LEXMARK

LEXMARK INTERNATIONAL

TEST REPORT

for

FCC PART 15
INDUSTRY CANADA RSS-210

TRADE NAME: Proximity card Reader

REGULATORY TYPE/MODEL NUMBER: LEX-M05-002

Test Report Number: 618-EMC-2008-FCC-031208

Date: March 12, 2008

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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
Regulatory Type/Model Number	LEX-M05-002
FCC ID	IYLLEXM05002
Industry Canada ID	2376A-M05002
Device Category	Mobile
RF Exposure Category	General Population/Uncontrolled Environment
Transmission Modes	Prox by HID
Frequency Range (MHz)	123.244 – 126.451 kHz
Designation of Emission	10K0A1D
Maximum Radiated Electric Field @ 10 meter distance	46.65 dB(μV/m))
Antenna Type	Loop antenna integrated on PCB
EUT Power Supply	Power obtained via USB interface

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 119 – 127 kHz. The EUT is tested to the general radiated emission limits of §15.209 [3] and §2.6 [4] in lieu of §15.225 [3] and §A2.6 [3].

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] RSS-102, Issue 2, *Radio Frequency Exposure Compliance of Radiocommunications Apparatus (All Frequency Bands).*

[7] 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

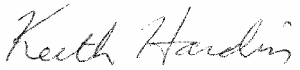
The purpose of this testing was to evaluate the EUT for compliance to the FCC and Industry Canada Rules for an intentional radiator operating in the frequency range 119 - 127 kHz. This data demonstrates that the EUT complies with these requirements.

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	7
§15.205	Bandwidth of emissions	Compliant	10
§15.207	AC conducted emissions	Compliant	23
§15.209	Radiated emissions	Compliant	17

Industry Canada	Description of Test	Result	Page of this Report
§2.1 [4]	Bandwidth of emission	Compliant	10
§2.6 [4]	Radiated emissions	Compliant	17
§7.1.4 [5]	Antenna requirement	Compliant	7
§7.2.2 [5]	AC conducted emissions	Compliant	23
§4.2 [6]	RF exposure	Compliant	26

This report has been reviewed by:

Keith Hardin  March 12, 2008

Name Signature Date

4 DESCRIPTION OF EUT

The Equipment Under Test (EUT) is a contactless card reader option for a printer. The EUT can read from a 125 kHz HID proximity card and read/write from virtually any contact smart card. The dual interface feature, implemented on a small PCB, supports end-user environments where both HID proximity and contact smart card technology may be in use. The only connection to the EUT is via a detachable USB cable. Power to the EUT is provided through this USB cable.

4.1 EUT PHOTOS

Figure 1. Top view of EUT.

Figure 2. Back view of EUT.

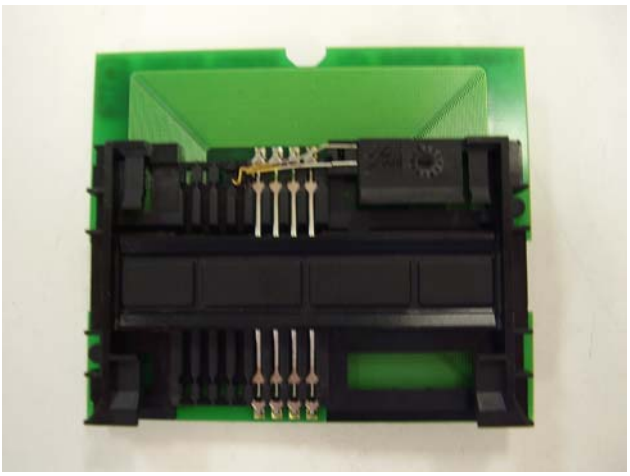


Figure 3. Close-up top view of EUT.

Figure 4. Close-up bottom view of EUT.

4.2 EUT ANTENNA

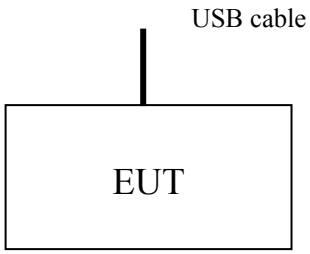
The EUT employs a planar loop antenna integrated on the printed circuit board of the EUT as shown in Figures 3 and 4. The EUT meets the requirement in [3] and [5] that no antenna other than that furnished by the responsible party can be used with the device.

4.3 EUT CLOCK FREQUENCIES

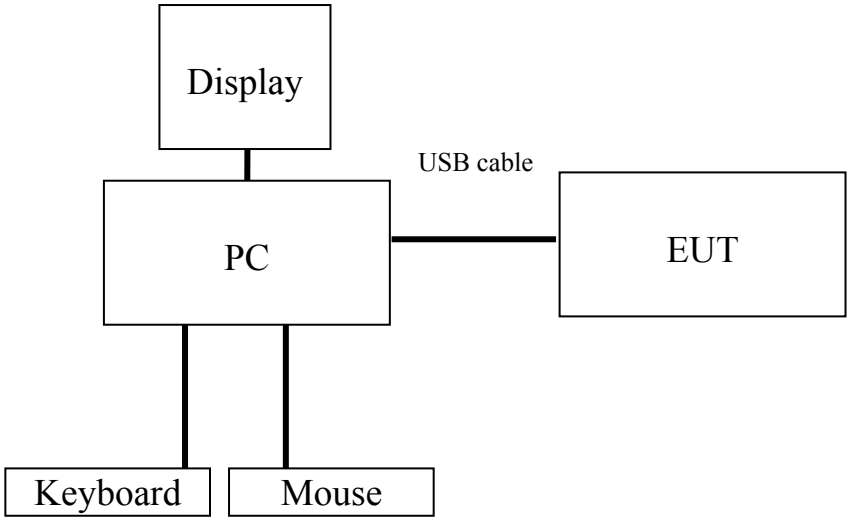
Description	Frequency (MHz)
Digital Reference Clock	8.0

