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In-house Report
February 1977

VLF/LF ATMOSPHERIC NOISE STATISTICS RECORDED AT VIENNA, NEW YORK

Wayne Bonser
Lt Anthony J. Mlinar
George A. Pfeiffer

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ROME AIR DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
GRIFFISS AIR FORCE BASE, NEW YORK 13441

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PREFACE

This report details the preliminary work performed in the field of VLF Atmospheric Noise Analysis by RADC for the Defense Communications Agency (DCA). This work was accomplished under the Tri Service Propagation Measurement Program, also known as RADC project 97530001 (R184). The program manager is Mr. Alfred D. Paoni.

Megatek Corporation, Harbor City, CA developed the original design and built three Statistical Noise Analyzers by which atmospheric noise is measured and its characteristics recorded.

Mr. George Pfeiffer (RADC) has been instrumental in the acquisition of the Statistical Noise Analyzers and the collection of atmospheric noise data. Mr. Pfeiffer has management responsibility for the installation, operation, and maintenance of the three collection sites.

This report has been reviewed by the RADC Office of Information and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

This report has been reviewed and is approved for publication. Any further details can be obtained by contacting RADC/DCCL (Mr. Alfred D. Paoni/315-330-3077).

Approved: LAURENCE W. DOUBLEDAY
Chief, Communications Transmission Branch
Communications and Control Division

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This report documents the preliminary work performed in the field of Atmospheric Noise Analysis. The data presented in this report characterizes the "real-world" atmospheric noise conditions as were observed during the first half of 1975 at Vienna, New York, and gives the VLF communication community an opportunity to become familiar with the equipment, the methods, and the statistics collected.

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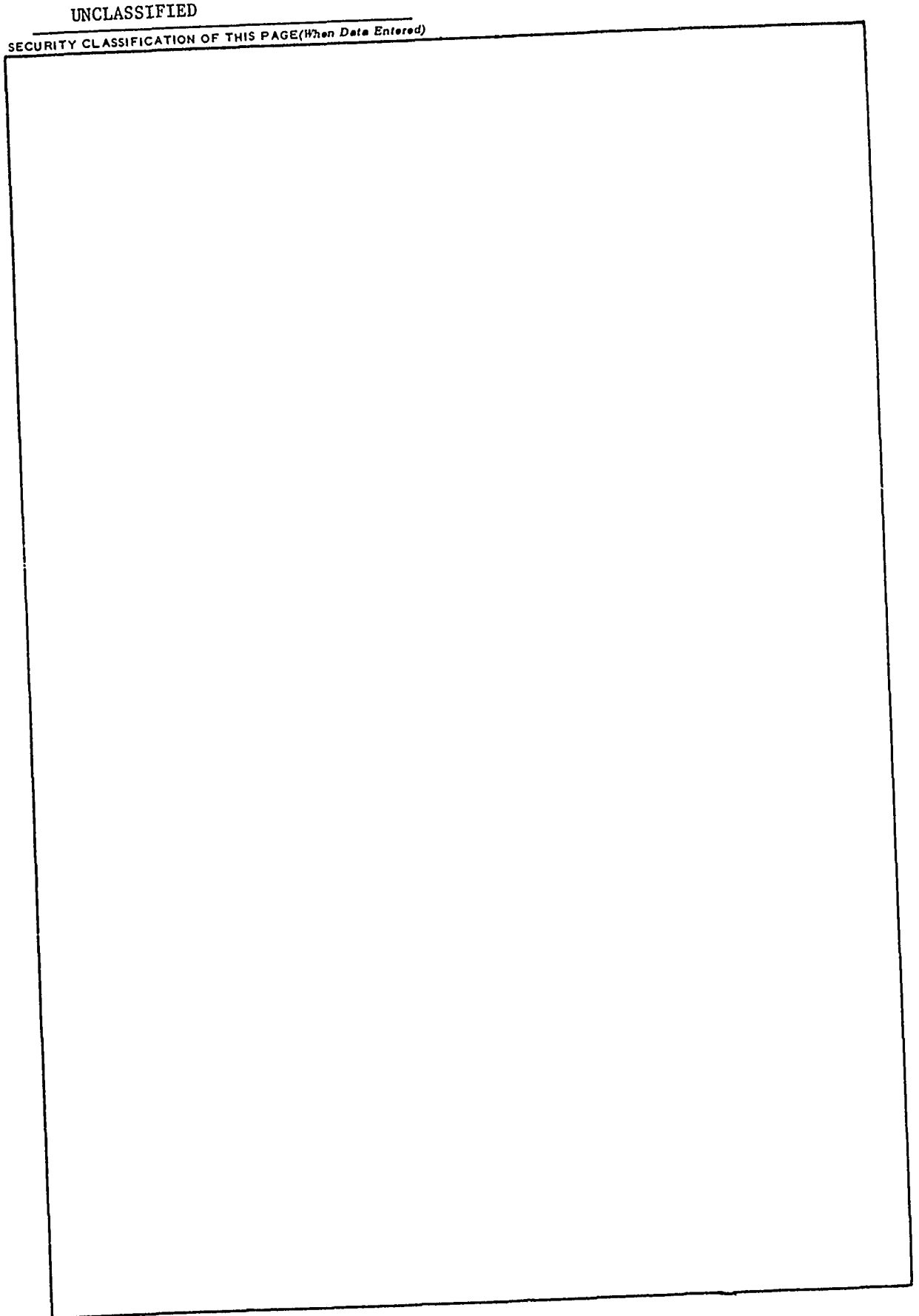

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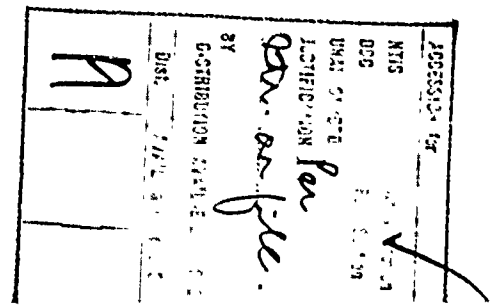

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LIST OF ABBREVIATIONS

ADEN	Amplitude Density Function
ACUM	Amplitude Cumulative Distribution
APD	Amplitude Probability Distribution
bpi	bits per inch
dB	decibels
EAVE	Envelope Voltage Average Value
ERMS	Envelope Voltage Root-Mean-Square Value
EVD	Envelope Voltage Deviation
Hrs	Hours
Hz	Hertz
ips	inches per second
KHz	Kilo Hertz
SAVE	Space Moment (Average)
SCUM	Space - Cumulative Distribution
SDEN	Space Density
SMSQ	Space Moment (Squared)
SNA	Statistical Noise Analyzer
SVAR	Space Variance
VLF/LF	Very Low Frequency and Low Frequency
WAVE	Width Moment (Average)
WCUM	Width-Cumulative Distribution
WDEN	Width Density
WMSQ	Width Moment (Squared)
WVAR	Width Variance

CHAPTER I

INTRODUCTION

1.0 GENERAL

An important segment of the Department of Defense's Minimal Essential Emergency Communications Network (MEECN) is the Very Low Frequency and Low Frequency (VLF/LF) communications. Assurance of reliable communications requires the knowledge of transmission amplitudes, propagation characteristics, receiver characteristics, noise levels and time distributions. Determination of character-error-rates, and the minimal levels required for satisfactory VLF reception, in the absence of interfering transmissions, requires detailed knowledge of the VLF noise environment.

The measurement of atmospheric noise is accomplished by the utilization of specialized VLF receive and analysis systems. The receiver/analyzer known as a Statistical Noise Analyzer (SNA) is controlled by a mini-computer. These receivers measure noise amplitude, pulse width, and pulse spacings on ten channels within the 10-60 KHz spectrum. The data collected by one of these analyzers, at RADC's Vienna Test Annex and the subsequent analysis, is the subject of this report.

1.1 THE REPORT

The recently developed ten channel, automatic Statistical Noise Analyzers have been installed at sites around the world (North Dakota USA; Greenland; and Sweden). The data gathered at these sites will be analyzed and correlated to give the VLF noise characteristics in the Northern Area.

Data was collected by one Statistical Noise Analyzer at a site near Rome, N.Y., before installation of the receivers at distant sites, to allow a "burn-in" period for one such unit and enable RADC engineers to develop collection schedules and analysis programs. The data analyzed for the Spring (March, April, May) period and the characteristics of the analyzers are presented here to give the VLF communications community an opportunity to familarize themselves with the equipment, the methods, and the statistics collected.

1.2 SIGNIFICANCE OF THE EFFORT

The use of a specialized measurement system which automatically collects atmospheric noise measurements on a multiple of frequencies in the VLF spectrum, is a relatively new concept. The types of statistics now being studied have never been available before and will lead to a more thorough understanding of atmospheric noise characteristics. Pulse width and pulse spacing, of atmospheric noise spikes, are some of the statistics now being collected which have never before been the subject of investigation. CCIR curves have never been adjusted to real-world data, at these frequencies. A historgram of data, taken over a number of years, will allow the seasonal trends to be determined without extrapolation. All the information derived from this data will be useful in upgrading computer propagation models and possibly for adjustment of the CCIR curves for the High Latitudes and low frequencies.

1.3 BACKGROUND

The noise environment can be divided into two broad categories: internal noise, and externally emitted interference. The internal noise originates either as thermal noise from within electronic devices, or as power line or power supply fluctuations which develop from increasing (decreasing) loads, or are residual components of filtering networks. This type of noise can be easily measured, is consistent, and is predicticable.

External noise can be separated into several definitive groups: Electrostatic, Atmospheric, and Man-made.

Precise measurements of propagation statics and atmospheric noise properties have been insufficient in quantity to permit accurate determination of message reception reliability at VLF. To augment available propagation data, both the Air Force and the Navy have developed sophisticated mathematical models.

Sufficient geophysical data has been gathered in the Temporate Zone to substantiate the accuracy of the models there. However, the quantity of data collected in the Northern Regions has been too limited to validate these prediction models for areas above the 50th parallel. In order to obtain the necessary information on propagation characteristics and atmospheric noise properties, the Defense Communications Agency has organized the Tri-Service Propagation Measurement Program.

There are two integral portions of this program: the collection of geophysical parameters of VLF/LF transverse magnetic waves, over long paths at high altitudes; and the collection and analysis of atmospheric noise data. The latter is being accomplished through the

utilization of Statistical Noise Analyzers positioned along a straight line across the Northern Hemisphere (above the 50th parallel).

1.4 ORGANIZATION

This report is organized as follows:

Chapter 2 describes the equipment used in the collection and analysis of the atmospheric noise data.

Chapter 3 explains which parameters are measured, what statistics are calculated, and what the correlation of data provides.

Chapter 4 describes the data collected at RADC's Vienna Test annex and the subsequent analysis.

Chapter 5 contains all the graphs which were drawn from the Vienna data.

Chapter 6 summarizes the results of the analysis of the Vienna data and the plan for the actual collection of atmospheric noise data in the Northern Area.

CHAPTER 2

EQUIPMENT CONFIGURATION

2.0 MINI-COMPUTER

The Nova 1200 minicomputer has 16K (16 bit) of core memory, and a processor cycle time of 2.6 microseconds. This Nova is equipped with hardware multiply/divide circuitry and a "program-load" option which allows the automatic loading of absolute binary programs. The Nova controls all the peripheral devices, including the Statistical Noise Analyzer. The Nova also computes (on a real-time basis) the statistics which can be calculated from the measured data.

2.1 PAPERTAPE READER

The high speed papertape reader can be adapted to read 5, 6, 7 or 8 channel punched papertape. This unit can read at a speed of 100-600 characters per second and is the secondary input device..

2.2 MAGNETIC TAPE

A magnetic tape drive is used to record digital data for further analysis and correlation. The tape speed is 12.5 ips (inches per second) with a recording density of 800 bpi (bits per inch). This is the primary output device.

2.3 DIGITAL CLOCK

This clock is used for time-of-day information and for the control of system functions dependent on time. This clock is resettable (24 Hrs) and transfers data (Hrs, Mins, Secs, 10th Secs) back to the Nova via the Statistical Noise Analyzer.

2.4 TELETYPE

An ASR 33 Teletype sends and receives messages at 100 words per minute and is the primary input device and operator interface.

2.5 STATISTICAL NOISE ANALYZER

The Statistical Noise Analyzer (SNA) receives, through its own crossed-loop antenna, noise and signal voltages which, after detection, are categorized into 42 amplitude levels. The SNA simultaneously measures pulse width and pulse spacing. The data is transmitted to the Nova computer at a 10KHz rate. The receiver bandwidths are selectable at 2KHz, 1KHz, 600Hz, and 200Hz. The frequency range of the

Statistical Noise Analyzer is 10KHz to 100KHz. The antenna patterns are either a "figure-eight" pattern oriented in any one of four directions, or an omnidirectional pattern. The SNA has a dynamic range of over 120dB.

2.6 REDUCTION/CORRELATION SYSTEM

The final analysis center is located at RADC and is comprised of a Nova 1200 Jumbo computer equipped with 32k of memory, hardware multiply/divide circuitry, floating point arithmetic circuitry, real-time clock, and program load option. This system is presently configured with the following peripheral devices: a teletype, a papertape reader, a flat-bed plotter, a 1.25 million work disk, and two 9 track magnetic tape drives. This system is utilized to correlate the statistical data recorded on digital tape by the SNA's, plot graphs, and tabulate seasonal statistics.

CHAPTER 3

PARAMETERS

3.0 MEASUREMENTS & STATISTICS

The Statistical Noise Analyzer compiles data by measuring the highest amplitude level (threshold) which was exceeded by a noise sample. There are 42 threshold levels that are set at 3dB increments. The fraction of time a sample remains above a certain level (set by the operator) is also measured. The following statistics are then calculated by the Nova 1200 minicomputer:

AMPLITUDE STATISTICS:

a. The Density Function (ADEN)

b. The Cumulative Distribution (ACUM)

c. The Amplitude Probability Distribution (APD)

d. The Envelopes Average Value (EAVE)

e. The Envelopes RMS Value (ERMS)

f. The Envelope Voltage Deviation (APD)

TIME STATISTICS:

a. Width & Space Density (WDEN/SDEN)

b. Width & Space Cumulative Distribution (WCUM/SCUM)

c. First Spacing Moments (WAVE/SAVE)

d. Second Spacing Moments (WMSQ/SMSQ)

e. Width & Space Variance (WVAR/SVAR)

3.1 CORRELATION

These statistics, when compared month to month, will display seasonal trends and the differences between receiver site locations. When enough data is gathered and statistics calculated, a comparison between predicted noise values and measured values can be made to determine the validity of CCIR predictions.

CHAPTER IV

VIENNA COLLECTION & ANALYSIS

4.0 DATA COLLECTED

From January 1975 through June 1975 one Statistical Noise Analyzer was operated on these ten frequencies: 10.7, 14.0, 17.0, 20.0, 27.0, 40.0, 43.0, 47.0, 50.0, and 55.0 Kilo Hertz. The statistics on Amplitude were of major interest and are the only statistics which are presented in this report. The specific items of concern were the behavior of EVD and ERMS values over time and frequency.

4.1 ANALYSIS

During the first two months at Vienna many adjustments and equipment tests were performed. For this reason, the months with the largest atmospheric noise data-base were March, April, May, and June. However, the data tabulated over all six months (Jan-June) was plotted, via a NOVA 1200/DP1 plotter, as Amplitude versus Time for each of the ten frequencies monitored. Then, after careful examination, the three-month period, March, April, May, was selected as the most comprehensive time span to be used in further analysis. This is the same time block used by CCIR as the "Spring Season."

The data from this time period was averaged, and the standard deviations were calculated. These averages (EVD & RMS) and their limits ($\pm$ standard deviation) were plotted on an hour-by-hour scale, as a continuous Bargraph, for each of the ten frequencies. These graphs display the effects of time-of-day on EVD and ERMS. The mean values were plotted by hand on a scale of Amplitude versus Frequency. These graphs display the frequency characteristics of EVD and ERMS at VLF. These plots, and others, are presented in the following chapter.

5.0 - PLOTTED DATA

CHAPTER V

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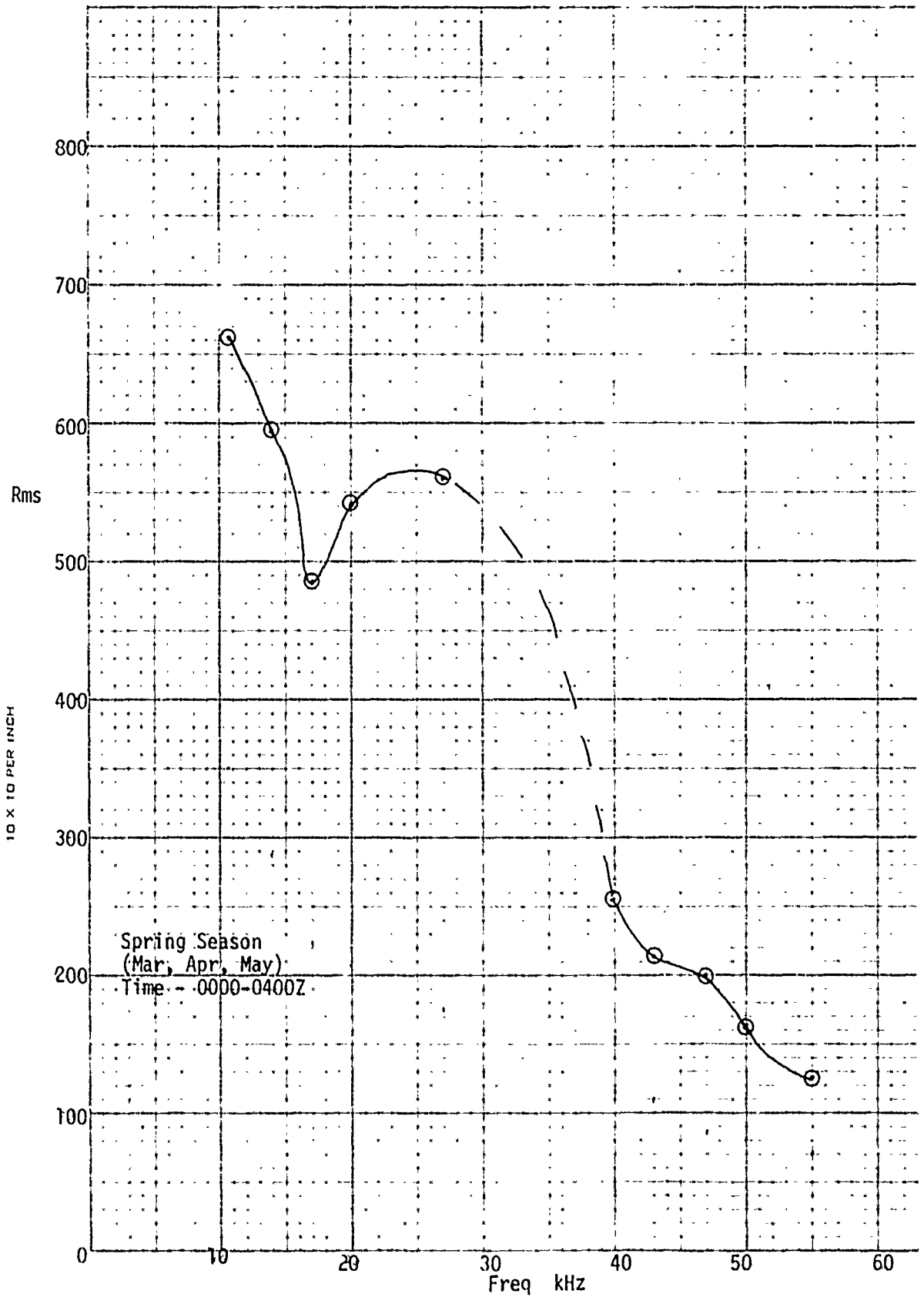
5.1 - ERMS vs FREQ. (SPRING SEASON)


800
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Rms
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10 X 10 PER INCH
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Spring Season
(Mar, Apr, May)
Time - 0000-0400Z
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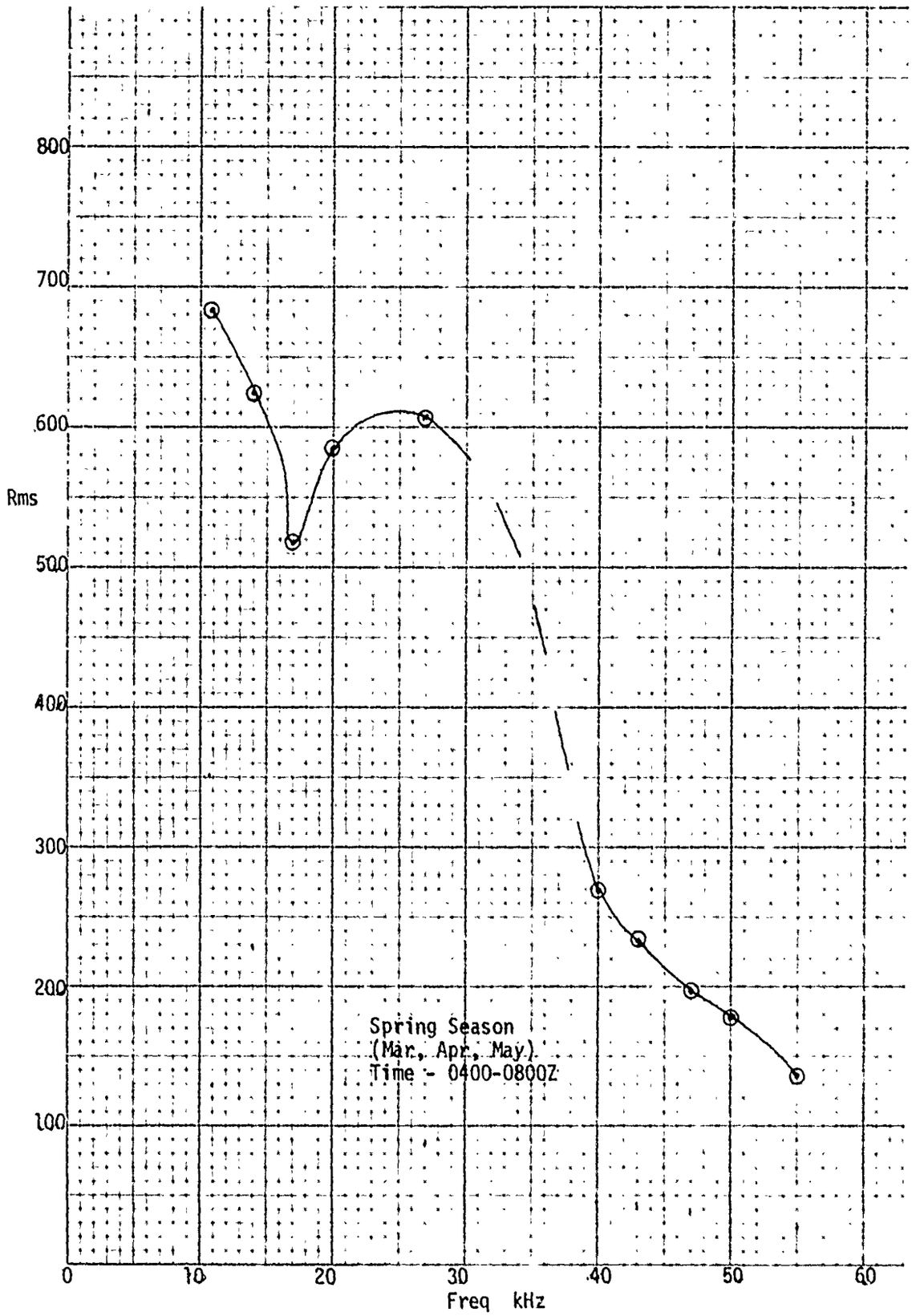
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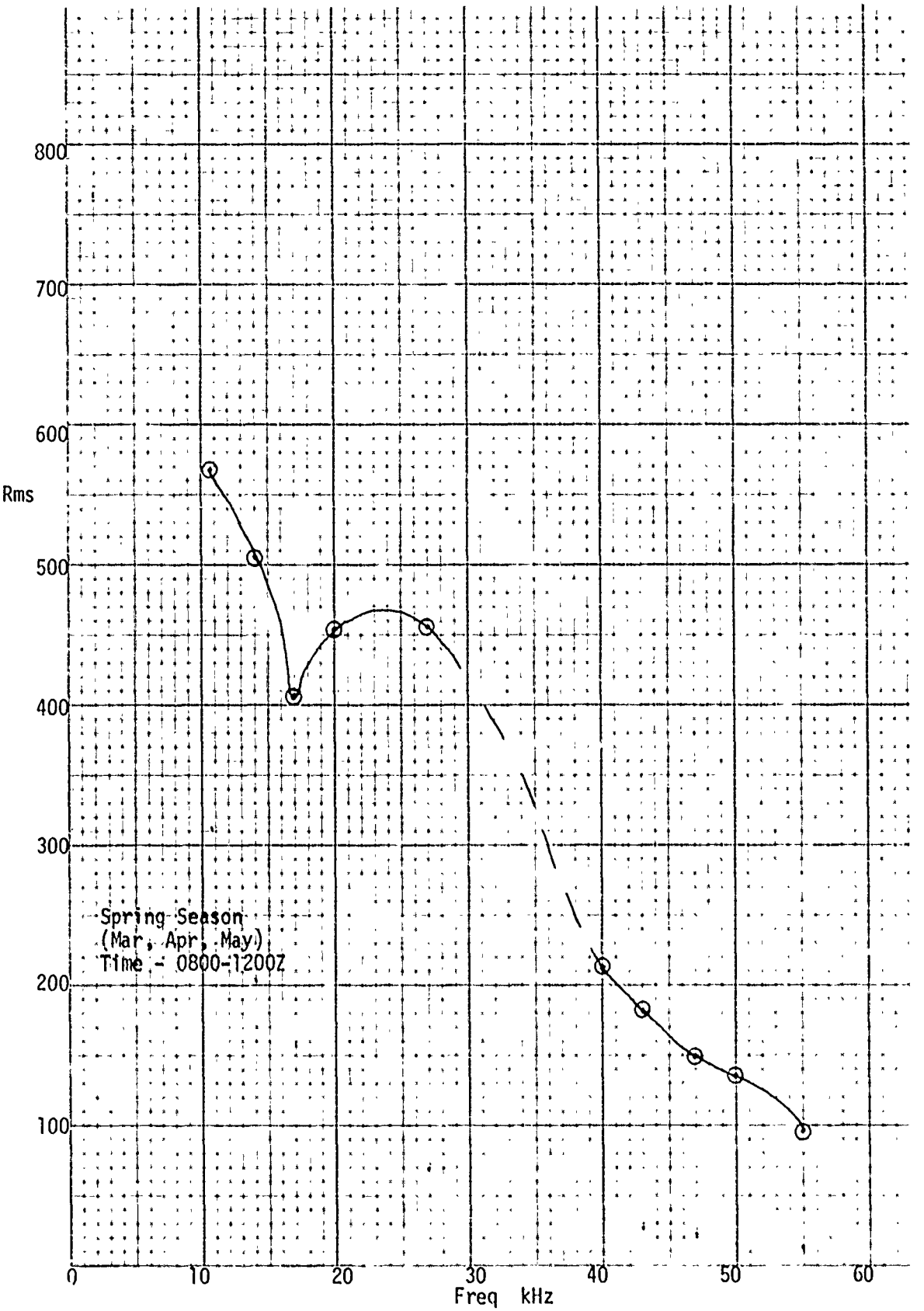
Spring Season
(Mar, Apr, May)
Time - 0400-0800Z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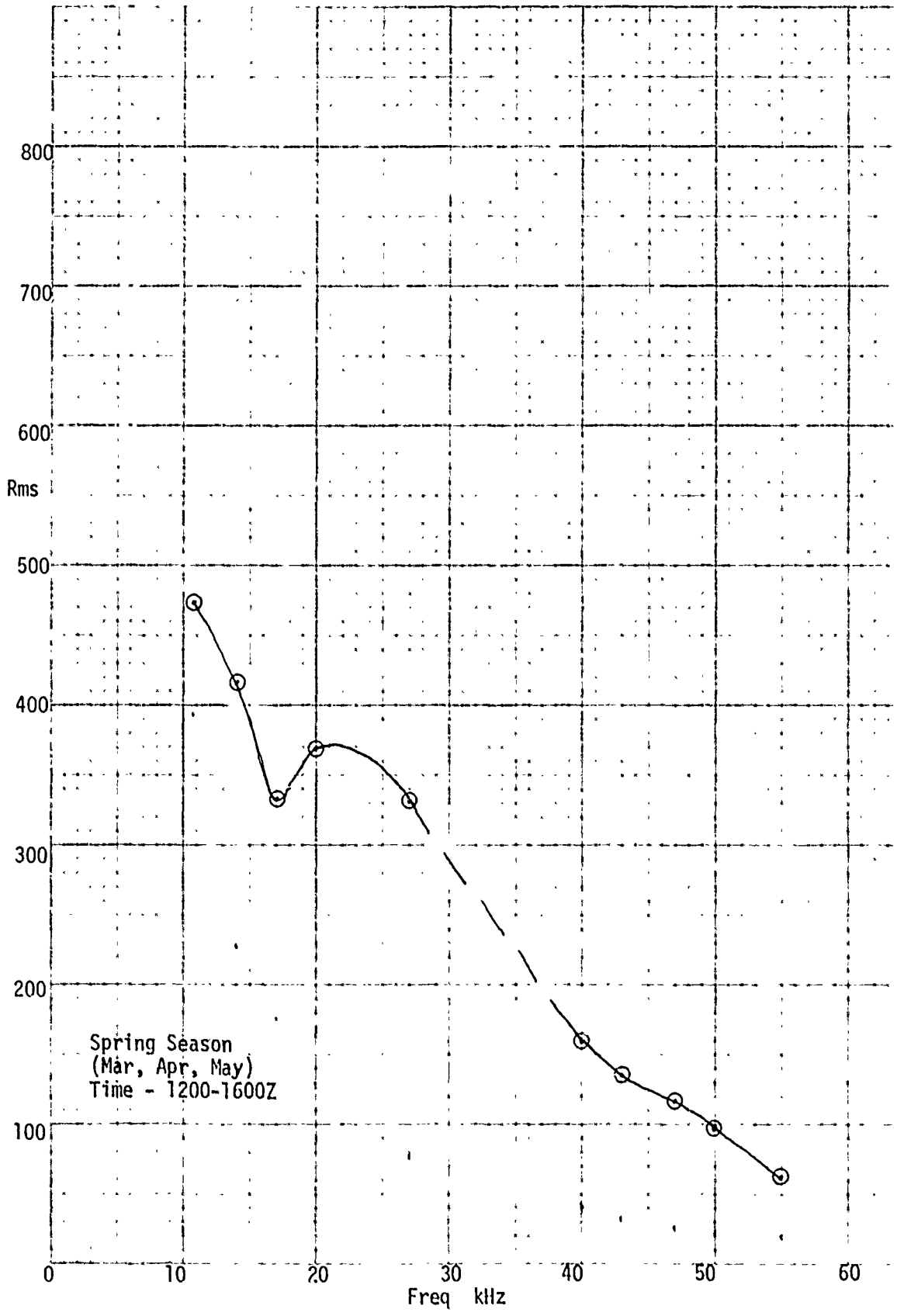
(Mar, Apr, May)
Time - 0800-1200Z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(Mar, Apr, May)
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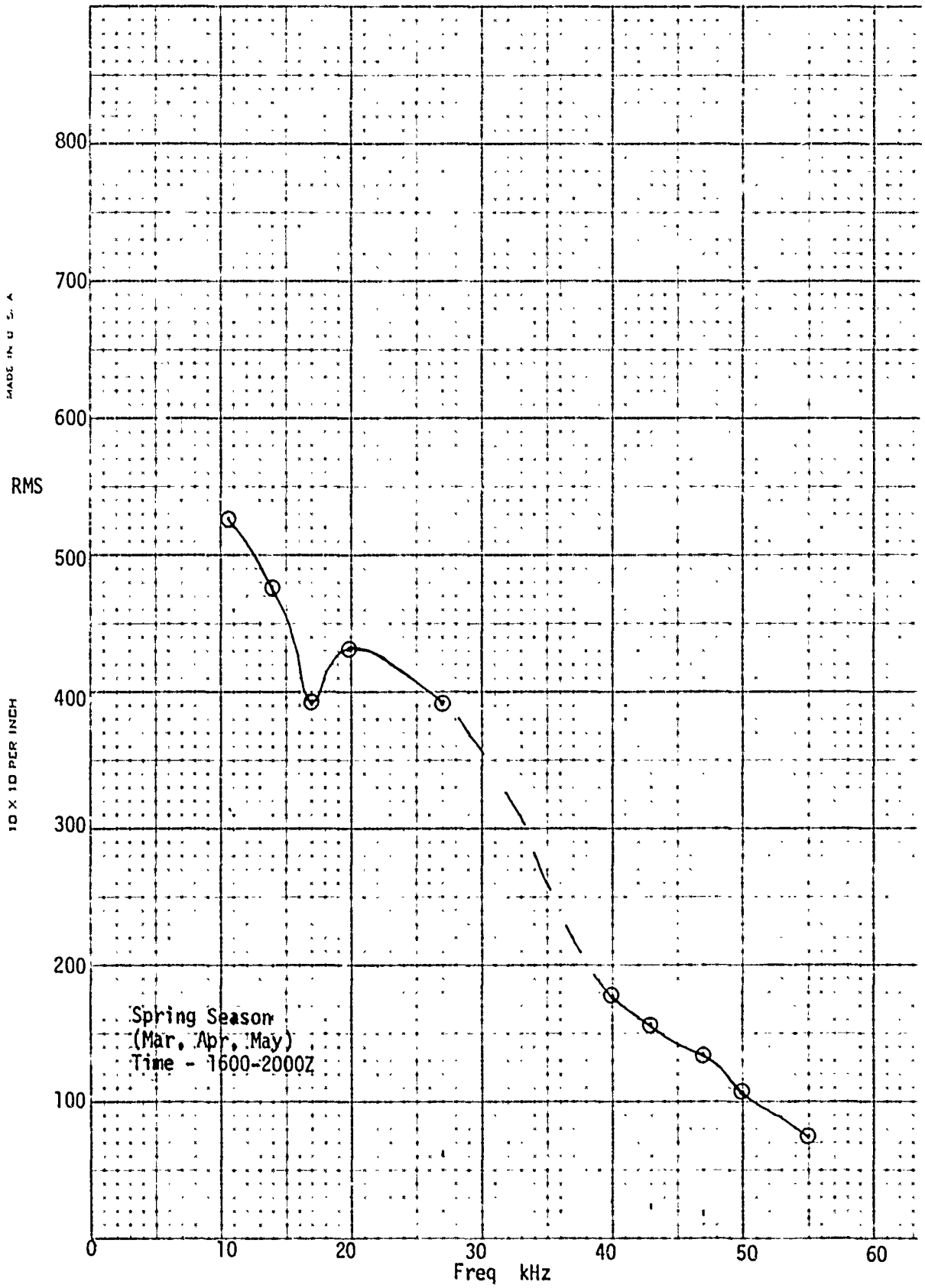
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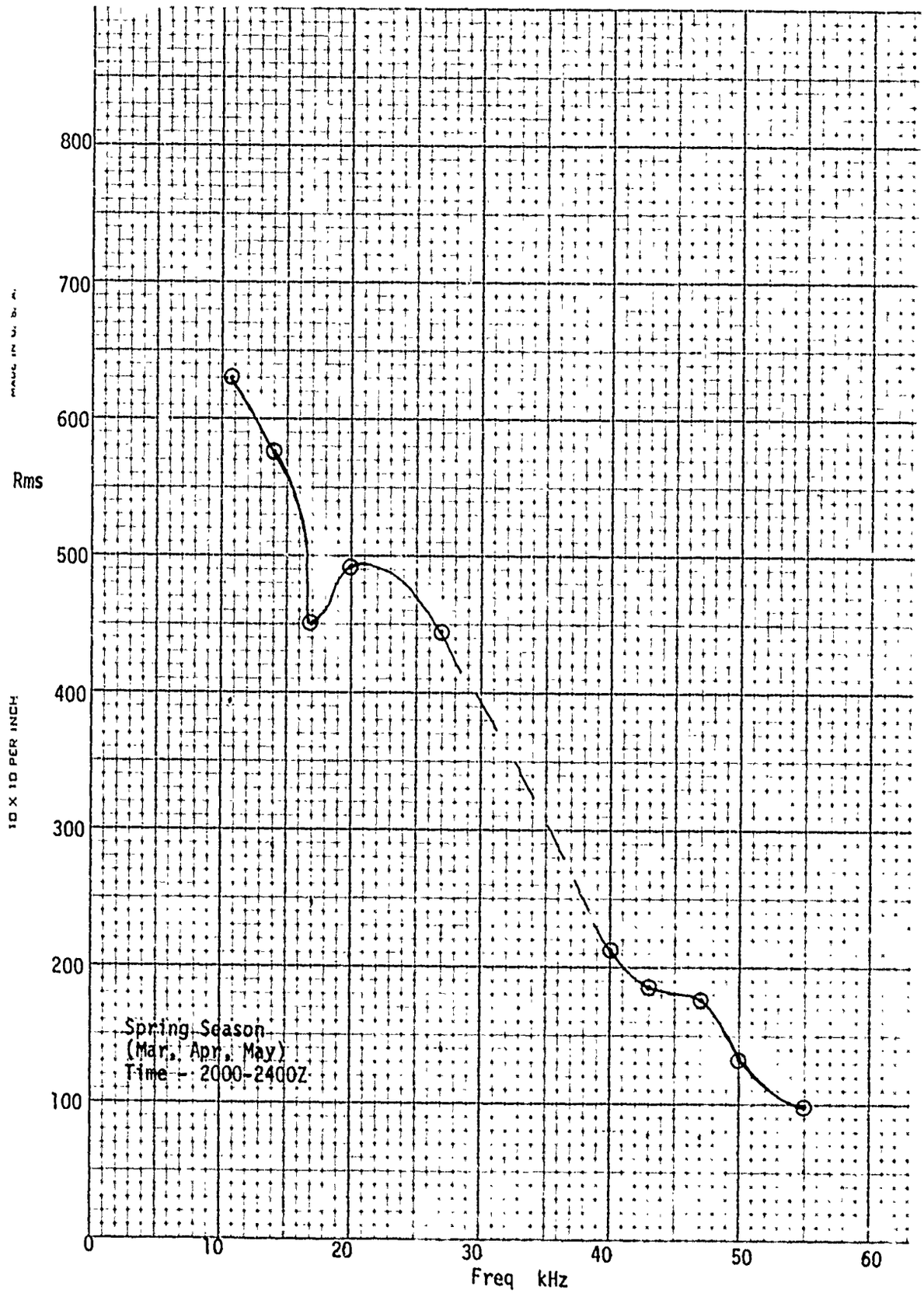
(Mar, Apr, May)
Time - 1600-2000Z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Spring Season
(Mar. Apr. May)
Time - 2000-2400Z

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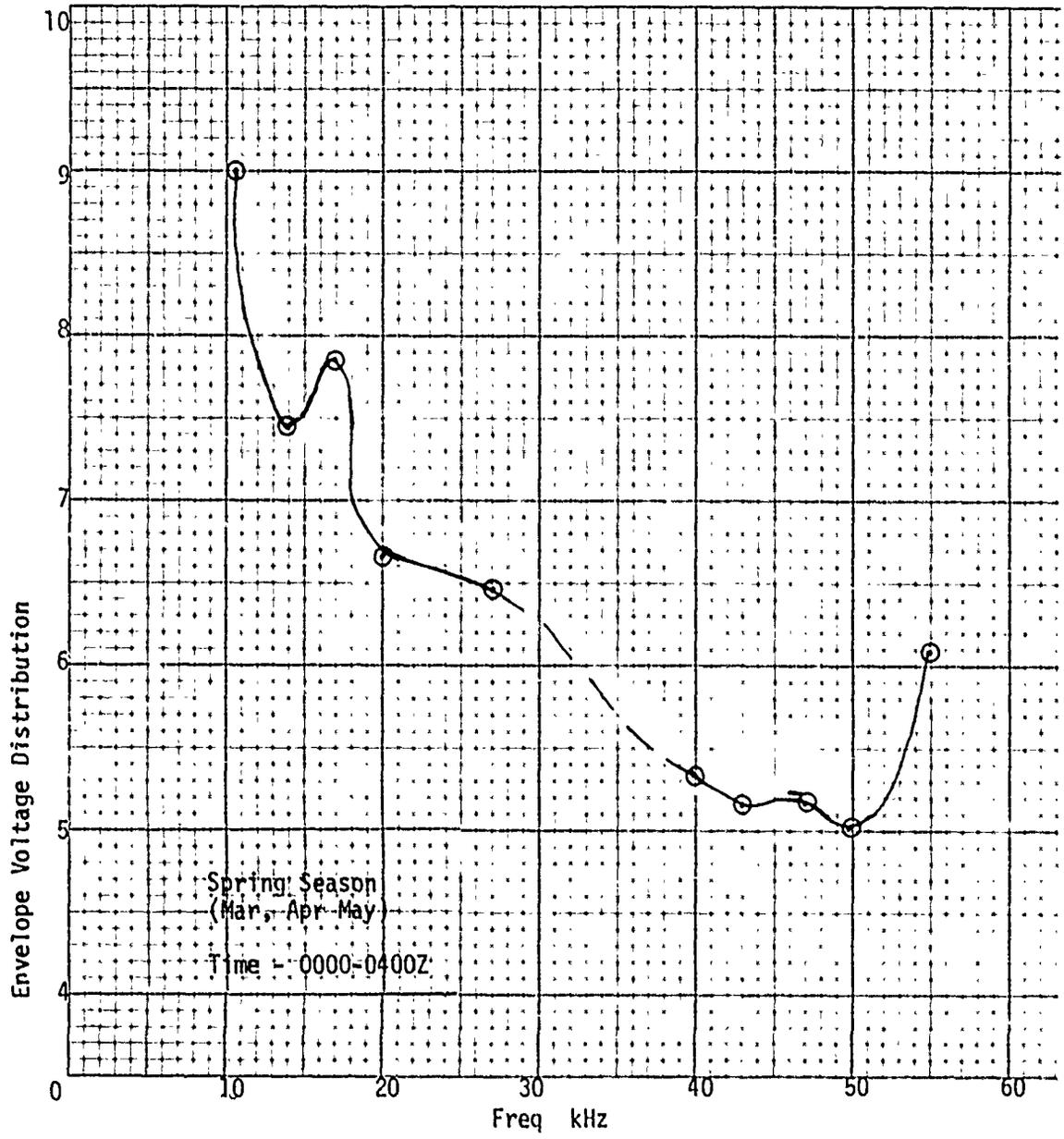
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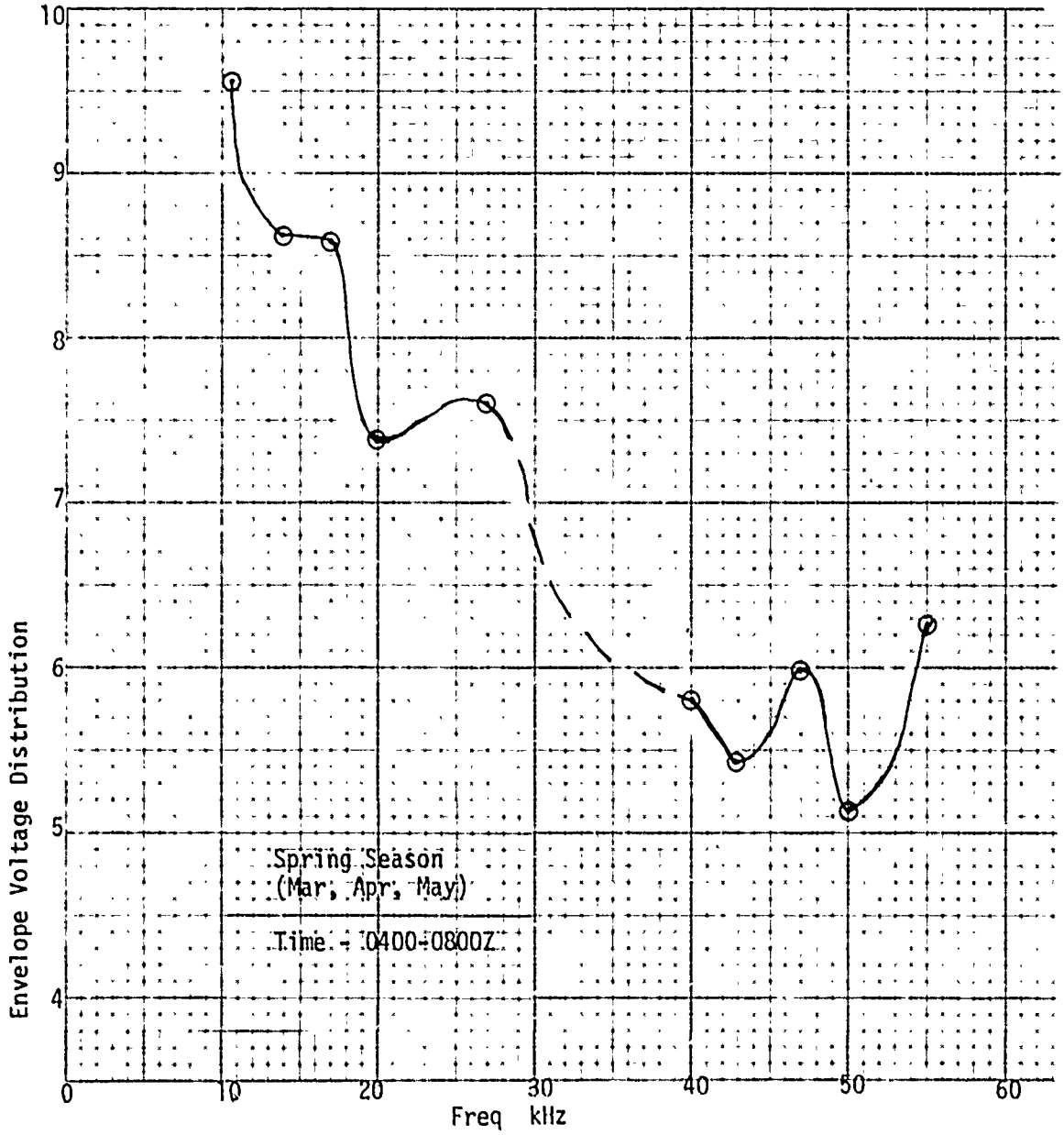
Spring Season
(Mar, Apr May)
Time - 0000-0400Z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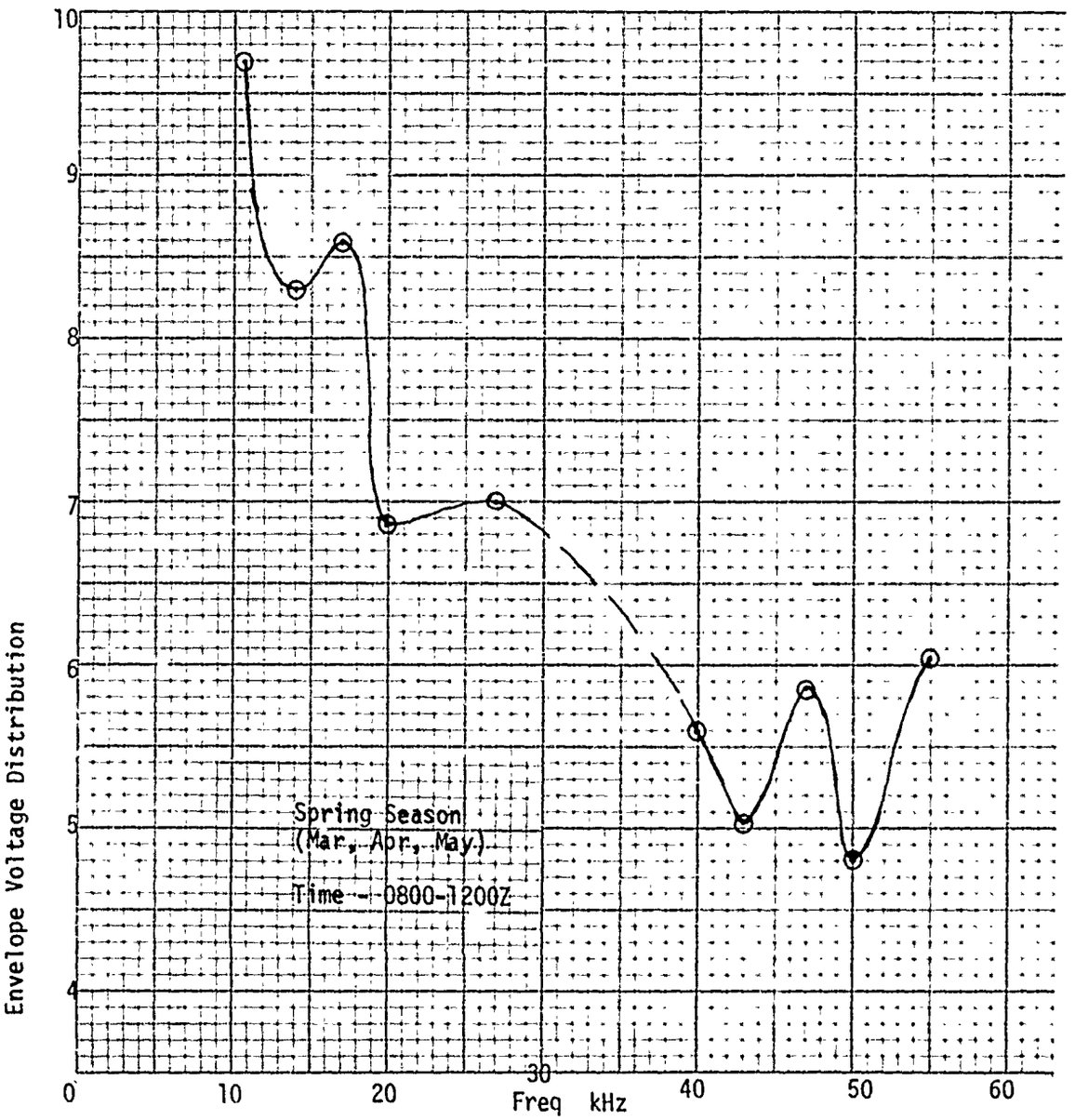
Spring Season
(Mar, Apr, May)
Time - 0400-0800Z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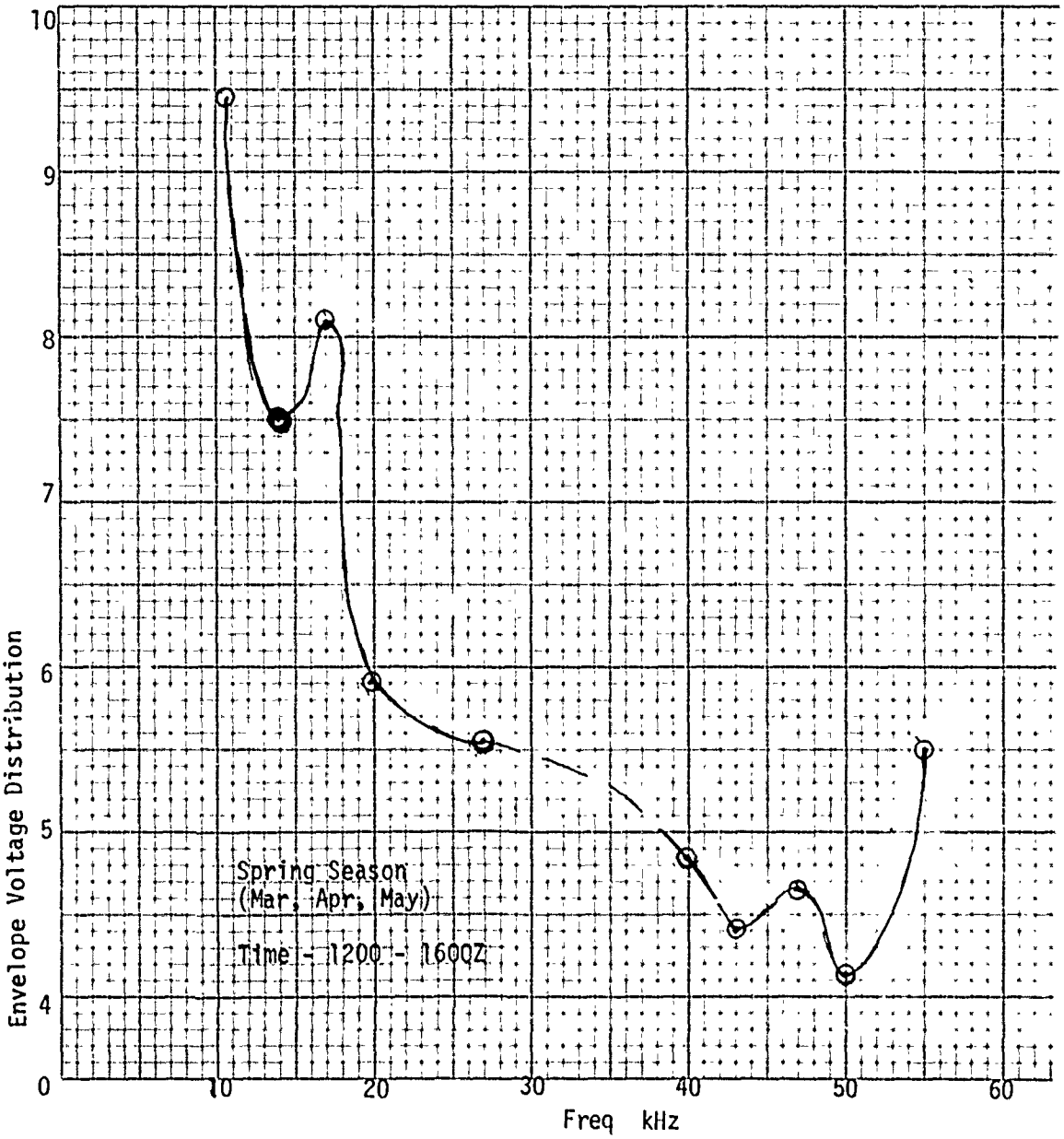
(Mar, Apr, May)
Time - 0800-1200Z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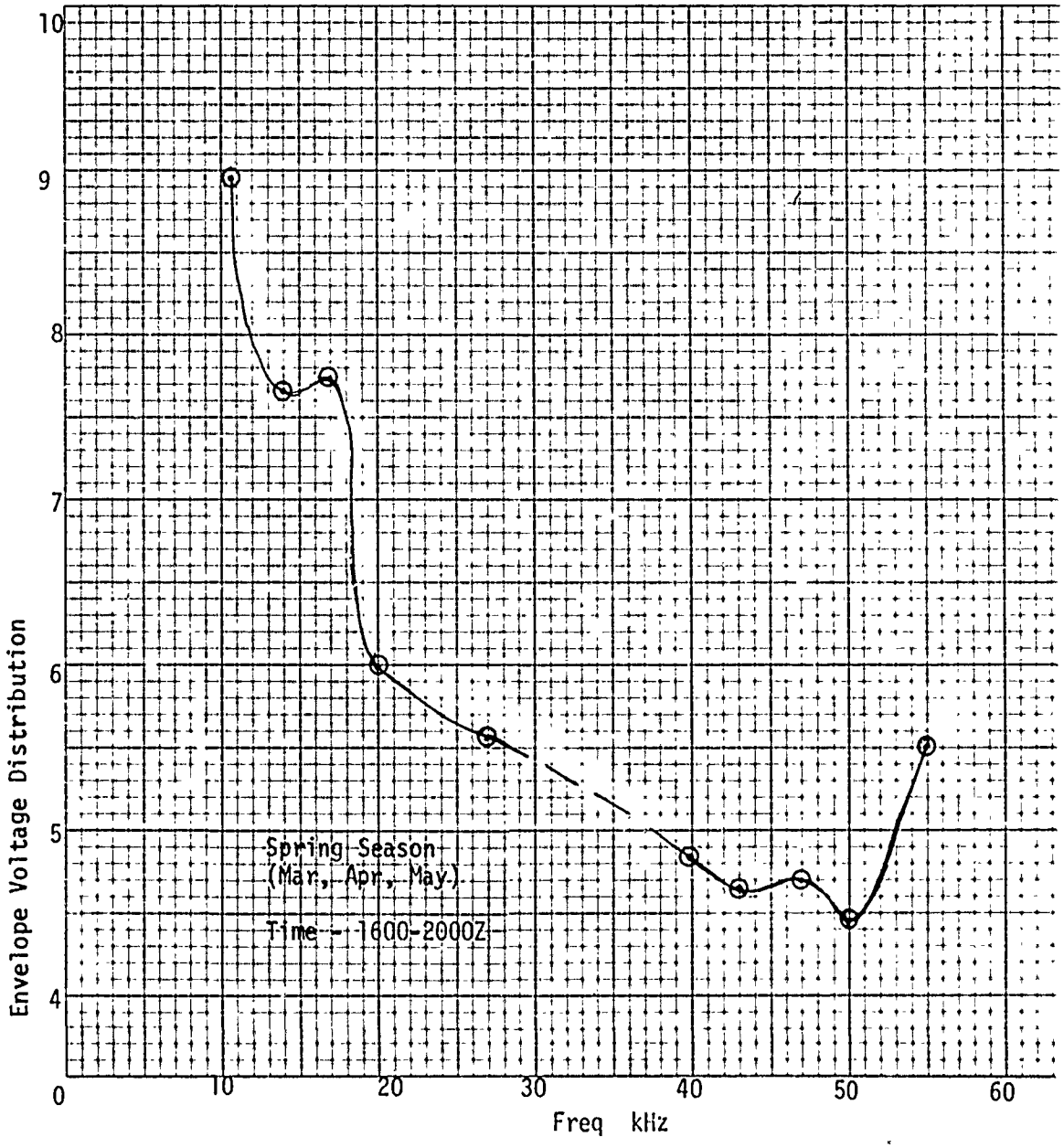
Spring Season
(Mar, Apr, May)
Time - 1200 - 1600Z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Envelope Voltage Distribution
Freq kHz
Spring Season
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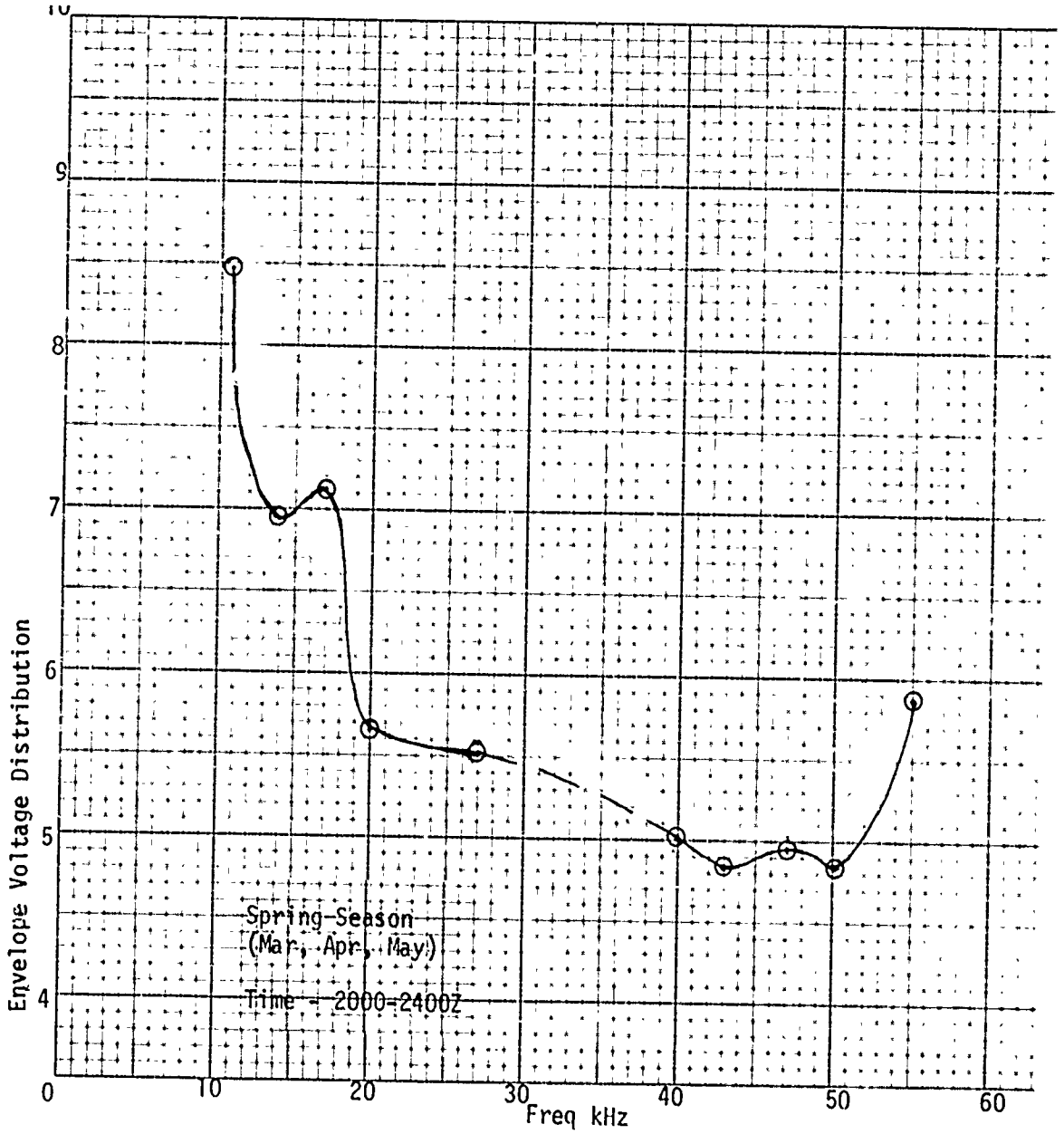
Time - 1600-2000Z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Spring-Season
(Mar, Apr, May)
Time - 2000-2400Z
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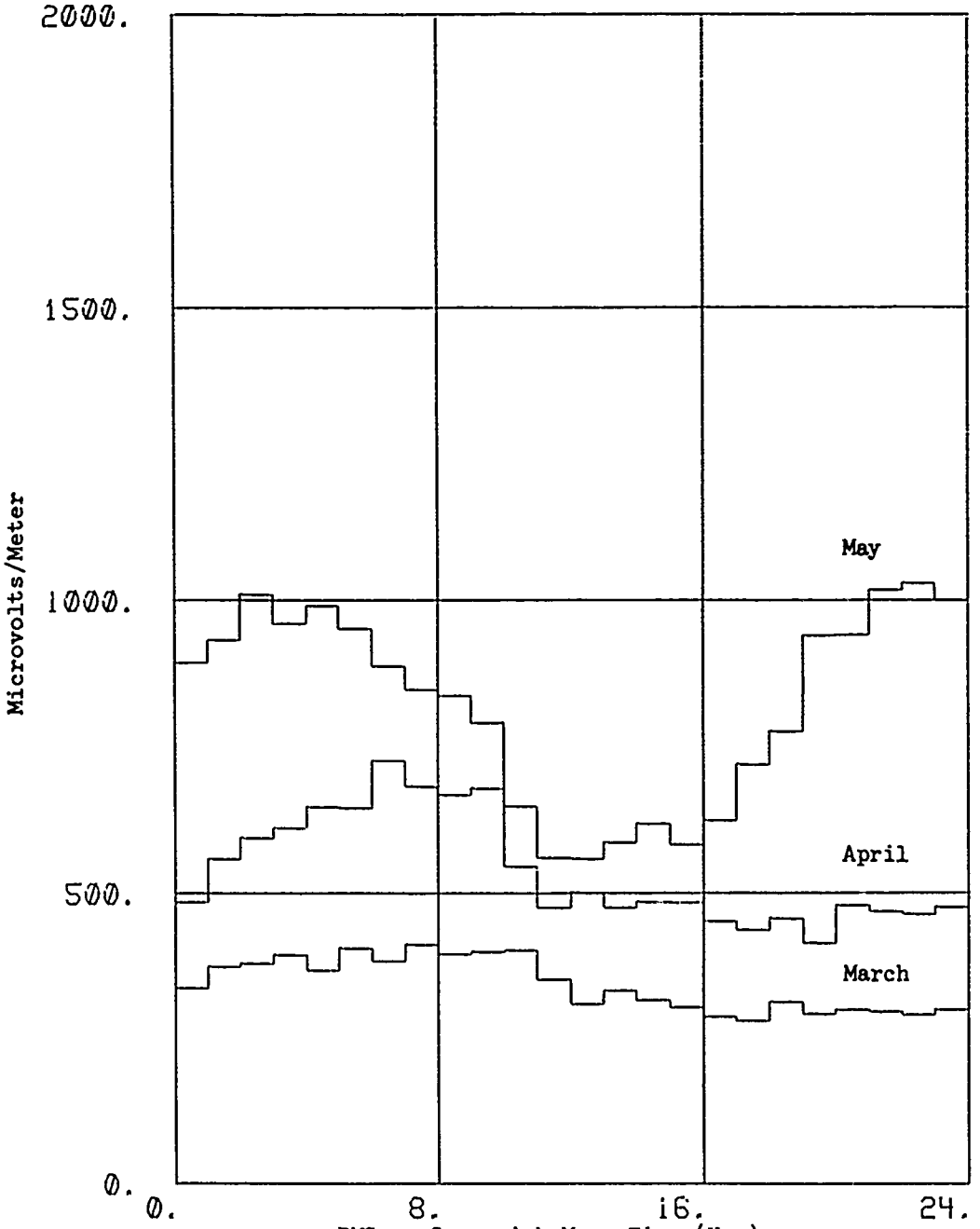
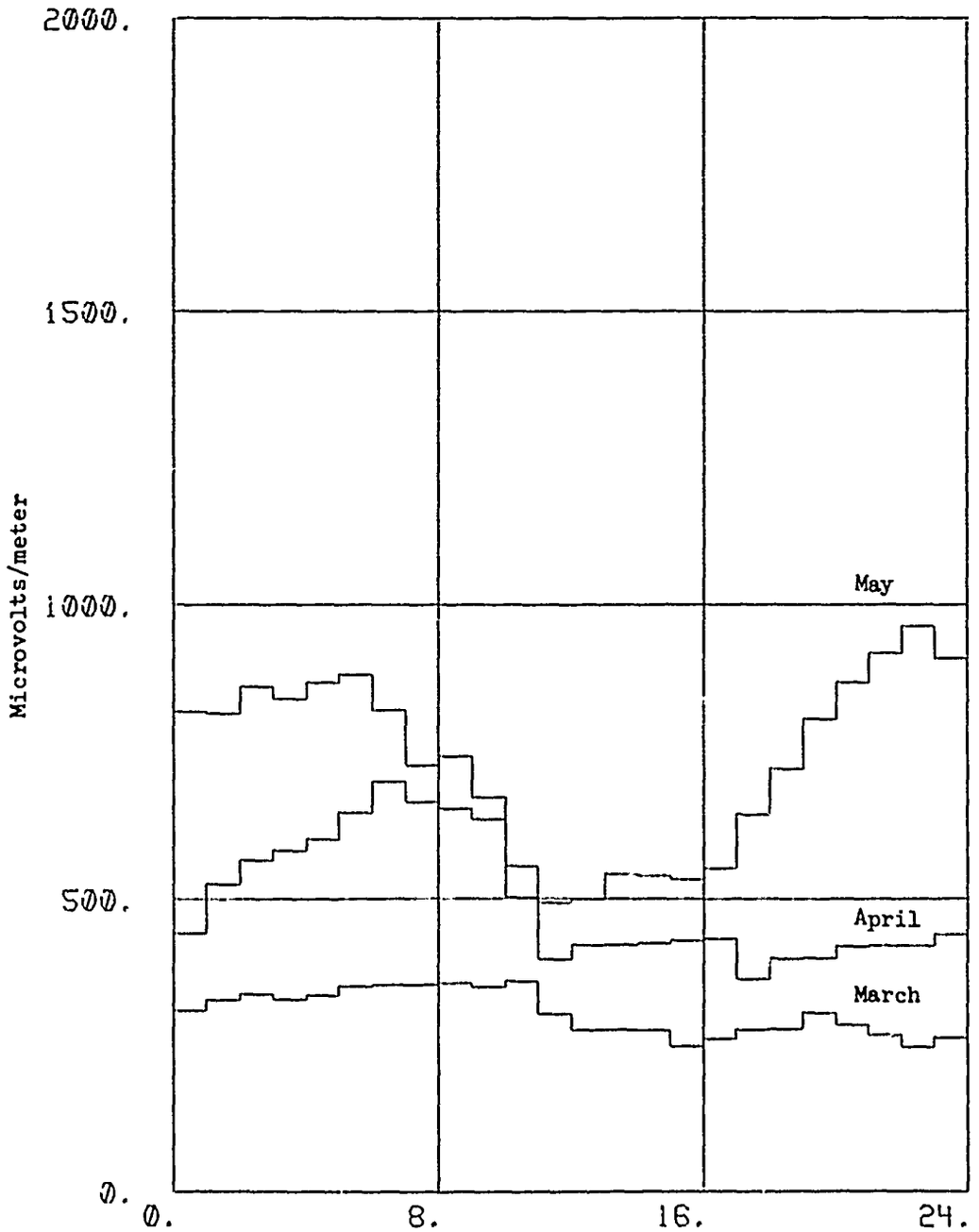
5.3 - ERMS vs TIME (SPRING VARIATION)



