ATTACHMENT A

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

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:

- Describe the loose-parts monitor system for CPSES.
- Describe the methodology used to measure impact energy sensitivity.
- Discuss the results of LPMS associated test and data reduction.
- 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:

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

One accelerometer is located at each of the following locations:

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

The accelerometers operate on the piezoelectic 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 1

CPSES Loose Parts Monitoring Sensor Locations

SENSOR	PROCESS MODULE	TYPE	LOCATION
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 1CP-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 1CP-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 pertubation 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.

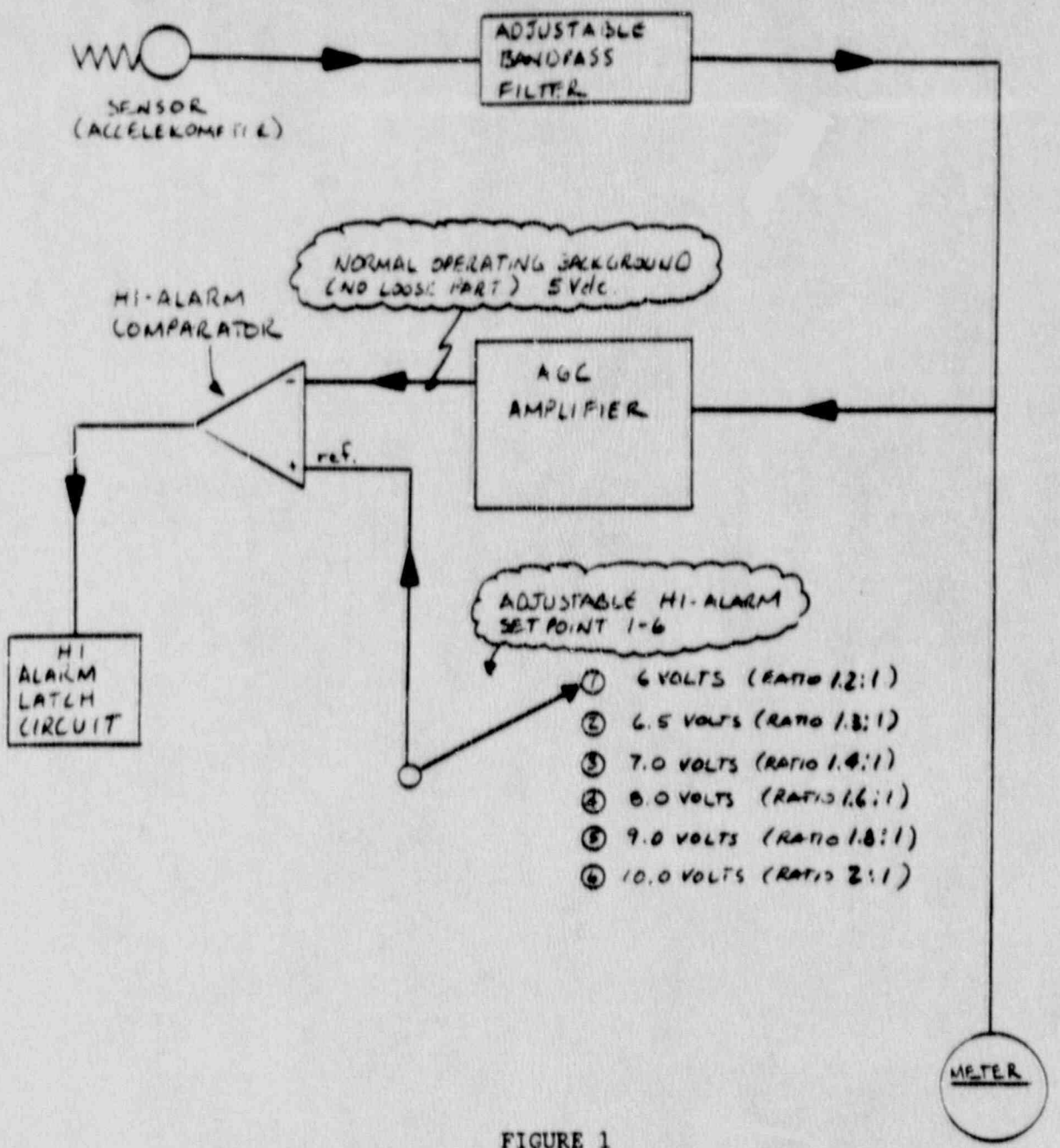
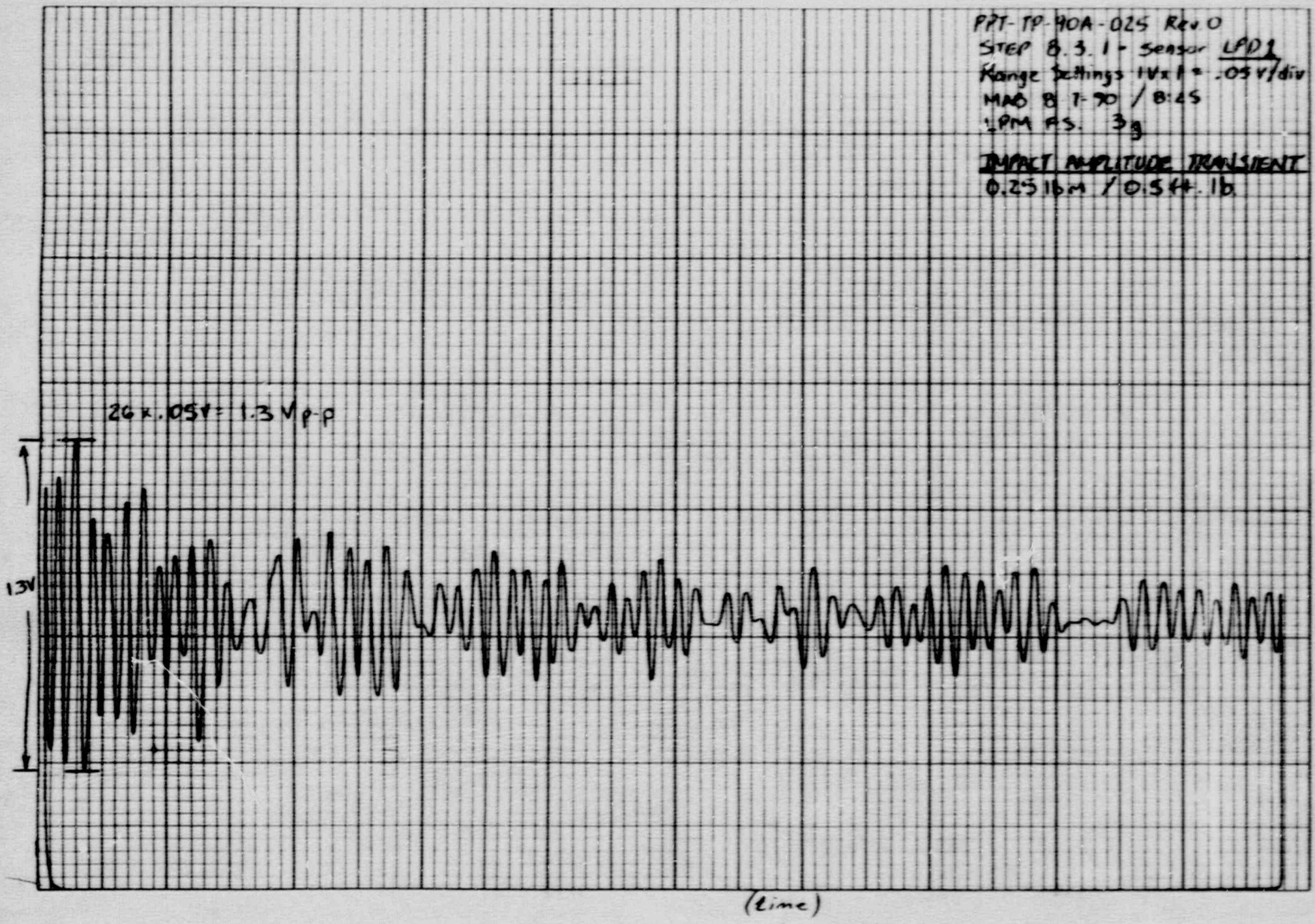


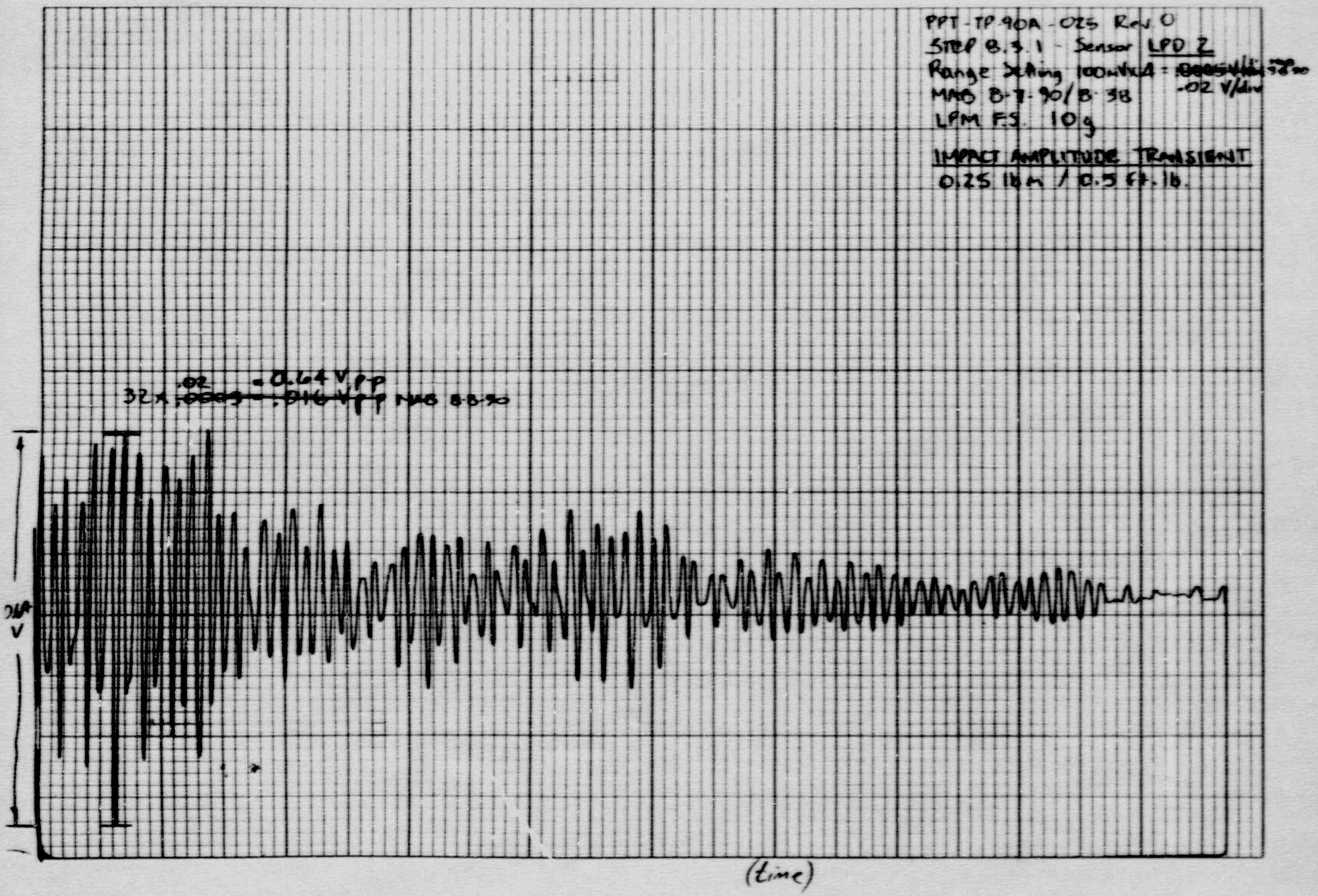
FIGURE 1
SIMPLIFIED BLOCK DIAGRAM OF
LOOSE PARTS DETECTOR HI-ALAIM PROCESS

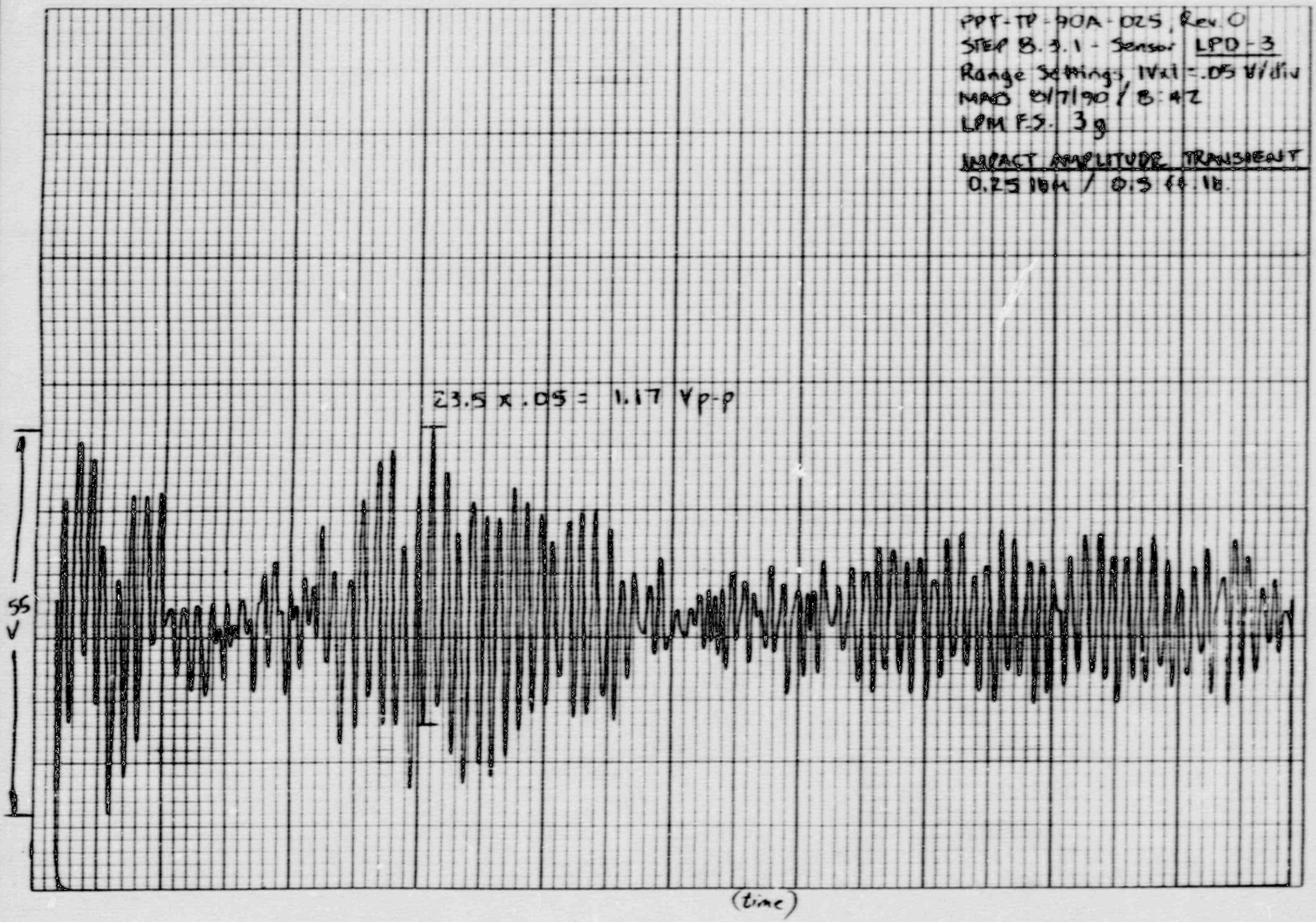
3.0 Data

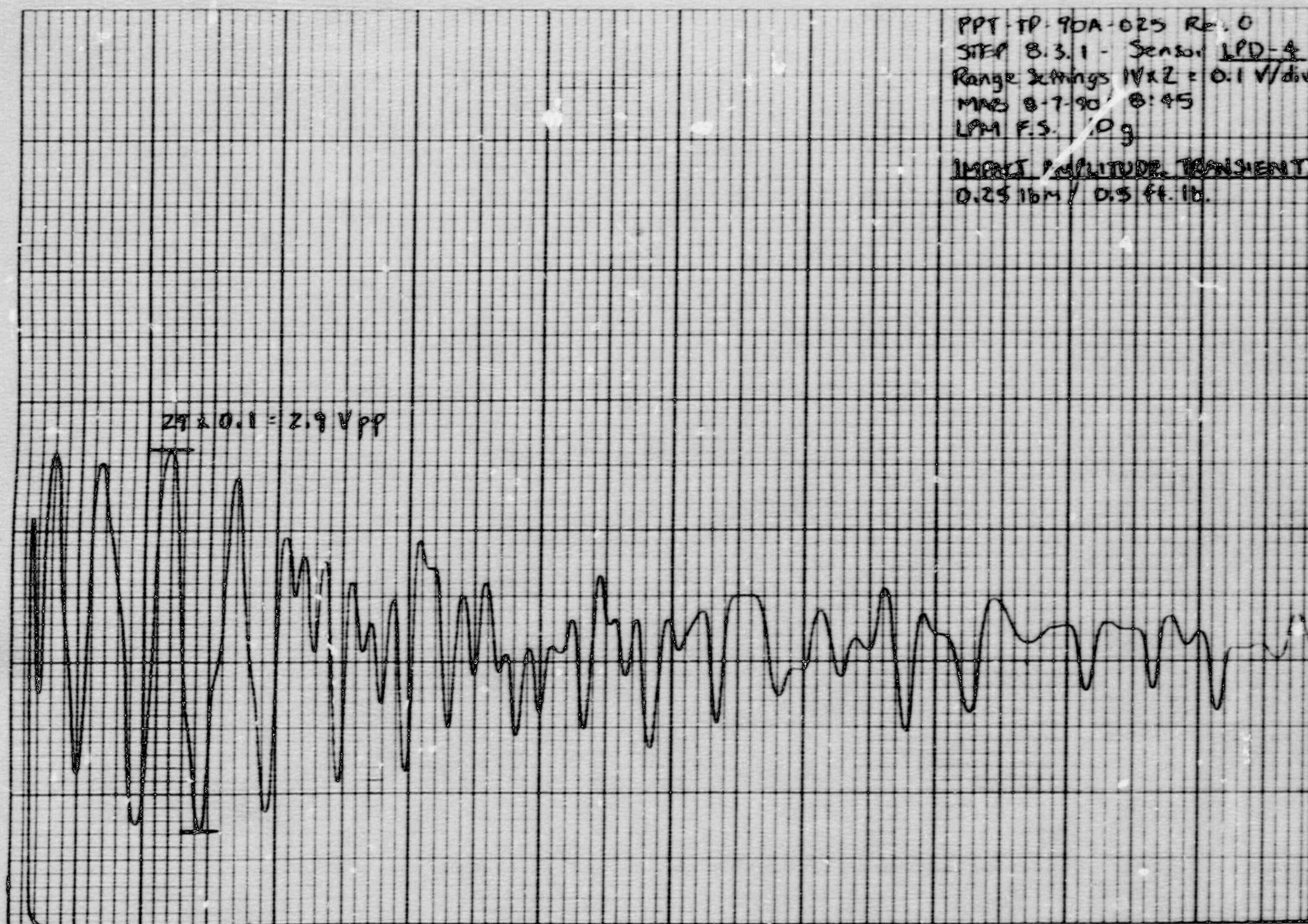
3.1 Impact Amplitudes

The following X-Y plots were made using data collected during pre-operational test 1CP-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 detemine Impact Amplitude in g's(p-p).




PPT-TP-90A-025 Rev. 0
STEP 8.3.1 - Sensor LPD 2
Range Xing 100mV/A = .02 V/div
MAB 8-7-90/B-38
LPM F.S. 10 g
IMPACT AMPLITUDE TRANSIENT
0.25 lbm / 0.5 ft.lb.
32 x .02 = 0.64 Vpp
MAB 8-8-90
V
(time)





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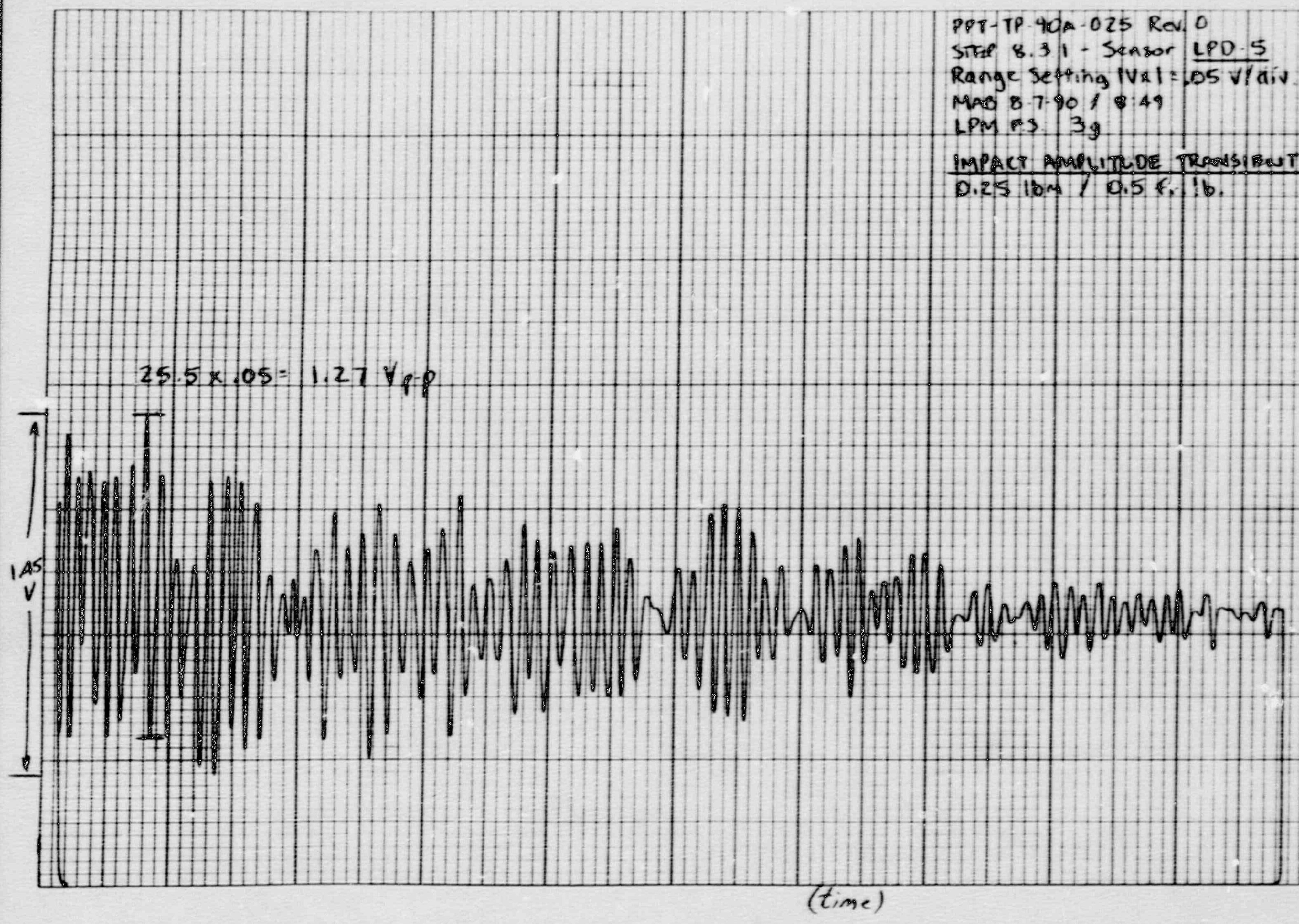
PPT-TP-40A-025 Rev. 0
STEP 8.3.1 - Sensor LPD-5
Range Setting |Va| = .05 V/div
MAB 8-7-90 / 8:49
LPM FS 3g
IMPACT AMPLITUDE TRANSIENT
0.25 lbm / 0.5 f. lb.
25.5 x .05 = 1.27 Vp-p
1.45 V
(time)
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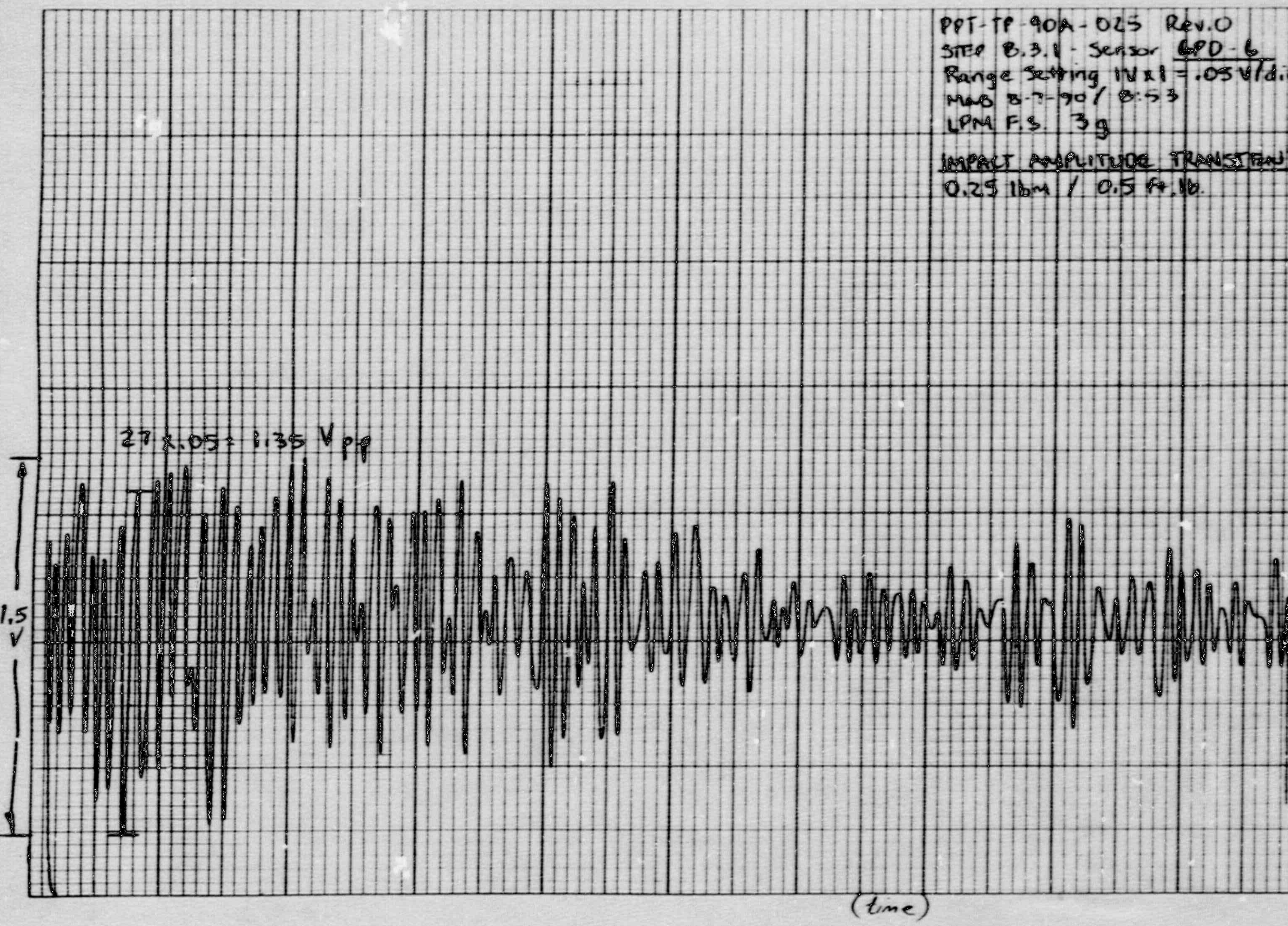


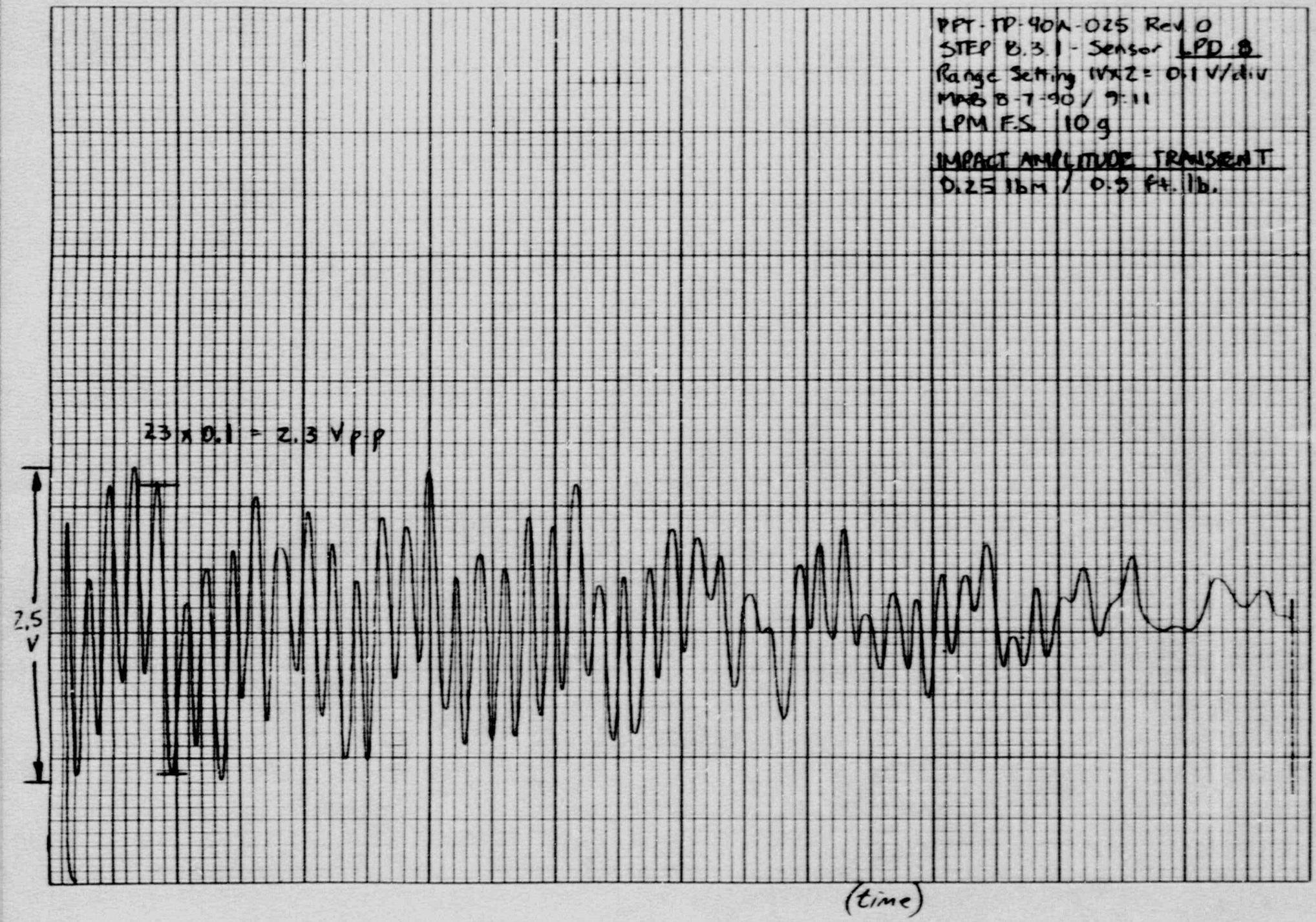
PPT-TP-9DA-025 Rev. O
STEP 8.3.1 - Sensor LPD-7
Range Setting 100mV x 4 = .02 V/div
MMS 8-7-90 / 9:09
LPM F.S. 3g

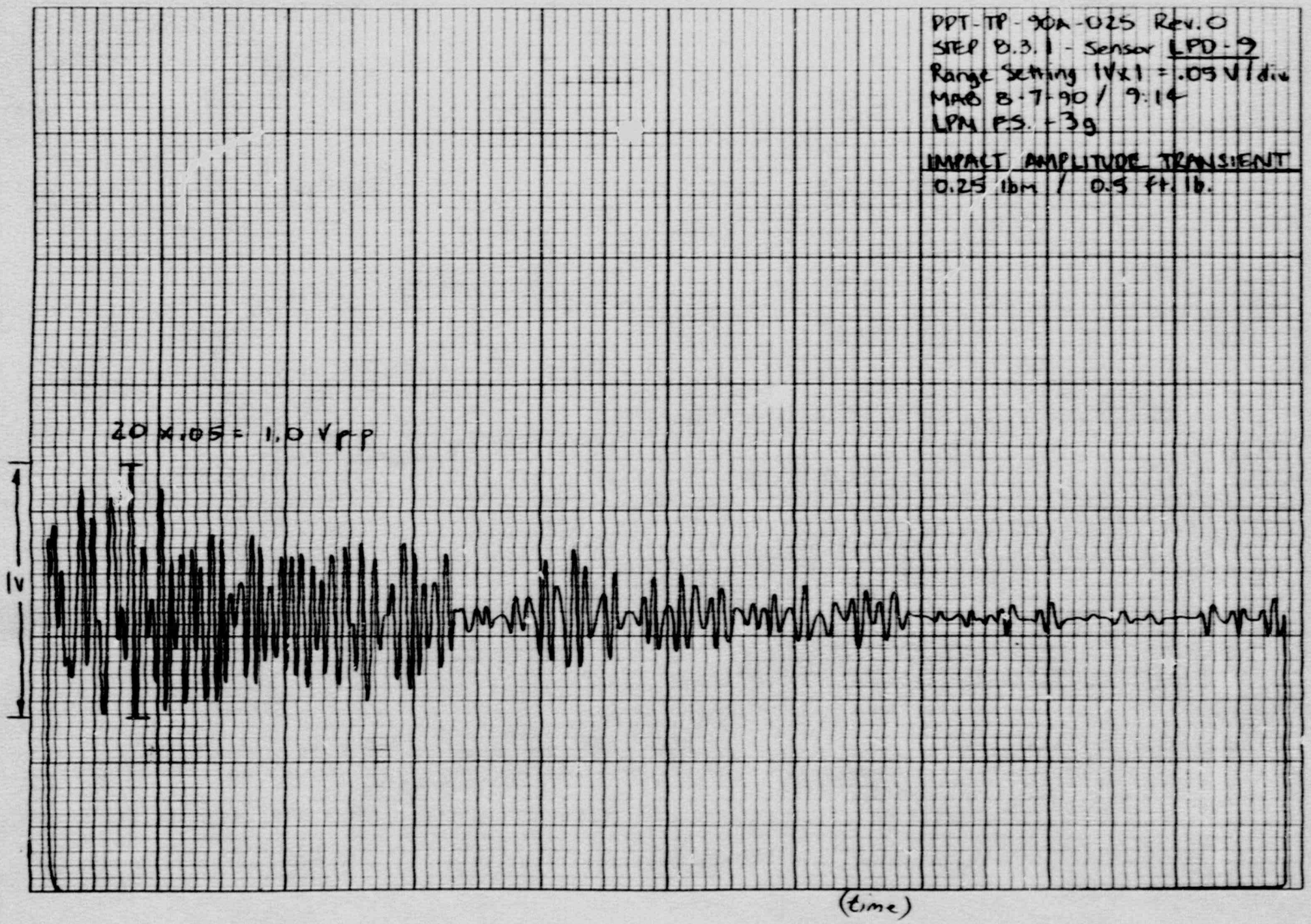
IMPACT AMPLITUDE TRANSIENT
0.25 lbm. / 0.5 ± .1lb.

33 x .02 = 0.66 V p-p

0.74 V

(time)



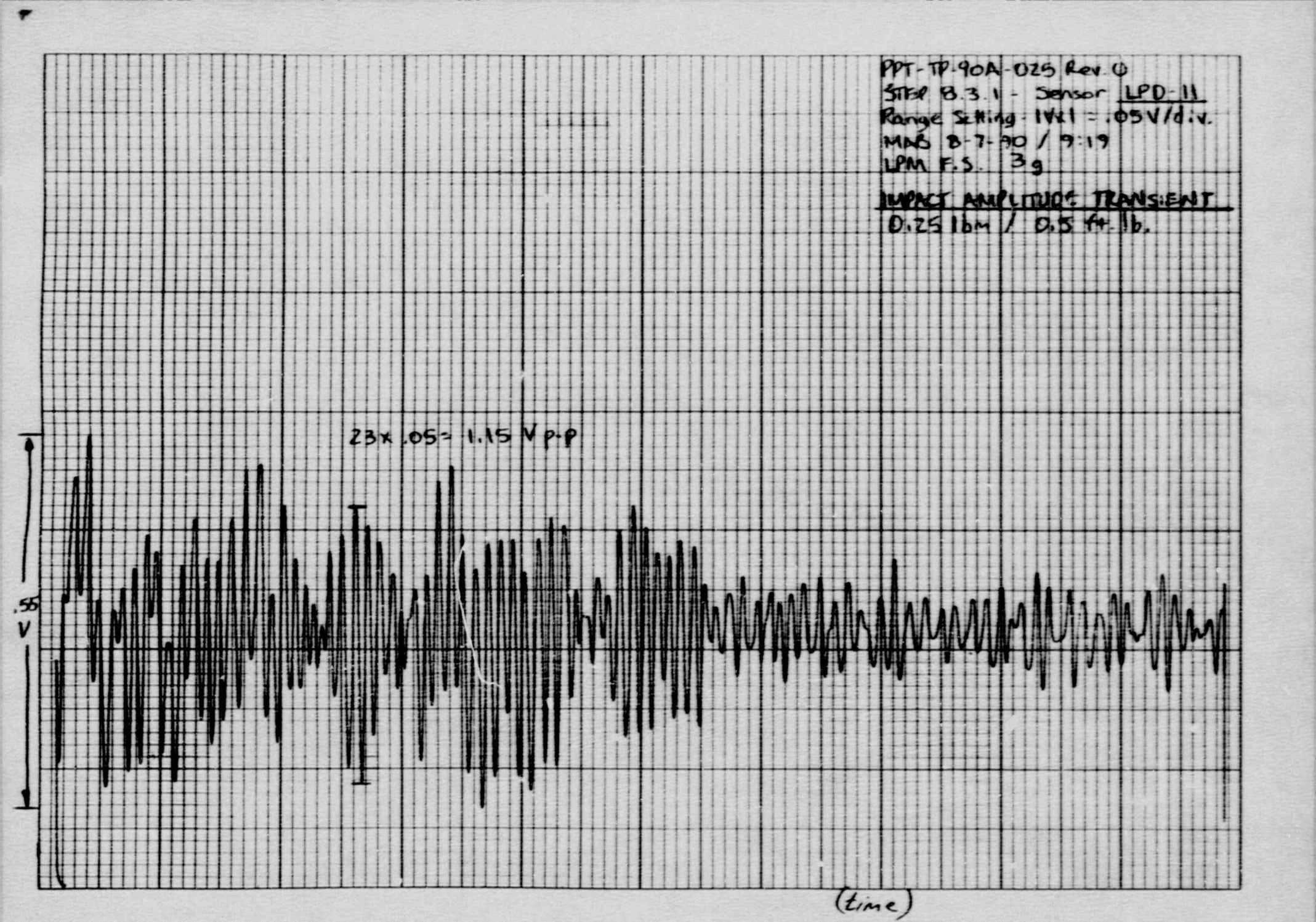


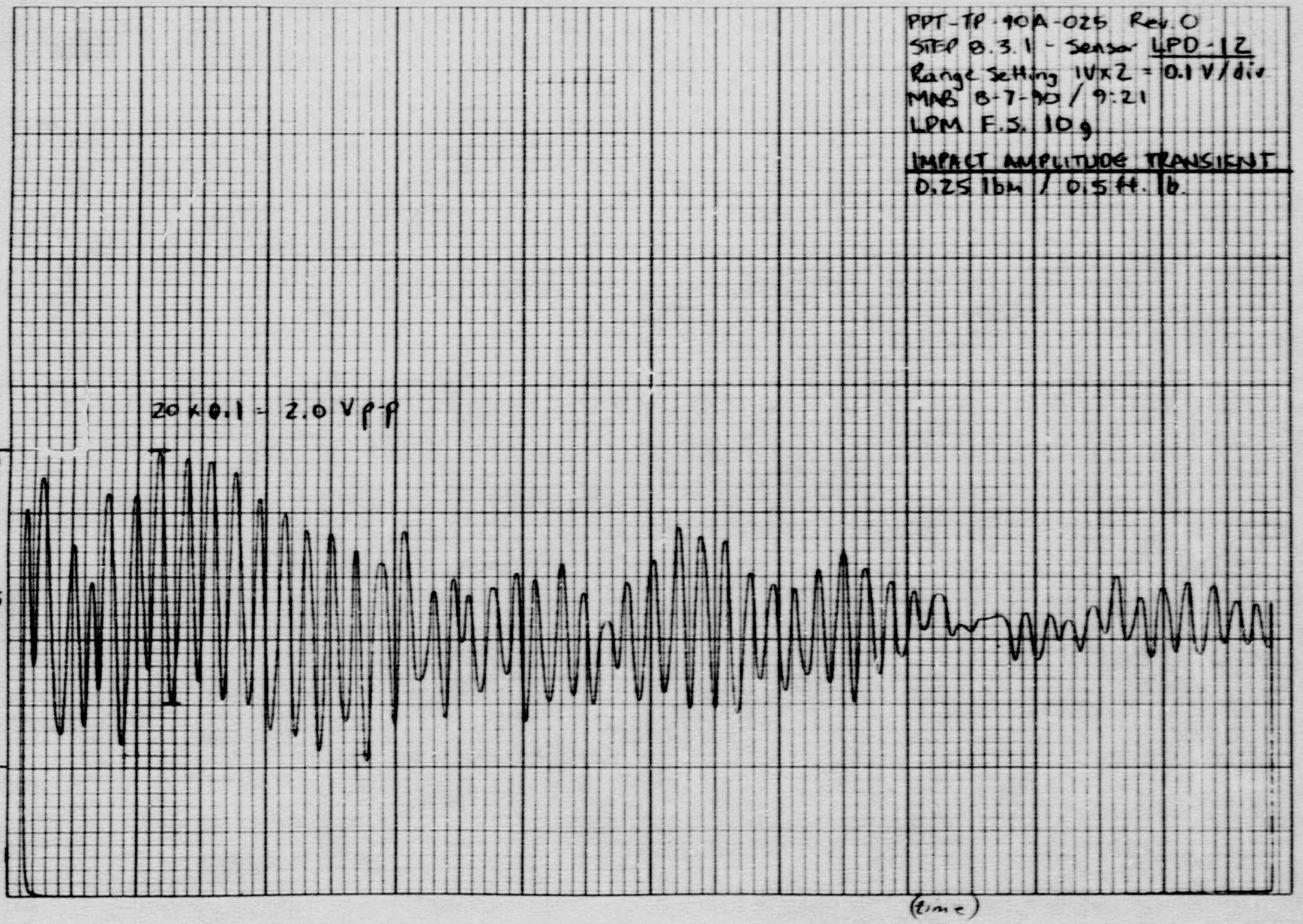
PPT-TP-90A-025 Rev. O
STEP 8.3.1 - Sensor LPD-10
Range Setting 1V x 1 x 2 = .025 V/div.
MMD 8-7-90 / 9:17
LPM F.S 3g

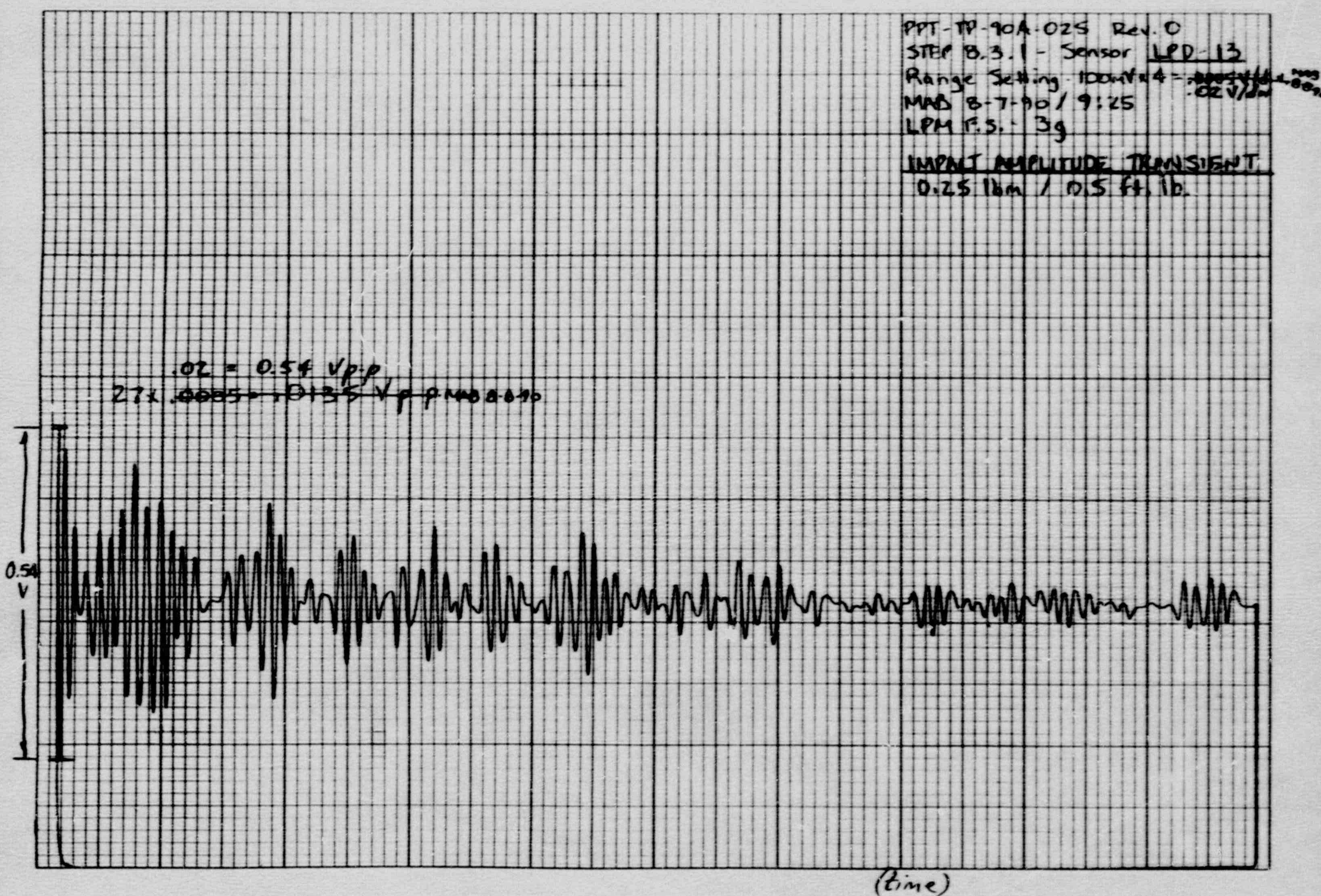
IMPACT AMPLITUDE TRANSIENT
0.25 lbm / 0.5 ft. lb.