5 TEST CONFIGURATIONS

5.1 TEST SETUP FOR RADIATED EMISSIONS



5.2 TEST SETUP FOR CONDUCTED EMISSIONS



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

Description	Manufacturer	Model
Personal Computer	Dell	Dimension C521
LCD	Dell	E177FPb

6 CABLE INFORMATION

Cables used for testing included the following:

Cable Description	Cable Length (meters)	Ferrites	Shield Status
USB cable from PC to EUT	2	No	Shielded

7 TESTING & MEASUREMENT EQUIPMENT

Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
EMI receiver	Rhode & Schwarz	ESI7	100092	4/9/09
EMI receiver	Rhode & Schwarz	ESIB7	100093	12/14/08
EMI receiver	Rhode & Schwarz	ESIB40	1112950683	10/18/09
EMI receiver	Rhode & Schwarz	ESIB40	100148	4/26/09
EMI receiver	Rhode & Schwarz	ESCI	100346	7/30/08
EMI receiver	Rhode & Schwarz	ESCI	100347	7/18/09
Bi-Log antenna	Chase	CBL6111C	2459	9/21/08
Bi-Log antenna	Chase	CBL6111C	2460	10/2/08
Loop antenna (9 kHz - 30 MHz)	Rhode & Schwarz	HFH 2Z2	881056/074	10/18/08
LISN	Rhode & Schwarz	ESH2-Z5	848765/017	8/2/09
LISN	Rhode & Schwarz	ESH2-Z5	890484/012	8/30/09

8 TEST RESULTS

8.1 BANDWIDTH OF EMISSION

Criteria for Bandwidth of Emission: The nominal bandwidth shall be such that the fundamental modulation products lie totally within the the bands listed in Tables 2, 3, 4, and 5 of [4] and do not fall inside the restricted bands of operation listed in [3] and [4].

Test Procedure for Bandwidth of Emission: The EUT configuration shown in Section 5.1 was located in a semi-anechoic chamber. A receive loop antenna was located 3 meters from the EUT and connected directly to the input of the spectrum analyzer via a coaxial cable.

For measuring the 99% bandwidth, the resolution and video bandwidths of the analyzer were set to 300 Hz and 1 kHz, respectively. The frequency span was set to 50 kHz 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.

For measuring the 20 dB bandwidth, the resolution and video bandwidths of the analyzer were set to 1 kHz and 3 kHz, respectively. The frequency span was set to 50 kHz so that the entire channel of operation could be displayed on the spectrum analyzer. Markers were then used to measure the upper and lower frequencies where the amplitude was 20 dB below the point of maximum amplitude. The difference in the frequencies of these two markers is the 20 dB bandwidth.

The EUT was tested in both the standby mode and while actively reading from a proximity card.

Results for Bandwidth of Emission: See Figures 5 - 8 for results. The measured bandwidths are summarized in Table 1.

Mode of Operation	99% Bandwidth (kHz)	20 dB Bandwidth (kHz)
Standby	5.51	5.61
Actively communicating	5.61	5.31

Table 1. Measured 99% and 20 dB bandwidths.

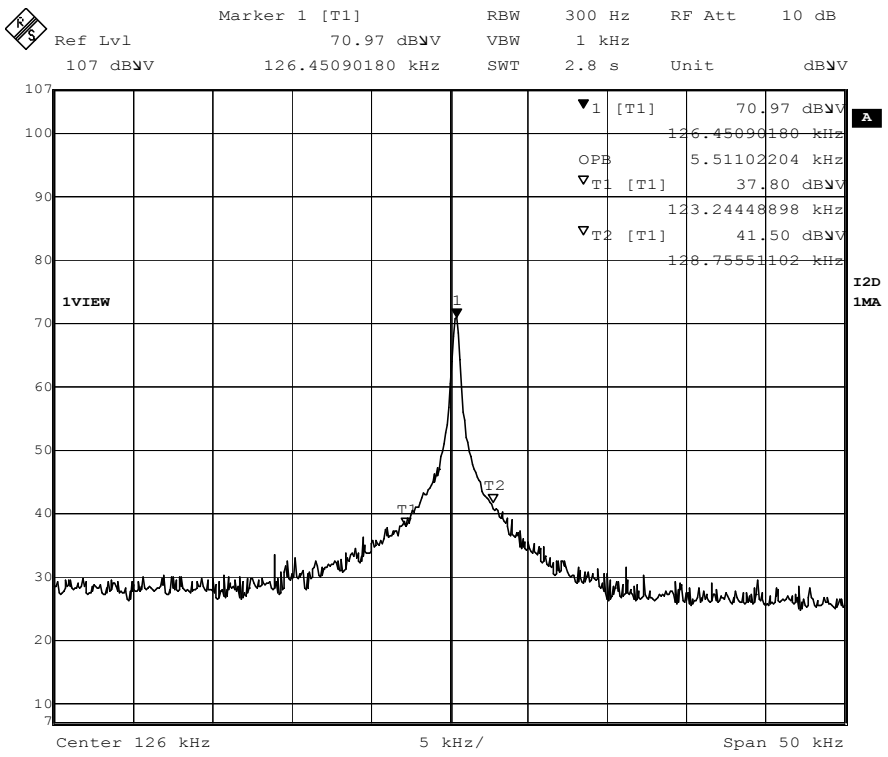


Figure 5. Bandwidth of emission (99% Bandwidth); standby mode.

