



Dongguan Yaxu (AiT) Technology Limited

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FCC PART 15 SUBPART C TEST REPORT

FCC PART 15.247

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Date of issue..... : Jul. 12, 2017

Representative Laboratory Name .. : Dongguan Yaxu (AiT) Technology Limited

Address..... : No.22, Jinqianling Third Street, Jitigang, Huangjiang, Dongguan, Guangdong, China

Applicant's name : Music Wave Limited

Address..... : Room 07, 14/F, Block B, Wing Cheung Industrial Building, 58-70 Kwai Cheong Road, Kwai Chung, Hong Kong

Test specification :

Standard : **FCC Part 15.247: Operation within the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz**

TRF Originator : Dongguan Yaxu (AiT) Technology Limited

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Test item description : Car Audio

Trade Mark : N/A

Manufacturer : Music Wave Limited

Model/Type reference..... : MW101

Listed Models : RAD-1700BT,RAD-1750GB,MW038,MW100,MW103,MW201, MW202, MW203, SCT 9411BMR

Modulation Type : GFSK,8DPSK,π/4DQPSK

Operation Frequency..... : From 2402MHz to 2480MHz

Rating : DC 12V

Result..... : **PASS**



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1 TEST STANDARDS

The tests were performed according to following standards:

[FCC Rules Part 15.247](#): Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

[ANSI C63.10-2013](#): American National Standard for Testing Unlicensed Wireless Devices



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2 SUMMARY

2.1 General Remarks

| | | |
|--------------------------------|---|---------------|
| Date of receipt of test sample | : | Jul. 02, 2017 |
| Testing commenced on | : | Jul. 05, 2017 |
| Testing concluded on | : | Jul. 12, 2017 |

2.2 Product Description

The **Music Wave Limited**'s Model: MW101 or the "EUT" as referred to in this report; more general information as follows, for more details, refer to the user's manual of the EUT.

| | |
|----------------------------|---|
| Name of EUT | Car Audio |
| Model Number | MW101 |
| Listed Models | RAD-1700BT,RAD-1750GB,MW038,MW100,MW103,MW201,MW202, MW203, SCT 9411BMR |
| Model differences | All models are the same circuit and RF module, except model name. |
| Antenna Type | PCB |
| Antenna Gain | 1.21dBi(Calculated) |
| BT FCC Operation frequency | 2402MHz-2480MHz |
| BT Modulation Type | GFSK,8DPSK,π/4DQPSK(BT 2.1+EDR) |
| Hardware version | V1.1 |
| Software version | V4.0 |
| Bluetooth | Supported BT 2.1+EDR |
| Extreme temp. Tolerance | -10°C to +40°C |
| Extreme vol. Limits | 10.8VDC to 13.2VDC (nominal: 12VDC) |
| adapter | N/A |

2.3 Equipment Under Test

Power supply system utilised

| | | | |
|----------------------|---|--|-----------------------------------|
| Power supply voltage | : | <input type="radio"/> 120V / 60 Hz | <input type="radio"/> 115V / 60Hz |
| | | <input checked="" type="radio"/> 12 V DC | <input type="radio"/> 24 V DC |
| | | <input type="radio"/> Other (specified in blank below) | |

2.4 EUT operation mode

The EUT has been tested under typical operating condition. There are EDR (Enhanced Data Rate) and BDR (Basic Data Rate) mode. The Applicant provides communication tools software to control the EUT for staying in continuous transmitting and receiving mode for testing. There are 79 channels of EUT, and the test carried out at the lowest channel, middle channel and highest channel. all test performed use fully-charged battery.

| Channel | Frequency(MHz) | Channel | Frequency(MHz) |
|---------|----------------|---------|----------------|
| 00 | 2402 | 40 | 2442 |
| 01 | 2403 | 41 | 2443 |
| 02 | 2404 | 42 | 2444 |
| 03 | 2405 | 43 | 2445 |
| 04 | 2406 | 44 | 2446 |
| 05 | 2407 | 45 | 2447 |
| 06 | 2408 | 46 | 2448 |



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| | | | |
|----|------|----|------|
| 07 | 2409 | 47 | 2449 |
| 08 | 2410 | 48 | 2450 |
| 09 | 2411 | 49 | 2451 |
| 10 | 2412 | 50 | 2452 |
| 11 | 2413 | 51 | 2453 |
| 12 | 2414 | 52 | 2454 |
| 13 | 2415 | 53 | 2455 |
| 14 | 2416 | 54 | 2456 |
| 15 | 2417 | 55 | 2457 |
| 16 | 2418 | 56 | 2458 |
| 17 | 2419 | 57 | 2459 |
| 18 | 2420 | 58 | 2460 |
| 19 | 2421 | 59 | 2461 |
| 20 | 2422 | 60 | 2462 |
| 21 | 2423 | 61 | 2463 |
| 22 | 2424 | 62 | 2464 |
| 23 | 2425 | 63 | 2465 |
| 24 | 2426 | 64 | 2466 |
| 25 | 2427 | 65 | 2467 |
| 26 | 2428 | 66 | 2468 |
| 27 | 2429 | 67 | 2469 |
| 28 | 2430 | 68 | 2470 |
| 29 | 2431 | 69 | 2471 |
| 30 | 2432 | 70 | 2472 |
| 31 | 2433 | 71 | 2473 |
| 32 | 2434 | 72 | 2474 |
| 33 | 2435 | 73 | 2475 |
| 34 | 2436 | 74 | 2476 |
| 35 | 2437 | 75 | 2477 |
| 36 | 2438 | 76 | 2478 |
| 37 | 2439 | 77 | 2479 |
| 38 | 2440 | 78 | 2480 |
| 39 | 2441 | | |

2.5 Internal Identification of AE used during the test

| AE ID* | Description |
|--------|-------------------|
| AE1 | Notebook(M/N:B50) |
| AE2 | adapter |

AE2

Model: HS05001000ES

INPUT: AC100-240V 50/60Hz 0.3A Max

OUTPUT: DC 5.0V 1.0A

*AE ID: is used to identify the test sample in the lab internally.

2.6 Related Submittal(s) / Grant (s)

This submittal(s) (test report) is intended for **FCC ID: 2AKVT-MW101** filing to comply with Section 15.247 of the FCC Part 15, Subpart C Rules.

2.7 Modifications

No modifications were implemented to meet testing criteria.



3 TEST ENVIRONMENT

3.1 Address of the test laboratory

Dongguan Yaxu (AiT) Technology Limited

No.22, Jinqianling Third Street, Jitigang, Huangjiang, Dongguan, Guangdong, China

3.2 Test Facility

The test facility is recognized, certified, or accredited by the following organizations:

FCC-Registration No.: 248337

Dongguan Yaxu (AiT) Technology Limited. EMC Laboratory has been registered and fully described in a report filed with the FCC (Federal Communications Commission). The acceptance letter from the FCC is maintained in our files.

3.3 Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Temperature: 15-35 ° C

Humidity: 30-60 %

Atmospheric pressure: 950-1050mbar

3.4 Test Conditions

| Test Case | Test Conditions | |
|--|------------------|---|
| | Configuration | Description |
| 20dB Emission Bandwidth (EBW) | Meas. Method | ANSI C63.10:2013 |
| | Test Environment | NTNV |
| | EUT Conf. | TM1_DH5_Ch00,TM1_DH5_Ch39,TM1_DH5_Ch78, TM3_3DH5_Ch00,TM3_3DH5_Ch39,TM3_3DH5_Ch78, |
| Carrier Frequency Separation | Meas. Method | ANSI C63.10:2013 |
| | Test Environment | NTNV |
| | EUT Conf. | TM1_DH5_Hop, TM3_3DH5_Hop, |
| Number of Hopping Channel | Meas. Method | ANSI C63.10:2013 |
| | Test Environment | NTNV |
| | EUT Conf. | TM1_DH5_Hop ,TM3_3DH5_Hop, |
| Time of Occupancy (Dwell Time) | Meas. Method | ANSI C63.10:2013 |
| | Test Environment | NTNV |
| | EUT Conf. | TM1_DH5_Ch39 ,TM3_3DH5_Ch39. |
| Maximum Peak Conducted Output Power | Meas. Method | ANSI C63.10:2013 |
| | Test Environment | NTNV |
| | EUT Conf. | TM1_DH3_Ch00,TM1_DH3_Ch39,TM1_DH3_Ch78,TM2_2DH3_Ch00,TM2_2DH3_Ch39,TM2_2DH3_Ch78,TM3_3DH3_Ch00,TM3_3DH3_Ch39,TM3_3DH3_Ch78, |
| Bandedge spurious emission (Conducted) | Meas. Method | ANSI C63.10:2013 |
| | Test Environment | NTNV |
| | EUT Conf. | TM1_DH3_Ch00,TM1_DH3_Ch78, TM3_3DH3_Ch00,TM3_3DH3_Ch78, |
| Conducted RF Spurious Emission | Meas. Method | ANSI C63.10:2013 |
| | Test Environment | NTNV |
| | EUT Conf. | TM1_DH5_Ch00, TM1_DH5_Ch39, TM1_DH5_Ch78, TM3_3DH5_Ch39, TM3_3DH5_Ch78. |



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| | | |
|--|------------------|---|
| Radiated Emissions in the Restricted Bands | Meas. Method | ANSI C63.10:2013 30 MHz to 1 GHz: Pre: RBW=100kHz; VBW=300kHz; Det. = Peak. Final: RBW=120kHz; Det. = CISPR Quasi-Peak. 1 GHz to 26.5GHz: Average: RBW=1 MHz; VBW= 10Hz; Det. = Peak; Sweep-time= Auto; Trace = Single. Peak: RBW=1 MHz; VBW= 3 MHz; Det. = Peak; Sweep-time= Auto; Trace≥ MaxHold * 100. |
| | Test Environment | NTNV |
| | EUT Conf. | 30 MHz-1GHz TM1_DH5_Ch00 (Worst Conf.). 1-18 GHz: TM1_DH5_Ch00, TM1_DH5_Ch39, TM1_DH5_Ch78, (Worst Conf.). |

| Test Case | Test Conditions | | |
|-----------------------------------|--------------------|------------------------------|--|
| | Configuration | Description | |
| AC Power Line Conducted Emissions | Measurement Method | AC mains conducted. | |
| | Test Environment | NTNV | |
| | EUT Configuration | TM1_DH5_Ch39. (Worst Conf.). | |

Note:

- For Radiated Emissions, By preliminary testing and verifying three axis (X, Y and Z) position of EUT transmitted status, it was found that "Z axis" position was the worst, then the final test was executed the worst condition and test data were recorded in this report.
- For π/4 QPSK its same modulation type with 8-DPSK, and based exploratory test, there is no significant difference of that two types test result, so except output power, all other items final test were only performed with the worse case 8-DPSK and GFSK.

3.5 Summary of measurement results

| Test Specification clause | Test case | Test Mode | Test Channel | Recorded In Report | | Pass | Fail | NA | NP | Remark |
|---------------------------|--|---------------------|---|---------------------|---|---|--------------------------|-------------------------------------|--------------------------|-------------------------|
| §15.247(b)(4) | Antenna gain | GFSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | GFSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.247(e) | Power spectral density | -/- | -/- | -/- | -/- | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | Not applicable for FHSS |
| §15.247(a)(1) | Carrier Frequency separation | GFSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | GFSK 8DPSK | <input checked="" type="checkbox"/> Middle | <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.247(a)(1) | Number of Hopping channels | GFSK 8DPSK | <input checked="" type="checkbox"/> Full | GFSK 8DPSK | <input checked="" type="checkbox"/> Full | <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.247(a)(1) | Time of Occupancy (dwell time) | GFSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | GFSK 8DPSK | <input checked="" type="checkbox"/> Middle | <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.247(a)(1) | Spectrum bandwidth of a FHSS system 20dB bandwidth | GFSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | GFSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.247(b)(1) | Maximum output power | GFSK Π/4DQPSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | GFSK Π/4DQPSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.247(d) | Band edge compliance conducted | GFSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Highest | GFSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Highest | <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.205 | Band edge compliance | GFSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Highest | GFSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Highest | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |



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| | radiated | | | | | | | | | |
|-----------------------|---|------------|---|------------|---|-------------------------------------|--------------------------|--------------------------|--------------------------|----------|
| §15.247(d) | TX spurious emissions conducted | GFSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | GFSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.247(d) | TX spurious emissions radiated | GFSK 8DPSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | GFSK | <input checked="" type="checkbox"/> Lowest <input checked="" type="checkbox"/> Middle <input checked="" type="checkbox"/> Highest | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.109 | RX spurious emissions radiated | -/- | -/- | -/- | -/- | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.209(a) | TX spurious Emissions radiated < 30 MHz | GFSK | -/- | GFSK | -/- | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |
| §15.107(a) §15.207 | Conducted Emissions < 30 MHz | GFSK | -/- | GFSK | -/- | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | complies |

Remark:

1. The measurement uncertainty is not included in the test result.
2. NA = Not Applicable; NP = Not Performed
3. We tested all test mode and recorded worst case in report

3.6 Equipments Used during the Test

| No | Test Equipment | Manufacturer | Model No | Serial No | Cal. Date | Cal. Due Date |
|----|-------------------------------------|--------------|------------------|--------------|------------|---------------|
| 1 | Spectrum Analyzer | ADVANTEST | R3182 | 150900201 | 2017.06.29 | 2018.06.28 |
| 2 | EMI Measuring Receiver | R&S | ESR | 101660 | 2016.12.12 | 2017.12.11 |
| 3 | Low Noise Pre Amplifier | Tsj | MLA-10K01-B01-27 | 1205323 | 2017.06.29 | 2018.06.28 |
| 4 | Low Noise Pre Amplifier | Tsj | MLA-0120-A02-34 | 2648A04738 | 2017.12.02 | 2017.12.01 |
| 5 | TRILOG Super Broadband test Antenna | SCHWARZBEC K | VULB9160 | 9160-3206 | 2016.12.03 | 2017.12.02 |
| 6 | Broadband Horn Antenna | SCHWARZBEC K | BBHA9120D | 452 | 2016.12.03 | 2017.12.02 |
| 7 | SHF-EHF Horn | SCHWARZBEC K | BBHA9170 | BBHA917036 7 | 2016.12.03 | 2017.12.02 |
| 8 | 50Ω Coaxial Switch | Anritsu | MP59B | 6200264416 | 2016.09.26 | 2017.09.25 |
| 9 | EMI Test Receiver | R&S | ESCI | 100124 | 2017.06.29 | 2018.06.28 |
| 10 | LISN | Kyoritsu | KNW-242 | 8-837-4 | 2017.06.29 | 2018.06.28 |
| 11 | LISN | Kyoritsu | KNW-407 | 8-1789-3 | 2017.06.29 | 2018.06.28 |



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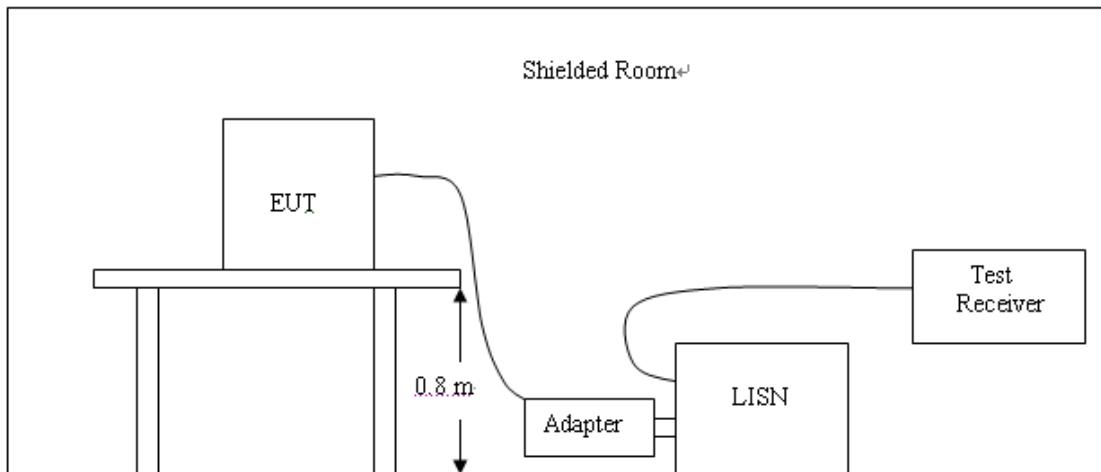
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| | | | | | | |
|--|------------------------------------|----------|------------|--------------|------------|------------|
| 12 | 50Ω Coaxial Switch | Anritsu | MP59B | 6200264417 | 2016.09.25 | 2017.09.24 |
| 13 | Loop Antenna | ARA | PLA-1030/B | 1029 | 2017.03.20 | 2018.03.19 |
| 14 | Radiated Cable 1# (30MHz-1GHz) | FUJIKURA | 5D-2W | 01 | 2017.01.04 | 2018.01.03 |
| 15 | Radiated Cable 2# (1GHz -25GHz) | FUJIKURA | 10D2W | 02 | 2016.12.25 | 2017.12.24 |
| 16 | Conducted Cable 1#(9KHz-30MHz) | FUJIKURA | 1D-2W | 01 | 2017.01.04 | 2018.01.03 |
| 17 | SMA Antenna connector | Dosin | Dosin-SMA | N/A | N/A | N/A |
| 18 | Power Meter | R&S | NRVS | 100696 | 2017.07.06 | 2018.07.05 |
| 19 | Power Sensor | R&S | URV5-Z4 | 0395.1619.05 | 2017.07.06 | 2018.07.05 |
| Note: The SMA antenna connector is soldered on the PCB board in order to perform conducted tests and this SMA antenna connector is listed in the equipment list. | | | | | | |

4 TEST CONDITIONS AND RESULTS

4.1 AC Power Conducted Emission

TEST CONFIGURATION



TEST PROCEDURE

1. The equipment was set up as per the test configuration to simulate typical actual usage per the user's manual. The EUT is a tabletop system; a wooden table with a height of 0.8 meters is used and is placed on the ground plane as per ANSI C63.10:2013.
2. Support equipment, if needed, was placed as per ANSI C63.10:2013
3. All I/O cables were positioned to simulate typical actual usage as per ANSI C63.10:2013
4. All support equipments received AC power from a second LISN, if any.
5. The EUT test program was started. Emissions were measured on each current carrying line of the EUT using a spectrum Analyzer / Receiver connected to the LISN powering the EUT. The LISN has two monitoring points: Line 1 (Hot Side) and Line 2 (Neutral Side). Two scans were taken: one with Line 1 connected to Analyzer / Receiver and Line 2 connected to a 50 ohm load; the second scan had Line 1 connected to a 50 ohm load and Line 2 connected to the Analyzer / Receiver.
6. Analyzer / Receiver scanned from 150 KHz to 30MHz for emissions in each of the test modes.
7. During the above scans, the emissions were maximized by cable manipulation.

