FCC Test Report

Report No.: LGD-ESH-P20080757B-2

FCC ID: Q4B-P4

Product: BLE and 6LoWPAN Wireless module

Test Model: IPPAN4-LROT

Received Date: Aug.10, 2020

Test Date: Aug.10 to Sep.09, 2020

Issued Date: Sep.09, 2020

Applicant: The Watt Stopper, Inc.

Address: 2700 Zanker Road Suite 168 San Jose, CA 95134

Manufacturer: Shanghai Legrand Electrical Co., Ltd

Address: 1/F, Building 1, No. 1358 Xiangyang Road, Minhang District, Shanghai, China

Issued By: BUREAU VERITAS ADT (Shanghai) Corporation

Lab Address: No. 829, Xinzhuan Road, Shanghai, P.R.China (201612)

Test Lab
Cert 2343.01

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Release Control Record

Issue No.	Description	Date Issued
LGD-ESH-P20080757B-2	Original release	Sep.09, 2020

1 Certificate of Conformity

Product: BLE and 6LoWPAN Wireless module

Brand: legrand

Test Model: IPPAN4-LROT

Applicant: The Watt Stopper, Inc.

Test Date: Aug.10 to Sep.09, 2020

Standards: 47 CFR FCC Part 15, Subpart C (Section 15.247)
ANSI C63.10:2013

The above equipment has been tested by **BUREAU VERITAS ADT (Shanghai) Corporation**, and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's EMC characteristics under the conditions specified in this report.

Prepared by : Yuan Zhang , **Date:** Sep.09, 2020

Yuan ZHANG

Project Engineer

Approved by : , **Date:** Sep.09, 2020

Daniel SUN

EMC Lab Manager

2 Summary of Test Results

The EUT has been tested according to the following specifications:

47 CFR FCC Part 15, Subpart C (SECTION 15.247)			
FCC Clause	Test Item	Result	Remarks
15.203	Antenna Requirement	PASS	No antenna connector is used.
15.207	AC Power Conducted Emission	PASS	Meet the requirement of limit.
15.247(a)(2)	Minimum 6dB Bandwidth	PASS	Meet the requirement of limit.
15.247(b)	Conducted Output Power	PASS	Meet the requirement of limit.
15.247(e)	Power Spectral Density	PASS	Meet the requirement of limit.
15.247(d)	Conducted Band Edges Measurement	PASS	Meet the requirement of limit.
15.247(d)	Conducted Spurious Emissions	PASS	Meet the requirement of limit.
15.247(d)	Emissions in restricted frequency bands	PASS	Meet the requirement of limit.
15.205 / 15.209 / 15.247(d)	Radiated Emissions Measurement	PASS	Meet the requirement of limit.

2.1 Test Instruments

Equipment	Manufacturer	Model No.	Serial No.	Last Cal.	Next Cal.
Hybrid Antenna(25MHz-1.5GHz)	Schwarzbeck	VULB9168	E1A1012	Jul.29, 20	Jul.28, 22
Horn Antenna(1GHz -18GHz)	Schwarzbeck	BBHA9120D	E1A1017	Aug.25, 20	Aug.24, 22
Double Ridge Horn Antenna(18G-40G)	COM-POWER	AH-840	E1A1040	Jul.15, 20	Jul.14, 22
Pre-Amplifier(100kHz-1.3GHz)	Agilent	8447D	E1A2001	Apr.20, 20	Apr.19, 21
Pre-Amplifier(0.5GHz-18GHz)	EMCI	EMC184045SE	E1A2009	Jul.06, 20	Jul.05, 21
Pre-Amplifier(18GHz-40GHz)	EMCI	EMC051845SE	E1A2008	Jul.06, 20	Jul.05, 21
EMI test recerver	R&S	ESR7	E1R1005	Apr.20, 20	Apr.19, 21
Spectrum Analyzer	Keysight	N9030B	E1S1003	Jul.23, 20	Jul.22, 21
Spectrum Analyzer	Keysight	N9020A	E1S1004	Mar.03, 20	Mar.02, 21
EMI test recerver	R&S	ESCS30	E1R1001	May.12, 20	May.11, 21
LISN	R&S	ENV216	E1L1011	May.12, 20	May.11, 21
Humidity&Temp Tester	Baolima	WS508	E1H1011	Apr. 03, 20	Apr. 02, 21
RF Control Unit	Toscend	JS0806-2	E1C5003	N/A	N/A
Test Software	ADT	ADT_COND_V7.3.1	N/A	N/A	N/A
Test Software	Toscend	JS32-RE	N/A	N/A	N/A
Test Software	Toscend	JS1120	N/A	N/A	N/A
Test Software	Toscend	JS1120-3	N/A	N/A	N/A

2.2 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT:

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

Measurement	Frequency	Expanded Uncertainty (k=2) (±)
Conducted Emissions at mains ports	150kHz ~ 30MHz	1.83 dB
Radiated Emissions up to 1 GHz	30MHz ~ 1GHz	5.36 dB
Radiated Emissions above 1 GHz	1GHz ~ 6GHz	3.47 dB
	6GHz ~ 18GHz	3.75 dB
	18GHz ~ 40GHz	3.30 dB

2.3 Modification Record

There were no modifications required for compliance.

3 General Information

3.1 General Description of EUT

Product	BLE and 6LoWPAN Wireless module
Brand	legrand
Test Model	IPPAN4-LROT
Power Rating	2.0-3.3Vdc
Modulation Type	O-QPSK
Modulation Technology	DSSS
Operating Frequency	2405MHz to 2480MHz
Number of Channel	16
Antenna Type	Ant1: Ceramic Ant2: Dipole
Antenna Connector	--
Antenna Gain	Ant1:0.5dBi Ant2:4dBi
Product SW/HW version	V1.0/ IPPAN4-LROT
Radio SW/HW version	V1.0/NA
Test SW version	V17.0.2
RF power setting in Test SW	-4dBm for CH11~CH25, -8dBm for CH26

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

3.2 Description of Test Modes

16 channels are provided for 802.15.4.

CHANNEL	FREQUENCY	CHANNEL	FREQUENCY
11	2405 MHz	19	2445 MHz
12	2410 MHz	20	2450 MHz
13	2415 MHz	21	2455 MHz
14	2420 MHz	22	2460 MHz
15	2425 MHz	23	2465 MHz
16	2430 MHz	24	2470 MHz
17	2435 MHz	25	2475 MHz
18	2440 MHz	26	2480 MHz

3.2.1 Test Mode Applicability:

EUT Configure Mode	Applicable to				Description
	RE ≥ 1G	RE < 1G	PLC	APCM	
-	√	√	√	√	-

Where **RE≥1G:** Radiated Emission above 1GHz **RE< 1G:** Radiated Emission below 1GHz

PLC: Power Line Conducted Emission **APCM:** Antenna Port Conducted Measurement

Radiated Emission Test (Above 1 GHz):

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	DATA RATE (Mbps)
-	802.15.4	11 to 26	11,18, 26	DSSS	OQPSK	250kbps

Radiated Emission Test (Below 1 GHz):

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	DATA RATE (Mbps)
-	802.15.4	11 to 26	11	DSSS	OQPSK	250kbps

Power Line Conducted Emission Test:

☐ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

☐ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	DATA RATE (Mbps)
-	802.15.4	11 to 26	11	DSSS	OQPSK	250kbps

Antenna Port Conducted Measurement

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	DATA RATE (Mbps)
-	802.15.4	11 to 26	11,18, 26	DSSS	OQPSK	250kbps

3.2.2 Test Condition:

Applicable to	Normal Environmental Conditions	Normal Input Power
RE ≥ 1G	23deg. C, 58%RH	DC 3.3V
RE < 1G	23deg. C, 58%RH	DC 3.3V
PLC	23deg. C, 58%RH	DC 3.3V
APCM	25deg. C, 60%RH	DC 3.3V

3.3 Description of Support Units

The EUT has been tested as an independent unit together with other necessary accessories or support units.

3.4 General Description of Applied Standards

The EUT is a RF Product. According to the specifications of the manufacturer, it must comply with the requirements of the following standard:

FCC Part 15, Subpart C (15.247)

KDB 558074 D01 DTS Meas Guidance v05r02

ANSI C63.10:2013

All relaxed test items have been performed and recorded as per the above standard.

4 Test Procedure and Results

4.1 AC Power Conducted Emission

4.1.1 Limits

Frequency (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15 - 0.5	66 - 56	56 - 46
0.50 - 5.0	56	46
5.0 - 30.0	60	50

Note: 1. The lower limit shall apply at the transition frequencies.

2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

4.1.2 Test Procedures

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). 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 lines of the power mains connected to the EUT were checked for maximum conducted interference.

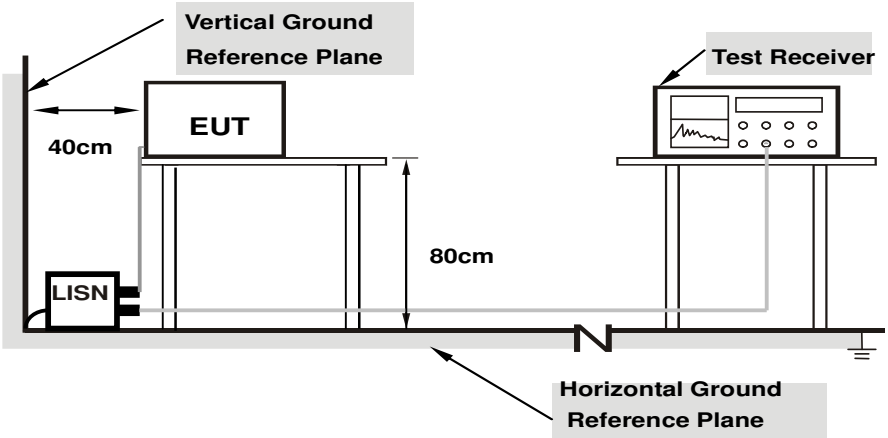
c. The frequency range from 150kHz to 30MHz was searched. Emission levels under (Limit - 20dB) was not recorded.

NOTE: The resolution bandwidth and video bandwidth of test receiver is 9kHz for quasi-peak detection (QP) and average detection (AV) at frequency 0.15MHz-30MHz.

4.1.3 Deviation from Test Standard

No deviation.

4.1.4 Test Setup



Note: 1.Support units were connected to second LISN.

For the actual test configuration, please refer to the attached file (Test Setup Photo).

