

RF Test Report

2.4 GHz Bluetooth

Report No. : FCCCBNW-WAY-P22120056-3R2
Customer : Pittasoft Co.,Ltd.
Address : A4th floor, ABN Tower, 331, Pangyo-ro, Bundang-gu,
Seongnam-si, Gyeonggi-do, Republic of Korea
Use of Report : Certification
Model Name : Series 2.0
FCC ID : YCK-SERIES2
Date of Test : 2022.12.10 to 2023.01.03
Test Method Used : FCC 47 CFR PART 15 Subpart C (Section §15.247)
KDB55804 D01v05r02, ANSI C63.10-2013
Testing Environment : Refer to the Test Condition

Test Result : ☒ Pass ☐ Fail

ISSUED BY: BV CPS ADT Korea Ltd., EMC/RF Laboratory

ADDRESS: Innoplex No.2 106, Sinwon-ro 306, Yeongtong-gu,
Suwon-si, Gyeonggi-do, Korea 16675

TEST LOCATION: HeungAn-daero 49, DongAn-gu, Anyang-si,
Gyeonggi-do, Korea, 14119

Tested by

Name : Donghoon Kang

(Signature)

Technical Manager

Name : Jungwoo Kim

(Signature)

2023. 01. 25

BV CPS ADT Korea Ltd.

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RELEASE CONTROL RECORD

| REPORT NO. | REASON FOR CHANGE | DATE ISSUED |
|---------------------------|----------------------|-------------|
| FCCCBNW-WAY-P22120056-3 | Original release | 2023.01.11 |
| FCCCBNW-WAY-P22120056-3R1 | correction of errors | 2023.01.19 |
| FCCCBNW-WAY-P22120056-3R2 | correction of errors | 2023.01.25 |

Table of Contents

| | |
|------------------------------------------------------|-----------|
| RELEASE CONTROL RECORD | 2 |
| 1 SUMMARY OF TEST RESULTS..... | 5 |
| 1.1 DECISION RULES FOR STATEMENT OF CONFORMITY | 6 |
| 1.2 MEASUREMENT UNCERTAINTY | 6 |
| 2 GENERAL INFORMATION | 7 |
| 2.1 GENERAL DESCRIPTION OF EUT..... | 7 |
| 2.2 DESCRIPTION OF TEST MODE | 8 |
| 2.3 INSTRUMENT CALIBRATION | 8 |
| 2.4 EUT CONFIGURATION | 8 |
| 2.6 GENERAL DESCRIPTION OF APPLIED STANDARDS | 8 |
| 2.7 TEST EQUIPMENT..... | 9 |
| 3 TEST RESULTS | 10 |
| 3.1 ANTENNA REQUIREMENT..... | 10 |
| 3.2 20 dB BANDWIDTH..... | 11 |
| 3.2.1 Test Procedure..... | 11 |
| 3.2.2 Test Setup | 11 |
| 3.2.3 Test Result..... | 12 |
| 3.3 MAXIMUM PEAK OUTPUT POWER..... | 16 |
| 3.3.1 Regulation..... | 16 |
| 3.3.2 Test Procedure..... | 16 |
| 3.3.3 Test Setup | 17 |
| 3.3.4 Test Result..... | 18 |
| 3.4 CARRIER FREQUENCY SEPARATION..... | 22 |
| 3.4.1 Regulation..... | 22 |
| 3.4.2 Test Procedure..... | 22 |
| 3.4.3 Test Setup | 22 |
| 3.4.4 Test Result..... | 23 |
| 3.5 NUMBER OF HOPPING CHANNELS | 25 |
| 3.5.1 Regulation..... | 25 |
| 3.5.2 Test Procedure..... | 25 |
| 3.5.3 Test Setup | 26 |
| 3.5.4 Test Result..... | 26 |
| 3.6 TIME OF OCCUPANCY (DWEIL TIME) | 28 |
| 3.6.1 Regulation..... | 28 |

| | | |
|-----------------------------------------------------------------|---------------------------------------------------------|-----------|
| 3.6.2 | <i>Test Procedure</i> | 28 |
| 3.6.3 | <i>Test Setup</i> | 29 |
| 3.6.4 | <i>Test Result</i> | 29 |
| 3.7 | SPURIOUS EMISSION, BAND EDGE AND RESTRICTED BANDS..... | 31 |
| 3.7.1 | <i>Regulation</i> | 31 |
| 3.7.2 | <i>Test Procedure</i> | 32 |
| 3.7.3 | <i>Test Setup</i> | 36 |
| 3.7.4 | <i>Test Result of Radiated Spurious Emission</i> | 38 |
| 3.7.5 | <i>Test Result of Conducted Spurious Emission</i> | 45 |
| 3.8 | AC CONDUCTED EMISSIONS (150 KHZ TO 30 MHZ)..... | 57 |
| 3.8.1 | <i>Regulation</i> | 57 |
| 3.8.2 | <i>Test Procedure</i> | 57 |
| 3.8.3 | <i>Test Setup</i> | 58 |
| 3.8.4 | <i>Test Result</i> | 58 |
| APPENDIX – INFORMATION OF THE TESTING LABORATORIES | | 59 |

1 Summary of Test Results

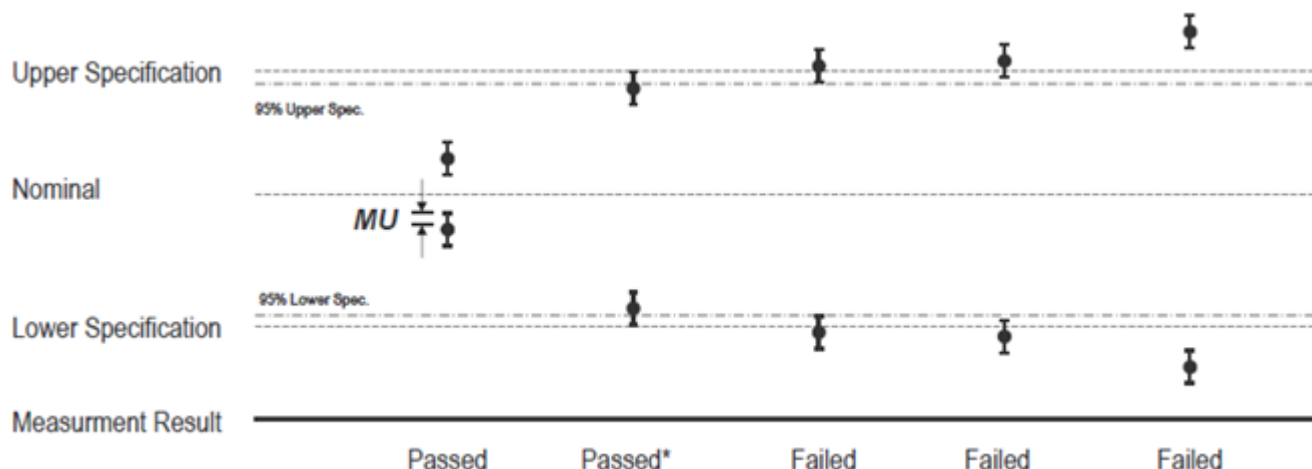
The EUT has been tested according to the following specifications

| Applied Standard : FCC Part 15, Subpart C 15.247 | | | | | |
|--------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------------------|-----------------------|-------------|
| FCC Part Section(s) | Test Description | Limit | Test Condition | Test Result | Reference |
| 15.247(a) | Carrier Frequency Separation | ≥ 25 kHz or \geq Two thirds of the 20 dB BW, whichever is greater. | Conducted | PASS | Section 3.4 |
| 15.247(a) | Number of Hopping Frequencies | ≥ 15 hops | | PASS | Section 3.5 |
| 15.247(a) | 20 dB Bandwidth | N/A | | PASS | Section 3.2 |
| 15.247(a) | Dwell Time | ≤ 0.4 seconds | | PASS | Section 3.6 |
| 15.247(b) | Transmitter Output Power | ≤ 1 Watt , if CHs ≥ 75 Others ≤ 0.125 W | | PASS | Section 3.3 |
| 15.247(d) | Conducted spurious emissions | ≥ 20 dBc In any 100 kHz bandwidth | | PASS | Section 3.7 |
| 15.205 15.209 | General Field Strength Limits (Restricted Bands and Radiated Emission Limits) | Emissions in Restricted bands must meet the radiated limits detailed in 15.209 | Radiated | PASS | Section 3.7 |
| 15.207 | AC Conducted Emissions (150 kHz – 30 MHz) | $<$ FCC 15.207 limits | AC Line Conducted | NA ^(Note3) | Section 3.8 |
| 15.203 | Antenna Requirement | FCC 15.203 | - | PASS | Section 3.1 |

NOTES

- 1) The general test methods used to test on this devices are ANSI C63.10.
- 2) Determining compliance based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty.
- 3) This Devices which only employ battery power for operation.

1.1 Decision Rules for Statement of Conformity



QUA-52 Decision Rule(QA Document) was applied.

Step 1) : Reference Check, Daily Check, Peripheral device Check

Step 2) : Re-test Procedure (Repeat the test maximum 3 times, Different Test Engineer)

- 1) If the original test results are subject to retesting and the judgement is unclear, the retest is carried out.
- 2) If the result of the first retest is the same as the initial test, the judgement is made based on the value.
- 3) If the result of the first retest differ from the results of the initial test, the second re-test is carried out.
- 4) After completion of the second retest, the average of the three test results is determined as the final result. However, if the deviation of the three test values is more than 5 % of the reference value, the technical manager should review the reproducibility of the test from the beginning.

1.2 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2

| Measurement Items | Frequency Range | Expanded Uncertainty $U = kU_c (k = 2)$ |
|-----------------------------|-------------------|--------------------------------------------|
| Radiated Spurious Emissions | 9 kHz – 30 MHz | 2.06 |
| | 30 MHz – 1 GHz | 4.48 |
| | 1 GHz – 18 GHz | 5.24 |
| | 18 GHz – 26.5 GHz | 5.08 |

This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level using a coverage factor of $k = 2$.

2 General Information

2.1 General Description of EUT

| | |
|----------------------------------------|----------------------------------------------------|
| Equipment Class | Sperad Spectrum Transmitter (DSS) |
| Product name | CAR DASHCAM |
| FCC ID | YCK-SERIES2 |
| Model | Series 2.0 |
| Additional model name | NA |
| Identification No. of EUT | - |
| Power Supply | DC 12 V , DC 24V |
| Modulation Type (Data Rate) | GFSK(1 Mbps), π /4DQPSK(2 Mbps), 8DPSK(3 Mbps) |
| Operating Frequency | 2 402 MHz to 2 480 MHz |
| Output Power | 13.15 dBm |
| Antenna Type | Chip Antenna |
| Antenna Gain | 1.88 dBi |
| H/W Version | 1.0 |
| S/W Version | 1.0 |

NOTES

- 1) The above equipment has been tested by **Bureau Veritas Consumer Products Services ADT Korea**, and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's RF characteristics under the conditions specified in this report.

2) List of Accessories

| Accessories | Brand | Model | Manufacturer | Specification |
|-------------|-------|-------|--------------|---------------|
| - | - | - | - | - |

2.2 Description of Test Mode

The EUT has been tested with all modes of operating conditions to determine the worst case emission characteristics.

| Test Mode | | Tested Frequency (MHz) | | |
|-----------|-----------------------|------------------------|-------|-------|
| TM 1 | GFSK(1 Mbps) | 2 402 | 2 440 | 2 480 |
| TM 2 | $\pi/4$ DQPSK(2 Mbps) | 2 402 | 2 440 | 2 480 |
| TM 3 | 8DPSK(3 Mbps) | 2 402 | 2 440 | 2 480 |

Note: A test was performed for each voltage.

