

Nebraska Center for Excellence in Electronics
4740 Discovery Drive
Lincoln, NE 68521
Phone: 402-472-5880
Fax: 402-472-5881



EMC Test Report

Company: Radiotronix
905 Messenger Lane
Moore, OK 73160

Contact: Tom Marks

Product: Wi.232 25mW FHSS Module
FCC ID: Q7V-3F090008X

Test Report No: R020906-01A

APPROVED BY: Doug Kramer
Senior Test Engineer

DATE: 5 April 2006

Total Pages: 55

A handwritten signature in black ink, appearing to read "Doug Kramer", written over a horizontal line.

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1.0 Summary of test results**1.1 Test Results**

Based on the data collected with the unit as configured:

Test	Test Specification	Results
CFR 47, FCC Part 15.203	Part 15.203	Complies
CFR 47, FCC Part 15.207	Part 15.207, Class B	N/A
CFR 47, FCC Part 15.209	Part 15.209, Class B	Complies
CFR 47, FCC Part 15.247	Part 15.247	Complies

1.2 Test Methods**1.2.1 Conducted Emissions**

Measurements of conducted emissions to the limits set in CFR 47 Part 15.207 were performed using the methods shown in ANSI/IEEE C63.4: 2003. Measurements of the EUT can be found in Appendix B figure 21.

1.2.2 Radiated Emissions

Compliance to CFR 47 Parts 15.209 and 15.247 was tested in accordance with the methods of ANSI/IEEE C63.4: 2003. Several configurations were examined and the results presented represent a worst-case scenario. The EUT was placed on a wooden table approximately 80cm high and centered on a 4m diameter turntable. The table was rotated to find the angles of maximum emissions and the receiving antenna was moved from 1m to 4m in both vertical and horizontal positions. All measurements were taken at a distance of 3m from the EUT for Part 15.209 intentional radiator measurements, and 3m for 15.247 measurements of the fundamental frequency in the 902MHz to 928MHz band and subsequent harmonics.

1.3 Reason for Amendment

This report has been amended to provide the correct limits in tables where the actual limit for the frequency band is 20dB below the carrier.

2.0 Description

2.1 Equipment under test

The Equipment under test (EUT) was a Radiotronix wireless module (Wi.232 25mW FHSS Module, FCC ID: Q7V-3F090008X). The EUT can be set to 32 different channels ranging from 902.971 to 926.277 and utilized a digital modulation scheme.

2.1.1 Identification: Wi.232 25mW FHSS Module

2.1.2 EUT received date: 9 Feb 06

2.1.3 EUT tested dates: 9 Mar 06 – 23 Mar 06

2.1.4 Manufacturer: Radiotronix

2.1.5 Serial number: NCEE Test 3

2.2 Laboratory description

All testing was performed at the NCEE Lincoln facility, which is a FCC registered lab. This site has been fully described in a report submitted to your office, and accepted in a letter dated May 4, 2001. Laboratory environmental conditions varied slightly throughout the tests:

Relative humidity of $45 \pm 4\%$

Temperature of $20 \pm 3^\circ$ Celsius

2.3 Special equipment or setup

The EUT was tested with a Radiotronix evaluation board, P/N 5F0-000-06C and powered by 3 AAA batteries. The EUT was set to a BAUD rate of 19200 (rate at which the emissions were maximized), and the transmitter was set to "High Power", which was the highest possible output setting in the configuration software. The EUT was tested with 4 antennas:

- | | |
|----------------------------------|----------------------|
| 1. Manufacturer: Antenna Factor, | P/N: ANT-916-CW-HW |
| 2. Manufacturer: Antenna Factor, | P/N: ANT-916-CW-QW |
| 3. Manufacturer: Antenna Factor, | P/N: ANT-916-CW-RH |
| 4. Manufacturer: Antenna Factor, | P/N: ANT-ELE-S01-006 |
| | with magnetic base |

All radiated measurements were taken with all 4 antennas unless otherwise noted. Pictures of each of the antennas can be seen in figure 5 – 8.

3.0 Test equipment used

<i>Serial #</i>	<i>Manufacturer</i>	<i>Model</i>	<i>Description</i>	<i>Last cal.</i>
1647	EMCO	3142B	Biconilog antenna	10-Mar-05
1654	EMCO	3142B	Biconilog antenna	13-Mar-06*
6416	EMCO	3115	DRG Horn	12-Oct-05
100037	Rohde & Schwarz	ESIB26	EMI Test Receiver	10-Aug-05
082001/003	Rohde & Schwarz	TS-PR18	Preamplifier	N/A
2575	Rohde & Schwarz	ES-K1	Software v1.60	N/A

* This antenna was used for measurements after 20 Mar 06.

4.0 Detailed Results

Radiated emissions measurements were made by first using a spectrum analyzer getting a rough signal spectrum. Any points were then measured using a CISPR 16 compliant receiver with the following bandwidth setting:

30MHz - 1 GHz: 120kHz IF bandwidth, 60kHz steps

1GHz - 10GHz: 1MHz IF bandwidth, 500kHz steps

4.1 FCC Part 15.203 unique connector for antenna

The RF connector is an RP-SMA jack connector integrated into the module.

Figure 5 - 9 shows the EUT with the antennas tested.

4.2 FCC Part 15.207 Conducted Emissions

The EUT was tested with a 4.5VDC power supply. Measurements of the EUT can be found in Appendix B. The EUT was found to be compliant.

4.3 FCC Part 15.209 Radiated Emissions

The EUT was found to comply with the published limits. The EUT was tested at 3m and compared to FCC Class B limits, results can be seen in Figure 6 - 8. No emissions were found to exceed the limits.

4.4 FCC Part 15.247 Operation Within the 902-928 MHz Band

The EUT was tested at three different frequencies, one at the lowest possible transmitting frequency, one at the highest and one in the middle. These corresponded to channel 0, channel 31 and channel 16 respectively. The EUT was found to comply with the published regulations for the 902-928MHz band from FCC Part 15.247. All measurements were taken at a 3m distance.

4.4.1 Harmonics

Appendix B, Figure 9 - 20 show the radiated emissions plots from 30 MHz to 1 GHz and table 1 - 12 display the quasi-peak measurements. Table 13 - 24 of Appendix C show the harmonics measurements above 1 GHz up to the 6th harmonic. Figure 1, 2 shows the test setup.

4.4.2 Bandwidth and Bandedge

Appendix D, Figure 22 - 24 show measurements of the 6 dB bandwidth of the three operating frequencies tested, which are to be greater than 500 kHz. Figure 25 - 26 show the upper and lower bandedges of the 902-928 MHz operating band, at which measurements are to be at least 20 dB below that of the highest emission. Bandwidth and bandedge measurements can be found in table 25 - 26.

4.4.3 Channel Power and Power Spectral Density

The maximum allowed output power is 30dBm according to Part 15.247. In this system, the effective output power is less than 30dBm into the antenna. The maximum power spectral density is less than 8dBm as required by the standard. The channel power and power spectral density measurements can be found in Table 27 and Figure 27 - 32.