RMS vs Greenwich Mean Time (Hrs)
10.7 kHz
Spring Season - Monthly Variation



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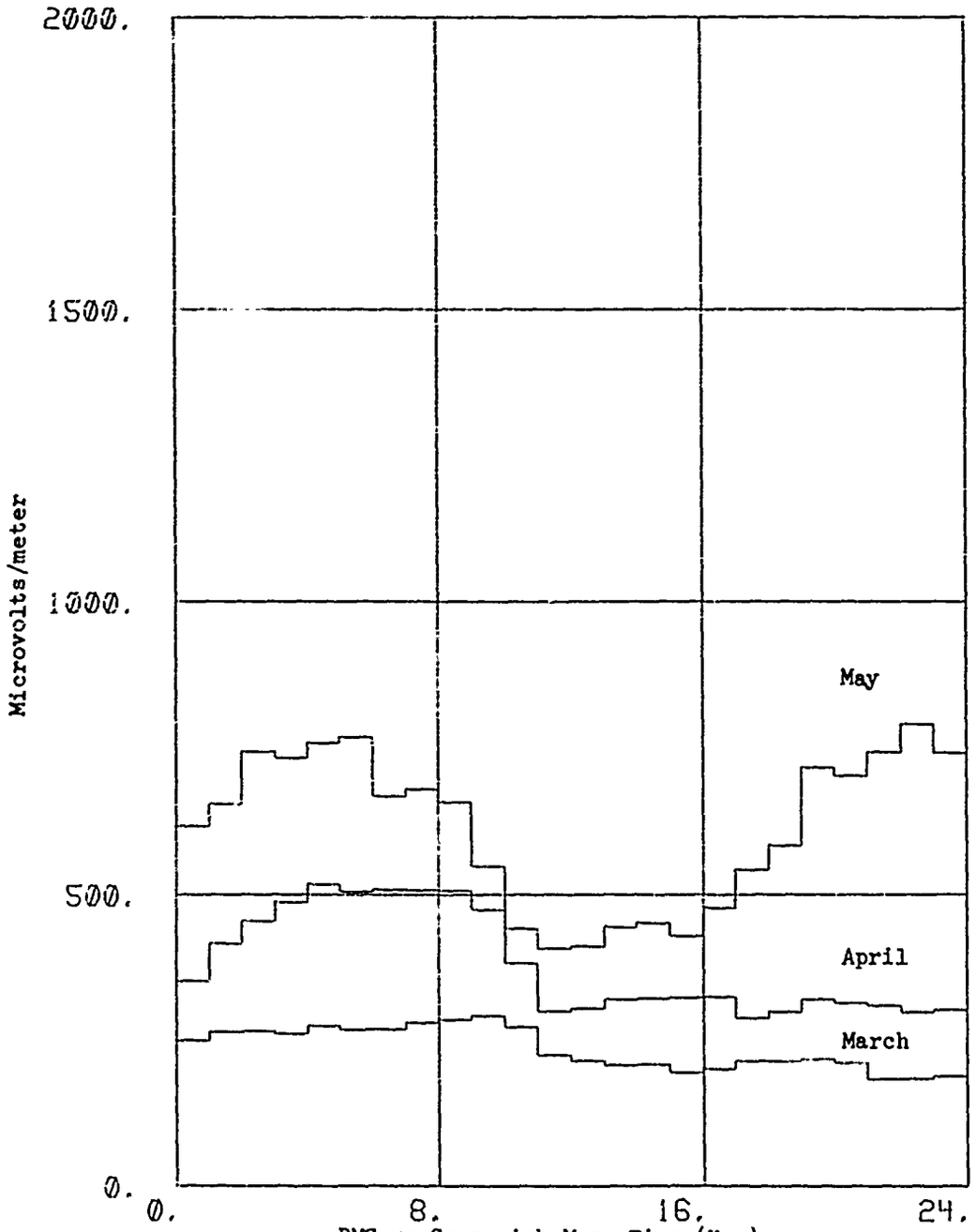
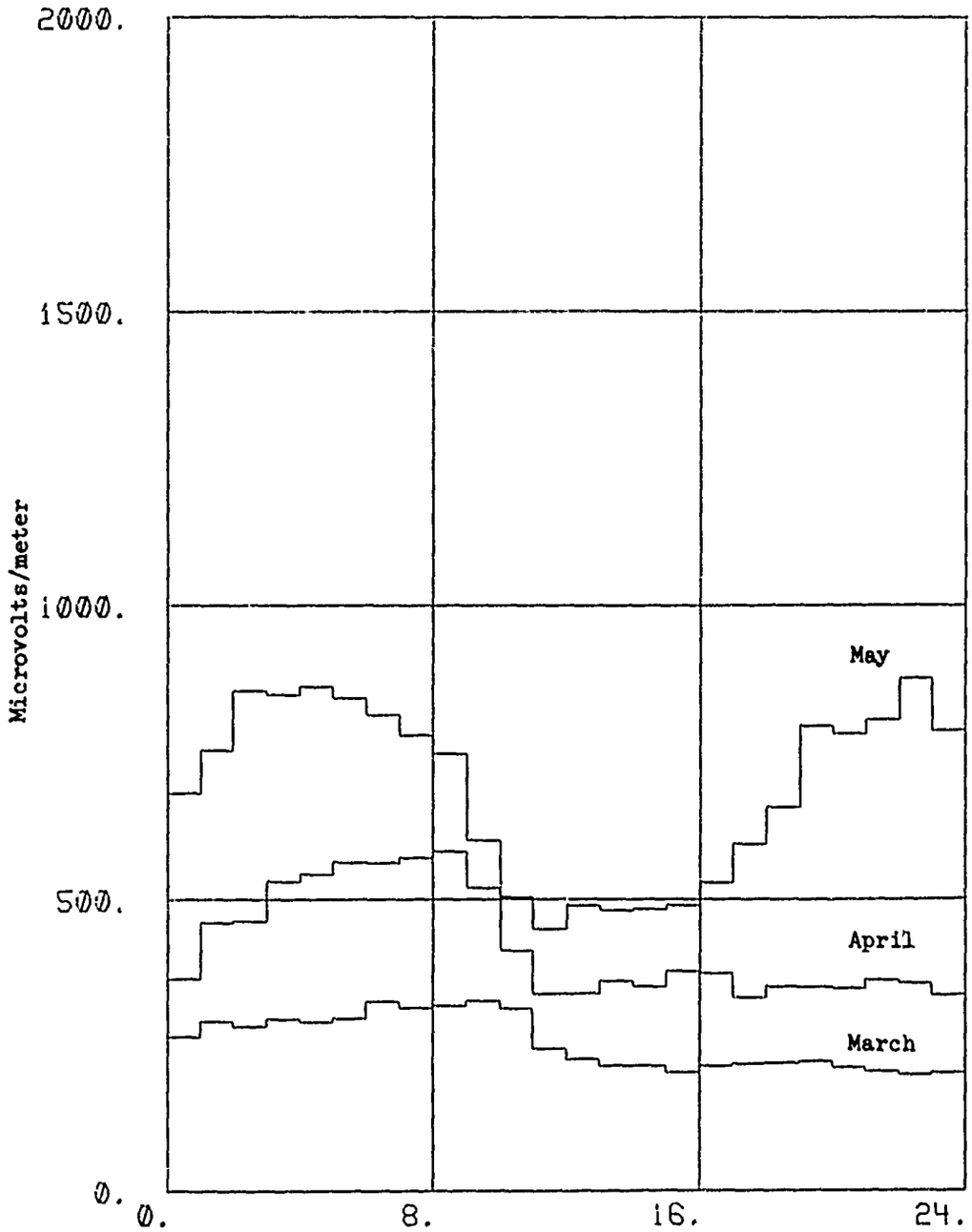
14.0 kHz
Spring Season - Monthly Variation



RMS vs Greenwich Mean Time (Hrs)
17.0 kHz
Spring Season - Monthly Variation


2000.
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Microvolts/meter
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April
March
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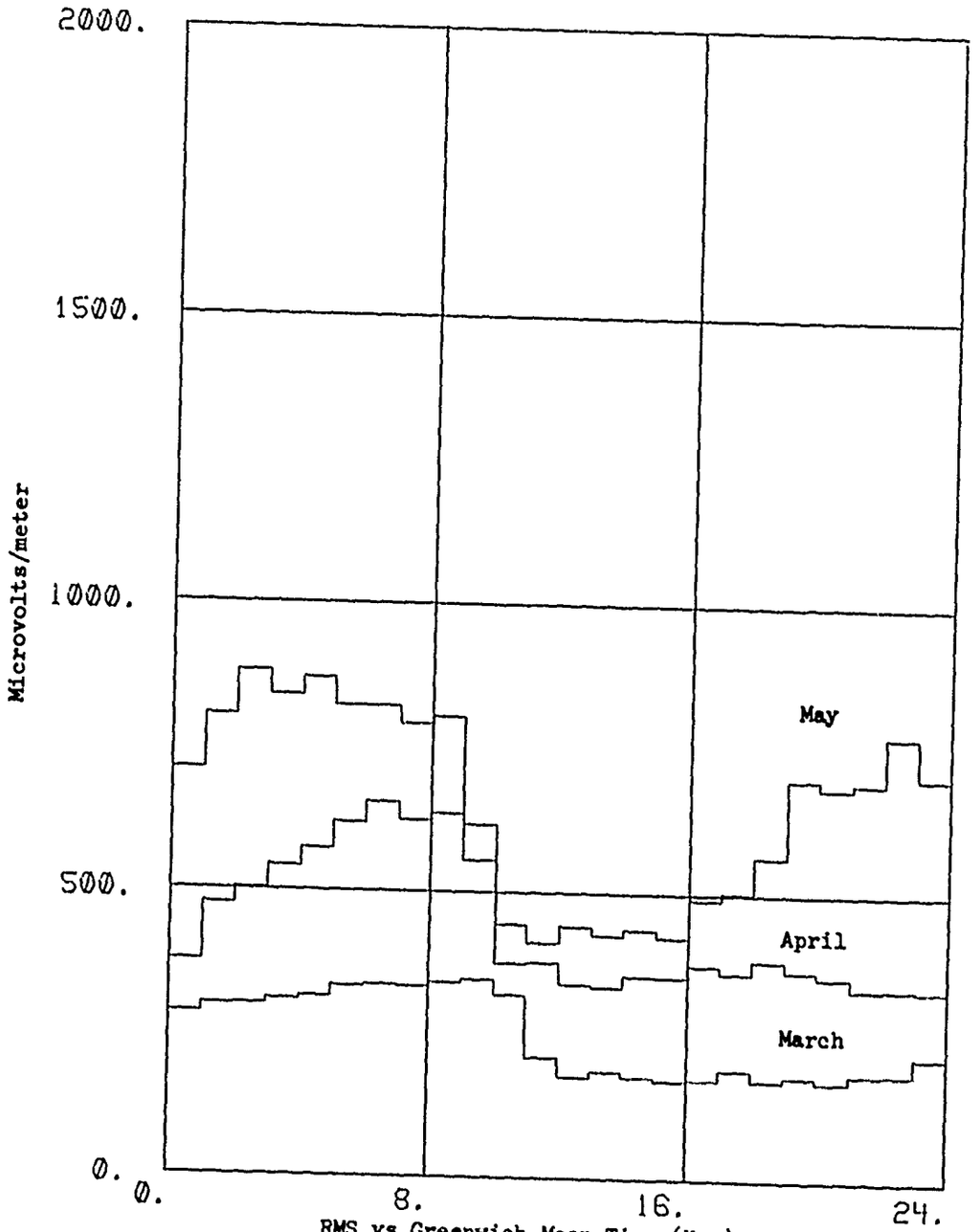
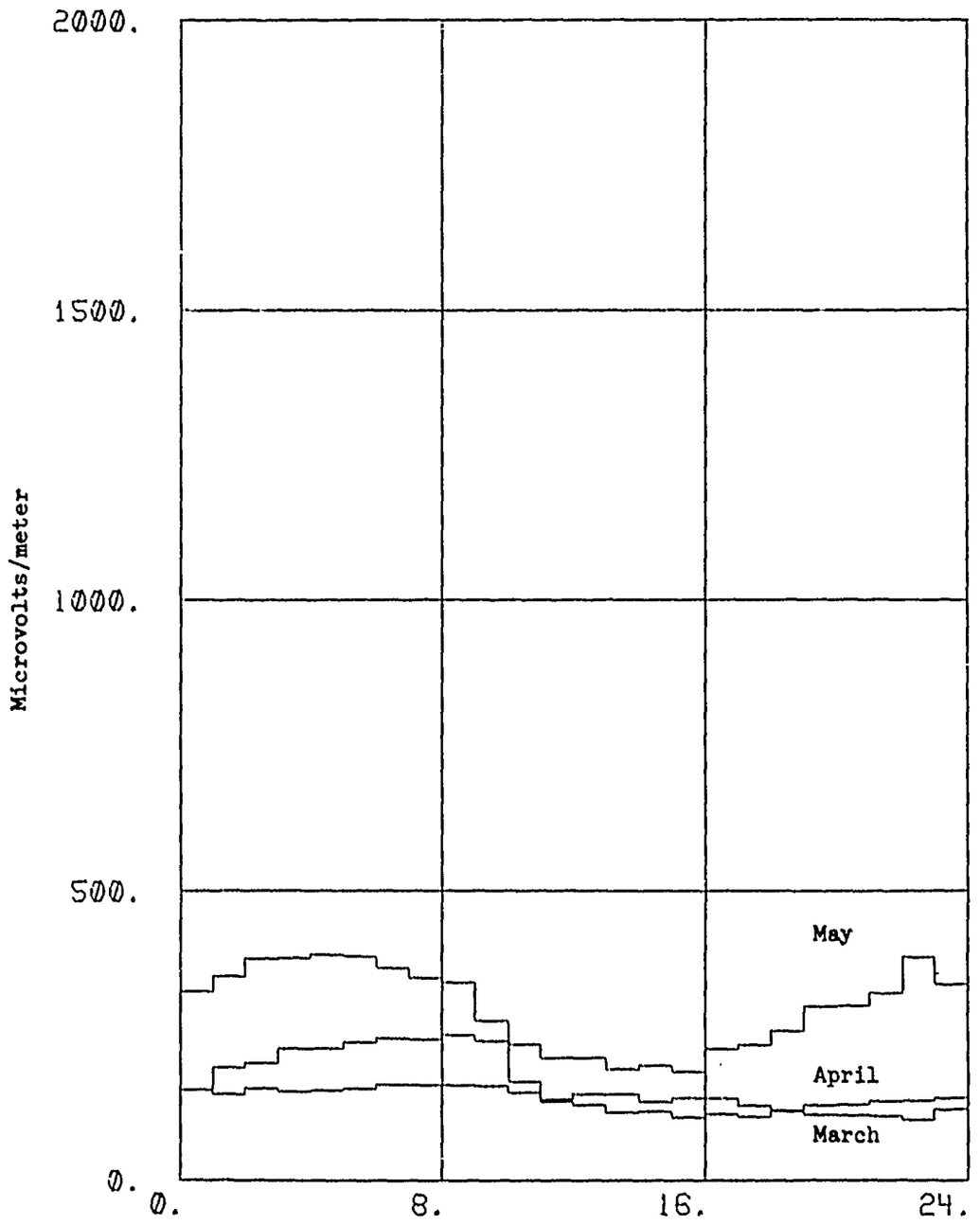
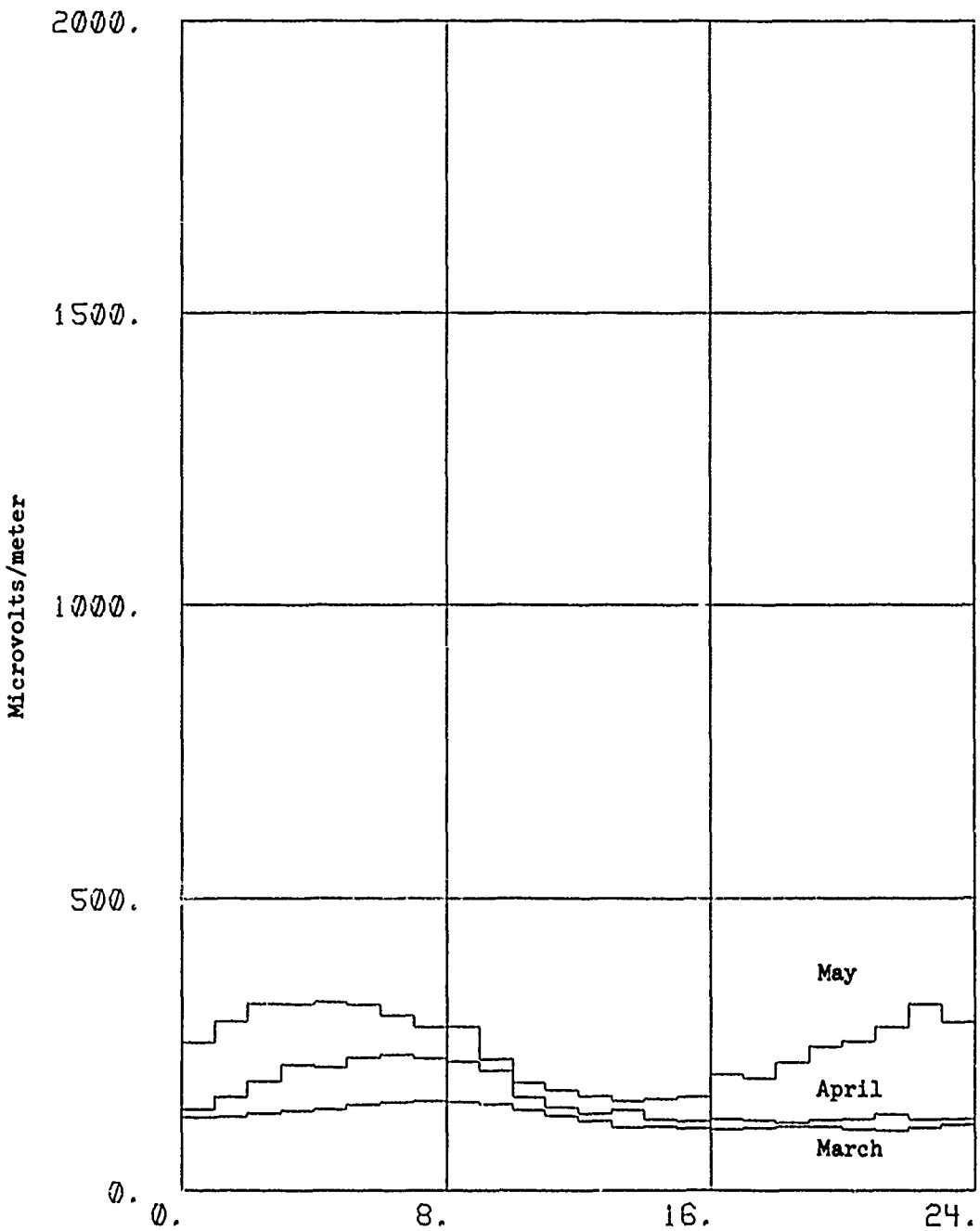
RMS vs Greenwich Mean_Time (Hrs)
20.0 kHz
Spring Season - Monthly Variation

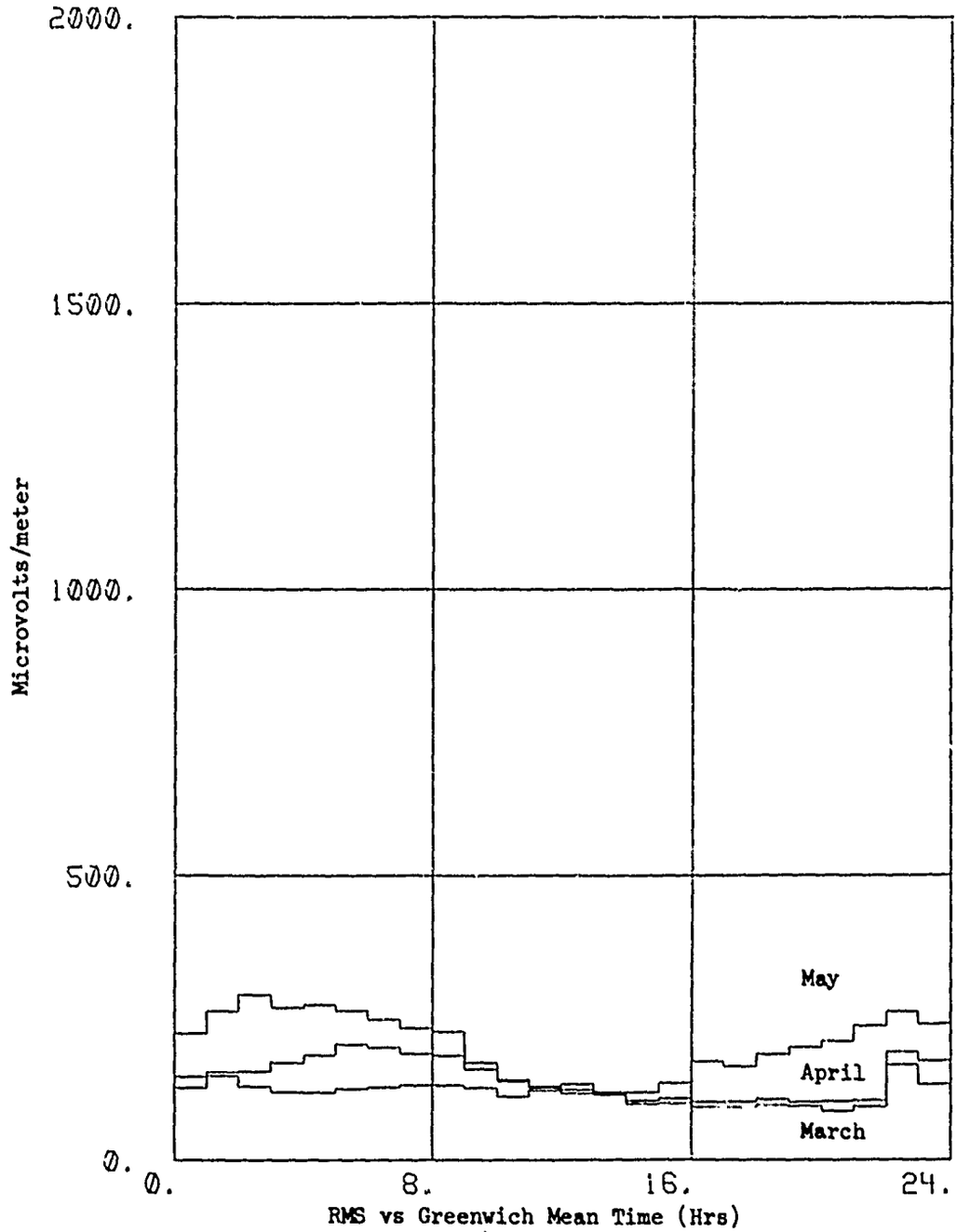


RMS vs Greenwich Mean Time (Hrs)
27.0 kHz
Spring Season - Monthly Variation

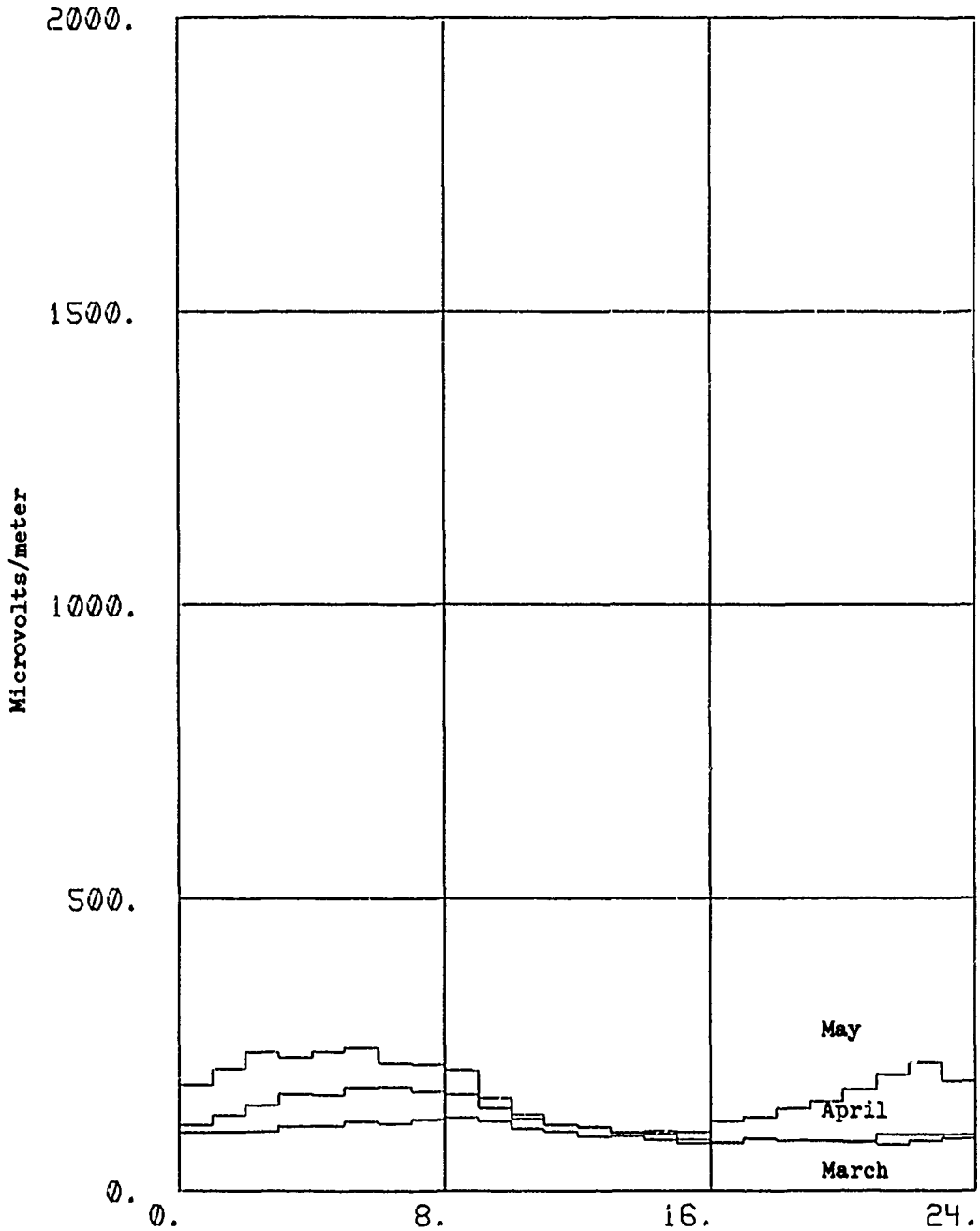


RMS vs Greenwich Mean Time (Hrs)
40.0 kHz
Spring Season - Monthly Variation

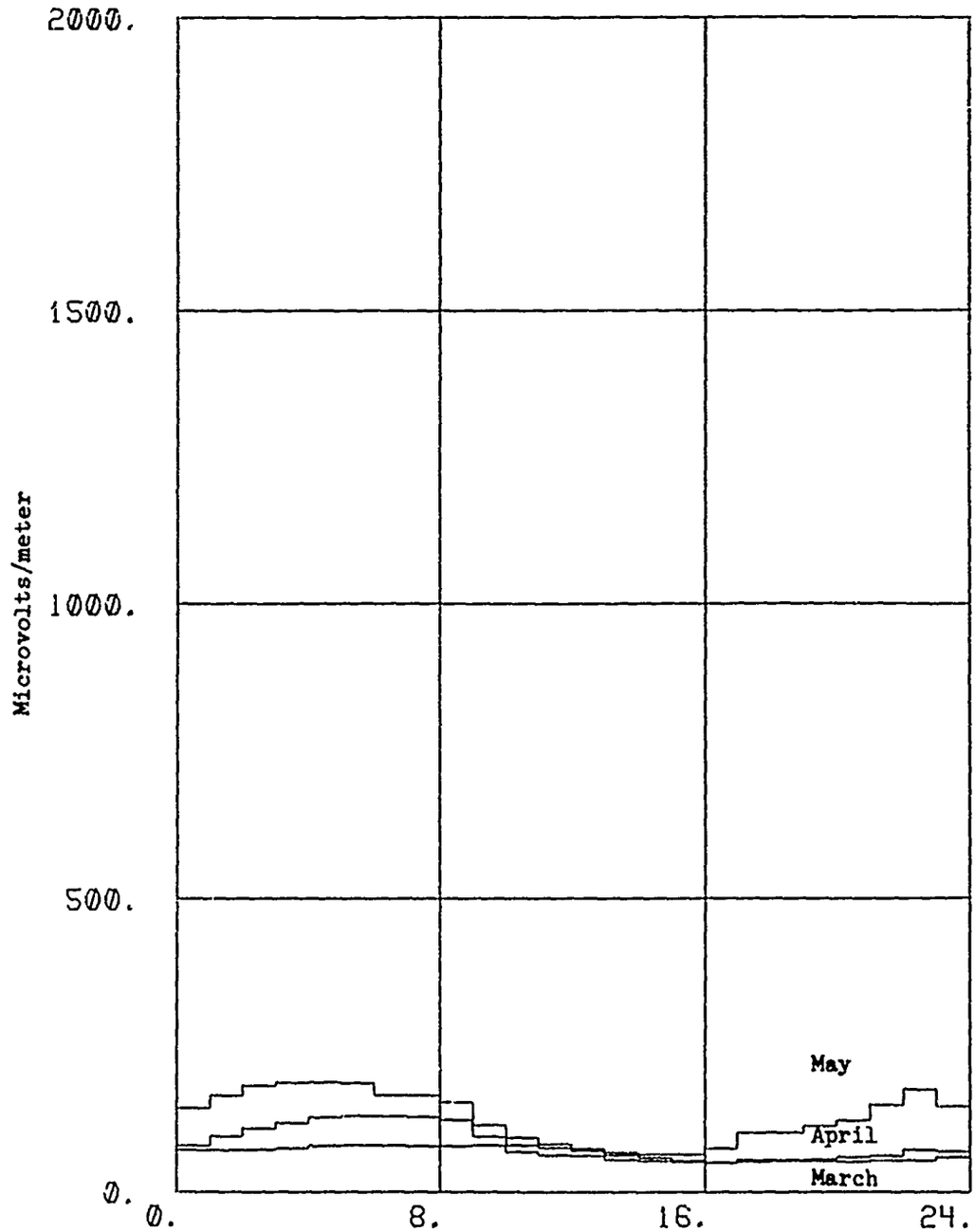

2000.
1500.
1000.
500.
0.
Microvolts/meter
May
April
March
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
43.0 kHz
Spring Season - Monthly Variation



RMS vs Greenwich Mean Time (Hrs)
47.0 kHz
Spring Season - Monthly Variation

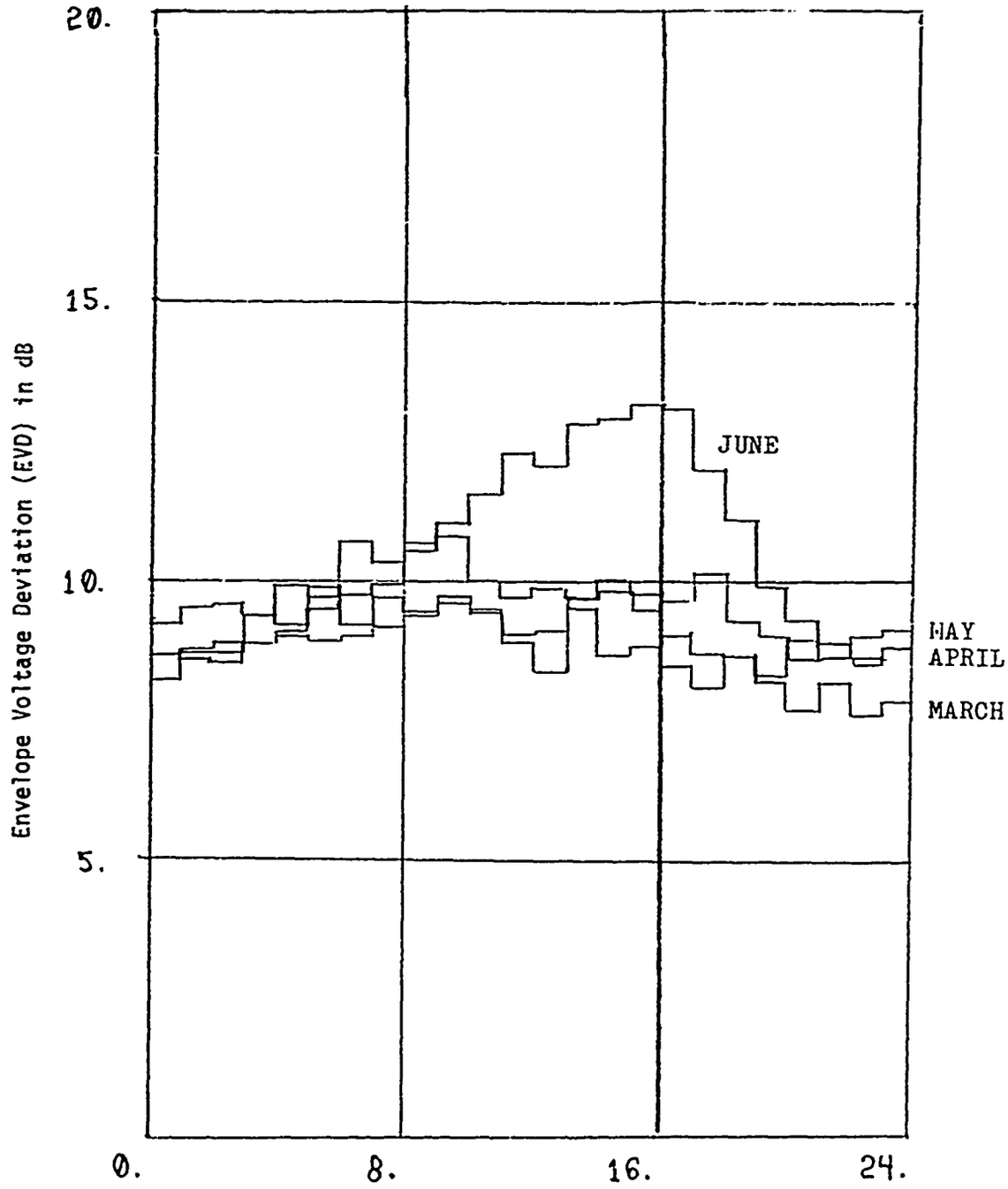


RMS va Greenwich Mean Time (Hrs)
50.0 kHz
Spring Season - Monthly Variation

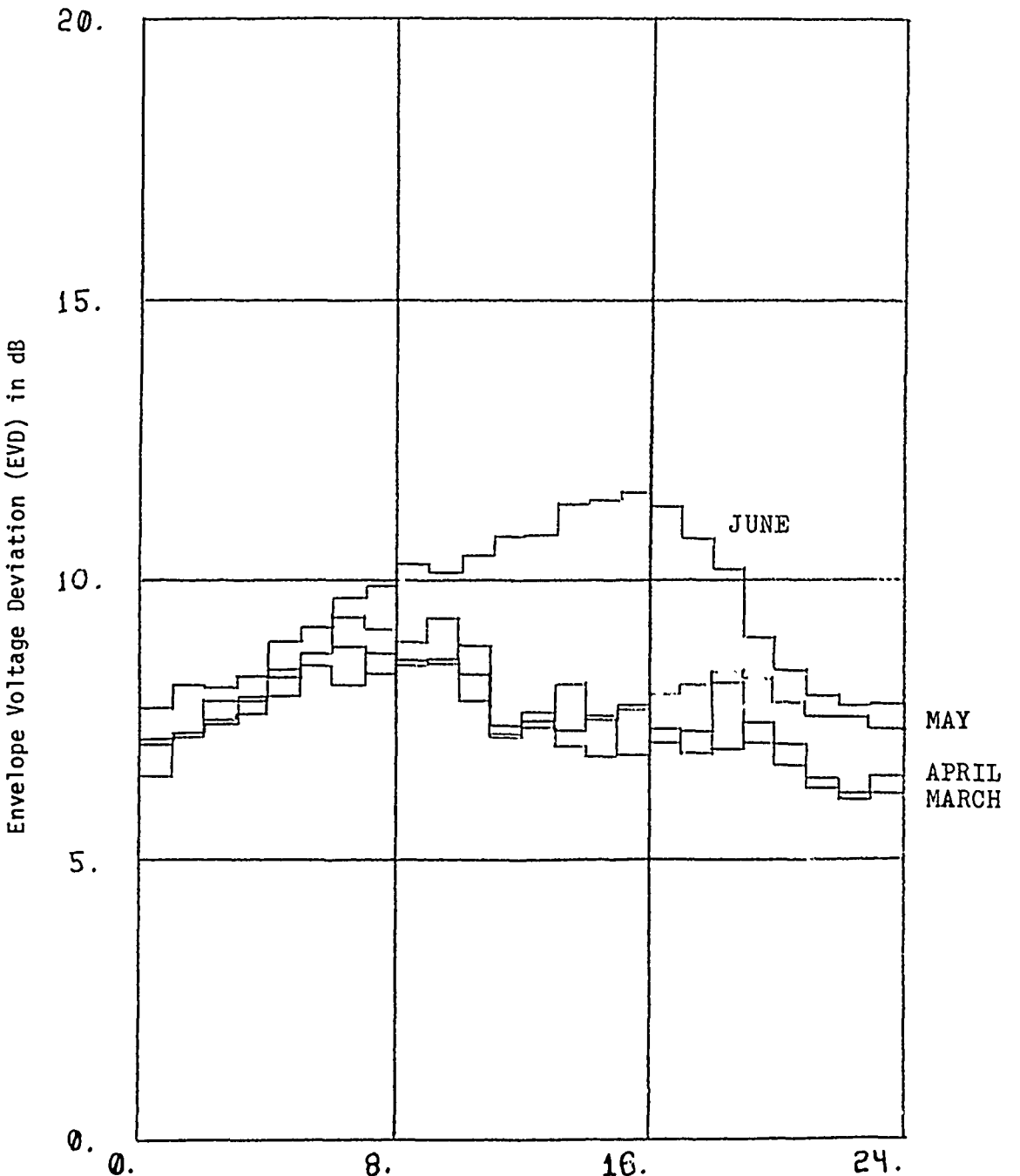


RMS vs Greenwich Mean Time (Hrs)
55.0 kHz
Spring Season - Monthly Variation

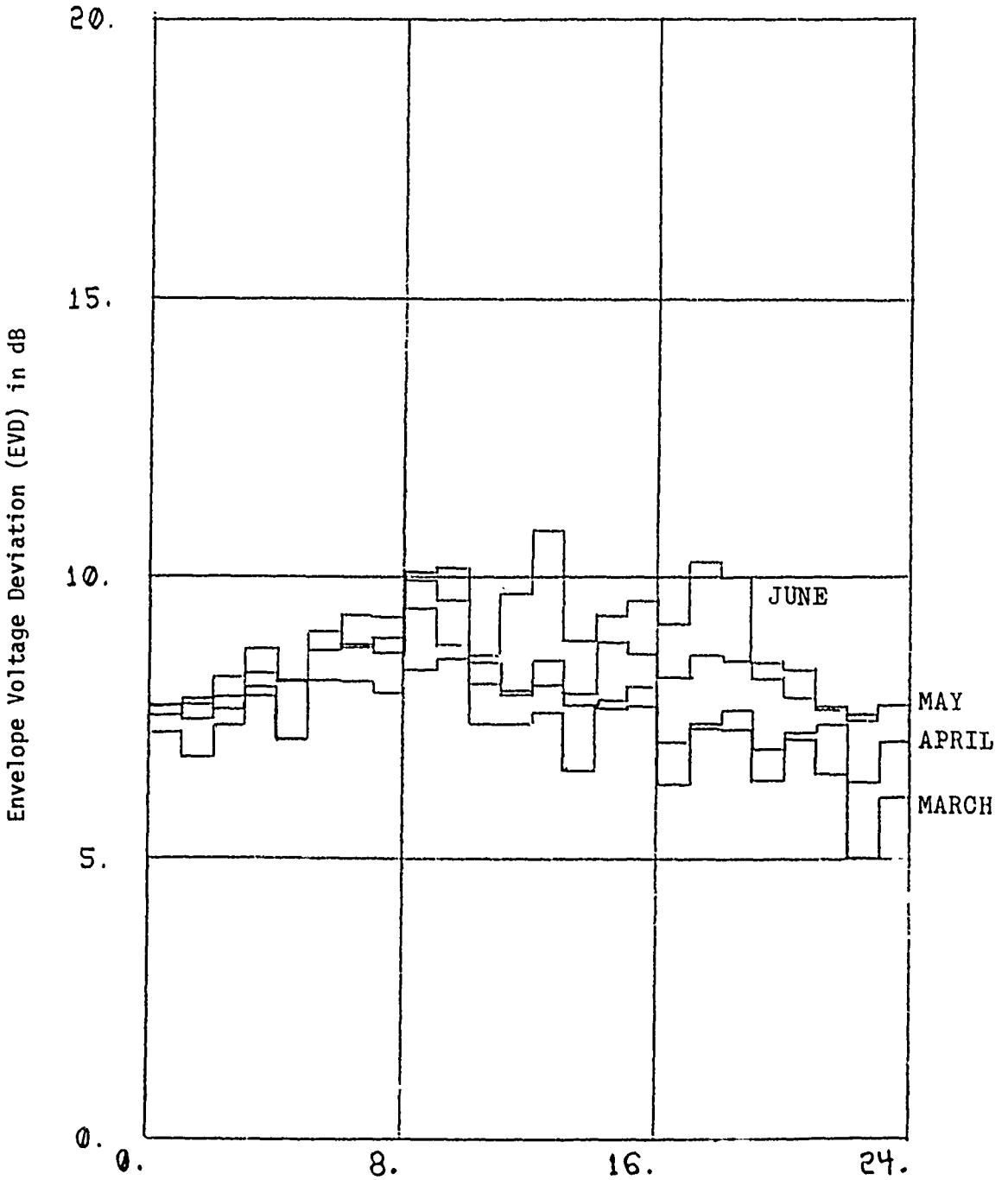
5.4 - EVD vs TIME (SPRING VARIATION)

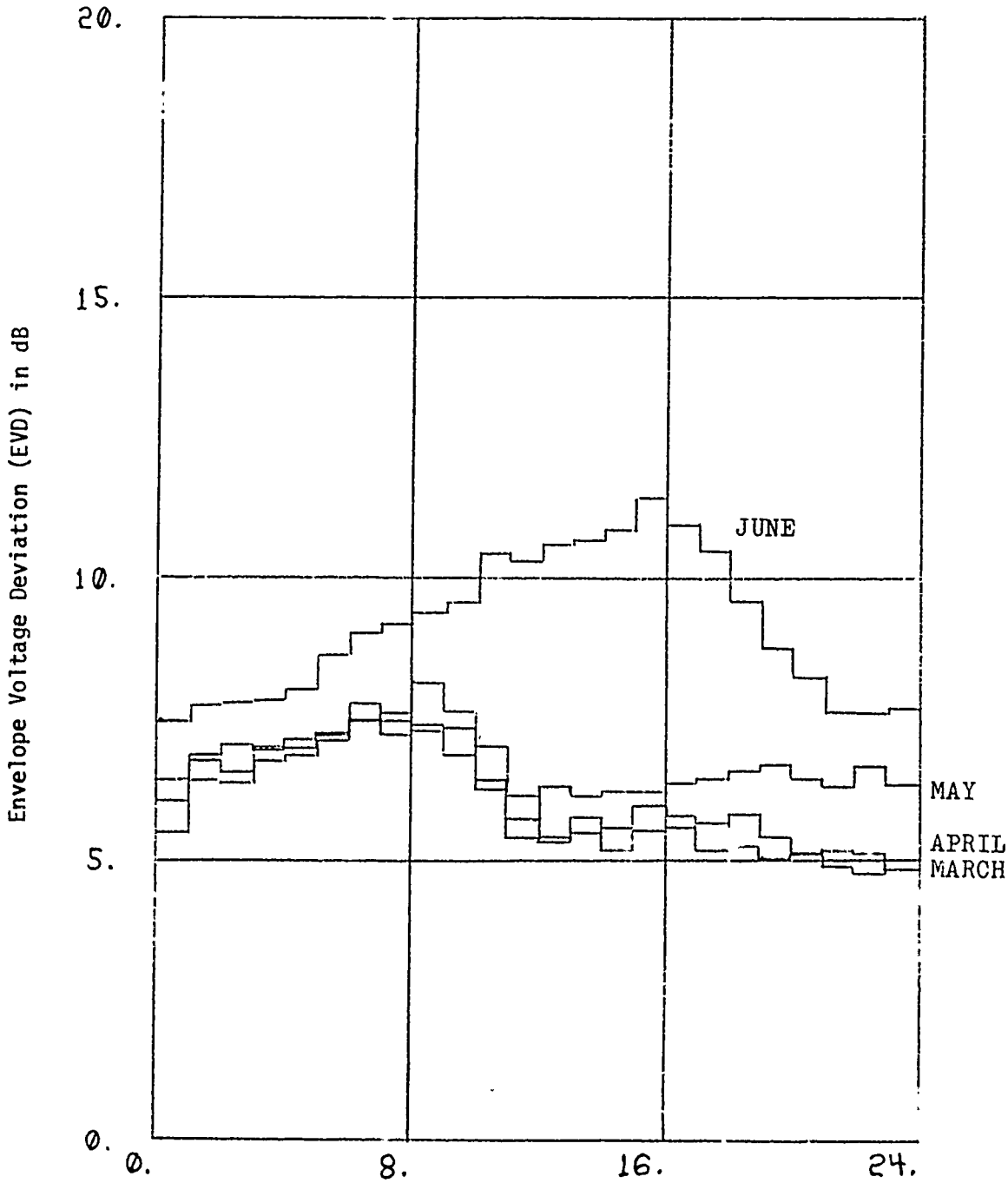


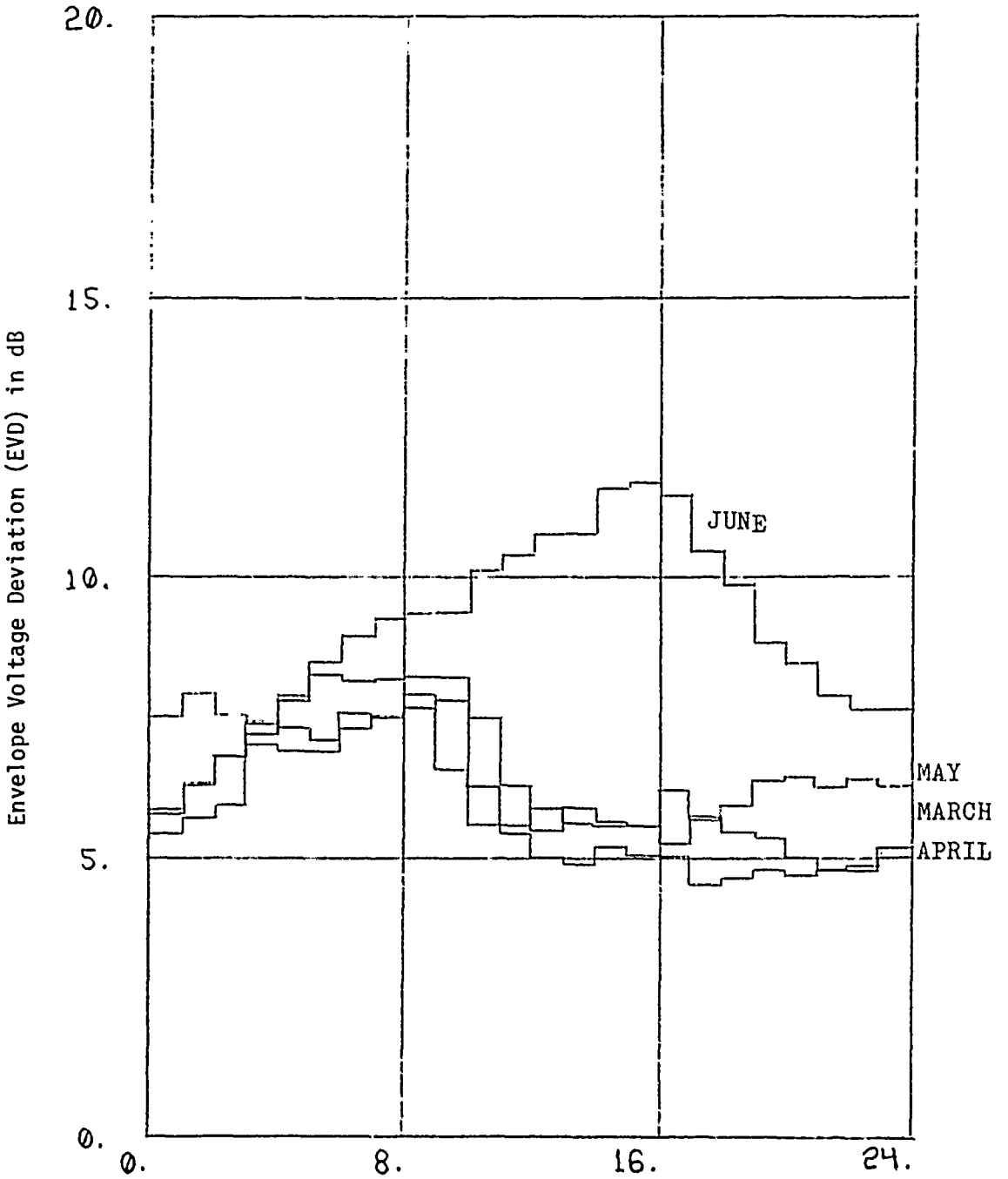
EVD vs Greenwich Mean Time (Hrs)
10.7 kHz
Spring Season - Monthly Variation

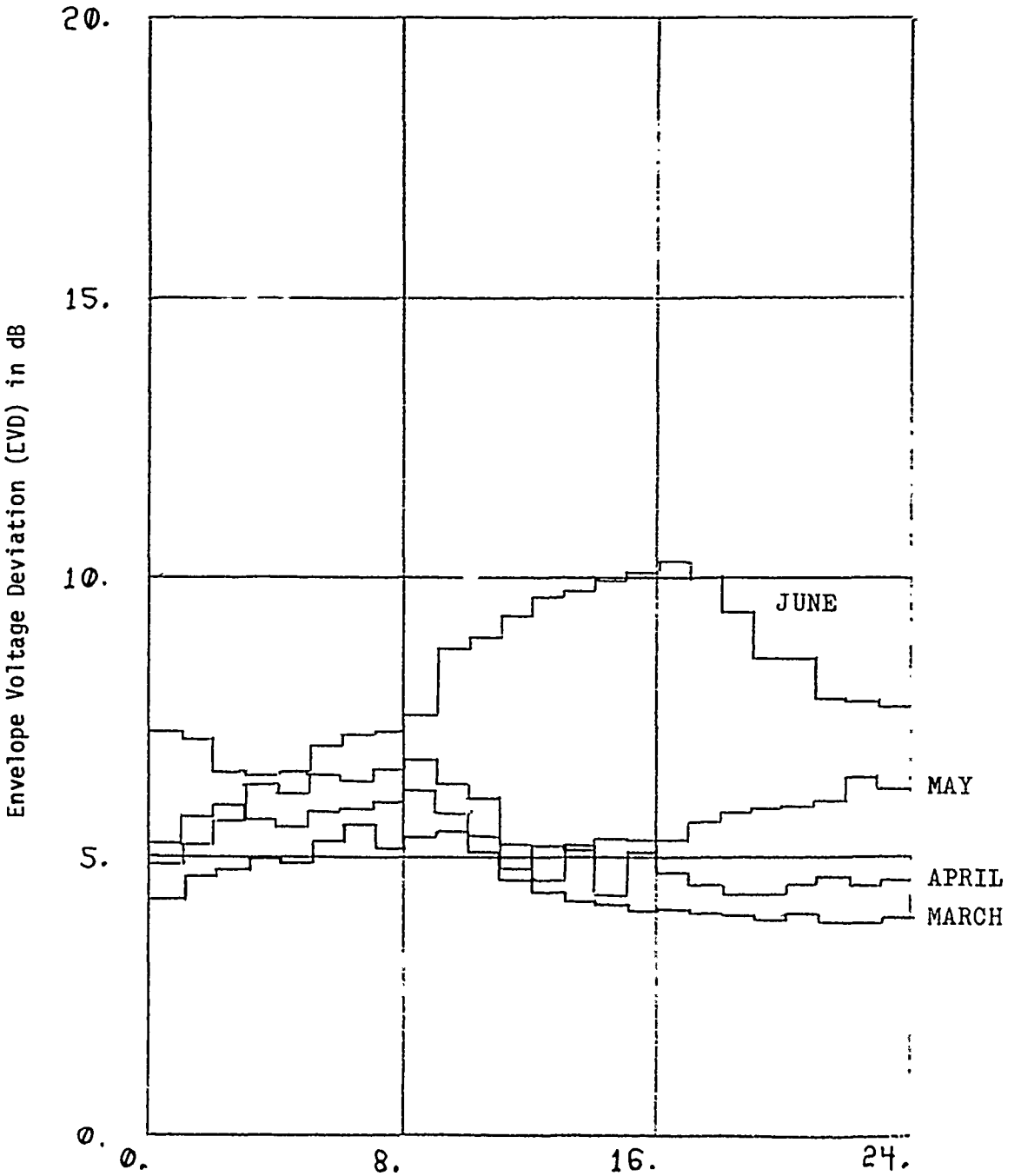


EVD vs Greenwich Mean Time (Hrs)
14.0 kHz
Spring Season - Monthly Variation

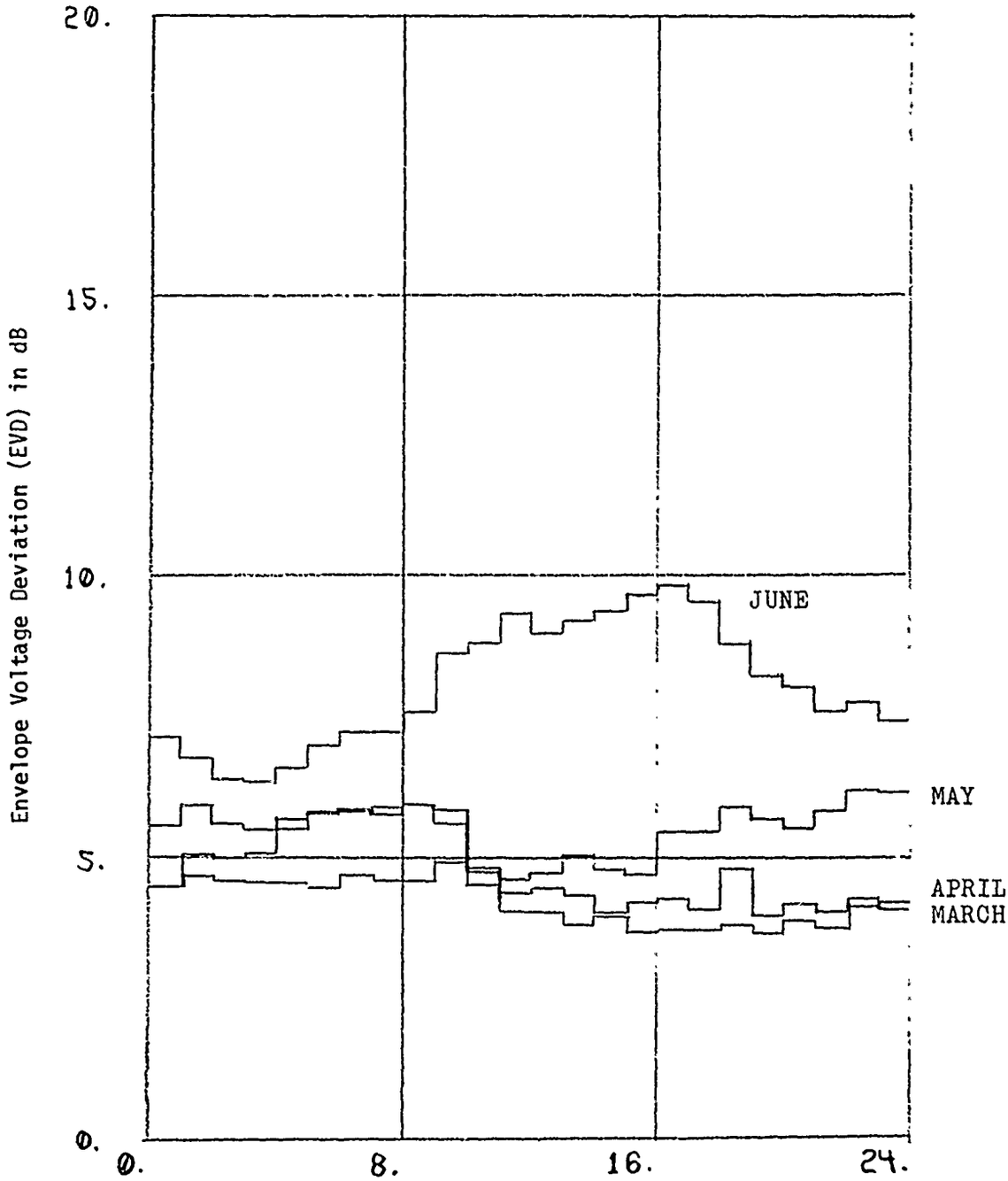

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
JUNE
MAY
APRIL
MARCH
EVD vs Greenwich Mean Time (Hrs)
17.0 kHz
Spring Season - Monthly Variation


20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
JUNE
MAY
APRIL
MARCH
EVD vs Greenwich Mean Time (Hrs)
20.0 kHz
Spring Season - Monthly Variation

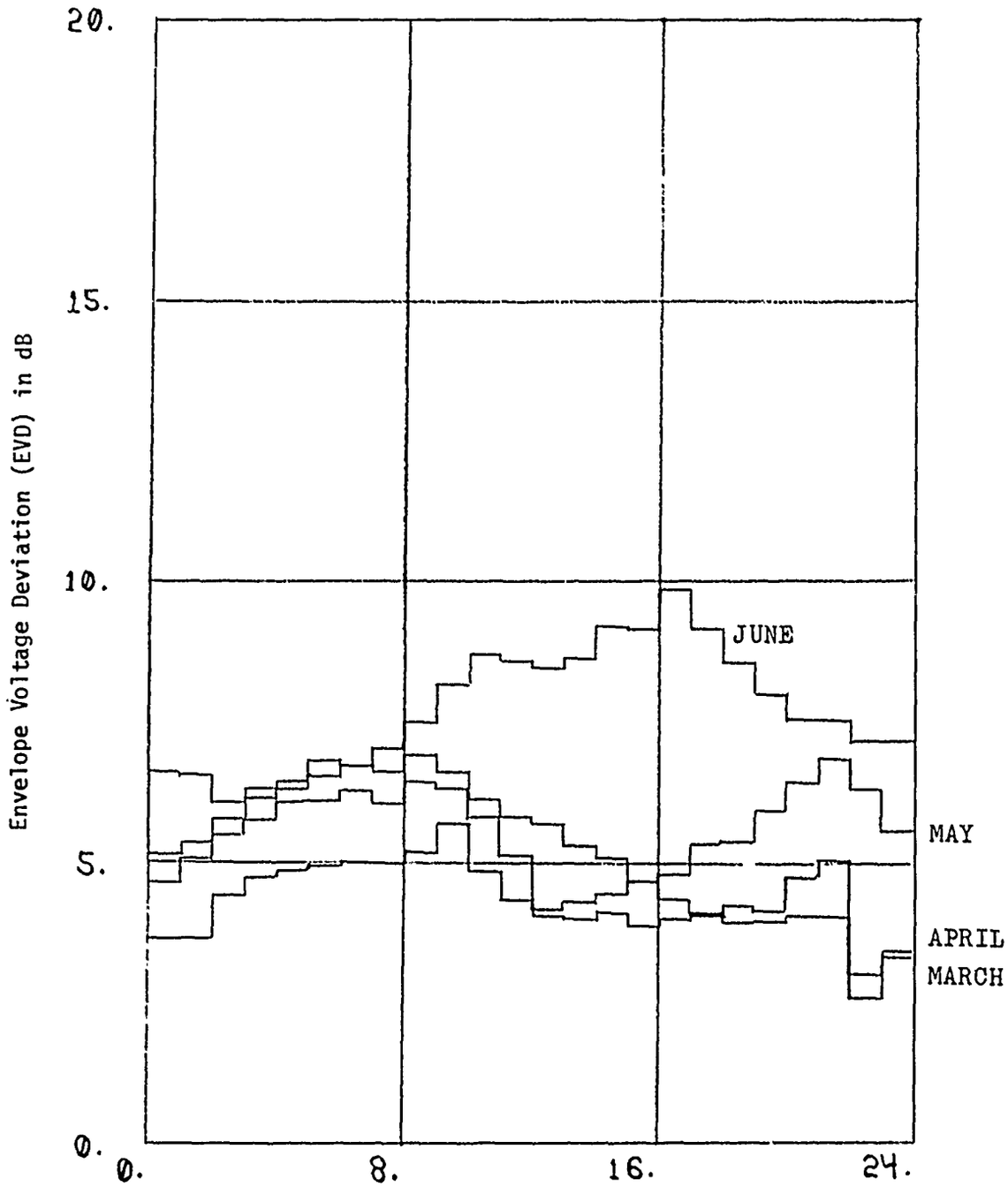

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
JUNE
MAY
MARCH
APRIL
EVD vs Greenwich Mean Time (Hrs)
27.0 kHz
Spring Season - Monthly Variation



