

FCC Test Report

(SRD)

Report No.: RF200602C21-1

FCC ID: QOQ-BGM220S2

Test Model: BGM220S22A

Series Model: BGX220S22A (refer to item 3.1 for more details)

Received Date: Jun. 02, 2020

Test Date: Jun. 09 ~ Jul. 07, 2020

Issued Date: Aug. 24, 2020

Applicant: Silicon Laboratories Finland Oy

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**FCC Registration /
Designation Number:** 788550 / TW0003



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Release Control Record

Issue No.	Description	Date Issued
RF200602C21-1	Original release.	Aug. 24, 2020

1 Certificate of Conformity

Product: Bluetooth Low Energy wireless radio module (Refer to item 3.1 for the more details)

Brand: Silicon Labs

Test Model: BGM220S22A

Series Model: BGX220S22A (refer to item 3.1 for more details)

Sample Status: Engineering sample fully representing the production model

Applicant: Silicon Laboratories Finland Oy

Test Date: Jun. 09 ~ Jul. 07, 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 Consumer Products Services (H.K.) Ltd., Taoyuan Branch**, 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 RF characteristics under the conditions specified in this report.

Prepared by :  , **Date:** Aug. 24, 2020
Polly Chien / Specialist

Approved by :  , **Date:** Aug. 24, 2020
Bruce Chen / Senior Project Engineer

2 Summary of Test Results

47 CFR FCC Part 15, Subpart C (Section 15.247)			
FCC Clause	Test Item	Result	Remarks
15.207	AC Power Conducted Emission	Pass	Meet the requirement of limit. Minimum passing margin is -20.76dB at 0.16955MHz.
15.205 / 15.209 / 15.247(d)	Radiated Emissions and Band Edge Measurement	Pass	Meet the requirement of limit. Minimum passing margin is -1.4dB at 37.76MHz & 70.74MHz.
15.247(d)	Antenna Port Emission	Pass	Meet the requirement of limit.
15.247(a)(2)	6dB bandwidth	Pass	Meet the requirement of limit.
15.247(b)	Conducted power	Pass	Meet the requirement of limit.
15.247(e)	Power Spectral Density	Pass	Meet the requirement of limit.
15.203	Antenna Requirement	Pass	Dipole antenna (ANT-2.4-CW-CT-RPS): No module's own connector, RF-pin only. Integral antenna: No antenna connector is used.

Note:

- For 2.4G band compliance with rule 15.247(d) of the band-edge items, the test plots were recorded in Annex A. Test Procedures refer to report 4.1.3.
- Determining compliance based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty.

2.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

Measurement	Frequency	Expanded Uncertainty (k=2) (±)
Conducted Emissions at mains ports	150kHz ~ 30MHz	2.79 dB
Radiated Emissions up to 1 GHz	9kHz ~ 30MHz	3.04 dB
	30MHz ~ 200MHz	3.86 dB
	200MHz ~ 1000MHz	3.87 dB
Radiated Emissions above 1 GHz	1GHz ~ 18GHz	2.29 dB
	18GHz ~ 40GHz	2.29 dB

2.2 Modification Record

There were no modifications required for compliance.

3 General Information

3.1 General Description of EUT

Product	Bluetooth Low Energy wireless radio module (Refer to note 1)
Brand	Silicon Labs
Test Model	BGM220S22A
Series Model	BGX220S22A
Model Difference	Refer to note 1
Sample Status	Engineering sample fully representing the production model
Power Supply Rating	3Vdc from host equipment
Modulation Type	GFSK
Transfer Rate	1Mbps
Operating Frequency	2401, 2481MHz
Number of Channel	2
Output Power	5.781mW
Antenna Type	Dipole antenna with 2.8dBi gain Integral antenna with 2.3dBi gain
Antenna Connector	Dipole antenna: No module's own connector, RF-pin only Integral antenna: NA
Accessory Device	NA
Cable Supplied	NA

Note:

- All models are listed as below. Model BGM220S22A is the representative for final test.

Product	Bluetooth Low Energy wireless radio module	
Model	BGM220S22A	BGX220S22A
Model differences	The only difference between the BGM220S22A and the BGM220S22A concerns the software running in the modules: the BGM220S22A is a marketing variant derived from the BGM220S22A where only a special application designed by Silicon Labs can run. Such special application is developed using the same SDK and on top of the same BLE stack used by all other customers of the main model.	

- The EUT is capable of running the Bluetooth Low Energy protocols and an additional custom protocol. However, in no circumstance the module will transmit using two or more protocols at the same time.
- Spurious emission of the simultaneous operation (DTS and SRD) has been evaluated and no non-compliance was found.
- The above Antenna information is declared by manufacturer and for more detailed features description, please refer to the manufacturer's specifications, the laboratory shall not be held responsible.
- The EUT is an engineering sample fully representing the production model, except for the values used to configure the RF TX power.
- The power setting used during testing with the EUT are list as below.

Freq. (MHz)	SRD
2401	70
2481	70

- The manufacturer reserves the right to further limit the max RF TX power in the firmware of production modules.

3.2 Description of Test Modes

2 frequencies are provided to this EUT:

Freq. (MHz)
2401
2481

3.2.1 Test Mode Applicability and Tested Channel Detail

EUT Configure Mode	Applicable to				Description
	RE \geq 1G	RE<1G	PLC	APCM	
A	√	√	√	√	EUT with Dipole antenna
B	√	√	√	-	EUT with Integral antenna

Where RE \geq 1G: Radiated Emission above 1GHz & Bandedge Measurement
 RE<1G: Radiated Emission below 1GHz
 PLC: Power Line Conducted Emission
 APCM: Antenna Port Conducted Measurement

Note:

- The EUT had been pre-tested on the positioned of each 3 axis. The worst case was found when positioned on Z-plane (antenna).
- "-" means no effect.

Radiated Emission Test (Above 1GHz):

- 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	Tested Freq. (MHz)	Modulation Technology	Data Rate (Mbps)
A, B	2401,	GFSK	1.0

Radiated Emission Test (Below 1GHz):

- 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	Tested Freq. (MHz)	Modulation Technology	Data Rate (Mbps)
A	2401	GFSK	1.0
B	2481	GFSK	1.0

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	Tested Freq. (MHz)	Modulation Technology	Data Rate (Mbps)
A	2401	GFSK	1.0
B	2481	GFSK	1.0

Antenna Port Conducted Measurement:

- This item includes all test value of each mode, but only includes spectrum plot of worst value of each mode.
- 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	Tested Freq. (MHz)	Modulation Technology	Data Rate (Mbps)
A	2401, 2481	GFSK	1.0

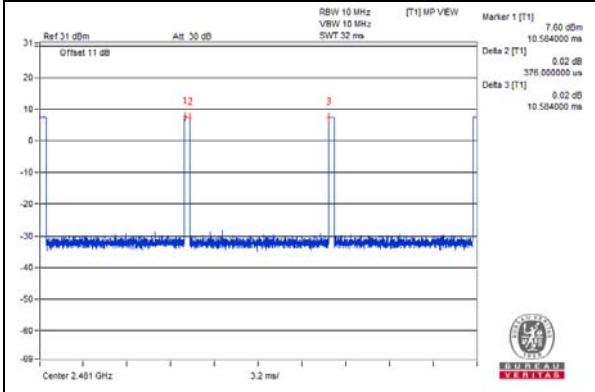
Test Condition:

Applicable to	Environmental Conditions	Input Power (System)	Tested by
RE \geq 1G	23 deg. C, 67% RH	120Vac, 60Hz	Adair Peng
RE<1G	23 deg. C, 67% RH	120Vac, 60Hz	Adair Peng
PLC	23 deg. C, 67% RH	120Vac, 60Hz	Adair Peng
APCM	25 deg. C, 60% RH	120Vac, 60Hz	Alan Wu

3.1 Duty Cycle of Test Signal

Duty cycle of test signal is < 98 %.

