Intel Corporation

DuPont Site EMC Laboratory

Ferrite Clamp/Tube Analysis

CISPR/G/143/CDV

31 August 1999

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Table of Contents

Section **Page #**

I. Introduction....1
II. Test Program....1
III. Test Facility, Equipment and Process....1
IV. Test Results....3
LPX Chassis w/ 75 MHz Pentium® Processor - Ferrites on Power Cords....3
LPX Chassis w/ 75 MHz Pentium® Processor - No Ferrites on Power Cords....4
NLX Chassis w/ 300 MHz Pentium® II Processor - Ferrites on Power and LAN Cords....5
NLX Chassis w/ 300 MHz Pentium® II Processor - No Ferrites on Power and LAN Cords....6
ATX Chassis w/ 550 MHz Pentium® III Processor - Ferrites on Power Cords....7
ATX Chassis w/ 550 MHz Pentium® III Processor - No Ferrites on Power Cords....8
V. Data Analysis....9
LPX Chassis w/ 75 MHz Pentium® Processor....9
NLX Chassis w/ 300 MHz Pentium® II Processor....10
ATX Chassis w/ 550 MHz Pentium® III Processor....11
VI. Conclusions....12
VII. Photographs....12
LPX System w/o Ferrite Clamps....13
LPX System w/ Ferrite Clamps on Power Cords....14
LPX System Power Clamp Detail....15
NLX System w/o Ferrite Clamps....16
NLX System w/ Ferrite Clamps on Power and LAN Cords....17
NLX System Ferrite Clamp Detail....18
ATX System w/o Ferrite Clamps....19
ATX System w/ Ferrite Clamps on Power Cords....20
ATX System Ferrite Clamp Detail....21

I. Introduction

CISPR/G/143/CDV proposes amending CISPR Publication 22, 3rd Edition, to include the use of ferrite clamps or tubes on all cables leaving the turntable when performing radiated emissions measurements. The stated purpose of this change is to improve repeatability between different test laboratories.

II. Test Program

The test program reported in this document was designed to provide a quick indication of the effect of placing ferrite clamps or tubes on cables which leave the turntable. Three pairs of tests were run. Each pair consisted of a test with and without ferrite clamps installed on the cables leaving the turntable. The test systems investigated were:

1. Tower configuration PC (ATX form factor) with a 550 MHz Pentium® III processor. The only peripherals connected were a monitor, keyboard and mouse. The cables leaving the turntable were the power cords for the system and monitor.

2. Desktop system (NLX form factor) with a 300 MHz Pentium® II processor. The peripherals connected during the test were the keyboard and mouse. The cables leaving the turntable were the system power cord and a 10BaseT LAN cable.

3. Desktop system (LPX form factor) with a 75 MHz Pentium® processor. The peripherals connected during the test were a monitor, keyboard and mouse. The cables leaving the turntable were the system power cord and the monitor power cord.

The ferrite clamps used were a Schaffner CDN 725 on the system power cord and a Schaffner INA 726 on the monitor power cord or the LAN cable as applicable. These ferrite clamps are part of the laboratory's IEC 61000-4-6 test system.

III. Test Facility, Equipment and Process

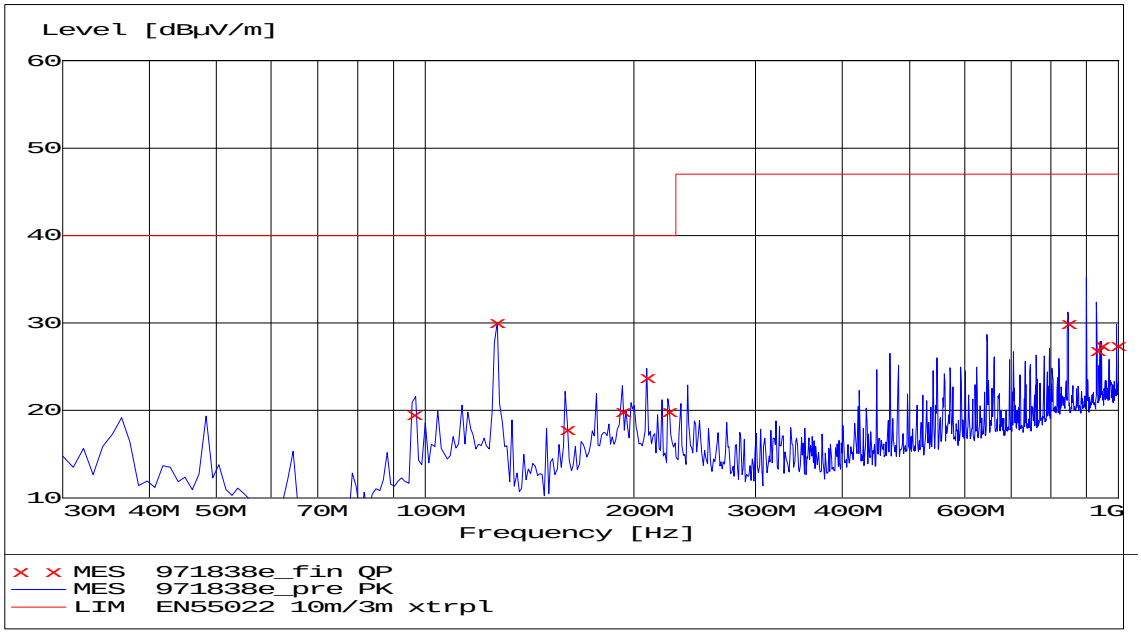
Testing was performed in the Intel DuPont Site EMC Laboratory's 3 meter RF semi-anechoic chamber. This chamber is sized to allow full 1 to 4 meter height scans using broad band antennas and has a 2 meter diameter turntable. The chamber is listed with the FCC for class B certification testing of personal computer systems and peripherals. The Intel DuPont Site EMC Laboratory is accredited by A2LA and BSMI (Taiwan) and is approved by the New Zealand Ministry of Commerce, GOST, VCCI (PLC and OATS facilities only) and NEMKO (Test by Manufacturer program).

A Rohde & Schwarz ESBI receiver, Miteq preamplifier and Chase CBL-6112 BiLog antenna were used for the tests, operating under the control of Rohde & Schwarz ES-K1 software.

The frequency range of 30 to 1000 MHz was scanned at 24 turntable positions (15 degree increments), at antenna heights of 100, 250 and 400 cm and at both horizontal and vertical polarities to find signals emitted by the EUT. Up to 15 signals were then identified by the software based on user supplied criteria. These signals were re-measured at the worst case turntable position, antenna height and polarity (from the steps previously checked) to determine their precise frequency. Each signal was then fully maximized by rotating the turntable through a complete 360 degree circle and scanning the antenna from 1 to 4 meters at the worst case polarity. Once the signal is maximized, a measurement is taken with the quasi-peak detector.

