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TEST REPORT

FCC PART 15.247

Report Reference No.: CTL1610310501-WF-04

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Product Name: RELESS RePad R606

Model/Type reference: R606

List Model(s): N/A

Trade Mark: RePad

FCC ID: 2AFL3-R606

Applicant's name: Hummingbird System Inc

Address of applicant: 2140 Peralta Blvd Suite 212D, Fremont, CA 94536

Test Firm: Shenzhen CTL Testing Technology Co., Ltd.

Address of Test Firm: Floor 1-A, Baisha Technology Park, No.3011, Shahexi Road,
Nanshan District, Shenzhen, China 518055

Test specification:

Standard: FCC Part 15.247: Operation within the bands 902-928 MHz,
2400-2483.5 MHz and 5725-5850 MHz.

TRF Originator: Shenzhen CTL Testing Technology Co., Ltd.

Master TRF: Dated 2011-01

Date of Receipt: Nov. 03, 2016

Date of Test Date: Nov. 04, 2016–March. 18, 2017

Data of Issue: March 18, 2017

Result: Pass

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TEST REPORT

Test Report No. :	CTL1610310501-WF-04	March 18, 2017 Date of issue
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Equipment under Test : RELESS RePad R606

Model /Type : R606

Listed Models : N/A

Applicant : **Hummingbird System Inc**

Address : 2140 Peralta Blvd Suite 212D, Fremont, CA 94536

Manufacturer : **Five Science and Technology Co.,LTD.**

Address : 12-13F, Block C2, Nanshan Zhiyuan, No. 1001
Xueyuan Road, Nanshan District, Shenzhen, China

Test result	Pass *
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* In the configuration tested, the EUT complied with the standards specified page 5.

The test report merely corresponds to the test sample.

It is not permitted to copy extracts of these test result without the written permission of the test laboratory.

**** Modified History ****

Revisions	Description	Issued Data	Report No.	Remark
Version 1.0	Initial Test Report Release	2017-03-18	CTL1610310501-WF-04	Tracy Qi



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1. SUMMARY

1.1. TEST STANDARDS

The tests were performed according to following standards:

FCC Rules Part 15.247: Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz

ANSI C63.10: 2013: American National Standard for Testing Unlicensed Wireless Devices

ANSI C63.4: 2014: –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 40GHz
Range of 9 kHz to 40GHz

KDB558074 D01 V03r05: Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

1.2. Test Description

FCC PART 15.247		
FCC Part 15.207	AC Power Conducted Emission	PASS
FCC Part 15.247(a)(2)	6dB Bandwidth	PASS
FCC Part 15.247(d)	Spurious RF Conducted Emission	PASS
FCC Part 15.247(b)	Maximum Conducted Output Power	PASS
FCC Part 15.247(e)	Power Spectral Density	PASS
FCC Part 15.109/ 15.205/ 15.209	Radiated Emissions	PASS
FCC Part 15.247(d)	Band Edge	PASS
FCC Part 15.203/15.247 (b)	Antenna Requirement	PASS

1.3. Test Facility

1.3.1 Address of the test laboratory

Shenzhen CTL Testing Technology Co., Ltd.

Floor 1-A, Baisha Technology Park, No. 3011, Shahexi Road, Nanshan, Shenzhen 518055 China

There is one 3m semi-anechoic chamber and two line conducted labs for final test. The Test Sites meet the requirements in documents ANSI C63.4 and CISPR 22/EN 55022 requirements.

1.3.2 Laboratory accreditation

The test facility is recognized, certified, or accredited by the following organizations:

IC Registration No.: 9618B

The 3m alternate test site of Shenzhen CTL Testing Technology Co., Ltd. EMC Laboratory has been registered by Certification and Engineer Bureau of Industry Canada for the performance of with Registration No.: 9618B.

FCC-Registration No.: 970318

Shenzhen CTL Testing Technology Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Registration No.: 970318.

1.4. Statement of the measurement uncertainty

The data and results referenced in this document are true and accurate. The reader is cautioned that there may be errors within the calibration limits of the equipment and facilities. The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16 - 4 "Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC Measurements" and is documented in the Shenzhen CTL Testing Technology Co., Ltd. quality system acc. to DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Hereafter the best measurement capability for CTL laboratory is reported:

Test	Measurement Uncertainty	Notes
Transmitter power conducted	± 0.57 dB	(1)
Transmitter power Radiated	± 2.20 dB	(1)
Conducted spurious emission 9KHz-40 GHz	± 2.20 dB	(1)
Occupied Bandwidth	± 0.01 ppm	(1)
Radiated Emission 30~1000MHz	± 4.10 dB	(1)
Radiated Emission Above 1GHz	± 4.32 dB	(1)
Conducted Disturbance 0.15~30MHz	± 3.20 dB	(1)

- (1) This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of $k=2$.

2. GENERAL INFORMATION

2.1. Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Normal Temperature:	25°C
Relative Humidity:	55 %
Air Pressure:	101 kPa

2.2. General Description of EUT

Product Name:	RELESS RePad R606
Model/Type reference:	R606
Power supply:	DC 3.8V from battery
Bluetooth BLE	
Supported type:	Version 4.0 for low Energy
Modulation:	GFSK
Operation frequency:	2402MHz to 2480MHz
Channel number:	40
Channel separation:	2 MHz
Antenna type:	FPC antenna
Antenna gain:	0dBi

Note: For more details, please refer to the user's manual of the EUT.

2.3. Description of Test Modes and Test Frequency

The Applicant provides communication tools software (AMFAN RF Test Tool) to control the EUT for staying in continuous transmitting (Duty Cycle more than 98%) and receiving mode for testing. There are 39 channels provided to the EUT and Channel 0/19/39 was selected for BT4.0 test.

Operation Frequency List BT4.0 :

Channel	Frequency (MHz)
0	2402
1	2404
02	2406
⋮	⋮
19	2440
⋮	⋮
37	2476
38	2478
39	2480

Note: The line display in grey were the channel selected for testing

2.4. Special Accessories

No.	Equipment	Manufacturer	Model No.	Serial No.	Length	shielded/ unshielded	Notes
1	PC	ASUS	X555YA	QCWB335	/	/	DOC
2	Power adapter	ASUS	Y481C	8AW0829002 095	1.00m	unshielded	DOC

2.5. Equipments Used during the Test

Test Equipment	Manufacturer	Model No.	Serial No.	Calibration Date	Calibration Due Date
LISN	R&S	ENV216	3560.6550.12	2016/06/02	2017/06/01
LISN	R&S	ESH2-Z5	860014/010	2016/06/02	2017/06/01
Bilog Antenna	Sunol Sciences Corp.	JB1	A061713	2016/06/02	2017/06/01
EMI Test Receiver	R&S	ESCI	103710	2016/06/02	2017/06/01
Spectrum Analyzer	Agilent	E4407B	MY41440676	2016/05/21	2017/05/20
Spectrum Analyzer	Agilent	N9020A	US46220290	2016/01/17	2017/01/16
Power Meter	Anritsu	ML2487B	110553	2016/06/02	2017/06/01
Power Sensor	Anritsu	MA2411B	100345	2016/05/21	2017/05/20
Controller	EM Electronics	Controller EM 1000	N/A	2016/05/21	2017/05/20
Horn Antenna	Sunol Sciences Corp.	DRH-118	A062013	2016/05/19	2017/05/18
Horn Antenna	SCHWARZBACK	BBHA 9170	BBHA9170184	2016/05/19	2017/05/18
Active Loop Antenna	SCHWARZBECK	FMZB1519	1519-037	2016/05/19	2017/05/18
Amplifier	Agilent	8349B	3008A02306	2016/05/19	2017/05/18
Amplifier	Agilent	8447D	2944A10176	2016/05/19	2017/05/18
Temperature/Humidity Meter	Gangxing	CTH-608	02	2016/05/20	2017/05/19
High-Pass Filter	K&L	9SH10-2700/ X12750-O/O	N/A	2016/05/20	2017/05/19
High-Pass Filter	K&L	41H10-1375/ U12750-O/O	N/A	2016/05/20	2017/05/19
Coaxial Cables	HUBER+SUHNER	SUCOFLEX 104PEA-10M	10m	2016/06/02	2017/06/01
Coaxial Cables	HUBER+SUHNER	SUCOFLEX 104PEA-3M	3m	2016/06/02	2017/06/01
Coaxial Cables	HUBER+SUHNER	SUCOFLEX 104PEA-3M	3m	2016/06/02	2017/06/01
RF Cable	Megalon	RF-A303	N/A	2016/06/02	2017/06/01
EMC Test Software	Audix	E3	N/A	N/A	N/A
EMC Test Software	R&S	ES-K1	N/A	N/A	N/A

The calibration interval was one year

2.6. Related Submittal(s) / Grant (s)

This submittal(s) (test report) is intended to comply with Section 15.247 of the FCC Part 15, Subpart C Rules.

2.7. Modifications

No modifications were implemented to meet testing criteria.