Information about the FHSS characteristics

A) The hopping sequence is pseudorandom

Note 1 : Pseudorandom Frequency Hopping Sequence Table as below:

Channel: 08, 24, 40, 56, 42, 54, 72, 09, 01, 11, 33, 41, 34, 42, 65, 73, 53, 69, 06, 22, 04, 20, 36, 52, 38, 46, 70, 78, 68, 76, 21, 29, 10, 26, 41, 58, 44, 60, 76, 13, 03, 11, 35, 43, 37, 45, 69, 77, 52, 71, 08, 24, 06, 24, 48, 56, 45, 46, 70, 01, 72, 06, 25, 33, 12, 28, 49, 60, 45, 58, 74, 13, 05, 18, 37, 49 etc

The System receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchroniztation with the transmitted signals.

B) All channels are used equally on average

C) The receiver input bandwidth equals the transmit bandwidth

D) The receiver hops in sequenc e with the transmit signal

2.3 INSTRUMENT CALIBRATION

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipments, which is traceable to recognized national standards.

2.4 EUT CONFIGURATION

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

2.6 General Description of Applied Standards

Generally the tests were performed according to the specifications of the standard, it must comply with the requirements of the following standards.

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

KDB 558074 D01 15.247 Meas Guidance v05r02

KDB 662911 D01 Multiple Transmitter Output v02r01

ANSI C63.10-2013

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

2.7 Test Equipment

Test Equipment is traceable to the National Institute of Standards and Technology (NIST). Measurement antenna used during testing were calibrated in accordance to the requirements of ANSI C63.5-2017.

| Manufacturer | Model | Description | Serial Number | Cal Date (yyyy.mm.dd) | Cal Due (yyyy.mm.dd) |
|---------------------------------|-----------------------|-------------------|---------------|-----------------------|----------------------|
| EMI Test Receiver | R&S | ESR7 | 102121 | 2022.11.21 | 2023.11.21 |
| Spectrum Analyzer | R&S | FSW50 | 101403 | 2022.11.22 | 2023.11.22 |
| Signal Analyzer | Keysight Technologies | N9030B | MY57142476 | 2022.11.22 | 2023.11.22 |
| Active Loop Antenna | R&S | HFH2-Z2E | 100881 | 2022.02.18 | 2023.02.18 |
| Trilog Antenna (with 6 dB ATT.) | Schwarzbeck | VULB 9163 | 01099 | 2022.09.03 | 2023.09.03 |
| Horn Antenna | R&S | HF907 | 102772 | 2022-12-03 | 2023-12-03 |
| Horn Antenna | Steatite Antenna | QSH-SL-18-26-S-20 | 19926 | 2022.11.23 | 2023.11.23 |
| Signal Conditioning Unit | R&S | SCU08F2 | 08400017 | 2022.11.21 | 2023.11.21 |
| Signal Conditioning Unit | R&S | SCU-18F | 180112 | 2022.11.21 | 2023.11.21 |
| Signal Conditioning Unit | R&S | SCU-26F | 260005 | 2022.11.23 | 2023.11.23 |
| High Pass Filter | Micro-Tronics | HPM17543 | 028 | 2022.06.03 | 2023.06.03 |
| High Pass Filter | Wt Microwave | WT-A1698-HS | WT190313-6-4 | 2022.11.22 | 2023.11.22 |
| Attenuator | API inmet | 40AH2W-10 | 3 | 2022.06.03 | 2023.06.03 |
| EXG Analog Signal Generator | Keysight Technologies | N5171B | MY56200336 | 2022.11.22 | 2023.11.22 |
| Signal Generator | R&S | SMB100A | MY41006053 | 2022.06.03 | 2023.06.03 |
| MIMO Power Set Master | Keysight Technologies | MP400B | NONE | 2022.12.02 | 2023.12.02 |
| DC Power Supply | Keysight Technologies | E3632A | MY62216181 | 2022.07.12 | 2023.07.12 |

3 Test Results

3.1 Antenna Requirement

Except from §15.203 of the FCC Rules/Regulations:

An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can 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 the section.

- The antenna(s) of the EUT are Permanently attached.
- There are no provisions for connection to an external antenna.

Result

The EUT complies with the requirement of §15.203

3.2 20 dB Bandwidth

3.2.1 Test Procedure

The 20 dB bandwidth & Occupied bandwidth were measured with a spectrum analyzer connected to RF antenna Connector(conducted measurement) while EUT was operating in transmit mode. The analyzer center frequency was set to the EUT carrier frequency, using the analyzer.

The bandwidth of the fundamental frequency was measured with the spectrum analyzer using below setting:

RBW = 1% to 5% of the 20 dB BW & Occupied BW

VBW $\geq 3 \times$ RBW

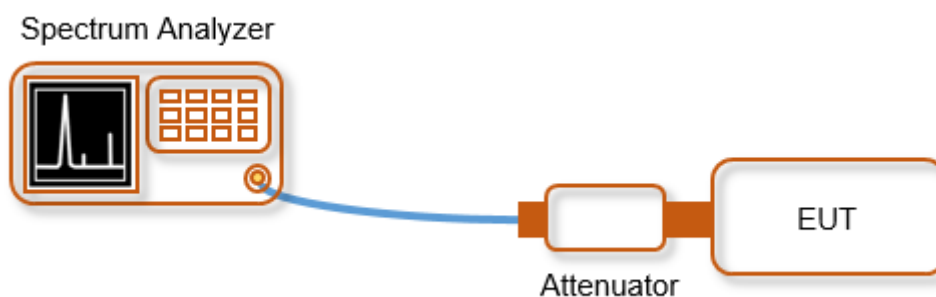
Span = between two times and five times the 20 dB bandwidth & Occupied BW

Sweep = auto

Detector function = peak

Trace = max hold

3.2.2 Test Setup



3.2.3 Test Result

[Test Data of 20 dB Bandwidth]

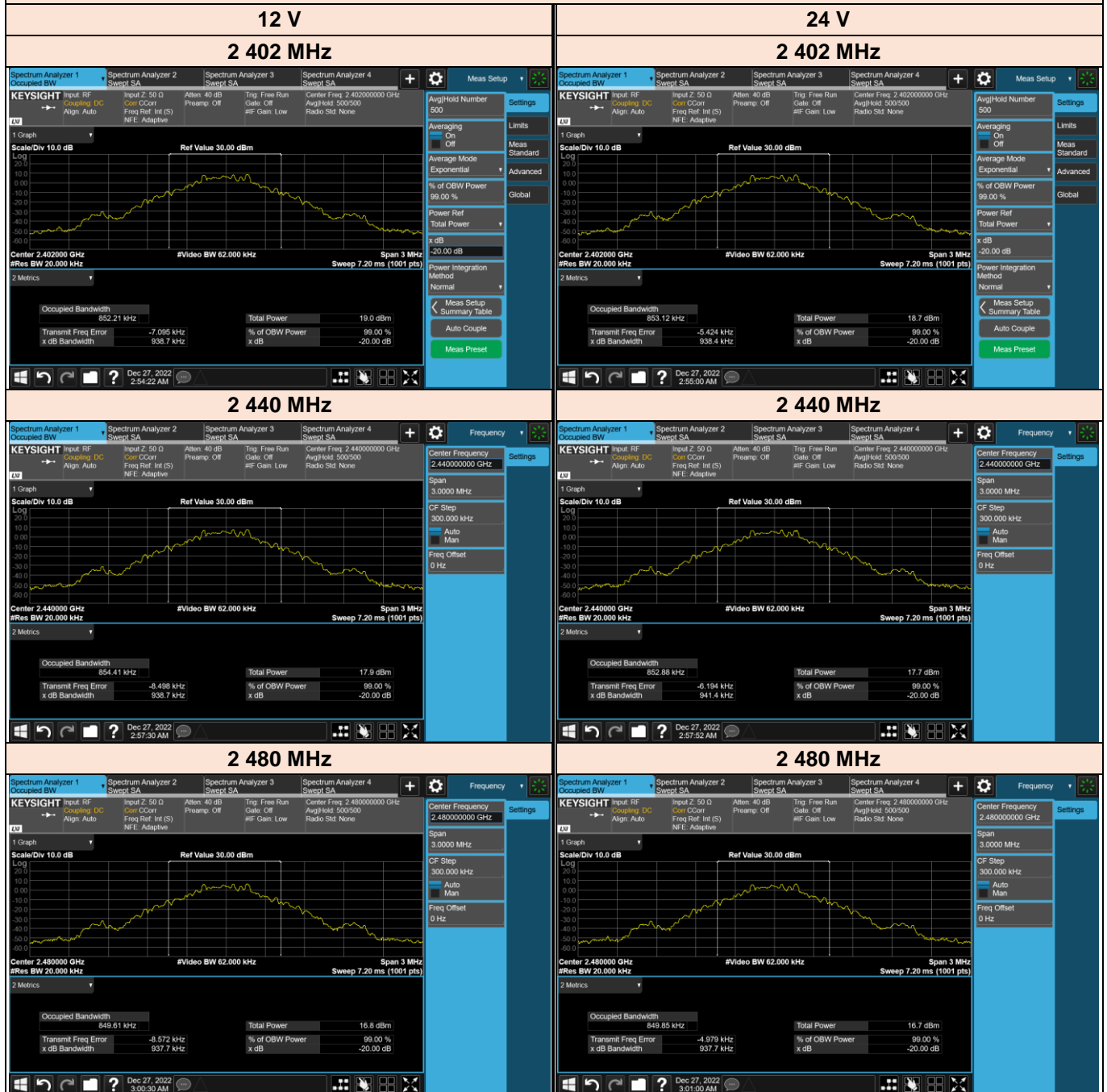
| Test Mode | Tested Frequency | 20 dB Bandwidth [MHz] | |
|-----------|------------------|-----------------------|--------|
| | | 12 V | 24 V |
| TM1 | 2 402 | 0. 939 | 0. 938 |
| | 2 440 | 0. 939 | 0. 941 |
| | 2 480 | 0. 938 | 0. 938 |
| TM2 | 2 402 | 1. 31 | 1. 31 |
| | 2 440 | 1. 31 | 1. 31 |
| | 2 480 | 1. 31 | 1. 31 |
| TM3 | 2 402 | 1. 27 | 1. 27 |
| | 2 440 | 1. 27 | 1. 27 |
| | 2 480 | 1. 27 | 1. 27 |



