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Zhong Shan City Richsound Electronic Industrial Ltd.

TEST REPORT

SCOPE OF WORK
FCC TESTING–TB523DW5, 100043839

REPORT NUMBER
211123006SZN-001

ISSUE DATE **[REVISED DATE]**

30 December 2021 [----------]

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TEST REPORT

Intertek Report No.: 211123006SZN-001

Zhong Shan City Richsound Electronic Industrial Ltd.

Application
For
Certification

FCC ID: Z8M-TB523DW5

onn. 5.1 wireless soundbar, Wireless Subwoofer, Surround Speaker(L/R)

Model: TB523DW5, 100043839

2.4GHz Transceiver

Report No.: 211123006SZN-001

We hereby certify that the sample of the above item is considered to comply with the requirements of FCC Part 15, Subpart C for Intentional Radiator, mention 47 CFR [10-1-20]

Prepared and Checked by:

Ryan Chen
Project Engineer

Approved by:

Sewen Guo
Senior Project Engineer
Date: 30 December 2021

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MEASUREMENT/TECHNICAL REPORT

This report concerns (check one:) Original Grant X Class II Change _____

Equipment Type: DSS - Part 15 Spread Spectrum Transmitter

Deferred grant requested per 47 CFR 0.457(d)(1)(ii)? Yes _____ No X

If yes, defer until: _____
date

Company Name agrees to notify the Commission by: _____
date

of the intended date of announcement of the product so that the grant can be issued on that date.

Transition Rules Request per 15.37? Yes _____ No X

If no, assumed Part 15, Subpart C for intentional radiator – the new 47 CFR [10-1-20 Edition] provision.

Report prepared by:

Ryan Chen
Intertek Testing Services Shenzhen Ltd. Longhua Branch
101, 201, Building B, No. 308 Wuhe Avenue, Zhangkengjing
Community, GuanHu Subdistrict, LongHua District, Shenzhen.
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Table of Contents

1.0 Summary of Test Results

Applicant: Zhong Shan City Richsound Electronic Industrial Ltd.
Address: No.16, East Shagang Road, Gangkou, ZHONGSHAN, Guangdong 528447, China.
Manufacturer: Zhong Shan City Richsound Electronic Industrial Ltd.
Address: No.16, East Shagang Road, Gangkou, ZHONGSHAN, Guangdong 528447, China.

Model: TB523DW5, 100043839

FCC ID: Z8M-TB523DW5

TEST	REFERENCE	RESULTS
Max. Output power / Max. e.i.r.p.	FCC 15.247(b)(1)	Pass
20dB Bandwidth	FCC 15.247(a)(1)	Pass
Channel Separation	FCC 15.247(a)(1)	Pass
Channel Number	FCC 15.247(a)(1) (iii)	Pass
Dwell Time	FCC 15.247(a)(1)(iii)	Pass
Out of Band Antenna Conducted Emission	FCC 15.247(d)	Pass
Radiated Emission in Restricted Bands	FCC 15.247(d), FCC 15.209, FCC 15.205	Pass
Band Edge	FCC 15.247(d), FCC 15.209, FCC 15.205	Pass
AC Conducted Emission	FCC 15.207	Pass

Notes: The EUT uses an Integral Antenna which in accordance to Section 15.203 is considered sufficient to comply with the provisions of this section.

2.0 General Description

2.1 Product Description

The equipment under test (EUT) is a onn. 5.1 wireless soundbar, Wireless Subwoofer, Surround Speaker(L/R) with Bluetooth FHSS technology operating in 2402-2480MHz and SRD 5.8GHz transmitting function operating in 5727-5819MHz. The EUT is powered by AC 100-240V~ 50/60Hz. For more detail information pls. refer to the user manual.
Bluetooth Version: 5.1 EDR
Antenna Type: Integral antenna
Antenna Gain: 3.35 dBi max
Modulation Type: GFSK, π/4-DQPSK

The Model: 100043839 is the same as the Model: TB523DW5 in hardware and electrical aspect. The difference in model number and trademark serves as packaging and marketing purpose only.
For electronic filing, the brief circuit description is saved with filename: descri.pdf.

2.2 Related Submittal(s) Grants

This is an application for certification of transceiver for the onn. 5.1 wireless soundbar, Wireless Subwoofer, Surround Speaker(L/R) which has Bluetooth function. Other digital functions were reported in the verification report: 211123006SZN-003.
For SRD 5.8GHz transmitting function is subjected to report: 211123006SZN-002.

2.3 Test Methodology

Both AC mains line-conducted and radiated emission measurements were performed according to the procedures in ANSI C63.10 (2013). Radiated emission measurement was performed in semi-anechoic chamber and conducted emission measurement was performed in shield room. For radiated emission measurement, preliminary scans were performed in the semi-anechoic chamber only to determine the worst case modes. All radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the "**Justification Section**" of this Application.

2.4 Test Facility

The Semi-anechoic chamber and shielding room used to collect the radiated data and conducted data are **Intertek Testing Services Shenzhen Ltd. Longhua Branch** and located at 101, 201, Building B, No. 308 Wuhe Avenue, Zhangkengjing Community, GuanHu Subdistrict, LongHua District, Shenzhen. This test facility and site measurement data have been fully placed on file with File Number: CN1188.

3.0 System Test Configuration

3.1 Justification

The system was configured for testing in a typical fashion (as a customer would normally use it), and in the confines as outlined in ANSI C63.10 (2013).

The EUT was powered by AC120V, 60Hz during the test.

All packets DH1, DH3 & DH5 mode in modulation type GFSK, π/4-DQPSK were tested and only the worst data was reported in this report.

For maximizing emissions below 30 MHz, the EUT was rotated through 360°, the centre of the loop antenna was placed 1 meter above the ground, and the antenna polarization was changed. For maximizing emissions, the EUT was rotated through 360°, the antenna height was varied from 1 meter to 4 meters above the ground plane, and the antenna polarization was changed. This step by step procedure for maximizing emissions led to the data reported in Section 4.

The EUT and transmitting antenna was centered on the turntable.

The equipment under test (EUT) was configured for testing in a typical fashion (as a customer would normally use it). The EUT was placed on a turn table, which enabled the engineer to maximize emissions through its placement in the three orthogonal axes.

3.2 EUT Exercising Software

The EUT exercise program (provided by client) used during radiated and conducted testing was designed to exercise the various system components in a manner similar to a typical use. The worst-case configuration is used in all specified testing.

The parameters of test software setting:
During the test, Channel and power controlling software provided by the applicant was used to control the operating channel as well as the output power level. The RF output power selection is for the setting of RF output power expected by the application and is going to be fixed on the firmware of the end product.

Test Software: FCC Asist 1.0.2.2

3.3 Special Accessories

N/A

3.4 Equipment Modification

Any modifications installed previous to testing by Zhong Shan City Richsound Electronic Industrial Ltd. will be incorporated in each production model sold / leased in the United States.

No modifications were installed by Intertek Testing Services Shenzhen Ltd. Longhua Branch.

3.5 Measurement Uncertainty

When determining the test conclusion, the Measurement Uncertainty of test has been considered.

3.6 Support Equipment List and Description

Description	Manufacturer	Model No.
Mobile Phone (Provided by Intertek)	SAMSUNG	SM-G9300
Test TV (Provided by Intertek)	SONY	KDL-24EX520
USB Memory (Provided by Intertek)	TOSHIBA	UHYBS-004G-BL
3.5mm to 3.5mm audio Cable (Provided by Applicant)	Richsound	Unshielded, Length 100cm
HDMI In Cable (Provided by Applicant)	Richsound	Shielded, Length 150cm
Detached AC power cord (Provided by Applicant)	Richsound	Unshielded, Length 150cm
Optical Cable	Richsound	Unshielded, Length 120cm
HDMI In Cable (Provided by Intertek)	N/A	Unshielded, Length 150cm
Dummy Load (Provided by Intertek)	N/A	Audio: 1kΩ HDMI: 100Ω

4.0 Test Results

Data is included worst-case configuration (the configuration which resulted in the highest emission levels).

4.1 Radiated Test Results

A sample calculation, configuration photographs and data tables of the emissions are included.

4.1.1 Field Strength Calculation

The field strength is calculated by adding the reading on the Spectrum Analyzer to the factors associated with preamplifiers (if any), antennas, cables, pulse desensitization and average factors (when specified limit is in average and measurements are made with peak detectors). A sample calculation is included below.

FS = RA + AF + CF - AG + PD + AV

Where FS = Field Strength in dBµV/m
RA = Receiver Amplitude (including preamplifier) in dBµV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB/m
AG = Amplifier Gain in dB
PD = Pulse Desensitization in dB
AV = Average Factor in -dB

In the radiated emission table which follows, the reading shown on the data table may reflect the preamplifier gain. An example of the calculations, where the reading does not reflect the preamplifier gain, follows:

FS = RA + AF + CF - AG + PD + AV

Assume a receiver reading of 62.0 dBµV is obtained. The antenna factor of 7.4 dB/m and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted. The pulse desensitization factor of the spectrum analyzer was 0 dB, and the resultant average factor was -10 dB. The net field strength for comparison to the appropriate emission limit is 32 dBµV/m. This value in dBµV/m was converted to its corresponding level in µV/m.

RA = 62.0 dBµV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
PD = 0 dB
AV = -10 dB

FS = 62 + 7.4 + 1.6 - 29 + 0 + (-10) = 32 dBµV/m
Level in µV/m = Common Antilogarithm [(32 dBµV/m)/20] = 39.8 µV/m

4.1.2 Radiated Emission Configuration Photograph

For electronic filing, the worst case radiated emission configuration photograph is saved with filename: radiated photos. pdf.

4.1.3 Radiated Emissions- FCC section 15.209

The data on the following page lists the significant emission frequencies, the limit and the margin of compliance. Numbers with a minus sign are below the limit.

Worst Case Radiated Emission

at 64.640000 / 239.960000 MHz

Judgement: Passed by 9.1 dB

TEST PERSONNEL:

Sign on file

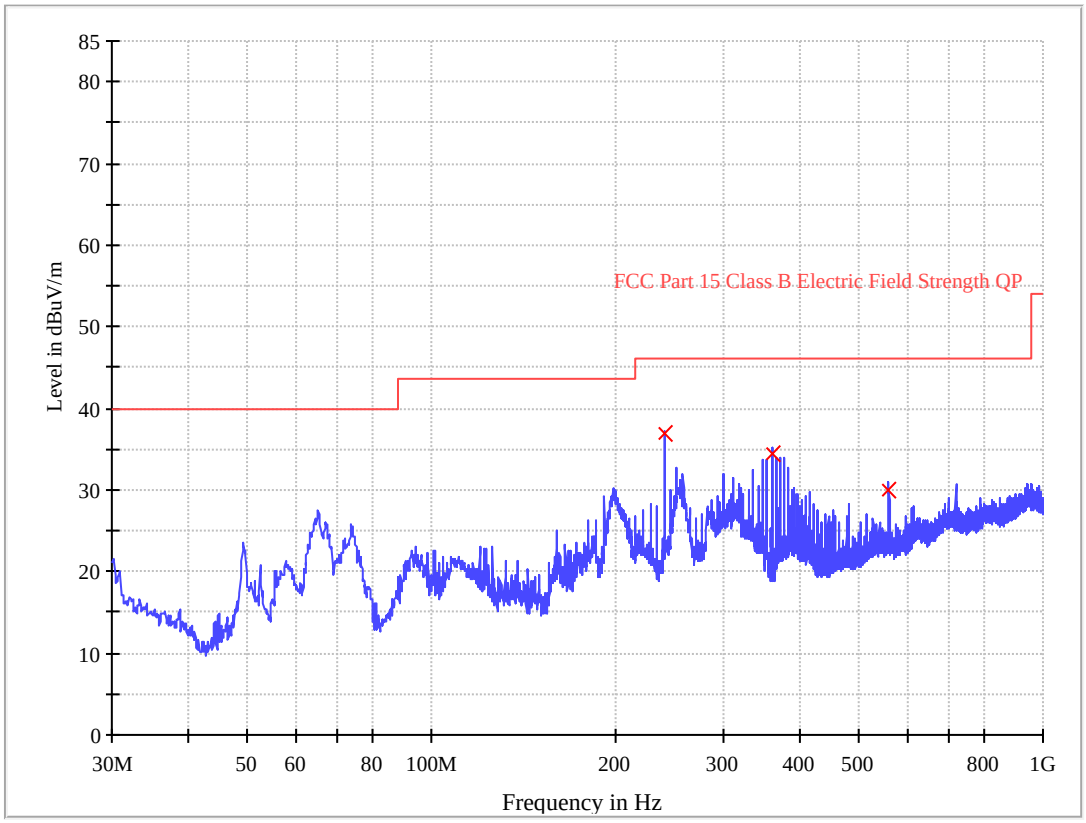
Ryan Chen, Project Engineer
Typed/Printed Name

08 December 2021
Date

Applicant: Zhong Shan City Richsound Electronic Industrial Ltd.
Date of Test: 08 December 2021
Model:TB523DW5
Worst-case operating Mode: Synchronous transmission
Modulation type: GFSK

ANT Polarity: Horizontal

FCC Part 15



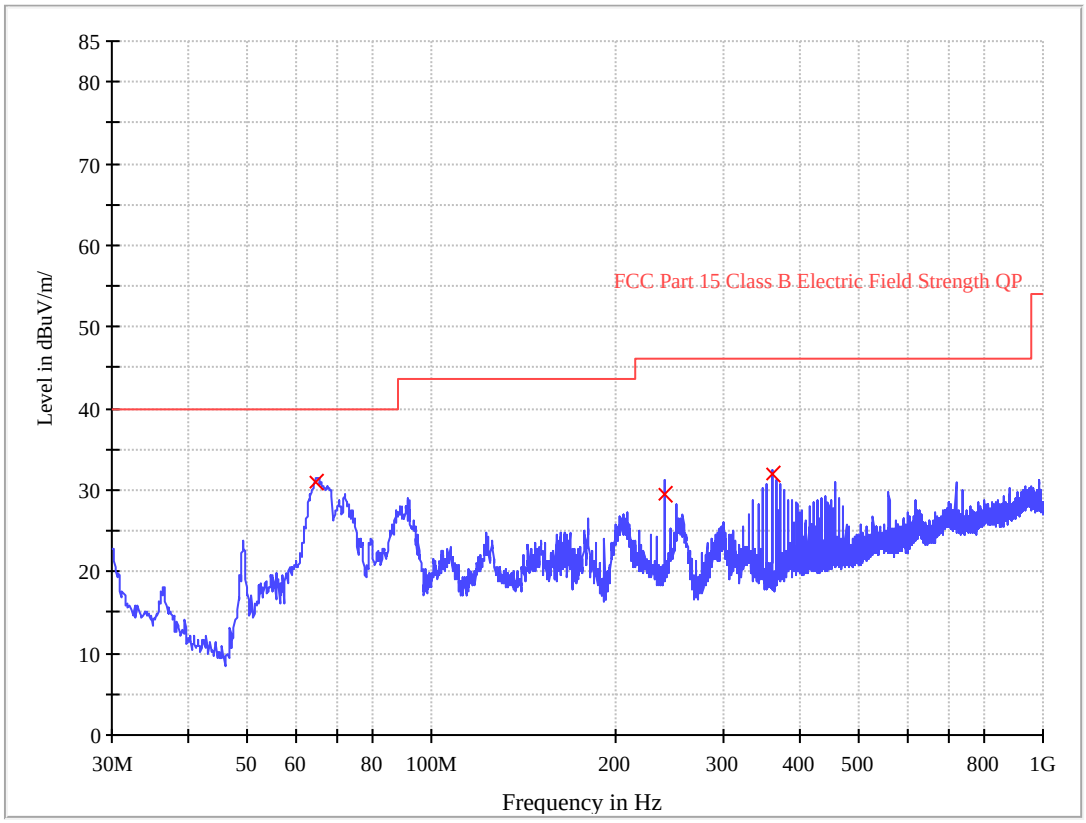
Frequency (MHz)	Quasi Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Polarization	Corr. (dB/m)	Margin - QPK (dB)	Limit – QPK dBµV/m)
239.960000	36.9	1000.0	120.000	H	14.5	9.1	46.0
359.921250	34.5	1000.0	120.000	H	18.4	11.5	46.0
559.983750	30.0	1000.0	120.000	H	23.2	16.0	46.0

