Radiated Emissions

The test conditions required and executed in this evaluation are listed below. Modulated or pulsed signal transmission is not employed by the EUT, so test requirements associated with this type of signaling is not required.

Measurement standards used

Table 7. Referenced standards by condition

Condition / objective	Reference to standard
Measurement standards	CFR 47 Part 15.31, which invokes ANSI C63.4-2003 in several instances.
Frequency range of measurements	CFR 47 Part 15.33
Conformity to radiated emission limits outside of transmission frequency band	CFR 47 Part 15.209 ANSI C63.4, Section 13.1.4.2
Conformity to in-band field strength limits	CFR 47 Part 15.225 ANSI C63.4, Section 13.1.5
Fundamental frequency stability during high and low ambient temp.	CFR 47 Part 15.225 ANSI C63.4, 13.1.6.1 (Frequency stability with respect to ambient temperature.)
Fundamental frequency stability during high and low supply voltage.	CFR 47 Part 15.225 ANSI C63.4, 13.1.6.2 (Frequency stability with respect to voltage variation)

Conformity to in-band transmission limits: Operation within the band of 13.553-13.567 MHz

In-band emission limits are to be less than or equal to 15,848 µV/m (84 $dB_{\mu V}$ /m) at 30 meters from the EUT.

Measurements taken closer than 30 meters are permissible provided that an extrapolation factor per CFR 47 Part 15.31 (f)(2) is used. In this test, the calibrated loop antenna is positioned 3 meters from the EUT and an extrapolation factor is determined empirically by measuring emissions at 3 and 10 meters. In turn, this factor is used to determine the distance factor used to scale the amplitudes to a 30 meter distance.

Quasi-peak measurements and extrapolation factor.

Table 8. Quasi-Peak Data for determining extrapolation factor

Freq. MHz	Measured (cable + AF included. dBuV/m	Det	Test Distance	Loop Antenna orientation
13.560	70.2	QP	3	perpendicular
	60.3		10	

Change in amplitude from 3 m to 10 m: 70.2 dBuV/m – 60.3 dBuV/m = 9.9 dB

? E_{factor} x {Log [(3 m) / (10 m)]^2 } = D_{factor}

where E_{factor} is the extrapolation factor

D_{factor} is the distance factor = 9.9 dB

E_{factor} x {Log[(3 m / 10 m)]^2 } = 9.9 dB

(2 * E_{factor}) x [Log (0.3)] = 9.9 dB

E_{factor} = 9.9 dB / (2 * Log 0.3)

= - 9.47 dB

With this extrapolation factor, D_{factor} can be determined for scaling the 3 meter amplitude out to 30 meters.

- 9.47 dB x {Log [(3 m) / (30 m)]^2 } = 18.94 dB

Table 9. Quasi-Peak Measurements - Fundamental. Amplitude scaled from 3 m to 30 m

Frequency MHz	3 m amplitude dBuV/m (incl. cable + AF)	Det	Test Distance meters	Loop Antenna Oriented	D_{factor} for scaling to 30 m dB	Resultant Measurement to compare to limit dBuV/m	FCC limit at 30m dBuV/m	Margin dB
13.560	70.2	QP	3	Perpen-dicular	18.94	51.26	84	-32.74

The product passes—with substantial margin—the requirements for the emission limits at the fundamental frequency.

Conformity to radiated emission limits outside of transmission frequency band

Emissions < 30 MHz

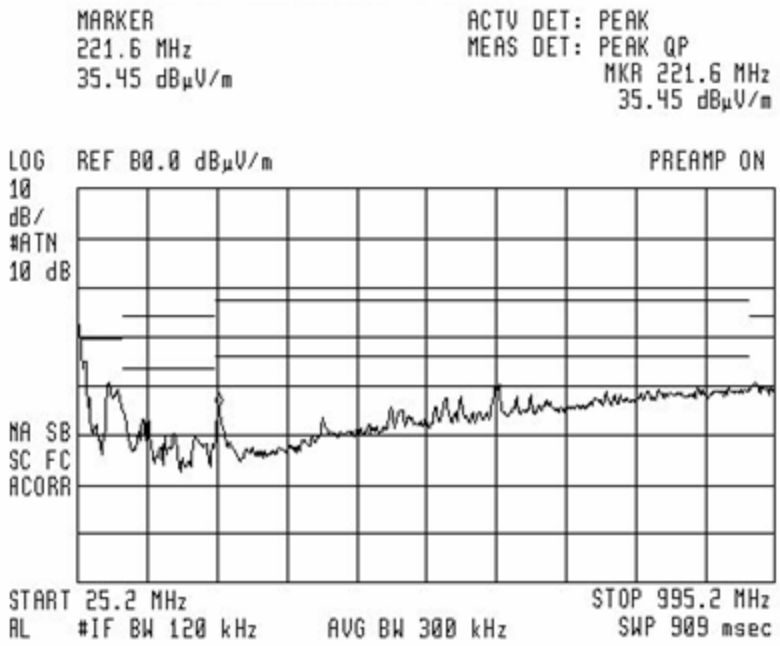
The emission of the second harmonic of 27.12 MHz was measured using the same method at that for the fundamental with the EUT positioned for maximum field strength detection.

