RESULTS

OF

ELECTROMAGNETIC SURVEY

FOR

LIGO SITE

HANFORD, WASHINGTON

BY

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1.0 SCOPE

The intent of this report is to present the results of the site survey of October 24-26, 1997, which was intended to record the electromagnetic conditions at the LIGO facility, prior to the installation of experiment electronics. The survey included the following tests:

1. RF Spectrum (Radiated), 10 kHz - 200 MHz
2. Conducted Emissions, Technical Power, 9 kHz - 200 MHz
3. Conducted Emissions, Technical Power, Time Domain
4. Ground Noise, Technical Power, 9 kHz - 200 MHz
5. Ground Noise, Technical Power, Time Domain.

2.0 TEST SITE

The electromagnetic site survey was performed at the LIGO facility on the Department of Energy Hanford Nuclear Reservation near Pasco, Washington.

The radiated emissions were measured at three locations:

1. Near the eastern end of the warehouse building, located across the access road and south of the Corner Station Laser and Vacuum Equipment Area.

2. Inside the Comer Station Laser and Vacuum Equipment Area, near the beam tube apex.

3. On the concrete pad adjacent to the outside of the Comer Station LVEA, on the (building) northeast side.

The conducted emissions were measured at one location:

1. Power panel for CDS Rack for BSC 1, Panel # W-CS-PD-105CDSAC-61.

Due to test time limitations, no testing was performed at the 4 km IFO PSL Power Panel.

3.0 SITE SURVEY TESTS PERFORMED

The site survey tests were performed in compliance with the EMI Survey Test Matrix for Hanford, provided by Caltech, dated October 1, 1997. Refer to Appendix A for a copy of that matrix. Testing details follow.

RF Spectrum (Radiated Emissions). 10 kHz - 200 MHz

At each radiated emissions test location, an active rod antenna (monopole antenna with counterpoise and integral preamplifier) and a biconical antenna were each set up on a tripod. An RF coaxial cable was run from each antenna in turn to the receiving spectrum analyzer. The spectrum analyzer scanned from 10 kHz through 30 MHz with the active rod antenna, and from 30 MHz through 200 MHz with the biconical antenna. The rod antenna was oriented vertically, to measure the vertical electric field component of incident electromagnetic fields. The biconical antenna was oriented both horizontally and vertically. For the horizontal polarization of the biconical antenna at each test location, two perpendicular orientations of the antenna were used. At each radiated test location, the counterpoise of the rod antenna was positioned approximately 50 inches above the ground or floor surface, while the center point of the biconical antenna was elevated approximately 64 inches in each case. Both narrowband (apparent signal amplitude independent of receiver bandwidth) and broadband (signal amplitude adjusted to an equivalent 1 MHz bandwidth) signal levels were recorded. The following bandwidths were utilized:

Frequency Range	Spectrum Analyzer Resolution Bandwidth for Radiated Broadband Testing	Spectrum Analyzer Resolution Bandwidth for Radiated Narrowband Testing
9 kHz - 150kHz	9 kHz	1 kHz
150 kHz - 30 MHz	120 kHz	9 kHz
30 MHz - 200 MHz	1 MHz	120 kHz.

It should be noted that 129 dBuV/m (narrowband electric field intensity) is 1 volt per meter, and 120 dBuV/m/MHz (broadband) is 1 volt per meter per megahertz bandwidth. The apparent amplitude of broadband (impulsive) signals increases with the wider receiving bandwidth used for the broadband testing, while the apparent amplitude of narrowband (CW, single frequency, or spectrally confined) signals does not increase with receiver bandwidth increase. As a first approximation, for general (non-receiver) electronic equipment, a field intensity of 1 volt per meter is a marginally significant field, assuming sufficient external or internal conductor length to function as a (unintentional) receiving antenna to may cause equipment upset. Intentional receivers, of course, may be upset by much lower levels, on the order of 0.1 - 10 microvolts per meter within their reception bandwidths.

RF "Q" of LVEA

This test was to be performed twice: once inside the LVEA, and once outside the building. The intent of the test was to determine whether the LVEA was likely to produce RF standing waves at higher than incident field strength due to effective enclosure Q. The indication of enclosure resonance would be a peak at a narrow range of frequencies inside the LVEA that did not occur during the test outside the LVEA. A broadband RF "white noise" source provided by LIGO at the Hanford site was attached to a simple wire dipole antenna, with each arm of the dipole measured to be 160 inches (4.06 meters) in length. The nominal resonant frequency of the wire antenna is approximated to be 36.9 MHz. The radiating broadband source was first set up inside the LVEA near the beam tube vertex. The wire antenna elements were stretched out across the floor from the noise source, which was sitting on top of a nonconductive (cardboard) box, approximately 16 inches above floor level. The radiated emissions were measured over the frequency range of 10 kHz - 200 MHz. The receiving rod antenna was vertically polarized only (10 kHz - 30 MHz), while the receiving biconical antenna (30 MHz - 200 MHz) was polarized both vertically and horizontally. Inside the LVEA, the horizontally polarized transmitting wire dipole antenna was successively oriented both east-west and north-south (building cardinal directions). The transmitting and receiving antennas were separated a measured 22 feet. For the outside test, the transmitting dipole antenna was oriented east-west (building cardinal directions) only.

Conducted Emissions, 9 kHz - 200 MHz

The intent of the conducted emissions testing was to record the conducted noise voltage and conducted noise current on the 120 VAC, 60 Hertz power system, with the HVAC (heating, ventilation, and air conditioning) system both on and off. The test location was as specified by the LIGO EMI test matrix. During the conducted emissions testing, the AC power line was terminated in a nominal 750 watt resistive load bank comprising four resistive elements. The elements were provided by MIT, which were wired in parallel on a sheet metal heatsink by the author. During testing, the load bank was placed directly on the concrete floor. The load bank sheet metal heatsink/mounting plate measures approximately 20 inches by 24 inches. For the conducted current testing, an RF clamp-on current probe was successively clamped around each of the two AC power leads (high and return), as well as around both leads simultaneously, to measure both differential mode and common mode emissions respectively. Both narrowband and broadband emissions were measured, using the following bandwidths:

Frequency Range	Spectrum Analyzer Resolution Bandwidth for Conducted Broadband Testing	Spectrum Analyzer Resolution Bandwidth for Conducted Narrowband Testina
9 kHz - 150 kHz	9 kHz	1 kHz
150 kHz - 30 MHz	120 kHz	9 kHz
30 MHz - 200 MHz	1 MHz	120 kHz.

Note that the bandwidths used for conducted emissions were identical to those used for the radiated emissions tests.

For the conducted voltage interference tests, the resistive load bank *was* used again, and a 0.1 microfarad capacitor in series with a 5 kilohm resistor series network was connected from each of the high and return AC power leads to the grounded resistive load bank heatsink. The 50 ohm spectrum analyzer input was connected across the 5 kilohm resistor. The purpose of the 0.1 uF/5k ohm network was to decouple the 120 VAC power frequency, to preclude damage to the sensitive spectrum analyzer input, while the 0.1 uF capacitor presented minimal loss to the higher signal frequencies to be measured. The use of such a line coupling network is common, and is similar to using a line impedance stabilization network.

The conducted EMI was measured in the following units. For convenience of reference, equivalent common units are shown.

Conducted EMI Voltage Units:

Narrowband	Broadband
dBuV	dBuV/MHz
Note: 120 dBuV = 1 volt.	Note: 120 dBuV/MHz = 1 volt per megahertz bandwidth.

Conducted EMI Current Units:

Narrowband	Broadband
dBuA	dBuA/MHz
Note: 120 dBuA = 1 ampere.	Note: 120 dBuA/MHz = 1 ampere per megahertz bandwidth.

Conducted Emissions, Time Domain

The intent of the time domain conducted emissions testing was to record oscillographic power line voltage and current waveforms, as well as to determine the level of power frequency harmonic distortion, also for both voltage and current. The voltage was measured directly with a standard voltage probe from a Tektronix THS720P 100 MHz bandwidth digital oscilloscope attached between the AC power line high and return lead, at the resistive load bank. The current was measured with the same oscilloscope and a Tektronix A621 clamp-on current probe clamped around the AC high lead. The harmonics were measured from the fundamental, 60 Hertz, through the seventeenth harmonic, 1,020 Hertz The harmonics were determined through usage of the Tektronix *Wavestar* software package. During testing, the oscilloscope was battery powered, eliminating concerns of error-producing ground loops.

Groundina (Conducted Emissions), 9 kHz - 200 MHz

This conducted emissions testing was similar to the frequency domain conducted emissions testing previously described. The voltage EMI was measured between the neutral, or return, power lead and ground. The current EMI was measured on the "green wire" AC ground conductor. Both broadband and narrowband testing was performed, using the previously described spectrum analyzer bandwidths.

Groundina (Conducted Emissions), Time Domain

This conducted emissions testing was similar to the time domain conducted emissions testing previously described. The voltage EMI was measured between the neutral line and ground, while the current EMI was measured on the green wire ground conductor to the resistive load bank. Both oscillographic and harmonic measurements were recorded.

4.0 TEST RESULTS

RF Spectrum (Radiated Emissions), 10 kHz - 200 MHz

The radiated emissions profile at the remote LIGO site was low. No significant emissions above the noise floor of the spectrum analyzer were recorded. No worrisome (with respect to potential electronic equipment upset) radiated signals were seen. Radiated emission levels were essentially identical with the HVAC both on and off.

RF "Q" of LVEA

No evidence of LVEA enclosure resonance was observed.

Conducted Emissions. 9 kHz - 200 MHz

The conducted emissions profile was also low. No significant emissions above the spectrum analyzer noise floor were observed. Again, no significant difference in emissions was caused by turning on the HVAC.

Conducted Emissions. Time Domain

The tested power line had no observed strong EMI sources. Power frequency harmonic distortion was very low.

Grounding (Conducted Emissions), 9 kHz - 200 MHz

The neutral-to-ground voltage and ground lead EMI current levels were quite low.

Grounding (Conducted Emissions). Time Domain

The neutral-to-ground voltages and ground current levels were very low.

5.0 CONCLUSIONS

At the time of the survey, the LIGO Hanford site was electromagnetically quiet. No significant radiated or conducted electromagnetic energy was detected.

APPENDIX A

EMI SURVEY TEST MATRIX

EMI SURVEY TEST MATRIX FOR HANFORD

#	Test Description	Bandwidth/Duration	Location	Conditions	Comments
1.	RF Spectrum	10 kHz - 200 MHz	Outdoors; Elev. above ground = 2m.(?).	Daytime, workweek.	Baseline for PEM and for internal comparisons.
2.	RF Spectrum	10 kHz - 200 MHz	Outdoors; Elev. above ground = 2 m.(?).	Night, weekend.	Baseline for PEM and for internal comparisons.
3.	RF Spectrum	10 kHz - 200 MHz	LVEA, Indoors, near vertex.	Night, weekend; all HVAC equipment operational as normal.	Baseline, want broadband and narrowband features.
4.	RF Spectrum.	10 kHz - 200 MHz	LVEA, Indoors, near vertex.	Night, weekend; all HVAC equipment off.	Baseline, want broadband and narrowband features.
5.	RF Q of LVEA.	10 kHz - 200 MHz.	LVEA, Indoors, near vertex.	Night, weekend; all HVAC off.	Using broadband RF source, measure power buildup vs. f and use outdoors spectrum for ratioing.

(Continued next page.)

EMI SURVEY TEST MATRIX FOR HANFORD (Continued)

#	Test Description	Bandwidth/Duration	Location	Conditions	Comments
6.	Conducted emissions, technical power.	9 kHz - 200 MHz.	4 km IFO PSL Power Panel.	Night, weekend; all HVAC on.	Baseline. Panel # W-CS-107-SB-01.
7.	Conducted emissions, technical power.	9 kHz - 200 MHz.	4 km IFO PSL Power Panel.	Night, weekend; all HVAC off.	Baseline. Panel # W-CS-107-SB-01.
8.	Conducted emissions, technical power.	9 kHz - 200 MHz.	Power Panel for COS Rack for BSC 1.	Night, weekend; all HVAC on.	Baseline. Panel # W-CS-PD-105-CDSAC-01.
9.	Conducted emissions, technical power.	9 kHz - 200 MHz.	Power Panel for COS Rack for BSC 1.	Night, weekend; all HVAC off.	Baseline. Panel # W-CS-PD-105-CDSAC-01.
10.	Conducted emissions, technical power.	Time domain with Tektronix digital storage scope; v(f), i(f), looking at f = n x 60 Hz, f<1kHz.	4 km IFO PSL Power Panel.	Night, weekend; all HVAC off.	Baseline. Panel # W-CS-107-SB-01.
11.	Conducted emissions, technical power.	Time domain with Tektronix digital storage scope; v(f), i(f), looking at f = n x 60 Hz, f<1kHz.	4 km IFO PSL Power Panel.	Night, weekend; all HVAC on.	Baseline. Panel # W-CS-107-SB-01.
12.	Conducted emissions, technical power.	Time domain with Tektronix digital storage scope; v(f), i(f), looking at f = n x 60 Hz, f<1kHz.	Power Panel for COS Rack for BSC 1.	Night, weekend; all HVAC off.	Baseline. Panel # W-CS-PD-105-CDSAC-01.
13.	Conducted emissions, technical power.	Time domain with Tektronix digital storage scope; v(f), i(f), looking at f = n x 60 Hz, f<1kHz.	Power Panel for COS Rack for BSC 1.	Night, weekend; all HVAC on.	Baseline. Panel # W-CS-PD-105-CDSAC-01.

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EMI SURVEY TEST MATRIX FOR HANFORD (Continued)

#	Test Description	Bandwidth/Duration	Location	Conditions	Comments
14.	Grounding.	9 kHz - 200 MHz.	4 km IFO PSL Power Panel.	Night, weekend; all HVAC off.	Baseline. Panel # W-CS-107-SB-01.
15.	Grounding.	9 kHz - 200 MHz.	4 km IFO PSL Power Panel.	Night, weekend; all HVAC on.	Baseline. Panel # W-CS-107-SB-01.
16.	Grounding.	9 kHz - 200 MHz.	Power Panel for COS Rack for BSC 1.	Night, weekend; all HVAC off.	Baseline. Panel # W-CS-PD-105-CDSAC-01.
17.	Grounding.	9 kHz - 200 MHz.	Power Panel for COS Rack for BSC 1.	Night, weekend; all HVAC on.	Baseline. Panel # W-CS-PD-105-CDSAC-01.
18.	Grounding.	Time domain with Tektronix digital storage scope; v(f), i(f), looking at f = n x 60 Hz, f<1kHz.	4 km IFO PSL Power Panel.	Night, weekend; all HVAC off.	Baseline. Panel # W-CS-107-SB-01.
19.	Grounding.	Time domain with Tektronix digital storage scope; v(f), i(f), looking at f = n x 60 Hz, f<1kHz.	4 km IFO PSL Power Panel.	Night, weekend; all HVAC on.	Baseline. Panel # W-CS-107-SB-01.
20.	Grounding.	Time domain with Tektronix digital storage scope; v(f), i(f), looking at f = n x 60 Hz, f<1kHz.	Power Panel for COS Rack for BSC 1.	Night, weekend; all HVAC off.	Baseline. Panel # W-CS-PD-105-CDSAC-01.
21.	Grounding.	Time domain with Tektronix digital storage scope; v(f), i(f), looking at f = n x 60 Hz, f<1kHz.	Power Panel for COS Rack for BSC 1.	Night, weekend; all HVAC on.	Baseline. Panel # W-CS-PD-105-CDSAC-01.

APPENDIX B

EMI SURVEY TEST DATA

APPENDIX B-1

EMI SURVEY TEST DATA -

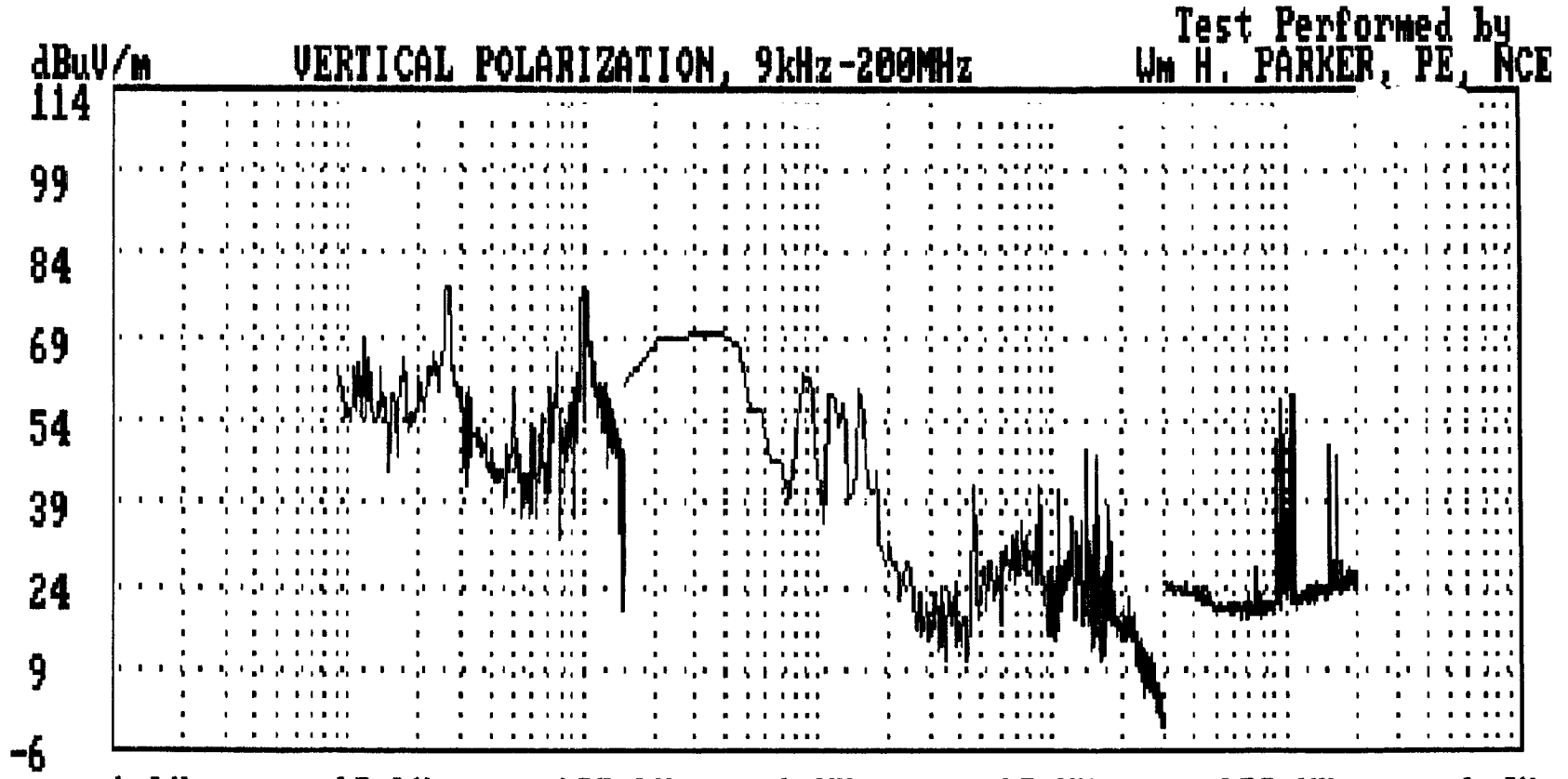
RF SPECTRUM (RADIATED EMISSIONS)

10 kHz - 200 MHz

1. Outdoors, daytime, workweek.
2. Outdoors, night/weekend.
3. LVEA, indoors, near beam tube vertex, night/weekend, HVAC on.
4. LVEA, indoors, near beam tube vertex, night/weekend, HVAC off.

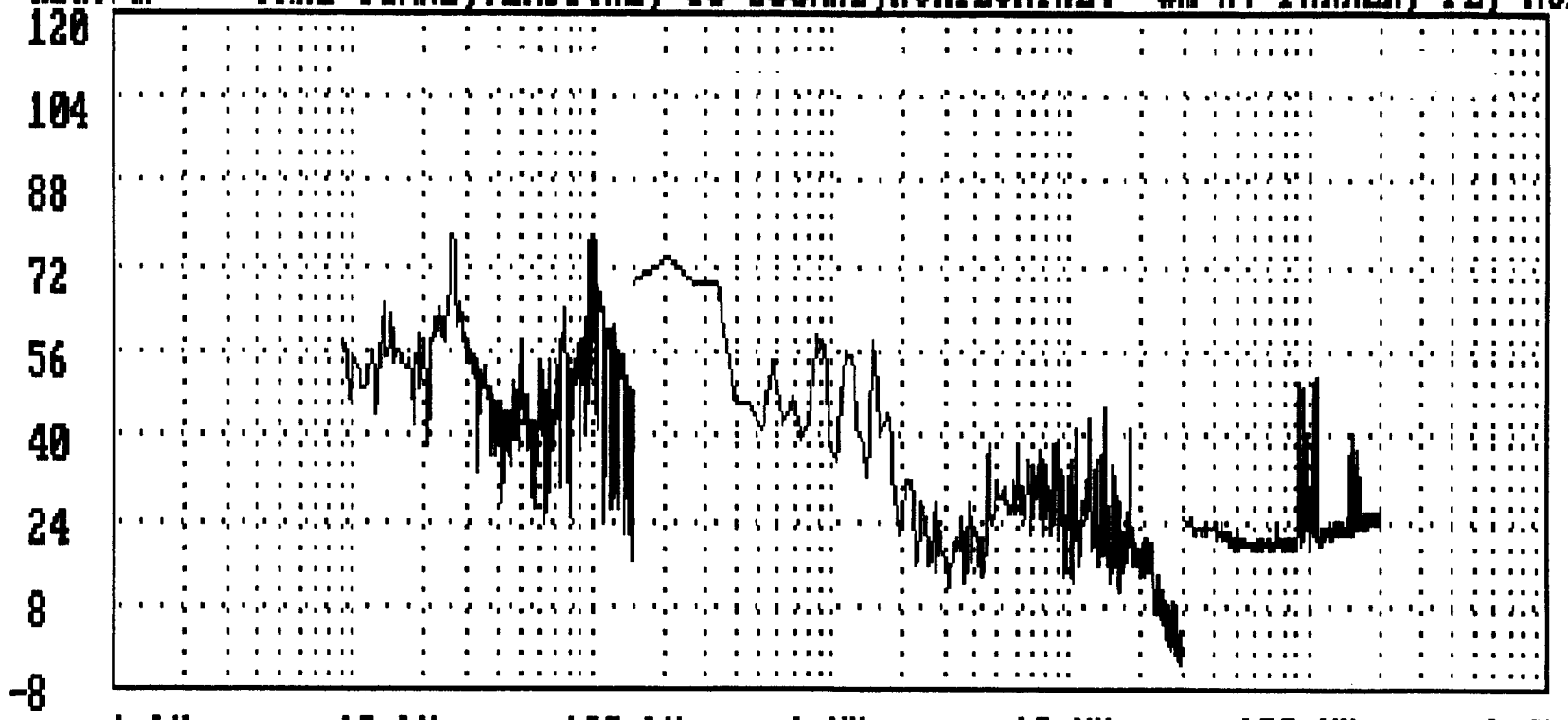
RADIATED EMISSIONS

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS



LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
ANTENNA POLARIZATION: (BICON.//TO ROAD)

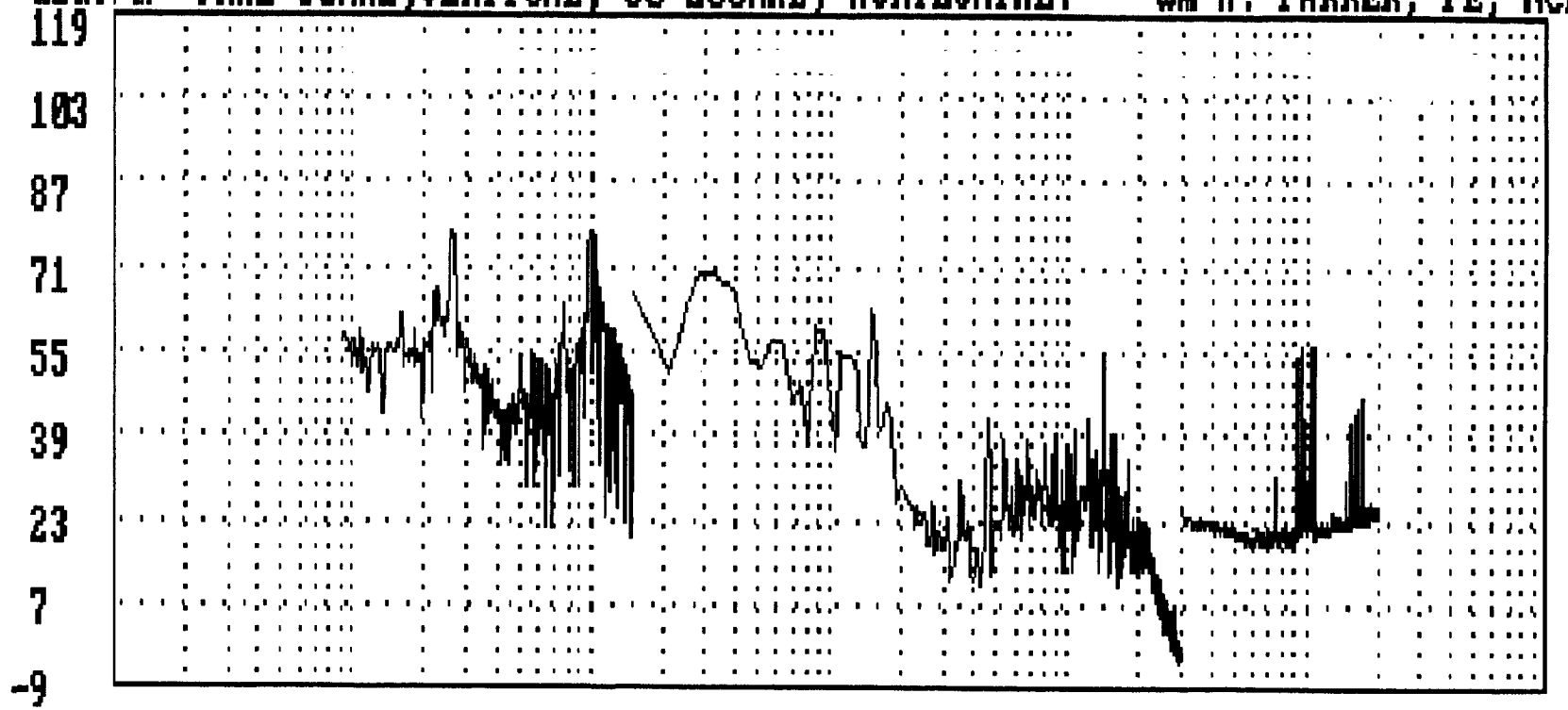
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY
14:14:55 10-24-97
LOCATION:OUTDOORS, NEAR WAREHOUSE, SE OF MAIN BLDG. (#1).

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
ANTENNA POLARIZATION: (BICON. PERPENDICULAR TO ROAD)

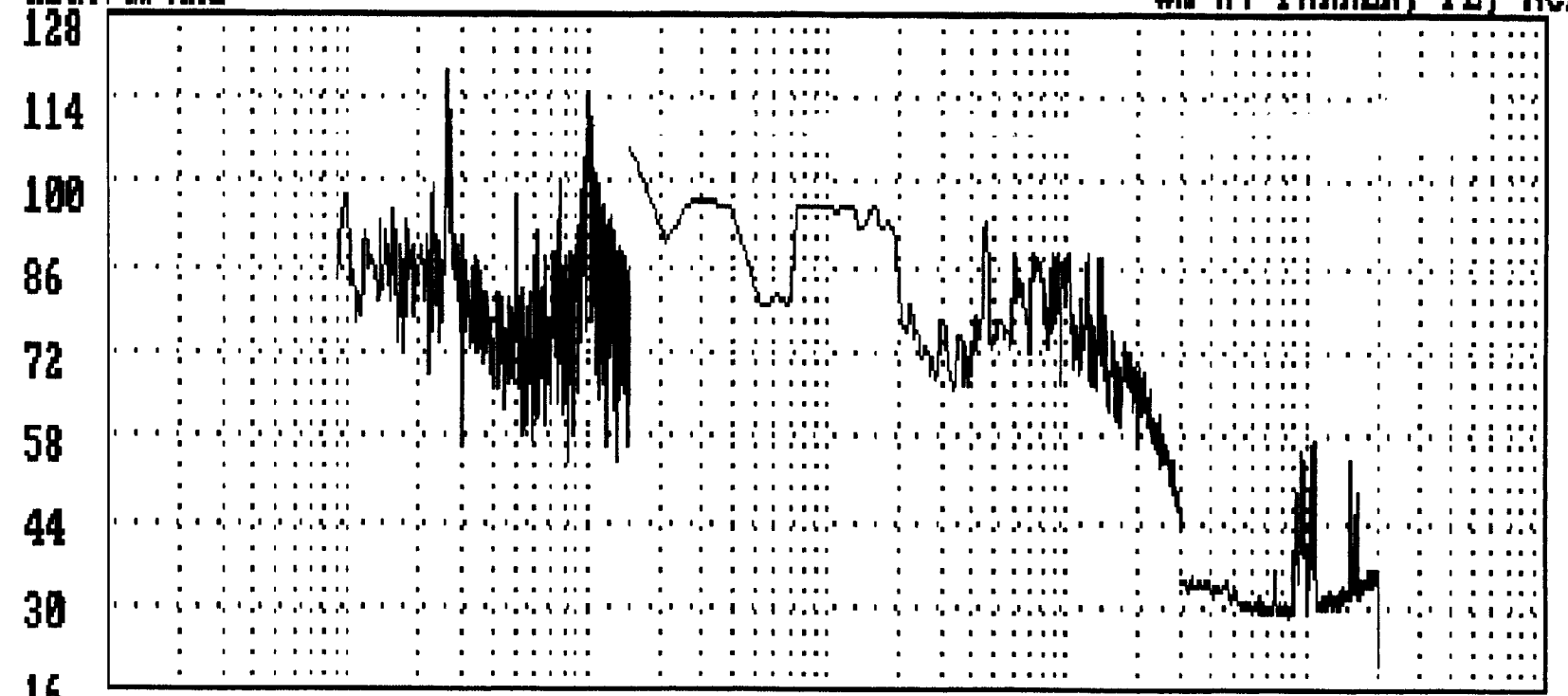
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY
14:56:40 10-24-97
LOCATION:OUTDOORS, NEAR WAREHOUSE, SE OF MAIN BLDG. (#1).

LIGO HANFORD SITE SURVEY - BROADBAND RADIATED EMISSIONS (/MHz BW)
ANTENNA POLARIZATION: VERTICAL

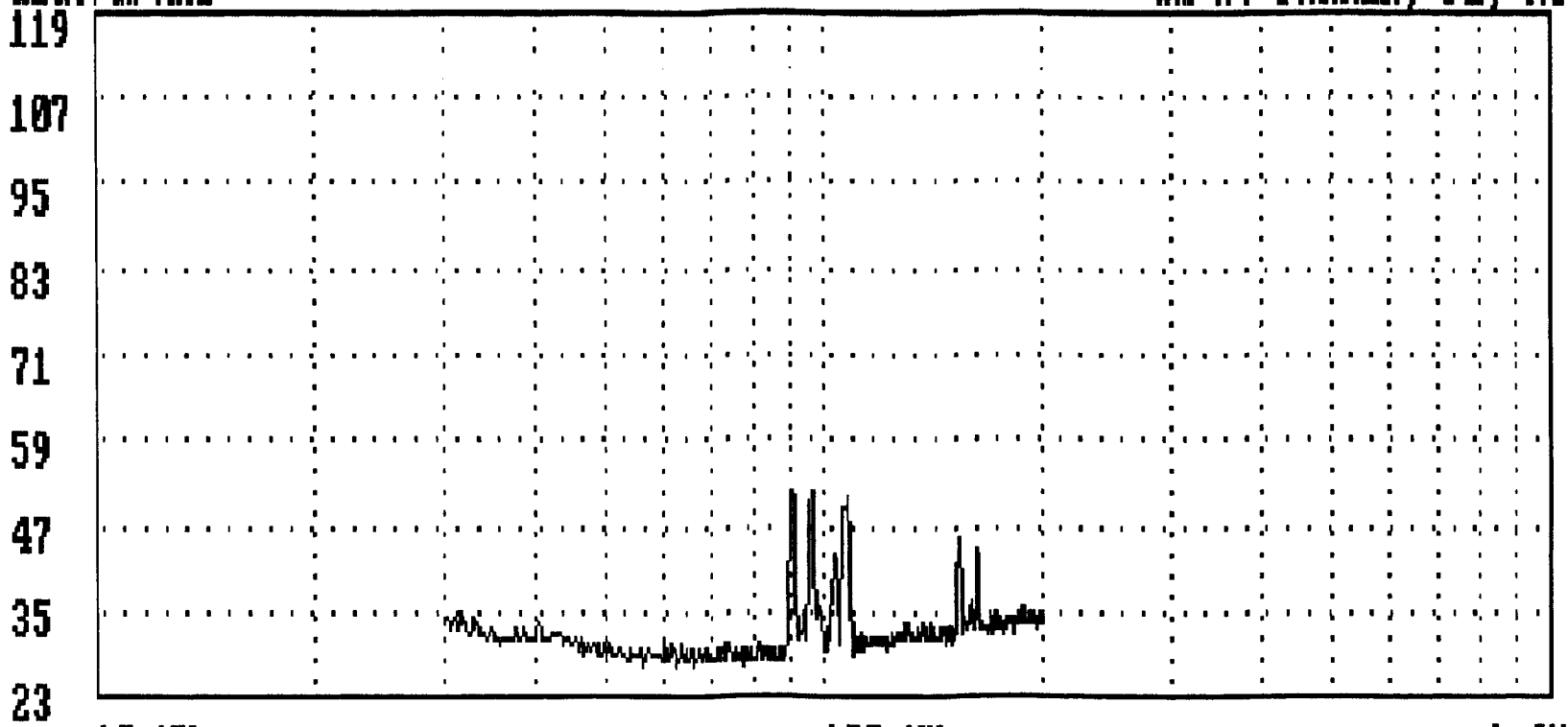
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY
17:52:07 10-24-97
LOCATION:OUTDOORS, NEAR WAREHOUSE, SE OF MAIN BLDG. (#1).

