

ATTACHMENT A

COMANCHE PEAK STEAM
ELECTRIC STATION
UNIT ONE
LOOSE PARTS MONITORING SYSTEM
SPECIAL REPORT

9011190122 901112
PDR ADDCK 05000445
P PDC

ABSTRACT

Regulating Guide 1.133, Revision 1, May 1981. Section C.3.a.(2)(a) requires the power operation alert levels of the Loose Parts Monitoring System (LPMS) to be reported to the Nuclear Regulatory Commission following the initial startup program. This report was written to comply with this requirement.

The power operation alert levels for the individual LPMS channels were based on the comparison and analysis of;

- (1) The basic system sensitivity during plant shutdown, and
- (2) The background noise measured during normal plant power operation.

LPMS Special Report

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1.0 INTRODUCTION

The purpose of this report is to:

- o Describe the loose-parts monitor system for CPSES.
- o Describe the methodology used to measure impact energy sensitivity.
- o Discuss the results of LPMS associated test and data reduction.
- o Document the LPMS power operation alert levels at completion of the ISU test program.

1.1 System Description

The Loose Parts Monitoring System employed at CPSES is the Babcock & Wilcox (B&W) reactor diagnostic system (RDS). This system is designed to monitor, alarm and diagnose loose parts.

The Loose Parts Monitoring System uses an array of active and passive accelerometers to detect metal to metal impacts indicative of loose parts in the RCS. The accelerometers are permanently installed at selected locations where a loose part would tend to collect or impact. The locations of the accelerometers provide a high degree of reliability in the detection of metal to metal impact in the reactor coolant system. Two accelerometers are located at each of the following locations:

- o Reactor Pressure Vessel - Upper Head Region
- o Reactor Pressure Vessel - Lower Region
- o All Steam Generators - Primary Coolant Inlet Region

One accelerometer is located at each of the following locations:

- o All Reactor Coolant Pumps
- o All Steam Generators - Upper Region

The accelerometers operate on the piezoelectric crystal effect with deformation of the crystal producing a measurable proportional charge. This signal is amplified, filtered, and conditioned to accentuate the frequency band known by measurement to correspond to metal to metal impacts. The system is designed to alarm the presence of unusual noises above normal background noise present in the plant. The system comprises eight active and twelve passive accelerometer channels. The active channels are monitored continuously for detection of loose parts. The passive channels are used for diagnostics (location determination) of a loose part that has been detected.

Sensor locations and LPM used for signal processing are shown in Table 1.

TABLE 1CPSLS Loose Parts Monitoring Sensor Locations

<u>SENSOR</u>	<u>PROCESS MODULE</u>	<u>TYPE</u>	<u>LOCATION</u>
1	LPM-1	ACTIVE	SG "A" Inlet
2	LPM-1	PASSIVE	SG "A" Inlet
3	LPM-2	PASSIVE	RCP "A"
4	LPM-3	PASSIVE	SG "A" Level Tap
5	LPM-2	ACTIVE	SG "B" Inlet
6	LPM-4	PASSIVE	SG "B" Inlet
7	LPM-5	PASSIVE	RCP "B"
8	LPM-6	PASSIVE	SG "B" Level Tap
9	LPM-3	ACTIVE	SG "C" Inlet
10	LPM-7	PASSIVE	SG "C" Inlet
11	LPM-8	PASSIVE	RCP "C"
12	LPM-1	PASSIVE	SG "C" Level Tap
13	LPM-4	ACTIVE	SG "D" Inlet
14	LPM-2	PASSIVE	SG "D" Inlet
15	LPM-3	PASSIVE	RCP "D"
16	LPM-4	PASSIVE	SG "D" Level Tap
17	LPM-5	ACTIVE	Reactor Cavity
18	LPM-6	ACTIVE	Reactor Cavity
19	LPM-7	ACTIVE	Reactor Head
20	LPM-8	ACTIVE	Reactor Head

2.0 METHODOLOGY

2.1 Data Acquisition

- 2.1.1 Impact energy data was collected during plant shutdown as part of the pre-operational test program under procedure LCP-PT-91-01 SFT. The data was directly recorded on magnetic tape using the integral four-channel reel-to-reel tape decks that were supplied with the LPMS. Impacts were imparted using calibrated weights of 0.25 lbm and 30 lbm within 3 feet of the sensor at a kinetic energy of 0.5 ft-lb (0.68 joules).
- 2.1.2 Operational baseline (background noise) data was recorded at reactor power levels of 0, 30, 50, 75 and 100% during the initial plant startup program under procedure ISU-211.
- 2.1.3 Procedure PPT-TP-90-025 documented the spectral comparison of data collected in 2.1.1 and 2.1.2, above. From this comparison, band pass filter "break frequencies" were determined. Filters were adjusted to band-limit the broad-band signal to that portion of the spectra that maximizes the signal-to-noise ratio. Following filter adjustments background noise was measured to establish alert levels per Reg. Guide 1.133, Section C.2.

2.2 Data Analysis

Procedure PPT-TP-90A-025 was developed to document data analysis and bandpass filter adjustments for determination of final alarm settings and power operation alert levels. The following is a chronological sequence on the performance of PPT-TP-90A-025.

- 2.2.1 Tapes recorded during the performance of pre-operational test LCP-PT-91-01 SFT were obtained from the document control center vault. Each tape had a calibration signal of 1KHz/1Vrms recorded as a predecessor to impact and background data.

Prior to tape analysis a 1KHz/1Vrms function generator signal was injected into a digital oscilloscope and spectrum analyzer with outputs routed to an X-Y plotter. Adjustments were made to the X-Y plotter to ensure linearity between graph paper scaling vs. actual signal to allow direct amplitude interpretation.

The taped 1KHz/1Vrms calibration signals were played back for each recorder channel and used to determine a "correction factor" to account for any losses associated between taped signals and actual field signal strength.

Following "correction factor" determination, recorded impact amplitude and transient capture frequency spectrum were plotted. Impact amplitudes (Vpp), with the 0.25 lbm weight, were normalized to g's p-p by multiplying each signal by the correction factor and module full scale range settings (g/v).

Sensor response to a 30 lbm weight impact was calculated by comparing the measured response difference between the 0.25 lbm and 30 lbm impacts at one of the sensor locations. This value was also normalized to g's p-p.

- 2.2.2 Tapes of background (baseline) data at 100% Reactor Power were played back and analyzed for frequency content. A spectral comparison was performed between the background and impact frequencies to determine "break frequencies" for bandpass filter adjustment.

After filter tuning, background noise was measured and normalized to g's p-p to provide a basis for alert level and alarm sensitivity settings.

- 2.2.3 In order to have a basic understanding of the LPMS signal processing at CPSES and the desired sensitivity requirements as stated in Reg. Guide 1.133 the following is provided:

NRC Regulatory Guide 1.133 makes the following statement concerning sensitivity.

"The on-line sensitivity of the automatic detection system should be such that, as a minimum, the system can detect a metallic loose part that weight from .25 lb (0.11 kg) to 30 lb (13.6 Kg) and impacts with a kinetic energy of 0.5 ft-lb (0.68 joules) on the inside surface of the reactor coolant pressure boundary within 3 feet (0.91 meter) of a sensor. If the recommended sensitivity cannot be achieved by automatic alert because of specific in-plant conditions, these conditions and the actual on-line sensitivity should be specified at the time the alert level is provided. As an example, one acceptable method of verifying this on-line sensitivity is to demonstrate (1) the basic system sensitivity during the plant shutdown and (2) that the background noise measured during normal plant operation is sufficiently small that the signal associated with the specified detectable loose-part impact would be clearly discernible in the presence of this background noise."

As the Commission position infers, the ability to detect a given impact energy is dependent on system background noise level and on the size of the impacting object. Typical background acceleration noise level (g) ranges from .1g to 2g peak to peak. During testing and calibration of B&W LPM Systems, acceleration response to a 0.5 ft-lb impact has been

measured from > 30g for a 0.25 lb ball down to 0.4g for a 30 lb. ball. Thus, the lower level 0.5 ft-lb impact responses could be masked by the background noise and therefore be undetectable. In this case the specific in-plant conditions and the actual on-line sensitivity would have to be specified.

The alarm threshold circuitry resides with the loose part detector module (LPM) for each of the eight active channels at CPSES (see Fig. 1). Each module contains an Automatic Gain Control (AGC) circuit which allows a floating alarm threshold. The AGC output signal is routed to the alarm comparator and is adjusted for an output of 5 volts d.c. The input to the AGC is a d.c. value proportional to the AC output of the sensor (accelerometer). The AGC output (5 Vd.c.) remains constant for slow changes or long term variations in the background noise levels due to plant operating parameters. If a loose-parts signal occurs, the AGC circuit is too slow to react so that the transient (impact signal) adds to the output of the AGC circuit. The reference or comparator setpoint, is determined by the HI-ALARM setting selected on the individual LPM. When the AGC output exceeds the alarm threshold, the comparator switches giving an alarm.

This explanation is to show that the high alarm threshold is actually a ratio of the normal operating background noise level to the impact amplitude. For example, if the alarm threshold (HI-ALARM) is set on 3 (or 7.0 volts) then the alarm ratio is 7 : 5 or 1.4:1 and the impact signal must exceed the background noise by 1.4:1 to trigger the alarm. Transients with amplitude less than background noise would not be detected.

The AGC circuit is part of the discrimination designed into the LPMS to help prevent spurious alarms. In addition there is logic discrimination within the Digital Loose Parts Locator (DLPL) that affects sensitivity. The DLPL requires at least two channels to alarm to consider an alarm condition to be valid. This two channel criteria means that sensitivity is determined by the adjacent sensor and not the sensor nearest the impact origin.

- 2.2.4 Alert levels that would provide early detection of a loose part with a minimum amount of false alarms were determined originally by adjusting the Hi-Alarm setpoint to the lowest non-alarming setting while operating at the 100% power plateau.

For the eight (8) active LPMS channels, adjacent sensors were monitored during impacts to determine if the sensitivity (Hi-Alarm) settings were adequate to automatically detect a loose part under power operation background noise levels. As an example, if the background noise signal after filter adjustments measured 100 millivolts p-p and the Full Scale (F.S.) Range LPM setting was 3 g/V, the background amplitude would be 0.3g p-p.

If the Hi-Alarm setting is at 5 which corresponds to 9.0 volts, the AGC is at 5.0 volts, then the alarm ratio would be 1.8:1 and the signal impact perturbation must be at least 1.8 times greater than background (0.54 p-p in this example) to cause an alarm.

The adjacent sensor response can now be compared to this alert level to determine if the system is sensitive enough to detect a loose part above background noise levels.

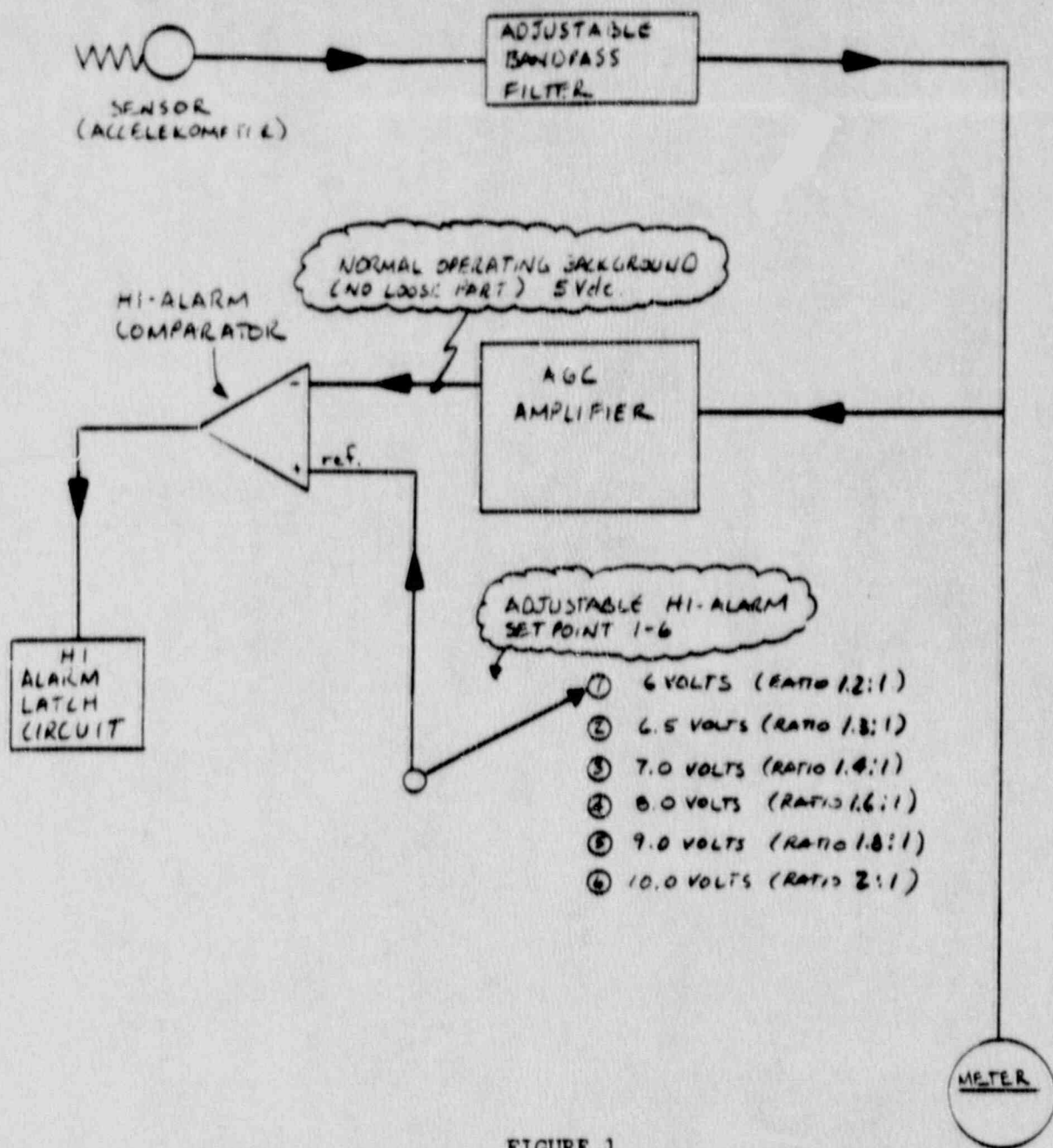


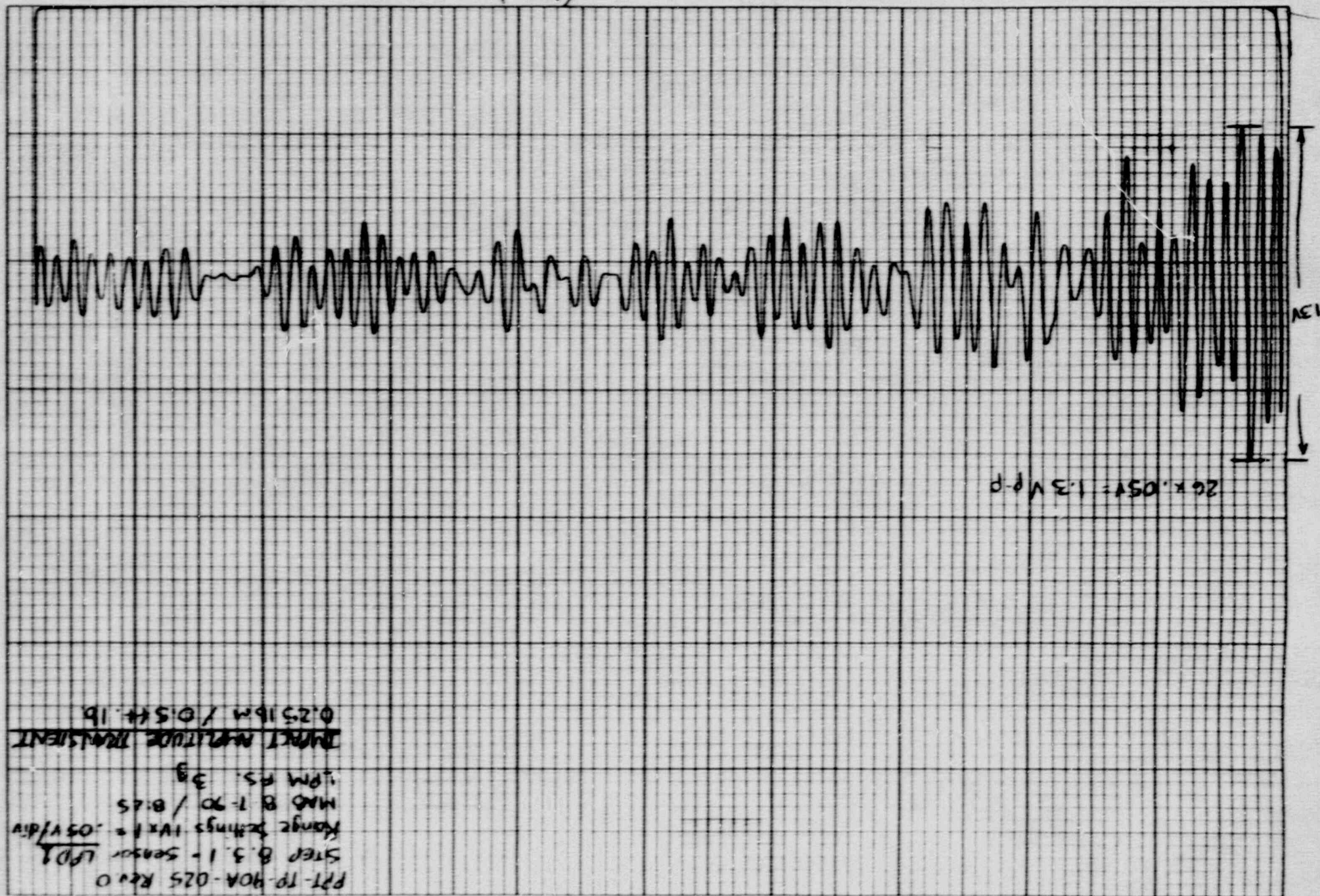
FIGURE 1
SIMPLIFIED BLOCK DIAGRAM OF
LOOSE PARTS DETECTOR HI-ALARM PROCESS

3.0 Data

3.1 Impact Amplitudes

The following X-Y plots were made using data collected during pre-operational test LCP-PT-91-01 SFT. Sensor settings and impact weight is listed in the upper right-hand corner of each graph. Highest peak-to-peak voltage levels are recorded on the y-axis. The peak voltage is then multiplied by the "tape loss" correction factor and the Full Scale Setting of the LPM to determine Impact Amplitude in g's(p-p).

(time)



PPT-TP-90A-025 Rev. 0

STEP 0.3.1 - Sensor LPD 2

Range 200mV 100mV = 0.005V/div

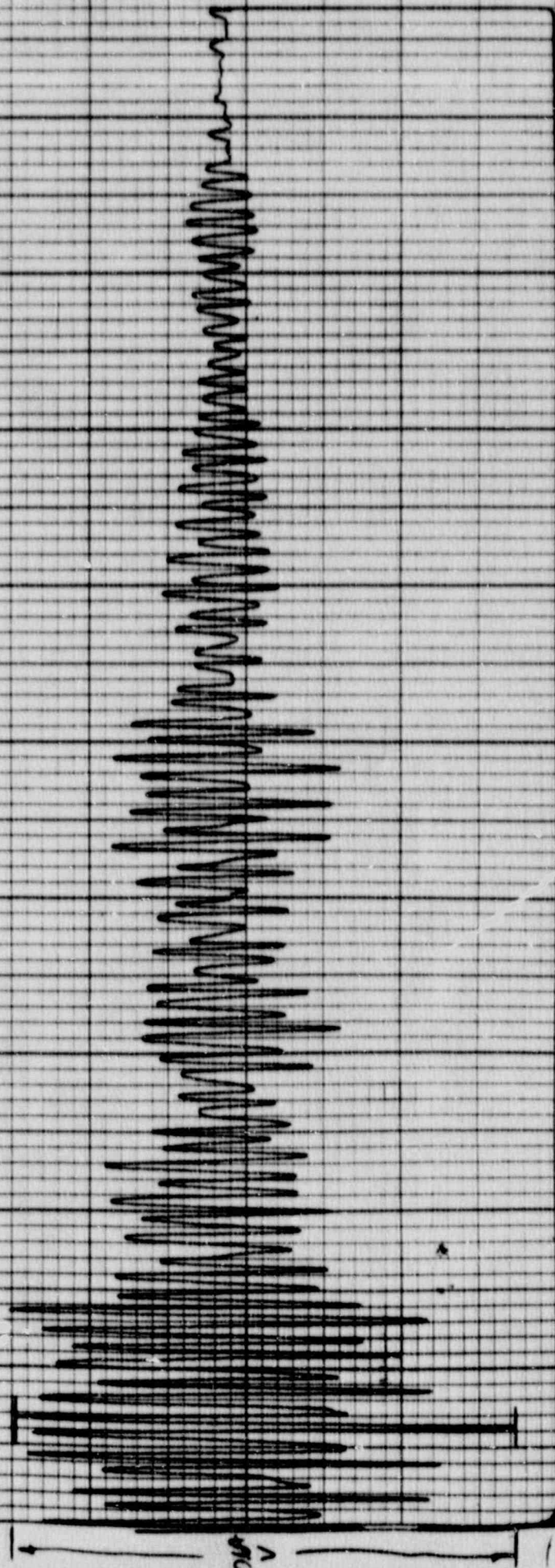
MMO 0.7 90/B 38

LFM FS 10g

IMPACT AMPLITUDE TRANSIENT

0.25 14m / 0.5 ft. lb.

0.008 ON 14-918-5000 x 20
0.02 0.06 VPP
0.07 VPP

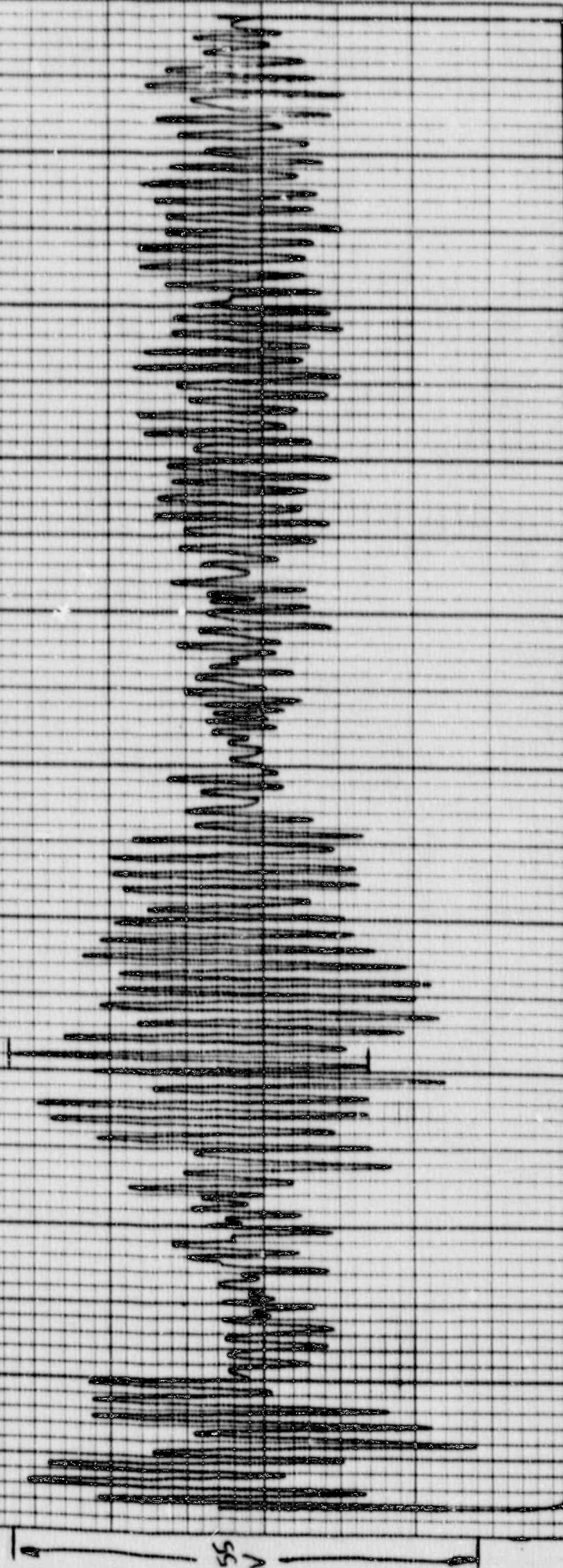


time

PPT-TP-90A-025, Rev. 0
 STEP 8.3.1 - Sensor LPD-3
 Range Settings: 1V/div
 MAG 0.17190 / 8.42
 LPM F.S. 3g

IMPACT AMPLITUDE TRANSECT
 0.25 IN / 0.5 IN

23.5 x 1.1 = 50 x 5.12

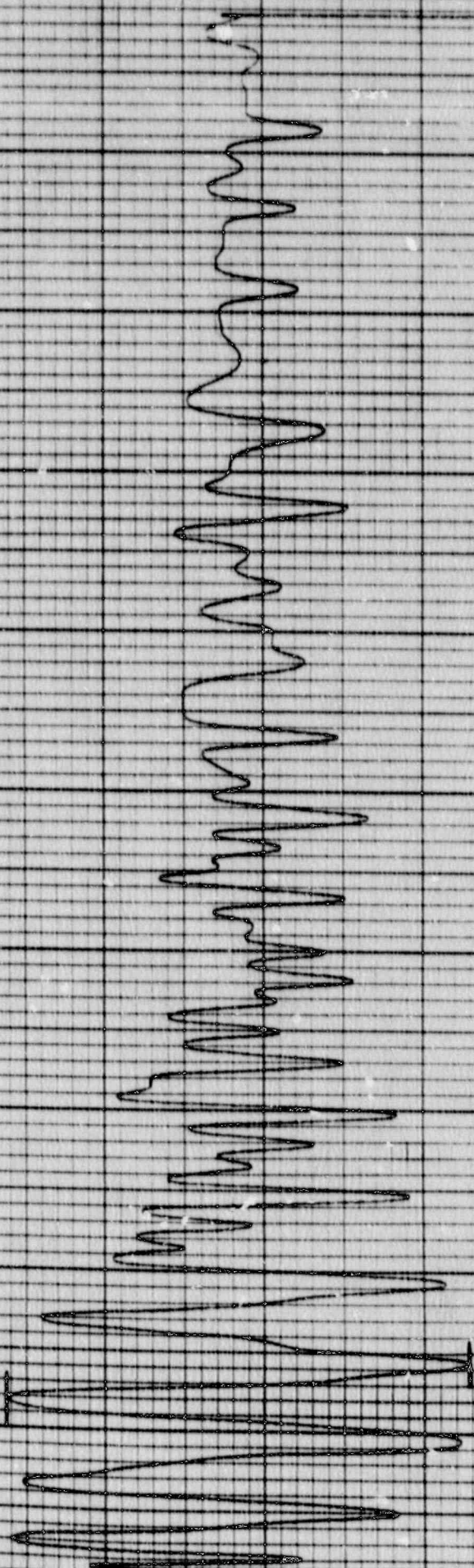


(time)

PPT-TP-90A-025 RE-0
 STEP 8.3.1 - Sensor LRD-4
 Range Settings WKZ = 0.1 V/div
 MMS 8-7-90 8:45
 LPA F.S. 10g

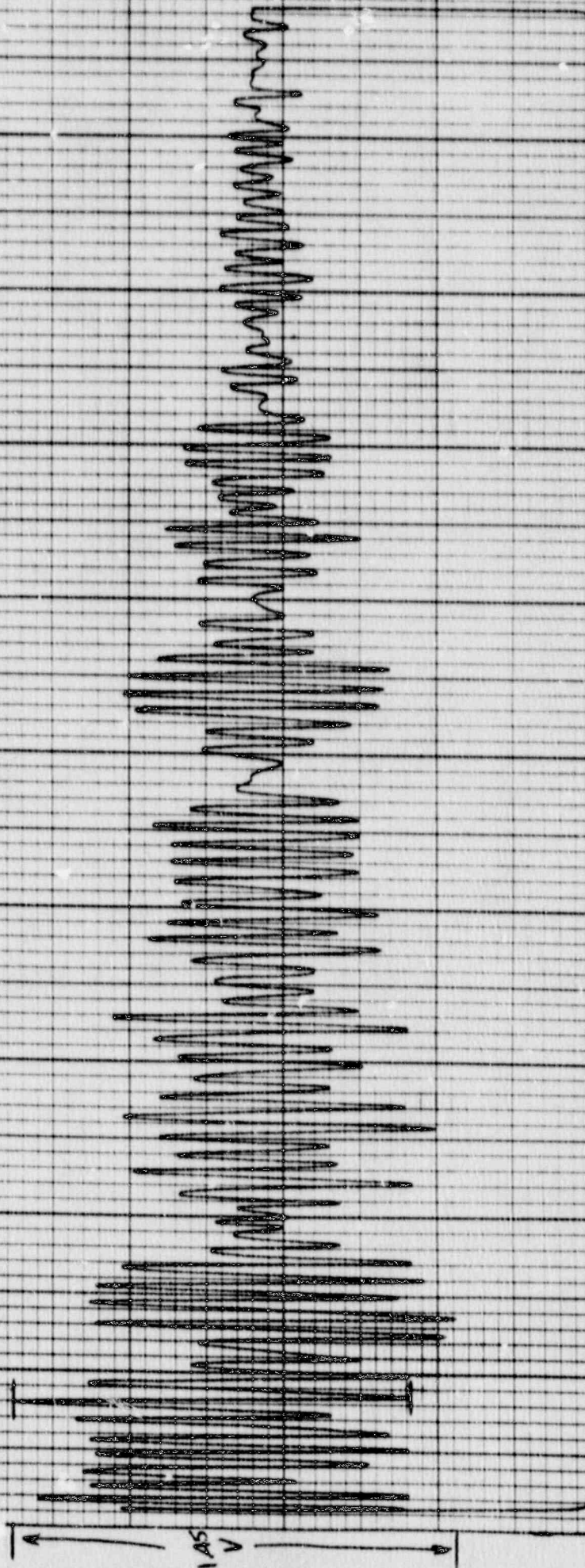
IMAXI AMPLITUDE TRANSCIENT
 0.25 lbm / 0.5 ft. lb.

ddA 6.2 - 1.0 x 5z



PPT-TP 40A-025 Rev. 0
 SFD 8.31 - Sensor LPD-5
 Range Setting 1V/div = 0.5 V/div
 MAG 8.7-90 / 8.49
 LPM FS 3g
 IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft/lb.

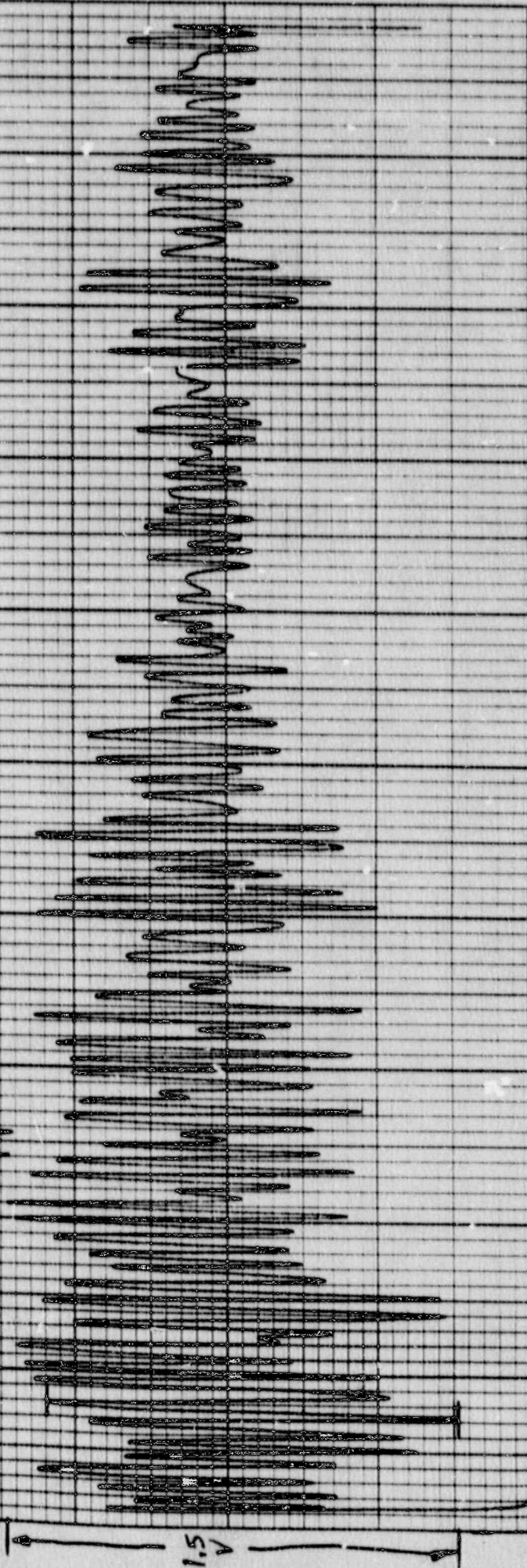
25.5 x 0.5 = 50 x 5.52



PPT-TP-90A-025 Rev.0
 STEP 8.3.1 - Sensor 680-6
 Range Setting IN XI = .05V/div
 MAG 8.7-90 / 8.53
 LPM F.S. 3g

IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft. lb.

27 x 1.35 Vpp
 54.1 = 50.8 x 1.2

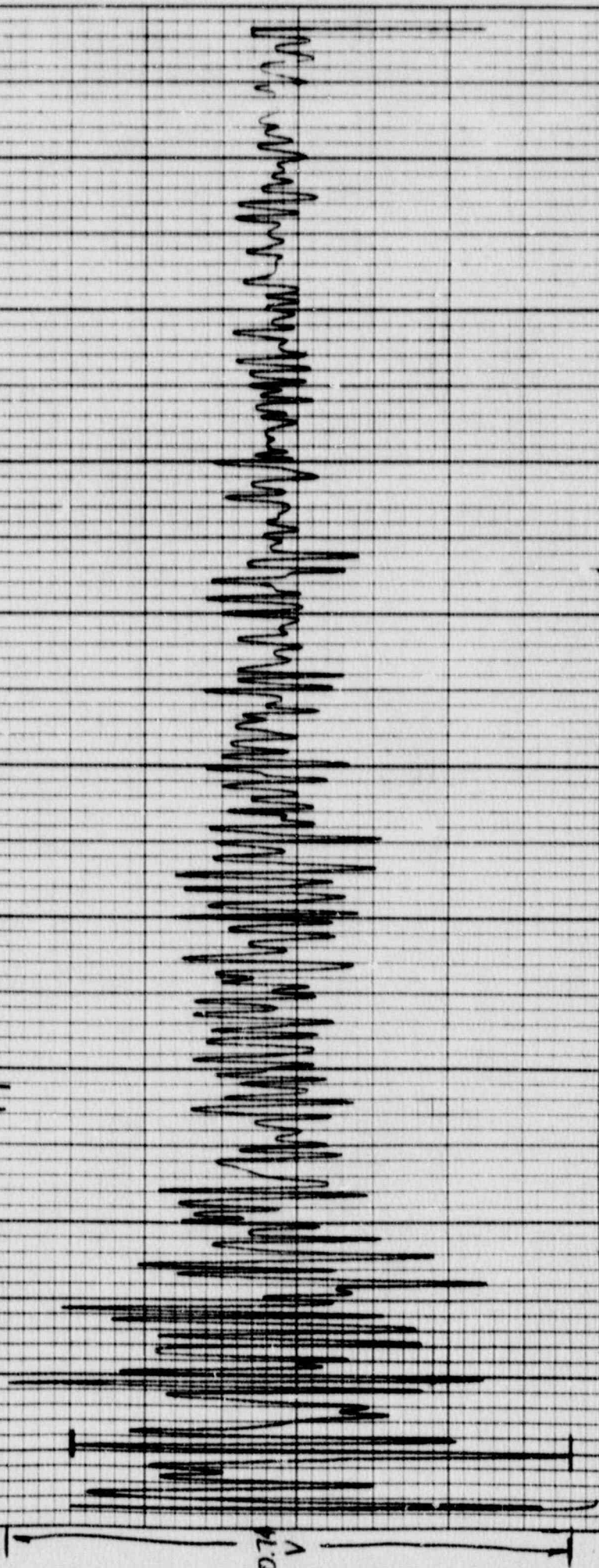


(time)

PPT-TP-90A-025 Rev. 0
 SIF 8.3.1 - Sensor HPD-7
 Range Setting 100mV/div = 100mV/div
 MAG 8.7-90/9:09
 LPM F.S. 3g

IMPACT AMPLITUDE TRANSIENT
 0.25 10mV / 0.5 1b.

0.25 10mV / 0.5 1b. = 50000 x 10
 0.25 10mV / 0.5 1b. = 20

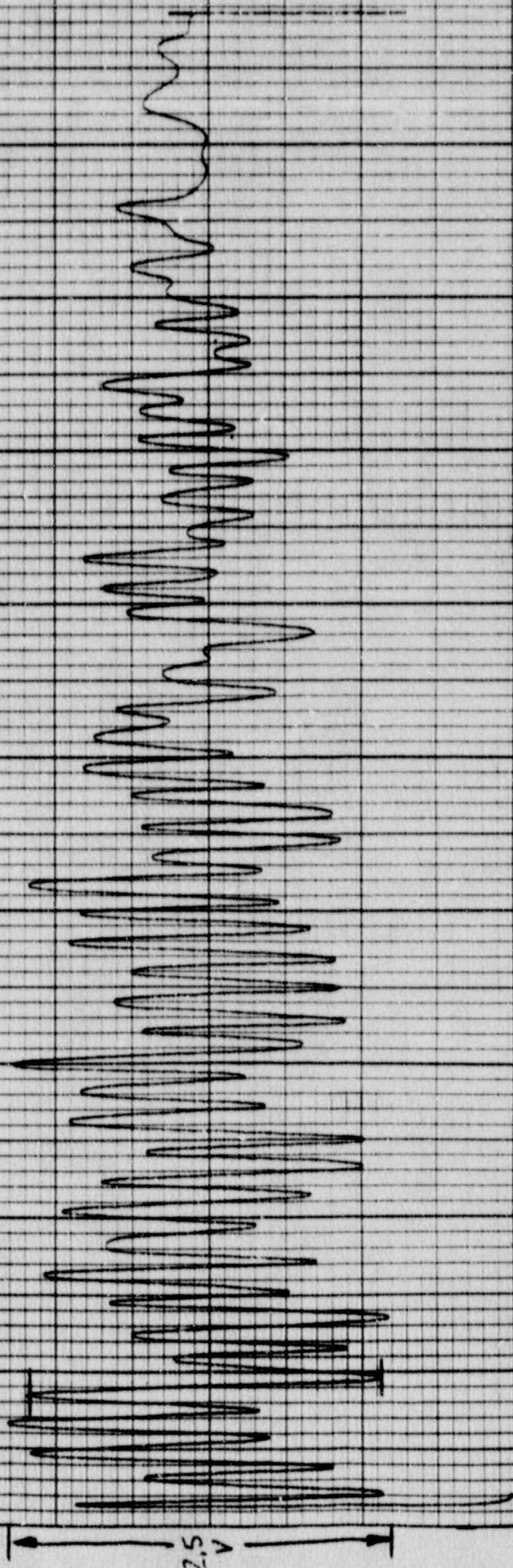


(time)

PPT-TP-90A-025 Rev. 0
 STEP B.3.1 - Sensor LPD.8
 Range Setting WXZ = 0.1 V/div
 MMS 8-7-90 / 9:11
 LPM FS 10g

IMPACT AMPLITUDE TRANSCIENT
0.25 lbm / 0.5 ft. lb.

$\Delta V_{E'Z} = 1.0 \times 10^{-2}$

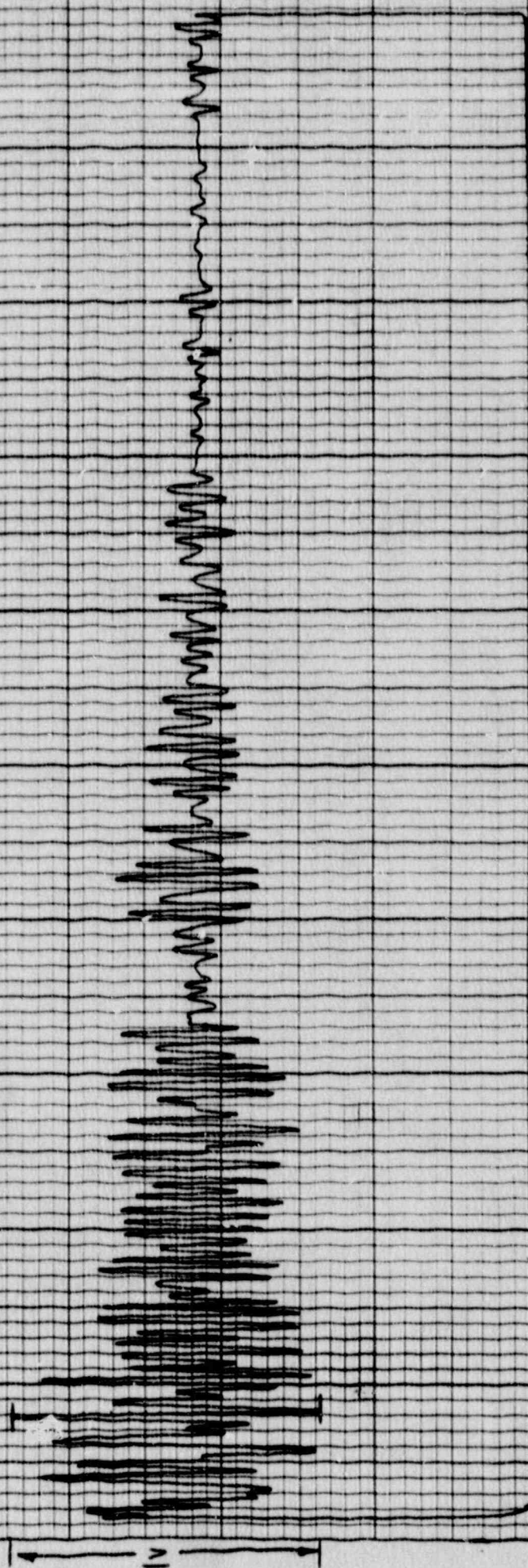


(time)

PPT-TP-90A-025 Rev.0
 STEP 8.3.1 - Sensor LPD-9
 Range Setting $1V \times 1 = .05 V/div$
 MAG 8.7-90 / 9:14
 LPM PS. - 39

IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft. lb.