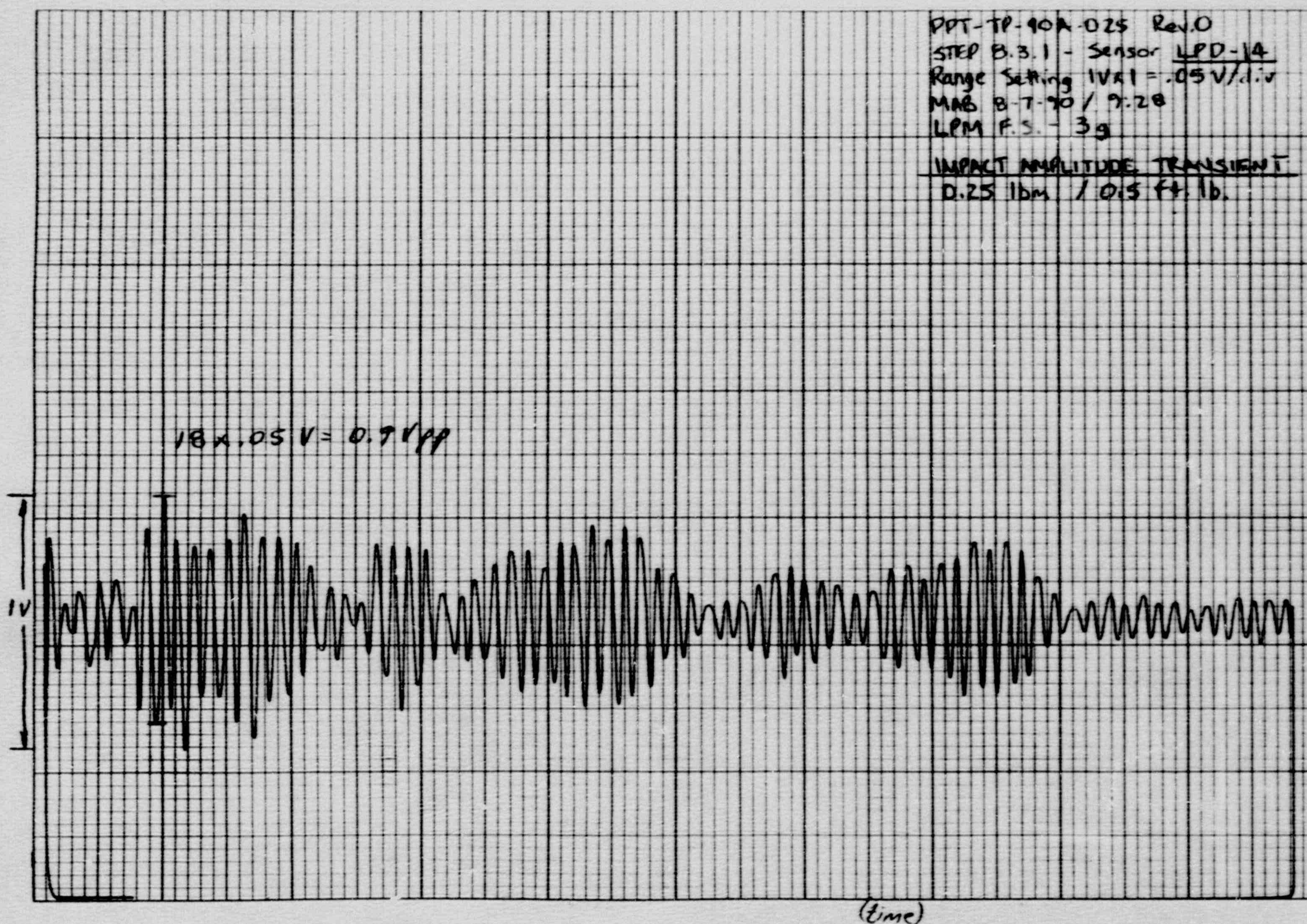
39 x .025 = 0.975 Vp-p

1V









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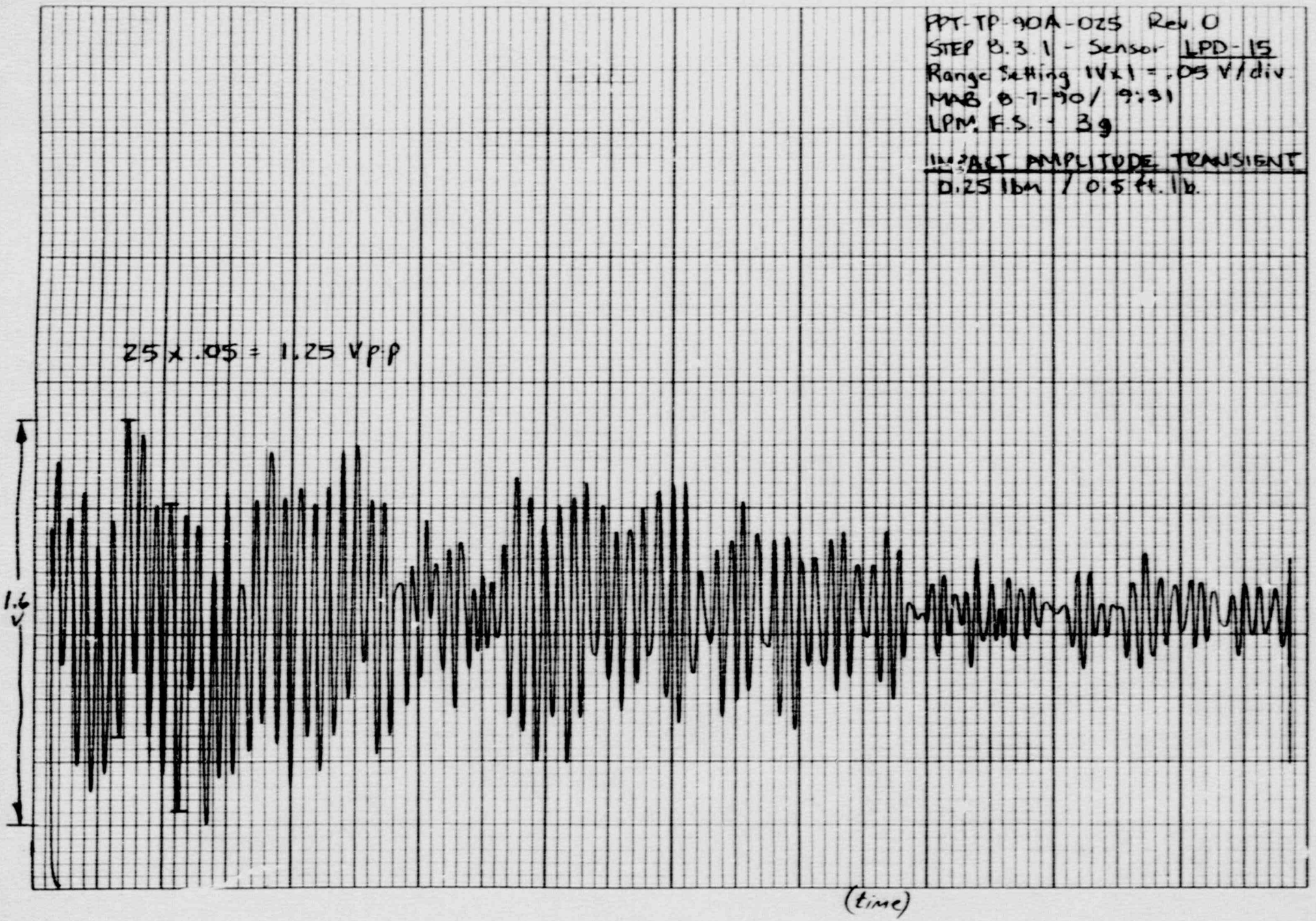

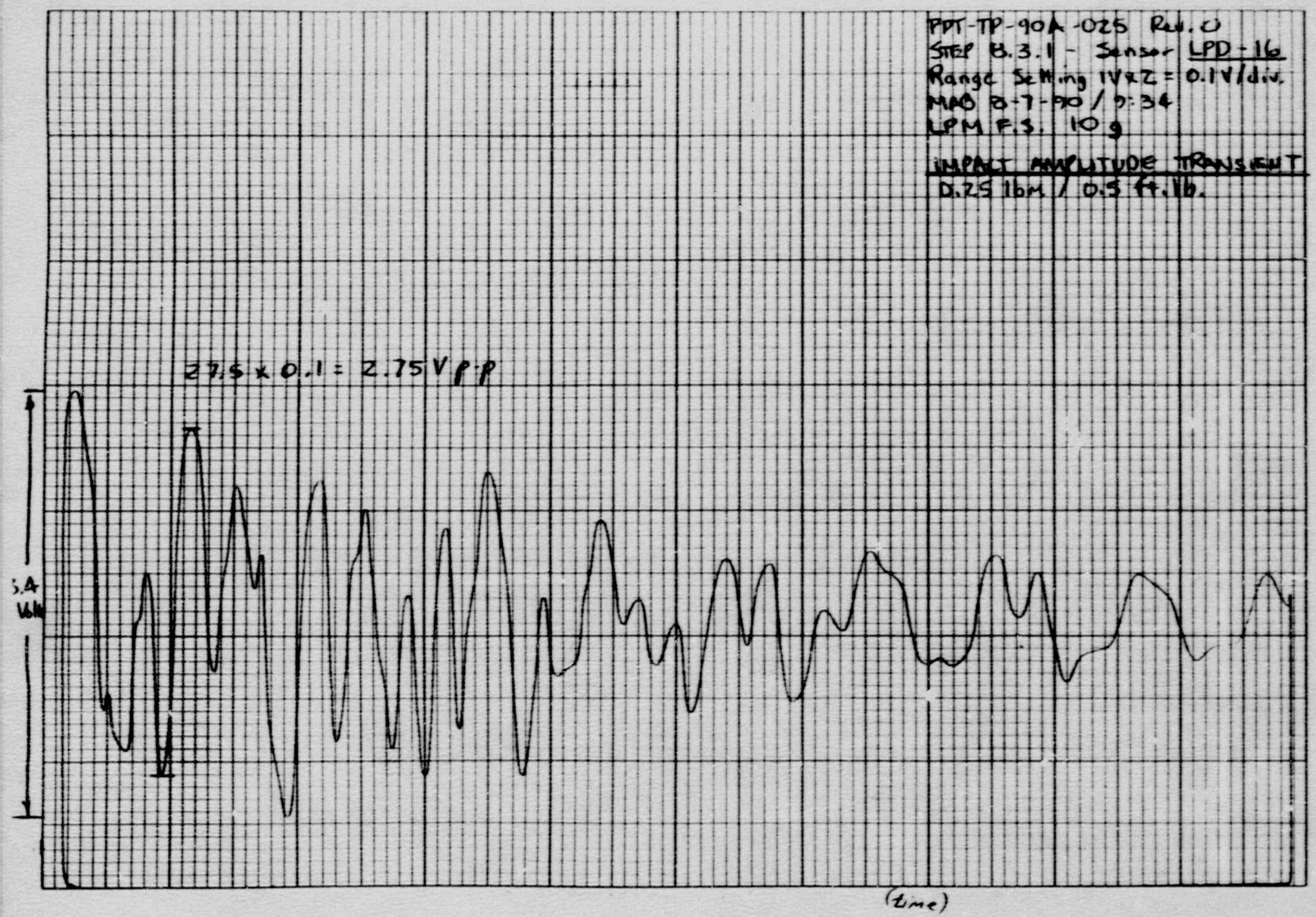

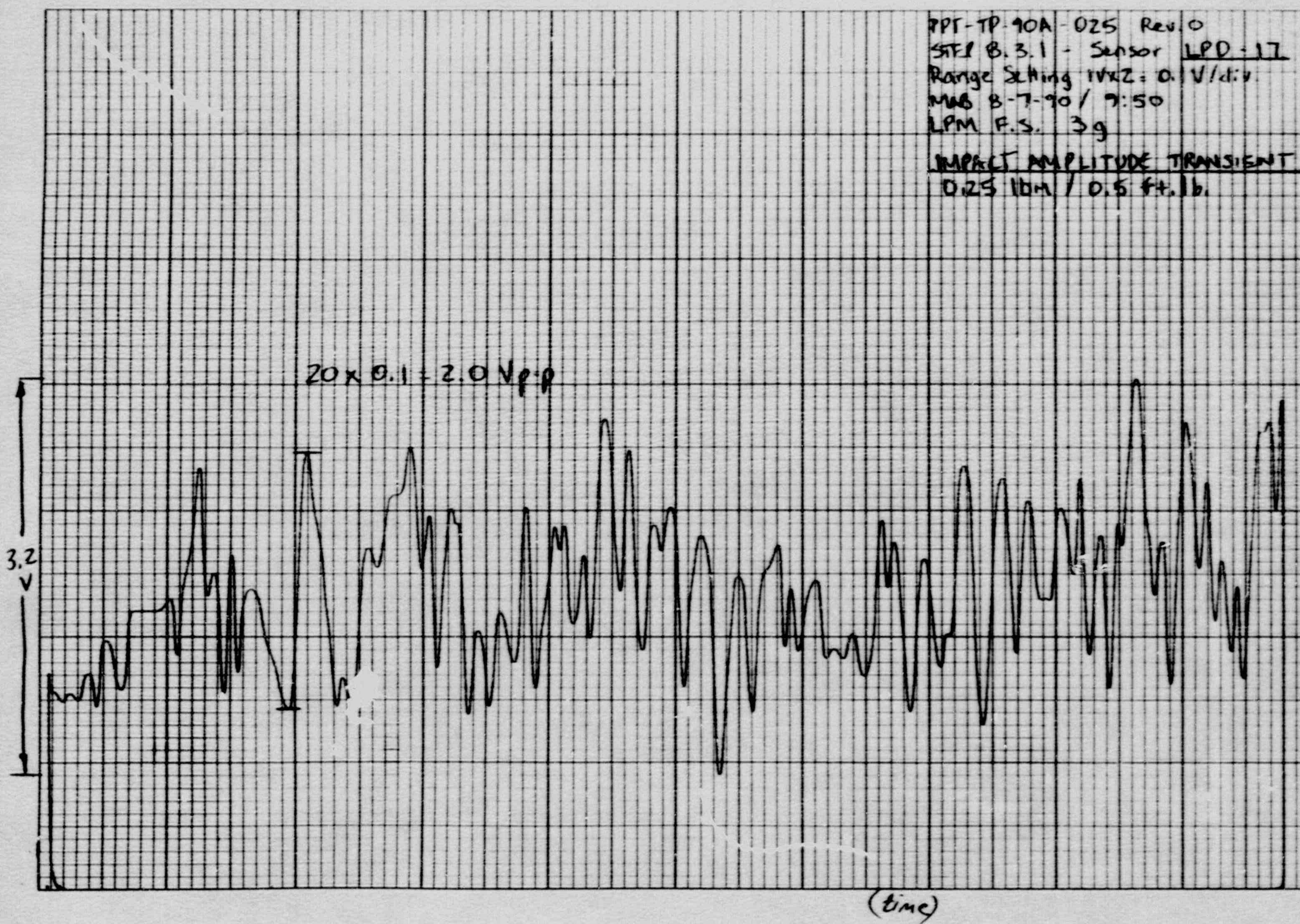

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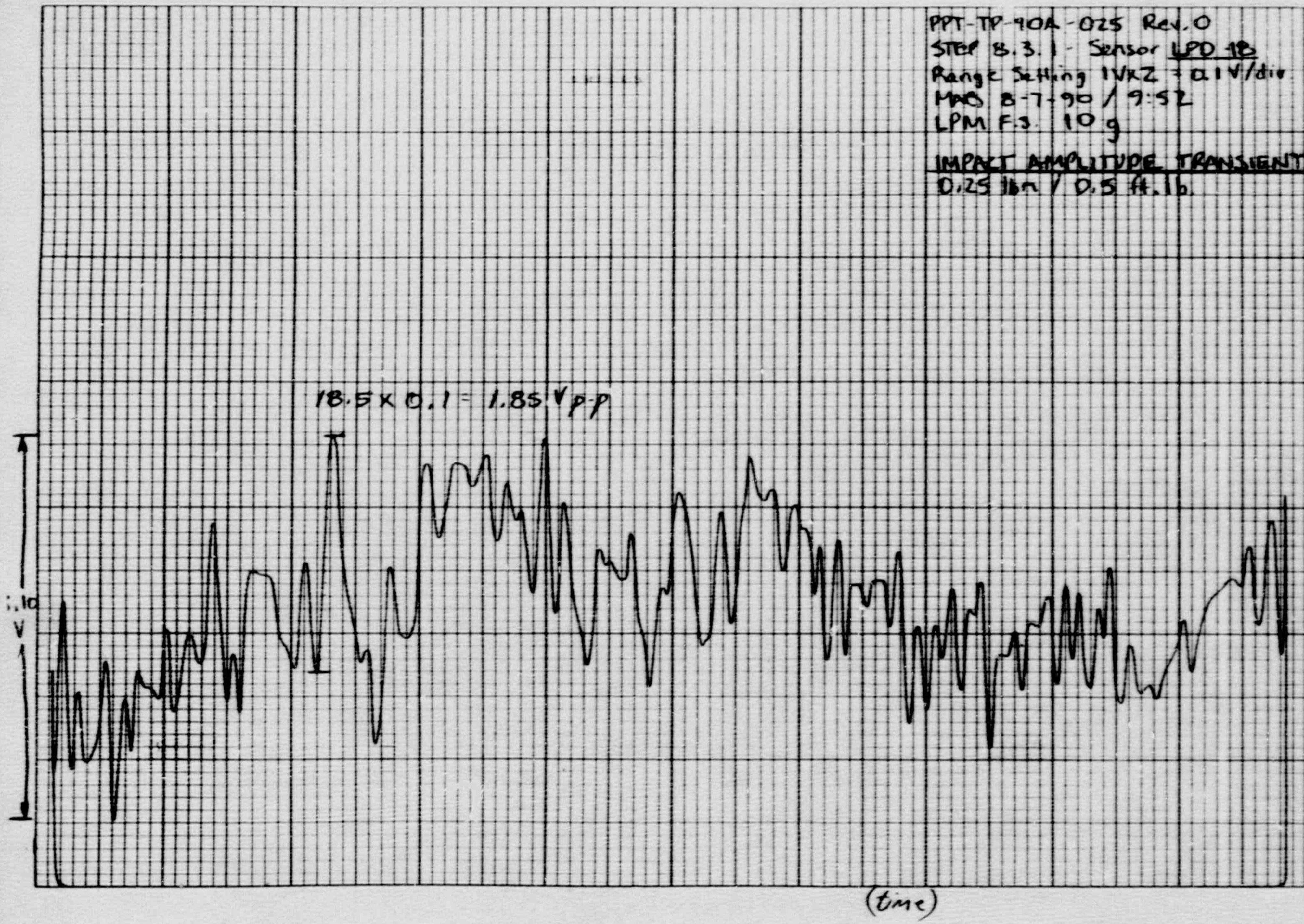

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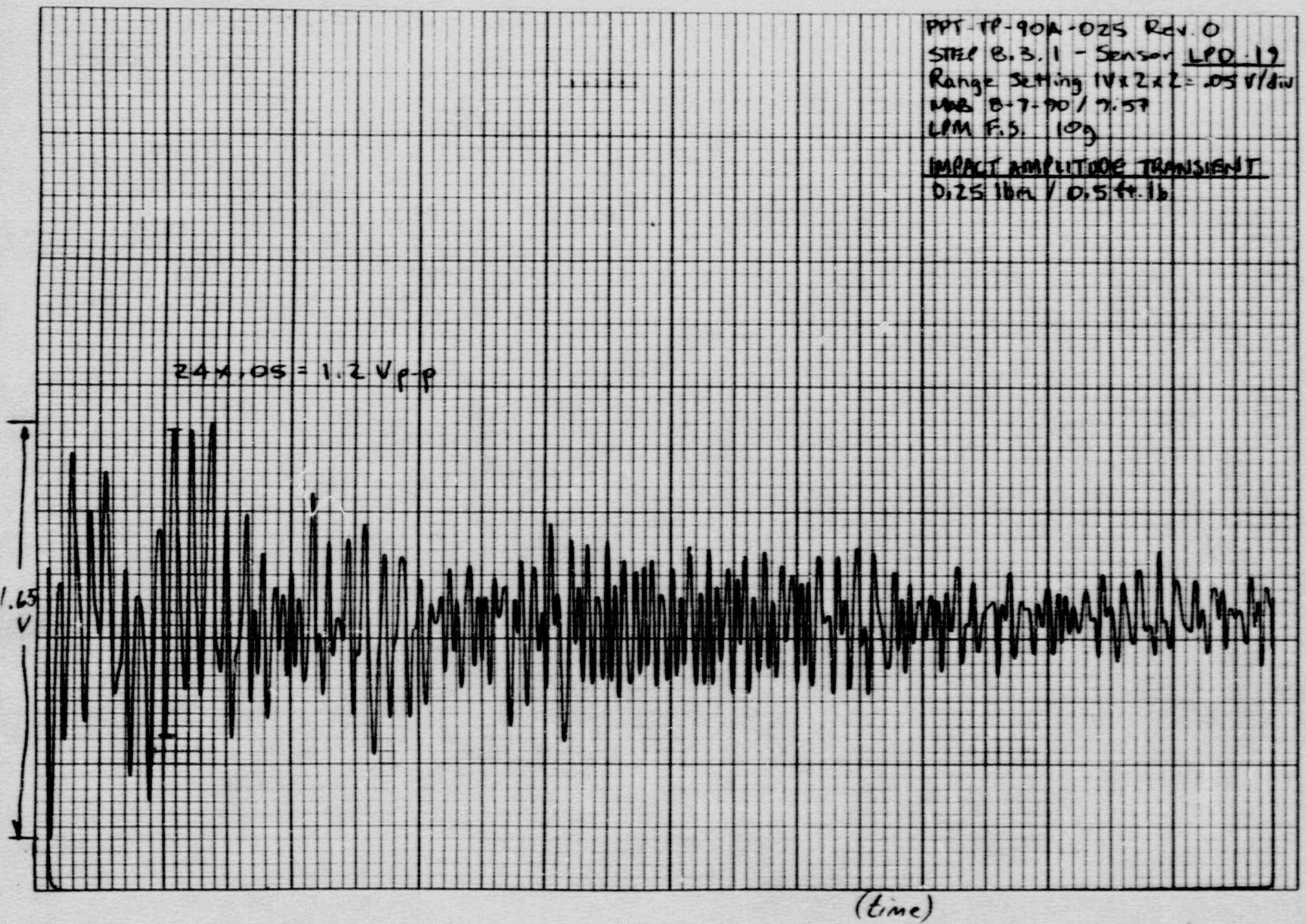


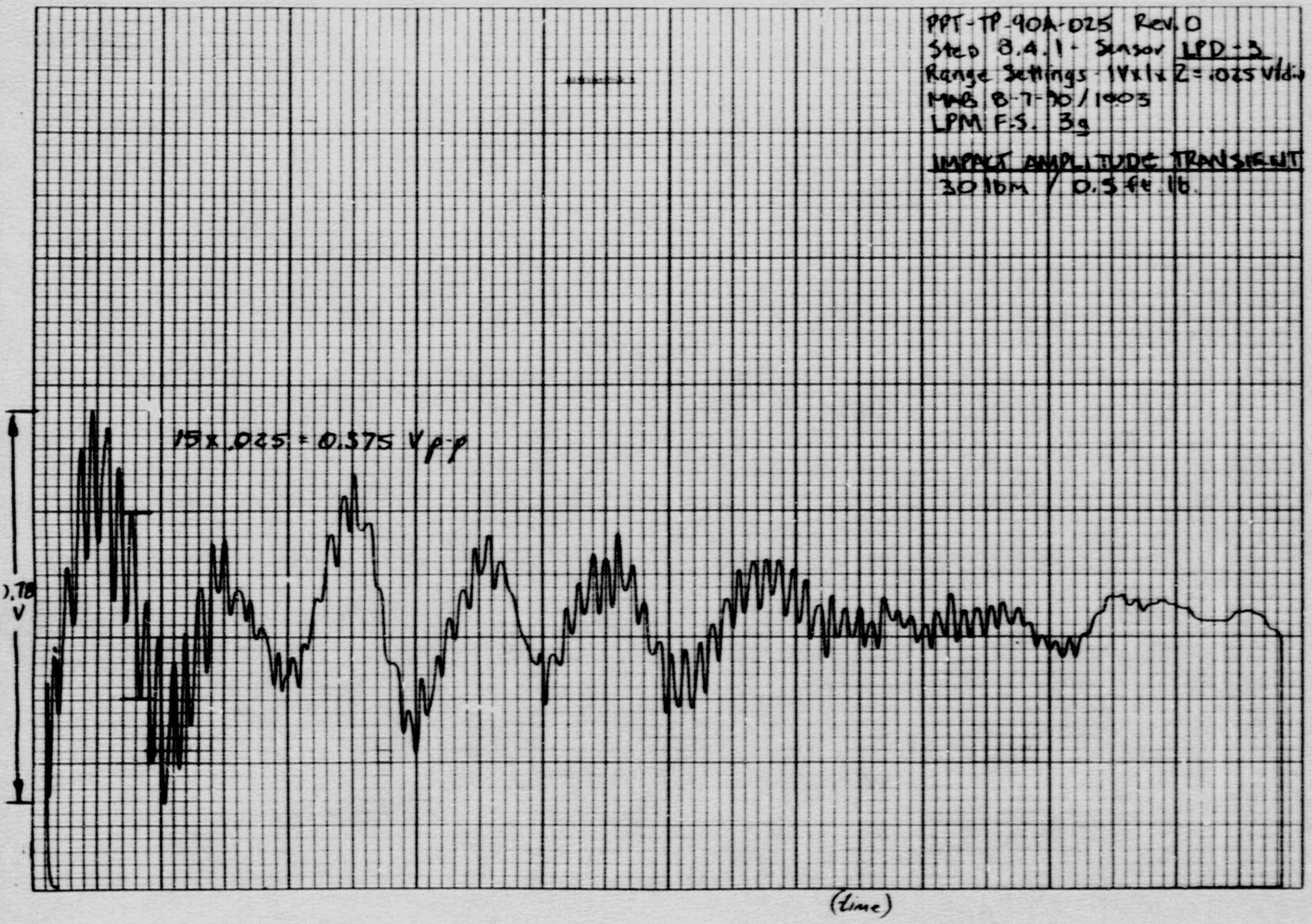
PDT-TP-90A-025 Rev. 0
STEP 8.3.1 - Sensor LPD-20
Range Settings 1Vx2 = 0.1V/div
MAB 8-7-90 / 10:00
LPM F.S. - 3g

IMPACT AMPLITUDE TRANSIENT
0.25 lbm / 0.5 ft.lb.

15 x 0.1 = 1.5 Vp-p

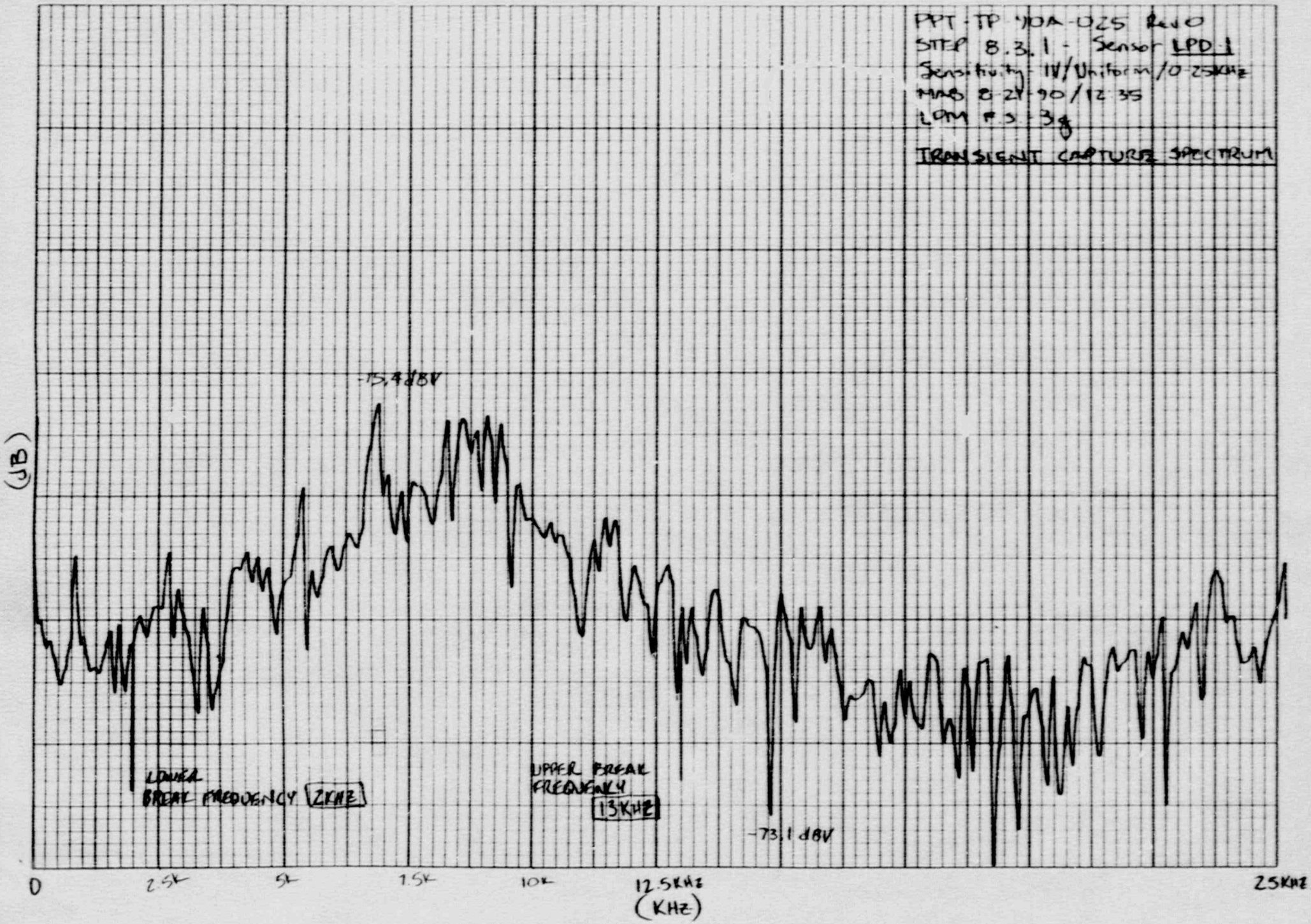
1.5 V

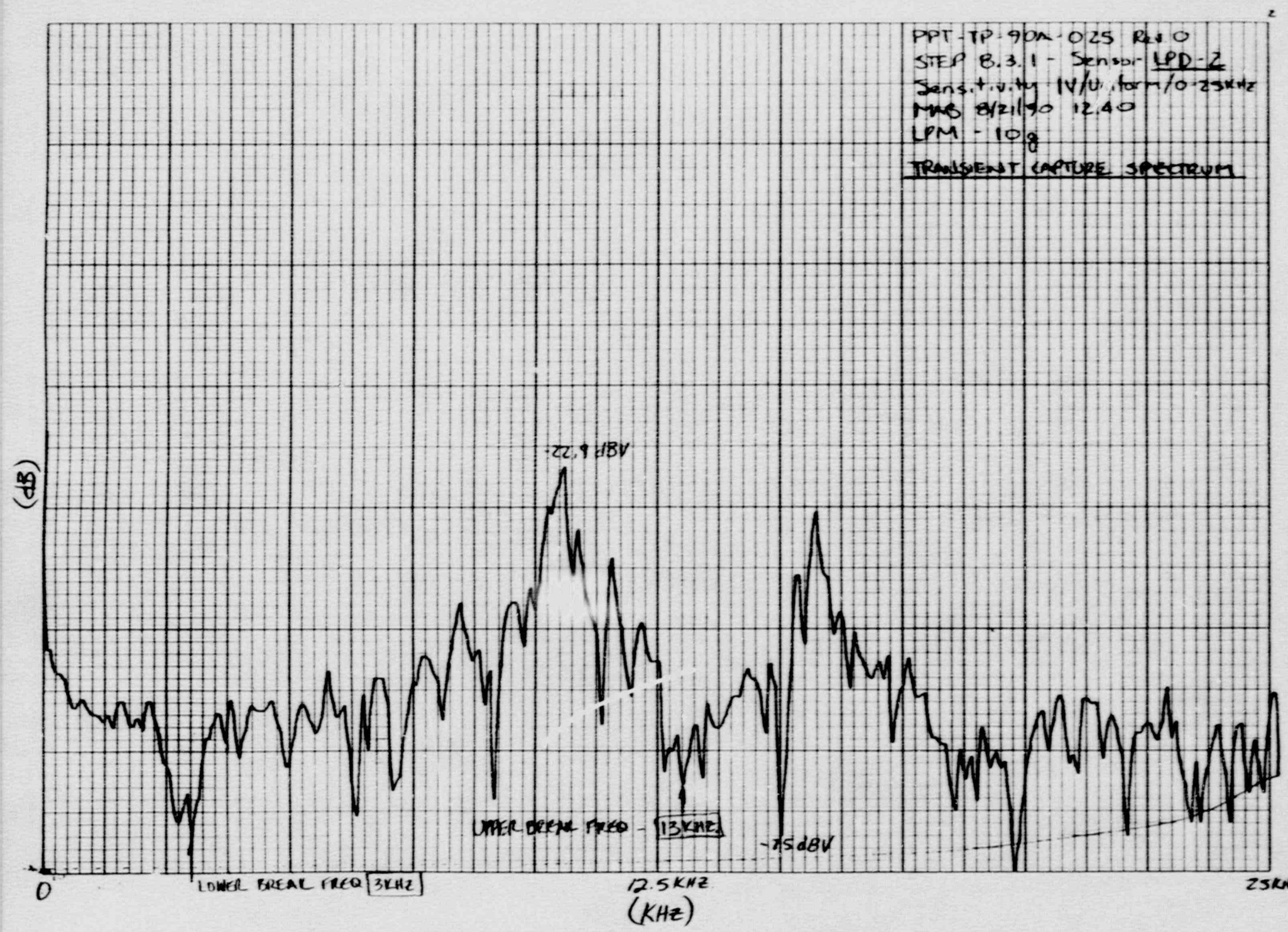
(time)


PPT-TP-90A-025 Rev. 0
Step 8.4.1 Sensor LPD-3
Range Settings 1Vx1x Z=.025 V/div
MMS 8-7-90/1003
LPM F.S. 3g
IMPACT AMPLITUDE TRANSIENT
30 lbM / 0.5 ft lb.
15 x .025 = 0.375 V p-p
.78 V
(time)

3.2 Impact Frequency Spectrum

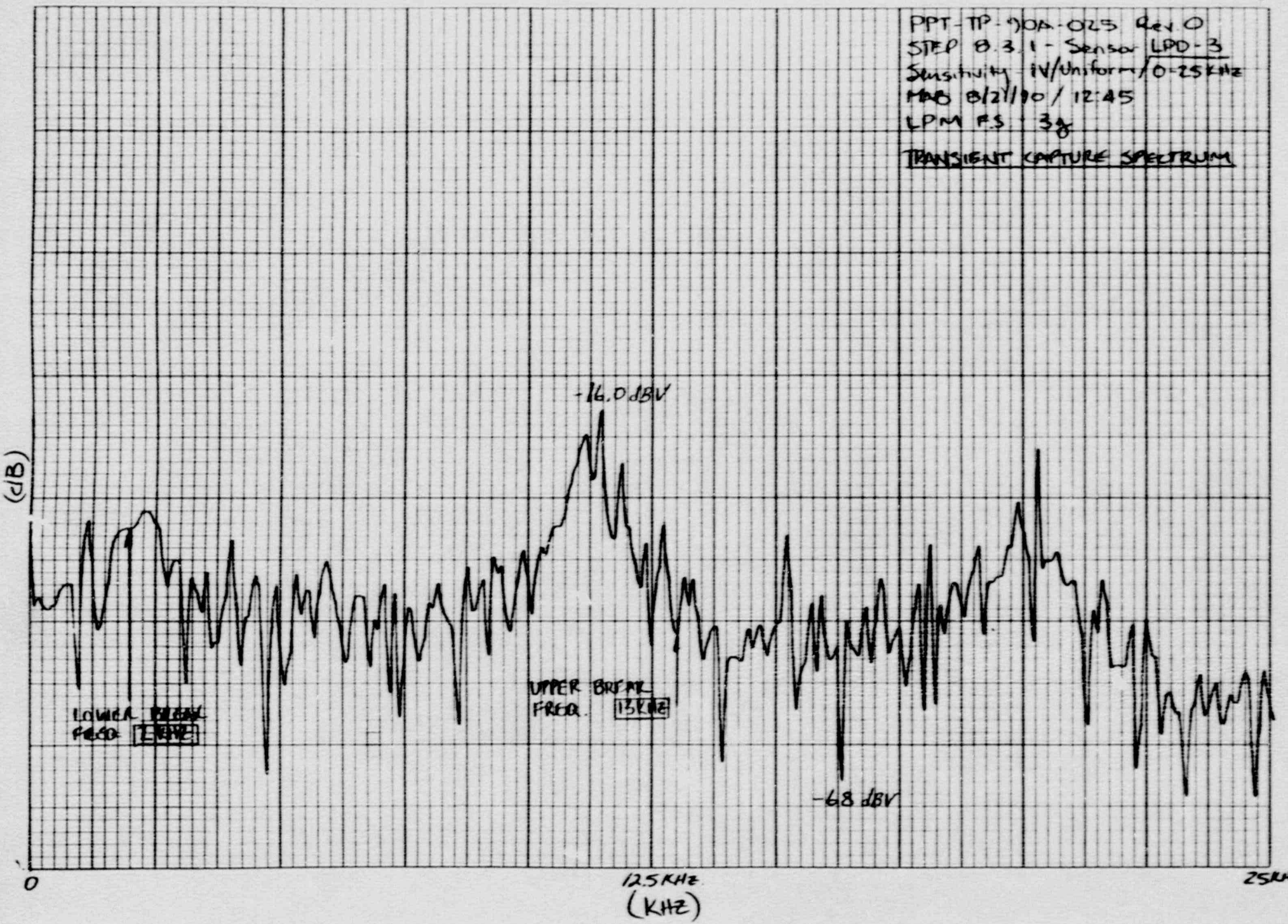
The following X-Y plots were made using data collected during pre-operational test 1CP-PT-91-01 SFT. Sensor settings and determined break frequencies are listed.





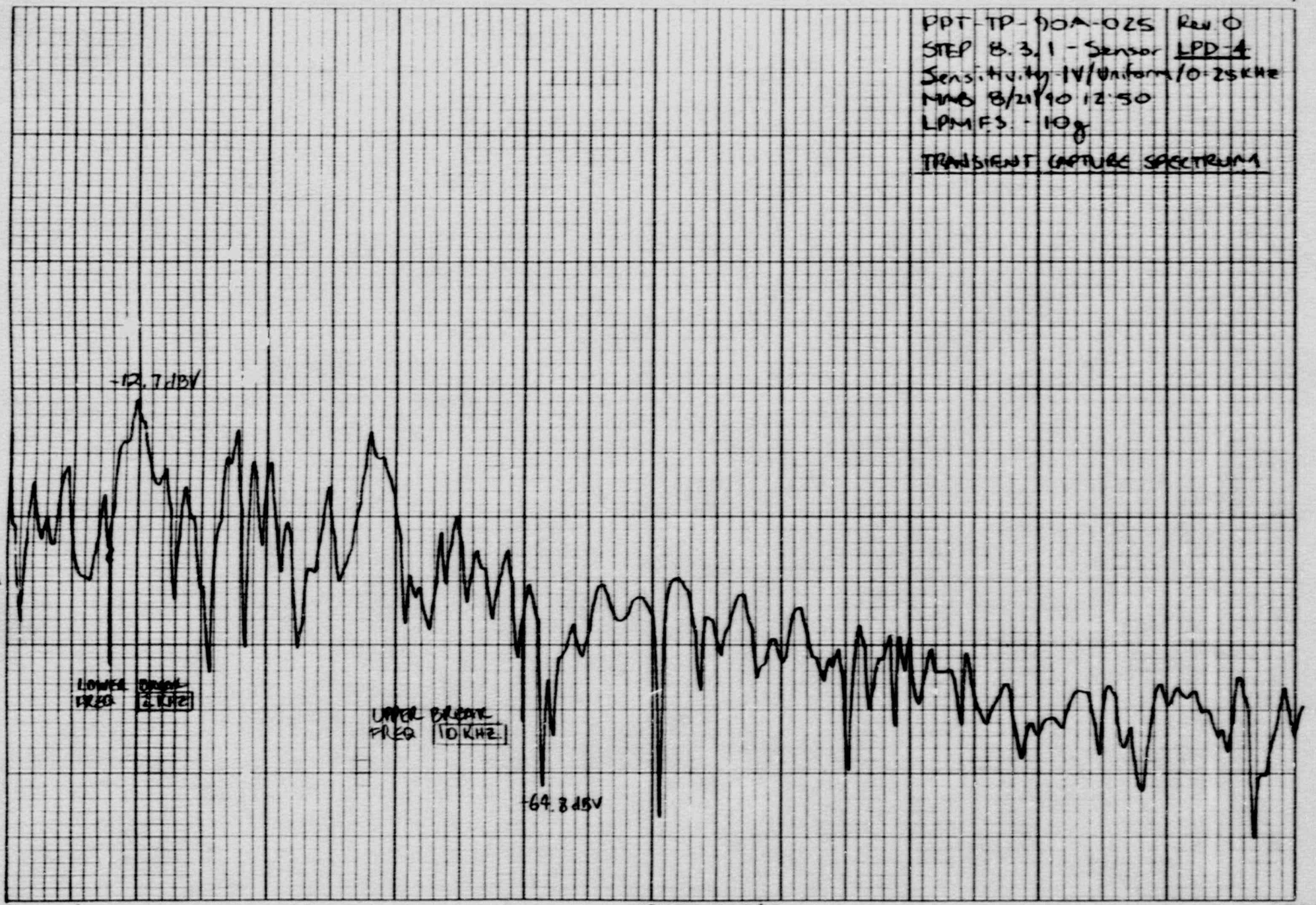
PPT-TP-90A-025 Rev O
STEP 8.3.1 - Sensor LPD-3
Sensitivity 1V/Uniform/0-25KHz
MAB 8/2/90 / 12:45
LPM FS 38

TRANSIENT CAPTURE SPECTRUM

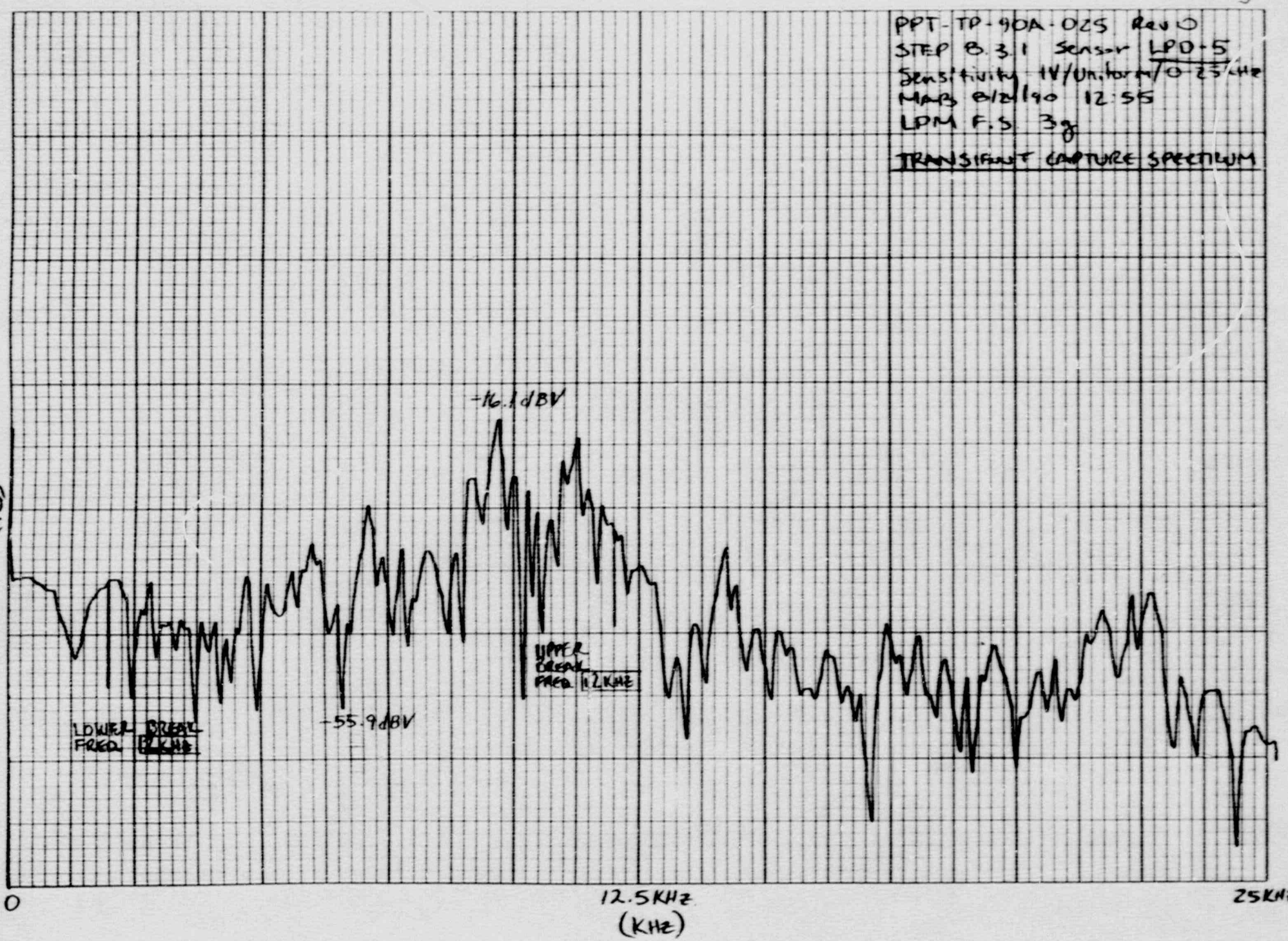


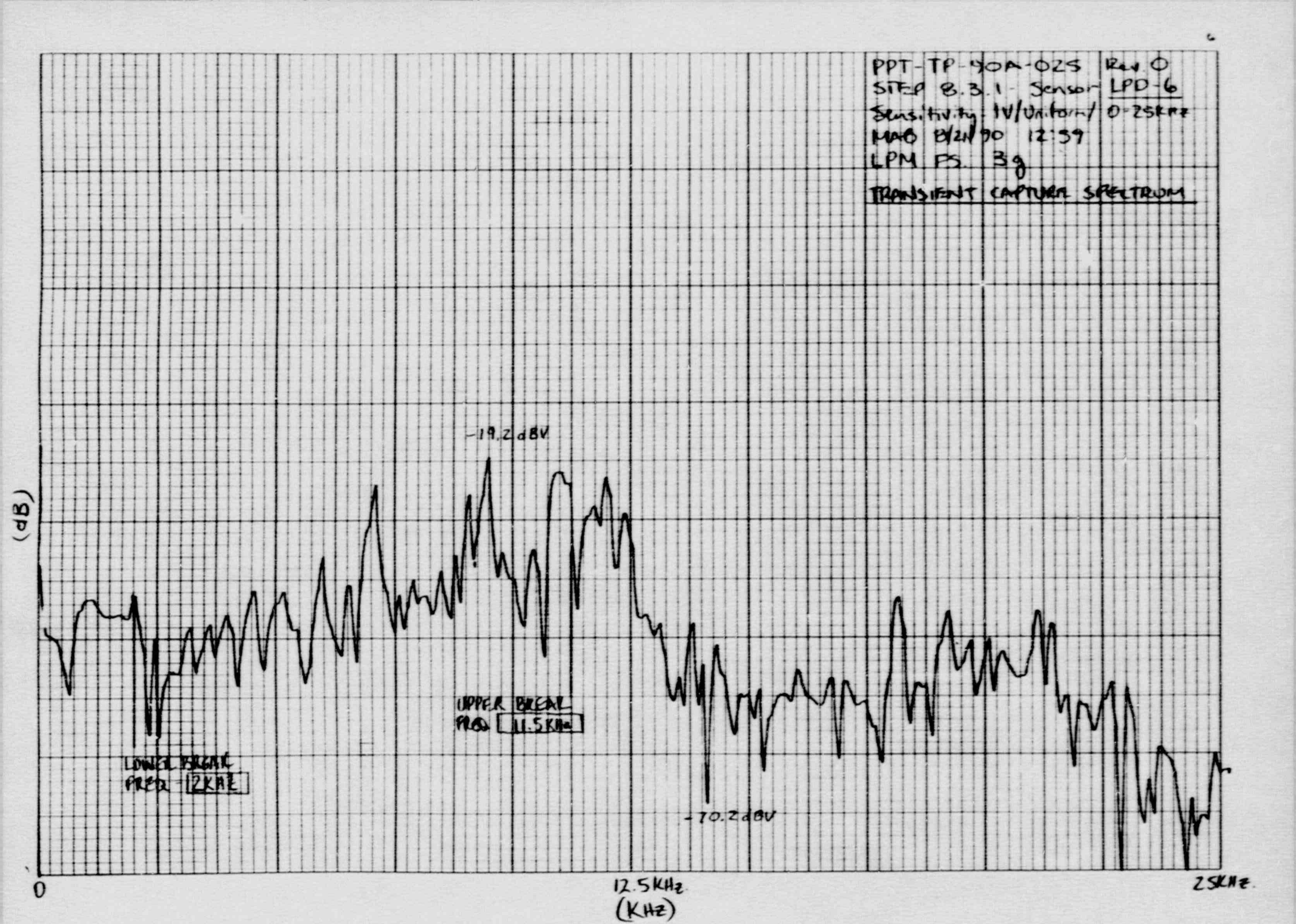
PPT-TP-90A-025 Rev 0
STEP 8.3.1 - Sensor LPD-4
Sens. Hy. by - 1V/Uniform/0-25KHz
MMB 8/20/90 12:50
LPM F.S. - 10g

TRANSIENT CAPTURE SPECTRUM



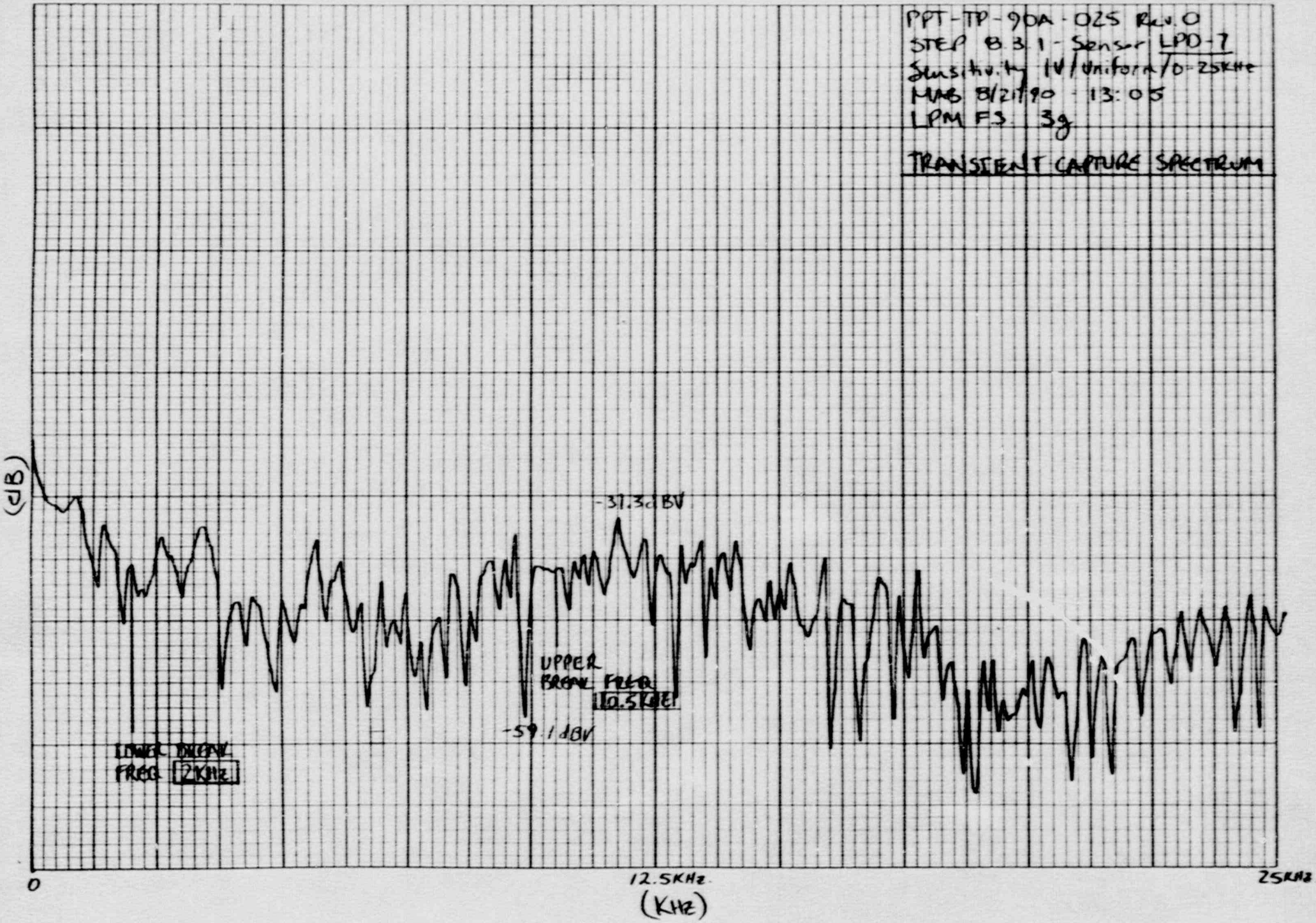
PPT-TP-90A-025 Rev 0
STEP 8.3.1 Sensor LPD-5
Sensitivity 1V/Unit rms/0-25 KHz
MAB 8/28/90 12:55
LPM F.S 3g
TRANSIENT CAPTURE SPECTRUM