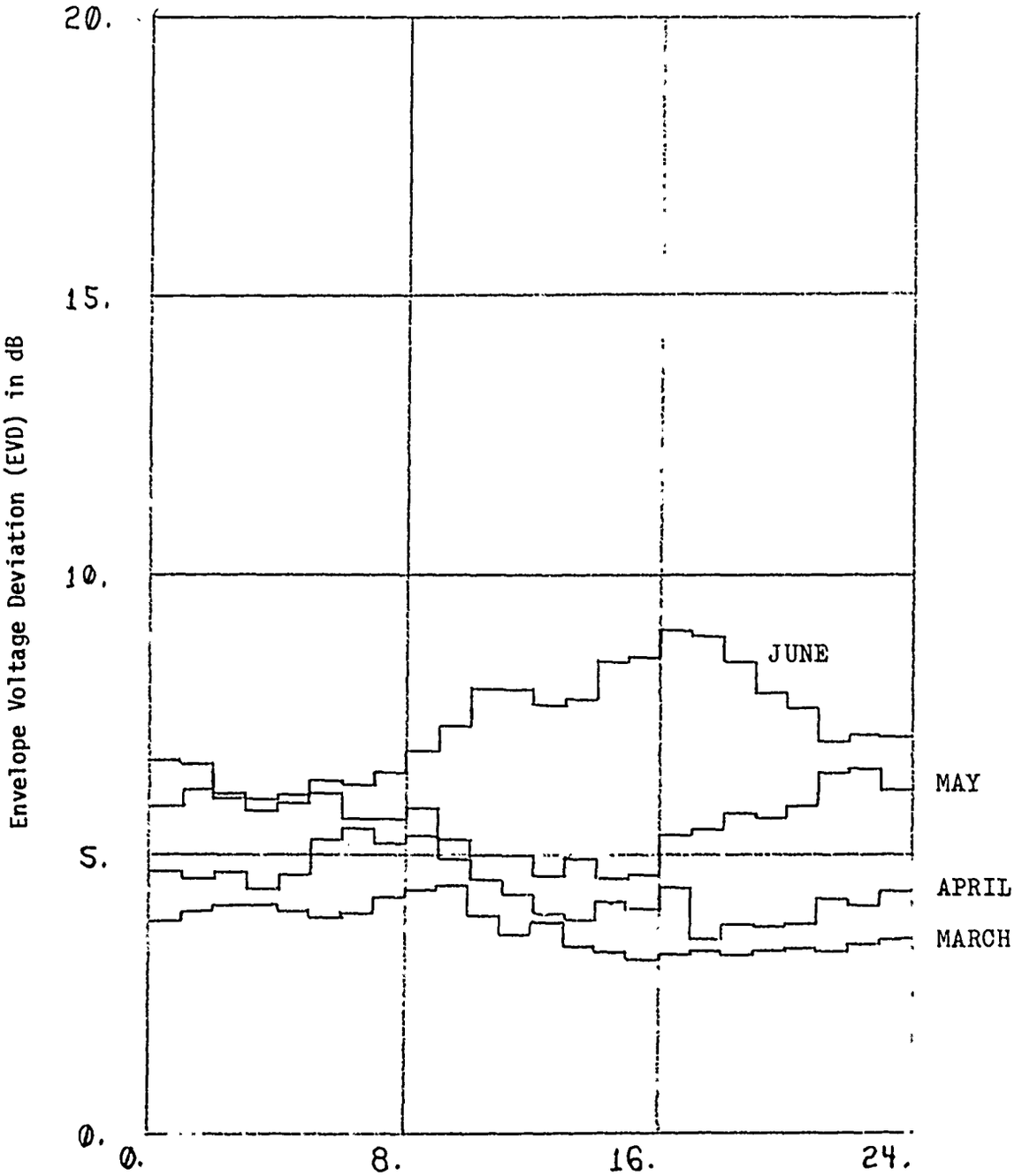
EVD vs Greenwich Mean Time (Hrs)
40.0 kHz
Spring Season - Monthly Variation



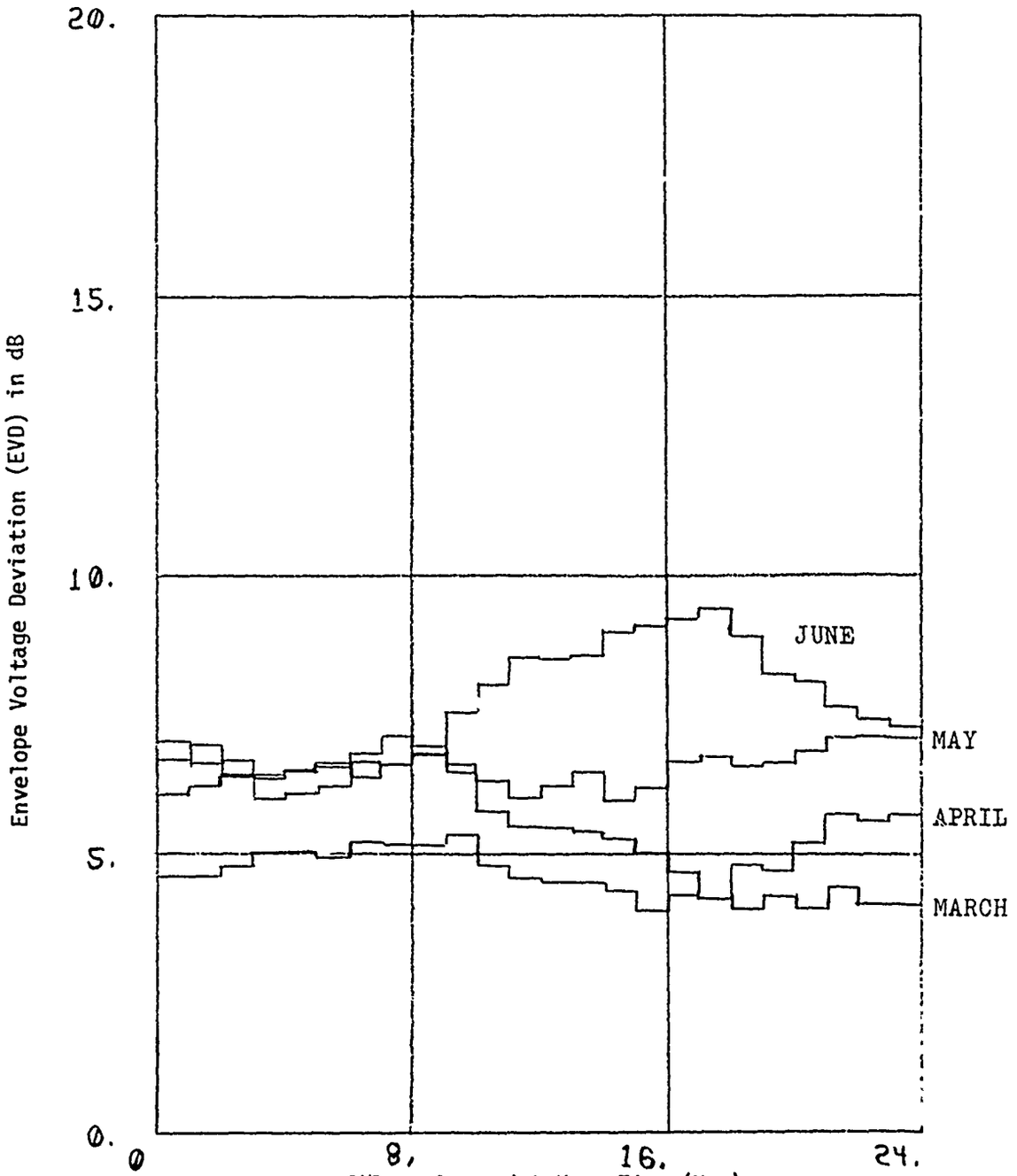
EVD vs Greenwich Mean Time (Hrs)
43.0 kHz
Spring Season - Monthly Variation



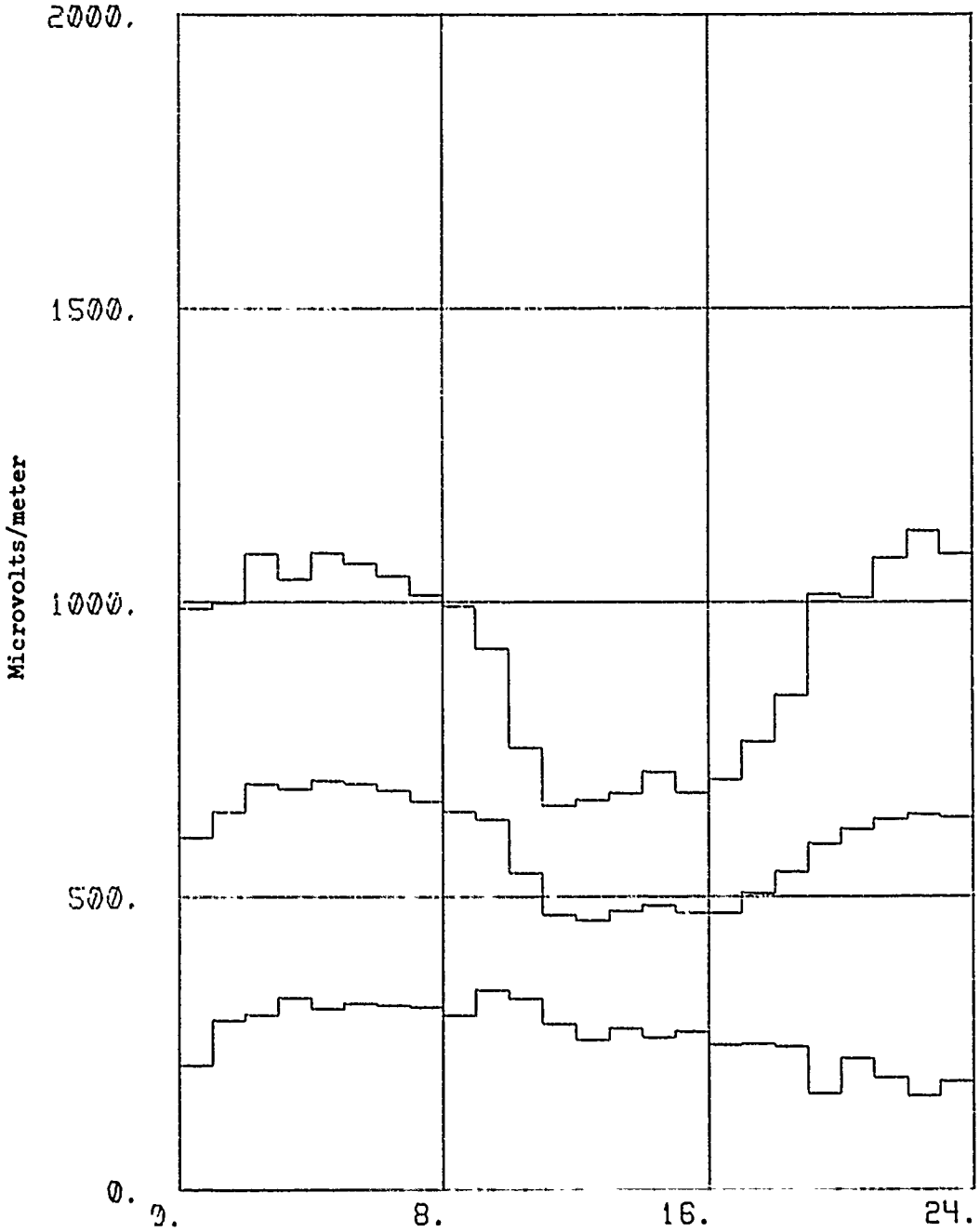
EVD vs Greenwich Mean Time (Hrs)
47.0 kHz
Spring Season - Monthly Variation



EVD vs Greenwich Mean Time (Hrs)
50.0 kHz
Spring Season - Monthly Variation

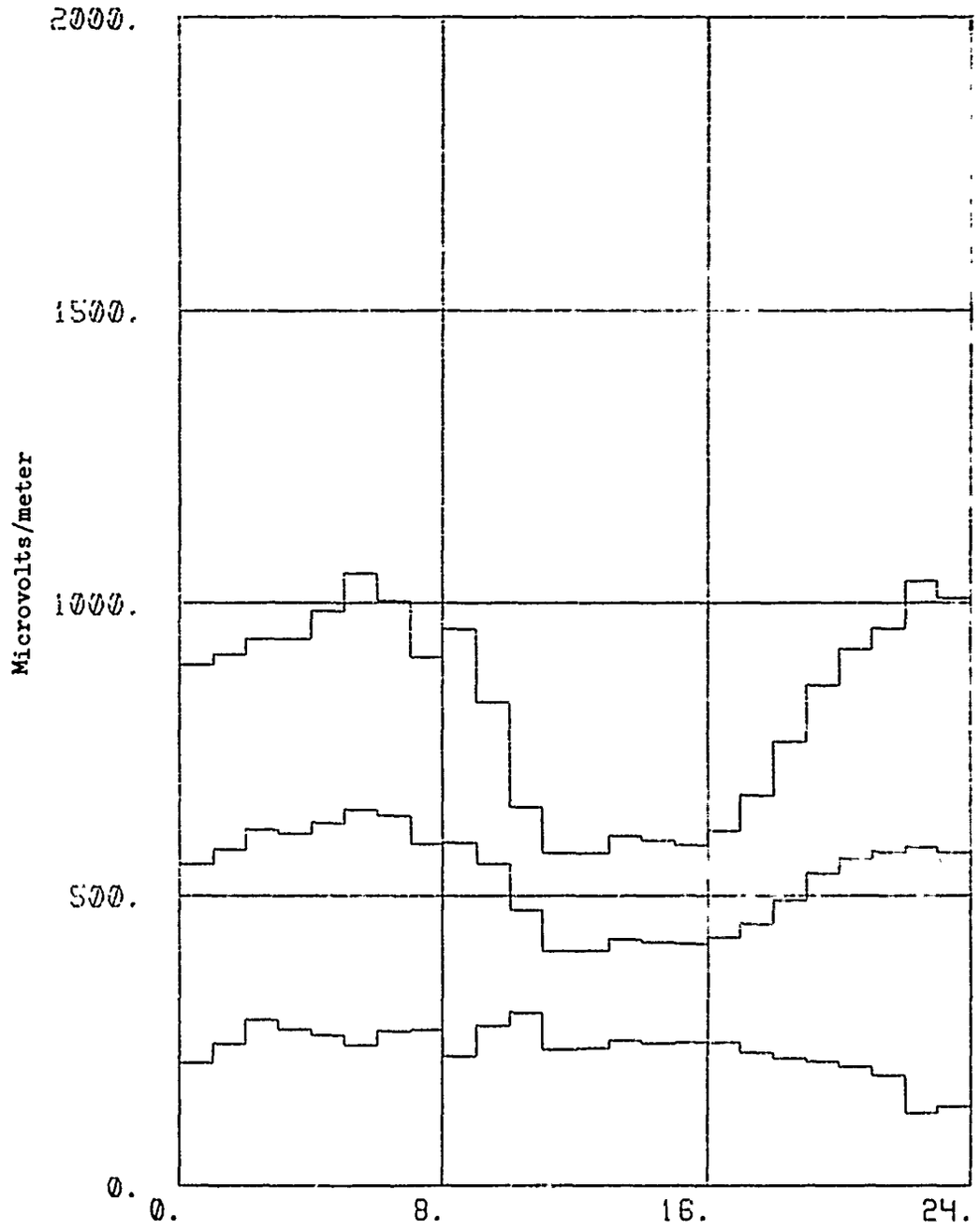

20.
15.
10.
5.
0.
0
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
JUNE
MAY
APRIL
MARCH
EVD vs Greenwich Mean Time (Hrs)
55.0 kHz
Spring Season - Monthly Variation

5.5 - ERMS vs TIME (@ FREQS. - SPRING SEASON)

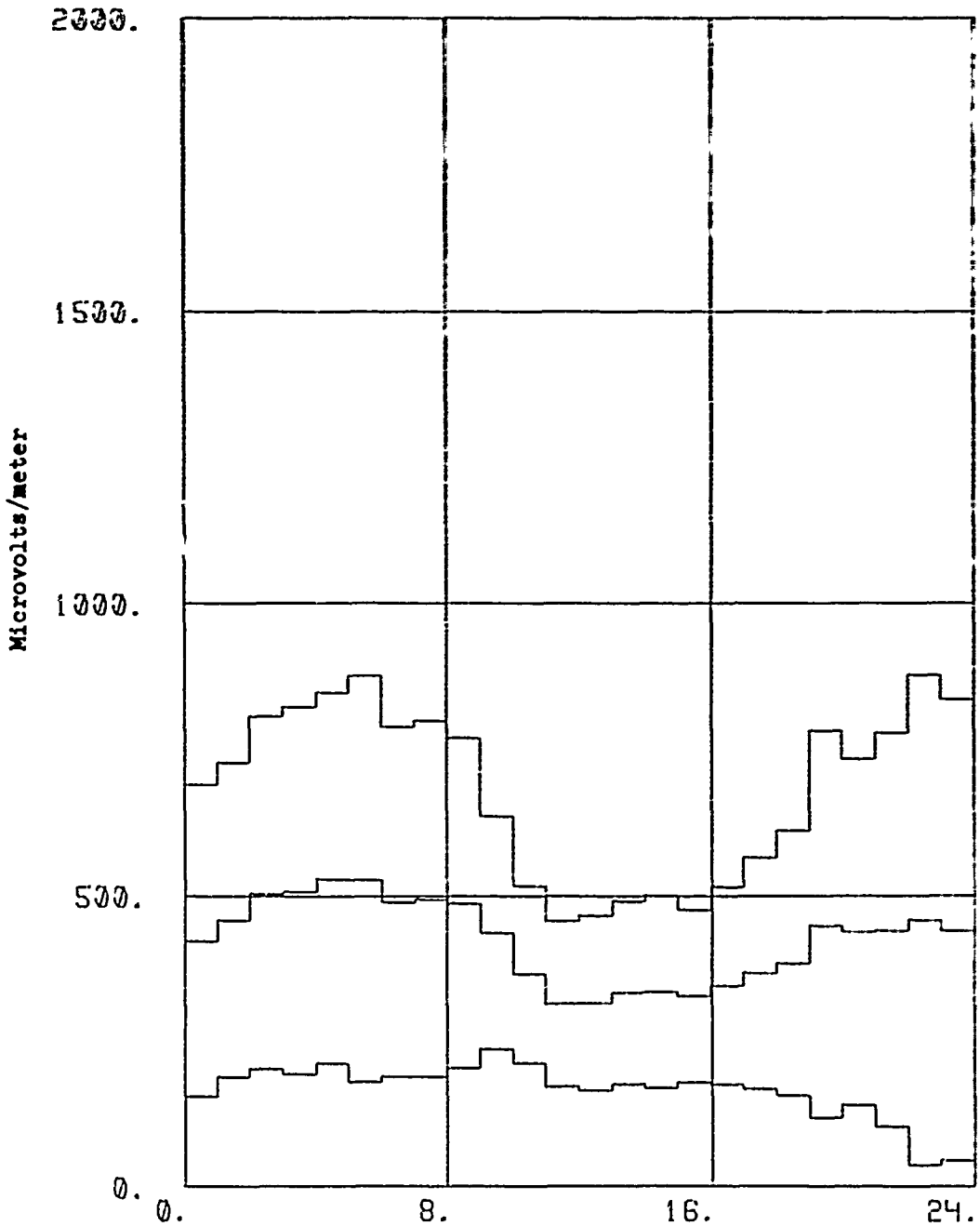


RMS vs Greenwich Mean Time (Hrs)
10.7 kHz
Spring Season-March, April, May

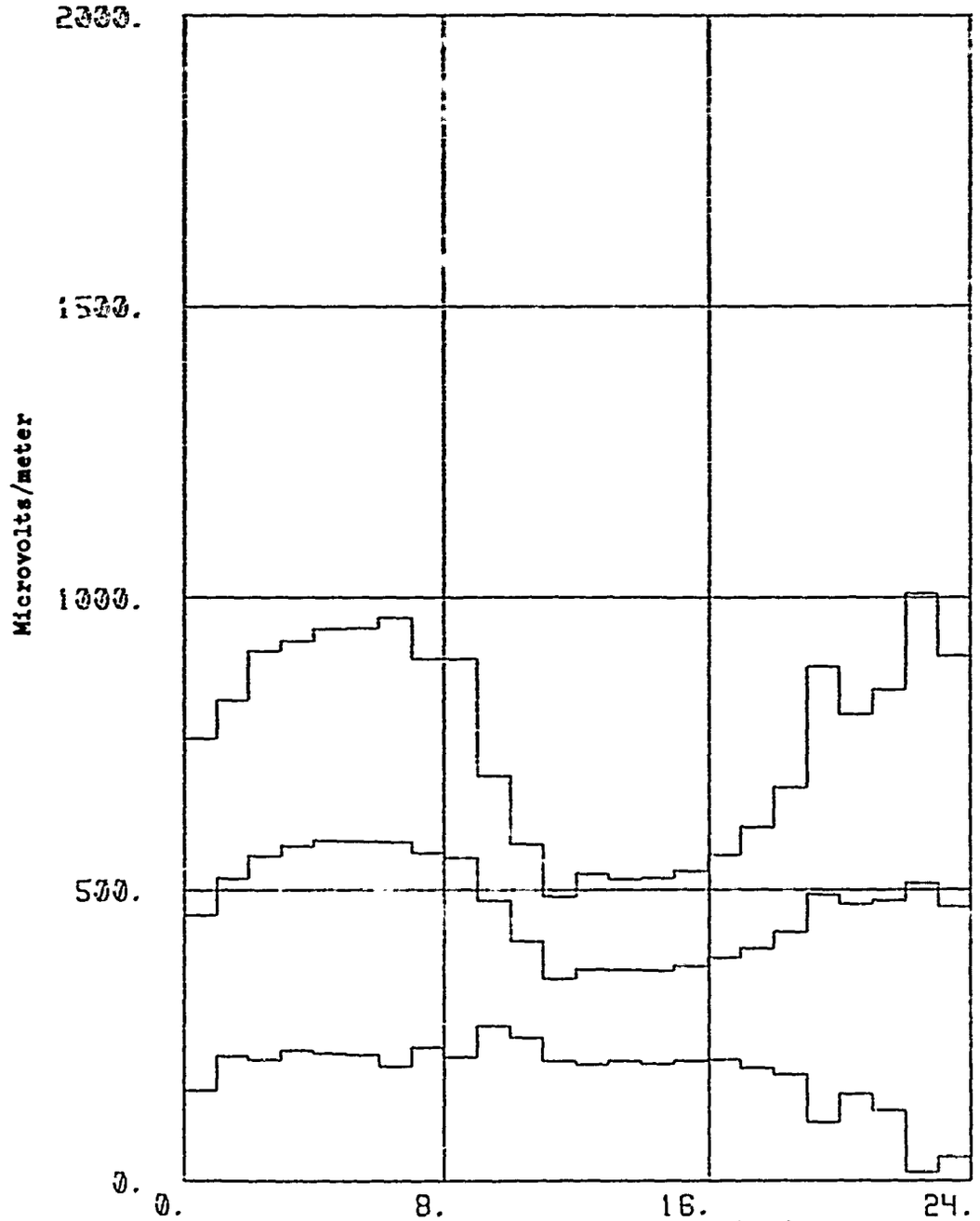
COPY

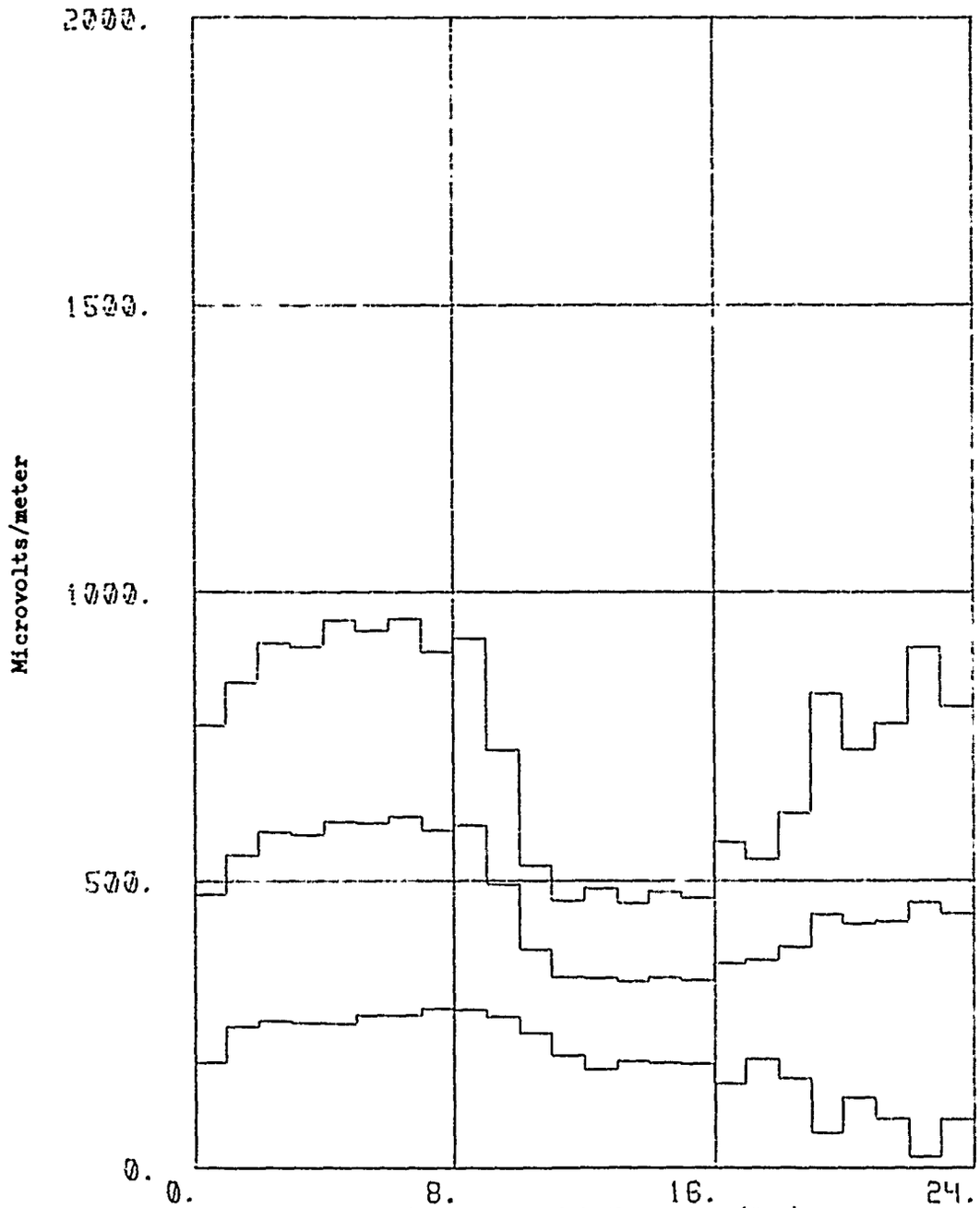


RMS vs Greenwich Mean Time (Hrs)
14.0 kHz
Spring Season-March, April, May

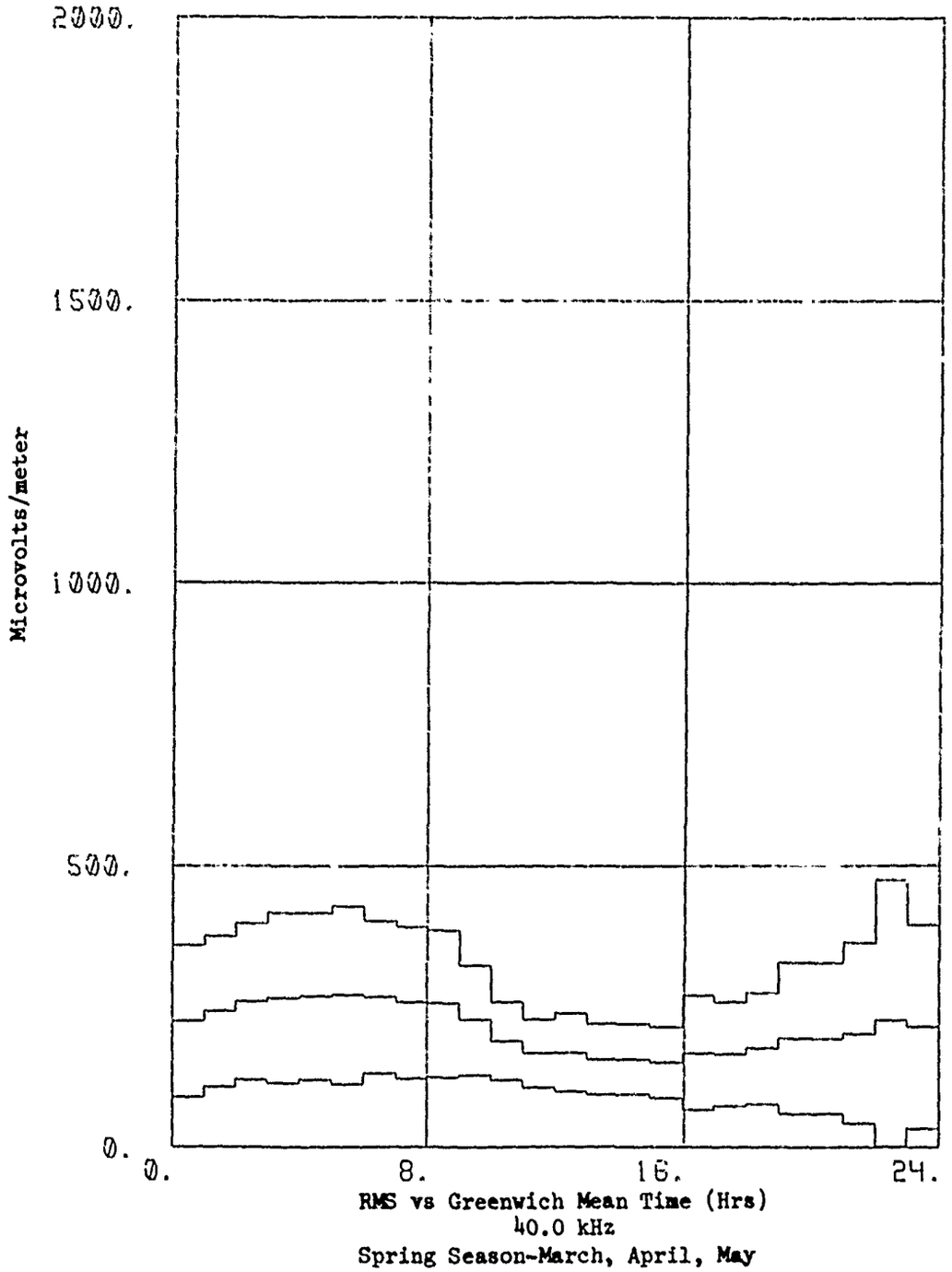


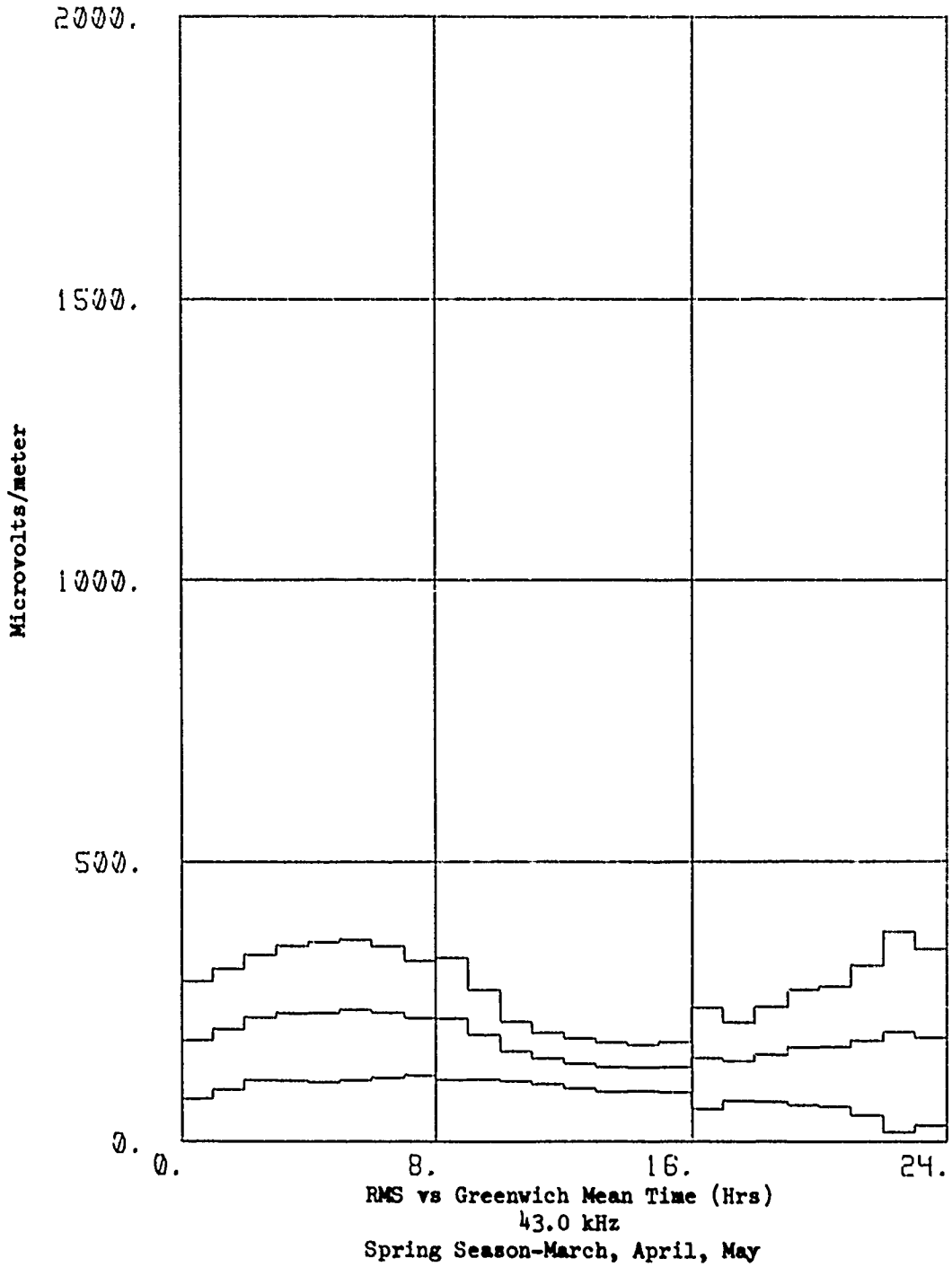
RMS vs Greenwich Mean Time (Hrs)
17.0 kHz
Spring Season-March, April, May

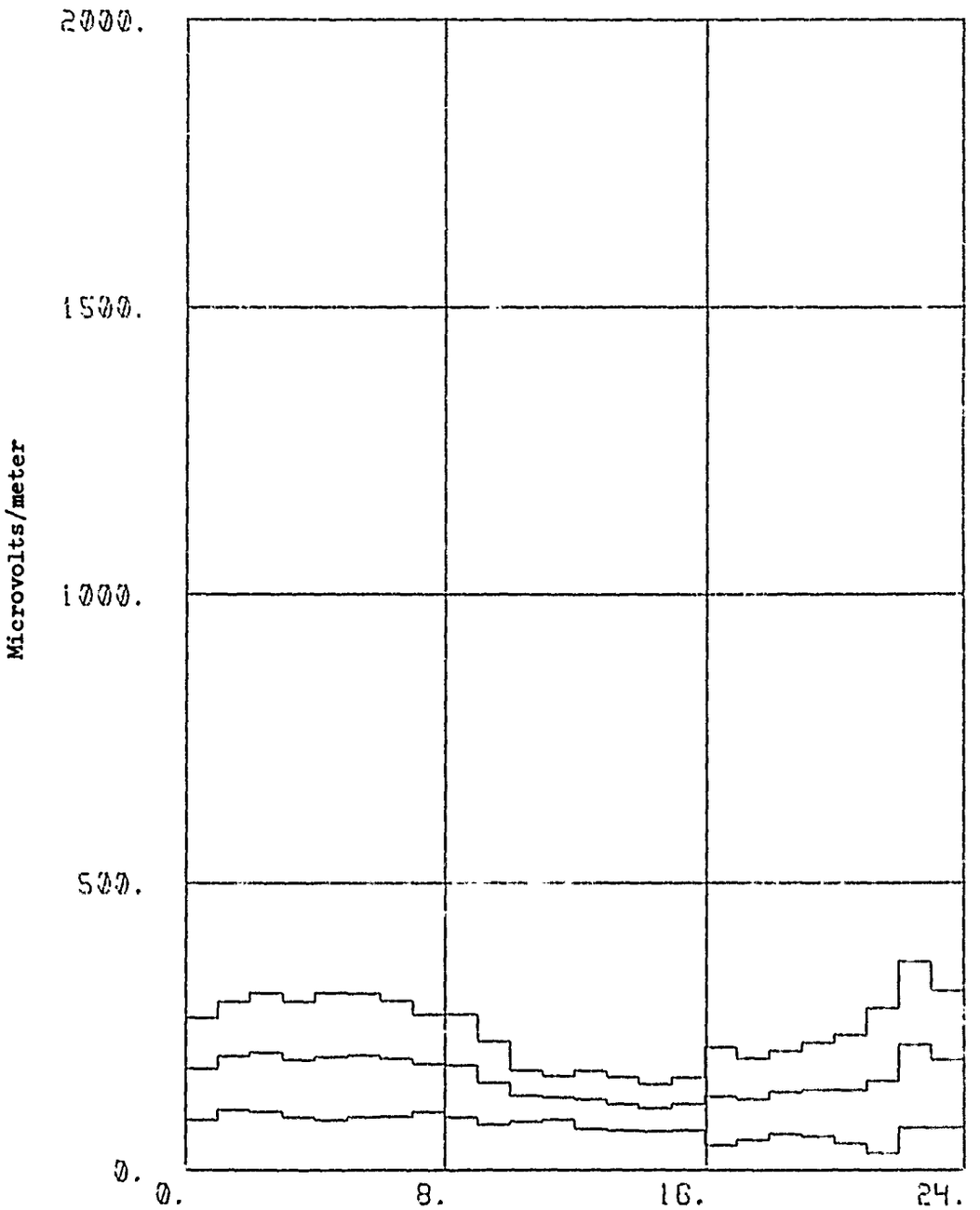

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
20.0 kHz
Spring Season-March, April, May

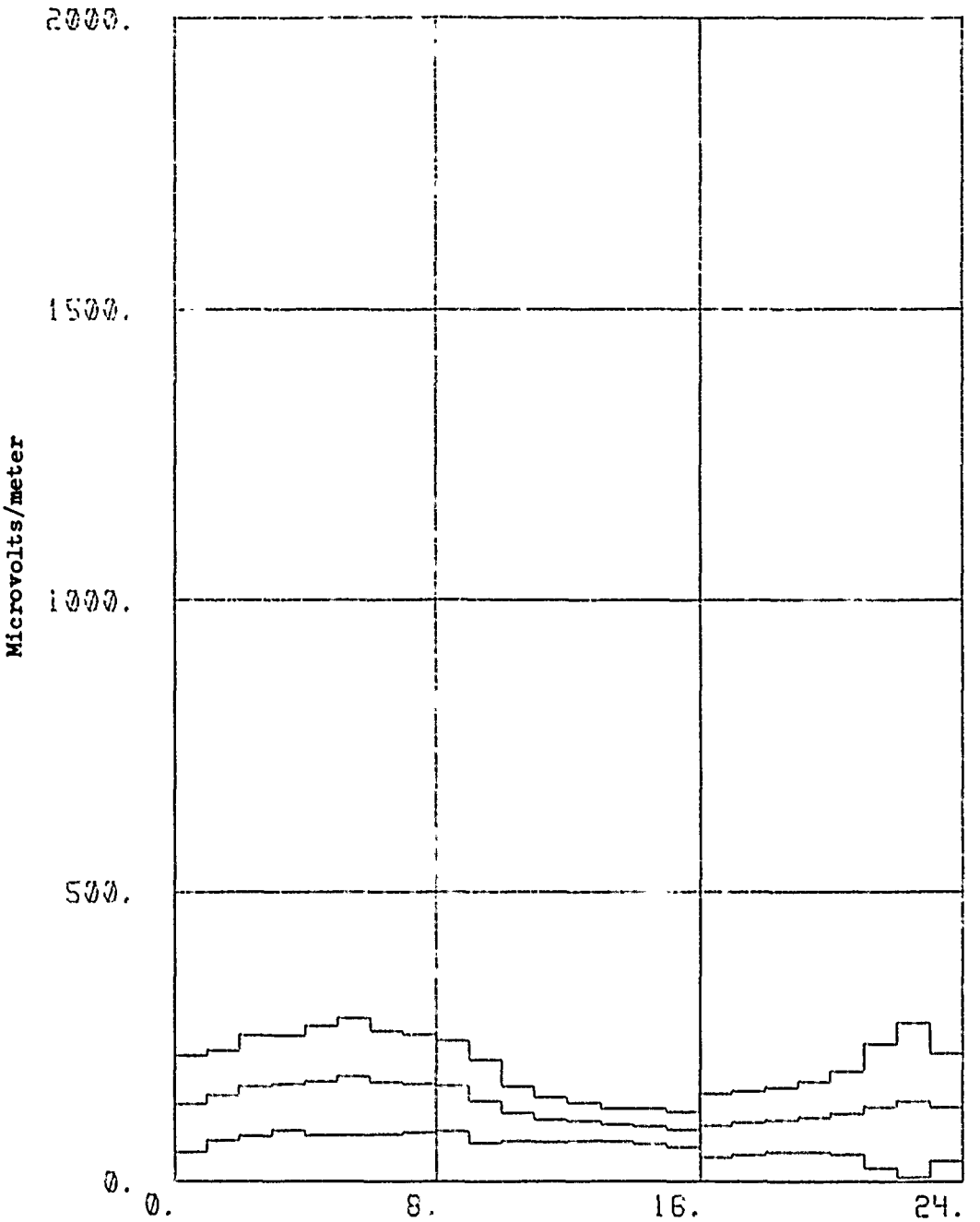


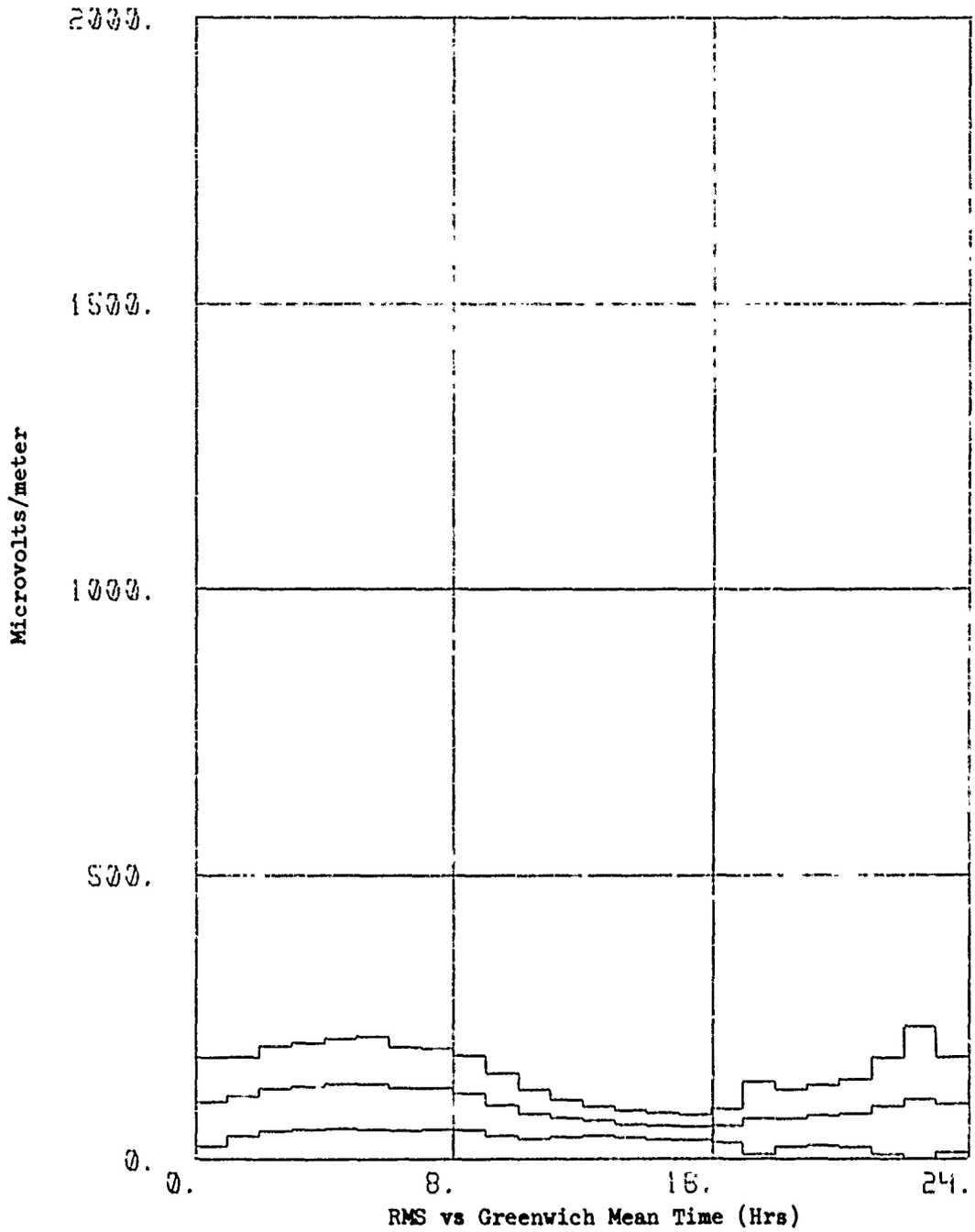
RMS vs Greenwich Mean Time (Hrs)
27.0 kHz
Spring Season-March, April, May


2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
40.0 kHz
Spring Season-March, April, May

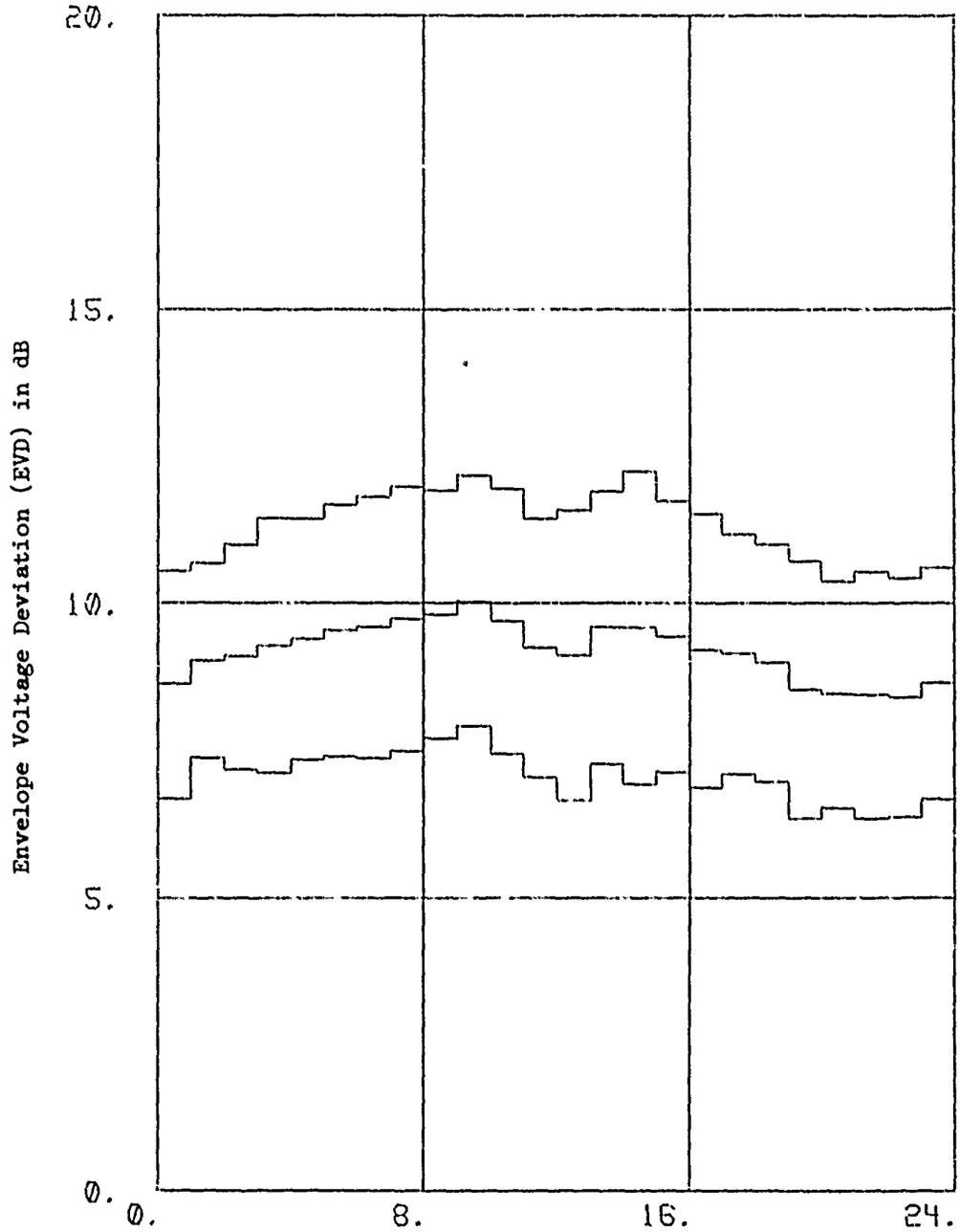

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
43.0 kHz
Spring Season-March, April, May

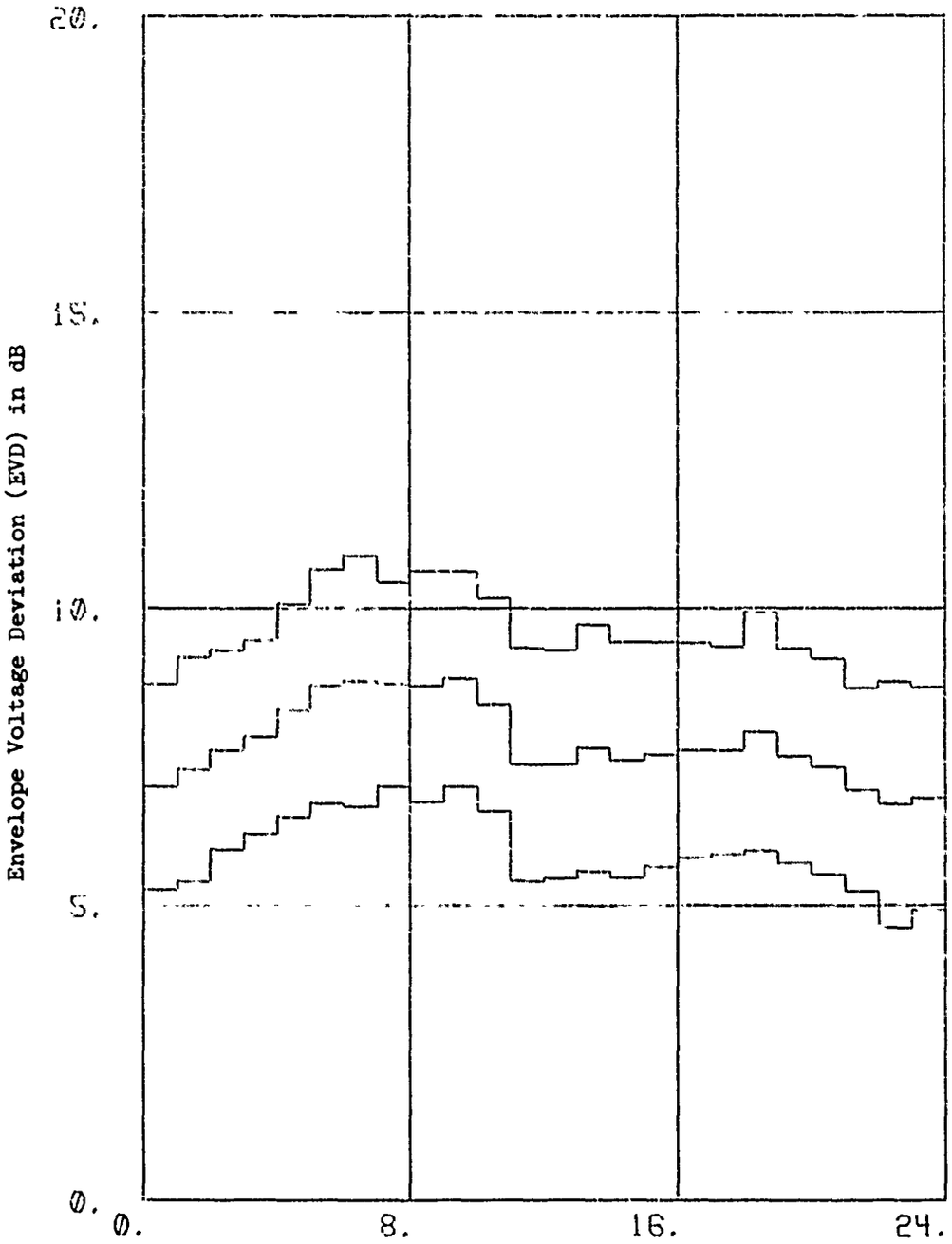

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
47.0 kHz
Spring Season-March, April, May

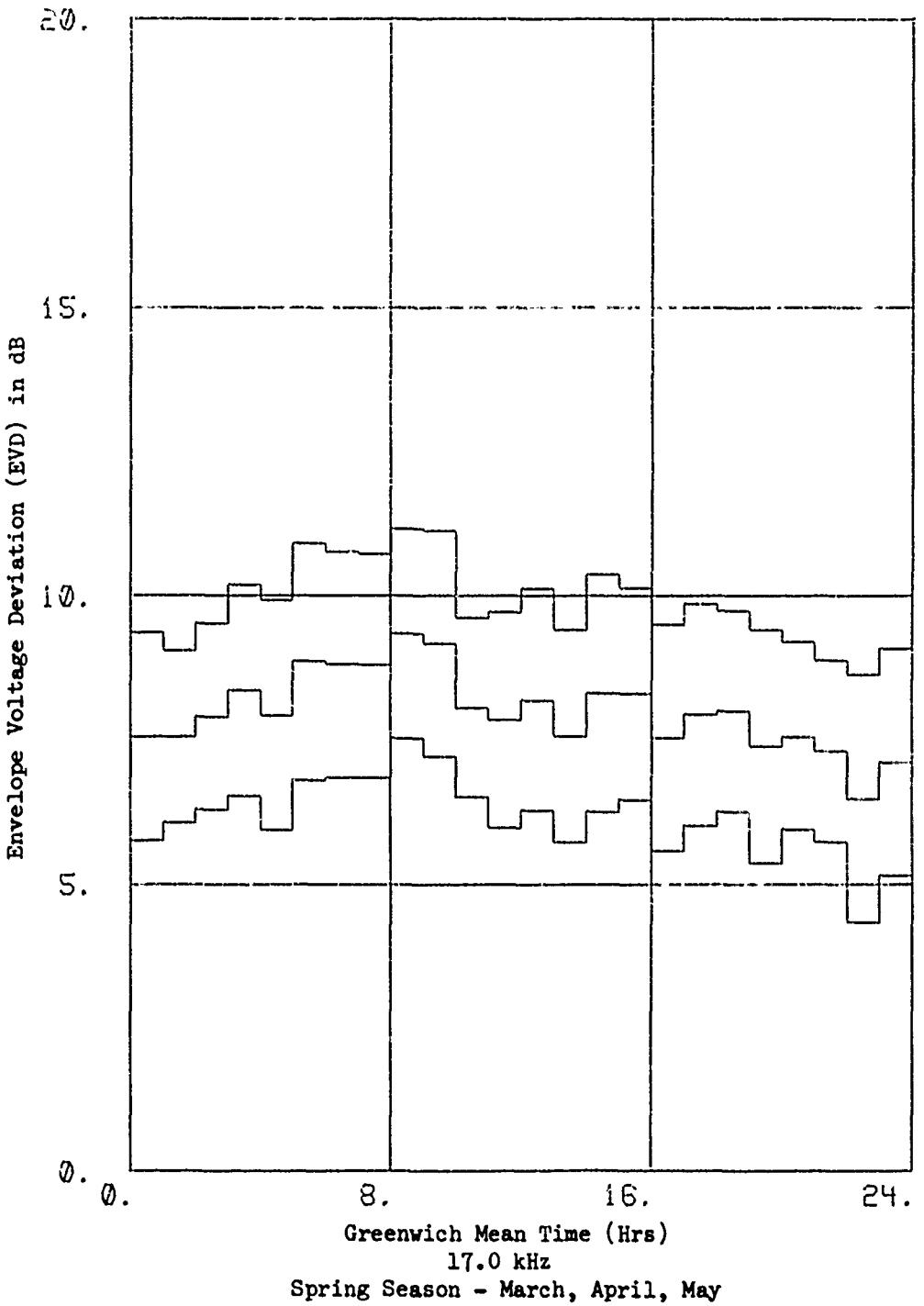

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
50.0 kHz
Spring Season-March, April, May

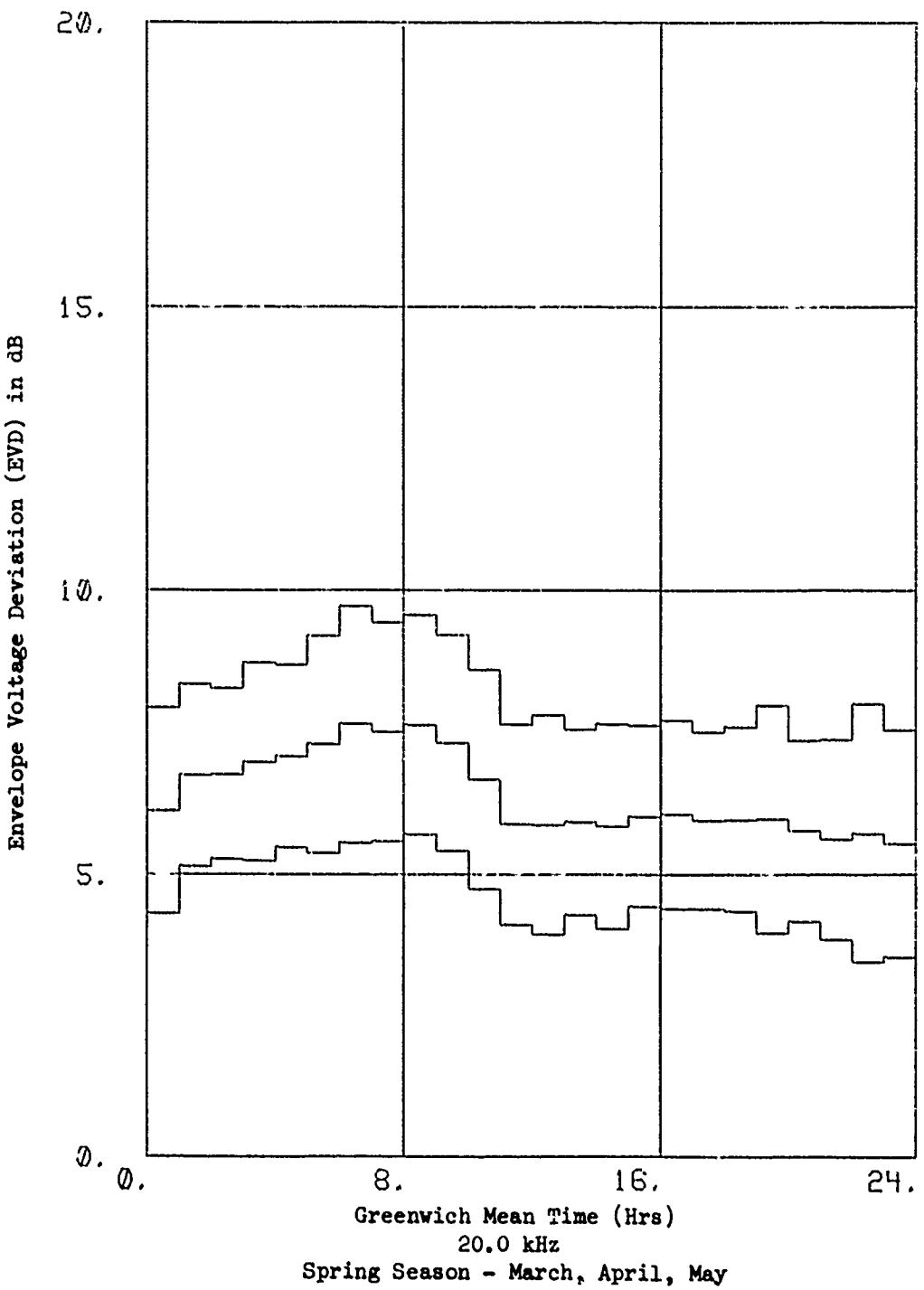

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
55.0 kHz
Spring Season-March, April, May

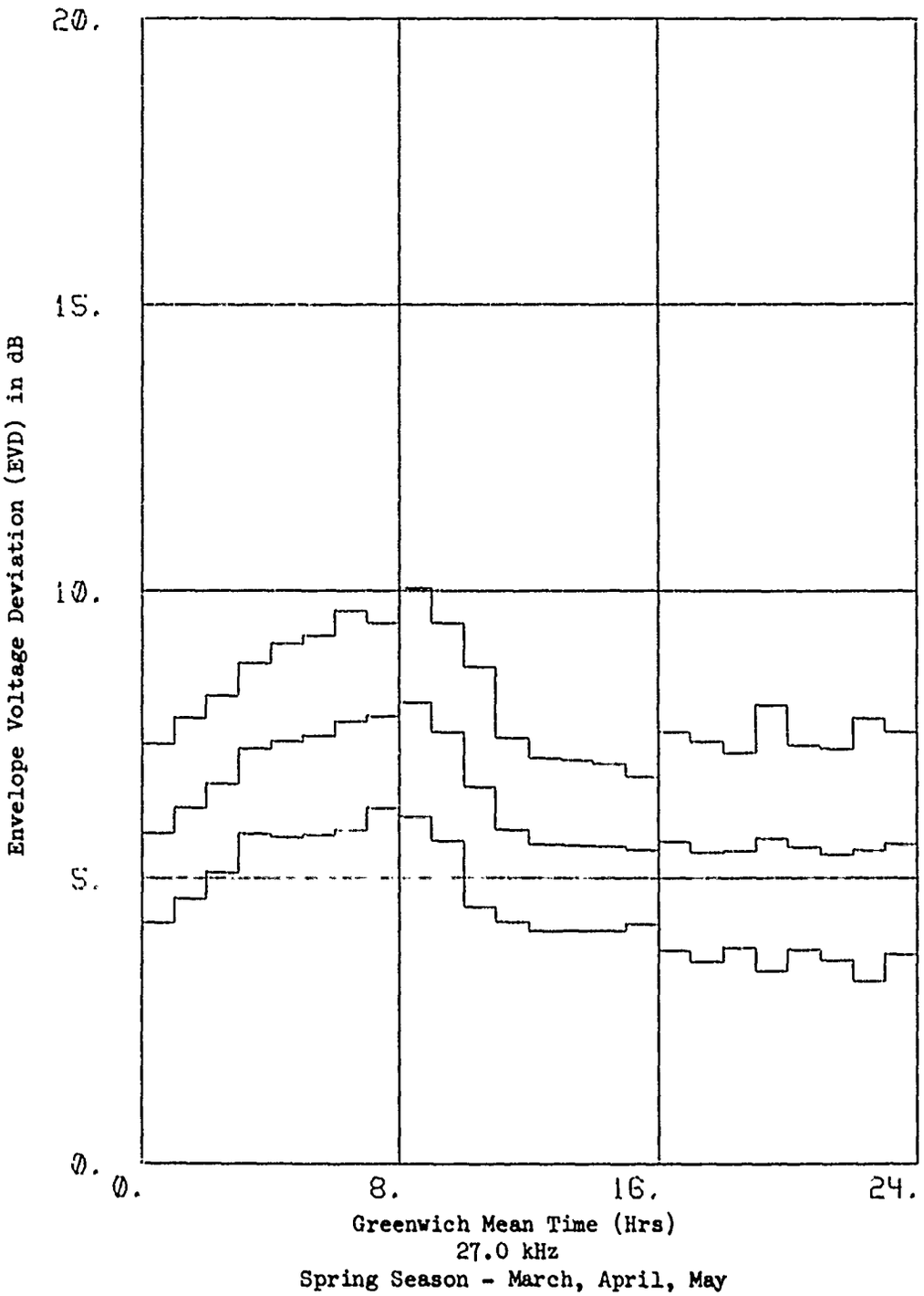
5.6 - EVD vs TIME (@ FREQ. - SPRING SEASON)

