

FCC Test Report

Product Name	Realtime radio module
Model No.	TM5317-21
FCC ID.	NI4-TM5317-21

Applicant	Toyota Motor Corporation
Address	1, Toyota-Cho Toyota Aichi, 471-8572 Japan

Date of Receipt	Jan. 11, 2021
Issued Date	Mar. 05, 2021
Report No.	2110302R-E3032110109
Report Version	V1.0



The test results relate only to the samples tested.

The test results shown in the test report are traceable to the national/international standard through the calibration report of the equipment and evaluated measurement uncertainty herein.

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Measurement uncertainties evaluated for each testing system and associated connections are given here to provide the system information for reference. Compliance determinations do not take into account measurement uncertainties for each testing system, but are based on the results of the compliance measurement.

Test Report

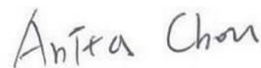
Issued Date: Mar. 05, 2021

Report No.: 2110302R-E3032110109



Product Name	Realtime radio module
Applicant	Toyota Motor Corporation
Address	1, Toyota-Cho Toyota Aichi, 471-8572 Japan
Manufacturer	TOYOTA TECHNICAL DEVELOPMENT CORPORATION
Factory	OYO ELECTRIC CO. ,LTD.
Model No.	TM5317-21
FCC ID.	NI4-TM5317-21
EUT Rated Voltage	DC 5V (Power by Host)
EUT Test Voltage	AC 120V/60Hz
Trade Name	TOYOTA
Applicable Standard	FCC CFR Title 47 Part 15 Subpart C ANSI C63.4: 2014, ANSI C63.10: 2013
Test Result	Complied

Documented By :



(Senior Engineering Adm. Specialist / Anita Chou)

Tested By :



(Manager, Product Testing / Tom Hsieh)

Approved By :



(Director / Vincent Lin)

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Attachment 1: EUT Test Photographs

Attachment 2: EUT Detailed Photographs

Revision History

Report No.	Version	Description	Issued Date
2110302R-E3032110109	V1.0	Initial issue of report.	2021-03-05

1. GENERAL INFORMATION

1.1. EUT Description

Product Name	Realtime radio module
Trade Name	TOYOTA
Model No.	TM5317-21
FCC ID.	NI4-TM5317-21
Frequency Range	2402 – 2480MHz
Channel Number	79
Type of Modulation	GFSK
Antenna Type	FlexPIFA Antenna
Channel Control	Auto
Antenna Gain	Refer to the table “Antenna List”

Antenna List

No.	Manufacturer	Part No.	Antenna Type	Peak Gain
1	Laird connectivity	001-0016	FlexPIFA Antenna	2.5dBi for 2.4GHz

Note: The antenna of EUT conforms to FCC 15.203.

Center Frequency of Each Channel:

Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
Channel 01:	2402 MHz	Channel 02:	2403 MHz	Channel 03:	2404 MHz	Channel 04:	2405 MHz
Channel 05:	2406 MHz	Channel 06:	2407 MHz	Channel 07:	2408 MHz	Channel 08:	2409 MHz
Channel 09:	2410 MHz	Channel 10:	2411 MHz	Channel 11:	2412 MHz	Channel 12:	2413 MHz
Channel 13:	2414 MHz	Channel 14:	2415 MHz	Channel 15:	2416 MHz	Channel 16:	2417 MHz
Channel 17:	2418 MHz	Channel 18:	2419 MHz	Channel 19:	2420 MHz	Channel 20:	2421 MHz
Channel 21:	2422 MHz	Channel 22:	2423 MHz	Channel 23:	2424 MHz	Channel 24:	2425 MHz
Channel 25:	2426 MHz	Channel 26:	2427 MHz	Channel 28:	2428 MHz	Channel 28:	2429 MHz
Channel 29:	2430 MHz	Channel 30:	2431 MHz	Channel 31:	2432 MHz	Channel 32:	2433 MHz
Channel 33:	2434 MHz	Channel 34:	2435 MHz	Channel 35:	2436 MHz	Channel 36:	2437 MHz
Channel 37:	2438 MHz	Channel 38:	2439 MHz	Channel 39:	2440 MHz	Channel 40:	2441 MHz
Channel 41:	2442 MHz	Channel 42:	2443 MHz	Channel 43:	2444 MHz	Channel 44:	2445 MHz
Channel 45:	2446 MHz	Channel 46:	2447 MHz	Channel 47:	2448 MHz	Channel 48:	2449 MHz
Channel 49:	2450 MHz	Channel 50:	2451 MHz	Channel 51:	2452 MHz	Channel 52:	2453 MHz
Channel 53:	2454 MHz	Channel 54:	2455 MHz	Channel 55:	2456 MHz	Channel 56:	2457 MHz
Channel 57:	2458 MHz	Channel 58:	2459 MHz	Channel 59:	2460 MHz	Channel 60:	2461 MHz
Channel 61:	2462 MHz	Channel 62:	2463 MHz	Channel 63:	2464 MHz	Channel 64:	2465 MHz
Channel 65:	2466 MHz	Channel 66:	2467 MHz	Channel 67:	2468 MHz	Channel 68:	2469 MHz
Channel 69:	2470 MHz	Channel 70:	2471 MHz	Channel 71:	2472 MHz	Channel 72:	2473 MHz
Channel 73:	2474 MHz	Channel 74:	2475 MHz	Channel 75:	2476 MHz	Channel 76:	2477 MHz
Channel 77:	2478 MHz	Channel 78:	2479 MHz	Channel 79:	2480 MHz		

Note:

1. The EUT is an Realtime radio module with built-in GFSK transceiver.
2. The Realtime radio module is installed into a Wireless VIM Terminal Host (Trade name: TOYOTA, Model Name: TM5317B) to perform the test.
3. These tests were conducted on a sample for the purpose of demonstrating compliance of transmitter with Part 15 Subpart C Paragraph 15.247 for spread spectrum devices.
4. Regarding to the operation frequency, the lowest, middle and highest frequency are selected to perform the test.

Test Mode	Mode 1: Transmit
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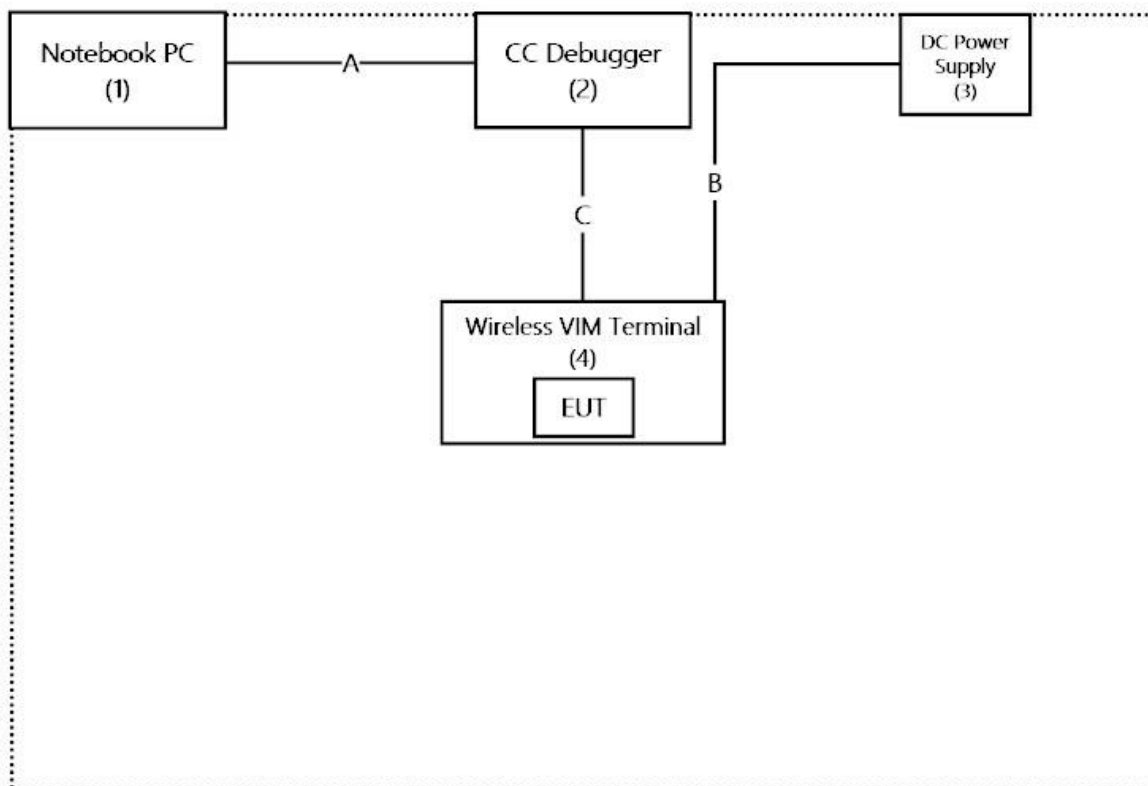
1.2. Tested System Details

The types for all equipment, plus descriptions of all cables used in the tested system (including inserted cards) are:

Product	Manufacturer	Model No.	Serial No.	Power Cord
1 Notebook PC	Lenovo	TP00067C	PF-0JR9MP	Non-Shielded, 1.8m
2 CC Debugger	Texas Instruments	N/A	N/A	N/A
3 DC Power Supply	Agilent	E3610A	MY40009845	Non-Shielded, 1.8m
4 Wireless VIM Terminal	TOYOTA TECHNICAL DEVELOPMENT CORPORATION	TM5317B	N/A	N/A

Signal Cable Type	Signal cable Description
A USB Cable	Non-Shielded, 2m
B Power Cable	Non-Shielded, 1.04m
C Control Cable	Non-Shielded, 0.19m

1.3. Configuration of Tested System



1.4. EUT Exercise Software

1. Setup the EUT as shown in Section 1.3.
2. Execute software “Flash_Programmer-1.12.8 ” on the EUT.
3. Configure the test mode, the test channel, and the data rate.
4. Press “OK” to start the continuous Transmit.
5. Verify that the EUT works properly.

1.5. Test Facility

Ambient conditions in the EMC laboratory:

Performed Item	Items	Required	Actual
Conducted Emission	Temperature (°C)	10~40 °C	19.1 °C
	Humidity (%RH)	10~90 %	56 %
Conductive	Temperature (°C)	10~40 °C	22 °C
	Humidity (%RH)	10~90 %	55 %

Ambient conditions in the Wenlin laboratory:

Performed Item	Items	Required	Actual
Radiated Emission	Temperature (°C)	10~40 °C	20.4 °C
	Humidity (%RH)	10~90 %	68.0 %

EMC laboratory:

USA : FCC Registration Number: TW3023

Canada : Company Number: 4075A

Site Description : Accredited by TAF
Accredited Number: 3023

Test Laboratory : DEKRA Testing and Certification Co., Ltd
Address : No.5-22, Ruishukeng, Linkou Dist., New Taipei City
24451, Taiwan, R.O.C.

Phone number : 886-2-2602-7968
Fax number : 866-2-2602-3286
Email address : info.tw@dekra.com
Website : <http://www.dekra.com.tw>

Wenlin laboratory:

USA : FCC Registration Number: TW0031

Canada : Company Number: 26443

Site Description : Accredited by TAF
Accredited Number: 3023

Test Laboratory : DEKRA Testing and Certification Co., Ltd
Address : No. 6, Lane 75, Wenlin St., Linkou Dist.,
New Taipei City 24457, Taiwan, R.O.C.

Phone number : 886-2-2602-7968
Fax number : 866-2-2602-3286

1.6. List of Test Equipment

For Conduction measurements /SR1 (EMC laboratory)

	Equipment	Manufacturer	Model No.	Serial No.	Cali. Data	Due. Data
X	EMI Test Receiver	R&S	ESR3	102041	2020.05.12	2021.05.11
X	LISN	Schwarzback	8226	8226/176	2020.05.29	2021.05.28
	LISN	Schwarzback	8226	8226/177	2020.05.29	2021.05/28
X	LISN	R&S	ESH3-Z5	836679/023	2020.04.07	2021.04.06

Note:

1. All equipments are calibrated every one year.
2. The test instruments marked with "X" are used to measure the final test results.
3. Test Software version : DEKRA Testing System V2.0

For Conducted measurements /CTR01 (EMC laboratory)

	Equipment	Manufacturer	Model No.	Serial No.	Cali. Data	Due. Data
X	Spectrum Analyzer	Agilent	N9010A	MY55150401	2020.09.15	2021.09.14
	Spectrum Analyzer	R&S	FSV30	103466	2020.12.28	2021.12.27
X	Power Meter	Anritsu	ML2496A	MY51000539	2020.05.13	2021.05.12
X	Power Sensor	Anritsu	MA2411B	MY59240002	2020.05.22	2021.05.21
X	Power Sensor	Anritsu	MA2411B	MY59240003	2020.05.22	2021.05.21

Note:

1. All equipments are calibrated every one year.
2. The test instruments marked with "X" are used to measure the final test results.
3. Test Software version : DEKRA Conduction Test System V9.0.5

For Radiated measurements /AC3 (Wenlin laboratory)

	Equipment	Manufacturer	Model No.	Serial No.	Cali. Data	Due. Data
X	Loop Antenna	AMETEK	HLA6121	49611	2020.03.16	2021.03.15
X	Bi-Log Antenna	SCHWARZBECK	VULB9168	01125	2020.07.20	2021.07.19
X	Horn Antenna	ETS-Lindgren	3117	00227700	2020.09.21	2021.09.20
X	Horn Antenna	Com-Power	AH-840	101087	2020.06.08	2021.06.07
X	Pre-Amplifier	EMCI	EMC330	060736	2020.06.04	2021.06.03
X	Pre-Amplifier	EMCI	PRAMP118	20200701	2020.06.10	2021.06.09
X	Pre-Amplifier	EMCI	PRAMP0510	20200703	2020.09.18	2021.09.17
X	Pre-Amplifier	EMCI	EMC184045SE	980314	2020.06.10	2021.06.09
X	Filter	MICRO TRONICS	BRM50702	G251	2020.09.17	2021.09.16
	Filter	MICRO TRONICS	BRM50716	G188	2020.09.17	2021.09.16
X	EMI Test Receiver	R&S	ESR7	101602	2019.12.16	2020.12.15
X	Spectrum Analyzer	R&S	FSV40	101148	2020.03.16	2021.03.15
X	Coaxial Cable	SUHNER	SUCOFLEX 106	RF002	2020.07.03	2021.07.02
X	Mircoflex Cable	HUBER SUHNER	SUCOFLEX 102	MY3381/2	2020.06.10	2021.06.09

Note:

1. Loop Antenna is calibrated every two years, the other equipments are calibrated every one year.
2. The test instruments marked with "X" are used to measure the final test results.
3. Test Software version : DEKRA Testing System V2.0

1.7. Uncertainty

Uncertainties have been calculated according to the DEKRA internal document, and is described in each test chapter of this report.

The reported expanded uncertainties are based on a standard uncertainty multiplied by a coverage factor of $k=2$, providing a level of confidence of approximately 95%.

Measurement uncertainties evaluated for each testing system and associated connections are given here to provide the system information for reference. Compliance determinations do not take into account measurement uncertainties for each testing system, but are based on the results of the compliance measurement.

EMC laboratory:

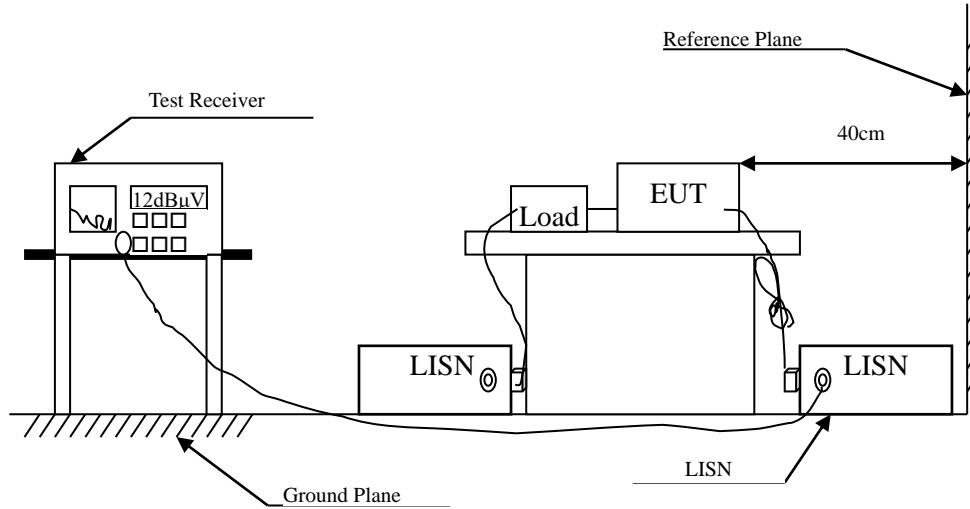
Test item	Uncertainty
Conducted Emission	± 3.42 dB
Peak Power Output	± 0.91 dB
RF Antenna Conducted Test	± 2.53 dB
Occupied Bandwidth	± 682.83 Hz
Power Density	± 2.53 dB
Duty Cycle	± 2.31 ms

Wenlin laboratory:

Test item	Uncertainty	
Radiated Emission	Under 1GHz ± 4.17 dB	Above 1GHz ± 4.22 dB
	Under 1GHz ± 4.17 dB	Above 1GHz ± 4.22 dB
Band Edge	Under 1GHz ± 4.17 dB	Above 1GHz ± 4.22 dB

2. Conducted Emission

2.1. Test Setup



2.2. Limits

FCC Part 15 Subpart C Paragraph 15.207 (dB μ V) Limit		
Frequency MHz	Limits	
	QP	AV
0.15 - 0.50	66-56	56-46
0.50-5.0	56	46
5.0 - 30	60	50

Remarks: In the above table, the tighter limit applies at the band edges.