Duty cycle = $0.376/10.584 = 0.036$, Duty factor = $10 * \log(1/0.036) = 14.44$



3.2 Description of Support Units

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

ID	Product	Brand	Model No.	Serial No.	FCC ID	Remarks
A.	Notebook	Dell	E5430	HMZJ7W1	FCC DoC Approved	-
B.	Fixture Board	NA	NA	NA	NA	Provided by client
C.	Load	NA	NA	NA	NA	-
D.	Antenna	Linx Technologies Inc.	ANT-2.4-CW-CT-SMA	NA	NA	Provided by client

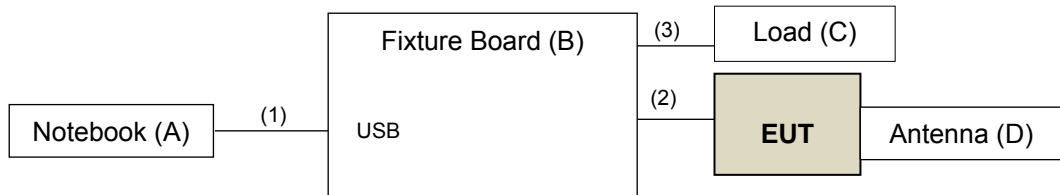
Note:

1. All power cords of the above support units are non-shielded (1.8m).
2. Items A acted as a communication partner to transfer data.

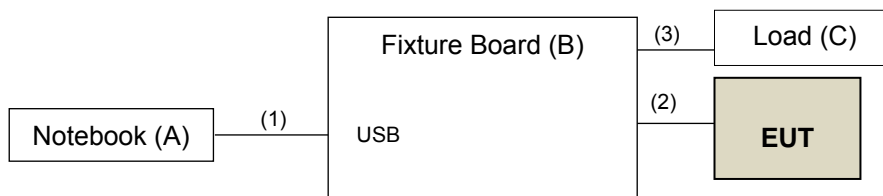
ID	Cable Descriptions	Qty.	Length (m)	Shielding (Yes/No)	Cores (Qty.)	Remarks
1.	USB cable	1	0.95	Y	0	Provided by client
2.	Flat cable	1	0.15	N	0	Provided by client
3.	LAN cable	1	1.5	N	0	Provided by Lab. RJ45, Cate.5e

3.2.1 Configuration of System under Test

Mode A



Mode B



3.3 General Description of Applied Standards and References

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

Test standard:

FCC Part 15, Subpart C (15.247)

ANSI C63.10-2013

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

References Test Guidance:

KDB 558074 D01 15.247 Meas Guidance v05r02

All test items have been performed as a reference to the above KDB test guidance.

4 Test Types and Results

4.1 Radiated Emission and Bandedge Measurement

4.1.1 Limits of Radiated Emission and Bandedge Measurement

Radiated emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table. Other emissions shall be at least 20dB below the highest level of the desired power:

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 1000MHz, 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 20dB under any condition of modulation.

4.1.2 Test Instruments

Description & Manufacturer	Model No.	Serial No.	Cal. Date	Cal. Due
Test Receiver ROHDE & SCHWARZ	ESCI	100424	Dec. 31, 2019	Dec. 30, 2020
Test Receiver ROHDE & SCHWARZ	ESR3	102579	Jun. 27, 2019	Jun. 26, 2020
			Jul. 07, 2020	Jul. 06, 2021
BILOG Antenna SCHWARZBECK	VULB9168	9168-171	Nov. 11, 2019	Nov. 10, 2020
HORN Antenna SCHWARZBECK	9120D	209	Nov. 24, 2019	Nov. 23, 2020
HORN Antenna SCHWARZBECK	BBHA 9170	BBHA9170241	Nov. 24, 2019	Nov. 23, 2020
Preamplifier Agilent (Below 1GHz)	8447D	2944A10738	Aug. 20, 2019	Aug. 19, 2020
Preamplifier Agilent (Above 1GHz)	8449B	3008A02465	Mar. 23, 2020	Mar. 22, 2021
RF Coaxial Cable WOKEN With 5dB PAD	8D-FB	Cable-CH3-01	Aug. 20, 2019	Aug. 19, 2020
RF signal cable HUBER+SUHNER	SUCOFLEX 104	Cable-CH3-03 (223653/4)	Aug. 20, 2019	Aug. 19, 2020
RF signal cable HUBER+SUHNER& EMCI	SUCOFLEX 104&EMC104-SM-SM- 8000	Cable-CH3-03 (309224+170907)	Aug. 20, 2019	Aug. 19, 2020
Software BV ADT	ADT_Radiated_ V7.6.15.9.5	NA	NA	NA
Antenna Tower inn-co GmbH	MA 4000	013303	NA	NA
Antenna Tower Controller BV ADT	AT100	AT93021702	NA	NA
Turn Table BV ADT	TT100	TT93021702	NA	NA
Turn Table Controller BV ADT	SC100	SC93021702	NA	NA
Boresight Antenna Fixture	FBA-01	FBA-SIP01	NA	NA
USB Wideband Power Sensor KEYSIGHT	U2021XA	MY55050005/MY551900 04/MY55190007/MY552 10005	Jul. 15, 2019	Jul. 14, 2020

Note: 1. The calibration interval of the above test instruments is 12 months and the calibrations are traceable to NML/ROC and NIST/USA.
2. The test was performed in HwaYa Chamber 3.

4.1.3 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 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. Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case 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.

Note:

1. 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 30MHz ~ 1GHz) / 1.5 meters (for above 1GHz) 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 detect 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:

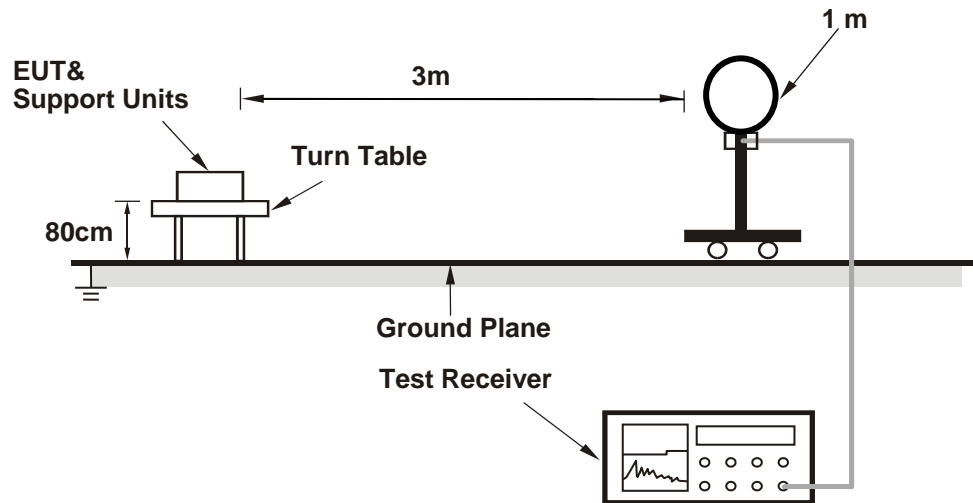
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at frequency below 1GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.
3. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is $\geq 1/T$ (Duty cycle < 98%) or 3 x RBW (Duty cycle $\geq 98\%$) for Average detection (AV) at frequency above 1GHz. (SRD: RBW = 1 MHz, VBW =3 kHz)
4. All modes of operation were investigated and the worst-case emissions are reported.

4.1.4 Deviation from Test Standard

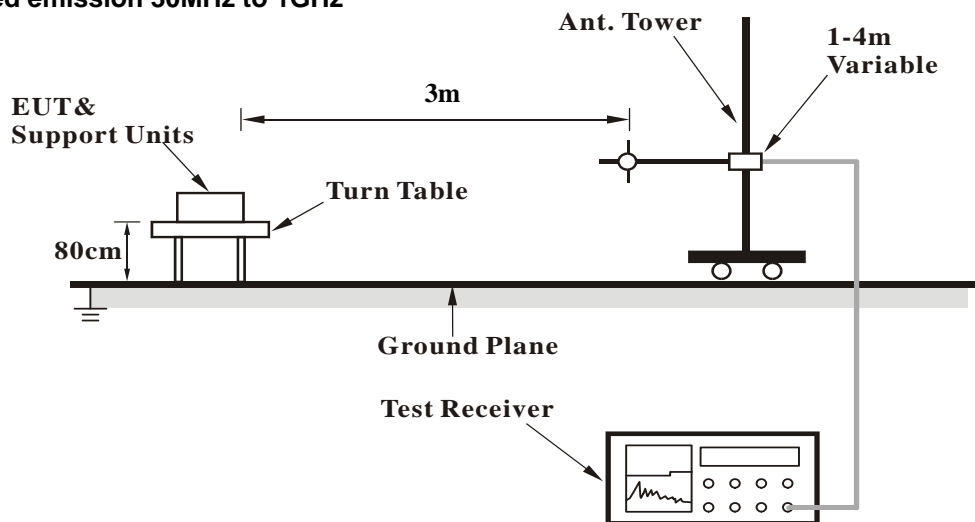
No deviation.