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. Quasi Peak (dBµV/m) = Corr. (dB/m) + Read Level (dBµV)
3. Margin (dB) = Limit Line (dBµV/m) – Level (dBµV/m)

Applicant: Zhong Shan City Richsound Electronic Industrial Ltd.
Date of Test: 08 December 2021
Model: TB523DW5
Worst-case operating Mode: Synchronous transmission
Modulation type: GFSK

ANT Polarity: Vertical

FCC Part 15



Frequency (MHz)	Quasi Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Polarization	Corr. (dB/m)	Margin - QPK (dB)	Limit – QPK (dBµV/m)
64.640000	30.9	1000.0	120.000	V	8.1	9.1	40.0
240.005000	29.4	1000.0	120.000	V	14.5	16.6	46.0
359.921250	31.9	1000.0	120.000	V	18.4	14.1	46.0

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. Quasi Peak (dBµV/m) = Corr. (dB/m) + Read Level (dBµV)
3. Margin (dB) = Limit Line (dBµV/m) – Level (dBµV/m)

4.1.4 Transmitter Spurious Emissions (Radiated) - FCC section 15.209

The data on the following page lists the significant emission frequencies, the limit and the margin of compliance. Numbers with a minus sign are below the limit.

Worst Case Radiated Emission

at 2399.161 MHz

Judgement: Passed by 6.45 dB

TEST PERSONNEL:

Sign on file

Ryan Chen, Project Engineer
Typed/Printed Name

08 December 2021
Date

Applicant: Zhong Shan City Richsound Electronic Industrial Ltd.
Date of Test: 08 December 2021
Model: TB523DW5
Worst-case operating Mode: Transmit (2402MHz)
Modulation type: GFSK

Table 1

Radiated Emissions

(2402MHz)

Polarization	Frequency (MHz)	Reading (dBµV)	Pre-Amp Gain (dB)	Antenna Factor (dB/m)	Net at 3m (dBµV/m)	Peak Limit at 3m (dBµV/m)	Margin (dB)
Horizontal	**2402.000	111.8	36.7	28.1	103.2	--	--
Horizontal	*4804.000	57.6	36.7	35.5	56.4	74.0	-17.6

Polarization	Frequency (MHz)	Reading (dBµV)	Pre-Amp Gain (dB)	Antenna Factor (dB/m)	Average Factor (-dB)	Net at 3m (dBµV/m)	Average Limit at 3m (dBµV/m)	Margin (dB)
Horizontal	**2402.000	111.8	36.7	28.1	22.5	80.7	--	--
Horizontal	*4804.000	57.6	36.7	35.5	22.5	33.9	54.0	-20.1

NOTES:
1. Peak detector is used for the emission measurement.

2. All measurements were made at 3 meters. Radiated emissions not detected at the 3-meter distance were measured at 0.3-meter and an inverse proportional extrapolation was performed to compare the signal level to the 3-meter limit. No other radiated emissions than those reported were detected at a test distance of 0.3-meter.

3. Negative value in the margin column shows emission below limit.

4. Horn antenna used for the emission over 1000MHz.

* Emission within the restricted band meets the requirement of section 15.205. The corresponding limit as per 15.209 is based on Quasi peak limit for frequencies below 1000 MHz and average limit for frequencies over 1000 MHz. The radio frequency emissions above 1GHz also meet corresponding 20dB permitted peak limit with a peak detector function.

** Fundamental emission was measured for determining band-edge compliance of using delta measurement technique.

Applicant: Zhong Shan City Richsound Electronic Industrial Ltd.
Date of Test: 08 December 2021
Model: TB523DW5
Worst-case operating Mode: Transmit (2441MHz)
Modulation type: GFSK

Table 2

Radiated Emissions

(2441MHz)

Polarization	Frequency (MHz)	Reading (dBµV)	Pre-Amp Gain (dB)	Antenna Factor (dB/m)	Net at 3m (dBµV/m)	Peak Limit at 3m (dBµV/m)	Margin (dB)
Horizontal	*4882.000	55.8	36.7	35.5	54.6	74.0	-19.4
Horizontal	*7323.000	59.1	36.1	37.2	60.2	74.0	-13.8

Polarization	Frequency (MHz)	Reading (dBµV)	Pre-Amp Gain (dB)	Antenna Factor (dB/m)	Average Factor (-dB)	Net at 3m (dBµV/m)	Average Limit at 3m (dBµV/m)	Margin (dB)
Horizontal	*4882.000	55.8	36.7	35.5	22.5	32.1	54.0	-21.9
Horizontal	*7323.000	59.1	36.1	37.2	22.5	37.7	54.0	-16.3

NOTES:
1. Peak detector is used for the emission measurement.

2. All measurements were made at 3 meters. Radiated emissions not detected at the 3-meter distance were measured at 0.3-meter and an inverse proportional extrapolation was performed to compare the signal level to the 3-meter limit. No other radiated emissions than those reported were detected at a test distance of 0.3-meter.

3. Negative value in the margin column shows emission below limit.

4. Horn antenna used for the emission over 1000MHz.

* Emission within the restricted band meets the requirement of section 15.205. The corresponding limit as per 15.209 is based on Quasi peak limit for frequencies below 1000 MHz and average limit for frequencies over 1000 MHz. The radio frequency emissions above 1GHz also meet corresponding 20dB permitted peak limit with a peak detector function.

Applicant: Zhong Shan City Richsound Electronic Industrial Ltd.
Date of Test: 08 December 2021
Model: TB523DW5
Worst-case operating Mode: Transmit (2480MHz)
Modulation type: GFSK

Table 3

Radiated Emissions

(2480MHz)

Polarization	Frequency (MHz)	Reading (dBµV)	Pre-Amp Gain (dB)	Antenna Factor (dB/m)	Net at 3m (dBµV/m)	Peak Limit at 3m (dBµV/m)	Margin (dB)
Horizontal	**2480.000	109.8	36.7	28.1	101.2	--	--
Horizontal	*4960.000	54.6	36.7	35.5	53.4	74.0	-20.6
Horizontal	*7440.000	57.6	36.1	37.2	58.7	74.0	-15.3

Polarization	Frequency (MHz)	Reading (dBµV)	Pre-Amp Gain (dB)	Antenna Factor (dB/m)	Average Factor (-dB)	Net at 3m (dBµV/m)	Average Limit at 3m (dBµV/m)	Margin (dB)
Horizontal	**2480.000	109.8	36.7	28.1	22.5	78.7	--	--
Horizontal	*4960.000	54.6	36.7	35.5	22.5	30.9	54.0	-23.1
Horizontal	*7440.000	57.6	36.1	37.2	22.5	36.2	54.0	-17.8

NOTES:
1. Peak detector is used for the emission measurement.
2. All measurements were made at 3 meters. Radiated emissions not detected at the 3-meter distance were measured at 0.3-meter and an inverse proportional extrapolation was performed to compare the signal level to the 3-meter limit. No other radiated emissions than those reported were detected at a test distance of 0.3-meter.
3. Negative value in the margin column shows emission below limit.
4. Horn antenna used for the emission over 1000MHz.

* Emission within the restricted band meets the requirement of section 15.205. The corresponding limit as per 15.209 is based on Quasi peak limit for frequencies below 1000 MHz and average limit for frequencies over 1000 MHz. The radio frequency emissions above 1GHz also meet corresponding 20dB permitted peak limit with a peak detector function.

** Fundamental emission was measured for determining band-edge compliance of using delta measurement technique.

4.2 Conducted Emission at Mains Terminal

4.2.1 Conducted Emissions Configuration Photograph

For electronic filing, the worst case conducted emission configuration photograph is saved with filename: conducted photos.pdf.

4.2.2 Conducted Emissions

Worst Case Conducted Configuration

at 0.306000 MHz

Judgement: Passed by 13.2 dB margin

TEST PERSONNEL:

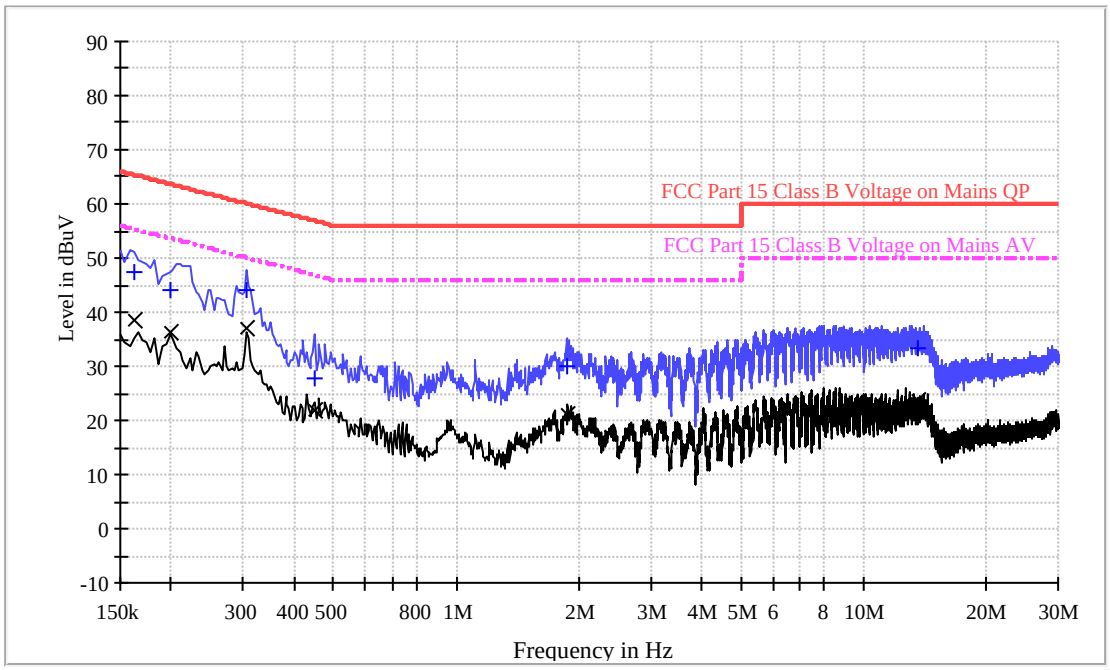
Sign on file

Ryan Chen, Project Engineer
Typed/Printed Name

08 December 2021
Date

Applicant: Zhong Shan City Richsound Electronic Industrial Ltd.
Date of Test: 08 December 2021
Model: TB523DW5
Worst-case operating Mode: Synchronous transmission
Modulation type: GFSK
Phase: Live

Conducted Emission Test - FCC



Result Table QP

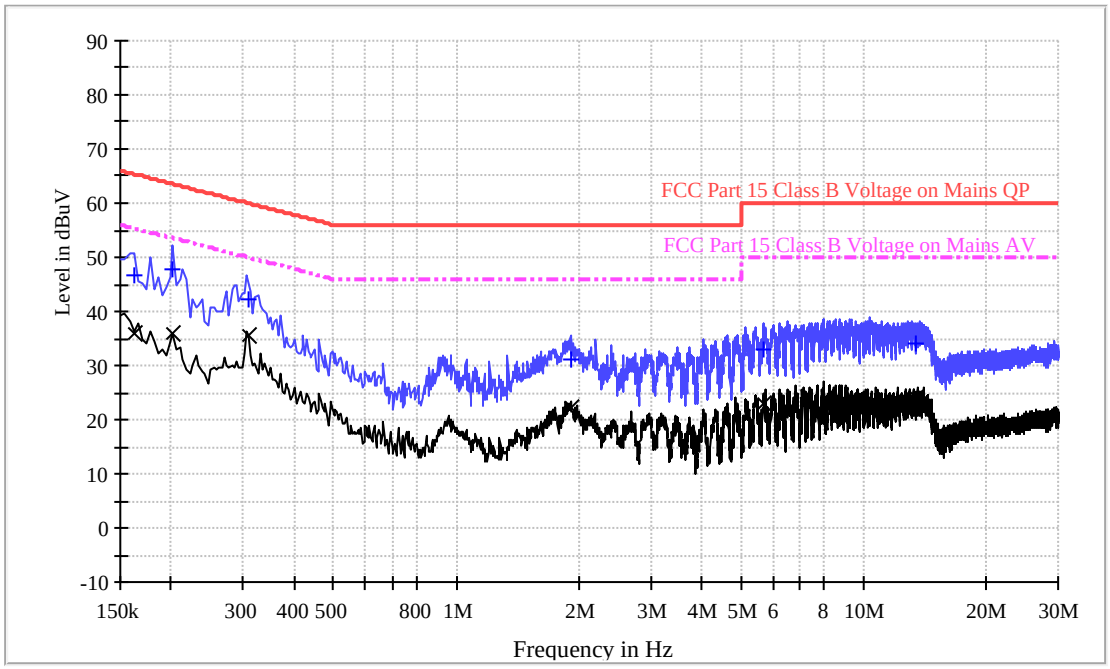
Frequency (MHz)	Quasi Peak (dBµV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.162000	47.4	9.000	L1	9.6	18.0	65.4
0.198000	44.2	9.000	L1	9.6	19.5	63.7
0.306000	43.9	9.000	L1	9.6	16.2	60.1
0.450000	27.7	9.000	L1	9.6	29.2	56.9
1.866000	29.9	9.000	L1	9.6	26.1	56.0
13.518000	33.4	9.000	L1	10.0	26.6	60.0

Result Table AV

Frequency (MHz)	Average (dBµV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.162000	38.6	9.000	L1	9.6	16.8	55.4
0.198000	36.4	9.000	L1	9.6	17.3	53.7
0.306000	36.9	9.000	L1	9.6	13.2	50.1
0.450000	21.7	9.000	L1	9.6	25.2	46.9
1.866000	21.1	9.000	L1	9.6	24.9	46.0
13.518000	23.6	9.000	L1	10.0	26.4	50.0

Applicant: Zhong Shan City Richsound Electronic Industrial Ltd.
Date of Test: 08 December 2021
Model: TB523DW5
Worst-case operating Mode: Synchronous transmission
Modulation type: GFSK
Phase: Neutral

Conducted Emission Test - FCC



Result Table QP

Frequency (MHz)	Quasi Peak (dBµV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.162000	46.5	9.000	N	9.5	18.9	65.4
0.202000	47.6	9.000	N	9.5	15.9	63.5
0.310000	42.2	9.000	N	9.5	17.8	60.0
1.906000	31.3	9.000	N	9.5	24.7	56.0
5.678000	33.1	9.000	N	9.6	26.9	60.0
13.494000	34.1	9.000	N	9.9	25.9	60.0

Result Table AV

Frequency (MHz)	Average (dBµV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.162000	35.8	9.000	N	9.5	19.6	55.4
0.202000	35.8	9.000	N	9.5	17.7	53.5
0.310000	35.7	9.000	N	9.5	14.3	50.0
1.906000	22.3	9.000	N	9.5	23.7	46.0
5.678000	22.8	9.000	N	9.6	27.2	50.0
13.494000	24.0	9.000	N	9.9	26.0	50.0

4.3 Peak Power

Maximum Conducted Output Power at Antenna Terminals, FCC Rules 15.247(b)(1).
The antenna port of the EUT was connected to the input of a spectrum analyzer. The analyzer was set for RBW > 20dB bandwidth and power was read directly in dBm.