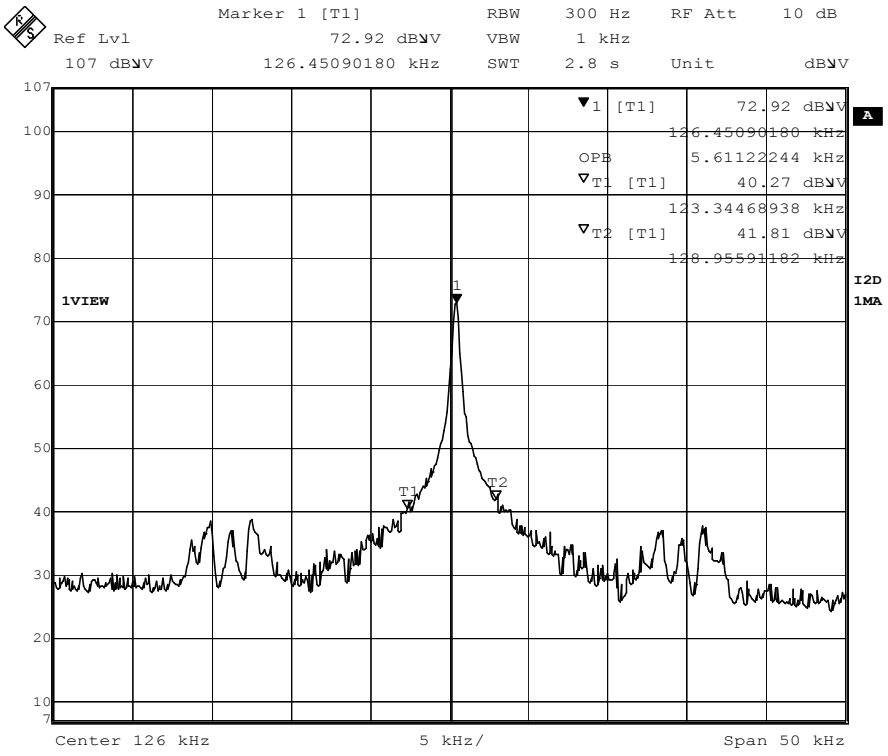


Figure 6. Bandwidth of emission (99% Bandwidth); actively reading from proximity card.

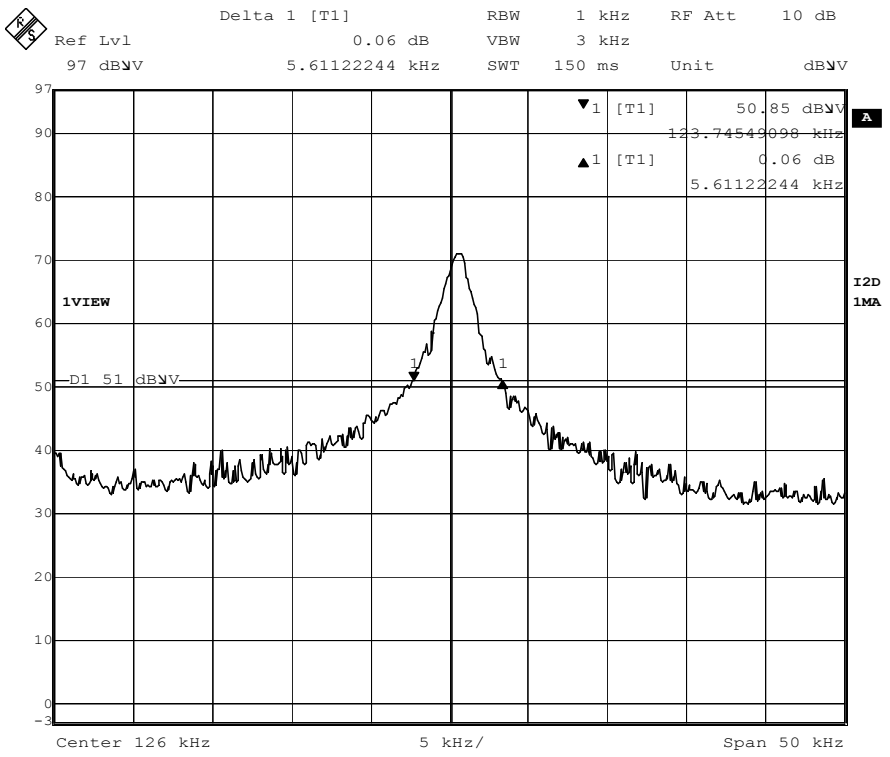


Figure 7. Bandwidth of emission (20 dB Bandwidth); standby mode.