Appendix A: Test Photos



Figure 1 - Radiated Emissions Test Setup



Figure 2 - Radiated Emissions Test Setup



Figure 3 - Conducted Emissions Setup



Figure 4 - Conducted Emissions Setup

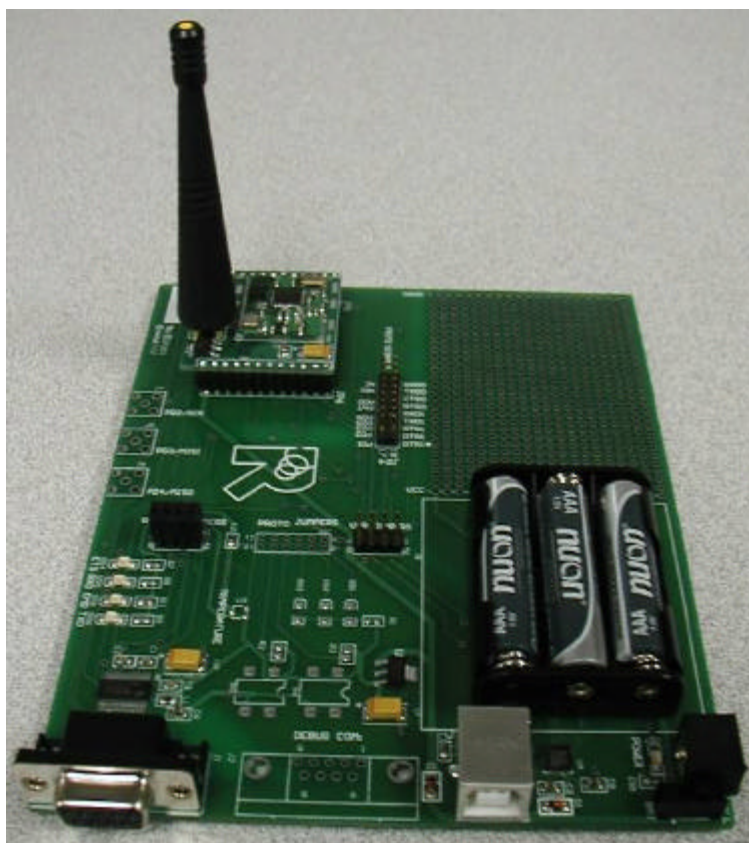


Figure 5 - EUT with ANT-916-CW-QW antenna, without shield for photo

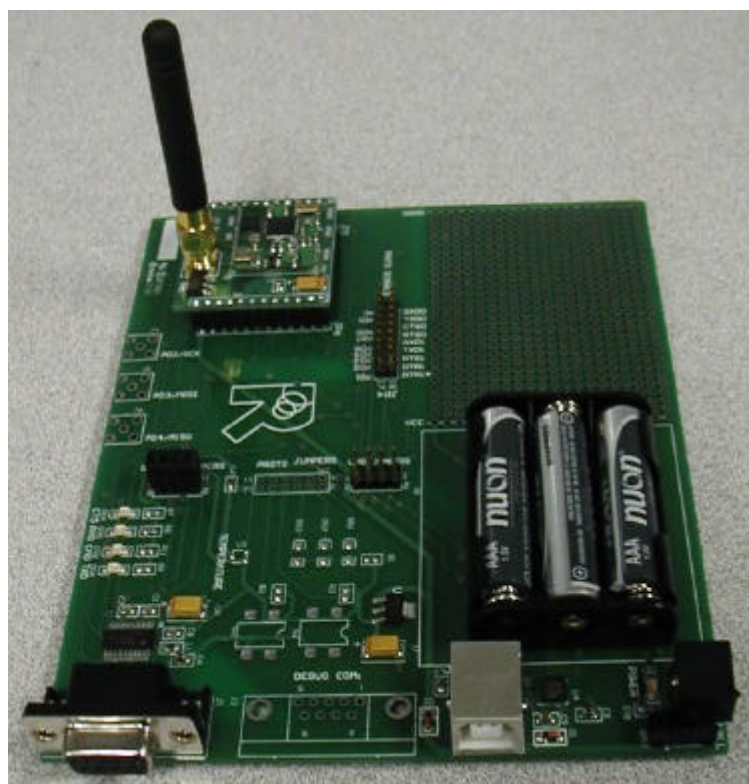


Figure 6 - EUT with ANT-916-CW-RH Antenna, without shield for photo

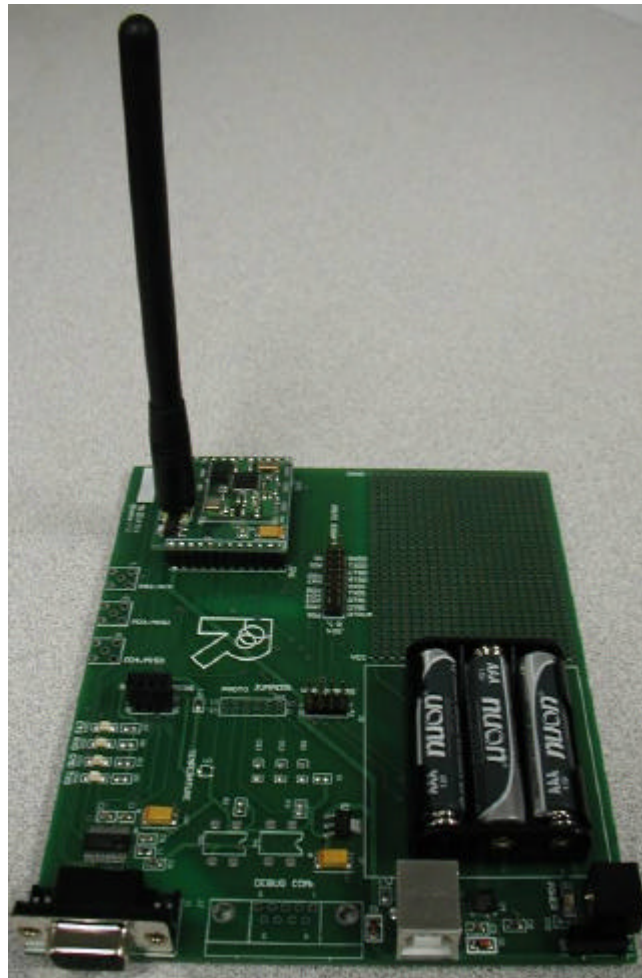


Figure 7 - EUT with ANT-916-CW-HW Antenna, without shield for photo

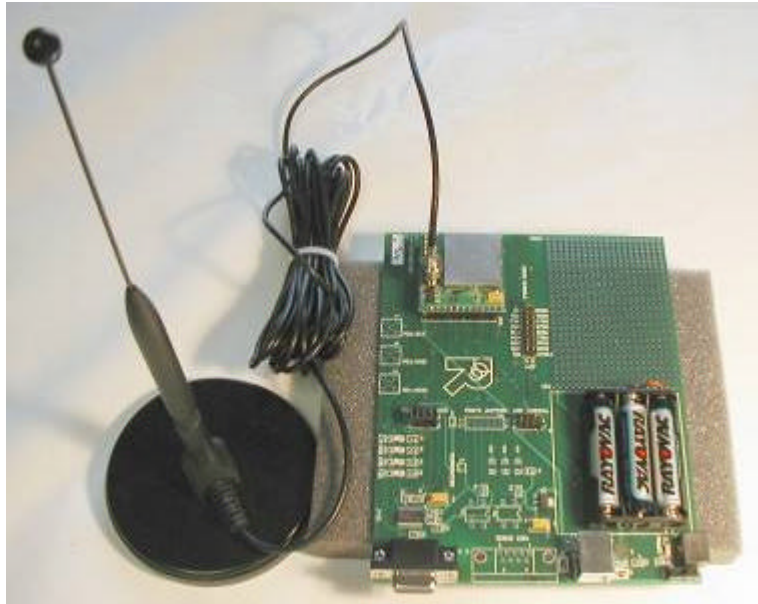


Figure 8 - EUT with ANT-ELE-S01-006 Antenna, with shield as tested

Appendix B: Emissions Plots

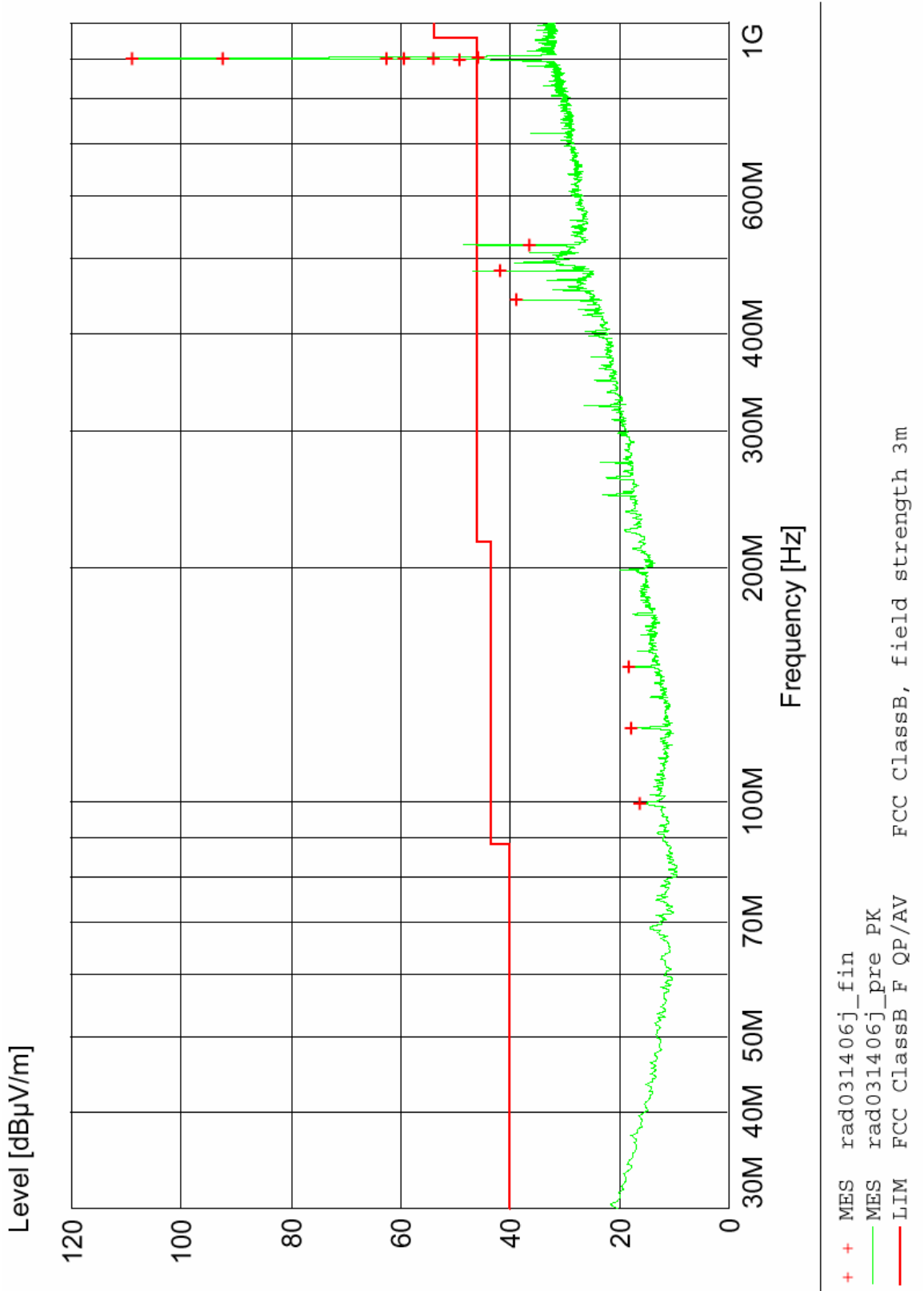


Figure 9 - Radiated Emissions Plot, ANT-916-CW-HW Antenna, Channel 0

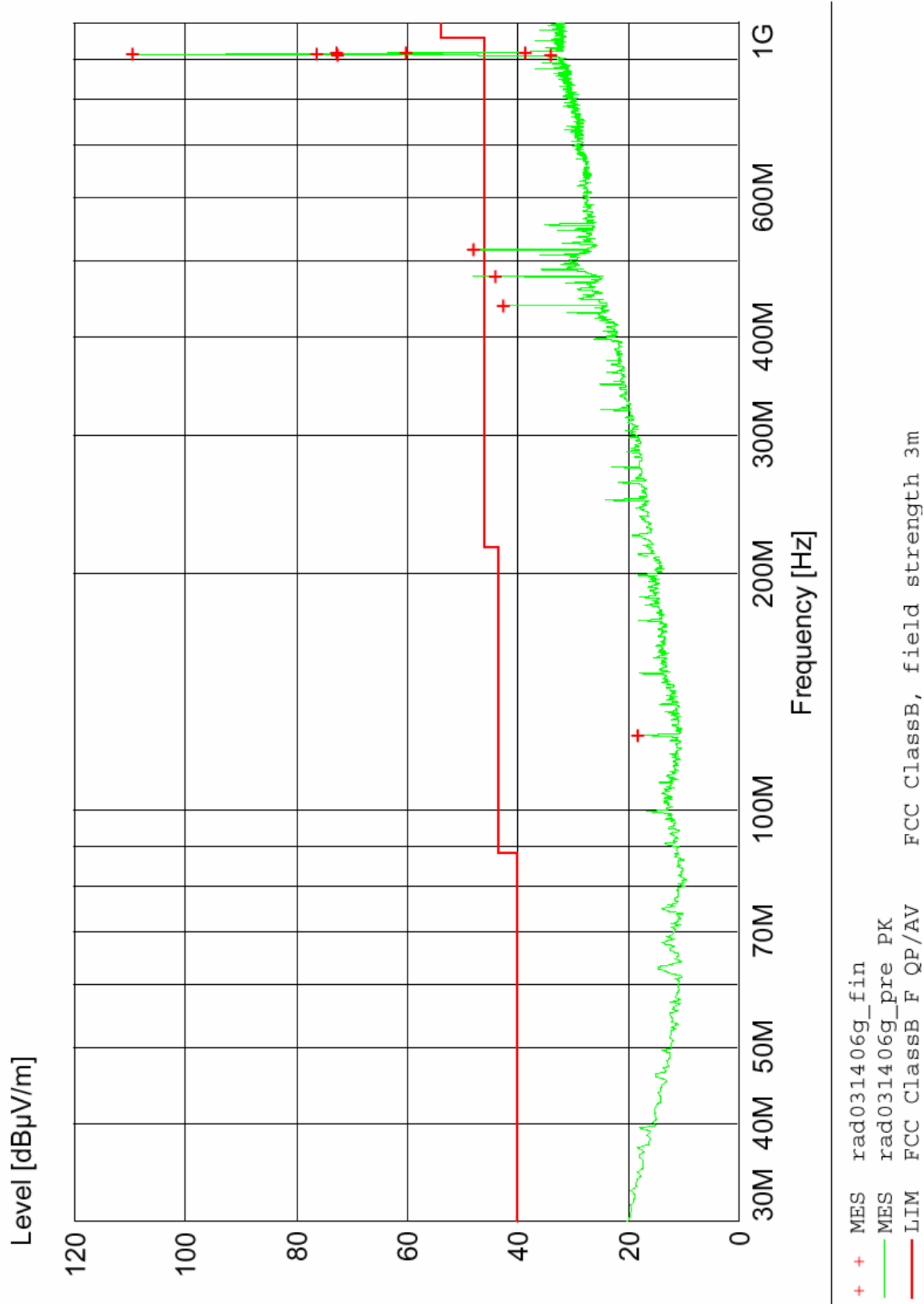


Figure 10 - Radiated Emissions Plot, ANT-916-CW-HW Antenna, Channel 16

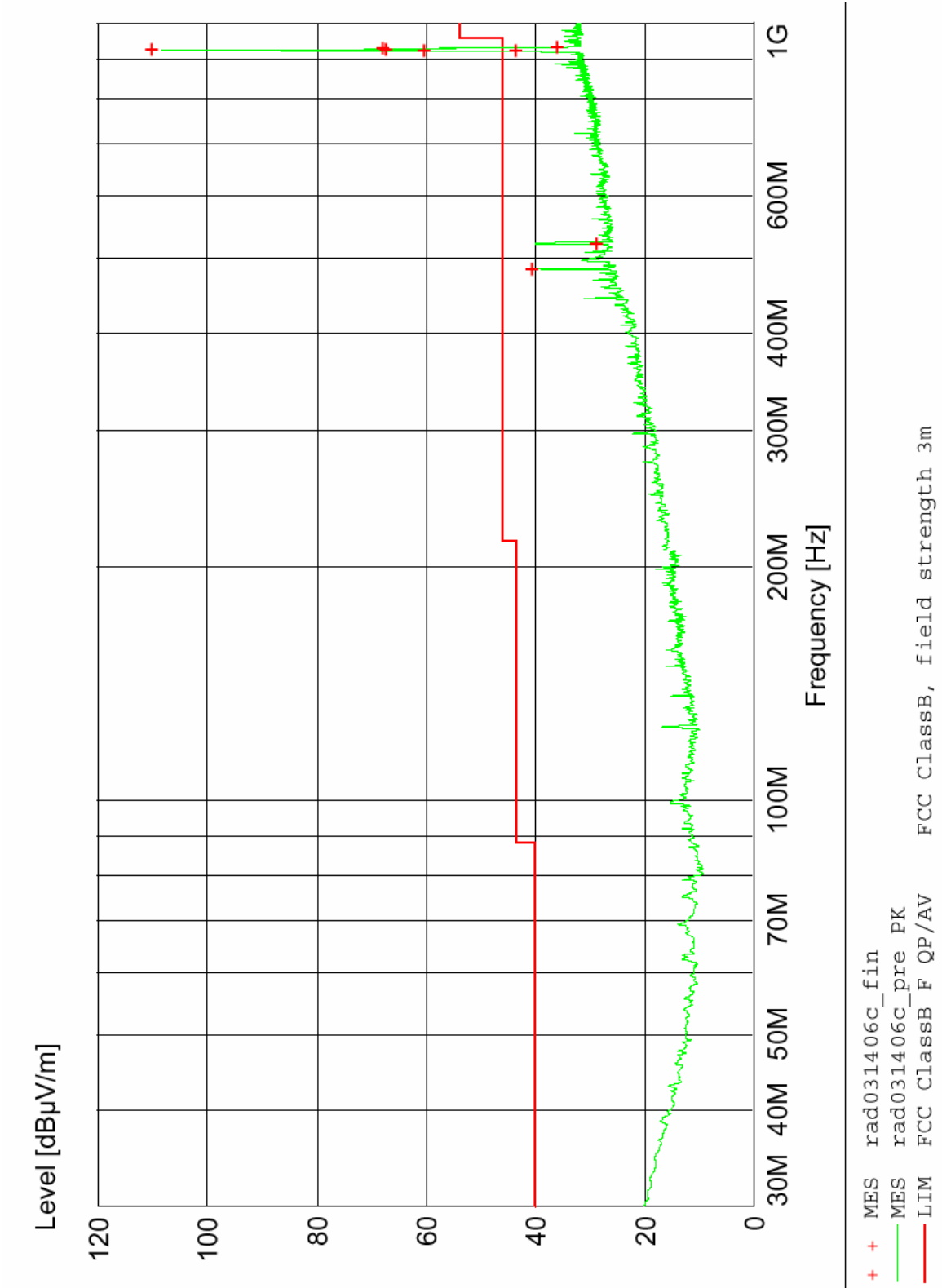


Figure 11 - Radiated Emissions Plot, ANT-916-CW-HW Antenna, Channel 31

Table 1

Radiated Emissions Quasi-peak Measurements, ANT-916-CW-HW Antenna, Channel 0

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dB μ V/m	dB μ V/m	dB	cm	deg	
99.42	16.37	43.5	27.13	269	214	HORI
124.26	17.93	43.5	25.57	249	233	HORI
149.1	18.19	43.5	25.31	150	178	HORI
441.66	39.01	46.00	6.99	111	117	VERT
480.66	41.89	46.00	4.11	99	271	VERT
519.66	36.46	46.00	9.54	99	262	VERT
899.04	49.19	93.35*	44.16	99	263	VERT
901.26	59.38	93.35*	33.97	120	0	VERT
902.64	92.44	N/A	N/A	115	28	VERT
902.82	113.35	N/A	N/A	112	100	VERT
904.44	53.86	N/A	N/A	99	91	VERT
904.74	62.71	N/A	N/A	104	265	VERT
907.38	45.75	N/A	N/A	99	261	VERT

Table 2

Radiated Emissions Quasi-peak Measurements, ANT-916-CW-HW Antenna, Channel 16

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dB μ V/m	dB μ V/m	dB	cm	deg	
124.26	18.39	43.50	25.11	149	204	HORI
438.06	42.76	46.00	3.24	111	240	VERT
476.94	43.88	46.00	2.12	109	273	VERT
515.94	48.07	93.53*	45.46	99	264	VERT
911.04	34.19	N/A	N/A	100	100	VERT
913.44	72.52	N/A	N/A	110	359	VERT
914.64	76.37	N/A	N/A	99	170	VERT
915.18	113.53	N/A	N/A	111	335	VERT
916.5	72.77	N/A	N/A	99	262	VERT
916.56	60.15	N/A	N/A	102	0	VERT
918.78	38.65	N/A	N/A	145	72	VERT

Table 3

Radiated Emissions Quasi-peak Measurements, ANT-916-CW-HW Antenna, Channel 31

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dB μ V/m	dB μ V/m	dB	cm	deg	
482.7	40.71	46.00	5.29	100	276	VERT
521.58	28.81	46.00	17.19	98	264	VERT
923.1	43.68	N/A	N/A	99	335	VERT
923.7	60.33	N/A	N/A	99	25	VERT
926.1	114.14	N/A	N/A	102	335	VERT
926.64	67.38	N/A	N/A	109	187	VERT
928.02	67.96	94.14*	26.18	99	264	VERT
930.3	36.03	94.14*	58.11	101	264	VERT

