LEXMARK

LEXMARK INTERNATIONAL

TEST REPORT

for

FCC PART 15
INDUSTRY CANADA RSS-210

TRADE NAME: RFID UHF Option

MODEL NUMBER: 4062-RF1

Test Report Number: L704-EMC-2009-FCC-051809

Date: May 18, 2009

1 TABLE OF CONTENTS

2 TECHNICAL REPORT

Manufacturer of Equipment-under-test	Lexmark International, Inc.
Address of Manufacturer	740 New Circle Rd. Lexington, Kentucky 40511

Equipment Under Test	
Trade Name(s)	RFID UHF Option
Model Number	4062-RF1
FCC ID	IYL4062-RF1
Industry Canada ID	2376A-4062RF1
Device Category	Mobile
RF Exposure Category	General Population/Uncontrolled Environment
Transmission Modes	EPC Gen 2
Frequency Range (MHz)	902.712 MHz – 927.280 MHz
Maximum Conducted RF Output Power (dBm)	29.79
Antenna Type	Cabled from PCB to mounted antenna
Antenna Location	Internal to EUT
Antenna Gain (dBi)	-9.6

2.1 PURPOSE OF TESTING

The purpose of this testing was to evaluate the EUT for compliance to the FCC and Industry Canada Rules for a frequency hopping RFID device operating in the frequency range 902-928 MHz.

2.2 APPLIED STANDARDS

[1] FCC Part 15 Rules and Regulations

[2] RSS-210, Issue 7, *Low Power License-Exempt Radiocommunication Devices (All Frequency Bands)*

[3] RSS-Gen, Issue 2, *General Requirements and Information for the Certification of Radiocommunication Equipment.*

3 SUMMARY

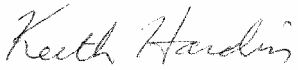
The purpose of this testing was to reevaluate the EUT for compliance to the FCC and Industry Canada Rules for a frequency hopping RFID device operating in the frequency range 902-928 MHz. The data included in this report demonstrates that the EUT complies with these requirements.

The following is a summary of the testing documented in this report:

FCC Rules	Description of Test	Result	Page of this Report
§15.247(a)(1)	Hopping channel separation	Compliant	15
§15.247(a)(1)(i)	Number of hopping channels	Compliant	17
§15.247(a)(1)(i)	20 dB bandwidth	Compliant	12
§15.247(a)(1)(i)	Average time of occupancy	Compliant	19
§15.247(b)(2)	Peak output power	Compliant	24
§15.247(d)	Conducted out of band emissions	Compliant	34
§15.203	Antenna	Compliant	8
§15.209	Radiated emissions	Compliant	39
§15.207	Conducted emissions	Compliant	51
§15.247(i)	RF exposure	Compliant	58

Industry Canada RSS-210 & RSS-Gen	Description of Test	Result	Page of this Report
§A8.1(2) [2]	Hopping channel separation	Compliant	15
§A8.1(3) [2]	Number of hopping channels	Compliant	17
§A8.1(3) [2]	20 dB bandwidth	Compliant	12
§A8.1(3) [2]	Average time of occupancy	Compliant	19
§A8.4(1) [2]	Peak output power	Compliant	24
§A8.5 [2]	Conducted out of band emissions	Compliant	34
§7.1.4 [3]	Antenna	Compliant	8
§7.2.3.2 [3]	Radiated emissions	Compliant	39
§7.2.2 [3]	Conducted emissions	Compliant	51
§5.5 [3]	RF exposure	Compliant	58

This report has been reviewed by:

Keith Hardin  May 18, 2009

Name Signature Date

4 DESCRIPTION OF EUT

The Equipment Under Test (EUT) is an RFID option for a Lexmark T650, T652 and T654 laserprinter and provides an integrated RFID reader capable of reading and writing to passive tags. The option sits immediately below the laserprinter and communicates with the printer via a serial cable to a serial option card installed in the expansion port of the printer. The RFID reader is a ThingMagic Mercury 5e multi-protocol UHF RFID reader. The option only supports the EPC Gen2 tag mode.

4.1 EUT PHOTOS

Figure 1. Front view of EUT installed with laserprinter.

Figure 2. Rear view of EUT installed with laserprinter.

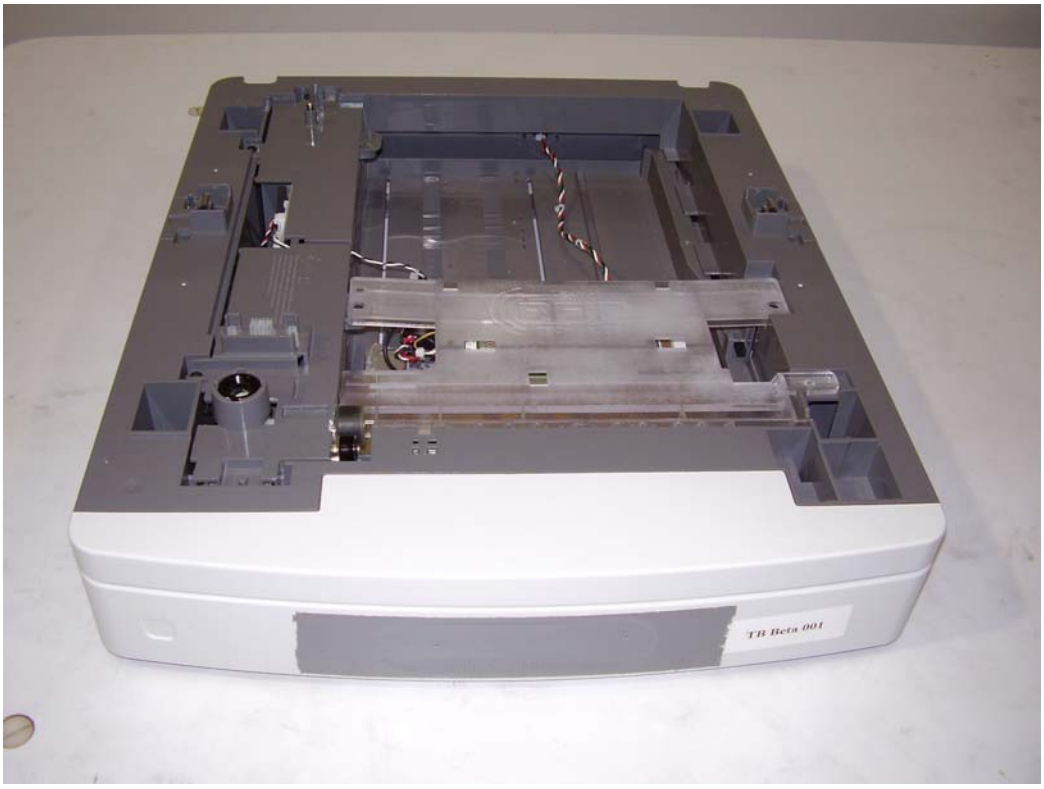


Figure 3. Top-front view of EUT.

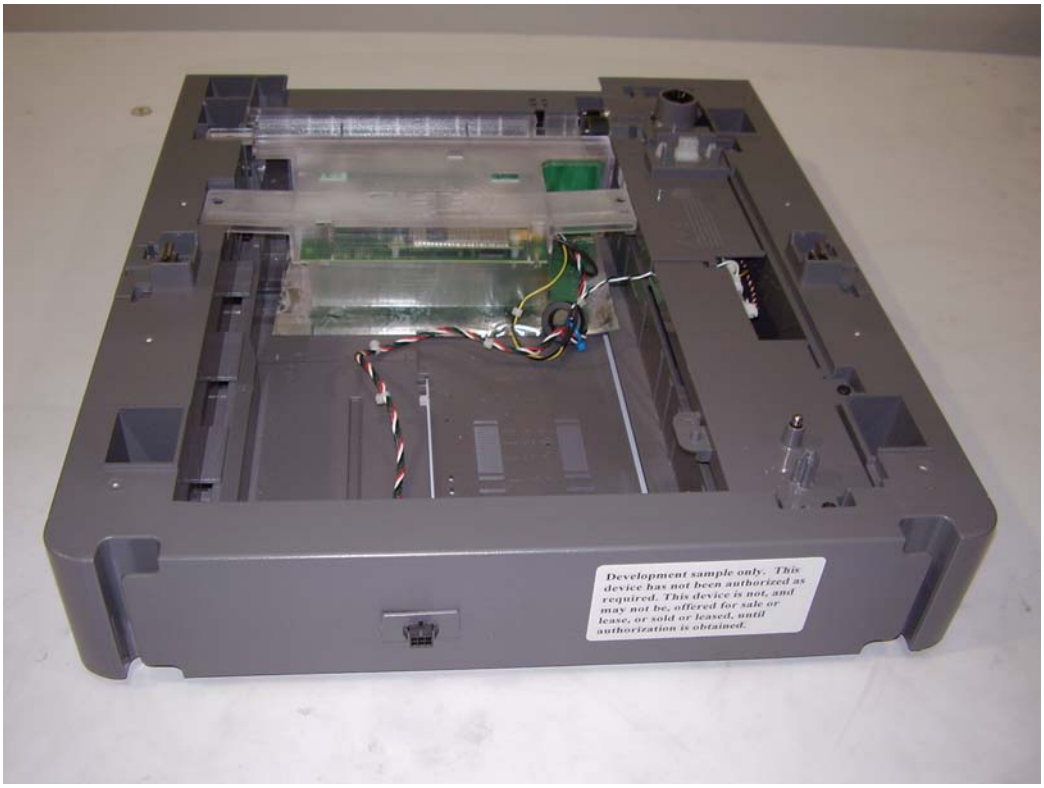


Figure 4. Top-rear view of EUT.

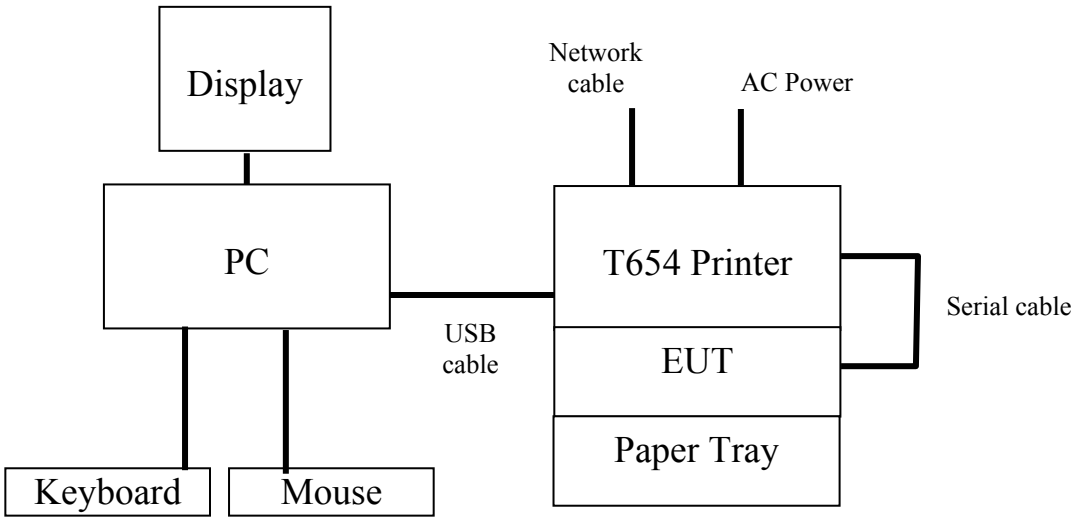
4.2 EUT ANTENNA

The EUT employs a planar antenna internal to the option, as shown in Figures 5 and 6. A coaxial cable connects the antenna to the RF output port of the transmitter. A MMCX connector is used at the RF output port and a SMA connector is used at the antenna. The SMA connector is soldered to the SMA jack on the antenna PCB. The RF port of the reader is not available externally and removal of or accessing the antenna would require disassembly of a portion of the EUT, which the user would not be expected to do. The EUT meets the requirement that no antenna other than the one supplied with the EUT can be used.

Figure 5. Front view of antenna removed from EUT.

Figure 6. Back view of antenna removed from EUT.

5 TEST CONFIGURATION



The following auxiliary equipment was used during the testing of the EUT:

Description	Manufacturer	Model
Laserprinter	Lexmark	T654dn
Personal Computer	Dell	Inspiron 531S
Display	Dell	1708FPb

6 CABLE INFORMATION

Cables used for testing included the following:

Cable Description	Cable Length (meters)	Ferrites	Shield Status
USB cable from PC to printer	2	No	Shielded
AC Line Cord to printer	2.4	No	Unshielded
PC to LCD display	2	Yes	Shielded
Network cable to printer	> 3	No	Unshielded
Serial cable from EUT to printer	0.63	No	Shielded

7 TESTING & MEASUREMENT EQUIPMENT

Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
EMI receiver	Rhode & Schwarz	ESI7	100092	11/20/09
EMI receiver	Rhode & Schwarz	ESIB7	100093	12/28/09
EMI receiver	Rhode & Schwarz	ESIB40	1112950683	7/13/10
EMI receiver	Rhode & Schwarz	ESIB40	100148	8/28/10
EMI receiver	Rhode & Schwarz	ESCI	100346	12/19/09
EMI receiver	Rhode & Schwarz	ESCI	100347	8/15/10
Spectrum analyzer	Rhode & Schwarz	FSP	100101	10/29/10
Bi-Log antenna	Chase	CBL6111C	2459	10/17/10
Bi-Log antenna	Chase	CBL6111C	2460	10/17/10
Loop antenna (9 kHz - 30 MHz)	Rhode & Schwarz	HFH 2Z2	881056/074	3/24/11
LISN	Rhode & Schwarz	ESH2-Z5	848765/017	8/2/09
LISN	Rhode & Schwarz	ESH2-Z5	890484/012	8/30/09
Horn antenna (1 - 18 GHz)	Antenna Research	DRG-1181A	1091	7/2/09
High Pass Filter	Mini-Circuits	VHP-16	N/A	As needed

8 TEST RESULTS

8.1 20 dB BANDWIDTH

Criteria for 20 dB Bandwidth: For frequency hopping systems operating in the 902-928 MHz band, the maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test Procedure for 20 dB Bandwidth: The antenna port of the EUT was connected directly to the input of the spectrum analyzer via a short coaxial cable. The insertion loss of the interconnecting coaxial cable was stored as transducer factors in the spectrum analyzer and automatically accounted for in the readings. The resolution and video bandwidths of the analyzer were set to 10 kHz and 30 kHz, respectively. The frequency span was set so that the entire channel of operation could be displayed on the spectrum analyzer. The max hold function was used to capture the maximum levels over this frequency range. Markers and display lines were then used to determine the two frequencies on the upper and lower edge of the channel where the amplitude was 20 dB below the highest amplitude within the channel. The difference in the frequencies of the upper and lower markers represents the 20 dB bandwidth of the channel.

With the EUT operating in the EPC Gen2 mode, the bandwidth of the EUT was measured on the highest, lowest and middle channels. The hopping function was disabled for this testing.

Results for 20 dB Bandwidth: See Table 1 and Figures 7 - 9 for results. The maximum 20 dB bandwidth measured was 80 kHz. The EUT met the requirements for 20 dB bandwidth.

Channel	20 dB Bandwidth (kHz)	20 dB Bandwidth Limit (kHz)
1	80.0	500.0
25	76.0	500.0
50	74.0	500.0

Table 1. Measured data for 20 dB bandwidths.

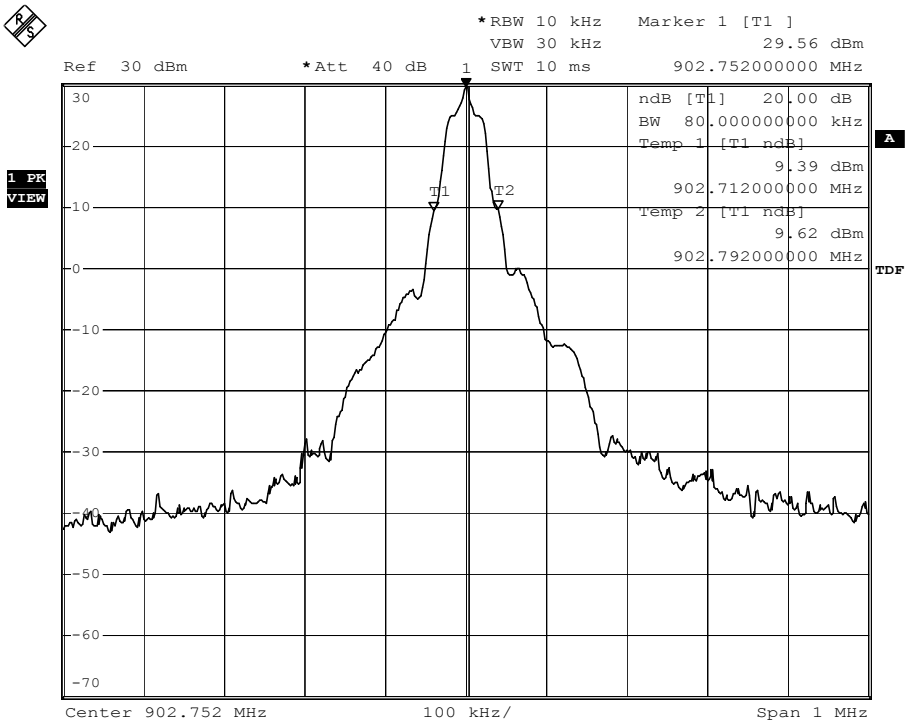


Figure 7. 20 dB Bandwidth, EPC Gen2, Channel 1.

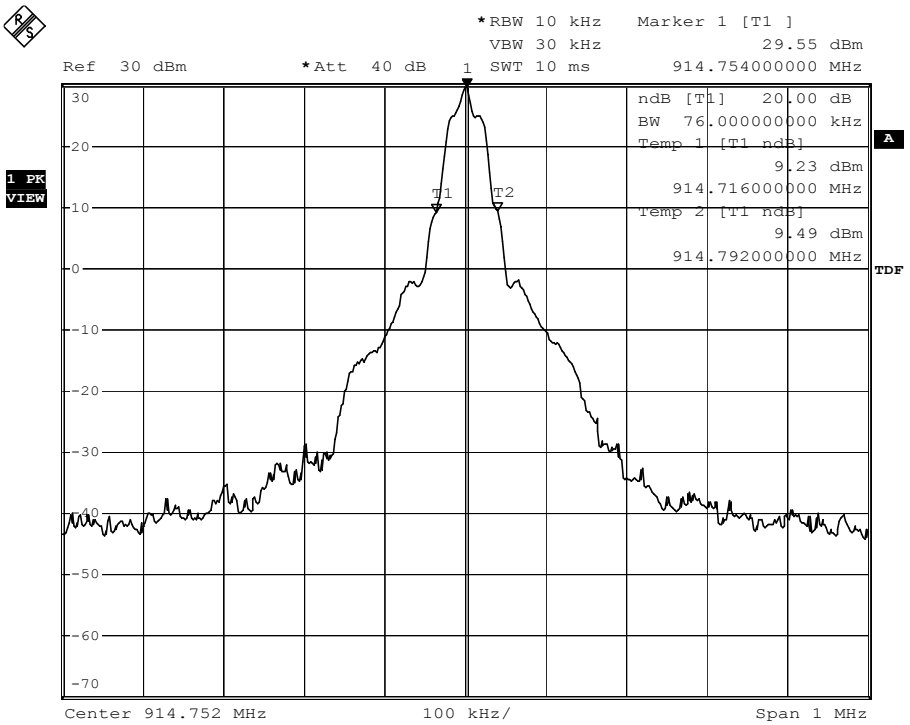


Figure 8. 20 dB Bandwidth, EPC Gen2, Channel 25.