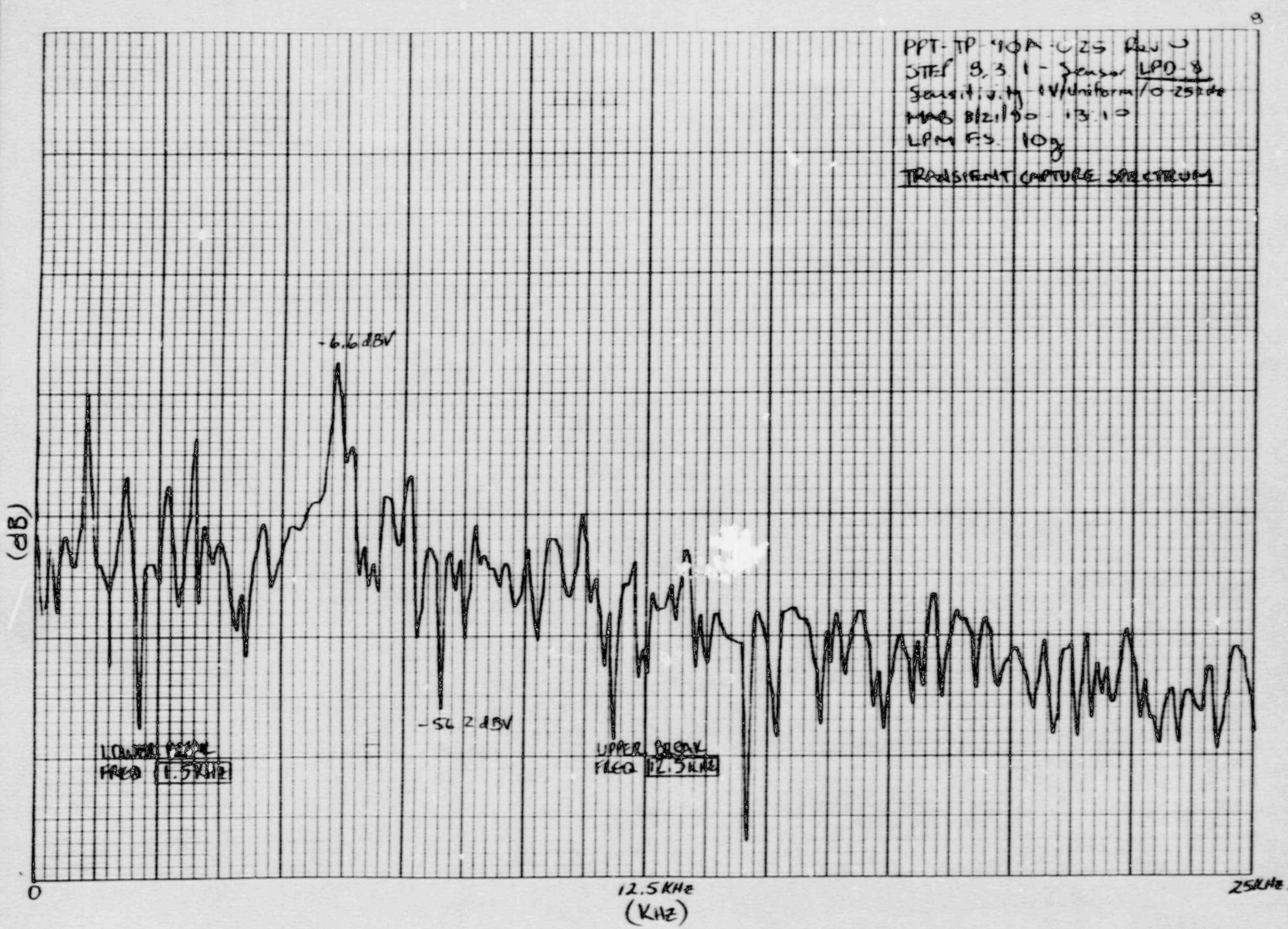




PPT-TP-90A-025 Rev. 0
STEP B 3.1 - Sensor LPD-7
Sensitivity 1V/Uniform/0-25KHz
MMS 8/21/90 - 13:05
LPM F3. 3g

TRANSIENT CAPTURE SPECTRUM





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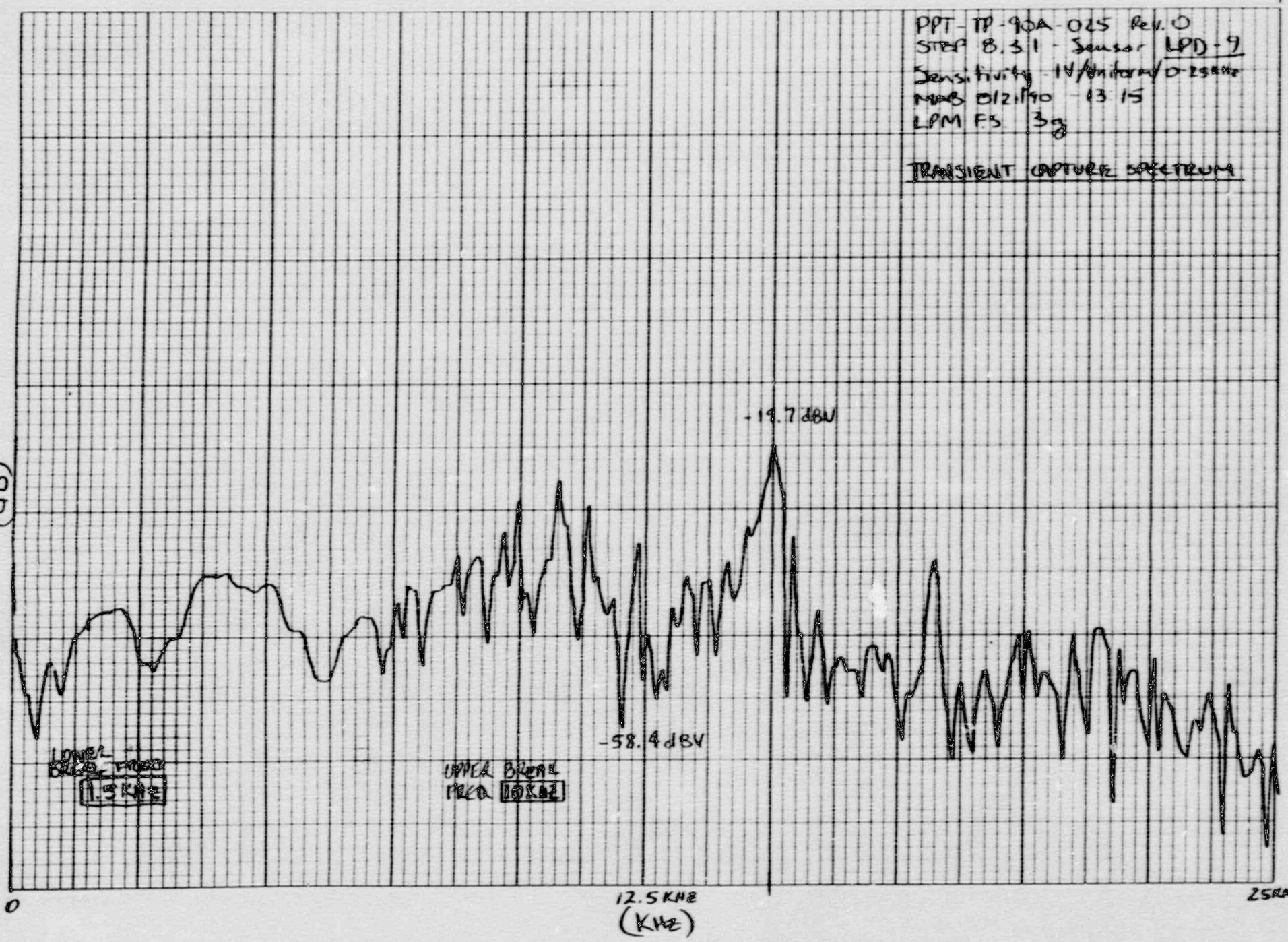
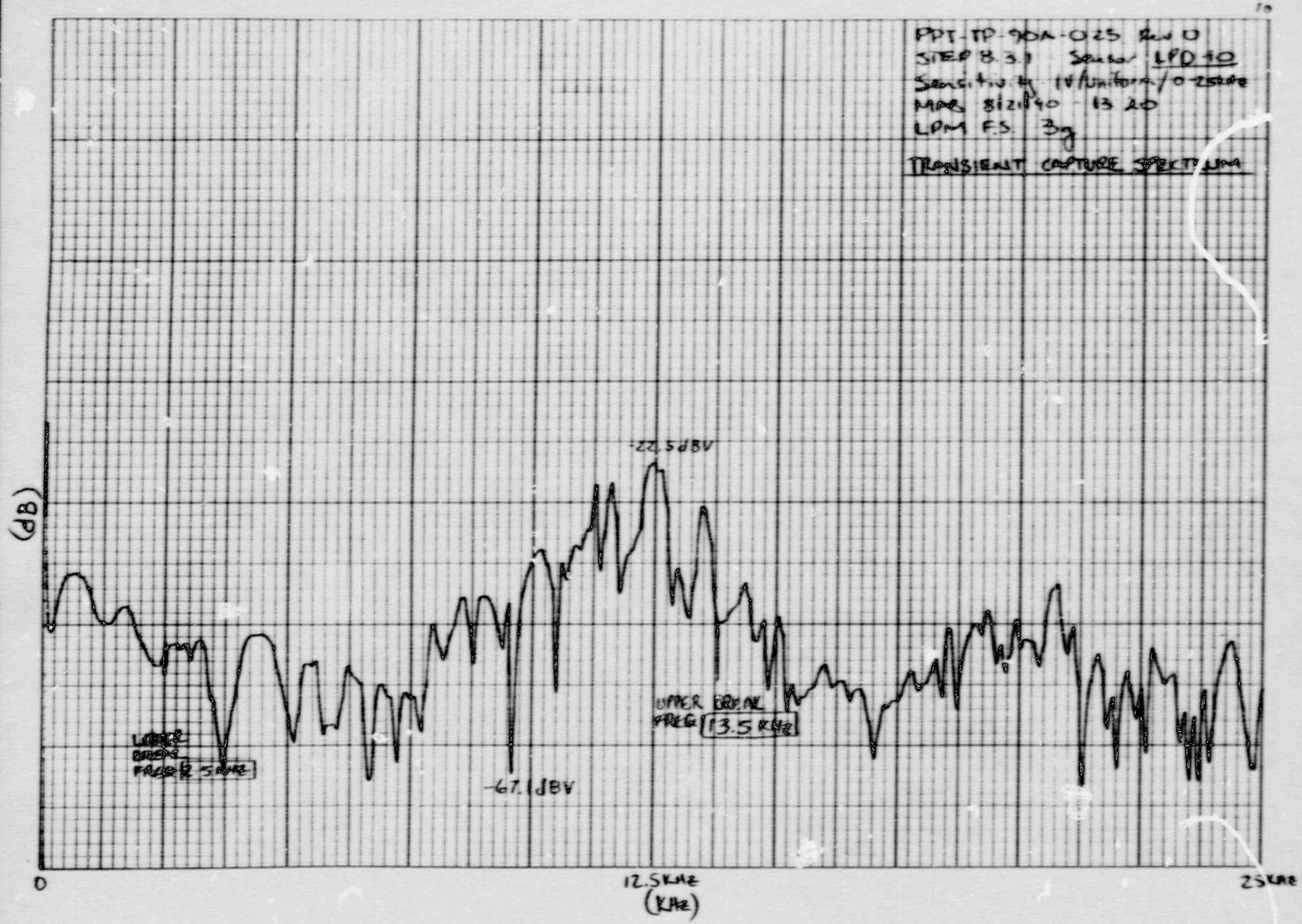
PPT-TP-90A-025 Rev. 0
STEP 8.3.1 - Sensor LPD-9
Sensitivity 1V/unit/0-25KHz
MAB 012190 13 15
LPM F5 3g

TRANSIENT CAPTURE SPECTRUM





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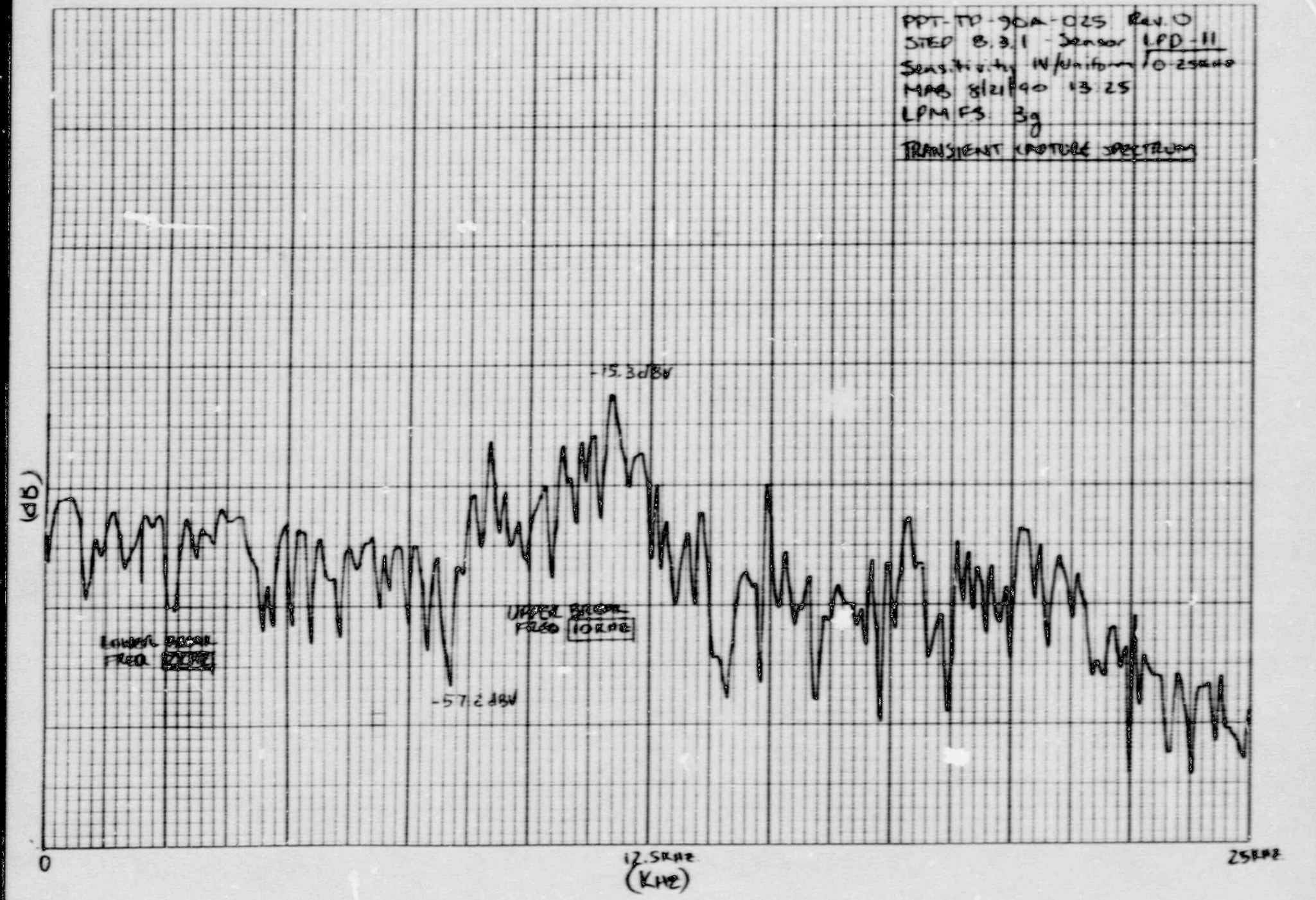

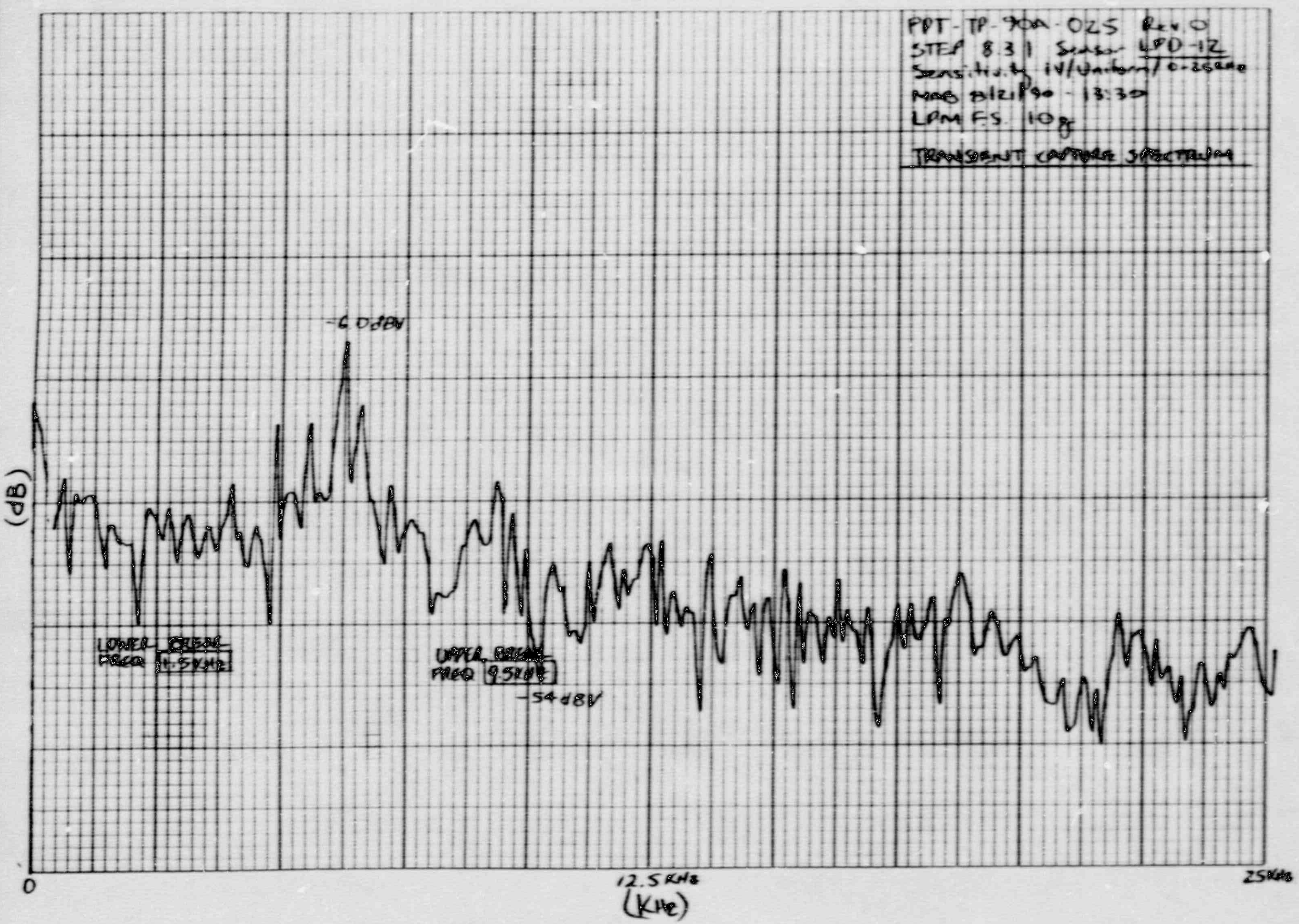

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

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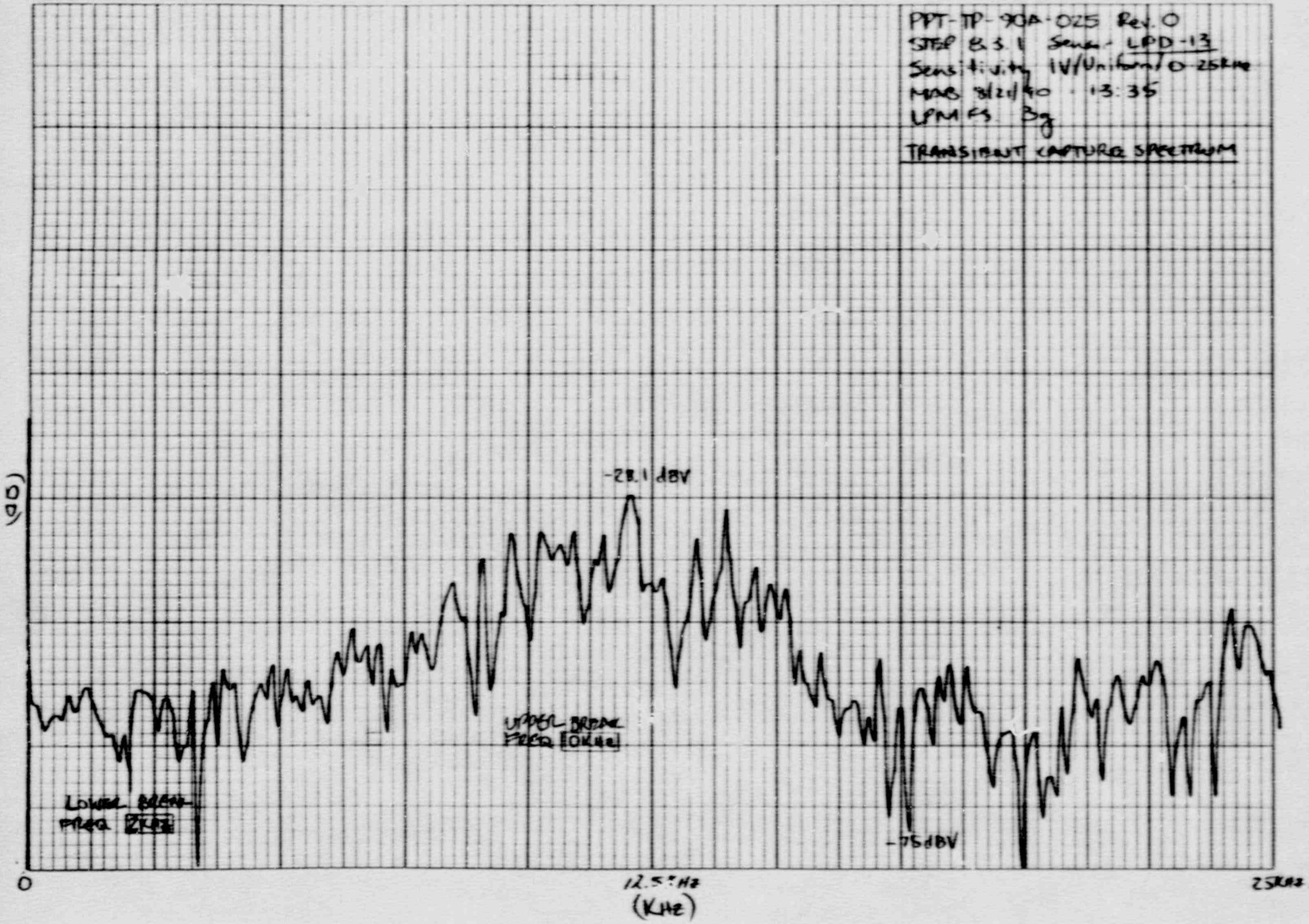
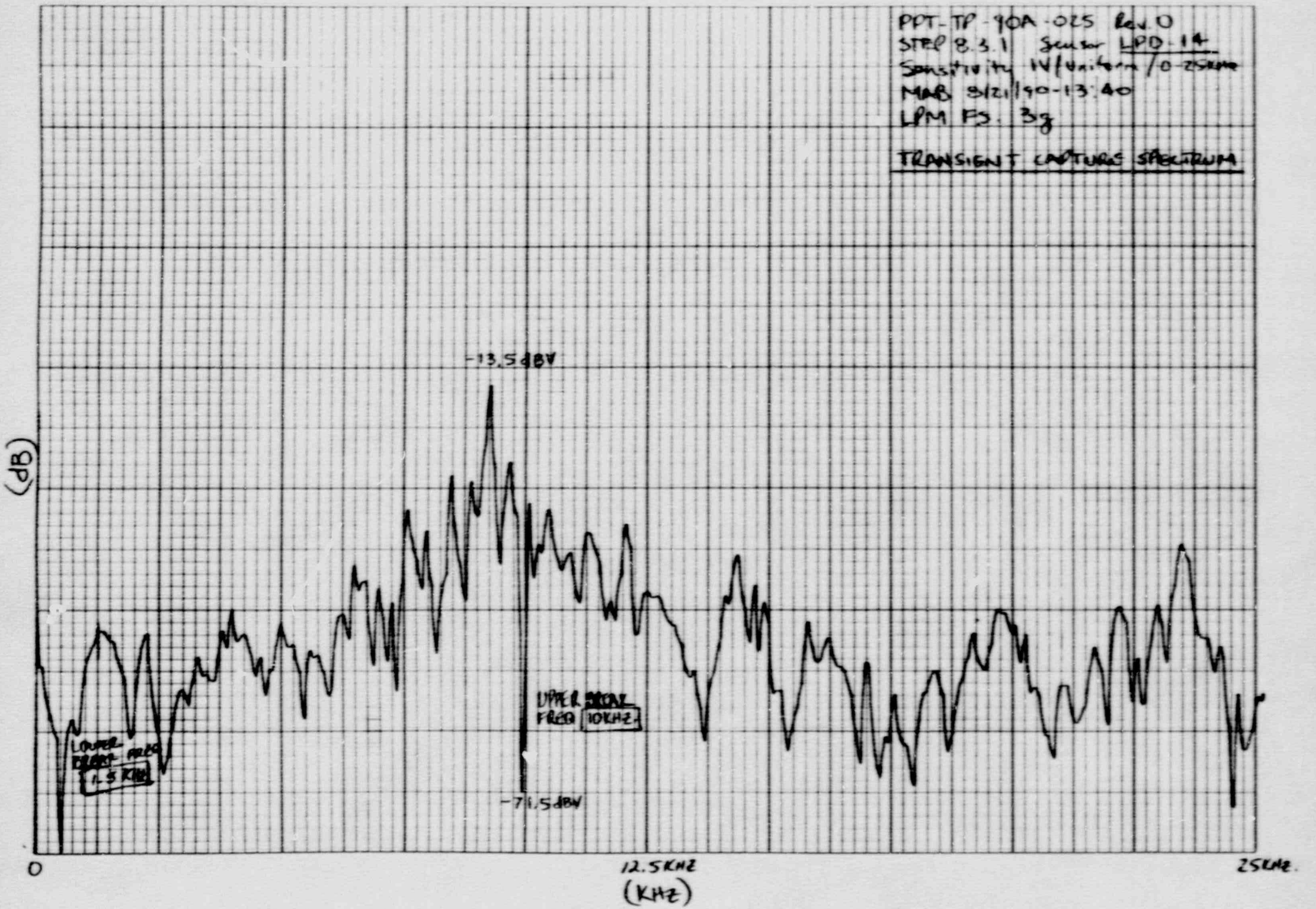


46/780

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO.



PPT-TP-90A-025 Rev. U
STEP 8 3.1 Sensor LPD-15
Sensitivity 1V/Unit rms / 0-25KHz
MDAS 11/21/90 - 13:45
LPM F.S. 3g
0

TRANSIENT CAPTURE SPECTRUM.

-11.1 dBV

-62.4 dBV

LOWER CURSOR FREQ 6.5 KHz

UPPER CURSOR FREQ 11 KHz

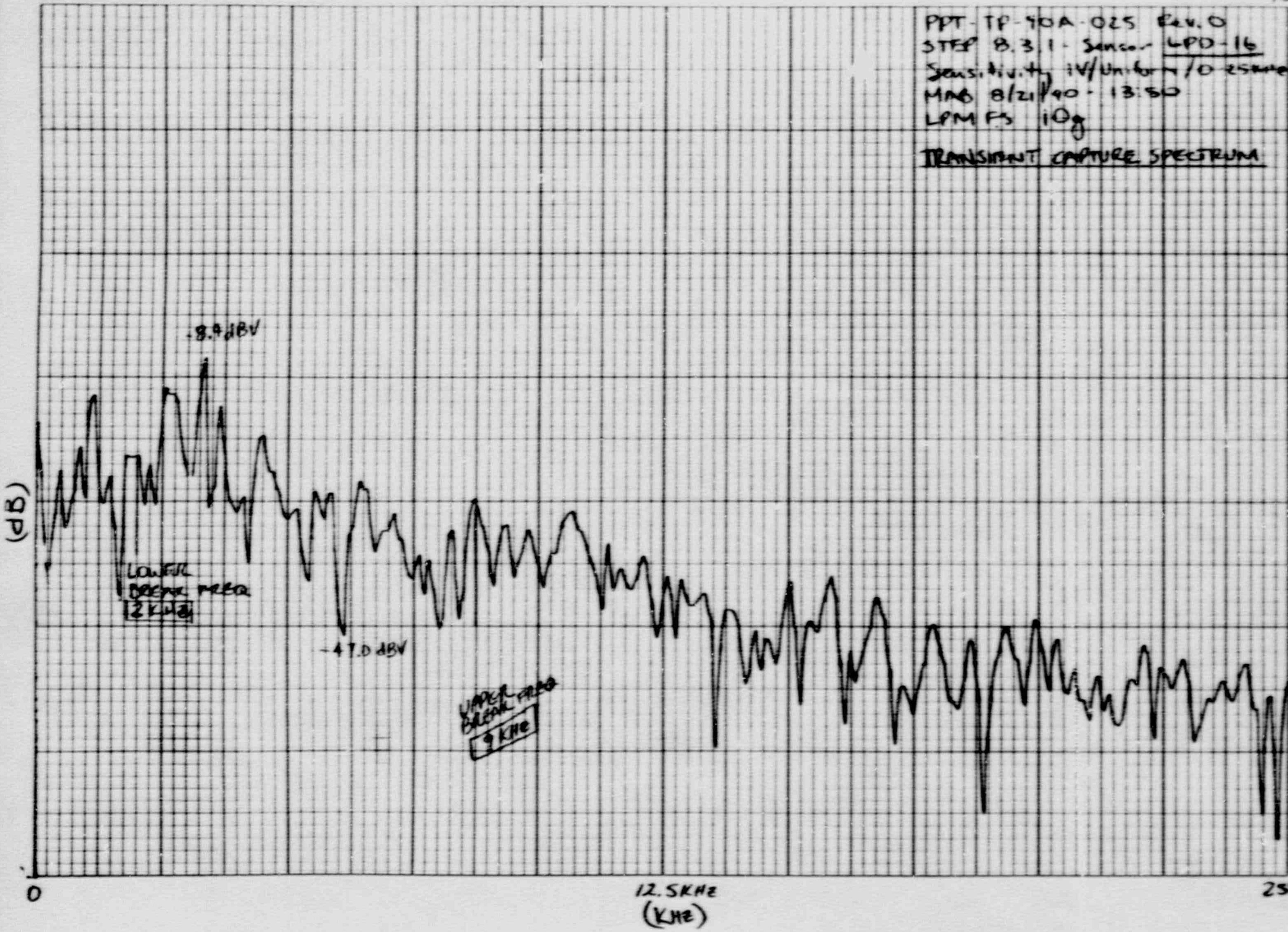
(dB)

0

12.5KHz

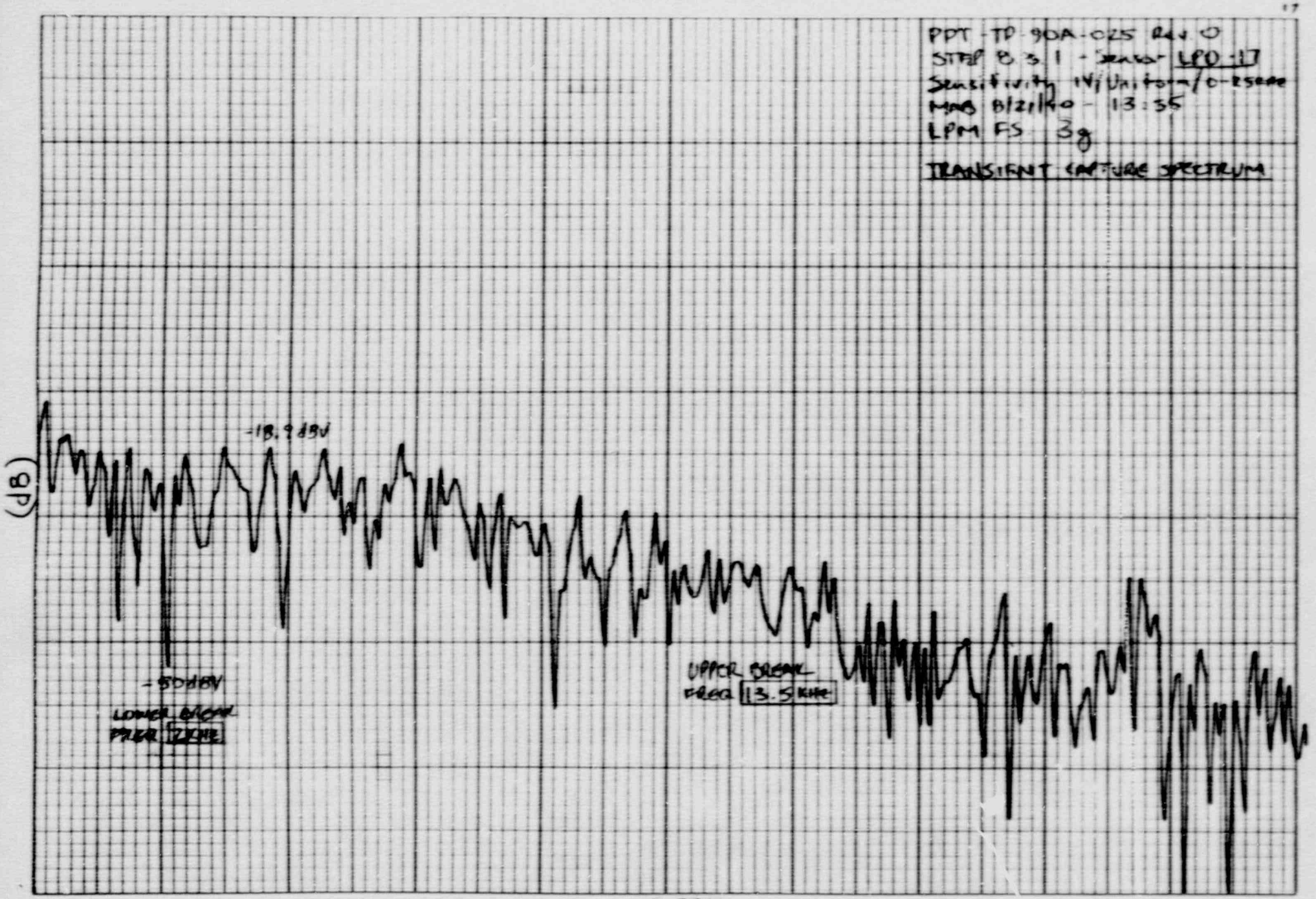
25KHz

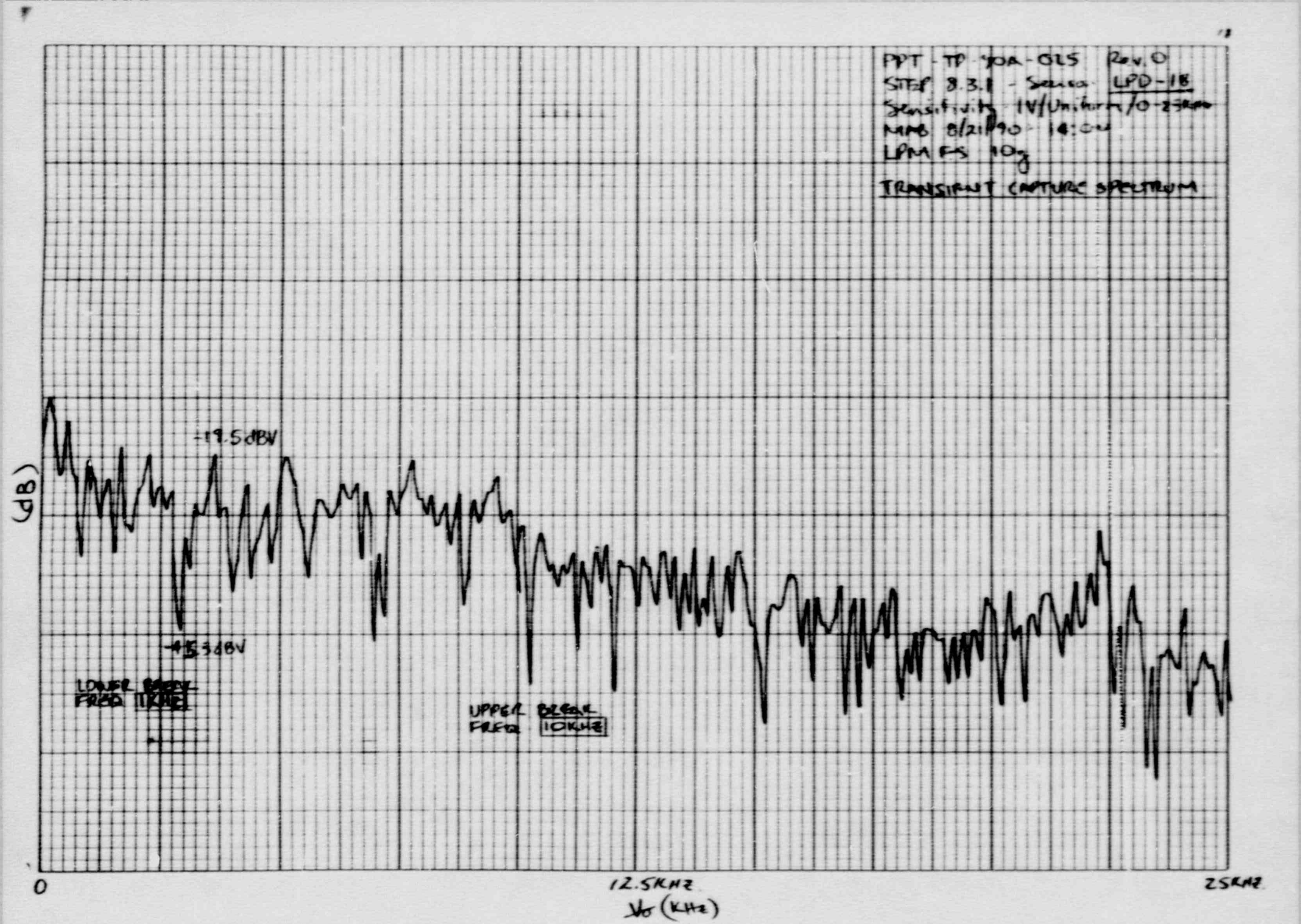
(KHz)



PPT-TP-90A-025 Rev 0
SITE# 831 - SENSOR LPO-17
Sensitivity 1V/Unit rms/0-Peak
MMS Bizilko - 13:35
LPM FS 3g

TRANSIENT CAPTURE SPECTRUM




PPT - TP 90A-015 Rev. O
SITE# 8.3.1 - Source LPD-18
Sensitivity 1V/Unit
MMB 8/21/90 - 14:04
LPM FS 10g
TRANSIENT CAPTURE SPECTRUM
+19.5dBV
+15.3dBV
LOWER BREAK FREQ 11KHz
UPPER BREAK FREQ 10KHz
(dB)
0
12.5KHz
25KHz
(KHz)

PPT-TP-90A-025 Rev 0
STEP 8.3.1 Sensor LPD-19
Sensitivity 1V/Unit/0.25 KHz
MAG 8/20/90 14:05
LPM F.S 10g

TRANSIENT CAPTURE SPECTRUM

-10.1 dBV

-37.2 dBV

LOWER BEARING FREQ 4.3 KHz

UPPER BEARING FREQ 12 KHz

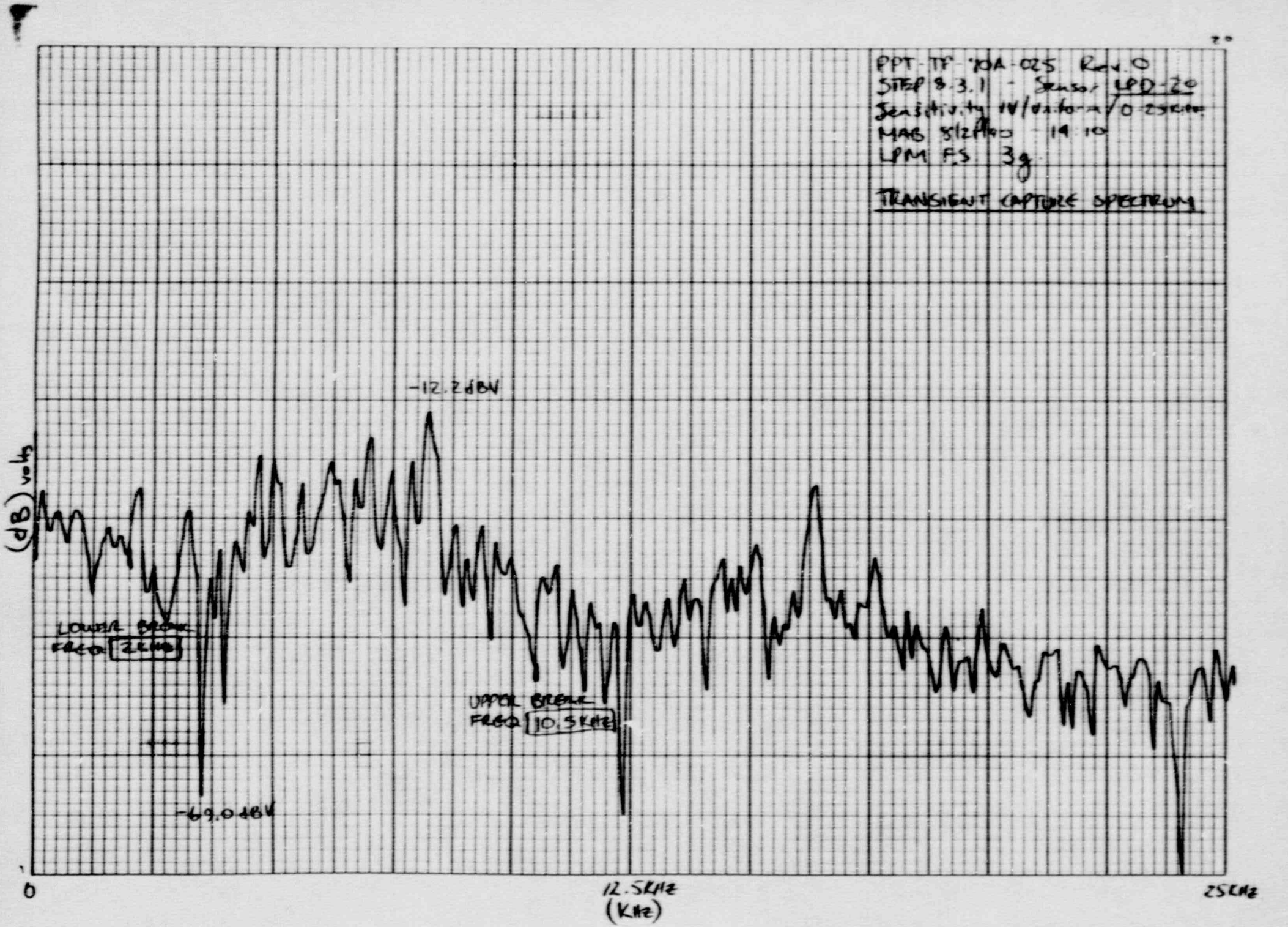
(dB)

0

12.5KHz

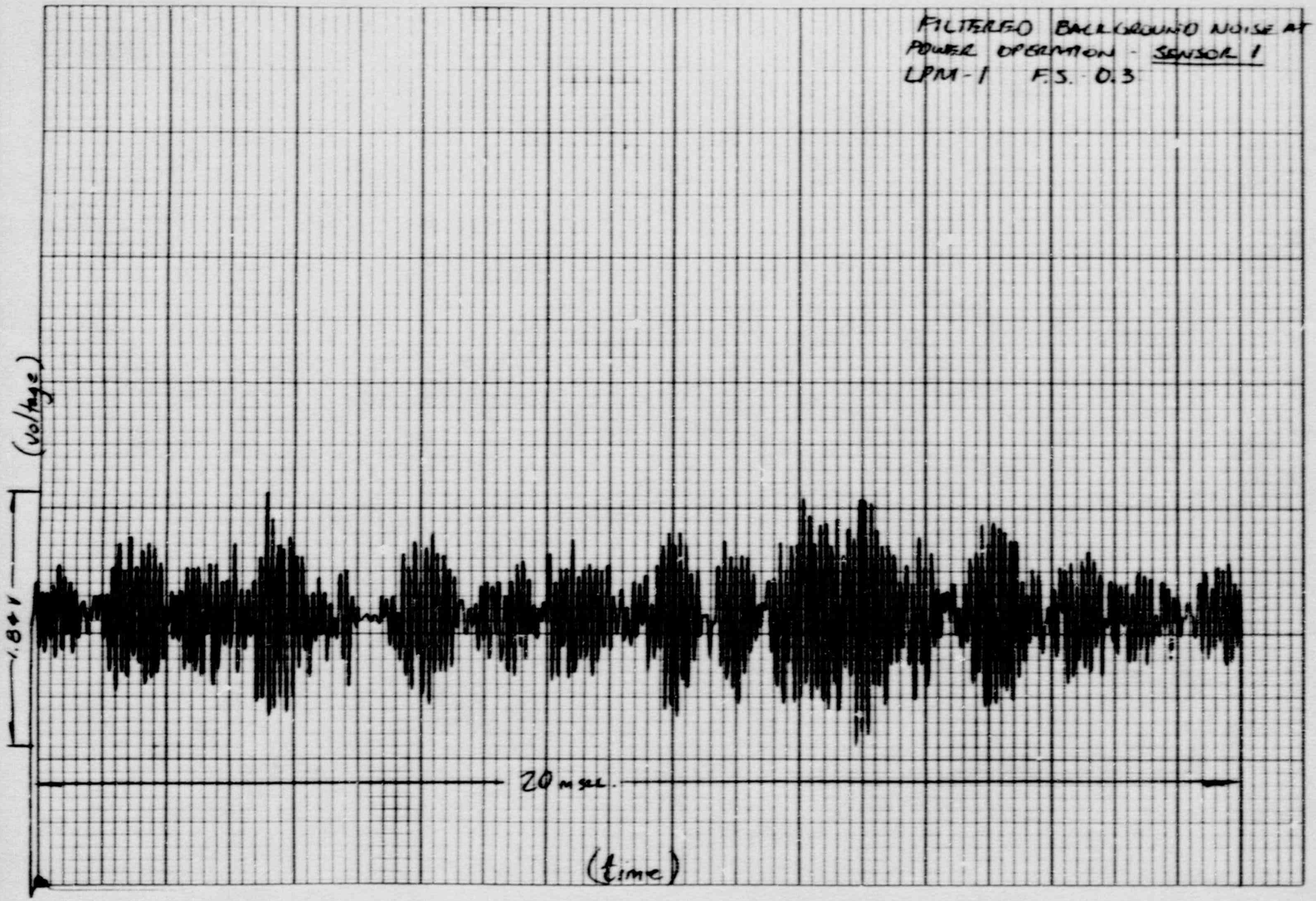
25KHz

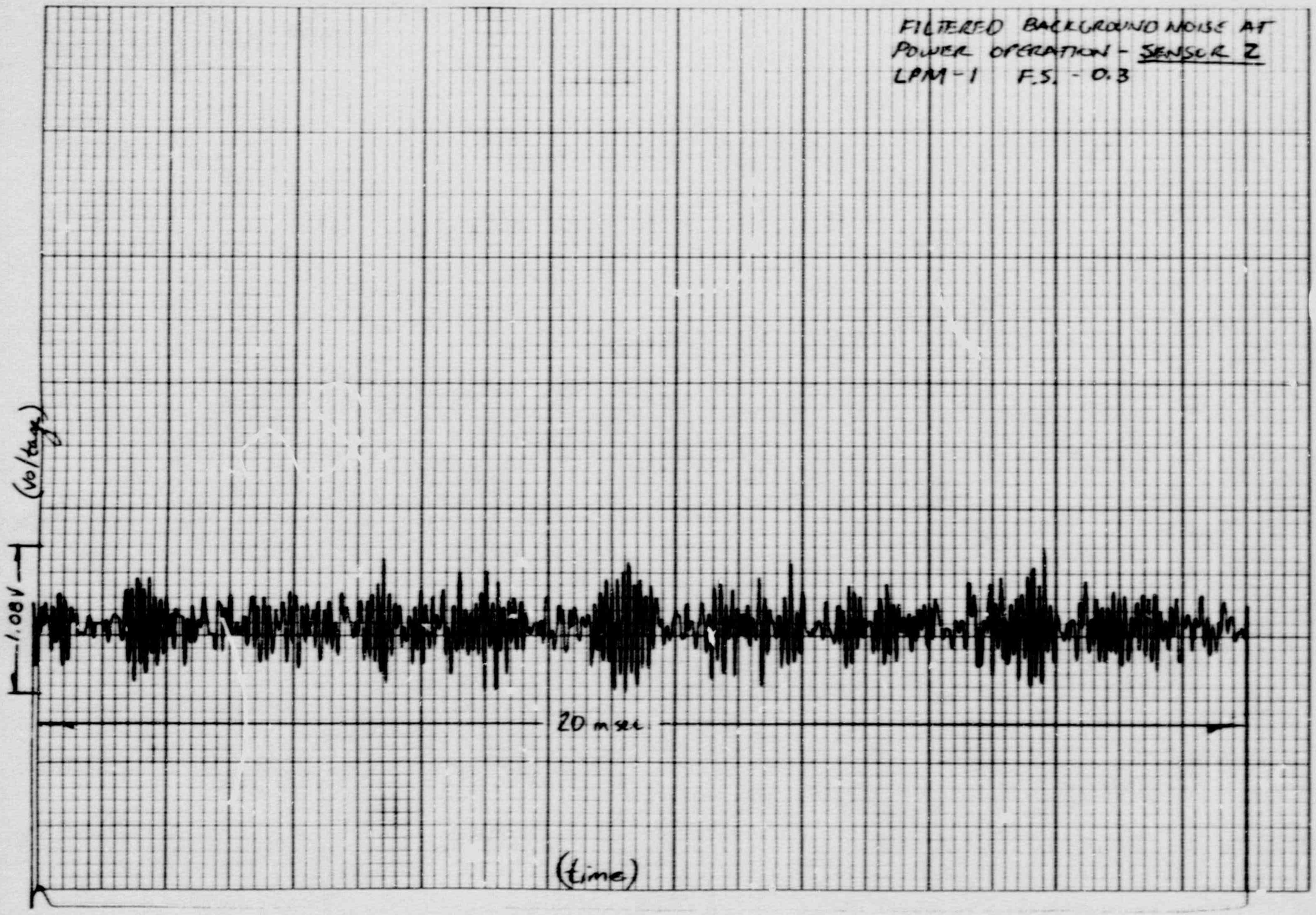
(KHz)

