

EMI TEST REPORT

FCC CERTIFICATION / ISED

Applicant:

LG Electronics MobileComm U.S.A., Inc.
1000 Sylvan Avenue, Englewood Cliffs NJ 07632
United States

Date of Receipt: May 09, 2018**Date of Issue:** May 24, 2018**Test Report No.** HCT-EM-1805-FI009**FCC ID**
IC**ZNFX510WM**
2703C-X510WM

Rule Part(s) / Standard(s): FCC CFR 47 PART 15 Subpart B Class B
ICES-003 Issue 6 Class B / ANSI C63.4-2014

EUT Type: Multi-band GSM/WCDMA/LTE Phone with BT and WiFi

Model Name: LM-X510WM

Additional Model Name: LMX510WM, X510WM

TA Information: Model Name: MCS-H06WR, Manufacturer: SUNLIN

Date of Test: May 16, 2018 – May 23, 2018

The device bearing the trade name and model specified above, has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in ANSI C63.4-2014. (See Test Report if any modifications were made for compliance)

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

HCT certifies that no party to application has been denied the FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C 862

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REVISION HISTORY

The revision history for this document is shown in table.

Report No.	Issue Date	Description
HCT-EM-1805-FI009	May 24, 2018	Initial Release



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1. GENERAL INFORMATION

1.1 Description of EUT

Its basic purpose is used for communications.

FCC ID	ZNFX510WM
IC	2703C-X510WM
Model	LM-X510WM
Additional Model	LMX510WM, X510WM
EUT Type	Multi-band GSM/WCDMA/LTE Phone with BT and WiFi
TX Frequency	824.20 MHz to 848.80 MHz (GSM 850) 1 850.20 MHz to 1 909.80 MHz (GSM 1 900) 1 852.4 MHz to 1 907.6 MHz (WCDMA B2) 1712.4 MHz to 1752.6 MHz (WCDMA B4) 826.40 MHz to 846.60 MHz (WCDMA B5) 1 850 MHz to 1 910 MHz (LTE B2) 1 710 MHz to 1 755 MHz (LTE B4) 824 MHz to 849 MHz (LTE B5) 2 496 MHz to 2 570 MHz (LTE B7) 699 MHz to 716 MHz (LTE B12) 777 MHz to 787 MHz (LTE B13) 704 MHz to 716 MHz (LTE B17) 1 710 MHz to 1 780 MHz (LTE B66) 2 402 MHz to 2 480 MHz (Bluetooth) 2 412 MHz to 2 462 MHz (WiFi 2.4 GHz)
RX Frequency	869.20 MHz to 893.80 MHz (GSM 850) 1 930.20 MHz to 1 989.80 MHz (GSM 1 900) 1 932.4 MHz to 1 987.6 MHz (WCDMA B2) 2 112.4 MHz to 2 152.6 MHz (WCDMA B4) 871.40 MHz to 891.60 MHz (WCDMA B5) 1 930 MHz to 1 990 MHz (LTE B2) 2 110 MHz to 2 155 MHz (LTE B4) 869 MHz to 894 MHz (LTE B5) 2 516 MHz to 2 690 MHz (LTE B7) 729 MHz to 746 MHz (LTE B12) 746 MHz to 756 MHz (LTE B13) 734 MHz to 746 MHz (LTE B17) 2 110 MHz to 2 200 MHz (LTE B66) 2 402 MHz to 2 480 MHz (Bluetooth)



1.2 Related Submittal(s) / Grant(s)

Original submittal only.