4.1.5 Test Setup

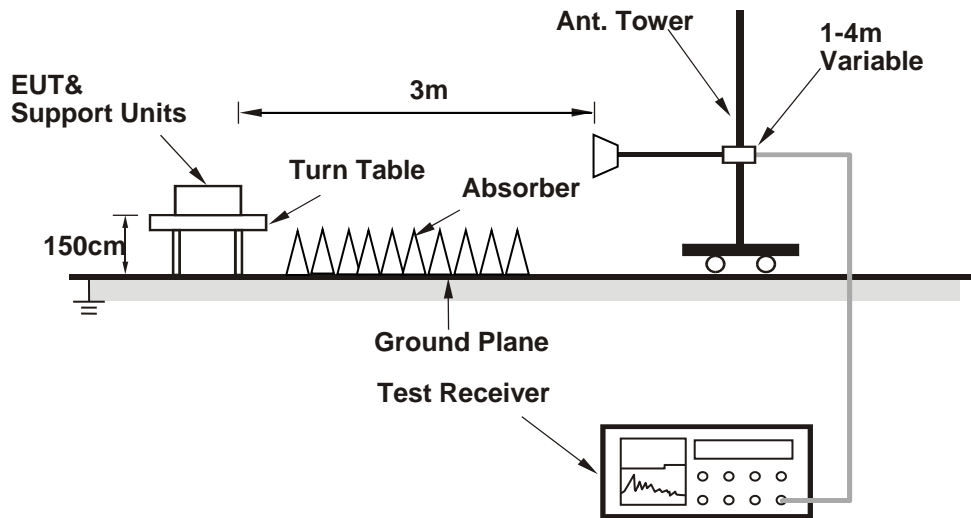
For Radiated emission below 30MHz



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).

4.1.6 EUT Operating Conditions

- a. Placed the EUT on the testing table.
- b. Prepared a notebook to act as a communication partner and placed it outside of testing area.
- c. The communication partner connected with EUT via a USB cable and ran a test program (CMD) to enable EUT under transmission condition continuously at specific channel frequency.
- d. The necessary accessories enable the system in full functions.

4.1.7 Test Results

Above 1GHz Data:

Mode A

FREQUENCY	TX (2401MHz)	DETECTOR FUNCTION	Peak (PK)
FREQUENCY RANGE	1GHz ~ 25GHz		Average (AV)

ANTENNA POLARITY & TEST DISTANCE: HORIZONTAL AT 3 M								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	2390.00	58.8 PK	74.0	-15.2	3.77 H	30	26.5	32.3
2	2390.00	47.2 AV	54.0	-6.8	3.77 H	30	14.9	32.3
3	*2401.00	88.6 PK			3.77 H	30	56.3	32.3
4	*2401.00	65.8 AV			3.77 H	30	33.4	32.3
5	4802.00	46.0 PK	74.0	-28.0	3.17 H	158	42.7	3.3
6	4802.00	23.2 AV	54.0	-30.9	3.17 H	158	19.9	3.3
7	12005.00	63.4 PK	74.0	-10.6	1.35 H	20	45.7	17.7
8	12005.00	40.6 AV	54.0	-13.5	1.35 H	20	22.8	17.7

ANTENNA POLARITY & TEST DISTANCE: VERTICAL AT 3 M								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	2390.00	62.5 PK	74.0	-11.5	2.78 V	328	30.2	32.3
2	2390.00	47.6 AV	54.0	-6.4	2.78 V	328	15.3	32.3
3	*2401.00	101.5 PK			2.78 V	328	69.2	32.3
4	*2401.00	78.7 AV			2.78 V	328	46.3	32.3
5	4802.00	52.2 PK	74.0	-21.8	1.73 V	138	48.9	3.3
6	4802.00	29.4 AV	54.0	-24.7	1.73 V	138	26.1	3.3
7	12005.00	64.0 PK	74.0	-10.0	3.51 V	79	46.3	17.7
8	12005.00	41.2 AV	54.0	-12.9	3.51 V	79	23.4	17.7

Remarks:

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(dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission Level – Limit value
5. " * ": Fundamental frequency.

FREQUENCY	TX (2481MHz)	DETECTOR FUNCTION	Peak (PK)
FREQUENCY RANGE	1GHz ~ 25GHz		Average (AV)

ANTENNA POLARITY & TEST DISTANCE: HORIZONTAL AT 3 M

NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	*2481.00	89.3 PK			1.49 H	140	56.9	32.4
2	*2481.00	66.5 AV			1.49 H	140	34.1	32.4
3	2483.50	33.0 PK	74.0	-41.0	1.49 H	140	36.4	-3.4
4	2483.50	10.1 AV	54.0	-43.9	1.49 H	140	13.5	-3.4
5	4962.00	47.1 PK	74.0	-26.9	3.93 H	246	43.0	4.1
6	4962.00	24.3 AV	54.0	-29.8	3.93 H	246	20.1	4.1
7	12405.00	62.5 PK	74.0	-11.5	1.10 H	51	44.6	17.9
8	12405.00	39.7 AV	54.0	-14.4	1.10 H	51	21.8	17.9

ANTENNA POLARITY & TEST DISTANCE: VERTICAL AT 3 M

NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	*2481.00	101.5 PK			1.99 V	334	69.1	32.4
2	*2481.00	78.7 AV			1.99 V	334	46.3	32.4
3	2483.50	45.2 PK	74.0	-28.8	1.99 V	334	48.6	-3.4
4	2483.50	22.3 AV	54.0	-31.7	1.99 V	334	25.7	-3.4
5	4962.00	50.6 PK	74.0	-23.4	1.77 V	348	46.5	4.1
6	4962.00	27.8 AV	54.0	-26.3	1.77 V	348	23.6	4.1
7	12405.00	67.3 PK	74.0	-6.7	3.74 V	180	49.4	17.9
8	12405.00	44.5 AV	54.0	-9.6	3.74 V	180	26.6	17.9

Remarks:

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(dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission Level – Limit value
5. " * ": Fundamental frequency.

Mode B

FREQUENCY	TX (2401MHz)	DETECTOR FUNCTION	Peak (PK)
FREQUENCY RANGE	1GHz ~ 25GHz		Average (AV)

ANTENNA POLARITY & TEST DISTANCE: HORIZONTAL AT 3 M								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	2390.00	58.8 PK	74.0	-15.2	3.01 H	190	26.5	32.3
2	2390.00	47.3 AV	54.0	-6.7	3.01 H	190	15.0	32.3
3	*2401.00	91.1 PK			3.01 H	190	58.8	32.3
4	*2401.00	68.3 AV			3.01 H	190	36.0	32.3
5	4802.00	47.3 PK	74.0	-26.7	1.75 H	315	44.2	3.1
6	4802.00	24.5 AV	54.0	-29.5	1.75 H	315	21.4	3.1
7	12005.00	63.0 PK	74.0	-11.0	2.47 H	326	45.7	17.3
8	12005.00	40.2 AV	54.0	-13.8	2.47 H	326	22.9	17.3

ANTENNA POLARITY & TEST DISTANCE: VERTICAL AT 3 M								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	2390.00	58.6 PK	74.0	-15.4	2.08 V	281	26.3	32.3
2	2390.00	47.3 AV	54.0	-6.7	2.08 V	281	15.0	32.3
3	*2401.00	103.4 PK			2.08 V	281	71.1	32.3
4	*2401.00	80.6 AV			2.08 V	281	48.2	32.3
5	4802.00	50.0 PK	74.0	-24.1	2.09 V	203	46.8	3.1
6	4802.00	27.1 AV	54.0	-26.9	2.09 V	203	24.0	3.1
7	12005.00	61.6 PK	74.0	-12.4	2.73 V	179	44.3	17.3
8	12005.00	38.8 AV	54.0	-15.2	2.73 V	179	21.5	17.3

Remarks:

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(dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission Level – Limit value
5. " * ": Fundamental frequency.