Table 10. Quasi-peak data for determining extrapolation factor

Frequency MHz	3 m amplitude dBuV/m (incl. cable + AF)	Det	Test Distance meters	Loop Antenna Oriented	D_{factor} for scaling to 30 m dB	Resultant Measurement to compare to limit dBuV/m	FCC limit at 30m dBuV/m	Margin dB
27.12	9.4	QP	3	Perpen-dicular	18.94	-9.24	29.5	-38.7

Emissions = 30 MHz

Radiated emissions were prescreened from 30 MHz to ~ 1 GHz, in a shielded room using a biconical antenna positioned ~ 1 meter above the EUT. The emissions profile is plotted below.



The photograph of the setup used to obtain the prescreen data is shown below. This is the same shielded room in which conducted emissions were measured.

Figure 10. Radiated—Rear View.

Final radiated emission measurements were executed at the OATS

Field strengths detected with a vertically polarized receiving antenna positioned 3 meters from the EUT are tabulated and plotted below. There were no other remarkable field strength levels above 220.87 MHz to 1 GHz.

Table 11. Quasi-peak Measurements: V-polarization at 3 meters.

Freq	Azimuth	Antenna Height	Peak Amp	QP Amp (corrected)	Limit	Margin
MHz	degrees	Meters	dBuV / m	dBuV / m	dBuV / m	dB
30.02	**0**	**1**	44.97	**37.96**	**40**	-2.04
37.22	**0**	**1**	34.79	**28.83**	**40**	-11.17
67.87	**190**	**1**	33.93	**27.76**	**40**	-12.24
54.25	**180**	**1**	37.27	**32.26**	**40**	-7.74
40.68	**220**	**1**	41.13	**35.5**	**40**	-4.5
81.37	**200**	**1**	43.15	**34.82**	**40**	-5.18
108.40	**0**	**1**	29.26	**22.16**	**43.5**	-21.34
113.87	**0**	**1**	27.12	**20.38**	**43.5**	-23.12
122.09	**0**	**1**	26.28	**18.88**	**43.5**	-24.62
135.56	**0**	**1**	23.75	**17.56**	**43.5**	-25.94
220.87	**0**	**1**	26.5	**20.34**	**46**	-25.66