2.3. Test Procedure

The EUT and Peripherals are connected to the main power through a line impedance stabilization network (L.I.S.N.). This provides a 50 ohm /50uH coupling impedance for the measuring equipment. The peripheral devices are also connected to the main power through a LISN that provides a 50ohm /50uH coupling impedance with 50ohm termination. (Please refer to the block diagram of the test setup and photographs.)

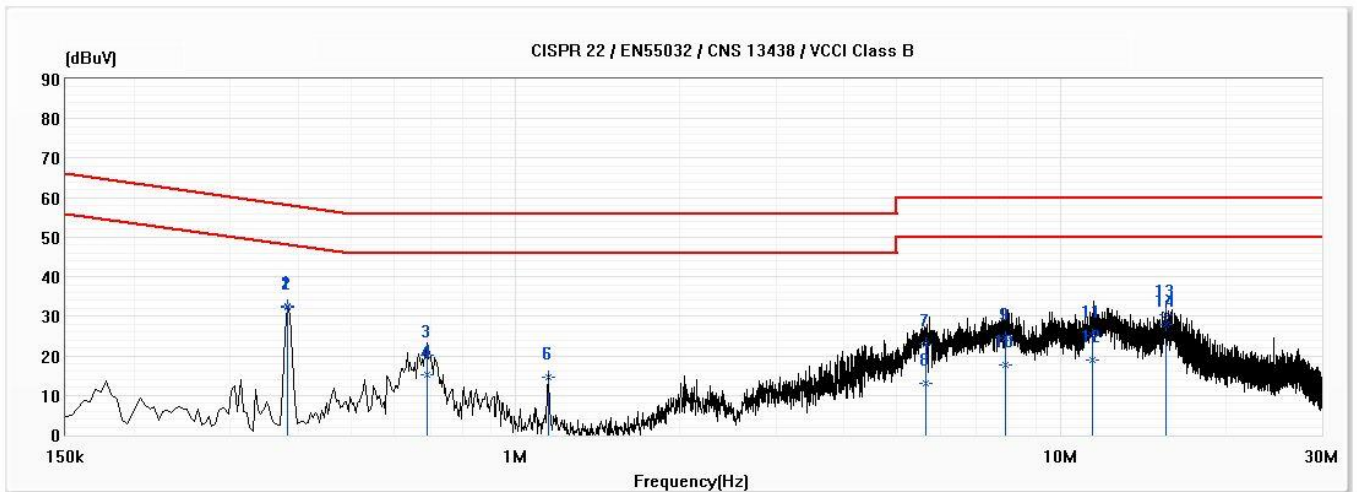
Both sides of A.C. line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all the interface cables must be changed according to ANSI C63.4: 2014 on conducted measurement.

Conducted emissions were investigated over the frequency range from 0.15MHz to 30MHz using a receiver bandwidth of 9kHz.

The EUT setup and the test procedure are according to ANSI C63.4, 2014 to comply with the requirements of FCC 47CFR Subpart C.

2.4. Test Result of Conducted Emission

Product : Realtime radio module
 Test Item : Conducted Emission Test
 Power Line : Line 1
 Test Mode : Mode 1: Transmit (2441MHz)
 Test Date : 2021/03/02

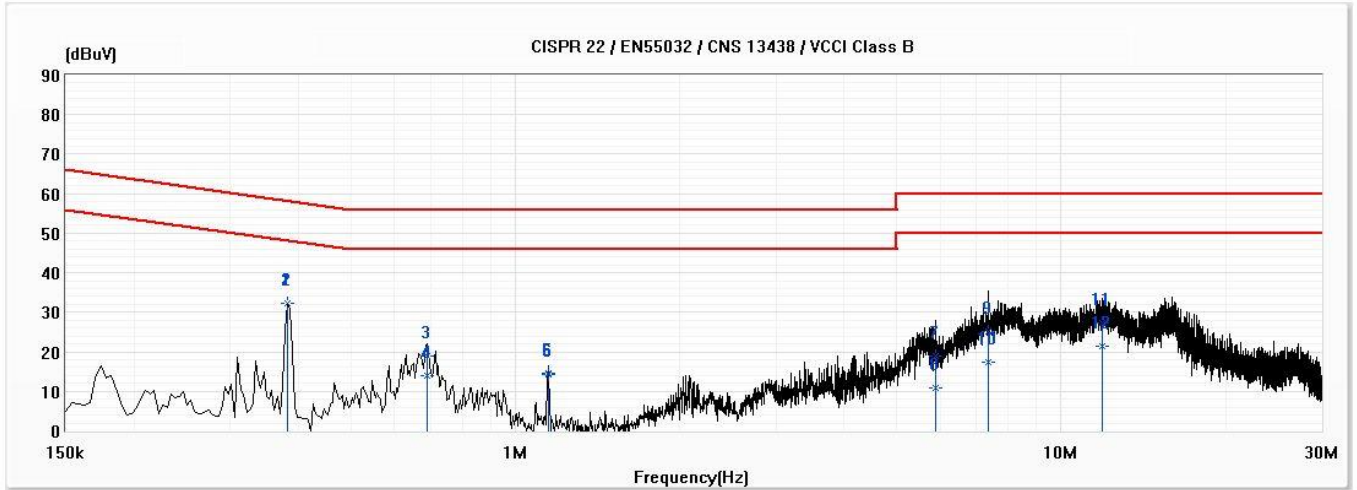


No	Frequency (MHz)	Emission Level (dBuV)	Limit (dBuV)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
1	0.383	32.54	58.21	-25.67	22.77	9.77	QP
*2	0.383	32.40	48.21	-15.81	22.63	9.77	AV
3	0.688	20.24	56.00	-35.76	10.45	9.79	QP
4	0.688	15.09	46.00	-30.91	5.31	9.79	AV
5	1.149	14.67	56.00	-41.33	4.86	9.81	QP
6	1.149	14.49	46.00	-31.51	4.67	9.81	AV
7	5.661	23.00	60.00	-37.00	13.07	9.93	QP
8	5.661	12.92	50.00	-37.08	2.99	9.93	AV
9	7.896	24.56	60.00	-35.44	14.56	10.00	QP
10	7.896	17.57	50.00	-32.43	7.57	10.00	AV
11	11.432	24.99	60.00	-35.01	14.89	10.09	QP
12	11.432	18.82	50.00	-31.18	8.72	10.09	AV
13	15.585	30.50	60.00	-29.50	20.33	10.18	QP
14	15.585	27.85	50.00	-22.15	17.68	10.18	AV

Note:

1. All Reading Levels are Quasi-Peak and average value.
2. “ * “ means the worst emission level.
3. Measurement Level = Reading Level + Correct Factor

Product : Realtime radio module
 Test Item : Conducted Emission Test
 Power Line : N
 Test Mode : Mode 1: Transmit (2441MHz)
 Test Date : 2021/03/02



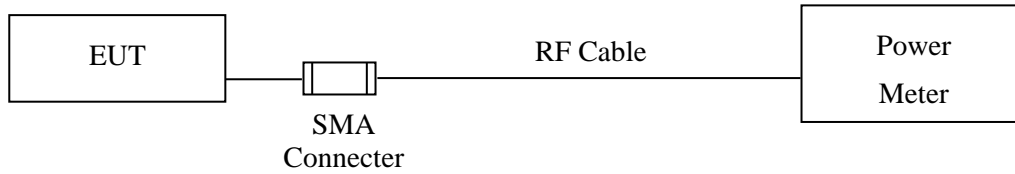
No	Frequency (MHz)	Emission Level (dBuV)	Limit (dBuV)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
1	0.383	32.35	58.22	-25.87	22.59	9.76	QP
*2	0.383	32.15	48.22	-16.07	22.39	9.76	AV
3	0.690	18.97	56.00	-37.03	9.19	9.78	QP
4	0.690	13.94	46.00	-32.06	4.16	9.78	AV
5	1.149	14.65	56.00	-41.35	4.84	9.81	QP
6	1.149	14.22	46.00	-31.78	4.41	9.81	AV
7	5.879	19.02	60.00	-40.98	9.07	9.95	QP
8	5.879	10.88	50.00	-39.12	0.93	9.95	AV
9	7.350	25.13	60.00	-34.87	15.13	10.00	QP
10	7.350	17.53	50.00	-32.47	7.53	10.00	AV
11	11.874	27.43	60.00	-32.57	17.28	10.16	QP
12	11.874	21.46	50.00	-28.54	11.31	10.16	AV

Note:

1. All Reading Levels are Quasi-Peak and average value.
2. “ * “ means the worst emission level.
3. Measurement Level = Reading Level + Correct Factor

3. Peak Power Output

3.1. Test Setup



3.2. Limit

The maximum peak power shall be less 1Watt.

3.3. Test Procedure

Tested according to FHSS test procedure of KDB 558074 section 9 (b for compliance to FCC 47CFR 15.247 requirements.

The EUT was tested according to C63.10:2013 for compliance to FCC 47CFR 15.247 requirements.

The maximum peak conducted output power using C63.10:2013 Section 11.9.1.3 PKPM1 Peak power meter method.

3.4. Test Result of Peak Power Output

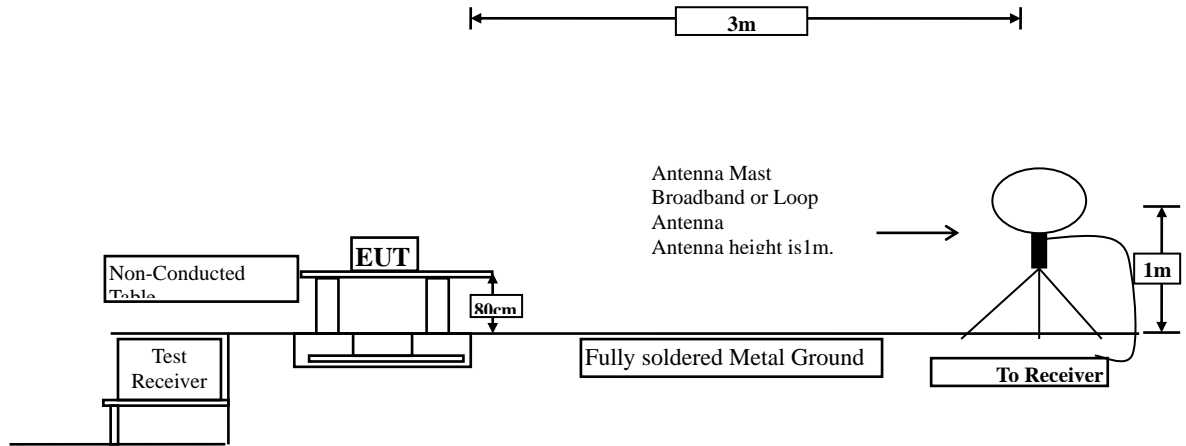
Product : Realtime radio module
Test Item : Peak Power Output
Test Mode : Mode 1: Transmit
Test Date : 2021/02/20

Channel No.	Frequency (MHz)	Measurement (dBm)	Required Limit	Result
Channel 01	2402	2.42	1 Watt= 30 dBm	Pass
Channel 40	2441	2.51	1 Watt= 30 dBm	Pass
Channel 79	2480	2.43	1 Watt= 30 dBm	Pass

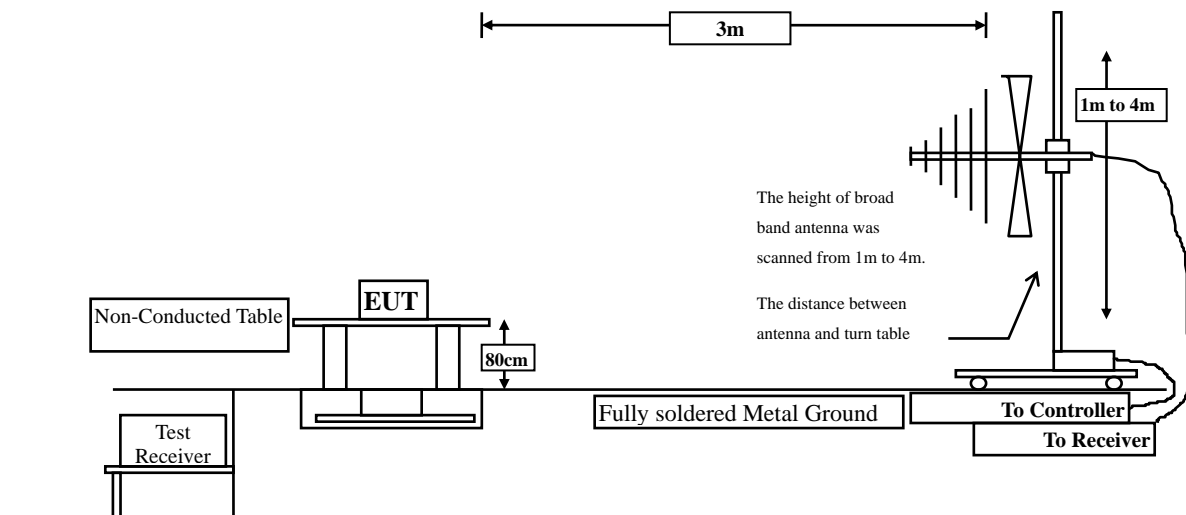
4. Radiated Emission

4.1. Test Setup

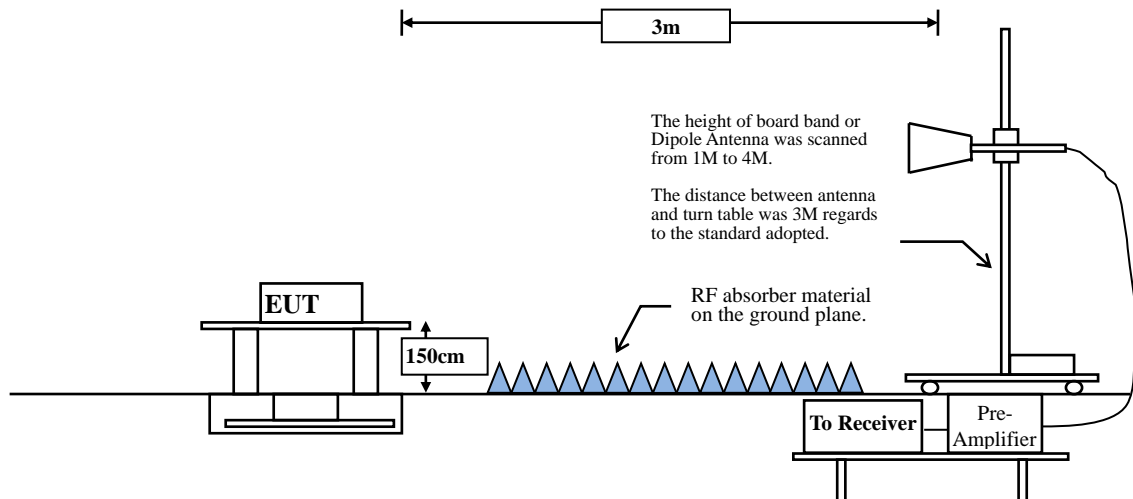
Radiated Emission Under 30MHz



Radiated Emission Below 1GHz



Radiated Emission Above 1GHz



4.2. Limits

➤ General Radiated Emission Limits

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 20dB below the level of the fundamental or to the general radiated emission limits in paragraph 15.209, whichever is the lesser attenuation.

FCC Part 15 Subpart C Paragraph 15.209 Limits		
Frequency MHz	Field strength (microvolts/meter)	Measurement distance (meter)
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

- Remarks:
1. RF Voltage (dBuV) = 20 log RF Voltage (uV)
 2. In the Above Table, the tighter limit applies at the band edges.
 3. Distance refers to the distance in meters between the measuring instrument antenna and the closed point of any part of the device or system.

4.3. Test Procedure

The EUT was setup according to ANSI C63.10, 2013 and tested compliance to FCC 47CFR 15.247 requirements.

Measuring the frequency range below 1GHz, the EUT is placed on a turn table which is 0.8 meter above ground, when measuring the frequency range above 1GHz, the EUT is placed on a turn table which is 1.5 meter above ground.

The turn table is rotated 360 degrees to determine the position of the maximum emission level.

The EUT was positioned such that the distance from antenna to the EUT was 3 meters.

The antenna is scanned between 1 meter and 4 meters to find out the maximum emission level. This is repeated for both horizontal and vertical polarization of the antenna. In order to find the maximum emission, all of the interface cables were manipulated according to ANSI C63.10: 2013 on radiated measurement.

The resolution bandwidth below 30MHz setting on the field strength meter is 9kHz and 30MHz~1GHz is 120kHz and above 1GHz is 1MHz.

Radiated emission measurements below 30MHz are made using Loop Antenna and 30MHz~1GHz are made using broadband Bilog antenna and above 1GHz are made using Horn Antennas.