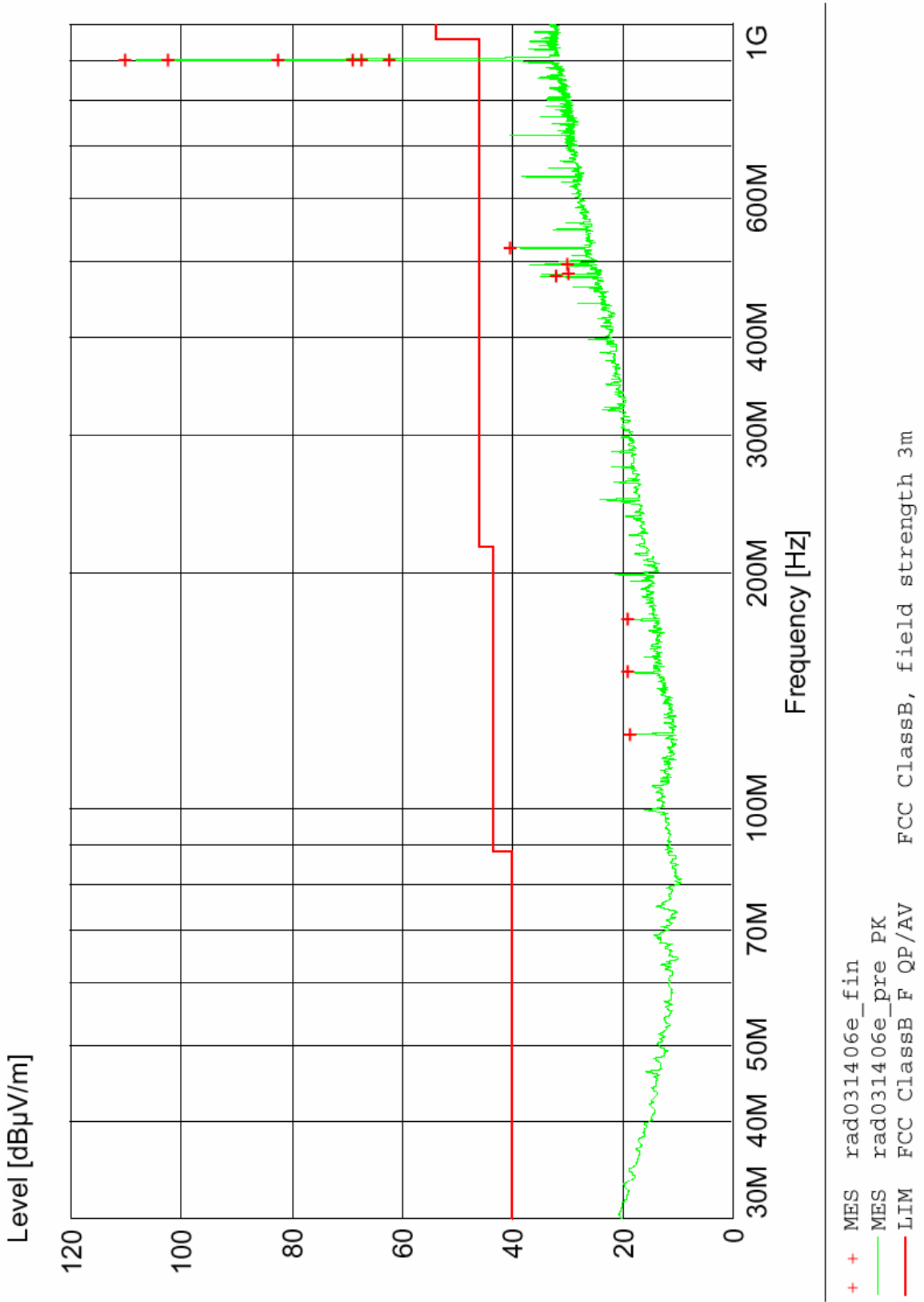


Figure 12 - Radiated Emissions Plot, ANT-916-CW-QW Antenna, Channel 0

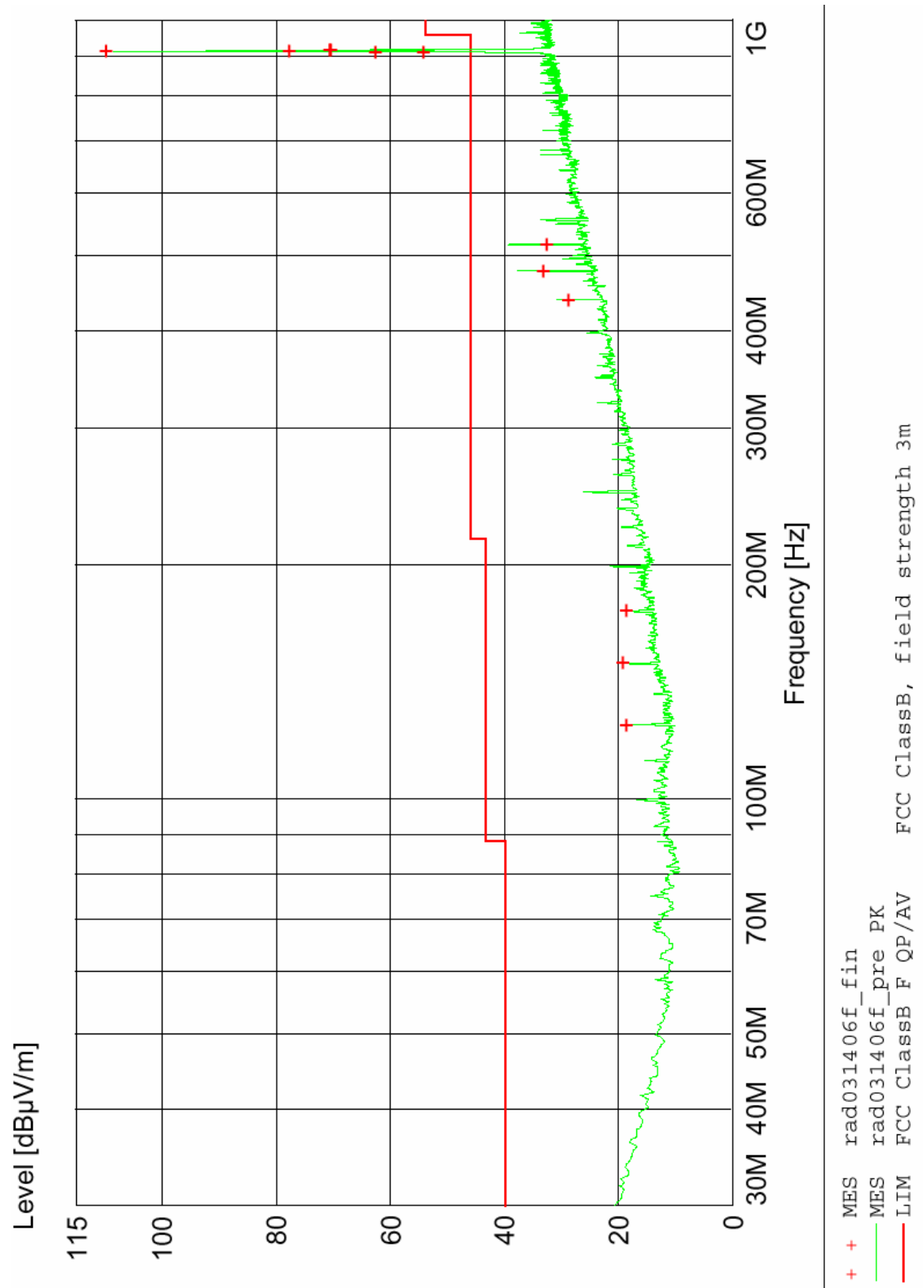


Figure 13 - Radiated Emission Plot, ANT-916-CW-QW Antenna, Channel 16

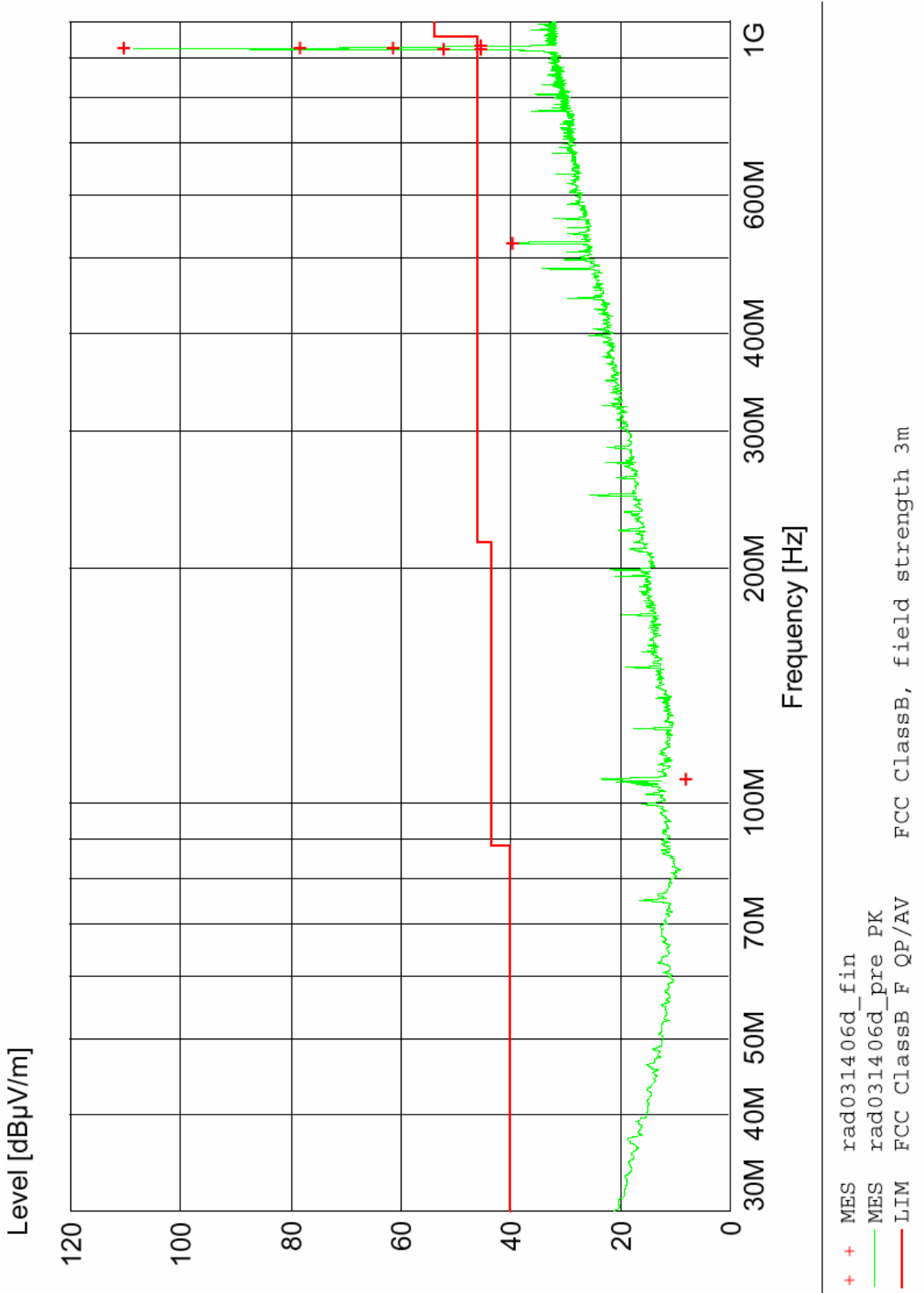


Figure 14 - Radiated Emissions Plot, ANT-916-CW-QW Antenna, Channel 31

Table 4

Radiated Emissions Quasi-peak Measurements, ANT-916-CW-QW Antenna, Channel 0

Frequency MHz	Level dB μ V/m	Limit dB μ V/m	Margin dB	Height cm	Angle deg	Pol.
124.32	18.71	43.5	24.79	152	221	HORI
149.16	19.1	43.5	24.4	149	248	HORI
174.06	19.18	43.5	24.32	150	208	HORI
477.24	32.14	46.00	13.86	149	359	HORI
480.66	29.84	46.00	16.16	110	266	VERT
495.24	30.04	46.00	15.96	240	329	HORI
519.84	40.58	90.16*	49.58	99	268	VERT
901.38	69.05	90.16*	21.11	195	333	VERT
902.64	82.54	N/A	N/A	102	257	VERT
903.18	110.16	N/A	N/A	109	259	VERT
904.44	62.32	N/A	N/A	99	257	VERT
905.04	67.37	N/A	N/A	109	244	VERT

Table 5

Radiated Emissions Quasi-peak Measurements, ANT-916-CW-QW Antenna, Channel 16

Frequency MHz	Level dB μ V/m	Limit dB μ V/m	Margin dB	Height cm	Angle deg	Pol.
124.32	18.7	43.5	24.8	150	215	HORI
149.16	19.26	43.5	24.24	140	235	HORI
174.06	18.66	43.5	24.84	149	213	HORI
438.06	28.76	46.00	17.24	101	125	VERT
476.94	33.23	46.00	12.77	109	271	VERT
515.94	32.76	46.00	13.24	98	0	VERT
913.08	62.70	N/A	N/A	99	268	VERT
913.14	54.14	N/A	N/A	99	208	HORI
914.64	77.67	N/A	N/A	101	271	VERT
915.18	109.70	N/A	N/A	102	266	VERT
916.56	70.70	N/A	N/A	121	330	VERT
917.04	70.54	N/A	N/A	99	260	VERT

Table 6

Radiated Emissions Quasi-peak Measurements, ANT-916-CW-QW Antenna, Channel 31

Frequency MHz	Level dB μ V/m	Limit dB μ V/m	Margin dB	Height cm	Angle deg	Pol.
107.16	8.05	43.50	35.45	343	21	HORI
521.58	39.78	46.00	6.22	98	358	VERT
923.10	45.44	N/A	N/A	99	267	VERT
923.70	52.20	N/A	N/A	119	260	VERT
924.90	61.41	N/A	N/A	99	265	VERT
926.46	110.44	N/A	N/A	119	102	VERT
926.64	78.34	N/A	N/A	106	269	VERT
930.30	45.48	90.44*	21.10	112	262	VERT