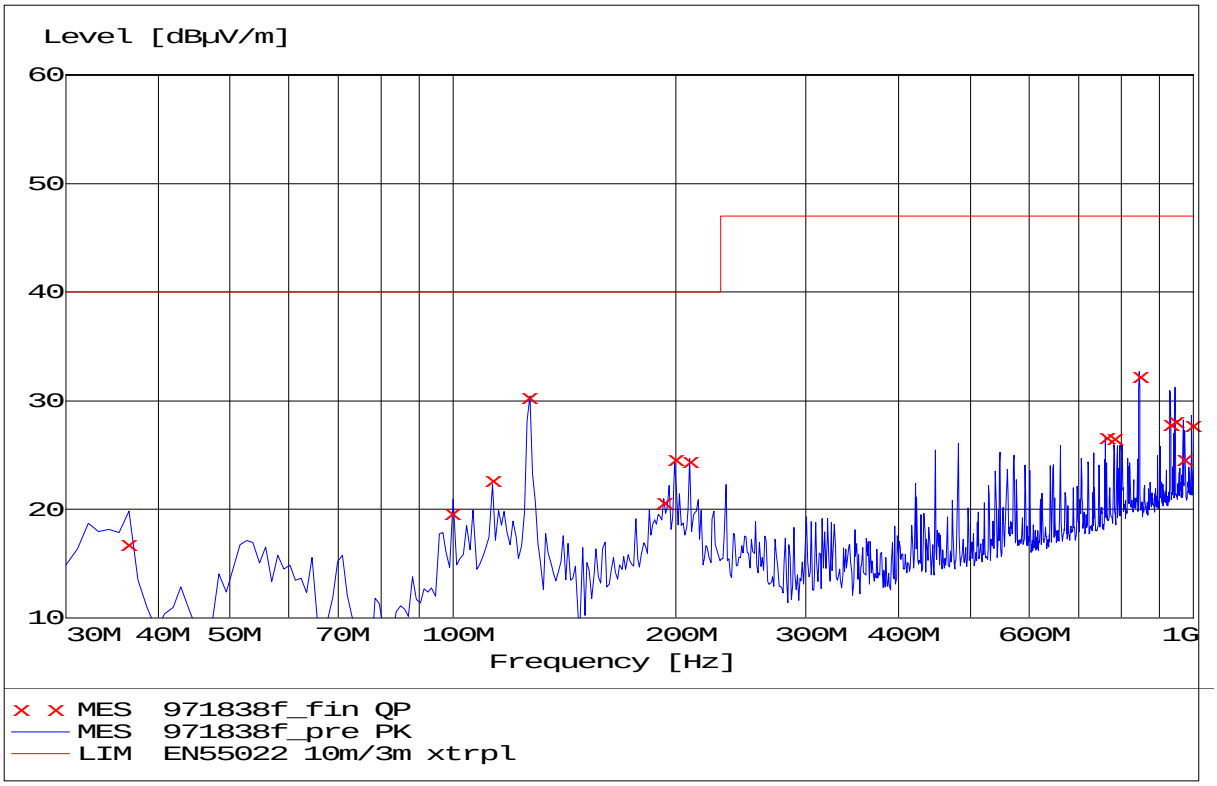
IV. Test Results

The following results were obtained during testing on August 30 and 31, 1999 on the three systems.



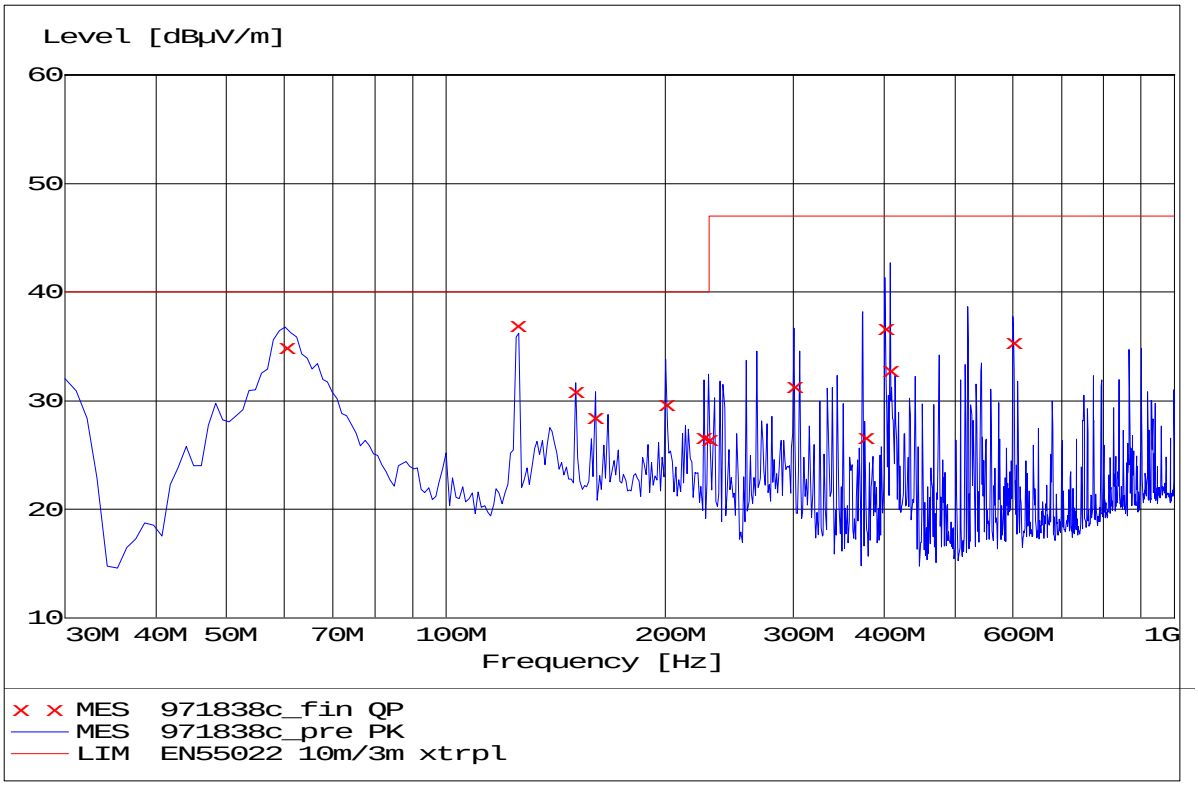
Frequency MHz	Level dBµV/m	Transd dB	Limit dBµV/m	Margin dB	Height cm	Azimuth deg	Pol
96.00	19.5	-27	40	20.5	118	47	VERT
126.45	30.0	-24	40	10.0	287	216	HORZ
159.60	17.8	-26	40	22.2	102	252	VERT
192.00	19.8	-27	40	20.2	102	18	VERT
208.00	23.7	-26	40	16.3	108	21	VERT
224.00	19.8	-26	40	20.2	265	21	VERT
844.80	29.9	-12	47	17.1	102	0	VERT
929.75	26.8	-11	47	20.2	317	0	VERT
944.20	27.4	-11	47	19.6	118	199	VERT
993.90	27.3	-10	47	19.7	122	202	VERT

