

Certificate of Test

NCT CO., LTD.

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Republic of Korea
(Tel: +82-31-323-6070 / Fax: +82-31-323-6071)

Report No.:
NW2201-F001

Page (1) / (61)

**1. Client**

- Name : SENA TECHNOLOGIES.Inc
- Address : 19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, Korea
- Date of Receipt : 2021-11-09

2. Use of Report : FCC & IC Approval**3. Test Sample**

- Description / Model : R1M / SP107
- FCC ID : S7A-SP107 / IC : 8154A-SP107

4. Place of Test : ☒ Fixed test ☐ Field test

(Address: 211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Republic of Korea)

5. Date of Test : 2021-11-26 ~ 2021-12-23**6. Test method used : FCC Part 15 Subpart C 15.247**

RSS-247 Issue 2(2017-02), RSS-GEN Issue 5(2019-03)

7. Testing Environment :

- Temperature: (25 ± 5) °C, Humidity: Less than 75 % R.H.

* Unless specified otherwise in the individual methods, the tests were conducted on ambient conditions.

8. Test Results : Refer to the test results

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.

This Test Report cannot be reproduced, except in full

This test report is not related to KOLAS recognition and RRA designation.

Affirmation	Tested by Jun-gi Sin	Technical Manager Changmin, Kim
-------------	--------------------------------	---

Jan 04, 2022

NCT CO., LTD.



Contact us at report@nct.re.kr to confirm the authenticity of this report

Table of contents

1. General Information	3
2. Information's about Test Item	3
3. Test Report	5
3.1 Test Summary	5
3.2 Test Report Version	6
3.3 Transmitter Requirements	
3.3.1 Antenna Requirement	7
3.3.2 20 dB Bandwidth & Occupied Bandwidth (99%)	8
3.3.3 Number of Hopping Frequencies	15
3.3.4 Time of Occupancy (Dwell Time)	18
3.3.5 Carrier Frequencies Separation	20
3.3.6 Peak Output Power	24
3.3.7 TX Radiated Spurious Emission and Conducted Spurious Emission	31
3.3.8 Conducted Emission	53

APPENDIX

APPENDIX I TEST SETUP	56
APPENDIX II TEST EQUIPMENT USED FOR TESTS	58
APPENDIX III UNCERTAIN	60

Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

1. General Information's

1.1 Test Performed

Laboratory : NCT Co., Ltd.
Address : 211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Korea
Telephone : +82-31-323-6070
Facsimile : +82-31-323-6071
FCC Designation No. : KR0166
FCC Registration No. : 409631
IC Site Registration No. : 25897

2. Information's about Test Item

2.1 Applicant Information

Company name : SENA TECHNOLOGIES.Inc
Address : 19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, Korea
Telephone / Facsimile : +82-2-571-8283 / +82-2-573-7710

2.2 Equipment Under Test (EUT) description

Test item particulars : R1M
Model and/or type reference : SP107
Additional model name : -
Serial number : Prototype
Antenna type and gain : Chip Antenna(M/N:SENA_009) with Max gain: 0.5 dBi
Date (s) of performance of tests: : 2021-11-26 ~ 2021-12-23
Date of receipt of test item : 2021-11-09
EUT condition : Pre-production, not damaged
Number of channel : 79
EUT Power Source : DC 3.8 V
Type of Modulation : BDR Mode(GFSK), EDR Mode(Pi/4 DQPSK, 8DPSK)
Firmware version : 1.0
Hardware version : 1.0
Test software name(version) : AB1565/68 Lab Test Tool-2.3.10

Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

2.3 Tested Frequency

Test Mode	Test frequency (MHz)		
	Low frequency	Middle frequency	High frequency
GFSK	2 402	2 441	2 480
Pi/4 DQPSK	2 402	2 441	2 480
8DPSK	2 402	2 441	2 480

2.4 Used Test Software Setting Value

Test Mode	Setting Item
	Power
GFSK	57
Pi/4 DQPSK	58
8DPSK	58

2.5 Worst-Case

BDR	GFSK(DH5)
EDR	8DPSK(3-DH5)

Note: The power measurement has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates.

3. Test Report

3.1 Test Summary

Applied	FCC Rule	IC Rule	Test Items	Test Condition	Result
☒	15.203	-	Antenna Requirement	Conducted	C
☒	15.247(a)	-	20 dB Bandwidth		C
☒	-	RSS GEN (6.7)	Occupied Bandwidth (99%)		C
☒	15.247(a)	RSS-247 (5.1)	Number of Hopping Frequencies		C
☒	15.247(a)	RSS-247 (5.1)	Time of Occupancy (Dwell Time)		C
☒	15.247(a)	RSS-247 (5.1)	Carrier Frequencies Separation		C
☒	15.247(b)	RSS-247 (5.4)	Peak Output Power		C
☒	15.247(d)	RSS-247 (5.5)	Conducted Spurious Emission		C
☒	15.247(d) 15.205 & 15.209	RSS-GEN (8.9 & 8.10)	Radiated Spurious Emission	Radiated	C
☒	15.207	RSS-GEN (8.8)	Conducted Emissions	AC Line Conducted	C

Note 1: C=Complies NC=Not Complies NT=Not Tested NA=Not Applicable

The sample was tested according to the following specification: ANSI C63.10:2013.

Compliance was determined by specification limits of the applicable standard according to customer requirements.

Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.2 Test Report Version

Test Report No.	Date	Description
NW2201-F001	2022-01-04	Initial issue

Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3 Transmitter Requirements

3.3.1 Antenna Requirement

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

According to §15.247(b)(4) e 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.

3.3.1.1 Result

Complies

(The transmitter has a Chip Antenna. The directional peak gain of the antenna is 0.5 dBi.)

3.3.2 20 dB Bandwidth & Occupied Bandwidth (99%)

3.3.2.1 Test Setup

Refer to the APPENDIX I.

3.3.2.2 Limit

Limit : Not Applicable

3.3.2.3 Test Procedure

1. 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.
2. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using below setting:
 RBW = 1% to 5% of the 20 dB Bandwidth & Occupied Bandwidth
 VBW $\geq 3 \times$ RBW
 Span = between two times and five times the 20 dB Bandwidth & Occupied Bandwidth
 Sweep = Auto
 Detector function = Peak
 Trace = Max Hold

3.3.2.4 Test Result

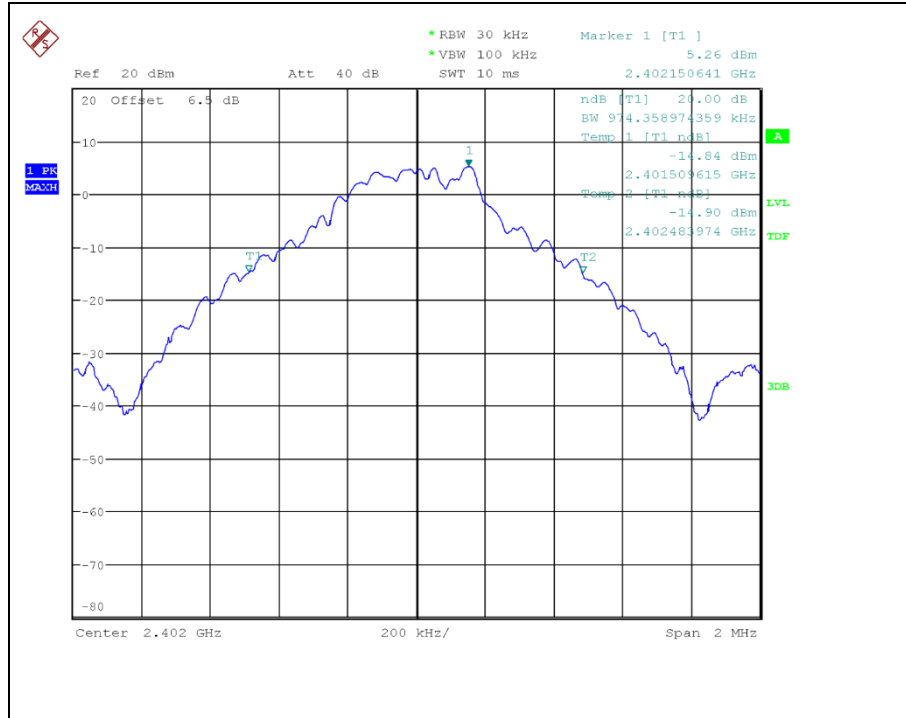
Test Mode	Test Frequency	20 dB Bandwidth (MHz)	Occupied Bandwidth (MHz)
GFSK	Low	0.974	0.891
	Middle	0.978	0.891
	High	0.978	0.888
8DPSK	Low	1.286	1.160
	Middle	1.286	1.160
	High	1.282	1.160

Test Repot No.: NW2201-F001

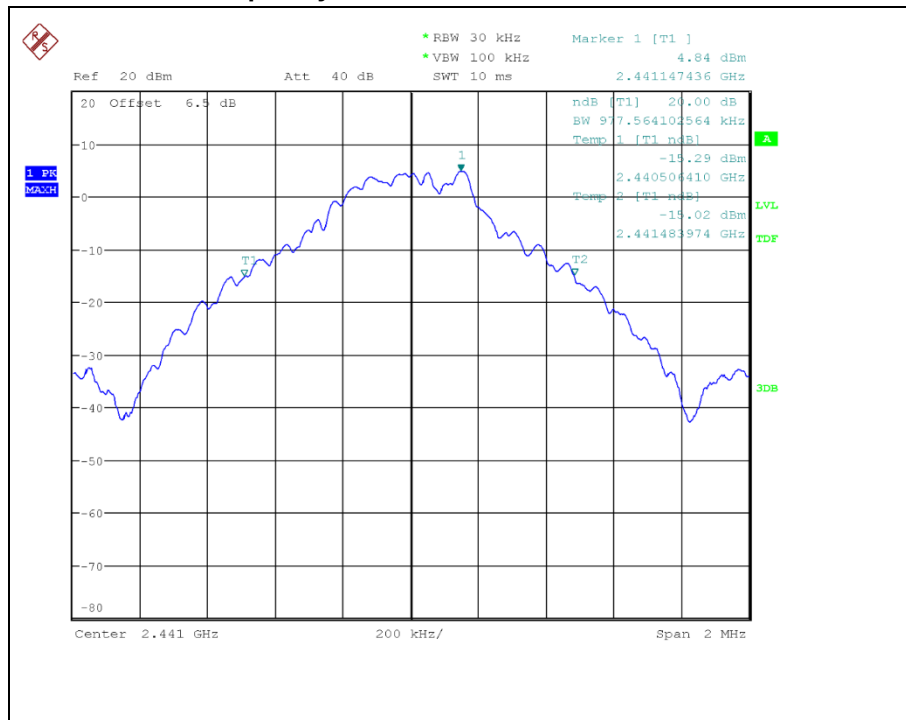
211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
 www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3.2.5 Test Plot