FREQUENCY	TX (2481MHz)	DETECTOR FUNCTION	Peak (PK)
FREQUENCY RANGE	1GHz ~ 25GHz		Average (AV)

ANTENNA POLARITY & TEST DISTANCE: HORIZONTAL AT 3 M

NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	*2481.00	92.9 PK			3.01 H	203	60.5	32.4
2	*2481.00	70.1 AV			3.01 H	203	37.7	32.4
3	2483.50	36.6 PK	74.0	-37.4	3.01 H	203	40.6	-4.0
4	2483.50	13.7 AV	54.0	-40.3	3.01 H	203	17.7	-4.0
5	4962.00	48.6 PK	74.0	-25.4	2.63 H	155	45.2	3.4
6	4962.00	25.7 AV	54.0	-28.3	2.63 H	155	22.4	3.4
7	12405.00	59.8 PK	74.0	-14.2	2.31 H	309	42.2	17.6
8	12405.00	37.0 AV	54.0	-17.0	2.31 H	309	19.4	17.6

ANTENNA POLARITY & TEST DISTANCE: VERTICAL AT 3 M

NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	*2481.00	103.5 PK			1.64 V	72	71.1	32.4
2	*2481.00	80.7 AV			1.64 V	72	48.3	32.4
3	2483.50	47.2 PK	74.0	-26.8	1.64 V	72	51.2	-4.0
4	2483.50	24.4 AV	54.0	-29.6	1.64 V	72	28.4	-4.0
5	4962.00	50.9 PK	74.0	-23.1	2.85 V	203	47.5	3.4
6	4962.00	28.0 AV	54.0	-26.0	2.85 V	203	24.7	3.4
7	12405.00	60.0 PK	74.0	-14.0	2.82 V	193	42.4	17.6
8	12405.00	37.2 AV	54.0	-16.8	2.82 V	193	19.6	17.6

Remarks:

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(dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission Level – Limit value
5. " * ": Fundamental frequency.

Below 1GHz worst-case data:

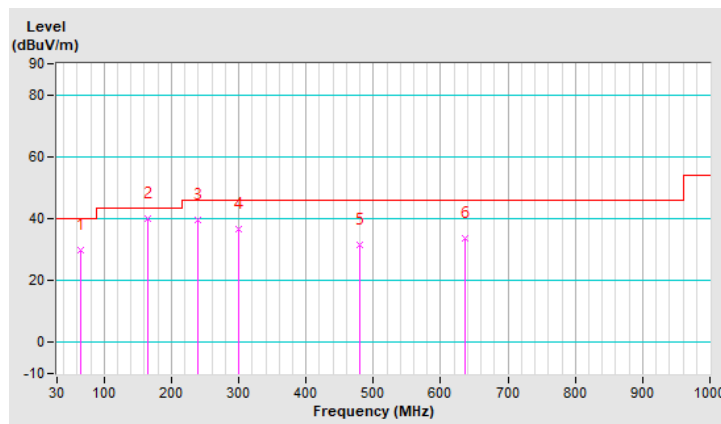
Mode A

FREQUENCY	TX (2401MHz)	DETECTOR FUNCTION	Quasi-Peak (QP)
FREQUENCY RANGE	9kHz ~ 1GHz		

ANTENNA POLARITY & TEST DISTANCE: HORIZONTAL AT 3 M								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	64.92	29.9 QP	40.0	-10.1	1.51 H	153	39.8	-9.9
2	165.80	40.2 QP	43.5	-3.3	1.51 H	266	48.9	-8.7
3	239.52	39.7 QP	46.0	-6.3	1.51 H	78	49.6	-9.9
4	299.66	36.5 QP	46.0	-9.5	1.00 H	72	43.9	-7.4
5	480.08	31.4 QP	46.0	-14.6	2.00 H	200	33.4	-2.0
6	637.22	33.5 QP	46.0	-12.5	1.51 H	52	32.0	1.5

Remarks:

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(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.

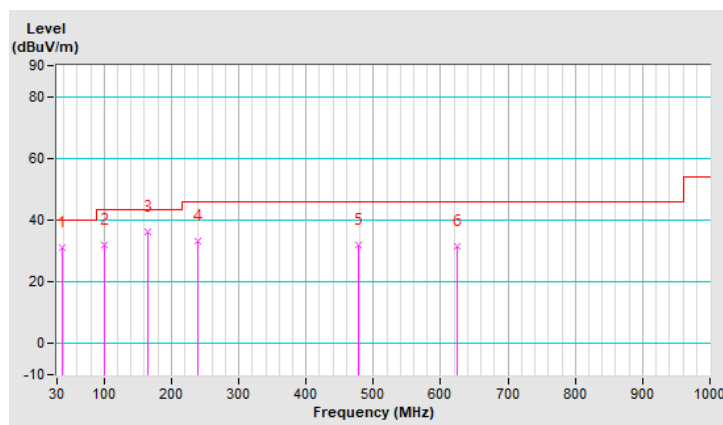


FREQUENCY	TX (2401MHz)	DETECTOR FUNCTION	Quasi-Peak (QP)
FREQUENCY RANGE	9kHz ~ 1GHz		

ANTENNA POLARITY & TEST DISTANCE: VERTICAL AT 3 M								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	37.76	31.0 QP	40.0	-9.0	1.00 V	145	40.7	-9.7
2	99.84	32.0 QP	43.5	-11.5	1.00 V	270	45.1	-13.1
3	165.80	36.3 QP	43.5	-7.2	1.00 V	145	45.0	-8.7
4	239.52	33.3 QP	46.0	-12.7	2.00 V	190	43.2	-9.9
5	478.14	32.1 QP	46.0	-13.9	1.00 V	220	34.1	-2.0
6	623.64	31.4 QP	46.0	-14.6	1.49 V	148	30.0	1.4

Remarks:

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(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.



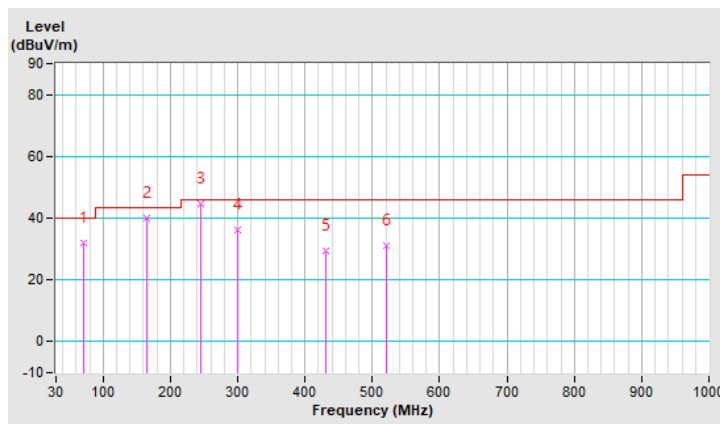
Mode B

FREQUENCY	TX (2481MHz)	DETECTOR FUNCTION	Quasi-Peak (QP)
FREQUENCY RANGE	9kHz ~ 1GHz		

ANTENNA POLARITY & TEST DISTANCE: HORIZONTAL AT 3 M								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	70.74	31.9 QP	40.0	-8.1	1.99 H	153	42.8	-10.9
2	165.80	40.1 QP	43.5	-3.4	1.49 H	256	48.8	-8.7
3	245.34	44.5 QP	46.0	-1.5	1.00 H	253	54.1	-9.6
4	299.66	36.1 QP	46.0	-9.9	1.00 H	240	43.5	-7.4
5	431.58	29.2 QP	46.0	-16.8	1.99 H	174	32.3	-3.1
6	520.82	31.2 QP	46.0	-14.8	1.49 H	144	32.1	-0.9

Remarks:

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(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.