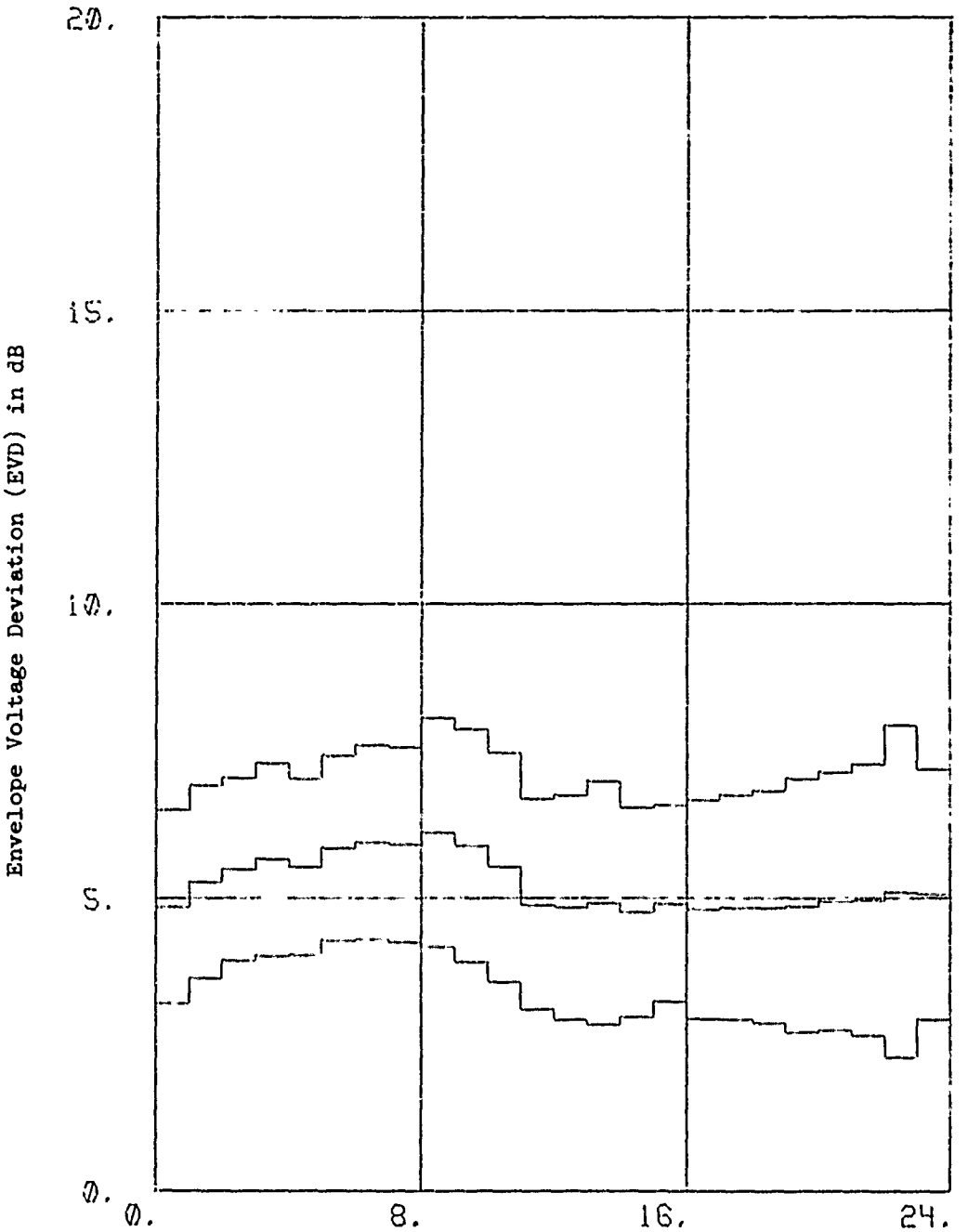

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
10.7 kHz
Spring Season - March, April, May

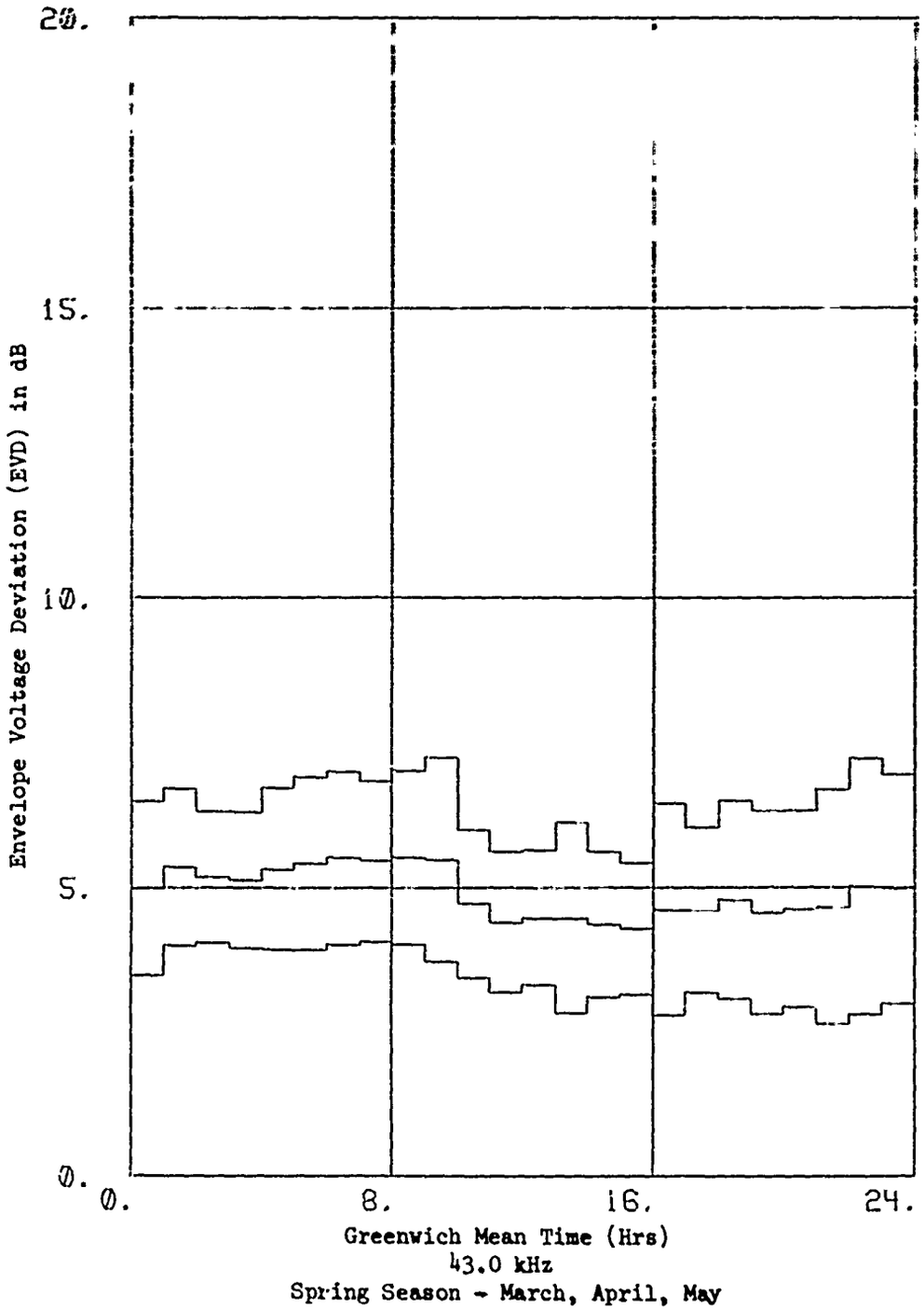

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
14.0 kHz
Spring Season - March, April, May

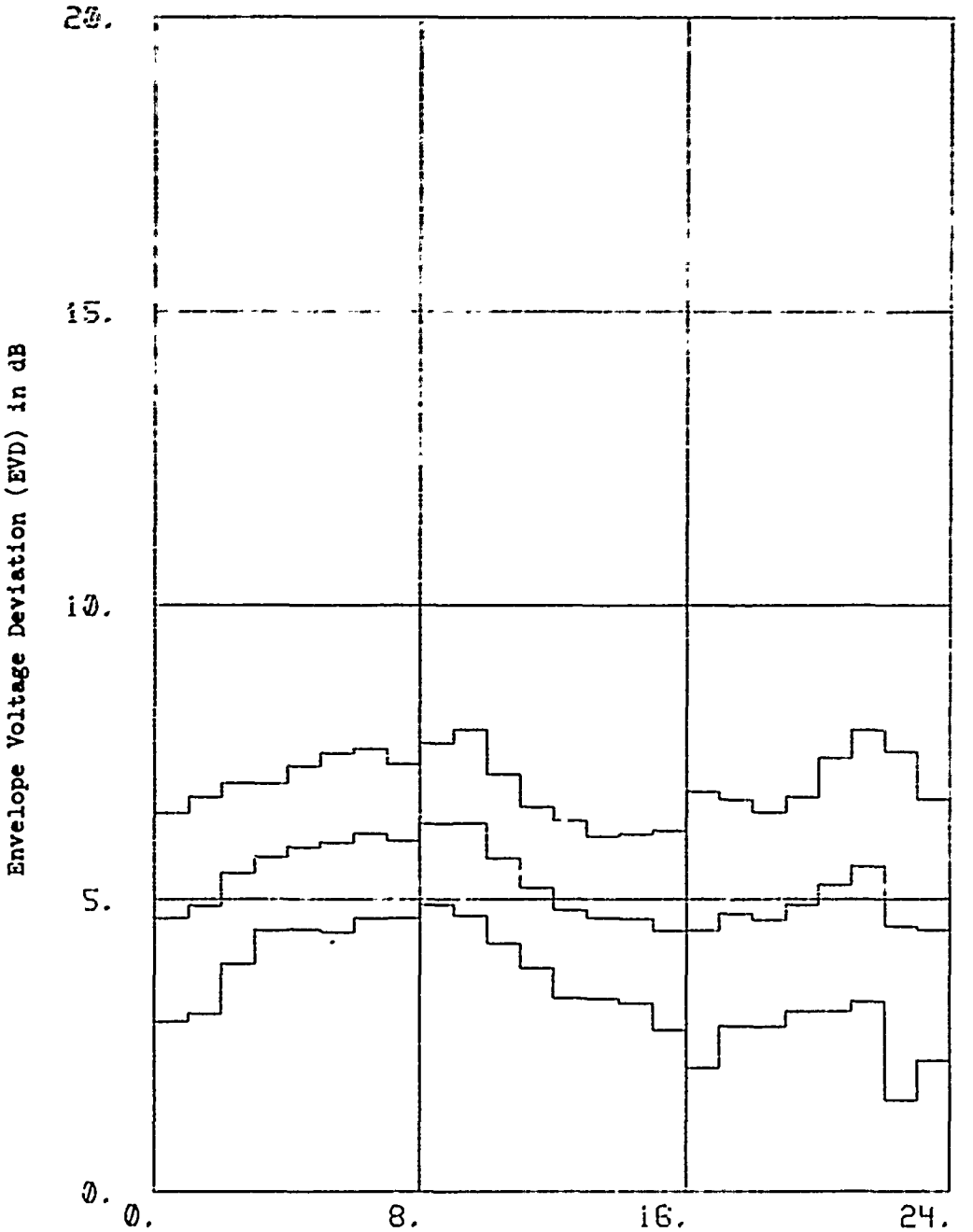

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
17.0 kHz
Spring Season - March, April, May

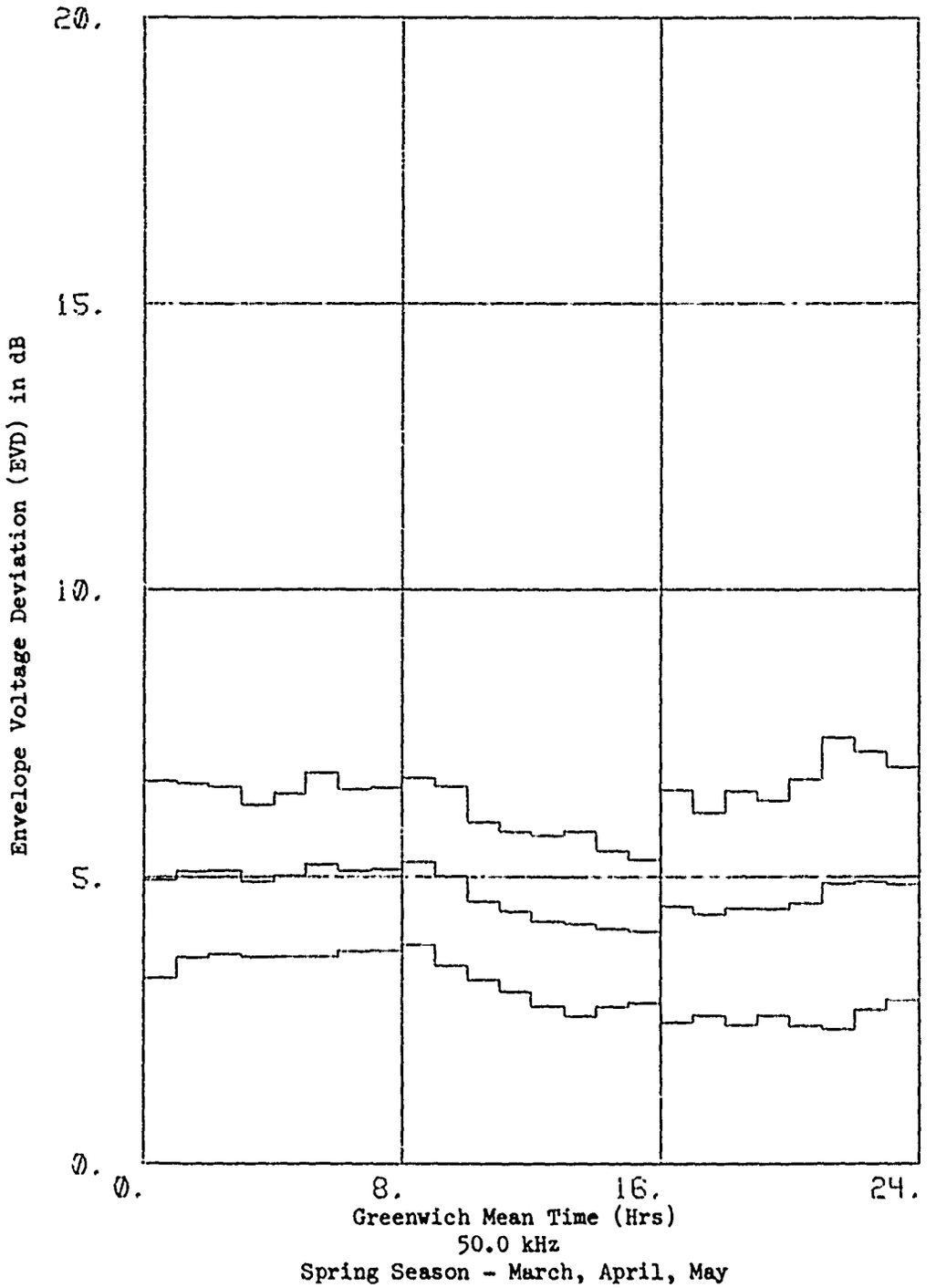

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
20.0 kHz
Spring Season - March, April, May

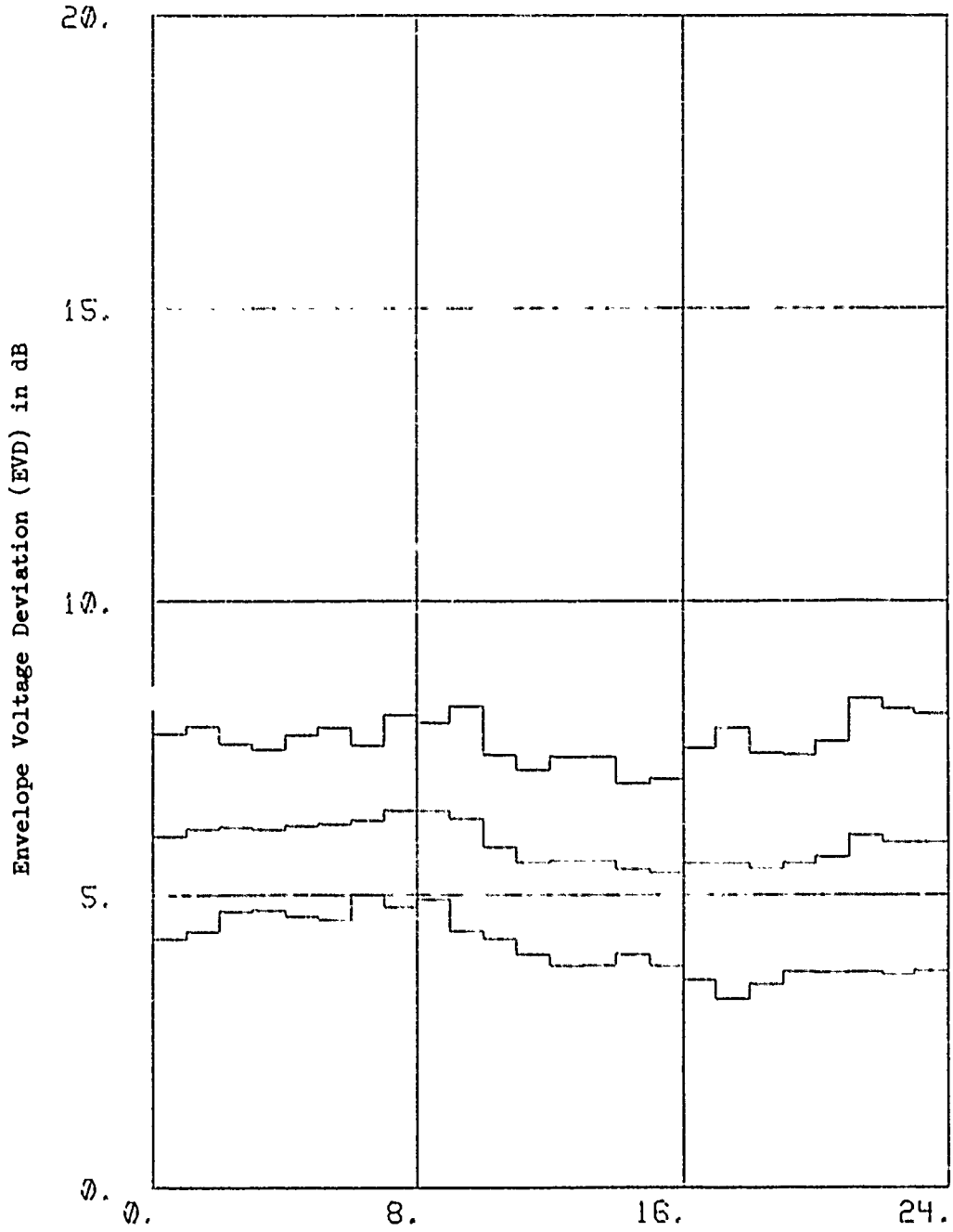

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
27.0 kHz
Spring Season - March, April, May


20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
40.0 kHz
Spring Season - March, April, May

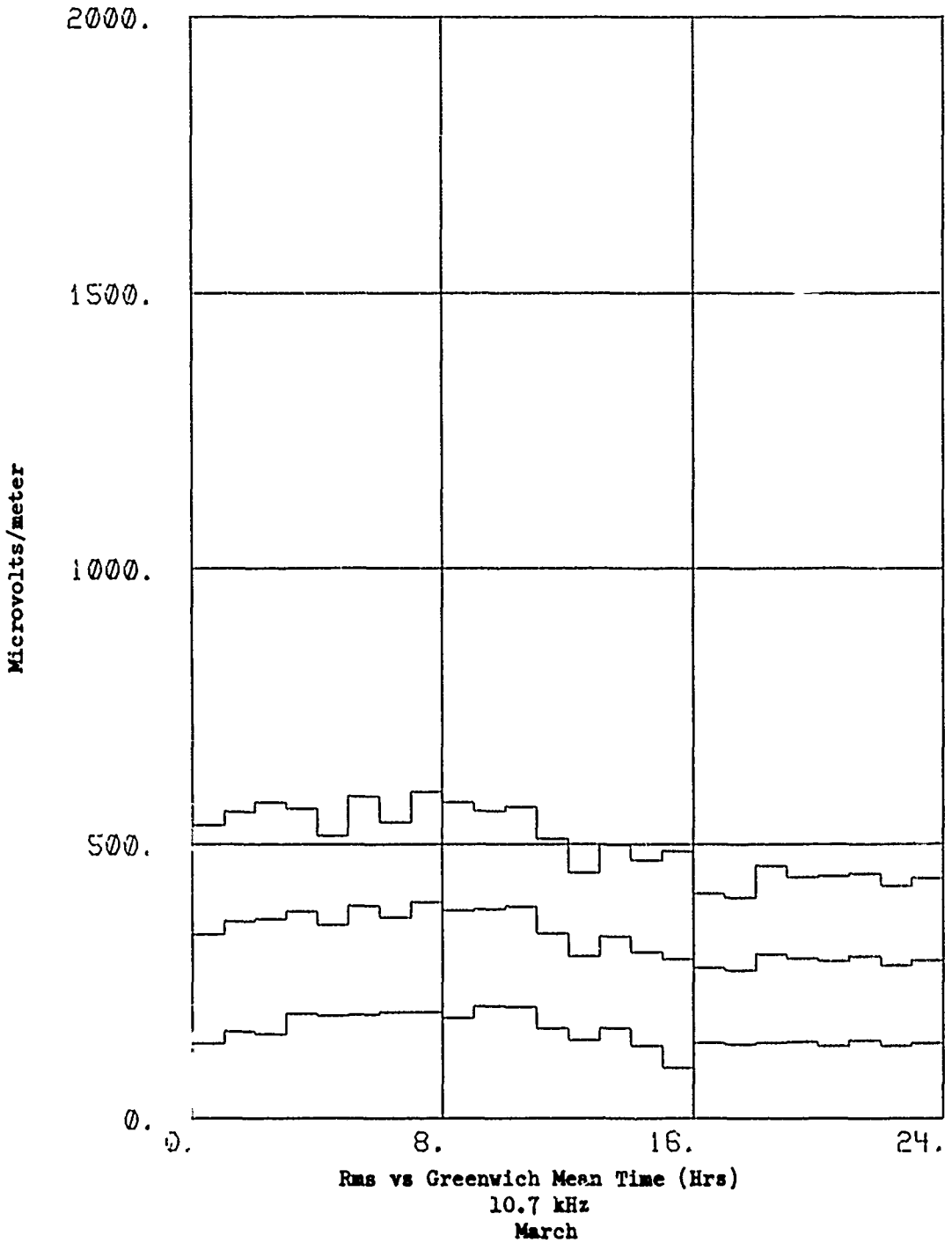

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
43.0 kHz
Spring Season - March, April, May

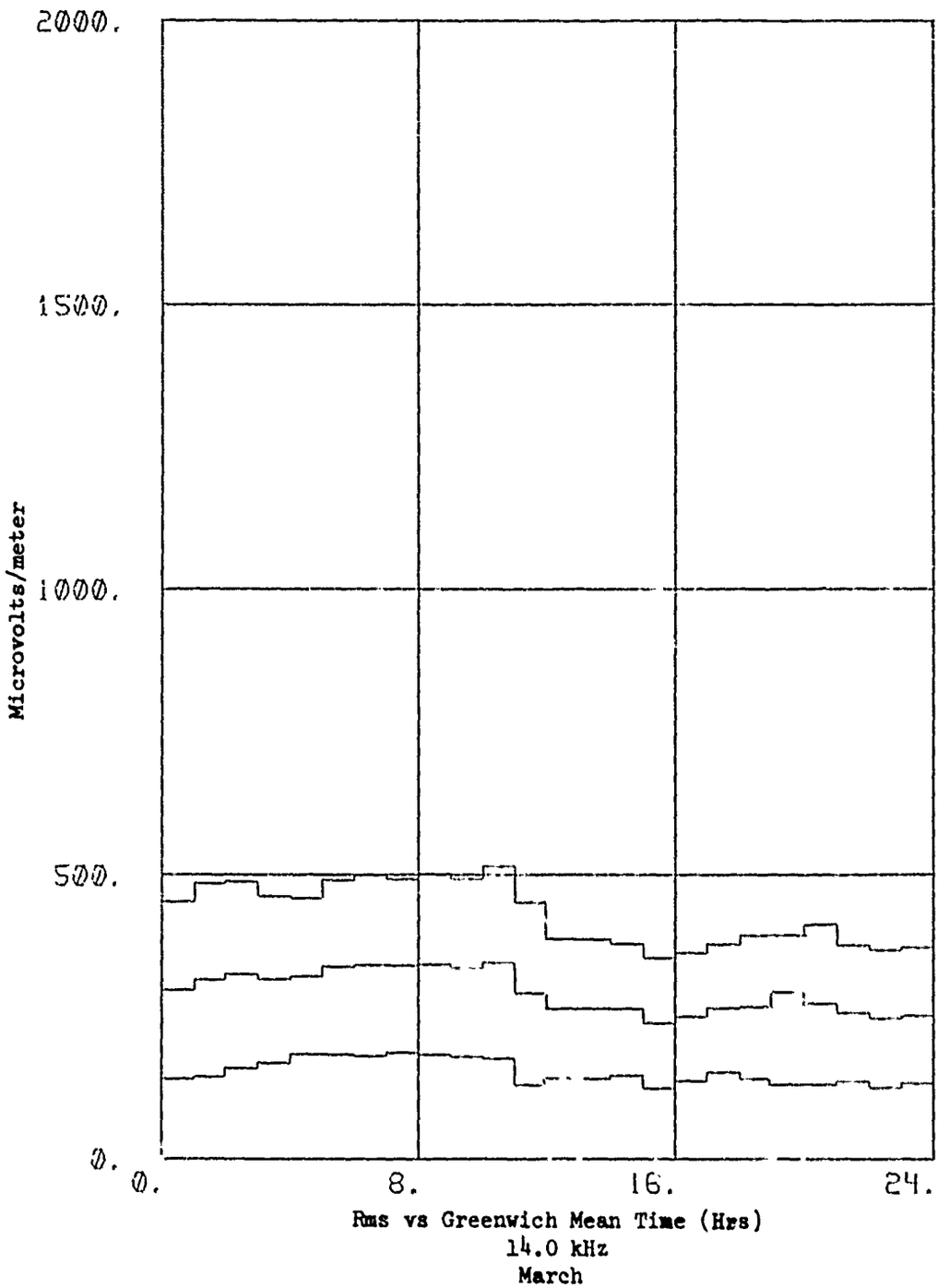

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
47.0 kHz
Spring Season - March, April, May

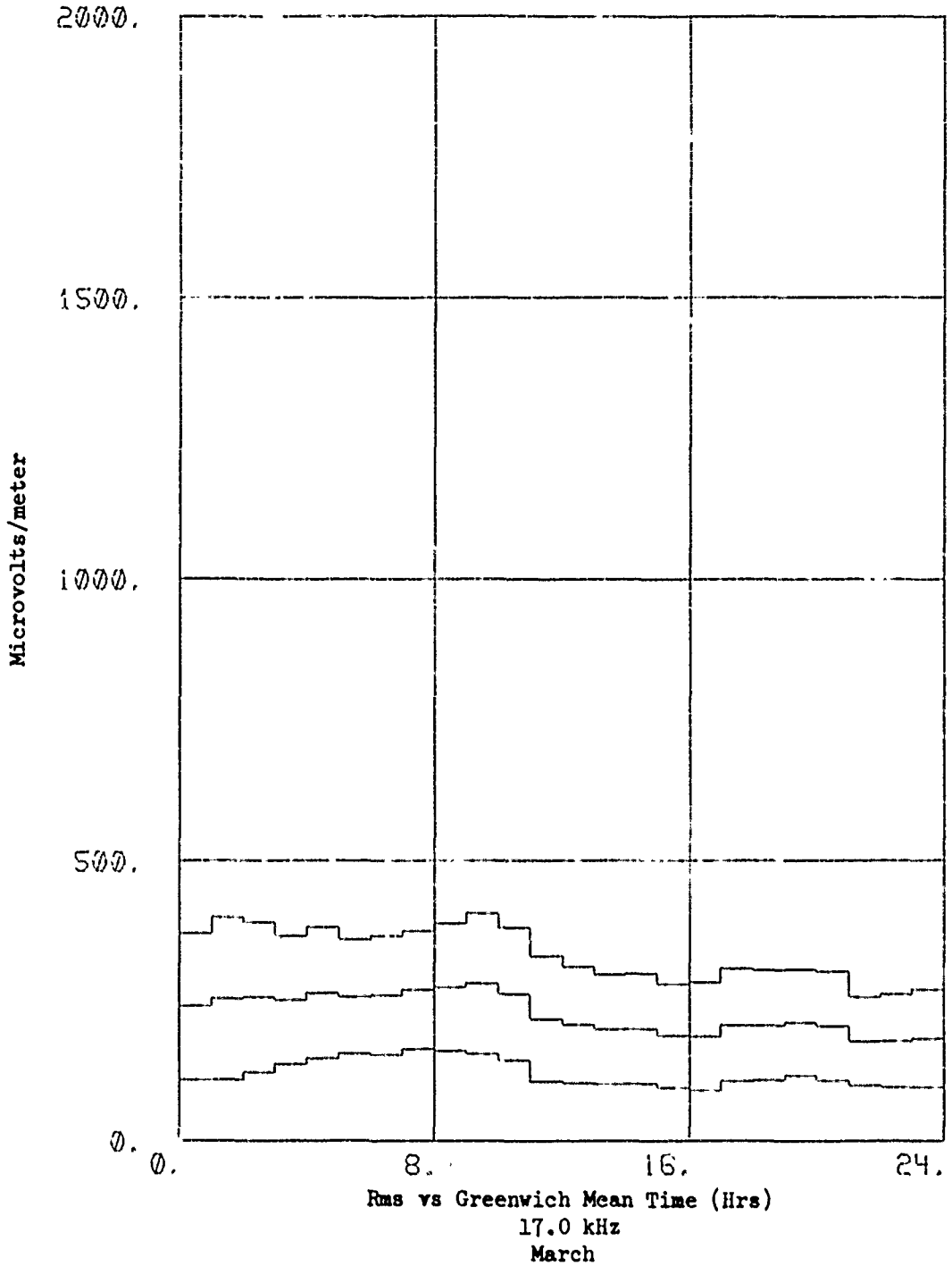

20.
15.
10.
5.
0.
Envelope Voltage Deviation (EVD) in dB
0.
8.
16.
24.
Greenwich Mean Time (Hrs)
50.0 kHz
Spring Season - March, April, May

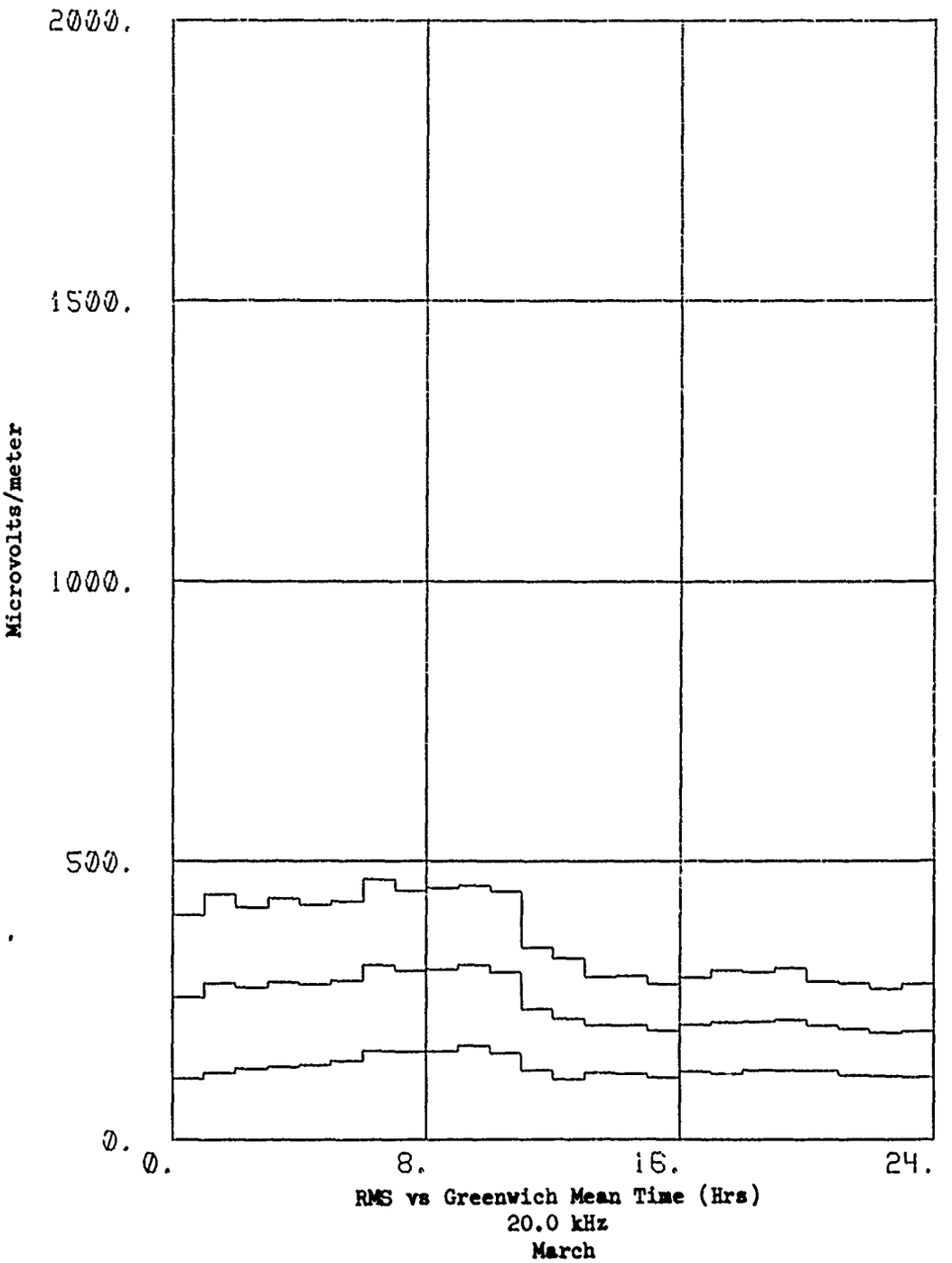

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
55.0 kHz
Spring Season - March, April, May

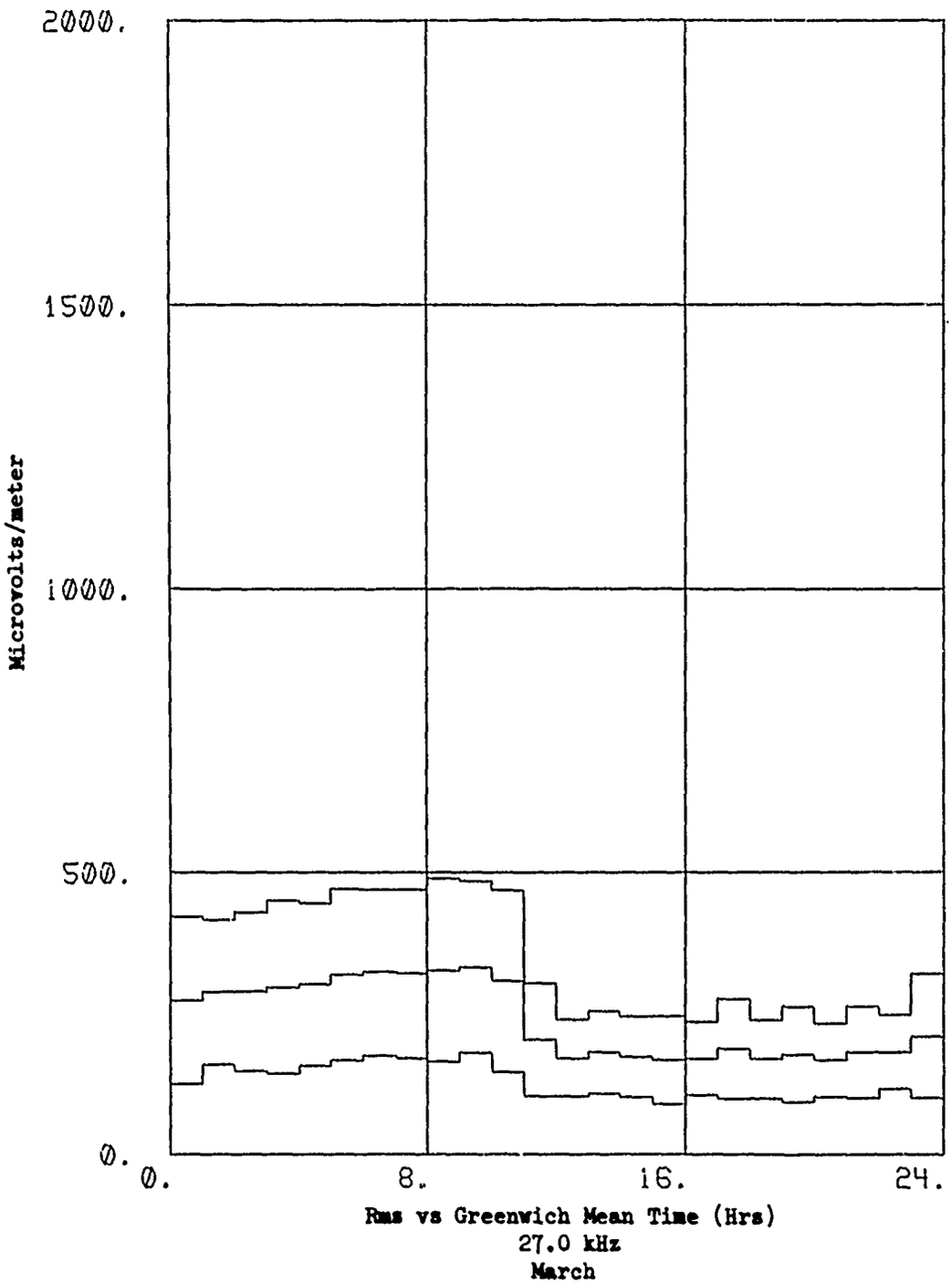
5.7 - ERMS vs TIME (@ FREQS. - FOR MARCH)

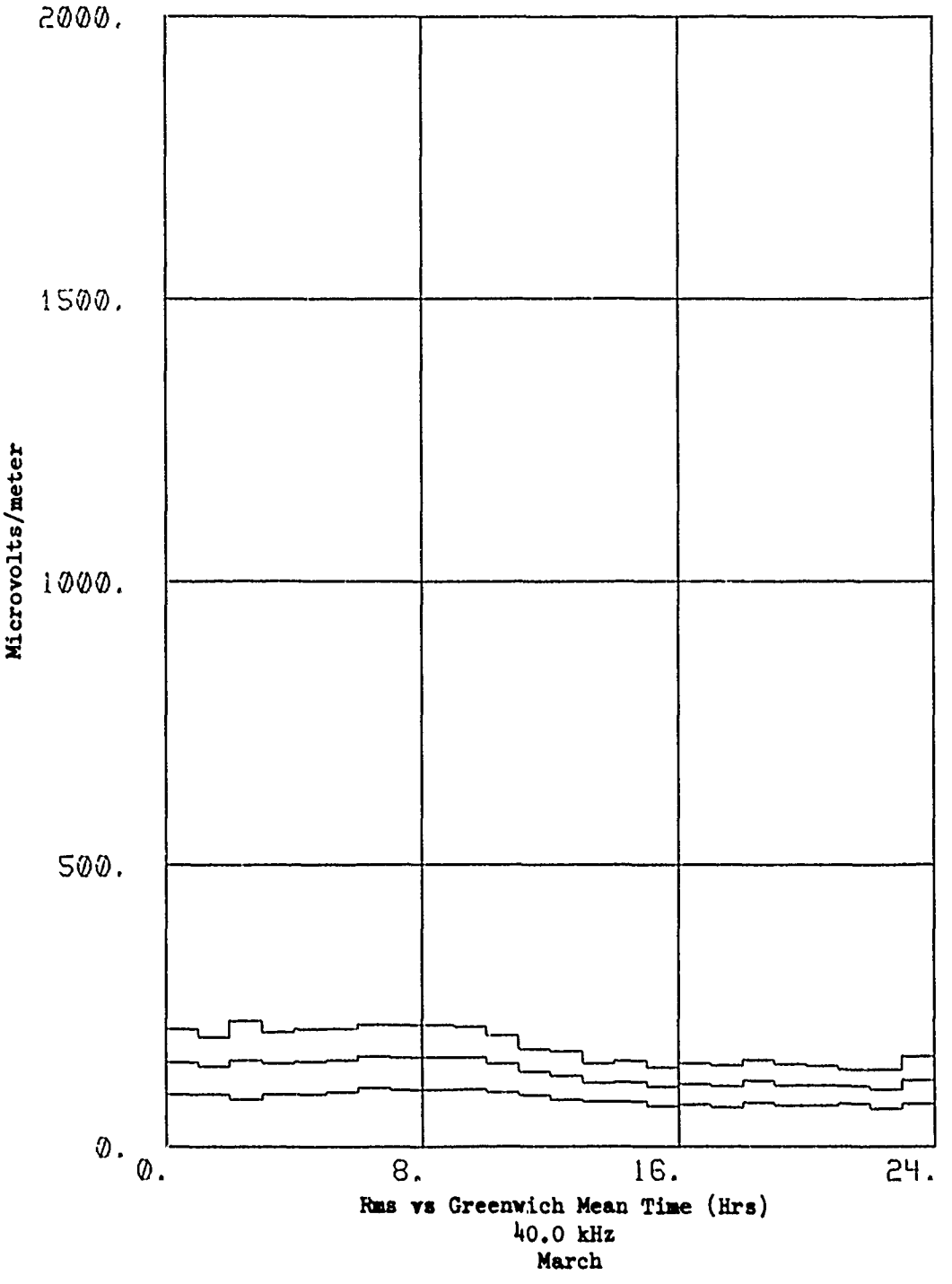

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
Rms vs Greenwich Mean Time (Hrs)
10.7 kHz
March

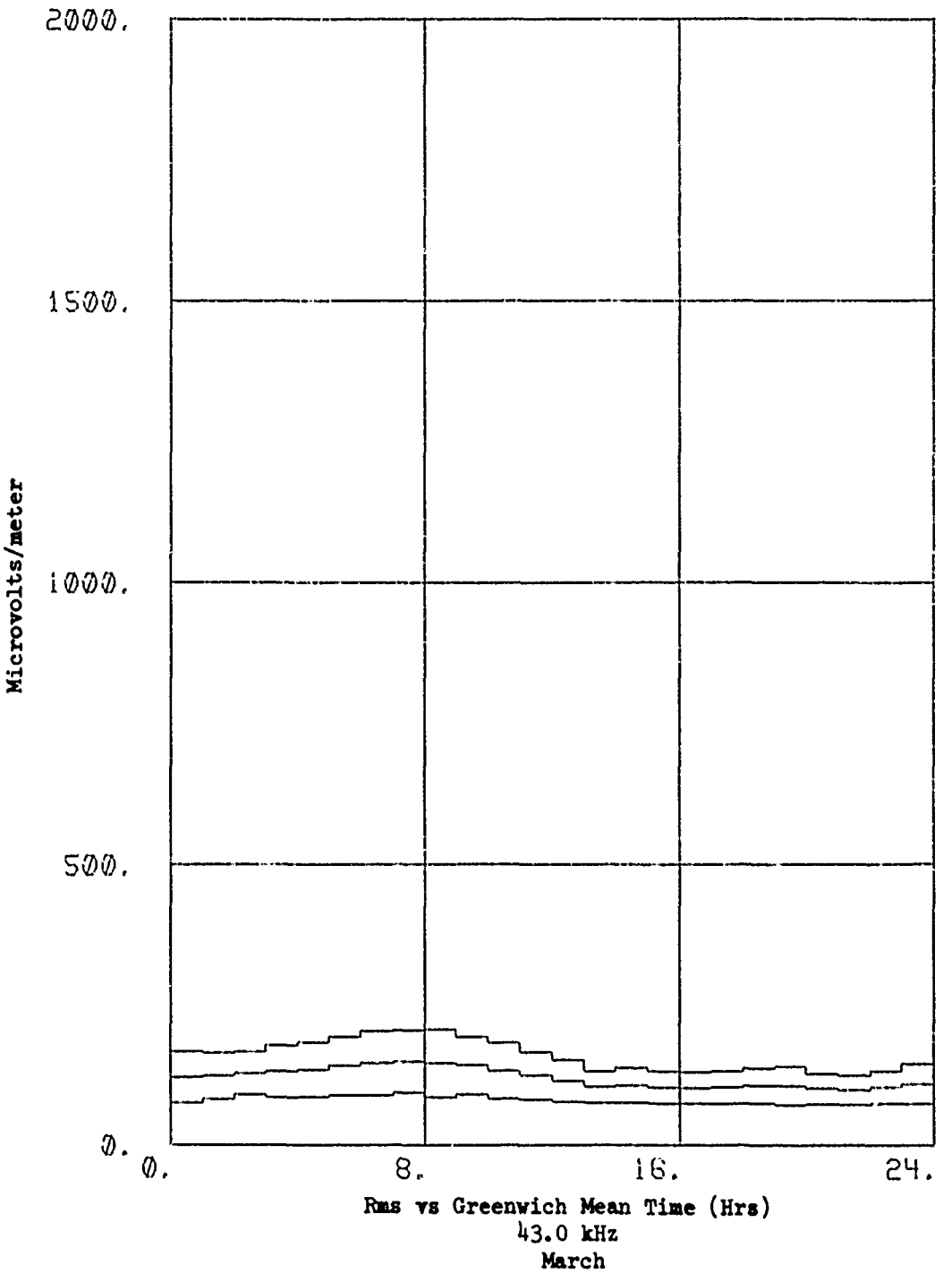

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
Rms vs Greenwich Mean Time (Hrs)
14.0 kHz
March

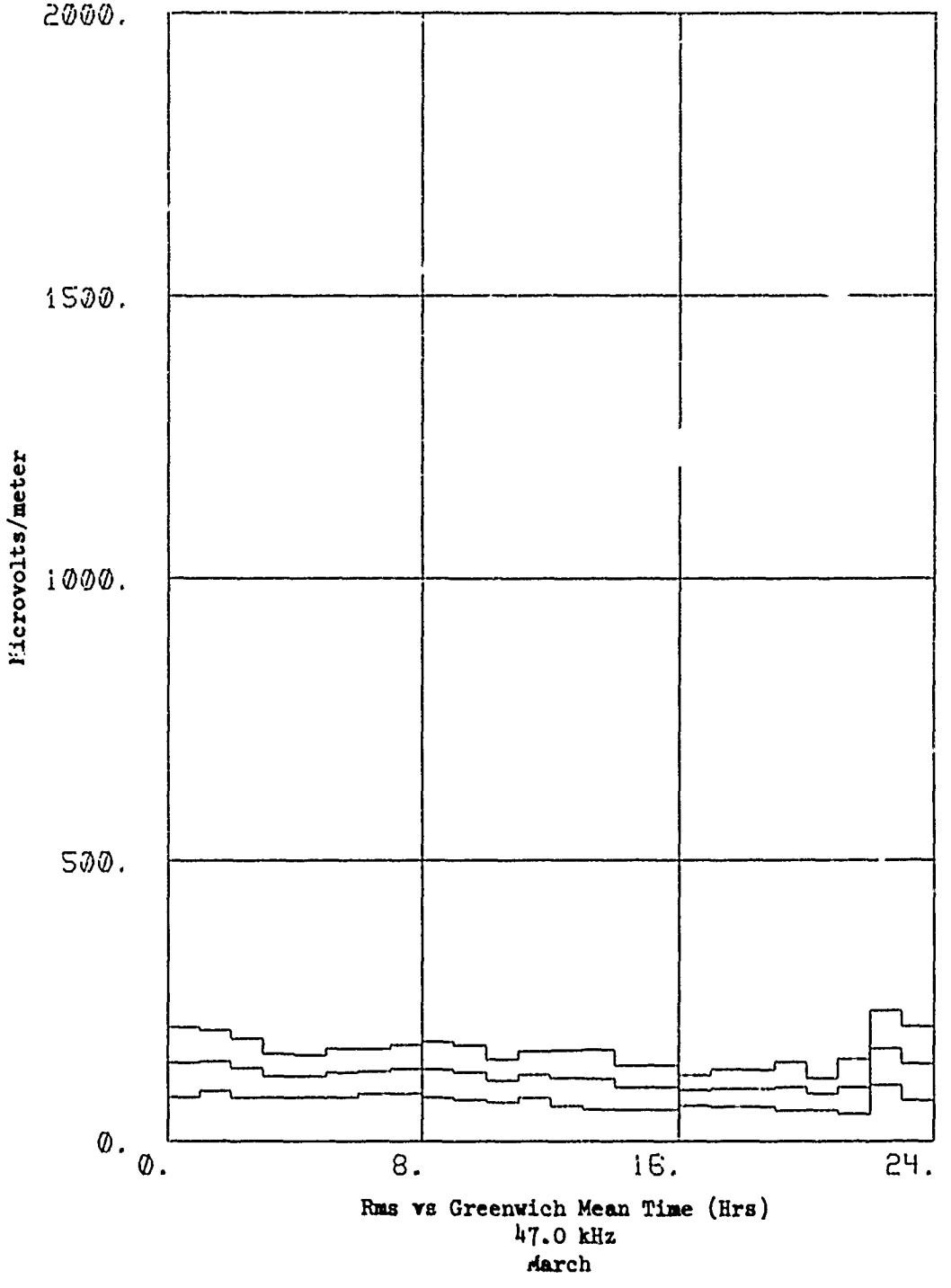

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
Rms vs Greenwich Mean Time (Hrs)
17.0 kHz
March

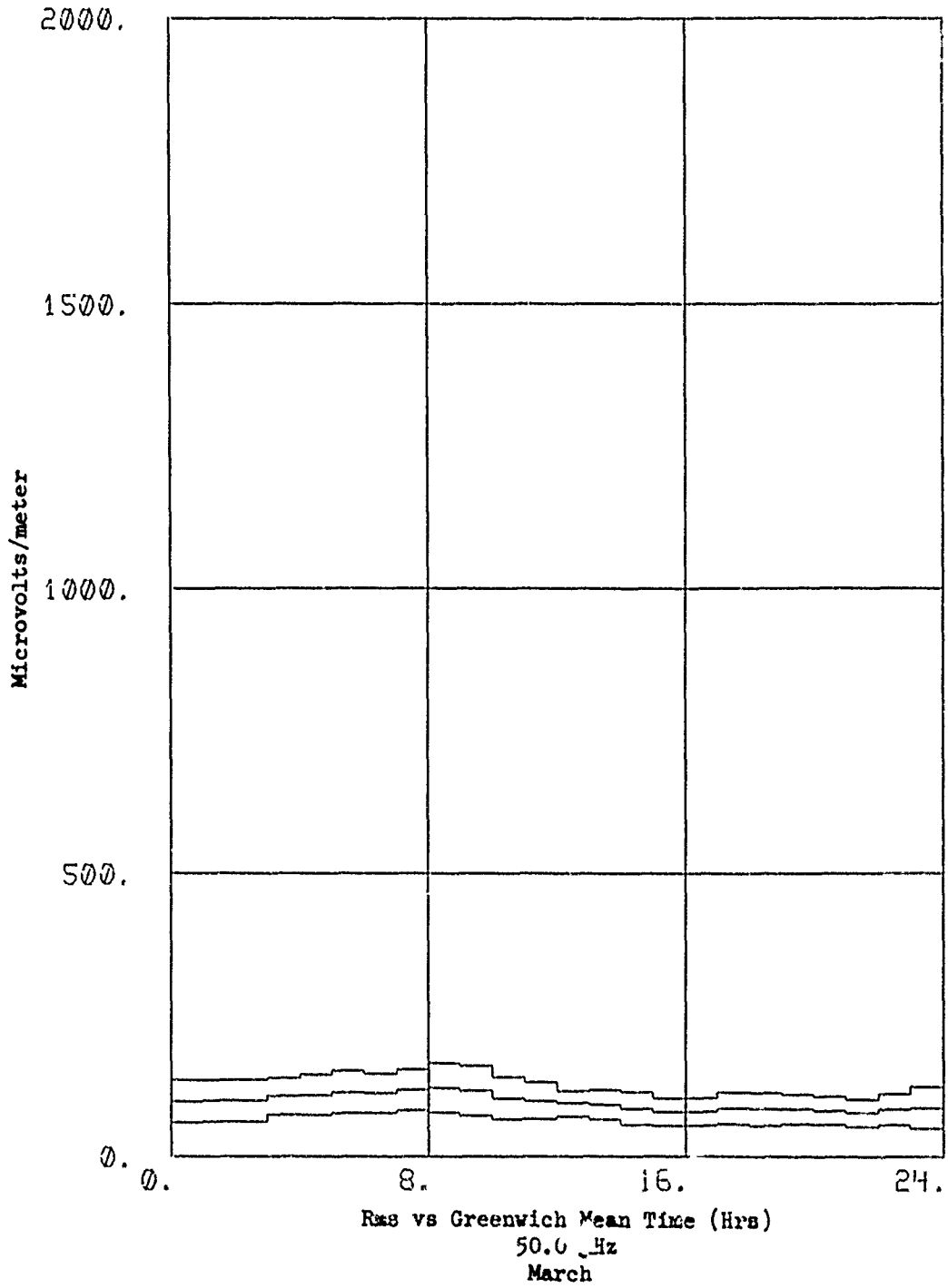

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
20.0 kHz
March

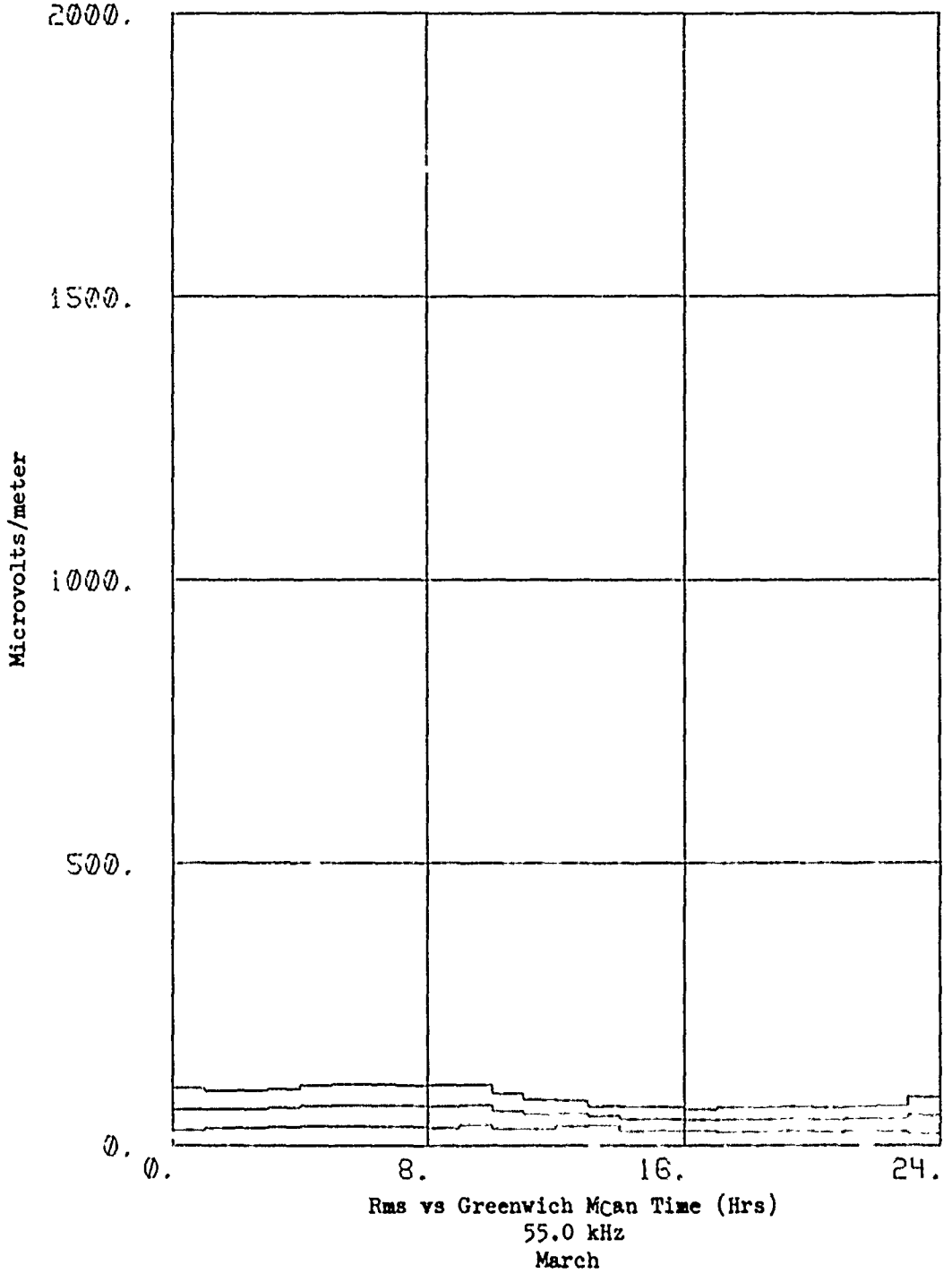

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
Rms vs Greenwich Mean Time (Hrs)
27.0 kHz
March


2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
Rms vs Greenwich Mean Time (Hrs)
40.0 kHz
March

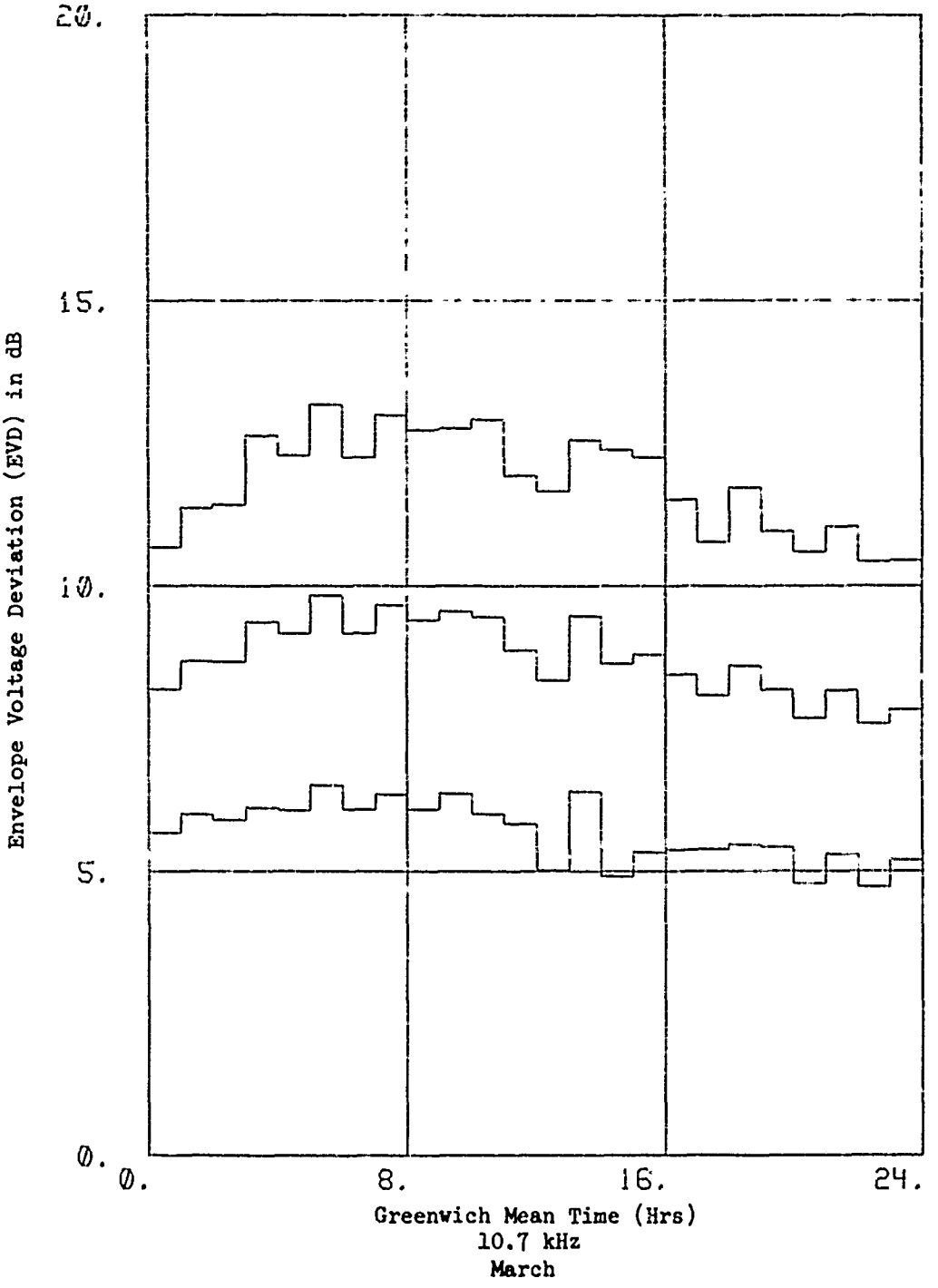

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
Rms vs Greenwich Mean Time (Hrs)
43.0 kHz
March

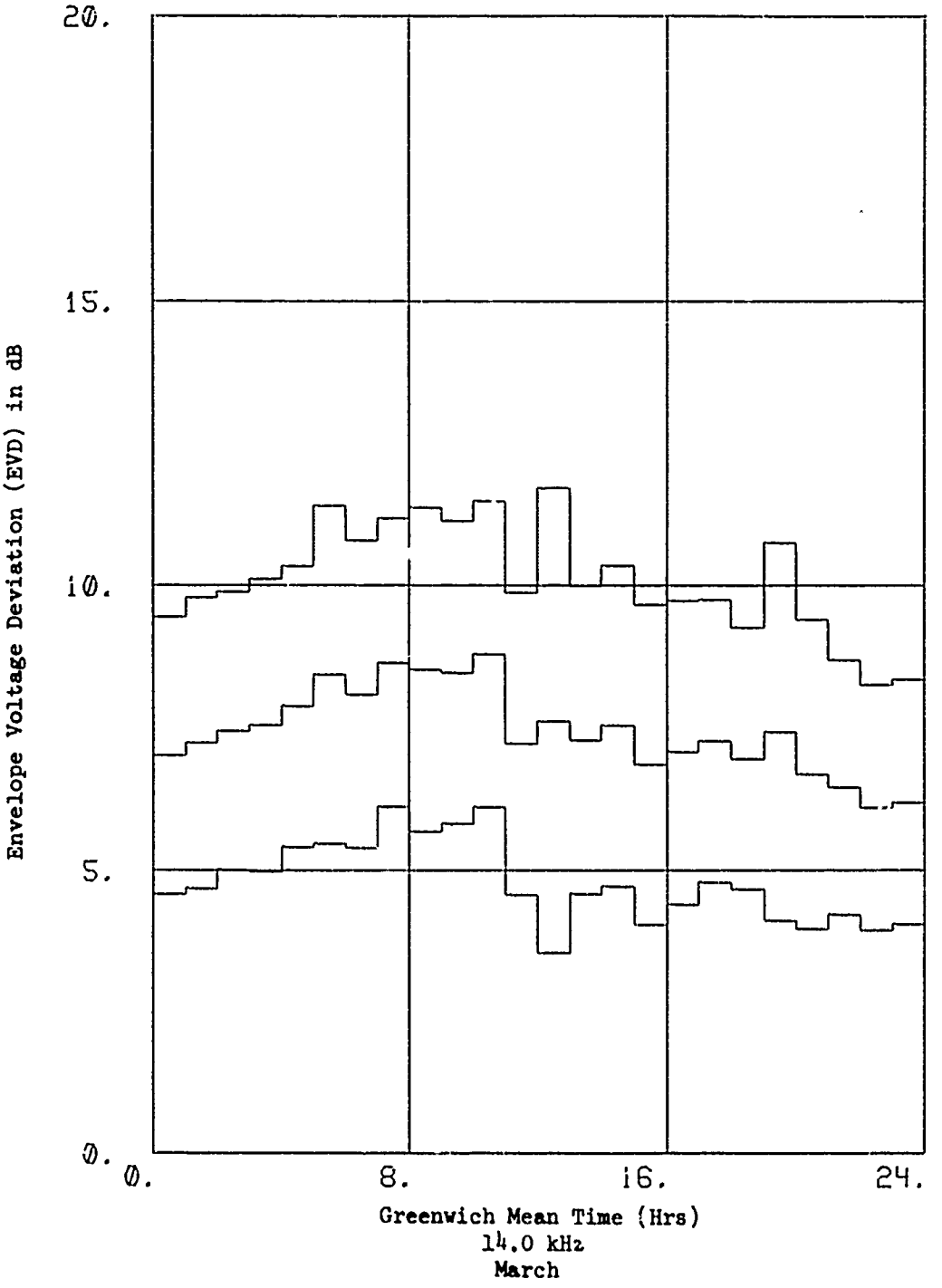

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
Rms vs Greenwich Mean Time (Hrs)
47.0 kHz
March