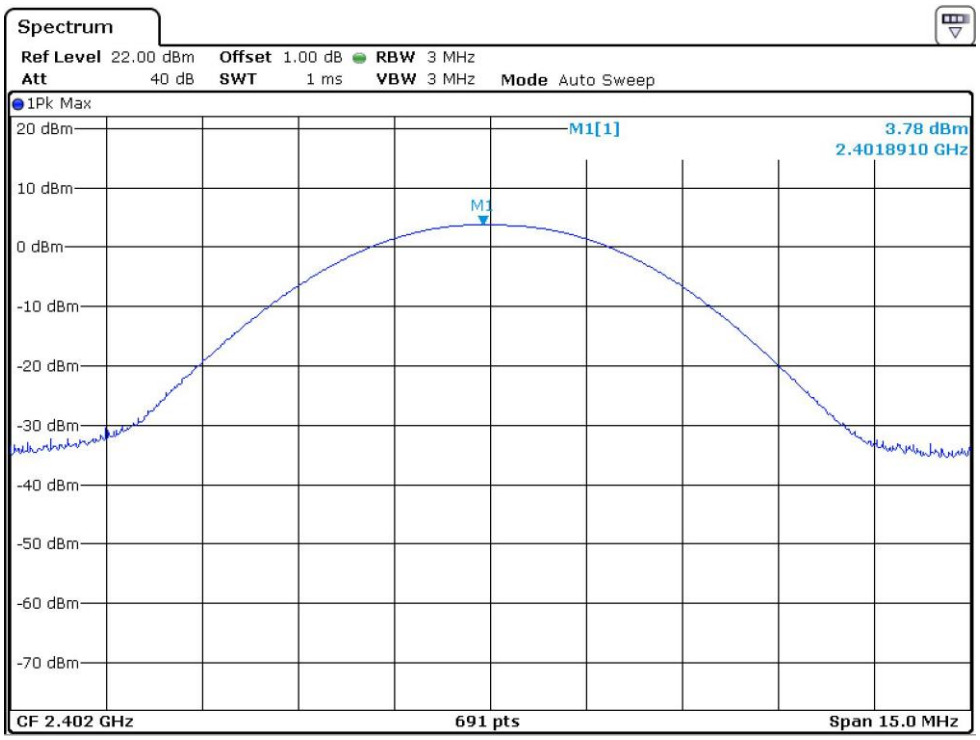
For antenna with gains of 6dBi or less, and frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, the systems operate with an output power no greater than 125 mW.

Antenna Gain = 3.35dBi			
Modulation Type	Frequency (MHz)	Output Power (Peak Reading) (dBm)	Output Power (mW)
GFSK	2402	3.78	2.39
	2441	4.31	2.70
	2480	4.72	2.96

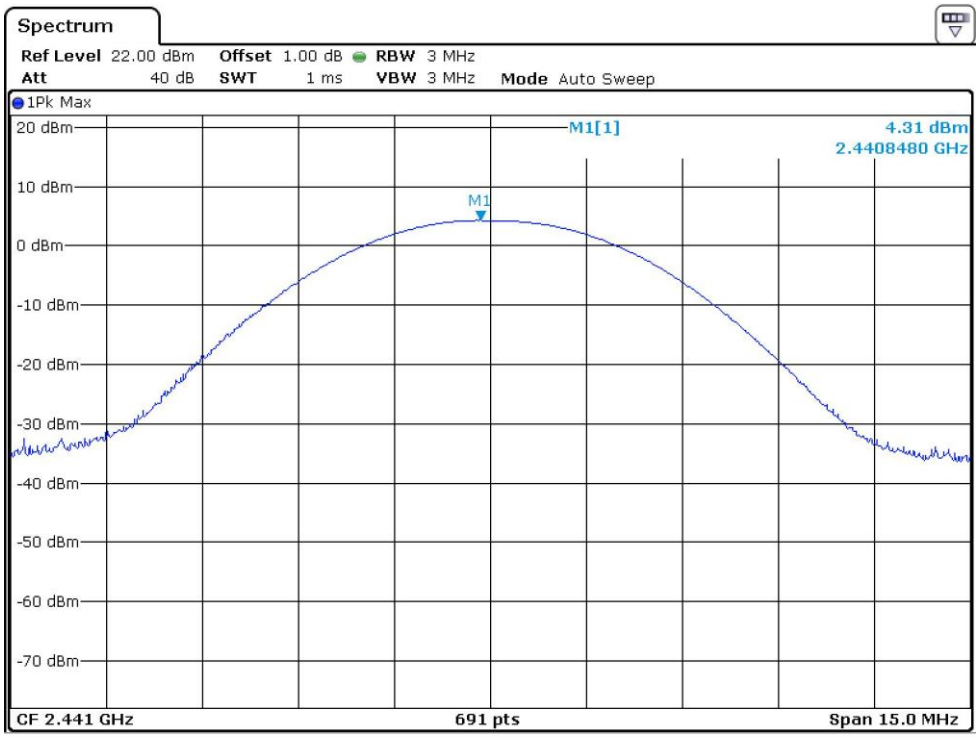
Cable loss: 2.0 dB External Attenuation: 0 dB

Modulation Type: GFSK

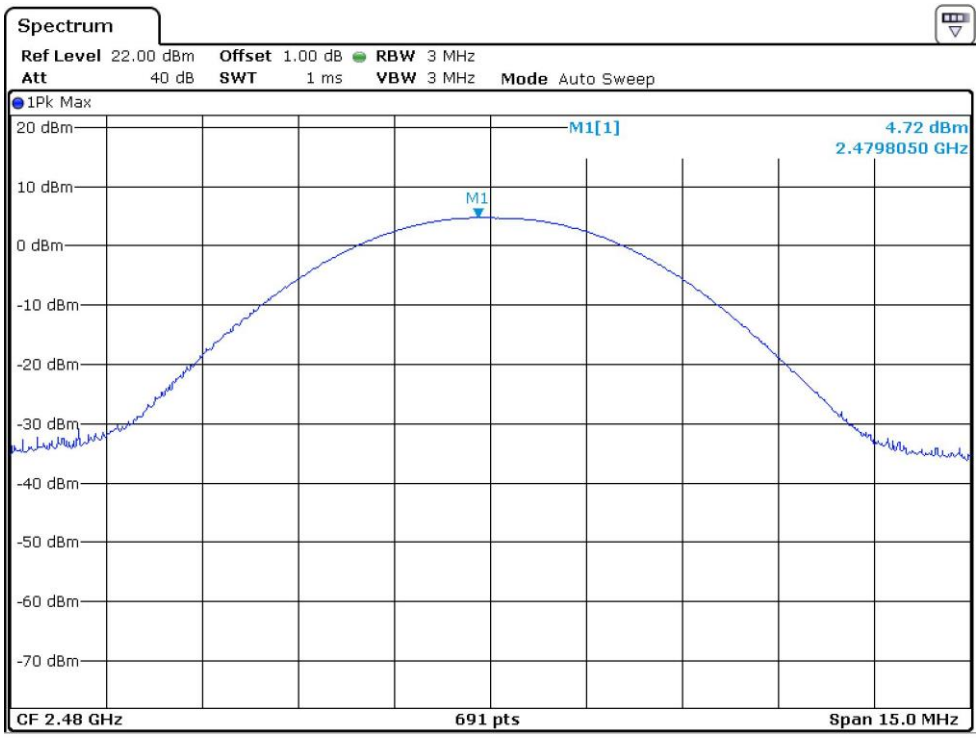
CH00



CH39



CH78


Spectrum
Ref Level 22.00 dBm Offset 1.00 dB RBW 3 MHz
Att 40 dB SWT 1 ms VBW 3 MHz Mode Auto Sweep
1Pk Max
M1[1]
4.72 dBm
2.4798050 GHz
M1
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
CF 2.48 GHz
691 pts
Span 15.0 MHz

4.4 20dB Bandwidth

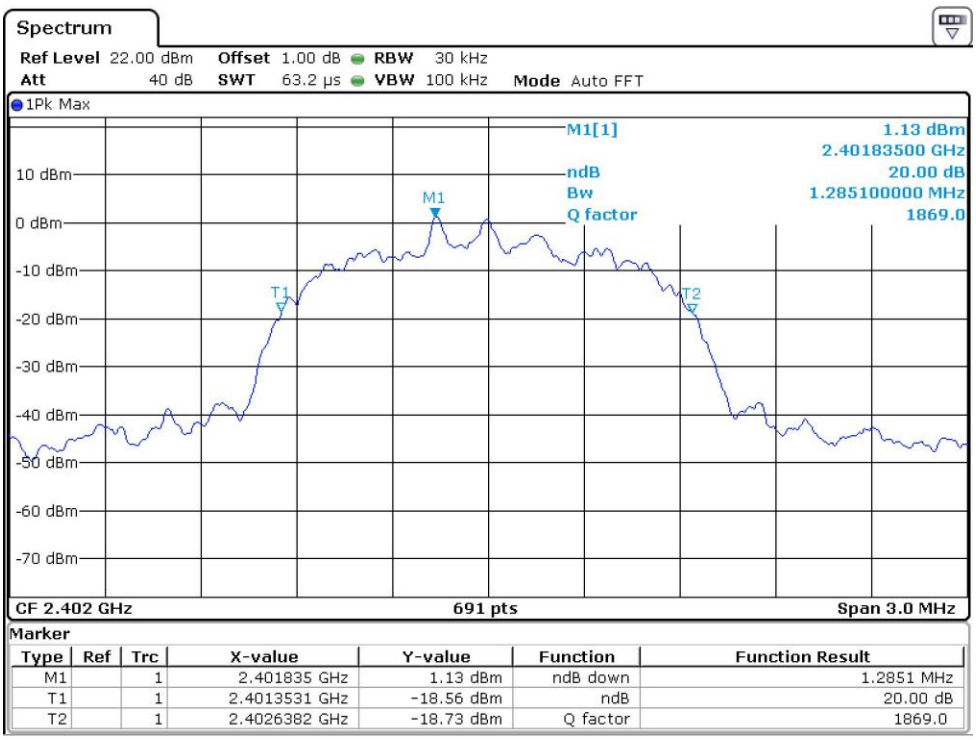
Maximum 20dB RF Bandwidth, FCC Rule 15.247(a) (1):

The antenna port of the EUT was connected to the input of a spectrum analyzer. Analyzer RBW was chosen so that the display was a result of the hopping channel modulation. For each RF output channel investigated, the spectrum analyzer center frequency was set to the channel carrier. Use the spectrum 20dB down delta function to measure the bandwidth.