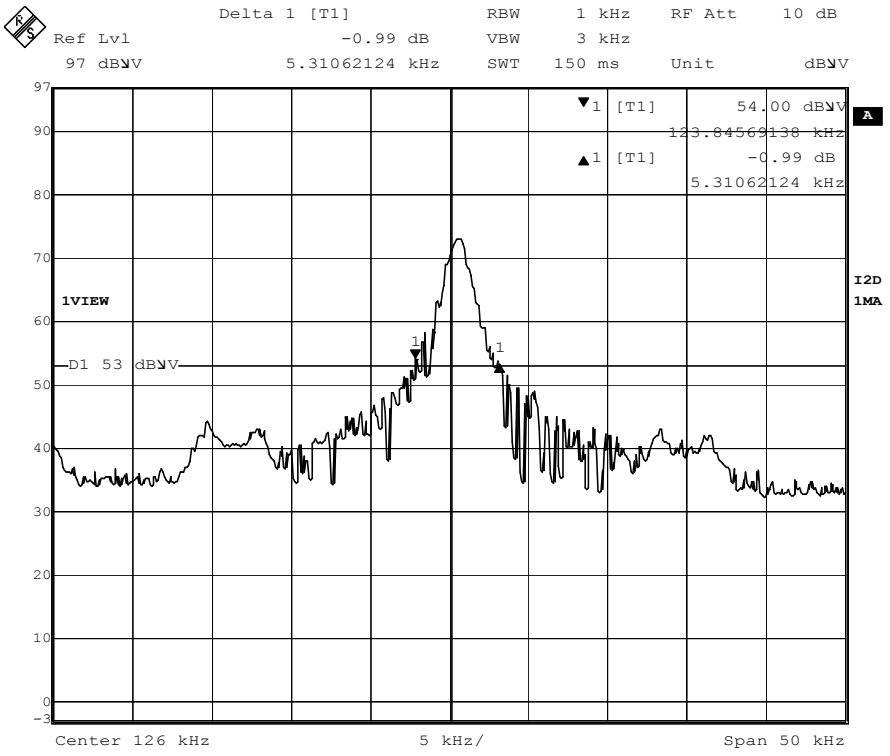


Figure 8. Bandwidth of emission (20 dB Bandwidth); actively reading from proximity card.

8.2 DUTY CYCLE MEASUREMENTS

Criteria for Duty Cycle Measurements: Devices which transmit pulsed emissions and are subject to a limit requiring an average detector function for radiated emissions shall initially be measured with an instrument that uses a peak detector. This peak measurement may then be corrected to a true average by using the appropriate factor for emission duty cycle.

Test Procedure for Duty Cycle Measurements: The EUT configuration shown in Section 5.1 was located in a semi-anechoic chamber. A receive loop antenna was located 3 meters from the EUT and connected directly to the input of the spectrum analyzer via a coaxial cable.

The resolution and video bandwidths of the analyzer were set to 1 kHz and 3 kHz, respectively. The frequency span was initially set to 50 kHz so that the entire channel of operation could be displayed on the spectrum analyzer. The max hold and marker functions were used to set the center frequency of the spectrum analyzer to the frequency of maximum amplitude. The span was then set to zero and the trigger set to video and adjusted so that the sweep is triggered at the midpoint of the pulse train that is observed on the display. The sweep time is then adjusted so that the desired number of pulses are observed on the display.

The factor to correct the peak measurement to a true average measurement is given as:

$$C = 20\log\left(\frac{T_{on}}{T_{period}}\right)$$

where T_{on} is the length of time that the pulse is on and T_{period} is the period of the pulse train.

The EUT was tested in both the standby mode and while actively reading from a proximity card. Since the duty cycle is different for each mode, the factor to correct the peak measurement to a true average measurement is different for each mode.

Results for Duty Cycle Measurements: The measured period and pulse width for the EUT when in the standby mode are shown in Figures 9 and 10; the measured period and pulse width for the EUT while actively communicating with a proximity card are shown in Figures 11 and 12. The factors used to calculate the true average of the radiated emission from the peak measurement are given in Table 2.

Mode of Operation	T_{on} (ms)	T_{period} (ms)	C (dB)
Standby	11.29	102.9	-19.19
Actively communicating	85.77	421.57	-13.83

Table 2. Correction factors for average emission levels.

