

FCC/IC TEST REPORT

Test report No.: EMC- FCC- R0146
FCC ID: TQ8-AM111A9GG
IC: 5074A-AM111A9GG
Type of equipment: DIGITAL CAR AUDIO SYSTEM
Basic Model Name: AM111A9GG
Variant Model Name: AM113A9GG, AM111A9GN, AM111A9GE,
AM111A9GL
Applicant: Hyundai Mobis Co., Ltd.
Max.RF Output Power: 4.80 dBm
FCC Rule Part(s): FCC Part 15 Subpart C 15.247
IC Rule: RSS-210, RSS-GEN
Frequency Range: 2 402 MHz ~ 2 480 MHz
Test result: Complied

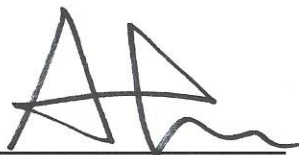
The above equipment was tested by EMC compliance Testing Laboratory for compliance with the requirements of FCC Rules and Regulations.

The results of testing in this report apply to the product/system which was tested only. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

Date of test: 2014. 02. 03 ~ 07

Issued date: 2014. 02. 10

Tested by:



AHN, BYUNG WOO

Approved by:



YU, SANG HOON

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1. Client information

Applicant: Hyundai Mobis Co., Ltd.
Address: 203, Teheran-ro, Gangnam-gu, Seoul, Korea (135-977)
Telephone number: +82-31-260-0098
Facsimile number: +82-31-899-1788
Contact person: Seung-Hoon Choe / csh@mobis.co.kr

Manufacturer: Hyundai Mobis Co., Ltd.
Address: 69-23, Hansam-Ro, Ducksan-Myeon, Jinchun-Gun,
Chungcheongbuk-Do 365-843 Korea

2. Laboratory information

Address

EMC compliance Ltd.

65, Sinwon-ro, Yeongtong-gu, Suwon- si, Gyeonggi-do, 443-390, Korea

Telephone Number: 82-31-336-9919 Facsimile Number: 82-505-299-8311

Certificate

KOLAS No.: 231

FCC Site Registration No.: 687132

VCCI Site Registration No.: R-3327, G-198, C-3706, T-1849

IC Site Registration No.:8035A-2

SITE MAP



EMC compliance Ltd.

65, Sinwon-ro, Yeongtong-gu, Suwon- si, Gyeonggi-do, 443-390, Korea

82-31-336-9919 (Main) 82-505-299-8311 (Fax)

3. Description of E.U.T.

3.1 Basic description

| | |
|-------------------------|--|
| Applicant | Hyundai Mobis Co., Ltd. |
| Address of Applicant | 203, Teheran-ro, Gangnam-gu, Seoul, Korea (135-977) |
| Manufacturer | Hyundai Mobis Co., Ltd. |
| Address of Manufacturer | 69-23, Hansam-Ro, Ducksan-Myeon, Jinchun-Gun, Chungcheongbuk-Do 365-843 Korea |
| Type of equipment | DIGITAL CAR AUDIO SYSTEM |
| Basic Model | AM111A9GG |
| Variant Model* | AM113A9GG, AM111A9GN, AM111A9GE, AM111A9GL |
| Serial number | Proto Type |

* Variant model names are different only for the marketing area, and all model names are electrically identical in construction, radio characteristics, and features.

3.2 General description

| | |
|--------------------|--|
| Frequency Range | 2 402 MHz ~ 2 480 MHz |
| Type of Modulation | Modulation technologies: FHSS Modulation : GFSK, $\pi/4$ DQPSK, 8DPSK |
| Number of Channels | 79 channels |
| Type of Antenna | Integral type |
| Antenna Gain | 3.5 dBi |
| Transmit Power | 4.80 dBm |
| Power supply | DC 14.4 V |

3.3 Test frequency

| | Frequency |
|------------------|-----------|
| Low frequency | 2 402 MHz |
| Middle frequency | 2 441 MHz |
| High frequency | 2 480 MHz |

3.4 Test Voltage

| mode | Voltage |
|------------------|-----------|
| Norminal voltage | DC 14.4 V |

※ 15.247 Requirements for Bluetooth transmitter

- This Bluetooth module has been tested by a Bluetooth Qualification Lab, and we confirm the following:
 - 1) This system is hopping pseudo-randomly.
 - 2) Each frequency is used equally on the average by each transmitter.
 - 3) The receiver input bandwidths that match the hopping channel bandwidths of their corresponding transmitters
 - 4) The receiver shifts frequencies in synchronization with the transmitted signals.
- 15.247(g): The system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this Section 15.247 should the transmitter be presented with a continuous data (or information) stream.
- 15.247(h): The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

4. Summary of test results

4.1 Standards & results

| FCC Rule | IC Rule | Parameter | Report Section | Test Result |
|--|--|---|----------------|-------------|
| 15.203, 15.247(b)(4) | RSS-GEN, 7.1.2 | Antenna Requirement | 5.1 | C |
| 15.247(b)(1), (4) | RSS-210, A8.4(2) | Maximum Peak Output Power | 5.2 | C |
| 15.247(a)(1) | RSS-210, A8.1(b) | Carrier Frequency Separation | 5.3 | C |
| 15.247(a)(1) | RSS-210, A8.1(a) | 20dB Channel Bandwidth | 5.4 | C |
| - | RSS-210, A1.1 | Occupied Bandwidth | 5.4 | C |
| 15.247(a)(iii) 15.247(b)(1) | RSS-210, A8.1(d) | Number of Hopping Channel | 5.5 | C |
| 15.247(a)(iii) | RSS-210, A8.1(d) | Time of Occupancy(Dwell Time) | 5.6 | C |
| 15.247(d), 15.205(a), 15.209(a) | RSS-210, A8.5 RSS-210, A2.9 RSS-GEN, 7.2.3 | Spurious Emission, BandEdge, Restricted Band | 5.7 | C |
| 15.247(i), 1.1307(b)(1) | - | RF Exposure | 5.8 | C |
| Note: C=complies NC= Not complies NT=Not tested NA=Not Applicable | | | | |

* The method of measurement used to test this DSS device is FCC Public Notice DA 00-705

* The general test methods used to test this device is ANSI C63.4 2003 (or 2009, or ANSI C63.10 2009)

4.2 Uncertainty

| Measurement Item | Combined Standard Uncertainty Uc | Expanded Uncertainty U = KUc (K = 2) |
|----------------------|---|---|
| Conducted RF power | ± 0.29 dB | ± 0.58 dB |
| Radiated disturbance | 30 MHz ~ 300 MHz : + 2.43 dB, - 2.44 dB 300 MHz ~ 1 000 MHz : + 2.49dB, - 2.50 dB 1 GHz ~ 6 GHz : + 3.10 dB, - 3.10 dB 6 GHz ~ 18 GHz : + 3.21 dB, - 3.27 dB | 30 MHz ~ 300 MHz : + 4.86 dB, - 4.88 dB 300 MHz ~ 1 000 MHz : + 4.98dB, - 4.99 dB 1 GHz ~ 6 GHz : + 6.19 dB, - 6.20 dB 6 GHz ~ 18 GHz : + 6.41 dB, - 6.53 dB |

5. Test results

5.1 Antenna Requirement

5.1.1 Regulation

According to §15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

And according to §15.247(b)(4), the conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

5.1.2 Result

-Complied

The transmitter has an integral type of antenna. The directional gain of the antenna is 3.5 dBi.

5.2 Maximum Peak Output Power

5.2.1 Regulation

According to §15.247(b)(1), for frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

According to §15.247(b)(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

5.2.2 Measurement Procedure

The method of measurement used to test this DSS device is FCC Public Notice DA 00-705.

1. Check the calibration of the measuring instrument (spectrum analyzer) using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface or Bluetooth tester and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer as follows: Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel RBW > the 20 dB bandwidth of the emission being measured VBW ≥ RBW Sweep = auto Detector function = peak Trace = max hold
5. Measure the highest amplitude appearing on spectral display and record the level to calculate results.
6. Repeat above procedures until all frequencies measured were complete.

5.2.3 Test Result

- Complied

* GFSK

| Channel | Frequency (MHz) | Result (dBm) | Limit (dBm) | Margin (dB) |
|---------|-----------------|--------------|-------------|-------------|
| Low | 2 402 | 3.50 | 30.00 | 26.50 |
| Middle | 2 441 | 2.43 | 30.00 | 27.57 |
| High | 2 480 | 2.56 | 30.00 | 27.44 |

* $\pi/4$ DQPSK

| Channel | Frequency (MHz) | Result (dBm) | Limit (dBm) | Margin (dB) |
|---------|-----------------|--------------|-------------|-------------|
| Low | 2 402 | 4.47 | 30.00 | 25.53 |
| Middle | 2 441 | 4.49 | 30.00 | 25.51 |
| High | 2 480 | 3.37 | 30.00 | 26.63 |

* 8DPSK

| Channel | Frequency (MHz) | Result (dBm) | Limit (dBm) | Margin (dB) |
|---------|-----------------|--------------|-------------|-------------|
| Low | 2 402 | 4.80 | 30.00 | 25.20 |
| Middle | 2 441 | 4.33 | 30.00 | 25.67 |
| High | 2 480 | 3.62 | 30.00 | 26.38 |

NOTE:

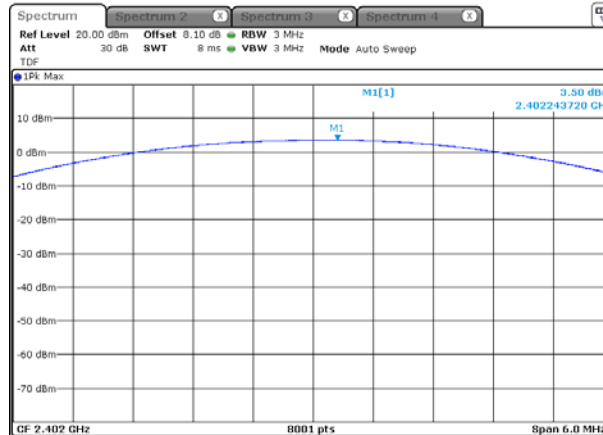
1. Since the directional gain of the integral antenna declared by the manufacturer ($G_{ANT} = 3.5$ dBi) does not exceed 6.0 dBi, there was no need to reduce the output power.
2. We took the insertion loss of the cable loss into consideration within the measuring instrument.

5.2.4 Test Plot

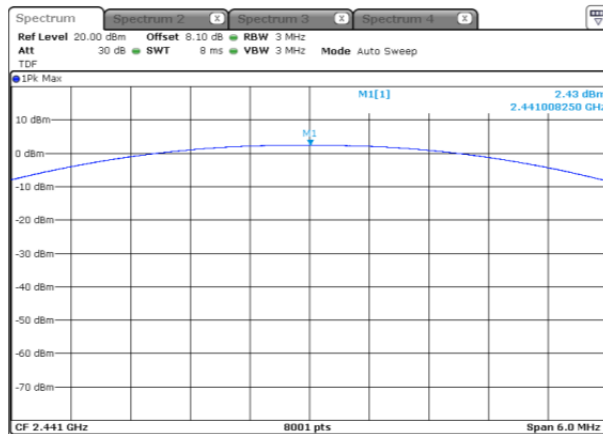
Figure 1. Plot of the Maximum Peak Output Power (Conducted)

* GFSK

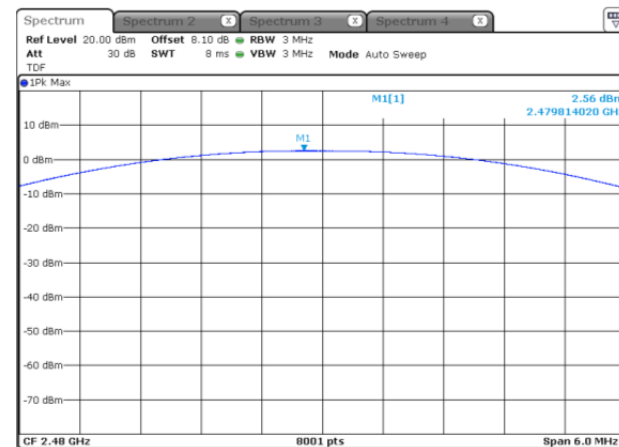
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

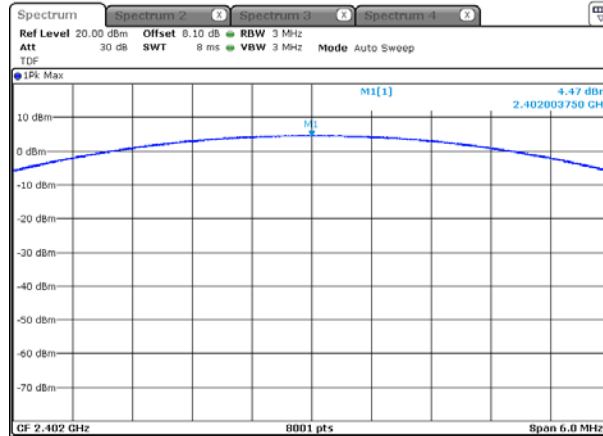


Highest Channel
(2 480 MHz)

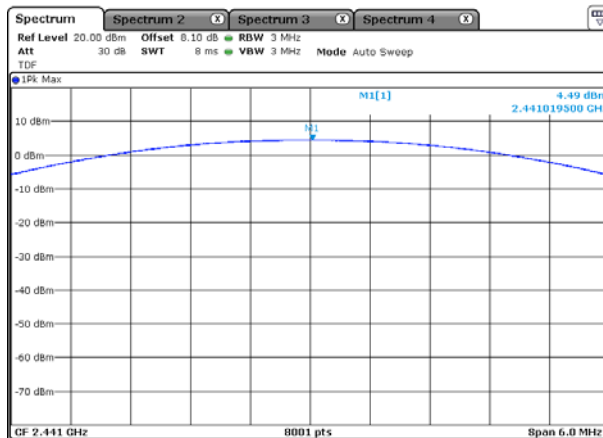


*** $\pi/4$ DQPSK**

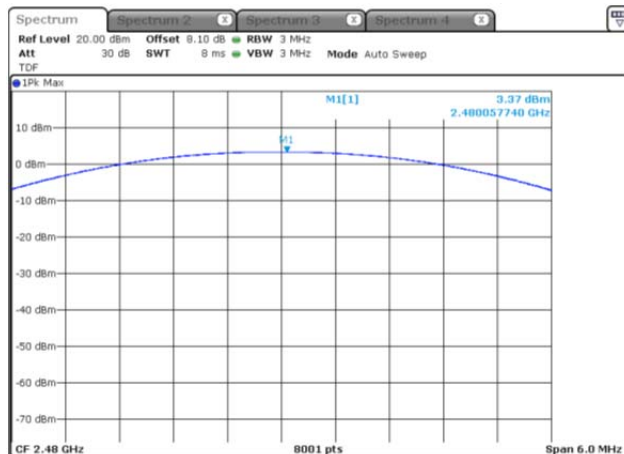
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