1.3 Test Facility

Test site is located at 74, SEOICHEON-RO, 578BEON-GIL, MAJANG-MYEON, ICHEON-SI, GYEONGGI-DO, SOUTH KOREA. Those measurement facilities are constructed in conformance with the requirements of ANSI C63.4-2014. The Normalized site attenuations (30 MHz to 1 GHz) and Site validation (1 GHz to 18 GHz) were performed in accordance with the standard in ANSI C63.4-2014

Measurement Facilities	Registration Number
Radiated Field strength measurement facility 3 m Semi Anechoic chamber	90661
Radiated Field strength measurement facility 10 m Semi Anechoic chamber	
Filing the EMI Measurement Facility (3 m Semi Anechoic Chamber and Shielded Room)	IC 5944A-4
Filing the EMI Measurement Facility (10 m Semi-Anechoic Chamber)	IC 5944A-2

1.4 Calibration of Measuring Instrument

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturers recommendations for utilizing calibration equipment, which is traceable to recognized national standards.

Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2006).



1.5 Tested System Details

All equipment descriptions used in the tested system (including inserted cards) are:

Device Type	Model Name	Serial Number	Manufacturer	FCC ID/ IC/ DoC
EUT	LM-X510WM	-	LG	ZNFX510WM 2703C-X510WM
Data cable	EAD63769721	-	Ningbo Broad	-
Earphone	EAB64468444	-	CRESYN	-
Travel adaptor	MCS-H06WR	-	SUNLIN	-
Micro SD card	SAMSUNG EVO+ microSDXC CLASS10 UHS-I (256 GB)	-	SAMSUNG	-

1.6 Cable Description

Product Name	Port	Power Cord Shielded (Y/N)	I/O Cable Shielded (Y/N)	Length (m)
EUT	Micro USB	Y	Y	(P)1.0
	Earphone	N/A	Y	(D)1.2

* The marked “(D)” means the data cable and “(P)” means the power cable.

1.7 Noise Suppression Parts on Cable. (I/O Cable)

Product Name	Port	Ferrite Bead (Y/N)	Location	Metal Hood (Y/N)	Location
EUT	Micro USB	N	N/A	Y	Both End
	Earphone	N	N/A	Y	EUT End



2. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.4-2014.

All measurement uncertainty values are shown with a coverage factor of $k = 2$ to indicate a 95 % level of confidence. The measurement data shown herein meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded Uncertainty (dB)
Conducted Emission (0.15 MHz to 30 MHz)	1.82 dB ($k = 2$)
3 m Radiated Emissions (30 MHz to 1 GHz)	5.20 dB ($k = 2$)
3 m Radiated Emissions (1 GHz to 18 GHz)	5.24 dB ($k = 2$)
3 m Radiated Emissions (18 GHz to 40 GHz)	5.40 dB ($k = 2$)



3. DESCRIPTION OF TEST

3.1 Measurement of Conducted Emission

The test procedure was in accordance with ANSI C63.4-2014, Clause 7.3

- a. The EUT was placed 0.4 meters from the conducting wall of the shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN).
If the EUT is connected to the PC through USB, the AC power-line adapter of the PC is directly connected to a line impedance stabilization network (LISN).
Other support units were connected to the power mains through another LISN. The two LISNs provide 50 Ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both conducted lines are measured in Quasi-Peak and Average mode, including the worst-case data points for each tested configuration.
- c. The frequency range from 150 kHz to 30 MHz was searched.

[Conducted Emission Limits]

Frequency (MHz)	Resolution Bandwidth (kHz)	Quasi-Peak (dB(μV))	Average (dB(μV))
0.15 to 0.5	9	66 to 56*	56 to 46*
0.5 to 5	9	56	46
5 to 30	9	60	50

**Decreases with the logarithm of the frequency.*



3.2 Measurement of Radiated Emission

The test procedure was in accordance with ANSI C63.4-2014, Clause 8.3

- The EUT was placed on the top of a turn table 0.8 meters above the ground at a semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.
- The EUT was set 3 m away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- The antenna height is varied from 1 m to 4 m above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 m to 4 m and the turn table was turned from 0 degrees to 360 degrees to find the maximum reading.
- The test-receiver system was set to Quasi-Peak detect function and specified bandwidth with maximum hold mode when the test frequency is below 1 GHz.
- The test-receiver system was set to Peak and Average detect function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz.
- Place the measurement antenna away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response.(1 GHz to 40 GHz)