LIGO HANFORD SITE SURVEY - BROADBAND RADIATED EMISSIONS (/MHz BW)
ANTENNA POLARIZATION: HORIZONTAL
BICONICAL PARALLEL TO ROAD.

Test Performed by
Wm H. PARKER, PE, NCE

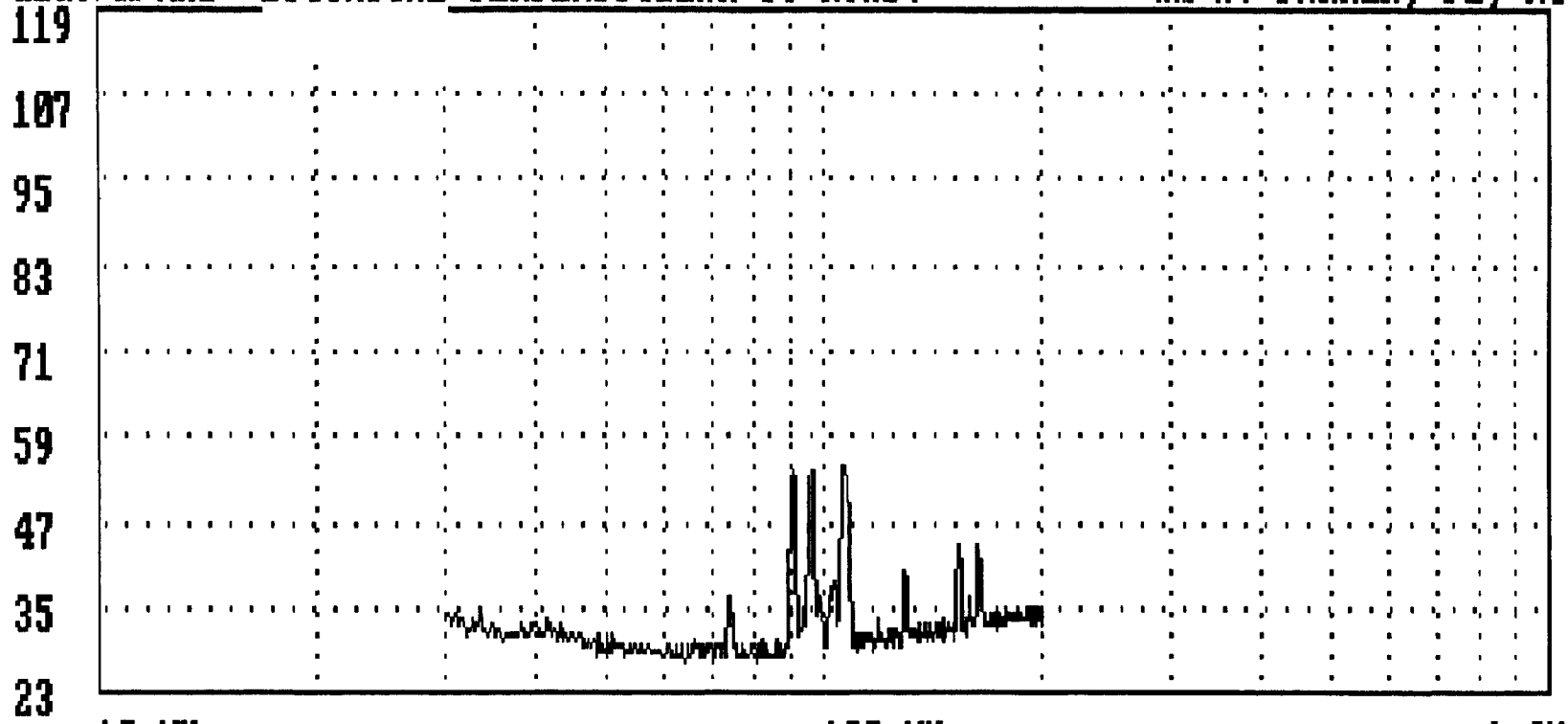


LIGO HANFORD SITE SURVEY 15:56:14 10-24-97
LOCATION:OUTDOORS, NEAR WAREHOUSE, SE OF MAIN BLDG. (#1).

LIGO HANFORD SITE SURVEY - BROADBAND RADIATED EMISSIONS (/MHz BW)

ANTENNA POLARIZATION: HORIZONTAL
BICONICAL PERPENDICULAR TO ROAD.

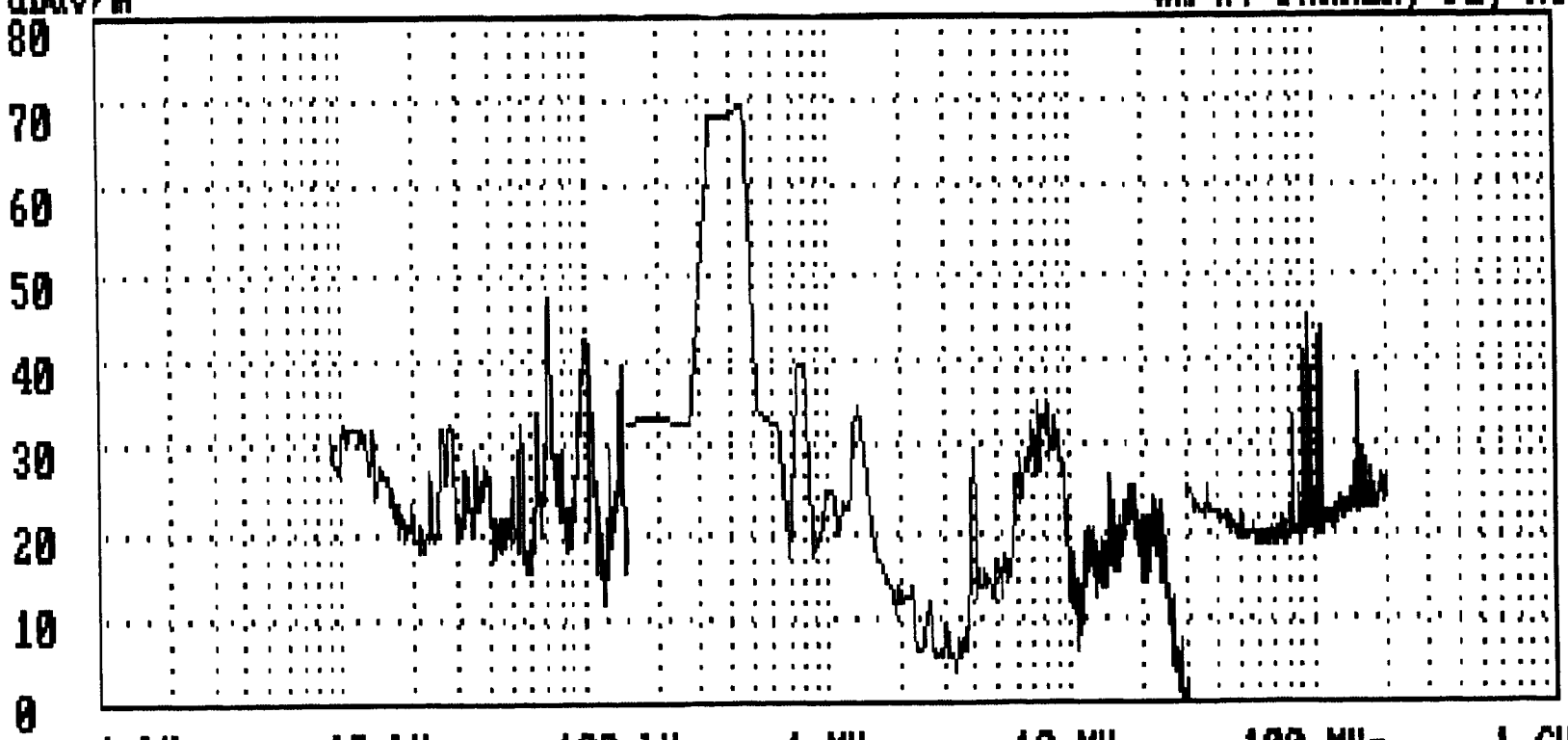
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY
15:46:20 10-24-97
LOCATION:OUTDOORS, NEAR WAREHOUSE, SE OF MAIN BLDG. (#1).

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
ANTENNA POLARIZATION: VERTICAL

Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

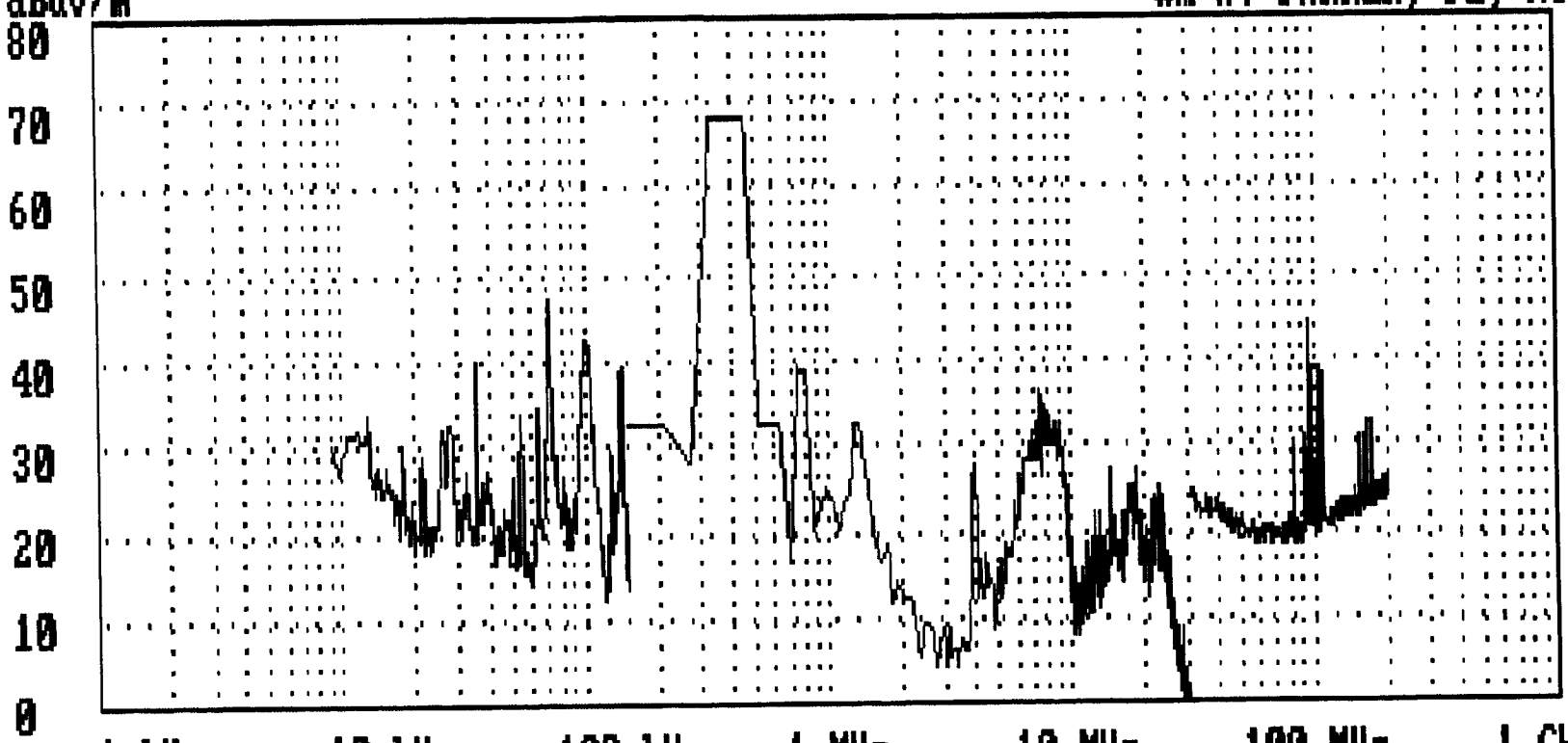
11:38:54 10-24-97

5

(HVAC ON)

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
ANTENNA POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL.,30-200MHz (BLDG N-S LINE)

Test Performed by
Wm H. PARKER, PE, NCE



11:56:18 10-24-97

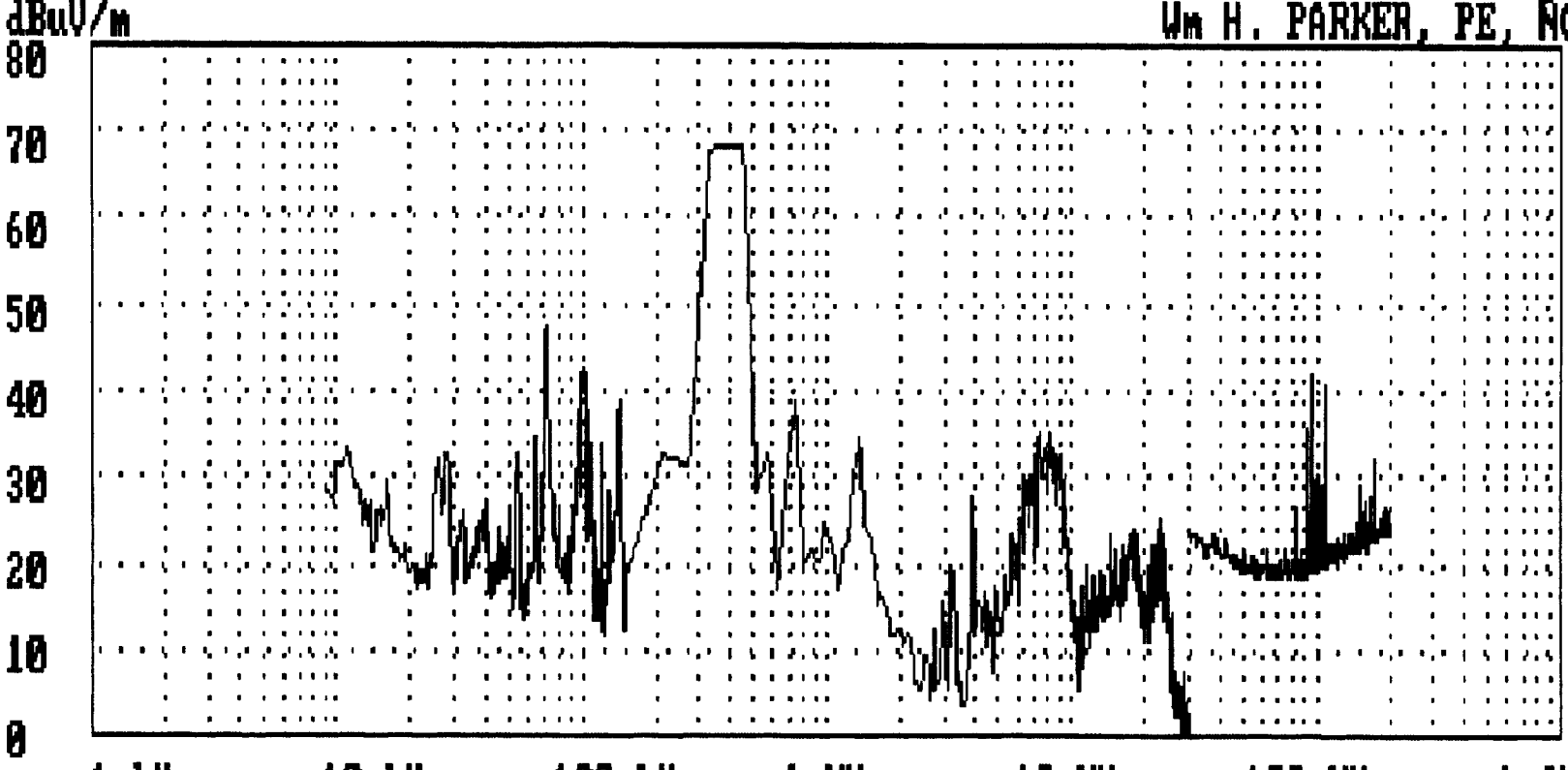
LIGO HANFORD SITE SURVEY
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

5

(HVAC ON)

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
ANTENNA POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30-200MHz (BLDG E-W LINE)

Test Performed by
Wm H. PARKER, PE, NCE



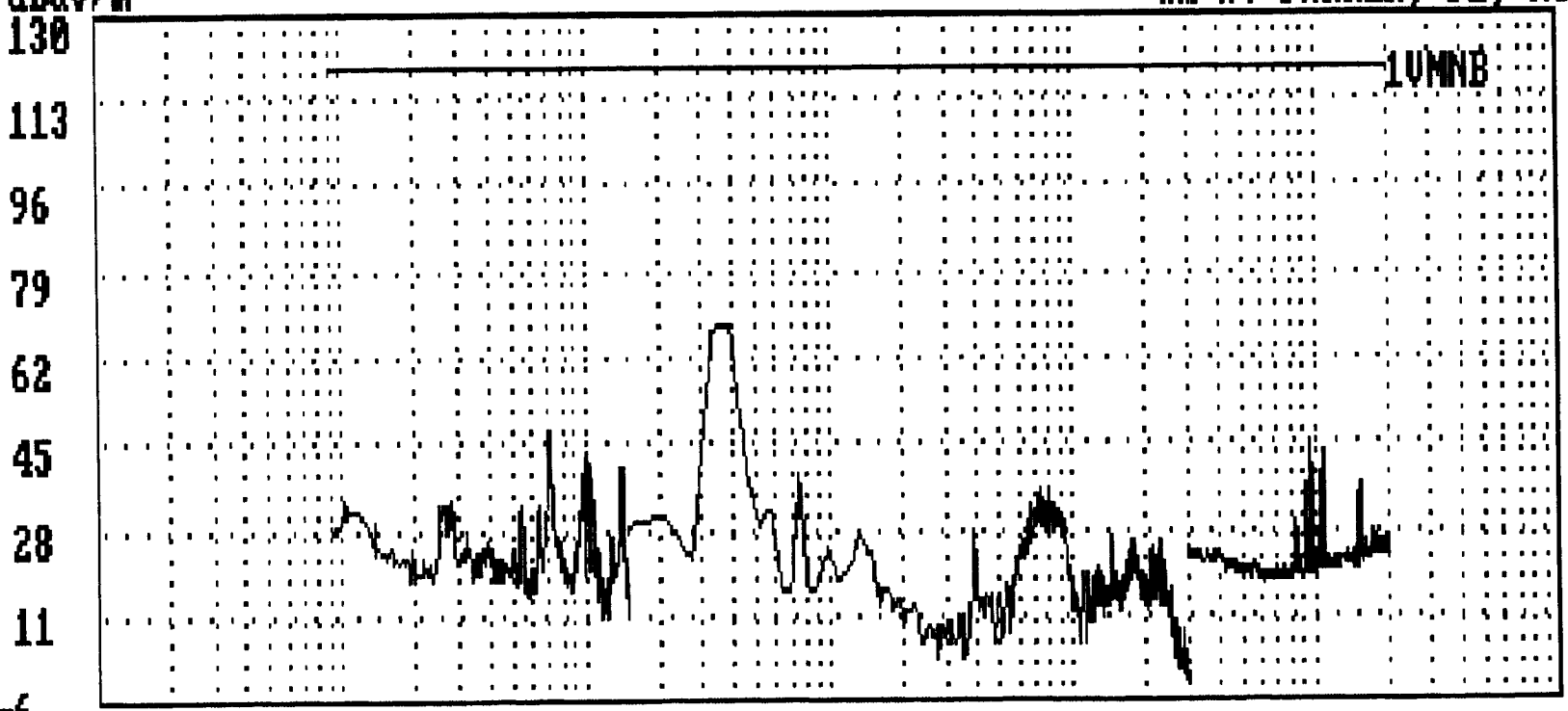
LIGO HANFORD SITE SURVEY
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

12:20:24 10-25-97

(HVAC ON)

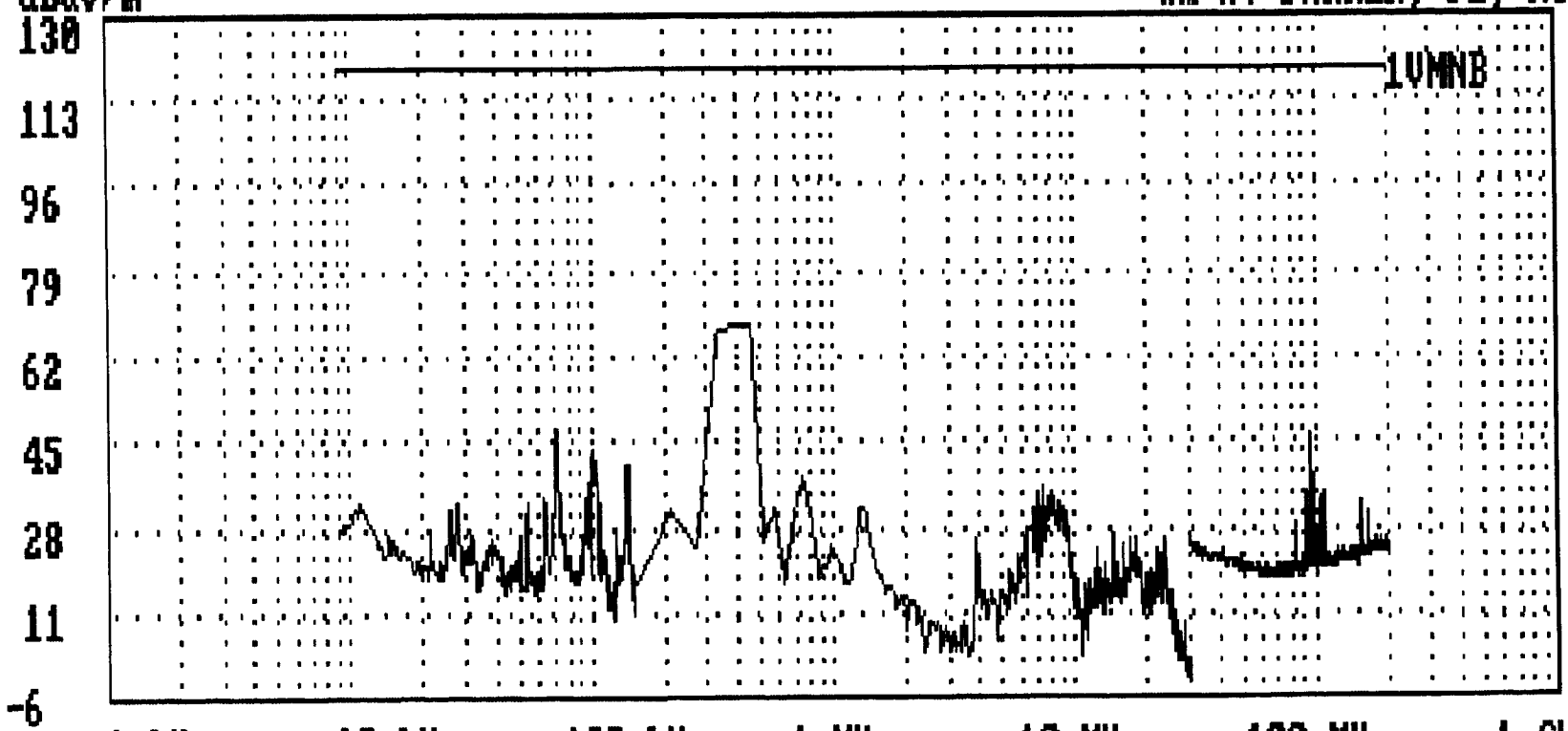
LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
ANTENNA POLARIZATION: VERTICAL

Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/HVAC OFF. 13:57:31 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

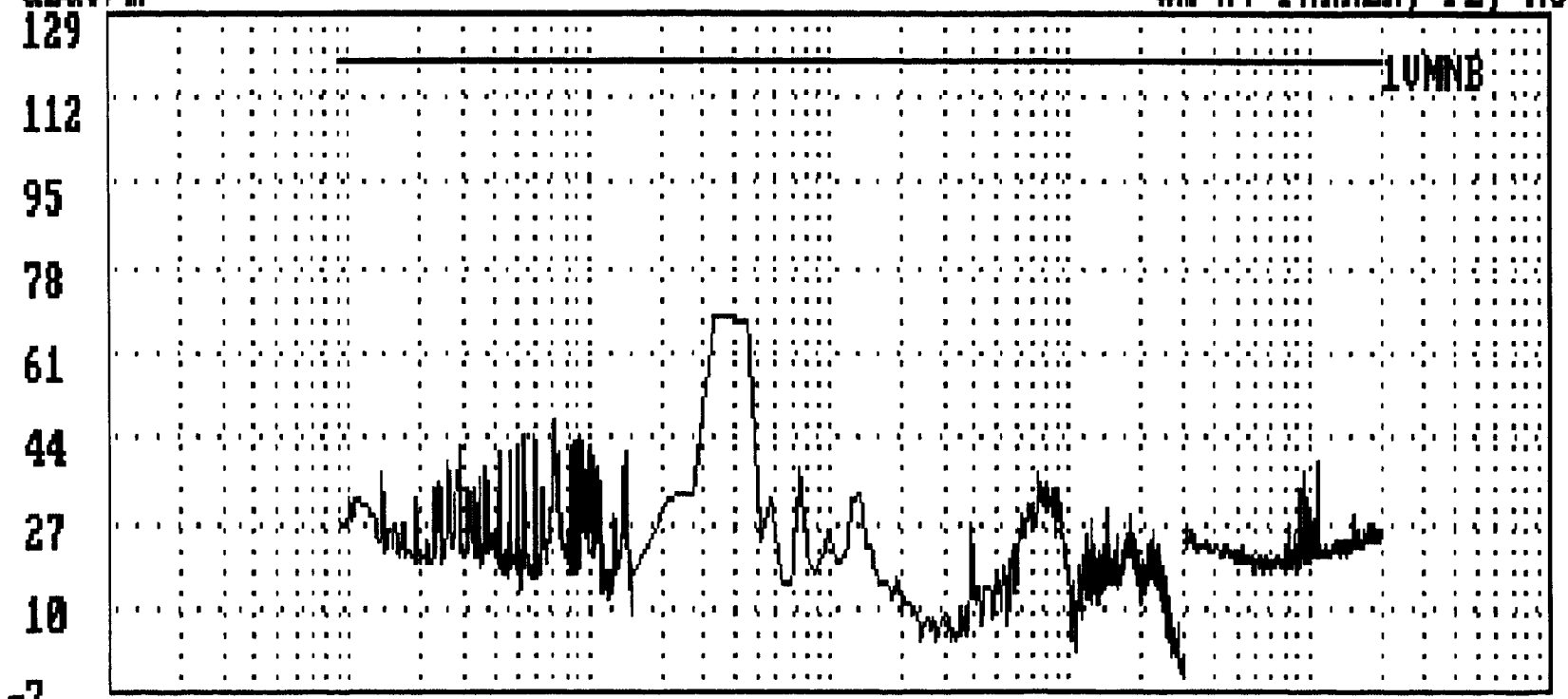
LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
ANTENNA POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30MHz-200MHz (BLDG N-S LINE) Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/HVAC OFF. 14:08:55 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
ANTENNA POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30-200MHz (BLDG E-W LINE)

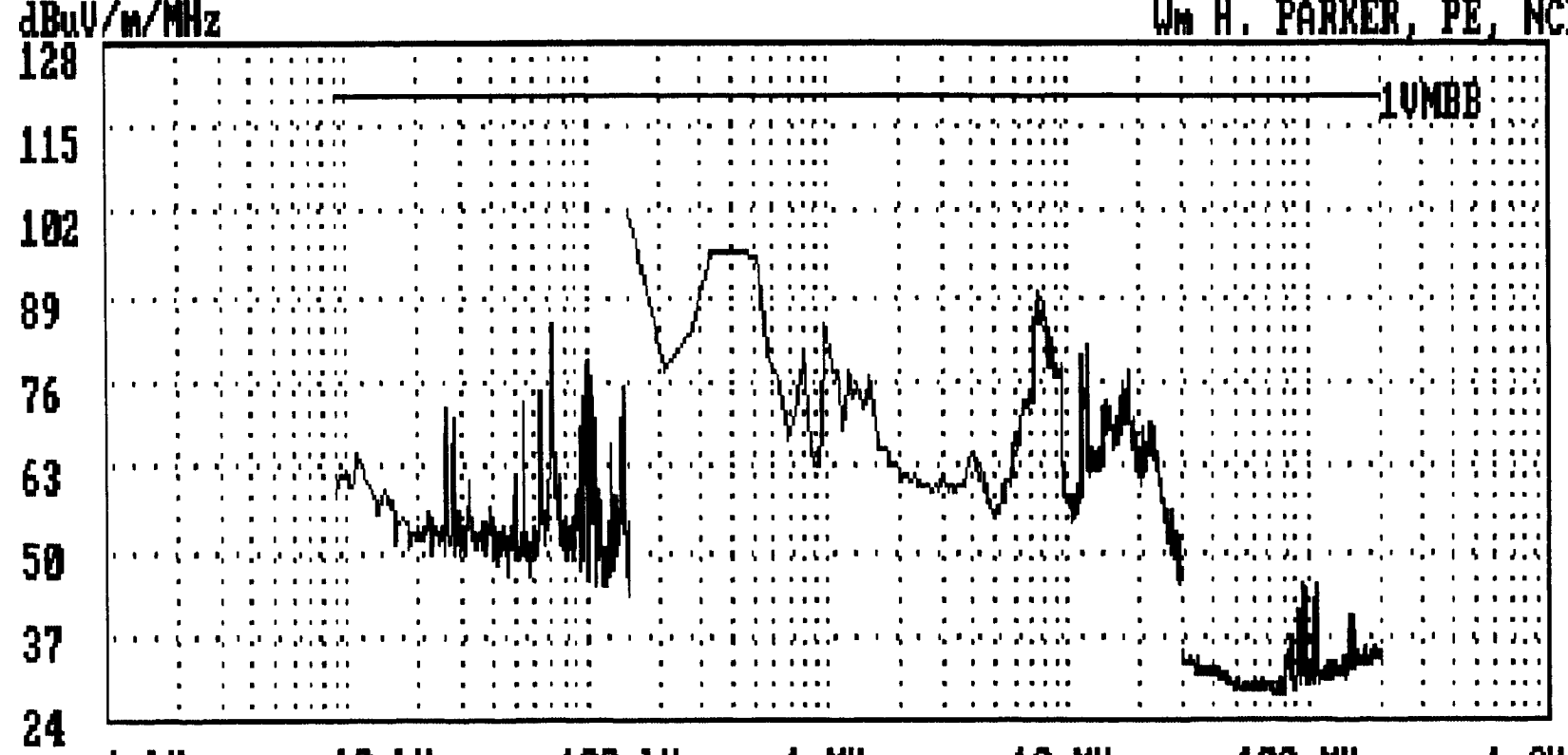
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/HVAC OFF. 14:22:14 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

LIGO HANFORD SITE SURVEY-BROADBAND RADIATED EMISSIONS (dBuV/m/MHz)
ANTENNA POLARIZATION: VERTICAL

Test Performed by
Wm H. PARKER, PE, NCE

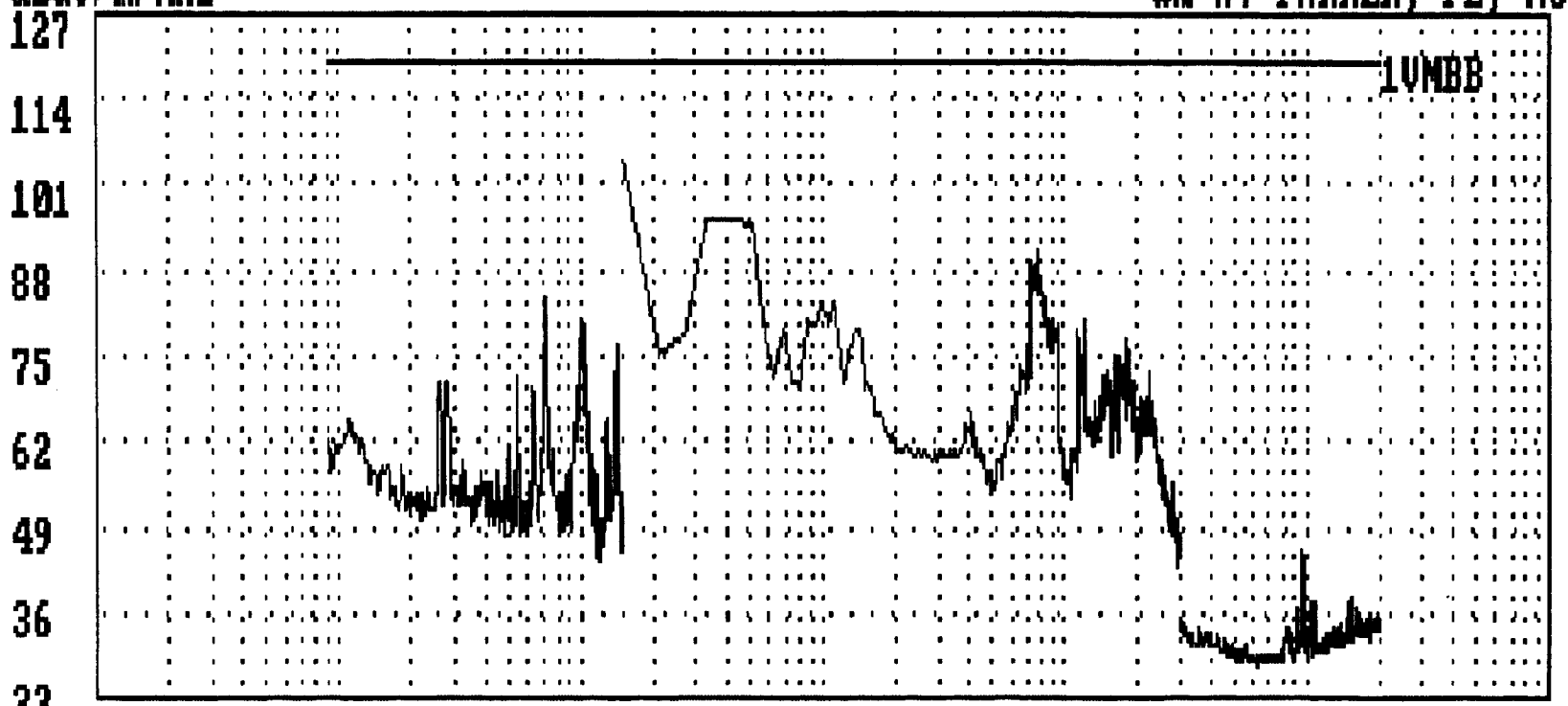


LIGO HANFORD SITE SURVEY
12:44:25 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

