LEXMARK

LEXMARK INTERNATIONAL

TEST REPORT

for

FCC PART 15
INDUSTRY CANADA RSS-210

TRADE NAME: Lexmark Internal RFID Subsystem

REGULATORY TYPE/MODEL NUMBER: LEX-M11-003

Test Report Number: L659-EMC-2008-FCC-030309

Date: March 3, 2009

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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)	Lexmark Internal RFID Subsystem
Regulatory Type/Model Number	LEX-M11-003
FCC ID	IYLM11003
Industry Canada ID	2376A-M11003
Device Category	Mobile
RF Exposure Category	General Population/Uncontrolled Environment
Transmission Modes	ISO 14443B
Frequency Range (99% BW)	12.69627 MHz - 14.17122244 MHz
Designation of Emission	A2D212K
Maximum Radiated Electric Field @ 10 meter distance	36.67 dB(μV/m)
Antenna Type	Loop antenna integrated on PCB
EUT Power Supply	Power obtained via external power supply

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 an intentional radiator operating in the frequency range 13.553 – 13.567 MHz. The EUT is tested to the radiated emission limits of §15.209 [3] and §A2.6 [4].

2.2 APPLIED STANDARDS

[1] CFR 47, Part 1.

[2] CFR 47, Part 2.

[3] CFR 47, Part 15.

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

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

[6] ANSI C63.4-2003, *American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.*

3 SUMMARY

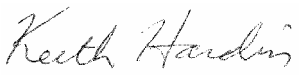
The purpose of this testing was to evaluate the EUT for compliance to the FCC and Industry Canada Rules for an intentional radiator operating in the frequency range 13.553 – 13.567 MHz. This data demonstrates that the EUT complies with these requirements.

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

FCC Rules	Description of Test	Result	Page of this Report
§15.203	Antenna requirement	Compliant	6
§15.205	Restricted bands of operation	Compliant	9
§15.209	Radiated emissions	Compliant	9
§15.207	AC conducted emissions	Compliant	18

Industry Canada RSS-210 & RSS-Gen	Description of Test	Result	Page of this Report
§7.1.4 [5]	Antenna requirement	Compliant	6
§2.6 [4]	Radiated emissions	Compliant	9
§2.1 [4]	Bandwidth	Compliant	16
§7.2.2 [5]	AC conducted emissions	Compliant	18

This report has been reviewed by:

Keith Hardin  March 3, 2009

Name Signature Date

4 DESCRIPTION OF EUT

The Equipment Under Test (EUT) is an RFID subsystem that will be used in a printer to provide communication between the engine of the printer and tags located on the ink tanks. The operating frequency of the EUT is 13.56 MHz. The reader supports tags in the ISO 14443B mode of transmission. The connection to the EUT from the main printed circuit board of the printer is via a flat-flex cable. Power to the EUT is provided through this flex cable.

The EUT was tested while mounted in a printer frame representative of the final installation. Also mounted on the frame was the printer engine controller PCB which is used to provide communication with the EUT. Test code running on the controller PCB was used to set the EUT in various test modes via the printer op-panel, which was removed for testing. Tags are mounted on the top-side of ink tanks which are located in the printhead carrier, which is positioned via the carrier motor. A maximum of four tags may be present on four tanks mounted in the printhead carrier. In order to read a tag, the desired tank is first positioned directly below the antenna of the EUT. The RF output of the EUT is enabled after the desired tank is positioned below the EUT antenna.

4.1 EUT PHOTOS

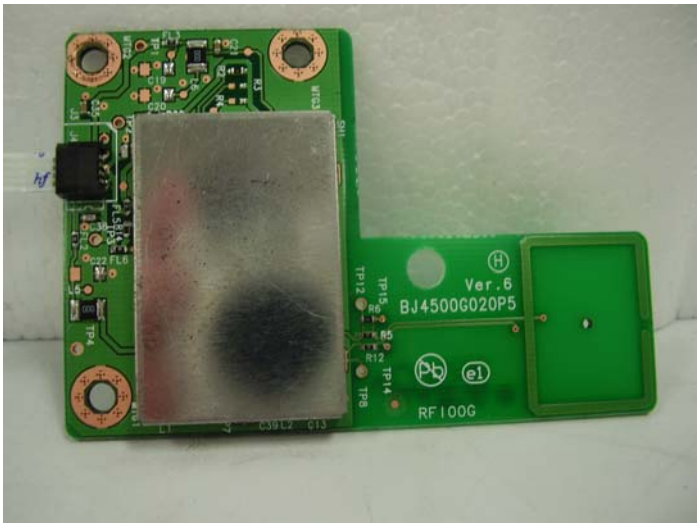


Figure 1. Top view of EUT.