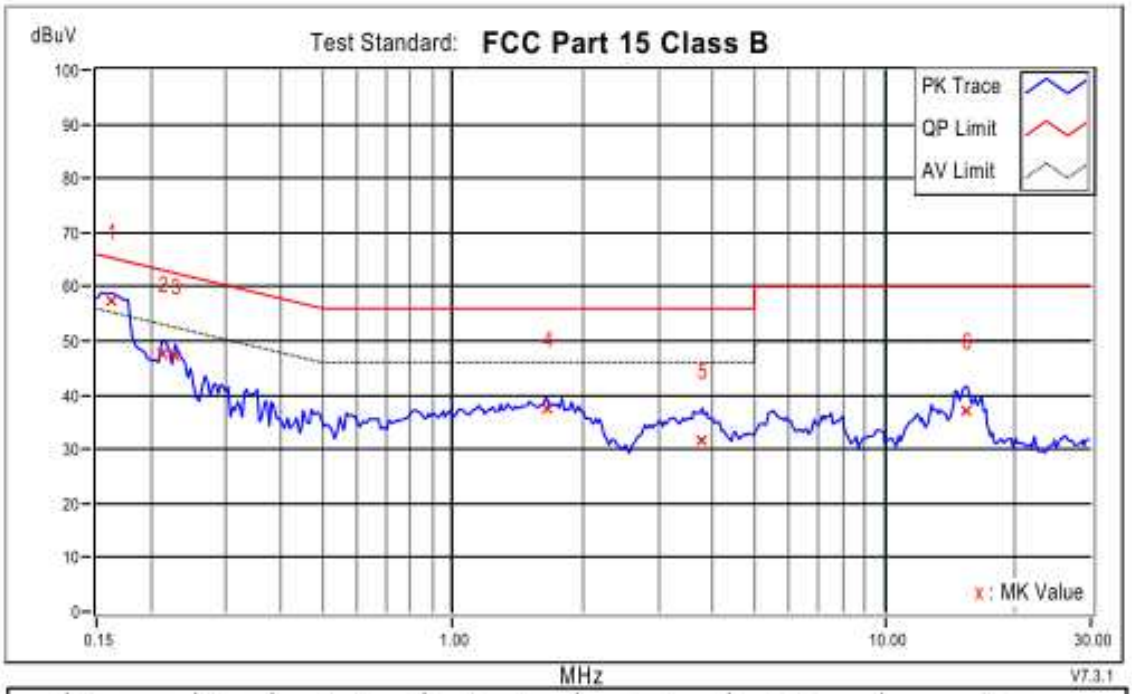
4.1.5 EUT Operating Conditions

Same as 4.1.6.

4.1.6 Test Results

Phase	Line (L)	Detector Function	Quasi-Peak (QP) / Average (AV)

Test Plot:



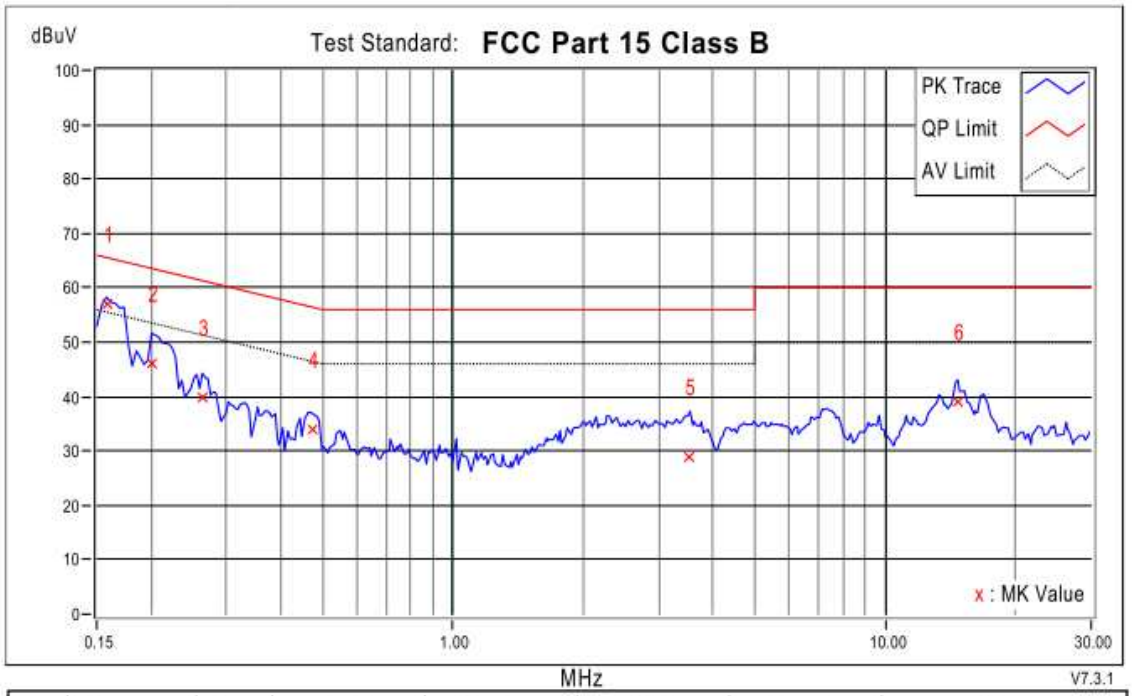
	Frequency	Corr. Factor	Reading dBuV		Emission dBuV		Limit dBuV		Margins dB		Notes
No.	MHz	dB	QP	AV	QP	AV	QP	AV	QP	AV	
*1	0.16173	9.83	47.54	31.31	57.37	41.14	65.37	55.37	-8.00	-14.23	
2	0.21256	9.83	37.82	21.34	47.65	31.17	63.10	53.10	-15.45	-21.93	
3	0.22820	9.80	37.31	23.16	47.11	32.96	62.51	52.51	-15.40	-19.55	
4	1.64906	9.69	27.80	18.91	37.49	28.60	56.00	46.00	-18.51	-17.40	
5	3.78783	9.80	21.84	13.43	31.64	23.23	56.00	46.00	-24.36	-22.77	
6	15.51310	10.09	26.96	16.47	37.05	26.56	60.00	50.00	-22.95	-23.44	

REMARKS:

1. Q.P. and AV. Are abbreviations of quasi-peak and average individually.
2. The emission levels of other frequencies were very low against the limit.
3. Margin value = Emission level – Limit value
4. Correction factor = Insertion loss + Cable loss
5. Emission Level = Correction Factor + Reading Value.

Phase	Neutral (N)	Detector Function	Quasi-Peak (QP) / Average (AV)

Test Plot:



	Frequency	Corr. Factor	Reading dBuV		Emission dBuV		Limit dBuV		Margins dB		Notes
No.	MHz	dB	QP	AV	QP	AV	QP	AV	QP	AV	
+1	0.15782	9.83	47.27	30.44	57.10	40.27	65.58	55.58	-8.48	-15.31	
2	0.20083	9.79	36.19	16.29	45.98	26.08	63.58	53.58	-17.60	-27.50	
3	0.26339	9.83	30.08	19.45	39.91	29.28	61.32	51.32	-21.41	-22.04	
4	0.47453	9.83	24.29	12.83	34.12	22.66	56.43	46.43	-22.31	-23.77	
5	3.54150	9.83	18.89	10.91	28.72	20.74	56.00	46.00	-27.28	-25.26	
6	14.73892	10.10	28.99	21.26	39.09	31.36	60.00	50.00	-20.91	-18.64	

REMARKS:

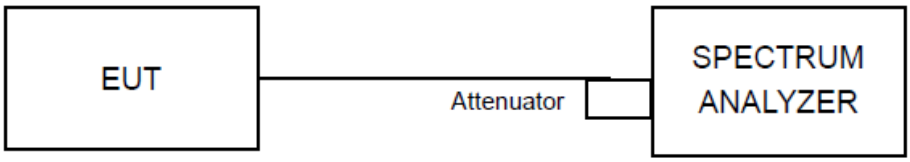
1. Q.P. and AV. are abbreviations of quasi-peak and average individually.
2. The emission levels of other frequencies were very low against the limit.
3. Margin value = Emission level - Limit value
4. Correction factor = Insertion loss + Cable loss
5. Emission Level = Correction Factor + Reading Value.

4.2 Minimum 6dB Bandwidth

4.2.1 Limit

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

4.2.2 Test Setup



4.2.3 Test Procedures

The EUT was tested according to DTS test procedure of “KDB558074 D01 DTS Meas Guidance” for compliance to FCC 47CFR 15.247 requirements (clause 8.2).

The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW $\geqslant$ 3 $\cdot$ RBW, peak detector with maximum hold) is implemented by the instrumentation function.

4.2.4 Deviation of Test Standard

No deviation.

4.2.5 Test Results

Test Mode	Antenna	Channel [MHz]	DTS BW [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
802.15.4	Ant1	2405	1.530	2404.250	2405.780	>=0.5	PASS
		2440	1.020	2439.520	2440.540	>=0.5	PASS
		2480	1.530	2479.235	2480.765	>=0.5	PASS
	Ant2	2405	1.470	2404.310	2405.780	>=0.5	PASS
		2440	1.380	2439.295	2440.675	>=0.5	PASS
		2480	1.065	2479.460	2480.525	>=0.5	PASS

802.15.4 _Ant1_2405

802.15.4 _Ant1_2440

802.15.4 _Ant1_2480

802.15.4 _Ant2_2405

802.15.4 _Ant2_2440

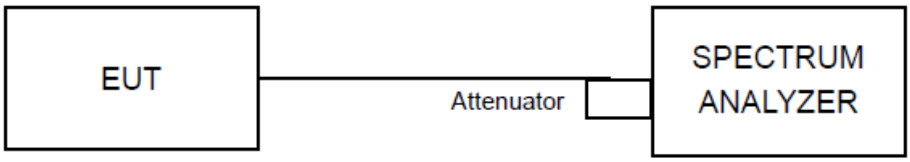
802.15.4 _Ant2_2480

4.3 Conducted Output Power

4.3.1 Limit

For systems using digital modulation in the 2400 – 2483.5 MHz bands: 1 Watt (30 dBm)

4.3.2 Test Setup



4.3.3 Test Procedures

The EUT was tested according to DTS test procedure of “KDB558074 D01 DTS Meas Guidance” for compliance to FCC 47CFR 15.247 requirements (clause 9.2.2.4).

a) Set RBW ⩾ DTS bandwidth

b) Set VBW ⩾ 3 RBW.

c) Set Span ⩾ 3 RBW.

d) Sweep time = auto couple.

e) Detector = peak

f) Trace mode = max hold.

g) Allow trace to fully stabilize

h) Use peak marker function to determine the peak amplitude level.

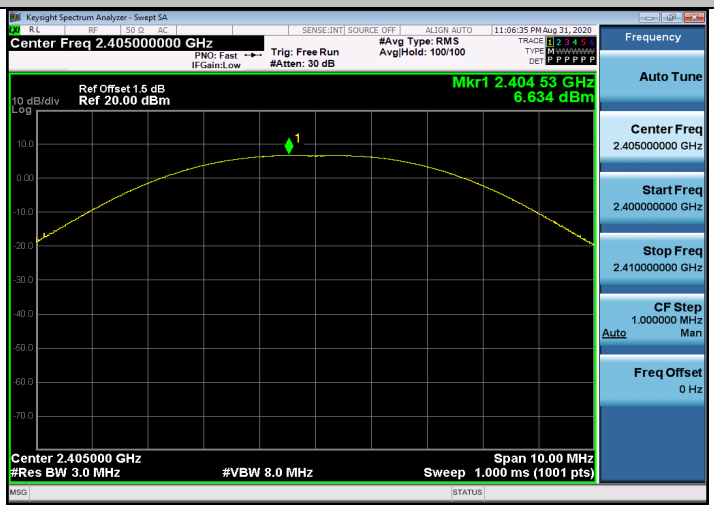
4.3.4 Deviation of Test Standard

No deviation.