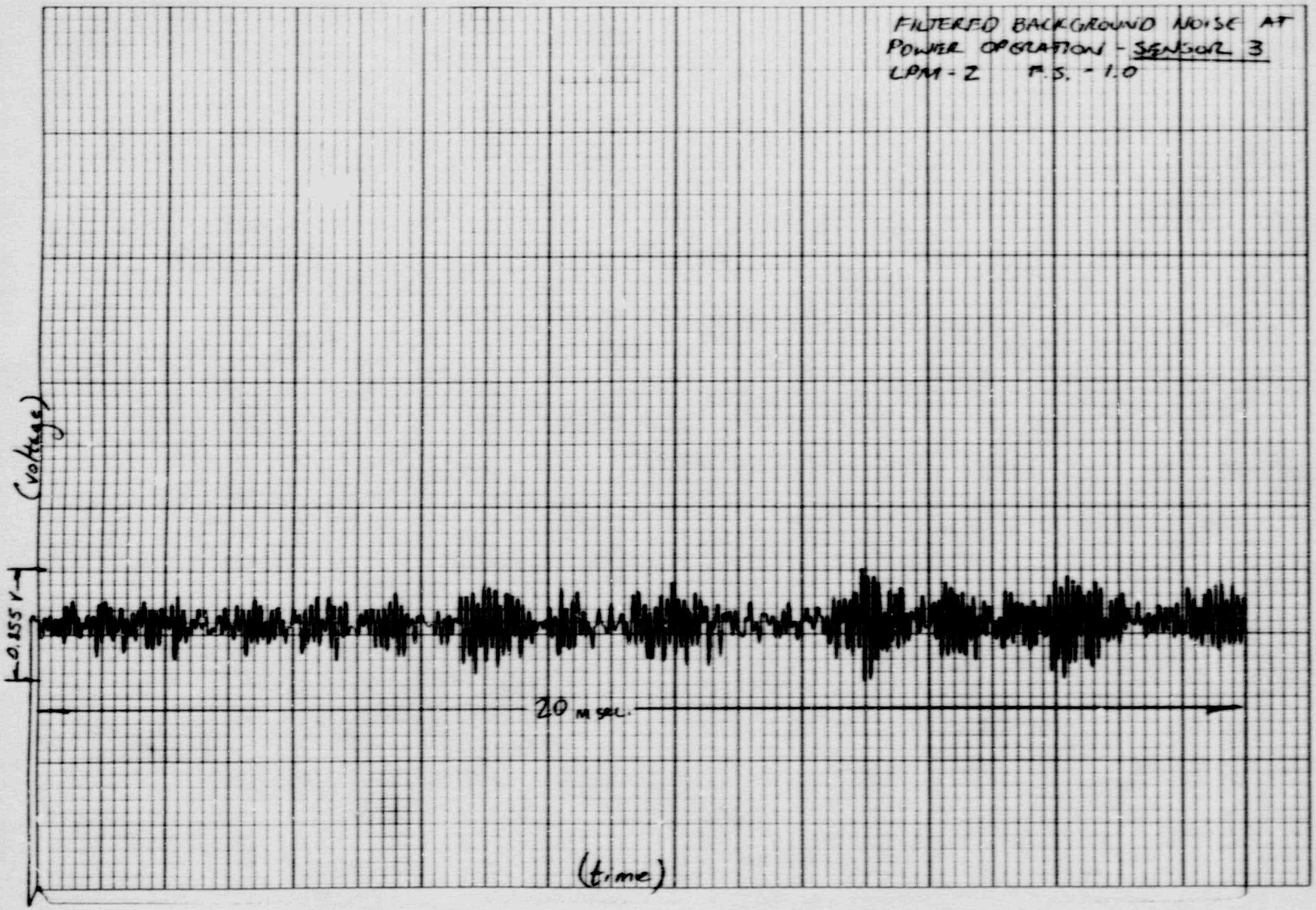


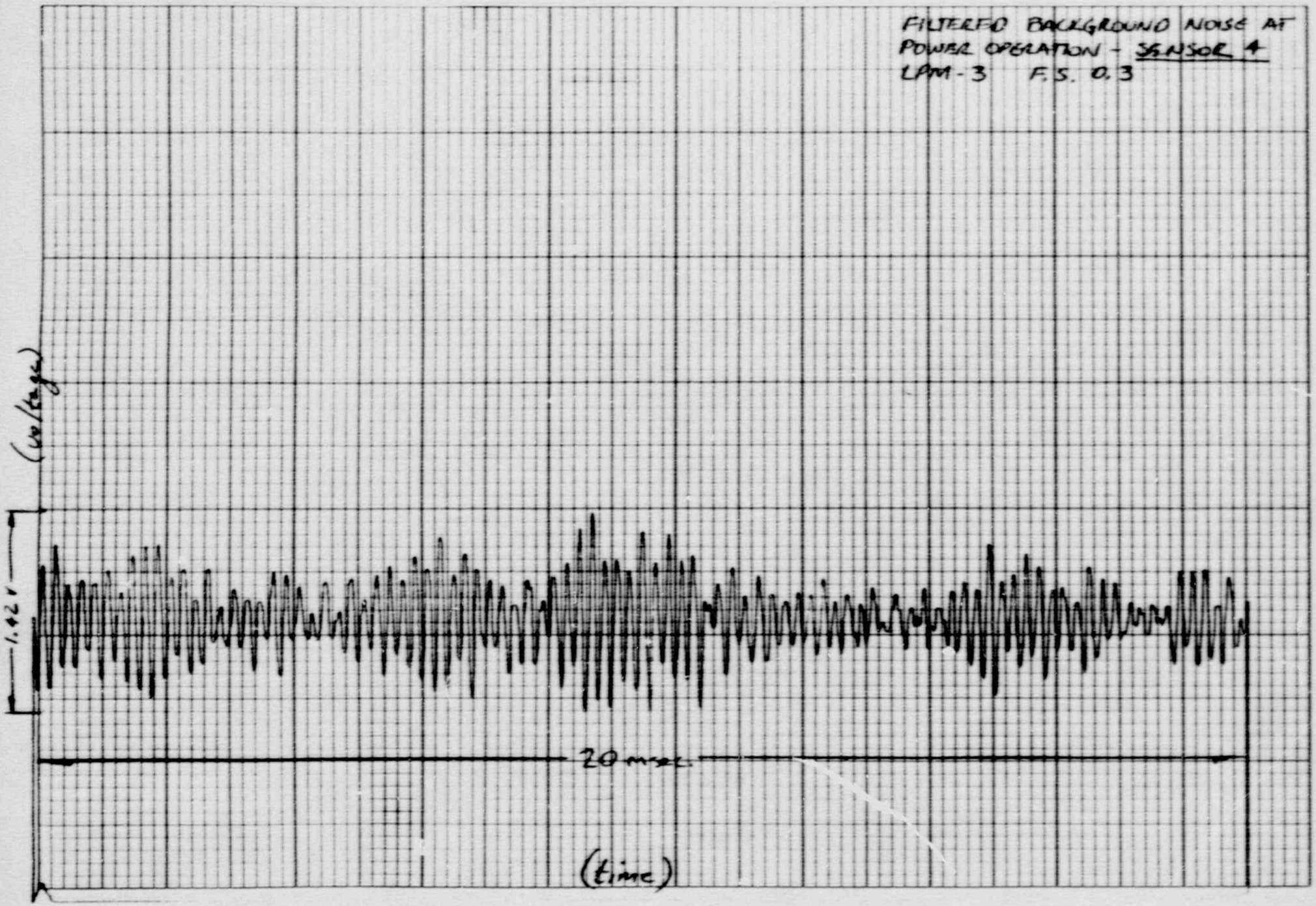
3.3 Background Amplitude (Power Operation)

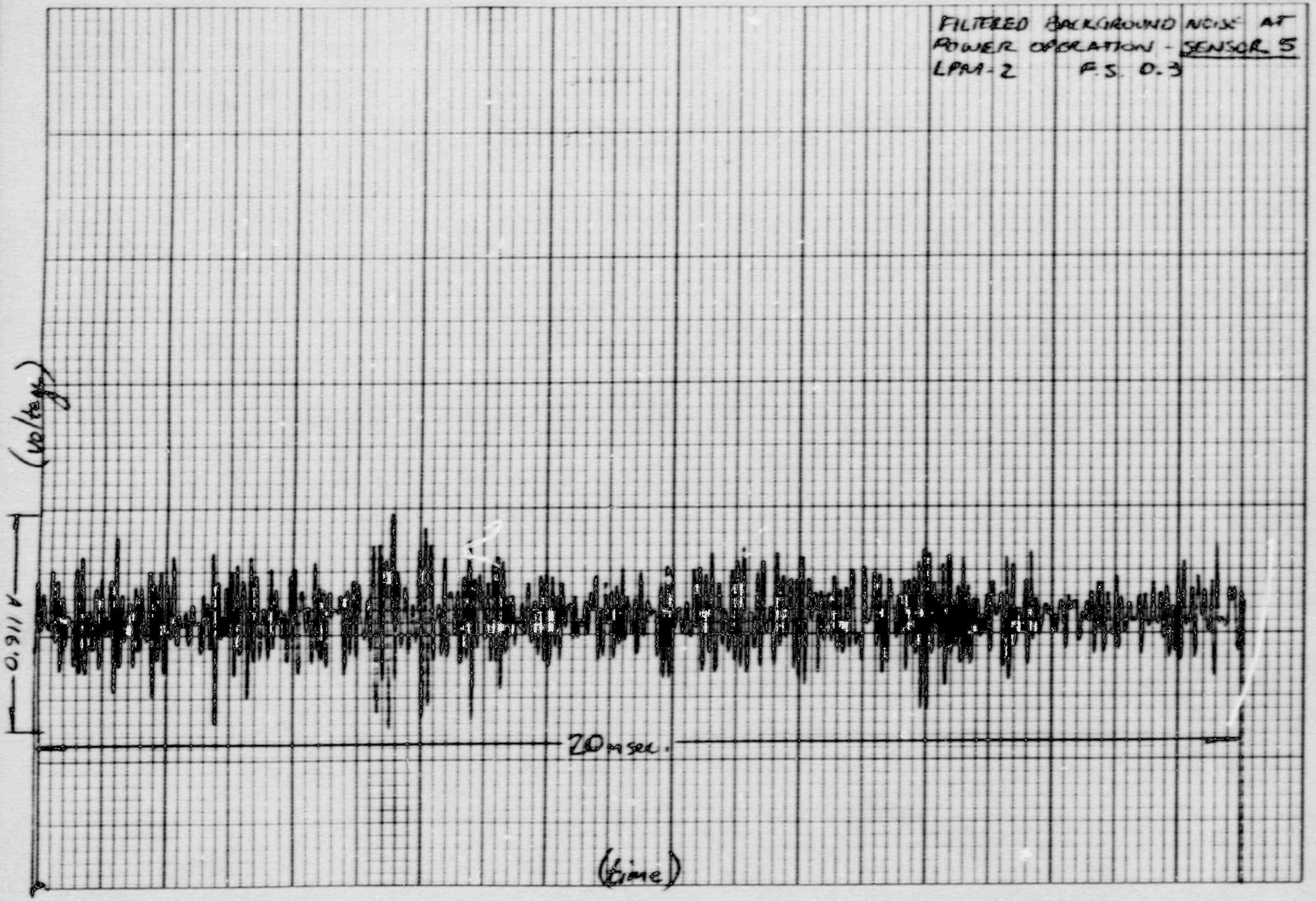
The following X-Y plots were made directly off an oscilloscope output while measuring filtered background noise levels at 95% power operation.

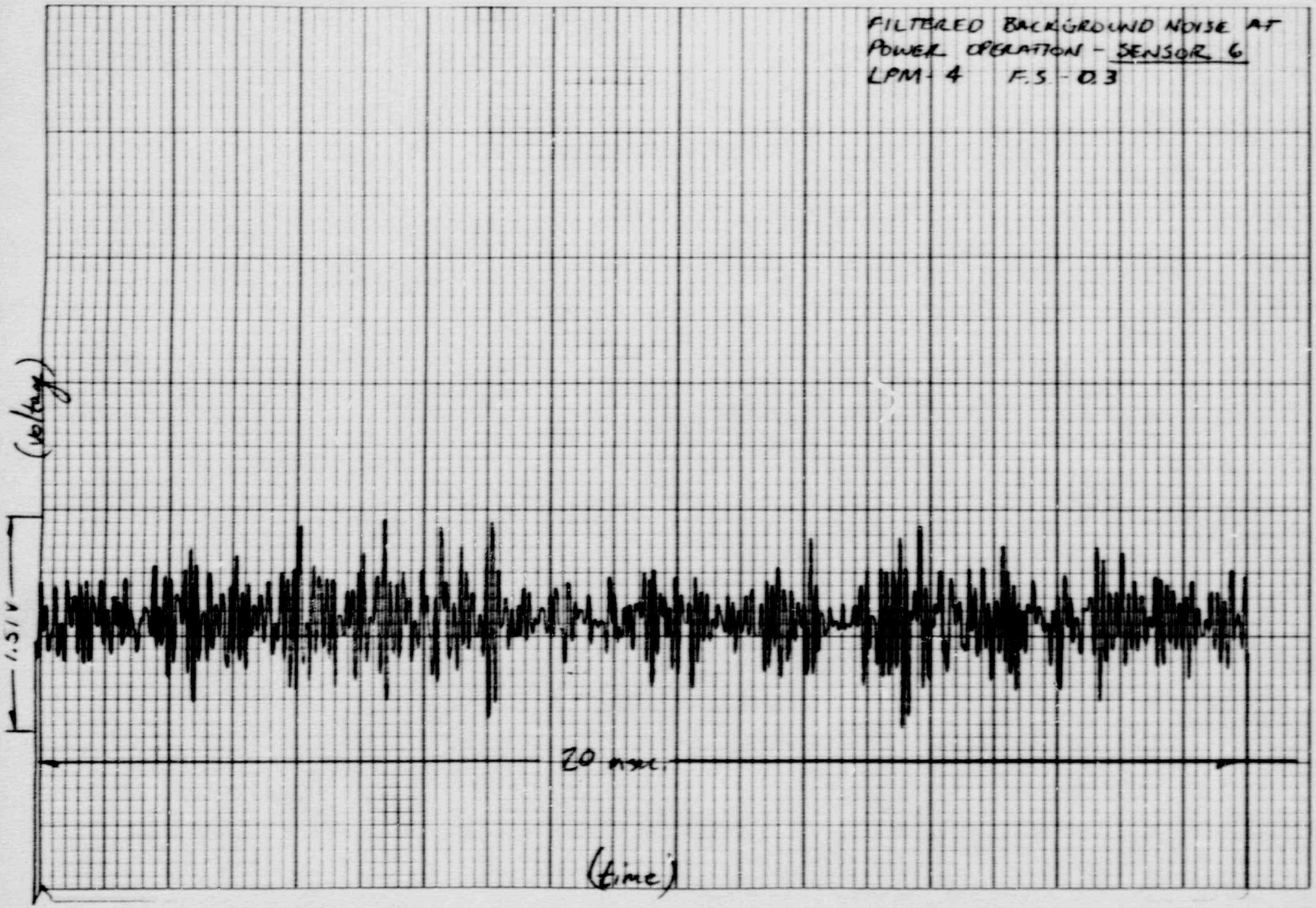

FILTERED BACKGROUND NOISE AT POWER OPERATION - SENSOR 1
LPM-1 F.S. 0.3
(voltage)
1.8 V
20 m sec.
(time)

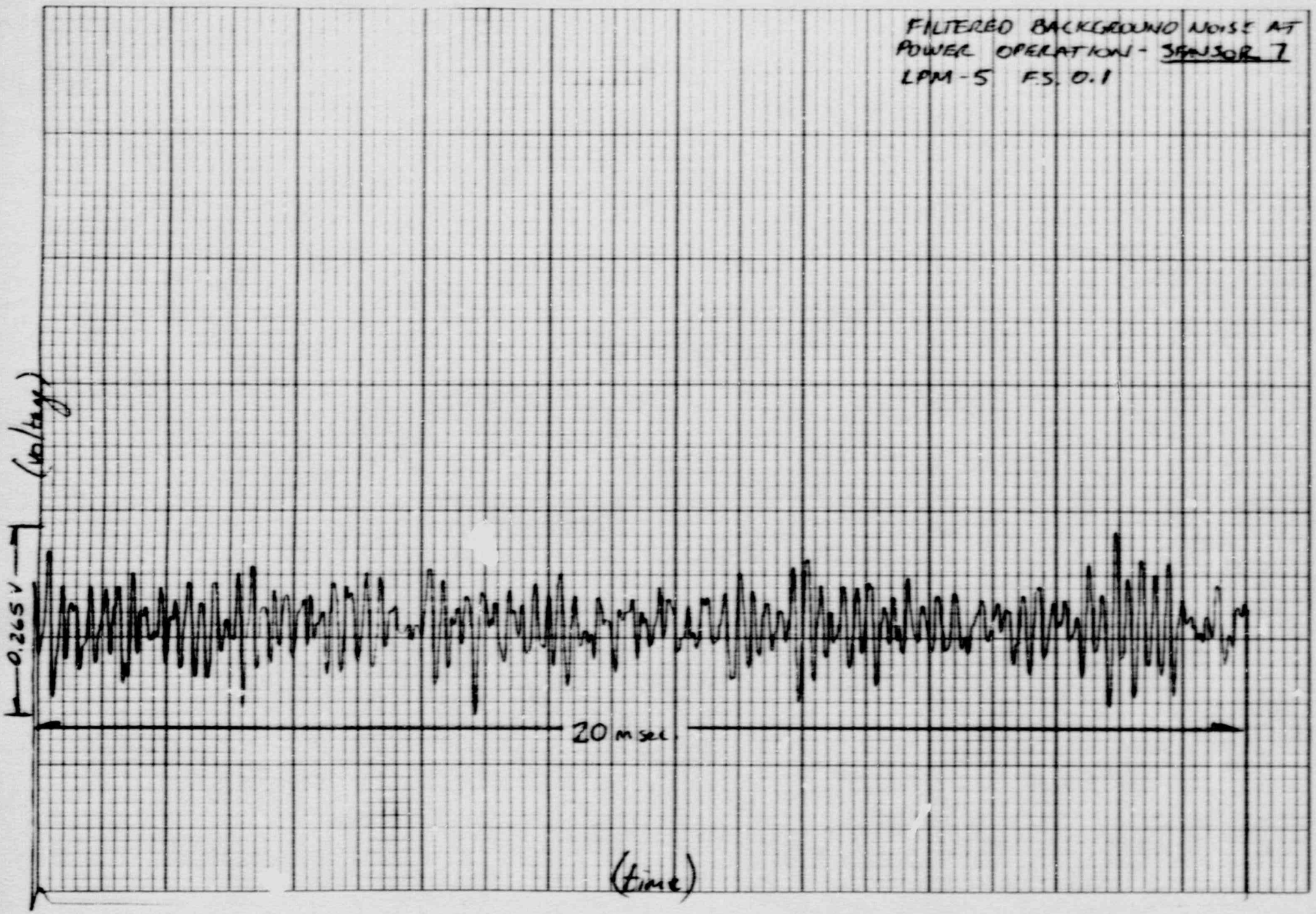

FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR Z
LPM-1 F.S. - 0.3
(voltage)
1.08V
20 msec
(time)

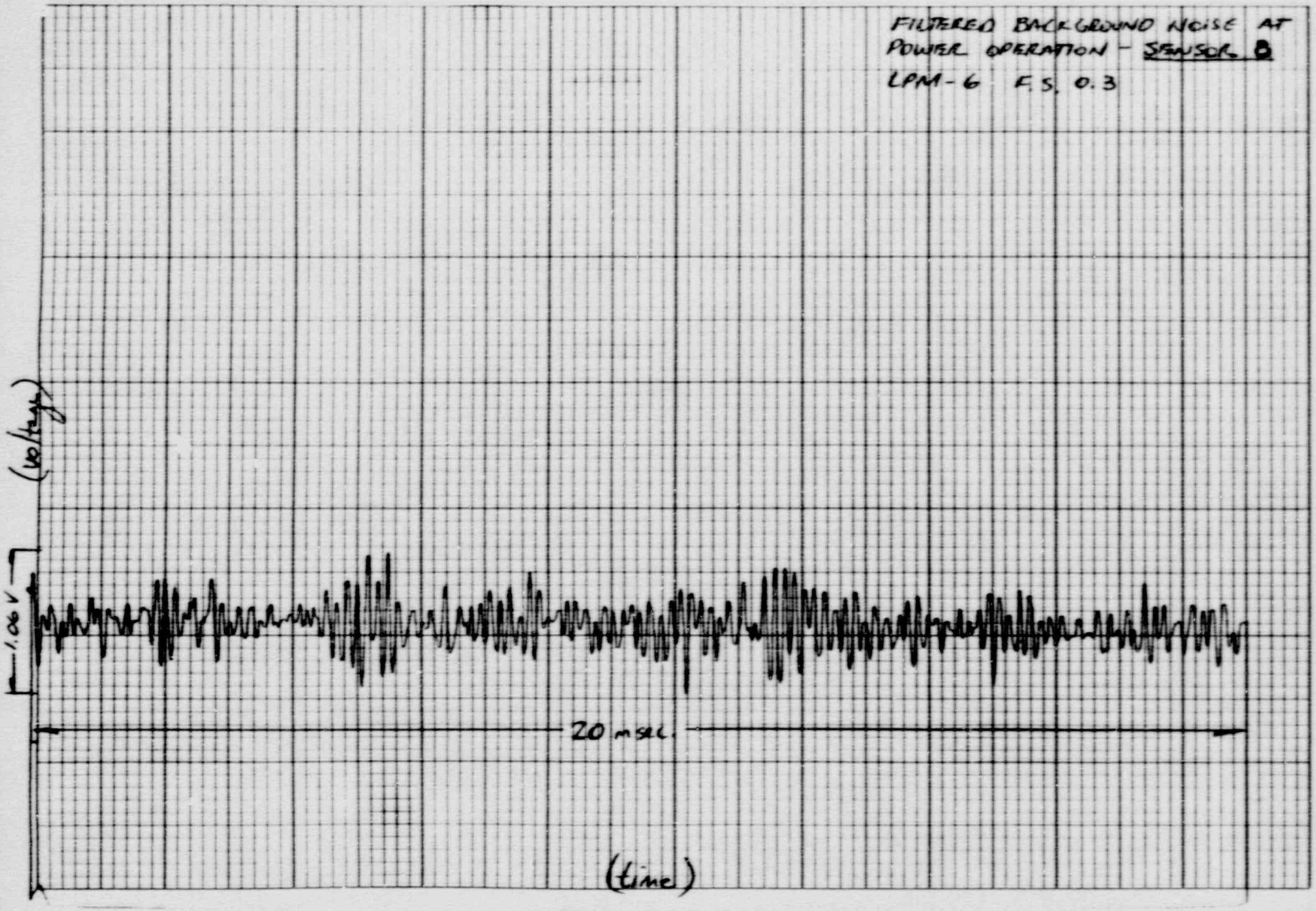

FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 3
LPM-2 F.S. - 1.0
(voltage)
0.155 V
20 m sec.
(time)

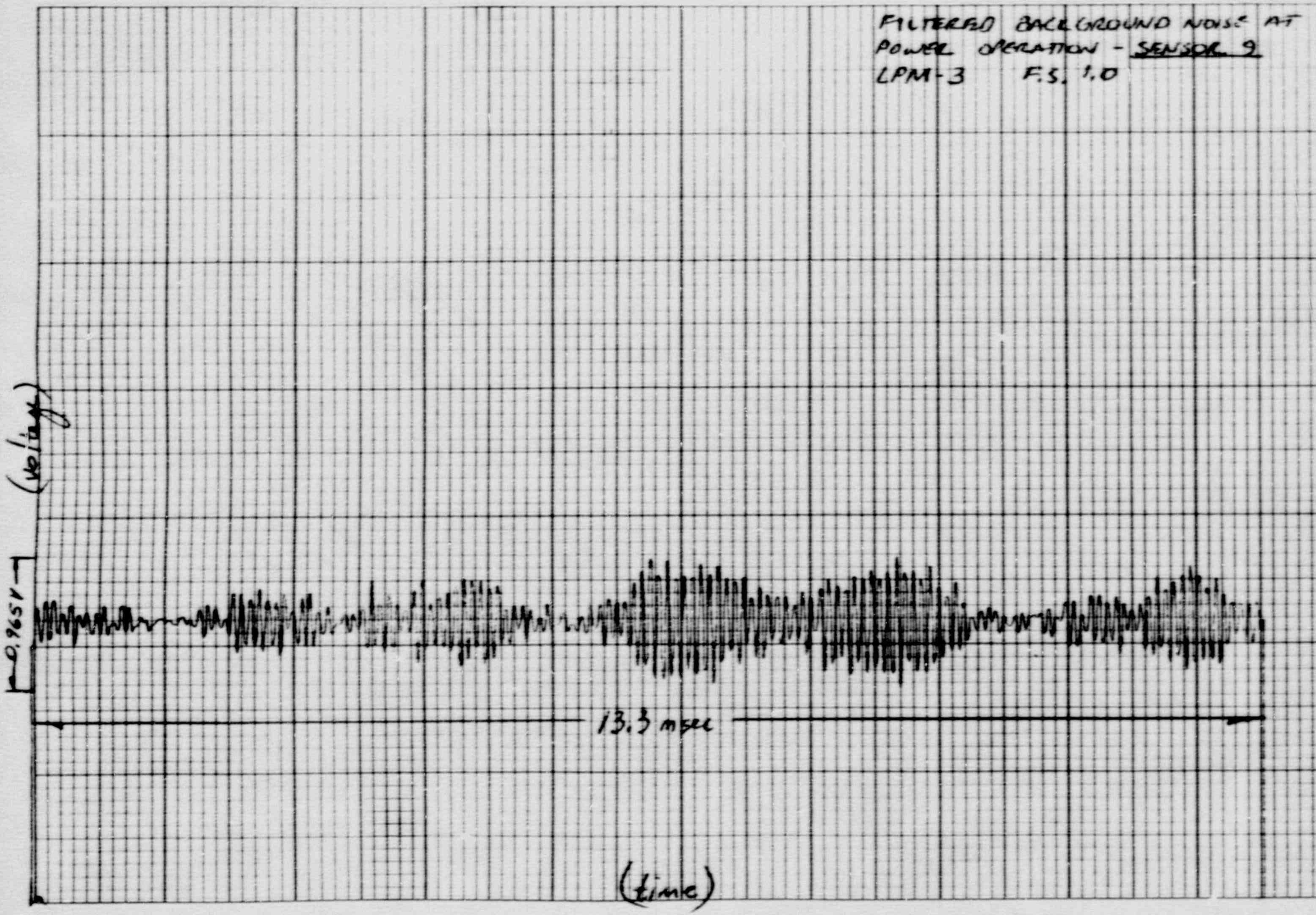

FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 4
LAM-3 F.S. 0.3
(volts/stage)
1.42 v
20 msec
(time)

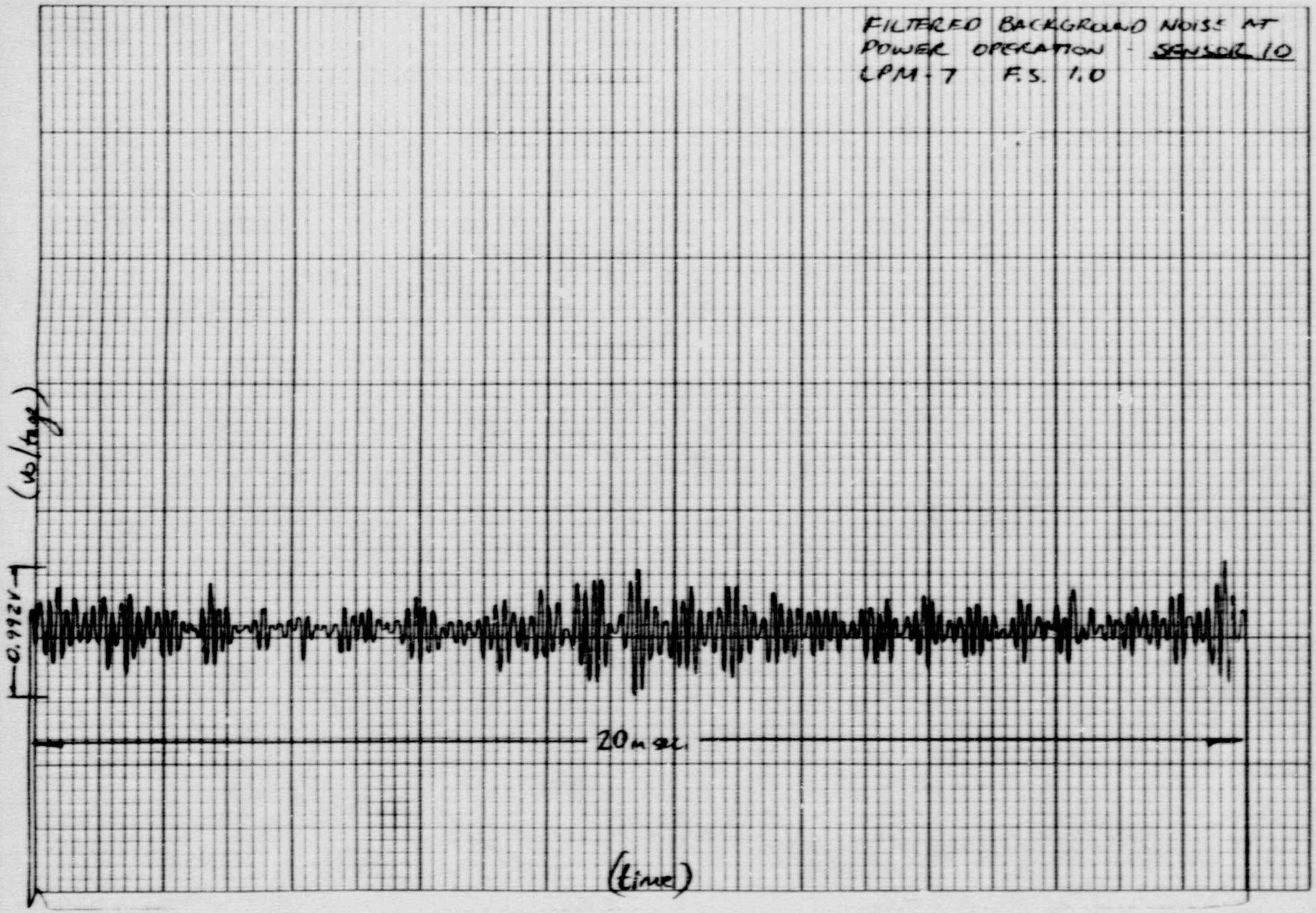

FILTERED BACKGROUND NOISE AT POWER OPERATION - SENSOR 5
LPM-2 F.S. 0.3
(volts)
0.911 V
20 msec.
(time)

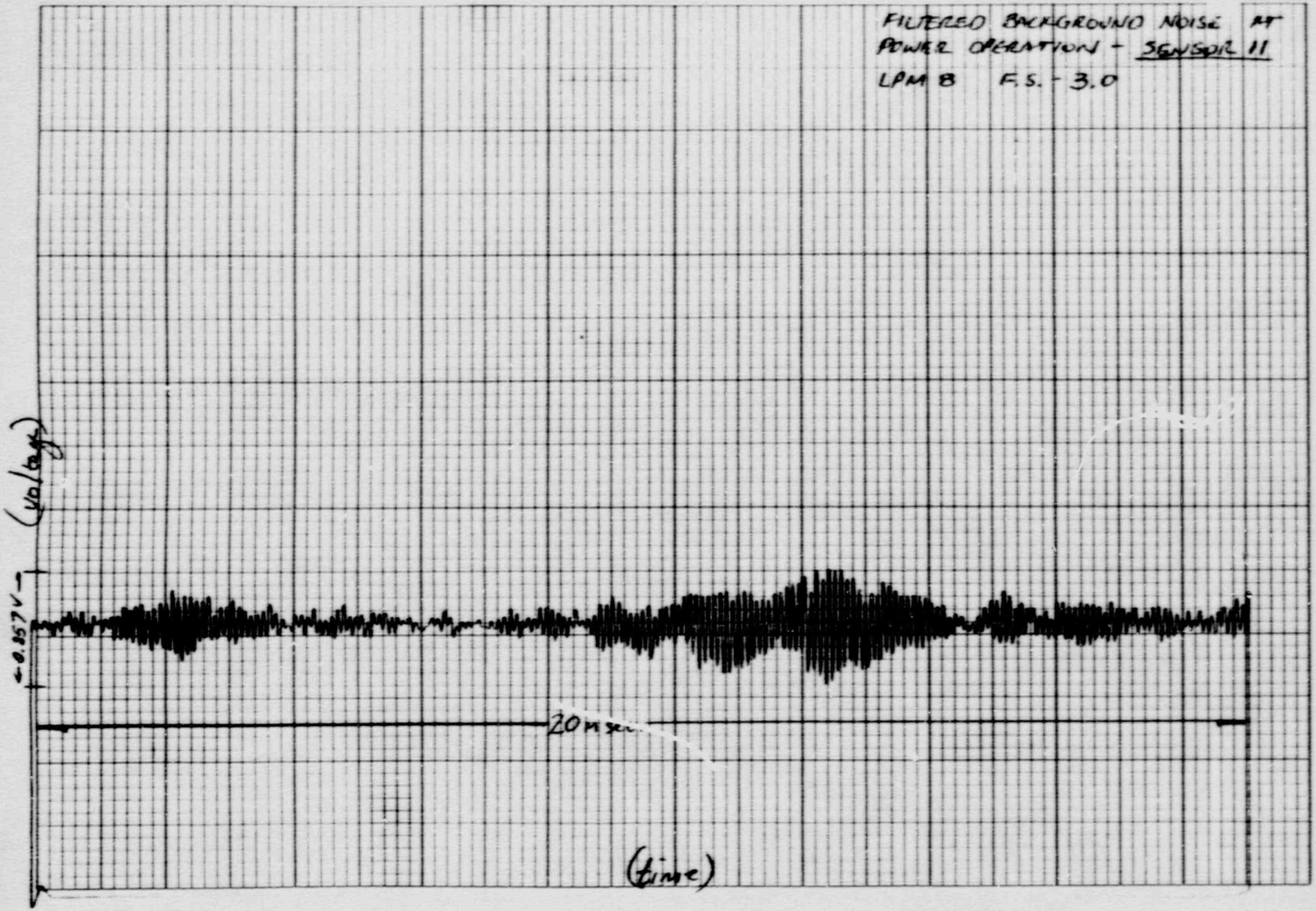

FILTERED BACKGROUND NOISE AT POWER OPERATION - SENSOR 6
LPM-4 F.S.-0.3
(voltage)
1.5 V
20 msec.
(time)

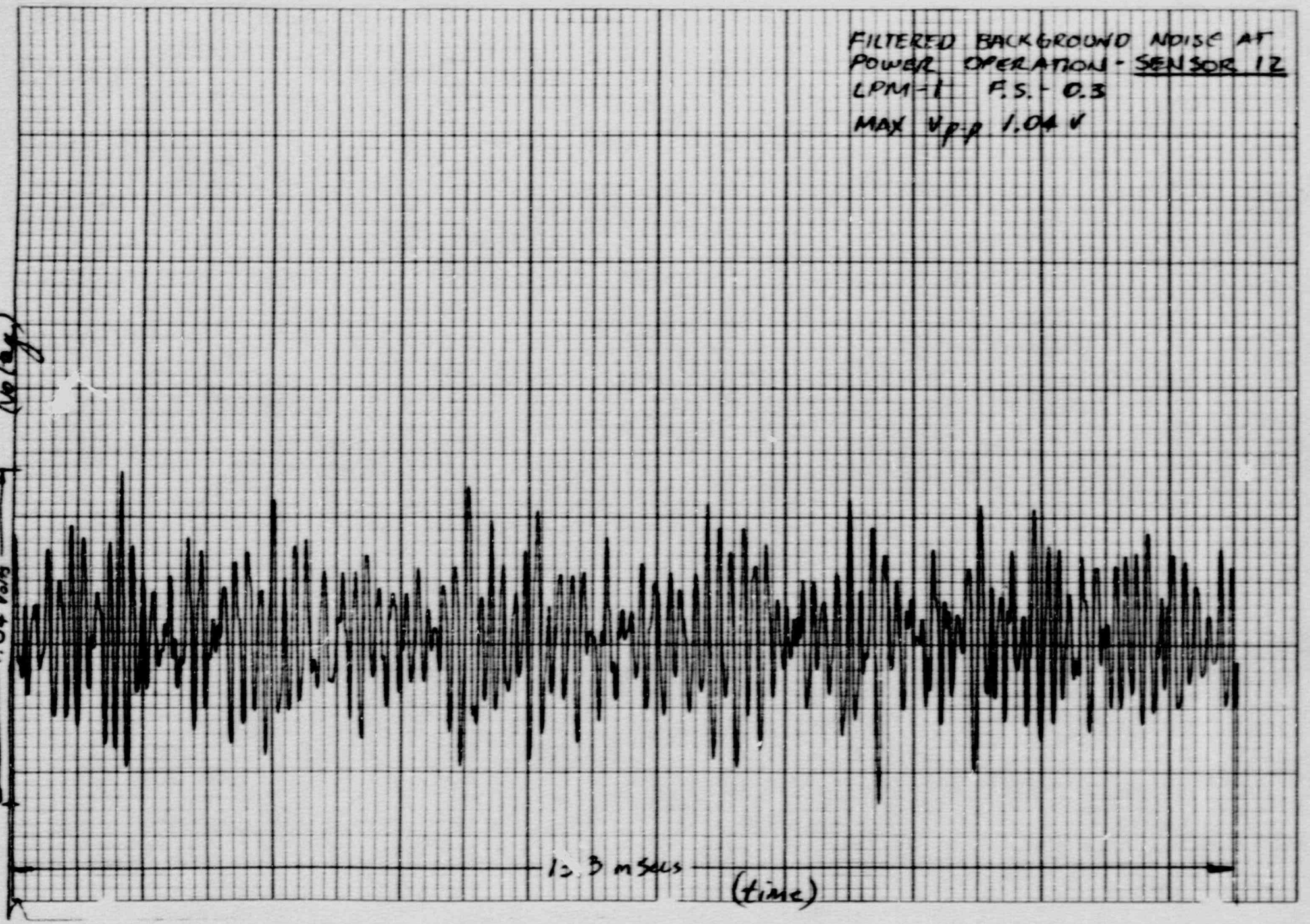

FILTERED BACKGROUND NOISE AT POWER OPERATION - SENSOR 7
LPM-5 F.S. 0.1
0.265 V
(voltage)
20 m sec
(time)

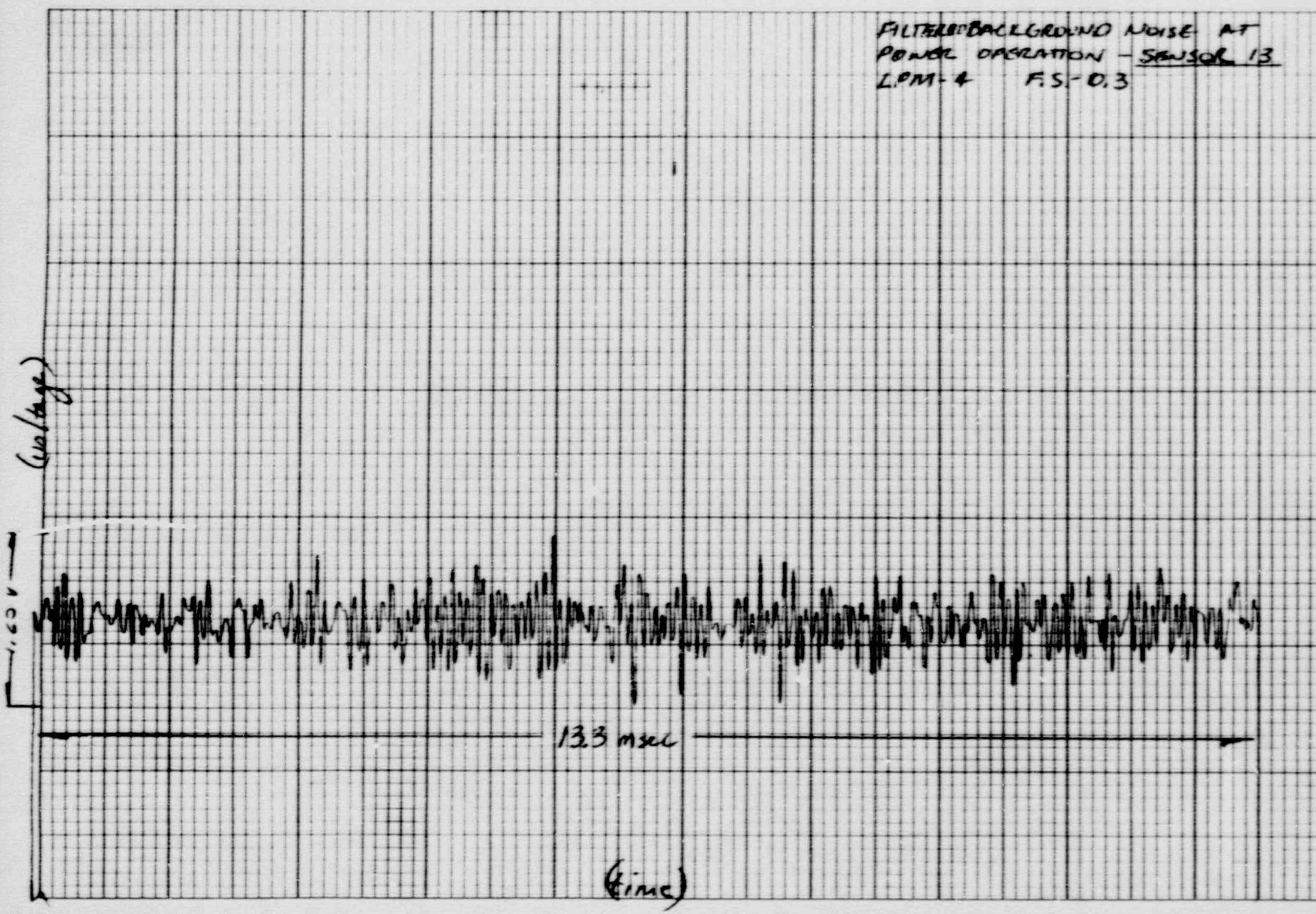

FILTERED BACKGROUND NOISE AT POWER OPERATION - SENSOR B
LPM-6 F.S. 0.3
(volts)
1.00 V
20 msec.
(time)

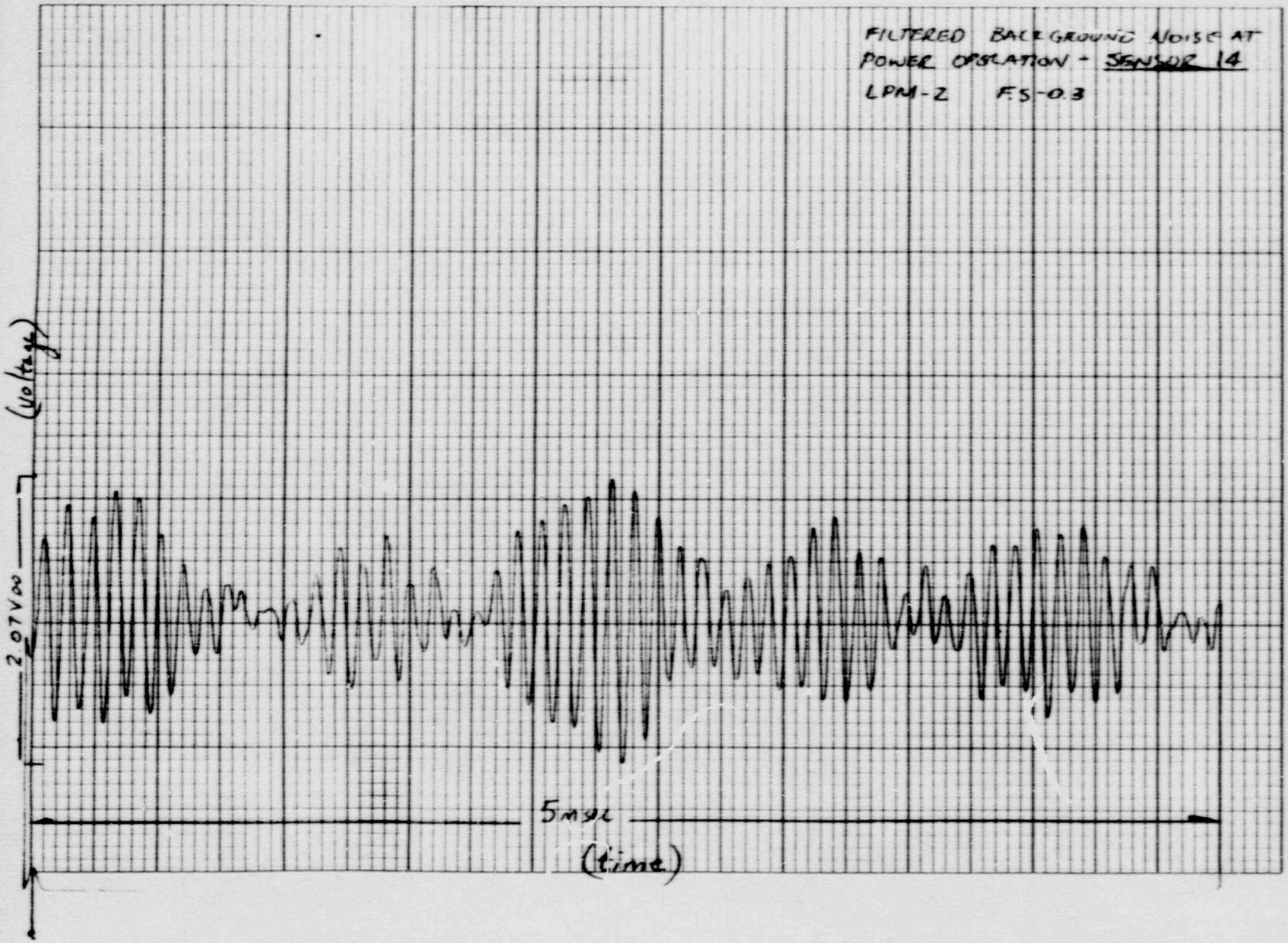


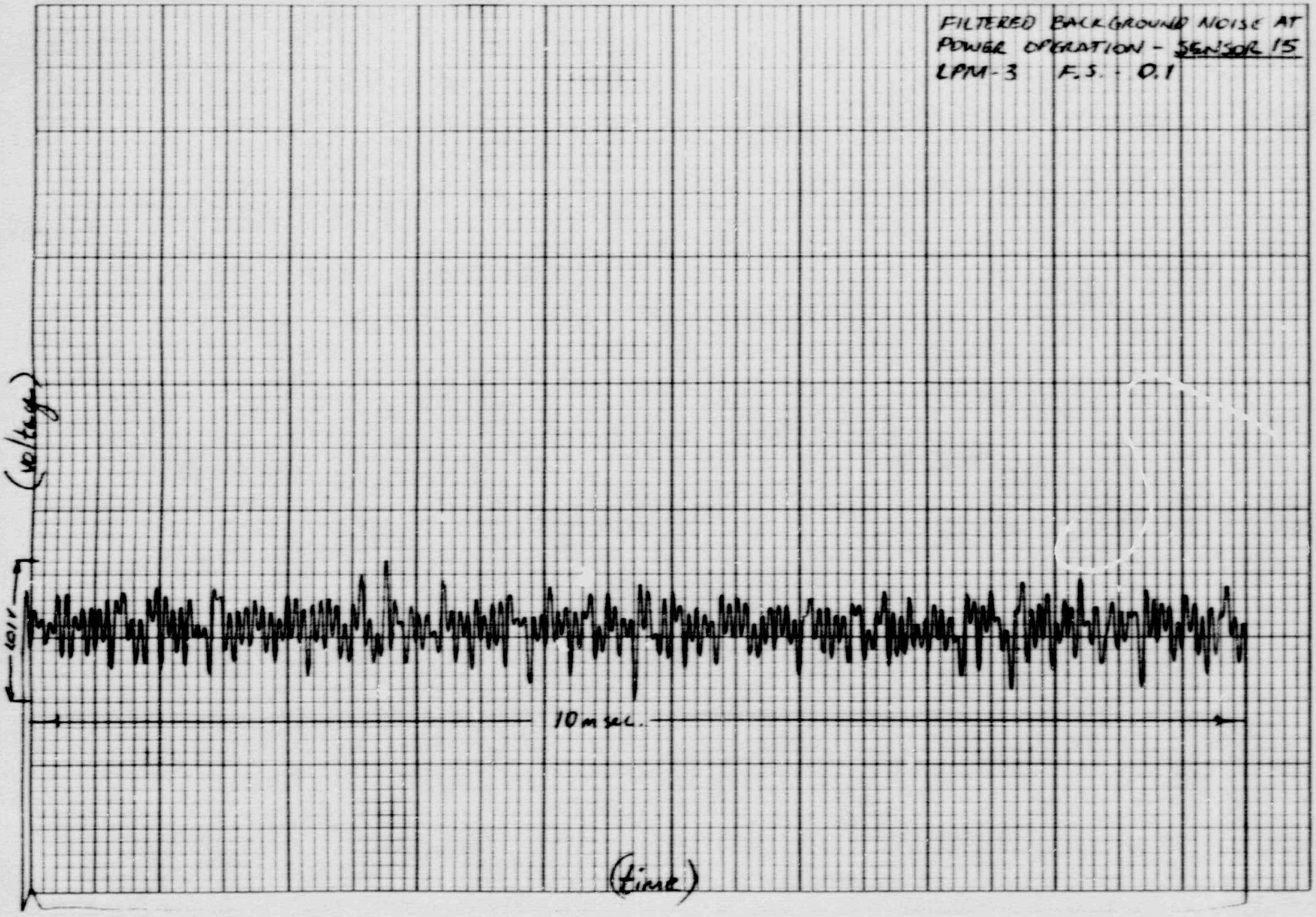

FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 10
LPM-7 F.S. 1.0
(lb/ft²)
0.992V
20 m sec
(time)


FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 11
LPM 8 F.S. - 3.0
(volts)
0.157V
20 m sec
(time)


FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 12
LPM-1 F.S. - 0.3
MAX Vp-p 1.04 V
(volts)
1.04 Volts
1.3 mSecs
(time)


FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 13
LPM-4 F.S.-0.3
(voltage)
13.3 msec
(time)




FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 15
LPM-3 F.S. - 0.1
(voltage)
10 m sec.
(time)