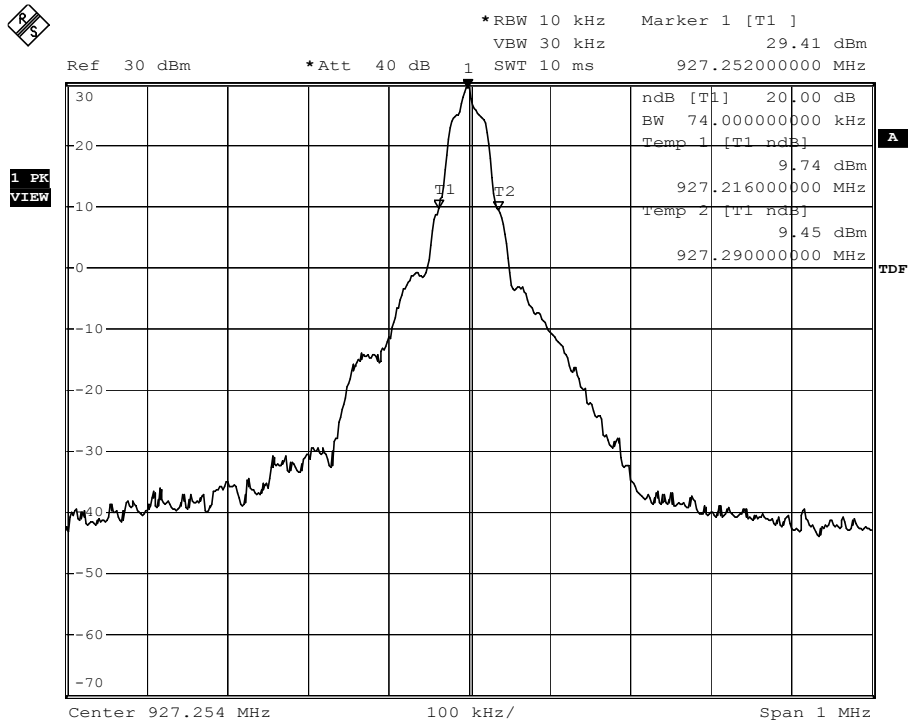


Figure 9. 20 dB Bandwidth, EPC Gen2, Channel 50.

8.2 HOPPING CHANNEL SEPARATION

Criteria for Hopping Channel Separation: Frequency hopping systems operating in the 902-928 MHz band shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Test Procedure for Hopping Channel Separation: The antenna port of the EUT was connected directly to the input of the spectrum analyzer via a short coaxial cable. The insertion loss of the interconnecting coaxial cable was stored as transducer factors in the spectrum analyzer and automatically accounted for in the readings. The resolution and video bandwidths of the analyzer were set to 100 kHz and 300 kHz, respectively. The center frequency was set to 915 MHz, the center of the hopping frequencies. The frequency span was set so that at least 4 channels could be observed. The max hold function was used to capture the maximum levels over this frequency range. Markers were then used to determine the difference in the frequencies of two channels.

The EUT was operated in the EPC Gen2 mode with the hopping function enabled.

Results for Hopping Channel Separation: See Figure 10 for results. The hopping channel separation is 504.0 kHz. Since the maximum 20 dB bandwidth was 80 kHz, the EUT met the requirement for hopping channel separation.

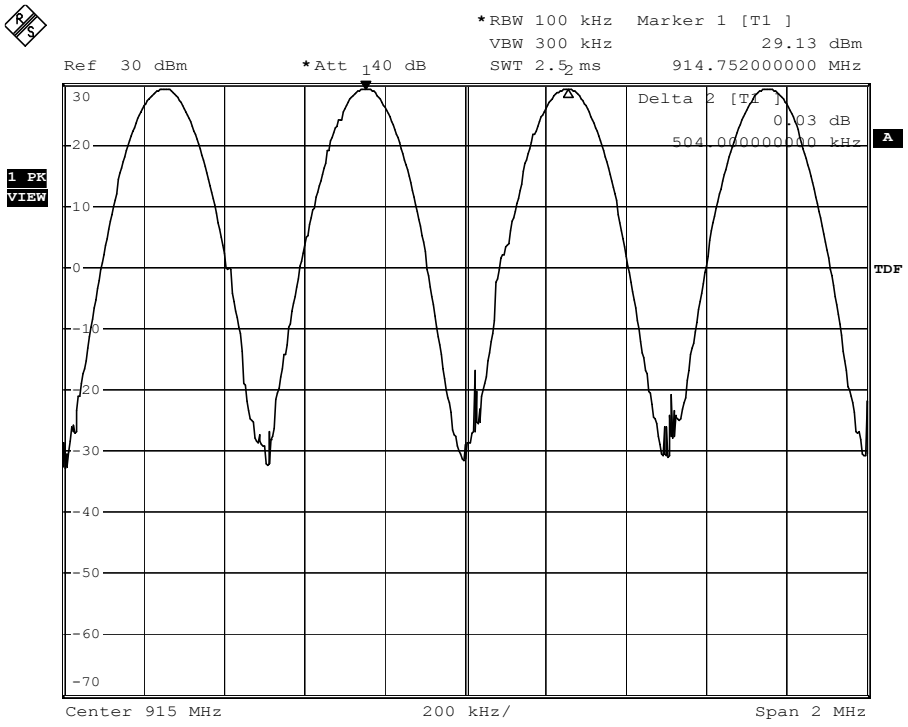


Figure 10. Hopping channel separation.

8.3 NUMBER OF HOPPING CHANNEL FREQUENCIES

Criteria for Number of Hopping Channel Frequencies: For frequency hopping systems operating in the 902-928 MHz band, if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies.

Test Procedure for Number of Hopping Channel Frequencies: The antenna port of the EUT was connected directly to the input of the spectrum analyzer via a short coaxial cable. The insertion loss of the interconnecting coaxial cable was stored as transducer factors in the spectrum analyzer and automatically accounted for in the readings. The resolution and video bandwidths of the analyzer were set to 100 kHz and 300 kHz, respectively. The frequency span was set so that the entire frequency range of operation could be displayed on the spectrum analyzer. The max hold function was used to capture the maximum levels over this frequency range.

The EUT was operated in the EPC Gen2 mode with the hopping function enabled.

Results for Number of Hopping Channel Frequencies: See Figure 11 for results. The number of hopping channels used by the EUT is 50. Since the range of the 20 dB bandwidth was 74 kHz – 80 kHz, the EUT met the requirements of using at least 50 hopping channel frequencies.

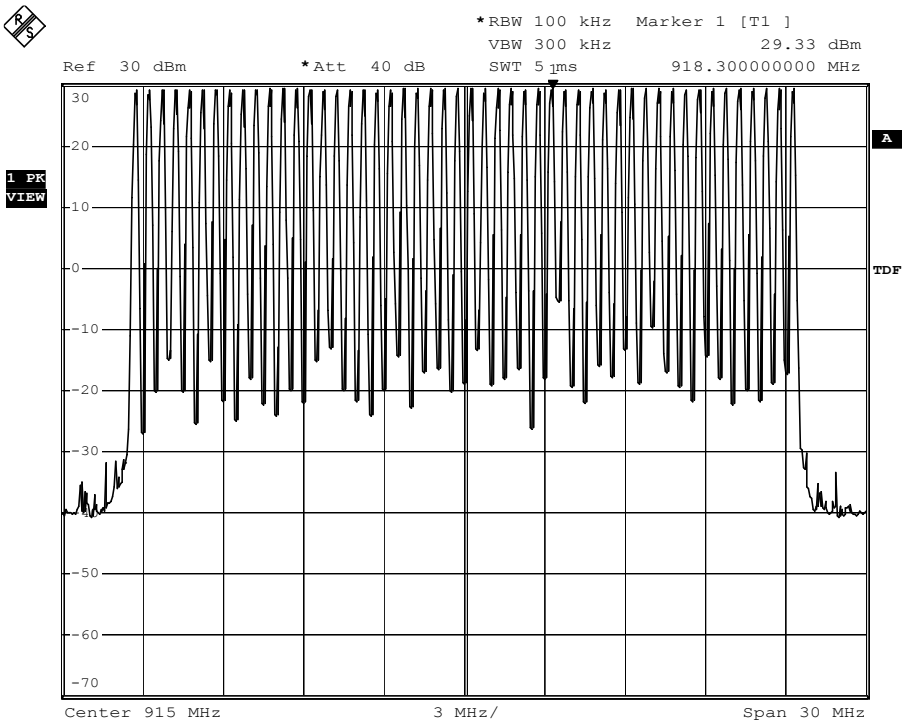


Figure 11. Number of hopping channels.

8.4 AVERAGE TIME OF OCCUPANCY

Criteria for Average Time of Occupancy: For frequency hopping systems operating in the 902-928 MHz band, if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the average time of occupancy on any frequency shall not be greater than 400 milliseconds within a 20 second period. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the average time of occupancy on any frequency shall not be greater than 400 milliseconds within a 10 second period.

Test Procedure for Average Time of Occupancy: The antenna port of the EUT was connected directly to the input of the spectrum analyzer via a short coaxial cable. The insertion loss of the interconnecting coaxial cable was stored as transducer factors in the spectrum analyzer and automatically accounted for in the readings. The resolution and video bandwidths of the analyzer were set to 100 kHz and 300 kHz, respectively The frequency span was set so that the entire channel of operation could be displayed on the spectrum analyzer. The max hold function was used to capture the maximum levels over this frequency range. The frequency that corresponded to the highest amplitude in the channel was then set to be the center frequency.

The span was then set to 0 MHz and the sweep time was set to 10 seconds. The number of times *N* the channel was occupied in a 10 second interval was then measured.

The sweep time was then set to 50 ms and the total time (t_{ON}) the channel was active within an occurrence was measured. The total time a channel was occupied within a period of 10 seconds can be calculated using the following equation:

$$t_{occupied} = N\ t_{ON}$$

For the total time a channel is occupied in a 20 second period, the above result is multiplied by two. The EUT was operated in the EPC Gen2 mode with the hopping function enabled. The measurements were performed while centered on the lowest, highest and middle channels.

Results for Average Time of Occupancy: See Table 2 for results. Measured number of occurrences and dwell times are found in Figures 12 - 17. From Table 1, the maximum 20 dB bandwidth was 76.0 kHz so the maximum occupancy time shall not be greater than 400 milliseconds in a 20 second period. The maximum occupancy time in a 20 second interval was 232 milliseconds. The EUT met the requirements for average time of occupancy.

Channel	Number Occurrences in 10 sec Interval	TON (ms)	Occupancy Time in 20 secs (ms)
1	10	10.9	218
25	10	11.5	230
50	10	11.6	232

Table 2. Measured data for occupancy times.

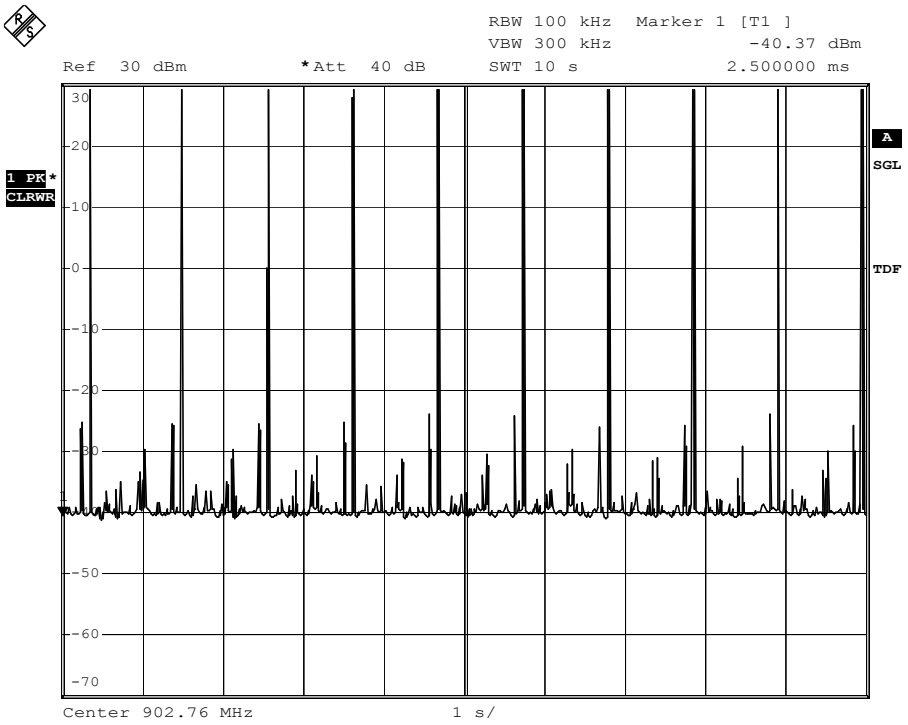


Figure 12. Number of ON events in a 10 second sweep; Channel 1.

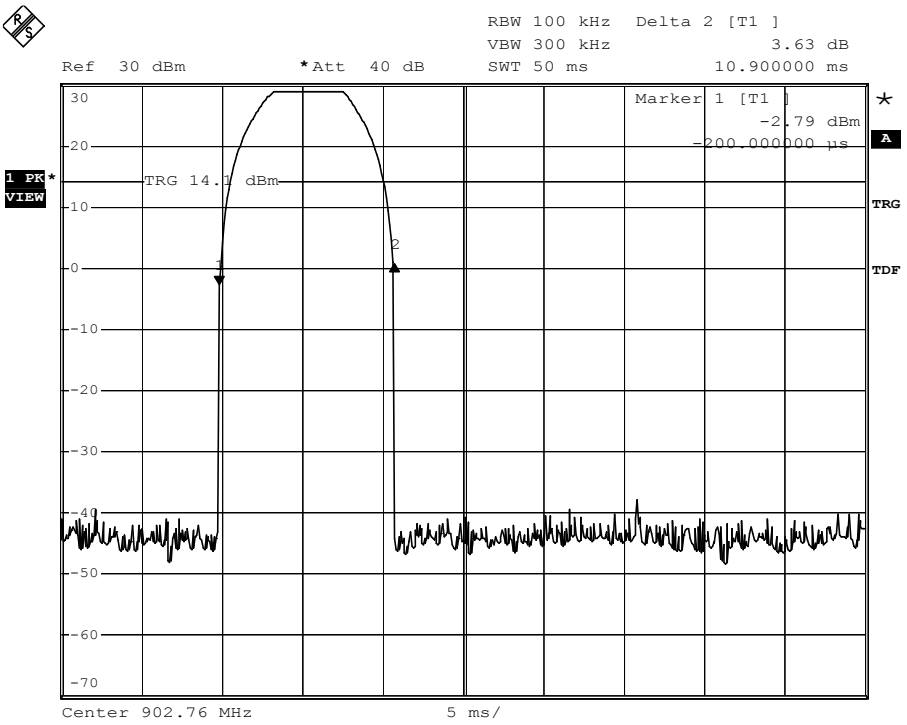


Figure 13. ON time; Channel 1.

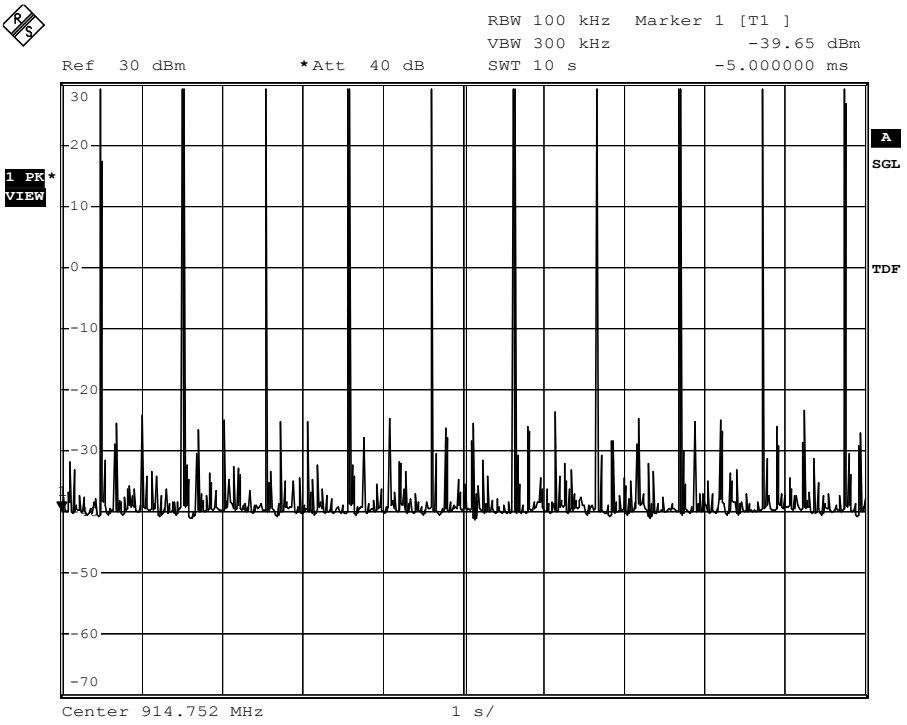


Figure 14. Number of ON events in a 10 second sweep; Channel 25.

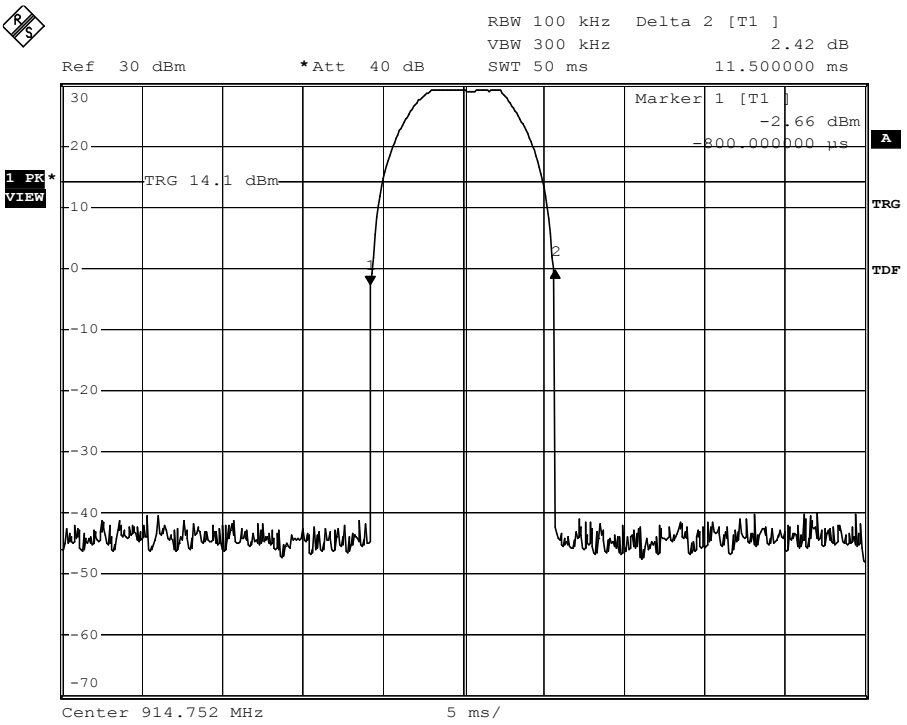


Figure 15. ON time; Channel 25.

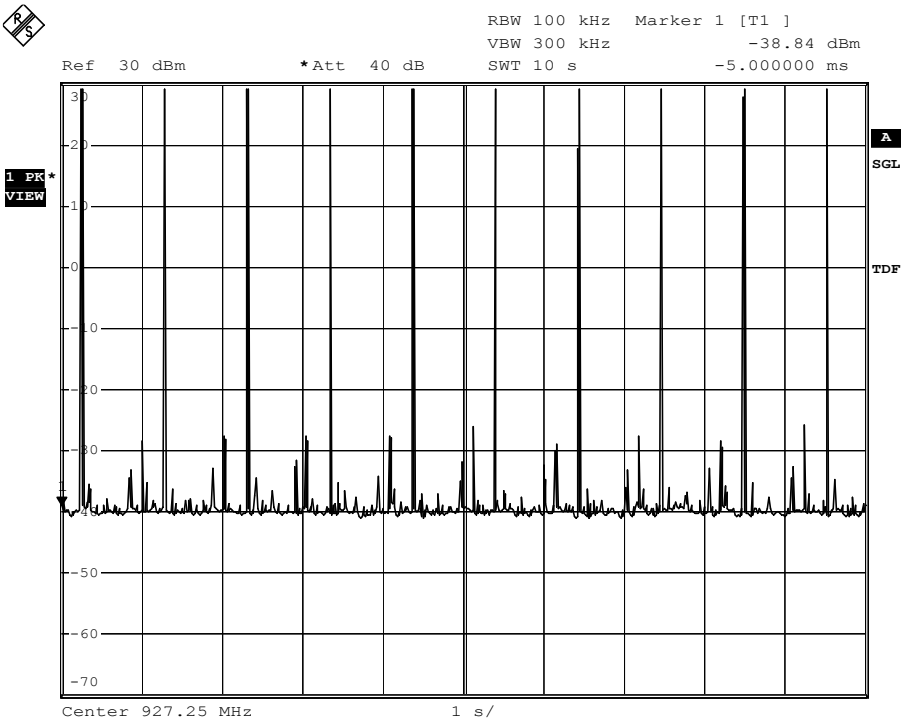


Figure 16. Number of ON events in a 10 second sweep; Channel 50.