GFSK _ Low frequency **20 dB Bandwidth**



GFSK _ Middle frequency **20 dB Bandwidth**

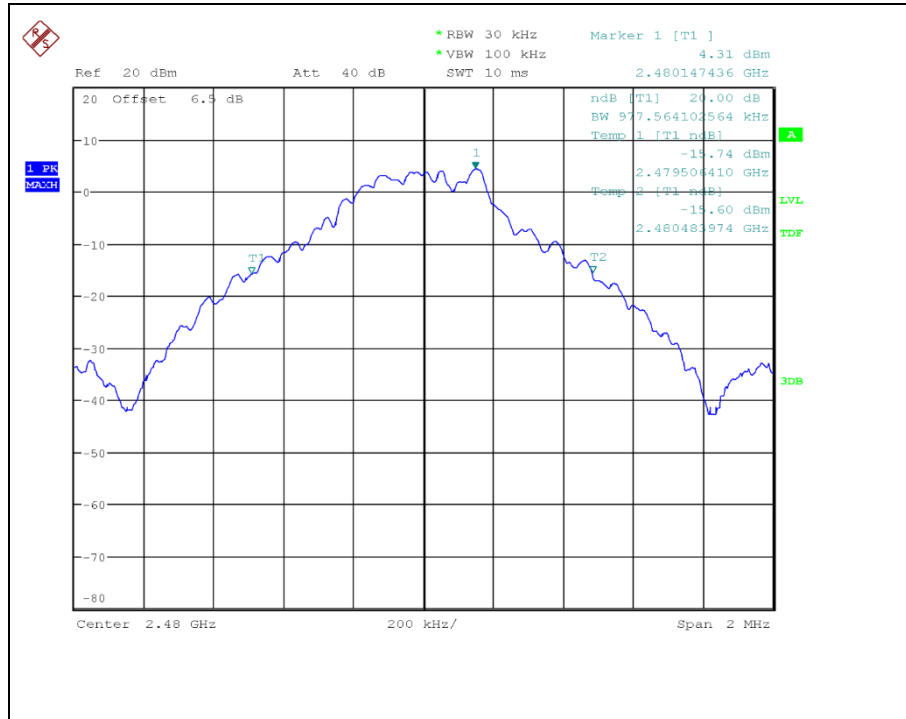


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

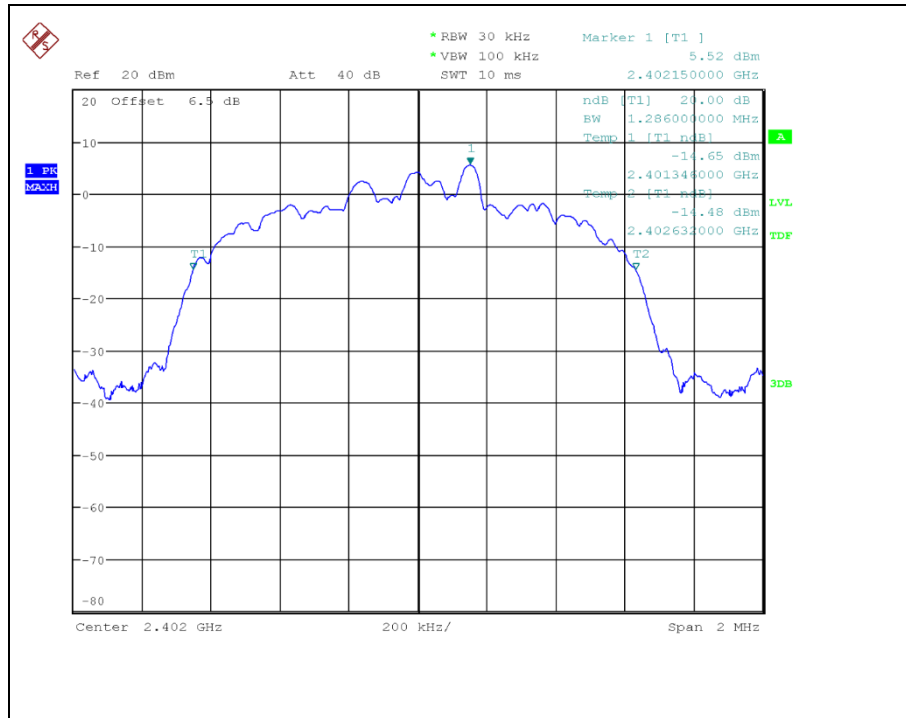
GFSK _ High frequency

20 dB Bandwidth



8DPSK _ Low frequency

20 dB Bandwidth

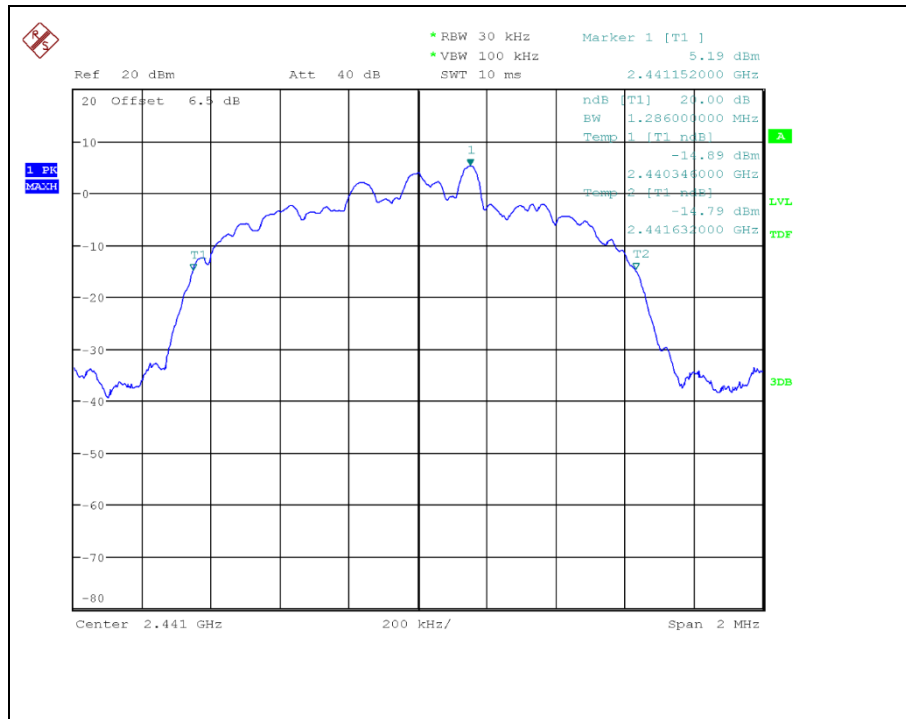


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

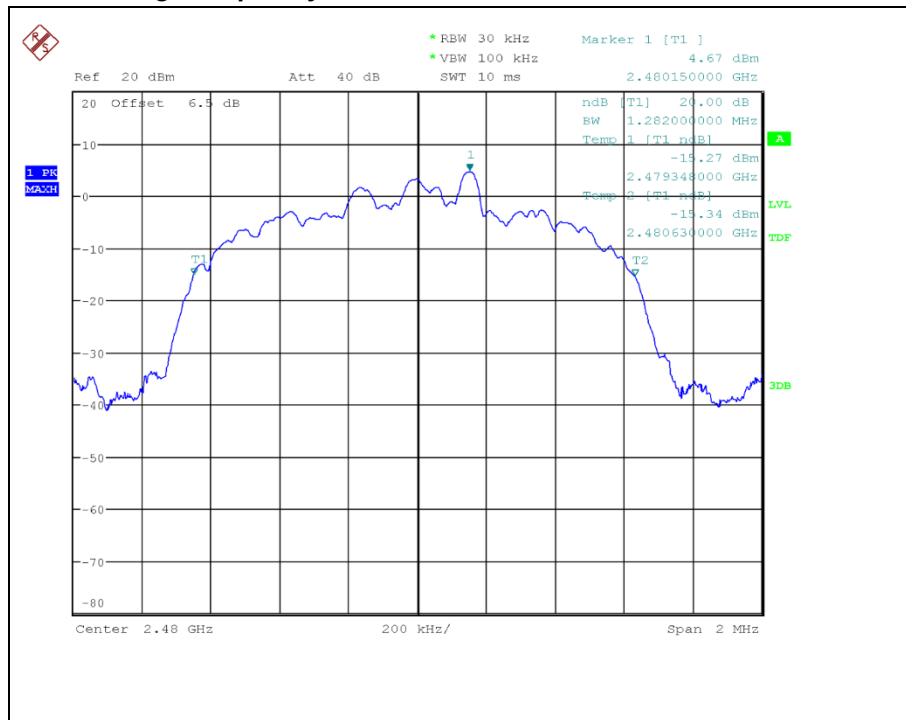
8DPSK _ Middle frequency

20 dB Bandwidth



8DPSK _ High frequency

20 dB Bandwidth

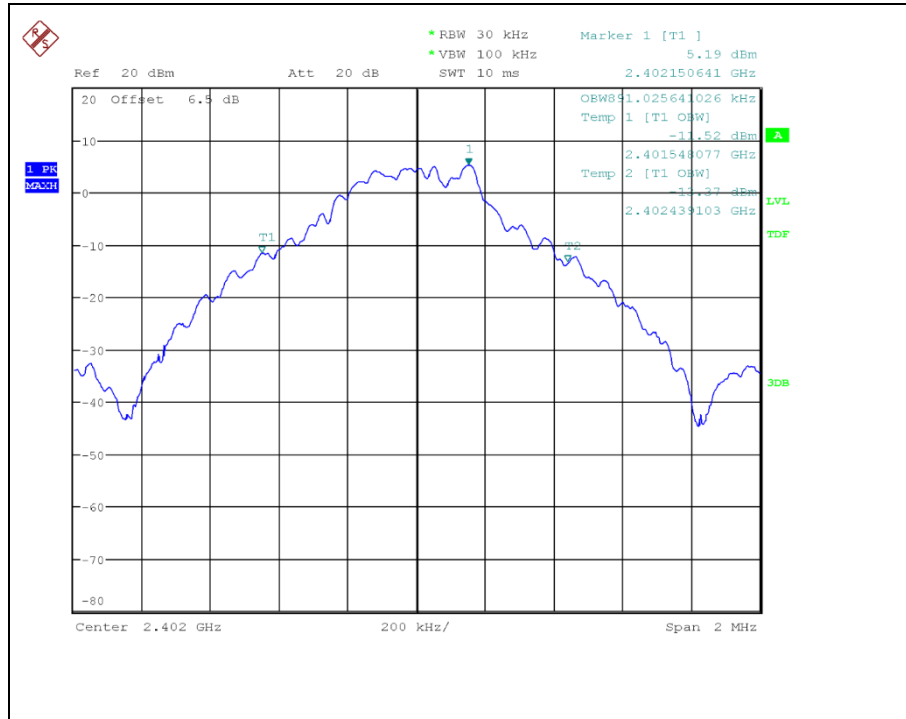


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

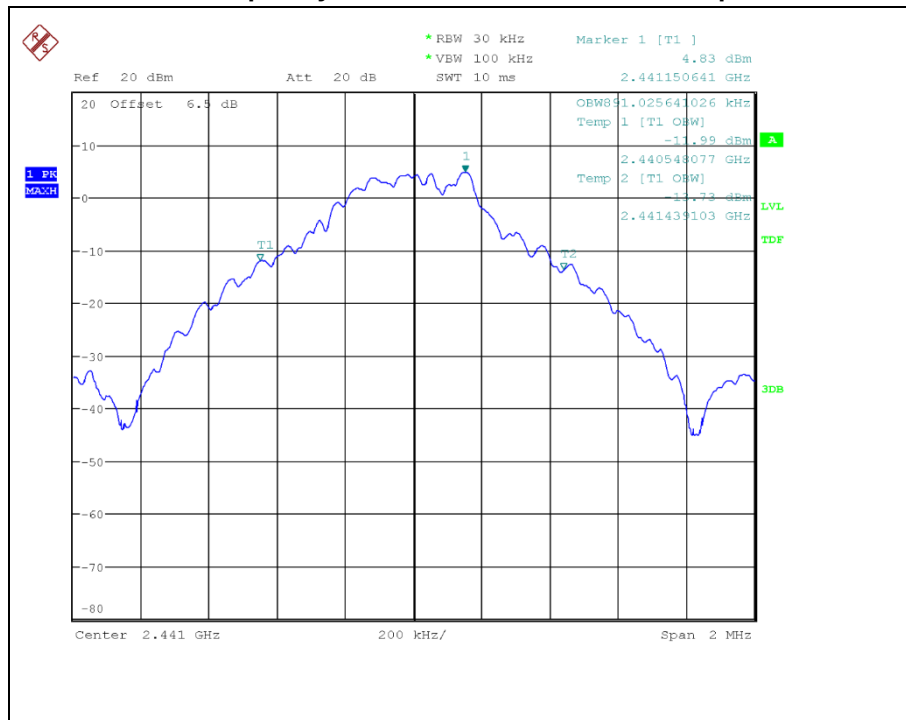
GFSK _ Low frequency

Occupied Bandwidth



GFSK _ Middle frequency

Occupied Bandwidth

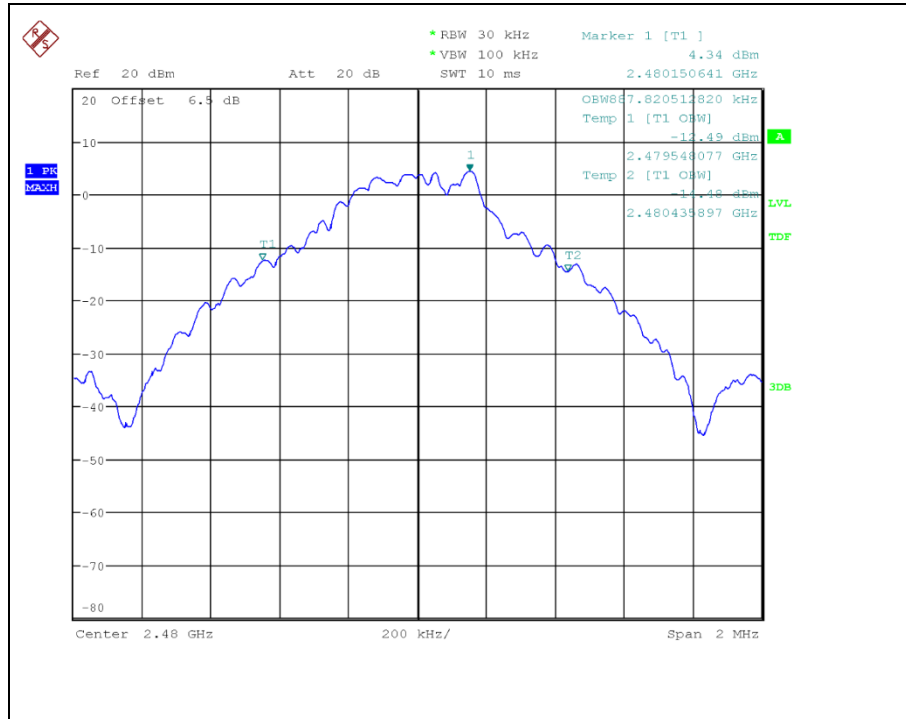


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