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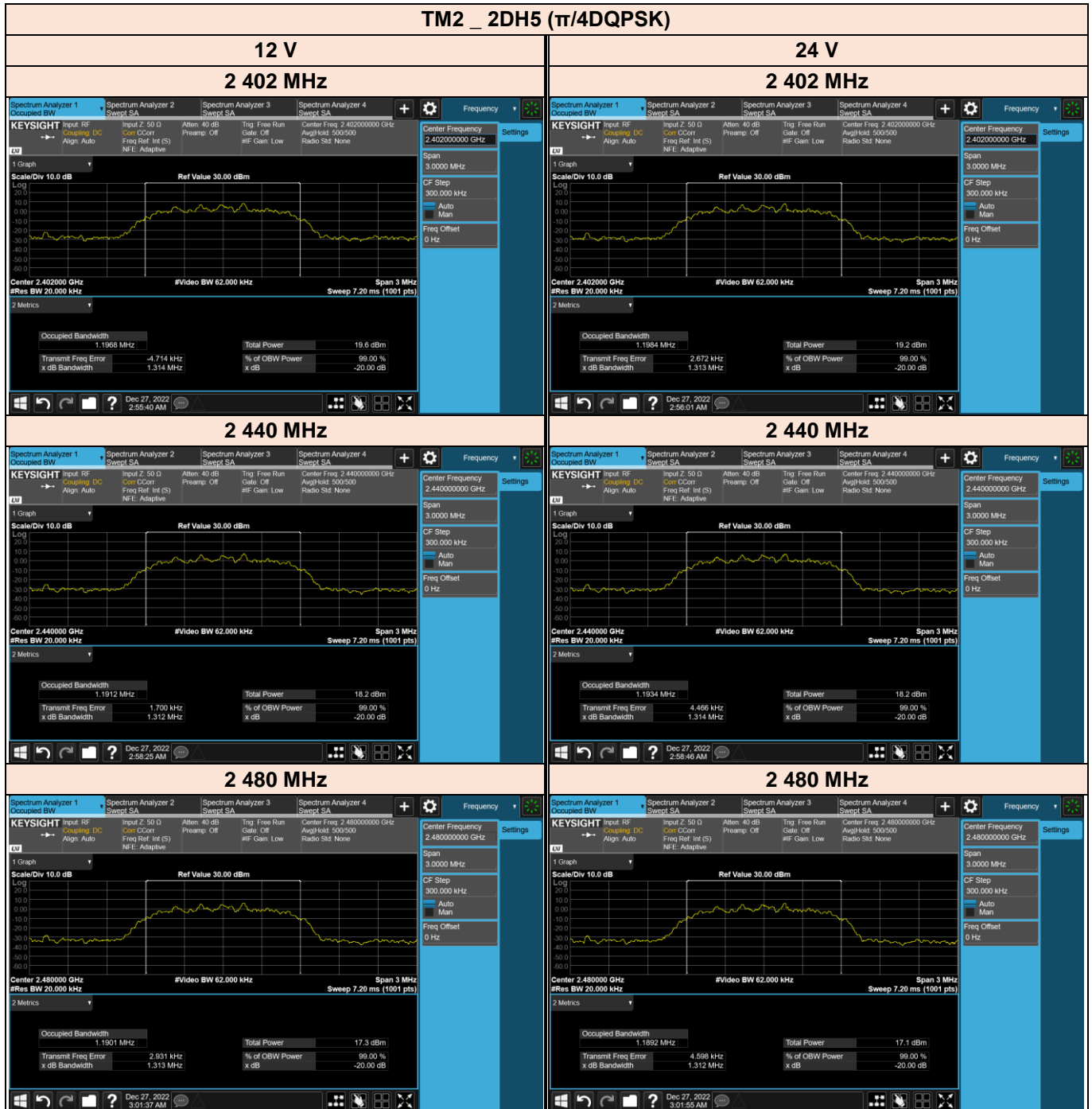
[Test Plot of 20 dB Bandwidth]

TM1 _ DH5 (GFSK)





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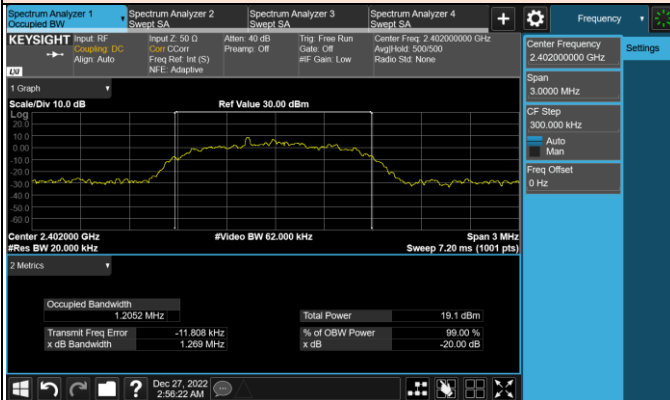


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TM3_3DH5 (8DPSK)

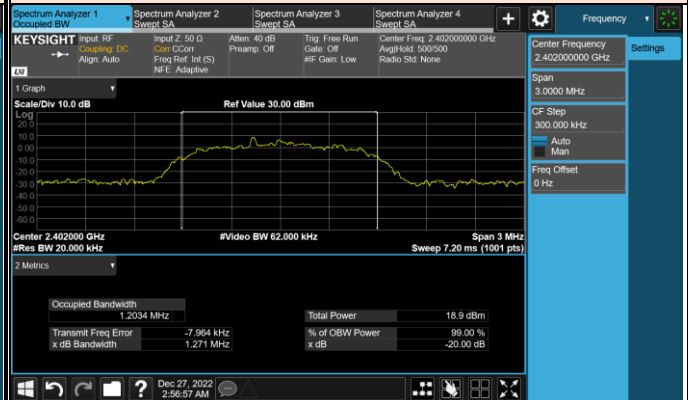
12 V

2 402 MHz

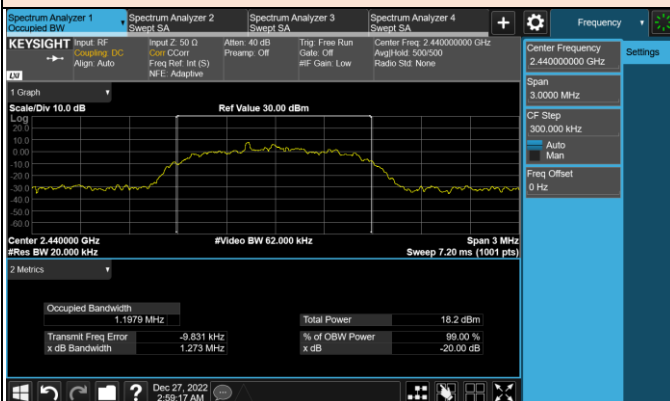


24 V

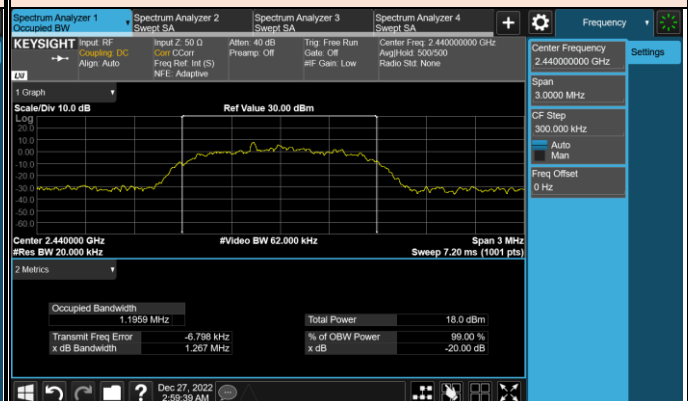
2 402 MHz



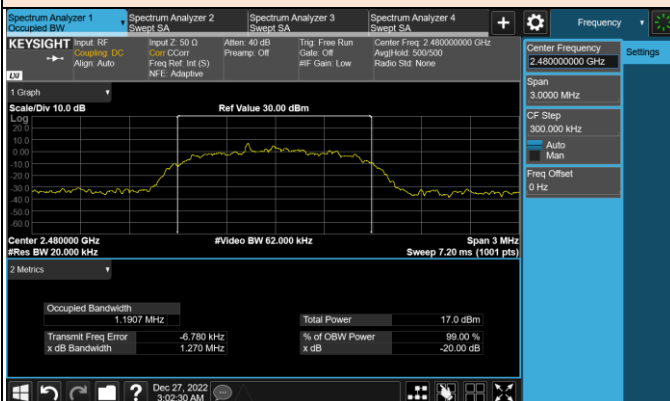
2 440 MHz



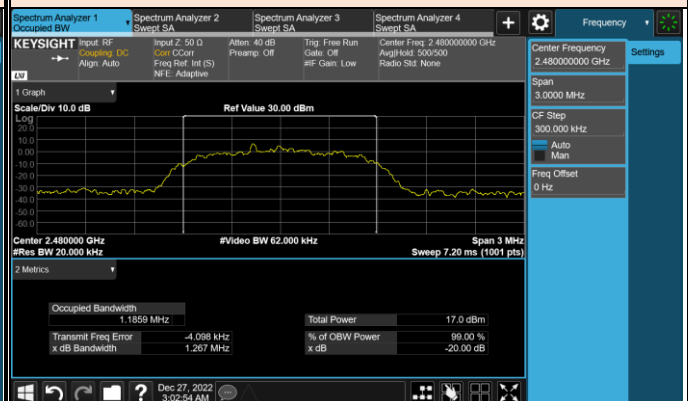
2 440 MHz



2 480 MHz



2 480 MHz



3.3 Maximum Peak Output Power

3.3.1 Regulation

§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.

§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.

§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.

3.3.2 Test Procedure

The method of measurement used to test this FHSS device is ANSI C63.10-2013

This is an RF conducted test to evaluate maximum peak output power. Use a direct connection between the antenna port of the unlicensed wireless device and the spectrum analyzer, through suitable attenuation.

- a) Use the following spectrum analyzer settings:

Peak Power Measurement

- 1) Span : Approximately five times the 20 dB bandwidth, centered on hopping channel.
- 2) RBW > 20 dB bandwidth of emission being measured.
- 3) VBW \geq RBW.
- 4) Sweep : Auto.
- 5) Detector function : Peak.
- 6) Trace : Max hold.
- b) Allow trace to stabilize
- c) Use the marker-to-peak function to set the marker to the peak of the emissions
- d) The indicated level is the peak output power, after any corrections for external attenuators and cables.
- e) A plot of the test results and setup description shall be included in the test report.

Average Power Measurement

Measurement using a power meter.

a) Average Power measurement using an RF average power meter, as follows:

- 1) The EUT is configured to transmit continuously, or to transmit with a constant duty cycle.
- 2) At all times when the EUT is transmitting, it shall be transmitting at its maximum power control level.
- 3) The integration period of the power meter exceeds the repetition period of the transmitted signal by at least a factor of five.

b) If the transmitter does not transmit continuously, measure the duty cycle, D, of the transmitter output signal.

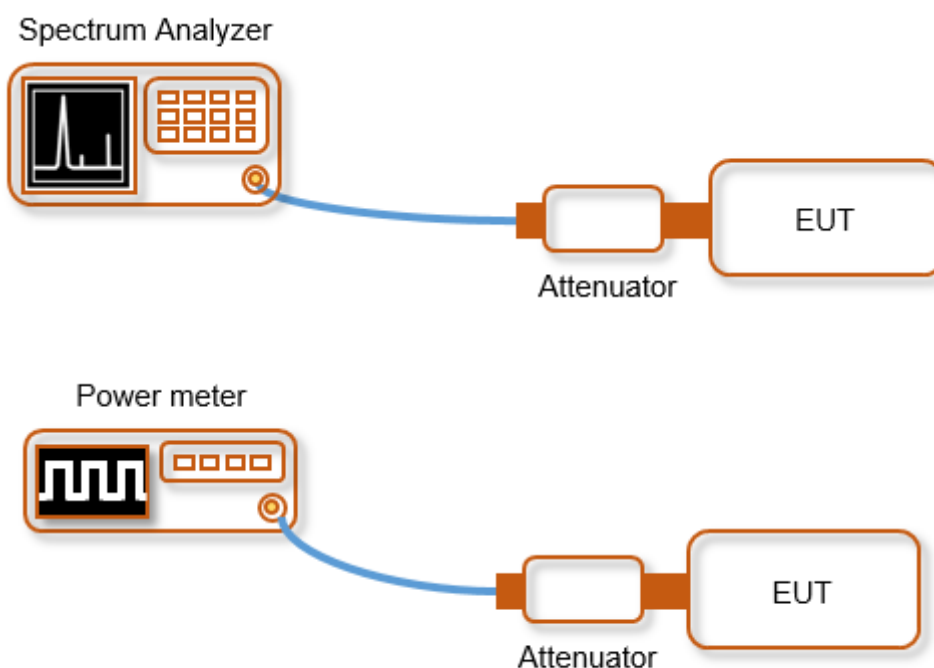
c) Measure the average power of the transmitter.