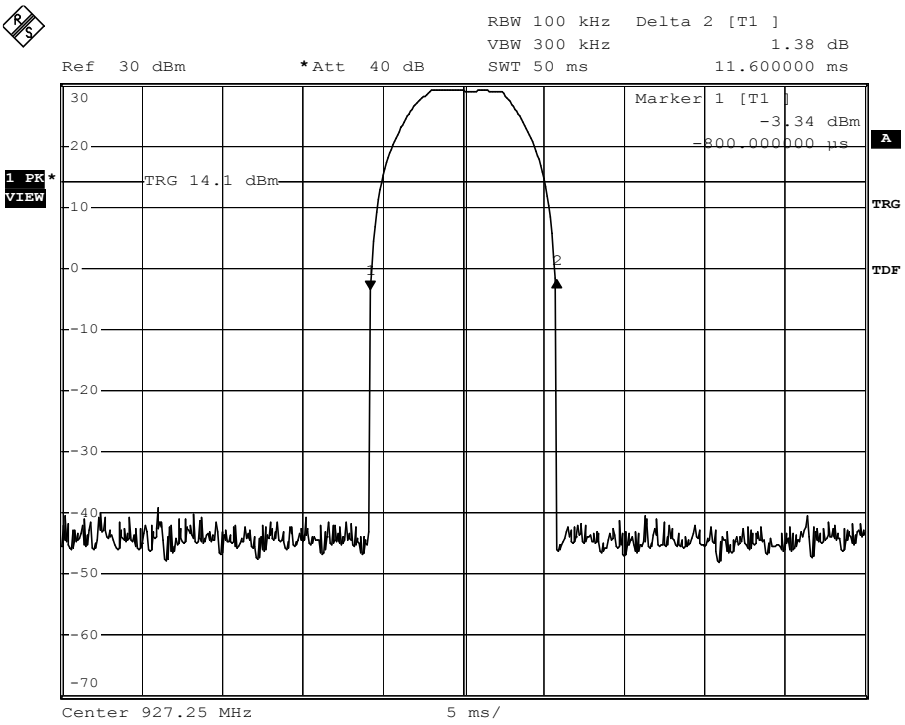


Figure 17. ON time; Channel 50.

8.5 CONDUCTED POWER

Criteria for Conducted Power: For systems using frequency hopping techniques in the 902 - 928 MHz band and employing at least 50 hopping channels, the maximum peak output power is 1 Watt (30 dBm). The variation of the input power shall be also be measured with the supply voltage varied between 85% and 115% of the nominal rated supply voltage.

Test Procedure for Conducted Power: The antenna port of the EUT was connected directly to the input of a spectrum analyzer via a short coaxial cable. The insertion loss of the interconnecting coaxial cable was stored as transducer factors in the spectrum analyzer and automatically accounted for in the readings. The resolution and video bandwidths of the analyzer were set to 1 MHz and 3 MHz, respectively. The frequency span was set to 2 MHz. The peak detector of the spectrum analyzer was used and the max hold function was used to capture the maximum levels over this frequency range. The peak search function was used to report the highest power level.

Power measurements were performed with the AC supply voltage to the EUT set to 102V/60Hz (85% nominal), 120V/60Hz (nominal) and 138V/60Hz (115% nominal).

The EUT was operated in the EPC Gen2 mode with the hopping function disabled.

Results for Conducted Power: See Figures 18 - 35 for results. Since the output power level of the EUT can be set via software control, measurements were made at the highest power setting and the lowest. The maximum conducted power for the lowest, highest and middle channels and various supply voltages was 29.79 dBm. The EUT met the requirement for a maximum output power of 30 dBm.

The results in Figures 18 - 35 also indicate the minimum and maximum frequency range of operation for the EUT. As seen in these results, the minimum center frequency of Channel 1 is 902.712 MHz and the maximum center frequency of Channel 50 is 927.280 MHz.

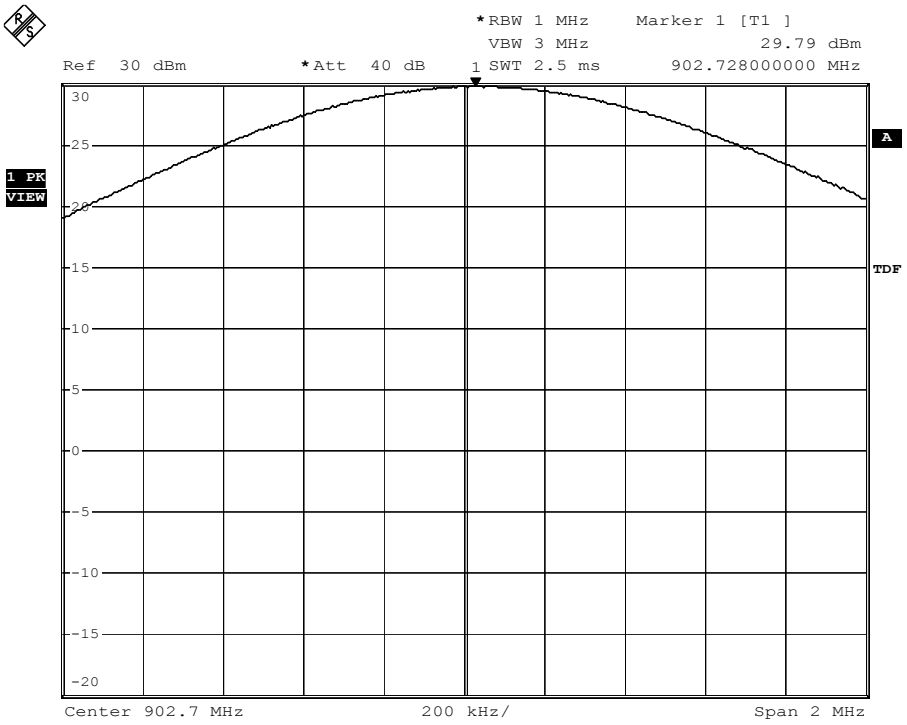


Figure 18. Conducted output power; Channel 1, nominal voltage.

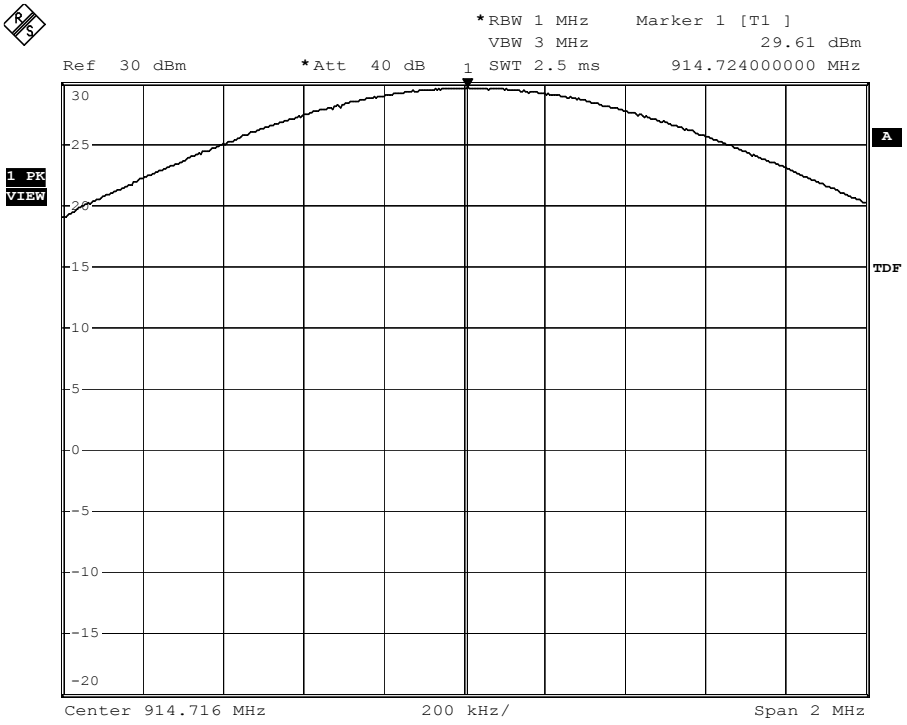


Figure 19. Conducted output power; Channel 25, nominal voltage.

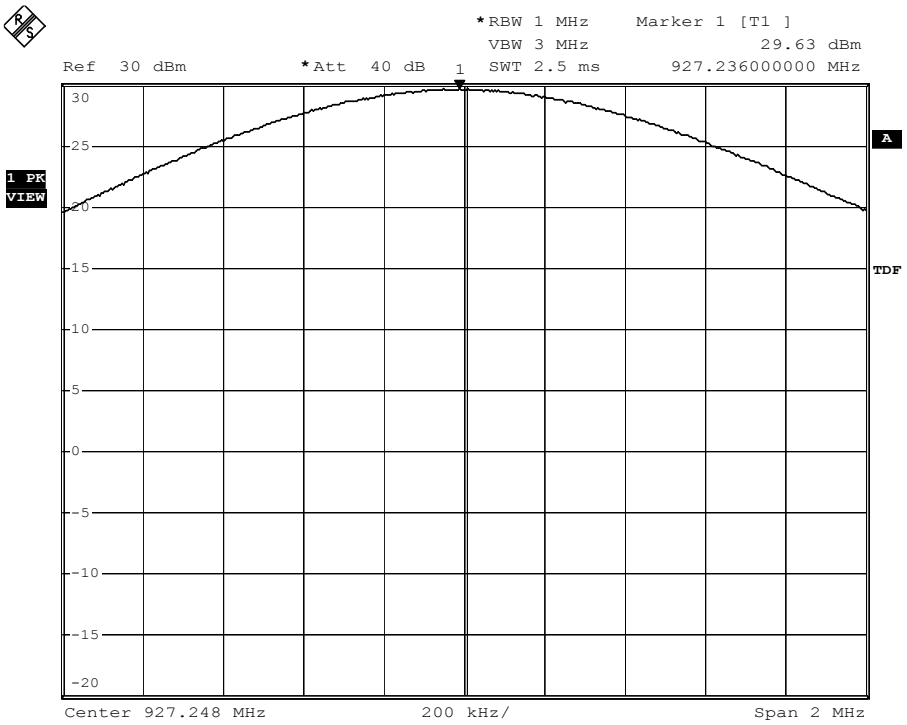


Figure 20. Conducted output power; Channel 50, nominal voltage.

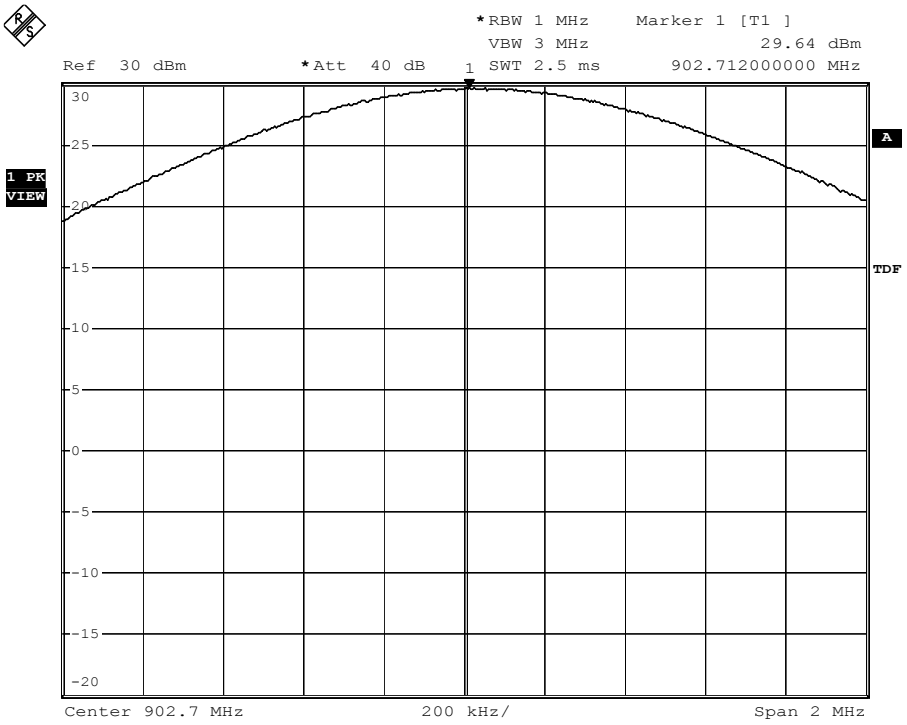


Figure 21. Conducted output power; Channel 1, 85% nominal voltage.

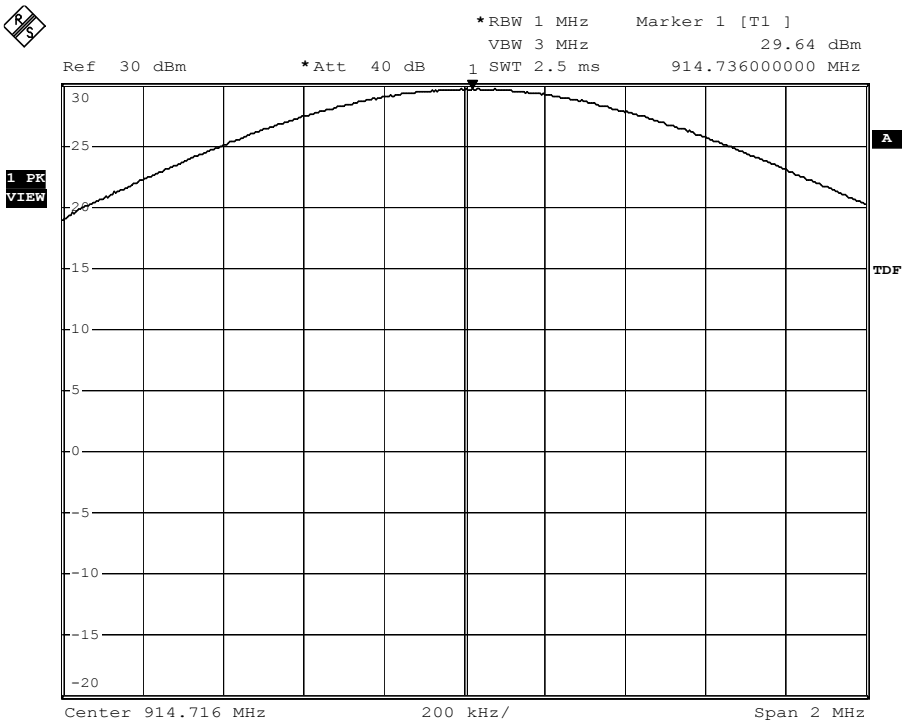


Figure 22. Conducted output power; Channel 25, 85% nominal voltage.

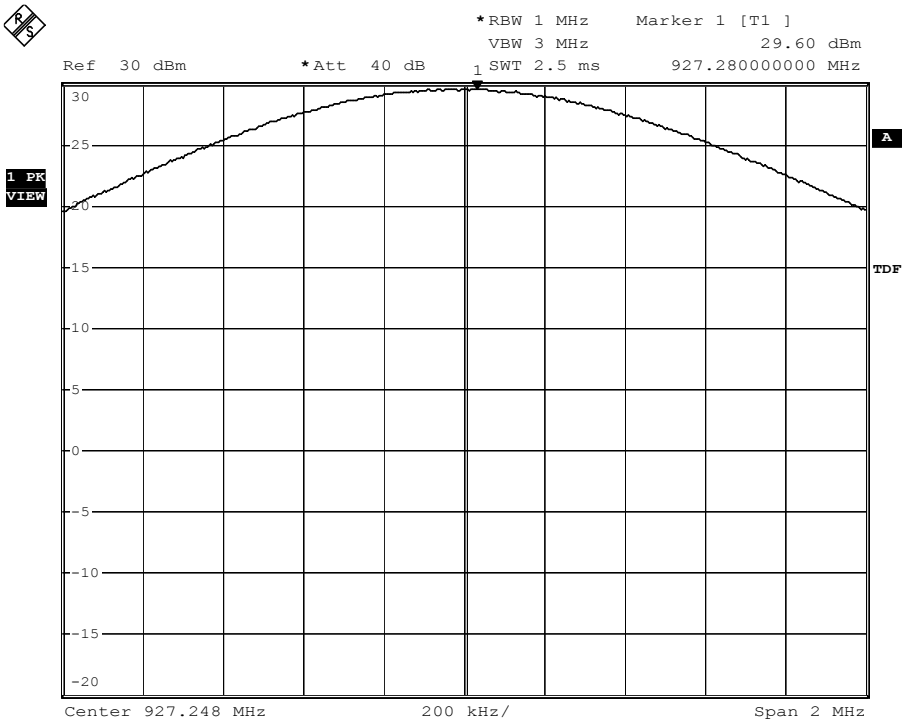


Figure 23. Conducted output power; Channel 50, 85% nominal voltage.

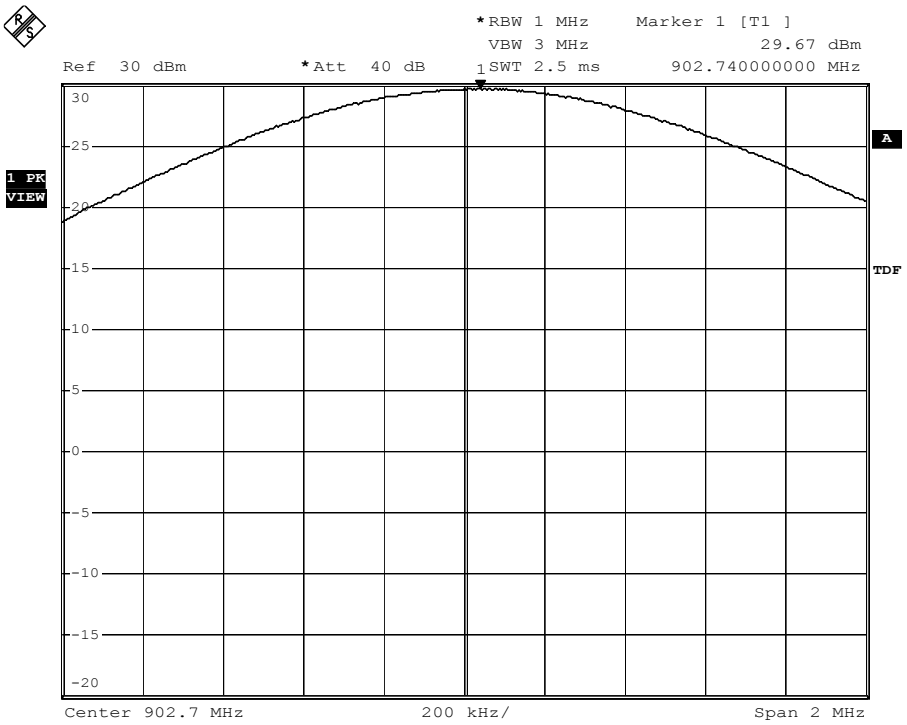


Figure 24. Conducted output power; Channel 1, 115% nominal voltage.