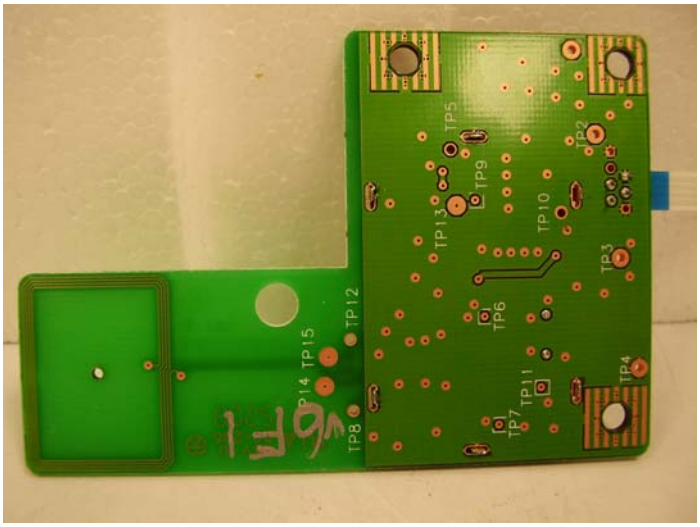


Figure 2. Bottom view of EUT.

Figure 3. EUT installed in test host..

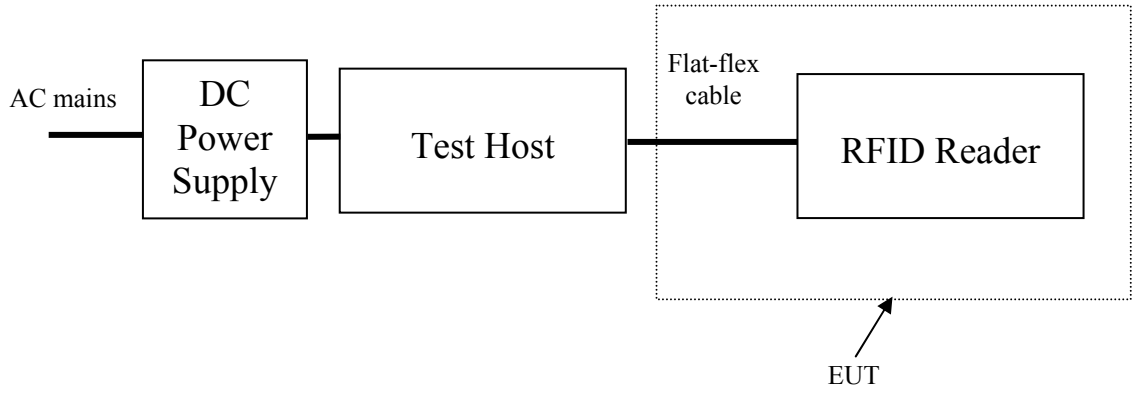
4.2 EUT ANTENNA

The EUT employs a planar loop antenna integrated on the printed circuit board of the EUT as shown in Figures 1 and 2. The EUT meets the requirement in [3] and [5] that no antenna other than that furnished by the responsible party can be used with the device.

4.3 EUT CLOCK FREQUENCIES

Description	Frequency (MHz)
RF Reference Clock	13.56

5 TEST CONFIGURATIONS



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

Description	Manufacturer	Model
Test Host	Lexmark	Base printer engine typical of all models EUT will be installed in.
DC Power Supply	Delta Electronics	EADP-25CB

6 CABLE INFORMATION

Cables used for testing included the following:

Cable Description	Cable Length (meters)	Ferrites	Shield Status
AC line cord to DC power supply	1.8	No	Unshielded
Flat flex cable from interface PCB to EUT	0.10	No	Unshielded

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	100385	12/19/09
EMI receiver	Rhode & Schwarz	ESCI	100347	8/5/10
EMI receiver	Rhode & Schwarz	FSP	100101	10/29/10
Bi-Log antenna	Chase	CBL6111C	2459	10/17/10
Bi-Log antenna	Chase	CBL6111C	2580	10/17/10
Loop antenna (9 kHz - 30 MHz)	Rhode & Schwarz	HFH 2Z2	881056/074	10/18/09
LISN	Rhode & Schwarz	ESH2-Z5	848765/017	8/2/09
LISN	Rhode & Schwarz	ESH2-Z5	890484/012	8/30/09
Rubidium Frequency Standard	Precision Test Systems	GPS10R	101012	N/A
T&H Chamber	Cincinnati Subzero	ZPH-44-6-SCT/AC	ZP0841773	12/17/09

8 TEST RESULTS

8.1 RADIATED EMISSIONS

Criteria for Radiated Emissions: For devices operating under §15.209 of [3] or §2.6 of [4], the electric field strength of any shall not exceed the values in Table 1.

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 1. Limits for radiated emissions.

Test Procedure for Radiated Emissions: Radiated emissions at frequencies less than 30 MHz were measured in Lexmark's 10 meter semi-anechoic chamber. Radiated emissions at frequencies greater than 30 MHz were measured in Lexmark's 3/5 meter semi-anechoic chamber. These facilities are registered with the FCC (registration number 949691 for 10 meter chamber and 991141 for 3/5 meter chamber) and Industry Canada (site number 2376A-1 for 10 meter chamber and 2376A-3 for 3/5 meter chamber).

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. For measurements at frequencies 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. A CISPR quasi-peak detector is used for measurements below 30 MHz except in the frequency ranges of 9 – 90 kHz and 110 – 490 kHz where an average detector is used.

Since the radiated emission limits 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. With this, the limit at 10 meters is given as:

$$Limit_{10meters} = Limit_{30meters} + 20\log\left((30/10)^2\right)$$

For measurement of radiated emissions at frequencies in the range 30 – 1000 MHz, a bilog antenna was used. The receiving antenna was connected to a spectrum analyzer and with the spectrum analyzer 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 the quasi-peak detector.

