

FCC Test Report

Report No.: FCC_RF_ SL21031201-SMK-001 Rev_2.0

Test Models: R1T

FCC ID: 2AW3A-1WWG20R1TKFB

Received Date: 04/23/2021

Test Date: 04/23/2021-08/03/2021

Issued Date: 08/03/2021

Applicant: Rivian Automotive, LLC

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Manufacturer: SMK Manufacturing, Inc

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Issued By: Bureau Veritas Consumer Products Services, Inc.

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Test Location (1): 775 Montague Expressway, Milpitas, CA 95035

FCC Registration /
540430

Designation Number:

ISED# / CAB identifier: 4842D



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Table of Contents

Release Control Record	4
1 Certificate of Conformity	5
2 Summary of Test Results	6
2.1 Measurement Uncertainty.....	6
2.2 Modification Record.....	6
3 General Information	7
3.1 General Description of EUT	7
3.2 Description of Test Modes	8
3.2.1 Test Mode Applicability and Tested Channel Detail	9
3.3 Description of Support Units	10
3.3.1 Configuration of System under Test	10
3.4 General Description of Applied Standards	10
4 Test Types and Results.....	11
4.1 Radiated Emission and Bandedge Measurement	11
4.1.1 Limits of Radiated Emission and Bandedge Measurement.....	11
4.1.2 Test Instruments	12
4.1.3 Test Procedures	13
4.1.4 Deviation from Test Standard.....	13
4.1.5 Test Setup.....	14
4.1.6 EUT Operating Conditions	15
4.1.7 Test Results	16
4.2 Conducted Emission Measurement	29
4.2.1 Limits of Conducted Emission Measurement	29
4.2.2 Test Procedures	29
4.2.3 Deviation from Test Standard.....	29
4.2.4 Test Setup.....	29
4.2.5 EUT Operating Conditions	29
4.2.6 Test Results	30
4.3 6dB Bandwidth Measurement & 99% Bandwidth Measurement	31
4.3.1 Limits of 6dB Bandwidth Measurement.....	31
4.3.2 Test Setup.....	31
4.3.3 Test Instruments	31
4.3.4 Test Procedure.....	31
4.3.5 Deviation from Test Standard.....	31
4.3.6 EUT Operating Conditions	31
4.3.7 Test Result	32
Data Rate 1Mbps	32
Data Rate 2bps	32
4.4 Conducted Output Power Measurement.....	40
4.4.1 Limits of Conducted Output Power Measurement.....	40
4.4.2 Test Setup.....	40
4.4.3 Test Instruments	40
4.4.4 Test Procedures	40
4.4.5 Deviation from Test Standard.....	40
4.4.6 EUT Operating Conditions	40
4.4.7 Test Results	41
4.5 Power Spectral Density Measurement.....	45
4.5.1 Limits of Power Spectral Density Measurement.....	45
4.5.2 Test Setup.....	45
4.5.3 Test Instruments	45
4.5.4 Test Procedure.....	45
4.5.5 Deviation from Test Standard.....	45
4.5.6 EUT Operating Condition	45

4.5.7 Test Results	46
4.6 Conducted Out of Band Emission Measurement	50
4.6.1 Limits of Conducted Out of Band Emission Measurement	50
4.6.2 Test Setup	50
4.6.3 Test Instruments	50
4.6.4 Test Procedure	50
4.6.5 Deviation from Test Standard	50
4.6.6 EUT Operating Condition	50
4.6.7 Test Results	51
5 Pictures of Test Arrangements.....	53
Appendix – Information on the Testing Laboratories	54

Release Control Record

Issue No.	Description	Date Issued
FCC_IC_RF_ SL21031201-SMK-001	Original Release	06/18/2021
FCC_IC_RF_ SL21031201-SMK-001 Rev_1.0	Update per reiview	07/07/2021
FCC_RF_ SL21031201-SMK-001 Rev_2.0	Update All Test Item	08/03/2021

1 Certificate of Conformity

Product: Rivian R1 Key Fob

Brand: Rivian

Test Models: R1T

Sample Status: Engineering sample

Applicant: Rivian Automotive, LLC

Test Date: 04/23/2021-08/03/2021

Standards: 47 CFR FCC Part 15, Subpart C (Section 15.247)

ANSI C63.10: 2013

558074 D01 15.247 Meas Guidance v05r02

The above equipment has been tested by **Bureau Veritas Consumer Products Services, Inc., Milpitas 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 EMC characteristics under the conditions specified in this report.

Prepared by :

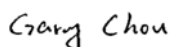


Said Abdelwafi/ Test Engineer

Date:

07/07/2021

Approved by :



Gary Chou / Engineer Reviewer

Date:

08/03/2021

2 Summary of Test Results

47 CFR FCC Part 15, Subpart C (SECTION 15.247)			
FCC	Test Item	Result	Remarks
15.207	AC Power Conducted Emission	N/A	Work with battery.
15.205 & 15.209 & 15.247(d)	Radiated Emissions and Band Edge Measurement	PASS	Meet the requirement of limit.
15.247(a)(2)	6dB bandwidth & 99% 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	Internal antenna: permanently SMT embedded, PCB corner mounting antenna which meet the requirement.

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) ($\pm$)
Conducted Emissions at mains ports	150kHz ~ 30MHz	3.51dB
Radiated Emissions up to 1 GHz	30MHz ~ 1GHz	3.73dB
Radiated Emissions above 1 GHz	1GHz ~ 6GHz	4.64dB
	6GHz ~ 18GHz	4.82dB
	18GHz ~ 40GHz	4.91dB

2.2 Modification Record

There were no modifications required for compliance.

3 General Information

3.1 General Description of EUT

Product	Rivian R1 Key Fob
Brand	Rivian
Test Models	R1T
Model Difference	N/A
Status of EUT	Engineering Sample
Power Input	Battery Powered
Power Supply Rating	3 Vdc
Modulation Type	GFSK
Modulation Technology	Bluetooth Low Energy
Transfer Rate	1Mbps/ 2Mbps
Operating Frequency	2.402 ~ 2.480GHz
Number of Channel	40
Output Power	2.14 mW
Antenna Name	2.4GHz MID SMT antenna
Antenna Series Number	479480001
Antenna Type	SMT antenna
Antenna Gain	3.7 dBi
Antenna Connector	N/A (SMT embedded, PCB corner mounting)

Note:

1. The above EUT information is declared by manufacturer and for more detailed features description, please refers to the manufacturer's specifications or user's manual.

FCC/IC/ CE RF Testing Units Setting (With Hole for LED Checking)

Part No.	Mode I	Hardware Rev.	Firmware (FW) Rev.	FW operation verification and Instruction	Sample/
PT00000508	R1T	Rev. F	rfCarrierWave_TestFw_001.out	Verify by ORG/ GRN LED  KeyFob Testing Setup ver 20210426.pdf	R1T: 4 Samples, Drawing

3.2 Description of Test Modes

40 channels are provided to this EUT:

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	10	2422	20	2442	30	2462
1	2404	11	2424	21	2444	31	2464
2	2406	12	2426	22	2446	32	2466
3	2408	13	2428	23	2448	33	2468
4	2410	14	2430	24	2450	34	2470
5	2412	15	2432	25	2452	35	2472
6	2414	16	2434	26	2454	36	2474
7	2416	17	2436	27	2456	37	2476
8	2418	18	2438	28	2458	38	2478
9	2420	19	2440	29	2460	39	2480

3.2.1 Test Mode Applicability and Tested Channel Detail

EUT CONFIGURE MODE	APPLICABLE TO				DESCRIPTION
	RE $\geq$ 1G	RE<1G	PLC	APCM	
-	√	√	-	√	-

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 **Y-plane**.

NOTE: "-" 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.

AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TYPE	DATA RATE (Mbps)
0 to 39	0,19,39	GFSK	1

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.

AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TYPE	DATA RATE (Mbps)
0 to 39	0,19,39	GFSK	1

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.

AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TYPE	DATA RATE (Mbps)
0 to 39	0,19,39	GFSK	1
0 to 39	0,19,39	GFSK	2

Test Condition:

APPLICABLE TO	ENVIRONMENTAL CONDITIONS	INPUT POWER	TESTED BY
RE $\geq$ 1G	25deg. C, 65%RH	3 Vdc	Said abdelwafi
RE<1G	25deg. C, 65%RH	3 Vdc	Said abdelwafi
PLC	25deg. C, 68%RH	3 Vdc	Said abdelwafi
APCM	21deg. C, 60%RH	3 Vdc	Said abdelwafi

3.3 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.	N/A	N/A	N/A	N/A	N/A	N/A
B.	N/A	N/A	N/A	N/A	N/A	N/A

Note: The core(s) is(are) originally attached to the cable(s).

3.3.1 Configuration of System under Test



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 standards:

47 CFR FCC Part 15, Subpart C (Section 15.247)

ANSI C63.10: 2013

558074 D01 15.247 Meas Guidance v05r02

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

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.	DATE OF CALIBRATION	DUE DATE OF CALIBRATION
EMI Receiver (Rohde and Schwarz)	ESW44	1328.4100K-101662-MH	10/23/2020	10/23/2021
Biconilog Antenna (Sunol)	JB6	A111717	9/4/2020	9/4/2021
Horn Antenn (ETS-Lindgren)	3117	218554	07/24/2020	7/24/2021
Pre-Amplifier (RF-Lambda)	RAMP00M50GA	18040300055	10/1/2020	10/1/2021
Hon Antenna DRG	SAS-574	579	08/05/2020	08/05//2022
PXA Signal Analyzer (Keysight)	N9030B	MY57140100	07/22/2020	07/22/2022
SMA Fixed Attenuator (50ohms, 2w, 30dB, DC-6GHz)	VAT-03W2+	n/a	07/21/2020	07/21/2022
FSB Antenna Cable, 0.5m (Microwave Town)	FSB360PK-KMKM-00.50M	201906110002	10/1/2020	10/1/2021
FSB Antenna Cable, 4m (Microwave Town)	FSB360PK-KMKM-400M	21030447-002	10/1/2020	10/1/2021
10m Semi-Anechoic Chambe (ETS-Lindgren)	S2010BL8X8	1462	07/21/2020	07/21/2022
Notch Filters MICRO-TRONICS	BRM50702	G242	07/21/2020	07/21/2022
Loop Antenna	N/A	00049120	11/25/2019	11/25/2021

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 detects 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:

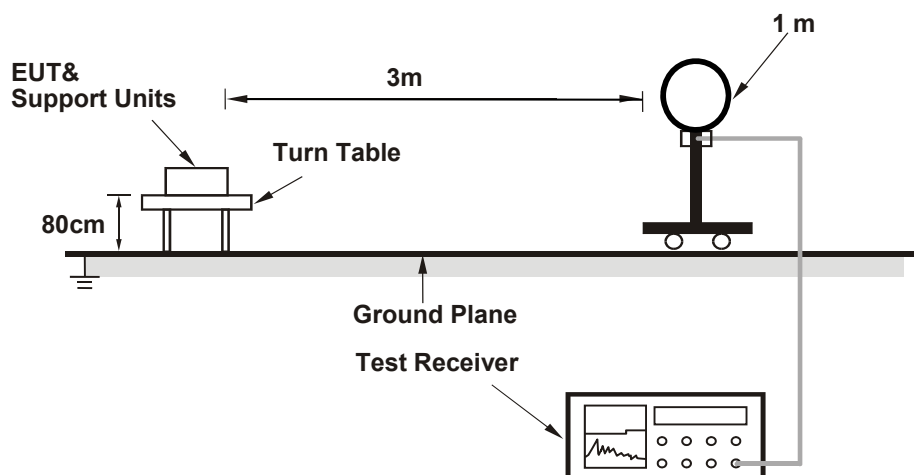
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at frequency below 1GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.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

4.1.4 Deviation from Test Standard

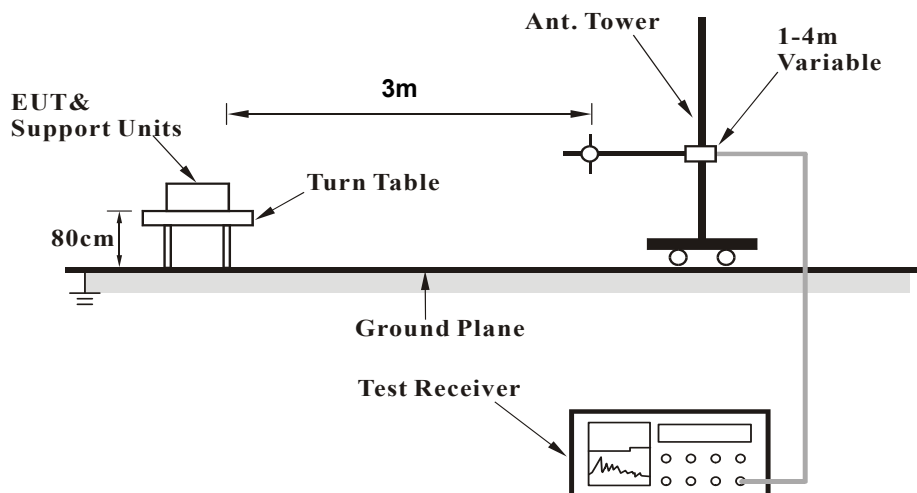
No deviation.