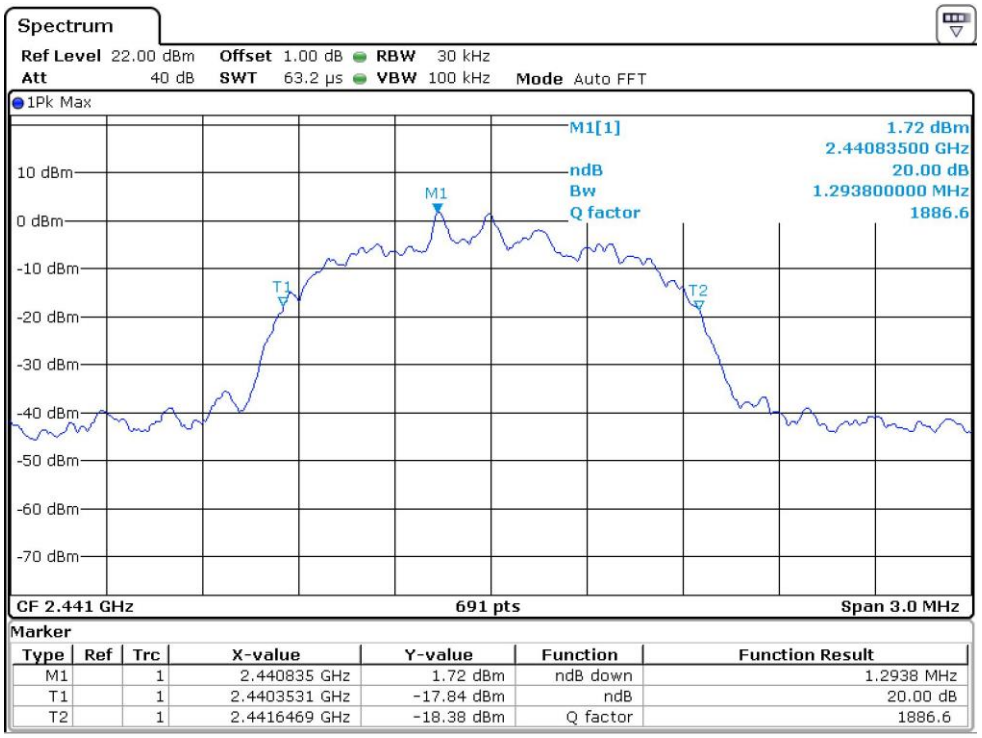
Frequency (MHz)	20 dB Bandwidth (MHz)
2402	1.2851
2441	1.2938
2480	1.2894

Modulation Type: GFSK

CH00



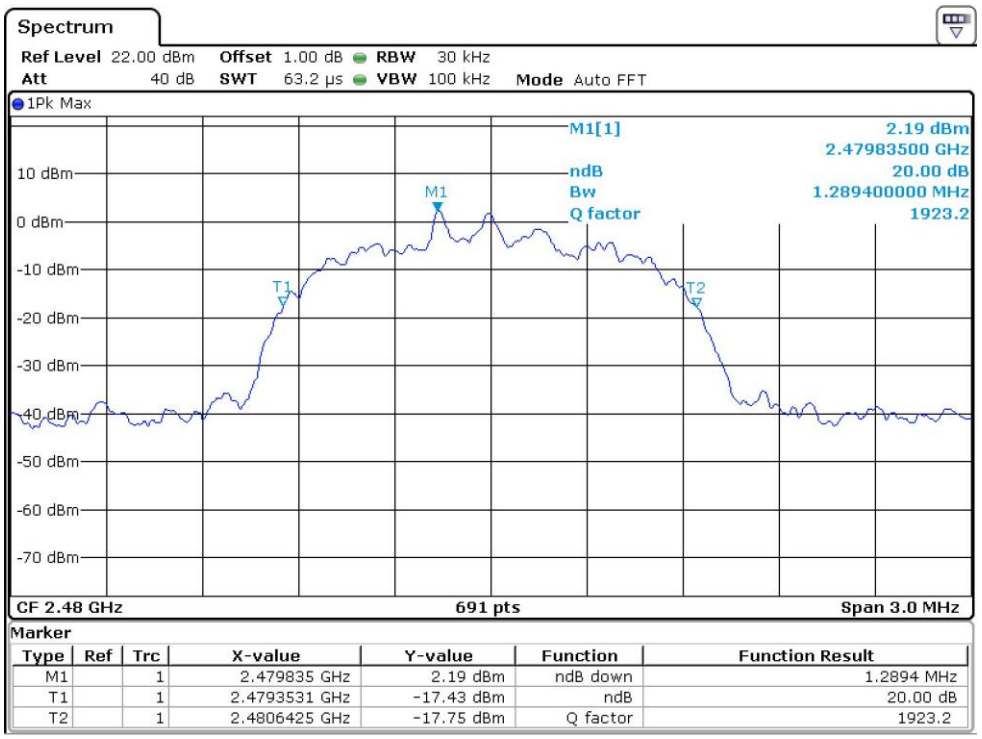
CH39



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.440835 GHz	1.72 dBm	ndB down	1.2938 MHz
T1		1	2.4403531 GHz	-17.84 dBm	ndB	20.00 dB
T2		1	2.4416469 GHz	-18.38 dBm	Q factor	1886.6

CH78



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.479835 GHz	2.19 dBm	ndB down	1.2894 MHz
T1		1	2.4793531 GHz	-17.43 dBm	ndB	20.00 dB
T2		1	2.4806425 GHz	-17.75 dBm	Q factor	1923.2

4.5 Channel Number (Number of Hopping Frequencies)

Minimum Number of Hopping Frequencies, FCC Rule 15.247(a) (1) (iii):

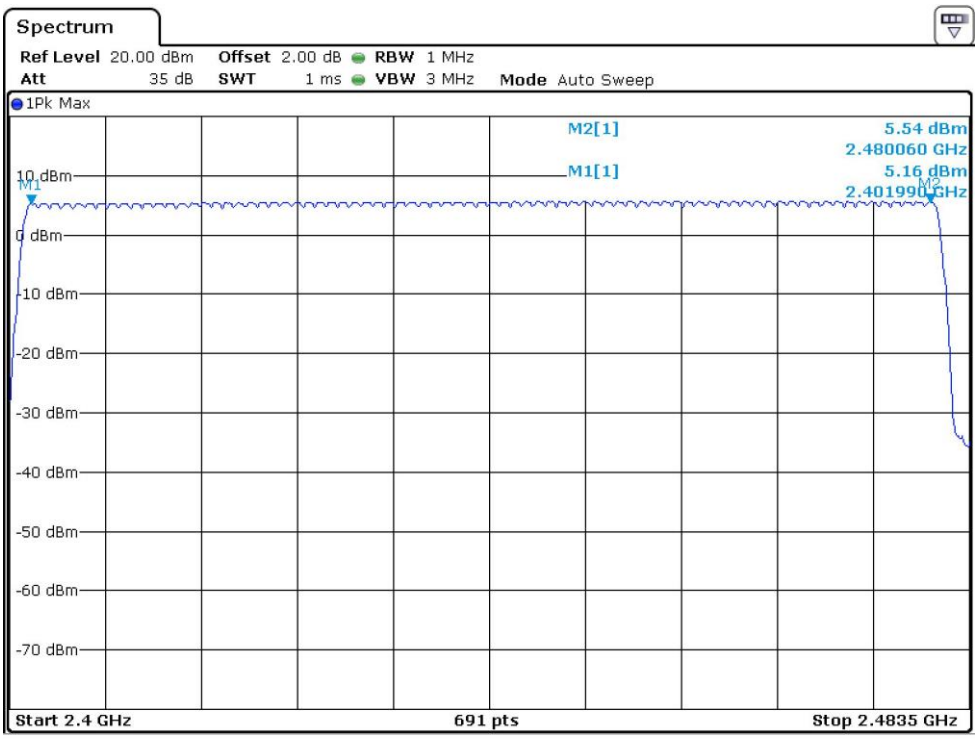
The RF passband of the EUT was divided into 3 approximately equal bands. With the analyzer set to MAX HOLD readings were taken for 2-3 minutes. The channel peaks so recorded were added together, and the total number compared to the minimum number of channels required in the regulation.

Number of hopping channels =	79

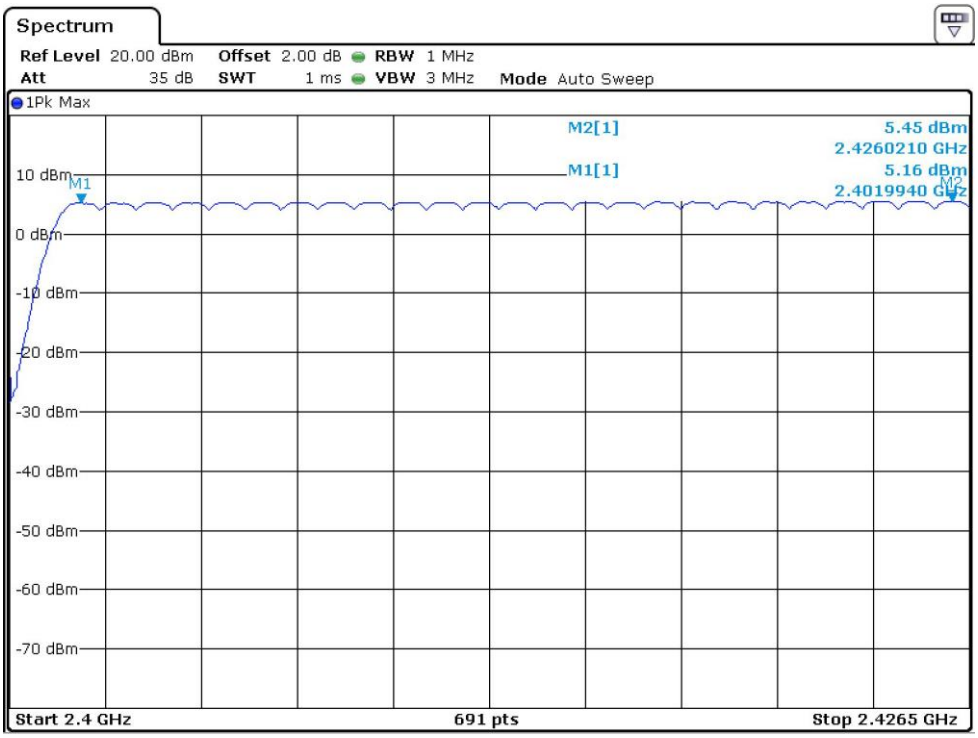
Note: In AFH mode, this device operates using 20 channels and it's satisfied the requirement of limit of minimum of 15 hopping channels.

Modulation Type: GFSK

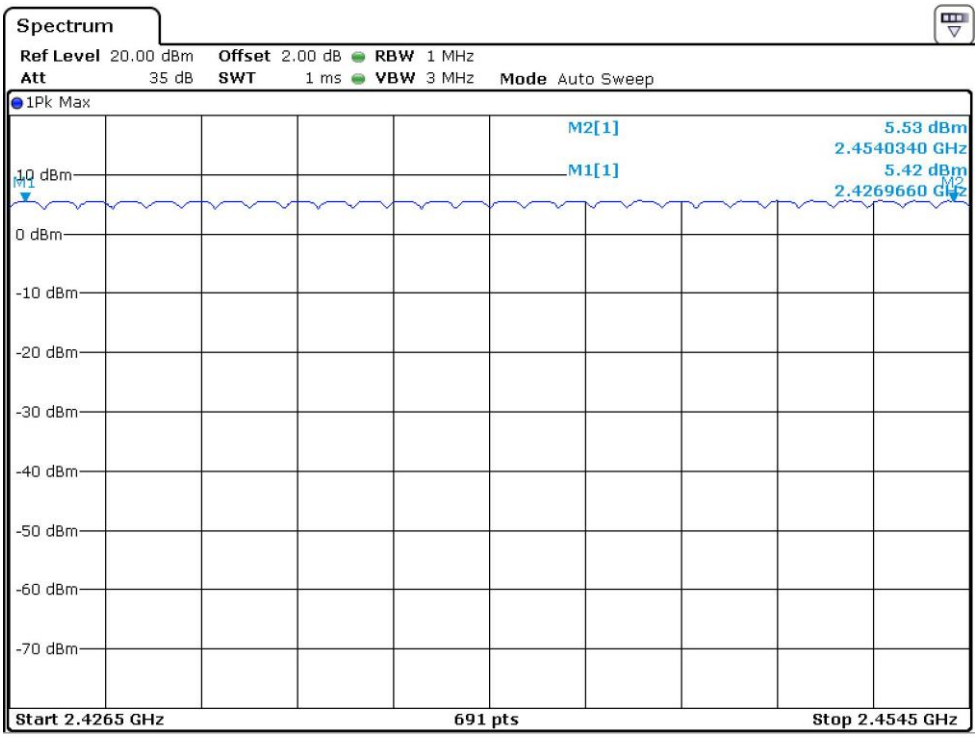
CH00-CH78



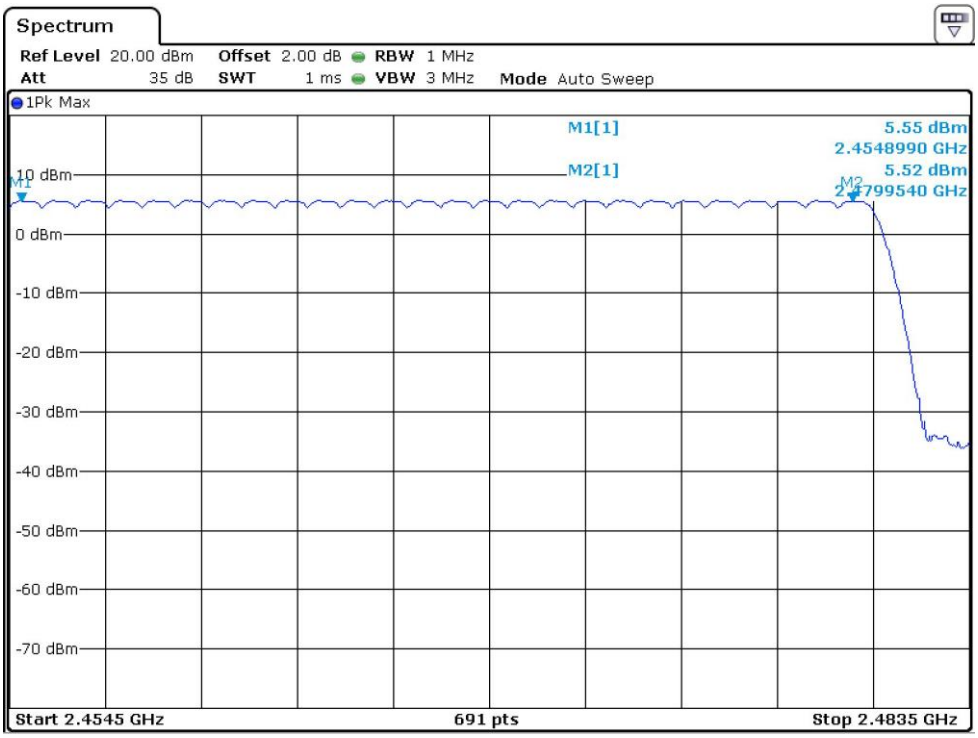
CH00-CH24



CH25-CH52



CH53-CH78


Spectrum
Ref Level 20.00 dBm Offset 2.00 dB RBW 1 MHz
Att 35 dB SWT 1 ms VBW 3 MHz Mode Auto Sweep
1Pk Max
M1[1] 5.55 dBm
2.4548990 GHz
M2[1] 5.52 dBm
2.4799540 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
Start 2.4545 GHz
691 pts
Stop 2.4835 GHz

4.6 Channel Separation (Carrier Frequency Separation)

Minimum Hopping Channel Carrier Frequency Separation, FCC Ref: 15.247(a)(1):