3. TEST CONDITIONS AND RESULTS

3.1. Conducted Emissions Test

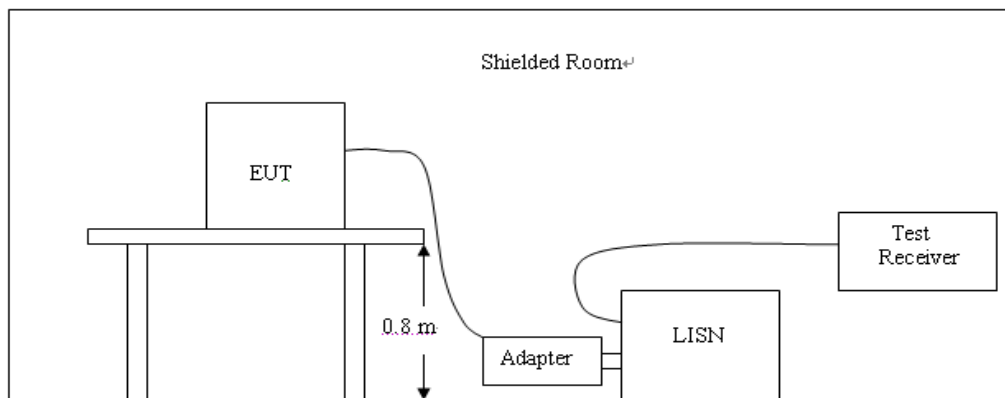
LIMIT

According to §15.207 (a): For an intentional radiator which is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed 250 microvolts (The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz). The limits at specific frequency range are listed as follows:

Frequency Range (MHz)	Limits (dBμV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50

* Decreasing linearly with the logarithm of the frequency

TEST CONFIGURATION



TEST PROCEDURE

1. The equipment was set up as per the test configuration to simulate typical actual usage per the user's manual. The EUT is a tabletop system; a wooden table with a height of 0.8 meters is used and is placed on the ground plane as per ANSI C63.10:2013.
2. Support equipment, if needed, was placed as per ANSI C63.10:2013.
3. All I/O cables were positioned to simulate typical actual usage as per ANSI C63.10:2013.
4. The adapter received AC120V/60Hz power through a Line Impedance Stabilization Network (LISN) which supplied power source and was grounded to the ground plane.
5. All support equipment received AC power from a second LISN, if any.
6. The EUT test program was started. Emissions were measured on each current carrying line of the EUT using a spectrum Analyzer / Receiver connected to the LISN powering the EUT. The LISN has two monitoring points: Line 1 (Hot Side) and Line 2 (Neutral Side). Two scans were taken: one with Line 1 connected to Analyzer / Receiver and Line 2 connected to a 50 ohm load; the second scan had Line 1 connected to a 50 ohm load and Line 2 connected to the Analyzer / Receiver.
7. Analyzer / Receiver scanned from 150 KHz to 30MHz for emissions in each of the test modes.
8. During the above scans, the emissions were maximized by cable manipulation.

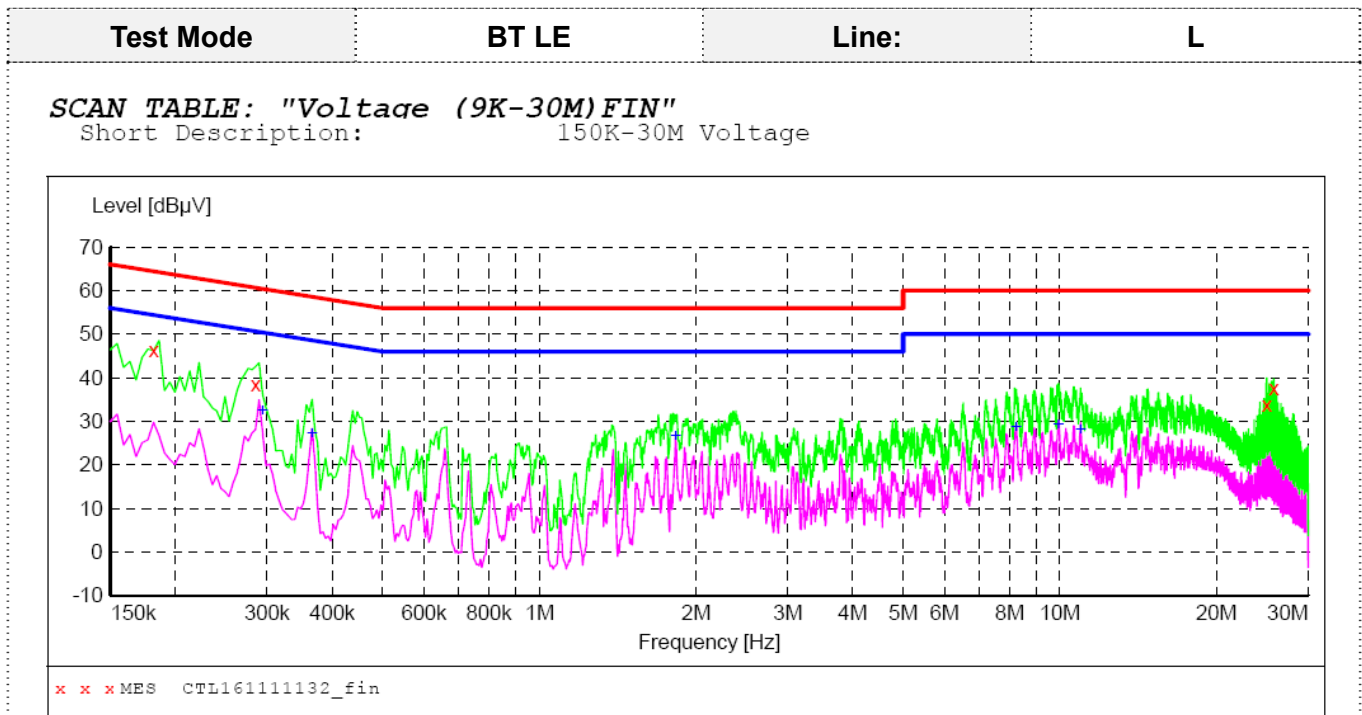
TEST RESULTS

Remark:

1. We measured both at AC 120V/60Hz and AC 240V/50Hz, recorded worst case at AC

120V/60Hz.

2. We measured both at AC power adapter and PC charge modes, recorded worst case at AC power adapter charge mode;
3. Measured all modes and recorded worst case at GFSK modulation High Channel


MEASUREMENT RESULT: "CTL161111132_fin"

11/11/2016 11:50AM

Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Detector	Line	PE
0.181501	46.20	10.2	64	18.2	QP	L1	GND
0.285001	38.50	10.2	61	22.2	QP	L1	GND
24.972001	33.70	11.1	60	26.3	QP	L1	GND
25.750501	37.50	11.1	60	22.5	QP	L1	GND

MEASUREMENT RESULT: "CTL161111132_fin2"

11/11/2016 11:50AM

Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Detector	Line	PE
0.294001	32.40	10.2	50	18.0	AV	L1	GND
0.366001	27.00	10.2	49	21.6	AV	L1	GND
1.828501	26.50	10.3	46	19.5	AV	L1	GND
8.245501	28.50	10.5	50	21.5	AV	L1	GND
9.933001	29.20	10.6	50	20.8	AV	L1	GND
10.963501	27.80	10.6	50	22.2	AV	L1	GND

Test Mode

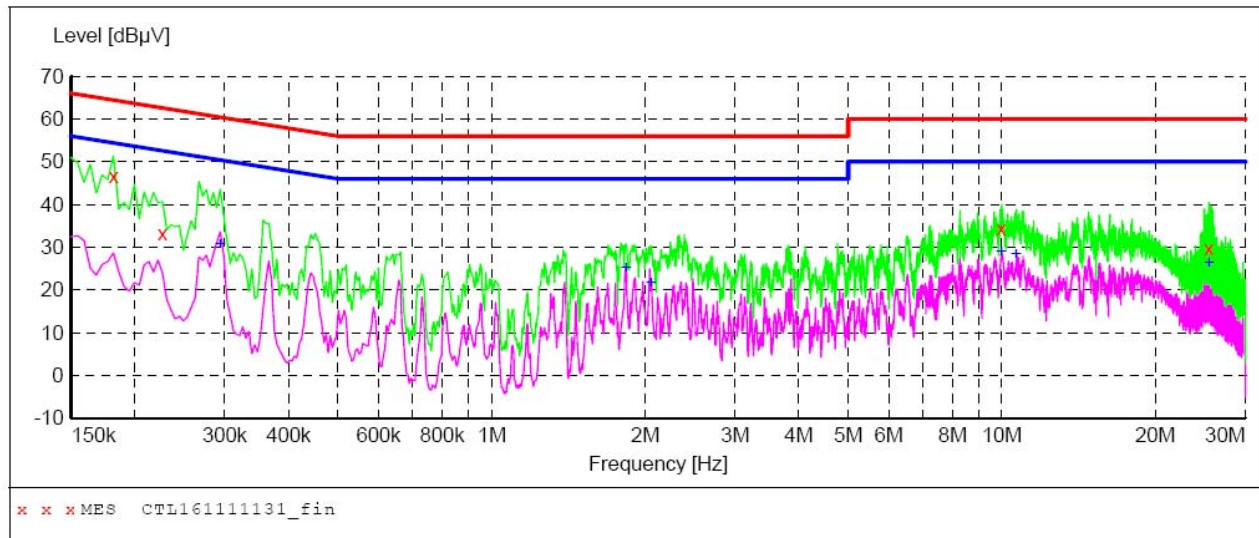
BT LE

Line:

N

SCAN TABLE: "Voltage (9K-30M)FIN"

Short Description: 150K-30M Voltage

**MEASUREMENT RESULT: "CTL161111131_fin"**

11/11/2016 11:42AM

Frequency MHz	Level dBμV	Transd dB	Limit dBμV	Margin dB	Detector	Line	PE
0.181501	46.60	10.2	64	17.8	QP	N	GND
0.226501	33.30	10.2	63	29.3	QP	N	GND
9.960001	34.50	10.6	60	25.5	QP	N	GND
25.444501	29.60	11.1	60	30.4	QP	N	GND

MEASUREMENT RESULT: "CTL161111131_fin2"

11/11/2016 11:42AM

Frequency MHz	Level dBμV	Transd dB	Limit dBμV	Margin dB	Detector	Line	PE
0.294001	30.50	10.2	50	19.9	AV	N	GND
1.833001	24.90	10.3	46	21.1	AV	N	GND
2.053501	21.40	10.4	46	24.6	AV	N	GND
9.978001	28.80	10.6	50	21.2	AV	N	GND
10.657501	28.10	10.6	50	21.9	AV	N	GND
25.449001	26.20	11.1	50	23.8	AV	N	GND

3.2. Radiated Emissions

LIMIT

For intentional device, according to § 15.209(a), the general requirement of field strength of radiated emission out of authorized band shall not exceed the following table at a 3 meters measurement distance.