4.1.5 Test Setup

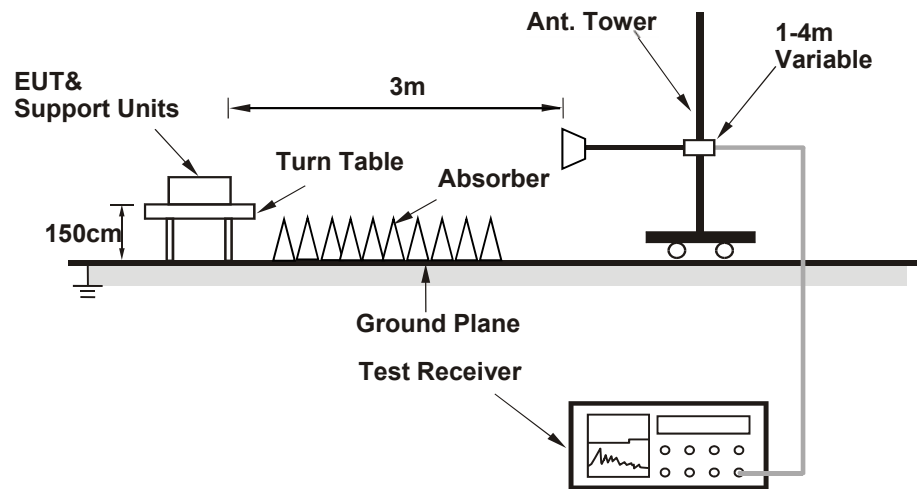
For Radiated emission below 30MHz



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).

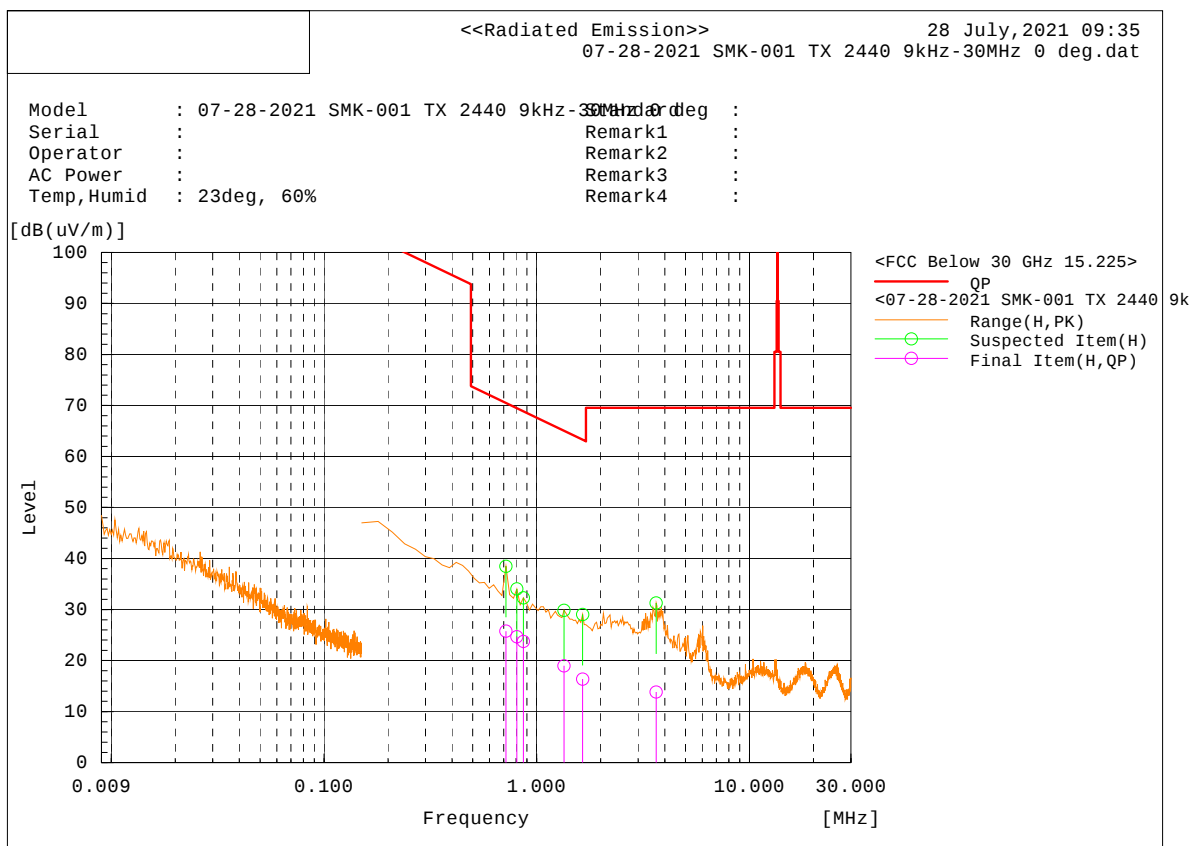
4.1.6 EUT Operating Conditions

- a. Controlling software has been activated to set the EUT on specific status.

4.1.7 Test Results

Test results of radiated emission Data Rate 1Mbps (9 kHz-30MHz)

CHANNEL	TX Channel 17	DETECTOR FUNCTION	Quasi Peak
FREQUENCY RANGE	30MHz – 1GHz		



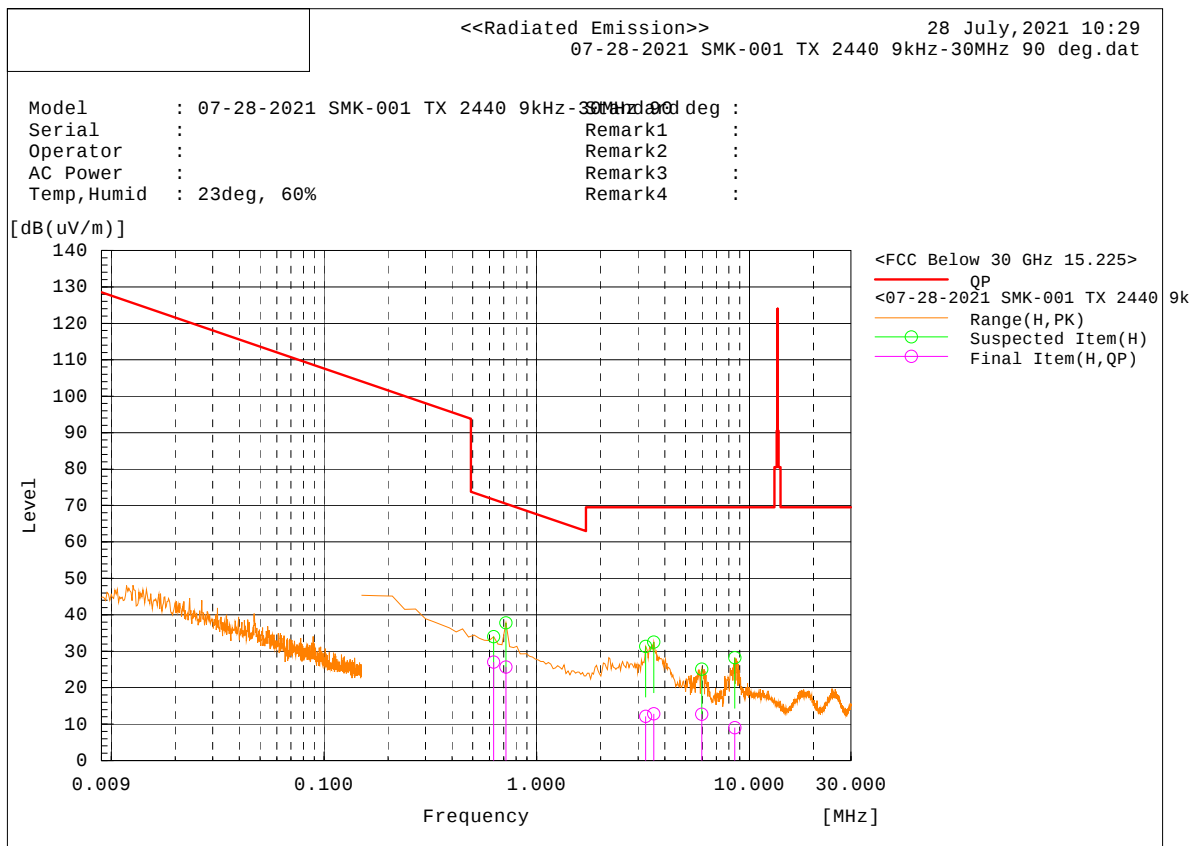
Antenna Polarity & Test Distance: Vertical and Horizontal at 3m

No.	Frequency (MHz)	Degree (0/90)	Reading QP [dB(uV)]	Factor [dB(1/m)]	Level QP [dB(uV/m)]	LimitQP [dB(uV/m)]	Margin QP [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	0.717	H	10.2	15.6	25.8	70.5	44.7	100	0	Pass
2	0.807	H	10	14.7	24.7	69.5	44.8	100	97.8	Pass
3	0.866	H	9.7	14	23.7	68.8	45.1	100	53.4	Pass
4	1.344	H	8.3	10.7	19	65	46	100	131.5	Pass
5	1.643	H	7.1	9.3	16.4	63.3	46.9	100	263.1	Pass
6	3.642	H	10	3.8	13.8	69.5	55.7	100	284.5	Pass

REMARKS:

- Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
- Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
- Margin = Limit value (dBuV/m) - Level (dBuV/m)

CHANNEL	TX Channel 17	DETECTOR FUNCTION	Quasi Peak
FREQUENCY RANGE	30MHz – 1GHz		



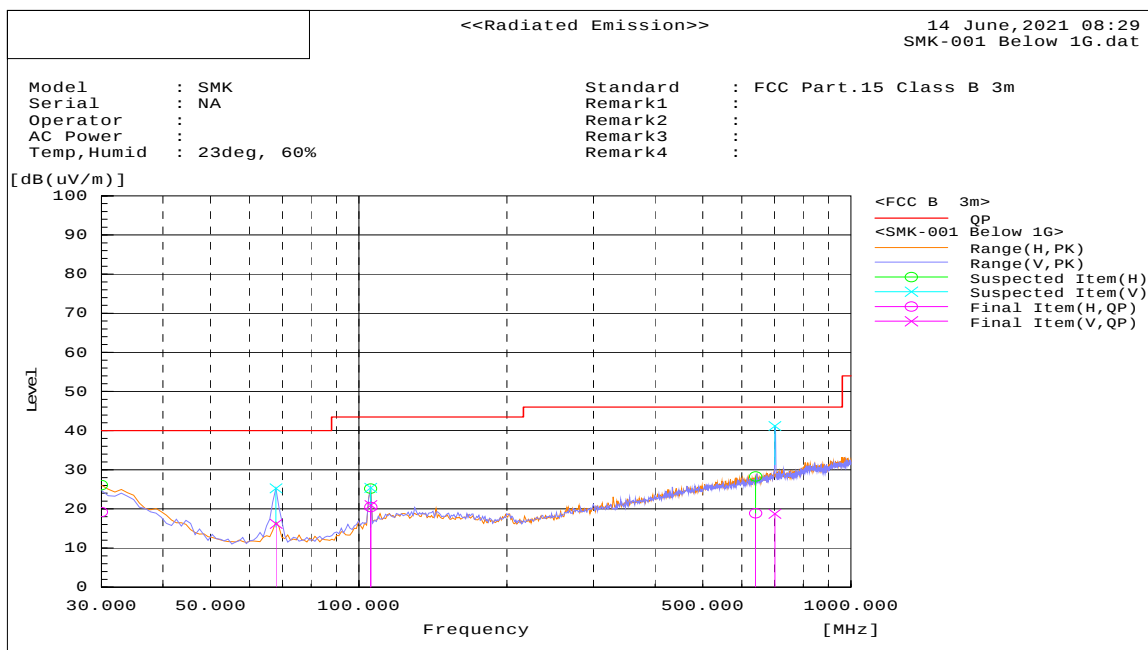
Antenna Polarity & Test Distance: Vertical and Horizontal at 3m										
No.	Frequency (MHz)	Degree (0/90)	Reading QP [dB(uV)]	Factor [dB(1/m)]	Level QP [dB(uV/m)]	Limit QP dB(uV/m)	Margin QP [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	0.628	90	10.4	16.6	27	71.7	44.7	100	1.7	Pass
2	0.717	90	10.1	15.6	25.7	70.5	44.8	100	228.3	Pass
3	3.254	90	7.7	4.5	12.2	69.5	57.3	100	258.8	Pass
4	3.553	90	8.9	3.9	12.8	69.5	56.7	100	252.2	Pass
5	5.971	90	10.1	2.6	12.7	69.5	56.8	100	234	Pass
6	8.538	90	6.6	2.4	9	69.5	60.5	100	71.7	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Limit value (dBuV/m) - Level (dBuV/m)

Below 1GHz worse case data Data Rate 1Mbps:

CHANNEL	TX Channel 17	DETECTOR FUNCTION	Quasi Peak
FREQUENCY RANGE	30MHz – 1GHz		



Antenna Polarity & Test Distance: Vertical and Horizontal at 3m										
No.	Frequency (MHz)	Polarization (H/V)	Reading QP [dB(uV)]	Factor [dB(1/m)]	Level QP [dB(uV/m)]	LimitQP [dB(uV/m)]	Margin QP [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	30.002	H	-7.7	26.9	19.2	40	20.8	338	131	Pass
2	67.921	V	3	13.2	16.2	40	23.8	101	285	Pass
3	105.77	H	3	17.5	20.5	43.5	23	320	148	Pass
4	105.745	V	3.1	17.9	21	43.5	22.5	116	28.1	Pass
5	640.433	H	-8.7	27.6	18.9	46	27.1	108	0.8	Pass
6	700.39	V	-9.1	27.9	18.8	46	27.2	261	0.3	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Limit value (dBuV/m) - Level (dBuV/m)