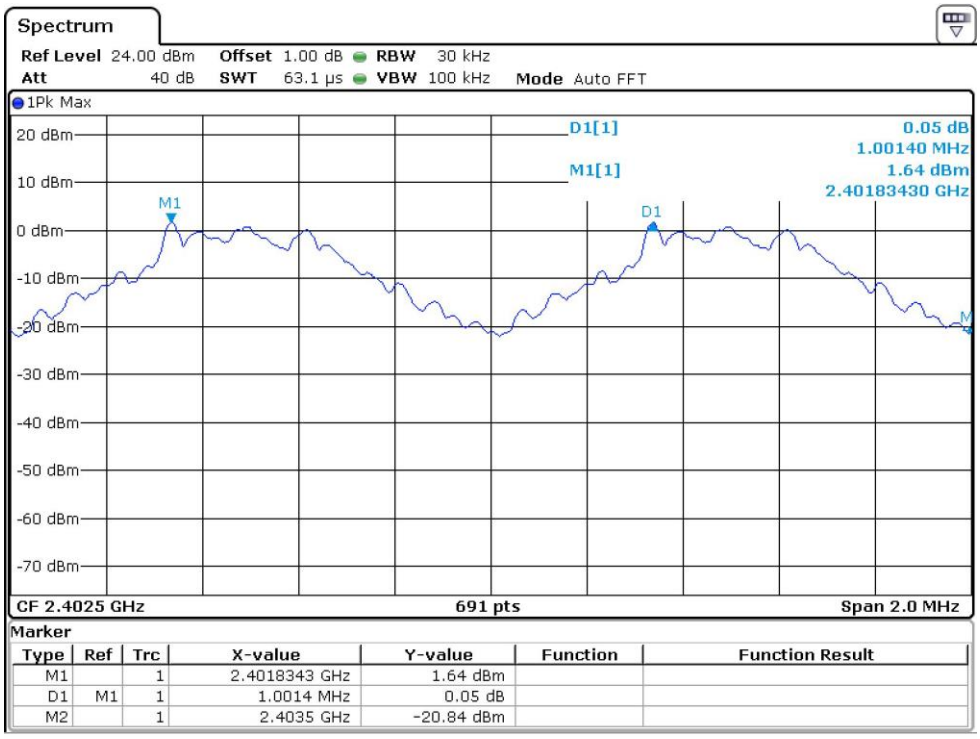
Using the DELTA MARKER function of the analyzer, the frequency separation between two adjacent channels was measured and compared against the limit:

Not less than 2/3 of 20dB bandwidth of hopping channel: 1.2938 x 2/3 = 0.863MHz

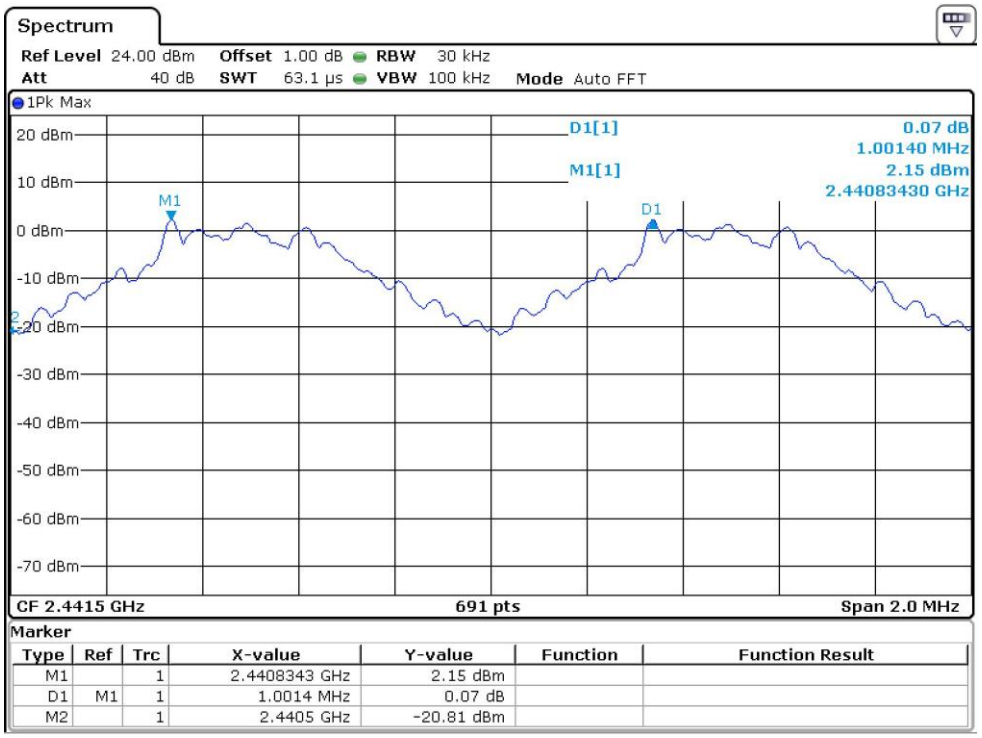
Modulation Type	Channel Number	Channel Frequency (MHz)	Channel Separation (MHz)	Limit (MHz)	Verdict
GFSK	0	2402	1.00140	>0.863	PASS
	39	2441	1.00140	>0.863	PASS
	78	2480	1.00140	>0.863	PASS

Modulation Type: GFSK

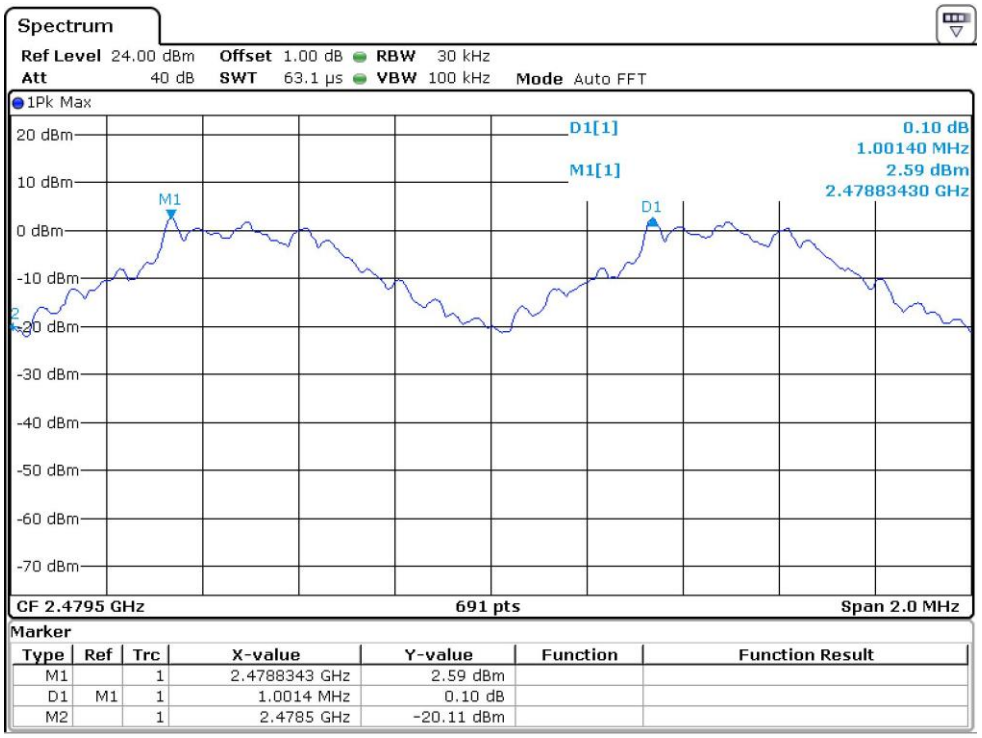
Low Channel



Middle Channel



High Channel



4.7 Dwell Time (Time of Occupancy)

Average Channel Occupancy Time, FCC Ref: 15.247(a) (1)(iii):

The spectrum analyzer center frequency was set to one of the known hopping channels with a longer sweep time to show two successive hops on a channel; the SPAN was set to ZERO SPAN, and the TRIGGER was set to VIDEO. RBW shall be ≤channel spacing and where possible RBW should be set >>1/T, where T is the expected dwell time per channel. The time duration of the transmissions so captured was measured with the MARKER DELTA function.

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Different modes of operation were performed and only the worst case data was reported.

Worst Test Result:

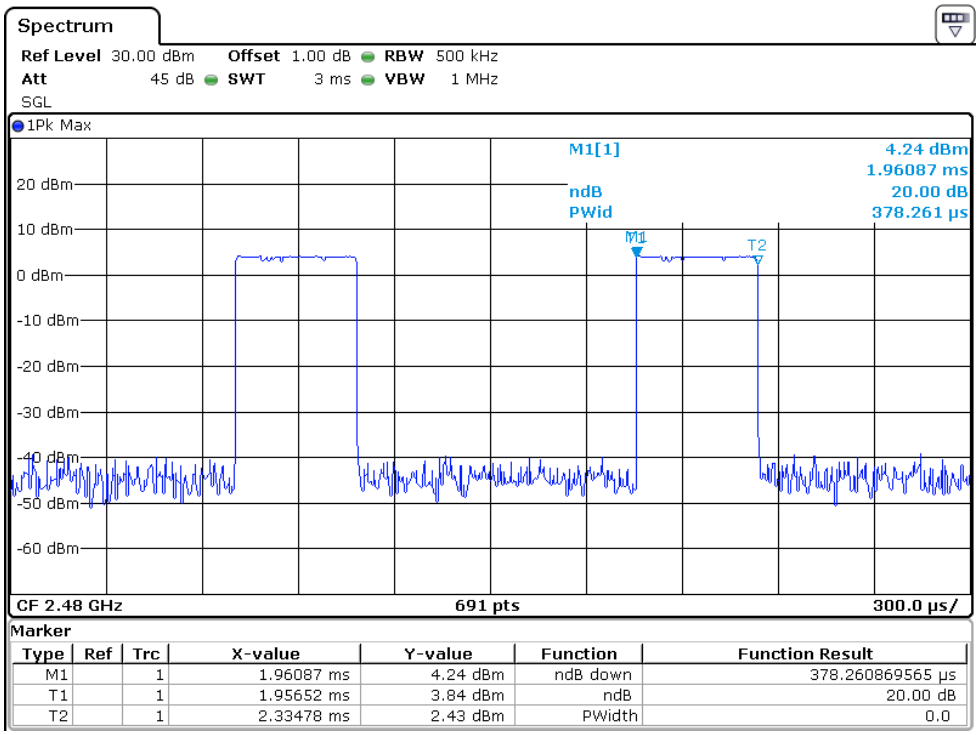
Normal hopping mode

Modulation Type	Packet	Max Dwell Time	Limit (s)	Result
GFSK	DH1	0.378ms * 889 = 336.042ms	0.4	Pass
	DH3	1.638 * 223= 365.274ms	0.4	Pass
	DH5	2.887ms * 95 = 274.265ms	0.4	Pass

AFH mode:

Modulation Type	Packet	Max Dwell Time	Limit (s)	Result
GFSK	DH1	0.378ms * 130 = 49.14ms	0.4	Pass
	DH3	1.638ms * 82 = 134.316ms	0.4	Pass
	DH5	2.887ms * 61 = 176.107ms	0.4	Pass

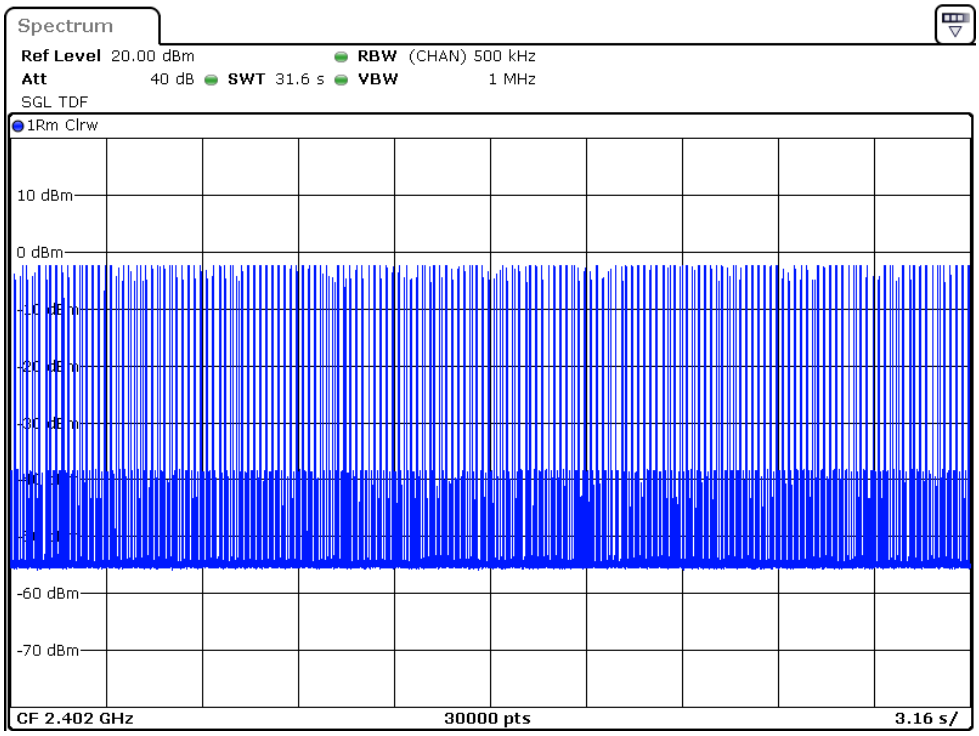
Modulation Type: GFSK
Packet: DH1



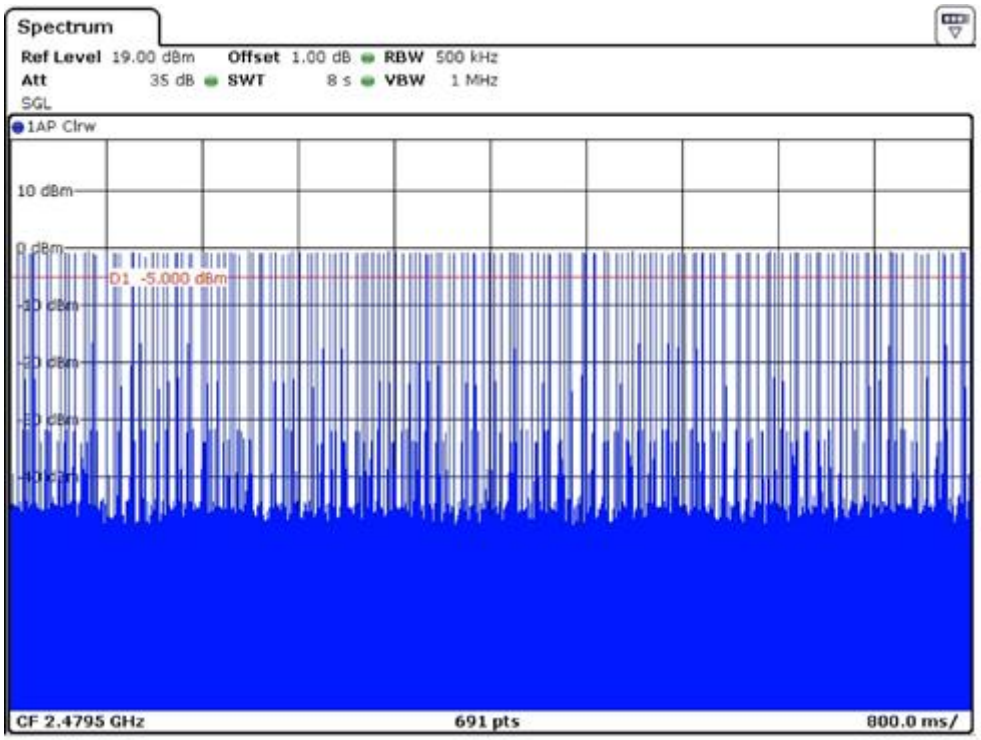
Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	1.96087 ms	4.24 dBm	ndB down	378.260869565 µs
T1		1	1.95652 ms	3.84 dBm	ndB	20.00 dB
T2		1	2.33478 ms	2.43 dBm	PWidth	0.0