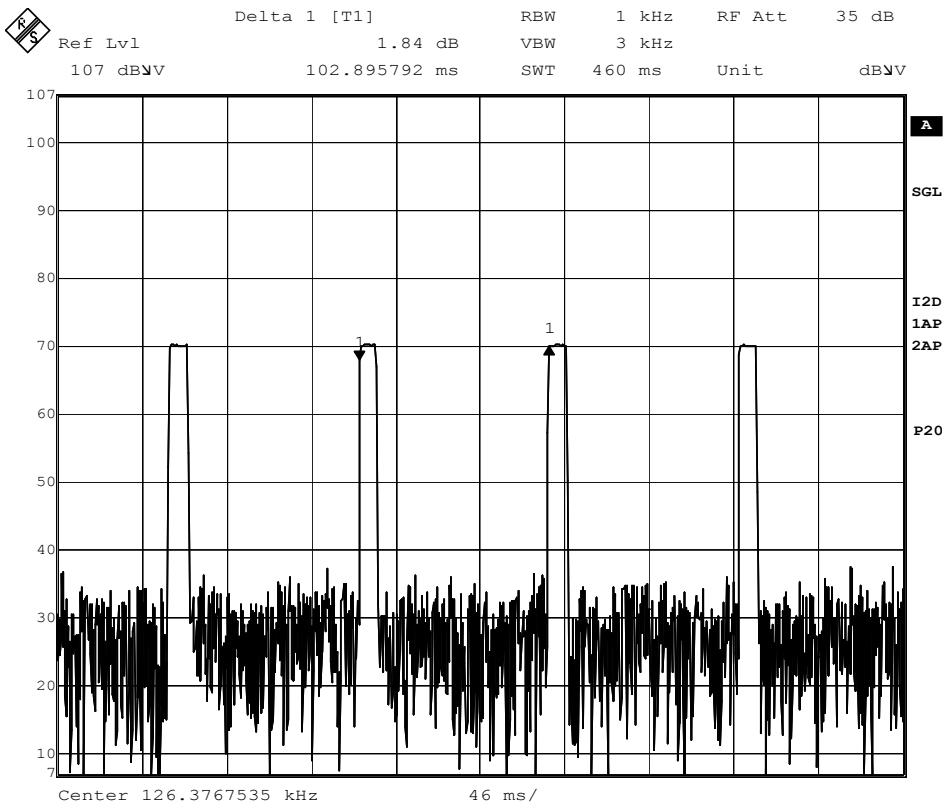


Figure 9. Pulse train period; standby mode.

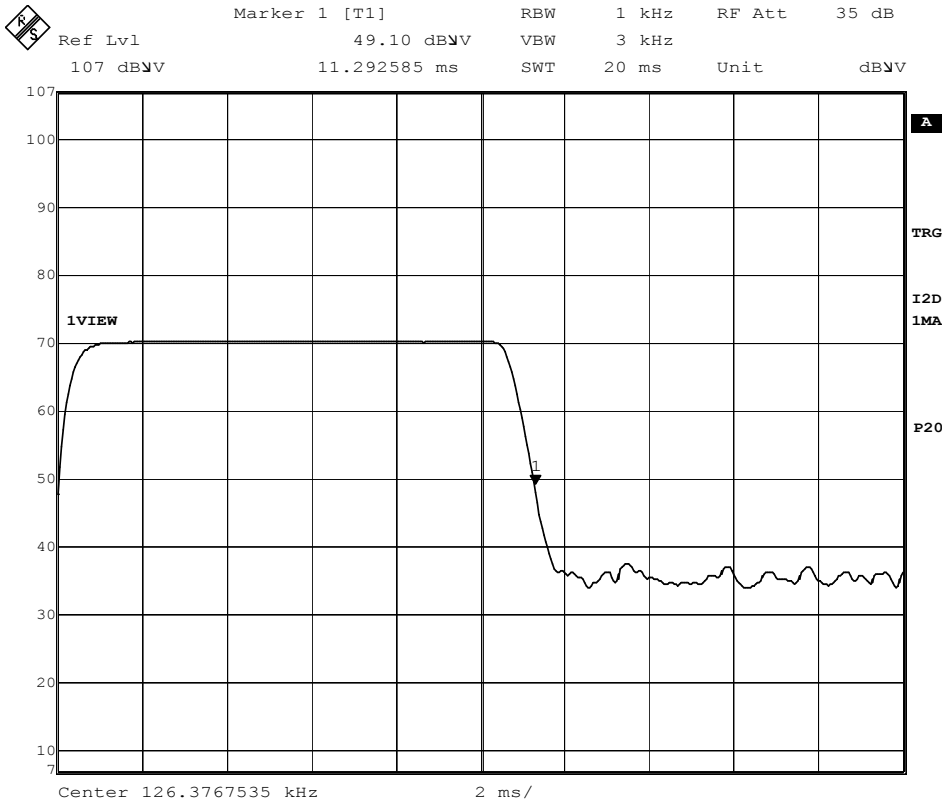


Figure 10. Pulse width; standby mode.

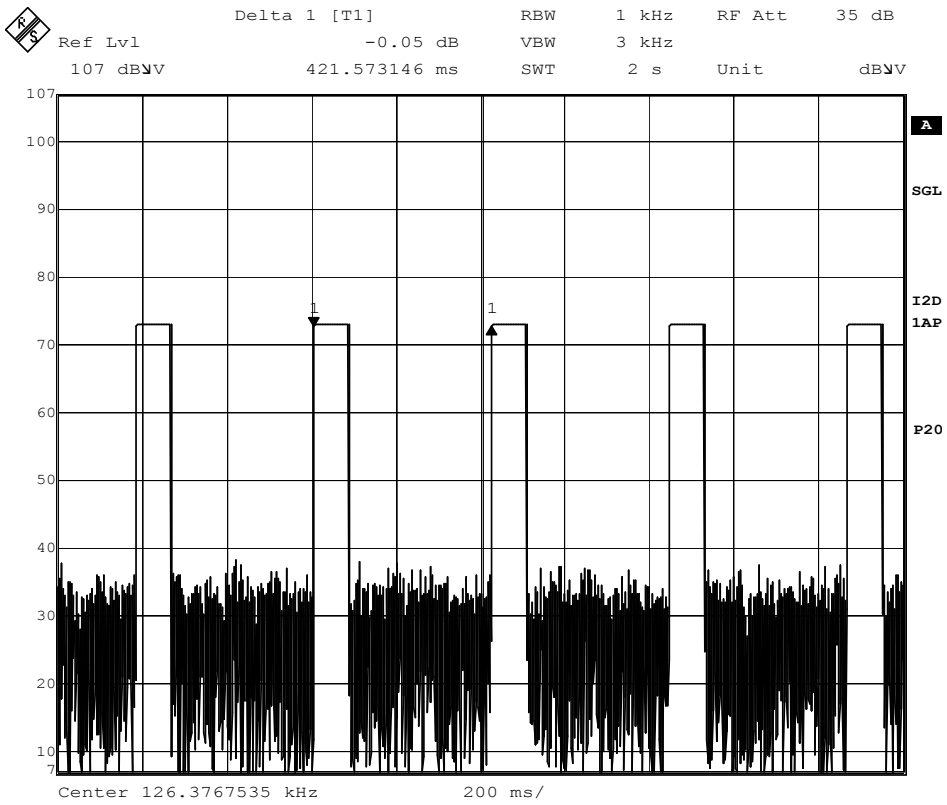


Figure 11. Pulse train period; actively reading from proximity card.