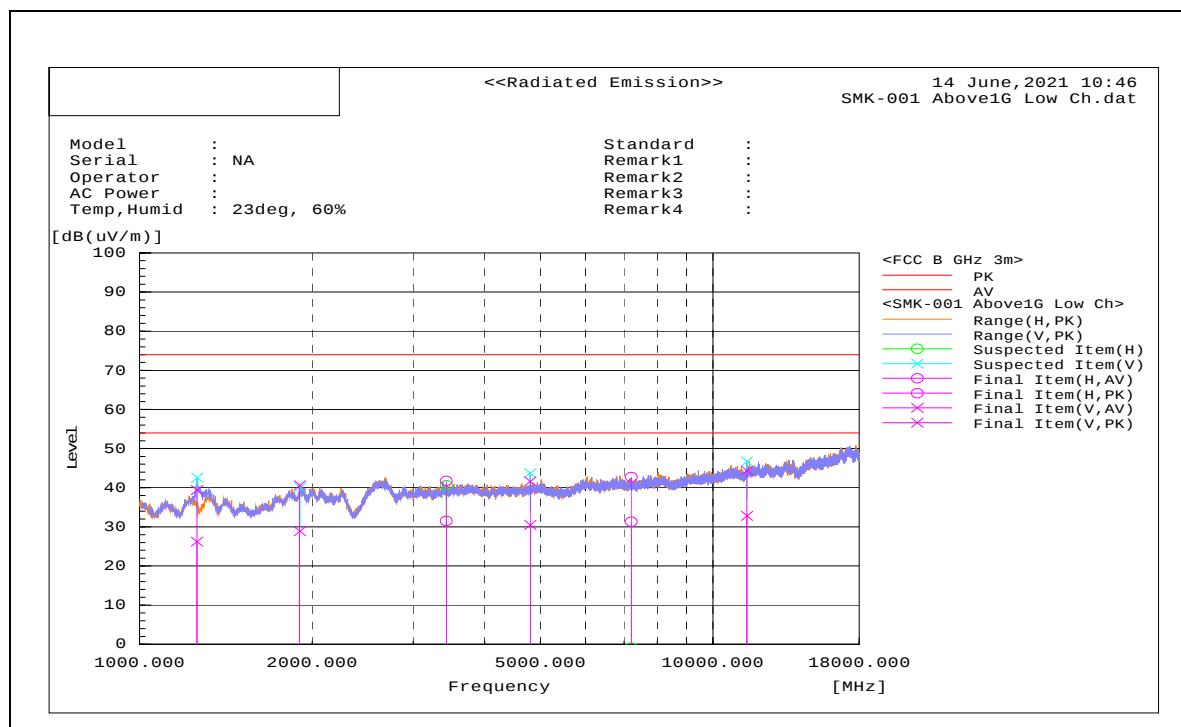
ABOVE 1GHz TEST DATA Data Rate 1Mbps:

CHANNEL	TX Ch 0 (2402MHz)	DETECTOR	Peak
FREQUENCY RANGE	1GHz ~ 25GHz	FUNCTION	Average

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m														
No	Frequency (MHz)	Polarization (H/V)	Reading AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	1259.49	V	42.7	55.9	-16.5	26.2	39.4	-	-	-	-	-	-	-
2	1902.512	V	41.6	53.3	-12.7	28.9	40.6	-	-	-	-	-	-	-
3	3426.973	H	40.1	50.3	-8.6	31.5	41.7	-	-	-	-	-	-	-
4	4802.296	V	36.5	47.6	-6	30.5	41.6	54	74	23.5	32.4	315.3	131.6	Pass
5	7205.957	H	32.1	43.5	-0.8	31.3	42.7	-	-	-	-	-	-	-
6	11465.35	V	26.7	38.3	6.1	32.8	44.4	54	74	21.2	29.6	270.3	185.8	Pass
7	24917.268	H	21.1	33.1	17.8	38.9	50.9	-	-	-	-	-	-	-
8	24918.376	V	22	34	17.8	39.8	51.8	-	-	-	-	-	-	-

REMARKS:

1. Emission level (dBuV/m) = Reading Value (dBuV) + Factor (dB)
2. AF (dB/m) = Antenna Factor (dB/m) – Preamplifier Gain (dB).
3. Margin = Limit value (dBuV/m) - Level (dBuV/m)



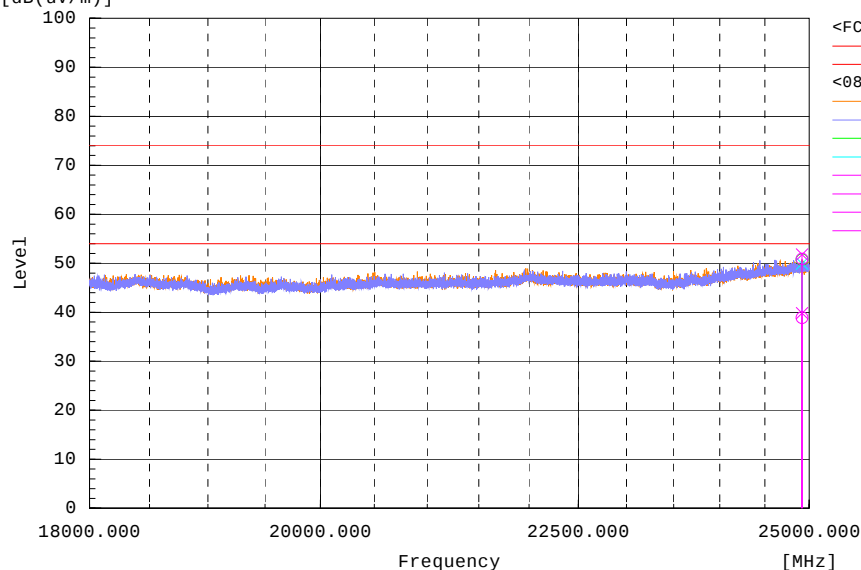
<<Radiated Emission>>

2 August, 2021 09:12

08-02-2021 SMK-001 1MBPS TX 2402MHz 18GHz-25GHz.dat

Model : 08-02-2021 SMK-001 1MBPS TX 2402MHz 18GHz-25GHz FCC Class B GHz 3m
Serial :
Operator :
AC Power :
Temp, Humid : 23deg, 60%
Remark1 :
Remark2 :
Remark3 :
Remark4 :

[dB(uV/m)]

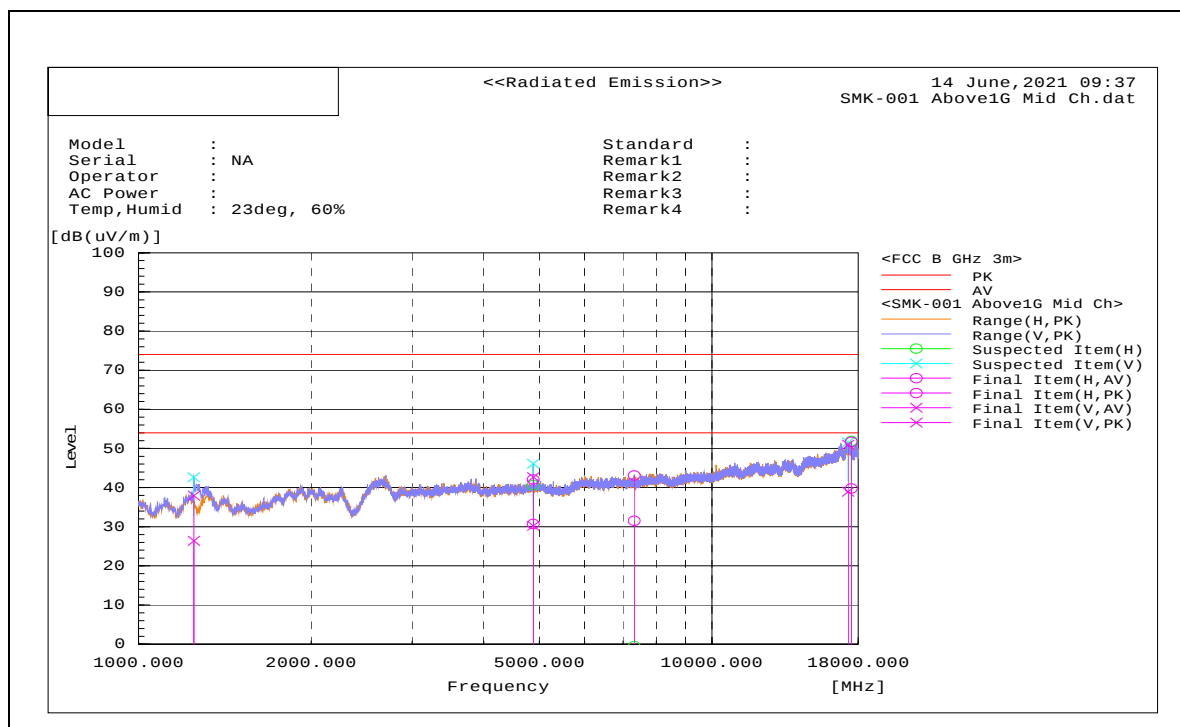


CHANNEL	TX Ch 19 (2440MHz)	DETECTOR	Peak
FREQUENCY RANGE	1GHz ~ 25GHz	FUNCTION	Average

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m														
No	Frequency (MHz)	Polarization (H/V)	Reading AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	1249.148	V	42.9	54.4	-16.5	26.4	37.9	-	-	-	-	-	-	-
2	4878.938	V	36.2	48.7	-6	30.2	42.7	54	74	23.8	31.3	378.7	22.6	Pass
3	4880.093	H	36.7	48.1	-6	30.7	42.1	54	74	23.3	31.9	107.6	3.1	Pass
4	7319.587	H	32	43.6	-0.5	31.5	43.1	54	74	22.5	30.9	104.5	0	Pass
5	17286.36	V	23.8	35.8	15.2	39	51	-	-	-	-	-	-	-
6	17506.87	H	23.4	35.3	16.4	39.8	51.7	-	-	-	-	-	-	-
7	24973.982	V	22	33.5	17.9	39.9	51.4	-	-	-	-	-	-	-
8	24975.694	H	21.4	32.6	17.9	39.3	50.5	-	-	-	-	-	-	-

REMARKS:

1. Emission level (dBuV/m) = Reading Value (dBuV) + Factor (dB)
2. AF (dB/m) = Antenna Factor (dB/m) – Pre-amplifier Gain (dB).
3. Margin = Limit value (dBuV/m) - Level (dBuV/m)



<<Radiated Emission>>

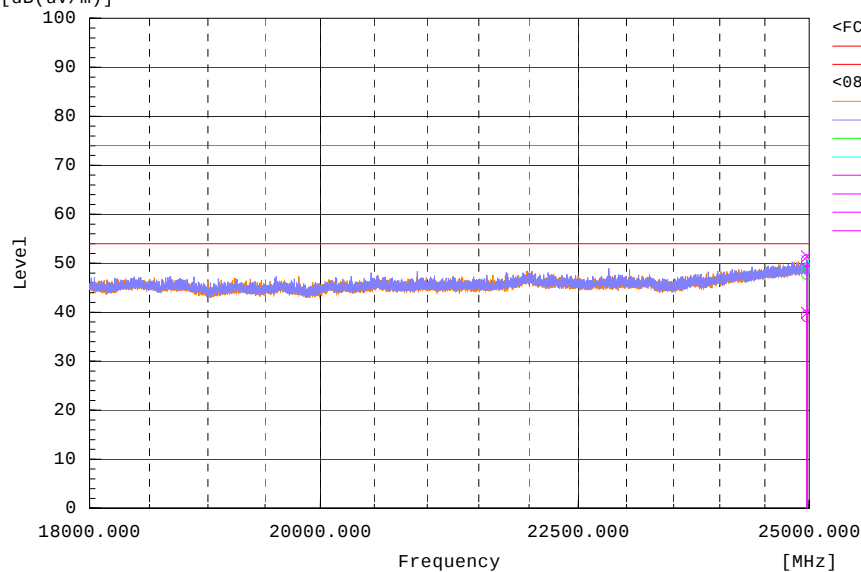
2 August, 2021 10:07

08-02-2021 SMK-001 1MBPS TX 2440MHz 18GHz-25GHz.dat

Model : 08-02-2021 SMK-001 1MBPS TX 2440MHz 18GHz-25GHz FCC Class B GHz 3m
Serial :
Operator :
AC Power :
Temp, Humid : 23deg, 60%

Remark1 :
Remark2 :
Remark3 :
Remark4 :

[dB(uV/m)]