At frequencies below 30 MHz, the EUT was tested while actively communicating with a tag, with RF on without a tag present and in the standby mode. At frequencies above 30 MHz, the EUT was tested while actively communicating with a tag and in the standby mode. At the fundamental

operating frequency of the EUT, the maximum radiated electric field was measured with the supply voltage of the EUT set to a nominal voltage of 120VAC (V_{nom}), 102 VAC (85% V_{nom}) and 138 VAC (115% V_{nom}). A variac was used to adjust the AC line voltage to the EUT.

Results for Radiated Emissions: Tables 2 - 12 contain data on the radiated emissions of significant amplitude from the EUT configuration shown in Section 5. The frequency range from 1.705 MHz – 1000 MHz was investigated for spurious emissions. This data indicates that the EUT meets the requirements for radiated emissions. The maximum emission for all conditions was 36.67 dB(μV/m) at 13.5611 MHz.

Frequency (MHz)	Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
13.5611209	20.77	36.67	48.58	11.91
27.12224	22.63	31.11	48.58	17.47

Table 2. Radiated emissions below 30 MHz; transmitting without tag; $V = V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
13.5611209	20.77	36.20	48.58	12.38
27.12224	22.63	30.45	48.58	18.13

Table 3. Radiated emissions below 30 MHz; transmitting with tag; $V = V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
13.5611209	20.77	25.14	48.58	23.44
27.12224	22.63	23.22	48.58	25.36

Table 4. Radiated emissions below 30 MHz; standby mode; $V = V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
13.5611209	20.77	36.50	48.58	12.08

Table 5. Field strength at fundamental; transmitting without tag; $V = 85\% V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
13.5611209	20.77	36.0	48.58	12.58

Table 6. Field strength at fundamental; transmitting with tag; $V = 85\% V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
13.5611209	20.77	25.29	48.58	23.29

Table 7. Field strength at fundamental; standby mode; $V = 85\% V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
13.5611209	20.77	36.53	48.58	12.05

Table 8. Field strength at fundamental; transmitting without tag; $V = 115\% V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
13.5611209	20.77	36.03	48.58	12.55

Table 9. Field strength at fundamental; transmitting with tag; $V = 115\% V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
13.5611209	20.77	25.27	48.58	23.31

Table 10. Field strength at fundamental; standby mode; $V = 115\% V_{nom}$.

Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
40.678	V	-21.93	13.49	24.06	40	15.94
54.244	V	-21.86	6.54	18.94	40	15.94
149.173	H	-20.96	10.88	27.72	43.5	15.78
176.304	H	-20.77	9.27	30.70	43.5	12.8
393.268	V	-19.46	15.4	30.61	46	15.39
393.272	H	-19.46	15.4	40.97	46	5.03
406.831	H	-19.30	16.0	38.50	46	7.5
420.395	H	-19.35	16.32	35.51	46	10.49
542.441	H	-18.95	18.92	40.34	46	5.66
542.441	V	-18.95	18.92	36.38	46	9.62
556.006	H	-18.88	19.4	36.97	46	9.04
556.018	V	-18.88	19.4	32.70	46	13.3
569.567	H	-18.81	19.68	32.90	46	13.1

Table 11. Results for radiated emissions 30 - 1000 MHz; transmitting with tag.

Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
41.39	V	-21.93	13.07	22.37	40	17.63
60.298	H	-21.70	5.8	18.03	40	21.97
63.208	V	-21.70	5.86	23.92	40	16.08
87.923	V	-21.47	8.59	23.59	40	16.41
87.935	H	-21.47	8.59	14.16	40	25.84
94.786	V	-21.38	9.32	17.97	43.5	25.53
97.492	V	-21.28	9.72	17.01	43.5	26.49
147.403	H	-20.86	11.03	13.42	43.5	30.08
234.203	H	-20.34	10.53	20.64	46	25.37

Table 12. Results for radiated emissions 30 – 1000 MHz; standby mode.

Figure 4. Test configuration for radiated emissions at $f < 30$ MHz (front view).

Figure 5. Test configuration for radiated emissions at $f < 30$ MHz (back view).