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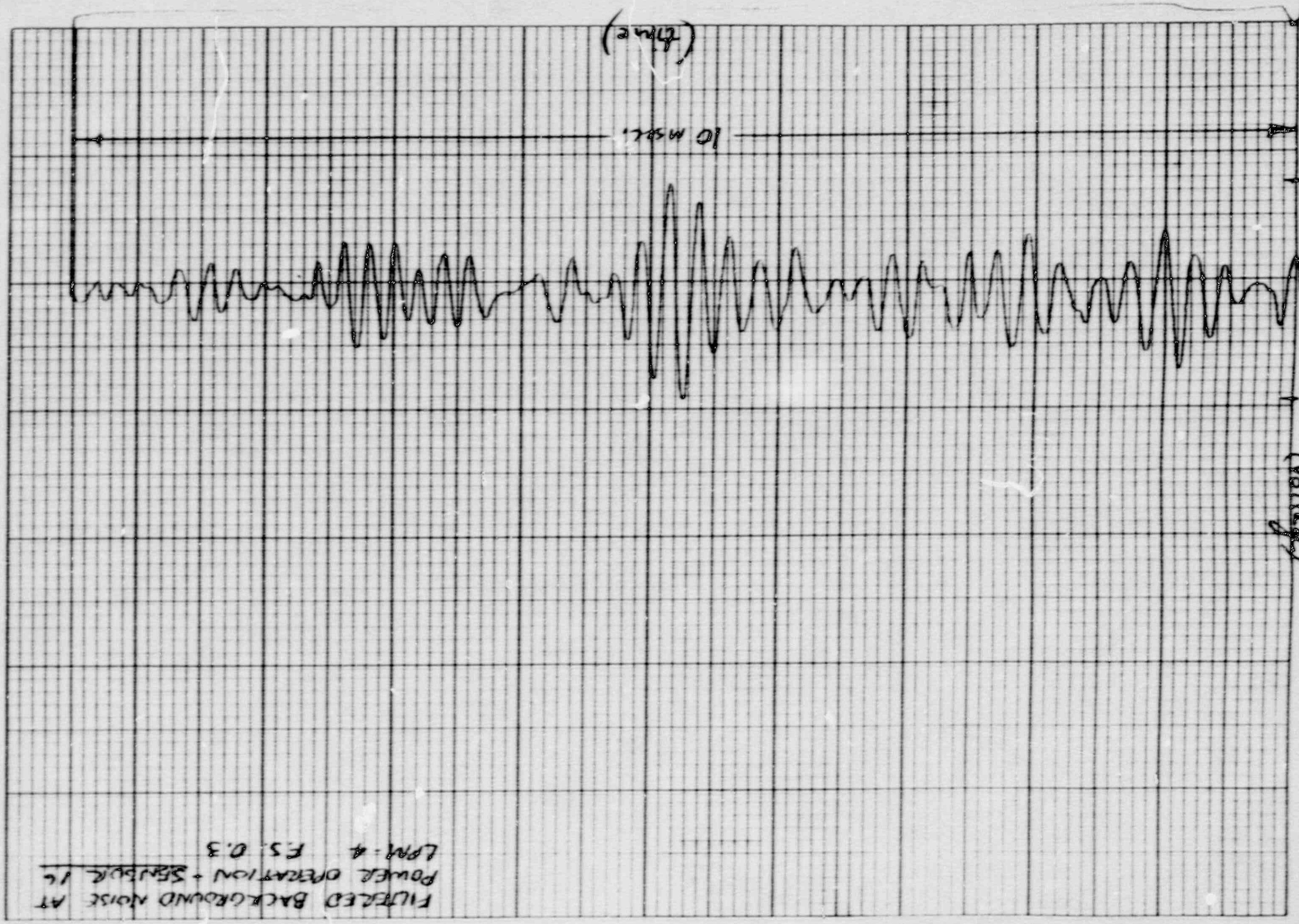
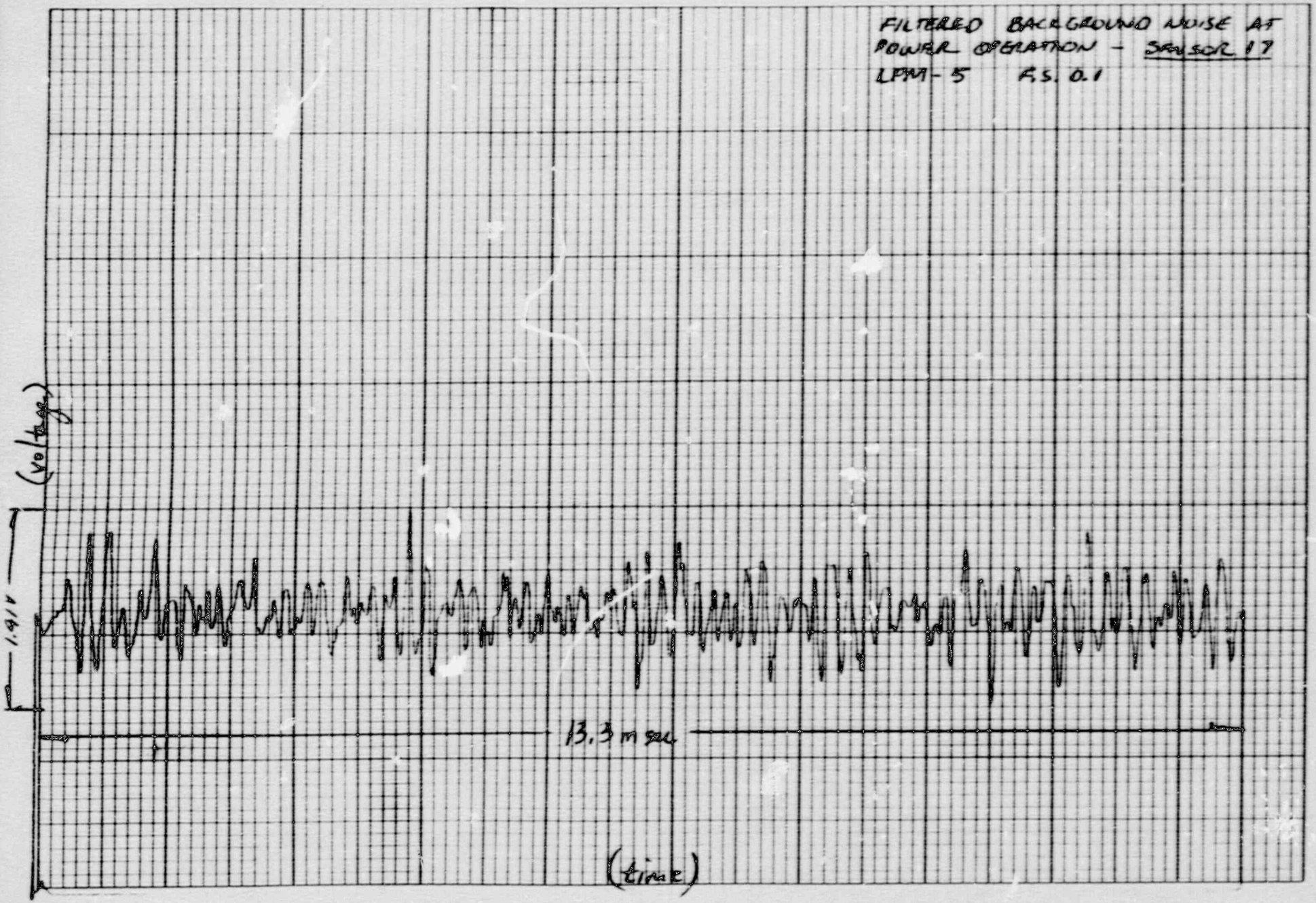
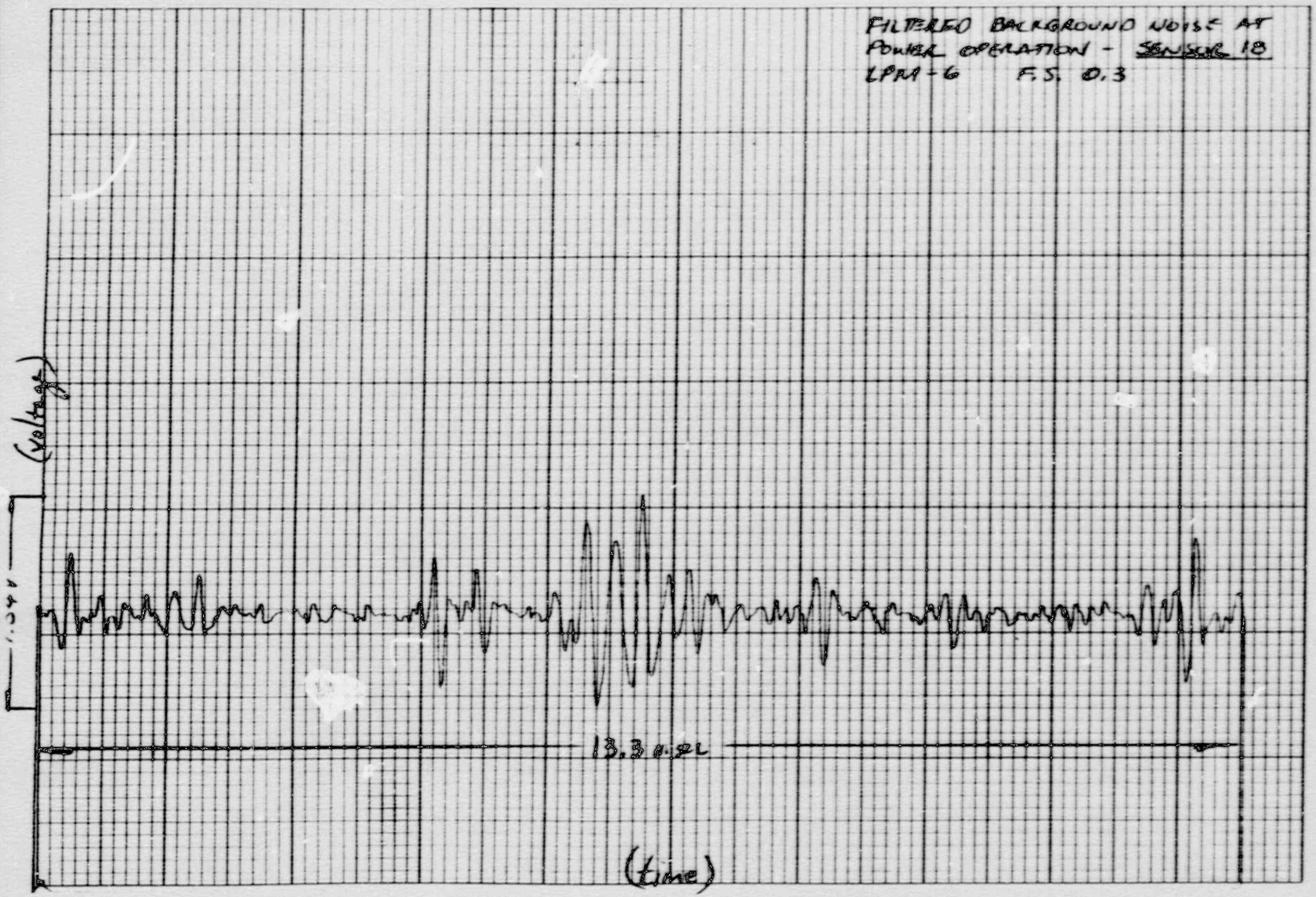
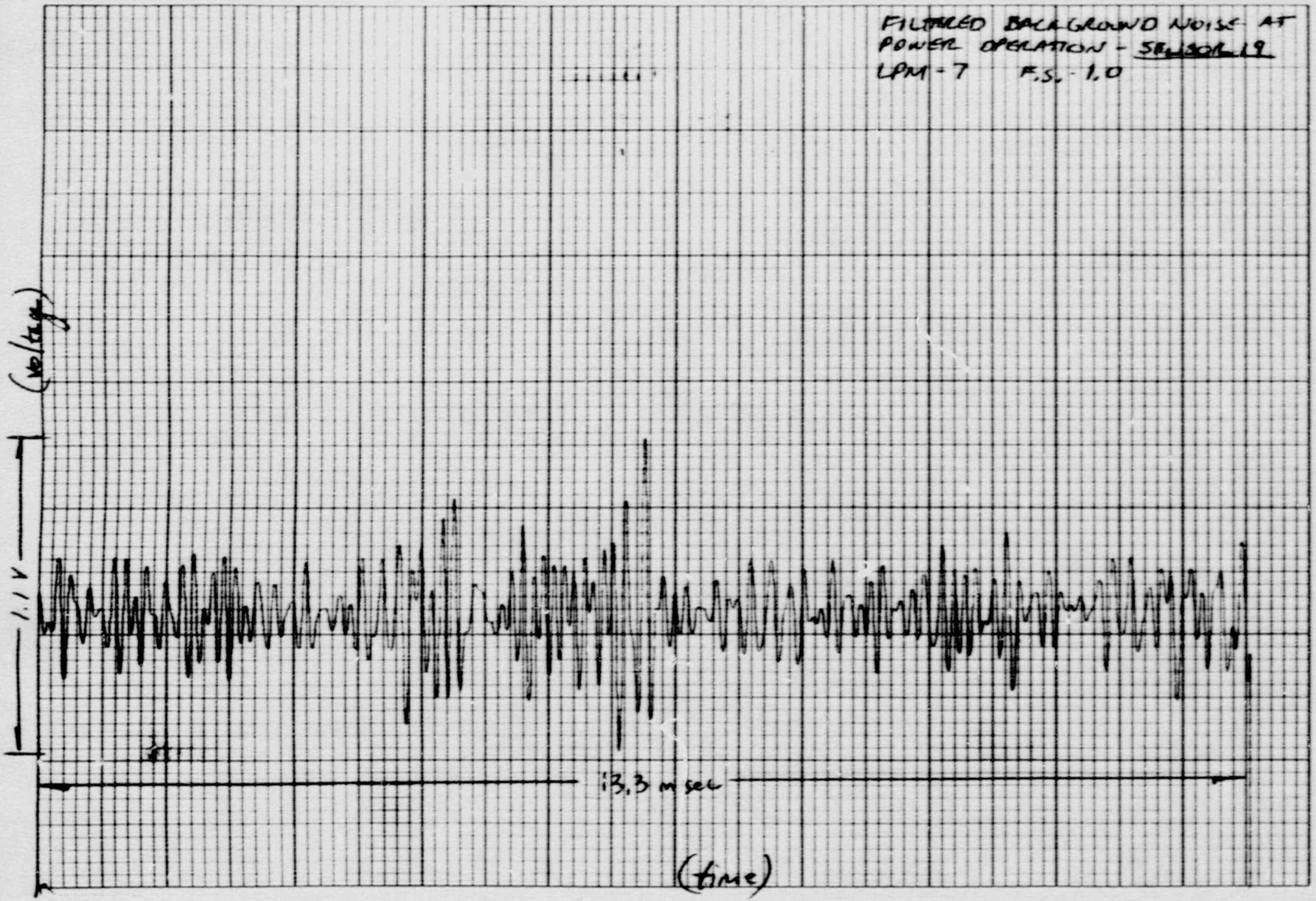
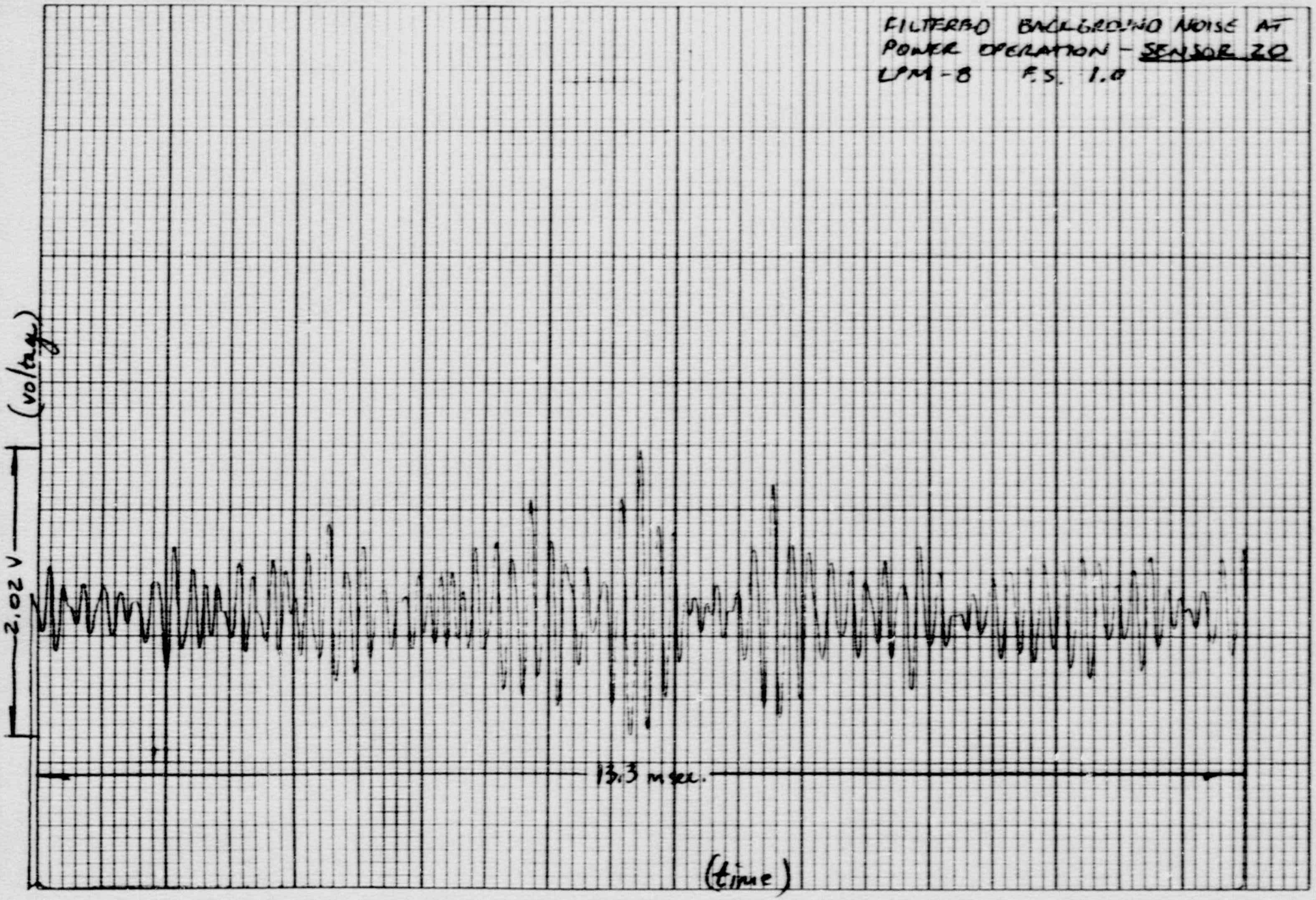




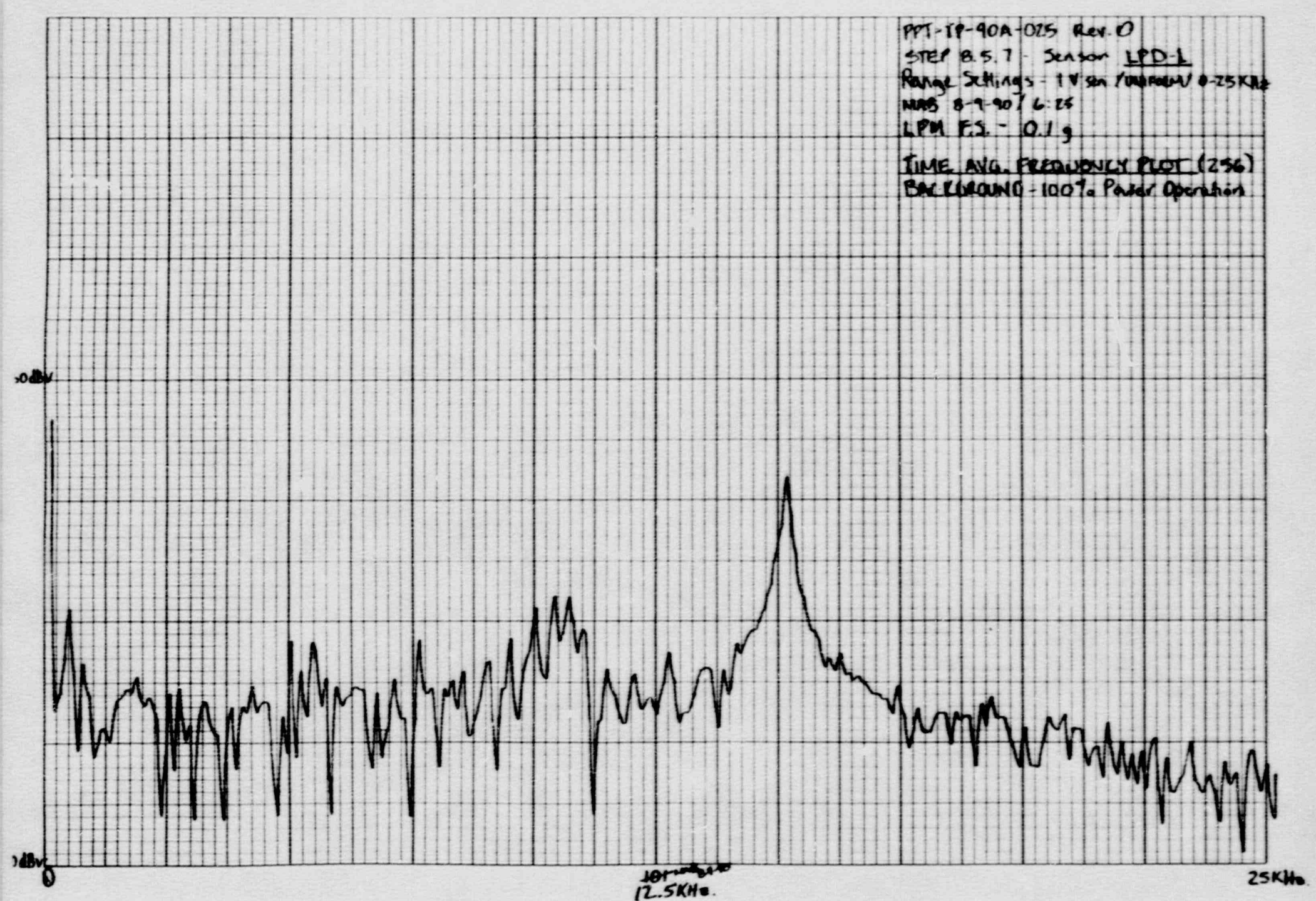

FILTERED BACKGROUND NOISE AT
POWER OPERATION - SENSOR 18
LPM-6 F.S. 0.3
(voltage)
13.3 sec
(time)

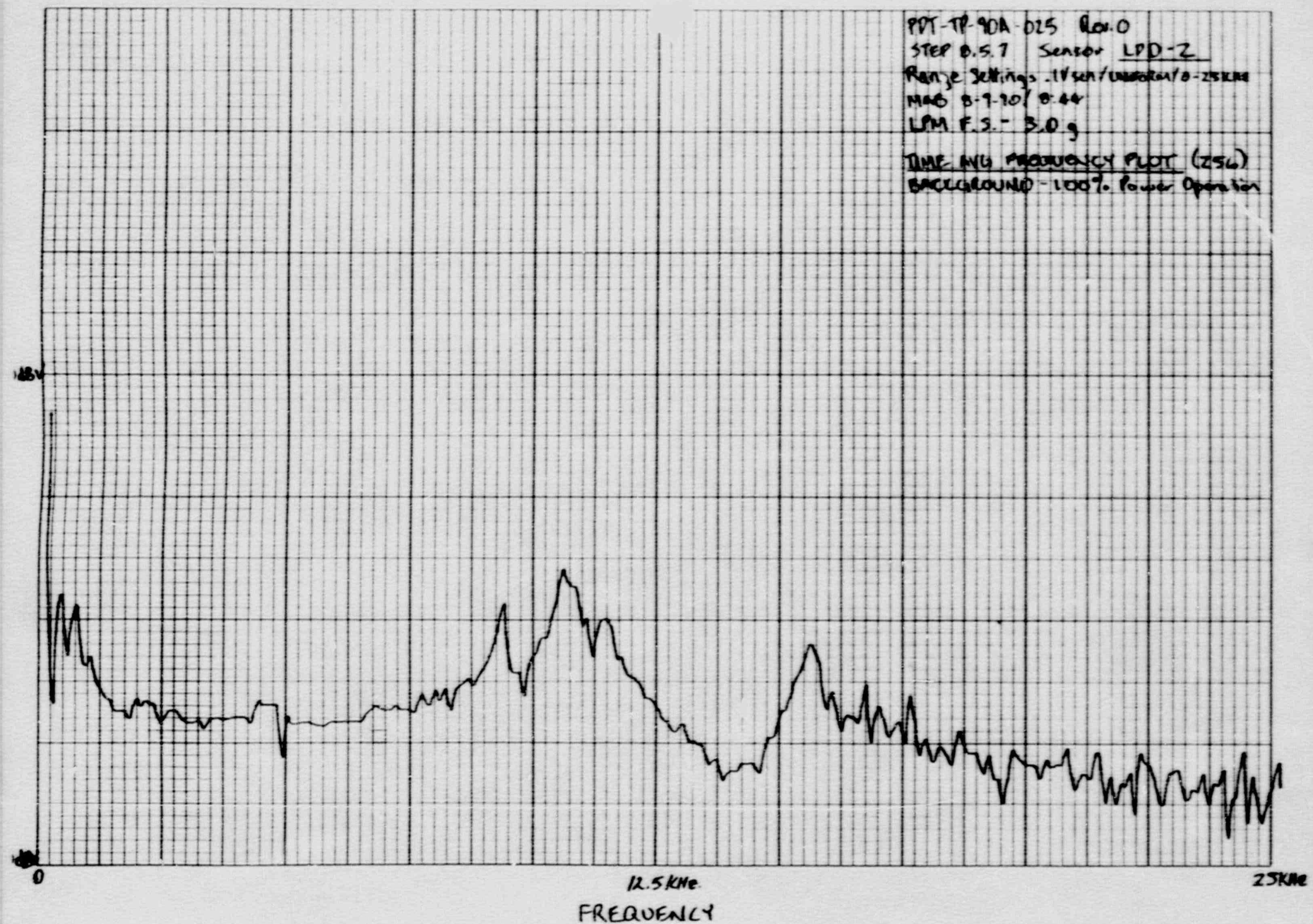


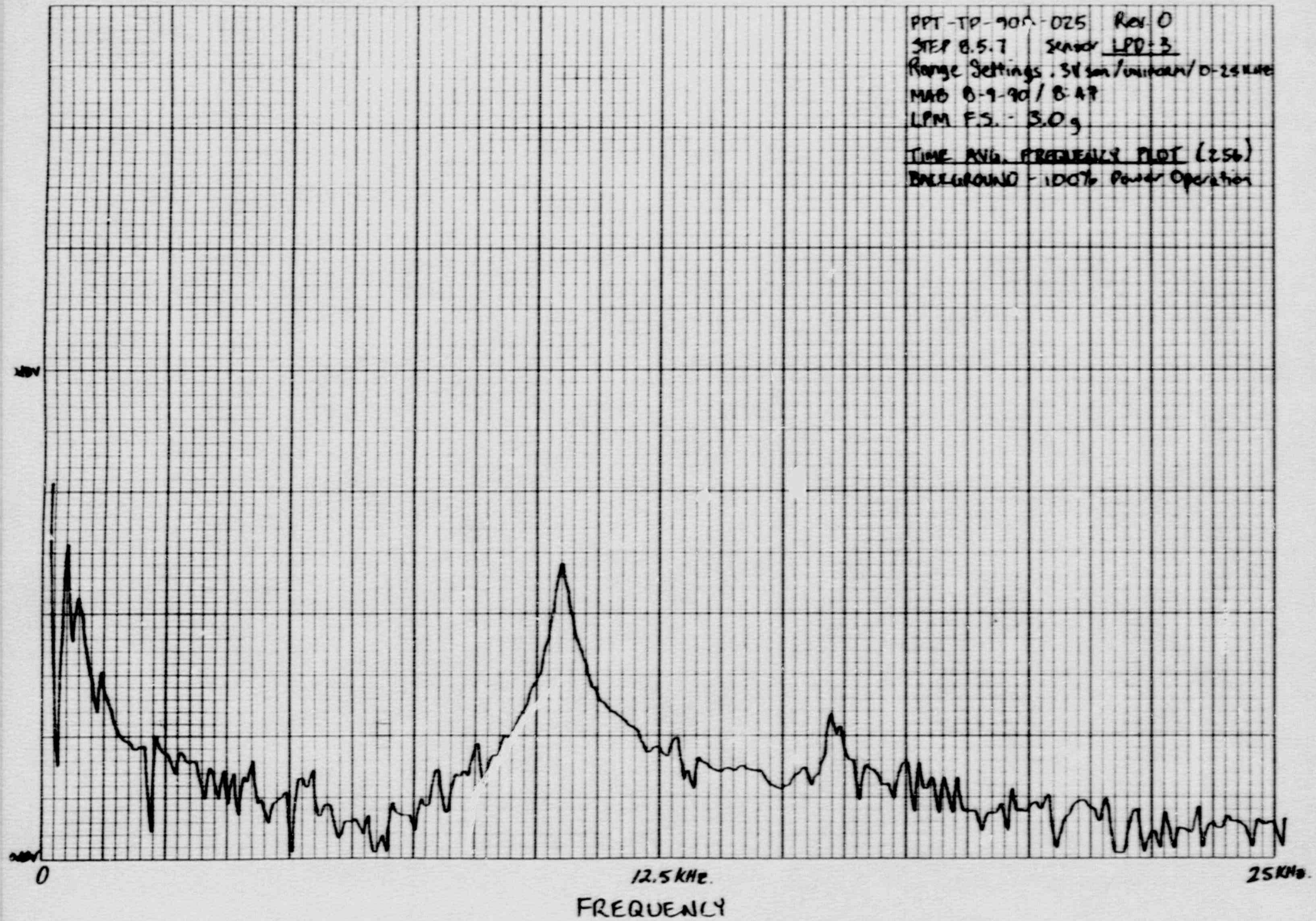


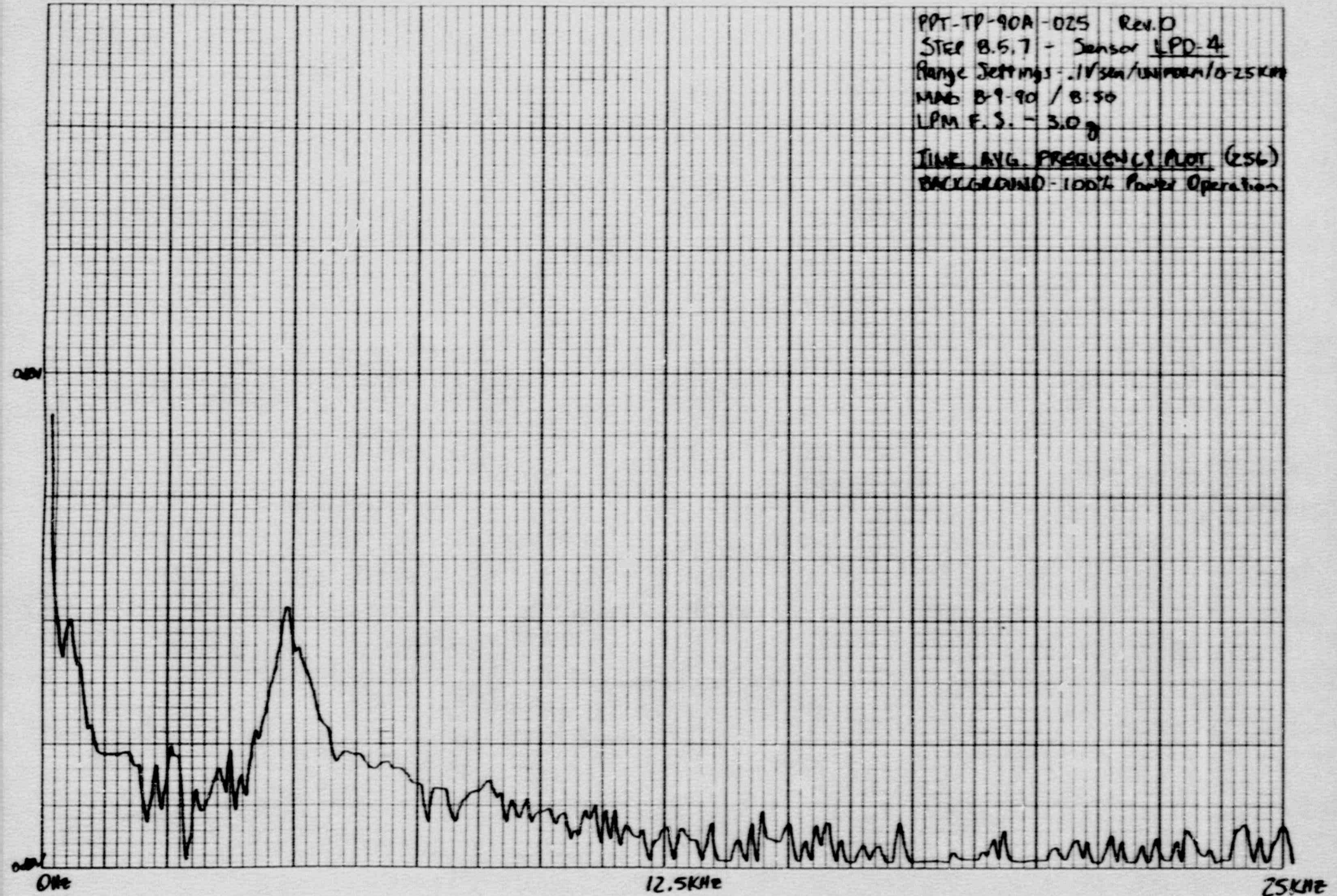
3.4 Background Frequency Spectrum (100% Power)

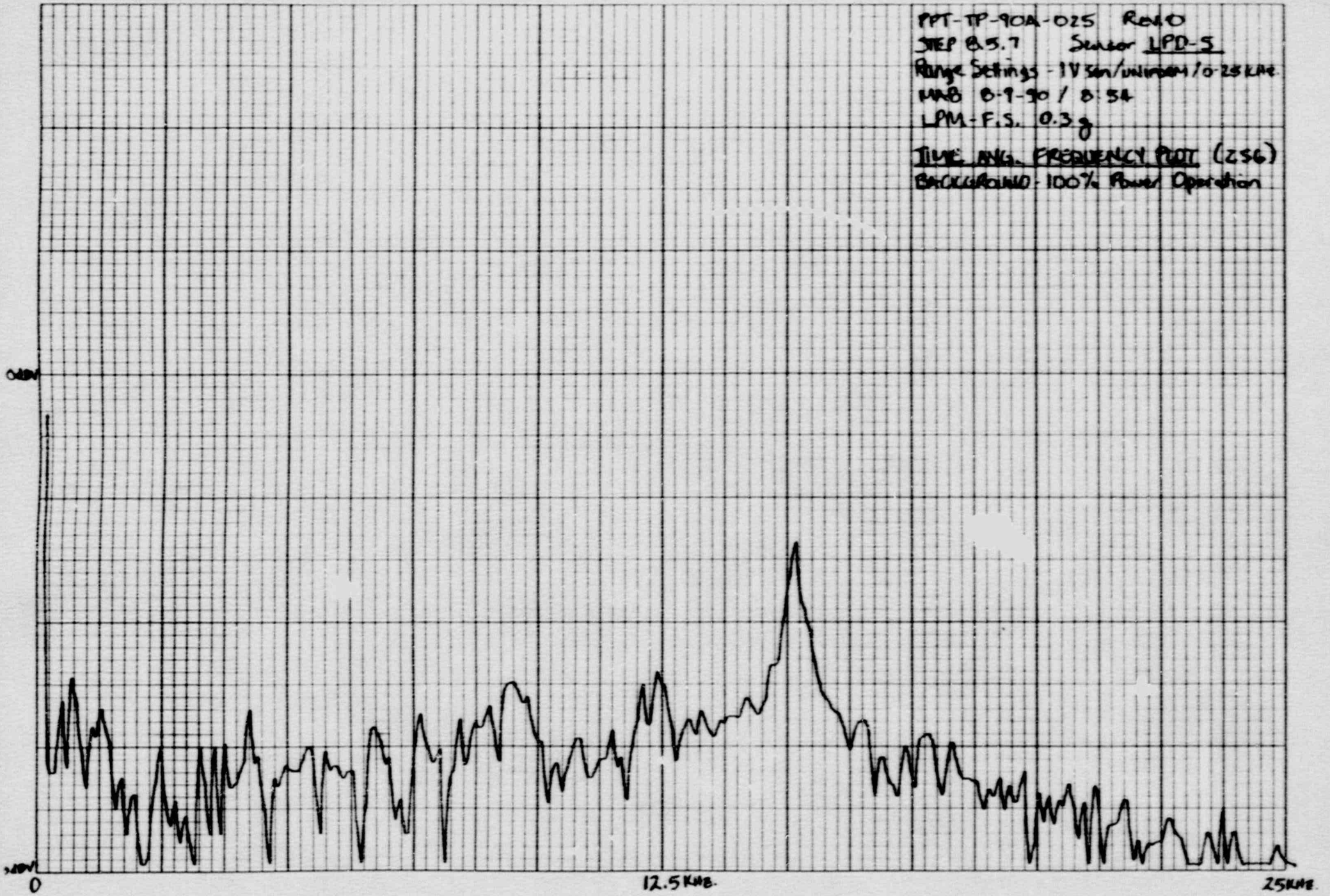
The following X-Y plots were made using tapes recorded during initial startup test ISU-211A. The background frequency content was compared to the impact frequencies (see Section 3.2) to determine "break frequencies" for bandpass filter adjustments.

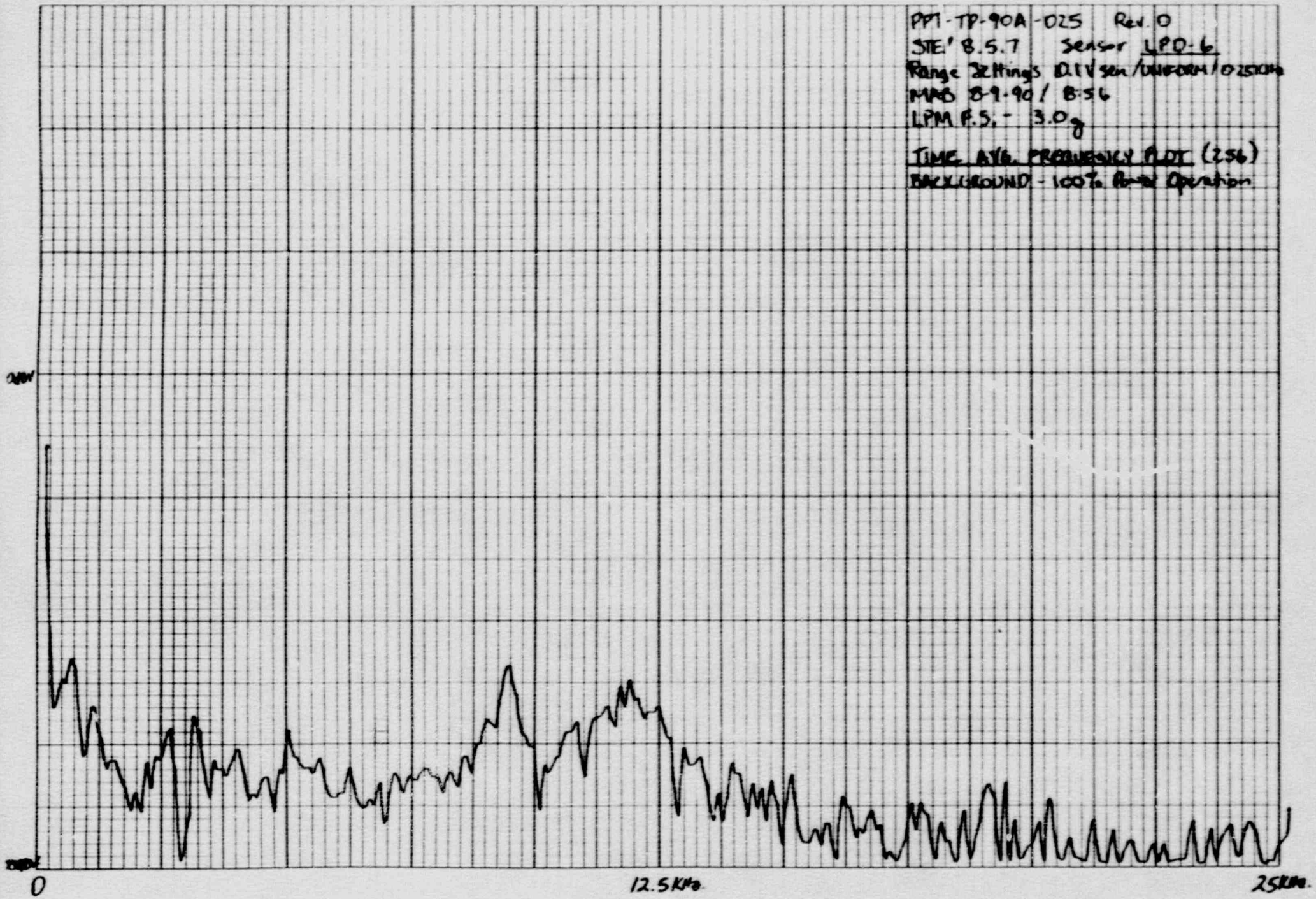

PPT-TP-90A-025 Rev. O
STEP 8.5.7 - Sensor LPD-1
Range Settings - 1V/cm / 0-25KHz
NRB 8-9-90 / 6:25
LPM F.S. - 0.1 g
TIME AVG. FREQUENCY PLOT (256)
BACKGROUND - 100% Power Operation
0dBv
0
12.5KHz.
25KHz.
FREQUENCY





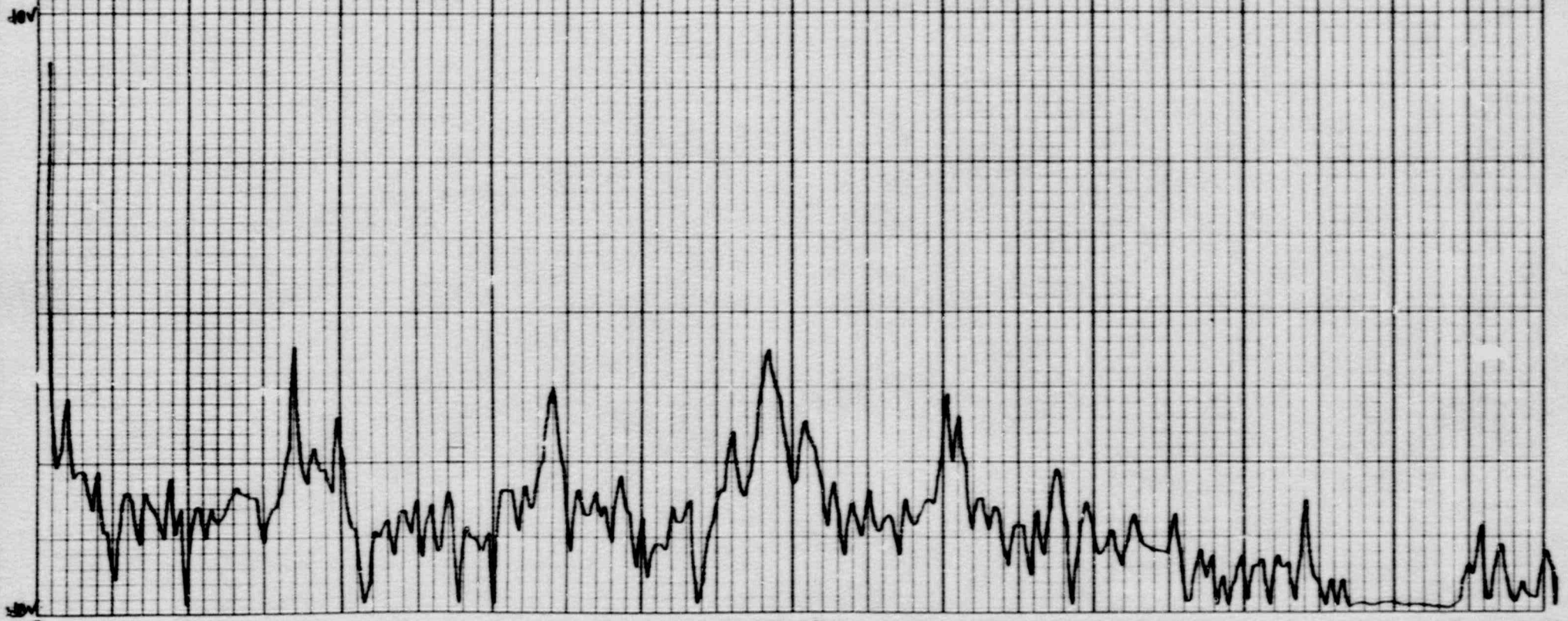


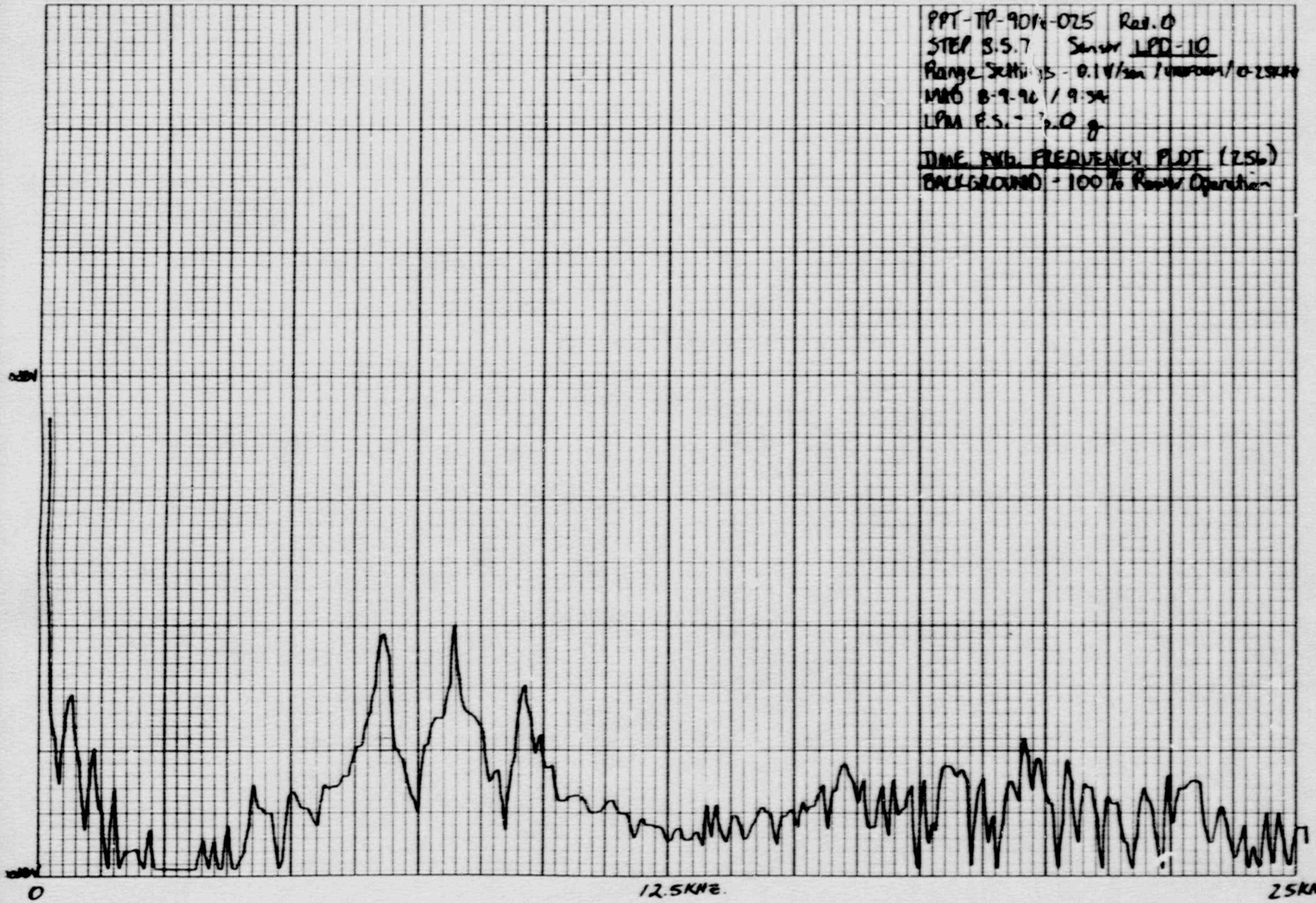

PPT-TP-90A-025 Rev.0
STEP 5.7 Sensor LPD-5
Range Settings - 1V/cm/universal/0-25 KHz
MRB 8-9-90 / 8:54
LPM-F.S. 0.3 g
TIME AVG. FREQUENCY PLOT (256)
BACKGROUND - 100% Power Operation
0
12.5 KHz
25 KHz
FREQUENCY