AC Power Conducted Emission Limit

For intentional device, according to § 15.207(a) AC Power Conducted Emission Limits is as following :

| Frequency (MHz) | Maximum RF Line Voltage (dB μ V) | |
|--------------------|---|--------|
| | Q.P. | Ave. |
| 0.15 - 0.50 | 66-56* | 56-46* |
| 0.50 - 5.00 | 56 | 46 |
| 5.00 - 30.0 | 60 | 50 |

* Decreasing linearly with the logarithm of the frequency



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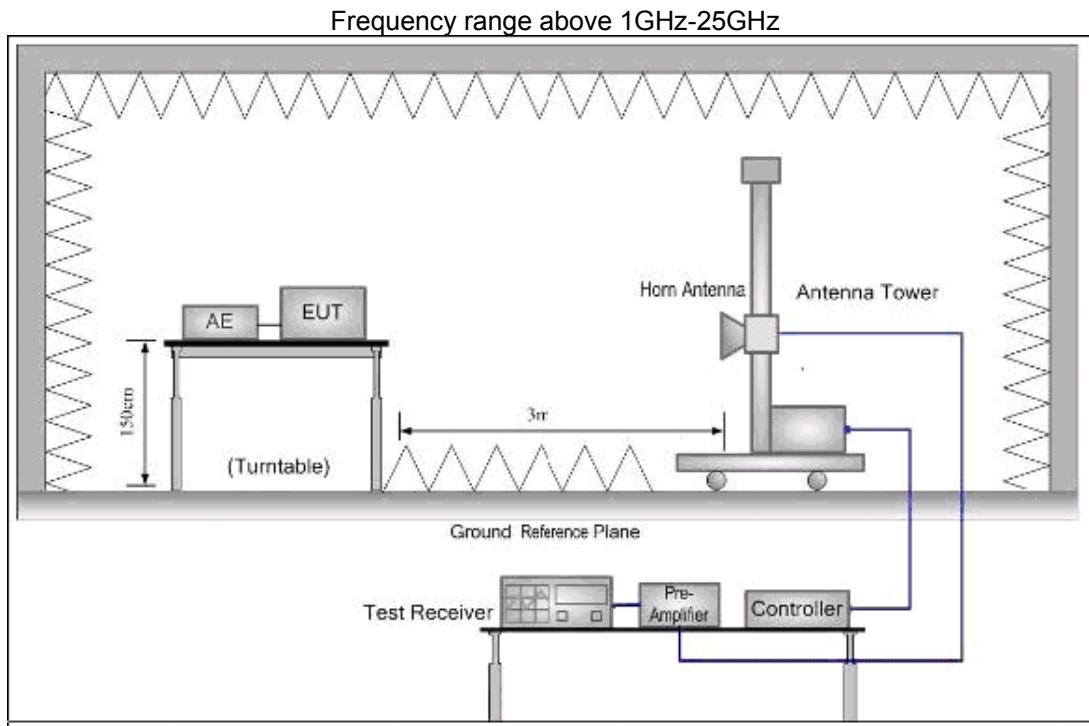
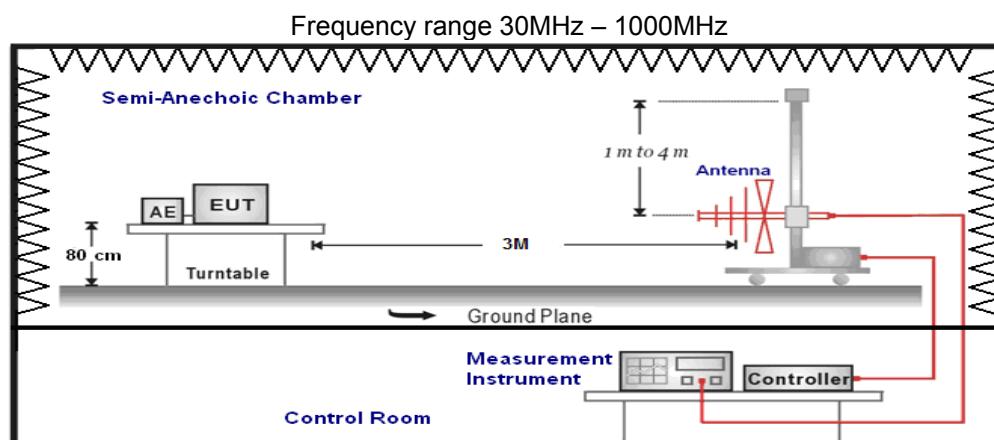
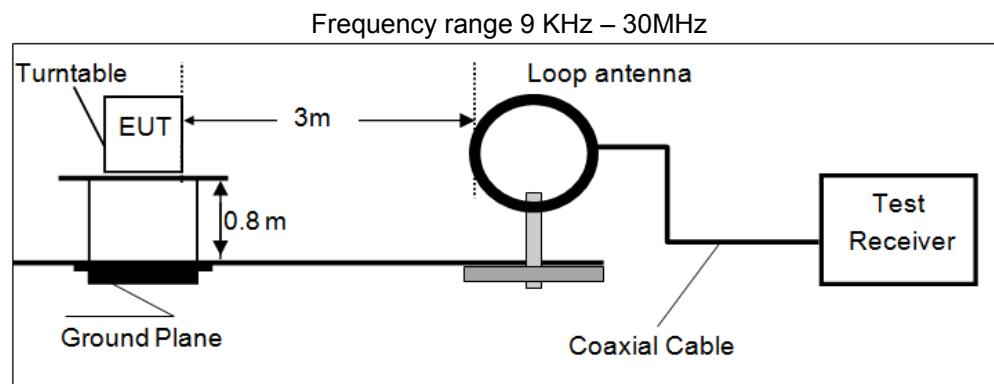
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TEST RESULTS

Due to this device is powered by battery only, this test is not required.

4.2 Radiated Emission

TEST CONFIGURATION



TEST PROCEDURE



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1. The EUT was placed on a turn table which is 0.8m(1.5m above 1G) above ground plane.
2. Maximum procedure was performed by raising the receiving antenna from 1m to 4m and rotating the turn table from 0°C to 360°C to acquire the highest emissions from EUT.
3. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
4. Repeat above procedures until all frequency measurements have been completed.
5. The EUT maximum operation frequency was 2480MHz.so radiated emission test frequency band from 9 KHz to 25GHz.
6. For the radiated emission test above 1GHz:

Place the measurement antenna away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The measurement antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal. The final measurement antenna elevation shall be that which maximizes the emissions. The measurement antenna elevation for maximum emissions shall be restricted to a range of heights of from 1 m to 4 m above the ground or reference ground plane.

7. The distance between test antenna and EUT as following table states:

| Test Frequency range | Test Antenna Type | Test Distance |
|----------------------|----------------------------|---------------|
| 9KHz-30MHz | Active Loop Antenna | 3 |
| 30MHz-1GHz | Ultra-Broadband Antenna | 3 |
| 1GHz-18GHz | Double Ridged Horn Antenna | 3 |
| 18GHz-25GHz | Horn Anternna | 3 |

8. Setting test receiver/spectrum as following table states:

| Test Frequency range | Test Receiver/Spectrum Setting | Detector |
|----------------------|--|-----------------------|
| 9KHz-150KHz | RBW=200Hz/VBW=3KHz,Sweep time=Auto | QP |
| 150KHz-30MHz | RBW=9KHz/VBW=100KHz,Sweep time=Auto | QP |
| 30MHz-1GHz | RBW=120KHz/VBW=1000KHz,Sweep time=Auto | QP |
| 1GHz-40GHz | Peak Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto | Peak (Receiver) |
| | Average Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto | Average (Receiver) |

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor and subtracting the Amplifier Gain and Duty Cycle Correction Factor (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$\text{FS} = \text{RA} + \text{AF} + \text{CL} - \text{AG}$$

| | |
|---------------------------|--|
| Where FS = Field Strength | CL = Cable Attenuation Factor (Cable Loss) |
| RA = Reading Amplitude | AG = Amplifier Gain |
| AF = Antenna Factor | |

For example

| Frequency (MHz) | FS (dB μ V/m) | RA (dB μ V/m) | AF (dB) | CL (dB) | AG (dB) | Transd (dB) |
|-----------------|-------------------|-------------------|---------|---------|---------|-------------|
| 300.00 | 40 | 58.1 | 12.2 | 1.6 | 31.90 | -18.1 |

Transd=AF +CL-AG



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RADIATION LIMIT

For intentional device, according to § 15.209(a), the general requirement of field strength of radiated emission from intentional radiators at a distance of 3 meters shall not exceed the following table. According to § 15.247(d), in any 100kHz bandwidth outside the frequency band in which the EUT is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of desired power.

The pre-test have done for the EUT in three axes and found the worst emission at position shown in test setup photos.

| Frequency (MHz) | Distance (Meters) | Radiated (dB μ V/m) | Radiated (μ V/m) |
|-----------------|-------------------|-------------------------|-----------------------|
| 0.009-0.49 | 300 | 20log(2400/F(KHz))+80 | 2400/F(KHz) |
| 0.49-1.705 | 30 | 20log(24000/F(KHz))+40 | 24000/F(KHz) |
| 1.705-30 | 30 | 20log(30)+40 | 30 |
| 30-88 | 3 | 40.0 | 100 |
| 88-216 | 3 | 43.5 | 150 |
| 216-960 | 3 | 46.0 | 200 |
| Above 960 | 3 | 54.0 | 500 |

TEST RESULTS

Remark:

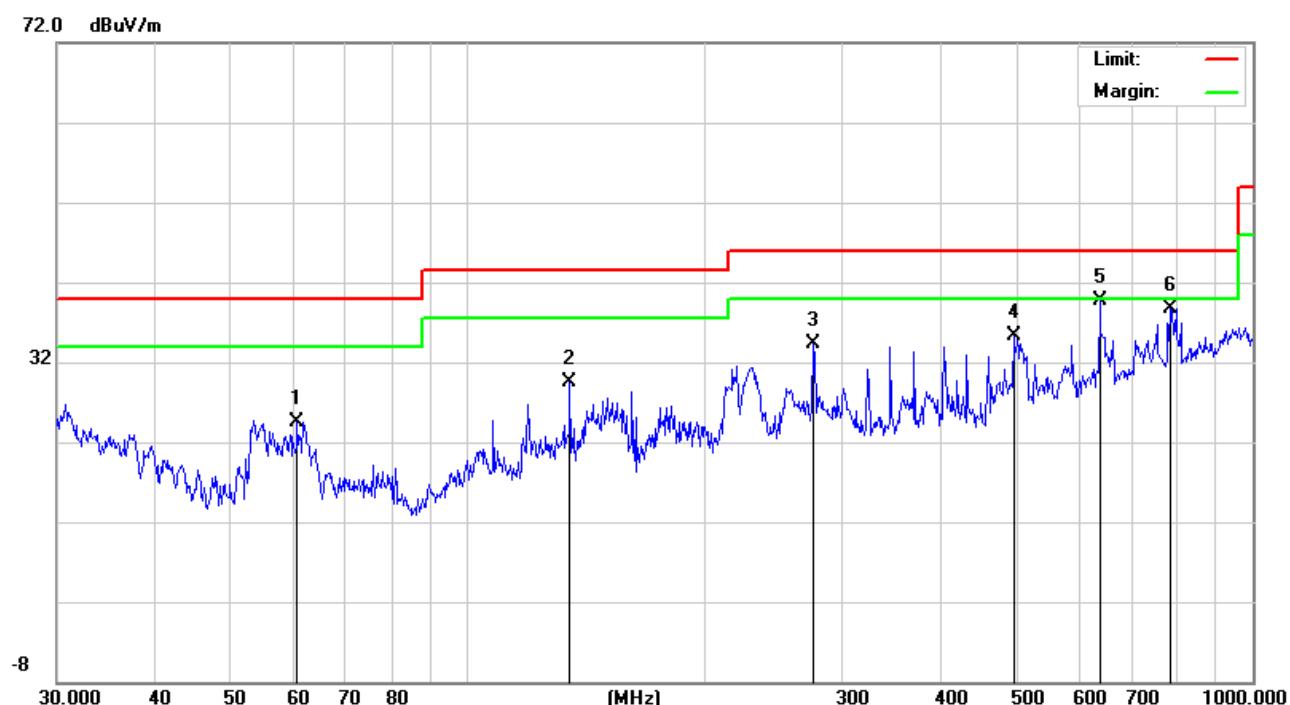
1. The radiated measurement are performed the each channel (low/mid/high) at all Packet type (DH1, DH3 and DH5) also for difference modulation type (GFSK, 8DPSK), recorded worst case at GFSK_DH5_Low channel (Channel 00) for below 1GHz and GFSK_DH5_Low channel (Channel 00), GFSK_DH5_Middle channel (Channel 39), GFSK_DH5_High channel (Channel 78) for above 1G.
2. ULTRA-BROADBAND ANTENNA for the radiation emission test below 1G.
3. HORN ANTENNA for the radiation emission test above 1G.
4. “--” means not recorded as emission levels lower than limit.
5. Margin= Limit - Level

For 9KHz to 30MHz

| Frequency (MHz) | Corrected Reading (dB μ V/m) @3m | FCC Limit (dB μ V/m) @3m | Margin (dB) | Detector | Result |
|-----------------|--------------------------------------|------------------------------|-------------|----------|--------|
| 12.45 | 43.14 | 69.54 | 26.40 | QP | PASS |
| 24.41 | 42.68 | 69.54 | 26.86 | QP | PASS |

For 30MHz to 1000MHz

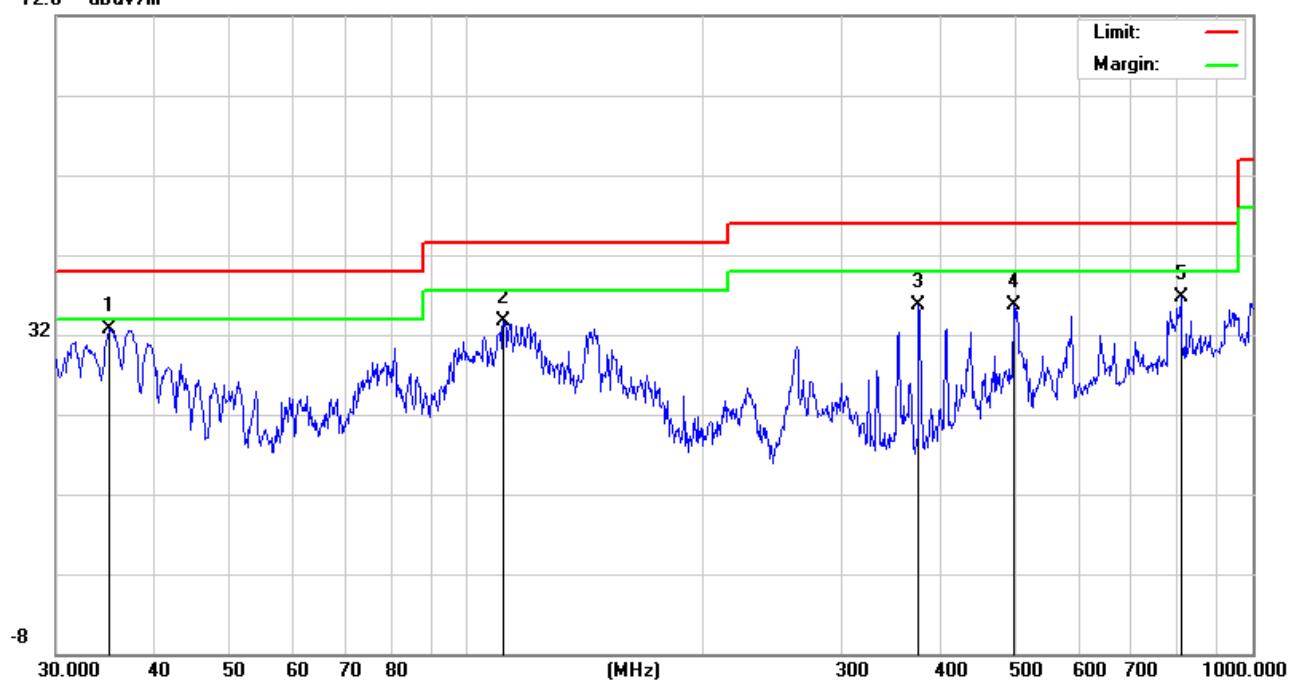
(a) Antenna polarization: Horizontal



| No. | Mk. | Freq. | Reading | Correct | Measure- | Limit | Over | Antenna | Table | | |
|-----|-----|----------|---------|---------|----------|--------|--------|----------|-------|--------|---------|
| | | | Level | Factor | ment | | | | | | |
| | | MHz | dBuV | dB | dBuV/m | dBuV/m | dB | Detector | cm | degree | Comment |
| 1 | | 60.7043 | 19.20 | 5.30 | 24.50 | 40.00 | -15.50 | peak | | | |
| 2 | | 135.0319 | 17.27 | 12.25 | 29.52 | 43.50 | -13.98 | QP | | | |
| 3 | | 275.1569 | 20.14 | 14.07 | 34.21 | 46.00 | -11.79 | QP | | | |
| 4 | | 495.9343 | 14.71 | 20.59 | 35.30 | 46.00 | -10.70 | QP | | | |
| 5 | * | 638.3686 | 16.31 | 23.47 | 39.78 | 46.00 | -6.22 | QP | | | |
| 6 | | 785.0934 | 12.65 | 26.10 | 38.75 | 46.00 | -7.25 | QP | | | |

(b) Antenna polarization: vertical

72.0 dBuV/m



| No. | Mk. | Freq. MHz | Reading Level | Correct Factor | Measure- ment | Limit | Over | Antenna Height cm | Table Degree | Comment |
|-----|-----|--------------|------------------|-------------------|------------------|--------|--------|-------------------------|-----------------|---------|
| | | | dBuV | dB | dBuV/m | dBuV/m | dB | Detector | degree | |
| 1 | * | 35.1278 | 16.80 | 15.81 | 32.61 | 40.00 | -7.39 | QP | | |
| 2 | | 111.3468 | 21.94 | 11.72 | 33.66 | 43.50 | -9.84 | QP | | |
| 3 | | 375.9384 | 18.74 | 16.96 | 35.70 | 46.00 | -10.30 | QP | | |
| 4 | | 495.9343 | 15.16 | 20.59 | 35.75 | 46.00 | -10.25 | QP | | |
| 5 | | 810.2653 | 10.43 | 26.25 | 36.68 | 46.00 | -9.32 | QP | | |

Note:

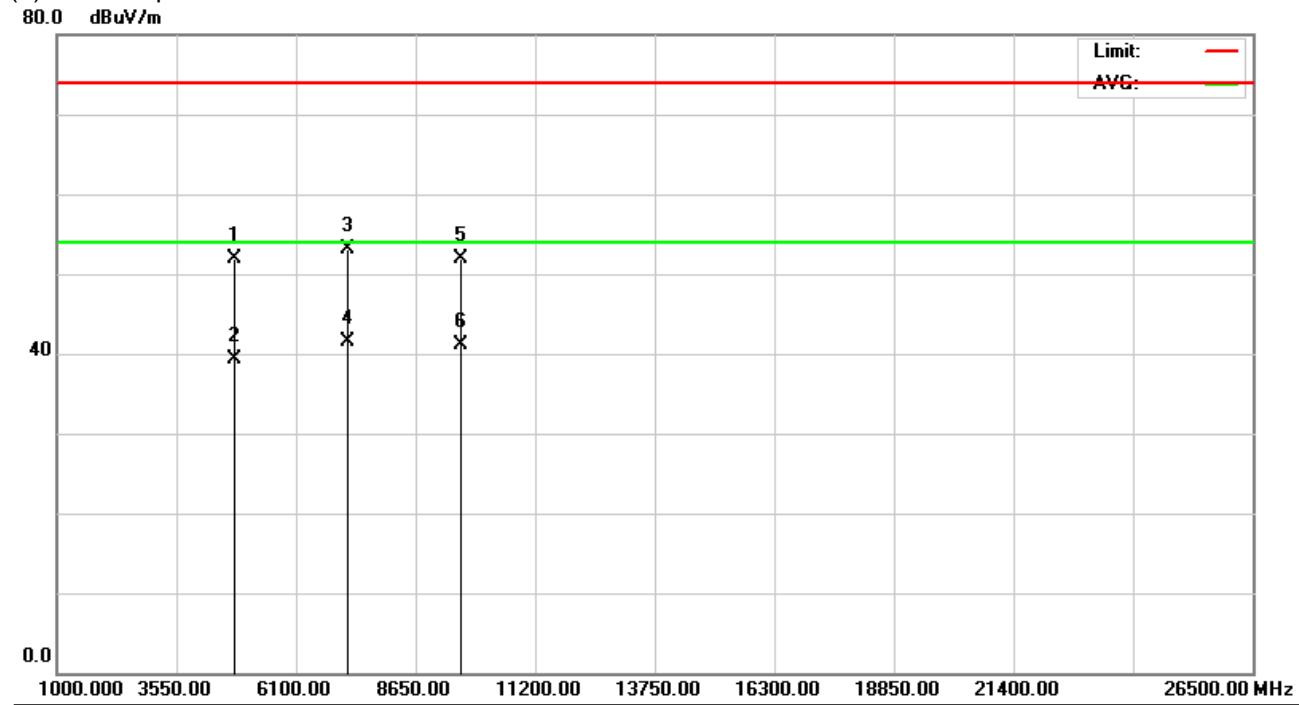
Measurement Level = Reading Level + Factor

Remark: Factor = Antenna Factor + Cable Loss - Pre-amplifier

For 1GHz to 25GHz

Note: We tested GFSK Mode and 8DPSK, recorded the worst case at the GFSK (DH5) Mode.