LPX Chassis w/ 75 MHz Pentium® Processor - Ferrites on Power Cords



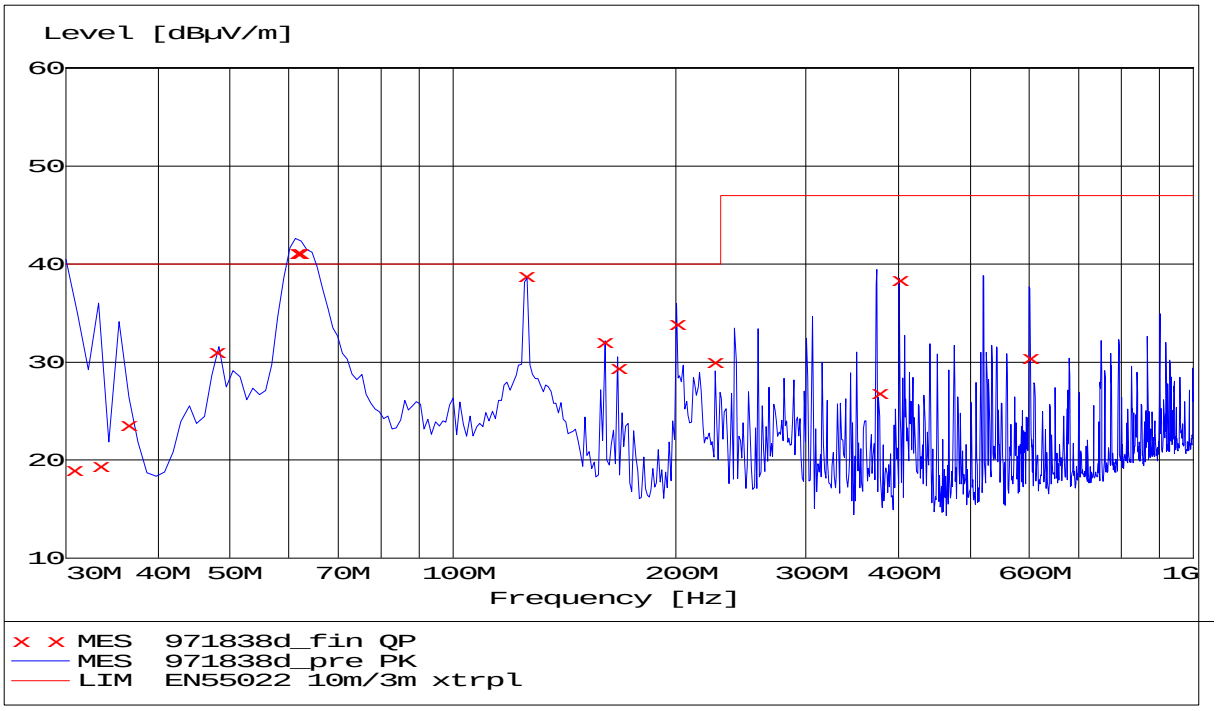
Frequency MHz	Level dBµV/m	Transd dB	Limit dBµV/m	Margin dB	Height cm	Azimuth deg	Pol
36.25	16.8	-21	40	23.2	101	221	VERT
99.35	19.6	-26	40	20.4	102	21	VERT
112.75	22.6	-24	40	17.4	102	254	VERT
126.20	30.3	-24	40	9.7	292	218	HORZ
192.00	20.6	-27	40	19.4	102	0	VERT
198.75	24.6	-27	40	15.4	102	40	VERT
208.00	24.4	-26	40	15.6	102	13	VERT
761.05	26.6	-13	47	20.4	101	50	HORZ
780.05	26.5	-13	47	20.5	101	28	VERT
844.80	32.2	-12	47	14.8	101	0	VERT
929.75	27.8	-11	47	19.2	152	0	VERT
944.20	28.1	-11	47	18.9	121	190	VERT
969.05	24.6	-10	47	22.4	123	186	VERT
993.90	27.7	-10	47	19.3	169	220	VERT