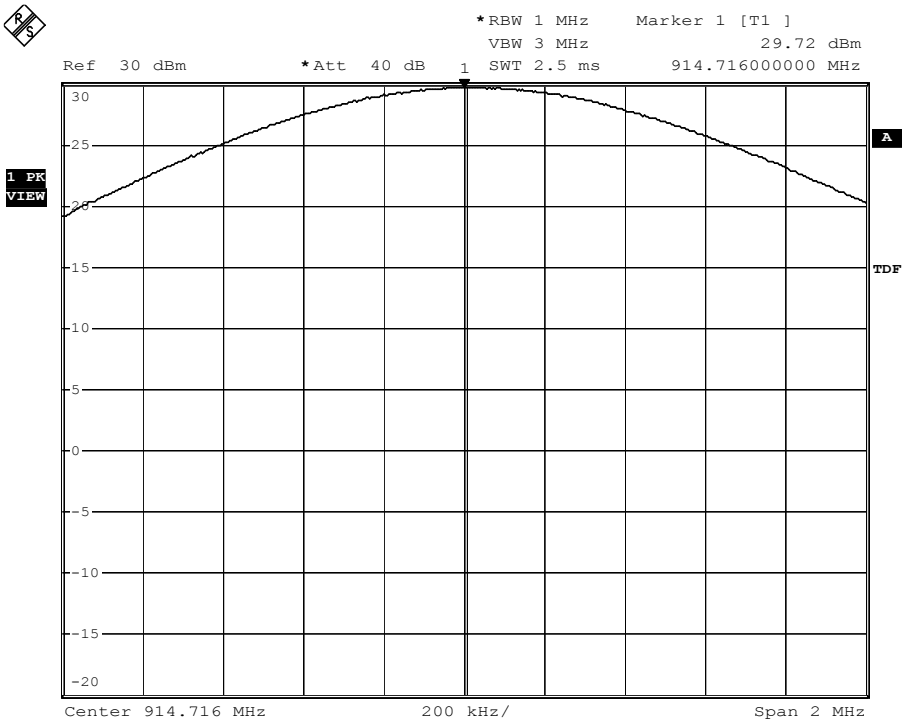


Figure 25. Conducted output power; Channel 25, 115% nominal voltage.

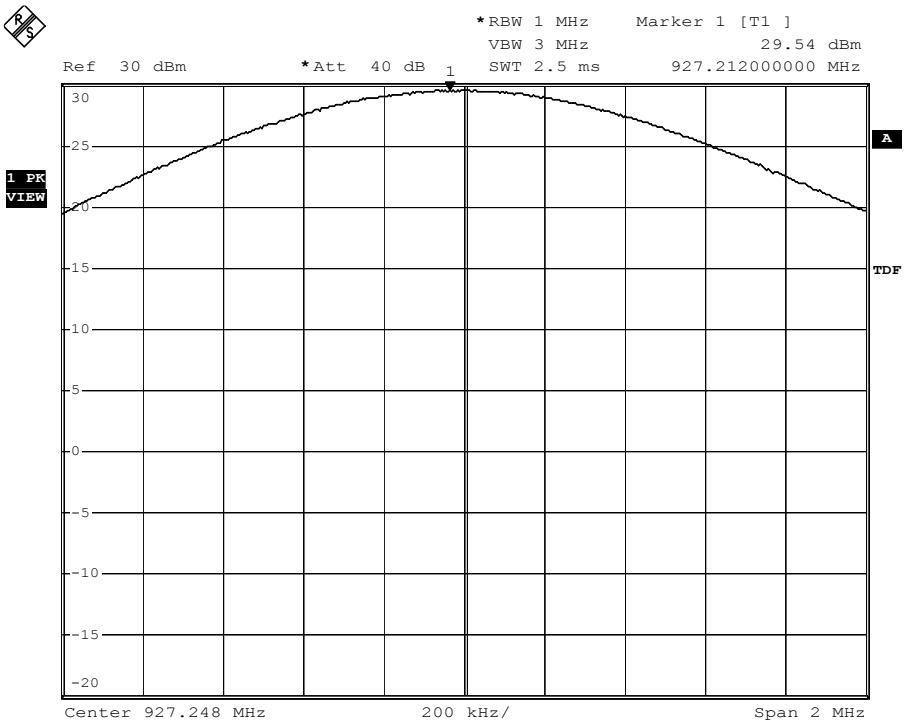


Figure 26. Conducted output power ;Channel 50, 115% nominal voltage.

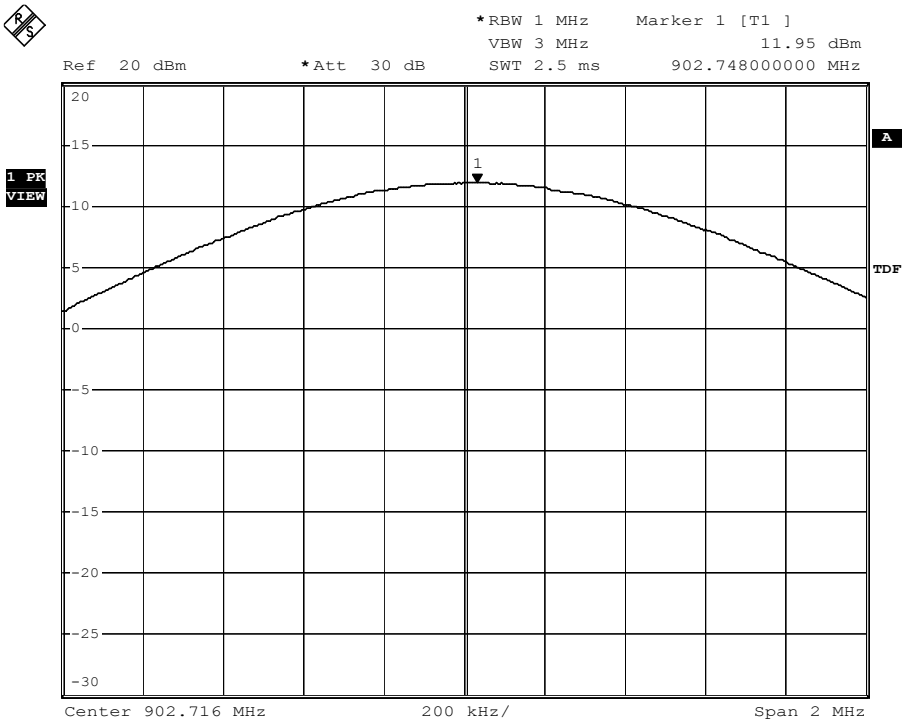


Figure 27. Conducted output power (low power setting); Channel 1, nominal voltage.

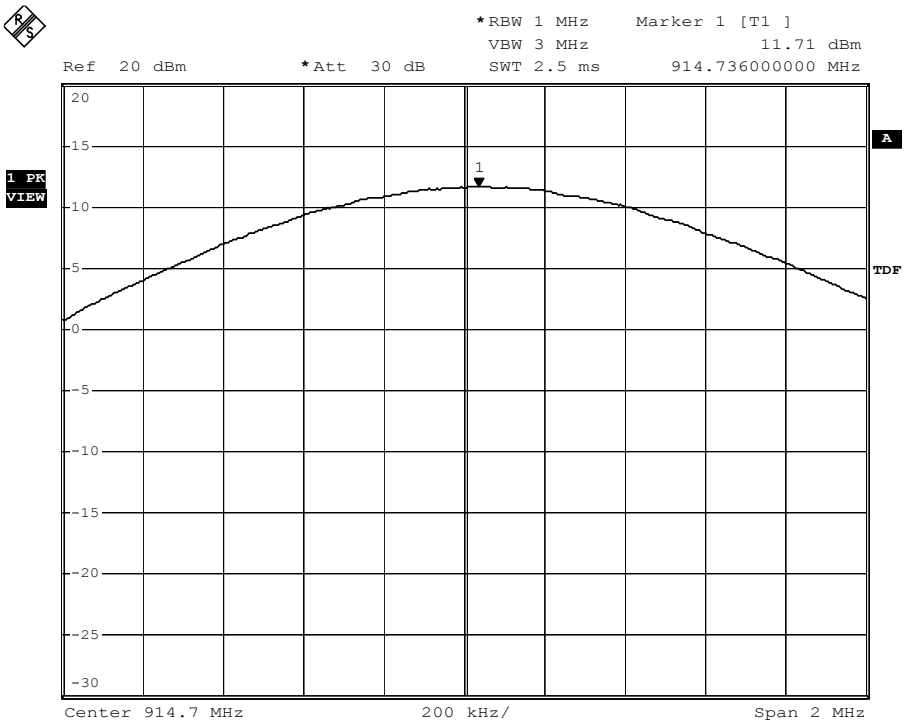


Figure 28. Conducted output power (low power setting); Channel 25, nominal voltage.

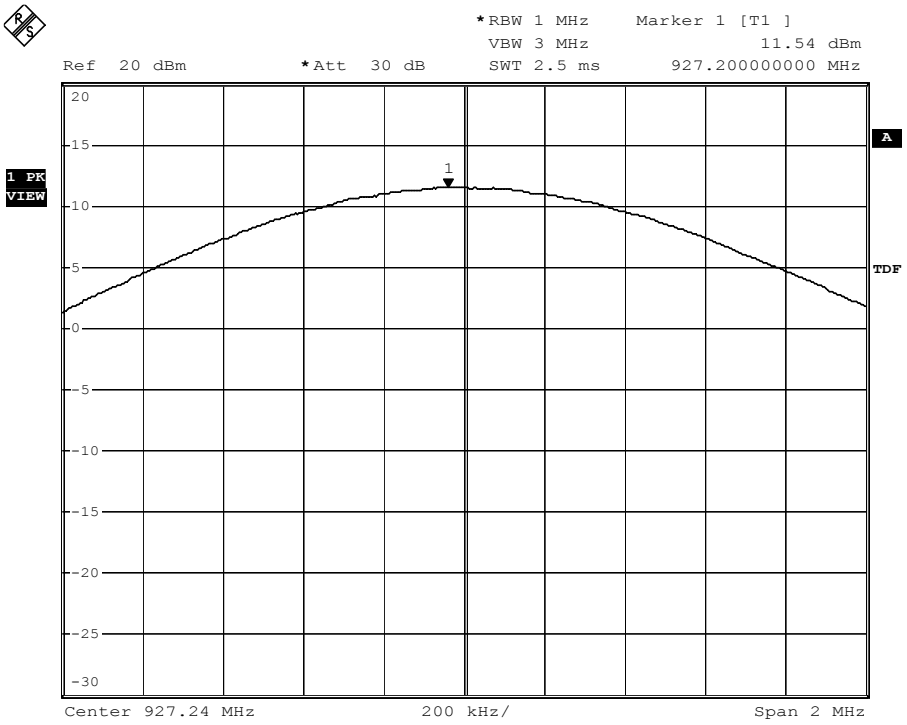


Figure 29. Conducted output power (low power setting); Channel 50, nominal voltage.

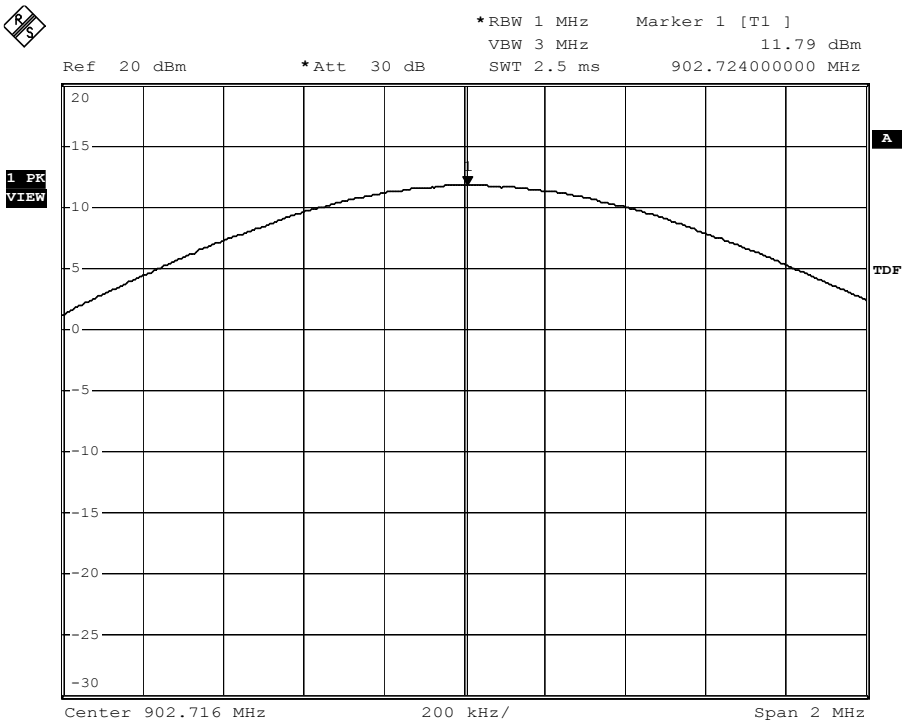


Figure 30. Conducted output power (low power setting); Channel 1, 85% nominal voltage.

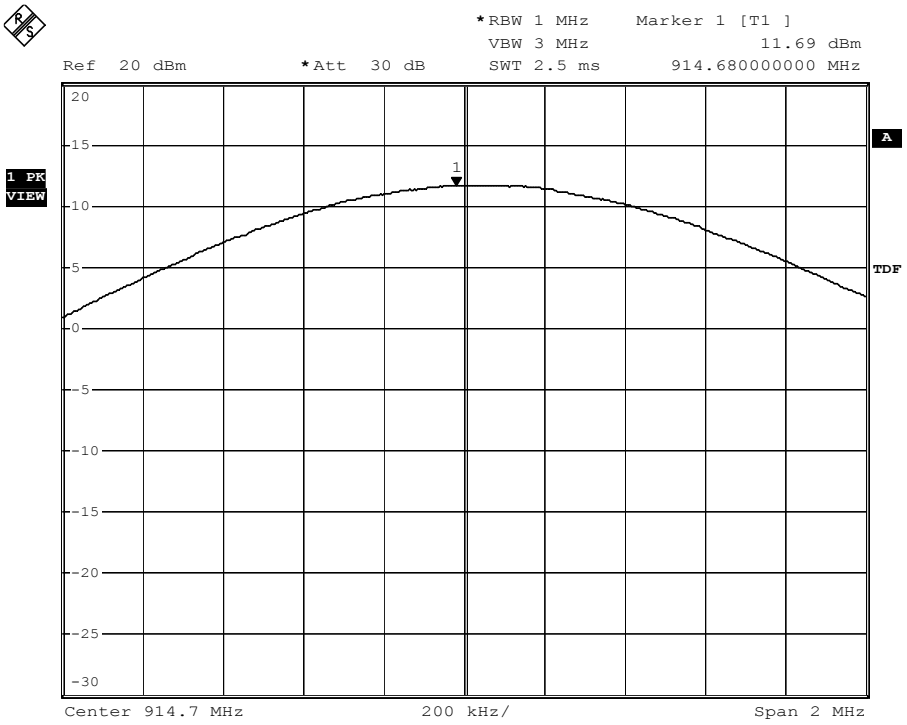


Figure 31. Conducted output power (low power setting); Channel 25, 85% nominal voltage.

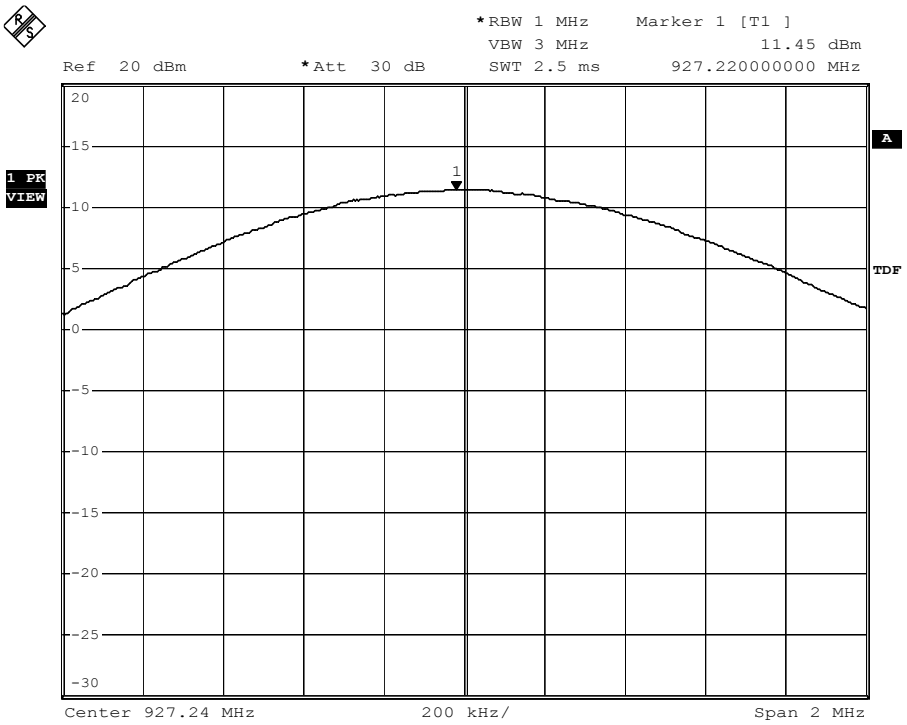


Figure 32. Conducted output power (low power setting); Channel 50, 85% nominal voltage.

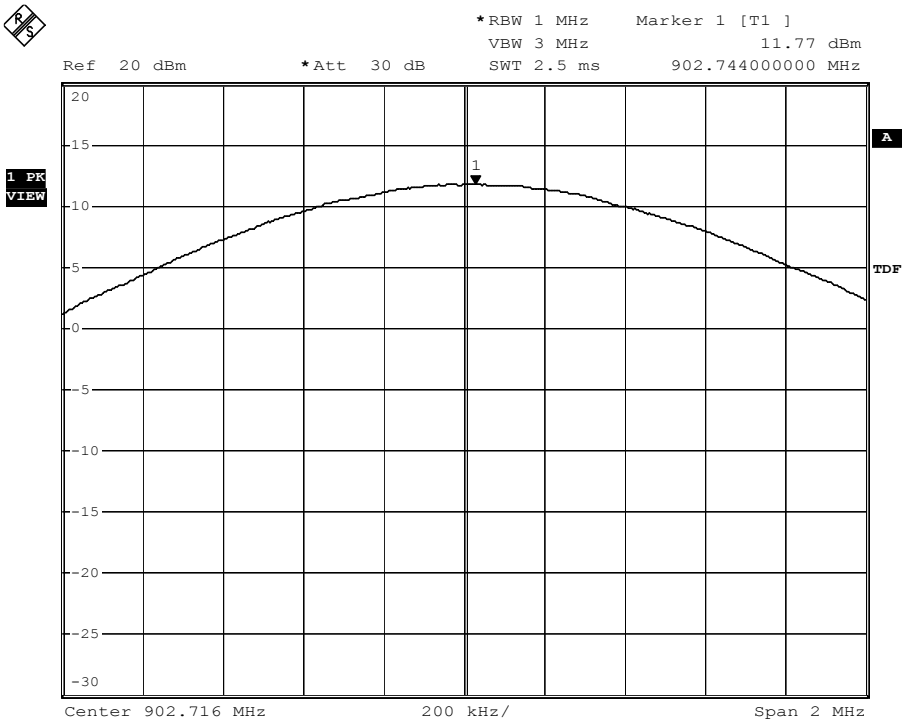


Figure 33. Conducted output power (low power setting); Channel 1, 115% nominal voltage.