This measurement is an average over both the ON and OFF periods of the transmitter.

d) Correct the measurement in dBm by adding $[10 \log (1 / D)]$, where D is the duty cycle.

Please refer D value at page 11 2.4 Duty cycle of test signal.

3.3.3 Test Setup



3.3.4 Test Result

[Test Result of Peak Power & Average Power]

Limit: 0.125 Watt

| Test Mode | Tested Frequency | 12 V | | | |
|-----------|------------------|----------------------|---------|---------------------|---------|
| | | Measured Power [dBm] | | Measured Power [mW] | |
| | | PK | Average | PK | Average |
| TM1 | 2 402 | 11.95 | 11.73 | 15.67 | 14.89 |
| | 2 440 | 11.22 | 10.96 | 13.24 | 12.47 |
| | 2 480 | 9.84 | 9.59 | 9.64 | 9.10 |
| TM2 | 2 402 | 13.15 | 11.46 | 20.65 | 14.00 |
| | 2 440 | 11.99 | 9.78 | 15.81 | 9.51 |
| | 2 480 | 10.78 | 8.57 | 11.97 | 7.19 |
| TM3 | 2 402 | 12.81 | 11.42 | 19.10 | 13.87 |
| | 2 440 | 11.86 | 9.53 | 15.35 | 8.97 |
| | 2 480 | 10.8 | 8.51 | 12.02 | 7.10 |

Note: Average Power = Measurement Average Power + Duty cycle fator.

| Test Mode | Tested Frequency | 24 V | | | |
|-----------|------------------|----------------------|---------|---------------------|---------|
| | | Measured Power [dBm] | | Measured Power [mW] | |
| | | PK | Average | PK | Average |
| TM1 | 2 402 | 11.81 | 11.64 | 15.17 | 14.60 |
| | 2 440 | 10.8 | 10.62 | 12.02 | 11.55 |
| | 2 480 | 9.73 | 9.52 | 9.40 | 8.96 |
| TM2 | 2 402 | 12.78 | 11.32 | 18.97 | 13.55 |
| | 2 440 | 11.77 | 9.73 | 15.03 | 9.39 |
| | 2 480 | 10.68 | 8.56 | 11.69 | 7.18 |
| TM3 | 2 402 | 12.68 | 11.41 | 18.54 | 13.85 |
| | 2 440 | 11.71 | 9.39 | 14.83 | 8.70 |
| | 2 480 | 10.59 | 8.33 | 11.46 | 6.82 |

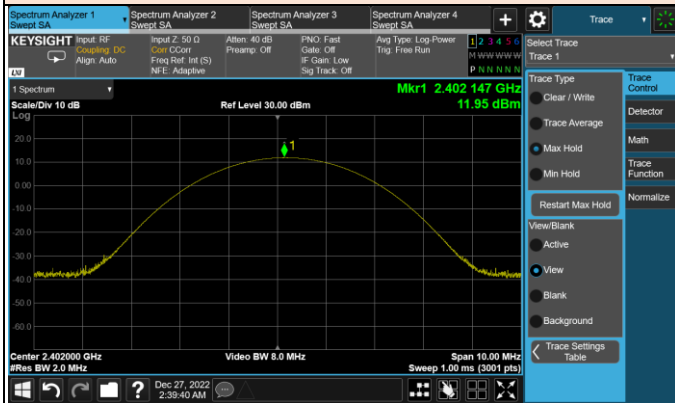
Note: Average Power = Measurement Average Power + Duty cycle fator.

[Test Plot of Peak Power]

TM1 _ DH5 (GFSK)

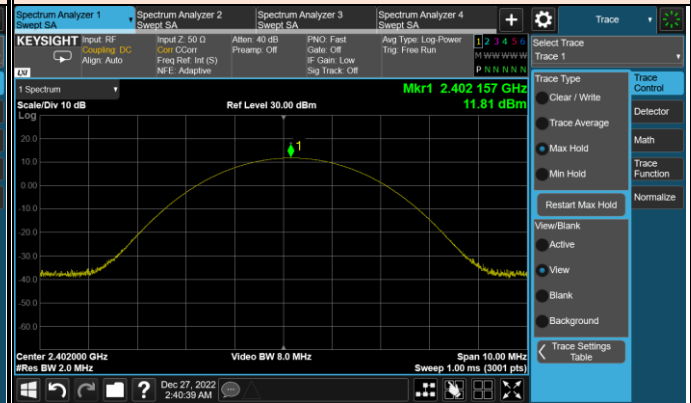
12 V

2 402 MHz

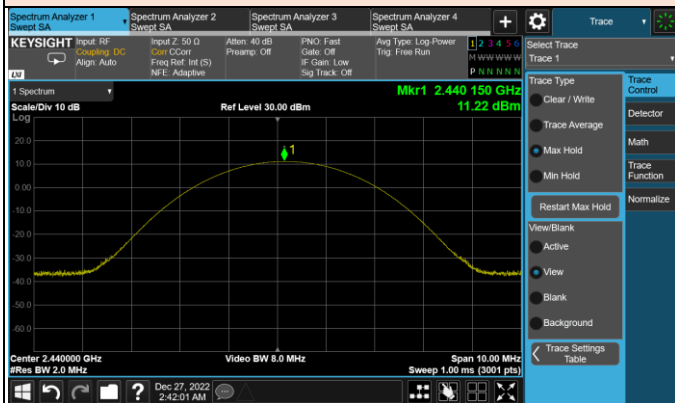


24 V

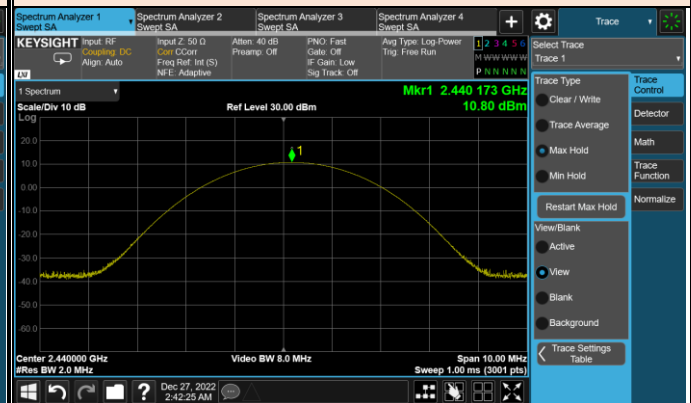
2 402 MHz



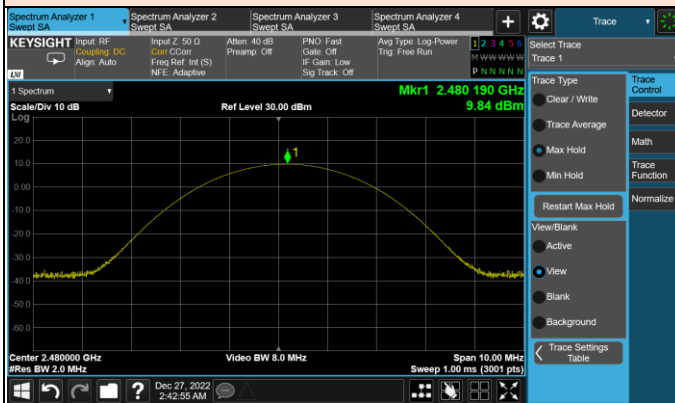
2 440 MHz



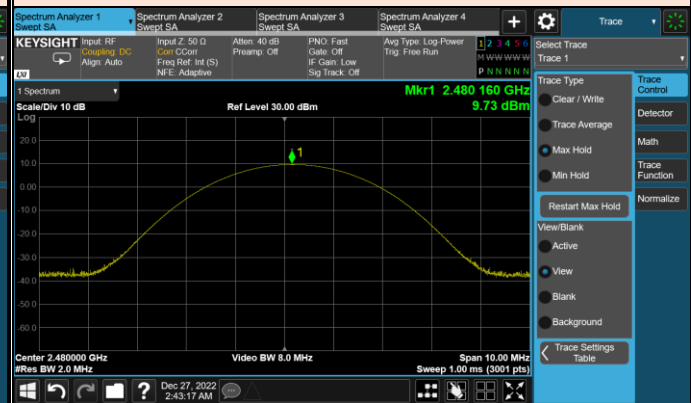
2 440 MHz



2 480 MHz



2 480 MHz



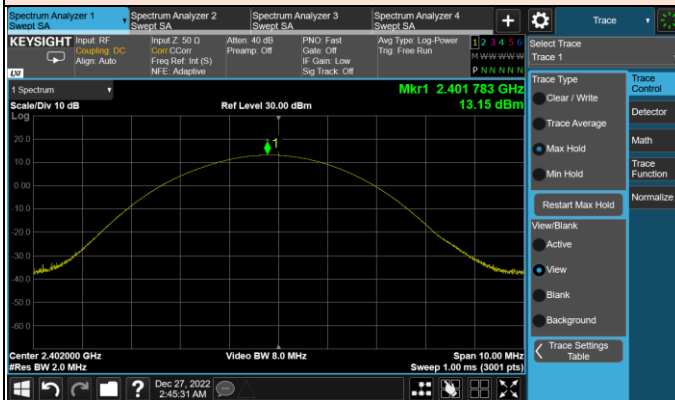


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TM2_2DH5 ($\pi/4$ DQPSK)