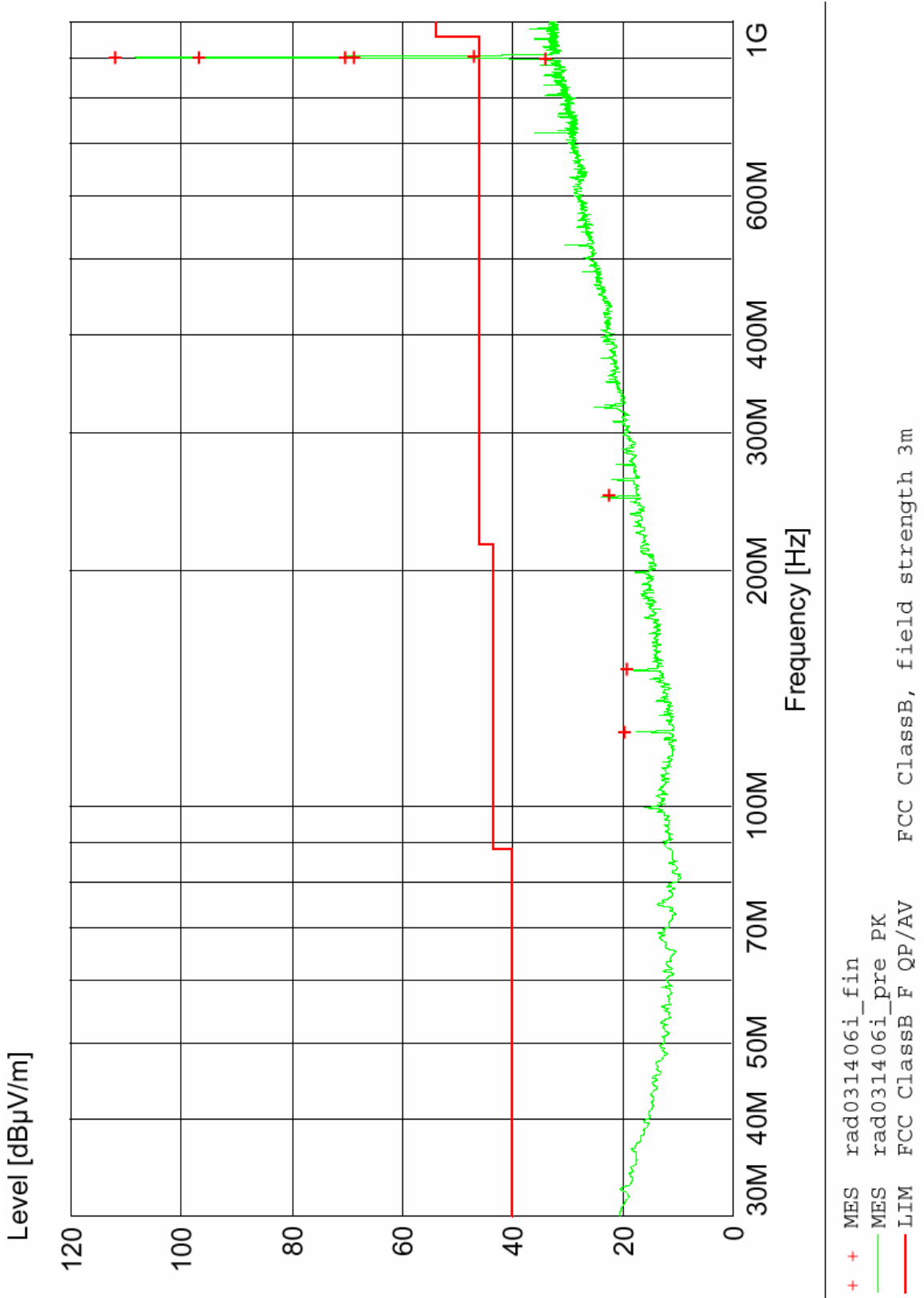


Figure 15 - Radiated Emissions Plot, ANT-916-CW-RH Antenna, Channel 0

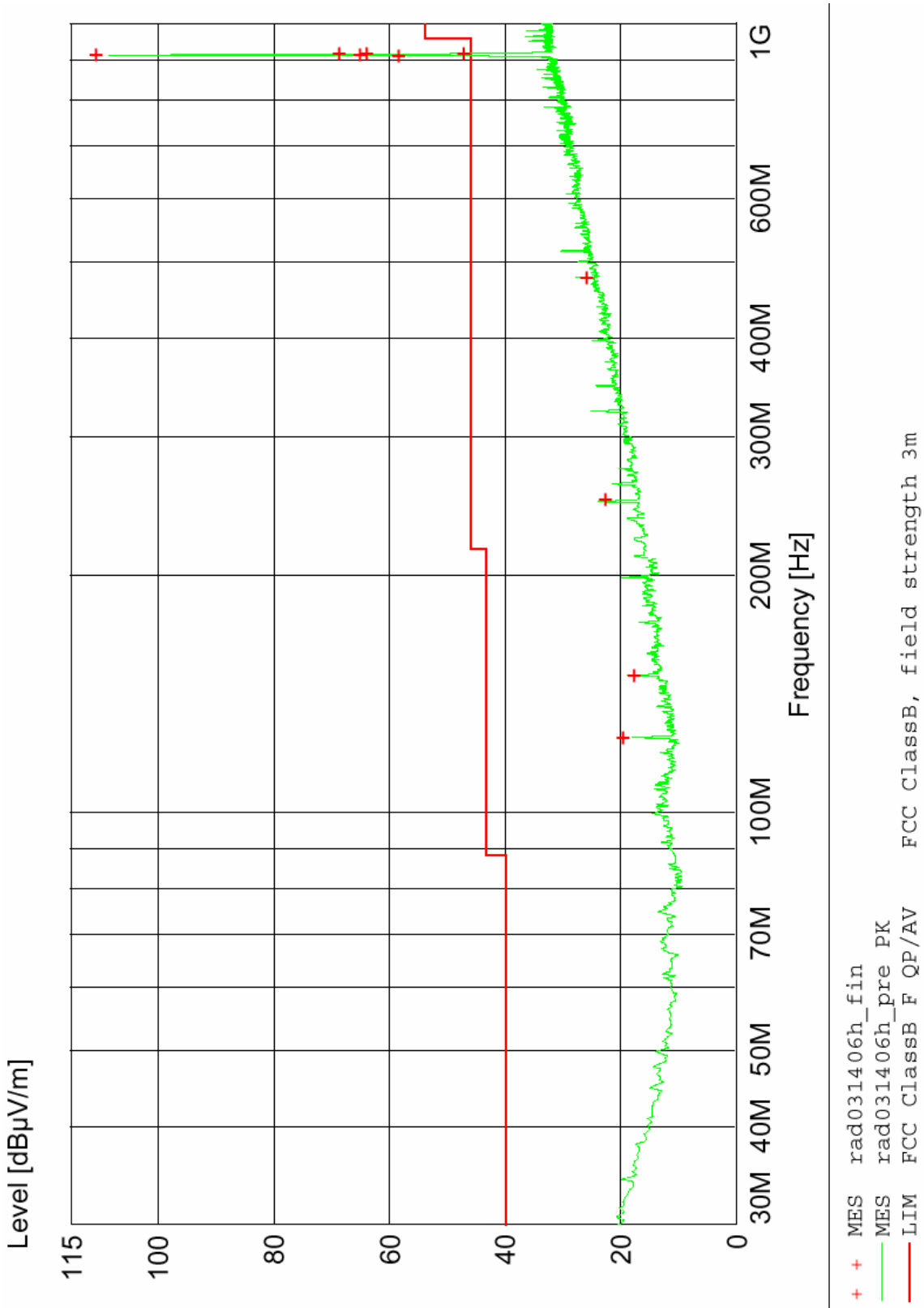


Figure 16 - Radiated Emissions Plot, ANT-916-CW-RH Antenna, Channel 16

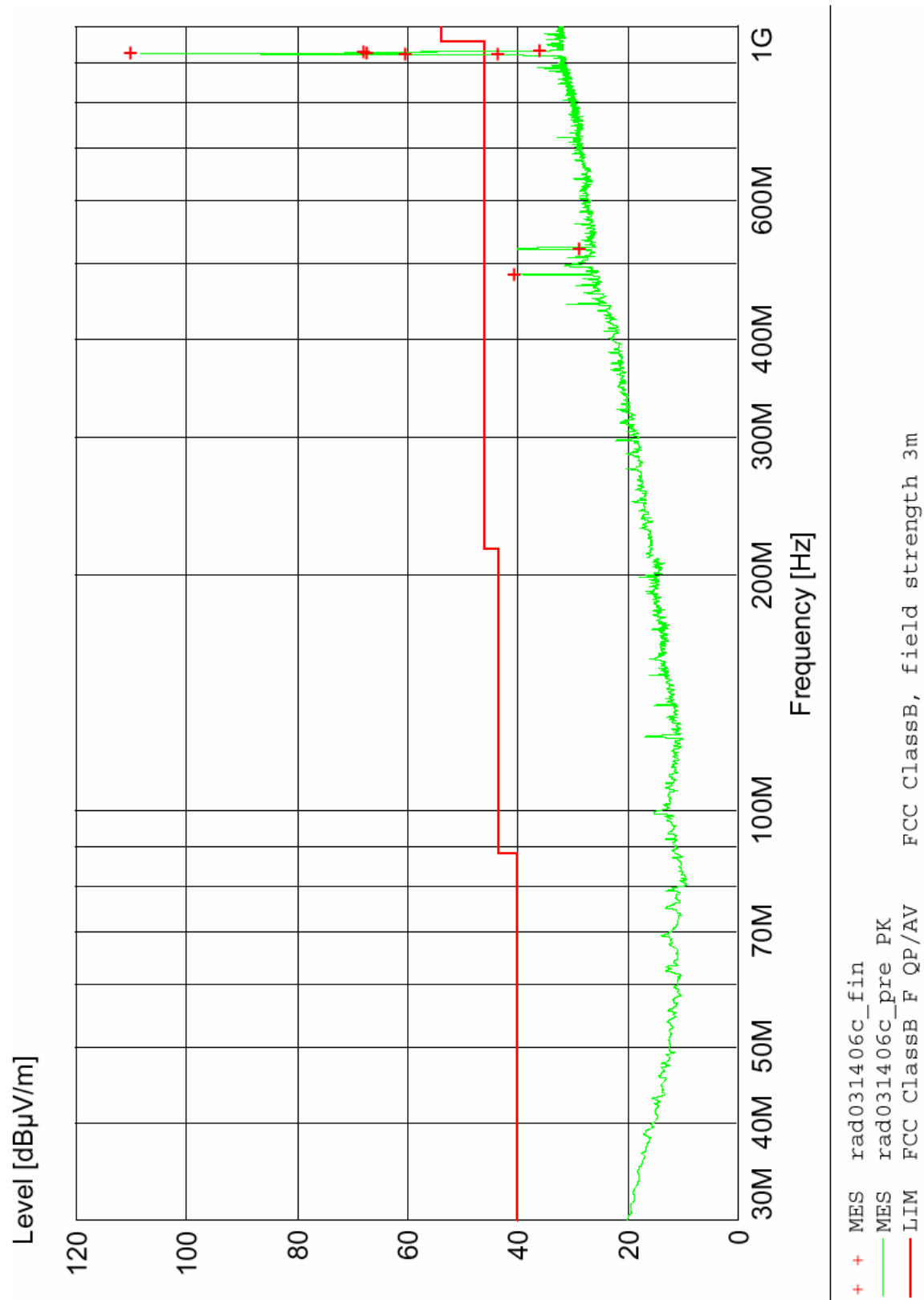


Figure 17 - Radiated Emissions Plot, ANT-916-CW-RH Antenna, Channel 31

Table 7

Radiated Emissions Quasi-peak Measurements, ANT-916-CW-RH Antenna, Channel 0

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dBμV/m	dBμV/m	dB	cm	deg	
124.26	19.80	43.50	23.7	150	214	HORI
149.16	19.36	43.50	24.14	165	252	HORI
248.52	22.62	46.00	23.38	98	213	HORI
899.64	34.16	46.00	11.84	99	206	HORI
901.62	70.45	91.99*	21.54	99	201	HORI
902.82	111.99	N/A	N/A	112	261	VERT
904.14	68.67	N/A	N/A	99	179	HORI
906.84	47.08	N/A	N/A	101	188	HORI

Table 8

Radiated Emissions Quasi-peak Measurements, ANT-916-CW-RH Antenna, Channel 16

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dBμV/m	dBμV/m	dB	cm	deg	
124.26	19.66	43.50	23.84	149	191	HORI
149.1	17.84	43.50	25.66	191	202	HORI
248.52	22.74	46.00	23.26	119	223	HORI
476.94	26.04	46.00	19.96	204	114	VERT
912.18	58.33	N/A	N/A	100	260	VERT
913.62	65.16	N/A	N/A	99	247	VERT
915.18	110.88	N/A	N/A	99	264	HORI
916.68	64.06	N/A	N/A	109	272	VERT
916.92	68.79	N/A	N/A	133	119	VERT
918.84	47.27	N/A	N/A	100	197	HORI

Table 9

Radiated Emissions Quasi-peak Measurements, ANT-916-CW-RH Antenna, Channel 31

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dBμV/m	dBμV/m	dB	cm	deg	
482.7	40.71	46.00	5.29	100	276	VERT
521.58	28.81	46.00	17.19	98	264	VERT
923.1	43.68	N/A	N/A	99	335	VERT
923.7	60.33	N/A	N/A	99	25	VERT
926.1	110.14	N/A	N/A	102	335	VERT
926.64	67.38	N/A	N/A	109	187	VERT
928.02	67.96	N/A	N/A	99	264	VERT
930.3	36.03	90.14*	54.11	101	264	VERT