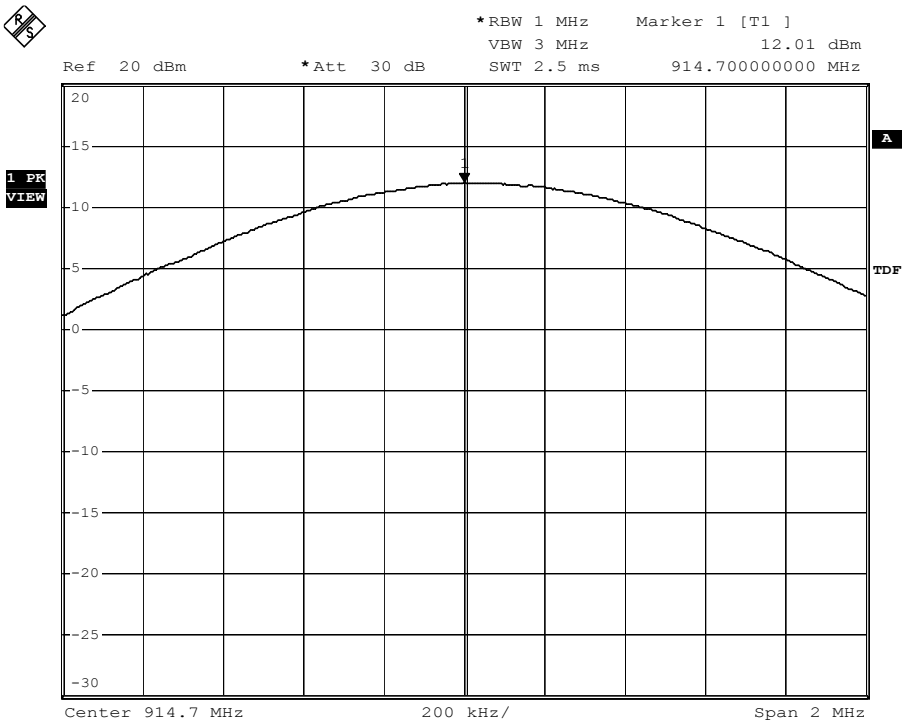


Figure 34. Conducted output power (low power setting); Channel 25, 115% nominal voltage.

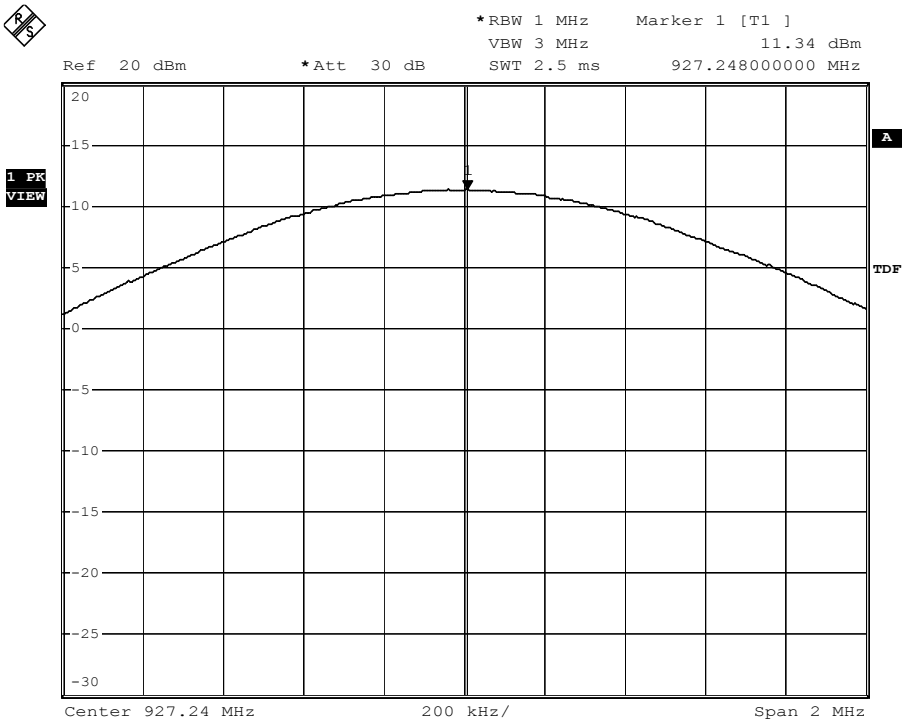


Figure 35. Conducted output power (low power setting); Channel 50, 115% nominal voltage.

8.6 OUT OF BAND EMISSIONS AT ANTENNA TERMINALS

Criteria for Out of Band Emissions at Antenna Terminals: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated EUT is operating, the radio frequency power that is produced by the EUT shall be at least 20 dB below that within the 100 kHz bandwidth within the band that contains the highest level of the desired power. This measurement shall be based upon either an RF conducted or a radiated measurement provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based upon the use of RMS averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB.

Test Procedure for Out of Band Emissions at Antenna Terminals: The antenna port of the EUT was connected directly to the input of the spectrum analyzer. The insertion loss of the interconnecting coaxial cable was stored as transducer factors in the spectrum analyzer and automatically accounted for in the readings. The resolution and video bandwidths of the analyzer were set to 100 kHz and 300 kHz, respectively.

In order to establish the power level in the 100 kHz bandwidth within the band that contains the desired power, the spectrum analyzer was set to sweep from 900 MHz to 930 MHz. The hopping function was enabled and the levels recorded.

The frequency span was then set to sweep from 10 MHz to 10 GHz, excluding the 900 MHz to 930 MHz band. The max hold function was used to capture the maximum levels over this frequency range. Markers and display lines were then used to determine the difference in amplitude of the fundamental emission and the highest emission other than the fundamental.

In order to confirm that the edges of the transmitting bands were compliant, further measurements were made in a frequency range immediately below the lowest channel of operation and in a frequency range immediately above the highest channel of operation. In these cases, measurements were performed in the EPC Gen2 mode and with both the hopping function enabled and disabled.

Results for Out of Band Emissions at Antenna Terminals: Figure 36 contains the results of the in-band power with the hopping function enabled. The highest power level within the desired band was 25.0 dBm. Figures 37 - 39 contain the power levels over the frequency range of 10 MHz - 10 GHz when the hopping function was enabled. This data indicates that all out of band emissions in the frequency range 10 MHz - 10 GHz were at least 20 dB below the in-band signal.

Figures 40 - 43 contain measurements for band-edge compliance in all modes with the hopping function enabled and disabled. This data indicates that all out of band emissions immediately adjacent to the highest and lowest channels of operation were at least 20 dB below the in-band signal.

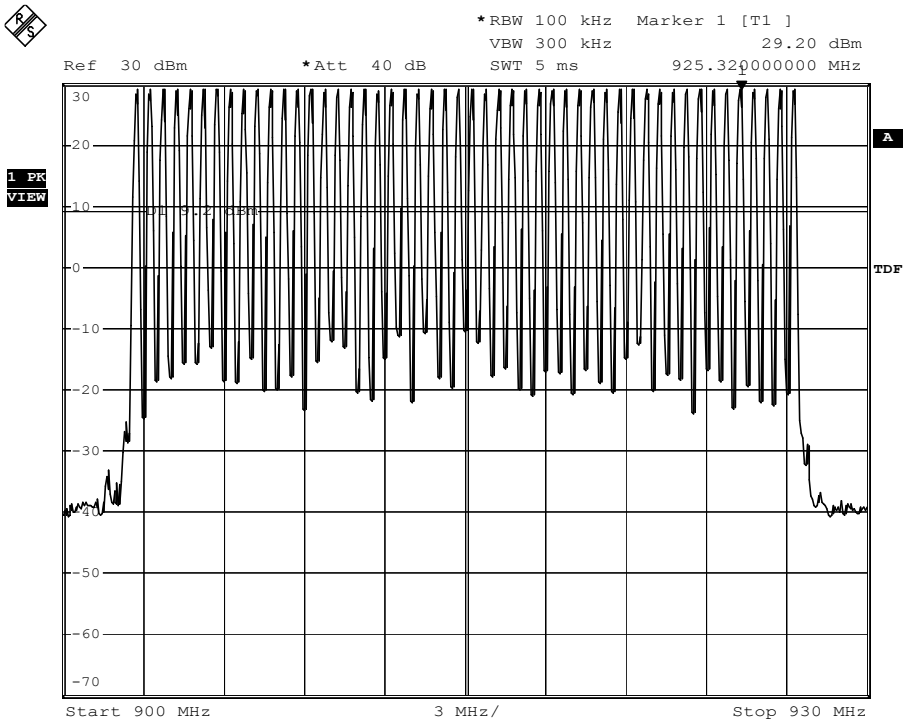


Figure 36. In band emissions at antenna port; 900 MHz - 930 MHz.

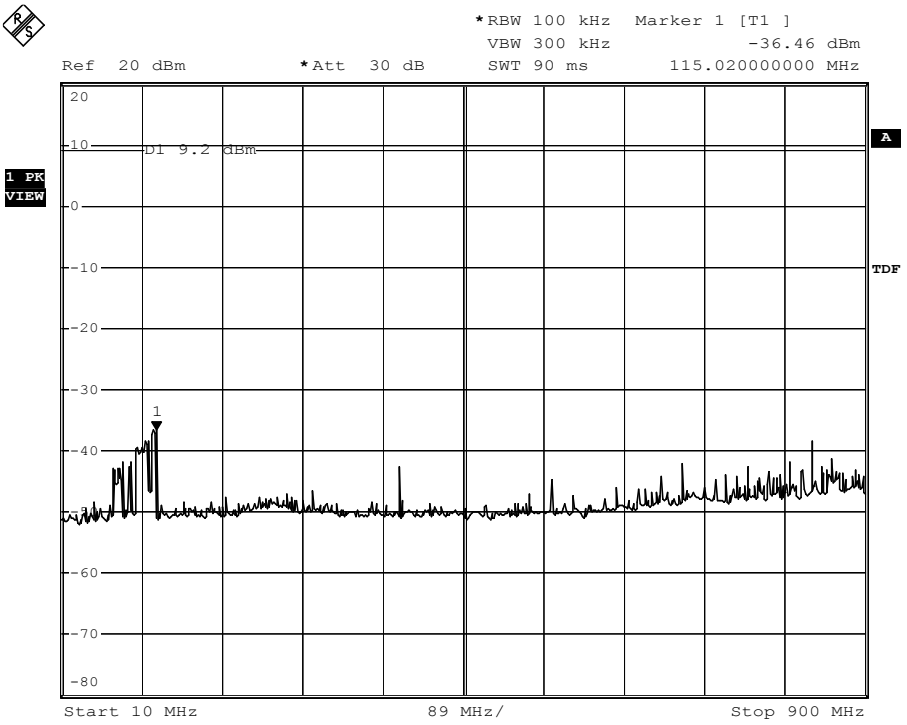


Figure 37. Out of band emissions at antenna port; 10 MHz - 900 MHz.

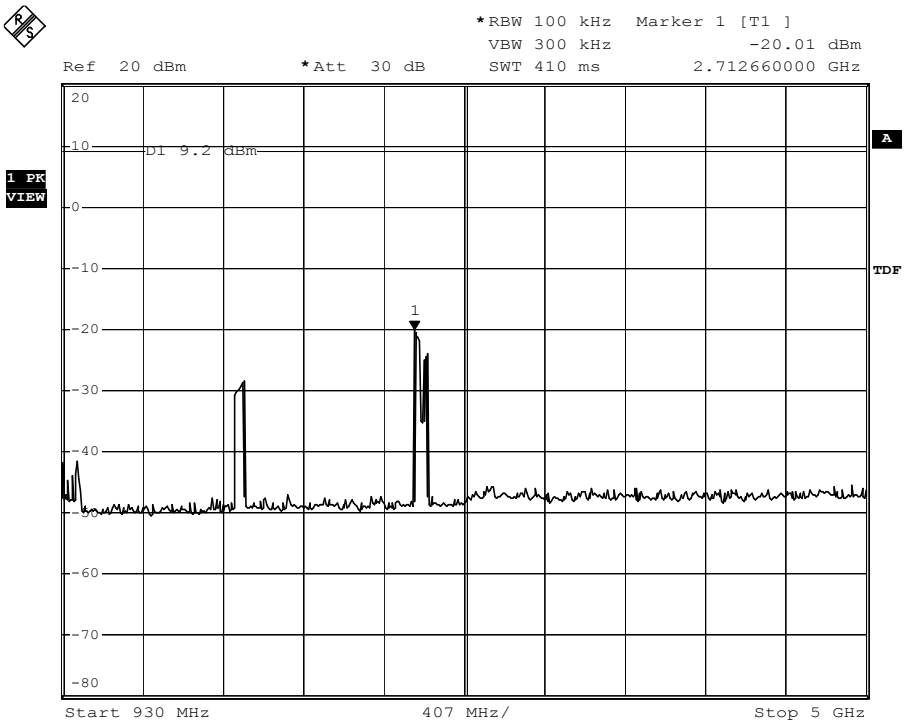


Figure 38. Out of band emissions at antenna port; 930 MHz - 5 GHz.

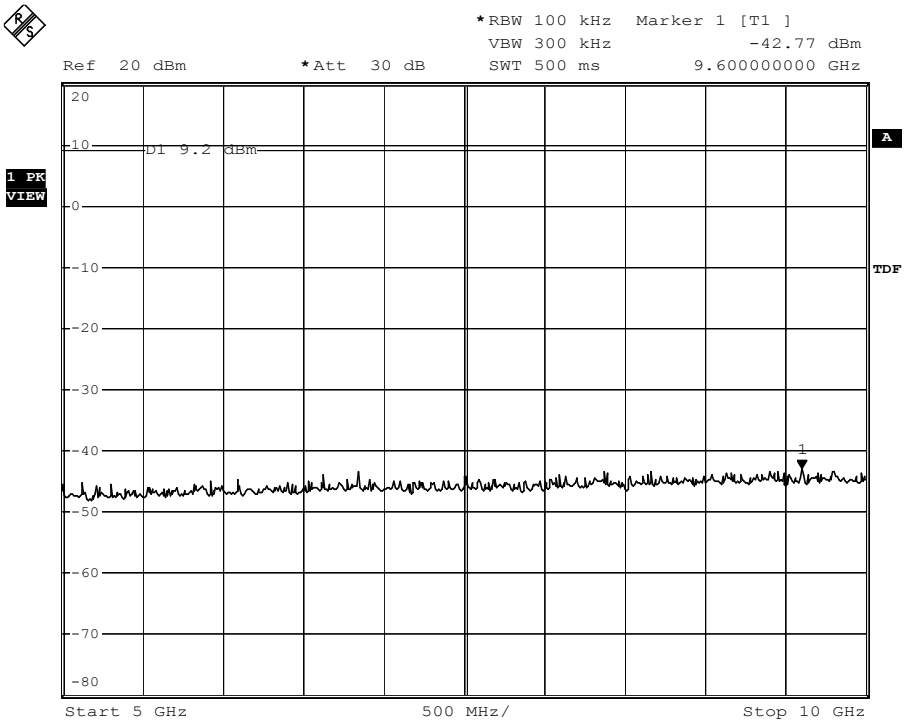


Figure 39. Out of band emissions at antenna port; 5 GHz - 10 GHz.

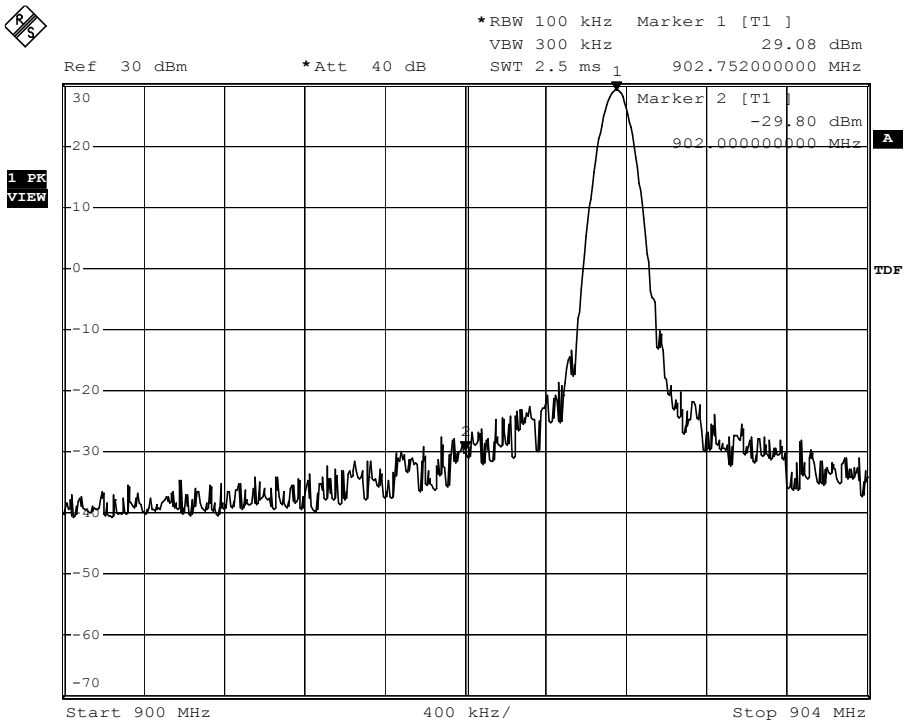


Figure 40. Band edge compliance; EPC Gen2 mode; Channel 1, hopping disabled.

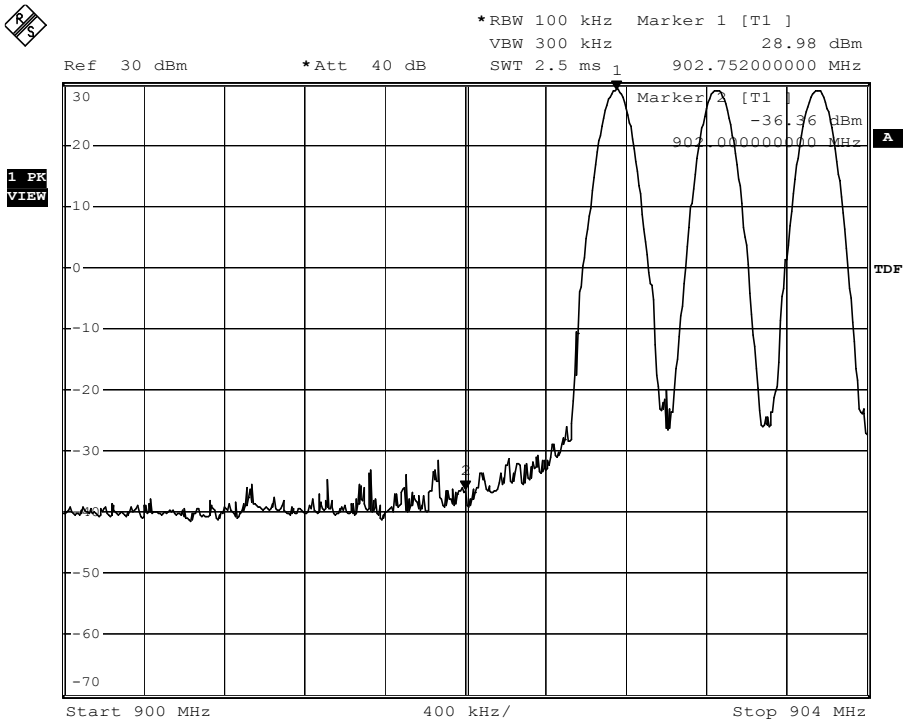


Figure 41. Band edge compliance; EPC Gen2 mode; Channel 1, hopping enabled.