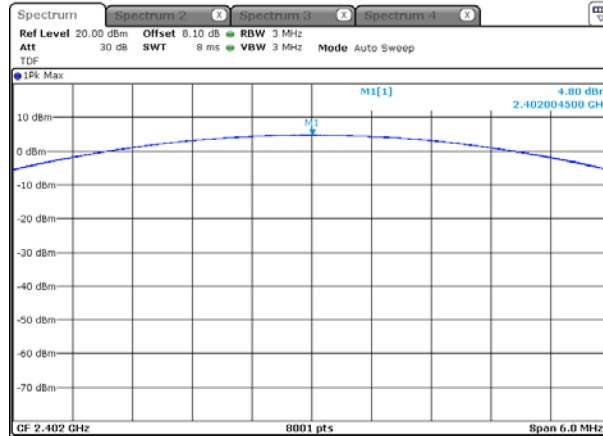


Highest Channel
(2 480 MHz)

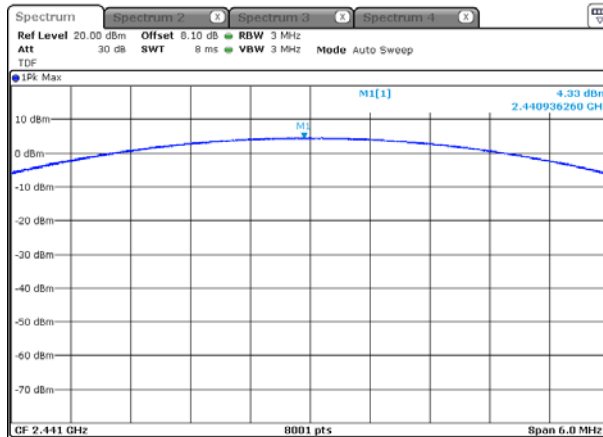


*** 8DPSK**

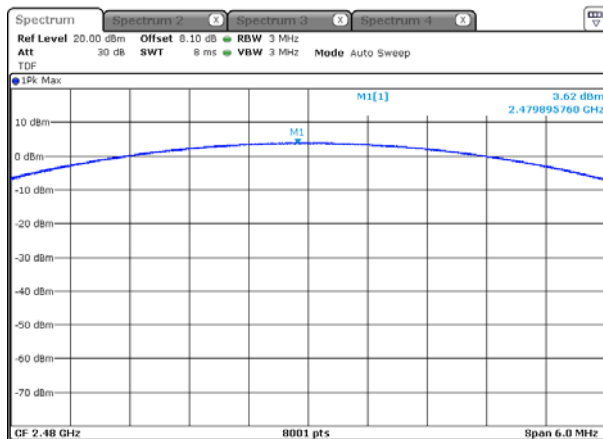
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)



Highest Channel
(2 480 MHz)



5.3 Carrier Frequency Separation

5.3.1 Regulation

According to §15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, 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, provided the systems operate with an output power no greater than 125 mW

5.3.2 Measurement Procedure

The method of measurement used to test this DSS device is FCC Public Notice DA 00-705.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface or Bluetooth tester.
4. Set the spectrum analyzer as follows: Span = wide enough to capture the peaks of two adjacent channels Resolution (or IF) Bandwidth (RBW) $\geq 1\%$ of the span Video (or Average) Bandwidth (VBW) \geq RBW Sweep = auto Detector function = peak Trace = max hold
5. Measure the separation between the peaks of the adjacent channels using the marker-delta function.
6. Repeat above procedures until all frequencies measured were complete.

5.3.3 Test Result

- Complied

*** GFSK**

| Channel | Carrier frequency separation (MHz) | Limit |
|---------|------------------------------------|--|
| Low | 1.001 | ≥ 25 kHz or two-thirds of the 20 dB bandwidth |
| Middle | 1.003 | ≥ 25 kHz or two-thirds of the 20 dB bandwidth |
| High | 0.999 | ≥ 25 kHz or two-thirds of the 20 dB bandwidth |

*** $\pi/4$ DQPSK**

| Channel | Carrier frequency separation (MHz) | Limit |
|---------|------------------------------------|--|
| Low | 1.001 | ≥ 25 kHz or two-thirds of the 20 dB bandwidth |
| Middle | 0.999 | ≥ 25 kHz or two-thirds of the 20 dB bandwidth |
| High | 1.000 | ≥ 25 kHz or two-thirds of the 20 dB bandwidth |

*** 8DPSK**

| Channel | Carrier frequency separation (MHz) | Limit |
|---------|------------------------------------|--|
| Low | 1.000 | ≥ 25 kHz or two-thirds of the 20 dB bandwidth |
| Middle | 0.999 | ≥ 25 kHz or two-thirds of the 20 dB bandwidth |
| High | 0.998 | ≥ 25 kHz or two-thirds of the 20 dB bandwidth |

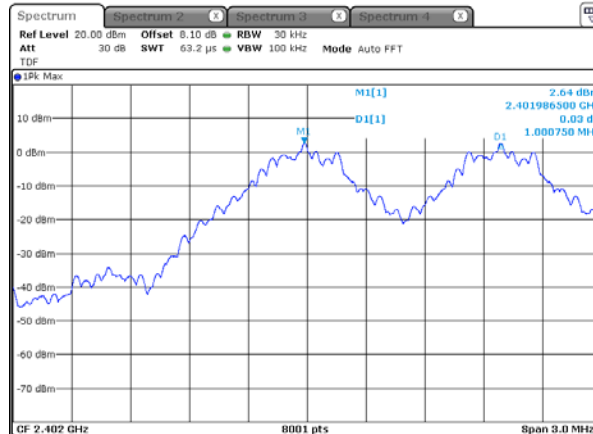
NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

5.3.4 Test Plot

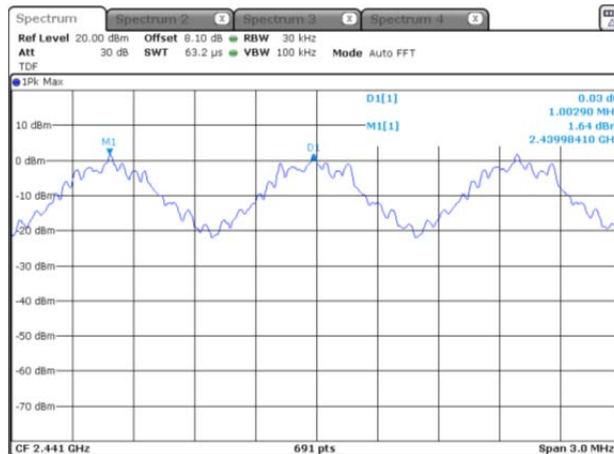
Figure 2. Plot of the Carrier Frequency Separation (Conducted)

*** GFSK**

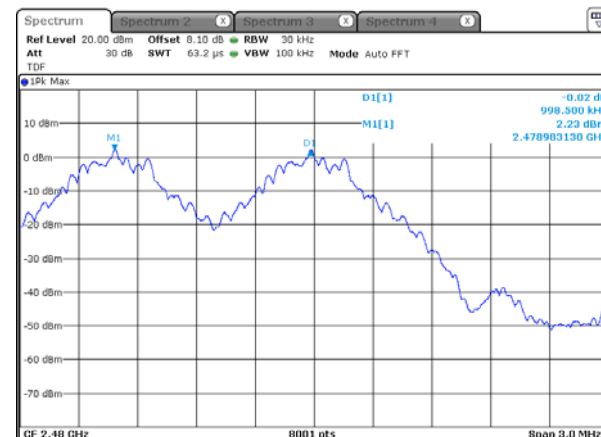
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

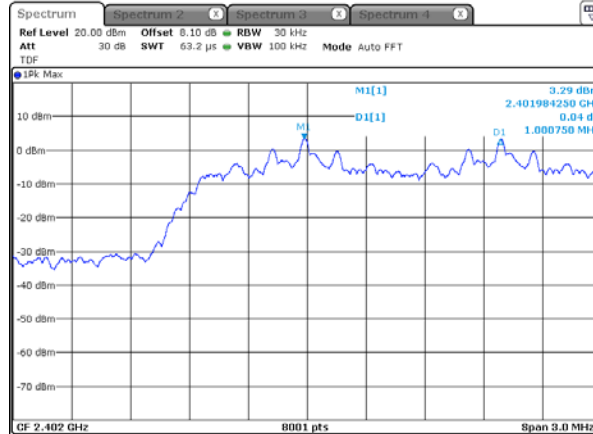


Highest Channel
(2 480 MHz)

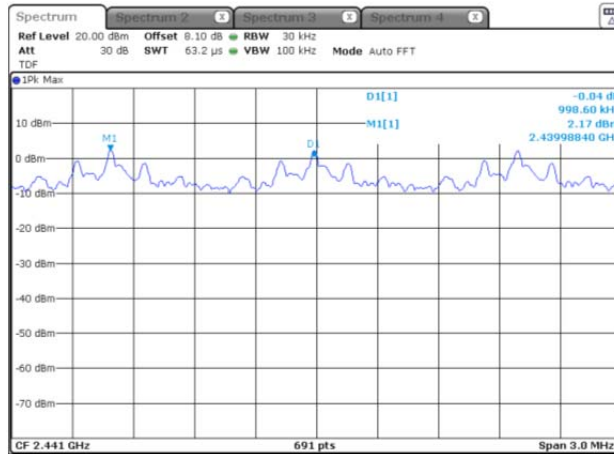


* $\pi/4$ DQPSK

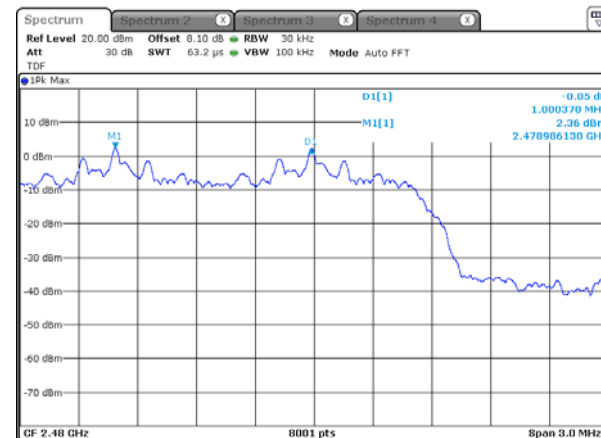
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

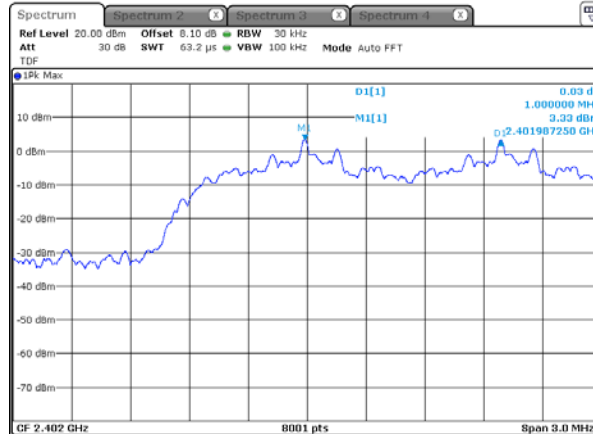


Highest Channel
(2 480 MHz)

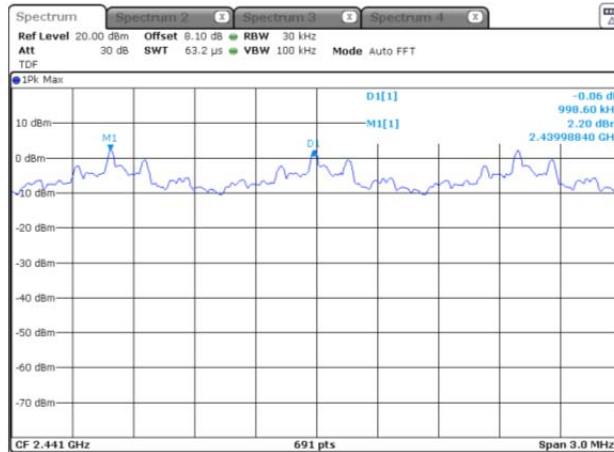


*** 8DPSK**

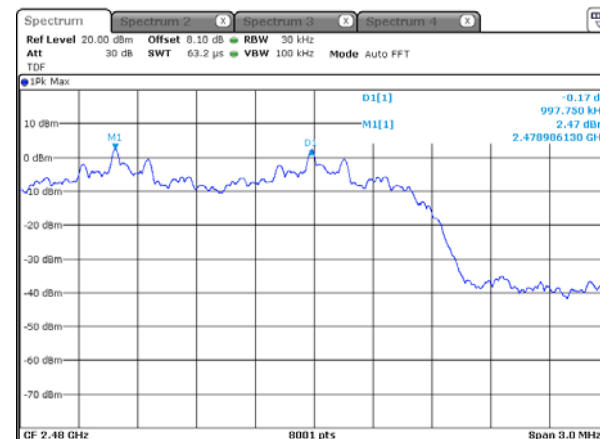
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)



Highest Channel
(2 480 MHz)



5.4 20 dB Channel Bandwidth

5.4.1 Regulation

According to §15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, 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, provided the systems operate with an output power no greater than 125 mW

5.4.2 Measurement Procedure

The method of measurement used to test this DSS device is FCC Public Notice DA 00-705.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface or Bluetooth tester and make sure the spectrum analyzer is operated in its linear range.
4. Set the spectrum analyzer as follows: Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel $RBW \geq 1\%$ of the 20 dB bandwidth $VBW \geq RBW$ Sweep = auto Detector function = peak Trace = max hold
5. Set a reference level on it equal to the highest peak value.
6. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
7. Repeat above procedures until all frequencies measured were complete..