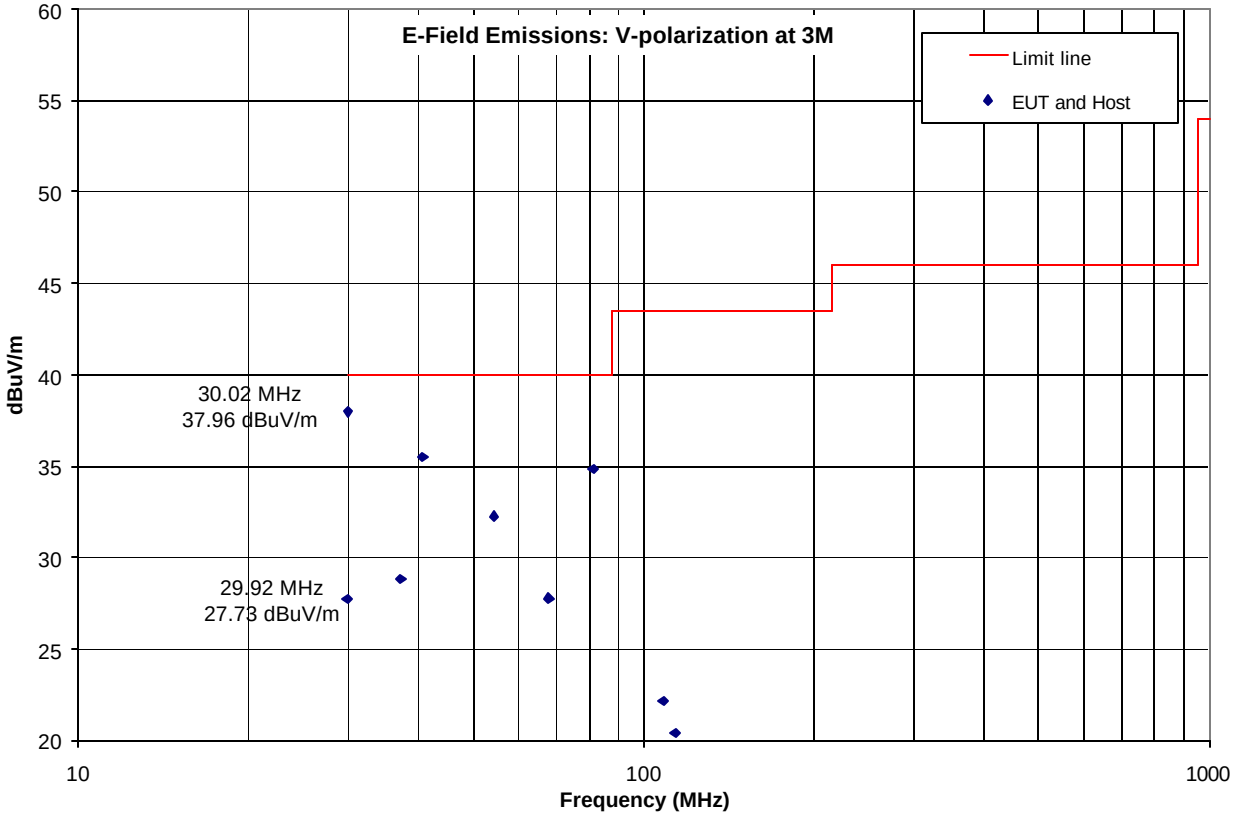


Figure 7. Plot of quasi-peak measurements: V-polarization.

Given a measurement uncertainty[1] of ± 1.4 dB (at 95% confidence level), the emission at 30.02 MHz has enough margin at 2.04 dB below the limit.

Emissions with a horizontally polarized receiving antenna positioned 3 meters from the EUT are tabulated and plotted below.

Table 12. Quasi-peak measurements: H-polarization at 3 meters.

Freq MHz	Azimuth degrees	Antenna Height Meters	Peak Amp dBuV / m	QP Amp (corrected) dBuV / m	Limit dBuV / m	Margin dB
30.00	**0**	**4**	33.47	**27.66**	**40**	**-12.34**
37.03	**0**	**2.5**	28.26	**22.38**	**40**	**-17.62**
40.61	**150**	**4**	31.56	**20.92**	**40**	**-19.08**
54.20	**300**	**3.3**	31.33	**26.14**	**40**	**-13.86**
67.71	**0**	**3.5**	28.48	**19.32**	**40**	**-20.68**
81.27	**0**	**3.5**	42.54	**36.68**	**40**	**-3.32**
108.50	**0**	**3.5**	22.59	**16.59**	**43.5**	**-26.91**
122.10	**0**	**3.5**	21.04	**15.13**	**43.5**	**-28.37**
135.68	**0**	**3.5**	20.66	**14.34**	**43.5**	**-29.16**
113.85	**0**	**3.5**	22.7	**15.48**	**43.5**	**-28.02**
220.85	**0**	**3.5**	26.04	**18.64**	**46**	**-27.36**