[Radiated Emission Limits]

Frequency (MHz)	Antenna Distance (m)	Field Strength ($\mu\text{V}/\text{m}$)	Quasi-Peak ($\text{dB}(\mu\text{V})/\text{m}$)
30 to 88	3	100	40.0
88 to 216	3	150	43.5
216 to 960	3	200	46.0
Above 960	3	500	54.0
Frequency (MHz)	Antenna Distance (m)	Peak ($\text{dB}(\mu\text{V})/\text{m}$)	Average ($\text{dB}(\mu\text{V})/\text{m}$)
Above 1 000	3	74	54

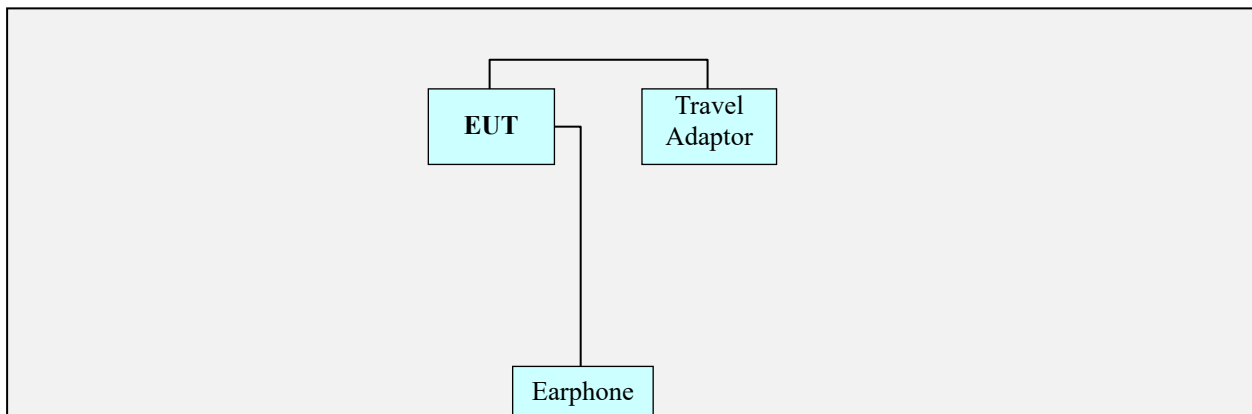


3.2.1 Frequency Range of Radiated Measurements

An unintentional radiator, including a digital device, the spectrum shall be investigated from the lowest radio frequency signal generated or used in the device, without going below the lowest frequency for which a Radiated Emission limit is specified, up to the frequency shown in the following table

Highest frequency generated or used in the device or on which the device operates or tunes (MHz)	Upper frequency of measurement range (MHz)
Below 1.705	30
1.705 to 108	1 000
108 to 500	2 000
500 to 1 000	5 000
Above 1 000	5 th harmonic of the highest frequency or 40 GHz, whichever is lower

3.3 Configuration of Tested System



Non-Conductive Table
Power Line: 120 VAC



4. PRELIMINARY TEST

4.1 Conducted Emission Test

It was tested the following operating mode, after connecting all peripheral devices.

Operation Mode: ☒ Camera (Front) & MP3 mode
☒ Camera (Rear) & FM Radio mode
☒ Idle mode

NOTE. *The worst-case emissions are reported.*

4. 2 Radiated Emission Test

It was tested the following operating mode, after connecting all peripheral devices.