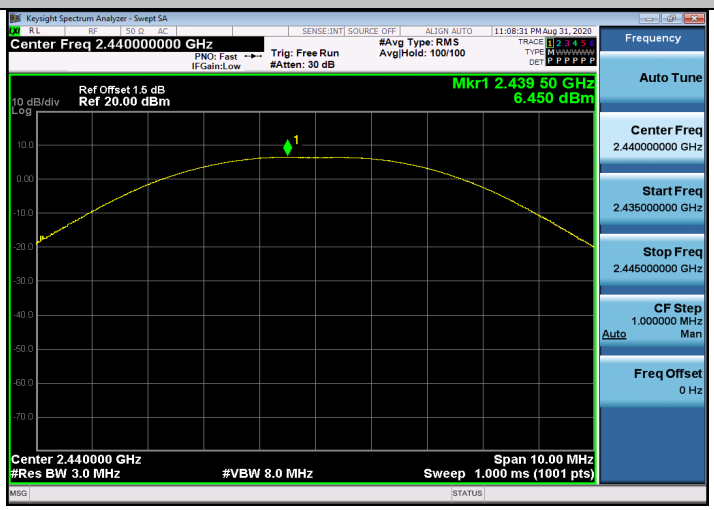
4.3.5 Test Results

Test Mode	Antenna	Channel [MHz]	Power [dBm]	Limit [dBm]	Verdict
802.15.4	Ant1	2405	6.63	<=30	PASS
		2440	6.45	<=30	PASS
		2480	-2.54	<=30	PASS
	Ant2	2405	15.51	<=30	PASS
		2440	15.46	<=30	PASS
		2480	7.23	<=30	PASS

802.15.4_Ant1_2405

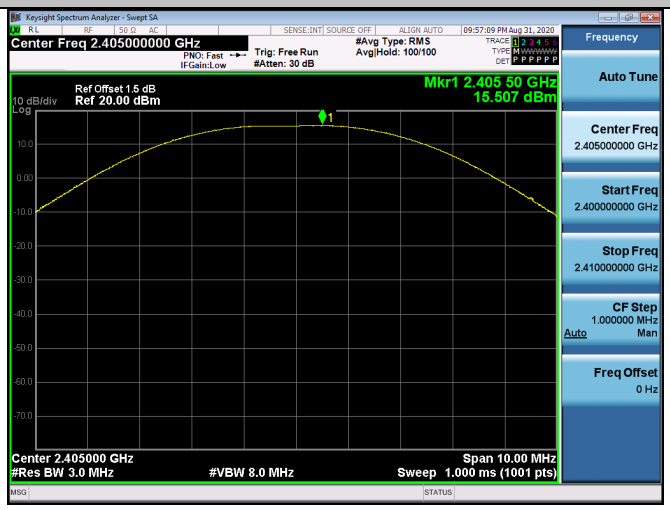


802.15.4_Ant1_2440

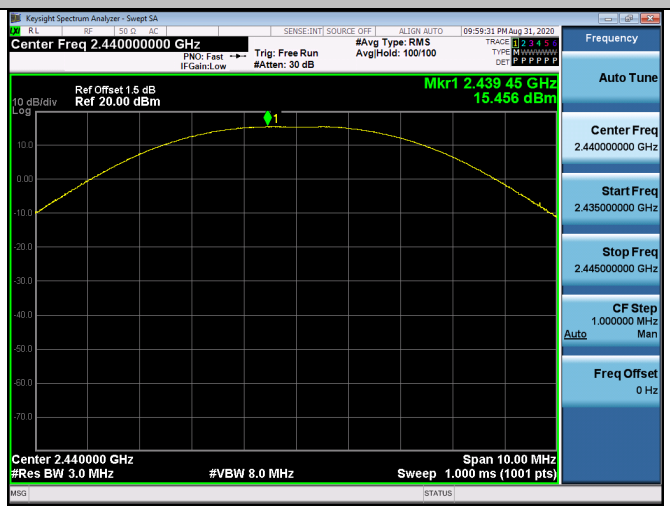


802.15.4_Ant1_2480

802.15.4_Ant2_2405



802.15.4_Ant2_2440



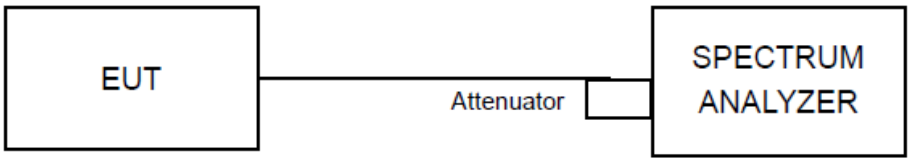
802.15.4_Ant2_2480

4.4 Power Spectral Density

4.4.1 Limit

The Maximum of Power Spectral Density Measurement is 8 dBm.

4.4.2 Test Setup



4.4.3 Test Procedures

The power output per FCC § 15.247(e) was tested according to DTS test procedure of “KDB558074 D01 DTS Meas Guidance” (clause 10.5) for compliance to FCC 47CFR 15.247 requirements.

a) Set analyzer center frequency to DTS channel center frequency.

b) Set the span to 1.5 times the DTS bandwidth.

c) Set the RBW to: 3 kHz $\leqslant$ RBW $\leqslant$ 100 kHz.

d) Set the VBW $\geqslant$ 3 ×RBW.

e) Detector = peak.

f) Sweep time = auto couple.

g) Trace mode = max hold.

h) Allow trace to fully stabilize.

i) Use the peak marker function to determine the maximum amplitude level within the RBW.

j) If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

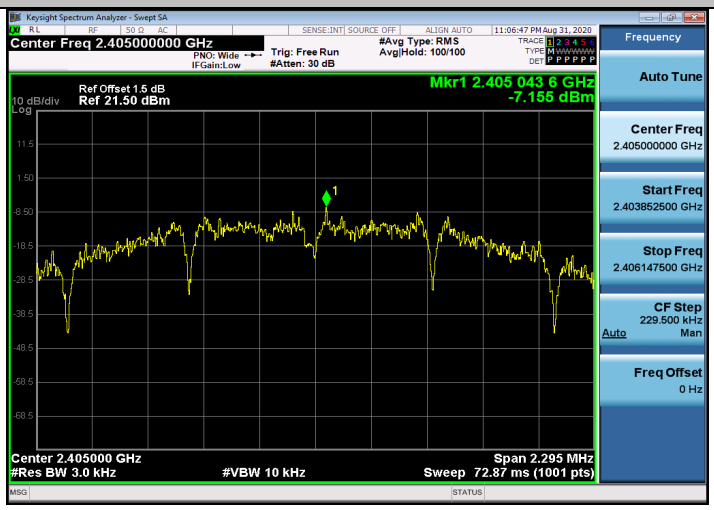
4.4.4 Deviation of Test Standard

No deviation.

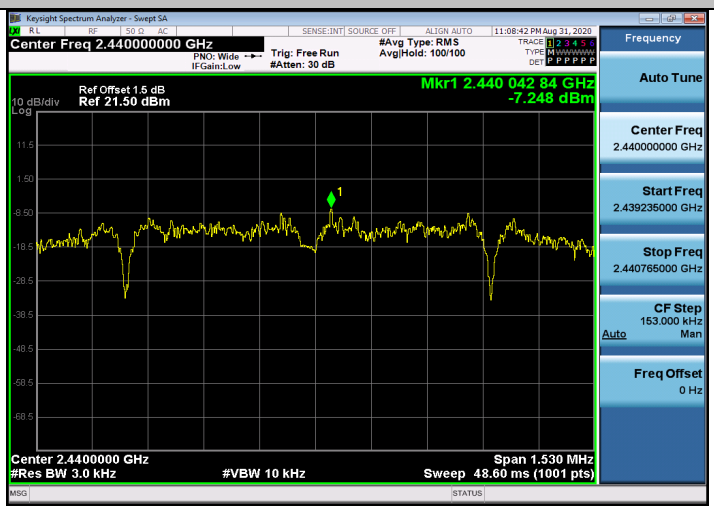
4.4.5 Test Results

Test Mode	Antenna	Channel [MHz]	PSD[dBm/3kHz]	Limit[dBm/3kHz]	Verdict
802.15.4	Ant1	2405	-7.16	<=8	PASS
		2440	-7.25	<=8	PASS
		2480	-17.54	<=8	PASS
	Ant2	2405	1.69	<=8	PASS
		2440	1.72	<=8	PASS
		2480	-6.68	<=8	PASS

802.15.4_Ant1_2405

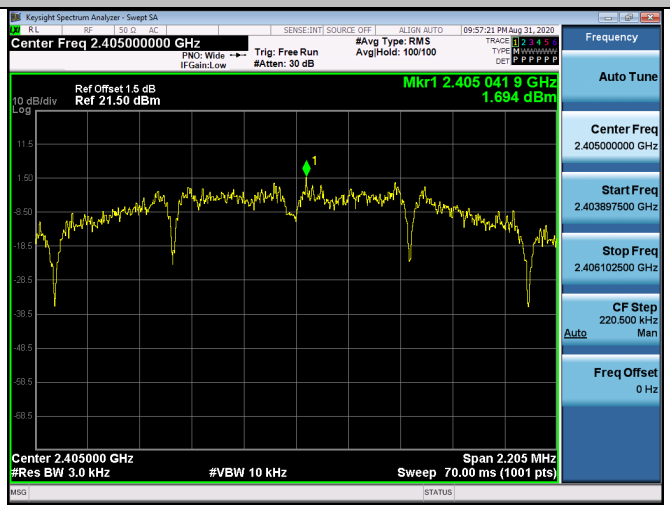


802.15.4_Ant1_2440



802.15.4_Ant1_2480

802.15.4_Ant2_2405



802.15.4_Ant2_2440

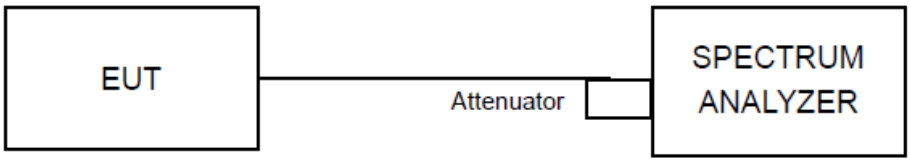
802.15.4_Ant2_2480

4.5 Conducted Band Edges Measurement

4.5.1 Limit

Below 20 dB of the highest emission level of operating band (in 100 kHz Resolution Bandwidth).

4.5.2 Test Setup



4.5.3 Test Procedures

The EUT was tested according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance" (clause 11.0) for compliance to FCC 47CFR 15.247 requirements.

MEASUREMENT PROCEDURE REF

1. Set the RBW = 100 kHz.
2. Set the VBW ⩾ 300 kHz.
3. Detector = peak.
4. Sweep time = auto couple.
5. Trace mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.

MEASUREMENT PROCEDURE OOBE

1. Set RBW = 100 kHz.
2. Set VBW ⩾ 300 kHz.
3. Detector = peak.
4. Sweep = auto couple.
5. Trace Mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum amplitude level.