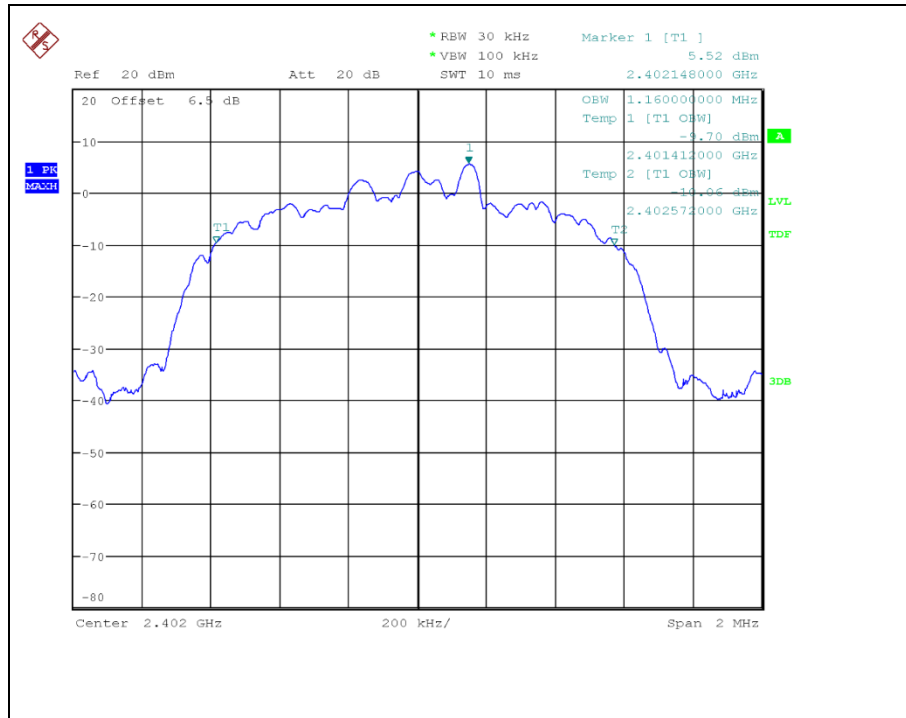
GFSK _ High frequency

Occupied Bandwidth



8DPSK _ Low frequency

Occupied Bandwidth

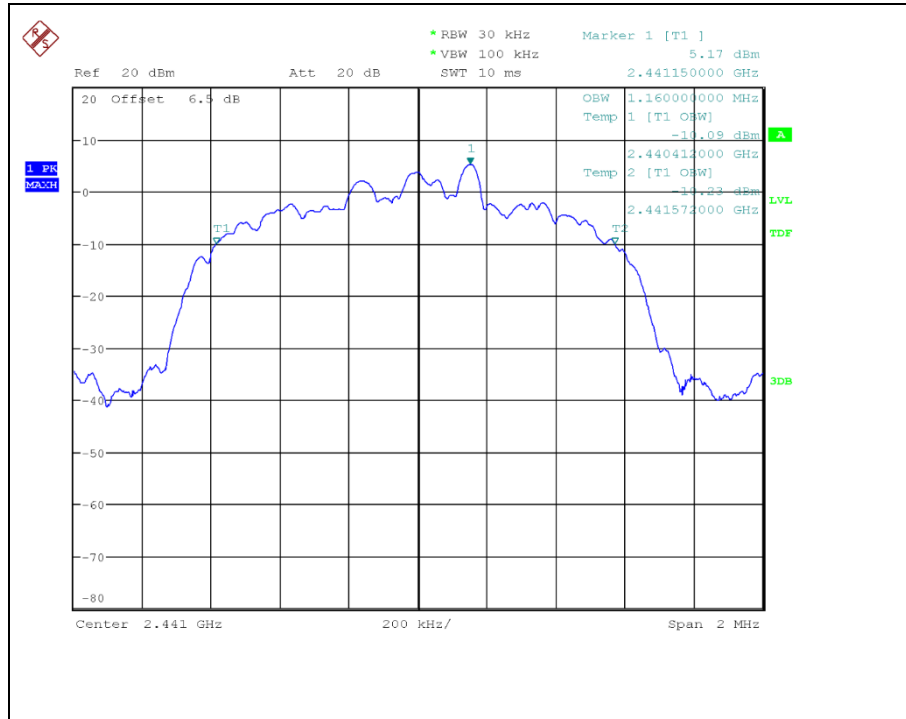


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

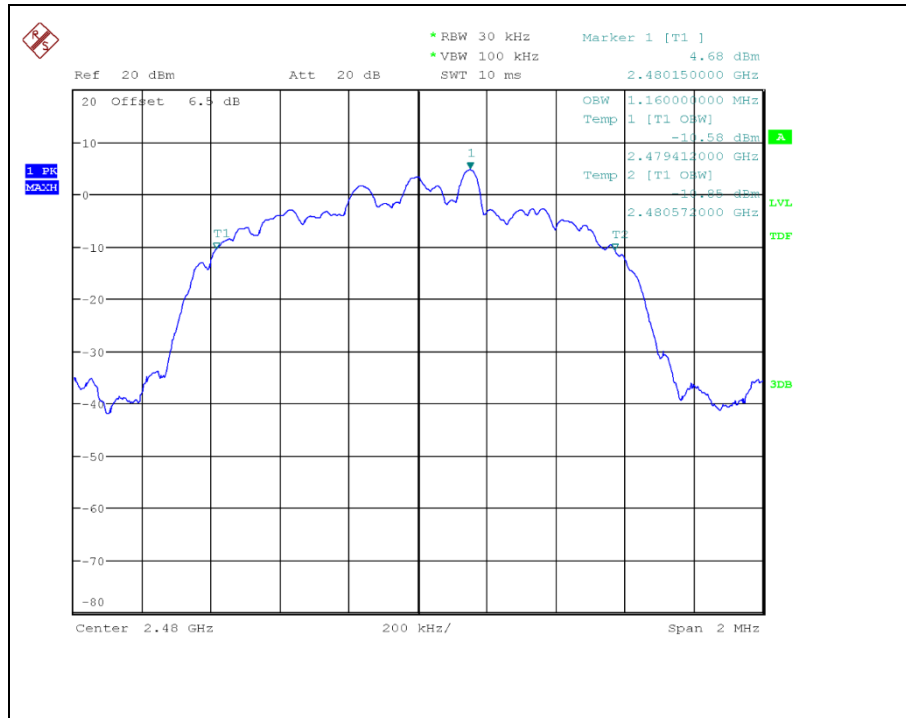
8DPSK _ Middle frequency

Occupied Bandwidth



8DPSK _ High frequency

Occupied Bandwidth



Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3.3 Number of Hopping Frequencies

3.3.3.1 Test Setup

Refer to the APPENDIX I.

3.3.3.2 Limit

Limit : ≥ 15 hops

3.3.3.3 Test Procedure

The number of hopping frequencies was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.

To get higher resolution, two frequency ranges for FH mode within the 2400 ~ 2483.5 MHz were examined.

The spectrum analyzer is set to:

Span = 50 MHz

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.