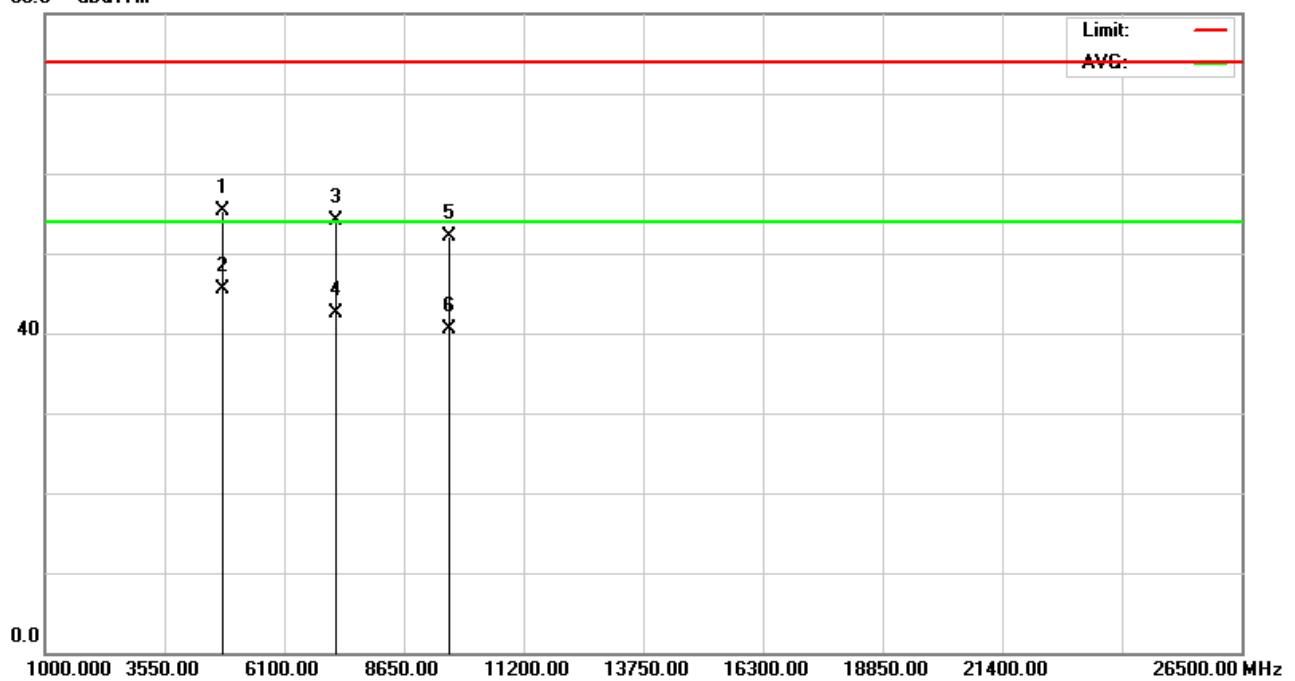
(a) Antenna polarization: Horizontal



| No. | Mk. | Freq. | Reading | Correct | Measure- | Limit | Over | |
|-----|-----|----------|---------|---------|----------|--------|--------|----------|
| | | | Level | Factor | ment | | | |
| | | MHz | dBuV | dB | dBuV/m | dBuV/m | dB | Detector |
| 1 | | 4804.000 | 56.72 | -4.86 | 51.86 | 74.00 | -22.14 | peak |
| 2 | | 4804.000 | 44.15 | -4.86 | 39.29 | 54.00 | -14.71 | AVG |
| 3 | | 7206.000 | 53.69 | -0.58 | 53.11 | 74.00 | -20.89 | peak |
| 4 | * | 7206.000 | 42.08 | -0.58 | 41.50 | 54.00 | -12.50 | AVG |
| 5 | | 9608.000 | 47.14 | 4.81 | 51.95 | 74.00 | -22.05 | peak |
| 6 | | 9608.000 | 36.22 | 4.81 | 41.03 | 54.00 | -12.97 | AVG |

(b) Antenna polarization: Vertical

80.0 dBuV/m



| No. | Mk. | Freq. MHz | Reading Level dBuV | Correct Factor dB | Measure- ment dBuV/m | Limit dBuV/m | Over dB | Over Detector |
|-----|-----|--------------|--------------------------|-------------------------|----------------------------|-----------------|------------|------------------|
| 1 | | 4804.000 | 60.12 | -4.86 | 55.26 | 74.00 | -18.74 | peak |
| 2 | * | 4804.000 | 50.37 | -4.86 | 45.51 | 54.00 | -8.49 | AVG |
| 3 | | 7206.000 | 54.78 | -0.58 | 54.20 | 74.00 | -19.80 | peak |
| 4 | | 7206.000 | 43.16 | -0.58 | 42.58 | 54.00 | -11.42 | AVG |
| 5 | | 9608.000 | 47.22 | 4.81 | 52.03 | 74.00 | -21.97 | peak |
| 6 | | 9608.000 | 35.78 | 4.81 | 40.59 | 54.00 | -13.41 | AVG |

Note:

10-25GHz at least have 20dB margin. No recording in the test report.

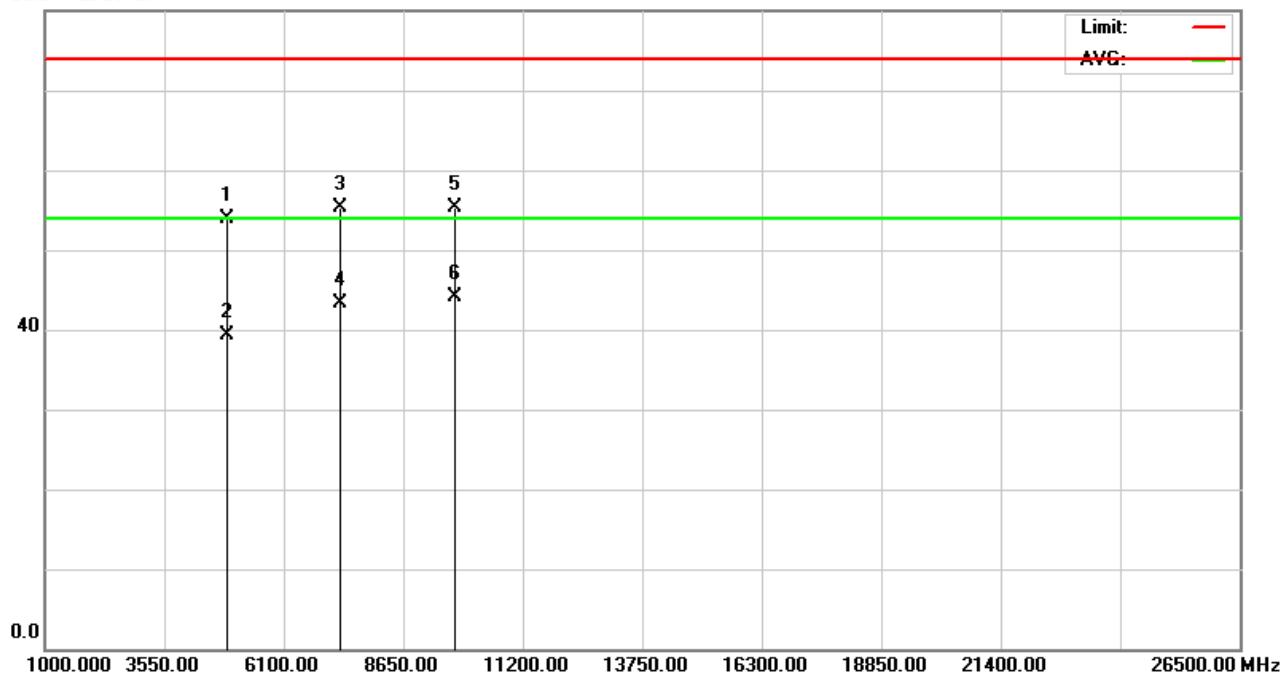
Measurement Level = Reading Level + Factor

Remark: Factor = Antenna Factor + Cable Loss - Pre-amplifier

Lowest channel: 2402 MHz

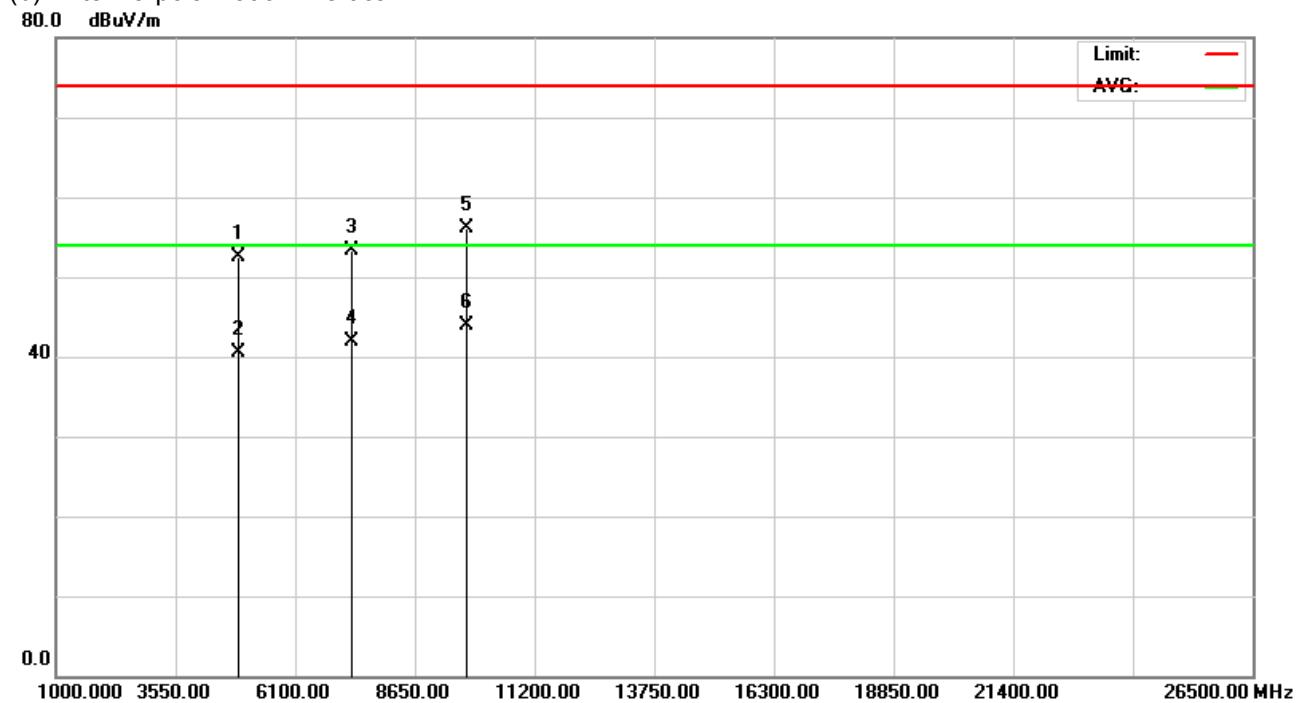
Data rate: 1Mbps

(a) Antenna polarization: Horizontal
80.0 dBuV/m



| No. | Mk. | Freq. | Reading Level | Correct Factor | Measurement | Limit | Over | Antenna Height | Table Degree | | |
|-----|-----|----------|---------------|----------------|-------------|--------|--------|----------------|--------------|--------|---------|
| | | MHz | dBuV | dB | dBuV/m | dBuV/m | dB | Detector | cm | degree | Comment |
| 1 | | 4882.000 | 58.71 | -4.73 | 53.98 | 74.00 | -20.02 | peak | | | |
| 2 | | 4882.000 | 44.12 | -4.73 | 39.39 | 54.00 | -14.61 | AVG | | | |
| 3 | | 7323.000 | 55.63 | -0.30 | 55.33 | 74.00 | -18.67 | peak | | | |
| 4 | | 7323.000 | 43.62 | -0.30 | 43.32 | 54.00 | -10.68 | AVG | | | |
| 5 | | 9764.000 | 50.12 | 5.26 | 55.38 | 74.00 | -18.62 | peak | | | |
| 6 | * | 9764.000 | 38.75 | 5.26 | 44.01 | 54.00 | -9.99 | AVG | | | |

(b) Antenna polarization: Vertical



| No. | Mk. | Freq. | Reading Level | Correct Factor | Measure-ment | Limit | Over | Antenna Height | Table Degree | | |
|-----|-----|----------|---------------|----------------|--------------|--------|--------|----------------|--------------|--------|---------|
| | | MHz | dBuV | dB | dBuV/m | dBuV/m | dB | Detector | cm | degree | Comment |
| 1 | | 4882.000 | 57.14 | -4.73 | 52.41 | 74.00 | -21.59 | peak | | 0 | |
| 2 | | 4882.000 | 45.25 | -4.73 | 40.52 | 54.00 | -13.48 | AVG | | 0 | |
| 3 | | 7323.000 | 53.68 | -0.30 | 53.38 | 74.00 | -20.62 | peak | | 0 | |
| 4 | | 7323.000 | 42.14 | -0.30 | 41.84 | 54.00 | -12.16 | AVG | | 0 | |
| 5 | | 9764.000 | 50.88 | 5.26 | 56.14 | 74.00 | -17.86 | peak | | 0 | |
| 6 | * | 9764.000 | 38.71 | 5.26 | 43.97 | 54.00 | -10.03 | AVG | | 0 | |

Note:

10~25GHz at least have 20dB margin. No recording in the test report.

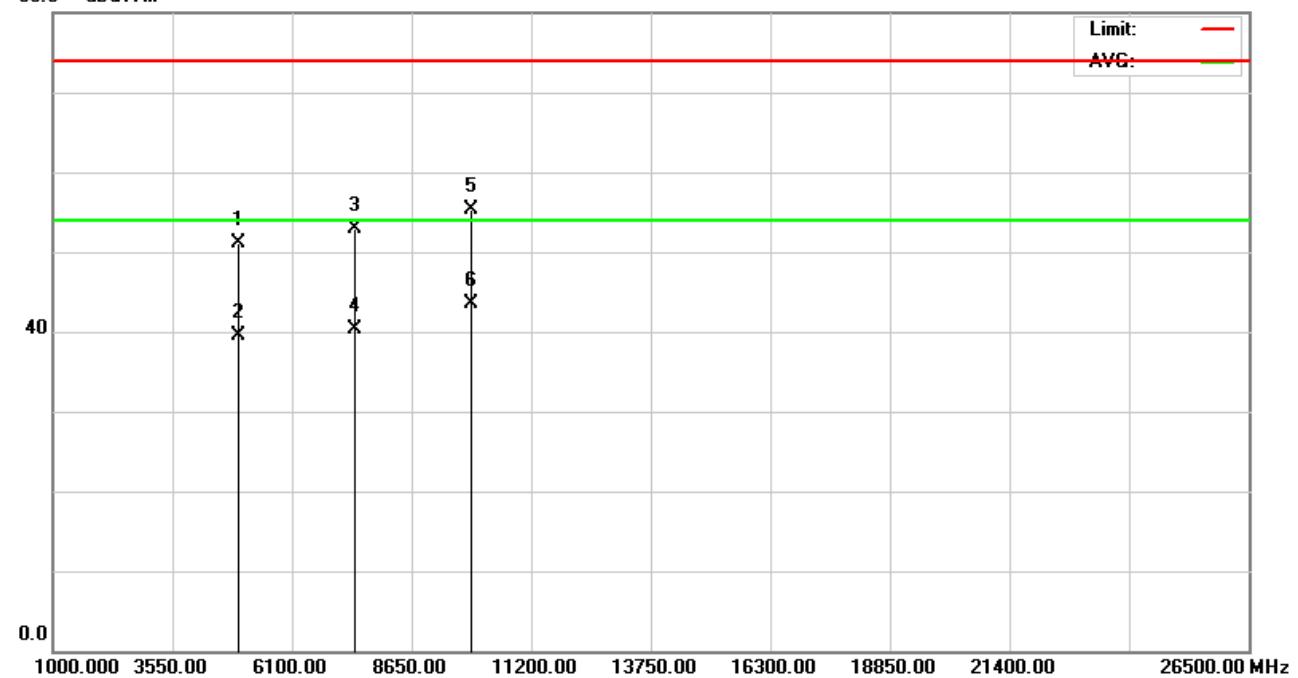
Measurement Level = Reading Level + Factor

Remark: Factor = Antenna Factor + Cable Loss - Pre-amplifier

Middle Channel: 2441 MHz

Data rate: 1Mbps

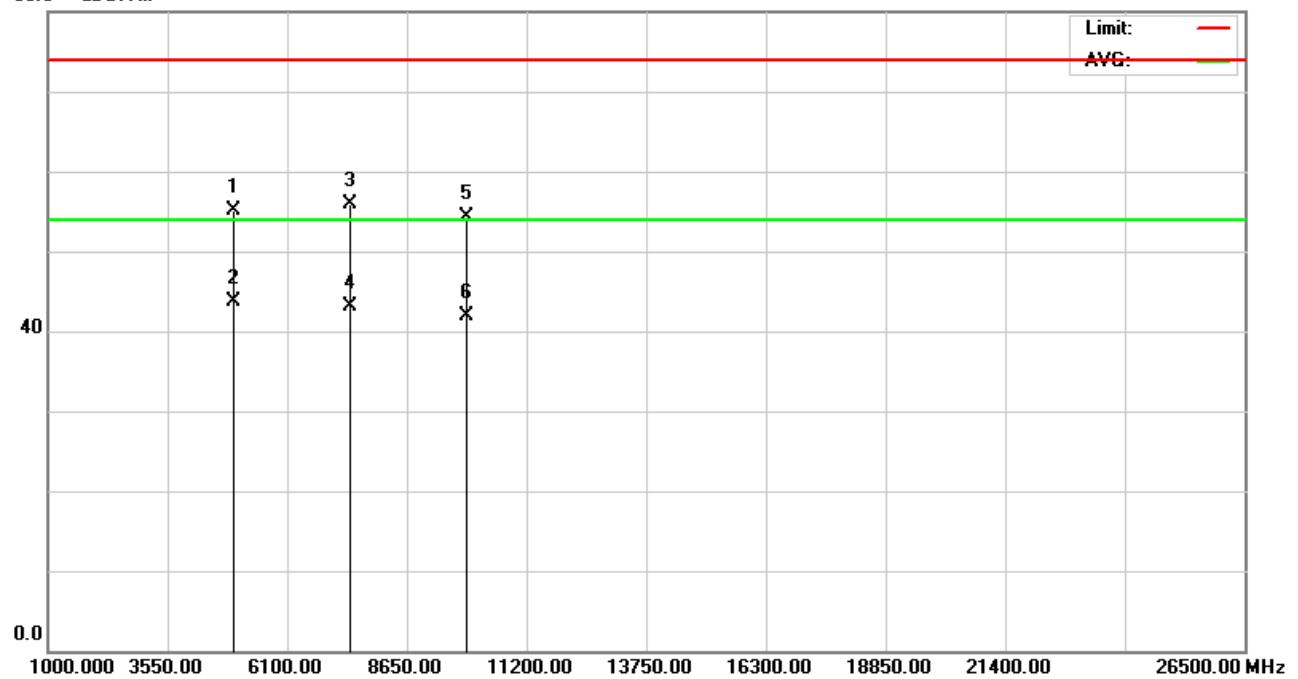
(a) Antenna polarization: Horizontal
80.0 dBuV/m



| No. | Mk. | Freq. MHz | Reading Level dBuV | Correct Factor dB | Measure- ment dBuV/m | Limit dBuV/m | Over dB | Over Detector |
|-----|-----|--------------|--------------------------|-------------------------|----------------------------|-----------------|------------|------------------|
| 1 | | 4960.000 | 55.72 | -4.60 | 51.12 | 74.00 | -22.88 | peak |
| 2 | | 4960.000 | 44.11 | -4.60 | 39.51 | 54.00 | -14.49 | AVG |
| 3 | | 7440.000 | 52.93 | -0.02 | 52.91 | 74.00 | -21.09 | peak |
| 4 | | 7440.000 | 40.38 | -0.02 | 40.36 | 54.00 | -13.64 | AVG |
| 5 | | 9920.000 | 49.72 | 5.66 | 55.38 | 74.00 | -18.62 | peak |
| 6 | * | 9920.000 | 37.82 | 5.66 | 43.48 | 54.00 | -10.52 | AVG |

(b) Antenna polarization: Vertical

80.0 dBuV/m



| No. | Mk. | Freq. | Reading Level | Correct Factor | Measure-ment | Limit | Over | |
|-----|-----|----------|---------------|----------------|--------------|--------|--------|----------|
| | | MHz | dBuV | dB | dBuV/m | dBuV/m | dB | Detector |
| 1 | | 4960.000 | 59.72 | -4.60 | 55.12 | 74.00 | -18.88 | peak |
| 2 | * | 4960.000 | 48.37 | -4.60 | 43.77 | 54.00 | -10.23 | AVG |
| 3 | | 7440.000 | 55.97 | -0.02 | 55.95 | 74.00 | -18.05 | peak |
| 4 | | 7440.000 | 43.12 | -0.02 | 43.10 | 54.00 | -10.90 | AVG |
| 5 | | 9920.000 | 48.67 | 5.66 | 54.33 | 74.00 | -19.67 | peak |
| 6 | | 9920.000 | 36.25 | 5.66 | 41.91 | 54.00 | -12.09 | AVG |

Note:

10~25GHz at least have 20dB margin. No recording in the test report.

Measurement Level = Reading Level + Factor

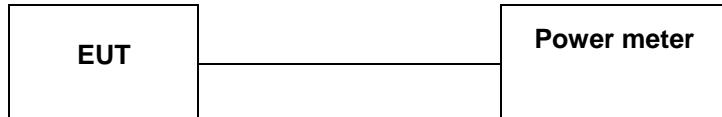
Remark: Factor = Antenna Factor + Cable Loss - Pre-amplifier

Highest Channel: 2480 MHz

Data rate: 1Mbps

4.3 Maximum Peak Output Power

TEST CONFIGURATION



TEST PROCEDURE

According to ANSI C63.10:2013 Maximum peak conducted output power: Connect antenna port into power meter and reading Peak values.

LIMIT

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.

TEST RESULTS

Remark: We test maximum peak output power at difference Packet Type (DH1, DH3 and DH5), recorded worst case at DH5

4.3.1 GFSK Test Mode

A. Test Verdict

| Channel | Frequency (MHz) | Measured Output Peak Power (dBm) | Limits (dBm) | Verdict |
|---------|-----------------|----------------------------------|--------------|---------|
| 00 | 2402 | 2.34 | 21 | PASS |
| 39 | 2441 | 2.48 | 21 | PASS |
| 78 | 2480 | 2.67 | 21 | PASS |

Note:

1.The test results including the cable lose.

4.3.2 π/4 DQPSK Test Mode

A. Test Verdict

| Channel | Frequency (MHz) | Measured Output Peak Power (dBm) | Limits (dBm) | Verdict |
|---------|-----------------|----------------------------------|--------------|---------|
| 00 | 2402 | 2.55 | 21 | PASS |
| 39 | 2441 | 2.17 | 21 | PASS |
| 78 | 2480 | 2.23 | 21 | PASS |

Note:

1.The test results including the cable lose.

4.3.3 8DPSK Test Mode

A. Test Verdict

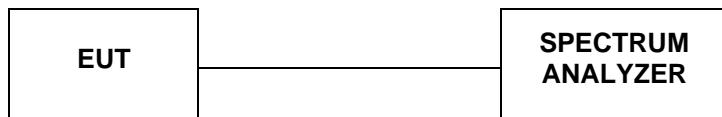
| Channel | Frequency (MHz) | Measured Output Peak Power (dBm) | Limits (dBm) | Verdict |
|---------|-----------------|----------------------------------|--------------|---------|
| 00 | 2402 | 1.89 | 21 | PASS |
| 39 | 2441 | 1.76 | 21 | PASS |
| 78 | 2480 | 1.88 | 21 | PASS |

Note:

1.The test results including the cable lose.