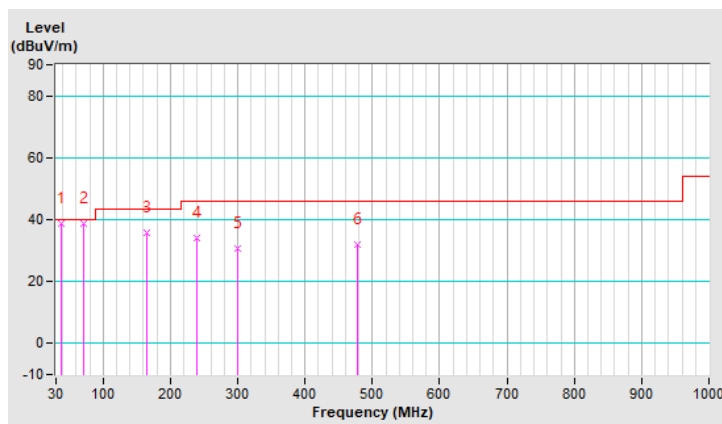


FREQUENCY	TX (2481MHz)	DETECTOR FUNCTION	Quasi-Peak (QP)
FREQUENCY RANGE	9kHz ~ 1GHz		

ANTENNA POLARITY & TEST DISTANCE: VERTICAL AT 3 M								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	37.76	38.6 QP	40.0	-1.4	1.00 V	67	48.3	-9.7
2	70.74	38.6 QP	40.0	-1.4	1.00 V	302	49.5	-10.9
3	165.80	35.6 QP	43.5	-7.9	1.00 V	136	44.3	-8.7
4	239.52	34.2 QP	46.0	-11.8	2.00 V	128	44.1	-9.9
5	299.66	30.6 QP	46.0	-15.4	1.00 V	56	38.0	-7.4
6	478.14	31.8 QP	46.0	-14.2	1.00 V	201	33.8	-2.0

Remarks:

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(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.



4.2 Conducted Emission Measurement

4.2.1 Limits of Conducted Emission Measurement

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.

4.2.2 Test Instruments

Tested date: Jul. 09, 2020

Description & Manufacturer	Model No.	Serial No.	Cal. Date	Cal. Due
Test Receiver ROHDE & SCHWARZ	ESCI	100613	Dec. 11, 2019	Dec. 10, 2020
RF signal cable Woken	5D-FB	Cable-cond1-01	Sep. 05, 2019	Sep. 04, 2020
LISN ROHDE & SCHWARZ (EUT)	ENV216	101826	Feb. 20, 2020	Feb. 19, 2021
LISN ROHDE & SCHWARZ (Peripheral)	ESH3-Z5	100311	Aug. 22, 2019	Aug. 21, 2020
Software ADT	BV ADT_Cond_ V7.3.7.4	NA	NA	NA

- Note: 1. The calibration interval of the above test instruments is 12 months and the calibrations are traceable to NML/ROC and NIST/USA.
 2. The test was performed in HwaYa Shielded Room 1 (Conduction 1).
 3. The VCCI Site Registration No. is C-12040.

4.2.3 Test Procedures

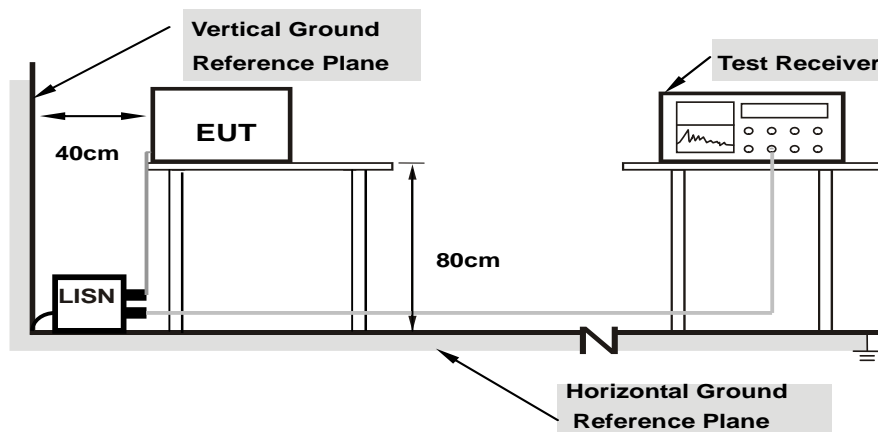
- The EUT was placed 0.4 meters from the conducting wall of the shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). Other support units were connected to the power mains through another LISN. The two LISNs provide 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- Both lines of the power mains connected to the EUT were checked for maximum conducted interference.
- 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.

4.2.4 Deviation from Test Standard

No deviation.

4.2.5 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).

4.2.6 EUT Operating Conditions

Same as item 4.1.6.

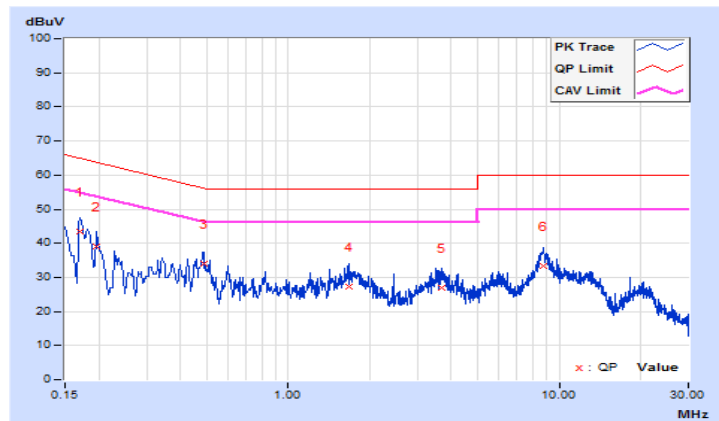
4.2.7 Test Results

Phase	Line (L)	Detector Function	Quasi-Peak (QP) / Average (AV)
Test Mode	A	Frequency	2401MHz

No	Freq. [MHz]	Corr. Factor (dB)	Reading Value		Emission Level		Limit		Margin	
			[dB (uV)]		[dB (uV)]		[dB (uV)]		(dB)	
			Q.P.	AV.	Q.P.	AV.	Q.P.	AV.	Q.P.	AV.
1	0.16955	9.63	33.93	19.87	43.56	29.50	64.98	54.98	-21.42	-25.48
2	0.19692	9.62	29.46	13.71	39.08	23.33	63.74	53.74	-24.66	-30.41
3	0.48626	9.65	24.32	14.13	33.97	23.78	56.23	46.23	-22.26	-22.45
4	1.66708	9.71	17.72	10.85	27.43	20.56	56.00	46.00	-28.57	-25.44
5	3.67291	9.78	17.18	9.40	26.96	19.18	56.00	46.00	-29.04	-26.82
6	8.77937	9.85	23.59	17.77	33.44	27.62	60.00	50.00	-26.56	-22.38

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.

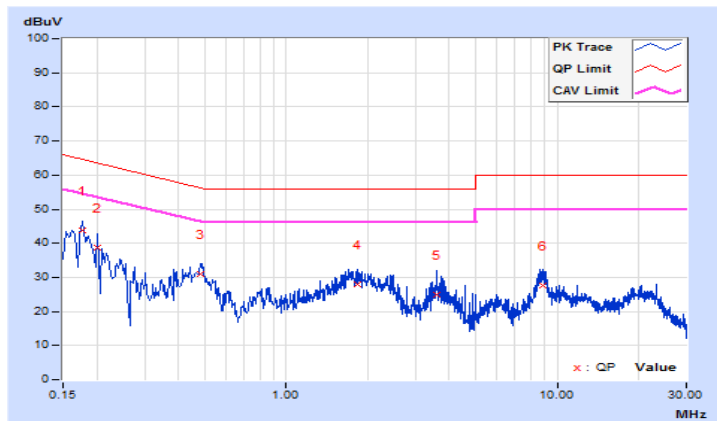


Phase	Neutral (N)	Detector Function	Quasi-Peak (QP) / Average (AV)
Test Mode	A	Frequency	2401MHz

No	Freq. [MHz]	Corr. Factor (dB)	Reading Value [dB (uV)]		Emission Level [dB (uV)]		Limit [dB (uV)]		Margin (dB)	
			Q.P.	AV.	Q.P.	AV.	Q.P.	AV.	Q.P.	AV.
			1	0.17737	9.65	34.14	20.97	43.79	30.62	64.61
2	0.20083	9.64	29.06	13.78	38.70	23.42	63.58	53.58	-24.88	-30.16
3	0.48550	9.67	21.26	10.96	30.93	20.63	56.24	46.24	-25.31	-25.61
4	1.82348	9.75	18.31	11.29	28.06	21.04	56.00	46.00	-27.94	-24.96
5	3.61035	9.81	15.10	7.31	24.91	17.12	56.00	46.00	-31.09	-28.88
6	8.84193	9.89	17.78	11.05	27.67	20.94	60.00	50.00	-32.33	-29.06

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.