(HVAC ON)

LIGO HANFORD SITE SURVEY-BROADBAND RADIATED EMISSIONS (dBuV/m/MHz)
ANTENNA POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30-200MHz (BLDG N-S LINE)

Test Performed by
Wm H. PARKER, PE, NCE

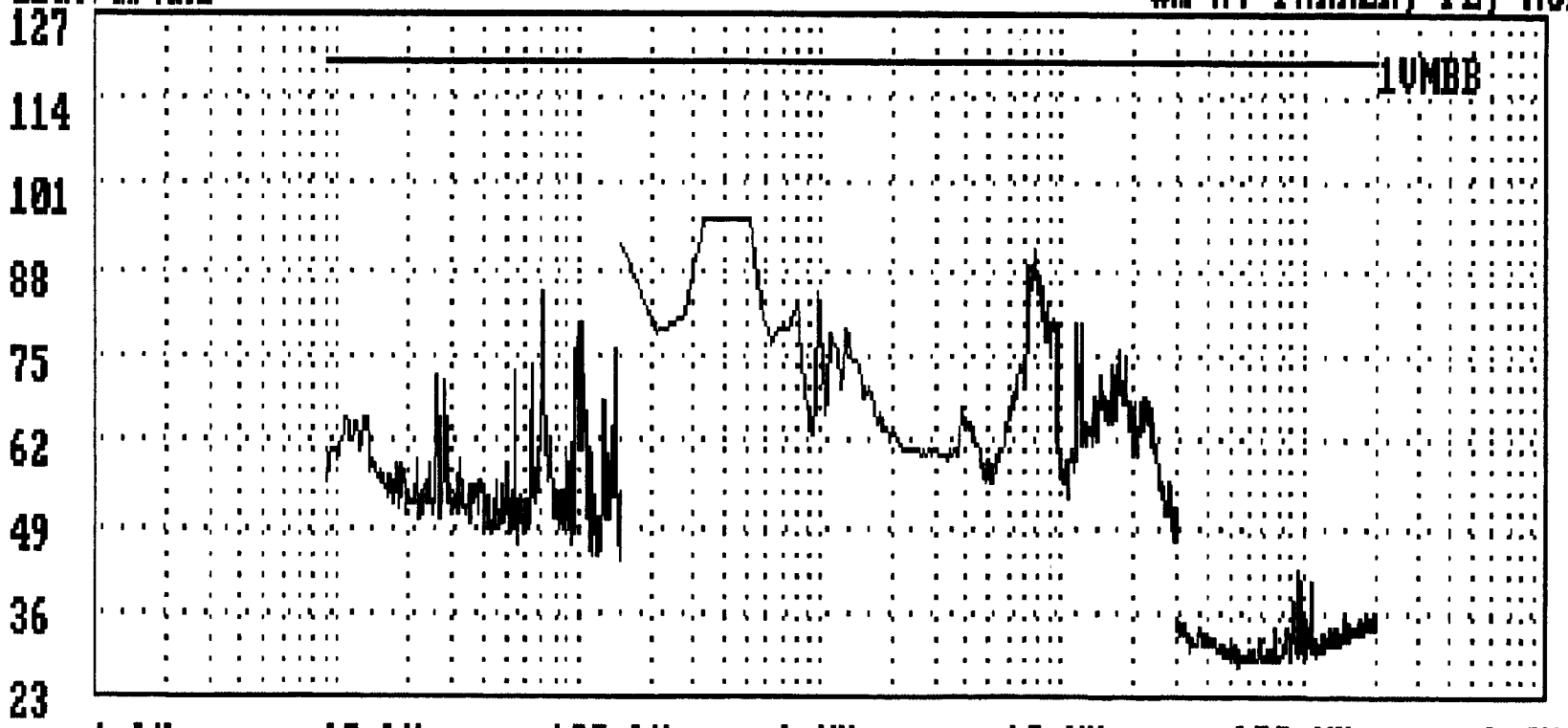


LIGO HANFORD SITE SURVEY
12:53:37 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

(HVAC ON)

LIGO HANFORD SITE SURVEY-BROADBAND RADIATED EMISSIONS (dBuV/m/MHz)
ANTENNA POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30-200MHz (BLDG E-W LINE)

Test Performed by
Wm H. PARKER, PE, NCE



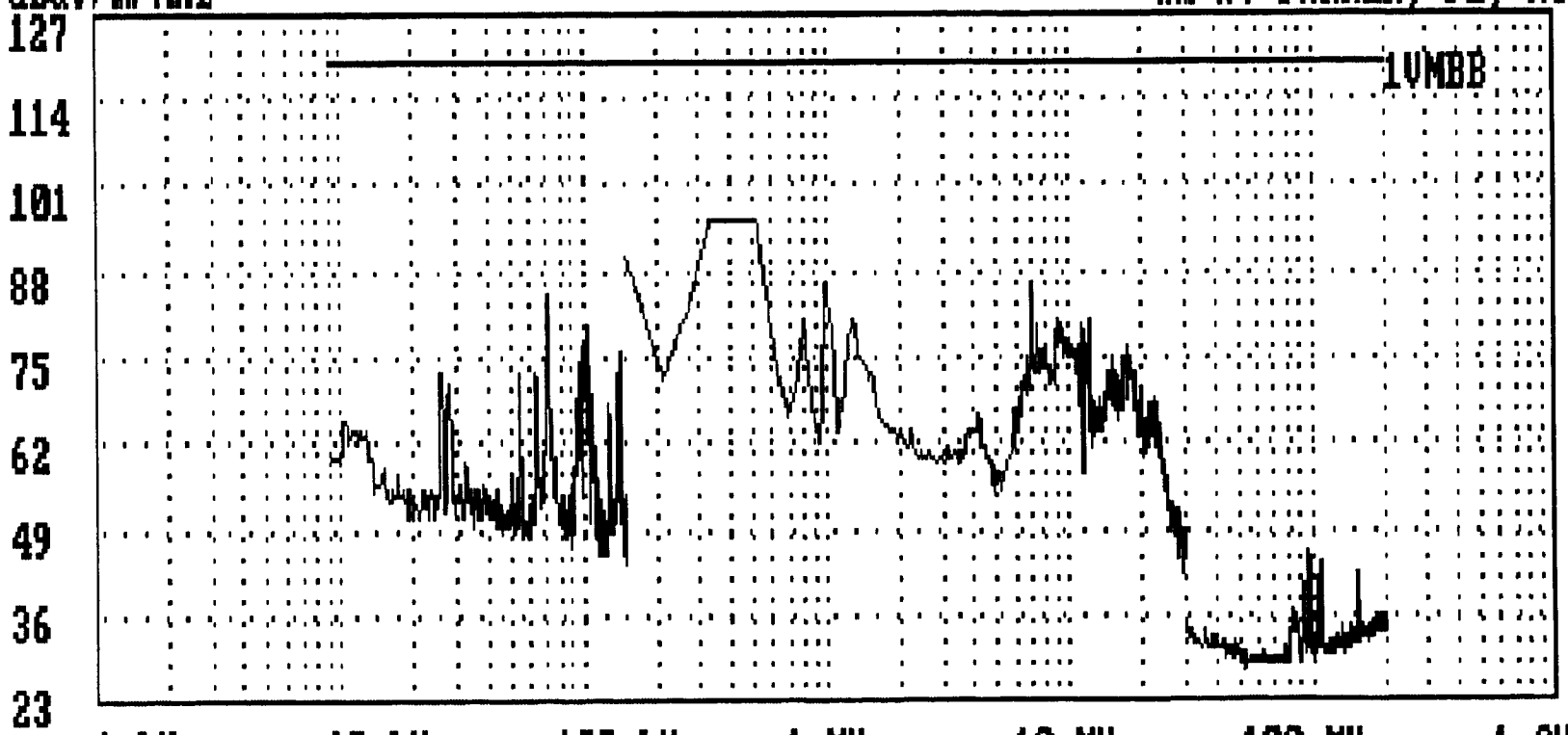
LIGO HANFORD SITE SURVEY
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

13:04:34 10-25-97

(HVAC ON)

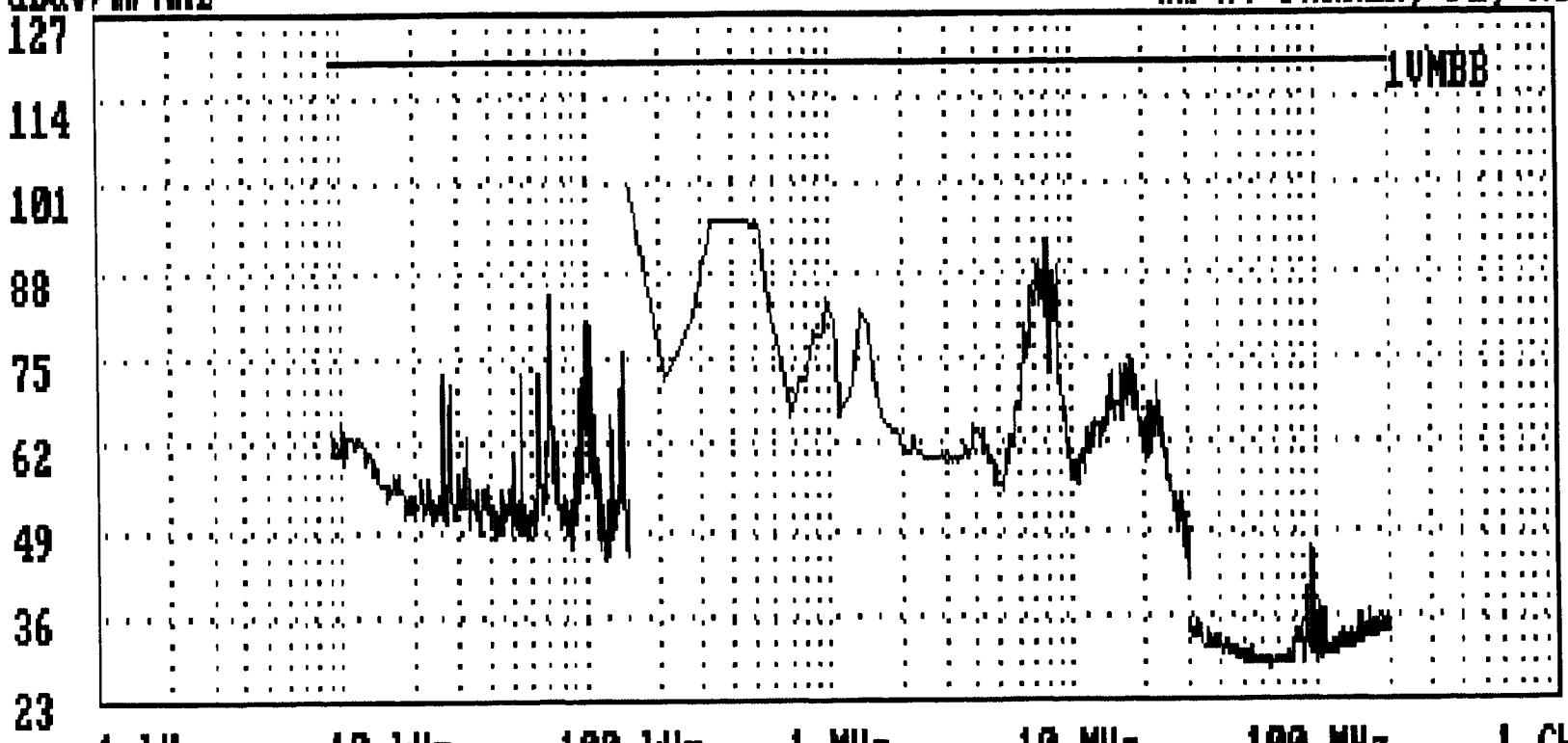
LIGO HANFORD SITE SURVEY-BROADBAND RADIATED EMISSIONS (dBuV/m/MHz)
ANTENNA POLARIZATION: VERTICAL

Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/HVAC OFF. 13:19:46 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

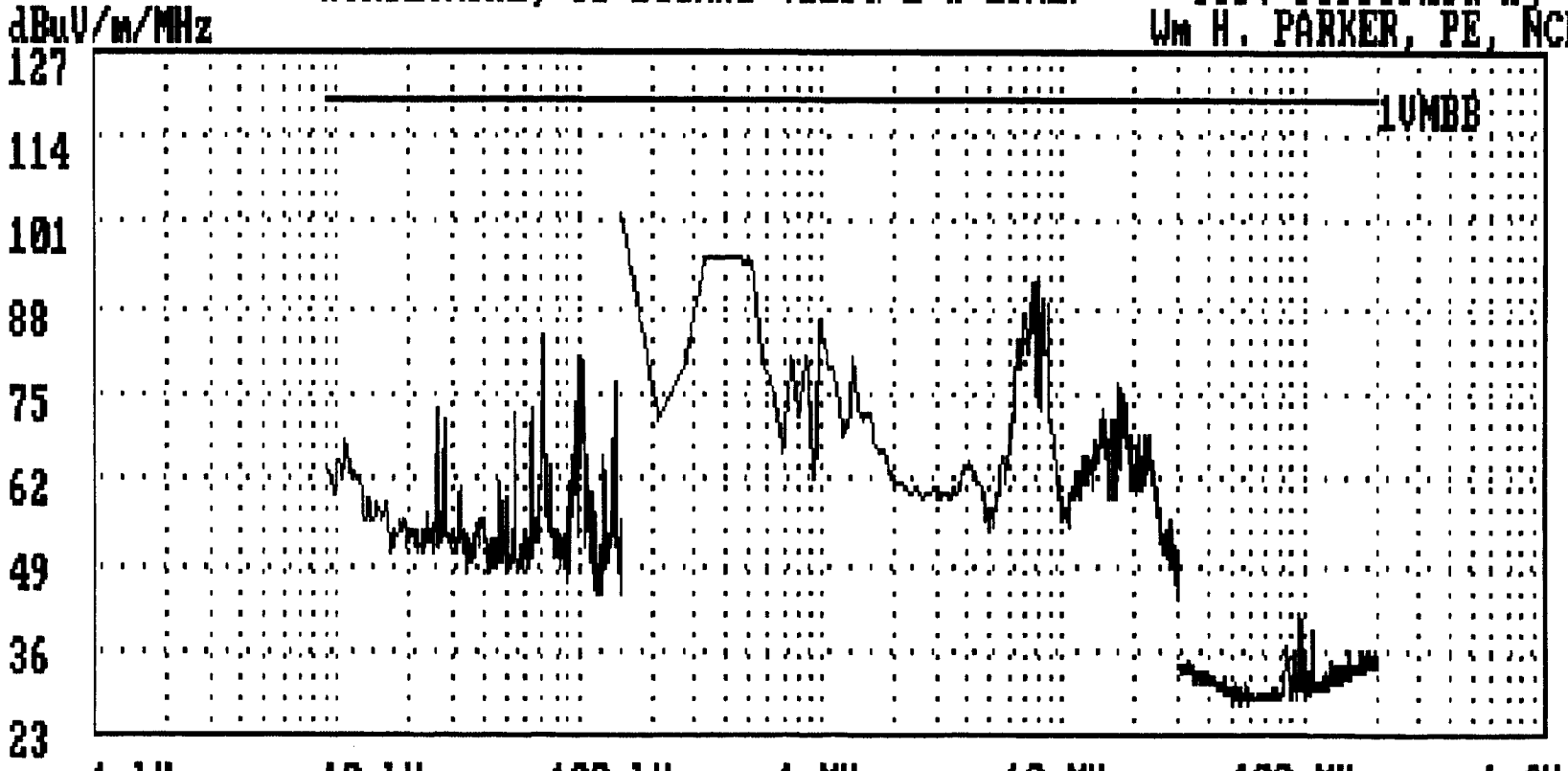
LIGO HANFORD SITE SURVEY-BROADBAND RADIATED EMISSIONS (dBuV/m/MHz)
ANTENNA POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30MHz-200MHz (BLDG N-S LINE) Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/HVAC OFF. 13:33:55 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

LIGO HANFORD SITE SURVEY-BROADBAND RADIATED EMISSIONS (dBuV/m/MHz)
ANTENNA POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30-200MHz (BLDG E-W LINE)

Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/HVAC OFF. 13:47:10 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

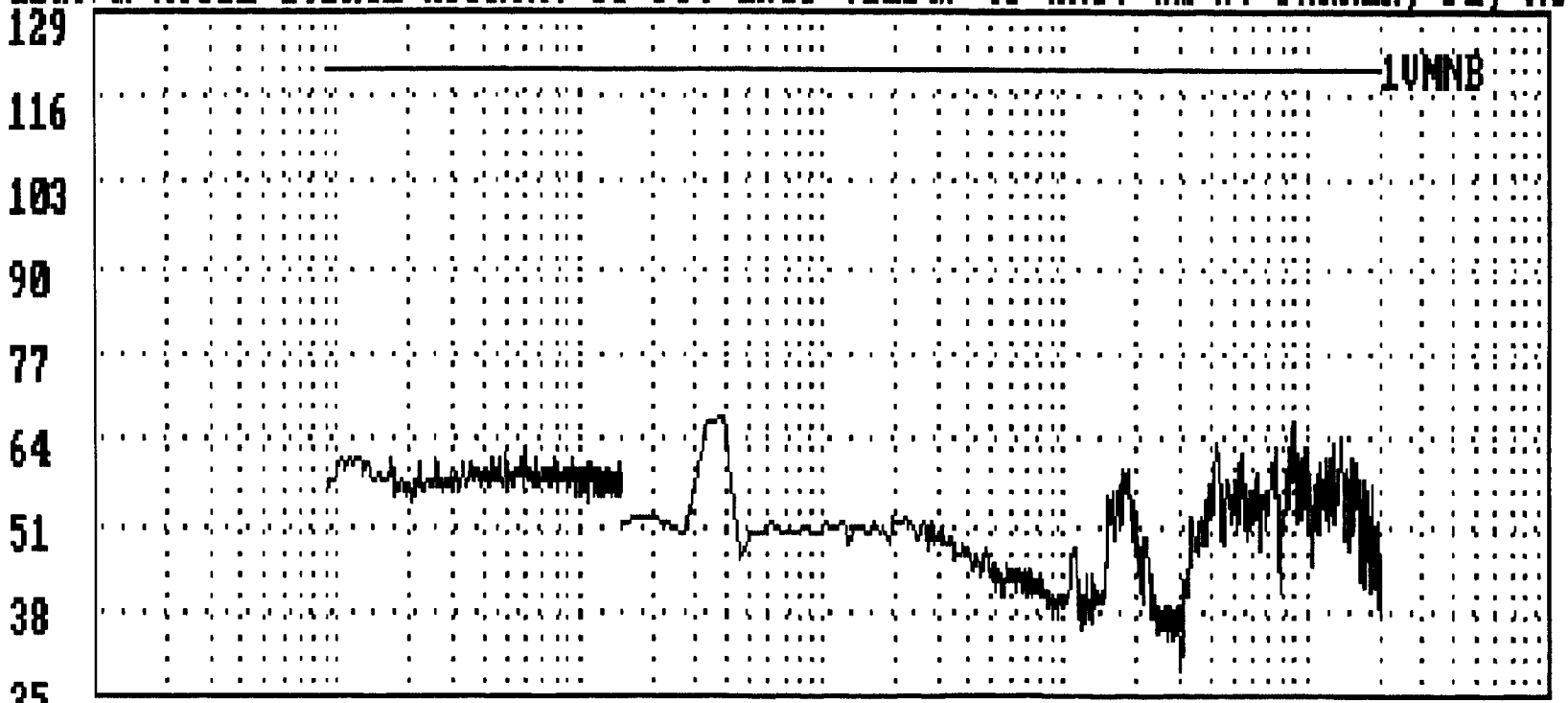
APPENDIX B-2

EMI SURVEY TEST DATA

5. RF "Q" LVEA, 10 kHz - 200 MHz

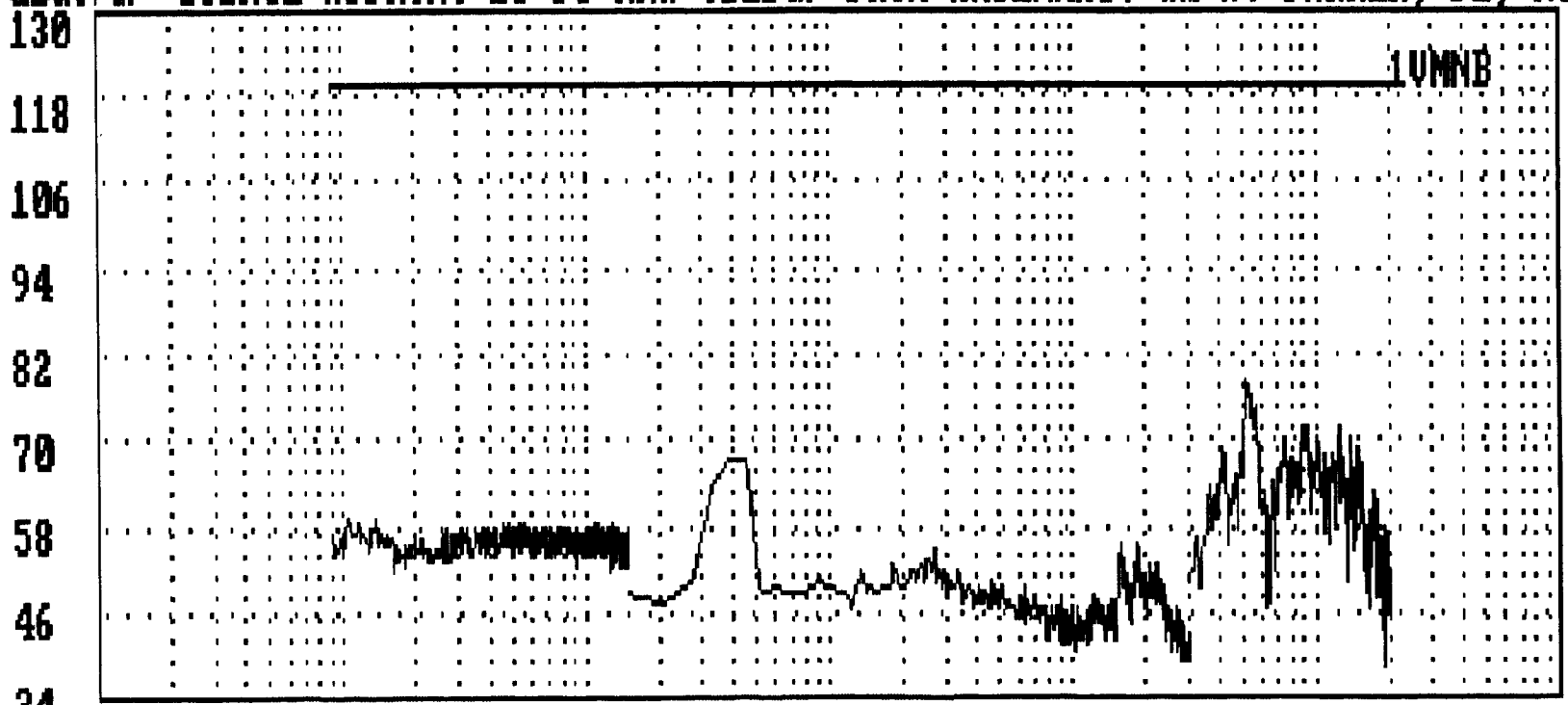
LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
POLARIZATION: VERTICAL

Test Performed by
dBuV/m NOISE SOURCE APPROX. 55 FT. EAST (BLDG) OF ANT. Wm H. PARKER, PE, NCE



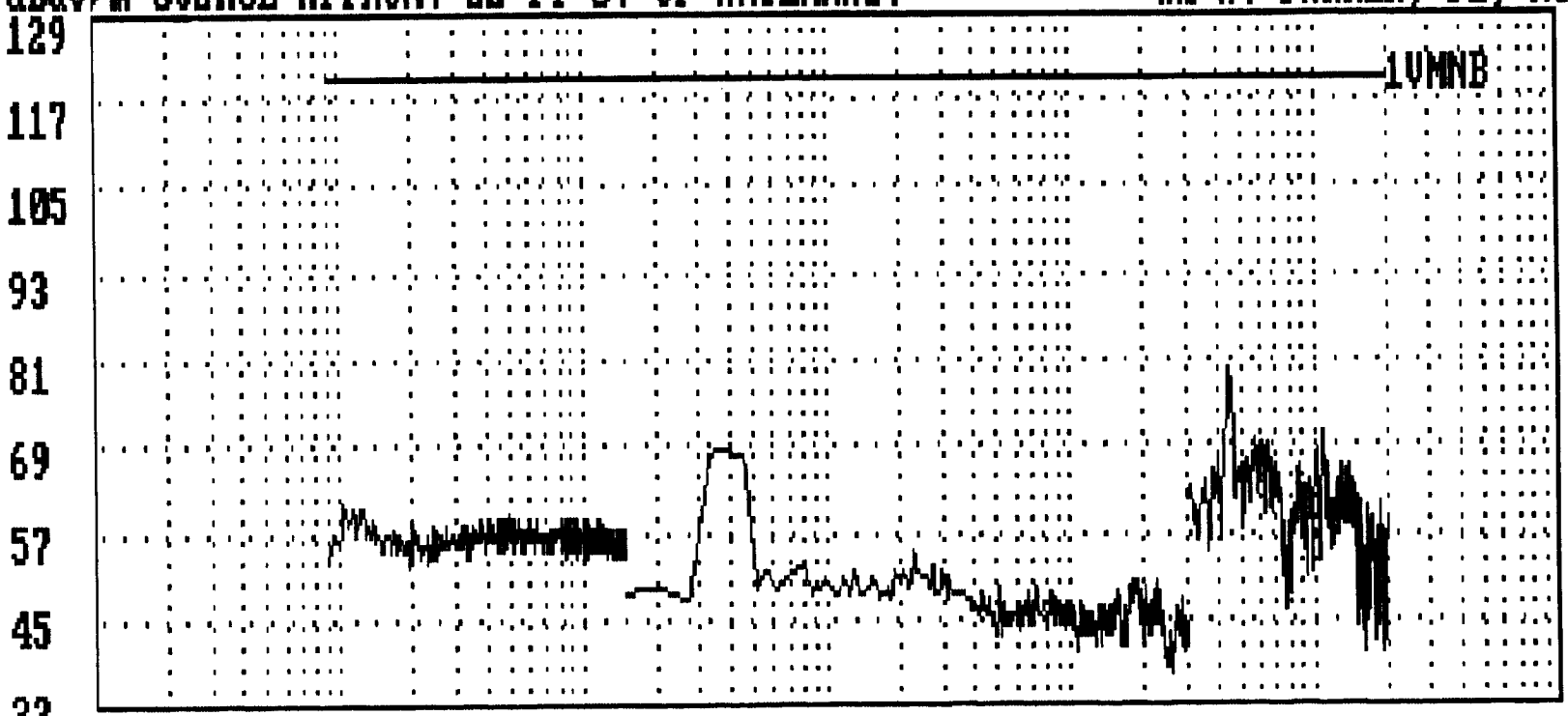
LIGO HANFORD SITE SURVEY W/WHITE NOISE SOURCE. 16:00:27 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
POLARIZATION: VERTICAL, 9kHz-30MHz; HORIZ.,30-200MHz.
Test Performed by
dBuV/m SOURCE APPROX. 28 FT NNW (BLDG) FROM ANTENNAS. Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/WHITE NOISE SOURCE. 16:19:10 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
POLARIZATION: VERTICAL, 9kHZ-30MHz; HORIZ., 30-200MHz.
Test Performed by
dBuV/m SOURCE APPROX. 22 FT S. OF ANTENNAS. Wm H. PARKER, PE, NCE

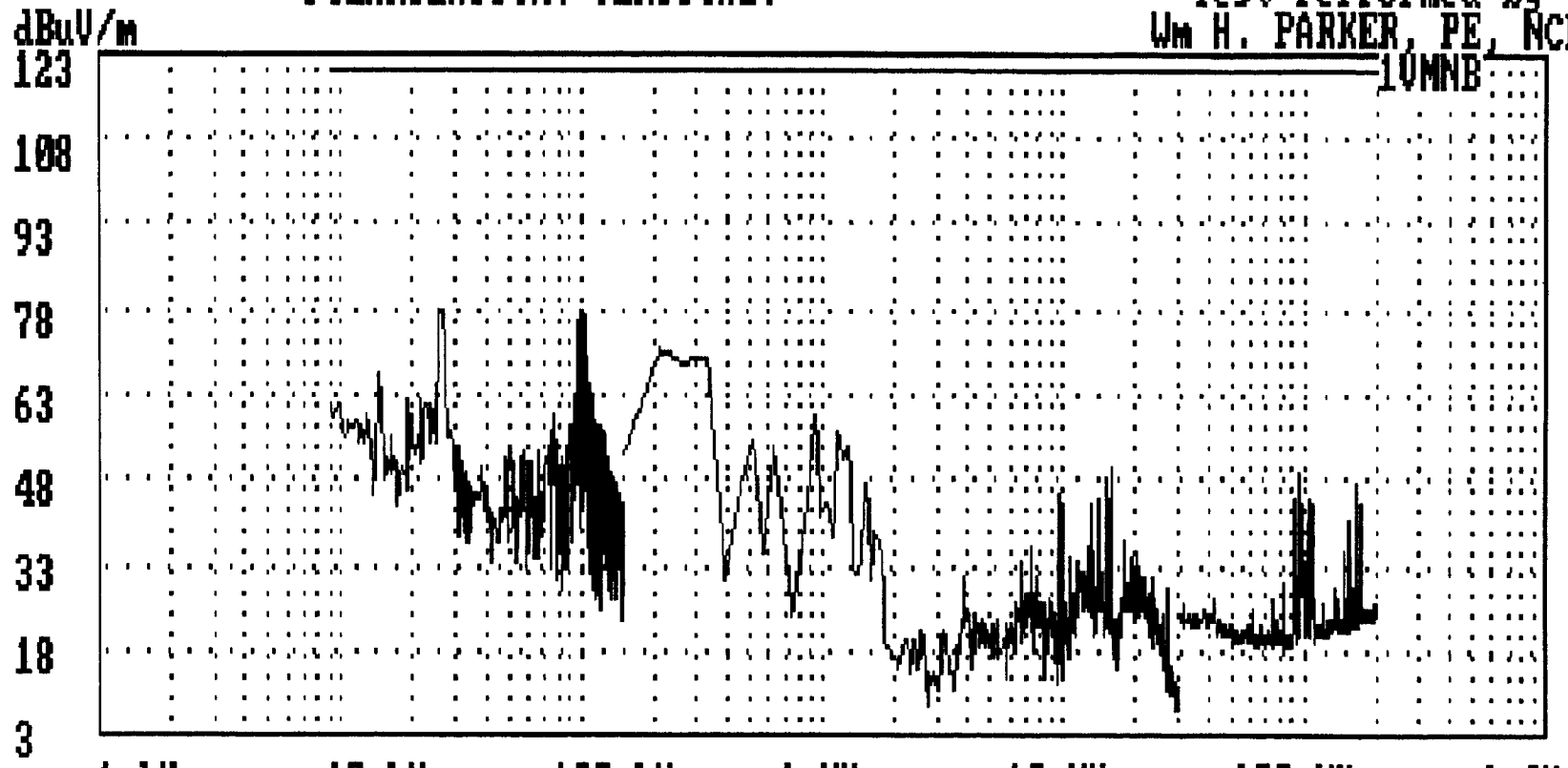


LIGO HANFORD SITE SURVEY U/WHITE NOISE SOURCE. 16:33:33 10-25-97
LOCATION:INSIDE LVEA, NEAR VERTEX (POSITION #2).

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS

POLARIZATION: VERTICAL.