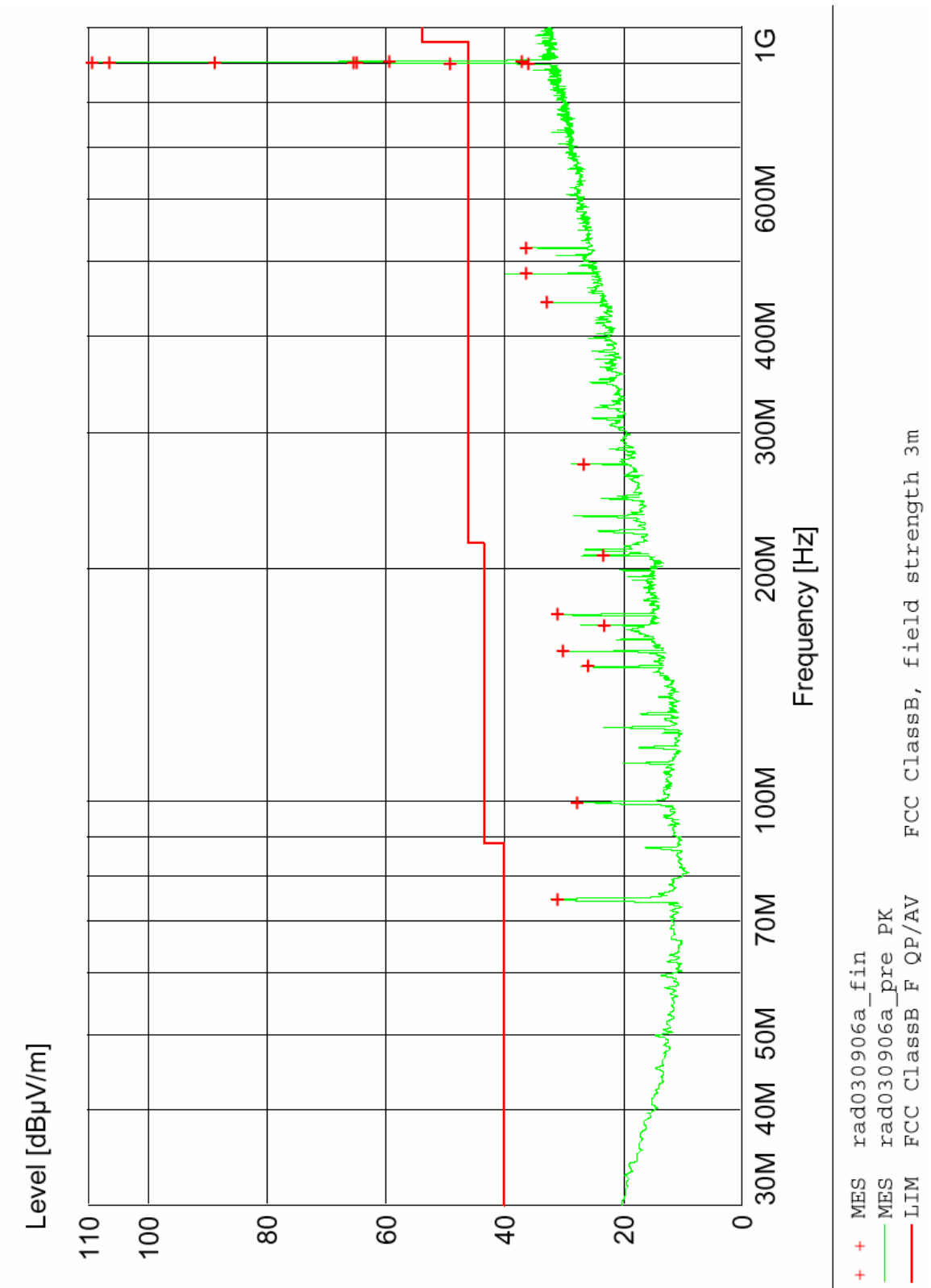


Figure 18 - Radiated Emissions Plot, ANT-ELE-S01-006 Antenna, Channel 0

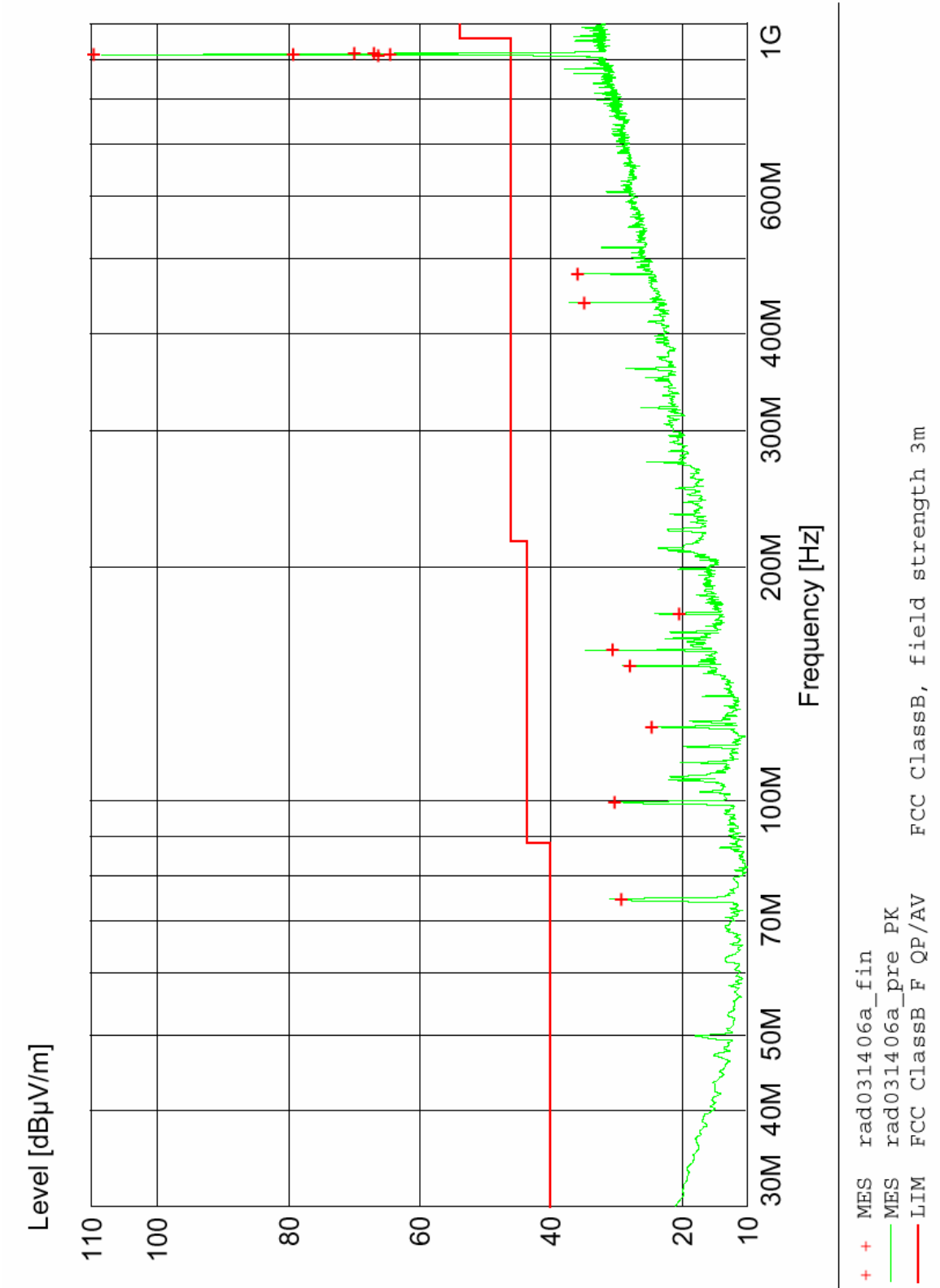


Figure 19 - Radiated Emissions Plot, ANT-ELE-S01-006 Antenna, Channel 16

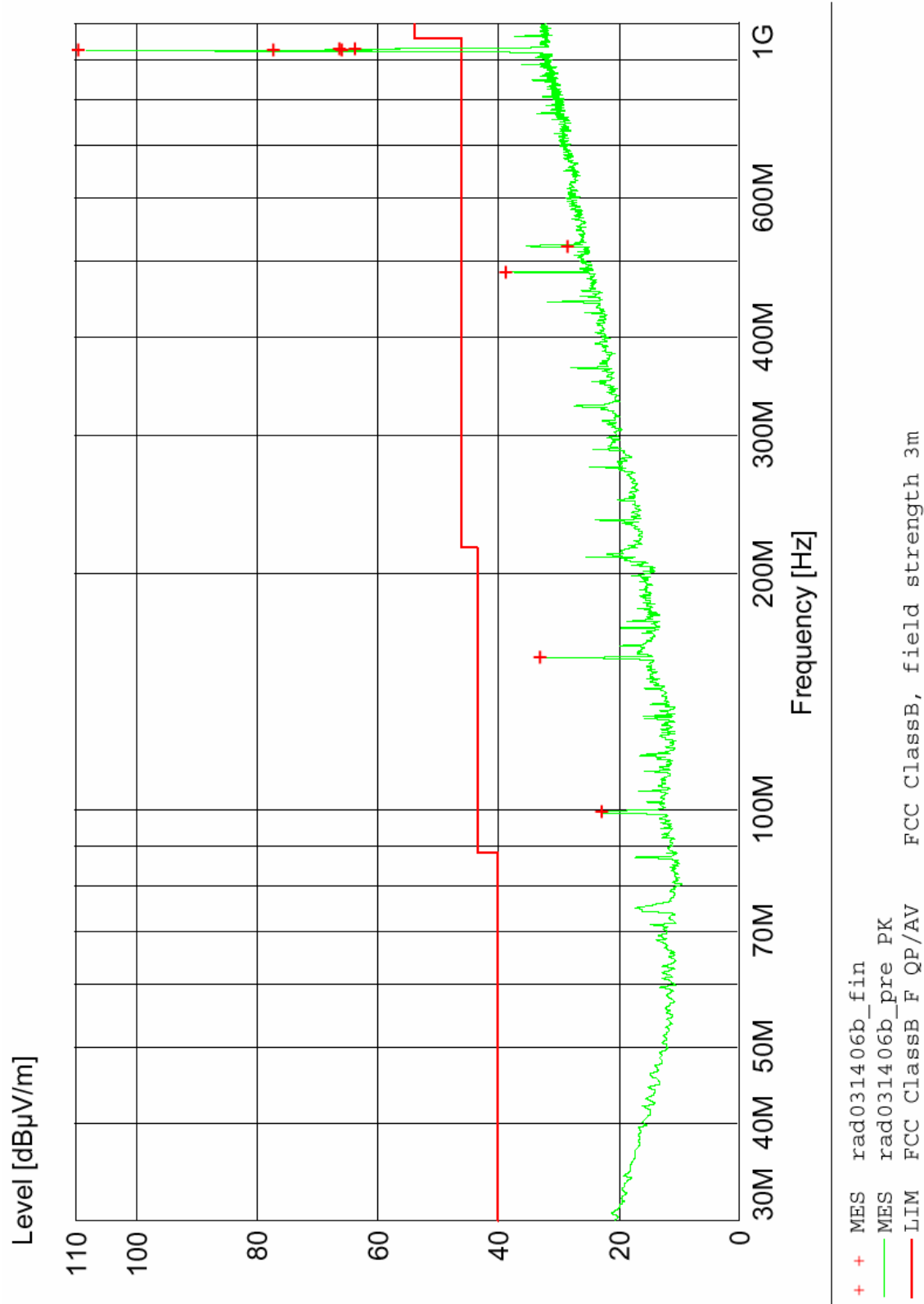


Figure 20 - Radiated Emissions plot, ANT-ELE-S01-006 Antenna, Channel 31

Table 10

Radiated Emissions Quasi-peak Measurements, ANT-ELE-S01-006 Antenna, Channel 0

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dBμV/m	dBμV/m	dB	cm	deg	
74.58	31.03	40.00	8.97	361.00	182.00	HORI
99.42	27.90	43.50	15.60	310.00	325.00	HORI
149.16	25.92	43.50	17.58	99.00	118.00	VERT
156.00	30.20	43.50	13.30	99.00	238.00	VERT
168.78	23.30	43.50	20.20	104.00	109.00	VERT
174.00	30.95	43.50	12.55	101.00	229.00	VERT
207.78	23.36	43.50	20.14	98.00	0.00	VERT
273.00	26.78	46.00	19.22	233.00	77.00	VERT
441.66	32.80	46.00	13.20	141.00	190.00	VERT
480.66	36.30	46.00	9.70	109.00	116.00	VERT
519.66	36.43	46.00	9.57	115.00	94.00	VERT
897.84	35.98	46.00	10.02	178.00	207.00	VERT
899.64	49.13	89.50*	40.37	121.00	103.00	VERT
901.20	65.46	89.50*	70.54	109.00	175.00	VERT
902.82	109.5	N/A	N/A	188	59	VERT
903.18	106.60	N/A	N/A	191.00	17.00	VERT
904.98	64.89	N/A	N/A	198.00	355.00	VERT
905.59	59.50	N/A	N/A	191.00	59.00	VERT
905.84	37.15	N/A	N/A	115.00	107.00	VERT

Table 11

Radiated Emissions Quasi-peak Measurements, ANT-ELE-S01-006 Antenna, Channel 16

Frequency	Level	Limit	Margin	Height	Angle	Pol.
MHz	dBμV/m	dBμV/m	dB	cm	deg	
74.58	29.22	40.00	10.78	400.00	183.00	HORI
99.42	30.29	43.50	13.21	327.00	184.00	HORI
124.26	24.49	43.50	19.01	149.00	359.00	HORI
149.10	27.95	43.50	15.55	99.00	105.00	VERT
156.00	30.56	43.50	12.94	101.00	119.00	VERT
173.94	20.48	43.50	23.02	99.00	110.00	VERT
437.94	34.90	46.00	11.10	115.00	332.00	VERT
476.94	35.87	46.00	10.13	114.00	85.00	VERT
913.08	66.41	N/A	N/A	99.00	30.00	VERT
913.50	64.43	N/A	N/A	101.00	31.00	VERT
914.64	79.18	N/A	N/A	100.00	359.00	VERT
915.18	109.72	N/A	N/A	99	61	VERT
916.68	70.00	N/A	N/A	99.00	1.00	VERT
916.92	66.97	N/A	N/A	99.00	334.00	VERT

Table 12

Radiated Emissions Quasi-peak Measurements, ANT-ELE-S01-006 Antenna, Channel 31

99.36	22.91	43.50	20.59	350.00	352.00	HORI
156.00	33.07	43.50	10.43	99.00	243.00	VERT
482.58	38.75	46.00	7.25	100.00	271.00	VERT
521.58	28.54	46.00	17.46	98.00	96.00	VERT
924.78	65.94	N/A	N/A	101.00	357.00	VERT
926.1	109.63	N/A	N/A	98	25	VERT
926.64	77.30	N/A	N/A	100.00	61.00	VERT
928.14	66.30	N/A	N/A	98.00	359.00	VERT
928.44	63.71	N/A	N/A	101.00	0.00	VERT

Note: According to CFR 47 FCC Part 15, paragraph (c), in any 100 kHz bandwidth outside of the specified frequency band of the transmitter, the field strength must be 20dB below that of the highest field strength generated by the transmitter. All of the limits with a “” have been adjusted so that they are 20dB below the highest emission produced. None of the mentioned points fall into a restricted band.

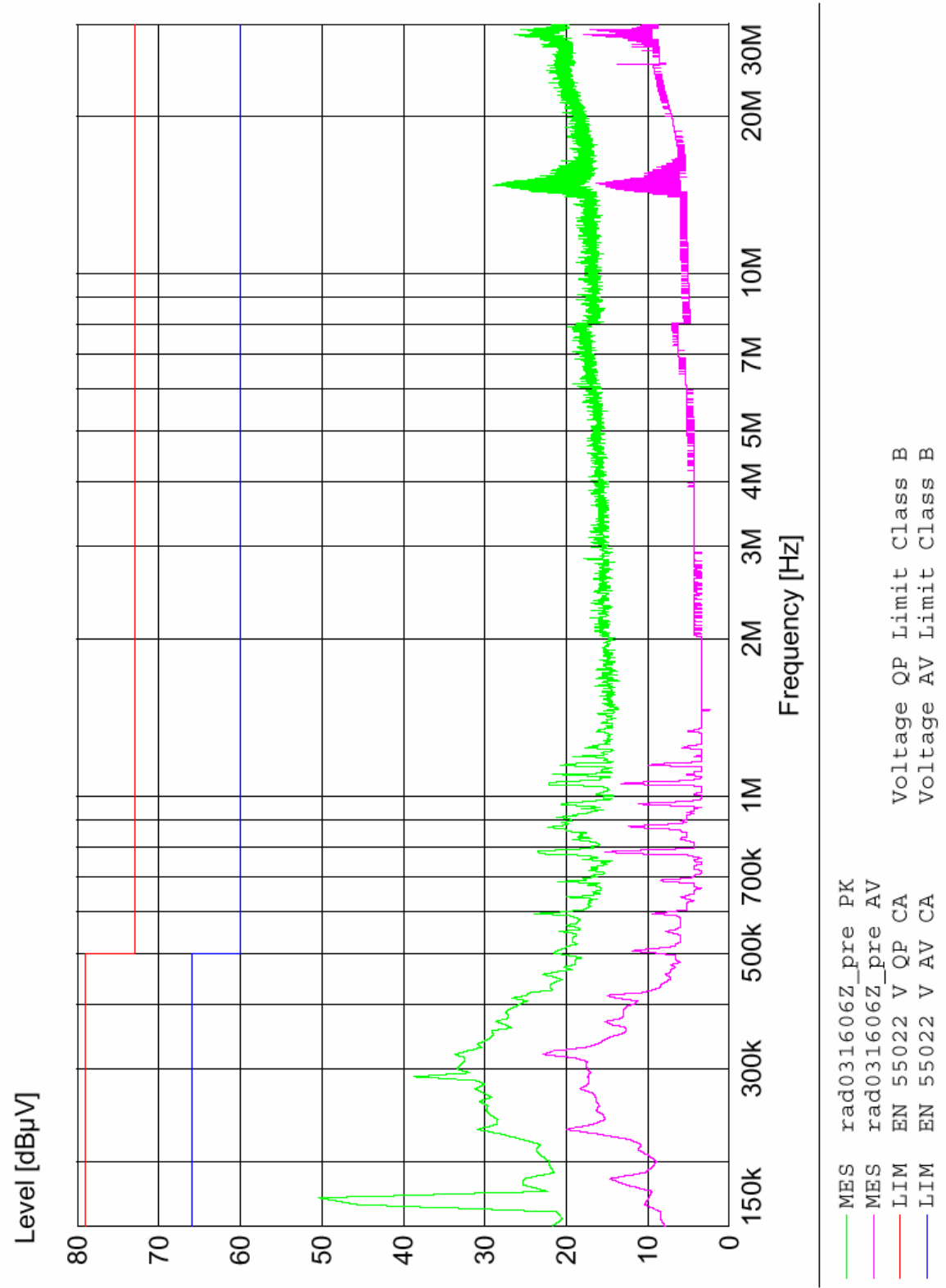


Figure 21 - Conducted AC Mains Emissions Plot

Using Radioshack 1.5 – 12VDC adapter, P/N 273-1662A, set to 4.5V

Appendix C: Harmonics Measurements

Table 13

Radiated Emissions Harmonics Measurements, ANT-916-CW-HW Antenna, Channel 0

Frequency	Level	Limit	Margin	Height	Angle	Pol.	Detector
MHz	dB μ V/m	dB μ V/m	dB	cm	deg		
1806.00	57.14	93.35*	36.21	201	341	VERT	Av
2708.50	52.57	53.9	1.33	119	225	VERT	Av
2709.50	40.61	53.9	13.29	378	167	VERT	Av
3602.00	42.48	53.9	11.42	249	337	VERT	Av
4489.50	44.56	53.9	9.34	149	0	VERT	Av
5418.00	49.15	53.9	4.75	249	0	HORI	Av
6303.50	51.84	53.9	2.06	128	162	VERT	Av
7240.50	29.94	53.9	23.96	350	276	VERT	Av
8129.50	33.34	53.9	20.56	100	235	HORI	Av
9865.00	34.9	53.9	19	169	359	HORI	Av
1806.00	64.83	93.35*	28.52	201	341	VERT	Pk
2708.50	61.51	73.9	12.39	119	225	VERT	Pk
2709.50	53.85	73.9	20.05	378	167	VERT	Pk
3602.00	55.88	73.9	18.02	249	337	VERT	Pk
4489.50	57.99	73.9	15.91	149	0	VERT	Pk
5418.00	62.56	73.9	11.34	249	0	HORI	Pk
6303.50	65.07	73.9	8.83	128	162	VERT	Pk
7240.50	43.54	73.9	30.36	350	276	VERT	Pk
8129.50	46.99	73.9	26.91	100	235	HORI	Pk
9865.00	48.25	73.9	25.65	169	359	HORI	Pk

Table 14

Radiated Emissions Harmonics Measurements, ANT-916-CW-HW Antenna, Channel 16

Frequency	Level	Limit	Margin	Height	Angle	Pol.	Detector
MHz	dB μ V/m	dB μ V/m	dB	cm	deg		
1830.00	58.74	93.53*	34.79	201	337	VERT	Av
2745.50	50.35	53.9	3.55	119	238	VERT	Av
3664.50	42.99	53.9	10.91	397	0	VERT	Av
4583.50	44.69	53.9	9.21	391	0	VERT	Av
5488.50	49.75	53.9	4.15	396	322	HORI	Av
6410.50	51.71	53.9	2.19	107	104	VERT	Av
7329.50	30.96	53.9	22.94	381	90	VERT	Av
8232.50	32.9	53.9	21	269	330	VERT	Av
9154.50	34.62	53.9	19.28	256	90	VERT	Av
1830.00	64.55	93.53*	28.98	201	337	VERT	Pk
2745.50	59.52	73.9	14.38	119	238	VERT	Pk
3664.50	56.13	73.9	17.77	397	0	VERT	Pk
4583.50	58.18	73.9	15.72	391	0	VERT	Pk
5488.50	63.09	73.9	10.81	396	322	HORI	Pk
6410.50	64.89	73.9	9.01	107	104	VERT	Pk
7329.50	44.62	73.9	29.28	381	90	VERT	Pk
8232.50	46.69	73.9	27.21	269	330	VERT	Pk
9154.50	48.19	73.9	25.71	256	90	VERT	Pk