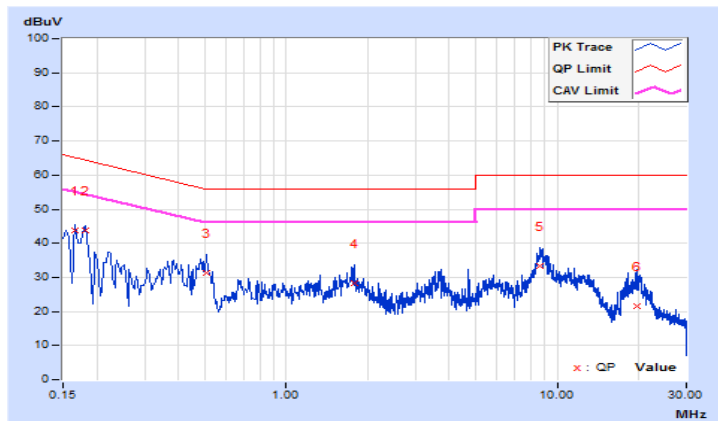


Phase	Line (L)	Detector Function	Quasi-Peak (QP) / Average (AV)
Test Mode	B	Frequency	2481MHz

No	Freq. [MHz]	Corr. Factor (dB)	Reading Value [dB (uV)]		Emission Level [dB (uV)]		Limit [dB (uV)]		Margin (dB)	
			Q.P.	AV.	Q.P.	AV.	Q.P.	AV.	Q.P.	AV.
			1	0.16564	9.63	34.23	20.55	43.86	30.18	65.18
2	0.18122	9.62	34.03	22.93	43.65	32.55	64.43	54.43	-20.78	-21.88
3	0.50908	9.66	21.72	11.06	31.38	20.72	56.00	46.00	-24.62	-25.28
4	1.77656	9.72	18.67	11.34	28.39	21.06	56.00	46.00	-27.61	-24.94
5	8.66989	9.85	23.62	17.79	33.47	27.64	60.00	50.00	-26.53	-22.36
6	19.60225	9.91	11.68	4.77	21.59	14.68	60.00	50.00	-38.41	-35.32

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.

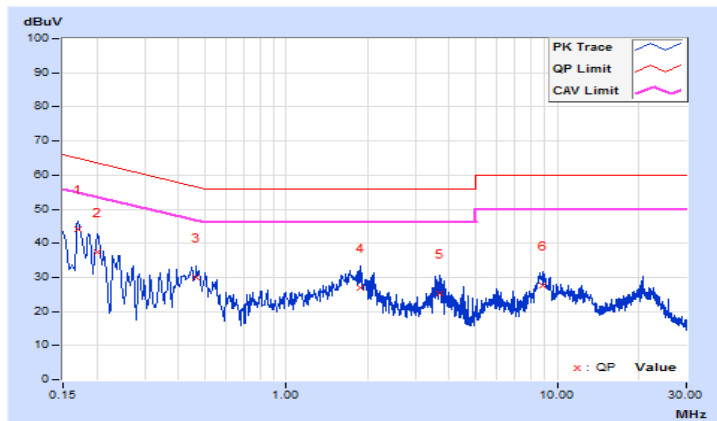


Phase	Neutral (N)	Detector Function	Quasi-Peak (QP) / Average (AV)
Test Mode	B	Frequency	2481MHz

No	Freq. [MHz]	Corr. Factor (dB)	Reading Value [dB (uV)]		Emission Level [dB (uV)]		Limit [dB (uV)]		Margin (dB)	
			Q.P.	AV.	Q.P.	AV.	Q.P.	AV.	Q.P.	AV.
			1	0.16955	9.65	34.57	20.66	44.22	30.31	64.98
2	0.20083	9.64	27.85	11.79	37.49	21.43	63.58	53.58	-26.09	-32.15
3	0.46671	9.67	20.39	10.12	30.06	19.79	56.57	46.57	-26.51	-26.78
4	1.87040	9.75	17.35	11.01	27.10	20.76	56.00	46.00	-28.90	-25.24
5	3.67291	9.81	15.37	7.23	25.18	17.04	56.00	46.00	-30.82	-28.96
6	8.82629	9.89	17.60	10.95	27.49	20.84	60.00	50.00	-32.51	-29.16

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.

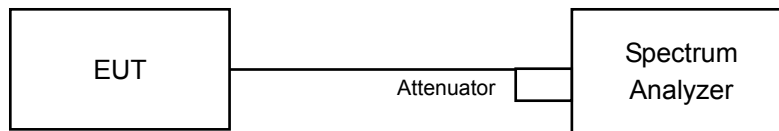


4.3 6dB Bandwidth Measurement

4.3.1 Limits of 6dB Bandwidth Measurement

The minimum of 6dB Bandwidth Measurement is 0.5 MHz.

4.3.2 Test Setup



4.3.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.3.4 Test Procedure

- Set resolution bandwidth (RBW) = 100kHz.
- Set the video bandwidth (VBW) $\geq 3 \times$ RBW, Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two amplitude points (upper and lower) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

4.3.5 Deviation from Test Standard

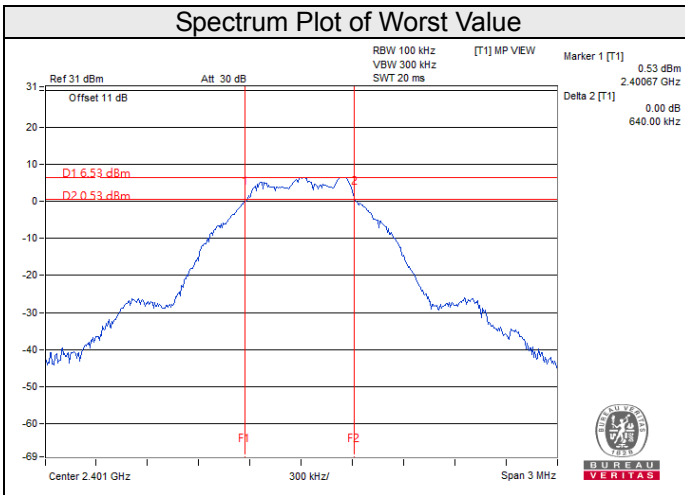
No deviation.

4.3.6 EUT Operating Conditions

The software provided by client to enable the EUT under transmission condition continuously at lowest, middle and highest channel frequencies individually.

4.3.7 Test Result

Frequency (MHz)	6dB Bandwidth (MHz)	Minimum Limit (MHz)	Pass / Fail
2401	0.64	0.5	Pass
2481	0.64	0.5	Pass

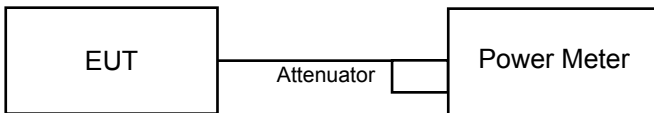


4.4 Conducted Output Power Measurement

4.4.1 Limits of Conducted Output Power Measurement

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

4.4.2 Test Setup



4.4.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.4.4 Test Procedures

For Peak Power

A peak power sensor was used on the output port of the EUT. A power meter was used to read the response of the peak power sensor. Record the power level.

For Average Power

Average power sensor was used to perform output power measurement, trigger and gating function of wide band power meter is enabled to measure max output power of TX on burst. Duty factor is not added to measured value.

4.4.5 Deviation from Test Standard

No deviation.

4.4.6 EUT Operating Conditions

Same as item 4.3.6.

4.4.7 Test Results

For Peak Power

Frequency (MHz)	Peak Power (mW)	Peak Power (dBm)	Limit (dBm)	Pass/Fail
2401	5.781	7.62	30	Pass
2481	5.649	7.52	30	Pass

For Average Power

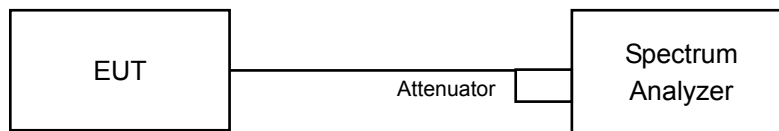
Frequency (MHz)	Average Power (mW)	Average Power (dBm)
2401	5.768	7.61
2481	5.610	7.49

4.5 Power Spectral Density Measurement

4.5.1 Limits of Power Spectral Density Measurement

The Maximum of Power Spectral Density Measurement is 8dBm in any 3 kHz.