5.4.3 Test Result

- Complied

* GFSK

| Channel | 20dB Channel Bandwidth(MHz) | Carrier frequency Separation(MHz) | Occupied Bandwidth (99% BW)(MHz) |
|---------|-----------------------------|-----------------------------------|----------------------------------|
| Low | 0.818 | 1.001 | 0.875 |
| Middle | 0.818 | 1.003 | 0.867 |
| High | 0.817 | 0.999 | 0.870 |

* $\pi/4$ DQPSK

| Channel | 20dB Channel Bandwidth(MHz) | Carrier frequency Separation(MHz) | Occupied Bandwidth (99% BW)(MHz) |
|---------|-----------------------------|-----------------------------------|----------------------------------|
| Low | 1.277 | 1.001 | 1.202 |
| Middle | 1.270 | 0.999 | 1.198 |
| High | 1.248 | 1.000 | 1.194 |

* 8DPSK

| Channel | 20dB Channel Bandwidth(MHz) | Carrier frequency Separation(MHz) | Occupied Bandwidth (99% BW)(MHz) |
|---------|-----------------------------|-----------------------------------|----------------------------------|
| Low | 1.268 | 1.000 | 1.217 |
| Middle | 1.216 | 0.999 | 1.179 |
| High | 1.212 | 0.998 | 1.170 |

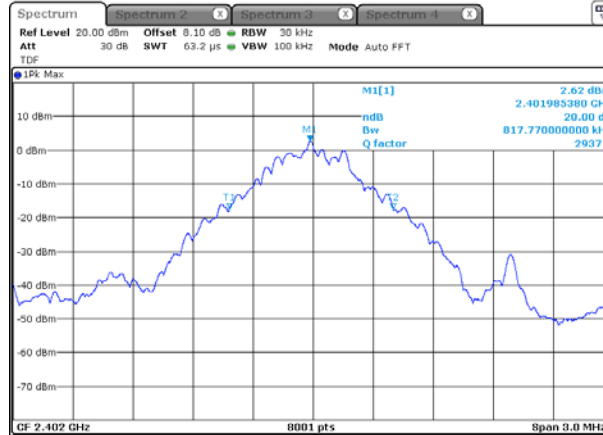
NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

5.4.4 Test Plot

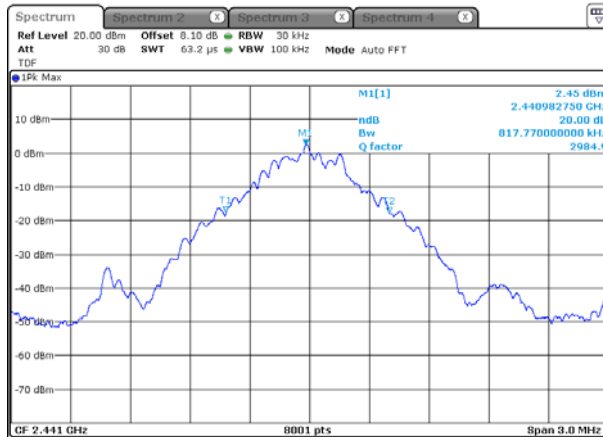
Figure 3. Plot of the 20dB Channel Bandwidth/ Occupied Bandwidth (Conducted)

* GFSK (20dB Channel Bandwidth)

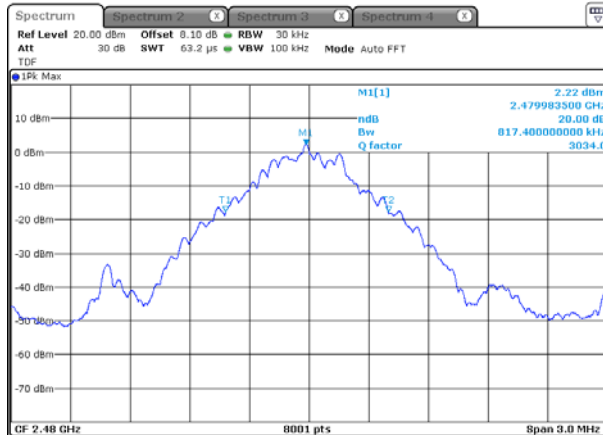
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

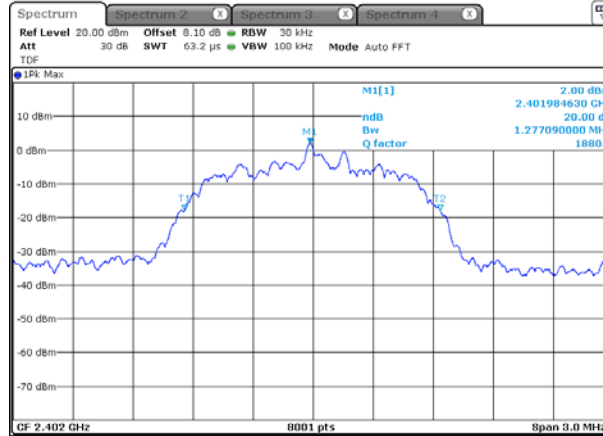


Highest Channel
(2 480 MHz)

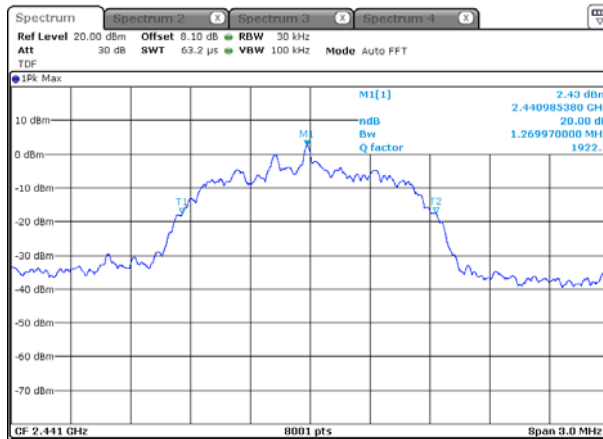


*** $\pi/4$ DQPSK (20dB Channel Bandwidth)**

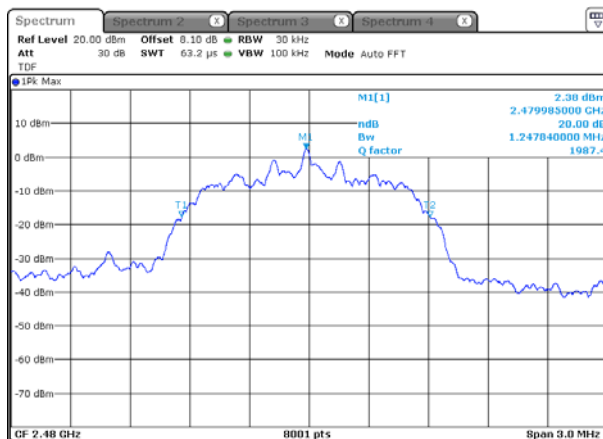
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

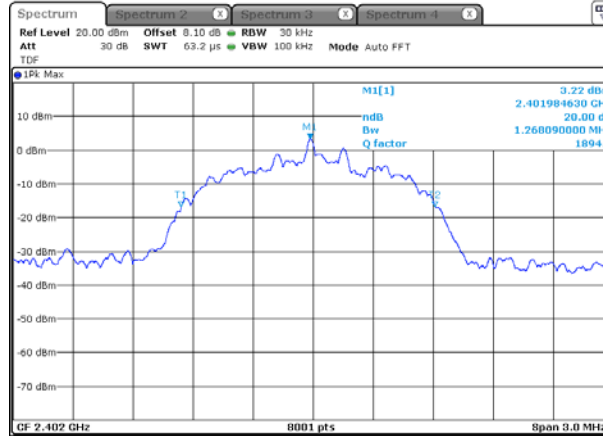


Highest Channel
(2 480 MHz)

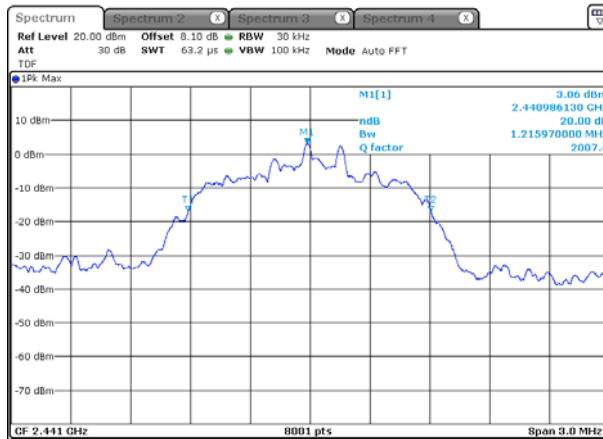


*** 8DPSK (20dB Channel Bandwidth)**

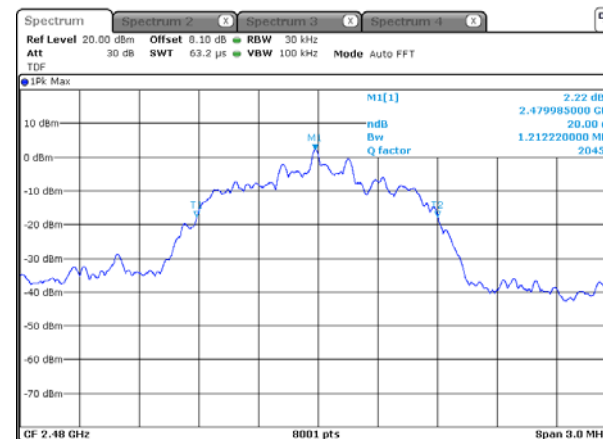
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

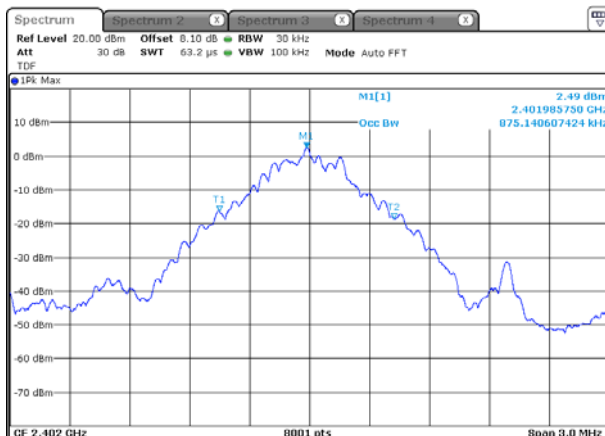


Highest Channel
(2 480 MHz)

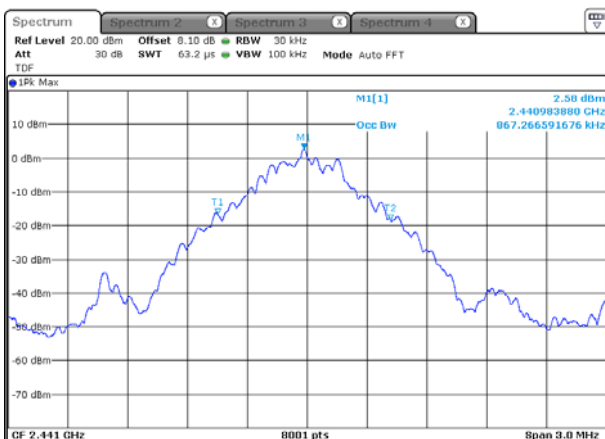


*** GFSK (Occupied Bandwidth)**

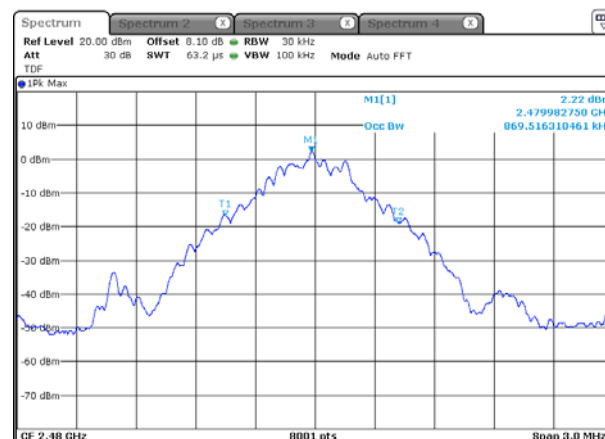
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

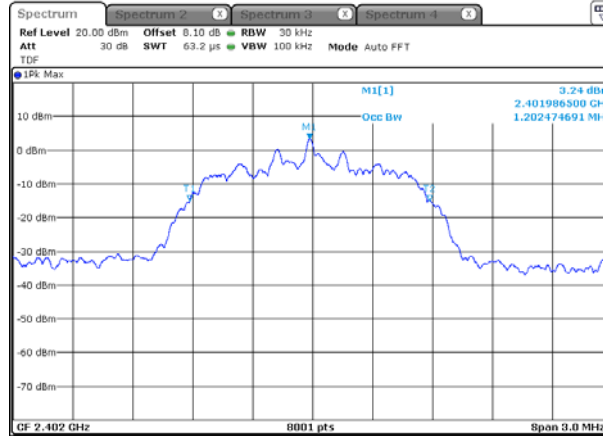


Highest Channel
(2 480 MHz)

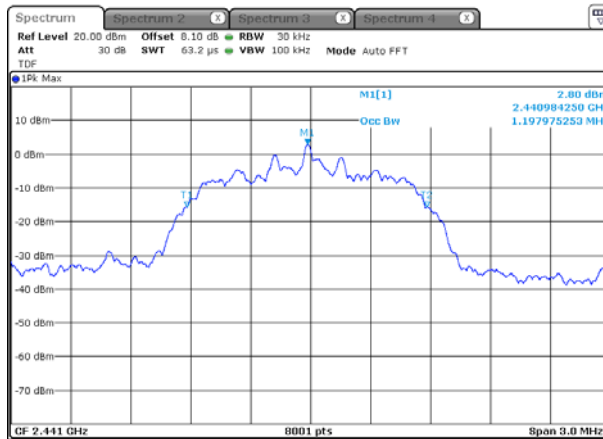


*** $\pi/4$ DQPSK (Occupied Bandwidth)**

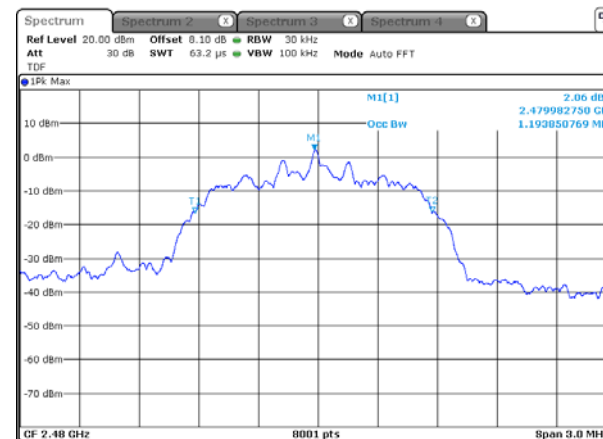
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