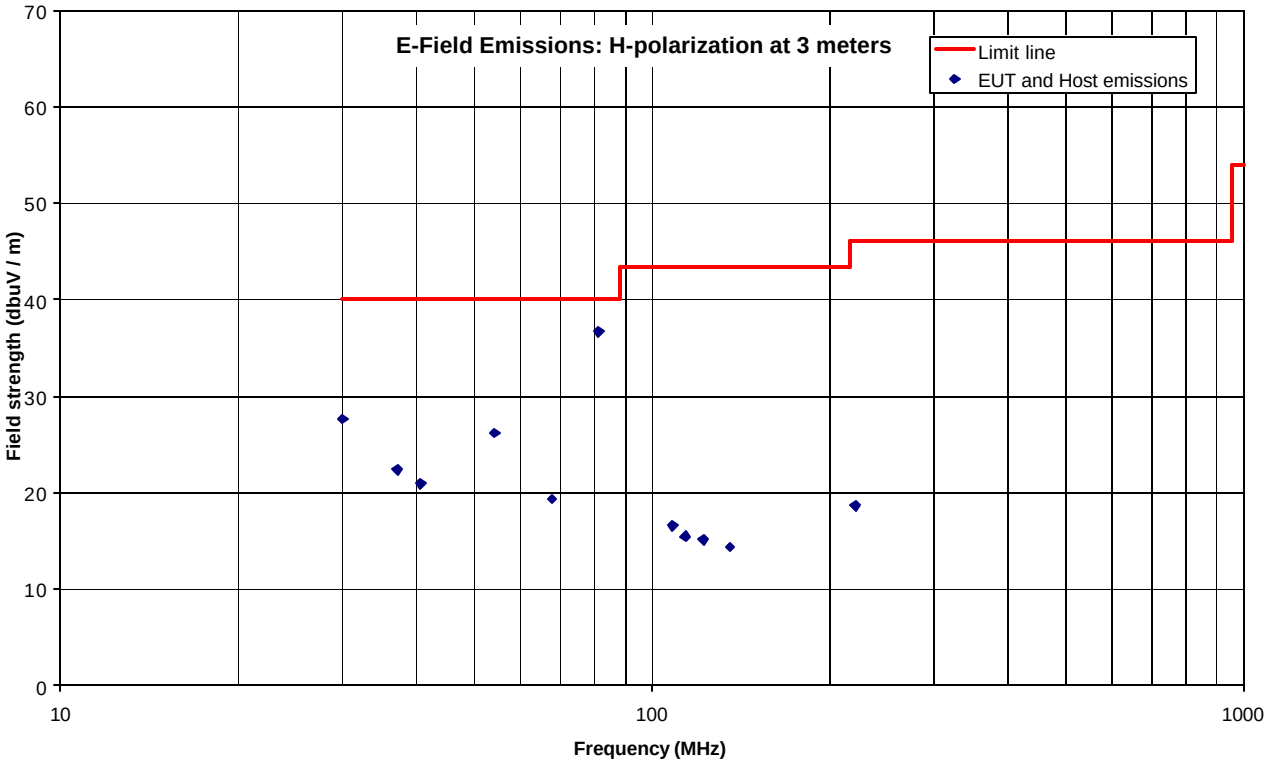


Figure 8. Plot of Quasi-Peak Measurements: H-polarization.

Given a measurement uncertainty[2] of ± 1.4 dB (at 95% confidence level), the emission at 81.27 MHz has enough margin at 3.32 dB below the limit.

The host computer's contribution to the radiated emission characteristics are discussed in Appendix B.

Fundamental frequency stability

The frequency tolerance is reported as a function of ambient temperature and supply voltage, exclusively: **during high and low ambient temperature, and during high and low supply voltages.**

While the supply voltage variation cited in the standard pertains to a-c mains connected or battery powered equipment, the subject EUT is powered by 5 Vdc supplied via the USB cable from a desktop computer. Therefore, a "breakout" USB cable enabled the use of a variable voltage supply to vary the d-c operating voltage range into the product. This range is 5 ± 1 Vdc which is the operating range specified for the product (see spec sheet).

For temperature variation effects testing, the EUT was placed in a temperature controlled chamber. Baseline measurements were made with the EUT at room temperature (24 deg. C) and at nominal DC supply voltage of 5 V.

The chamber temperature was reduced to –20 deg. C. The system was allowed to stabilize, approximately 20 minutes, and the frequency measurements were repeated.

The chamber temperature was then increased to +50 dec C. After 20 minutes to allow for temperature stabilization, the frequency measurements were repeated.

Below are tabulated results of these tests.

Table 13. Frequency stability measurements

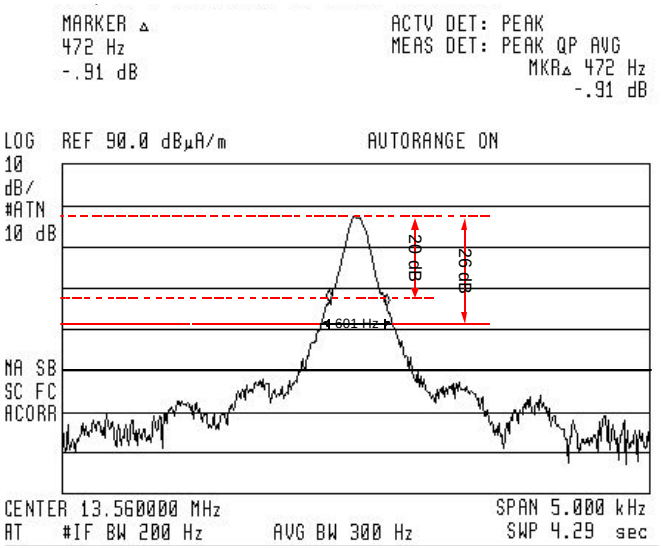
Chamber Temp. (deg. C)	80% supply voltage (4 V_{dc}) measured		100% supply voltage (5 V_{dc}) measured (Hz)		120% supply voltage (6 V_{dc}) measured (Hz)		Maximum Frequency Variant	LIMIT 15.225c ±0.01% of fundamental (Hz)	
	MHz	dBuV/m	MHz	dBuV/m	MHz	dBuV/m			
	VOLTAGE VARIATION EFFECT								
24	13.56	65.97	13.56	70.20	13.56	62.46	0.00	±1,356	Pass
	TEMPERATURE VARIATION EFFECT								
25			13.560 057						
50			13.560 107						
-20			13.559 976						
							131 Hz	±1,356	Pass

Frequency stability under both scenarios meets the requirements with substantial margin.

Occupied bandwidth data

The 20dB and 26 dB bandwidth was determined for this non-modulated carrier using a 300Hz bandwidth on the HP8546 EMI receiver. The loop antenna was positioned at 3 meters from the EUT. A tabulation and plot of the results are provided below.