LPX Chassis w/ 75 MHz Pentium® Processor - No Ferrites on Power Cords



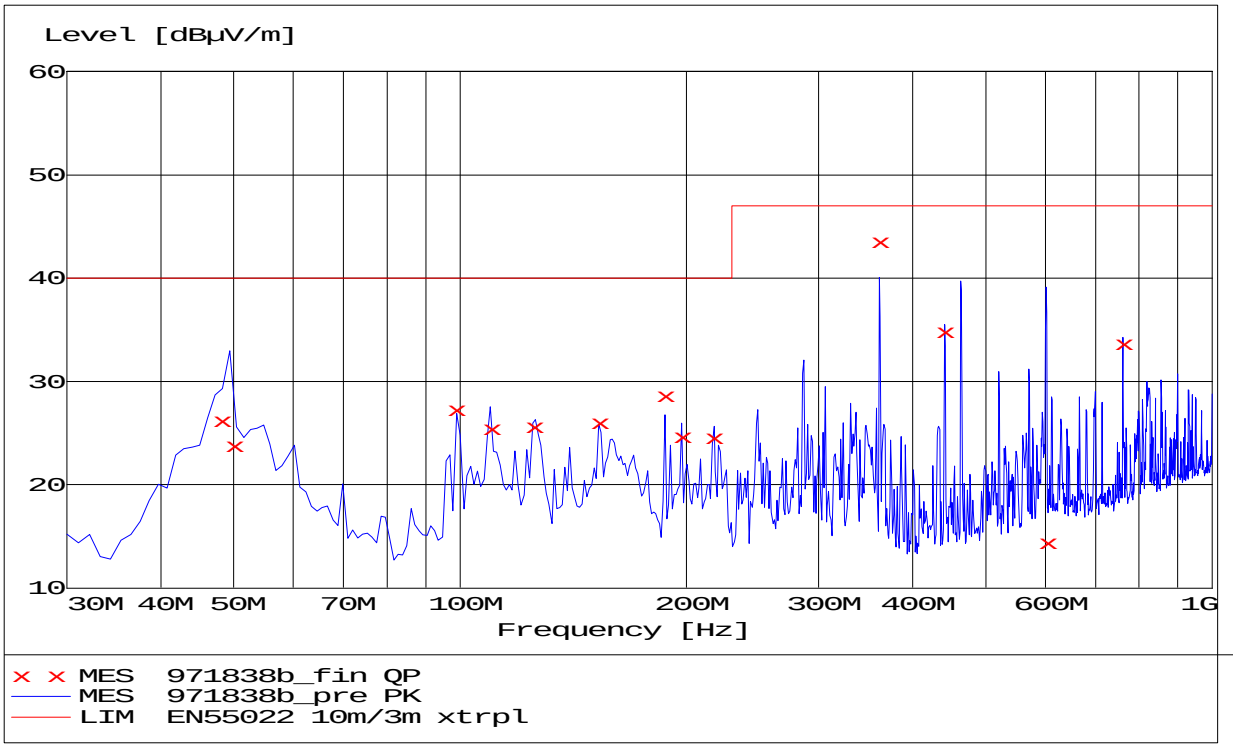
Frequency MHz	Level dBµV/m	Transd dB	Limit dBµV/m	Margin dB	Height cm	Azimuth deg	Pol
60.20	34.9	-30	40	5.1	102	327	VERT
125.00	36.9	-24	40	3.1	279	276	HORZ
150.00	30.8	-25	40	9.2	326	275	HORZ
159.70	28.4	-26	40	11.6	196	238	HORZ
200.00	29.6	-27	40	10.4	102	100	VERT
225.00	26.6	-26	40	13.4	102	100	VERT
229.10	26.4	-25	40	13.6	167	47	HORZ
299.95	31.3	-22	47	15.7	114	110	HORZ
375.00	26.6	-20	47	20.4	102	76	HORZ
399.90	36.6	-19	47	10.4	132	134	HORZ
406.10	32.8	-19	47	14.2	101	68	HORZ
599.85	35.4	-15	47	11.6	102	207	VERT

NLX Chassis w/ 300 MHz Pentium® II Processor - Ferrites on Power and LAN Cords



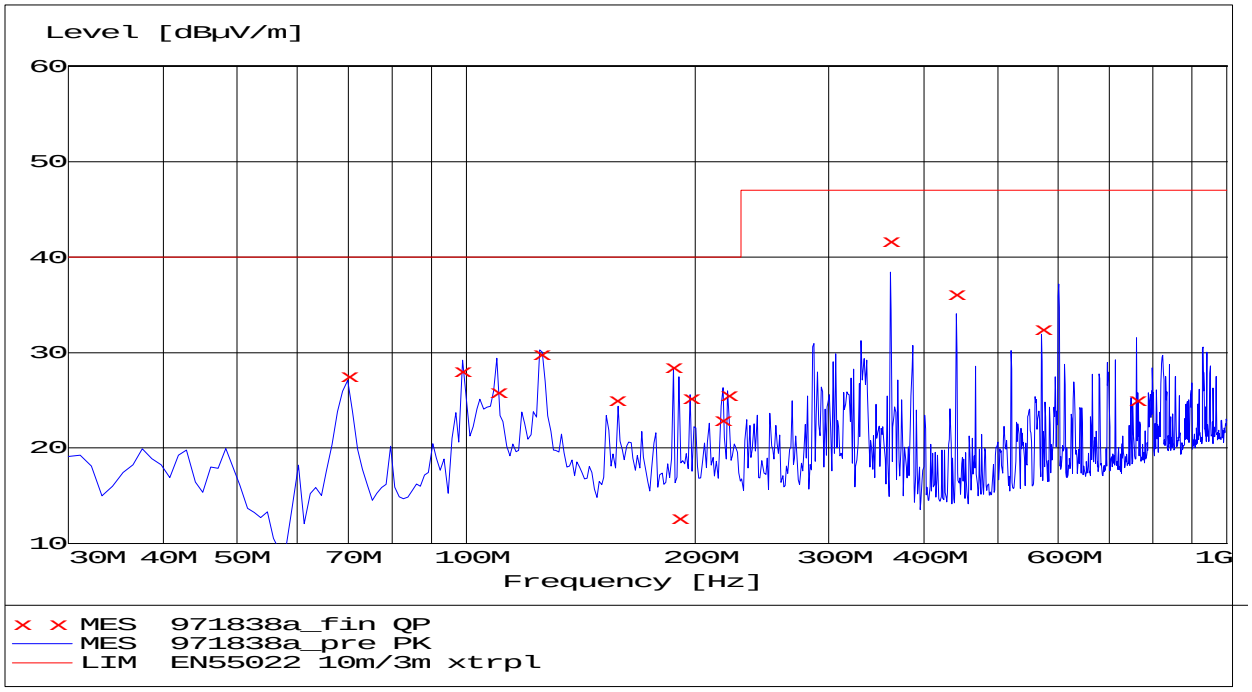
Frequency MHz	Level dBµV/m	Transd dB	Limit dBµV/m	Margin dB	Height cm	Azimuth deg	Pol
30.65	19.0	-18	40	21.0	104	143	VERT
33.30	19.4	-19	40	20.6	120	163	VERT
36.25	23.6	-21	40	16.4	102	187	VERT
47.80	31.1	-27	40	8.9	102	0	VERT
61.30	41.1	-31	40	-1.0	102	0	VERTL
61.95	41.1	-31	40	-1.0	101	359	VERTL
125.00	38.8	-24	40	1.2	101	215	VERTL
159.70	32.0	-26	40	8.0	102	182	VERT
166.60	29.4	-26	40	10.6	102	187	VERT
199.95	33.9	-27	40	6.1	101	53	VERT
225.00	30.0	-26	40	10.0	101	232	VERT
375.00	26.8	-20	47	20.2	102	229	HORZ
399.90	38.4	-19	47	8.6	143	177	VERT
598.95	30.4	-15	47	16.6	124	7	VERT

NLX Chassis w/ 300 MHz Pentium® II Processor - No Ferrites on Power and LAN Cords