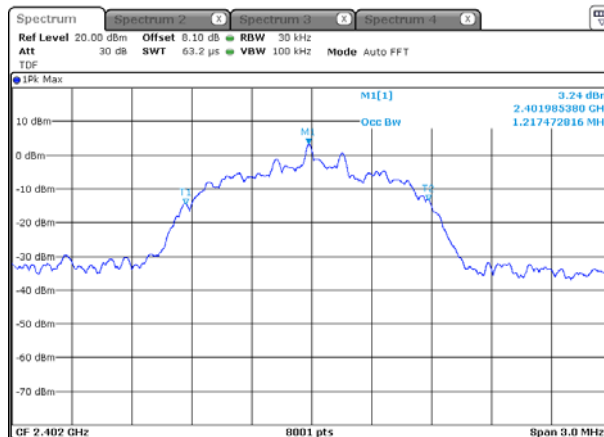


Highest Channel
(2 480 MHz)

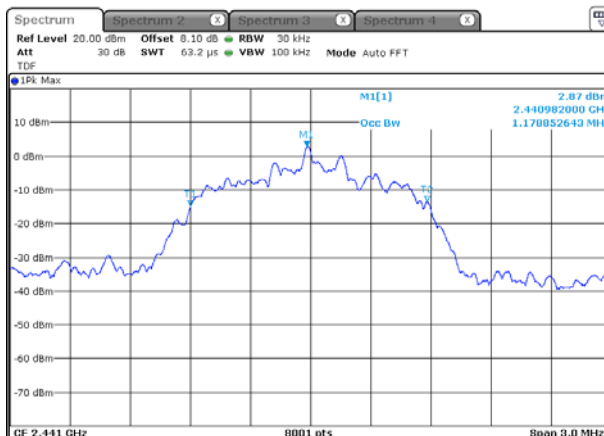


*** 8DPSK (Occupied Bandwidth)**

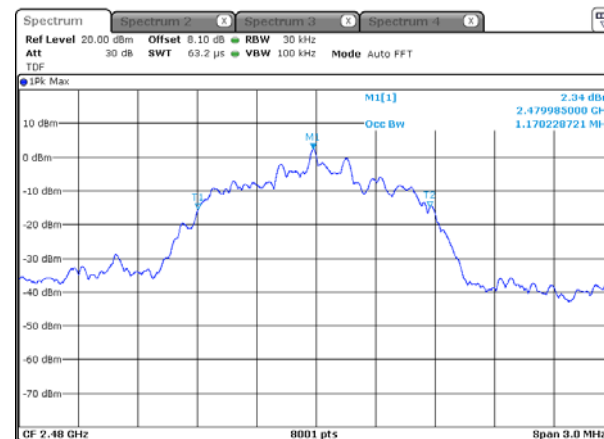
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)



Highest Channel
(2 480 MHz)



5.5 Number of Hopping Channels

5.5.1 Regulation

According to §15.247(a)(1)(iii), Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used. According to §15.247(b)(1), For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

5.5.2 Measurement Procedure

The method of measurement used to test this DSS device is FCC Public Notice DA 00-705.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
3. Turn on the EUT and set the hopping function enabled by controlling it via UART interface or Bluetooth tester.
4. Set the spectrum analyzer as follows: Span = the frequency band of operation $RBW \geq 1\%$ of the span $VBW \geq RBW$ Sweep = auto Detector function = peak Trace = max hold
5. Record the number of hopping channels.

5.5.3 Test Result

- Complied

* GFSK

| Frequency | Number of hopping channel | Limit |
|-------------------|---------------------------|-----------|
| 2 402 – 2 480 MHz | 79 | ≥ 15 |

* $\pi/4$ DQPSK

| Frequency | Number of hopping channel | Limit |
|-------------------|---------------------------|-----------|
| 2 402 – 2 480 MHz | 79 | ≥ 15 |

* 8DPSK

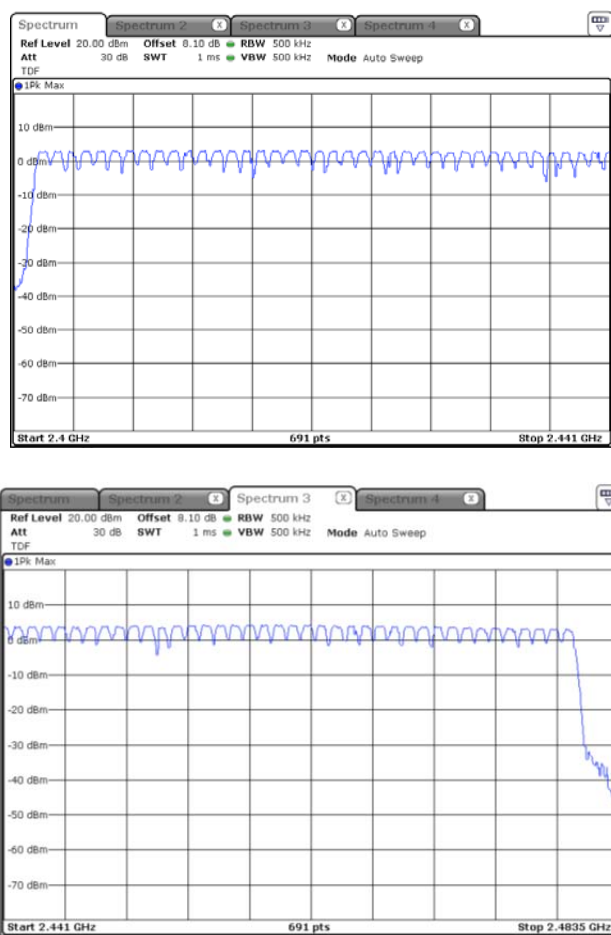
| Frequency | Number of hopping channel | Limit |
|-------------------|---------------------------|-----------|
| 2 402 – 2 480 MHz | 79 | ≥ 15 |

NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

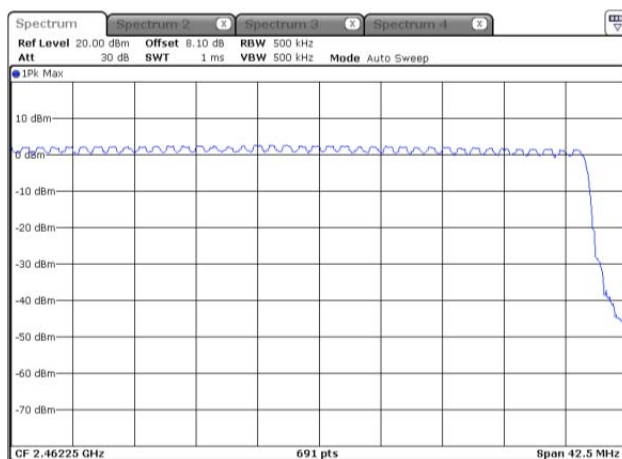
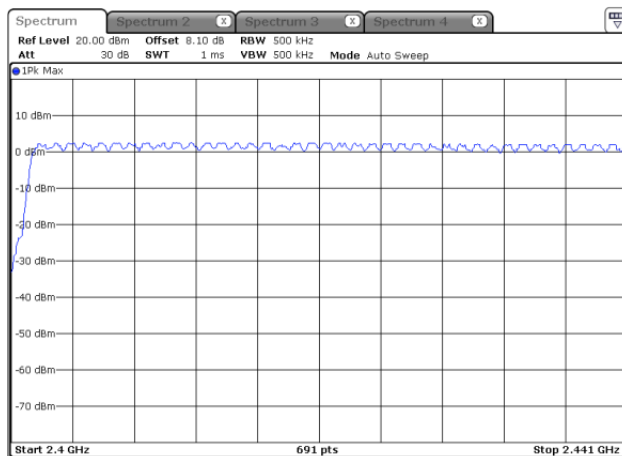
5.5.4 Test Plot

Figure 4. Plot of the Number of Hopping Channels (Conducted)

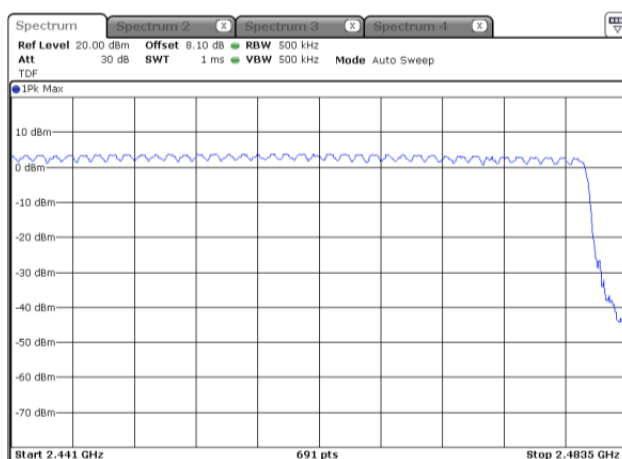
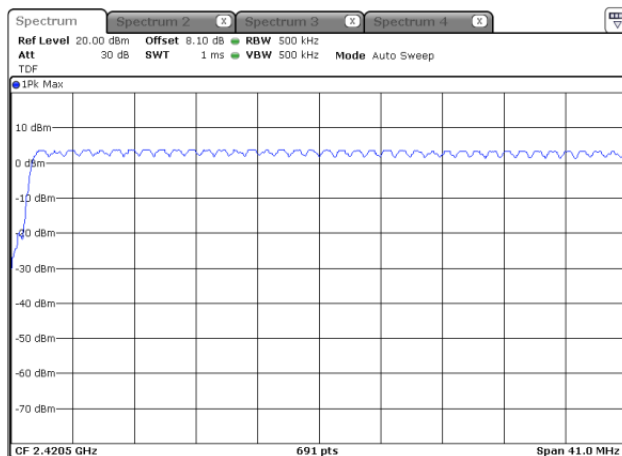
* GFSK



* $\pi/4$ DQPSK



*** 8DPSK**



5.6 Time of Occupancy(Dwell Time)

5.6.1 Regulation

According to §15.247(a)(1)(iii), frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

5.6.2 Measurement Procedure

The method of measurement used to test this DSS device is FCC Public Notice DA 00-705.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
3. Turn on the EUT and set it to any one measured frequency within its operating range by controlling it via UART interface or Bluetooth tester.
4. Set the spectrum analyzer as follows: Span = zero span, centered on a hopping channel RBW = 1 MHz VBW \geq RBW Sweep = as necessary to capture the entire dwell time per hopping channel
Detector function = peak Trace = max hold
5. Measure the dwell time using the marker-delta function.
6. Repeat above procedures until all frequencies measured were complete.
7. Repeat this test for different modes of operation (e.g., data rate, modulation format, etc.), if applicable.

5.6.3 Test Result

- Complied

* GFSK

| Channel | Reading[ms] | Hopping rate[hop/s] | Number of Channels | Actual[s] | Limit[s] |
|---------|-------------|---------------------|--------------------|-----------|----------|
| Low | 2.896 | 266.667 | 79 | 0.309 | 0.40 |
| Middle | 2.898 | 266.667 | 79 | 0.309 | 0.40 |
| High | 2.898 | 266.667 | 79 | 0.309 | 0.40 |

* $\pi/4$ DQPSK

| Channel | Reading[ms] | Hopping rate[hop/s] | Number of Channels | Actual[s] | Limit[s] |
|---------|-------------|---------------------|--------------------|-----------|----------|
| Low | 2.912 | 266.667 | 79 | 0.311 | 0.40 |
| Middle | 2.902 | 266.667 | 79 | 0.310 | 0.40 |
| High | 2.912 | 266.667 | 79 | 0.311 | 0.40 |

* 8DPSK

| Channel | Reading[ms] | Hopping rate[hop/s] | Number of Channels | Actual[s] | Limit[s] |
|---------|-------------|---------------------|--------------------|-----------|----------|
| Low | 2.912 | 266.667 | 79 | 0.311 | 0.40 |
| Middle | 2.912 | 266.667 | 79 | 0.311 | 0.40 |
| High | 2.907 | 266.667 | 79 | 0.310 | 0.40 |

Actual = Reading \times (Hopping rate / Number of channels) \times Test period

Test period = 0.4 [seconds / channel] \times 79 [channel] = 31.6 [seconds]

NOTE:

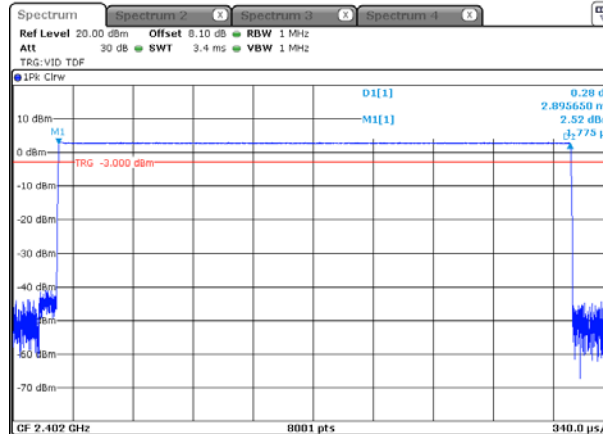
- We took the insertion loss of the cable loss into consideration within the measuring instrument.