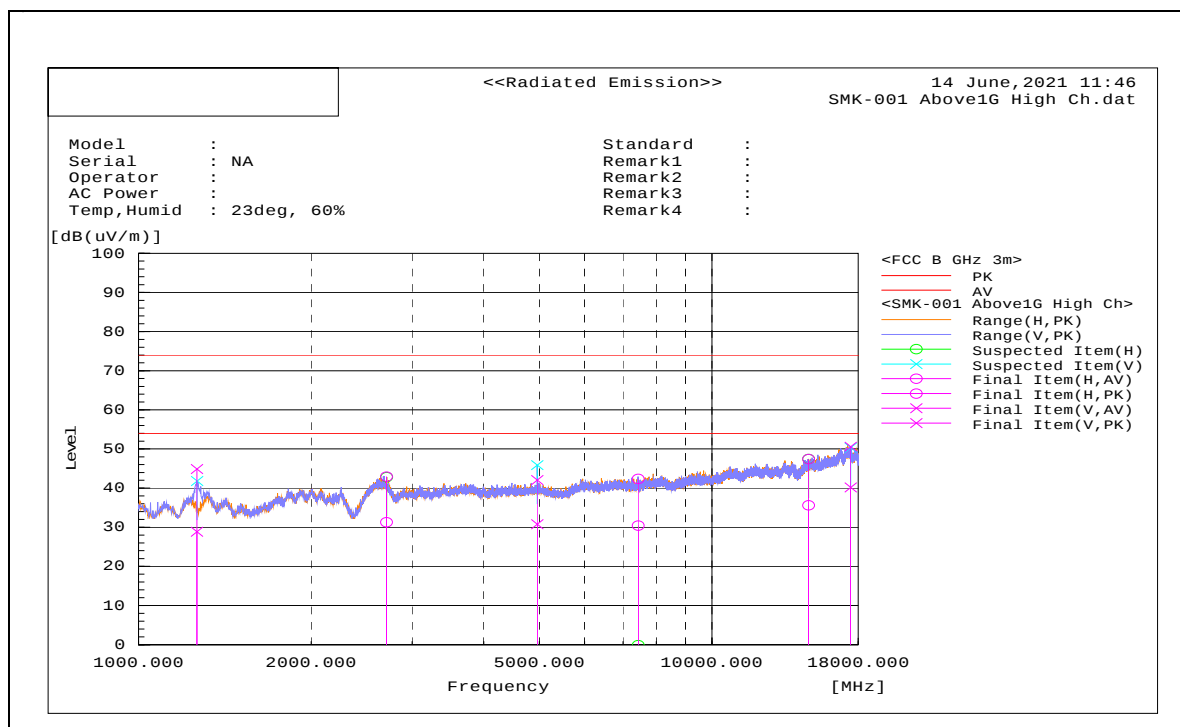


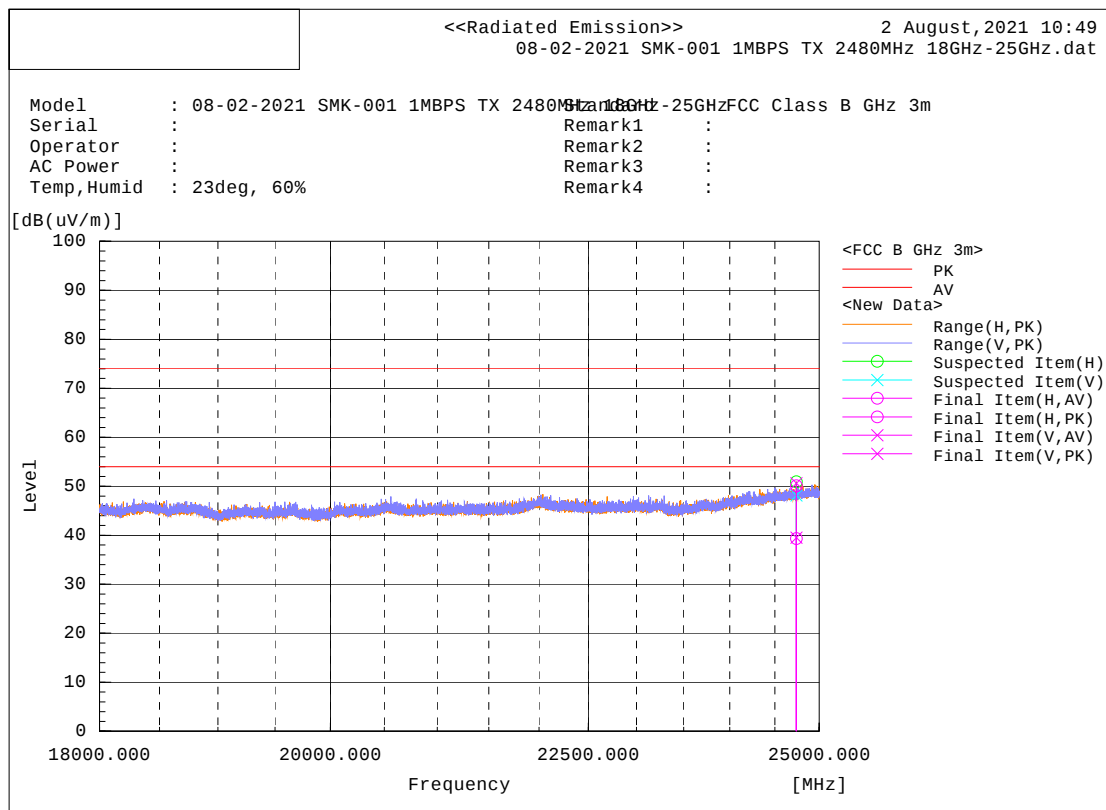
CHANNEL	TX Ch 39 (2480MHz)	DETECTOR	Peak
FREQUENCY RANGE	1GHz ~ 25GHz	FUNCTION	Average

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m														
No	Frequency (MHz)	Polarization (H/V)	Reading AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	1264.904	V	45.4	61.4	-16.5	28.9	44.9	-	-	-	-	-	-	-
2	2707.647	H	41.7	53.3	-10.4	31.3	42.9	54	74	22.7	31.1	196.3	62.8	Pass
3	4958.724	V	36.7	48	-5.9	30.8	42.1	54	74	23.2	31.9	337.1	315.6	Pass
4	7440.057	H	30.5	42.5	-0.1	30.4	42.4	54	74	23.6	31.6	239.4	44.4	Pass
5	14740.87	H	25.9	37.7	9.7	35.6	47.4	-	-	-	-	-	-	-
6	17459.69	V	24	34.4	16.2	40.2	50.6	-	-	-	-	-	-	-
7	24741.806	H	21.7	32.5	17.6	39.3	50.1	-	-	-	-	-	-	-
8	24741.438	V	21.9	33.1	17.6	39.5	50.7	-	-	-	-	-	-	-

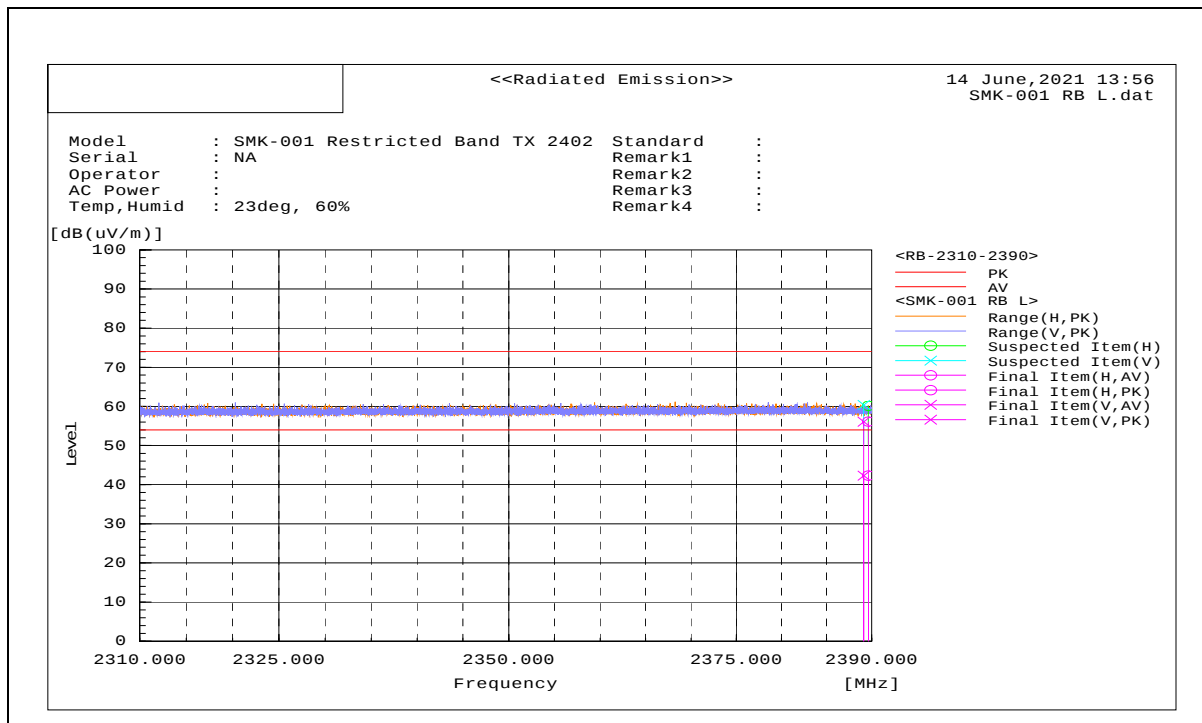
REMARKS:

1. Emission level (dBuV/m) = Reading Value (dBuV) + Factor (dB)
2. AF (dB/m) = Antenna Factor (dB/m) – Preamplifier Gain (dB).
3. Margin = Limit value (dBuV/m) - Level (dBuV/m)





RESTRICTED BAND Data Rate 1Mbps (LOW CHANNEL)

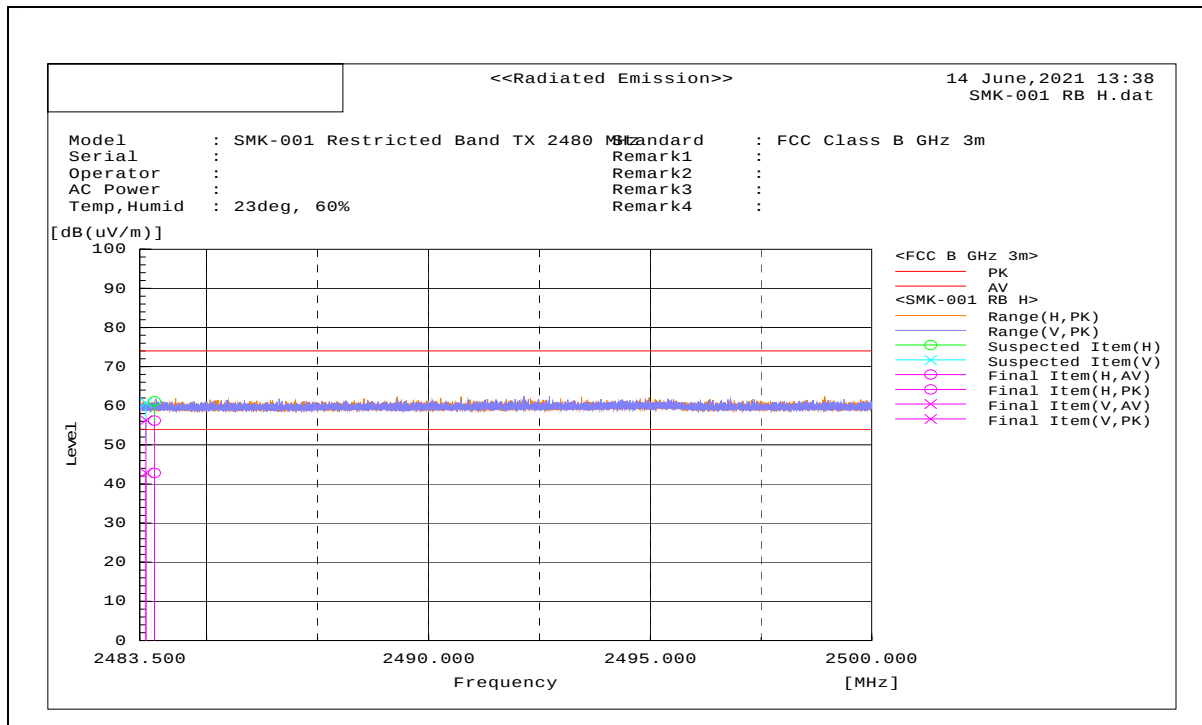


Antenna Polarity & Test Distance: Vertical and Horizontal at 3m														
No	Frequency (MHz)	Polarization (H/V)	Reading AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	2389.128	V	7.3	21.1	35	42.3	56.1	54	74	11.7	17.9	356.2	17.2	Pass
2	2389.64	H	7.3	21.1	35	42.3	56.1	54	74	11.7	17.9	106.2	14.7	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Limit value (dBuV/m) - Level (dBuV/m)

RESTRICTED BAND Data Rate 1Mbps (HIGH CHANNEL)

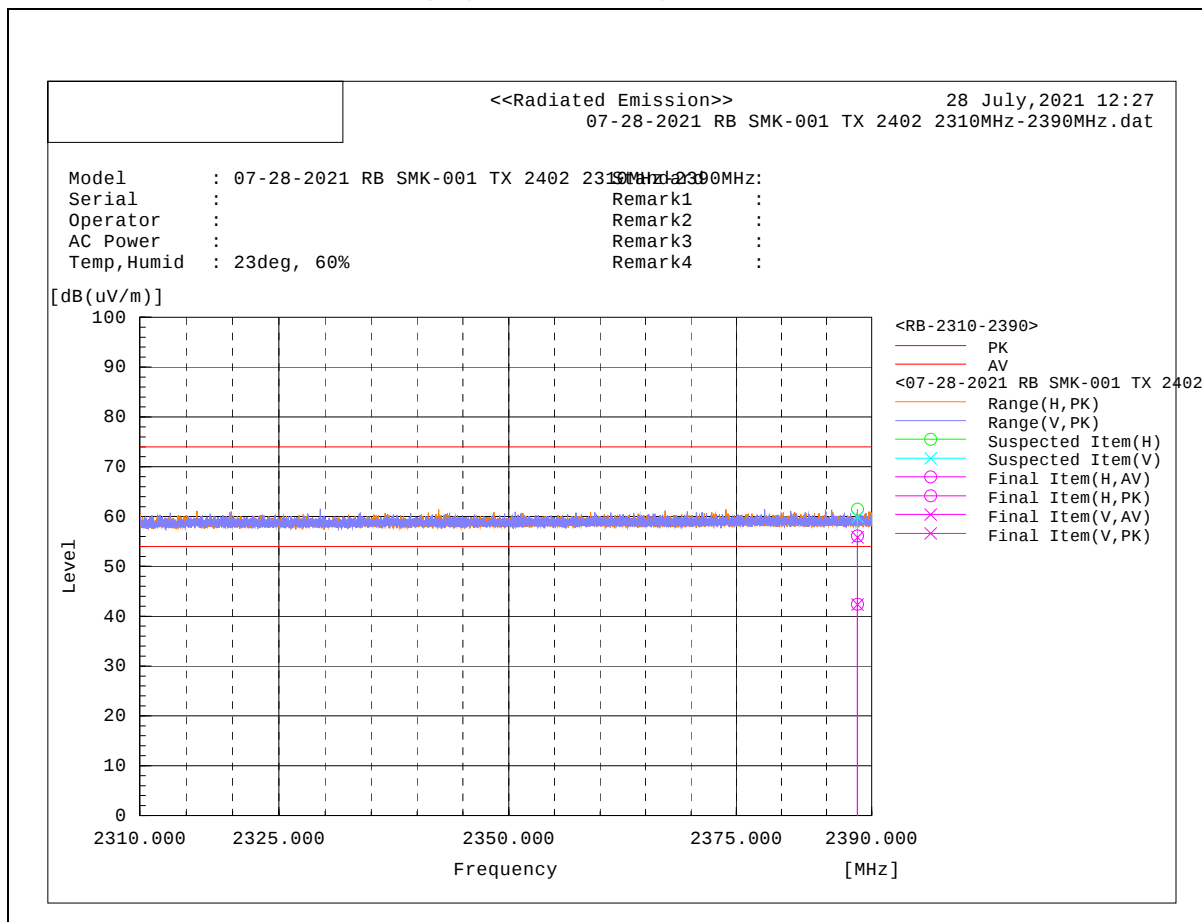


Antenna Polarity & Test Distance: Vertical and Horizontal at 3m														
No	Frequency (MHz)	Polarization (H/V)	Reading AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	2483.639	V	7.5	20.9	35.4	42.9	56.3	54	74	11.1	17.7	211.9	143.6	Pass
2	2483.832	H	7.4	20.8	35.4	42.8	56.2	54	74	11.2	17.8	399.1	323.2	Pass