Operation Mode: ☒ Camera (Front) & MP3 mode
☒ Camera (Rear) & FM Radio mode
☒ Idle mode

NOTE. *The worst-case emissions are reported.*



5. CONDUCTED AND RADIATED EMISSION TEST SUMMARY

5.1 Conducted Emission Test

The test results of conducted emission at mains ports provide the following information:

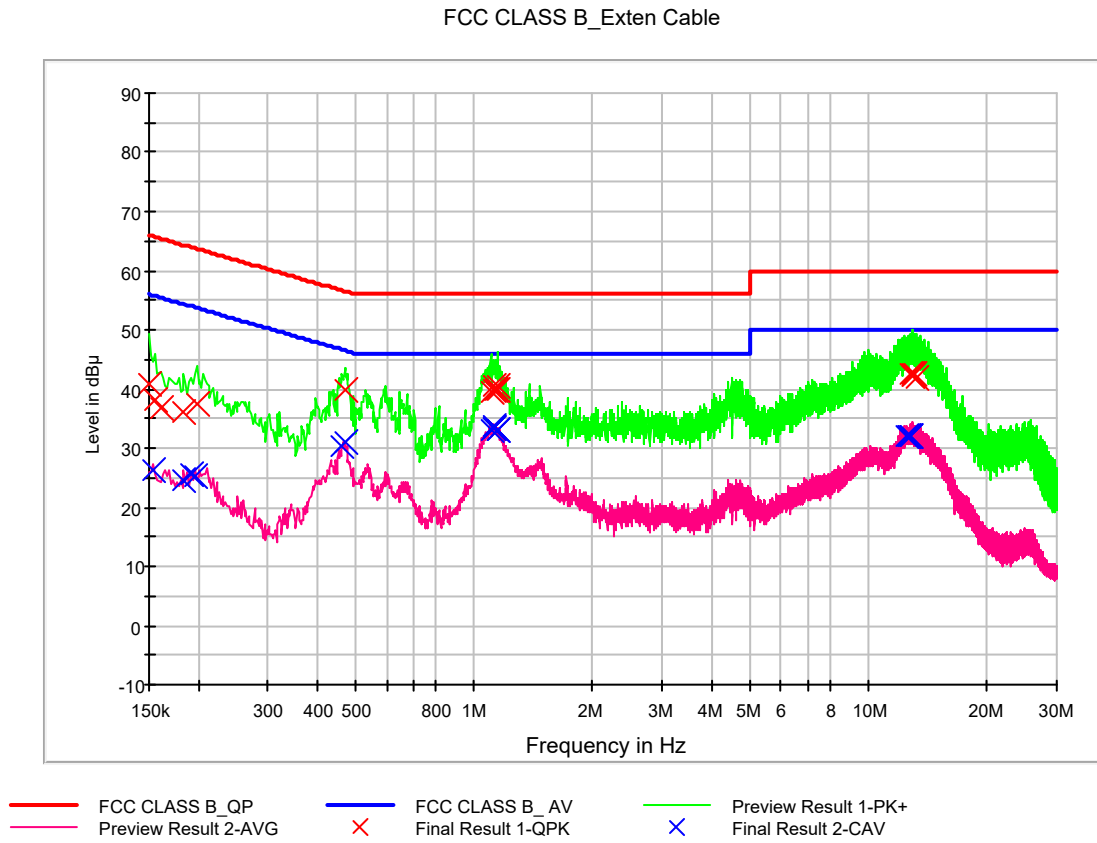
Rule Part / Standard	FCC PART 15 Subpart B Class B ICES-003 Issue 6 Class B / ANSI C63.4-2014
Detector	Quasi-Peak, CISPR-Average
Bandwidth	9 kHz (6 dB)
Worst Case of Operation Mode	Camera (Rear) & FM Radio mode
Kind of Test Site	Shielded Room
Temperature	23.0 °C
Relative Humidity	47.2 %
Test Date	May 17, 2018

- Calculation Formula:

1. Conductor L1 = Hot, Conductor N = Neutral
2. Corr. = LISN Factor + Cable Loss
3. QuasiPeak or CAverage= Receiver Reading + Corr.
4. Margin = Limit – QuasiPeak or CAverage



Figure 1: Conducted Emission, AC Main Port, Line (L1)





QuasiPeak Final Result, Line (L1)