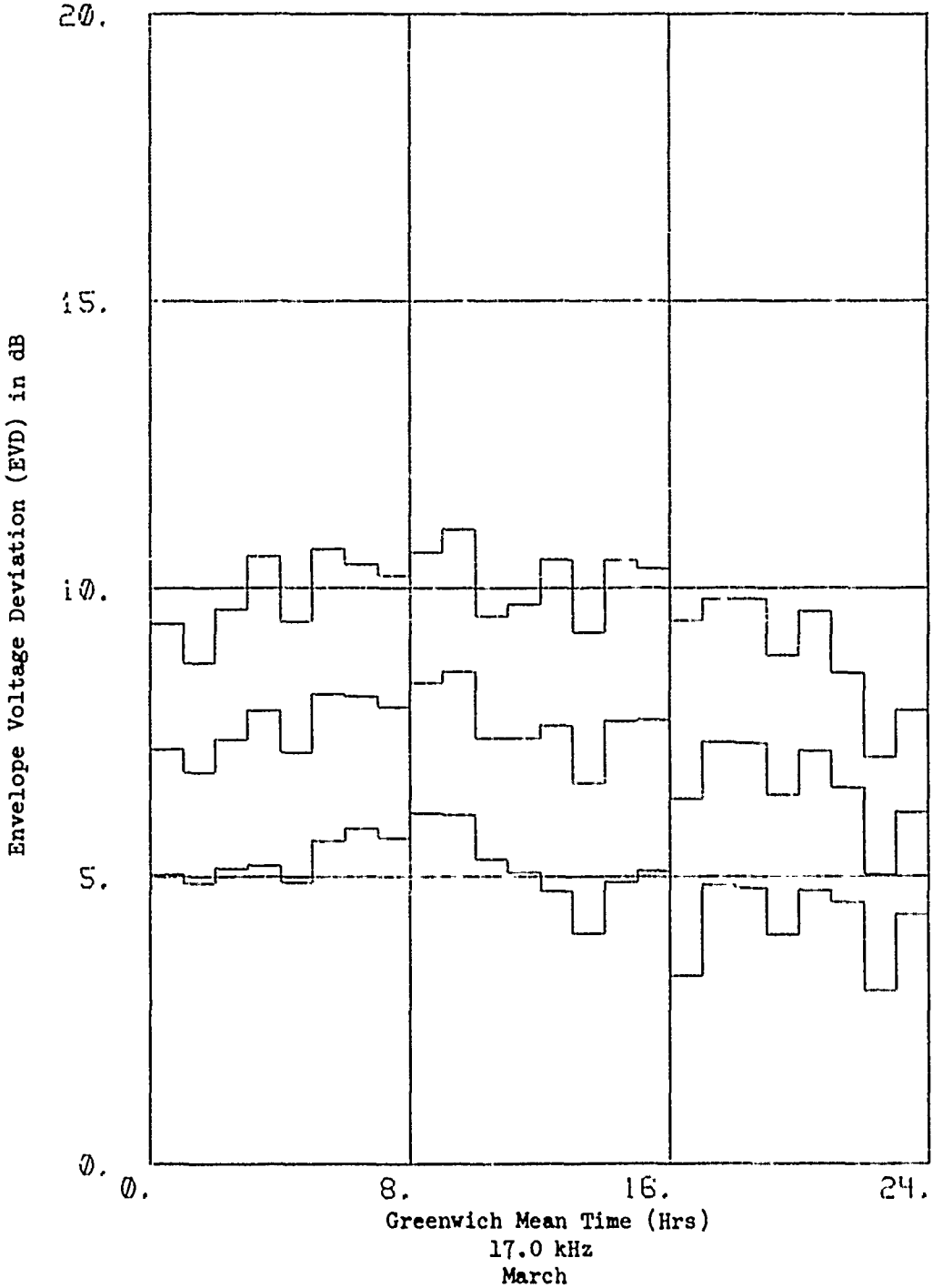

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
Rms vs Greenwich Mean Time (Hrs)
50.0 Hz
March

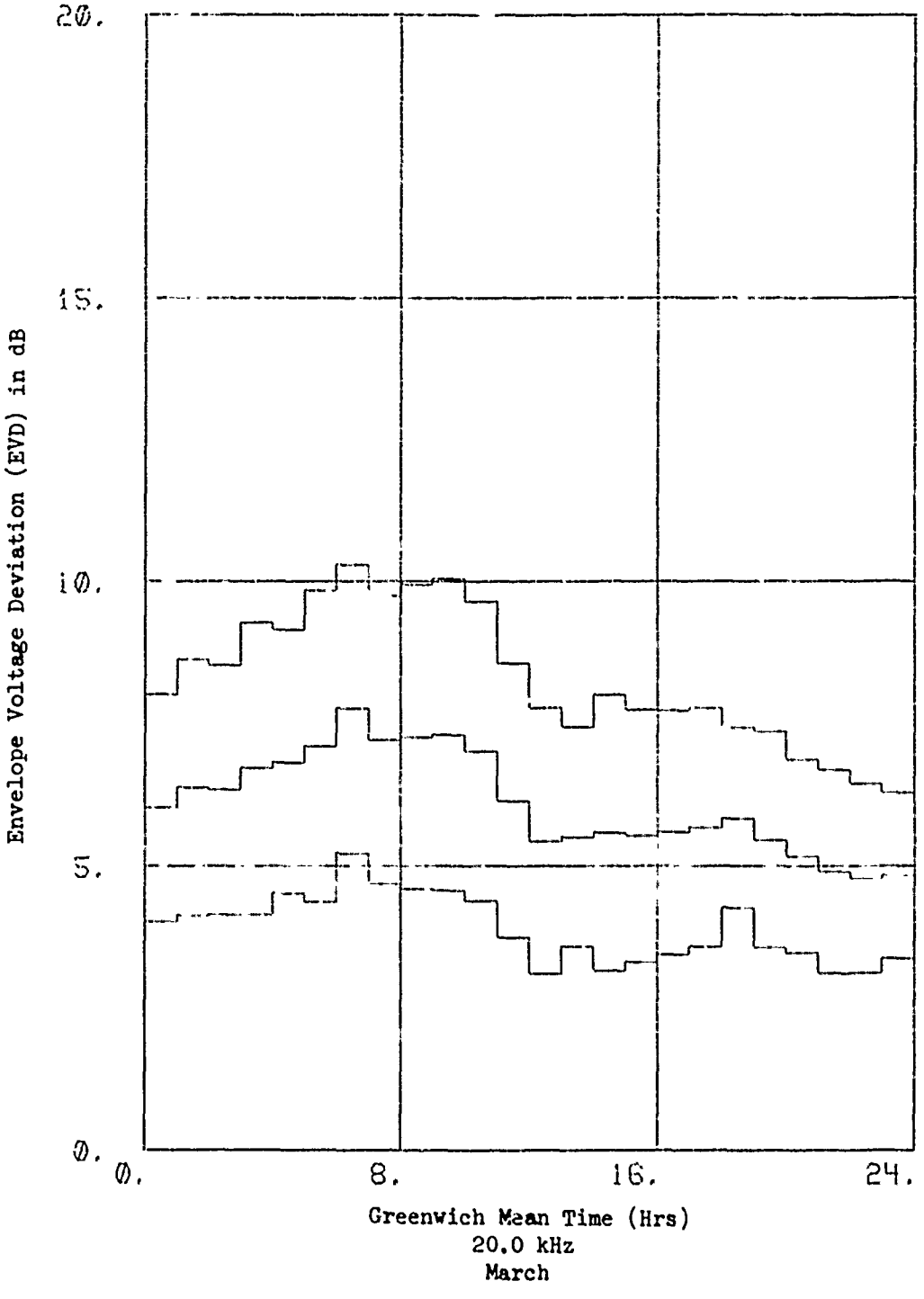

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
Rms vs Greenwich Mean Time (Hrs)
55.0 kHz
March

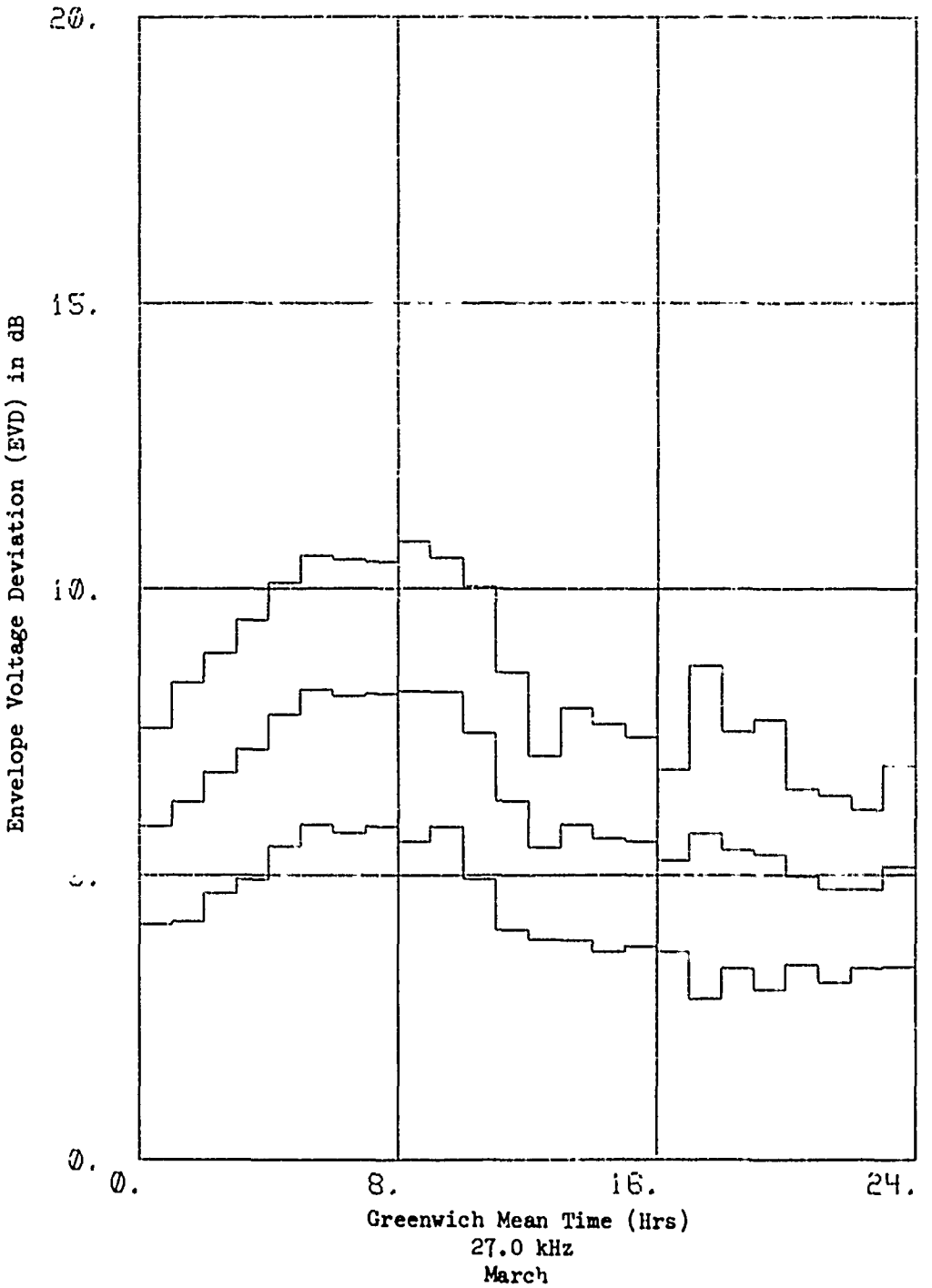
5.8 - EVD vs TIME (@ FREQS. - FOR MARCH)

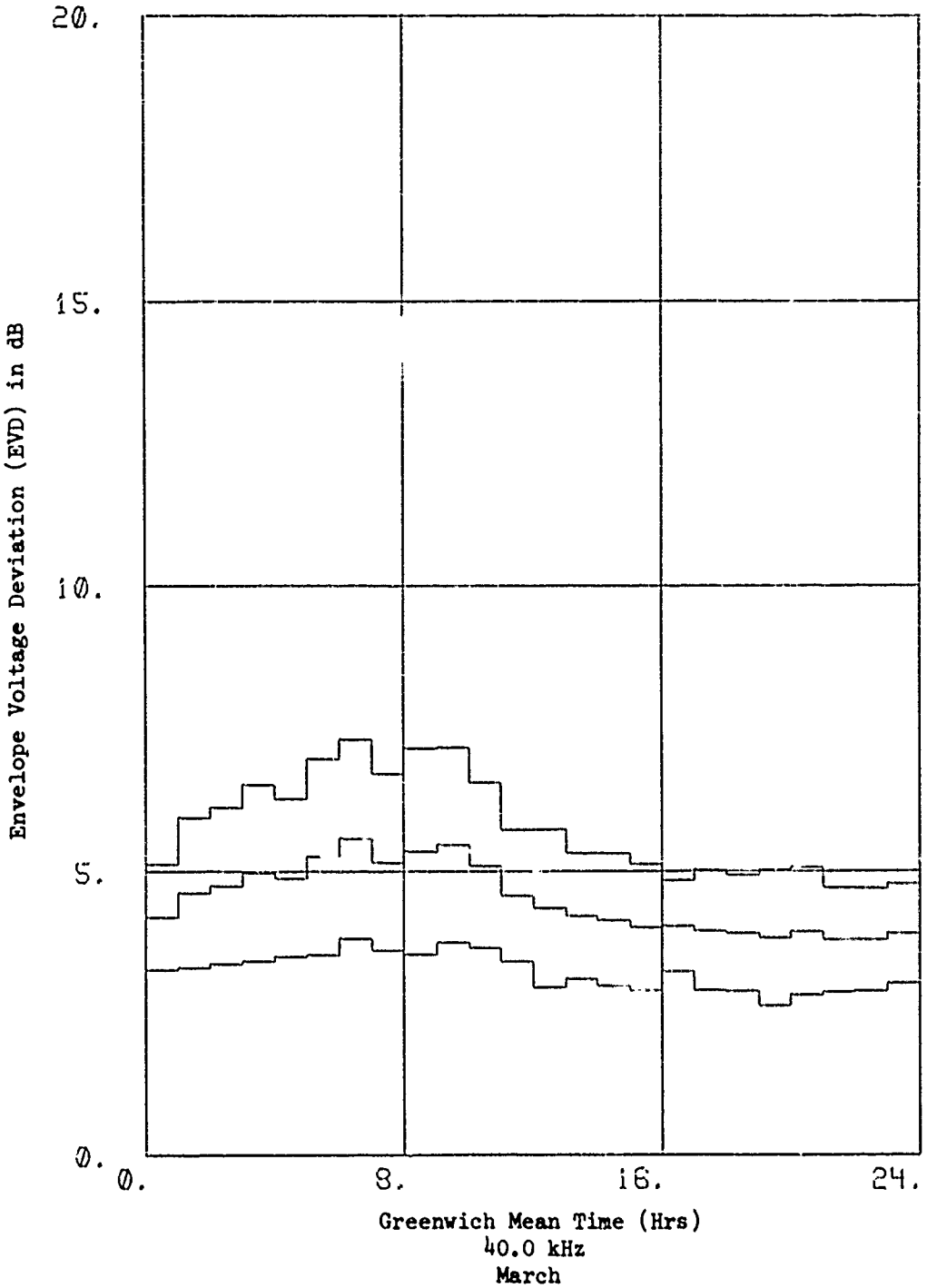

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
10.7 kHz
March

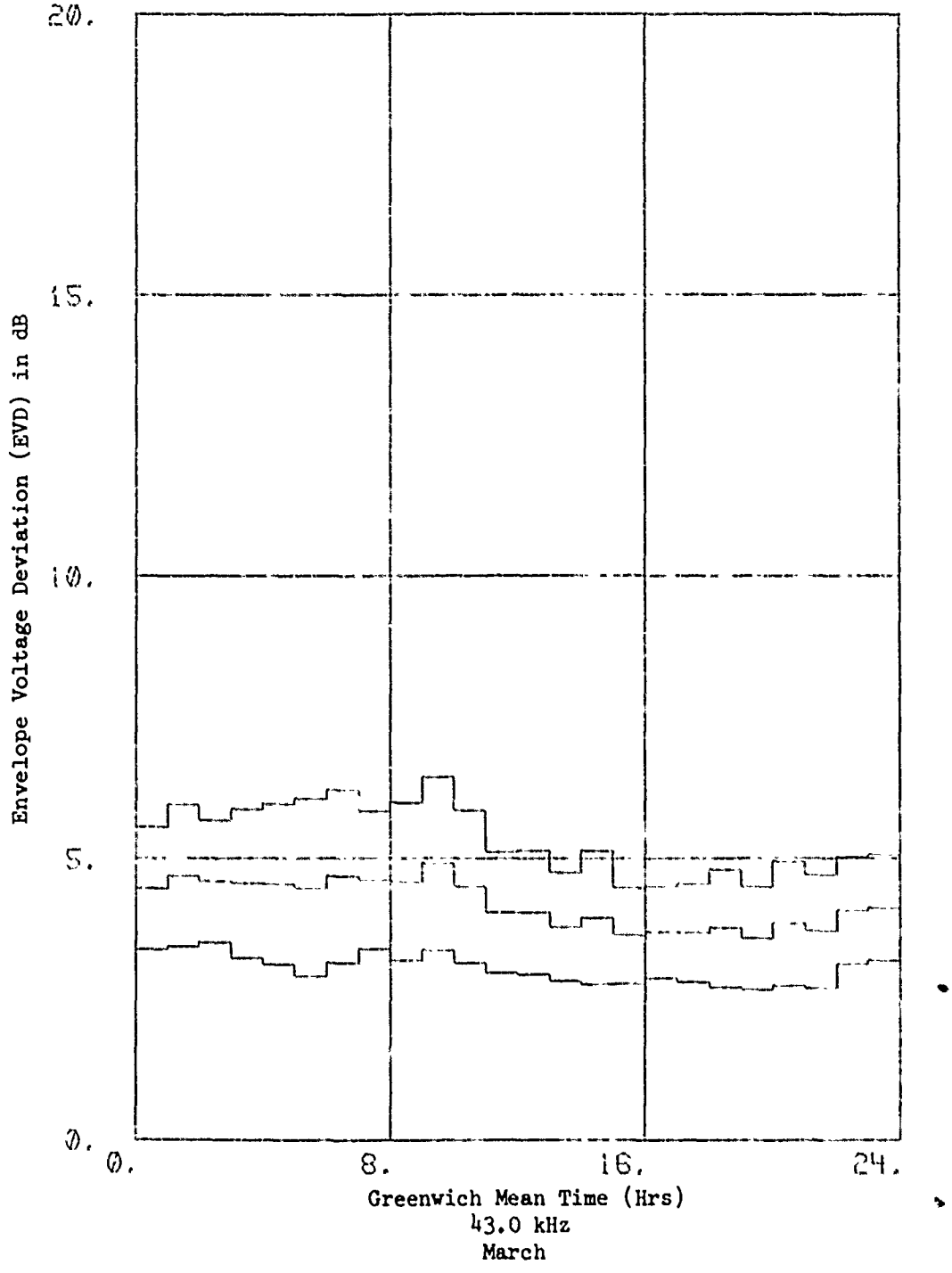

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
14.0 kHz
March

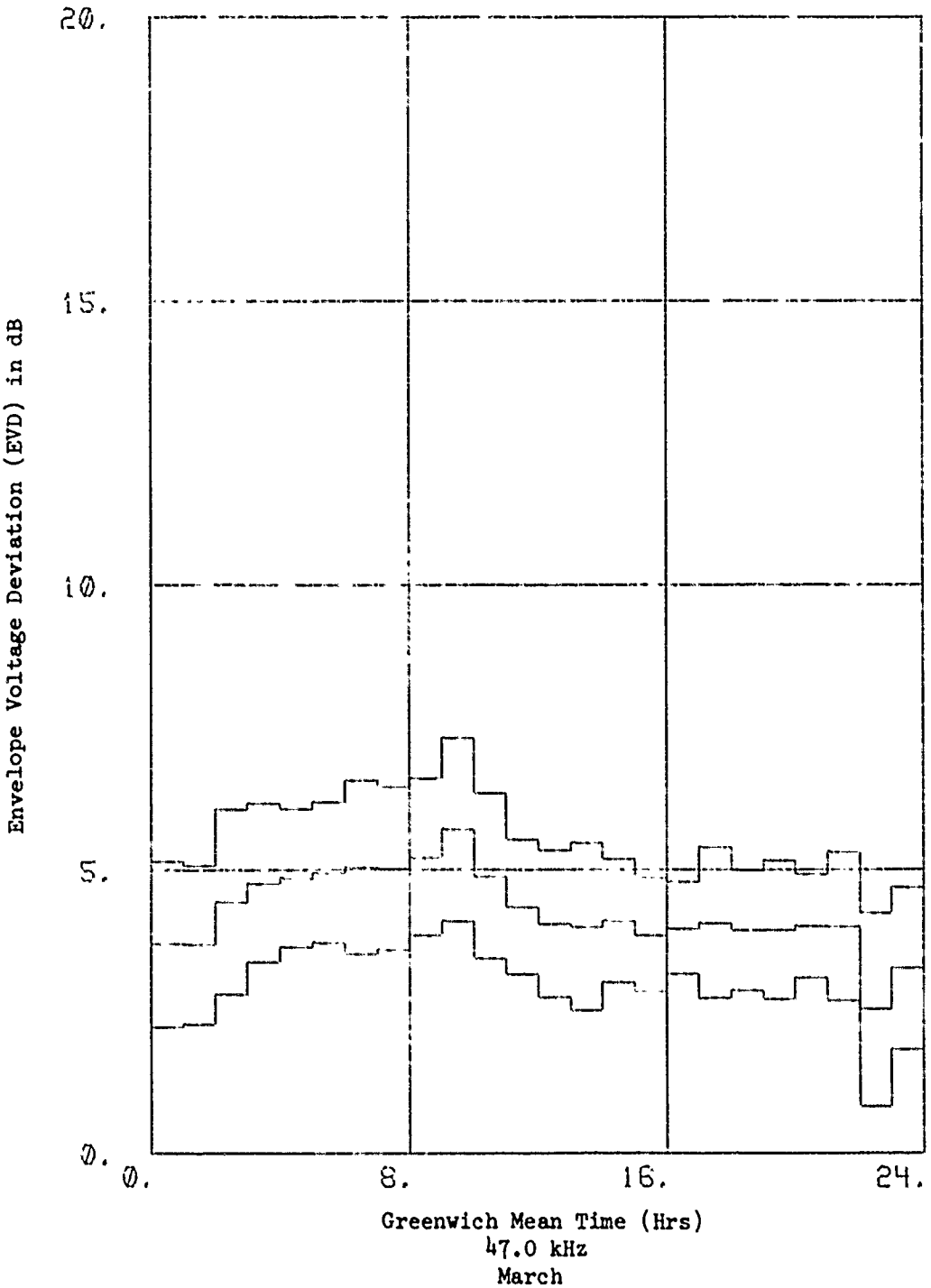

20.
15.
10.
5.
0.
Envelope Voltage Deviation (EVD) in dB
0.
8.
16.
24.
Greenwich Mean Time (Hrs)
17.0 kHz
March

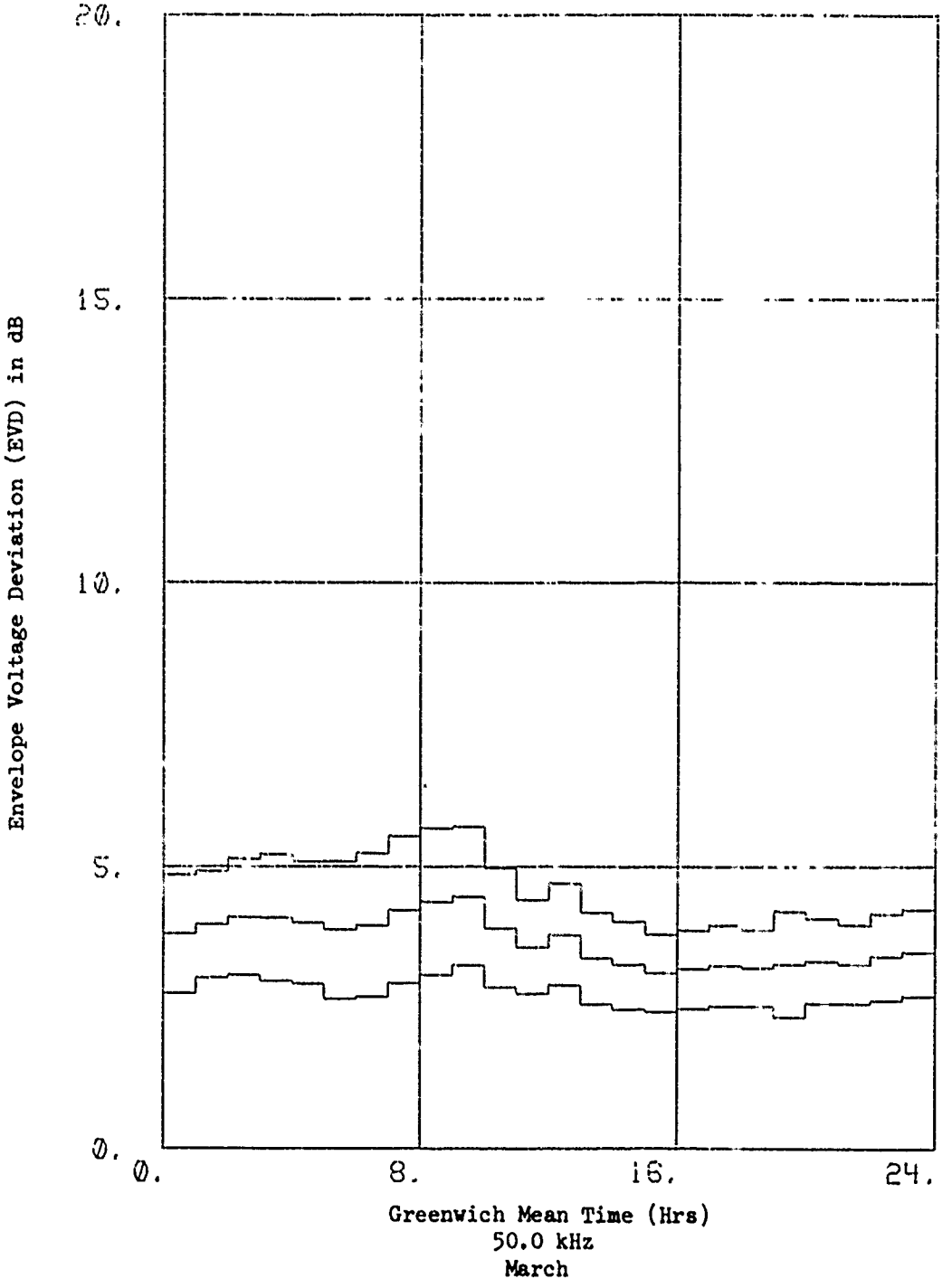

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
20.0 kHz
March

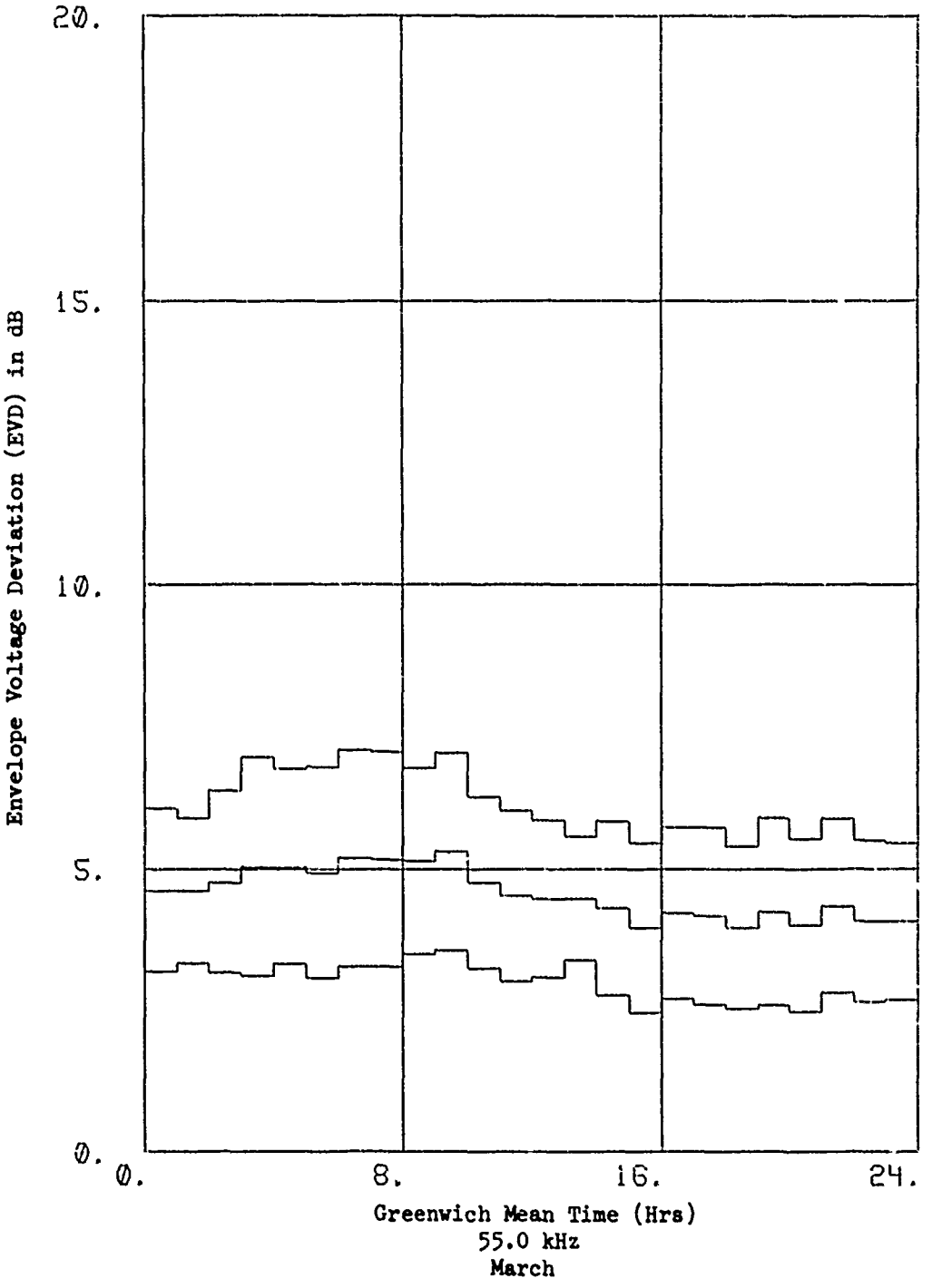

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
27.0 kHz
March


20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
40.0 kHz
March

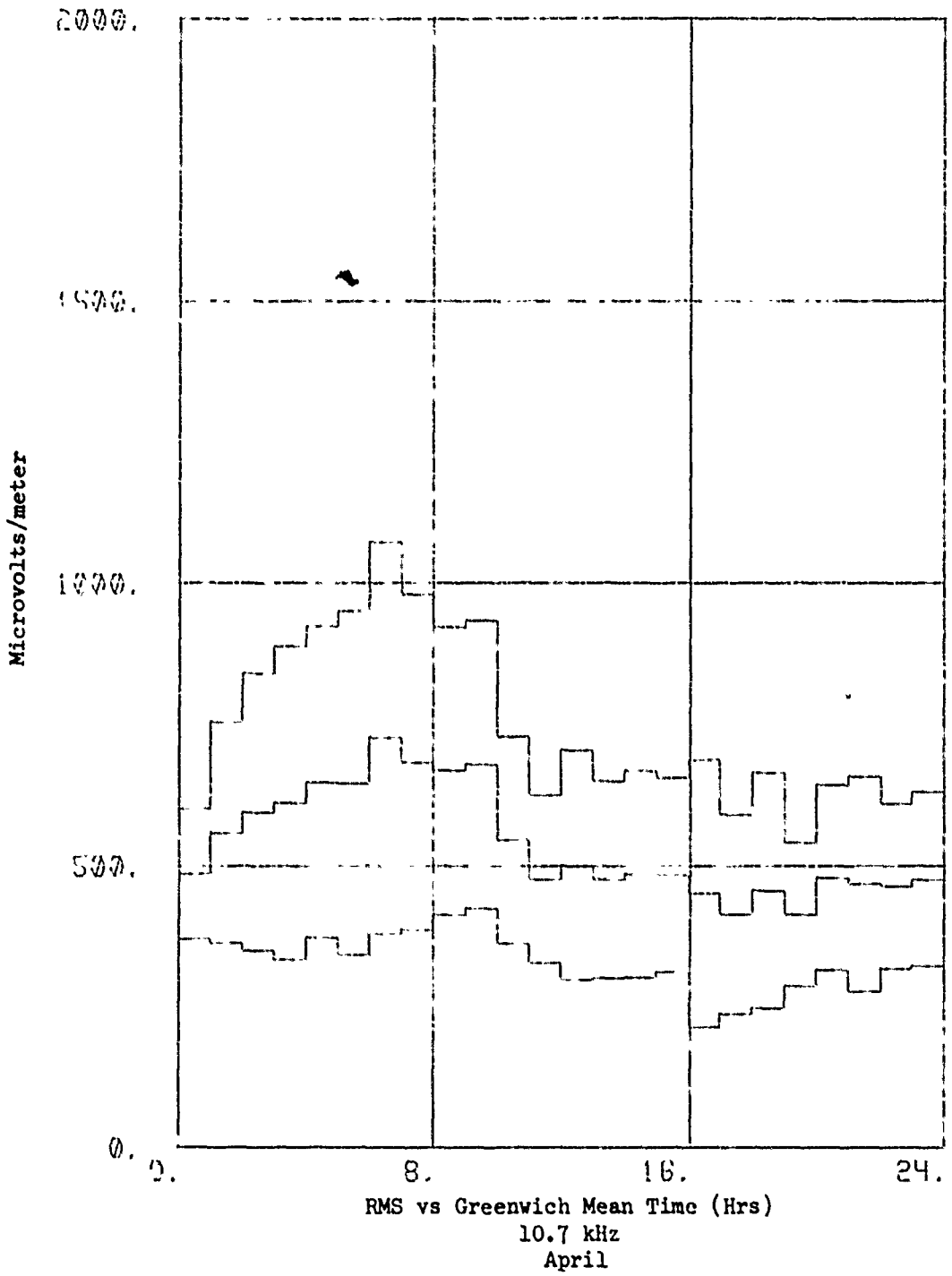

20.
15.
10.
5.
0.
Envelope Voltage Deviation (EVD) in dB
0.
8.
16.
24.
Greenwich Mean Time (Hrs)
43.0 kHz
March

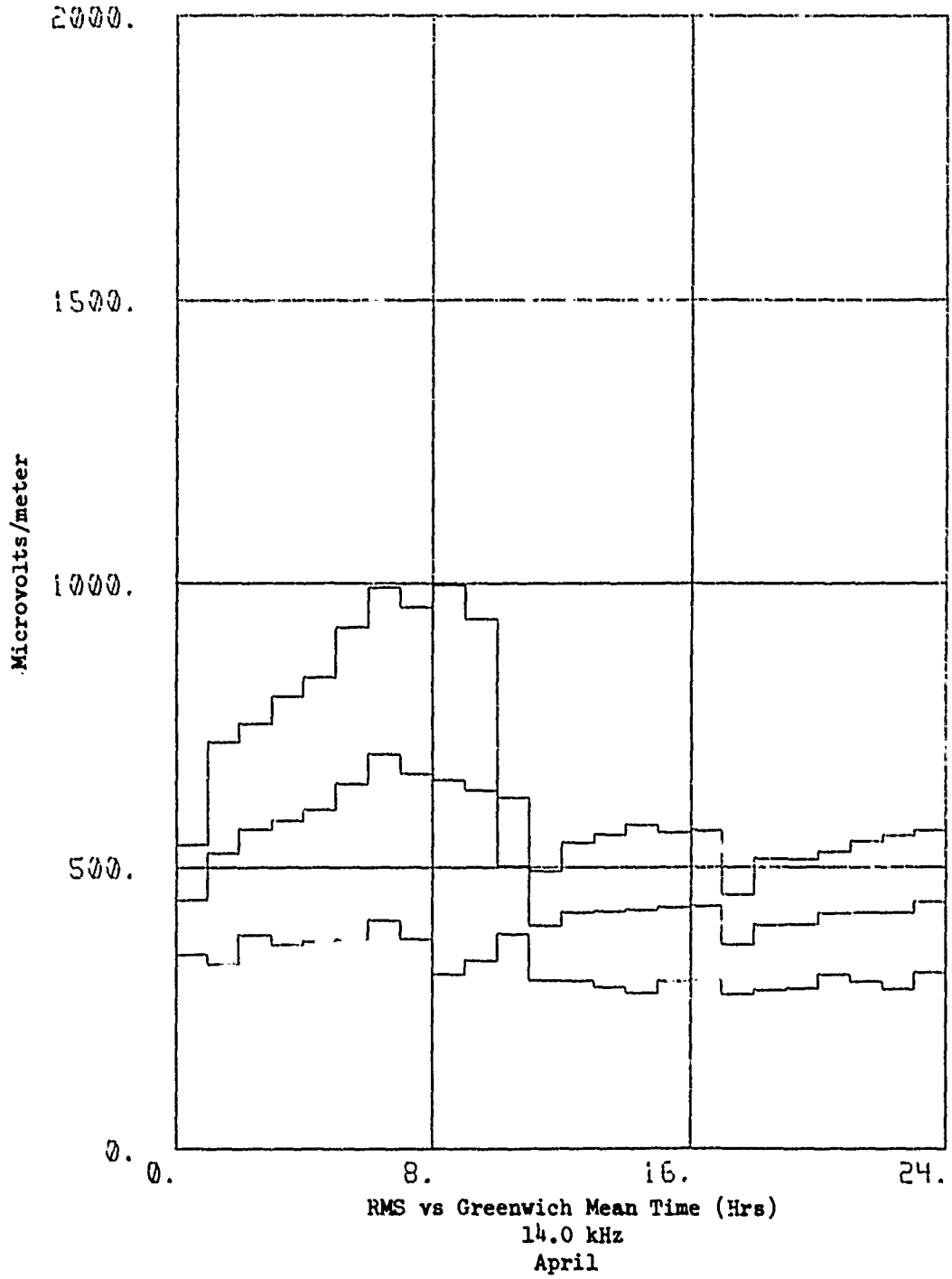

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
47.0 kHz
March

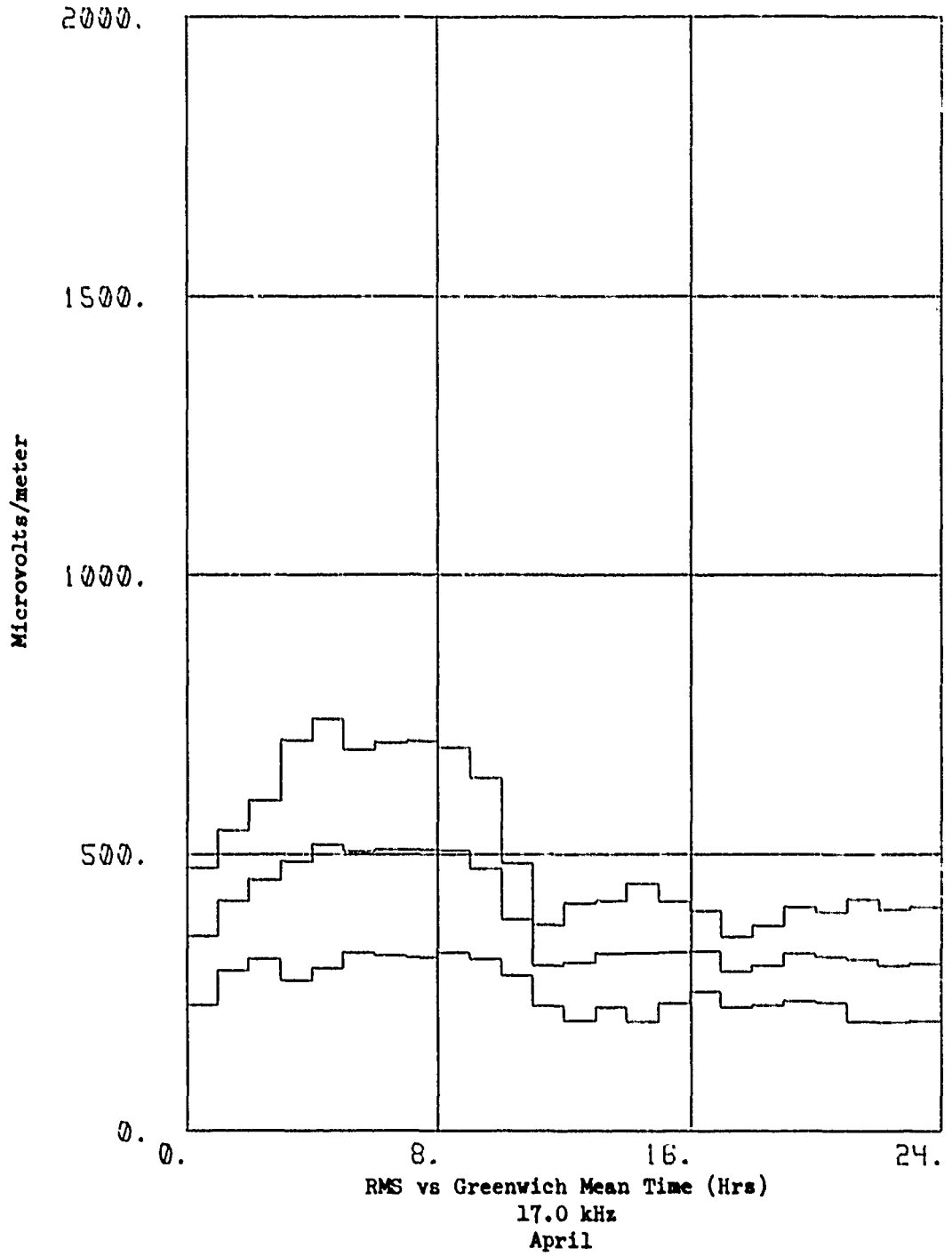

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
50.0 kHz
March

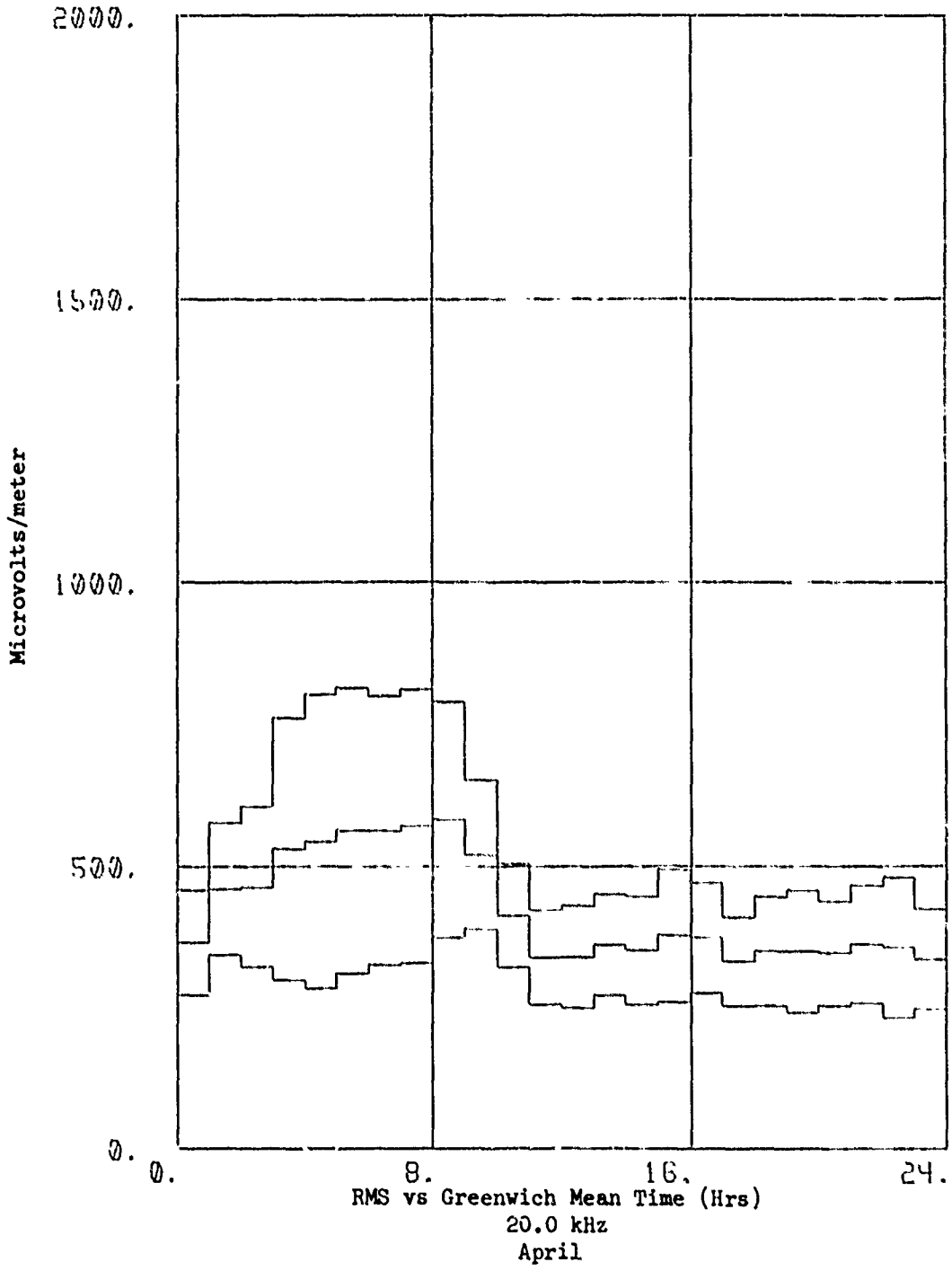

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
55.0 kHz
March

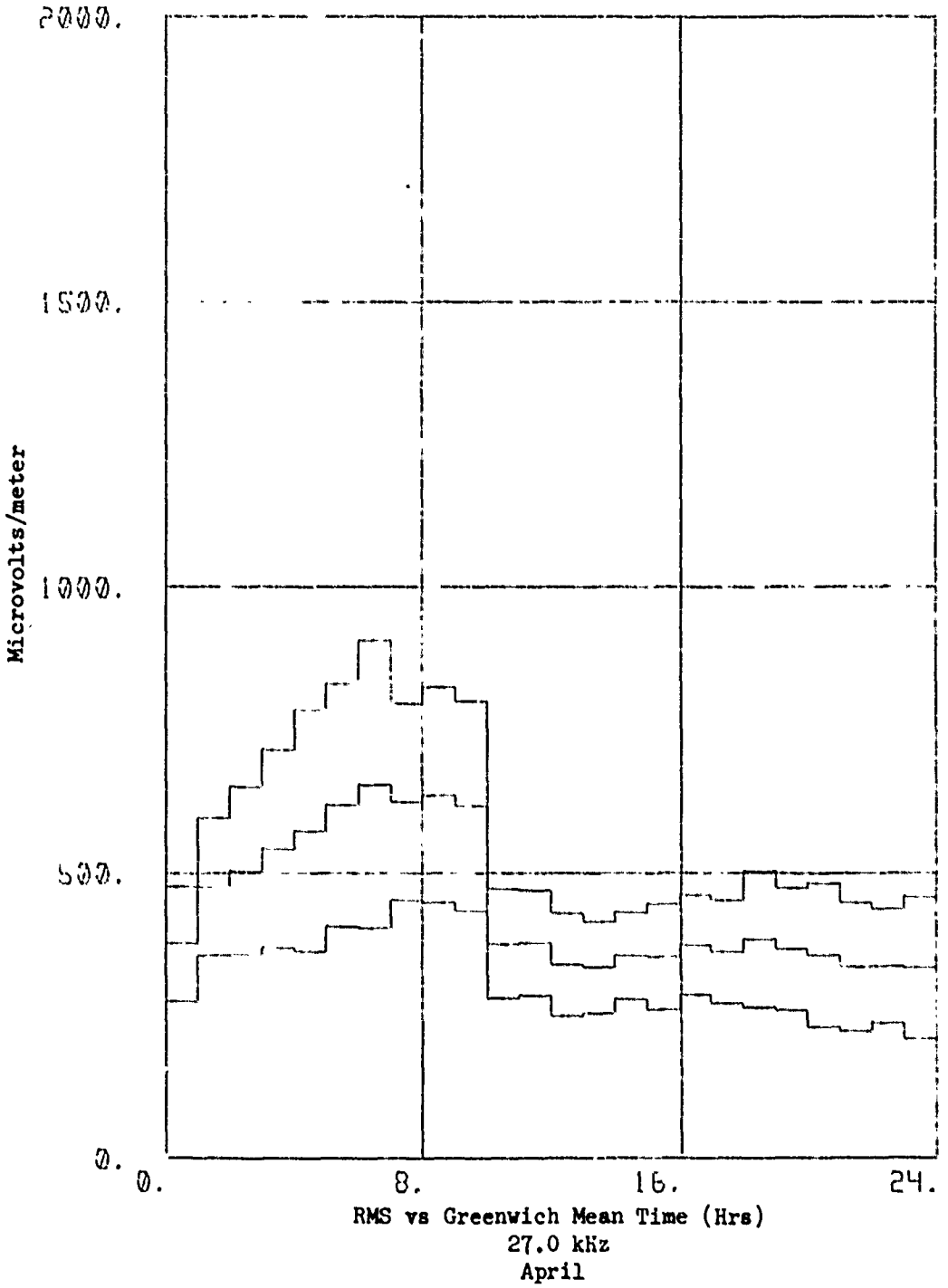
5.9 - ERMS vs TIME (@ FREQS. - FOR APRIL)