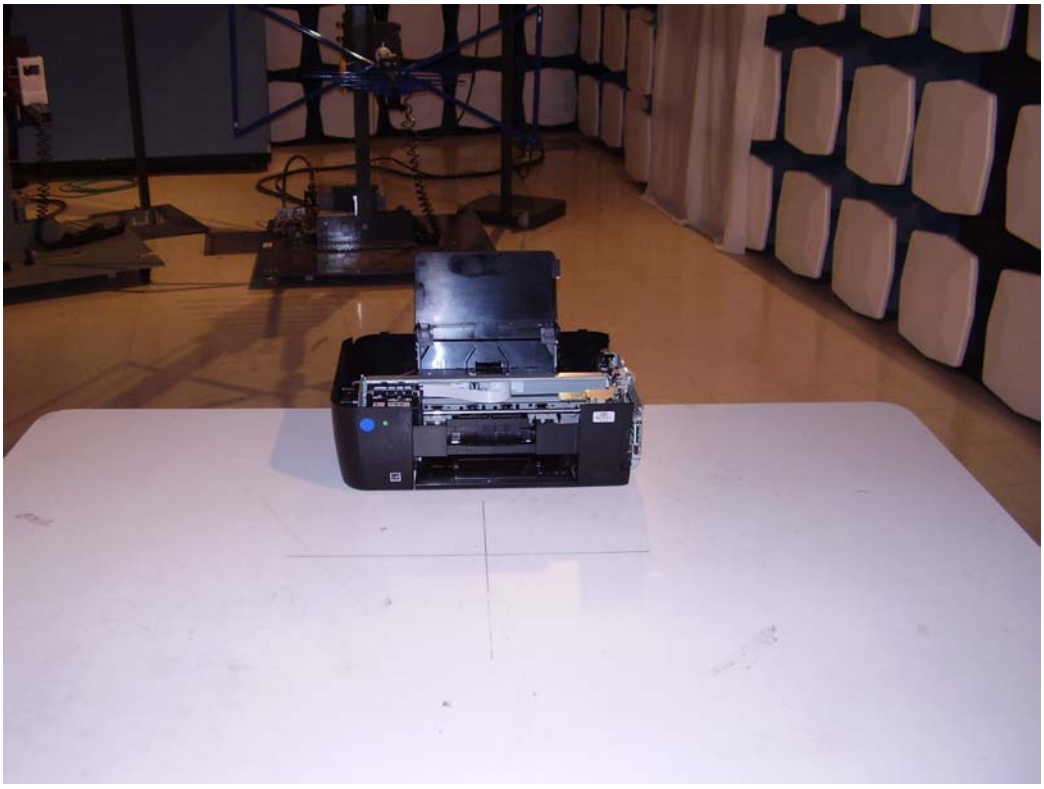


Figure 6. Test configuration for radiated emissions at $f > 30$ MHz (front view).

Figure 7. Test configuration for radiated emissions at $f > 30$ MHz (back view).

8.2 BANDWIDTH OF EMISSION

Criteria for Bandwidth of Emission: The bandwidth of emission of the EUT shall be measured and reported. The nominal bandwidth shall be such that the fundamental modulation products lie totally within the the bands listed in Tables 2 and 3 of [4] and do not fall inside the restricted bands of operation listed in [3] and [4]. The amplitude of any emissions falling within the restricted bands must be below the general limits of §15.209 in [3] and Table 2 and 3 of [4].

Test Procedure for Bandwidth of Emission: The EUT was located in a semi-anechoic chamber. A receive loop antenna was located approximately 1 meters from the EUT and connected directly to the input of the spectrum analyzer via a coaxial cable. The resolution bandwidth of the analyzer was set to approximately 10% of the span and the video bandwidth was set to approximately 3 times the resoluton bandwidth. The frequency span was set so that the entire channel of operation could be displayed on the spectrum analyzer. The integrated bandwidth measurement function of the spectrum analyzer was used to measure the 99% bandwidth of the transmitted signal

The EUT was tested while communicating with a tag and while transmitting only a carrier.

Results for Bandwidth of Emission: See Figures 8 - 9 for results. The 99% bandwidth measured with the tag present was 1.47494 MHz. The 99% bandwidth measured without the tag present was 48.0926 kHz. When communicating with the tag, the minimum frequency defining the 99% bandwidth was 12.69627 MHz and the maximum frequency was 14.17122244 MHz. Without the tag present, the minimum frequency defining the 99% bandwidth was 13.53720441 MHz and the maximum frequency was 13.58530060 MHz. The data in Section 8.1 demonstrates that the amplitude of the EUT emission at the fundamental frequency of operation is below the general limits of §15.209 in [3] and Table 2 and 3 of [4].

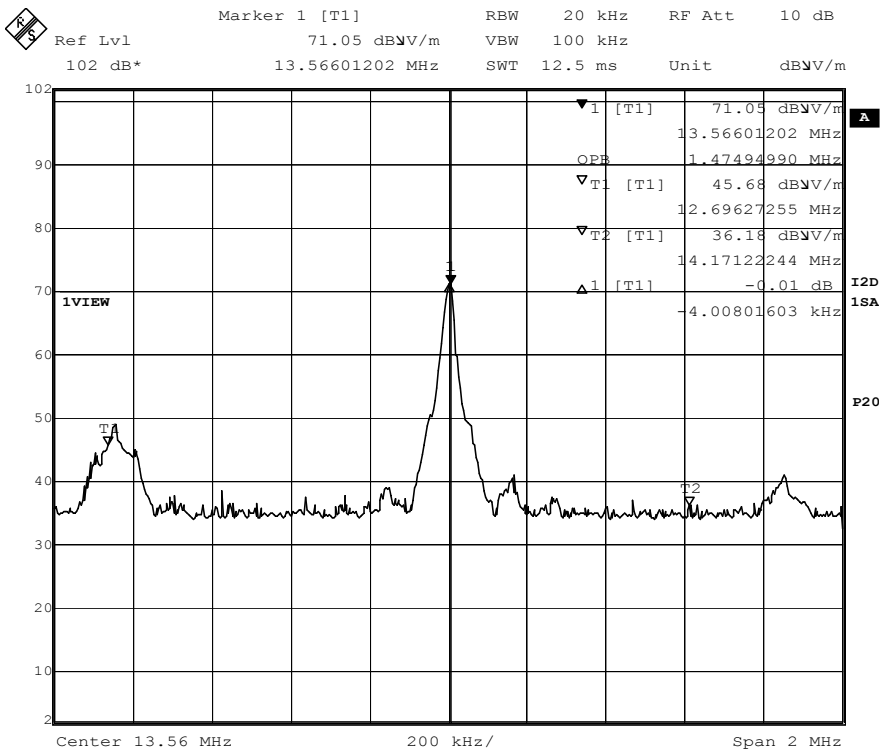


Figure 8. Bandwidth of emission when communicating with a tag (99% Bandwidth).