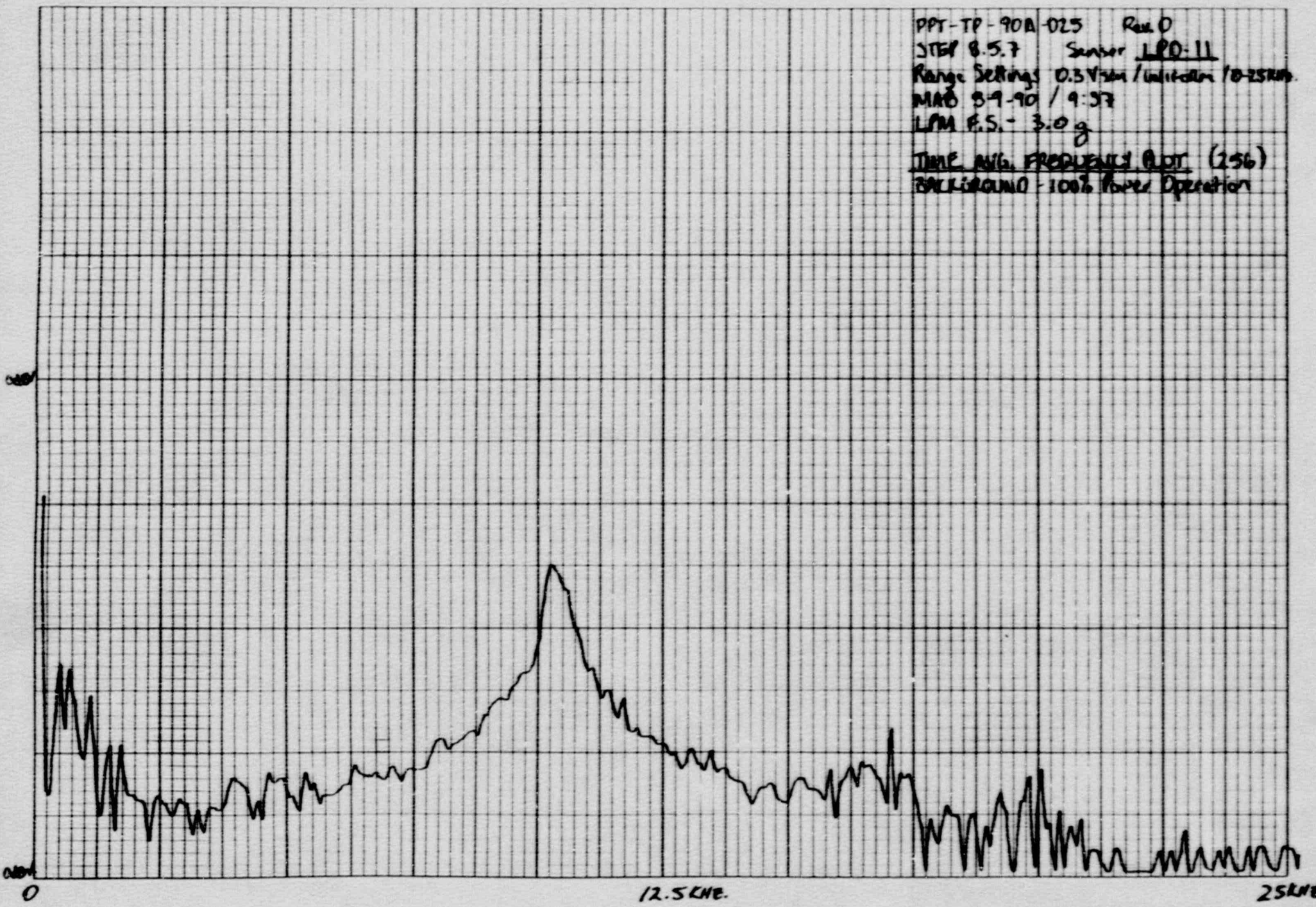


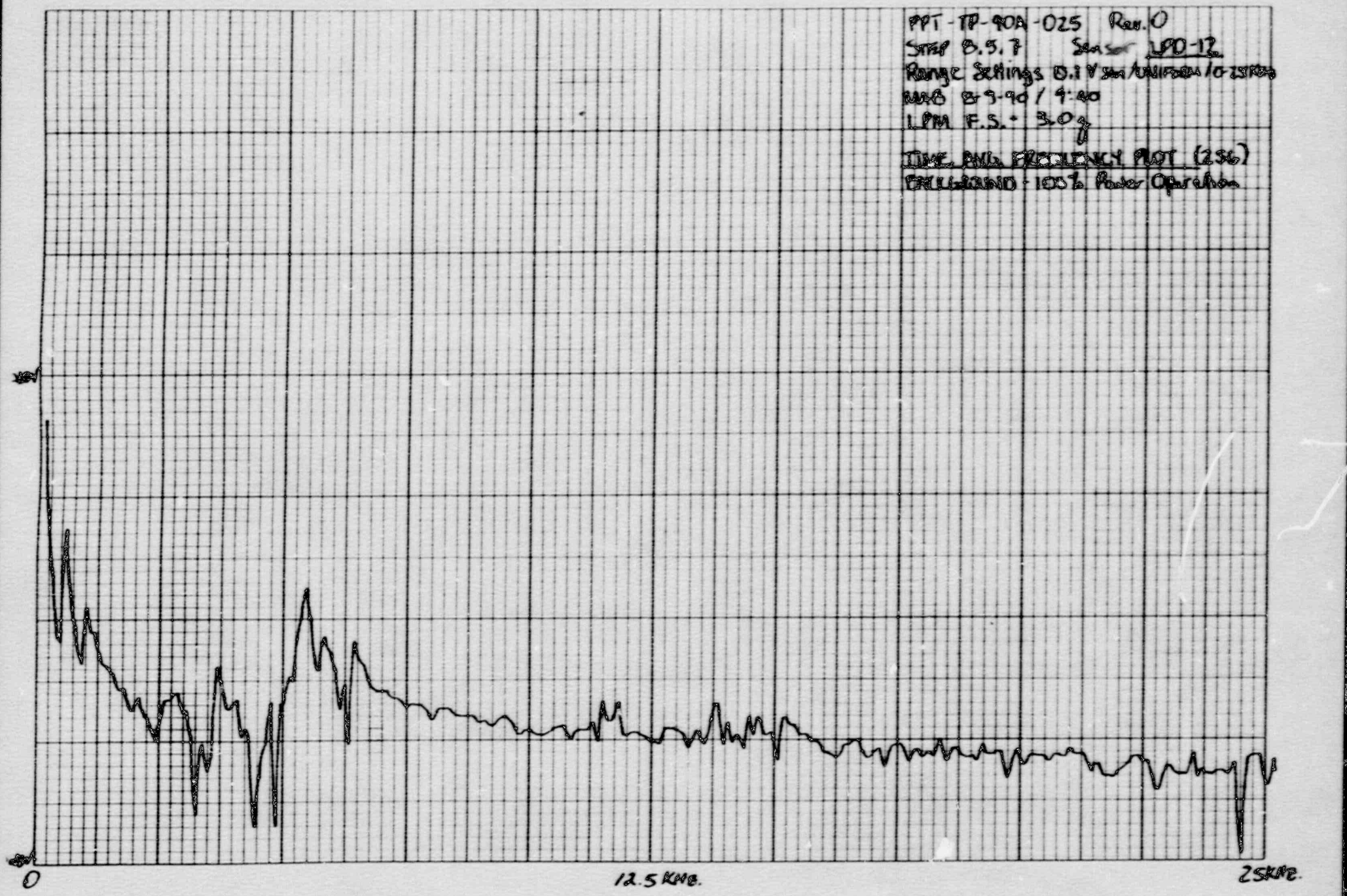
PPT-TP-902-025 Rev. O
STEP B.S.7 Sensor LPD-7
Range Settings: .1V/cm/100cm/sec/0-25KHz
NWS 8-9-90 / 9:00
LPM F.S. = 1.0 g

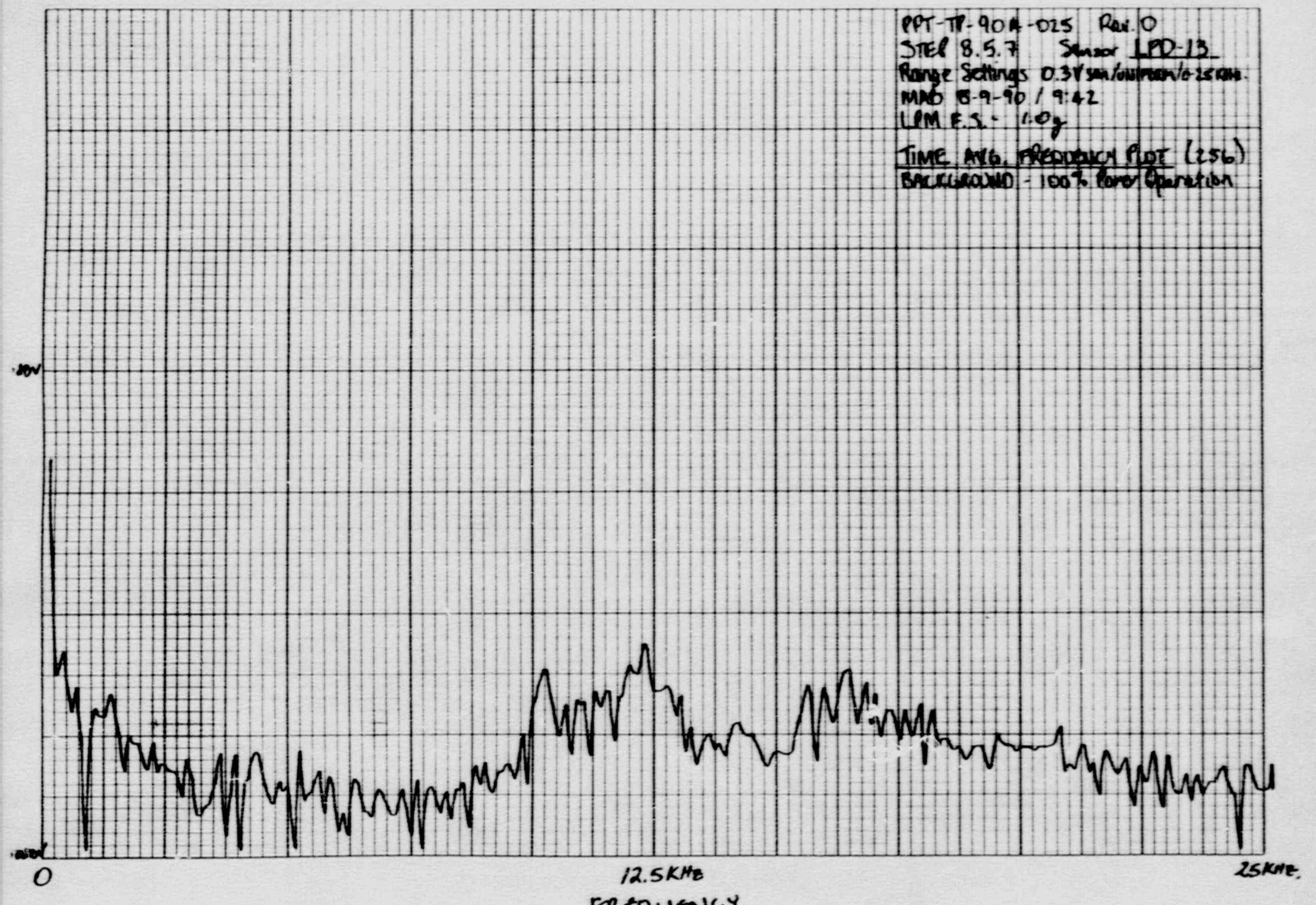
TIME AVG. FREQUENCY PLOT (256)
BACKGROUND - 100% Power Operation



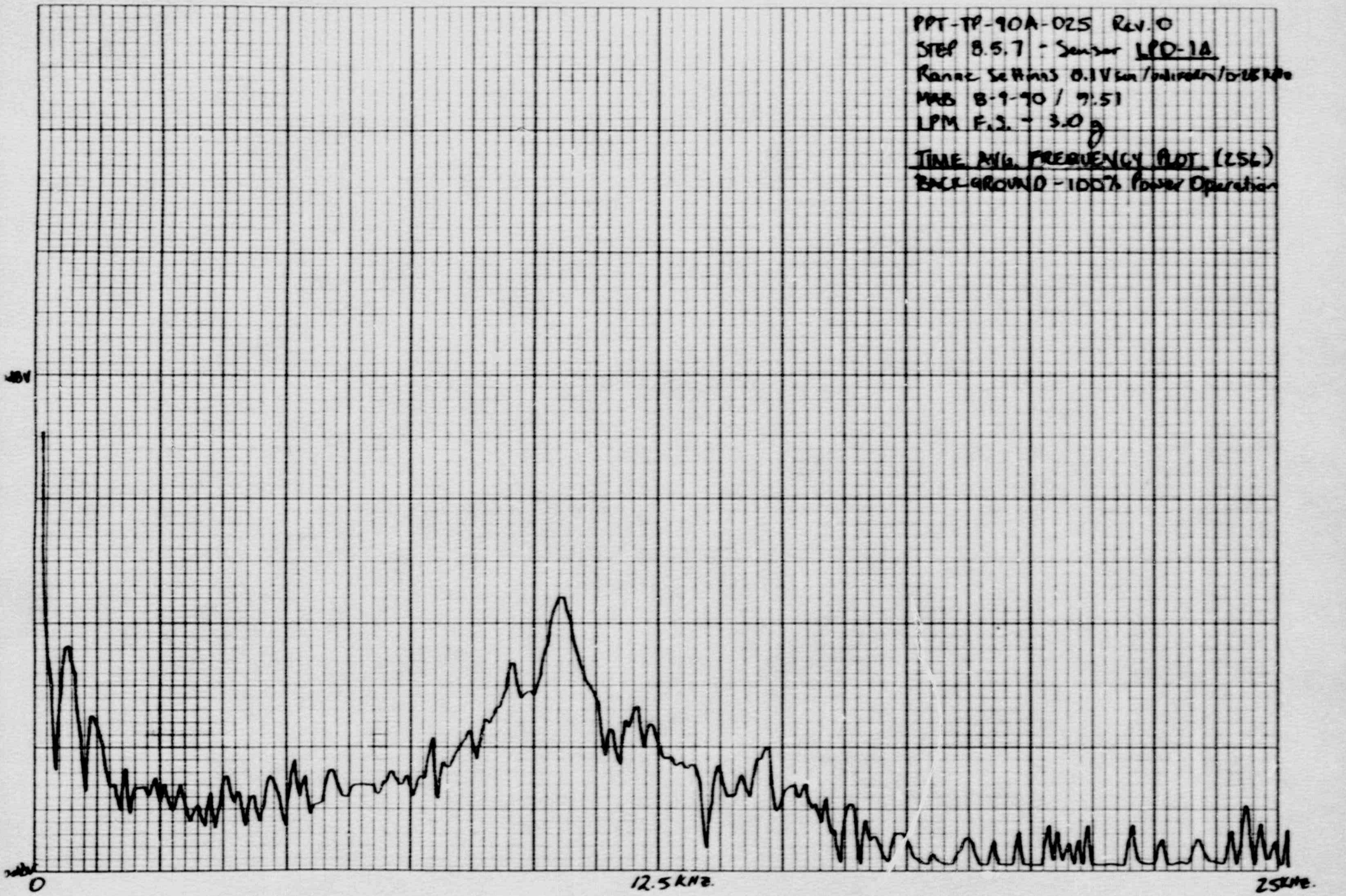


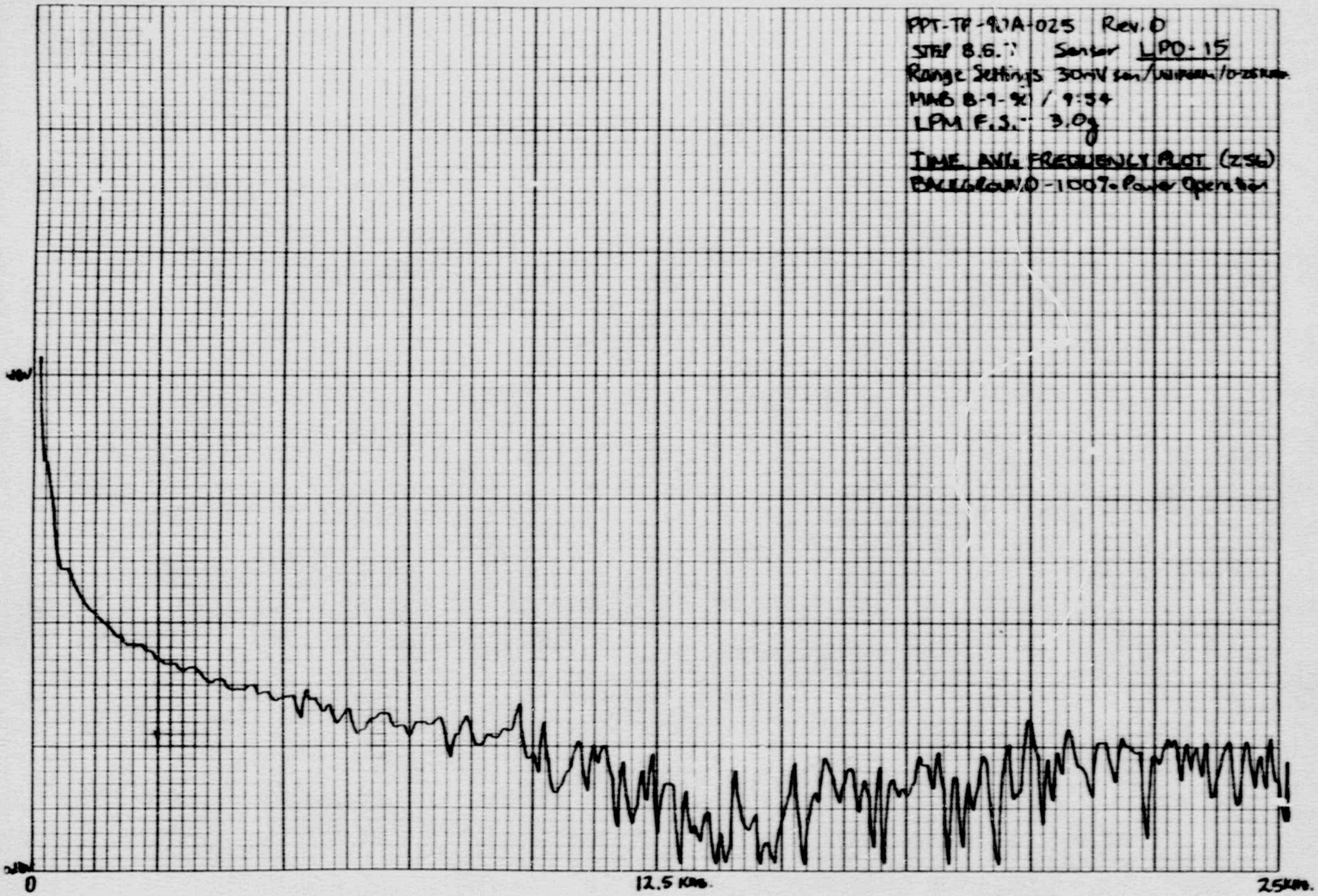


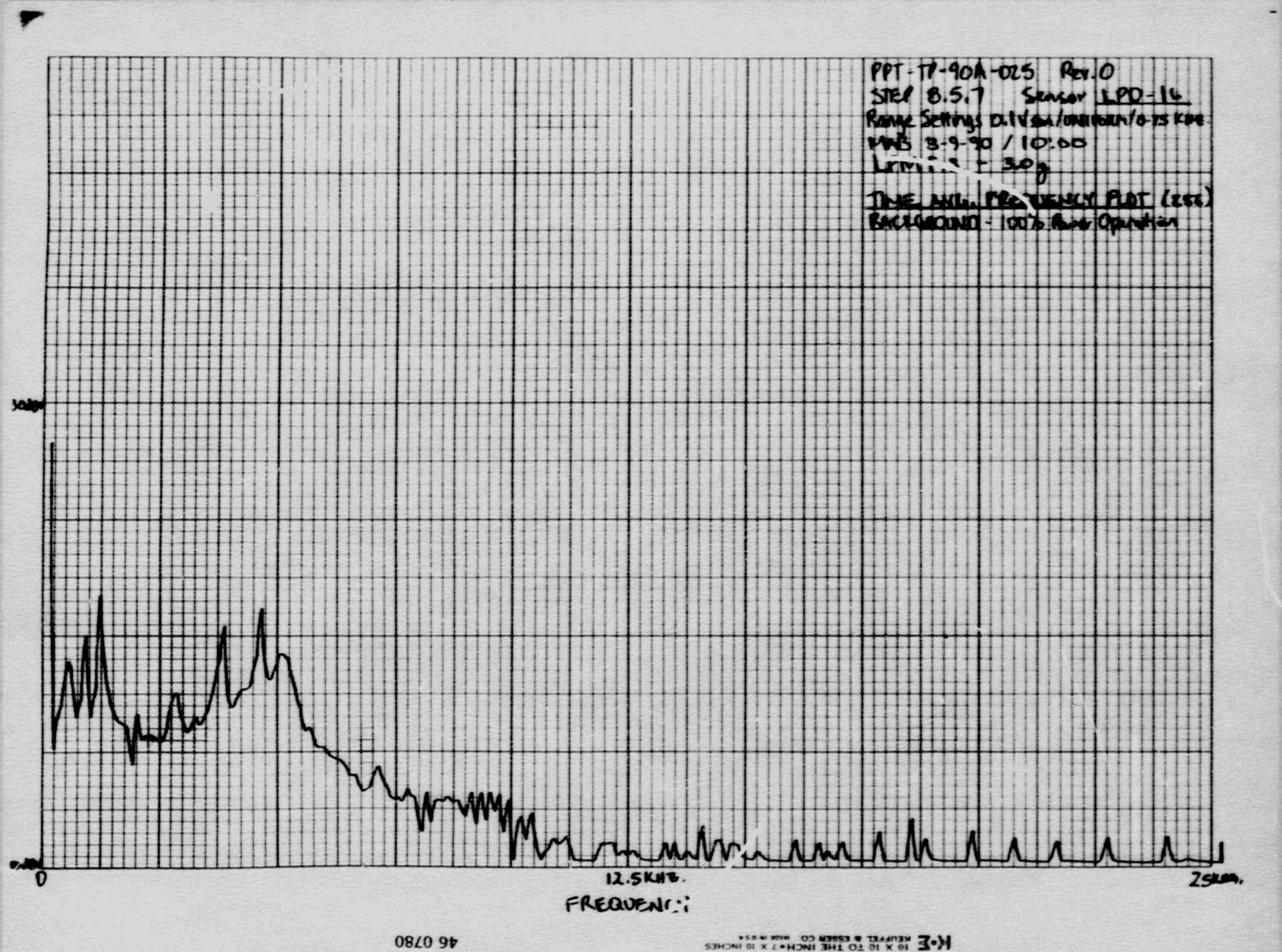




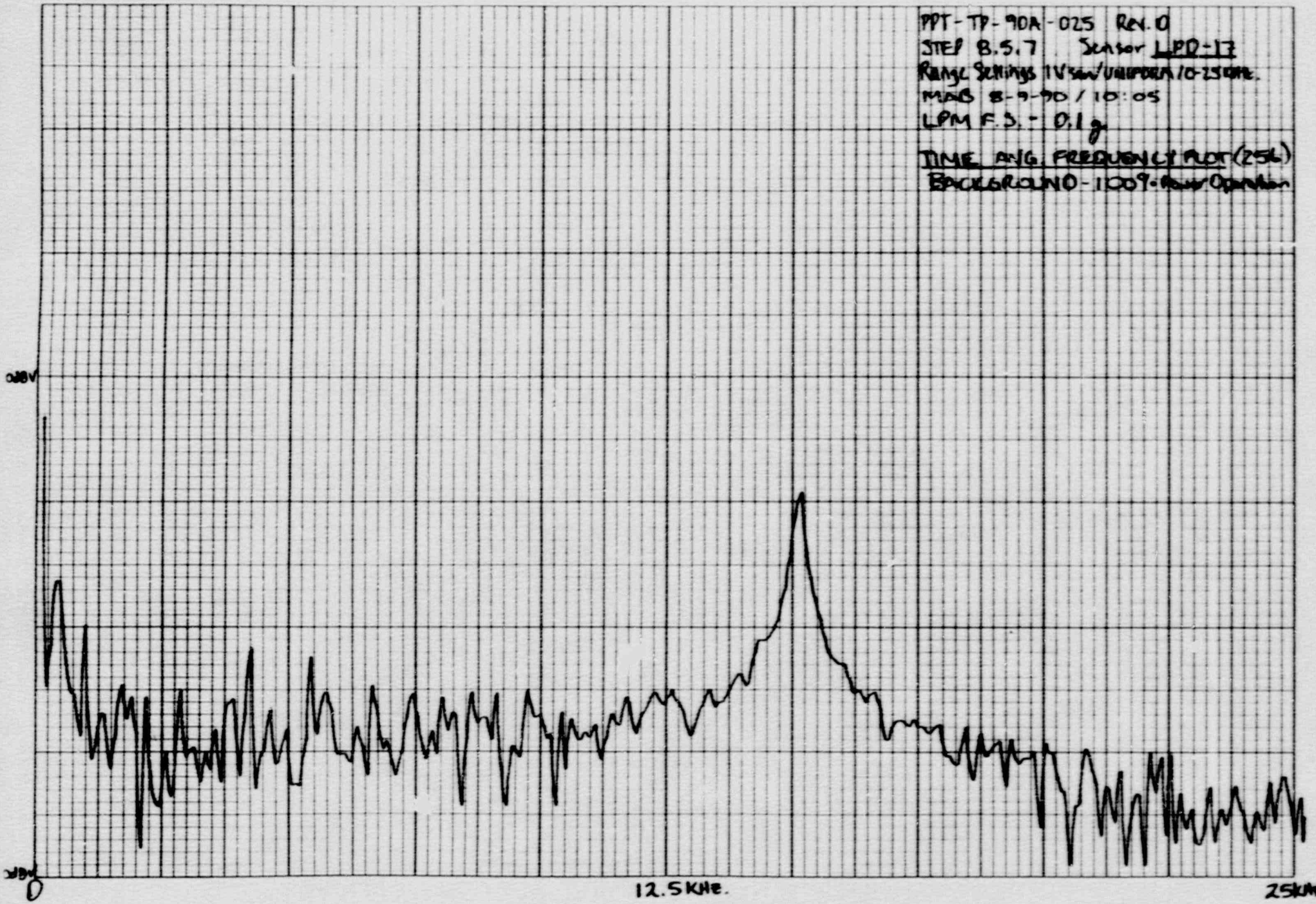
PPT-TP-90A-025 Rev. 0
STEP 8.5.7 - Sensor LPD-1A
Range Settings 0.1V/cm / 0.01g/cm / 0.05 KHz
MAB 8-9-90 / 9:51
LPM F.S. - 3.0 g
TIME AVG. FREQUENCY PLOT (256)
BACKGROUND - 100% Power Operation

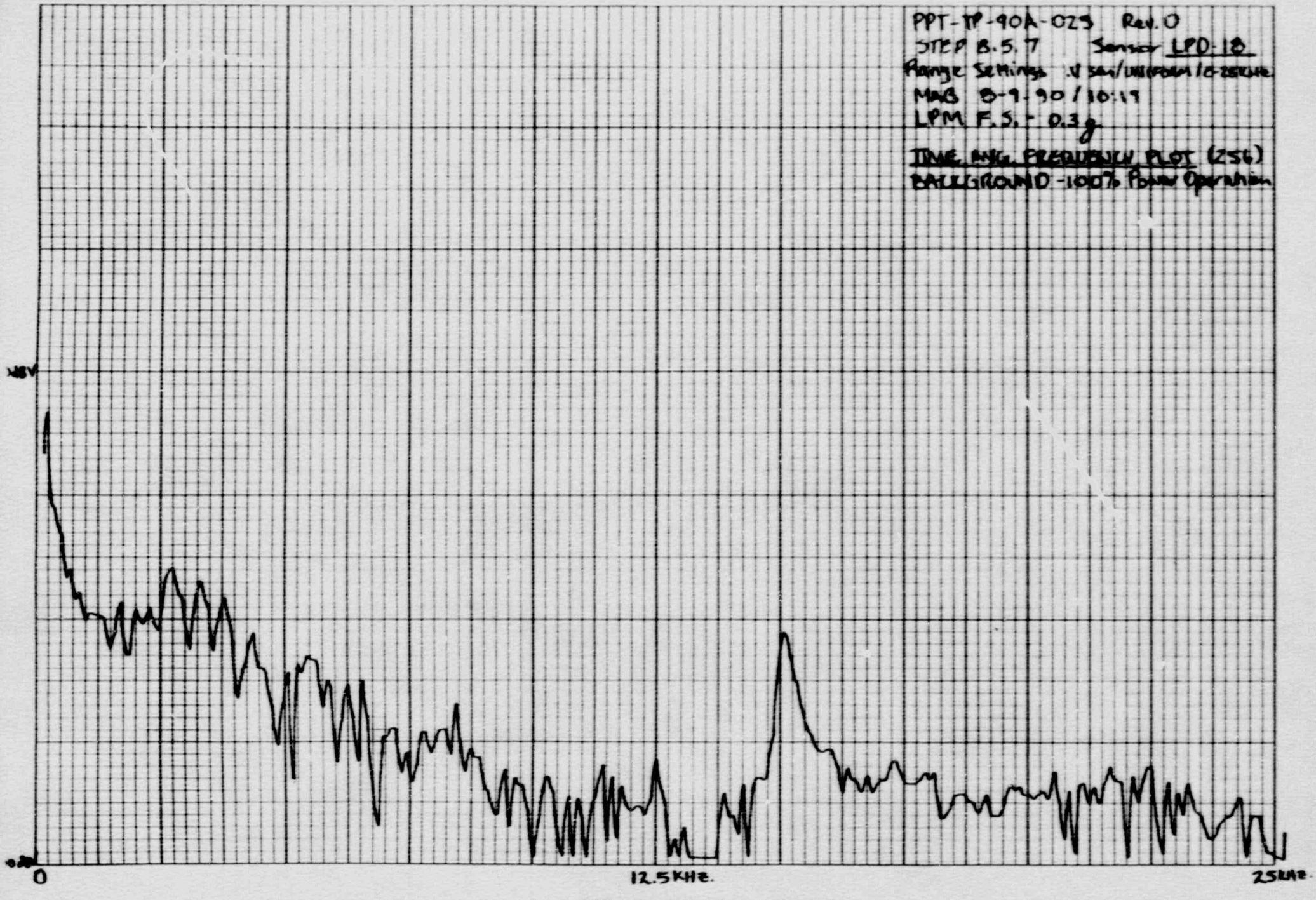


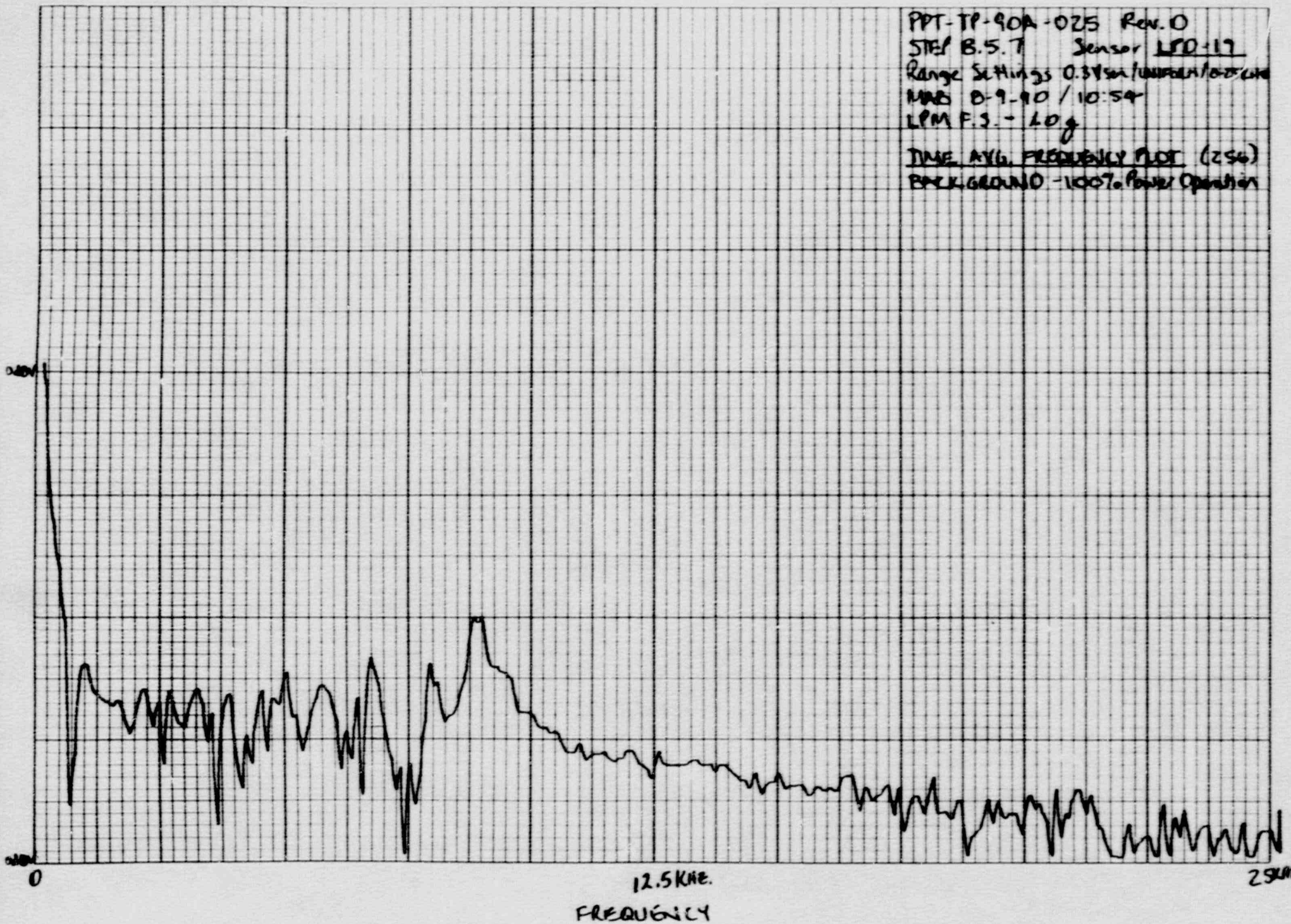

PPT-TP-97A-025 Rev. D
STEP 8.6.3 Sensor LPO-15
Range Settings 30mV sen/division/0-25 KHz
MAB 8-9-97 / 9:54
LPM F.S. = 3.0g
TIME AVG FREQUENCY PLOT (Z-Sec)
BACKGROUND - 100% Power Operation
0
12.5 KHz.
25KHz.
FREQUENCY

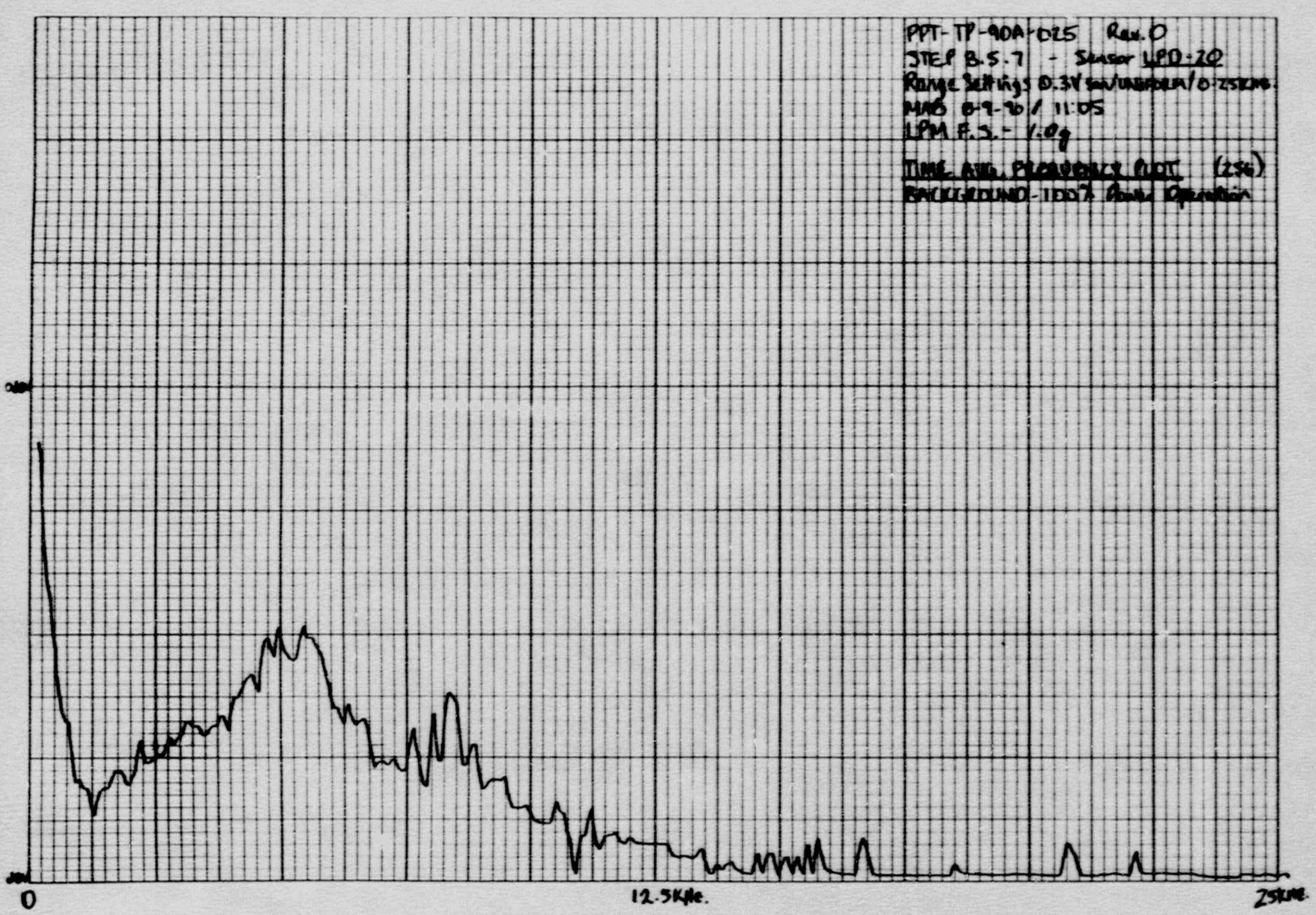


PPT-TP-90A-025 Rev. D
STEP 8.5.7 Sensor LPD-17
Range Settings 1V/cm/UNIPOLAR/0-25KHz.
MADE 8-9-90 / 10:05
LPM F.S. - 0.1g
TIME AVG. FREQUENCY PLOT (256)
BACKGROUND - 1009 - Flow Operation



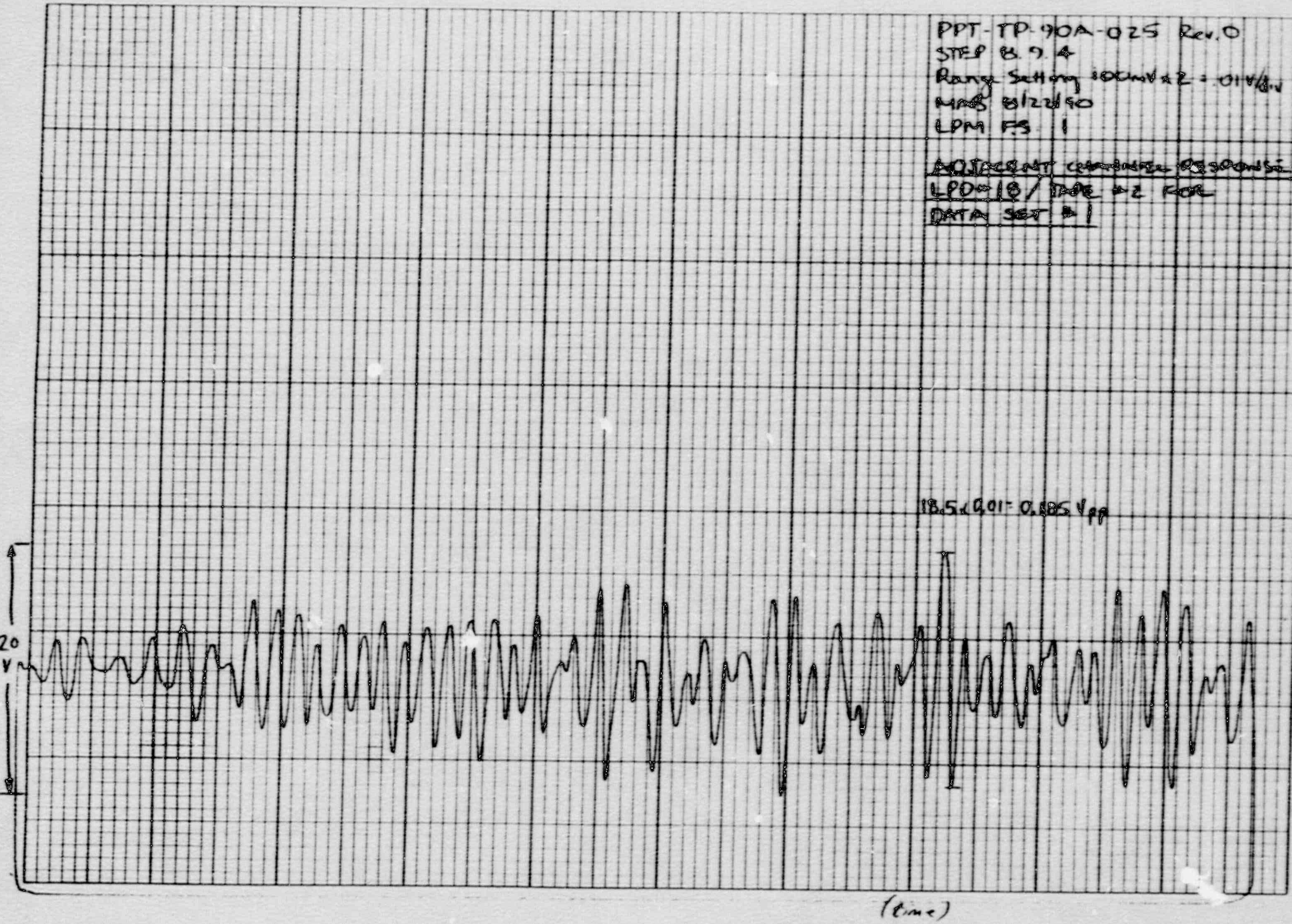


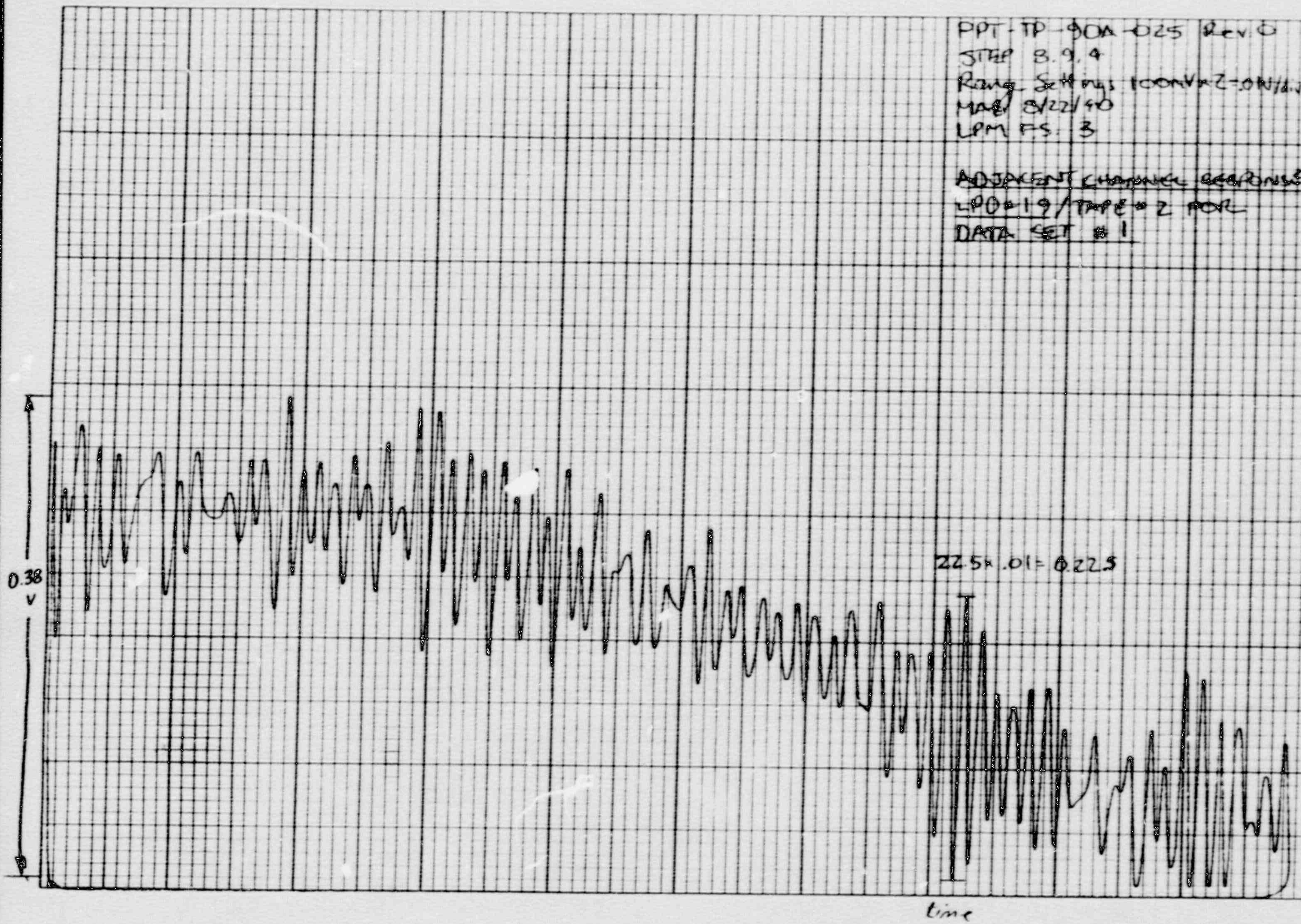


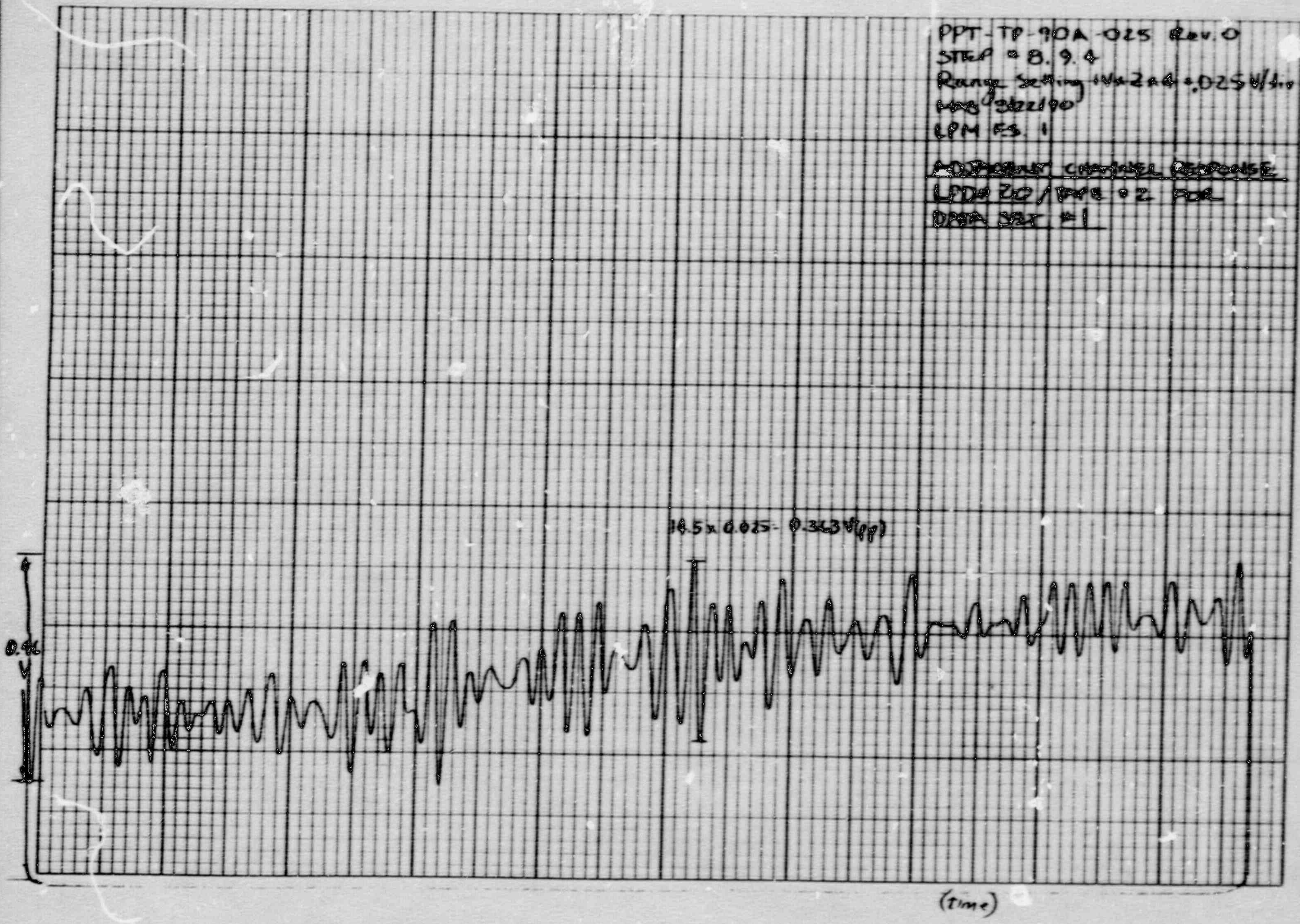


3.5 Adjacent Channel Response

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.