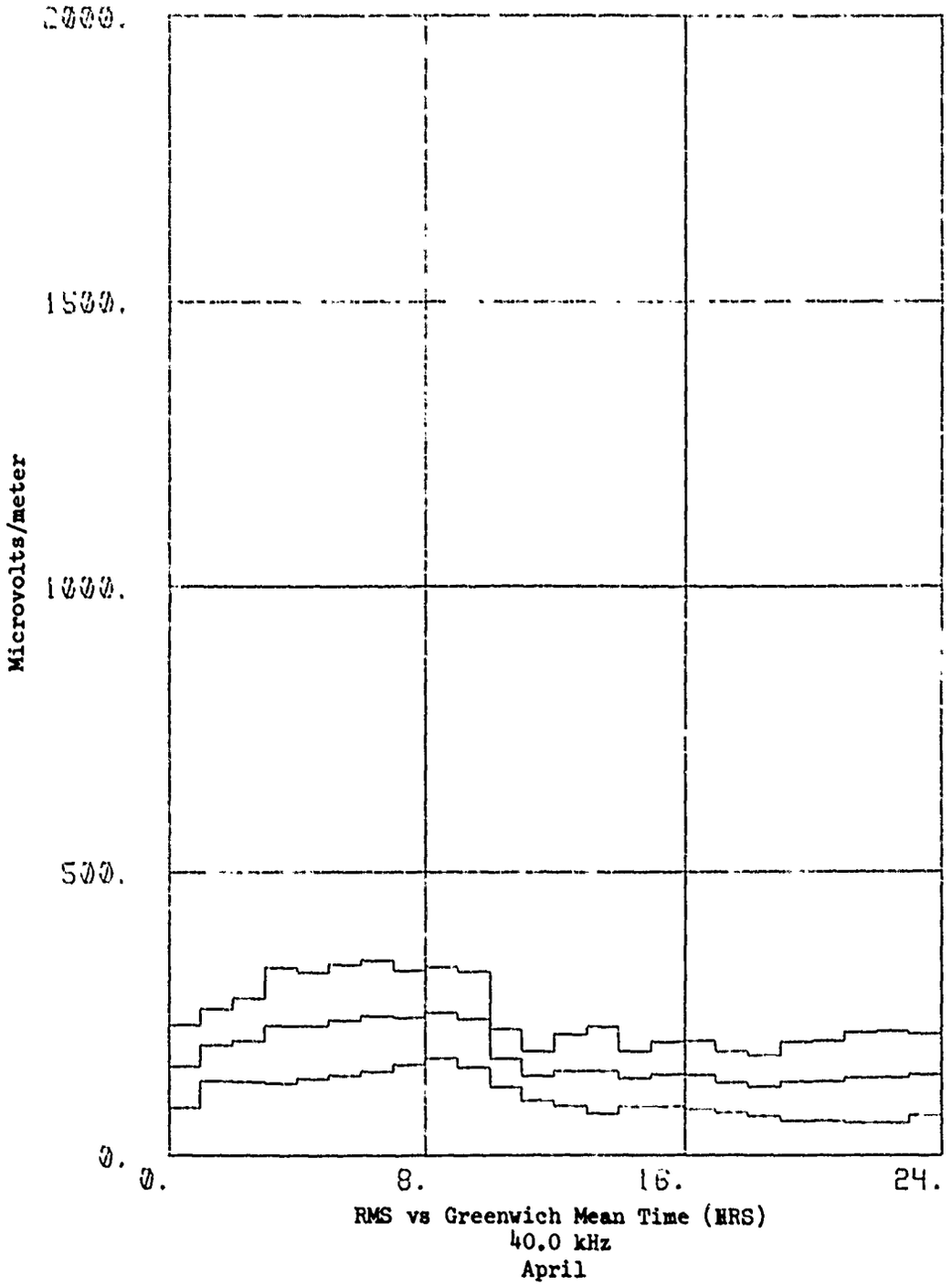

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
10.7 kHz
April

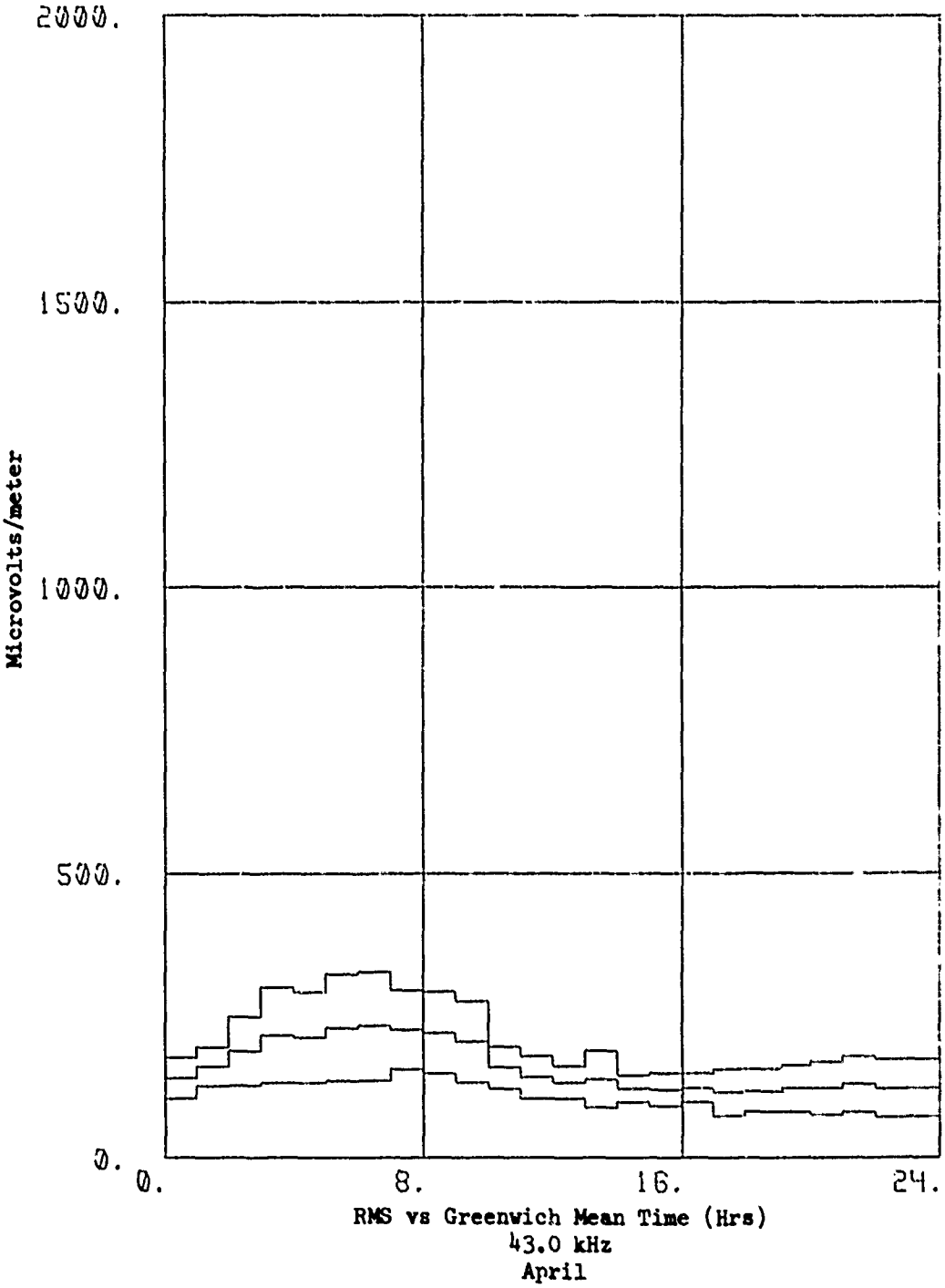

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
14.0 kHz
April

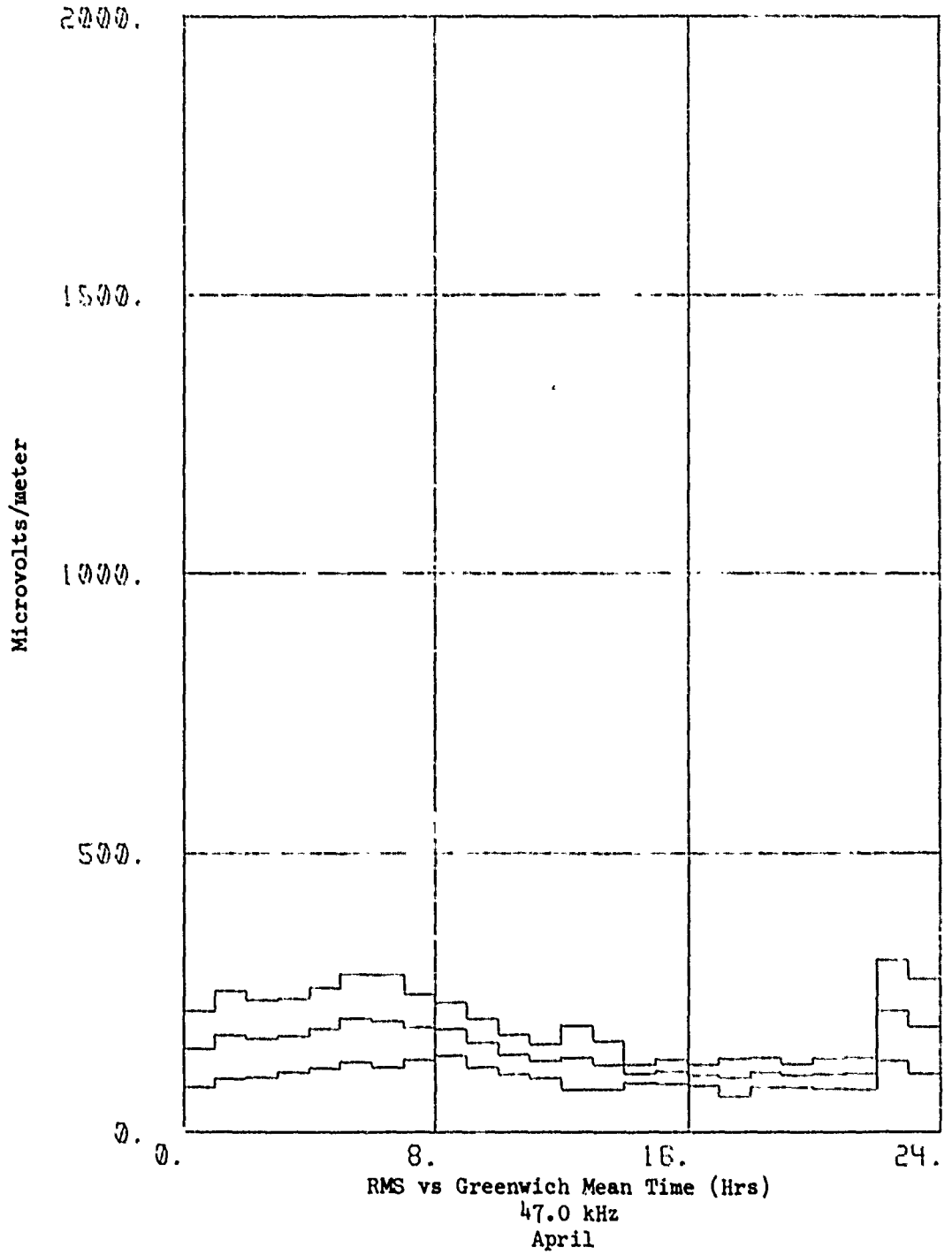

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
17.0 kHz
April

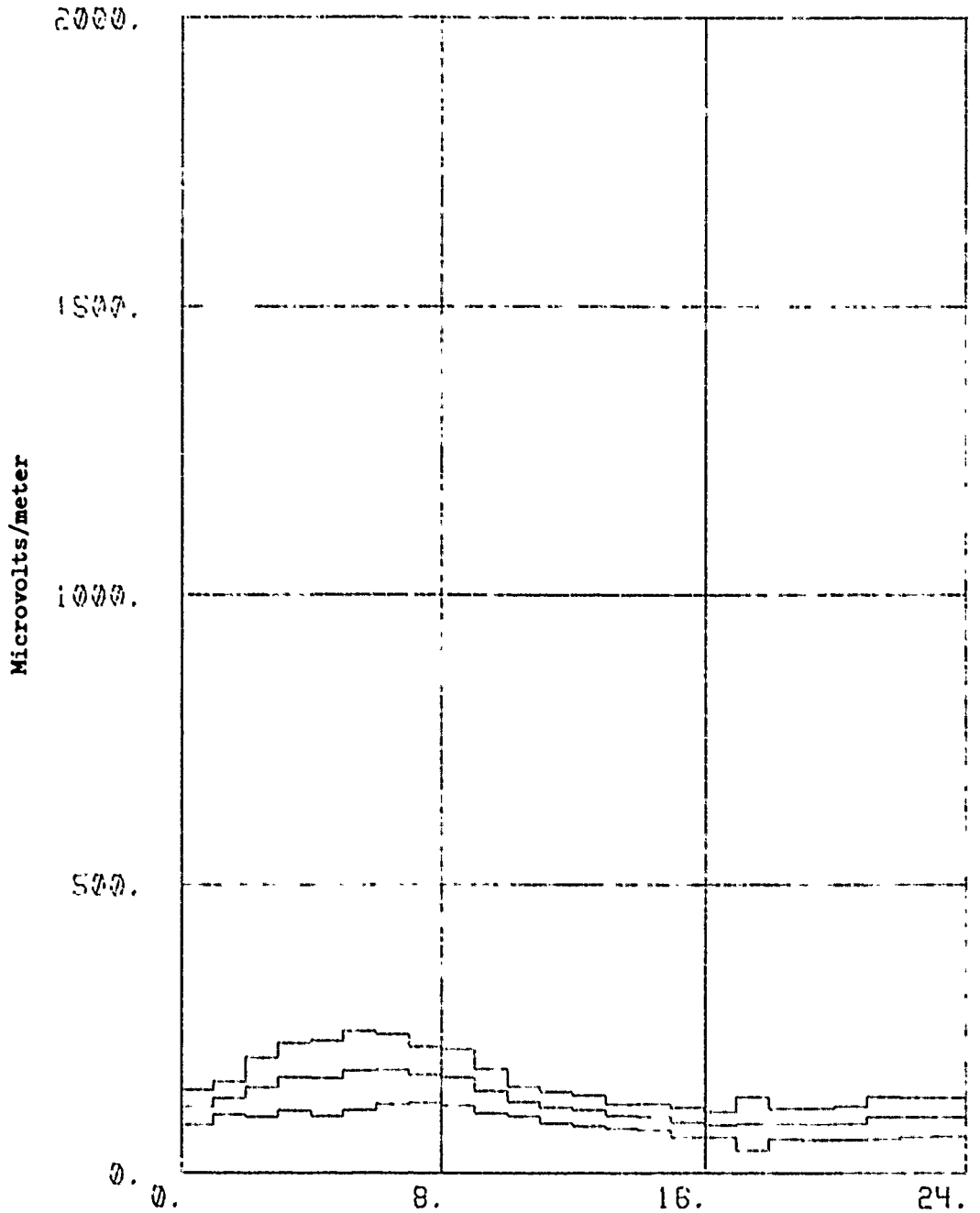

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
20.0 kHz
April

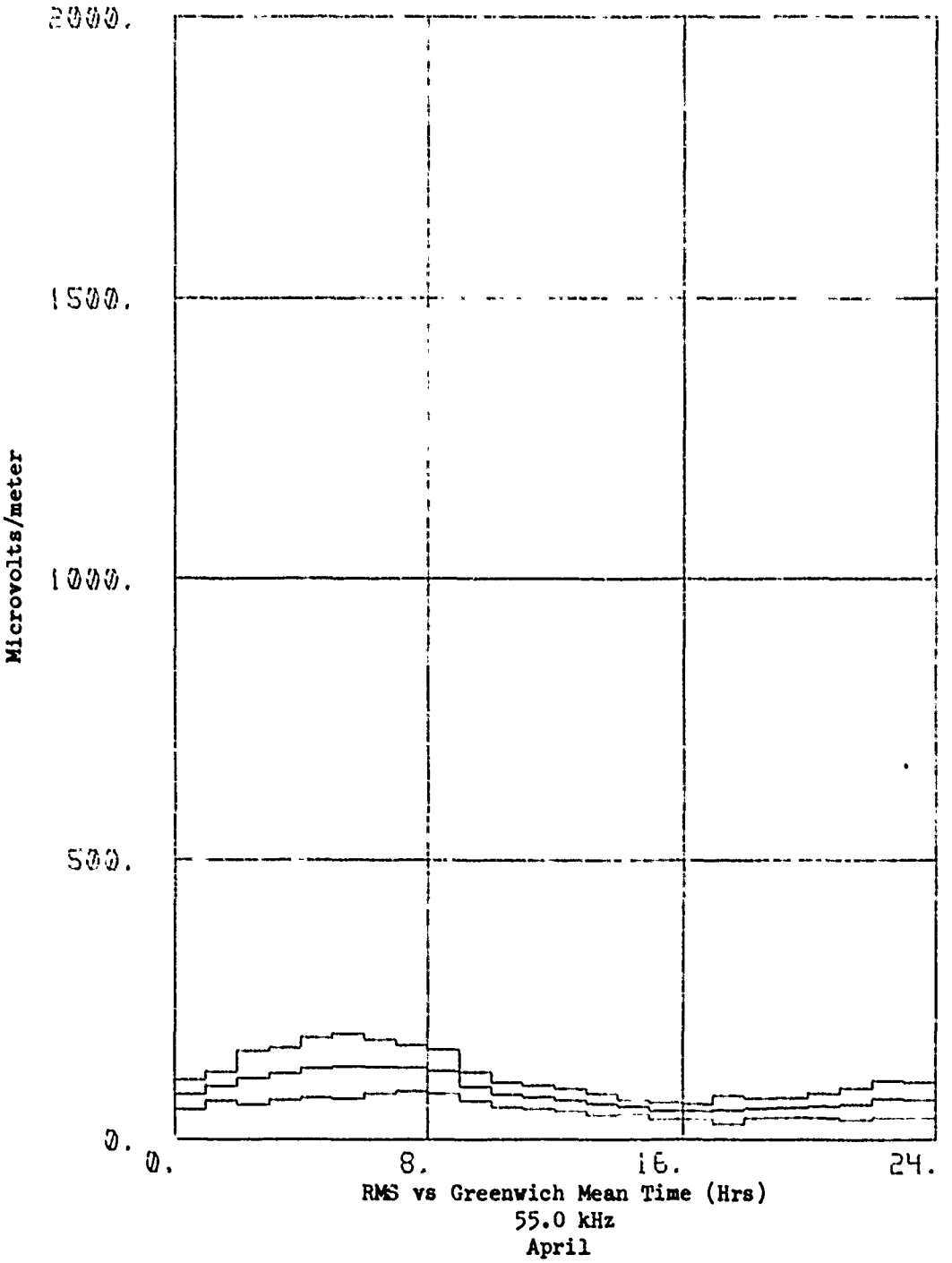

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
27.0 kHz
April


2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (HRS)
40.0 kHz
April

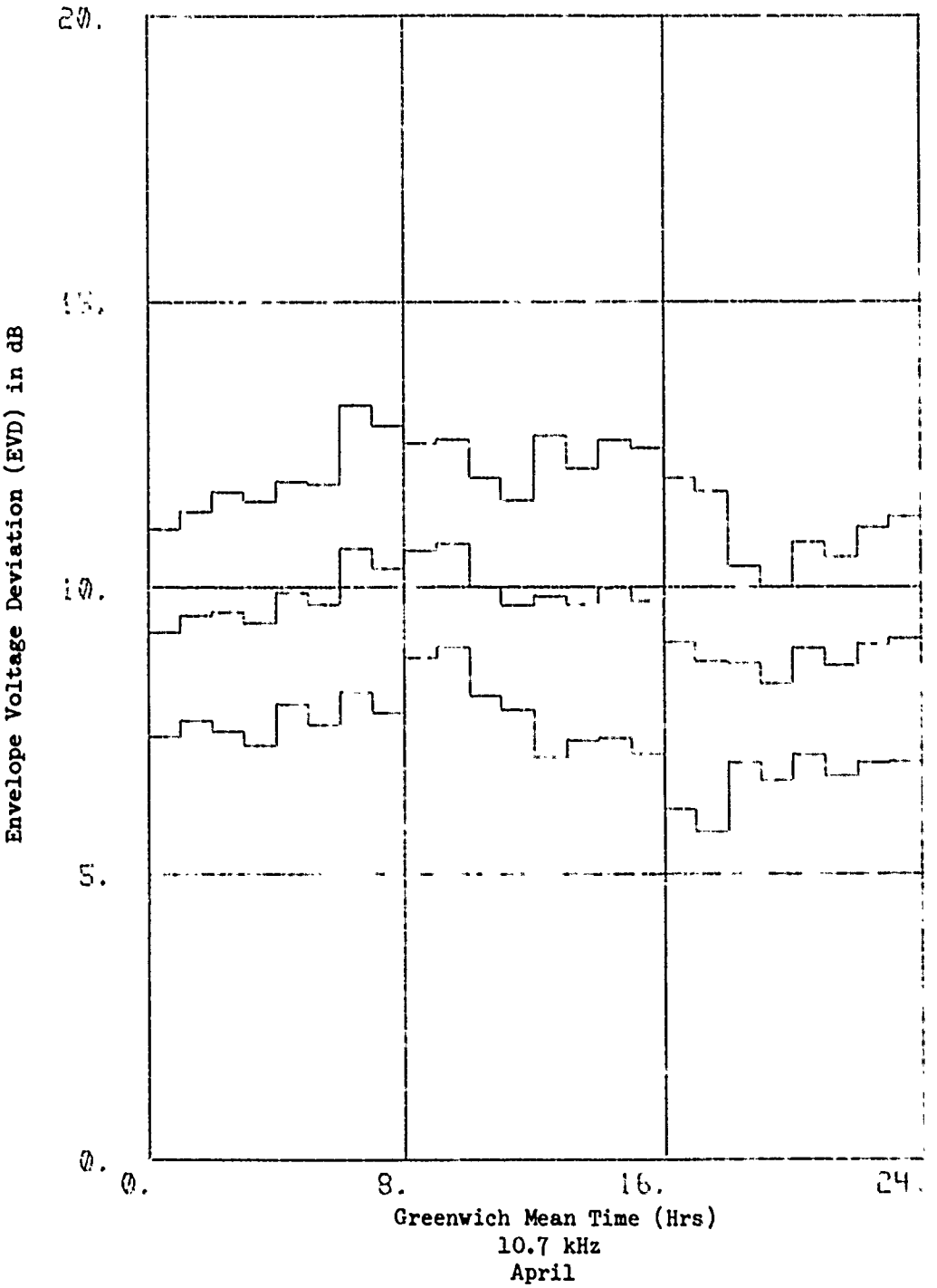

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
43.0 kHz
April

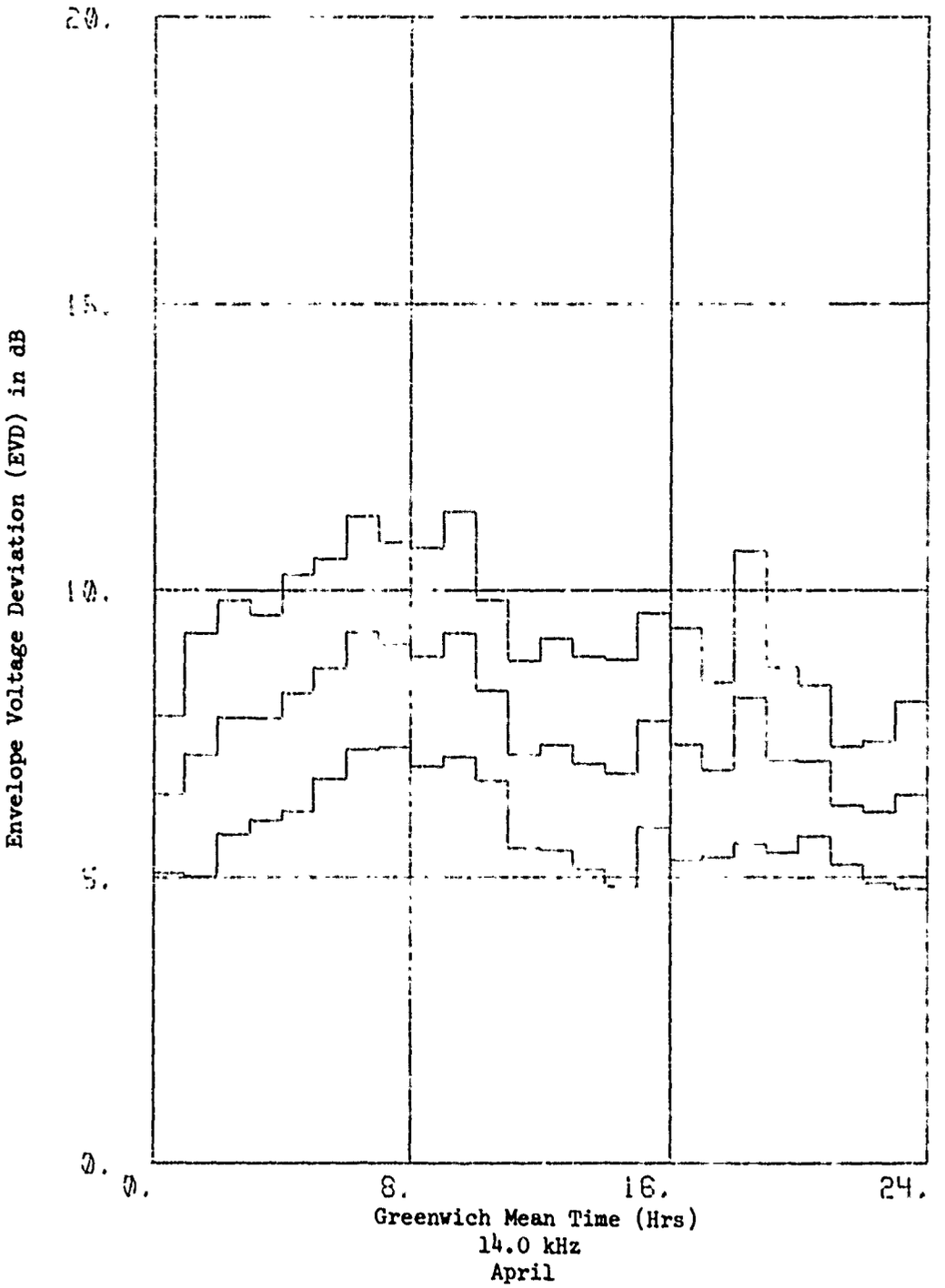

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
47.0 kHz
April

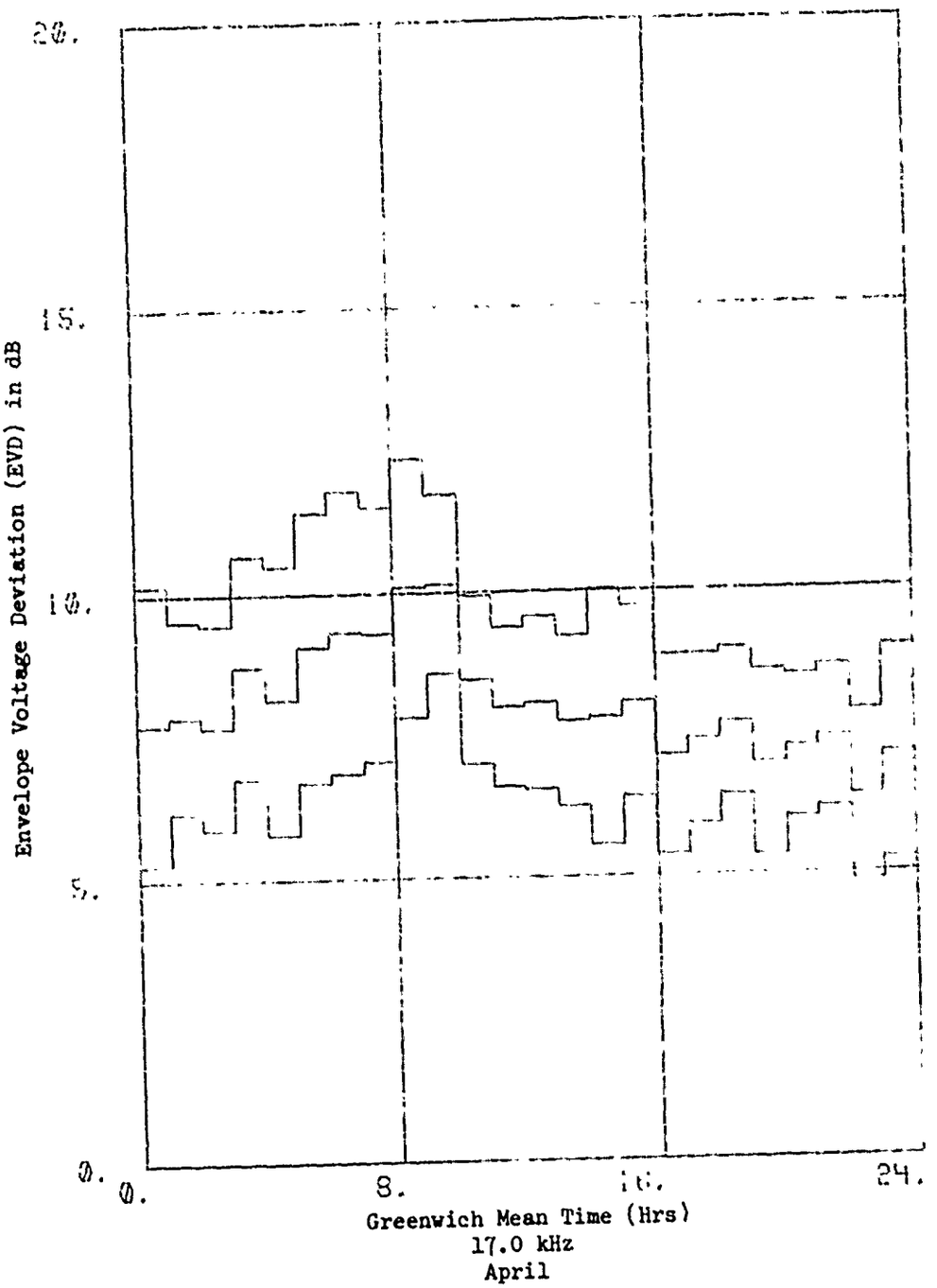

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
50.0 kHz
April

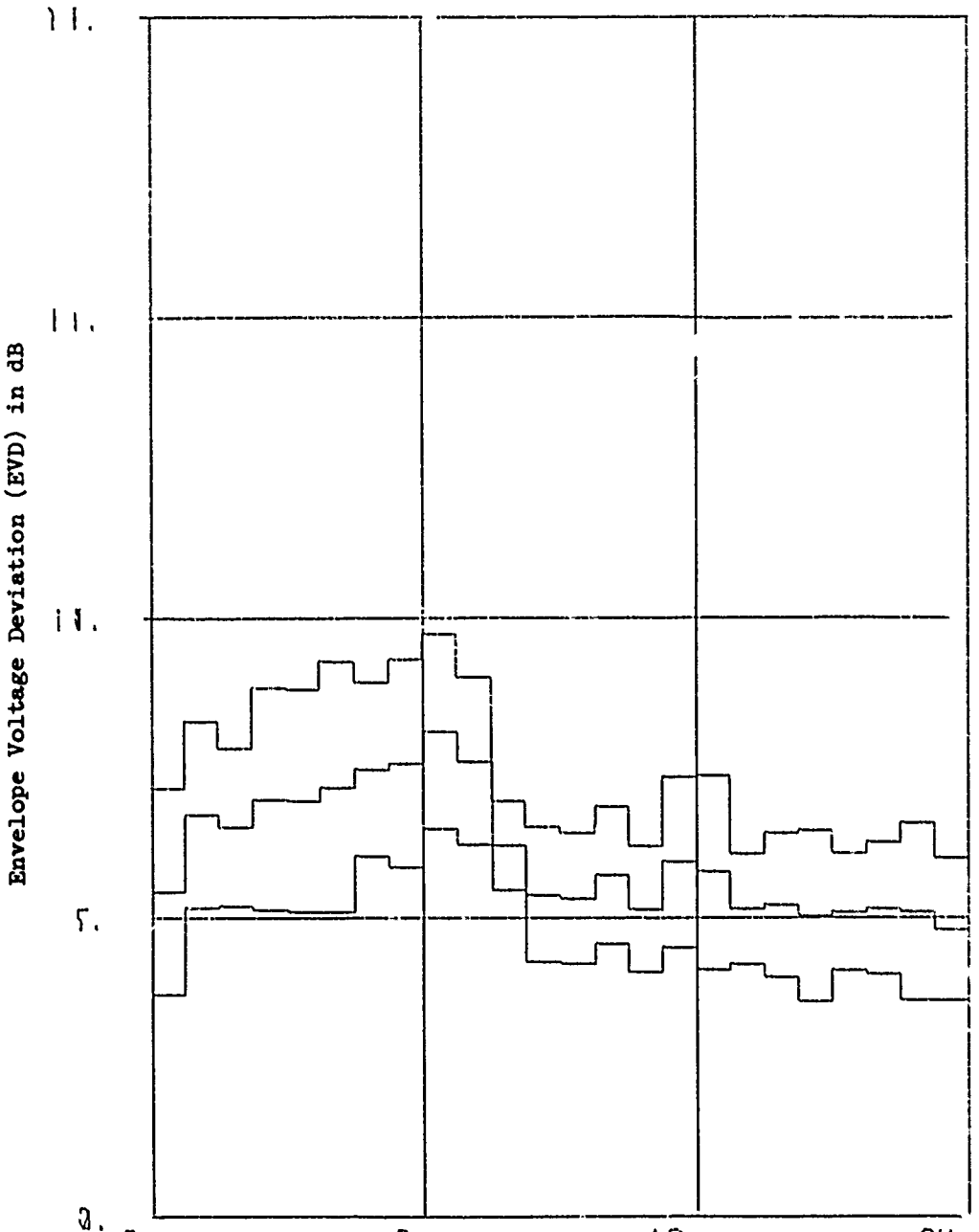

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
55.0 kHz
April

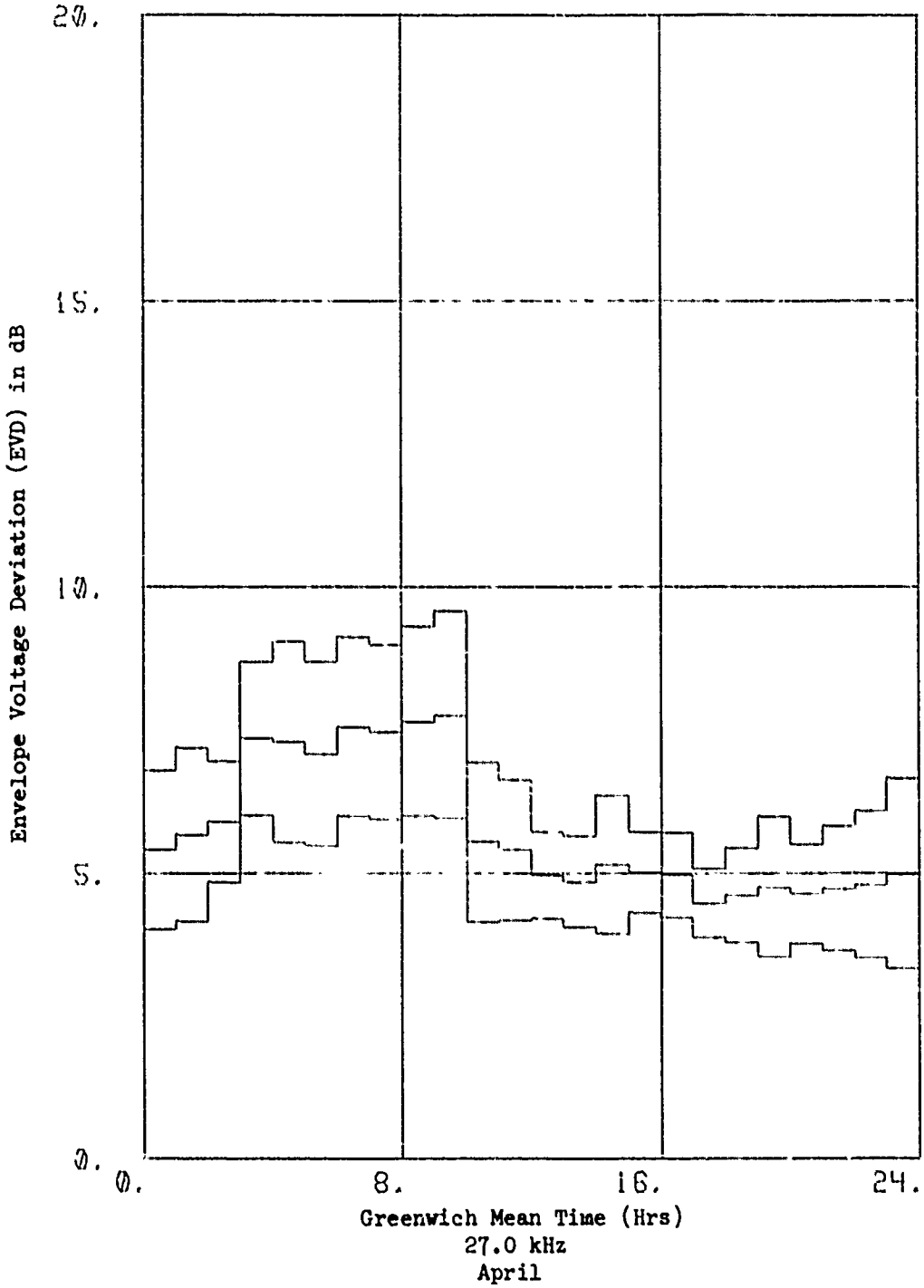
5.10 - EVD vs TIME (@ FREQS. - FOR APRIL)

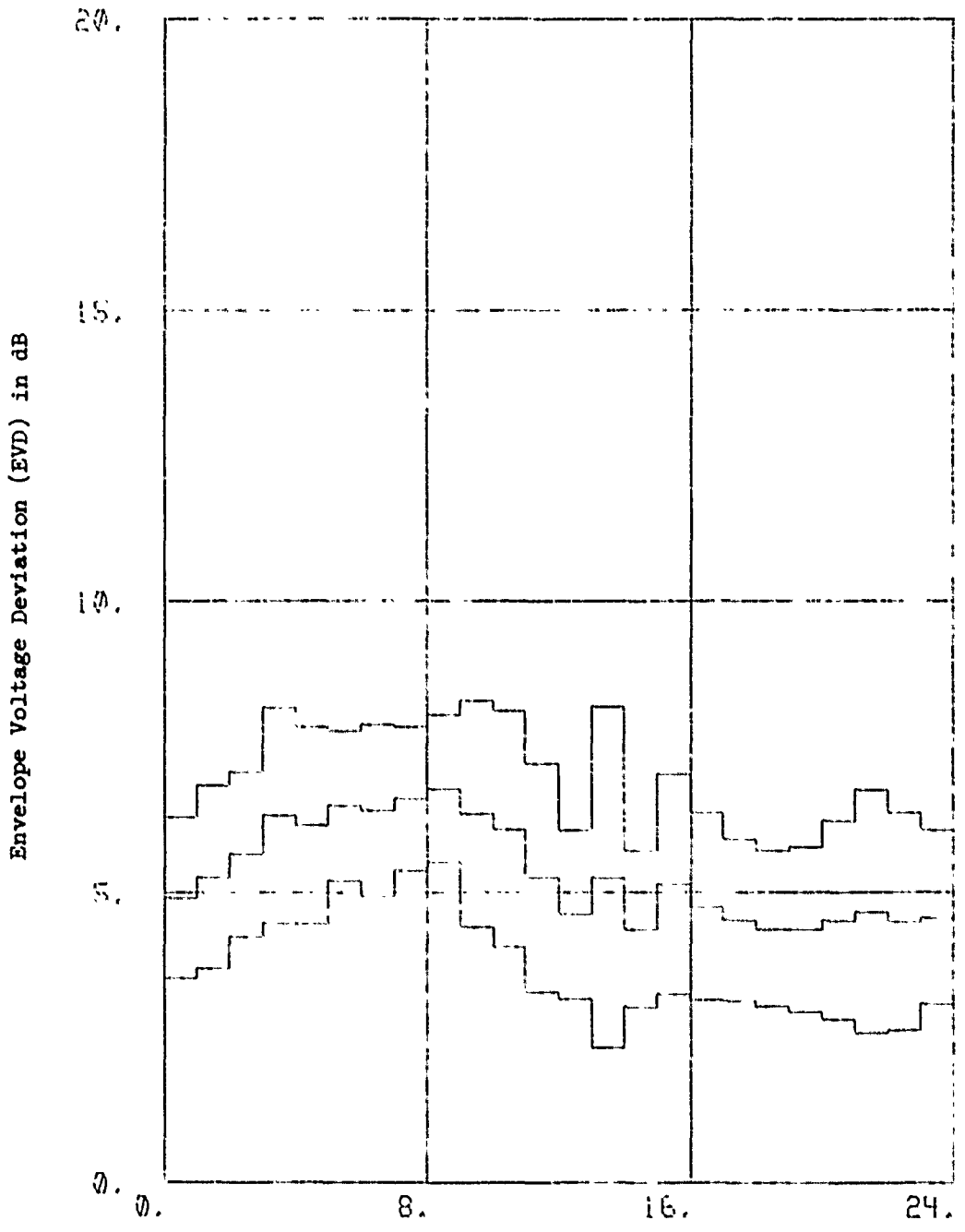

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
10.7 kHz
April

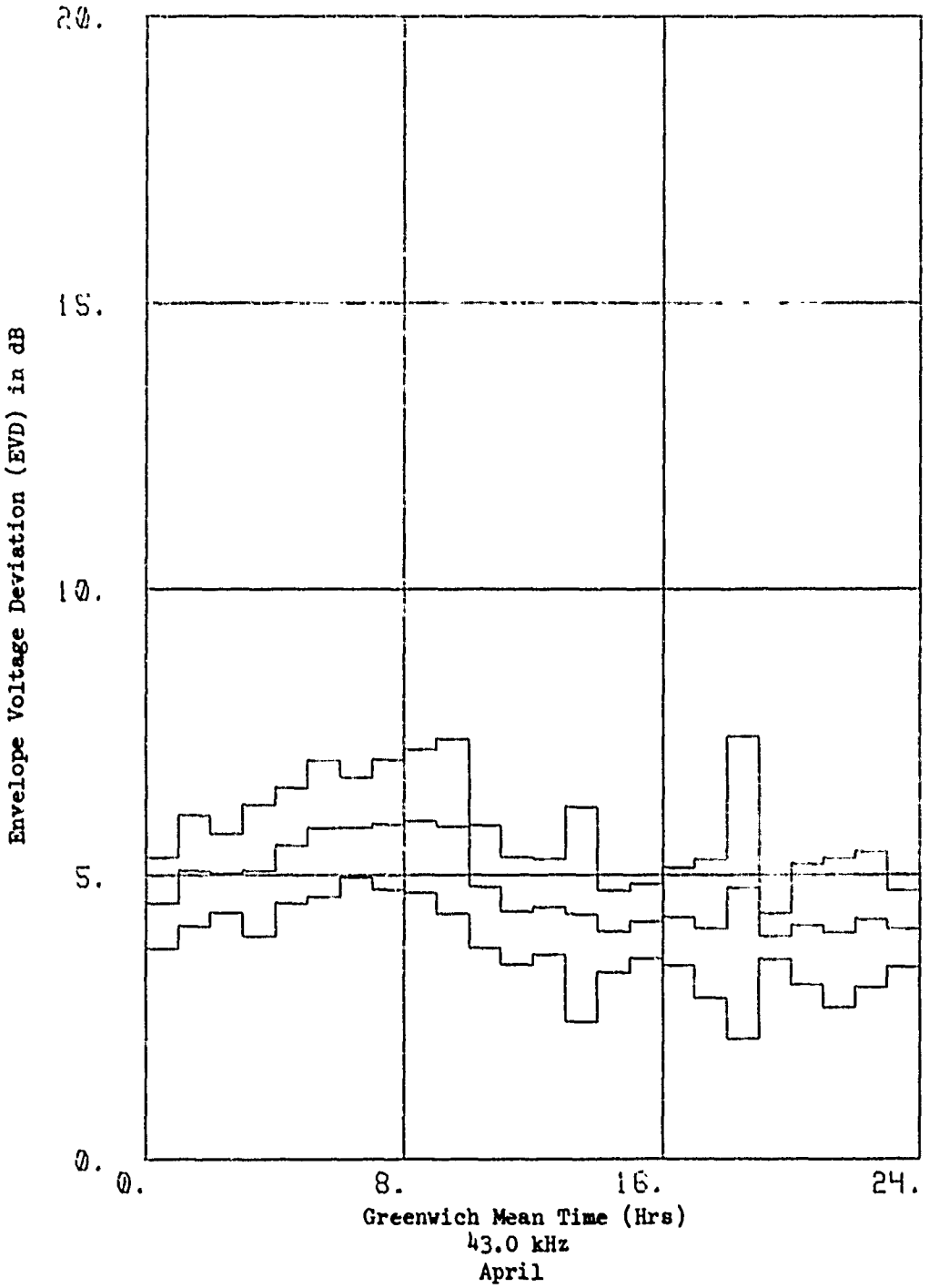

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
14.0 kHz
April

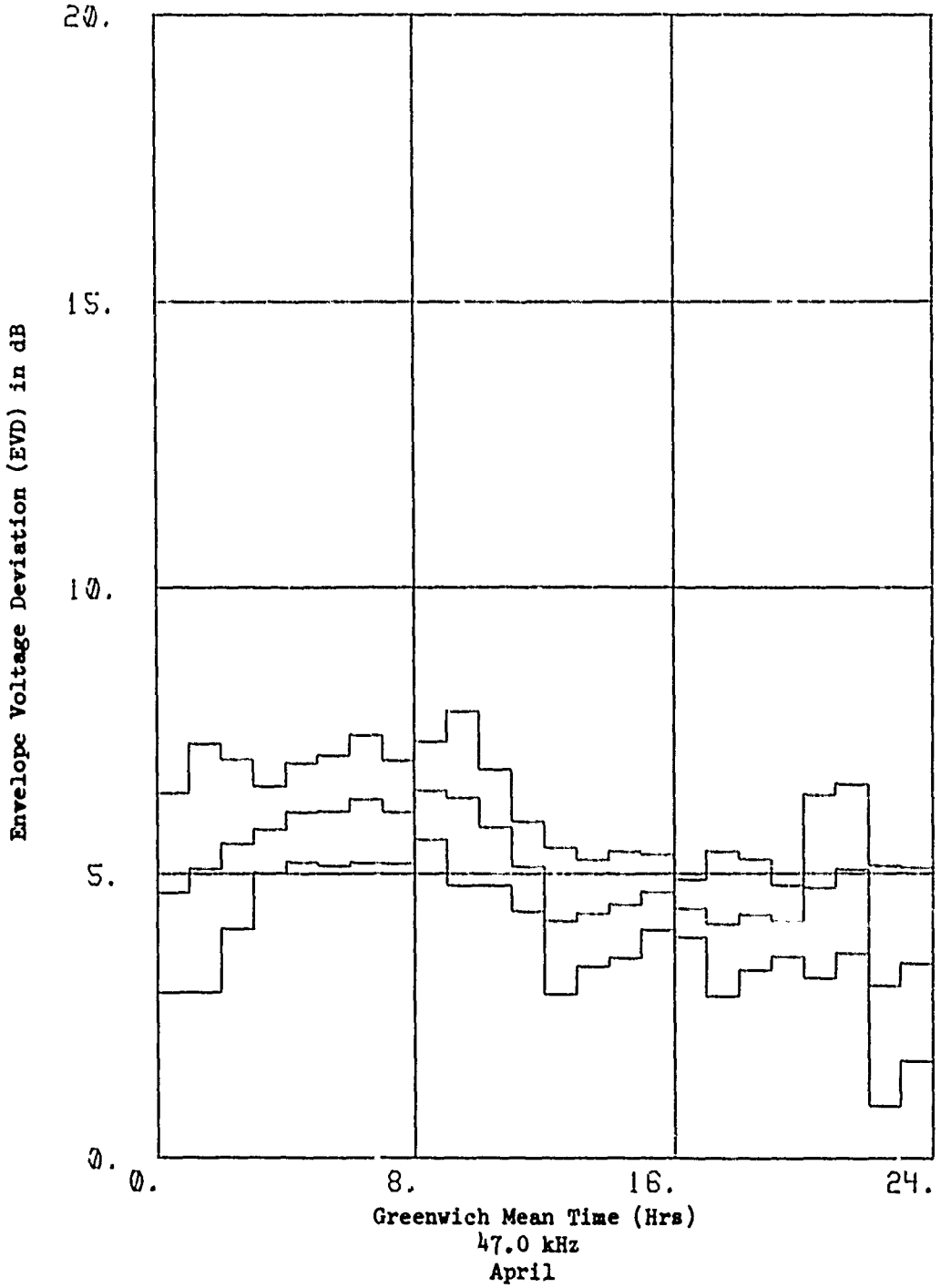

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
17.0 kHz
April

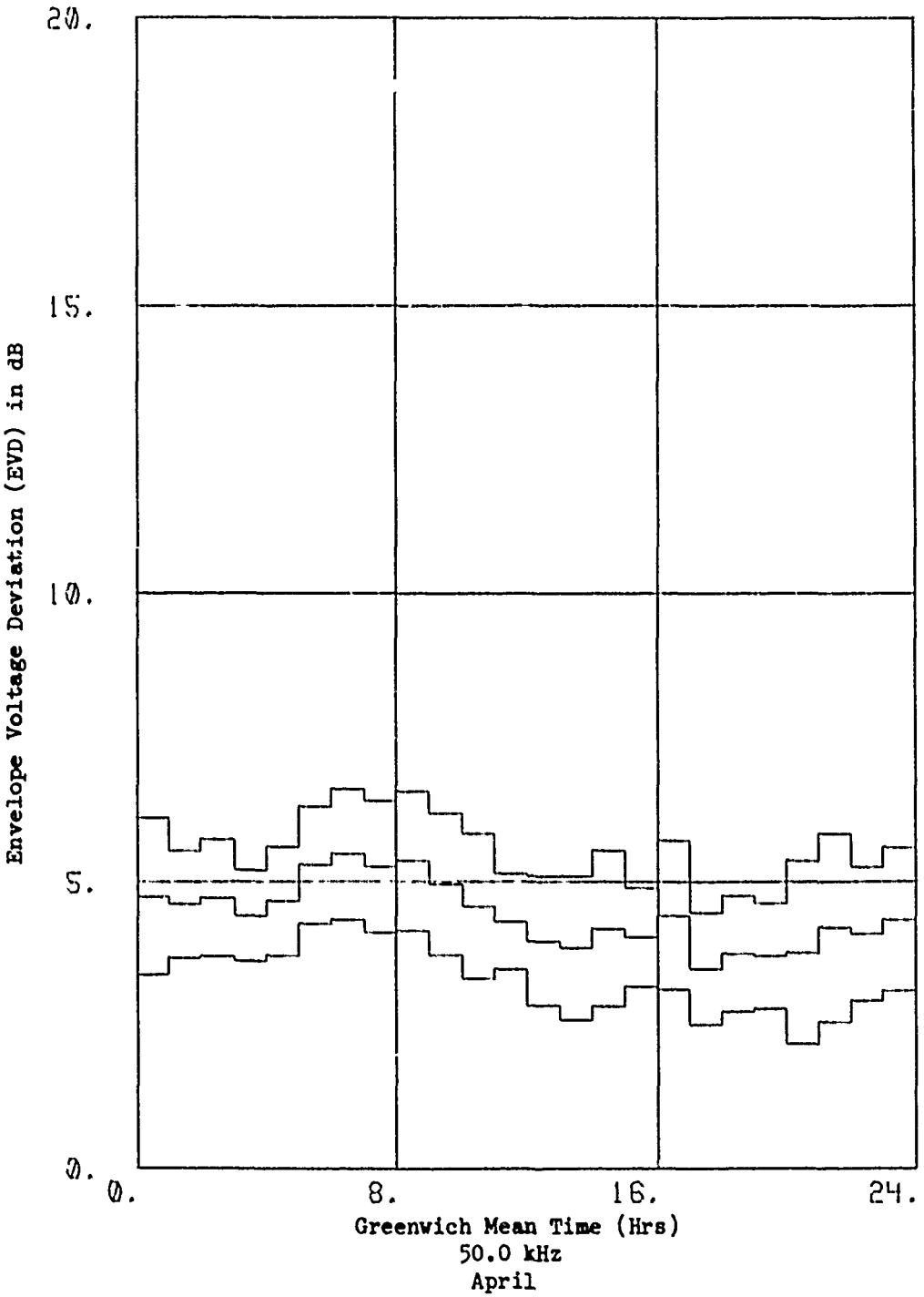

Envelope Voltage Deviation (EVD) in dB
0.
8.
16.
24.
Greenwich Mean Time (Hrs)
20.0 kHz
April

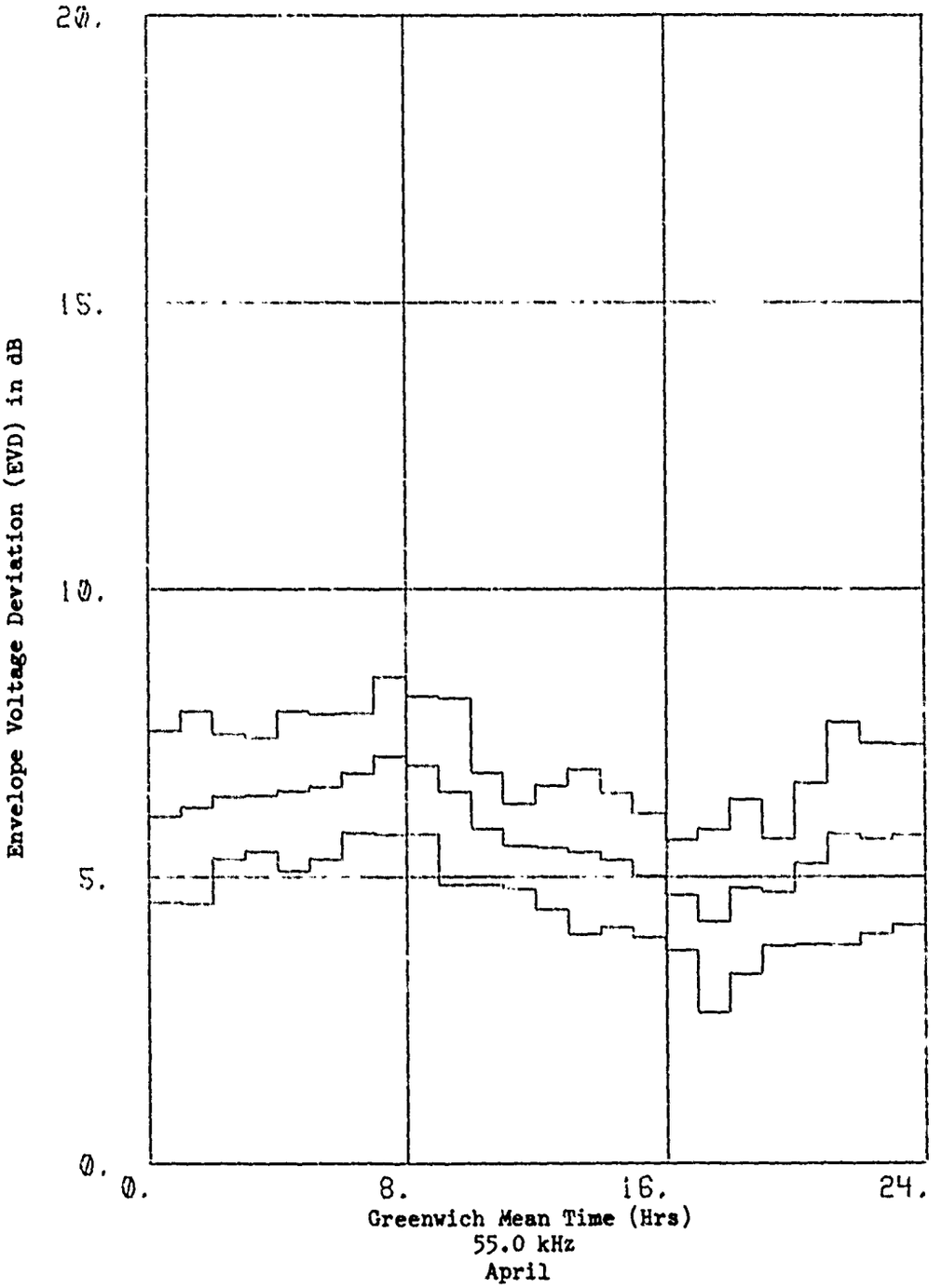

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
27.0 kHz
April


20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
40.0 kHz
April

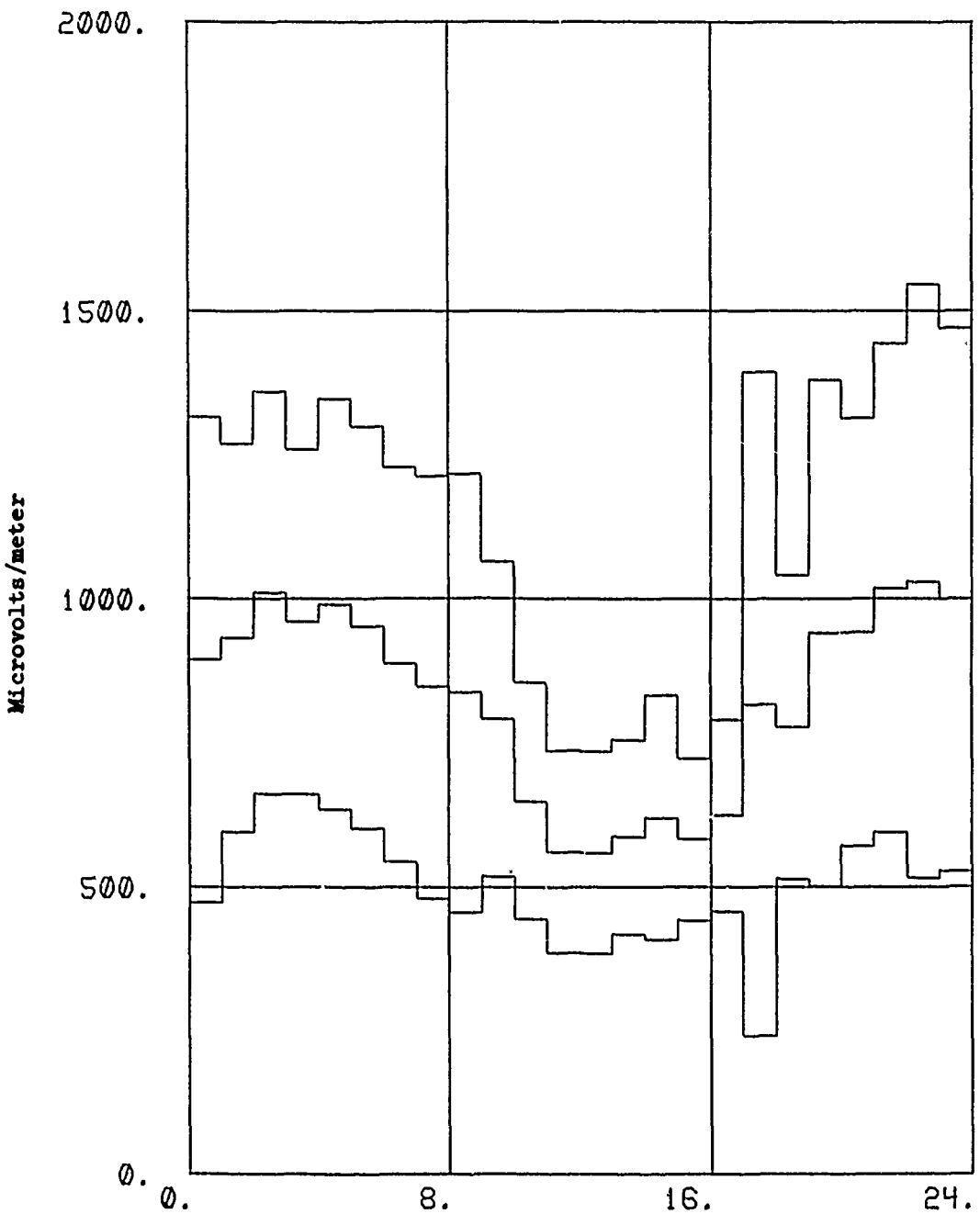

20.
15.
10.
5.
0.
Envelope Voltage Deviation (EVD) in dB
0.
8.
16.
24.
Greenwich Mean Time (Hrs)
43.0 kHz
April


20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
47.0 kHz
April

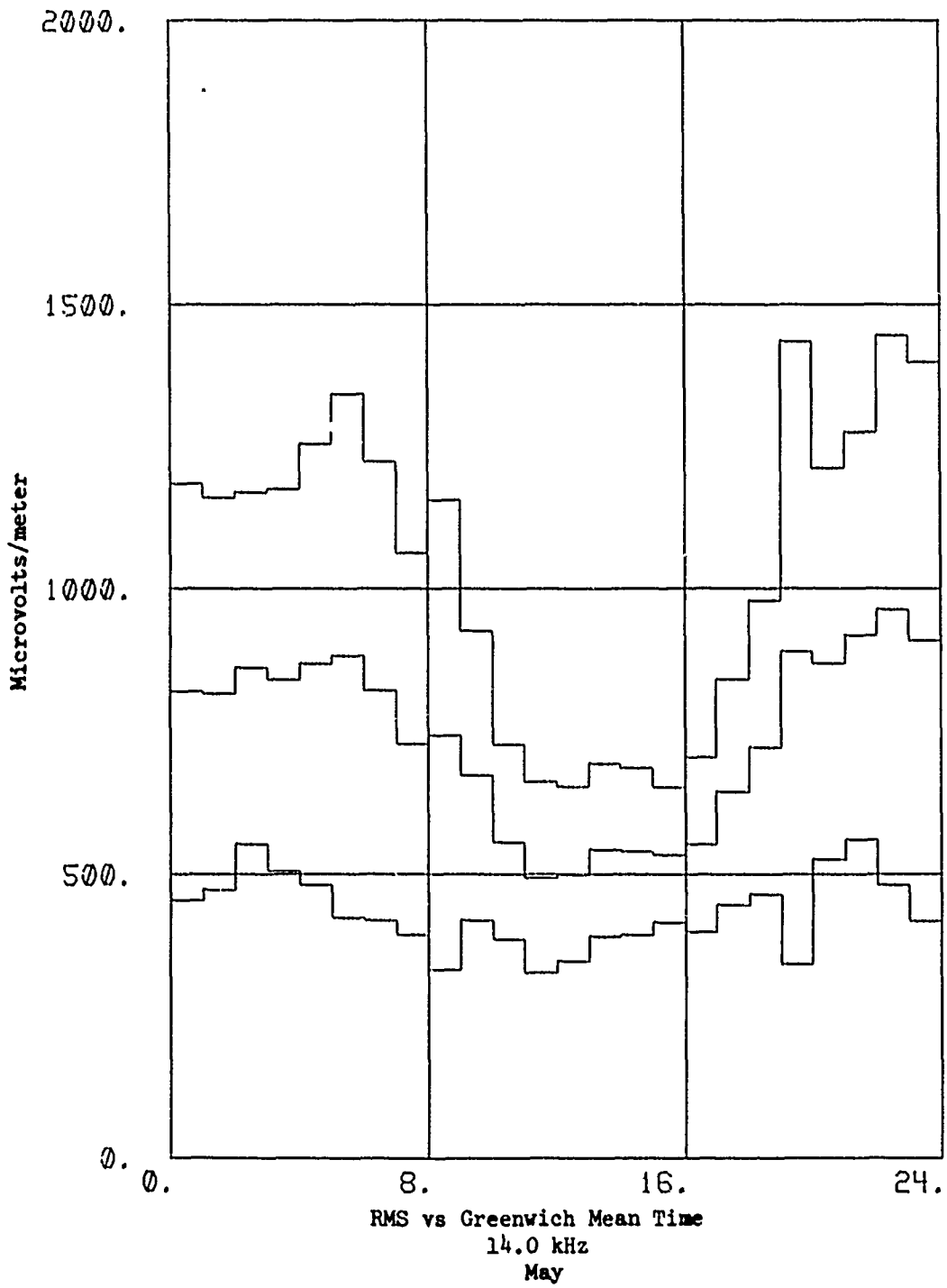

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
50.0 kHz
April

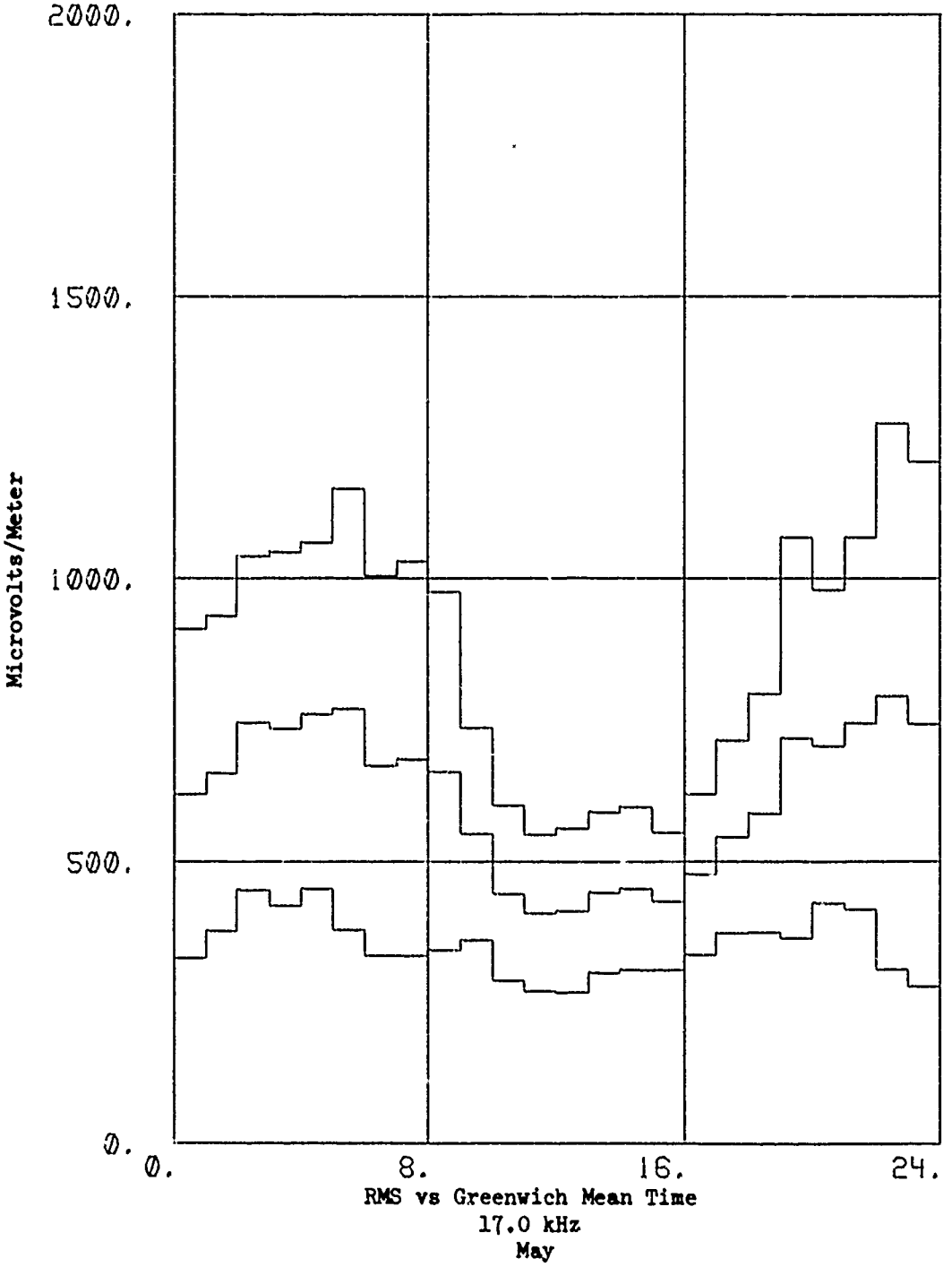

20.
15.
10.
5.
0.
Envelope Voltage Deviation (EVD) in dB
0.
8.
16.
24.
Greenwich Mean Time (Hrs)
55.0 kHz
April

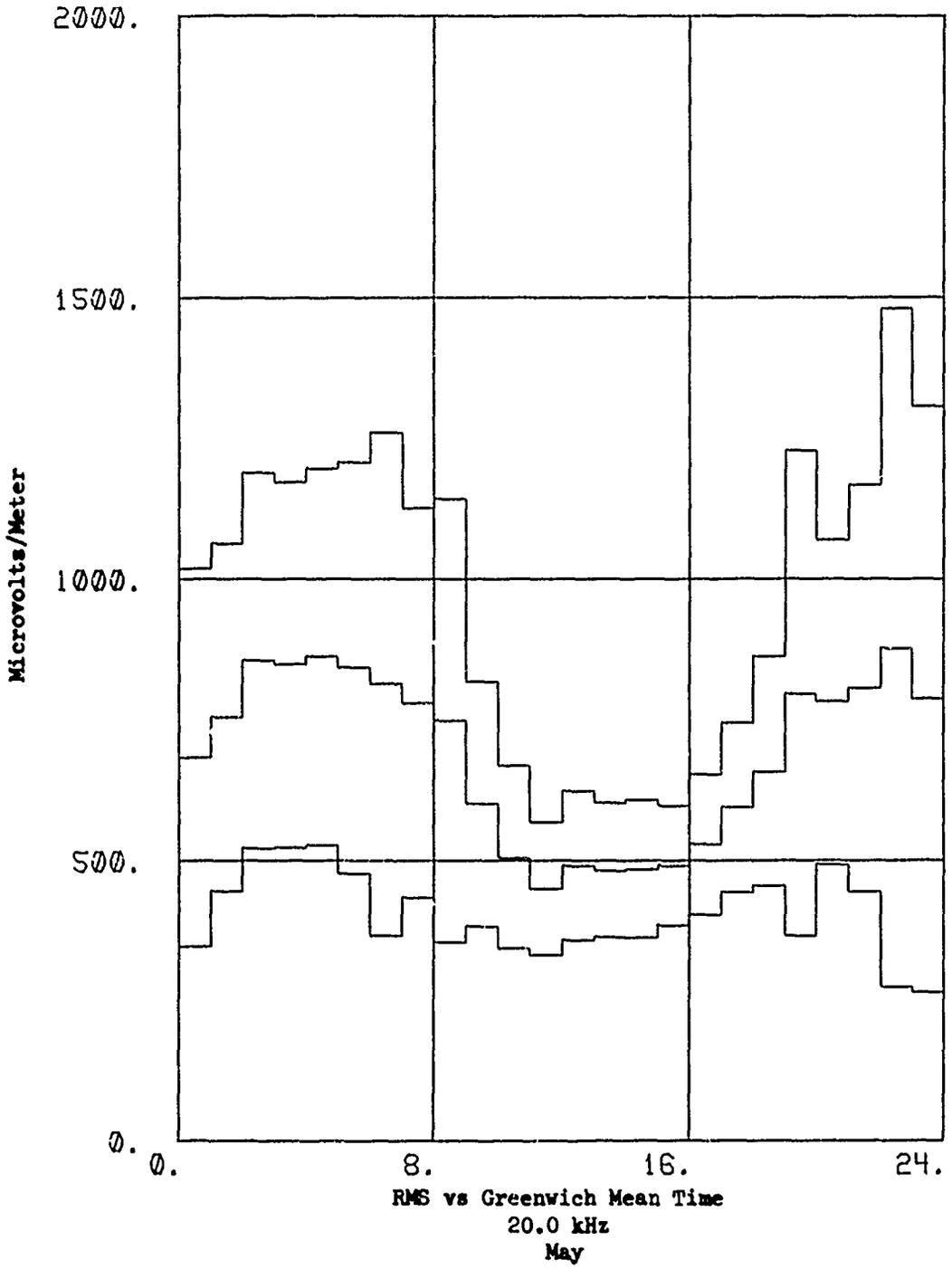
5.11 - ERMS vs TIME (@ FREQS. - FOR MAY)

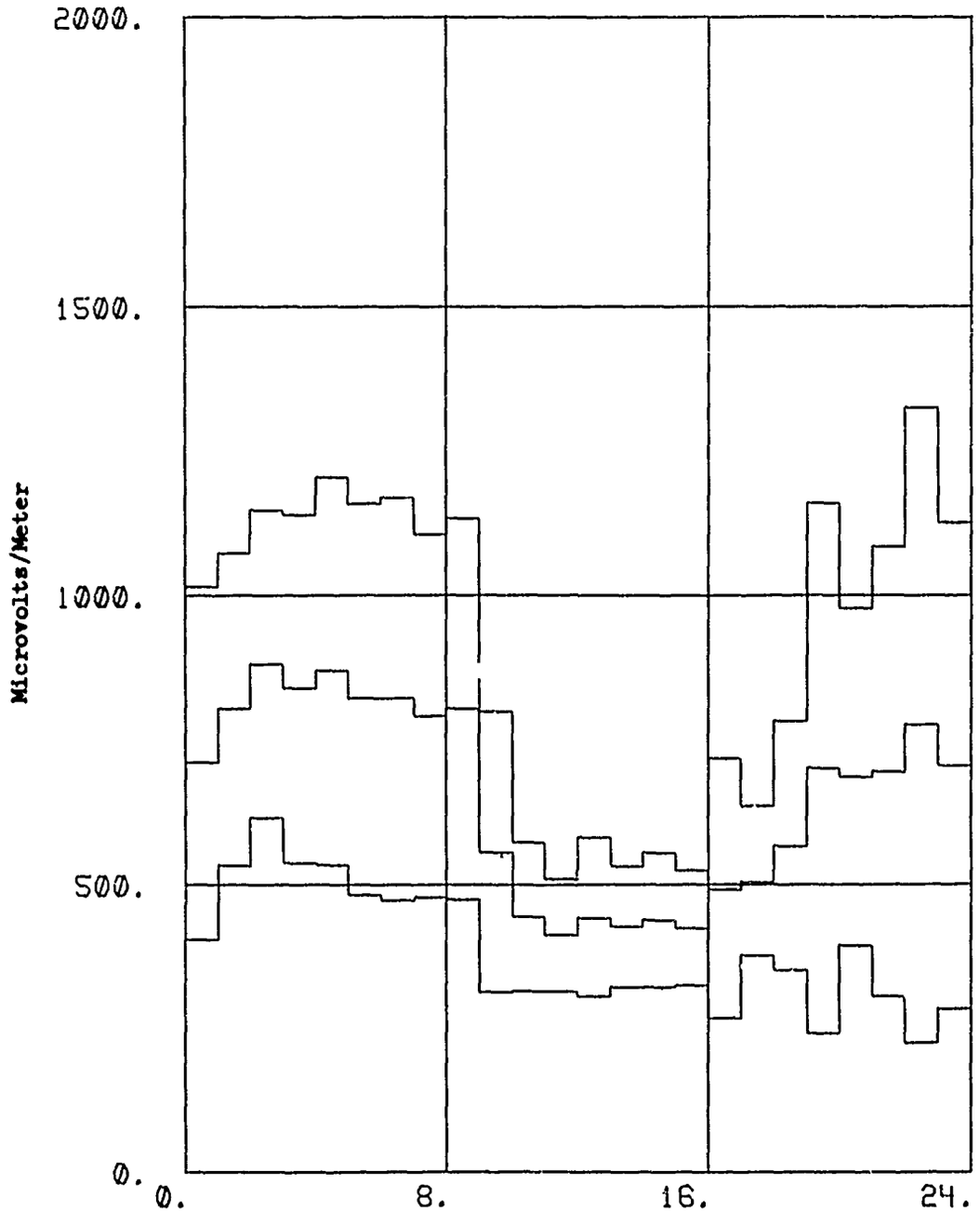


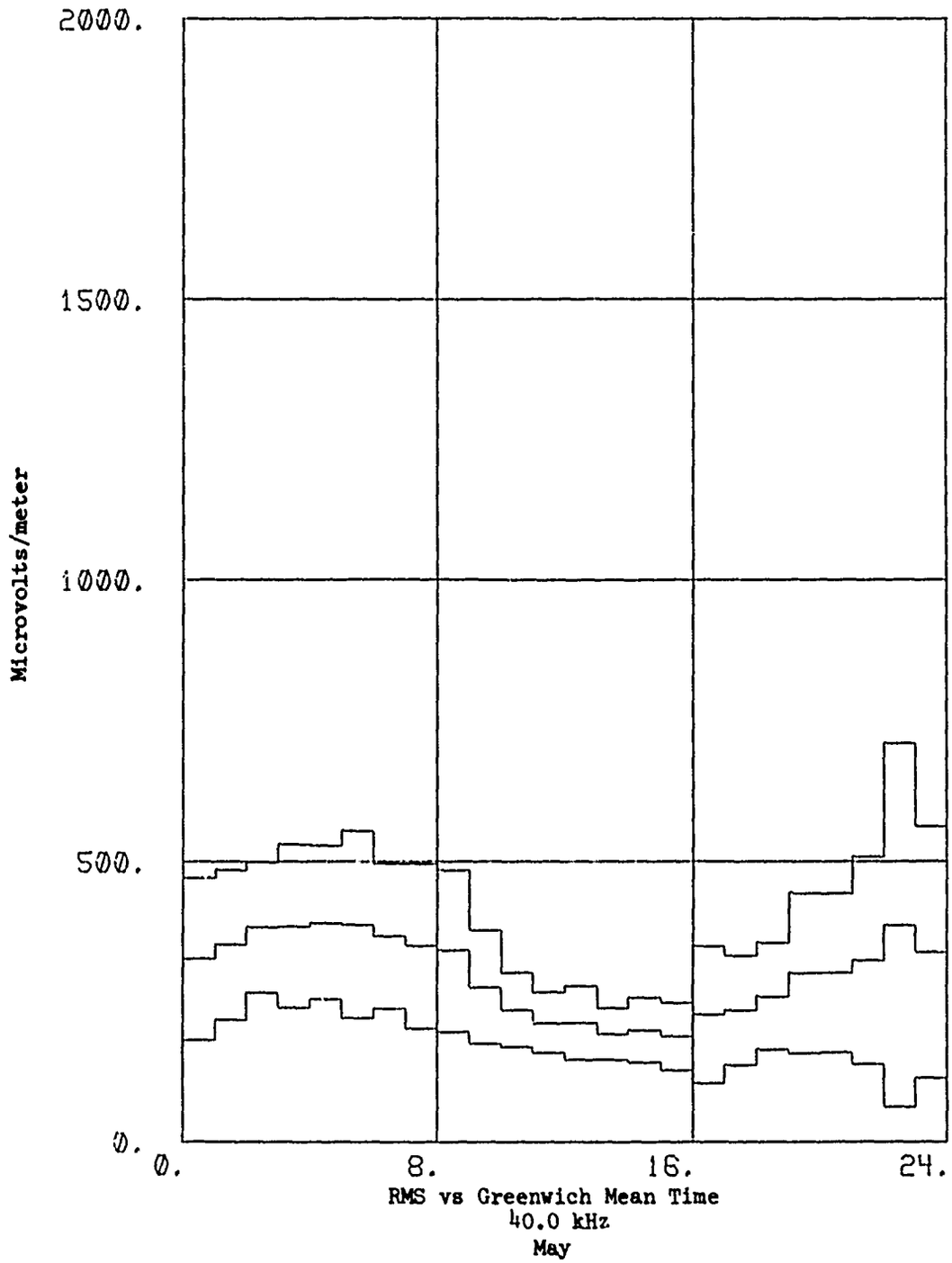
RMS vs Greenwich Mean Time
10.7 kHz
May

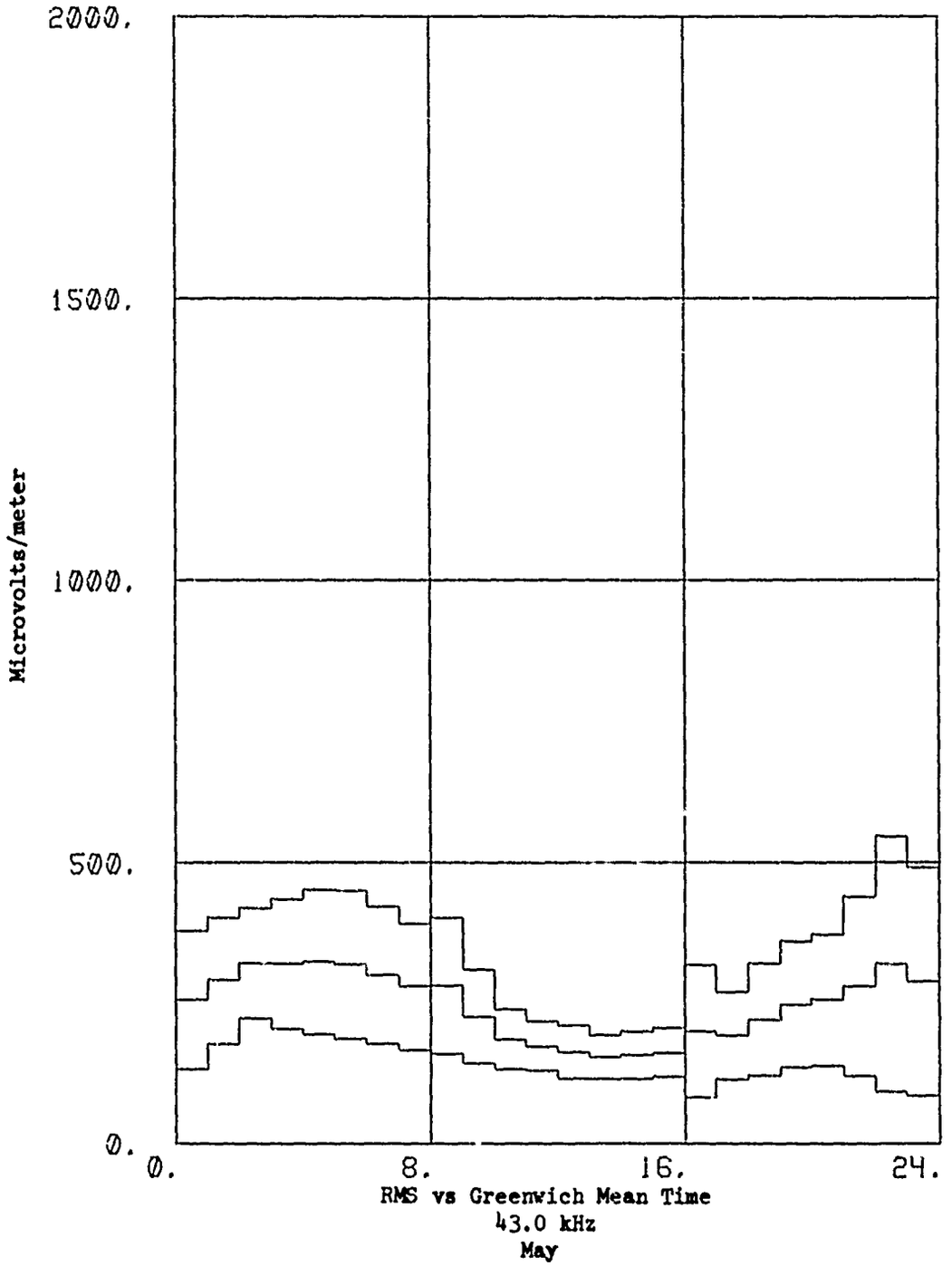

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time
14.0 kHz
May


2000.
1500.
1000.
500.
0.
Microvolts/Meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time
17.0 kHz
May