5.6.4 Test Plot

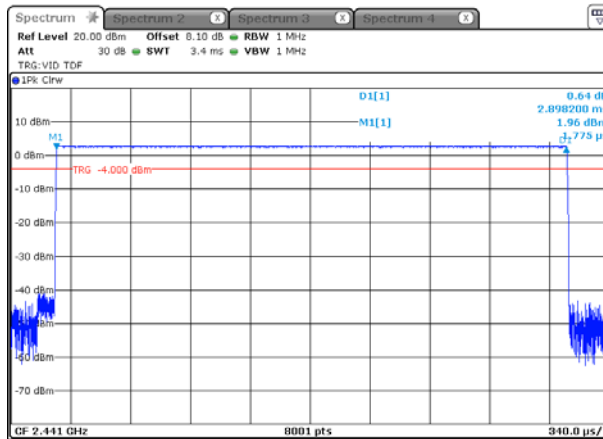
Figure 5. Plot of the Time of Occupancy (Conducted)

* **GFSK**

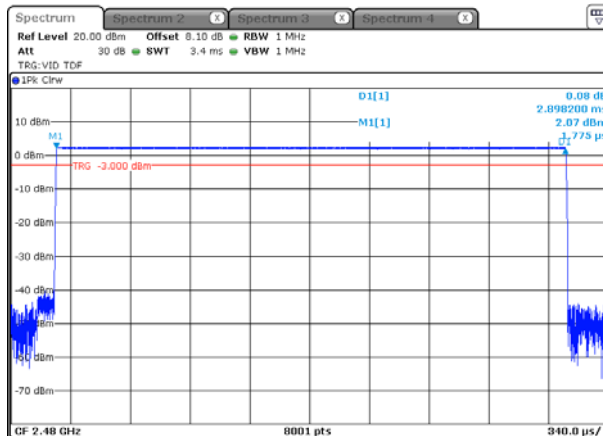
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

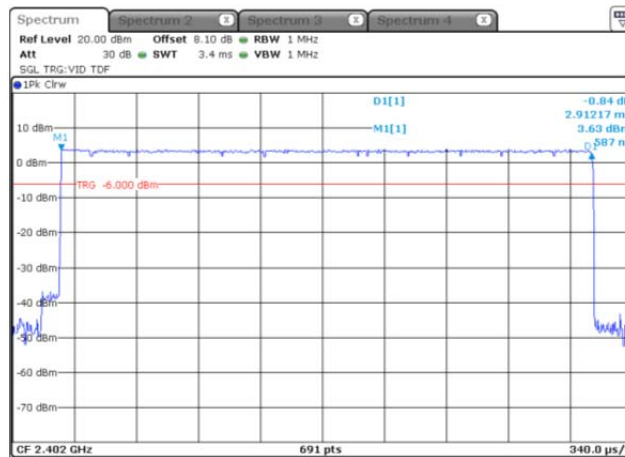


Highest Channel
(2 480 MHz)

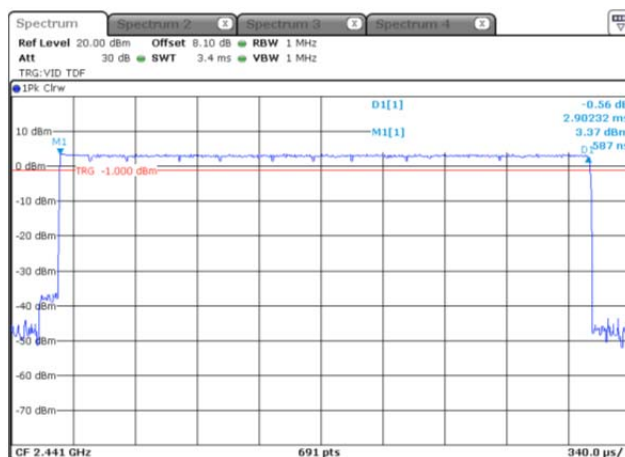


* $\pi/4$ DQPSK

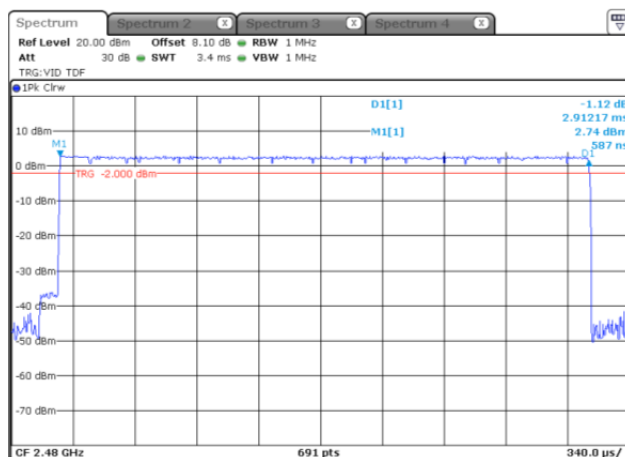
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)

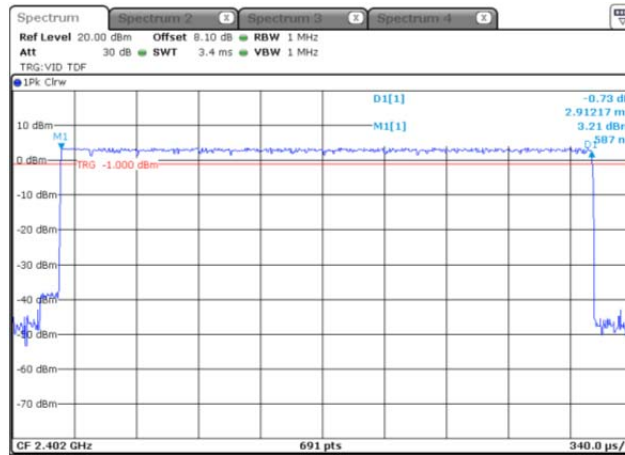


Highest Channel
(2 480 MHz)

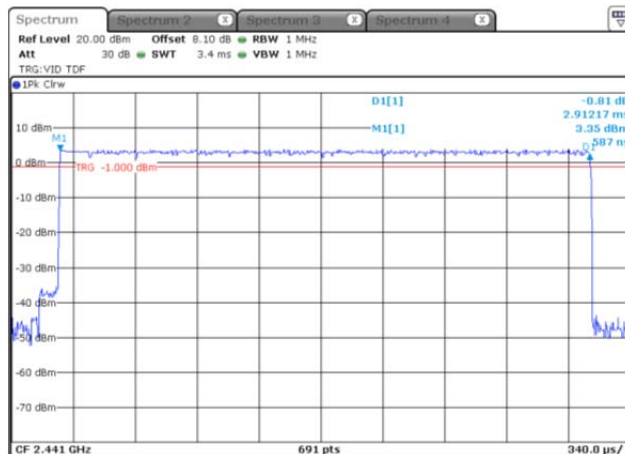


*** 8DPSK**

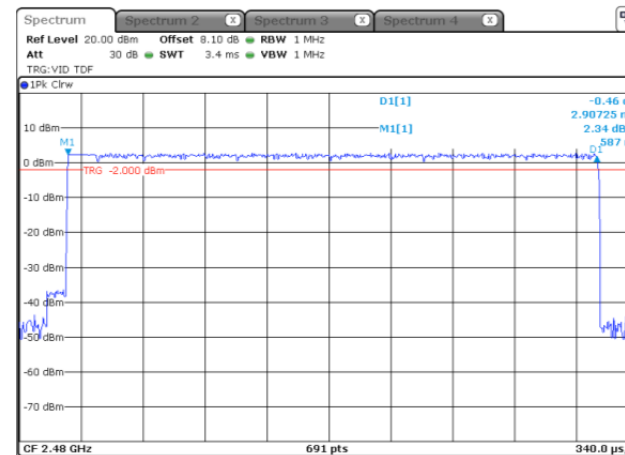
Lowest Channel
(2 402 MHz)



Middle Channel
(2 441 MHz)



Highest Channel
(2 480 MHz)



5.7 Spurious Emission, Band edge, and Restricted bands

5.7.1 Regulation

According to §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 a radiated 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, as permitted under paragraph (b)(3) of this section, 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)).

According to §15.209(a), Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

| Frequency (MHz) | Field strength ($\mu\text{V/m}$) | Measurement distance (m) |
|-----------------|------------------------------------|--------------------------|
| 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 |

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54–72 MHz, 76–88 MHz, 174–216 MHz or 470–806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.

According to § 15.205(a) and (b), only spurious emissions are permitted in any of the frequency bands listed below:

| MHz | MHz | MHz | GHz |
|---------------------|-----------------------|-----------------|---------------|
| 0.009 - 0.110 | 16.42 - 16.423 | 399.9 - 410 | 4.5 - 5.15 |
| 0.495 - 0.505 | 16.69475 - 16.69525 | 608 - 614 | 5.35 - 5.46 |
| 2.1735 - 2.1905 | 16.80425 - 16.80475 | 960 - 1240 | 7.25 - 7.75 |
| 4.125 - 4.128 | 25.5 - 25.67 | 1300 - 1427 | 8.025 - 8.5 |
| 4.17725 - 4.17775 | 37.5 - 38.25 | 1435 - 1626.5 | 9.0 - 9.2 |
| 4.20725 - 4.20775 | 73 - 74.6 | 1645.5 - 1646.5 | 9.3 - 9.5 |
| 6.215 - 6.218 | 74.8 - 75.2 | 1660 - 1710 | 10.6 - 12.7 |
| 6.26775 - 6.26825 | 108 - 121.94 | 1718.8 - 1722.2 | 13.25 - 13.4 |
| 6.31175 - 6.31225 | 123 - 138 | 2200 - 2300 | 14.47 - 14.5 |
| 8.291 - 8.294 | 149.9 - 150.05 | 2310 - 2390 | 15.35 - 16.2 |
| 8.362 - 8.366 | 156.52475 - 156.52525 | 2483.5 - 2500 | 17.7 - 21.4 |
| 8.37625 - 8.38675 | 156.7 - 156.9 | 2690 - 2900 | 22.01 - 23.12 |
| 8.41425 - 8.41475 | 162.0125 - 167.17 | 3260 - 3267 | 23.6 - 24.0 |
| 12.29 - 12.293 | 167.72 - 173.2 | 3332 - 3339 | 31.2 - 31.8 |
| 12.51975 - 12.52025 | 240 - 285 | 3345.8 - 3358 | 36.43 - 36.5 |
| 12.57675 - 12.57725 | 322 - 335.4 | 3600 - 4400 | Above 38.6 |
| 13.36 - 13.41 | | | |

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

5.7.2 Measurement Procedure

The method of measurement used to test this DSS device is FCC Public Notice DA 00-705.

1) Band-edge Compliance of RF Conducted Emissions

1. Set the spectrum analyzer as follows:

- Span = wide enough to capture the peak level of the emission operating on the channel closest to the bandedge, as well as any modulation products which fall outside of the authorized band of operation
- RBW \geq 1% of the span
- VBW \geq RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

2. Allow the trace to stabilize. Set the marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is greater than that at the band-edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.
3. Now, using the same instrument settings, enable the hopping function of the EUT. Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

2) Spurious RF Conducted Emissions:

1. Set the spectrum analyzer as follows:
 - Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic.
Typically, several plots are required to cover this entire span.
 - RBW = 100 kHz
 - VBW \geq RBW
 - Sweep = auto
 - Detector function = peak
 - Trace = max hold
2. Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded.
a 4 × 4 meter at the Open Area Test Site. The EUT was tested at a distance 3 meters.
3. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.

3) Spurious Radiated Emissions:

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters.
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360°.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 9 kHz to 30 MHz using the loop antenna, and from 30 to 1000 MHz using the TRILOG broadband antenna, and from 1000 MHz to 26500 MHz using the horn antenna.
4. To obtain the final measurement data, the EUT was arranged on a turntable situated on a 4 × 4 meter at the Open Area Test Site. The EUT was tested at a distance 3 meters.
5. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.

5.7.3 Test Result

- Complied

1. Band edge compliance of RF Conducted Emissions was shown in figure 6.
2. Band edge compliance of RF Radiated Emissions was shown in figure 7.
3. Spurious RF conducted Emissions were shown in the Figure 8.

Note: We took the insertion loss of the cable into consideration within the measuring instrument.

4. Measured value of the Field strength of spurious Emissions (Radiated)

* Below 1 GHz data (worst-case: 8DPSK)

8DPSK Low channel (2 402 MHz)

| Frequency [MHz] | Receiver Bandwidth [kHz] | Pol. [V/H] | Reading [dB(μV)] | Factor [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|--|--------------------------------|---------------|---------------------|----------------|----------------------|---------------------|----------------|
| Quasi-Peak DATA. Emissions below 30 MHz | | | | | | | |
| Below 30.00 | Not Detected | - | - | - | - | - | - |
| Quasi-Peak DATA. Emissions below 1GHz | | | | | | | |
| Below 1 000.00 | Not Detected | - | - | - | - | - | - |

*** Above 1 GHz data**

GFSK Low channel (2 402 MHz)

| Frequency [MHz] | Receiver Bandwidth [kHz] | Pol. [V/H] | Reading [dB(μV)] | Factor [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|--------------------------------|---------------|---------------------|----------------|----------------------|---------------------|----------------|
| Peak DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | V | 48.0 | 0.2 | 48.2 | 74.0 | 25.8 |
| 4 804.06 | 1 000 | V | 43.3 | 7.0 | 50.3 | 74.0 | 23.7 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |
| Average DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | V | 45.3 | 0.2 | 45.5 | 54.0 | 8.5 |
| 4 804.06 | 1 000 | V | 36.0 | 7.0 | 43.0 | 54.0 | 11.0 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |

GFSK Middle channel (2 441 MHz)

| Frequency [MHz] | Receiver Bandwidth [kHz] | Pol. [V/H] | Reading [dB(μV)] | Factor [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|--------------------------------|---------------|---------------------|----------------|----------------------|---------------------|----------------|
| Peak DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | V | 47.9 | 0.2 | 48.1 | 74.0 | 25.9 |
| 4 881.91 | 1 000 | V | 41.5 | 7.2 | 48.7 | 74.0 | 25.3 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |
| Average DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | V | 45.4 | 0.2 | 45.6 | 54.0 | 8.4 |
| 4 881.91 | 1 000 | V | 36.9 | 7.2 | 44.1 | 54.0 | 9.9 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |

GFSK_High channel (2 480 MHz)

| Frequency [MHz] | Receiver Bandwidth [kHz] | Pol. [V/H] | Reading [dB(μV)] | Factor [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|--------------------------------|---------------|---------------------|----------------|----------------------|---------------------|----------------|
| Peak DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | V | 48.4 | 0.2 | 48.6 | 74.0 | 25.4 |
| 4 959.75 | 1 000 | V | 40.8 | 7.4 | 48.2 | 74.0 | 25.8 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |
| Average DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | V | 44.7 | 0.2 | 44.9 | 54.0 | 9.1 |
| 4 959.75 | 1 000 | V | 34.3 | 7.4 | 41.7 | 54.0 | 12.3 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |

8DPSK_Low channel (2 402 MHz)

| Frequency [MHz] | Receiver Bandwidth [kHz] | Pol. [V/H] | Reading [dB(μV)] | Factor [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|--------------------------------|---------------|---------------------|----------------|----------------------|---------------------|----------------|
| Peak DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | H | 47.9 | 0.2 | 48.1 | 74.0 | 25.9 |
| 4 804.06 | 1 000 | V | 43.7 | 7.0 | 50.7 | 74.0 | 23.3 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |
| Average DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | H | 46.3 | 0.2 | 46.5 | 54.0 | 7.5 |
| 4 804.06 | 1 000 | V | 36.3 | 7.0 | 43.3 | 54.0 | 10.7 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |

8DPSK Middle channel (2 441 MHz)

| Frequency [MHz] | Receiver Bandwidth [kHz] | Pol. [V/H] | Reading [dB(μV)] | Factor [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|--------------------------------|---------------|---------------------|----------------|----------------------|---------------------|----------------|
| Peak DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | V | 48.1 | 0.2 | 48.3 | 74.0 | 25.7 |
| 4 881.91 | 1 000 | V | 41.4 | 7.2 | 48.6 | 74.0 | 25.4 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |
| Average DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | V | 45.6 | 0.2 | 45.8 | 54.0 | 8.2 |
| 4 881.91 | 1 000 | V | 35.4 | 7.2 | 42.6 | 54.0 | 11.4 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |

8DPSK High channel (2 480 MHz)

| Frequency [MHz] | Receiver Bandwidth [kHz] | Pol. [V/H] | Reading [dB(μV)] | Factor [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|--------------------------------|---------------|---------------------|----------------|----------------------|---------------------|----------------|
| Peak DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | V | 48.4 | 0.2 | 48.6 | 74.0 | 25.4 |
| 4 959.75 | 1 000 | H | 41.9 | 7.4 | 49.3 | 74.0 | 24.7 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |
| Average DATA. Emissions above 1GHz | | | | | | | |
| 2 809.50 | 1 000 | V | 46.2 | 0.2 | 46.4 | 54.0 | 7.6 |
| 4 959.75 | 1 000 | H | 35.5 | 7.4 | 42.9 | 54.0 | 11.1 |
| Above 5 000.00 | Not Detected | - | - | - | - | - | - |

Factor(dB) = ANT Factor+ Amp Gain + Cable Loss

Margin (dB) = Limit - Result

[Result = Reading – Factor]

1. H = Horizontal, V = Vertical Polarization

2. ATT = Attenuation (10 dB pad and/or Insertion Loss of HPF), AF/CL = Antenna Factor and Cable Loss

* The spurious emission at the frequency does not fall in the restricted bands.