Frequency MHz	Level dBµV/m	Transd dB	Limit dBµV/m	Margin dB	Height cm	Azimuth deg	Pol
48.00	26.2	-27	40	13.8	117	0	VERT
49.85	23.8	-28	40	16.2	104	33	VERT
98.30	27.2	-26	40	12.8	225	136	HORZ
109.70	25.4	-25	40	14.6	118	62	VERT
124.85	25.6	-24	40	14.4	286	255	HORZ
152.65	26.0	-26	40	14.0	102	157	VERT
186.60	28.6	-27	40	11.4	183	253	HORZ
196.65	24.6	-27	40	15.4	136	239	HORZ
216.35	24.5	-26	40	15.5	150	239	HORZ
359.80	43.5	-20	47	3.5	167	14	VERT
439.70	34.8	-18	47	12.2	147	325	VERT
601.60	14.4	-15	47	32.6	102	0	VERT
760.30	33.7	-14	47	13.3	102	213	HORZ

ATX Chassis w/ 550 MHz Pentium® III Processor - Ferrites on Power Cords



Frequency MHz	Level dBµV/m	Transd dB	Limit dBµV/m	Margin dB	Height cm	Azimuth deg	Pol
69.8	27.5	-30.3	40	12.5	181	0	VERT
98.3	28	-26.3	40	12	102	84	VERT
109.7	25.8	-24.7	40	14.2	115	84	VERT
124.85	29.8	-24	40	10.2	283	266	HORZ
157.3	25	-25.8	40	15	174	262	HORZ
186.6	28.4	-27	40	11.6	178	252	HORZ
190.05	12.6	-27.1	40	27.4	209	0	HORZ
196.65	25.2	-26.9	40	14.8	127	235	HORZ
216.35	22.9	-26	40	17.1	101	62	VERT
220.5	25.5	-26	40	14.5	143	254	HORZ
359.75	41.6	-19.8	47	5.4	190	2	VERT
439.7	36.1	-18.1	47	10.9	142	337	VERT
570.2	32.4	-15.4	47	14.6	102	8	VERT
759.55	25	-13.5	47	22	109	348	VERT

ATX Chassis w/ 550 MHz Pentium® III Processor - No Ferrites on Power Cords

V. Data Analysis

The effect of the presence of the ferrite clamps on the data is shown in the following tables. Frequencies that differ slightly are listed with the frequency with ferrite clamps first. Where no comparable signals were found in one condition the entry is left blank.

LPX Chassis w/ 75 MHz Pentium® Processor

Frequency (MHz)	w/ Ferrite Clamps (dBuV/m)	w/o Ferrite Clamps (dBuV/m)	Delta (dB)
36.25	-	16.8	-
96.00	19.5	-	-
99.35	-	19.6	-
112.75	-	22.6	-
126.45 / 126.20	30.0	30.3	-0.3
159.60	17.8	-	-
192.00	19.8	20.6	-0.8
208.00	23.7	24.4	-0.7
224.00	19.8	-	-
761.05	-	26.6	-
780.05	-	26.5	-
844.80	29.9	32.2	-2.3
929.75	26.8	27.8	-1.0
944.20	27.4	28.1	-0.7
969.05	-	24.6	-
993.90	27.3	27.7	-0.4

NLX Chassis w/ 300 MHz Pentium® II Processor

Frequency (MHz)	w/ Ferrite Clamps (dBuV/m)	w/o Ferrite Clamps (dBuV/m)	Delta (dB)
30.65	-	19.0	-
33.30	-	19.4	-
36.25	-	23.6	-
47.80	-	31.1	-
60.20 / 61.30	34.9	41.1	-6.2
60.20 / 61.95	34.9	41.1	-6.2
125.00	36.9	38.8	-1.9
150.00	30.8	-	-
159.70	28.4	32.0	-3.6
166.60	-	29.4	-
200.00 / 199.95	29.6	33.9	-4.3
225.00	26.6	30.0	-3.4
229.10	26.4	-	-
299.95	31.3	-	-
375.00	26.6	26.8	-0.2
399.90	36.6	38.4	-1.8
406.10	32.8	-	-
599.85 / 598.95	35.4	30.4	5.0

ATX Chassis w/ 550 MHz Pentium® III Processor

Frequency (MHz)	w/ Ferrite Clamps (dBuV/m)	w/o Ferrite Clamps (dBuV/m)	Delta (dB)
48.00	26.2	-	-
49.85	23.8	-	-
69.8	-	27.5	-
98.3	27.2	28.0	-0.8
109.7	25.4	25.8	-0.4
124.85	25.6	29.8	-4.2
152.65	26.0	-	-
157.30	-	25.0	-
186.60	28.6	28.4	0.2
190.05	-	12.6	-
196.65	24.6	25.2	-0.6
216.35	24.5	22.9	1.6
220.50	-	25.5	-
359.80 / 359.75	43.5	41.6	1.9
439.70	34.8	36.1	-1.3
570.2	-	32.4	-
601.60	14.4	-	-
760.30 / 759.55	33.7	25.0	8.7

