the above recording.

August 27, 1972

MONOCAB

8:05	Main guideway power-on and both vehicles running automatic.
8:43	Both vehicles stopped.
8:54	Both vehicles running automatic.
9:11	Both vehicles stopped.
9:14	Both vehicles running automatic.
9:33	Both vehicles stopped (Coffee!)
10:09	Both vehicles running automatic.
11:08	Both vehicles stopped.
11:15	Both vehicles running automatic.
11:25	Both vehicles stopped.
11:35	Both vehicles running automatic.
11:50	Both vehicles stopped (Lunch).