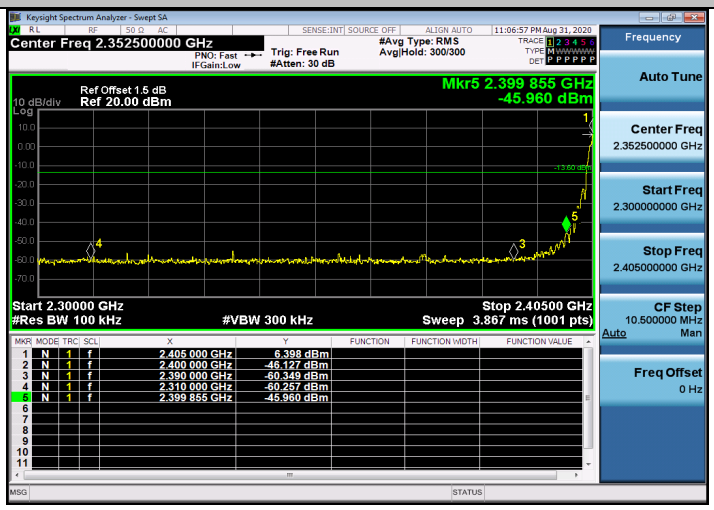
4.5.4 Deviation of Test Standard

No deviation.

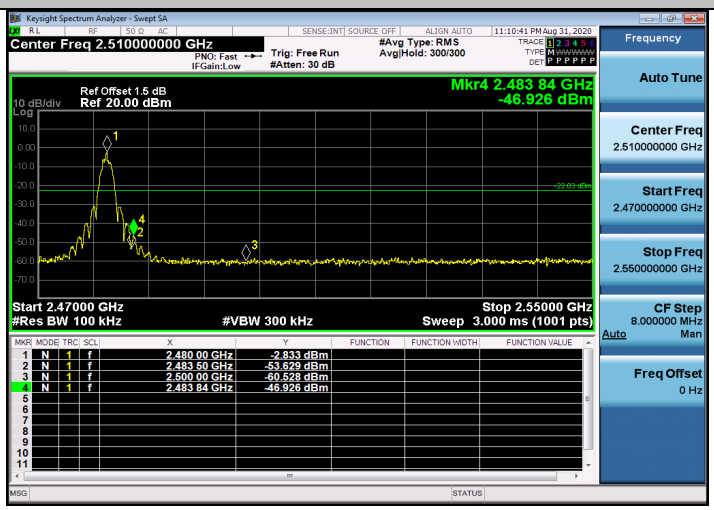
4.5.5 Test Results

Test Mode	Antenna	ChName	Channel [MHz]	RefLevel [dBm]	Max. Spurious Level [dBm]	Limit [dBm]	Verdict
802.15.4	Ant1	Low	2405	6.40	-45.96	<=-13.6	PASS
		High	2480	-2.83	-46.93	<=-22.83	PASS
	Ant2	Low	2405	11.19	-36.94	<=-8.81	PASS
		High	2480	3.49	-37.97	<=-16.51	PASS

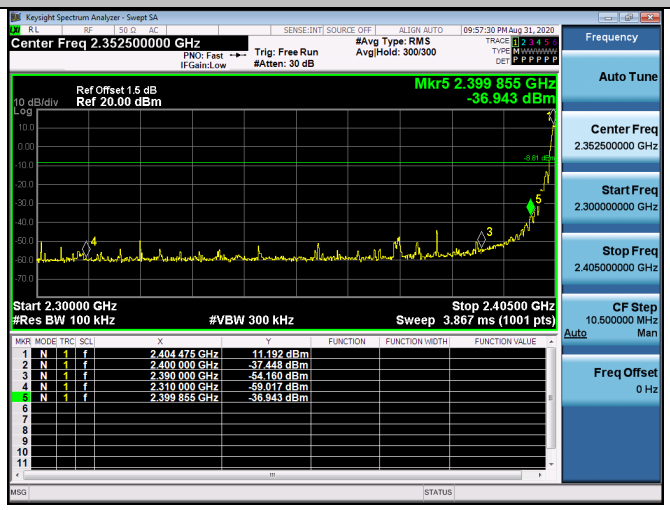
802.15.4_Ant1_Low_2405



802.15.4_Ant1_High_2480



802.15.4_Ant2_Low_2405



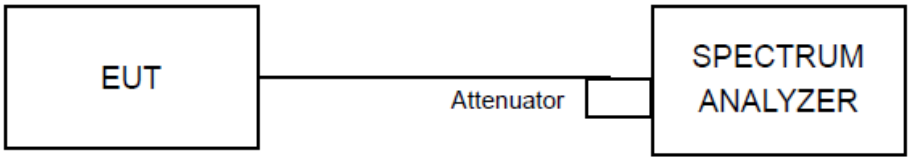
802.15.4_Ant2_High_2480

4.6 Conducted Spurious Emissions

4.6.1 Limit

Below 20 dB of the highest emission level of operating band (in 100 kHz Resolution Bandwidth).

4.6.2 Test Setup



4.6.3 Test Procedures

The EUT was tested according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance" (clause 11.0) for compliance to FCC 47CFR 15.247 requirements.

MEASUREMENT PROCEDURE REF

1. Set the RBW = 100 kHz.
2. Set the VBW ≥ 300 kHz.
3. Detector = peak.
4. Sweep time = auto couple.
5. Trace mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.

MEASUREMENT PROCEDURE OOBE

1. Set RBW = 100 kHz.
2. Set VBW ≥ 300 kHz.
3. Detector = peak.
4. Sweep = auto couple.
5. Trace Mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum amplitude level.

4.6.4 Deviation of Test Standard

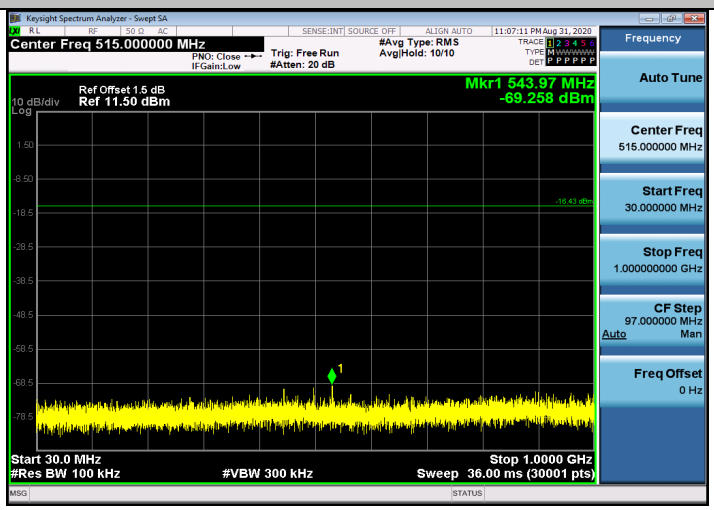
No deviation.

4.6.5 Test Results

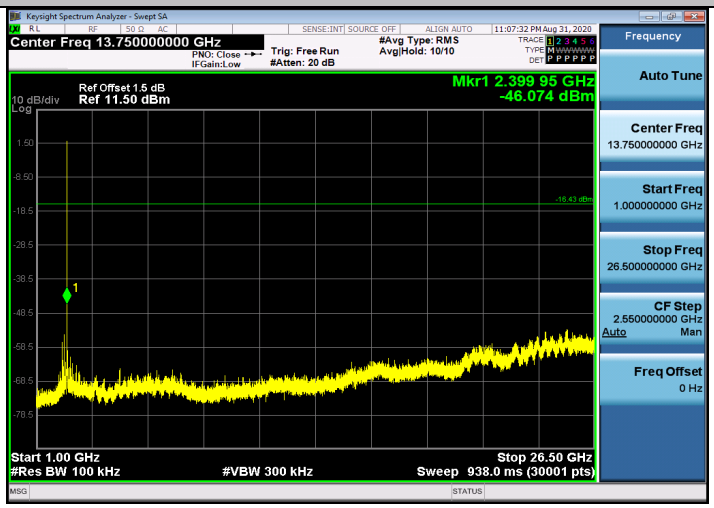
Test Mode	Antenna	Channel [MHz]	FreqRange [MHz]	RefLevel [dBm]	Result [dBm]	Limit [dBm]	Verdict
802.15.4	Ant1	2405	Reference	3.57	3.57	---	PASS
			30~1000	30~1000	-69.258	<=-16.427	PASS
			1000~26500	1000~26500	-46.074	<=-16.427	PASS
		2440	Reference	6.26	6.26	---	PASS
			30~1000	30~1000	-70.041	<=-13.743	PASS
			1000~26500	1000~26500	-53.136	<=-13.743	PASS
		2480	Reference	-2.64	-2.64	---	PASS
			30~1000	30~1000	-71.101	<=-22.638	PASS
			1000~26500	1000~26500	-49.52	<=-22.638	PASS
	Ant2	2405	Reference	12.44	12.44	---	PASS
			30~1000	30~1000	-69.746	<=-7.562	PASS
			1000~26500	1000~26500	-37.044	<=-7.562	PASS
		2440	Reference	12.45	12.45	---	PASS
			30~1000	30~1000	-70.042	<=-7.551	PASS
			1000~26500	1000~26500	-51.08	<=-7.551	PASS
		2480	Reference	3.03	3.03	---	PASS
			30~1000	30~1000	-70.903	<=-16.974	PASS
			1000~26500	1000~26500	-38.819	<=-16.974	PASS