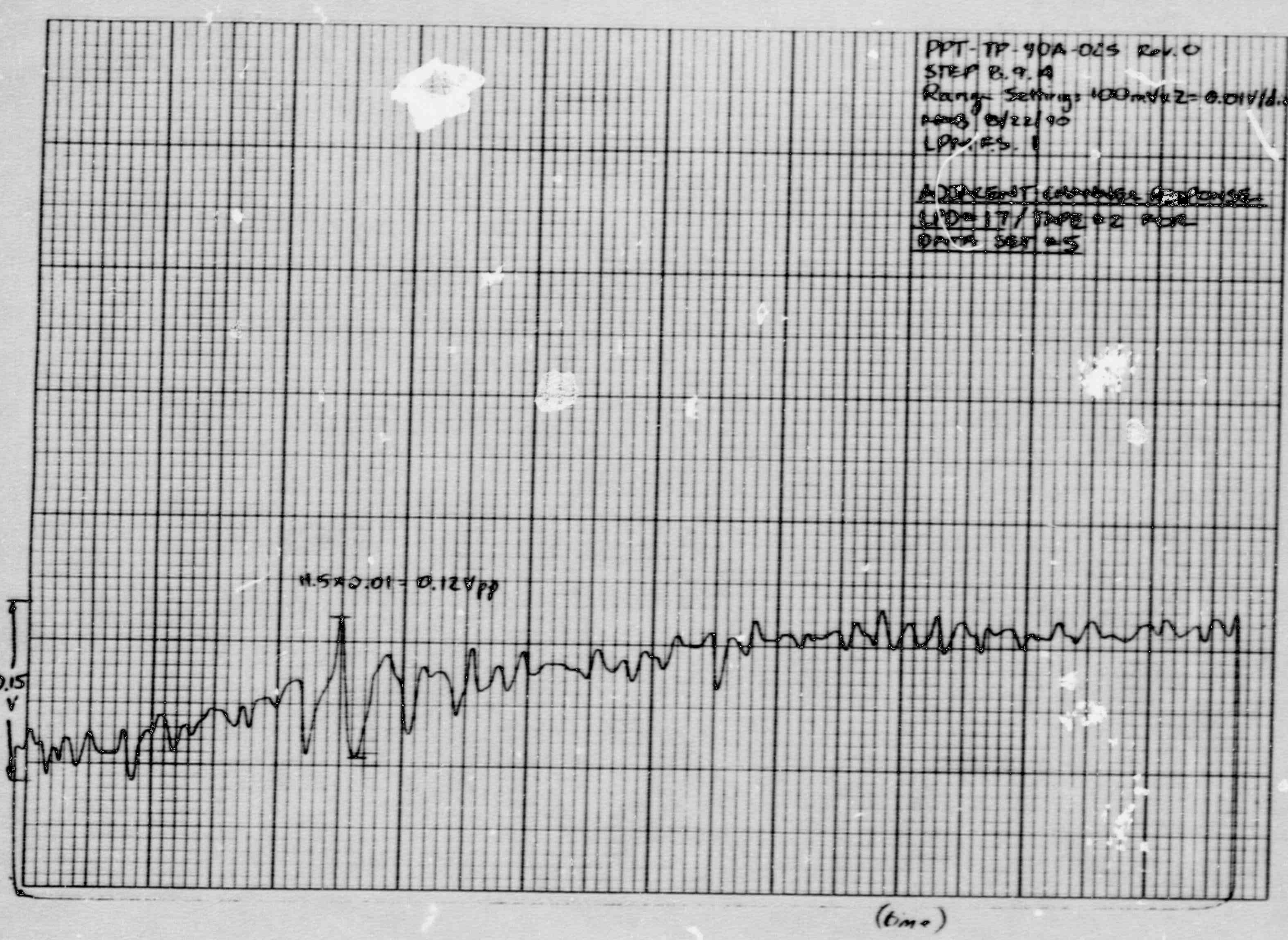




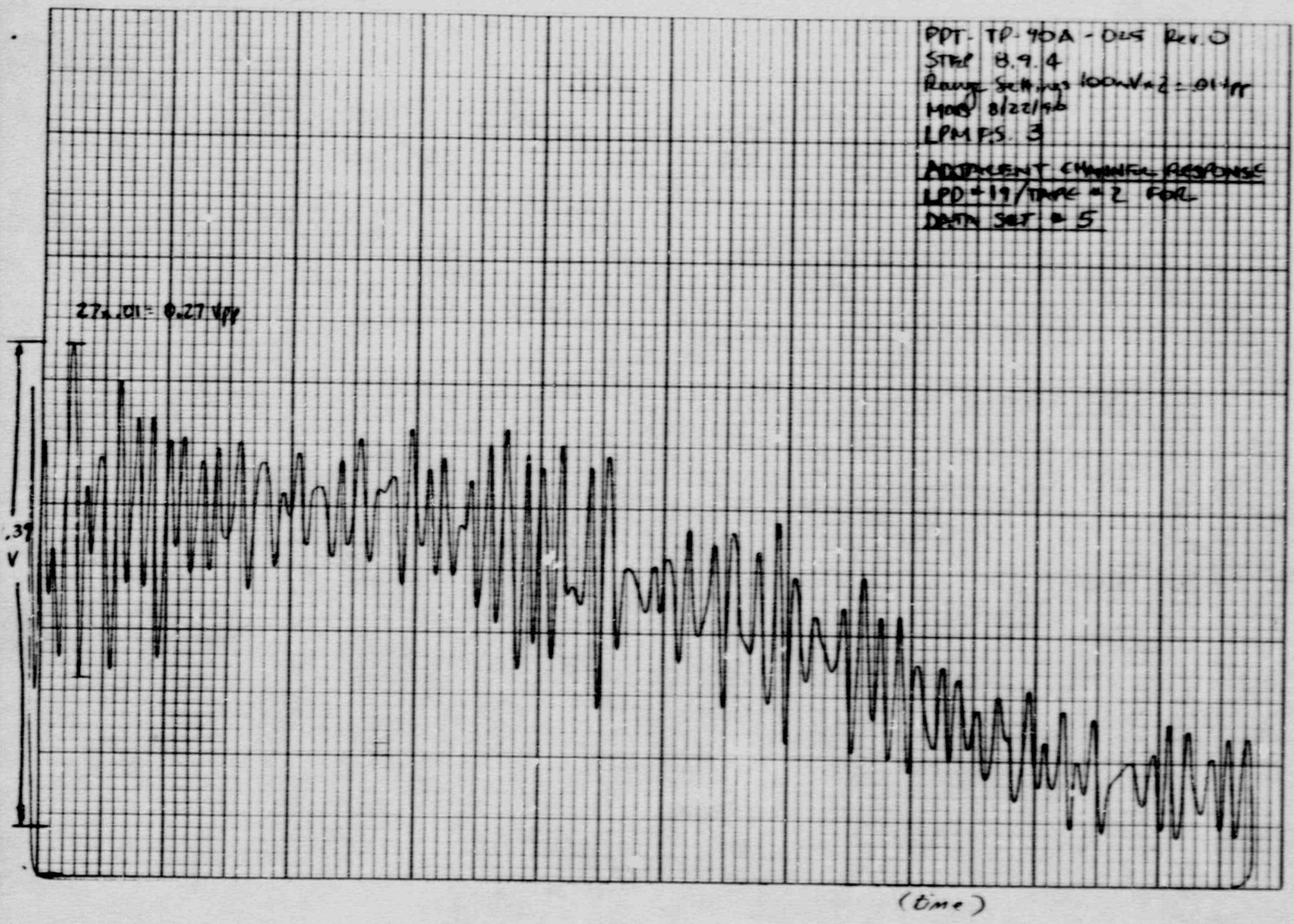


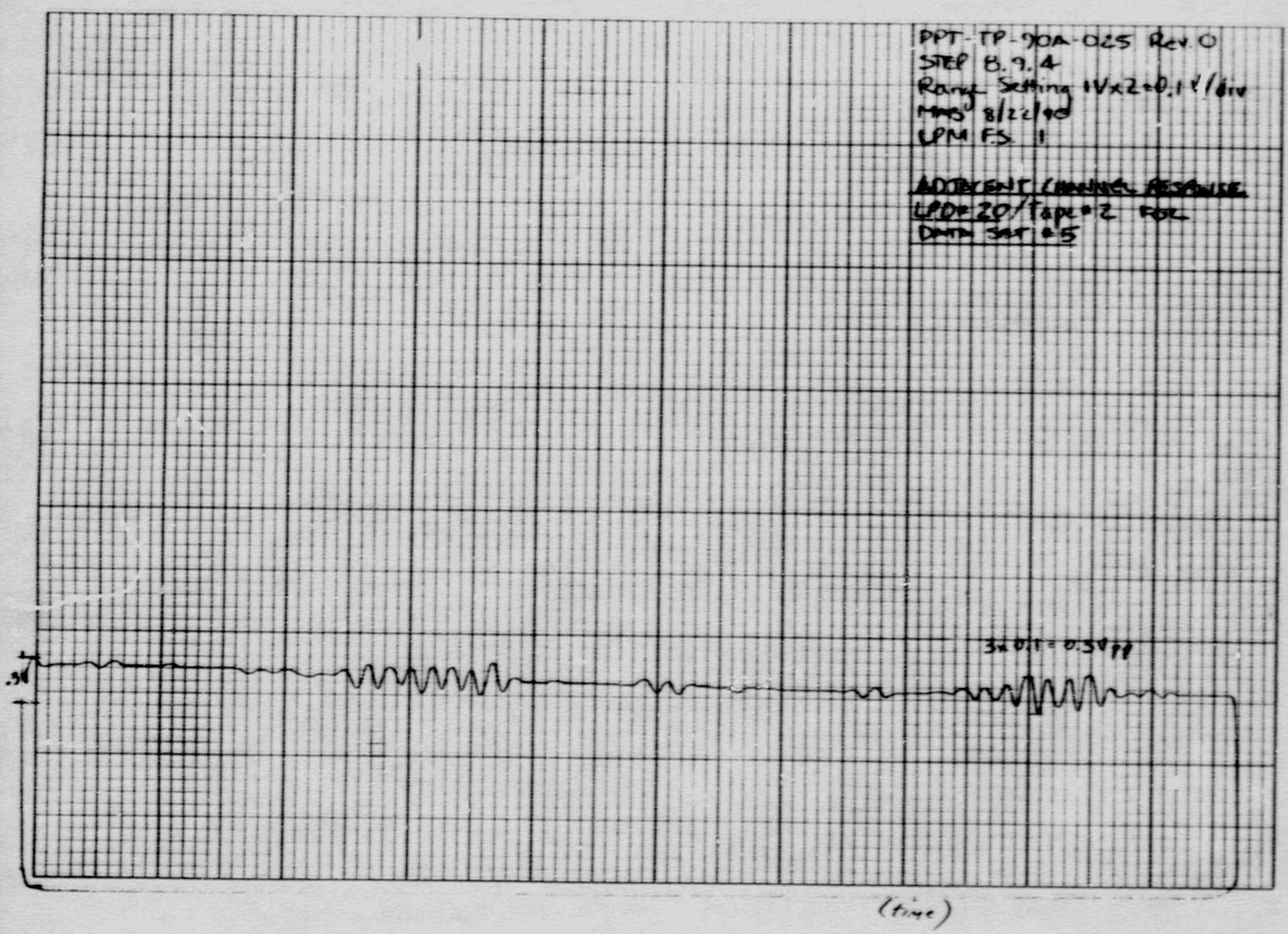
K+E 10 X 10 TO THE INCH X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

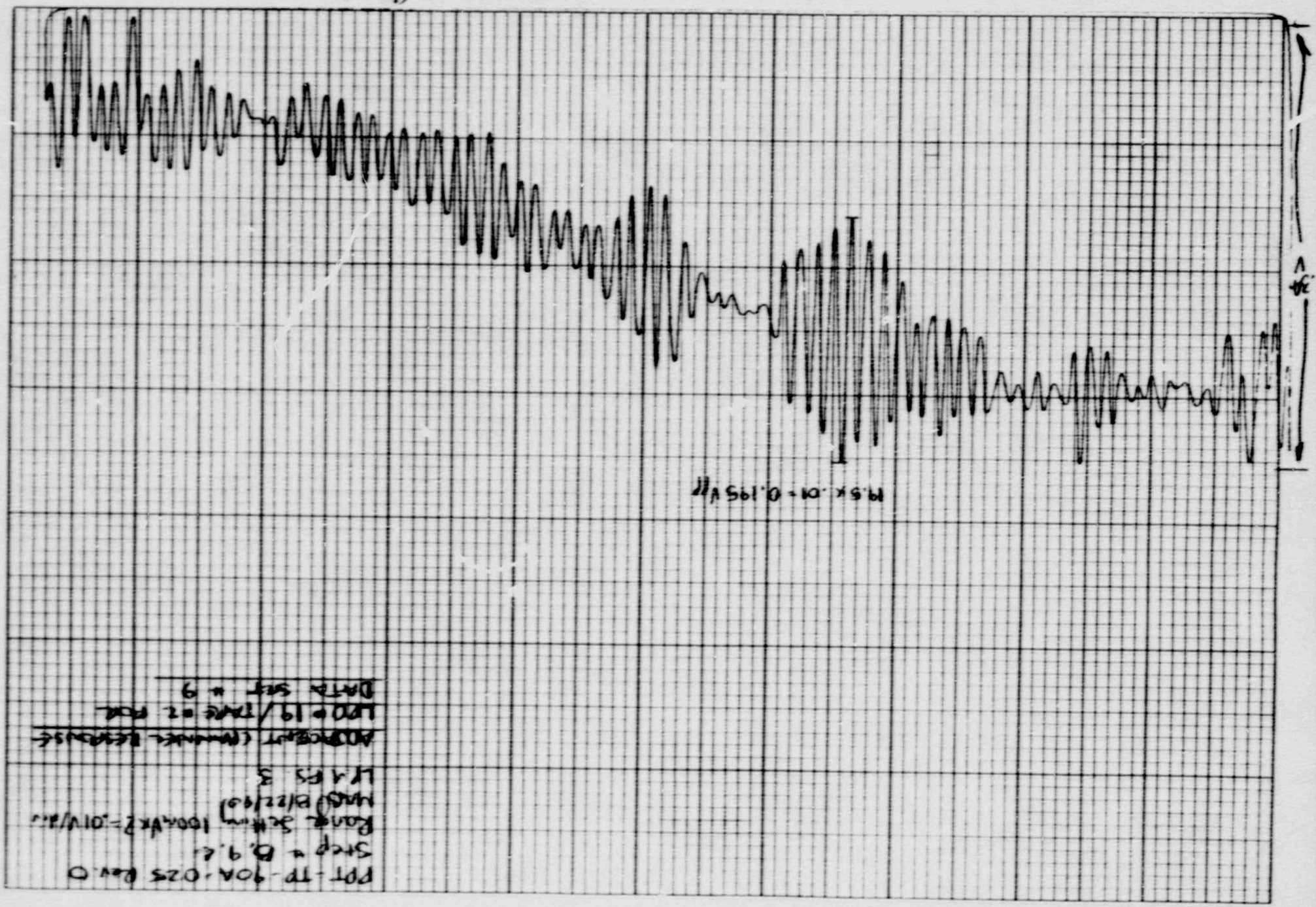
46 0780

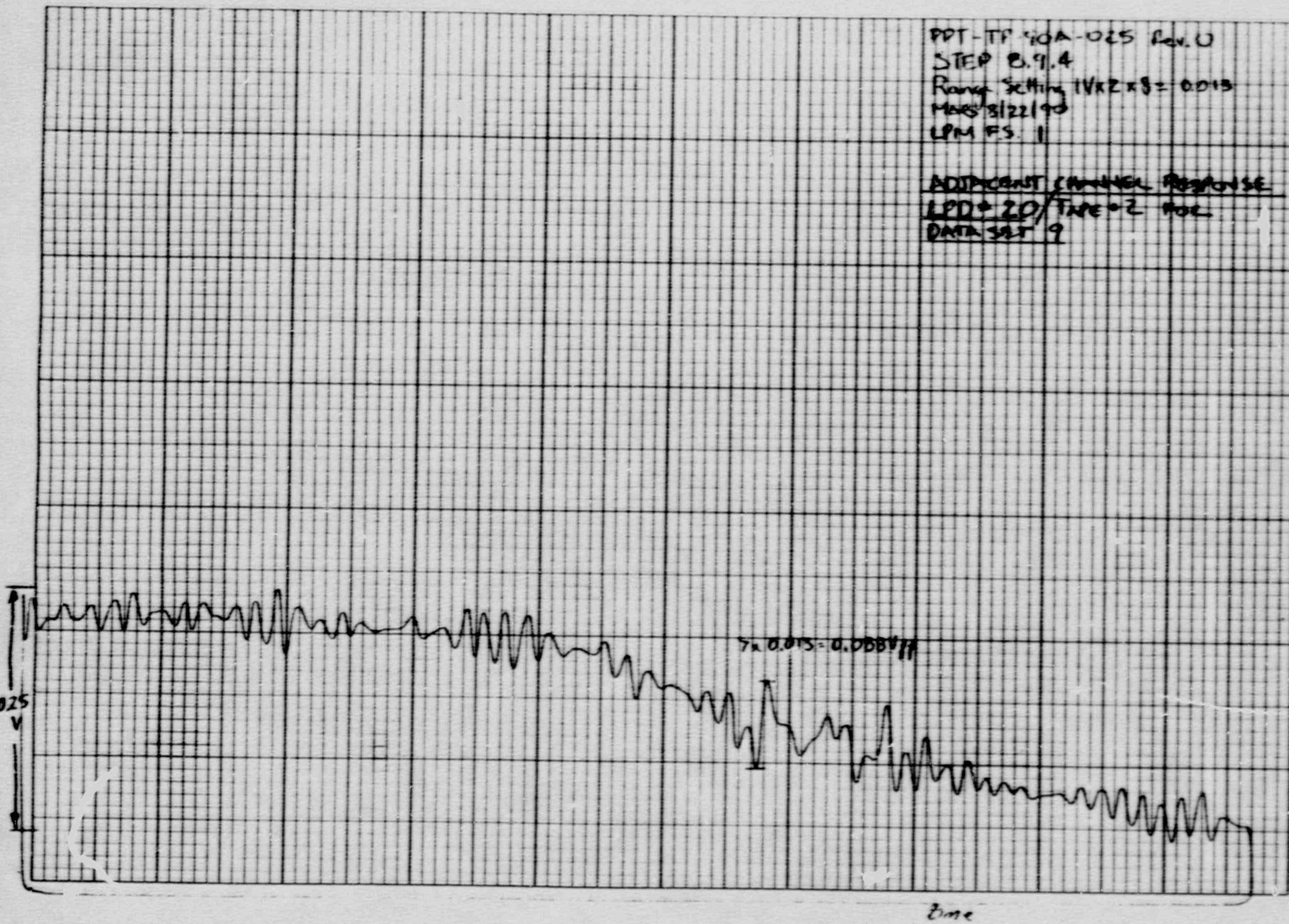

PPT-TP-90A-025 Rev.0
STEP B.9.A
Range Settings: 100mV÷2 = 0.01V/div
8/22/90
LPM ES. 1
ADJACENT CHANNEL RESPONSE
LPD=17 / TAPE #2 RDR
DATA SET #5
4.5×0.01 = 0.12Vpp
0.15 V
(time)

46 0780



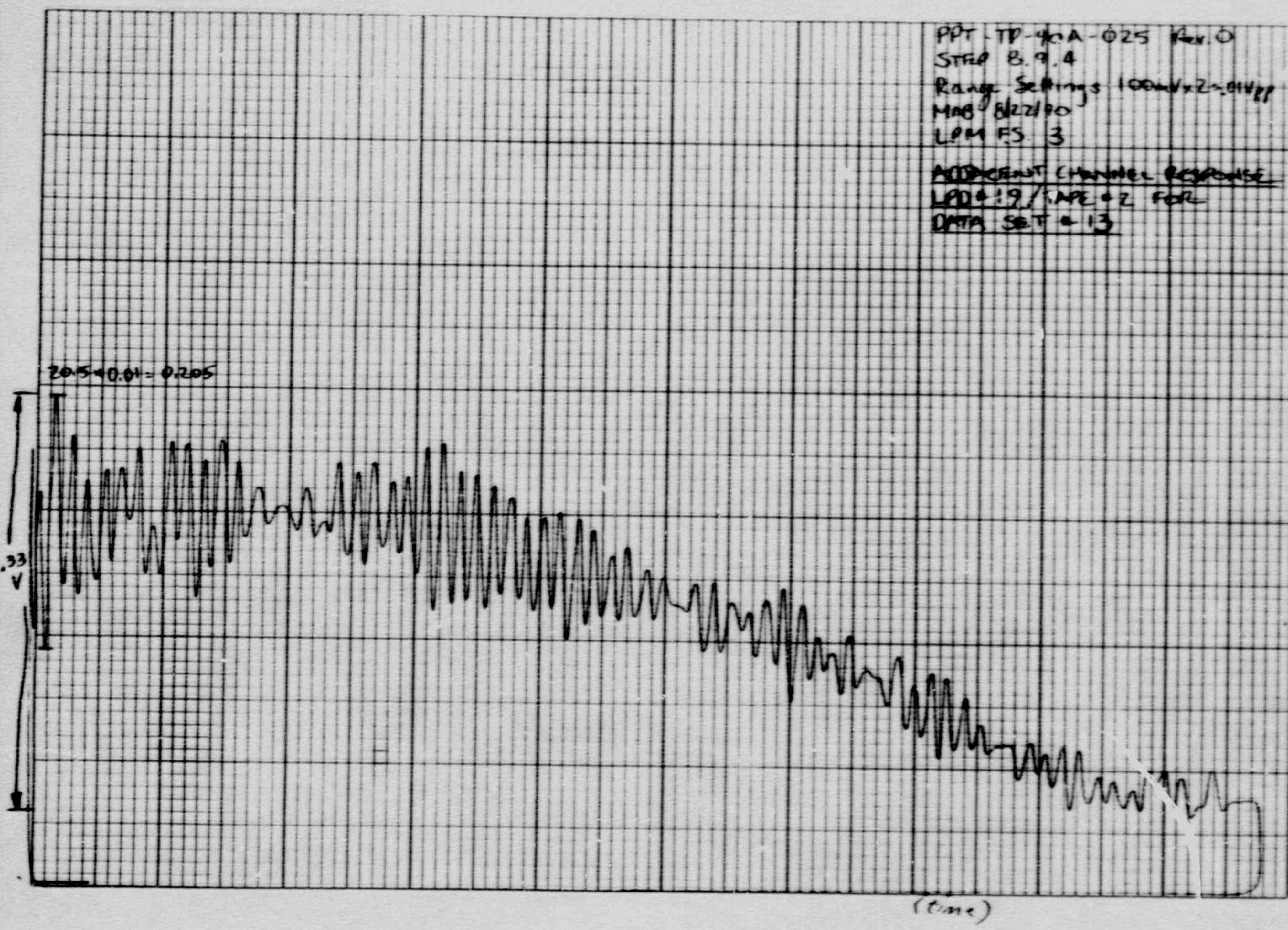

PPT-TP-90A-025 Rev 0
STEP 8.9.4
Range Setting 1V x 2 = 0.1 V/div
MMS 8/22/90
LPM F.S. 1
ADJACENT CHANNEL RESPONSE
LPD = 20/Tape = 2 FOR
DATA SET = 5
3 x 0.1 = 0.3 V pp
.3V
(time)


(time)
19.5 x .01 = 0.195 V/P



PPT-TP-90A-025 Rev.0
STEP 8.9.4
Range Setting: 100mV x 2 = 0.01 V/div
Mag Blazing
LPM FS 0.3

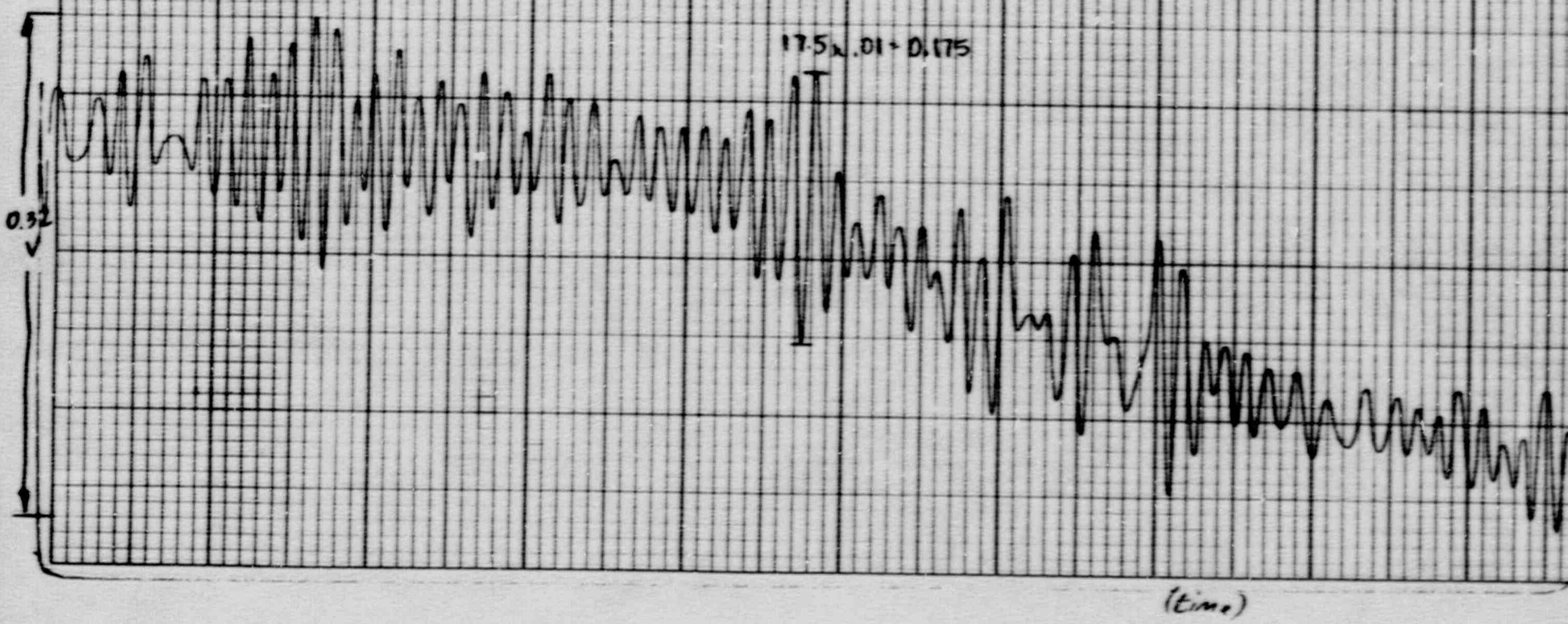
ADJACENT SENSOR RESPONSE
L90-18 / TAPE 2 FOR
DATA SET = 13

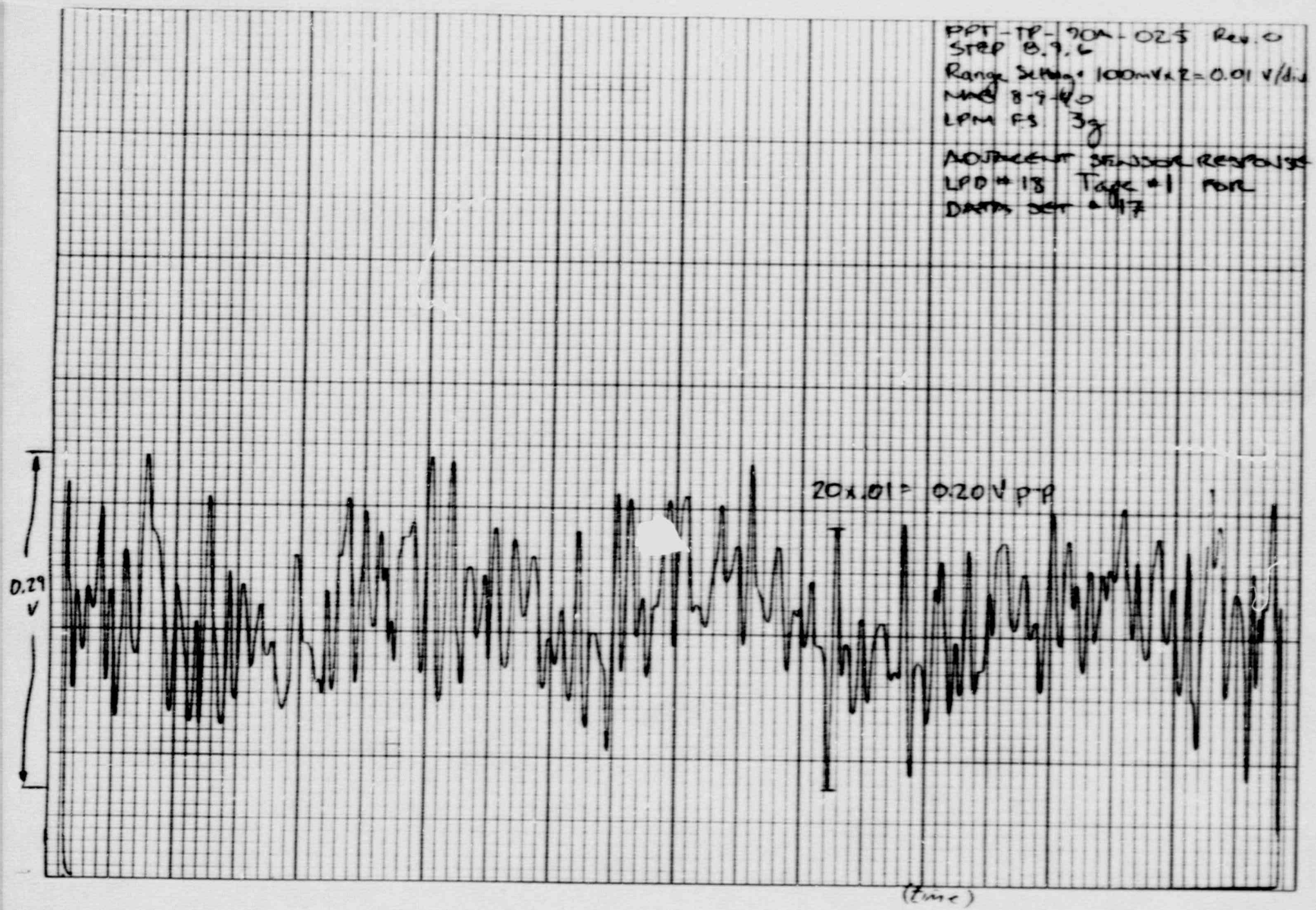


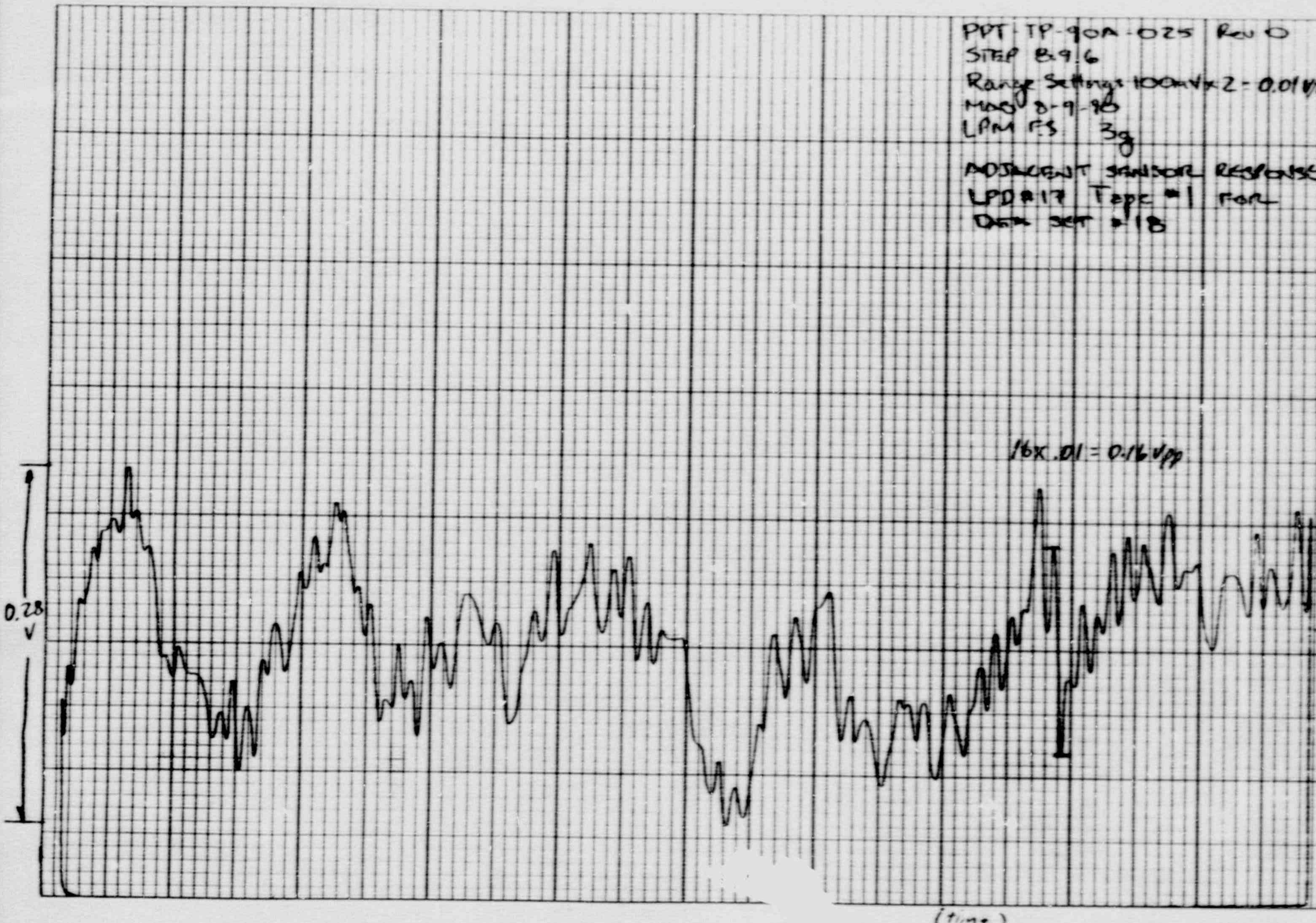
46 0780

PPT-TP-90A-025 Rev.0
STEP 8.9.4
Range Setting 100 mV x 2 = .01V/div
MAB 8/22/90
LPM F.S. 1

ADJACENT CHANNEL RESPONSE
LPD = 20 / Tape #2 FOR
DATA SET #13

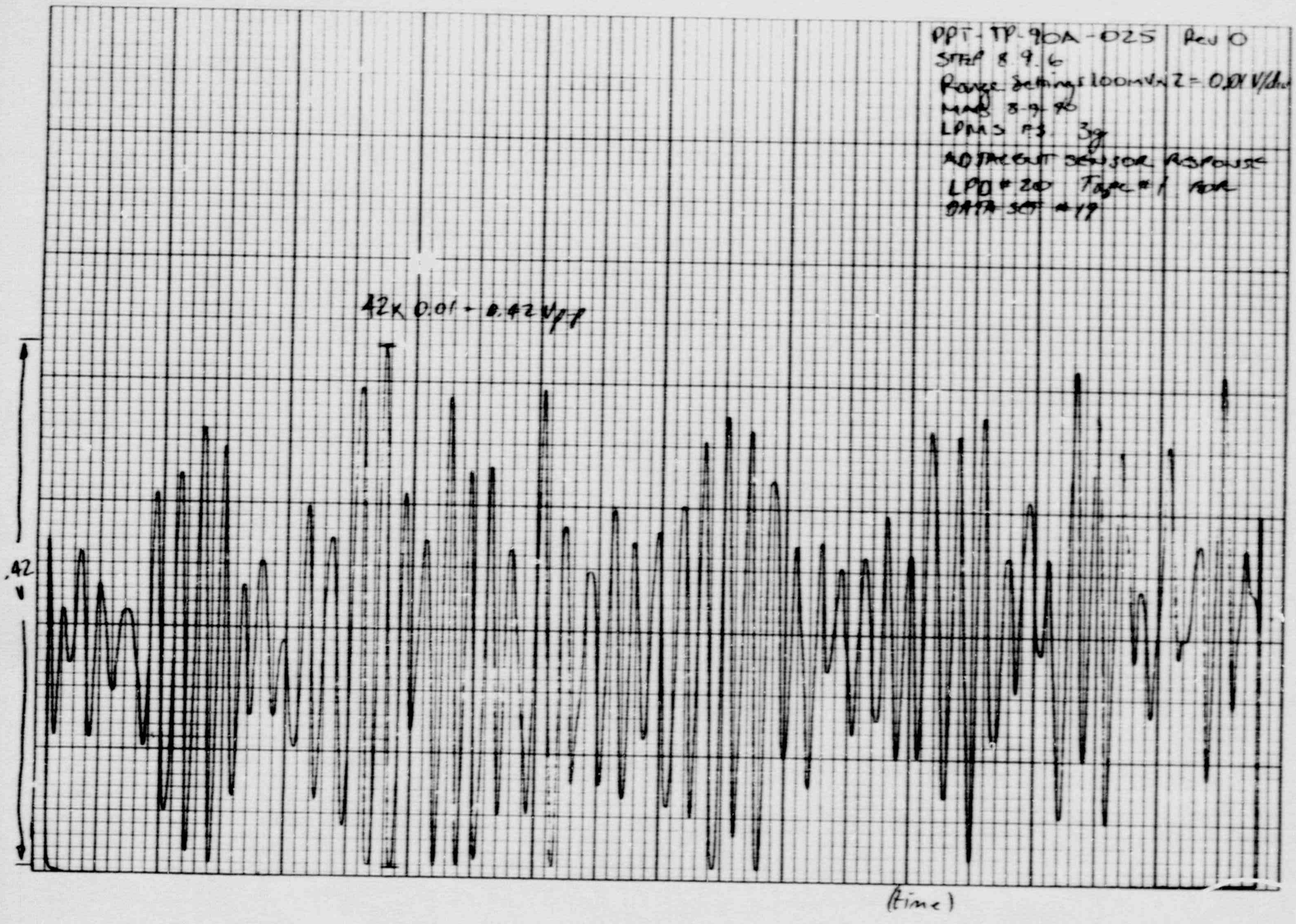






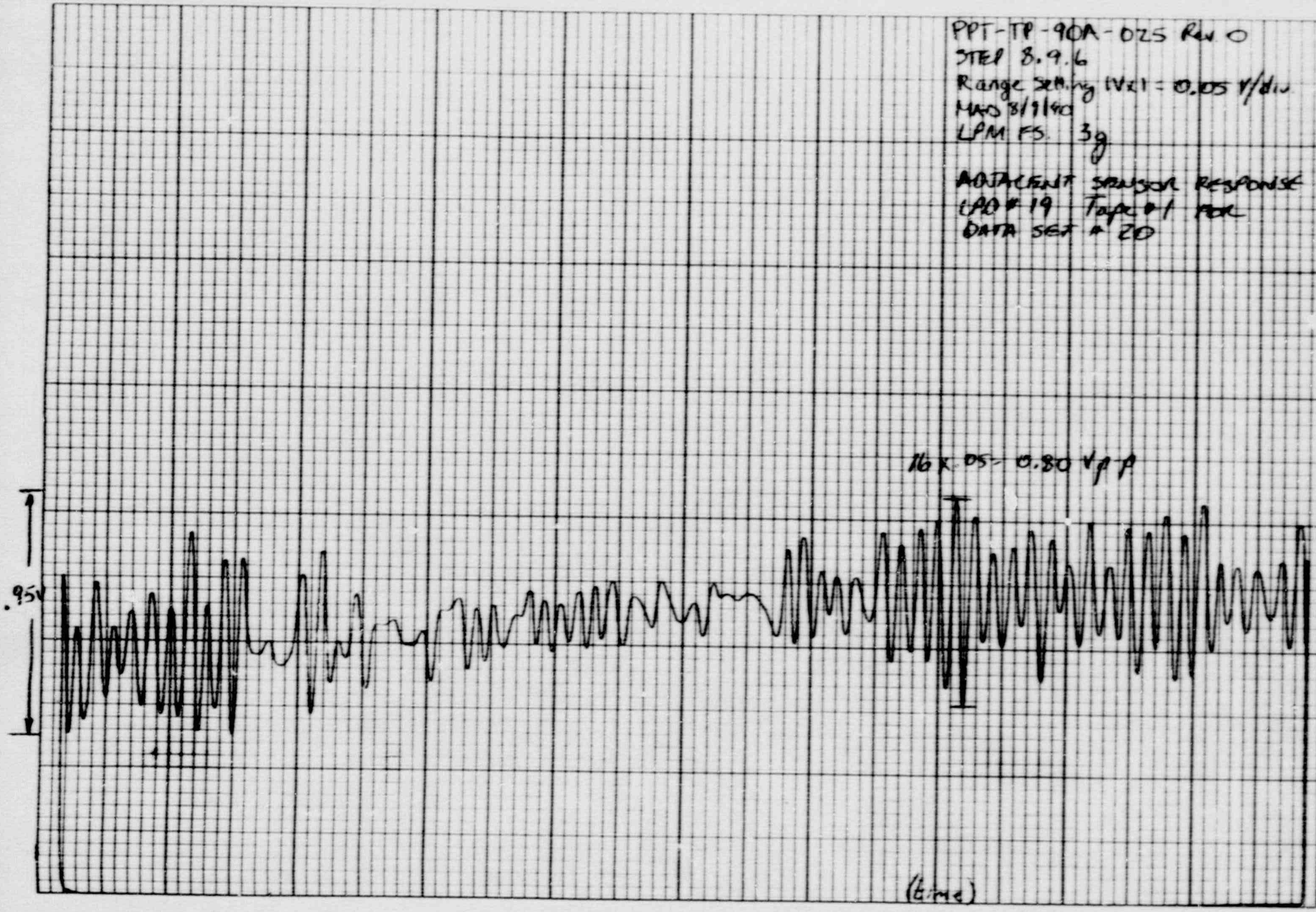
46 0780

K+E 10 X 10 TO THE INCH 7 X 10 INCHES KEUFFEL & ESSER CO.



46 0780

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



46 0780

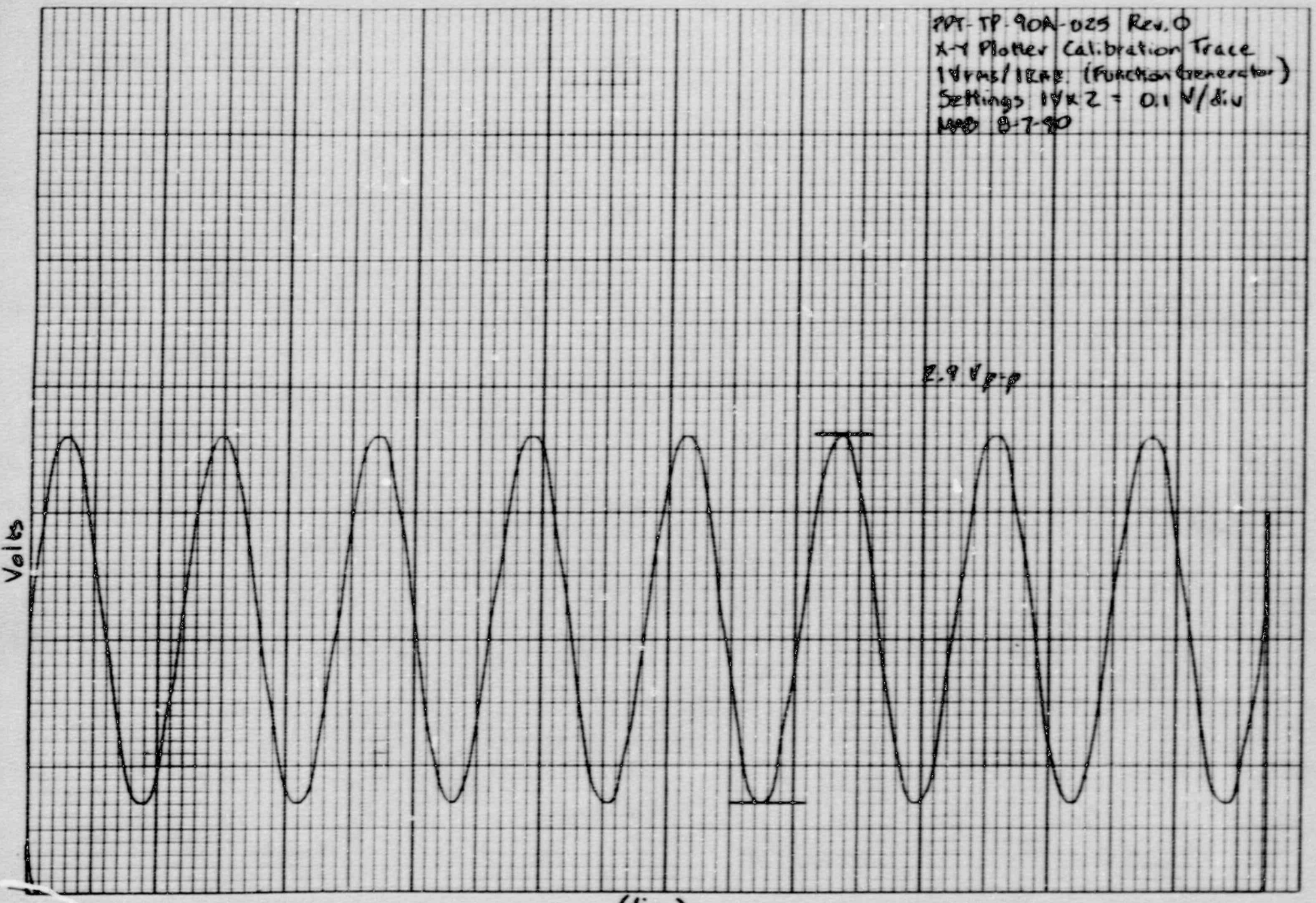
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

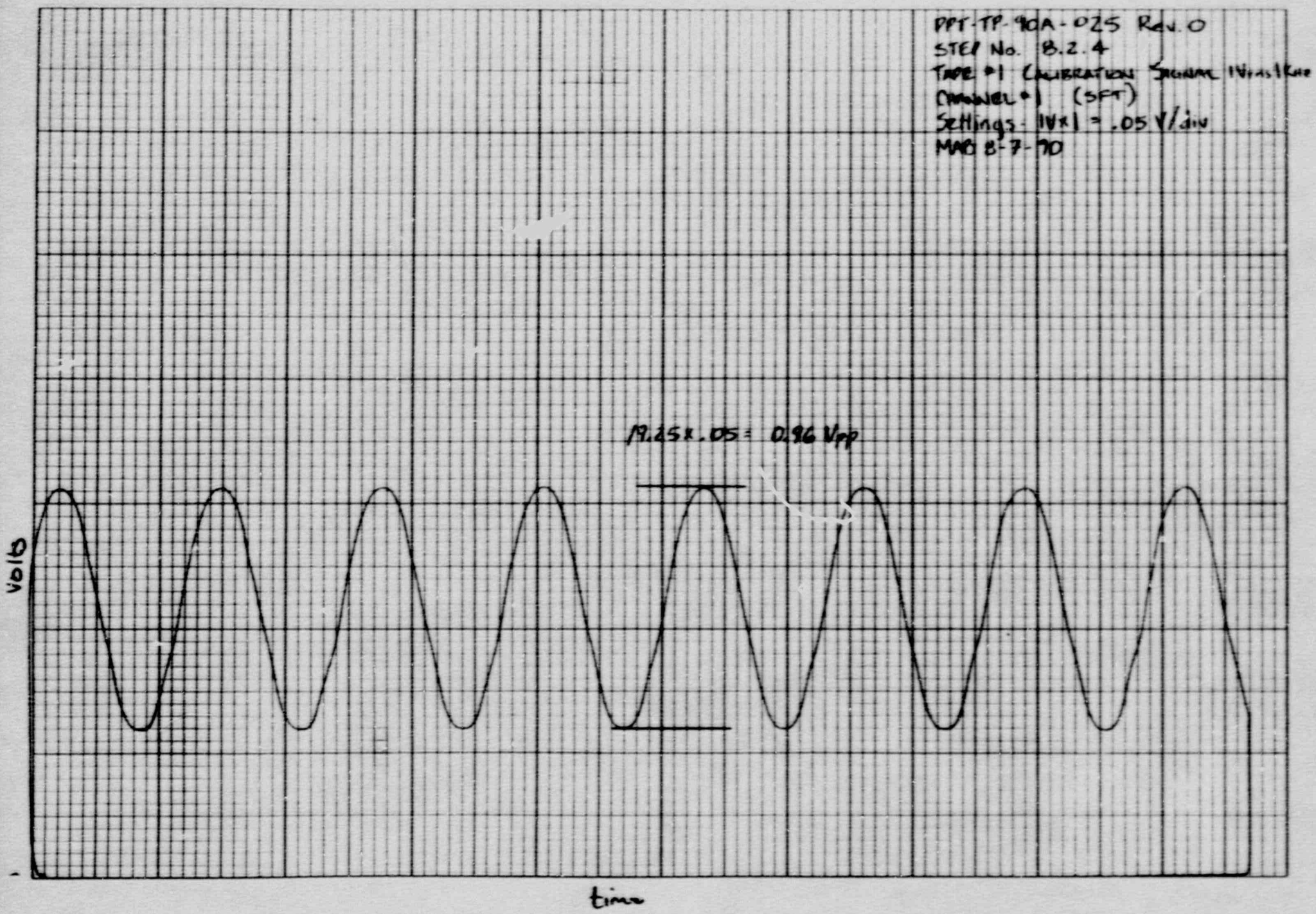
3.6 Calibration Traces

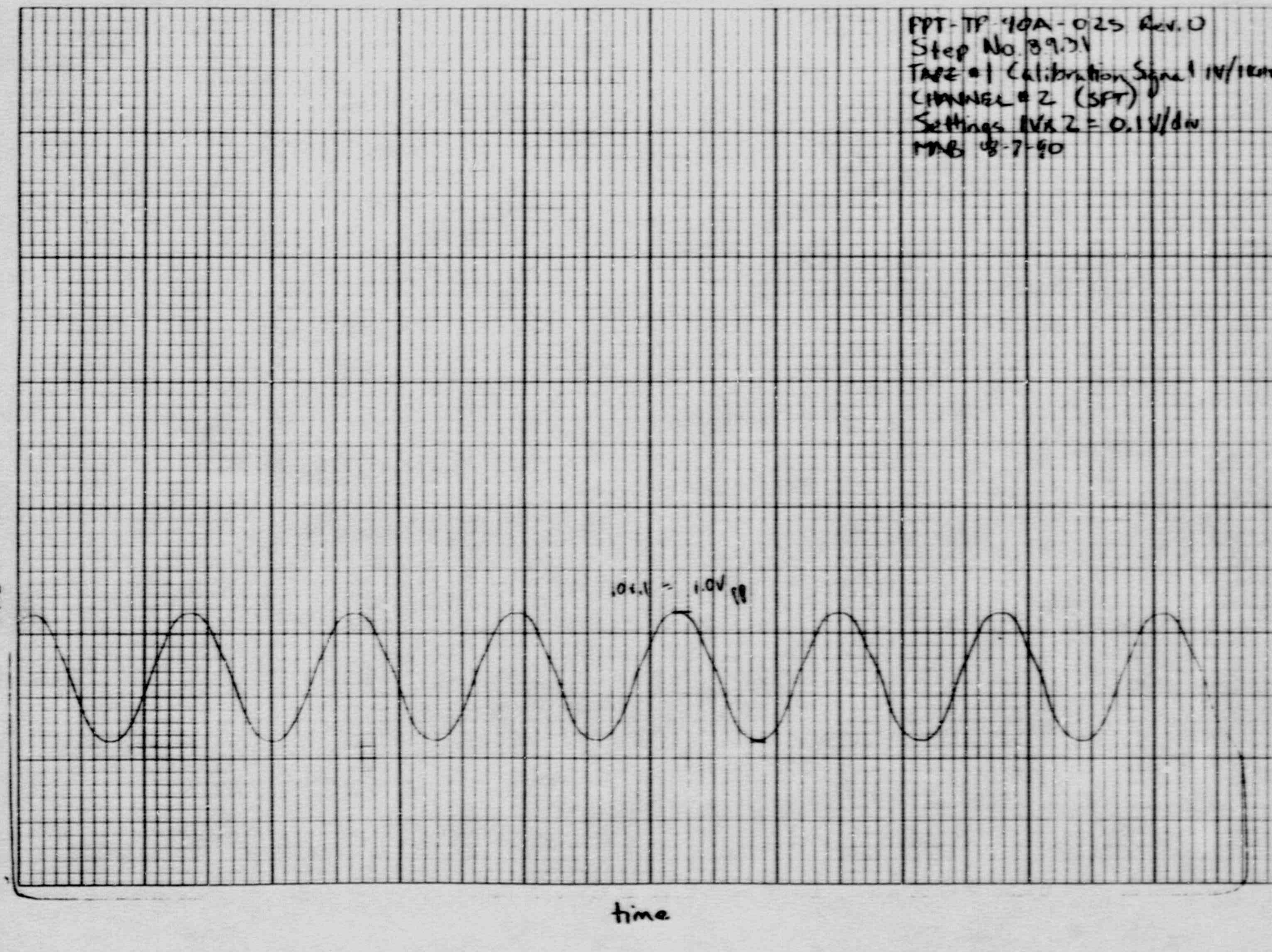
The following X-Y plots show X-Y plotter response to a 1 KHz/1 volt signal being injected from a signal generator and each respective tape channel response when playing back a recorded 1KHz/1 volt signal. The difference between the two were used to determine a correction factor.