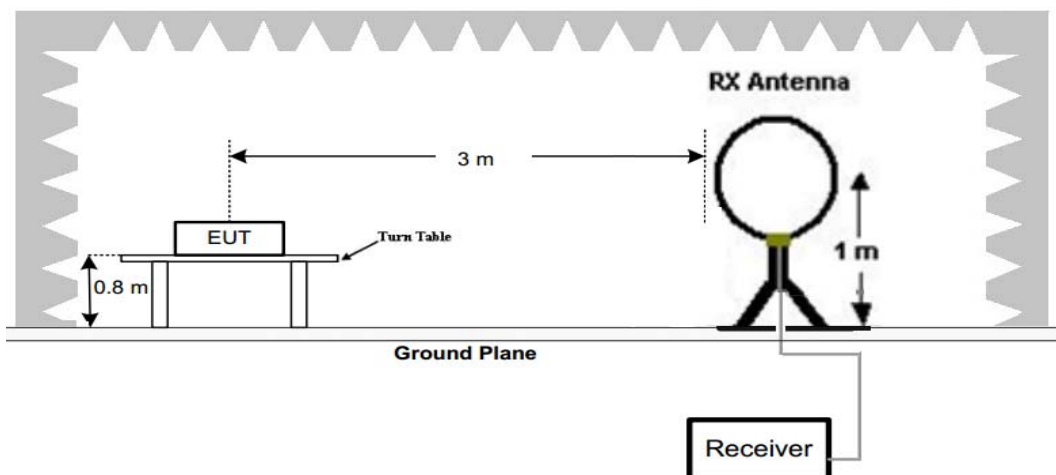
In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a)

Radiated emission limits

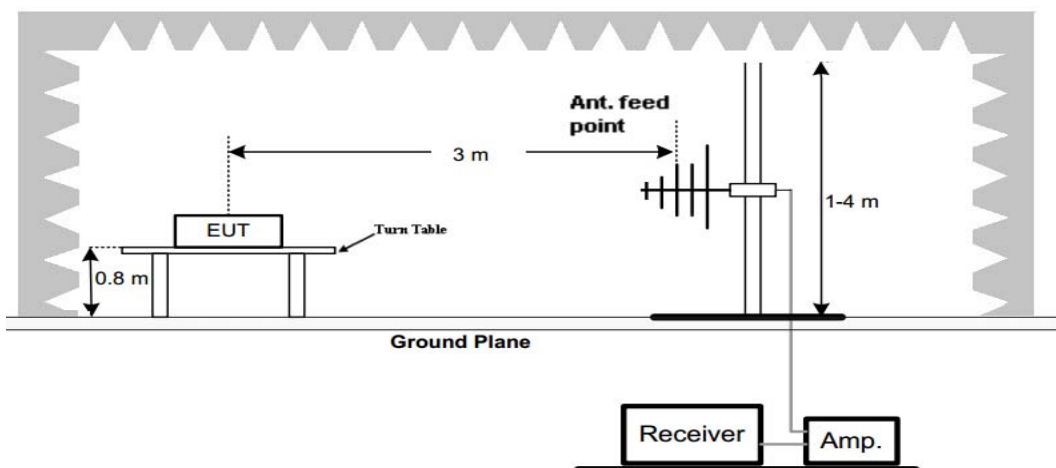
Frequency (MHz)	Distance (Meters)	Radiated (dBμV/m)	Radiated (μV/m)
0.009-0.49	3	$20\log(2400/F(\text{KHz}))+40\log(300/3)$	$2400/F(\text{KHz})$
0.49-1.705	3	$20\log(24000/F(\text{KHz}))+40\log(30/3)$	$24000/F(\text{KHz})$
1.705-30	3	$20\log(30)+40\log(30/3)$	30
30-88	3	40.0	100
88-216	3	43.5	150
216-960	3	46.0	200
Above 960	3	54.0	500

TEST CONFIGURATION

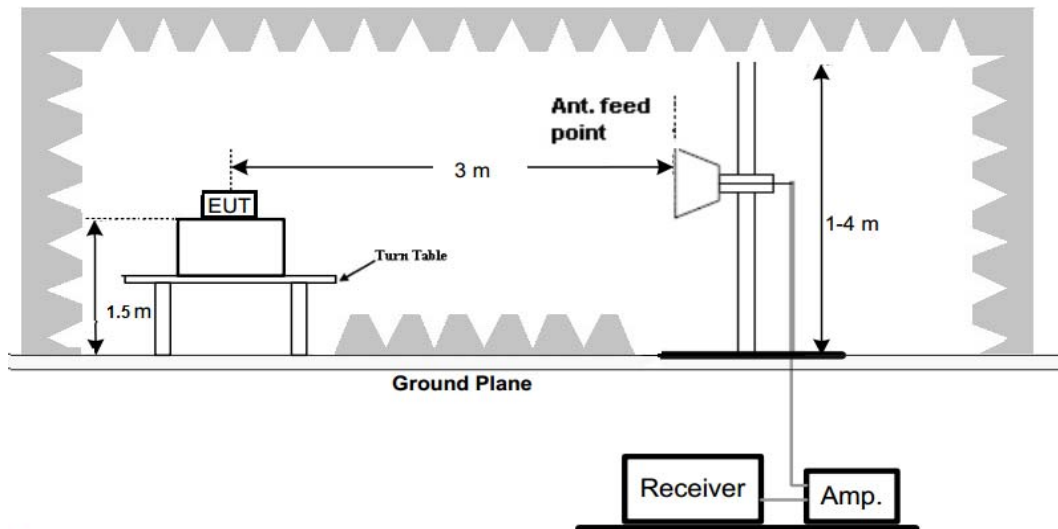
(A) Radiated Emission Test Set-Up, Frequency Below 30MHz



(B) Radiated Emission Test Set-Up, Frequency below 1000MHz



(C) Radiated Emission Test Set-Up, Frequency above 1000MHz

**TEST PROCEDURE**

- The EUT was placed on a turn table which is 0.8m above ground plane for below 1GHz and 1.50m above ground plane for above 1GHz.
- Maximum procedure was performed by raising the receiving antenna from 1m to 4m and rotating the turn table from 0°C to 360°C to acquire the highest emissions from EUT.
- And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
- Repeat above procedures until all frequency measurements have been completed.
- The distance between test antenna and EUT as following table states:

Test Frequency range	Test Antenna Type	Test Distance
9KHz-30MHz	Active Loop Antenna	3
30MHz-1GHz	Bilog Antenna	3
1GHz-18GHz	Horn Antenna	3
18GHz-25GHz	Horn Antenna	1

- Setting test receiver/spectrum as following table states:

Test Frequency range	Test Receiver/Spectrum Setting	Detector
9KHz-150KHz	RBW=200Hz/VBW=3KHz, Sweep time=Auto	QP/Average
150KHz-30MHz	RBW=9KHz/VBW=100KHz, Sweep time=Auto	QP/Average
30MHz-1GHz	RBW=120KHz/VBW=1000KHz, Sweep time=Auto	QP
1GHz-40GHz	Peak Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto	Peak
	Average Value: RBW=1MHz/VBW=10Hz, Sweep time=Auto	Peak

More procure as follows;

1) Sequence of testing 9 kHz to 30 MHz**Setup:**

- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
- If the EUT is a tabletop system, a rotatable table with 0.8 m height is used.
- If the EUT is a floor standing device, it is placed on the ground.
- Auxiliary equipment and cables were positioned to simulate normal operation conditions.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- The measurement distance is 3 meter.
- The EUT was set into operation.

Premeasurement:

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna height is 1.0 meter.
- At each turntable position the analyzer sweeps with peak detection to find the maximum of all emissions

Final measurement:

- Identified emissions during the premeasurement the software maximizes by rotating the turntable position (0° to 360°) and by rotating the elevation axes (0° to 360°).
- The final measurement will be done in the position (turntable and elevation) causing the highest emissions with QP detector.
- The final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

2) Sequence of testing 30 MHz to 1 GHz**Setup:**

- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables were positioned to simulate normal operation conditions
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- The measurement distance is 3 meter.
- The EUT was set into operation.