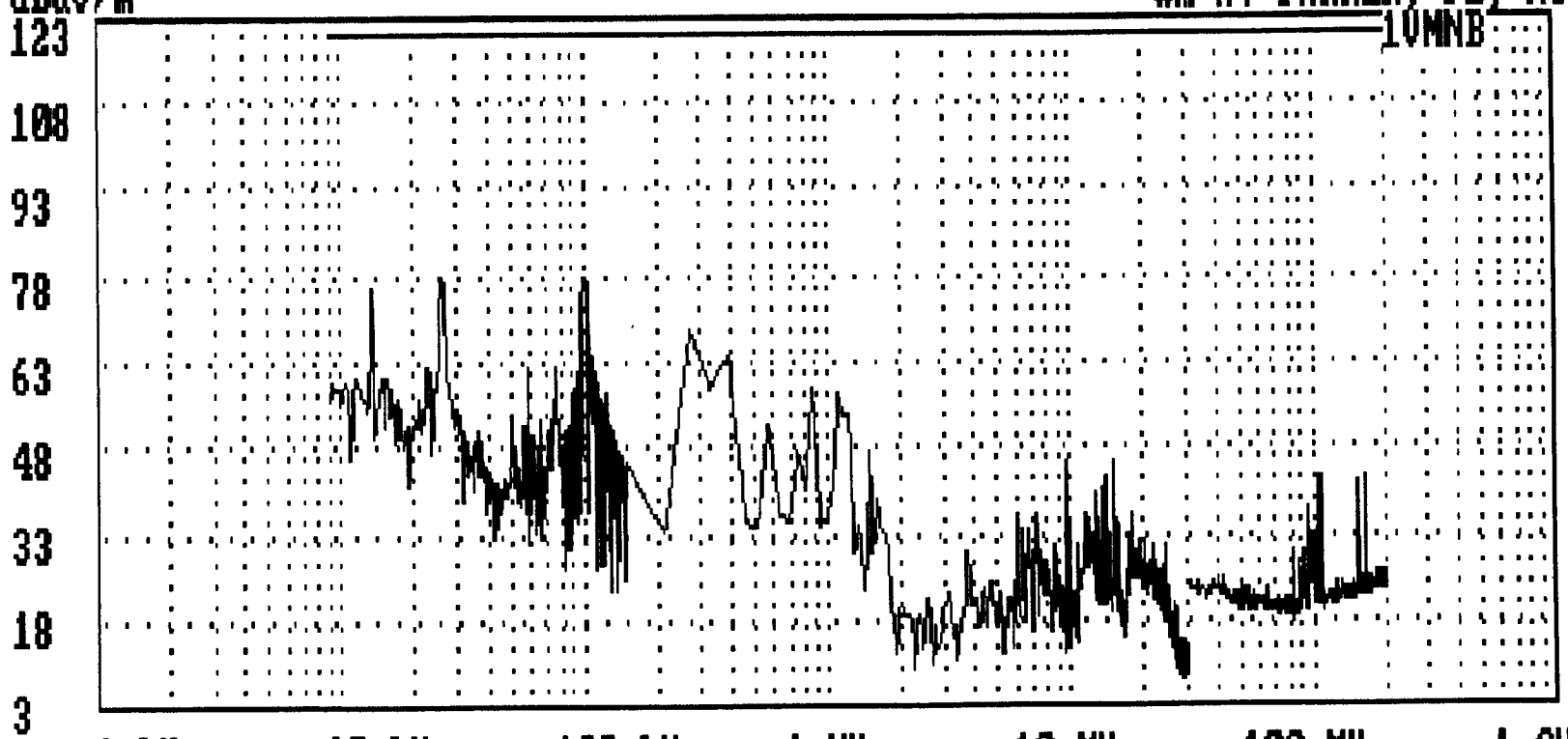
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY AMBIENT PROFILE. 11:16:41 10-26-97
ON CONCRETE PAD, BLDG NORTH, EAST OF BEAM TUBE ENCLOSURE.

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30-200MHz (BLDG N-S).

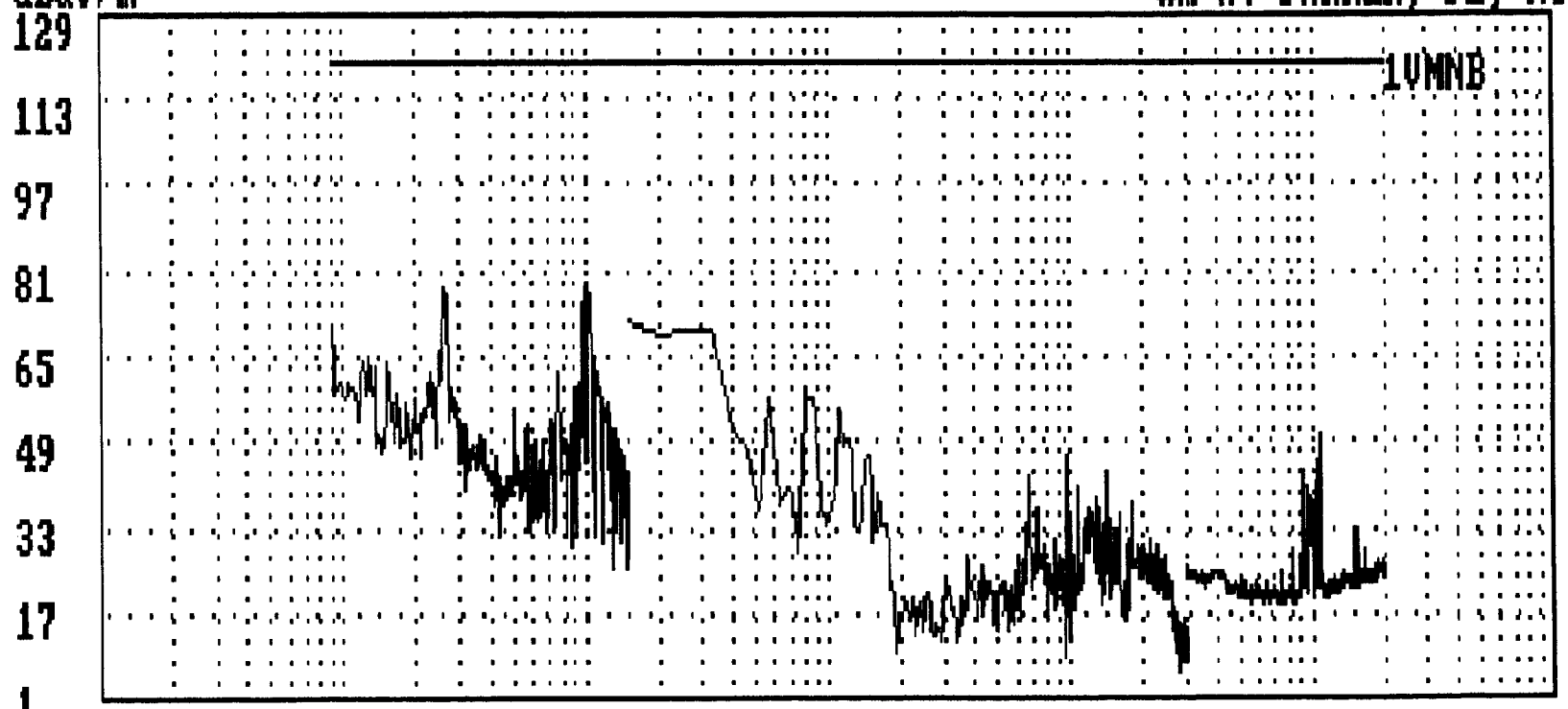
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY AMBIENT PROFILE. 11:51:21 10-26-97
ON CONCRETE PAD, BLDG NORTH, EAST OF BEAM TUBE ENCLOSURE.

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30-200MHz (BLDG E-W).

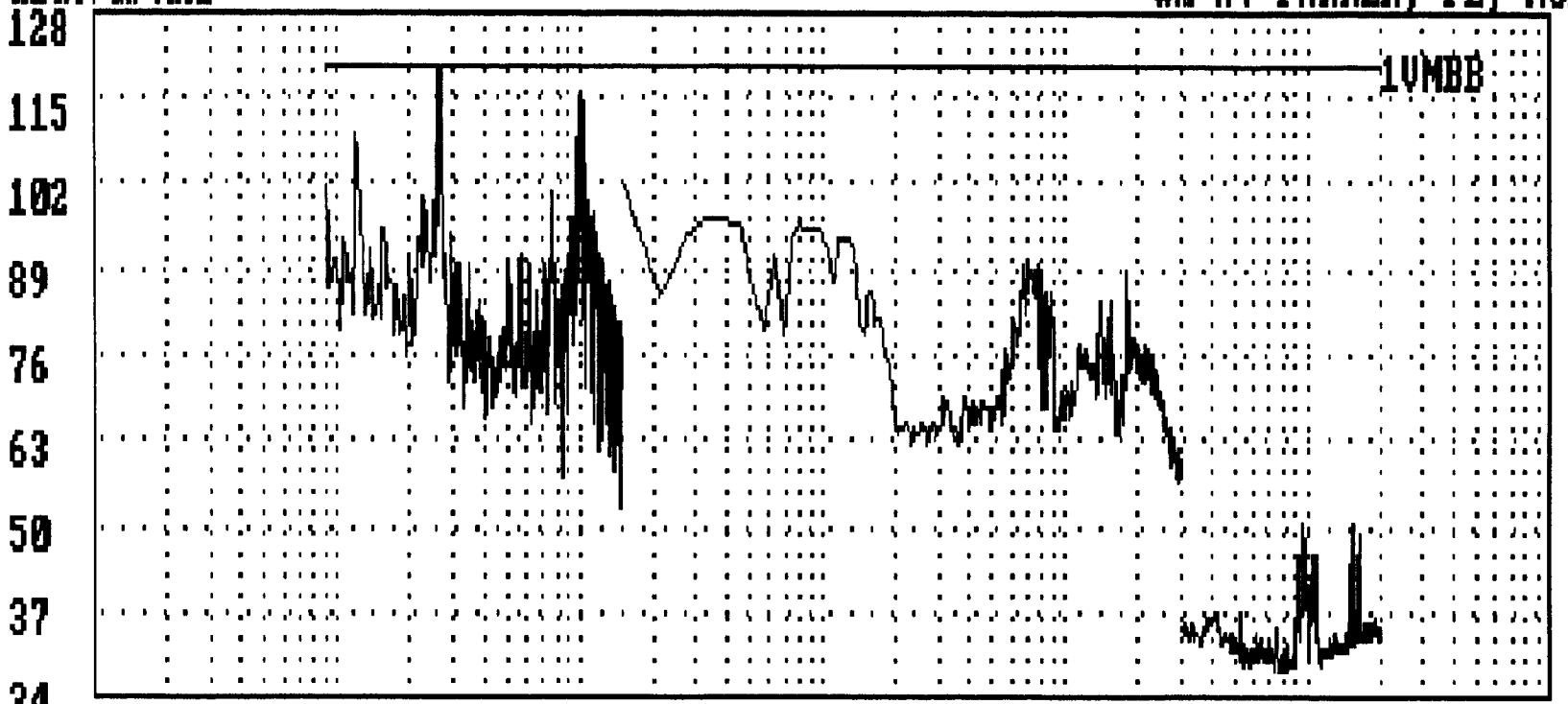
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY AMBIENT PROFILE. 11:39:53 10-26-97
ON CONCRETE PAD, BLDG NORTH, EAST OF BEAM TUBE ENCLOSURE.

LIGO HANFORD SITE SURVEY-BROADBAND RADIATED EMISSIONS (dBuV/m/MHz)
POLARIZATION: VERTICAL.

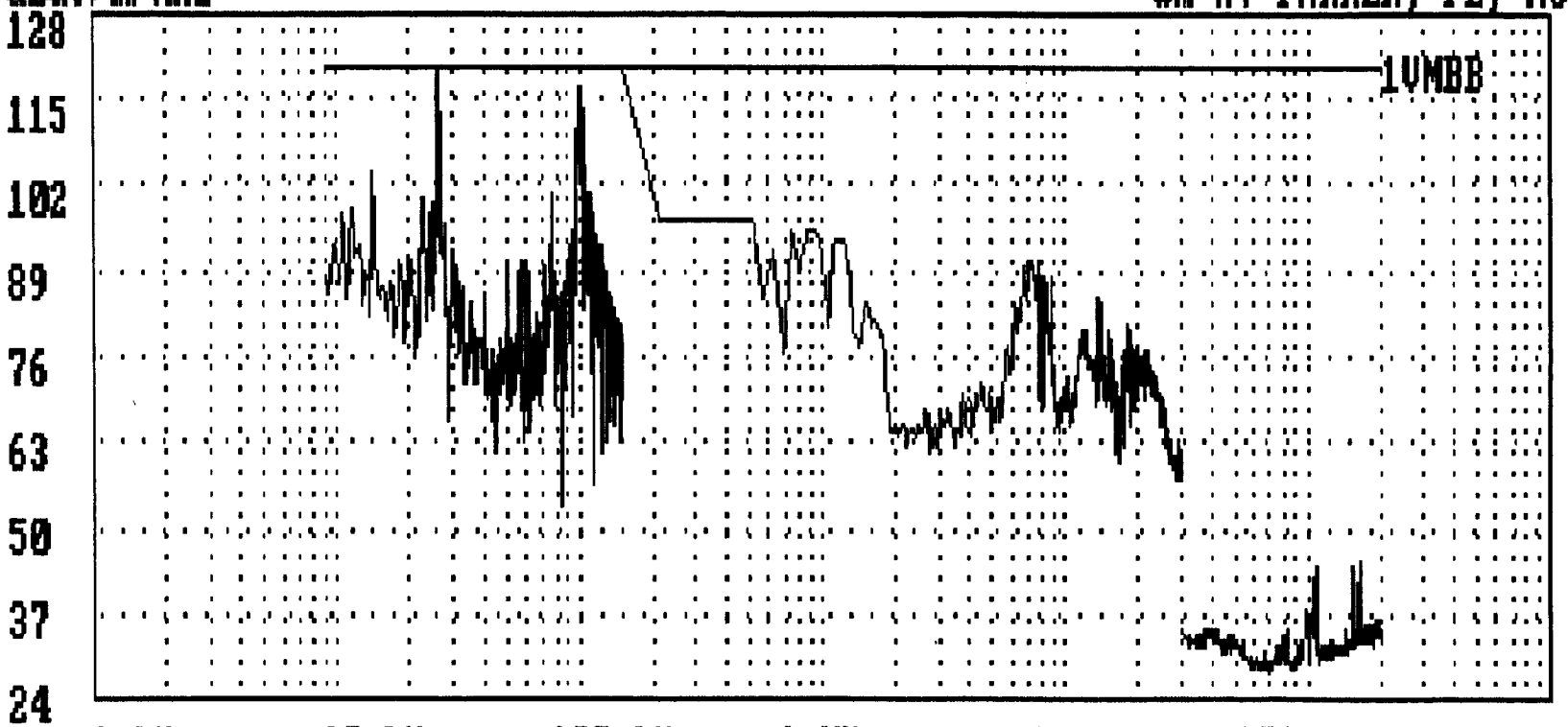
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY AMBIENT PROFILE, 12:02:43 10-26-97
ON CONCRETE PAD, BLDG NORTH, EAST OF BEAM TUBE ENCLOSURE.

LIGO HANFORD SITE SURVEY-BROADBAND RADIATED EMISSIONS (dBuV/m/MHz)
POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30-200MHz (BLDG N-S).

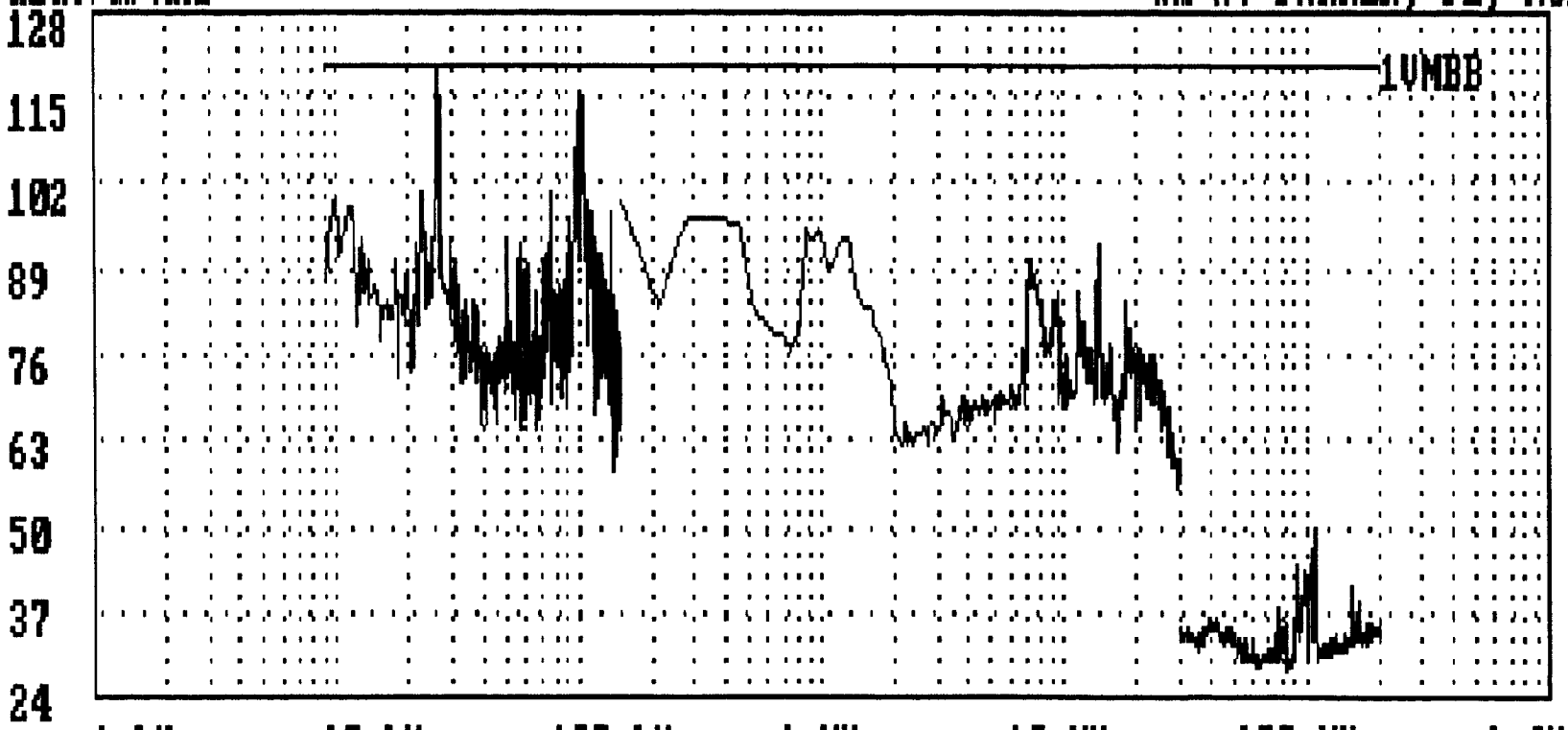
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY AMBIENT PROFILE. 12:23:41 10-26-97
ON CONCRETE PAD, BLDG NORTH, EAST OF BEAM TUBE ENCLOSURE.

LIGO HANFORD SITE SURVEY-BROADBAND RADIATED EMISSIONS (dBuV/m/MHz)
POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30-200MHz (BLDG E-W).

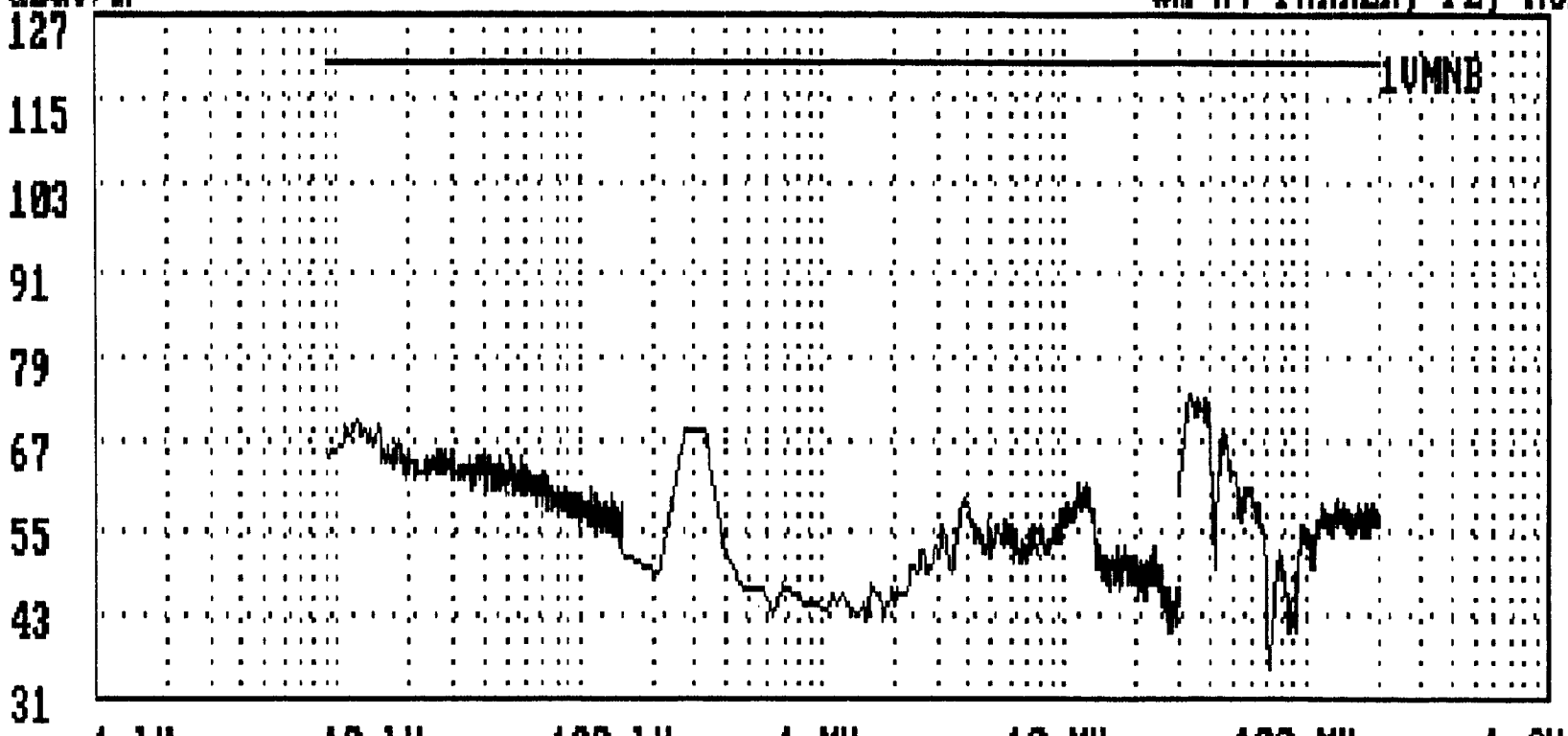
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY AMBIENT PROFILE. 12:11:14 10-26-97
ON CONCRETE PAD, BLDG NORTH, EAST OF BEAM TUBE ENCLOSURE.

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
ANTENNA POLARIZATION: VERTICAL

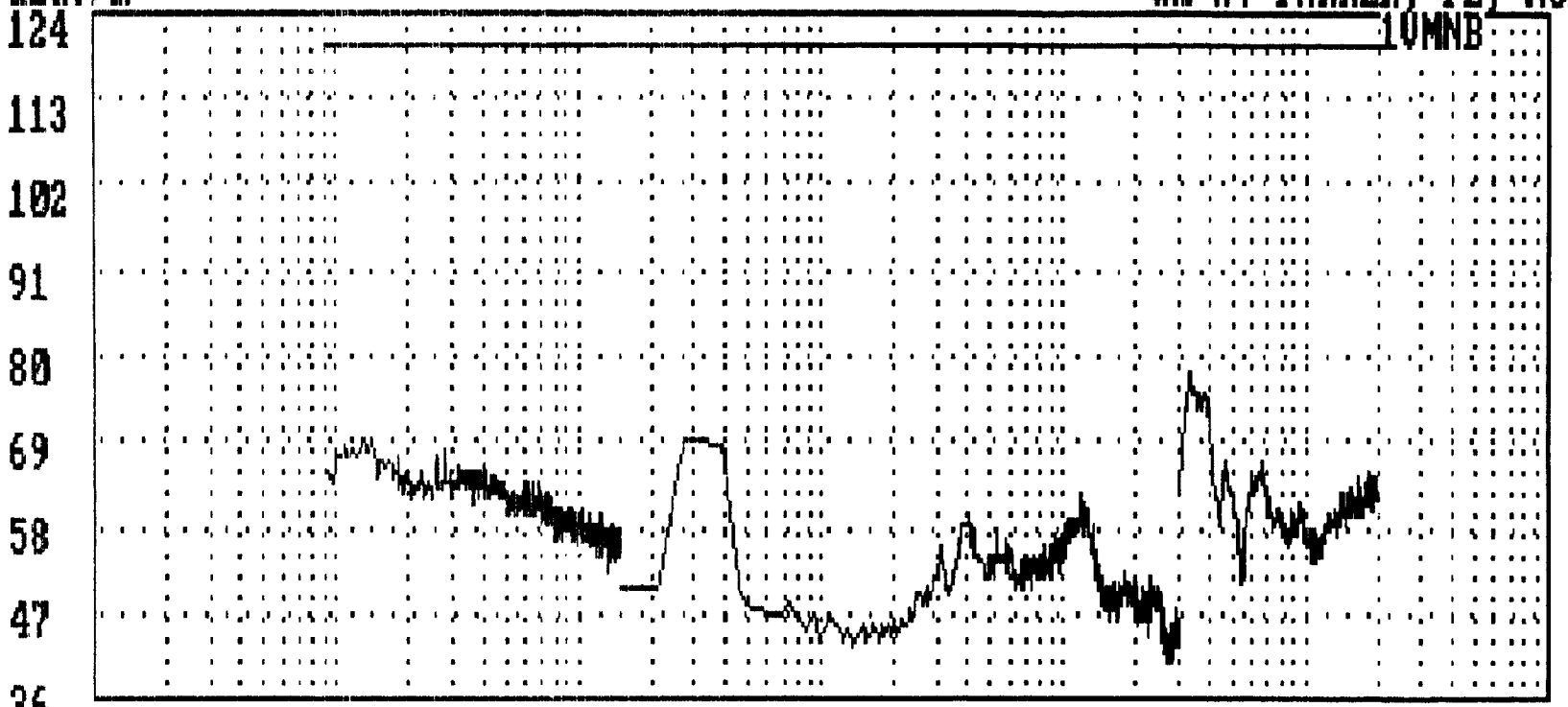
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY Q TEST-SOURCE OUTSIDE 10:44:07 10-26-97
ON CONCRETE PAD, BLDG NORTH, EAST OF BEAM TUBE ENCLOSURE.

LIGO HANFORD SITE SURVEY-RADIATED EMISSIONS
POLARIZATION: VERTICAL, 9kHz-30MHz;
HORIZONTAL, 30-200MHz.

Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY Q TEST-SOURCE OUTSIDE 11:02:00 10-26-97
ON CONCRETE PAD, BLDG NORTH, EAST OF BEAM TUBE ENCLOSURE.

APPENDIX B-3

EMI SURVEY TEST DATA

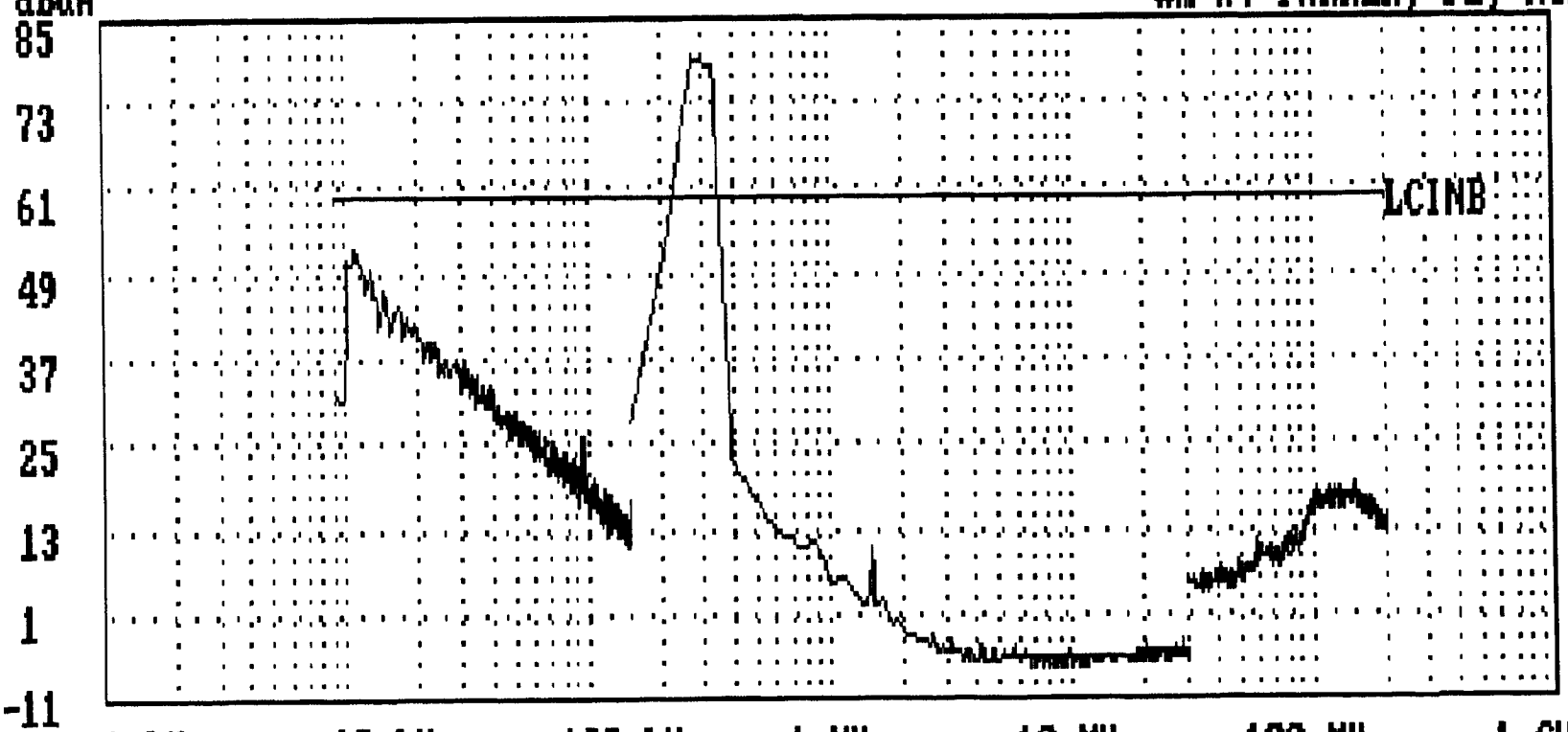
Conducted Emissions, Technical Power, 9 kHz - 200 MHz

8. Power Panel for CDS Rack for BSC-1, Night/weekend, HVAC on.

9. Power Panel for CDS Rack for BSC-1, Night/weekend, HVAC off.

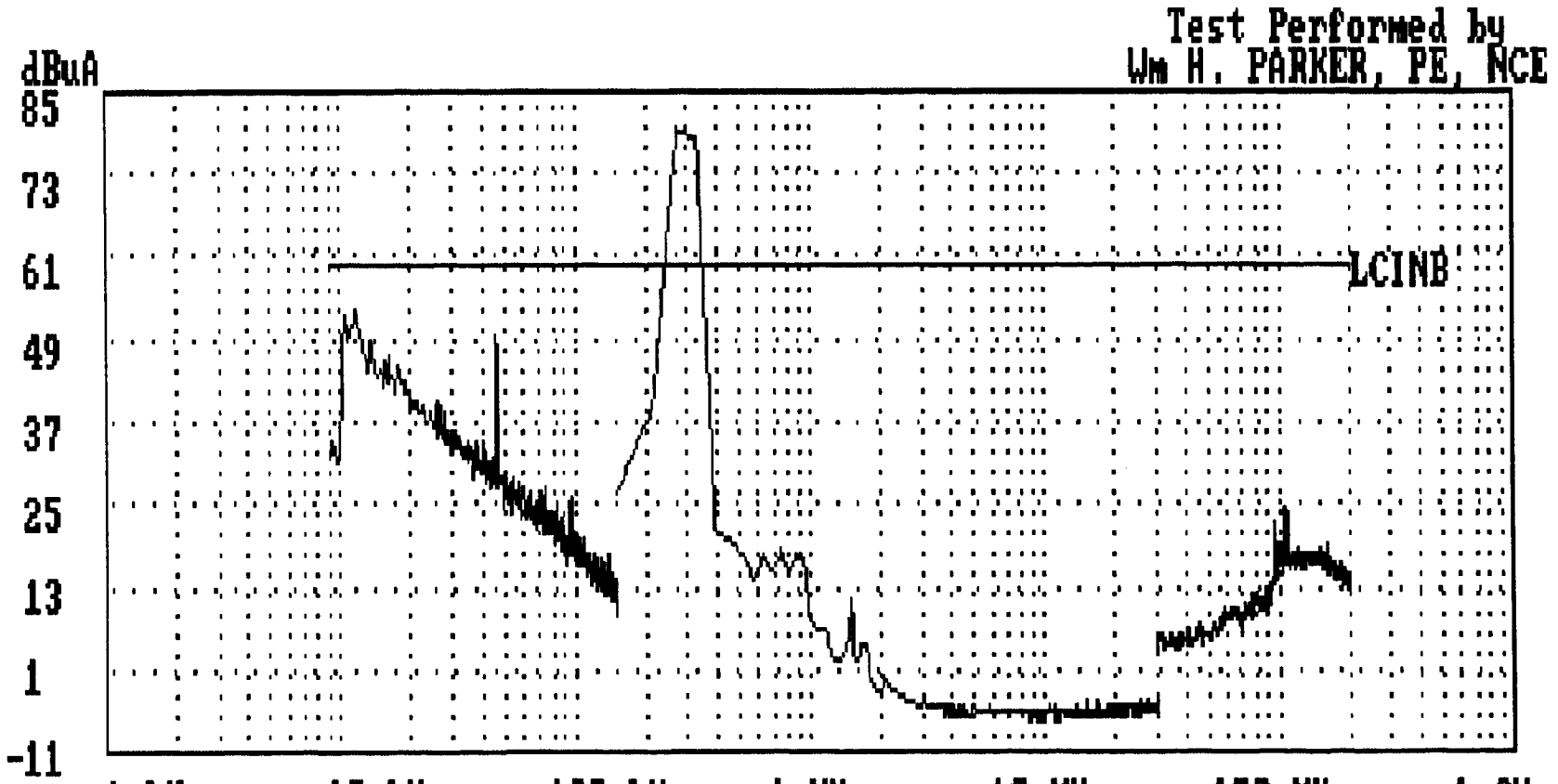
CONDUCTED EMISSIONS-HIGH LEAD
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuA)

Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/7 AMP/120VAC RES. LOAD. 14:13:39 10-26-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC ON.