Table 15

Radiated Emissions Harmonics Measurements, ANT-916-CW-HW Antenna, Channel 31

Frequency	Level	Limit	Margin	Height	Angle	Pol.	Detector
MHz	dB μ V/m	dB μ V/m	dB	cm	deg		
1853.00	59.5	94.14*	34.64	119	279	VERT	Av
2779.50	50.18	53.9	3.72	119	279	VERT	Av
3695.00	42.95	53.9	10.95	349	267	HORI	Av
4623.00	44.85	53.9	9.05	100	230	VERT	Av
5559.00	50.39	53.9	3.51	301	0	HORI	Av
6495.50	52.1	53.9	1.8	191	165	VERT	Av
7407.00	31.2	53.9	22.7	105	72	VERT	Av
8321.50	32.81	53.9	21.09	301	30	HORI	Av
9273.50	34.44	53.9	19.46	249	248	HORI	Av
1853.00	65.36	94.14*	28.78	119	279	VERT	Pk
2779.50	59.87	73.9	14.03	119	279	VERT	Pk
3695.00	56.09	73.9	17.81	349	267	HORI	Pk
4623.00	58.5	73.9	15.4	100	230	VERT	Pk
5559.00	63.67	73.9	10.23	301	0	HORI	Pk
6495.50	65.85	73.9	8.05	191	165	VERT	Pk
7407.00	44.92	73.9	28.98	105	72	VERT	Pk
8321.50	46.38	73.9	27.52	301	30	HORI	Pk
9273.50	47.85	73.9	26.05	249	248	HORI	Pk

Table 16

Radiated Emissions Harmonics Measurements, ANT-916-CW-QW Antenna, Channel 0

Frequency	Level	Limit	Margin	Height	Angle	Pol.	Detector
MHz	dB μ V/m	dB μ V/m	dB	cm	deg		
1806.00	55.59	90.16*	34.57	191	278	VERT	Av
2708.50	49.98	53.9	3.92	201	278	VERT	Av
3594.00	42.44	53.9	11.46	378	1	HORI	Av
4518.00	44.49	53.9	9.41	391	145	HORI	Av
5401.50	62.43	90.16*	27.73	391	100	VERT	Av
6319.50	51.76	53.9	2.14	99	36	VERT	Av
7253.00	30.38	53.9	23.52	107	95	HORI	Av
8155.00	45.86	53.9	8.04	397	250	VERT	Av
9006.50	48.68	53.9	5.22	397	0	VERT	Av
1806.00	63.78	90.16*	26.38	191	278	VERT	Pk
2708.50	58.87	73.9	15.03	201	278	VERT	Pk
3594.00	55.32	73.9	18.58	378	1	HORI	Pk
4518.00	57.77	73.9	16.13	391	145	HORI	Pk
5401.50	62.43	90.16*	27.73	391	100	VERT	Pk
6319.50	64.6	73.9	9.3	99	36	VERT	Pk
7253.00	44.08	73.9	29.82	107	95	HORI	Pk
8155.00	46.54	73.9	27.36	397	250	VERT	Pk
9006.50	48.55	73.9	25.35	397	0	VERT	Pk

Table 17

Radiated Emissions Harmonics Measurements, ANT-916-CW-QW Antenna, Channel 16

Frequency	Level	Limit	Margin	Height	Angle	Pol.	Detector
MHz	dBμV/m	dBμV/m	dB	cm	deg		
1829.50	54.3	89.7*	35.4	115	120	VERT	Av
2754.50	49.15	53.9	4.75	397	359	HORI	Av
3658.00	42.92	53.9	10.98	350	359	VERT	Av
4470.50	44.68	53.9	9.22	99	68	HORI	Av
5484.00	49.65	53.9	4.25	349	289	HORI	Av
6386.50	51.72	53.9	2.18	159	238	VERT	Av
7341.00	30.97	53.9	22.93	250	200	VERT	Av
8240.50	32.79	53.9	21.11	249	307	VERT	Av
9145.50	34.59	53.9	19.31	249	0	HORI	Av
1829.50	61.93	89.7*	27.77	115	120	VERT	Pk
2754.50	58.69	73.9	15.21	397	359	HORI	Pk
3658.00	55.71	73.9	18.19	350	359	VERT	Pk
4470.50	58.26	73.9	15.64	99	68	HORI	Pk
5484.00	63.05	73.9	10.85	349	289	HORI	Pk
6386.50	65.19	73.9	8.71	159	238	VERT	Pk
7341.00	44.42	73.9	29.48	250	200	VERT	Pk
8240.50	46.2	73.9	27.7	249	307	VERT	Pk
9145.50	47.72	73.9	26.18	249	0	HORI	Pk

Table 18

Radiated Emissions Harmonics Measurements, ANT-916-CW-QW Antenna, Channel 31

Frequency	Level	Limit	Margin	Height	Angle	Pol.	Detector
MHz	dBμV/m	dBμV/m	dB	cm	deg		
1853.00	55.77	90.44*	34.67	201	337	VERT	Av
2779.50	48.8	53.9	5.1	201	240	VERT	Av
3709.00	43.1	53.9	10.8	150	137	VERT	Av
4626.00	44.84	53.9	9.06	314	22	VERT	Av
5560.50	50.43	53.9	3.47	249	287	VERT	Av
6485.00	51.96	53.9	1.94	141	139	HORI	Av
7395.00	31.21	53.9	22.69	314	69	VERT	Av
8358.00	32.83	53.9	21.07	119	0	HORI	Av
9286.00	37.85	53.9	16.05	255	144	VERT	Av
1853.00	62.62	90.44*	27.82	201	337	VERT	Pk
2779.50	57.04	73.9	16.86	201	240	VERT	Pk
3709.00	56.02	73.9	17.88	150	137	VERT	Pk
4626.00	58.01	73.9	15.89	314	22	VERT	Pk
5560.50	63.68	73.9	10.22	249	287	VERT	Pk
6485.00	65.18	73.9	8.72	141	139	HORI	Pk
7395.00	44.63	73.9	29.27	314	69	VERT	Pk
8358.00	46.83	73.9	27.07	119	0	HORI	Pk
9286.00	48.04	73.9	25.86	255	144	VERT	Pk

Table 19

Radiated Emissions Harmonics Measurements, ANT-916-CW-RH Antenna, Channel 0

Frequency MHz	Level dBµV/m	Limit dBµV/m	Margin dB	Height cm	Angle deg	Pol.	Detector
1806.00	56.18	91.99*	35.81	201	269	VERT	Av
2709.50	48.52	53.9	5.38	130	202	VERT	Av
3603.50	42.45	53.9	11.45	201	354	VERT	Av
4501.50	44.41	53.9	9.49	150	358	HORI	Av
5414.50	48.97	53.9	4.93	391	142	HORI	Av
6316.00	51.86	53.9	2.04	128	323	VERT	Av
7201.50	32.63	53.9	21.27	156	276	VERT	Av
8114.50	36.75	53.9	17.15	156	0	HORI	Av
9026.00	38.10	53.9	15.8	256	182	VERT	Av
1806.00	60.85	91.99*	31.14	201	269	VERT	Pk
2709.50	58.5	73.9	15.4	130	202	VERT	Pk
3603.50	55.76	73.9	18.14	201	354	VERT	Pk
4501.50	57.61	73.9	16.29	150	358	HORI	Pk
5414.50	61.98	73.9	11.92	391	142	HORI	Pk
6316.00	65.33	73.9	8.57	128	323	VERT	Pk
7201.50	42.85	73.9	31.05	156	276	VERT	Pk
8114.50	46.89	73.9	27.01	156	0	HORI	Pk
9026.00	49.32	73.9	24.58	256	182	VERT	Pk

Table 20

Radiated Emissions Harmonics Measurements, ANT-916-CW-RH Antenna, Channel 16

Frequency MHz	Level dBµV/m	Limit dBµV/m	Margin dB	Height cm	Angle deg	Pol.	Detector
1830.00	56.92	90.88*	33.96	141	128	VERT	Av
2745.50	47.93	53.9	5.97	120	275	HORI	Av
3646.50	42.85	53.9	11.05	165	156	HORI	Av
4481.50	44.51	53.9	9.39	391	188	VERT	Av
5488.50	49.75	53.9	4.15	99	189	HORI	Av
6408.50	51.84	53.9	2.06	249	40	HORI	Av
7317.00	30.82	53.9	23.08	249	8	HORI	Av
8233.00	32.91	53.9	20.99	327	0	VERT	Av
9131.50	34.7	53.9	19.2	314	322	VERT	Av
1830.00	61.36	90.88*	29.52	141	128	VERT	Pk
2745.50	57.39	73.9	16.51	120	275	HORI	Pk
3646.50	56.32	73.9	17.58	165	156	HORI	Pk
4481.50	57.36	73.9	16.54	391	188	VERT	Pk
5488.50	62.95	73.9	10.95	99	189	HORI	Pk
6408.50	65.17	73.9	8.73	249	40	HORI	Pk
7317.00	45.08	73.9	28.82	249	8	HORI	Pk
8233.00	46.83	73.9	27.07	327	0	VERT	Pk
9131.50	48.24	73.9	25.66	314	322	VERT	Pk

Table 21

Radiated Emissions Harmonics Measurements, ANT-916-CW-RH Antenna, Channel 31

Frequency	Level	Limit	Margin	Height	Angle	Pol.	Detector
MHz	dBμV/m	dBμV/m	dB	cm	deg		
1853.00	57.1	90.88*	33.78	100	118	VERT	Av
2778.50	48.74	53.9	5.16	214	238	VERT	Av
3717.50	43.27	53.9	10.63	327	109	VERT	Av
4627.00	46.77	53.9	7.13	398	45	HORI	Av
5562.50	50.58	53.9	3.32	227	4	HORI	Av
6466.00	51.76	53.9	2.14	106	174	VERT	Av
7416.50	31.32	53.9	22.58	392	30	VERT	Av
8334.50	32.81	53.9	21.09	350	49	VERT	Av
9255.00	34.37	53.9	19.53	150	102	VERT	Av
1853.00	63.35	90.88*	27.53	100	118	VERT	Pk
2778.50	58.58	73.9	15.32	214	238	VERT	Pk
3717.50	56.45	73.9	17.45	327	109	VERT	Pk
4627.00	58.01	73.9	15.89	398	45	HORI	Pk
5562.50	63.7	73.9	10.2	227	4	HORI	Pk
6466.00	65.58	73.9	8.32	106	174	VERT	Pk
7416.50	45.3	73.9	28.6	392	30	VERT	Pk
8334.50	46.94	73.9	26.96	350	49	VERT	Pk
9255.00	47.51	73.9	26.39	150	102	VERT	Pk

Table 22

Radiated Emissions Harmonics Measurements, ANT-ELE-S01-006 Antenna, Channel 0

Frequency	Level	Limit	Margin	Height	Angle	Pol.	Detector
MHz	dBμV/m	dBμV/m	dB	cm	deg		
1805.50	58.68	89.50*	30.82	100.00	164.00	VERT	Av
1806.00	41.82	53.90	12.08	250.00	52.00	VERT	Av
2709.50	52.60	53.90	1.30	100.00	103.00	VERT	Av
3604.00	42.35	53.90	11.55	237.00	321.00	VERT	Av
4509.50	44.33	53.90	9.57	350.00	359.00	HORI	Av
5418.50	49.03	53.9	4.87	178	2	VERT	Av
6310.50	51.88	53.9	2.02	150	174	VERT	Av
7256.50	30.22	53.9	23.68	379	111	HORI	Av
8107.00	33.32	53.9	20.58	150	108	VERT	Av
9039.50	35.07	53.9	18.83	214	173	HORI	Av
1805.50	64.54	89.50*	24.96	100	164	VERT	Pk
1806.00	51.54	73.9	22.36	250	52	VERT	Pk
2709.50	61.26	73.9	12.64	100	103	VERT	Pk
3604.00	56.53	73.9	17.37	237	321	VERT	Pk
4509.50	57.62	73.9	16.28	350	359	HORI	Pk
5418.50	62.56	73.9	11.34	178	2	VERT	Pk
6310.50	65.06	73.9	8.84	150	174	VERT	Pk
7256.50	43.7	73.9	30.2	379	111	HORI	Pk
8107.00	46.63	73.9	27.27	150	108	VERT	Pk
9039.50	49.16	73.9	24.74	214	173	HORI	Pk

Table 23

Radiated Emissions Harmonics Measurements, ANT-ELE-S01-006 Antenna, Channel 16

Frequency MHz	Level dB μ V/m	Limit dB μ V/m	Margin dB	Height cm	Angle deg	Pol.	Detector
1830.00	58.73	89.72*	30.99	119	354	VERT	Av
2744.50	50.54	53.90	3.36	118	308	VERT	Av
3664.50	43.02	53.90	10.88	178	328	VERT	Av
4582.50	44.71	53.90	9.19	291	237	HORI	Av
5499.00	49.79	53.9	4.11	349	234	VERT	Av
6424.00	51.58	53.9	2.32	169	21	VERT	Av
7325.00	30.92	53.9	22.98	149	101	VERT	Av
8242.00	32.9	53.9	21.00	349	354	VERT	Av
9144.00	37.65	53.9	16.25	256	324	VERT	Av
1830.00	62.96	89.72*	26.76	119	354	VERT	Pk
2744.50	57.88	73.9	16.02	118	308	VERT	Pk
3664.50	56.26	73.9	17.64	178	328	VERT	Pk
4582.50	58.82	73.9	15.08	291	237	HORI	Pk
5499.00	63.44	73.9	10.46	349	234	VERT	Pk
6424.00	65.04	73.9	8.86	169	21	VERT	Pk
7325.00	44.46	73.9	29.44	149	101	VERT	Pk
8242.00	46.62	73.9	27.28	349	354	VERT	Pk
9144.00	48.55	73.9	25.35	256	324	VERT	Pk

Table 24

Radiated Emissions Harmonics Measurements, ANT-ELE-S01-006 Antenna, Channel 31

Frequency MHz	Level dB μ V/m	Limit dB μ V/m	Margin dB	Height cm	Angle deg	Pol.	Detector
1852.50	36.09	89.63*	53.54	349.00	359	HORI	Av
1853.00	60.06	89.63*	29.57	105.00	162	VERT	Av
2755.00	51.15	53.90	2.75	256.00	88	VERT	Av
3676.00	44.98	53.90	8.92	249.00	359	HORI	Av
4572.50	44.65	53.90	9.25	350.00	198	VERT	Av
5495.50	49.78	53.9	4.12	369	0	HORI	Av
6424.00	51.55	53.9	2.35	179	330	HORI	Av
7333.00	31.01	53.9	22.89	192	55	HORI	Av
8237.00	32.93	53.9	20.97	105	359	VERT	Av
9130.50	34.7	53.9	19.2	99	4	HORI	Av
1852.50	49.16	89.63*	40.47	349	359	HORI	Pk
1853.00	65.88	89.63*	23.75	105	162	VERT	Pk
2755.00	59.3	73.9	14.6	256	88	VERT	Pk
3676.00	56.29	73.9	17.61	249	359	HORI	Pk
4572.50	58.11	73.9	15.79	350	198	VERT	Pk
5495.50	62.59	73.9	11.31	369	0	HORI	Pk
6424.00	65.04	73.9	8.86	179	330	HORI	Pk
7333.00	44.78	73.9	29.12	192	55	HORI	Pk
8237.00	46.59	73.9	27.31	105	359	VERT	Pk
9130.5	49.07	73.9	24.83	99	4	HORI	Pk

Appendix D: Bandwidth and bandedge data

Table 25

Bandwidth Measurements

Channel	6dB Bandwidth (kHz)	Minimum (kHz)	Margin (kHz)
0	500.06	500.00	0.06
16	500.06	500.00	0.06
31	500.06	500.00	0.06

Table 26

Bandedge Measurements

Channel	Bandedge (MHz)	Peak to Bandedge Delta (dB)	Minium (dB)	Margin (dB)
0.00	902.00	34.84	20.00	14.84
31.00	928.00	37.94	20.00	17.94

Bandwidth measurements were made with the antenna port connected directly to the spectrum analyzer. The resolution bandwidth was set to 100 kHz, the video bandwidth to 1 MHz. The spectrum analyzer was set to max hold.