Frequency (MHz)	QuasiPeak (dBuV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBuV)
0.150000	41.0	9.000	L1	9.7	25.0	66.0
0.156000	38.1	9.000	L1	9.7	27.6	65.7
0.160000	36.7	9.000	L1	9.7	28.8	65.5
0.184000	36.1	9.000	L1	9.7	28.2	64.3
0.198000	37.4	9.000	L1	9.7	26.3	63.7
0.472000	39.8	9.000	L1	9.7	16.7	56.5
1.102000	39.4	9.000	L1	9.8	16.6	56.0
1.122000	40.0	9.000	L1	9.8	16.0	56.0
1.128000	40.4	9.000	L1	9.8	15.6	56.0
1.134000	39.8	9.000	L1	9.8	16.2	56.0
1.146000	39.8	9.000	L1	9.8	16.2	56.0
1.150000	40.4	9.000	L1	9.8	15.6	56.0
12.776000	42.4	9.000	L1	10.2	17.6	60.0
12.854000	42.4	9.000	L1	10.2	17.6	60.0
12.936000	42.2	9.000	L1	10.2	17.8	60.0
12.964000	42.4	9.000	L1	10.2	17.6	60.0
13.034000	42.4	9.000	L1	10.2	17.6	60.0
13.286000	41.8	9.000	L1	10.2	18.2	60.0

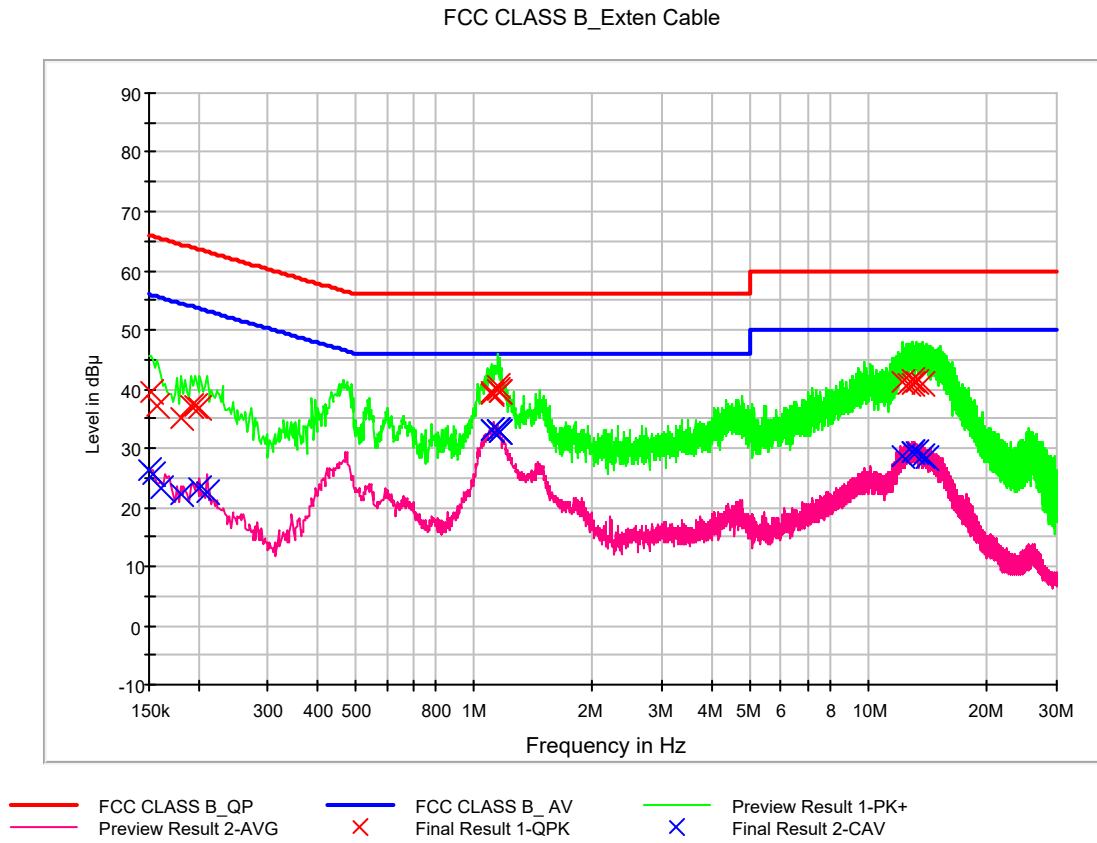


CAverage Final Result, Line (L1)