VBW $\geq$ RBW

Detector = Peak

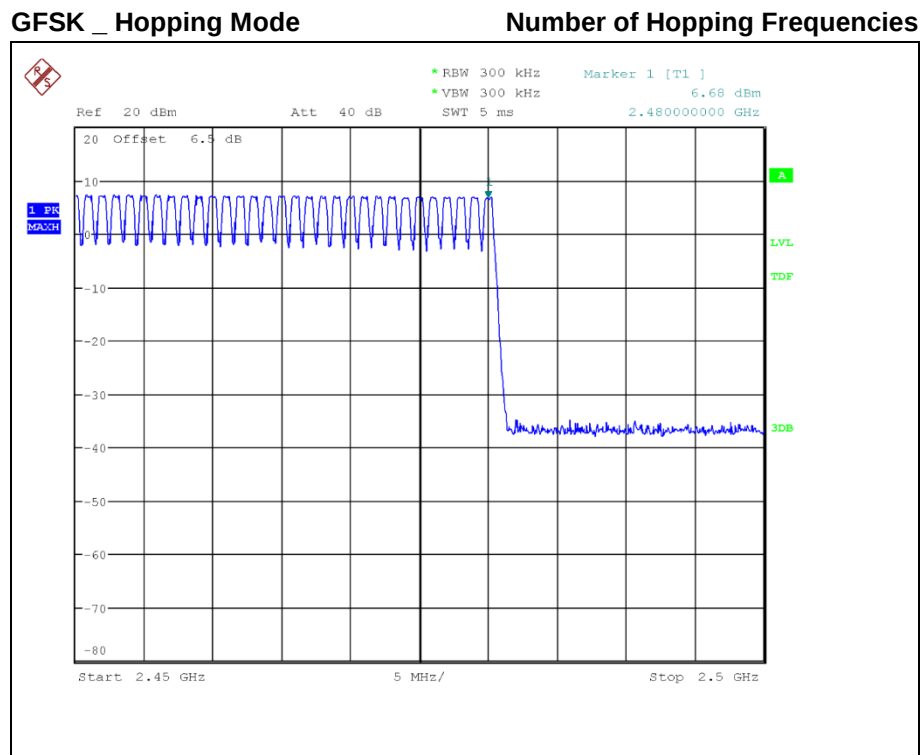
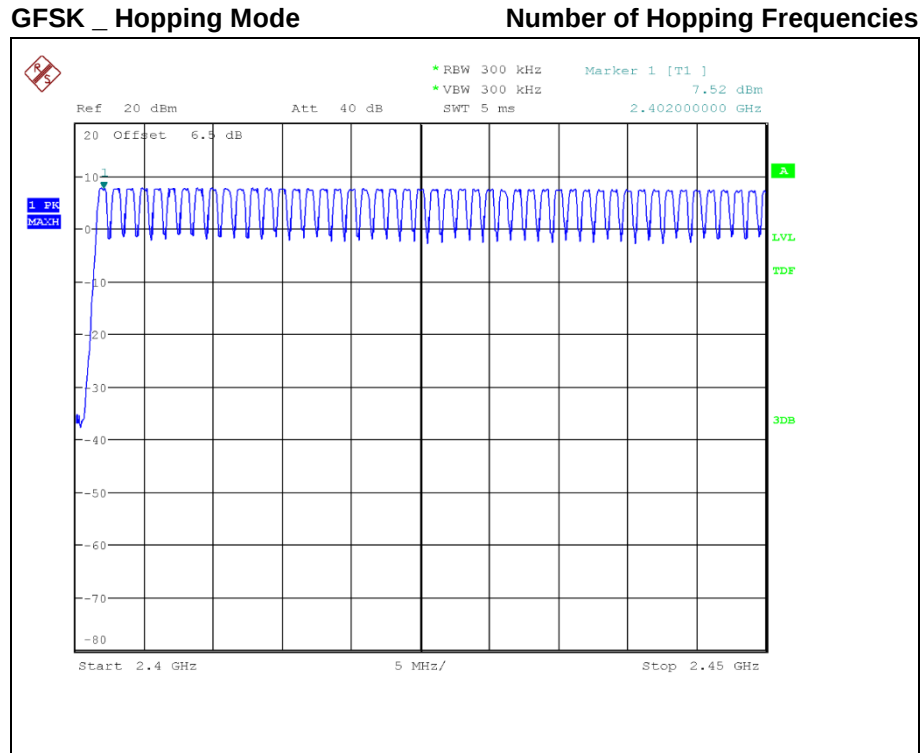
Sweep = Auto

Trace = Max hold

3.3.3.4 Test Result

Test Mode	Number of Hopping Channels
GFSK	79
8DPSK	79

3.3.3.5 Test Plot

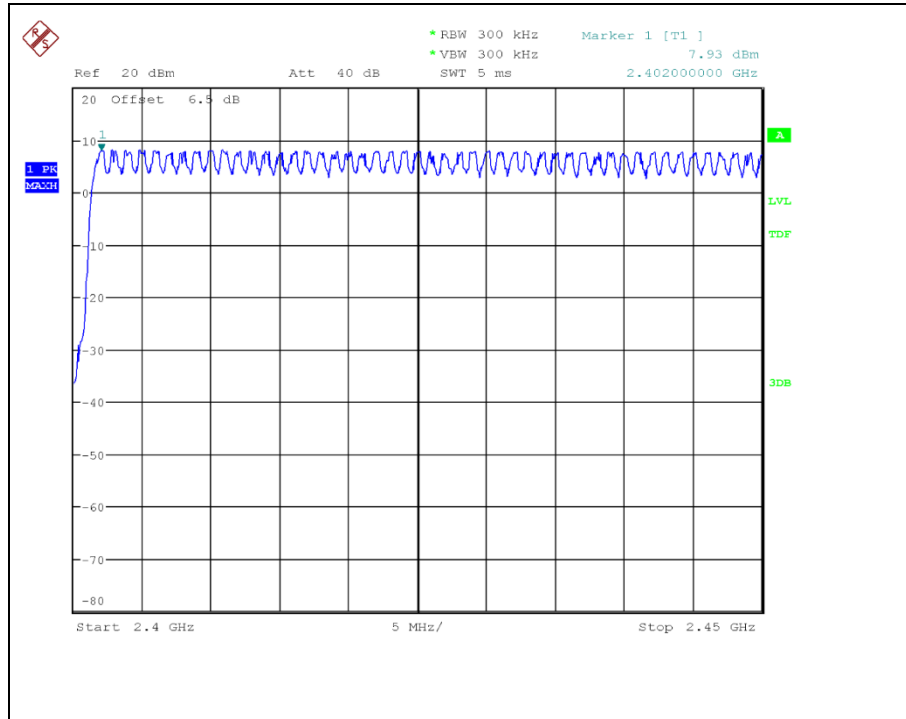


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

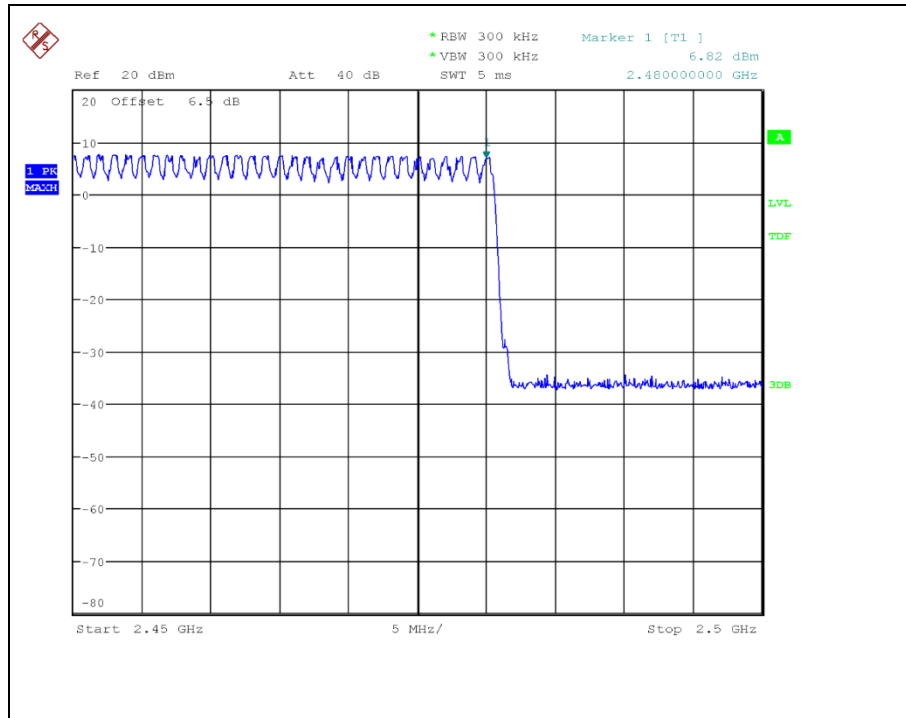
8DPSK _ Hopping Mode

Number of Hopping Frequencies



8DPSK _ Hopping Mode

Number of Hopping Frequencies



Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3.4 Time of Occupancy (Dwell Time)

3.3.4.1 Test Setup

Refer to the APPENDIX I.

3.3.4.2 Limit

The maximum permissible time of occupancy is 400 ms within a period of 400 ms multiplied by the number of hopping channels employed.

3.3.4.3 Test Procedure

The dwell time was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.

The spectrum analyzer is set to:

Center frequency = 2441 MHz

Span = Zero

RBW = 1 MHz (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)

VBW $\geq$ RBW

Detector = Peak

Trace = Max hold

3.3.4.4 Test Result

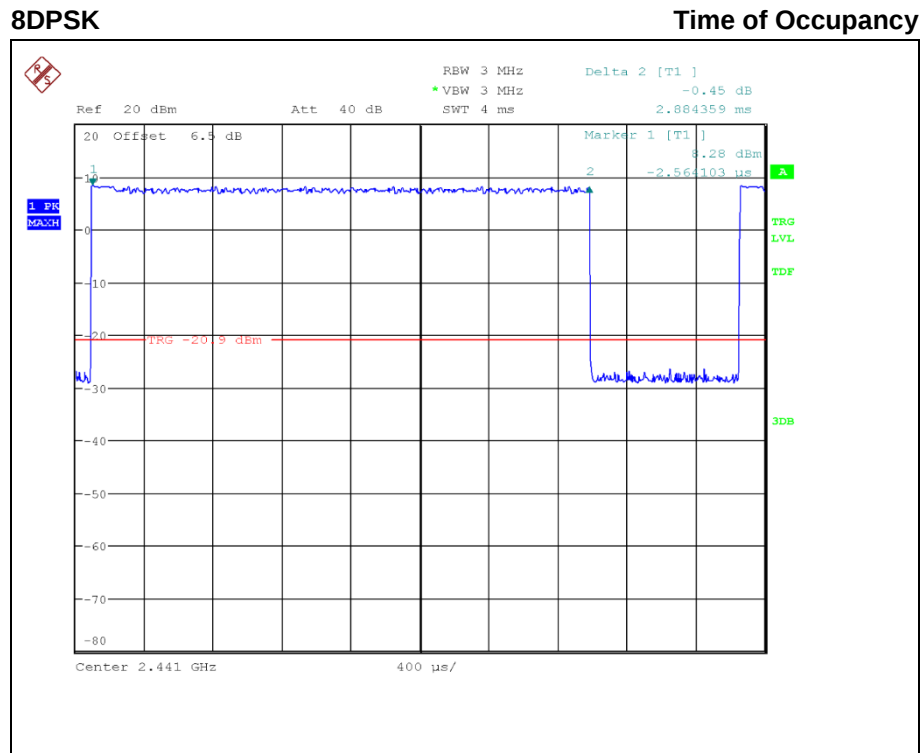
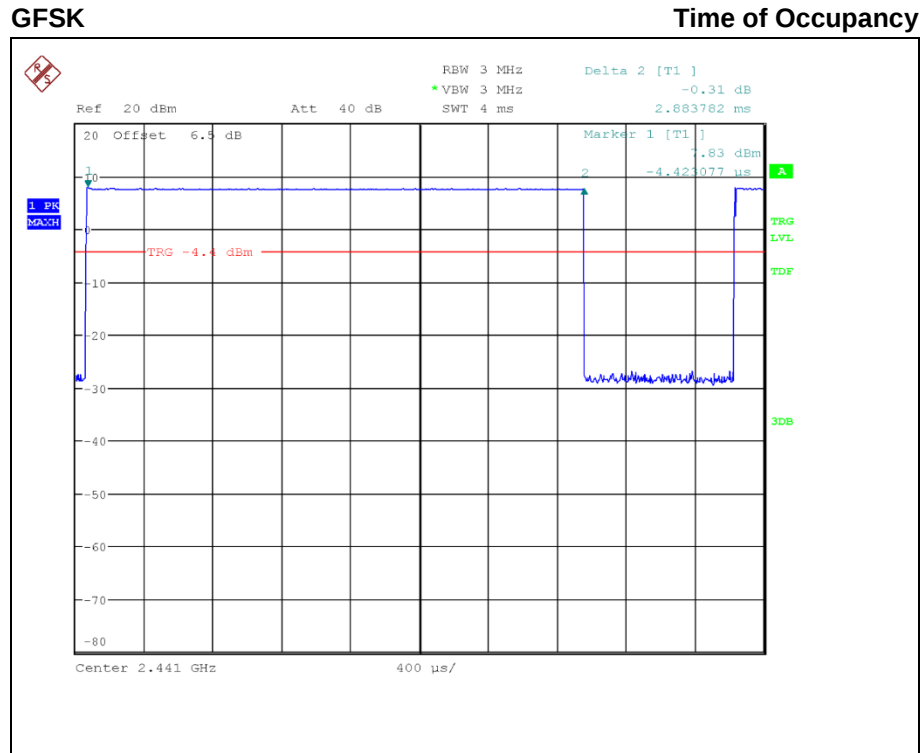
Test Mode	Number of Hopping Channels	Burst On Time (ms)	Result (sec)	Limit (sec)
GFSK (non-AFH)	79	2.884	0.31	0.40
GFSK (AFH)	79	2.884	0.15	0.40
8DPSK (non-AFH)	79	2.884	0.31	0.40
8DPSK (AFH)	79	2.884	0.15	0.40