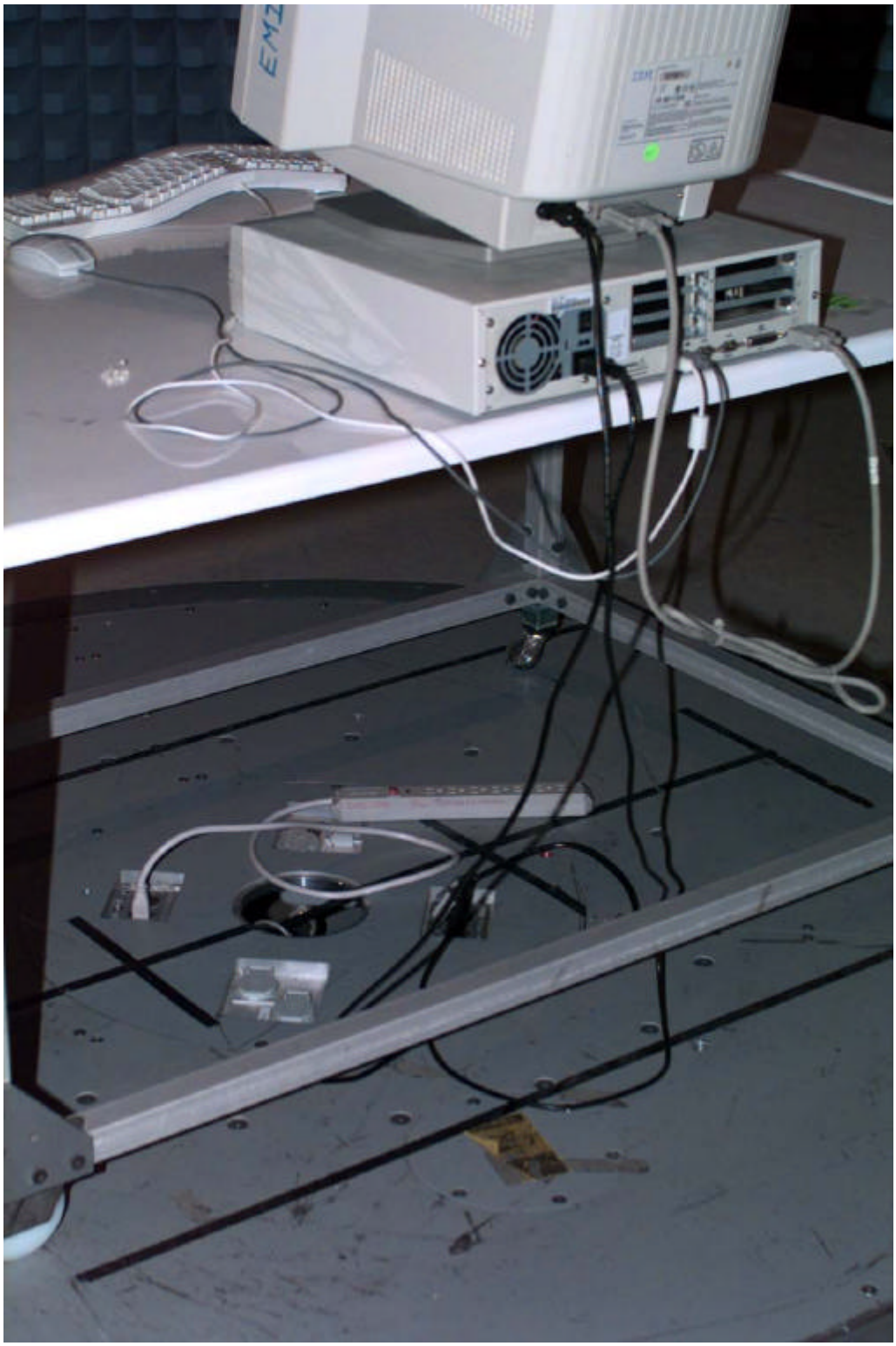
VI. Conclusions

The results show that the ferrite clamps used in the tests (Schaffner CDN 725 EM Clamp and Schaffner INA 726 Isolation Clamp) do have significant impacts on the measured radiated emissions levels from all three systems. Some signals go up while other signals go down. In the case of the NLX system a signal that was over the CISPR 22 Class B limit (adjusted to 3 meters using the 1/R relationship) was reduced by 6 dB when the clamps were installed on the power and LAN cables, bringing the signal under the limit. Note that the system involved was missing chassis parts critical for shielding and is used in the lab for miscellaneous purposes unrelated to EMC testing. The ATX form factor tower chassis had signals around 50 MHz significantly enhanced by adding the clamps and had other signals reduced.

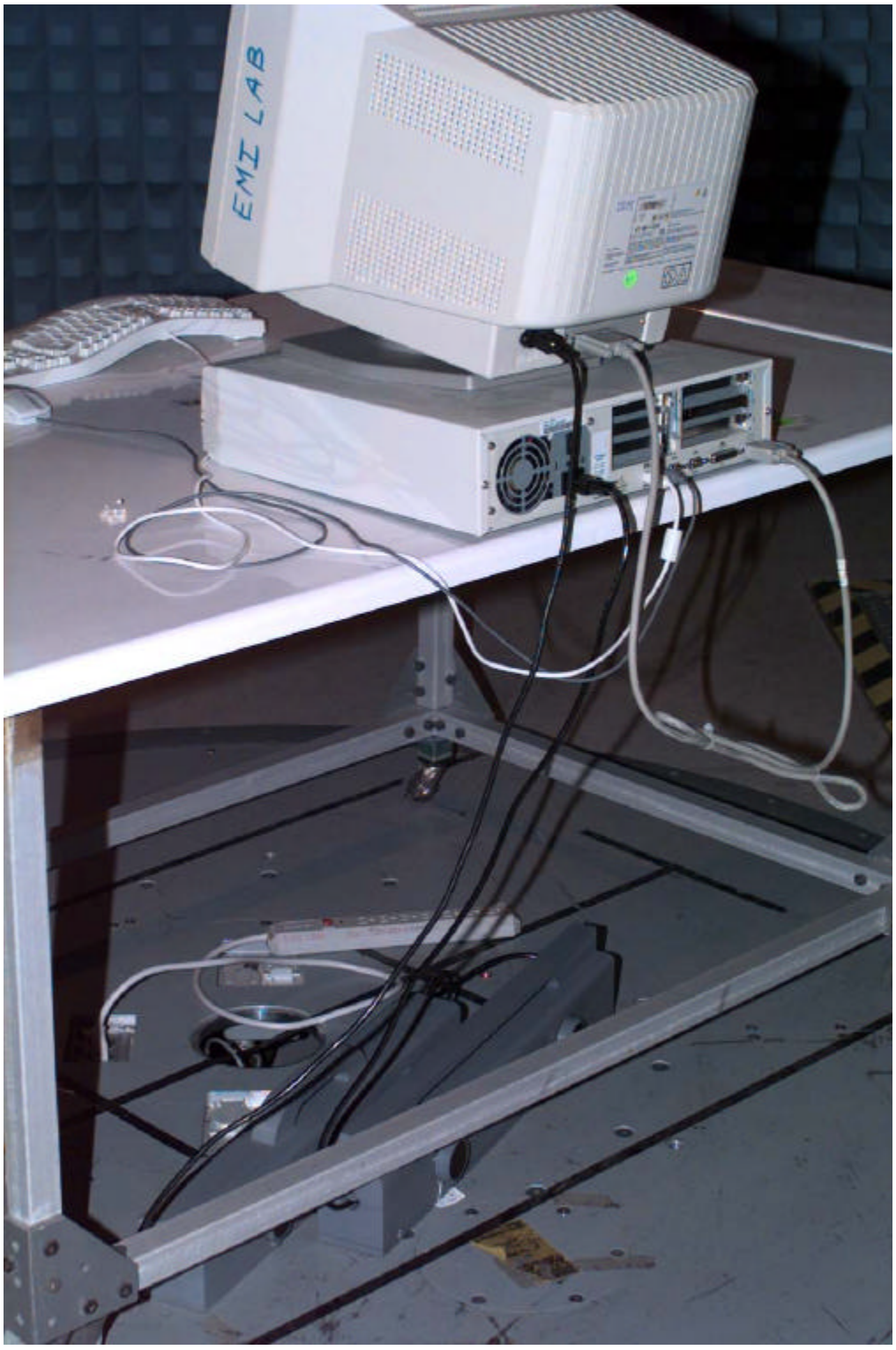
The value of ferrite clamps or tubes on cables leaving the turntable for reducing variations from one site to another was not evaluated in these experiments. What is demonstrated is the incompatibility between measurements using the clamps and measurements which do not use them. Should this CDV be accepted and pass FDIS voting there will be a major disagreement between CISPR 22 (as amended) and ANSI C63.4-1999. The result will be the necessity to perform radiated emissions testing twice, once with the ferrites and once without. Unless CISPR 22 and ANSI C63.4-1999 remain in agreement, this result will be unavoidable.