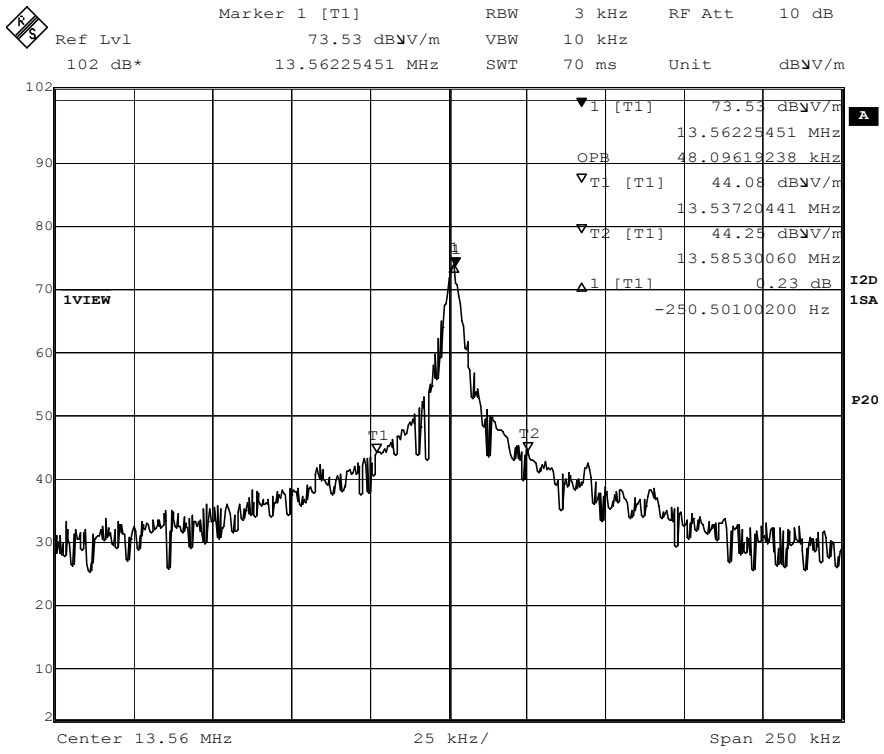


Figure 9. Bandwidth of emission without a tag present (99% Bandwidth).

8.3 AC CONDUCTED EMISSIONS

Criteria for AC Conducted Emissions: The emissions conducted onto the AC power line by the EUT shall not exceed the values in Table 13.

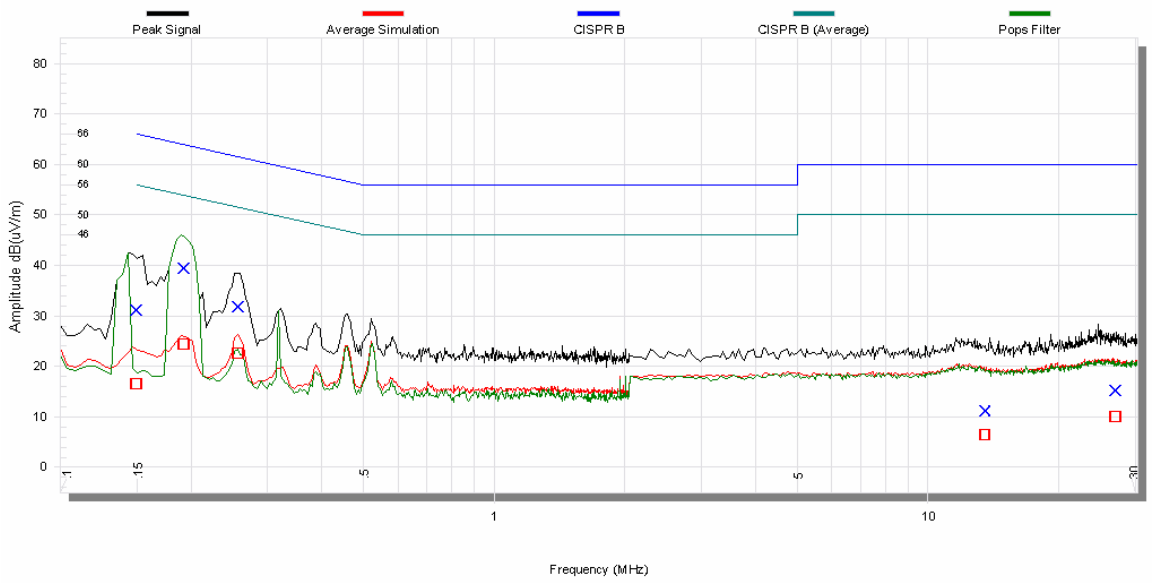
Frequency Range (MHz)	Quasi-peak Limit (dB(μV))	Average Limit (dB(μV))
0.15 - 0.5	66 to 56	56 to 46
0.5 - 5	56	46
5 - 30	60	50

Table 13. Limits for conducted emissions.