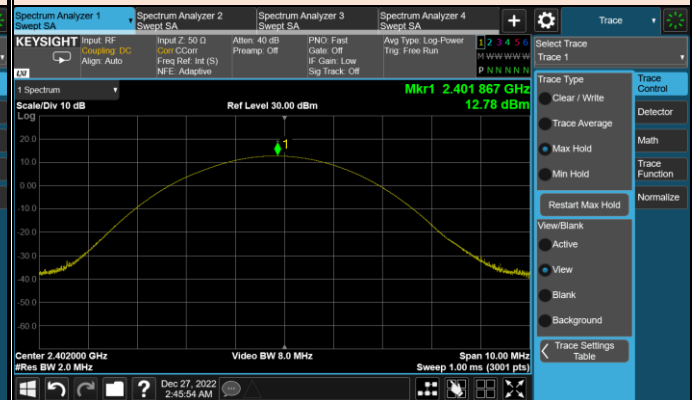
12 V

2 402 MHz

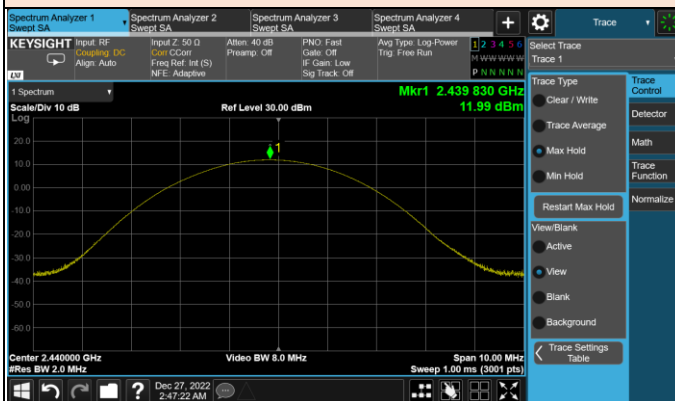


24 V

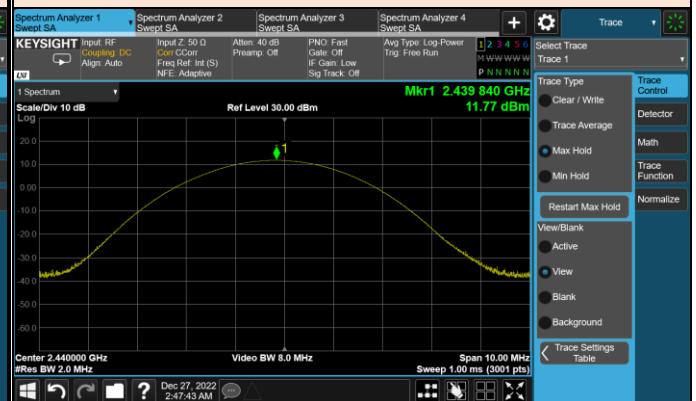
2 402 MHz



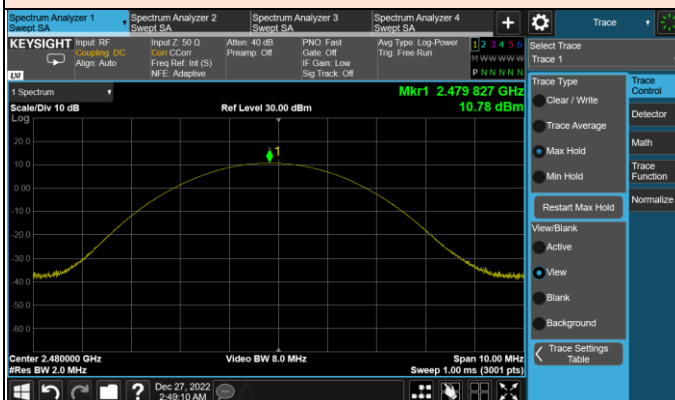
2 440 MHz



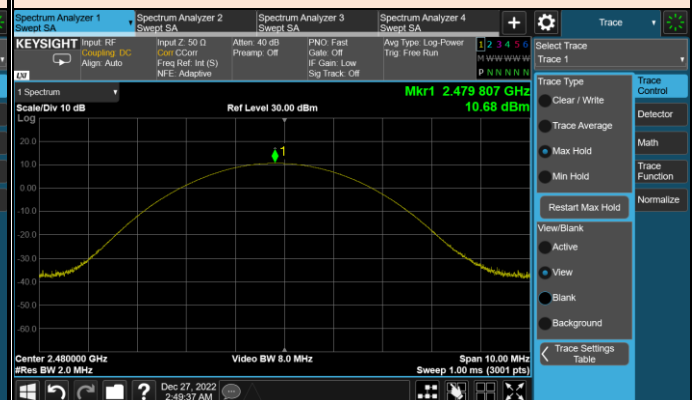
2 440 MHz



2 480 MHz



2 480 MHz



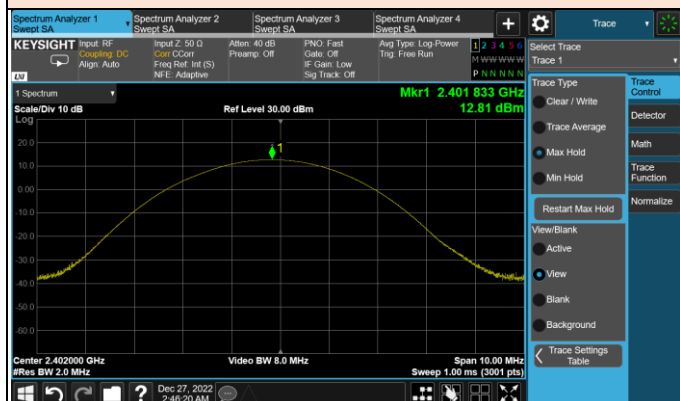


BUREAU
VERITAS

TM3_3DH5 (8DPSK)

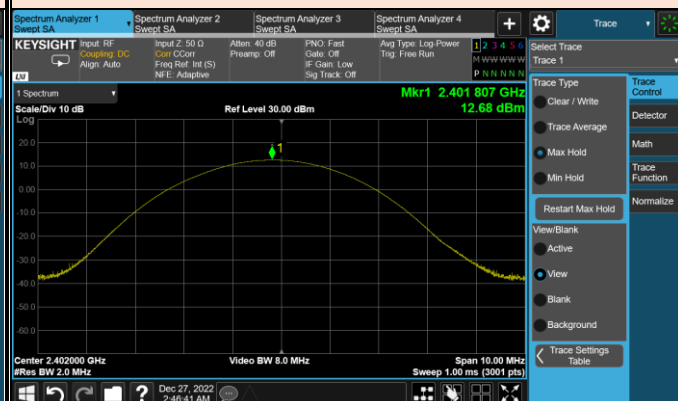
12 V

2 402 MHz

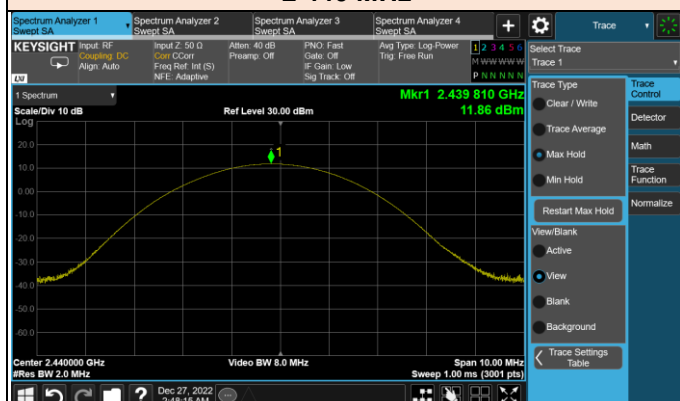


24 V

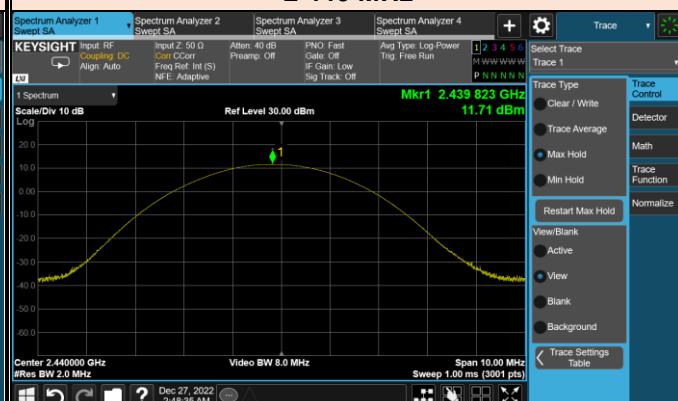
2 402 MHz



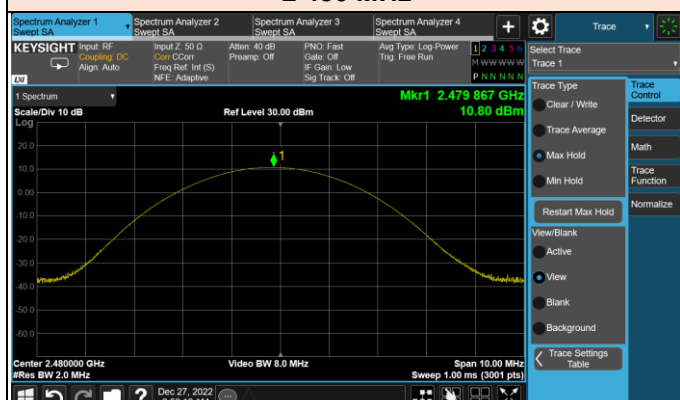
2 440 MHz



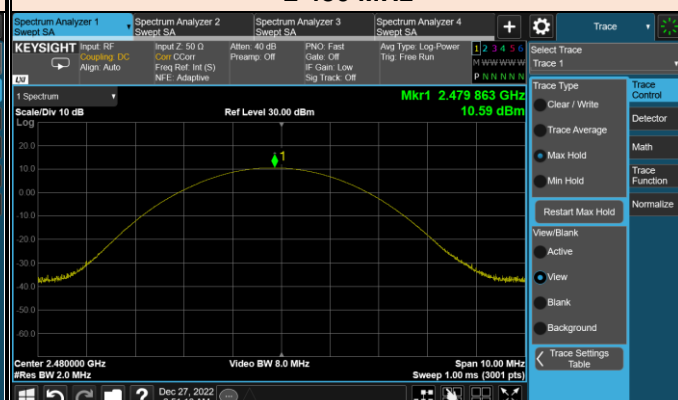
2 440 MHz



2 480 MHz



2 480 MHz



3.4 Carrier Frequency Separation

3.4.1 Regulation

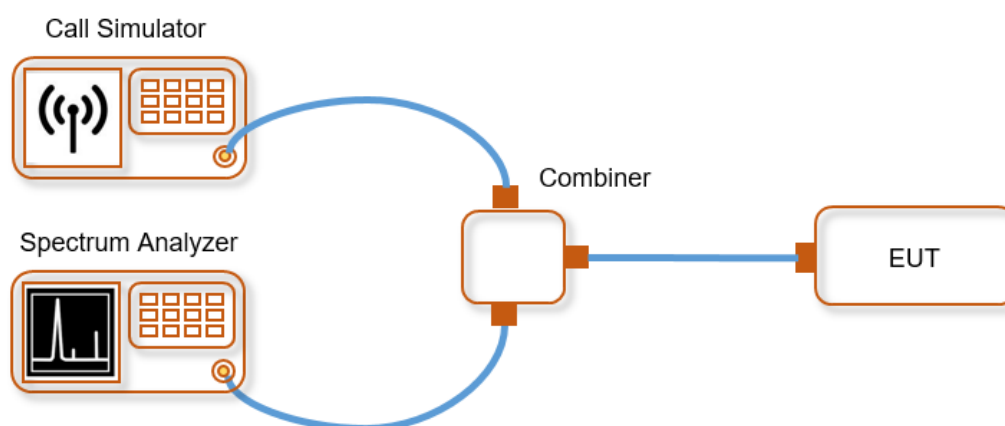
§15.247(a)(1) : Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier 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.

3.4.2 Test Procedure

The method of measurement used to test this FHSS device is ANSI C63.10-2013.

- The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:
- Span: Wide enough to capture the peaks of two adjacent channels.
- RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- Video (or average) bandwidth (VBW) \geq RBW.
- Sweep: Auto.
- Detector function: Peak.
- Trace: Max hold.
- Allow the trace to stabilize.
- Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.