Frequency (MHz)	CAverage (dBuV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBuV)
0.154000	26.4	9.000	L1	9.7	29.4	55.8
0.184000	24.7	9.000	L1	9.7	29.6	54.3
0.192000	25.6	9.000	L1	9.7	28.4	53.9
0.196000	25.4	9.000	L1	9.7	28.4	53.8
0.462000	30.5	9.000	L1	9.7	16.2	46.7
0.470000	31.1	9.000	L1	9.7	15.4	46.5
1.112000	33.1	9.000	L1	9.8	12.9	46.0
1.118000	33.3	9.000	L1	9.8	12.7	46.0
1.124000	33.7	9.000	L1	9.8	12.3	46.0
1.128000	33.2	9.000	L1	9.8	12.8	46.0
1.146000	33.0	9.000	L1	9.8	13.0	46.0
1.150000	33.1	9.000	L1	9.8	12.9	46.0
12.528000	32.2	9.000	L1	10.2	17.8	50.0
12.568000	32.0	9.000	L1	10.2	18.0	50.0
12.678000	32.2	9.000	L1	10.2	17.8	50.0
12.712000	32.0	9.000	L1	10.2	18.0	50.0
12.782000	32.2	9.000	L1	10.2	17.8	50.0
12.834000	32.1	9.000	L1	10.2	17.9	50.0



Figure 2: Conducted Emission, AC Main Port, Line (N)





QuasiPeak Final Result, Line (N)

Frequency (MHz)	QuasiPeak (dBuV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBuV)
0.152000	39.4	9.000	N	9.7	26.5	65.9
0.158000	37.1	9.000	N	9.7	28.5	65.6
0.180000	35.0	9.000	N	9.7	29.5	64.5
0.192000	37.0	9.000	N	9.7	27.0	63.9
0.196000	37.0	9.000	N	9.7	26.8	63.8
0.202000	36.8	9.000	N	9.7	26.7	63.5
1.102000	39.6	9.000	N	9.8	16.4	56.0
1.114000	39.2	9.000	N	9.8	16.8	56.0
1.146000	39.9	9.000	N	9.8	16.1	56.0
1.150000	40.4	9.000	N	9.8	15.6	56.0
1.156000	39.4	9.000	N	9.8	16.6	56.0
1.160000	39.5	9.000	N	9.8	16.5	56.0
12.242000	41.2	9.000	N	10.3	18.8	60.0
12.598000	41.0	9.000	N	10.4	19.0	60.0
12.856000	41.6	9.000	N	10.4	18.4	60.0
12.960000	40.9	9.000	N	10.4	19.1	60.0
13.202000	41.3	9.000	N	10.4	18.7	60.0
13.680000	40.7	9.000	N	10.4	19.3	60.0



CAverage Final Result, Line (N)