REMARKS:

- Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
- Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
- Margin = Limit value (dBuV/m) - Level (dBuV/m)

RESTRICTED BAND Data Rate 2Mbps (LOW CHANNEL)

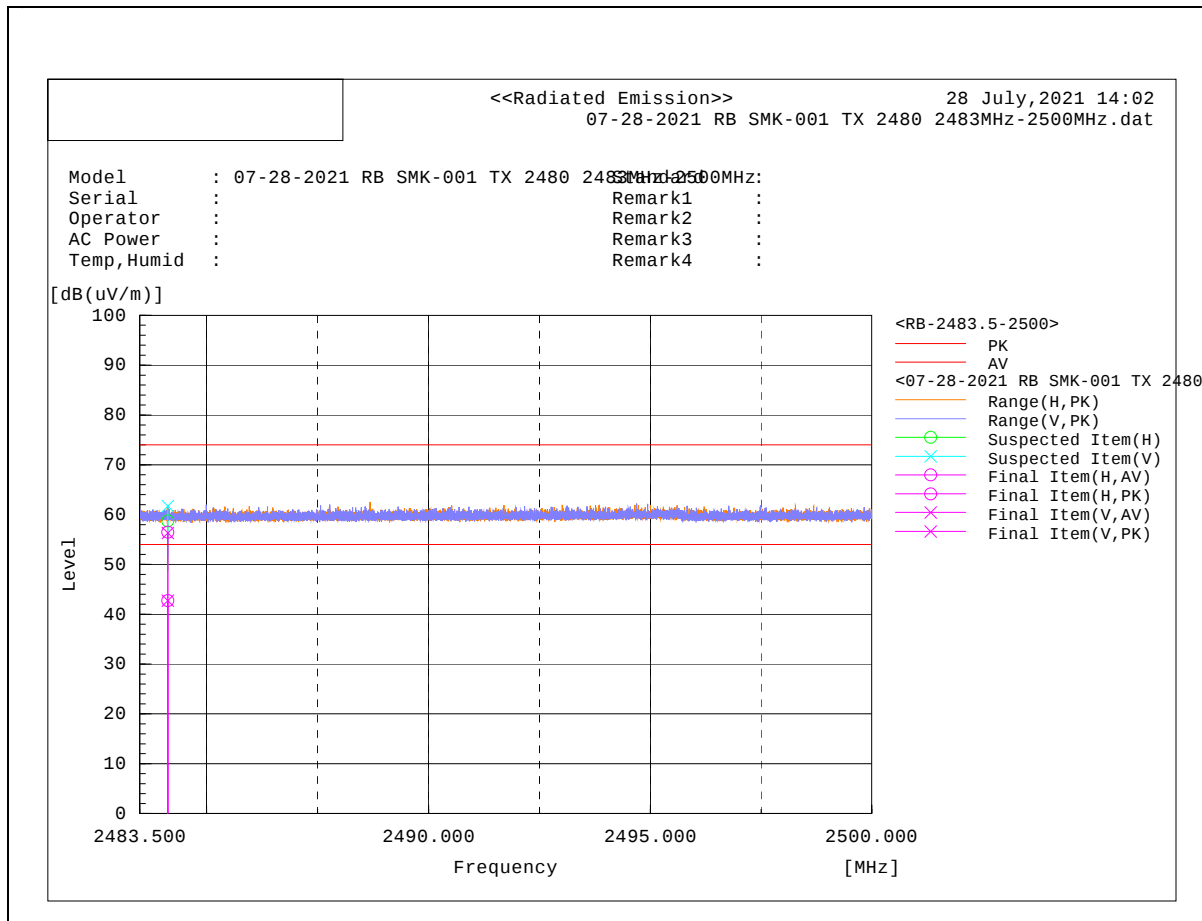


Antenna Polarity & Test Distance: Vertical and Horizontal at 3m														
No	Frequency (MHz)	Polarization (H/V)	Reading AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	2388.432	H	7.4	21.1	35	42.4	56.1	54	74	11.6	17.9	332	184	Pass
2	2388.432	V	7.4	20.8	35	42.4	55.8	54	74	11.6	18.2	171	289	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Limit value (dBuV/m) - Level (dBuV/m)

RESTRICTED BAND Data Rate 2Mbps (HIGH CHANNEL)



Antenna Polarity & Test Distance: Vertical and Horizontal at 3m														
No	Frequency (MHz)	Polarization (H/V)	Reading AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/Fail
1	2484.132	V	7.3	20.9	35.4	42.7	56.3	54	74	11.3	17.7	106	193.8	Pass
2	2484.132	H	7.3	21.1	35.4	42.7	56.5	54	74	11.3	17.5	162	14.2	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Limit value (dBuV/m) - Level (dBuV/m)

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 Procedures

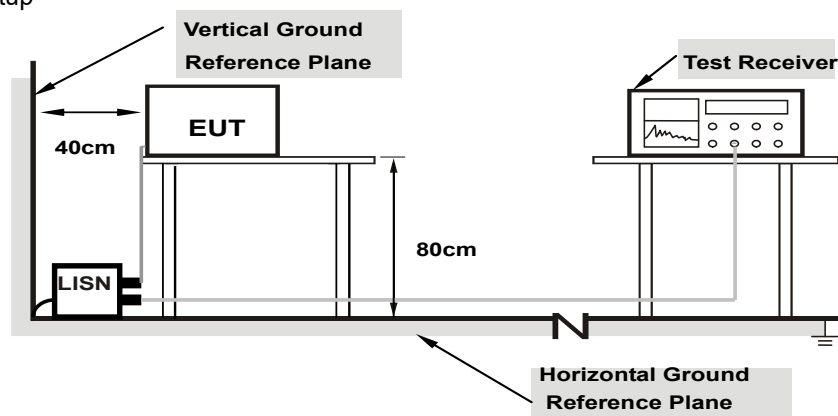
- The EUT was placed 0.4 meters from the conducting wall of the shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). Other support units were connected to the power mains through another LISN. The two LISNs provide 50 ohm/ 50uH of coupling impedance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

4.2.3 Deviation from Test Standard

No deviation.

4.2.4 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).

4.2.5 EUT Operating Conditions

Same as 4.1.6.

4.2.6 Test Results

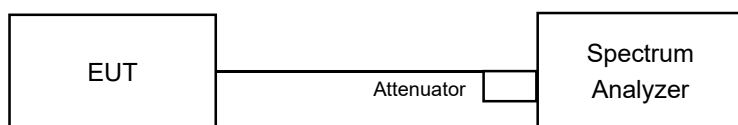
N/A (Unit powered by battery).

4.3 6dB Bandwidth Measurement & 99% 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

99% Bandwidth Measurement

Refer to ANSI C63.10 section 6.9.3

-6dB Bandwidth Measurement

- 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

Data Rate 1Mbps

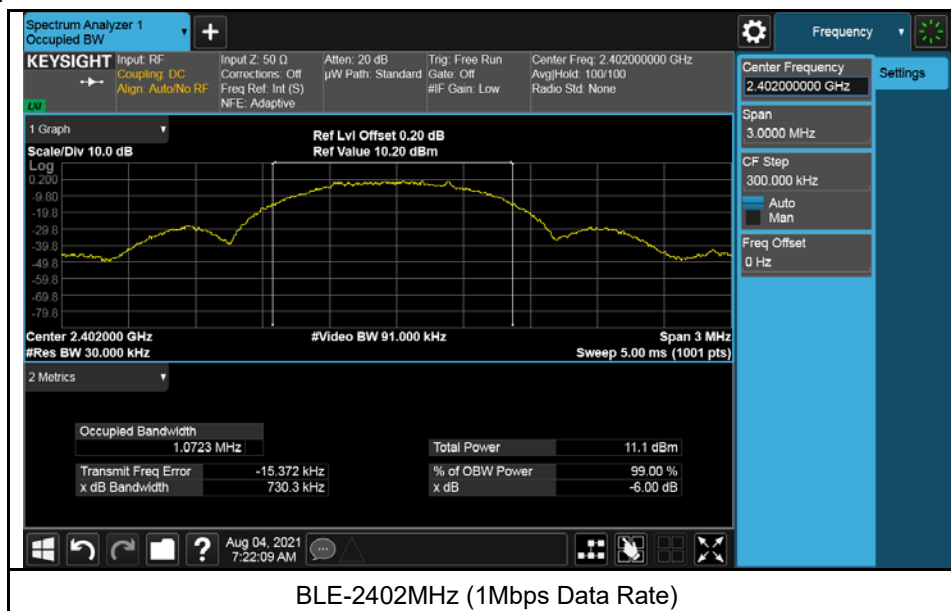
Channel	Frequency (MHz)	6dB Bandwidth (MHz)	99% Bandwidth (MHz)	Minimum Limit (MHz)	Pass / Fail
37	2402	0.7156	1.0723	0.5	PASS
17	2440	0.7122	1.0718	0.5	PASS
39	2480	0.6768	1.0518	0.5	PASS

Data Rate 2bps

Channel	Frequency (MHz)	6dB Bandwidth (MHz)	99% Bandwidth (MHz)	Minimum Limit (MHz)	Pass / Fail
37	2402	1.415	2.0912	0.5	PASS
17	2440	1.505	2.1212	0.5	PASS
39	2480	1.515	2.1202	0.5	PASS

Test Plots:

99% Occupied Bandwidth:

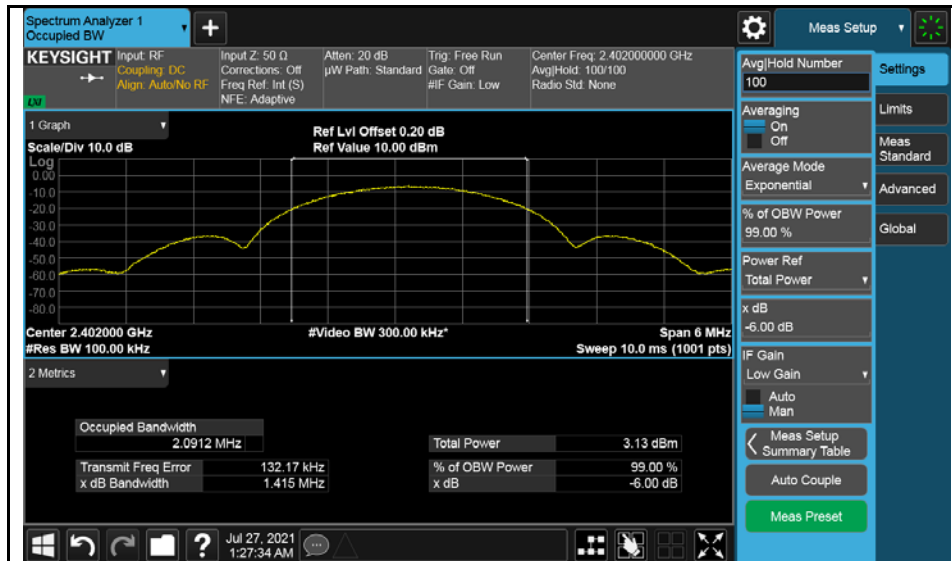




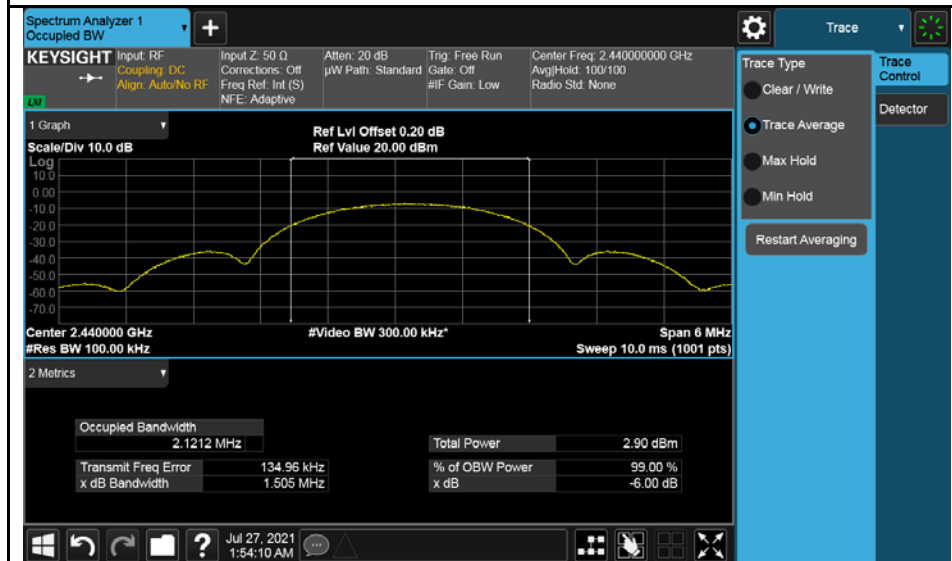
BLE-2440MHz (1Mbps Data Rate)