The measurement is divided into the Preliminary Measurement and the Final Measurement.

The suspected frequencies are searched for in Preliminary Measurement with the measurement antenna kept pointed at the source of the emission both in azimuth and elevation, with the polarization of the antenna oriented for maximum response. The antenna is pointed at an angle towards the source of the emission, and the EUT is rotated in both height and polarization to maximize the measured emission. The emission is kept within the illumination area of the 3 dB bandwidth of the antenna.

The measurement frequency range from 9kHz - 10th Harmonic of fundamental was investigated.

RBW and VBW Parameter setting:

According to C63.10 Section 11.12.2.4 Peak measurement procedure.

RBW = as specified in Table 1.

$VBW \geq 3 \times RBW$.

Table 1 —RBW as a function of frequency

Frequency	RBW
9-150 kHz	200-300 Hz
0.15-30 MHz	9-10 kHz
30-1000 MHz	100-120 kHz
> 1000 MHz	1 MHz

According to C63.10 Section 11.12.2.5 Average measurement procedure.

RBW = 1MHz.

VBW = 10Hz, when duty cycle $\geq 98\%$

$VBW \geq 1/T$, when duty cycle $< 98\%$

(T refers to the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.)

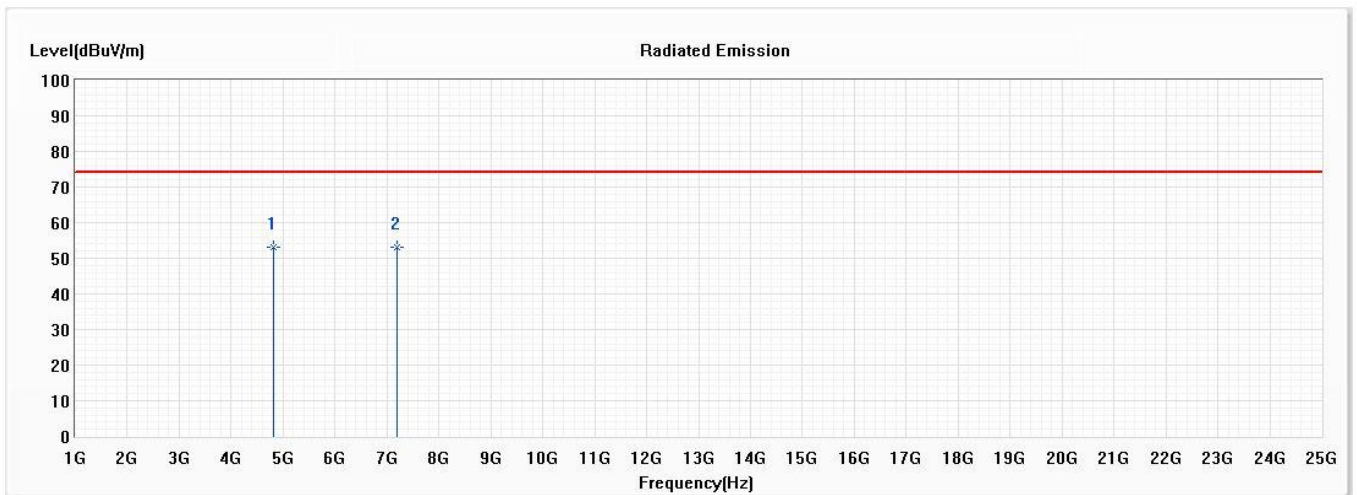
2.4GHz band	Duty Cycle (%)	T (ms)	1/T (Hz)	VBW (Hz)
GFSK	62.32	0.225	4444	5k

Note: Duty Cycle Refer to Section 9.

4.4. Test Result of Radiated Emission

Product : Realtime radio module
 Test Item : Harmonic Radiated Emission
 Test Mode : Mode 1: Transmit (2402MHz)
 Test Date : 2021/02/24

Horizontal



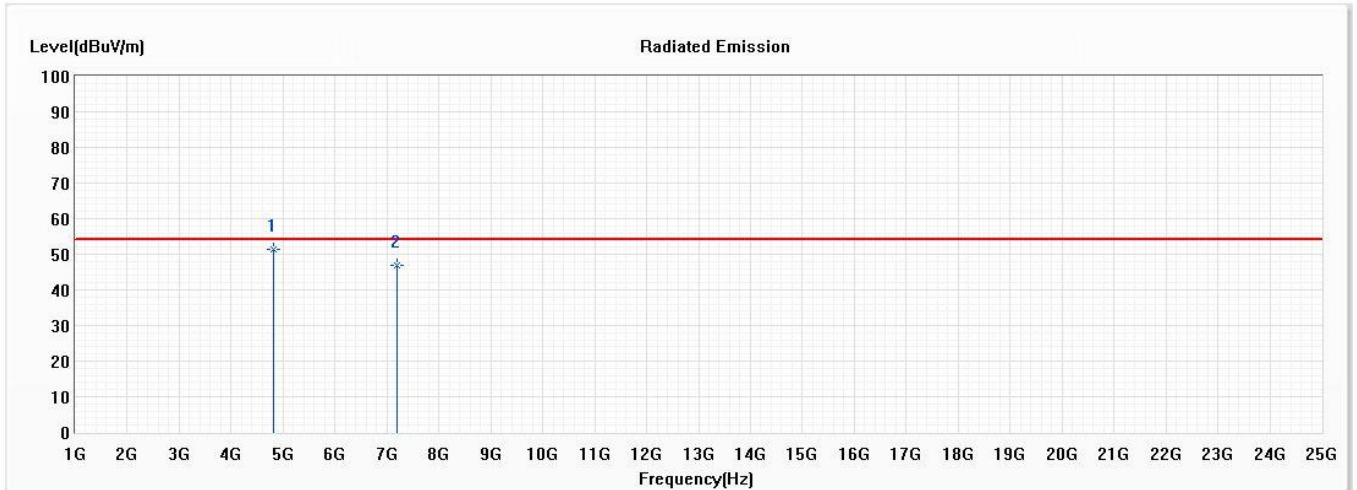
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
* 1	4805.500	53.18	74.00	-20.82	64.04	-10.86	PK
2	7204.000	53.08	74.00	-20.92	58.66	-5.58	PK

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The average measurement was not performed when the peak measured data under the limit of average detection.
5. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product : Realtime radio module
 Test Item : Harmonic Radiated Emission
 Test Mode : Mode 1: Transmit (2402MHz)
 Test Date : 2021/02/24

Horizontal



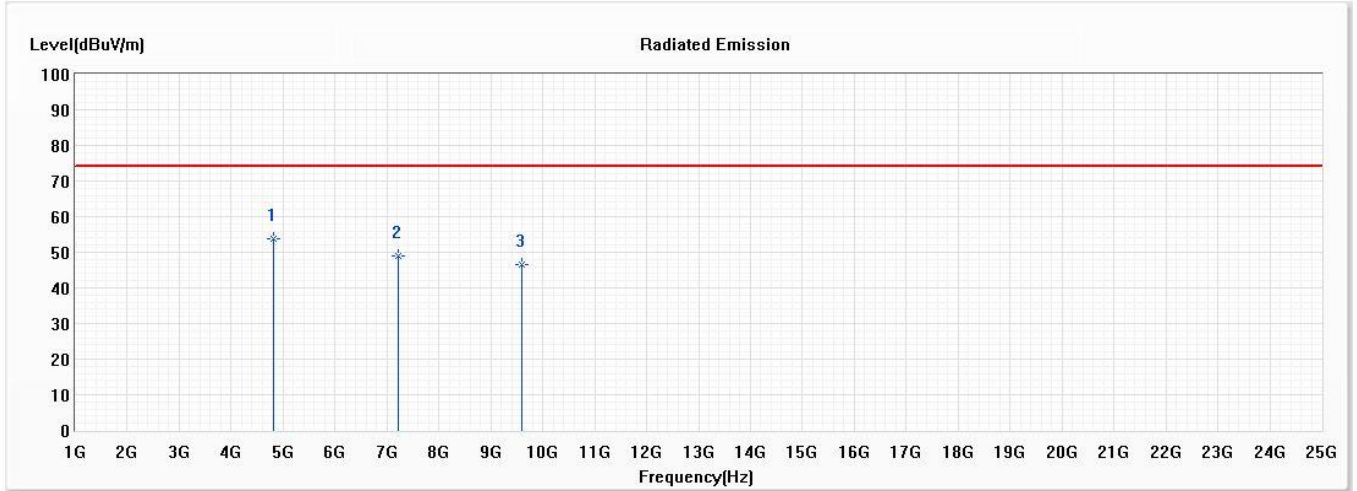
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
* 1	4805.500	51.51	54.00	-2.49	62.37	-10.86	AV
2	7206.000	46.79	54.00	-7.21	52.36	-5.57	AV

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The average measurement was not performed when the peak measured data under the limit of average detection.
5. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product : Realtime radio module
 Test Item : Harmonic Radiated Emission
 Test Mode : Mode 1: Transmit (2402MHz)
 Test Date : 2021/02/24

Vertical



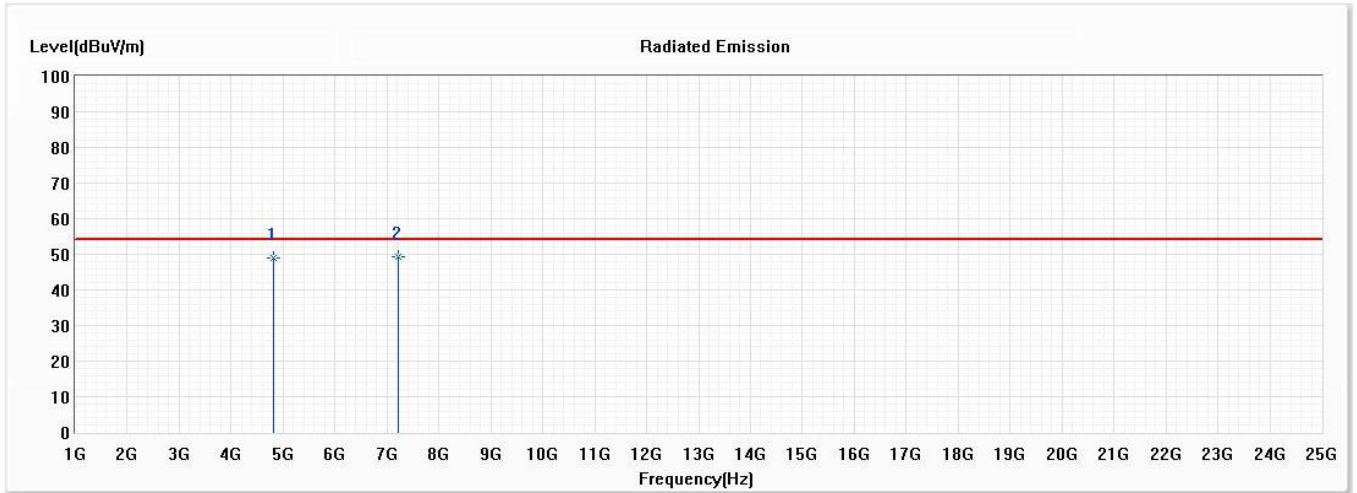
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
* 1	4805.650	53.95	74.00	-20.05	64.81	-10.86	PK
2	7206.800	49.12	74.00	-24.88	54.69	-5.57	PK
3	9608.000	46.54	74.00	-27.46	49.88	-3.34	PK

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The average measurement was not performed when the peak measured data under the limit of average detection.
5. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product : Realtime radio module
 Test Item : Harmonic Radiated Emission
 Test Mode : Mode 1: Transmit (2402MHz)
 Test Date : 2021/02/24

Vertical



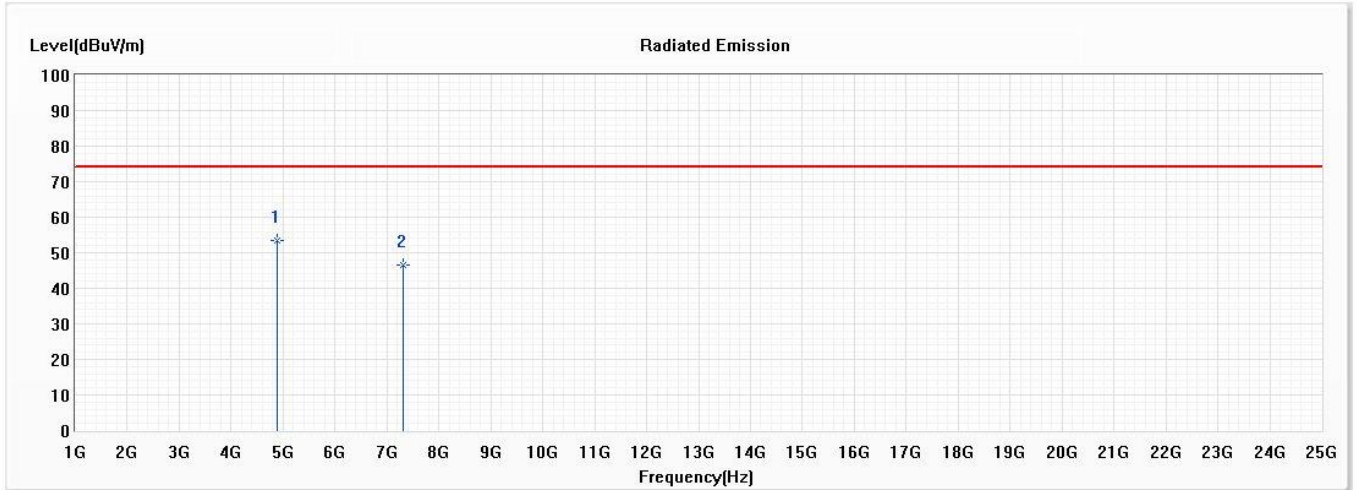
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
1	4805.650	49.12	54.00	-4.88	59.98	-10.86	AV
* 2	7206.800	49.20	54.00	-4.80	54.77	-5.57	AV

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The average measurement was not performed when the peak measured data under the limit of average detection.
5. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product : Realtime radio module
 Test Item : Harmonic Radiated Emission
 Test Mode : Mode 1: Transmit (2441MHz)
 Test Date : 2021/02/24

Horizontal



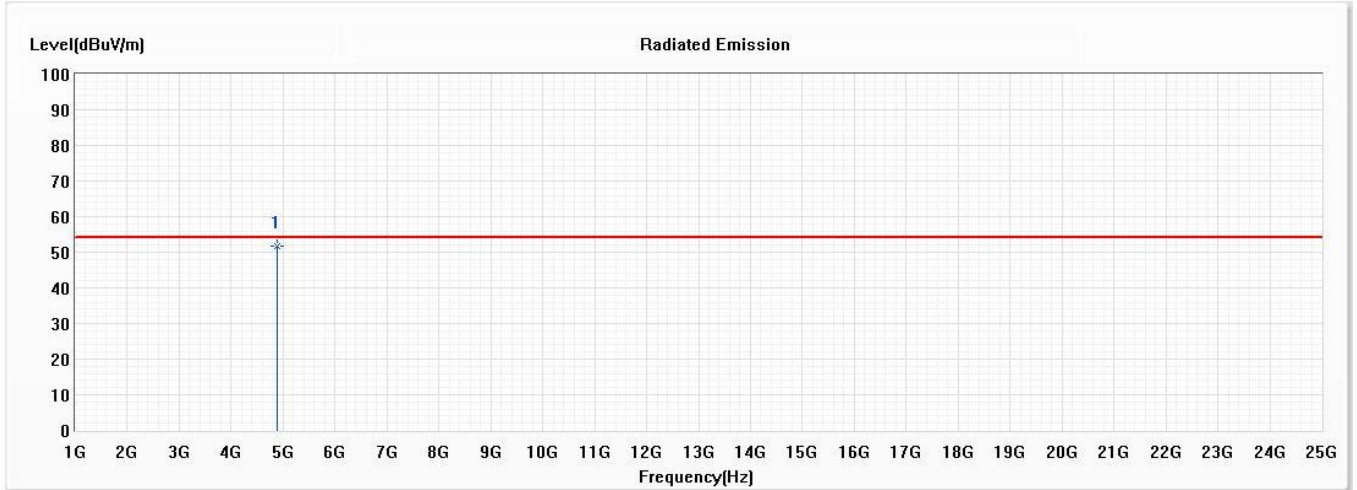
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
* 1	4879.620	53.57	74.00	-20.43	64.16	-10.59	PK
2	7321.000	46.56	74.00	-27.44	52.19	-5.63	PK

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The average measurement was not performed when the peak measured data under the limit of average detection.
5. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product : Realtime radio module
 Test Item : Harmonic Radiated Emission
 Test Mode : Mode 1: Transmit (2441MHz)
 Test Date : 2021/02/24