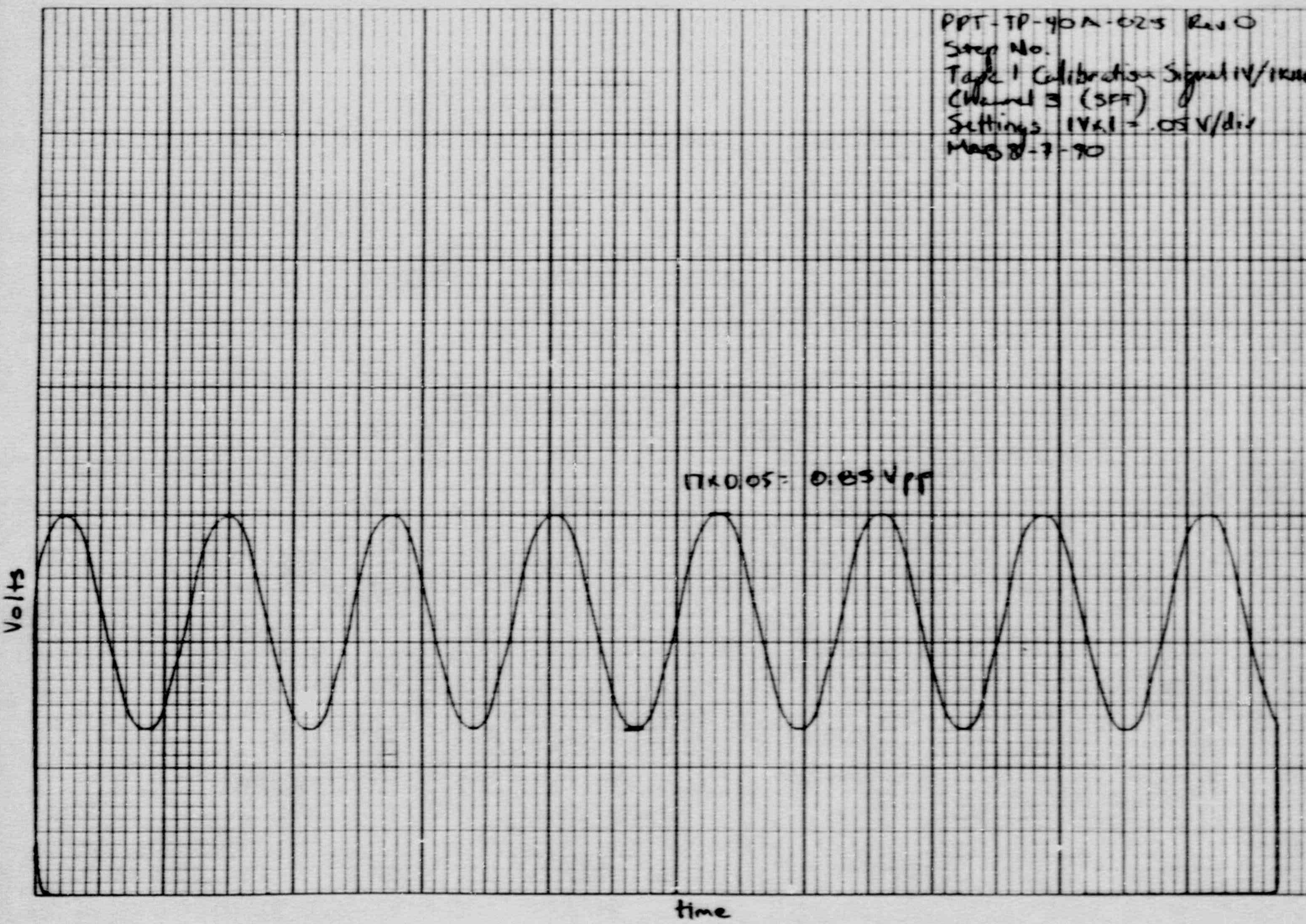
PPT-TP-90A-025 Rev. 0
X-Y Plotter Calibration Trace
1 Vrms/1 KHz (Function Generator)
Settings 1V x 2 = 0.1 V/div
MWB 8-7-90

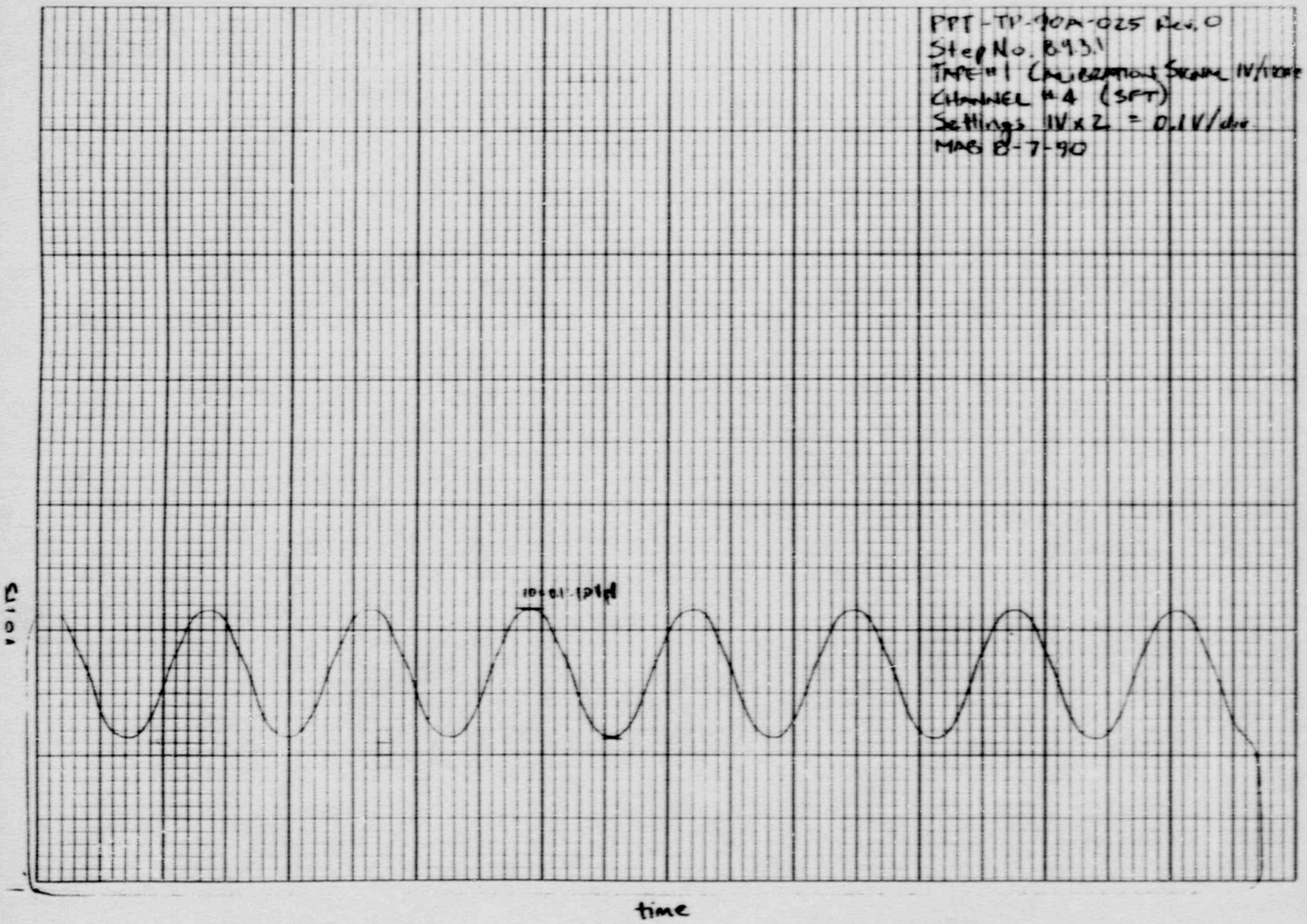
2.9 V p-p

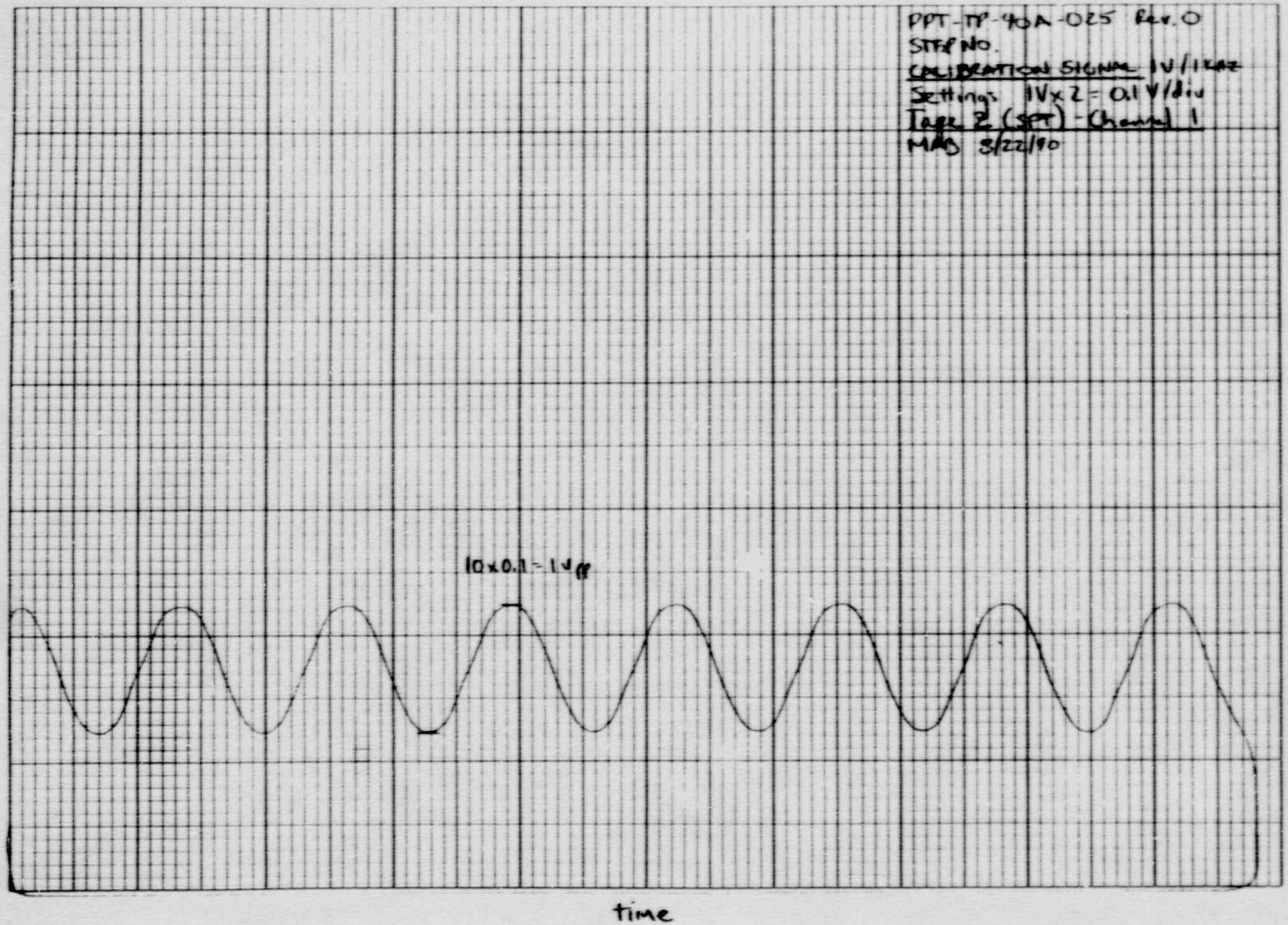


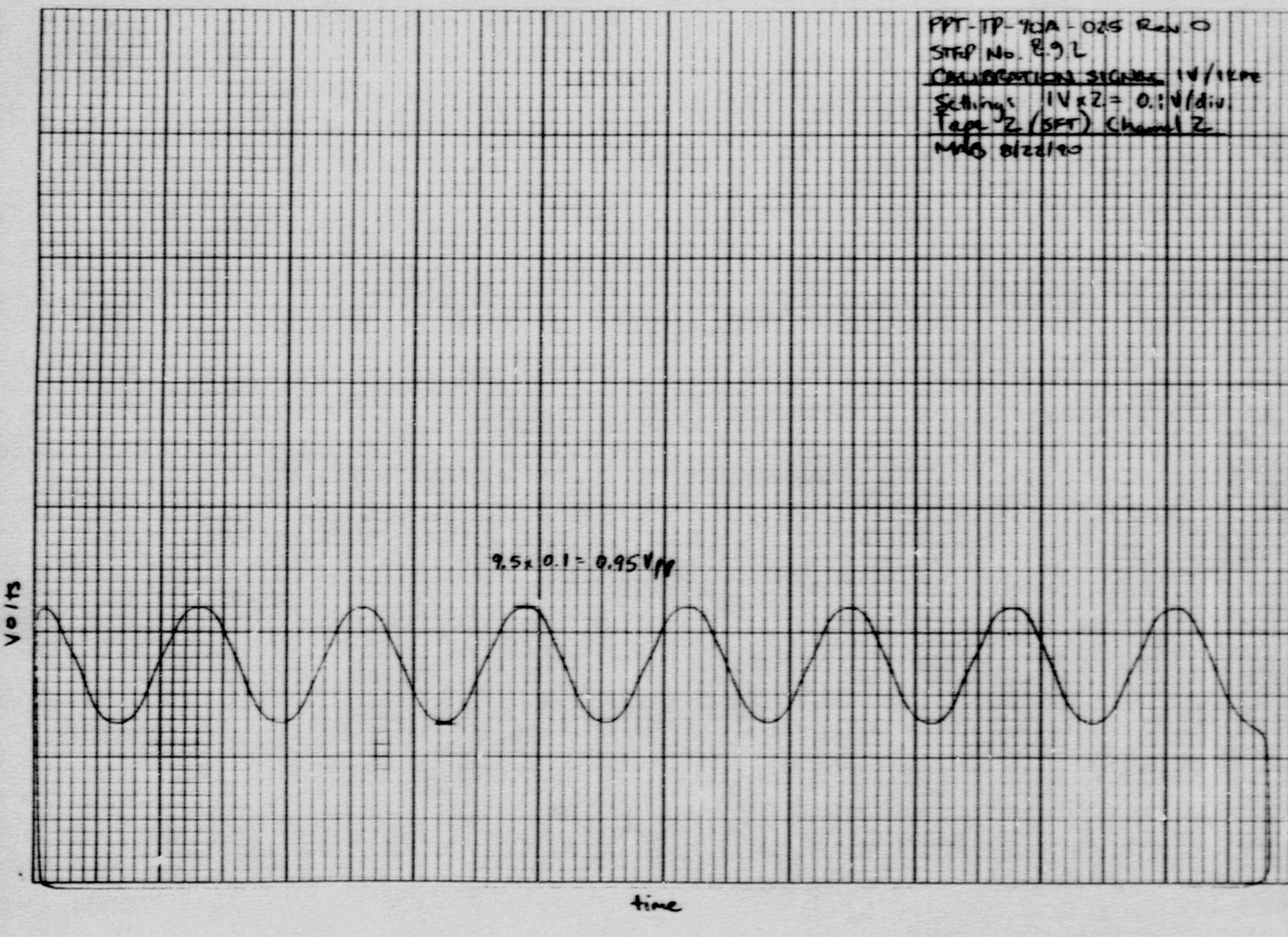

PPT-TP-90A-025 Rev. 0
STEP No. 8.2.4
TAPE #1 CALIBRATION SIGNAL 1V+1KHz
CHANNEL #1 (SFT)
Settings: 1V×1 = .05 V/div
MAG 8-7-90
19.25×.05 = 0.96 Vpp
Volts
time

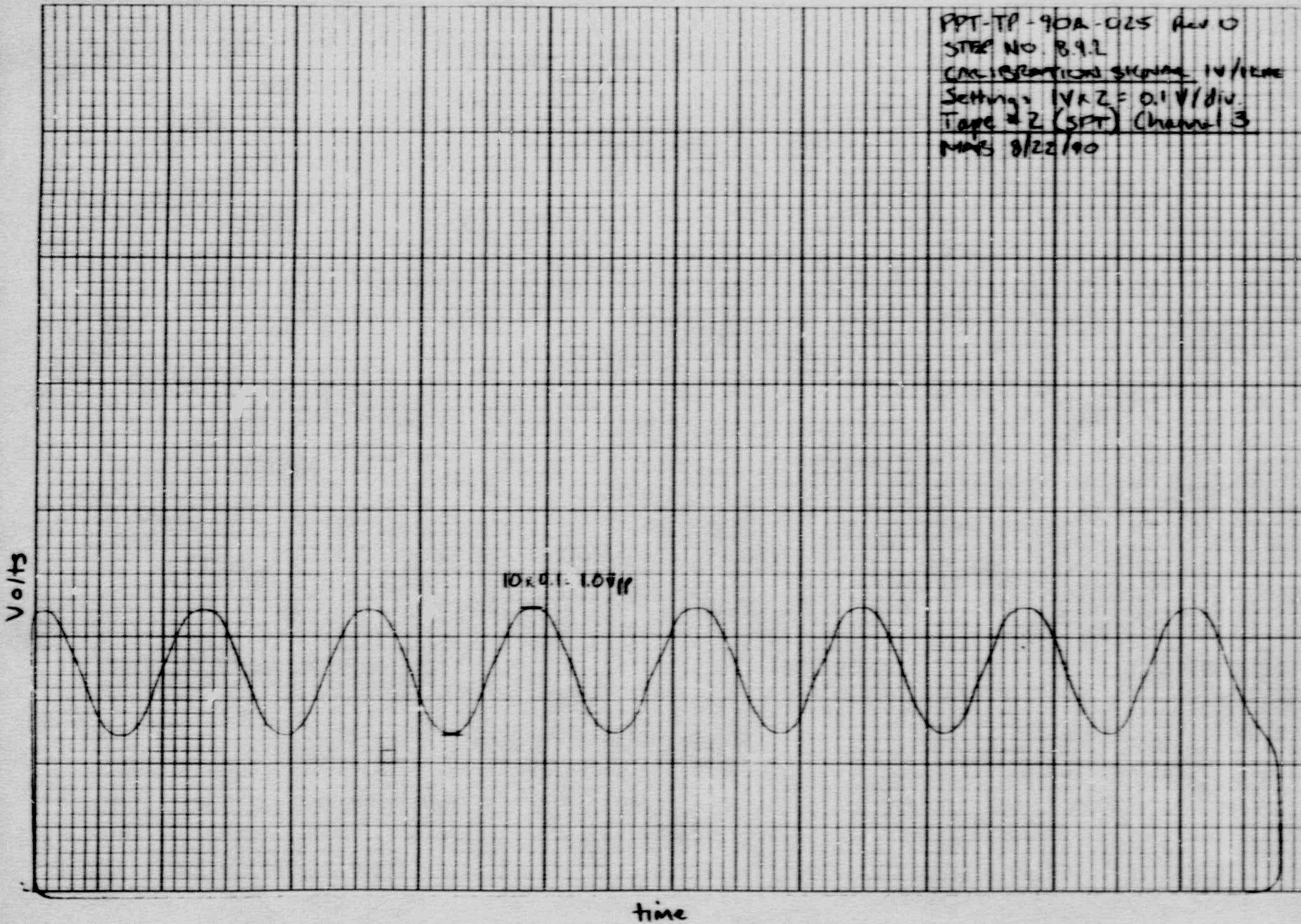

FPT-TP-40A-025 Rev.0
Step No. 89.3.1
TAPE #1 Calibration Signal 1V/1kHz
CHANNEL #2 (SFT)
Settings IVx2 = 0.1V/div
MAB 8-7-90
time

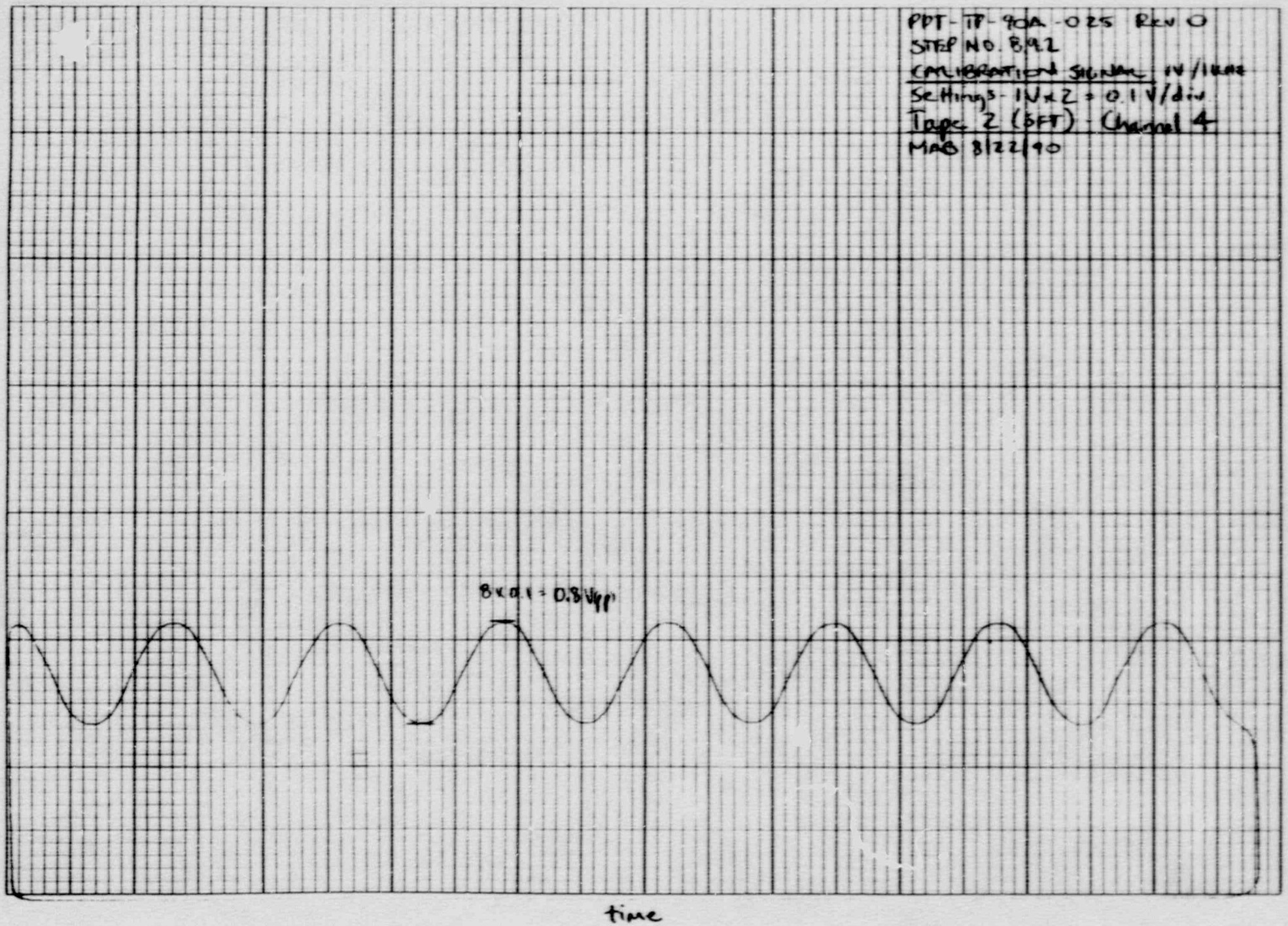


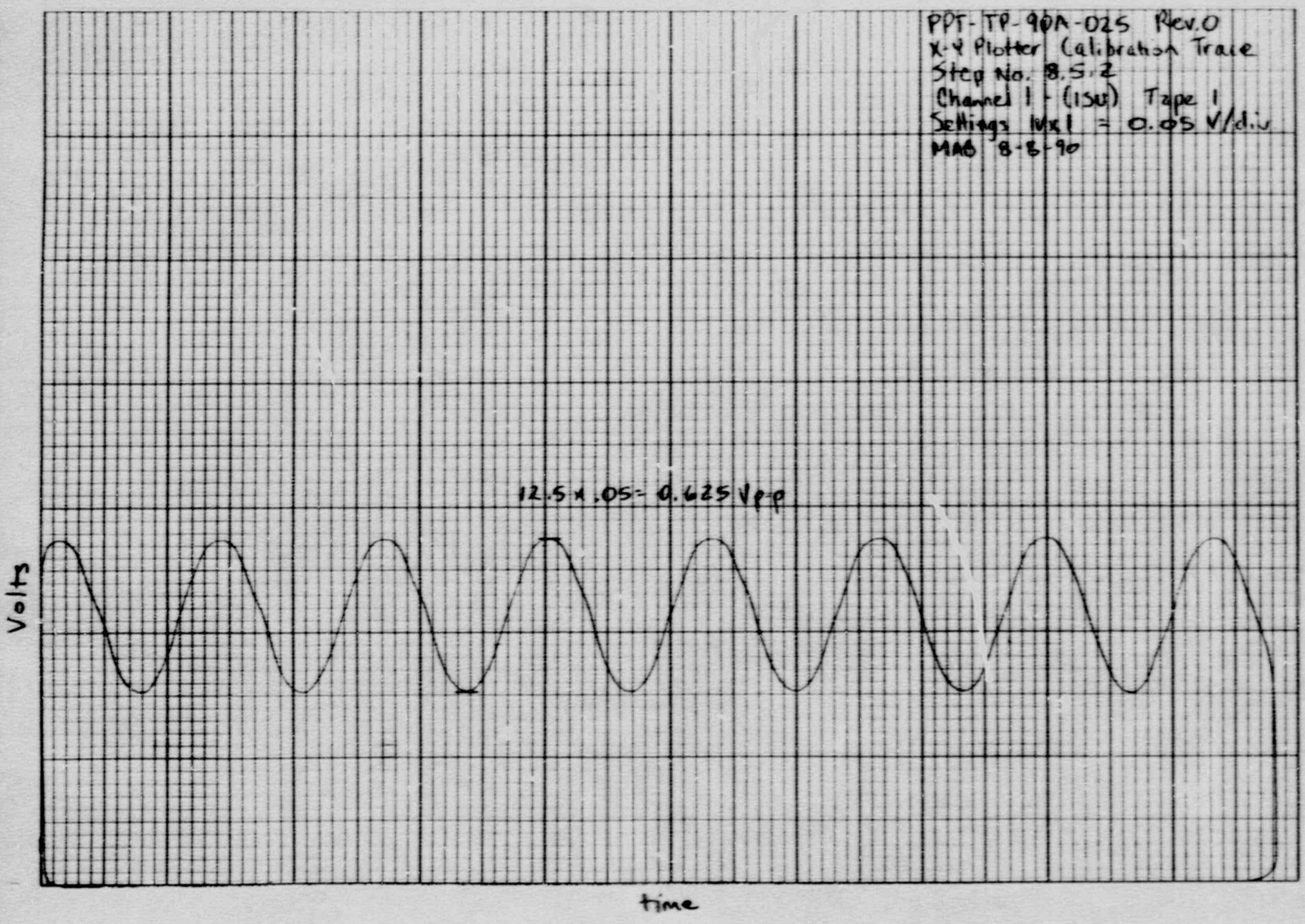

PPT-TV-90A-025 Rev. 0
Step No. 8.9.1
TAPE #1 CALIBRATION SIGNAL 1V/10KHz
CHANNEL #4 (SFT)
Settings 1V x 2 = 0.1V/div
MAG 8-7-90
10 x 0.1 = 1V
0.1V
time

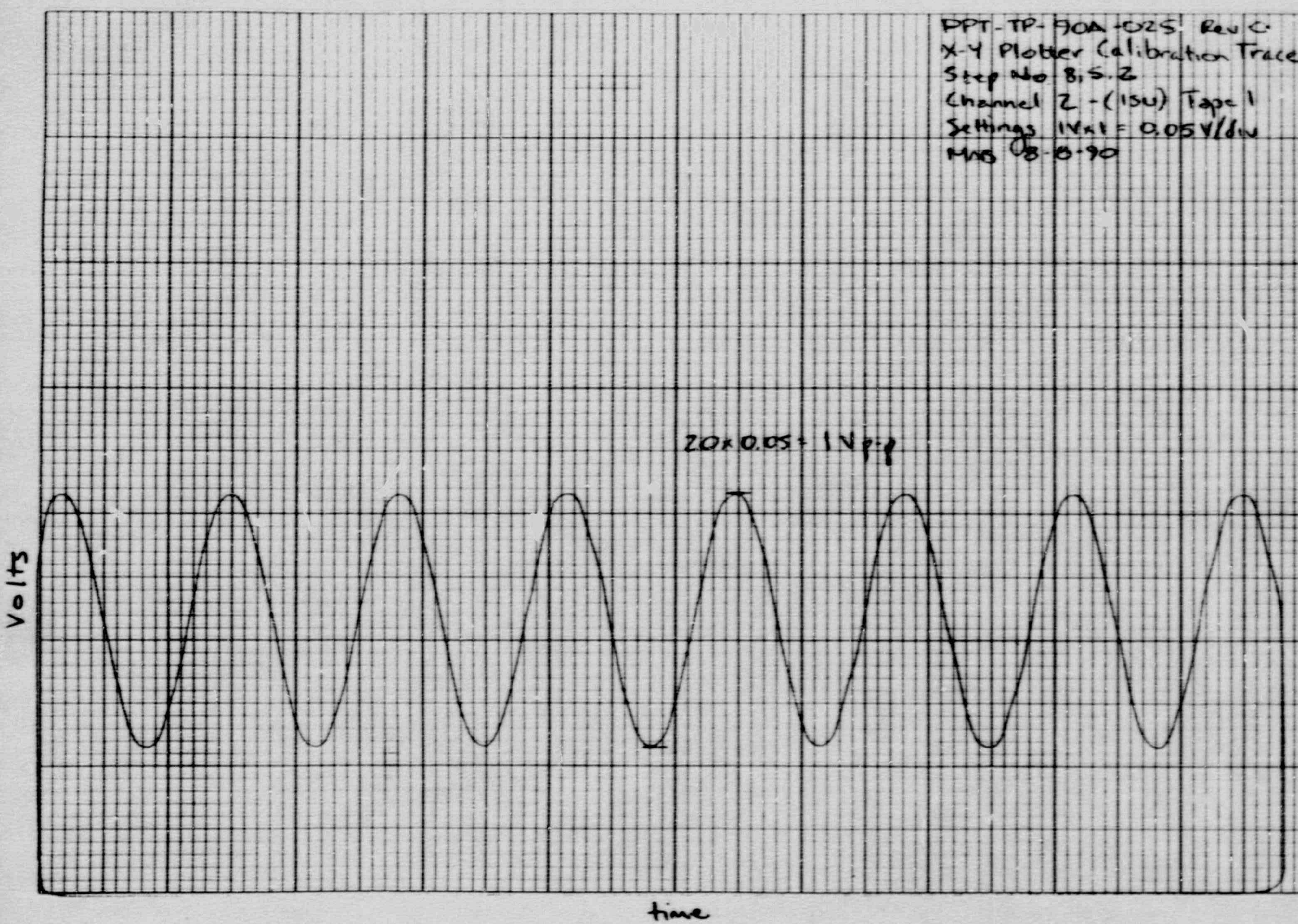

PPT-TP-90A-025 Rev. 0
STEP NO.
CALIBRATION SIGNAL 1V/1KHz
Settings: 1V x 2 = 0.1 V/div
Tape 2 (SPT) - Channel 1
MAB 3/22/90
10 x 0.1 = 1 Vpp
VOLTS
time

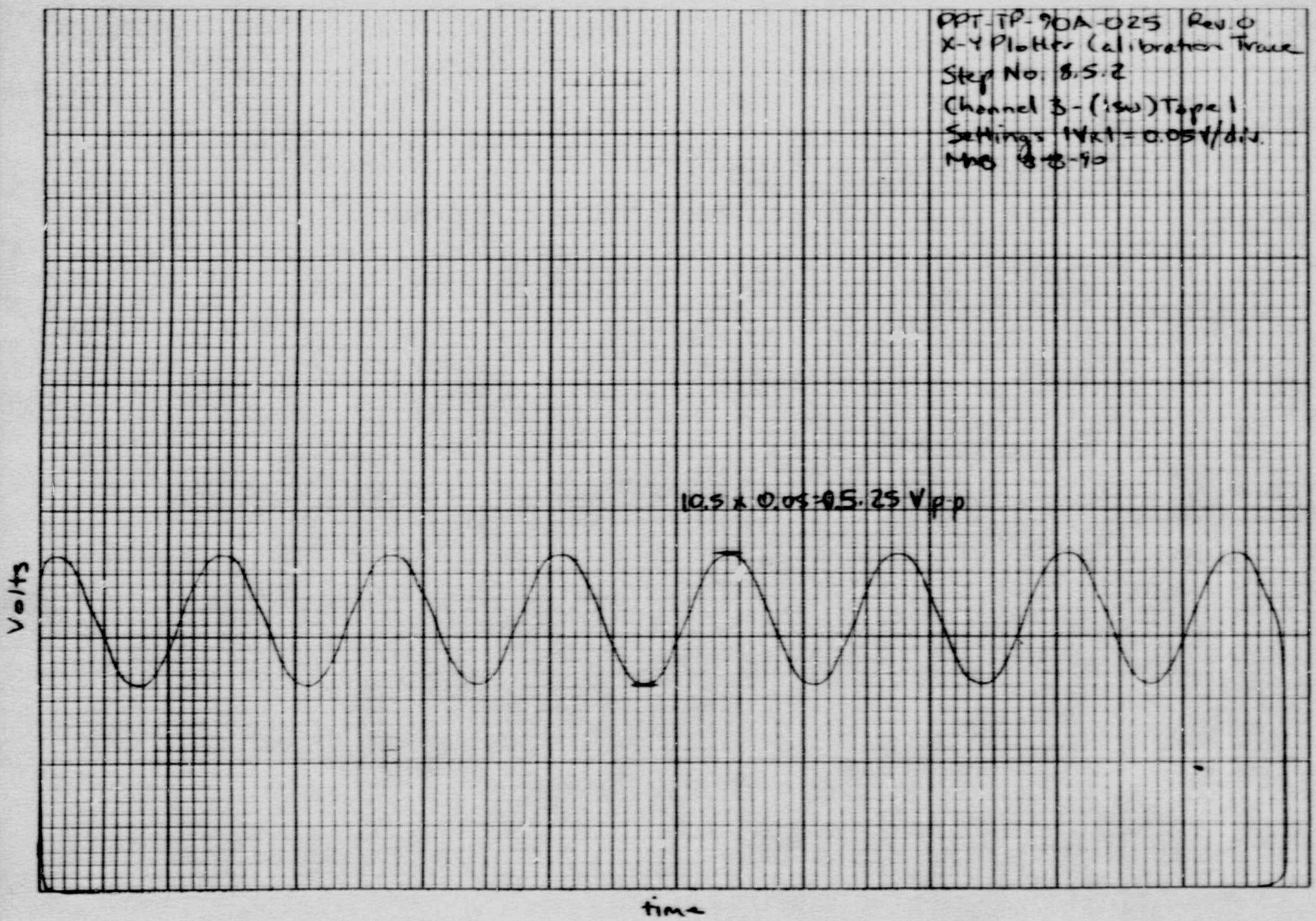


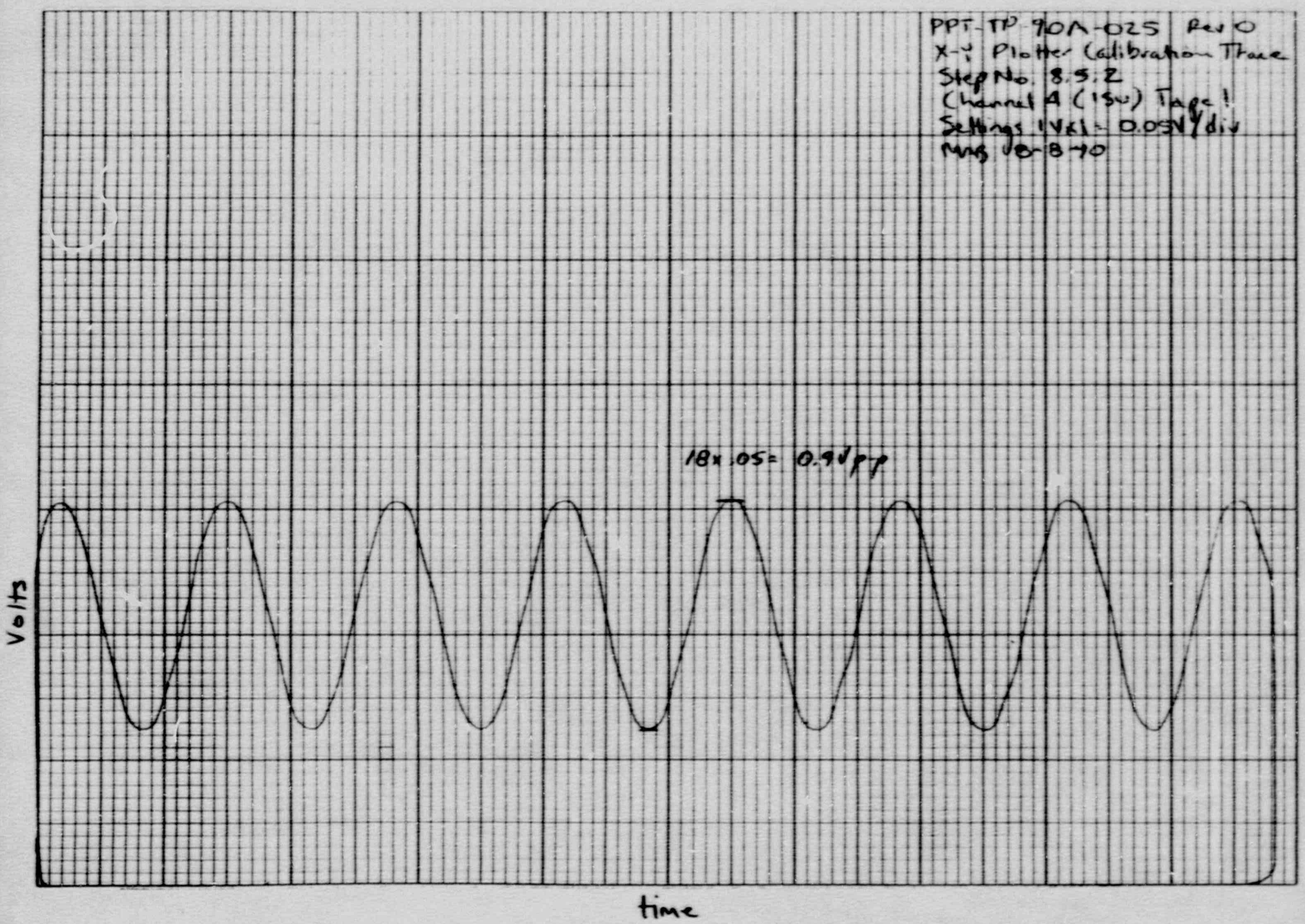







PPT-TP-90A-025 Rev C
X-Y Plotter Calibration Trace
Step No 8.5.2
Channel 2 -(15U) Tape 1
Settings 1Vx1 = 0.05V/div
MAB 8-8-90
20x0.05 = 1Vp-p
Volts
time


PPT-TP-90A-025 Rev 0
X-Y Plotter Calibration Trace
Step No. 8.5.2
Channel 3 - (1sw) Tape 1
Settings: 1V x1 = 0.05 V/div.
MAG 8-8-96
10.5 x 0.05 = 0.525 V p-p
Volts
time

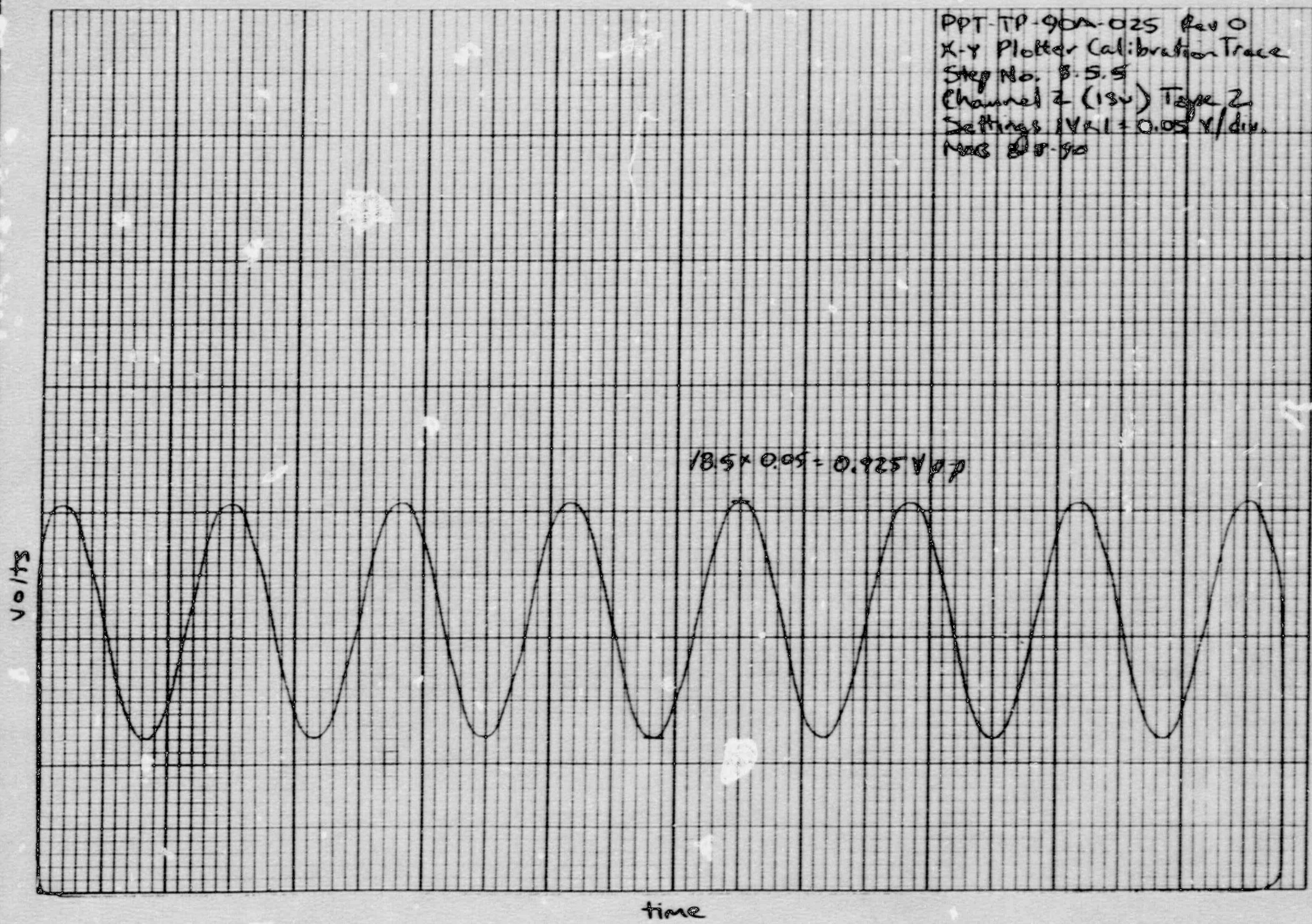


PPT-TP-90A-025 Rev 0
X-Y Plotter Calibration Trace
Step No 8.5.5
Channel 1 (13U) Tape 2
Settings 1V×1 = 0.05 V/div.
MAB 8-8-90

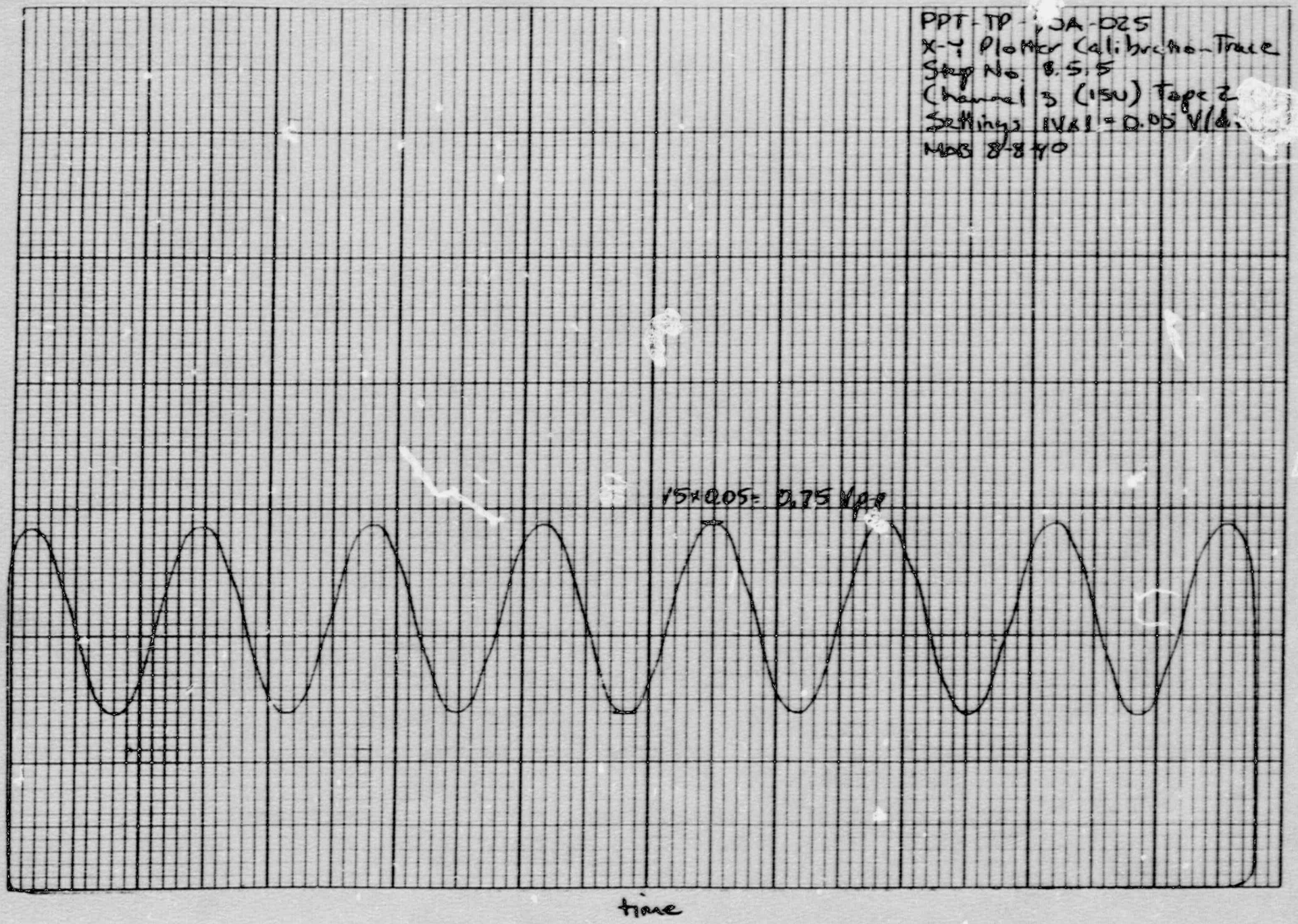
2.25 × 0.05 = 1.125 V p-p

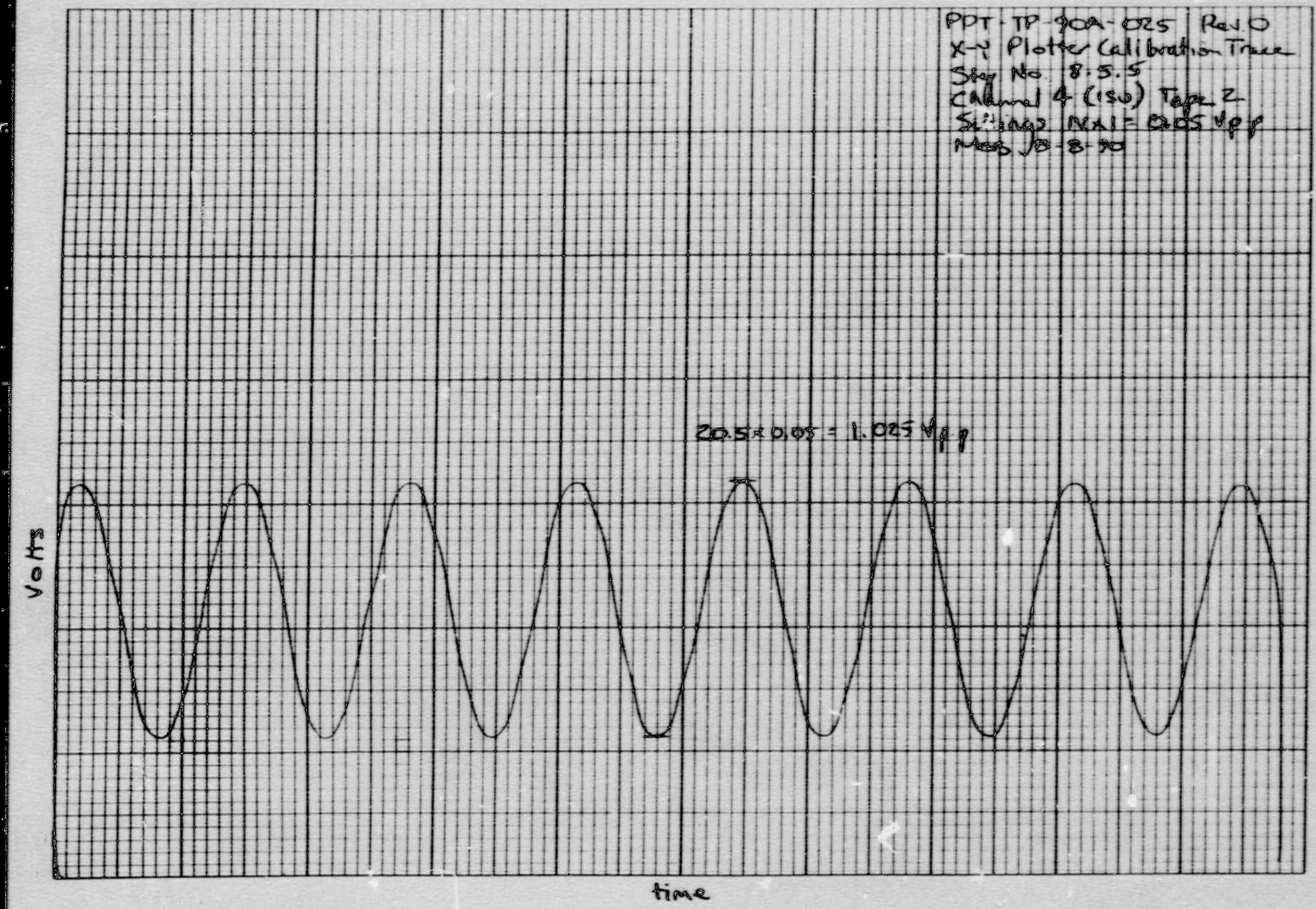
Volts

time



PPT-TP-JA-025
X-Y Plotter Calibration-Trace
Step No 8.5.5
Channel 3 (15V) Tape 2
Settings 1V&I - 0.05 V/div
MDS 8-8-90





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 where 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.

Hi-Alarm Setting	Ratio
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 with 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	LPM	FILTER SETTINGS High Pass (KHz)	FILTER SETTINGS Low Pass (KHz)	Background Noise Level (g p-p)	Hi-Alarm Setting	Alert Level (g p-p)	SENSOR RESPONSE 0.25 lbm (g p-p)	SENSOR RESPONSE 30 lbm (g p-p)	ADJACENT SENSOR RESPONSE 0.25 lbm (g p-p)	ADJACENT SENSOR RESPONSE 30 lbm (g p-p)	Notes
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	8.85	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	4,8
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.