Frequency (MHz)	CAverage (dBuV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBuV)
0.150000	26.3	9.000	N	9.7	29.7	56.0
0.154000	25.7	9.000	N	9.7	30.1	55.8
0.160000	23.2	9.000	N	9.7	32.3	55.5
0.180000	22.3	9.000	N	9.7	32.1	54.5
0.202000	23.3	9.000	N	9.7	30.2	53.5
0.210000	22.5	9.000	N	9.7	30.7	53.2
1.102000	33.1	9.000	N	9.8	12.9	46.0
1.114000	32.9	9.000	N	9.8	13.1	46.0
1.146000	32.9	9.000	N	9.8	13.1	46.0
1.150000	33.0	9.000	N	9.8	13.0	46.0
1.156000	32.6	9.000	N	9.8	13.4	46.0
1.160000	32.6	9.000	N	9.8	13.4	46.0
12.242000	28.6	9.000	N	10.3	21.4	50.0
12.958000	29.2	9.000	N	10.4	20.8	50.0
12.988000	29.2	9.000	N	10.4	20.8	50.0
13.202000	29.4	9.000	N	10.4	20.6	50.0
13.680000	28.6	9.000	N	10.4	21.4	50.0
14.016000	28.4	9.000	N	10.4	21.6	50.0



5.2 Radiated Emission Test

The test results of radiated emission provide the following information:

-For Measurement Below 1 GHz

Rule Part / Standard	FCC PART 15 Subpart B Class B ICES-003 Issue 6 Class B / ANSI C63.4-2014
Detector	Quasi-Peak
Bandwidth	120 kHz (6 dB)
Worst Case of Operation Mode	Camera (Rear) & FM Radio mode
Kind of Test Site	3 m semi anechoic chamber
Temperature	22.3 °C
Relative Humidity	43.9 %
Test Date	May 16, 2018

Frequency (MHz)	Quasi Peak (dBμV/m)	Antenna Height (cm)	POL. (H/V)	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
31.323200	24.7	225.0	V	308.0	18.8	15.3	40.0
50.599200	18.0	99.9	V	298.0	20.3	22.0	40.0
114.596800	19.6	174.9	V	209.0	17.2	23.9	43.5
165.206400	18.2	125.1	V	188.0	19.8	25.3	43.5
634.662400	27.7	292.8	V	136.0	27.9	18.3	46.0
937.309600	31.4	274.9	H	145.0	31.5	14.6	46.0

- Calculation Formula:

1. POL. H = Horizontal, POL. V = Vertical
2. QuasiPeak = Reading (Receiver Reading) + Corr.
3. Corr. (Correction Factor) = Antenna Factor + Cable Loss
4. Margin = Limit - QuasiPeak



-For Measurement Above 1 GHz

Rule Part / Standard	FCC PART 15 Subpart B Class B ICES-003 Issue 6 Class B / ANSI C63.4-2014
Detector	Peak mode: Peak (RBW: 1 MHz, VBW: 3 MHz) CISPR-Average mode: Peak (RBW: 1 MHz, VBW: 10 Hz)
Highest Operating Frequency	2 690 MHz
Tested Frequency Range	1 GHz to 18 GHz
Worst Case of Operation Mode	Camera (Rear) & FM Radio mode
Kind of Test Site	3 m semi anechoic chamber
Temperature	23.9 °C
Relative Humidity	44.8 %
Test Date	May 23, 2018

Frequency (MHz)	Peak (dBμV/m)	Antenna Height (cm)	POL. (H/V)	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1391.255000	31.6	197.6	V	259.0	-28.6	42.4	74.0
3096.510000	33.8	277.4	H	114.0	-22.8	40.2	74.0
4603.665000	36.4	149.5	V	309.0	-19.4	37.6	74.0
6038.345000	38.1	100.0	H	333.0	-16.4	35.9	74.0
7827.405000	42.0	249.7	H	328.0	-12.0	32.0	74.0
9206.440000	43.4	198.4	V	55.0	-11.1	30.6	74.0

Frequency (MHz)	CAverage (dBμV/m)	Antenna Height (cm)	POL. (H/V)	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBμV/m)
1391.255000	17.6	197.6	V	259.0	-28.6	36.4	54.0
3096.510000	21.0	277.4	H	114.0	-22.8	33.0	54.0
4603.665000	23.1	149.5	V	309.0	-19.4	30.9	54.0
6038.345000	25.2	100.0	H	333.0	-16.4	28.8	54.0
7827.405000	29.4	249.7	H	328.0	-12.0	24.6	54.0
9206.440000	30.3	198.4	V	55.0	-11.1	23.7	54.0