802.15.4 _Ant1_2405_0~Reference

802.15.4 _Ant1_2405_30~1000

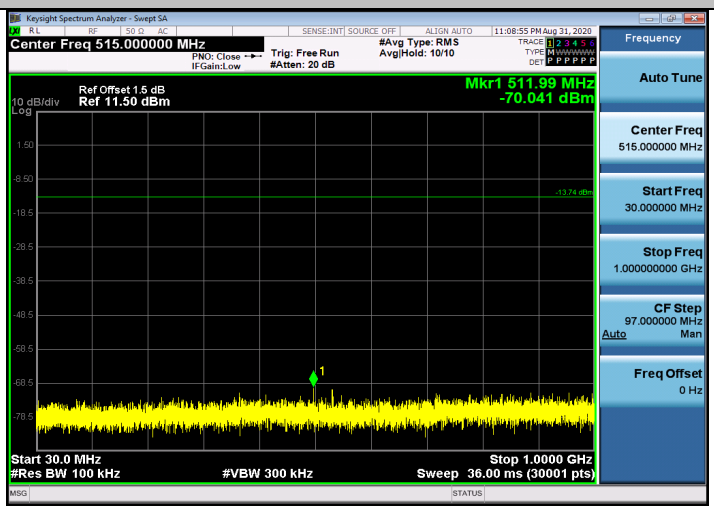


802.15.4 _Ant1_2405_1000~26500

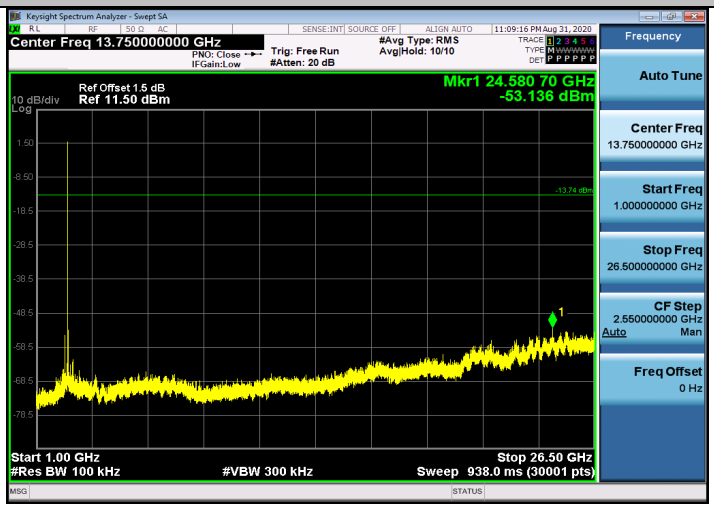


802.15.4 _Ant1_2440_0~Reference

802.15.4 _Ant1_2440_30~1000

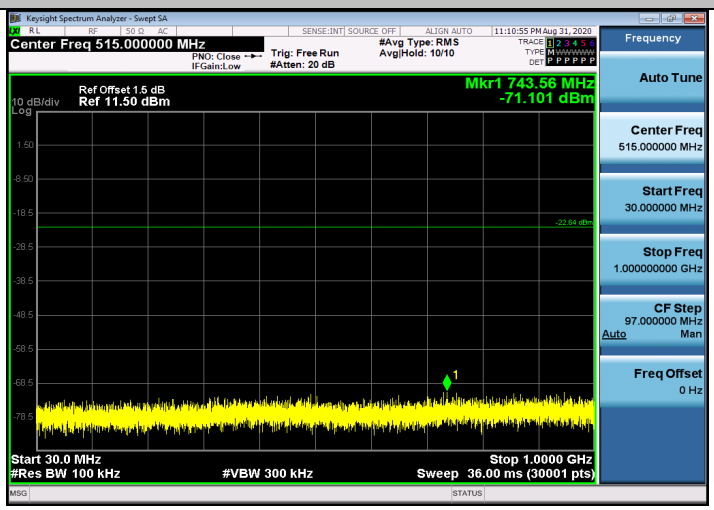


802.15.4 _Ant1_2440_1000~26500

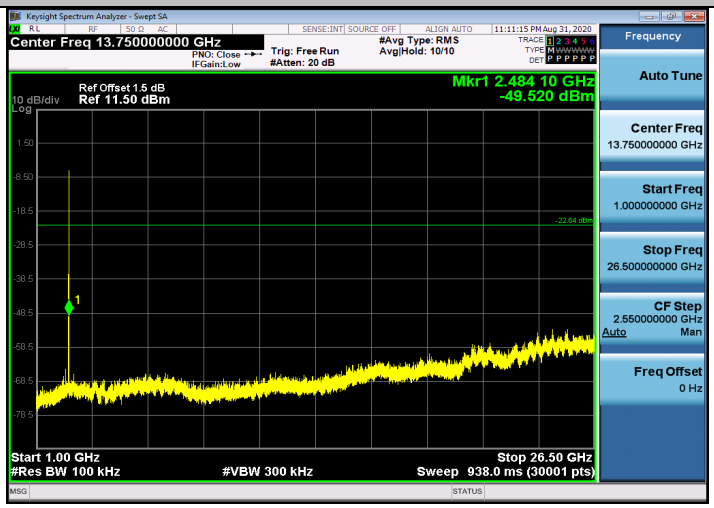


802.15.4 _Ant1_2480_0~Reference

802.15.4 _Ant1_2480_30~1000

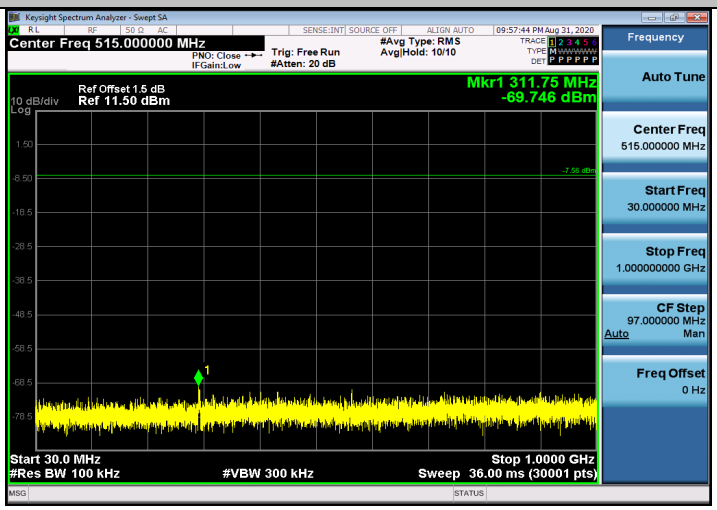


802.15.4 _Ant1_2480_1000~26500

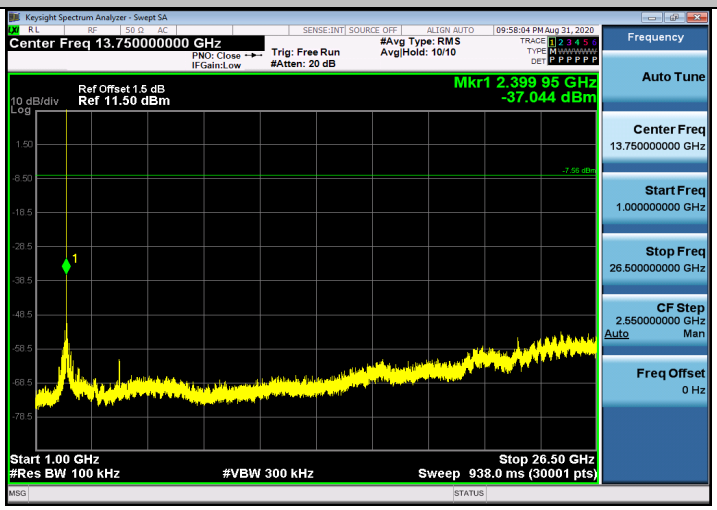


802.15.4 _Ant2_2405_0~Reference

802.15.4 _Ant2_2405_30~1000

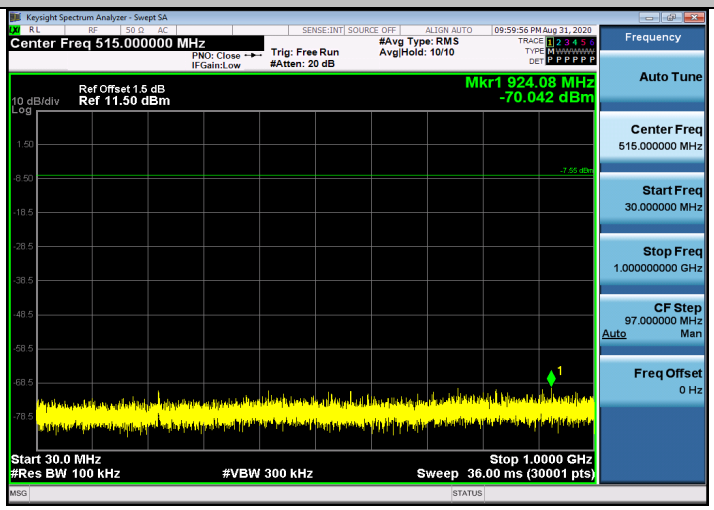


802.15.4 _Ant2_2405_1000~26500

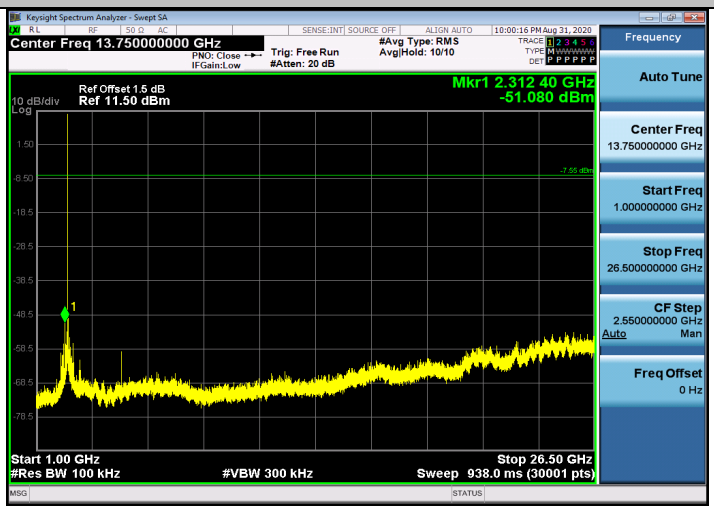


802.15.4 _Ant2_2440_0~Reference

802.15.4 _Ant2_2440_30~1000

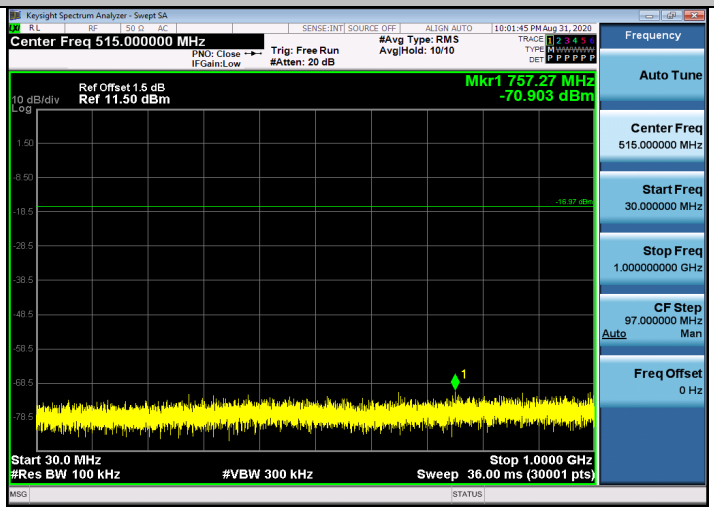


802.15.4 _Ant2_2440_1000~26500

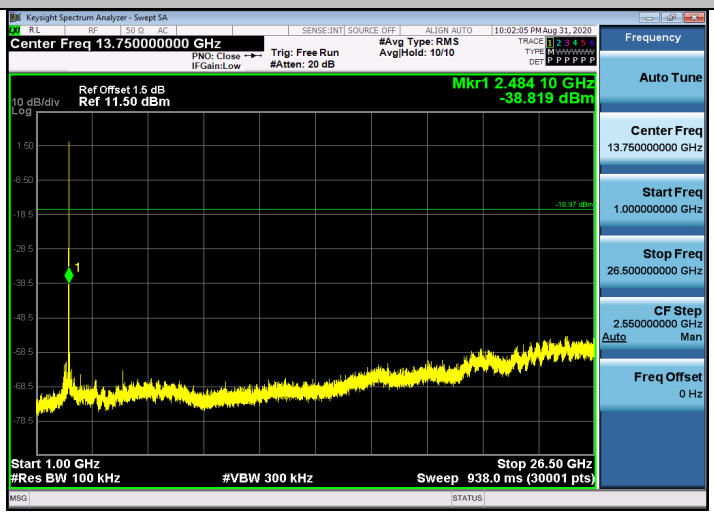


802.15.4 _Ant2_2480_0~Reference

802.15.4 _Ant2_2480_30~1000



802.15.4 _Ant2_2480_1000~26500



4.7 Emissions in restricted frequency bands

4.7.1 Test Limit

For 15.205 requirement:

Radiated emissions which fall in the restricted bands, as defined in Section 15.205(a) of FCC part15, must also comply with the radiated emission limits specified in Section 15.209(a).

Frequency (MHz)	Frequency (MHz)	Frequency (MHz)	Frequency (GHz)
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
1 0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	(2)
13.36 - 13.41	--	--	--

All out of band emissions appearing in a restricted band as specified in Section 15.205 of the Title 47CFR must not exceed the limits shown in Table per Section 15.209.