4.4 20dB Bandwidth

TEST CONFIGURATION



TEST PROCEDURE

The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with RBW=100 KHz and VBW=300KHz. The 20dB bandwidth is defined as the total spectrum the power of which is higher than peak power minus 20dB.

LIMIT

For frequency hopping systems operating in the 2400MHz-2483.5MHz no limit for 20dB bandwith.

TEST RESULTS

4.4.1 GFSK Test Mode

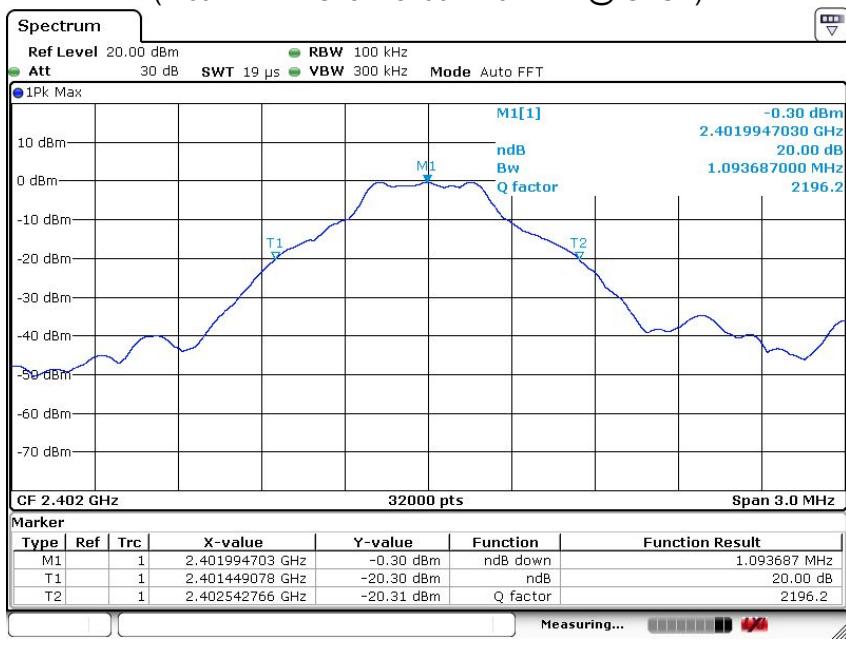
A. Test Verdict

| Channel | Frequency (MHz) | 20dB Bandwidth (MHz) | Refer to Plot | Limits (MHz) | Verdict |
|---------|-----------------|----------------------|---------------|--------------|---------|
| 00 | 2402 | 1.0937 | Plot 4.4.1 A | / | PASS |
| 39 | 2441 | 1.0938 | Plot 4.4.1 B | / | PASS |
| 78 | 2480 | 1.0869 | Plot 4.4.1 C | / | PASS |

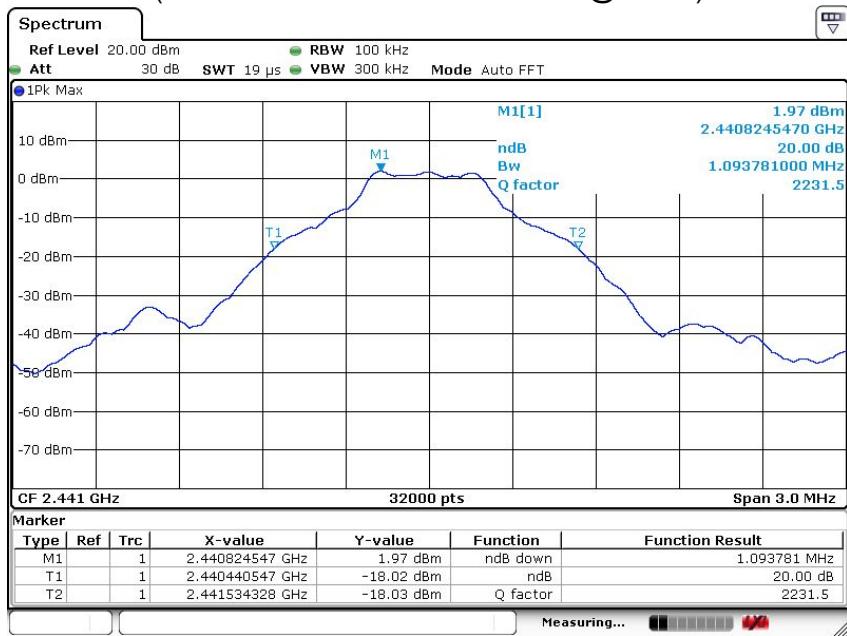
Note: 1.The test results including the cable lose.

B. Test Plots

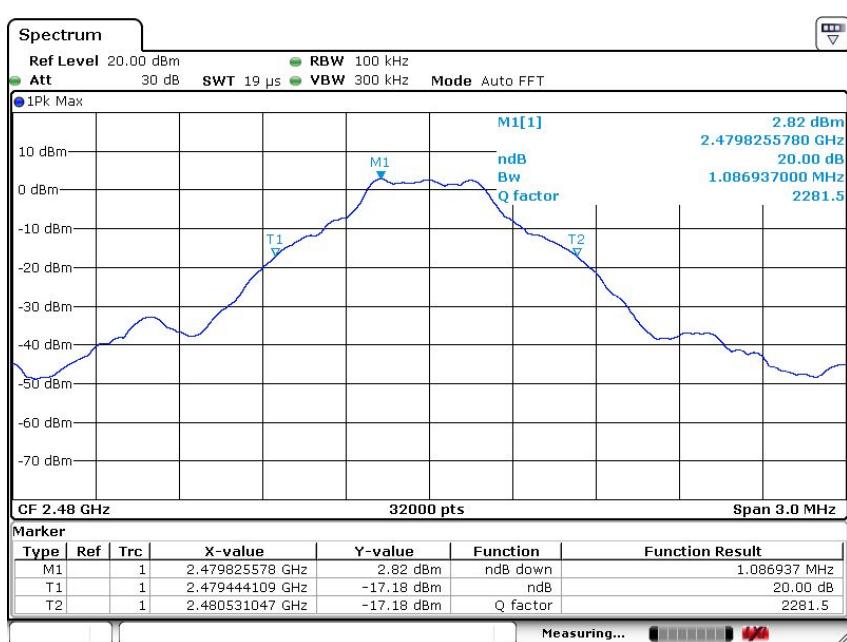
(Plot 4.4.1 A: Channel 00: 2402MHz @ GFSK)



(Plot 4.4.1 B: Channel 39: 2441MHz @ GFSK)



(Plot 4.4.1 C: Channel 78: 2480MHz @ GFSK)



4.4.2 8DPSK Test Mode

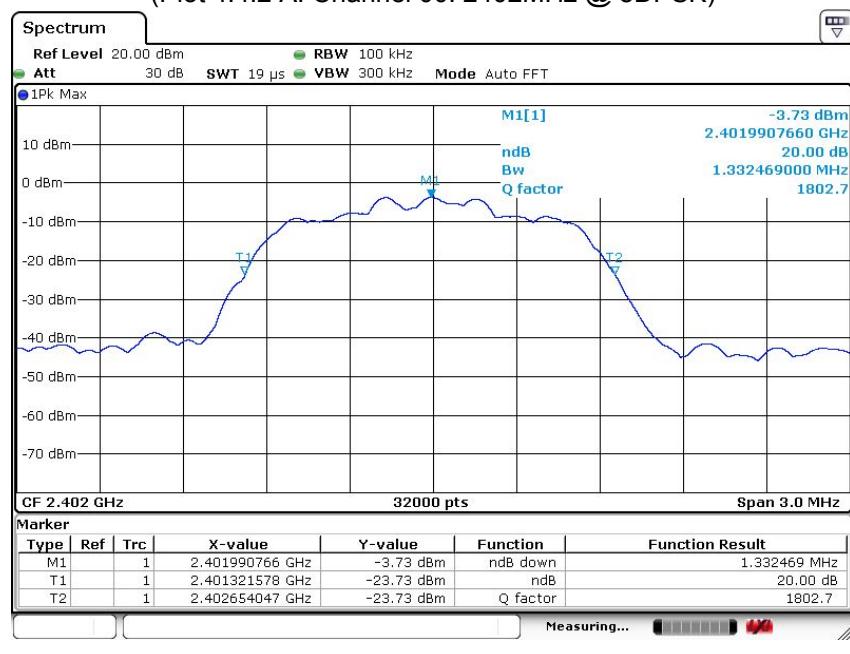
A. Test Verdict

| Channel | Frequency (MHz) | 20dB Bandwidth (MHz) | Refer to Plot | Limits (MHz) | Verdict |
|---------|-----------------|----------------------|---------------|--------------|---------|
| 00 | 2402 | 1.3325 | Plot 4.4.2 A | / | PASS |
| 39 | 2441 | 1.3385 | Plot 4.4.2 B | / | PASS |
| 78 | 2480 | 1.3340 | Plot 4.4.2 C | / | PASS |

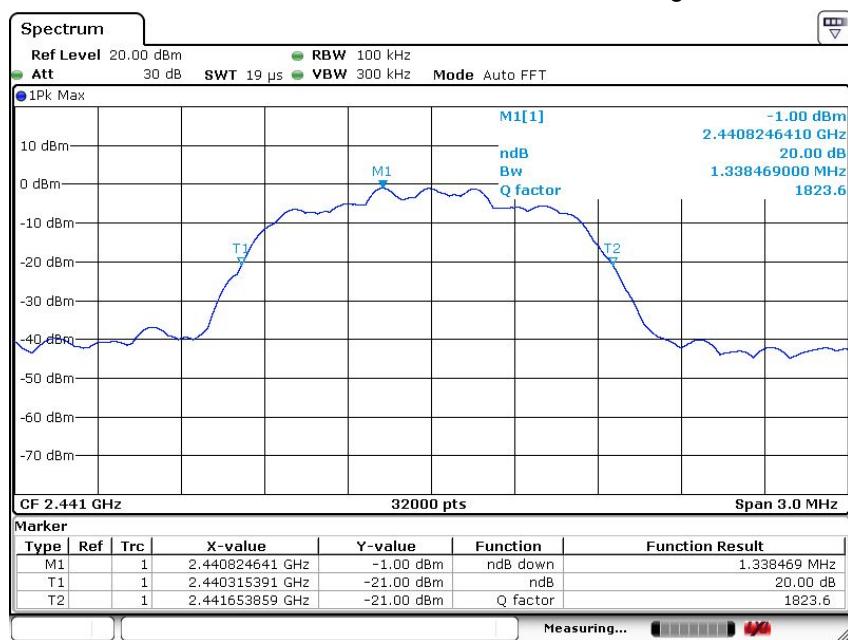
Note: 1.The test results including the cable lose.

B. Test Plots

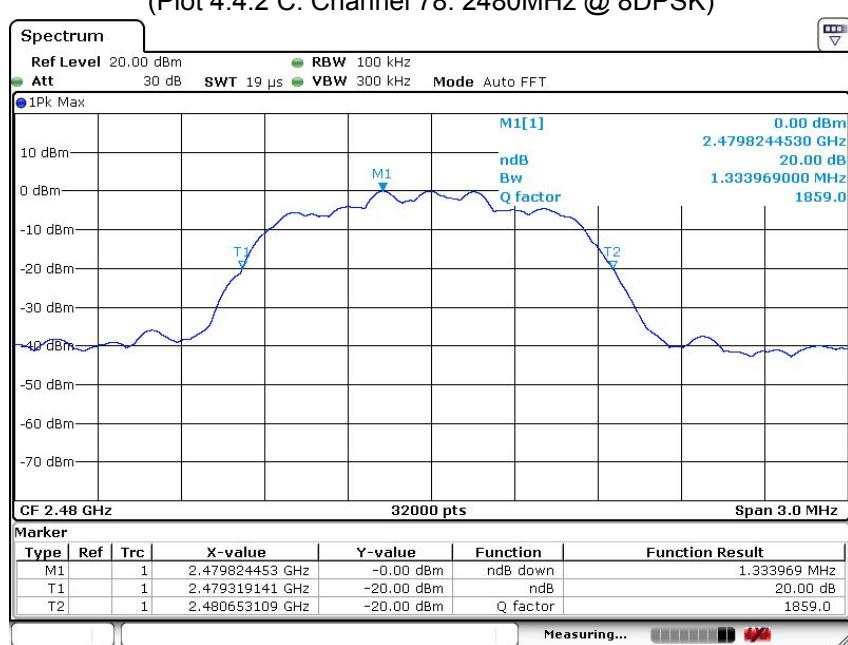
(Plot 4.4.2 A: Channel 00: 2402MHz @ 8DPSK)



(Plot 4.4.2 B: Channel 39: 2441MHz @ 8DPSK)



(Plot 4.4.2 C: Channel 78: 2480MHz @ 8DPSK)



4.5 Band Edge

Applicable Standard

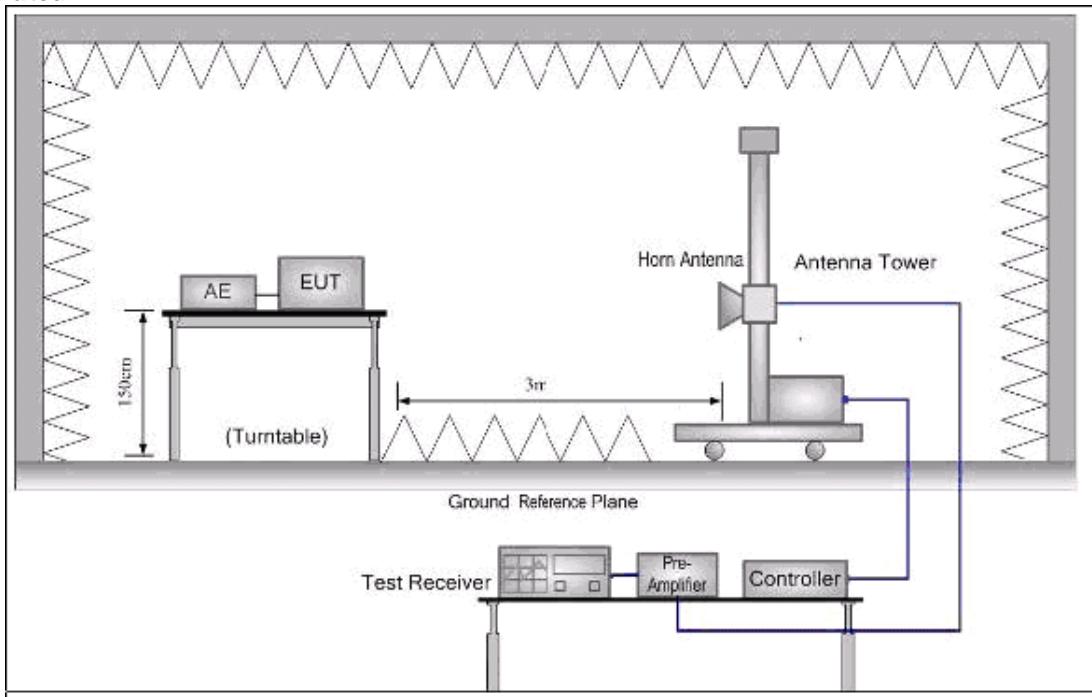
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the 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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

TEST PROCEDURE

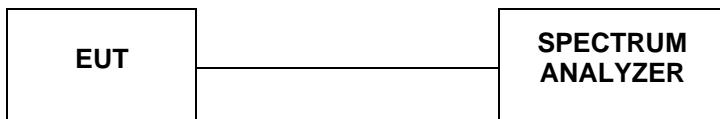
1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set both RBW and VBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100kHz bandwidth from band edge, for Radiated emissions restricted band RBW=1MHz, VBW=3MHz.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.

TEST CONFIGURATION

For Radiated



For Conducted



TEST PROCEDURE

1. The EUT was placed on a turn table which is 0.8m(1.5m above 1G) above ground plane.
2. Maximum procedure was performed by raising the receiving antenna from 1m to 4m and rotating the turn table from 0°C to 360°C to acquire the highest emissions from EUT.
3. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
4. Repeat above procedures until all frequency measurements have been completed..
5. The distance between test antenna and EUT was 3 meter:
6. Setting test receiver/spectrum as following table states:

| Test Frequency range | Test Receiver/Spectrum Setting | Detector |
|----------------------|--|-----------------------|
| 1GHz-40GHz | Peak Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto | Peak (Receiver) |
| 1GHz-40GHz | Average Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto | Average (Receiver) |

LIMIT

Below -20dB of the highest emission level in operating band.

Radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a)

TEST RESULTS

Remark:

1. We test Band Edge at difference Packet Type (DH1, DH3 and DH5), recorded worst case at DH5.
2. “--” means not recorded as emission levels lower than limit.

4.5.1 For Radiated Bandedge Measurement

Remark: we tested radiated bandedge at both hopping and no-hopping modes, recorded worst case at no-hopping mode

4.5.1.1 Test data

| Data rate | Test channel | Ant.P ol. H/V | Freq. (MHz) | Reading | | Ant/CF CF(dB) | Act | | Limit | |
|-----------|--------------|------------------|----------------|----------------|--------------|------------------|------------------|----------------|------------------|----------------|
| | | | | Peak (dBuv) | AV (dBuv) | | Peak (dBuv/m) | AV (dBuv/m) | Peak (dBuv/m) | AV (dBuv/m) |
| 1Mbps | CH00 | V | 2390 | 38.47 | 29.64 | -5.79 | 32.68 | 23.85 | 74 | 54 |
| | CH00 | H | 2390 | 40.22 | 30.25 | -5.79 | 34.43 | 24.46 | 74 | 54 |
| | CH78 | V | 2483.5 | 43.69 | 32.89 | -4.98 | 38.71 | 27.91 | 74 | 54 |
| | CH78 | H | 2483.5 | 40.14 | 29.48 | -4.98 | 35.16 | 24.5 | 74 | 54 |
| 3Mbps | CH00 | V | 2390 | 38.62 | 26.55 | -5.79 | 32.83 | 20.76 | 74 | 54 |
| | CH00 | H | 2390 | 40.11 | 30.67 | -5.79 | 34.32 | 24.88 | 74 | 54 |
| | CH78 | V | 2483.5 | 38.39 | 28.41 | -4.98 | 33.41 | 23.43 | 74 | 54 |



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| | | | | | | | | | | |
|--|------|---|--------|-------|-------|-------|-------|-------|----|----|
| | CH78 | H | 2483.5 | 41.16 | 30.55 | -4.98 | 36.18 | 25.57 | 74 | 54 |
|--|------|---|--------|-------|-------|-------|-------|-------|----|----|

Remark:

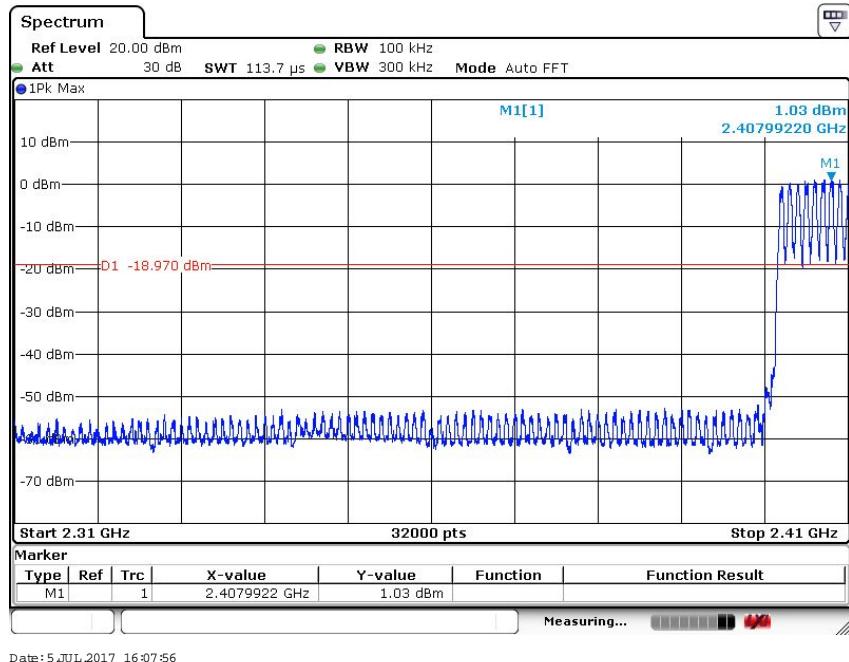
- (1) Radiated emissions measured in frequency range above 1000MHz were made with an instrument using Peak detector mode.
- (2) During the measurements above 1 GHz it is taken care of that the EUT is always within the 3 dB cone of radiation BW of the used antenna
- (3) Corr.Factor = Antenna Factor + Cable Loss – Pre-amplifier.