** The measured result is within the test standard limit by a margin less than the measurement uncertainty; it is therefore not possible to state compliance based on the 95 % level of confidence. However, the result indicates that compliance is more probable than non-compliance.

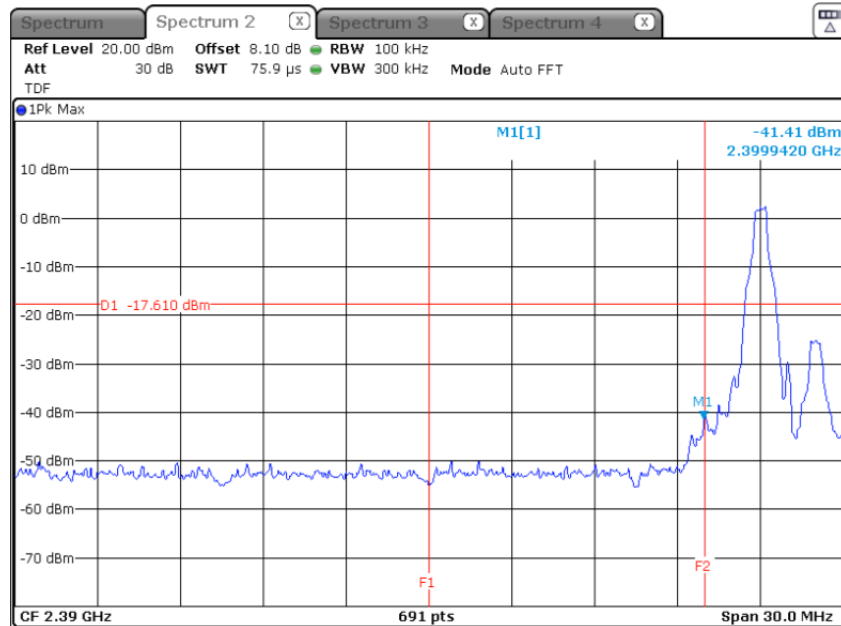
NOTE: All emissions not reported were more than 20 dB below the specified limit or in the noise floor.

5.7.4 Test Plot

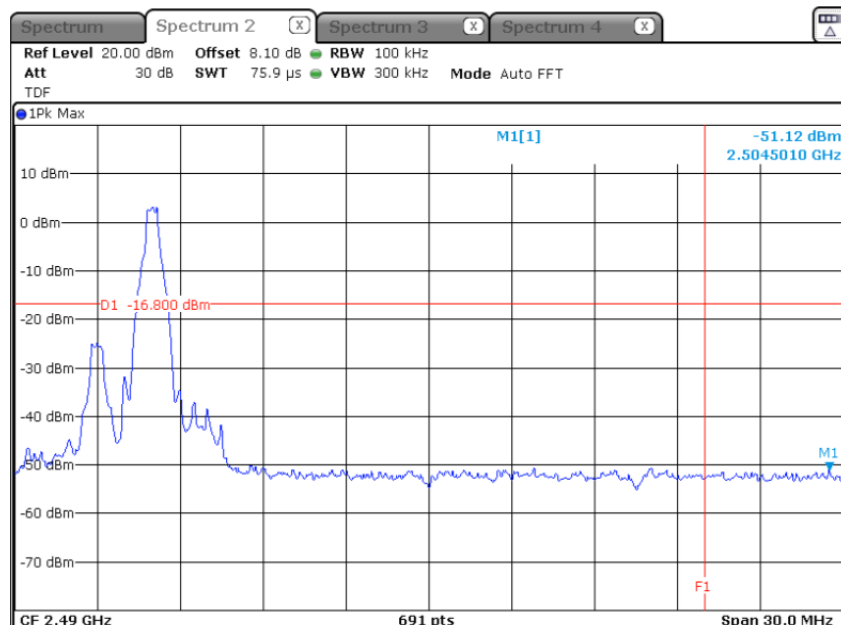
Figure 6. Plot of the Band Edge (Conducted)

* GFSK (Without hopping)

Lowest Channel
(2 402 MHz)

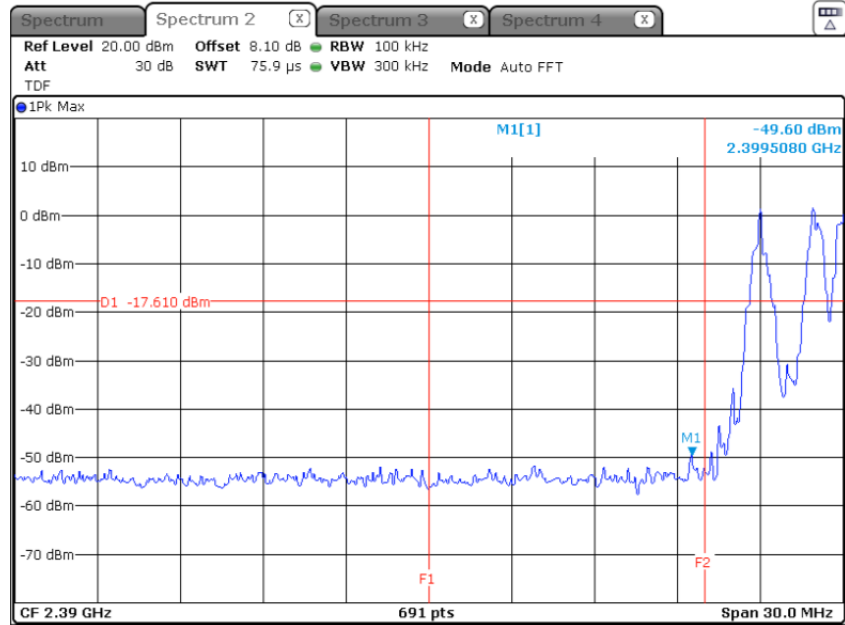


Highest Channel
(2 480 MHz)

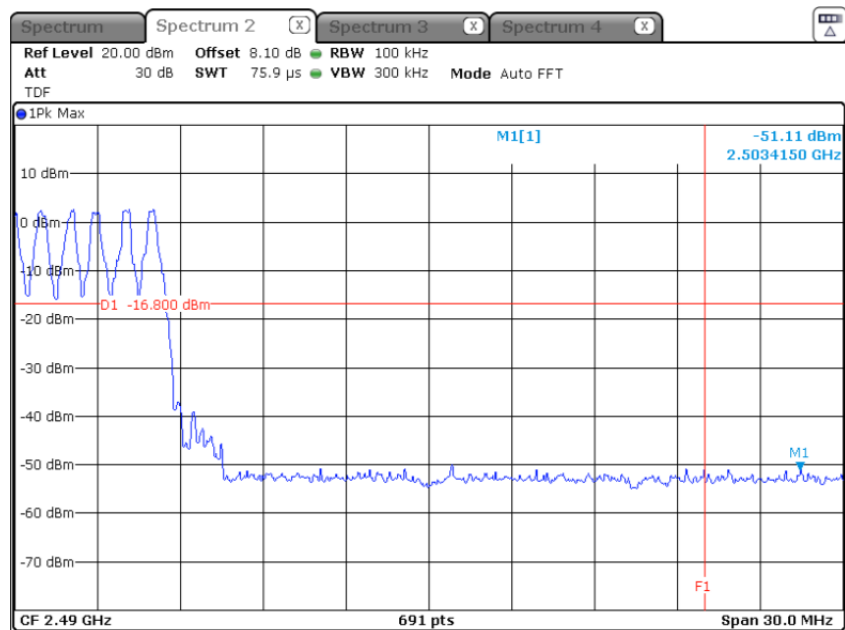


*** GFSK (With hopping)**

Lowest Channel
(2 402 MHz)

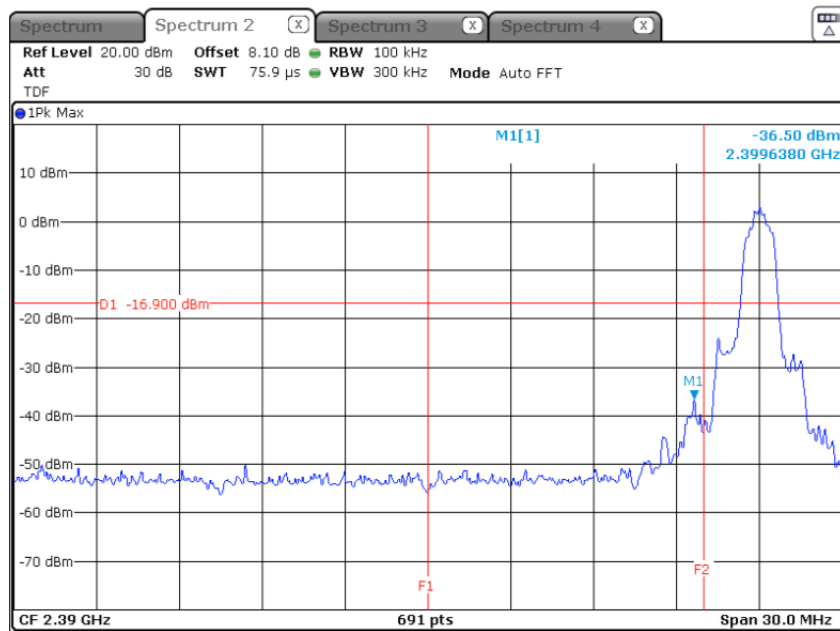


Highest Channel
(2 480 MHz)

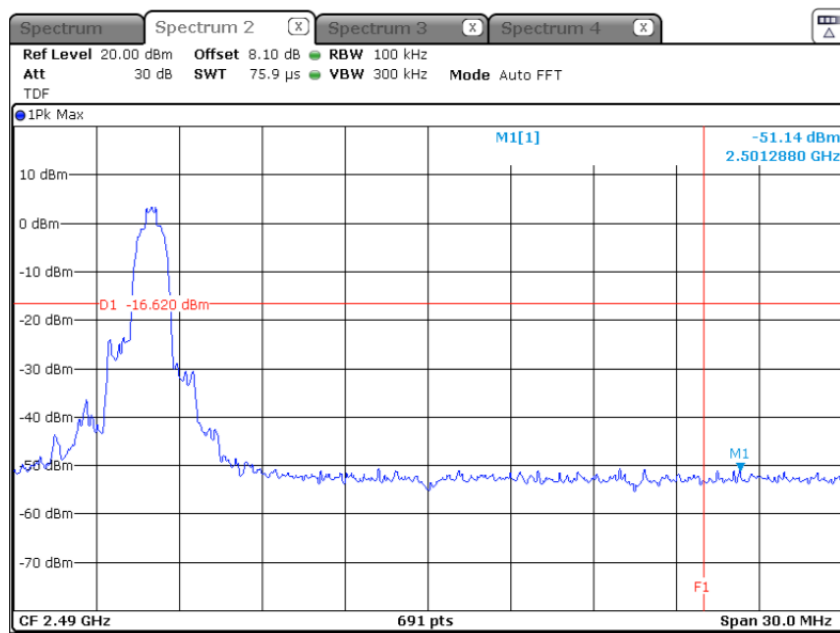


*** $\pi/4$ DQPSK (Without hopping)**

Lowest Channel
(2 402 MHz)

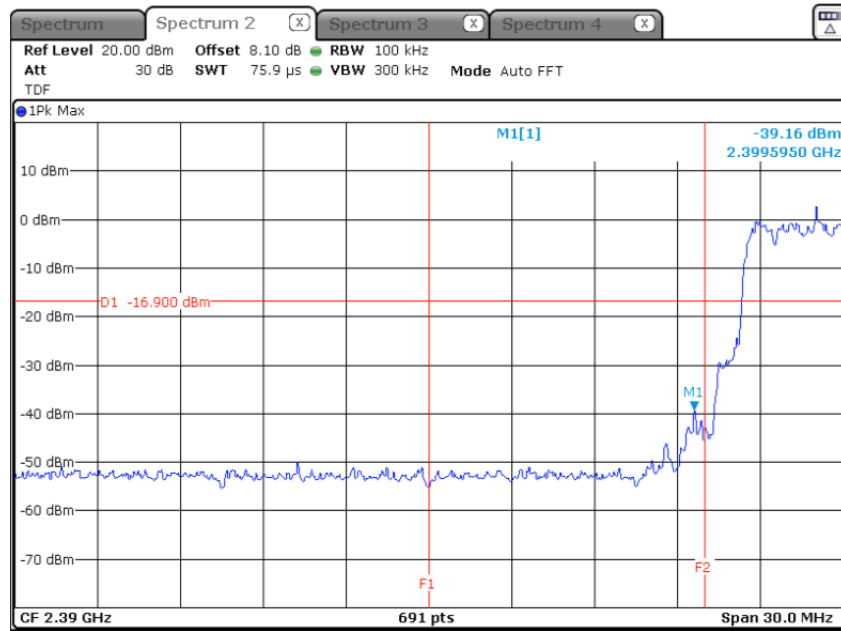


Highest Channel
(2 480 MHz)