$20 \times 0.1 = 50 \times 0.2$

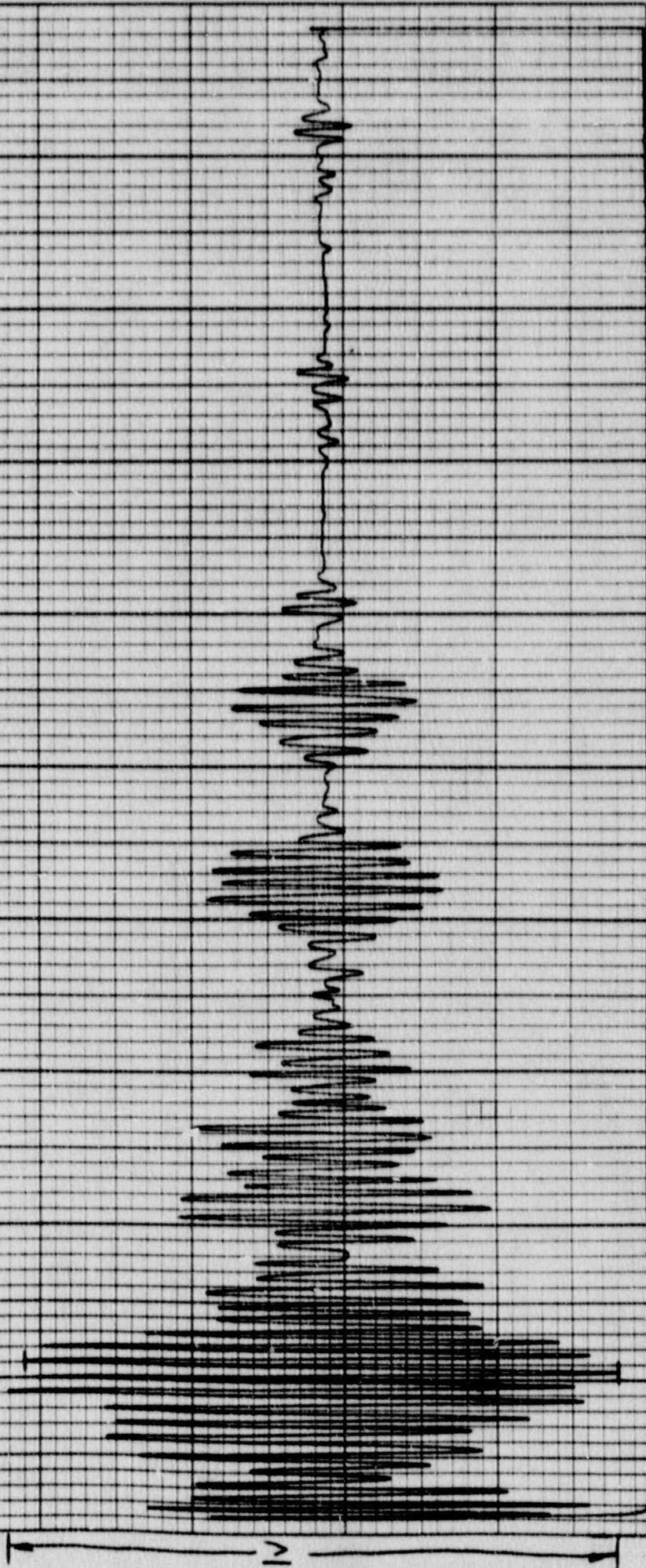


(time)

PPT-TP-90N-025 Rev. 0
 STEP 8.3.1 - Sensor WPD-10
 Range Setting $1V \times 1 \times 2 = 0.25V/div$
 WMS 8-7-90 / 9:17
 LDM FS 3g

HYPERT AMPLITUDE TRANSDUCER
 0.25 lbm / 0.5 ft. lb.

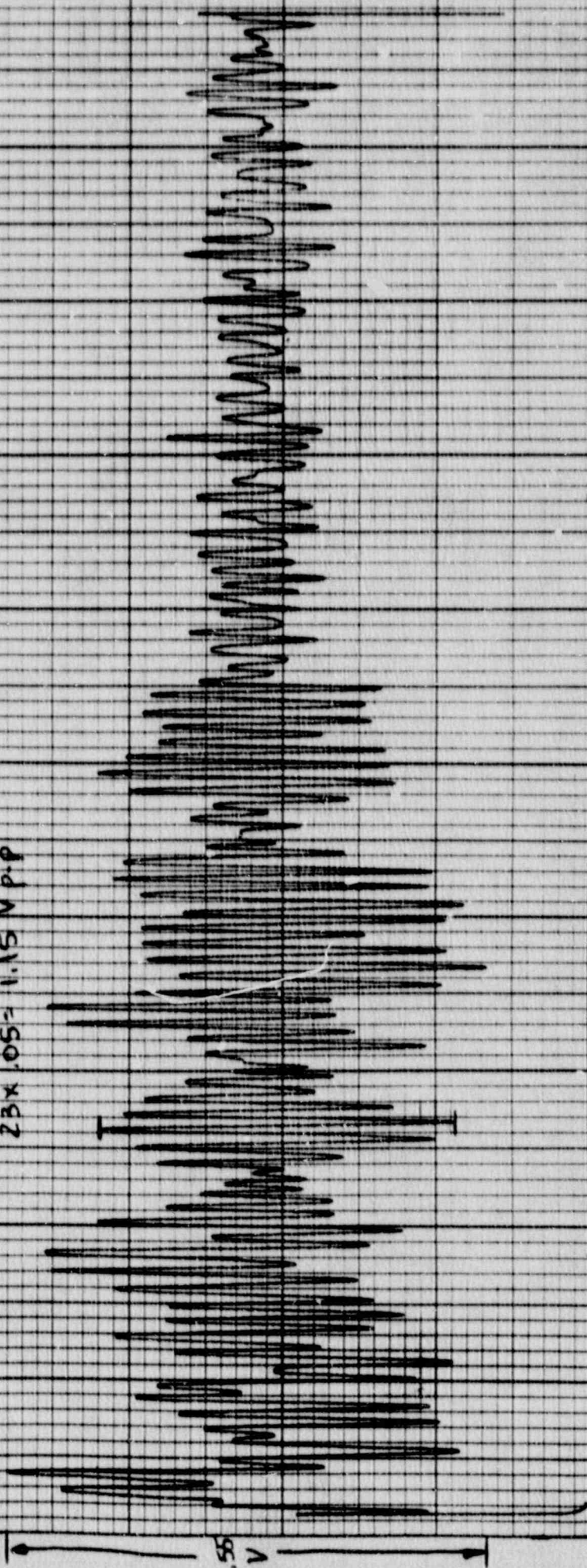
8-11-90 10:52:00 = 520' x 6E



PPT-TP-90A-025 Rev. 0
 STEEL B.3.1 - Sensor LPD-11
 Range Setting: 1V/1 = .05V/d.v.
 MMS 8-7-80 / 9:19
 LPM F.S. 3g

IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft-lb.

51.1 ~ 50' x 2

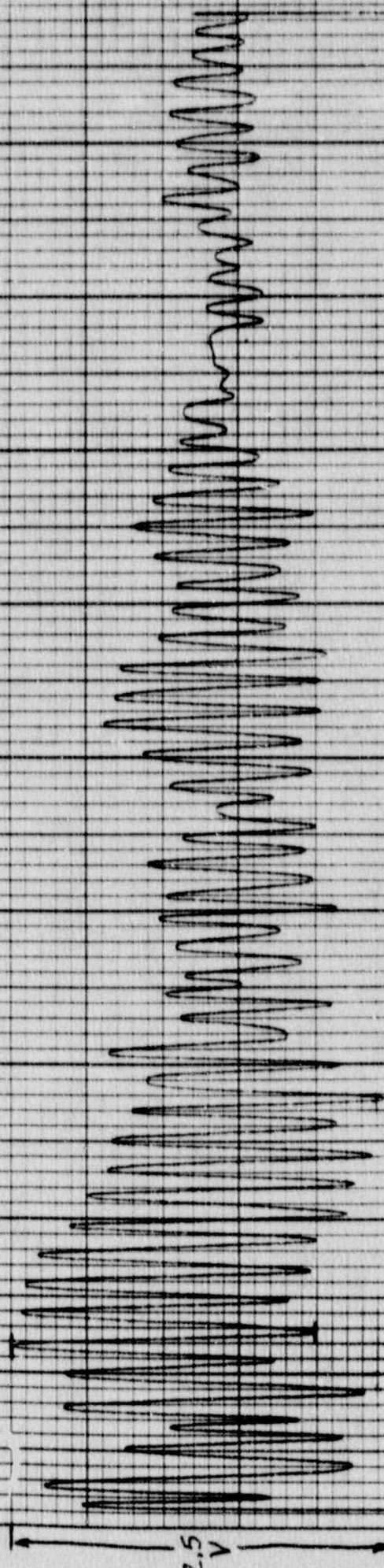


(time)

PPT-TP-90A-025 Rev. 0
 STEP 8.3.1 - Sensor LPD-12
 Range Setting 1VXZ = 0.1 V/div
 MNS 8-7-90 / 9:21
 LPM F.5. 10g

IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft. lb.

20 x 0.2 = 1.0 x 0.2

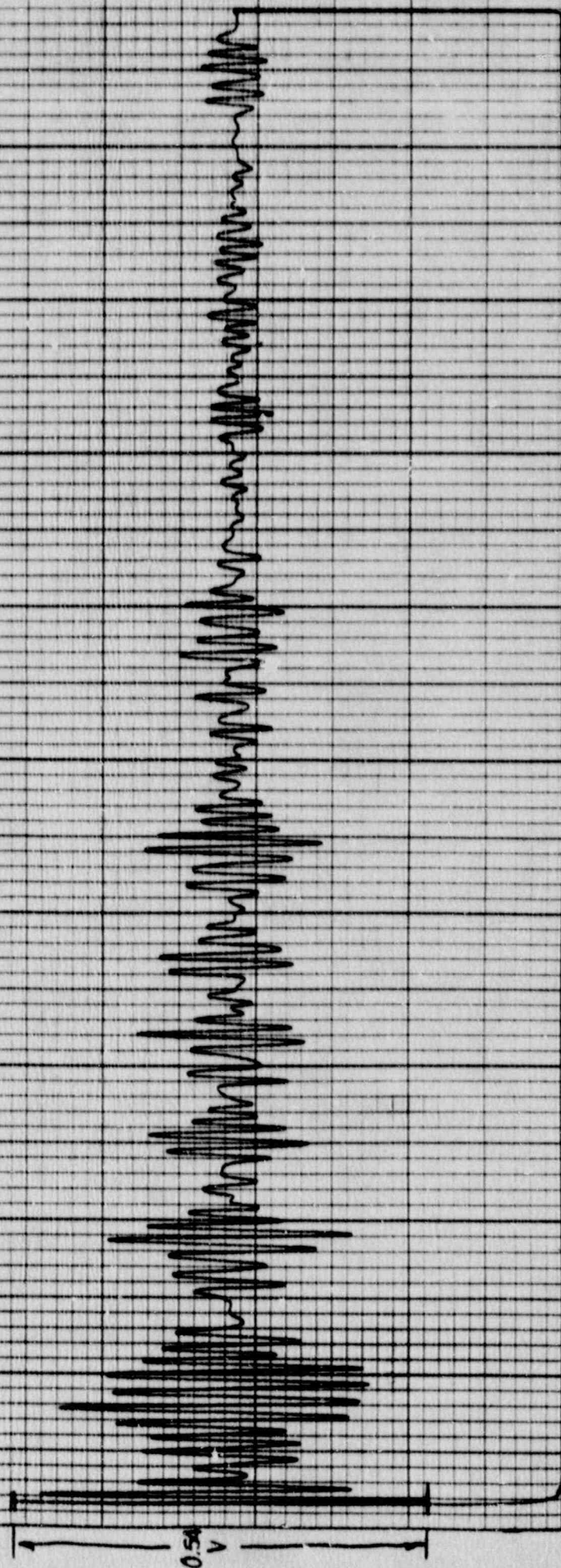


(2 in)

PPT-TV-90A-025 Rev. 0
 STEP 18.3.1 - Sensor LPT-13
 Range Setting 100mV/4 - 0.025V/4
 MAG 8-7-90 / 9:25
 LPM F.S. - 3g

IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft. lb.

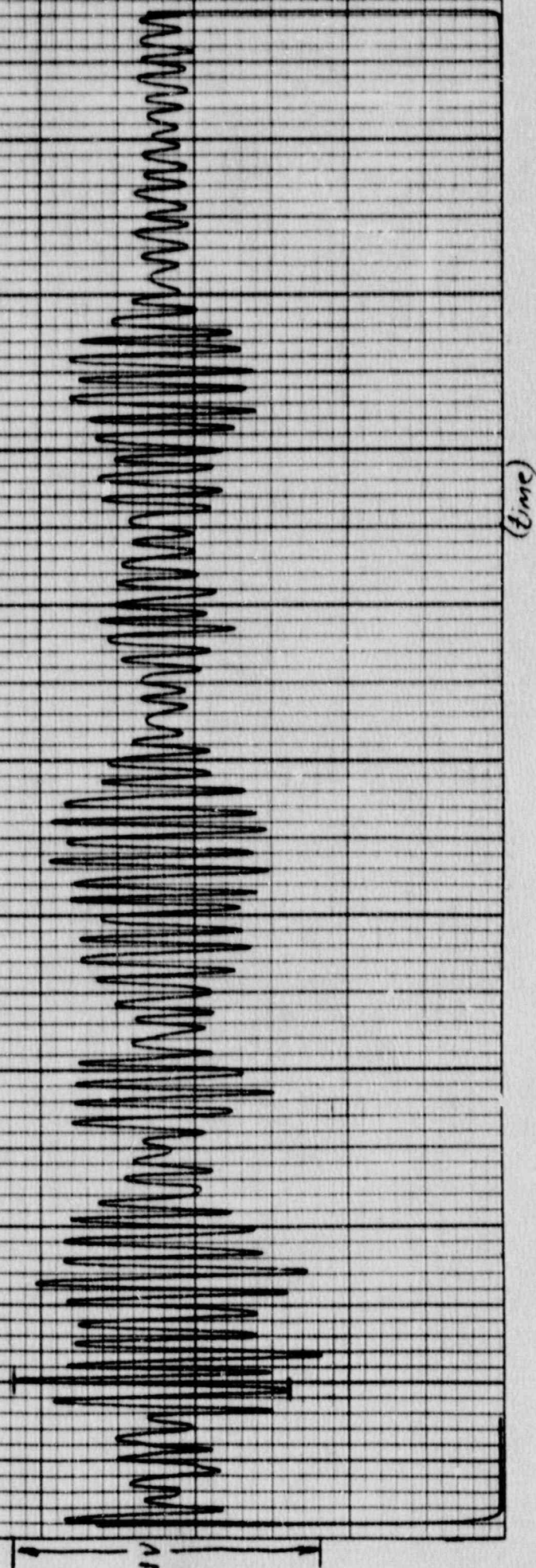
271.00005 V p.p
 0.54 VP.P
 0.50 = 20



PPT-TP-90A-025 Rev.0
 STEP B.3.1 - Sensor LPD-14
 Range Setting 1V/1 = .05 V/1.0
 MAG B-7-70 / 7.28
 LPM F.S. - 3g

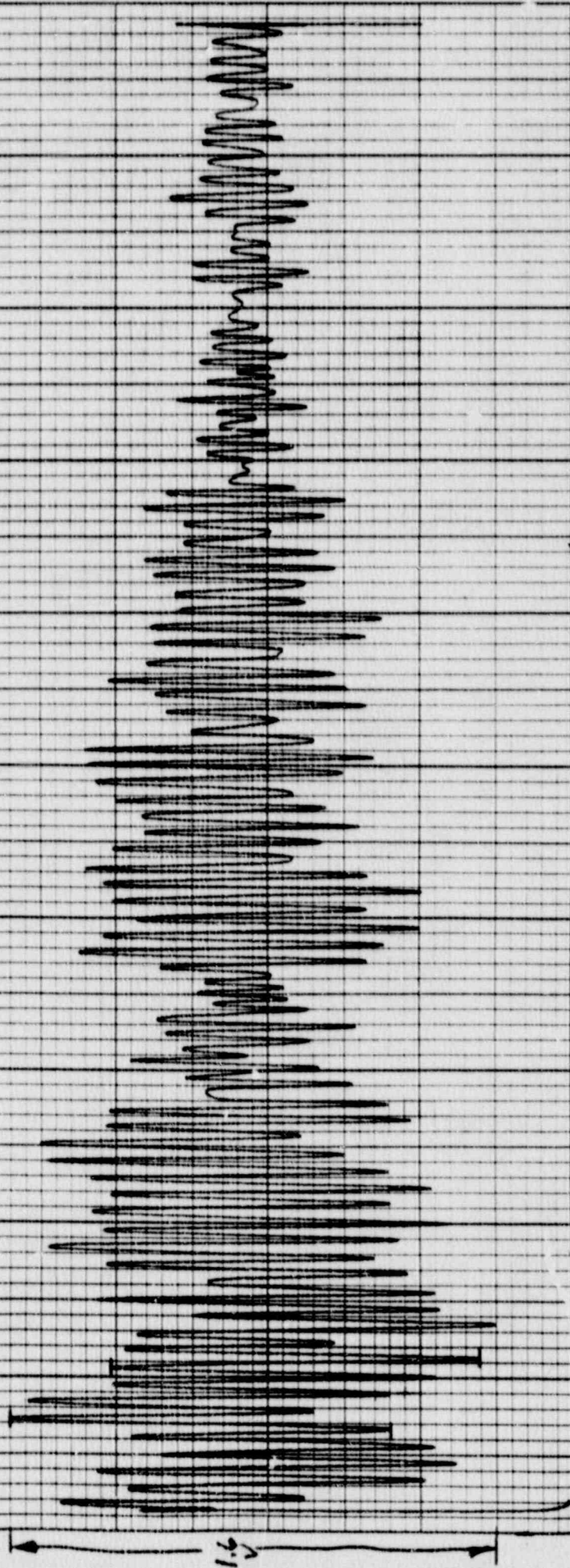
IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft/lb

661.6.0 = 150.0 x 81



PPT-TP-90A-025 Rev. 0
 STEP 0.31 - Sensor LPD-15
 Range Setting 1Vx1 = .05 V/div
 MAG 0.7-90 / 9.91
 LPM F.S. - 3g
 IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft. lb.

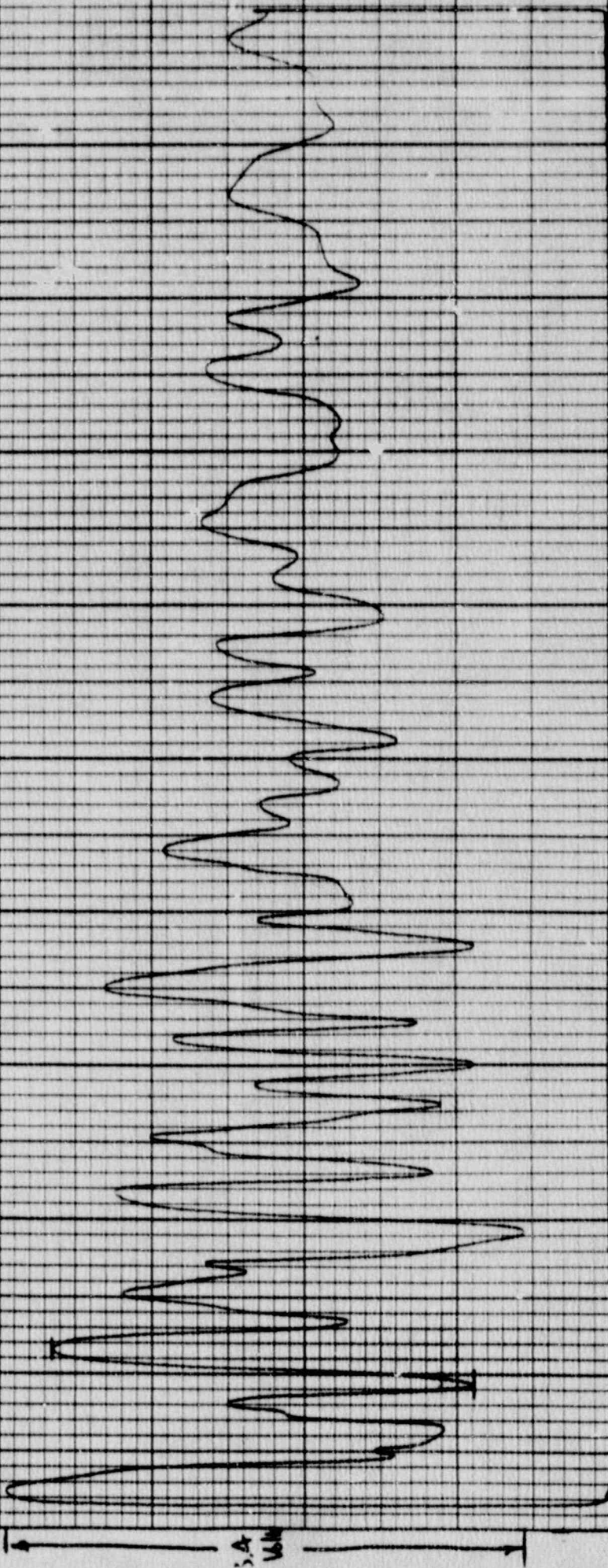
25 x 52.1 = 50 x 52



PPT-TP-90A-025 Rev. 0
 STEP B.3.1 - Sensor LPD-16
 Range Setting 1V x 2 = 0.1V/div.
 MAG 8.7-90 / 0.34
 LPM FS. 10 g

IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft. lb.

4.1 V SLT Z = 1.0 x 5.42



(time)

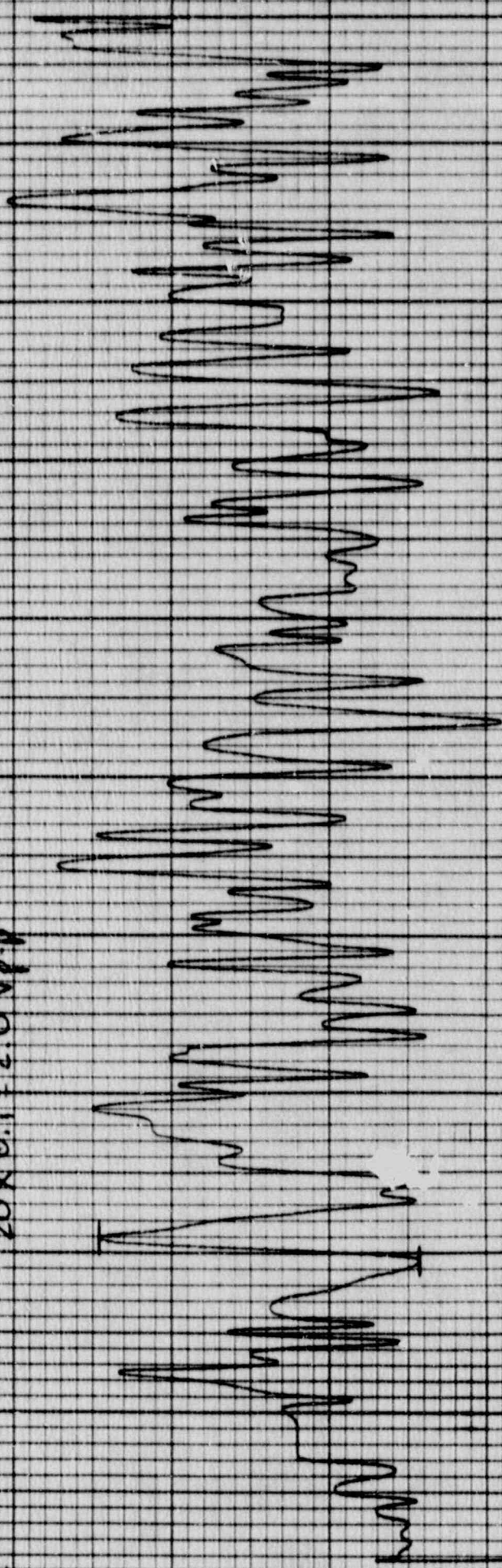
RPT-TP-90A-025 Rev 0
 SET 8.3.1 - Sensor LPD-17
 Range Setting 1V/2 = 0.1 V/div
 MAG 8-7-90 / 9:50
 LPM F.S. 39

IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft. lb.

20 x 0.2 = 1.0 x 0.2

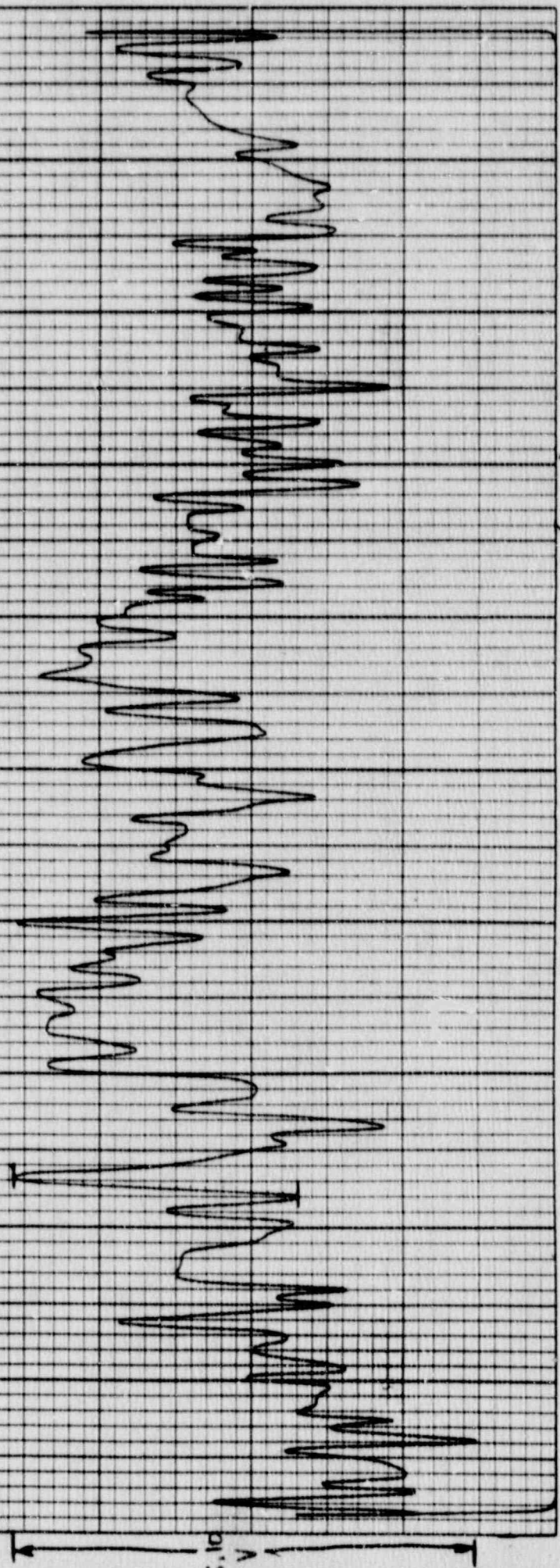
3.2 V

(time)



PPT-TP-40A-025 Rev. 0
 STEP 8.3.1 - Sensor LPO-1B
 Range Setting 1V/KZ = 0.1V/div
 MAG 8-7-90 / 9:52
 LPM FS 10 g
IMPERI AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft. lb.

18 x 0.1 = 1.85 V p-p

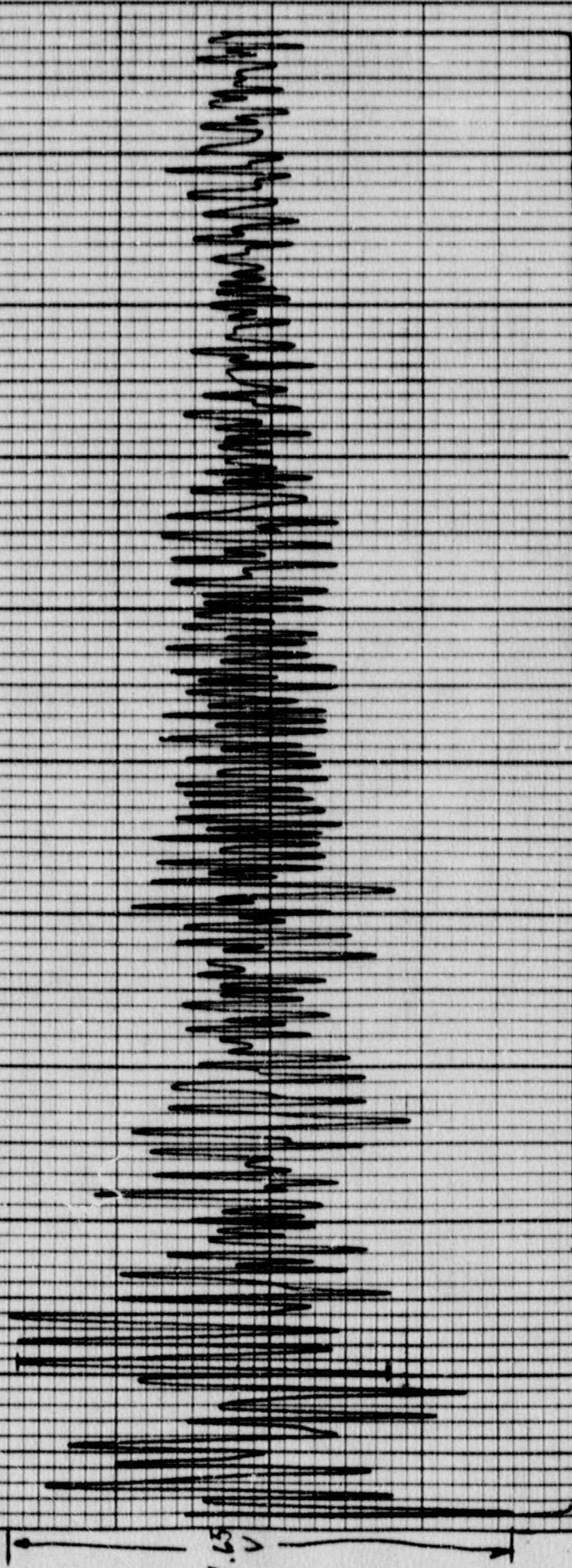


(time)

PPT-TP-90A-025 Rev. 0
 STEEL 8.3.1 - Sensor LPD-12
 Range Setting 1V x 2 x 2 = .05 V/div
 VOB 8-7-70 / 7:57
 LPM F.5. 10g

IMPACT AMPLITUDE TRANSDUCENT
 0.25 lbm / 0.5 ft. lb

8-3 V 2:1 = 50' x 42

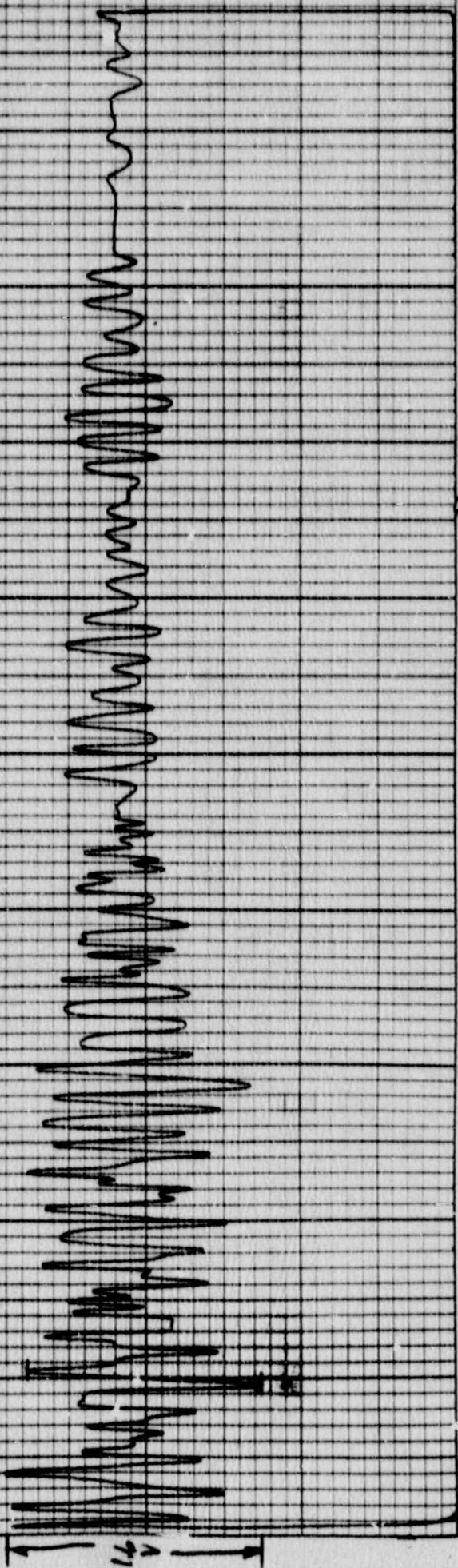


(time)

PPT-TP-90A-025 Rev. 0
 STB 8.3.1 - Sensor LPD-ZO
 Range Settings 1V/2 = 0.1V/div
 WAB 8-7-90 / 10:00
 LPM F.S. - 39

IMPACT AMPLITUDE TRANSIENT
 0.25 lbm / 0.5 ft·lb

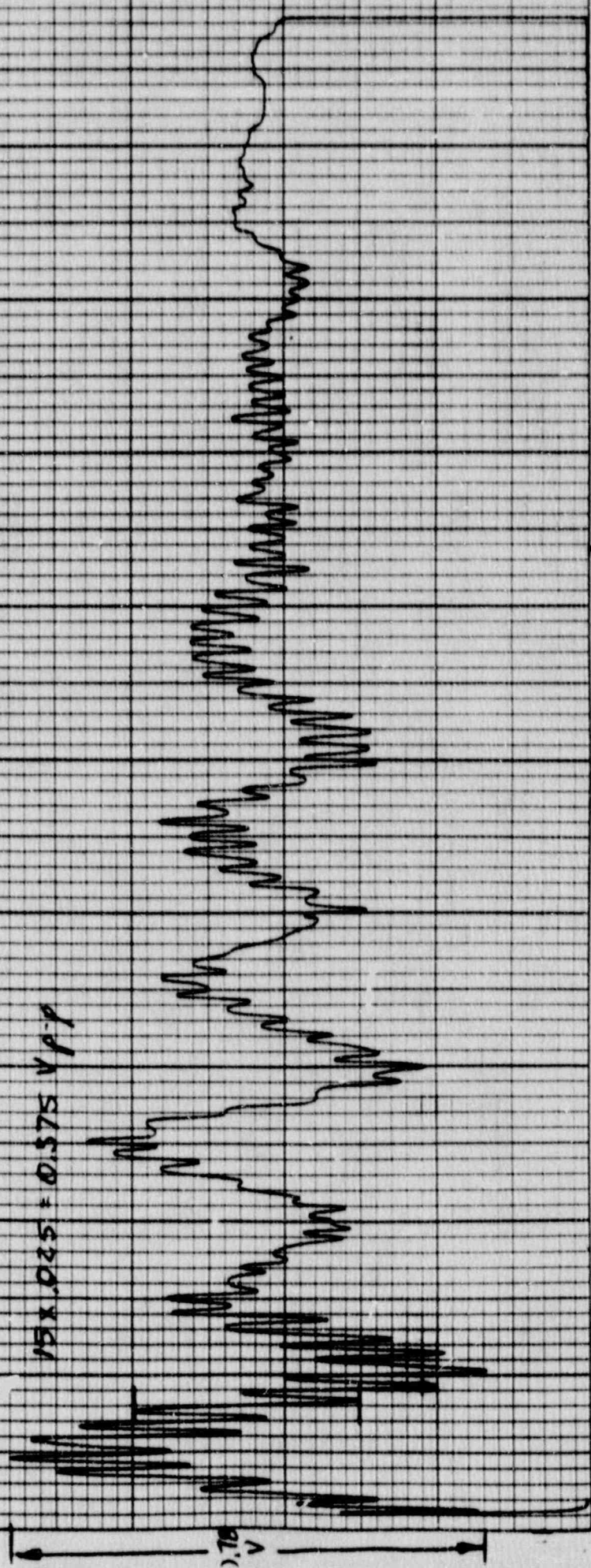
15' 0.5" = 1.0 x 5'



(2w/3)

PPT-TP-90A-025 Rev. 0
 Std 8.4.1 - Sensor LPD-2
 Range Settings - 1V x 1 x Z = .025 V/div
 PWS 8-7-90 / 1003
 LPM F.S. 3g
 IMPACT AMPLITUDE TRANSIENT
 30 lbm / 0.5 ft lb

15 x 0.25 = 3.75 x 10⁻³
 15 x 0.25 = 3.75 x 10⁻³



time

3.2 Impact Frequency Spectrum

The following X-Y plots were made using data collected during pre-operational test 1CP-PT-91-01 SFT. Sensor settings and determined break frequencies are listed.

2MKS2

(2HX)
2MKS21

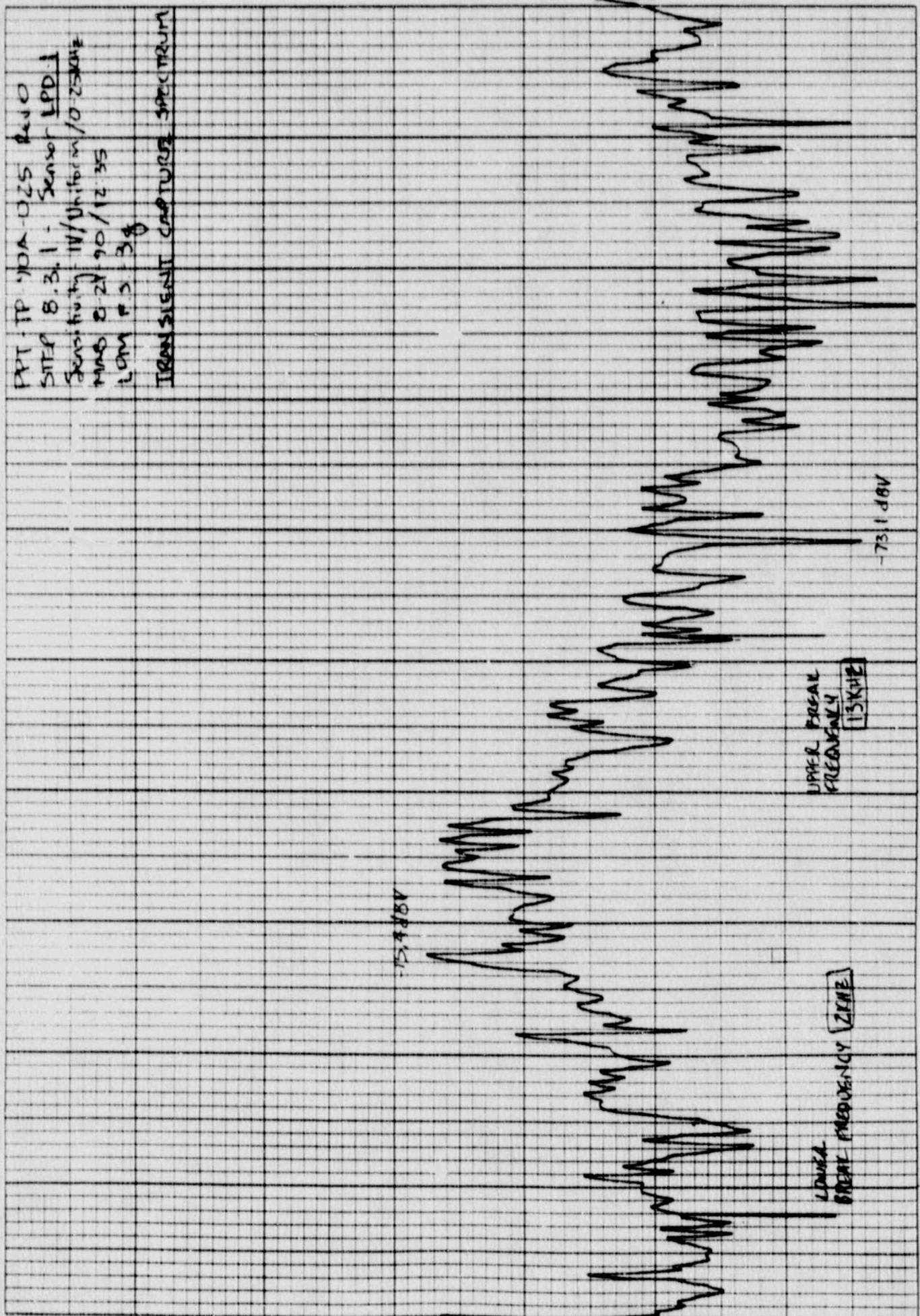
X01

X51

X5

X52

0



PPT TP 10A-05 Rev 0
STEP 8.3.1 - Sensor LPD.1
Sensitivity: 1V/Uniform/0.55kHz
ANS 8.21.90/35
LOW # 5 3g

(JB)

DPT-TP-90A-025 R2.0
 STEP 8.3.1 - Sensor-LPD-2
 Sensitivity 1V/V, form/0-25kHz
 MAG 8/21/90 12.40
 LPM - 10g

TRANSIENT CAPTURE SPECTRUM

(dB)

ABP 6.22

ABP 51

13.5 kHz

UPPER BEAM FREQ

2115 0701 2130 2000 1

12.5 kHz

(kHz)

25 kHz

46 0780

K&E
 10 X 10 TO THE INCH • 7 X 10 INCHES
 REUPPEL & ESSER CO. MADE IN U.S.A.