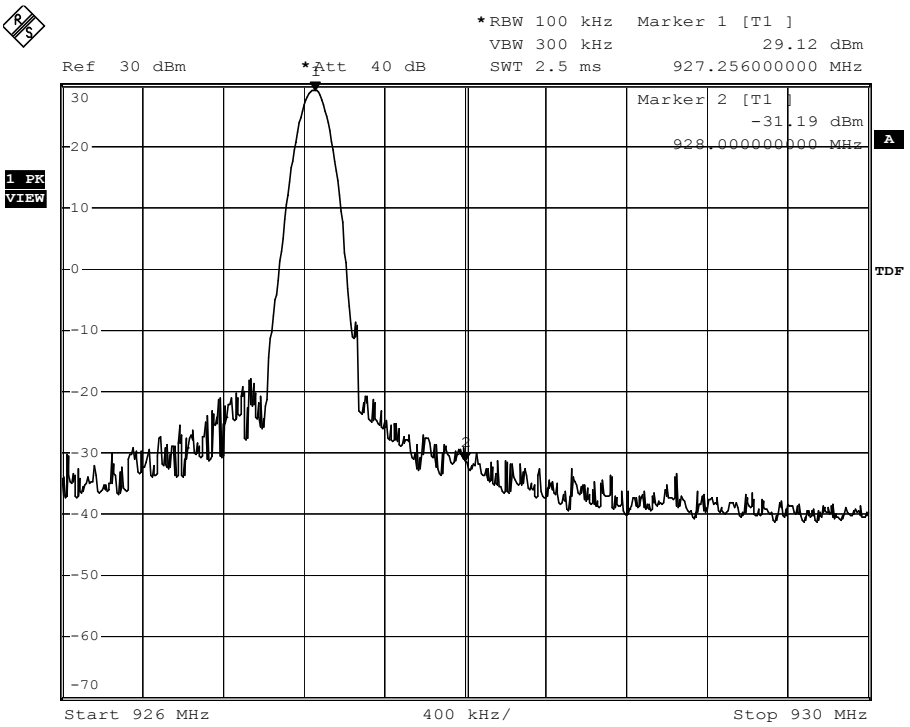


Figure 42. Band edge compliance; EPC Gen2 mode; Channel 50, hopping disabled.

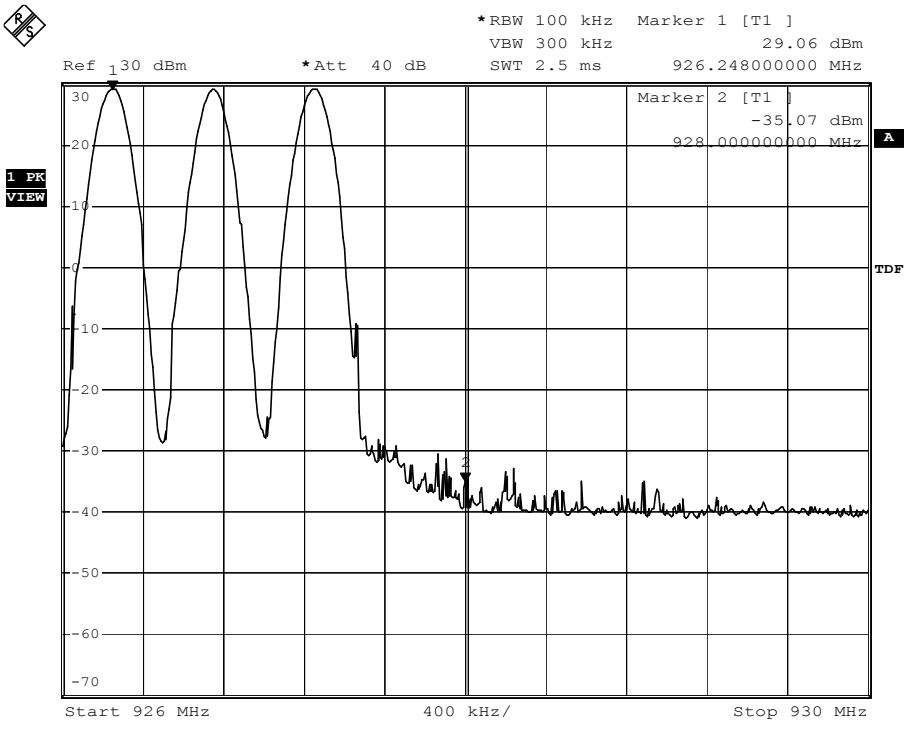


Figure 43. Band edge compliance; EPC Gen2 mode; Channel 50, hopping enabled.

8.7 RADIATED SPURIOUS EMISSIONS

Criteria for Radiated Spurious Emissions: The radiated spurious emissions of the transmitter shall not exceed the values in Table 3.

Frequency Range (MHz)	Limit (dB(μV/m))	Measurement Distance (m)
1.705 - 30	29.5	30
30 - 88	40	3
88 - 216	43.5	3
216 - 960	46	3
960 - 1000	54	3
Above 1000	54 (average detector) 74 (peak detector)	3

Table 3. Limits for spurious emissions.

Test Procedure for Radiated Spurious Emissions: Radiated spurious emissions were measured in Lexmark's 3 meter semi-anechoic chamber. This facility is registered with the FCC (registration number 991141) and Industry Canada (reference file number 2376A-3).

The EUT configuration shown in Section 5 was placed atop a 0.8 meter high wooden table with a rectangular surface measuring 1.5m x 1.0m. The test setup is shown in Figures 44 and 45.

The receiving antenna was connected to a spectrum analyzer. The insertion loss of the interconnecting coaxial cable and antenna factors were stored as transducer factors in the spectrum analyzer and automatically accounted for in the readings. While the spectrum analyzer was in peak hold mode, the EUT configuration was rotated continuously and the antenna scanned from 1 - 4 meters in height. After obtaining a plot of the peak emissions, those emissions close to the limit were investigated using either the quasi-peak or average detector, as required.

For measurements below 30 MHz, a calibrated loop antenna was used. The antenna was located 10 meters from the EUT with a height of the center of the loop antenna at 1 meter. The axis of the antenna was rotated to maximize the emissions. Since the limits in Table 3 for emissions below 30 MHz are specified at 30 meters, and measurements were made at 10 meters, the limit is translated to 10 meters by using a $1/r^2$ relationship, or 40 dB/decade.

The EUT was exercised by continuously transmitting with the hopping function enabled. The output power of the EUT was set to the maximum (26 dBm) and was also tested at 15 dBm, the lowest power level expected to be used. During this testing, the printer was also printing so that this unintentional radiator mode was tested. In addition, the idle or standby mode was also tested.

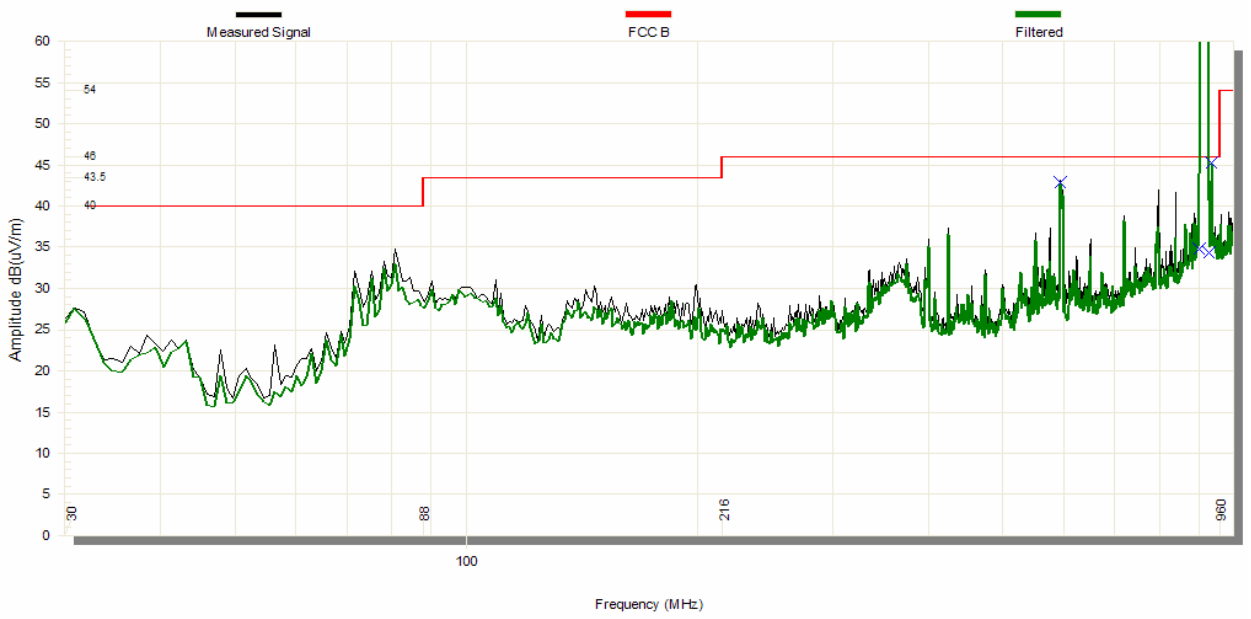
Results for Radiated Spurious Emissions: Tables 4 - 14 contain data on the radiated spurious emissions of significant amplitude from the EUT configuration shown in Section 5. The frequency range from 16 MHz - 10 GHz was investigated for spurious emissions. This data indicates that the EUT met the requirements for radiated spurious emissions. The EUT also met the FCC Class B limits specified for unintentional radiators.

Radiated Project: Thunderbolt Official, Run No: 15, 5/7/2009 5:35:19 PM
Vertical, Frequency Range: Full
Product Name: RFID UHF Option for T65x, S/N: TB Beta 001
EUT Line Voltage: 120V/60Hz
Mode: Printing and RF on; hopping turned on
Tested by: JTF, Temperature: 75.3F, Humidity: 51.4% RH
Test Setup: PC #485, LCD#824, T654dn (S/N 7922MCD) with Firefly 1 GB thumbdrive, envelope feeder & top output option, USB + Ethernet cables attached
Power setting = 30 dBm
Additional information: 220 pF cap across diode, toroid on serial cable

Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	QP Amplitude (dB(uV/m))	Limit (dB(uV/m))	Margin (dB)	Max Height (meters)	Max Angle (Deg)
31.38	V3	-22.154	18.241	37.432	40	2.57	1	274
32.072	V3	-22.127	17.864	37.44	40	2.56	1	285
265.459	V3	-20.248	13.727	28.068	46	17.93	1.8	319
594.916	V3	-18.698	19.308	42.801	46	3.2	1.7	134
630.417	V3	-18.723	19.6	31.117	46	14.88	1.6	116
796.479	V3	-18.009	21.424	33.324	46	12.68	1.3	108
902	V3	-17.154	22.9	32.814	46	13.19	1.4	71
928	V3	-17.082	23	33.572	46	12.43	1.9	178

Table 4. Radiated spurious emissions < 1 GHz; transmitting; 30 dBm power setting, vertical polarization.

Radiated Project: Thunderbolt Official, Run No: 16, 5/7/2009 5:58:38 PM
Horizontal, Frequency Range: Full
Product Name: RFID UHF Option for T65x, S/N: TB Beta 001
EUT Line Voltage: 120V/60Hz
Mode: Printing and RF on; hopping turned on
Tested by: JTF, Temperature: 75.3F, Humidity: 51.4% RH
Test Setup: PC #485, LCD#824, T654dn (S/N 7922MCD) with Firefly 1 GB thumbdrive, envelope feeder & top output option
USB + Ethernet cables attached
Power setting = 30 dBm
Additional information: 220 pF cap across diode, toroid on serial cable



Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	QP Amplitude (dB(uV/m))	Limit (dB(uV/m))	Margin (dB)	Max Height (meters)	Max Angle (Deg)
594.495	H3	-18.698	19.351	42.798	46	3.2	1.3	107
902	H3	-17.154	22.9	34.768	46	11.23	1.4	359
928	H3	-17.082	23	34.317	46	11.68	2.6	327
936.008	H3	-16.9	23.1	45.23	46	.77	1.4	359

Table 5. Radiated spurious emissions < 1 GHz; transmitting; 30 dBm power setting, horizontal polarization.

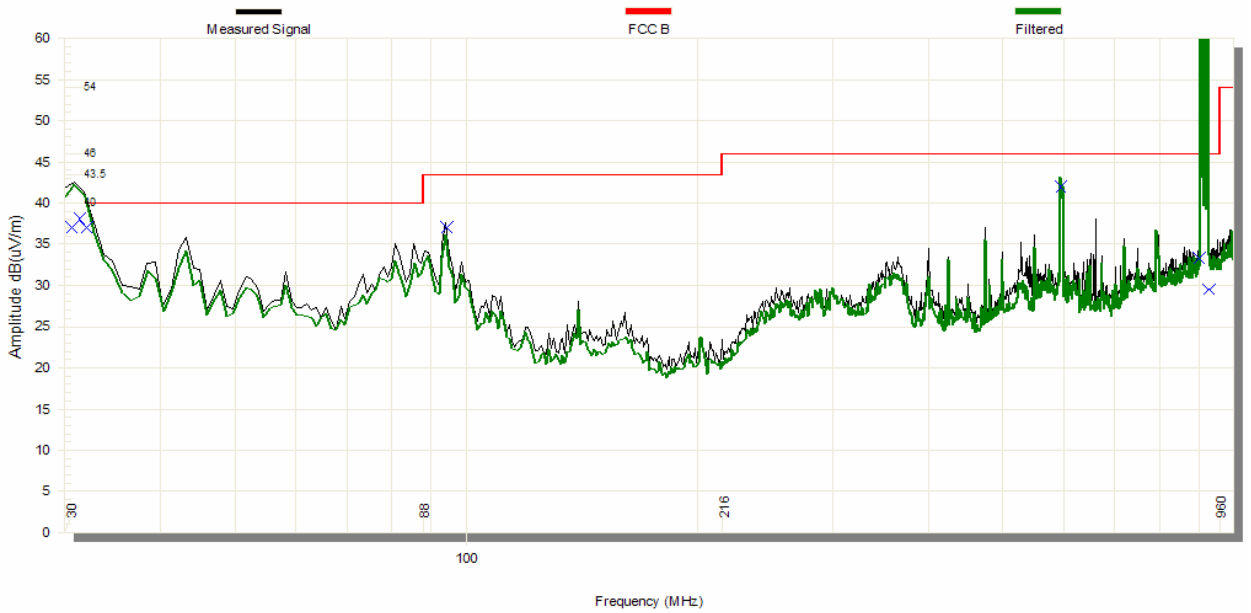
Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	Peak Amplitude (dB(uV/m))	Peak Limit (dB(uV/m))	Peak Margin (dB)	Max Height (meters)	Max Angle (Deg)	Average Amplitude (dB(uV/m))	Average Margin (dB)
1592.1	V3	-24.14	26.546	51.34	74	22.66	1.8	141	34.13	19.87
1789.6	V3	-24.96	27.395	50.17	74	23.83	1	96	28.71	25.29
1807.7	V3	-24.93	27.473	50.03	74	23.97	1.8	293	30.14	23.86
1815.6	V3	-24.92	27.507	49.71	74	24.29	1	303	28.89	25.11
1824.5	V3	-24.91	27.545	49.13	74	24.87	1	324	29.15	24.85
1833.5	V3	-24.91	27.584	48.94	74	25.06	1	324	29.25	24.75
1846.6	V3	-24.89	27.64	50.36	74	23.64	1.9	316	29.24	24.76
1989	V3	-24.97	28.253	49.19	74	24.81	1	90	31.39	22.61

Table 6. Radiated spurious emissions > 1 GHz; transmitting; 30 dBm power setting, vertical polarization.

Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	Peak Amplitude (dB(uV/m))	Peak Limit (dB(uV/m))	Peak Margin (dB)	Max Height (meters)	Max Angle (Deg)	Average Amplitude (dB(uV/m))	Average Margin (dB)
1590.7	H3	-24.14	26.54	52.9	74	21.1	1	91	32.53	21.47
1796	H3	-24.95	27.423	43.88	74	30.12	1	267	26.87	27.13
1827.4	H3	-24.89	27.558	44.90	74	29.10	1	83	26.60	27.40
1834.6	H3	-24.98	27.589	45.86	74	28.14	1	339	27.07	26.93
1852.5	H3	-24.87	27.666	46.47	74	27.53	1	22	27.24	26.76
2714.3	H3	-24.39	29.586	53.52	74	20.48	1	314	31.98	22.02
2741.4	H3	-24.37	29.634	39.13	74	34.87	1	358	25.40	28.60

Table 7. Radiated spurious emissions > 1 GHz; transmitting; 30 dBm power setting, horizontal polarization.

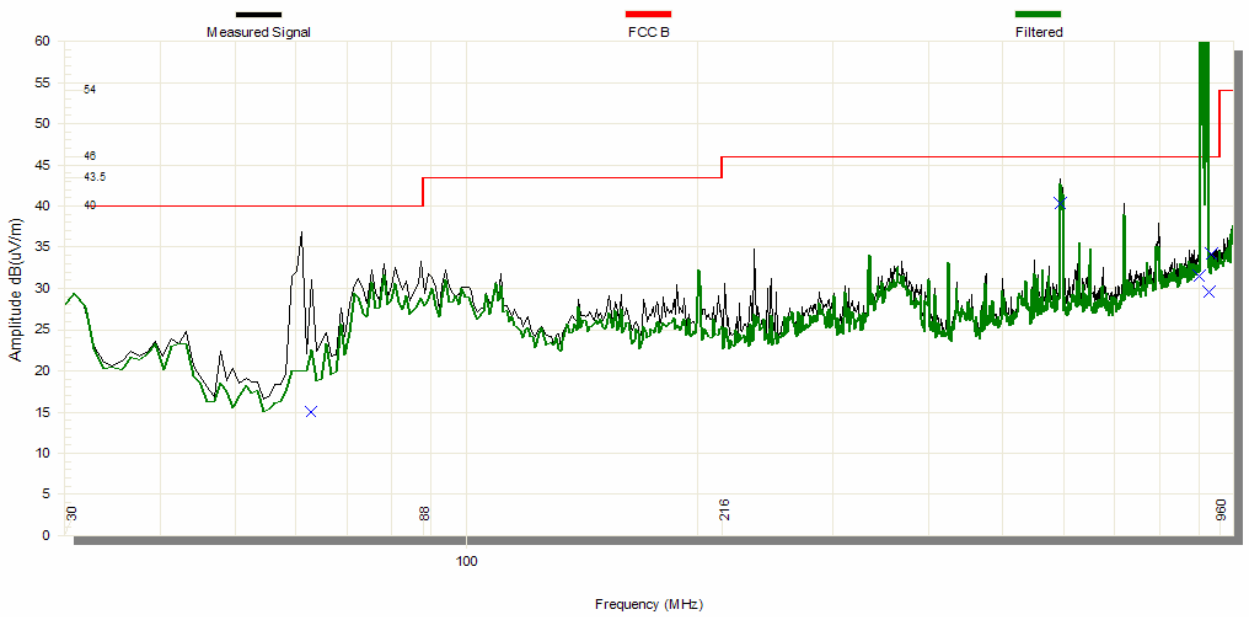
Radiated Project: Thunderbolt Official, Run No: 18, 5/8/2009 10:12:39 AM
Vertical, Frequency Range: Full
Product Name: RFID UHF Option for T65x, S/N: TB Beta 001
EUT Line Voltage: 120V/60Hz
Mode: Printing and RF on; hopping turned on Tested by: JTF Temperature: 75.3F, Humidity: 51.4% RH
Test Setup: PC #485, LCD#824, T654dn (S/N 7922MCD) with Firefly 1 GB thumbdrive, envelope feeder & top output option; USB + Ethernet cables attached
Power setting = 5 dBm
Additional information: 220 pF cap across diode, toroid on serial cable
Reseated RF shield on radio



Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	QP Amplitude (dB(uV/m))	Limit (dB(uV/m))	Margin (dB)	Max Height (meters)	Max Angle (Deg)
30.638	V3	-22.154	18.649	36.998	40	3	1.3	359
31.409	V3	-22.155	18.225	38.106	40	1.89	1	234
32.021	V3	-22.127	17.89	36.973	40	3.03	1	359
94.372	V3	-21.383	9.256	36.999	43.5	6.5	1.4	359
594.916	V3	-18.698	19.308	41.979	46	4.02	1.7	131
902	V3	-17.154	22.9	33.249	46	12.75	1.4	33
928	V3	-17.082	23	29.482	46	16.52	1	359

Table 8. Radiated spurious emissions < 1 GHz; transmitting; low power setting, vertical polarization.