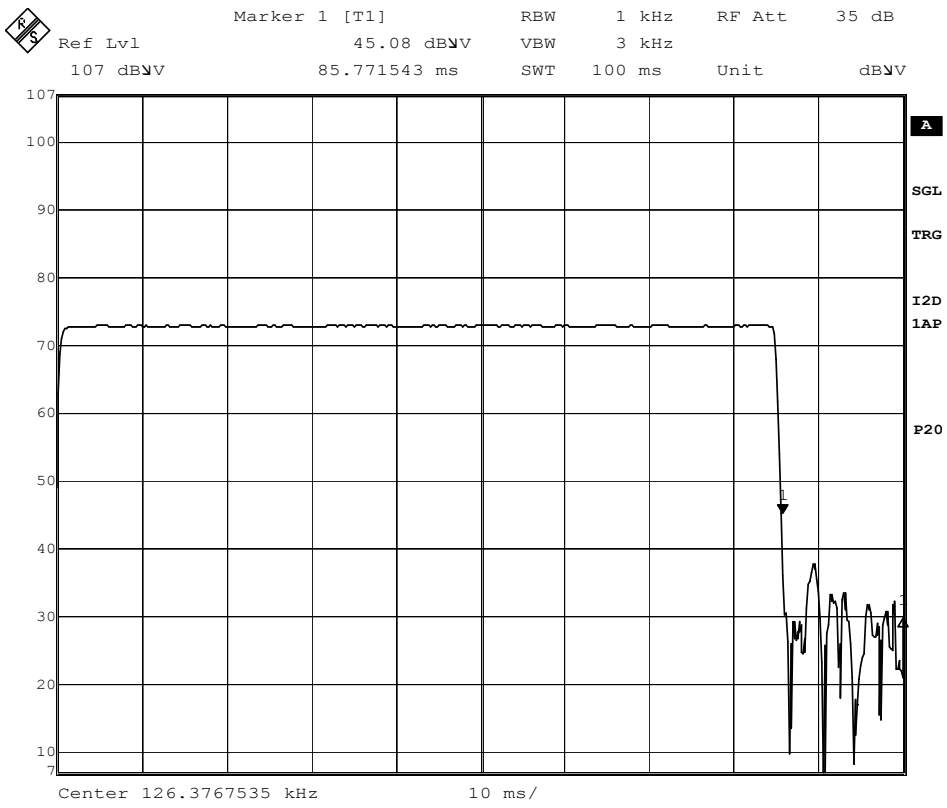


Figure 12. Pulse width; actively reading from proximity card.

8.3 RADIATED EMISSIONS

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

Frequency Range (MHz)	Limit (dB(μV/m))	Measurement Distance (m)
0.009 – 0.490	$20\log(2400/F_{kHz})$	300
0.490 – 1.705	$20\log(24000/F_{kHz})$	30
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 radiated emissions.

The limits in Table 3 are based upon measurements using a quasi-peak detector except for the frequency bands 9 – 90 kHz and 110 – 490 kHz and above 1000 MHz where an average detector is used. In addition, in these bands where an average detector is specified, there is also a limit on the emissions measured using a peak detector that is 20 dB above the average limit.

Test Procedure for Radiated Emissions: Radiated emissions at frequencies below 30 MHz were measured in Lexmark's 10 meter chamber. Radiated emissions above 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 5.1 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 13 and 14. The host PC was located outside of the chamber for this testing; only the EUT was located inside the chamber.

For measurements below 30 MHz, a calibrated loop antenna was used. The antenna was located either 10 meters or 3 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 limit in Table 3 for emissions in the frequency range 0.009 – 0.490 MHz is specified at 300 meters, a method to extrapolate the measured values from the actual measurement distance to 300 meters must be employed. Measurements are made at both 3 meters and 10 meters and the electric field at 300 meters is then calculated using the following relationship:

$$E_{300m} = E_{10m} + K$$

where *K* is the extrapolation factor:

$$K = 20\log\left(\left(\frac{10}{300}\right)^{a}\right)$$

with:

$$a = \frac{Amplitude_{3meters} - Amplitude_{10meters}}{20\log\left(\frac{10}{3}\right)}$$

For emissions measured in the frequency the range 0.490 – 30 MHz, the emission levels measured at 10 meters are translated to 30 meters using a $1/r^2$ relationship, or 40 dB/decade. With this, the levels at 30 meters are given as:

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

For measurement of emissions in the frequency 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. The receive antenna was located 3 meters from the EUT. After obtaining a plot of the peak emissions, those emissions closest to the limit were investigated using the quasi-peak detector.

The EUT was tested in both the standby mode and while actively reading from a proximity card. At the fundamental operating frequency of the EUT, the maximum radiated electric field was measured with the AC voltage of the host PC set to a nominal voltage of 117VAC/60Hz (V_{nom}), 99.5VAC/60Hz (85% V_{nom}) and 134.6VAC/60Hz (115% V_{nom}).