CONDUCTED EMISSIONS-RETURN LEAD.
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuA)

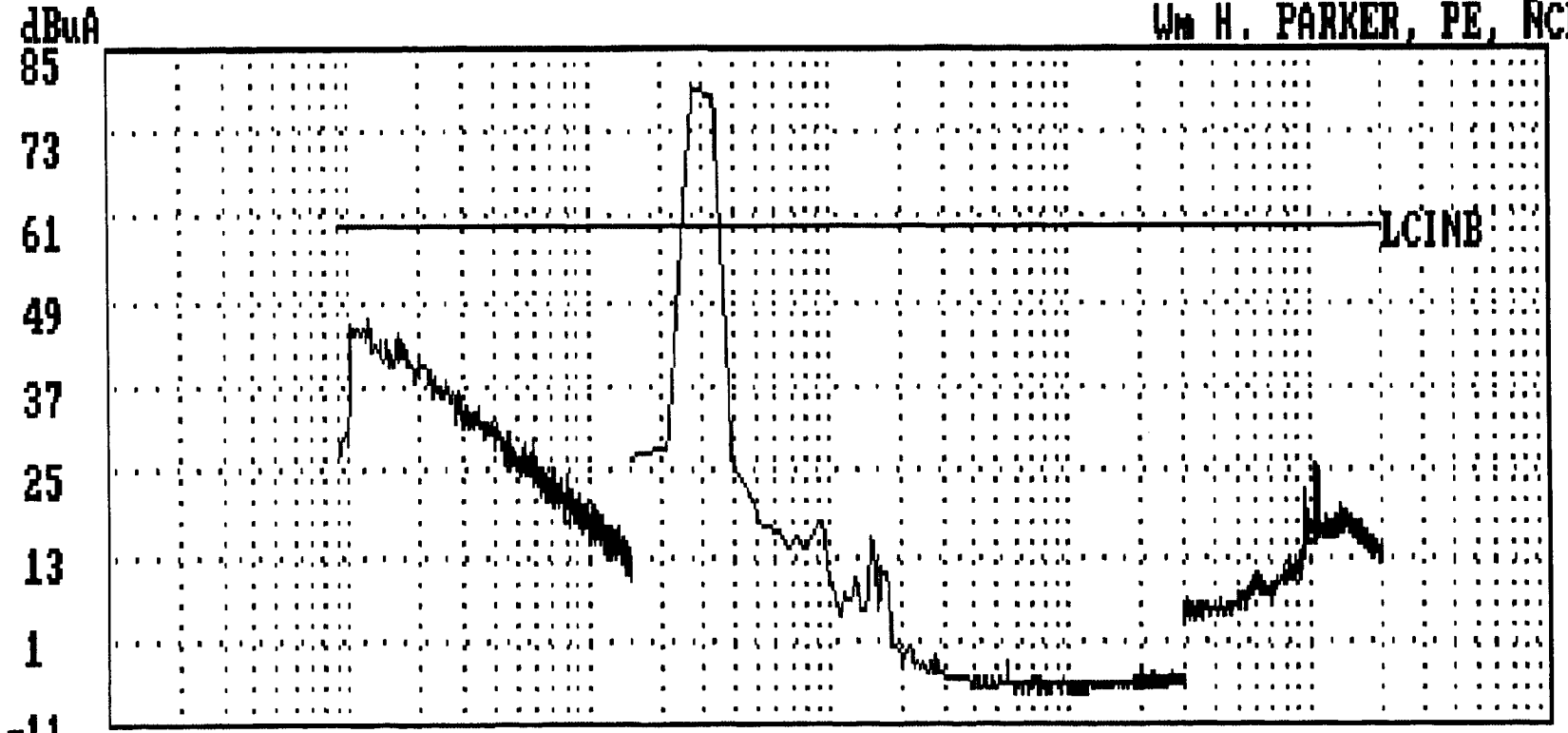


LIGO HANFORD SITE SURVEY W/7 AMP/120VAC RES. LOAD. 14:23:07 10-26-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC ON.

CONDUCTED EMISSIONS-COMMON MODE (HIGH & RTN LEADS)

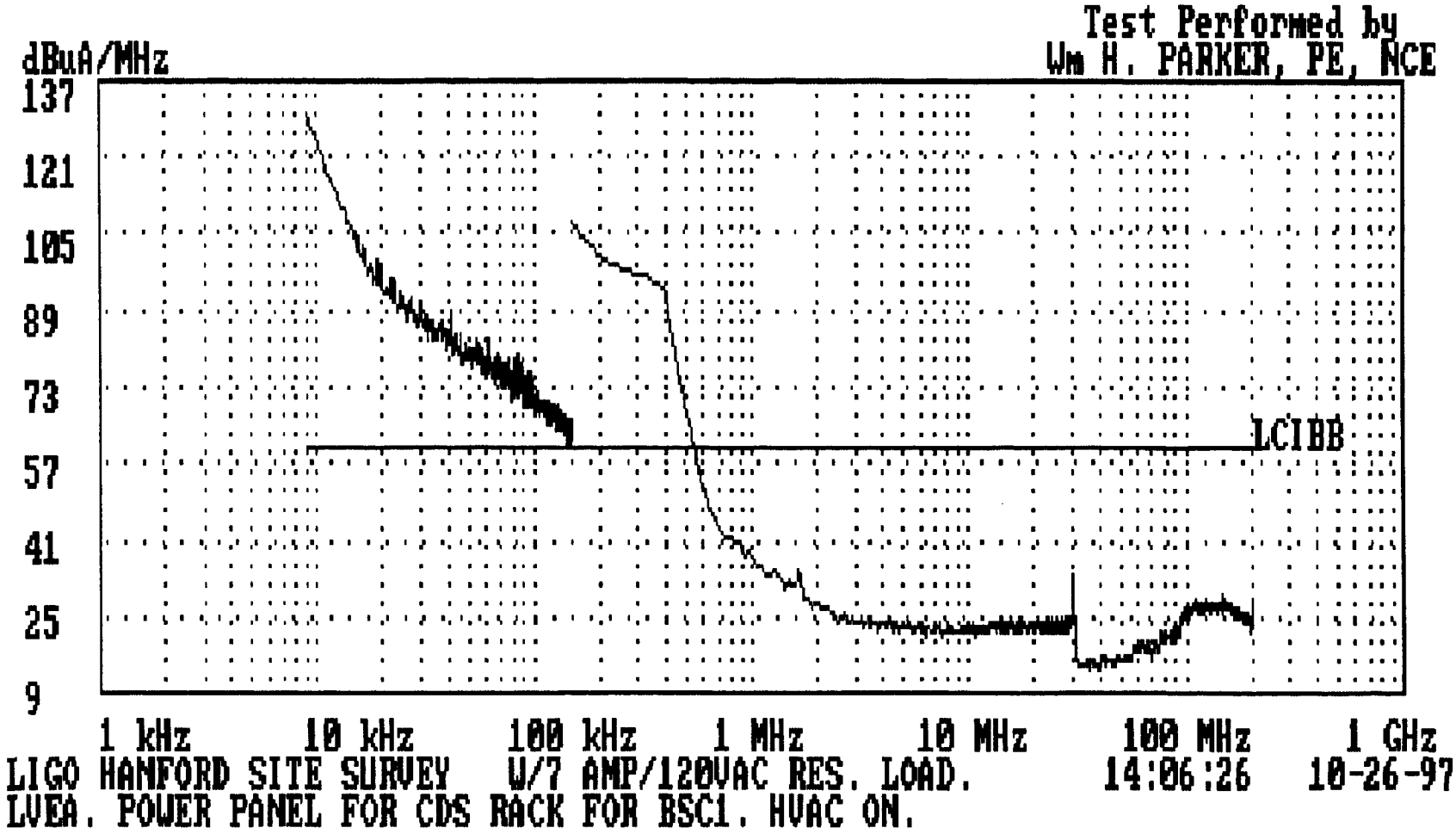
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuA)

Test Performed by
Wm H. PARKER, PE, NCE



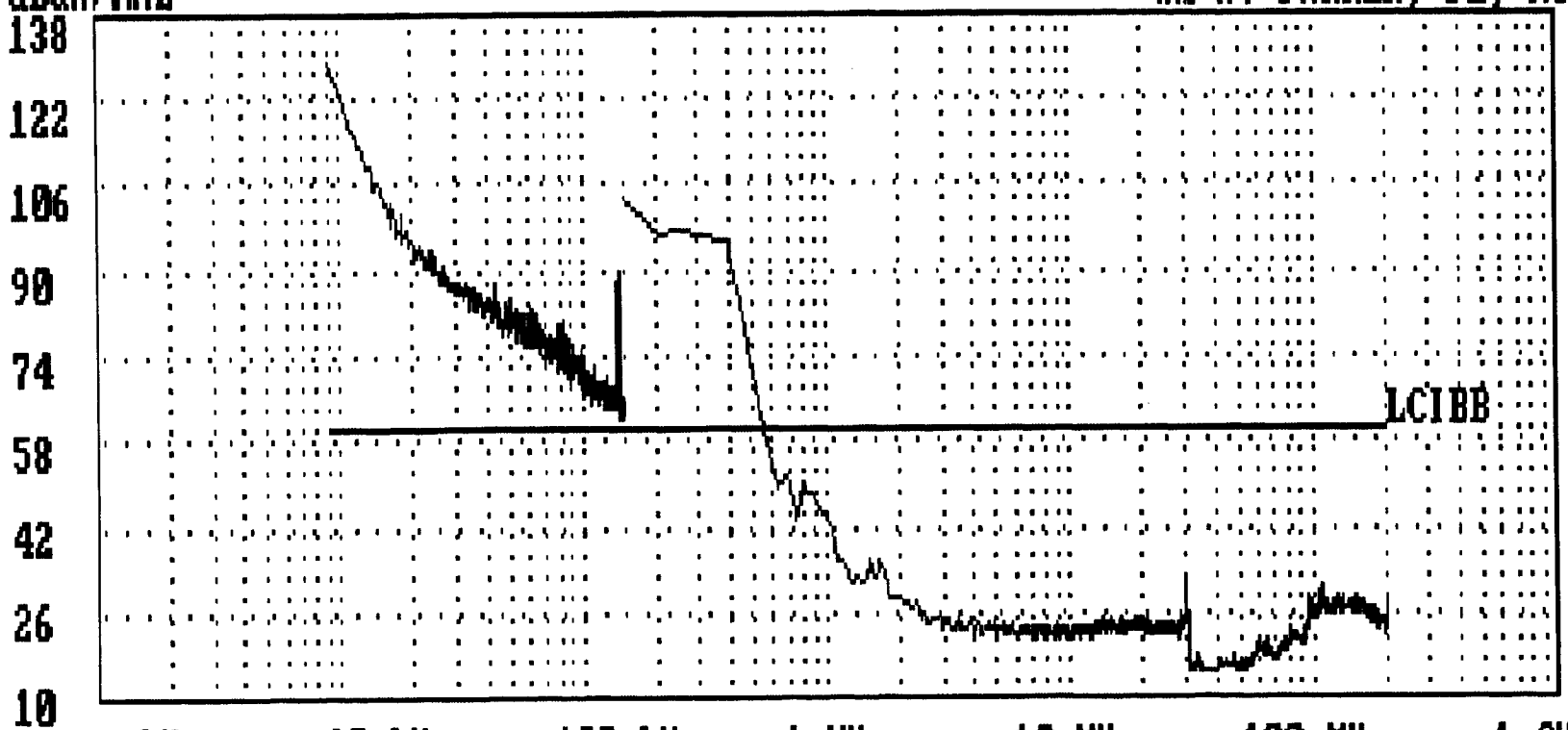
LIGO HANFORD SITE SURVEY W/7 AMP/120VAC RES. LOAD. 14:51:02 10-26-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC ON.

CONDUCTED EMISSIONS-HIGH LEAD
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS, BROADBAND (dBuA/MHz)



CONDUCTED EMISSIONS-RETURN LEAD.
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS, BROADBAND (dBuA/MHz)

Test Performed by
Wm H. PARKER, PE, NCE

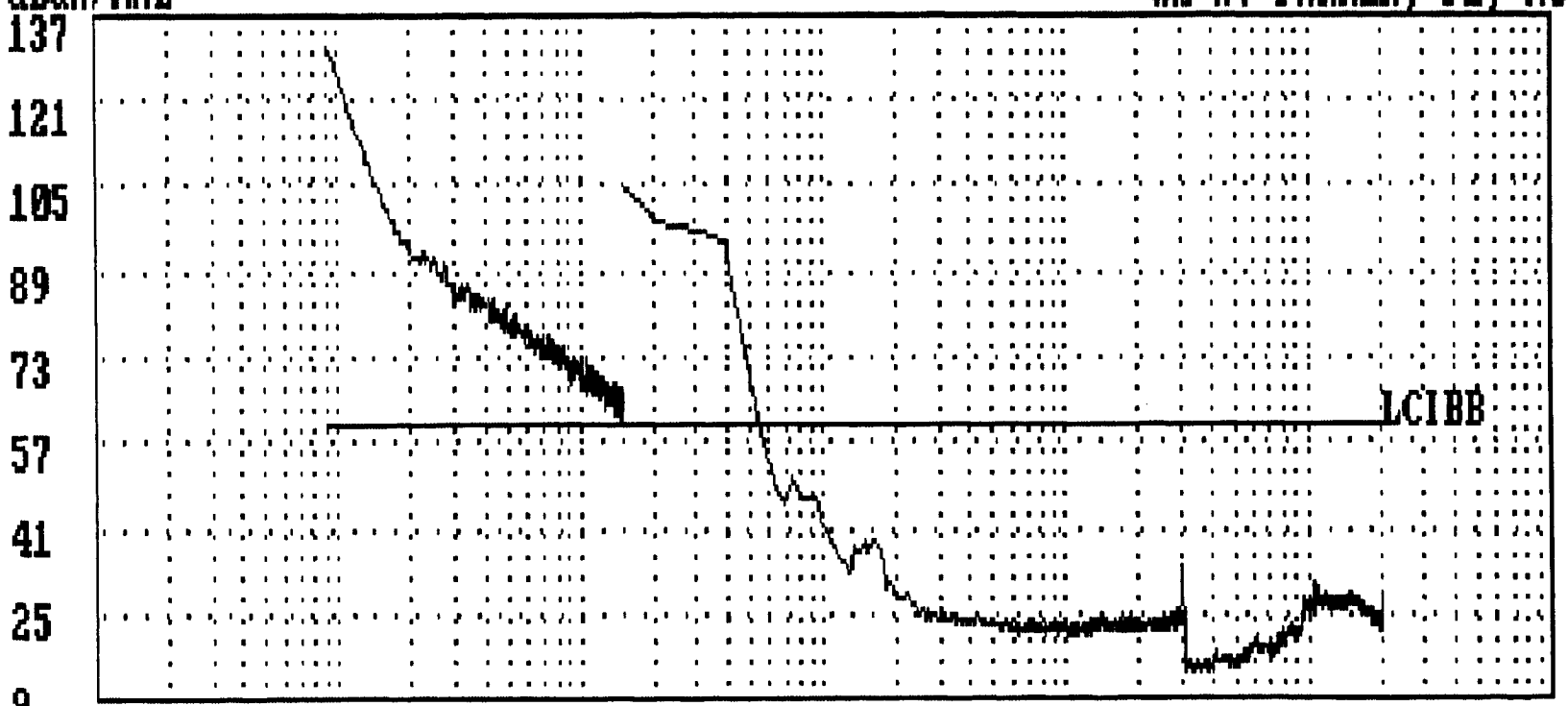


LIGO HANFORD SITE SURVEY W/7 AMP/120VAC RES. LOAD. 14:35:06 10-26-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC ON.

CONDUCTED EMISSIONS-COMMON MODE (HIGH & RTN LEADS)

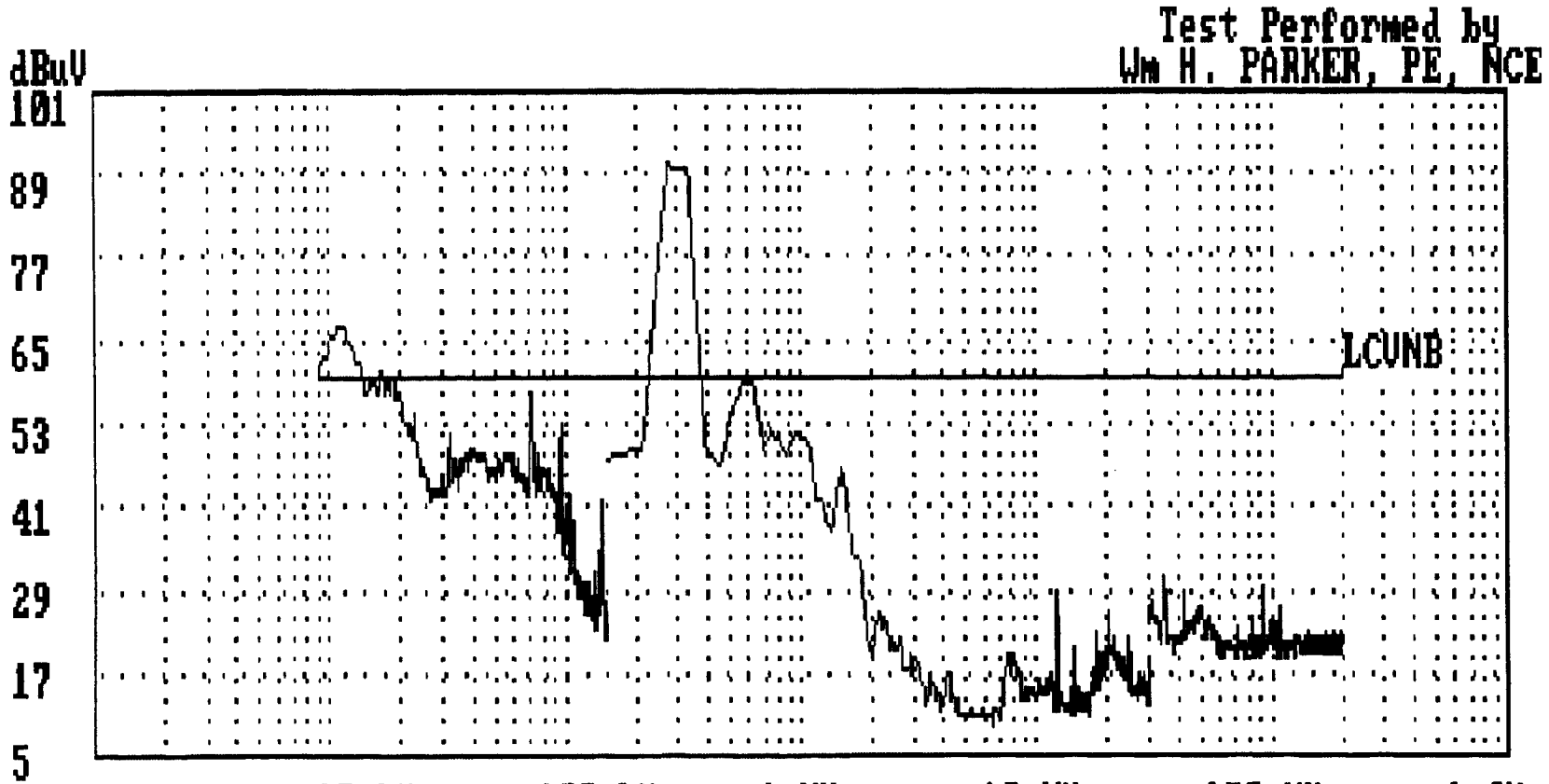
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS, BROADBAND (dBuA/MHz)

Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/7 AMP/120VAC RES. LOAD. 14:42:16 10-26-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC ON.

CONDUCTED EMISSIONS-HIGH LEAD
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuV)

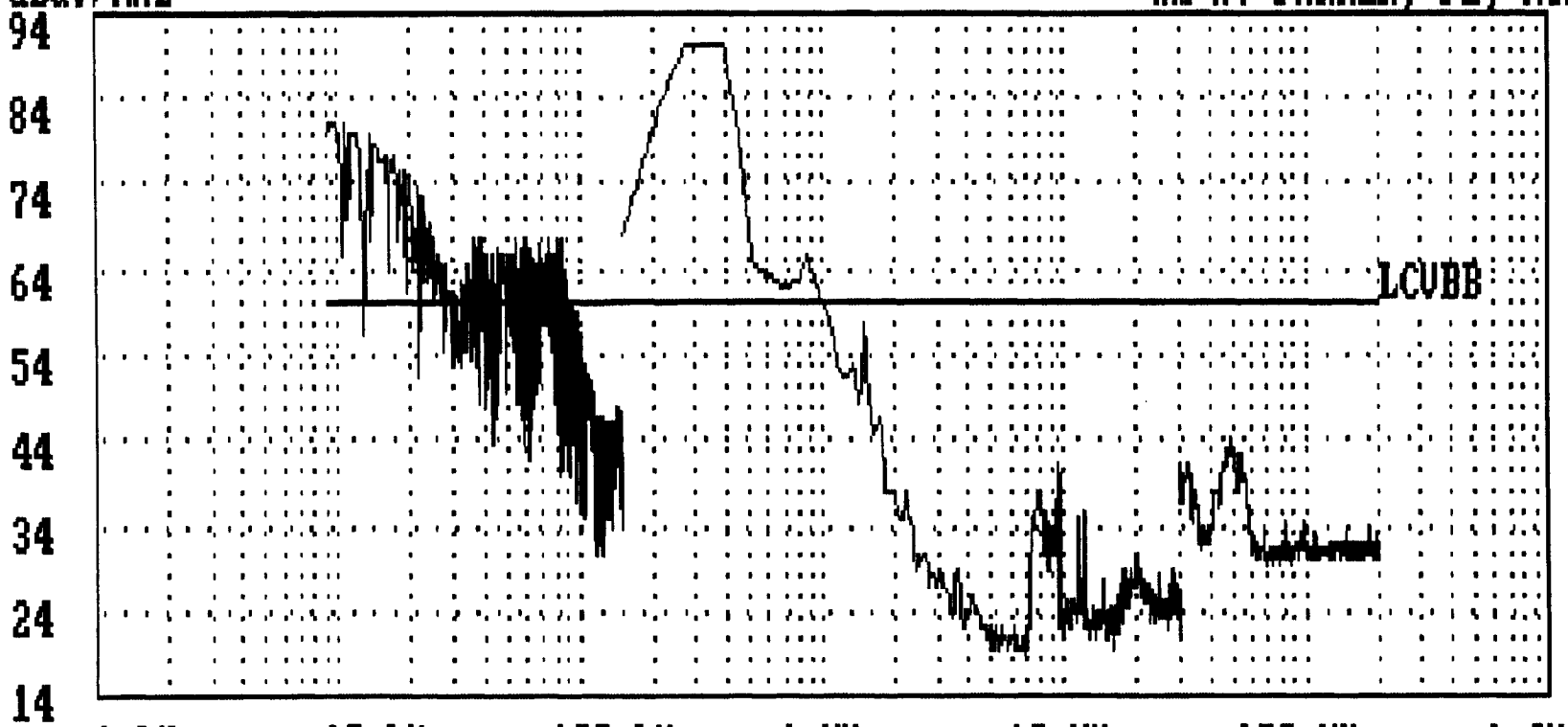


LIGO HANFORD SITE SURVEY W/7 AMP/120VAC RES. LOAD. 15:14:21 10-26-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC ON.

CONDUCTED EMISSIONS-HIGH LEAD

LIGO HANFORD SITE SURVEY-BROADBAND CONDUCTED EMISSIONS (dBuV/MHz)

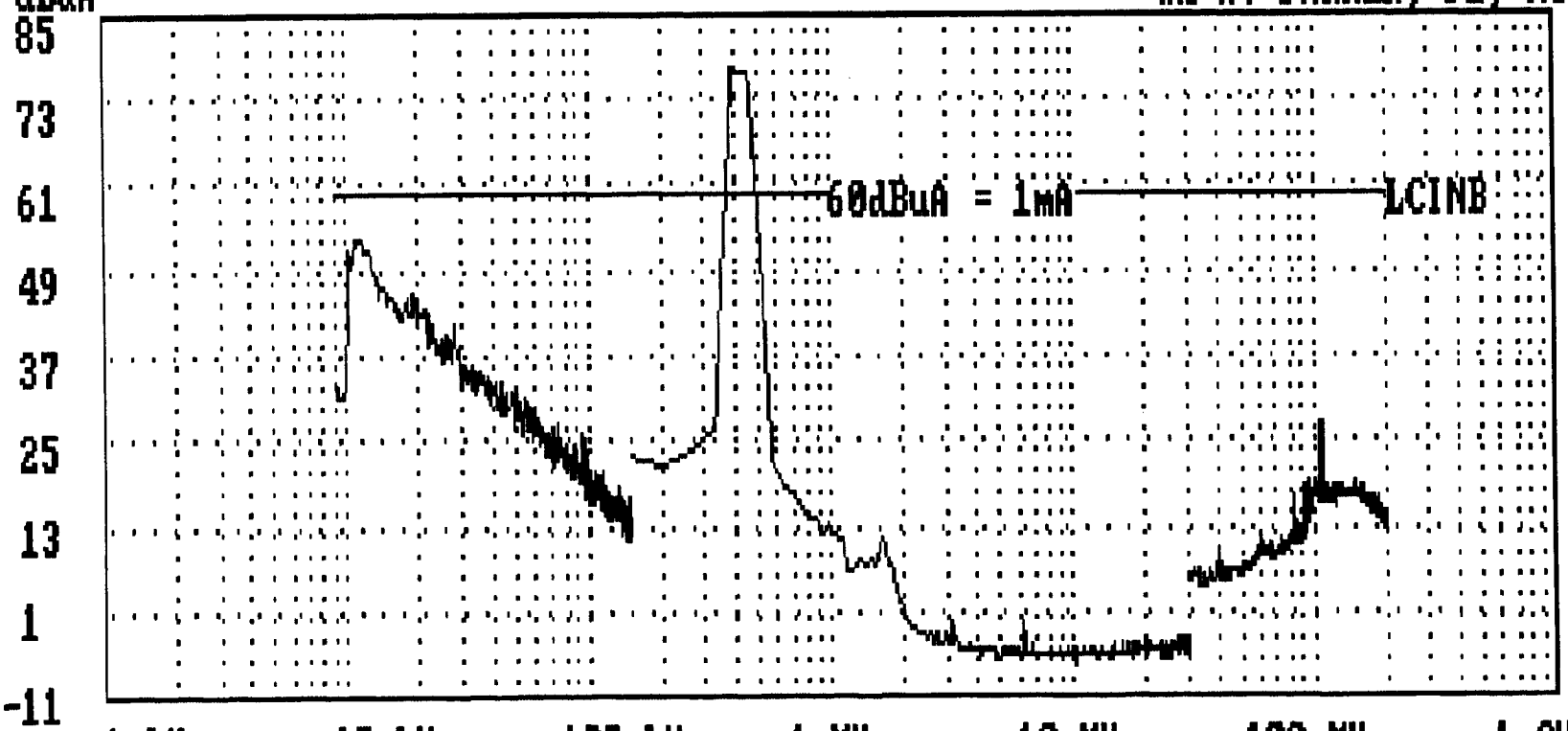
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/7 AMP/120VAC RES. LOAD. 15:05:13 10-26-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC ON.

CONDUCTED EMISSIONS HIGH LEAD
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuA)

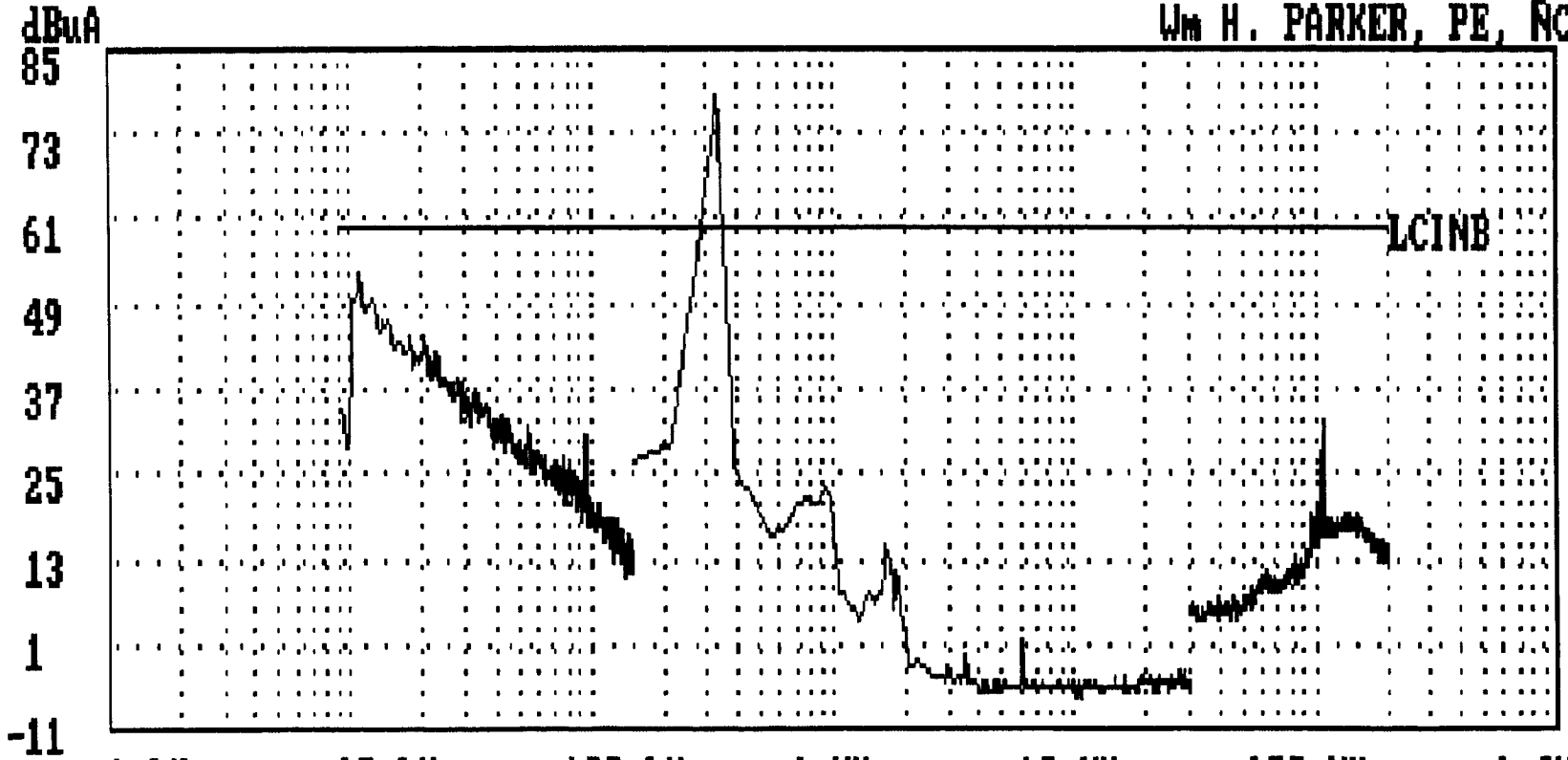
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/7 AMP/120 VAC RES.LOAD 17:39:38 10-25-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC OFF.

CONDUCTED EMISSIONS RTN LEAD
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuA)

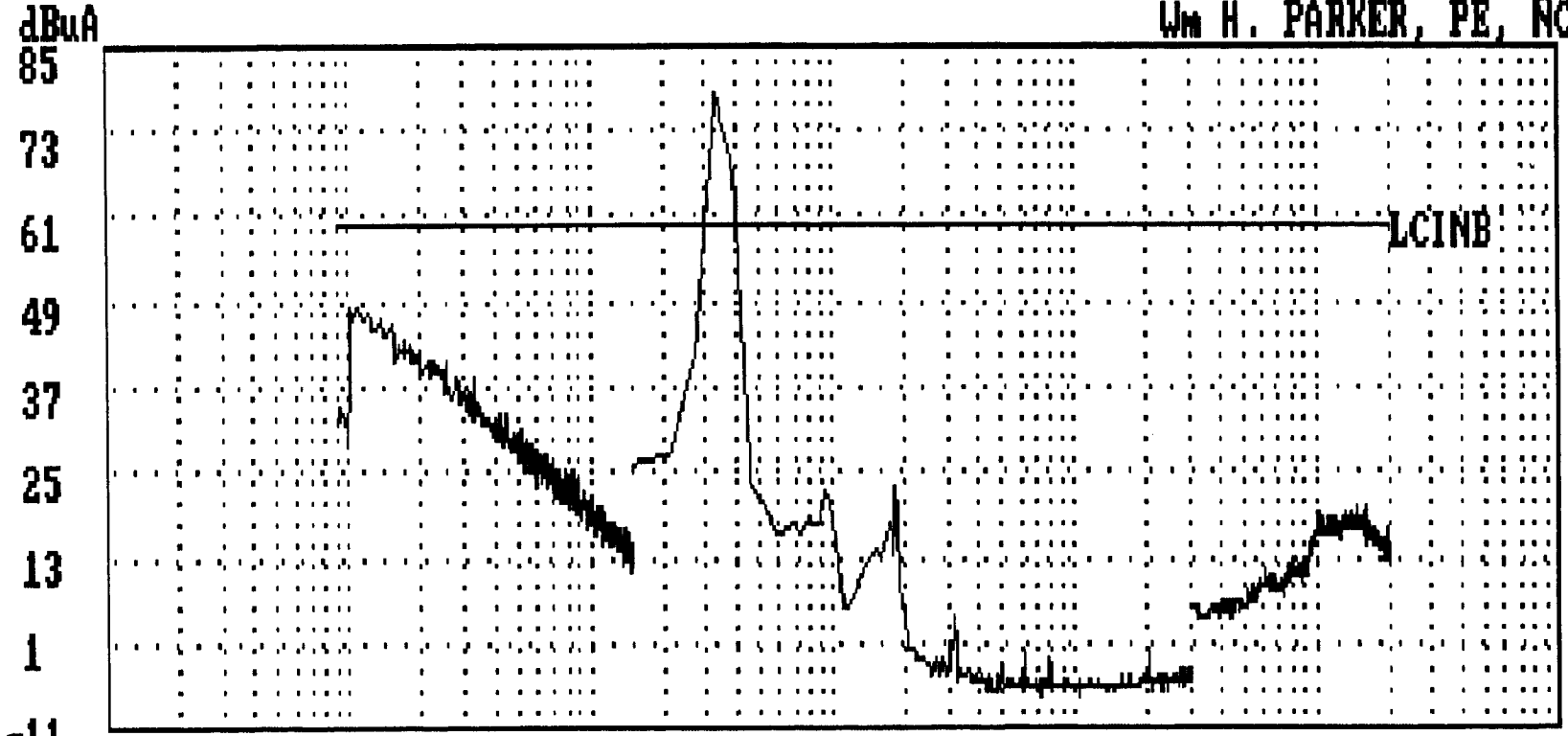
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/7 AMP/120 VAC RES.LOAD 18:36:22 10-25-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC OFF.