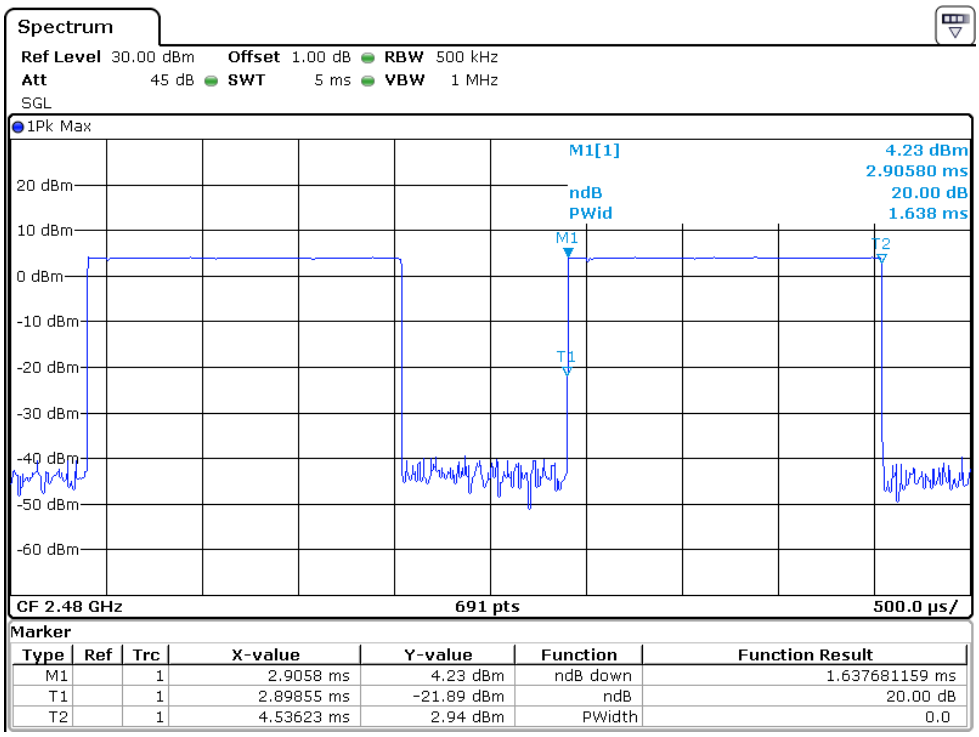
Number of hops (Normal hopping mode)



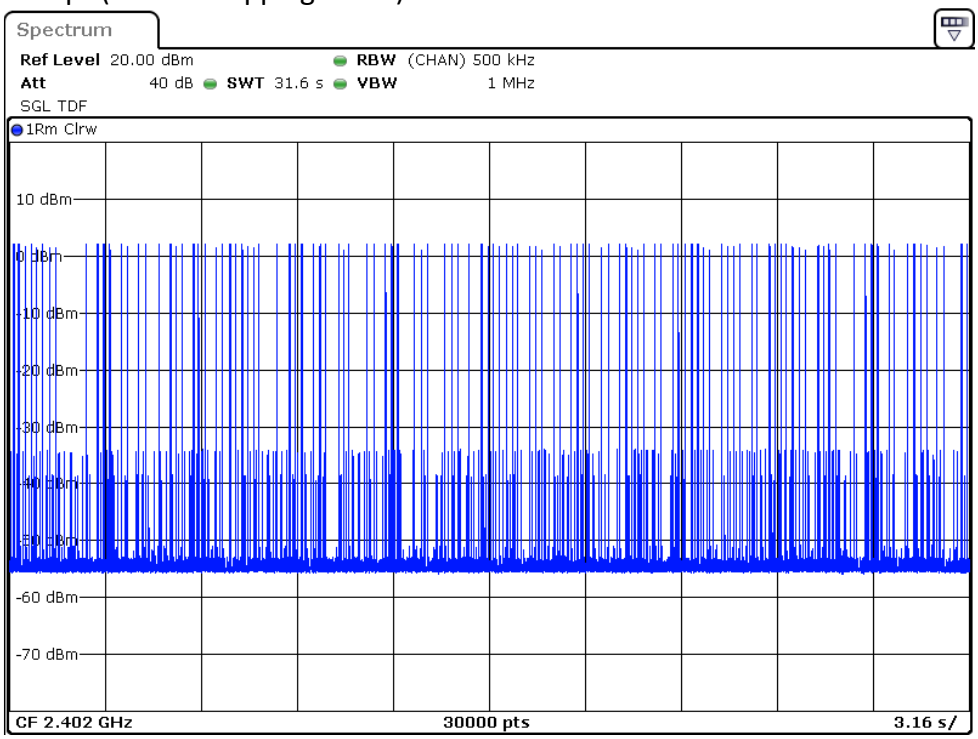
Number of hops (AFH mode)



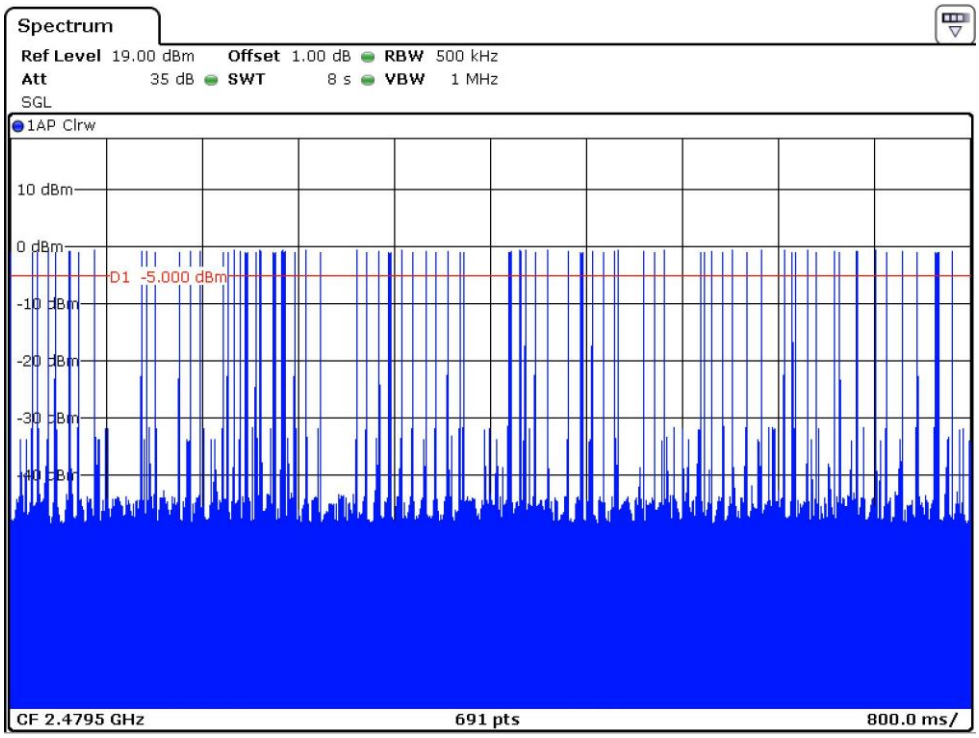
Packet: DH3



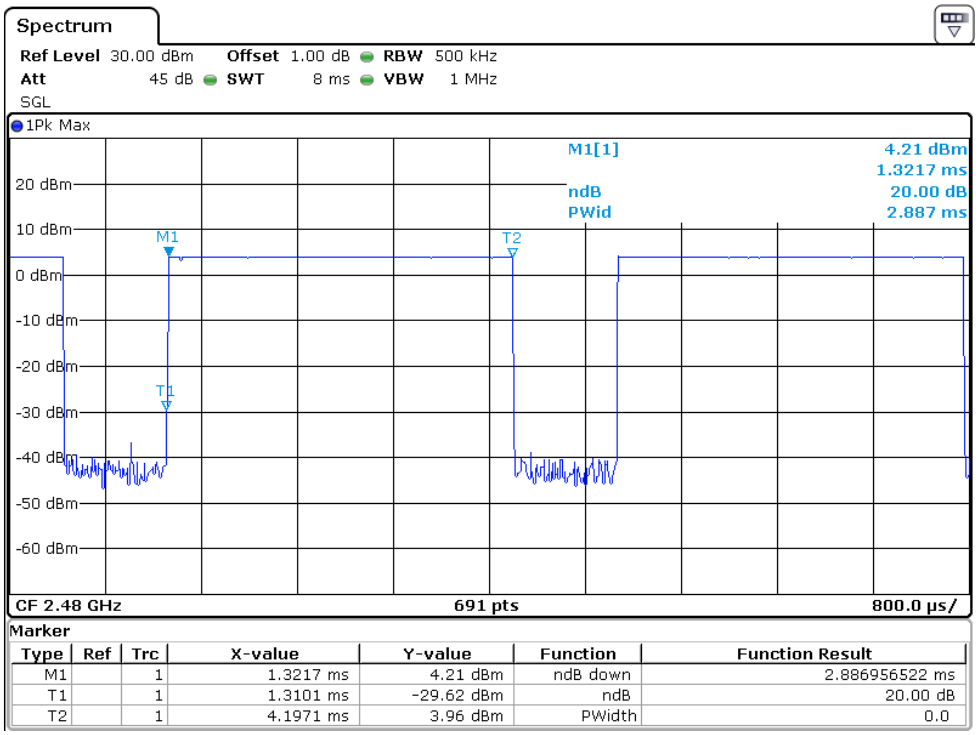
Number of hops (Normal hopping mode)



Number of hops (AFH mode)



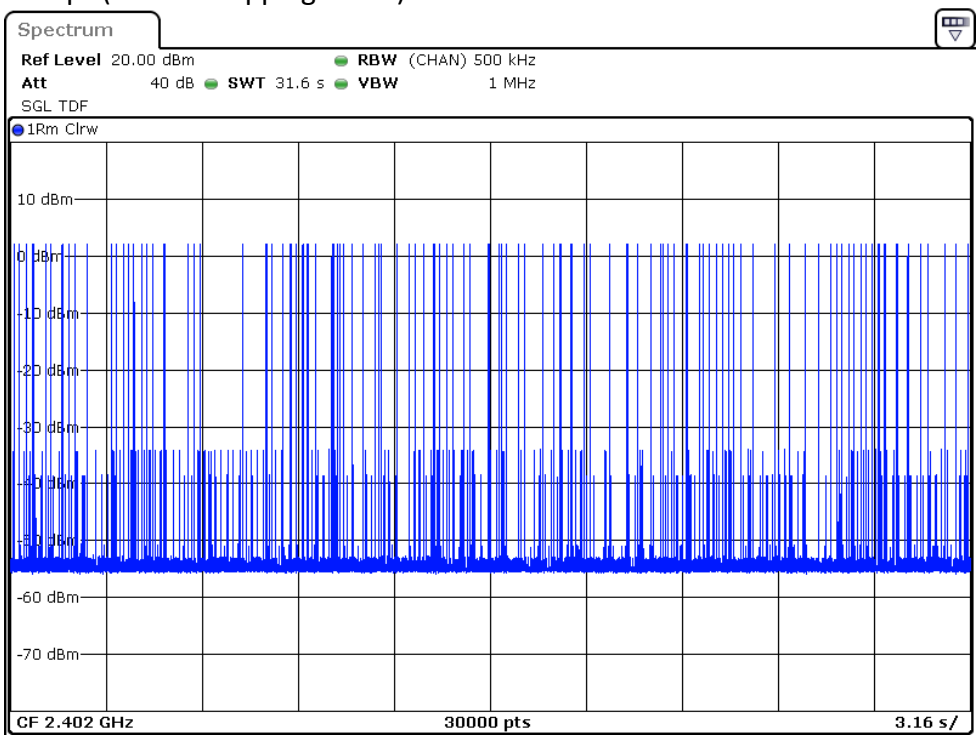
Packet: DH5



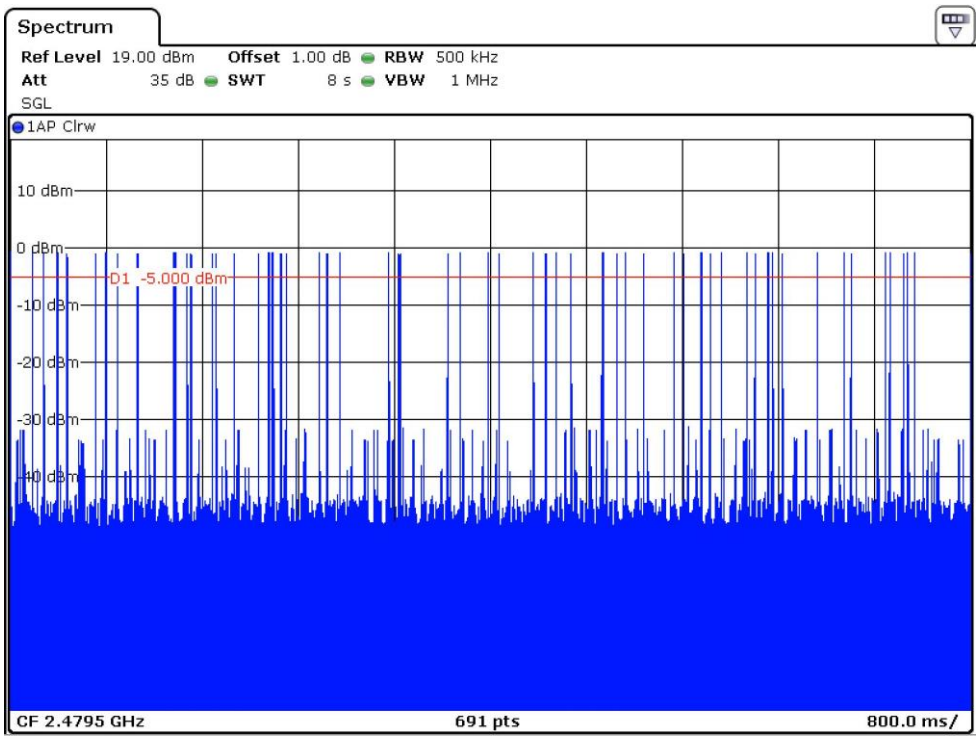
Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	1.3217 ms	4.21 dBm	ndB down	2.886956522 ms
T1		1	1.3101 ms	-29.62 dBm	ndB	20.00 dB
T2		1	4.1971 ms	3.96 dBm	PWidth	0.0

Number of hops (Normal hopping mode)



Number of hops (AFH mode)



4.8 Band Edge

Out of Band Conducted Emissions, FCC Rule 15.247(d):

In any 100 KHz bandwidth outside the EUT passband, the RF power produced by the modulation products of the spreading sequence, the information sequence, and the carrier frequency shall be at least 20 dB below that of the maximum in-band 100 kHz emission, or else shall meet the general limits for radiated emissions at frequencies outside the passband, whichever results in lower attenuation.