PPT-TP-00A-025 Rev.0
 STEP 03.1 - Sensor LPD-3
 Sensitivity 1V/Uniform/0-25KHz
 MAG 0.2/100/12:45
 LPM FS 38

TRANSIENT CAPTURE SPECTRUM

16.0 dBV

187.89-

UPPER BOUND
 FREQ. 13KHz

16.0 dBV

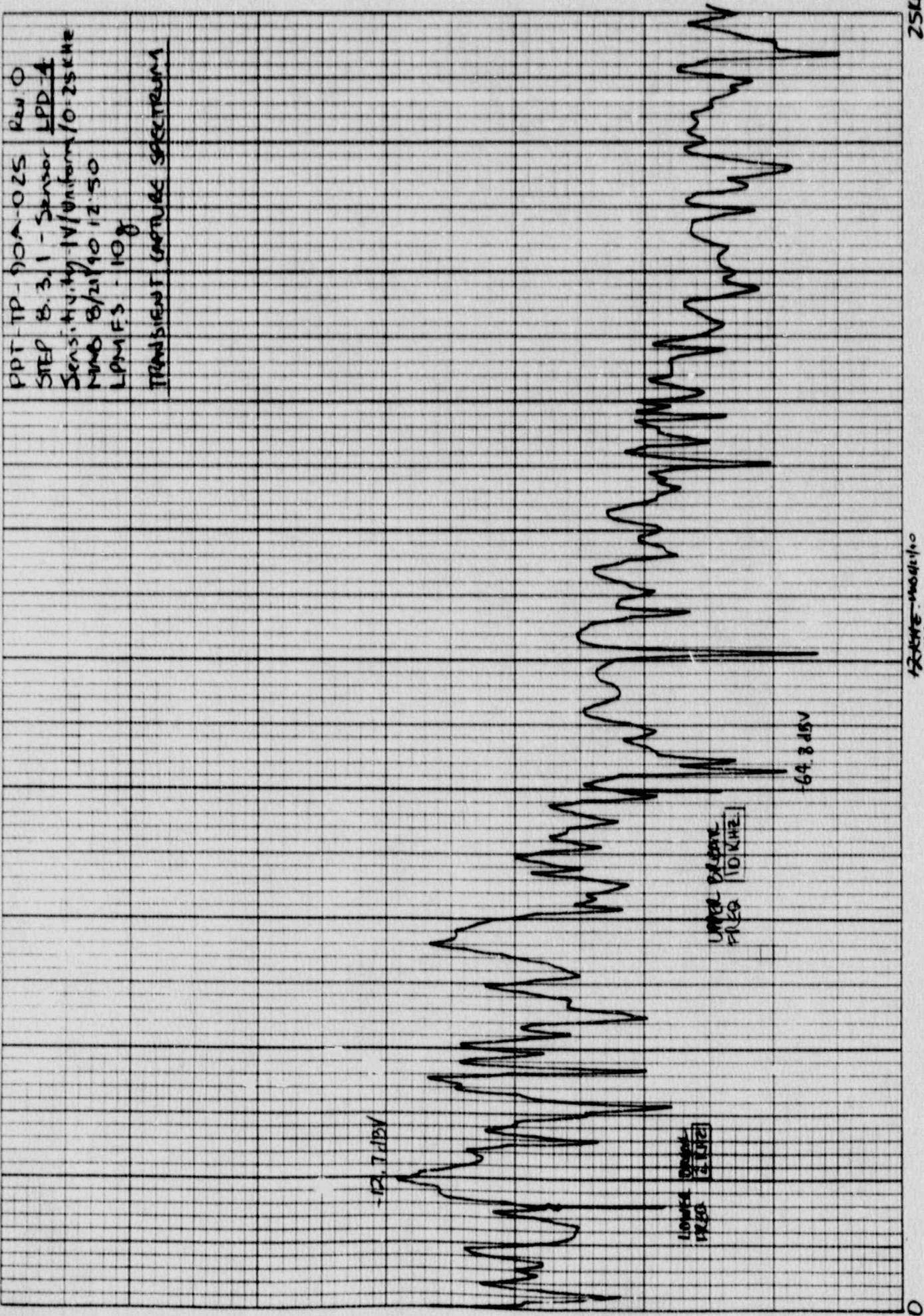
(dB)

12.5 KHz (24K)

25KHz

PPT-TP-90A-025 Rev 0
 STEP 8.3.1 - Sensor LPD-4
 Sensitivity: 1V/100mV/0.25kHz
 NMD 8/21/90 12:50
 LPMFS - 10g

TRANSIENT CAPTURE SPECTRUM



25kHz

12.5 kHz
 10 kHz
 (2K)

PPT-TP-90A-025 Rev C
 STEP 8.3.1 Sensor LPD-5
 Sensitivity 1V/Unit/m/0.25 kHz
 MAPS 8/2/90 12:55
 LPM F.5 38
 TRANSDUCER CAPTURE SPECTRUM

ABP 1.29-

UPPER
CUT
FREQ 11.2 KHz

ABP 6.55-

LOWER
CUT
FREQ 1.0 KHz

(dB)

12.5 KHz
(KHz)

25 KHz

PPT-TP-90A-025 Rev 0
 SITE 8.3.1 - Sensor
 LPD-6
 Sensitivity: 1V/Unit/mV 0-25kHz
 MAG 82N/90 12:39
 LPM FS 39
 TRANSIENT CAPTURE SPECTRUM

(dB)

82.61

UPPER BAND
 11.5 kHz

LOWER BAND
 12 kHz

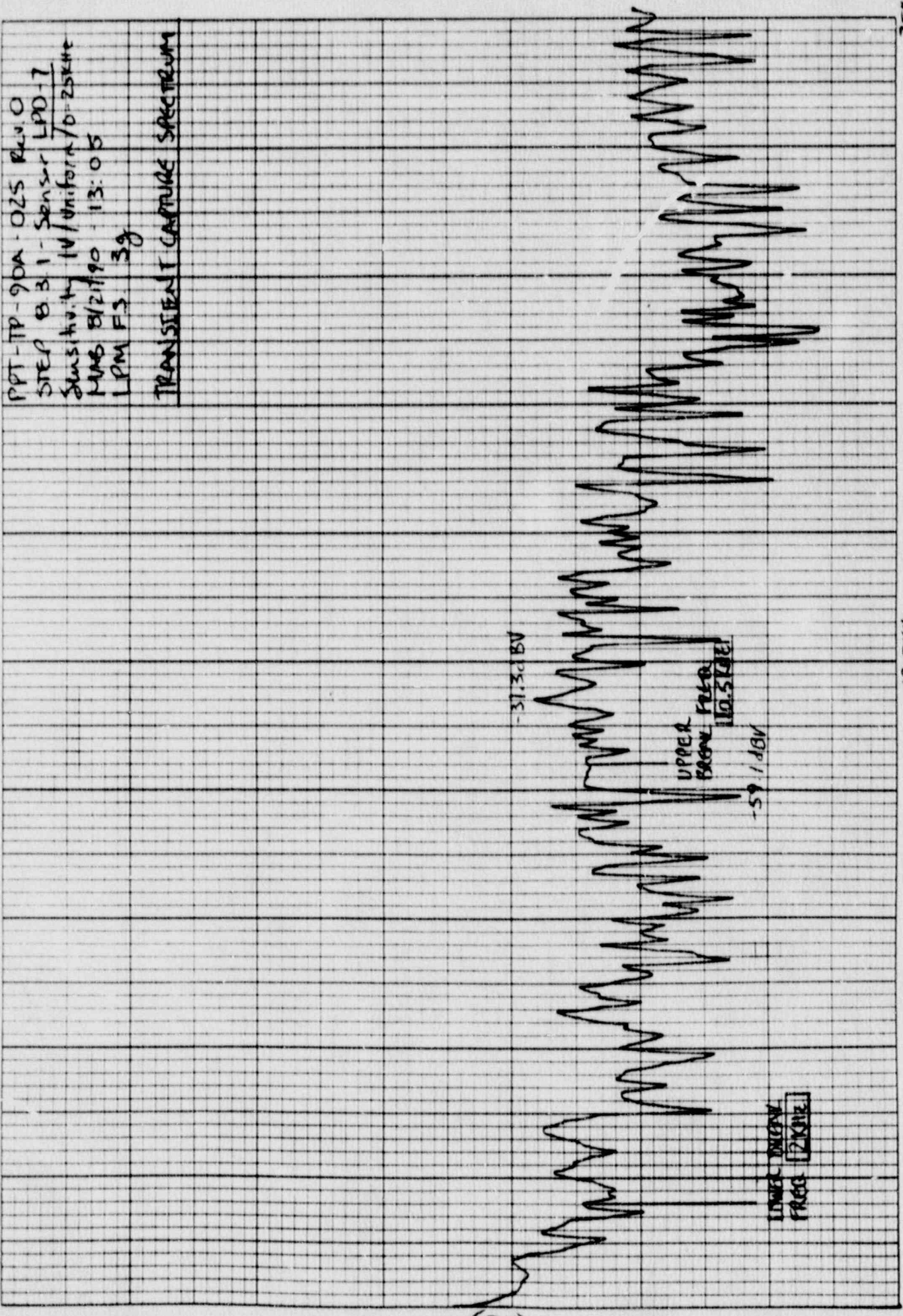
70.2 dB

12.5 kHz
 (24K)

25 kHz

PPT-TP-90A-025 Rev.0
STEP 8.3.1 - Sensor LPD-7
Sensitivity 1V/Uniform 0-25kHz
Date 8/21/90 - 13:05
LPM FS 3g

TRANSIENT CAPTURE SPECTRUM

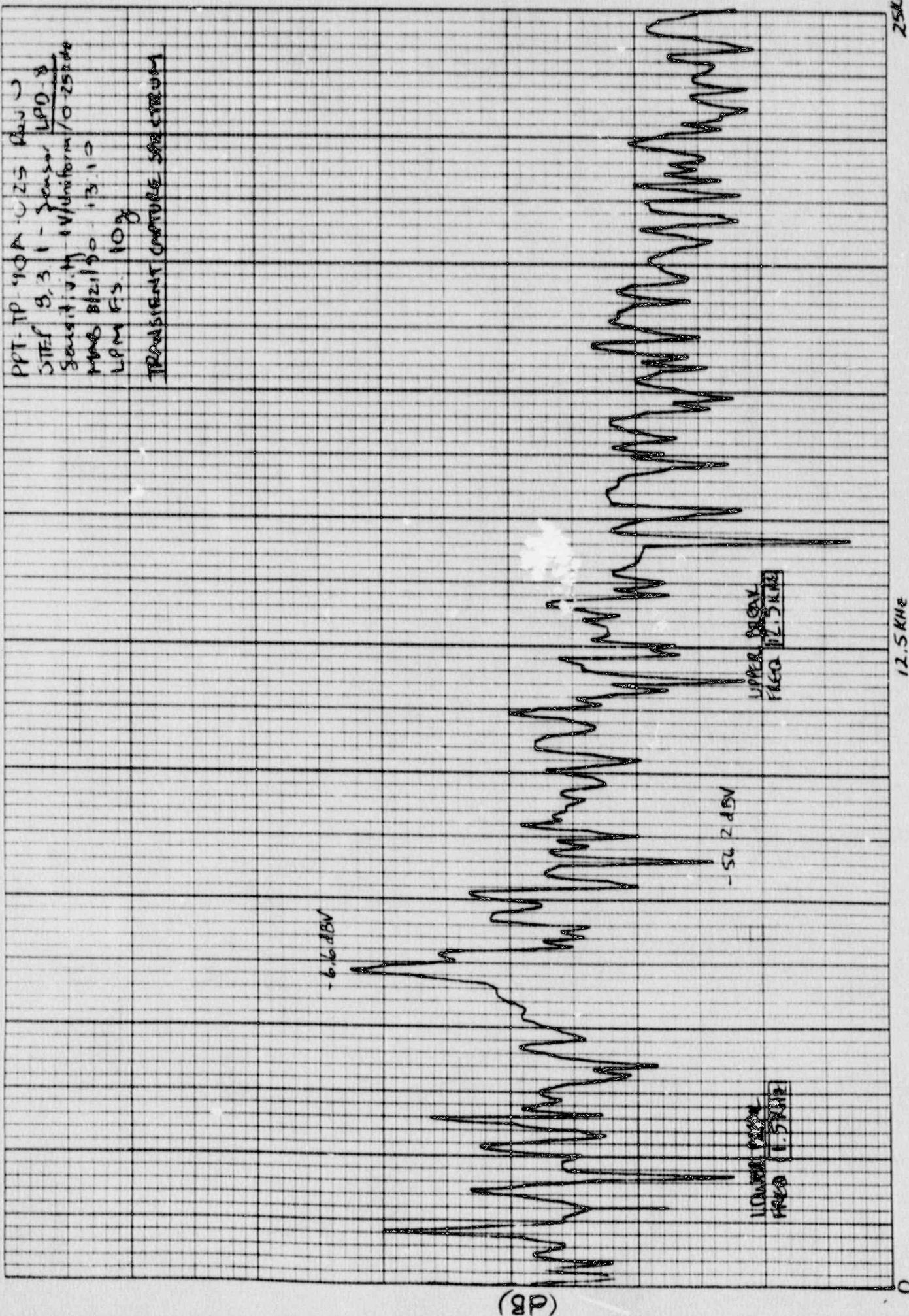


25 kHz

(24K)
12.5 kHz

250Hz

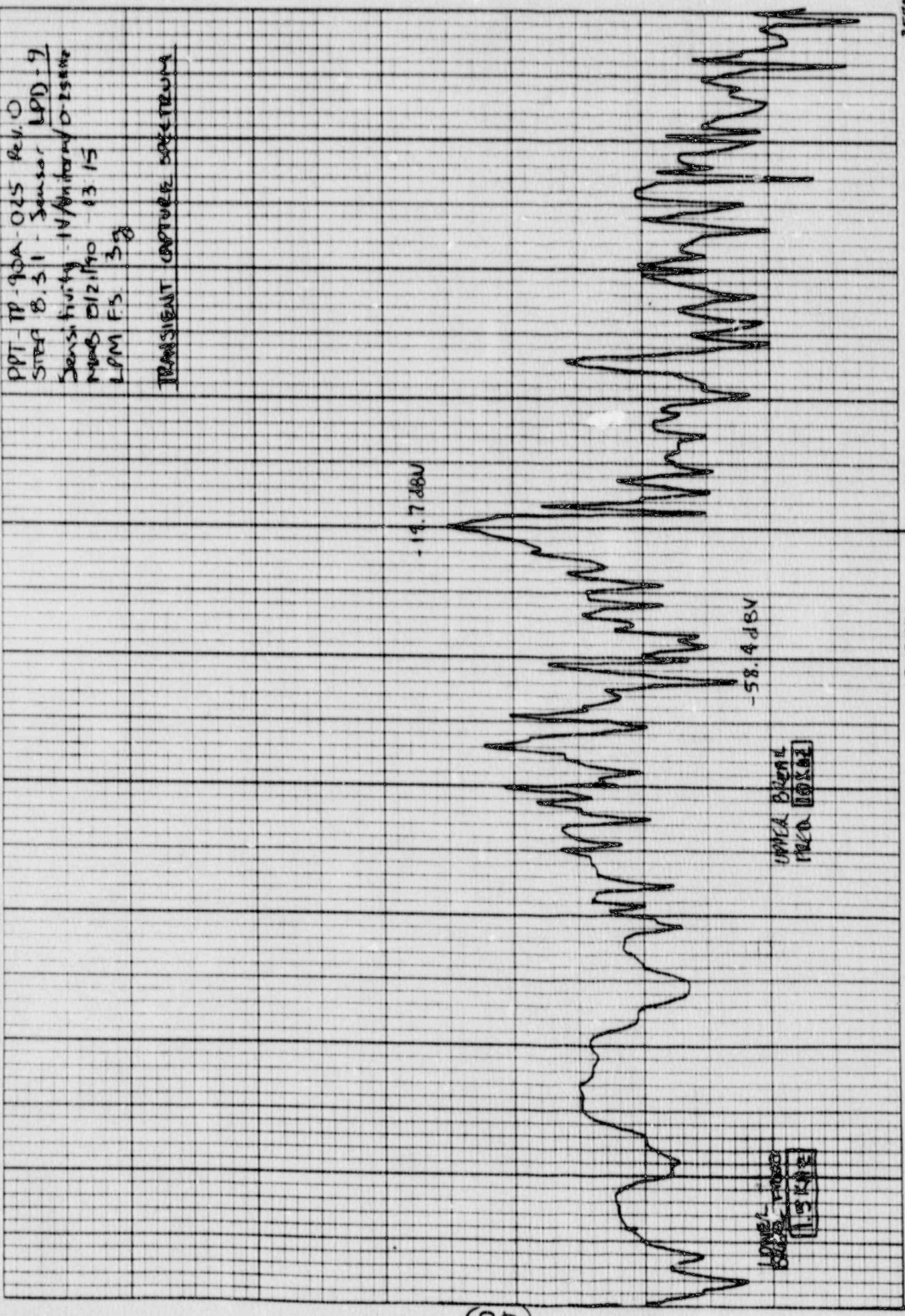
(21K)
17.5KHz



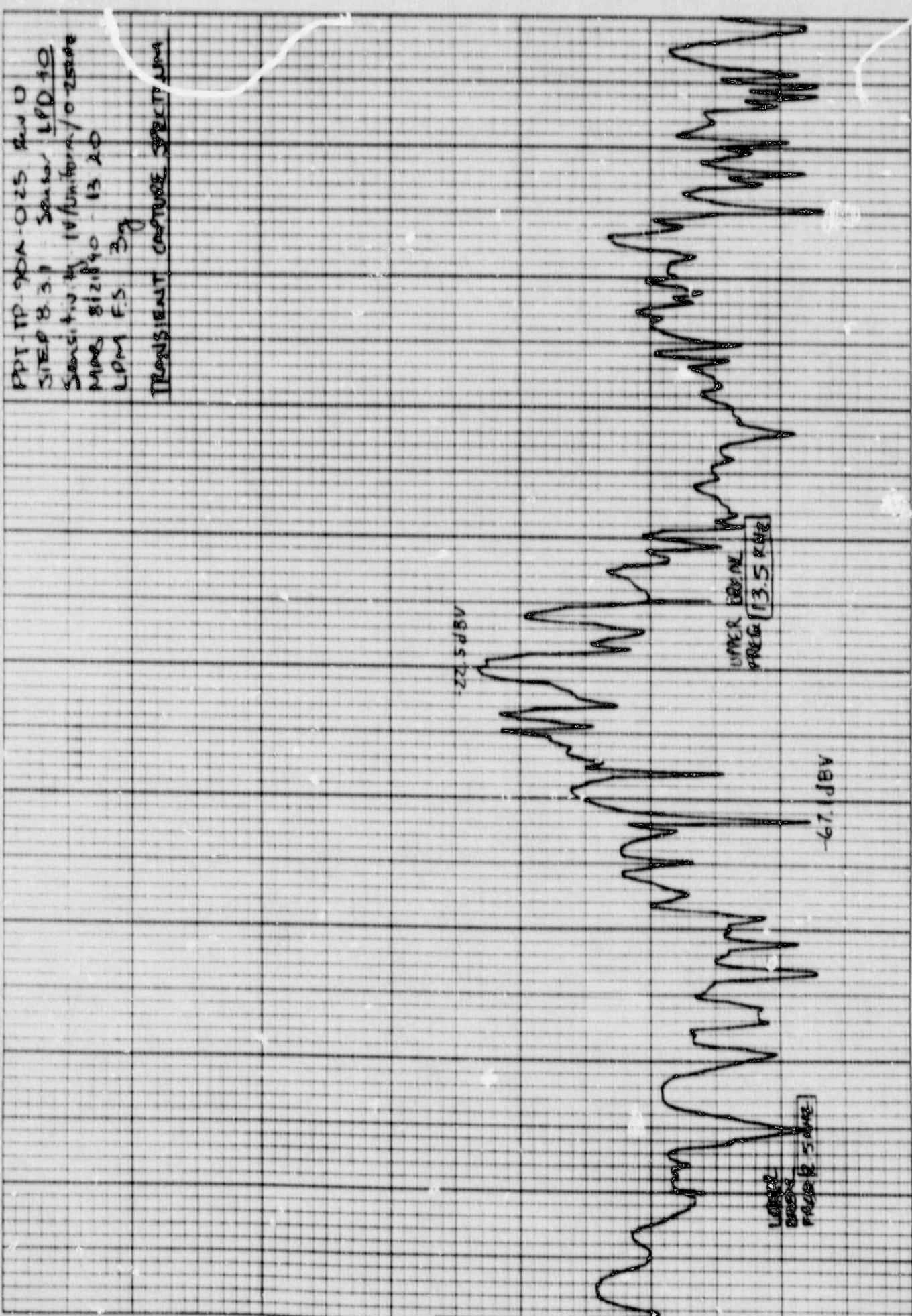
PPT-TP-A-25 Rev C
SPE 9.3 - Sensor LPO-8
Sensitivity 1 V/div
Time Base 100 ms
LPM FS 10g

PPT-TP-90A-025 Rev. 0
 STEP 8.51 - Sensor LPD-2
 Sensitivity - 1V/Unitary/0.25cm
 MOD 0121790 - 13.15
 LPM FS 38

TRANSIENT CAPTURE SPECTRUM



PPT-TP-90A-025 Rev D
 S/N 8.3.1 Sensor LFD 40
 Sensitivity: 10 V/Unit/0.2500e
 MAG 812.40 - 13.20
 LOW F.S. 3g
 TRANSIENT CAPTURE SPECTRUM



2MS2

(347)
 2MS2.1

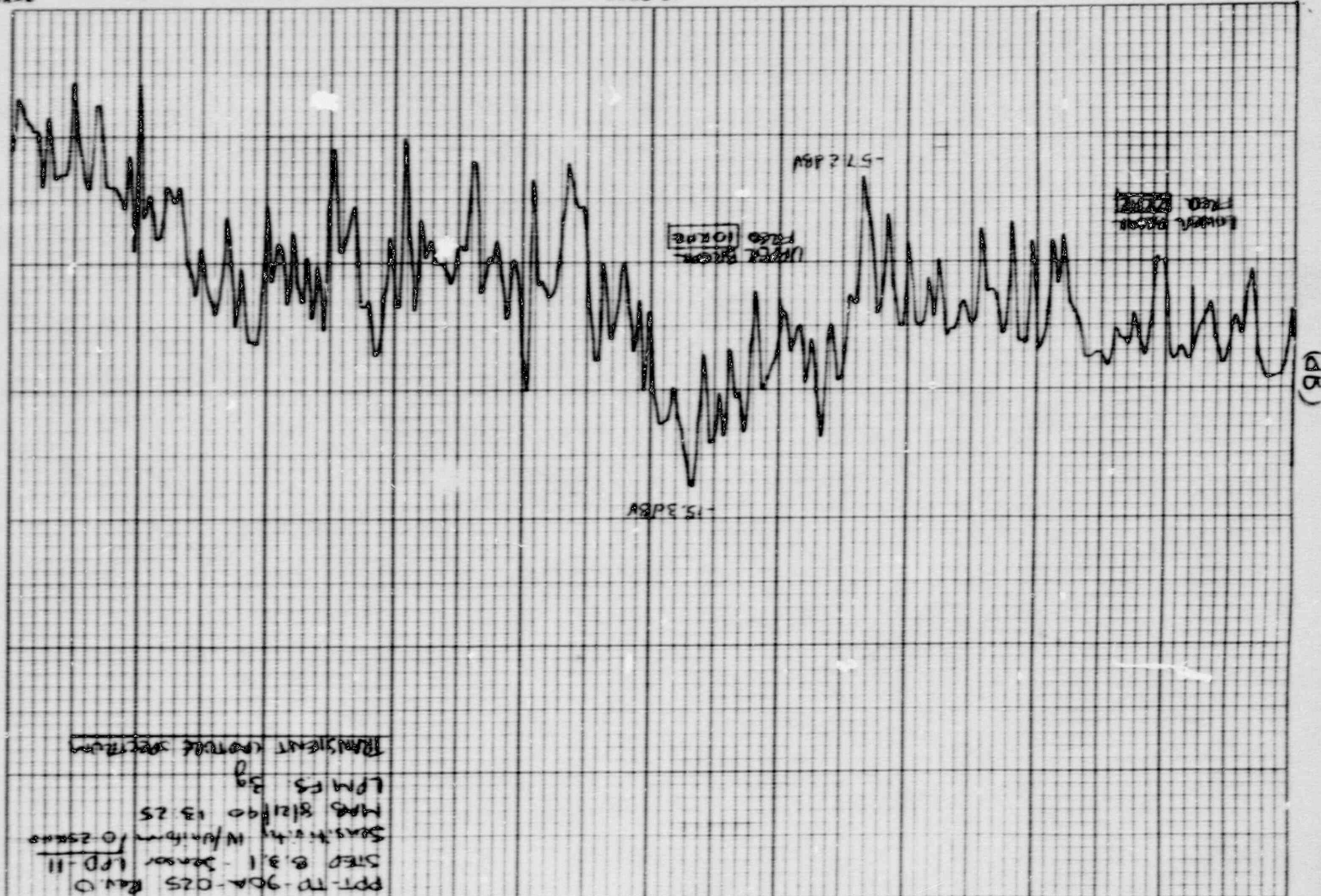
K-E 10 X 10 TO THE INCH 1 X 10 INCHES
 HUNTER & ESSER CO. NEW YORK

46 076u

25152

(211)
12.5KHz

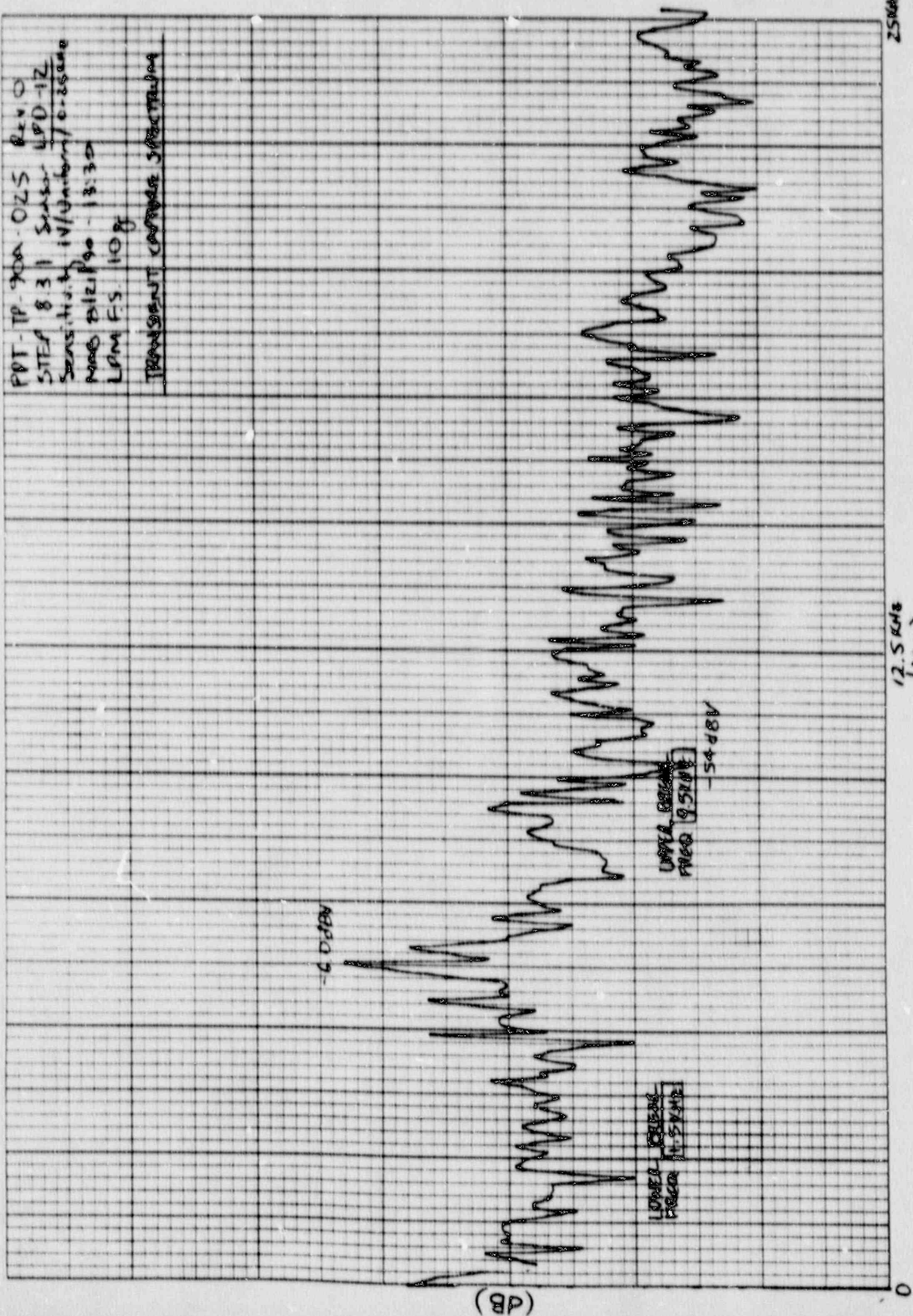
0



(dB)

00052

(Kve)
000521

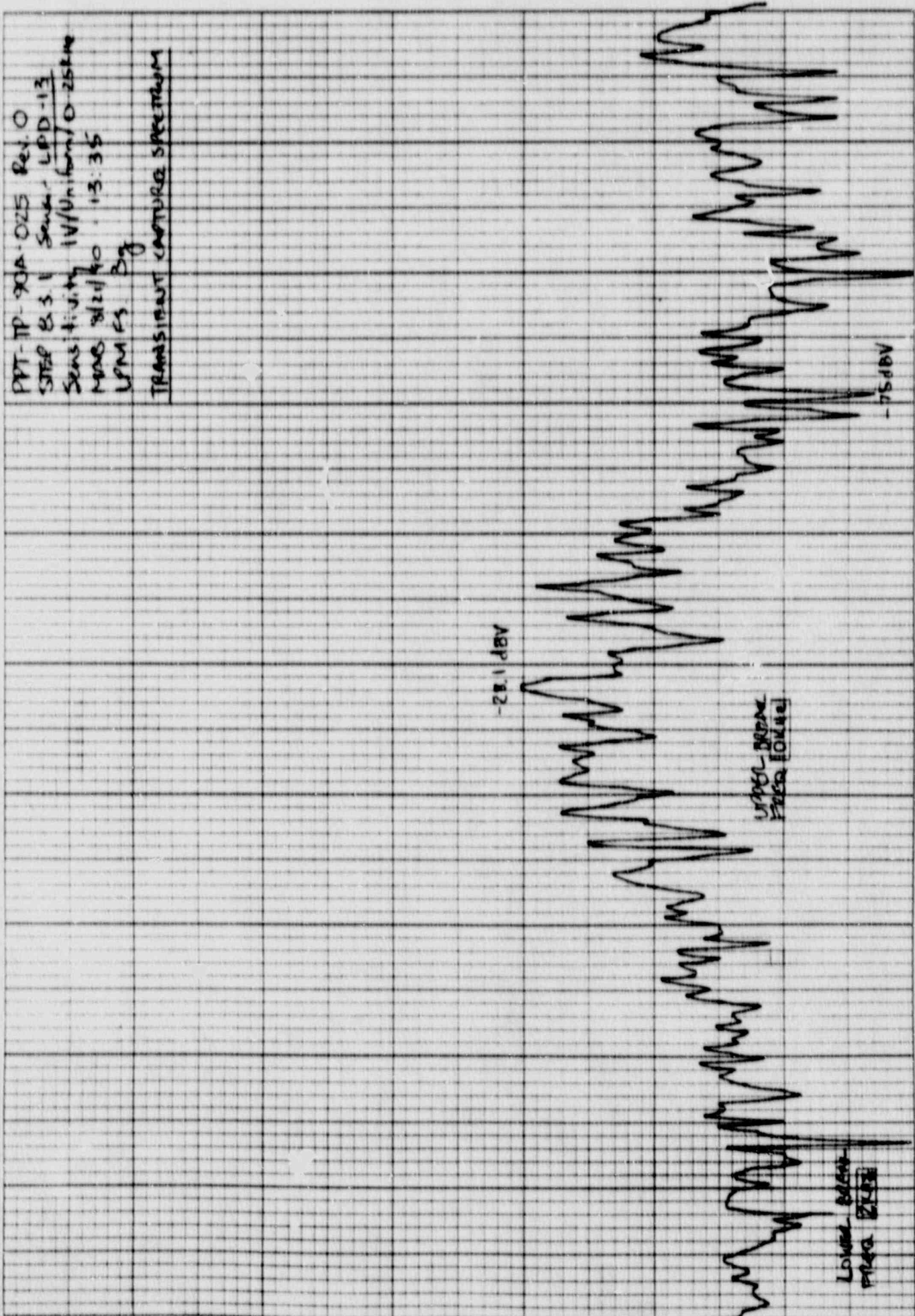


PDT-TP-90A-025 Rev 0
SITE# 831 Sides- 400-12
Sensitivity 1V/Uniform/0.25sec
WAS 11/21/90 - 18:30
LPM F.S. 10 ft
TRANSDUCENT CAPACITIVE SENSITIVITY

(dB)

PPT-TP-90A-025 Rev. 0
 STEP 8.3.1 Sensor LPD-13
 Sensitivity 1V/Unit/0-25KHz
 Date 8/24/90 13:35
 LPD-13 By

TRANSIENT CAPTURE SPECTRUM



(217X)
 #H: 5.71

20052

PDT-TP-90A-025 Rev. 0
 STEP 8.3.1 Sensor LPD-14
 Sensitivity 1V/100mV/0-25000
 MAB 5121190-13.40
 LPM FS 3g

TRANSIENT CAPTURES SPECTRUM

APP 5.11-

APP 5.11-
 UPPER 5000
 FREQ 10000

APP 5.11-

APP 5.11-
 LOWER 5000
 FREQ 10000

(dB)

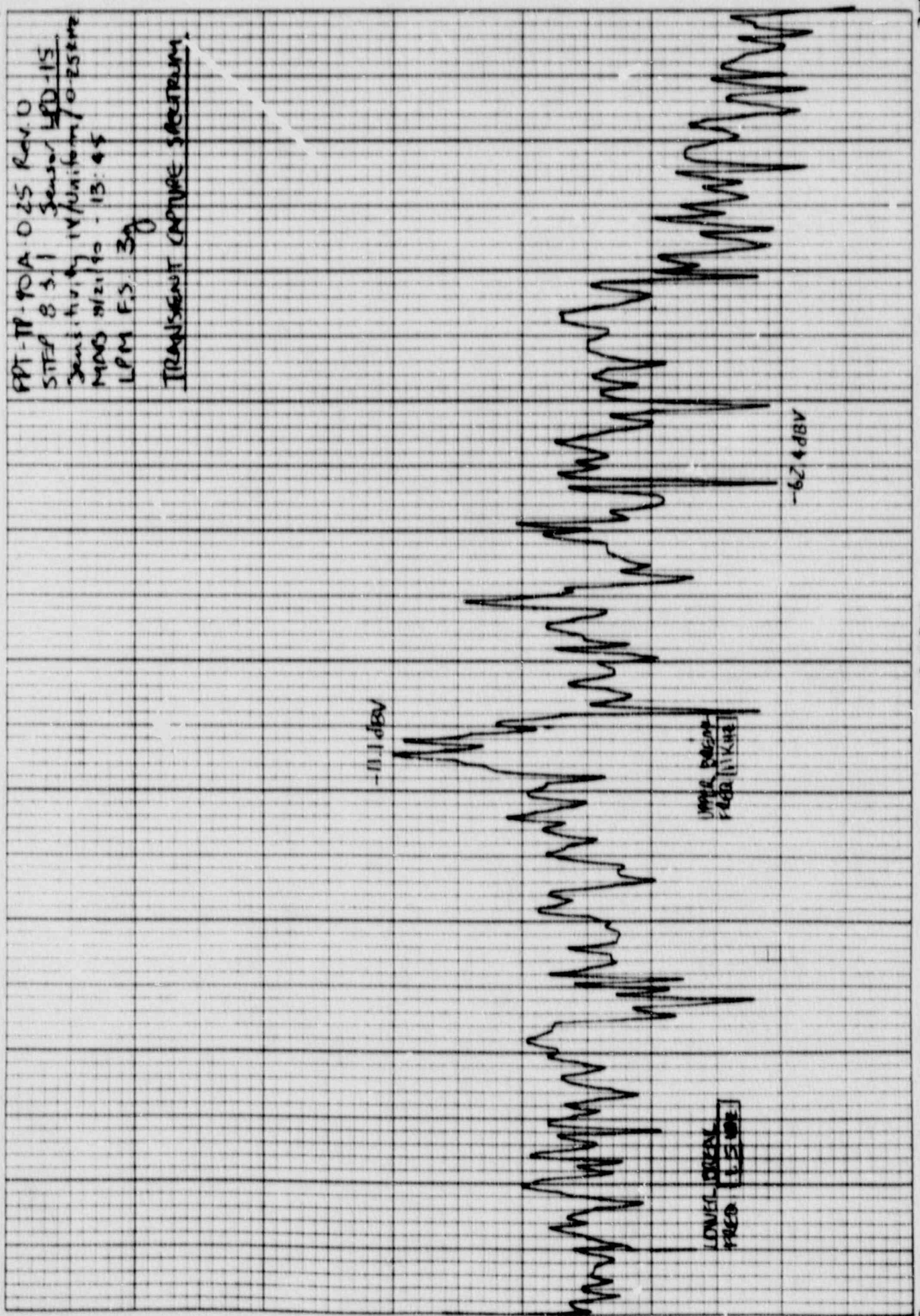
(247)
 247.571

247.572

51

PPT-TP-90A-025 Rev.0
STEP 83.1 Sensor LPD-15
Sensitivity 1V/Uniform/0-25cm/s
MMS 9/21/90 - 13:45
LPM FS 3g

TRANSIENT CAPTURE SPECTRUM



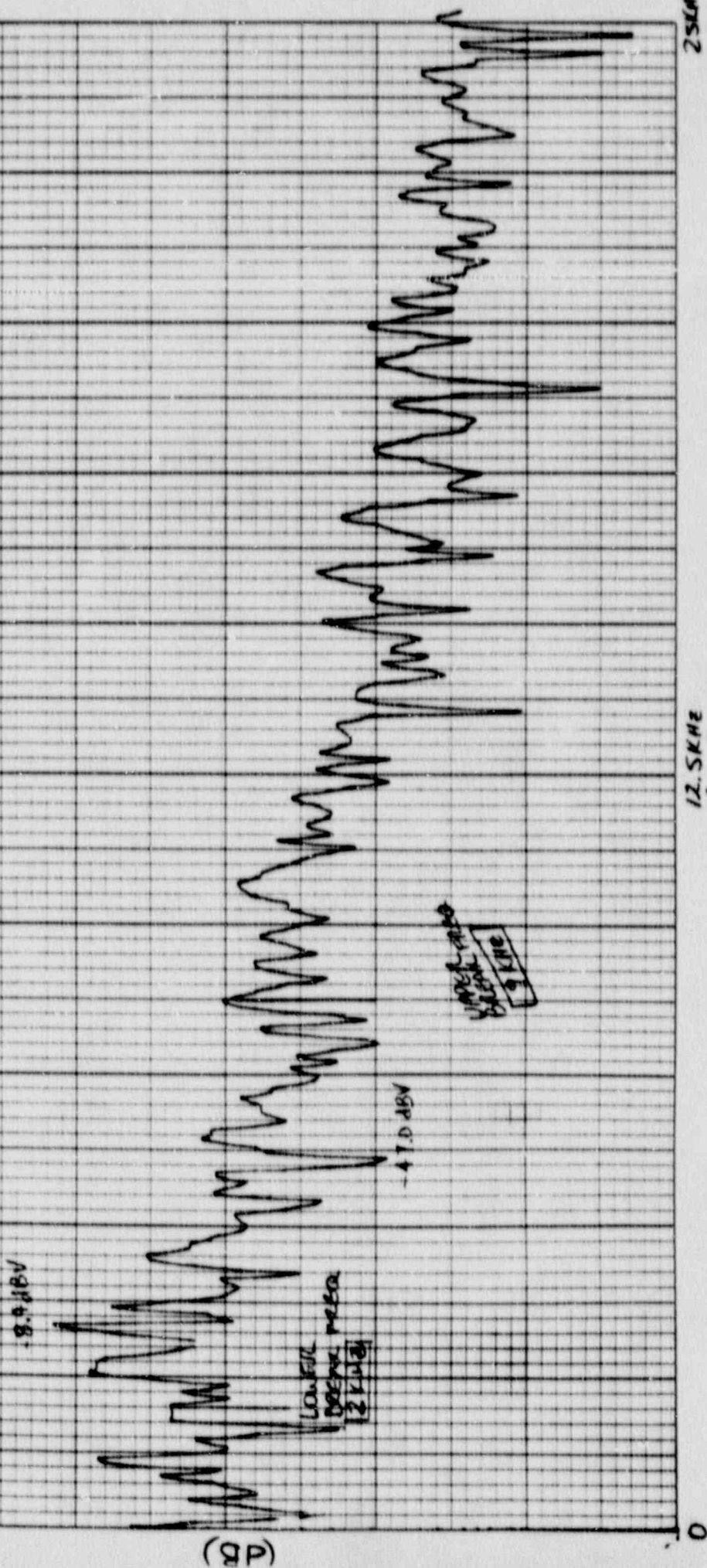
(dB)

2MS2

(2MS2)
2MS21

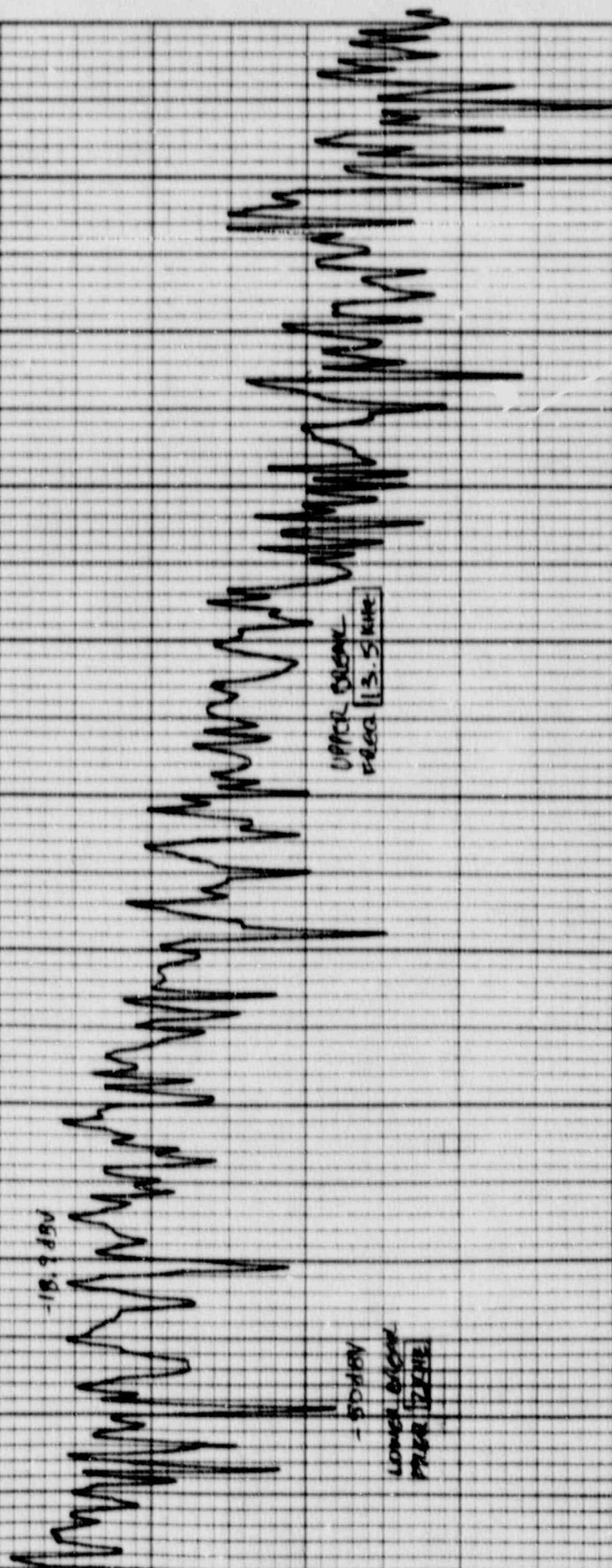
PPT-TP-70A-025 E4V.0
 STEP 8.3.1 - Sensor WPD-16
 Sensitivity iV/Unit/10-25mV
 MAG 8/2/90 - 13:50
 LPM FS 10g