Fundamental (MHz)	Measured 20dB Bandwidth	Measured 26dB Bandwidth
13.56	472 Hz	601 Hz



9. GENERAL AND SPECIAL CONDITIONS

Variance in measurement method with loop antenna

ANSI C63.4-2003 stipulates that the loop antenna be rotated about its vertical axis to search for maximum emissions in addition to rotating the turntable through 360 degrees. In lieu of rotating the loop antenna, the RFID device (the EUT) was oriented in three mutually orthogonal positions. See Section 3.0 Equipment and cable arrangement for details.

The rationale for using this alternative method is:

a. Mutual orthogonal orientations of the EUT effects similar angular relationships between the emission source and receiving antenna as when the loop antenna is rotated. Given the size of the EUT, this was very simple to do.

b. The impact on emission level changes were greater when manipulating the EUT rather than rotating the loop antenna.

c. More sides of the EUT are presented to the receiving antenna while progressing through the 360 deg. table top rotation.

Additions to achieve compliance

It is required that two turns of the USB cable pass through a toroidal ferrite (Tokin p/n ESD SR-250) to reduce spurious emissions above 30 MHz. The location of the toroid is between one and two inches from the exterior of the housing.

10. SUMMARY OF RESULTS

a) This test series evaluated the product to FCC Part 15, Subpart C.

b) The product is compliant to the requirement of CFR 47, FCC Part 15, SubPart C for operation in the 13.553-13.567MHz frequency band.

c) The product was received on August 21, 2007 and this test series commenced on the same date.

d) In 120VAC 60Hz operation, the highest mains conducted emission (spurious) was 10.8 dB below the limit at 250 kHz when measuring between neutral and ground.

e) Comparison of conducted emissions executed with the EUT's antenna versus a 50? "dummy" load replacing the antenna revealed no remarkable emission levels within the fundamentals bandwidth.

f) The fundamental frequency variance within a temperature range of –20°C to +50°C is 131 Hz vs. 1,356 Hz limit.

g) D-C supply variation of 5 ± 1 Vdc resulted in no measurable frequency variation of the fundamental.

h) The 13.56MHz fundamental was measured using a loop antenna at distances of 3 and 10 meters. Field strengths of 70.2 dBuV/m and 60.3 dBuV/m which are both below the 84 dBuV/m limit at 30 meters.

i) Results cited in "h" preclude the need to extrapolate measurements out to 30m. Nevertheless, a calculation was done with a resultant measurement of 51.26 dBuV/m (32.74 dB below the limit).

j) The spurious emission level above 30 MHz that were nearest the limit occurred at 30.02 MHz (2.04 dB below) with a vertical polarized antenna, and 81.27 MHz (3.32 dB below) with a horizontally polarized antenna. The emission limits are 40 dBuV/m at both frequencies.

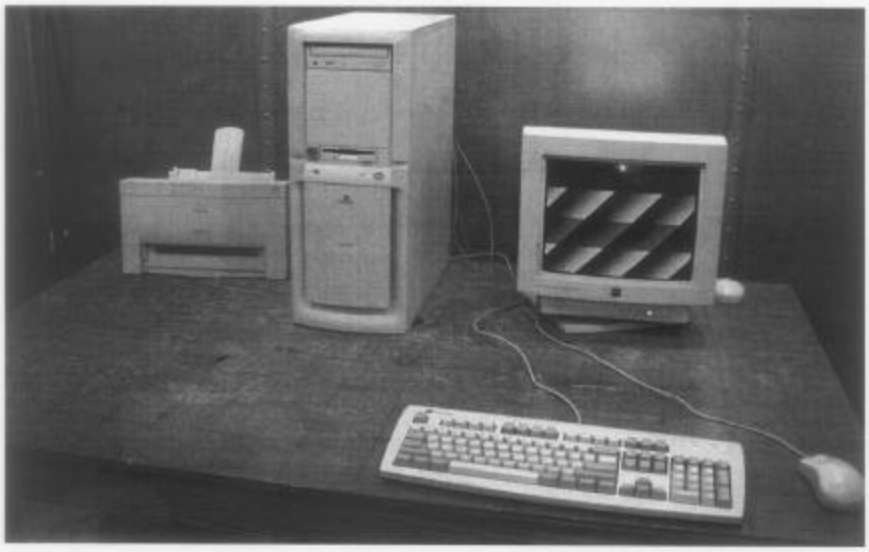
k) Emissions of the host computer were evaluated using data from a previous test. It did not contribute and remarkable emission levels and enabled discernment of EUT-specific emissions.