Bandedge measurements were made at a 3m distance. All 4 antennas were tested, and the ANT-916-CW-HW antenna was found to have the highest emissions at the bandedges, so it was this antenna that was used for measurements. The height and angle of the EUT was adjusted so as to produce maximum emissions. The spectrum analyzer was set to max hold.

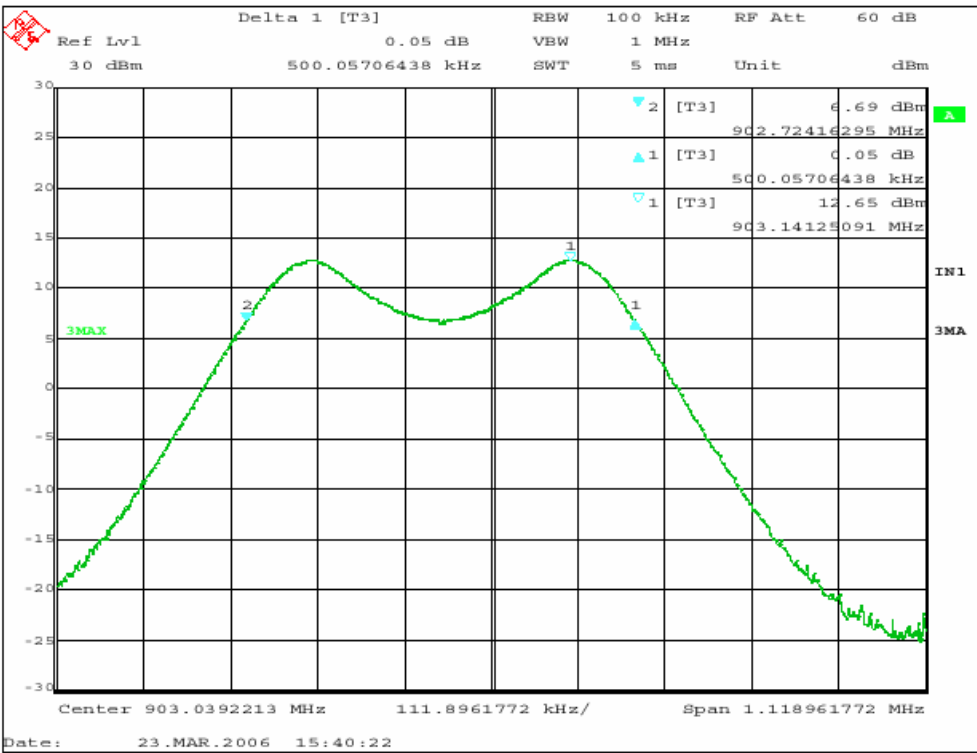


Figure 22 - Channel 0, 6db Bandwidth, conducted

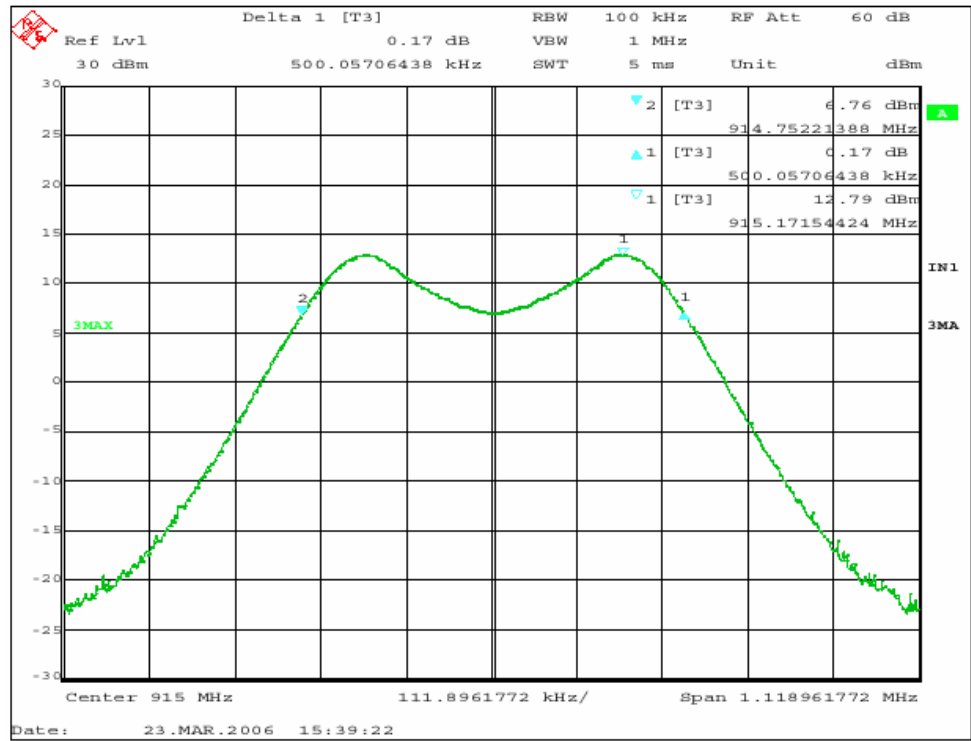


Figure 23 - Channel 16, 6db Bandwidth, conducted

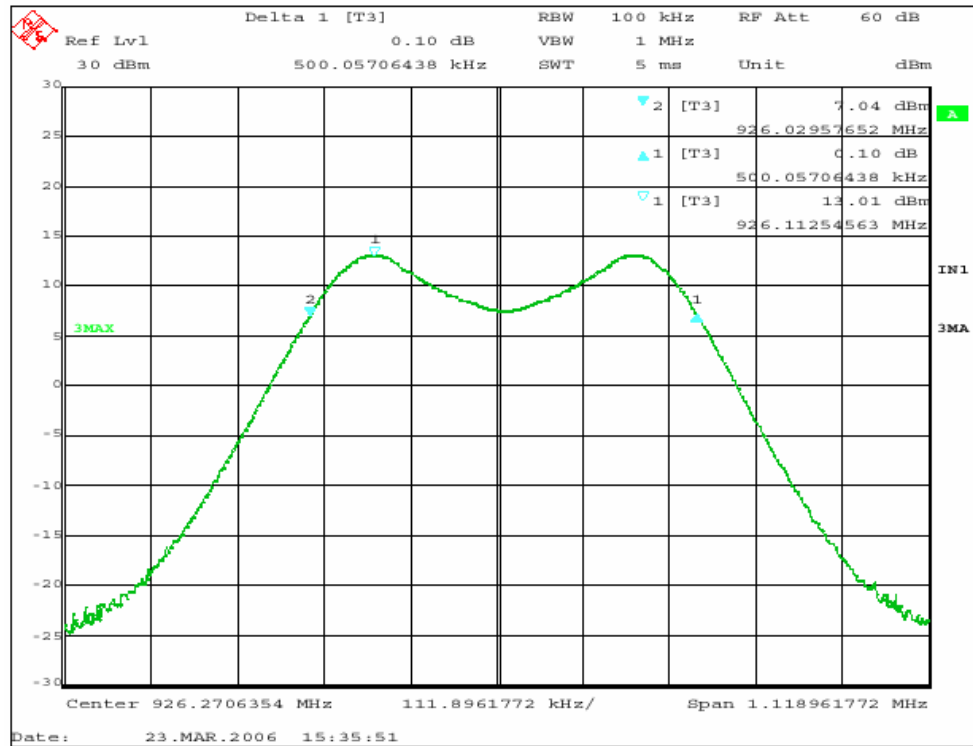


Figure 24 - Channel 31, 6db Bandwidth, conducted

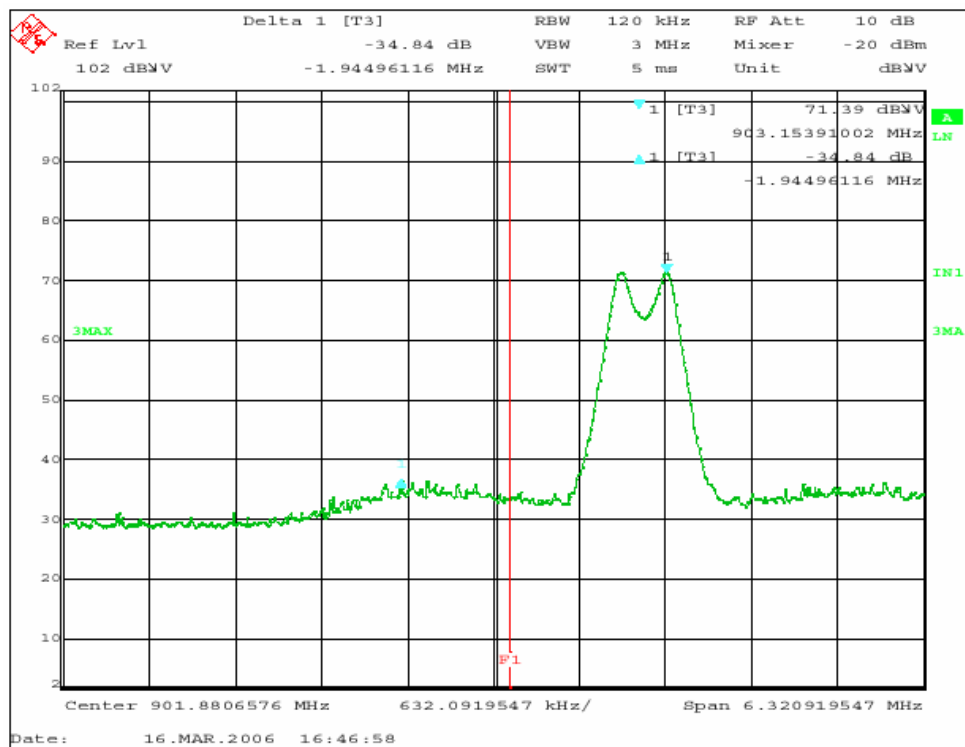


Figure 25 - Channel 0, 902MHz Bandedge, radiated uncorrected

Vertical red line depicts 902MHz bandedge, Highest out-of-band emission is 34.84dB below peak output.

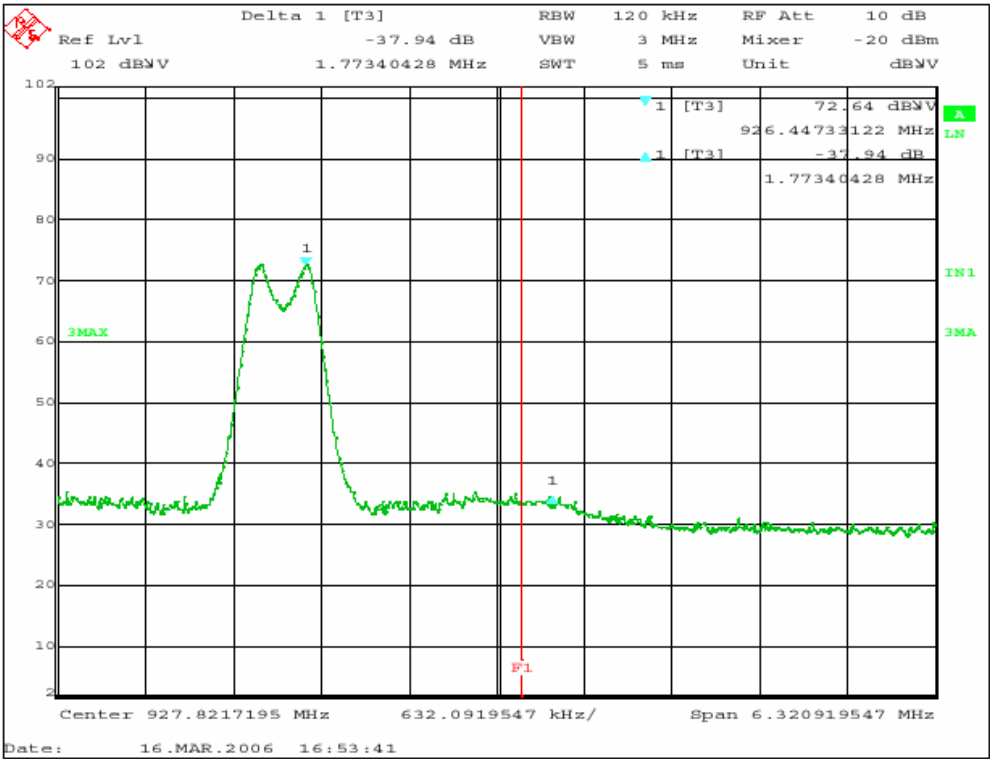


Figure 26 - Channel 31, 928MHz Bandedge, radiated uncorrected

Vertical red line depicts 902MHz bandedge, Highest out-of-band emission is 37.94dB below peak output.

Appendix E: Channel Power and Power Spectral Density Measurements (Radiated)

Table 27
Channel Power and Power Spectral Density Measurements

Channel	Channel Power (dBm)	Limit (dBm)	Margin (dBm)	Power Spectral Density (dBm)	Limit (dBm)	Margin (dB)
0	12.44	30.00	17.56	5.49	8.00	2.51
16	12.40	30.00	17.60	5.32	8.00	2.68
31	12.20	30.00	17.80	4.93	8.00	3.07

All channel power measurements were made with the antenna port directly connected to the spectrum analyzer. Channel power measurements were made with a resolution bandwidth of 100 kHz and a video bandwidth of 1 MHz. The sweep time was 1s. The spectrum analyzer was set to sample capture.

All power spectral density measurements were made with a resolution bandwidth of 3 kHz and a video bandwidth of 10 kHz. The sweep time was 100s. The spectrum analyzer was to sample capture.