Furthermore, delta measurement technique for measuring bandage emissions was shown as below:

(i) Lower channel 2402MHz:

Peak Resultant field strength = Fundamental emissions (peak value) – delta from the bandedge plot
= 103.2dBμv/m-35.65dB
= 67.55dBμv/m

Average Resultant field strength = Fundamental emissions (Average value) – delta from the bandedge plot
= 80.7dBμv/m-35.65dB
= 45.05dBμv/m

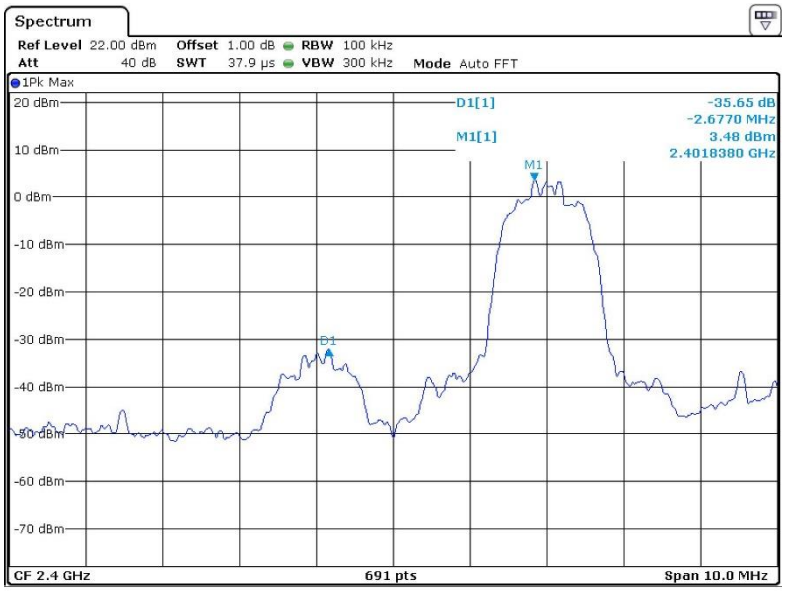
(ii) Upper channel 2480MHz:

Peak Resultant field strength = Fundamental emissions (peak value) – delta from the bandedge plot
= 101.2dBμv/m-43.61dB
= 57.59dBμv/m

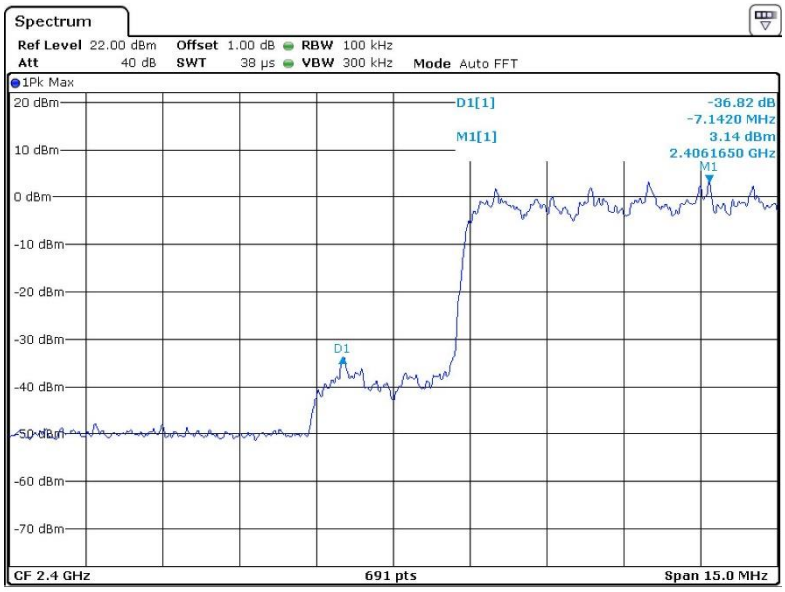
Average Resultant field strength = Fundamental emissions (Average value) – delta from the bandedge plot
= 78.7dBμv/m-43.61dB
= 35.09dBμv/m

The resultant field strength meets the general radiated emission limit in section 15.209, which does not exceed 74dBμv/m (Peak Limit) and 54dBμv/m (Average Limit).

Modulation Type: GFSK
Low channel:
Hopping function off

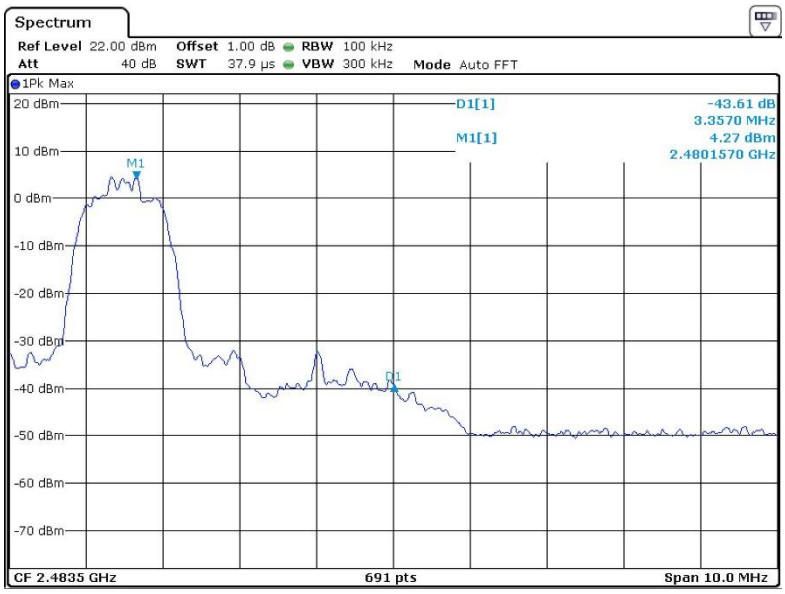


Hopping function On

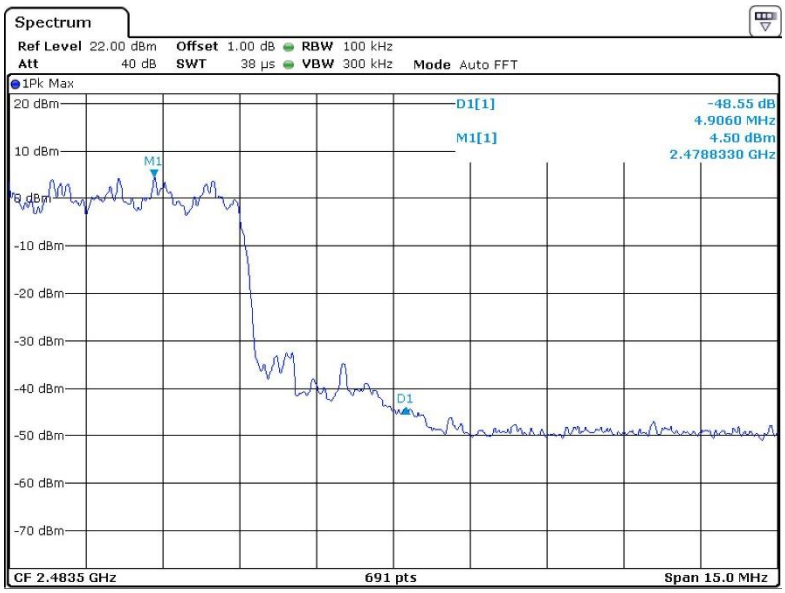


High channel:

Hopping function off



Hopping function On



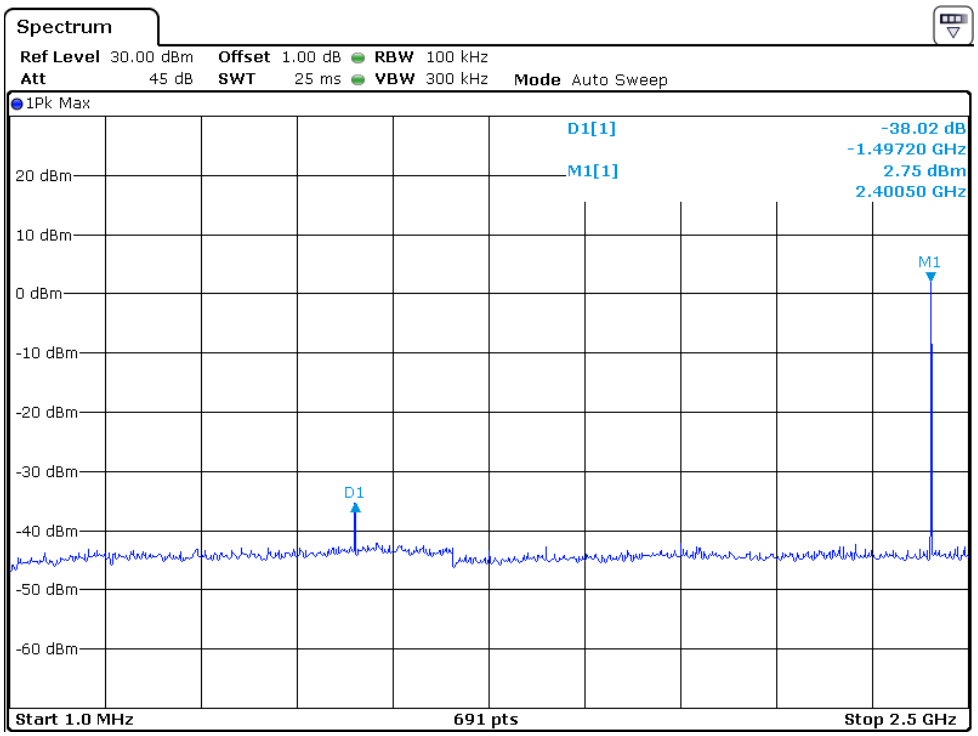
4.9 Transmitter Spurious Emissions (Conducted)

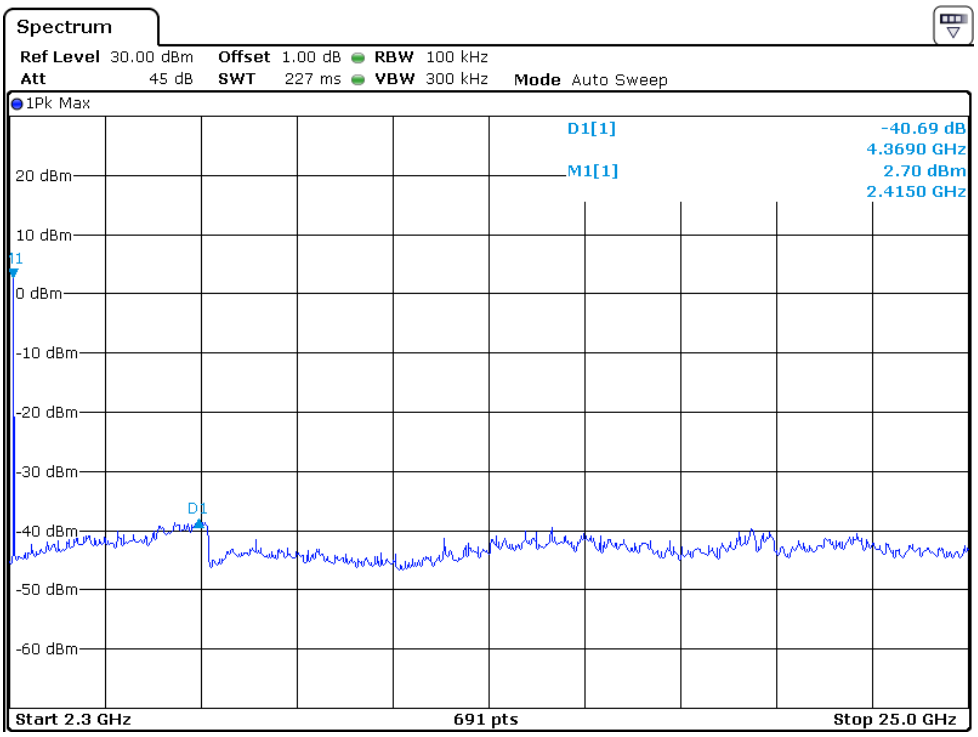
Out of Band Conducted Spurious Emissions, FCC Rule 15.247(d):

All spurious emission and up to the tenth harmonic was measured and they were found to be at least 20 dB below the highest level of the desired power in the passband.