APPENDIX A CONDUCTED EMISSIONS OF HOST COMPUTER

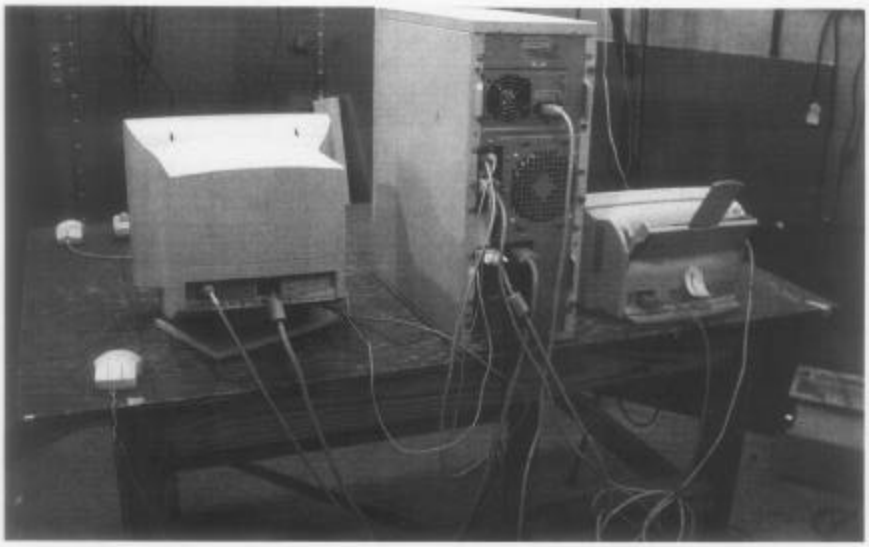
This test data of the host computer alone provides a reasonable baseline of its conducted emissions. The setup used is similar to that used for the when the subject EUT was attached. The difference is that the monitor and tower are in opposite positions, and a printer was connected to the PC tower via an RS-232 connection.

Below is a photo of the test setup.

LINE CONDUCTED SETUP WITH VGA
FRONT VIEW

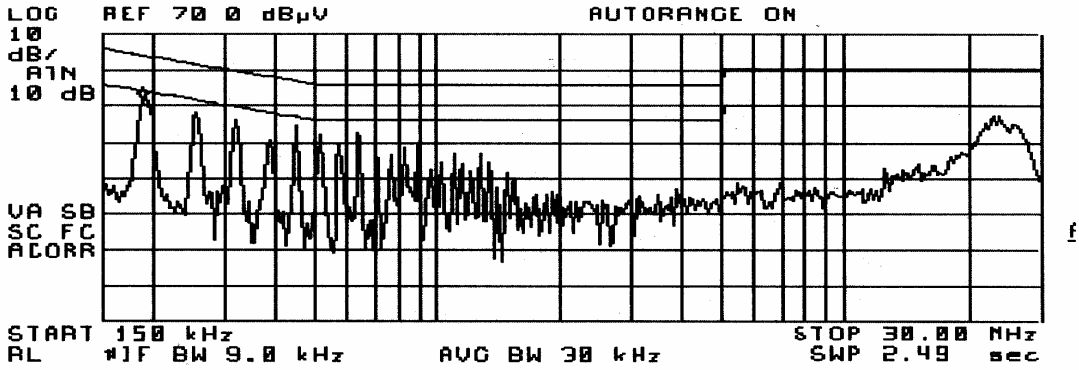


REAR VIEW



Data obtained from this setup follows.

PHASE to Ground Measurement.
Class B
Plot of Peak Values



Tabulated Quasi-Peak/Average Measurements.

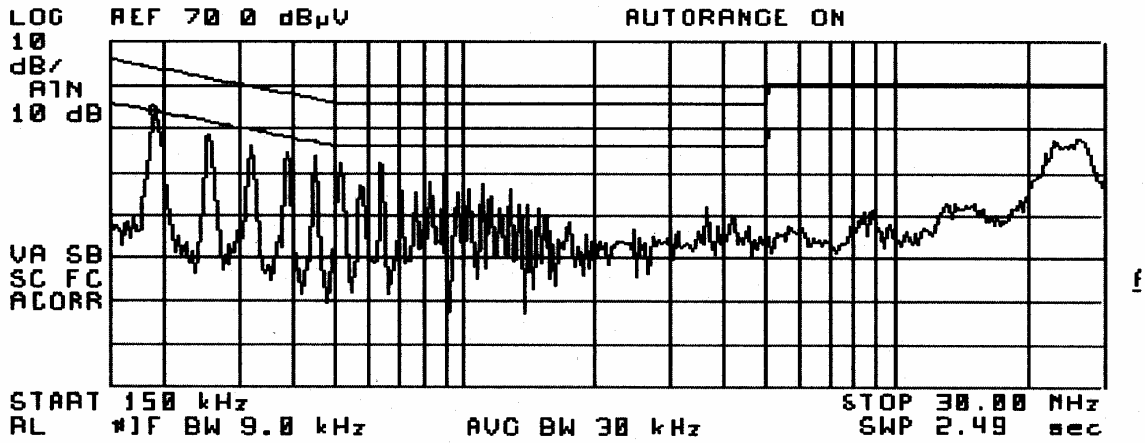
Frequency	dBuV Reading		dBuV EN55022 B Limit		dB Margin	
MHz	QP	Avg	QP	Avg	QP	Avg
0.194	52.60	48.03	63.86	53.86	-11.26	-5.83
0.259	48.72	46.04	61.47	51.47	-12.75	-5.43
0.323	46.33	42.29	59.63	49.63	-13.30	-7.34
0.452	44.77	43.01	56.83	46.83	-12.06	-3.82
0.646	43.03	41.22	56.00	46.00	-12.97	-4.78
23.149	44.80	35.22	60.00	50.00	-15.20	-14.78