Premeasurement:

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1 to 4 meter.
- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement:

- The final measurement will be performed with minimum the six highest peaks.
- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position ($\pm 45^\circ$) and antenna movement between 1 and 4 meter.
- The final measurement will be done with QP detector with an EMI receiver.
- The final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

3) Sequence of testing 1 GHz to 18 GHz**Setup:**

- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables were positioned to simulate normal operation conditions
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- The measurement distance is 3 meter.
- The EUT was set into operation.

Premeasurement:

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height scan range is 1 meter to 2.5 meter.
- At each turntable position and antenna polarization the analyzer sweeps with peak detection to find the maximum of all emissions.

Final measurement:

- The final measurement will be performed with minimum the six highest peaks.
- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position ($\pm 45^\circ$) and antenna movement between 1 and 4 meter. This procedure is repeated for both antenna polarizations.
- The final measurement will be done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and Average detector.
- The final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

4) Sequence of testing above 18 GHz**Setup:**

- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables were positioned to simulate normal operation conditions
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- The measurement distance is 1 meter.
- The EUT was set into operation.

Premeasurement:

- The antenna is moved spherical over the EUT in different polarizations of the antenna.

Final measurement:

- The final measurement will be performed at the position and antenna orientation for all detected emissions that were found during the premeasurements with Peak and Average detector.
- The final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

Field Strength Calculation

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

$$FS = RA + AF + CL - AG$$

Where FS = Field Strength	CL = Cable Attenuation Factor (Cable Loss)
RA = Reading Amplitude	AG = Amplifier Gain
AF = Antenna Factor	

For example

Frequency (MHz)	FS (dBμV/m)	RA (dBμV/m)	AF (dB)	CL (dB)	AG (dB)	Transd (dB)
300.00	40	58.1	12.2	1.6	31.90	-18.1

$$\text{Transd} = \text{AF} + \text{CL} - \text{AG}$$

TEST RESULTS

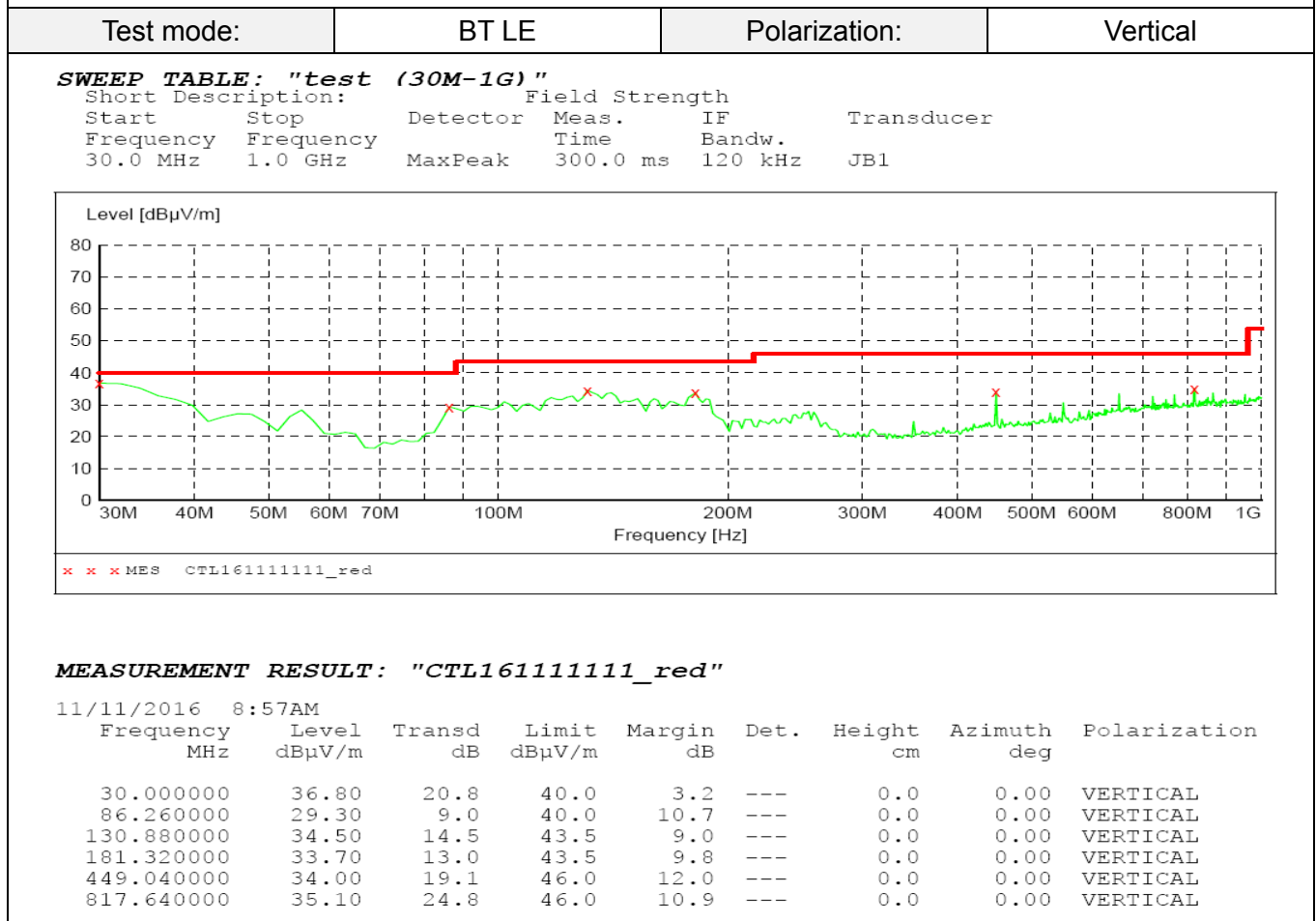
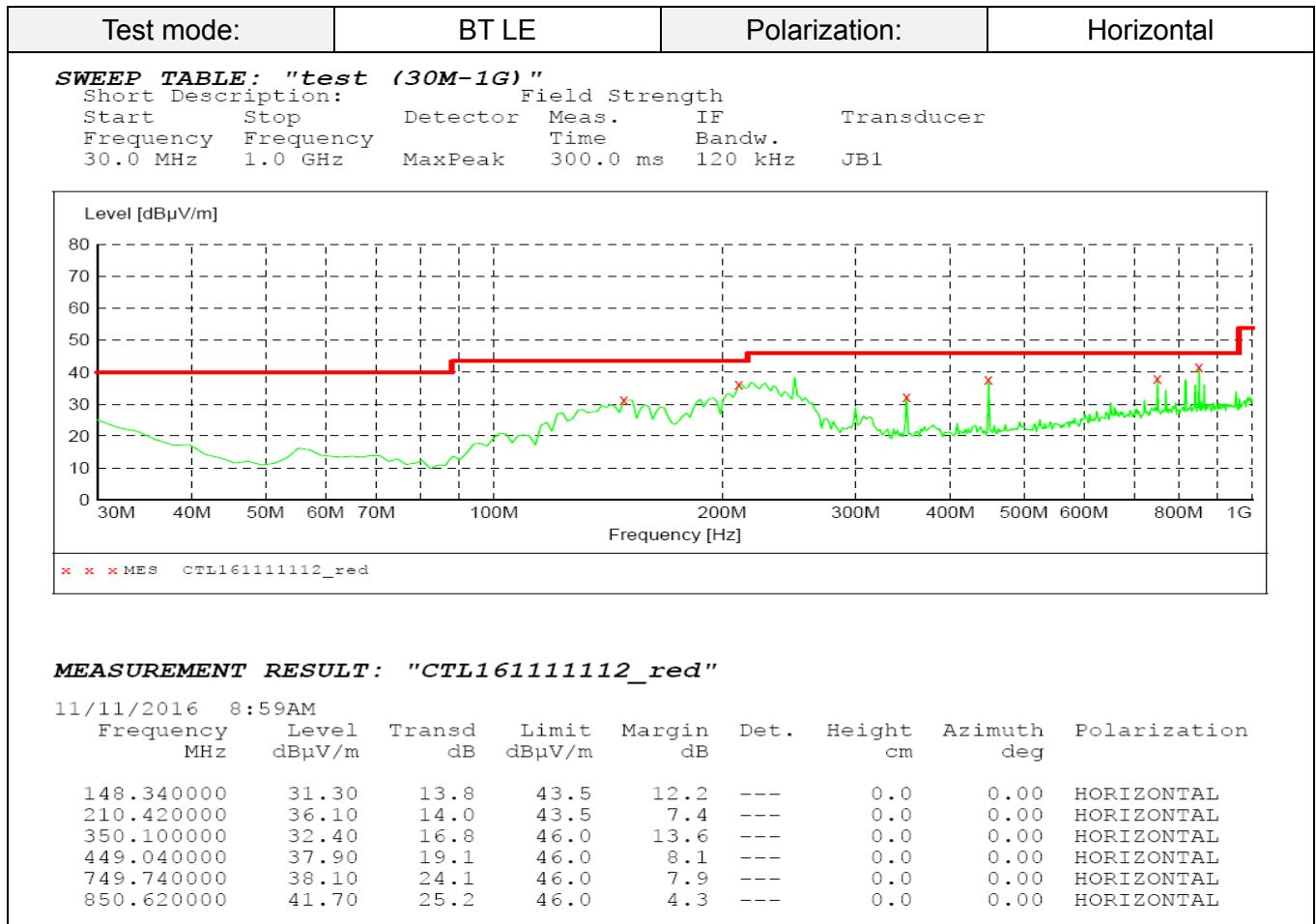
Remark:

1. All three channels (lowest/middle/highest) were measured below 1GHz and recorded worst case at low channel.
2. Radiated emission test from 9 KHz to 10th harmonic of fundamental was verified, and no emission found except system noise floor in 9 KHz to 30MHz and not recorded in this report.
3. "---" means not recorded as emission levels lower than limit.
4. Margin= Limit - Level

For 9 KHz to 30MHz

Frequency (MHz)	Corrected Reading (dBμV/m)@3m	FCC Limit (dBμV/m) @3m	Margin (dB)	Detector	Result
---	---	---	---	---	---



For 30MHz-1GHz

For 1GHz to 25GHz**BT4.0 Mode (above 1GHz)**

Frequency(MHz):			2402		Polarity:			HORIZONTAL	
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
4804.00	49.52	PK	74.00	24.48	45.01	33.49	6.91	35.89	4.51
4804.00	--	AV	54.00	--	--	--	--	--	--
5135.75	39.26	PK	74.00	34.74	32.03	34.41	7.11	34.28	7.23
5135.75	--	AV	54.00	--	--	--	--	--	--
7206.00	46.28	PK	74.00	27.72	35.17	36.95	9.18	35.03	11.11
7206.00	--	AV	54.00	--	--	--	--	--	--

Frequency(MHz):			2402		Polarity:			VERTICAL	
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
4804.00	50.11	PK	74.00	23.89	45.60	33.49	6.91	35.89	4.51
4804.00	--	AV	54.00	--	--	--	--	--	--
5322.50	40.26	PK	74.00	33.74	32.73	34.66	7.21	34.35	7.53
5322.50	--	AV	54.00	--	--	--	--	--	--
7206.00	46.98	PK	74.00	27.02	35.87	36.95	9.18	35.03	11.11
7206.00	--	AV	54.00	--	--	--	--	--	--

Frequency(MHz):			2440		Polarity:			HORIZONTAL	
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
4880.00	49.52	PK	74.00	24.48	44.87	33.60	6.95	35.90	4.65
4880.00	--	AV	54.00	--	--	--	--	--	--
5315.25	40.63	PK	74.00	33.37	33.11	34.66	7.21	34.34	7.52
5315.25	--	AV	54.00	--	--	--	--	--	--
7320.00	46.45	PK	74.00	27.55	34.76	37.46	9.23	35.00	11.69
7320.00	--	AV	54.00	--	--	--	--	--	--

Frequency(MHz):			2440		Polarity:			VERTICAL	
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
4880.00	50.56	PK	74.00	23.44	45.91	33.60	6.95	35.90	4.65
4880.00	--	AV	54.00	--	--	--	--	--	--
5013.25	40.42	PK	74.00	33.58	33.59	34.03	7.04	34.23	6.83
5013.25	--	AV	54.00	--	--	--	--	--	--
7320.00	46.74	PK	74.00	27.26	35.05	37.46	9.23	35.00	11.69
7320.00	--	AV	54.00	--	--	--	--	--	--

Frequency(MHz):			2480		Polarity:			HORIZONTAL	
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
4960.00	49.44	PK	74.00	24.56	44.52	33.84	7.00	35.92	4.92
4960.00	--	AV	54.00	--	--	--	--	--	--
5245.50	40.75	PK	74.00	33.25	33.32	34.59	7.17	34.32	7.43
5245.50	--	AV	54.00	--	--	--	--	--	--
7440.00	46.32	PK	74.00	27.68	34.37	37.64	9.28	34.97	11.95
7440.00	--	AV	54.00	--	--	--	--	--	--

Frequency(MHz):			2480		Polarity:			VERTICAL	
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
4960.00	50.66	PK	74.00	23.34	45.74	33.84	7.00	35.92	4.92
4960.00	--	AV	54.00	--	--	--	--	--	--
5011.25	41.25	PK	74.00	32.75	34.43	34.02	7.04	34.23	6.82
5011.25	--	AV	54.00	--	--	--	--	--	--
7440.00	46.89	PK	74.00	27.11	34.94	37.64	9.28	34.97	11.95
7440.00	--	AV	54.00	--	--	--	--	--	--

Remark:

1. Emission level (dBuV/m) =Raw Value (dBuV) +Correction Factor (dB/m)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) +Cable Factor (dB)-Pre-amplifier Factor
3. Margin value = Limit value- Emission level.
4. -- Mean the PK detector measured value is below average limit.
5. The other emission levels were very low against the limit.
6. RBW=1MHz VBW=3MHz Peak detector is for Peak value; RBW=1MHz VBW=10Hz Peak detector is for Average value.

3.3. Maximum Conducted Output Power

LIMIT

The Maximum Peak Output Power Measurement is 30dBm.

TEST PROCEDURE

According to KDB558074 D01 DTS Measurement Guidance Section 9.1 Maximum peak conducted output power, 9.1.2 the maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall utilize a fast-responding diode detector.

According to KDB558074 D01 DTS Measurement Guidance Section 9.2 Maximum average conducted output power, 9.2.3.1 Method AVGPM (Measurement using an RF average power meter)

(a) As an alternative to spectrum analyzer or EMI receiver measurements, measurements may be performed using a wideband RF power meter with a thermocouple detector or equivalent if all of the conditions listed below are satisfied.

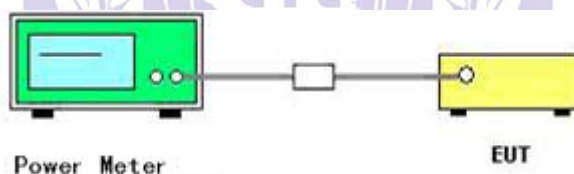
- 1) The EUT is configured to transmit continuously, or to transmit with a constant duty factor.
- 2) At all times when the EUT is transmitting, it shall be transmitting at its maximum power control level.
- 3) The integration period of the power meter exceeds the repetition period of the transmitted signal by at least a factor of five.

(b) If the transmitter does not transmit continuously, measure the duty cycle (x) of the transmitter output signal as described in Section 6.0.

(c) Measure the average power of the transmitter. This measurement is an average over both the on and off periods of the transmitter.

(d) Adjust the measurement in dBm by adding $10\log(1/x)$, where x is the duty cycle to the measurement result.

TEST CONFIGURATION



TEST RESULTS

Test Mode	Channel	Frequency (MHz)	Measured Peak Output Power (dBm)	Measured Average Output Power (dBm)	Limits (dBm)	Verdict
BT – LE	0	2402	1.66	0.55	30	PASS
	19	2440	2.63	1.26		
	39	2480	2.56	1.22		

Remark:

1. Test results including cable loss;
2. Average power is for report only;

3.4. Power Spectral Density

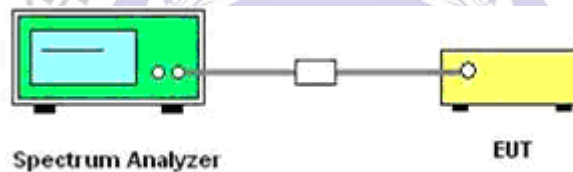
LIMIT

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

TEST PROCEDURE

1. Use this procedure when the maximum peak conducted output power in the fundamental emission is used to demonstrate compliance.
2. Set the RBW ≥ 3 kHz.
3. Set the VBW $\geq 3 \times$ RBW.
4. Set the span to 1.5 times the DTS channel bandwidth.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum power level.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.
11. The resulting peak PSD level must be 8dBm.

TEST CONFIGURATION



TEST RESULTS

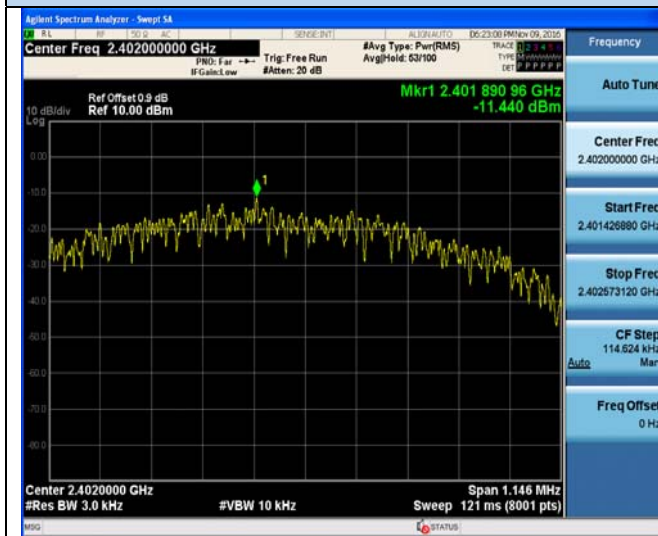
Test Mode	Channel	Frequency (MHz)	Measured Peak Power Spectral Density (dBm/3KHz)	Limits (dBm/3KHz)	Verdict
BT – LE	0	2402	-11.440	8	PASS
	19	2440	-9.540		
	39	2480	-9.566		

Remark:

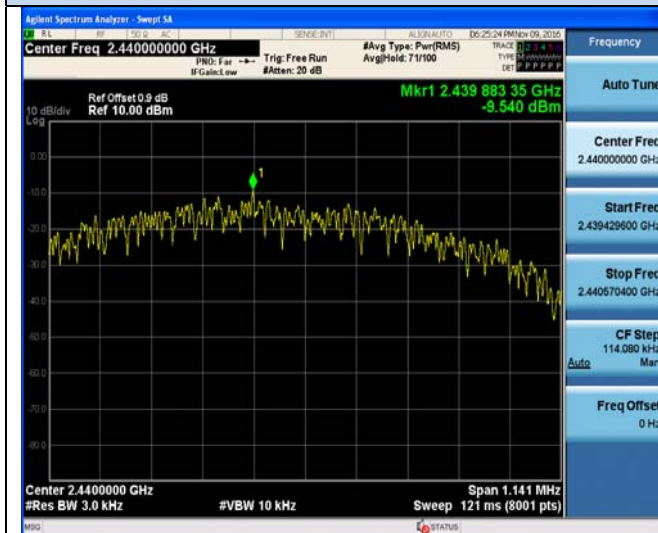
1. Test results including cable loss;
2. Please refer to following plots;

Peak Power Spectrum Density

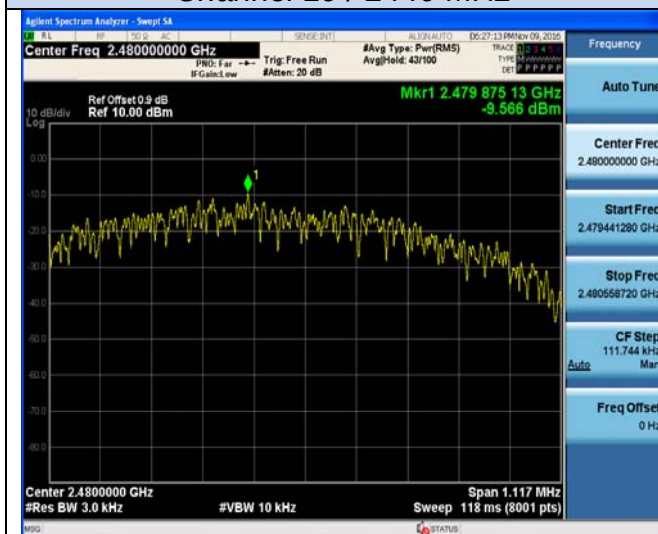
BT – LE



Channel 0 / 2402 MHz



Channel 19 / 2440 MHz



Channel 39 / 2480 MHz

3.5. 6dB Bandwidth

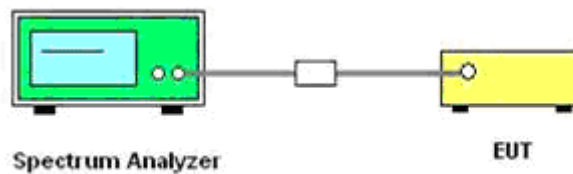
LIMIT

For digital modulation systems, the minimum 6 dB bandwidth shall be at least 500 kHz.

TEST PROCEDURE

The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 KHz RBW and 300 KHz VBW. The 6dB bandwidth is defined as the total spectrum the power of which is higher than peak power minus 6dB.

TEST CONFIGURATION

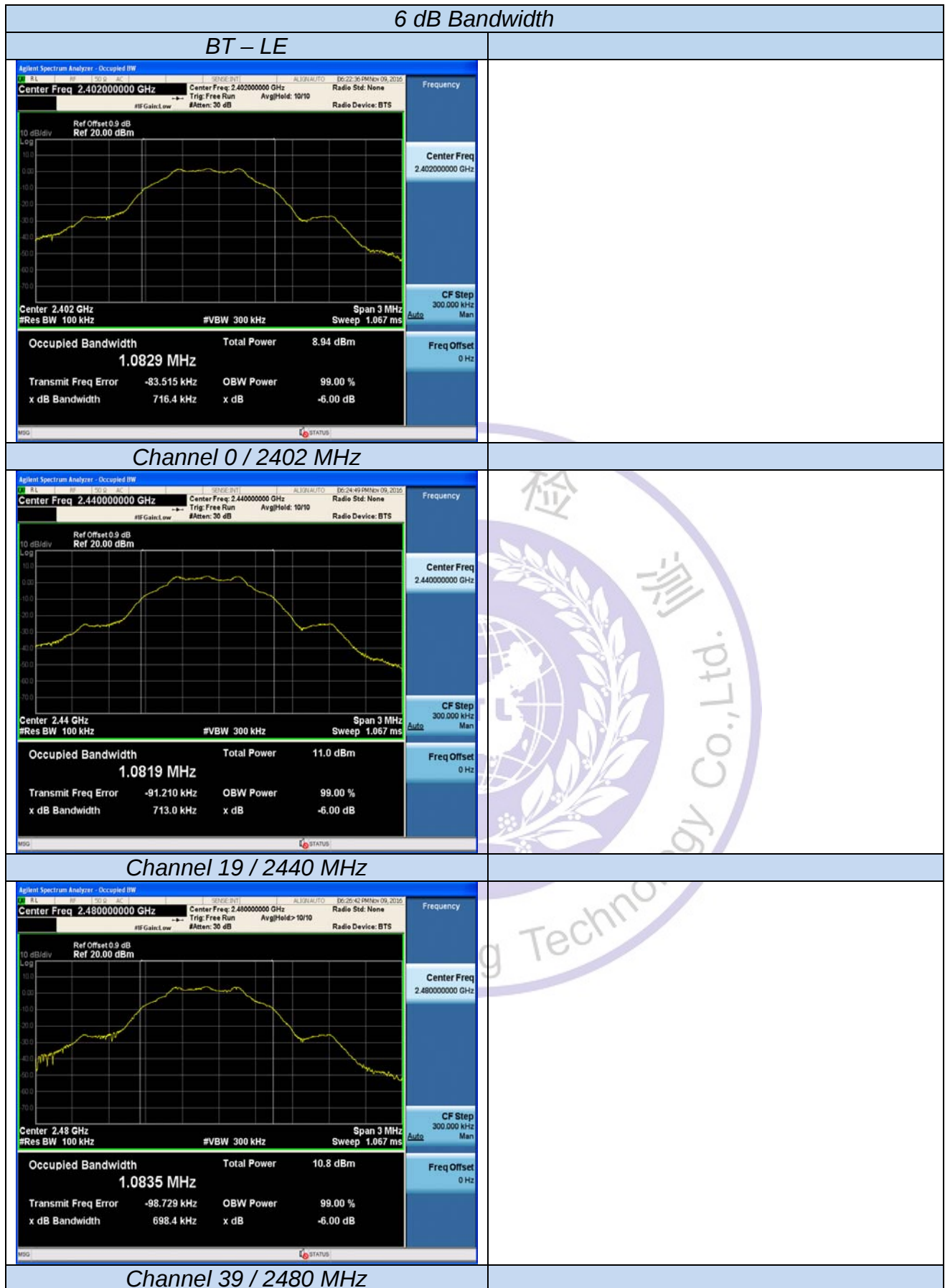


TEST RESULTS

Test Mode	Channel	Frequency (MHz)	6dB Bandwidth (MHz)	Limits (MHz)	Verdict
BT - LE	0	2402	0.7164	0.500	PASS
	19	2440	0.7130		
	39	2480	0.6984		

Remark:

1. Test results including cable loss;
2. Please refer to following plots;



3.6. Conducted Spurious Emissions

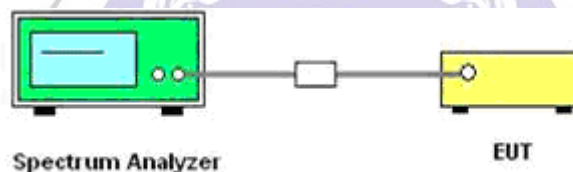
LIMIT

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on 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 on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required.

TEST PROCEDURE

Connect the transmitter output to spectrum analyzer using a low loss RF cable, and set the spectrum analyzer to RBW=100 kHz, VBW= 300 kHz, peak detector, and max hold. Measurements utilizing these setting are made of the in-band reference level, bandedge and out-of-band emissions. The spectrum from 9 KHz to 25GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

TEST CONFIGURATION



TEST RESULTS

Test Mode	Channel	Frequency (MHz)	Spurious RF Conducted Emission (dBc)	Limits (dBc)	Verdict
BT – LE	0	2402	<-20	-20	PASS
	19	2440	<-20		
	39	2480	<-20		

Remark:

1. Test results including cable loss;
2. “---” means that the fundamental frequency not for 15.209 limits requirement.
3. Please refer to following plots;
4. Not recorded emission values from 9 KHz to 30 MHz as emission levels 20dB lower than emission limit;