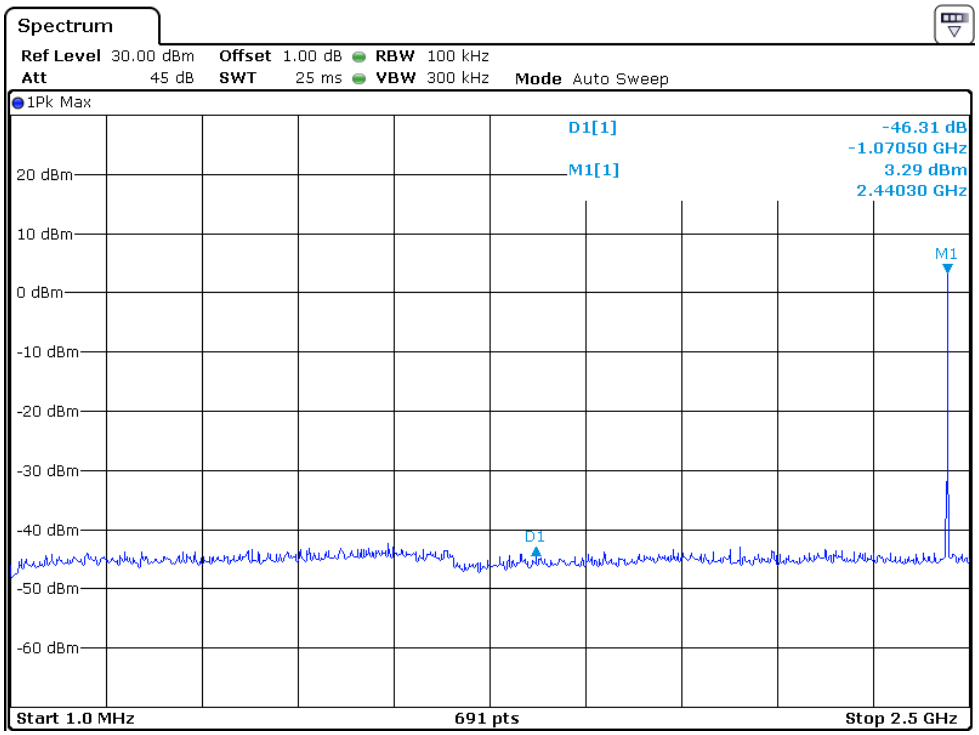
Modulation Type: GFSK

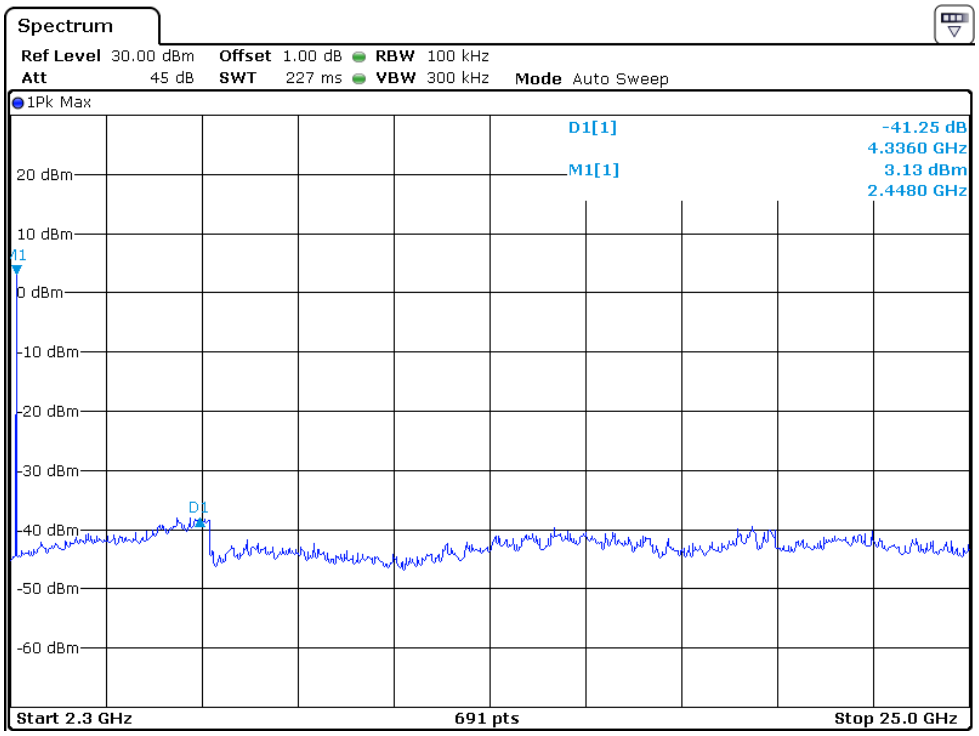
CH00



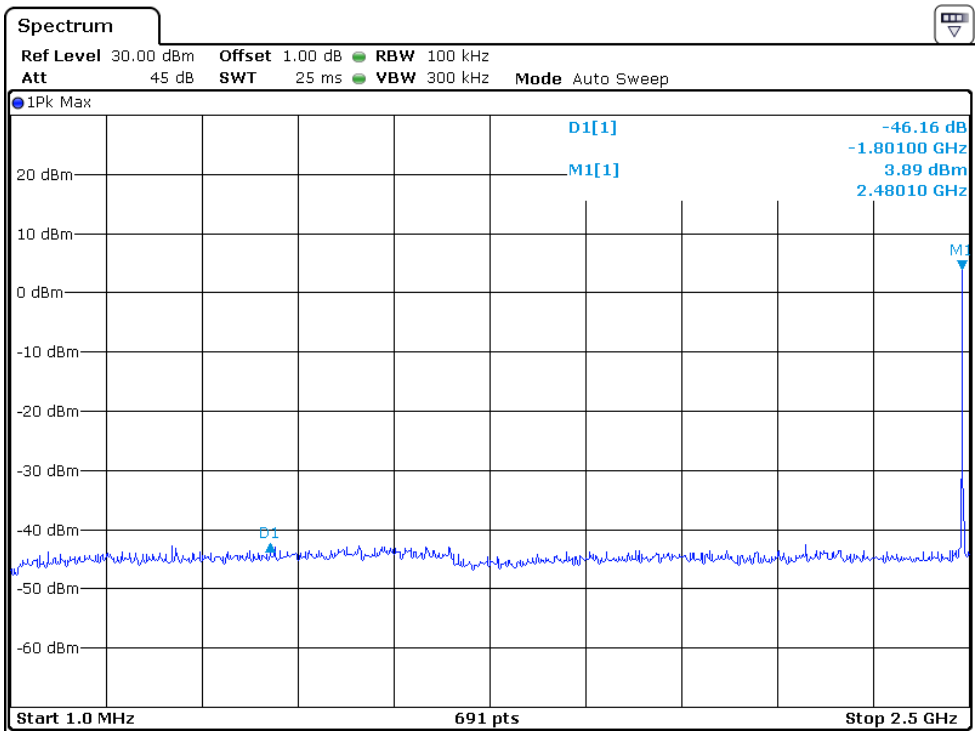


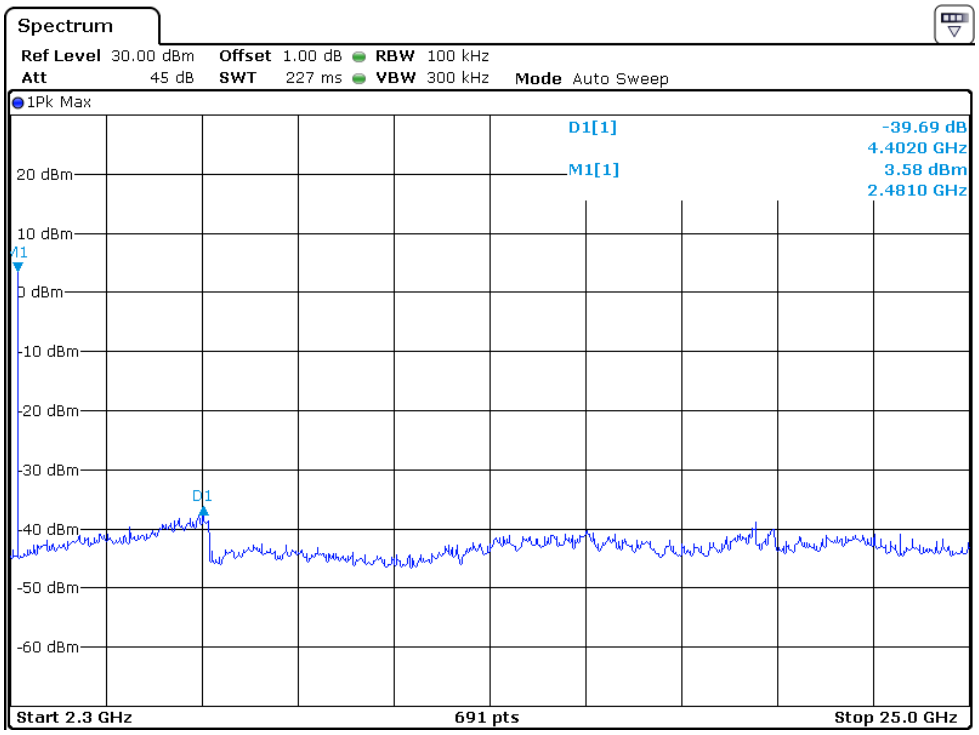
CH39


Spectrum
Ref Level 30.00 dBm Offset 1.00 dB RBW 100 kHz
Att 45 dB SWT 25 ms VBW 300 kHz Mode Auto Sweep
1Pk Max
D1[1] -46.31 dB
-1.07050 GHz
M1[1] 3.29 dBm
2.44030 GHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
M1
D1
Start 1.0 MHz
691 pts
Stop 2.5 GHz


Spectrum
Ref Level 30.00 dBm Offset 1.00 dB RBW 100 kHz
Att 45 dB SWT 227 ms VBW 300 kHz Mode Auto Sweep
1Pk Max
D1[1] -41.25 dB
4.3360 GHz
M1[1] 3.13 dBm
2.4480 GHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
M1
D1
Start 2.3 GHz
691 pts
Stop 25.0 GHz

CH78


Spectrum
Ref Level 30.00 dBm Offset 1.00 dB RBW 100 kHz
Att 45 dB SWT 25 ms VBW 300 kHz Mode Auto Sweep
1Pk Max
D1[1] -46.16 dB
-1.80100 GHz
M1[1] 3.89 dBm
2.48010 GHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
D1
M1
Start 1.0 MHz
691 pts
Stop 2.5 GHz


Spectrum
Ref Level 30.00 dBm Offset 1.00 dB RBW 100 kHz
Att 45 dB SWT 227 ms VBW 300 kHz Mode Auto Sweep
1Pk Max
D1[1] -39.69 dB
4.4020 GHz
M1[1] 3.58 dBm
2.4810 GHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
D1
M1
Start 2.3 GHz
691 pts
Stop 25.0 GHz

5.0 Equipment Photographs

For electronic filing, the photographs of the tested EUT are saved with filename: external photos.pdf & internal photos.pdf.

6.0 Product Labelling

For electronic filing, the FCC ID label artwork and the label location are saved with filename: label.pdf.

7.0 Technical Specifications

For electronic filing, the block diagram and schematics of the tested EUT are saved with filename: block.pdf and circuit.pdf respectively.

8.0 Instruction Manual

For electronic filing, a preliminary copy of the Instruction Manual is saved with filename: manual.pdf.

This manual will be provided to the end-user with each unit sold/leased in the United States.

9.0 Miscellaneous Information

This miscellaneous information includes details of the measured bandedge, the test procedure and calculation of factor such as pulse desensitization.

9.1 Discussion of Pulse Desensitization

Pulse desensitivity is not applicable for this device. The effective period (T_{eff}) is approximately 625µs for Bluetooth. With a resolution bandwidth (3dB) of 1MHz, so the pulse desensitivity factor is 0dB.

9.2 Calculation of Average Factor

Based on the Bluetooth Specification Version 5.1 (EDR mode) and worst case AFH mode, transmitter ON time is independent of packet type (DH1, DH3 and DH5) and packet length, the AFH mode Duty cycle connection factor as below:

Channel hop rate = 800 hops/second (AFH Mode)

Adjusted channel hop rate for DH5 mode = 133.33 hops/second

Time per channel hop = 1 / 133.33 hops/second = 7.5 ms

Time to cycle through all channels = 7.5 x 20 channels = 150 ms

Number of times transmitter hits on one channel = 100 ms / 150 ms = 1 time(s)

Worst case dwell time = 7.5 ms

Duty cycle connection factor = 20log10 (7.5ms / 100ms) = -22.5 dB

9.3 Emissions Test Procedures

The following is a description of the test procedure used by Intertek Testing Services in the measurements of transmitters operating under Part 15, Subpart C rules.

The test set-up and procedures described below are designed to meet the requirements of ANSI C63.10: 2013.

The transmitting equipment under test (EUT) is placed on a styrene turntable which is four feet in diameter, up to 1GHz 0.8m and above 1GHz 1.5m in height above the ground plane. During the radiated emissions test, the turntable is rotated and any cables leaving the EUT are manipulated to find the configuration resulting in maximum emissions. The EUT is adjust through all three orthogonal axes to obtain maximum emission levels. The antenna height and polarization are varied during the testing to search for maximum signal levels.

Detector function for radiated emissions is in peak mode. Average readings, when required, are taken by measuring the duty cycle of the equipment under test and subtracting the corresponding amount in dB from the measured peak readings. A detailed description for the calculation of the average factor can be found in section 9.2.

The frequency range scanned is from the lowest radio frequency signal generated in the device which is greater than 9 kHz to the tenth harmonic of the highest fundamental frequency or 40 GHz, whichever is lower. For line conducted emissions, the range scanned is 150 kHz to 30 MHz with RBW 9KHz used.

9.3 Emissions Test Procedures (cont'd)

The EUT is warmed up for 15 minutes prior to the test.

AC power to the unit is varied from 85% to 115% nominal and variation in the fundamental emission field strength is recorded. If battery powered, a new, fully charged battery is used.

Conducted measurements are made as described in ANSI C63.10: 2013.

The IF bandwidth used for measurement of radiated signal strength was 10 kHz for emission below 30 MHz and 120 kHz for emission from 30 MHz to 1000 MHz. Where pulsed transmissions of short enough pulse duration warrant, a greater bandwidth is selected according to the recommendations of Hewlett Packard Application Note 150-2. Above 1000 MHz, a resolution bandwidth of 1 MHz is used (RBW 3MHz used for fundamental emission).

Transmitter measurements are normally conducted at a measurement distance of three meters. However, to assure low enough noise floor in the restricted bands and above 1 GHz, signals are acquired at a distance of one meter or less. All measurements are extrapolated to three meters using inverse scaling, but those measurements taken at a closer distance are so marked.

10 Test Equipment List

Equipment No.	Equipment	Manufacturer	Model No.	Serial No.	Cal. Date	Due Date
SZ061-12	BiConiLog Antenna	ETS	3142E	00166158	2021-08-04	2024-08-04
SZ185-02	EMI Receiver	R&S	ESCI	100547	2021-07-12	2022-07-12
SZ061-08	Horn Antenna	ETS	3115	00092346	2021-09-05	2024-09-05
SZ061-06	Active Loop Antenna	Electro-Metrics	EM-6876	217	2021-05-18	2023-05-18
SZ056-03	Spectrum Analyzer	R&S	FSP 30	101148	2021-05-10	2022-05-10
SZ056-06	Signal Analyzer	R&S	FSV 40	101101	2020-12-22	2021-12-22
SZ181-04	Preamplifier	Agilent	8449B	3008A02474	2021-05-10	2022-05-10
SZ188-01	Anechoic Chamber	ETS	RFD-F/A-100	4102	2018-12-15	2021-12-15
SZ062-24	RF Cable	RADIALL	SF104PE	--	2021-10-26	2022-10-26
SZ062-25	RF Cable	RADIALL	SF104PE	--	2021-10-26	2022-10-26
SZ062-38	RF Cable	RADIALL	A50-3.5M3.5M-8M	--	2021-06-04	2022-06-04
SZ067-04	Notch Filter	Micro-Tronics	BRM50702-02	--	2021-05-11	2022-05-11
SZ185-02	EMI Test Receiver	R&S	ESCI	100692	2021-07-12	2022-07-12
SZ187-01	Two-Line V-Network	R&S	ENV216	100072	2021-11-02	2022-11-02
SZ187-02	Two-Line V-Network	R&S	ENV216	100072	2021-05-12	2022-05-12
SZ062-16	RF Cable	HUBER+SUHNER	CBL2-BN-1m	110127-2231000	2021-10-26	2022-10-26
SZ188-03	Shielding Room	ETS	RFD-100	4100	2020-01-07	2023-01-07

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