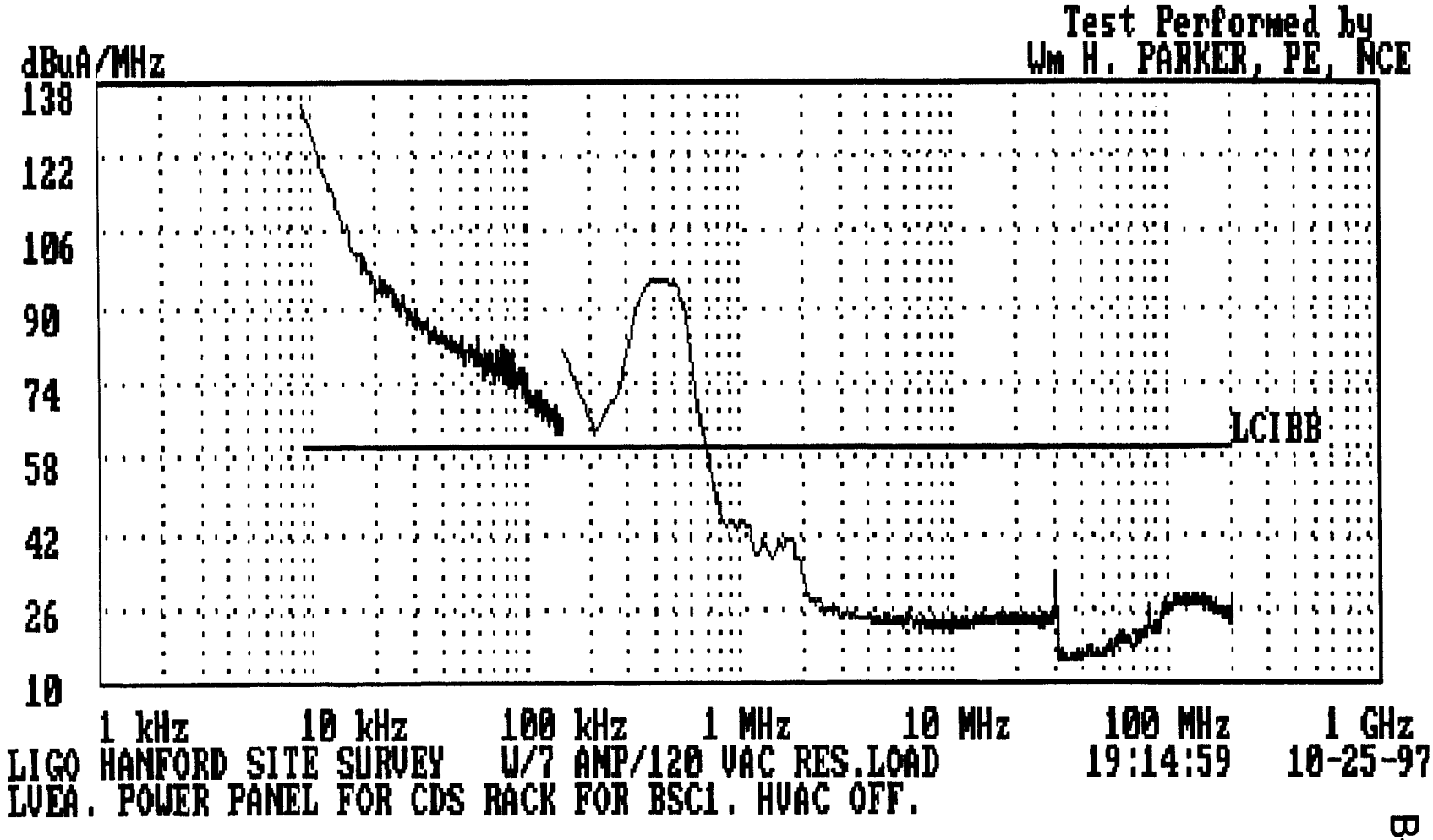
CONDUCTED EMISSIONS-COMMON MODE (HIGH & RTN)
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuA)

Test Performed by
Wm H. PARKER, PE, NCE



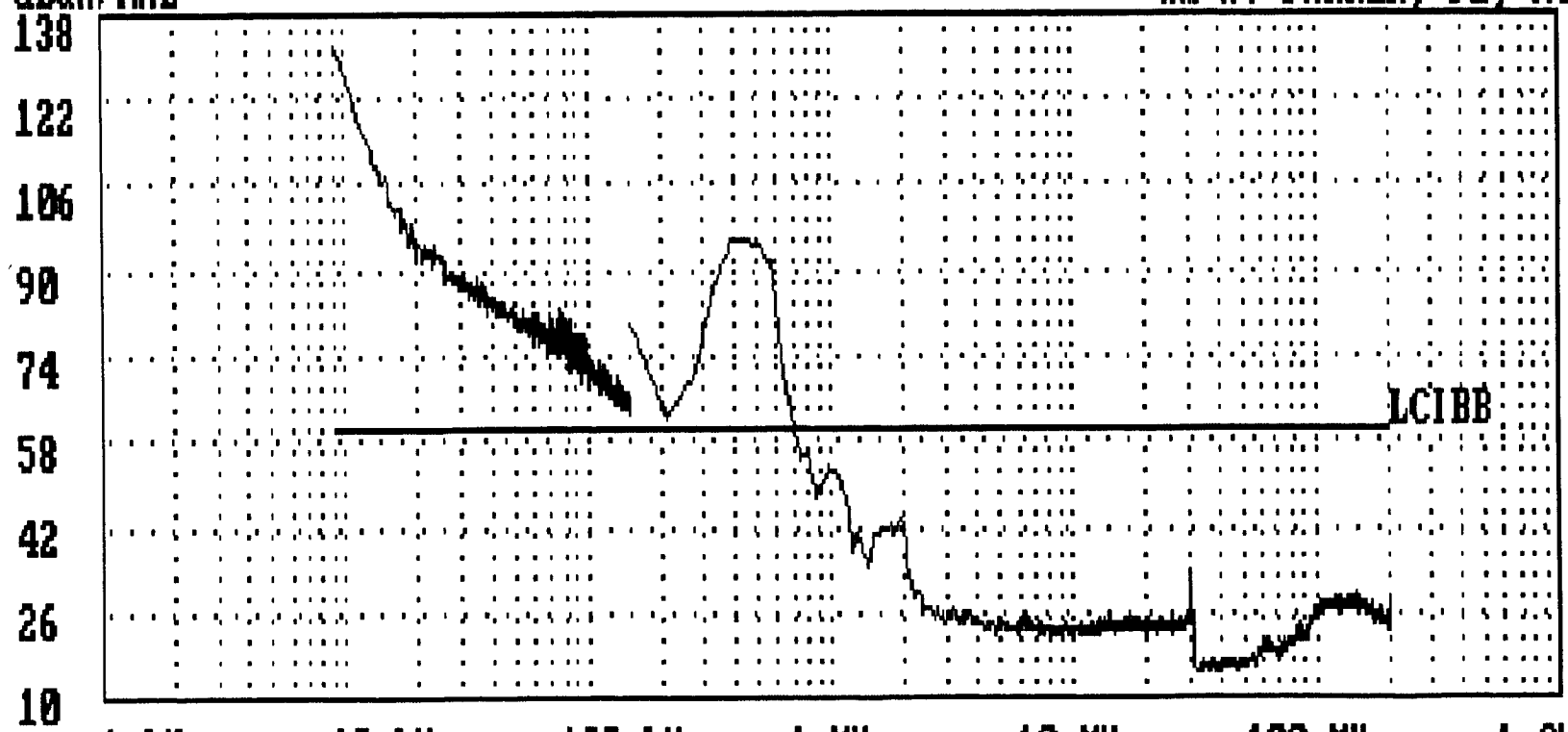
LIGO HANFORD SITE SURVEY W/7 AMP/120 VAC RES.LOAD 18:47:18 10-25-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC OFF.

CONDUCTED EMISSIONS-HIGH LEAD
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS, BROADBAND (dBuA/MHz)



CONDUCTED EMISSIONS-RTN LEAD
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS, BROADBAND (dBuA/MHz)

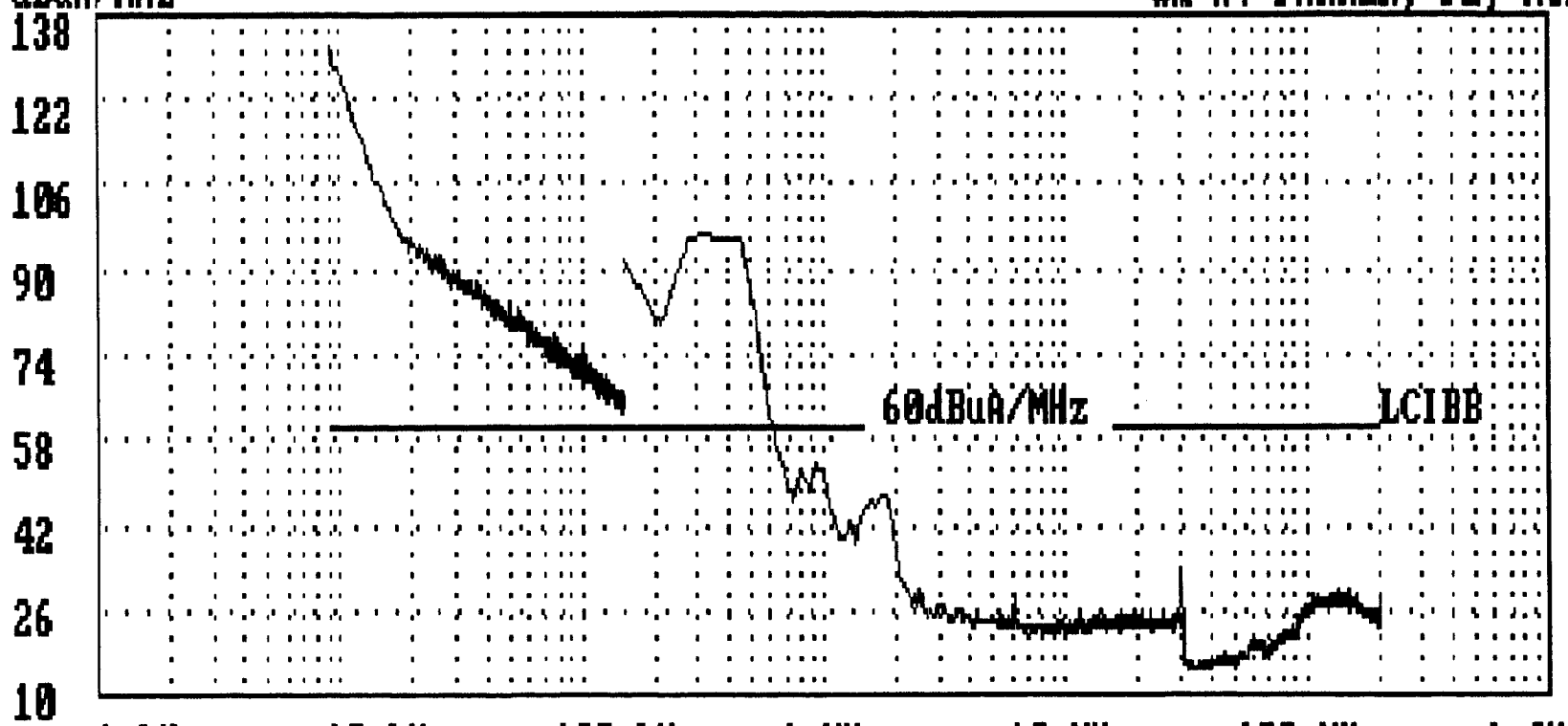
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/7 AMP/120 VAC RES.LOAD 19:40:42 10-25-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC OFF.

CONDUCTED EMISSIONS-COMMON MODE (HIGH & RTN)
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS, BROADBAND (dBuA/MHz)

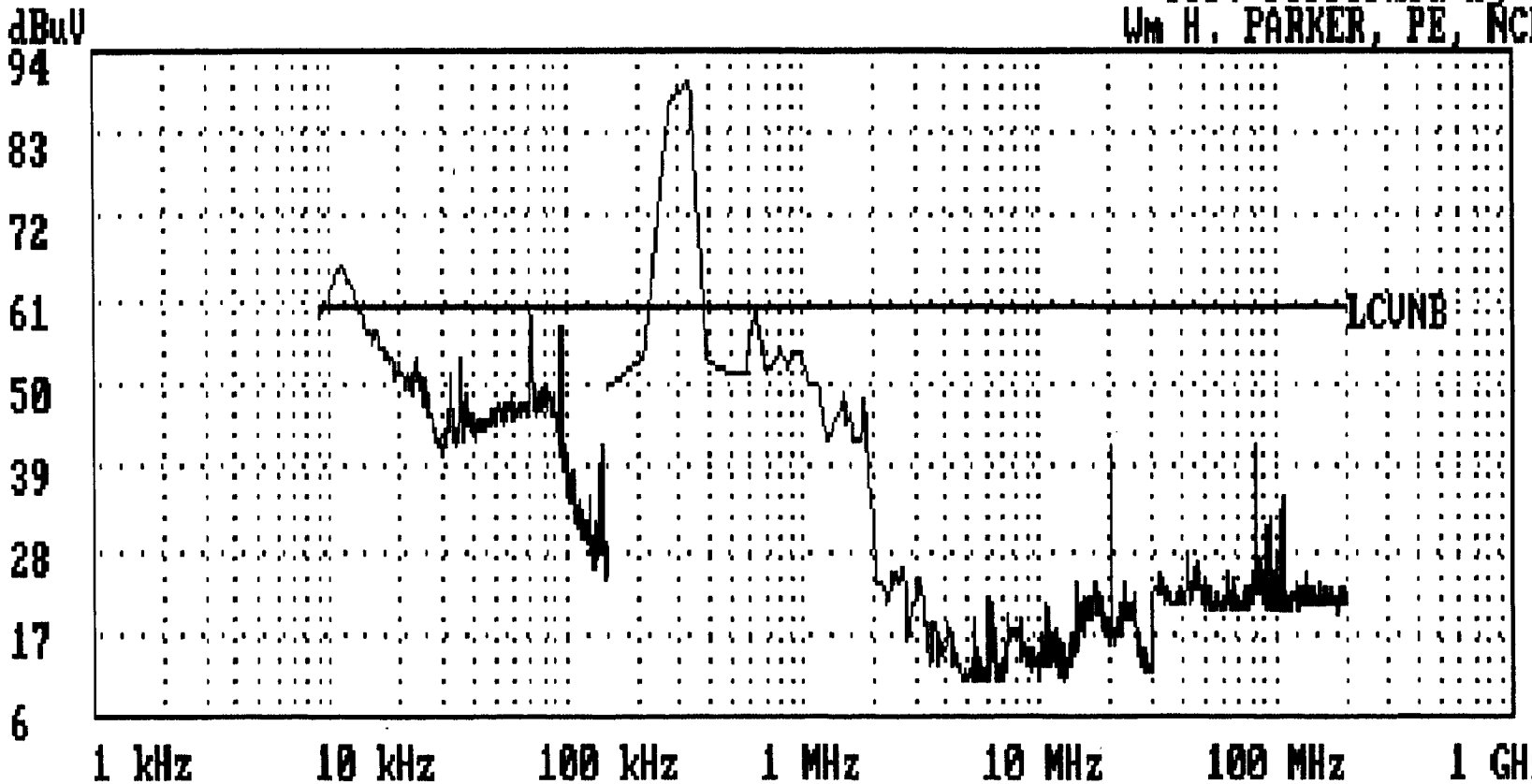
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/7 AMP/120 VAC RES.LOAD 19:01:54 10-25-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC OFF.

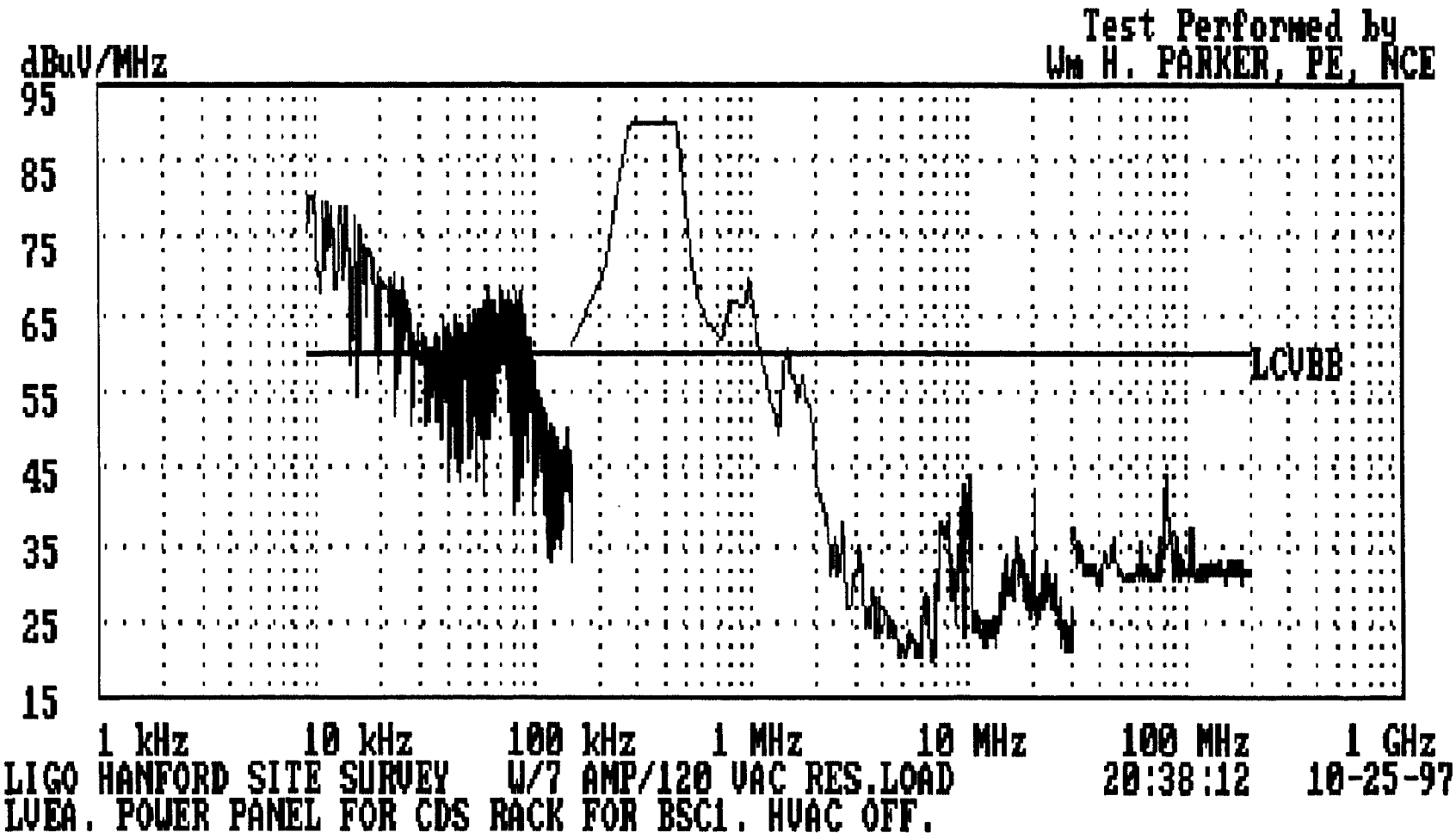
CONDUCTED EMISSIONS HIGH LEAD
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuV)

Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/7 AMP/120 VAC RES.LOAD 20:23:53 10-25-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC OFF.

CONDUCTED EMISSIONS HIGH LEAD
LIGO HANFORD SITE SURVEY-BROADBAND CONDUCTED EMISSIONS (dBuV/MHz)



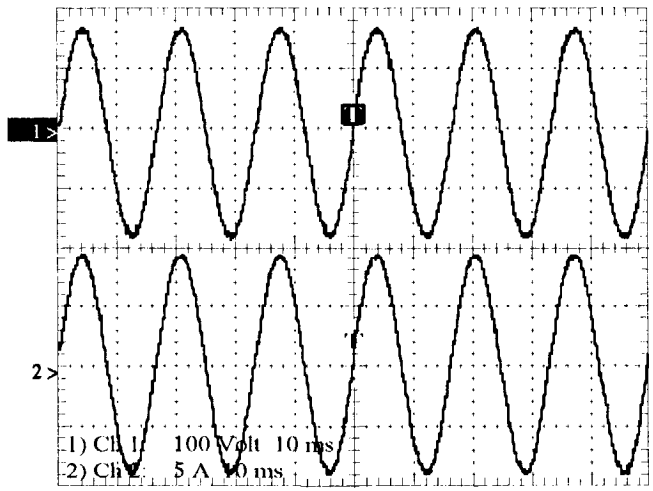
APPENDIX B-4

EMI SURVEY TEST DATA

Conducted Emissions, Technical Power, Time Domain

12. Power Panel for CDS Rack for BSC-1, Night/weekend, HVAC off.

13. Power Panel for CDS Rack for BSC-1, Night/weekend, HVAC on.

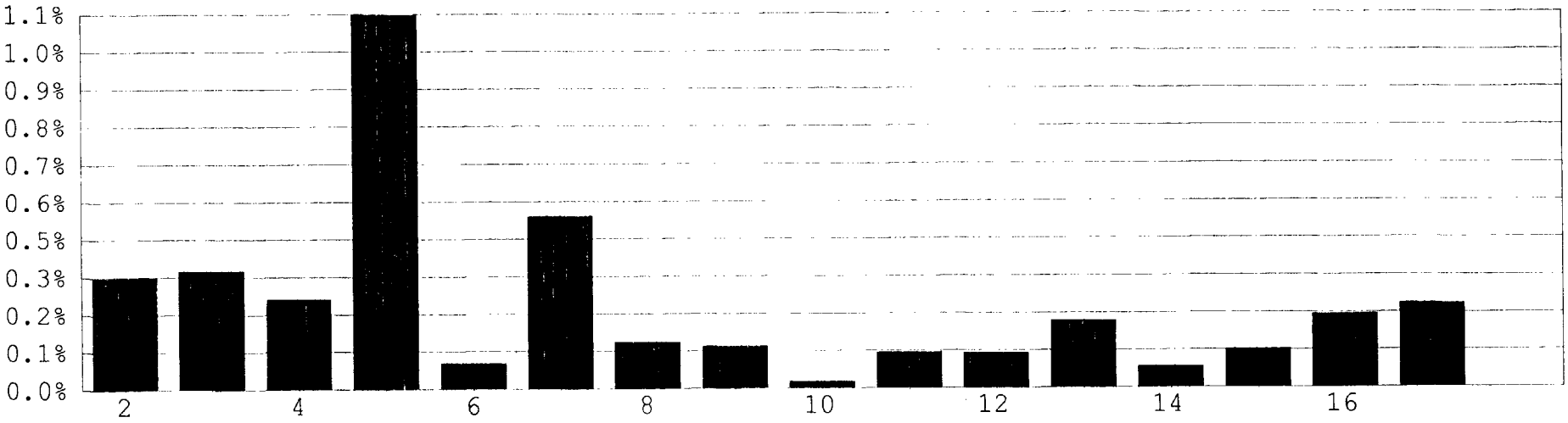


Hot-to-neutral voltage, HVAC off, 100V/division.

Hot line current, 5 Amperes/division.

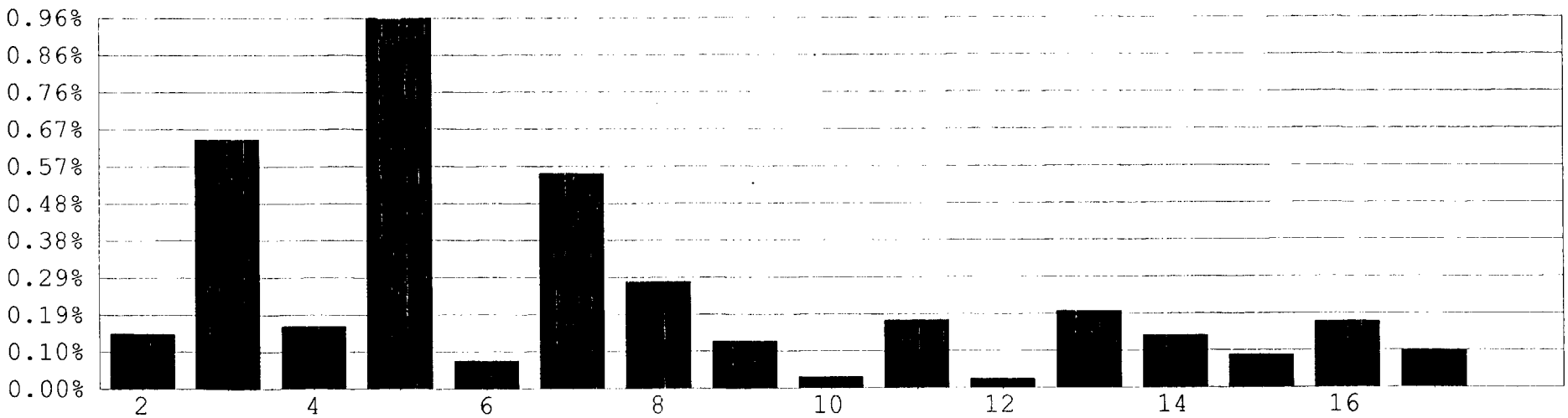
B-4-1

①



Voltage: Ch 1
Current: Ch 2
Harmonics: 17
Type: Voltage Magnitude

High line voltage harmonics, HVAC off.



Voltage: Ch 1
Current: Ch 2
Harmonics: 17
Type: Current Magnitude

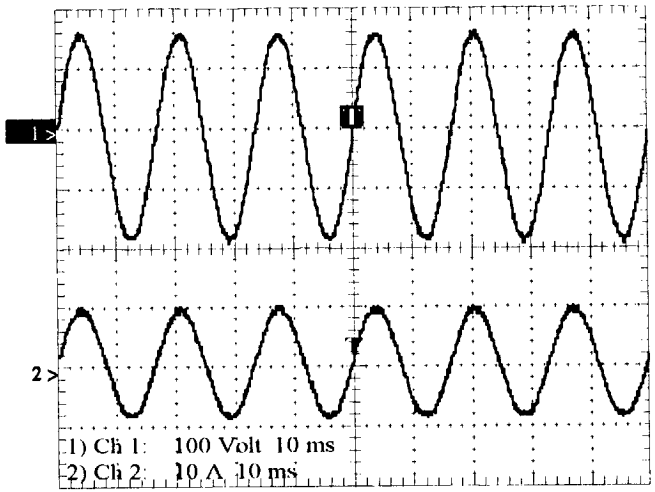
High line current harmonics, HVAC off.

Voltage : Ch 1 Current : Ch 2 HVAC off.

Voltage = 122 Volts Current = 6.37 Amps Power = 773 Watts

Voltage THD = 1.46% Current THD = 1.39%
Power Factor = 993 m Displacement Power Factor = -4.31 Degrees
Instantaneous Power = 779 VA Reactive Power = 94.6 VAR

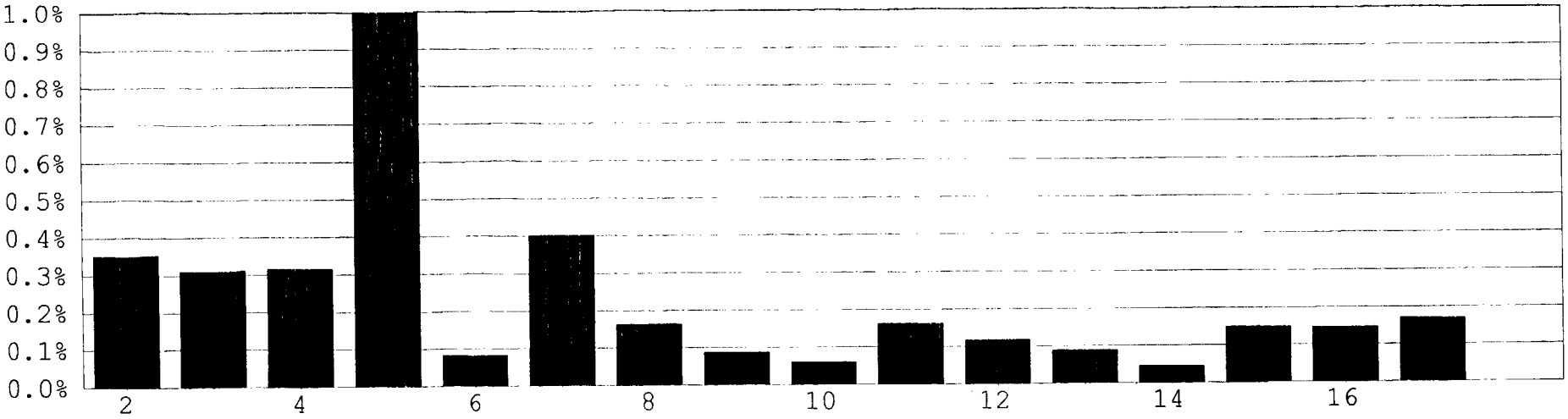
	Freq	Voltage RMS	Voltage % F	Voltage Phase	Current RMS	Current % F	Current Phase
Fundamental	60 Hz	122 V	100.00%	0.0	6.37 A	100.00%	0.0
Harmonic 2	120 Hz	414 mV	0.34%	113	9.24 mA	0.15%	77.1
Harmonic 3	180 Hz	441 mV	0.36%	163	41 mA	0.64%	-170
Harmonic 4	240 Hz	337 mV	0.28%	-93.1	10.4 mA	0.16%	68.7
Harmonic 5	300 Hz	1.38 V	1.14%	165	60.9 mA	0.96%	180
Harmonic 6	360 Hz	95.6 mV	0.08%	83.4	4.68 mA	0.07%	167
Harmonic 7	420 Hz	636 mV	0.52%	-125	35.5 mA	0.56%	-111
Harmonic 8	480 Hz	173 mV	0.14%	43.7	17.6 mA	0.28%	-95.5
Harmonic 9	540 Hz	157 mV	0.13%	163	7.83 mA	0.12%	-111
Harmonic 10	600 Hz	28 mV	0.02%	29.4	1.91 mA	0.03%	68.8
Harmonic 11	659 Hz	134 mV	0.11%	-160	11.3 mA	0.18%	-60.8
Harmonic 12	719 Hz	130 mV	0.11%	-88.1	1.56 mA	0.02%	67.4
Harmonic 13	779 Hz	250 mV	0.21%	145	12.8 mA	0.20%	-91
Harmonic 14	839 Hz	79.3 mV	0.07%	-90.8	8.71 mA	0.14%	99
Harmonic 15	899 Hz	142 mV	0.12%	-47.7	5.45 mA	0.09%	-151
Harmonic 16	959 Hz	272 mV	0.22%	73.4	11 mA	0.17%	-101
Harmonic 17	1.02 kHz	312 mV	0.26%	74.4	6.06 mA	0.10%	37.6
Harmonic 18							
Harmonic 19							
Harmonic 20							
Harmonic 21							
Harmonic 22							
Harmonic 23							
Harmonic 24							
Harmonic 25							
Harmonic 26							
Harmonic 27							
Harmonic 28							
Harmonic 29							
Harmonic 30							
Harmonic 31							
Harmonic 32							
Harmonic 33							
Harmonic 34							
Harmonic 35							
Harmonic 36							



Hot-to-neutral voltage,
HVAC ON, 100 volts/division.

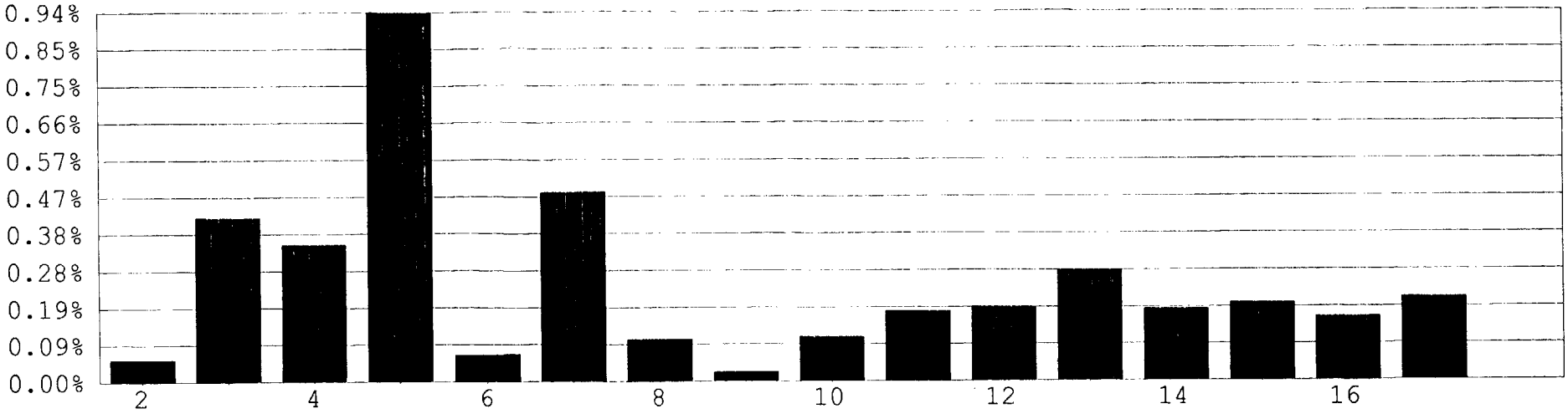
Hot line current,
10 amperes/division.