Test Procedure for AC Conducted Emissions: The test configuration shown Section 5 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. As shown in Figures 10 and 11, the EUT was placed atop a 0.8 meter high wooden table with a rectangular surface measuring 1.5m x 1.0m. The back edge of the EUT was aligned with the back edge of the table and located 40 cm from the metal wall of the shielded room. The AC line cord of the DC power supply was plugged into the LISN (Line Impedance Stabilization Network) with the excess of the line cord length bundled in the center.

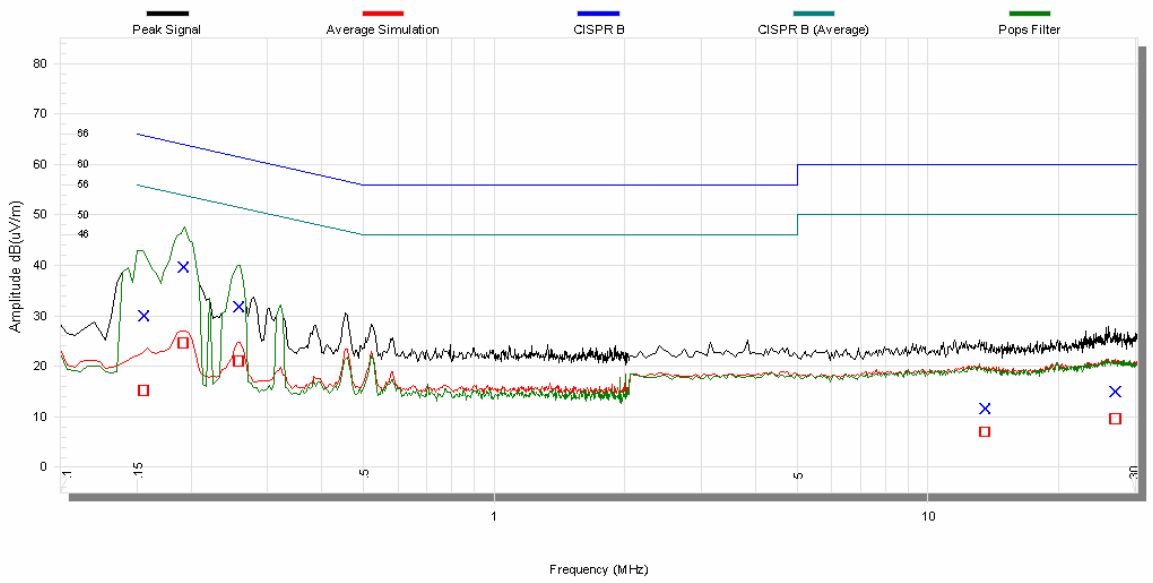
The EUT was operated in the standby mode and while transmitting. When testing the EUT with the RF turned on, the loop antenna of the EUT was disconnected and the RF output terminated with a 68Ω resistor as allowed in Section 13.2 of [6]. This is accomplished by replacing 0Ω resistors on the EUT printed circuit board with a 68Ω resistor. When testing in the standby mode, the loop antenna of the EUT was connected as in normal operation.

Results for AC Conducted Emissions: Tables 14 through 17 contain the AC conducted emissions for the EUT while in the standby mode and with the RF turned on with the antenna replaced with the 68Ω resistor. The EUT met the requirements for AC conducted emissions given in Table 13.



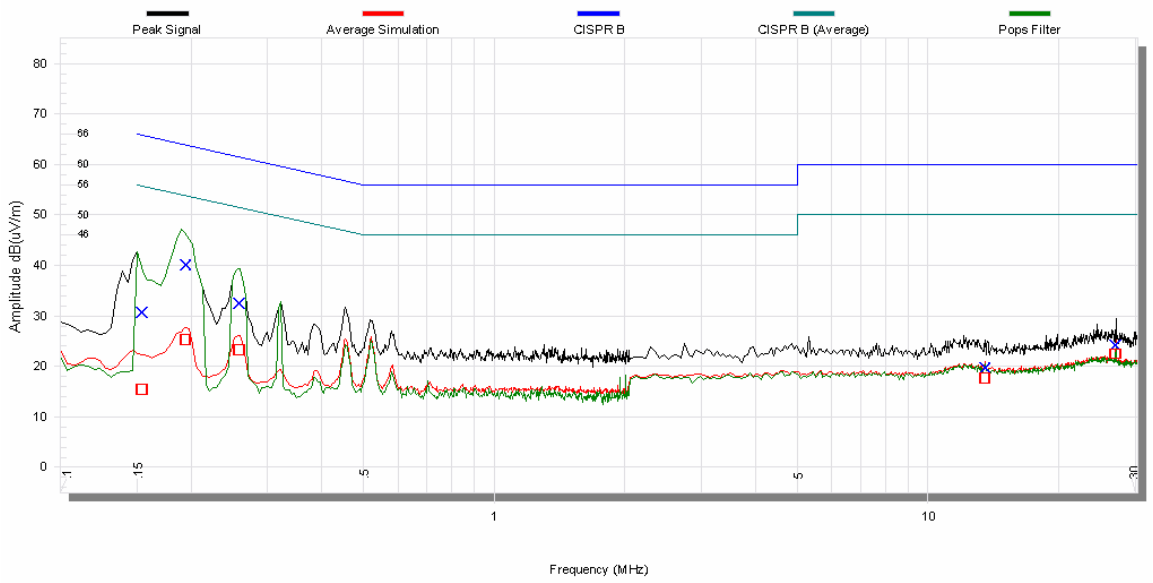
Freq (MHz)	Test Type	Factor	QP Amp	QP Limit	Margin QP	Avg Amp	Avg Limit	Margin Avg
0.15	Phase	11.26	31.18	66	34.82	16.52	56	39.48
0.193	Phase	10.663	39.44	64.77	25.33	24.41	54.77	30.36
0.257	Phase	10.208	31.81	62.93	31.12	22.57	52.93	30.36
13.561	Phase	11.277	11.14	60	48.86	6.49	50	43.51
27.121	Phase	12.18	15.19	60	44.81	10.13	50	39.87