2000.
1500.
1000.
500.
0.
Microvolts/Meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time
20.0 kHz
May


2000.
1500.
1000.
500.
0.
Microvolts/Meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time
27.0 kHz
May


2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time
40.0 kHz
May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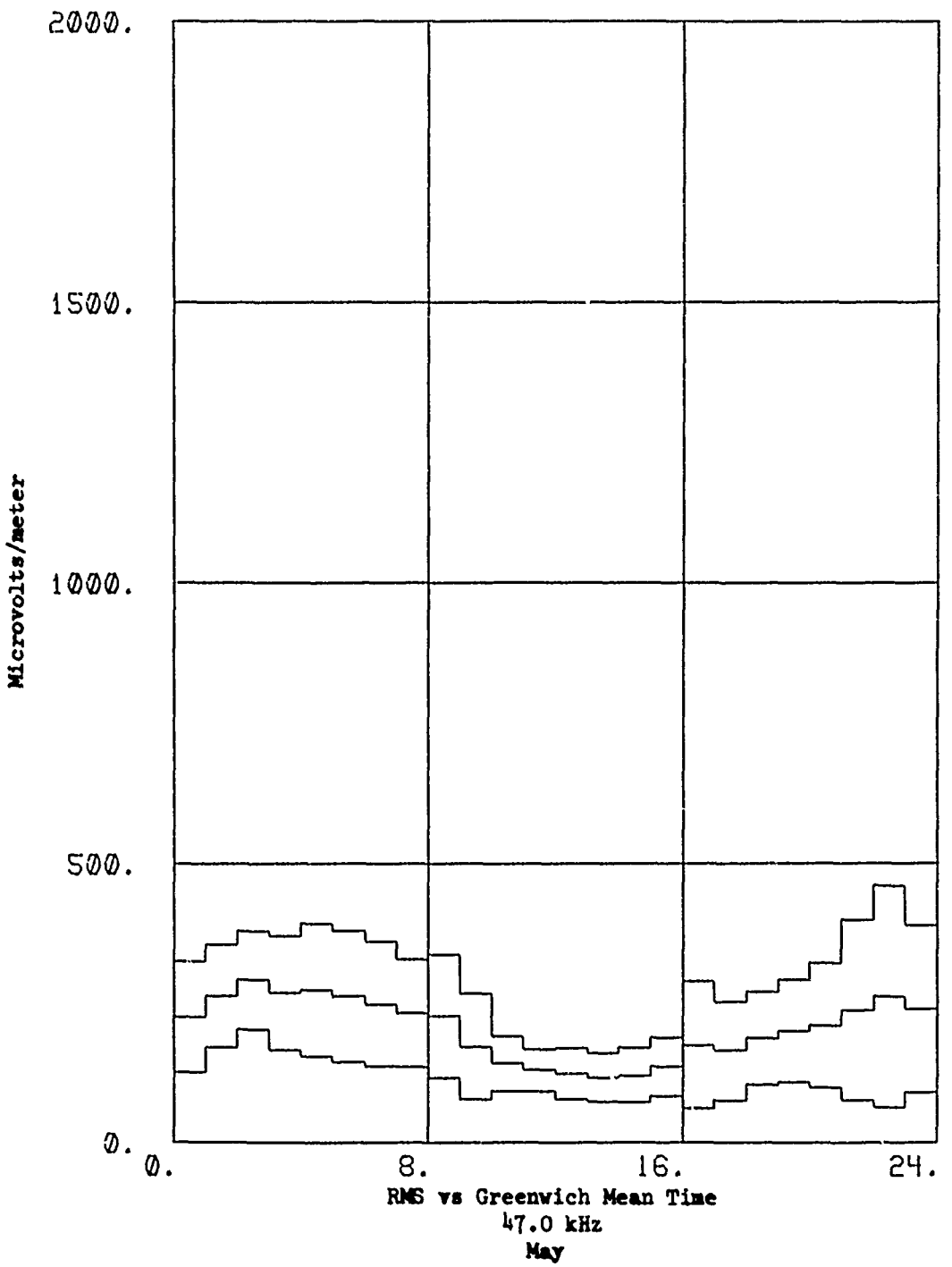
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time
43.0 kHz
May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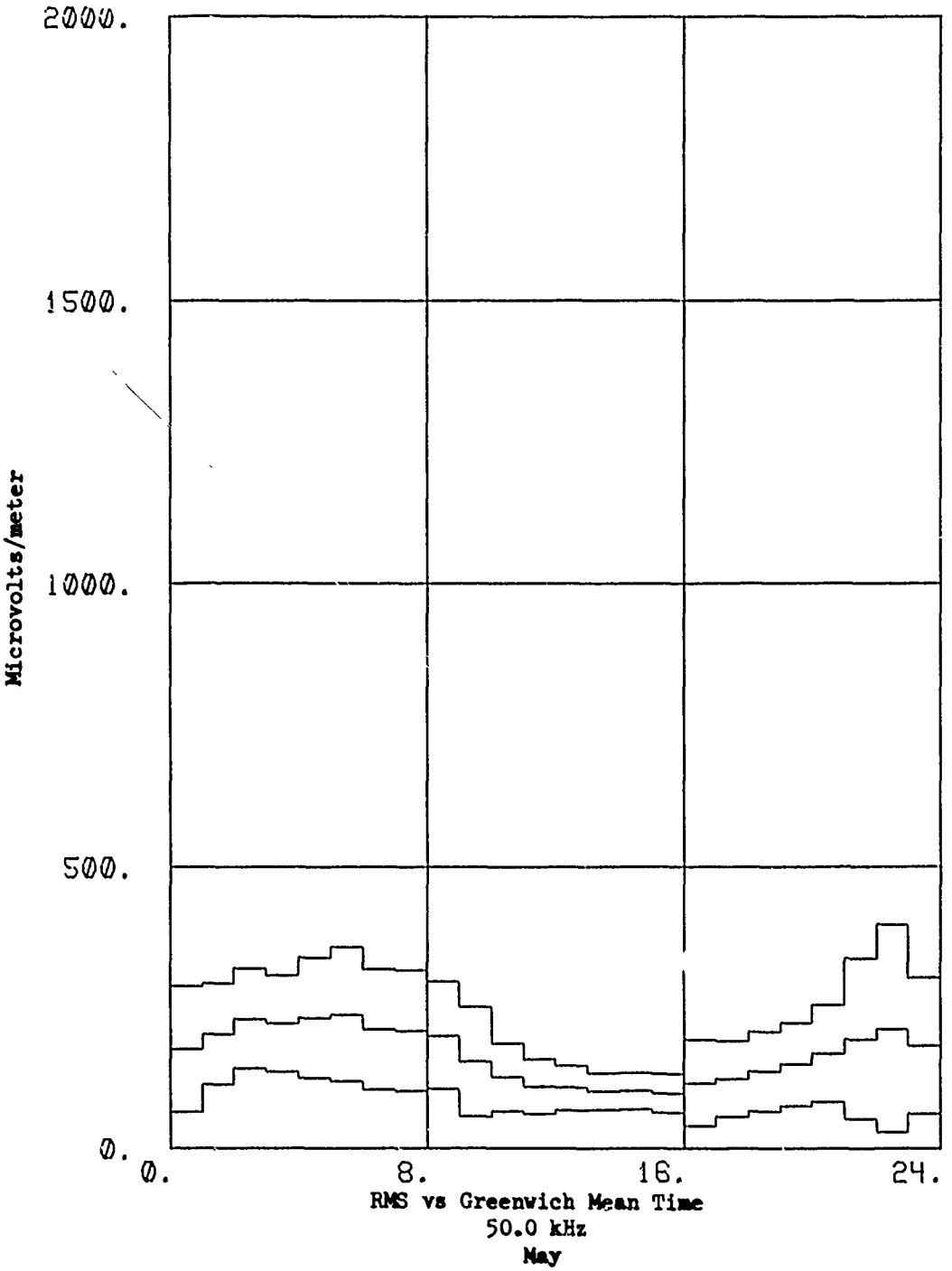
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time
47.0 kHz
May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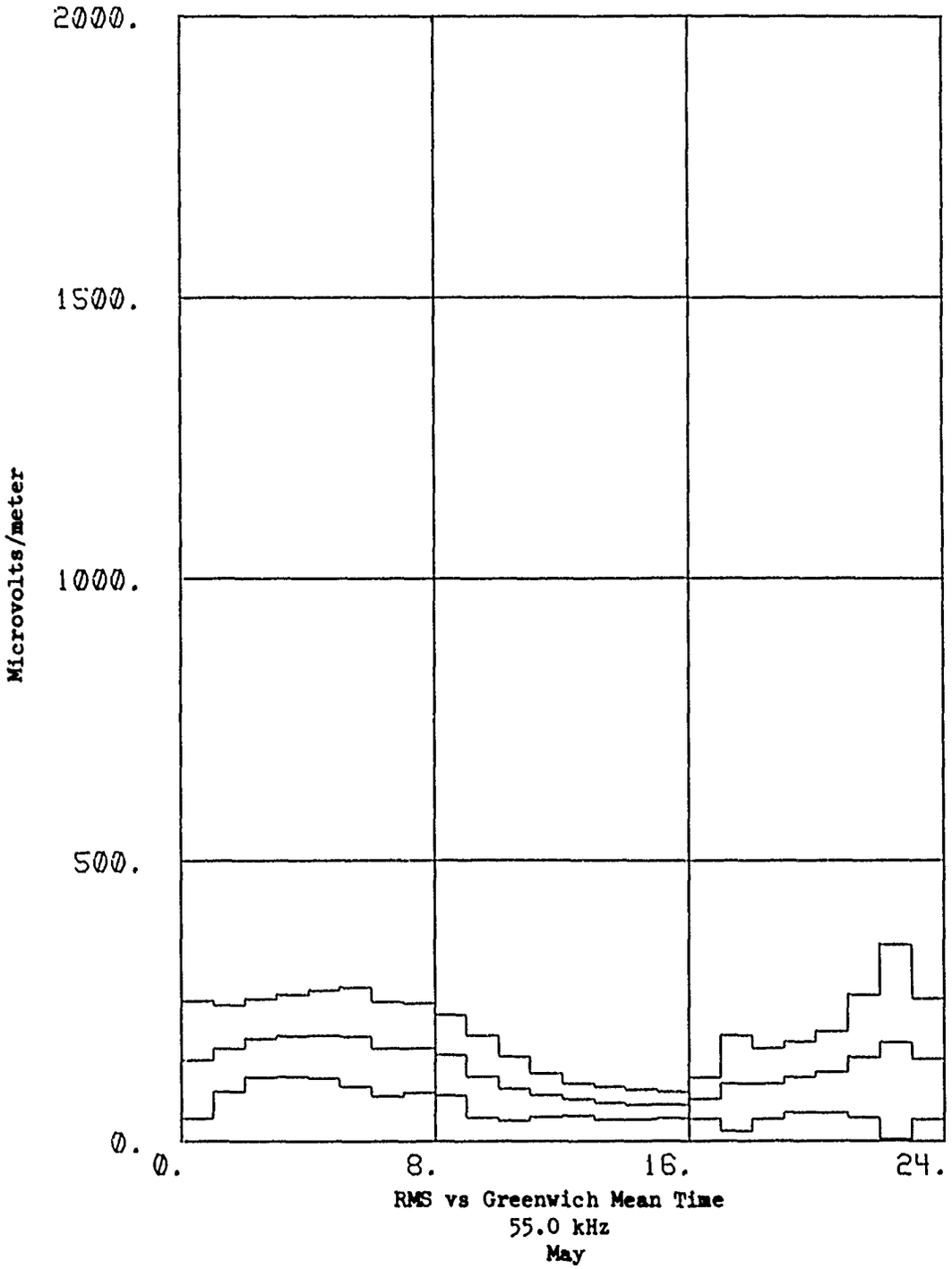
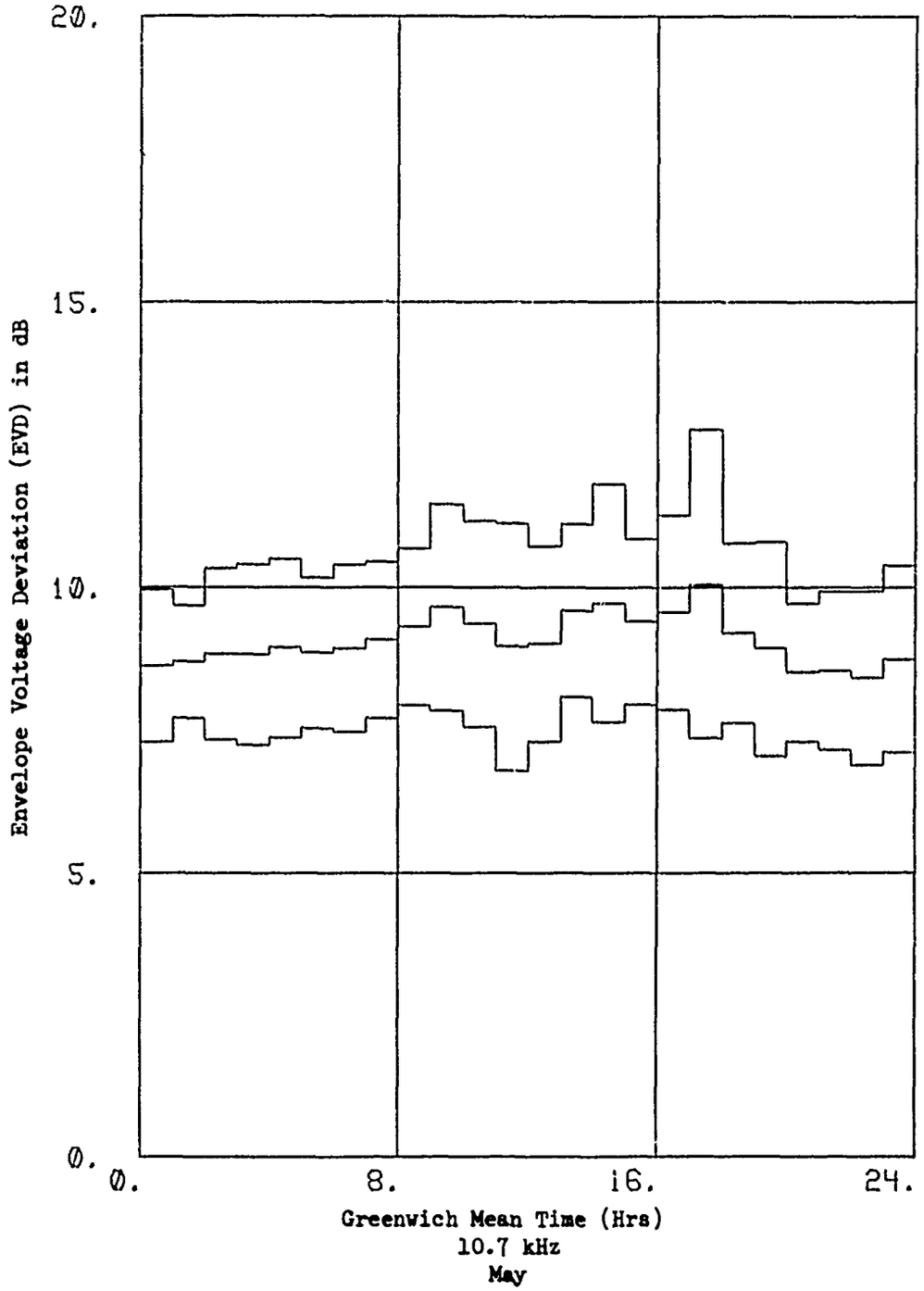
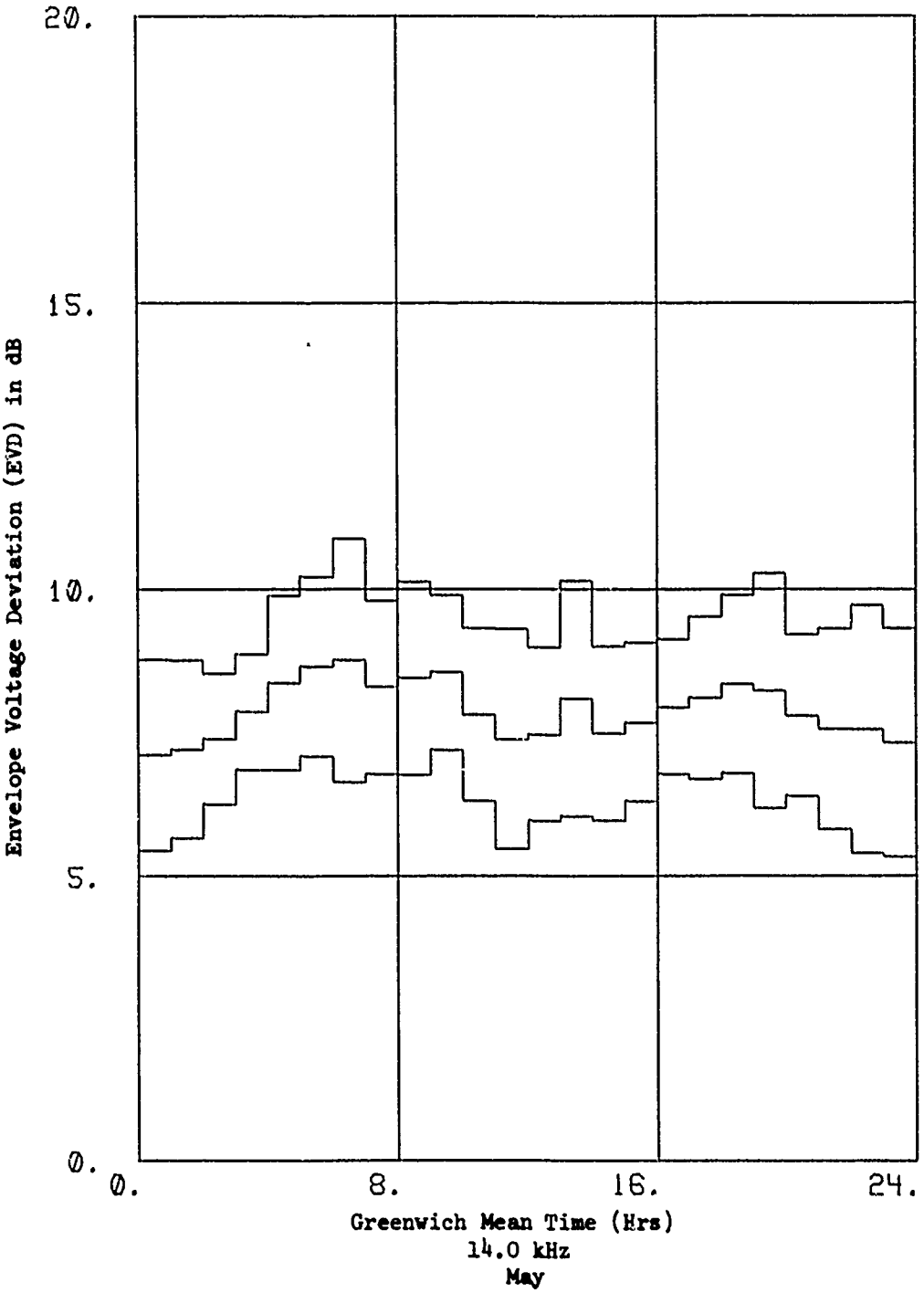
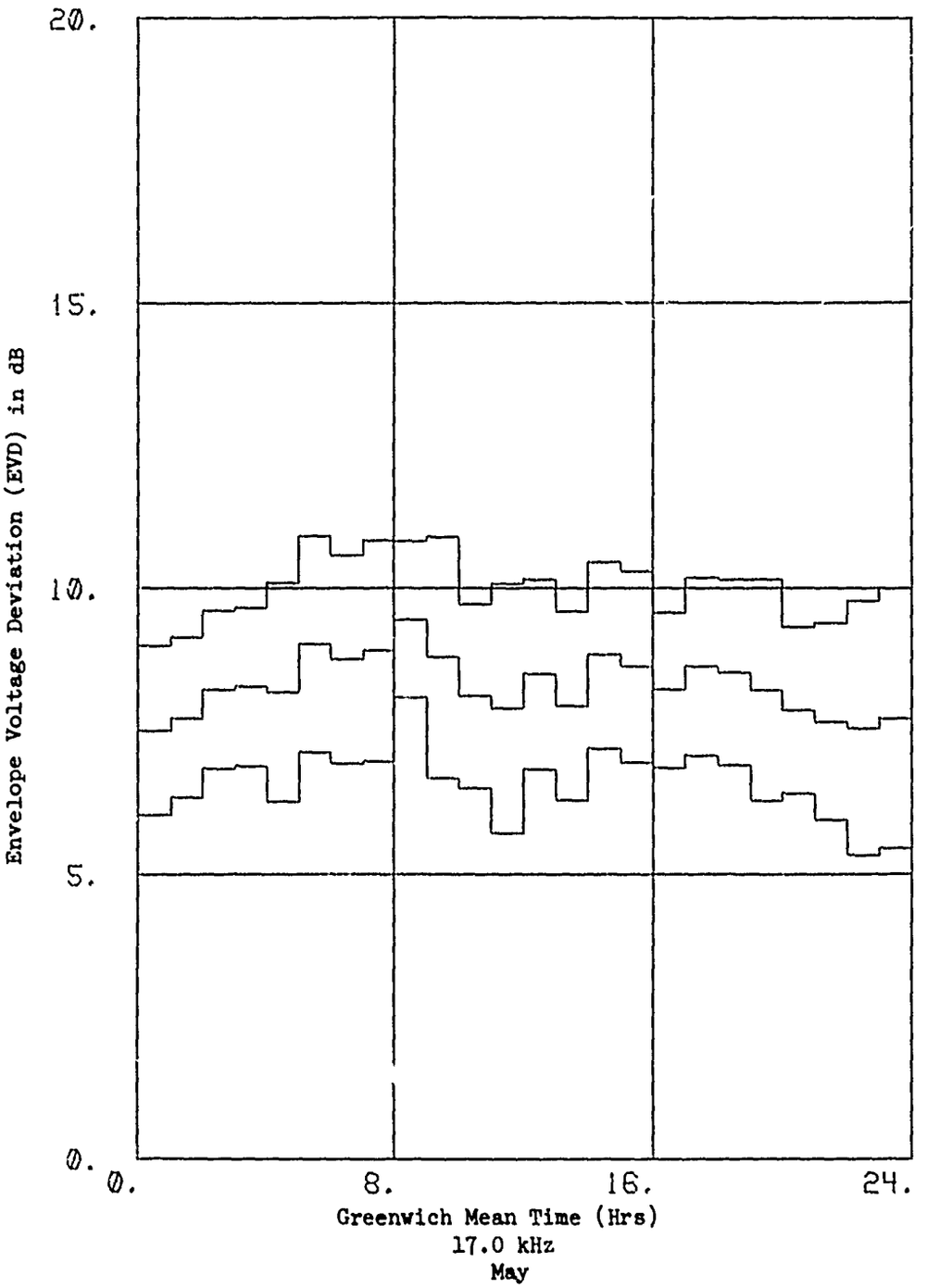
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time
50.0 kHz
May

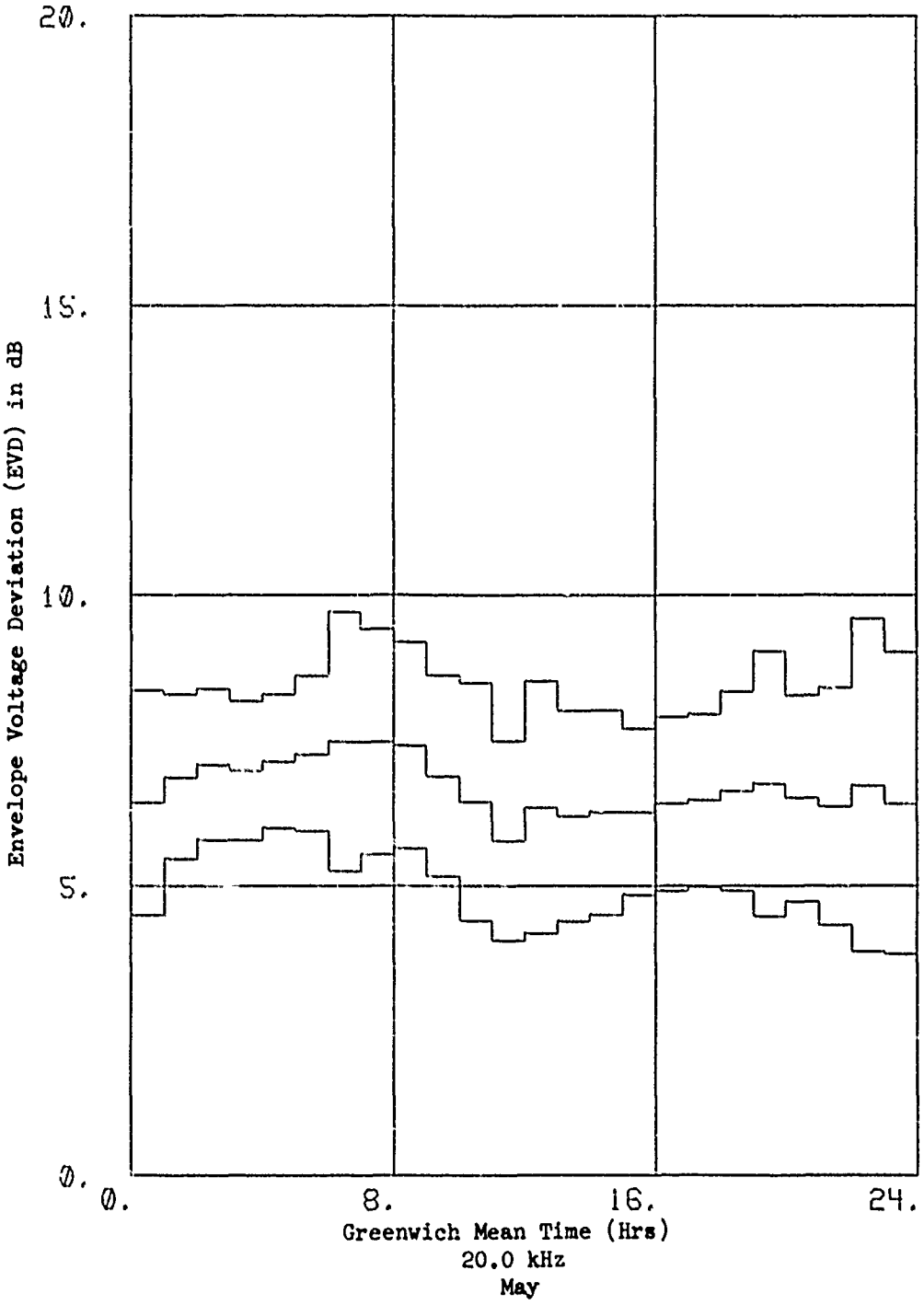

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time
55.0 kHz
May

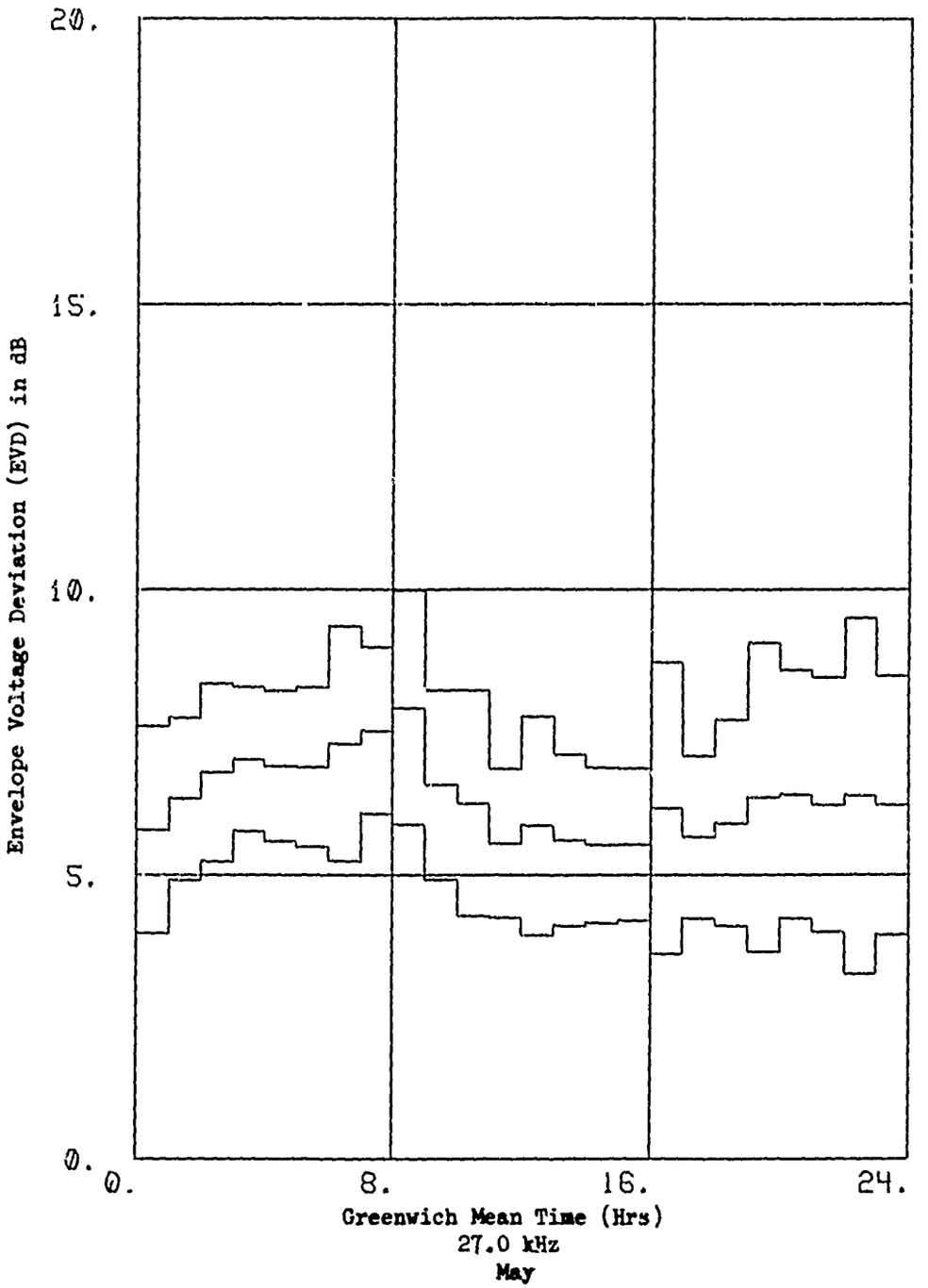
5.12 - EVD vs TIME (@ FREQS. - FOR MAY)

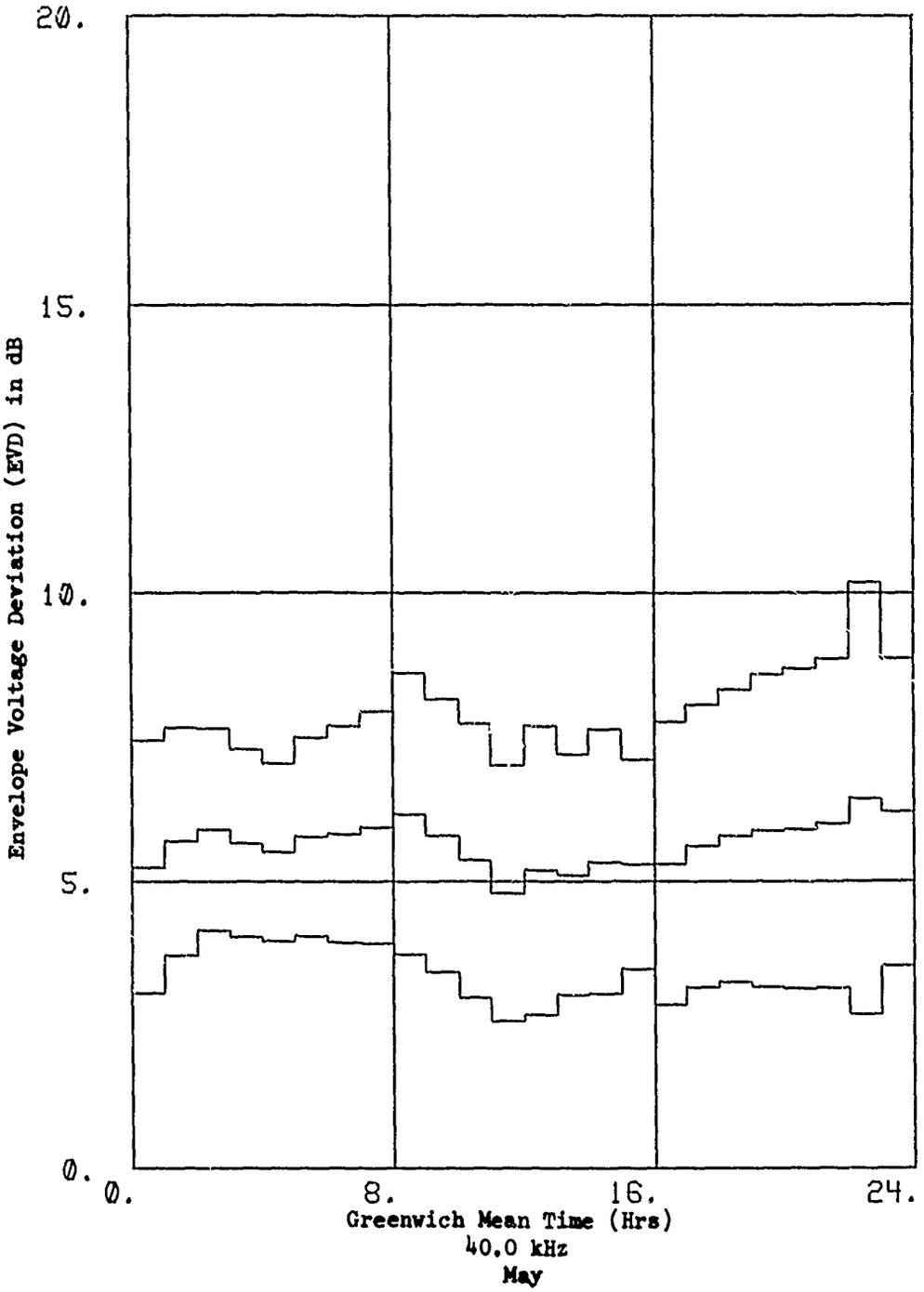

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
10.7 kHz
May

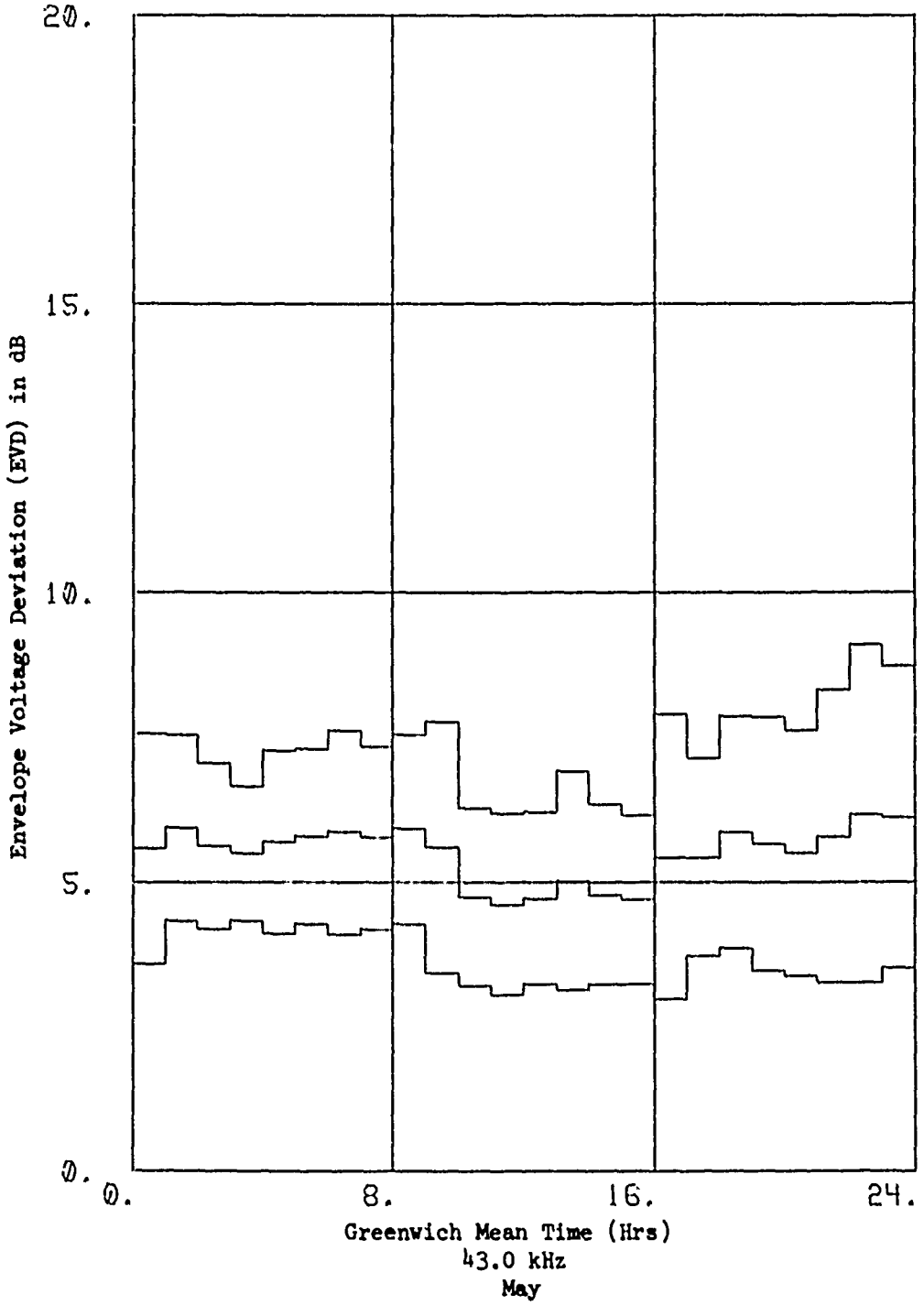

20.
15.
10.
5.
0.
Envelope Voltage Deviation (EVD) in dB
0.
8.
16.
24.
Greenwich Mean Time (Hrs)
14.0 kHz
May

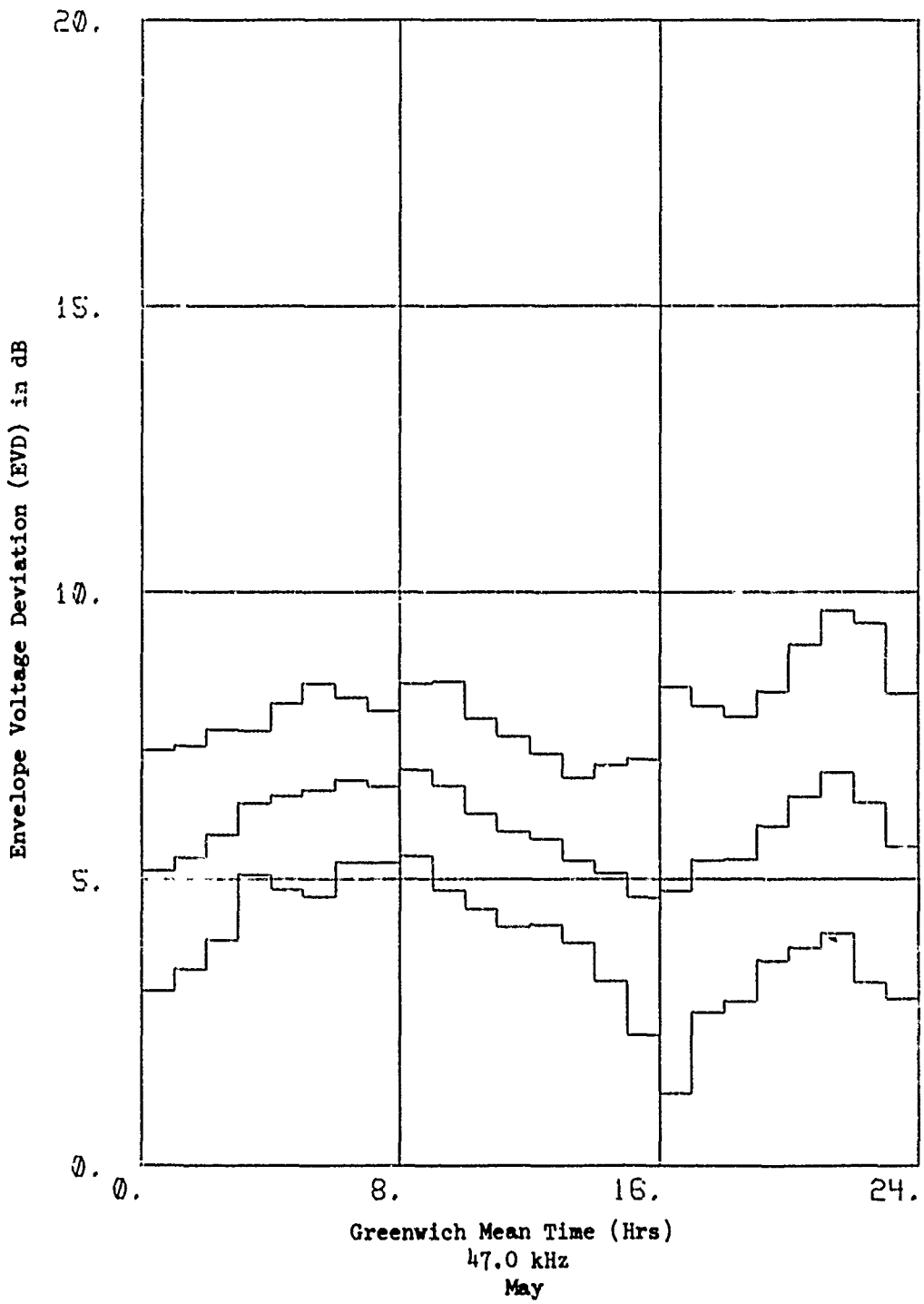

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
17.0 kHz
May

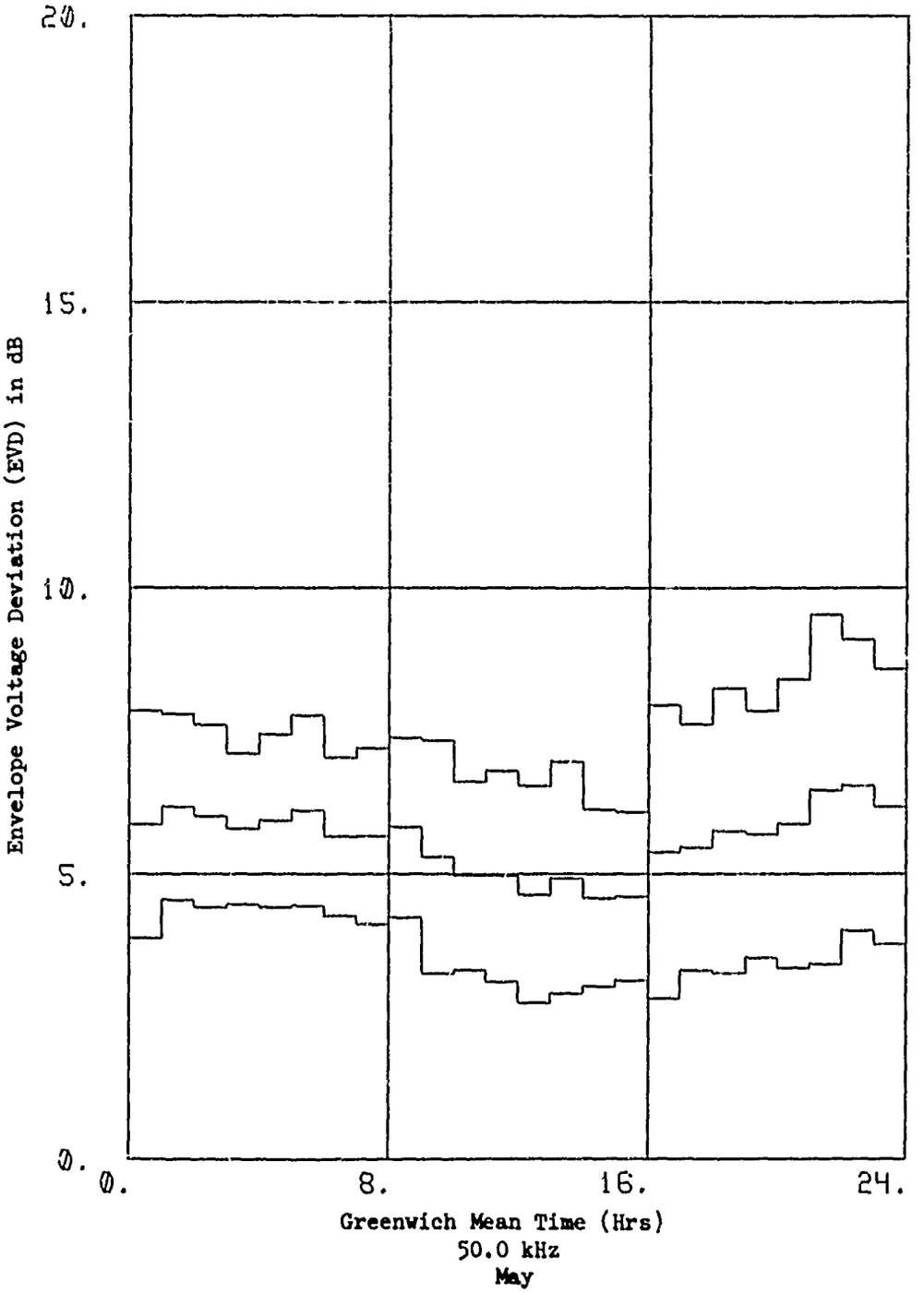

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
20.0 kHz
May

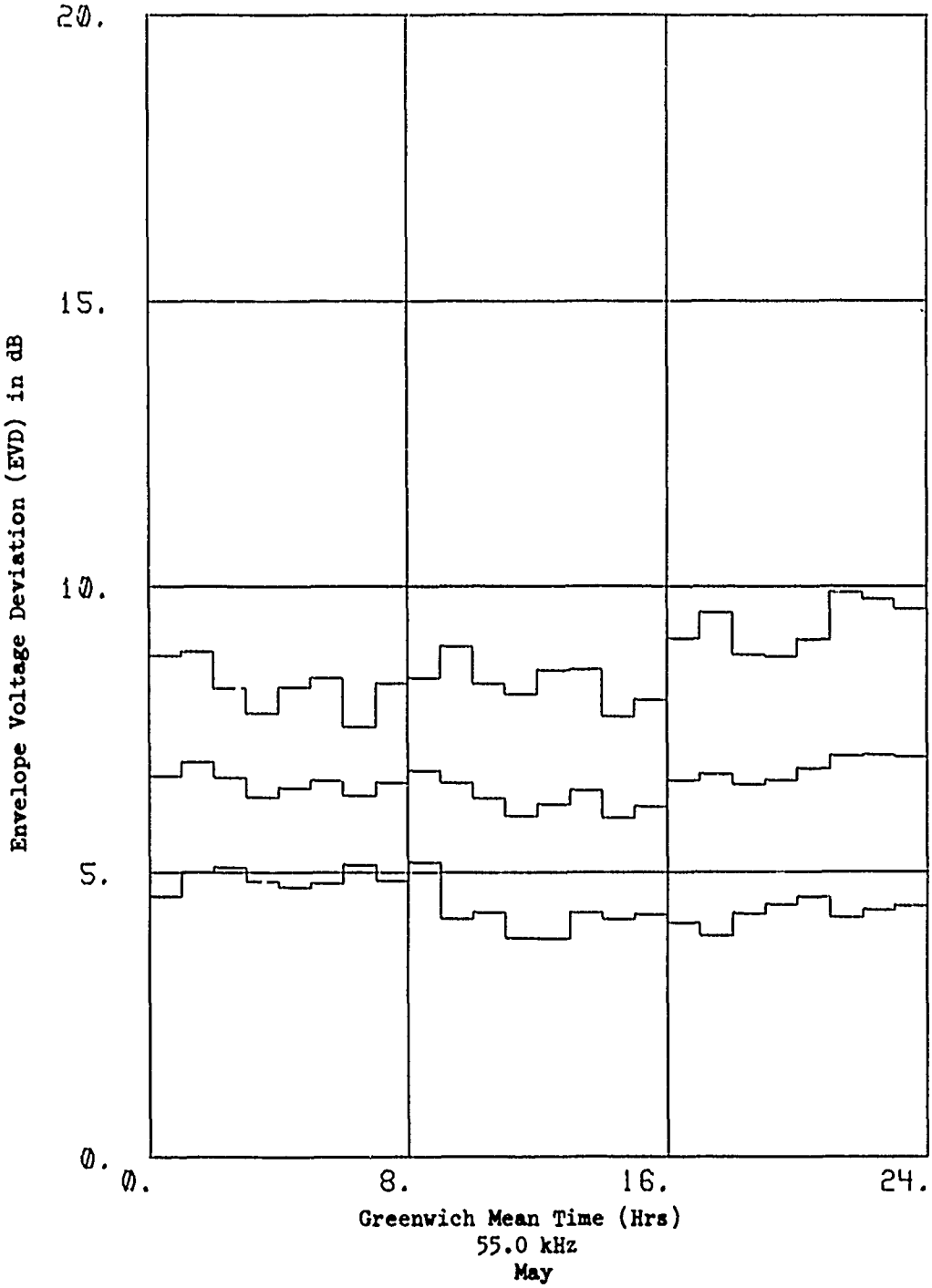

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
27.0 kHz
May


20.
15.
10.
5.
0.
Envelope Voltage Deviation (EVD) in dB
0.
8.
16.
24.
Greenwich Mean Time (Hrs)
40.0 kHz
May

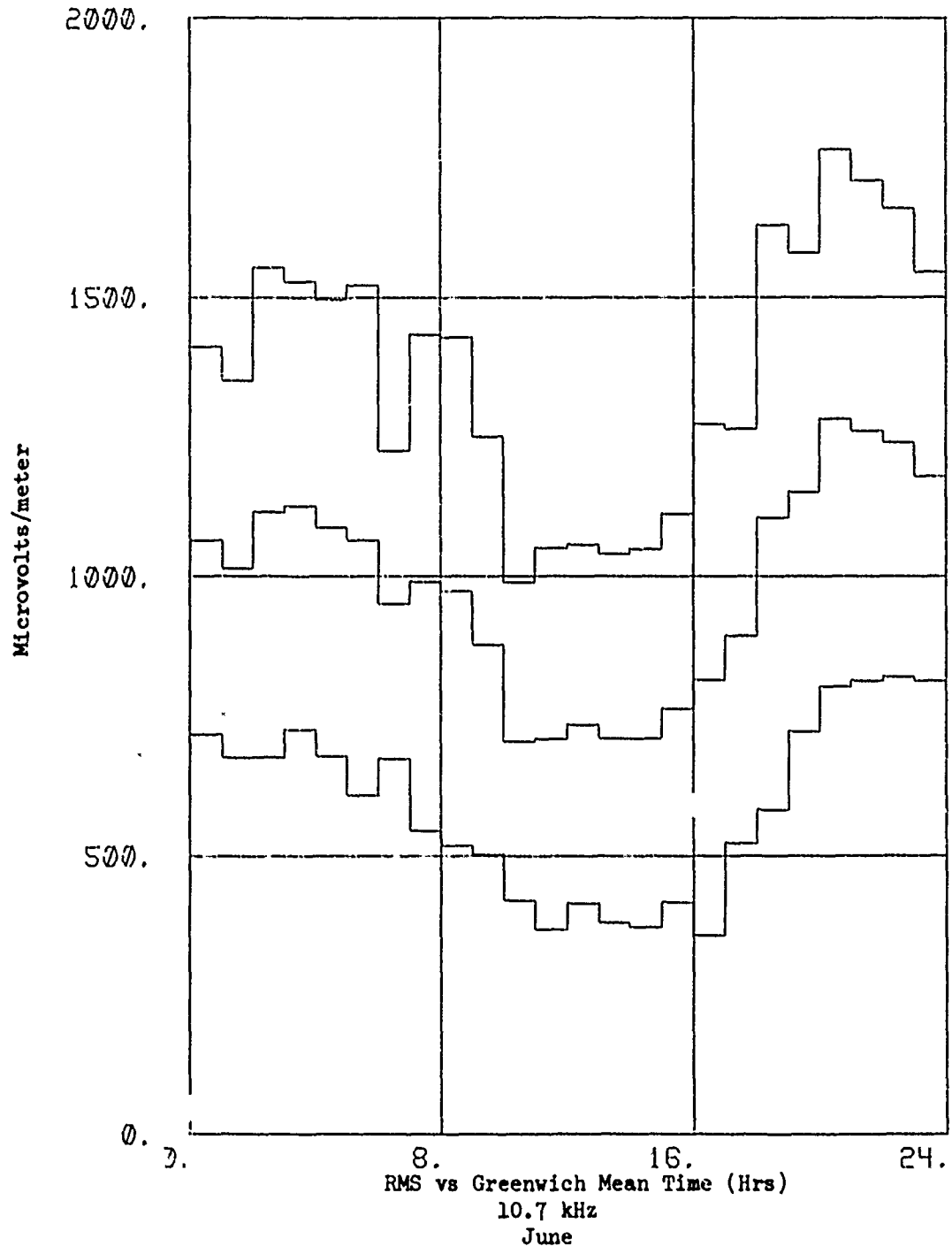

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
43.0 kHz
May

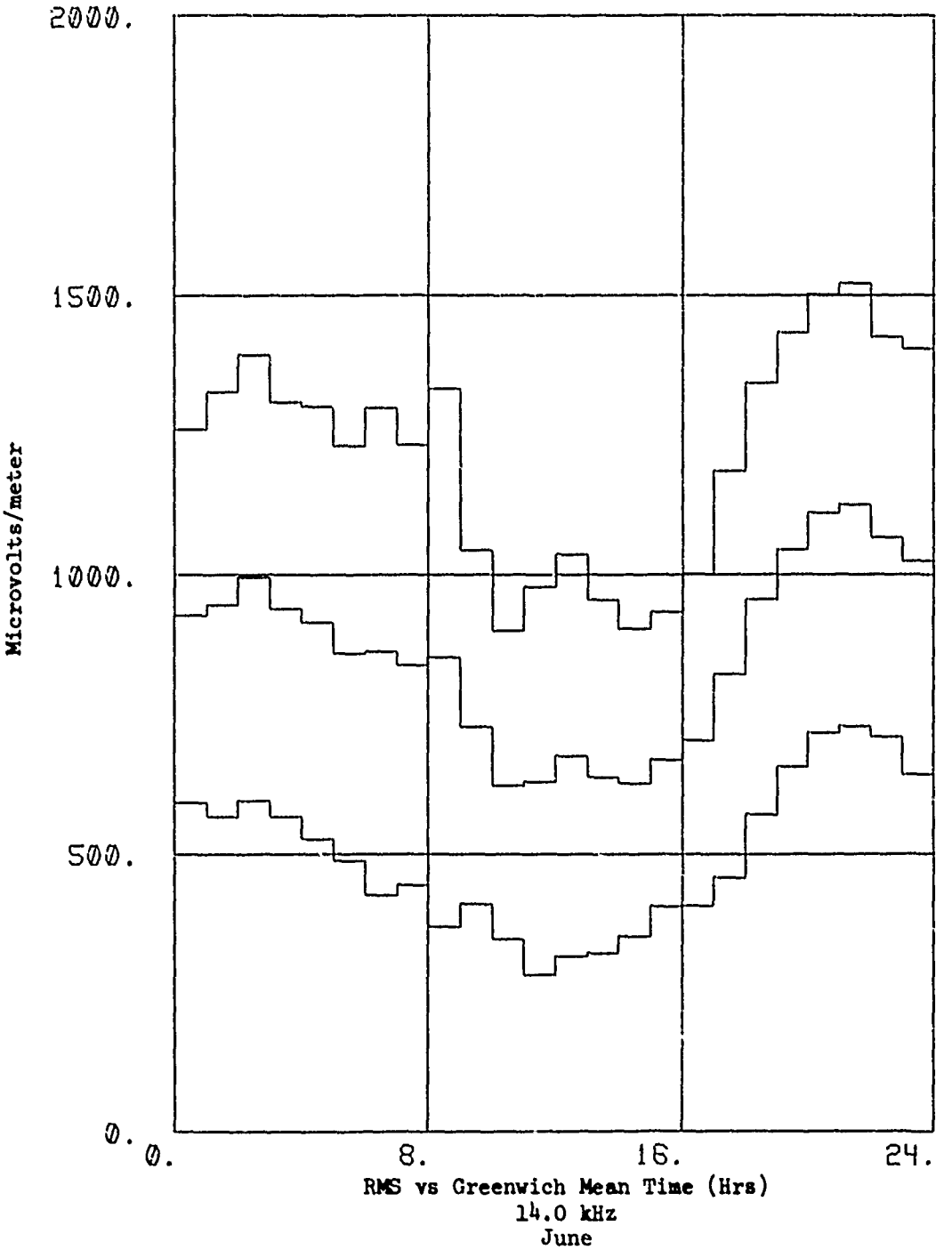

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
47.0 kHz
May

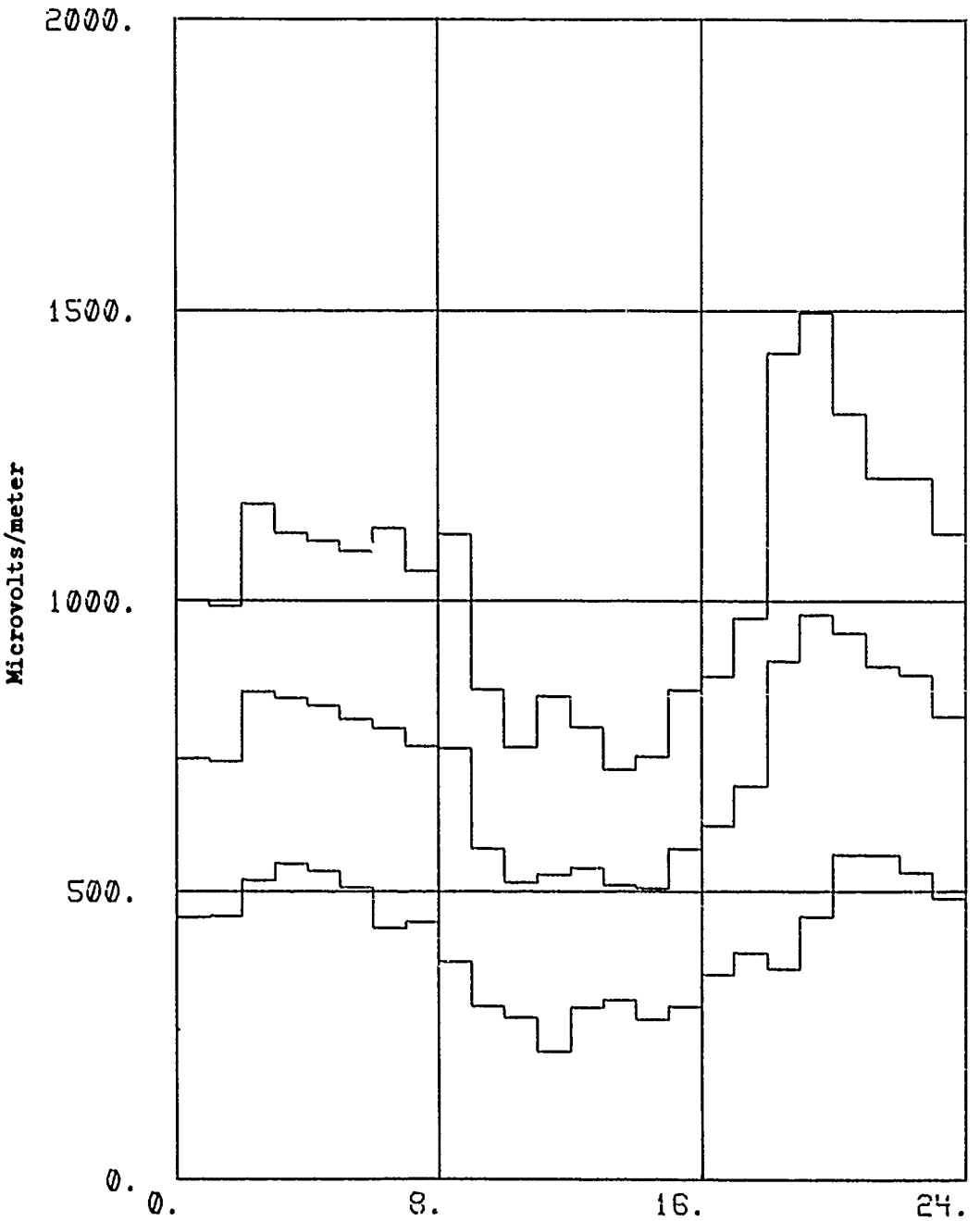

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
50.0 kHz
May

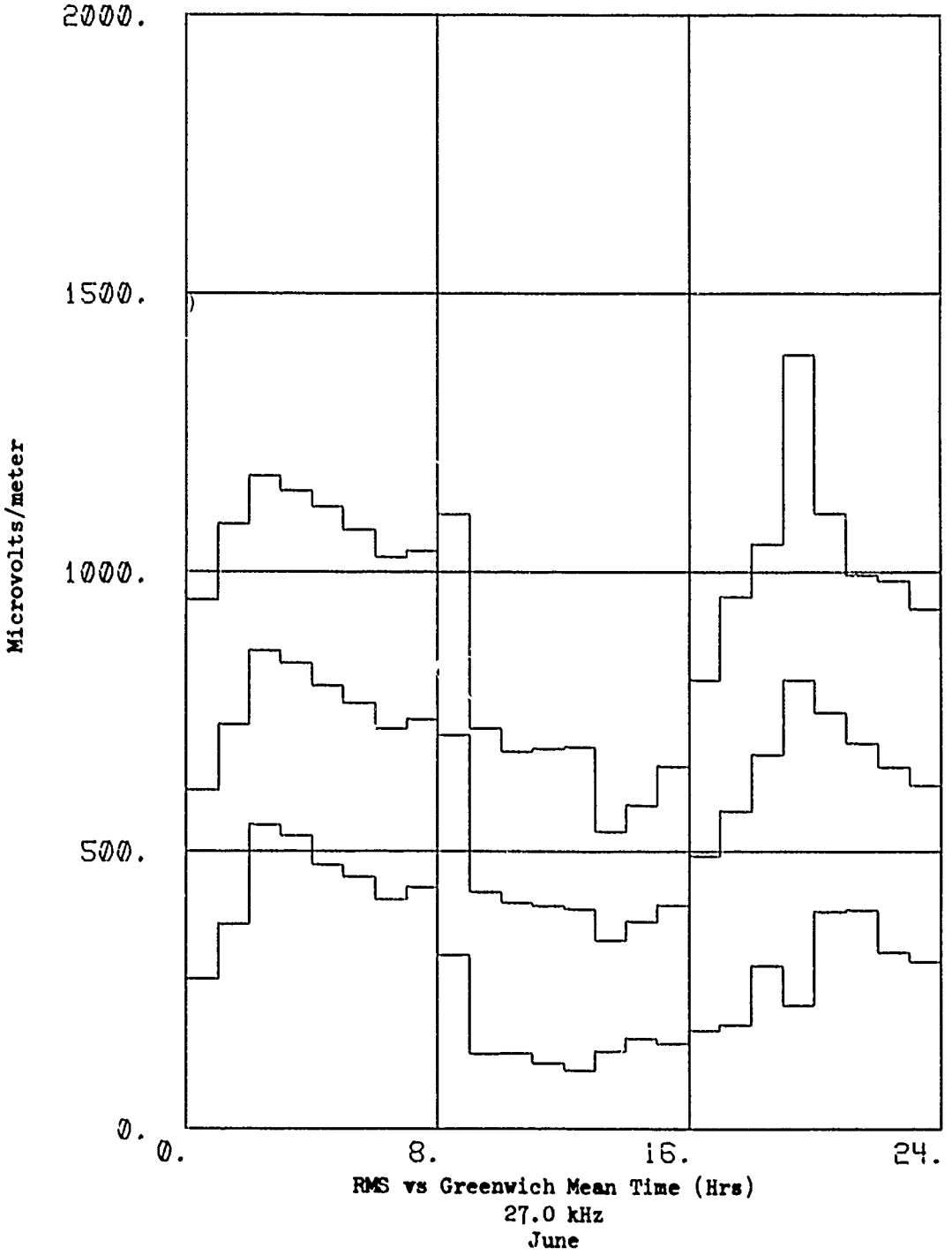

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
55.0 kHz
May

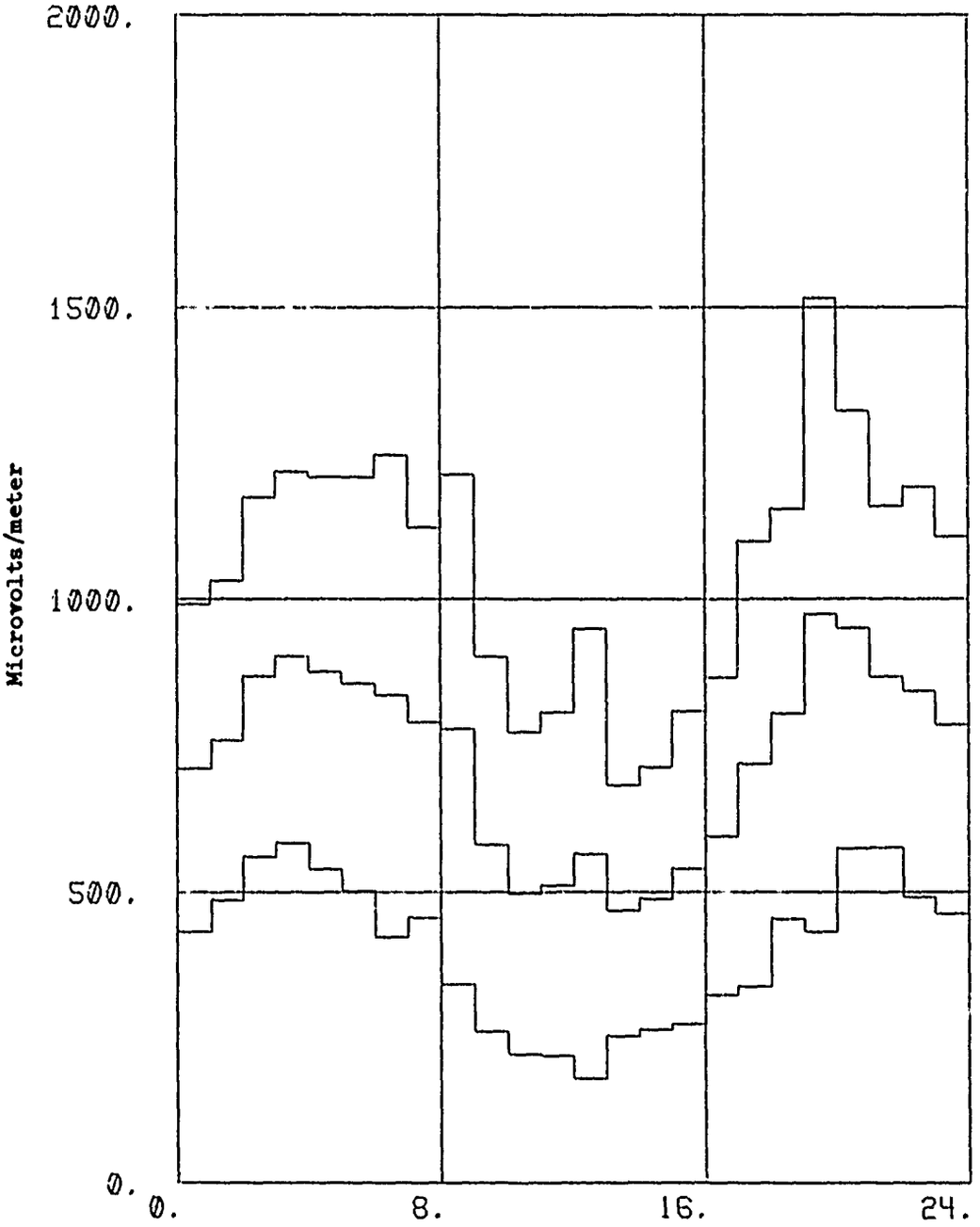
5.13 - ERMS vs TIME (@ FREQS. - FOR JUNE)