3.4.3 Test Setup



3.4.4 Test Result

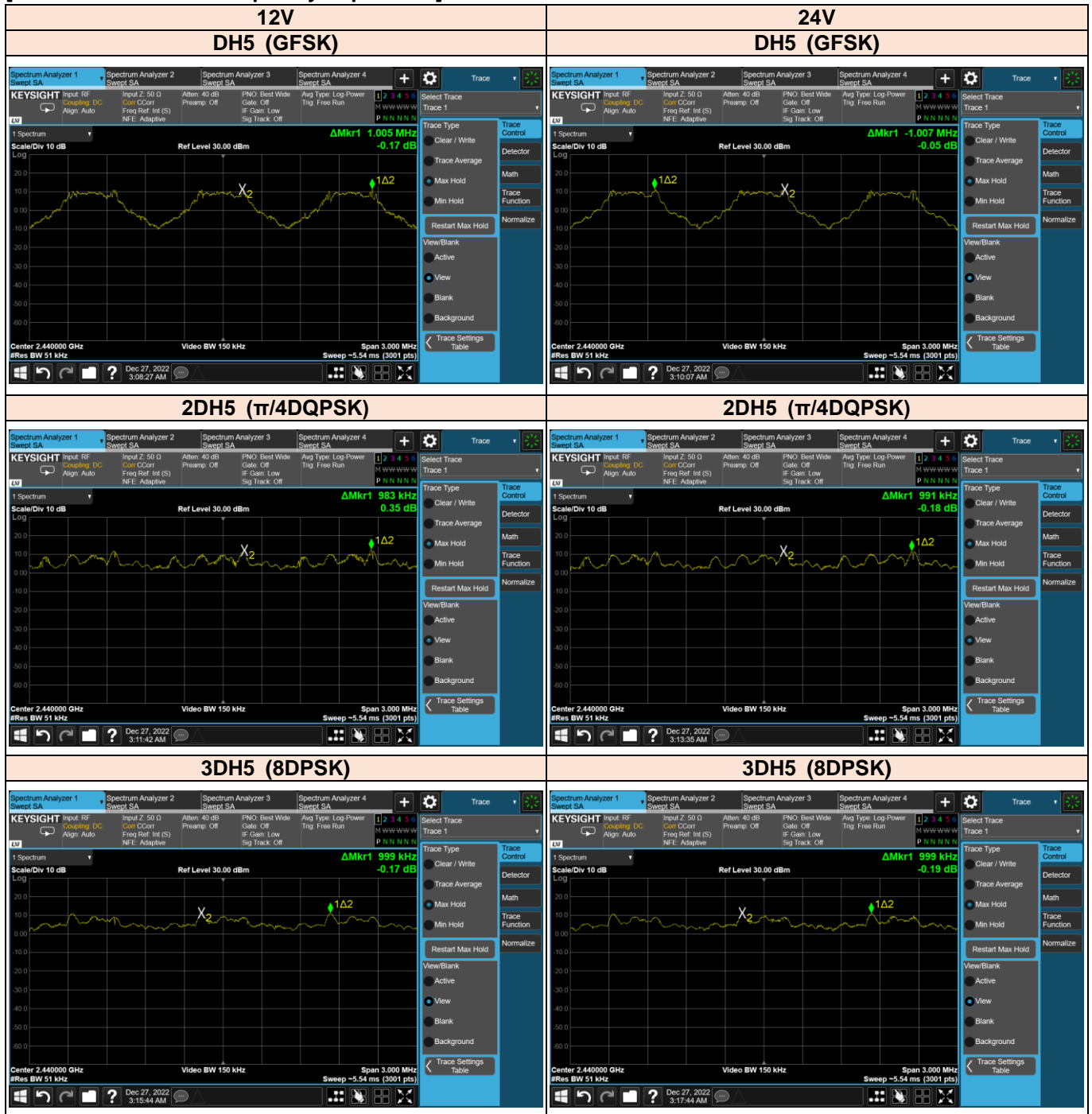
[Test Result of Carrier Frequency Separation]

Limit : ≥ 25 kHz or \geq Two-Thirds of the 20 dB BW whichever is greater

| Test Mode | Tested Frequency | Measured Power [MHz] | |
|-----------|------------------|----------------------|-------|
| | | 12V | 24V |
| TM1 | Hopping | 1.005 | 1.007 |
| TM2 | Hopping | 0.983 | 0.991 |
| TM3 | Hopping | 0.999 | 0.999 |



[Test Plot of Carrier Frequency Separation]



3.5 Number of Hopping Channels

3.5.1 Regulation

§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.

§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.

3.5.2 Test Procedure

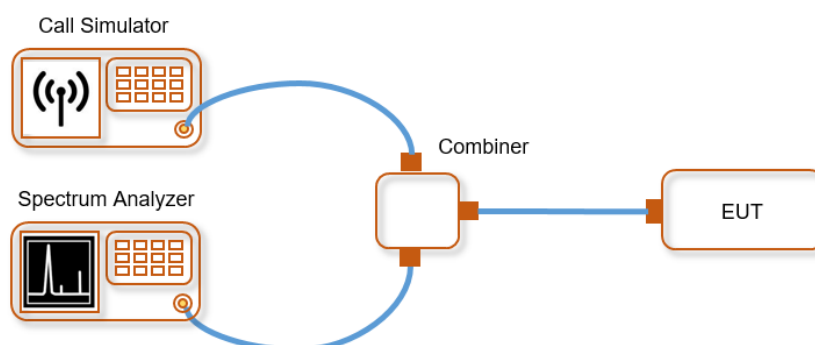
The method of measurement used to test this FHSS device is ANSI C63.10-2013.

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

- a) Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- b) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- c) VBW \geq RBW.
- d) Sweep: Auto.
- e) Detector function: Peak.
- f) Trace: Max hold.
- g) Allow the trace to stabilize.

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies. Compliance of an EUT with the appropriate regulatory limit shall be determined for the number of hopping channels. A plot of the data shall be included in the test report.

3.5.3 Test Setup



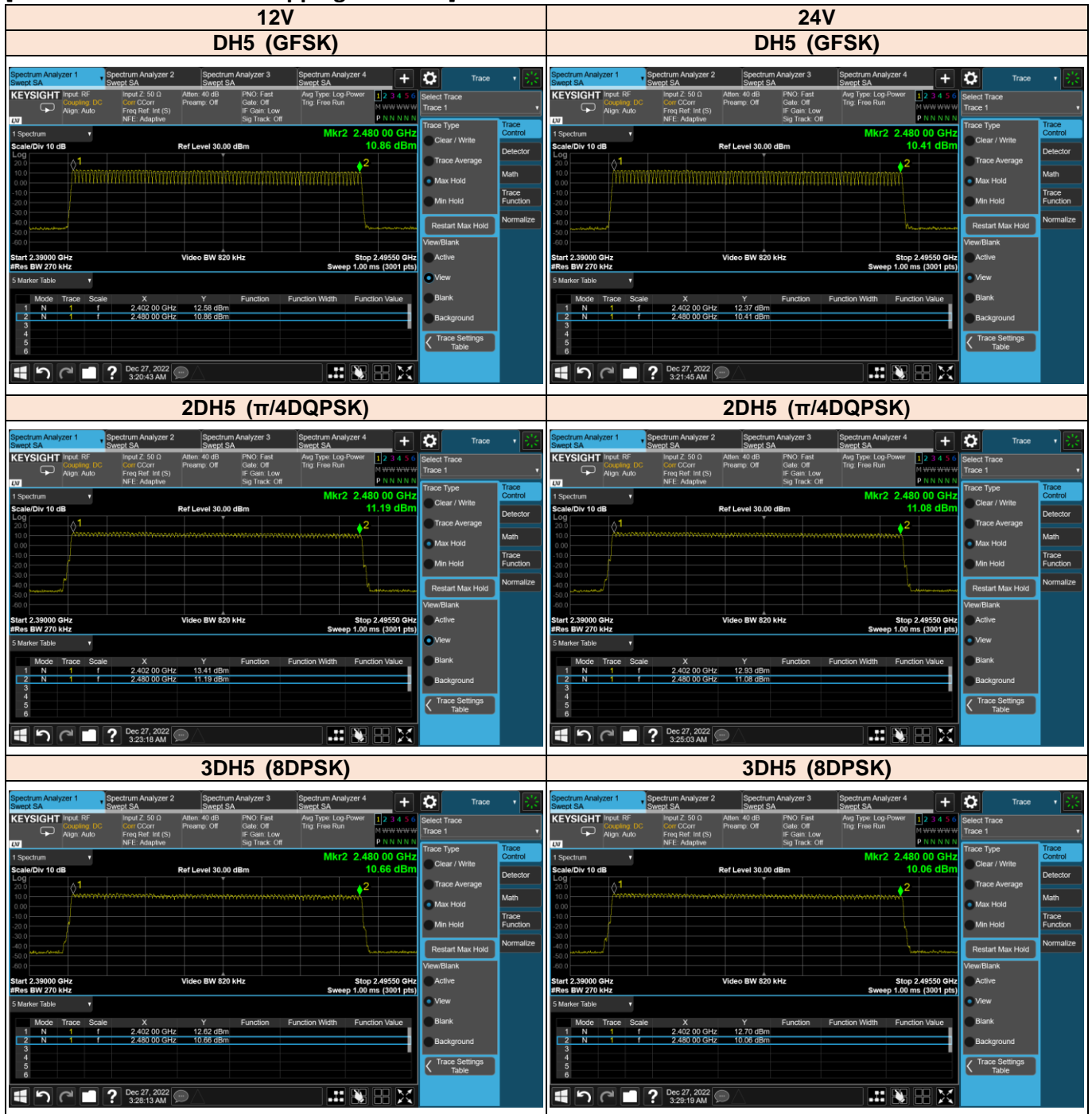
3.5.4 Test Result

[Test Result of Number of Hopping Channels]

Limit : ≥ 15 hops

| Test Mode | Tested Frequency | Test Result (Total hops) | |
|-----------|------------------|--------------------------|-----|
| | | 12V | 24V |
| TM1 | Hopping | 79 | 79 |
| TM2 | Hopping | 79 | 79 |
| TM3 | Hopping | 79 | 79 |

[Test Plot of Number of Hopping Channels]



3.6 Time of Occupancy (Dwell Time)

3.6.1 Regulation

§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.

3.6.2 Test Procedure

The method of measurement used to test this FHSS device is ANSI C63.10-2013.

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

- a) Span: Zero span, centered on a hopping channel.
- b) RBW shall be \leq channel spacing and where possible RBW should be set $\gg 1/T$, where T is the expected dwell time per channel.
- c) Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
- d) Detector function: Peak.
- e) Trace: Max hold.

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

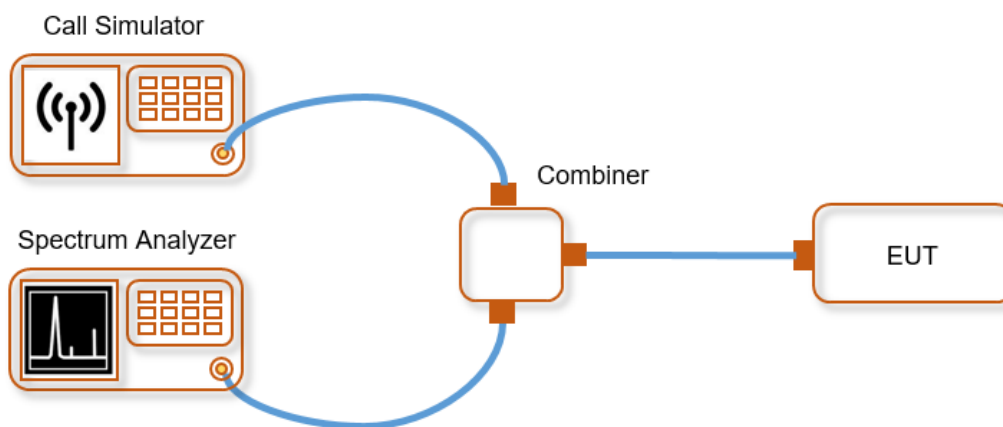
Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

$$\begin{aligned} &(\text{Number of hops in the period specified in the requirements}) = \\ &(\text{number of hops on spectrum analyzer}) \times (\text{period specified in the requirements} / \text{analyzer sweep time}) \end{aligned}$$

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirements. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.