4.5.2 For Conducted Bandedge Measurement

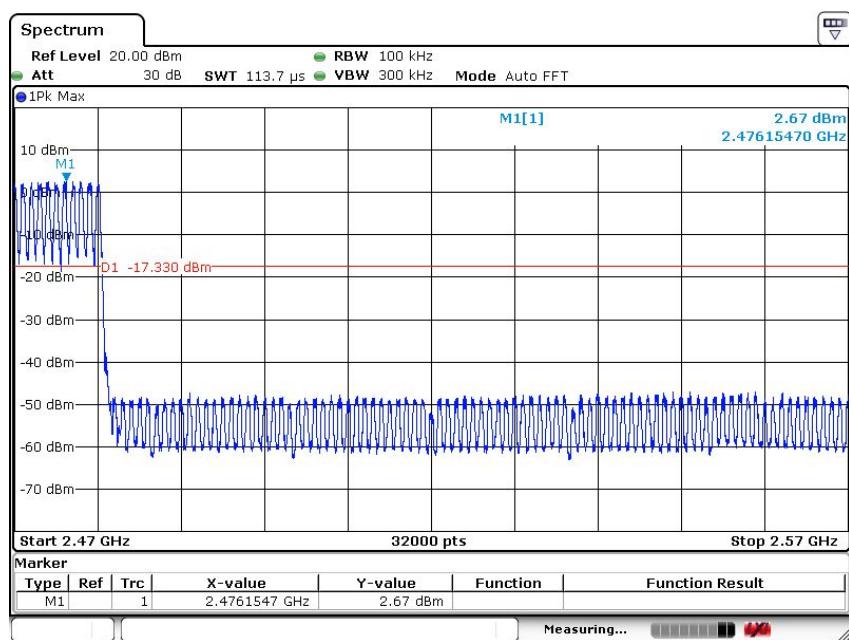
4.5.2.1 GFSK Test Mode

We tested hopping mode and non-hopping mode, and recorded the worst case at the hopping mode.

A. Test Plots



(Plot 4.5.2.1 A: Hopping Mode @ GFSK)

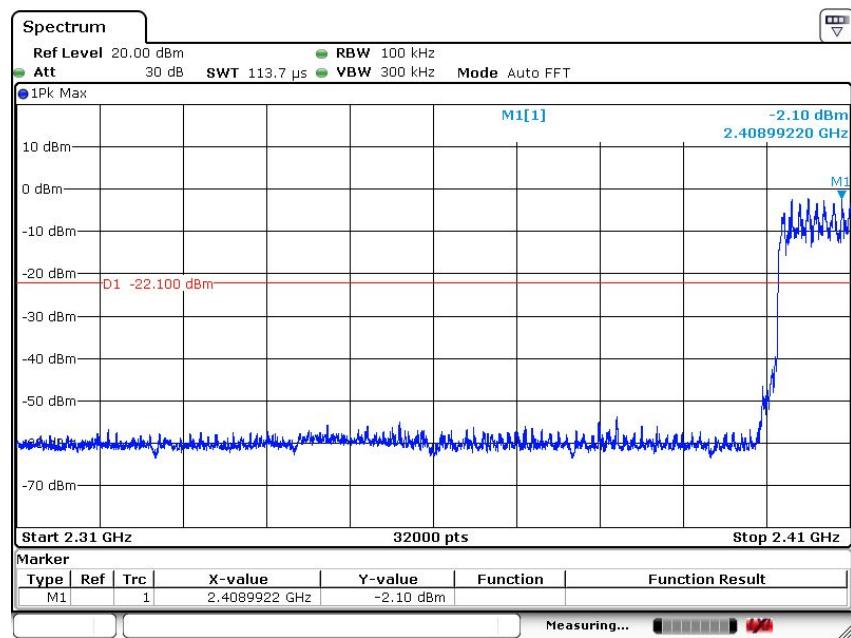


(Plot 4.5.2.1 B: Hopping Mode @ GFSK)

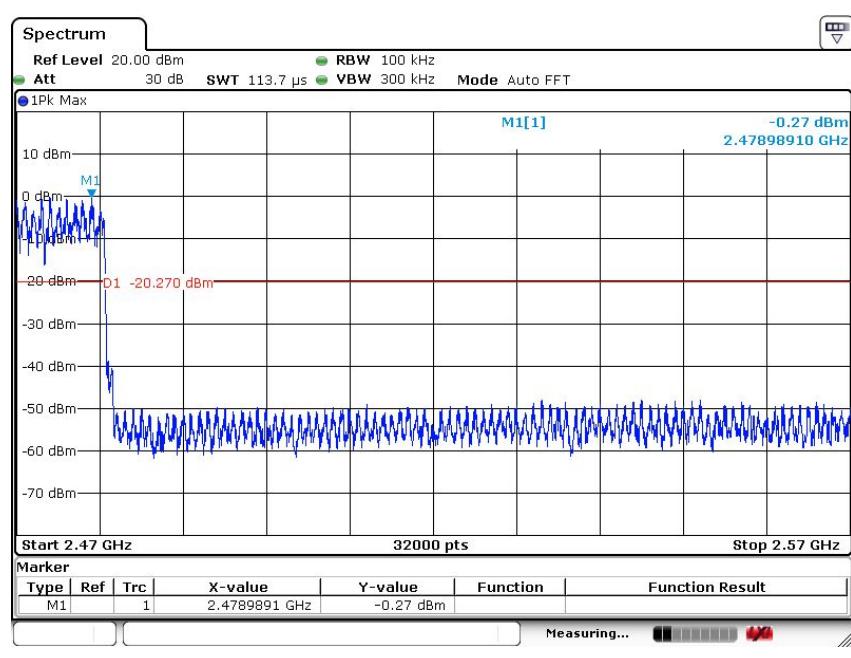
4.5.2.2 8DPSK Test Mode

We tested hopping mode and non-hopping mode, and recorded the worst case at the hopping mode.

A. Test Plots



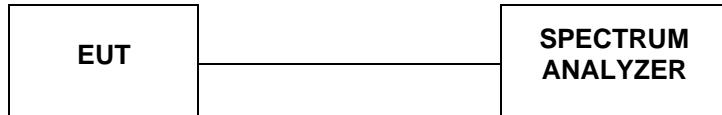
(Plot 4.5.2.2 A: Hopping Mode @ 8DPSK)



(Plot 4.5.2.2 B: Hopping Mode @ 8DPSK)

4.6 Frequency Separation

TEST CONFIGURATION



TEST PROCEDURE

The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with RBW=30 KHz and VBW=100KHz.

LIMIT

According to 15.247(a)(1),frequency hopping systems shall have hopping channel carrier frequencies separated by minimum of 25KHz or the 2/3*20dB bandwidth of the hopping channel, whichever is greater.

TEST RESULTS

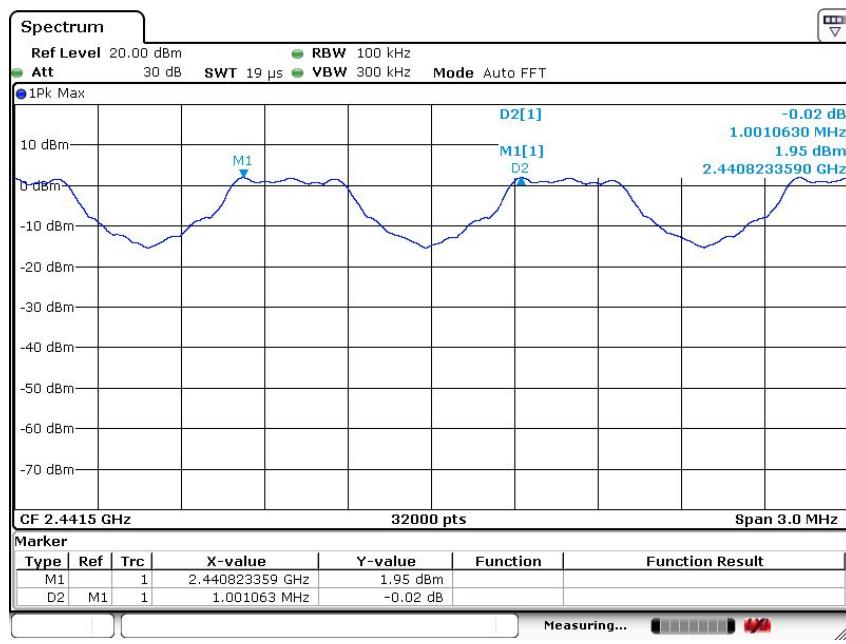
Remark: 1. We test Frequency Separation at difference Packet Type (DH1, DH3 and DH5) and all test channels, recorded worst case at DH5 and middle channel.

4.6.1 GFSK Test Mode

A. Test Verdict

| Channel | Frequency (MHz) | Channel Separation (MHz) | Refer to Plot | Limits (MHz) | Verdict |
|---------|-----------------|--------------------------|---------------|--------------|---------|
| 38 | 2440 | | | | |
| 39 | 2441 | 1.0011 | Plot 4.6.1 A | 0.8702 | PASS |

B. Test Plots



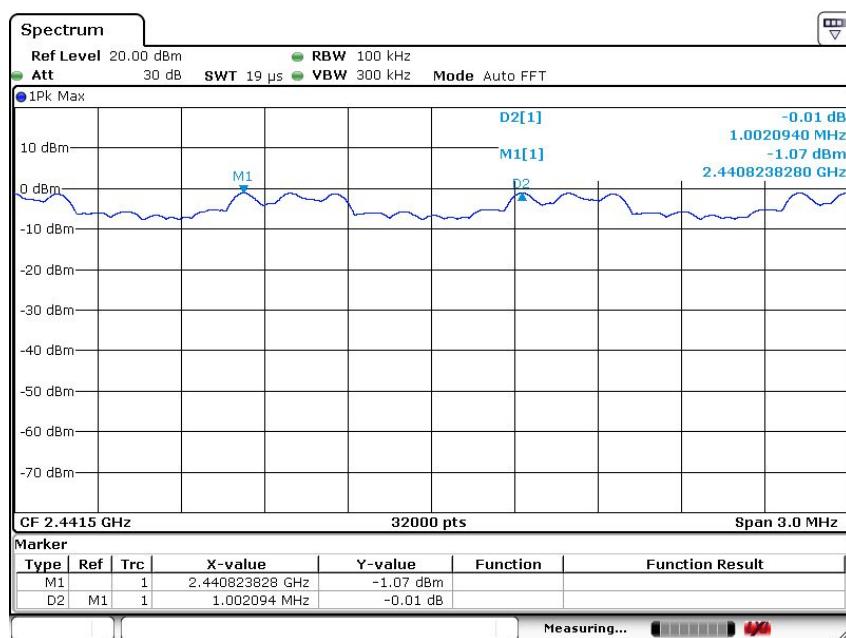
(Plot 4.6.1 A: Channel 39: 2441MHz @ GFSK)

4.6.2 8DPSK Test Mode

A. Test Verdict

| Channel | Frequency (MHz) | Channel Separation (MHz) | Refer to Plot | Limits (MHz) | Verdict |
|---------|-----------------|--------------------------|---------------|--------------|---------|
| 38 | 2440 | 1.0002 | Plot 4.6.2 A | 0.84936 | PASS |
| 39 | 2441 | | | | |

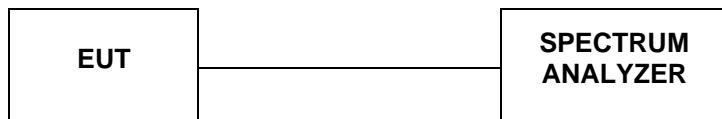
B. Test Plots



(Plot 4.6.2 A: Channel 39: 2441MHz @ 8DPSK)

4.7 Number of hopping frequency

TEST CONFIGURATION



TEST PROCEDURE

The transmitter output was connected to the spectrum analyzer through an attenuator. Set spectrum analyzer start 2400MHz to 2483.5MHz with RBW=100 KHz and VBW=300 KHz.

LIMIT

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.

TEST RESULTS

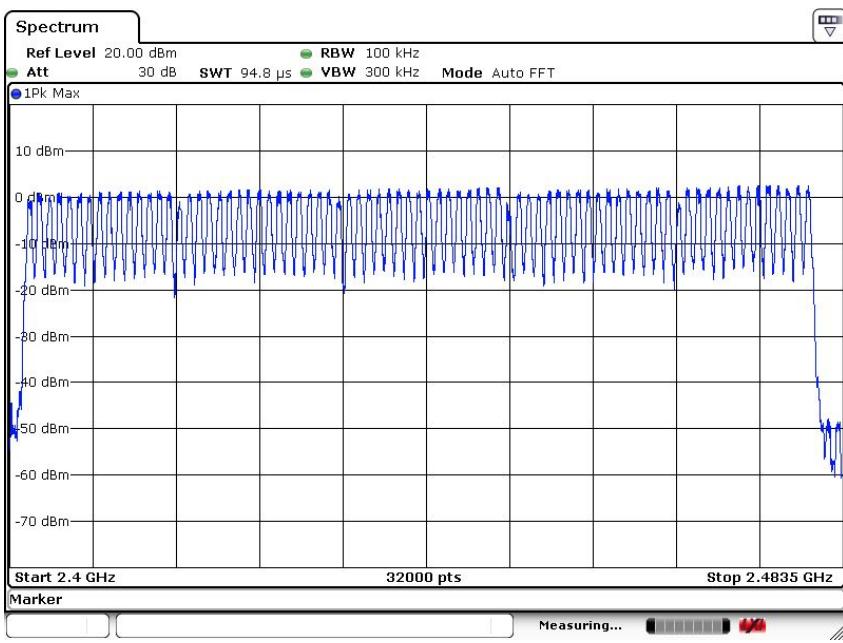
Remark: 1. We test Frequency Separation at difference Packet Type (DH1, DH3 and DH5), recorded worst case at DH5.

4.7.1 GFSK Test Mode

A. Test Verdict

| Hopping Channel Frequency Range (MHz) | Number of Hopping Channel | Refer to Plot | Limit | Verdict |
|---------------------------------------|---------------------------|---------------|-------|---------|
| 2400-2483.5 | 79 | Plot 4.7.1 A1 | ≥15 | PASS |

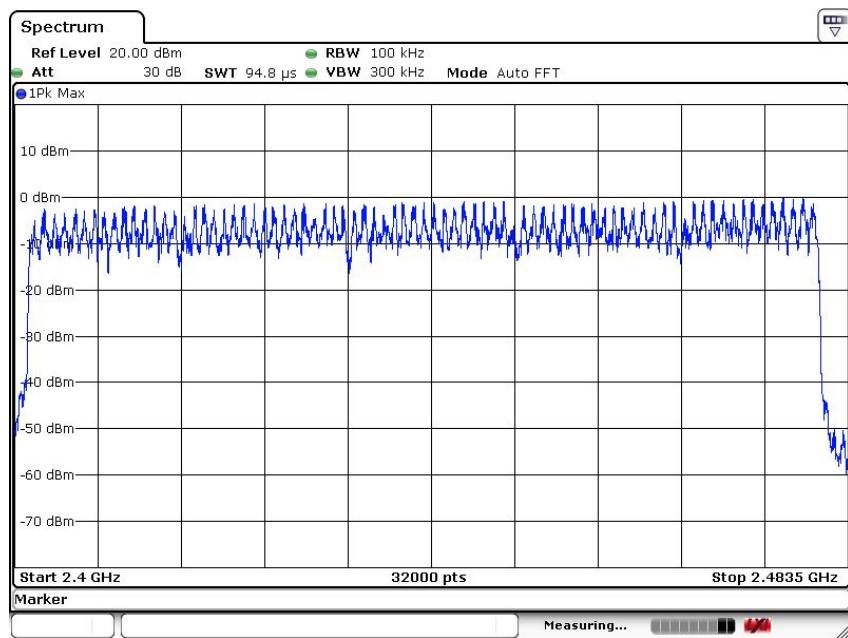
B. Test Plots



(Plot 4.7.1 A1: @ GFSK)

4.7.2 8DPSK Test Mode**A. Test Verdict**

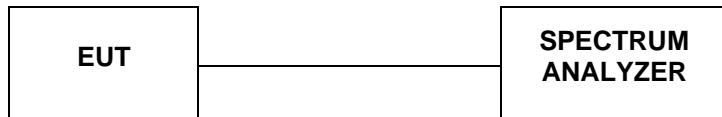
| Hopping Channel Frequency Range (MHz) | Number of Hopping Channel | Refer to Plot | Limit | Verdict |
|---------------------------------------|---------------------------|---------------|-------|---------|
| 2400-2483.5 | 79 | Plot 4.7.2 A1 | ≥15 | PASS |

B. Test Plots

(Plot 4.7.2 A1: @ 8DPSK)

4.8 Time of Occupancy (Dwell Time)

TEST CONFIGURATION



TEST PROCEDURE

The transmitter output was connected to the spectrum analyzer through an attenuator. Set center frequency of spectrum analyzer=operating frequency with RBW=1MHz and VBW=1MHz, Span=0Hz.

LIMIT

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.

TEST RESULTS

The Dwell Time=Burst Width*Total Hops. The detailed calculations are showed as follows:

The duration for dwell time calculation: $0.4[\text{s}]*\text{hopping number}=0.4[\text{s}]*79[\text{ch}]=31.6[\text{s}*\text{ch}]$;

The burst width [ms/hop/ch], which is directly measured, refers to the duration on one channel hop.

The hops per second for all channels: The selected EUT Conf uses a slot type of 5-Tx&1-Rx and a hopping rate of 1600 [ch*hop/s] for all channels. So the final hopping rate for all channels is $1600/6=266.67 [\text{ch}*\text{hop}/\text{s}]$

The hops per second on one channel: $266.67 [\text{ch}*\text{hops}/\text{s}]/79 [\text{ch}]=3.38 [\text{hop}/\text{s}]$;

The total hops for all channels within the dwell time calculation duration: $3.38 [\text{hop}/\text{s}]*31.6[\text{s}*\text{ch}]=106.67 [\text{hop}*\text{ch}]$;

The dwell time for all channels hopping: $106.67 [\text{hop}*\text{ch}]*\text{Burst Width} [\text{ms}/\text{hop}/\text{ch}]$.

Remark: 1. We test Frequency Separation at all test channels, recorded worst case at middle channel.

A. Test Verdict

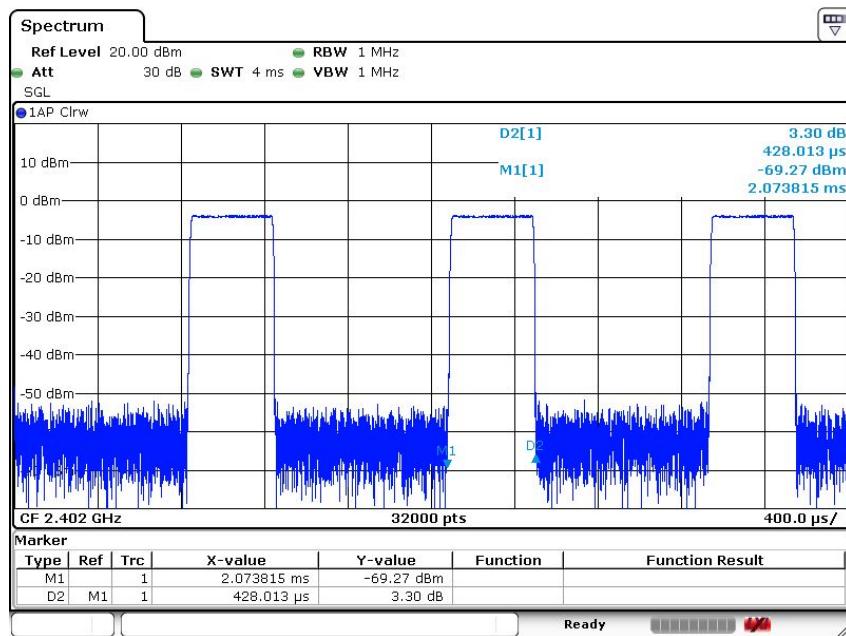
4.8.1 GFSK Test Mode

| Mode | Frequency (MHz) | Pulse Width (ms) | Dwell Time (S) | Limit (S) | Refer to Plot | Verdict |
|------|---|------------------|----------------|-----------|---------------|---------|
| DH1 | 2402 | 0.428 | 0.154 | 0.4 | Plot 4.8.1 A | PASS |
| | Note: Dwell time=Pulse time (ms) $\times (1600 \div 2 \div 79) \times 31.6$ Second | | | | | |
| DH3 | 2402 | 1.684 | 0.280 | 0.4 | Plot 4.8.1 B | PASS |
| | Note: Dwell time=Pulse time (ms) $\times (1600 \div 4 \div 79) \times 31.6$ Second | | | | | |
| DH5 | 2402 | 2.930 | 0.312 | 0.4 | Plot 4.8.1 C | PASS |
| | Note: Dwell time=Pulse Time (ms) $\times (1600 \div 6 \div 79) \times 31.6$ Second | | | | | |