Note: Dwell Time = $0.4 \times \text{Hopping channel} \times \text{Burst On Time} \times ((\text{Hopping rate} / \text{Time slots}) / \text{Hopping channel})$

- Time slots for FH5 = 6 slots (TX = 5 slot / RX = 1 slot)

- Hopping Rate = 1600 for FH mode & 800 for AFH mode

3.3.4.5 Test Plot



Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
 www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3.5 Carrier Frequencies Separation

3.3.5.1 Test Setup

Refer to the APPENDIX I.

3.3.5.2 Limit

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

3.3.5.3 Test Procedure

The carrier frequency separation was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled. After the trace being stable, the reading value between the peaks of the adjacent channels using the marker delta function was recorded as the measurement results.

The spectrum analyzer is set to:

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.

VBW $\geq$ RBW

Detector = Peak

Sweep = Auto

Trace = Max hold

3.3.5.4 Test Result

Test Mode	Test Frequency	Carrier Frequencies Separation (kHz)	Min. Limit (kHz)
GFSK	Low	1.002	0.650
	Middle	1.005	0.652
	High	1.002	0.652
8DPSK	Low	1.002	0.857
	Middle	1.002	0.857
	High	1.002	0.855

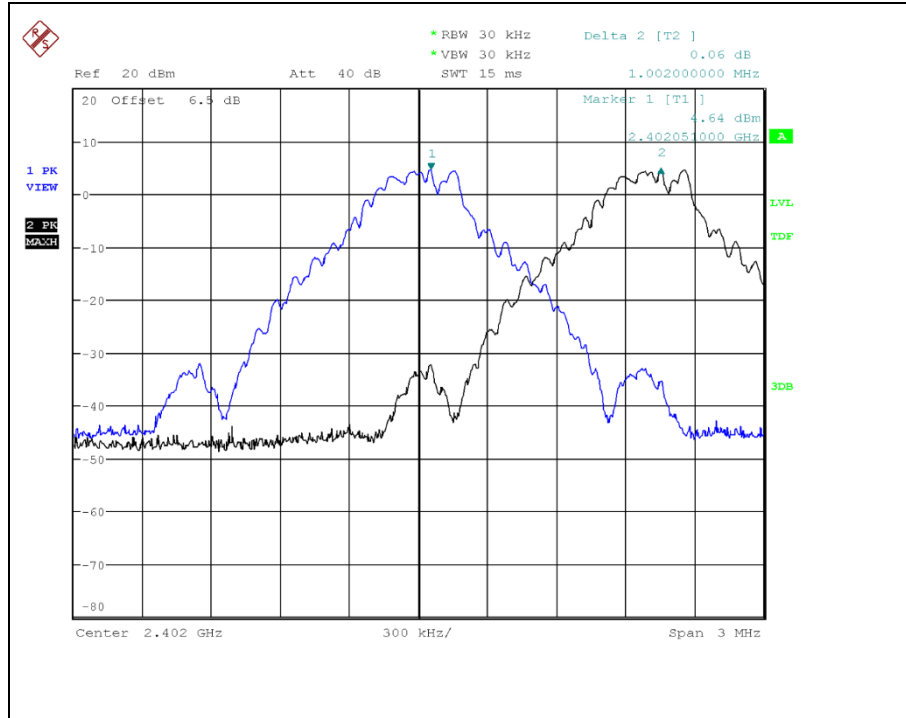
Note: Limit(kHz) = Test Result of 20 dB BW * 2/3

Test Repot No.: NW2201-F001

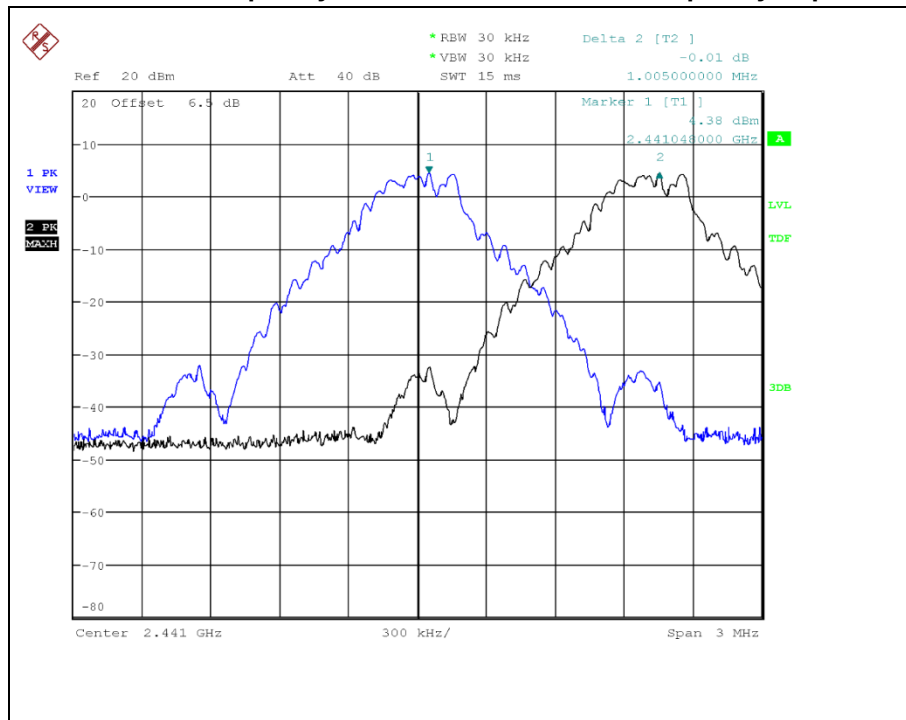
211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3.5.5 Test Plot