The measured transmit time and time between hops shall be consistent with the values described in the operational description for the EUT.

3.6.3 Test Setup



3.6.4 Test Result

[Test Result of Dwell Time]

| Test Mode | On Time (ms) | Period (ms) | Duty Cycle(X) | Duty Cycle(D) | D.C.C.F [dB] | D.C.F ^{Note1} [dB] | Channels | Dwell Time (s) |
|-----------|--------------|-------------|---------------|---------------|--------------|-----------------------------|----------|----------------|
| TM1 | 2.870 | 3.770 | 0.761 | 76.13 | 1.18 | -24.82 | 79 | 0.306 |
| TM2 | 2.875 | 3.780 | 0.761 | 76.06 | 1.19 | -24.81 | 79 | 0.307 |
| TM3 | 2.885 | 3.790 | 0.761 | 76.12 | 1.18 | -24.78 | 79 | 0.308 |

Note1

D.C.F Calculation. (D.C.F = Duty Cycle Correction Factor)

*Time to cycle through all channels = $\Delta t = T \text{ [ms]} \times 20$ minimum hopping channels , where T = pulse width = On Time

* $100 \text{ ms} / \Delta t \text{ [ms]} = H \rightarrow$ Round up to next highest integer, to account for worst case, $H' = 2$

*The Worst Case Dwell Time = $T \text{ [ms]} \times H'$

*D.C.F = $20 \text{ Log}(\text{The Worst Case Dwell Time} / 100 \text{ ms}) \text{ dB}$

Note2

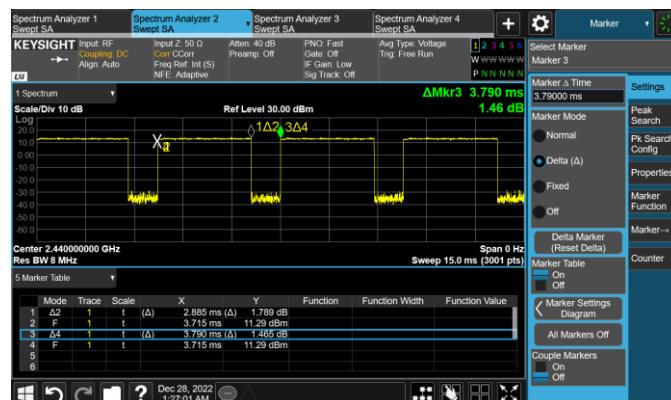
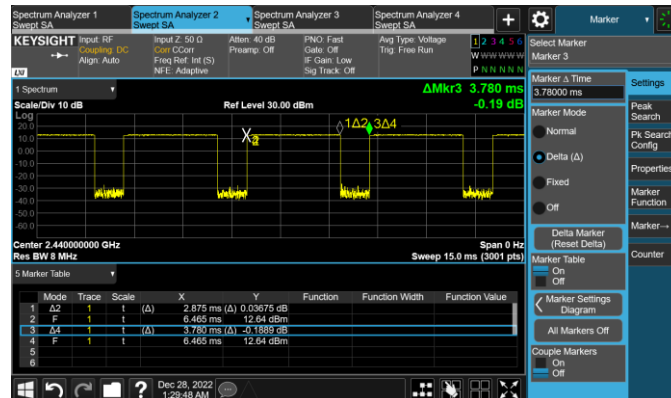
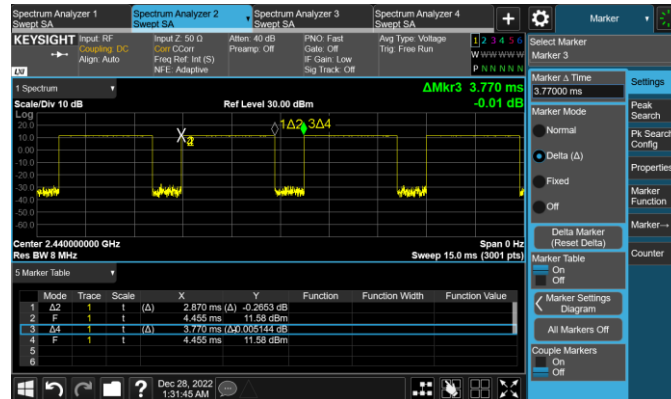
Dwell Time = $0.4 \times \text{Hopping Channels} \times \text{On time} \times ((\text{Hopping rate} / \text{Time slots}) / \text{Hopping channels})$

* Time slots for DH5 = 6 slots (TX = 5 slots , RX = 1 slot)

* Hopping rate = 1 600 for FH Mode

[Test Plot of Dwell Time]

Dwell Time



3.7 Spurious Emission, Band edge and Restricted Bands

3.7.1 Regulation

§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 §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)).

§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 (microvolts/meter) | Measurement distance (meters) |
|-----------------|-----------------------------------|-------------------------------|
| 0.009-0.490 | 2400/F(kHz) | 300 |
| 0.490-1.705 | 24000/F(kHz) | 30 |
| 1.705-30.0 | 30 | 30 |
| 30-88 | 100** | 3 |
| 88-216 | 150** | 3 |
| 216-960 | 200** | 3 |
| Above 960 | 500 | 3 |

**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.

§15.205(a) : Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

| MHz | MHz | MHz | GHz |
|--------------------------|---------------------|---------------|------------------|
| 0.090-0.110 | 16.42-16.423 | 399.9-410 | 4.5-5.15 |
| ¹ 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 | (²) |
| 13.36-13.41 | | | |

¹Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.

²Above 38.6

§15.205 (b) : Except as provided in paragraphs (d) and (e) of this section, 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.

3.7.2 Test Procedure

Band-edge Compliance for RF Conducted Emissions

These procedures are applicable for determining compliance at authorized-band band-edges where the requirements are expressed as a value relative to the in-band signal level. Procedures for determining compliance with field strength limits at or close to the band-edges are given in 6.10.6 (see also Table A.2).

Band-edge tests are typically performed as a conducted test but may be performed as radiated measurements on a test site meeting the specifications in 5.2, at the measurement distances specified in 5.3. The instrumentation shall meet the requirements in 4.1.1 using the bandwidths and detectors specified in 4.1.4.2.

When performing radiated measurements, the measurement antenna(s) shall meet the specifications in 4.3. The EUT shall be connected to an antenna and operated at the highest power settings following procedures in 6.3.

For other than frequency-hopping devices, this test sequence shall be performed once. For devices that support frequency hopping, this test sequence shall be performed twice: once with the hopping function turned OFF and then repeated with the hopping function turned ON. The purpose of the test with the hopping function turned on is to confirm that the RF power remains OFF while the device is changing frequencies, and that the oscillator stabilizes at the new frequency before RF power is turned back ON. Overshoot of any oscillator, including phase-lock-loop stabilized oscillators, can cause the device to be temporarily tuned to frequencies outside the authorized band, and it is important that no transmissions occur during such temporary periods. Particular attention to the hopping sequence requirements specified below is needed in the case of adaptive frequency-hopping devices:

- a) Connect the EMI receiver or spectrum analyzer to the EUT using an appropriate RF cable connected to the EUT output. Configure the spectrum analyzer settings as described in step e) (be sure to enter all losses between the unlicensed wireless device output and the spectrum analyzer).
- b) Set the EUT to the lowest frequency channel (for the hopping on test, the hopping sequence shall include the lowest frequency channel).
- c) Set the EUT to operate at maximum output power and 100% duty cycle, or equivalent “normal mode of operation” as specified in 6.10.3.
- d) If using the radiated method, then use the applicable procedure(s) of 6.4, 6.5, or 6.6, and orient the EUT and measurement antenna positions to produce the highest emission level.
- e) Perform the test as follows:
 - 1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.
 - 2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $[10 \log (OBW/RBW)]$ below the reference level. Specific guidance is given in 4.1.5.2.
 - 3) Attenuation: Auto (at least 10 dB preferred).
 - 4) Sweep time: Coupled.
 - 5) Resolution bandwidth: 100 kHz.
 - 6) Video bandwidth: 300 kHz.
 - 7) Detector: Peak.
 - 8) Trace: Max hold.
- f) Allow the trace to stabilize. For the test with the hopping function turned ON, this can take several minutes to achieve a reasonable probability of intercepting any emissions due to oscillator overshoot.

- g) 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.
- h) Repeat step c) through step e) for every applicable modulation.
- i) Set the EUT to the highest frequency channel (for the hopping on test, the hopping sequence shall include the highest frequency channel) and repeat step c) through step d).
- j) The band-edge measurement shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

Spurious RF Conducted Emissions

Conducted spurious emissions shall be measured for the transmit frequency, per 5.5 and 5.6, and at the maximum transmit powers.

Connect the primary antenna port through an attenuator to the spectrum analyzer input; in the results, account for all losses between the unlicensed wireless device output and the spectrum analyzer. The instrument shall span 30 MHz to 10 times the operating frequency in GHz, with a resolution bandwidth of 100 kHz, video bandwidth of 300 kHz, and a coupled sweep time with a peak detector. The band 30 MHz to the highest frequency may be split into smaller spans, as long as the entire spectrum is covered.

Spurious Radiated Emissions

1. The preliminary radiated measurement were performed to determine the frequency producing the maximum emissions in an semi-anechoic chamber at a distance of 3 meters.
2. The EUT was placed on the top of the 0.8-meter height, 1 x 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 Bi-Log 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 x 4 meter in an semi-anechoic chamber. 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 fuction with specified bandwidth.
6. The 0.8 m height is for below 1 GHz testing, and 1.5 m is for above 1GHz testing.

- Procedure for unwanted emissions measurements below 1 000 MHz

The procedure for unwanted emissions measurements below 1 000 MHz is as follows:

- a) Follow the requirements in 12.7.4.
- b) Compliance shall be determined using CISPR quasi-peak detection; however, peak detection is permitted as an alternative to quasi-peak detection.