RF Conducted Spurious Emissions
BT – LE GFSK

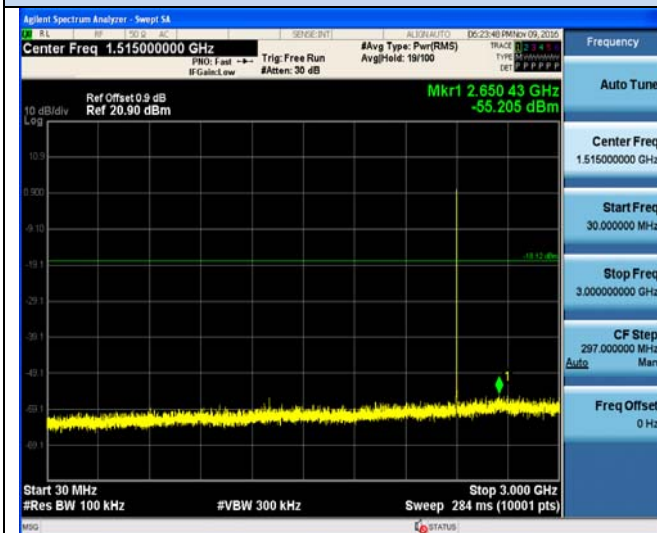
Channel 0 / 2402 MHz



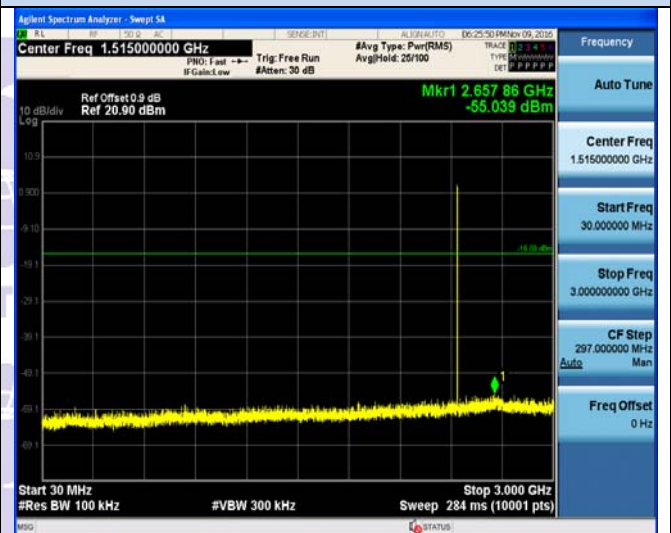
Channel 19 / 2440 MHz



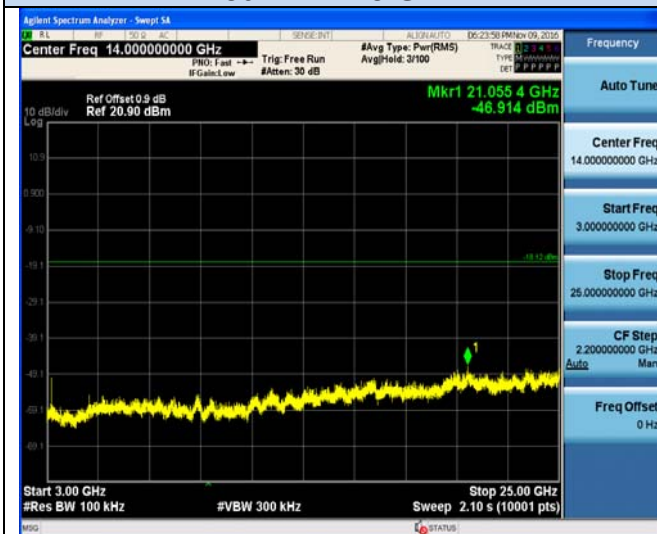
2400 MHz – 2404 MHz



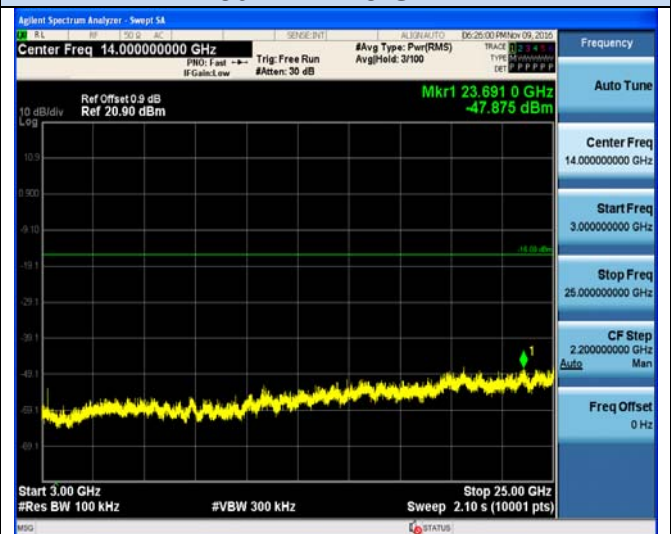
2438 MHz – 2442 MHz



30 MHz – 3 GHz



30 MHz – 3 GHz



3 GHz – 25 GHz

3 GHz – 25 GHz

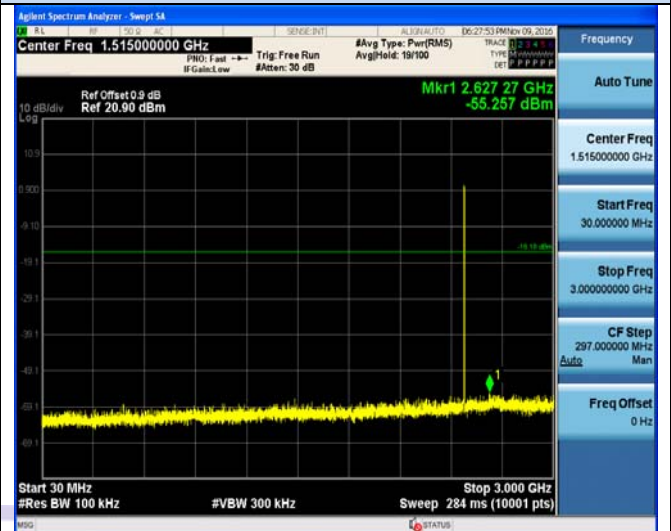
RF Conducted Spurious Emissions

BT – LE GFSK

Channel 39 / 2480MHz



Channel 39 / 2480MHz



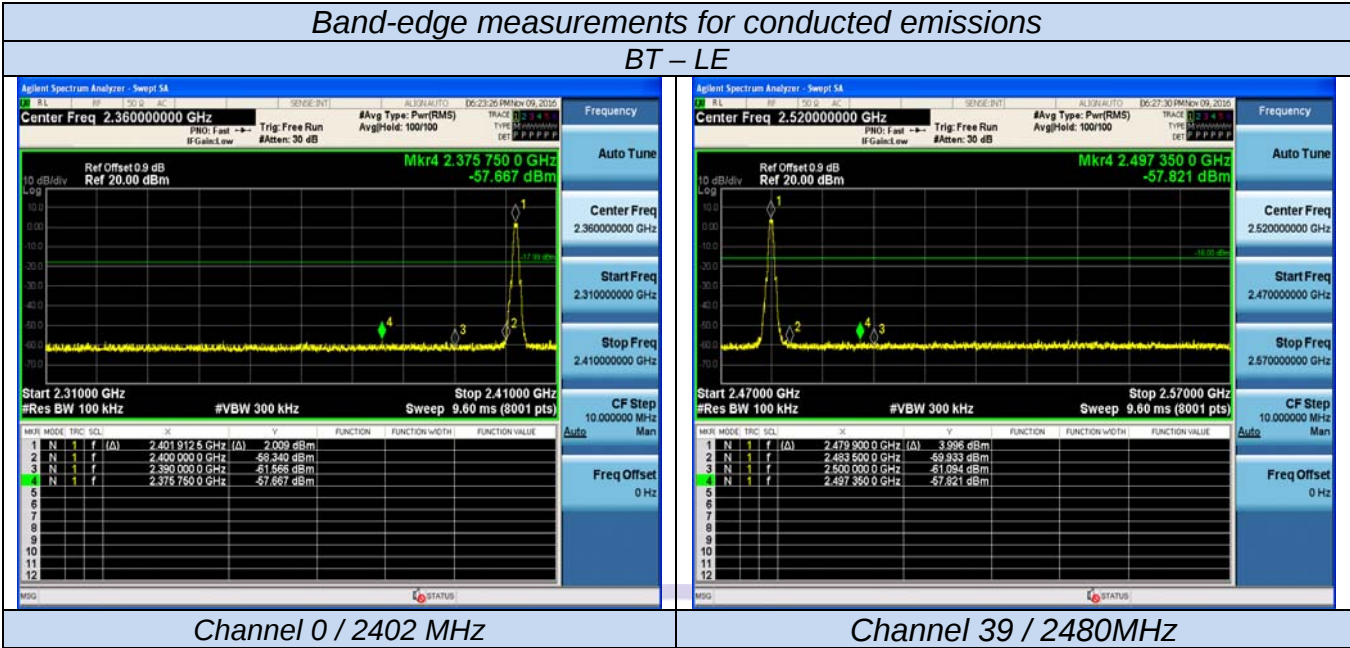
2478 MHz – 2482 MHz



30 MHz – 3 GHz



3 GHz – 25 GHz



3.7. Band-edge measurements for radiated emissions

LIMIT

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on 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 on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required.

TEST PROCEDURE

According to KDB 558074 D01 V03 for Antenna-port conducted measurement. Antenna-port conducted measurements may also be used as an alternative to radiated measurements for demonstrating compliance in the restricted frequency bands. If conducted measurements are performed, then proper impedance matching must be ensured and an additional radiated test for cabinet/case spurious emissions is required.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to an EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set both RBW and VBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100kHz bandwidth from band edge, for Radiated emissions restricted band RBW=1MHz, VBW=3MHz for peak detector and RBW=1MHz, VBW=1/B for Peak detector.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.
6. Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency (see 12.2.2, 12.2.3, and 12.2.4 for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).
7. Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP level (see 12.2.5 for guidance on determining the applicable antenna gain)
8. Add the appropriate maximum ground reflection factor to the EIRP level (6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive and 0 dB for frequencies > 1000 MHz).
9. For devices with multiple antenna-ports, measure the power of each individual chain and sum the EIRP of all chains in linear terms (e.g., Watts, mW).
10. Convert the resultant EIRP level to an equivalent electric field strength using the following relationship:
$$E = \text{EIRP} - 20 \log D + 104.8$$

Where:

E = electric field strength in dBμV/m,

EIRP = equivalent isotropic radiated power in dBm

D = specified measurement distance in meters.