TRANSIENT CAPTURE SPECTRUM



PPT - TD-90A-025 Rev. 0
 STEP 0.31 - Sensor LPO-17
 Sensitivity 1V/Unit, form 0-25000
 MAG 0121110 - 13:55
 LPM FS 3g

TRANSIENT CAPTURE SPECTRUM



(247)
 2475.71

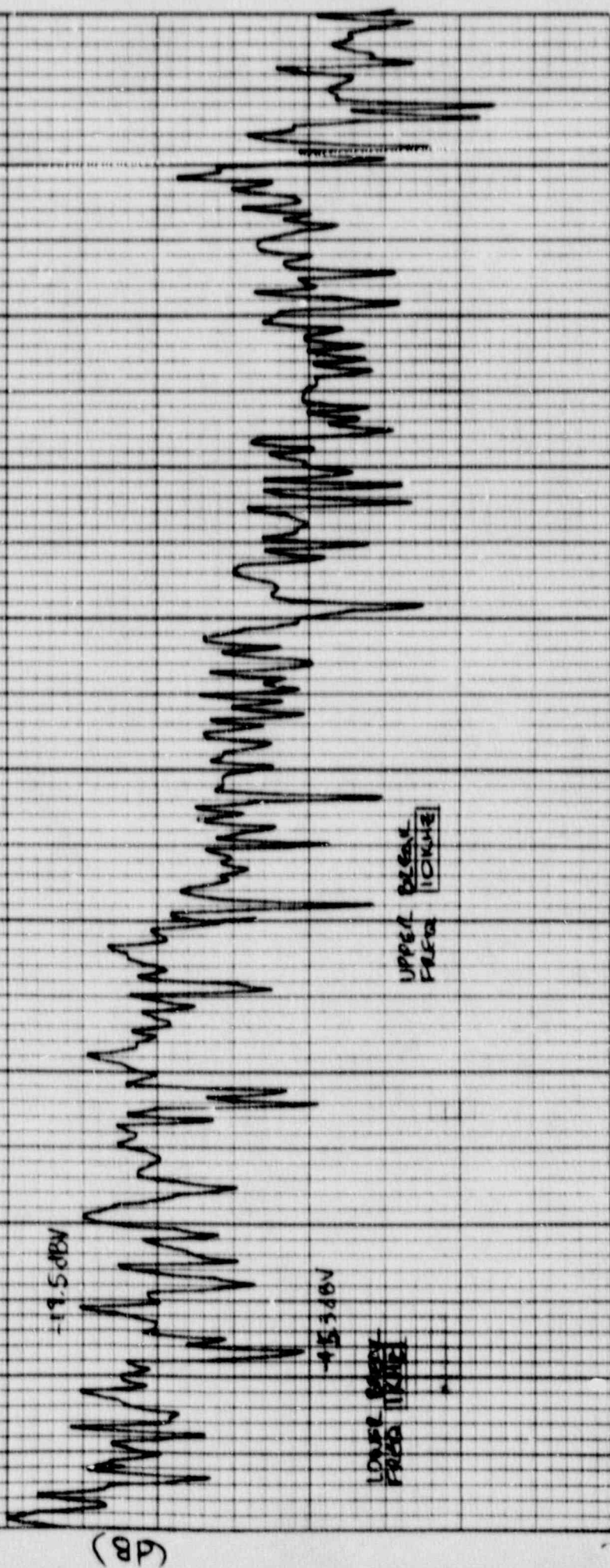
24752

2MYS2

$$12.5 \times 10^3 \text{ (kg)} \times 9.8 \text{ (N/kg)}$$

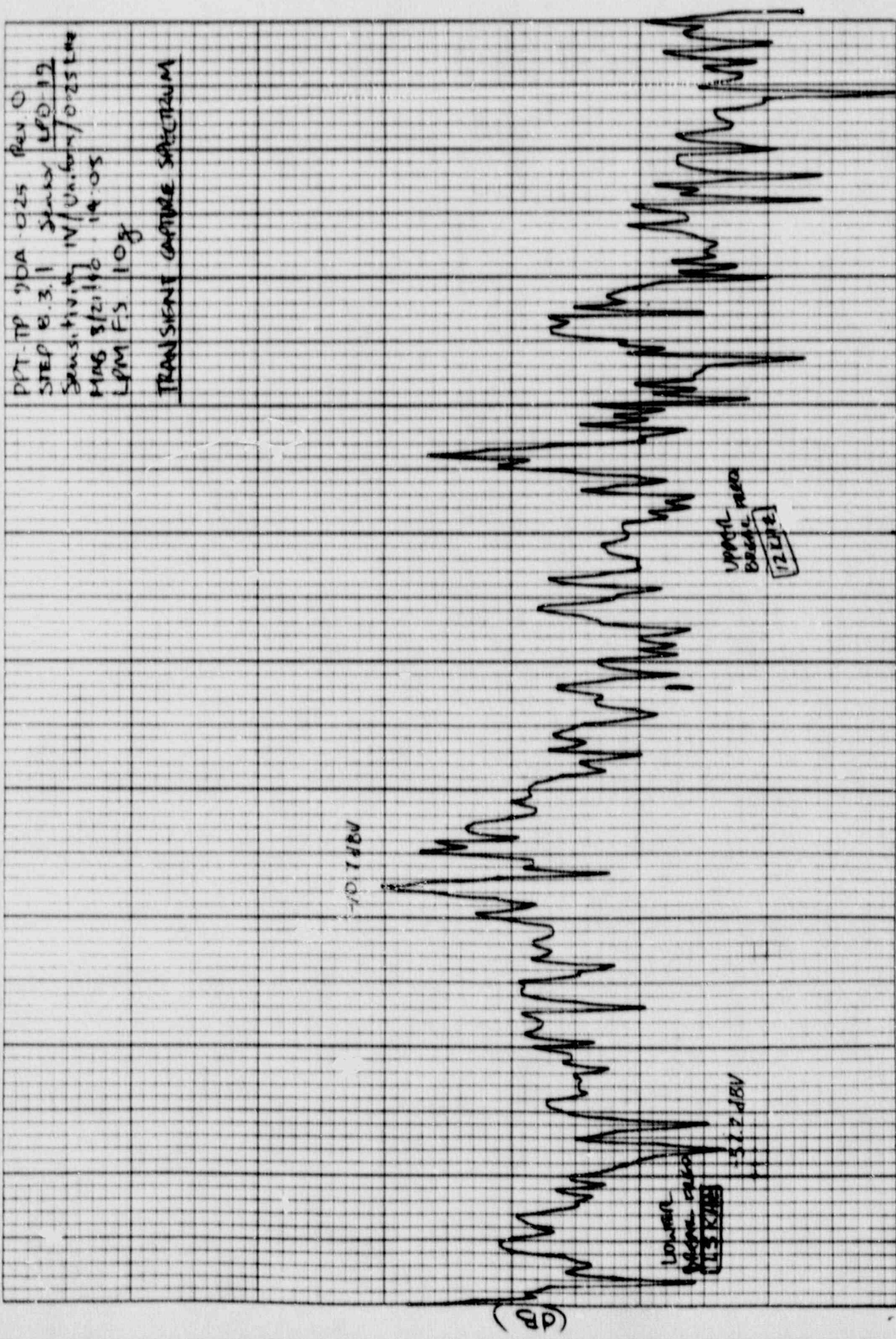
PPT - TP 90A - QLS Rev. 0
STEP 8.3.1 - Sensor LPD-18
Sensor: Fujik IV/Universal 70-2-5000
NWB 8/21/90 14:00
LPM FS 103

TRANSIENT CATURE SPECTRUM



2052

(2M)
2175-71



TRANSIENT CAPTURE SPECTRUM

PPT-TP 10A 025 REV D
STEP 0.3.1 SENS 100 12
SENSITIVITY 1V/Div. 10/0.25 Lm
MAG 8/21/6 14-05
LPM F.5 10g

NBP 2.75

PPT-TP-10A-025 Rev. 0
 STEP 8.3.1 - Sensor LPD-20
 Sensitivity 10/0.00-1/0.25cm
 MAG 812Hz - 14.10
 LPM FS 3g

TRANSIENT CAPTURE SPECTRUM

12.21-

(dB) Volts

10.5 kHz

UPPER BEAT
 FREQ 10.5 kHz

10.69-

(24K)
 2175-71

20752

3.3 Background Amplitude (Power Operation)

The following X-Y plots were made directly off an oscilloscope output while measuring filtered background noise levels at 95% power operation.

FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 1
LPM-1 F.S. 0.3

(Voltage)

1.84V

20mV

(time)

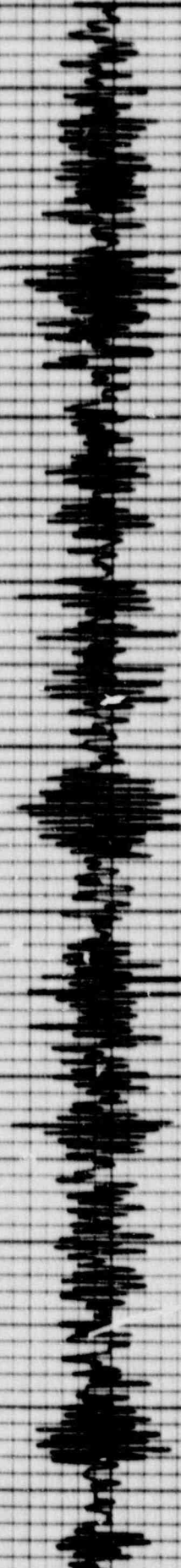
FILTERED BACKGROUND NOISE AT
 POWER OPERATION - SENSOR 2
 LPM-1 F.S. - 0.3

(Volts)

1.08V

20 sec

(time)



FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 3
LPM - 2 P.S. - 1.0

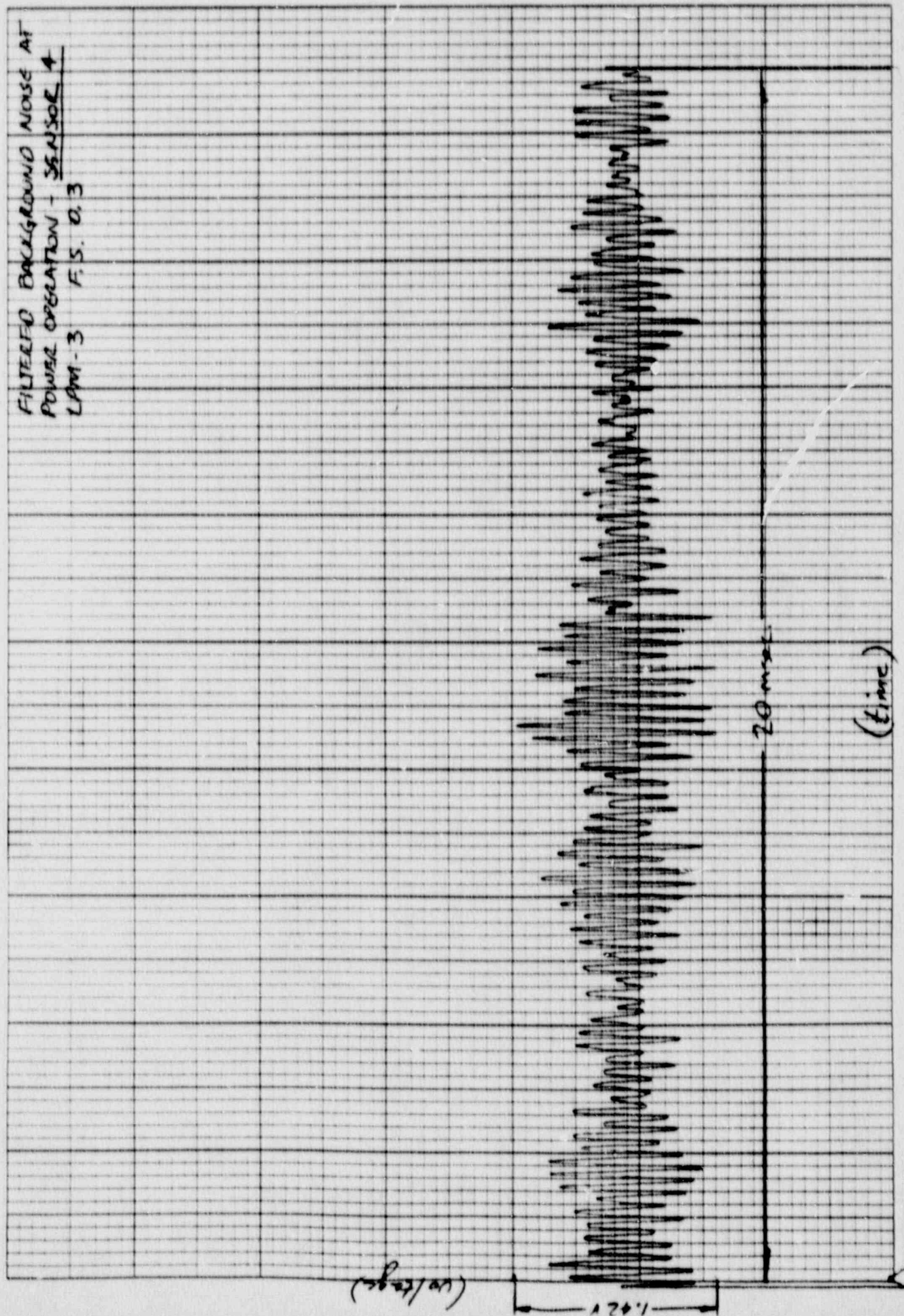
(Voltage)

0.155 V

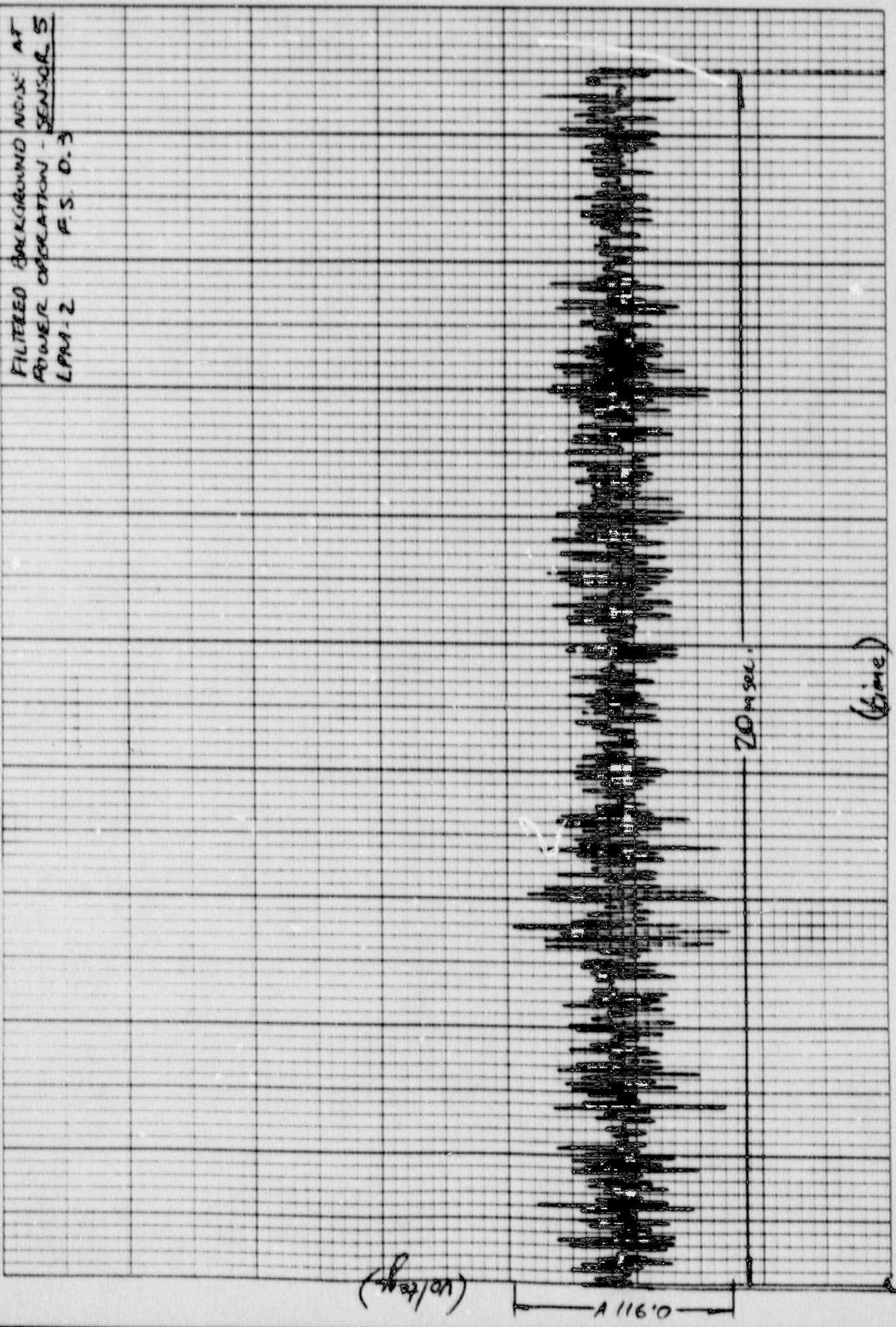
20 m sec.

(time)

FILTERED BACKGROUND NOISE AT
 POWER OPERATION - SENSOR 4
 LAM-3 F.S. 0.3



FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 5
LPM-2 F.S. O.3



FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 6
LPM 4 F.S - 0.3

(volts)

1.5 V

20 sec

(time)

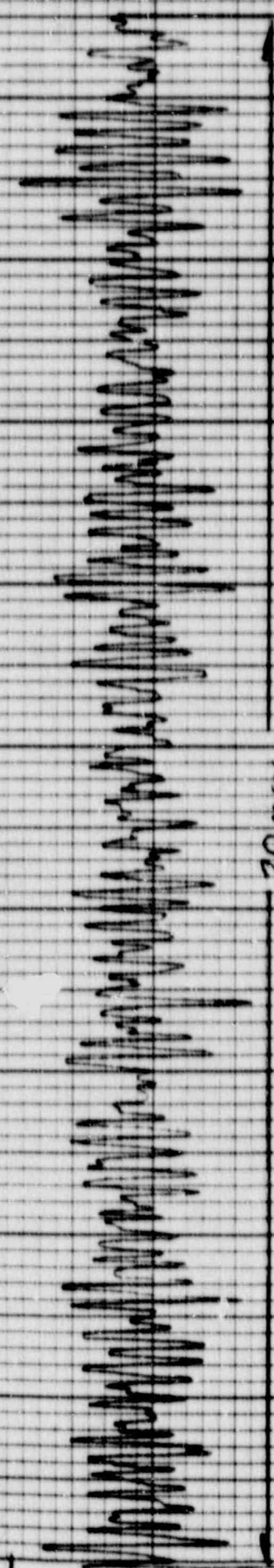
FILTERED BACKGROUND NOISE AT
 POWER OPERATION - SPRINGER 1
 LPM - 5 F.S. 0.1

(volts)

0.265 V

20 msec

(time)



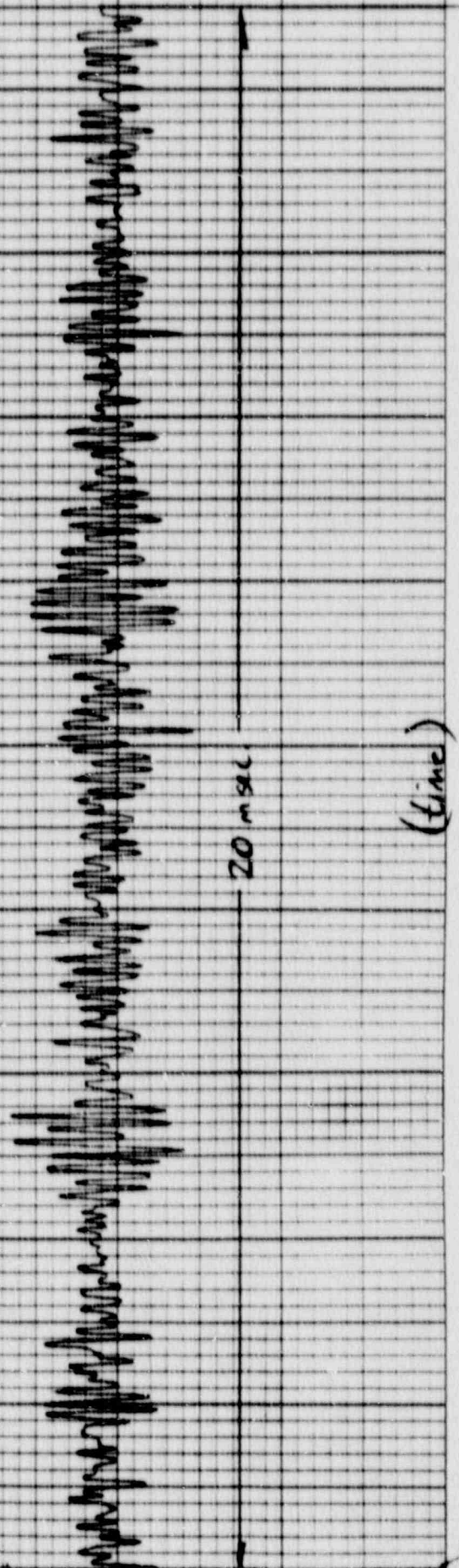
FILTERED BACKGROUND NOISE AT
 POWER OPERATION - SENSORS 8
 LPM-6 F.S. 0.3

(volts)

1.0V

20 ms

(time)



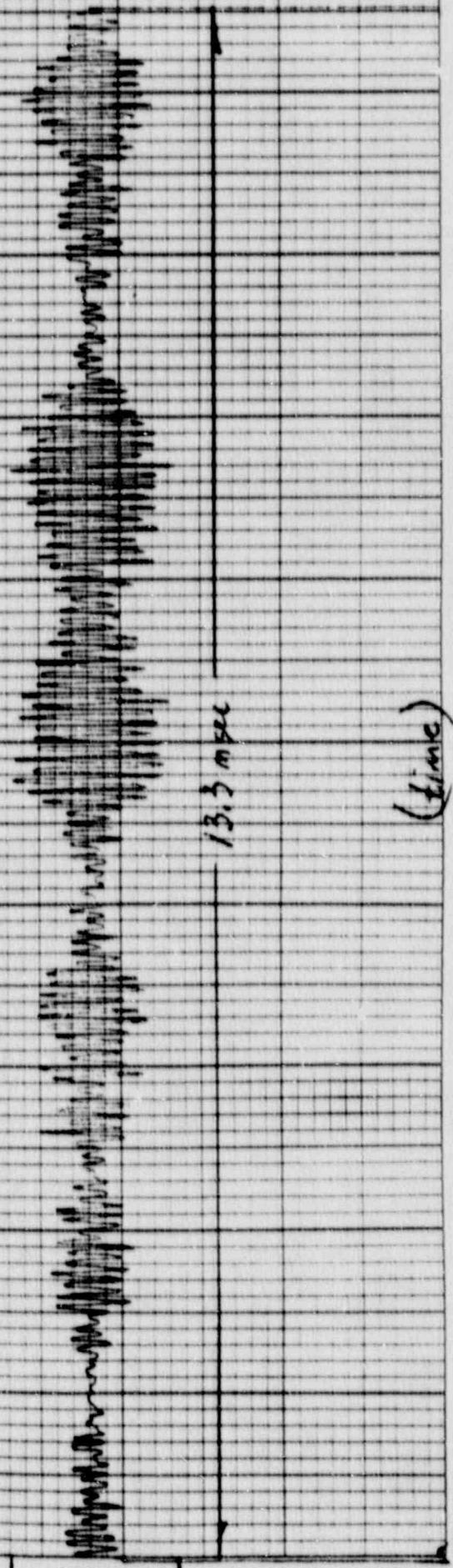
FILTERED BACK GROUND NOISE AT
 POWER OPERATION - SENSOR 9
 LPM-3 F.S. 1.0

(Volts)

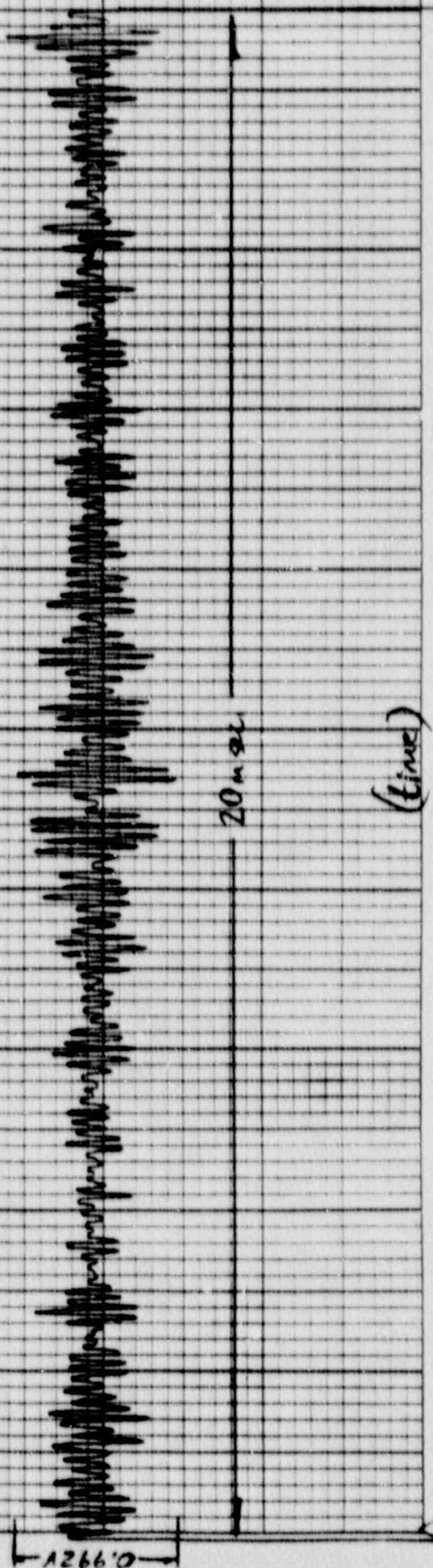
0.965V

13.3 msec

(Time)



FILTERED BACKGROUND NOISE AT
 POWER OPERATION - SENSOR 10
 LPM 7 F.S. 1.0



FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR II

LPM B F.S. - 3.0

(volts)

0.57V

20 sec

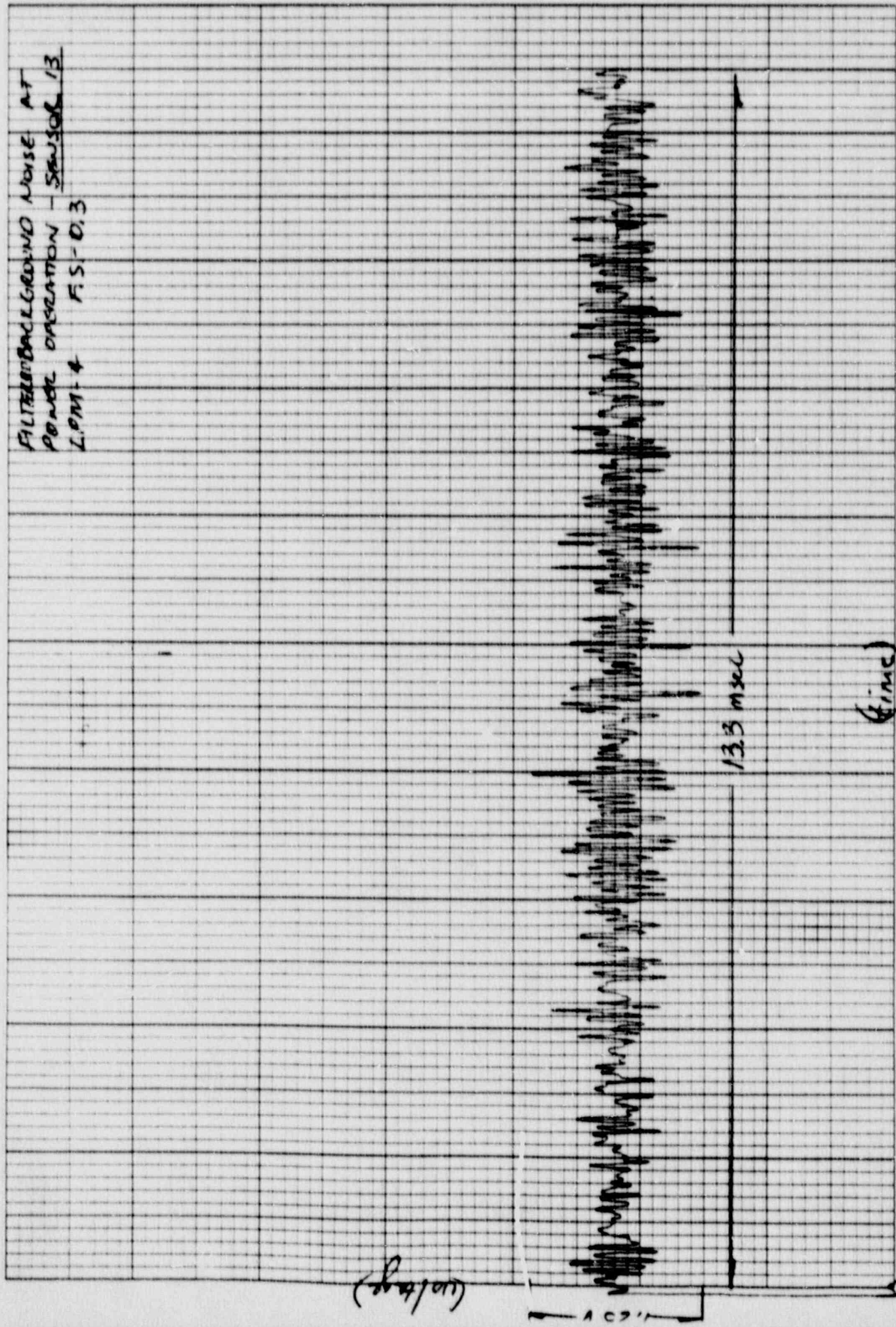
(time)

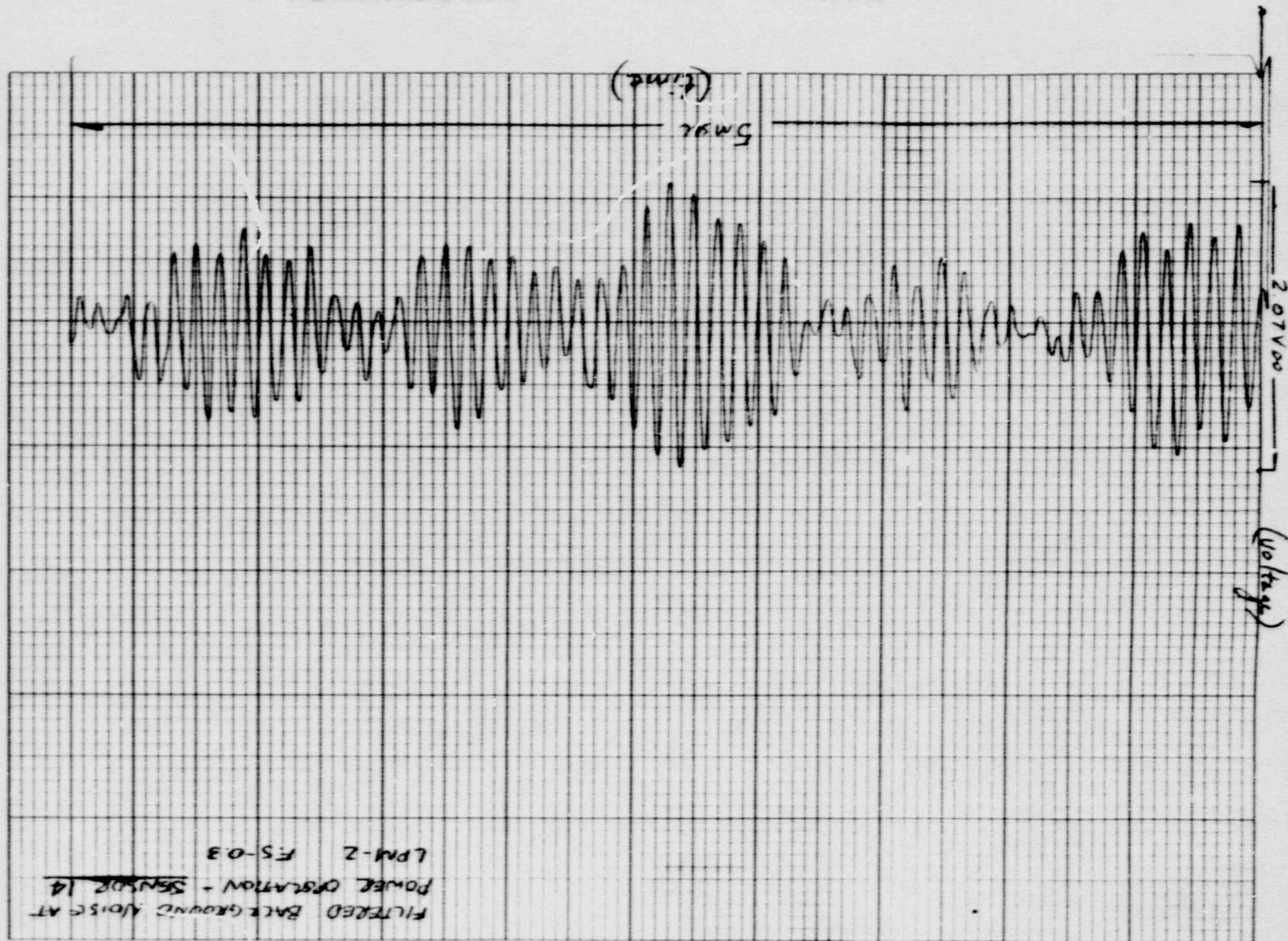
(No. 10)

1.04 Volts

12.3 ms (time)

FILTERED BACKGROUND NOISE AT
 POWER OPERATION - SENSOR 13
 LPM-4 F.S.-0.3





FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 15
LPM-3 F.S. - 0.1

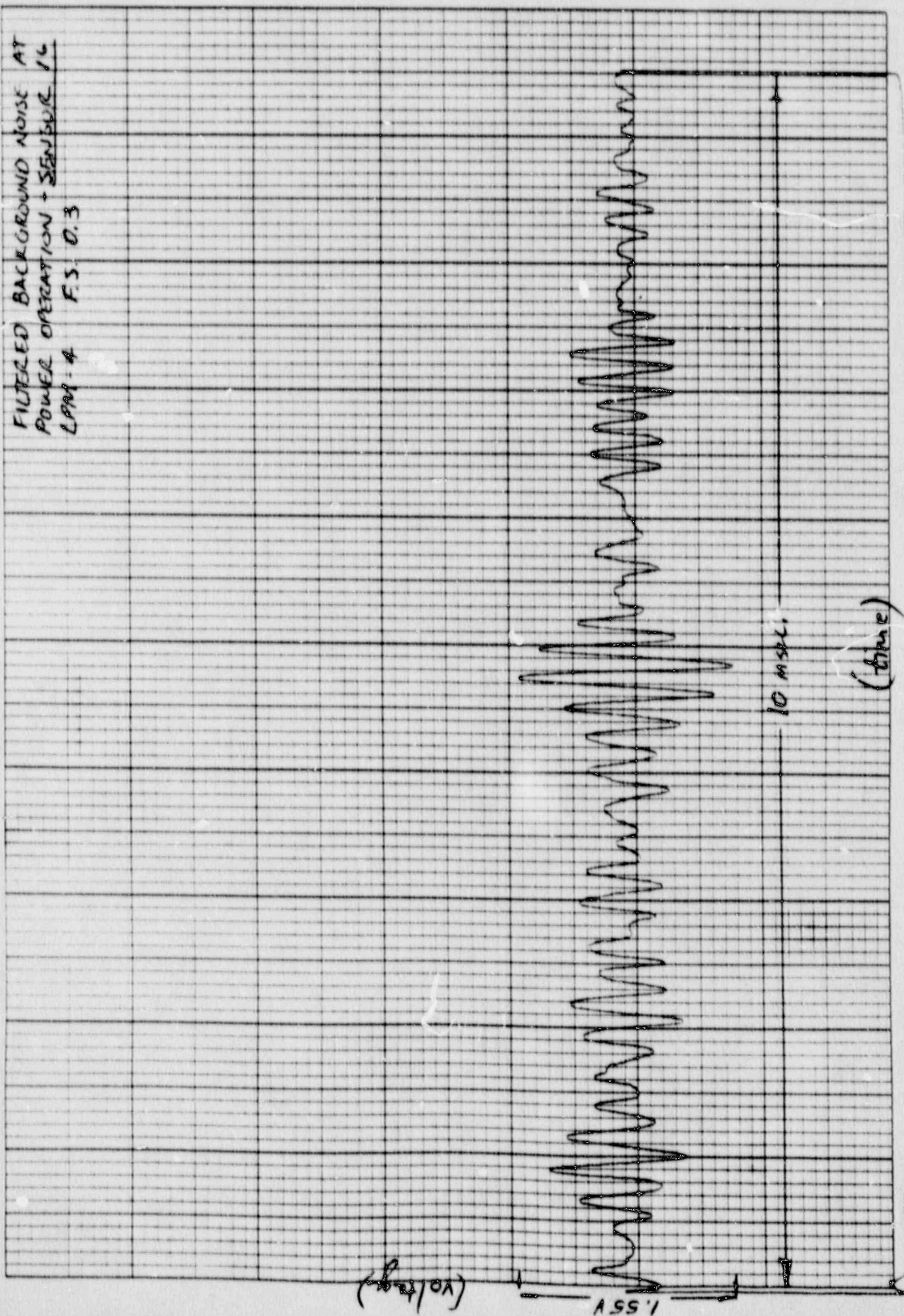
(volts)

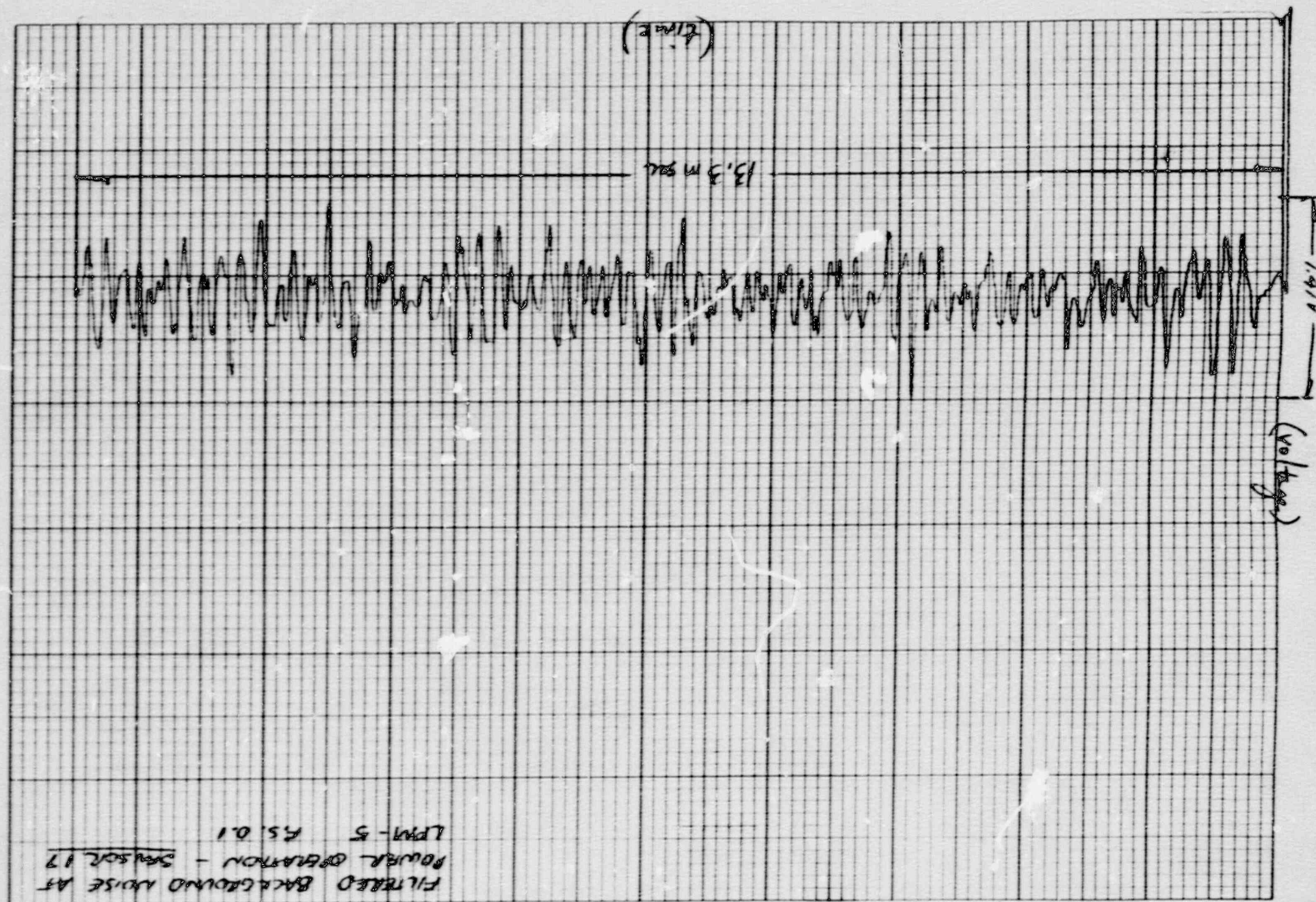
10V

10 msec

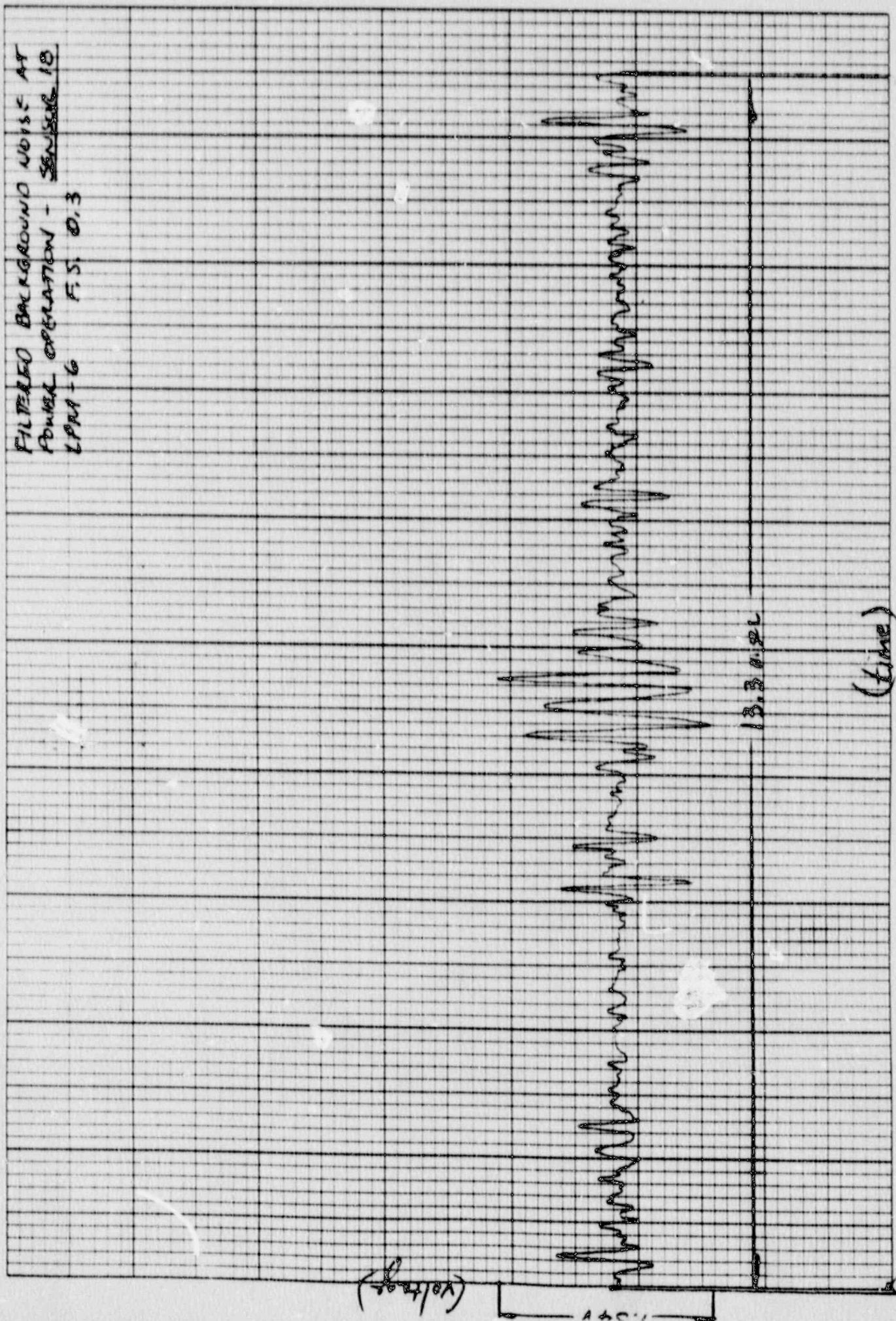
(Time)

FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSITIVE 16
LPA - 4 F.S. 0.3





FILTERED BACKGROUND NOISE AT
POWER OPERATION - ~~SENSE~~ 10
LPRA-6 F.S. 0.3



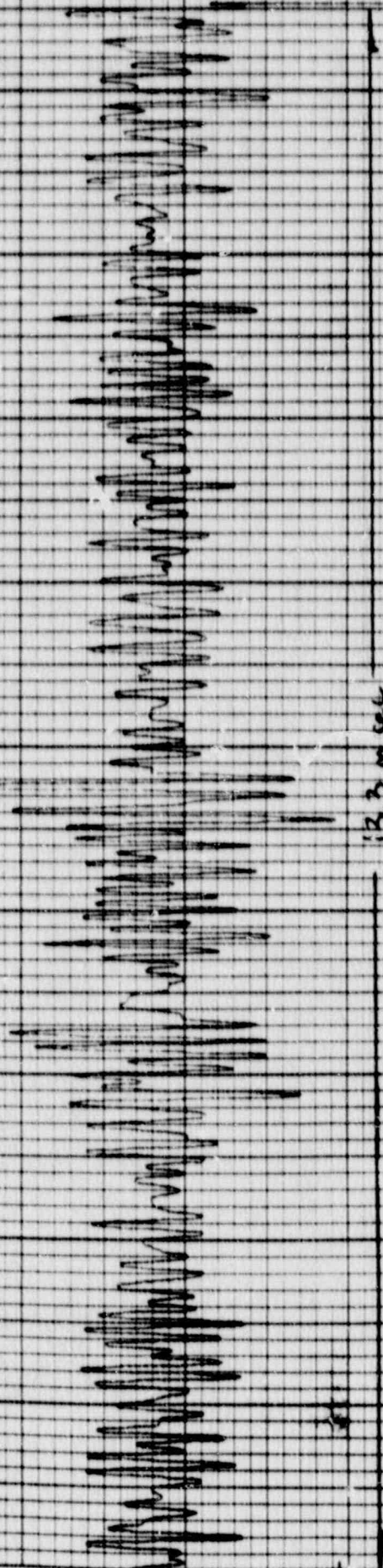
FILTERED BACKGROUND NOISE AT
 POWER OPERATION - STANDARD
 LPM - 7 F.S. - 1.0

(volts)

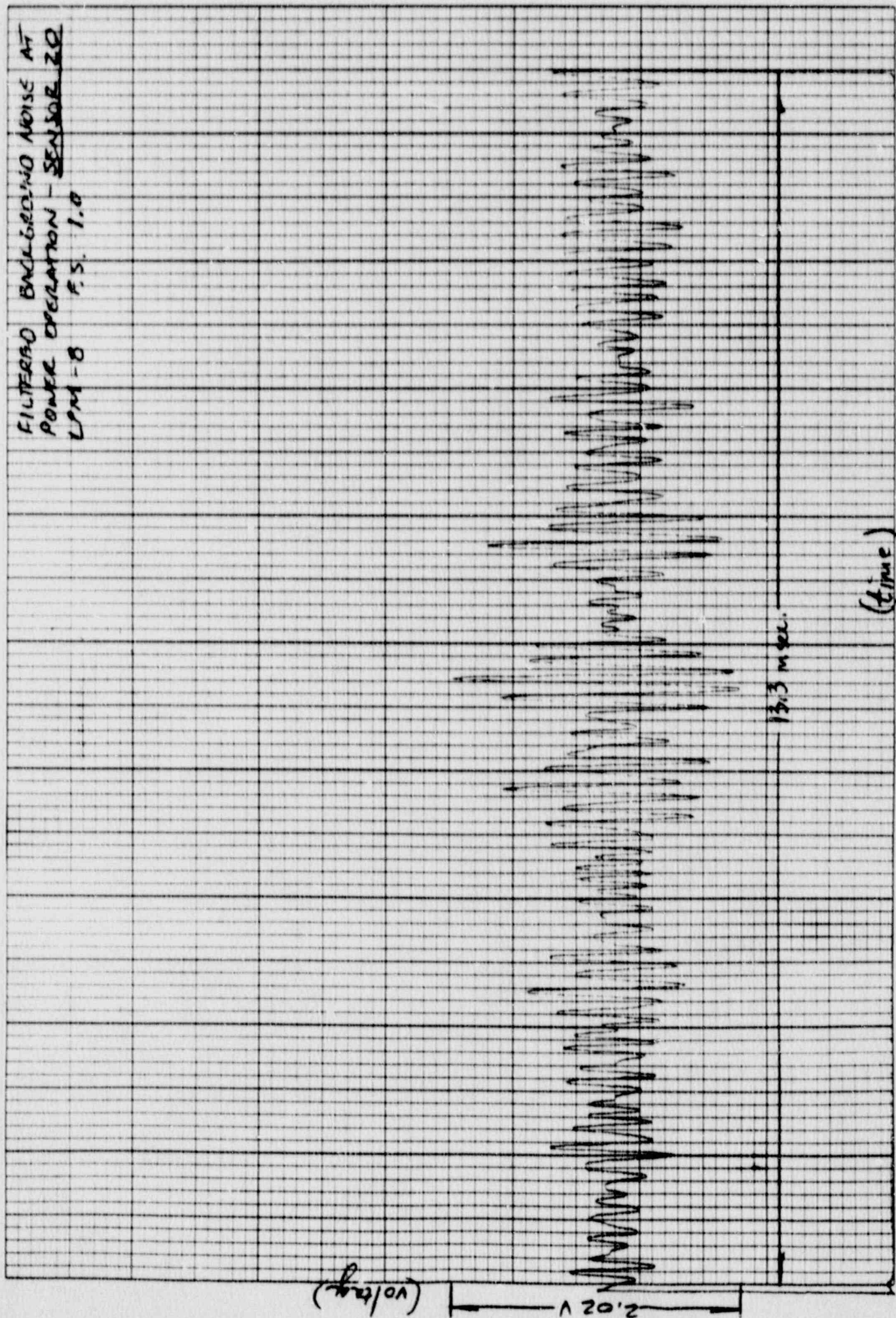
1 V

13.3 msec

(time)



FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 20
LPM - 8 F.S. 1.0

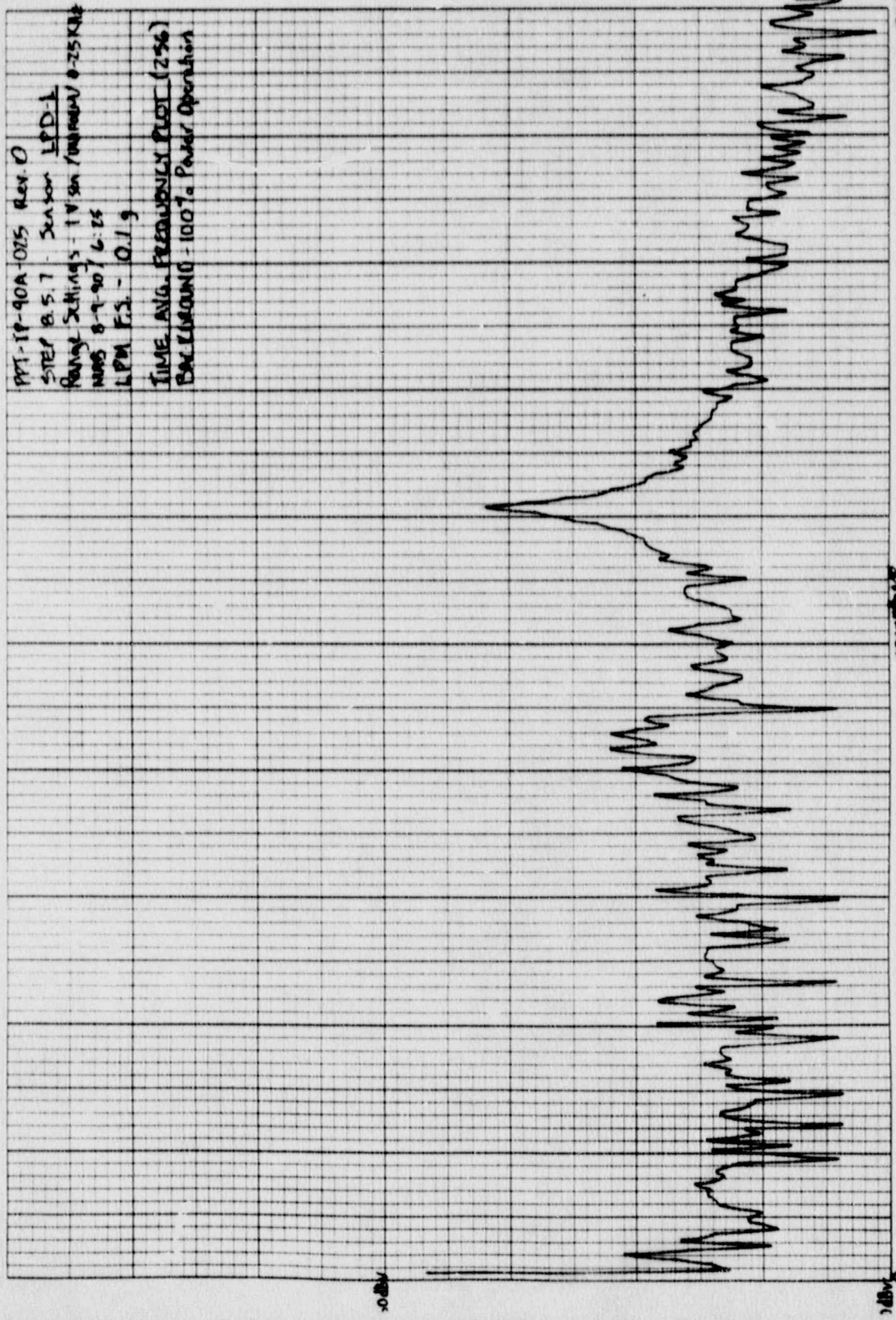


3.4 Background Frequency Spectrum (100% Power)

The following X-Y plots were made using tapes recorded during initial startup test ISU-211A. The background frequency content was compared to the impact frequencies (see Section 3.2) to determine "break frequencies" for bandpass filter adjustments.

PPT-IP-90A-015 Rev. 0
STEP 8.5.7 - Sensor LPD-1
Range Settings - 1 V on / 100 mV on 0-25 kHz
WSS 8-9-90 / 6:25
LPM F.S. - 0.1 g

TIME AVG. FREQUENCY PLOT (256)
Background - 100% Power Operation



25 kHz

12.5 kHz

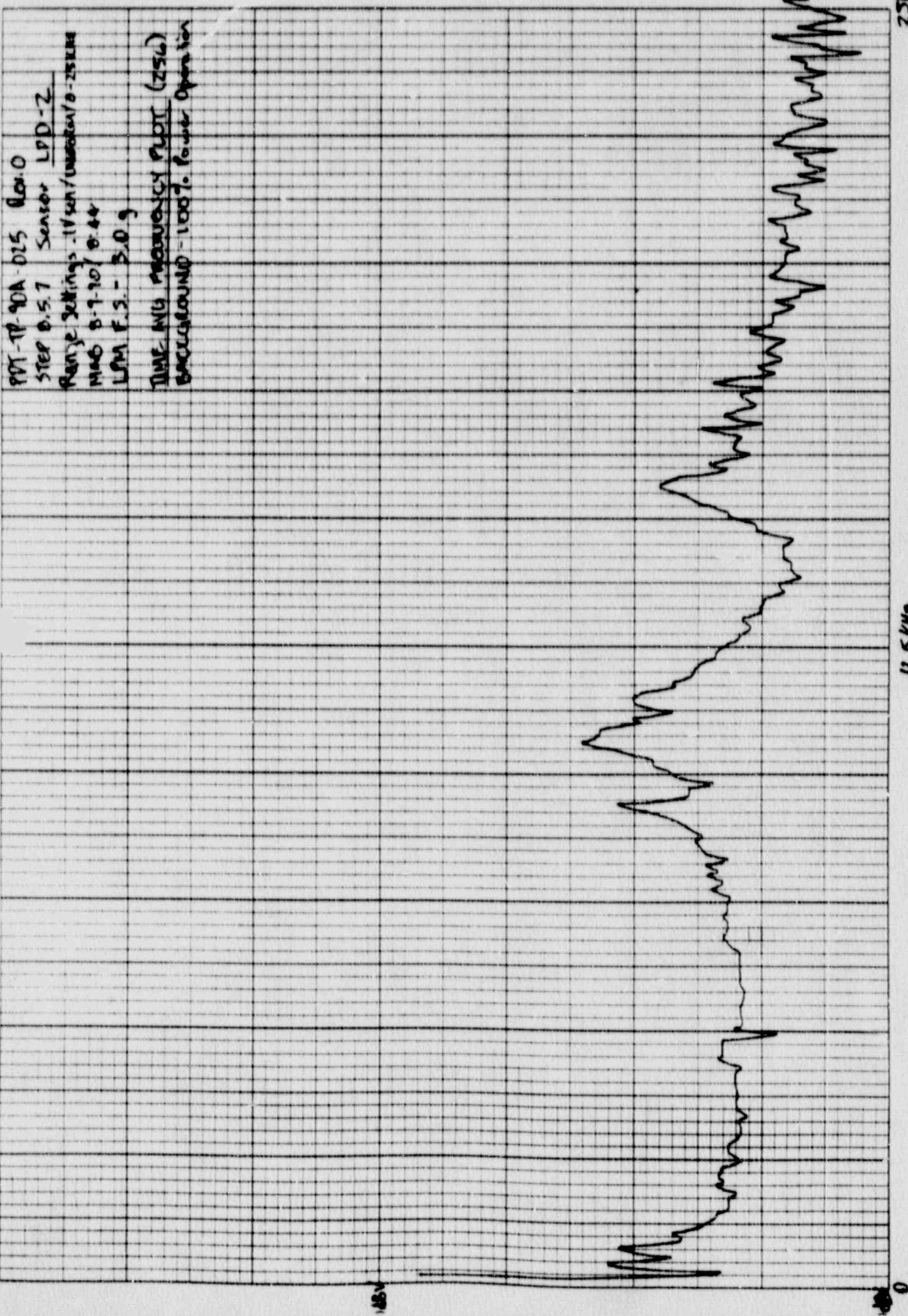
FREQUENCY

10 X 10 TO THE INCH • 7 X 10 INCHES
H. E. MEUFEL & ESSER CO. MADE IN U.S.A.

46 0780

POT-TP-90A-025 Rev.0
STEP 0.5.7 Sensor LPD-2
Range Settings: 14500/100000/0-25KHz
Mag 0.1-10/0.44
LPM F.S. - 3.0 g

TIME AND FREQUENCY PLOT (Z56)
Background - 100% Power Operation



12.5 kHz
FREQUENCY

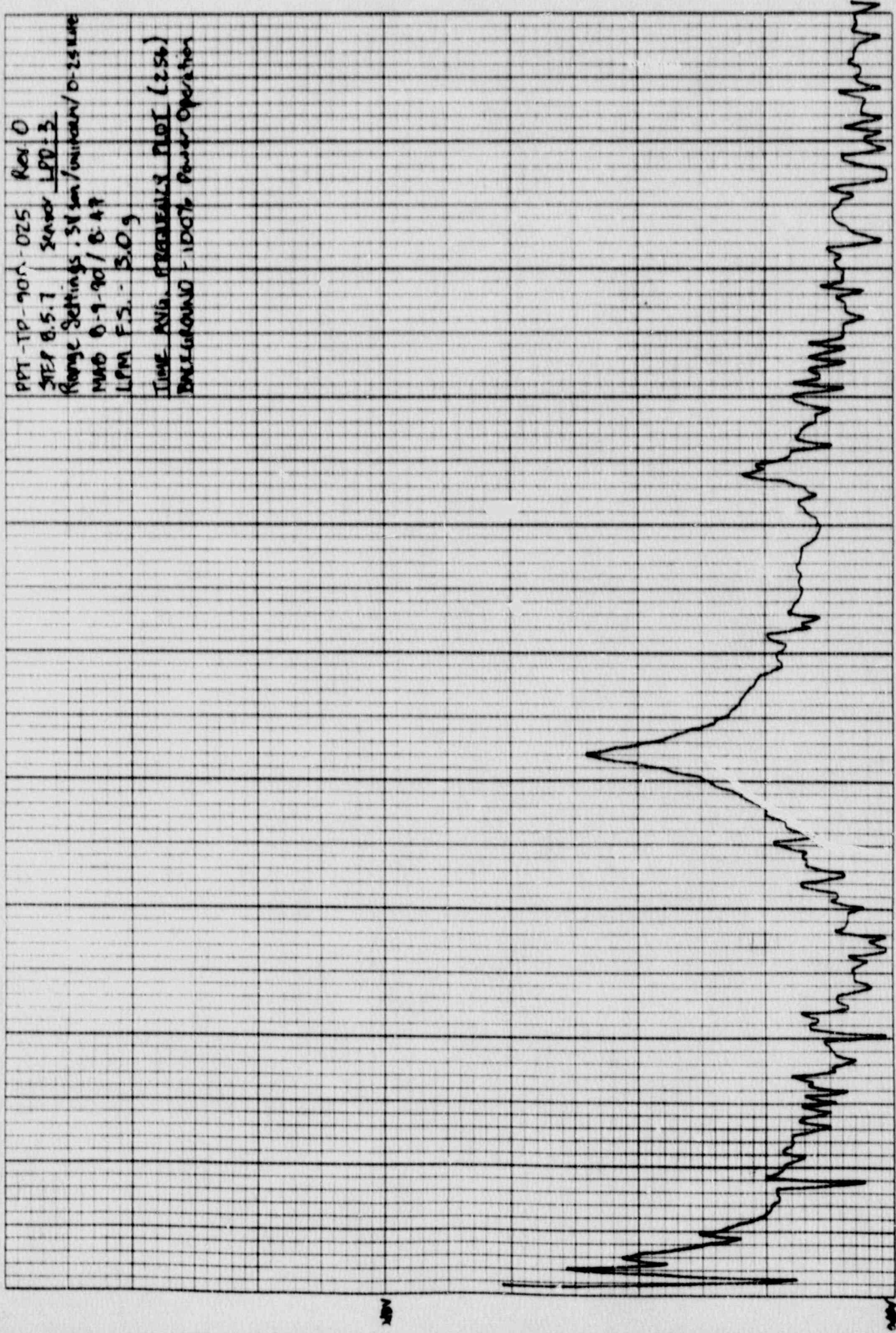
46 0780

K.E. 10 X 10 TO THE INCHES
KIEPPEL & ESSER CO. MADE IN U.S.A.

25KHz

PPT-TP-906-020 Rev 0
 STEP 8.5.7 Sensor LPO-3
 Range Settings: 31 km / unit / km / 0-25 km
 MAG 0-9-90 / 0-47
 LPM FS - 3.0 g

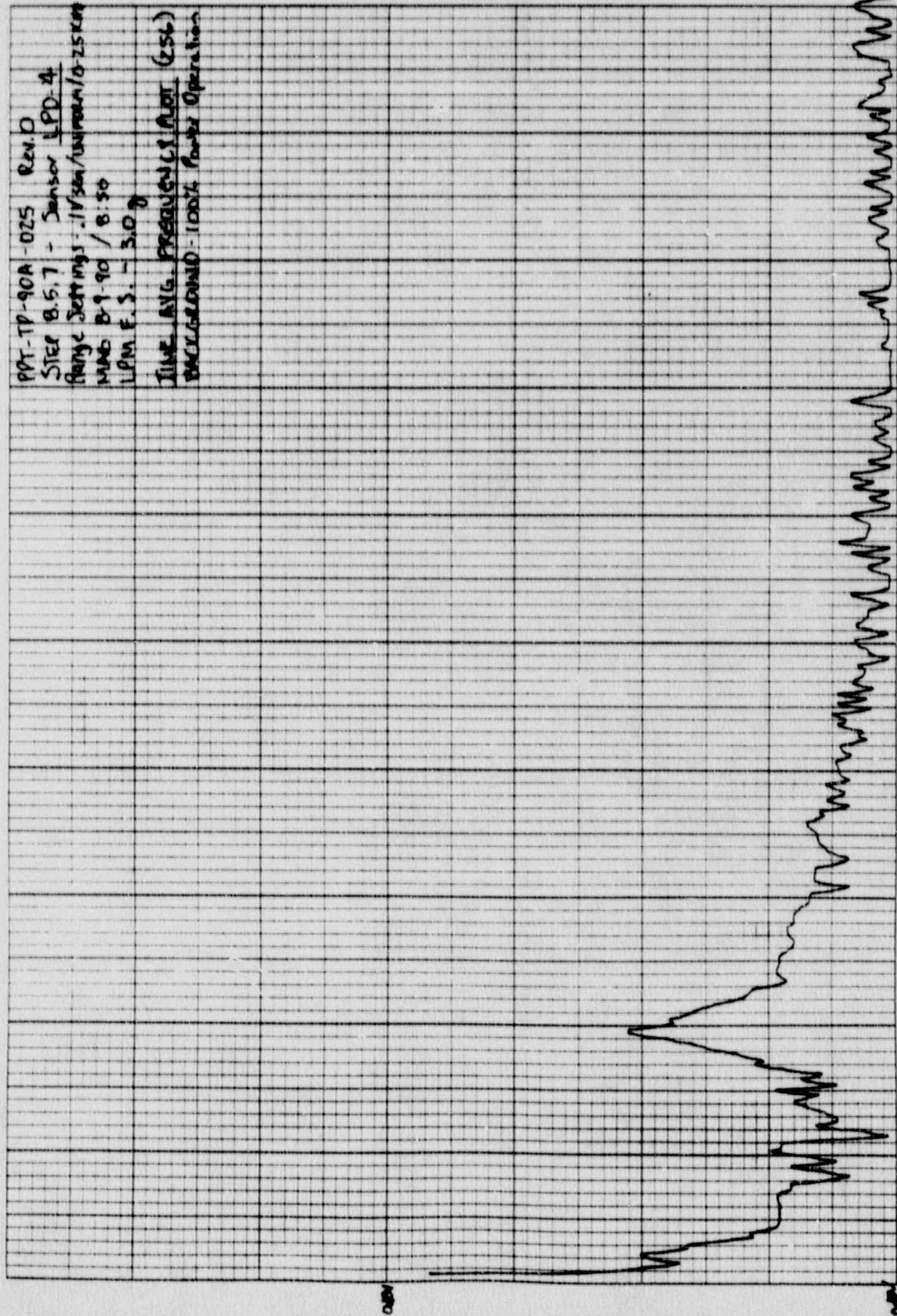
TIME 256 FREQUENCY PLOT (256)
 BACKGROUND - 100% Power Operation



12.5 kHz
 FREQUENCY

25 kHz

PPT-TP-90A-025 Rev.D
 STEER 8.5.7 - Sensor LPD-A
 Range Settings: 1V/Sec/100mm/0-25KHz
 MAG 8-9-90 / 8:50
 LPM F.S. - 3.0 g
 TIME AVG. FREQUENCY PLOT (256)
 BACKGROUND - 100% Power Operation



25KHz

25KHz

FREQUENCY

10 X 10 TO THE INCH • 7 X 10 INCHES
 H.E. NEUFEL & ESSER CO. MADE IN U.S.A.

46 0780

PPT-TP-90A-025 Rev. 0

MEP 0.5.7 Senior LPD-5

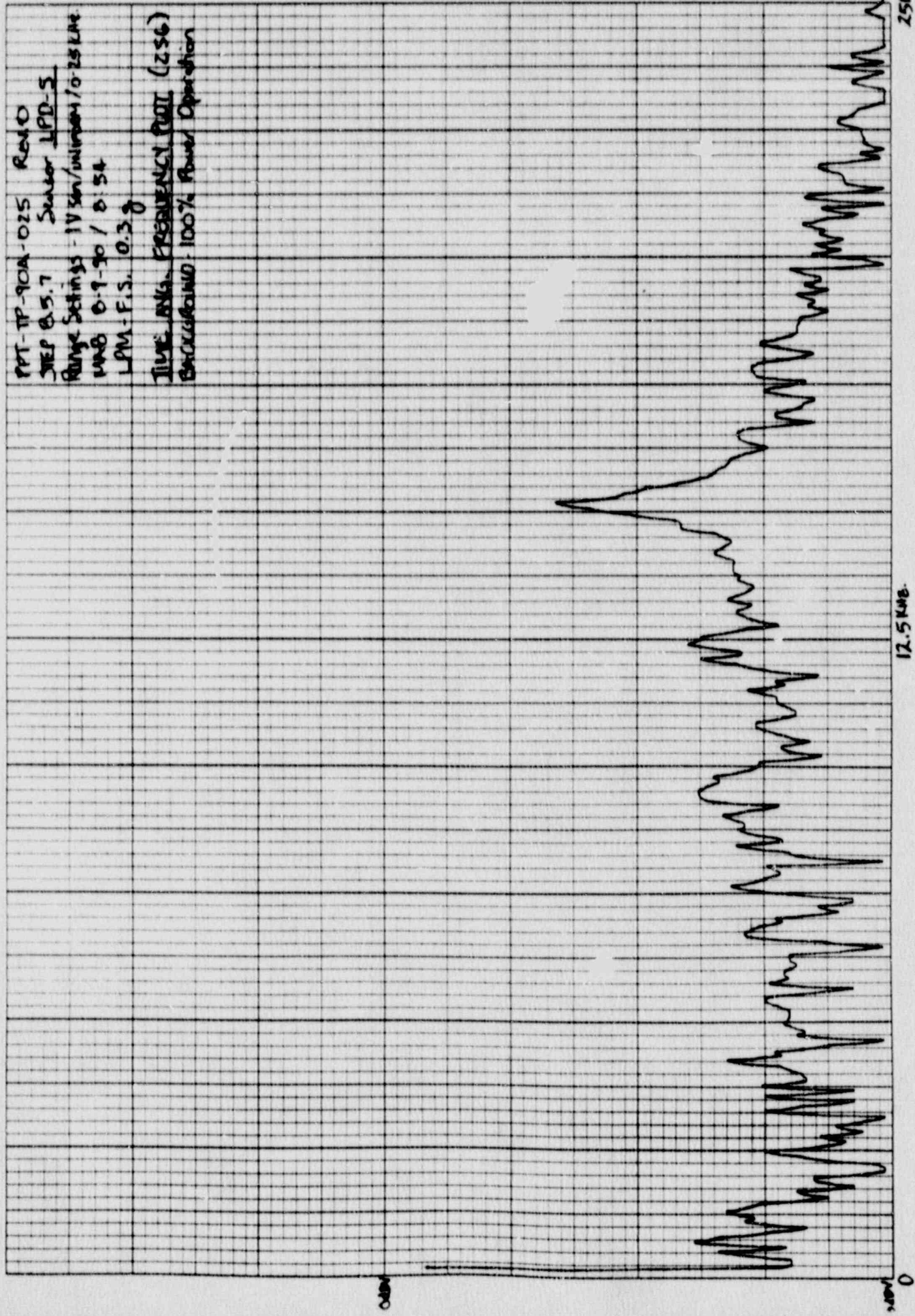
Range Settings - 1V 30mV/division / 0.25 kHz

WAB 0.9-90 / 0.54

LPM-F.S. 0.3g

TIME BASE FREQUENCY PLOT (Z56)

BACKGROUND: 100% Power Operation



0.5.71

FREQUENCY

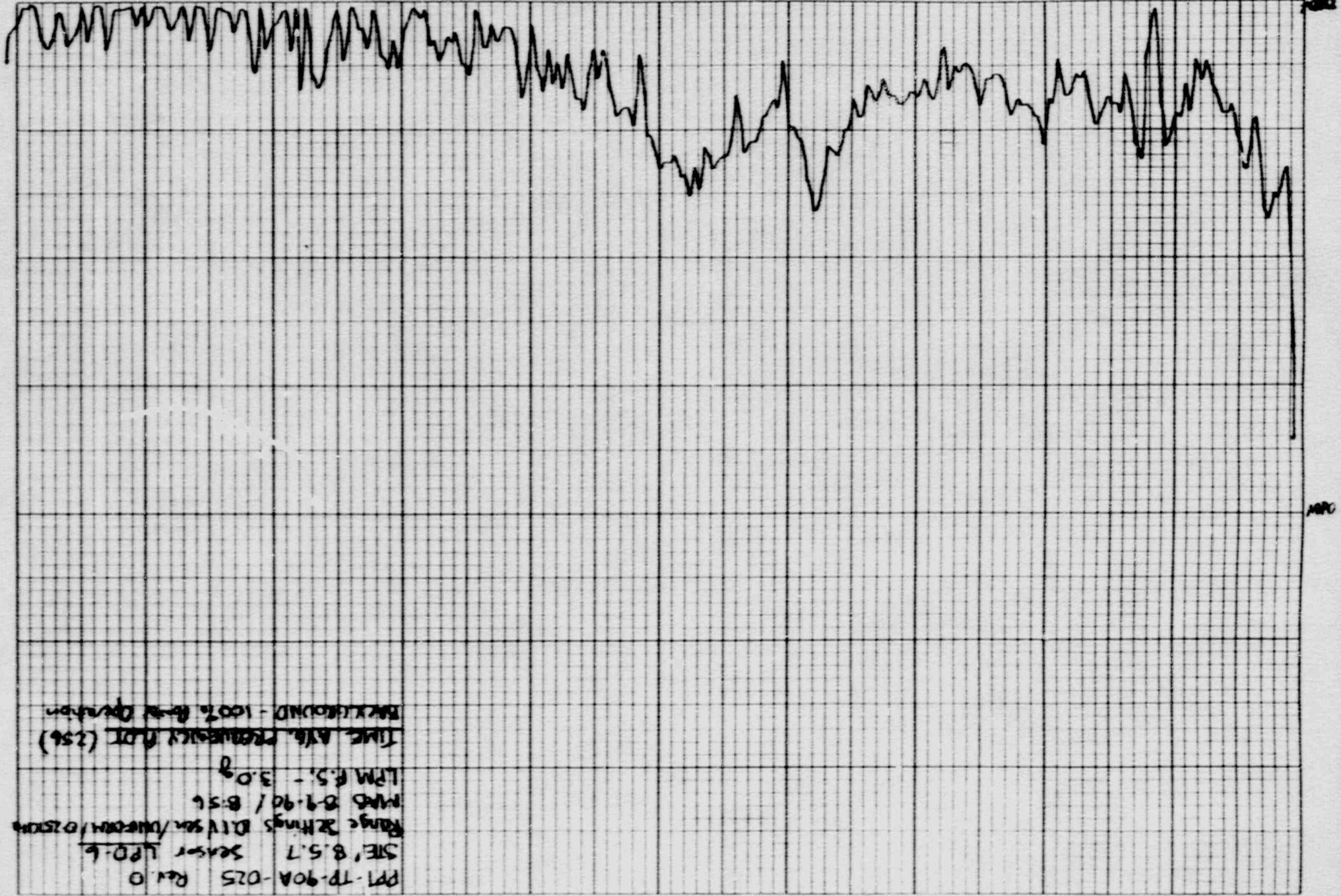
0.5.71

FREQUENCY

12.5 kHz

25 kHz

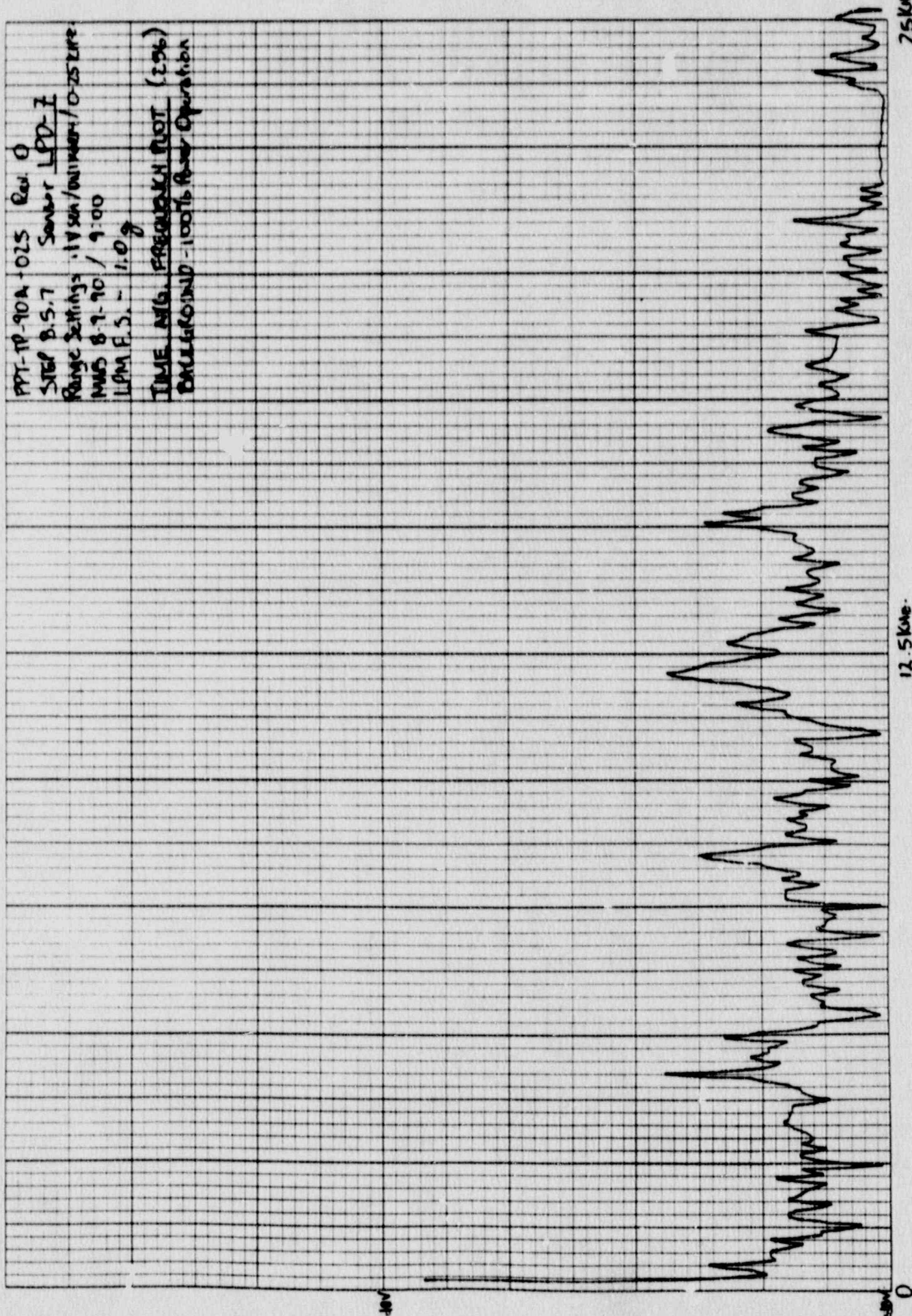
0



PPT-TP-90A-025 Rev 0
 STE 8.5.7 Sensor LPO-6
 Range 2 kHz/div 100 kHz/div 0.25 kHz/div
 RMS 8.9.90 / 8.56
 LPM 8.5. - 3.0 g
 TIME AVE. FREQUENCY PLOT (256)
 BACKGROUND - 100% (low operation)

PPT-10-90A-025 Rev. 0
 STEP 8.5.7 Sensor LPD-7
 Range Settings: 1.0 sec/0.1 sec/0-25 kHz
 MMS 8.7-90 / 9:00
 LPA F.S. - 1.0 g

TIME N16. FREQUENCY PLOT (296)
 BACKGROUND - 100% Base Operation



25 kHz

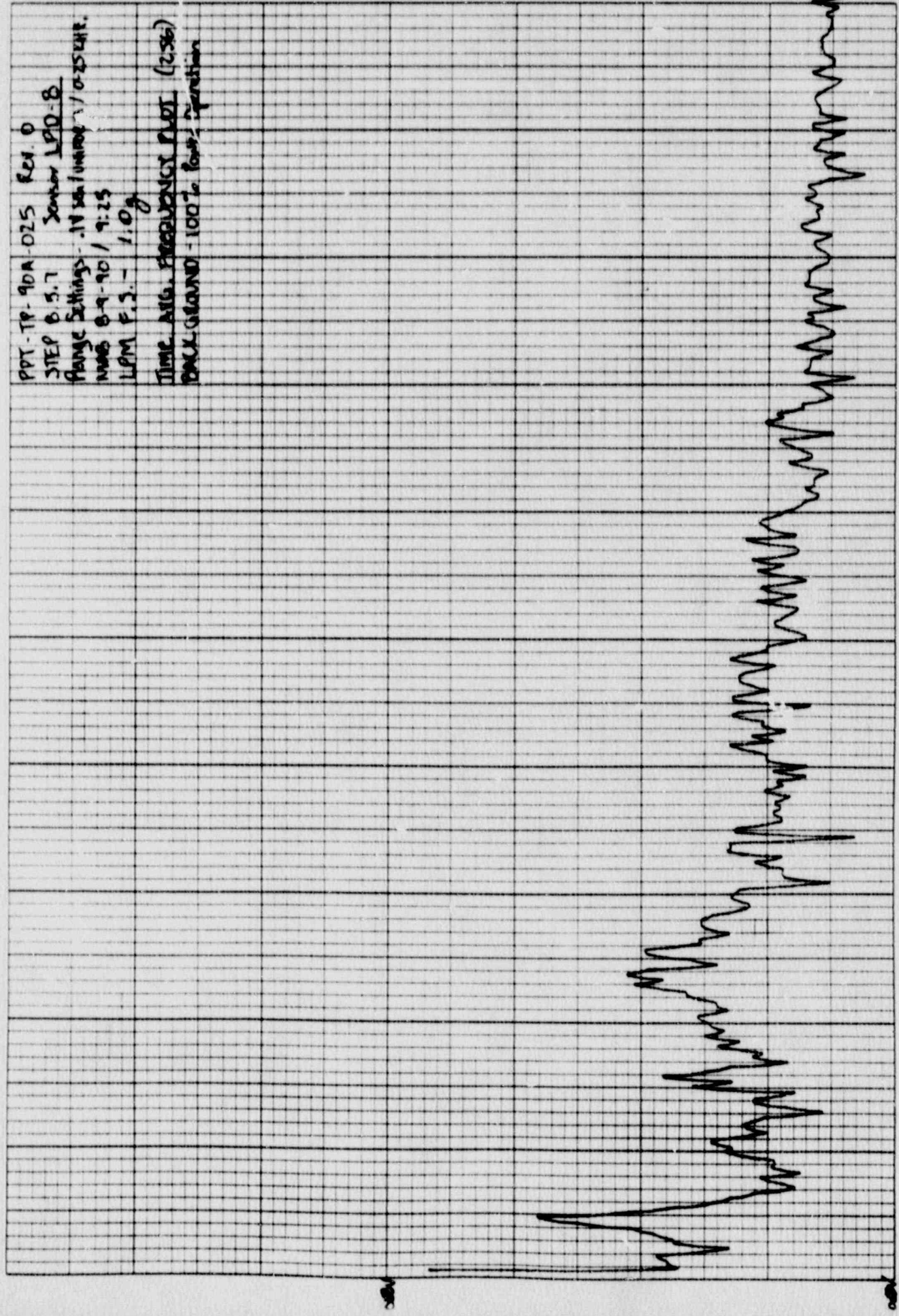
12.5 kHz

Frequency

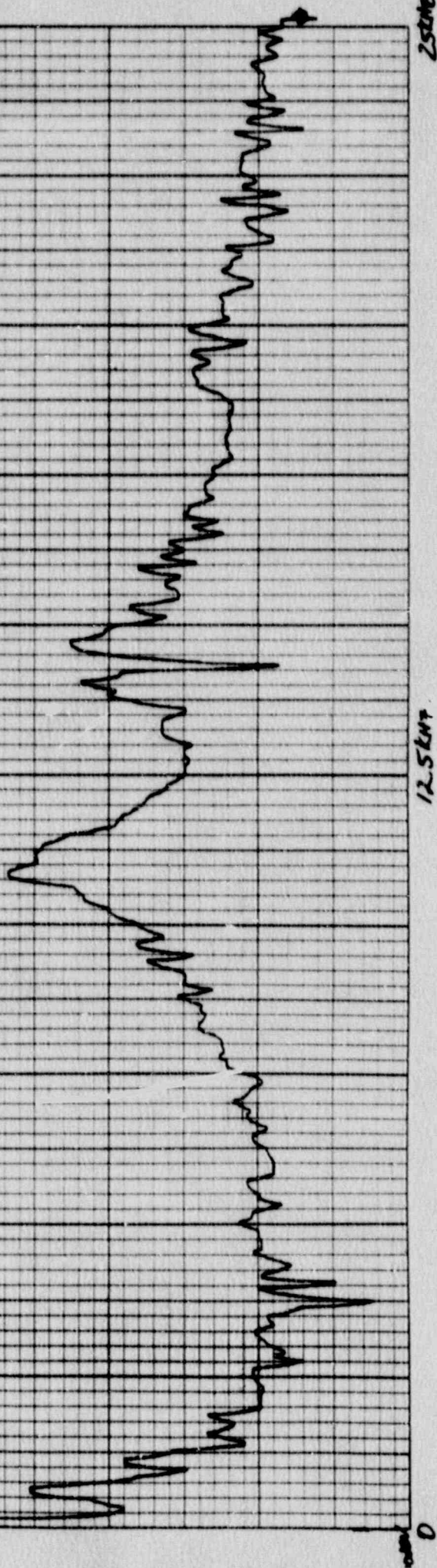
46 0780

K&E
 10 X 10 TO THE INCH • 7 X 10 INCHES
 REUFEL & ESSER CO. MADE IN USA

PPT-TP-90A-025 Rev. 0
 STEP 0.5.7 Sensor LPO-B
 Range Settings - 14 sec / 1000 Hz / 0.25 kHz
 MAG 0.9-90 / 9.25
 LPM F.3 - 1.0g
 TIME 1816. FREQUENCY PLOT (256)
 BACK GROUND - 100% Power Spectrum



PPT-TP-90A-025 Rev. 0
 STEP 8.5.7 Sensor LPP-2
 Range Settings 0.1V_{sm}/1000mV/10-ZS_{sm}
 MAG 0.7-70/7-32
 LPA F.S. - 1.0g
 TIME AVG. FREQUENCY PLOT (256)
 OPERATING - 100% Power Operation



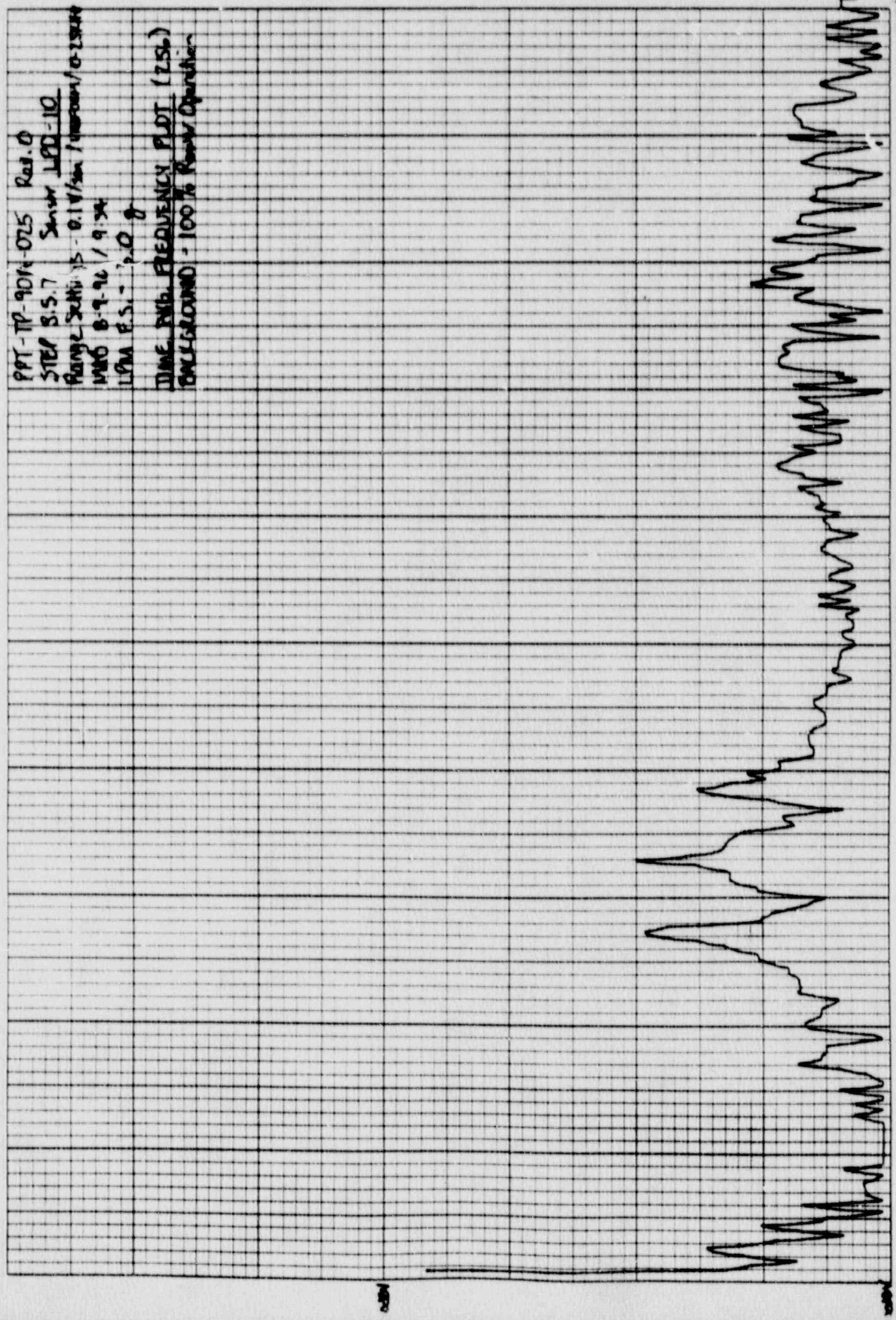
FREQUENCY

46 0780

H.E. 10 X 10 TO THE INCH 7 X 10 INCHES
 REUFFEL & ESSER CO. MADE IN U.S.A.