FCC Part 15 Subpart C Paragraph 15.209		
Frequency [MHz]	Field Strength [uV/m]	Measured Distance [Meters]
0.009 - 0.490	2400/F (kHz)	300
0.490 - 1.705	24000/F (kHz)	30
1.705 - 30	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

4.7.2 Test Procedure Reference

ANSI C63.10 Section 6.3 (General Requirements)

ANSI C63.10 Section 6.6 (Standard test method above 1GHz)

4.7.3 Test Procedures

Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW = 3MHz
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize

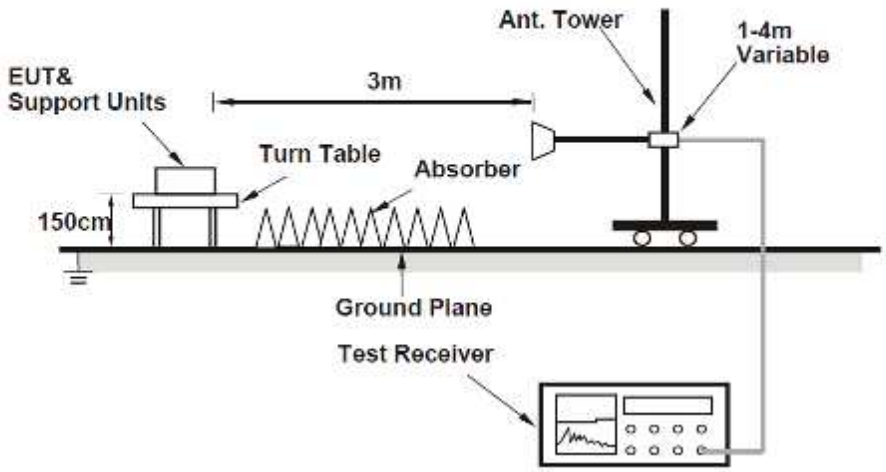
Average Measurements above 1GHz (Method VB)

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW; If the EUT is configured to transmit with duty cycle ≥ 98%, set VBW = 10 Hz.

   If the EUT duty cycle is < 98%, set VBW ≥ 1/T. T is the minimum transmission duration.
3. Detector = Peak
5. Sweep time = auto
6. Trace mode = max hold
7. Trace was allowed to stabilize

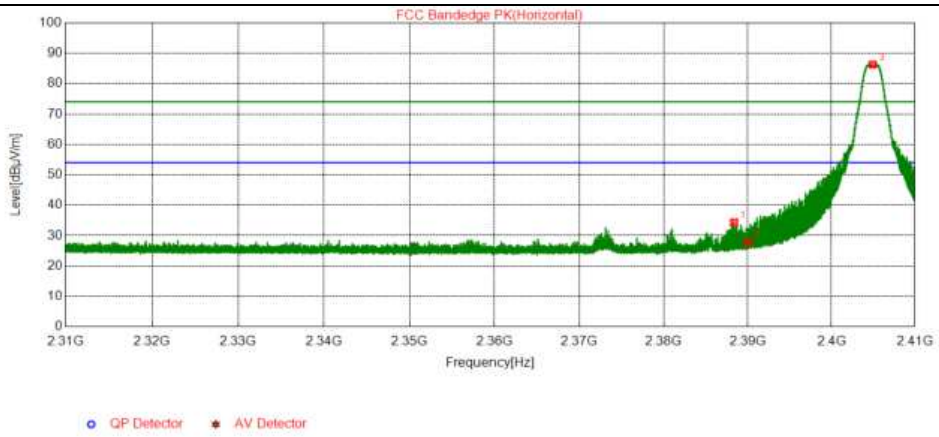
4.7.4 Test Setup

For Radiated emission above 1GHz



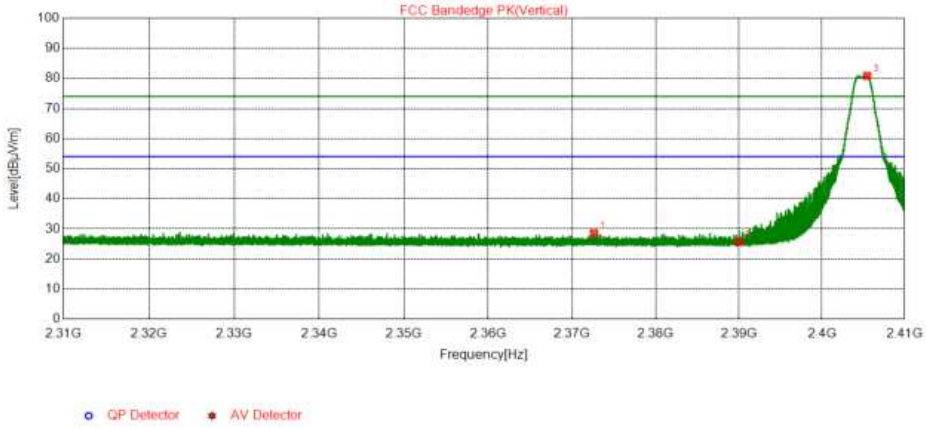
4.7.5 Test Results

802.15.4 _Ant1_2405 / Horizontal



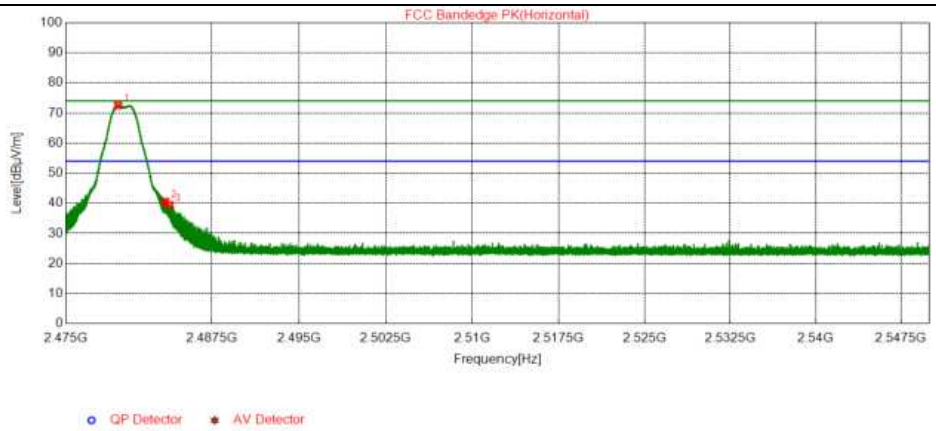
NO.	Freq. [MHz]	Reading [dBµV/m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity	Detector
1	2388.3700	44.28	34.31	74.00	39.69	150	59	Horizontal	PK
2	2390.0000	37.79	27.83	74.00	46.17	150	59	Horizontal	PK
3	2404.9450	96.25	86.32	74.00	-12.32	150	59	Horizontal	PK

802.15.4 _Ant1_2405 / Vertical



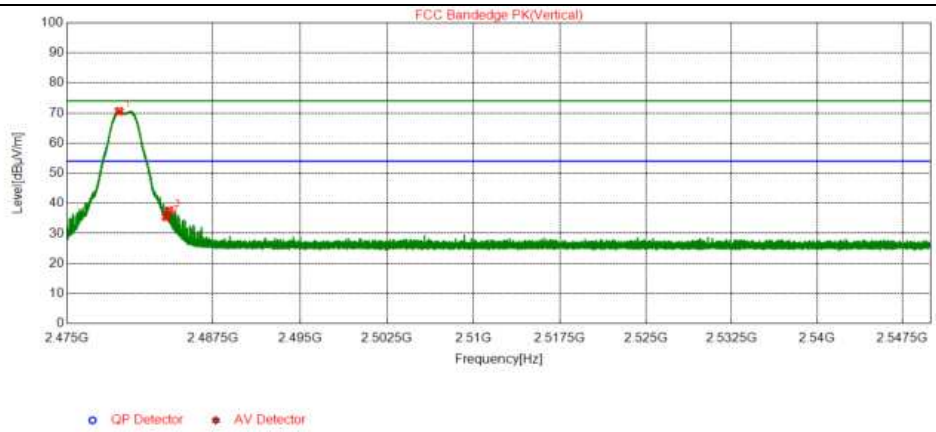
NO.	Freq. [MHz]	Reading [dBµV/m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity	Detector
1	2372.6000	38.53	28.53	74.00	45.47	150	118	Vertical	PK
2	2390.0000	35.62	25.66	74.00	48.34	150	252	Vertical	PK
3	2405.4850	90.77	80.84	74.00	-6.84	150	118	Vertical	PK

802.15.4 _Ant1_2480 / Horizontal



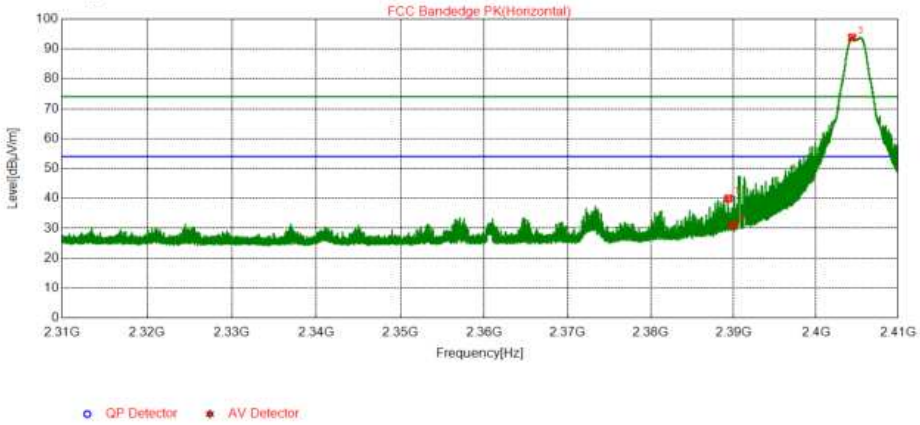
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity	Detector
1	2479.4625	82.33	72.53	74.00	1.47	150	85	Horizontal	PK
2	2483.5050	50.34	40.55	74.00	33.45	150	254	Horizontal	PK
3	2483.8838	49.20	39.41	74.00	34.59	150	271	Horizontal	PK

802.15.4 _Ant1_2480 /Vertical



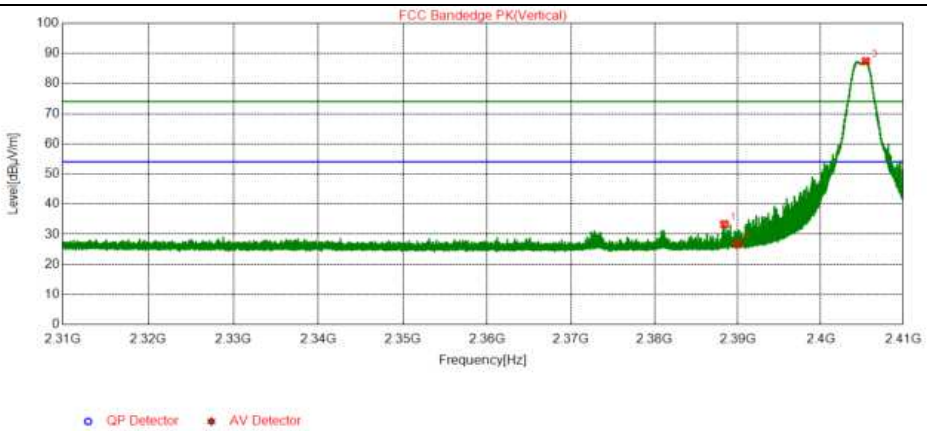
NO.	Freq. [MHz]	Reading [dBμV/m]	Level [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity	Detector
1	2479.4663	80.39	70.59	74.00	3.41	150	225	Vertical	PK
2	2483.5013	45.28	35.49	74.00	38.51	150	89	Vertical	PK
3	2483.7300	47.33	37.54	74.00	36.46	150	209	Vertical	PK