VII. Photographs

The following photographs show the rear of the three systems, with and without the ferrite clamps. Close-up photographs of the ferrite clamps are also provided to show how they were placed on the turntable under the EUT support table.

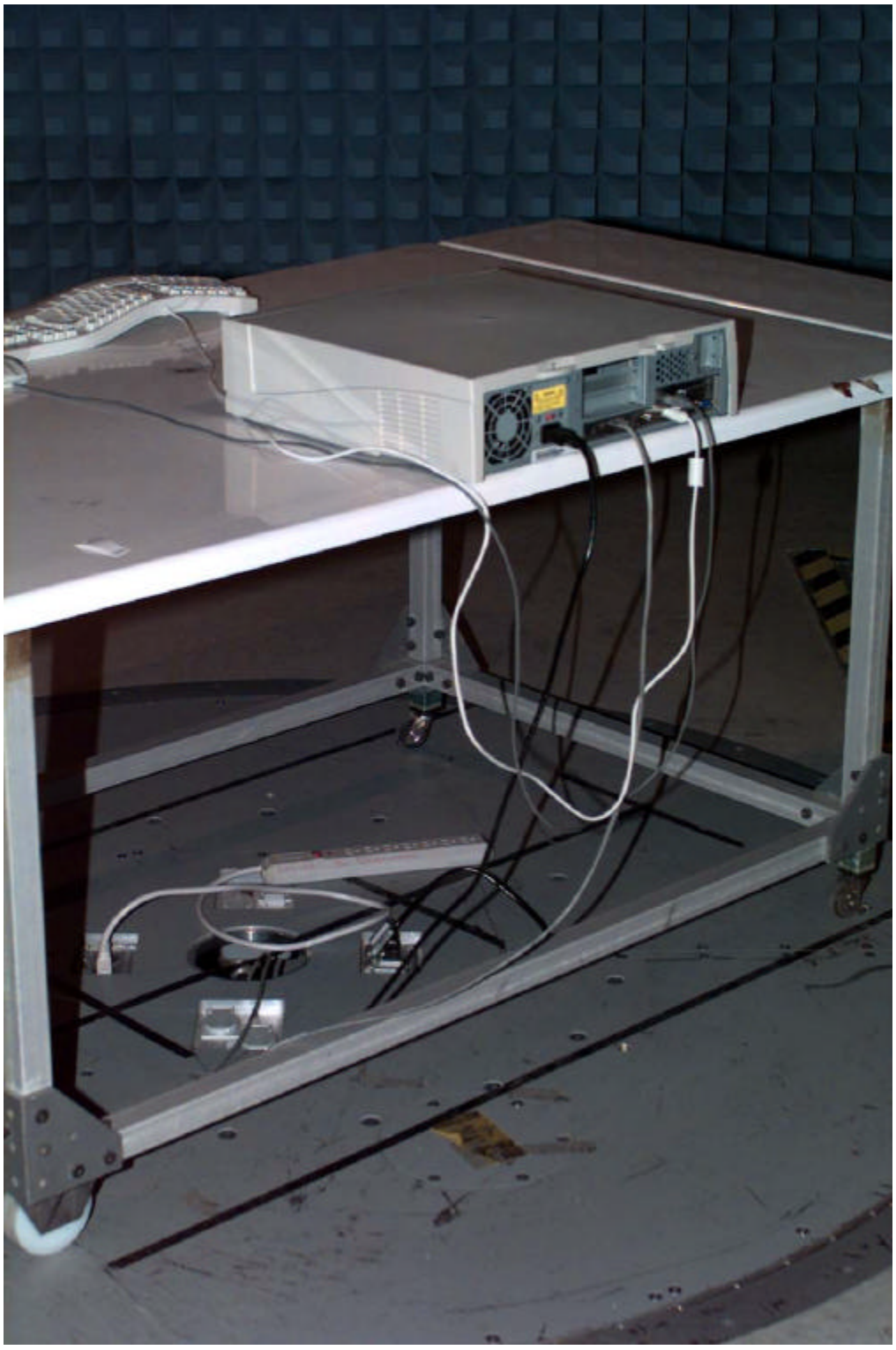


LPX System w/o Ferrite Clamps



LPX System w/ Ferrite Clamps on Power Cords