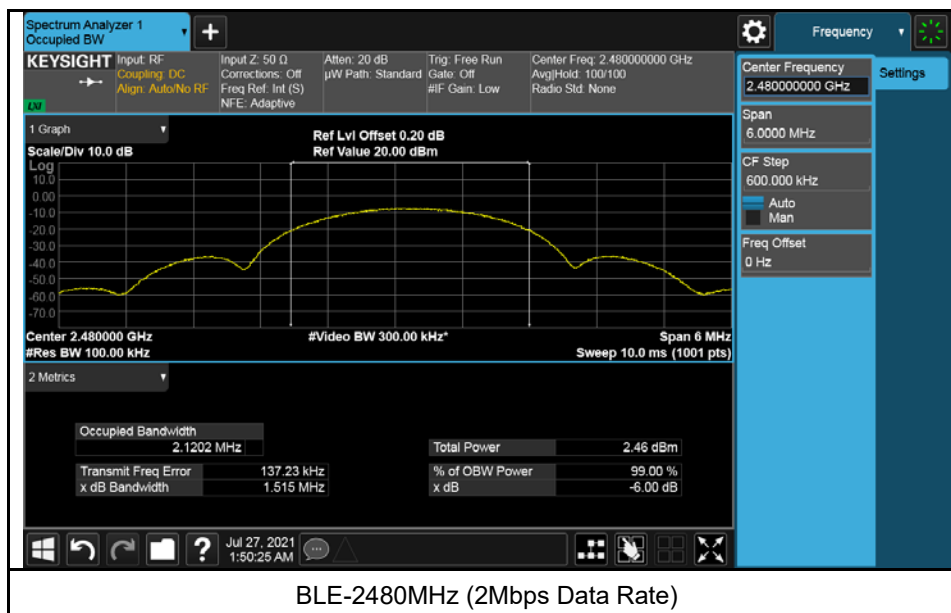
BLE-2480MHz (1Mbps Data Rate)



BLE-2402MHz (2Mbps Data Rate)



BLE-2440MHz (2Mbps Data Rate)



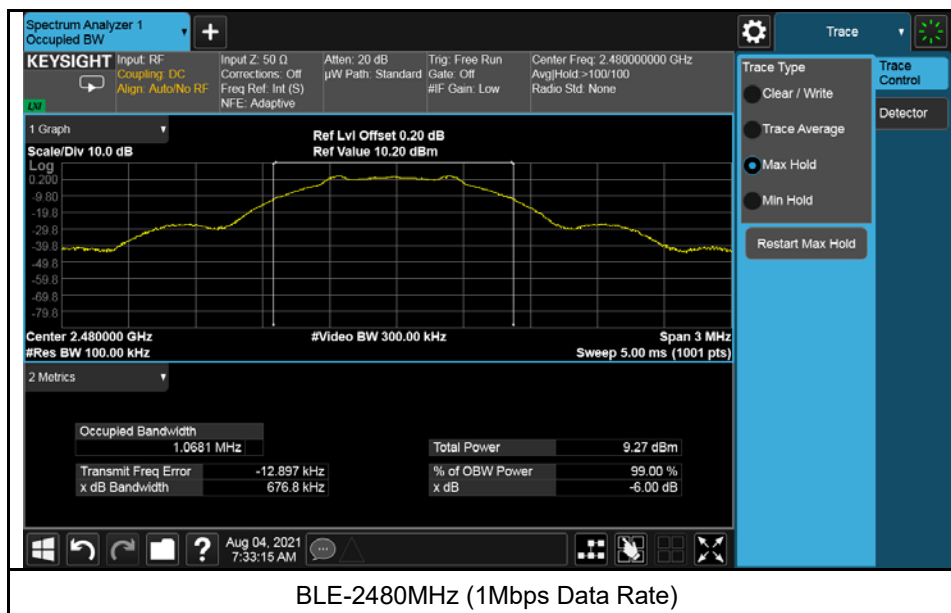
6 dB Occupied Bandwidth:

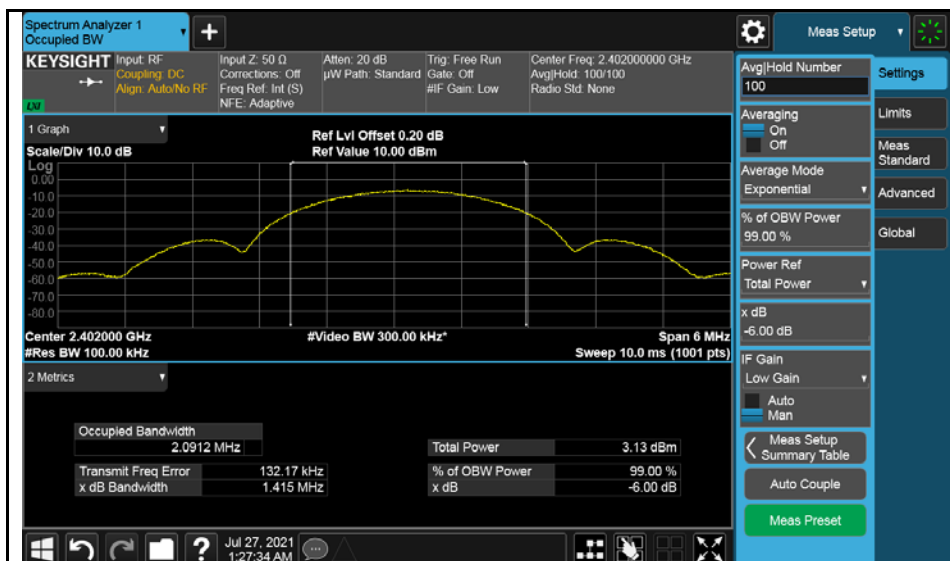


BLE-2402MHz (1Mbps Data Rate)

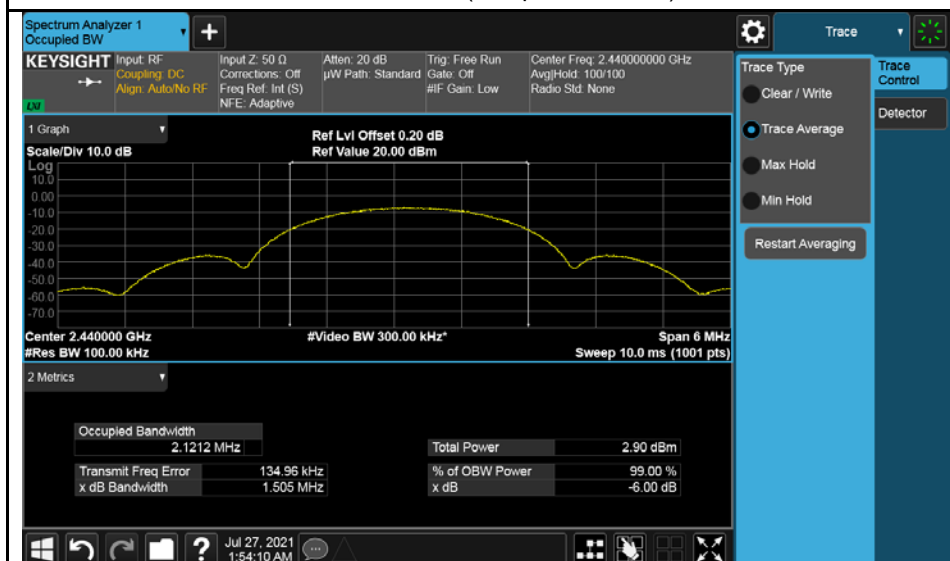


BLE-2440MHz (1Mbps Data Rate)

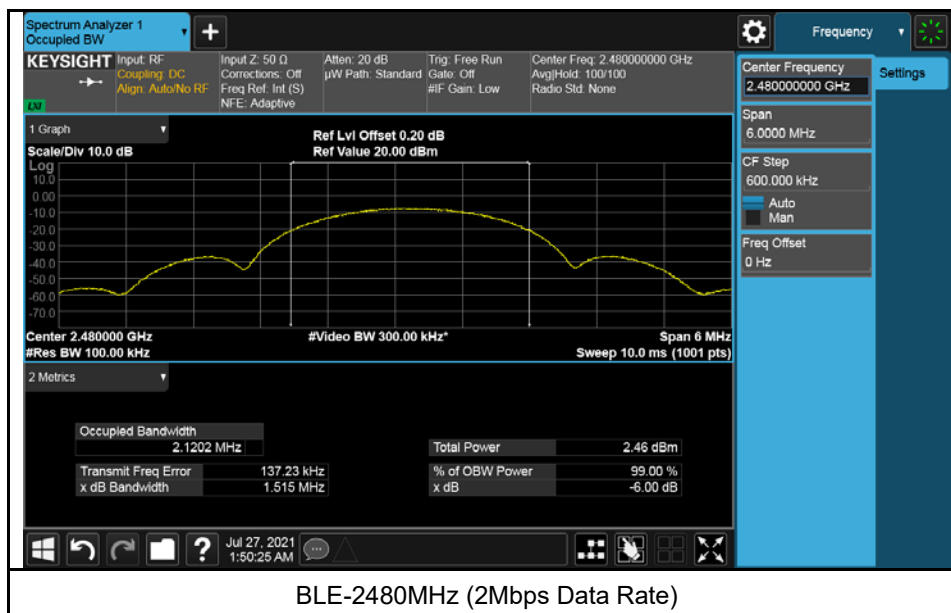




BLE-2402MHz (2Mbps Data Rate)



BLE-2440MHz (2Mbps Data Rate)

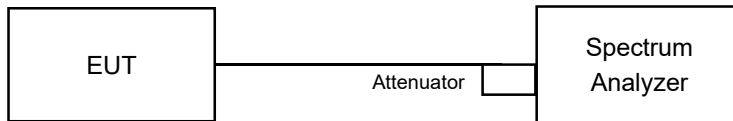


4.4 Conducted Output Power Measurement

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

- a. Set the RBW $\geq$ DTS bandwidth.
- b. Set VBW $\geq 3 \times$ RBW.
- c. Set span $\geq 3 \times$ 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.

4.4.5 Deviation from Test Standard

No deviation.

4.4.6 EUT Operating Conditions

Same as Item 4.3.6.

4.4.7 Test Results

Data Rate: 1Mbps

Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Pass/Fail
37	2402	2.87	30	Pass
17	2440	2.6	30	Pass
39	2480	2.61	30	Pass

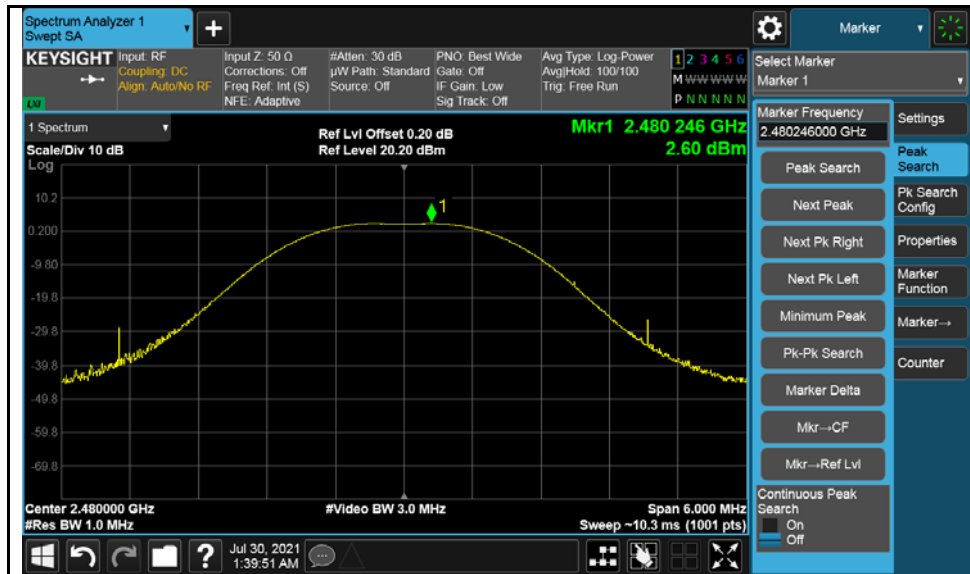
Data Rate: 2Mbps

Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Pass/Fail
37	2402	3.31	30	Pass
17	2440	3.04	30	Pass
39	2480	2.73	30	Pass

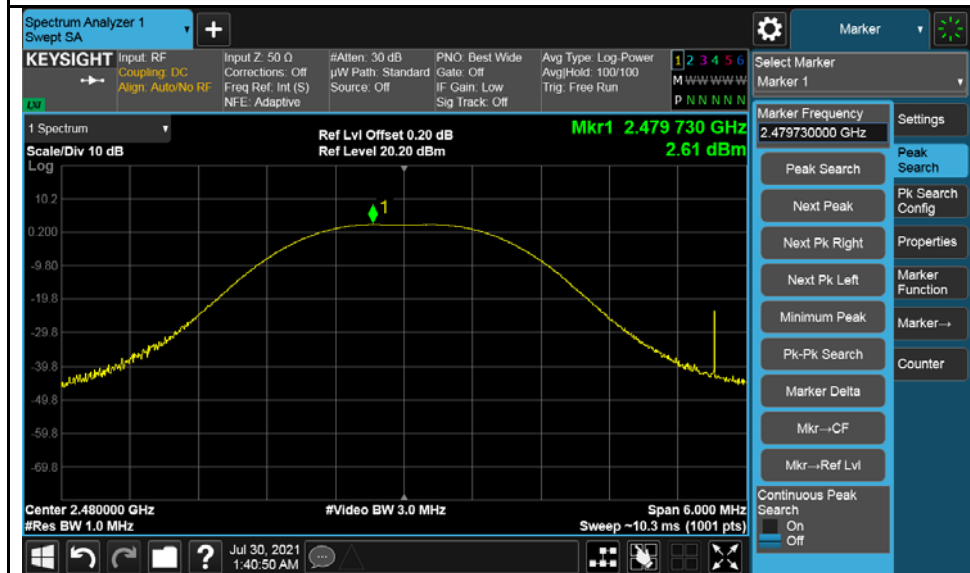
Test Plots:



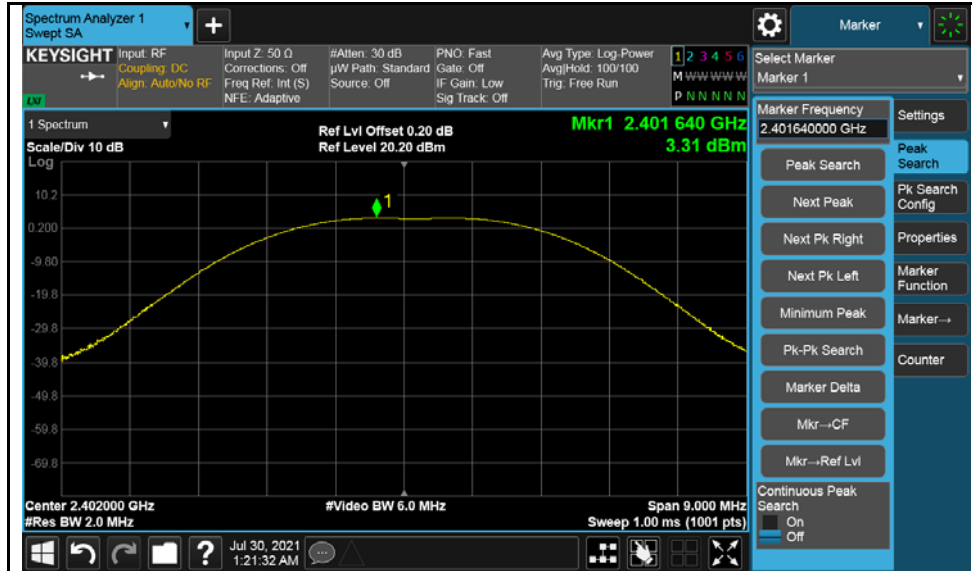
BLE-2402MHz (1Mbps Data Rate)



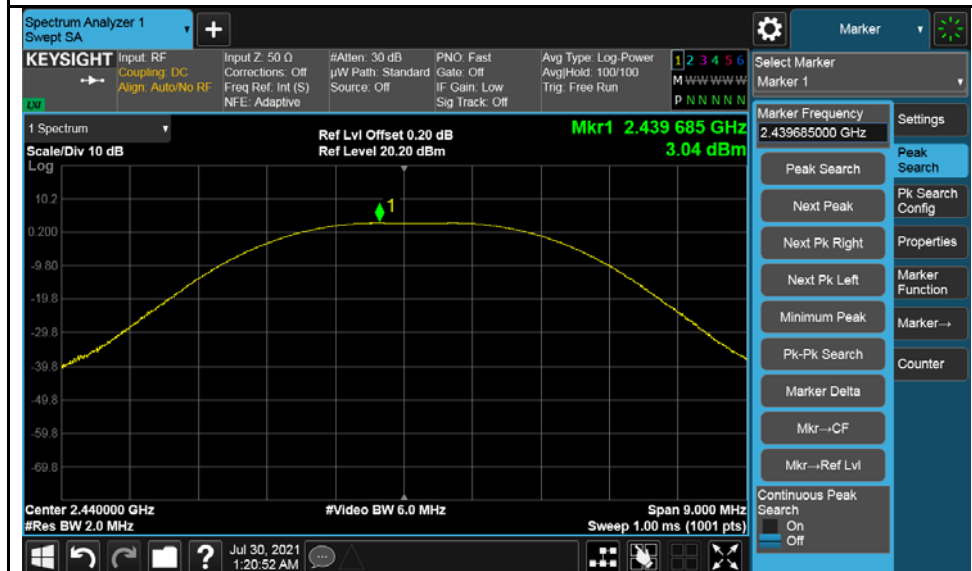
BLE-2440MHz (1Mbps Data Rate)



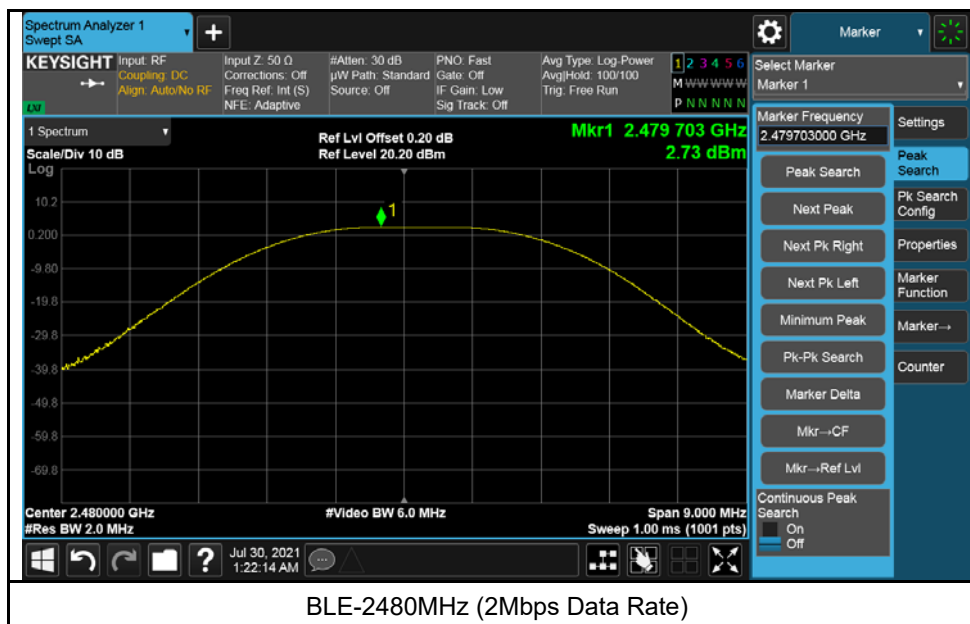
BLE-2480MHz (1Mbps Data Rate)



BLE-2402MHz (2Mbps Data Rate)



BLE-2440MHz (2Mbps Data Rate)

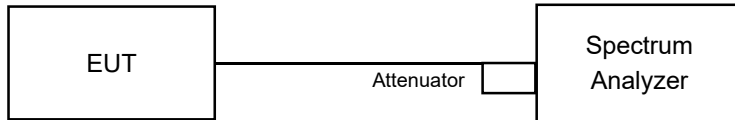


4.5 Power Spectral Density Measurement

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

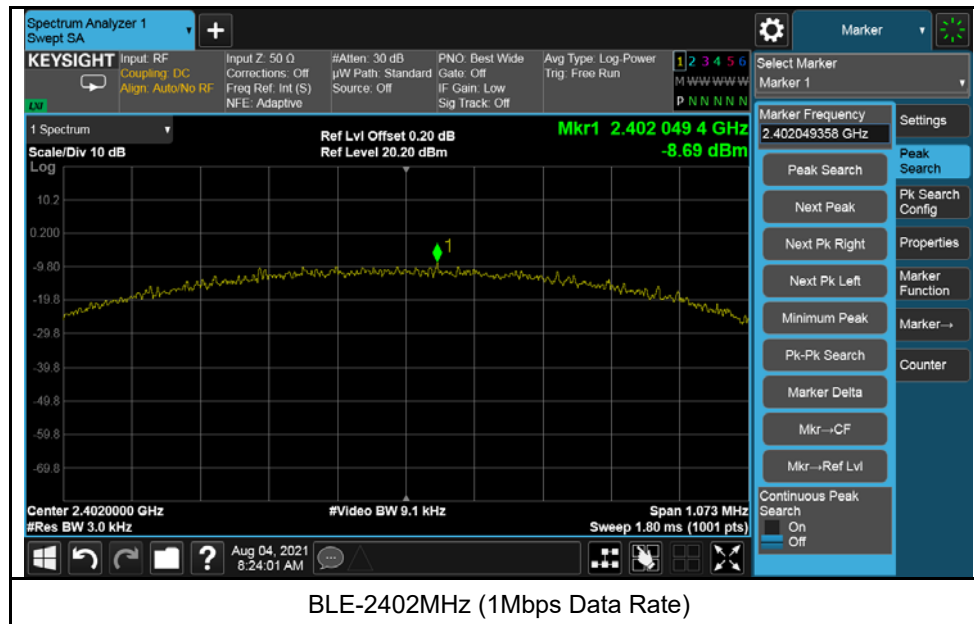
Data Rate: 1Mbps

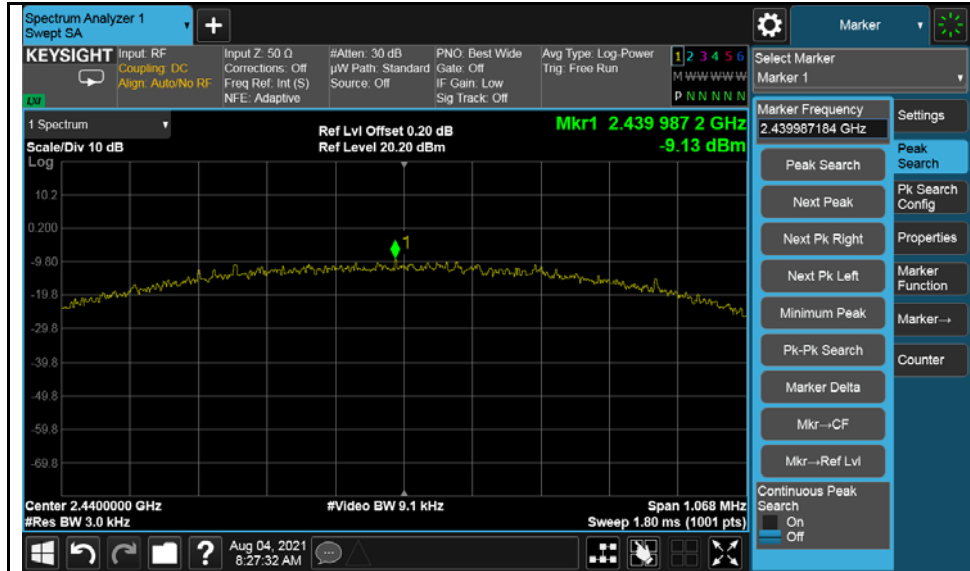
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Pass/Fail
37	2402	-8.69	8	Pass
17	2440	-9.13	8	Pass
39	2480	-7.92	8	Pass

Data Rate: 2Mbps

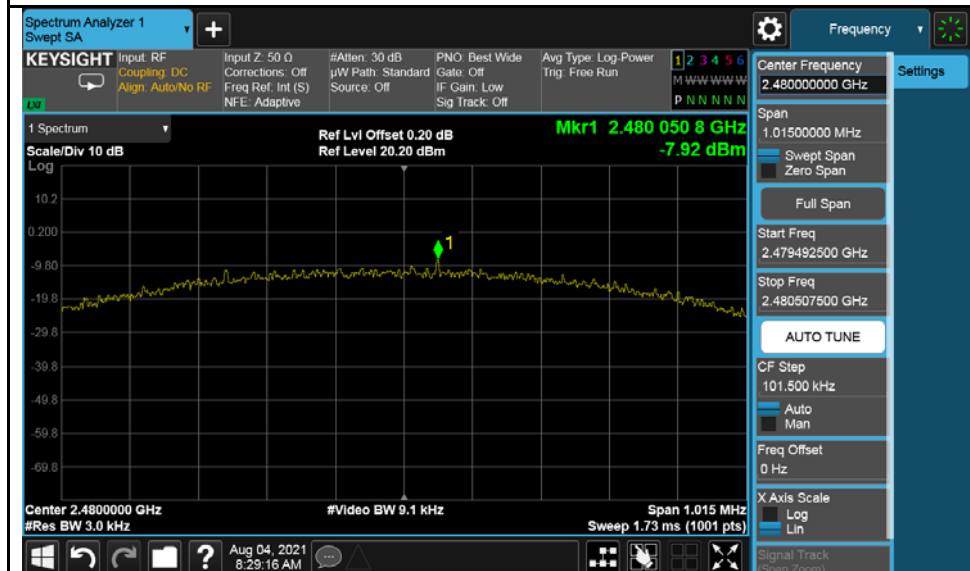
Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)	Pass/Fail
37	2402	-11.84	8	Pass
17	2440	-11.96	8	Pass
39	2480	-11.24	8	Pass

Test Plots:

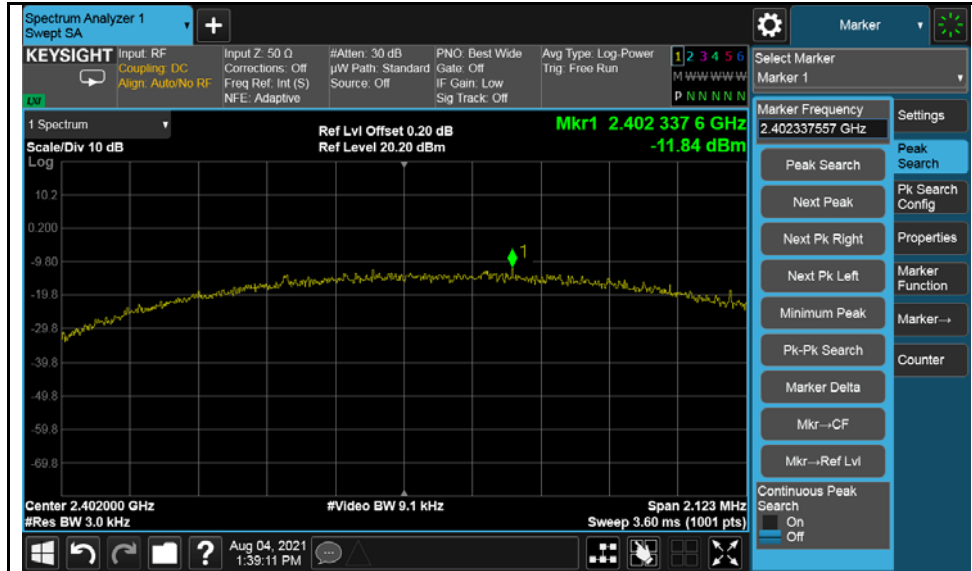




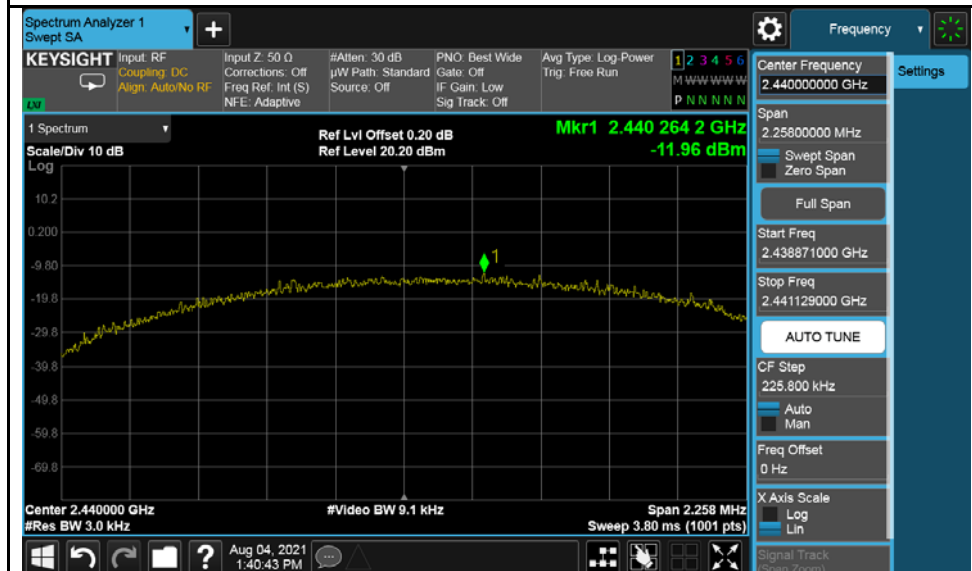
BLE-2440MHz (1Mbps Data Rate)



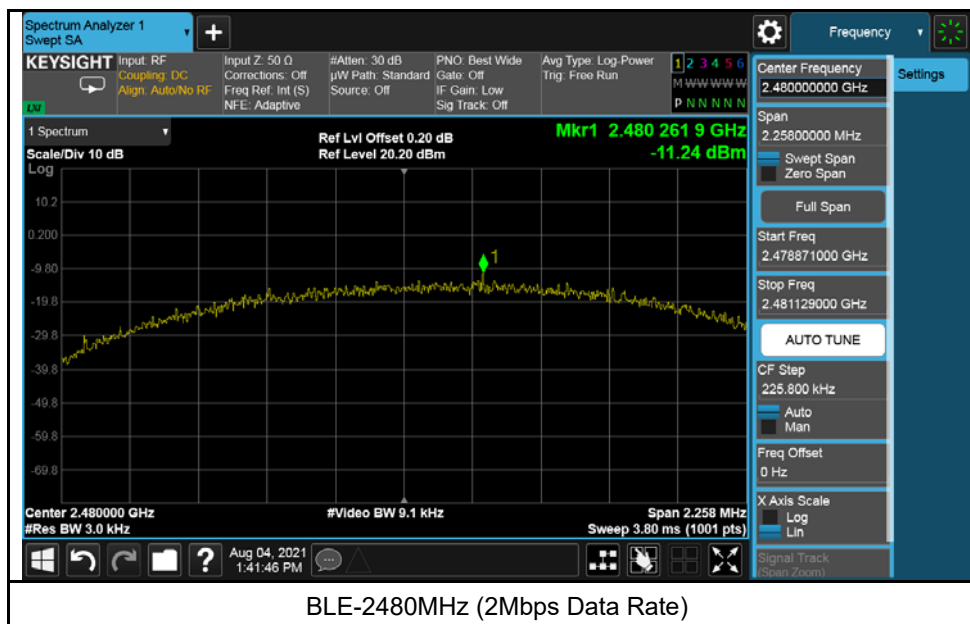
BLE-2480MHz (1Mbps Data Rate)



BLE-2402MHz (2Mbps Data Rate)



BLE-2440MHz (2Mbps Data Rate)

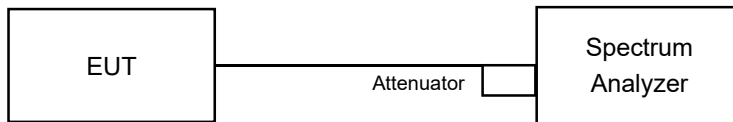


4.6 Conducted Out of Band Emission Measurement

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

1. Set the RBW = 100 kHz.
2. Set the VBW $\geq$ 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 OOB

1. Set RBW = 100 kHz.
2. Set VBW $\geq$ 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.

4.6.5 Deviation from Test Standard

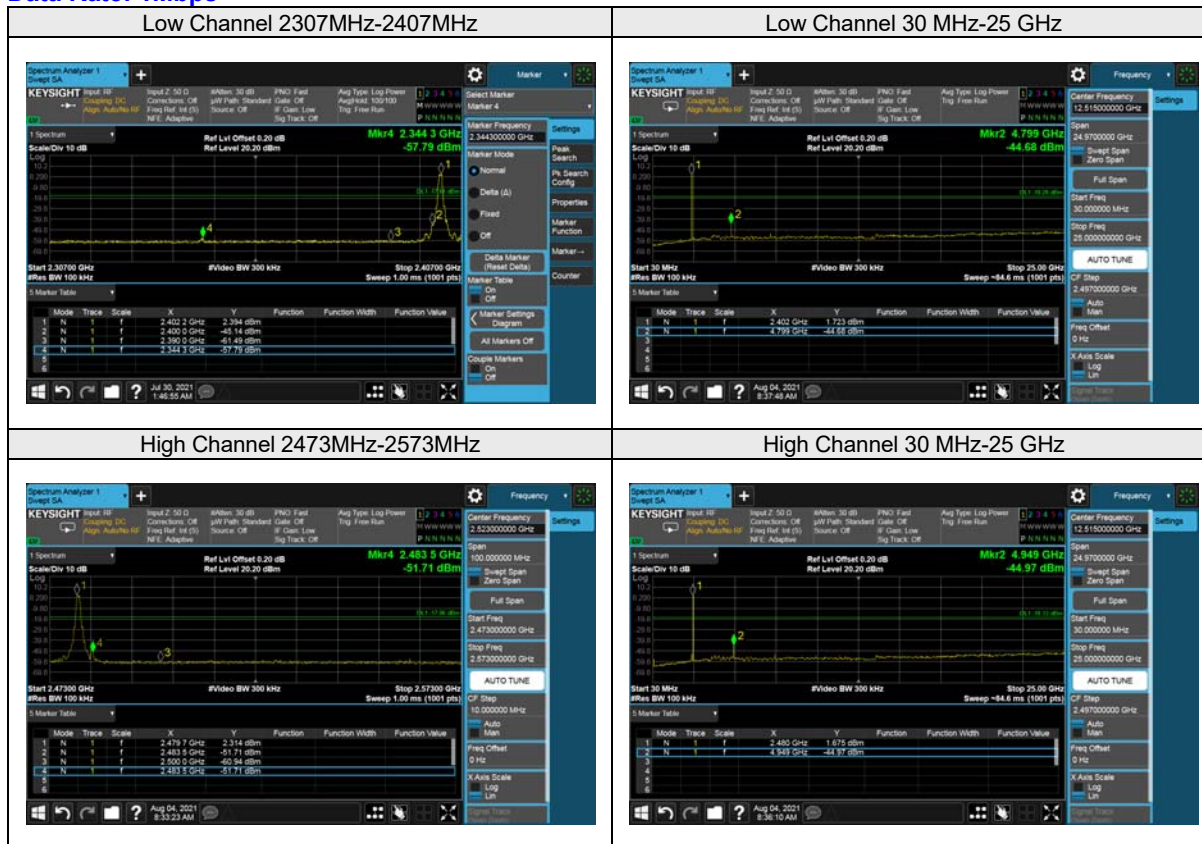
No deviation.

4.6.6 EUT Operating Condition

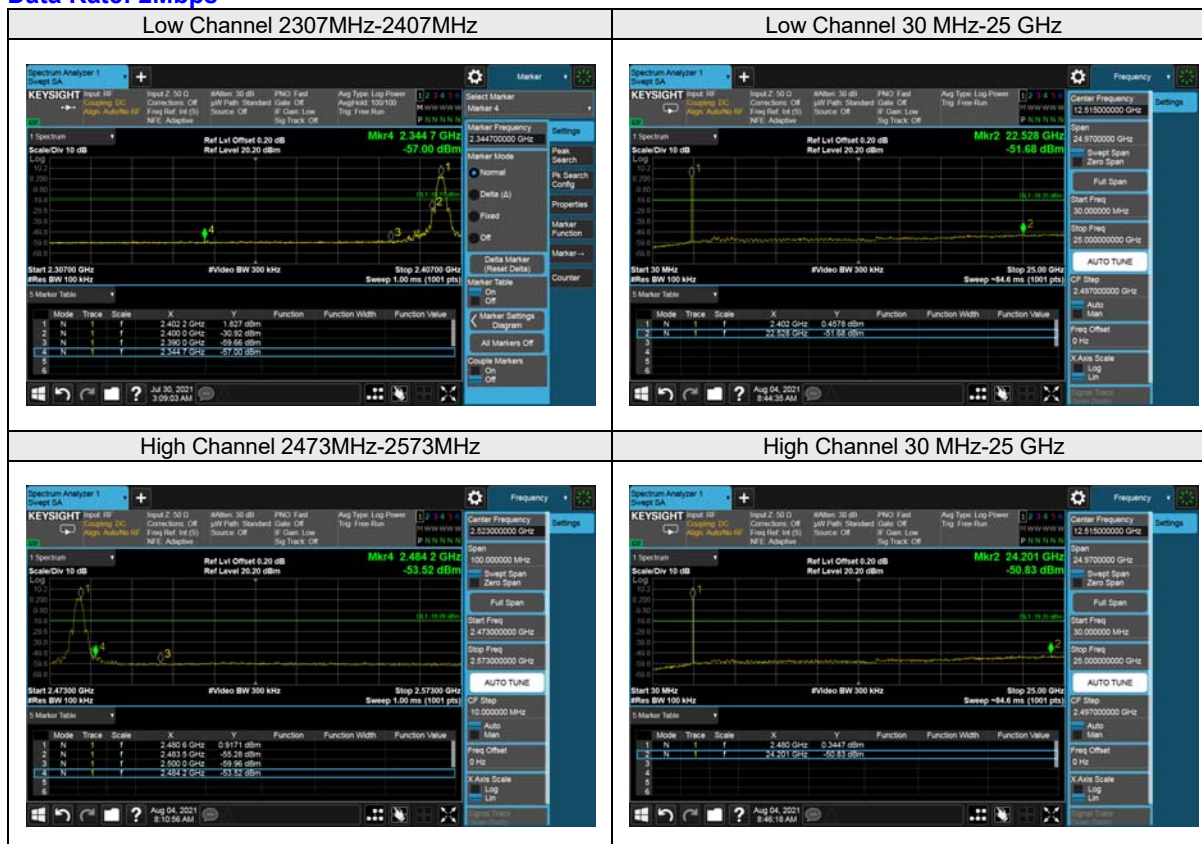
Same as Item 4.3.6

4.6.7 Test Results

Data Rate: 1Mbps



Data Rate: 2Mbps



5 Pictures of Test Arrangements

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

Appendix – Information on the Testing Laboratories

Bureau Veritas is a global leader in testing, inspection and certification (TIC) services. We help businesses improve safety, sustainability and productivity; and our clients include the majority of leading brands in retail, manufacturing and other industries. With a presence in every major country around the world, our quality assurance and compliance solutions are vital in helping our customers enhance product quality and concept-to-consumer journeys. We also assist with increasing speed to market, profitability and brand equity throughout the supply chain. Bureau Veritas is a leading wireless/IoT testing, inspection, audit and certification provider, with a global network of test laboratories to support the IoT industry in areas of connectivity, security, interoperability as well as quality, health & safety, and environmental/chemical requirements.

If you have any comments, please feel free to contact us at the following:

Milpitas EMC/RF/Safety/Telecom Lab

775 Montague Expressway, Milpitas, CA 95035
Tel: +1 408 526 1188

Sunnyvale OTA/Bluetooth Lab

1293 Anvilwood Avenue, Sunnyvale, CA 94089
Tel: +1 669 600 5293

Littleton EMC/RF/Safety/Environmental Lab

1 Distribution Center Cir #1, Littleton, MA 01460
Tel: +1 978 486 8880

Email: sales.eaw@us.bureauveritas.com

Web Site: www.cpsusa-bureauveritas.com

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

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