Table 14. Results for AC conducted emissions, phase conductor, standby mode.



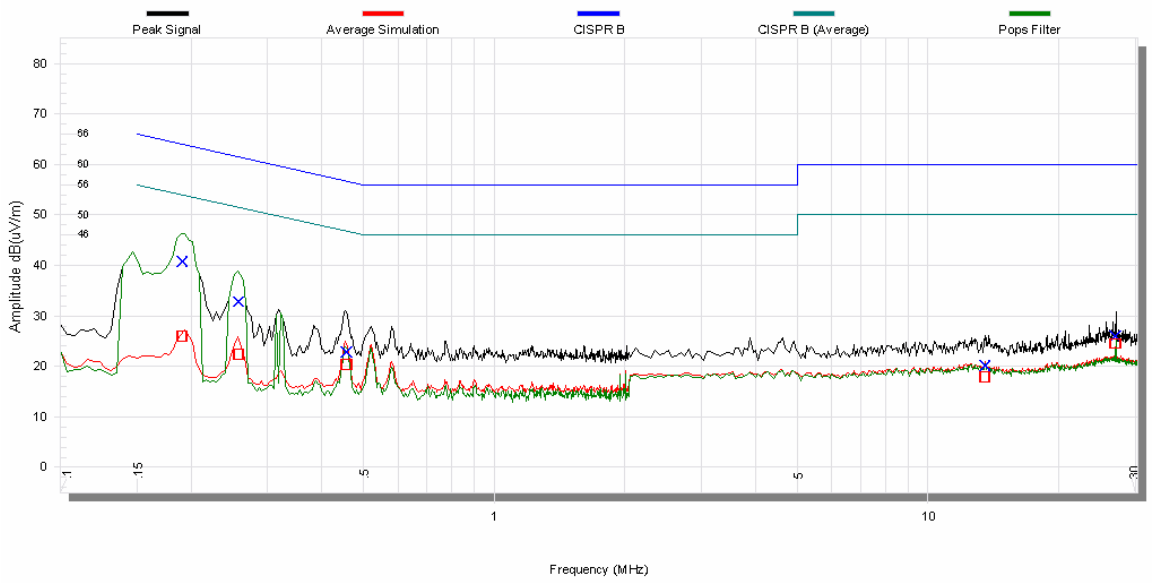
Freq (MHz)	Test Type	Factor	QP Amp	QP Limit	Margin QP	Avg Amp	Avg Limit	Margin Avg
0.156	Neutral	11.177	29.97	65.83	35.86	15.19	55.83	40.64
0.192	Neutral	10.67	39.74	64.79	25.05	24.59	54.79	30.2
0.258	Neutral	10.208	31.76	62.91	31.15	21.08	52.91	31.83
13.561	Neutral	11.277	11.63	60	48.37	7.05	50	42.95
27.124	Neutral	12.18	14.96	60	45.04	9.68	50	40.32

Table 15. Results for AC conducted emissions, neutral conductor, standby mode.



Freq (MHz)	Test Type	Factor	QP Amp	QP Limit	Margin QP	Avg Amp	Avg Limit	Margin Avg
0.154	Phase	11.201	30.66	65.88	35.22	15.47	55.88	40.41
0.195	Phase	10.635	40.14	64.72	24.58	25.28	54.72	29.44
0.259	Phase	10.208	32.56	62.88	30.32	23.29	52.88	29.59
13.561	Phase	11.277	19.75	60	40.25	17.76	50	32.24
27.124	Phase	12.18	24.13	60	35.87	22.53	50	27.47

Table 16. Results for AC conducted emissions, phase conductor, RF ON.



Freq (MHz)	Test Type	Factor	QP Amp	QP Limit	Margin QP	Avg Amp	Avg Limit	Margin Avg
0.191	Neutral	10.684	40.8	64.82	24.02	26	54.82	28.82
0.258	Neutral	10.208	32.84	62.9	30.06	22.39	52.9	30.51
0.458	Neutral	10.179	22.9	57.21	34.31	20.41	47.21	26.8
13.561	Neutral	11.277	20.1	60	39.9	17.98	50	32.02
27.121	Neutral	12.18	25.98	60	34.02	24.54	50	25.46

Table 17. Results for AC conducted emissions, neutral conductor, RF ON.