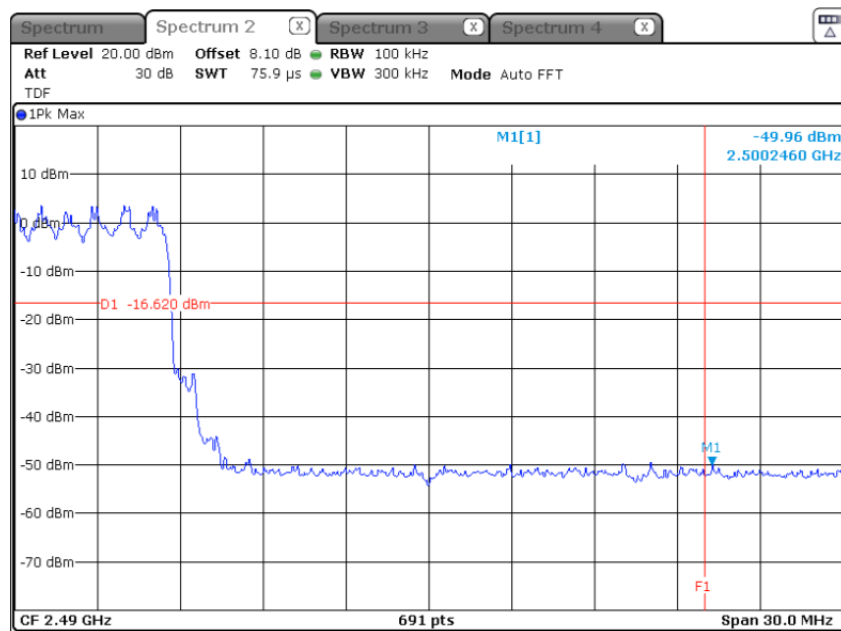


* $\pi/4$ DQPSK (With hopping)

Lowest Channel
(2 402 MHz)

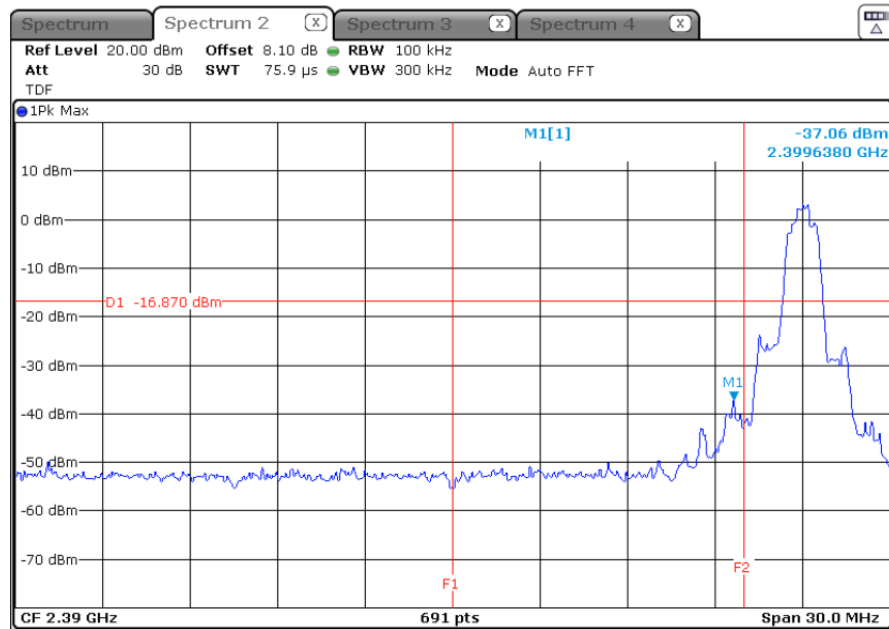


Highest Channel
(2 480 MHz)

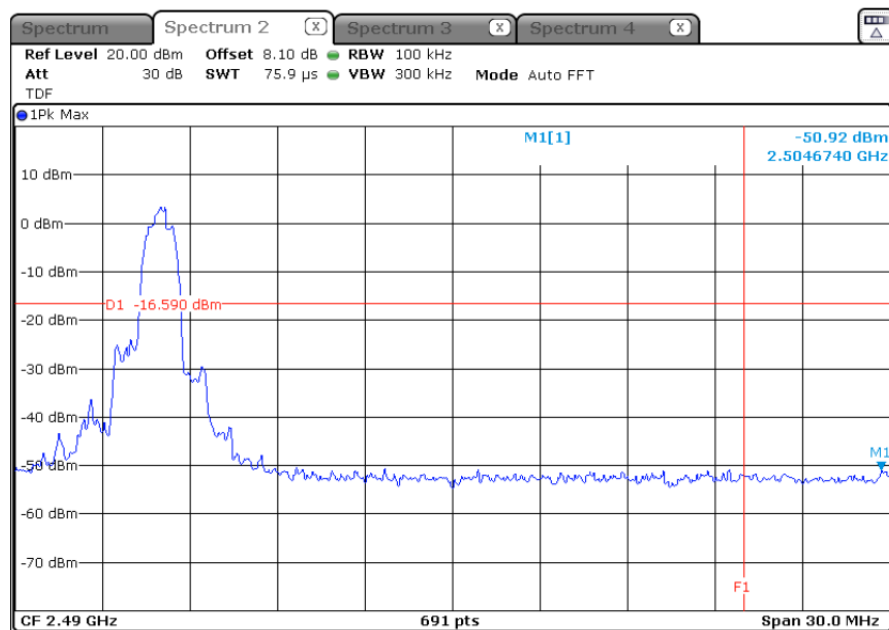


*** 8DPSK (Without hopping)**

Lowest Channel
(2 402 MHz)

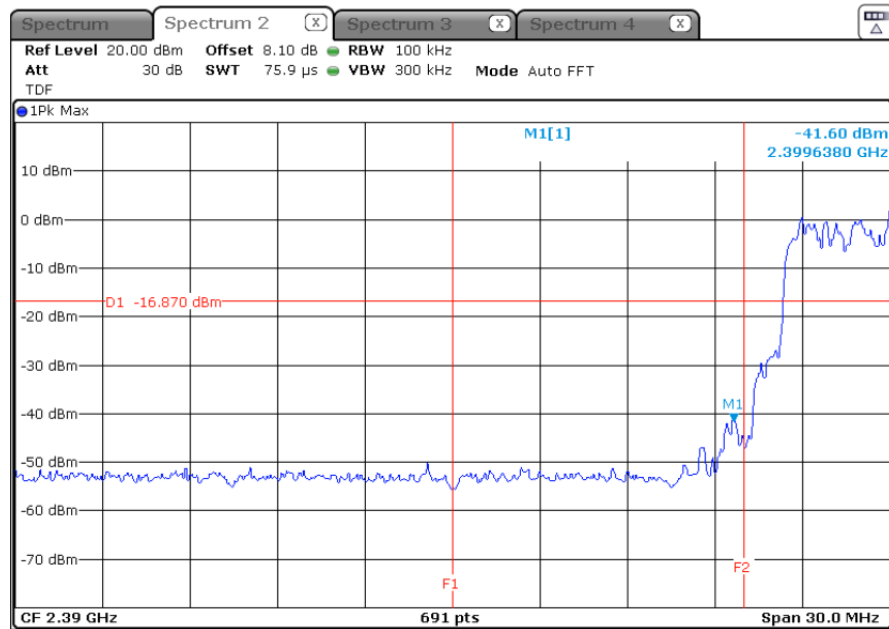


Highest Channel
(2 480 MHz)

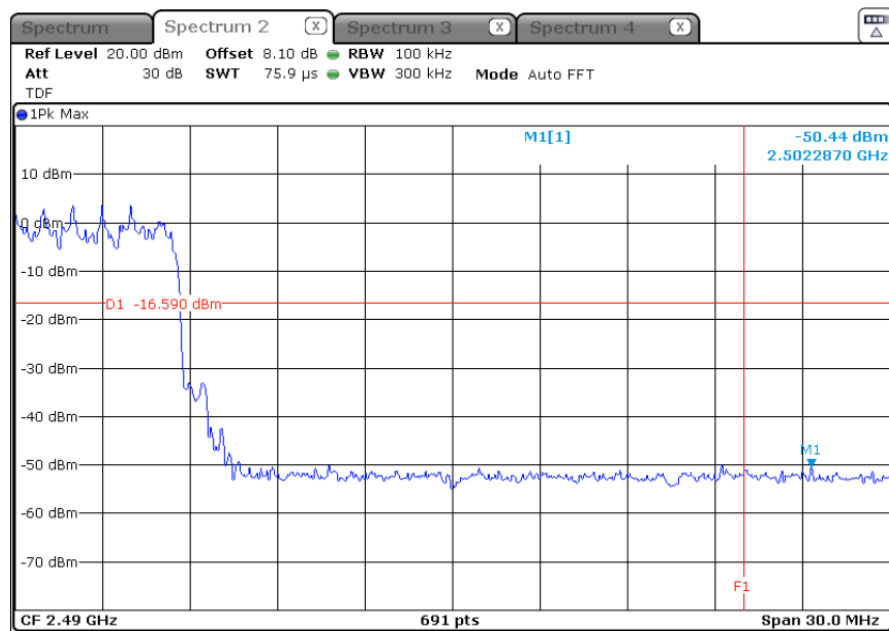


*** 8DPSK (With hopping)**

Lowest Channel
(2 402 MHz)



Highest Channel
(2 480 MHz)

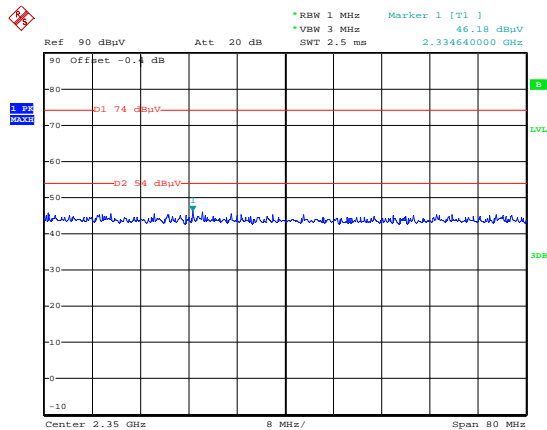


5.7.4 Test Plot (Continue)

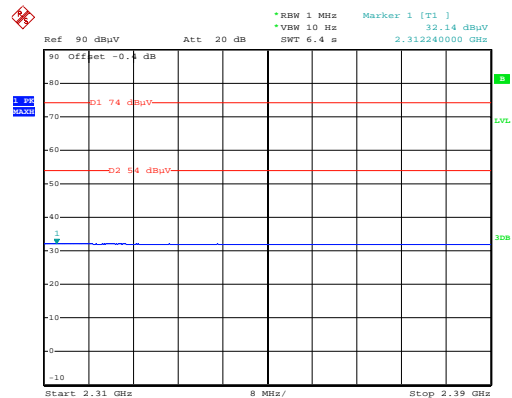
Figure 7. Plot of the Band Edge (Radiated)