4.8.2 8DPSK Test Mode

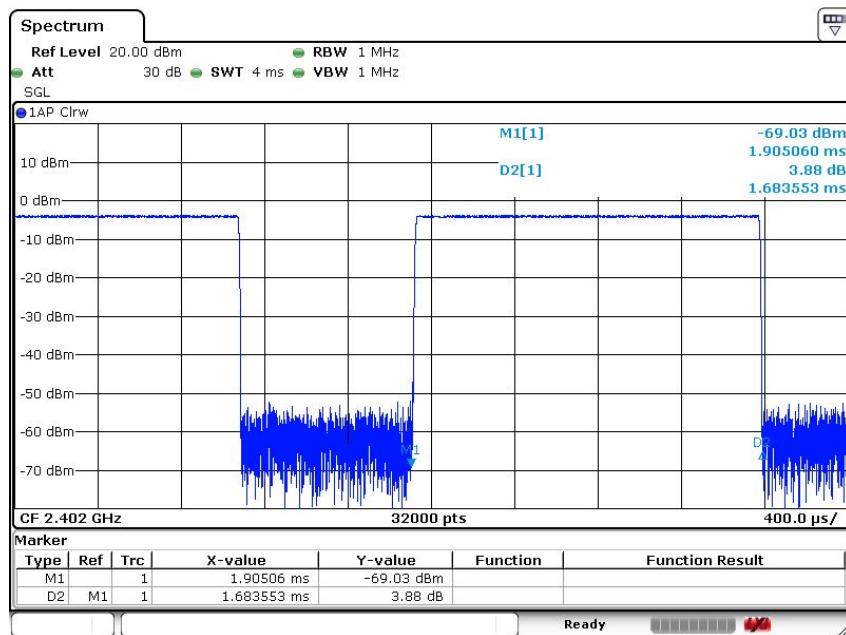
| Mode | Frequency (MHz) | Pulse Width (ms) | Dwell Time (S) | Limit (S) | Refer to Plot | Verdict |
|------|---|------------------|----------------|-----------|---------------|---------|
| DH1 | 2402 | 0.442 | 0.139 | 0.4 | Plot 4.8.2 A | PASS |
| | Note: Dwell time=Pulse time (ms) $\times (1600 \div 2 \div 79) \times 31.6$ Second | | | | | |
| DH3 | 2402 | 1.691 | 0.281 | 0.4 | Plot 4.8.2 B | PASS |
| | Note: Dwell time=Pulse time (ms) $\times (1600 \div 4 \div 79) \times 31.6$ Second | | | | | |
| DH5 | 2402 | 2.944 | 0.314 | 0.4 | Plot 4.8.2 C | PASS |
| | Note: Dwell time=Pulse Time (ms) $\times (1600 \div 6 \div 79) \times 31.6$ Second | | | | | |

B. Test Plots



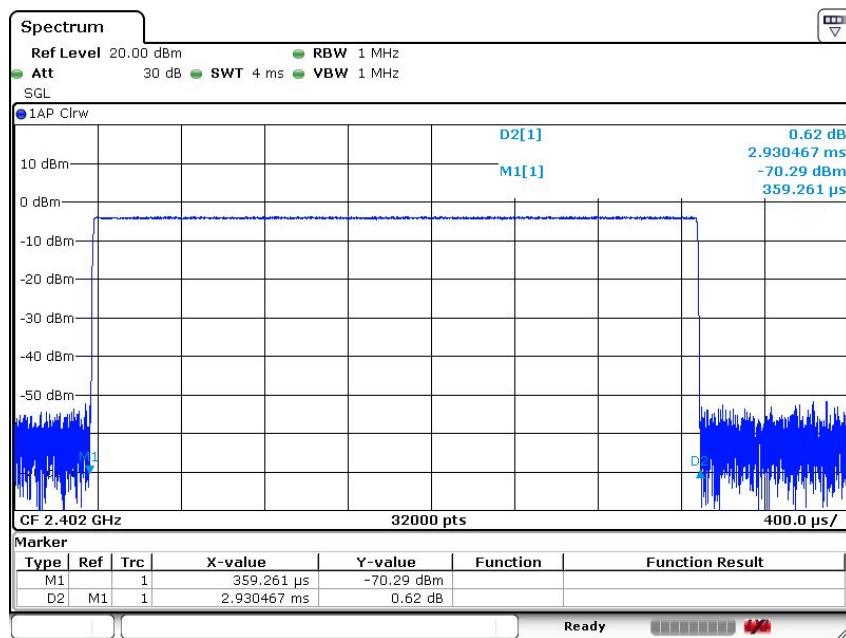
Date: 5 JUL 2017 16:27:34

(Plot 4.8.1.A: Channel 00: 2402MHz @ GFSK @ DH1)

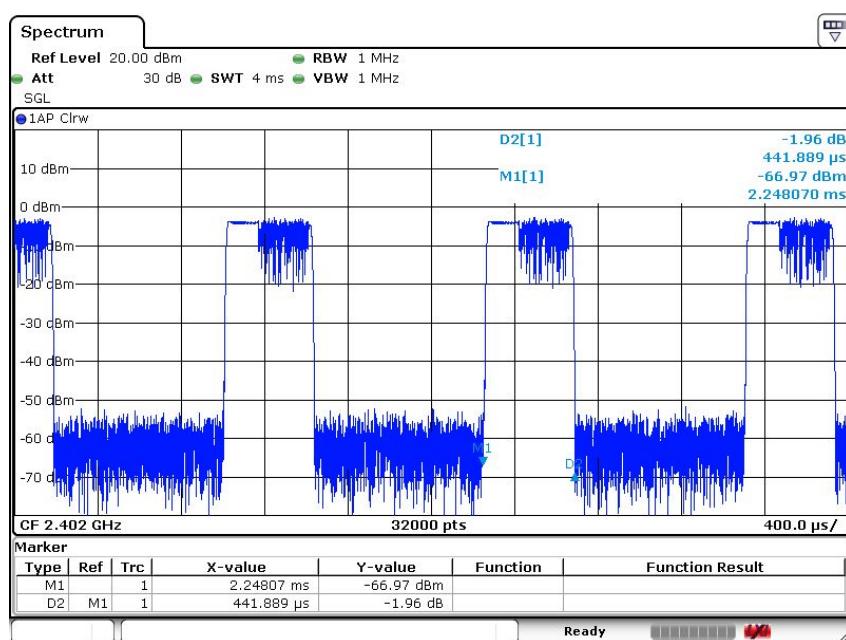


Date: 5 JUL 2017 16:28:18

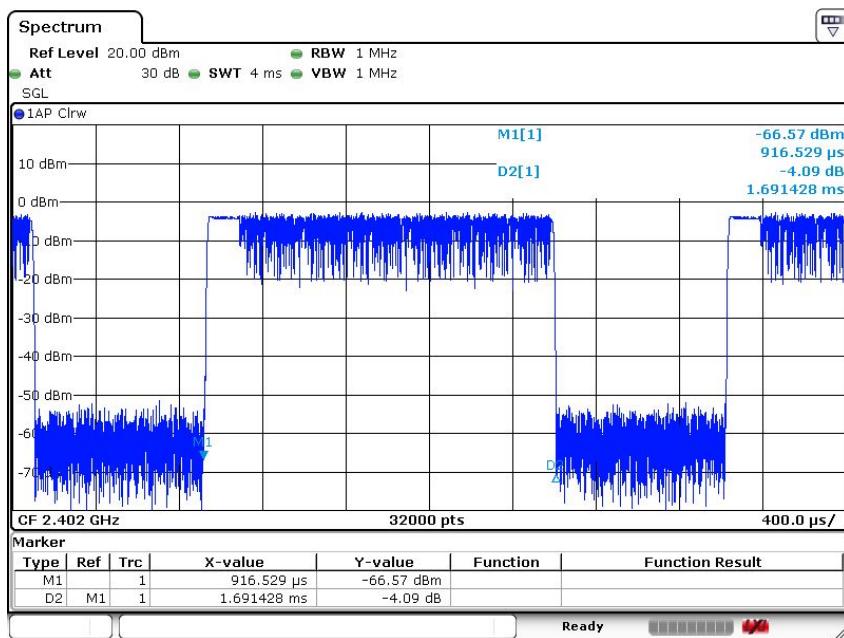
(Plot 4.8.1.B: Channel 00: 2402MHz @ GFSK @ DH3)



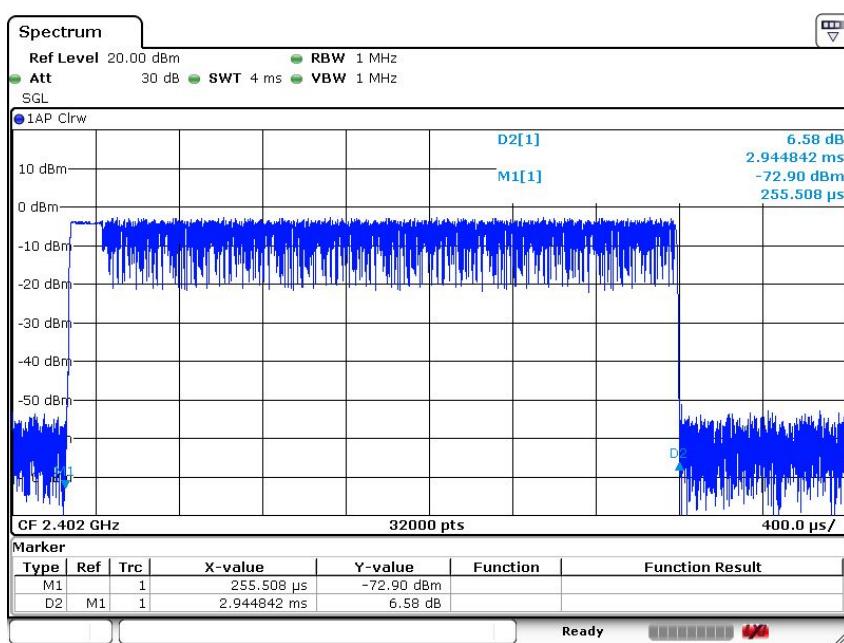
(Plot 4.8.1.C: Channel 00: 2402MHz @ GFSK @ DH5)



(Plot 4.8.2.A: Channel 00: 2402MHz @ 8DPSK @ DH1)



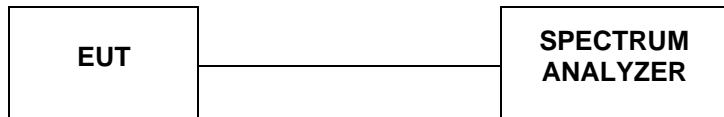
(Plot 4.8.2.B: Channel 00: 2402MHz @ 8DPSK @ DH3)



(Plot 4.8.2.C: Channel 00: 2402MHz @ 8DPSK @ DH5)

4.9 Spurious RF Conducted Emission

TEST CONFIGURATION



TEST PROCEDURE

The Spurious RF conducted emissions compliance of RF radiated emission should be measured by following the guidance in ANSI C63.10:2013 with respect to maximizing the emission by rotating the EUT, measuring the emission while the EUT is situated in three orthogonal planes (if appropriate), adjusting the measurement antenna height and polarization etc. Set RBW=100kHz and VBM= 300KHz to measure the peak field strength , and measurement frequency range from 9KHz to 26.5GHz.

LIMIT

1. Below -20dB of the highest emission level in operating band.
2. Fall in the restricted bands listed in section 15.205. The maximum permitted average field strength is listed in section 15.209.

TEST RESULTS

Remark:

1. We test Frequency Separation at difference Packet Type (DH1, DH3 and DH5), recorded worst case at DH5.
2. For 9KHz -30MHz, The amplitude of spurious emissions which are attenuated by more than 20dB below the permissible value has no need to be reported.

4.9.1 GFSK Test Mode

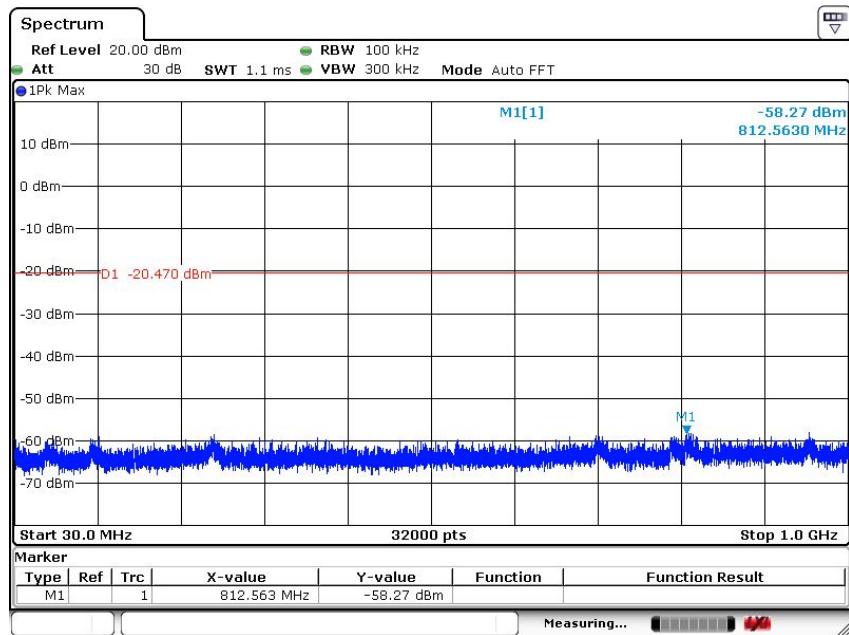
A. Test Verdict

| Channel | Frequency (MHz) | Frequency Range | Sweep Points | Refer to Plot | Limit (dBc) | Verdict |
|---------|-----------------|-----------------|--------------|---------------|-------------|---------|
| 00 | 2402 | 30MHz-1GHz | 9700 | Plot 4.9.1 A1 | -20 | PASS |
| | | 1MHz-3GHz | 20000 | Plot 4.9.1 A2 | -20 | PASS |
| | | 3GHz-13GHz | 100000 | Plot 4.9.1 A3 | -20 | PASS |
| | | 13GHz-25GHz | 120000 | Plot 4.9.1 A4 | -20 | PASS |
| 39 | 2441 | 30MHz-1GHz | 9700 | Plot 4.9.1 B1 | -20 | PASS |
| | | 1MHz-3GHz | 20000 | Plot 4.9.1 B2 | -20 | PASS |
| | | 3GHz-13GHz | 100000 | Plot 4.9.1 B3 | -20 | PASS |
| | | 13GHz-25GHz | 120000 | Plot 4.9.1 B4 | -20 | PASS |
| 78 | 2480 | 30MHz-1GHz | 9700 | Plot 4.9.1 C1 | -20 | PASS |
| | | 1MHz-3GHz | 20000 | Plot 4.9.1 C2 | -20 | PASS |
| | | 3GHz-13GHz | 100000 | Plot 4.9.1 C3 | -20 | PASS |
| | | 13GHz-25GHz | 120000 | Plot 4.9.1 C4 | -20 | PASS |

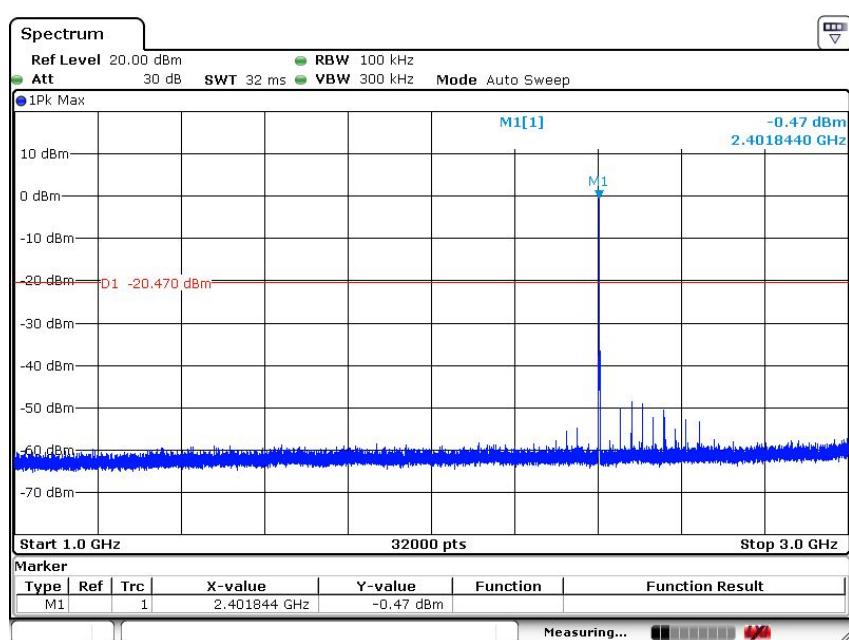
Note:

1. The test results including the cable lose.

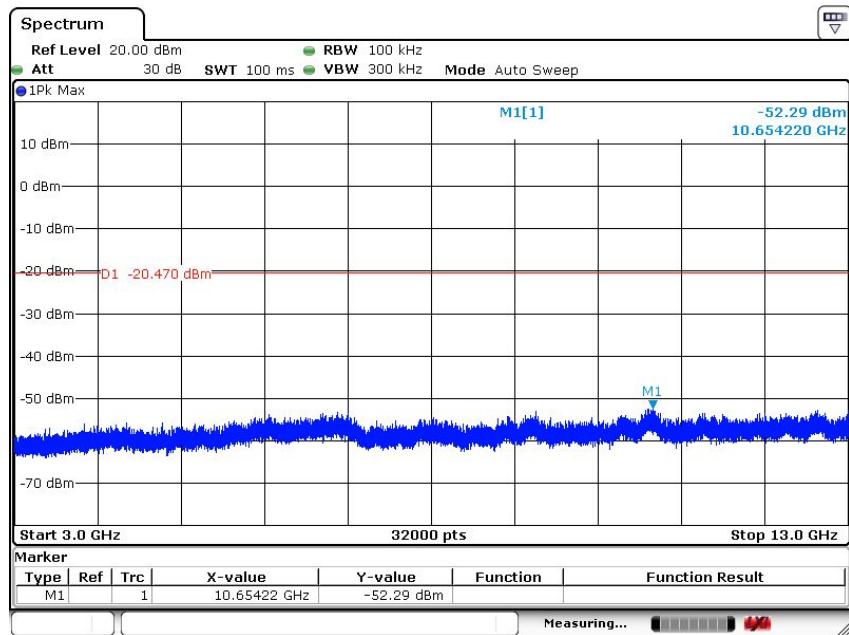
B. Test Plots



(Plot 4.9.1 A1: Channel 00: 2402MHz @ GFSK)

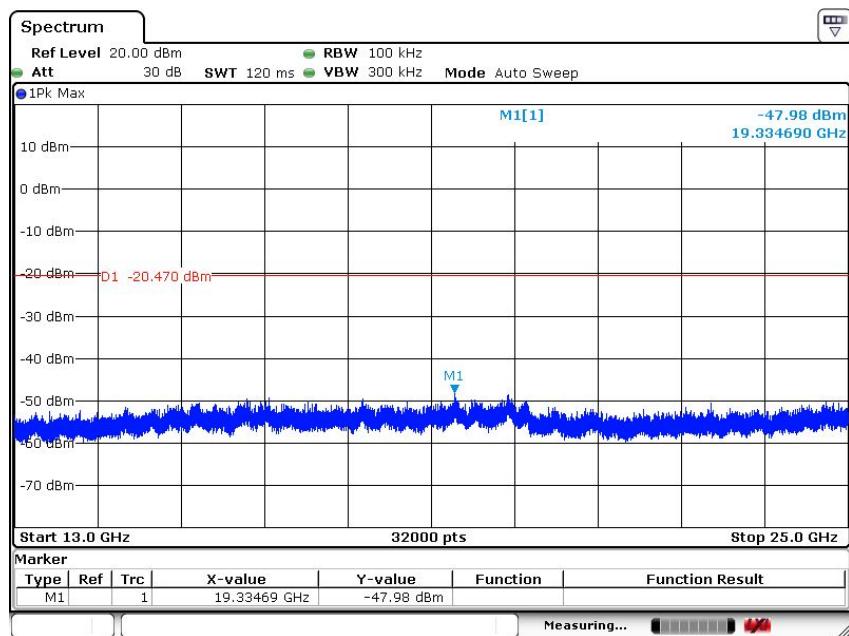


(Plot 4.9.1 A2: Channel 00: 2402MHz @ GFSK)



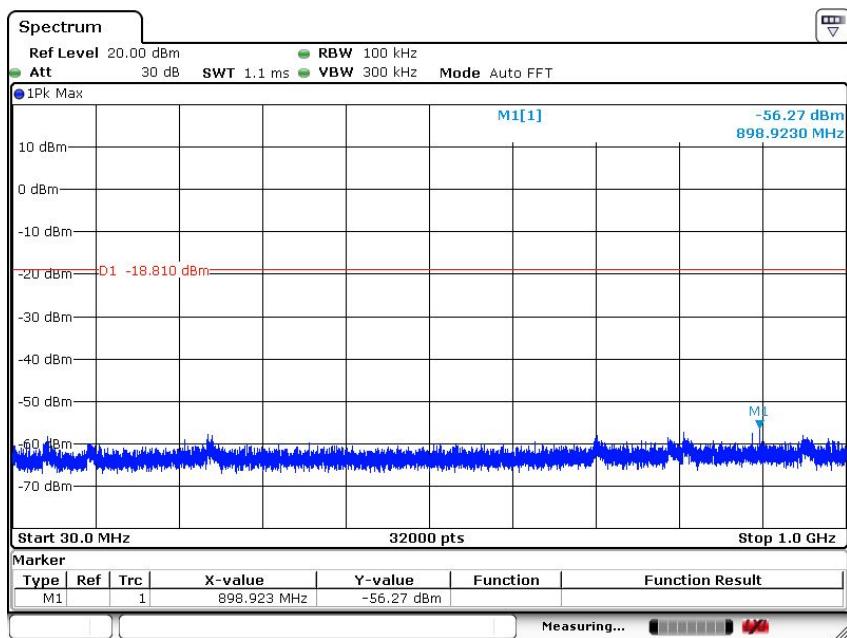
Date: 5 JUL 2017 16:11:07

(Plot 4.9.1 A3: Channel 00: 2402MHz @ GFSK)