Results for Radiated Emissions: Tables 4 - 11 contain data on the radiated emissions of significant amplitude from the EUT configuration shown in Section 5.1. The frequency range from 9 kHz – 1000 MHz was investigated for radiated emissions. This data indicates that the EUT met the requirements for radiated emissions.

Frequency (MHz)	Detector	Factor (dB(1/m))	Measurement Distance (meters)		Amplitude (dB(μV/m))		*K* (dB)	Average Correction Factor (dB)	Corrected Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)	Peak Limit dB(μV/m))	Peak Margin (dB)
			d_1	d_2	d_1	d_2							
0.126	Peak	20.03	3	10	71.65	45.82	-72.97	-19.19	-46.34	25.57	71.91	45.57	72.72

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

Frequency (MHz)	Detector	Factor (dB(1/m))	Measurement Distance (meters)		Amplitude (dB(μV/m))		Extrapolation Factor (dB)	Average Correction Factor (dB)	Corrected Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)	Peak Limit (dB(μV/m))	Peak Margin (dB)
			d_1	d_2	d_1	d_2							
0.1264	Peak	20.03	3	10	72.15	45.68	-74.78	-13.83	-42.93	25.57	68.5	45.57	74.67
0.1005	QP	20.4	N/A	10	N/A	27.04	-40	N/A	-12.96	27.56	40.52	N/A	N/A
11.8257	QP	20.49	N/A	10	N/A	34.74	-40	N/A	-5.26	29.5	34.76	N/A	N/A

Table 5. Radiated emissions below 30 MHz; actively communicating with card; $V = V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Measurement Distance (meters)		Peak Amplitude (dB(μV/m))		Extrapolation Factor (dB)	Average Correction Factor (dB)	Corrected Amplitude (dB(μV/m))	Average Limit @ 300 meters (dB(μV/m))	Average Margin (dB)	Peak Limit @ 300 meters (dB(μV/m))	Peak Margin (dB)
		d_1	d_2	d_1	d_2							
0.1264	20.03	3	10	71.35	45.22	-73.82	-19.19	-47.79	25.57	73.36	45.57	74.17

Table 6. Field strength at fundamental; standby mode; $V = 85\% V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Measurement Distance (meters)		Peak Amplitude (dB(μV/m))		Extrapolation Factor (dB)	Average Correction Factor (dB)	Corrected Amplitude (dB(μV/m))	Average Limit @ 300 meters (dB(μV/m))	Average Margin (dB)	Peak Limit @ 300 meters (dB(μV/m))	Peak Margin (dB)
		d_1	d_2	d_1	d_2							
0.1264	20.03	3	10	71.39	46.65	-69.89	-13.83	-37.07	25.57	62.64	45.57	68.81

Table 7. Field strength at fundamental; actively communicating with card; $V = 85\% V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Measurement Distance (meters)		Peak Amplitude (dB(μV/m))		Extrapolation Factor (dB)	Average Correction Factor (dB)	Corrected Amplitude (dB(μV/m))	Average Limit @ 300 meters (dB(μV/m))	Average Margin (dB)	Peak Limit @ 300 meters (dB(μV/m))	Peak Margin (dB)
		d_1	d_2	d_1	d_2							
0.1264	20.03	3	10	71.37	45.68	-72.57	-19.19	-46.08	25.57	71.65	45.57	72.46

Table 8. Field strength at fundamental; standby mode; $V = 115\% V_{nom}$.

Frequency (MHz)	Factor (dB(1/m))	Measurement Distance (meters)		Peak Amplitude (dB(μV/m))		Extrapolation Factor (dB)	Average Correction Factor (dB)	Corrected Amplitude (dB(μV/m))	Average Limit @ 300 meters (dB(μV/m))	Average Margin (dB)	Peak Limit @ 300 meters (dB(μV/m))	Peak Margin (dB)
		d_1	d_2	d_1	d_2							
0.1264	20.03	3	10	72.23	45.48	-75.57	-13.83	-43.92	25.57	69.49	45.57	75.66

Table 9. Field strength at fundamental; actively communicating with card; $V = 115\% V_{nom}$.

Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
39.293	V	-22.12	14.19	33.73	40	6.27
40.045	V	-21.93	13.78	34.34	40	5.66
46.647	V	-22.00	10.14	38.58	40	1.42
46.89	V	-22.00	10.01	38.32	40	1.69
87.82	V	-21.47	8.57	38.57	40	1.44
385.343	V	-19.51	15.17	39.31	46	6.69

Table 10. Results for radiated emissions 30 - 1000 MHz; standby mode.

Frequency (MHz)	Polarity	Cable Loss (dB)	Antenna Factor (dB(1/m))	Amplitude (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
40.006	V	-21.93	13.80	33.47	40	6.53
43.376	V	-22.00	10.29	37.49	40	2.51
46.657	V	-22.00	10.14	37.20	40	2.8
87.573	V	-21.47	8.54	37.65	40	2.36
87.833	V	-21.47	8.58	37.64	40	2.36
385.353	V	-19.51	15.17	39.65	46	6.35

Table 11. Results for radiated emissions 30 – 1000 MHz; actively communicating with card.

Figure 13. Test configuration for radiated emissions (front view).

Figure 14. Test configuration for radiated emissions (back view).

8.4 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 12.

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 12. Limits for conducted emissions.

Test Procedure for AC Conducted Emissions: The test configuration shown Section 5.2 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 15 and 16, the EUT 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 host PC was plugged into the LISN (Line Impedance Stabilization Network) with the excess of the PC line cord length bundled in the center. The USB cable was 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 this cable was 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

For this testing, the EUT was operated in both standby and while actively communicating with a proximity card.