Horizontal



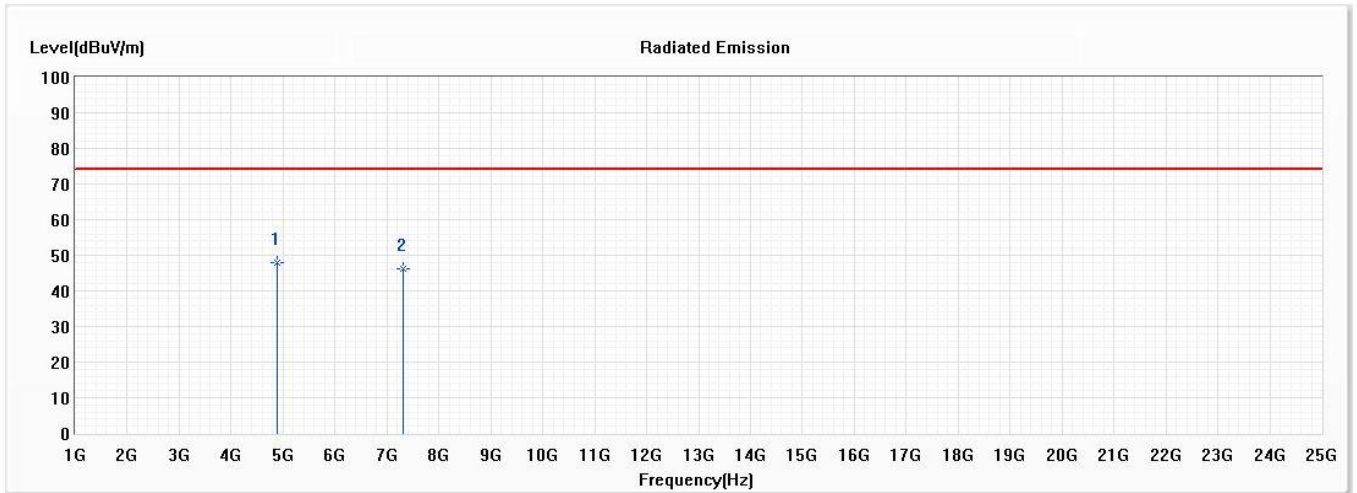
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
* 1	4879.620	51.75	54.00	-2.25	62.34	-10.59	AV

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The average measurement was not performed when the peak measured data under the limit of average detection.
5. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product : Realtime radio module
 Test Item : Harmonic Radiated Emission
 Test Mode : Mode 1: Transmit (2441MHz)
 Test Date : 2021/02/24

Vertical



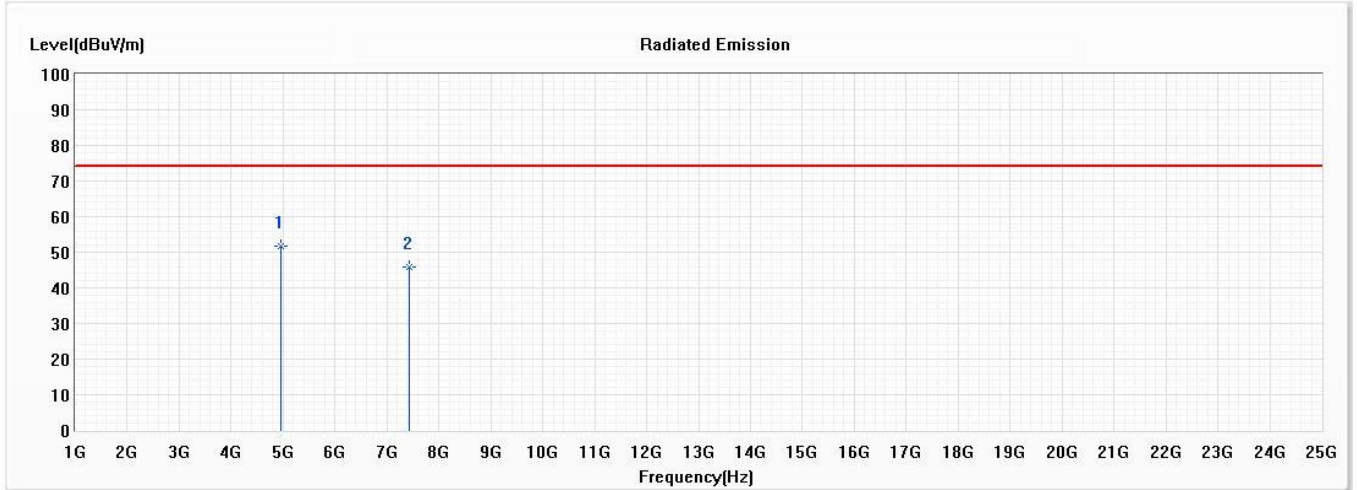
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
* 1	4879.000	48.07	74.00	-25.93	58.66	-10.59	PK
2	7320.900	46.25	74.00	-27.75	51.88	-5.63	PK

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The average measurement was not performed when the peak measured data under the limit of average detection.
5. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product : Realtime radio module
 Test Item : Harmonic Radiated Emission
 Test Mode : Mode 1: Transmit (2441MHz)
 Test Date : 2021/02/24

Vertical



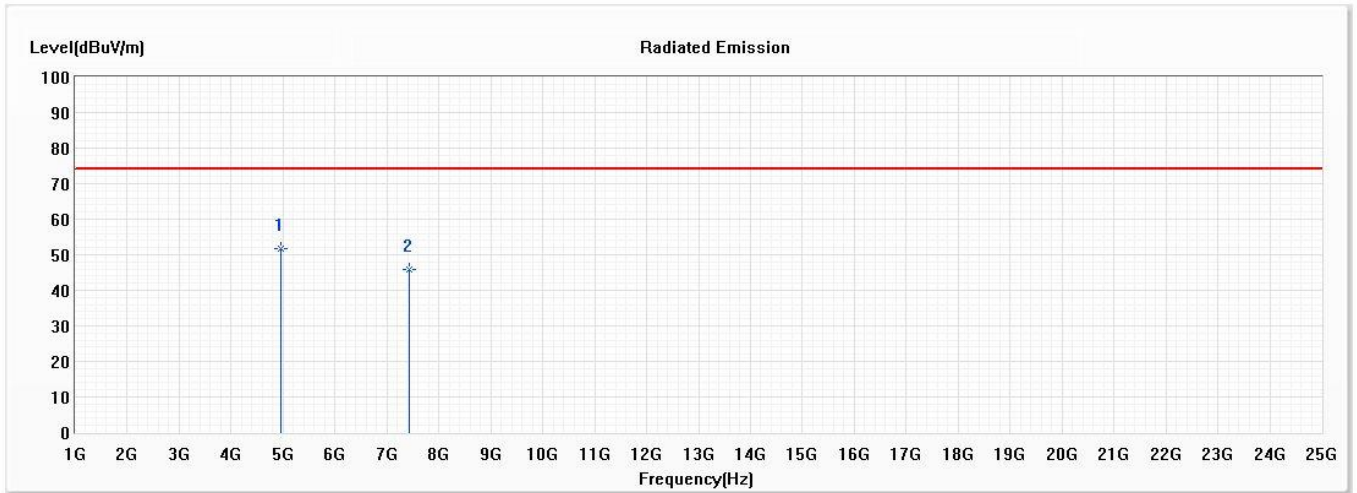
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
* 1	4957.500	51.81	74.00	-22.19	62.24	-10.43	PK
2	7438.300	45.95	74.00	-28.05	51.45	-5.50	PK

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The average measurement was not performed when the peak measured data under the limit of average detection.
5. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product : Realtime radio module
 Test Item : Harmonic Radiated Emission
 Test Mode : Mode 1: Transmit (2480MHz)
 Test Date : 2021/02/24

Horizontal



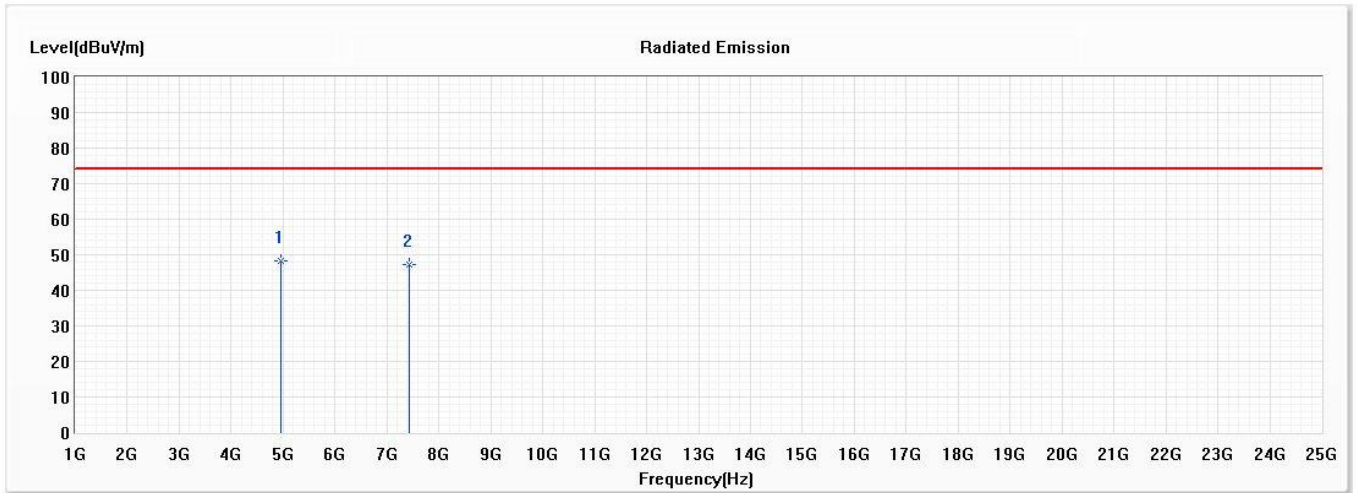
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
* 1	4957.500	51.81	74.00	-22.19	62.24	-10.43	PK
2	7438.300	45.95	74.00	-28.05	51.45	-5.50	PK

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The average measurement was not performed when the peak measured data under the limit of average detection.
5. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product : Realtime radio module
 Test Item : Harmonic Radiated Emission
 Test Mode : Mode 1: Transmit (2480MHz)
 Test Date : 2021/02/24

Vertical



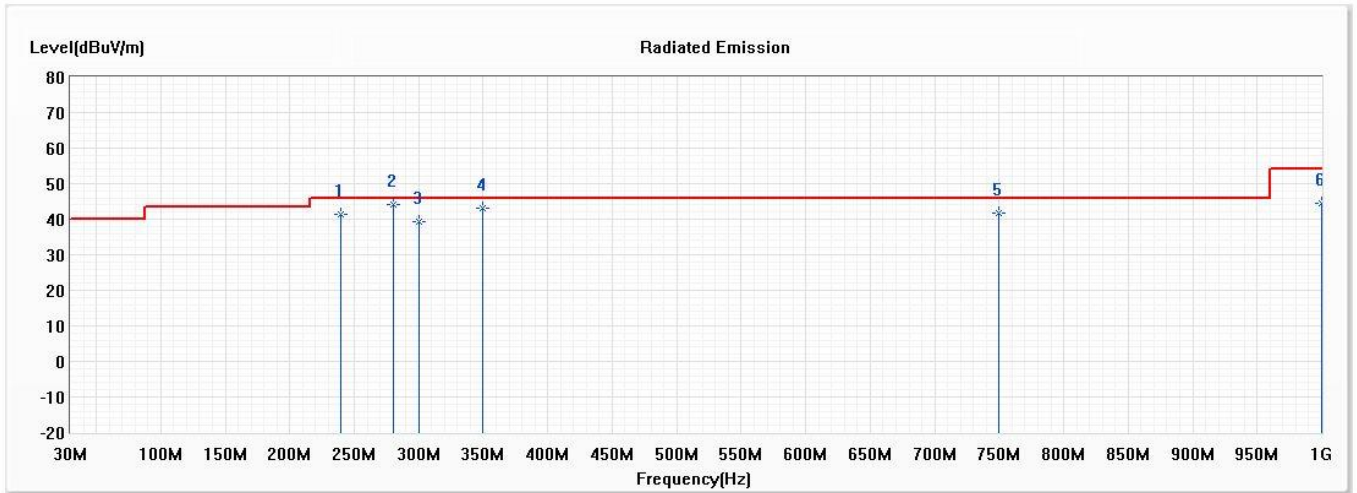
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
* 1	4957.700	48.29	74.00	-25.71	58.72	-10.43	PK
2	7438.200	47.07	74.00	-26.93	52.57	-5.50	PK

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The average measurement was not performed when the peak measured data under the limit of average detection.
5. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product : Realtime radio module
 Test Item : General Radiated Emission
 Test Mode : Mode 1: Transmit (2441MHz)
 Test Date : 2021/02/25

Horizontal



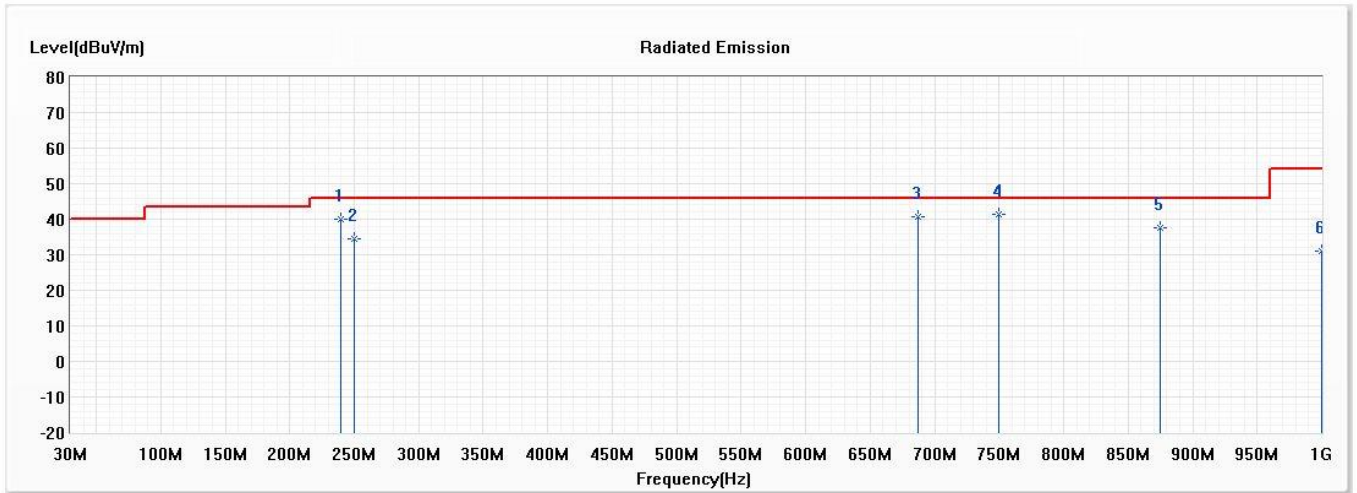
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
1	240.000	41.30	46.00	-4.70	61.30	-20.00	QP
* 2	280.000	44.20	46.00	-1.80	62.74	-18.54	QP
3	300.000	39.40	46.00	-6.60	57.46	-18.06	QP
4	350.000	43.10	46.00	-2.90	59.90	-16.80	QP
5	750.040	41.80	46.00	-4.20	45.49	-3.69	QP
6	999.900	44.50	54.00	-9.50	49.93	-5.43	QP

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The emission levels of other frequencies are very lower than the limit and not show in test report.
5. No emission found between lowest internal used/generated frequency to 30MHz.

Product : Realtime radio module
 Test Item : General Radiated Emission
 Test Mode : Mode 1: Transmit (2441MHz)
 Test Date : 2021/02/25

Vertical



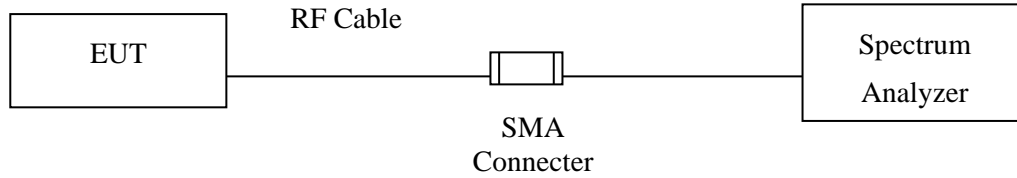
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
1	240.000	40.10	46.00	-5.90	60.10	-20.00	QP
2	250.000	34.50	46.00	-11.50	54.26	-19.76	QP
3	687.520	40.65	46.00	-5.35	50.40	-9.75	QP
* 4	750.050	41.22	46.00	-4.78	44.91	-3.69	QP
5	875.040	37.55	46.00	-8.45	42.19	-4.64	QP
6	999.900	31.10	54.00	-22.90	36.53	-5.43	QP

Note:

1. All Readings below 1GHz are Quasi-Peak, above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. Correct Factor = Antenna factor + Cable loss – Amplifier gain.
4. The emission levels of other frequencies are very lower than the limit and not show in test report.
5. No emission found between lowest internal used/generated frequency to 30MHz.

5. RF Antenna Conducted Test

5.1. Test Setup



5.2. Limits

According to FCC Section 15.247(d). In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

5.3. Test Procedure

Tested according to FHSS test procedure of KDB558074 section 9 b) for compliance to FCC 47CFR 15.247 requirements.