B-4-5



Voltage: Ch 1
Current: Ch 2
Harmonics: 17
Type: Voltage Magnitude

High line voltage harmonics, HVAC ON.



Voltage: Ch 1
Current: Ch 2
Harmonics: 17
Type: Current Magnitude

High line current harmonics, HVAC ON.

Voltage : Ch 1 Current : Ch 2 HVAC ON.

Voltage = 121 Volts Current = 6.35 Amps Power = 755 Watts

Voltage THD = 1.31% Current THD = 1.32%
Power Factor = 982 m Displacement Power Factor = -3.69 Degrees
Instantaneous Power = 769 VA Reactive Power = 145 VAR

	Freq	Voltage RMS	Voltage % F	Voltage Phase	Current RMS	Current % F	Current Phase
Fundamental	60 Hz	120 V	100.00%	0.0	6.34 A	100.00%	0.0
Harmonic 2	120 Hz	434 mV	0.36%	92.3	3.68 mA	0.06%	75.4
Harmonic 3	180 Hz	383 mV	0.32%	173	26.6 mA	0.42%	-145
Harmonic 4	240 Hz	389 mV	0.32%	-111	22.3 mA	0.35%	81.3
Harmonic 5	300 Hz	1.23 V	1.02%	162	59.9 mA	0.94%	-167
Harmonic 6	360 Hz	102 mV	0.09%	140	4.42 mA	0.07%	106
Harmonic 7	420 Hz	494 mV	0.41%	-111	30.7 mA	0.48%	-100
Harmonic 8	480 Hz	201 mV	0.17%	63.6	6.86 mA	0.11%	82.9
Harmonic 9	540 Hz	109 mV	0.09%	-172	1.52 mA	0.02%	-174
Harmonic 10	600 Hz	75.3 mV	0.06%	42.7	7.28 mA	0.11%	70.3
Harmonic 11	659 Hz	200 mV	0.17%	175	11.5 mA	0.18%	-150
Harmonic 12	719 Hz	146 mV	0.12%	-37.8	12 mA	0.19%	-31.6
Harmonic 13	779 Hz	110 mV	0.09%	174	18 mA	0.28%	-112
Harmonic 14	839 Hz	56.8 mV	0.05%	102	11.7 mA	0.19%	-138
Harmonic 15	899 Hz	186 mV	0.15%	39.9	12.7 mA	0.20%	-73.7
Harmonic 16	959 Hz	182 mV	0.15%	114	10.4 mA	0.16%	56
Harmonic 17	1.02 kHz	210 mV	0.18%	11.5	13.6 mA	0.21%	-180
Harmonic 18							
Harmonic 19							
Harmonic 20							
Harmonic 21							
Harmonic 22							
Harmonic 23							
Harmonic 24							
Harmonic 25							
Harmonic 26							
Harmonic 27							
Harmonic 28							
Harmonic 29							
Harmonic 30							
Harmonic 31							
Harmonic 32							
Harmonic 33							
Harmonic 34							
Harmonic 35							
Harmonic 36							

APPENDIX B-5

EMI SURVEY TEST DATA

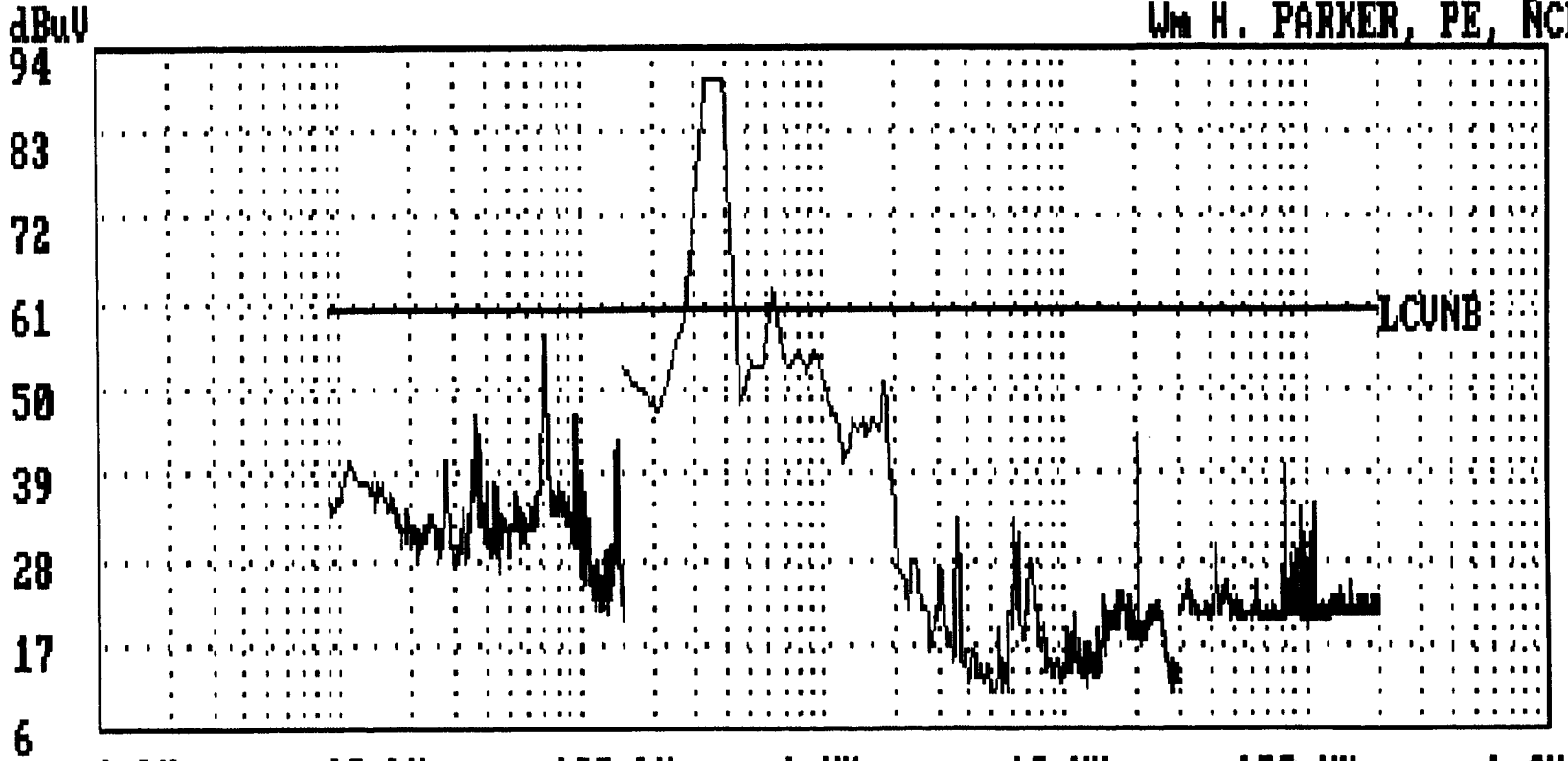
Grounding, Technical Power, 9 kHz - 200 MHz

16. Power Panel for CDS Rack for BSC-1, Night/weekend, HVAC off.

17. Power Panel for CDS Rack for BSC-1, Night/weekend, HVAC on.

CONDUCTED EMISSIONS-RTN LEAD
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuV)

Test Performed by
Wm H. PARKER, PE, NCE

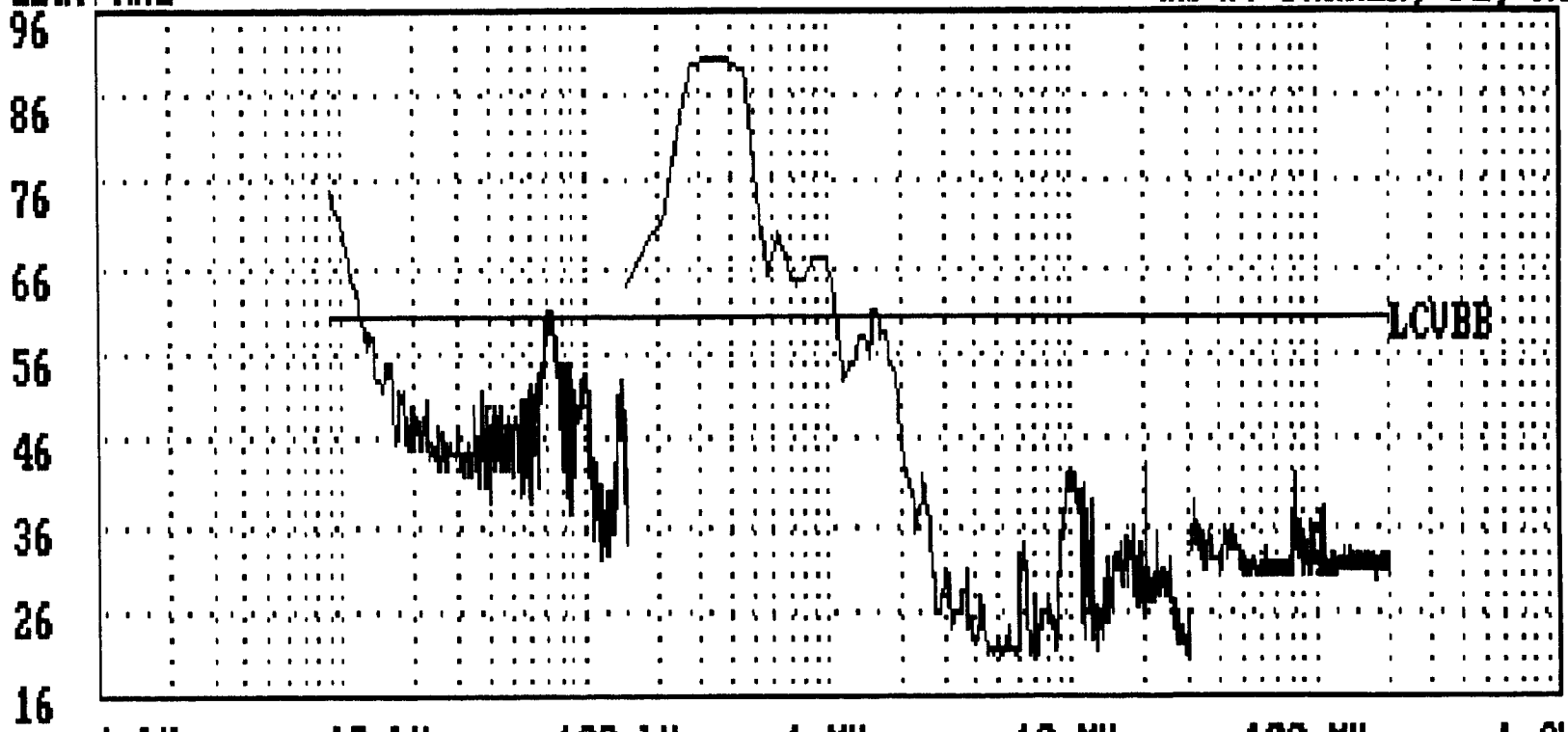


LIGO HANFORD SITE SURVEY W/7 AMP/120 VAC RES.LOAD 20:51:31 10-25-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC OFF.

CONDUCTED EMISSIONS-RTN LEAD

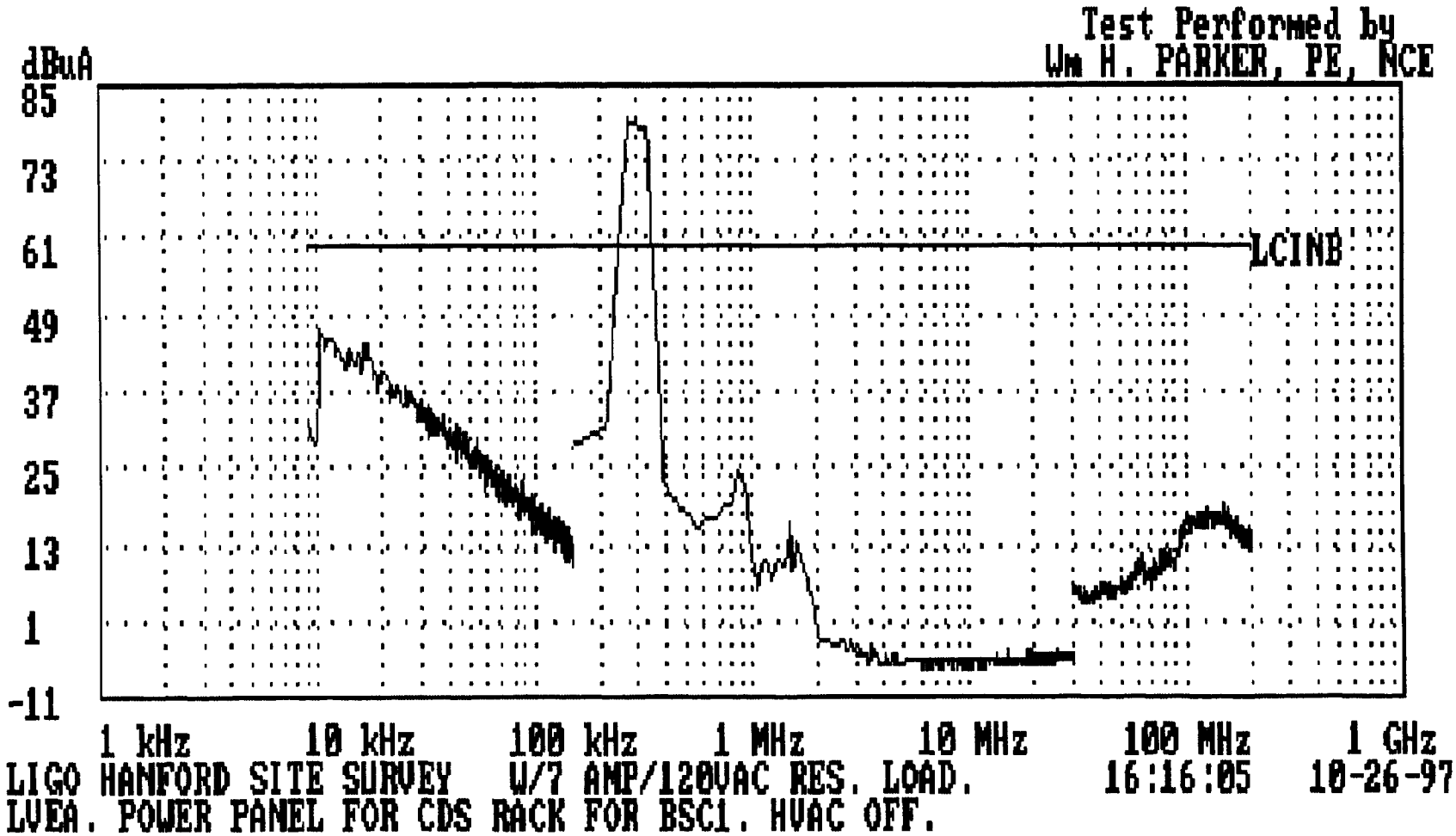
LIGO HANFORD SITE SURVEY-BROADBAND CONDUCTED EMISSIONS (dBuV/MHz)

Test Performed by
Wm H. PARKER, PE, NCE

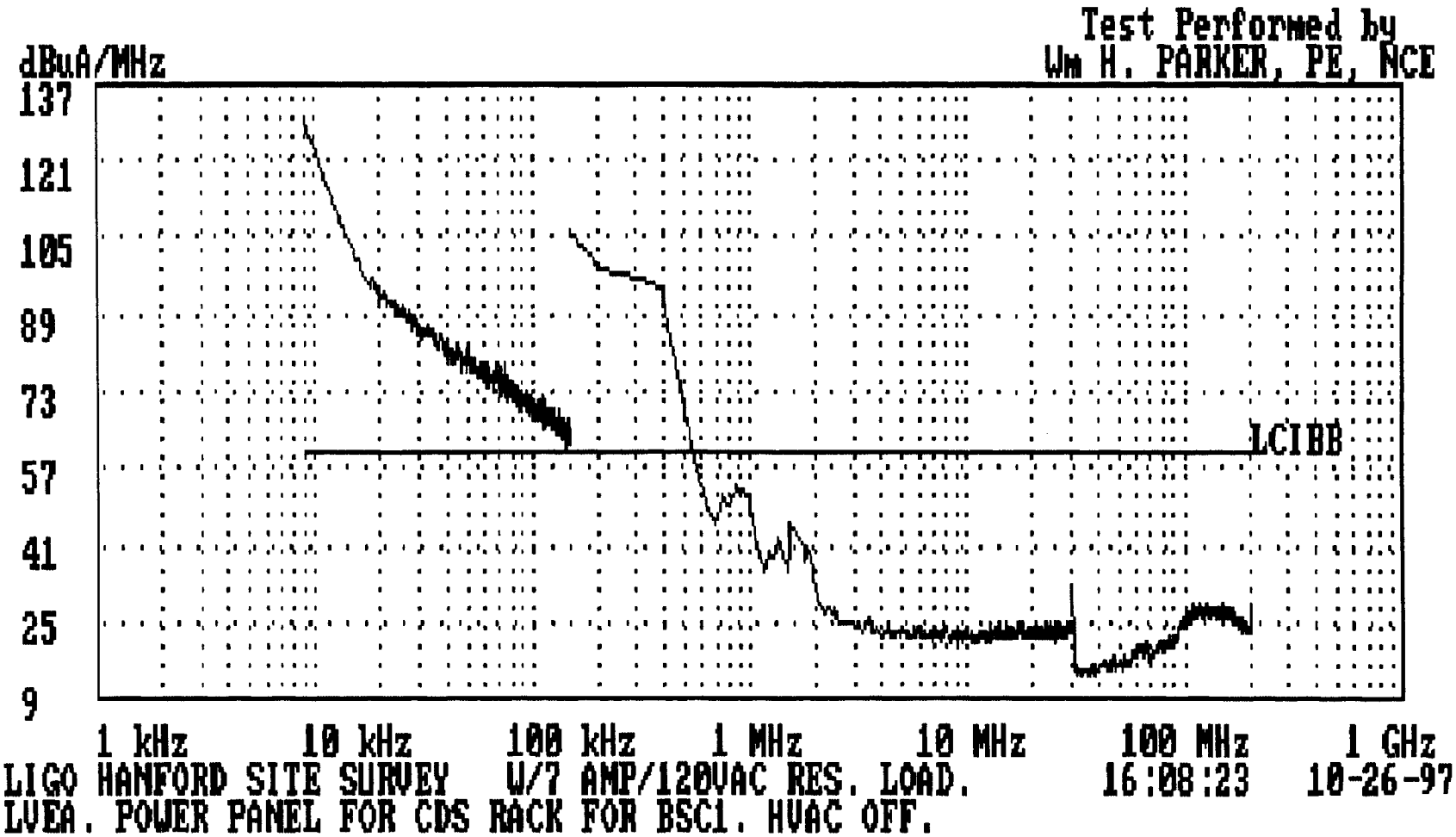


LIGO HANFORD SITE SURVEY W/7 AMP/120 VAC RES.LOAD 21:01:29 10-25-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC OFF.

CONDUCTED EMISSIONS-GROUND WIRE
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuA)

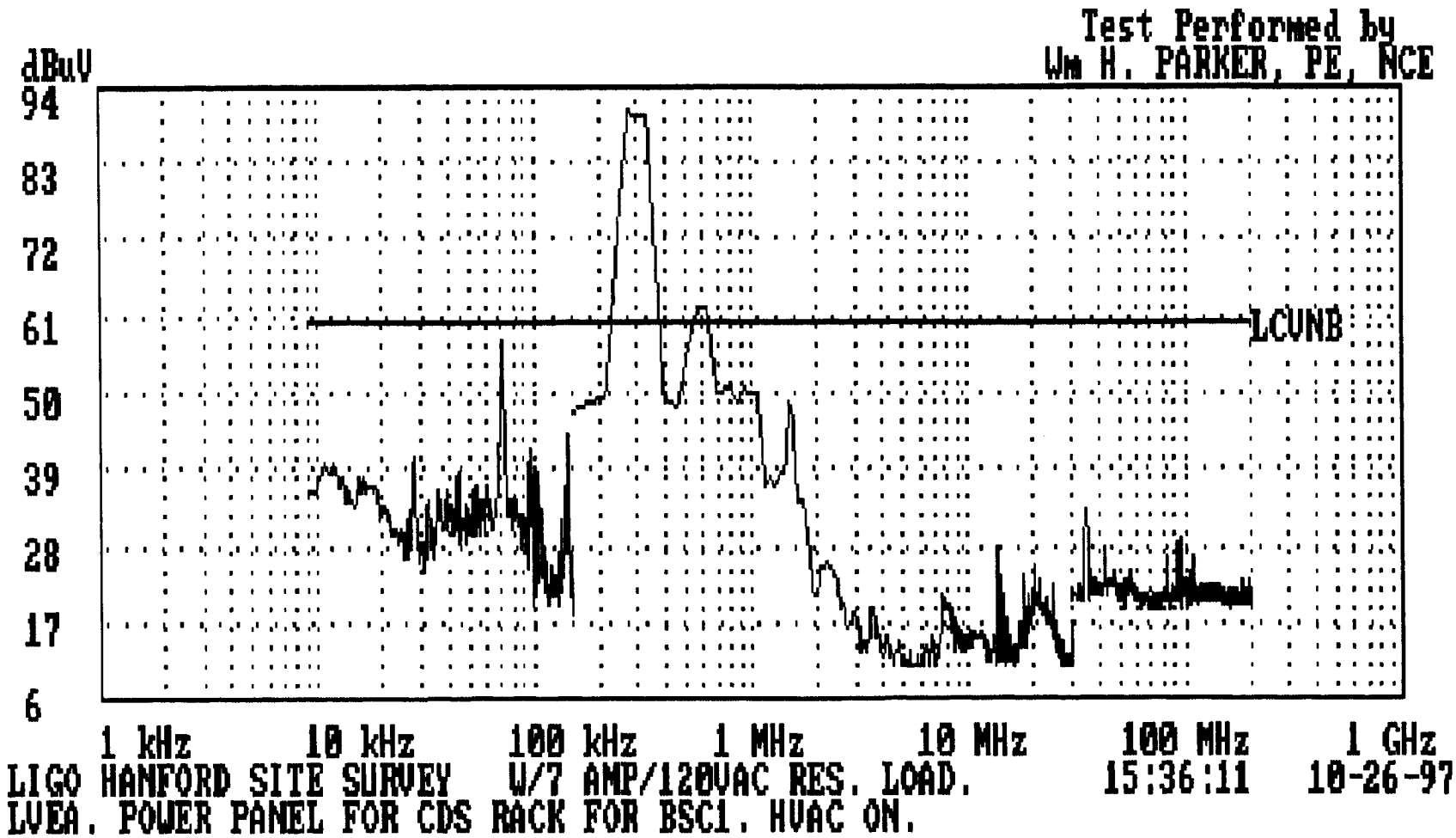


CONDUCTED EMISSIONS-GROUND WIRE
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS, BROADBAND (dBuA/MHz)

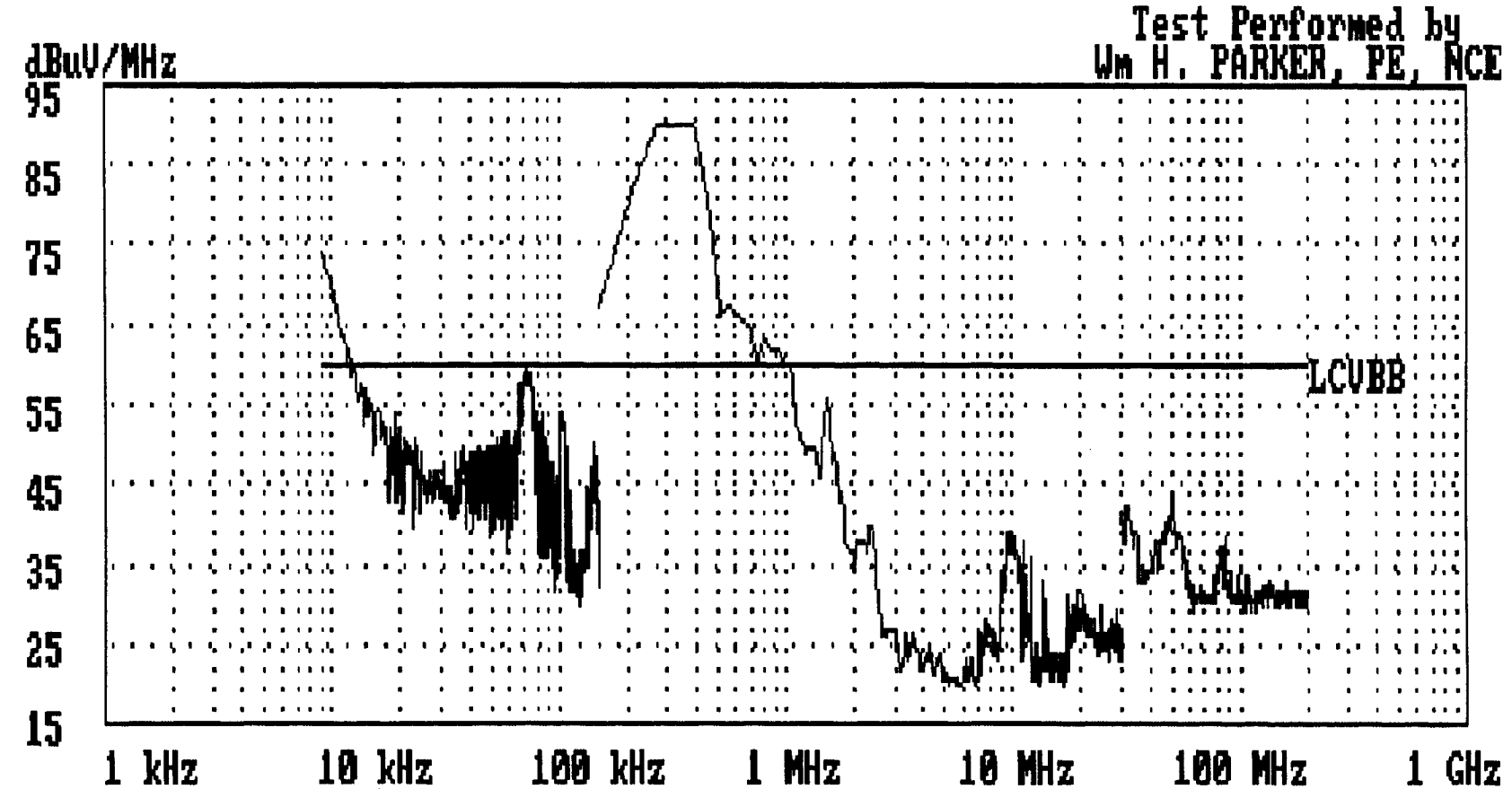


CONDUCTED EMISSIONS-RETURN LEAD (TO GROUND)

LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuV)

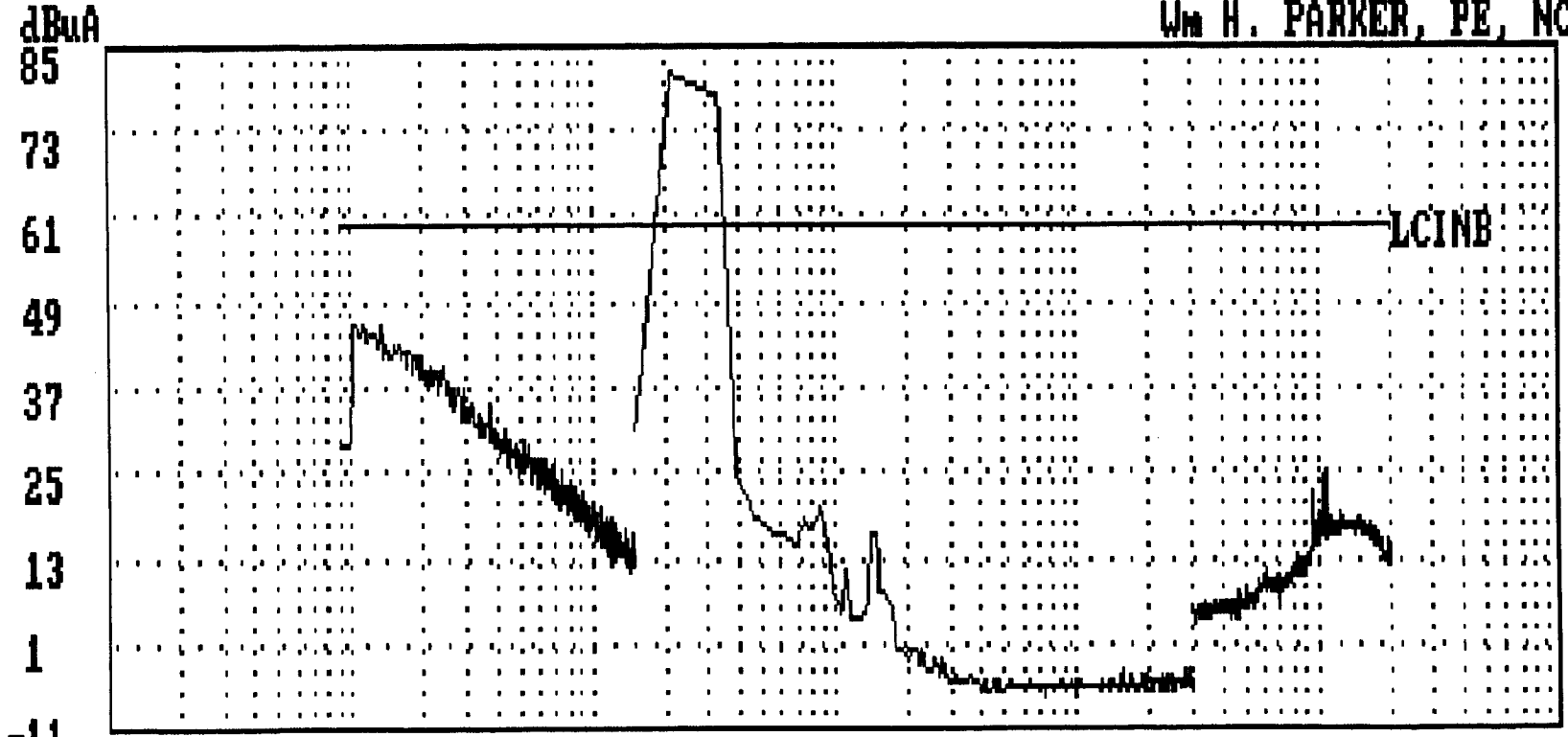


CONDUCTED EMISSIONS-RETURN LEAD
LIGO HANFORD SITE SURVEY-BROADBAND CONDUCTED EMISSIONS (dBuV/MHz)



CONDUCTED EMISSIONS-GROUND LEAD
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS (dBuA)

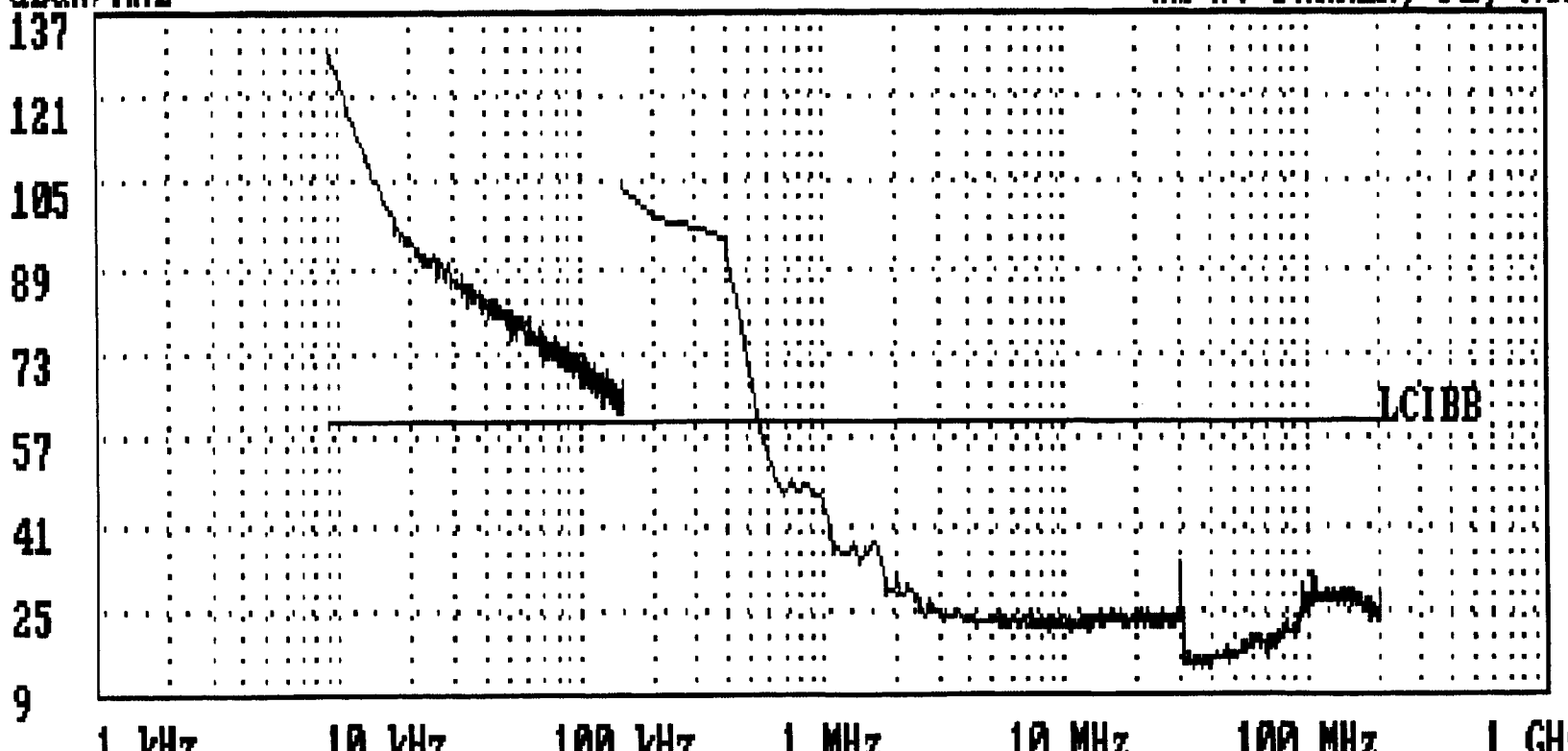
Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY U/7 AMP/120VAC RES. LOAD. 13:46:13 10-26-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC ON.