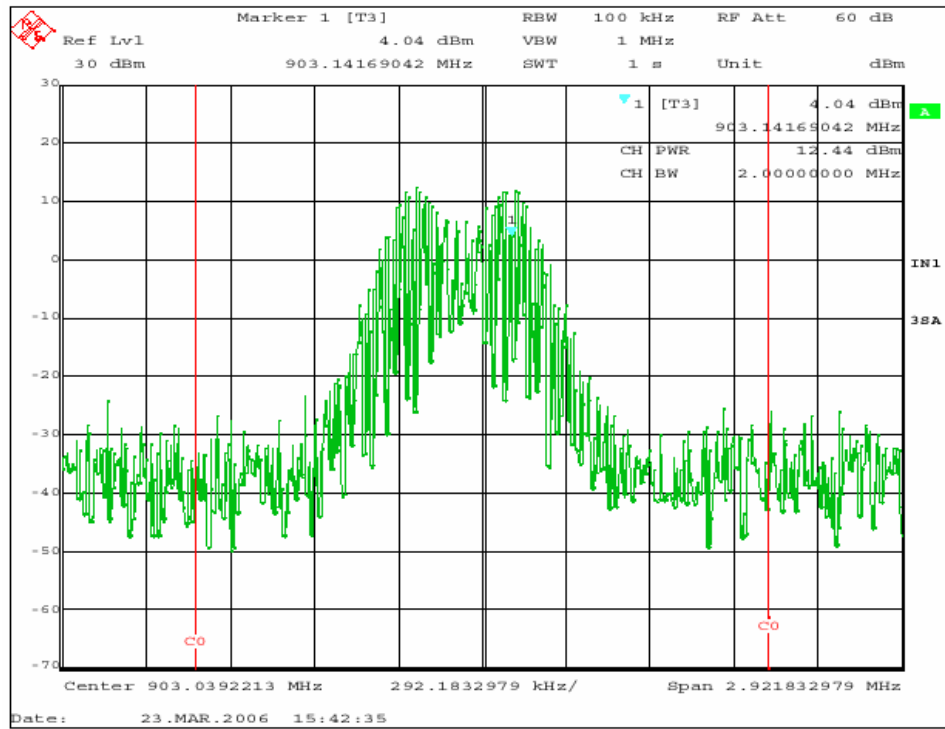


Figure 27 - Channel Power Measurements, Channel 0, 19200 baud

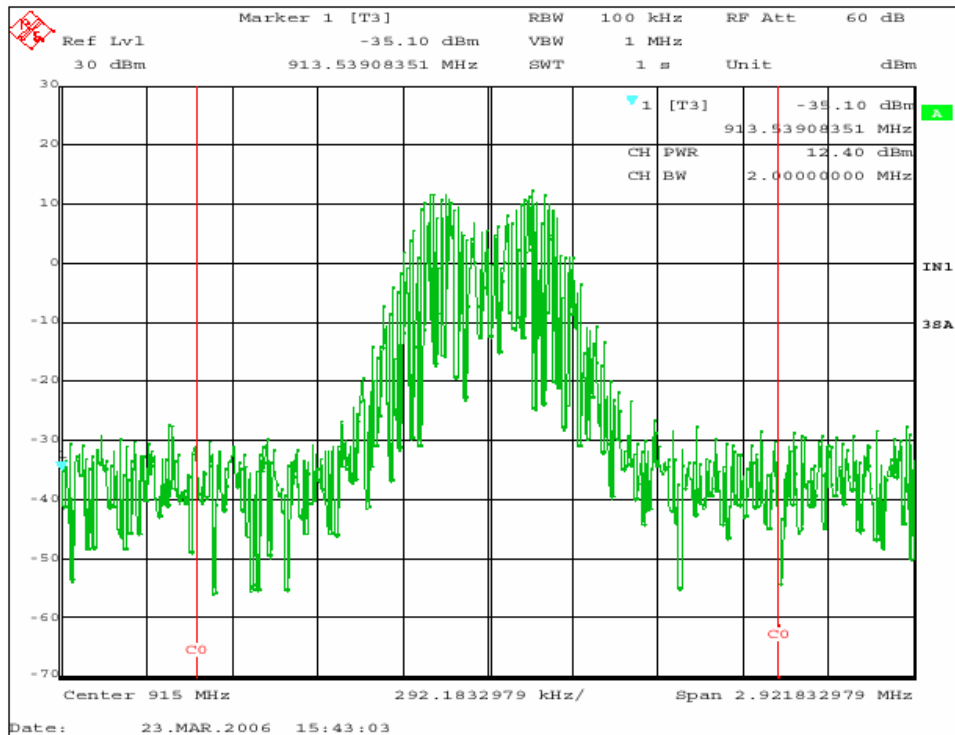


Figure 28 - Channel Power Measurements, Channel 16, 19200 baud

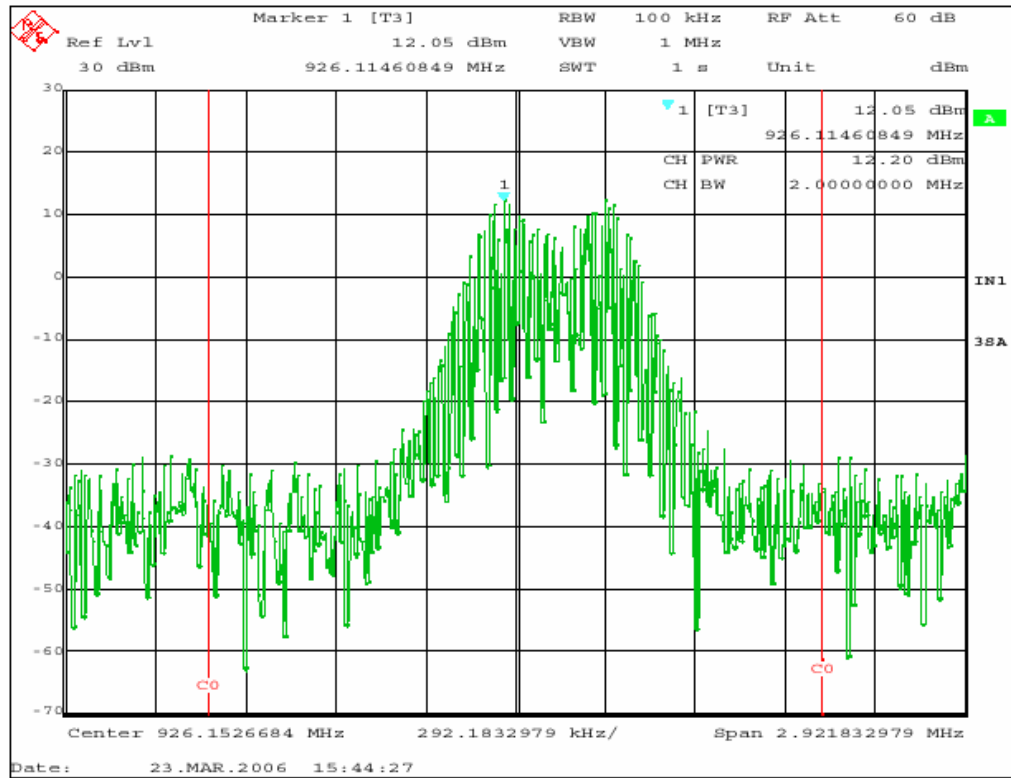


Figure 29 - Channel Power Measurements, Channel 31, 19200 baud

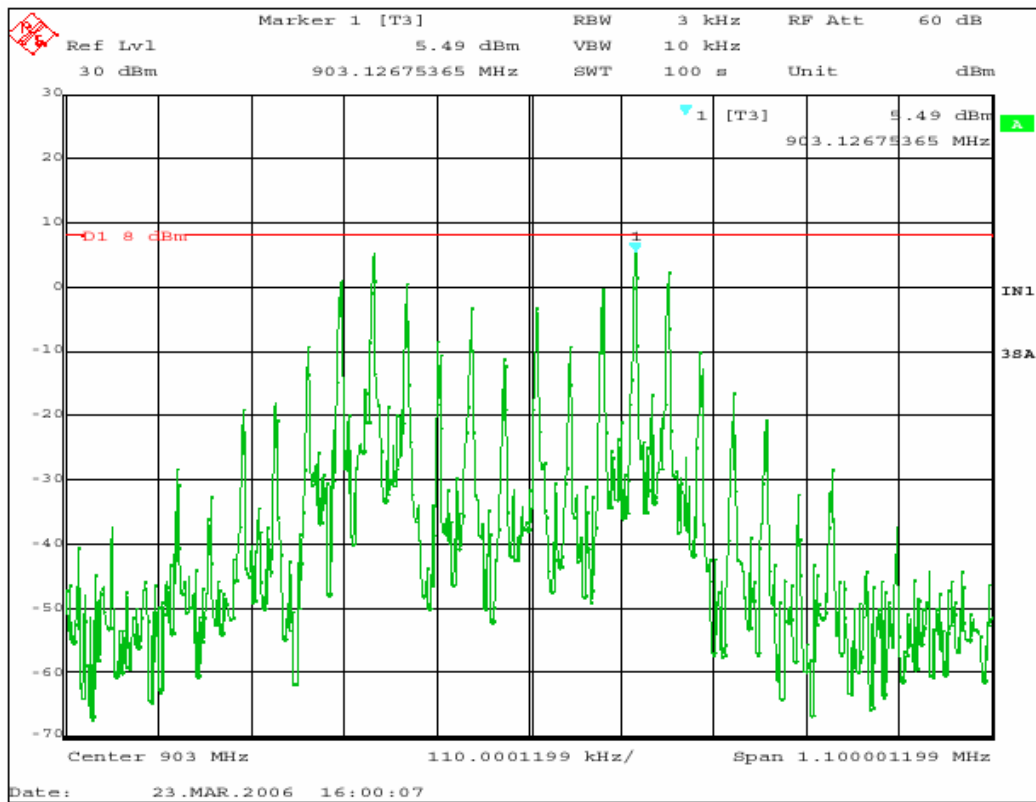


Figure 30 - Power Spectral Density, Channel 0

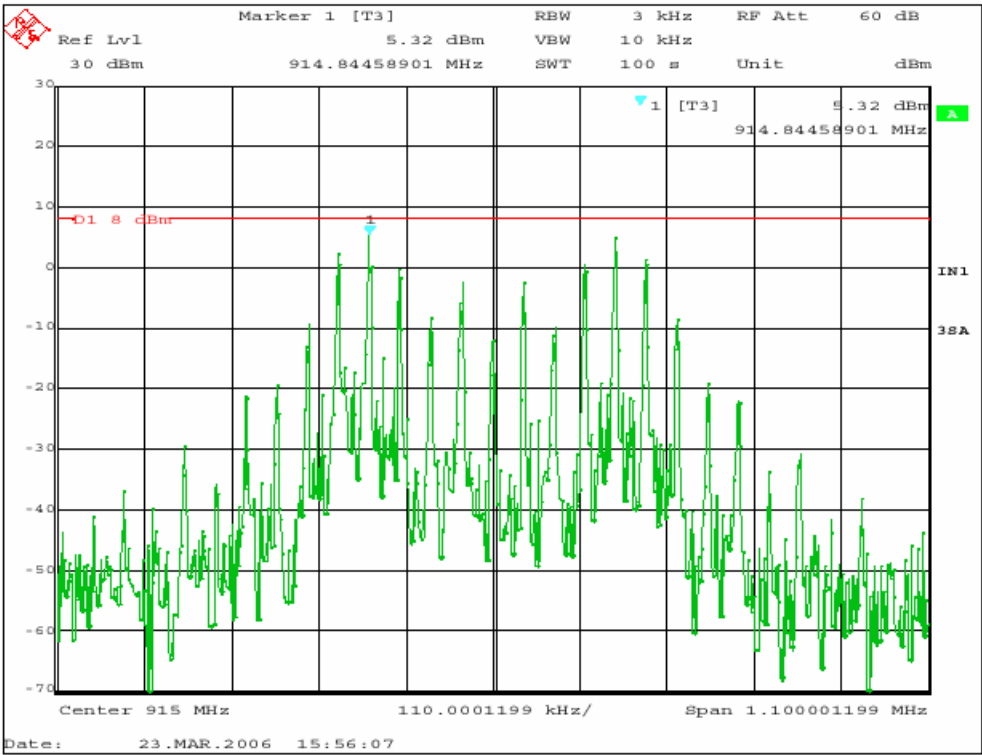


Figure 31 - Power Spectral Density, Channel 16

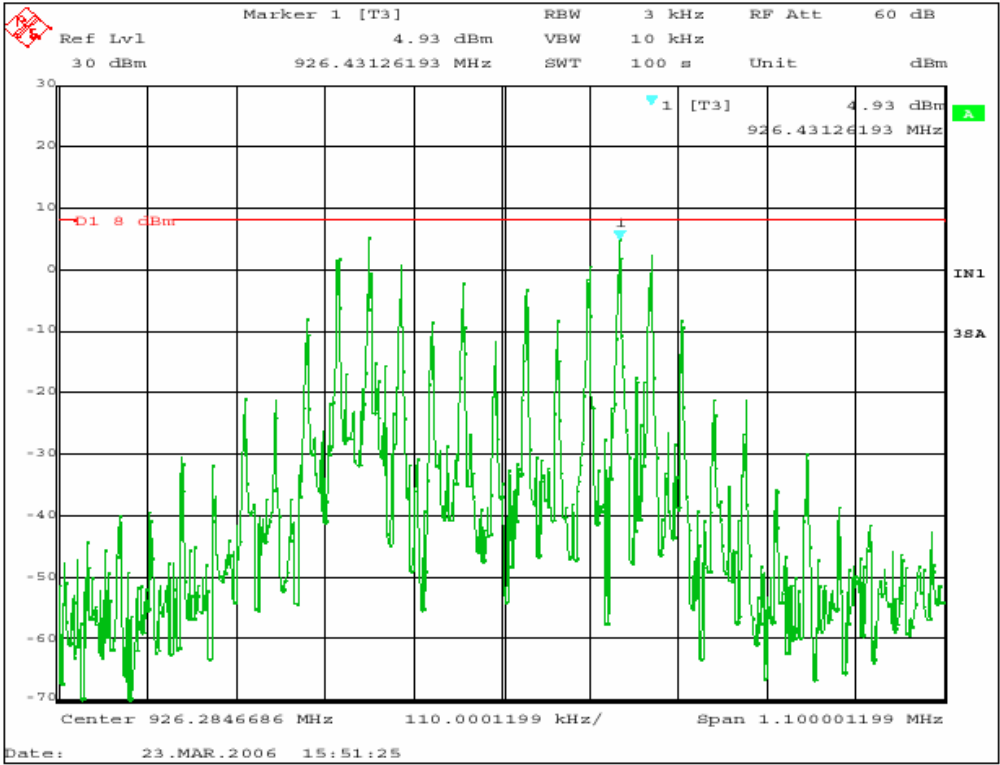


Figure 32 - Power Spectral Density, Channel 31

Appendix F: Sample Calculation

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF - (-CF + AG) + AV$$

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm} [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

AV is calculated by the taking the $20 \cdot \log(T_{\text{on}}/100)$ where T_{on} is the maximum transmission time in any 100ms window.

Appendix G: RF Exposure Evaluation

FCC ID: Q7V-3F090008X**RF Exposure Statement for Wi.232 25mW FHSS Module:****Notice in Installation Manual:**

FCC Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 2.1cm (0.83 inches) between the radiator and your body.

RF Exposure Calculations:

The following information provides the minimum separation distances for the two major antenna types used in this system.

Omnidirectional Antenna:

The 5 dBi omni antenna is the maximum gain antenna certified for use with the product. The minimum separation distance is calculated from **FCC OET 65 Appendix B, Table 1B** Guidelines for General Population/Uncontrolled Exposure. This calculation is based on the highest EIRP possible from the system, considering maximum power and antenna gain, and considering a 1.0 mW/cm² uncontrolled exposure limit. The formula used was:

$$S = (P_o * G) / (4 * \pi * r^2) \text{ or } r = \text{SQRT} [(P_o * G) / (4 * \pi * S)]$$

Where S = 1.0 mW/cm² for 2400 MHz

Where P_o = 17.6 mW (Peak RF, 12.44dBm)

Where G = 3.16 (numeric equivalent to 5 dBi antenna gain with 0.0 dB cable loss)

Where r = Minimum Safe Distance from antenna (cm)

For Q7V-3F090008X, r = 2.1 cm (0.83 inches)

For a distance [r] of 20cm from this antenna, the field density S = 0.012 mW/cm²

Notes:

1. The minimum safe distance is based on a conservative “worse case” prediction, i.e. using the formula shown above and no duty factor. In practice the minimum distance will be much shorter. (Ref. 2)
2. The minimum safe distance has been calculated for the maximum allowed Power Density (S) limit of 1.0 mW/cm² in the frequency range 1500-100,000 MHz for uncontrolled environments (Ref. 2).

References:

1. FCC Part 15, sub-clause 15.247 (b) (4) (i)
2. FCC OET Bulletin 65, Edition 97-01
3. FCC Supplement C to OET Bulletin 65, edition 01-01

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