GFSK _ Low frequency **Carrier Frequency Separation**



GFSK _ Middle frequency **Carrier Frequency Separation**

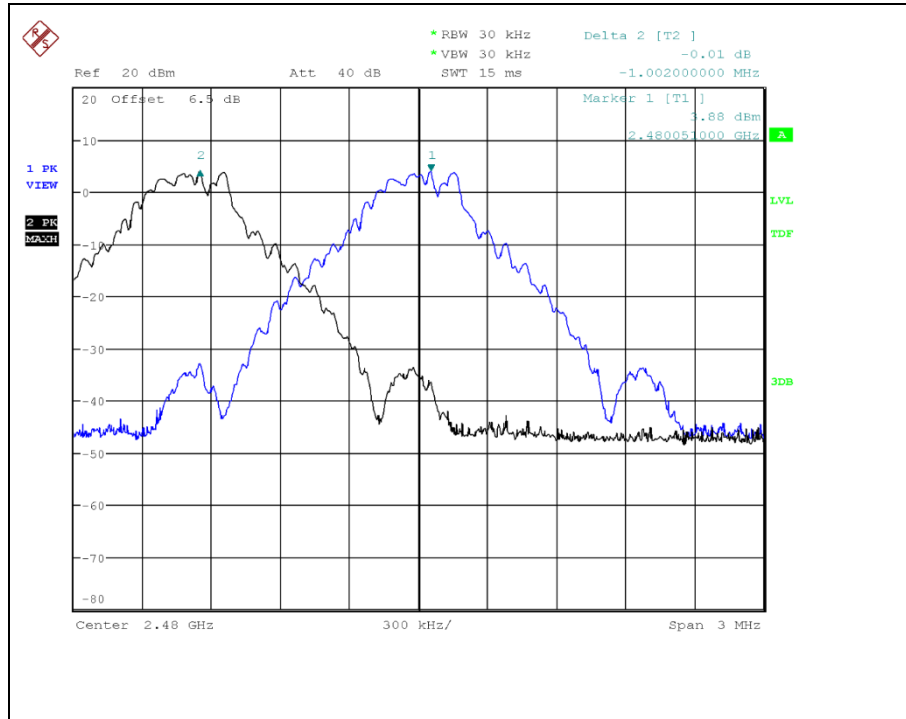


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

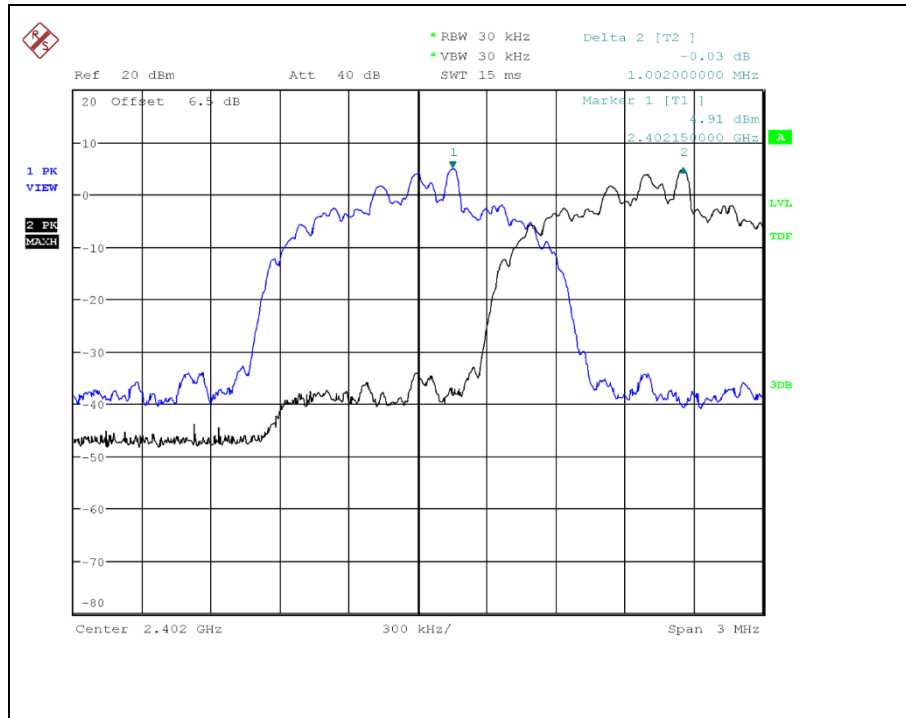
GFSK _ High frequency

Carrier Frequency Separation



8DPSK _ Low frequency

Carrier Frequency Separation

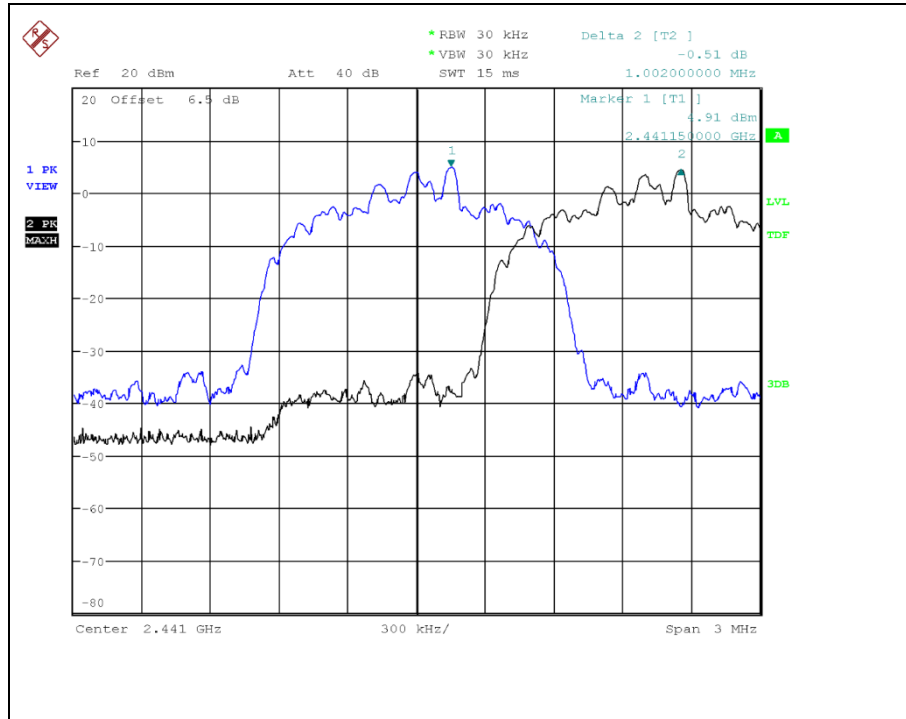


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

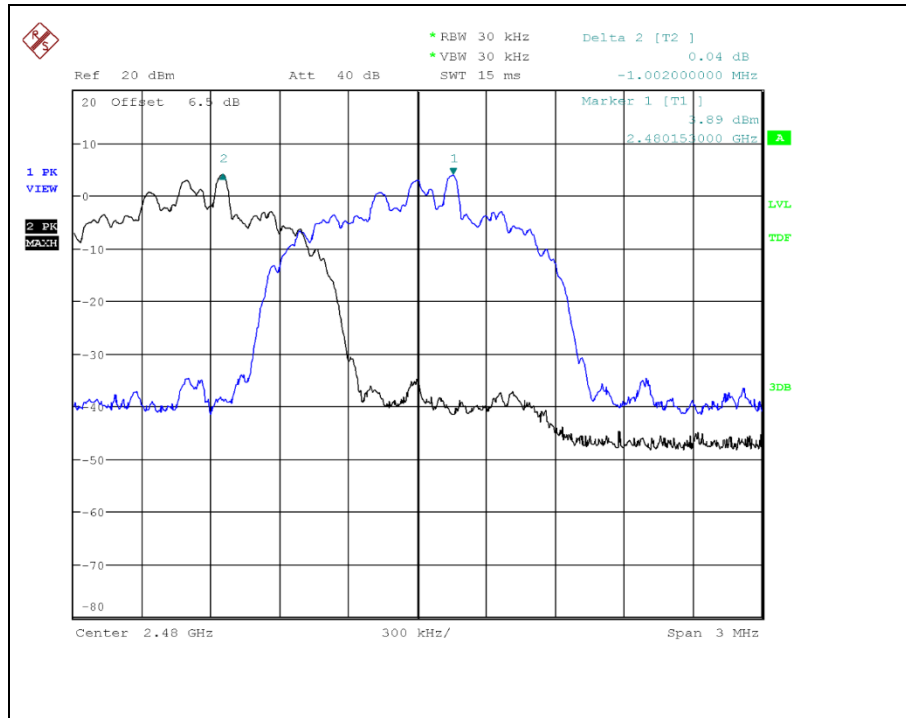
8DPSK _ Middle frequency

Carrier Frequency Separation



8DPSK _ High frequency

Carrier Frequency Separation



Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3.6 Peak Output Power

3.3.6.1 Test Setup

Refer to the APPENDIX I.

3.3.6.2 Limit

■ FCC Requirements

The maximum peak output power of the intentional radiator shall not exceed the following:

1. §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.
2. §15.247(b)(1), For frequency hopping systems operating in the 2400 – 2483.5 MHz employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725 – 5805 MHz band: 1 Watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

■ IC Requirements

1. RSS-247(5.4) (b), For FHSS operating in the band 2400 - 2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channels, the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p shall not exceed 4 W, except as provided in section 5.4(e)

3.3.6.3 Test Procedure

1. The RF output power was measured with a spectrum analyzer connected to the RF Antenna connector (conducted measurement) while EUT was operating in transmit mode at the appropriate center frequency, a spectrum analyzer was used to record the shape of the transmit signal.
2. The peak output power of the fundamental frequency was measured with the spectrum analyzer using;
Span = approximately 5 times of the 20 dB bandwidth, centered on a hopping channel
RBW $\geq$ 20 dB Bandwidth
VBW $\geq$ RBW
Sweep = Auto
Detector function = Peak
Trace = Max Hold

3.3.6.4 Test Result

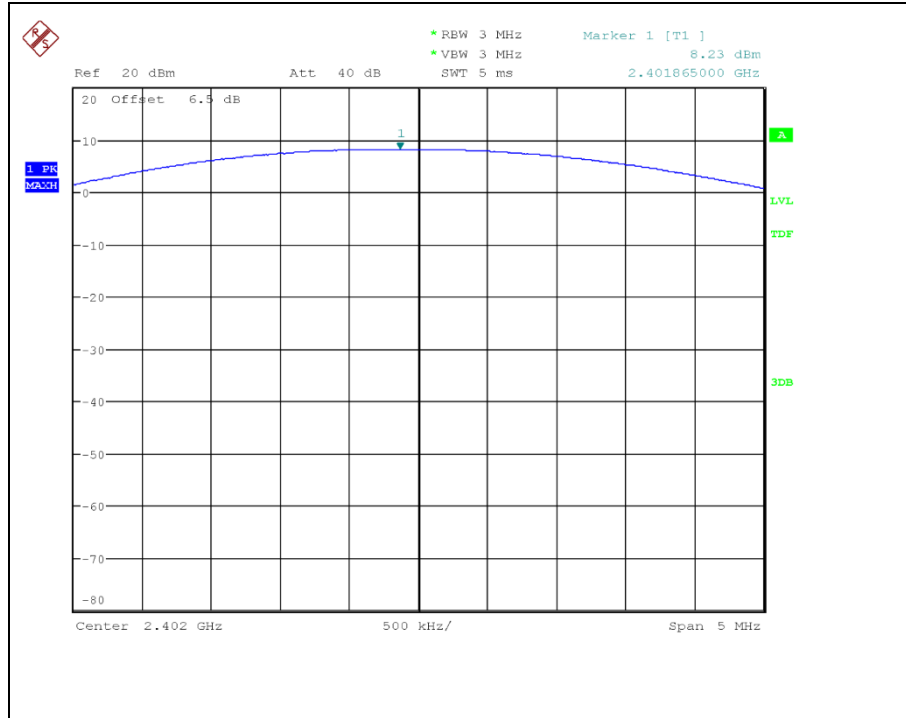
Test Mode	Test Frequency	Peak Output Power	
		dBm	mW
GFSK	Low	8.23	6.65
	Middle	7.89	6.15
	High	7.38	5.47
Pi/4 DQPSK	Low	8.46	7.01
	Middle	8.14	6.52
	High	7.66	5.83
8DPSK	Low	8.49	7.06
	Middle	8.15	6.53
	High	7.68	5.86

Test Repot No.: NW2201-F001

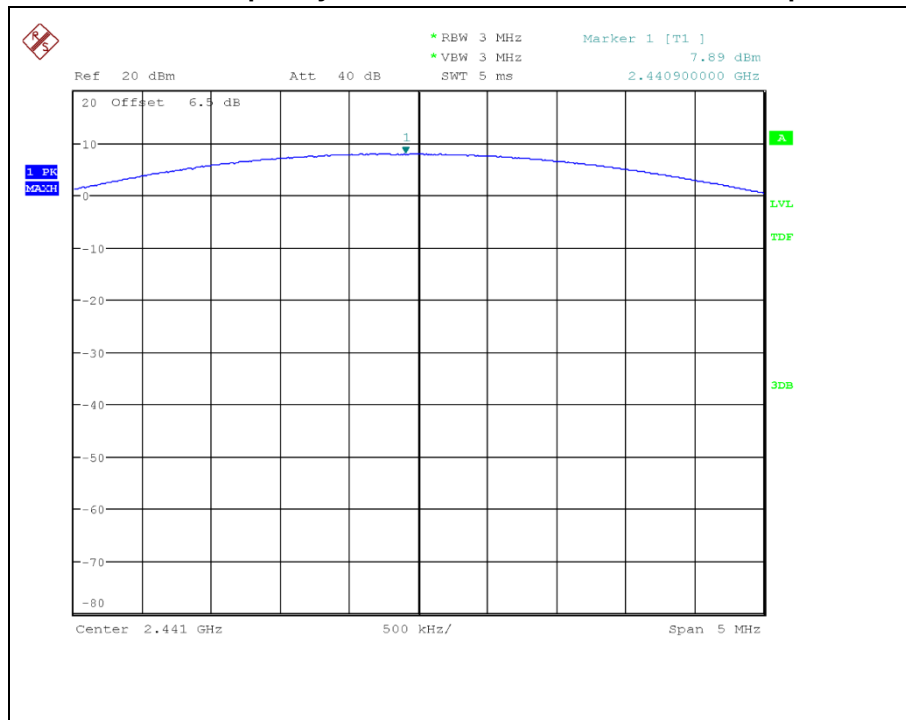
211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3.6.5 Test Plot