4.5.2 Test Setup



4.5.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.5.4 Test Procedure

- Set analyzer center frequency to DTS channel center frequency.
- Set the span to 1.5 times the DTS bandwidth.
- Set the RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
- Set the VBW $\geq 3 \times \text{RBW}$.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level within the RBW.

4.5.5 Deviation from Test Standard

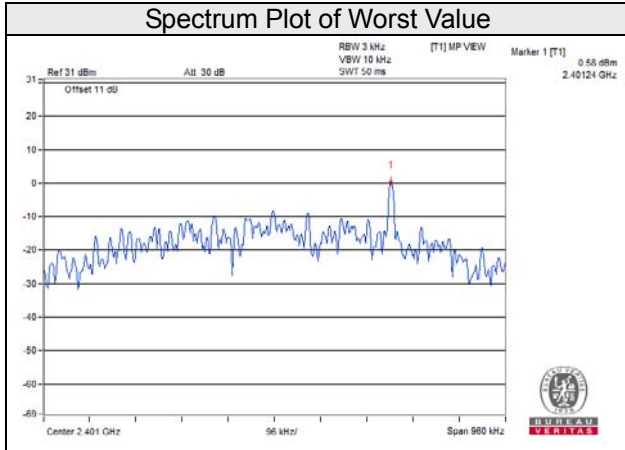
No deviation.

4.5.6 EUT Operating Condition

Same as item 4.3.6

4.5.7 Test Results

Freq. (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Pass / Fail
2401	0.58	8	Pass
2481	0.43	8	Pass

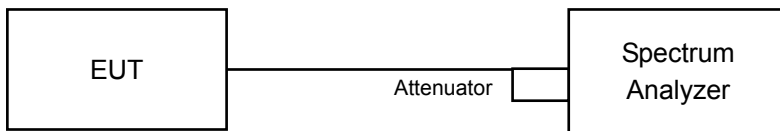


4.6 Conducted Out of Band Emission Measurement

4.6.1 Limits of Conducted Out of Band Emission Measurement

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

4.6.2 Test Setup



4.6.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.6.4 Test Procedure

Measurement Procedure REF

- Set the RBW = 100 kHz.
- Set the VBW \geq 300 kHz.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.

Measurement Procedure OOB

- Set RBW = 100 kHz.
- Set VBW \geq 300 kHz.
- Detector = peak.
- Sweep = auto couple.
- Trace Mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level.

4.6.5 Deviation from Test Standard

No deviation.

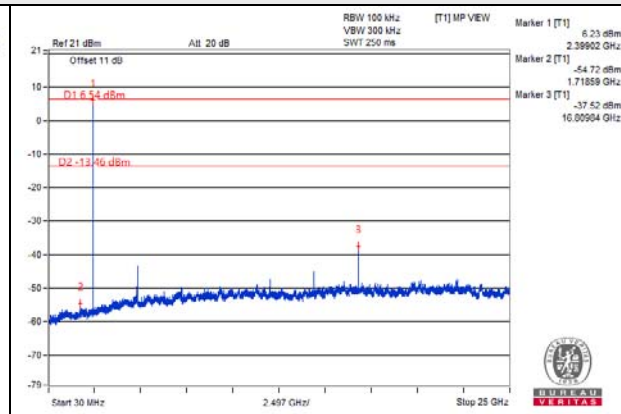
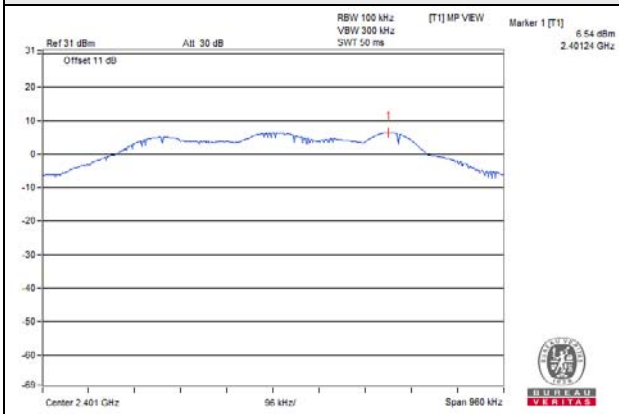
4.6.6 EUT Operating Condition

Same as item 4.3.6

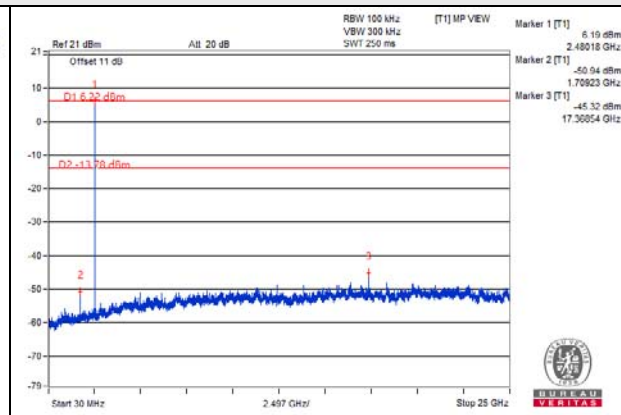
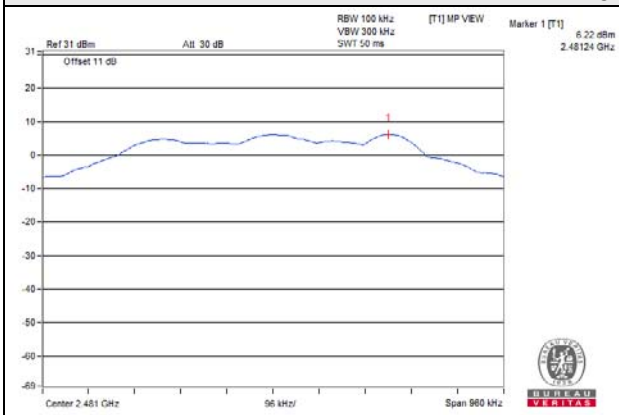
4.6.7 Test Results

The spectrum plots are attached on the following pages. B1 line indicates the highest level, and B2 line indicates the 20dB offset below B1. It shows compliance with the requirement.