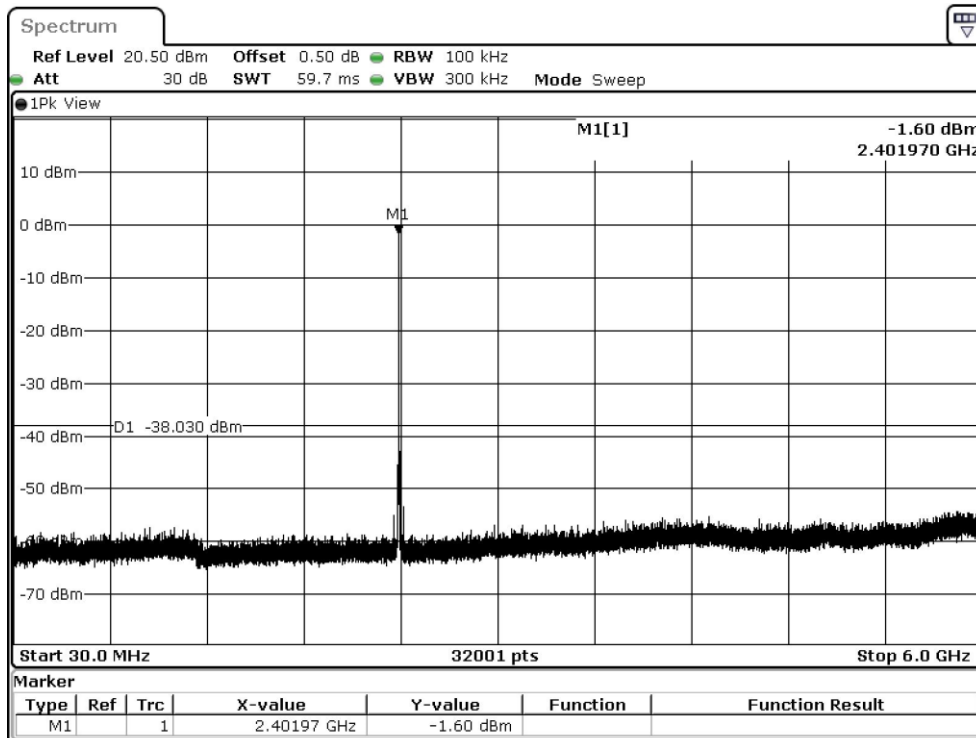
The EUT was tested according to C63.10:2013 Section 11.11 for compliance to FCC 47CFR 15.247 requirements.

Set RBW = 100 kHz, Set VBW > RBW, scan up through 10th harmonic.

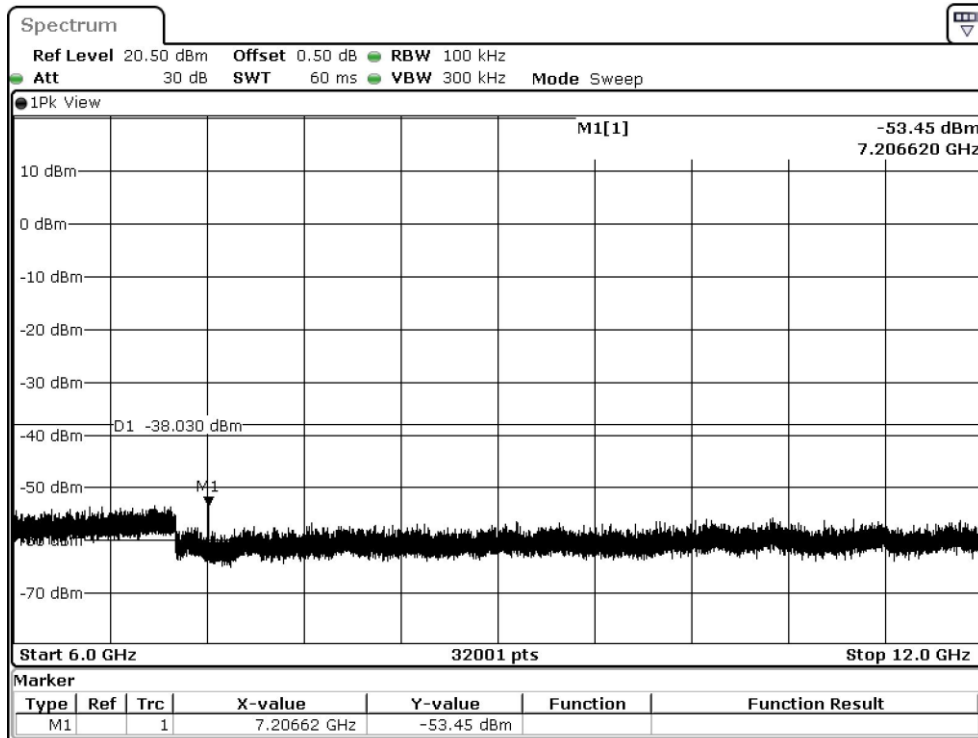
5.4. Test Result of RF Antenna Conducted Test

Product : Realtime radio module
 Test Item : RF Antenna Conducted Test
 Test Mode : Mode 1: Transmit
 Test Date : 2021/02/20

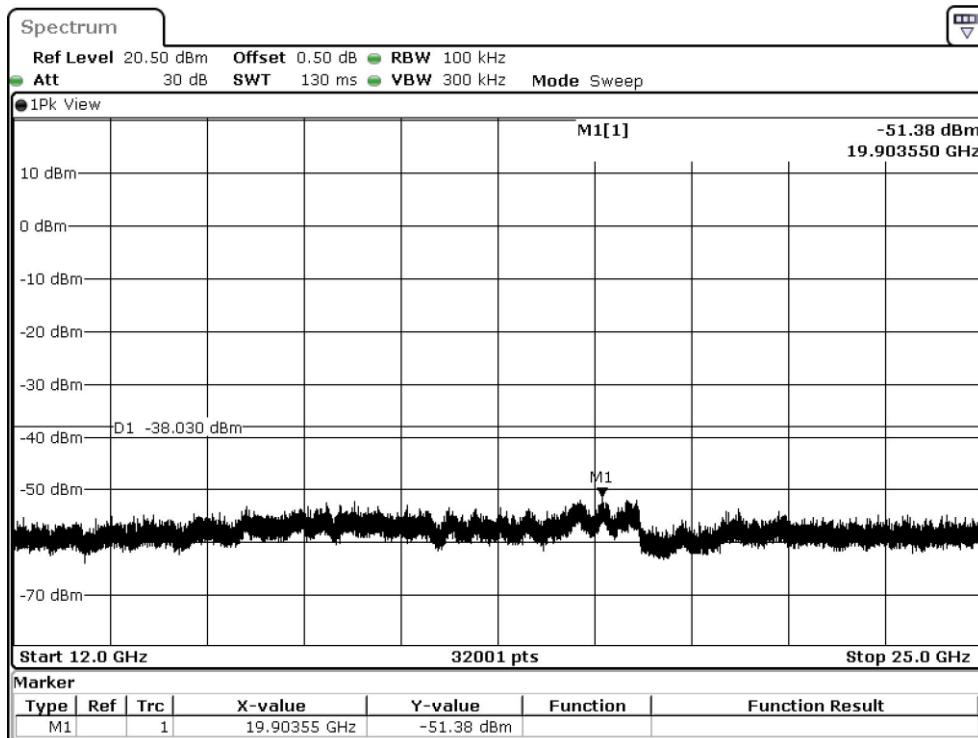
Figure Channel 01:



Date: 1.MAR.2021 21:36:47

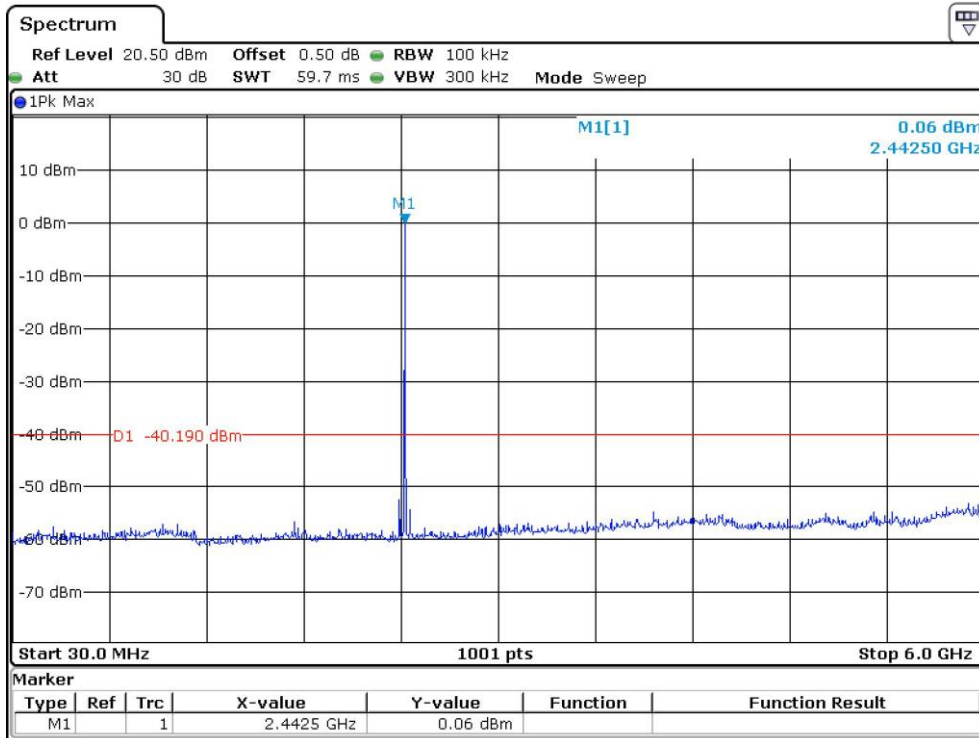


Date: 1.MAR.2021 21:37:10

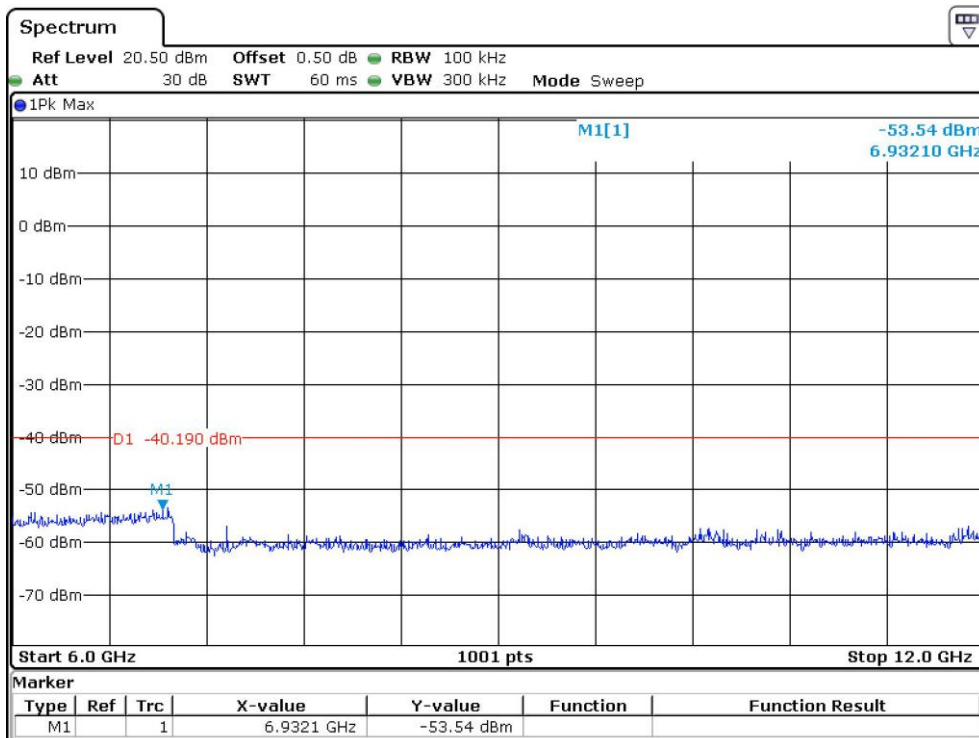


Date: 1.MAR.2021 21:37:33

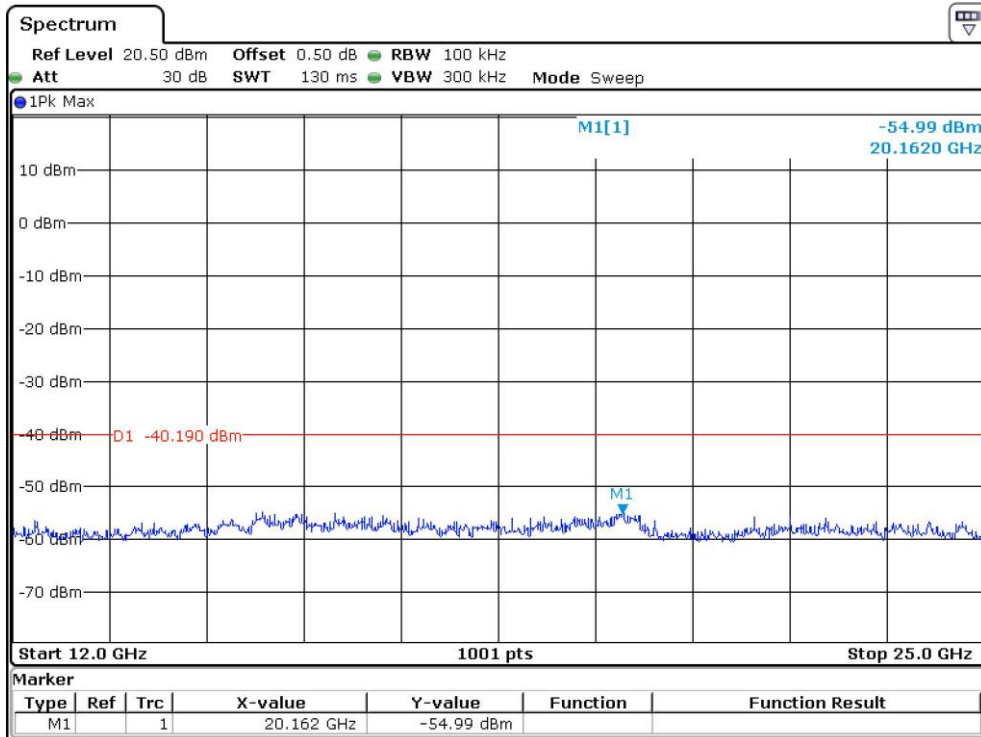
Figure Channel 40:



Date: 5.MAR.2021 18:44:57

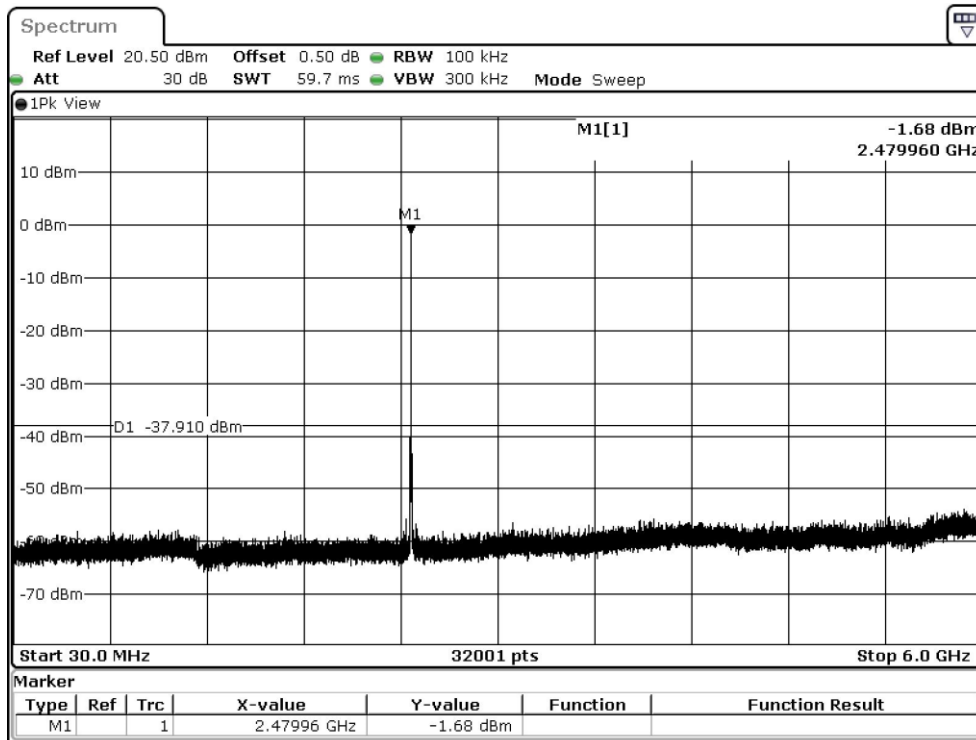


Date: 5.MAR.2021 18:45:39

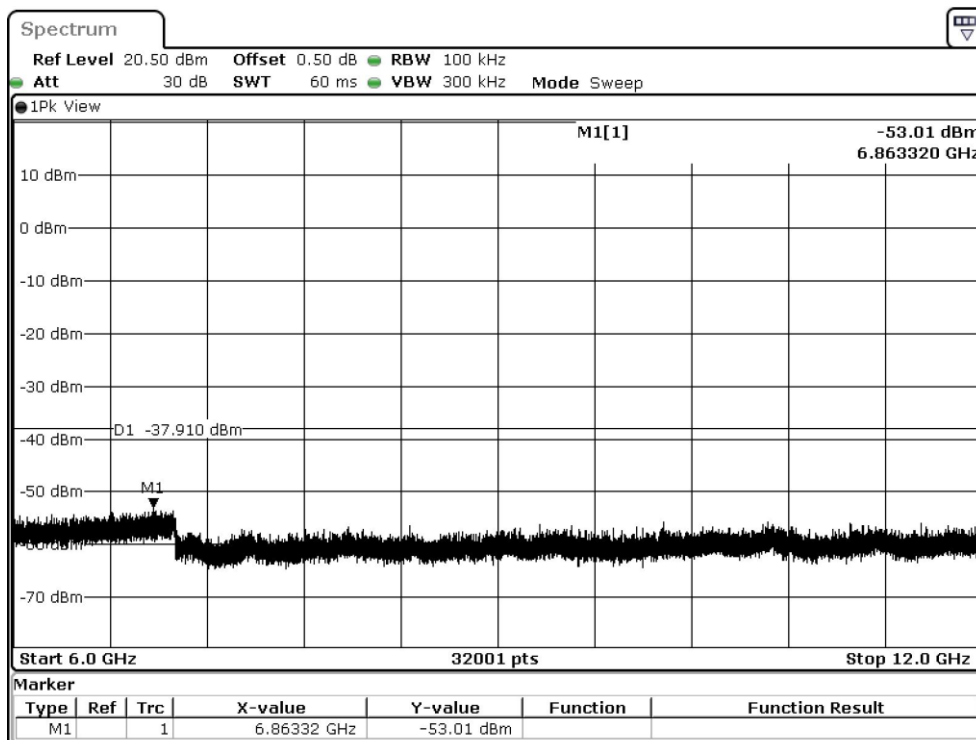


Date: 5.MAR.2021 18:46:06

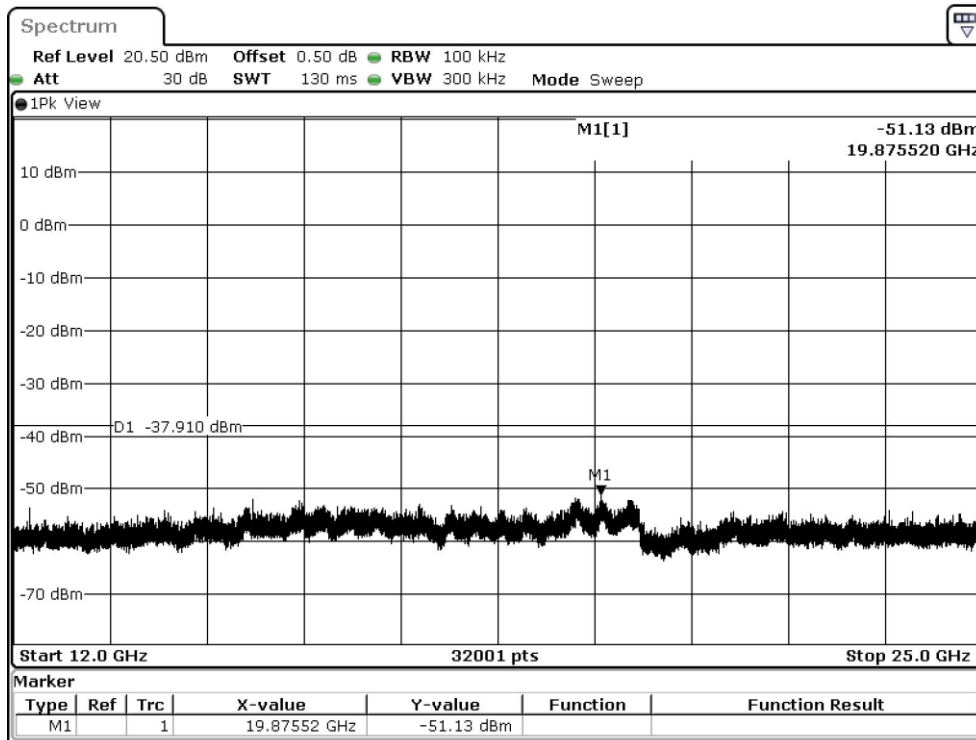
Figure Channel 79:



Date: 1.MAR.2021 21:40:04



Date: 1.MAR.2021 21:40:28



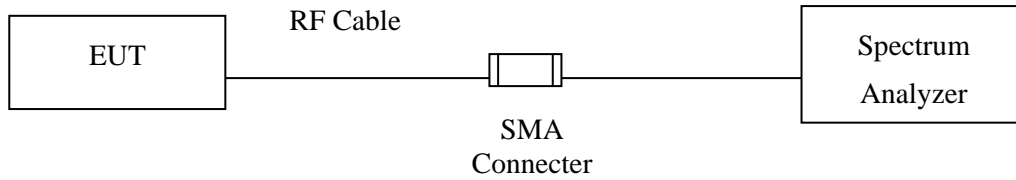
Date: 1.MAR.2021 21:40:51

Note: The above test pattern is synthesized by multiple of the frequency range.

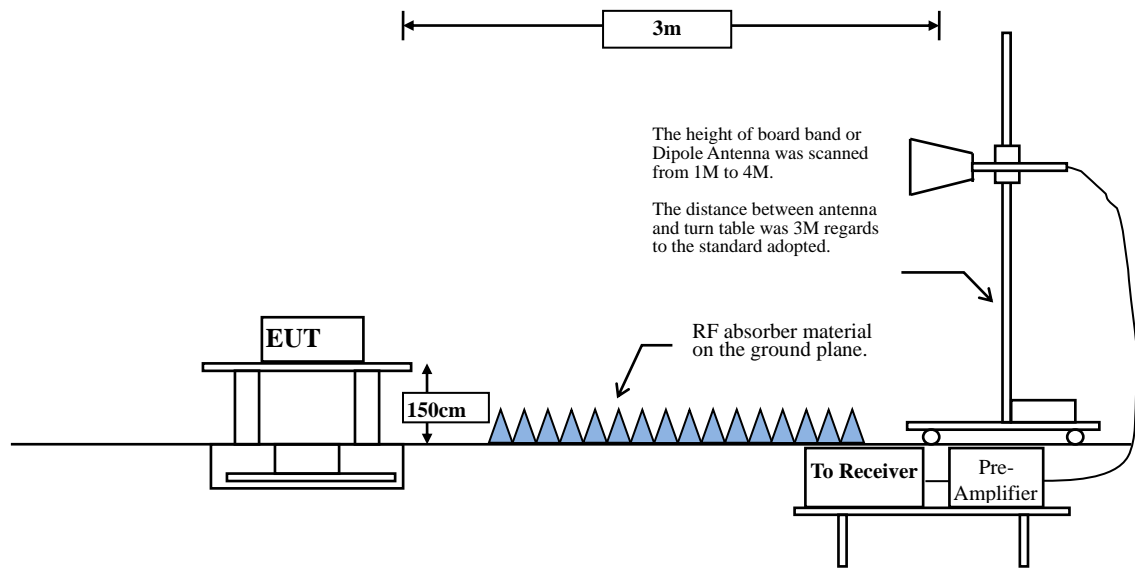
6. Band Edge

6.1. Test Setup

RF Conducted Measurement



RF Radiated Measurement:



6.2. Limit

According to FCC Section 15.247(d). In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

6.3. Test Procedure

The EUT is placed on a turn table which is 1.5 meter above ground. The turn table is rotated 360 degrees to determine the position of the maximum emission level. The EUT was positioned such that the distance from antenna to the EUT was 3 meters.

The antenna can move up and down between 1 meter and 4 meters to find out the maximum emission level.

Both horizontal and vertical polarization of the antenna are set on measurement. In order to find the maximum emission, all of the interface cables must be manipulated according to ANSI C63.10: 2013 on radiated measurement.

The bandwidth setting below 1GHz and above 1GHz on the field strength meter is 120 kHz and 1MHz, respectively.

RBW and VBW Parameter setting:

According to C63.10 Section 11.12.2.4 Peak measurement procedure.

RBW = as specified in Table 1.

$VBW \geq 3 \times RBW$.

Table 1 —RBW as a function of frequency

Frequency	RBW
9-150 kHz	200-300 Hz
0.15-30 MHz	9-10 kHz
30-1000 MHz	100-120 kHz
> 1000 MHz	1 MHz

According to C63.10 Section 11.12.2.5 Average measurement procedure.

RBW = 1MHz.

VBW = 10Hz, when duty cycle $\geq 98\%$

$VBW \geq 1/T$, when duty cycle $< 98\%$

(T refers to the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.)

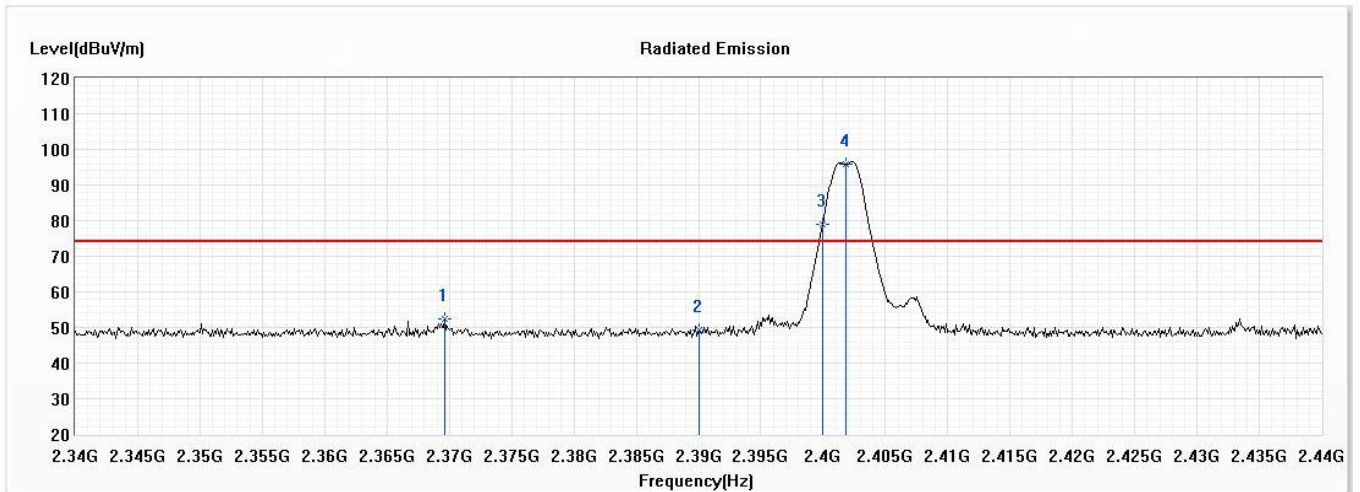
2.4GHz band	Duty Cycle (%)	T (ms)	1/T (Hz)	VBW (Hz)
GFSK	62.32	0.225	4444	5k

Note: Duty Cycle Refer to Section 9.

6.4. Test Result of Band Edge

Product : Realtime radio module
 Test Item : Band Edge
 Test Mode : Mode 1: Transmit (2402MHz)
 Test Date : 2021/02/25

Horizontal



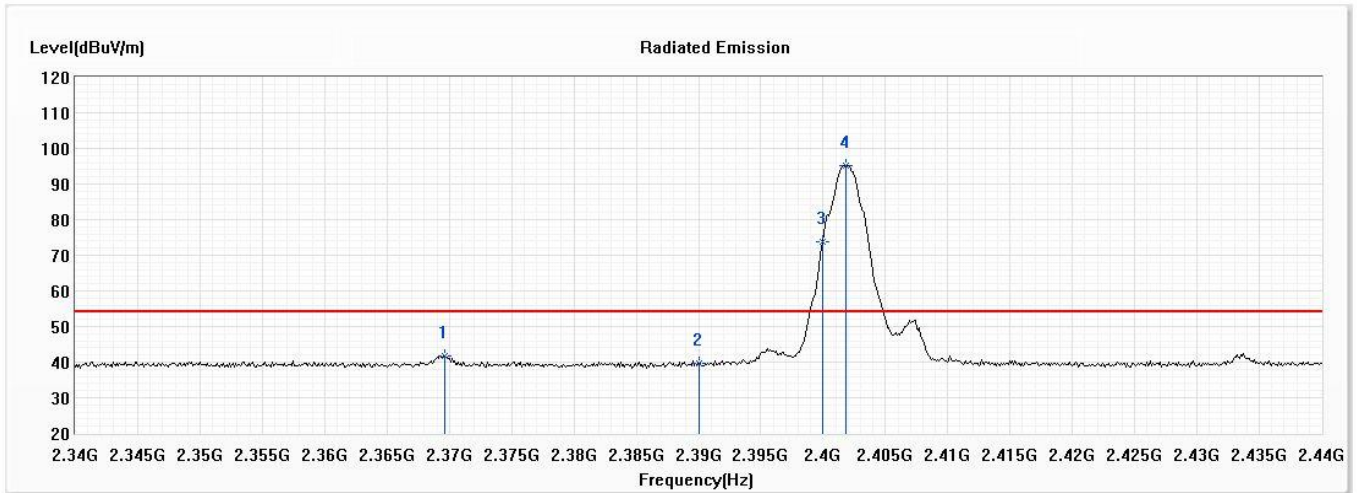
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
1	2369.600	52.28	74.00	-21.72	39.06	13.22	PK
2	2390.000	49.37	74.00	-24.63	36.22	13.15	PK
! 3	2400.000	78.94	--	--	65.82	13.12	PK
! 4	2401.800	96.00	--	--	82.87	13.13	PK

Note:

1. All readings above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. The average measurement was not performed when the peak measured data under the limit of average detection.

Product : Realtime radio module
 Test Item : Band Edge
 Test Mode : Mode 1: Transmit (2402MHz)
 Test Date : 2021/02/25

Horizontal



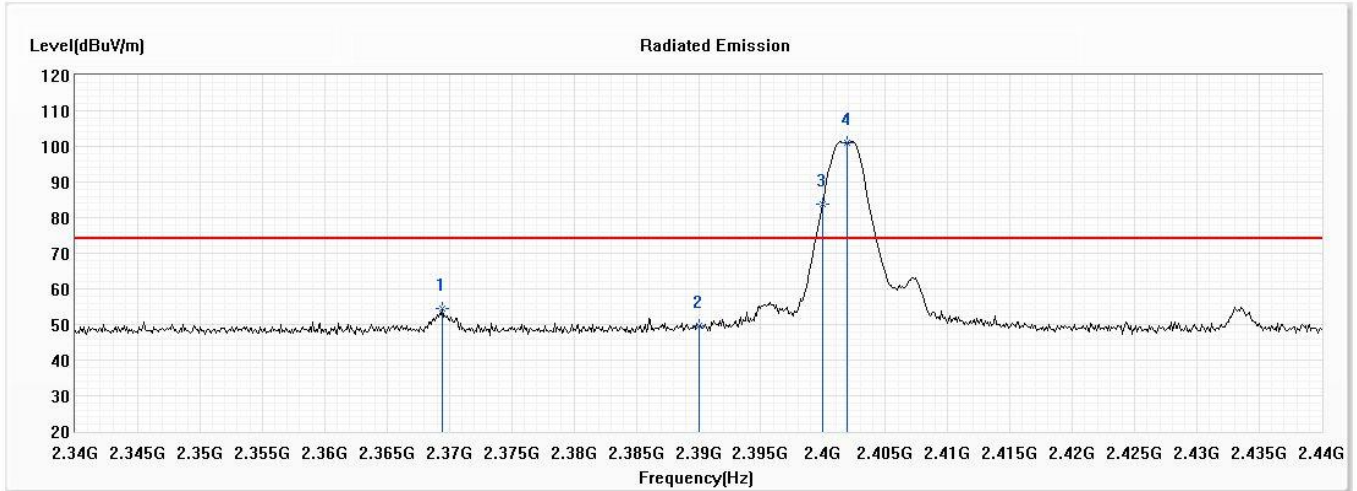
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
1	2369.600	41.86	54.00	-12.14	28.64	13.22	AV
2	2390.000	39.53	54.00	-14.47	26.38	13.15	AV
! 3	2400.000	73.72	--	--	60.60	13.12	AV
! 4	2401.800	95.27	--	--	82.14	13.13	AV

Note:

1. All readings above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. The average measurement was not performed when the peak measured data under the limit of average detection.