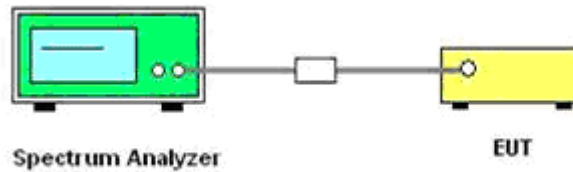
11. Since the out-of-band characteristics of the EUT transmit antenna will often be unknown, the use of a conservative antenna gain value is necessary. Thus, when determining the EIRP based on the measured conducted power, the upper bound on antenna gain for a device with a single RF output shall be selected as the maximum in-band gain of the antenna across all operating bands, or 2 dBi, whichever is greater. However, for devices that operate in multiple frequency bands while using the same transmit antenna, the highest gain of the antenna within the operating band nearest in frequency to the restricted band emission being measured may be used in lieu of the overall highest gain when the emission is at a frequency that is within 20 percent of the nearest band edge frequency, but in no

case shall a value less than 2 dBi be used.

12. Compare the resultant electric field strength level to the applicable regulatory limit.

13. Perform radiated spurious emission test duress until all measured frequencies were complete.

TEST CONFIGURATION



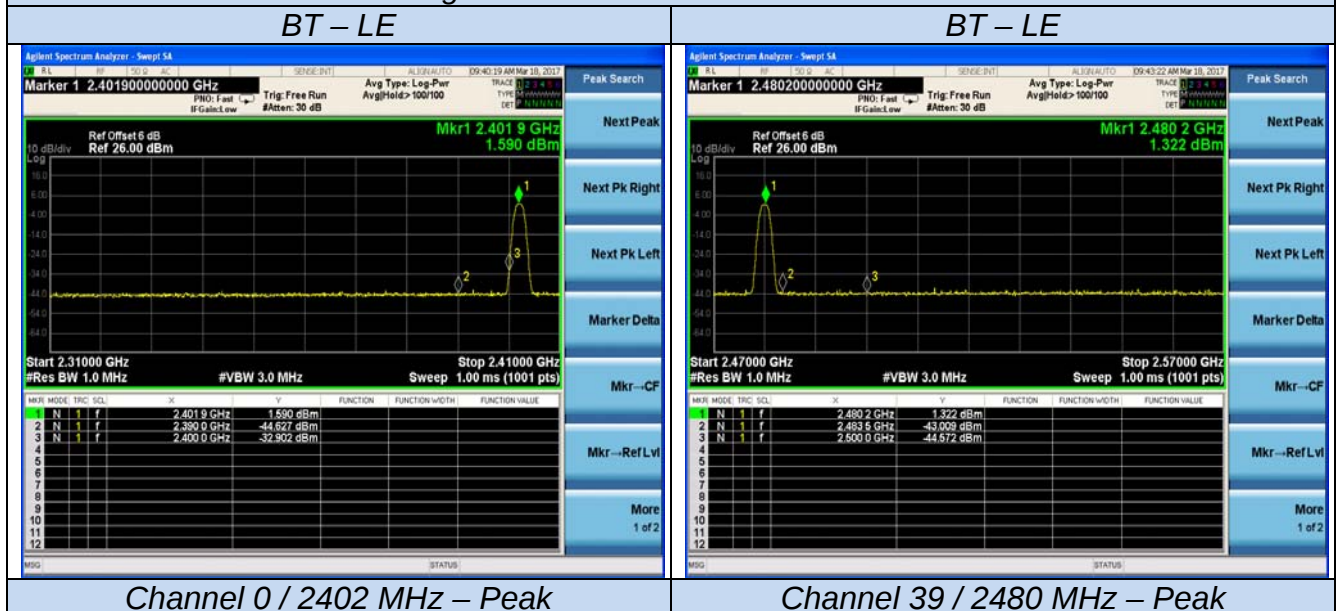
TEST RESULTS

BT – LE							
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Verdict
2390.000	-44.627	0.000	0.000	52.631	Peak	74.00	PASS
2401.900	1.590	0.000	0.000	98.848	Peak	---	PASS
2480.200	1.322	0.000	0.000	98.580	Peak	---	PASS
2483.500	-43.009	0.000	0.000	54.249	Peak	74.00	PASS
2500.000	-44.572	0.000	0.000	52.631	Peak	74.00	PASS

Remark:

1. Test results including cable loss;
2. “---“means that the fundamental frequency not for 15.209 limits requirement.
3. No need measure Average values if Peak values meets Average limits;
4. Please refer to following plots;

Band-edge measurements for radiated emissions



3.8. Antenna Requirement

Standard Applicable

For intentional device, according to FCC 47 CFR Section 15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

FCC CFR Title 47 Part 15 Subpart C Section 15.247(c) (1) (I):

(i) Systems operating in the 2400-2483.5 MHz band that is used exclusively for fixed. Point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.

Antenna Connected Construction

According to § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

The directional gains of antenna used for transmitting is 0 dBi, and the antenna is an internal antenna connect to PCB board and no consideration of replacement. Please see EUT photo for details. The WLAN and Bluetooth share same antenna.

Measurement

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module.

Conducted power refers ANSI C63.10:2013 Output power test procedure for DTS devices.

Radiated power refers to ANSI C63.10:2013 Radiated emissions tests.

Measurement parameters

Measurement parameter	
Detector:	Peak
Sweep Time:	Auto
Resolution bandwidth:	1MHz
Video bandwidth:	3MHz
Trace-Mode:	Max hold

Note: The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module.

Limits

FCC	ISED
Antenna Gain	
6 dBi	

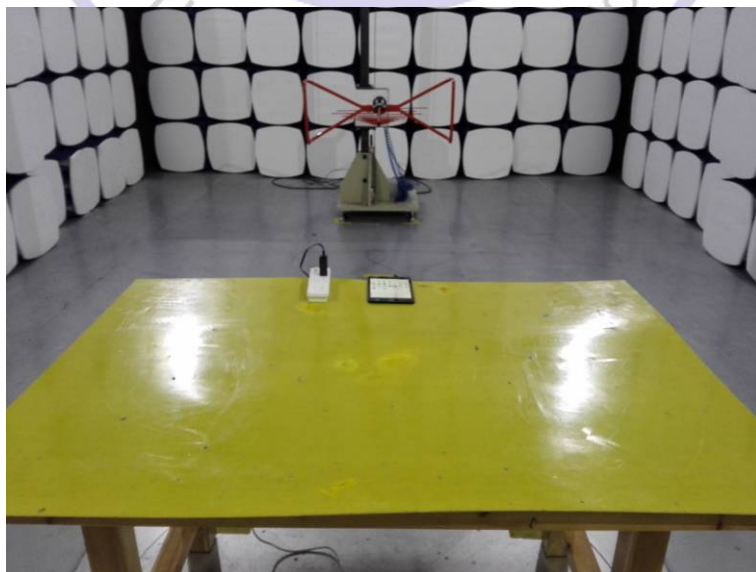
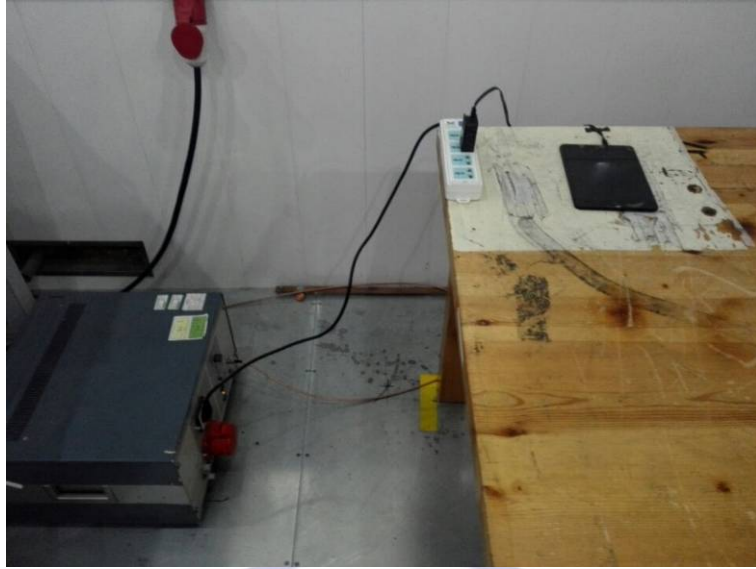
Test Result:

PASS

T_{nom}	V_{nom}	lowest channel 2402 MHz	middle channel 2440 MHz	highest channel 2480 MHz
Conducted power [dBm] Measured with GFSK modulation		1.592	2.084	2.347
Radiated power [dBm] Measured with GFSK modulation		0.065	1.396	-0.144
Gain [dBi] Calculated		-1.527	-0.688	-2.491
Measurement uncertainty			0.57 dB (cond.) / 2.20 dB (rad.)	



4. Test Setup Photos of the EUT





5. External and Internal Photos of the EUT

Please reference to the test report No.: CTL1610310501-WF-01

***** End of Report *****