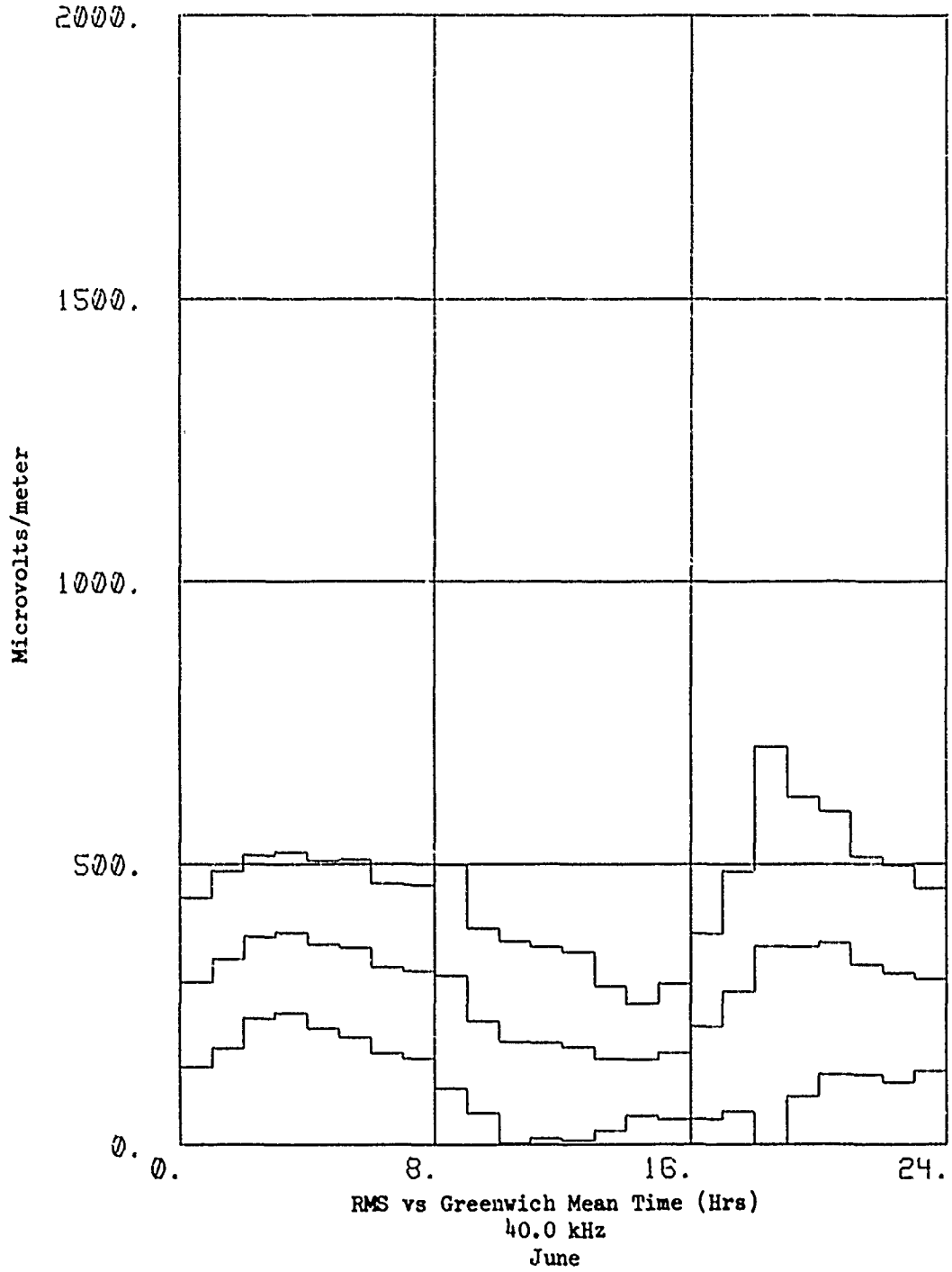

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
10.7 kHz
June

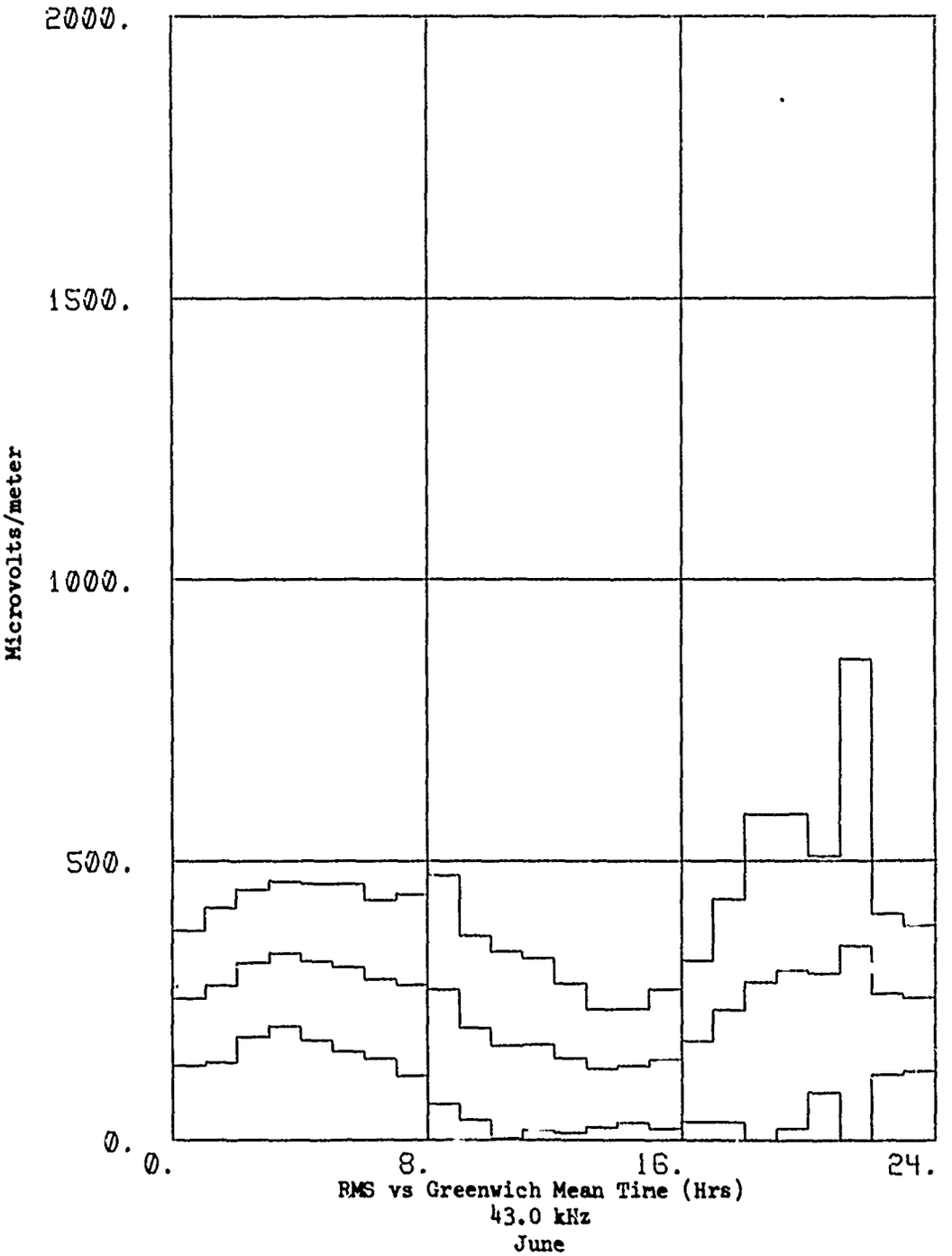

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
14.0 kHz
June

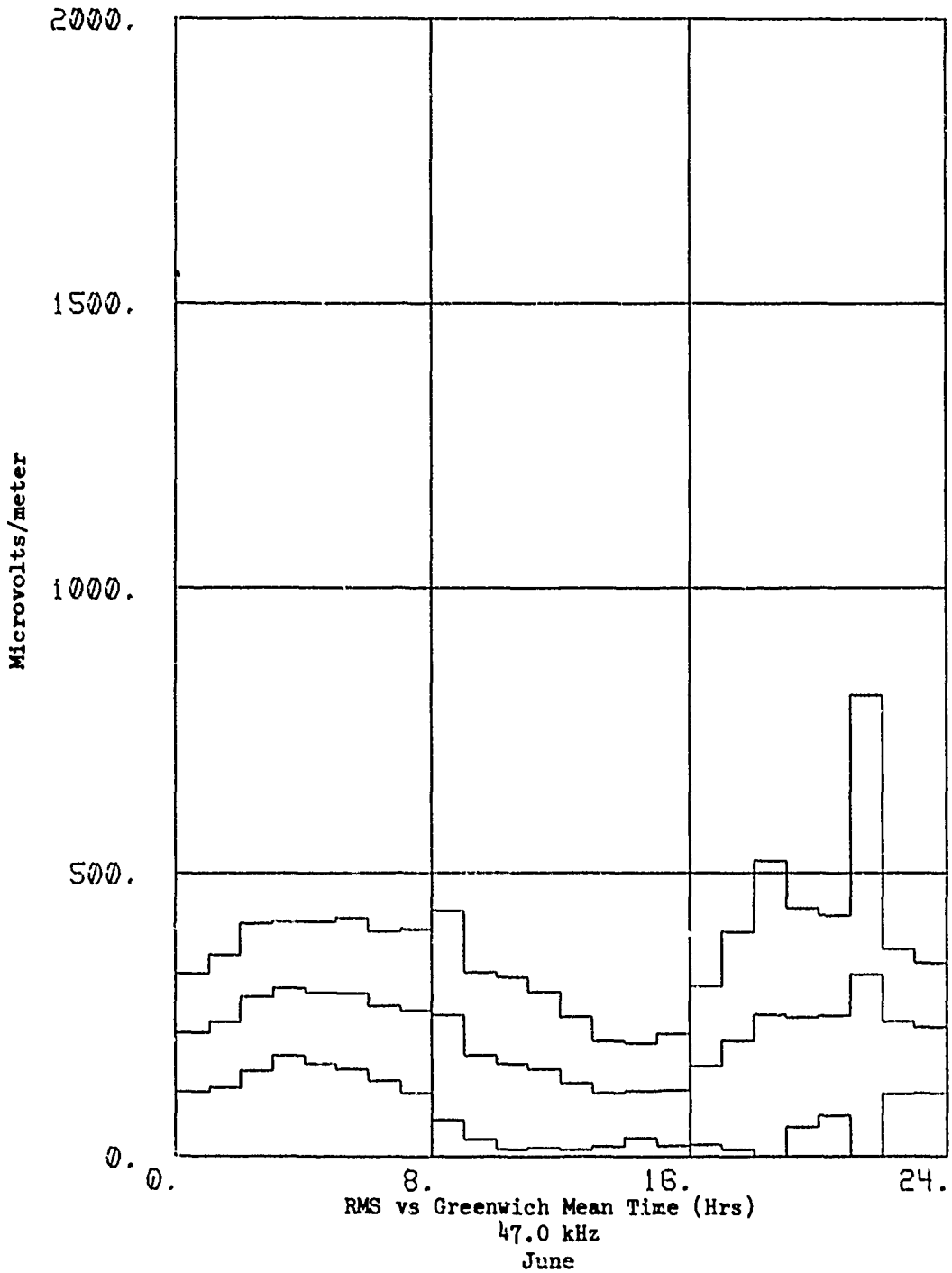

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
17.0 kHz
June

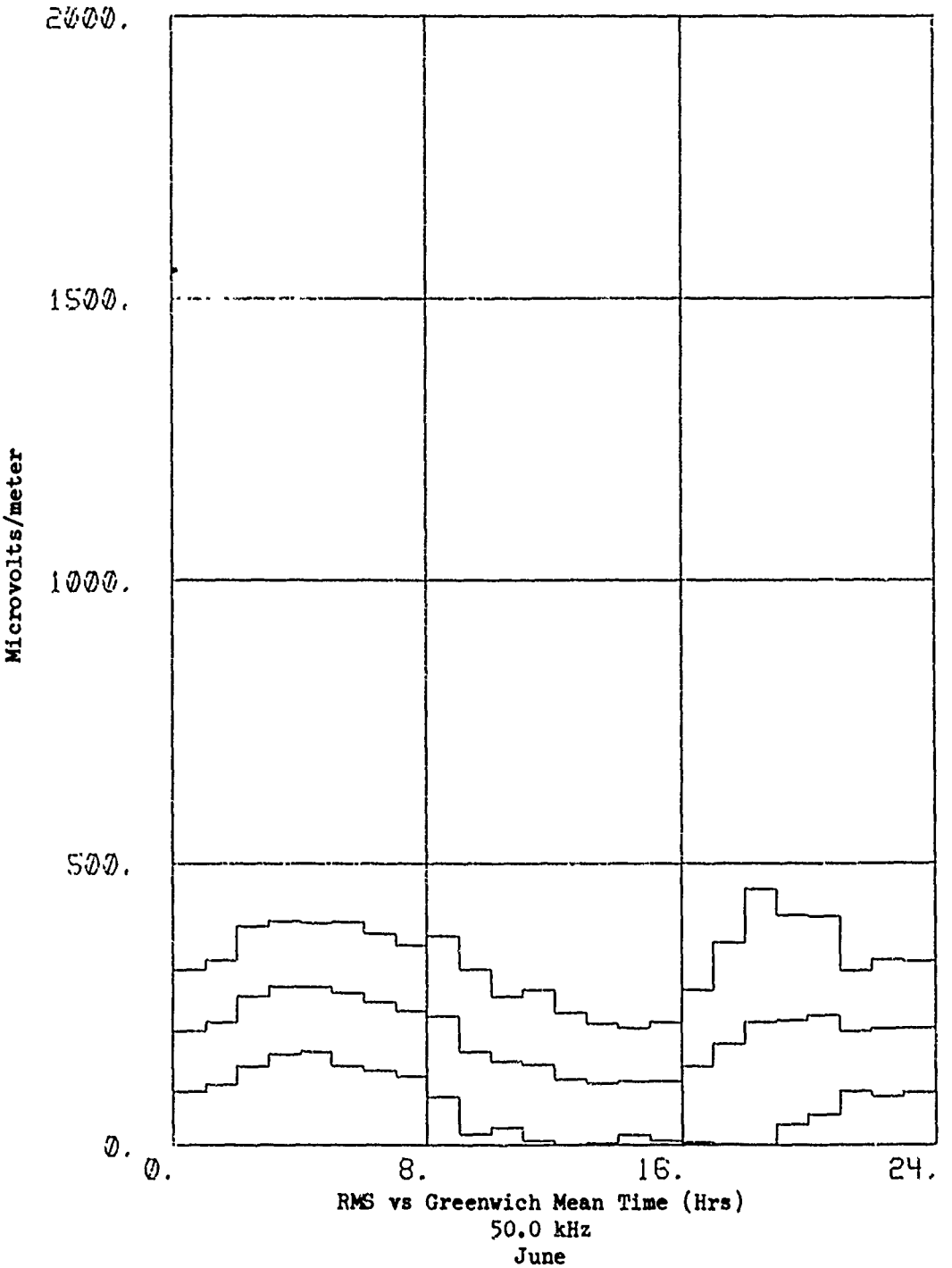

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
27.0 kHz
June

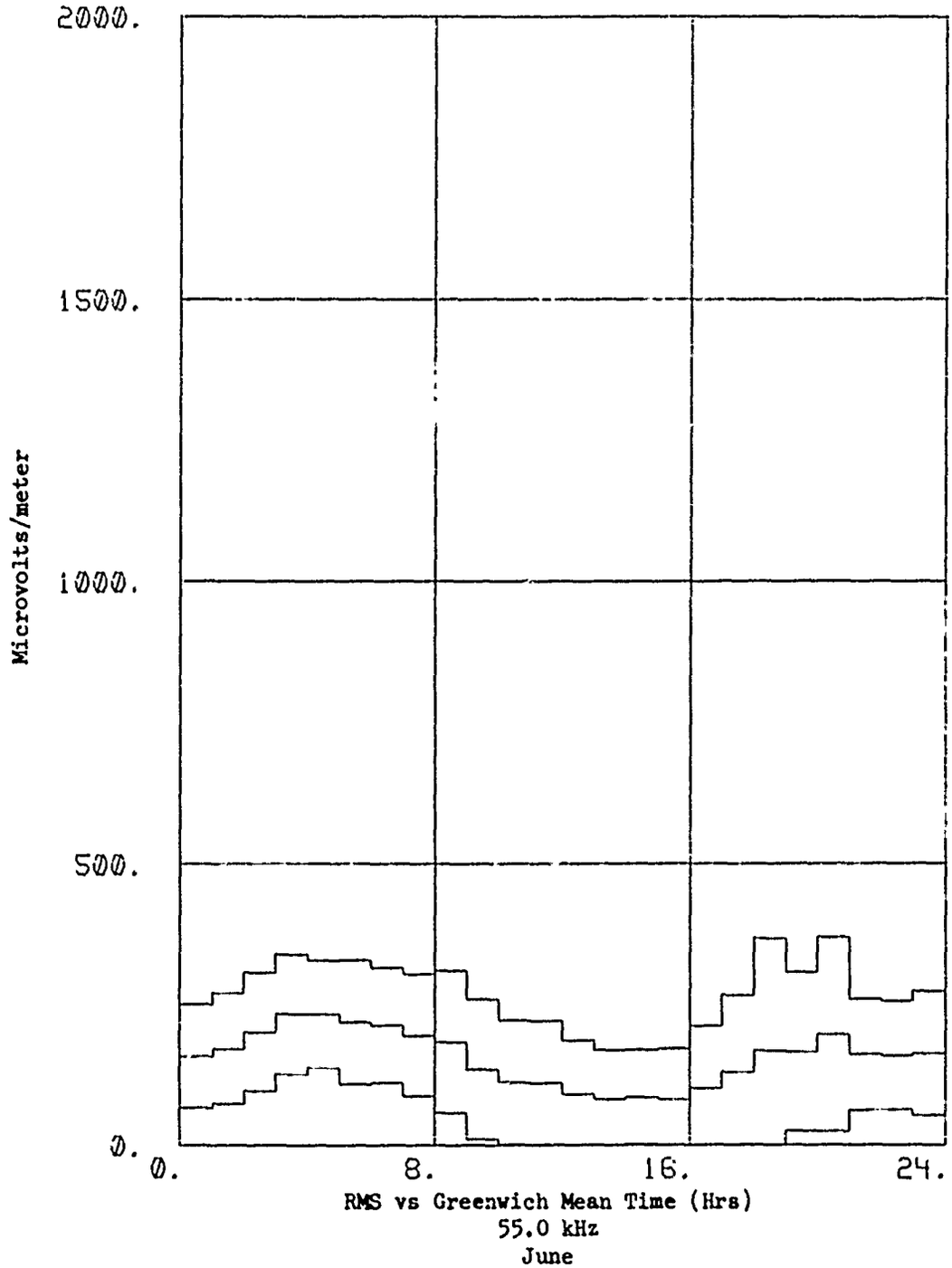

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
20.0 kHz
June


2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
40.0 kHz
June

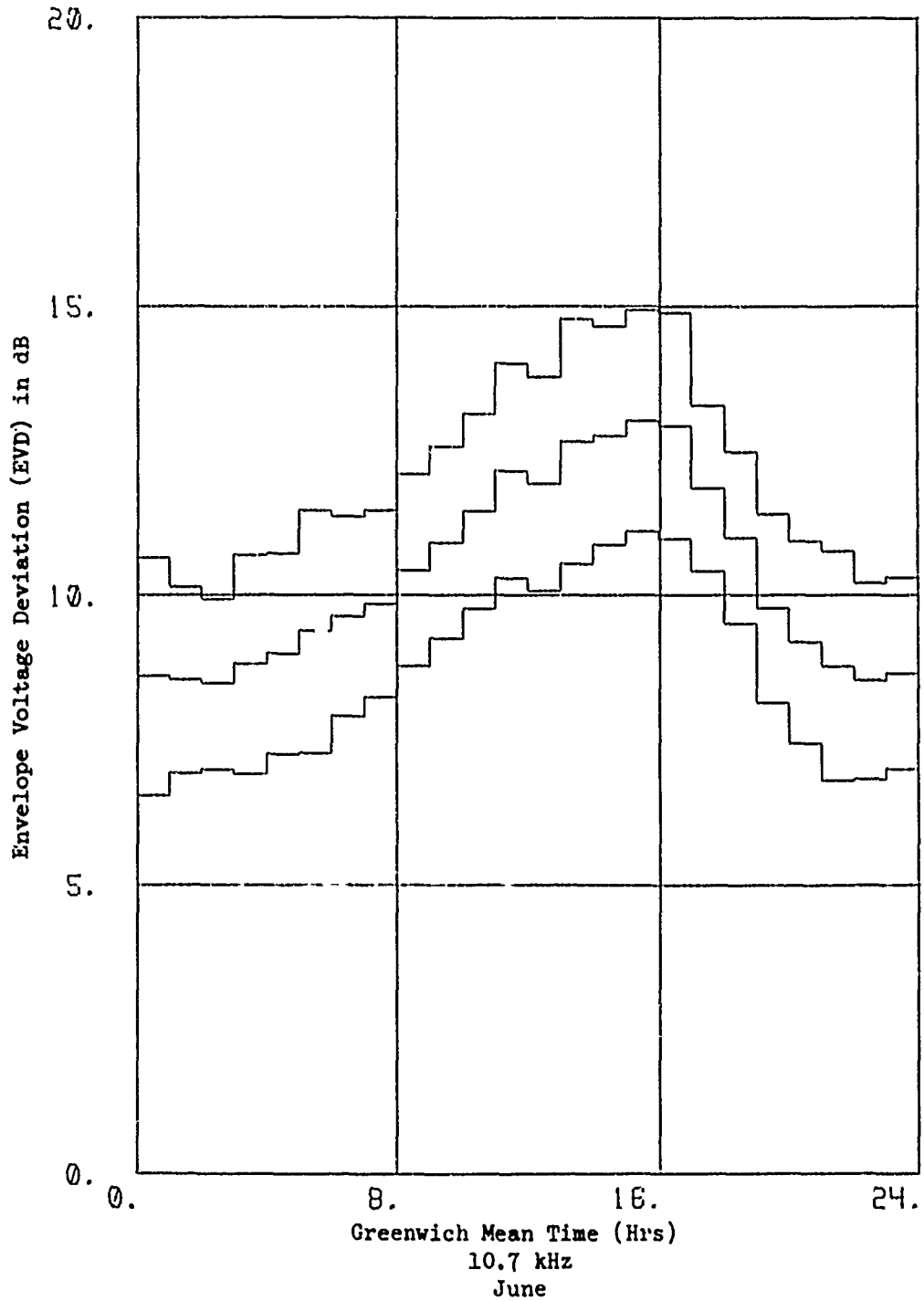

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
43.0 kHz
June

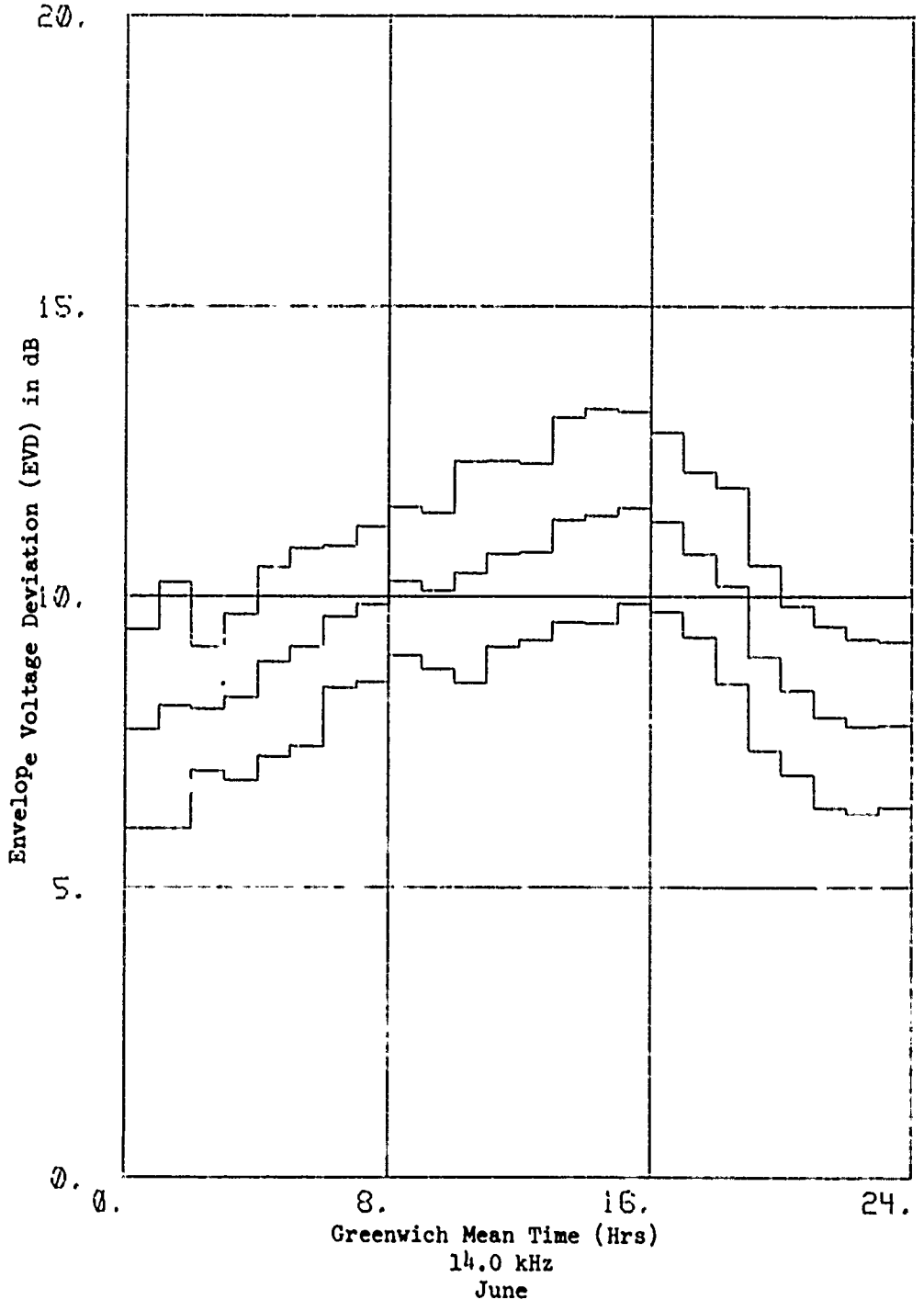

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
47.0 kHz
June

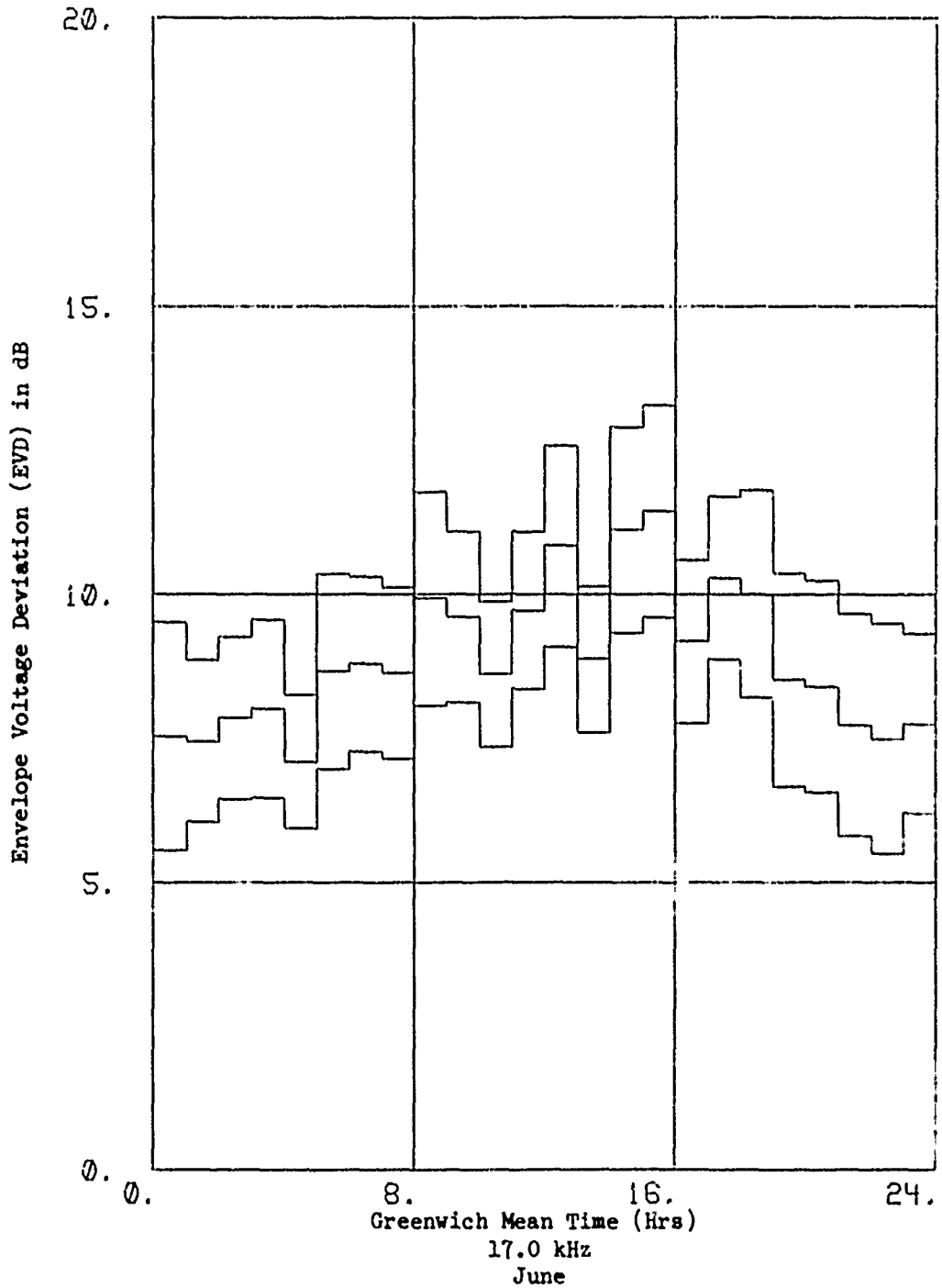

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
50.0 kHz
June

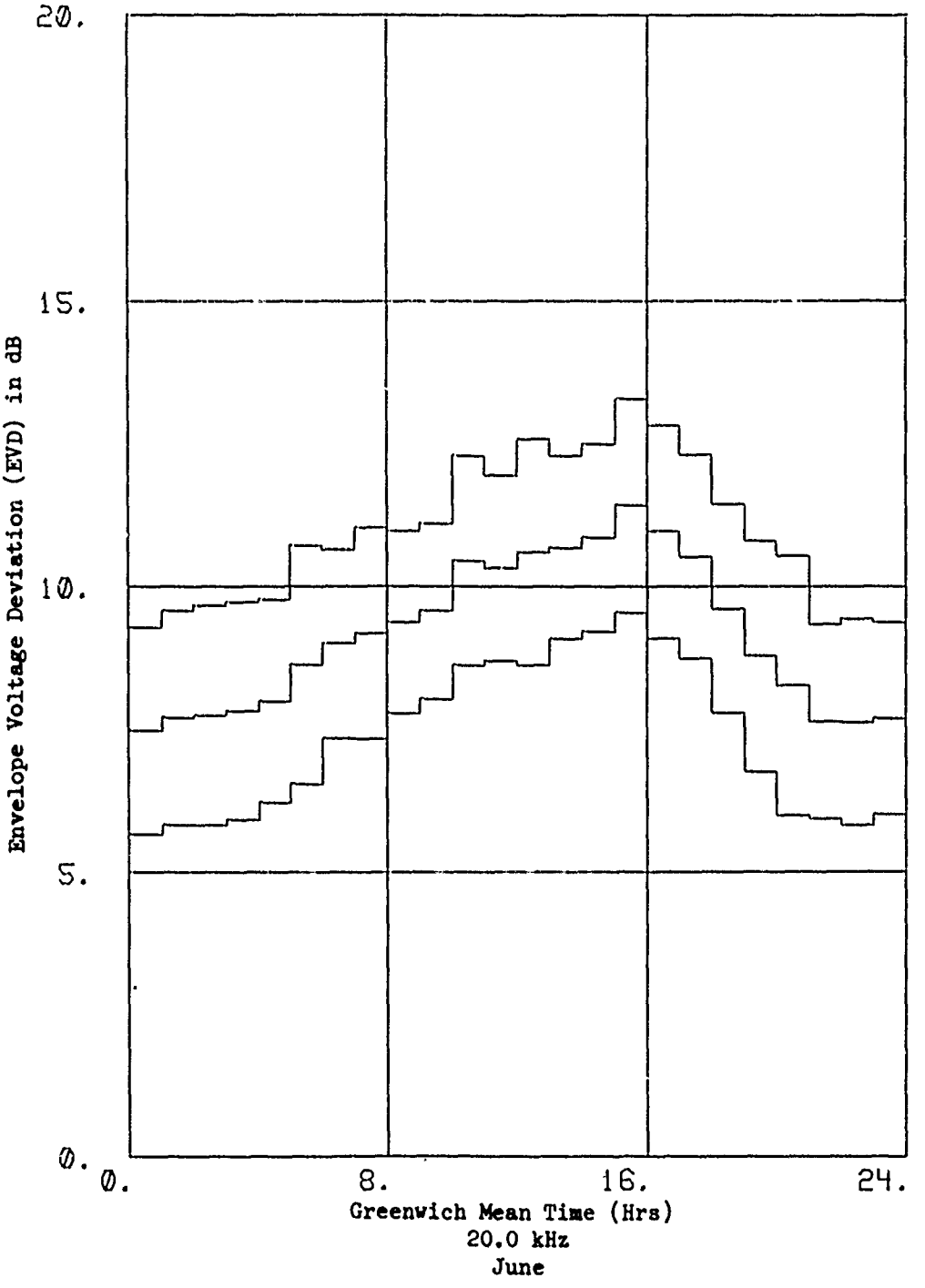

2000.
1500.
1000.
500.
0.
Microvolts/meter
0.
8.
16.
24.
RMS vs Greenwich Mean Time (Hrs)
55.0 kHz
June

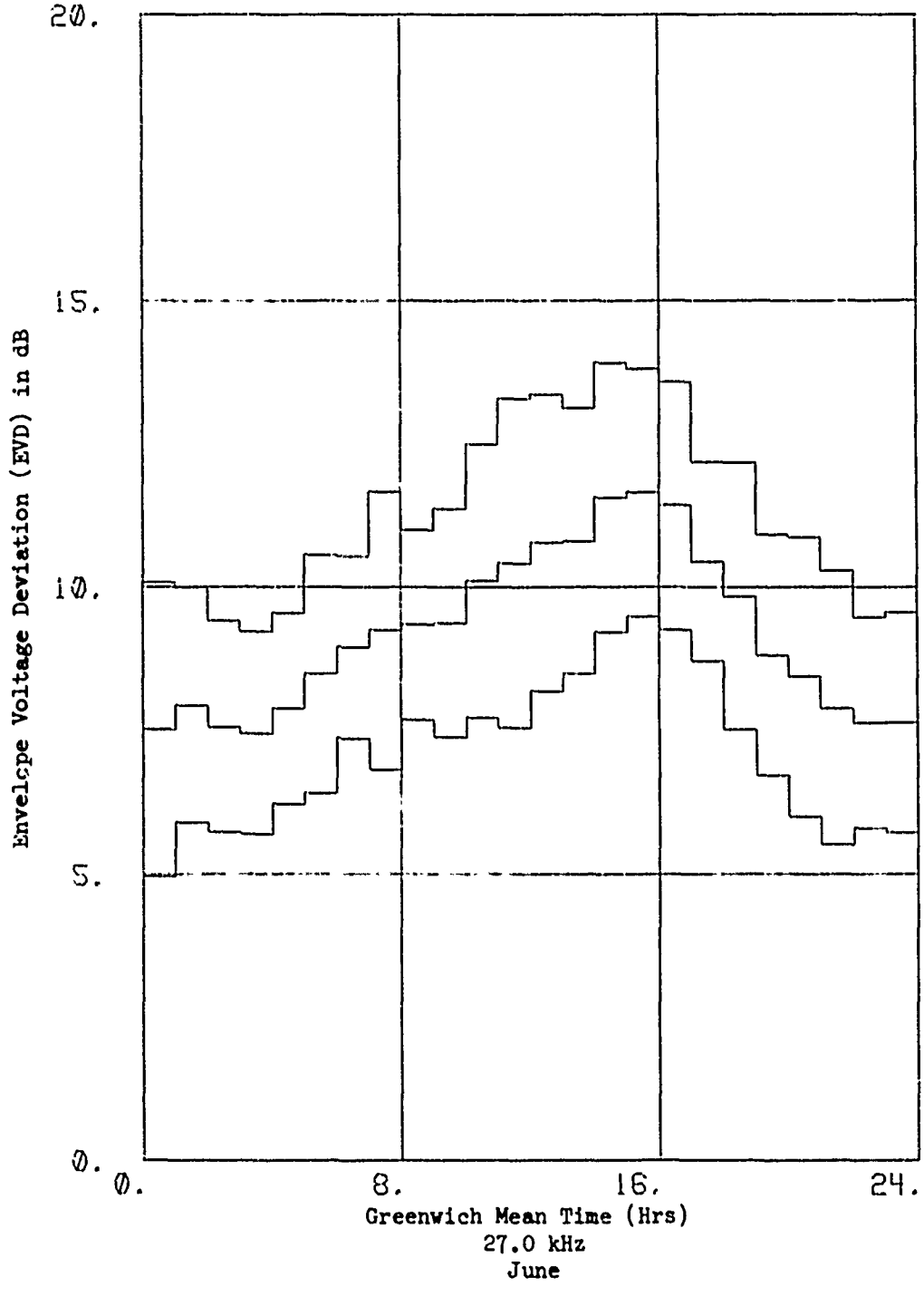
5.14 - EVD vs TIME (@ FREQS. - FOR JUNE)

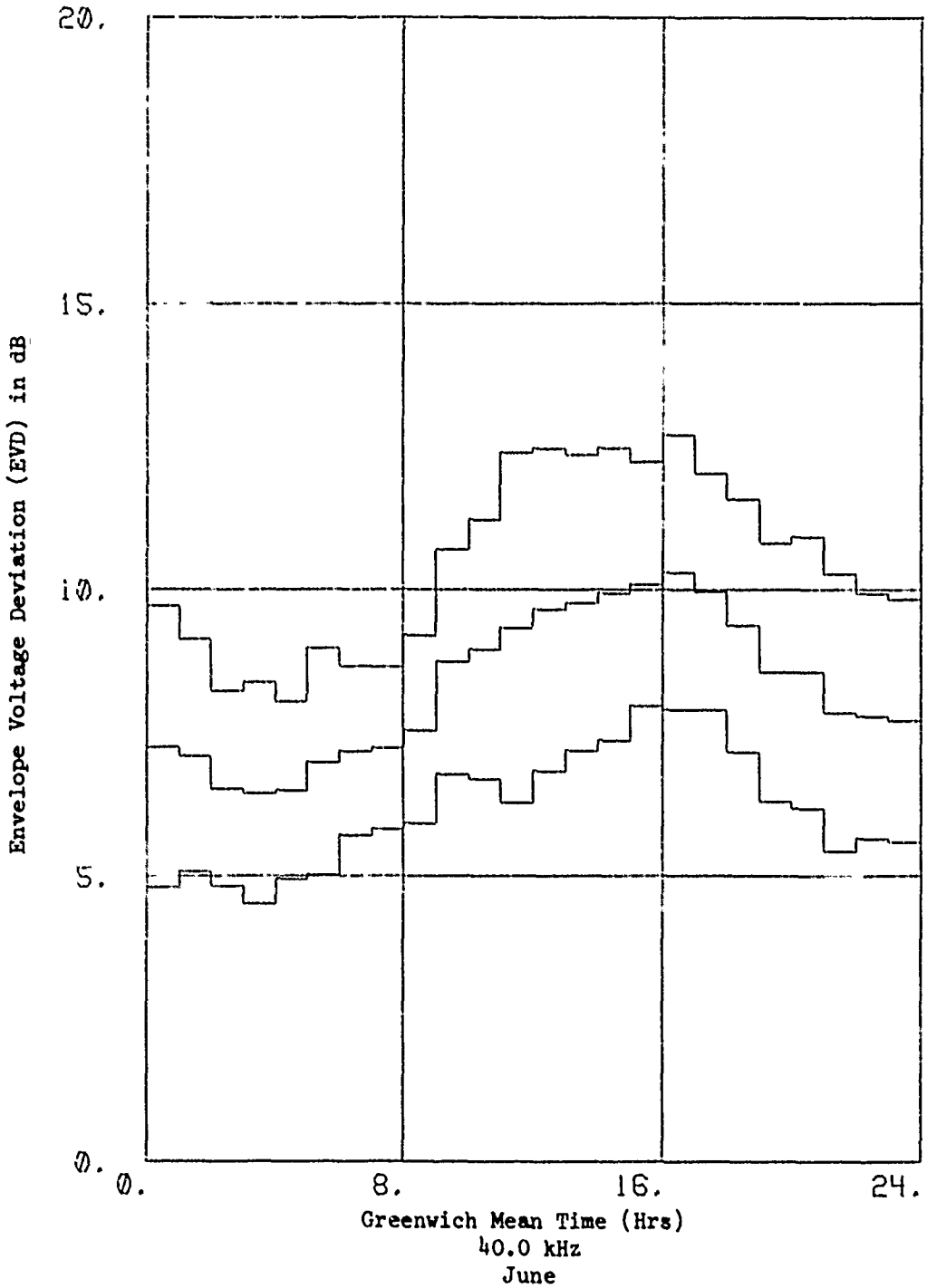

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
10.7 kHz
June

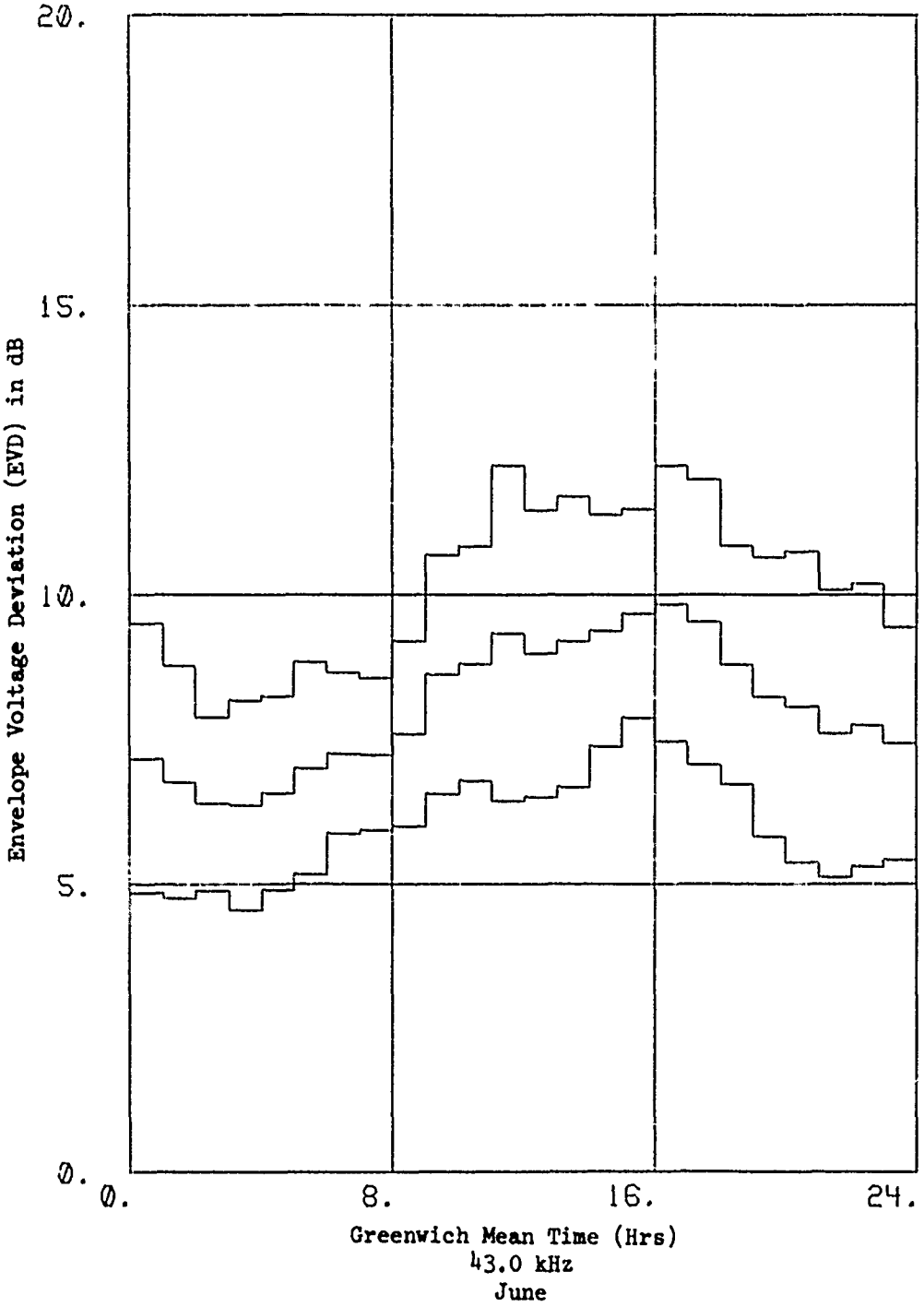

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
14.0 kHz
June

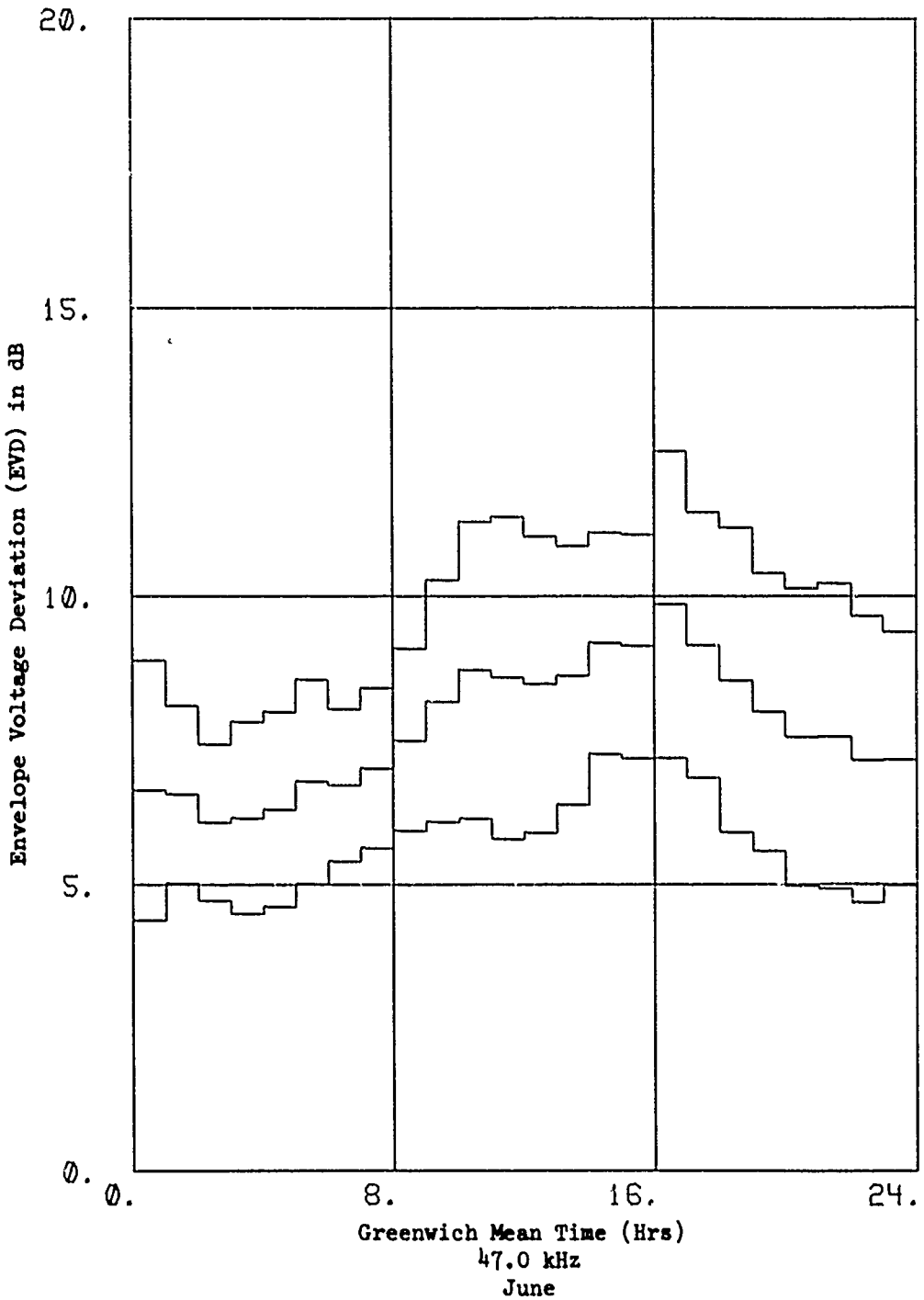

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
17.0 kHz
June

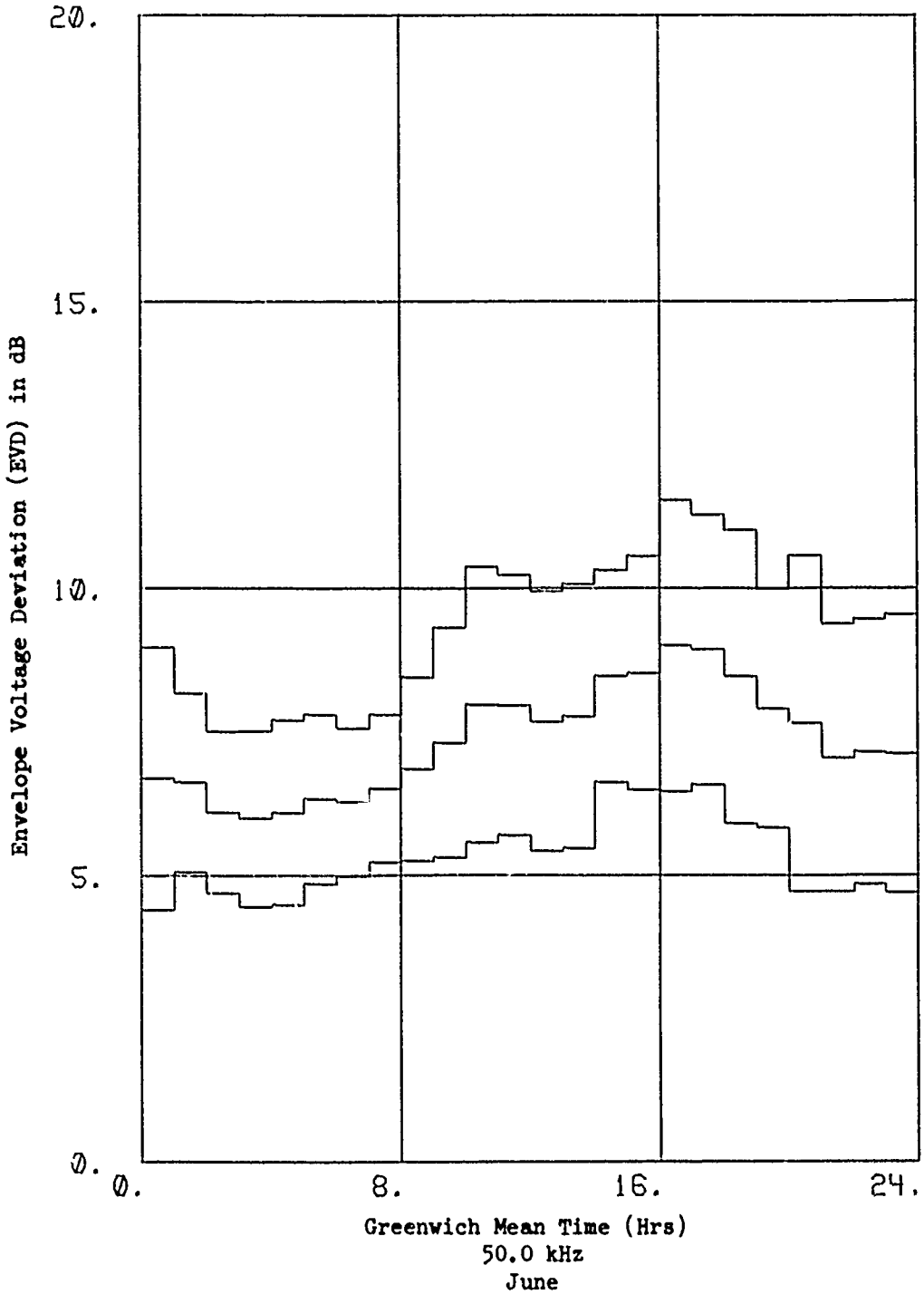

20.
15.
10.
5.
0.
Envelope Voltage Deviation (EVD) in dB
0.
8.
16.
24.
Greenwich Mean Time (Hrs)
20.0 kHz
June

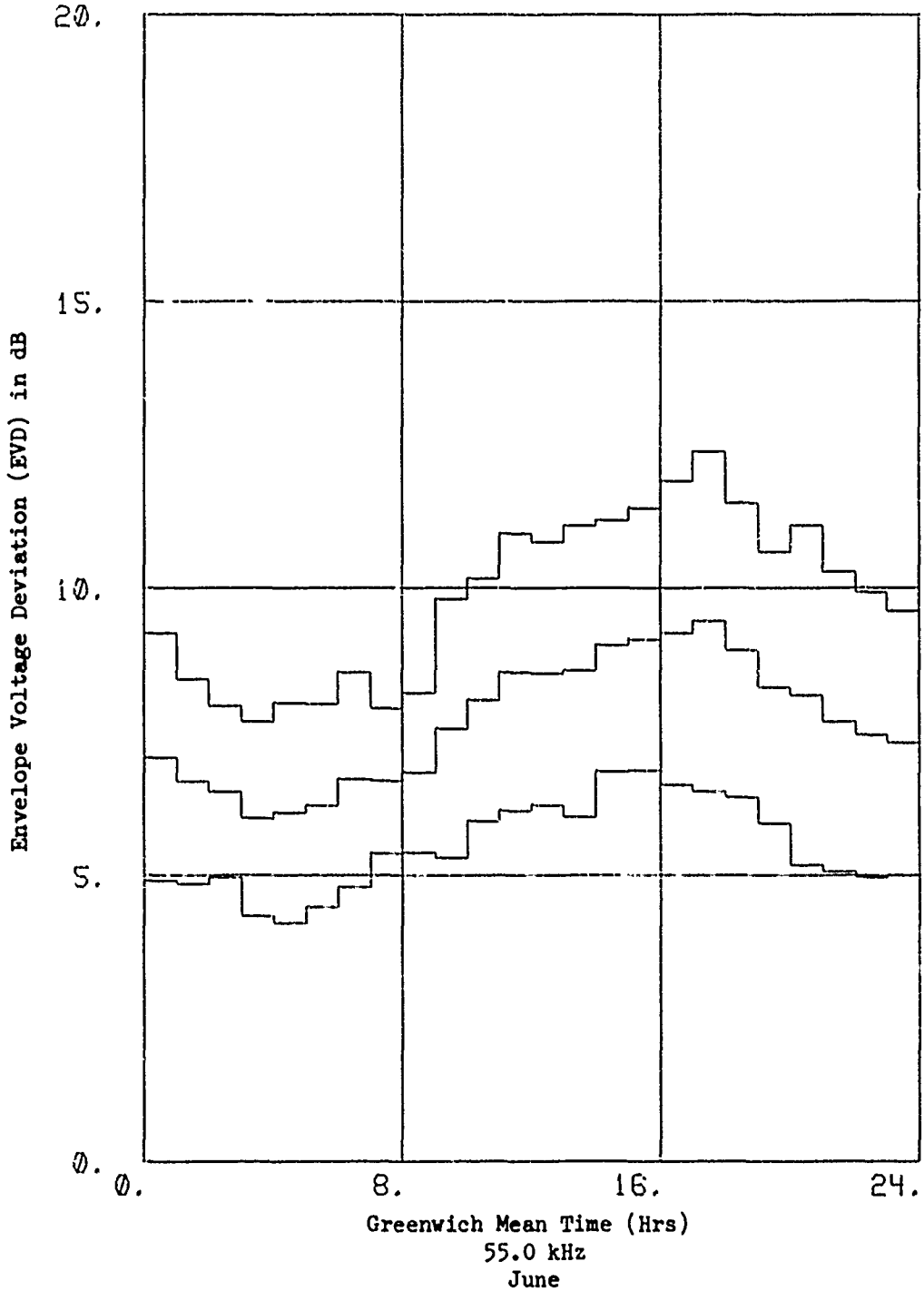

20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
27.0 kHz
June


20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
40.0 kHz
June


20.
15.
10.
5.
0.
Envelope Voltage Deviation (EVD) in dB
0.
8.
16.
24.
Greenwich Mean Time (Hrs)
43.0 kHz
June


20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
47.0 kHz
June


20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
50.0 kHz
June


20.
15.
10.
5.
0.
0.
8.
16.
24.
Envelope Voltage Deviation (EVD) in dB
Greenwich Mean Time (Hrs)
55.0 kHz
June

CHAPTER VI

SUMMARY AND PROJECTIONS

6.0 RESULTS OF VIENNA TEST RUN

From this limited data we still can discern the variation with frequency, time of day, diurnal effects, and the periods within a season of the average (RMS) atmospheric noise value and its impulsiveness. The RMS values of noise can be seen decreasing rapidly with increasing frequency (Section 5.1), and increasing during the night (Section 5.6). The impulsiveness (EVD) increases during certain periods during the day depending on the period within a season (Sections 5.7 - 5.14). The impulsiveness is seen to increase significantly during the day as the summer season commences. (Note the June plots for EVD - Sections 5.4 & 5.14). The RMS values for noise can be seen consistently increasing during the Spring Season (Section 5.3). Although substantiating data is not presented in this report, indications from the extremely limited data for Jan & Feb lead to the interpretation that the noise floor remains fairly constant during the Winter season and is slightly lower than that of March.

Amplitude Probability Densities were plotted against CCIR APD curves for corresponding EVD values and the coherence was fairly good. This is one statistic which will be carefully monitored during the collection effort and data analysis. Distinct changes in the APD and EVD curves can reveal the presence of local interference.

6.1 PROJECTED EFFORT

Now that all three Statistical Noise Analyzers are in place and operating at their remote sites, the data tapes are beginning to be returned to RADC for reduction and correlation. Preliminary indications lead us to believe that the theoretical APD curves, as developed by Rayleigh, Weibull, and Crichlow, may not be valid for the Northern Area of the world.

The data will be collected from these sites until September 1977. This will complete one full seasonal year and two summer seasons (when Equatorial storms are most prevalent). These units will then be moved to other sites where collection is necessary to fill in the data base, yielding a complete set of "real-world" data for an entire year for the Northern Area.

6.2 GOALS

It is the intent of the entire portion of the Tri-Service Propagation Program to establish an accurate data base from which the noise tables in the present propagation prediction models may be corrected to accurately characterize the "real" Northern Area atmospheric noise environment.

It is also expected that this data base will enable the accurate synthesis of new noise curves for the areas above the 50th parallel.

The Amplitude Probability Density curves will be examined closely to determine if it is necessary to reconstruct the theoretical APD curves to model the Northern Area noise. If it is deemed necessary to re-define the theoretical APD curves, this data base will supply all the necessary parameters to enable the formulation of a new set or sets of curves to accurately depict actual Northern Area distributions.

The width and space information may possibly lead to the design and fabrication of an Atmospheric Noise simulator which could be adjusted for season (or month), time of day, frequency, and area of the world. This type of simulator would be a great advantage to modem and receiver design engineers. Present simulators can only be adjusted for noise level and impulsiveness.

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METRIC SYSTEM

BASE UNITS:

Quantity	Unit	SI Symbol	Formula
length	metre	m	...
mass	kilogram	kg	...
time	second	s	...
electric current	ampere	A	...
thermodynamic temperature	kelvin	K	...
amount of substance	mole	mol	...
luminous intensity	candela	cd	...

SUPPLEMENTARY UNITS:

plane angle	radian	rad	...
solid angle	steradian	sr	...

DERIVED UNITS:

Acceleration	metre per second squared	...	m/s
activity (of a radioactive source)	disintegration per second	...	(disintegration)/s
angular acceleration	radian per second squared	...	rad/s
angular velocity	radian per second	...	rad/s
area	square metre	...	m
density	kilogram per cubic metre	...	kg/m
electric capacitance	farad	F	A·s/V
electrical conductance	siemens	S	A/V
electric field strength	volt per metre	...	V/m
electric inductance	henry	H	V·s/A
electric potential difference	volt	V	W/A
electric resistance	ohm		V/A
electromotive force	volt	V	W/A
energy	joule	J	N·m
entropy	joule per kelvin	...	J/K
force	newton	N	kg·m/s
frequency	hertz	Hz	(cycle)/s
illuminance	lux	lx	lm/m
luminance	candela per square metre	...	cd/m
luminous flux	lumen	lm	cd·sr
magnetic field strength	ampere per metre	...	A/m
magnetic flux	weber	Wb	V·s
magnetic flux density	tesla	T	Wb/m
magnetomotive force	ampere	A	...
power	watt	W	J/s
pressure	pascal	Pa	N/m
quantity of electricity	coulomb	C	A·s
quantity of heat	joule	J	N·m
radiant intensity	watt per steradian	...	W/sr
specific heat	joule per kilogram·kelvin	...	J/kg·K
stress	pascal	Pa	N/m
thermal conductivity	watt per metre·kelvin	...	W/m·K
velocity	metre per second	...	m/s
viscosity, dynamic	pascal·second	...	Pa·s
viscosity, kinematic	square metre per second	...	m/s
voltage	volt	V	W/A
volume	cubic metre	...	m
wavenumber	reciprocal metre	...	(wave)/m
work	joule	J	N·m

SI PREFIXES:

Multiplication Factors	Prefix	SI Symbol
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto*	h
10 = 10^{1}	deka*	da
0.1 = 10^{-1}	deci*	d
0.01 = 10^{-2}	centi*	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

* To be avoided where possible

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