Product : Realtime radio module
 Test Item : Band Edge
 Test Mode : Mode 1: Transmit (2402MHz)
 Test Date : 2021/02/25

Vertical



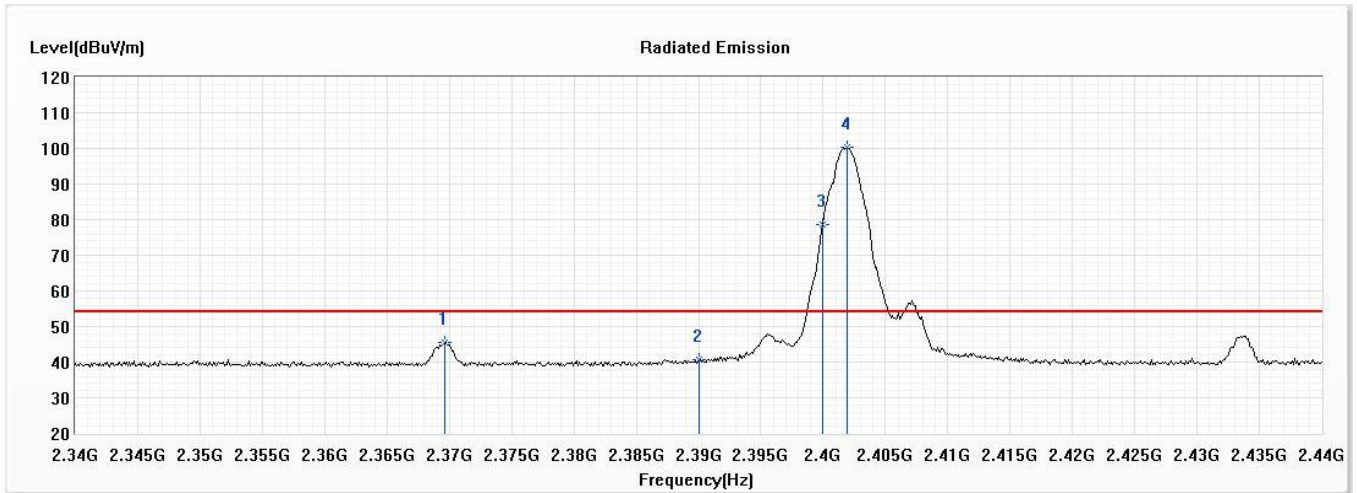
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
1	2369.400	54.52	74.00	-19.48	41.30	13.22	PK
2	2390.000	49.58	74.00	-24.42	36.43	13.15	PK
! 3	2400.000	83.73	--	--	70.61	13.12	PK
! 4	2401.900	100.93	--	--	87.79	13.14	PK

Note:

1. All readings above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. The average measurement was not performed when the peak measured data under the limit of average detection.

Product : Realtime radio module
 Test Item : Band Edge
 Test Mode : Mode 1: Transmit (2402MHz)
 Test Date : 2021/02/25

Vertical



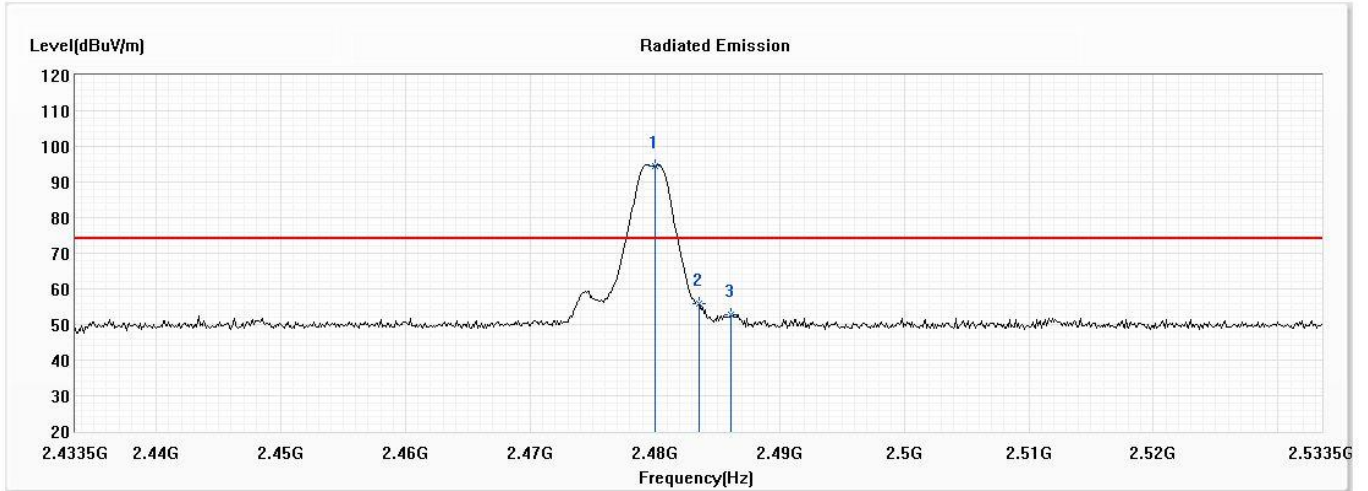
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
1	2369.600	45.50	54.00	-8.50	32.28	13.22	AV
2	2390.000	40.77	54.00	-13.23	27.62	13.15	AV
! 3	2400.000	78.57	--	--	65.45	13.12	AV
! 4	2401.900	100.24	--	--	87.10	13.14	AV

Note:

1. All readings above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. The average measurement was not performed when the peak measured data under the limit of average detection.

Product : Realtime radio module
 Test Item : Band Edge
 Test Mode : Mode 1: Transmit (2480MHz)
 Test Date : 2021/02/25

Horizontal



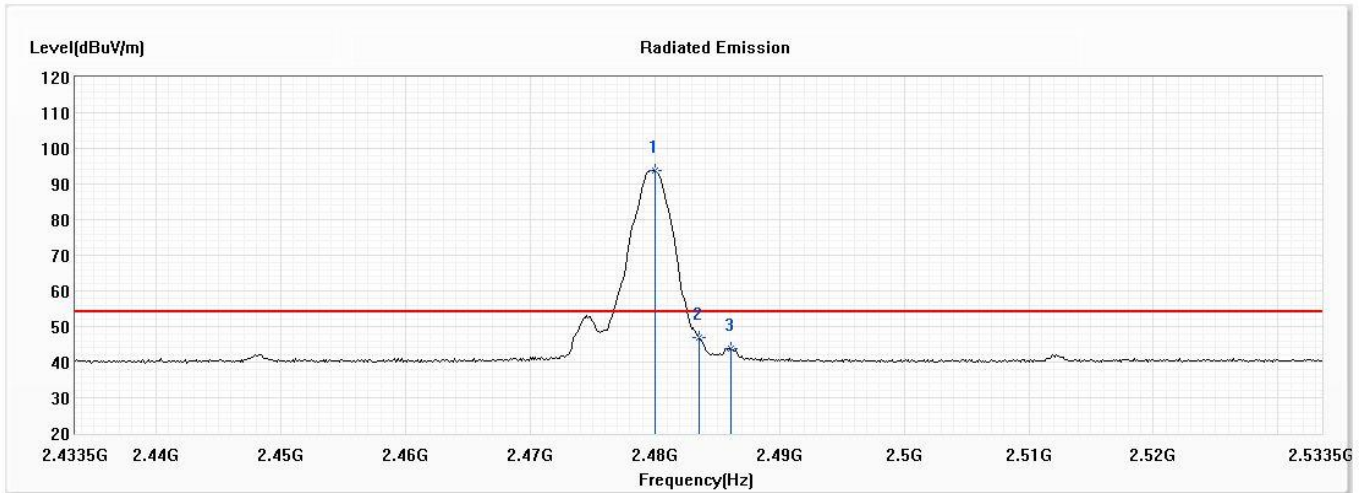
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
! 1	2480.000	94.39	--	--	80.97	13.42	PK
2	2483.500	55.77	74.00	-18.23	42.37	13.40	PK
3	2486.100	52.93	74.00	-21.07	39.55	13.38	PK

Note:

1. All readings above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. The average measurement was not performed when the peak measured data under the limit of average detection.

Product : Realtime radio module
 Test Item : Band Edge
 Test Mode : Mode 1: Transmit (2480MHz)
 Test Date : 2021/02/25

Horizontal



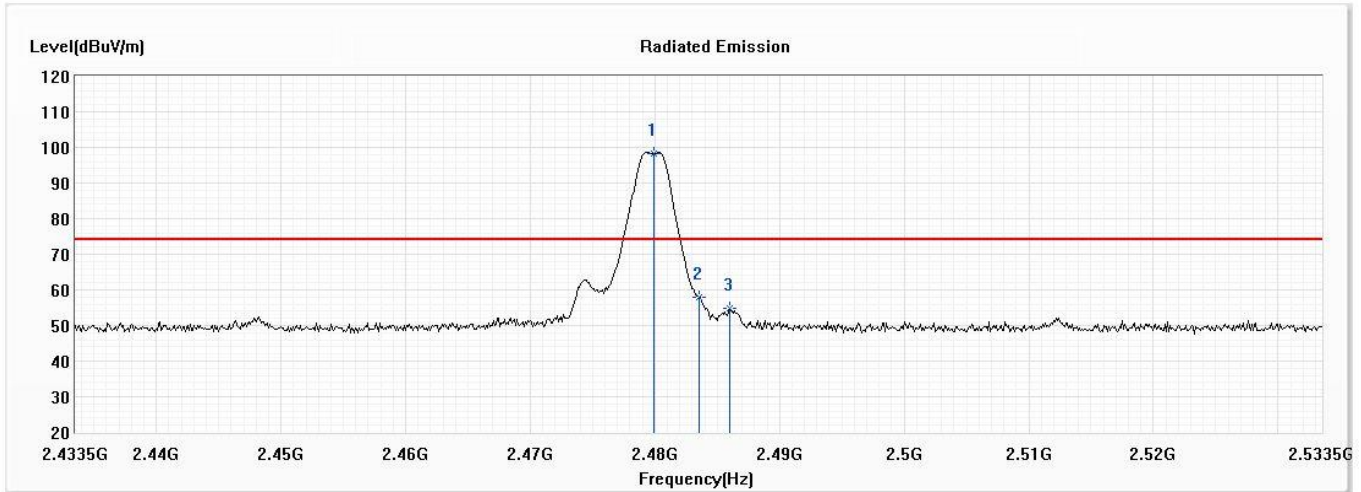
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
! 1	2480.000	93.70	--	--	80.28	13.42	AV
2	2483.500	47.06	54.00	-6.94	33.66	13.40	AV
3	2486.100	43.63	54.00	-10.37	30.25	13.38	AV

Note:

1. All readings above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. The average measurement was not performed when the peak measured data under the limit of average detection.

Product : Realtime radio module
 Test Item : Band Edge
 Test Mode : Mode 1: Transmit (2480MHz)
 Test Date : 2021/02/25

Vertical



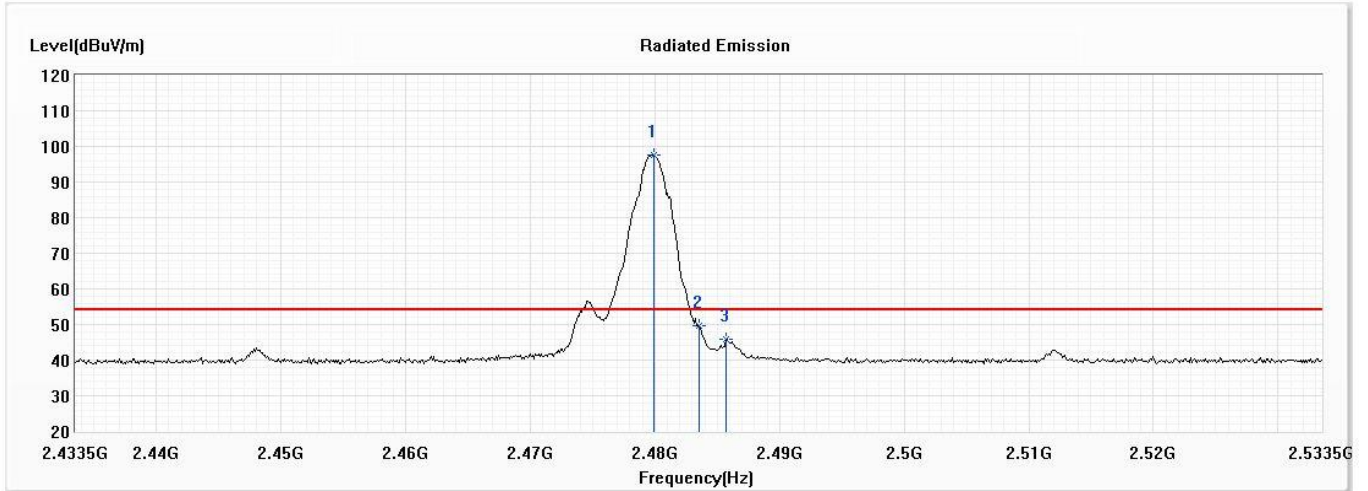
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
! 1	2479.900	98.25	--	--	84.83	13.42	PK
2	2483.500	57.91	74.00	-16.09	44.51	13.40	PK
3	2486.000	54.87	74.00	-19.13	41.49	13.38	PK

Note:

1. All readings above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. The average measurement was not performed when the peak measured data under the limit of average detection.

Product : Realtime radio module
 Test Item : Band Edge
 Test Mode : Mode 1: Transmit (2480MHz)
 Test Date : 2021/02/25

Vertical



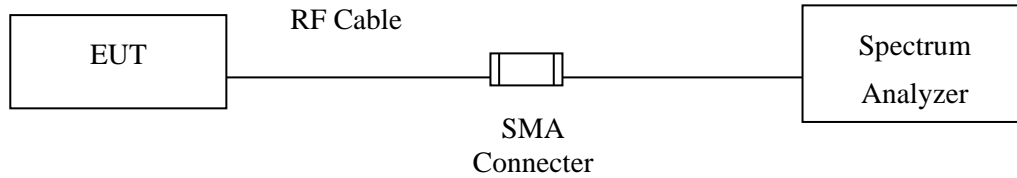
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Reading Level (dBuV)	Correct Factor (dB)	Detector Type
! 1	2479.900	97.42	--	--	84.00	13.42	AV
2	2483.500	49.65	54.00	-4.35	36.25	13.40	AV
3	2485.700	45.86	54.00	-8.14	32.47	13.39	AV

Note:

1. All readings above 1GHz are performed with peak and/or average measurements as necessary.
2. Measurement Level = Reading Level + Correct Factor.
3. The average measurement was not performed when the peak measured data under the limit of average detection.

7. Occupied Bandwidth

7.1. Test Setup



7.2. Limits

N/A

The minimum bandwidth shall be at least 500 kHz.

7.3. Test Procedure

Tested according to FHSS test procedure of KDB558074 section 9 (b for compliance to FCC 47CFR 15.247 requirements.

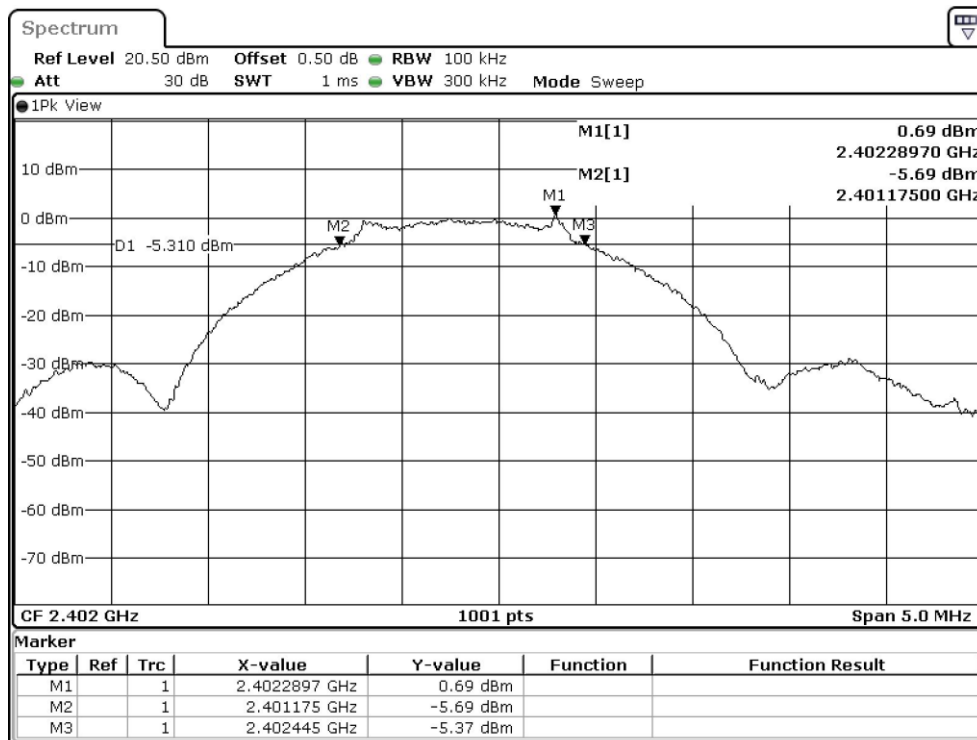
The EUT was setup according to ANSI C63.4, 2014; tested according to ANSI C63.10 Section 11.8 for compliance to FCC 47CFR 15.247 requirements.