25 kHz

PPT-TP-9014-025 Rad. 0
 STEP 8.5.7 Sensor LPO-10
 Range Setting 15 - 0.1V/sec 140000/0-25000
 MAG 8-9-90 / 9:50
 LPO 8.5.7 - 2.0 g
 TIME 1116 FREQUENCY PLOT (Z56)
 BACKGROUND - 100% Power Operation

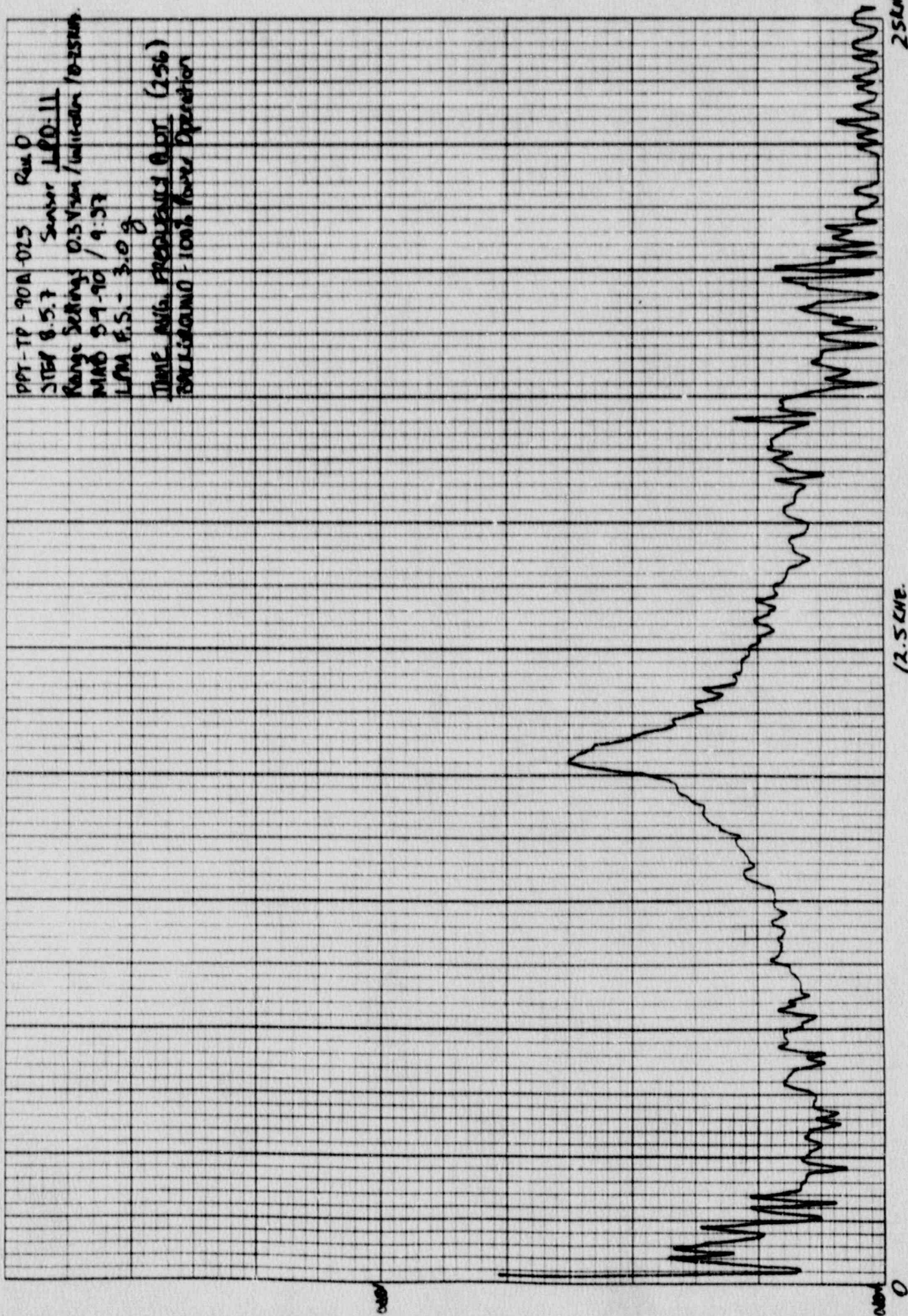


FREQUENCY

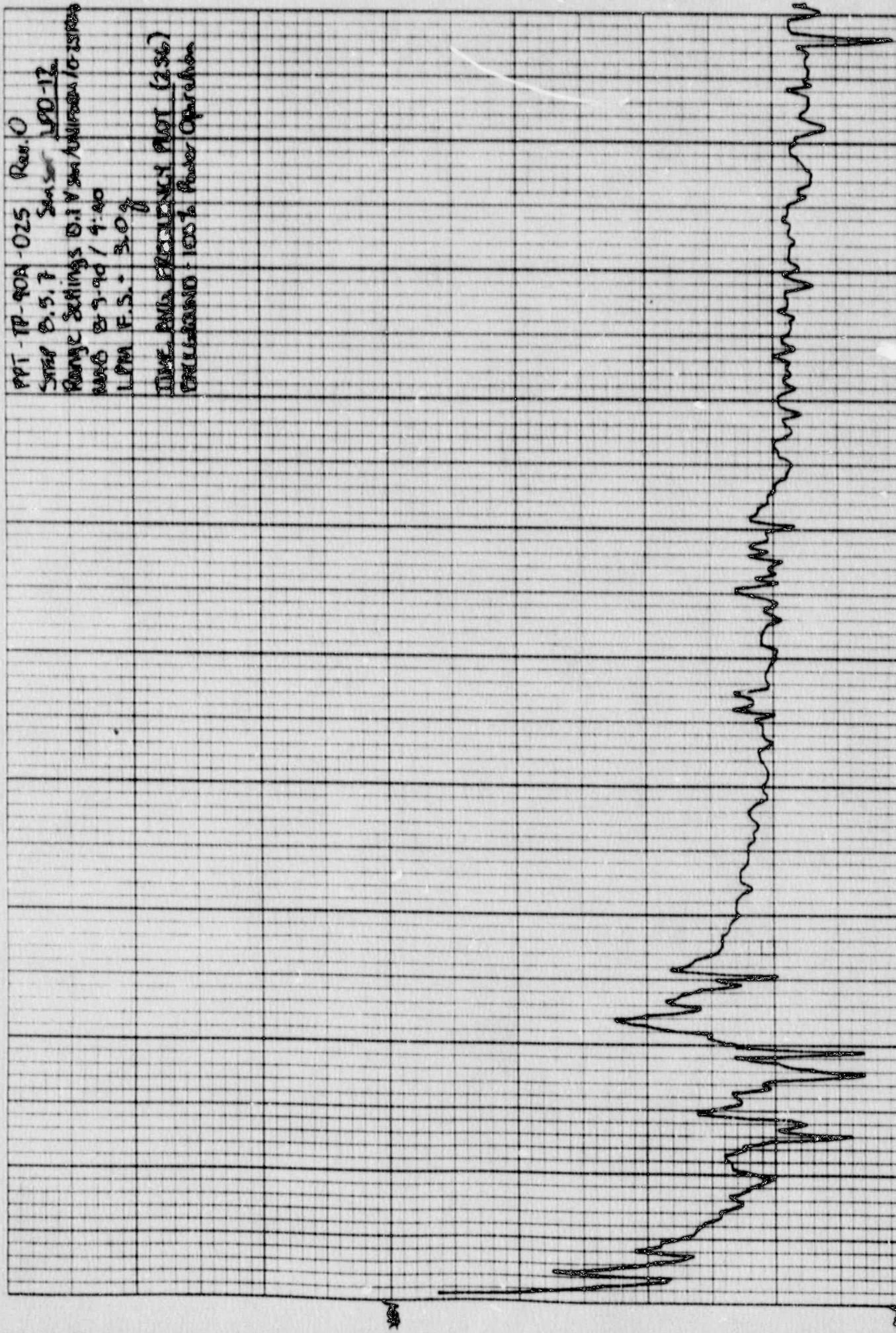
46 0780

K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
 KUFFEL & ESSER CO. MADE IN U.S.A.

PPT-TP-90A-025 Rev. 0
 STEP 8.5.7 Sensor LPO-11
 Range Settings 0.5 V/m / 10-25 Hz
 MAG 8.9-90 / 9.37
 LFM F.S. - 3.0 g
 TIME 256 FREQUENCY 0.1 Hz (256)
 CALIBRATION 100% Power Operation



PPT-TP-90A-025 Rev. 0
 SWP B.5.7 Sea 100-12
 Range Settings 0.1 V Sea Antenna 10-25 MHz
 MAG B-3-90 / 4-00
 LPA F.S. - 303
 TIME AND FREQUENCY PLOT (236)
 CHL 2360 - 100% Power Operation



25002

12.5 MHz

FREQUENCY

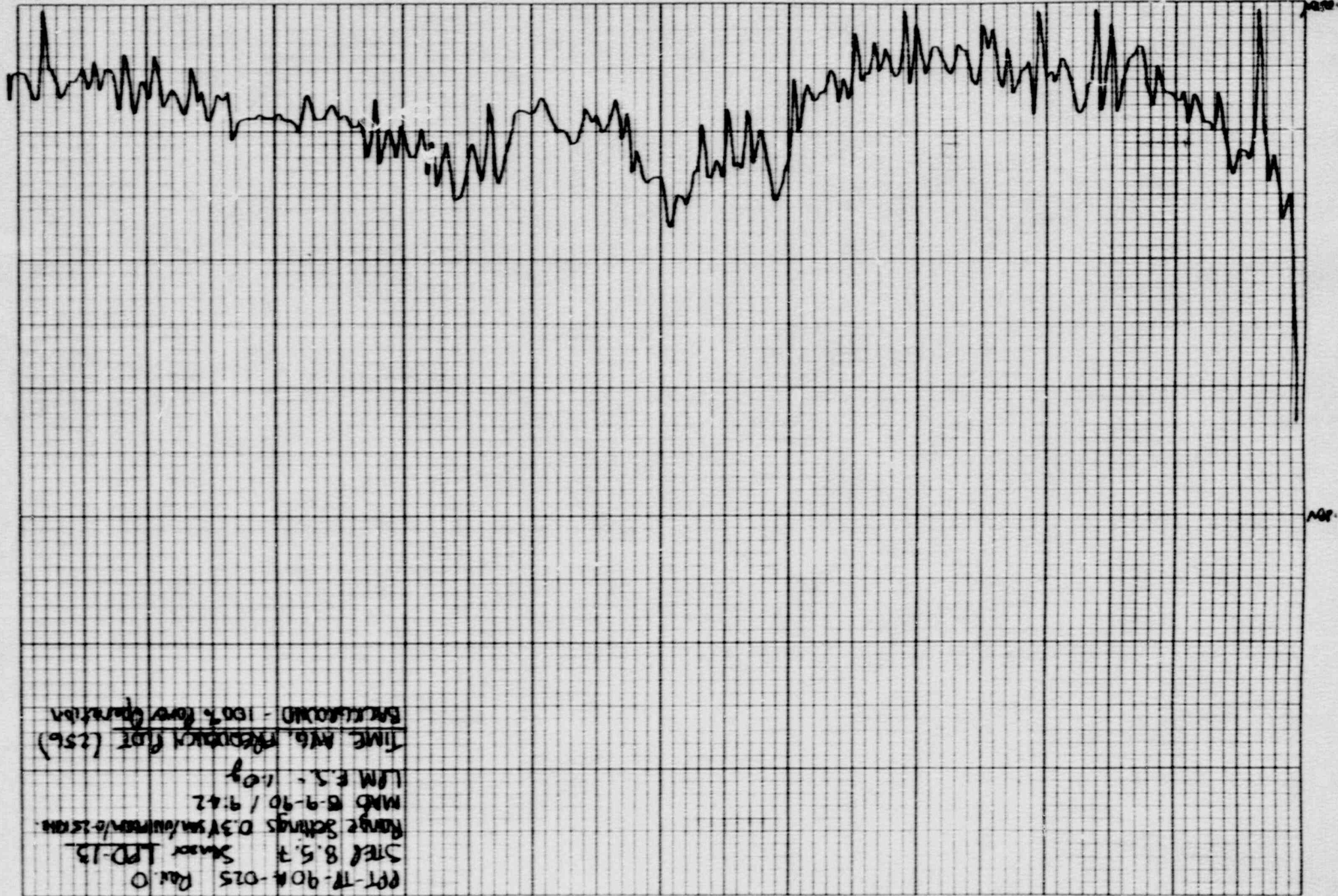
K.E. 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUPPEL & ESSER CO. MADE IN U.S.A.

46 0780

FREQUENCY

12.5 KHz

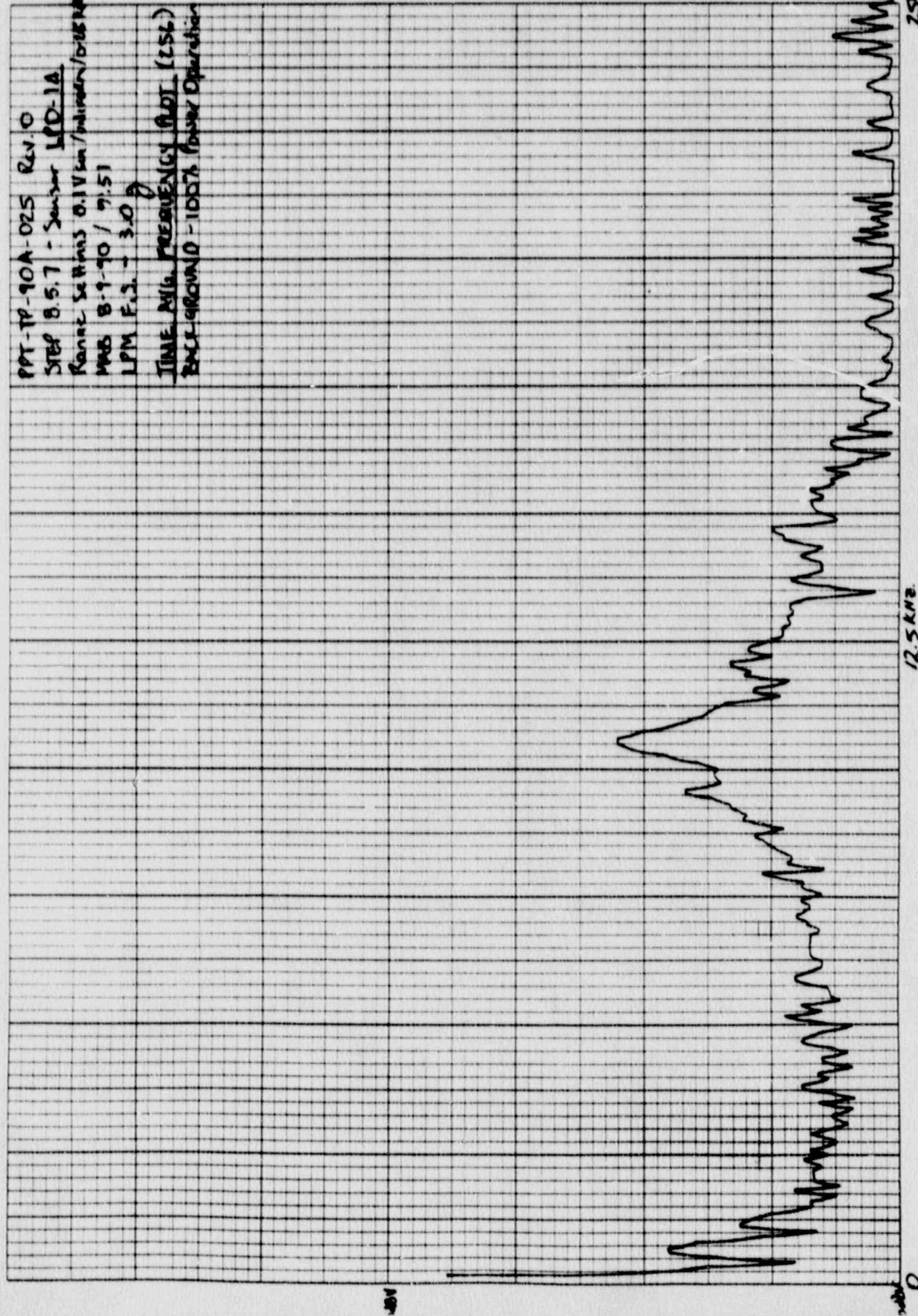
25 KHz



PPT-77-904-025 Rev. 0
Std 8.5.7
Range Settings 0.3V/div / 0.25cm
MKB 8-9-90 / 9:42
LIM 8.5 - 10g
Time Avg. Frequency Plot (256)
Saturated - 100% Power Operation

PPT-TP-90A-025 Rev. 0
STEP 8.5.7 - Sensor LFO-1A
Range Settings 0.1V/cm / Indicated / 0.1V/cm
MMS 8:49:50 / 9:51
LPM F.2. - 3.0 g

TIME vs. FREQUENCY PLOT (ZSL)
BACK-GROUND - 100% Power Operation

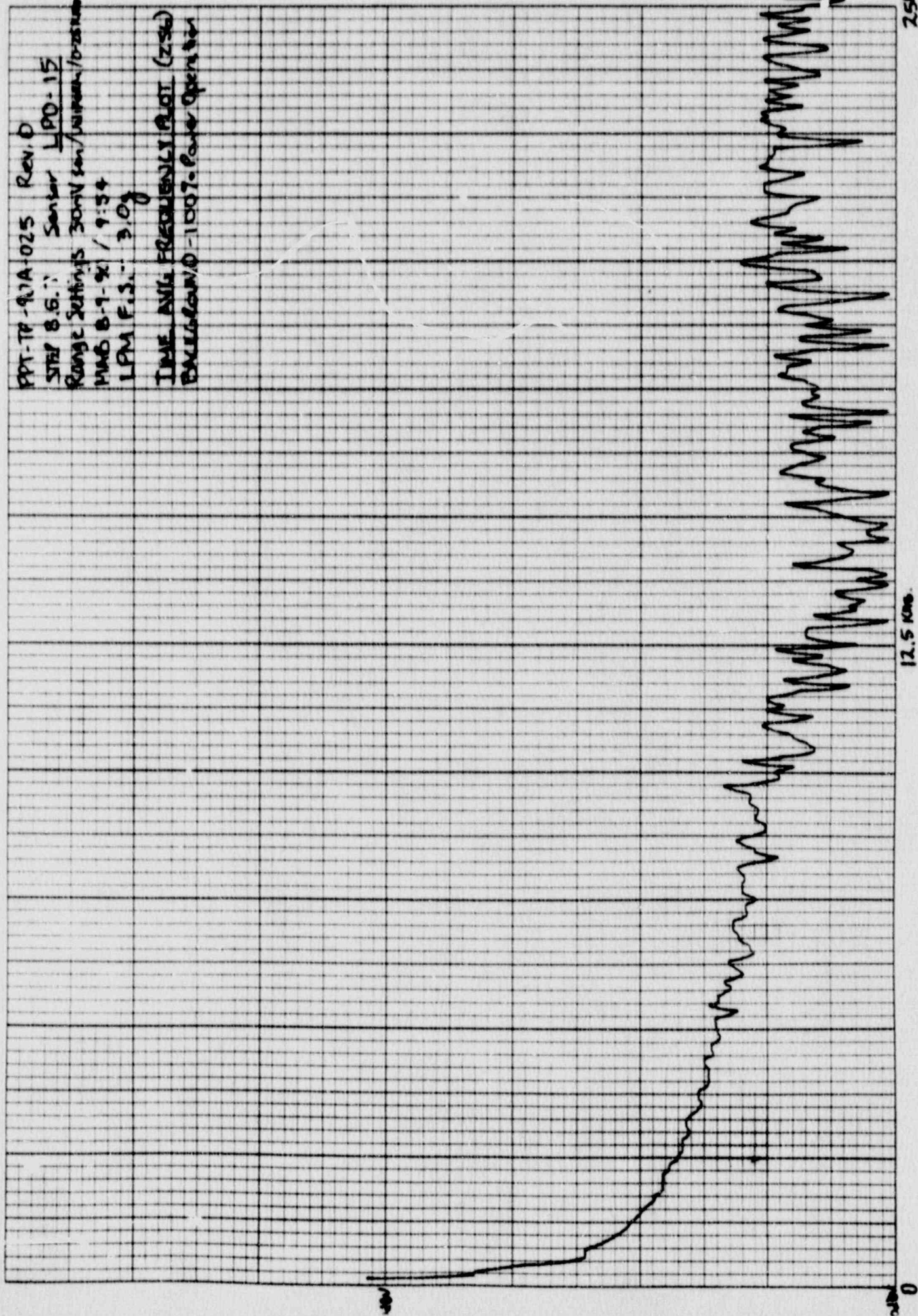


FREQUENCY

46 0780

10 X 10 TO THE INCH • 7 X 10 INCHES
K&E KEUFFEL & ESSER CO. MADE IN U.S.A.

PPT-TP-91A-025 Rev. D
 STIP 8.6.11 Senior LPO-15
 Range Settings 30mV sen / 10mV res / 10mV res
 MAG 0.1-90 / 9:34
 LPM F.S. 3.0g
 TIME AVG FREQUENCY PLOT (ZSG)
 BALLBOUNDED-1007-Page Operation



12.5

2500

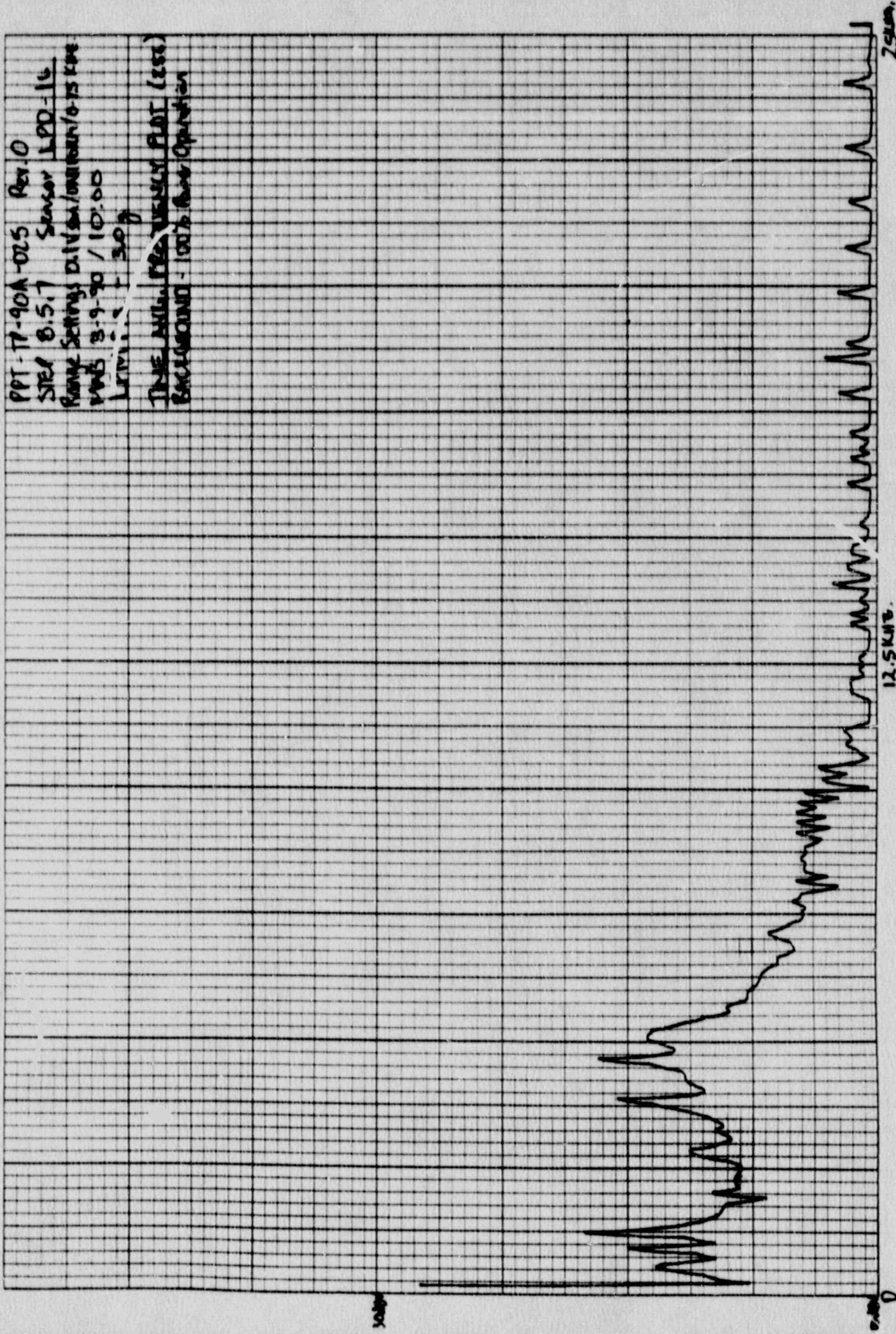
FREQUENCY

46 0780

K&E
 10 X 10 TO THE INCH • 7 X 10 INCHES
 NEUFEL & ESSER CO. MADE IN U.S.A.

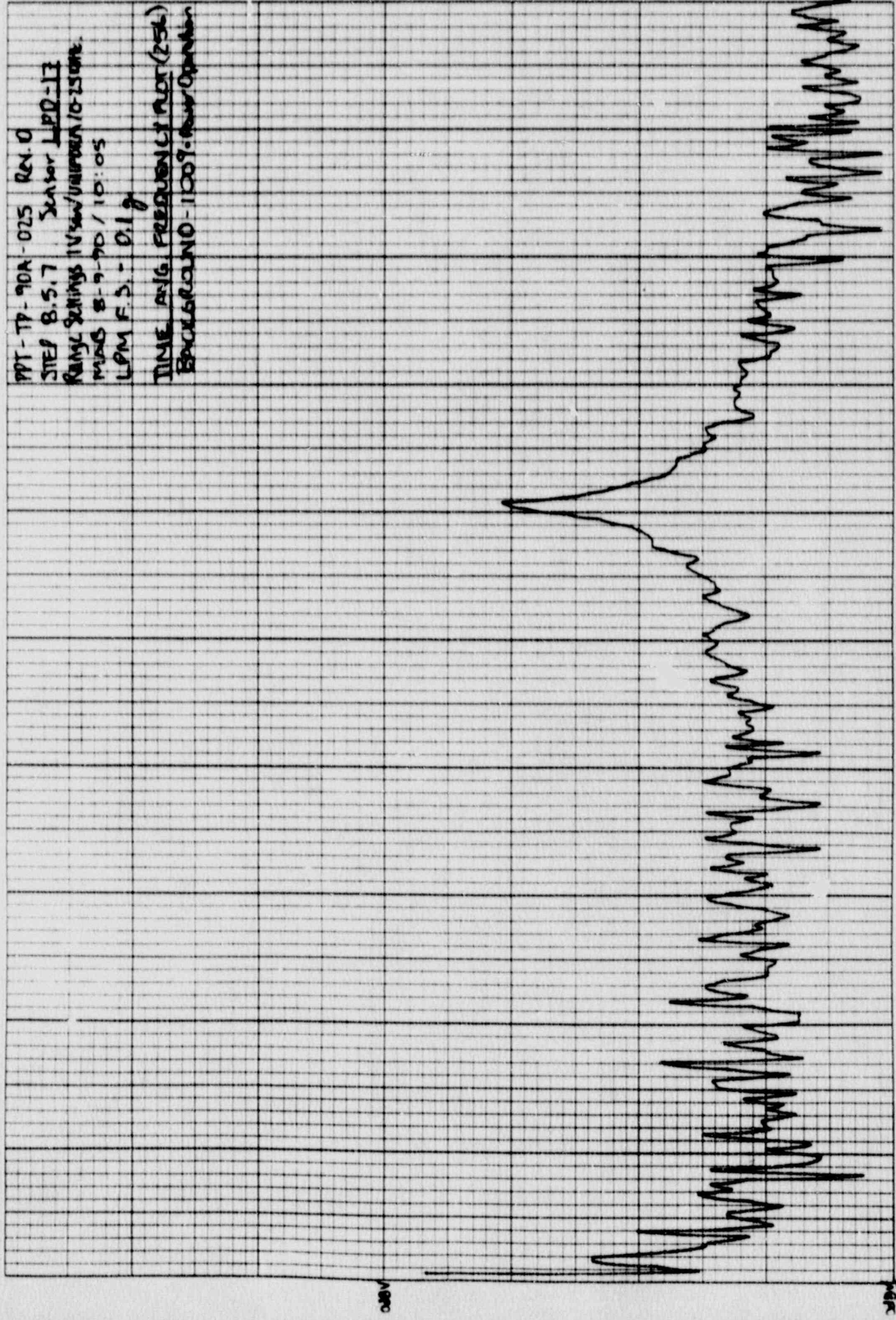
PPT-17-90A-025 Rev. 0
 STEL 8.5.1 Sensor LPD-16
 Range Settings 2.1V/5mV/10mV/0.75KHz
 WMS 8-9-90 / 10:00
 LRV 1.2 / 30g

TRUE HIGH FREQUENCY FLAT (see)
 BACKGROUND - 100% Burst Operation



FREQUENCY

PPT-TP-90A-025 REX.0
 STEP 8.5.7 Sensor LPD-13
 RANGE SETTINGS 1V_{SEN}/V_{REF} 10-250mV
 MAG 8-9-90 / 10:05
 LPM F.S. - 0.1g
 TIME ANLG. FREQUENCY PLOT (256)
 BACKGROUND - 11009.4m/s Operation



12.5 kHz
 FREQUENCY

256

PPT-TP-90A-023 Rev. 0

STEP 8.5.7 Sensor LPD: 18

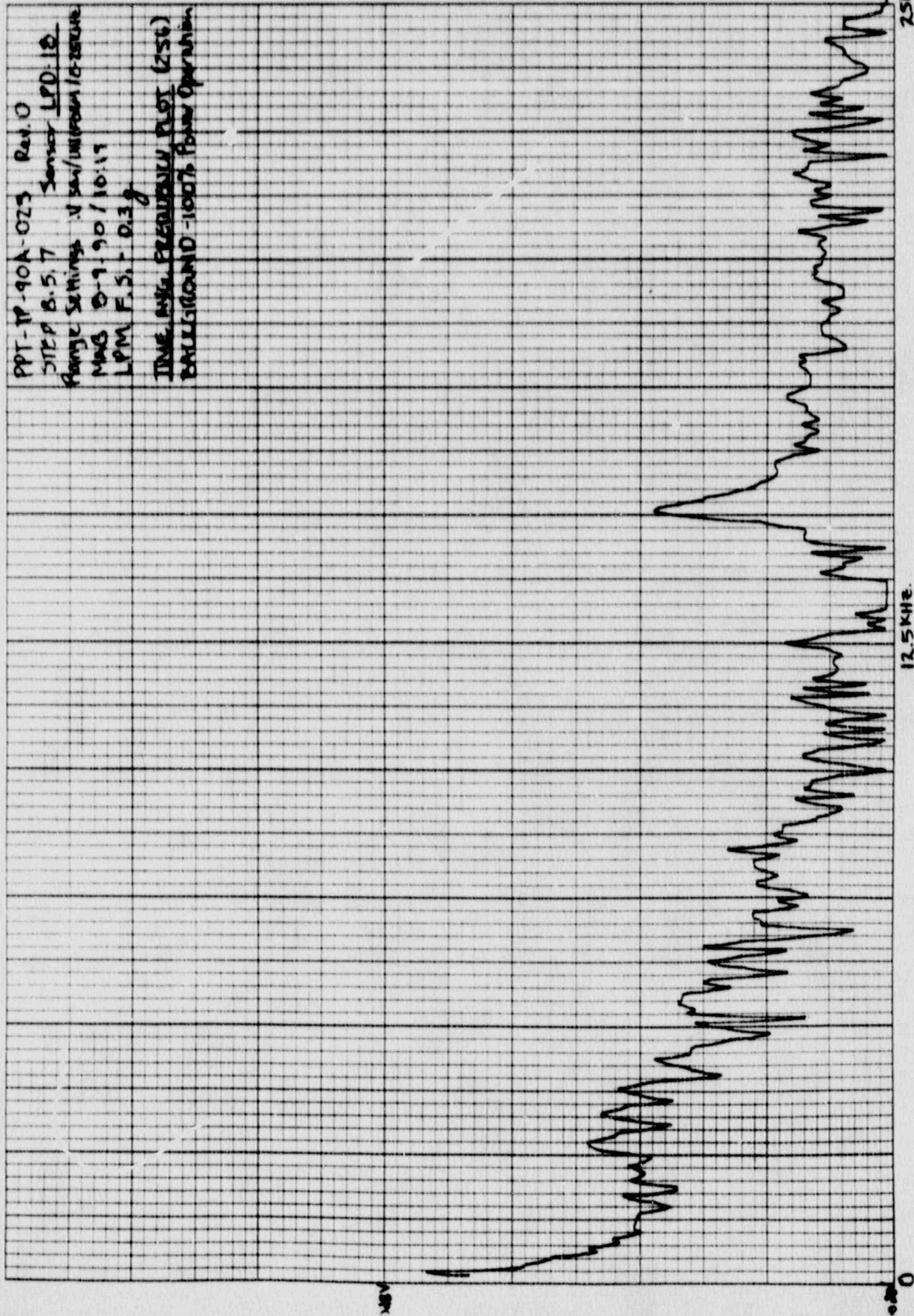
Range Settings: 10 sec/1000000/10-250000

Mag: 0-9.90/10:17

LPM F.S. = 0.3g

TIME: 15/10/2000 12:56

BACKGROUND - 100% Power Operation



12.5 kHz

25 dB

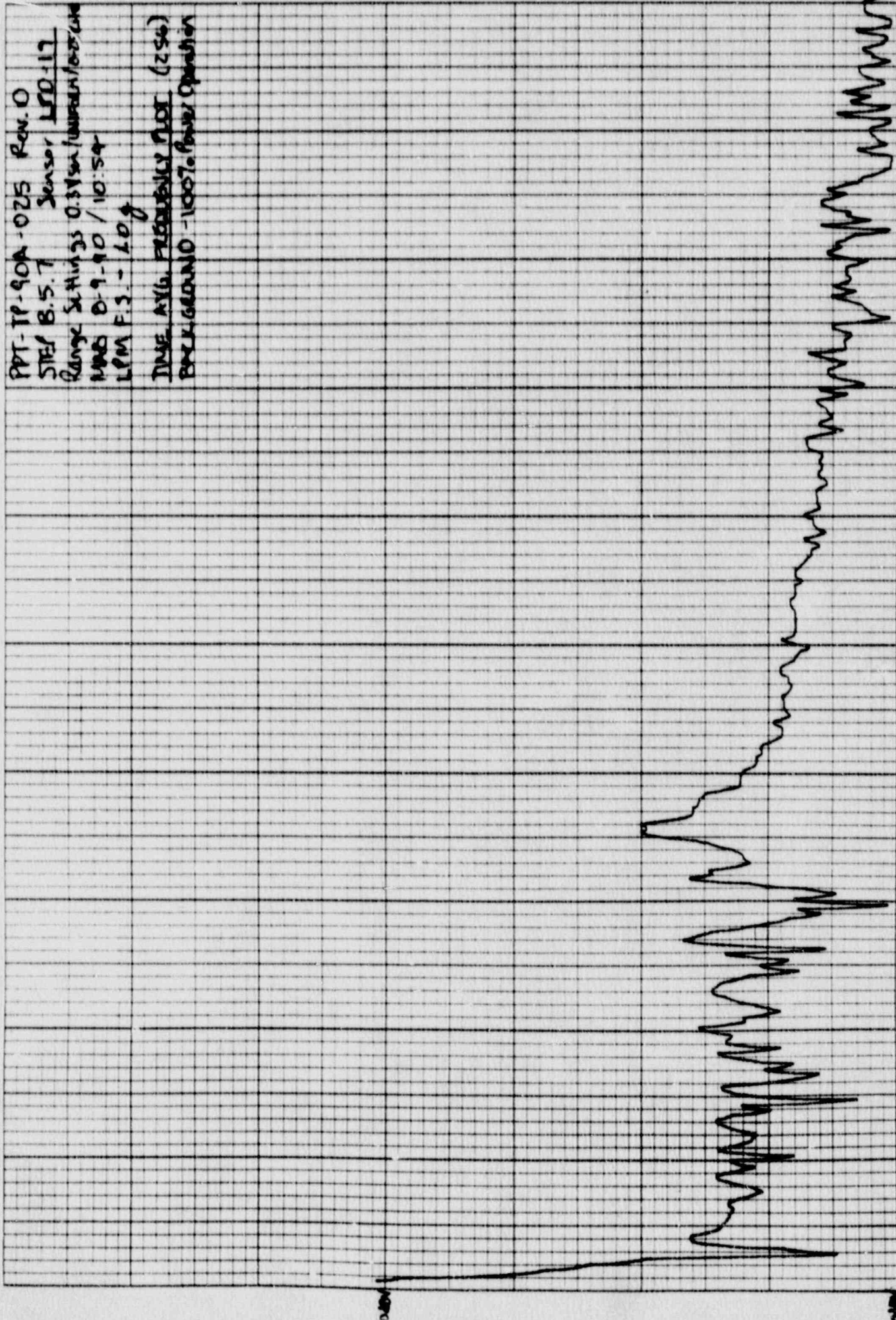
17 NOV 2000

46 0780

K.E. 10 X 10 TO THE INCH • 7 X 10 INCHES
NEUFEL & ESSER CO. MADE IN U.S.A.