*** GFSK**

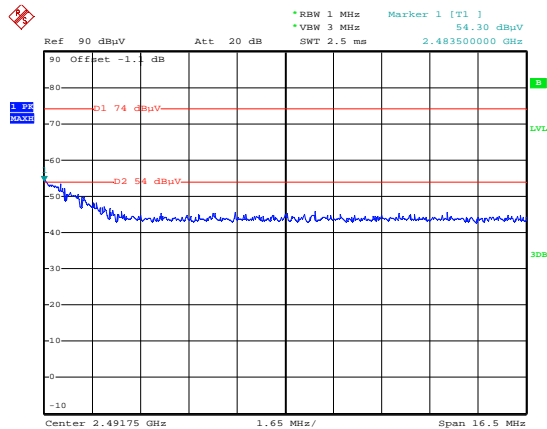
Lowest Channel(2 402 MHz): PEAK



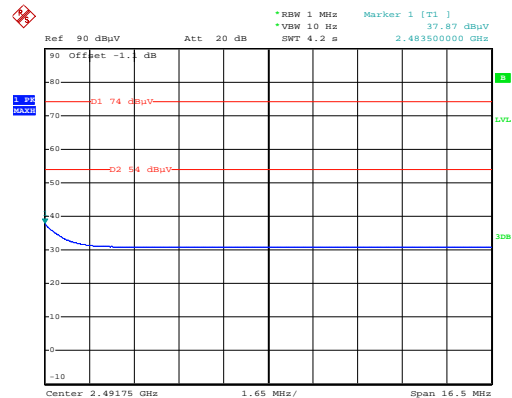
Lowest Channel(2 402 MHz): AVERAGE



Highest Channel(2 480 MHz): PEAK

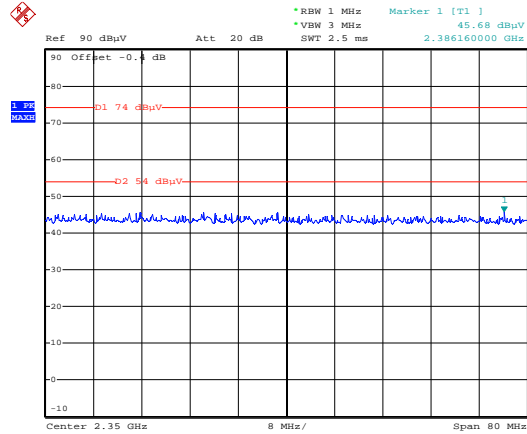


Highest Channel(2 480 MHz): AVERAGE

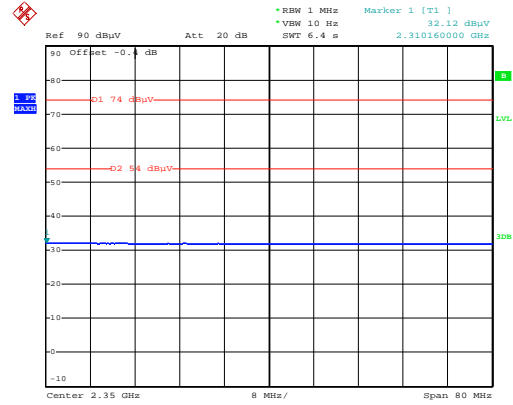


*** 8DPSK**

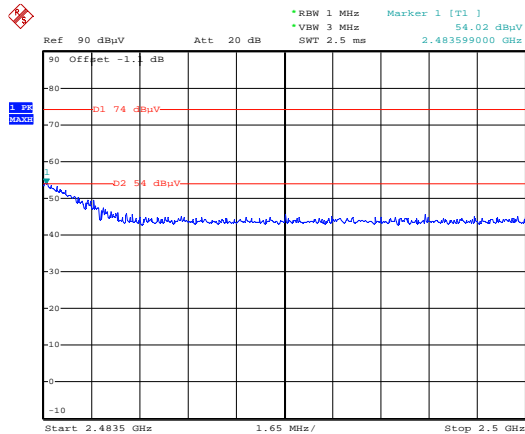
Lowest Channel(2 402 MHz): PEAK



Lowest Channel(2 402 MHz): AVERAGE



Highest Channel(2 480 MHz): PEAK



Highest Channel(2 480 MHz): AVERAGE

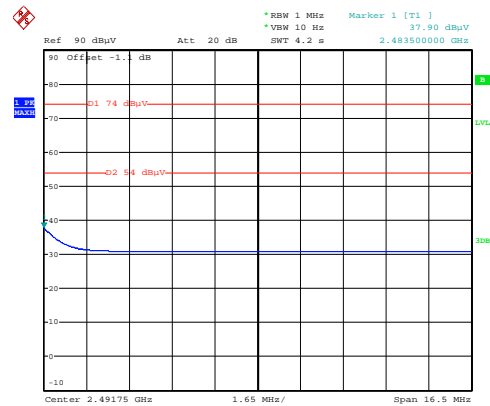
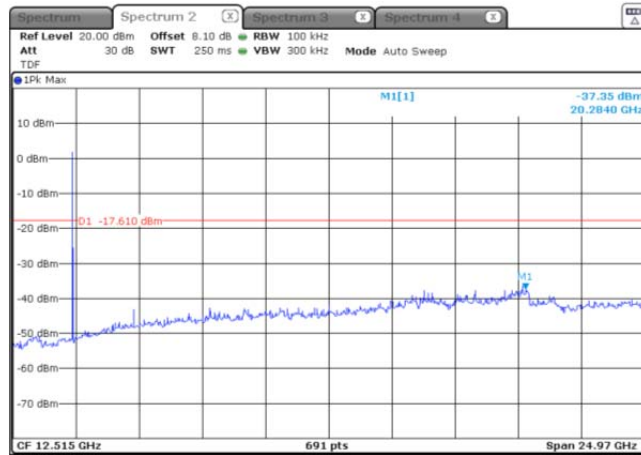


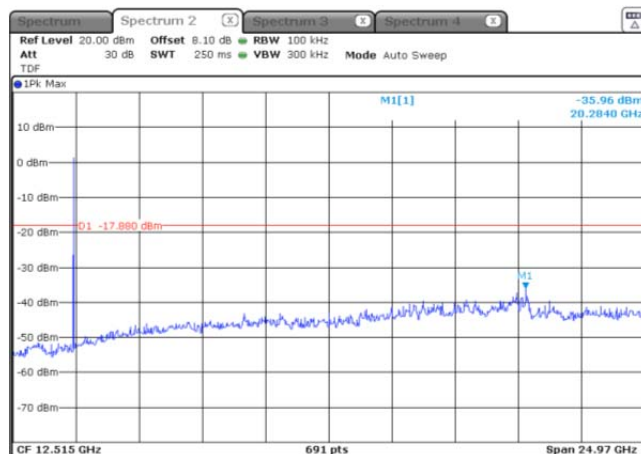
Figure 8. Plot of the Spurious RF conducted emissions

*** GFSK**

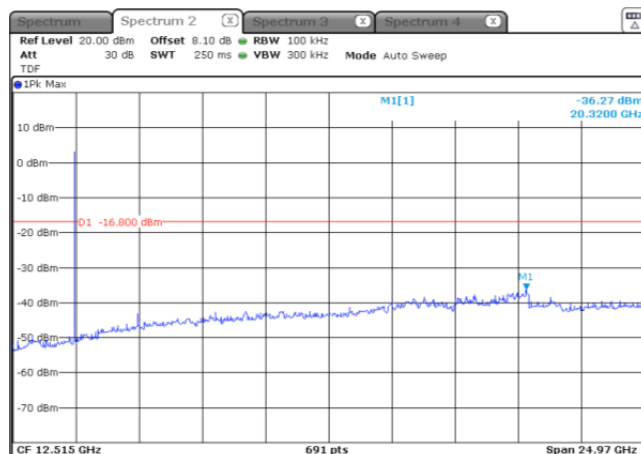
Lowest Channel(2 402 MHz):
30 MHz ~ 25 GHz



Middle Channel(2 441 MHz):
30 MHz ~ 25 GHz

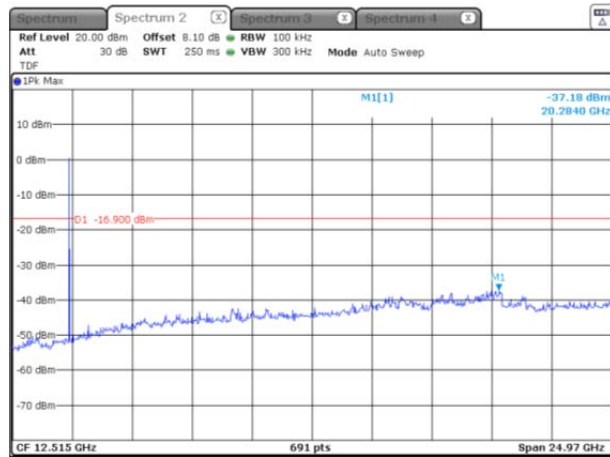


Highest Channel(2 480 MHz):
30 MHz ~ 25 GHz

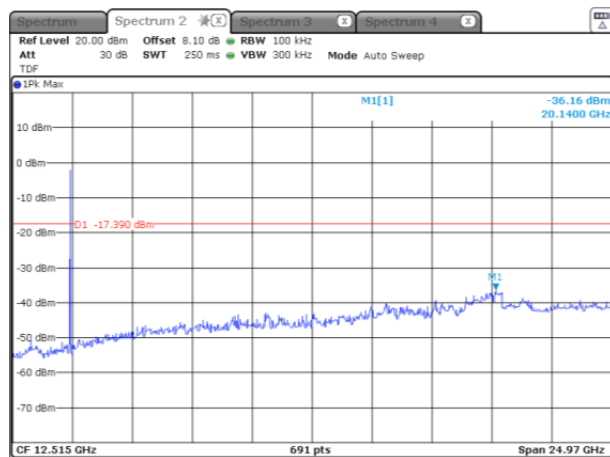


* $\pi/4$ DQPSK

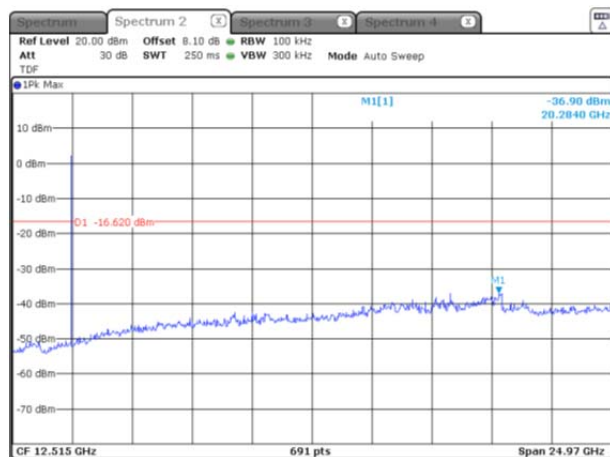
Lowest Channel(2 402 MHz):
30 MHz ~ 25 GHz



Middle Channel(2 441 MHz):
30 MHz ~ 25 GHz

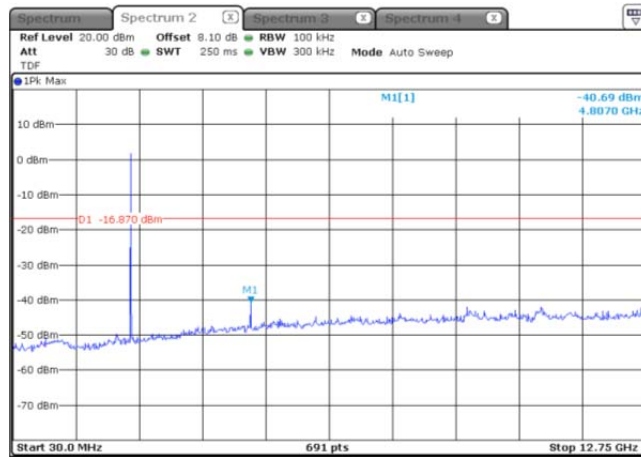


Highest Channel(2 480 MHz):
30 MHz ~ 25 GHz

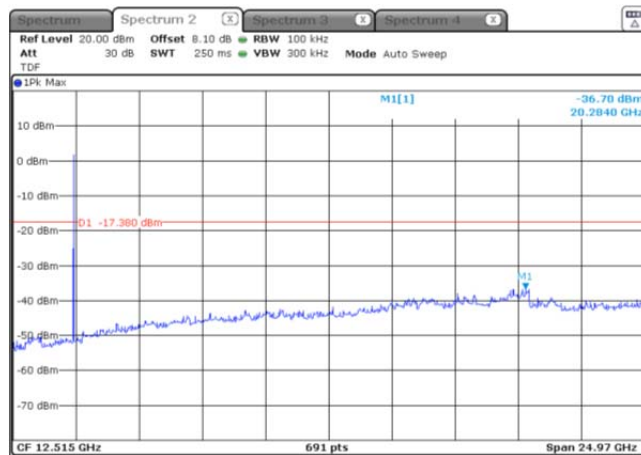


*** 8DPSK**

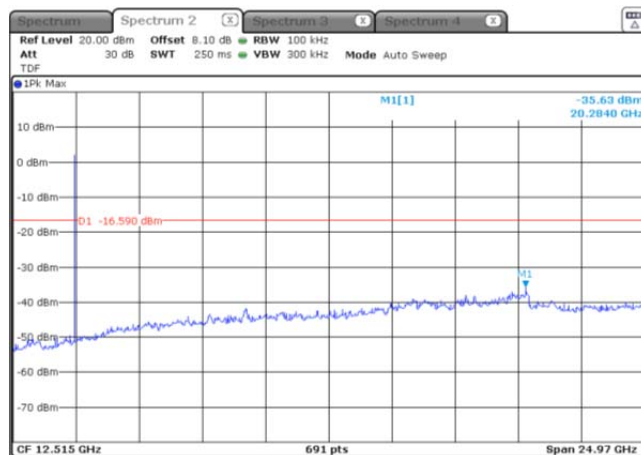
Lowest Channel(2 402 MHz):
30 MHz ~ 25 GHz



Middle Channel(2 441 MHz):
30 MHz ~ 25 GHz



Highest Channel(2 480 MHz):
30 MHz ~ 25 GHz



5.8 RF Exposure

5.8.1 Regulation

According to §15.247(i), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See § 1.1307(b)(1) of this Chapter.

Limits for Maximum Permissible Exposure: RF exposure is calculated.

| Frequency Range | Electric Field Strength [V/m] | Magnetic Field Strength [A/m] | Power Density [mW/cm ²] | Averaging Time [minute] |
|---|-------------------------------|-------------------------------|-------------------------------------|-------------------------|
| Limits for General Population / Uncontrolled Exposure | | | | |
| 0.3 ~ 1.34 | 614 | 1.63 | *(100) | 30 |
| 1.34 ~ 30 | 824 /f | 2.19/f | *(180/f ²) | 30 |
| 30 ~ 300 | 27.5 | 0.073 | 0.2 | 30 |
| 300 ~ 1500 | / | / | f/1500 | 30 |
| 1500 ~ 15000 | / | / | 1.0 | 30 |

f=frequency in MHz, *= plane-wave equivalent power density

MPE (Maximum Permissible Exposure) Prediction

Predication of MPE limit at a given distance: Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2 \quad (\Rightarrow R = \sqrt{PG/4\pi S})$$

S=power density [mW/cm²]

P=Power input to antenna [mW]

G=Power gain of the antenna in the direction of interest relative to an isotropic radiator

R= distance to the center of radiation of the antenna [cm]

| | |
|---|--|
| EUT: Maximum peak output power = 3.02 [mW](= 4.80 dBm) Antenna gain= 2.24(= 3.5 [dBi]) | |
| 100 mW, at 20 cm from an antenna 6[dBi] | $S = PG/4\pi R^2 = 100 \times 3.98 / (4 \times \pi \times 400)$ $= 0.07918 \text{ [mW/cm}^2\text{]} < 1.0 \text{ [mW/cm}^2\text{]}$ |
| 2.239 mW, at 20 cm from an antenna 3.5 [dBi] | $S = PG/4\pi R^2 = 0.00135 \text{ [mW/cm}^2\text{]} < 1.0 \text{ [mW/cm}^2\text{]}$ |
| 2.239 mW, at 2.5 cm from an antenna 3.5 [dBi] | $S = PG/4\pi R^2 = 0.08608 \text{ [mW/cm}^2\text{]} < 1.0 \text{ [mW/cm}^2\text{]}$ |

5.8.2 RF Exposure Compliance Issue

The information should be included in the user's manual:

This appliance and its antenna must not be co-located or operation in conjunction with any other antenna or transmitter. A minimum separation distance of 20 cm must be maintained between the antenna and the person for this appliance to satisfy the RF exposure requirements.

6. Test equipment used for test

| | Description | Manufacture | Model No. | Serial No. | Next Cal Date. |
|---|-------------------|---------------|------------|------------|----------------|
| ■ | DC Power Supply | Agilent | E3632A | MY51220373 | 14.12.24 |
| ■ | Signal Generator | R&S | SMR40 | 100007 | 14.06.11 |
| ■ | Spectrum Analyzer | R&S | FSV40 | 100988 | 15.01.29 |
| ■ | Loop Antenna | R&S | HFH2-Z2 | 100355 | 15.06.19 |
| ■ | Bi-Log Antenna | Schwarzbeck | VULB9163 | 552 | 14.07.18 |
| ■ | Horn Antenna | ETS-Lindgren | 3115 | 86706 | 14.08.20 |
| ■ | Horn Antenna | ETS-Lindgren | 3116 | 00086632 | 15.11.15 |
| ■ | Amplifier | Sonoma | 310N | 186280 | 14.02.15 |
| ■ | Amplifier | Schwarzbeck | BBV9718 | 233 | 14.05.03 |
| ■ | Amplifier | Schwarzbeck | BBV9721 | 2 | 14.05.09 |
| ■ | Attenuator | HP | 8491A | 16861 | 14.07.08 |
| ■ | Antenna Mast | Innco Systems | MA4000-EP | 303 | - |
| ■ | Turn Table | Innco Systems | DT2000S-1t | 79 | - |