7.4. Test Result of Occupied Bandwidth

Product : Realtime radio module
 Test Item : Occupied Bandwidth Data (6dB)
 Test Mode : Mode 1: Transmit
 Test Date : 2021/03/01

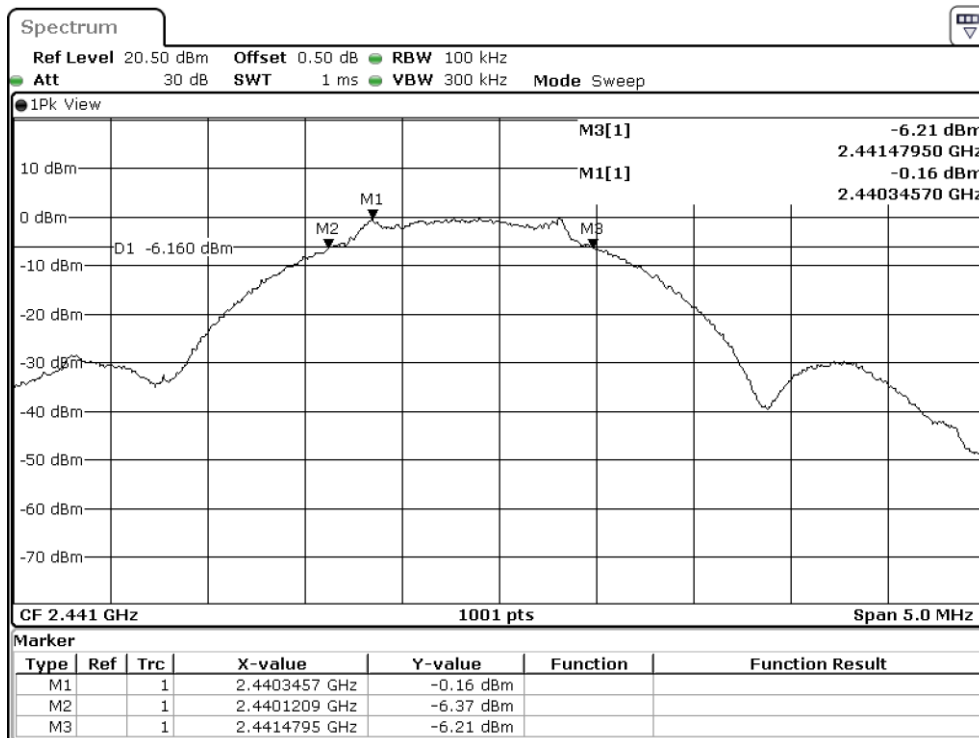
Channel No.	Frequency (MHz)	Measurement Level (kHz)	Required Limit (kHz)	Result
01	2402	1270	>500	Pass
40	2441	1358	>500	Pass
79	2480	1330	>500	Pass

Figure Channel 01:



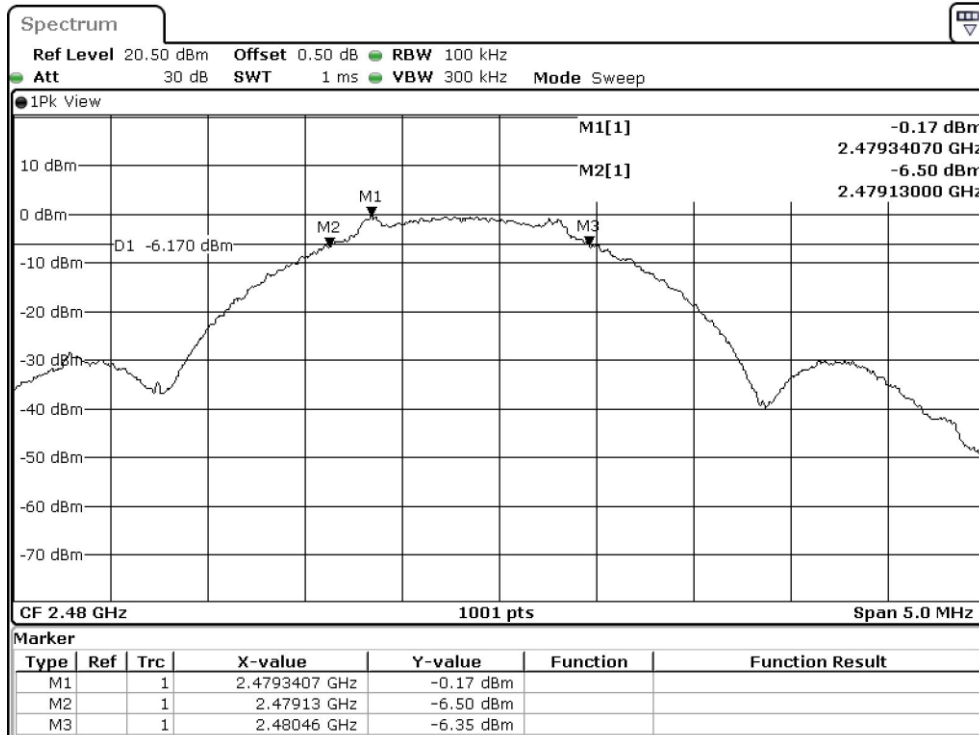
Date: 1.MAR.2021 21:35:40

Figure Channel 40:



Date: 1.MAR.2021 22:16:17

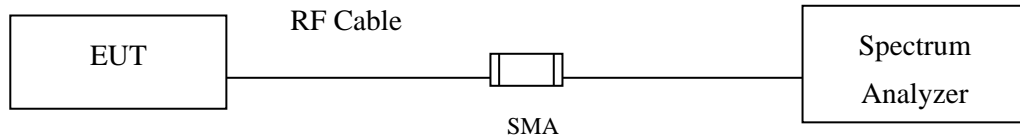
Figure Channel 79:



Date: 1.MAR.2021 21:38:57

8. Power Density

8.1. Test Setup



8.2. Limits

The transmitted power density averaged over any 1 second interval shall not be greater +8dBm in any 3kHz bandwidth.

8.3. Test Procedure

The EUT was setup according to ANSI C63.10, 2013; tested according to DTS test procedure of KDB 558074 for compliance to FCC 47CFR 15.247 requirements.

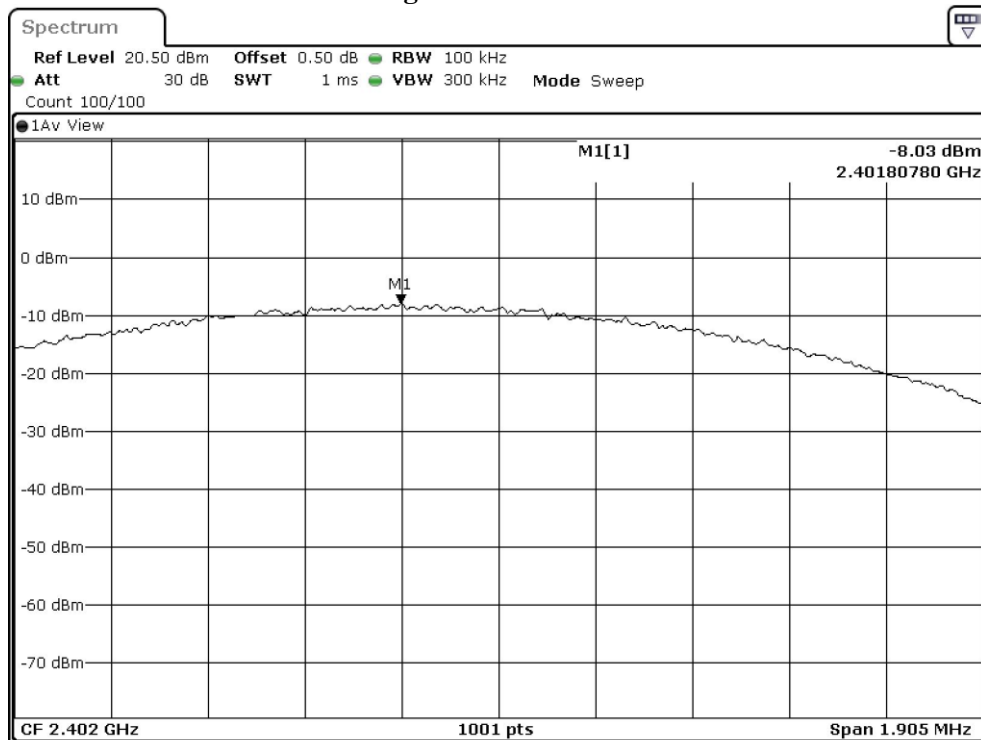
The maximum power spectral density using C63.10 Section 11.10.2 Method PKPSD (peak PSD)

8.4. Test Result of Power Density

Product : Realtime radio module
 Test Item : Power Density Data
 Test Mode : Mode 1: Transmit
 Test Date : 2021/03/01

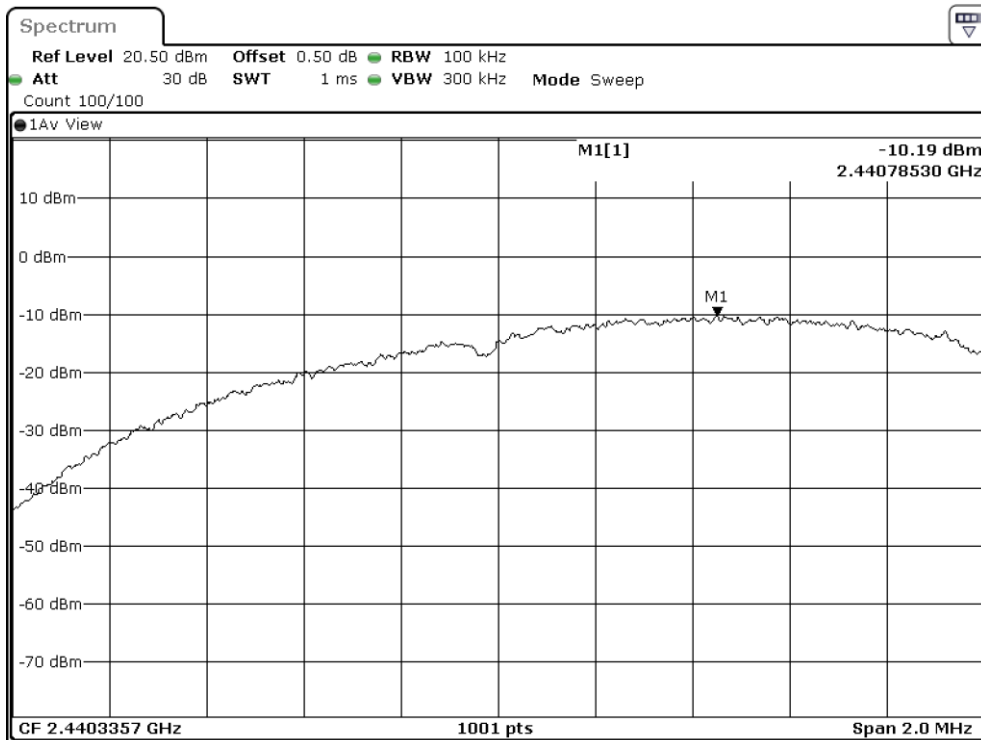
Channel No.	Frequency (MHz)	Measure Level (dBm)	Limit (dBm)	Result
01	2402	-8.03	≤ 8dBm	Pass
40	2441	-10.19	≤ 8dBm	Pass
79	2480	-7.91	≤ 8dBm	Pass

Figure Channel 01:



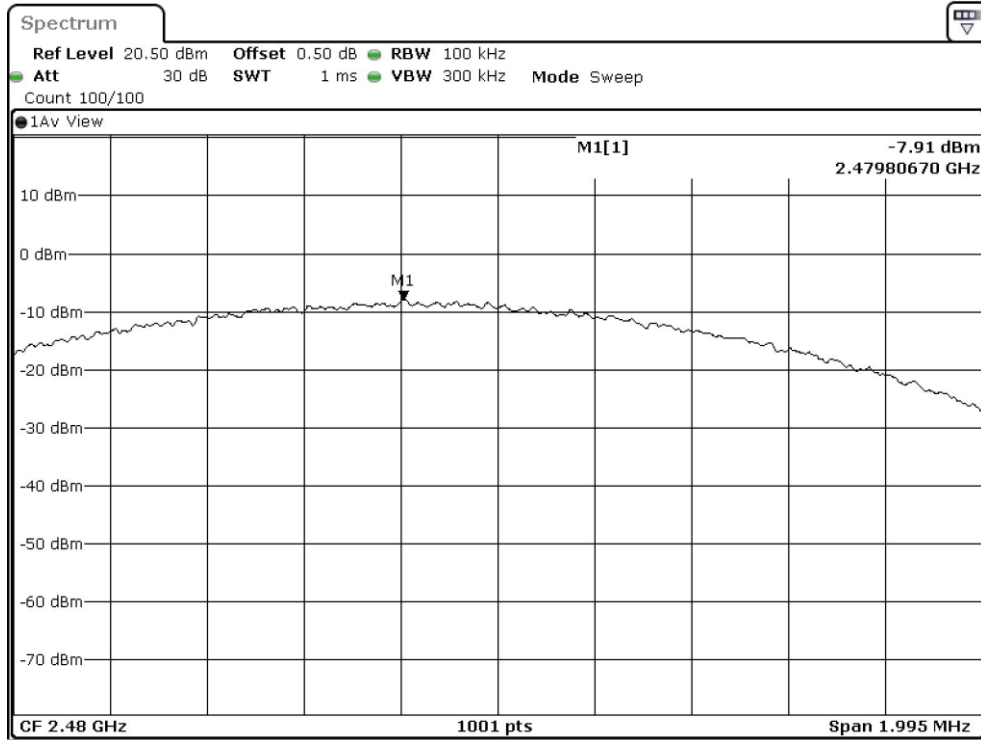
Date: 1.MAR.2021 21:36:01

Figure Channel 40:



Date: 1.MAR.2021 22:24:43

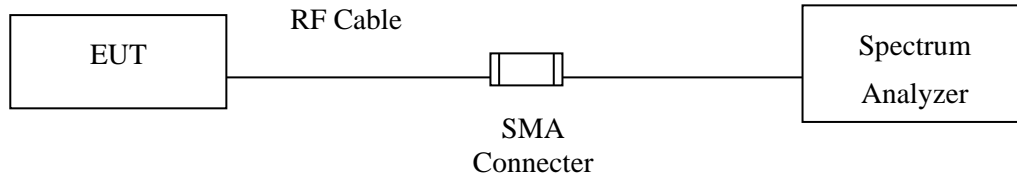
Figure Channel 79:



Date: 1.MAR.2021 21:39:19

9. Duty Cycle

9.1. Test Setup



9.2. Test Procedure

The EUT was setup according to ANSI C63.10 2013; tested according to ANSI C63.10 2013 for compliance to FCC 47CFR 15.247 requirements.

9.3. Test Result of Duty Cycle

Product : Realtime radio module
 Test Item : Duty Cycle
 Test Mode : Mode 1: Transmit

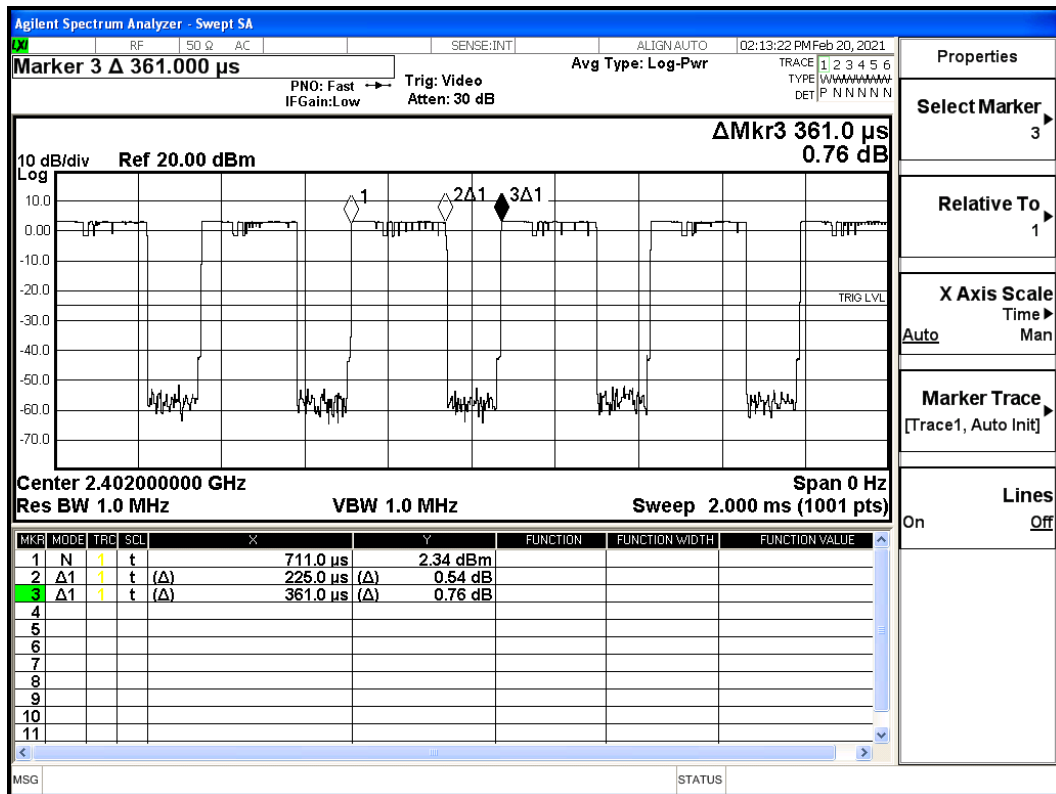
Duty Cycle Formula:

$$\text{Duty Cycle} = \text{Ton} / (\text{Ton} + \text{Toff})$$

$$\text{Duty Factor} = 10 \text{ Log} (1/\text{Duty Cycle})$$

Results:

2.4GHz band	Ton (ms)	Ton + Toff (ms)	Duty Cycle (%)	Duty Factor (dB)
GFSK	0.225	0.361	62.32	2.05



10. EMI Reduction Method During Compliance Testing

No modification was made during testing.