This plot of the phase-to-ground measurement versus the one with the EUT connected is practically the same except for the EUT's 13.56 MHz fundamental frequency. Therefore, most of the emissions are from the host computer and all fall below the limit.

Test Data:

Line Conducted 120VAC 60Hz: S-Video & VGA

NEUTRAL to Ground Measurement.
Class B
Plot of Peak Values



Tabulated Quasi-Peak/Average Measurements.

Frequency	dBuV Reading		dBuV EN55022 B Limit		dB Margin	
MHz	QP	Avg	QP	Avg	QP	Avg
0.194	52.13	47.37	63.87	53.87	-11.74	-6.50
0.258	48.44	45.50	61.49	51.49	-13.05	-5.99
0.323	45.99	42.12	59.63	49.63	-13.64	-7.51
0.387	44.56	38.89	58.12	48.12	-13.56	-9.23
0.451	44.10	42.32	56.86	46.86	-12.76	-4.54
0.516	41.95	38.20	56.00	46.00	-14.05	-7.80
0.646	42.34	40.55	56.00	46.00	-13.66	-5.45
24.313	44.85	34.84	60.00	50.00	-15.15	-15.16

This plot of the neutral-to-ground measurement versus the one with the EUT connected is practically the same except for the EUT's 13.56 MHz fundamental frequency. Therefore, most of the emissions are from the host computer and all fall below the limit.

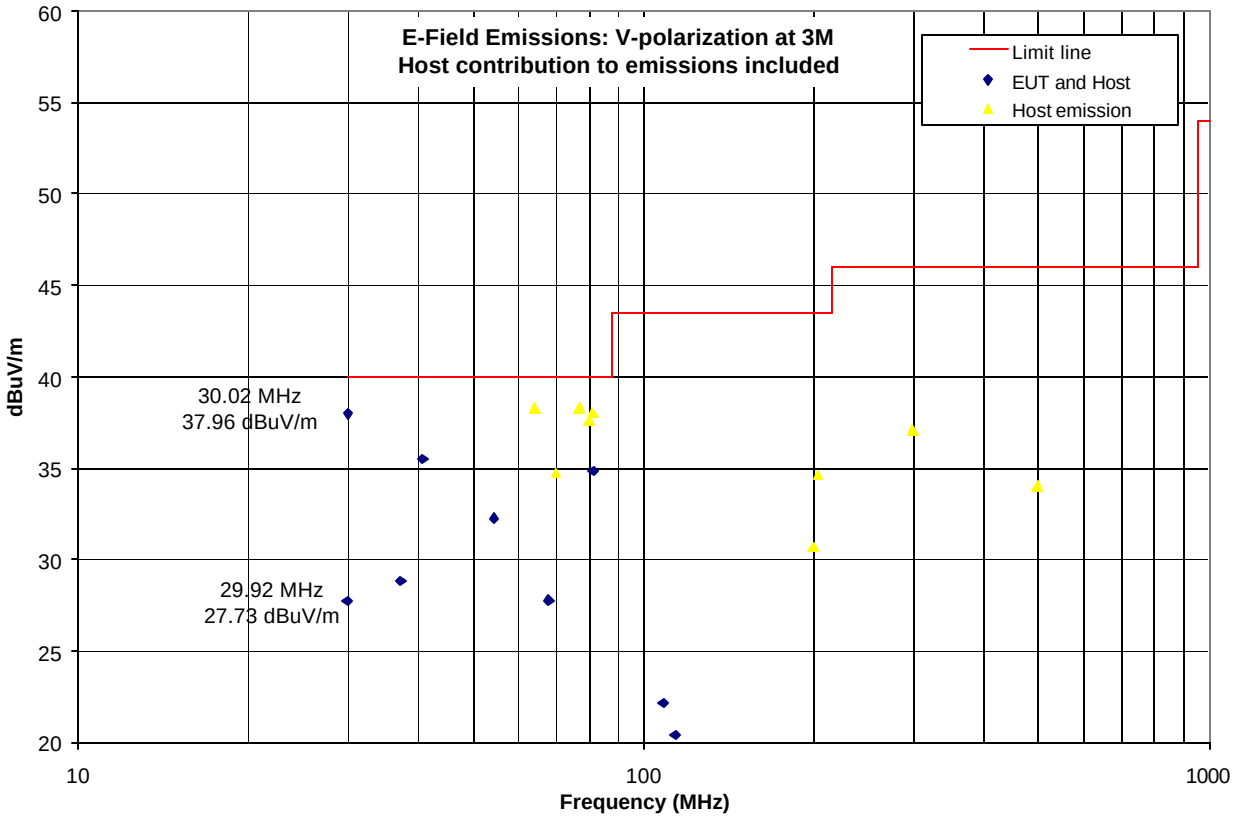
APPENDIX B RADIATED EMISSIONS OF HOST COMPUTER

Data is also available for the host computer's radiated emissions = 30 MHz. The setup is practically the same as that used for the conducted emissions.