PPT-TP-90A-025 Rev. 0
 STEEL B.5.7 Sensor LFD-17
 Range Settings 0.385m/1000m/1000m
 MODE 0-9-90/10:54
 LPM F.3 - 10g

TIME AYL6 FREQUENCY Plot (256)
 BACK GROUND - 10007. Power Operation



12.5 KHz

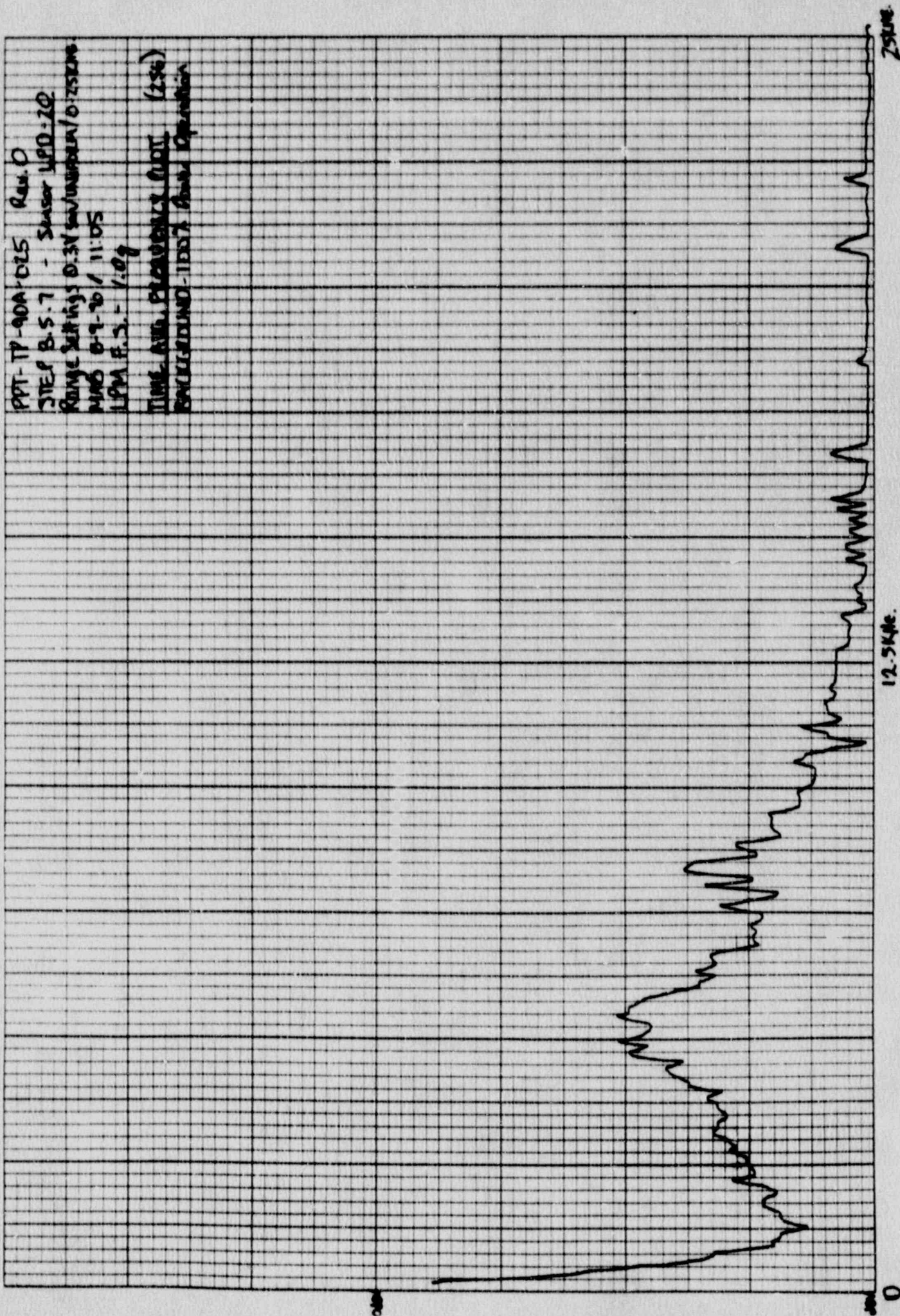
FREQUENCY

46 0780

H-E 10 X 10 TO THE INCH • 2 X 10 INCHES
 KEUFFEL & ESSER CO. MADE IN U.S.A.

PPT-TP-90A-025 Rev. 0
STEP B.5.7 - Sensor LFD-20
Range Settings 0.3V sensitivity/0.75200
MMS 0-9-20 / 11.05
LPA F.S. = 1.0g

TIME AVE. FREQUENCY PLOT (256)
BACKGROUND-100% Power Operation



FREQUENCY

46 0780

H.E. 10 X 10 TO THE INCH • 1 X 10 INCHES
HEUFFEL & ESSEN CO. NEW YORK, N.Y.

3.5 Adjacent Channel Response

The following X-Y plots were made using tapes recorded during pre-operational test 1-CP-PT-91-01 SFT. During impacts, the three closest adjacent channel sensors were recorded. The strongest signal was then compared to the background noise level on each of the 8 active sensors to determine system sensitivity.

PPT-TP-10A-025 Rev.0

STEP 8.9.4

Range Setting 100mV x 2 = 0.1V/div

MODE 2/2/50

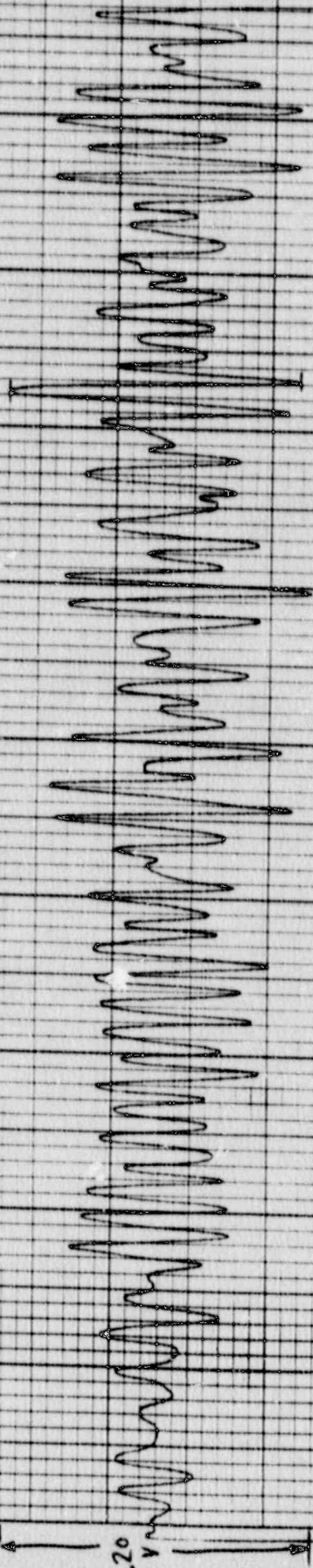
LPN FS 1

ACQUISITION CONTINUED 10:30:00

LPD 18 / TIME 12.000

DATA SET 1

18.5V 0.100V 5.00



(cont)

PPT-TP-90A-025 Rev 0

STEP 3, 9, 4

Range - Seismicity 100m-200m

Wet 8/22/90

LEM F-5 3

ADJACENT CHANNELS

100-19 / 100-20

DATA SET #1

5220 = 10' 45.22

Time

46 0780

K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
KIEFFEL & ESSER CO. MADE IN U.S.A.

PPT-TP 90A-02S Rev. 0

STEP B. 9. A

Range Setting: 100mV/2 = 0.01V/div

Time: 0.22/90

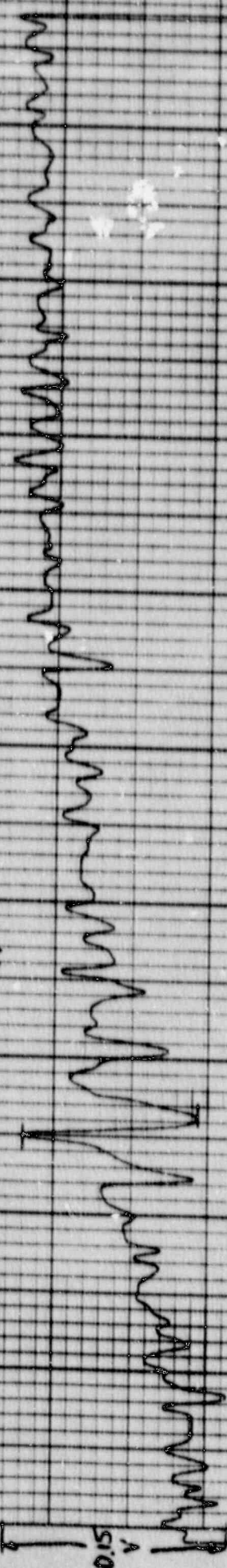
Low F.S. 1

ADJUST (CHANGE) RESPONSE

100mV/17msec 0.2 sec

0.2 sec

84A210-10.0X5.11

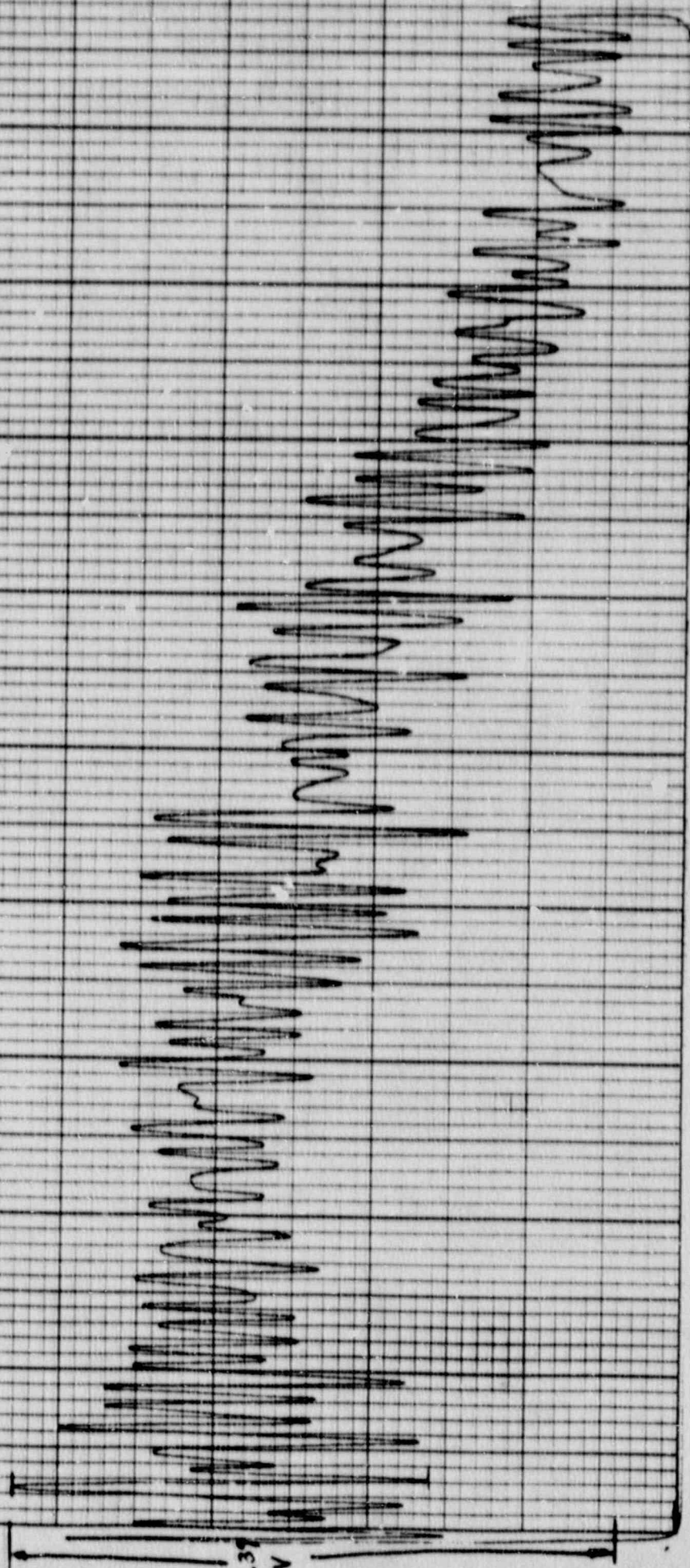


(ing)

DPT- TP-40A - 025 Rev. D
 STAL 8.9.4
 Range Settings 100mV/2 = 0.1V
 1400 8/22/96
 LPM FS. 3

ADJACENT CHANNEL RESPONSE
 LPD = 19/TIME = 2 FOR
 DRAIN SET = 5

27.122 = 10.142



(time)

DPT-TP-90A-025 Rev 0
 STEP 8.9.4
 Range Setting 1V x 2 = 0.1 V/div
 MAG 8/22/90
 LPM FS 1

ADDRESS CHANNEL RESISTANCE
 LPM 20/FAPC 2 FOR
 Data Set 0.5

100.50 = 1.0 V

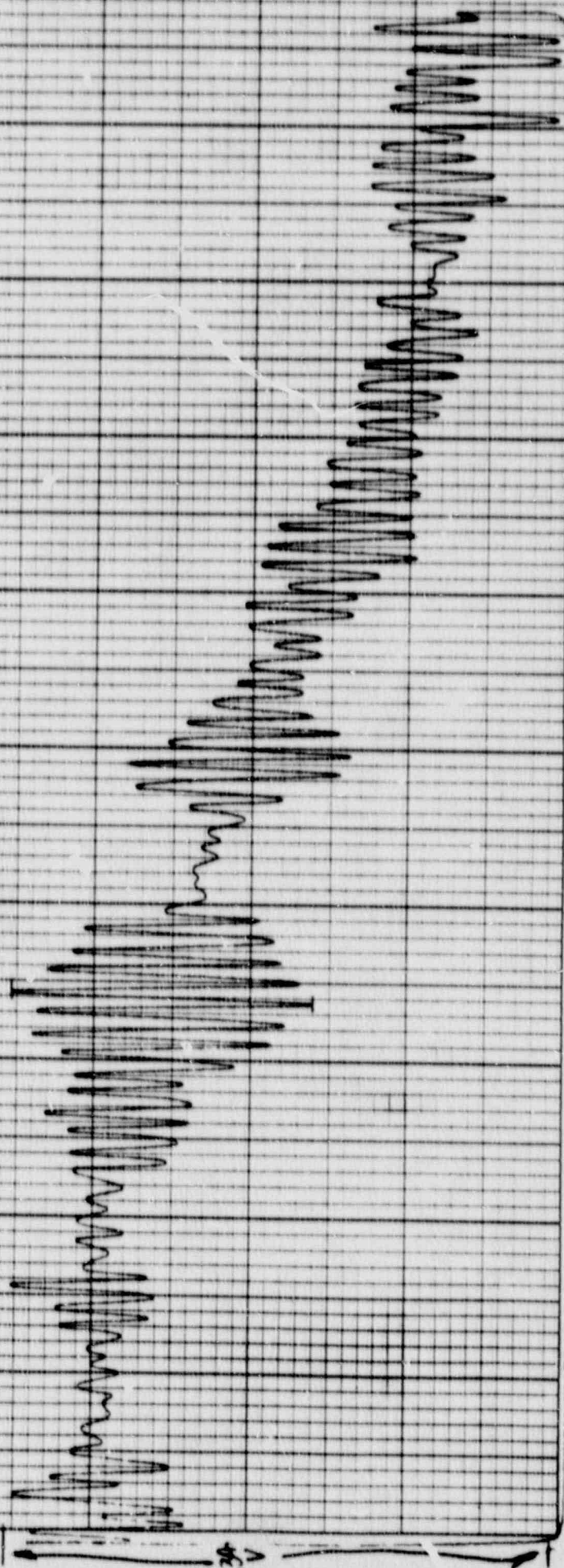


(time)

PPT-TP-90A-025 Rev. 0
 Step # 9.2.
 Range Se # 100mV/div
 Date 12/22/93
 LP 1 FS 3

ADJUSTMENT (MINIMUM RESPONSE)
 LPO # 19 / TAPE # 2 FOR
 DATA SET # 9

11A 561.0 - 10. x 5.6

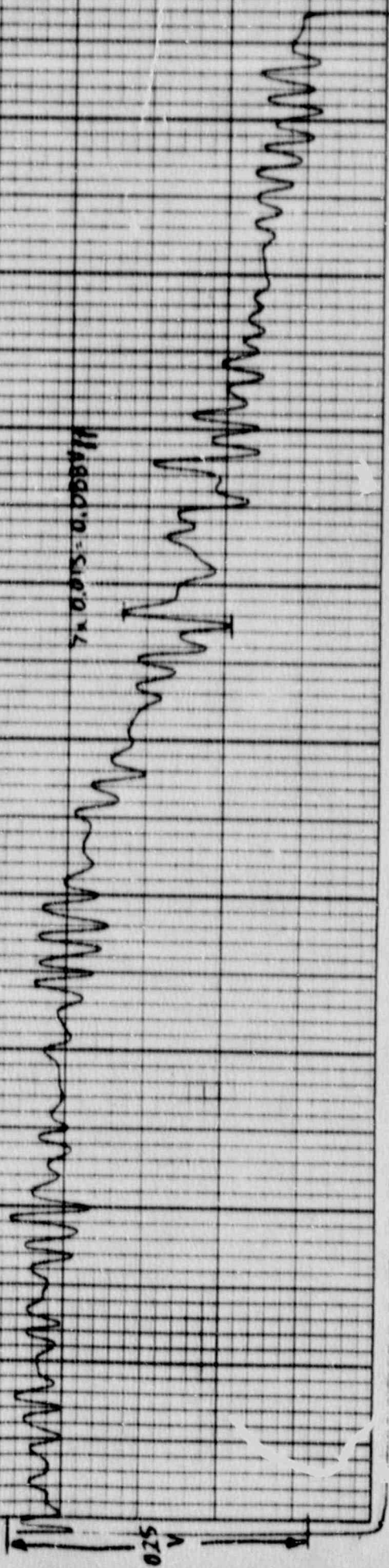


(time)

POT-TP-10A-025 Rev. 0
 STEP 8.9.4
 Range Setting 1V x 2 x 8 = 0.013
 Date 8/22/93
 LPM FS 11

ADDITIONAL CHANNEL RESPONSE
 LED + 2.0 / Time = 2 sec
 DATA SET 9

WABO'D-S100.14



2mV

PPT-TP-90A-025 Rev. D

STEP 8.9.4

Range Setting 100mV/2 = 0.01V/div

Wing 0122198

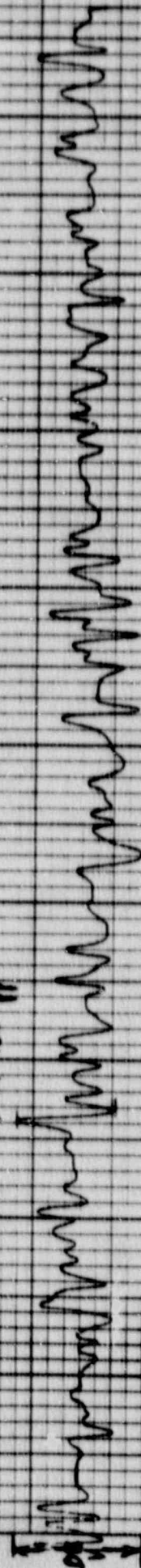
LPN 15. 0.3

ADJACENT SENSOR RESPONSE

LPN 15 / TAPE 2 FEM

DATA SET # 13

100mV 100ms



(2m)

PPT TP 40A-025 Rev. 0

STEP 8.9.4

Range Settings 100mV x 2 = 0.1V

MOB 8/22/90

LOM FS 3

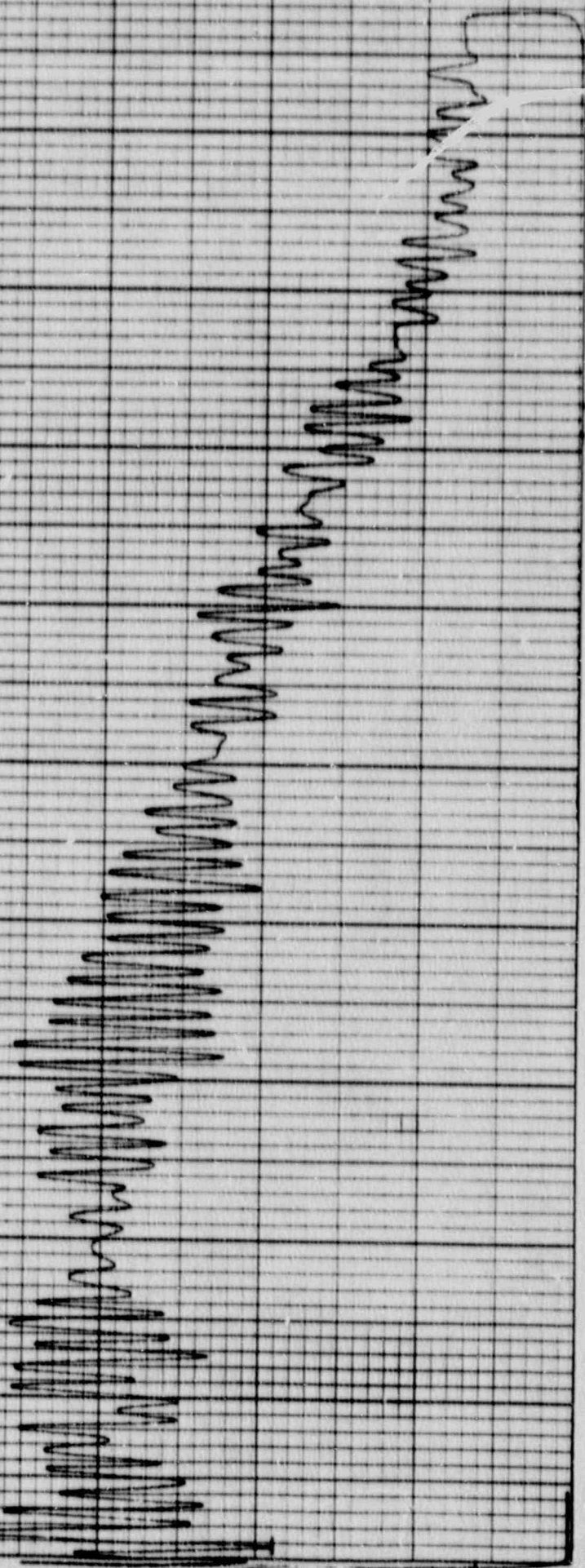
ADJUST CHANNEL RESPONSE

LFO 1.9 / MPE 0.2 FOR

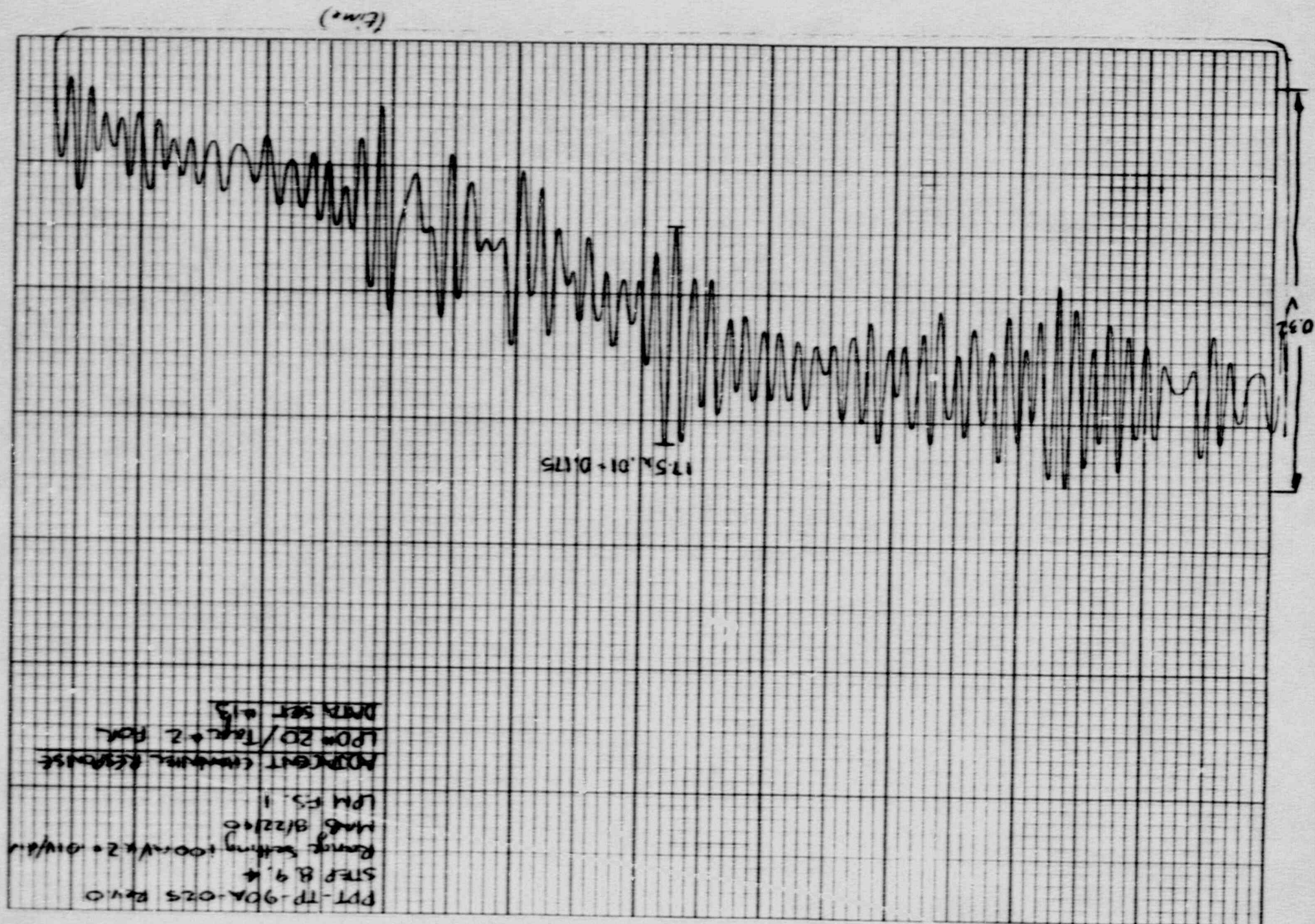
DATA SET 0.13

5020 = 10.0 x 5.02

A
EC

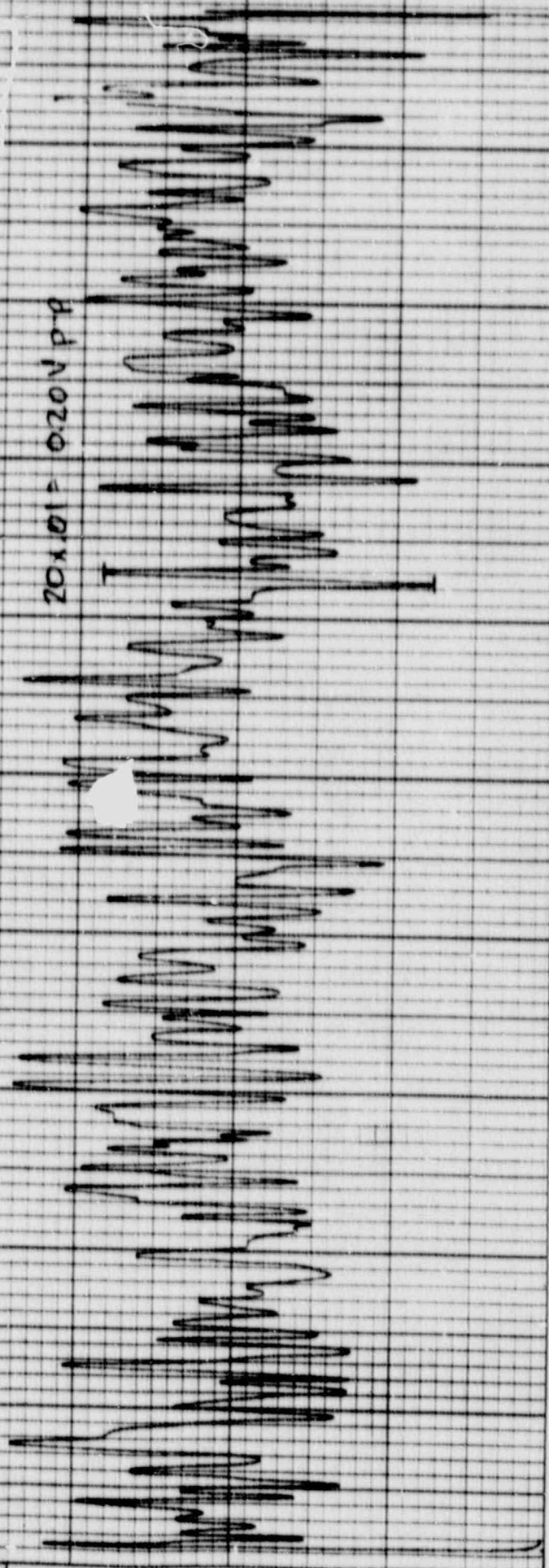


(2.12)



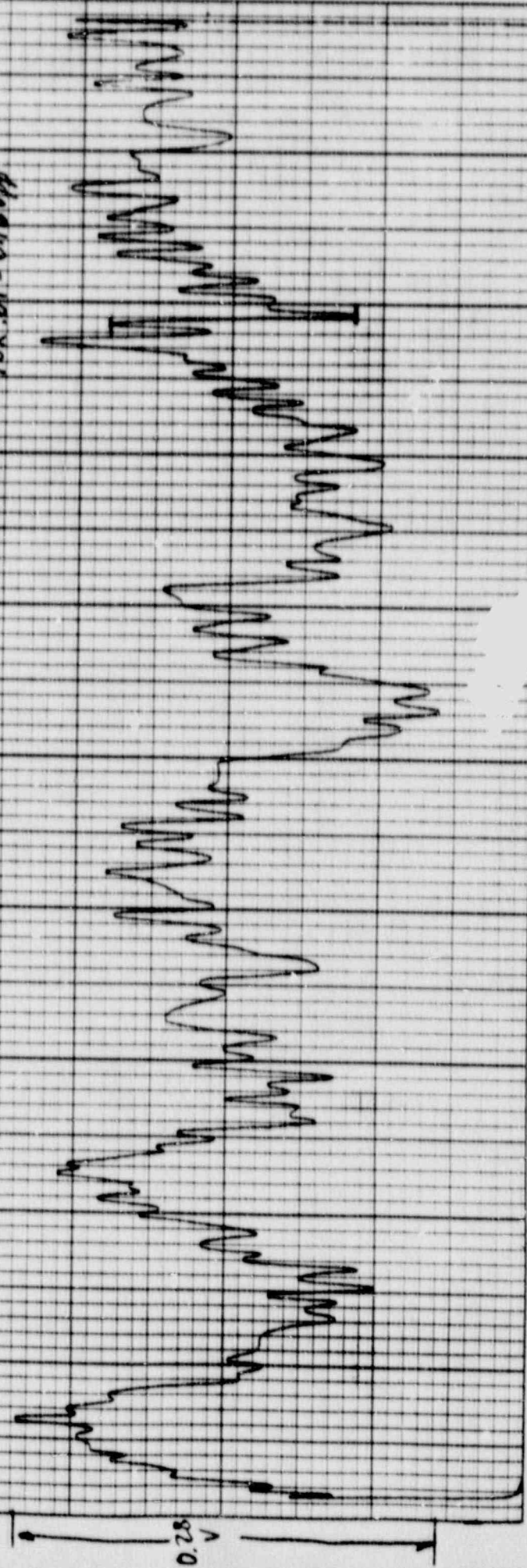
PPT-1P-20A-025 Rev. 0
 Step 8.9.6
 Range Setting: 100mV/div = 0.01 V/div
 Time 8.9.6.0
 LPM FS 3g
 AOUTMENT SENSOR RESPONSE
 LPO #18 Tap #1 ROR
 DATES SET 2/17

20x101 = 0.20V p-p



PVT IP-90A Rev 0
 STEP 8.9.6
 Range Settings 100mV x 2 = 0.01V/div
 HMO 8-9-96
 LPM FS 3g
 ADJACENT SENSOR RESISTANCE
 UPD #17 Type #1 FOR
 DATA SET #18

16X.01 = 0.16V/div



OPT-TP-90A-025 Rev 0

STEP 8.9.6

Range settings 100mV/div = 0.01V/div

mid 8.9.7b

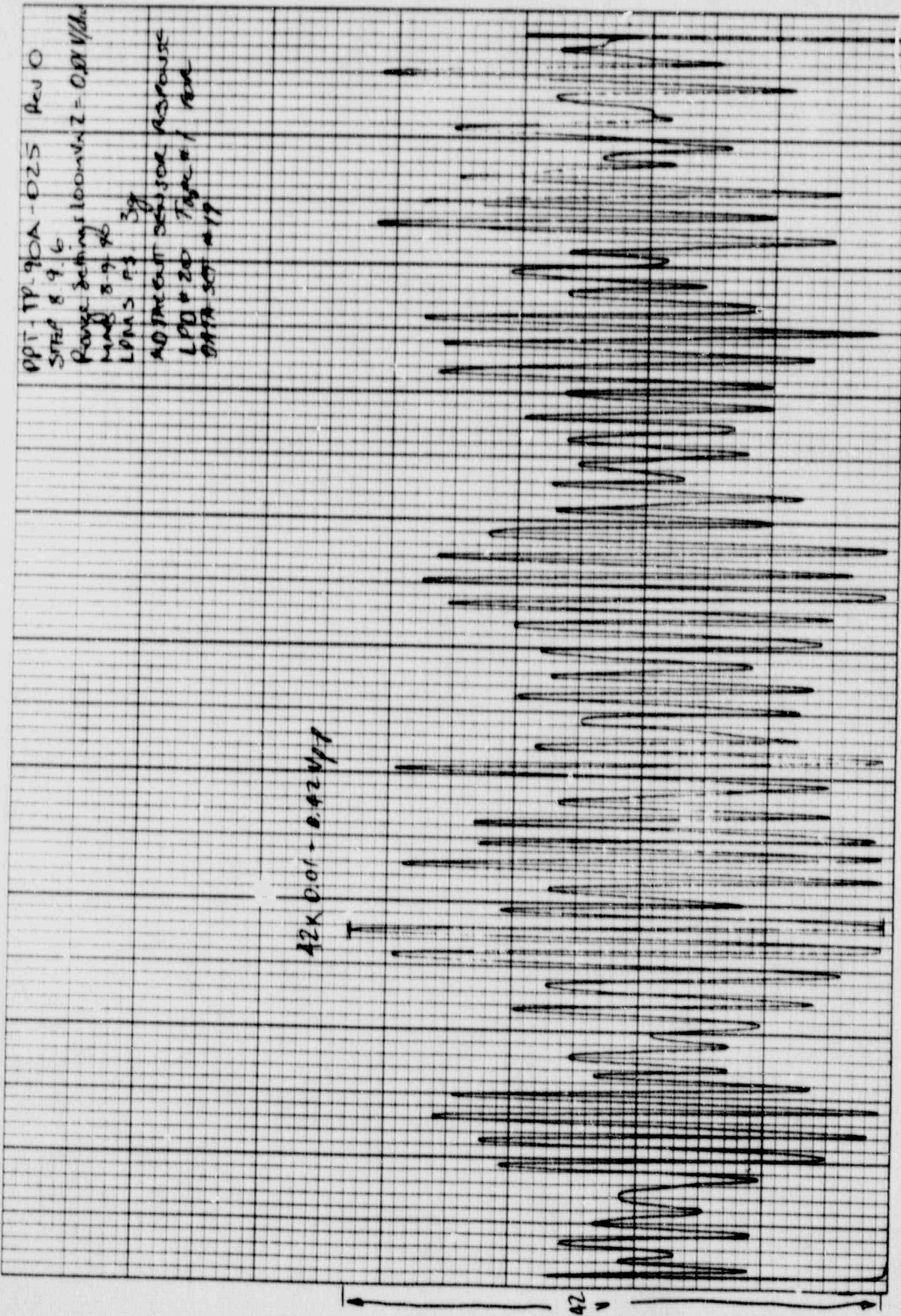
LPM3 P3 3g

ADJACENT SENSOR RESPONSE

LPO #20 Type #1 ROR

DATA SET #19

12x0.01-0.24Vpp



Time

PPT-TP-90A-025 Rev 0

STEP 8.9.6

Range Setting (V/div) = 0.05 V/div

WDS 8/9/90

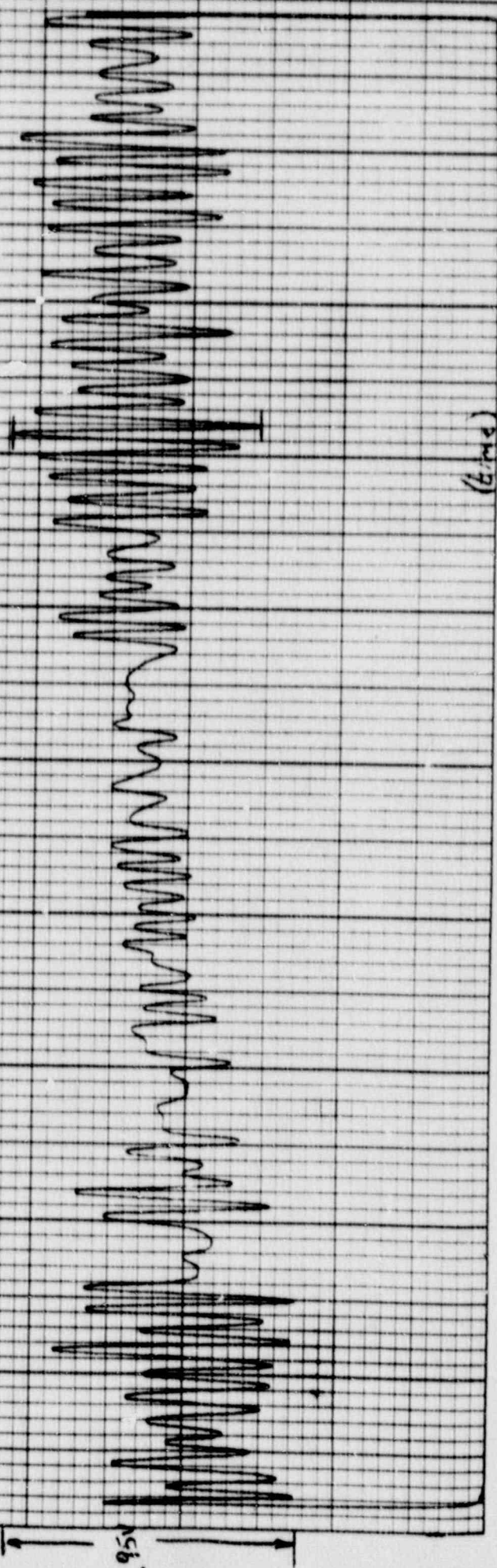
LPM FS 3g

ADDITIONAL SENSOR RESPONSE

CAD # 19 Tape 01

DATA SET # 20

16 X 05 = 0.80 V/div



3.5 Calibration Traces

The following X-Y plots show X-Y plotter response to a 1 KHz/1 volt signal being injected from a signal generator and each respective tape channel response when playing back a recorded 1KHz/1 volt signal. The difference between the two were used to determine a correction factor.