802.15.4 _Ant2_2405 / Horizontal



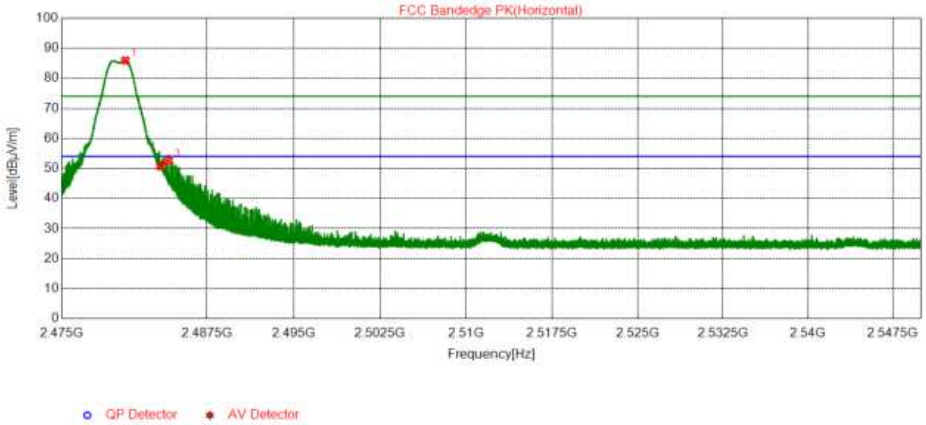
NO.	Freq. [MHz]	Reading [dBµV/m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity	Detector
1	2389.3700	49.95	39.99	74.00	34.01	150	253	Horizontal	PK
2	2390.0000	40.98	31.02	74.00	42.98	150	354	Horizontal	PK
3	2404.4100	103.75	93.82	74.00	-19.82	150	253	Horizontal	PK

802.15.4 _Ant2_2405 / Vertical



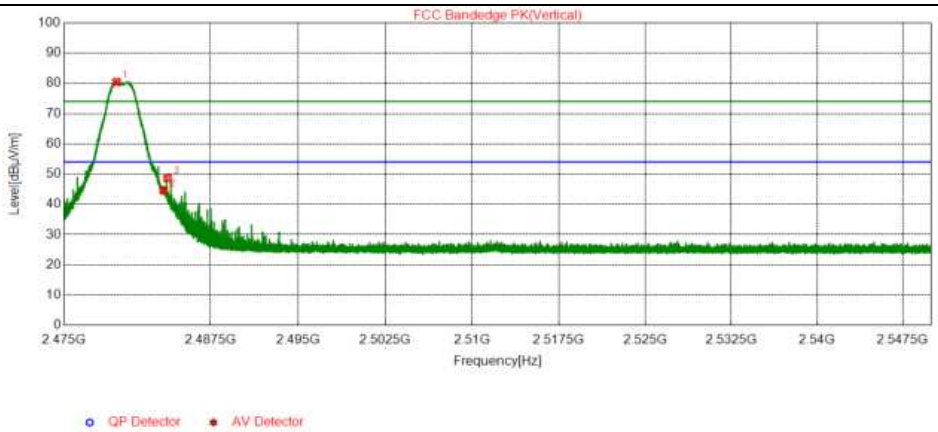
NO.	Freq. [MHz]	Reading [dBµV/m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity	Detector
1	2388.3900	43.26	33.30	74.00	40.70	150	108	Vertical	PK
2	2390.0000	36.71	26.75	74.00	47.25	150	209	Vertical	PK
3	2405.4750	97.32	87.39	74.00	-13.39	150	226	Vertical	PK

802.15.4 _Ant2_2480 / Horizontal



NO.	Freq. [MHz]	Reading [dBµV/m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity	Detector
1	2480.4713	95.72	85.92	74.00	-11.92	150	226	Horizontal	PK
2	2483.5050	60.49	50.70	74.00	23.30	150	226	Horizontal	PK
3	2484.1725	62.40	52.61	74.00	21.39	150	226	Horizontal	PK

802.15.4 _Ant2_2480 /Vertical



NO.	Freq. [MHz]	Reading [dBµV/m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity	Detector
1	2479.4775	90.25	80.45	74.00	-6.45	150	240	Vertical	PK
2	2483.5013	54.34	44.55	74.00	29.45	150	240	Vertical	PK
3	2483.8275	58.40	48.61	74.00	25.39	150	240	Vertical	PK

4.8 Radiated Emission Measurement

4.8.1 Limits

Radiated emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table.

Frequencies (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 ~ 0.490	2400/F (kHz)	300
0.490 ~ 1.705	24000/F (kHz)	30
1.705 ~ 30.0	30	30
30 ~ 88	100	3
88 ~ 216	150	3
216 ~ 960	200	3
Above 960	500	3

NOTE:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. For frequencies above 1000 MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20 dB under any condition of modulation.

4.8.2 Test Procedures

For Radiated emission below 30MHz

a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degree to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. Both X and Y axes of the antenna are set to make the measurement.

d. For each suspected emission, the EUT was arranged to its worst case and the rotate table was turned from 0 degree to 360 degree to find the maximum reading.

e. The test-receiver system was set to Quasi-Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

Note:

The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9kHz at frequency below 30MHz.

For Radiated emission above 30MHz

a. The EUT was placed on the top of a rotating table 0.8 meters (for below 1 GHz) / 1.5 meters (for above 1 GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The height of antenna is varied from one meter to four meters 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.

d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.

e. 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.

f. The test-receiver system was set to peak and average detected function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

Note:

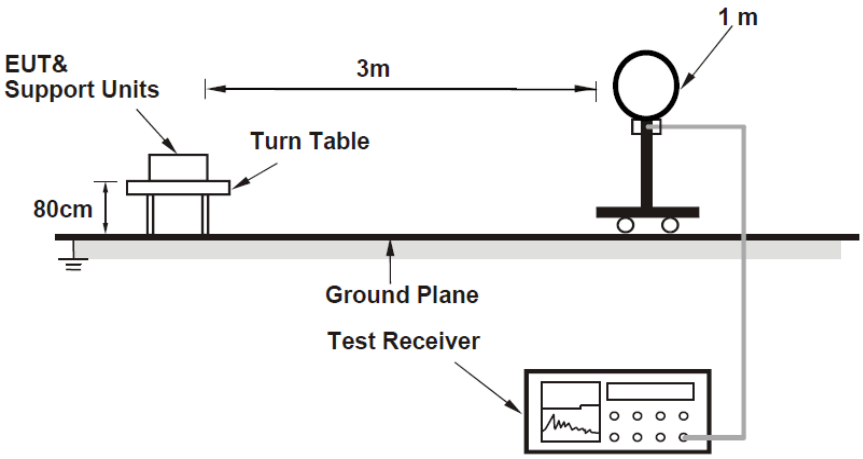
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz & 360 kHz for Quasi-peak detection (QP) at frequency below 1 GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1 GHz.
3. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 1/T for RMS Average (Duty cycle < 98 %) for Peak detection at frequency above 1 GHz.
4. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 10 Hz (Duty cycle ⩾ 98 %) for Average detection (AV) at frequency above 1 GHz.
5. All modes of operation were investigated and the worst-case emissions are reported.

4.8.3 Deviation from Test Standard

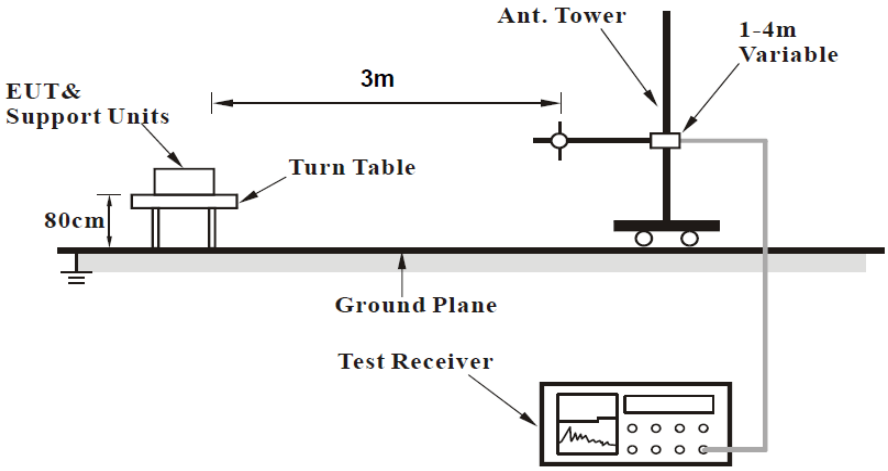
No deviation.

4.8.4 Test Setup

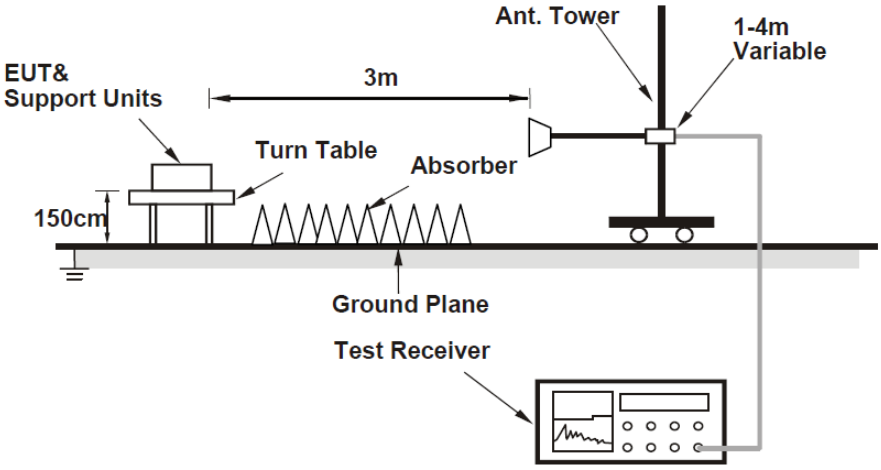
For Radiated emission below 30MHz



For Radiated emission 30MHz to 1GHz



For Radiated emission above 1GHz



For the actual test configuration, please refer to the attached file (Test Setup Photo).

4.8.5 EUT Operating Conditions

a. Placed the EUT on a testing table.

b. Use the software to control the EUT under transmission condition continuously at specific channel frequency.