GFSK _ Low frequency **Peak Output Power**



GFSK _ Middle frequency **Peak Output Power**

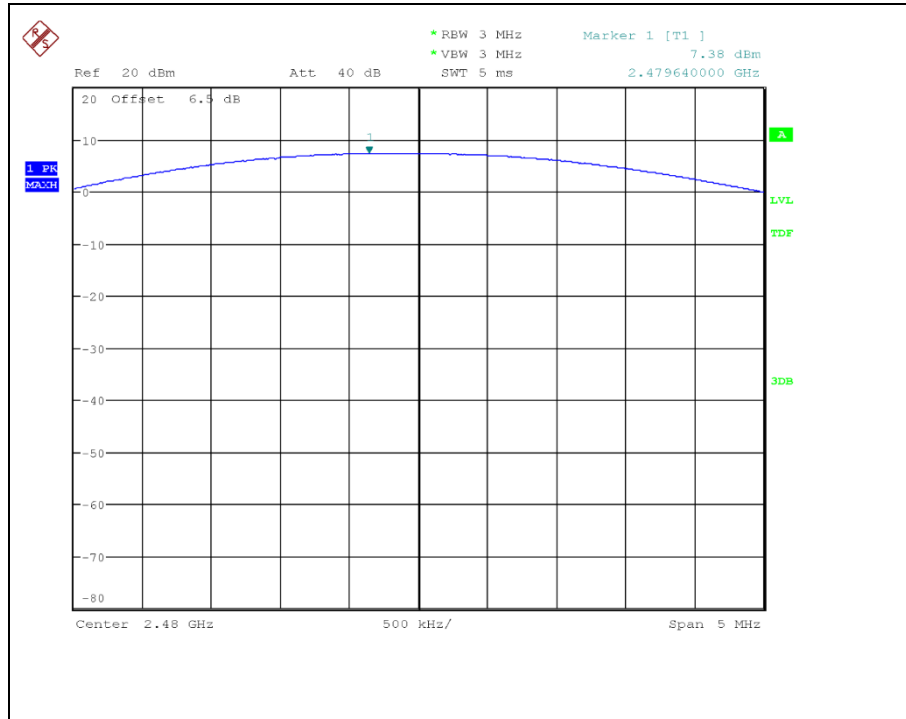


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

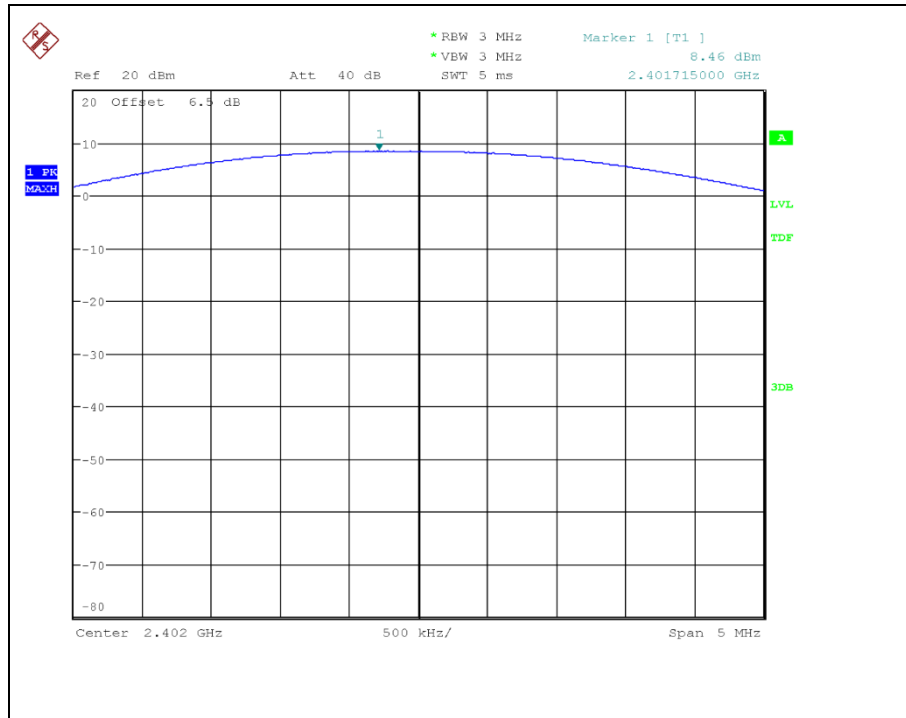
GFSK _ High frequency

Peak Output Power



Pi/4 DQPSK _ Low frequency

Peak Output Power

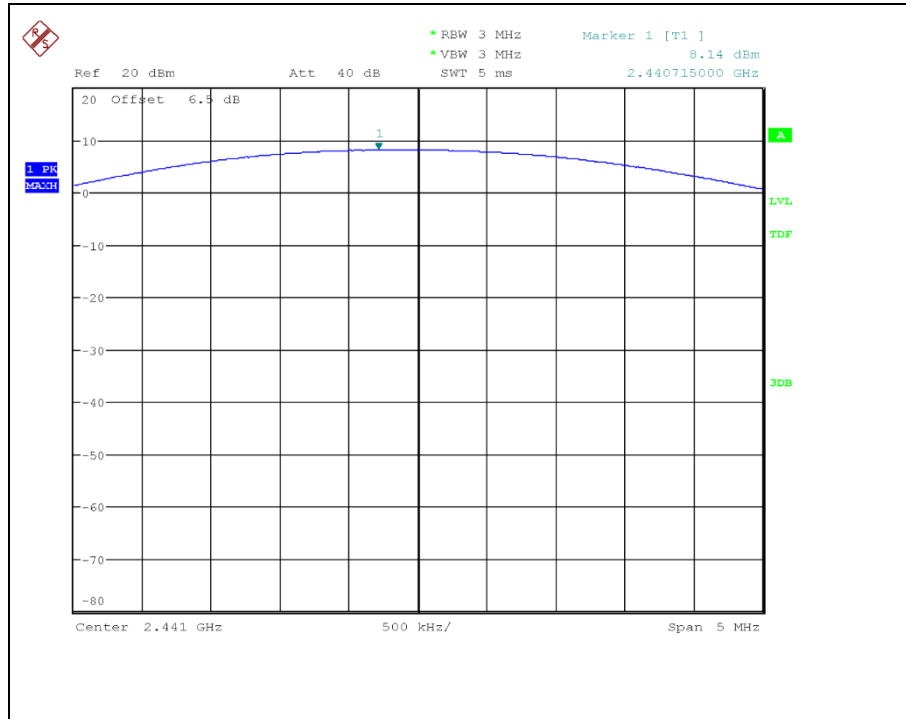


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

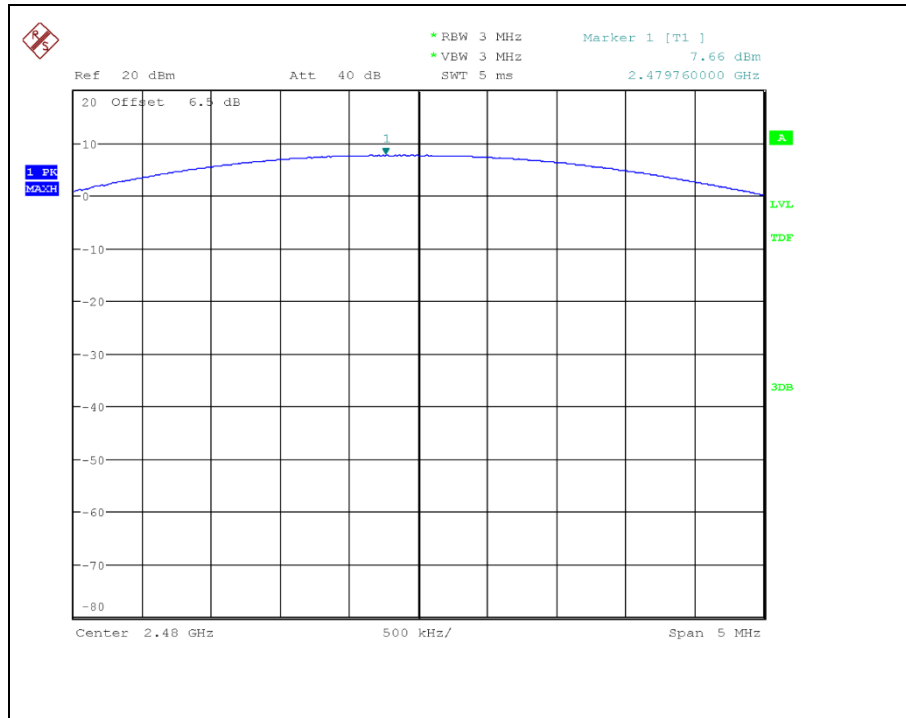
Pi/4 DQPSK _ Middle frequency

Peak Output Power



Pi/4 DQPSK _ High frequency

Peak Output Power

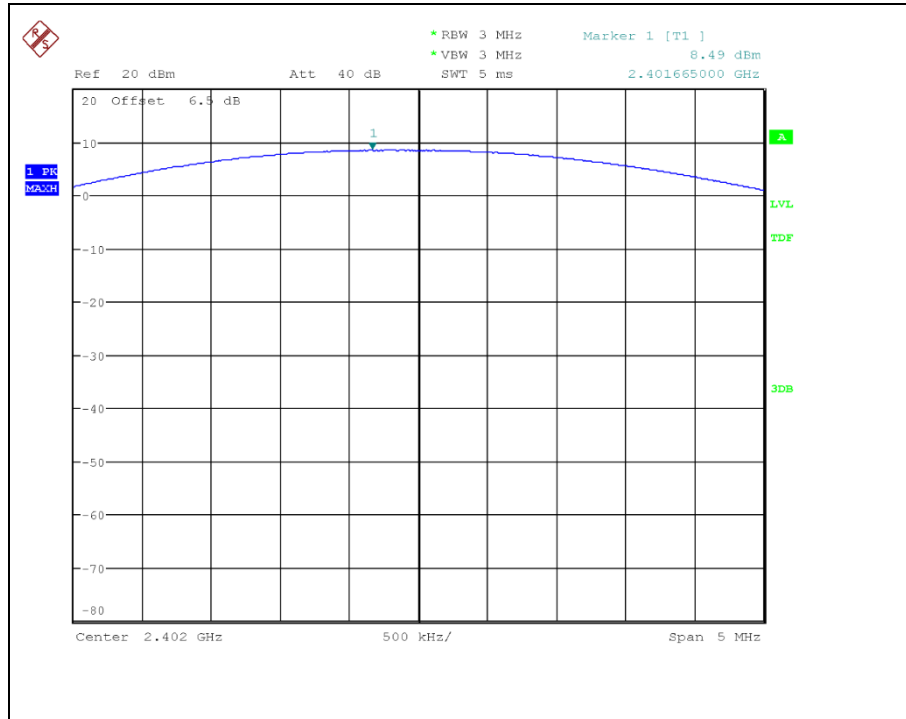


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

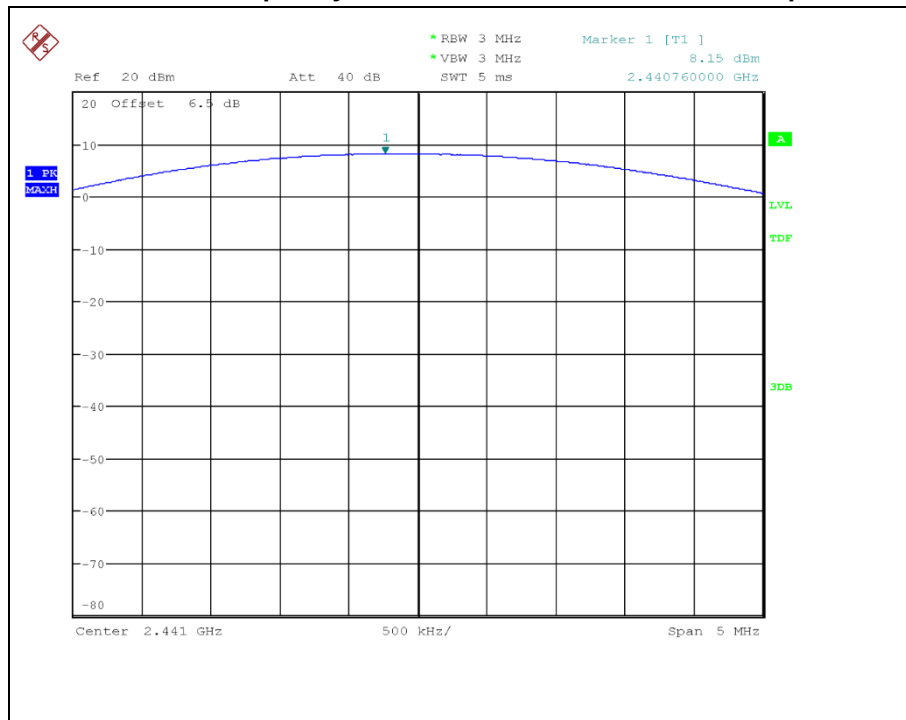
8DPSK _ Low frequency

Peak Output Power



8DPSK _ Middle frequency

Peak Output Power

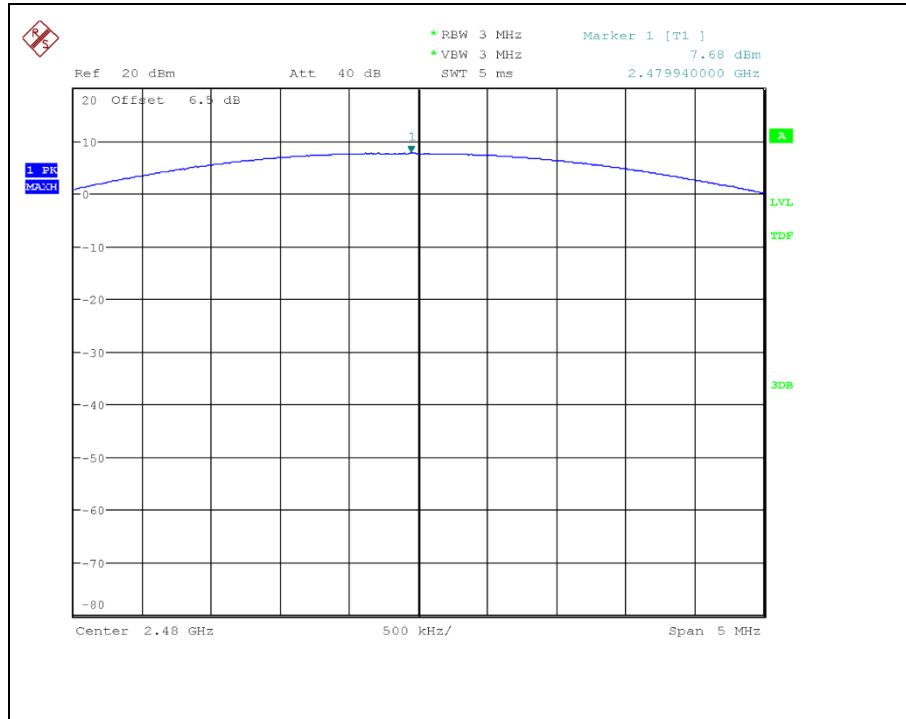


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

8DPSK _ High frequency

Peak Output Power



Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3.7 TX Radiated Spurious Emission and Conducted Spurious Emission

3.3.7.1 Test Setup

Refer to the APPENDIX I.

3.3.7.2 Limit

According to §15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph(b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in section §15.209(a) is not required. In addition, radiated emission which in the restricted band, as define in section §15.205(a), must also comply the radiated emission limits specified in section §15.209(a) (see section §15.205(c))

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

Frequency (MHz)	Limit (uV/m)	Measurement Distance (meter)
0.009 ~ 0.490	2400/F (kHz)	300
0.490 ~ 1705	24000/F (kHz)	30
1705 ~ 30.0	30	30
30 ~ 88	100 **	3
88 ~ 216	150 **	3
216 ~ 960	200 **	3
Above 960	500	3

** Except as provided in 15.209(g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54 - 72 MHz, 76 - 88 MHz, 174 - 216 MHz or 470 – 806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g. 15.231 and 15.241.

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

MHz	MHz	MHz	GHz
0.009 ~ 0.110	16.42 ~ 16.423	399.90 ~ 410	4.5 ~ 5.15
0.495 ~ 0.505	16.69475 ~ 16.69525	608 ~ 614	5.35 ~ 5.46
2.1735 ~ 2.1905	16.80425 ~ 16.80475	960 ~ 1240	7.25 ~ 7.75
4.125 ~ 4.128	25.5 ~ 25.67	1300 ~ 1427	8.025 ~ 8.5
4.17725 ~ 4.17775	37.5 ~ 38.	1435 ~ 1626.5	9.0 ~ 9.2
4.20725 ~ 4.20775	25 73 ~ 74.6	1645.5 ~ 1646.5	9.3 ~ 9.5
4.17725 ~ 4.17775	74.8 ~ 75.2	1660 ~ 1710	10.6 ~ 12.7
6.215 ~ 6.218	108 ~ 121.94	1718.8 ~ 1722.2	13.25 ~ 13.4
6.26775 ~ 6.26825	149.9 ~ 150.05	2200 ~ 2300	14.47 ~ 14.5
6.31175 ~ 6.31225	156.52475 ~ 156.52525	2310 ~ 2390	15.35 ~ 16.2
8.291 ~ 8.294	156.7 ~ 156.9	2483.5 ~ 2500	17.7 ~ 21.4
8.362 ~ 8.366	162.0125 ~ 167.17	2690 ~ 2900	22.01 ~ 23.12
8.37625 ~ 8.38675	3345.8 ~ 3358	3260 ~ 3267	23.6 ~ 24.0
8.41425 ~ 8.41475	3600 ~ 4400	3332 ~ 3339	31.2 ~ 31.8
12.51975 ~ 12.52025	3345.8 ~ 3358	240 ~ 285	36.43 ~ 36.5
12.57675 ~ 12.57725	3600 ~ 4400	322 ~ 335.4	Above 38.6
13.36 ~ 13.41			

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

3.3.7.3 Test Procedure for Radiated Spurious Emission

1. The EUT is placed on a non-conductive table. For emission measurements at or below 1 GHz, the table height is 80 cm. For emission measurements above 1 GHz, the table height is 1.5 m. The table was rotated 360 degrees to determine the position of the highest radiation.
2. During performing radiated emission below 1 GHz, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 GHz, the EUT was set 1 or 3 meter away from the interference-receiving antenna.
3. For measurements above 1 GHz absorbers are placed on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1 GHz, the absorbers are removed.