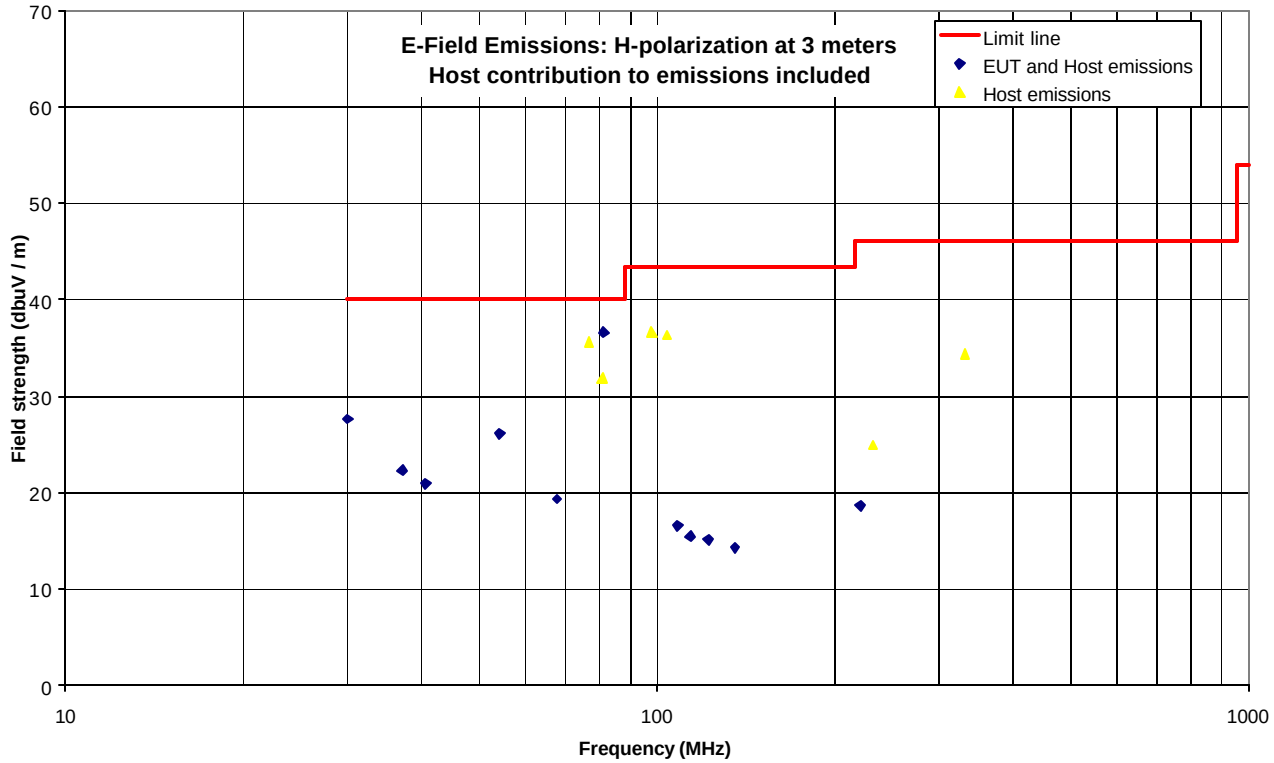
The plots that follow combine the data from the host PC "alone" versus that when the EUT is connected to the PC.

The below is that of the E-Filed emissions at 3 m. The emissions of the host were originally measured at a distance of 10 meters, so the amplitudes were scaled to that of a 30 meter distance.

The emission at 30 MHz (field strength of 37.96 dBuV / m) and 40.67 MHz (field strength of 35.5 dBuV/m) are primarily due to the EUT connection. The host emissions between 60 and 80 MHz are likely to have been caused by the connection of the tower to the printer. Nevertheless, all emissions are significantly below the limits.



Similar to the vertical emission plot above, the following plot shows field strength measured with horizontal polarization.



The emission of 36.68 dBuV / m at 81.27 MHz is exclusive to the RFID connection. This and other emissions assignable to the host computer are adequately under the limit.

[1] Measurement uncertainty is according to NAMAS publication NIS81 and NIST Technical Note 1297
[2] Ibid