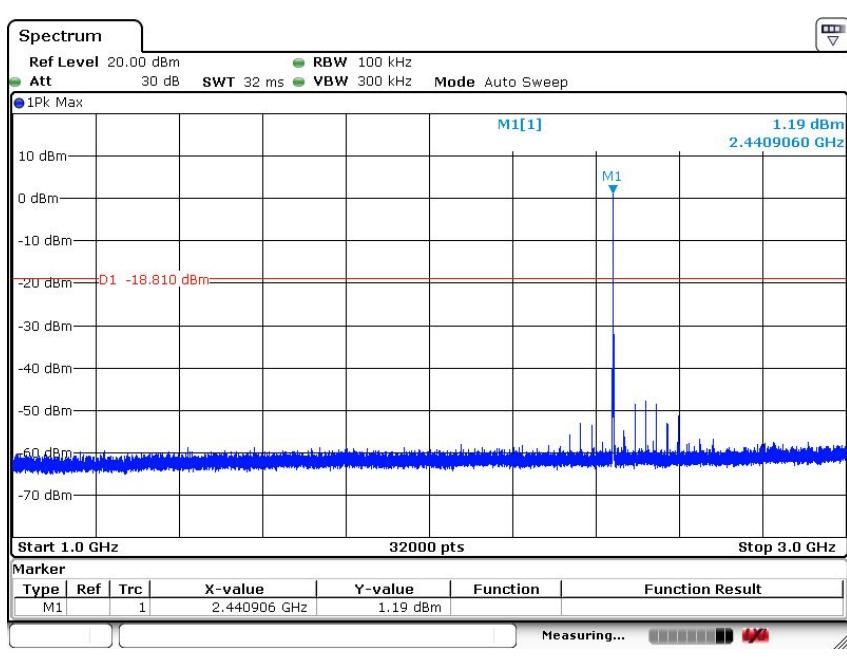


Date: 5 JUL 2017 16:11:25

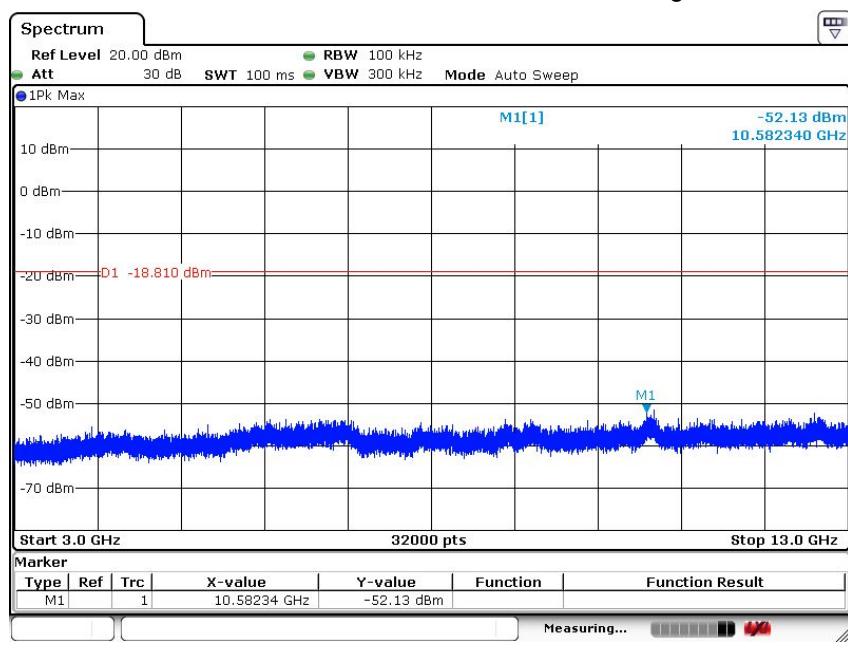
(Plot 4.9.1 A4: Channel 00: 2402MHz @ GFSK)



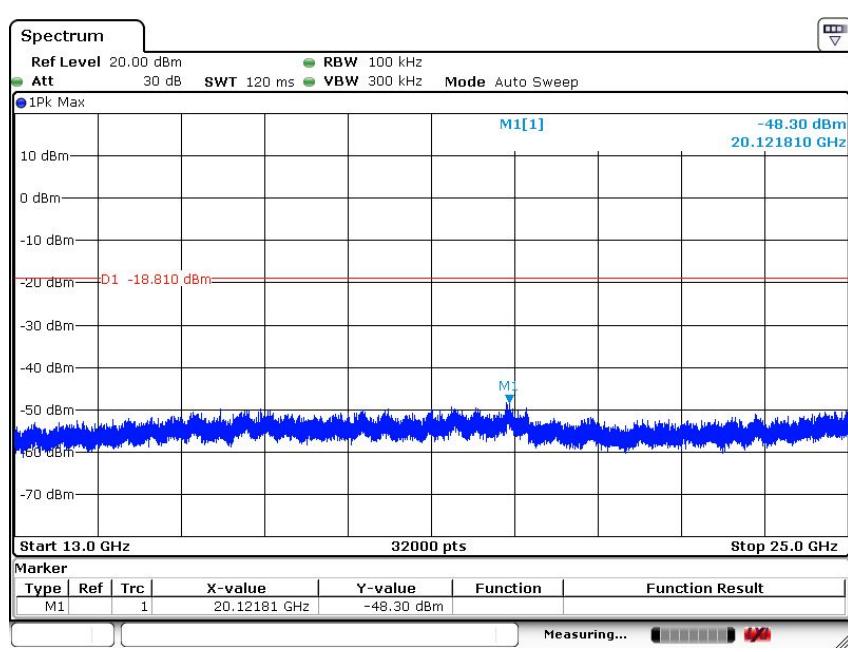
(Plot 4.9.1 B1: Channel 39: 2441MHz @ GFSK)



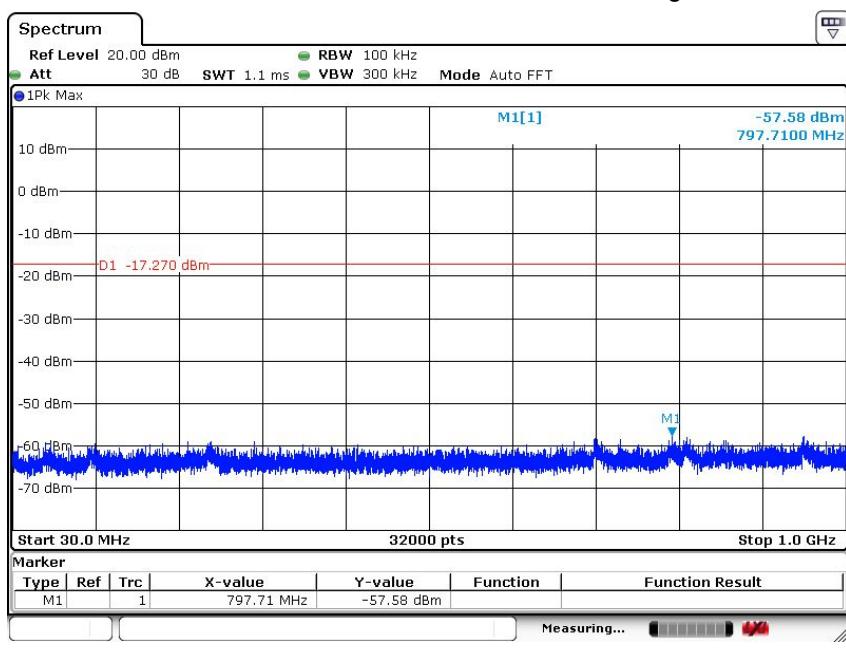
(Plot 4.9.1 B2: Channel 39: 2441MHz @ GFSK)



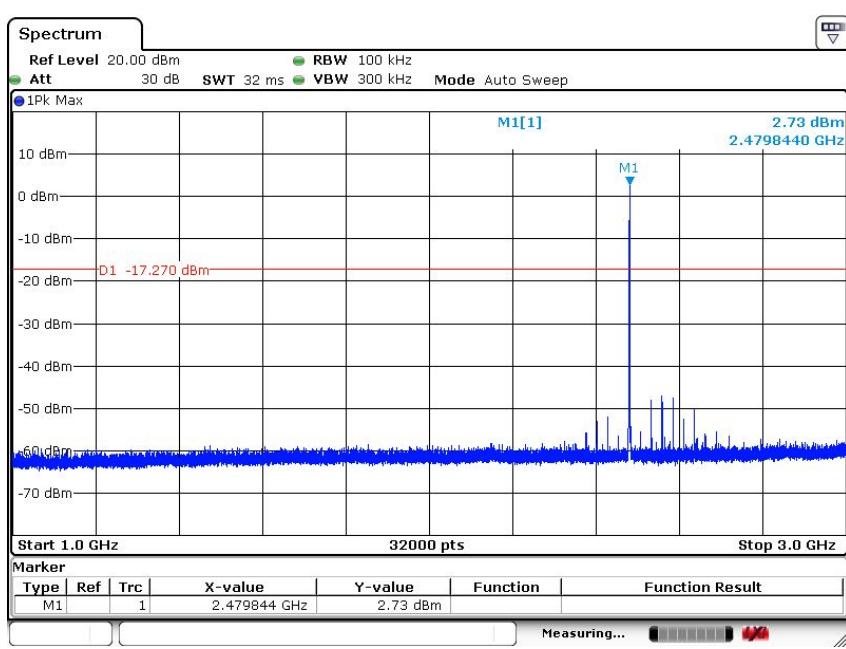
(Plot 4.9.1 B3: Channel 39: 2441MHz @ GFSK)



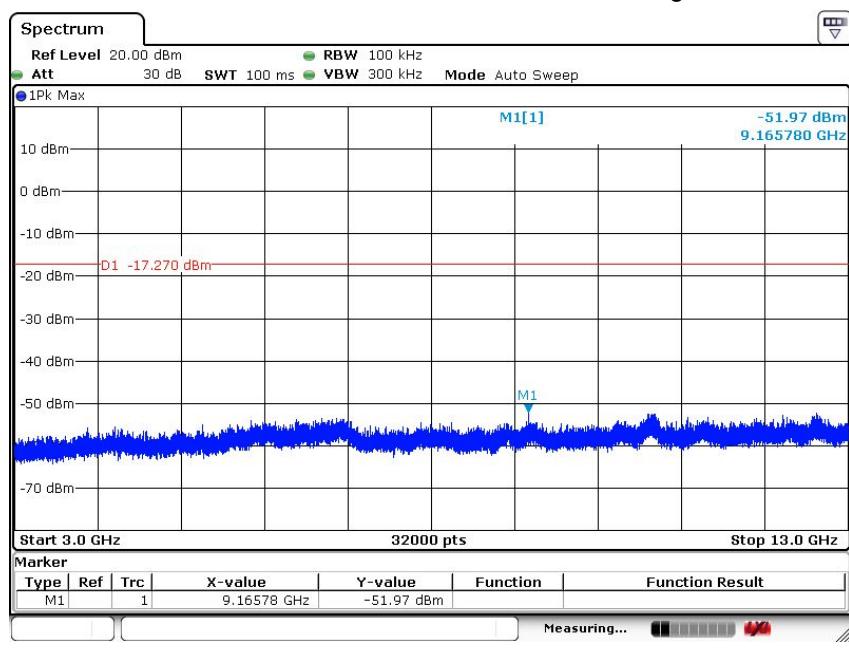
(Plot 4.9.1 B4: Channel 39: 2441MHz @ GFSK)



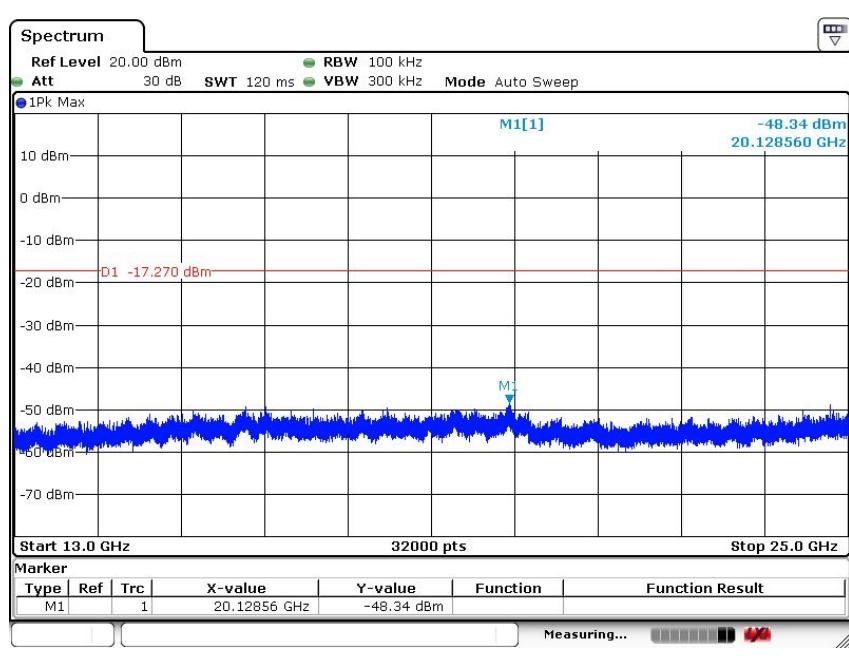
(Plot 4.9.1 C1: Channel 78: 2480MHz @ GFSK)



(Plot 4.9.1 C2: Channel 78: 2480MHz @ GFSK)



(Plot 4.9.1 C3: Channel 78: 2480MHz @ GFSK)



(Plot 4.9.1 C4: Channel 78: 2480MHz @ GFSK)

4.9.2 8DPSK Test Mode

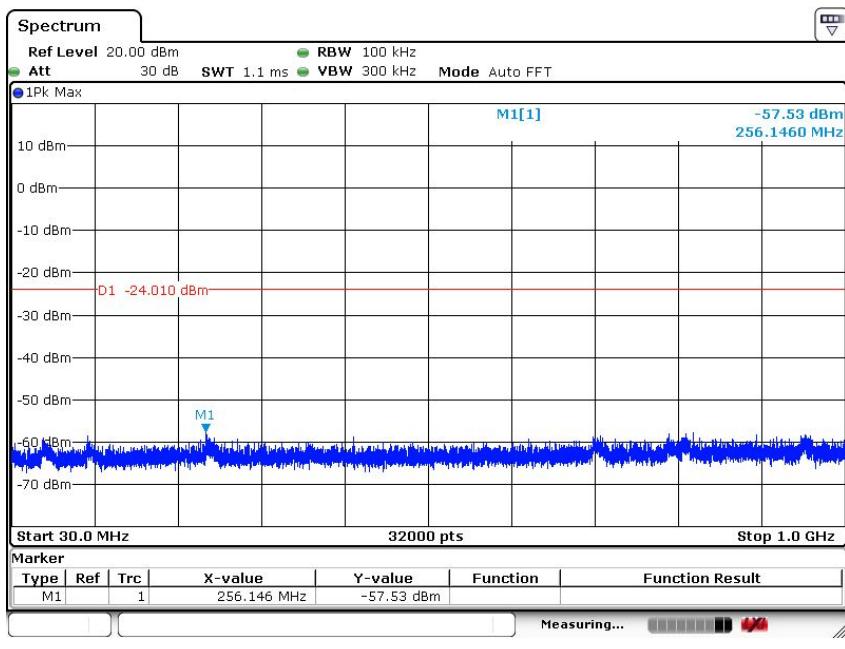
A. Test Verdict

| Channel | Frequency (MHz) | Frequency Range | Sweep Points | Refer to Plot | Limit (dBc) | Verdict |
|---------|-----------------|-----------------|--------------|---------------|-------------|---------|
| 00 | 2402 | 30MHz-1GHz | 9700 | Plot 4.9.2 A1 | -20 | PASS |
| | | 1MHz-3GHz | 20000 | Plot 4.9.2 A2 | -20 | PASS |
| | | 3GHz-13GHz | 100000 | Plot 4.9.2 A3 | -20 | PASS |
| | | 13GHz-25GHz | 120000 | Plot 4.9.2 A4 | -20 | PASS |
| 39 | 2441 | 30MHz-1GHz | 9700 | Plot 4.9.2 B1 | -20 | PASS |
| | | 1MHz-3GHz | 20000 | Plot 4.9.2 B2 | -20 | PASS |
| | | 3GHz-13GHz | 100000 | Plot 4.9.2 B3 | -20 | PASS |
| | | 13GHz-25GHz | 120000 | Plot 4.9.2 B4 | -20 | PASS |
| 78 | 2480 | 30MHz-1GHz | 9700 | Plot 4.9.2 C1 | -20 | PASS |
| | | 1MHz-3GHz | 20000 | Plot 4.9.2 C2 | -20 | PASS |
| | | 3GHz-13GHz | 100000 | Plot 4.9.2 C3 | -20 | PASS |
| | | 13GHz-25GHz | 120000 | Plot 4.9.2 C4 | -20 | PASS |

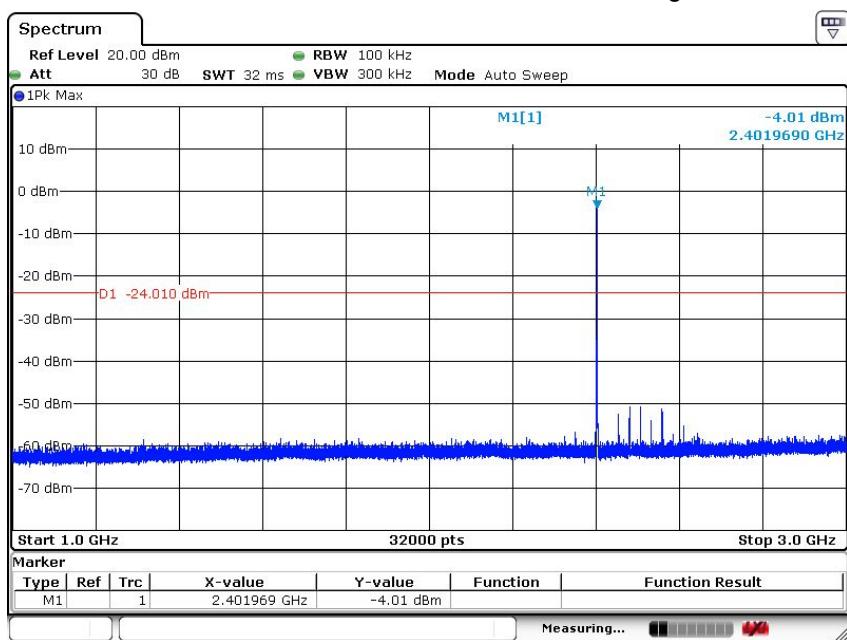
Note:

1. The test results including the cable lose.

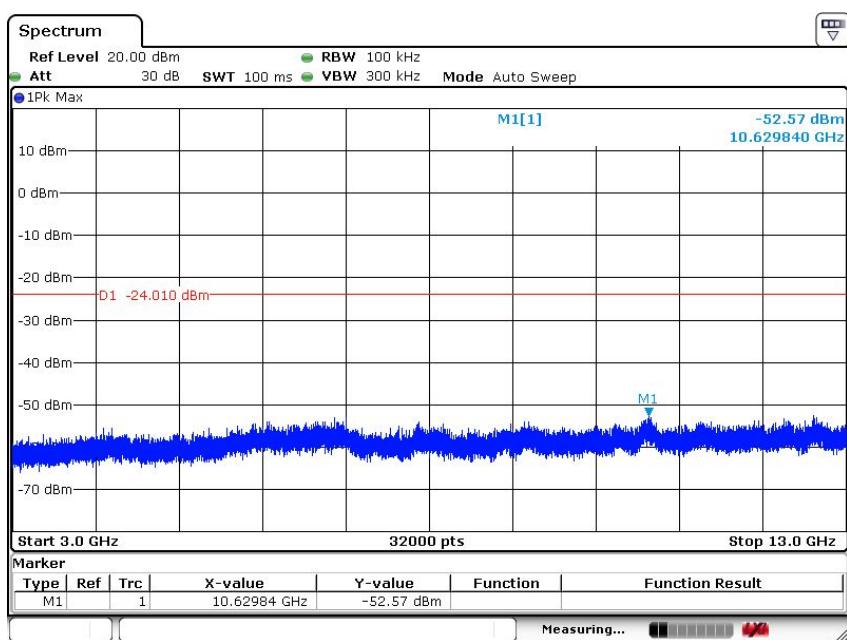
B. Test Plots



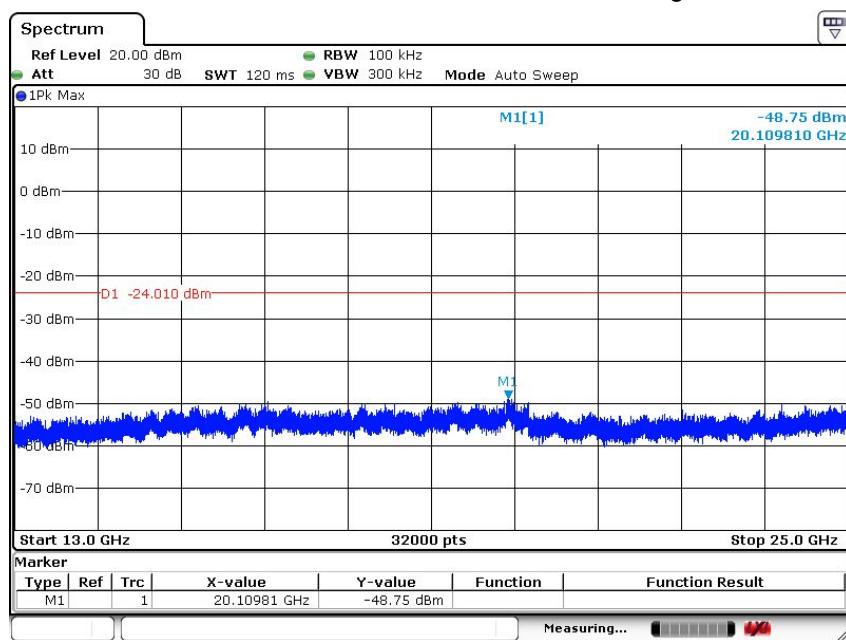
(Plot 4.9.2 A1: Channel 00: 2402MHz @ 8DPSK)