Radiated Project: Thunderbolt Official, Run No: 19, 5/8/2009 10:58:35 AM
Horizontal, Frequency Range: Full
Product Name: RFID UHF Option for T65x, S/N: TB Beta 001
EUT Line Voltage: 120V/60Hz
Mode: Printing and RF on; hopping turned on
Tested by: JTF, Temperature: 75.3F, Humidity: 51.4% RH
Test Setup: PC #485, LCD#824, T654dn (S/N 7922MCD) with Firefly 1 GB thumbdrive, envelope feeder & top output option
USB + Ethernet cables attached
Power setting = 5 dBm
Additional information: 220 pF cap across diode, toroid on serial cable
Reseated RF shield on radio



Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	QP Amplitude (dB(uV/m))	Limit (dB(uV/m))	Margin (dB)	Max Height (meters)	Max Angle (Deg)
62.835	H3	-21.7	5.842	15.017	40	24.98	4	215
594.565	H3	-18.698	19.344	40.289	46	5.71	1.4	114
902	H3	-17.154	22.9	31.478	46	14.52	1.4	15
928	H3	-17.082	23	29.603	46	16.4	1.4	359
936	H3	-16.984	23.1	34.179	46	11.82	1.4	359

Table 9. Radiated spurious emissions < 1 GHz; transmitting; low power setting, horizontal polarization.

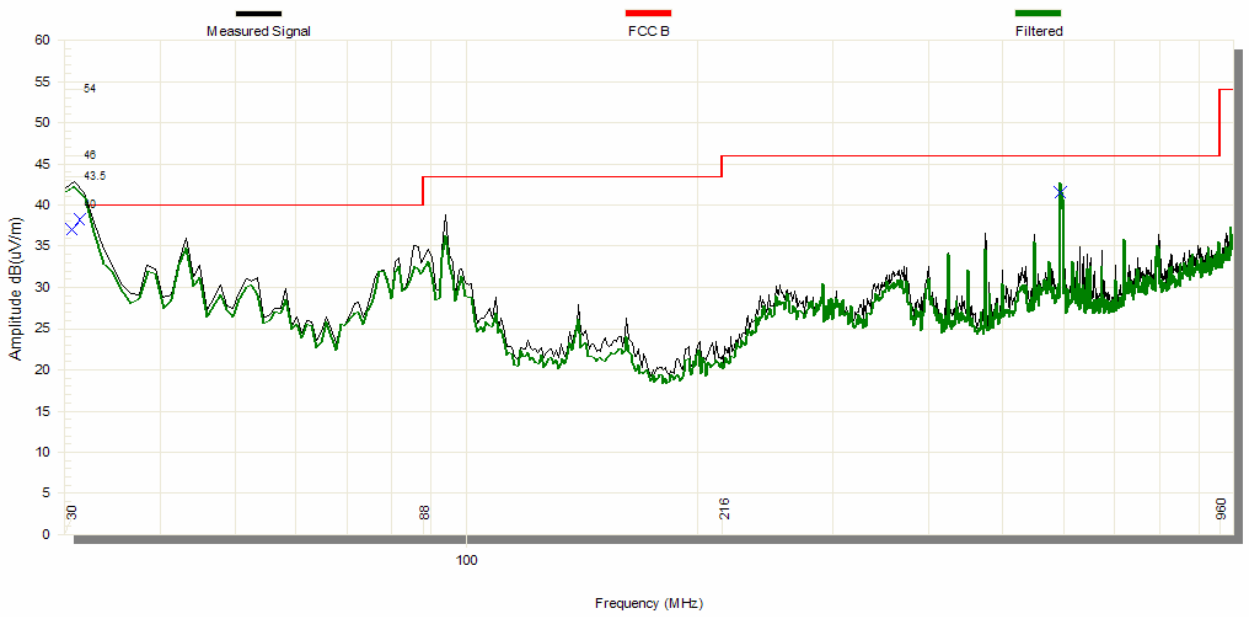
Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	Peak Amplitude (dB(uV/m))	Peak Limit (dB(uV/m))	Peak Margin (dB)	Max Height (meters)	Max Angle (Deg)	Average Amplitude (dB(uV/m))	Average Margin (dB)
1598.5	V3	-24.11	26.574	49.09	74	24.91	1.7	146	30.79	23.21
1870.9	V3	-24.90	27.745	44.86	74	29.14	1	81	27.19	26.81
1990.3	V3	-24.97	28.258	53.03	74	20.97	1	67	32.52	21.48

Table 10. Radiated spurious emissions > 1 GHz; transmitting, low power setting, vertical polarization.

Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	Peak Amplitude (dB(uV/m))	Peak Limit (dB(uV/m))	Peak Margin (dB)	Max Height (meters)	Max Angle (Deg)	Average Amplitude (dB(uV/m))	Average Margin (dB)
1595.3	H3	-24.12	26.56	52.71	74	21.29	1	284	30.25	23.75
1798.8	H3	24.93	27.435	43.41	74	30.59	1	86	26.85	27.15
1990.4	H3	-24.97	28.259	51.02	74	22.98	1	70	30.37	23.63

Table 11. Radiated spurious emissions > 1 GHz; transmitting, low power setting, horizontal polarization.

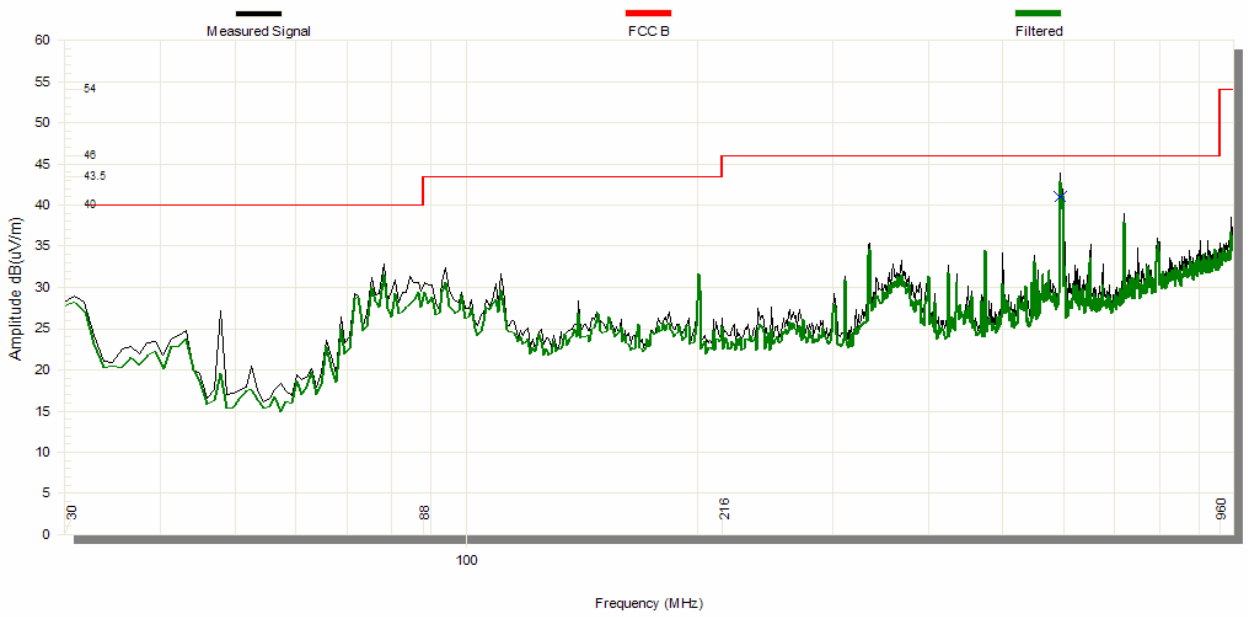
Radiated Project: Thunderbolt Official, Run No: 21, 5/8/2009 1:06:45 PM
Vertical, Frequency Range: Full
Product Name: RFID UHF Option for T65x, S/N: TB Beta 001
EUT Line Voltage: 120V/60Hz
Mode: Standby mode Tested by: JTF Temperature: 75.3F, Humidity: 51.4% RH
Test Setup: PC #485, LCD#824, T654dn (S/N 7922MCD) with Firefly 1 GB thumbdrive, envelope feeder & top output option; USB + Ethernet cables attached
Additional information: 220 pF cap across diode, toroid on serial cable



Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	QP Amplitude (dB(uV/m))	Limit (dB(uV/m))	Margin (dB)	Max Height (meters)	Max Angle (Deg)
30.648	V3	-22.154	18.644	37.04	40	2.96	1	220
31.419	V3	-22.155	18.22	38.259	40	1.74	1	353
594.485	V3	-18.698	19.352	41.456	46	4.54	1.6	141

Table 12. Radiated spurious emissions < 1 GHz; standby mode; vertical polarization.

Horizontal, Frequency Range: Full
Product Name: RFID UHF Option for T65x, S/N: TB Beta 001
EUT Line Voltage: 120V/60Hz
Mode: Standby mode Tested by: JTF, Temperature: 75.3F, Humidity: 51.4% RH
Test Setup: PC #485, LCD#824, T654dn (S/N 7922MCD) with Firefly 1 GB thumbdrive, envelope feeder & top output option; USB + Ethernet cables attached
Additional information: 220 pF cap across diode, toroid on serial cable



Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	QP Amplitude (dB(uV/m))	Limit (dB(uV/m))	Margin (dB)	Max Height (meters)	Max Angle (Deg)
594.495	H3	-18.698	19.351	40.987	46	5.01	1.2	235

Table 13. Radiated spurious emissions < 1 GHz; standby mode; horizontal polarization.

Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	Peak Amplitude (dB(uV/m))	Peak Limit (dB(uV/m))	Peak Margin (dB)	Max Height (meters)	Max Angle (Deg)	Average Amplitude (dB(uV/m))	Average Margin (dB)
1071.8	V3	-28.121	24.309	48.361	74	25.64	1.2	297	28.899	25.1
1193.1	V3	-27.822	24.83	50.117	74	23.88	1.1	174	33.241	20.76
1496.1	V3	-26.913	26.133	52.78	74	21.22	3.3	316	37.036	16.96
1593	V3	-26.629	26.55	51.96	74	22.04	1	336	34.641	19.36
1986.8	V3	-25.937	28.243	49.069	74	24.93	1	84	29.929	24.07

Table 14. Radiated spurious emissions > 1 GHz; standby mode, vertical polarization.

Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	Peak Amplitude (dB(uV/m))	Peak Limit (dB(uV/m))	Peak Margin (dB)	Max Height (meters)	Max Angle (Deg)	Average Amplitude (dB(uV/m))	Average Margin (dB)
1195.8	H3	-27.818	24.842	49.588	74	24.41	1	271	32.108	21.89
1591	H3	-26.634	26.541	49.645	74	24.36	1	71	31.49	22.51
1981	H3	-25.938	28.218	47.696	74	26.3	1.4	172	28.024	25.98

Table 15. Radiated spurious emissions > 1 GHz; standby mode, horizontal polarization.

Figure 44. Test configuration for transmitter spurious emissions (front view).

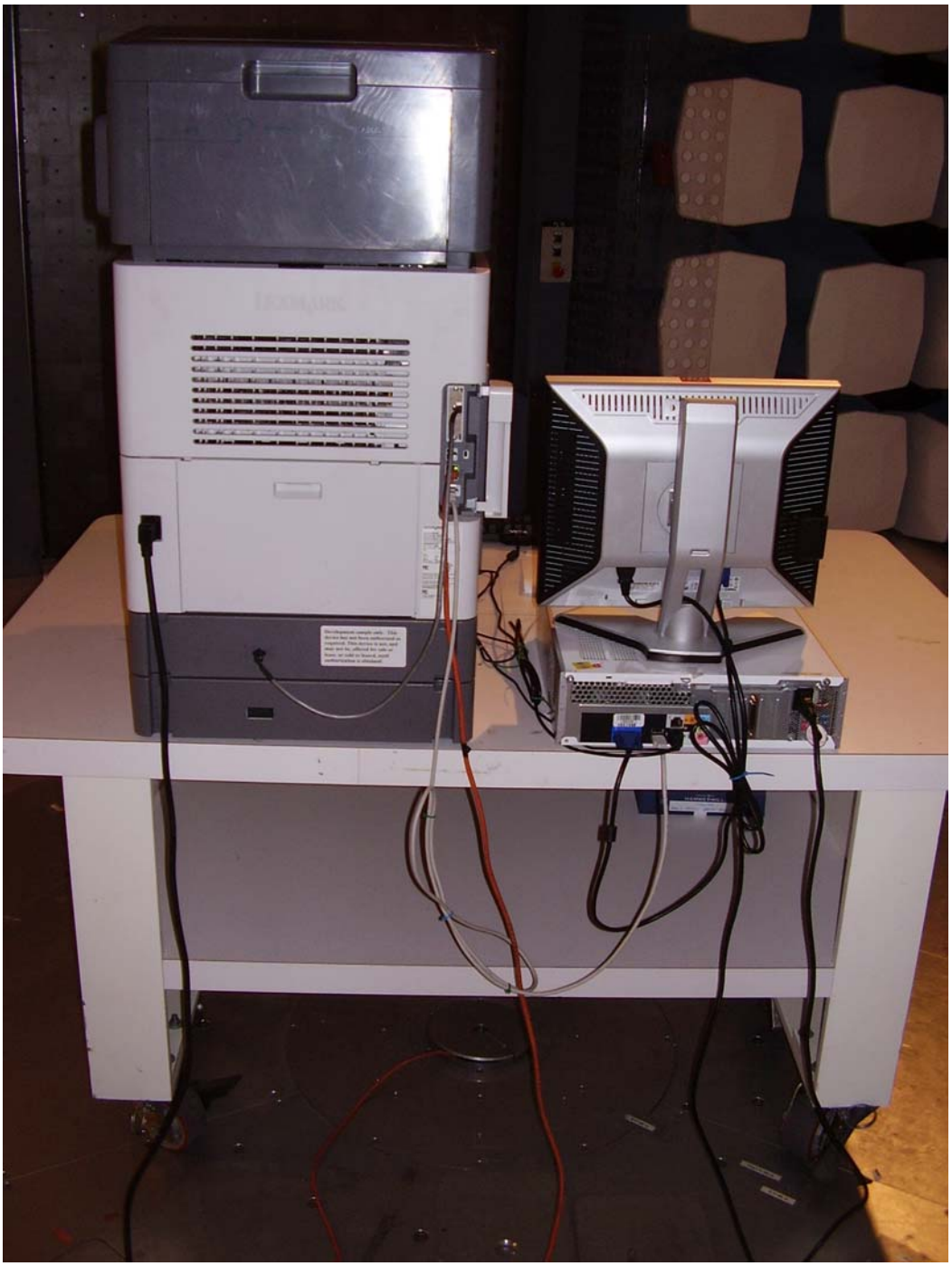


Figure 45. Test configuration for transmitter spurious emissions (back view).

8.8 CONDUCTED EMISSIONS

Criteria for Conducted Emissions [1**]:** The emissions conducted onto the AC power line by the EUT shall not exceed the values in Table 16.

Frequency Range (MHz)	Quasi-peak Limit (dB(μV))	Average Limit (dB(μV))
0.15 - 0.5	66 to 56	56 to 46
0.5 - 5	56	46
5 - 30	60	50

Table 16. Limits for conducted emissions.

Test Procedure for Conducted Emissions: The test configuration shown in Figures 46 and 47 was used for this testing. Conducted emissions testing was performed in an 18 ft. x 18 ft. all-welded shielded room located at Lexmark International's EMC test facilities.

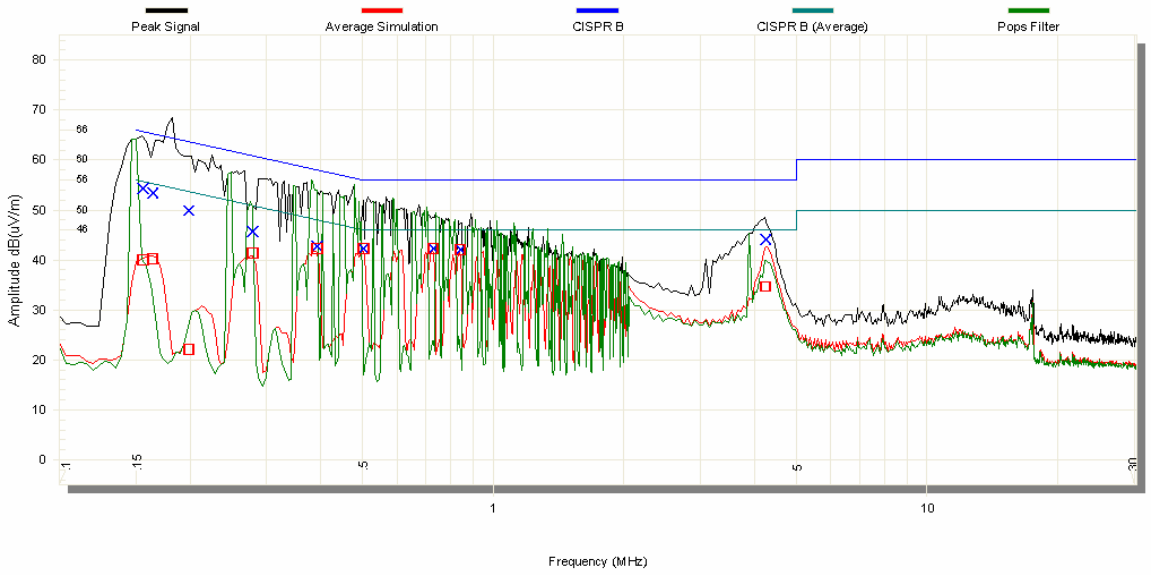
The EUT configuration shown in Section 5 was placed atop a 0.8 meter high wooden table with a rectangular surface measuring 1.5m x 1.0m. The back edges of all devices were located 40 cm from the metal wall of the shielded room.

The AC line cord of the EUT was plugged into the LISN (Line Impedance Stabilization Network) with the excess of the EUT line cord length bundled in the center. The USB, parallel and network cables were draped down from the rear of the EUT and PC, but hung no closer than 40 cm to the floor (ground plane). The excess of these cables were serpentined to form a bundle 30-40 cm in length, with the overall length of the cable not to exceed 1.0 meter in length

The EUT was exercised by continuously transmitting with the hopping enabled at the highest power setting and in the standby mode. During this testing, the printer was also printing so that this unintentional radiator mode was tested.

Results for Conducted Emissions: Tables 17 - 20 contain the conducted emission results when transmitting and in the standby mode. The EUT met the requirements for conducted emissions given in Table 16. The EUT also met the FCC Class B limits specified for unintentional radiators.