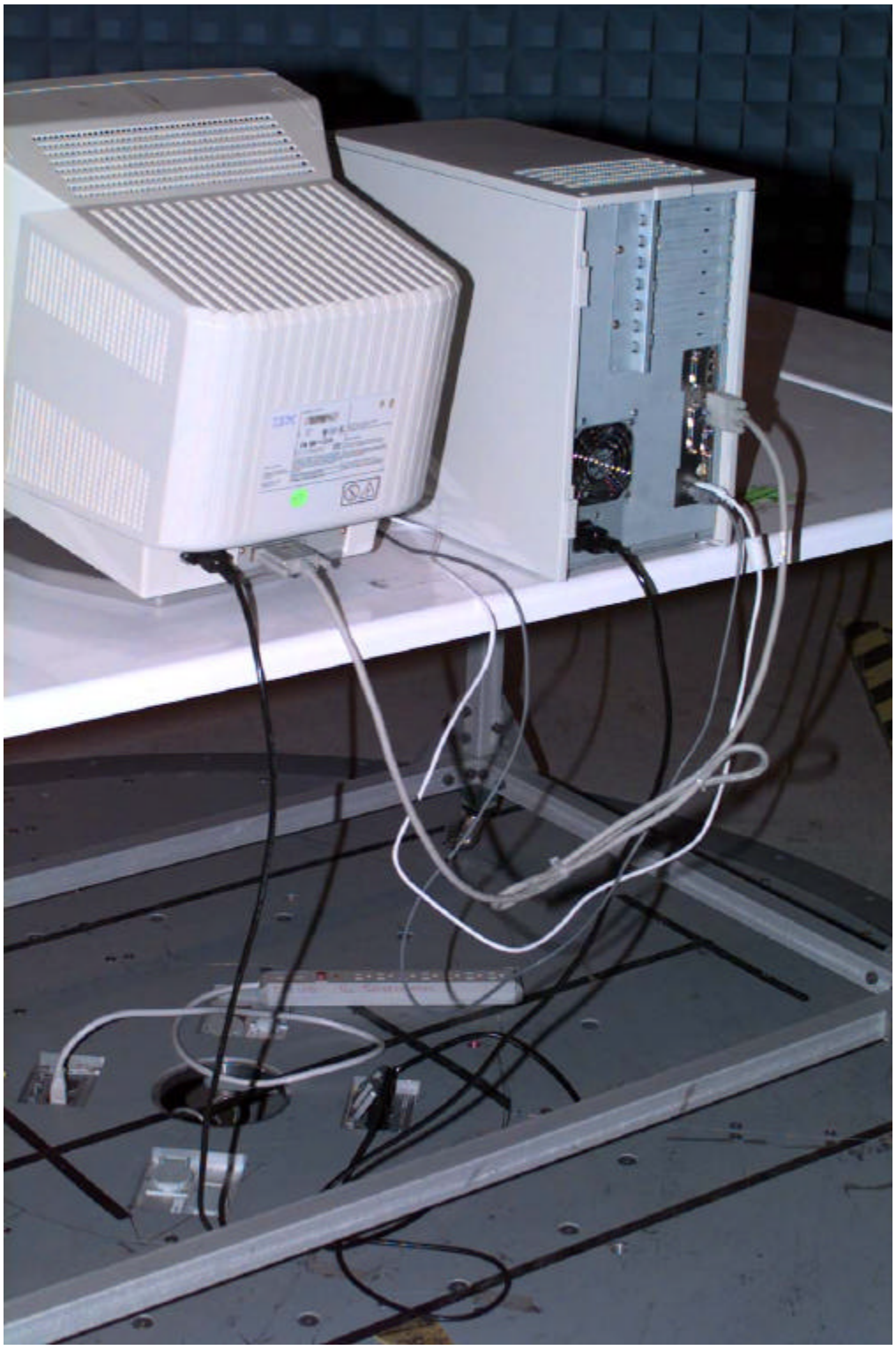
LPX System Power Clamp Detail



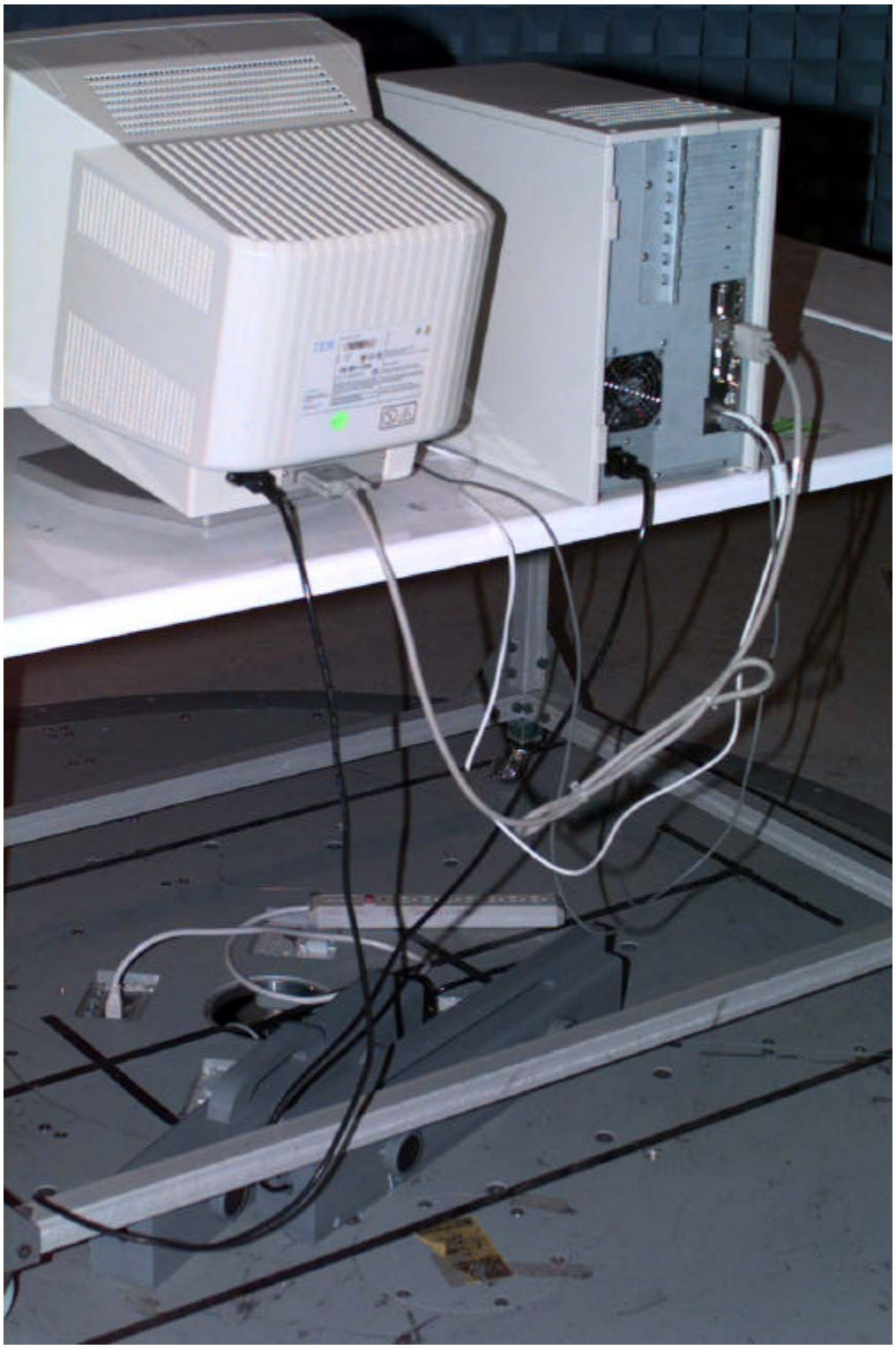
NLX System w/o Ferrite Clamps

NLX System w/ Ferrite Clamps on Power and LAN Cords

NLX System Ferrite Clamp Detail



ATX System w/o Ferrite Clamps



ATX System w/ Ferrite Clamps on Power Cords

ATX System Ferrite Clamp Detail