CONDUCTED EMISSIONS-GROUND LEAD.
LIGO HANFORD SITE SURVEY-CONDUCTED EMISSIONS, BROADBAND (dBuA/MHz)

Test Performed by
Wm H. PARKER, PE, NCE



LIGO HANFORD SITE SURVEY W/7 AMP/120VAC RES. LOAD. 13:56:19 10-26-97
LVEA. POWER PANEL FOR CDS RACK FOR BSC1. HVAC ON.

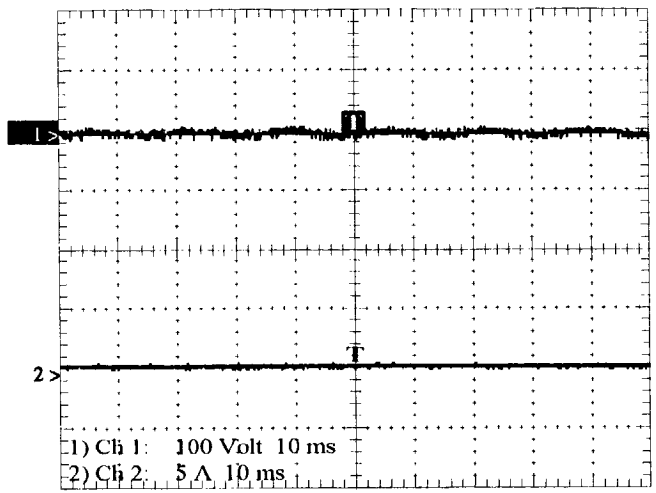
APPENDIX B-6

EMI SURVEY TEST DATA

Grounding, Technical Power, Time Domain

20. Power Panel for CDS Rack for BSC-1, Night/weekend, HVAC off.

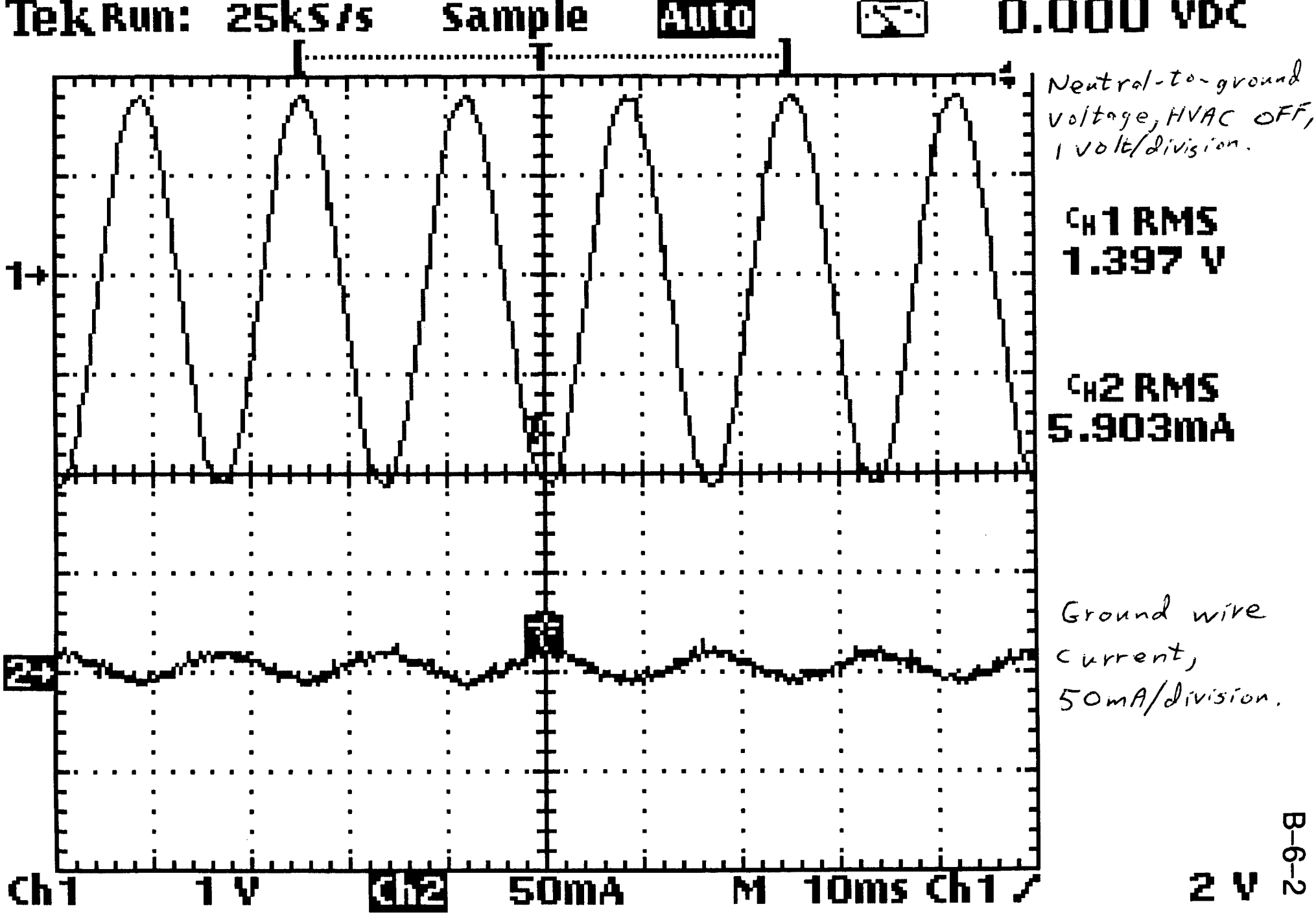
21. Power Panel for CDS Rack for BSC-1, Night/weekend, HVAC on.



Neutral-to-ground voltage,
HVAC OFF, 100 VOLTS/division.

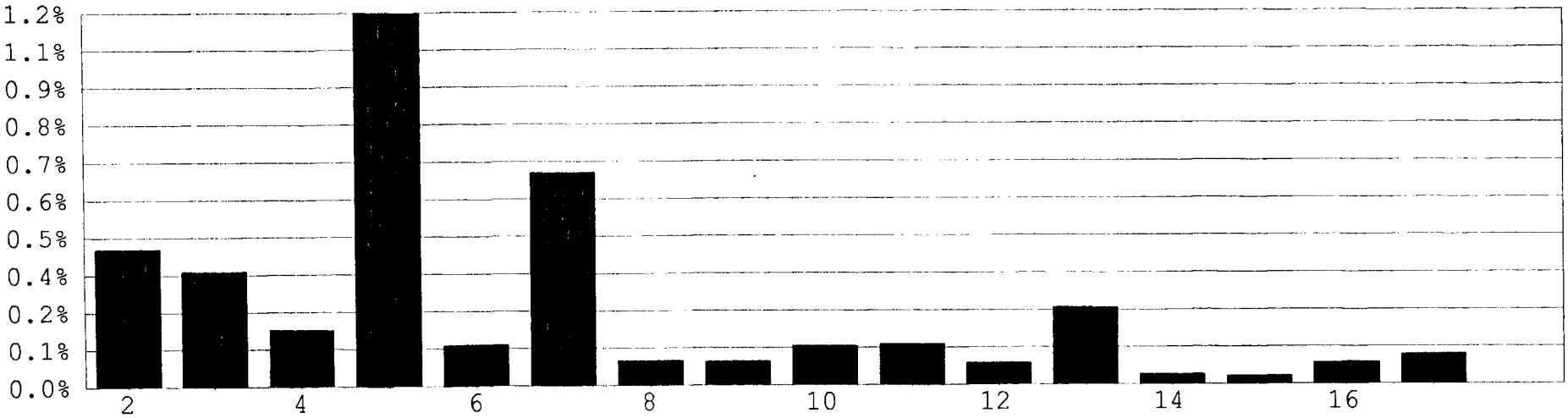
Ground wire current,
5 amperes/division.

B-6-1


Tek Run: 25kS/s Sample
Auto
0.000 VDC
Neutral-to-ground voltage, HVAC OFF, 1 volt/division.
CH1 RMS
1.397 V
CH2 RMS
5.903mA
Ground wire current, 50mA/division.
Ch1 1 V
Ch2 50mA
M 10ms Ch1
2 V

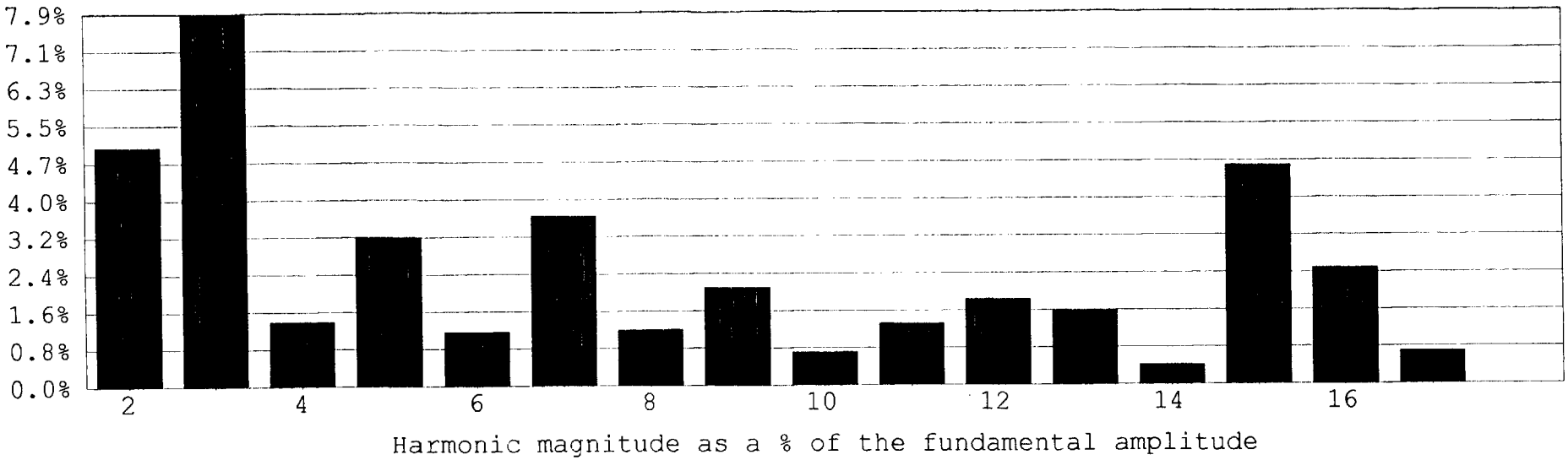
B-6-2

(5A)



Voltage: Ch 1
Current: Ch 2
Harmonics: 17
Type: Voltage Magnitude

Neutral-to-ground voltage harmonics, HVAC OFF.



Voltage: Ch 1
Current: Ch 2
Harmonics: 17
Type: Current Magnitude

Ground conductor current harmonics.

B-6-4

(7)

Voltage : Ch 1 (Neutral-to-ground voltage) Current : Ch 2 (Ground current) HVAC OFF.

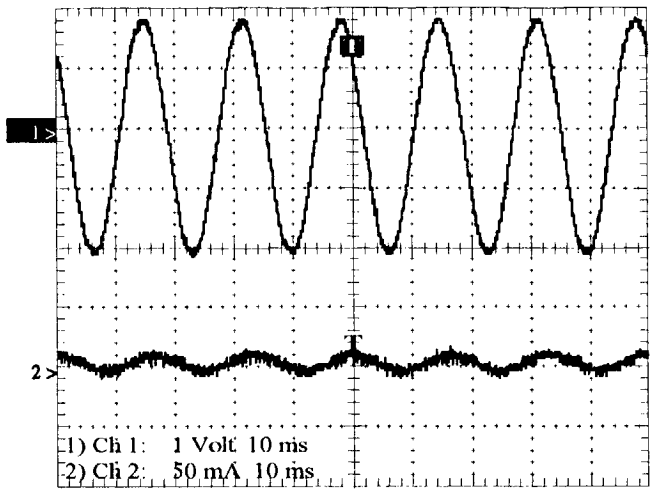
Voltage = 1.39 Volts Current = 5.66 mAmps Power = -4.58 mWatts

Voltage THD = 1.52% Current THD = 12.53%

Power Factor = -581 m Displacement Power Factor = -130 Degrees

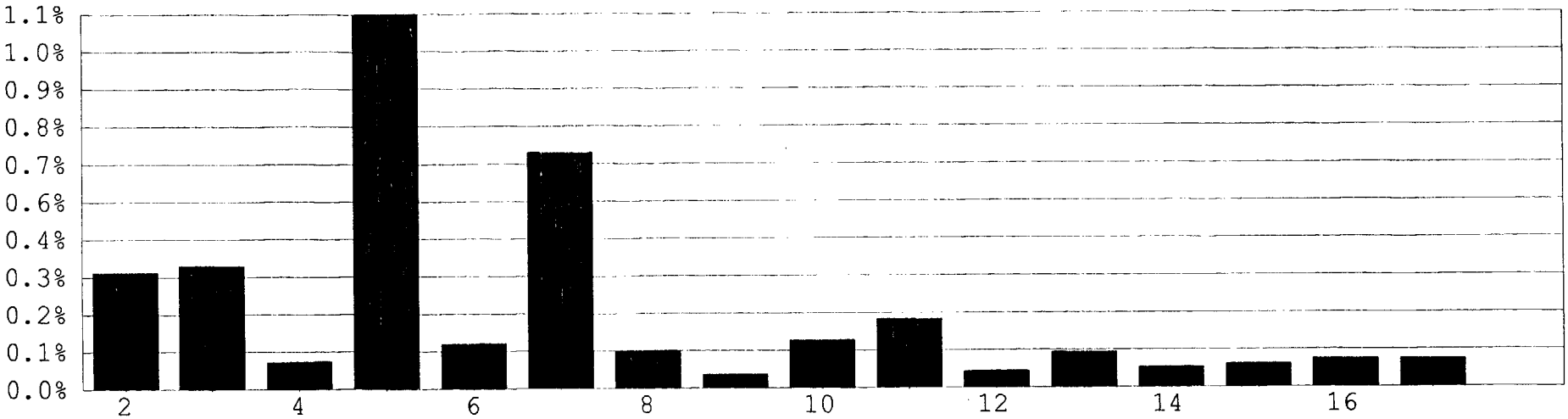
Instantaneous Power = 7.88 mVA Reactive Power = 6.42 mVAR

	Freq	Voltage RMS	Voltage % F	Voltage Phase	Current RMS	Current % F	Current Phase
Fundamental	59.9 Hz	1.39 V	100.00%	0.0	4.69 mA	100.00%	0.0
Harmonic 2	120 Hz	6.03 mV	0.43%	113	239 uA	5.09%	-30.4
Harmonic 3	180 Hz	5.05 mV	0.36%	161	371 uA	7.90%	46.2
Harmonic 4	240 Hz	2.49 mV	0.18%	-104	65.2 uA	1.39%	-69.9
Harmonic 5	300 Hz	16.2 mV	1.17%	158	149 uA	3.17%	-13
Harmonic 6	359 Hz	1.81 mV	0.13%	-92.7	54.2 uA	1.15%	-46.5
Harmonic 7	419 Hz	9.28 mV	0.67%	-137	169 uA	3.60%	-117
Harmonic 8	479 Hz	1.08 mV	0.08%	76.2	55.9 uA	1.19%	168
Harmonic 9	539 Hz	1.07 mV	0.08%	-170	97.5 uA	2.08%	-155
Harmonic 10	599 Hz	1.73 mV	0.12%	134	33.4 uA	0.71%	17
Harmonic 11	659 Hz	1.81 mV	0.13%	-125	61.9 uA	1.32%	-20.5
Harmonic 12	719 Hz	975 uV	0.07%	-82.1	86.6 uA	1.84%	111
Harmonic 13	779 Hz	3.4 mV	0.24%	-140	75 uA	1.60%	140
Harmonic 14	839 Hz	453 uV	0.03%	-83.4	19.8 uA	0.42%	127
Harmonic 15	899 Hz	372 uV	0.03%	173	218 uA	4.65%	-57
Harmonic 16	959 Hz	964 uV	0.07%	-124	116 uA	2.48%	-169
Harmonic 17	1.02 kHz	1.31 mV	0.09%	136	33 uA	0.70%	-14.1
Harmonic 18							
Harmonic 19							
Harmonic 20							
Harmonic 21							
Harmonic 22							
Harmonic 23							
Harmonic 24							
Harmonic 25							
Harmonic 26							
Harmonic 27							
Harmonic 28							
Harmonic 29							
Harmonic 30							
Harmonic 31							
Harmonic 32							
Harmonic 33							
Harmonic 34							
Harmonic 35							
Harmonic 36							



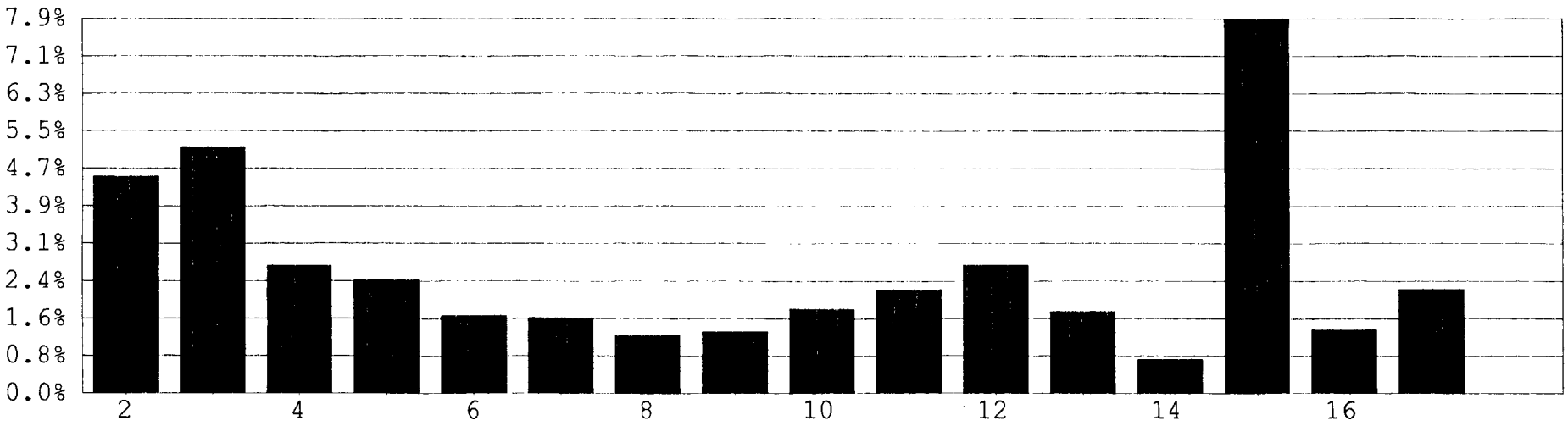
Neutral-to-ground voltage,
HVAC ON,
1 volt/division.

Ground wire current,
50 mA/division.



Voltage: Ch 1
Current: Ch 2
Harmonics: 17
Type: Voltage Magnitude

Neutral-to-ground voltage harmonics, HVAC ON.



Voltage: Ch 1
Current: Ch 2
Harmonics: 17
Type: Current Magnitude

Ground wire current harmonics, HVAC ON.

Voltage : Ch 1 Current : Ch 2

HVAC ON.

Voltage = 1.39 Volts (Neutral-to-ground). Current = 5.58 mAmps (Ground conductor). Power = 4.34 mWatts

Voltage THD = 1.46% Current THD = 12.50%

Power Factor = 559 m Displacement Power Factor = 44 Degrees

Instantaneous Power = 7.76 mVA Reactive Power = 6.43 mVAR

	Freq	Voltage RMS	Voltage % F	Voltage Phase	Current RMS	Current % F	Current Phase
Fundamental	60 Hz	1.38 V	100.00%	0.0	4.66 mA	100.00%	0.0
Harmonic 2	120 Hz	4.82 mV	0.35%	97.3	213 uA	4.56%	152
Harmonic 3	180 Hz	5.1 mV	0.37%	153	241 uA	5.17%	-170
Harmonic 4	240 Hz	1.14 mV	0.08%	-144	126 uA	2.70%	51.8
Harmonic 5	300 Hz	15.4 mV	1.12%	160	112 uA	2.39%	131
Harmonic 6	360 Hz	1.88 mV	0.14%	-67.2	77 uA	1.65%	-5.82
Harmonic 7	420 Hz	9.72 mV	0.71%	-134	74.3 uA	1.59%	126
Harmonic 8	480 Hz	1.56 mV	0.11%	63	57.4 uA	1.23%	82.9
Harmonic 9	540 Hz	578 uV	0.04%	-177	60.6 uA	1.30%	-19.7
Harmonic 10	600 Hz	1.99 mV	0.14%	112	83.1 uA	1.78%	-131
Harmonic 11	659 Hz	2.85 mV	0.21%	-151	102 uA	2.18%	8.18
Harmonic 12	719 Hz	692 uV	0.05%	29	126 uA	2.71%	45.2
Harmonic 13	779 Hz	1.48 mV	0.11%	-111	81.3 uA	1.74%	83.9
Harmonic 14	839 Hz	847 uV	0.06%	-88.2	33.9 uA	0.73%	-136
Harmonic 15	899 Hz	975 uV	0.07%	-89.8	367 uA	7.86%	89.8
Harmonic 16	959 Hz	1.18 mV	0.09%	-70.6	63.5 uA	1.36%	-68.3
Harmonic 17	1.02 kHz	1.18 mV	0.09%	84.2	103 uA	2.20%	-6.91
Harmonic 18							
Harmonic 19							
Harmonic 20							
Harmonic 21							
Harmonic 22							
Harmonic 23							
Harmonic 24							
Harmonic 25							
Harmonic 26							
Harmonic 27							
Harmonic 28							
Harmonic 29							
Harmonic 30							
Harmonic 31							
Harmonic 32							
Harmonic 33							
Harmonic 34							
Harmonic 35							
Harmonic 36							

APPENDIX C

TEST INSTRUMENTS

Appendix C - TEST INSTRUMENTS

The following test instruments and accessories were used during the testing covered by this report.

Item	Model No.	Manufacturer	Serial No.	Last Calibration Date
Spectrum analyzer	2712	Tektronix	B021985	19 July 1997
Analyzer Controller (Laptop computer)	NoteJet 486	Canon	2110020	Not applicable.
Oscilloscope	THS720P	Tektronix	B030989	13 Feb. 1997
LF current probe	A621	Tektronix	12FF7389	7 May 1997
Active rod antenna	SAS-200/550-1B	A.H. Systems	219	13 May 1996
Biconical antenna	SAS-200/542	A.H. Systems	655	13 May 1996
RF current probe	9301-1N	Solar Electronics	970303	10 Feb 1997

APPENDIX D

EMI SURVEY TEST LAYOUT AND PHOTOGRAPHS

D-1

LVEA

GROUP F-2 OCCUPANCY (SECTION 306.1)
ALLOWABLE AREA TYPE II NON-RATED 18,000 SF. (TABLE 5-B)
ALLOWABLE AREA INCREASES SEPARATION ON THREE SIDES (SECTION 505.1.2)
100% INCREASE = 36,000 SF.
ACTUAL AREA OF LVEA AND MECH RM. 40,740 SF W-CODE EXCEMPTION FROM FIRE MARSHALL PENDING.

OSB

GROUP B OCCUPANCY (SECTION 304.1)
ALLOWABLE AREA TYPE II NON-RATED 12,000 SF. (TABLE 5-B)
ALLOWABLE AREA INCREASES SEPARATION ON THREE SIDES (SECTION 505.1.2)
100% INCREASE = 24,000 SF.
ACTUAL AREA OF OSB 18,620 SF.

LEGEND / SCHEDULE

- ONE HOUR RATED WALL
- TWO HOUR FIRE WALL
- TWO HOUR OCCUPANCY SEPARATION WALL
- E — EXIT LOCATION
- ONE HOUR RATED CORRIDOR

EMI SURVEY TEST LAYOUT.

WAREHOUSE BUILDING

BLDG NORTH

TRUE NORTH

Road

MID-STATION
GROUP F OCCUPANCY
TYPE II NON RATED
SEE SHEET WA-A-201

CORNER STATION
LASER and VACUUM
EQUIPMENT AREA
(LVEA)
SEE SHEET WA-A-501

BLDG E-W

BLDG N-S

TWO HOUR OCCUPANCY SEPARATION WALL

MID-STATION
GROUP F OCCUPANCY
TYPE II NON RATED
SEE SHEET WA-A-201

END-STATION
GROUP F OCCUPANCY
TYPE II NON RATED
SEE SHEET WA-A-202

CORNER STATION
OPERATIONS
SUPPORT BUILDING
(OSB)
SEE SHEET WA-A-107

CORNER STATION
MAINTENANCE
BUILDING
GROUP F OCCUPANCY
TYPE II NON-RATED
SEE SHEET WA-A-112

① = Warehouse/Road Radiated Emissions Test Location.

② = LVEA Beam Tube Vertex Radiated Emissions and LVEA (INTERIOR) "Q" Test Location.

③ = LVEA (Exterior) "Q" Test Location.

BUILDING NORTH

TRUE NORTH

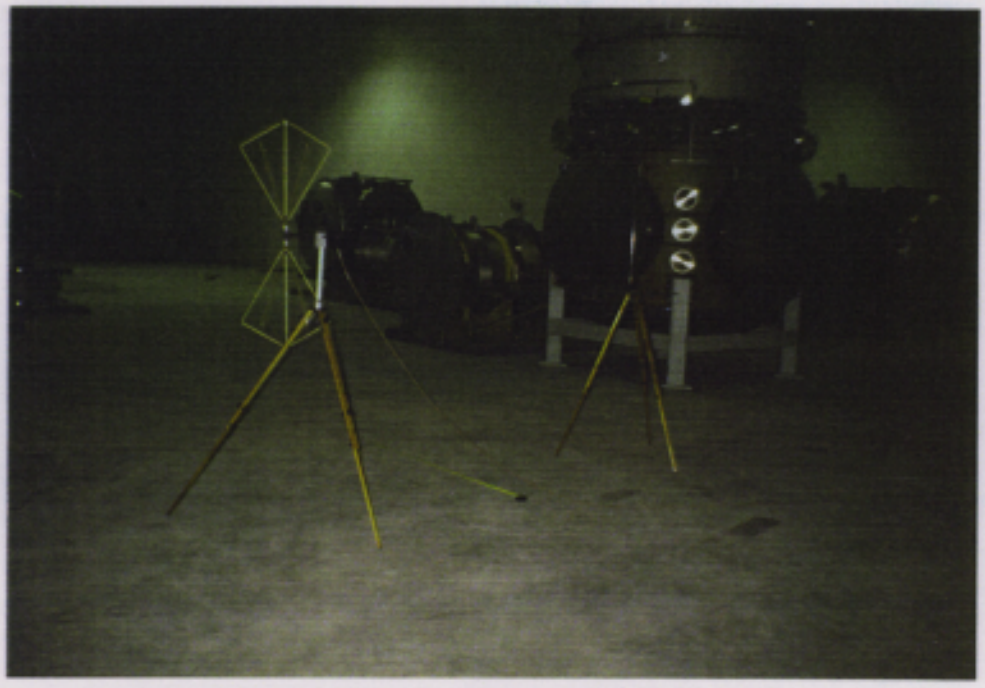
0 40 80 120 160FT
1" = 40 FT

ISSUED FOR CONSTRUCTION		
DRAWN	C.K.F.	5-12-96
CHECKED	TB	5-26-96
ENGINEER		

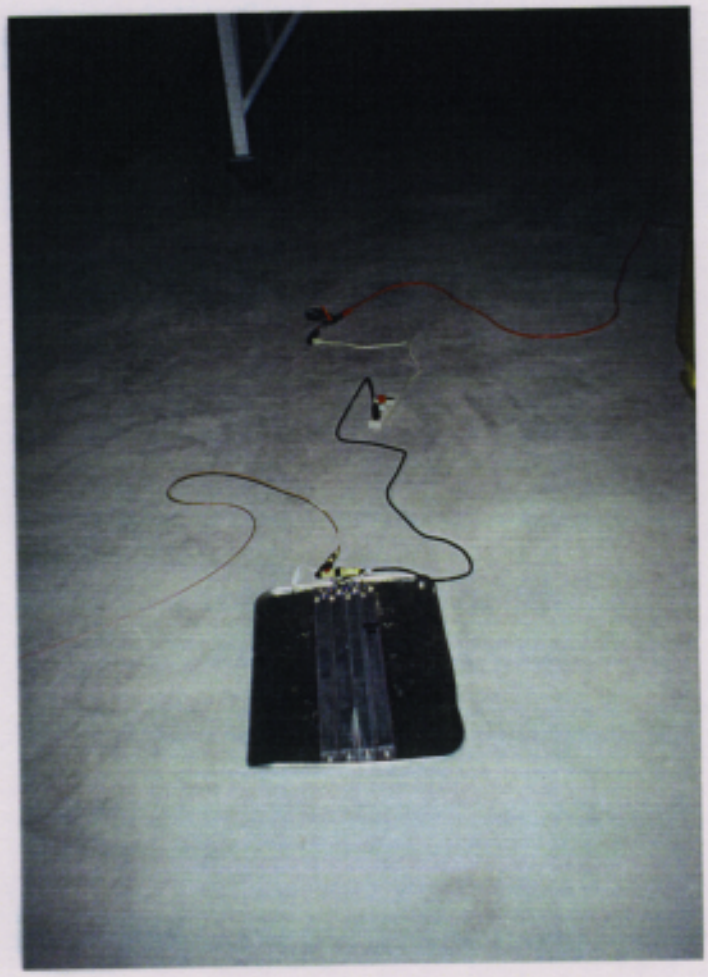
LASER INTERFEROMETER

RADIATED EMISSIONS TEST POSITION NO. 1, AT WAREHOUSE.

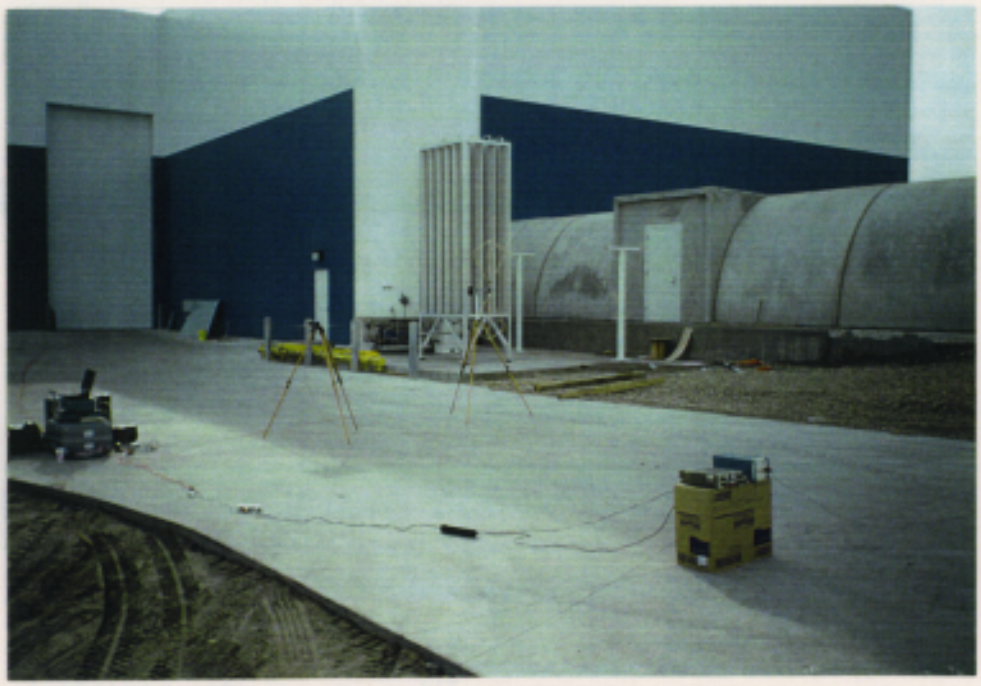
RADIATED EMISSIONS TEST POSITION NO. 1,AT WAREHOUSE.



RADIATED EMISSIONS TEST POSITION NO.2, IN LVEA (VERTEX)



RESISTIVE LOAD BANK FOR CONDUCTED EMISSIONS TESTING.



RADIATED TEST POSITION NO. 3, FOR EXTERIOR Q TEST.

RADIATED TEST POSITION NO. 3, FOR EXTERIOR Q TEST.