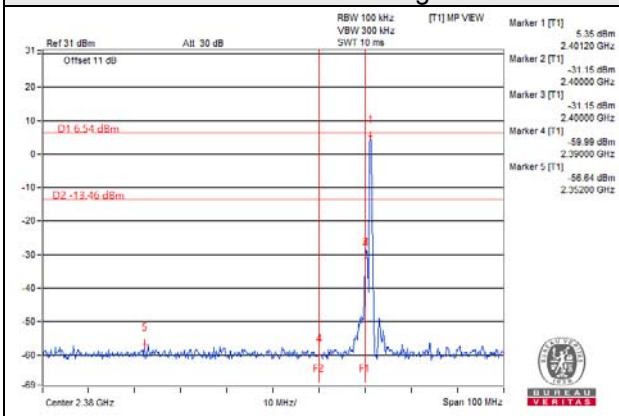
2401 MHz



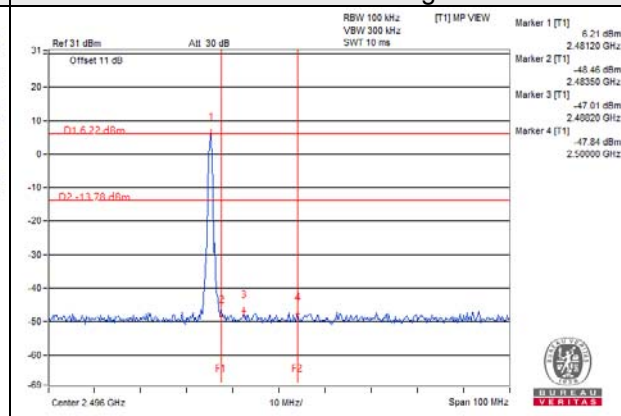
2481 MHz



2401 MHz Band edge

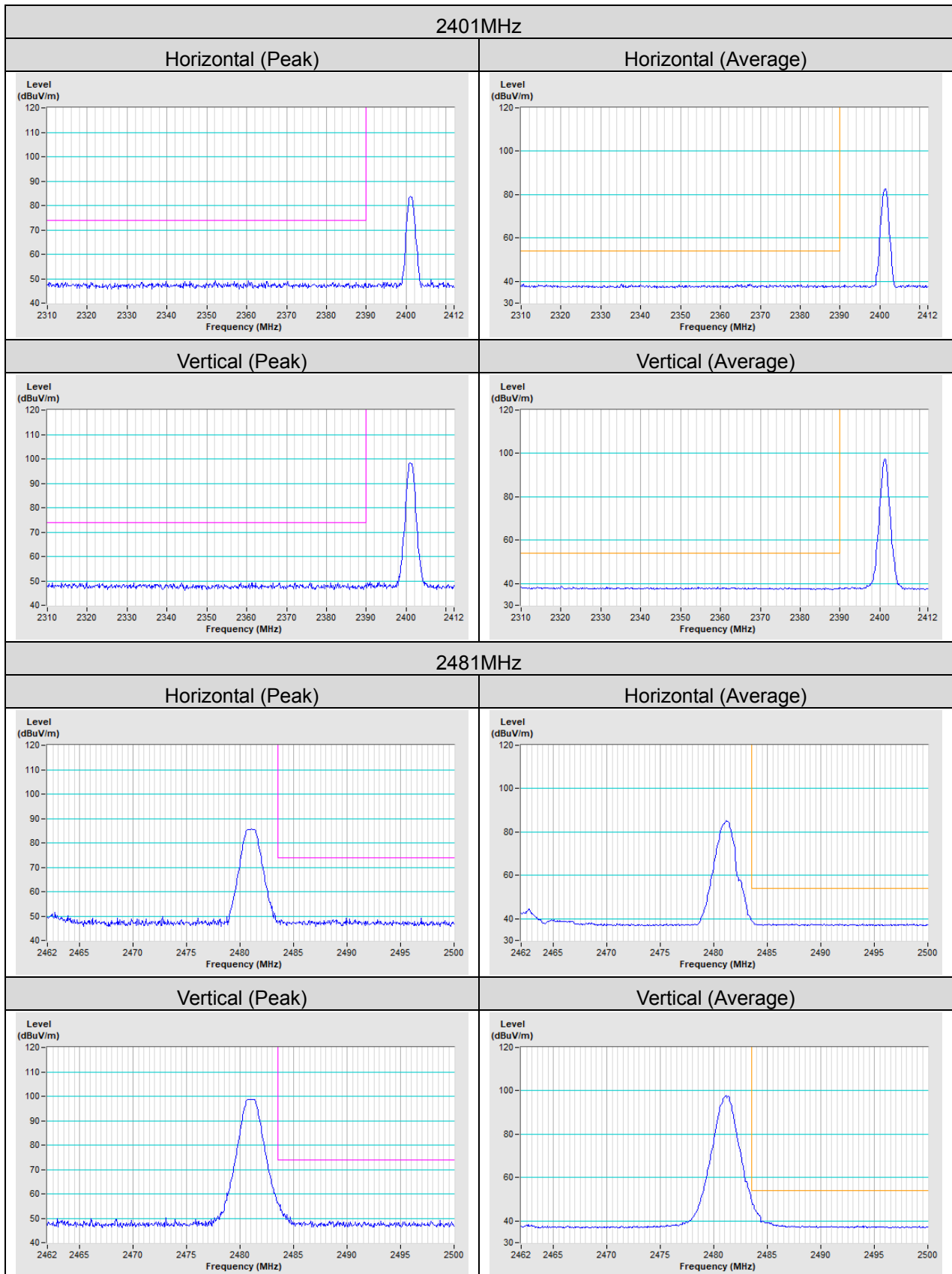


2481 MHz Band edge

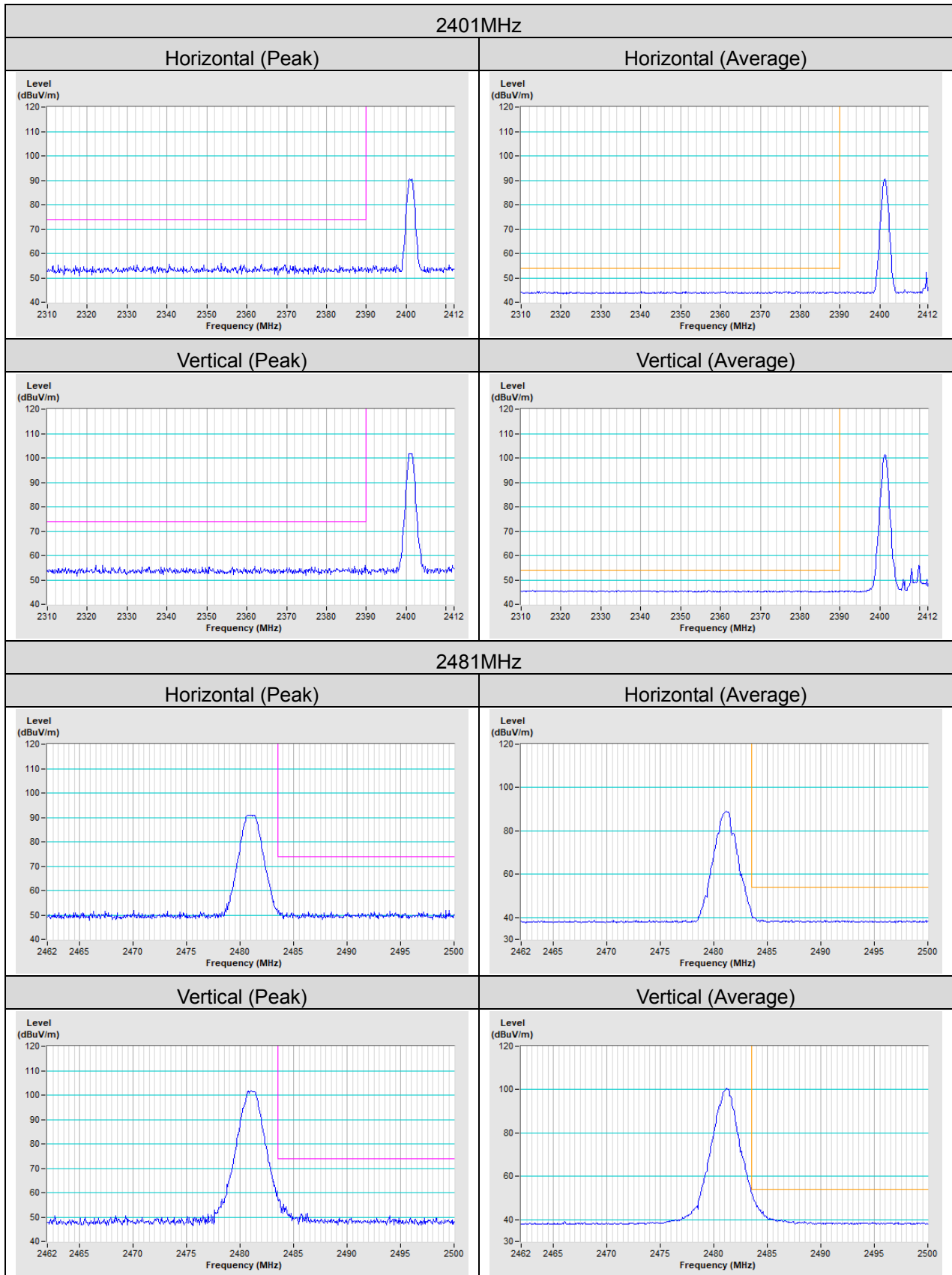


Annex A - Band Edge Measurement

Mode A



Mode B



5 Pictures of Test Arrangements

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

Appendix – Information of the Testing Laboratories

We, Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch, were founded in 1988 to provide our best service in EMC, Radio, Telecom and Safety consultation. Our laboratories are FCC recognized accredited test firms and accredited and approved according to ISO/IEC 17025.

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The address and road map of all our labs can be found in our web site also.

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