- Calculation Formula:

1. POL. H = Horizontal, POL. V = Vertical
2. Peak or CAverage = Reading (Receiver Reading) + Corr.
3. Corr. (Correction Factor) = Antenna Factor+ Cable Loss –Amplifier Gain
4. Margin = Limit - Peak or CAverage



6. LIST OF TEST EQUIPMENT

Type	Manufacturer	Model Name	Serial Number	Calibration Cycle	CAL Date
<u>Conducted Emission</u>					
☐ EMI Test Receiver	Rohde & Schwarz	ESCI	100584	1 year	06.20.2017
☒ EMI Test Receiver	Rohde & Schwarz	ESCI	100033	1 year	06.27.2017
☐ LISN	Rohde & Schwarz	ENV216	100073	1 year	07.18.2017
☒ LISN	Rohde & Schwarz	ENV216	102245	1 year	12.20.2017
☒ Software	Rohde & Schwarz	EMC32 VER8.54.0	-	-	-
<u>Radiated Emission</u>					
-For measurement below 1 GHz					
☒ EMI Test Receiver	Rohde & Schwarz	ESU40	100524	1 year	08.16.2017
☒ Trilog Antenna	Schwarzbeck	VULB 9168	760	2 year	04.06.2017
☐ Antenna master	HD GmbH	MA240	240/520	N/A	-
☐ Antenna master controller	HD GmbH	HD 100	100/637	N/A	-
☒ Antenna master	INNCO Systems	MA4640-XP-ET	-	N/A	-
☒ Antenna master controller	INNCO Systems	CO 3000	CO 3000/870/ 35990515/L	N/A	-
☒ Turn Table	INNCO Systems	-	-	N/A	-
☒ Turn Table controller	INNCO Systems	CO2000	-	N/A	-
☐ EMI Test Receiver	Rohde & Schwarz	ESU26	100241	1 year	08.16.2017
☐ Antenna master	INNCO Systems	MA4000-EP	MA4000/283	N/A	-
☐ Turn Table	INNCO Systems	DT3000-3T	DT3000/69	N/A	-
☒ Software	Rohde & Schwarz	EMC32 VER8.40.0	-	-	-
-For measurement above 1 GHz					
☒ EMI Test Receiver	Rohde & Schwarz	ESU40	100524	1 year	08.16.2017
☒ Antenna master	INNCO Systems	MA4640-XP-ET	-	N/A	-
☒ Antenna master controller	INNCO Systems	CO 3000	CO 3000/870/ 35990515/L	N/A	-
☒ Turn Table	INNCO Systems	-	-	N/A	-
☒ Turn Table controller	INNCO Systems	CO2000	-	N/A	-
☒ Horn Antenna	Schwarzbeck	BBHA 9120D	296	2 year	10.12.2016
☒ Low Noise Amplifier	TESTEK	TK-PA18H	170034-L	1 year	03.06.2018
☐ Power Amplifier	TESTEK	TK-PA1840H	170030-L	1 year	12.20.2017
☐ Horn Antenna	Schwarzbeck	BBHA 9170	BBHA9170#786	2 year	12.05.2017
☐ EMI Test Receiver	Rohde & Schwarz	ESU26	100241	1 year	08.16.2017
☐ Turn Table	INNCO Systems	DT3000-3T	DT3000/69	N/A	-
☒ Software	Rohde & Schwarz	EMC32 VER8.40.0	-	-	-



7. CONCLUSION

The data collected shows that the **EUT Type: Multi-band GSM/WCMDA/LTE Phone with BT and WiFi, Model: LM-X510WM** complies with §15.107 and §15.109 of the FCC rules and ICES-003 Issue 6 of the IC rules.



8. APPENDIX A. TEST SETUP PHOTOGRAPHS

Please refer to Appendix A