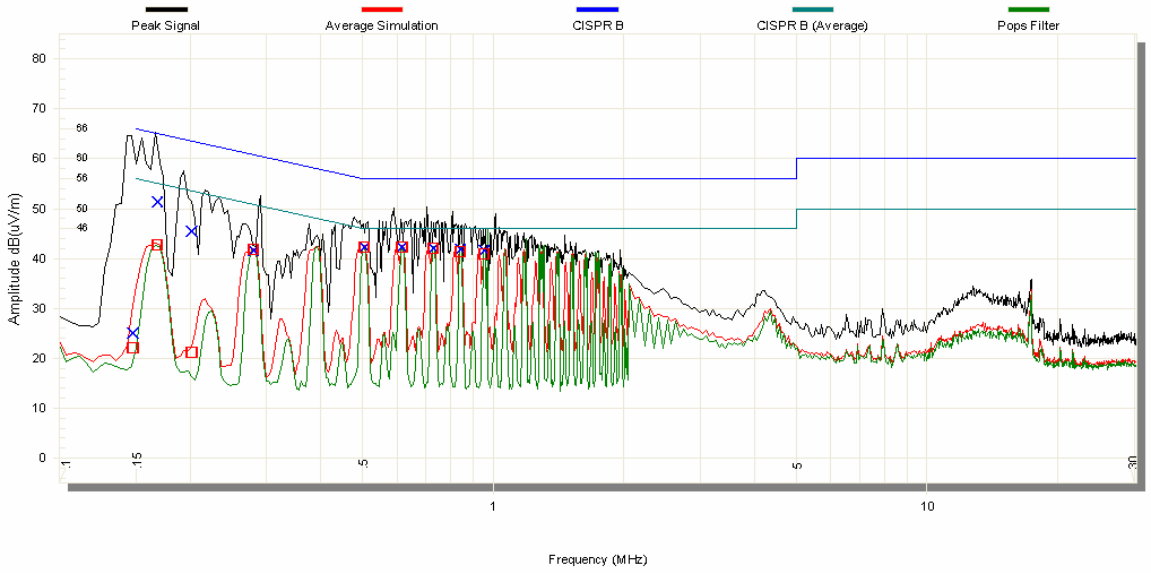
Conducted Project: Thunderbolt Official, Run No: 1, 5/11/2009 3:13:08 PM
Phase, 110V, 60Hz, Frequency Range: Full
Product Name: RFID UHF Option to T65x, S/N: TB Beta 001
Mode: Printing with RF on
Tested by: John Fessler, Temperature: 76.8F, Humidity: 47.2%RH
Test Setup: PC #875, LCD #831, T654dn (S/N 7922MCD) with Firefly 1 GB thumbdrive; Envelope feeder & top output option, USB + Ethernet cables attached; Power setting = 30 dBm
Additional information:
220 pF cap across diode, toroid on serial cable internally to tray



Freq (MHz)	Test Type	Factor	QP Amp	QP Limit	QP Margin	Avg Amp	Avg Limit	Avg Margin
.156	Phase	10.99	54.37	65.82	11.45	40.08	55.82	15.74
.165	Phase	10.884	53.43	65.57	12.14	40.31	55.57	15.26
.2	Phase	10.452	49.87	64.58	14.71	22.11	54.58	32.47
.28	Phase	10.091	45.62	62.29	16.67	41.45	52.29	10.84
.394	Phase	10.047	42.82	59.04	16.22	42.38	49.04	6.66
.504	Phase	10.055	42.29	56	13.71	42.31	46	3.69
.73	Phase	10.054	42.29	56	13.71	42.33	46	3.67
.842	Phase	10.056	42.07	56	13.93	42.01	46	3.99
4.255	Phase	10.199	44.12	56	11.88	34.71	46	11.29

Table 17. AC conducted emissions; Phase; transmitting with hopping enabled.

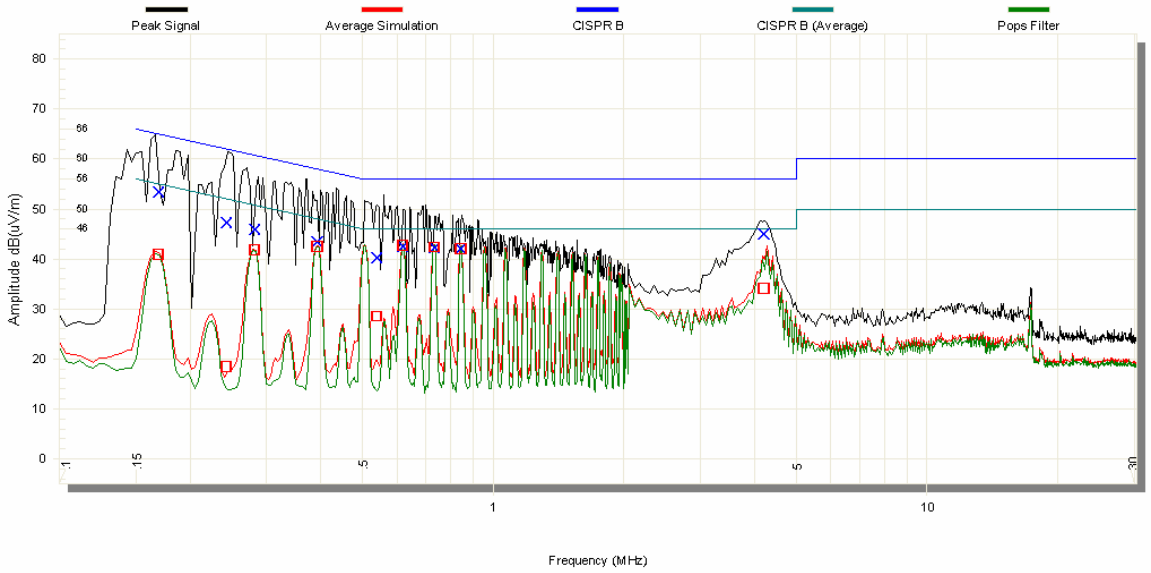
Conducted Project: Thunderbolt Official, Run No: 2, 5/11/2009 3:54:01 PM
Neutral, 110V, 60Hz, Frequency Range: Full
Product Name: RFID UHF Option to T65x, S/N: TB Beta 001
Mode: Prinitng with RF on
Tested by: John Fessler, Temperature: 76.8F, Humidity: 47.2%RH
Test Setup:
PC #875, LCD #831, T654dn (S/N 7922MCD) with Firefly 1 GB thumbdrive; Envelope feeder & top output option, USB + Ethernet cables attached; Power setting = 30 dBm
Additional information:
220 pF cap across diode, toroid on serial cable internally to tray



Freq (MHz)	Test Type	Factor	QP Amp	QP Limit	QP Margin	Avg Amp	Avg Limit	Avg Margin
.169	Neutral	10.836	51.31	65.47	14.16	42.76	55.47	12.71
.202	Neutral	10.419	45.42	64.5	19.08	21.14	54.5	33.36
.281	Neutral	10.09	41.65	62.26	20.61	41.93	52.26	10.33
.506	Neutral	10.055	42.3	56	13.7	42.36	46	3.64
.618	Neutral	10.063	42.37	56	13.63	42.27	46	3.73
.73	Neutral	10.054	42.13	56	13.87	42.01	46	3.99
.841	Neutral	10.056	41.89	56	14.11	41.46	46	4.54
.955	Neutral	10.058	41.7	56	14.3	41.03	46	4.97

Table 18. AC conducted emissions; Neutral; transmitting with hopping enabled.

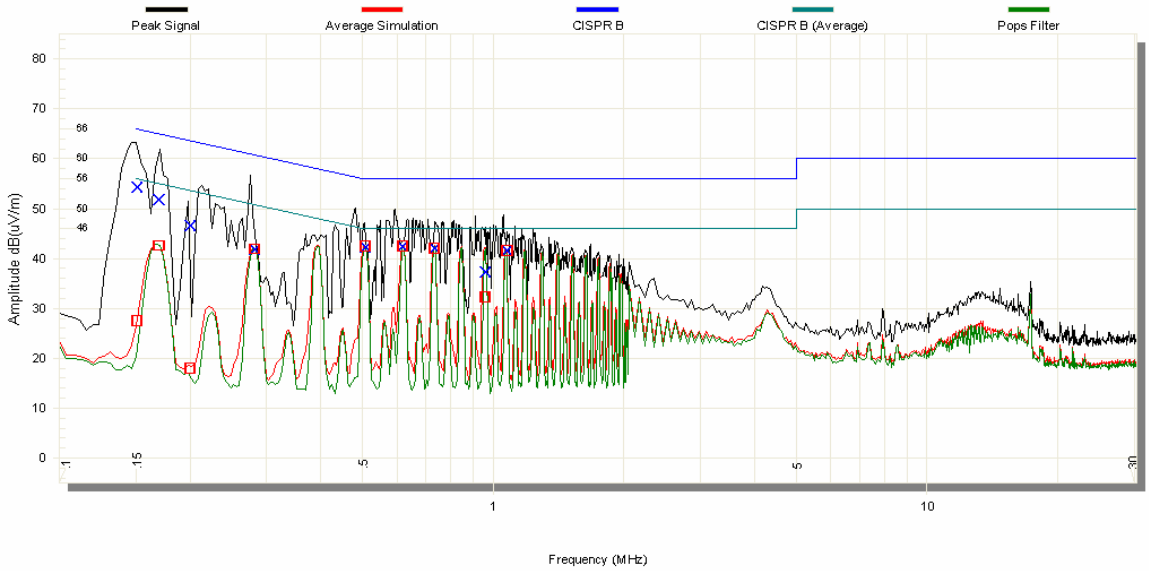
Conducted Project: Thunderbolt Official, Run No: 3, 5/11/2009 4:27:24 PM
Phase, 110V, 60Hz, Frequency Range: Full
Product Name: RFID UHF Option to T65x, S/N: TB Beta 001
Mode: Standby mode
Tested by: John Fessler, Temperature: 76.8F, Humidity: 47.2%RH
Test Setup:
PC #875, LCD #831, T654dn (S/N 7922MCD) with Firefly 1 GB thumbdrive; Envelope feeder & top output option, USB + Ethernet cables attached; Power setting = 30 dBm
Additional information:
220 pF cap across diode, toroid on serial cable internally to tray



Freq (MHz)	Test Type	Factor	QP Amp	QP Limit	QP Margin	Avg Amp	Avg Limit	Avg Margin
.17	Phase	10.824	53.44	65.44	12	40.9	55.44	14.54
.243	Phase	10.126	47.31	63.34	16.03	18.42	53.34	34.92
.282	Phase	10.089	46	62.23	16.23	41.79	52.23	10.44
.394	Phase	10.047	43.51	59.02	15.51	42.5	49.02	6.52
.541	Phase	10.056	40.31	56	15.69	28.59	46	17.41
.619	Phase	10.063	42.59	56	13.41	42.71	46	3.29
.732	Phase	10.054	42.37	56	13.63	42.42	46	3.58
.845	Phase	10.056	42.16	56	13.84	42.08	46	3.92
4.216	Phase	10.193	45.03	56	10.97	34.21	46	11.79

Table 19. AC conducted emissions; Phase; standby mode.

Conducted Project: Thunderbolt Official, Run No: 4, 5/11/2009 4:59:56 PM
Neutral, 110V, 60Hz, Frequency Range: Full
Product Name: RFID UHF Option to T65x, S/N: TB Beta 001
Mode: Standby mode
Tested by: John Fessler, Temperature: 76.8F, Humidity: 47.2%RH
Test Setup:
PC #875, LCD #831, T654dn (S/N 7922MCD) with Firefly 1 GB thumbdrive; Envelope feeder & top output option, USB + Ethernet cables attached; Power setting = 30 dBm
Additional information:
220 pF cap across diode, toroid on serial cable internally to tray



Freq (MHz)	Test Type	Factor	QP Amp	QP Limit	QP Margin	Avg Amp	Avg Limit	Avg Margin
.151	Neutral	11.051	54.32	65.96	11.64	27.48	55.96	28.48
.17	Neutral	10.82	51.75	65.43	13.68	42.63	55.43	12.8
.201	Neutral	10.44	46.54	64.55	18.01	18.07	54.55	36.48
.282	Neutral	10.089	41.83	62.23	20.4	41.95	52.23	10.28
.508	Neutral	10.055	42.35	56	13.65	42.54	46	3.46
.62	Neutral	10.064	42.38	56	13.62	42.49	46	3.51
.733	Neutral	10.053	42.13	56	13.87	42.16	46	3.84
.961	Neutral	10.057	37.39	56	18.61	32.3	46	13.7
1.082	Neutral	10.063	41.64	56	14.36	41.51	46	4.49

Table 20. AC conducted emissions; Neutral; standby mode.

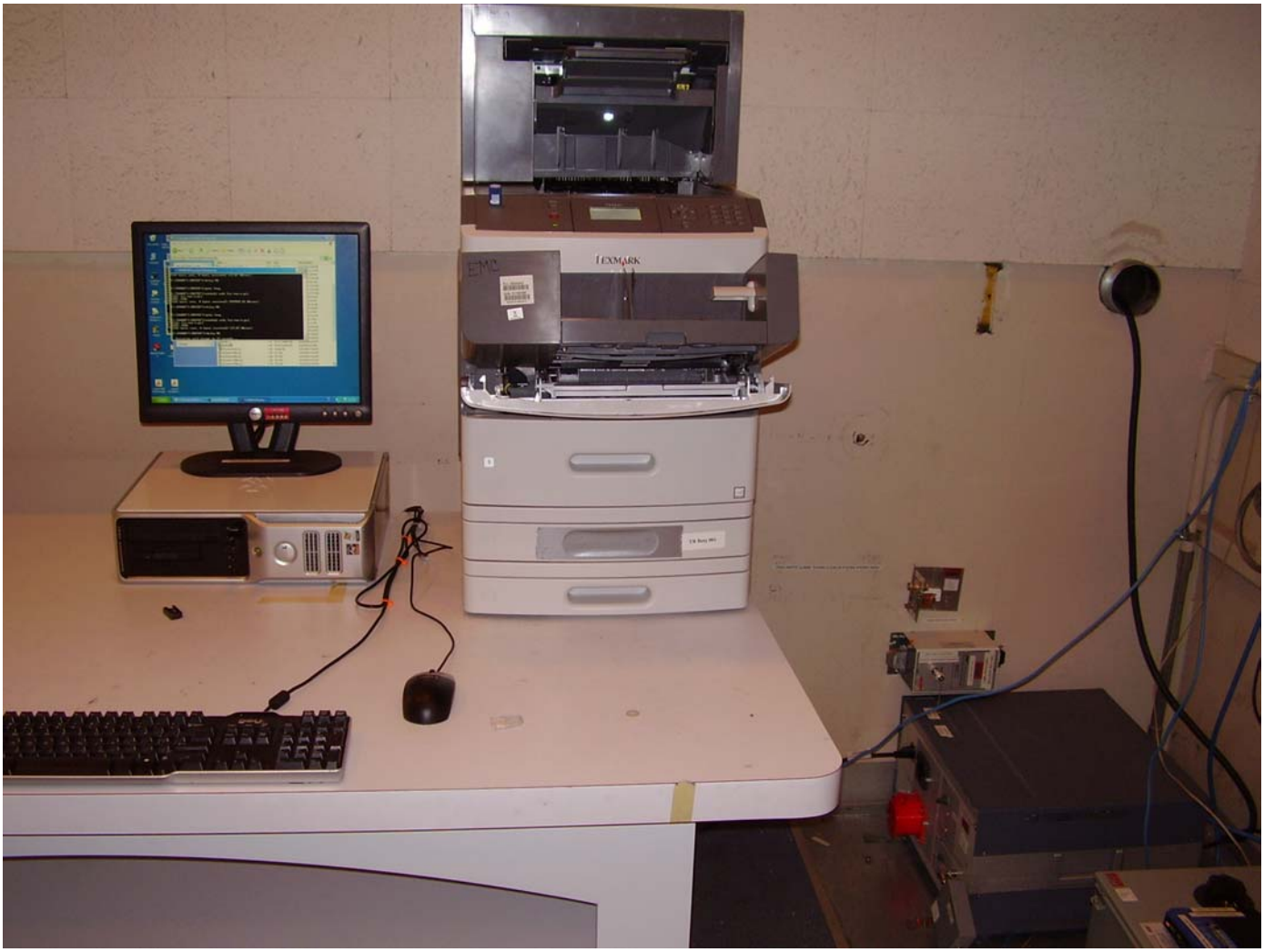


Figure 46. Test configuration for transmitter conducted emissions (front view).

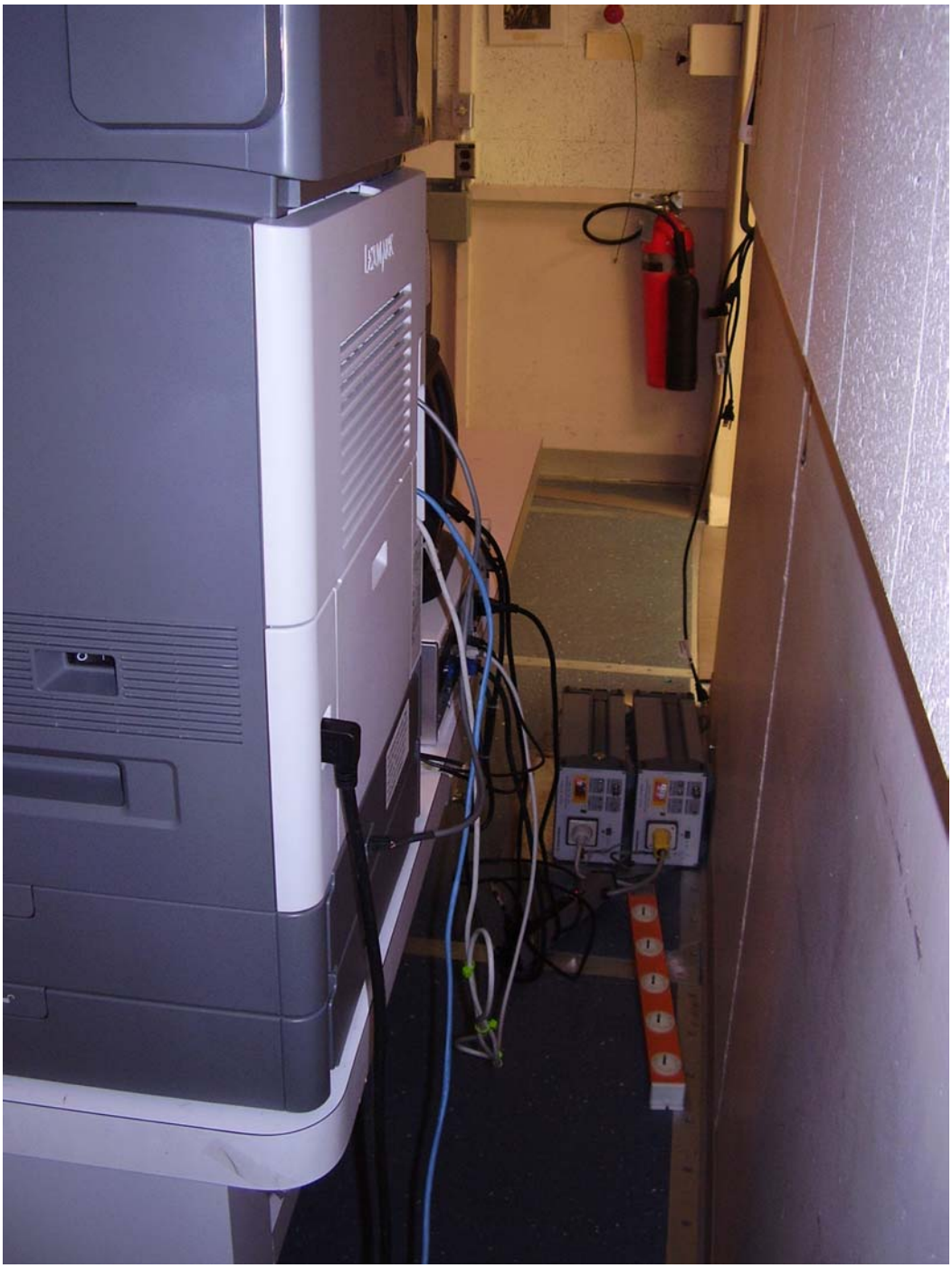


Figure 47. Test configuration for transmitter conducted emissions (side view).

8.9 MAXIMUM PERMISSIBLE EXPOSURE CALCULATIONS

Test Procedure for Maximum Permissable Exposure: Using the power measurements previously reported in this report, the power density at a distance of 20 cm from the EUT must be calculated.

The power density at a distance *d* from an antenna can be calculated from the following equation:

$$s = \frac{P_{inc} G}{4\pi d^2}$$

where P_{inc} is the power incident to the antenna and G is the gain of the antenna. From the conducted power measurements previously reported, the maximum for all modes of operation is 29.79 dBm (952.8 mW). Given the gain of the antenna to be -9.6 dBi (0.331), the power density at a distance of 20 cm from the EUT is given by:

$$s = \frac{(952.8mW)(0.331)}{4\pi(20cm)^2} = \frac{0.0627mW}{cm^2}$$

It is expected that due to the nature of the EUT, the user will be located at least 20 cm from the EUT.

Criteria for Maximum Permissable Exposure: Per §1.1310 of the FCC Rules, the limit of radiation exposure for a device operating in the frequency range of 902 - 928 MHz under the Limits for General Population/Uncontrolled Exposure, the maximum power density is 0.61 mW/cm^2. The EUT was well below this value for separation distances of 20 cm or greater.

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