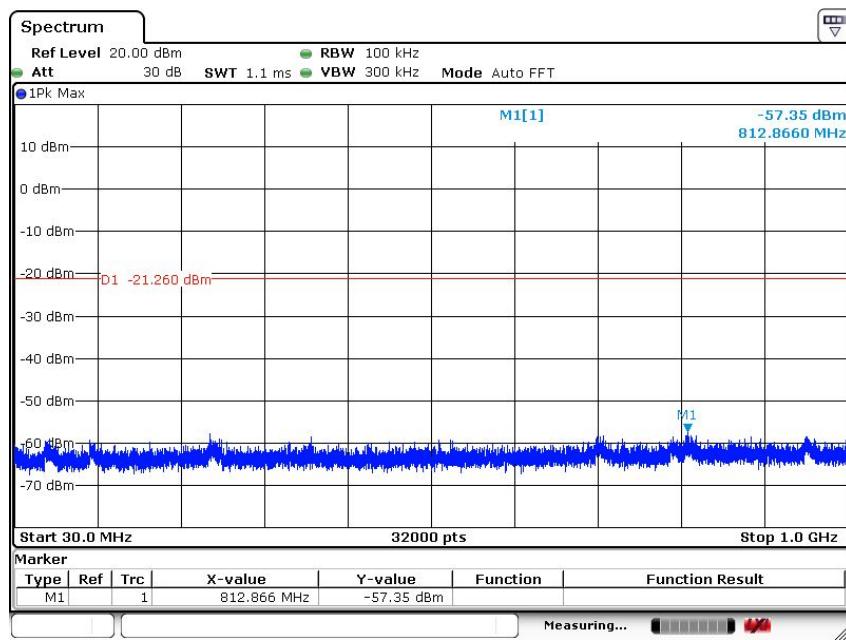
(Plot 4.9.2 A2: Channel 00: 2402MHz @ @ 8DPSK)



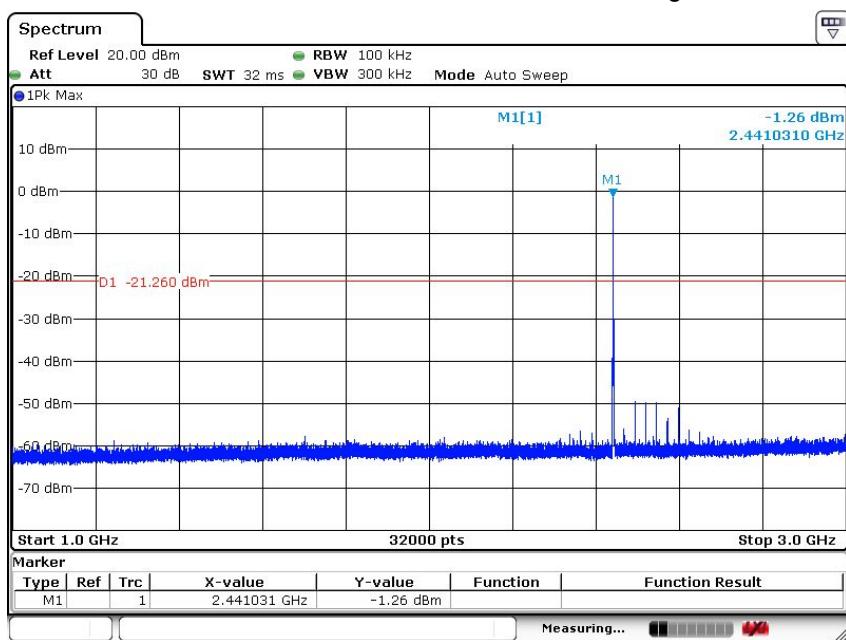
(Plot 4.9.2 A3: Channel 00: 2402MHz @ @ 8DPSK)



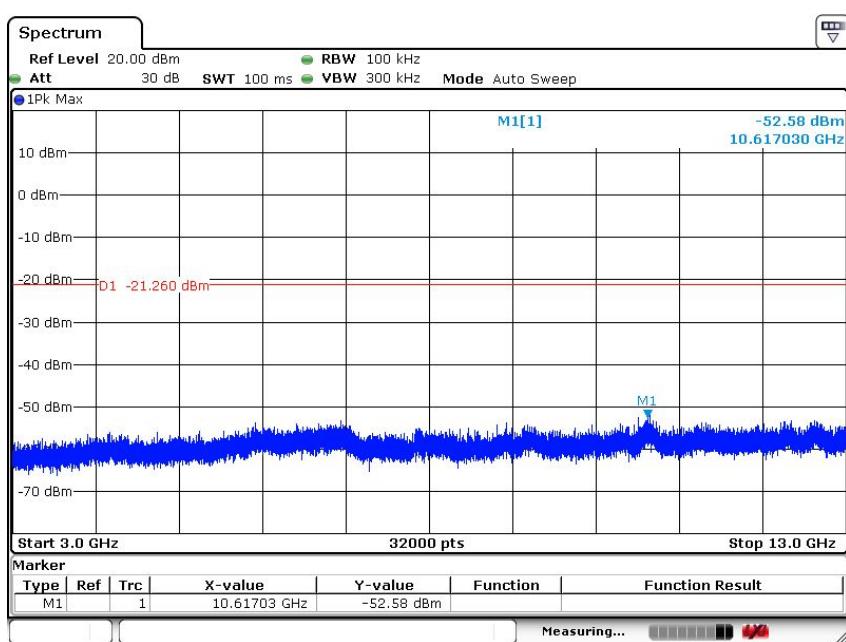
(Plot 4.9.2 A4: Channel 00: 2402MHz @ @ 8DPSK)



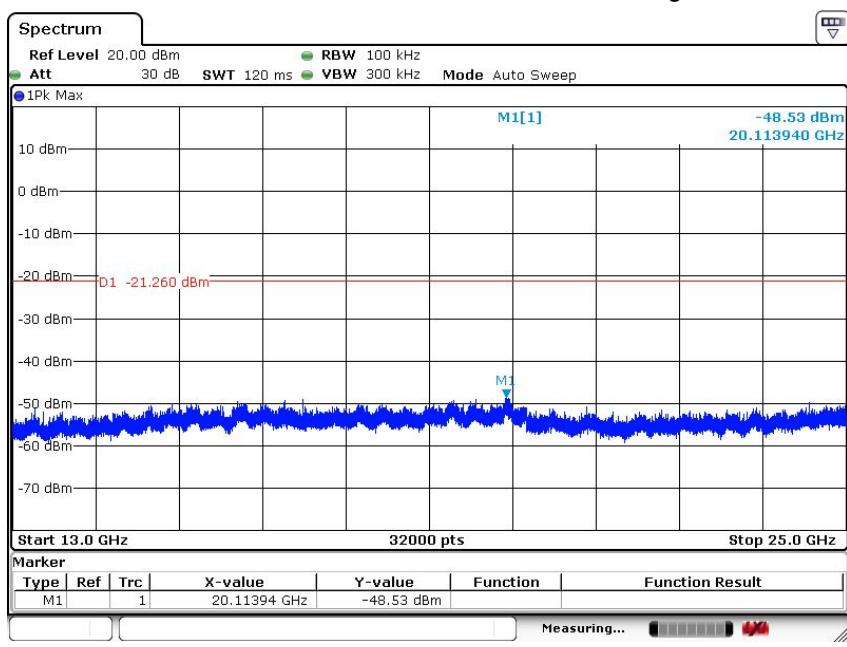
(Plot 4.9.2 B1: Channel 39: 2441MHz @ @ 8DPSK)



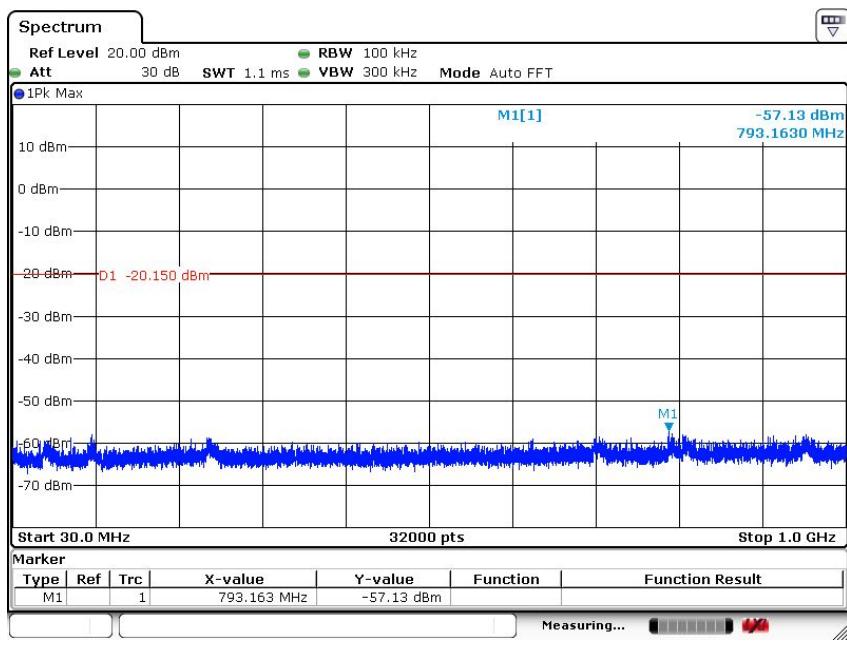
(Plot 4.9.2 B2: Channel 39: 2441MHz @ @ 8DPSK)



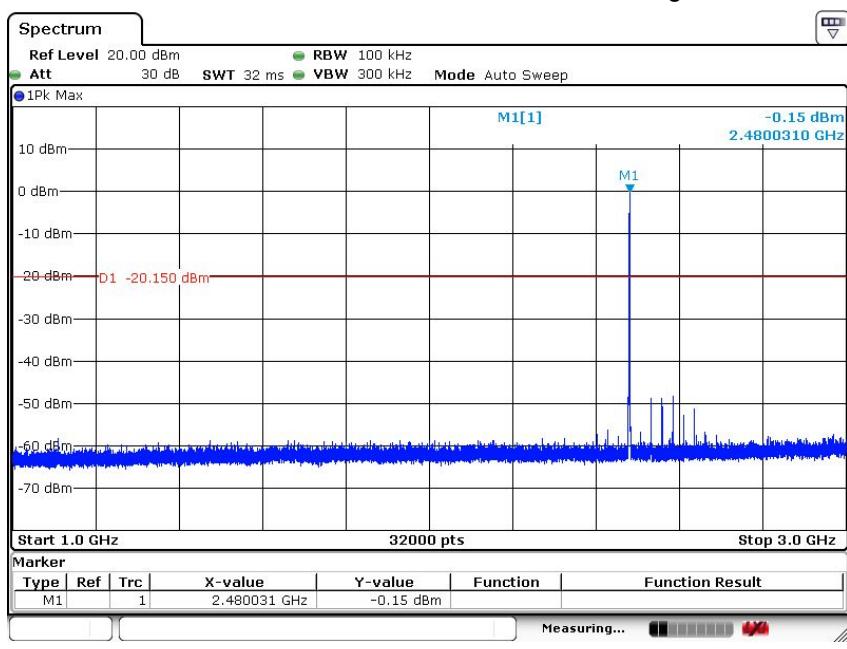
(Plot 4.9.2 B3: Channel 39: 2441MHz @ @ 8DPSK)



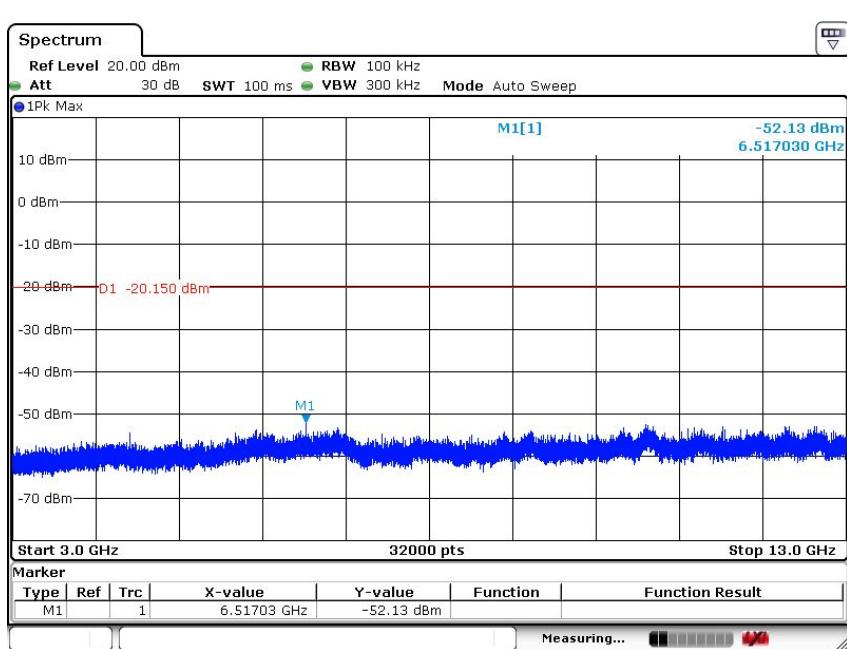
(Plot 4.9.2 B4: Channel 39: 2441MHz @ @ 8DPSK)



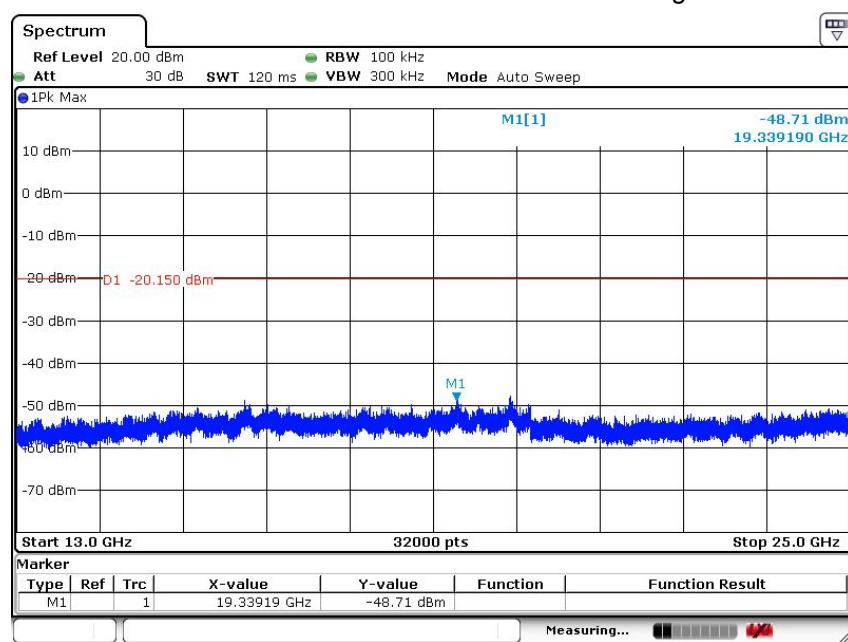
(Plot 4.9.2 C1: Channel 78: 2480MHz @ @ 8DPSK)



(Plot 4.9.2 C2: Channel 78: 2480MHz @ @ 8DPSK)



(Plot 4.9.2 C3: Channel 78: 2480MHz @ @ 8DPSK)



(Plot 4.9.2 C4: Channel 78: 2480MHz @ @ 8DPSK)

4.10 Pseudorandom Frequency Hopping Sequence

TEST APPLICABLE

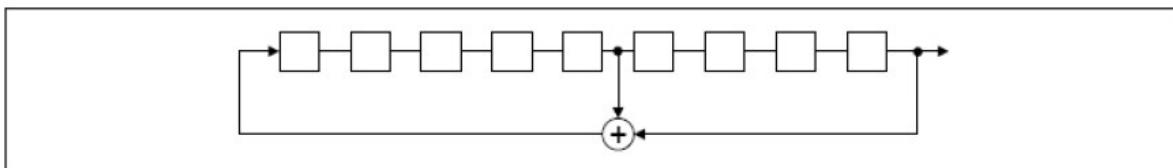
For 47 CFR Part 15C section 15.247 (a)(1) requirement:

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. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

EUT Pseudorandom Frequency Hopping Sequence Requirement

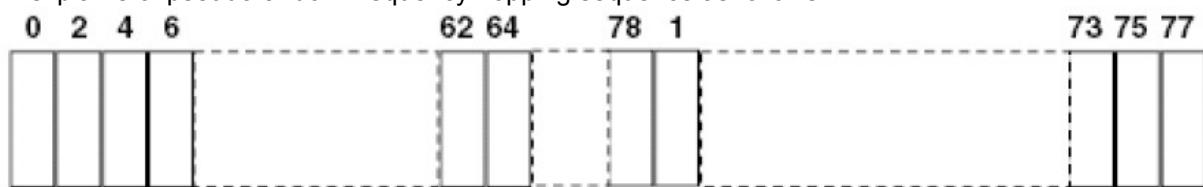
The pseudorandom frequency hopping sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first one of 9 consecutive ones, for example: the shift register is initialized with nine ones.

- Number of shift register stages: 9
- Length of pseudo-random sequence: $2^9 - 1 = 511$ bits
- Longest sequence of zeros: 8 (non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence

An example of pseudorandom frequency hopping sequence as follows:



Each frequency used equally one the average by each transmitter.

The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitter and shift frequencies in synchronization with the transmitted signals.



4.11 Antenna Requirement

Standard Applicable

For intentional device, according to FCC 47 CFR Section 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.

And according to FCC 47 CFR Section 15.247 (c), if transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

Refer to statement below for compliance

The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. Further, this requirement does not apply to intentional radiators that must be professionally installed.

Measurement

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module. For normal BT devices, the GFSK mode is used.

Measurement parameters

| Measurement parameter | |
|-----------------------|----------|
| Detector: | Peak |
| Sweep time: | Auto |
| Resolution bandwidth: | 1MHz |
| Video bandwidth: | 3MHz |
| Trace-Mode: | Max hold |

Limits

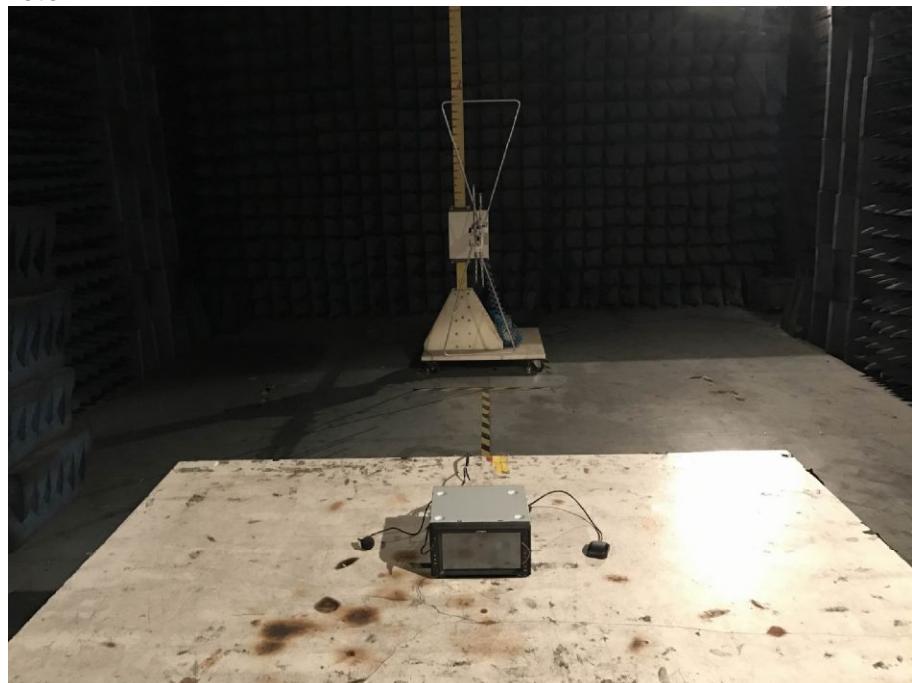
antenna type:PCB antenna

| FCC | IC |
|--------------|----|
| Antenna Gain | |
| 6 dBi | |

Results

Antenna type:PCB antenna

| T _{nom} | V _{nom} | Lowest Channel 2402 MHz | Middle Channel 2441 MHz | Highest Channel 2480 MHz |
|--|------------------|---|----------------------------|-----------------------------|
| Conducted power [dBm] Measured with GFSK modulation | | 2.34 | 2.48 | 2.67 |
| Radiated power [dBm] Measured with GFSK modulation | | 3.55 | 3.37 | 3.28 |
| Gain [dBi] Calculated | | 1.21 | 0.89 | 0.61 |
| Measurement uncertainty | | ± 0.6 dB (cond.) / ± 2.56 dB (rad.) | | |

Setup photo

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