Results for AC Conducted Emissions: Table 14 contains the emissions with the highest amplitudes for the EUT. The EUT met the requirements for conducted emissions given in Table 12.

Frequency (MHz)	Line	Correction Factors (dB)	Quasi-peak Amplitude (dB(μV))	Quasi-peak Limit (dB(μV))	Quasi-peak Margin (dB)	Average Amplitude (dB(μV))	Average Limit (dB(μV))	Average Margin (dB)
0.192	P	10.53	41.82	64.8	22.98	41.46	54.8	13.34
1.729	N	10.38	33.1	56	22.9	31.21	46	14.79
13.349	P	11.35	43.16	60	16.84	41.94	50	8.06
13.373	N	11.36	43.96	60	16.04	42.85	50	7.15
17.76	P	11.66	43.12	60	16.88	41.39	50	8.61
26.881	N	12.24	43.53	60	16.47	40.11	50	9.89

Table 13. Results for AC conducted emissions; actively communicating with proximity card.

Frequency (MHz)	Line	Correction Factors (dB)	Quasi-peak Amplitude (dB(μV))	Quasi-peak Limit (dB(μV))	Quasi-peak Margin (dB)	Average Amplitude (dB(μV))	Average Limit (dB(μV))	Average Margin (dB)
0.192	P	10.52	41.77	64.79	23.02	41.42	54.79	13.37
1.218	P	10.33	34.02	56	21.98	32.66	46	13.34
13.33	N	11.35	44.16	60	15.84	43.07	50	6.93
13.577	P	11.37	43.58	60	16.42	42.25	50	7.75
17.935	P	11.67	43.05	60	16.95	41.48	50	8.52
26.73	N	12.24	44.15	60	15.85	42.05	50	7.95

Table 14. Results for AC conducted emissions; standby mode.

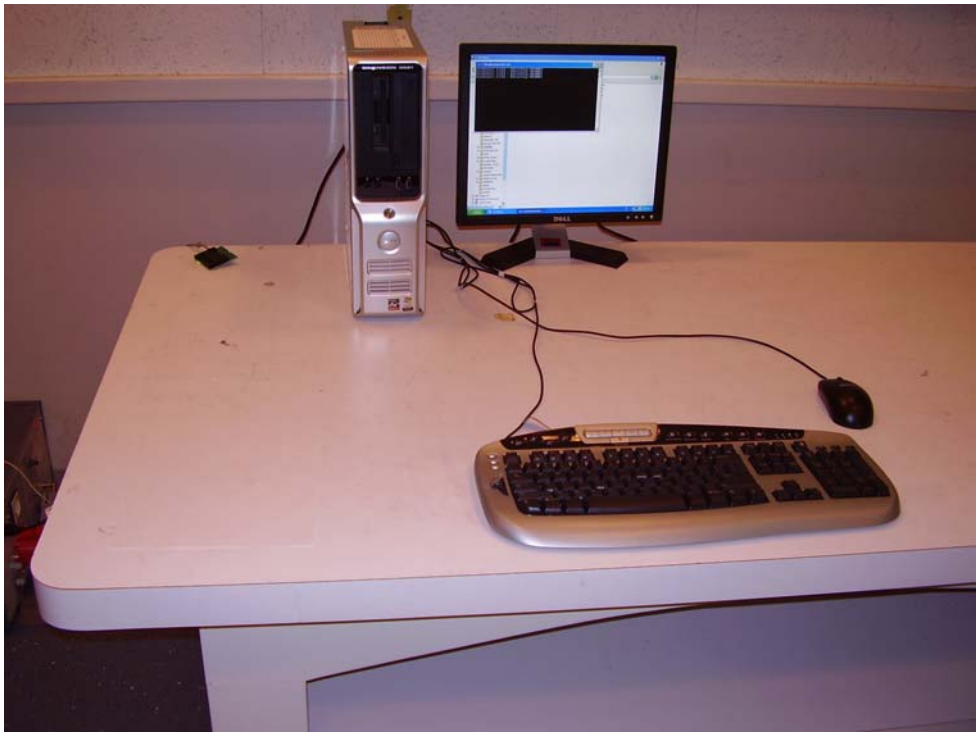


Figure 15. Test configuration for transmitter conducted emissions (front view).

Figure 16. Test configuration for transmitter conducted emissions (side view).

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 $1/r^3$ rolloff of the electric field, the distance from the EUT where the electric field equals the maximum allowed in [6] is calculated.

Per [6], the limit for the electric field in the category of general public in the frequency range of 0.003 – 1 MHz is:

$$E_{\lim it} = 280V/m = 168.94dB(\mu V/m)$$

Assuming a $1/r^3$ (60 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 is the following:

$$E(r) = E_{10m} + 20\log\left(\left(\frac{10}{r}\right)^3\right)$$

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

$$E_{\lim it} = E_{10m} + 20\log\left(\left(\frac{10}{r}\right)^3\right)$$

where the value of the distance r can be determined so that the equation is satisfied. Using a maximum peak electric field at 10 meters of 46.65 dB(μV/m), the value of r that satisfies this equation is found to be 9.2 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 [6], the limit of radiation exposure for a device operating at a frequency of 126 kHz under the Limits for Device used by the General Public is 168.94 dB(μV/m). The electric field radiated by the EUT was below this value for separation distances of 20 cm or greater.

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