Figure 10. Test configuration for transmitter conducted emissions (front view).

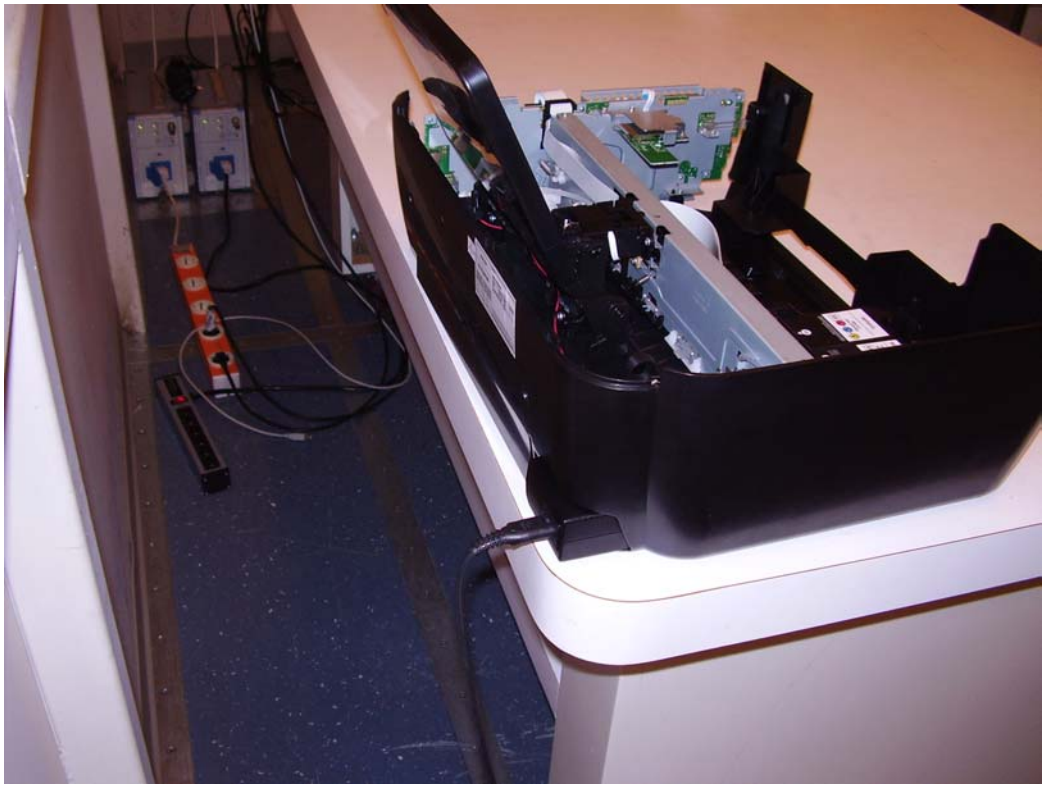


Figure 11. Test configuration for transmitter conducted emissions (side view).

8.4 DESIGNATION OF EMISSION

For ISO 14443 Type B, the reader to tag communication is ASK with a modulation index of 8% – 14%. The data bit rate during initialization and anti-collision shall nominally be 108 kbit/s.

The emission designator is calculated as follows:

First symbol: Amplitude modulation = A;

Second symbol: A single channel containing quantized or digital information with the use of a modulating sub-carrier = 2;

Third symbol: Data transmission, telemetry, telecommand = D.

For the necessary bandwidth B_n, the following equation is used:

$$B_n = 2BK$$

where

B = modulation baud rate = 106 kbit/s

K = numerical factor = 1

Therefore B_n = 212 kHz and emission designator is written as A2D212K.

8.5 MAXIMUM PERMISSIBLE EXPOSURE CALCULATIONS

Test Procedure for Maximum Permissable Exposure: Using the values of the maximum radiated electric field measurements previously reported in this report and assuming a $1/r^2$ rolloff of the electric field, the distance from the EUT where the electric field equals the maximum allowed in [1] is calculated.

Per §1.1310 of the FCC Rules [1], the limit for the category of general population/uncontrolled exposure in the frequency range of 1.34 – 30 MHz is:

$$E_{\lim it} = \frac{824}{f_{MHz}} V/m$$

Assuming a $1/r^2$ (40 dB/decade) rolloff of the electric field, the equation describing the electric field at any distance r relative to the field value E_{10m} measured at a 10 meter distance (36.67 dB(μV/m)) is the following:

$$E = E_{10m} + 20\log\left(\left(\frac{10}{r}\right)^2\right)$$

Setting the value of the electric field equal to the limit yields the following equation:

$$E_{\lim it} = E_{10m} + 20\log\left(\left(\frac{10}{r}\right)^2\right)$$

where the value of the distance r can be determined so that the equation is satisfied. The value of r that satisfies this equation is found to be 1.1 cm.

It is expected that due to the nature of the EUT and how it will be installed, 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 at a frequency of 13.56 MHz under the Limits for General Population/Uncontrolled Exposure is 155.67 dB(μV/m). The electric field radiated by the EUT was below this value for separation distances of 20 cm or greater.

NOTE:

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