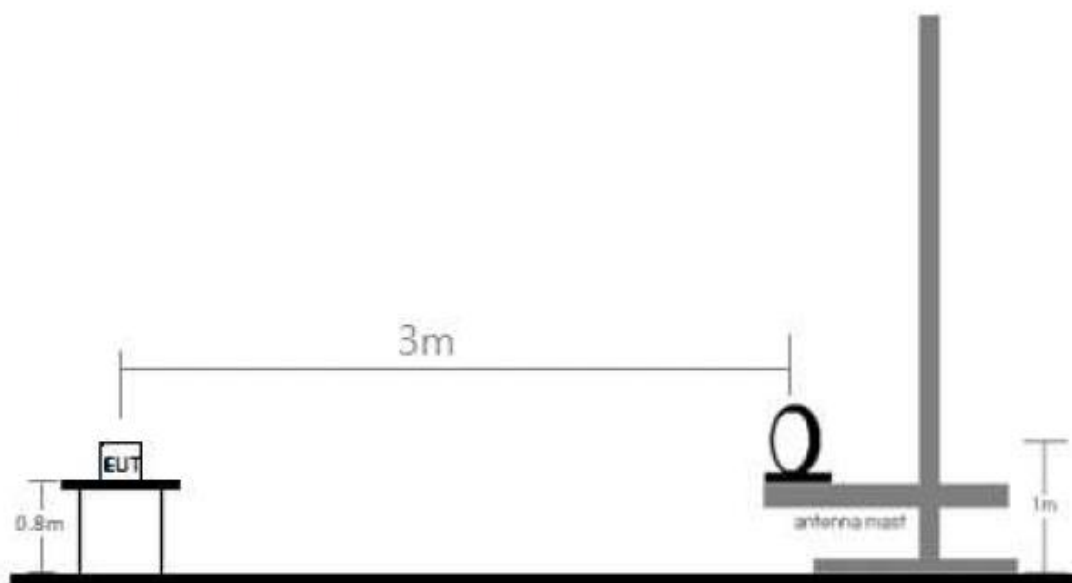
- Procedure for peak unwanted emissions measurements above 1 000 MHz

- a) The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection and frequency above 1 GHz.
- b) The result of Average measurement is calculated using PK result and duty correction factor

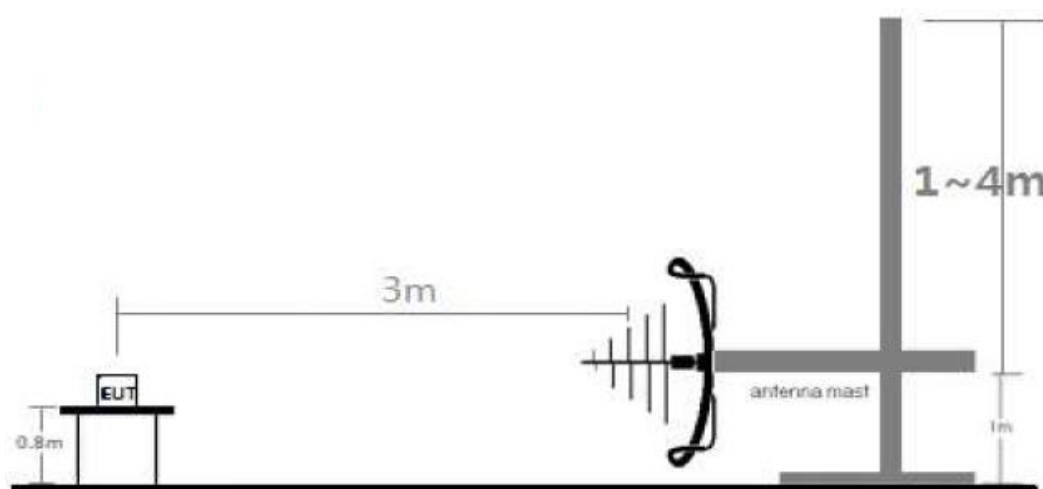
- Sample Calculation

- Field Strength Level [dB μ V/m] = Analyzer Level [dBm] + 107 + AFCL [dB/m] + Duty Cycle Correction [dB]
- AFCL [dB/m] = Antenna Factor [dB/m] + Cable loss [dB]
- Margin [dB] = Field Strength Level [dB μ V/m] – Limit [dB μ V/m]

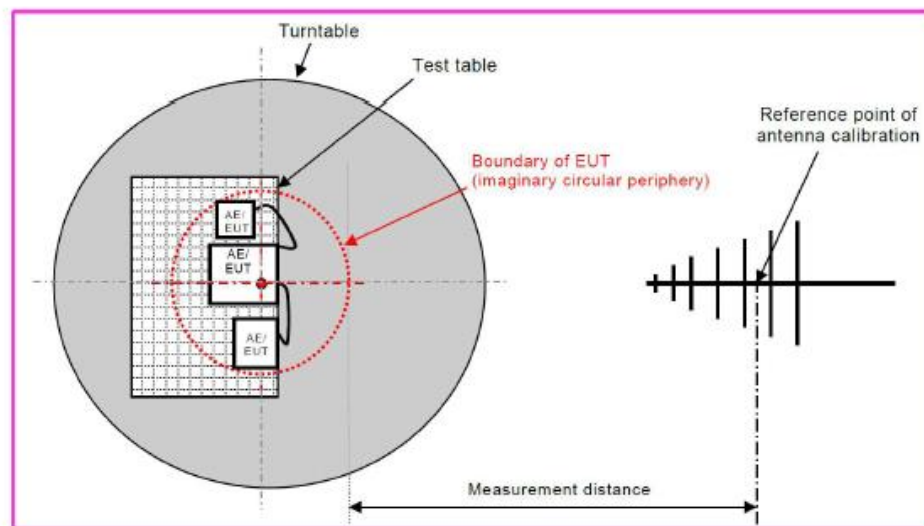
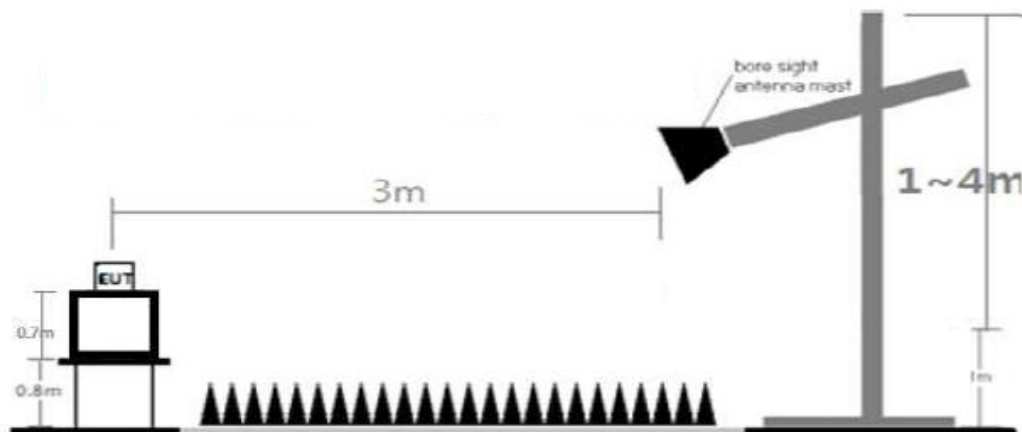
3.7.3 Test Setup



[Radiated Emission Test Setup Below 30 MHz]

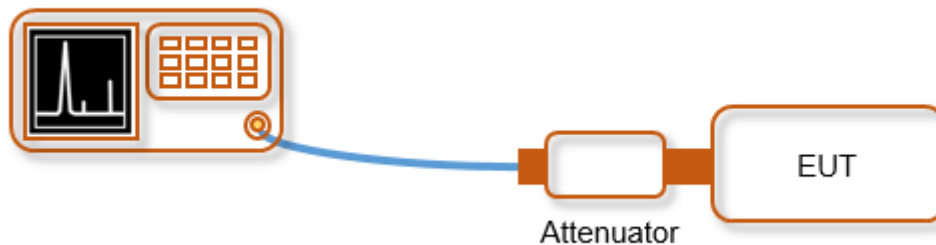


[Radiated Emission Test Setup Below 1 GHz]



[Radiated Emission Test Setup Above 1 GHz]

Spectrum Analyzer



[Conducted Spurious Emission]

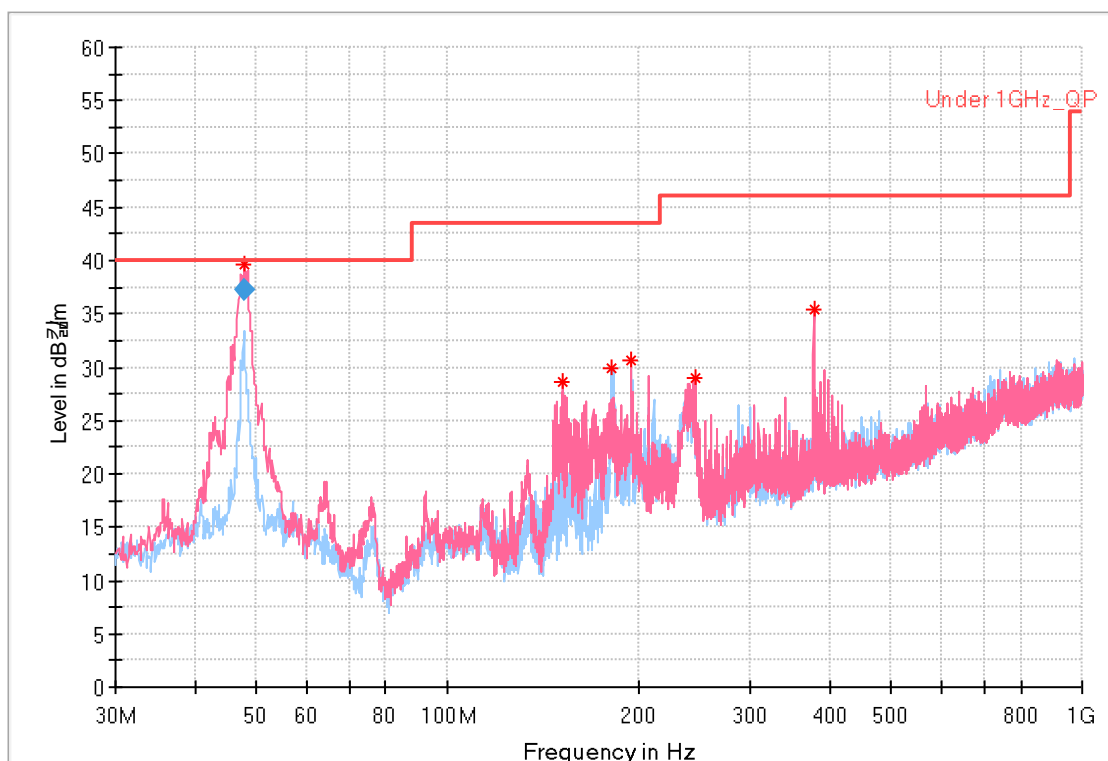
3.7.4 Test Result of Radiated Spurious Emission

Remarks

1. Quasi Peak(dBμV/m) = Quasi Peak Reading Value(dBμV/m) + Correction Factor(dB)
2. Total Factor(dB) = T.F (dB) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin(dB) = (Quasi Peak) Result (dBμV/m) – (Quasi Peak) Limit (dBμV/m)
4. Measurement Distance = 3 m.
6. DCCF = Duty Cycle Correction Factor.
7. No other spurious and harmonic emissions were found greater than listed emissions on above table

3.7.4.1 Radiated Emissions (Below 1 GHz)

Worst case - RSE(Below 1 GHz)_2DH5 / π/4DQPSK



| Tested Frequency [MHz] | Frequency [MHz] | Reading Value [dBμV] | Pol [H/V] | EUT Axis | Detector Mode | T.F [dB] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|------------------------|-----------------|----------------------|-----------|----------|---------------|----------|-----------------|----------------|-------------|
| 2402 | 47.95 | 57.79 | V | X | Peak | - 18.10 | 39.69 | 40.00 | 0.31 |
| | 47.95 | 55.31 | V | X | Quasi Peak | - 18.10 | 37.21 | 40.00 | 2.79 |
| | 152.03 | 52.69 | V | X | Peak | - 24.00 | 28.69 | 43.52 | 14.83 |
| | 181.61 | 52.38 | H | X | Peak | - 22.50 | 29.88 | 43.52 | 13.64 |
| | 195.00 | 51.05 | V | X | Peak | - 20.40 | 30.65 | 43.52 | 12.87 |
| | 245.92 | 47.87 | V | X | Peak | - 18.90 | 28.97 | 46.02 | 17.05 |
| | 377.65 | 51.09 | V | X | Peak | - 15.70 | 35.39 | 46.02 | 10.63 |