PAT-TP-90A-025 Rev. 0
 X-Y Plotter Calibration Trace
 1 V/div (Function Generator)
 Settings 1 V/div = 0.1 V/div
 1000 0-7-90

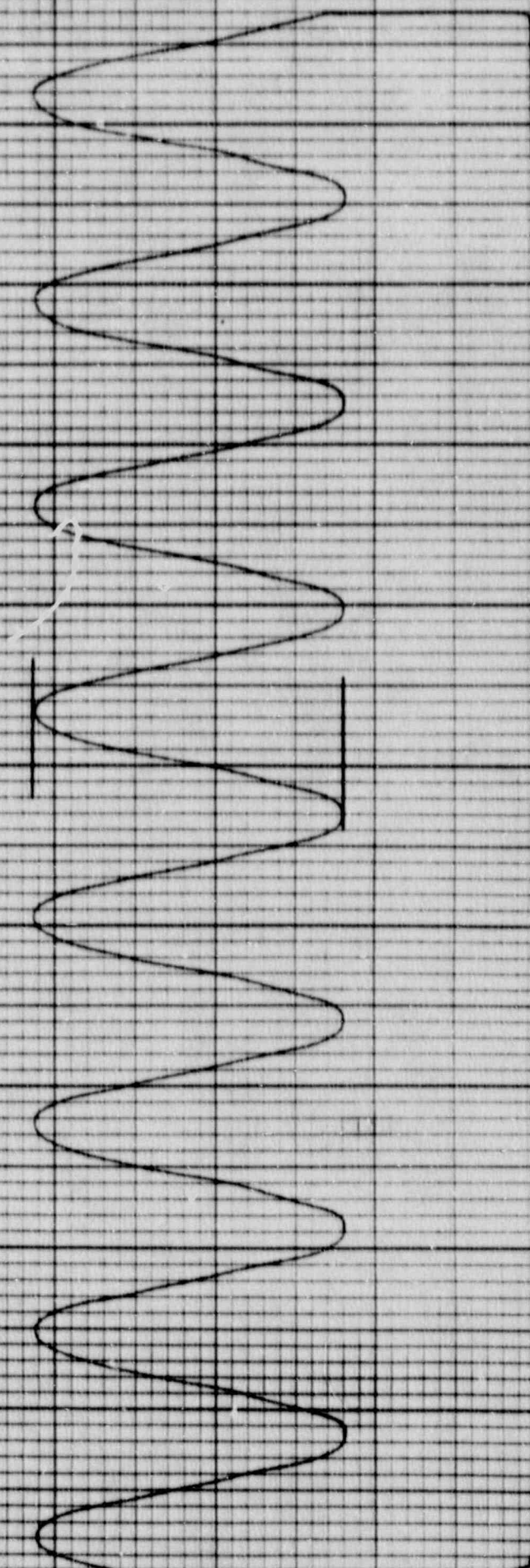
0.9 0.5 0.2

(time)

Volts

PPT-TP-40A-025 Rev. 0
 STEP No. B.2.4
 TAPE #1 (VIBRATION) SQUARE WAVE 1V/div
 CHANNEL #1 (SFT)
 Settings: $1V \times 1 = .05 V/div$
 MAG B-7-70

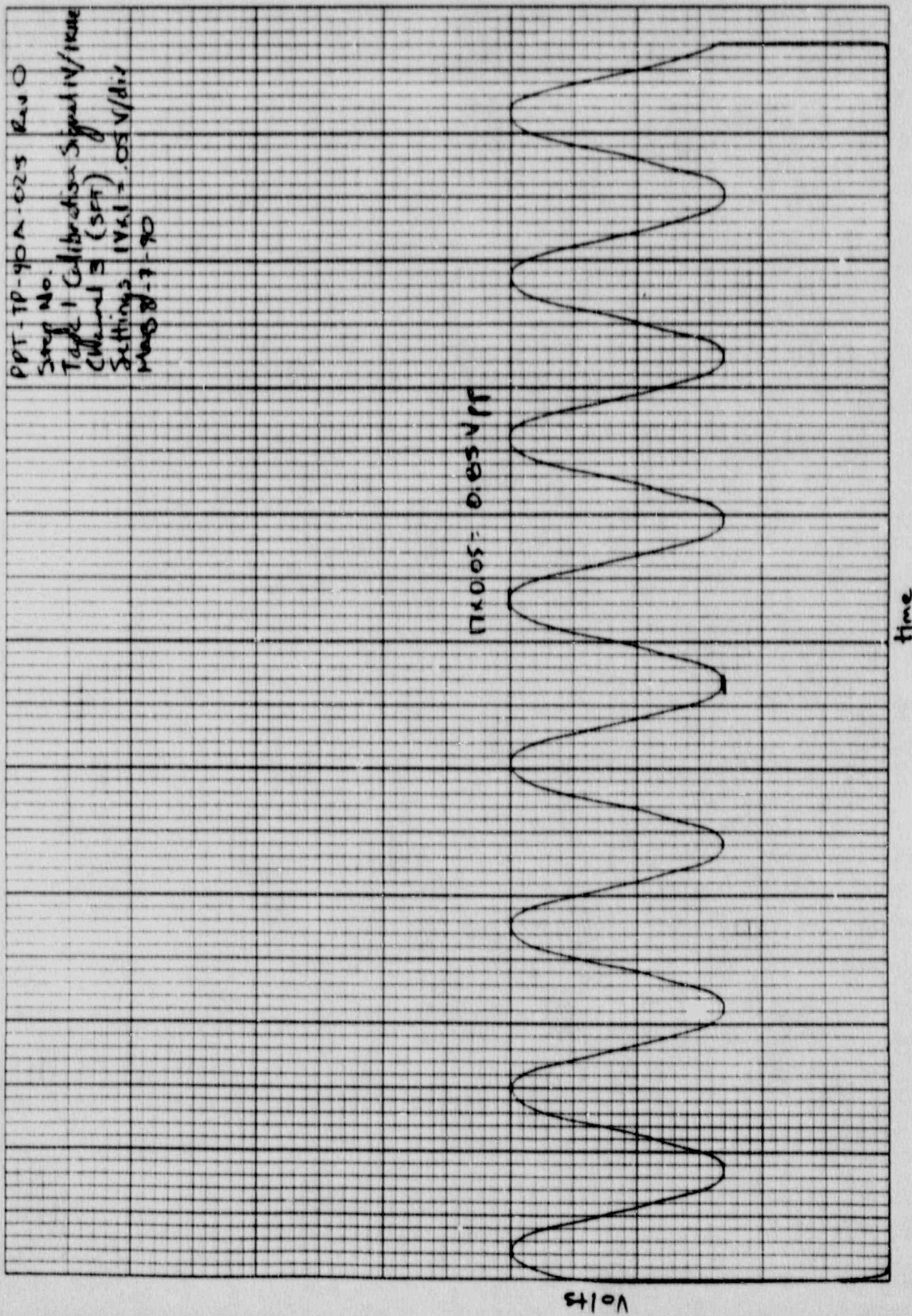
19.5 x .05 = .975 Vpp



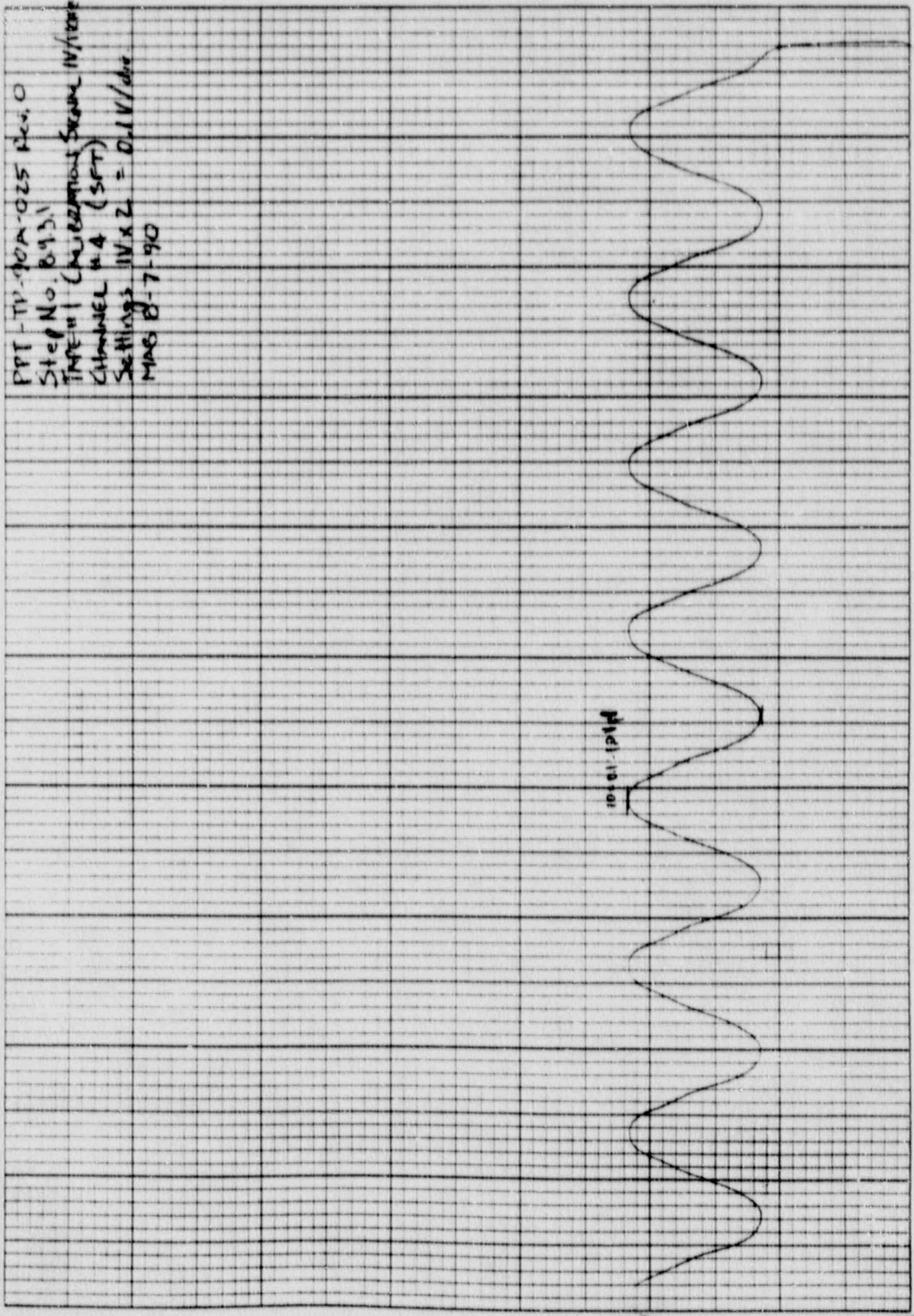
PPT-TP 10A-025 Rev. D
 Step No. 89.21
 Tape #1 Calibration Signal 1V/1cm
 Channel #2 (SFT)
 Settings 1V/2 = 0.1V/div
 MMB 8-7-90

B No. 1 - N. 10'

time



PPT-TV-90A-025 Rev. 0
 Step No. 893.1
 TYPE 11 (pulsation square wave)
 Channel 4 (SFT)
 Settings $1V \times 2 = 0.1V/div$
 MAG B-7-90



time

PPT-TP-40A-025 Rev. 0

STEP NO.

CALIBRATION SIGNATURE

Settings: 1V x 2 = 0.1 V/div

Trace 2 (SPT) - Channel 1

MMG 8/22/90

AMPL = 1.0 x 0.1

time

PPT-TP-02A-025 Rev. 0
 SITE No. 891
 OBSERVATION SIGNATURE
 Scaling: 1V x 2 = 0.1V/div
 Tap 2 (50%) Channel 2
 N/A 8/24/90

MA560-1.0 x 5.6

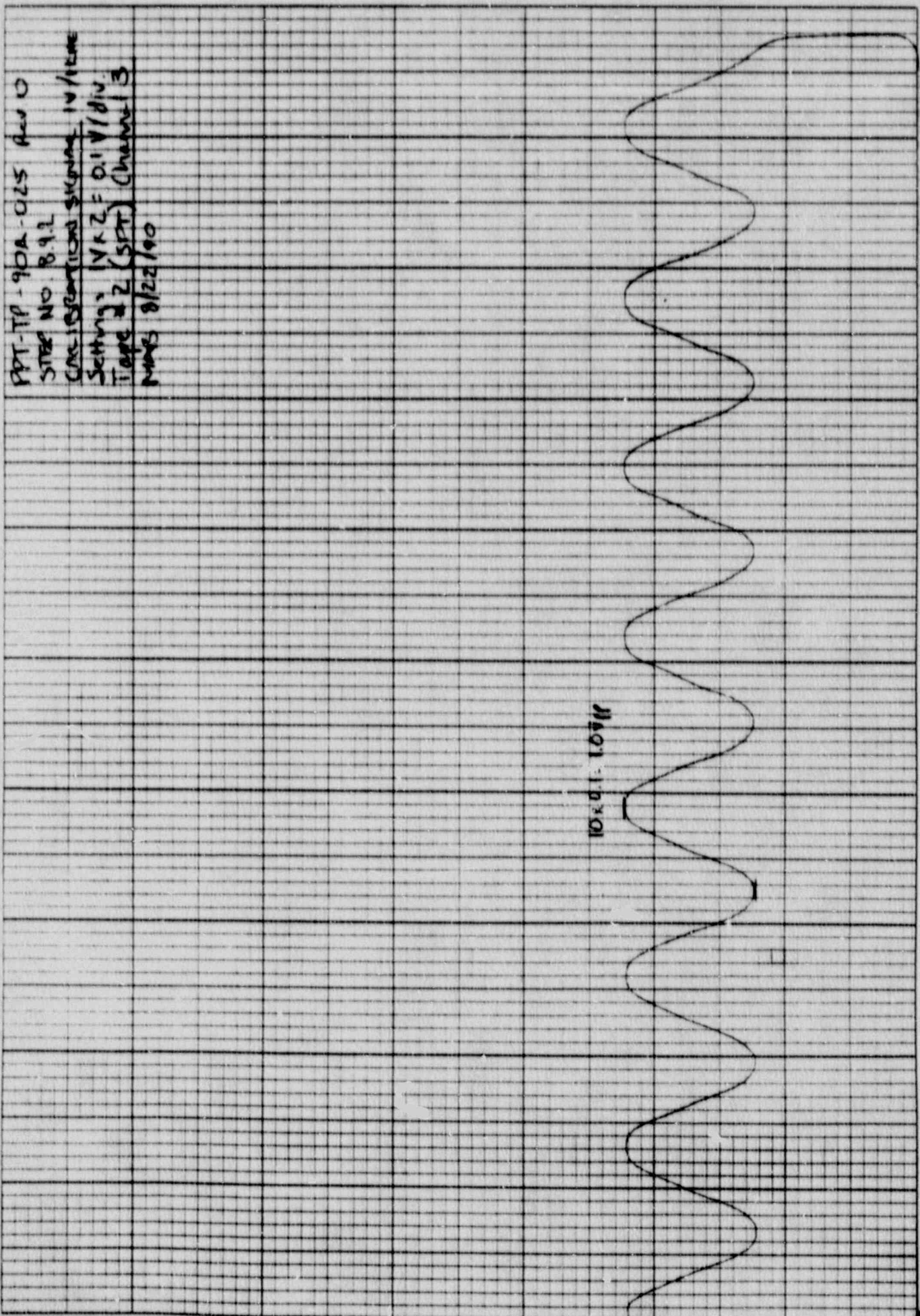
Volt

time

time

VOLTS

11601-10301



PPT-TP-90A-025 Rev O
STEP NO. 8.9.2
CNC OPERATIONS SKYLINE 10/10/00
Setting: VOLT = 0.1 V/div
Tape 22 (SPT) Channel 3
Date 8/22/90

PPT-TP-90A-025 REV 0
 STEP NO. 8/12
 CALIBRATION SIGNATURE IV/1/14/14
 Settings - $1V \times 2 = 0.1V/div$
 Trigs 2 (5FT) - Channel 4
 MAG 8/22/90

Volts

$14.80 = 10 \times 8$

time

46 0780

PPT-TP-90A-025 Rev.0
 X-Y Plotter Calibration Trace
 Step No. 8.5.2
 Channel 1 - (150) Tape 1
 Settings Mx1 = 0.05 V/div
 MAG 8-8-90

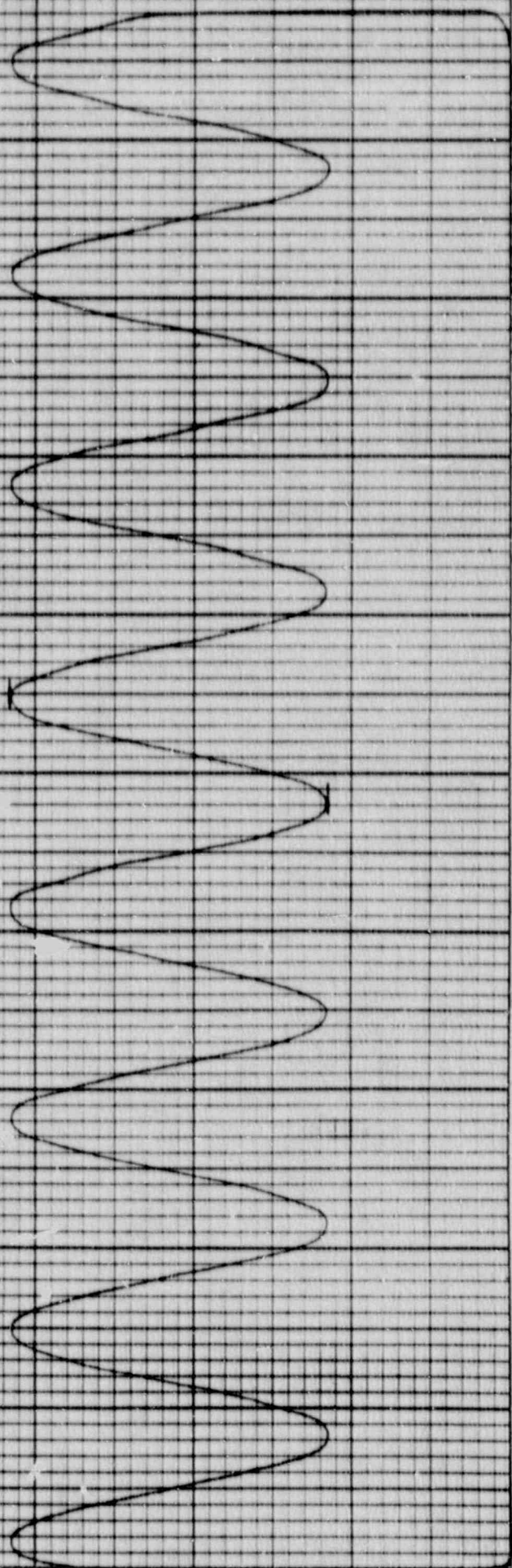
12.5 x .05 = .625 Vpp

Volt

time

DPT-TP-70A-025 Rev C
 X-Y Plotter Calibration Trace
 Step No. 8, 5, 2
 Channel 2 - (15u) Tape 1
 Settings INut = 0.05 V/div
 RMS 08-0-90

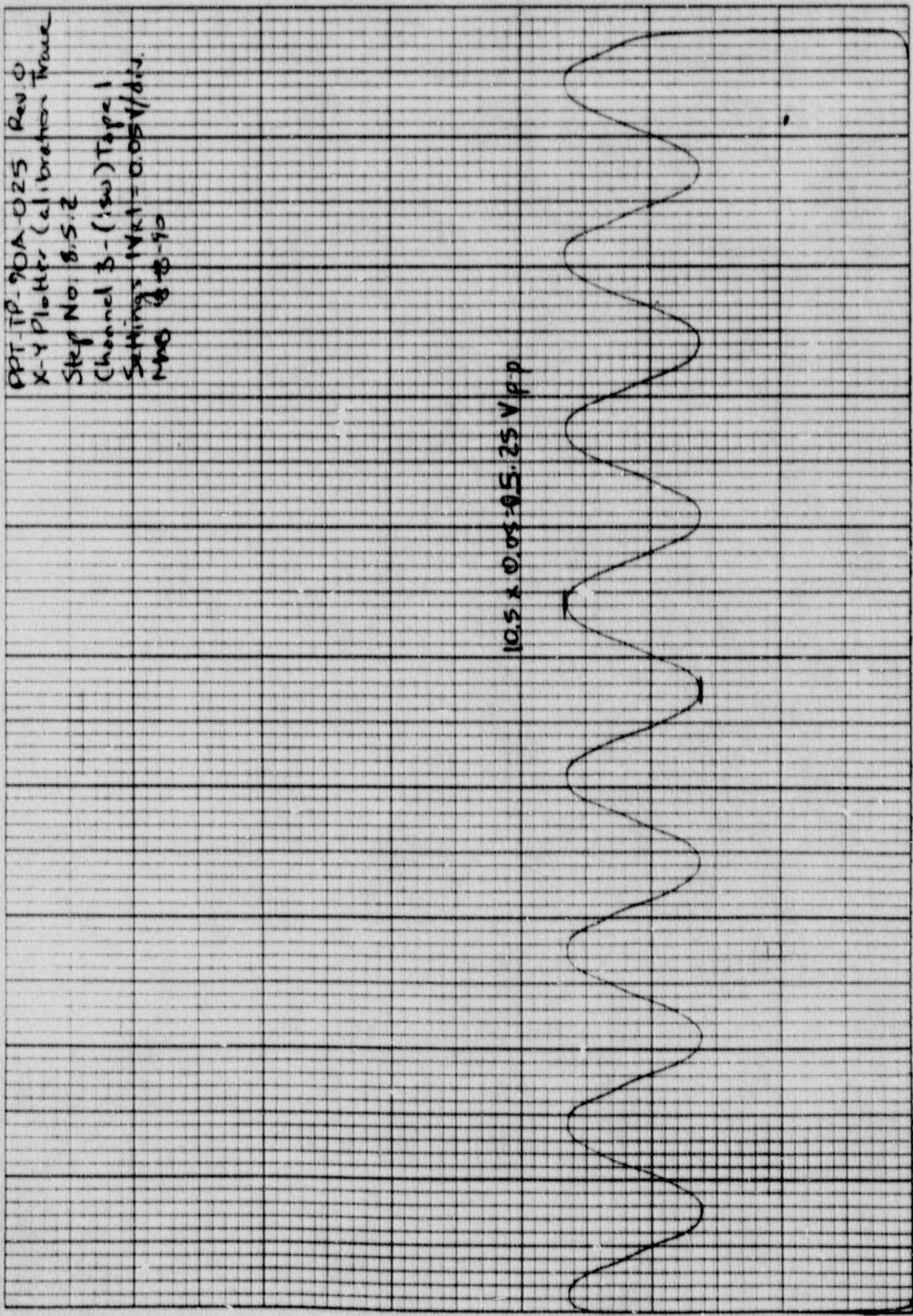
$1.1 \text{ N} 1 \pm 50.0 \times 10^2$



Volts

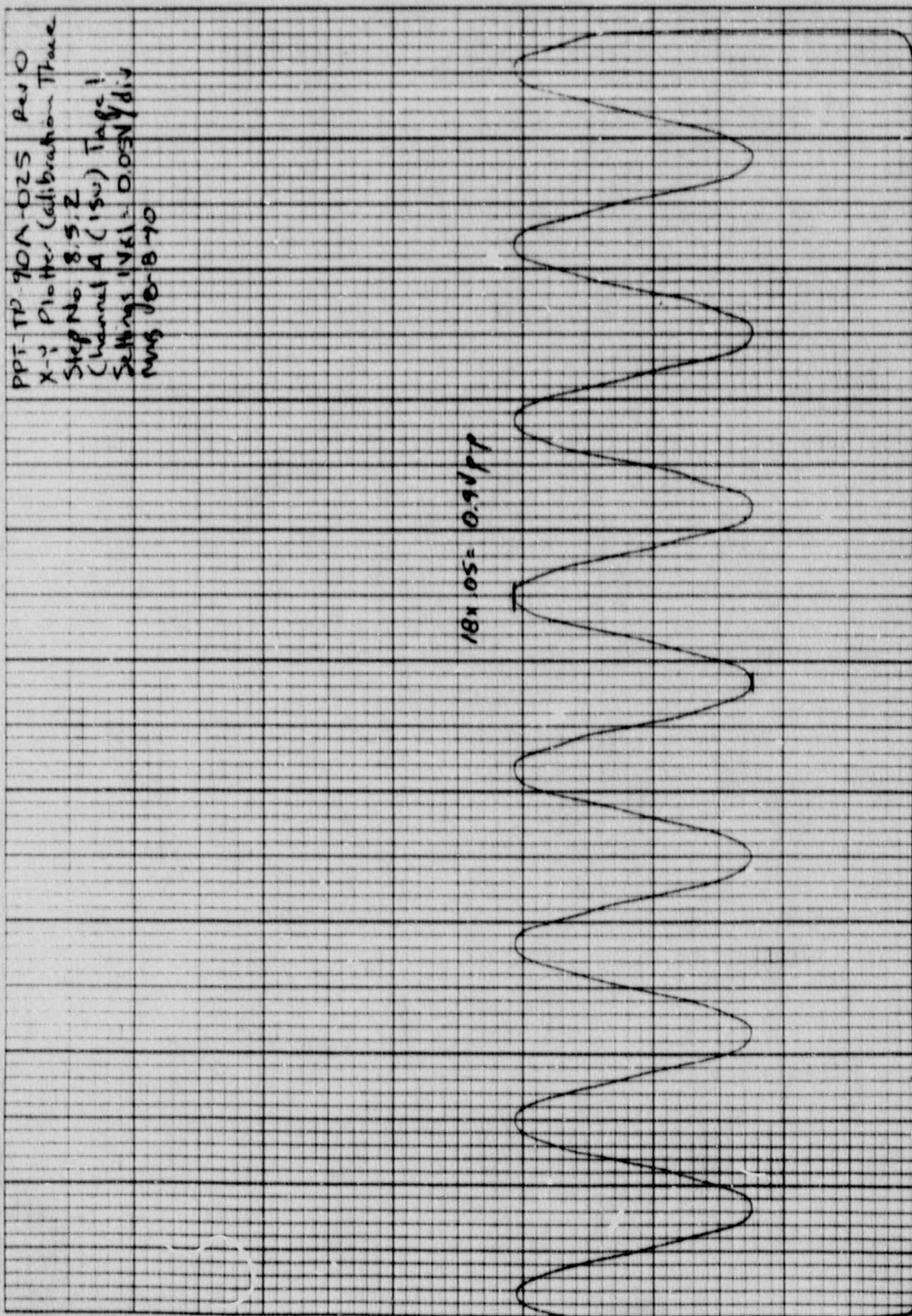
time

OPT-TP-90A-025 Rev. 0
 X-Y Plotter (calibration trace)
 Step No. 8.5.2
 Channel B - (isu) Type 1
 Settings: VRT = 0.05 V/div.
 No. 8.5.90



PPT-TP-70A-025 Rev 0
 X-1 Plotter (calibration trace)
 Step No. 8.5.2
 (channel A (15u) Tag 1)
 Settings 1V/div 0.05V/div
 rms for B-70

18x 0.90pp

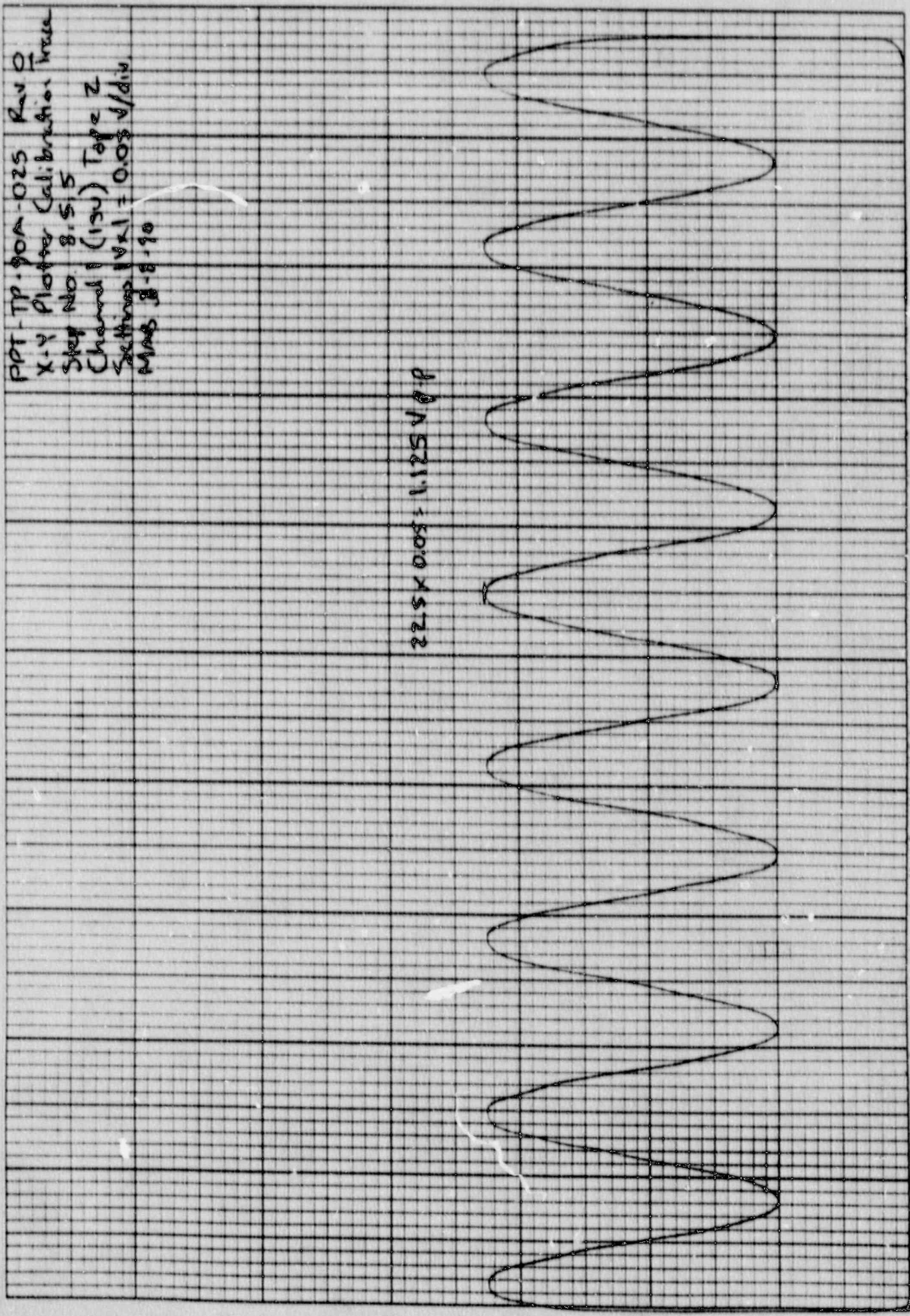


Volts

time

PPT-TP-60A-025 Rev 0
 X-Y Plotter Calibration Trace
 Strip No. 8-5-5
 Channel 1 (ns) Type Z
 Settings $V_{x1} = 0.03 \text{ V/div}$
 $V_{y1} = 0.03 \text{ V/div}$
 $V_{z1} = 0.03 \text{ V/div}$

$0.03 \text{ V} \times 21.1 \times 50.0 \times 5.72$

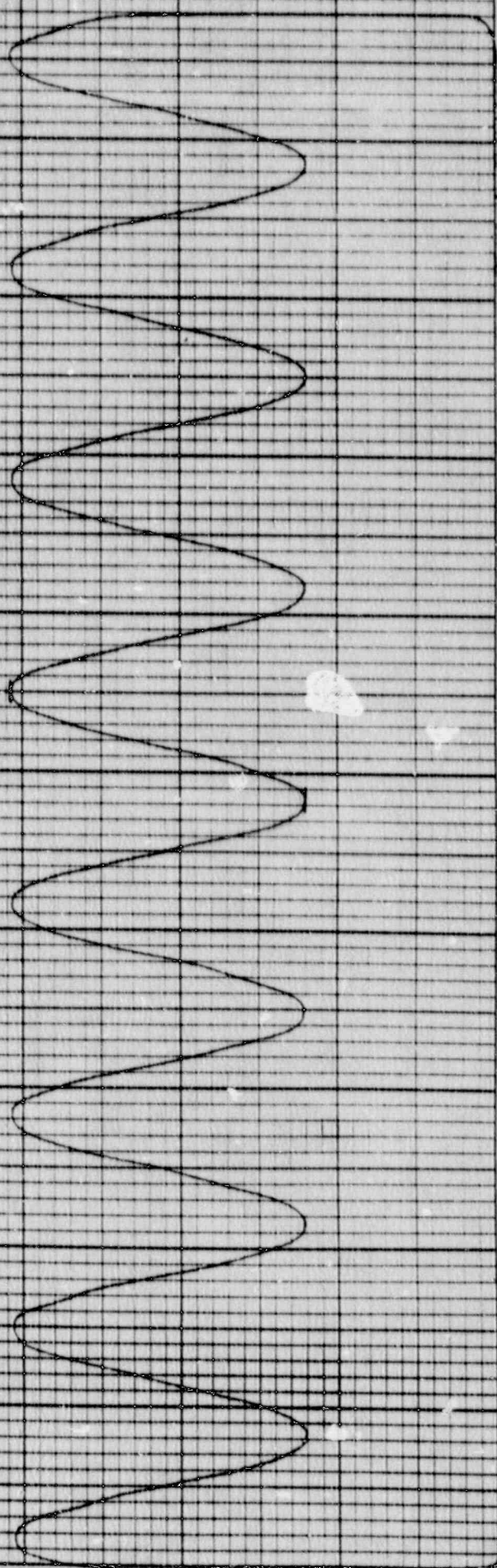


time

Volts

PPT-TP-60A-025 Rev 0
 X-Y Plotter Calibration Trace
 Step No. 8.5.5
 Channel 2 (15V) Type 2
 Settings 1V/div = 0.05 V/div
 MAG 20.0

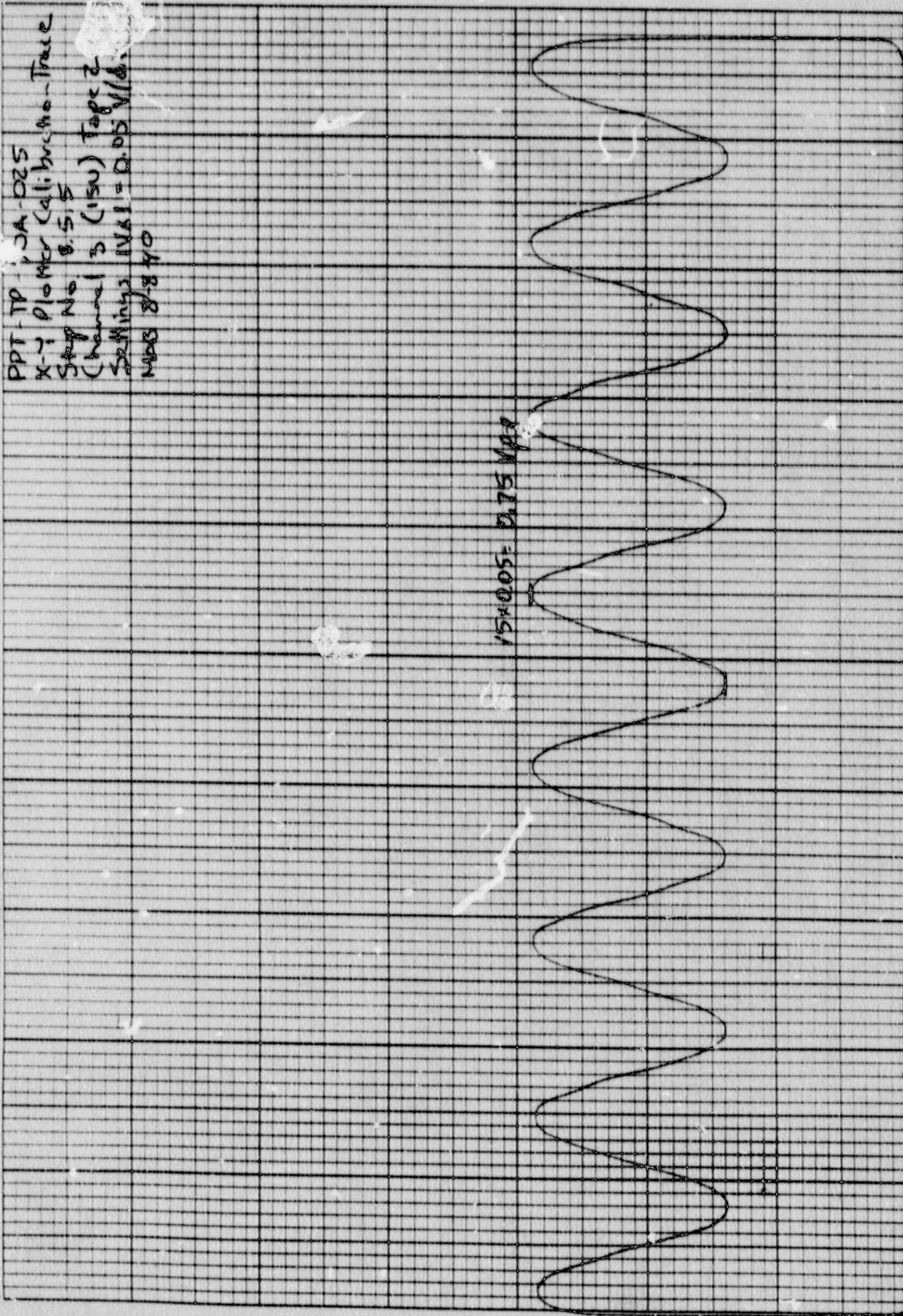
$40A526.0 = 50.0 \times 5.81$



time

Volts

PPT-TP 10A-025
 X-7 Plomer Calibration Trace
 Step No. 8.5.5
 Channel 3 (15u) Tap 2
 Settings IV 11 = 0.05 V/d.
 0488 8840



$15 \times 0.05 = 0.75 \text{ V}$

PPT-TP-90A-025 Rev.0
 X-2 Plotter Calibration Trace
 Slog No. 8-5-5
 Calmed 4 (150) Tape 2-
 Signal Rate = 0.05 VPP
 Mass No. 8-90

1.025 VPP
 $20 \times 520.1 = 10402.502$

time

VOLTS

3.7 Data Summation

Table 2 documents a detailed breakdown of each sensors frequency and amplitude response and individual characteristics. Description of each column is listed below:

Sensor - Sensor I.D. for which data is applicable for.

LPM - Loose Parts Module used for processing sensor signal during data collection and analysis.

Filter Settings - Based on the average values of low and high break frequencies for the active sensor channels.

High Pass - Low end "break frequency" given in Kilohertz (KHz). The high-pass filter is adjusted so that the processed signal is attenuated to 70.7% at this frequency. Frequencies lower than this value will be attenuated even greater. Processed signal strength at twice this frequency will be approximately 100%.

Low Pass - High end "break frequency" given in Kilohertz (KHz). The low-pass filter is adjusted so that the processed signal is attenuated to 70.7% at this frequency. Frequencies higher than this value will be attenuated even greater. Processed signal strength at one-half this frequency will be approximately 100%.

Background Noise Level - This value, given in g's peak-to-peak, is the normal operating background noise level. This value was determined after bandpass filters were adjusted.

Hi-Alarm Setting - This setting (1 thru 6) indicates the input ratio value required to bring in an alarm. Alarm settings and equivalent ratios are listed below.

<u>Hi-Alarm Setting</u>	<u>Ratio</u>
1	1.2
2	1.3
3	1.4
4	1.6
5	1.8
6	2.0

Alert Level - This value, given in g's peak-to-peak, is the required signal strength at power operation, to bring in an alarm. The value is a direct function of the normal operating background signal strength times the Hi-Alarm equivalent ratio.

Sensor Response -

- 0.25 lbm - This value, in g's peak-to-peak, was the measured response when impacting the associated piping within 3 feet of the listed sensor with a calibrated weight of 0.25 lbm at a kinetic energy of 0.5ft/lbs.
- 30 lbm - This value, in g's peak-to-peak, was the calculated response for impacting the associated piping within 3 feet of the listed sensor with a calibrated weight of 30 lbm at a kinetic energy of 0.5 ft./lbs. Calculated response was based on the ratio of the actual measure response between the 0.25 lbm and 30 lbm impacts for Sensor 3.

Adjacent Sensor Response

- 0.25 lbm - This value, in g's peak-to-peak, was the strongest measured response for an adjacent sensor when impacting the associated piping within 3 feet of the listed sensor with a calibrated weight of 0.25 lbm at a kinetic energy of 0.5 ft./lbs.
- 30 lbm - This value, in g's peak-to-peak, was the calculated response for an adjacent sensor when impacting the associated piping within 3 feet of the listed sensor with a calibrated weight of 30 lbm at a kinetic energy of 0.5 ft./lbs. Calculated response was based on the same ratio as the actual measured response between the 0.25 lbm and 30 lbm impacts for Sensor 3.

Notes -

1. - Active sensor, continuously monitored for detection of loose parts
2. - Adjacent sensor response not required for passive sensors since no automatic alarm detection is involved.
3. - Passive sensor, used for diagnostics after a loose part.
4. - Sensor response for 30 lbm object is actual measured value.
5. - Highest adjacent sensor response measured on Sensor #19.
6. - Highest adjacent sensor response measured on Sensor #17.
7. - Highest adjacent sensor response measured on Sensor #18.
8. - Highest adjacent sensor response measured on Sensor #20.

Table 2
CPSES LPMS Data Summation

Sensor	FILTER SETTINGS			Background Noise Level (g P-P)	Hi-Alarm Setting	Alert Level (g P-P)	SENSOR RESPONSE		ADJACENT SENSOR RESPONSE		Notes
	LPM	High Pass (KHz)	Low Pass (KHz)				0.25 lbn (g P-P)	30 lbn (g P-P)	0.25 lbn (g P-P)	30 lbn (g P-P)	
1	1	2	11	0.55	5	0.99	11.52	5.76	3.23	1.62	1,5
2	1	2	11	0.32			18.90	9.45	N/A	N/A	2,3
3	2	2	11	0.86			13.71	6.86	N/A	N/A	2,3,4
4	3	2	11	0.43			85.60	42.80	N/A	N/A	2,3
5	2	2	11	0.27	5	0.49	12.84	6.42	3.31	1.66	1,5
6	4	2	11	0.45			13.29	6.65	N/A	N/A	2,3
7	5	2	11	0.03			6.54	3.27	N/A	N/A	2,3
8	6	2	11	0.32			73.80	36.90	N/A	N/A	2,3
9	3	2	11	0.97	5	1.75	8.45	4.43	2.89	1.45	1,5
10	7	2	11	0.99			8.85	4.43	N/A	N/A	2,3
11	8	2	11	2.57			13.71	6.86	N/A	N/A	2,3
12	1	2	11	0.31			73.80	36.90	N/A	N/A	2,3
13	4	2	11	0.38	5	0.68	4.77	2.39	2.80	1.40	1,5
14	2	2	11	0.62			8.85	4.43	N/A	N/A	2,3
15	3	2	11	0.10			14.16	7.08	N/A	N/A	2,3
16	4	2	11	0.47			100.30	50.15	N/A	N/A	2,3
17	5	2	11	0.14	5	0.25	28.32	14.16	2.46	1.23	1,7
18	6	2	11	0.46	5	0.83	91.50	45.75	2.38	1.19	1,6
19	7	2	11	1.10	4	1.76	48.70	24.35	3.57	1.79	1,8
20	8	2	11	2.02	4	3.23	14.16	7.08	8.07	4.04	1,5

4.0 Results

As can be seen from results documented in Table 2 the normal operating background levels for the active sensors range from 0.14 to 2.02 g's peak-to-peak. The noisiest data was obtained from sensors located on the reactor head. Based on the final HI-ALARM settings recorded in ISU-211A it was determined that system performance would be improved if sensitivity was increased on the two sensors located on the reactor head.

Work Order C90-7073 was issued to increase the sensitivity of these sensors by decreasing the HI-ALARM settings from 5 to 4.

Sensor response indicates that each active LPM module will alarm when the piping is impacted with an object weighing 0.25 lbms to 30 lbms at an impact energy of 0.5 ft. lbs. within 3 feet of the sensor. The 30 lbm response was calculated based on the ratio of an actual 30 lbm to 0.25 lbm impact at the #3 sensor location. This ratio was determined to be approximately 1:2 which would indicate that the 30 lbm impact accelerometer response (output) would be approximately one-half of the 0.25 lbm impact. When looking at actual alert levels for each of the active channels the 30 lbm response ratio could be as low as 1:4.3 (or 23% of the 0.25 lbm response) and still result in an alarm condition.

Adjacent sensor response, which would be required to automatically initiate the main control room annunciation, indicates that an object weighing 0.25 lbms impacting at an energy of 0.5 ft. lbs. within 3 ft. of the sensor would easily be detected. 30 lbm objects impacting at the same location and with the same energy are less likely to bring in the main control board annunciation as can be seen from the adjacent sensor response column in Table 2. This decrease in overall system sensitivity can be attributed to "active" sensor location. All four steam generator inlets have one active sensor. The best adjacent sensor response was measured at sensor 19 on the reactor head when impacting near the SG inlet sensors.