4.8.6 Test Results

Radiated Emissions Range 9kHz~30MHz

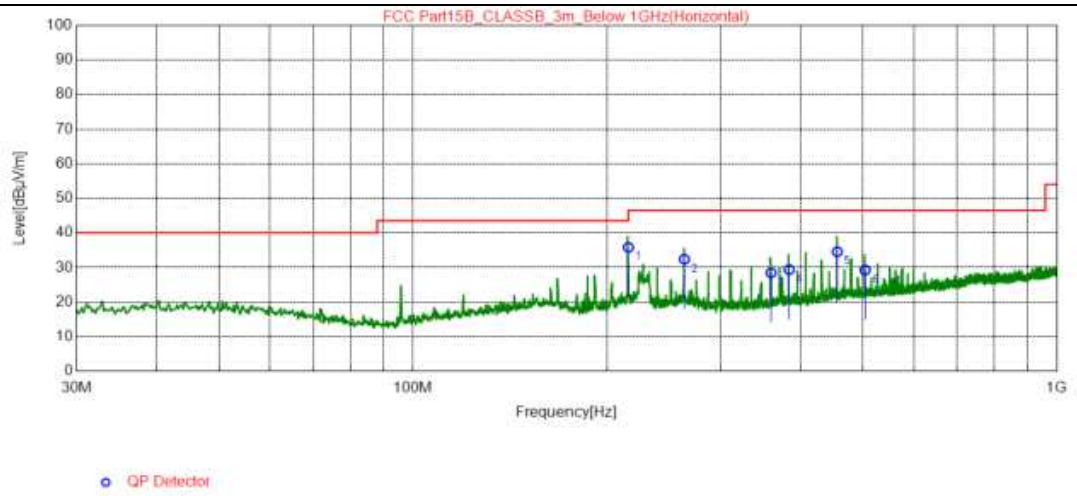
The amplitude of spurious emissions which are attenuated by more than 20 dB below the permissible value has no need to be reported.

Radiated Emissions Range 30MHz~1GHz

Below is the worst test data

Channel	802.15.4 _Ant1_2405	**Detector Function**	Quasi-Peak (QP)
Frequency Range	30MHz ~ 1GHz	**Antenna Polarity**	Horizontal

Test Plot:



NO.	Freq. [MHz]	QP Reading [dBµV/m]	Factor [dB]	QP Value [dBµV/m]	QP Limit [dBµV/m]	QP Margin [dB]	Height [cm]	Angle [°]	Polarity
1	216.0	47.45	-11.64	35.81	46.50	10.69	200	225	Horizontal
2	263.9	42.4	-10.01	32.39	46.50	14.11	200	340	Horizontal
3	359.9	36.92	-8.49	28.43	46.50	18.07	200	332	Horizontal
4	384.0	37.19	-7.82	29.37	46.50	17.13	200	328	Horizontal
5	456.0	41.15	-6.61	34.54	46.50	11.96	200	317	Horizontal
6	503.9	35.01	-5.76	29.25	46.50	17.25	200	314	Horizontal

REMARKS:

1. Emission Level(dBuV/m) = Spectrum reading (dBuV) + Correction Factor(Db/m)

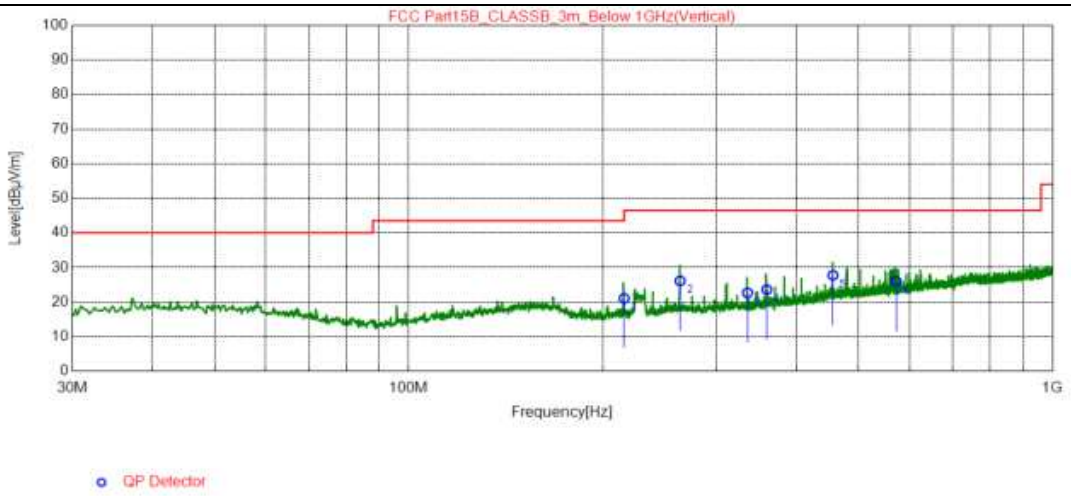
2. Correction Factor(Db/m) = Antenna Factor(Db/m) + Cable Factor(Db) – Pre-Amplifier Factor(Db)

3. The other emission levels were very low against the limit.

4. Margin value = Limit value – Emission Level

Channel	802.15.4 _Ant1_2405	Detector Function	Quasi-Peak (QP)
Frequency Range	30MHz ~ 1GHz	Antenna Polarity	Vertical

Test Plot:



NO.	Freq. [MHz]	QP Reading [dBµV/m]	Factor [dB]	QP Value [dBµV/m]	QP Limit [dBµV/m]	QP Margin [dB]	Height [cm]	Angle [°]	Polarity
1	216.0	32.7	-11.64	21.06	46.50	25.44	100	242	Vertical
2	263.9	36.15	-10.01	26.14	46.50	20.36	100	246	Vertical
3	335.9	31.56	-8.90	22.66	46.50	23.84	100	320	Vertical
4	359.9	32.08	-8.49	23.59	46.50	22.91	100	216	Vertical
5	456.0	34.35	-6.61	27.74	46.50	18.76	100	313	Vertical
6	571.4	30.93	-4.94	25.99	46.50	20.51	100	231	Vertical

REMARKS:

1. Emission Level(dBuV/m) = Original Spectrum reading (dBuV) + Correction Factor(dB/m)

2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)

3. The other emission levels were very low against the limit.

4. Margin value = Limit value – Emission Level

Radiated Emission Range 1GHz~10th Harmonic

Below is the worst test data

Channel	802.15.4 _Ant1_2405	**Detector Function**	Peak (PK)
Frequency Range	1GHz ~ 25GHz		Average (AV)

Spurious Emission Level							
No.	**Frequency (MHz)**	**Emission Level (dBuV/m)**	**Limit (dBuV/m)**	**Margin (dB)**	**Correction Factor (dB/m)**	**Antenna Polarity**	**Detector**
1	7212.6500	36.44	74.00	37.56	-4.69	H	PK
2	7214.3500	31.11	54.00	22.89	-4.69	H	AV
3	7214.3500	36.01	74.00	37.99	-4.68	V	PK
4	7216.0500	29.82	54.00	24.18	-4.69	V	AV

REMARKS:

1. Emission Level(dBuV/m) = Original Spectrum reading (dBuV) + Correction Factor(dB/m)

2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)

3. The other emission levels were very low against the limit.

4. Margin value = Limit value – Emission Level

Channel	802.15.4 _Ant1_2440	**Detector Function**	Peak (PK)
Frequency Range	1GHz ~ 25GHz		Average (AV)

Spurious Emission Level							
No.	**Frequency (MHz)**	**Emission Level (dBuV/m)**	**Limit (dBuV/m)**	**Margin (dB)**	**Correction Factor (dB/m)**	**Antenna Polarity**	**Detector**
1	7289.1500	34.50	74.00	39.50	-4.47	H	PK
2	7320.6000	28.84	54.00	25.16	-4.38	H	AV
3	7216.0500	36.01	74.00	37.99	-4.68	V	PK
4	7214.3500	29.82	54.00	24.18	-4.69	V	AV

REMARKS:

1. Emission Level(dBuV/m) = Original Spectrum reading (dBuV) + Correction Factor(dB/m)

2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)

3. The other emission levels were very low against the limit.

4. Margin value = Limit value – Emission Level

Channel	802.15.4 _Ant1_2480	**Detector Function**	Peak (PK)
Frequency Range	1GHz ~ 25GHz		Average (AV)

Spurious Emission Level							
No.	**Frequency (MHz)**	**Emission Level (dBuV/m)**	**Limit (dBuV/m)**	**Margin (dB)**	**Correction Factor (dB/m)**	**Antenna Polarity**	**Detector**
1	4927.0000	27.57	74.00	46.43	-9.26	H	PK
2	4913.4000	20.23	54.00	33.77	-9.28	H	AV
3	7252.6000	31.81	74.00	42.19	-7.32	V	PK
4	7251.7500	23.44	54.00	30.56	-7.18	V	AV

REMARKS:

1. Emission Level(dBuV/m) = Original Spectrum reading (dBuV) + Correction Factor(dB/m)

2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)

3. The other emission levels were very low against the limit.

4. Margin value = Limit value – Emission Level

Channel	802.15.4 _Ant2_2405	**Detector Function**	Peak (PK)
Frequency Range	1GHz ~ 25GHz		Average (AV)

Spurious Emission Level							
No.	**Frequency (MHz)**	**Emission Level (dBuV/m)**	**Limit (dBuV/m)**	**Margin (dB)**	**Correction Factor (dB/m)**	**Antenna Polarity**	**Detector**
1	7213.5000	35.17	74.00	38.83	-4.69	H	PK
2	7216.9000	30.75	54.00	23.25	-4.68	H	AV
3	7216.0500	36.06	74.00	37.94	-4.68	V	PK
4	7216.9000	29.70	54.00	24.30	-4.68	V	AV

REMARKS:

1. Emission Level(dBuV/m) = Original Spectrum reading (dBuV) + Correction Factor(dB/m)

2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)

3. The other emission levels were very low against the limit.

4. Margin value = Limit value – Emission Level

Channel	802.15.4 _Ant2_2440	**Detector Function**	Peak (PK)
Frequency Range	1GHz ~ 25GHz		Average (AV)

Spurious Emission Level							
No.	**Frequency (MHz)**	**Emission Level (dBuV/m)**	**Limit (dBuV/m)**	**Margin (dB)**	**Correction Factor (dB/m)**	**Antenna Polarity**	**Detector**
1	7297.6500	35.41	74.00	38.59	-4.45	H	PK
2	7319.7500	29.11	54.00	24.89	-4.38	H	AV
3	7321.4500	35.53	74.00	38.47	-4.38	V	PK
4	7319.7500	28.43	54.00	25.57	-4.38	V	AV

REMARKS:

1. Emission Level(dBuV/m) = Original Spectrum reading (dBuV) + Correction Factor(dB/m)

2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)

3. The other emission levels were very low against the limit.

4. Margin value = Limit value – Emission Level

Channel	802.15.4 _Ant2_2480	**Detector Function**	Peak (PK)
Frequency Range	1GHz ~ 25GHz		Average (AV)

Spurious Emission Level							
No.	**Frequency (MHz)**	**Emission Level (dBuV/m)**	**Limit (dBuV/m)**	**Margin (dB)**	**Correction Factor (dB/m)**	**Antenna Polarity**	**Detector**
1	7229.6500	34.46	74.00	39.54	-4.64	H	PK
2	7169.3000	26.67	54.00	27.33	-4.83	H	AV
3	7246.6500	34.36	74.00	39.64	-4.59	V	PK
4	7200.7500	27.13	54.00	26.87	-4.73	V	AV

REMARKS:

1. Emission Level(dBuV/m) = Original Spectrum reading (dBuV) + Correction Factor(dB/m)

2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)

3. The other emission levels were very low against the limit.

4. Margin value = Limit value – Emission Level

5 Pictures of Test Arrangements

Please refer to the attached file (Test Setup Photo).

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