4. The antenna is a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
5. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
(The EUT was pre-tested with three axes (X, Y, Z) and the final test was performed at the worst case.)
6. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
7. If the emission level of the EUT in peak mode was 10 dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

Measurement Instrument Setting

1. Frequency Range: Below 1 GHz
RBW = 100 or 120 kHz, VBW = 3 x RBW, Detector = Peak or Quasi Peak
2. Frequency Range: Above 1 GHz
Peak Measurement
RBW = 1 MHz, VBW = 3 MHz, Detector = Peak, Sweep time = Auto,
Trace mode = Max Hold until the trace stabilizes

Average Measurement
RBW = 1MHz, VBW $\geq$ 1/T, Detector = Peak, Sweep Time = Auto,
Trace Mode = Max Hold until the trace stabilizes

3.3.7.4 Test Procedure for Conducted Spurious Emission

1. The transmitter output was connected to the spectrum analyzer.
2. The reference level of the fundamental frequency was measured with the spectrum analyzer using
RBW = 100 kHz, VBW = 300 kHz.
3. The conducted spurious emission was tested each ranges were set as below.
Frequency range: 30 MHz ~ 26.5 GHz
RBW = 100 kHz, VBW = 300 kHz, Sweep Time = Auto, Detector = Peak,
Trace = Max Hold

LIMIT LINE = 20 dB below of the reference level of above measurement procedure Step 2. (RBW = 100 kHz, VBW = 300 kHz)

3.3.7.5 Test Result

9 kHz ~ 25 GHz Data (Modulation: GFSK)

● Low frequency

Frequency (MHz)	Reading		Pol.	Factor (dB)	DCCF (dB)	Limits		Result		Margin	
	(dBuV/m)					(dBuV/m)		(dBuV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
4 804.05	N/A	49.64	V	-4.40	-24.78	54.0	74.0	20.5	45.2	33.5	28.8

● Middle frequency

Frequency (MHz)	Reading		Pol.	Factor (dB)	DCCF (dB)	Limits		Result		Margin	
	(dBuV/m)					(dBuV/m)		(dBuV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
4 882.02	N/A	48.49	V	-4.40	-24.78	54.0	74.0	19.3	44.1	34.7	29.9

● High frequency

Frequency (MHz)	Reading		Pol.	Factor (dB)	DCCF (dB)	Limits		Result		Margin	
	(dBuV/m)					(dBuV/m)		(dBuV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
4 959.90	N/A	47.41	V	-4.26	-24.78	54.0	74.0	18.4	43.2	35.6	30.9

Note 1: The radiated emissions were investigated 9 kHz to 25 GHz. And no other spurious and harmonic emissions were found above listed frequencies.

Note 2: DCCF(Duty Cycle Correction Factor)

- Time to cycle through all channels = $\Delta t = T [\text{ms}] \times 20$ minimum hopping channels, where T = pulse width = 2.884 ms
- $100 \text{ ms} / \Delta t [\text{ms}] = H \rightarrow$ Round up to next highest integer, to account for worst case, $H' = 100 / (2.884 \times 20) = 1.73 \approx 2$
- The Worst Case Dwell Time = $T [\text{ms}] \times H' = 2.884 \text{ ms} \times 2 = 5.77 \text{ ms}$
- $\text{DCCF} = 20 \times \log(\text{The Worst Case Dwell Time} / 100 \text{ ms}) \text{ dB} = 20 \times \log(5.77 / 100) = -24.78 \text{ dB}$

Note 3: Sample Calculation.

Margin = Limit – Result / Peak Result = Peak Reading + TF / Average Result = Peak Reading + TF + DCCF
 TF = Ant factor + Cable Loss + Filter Loss – Amp Gain

Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
 www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

9 kHz ~ 25 GHz Data (Modulation: 8DPSK)

● Low frequency

Frequency	Reading		Pol.	Factor (dB)	DCCF (dB)	Limits		Result		Margin	
	(dBuV/m)					(dBuV/m)		(dBuV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
4 804.12	N/A	49.11	V	-4.40	-24.78	54.0	74.0	19.9	44.7	34.1	29.3

● Middle frequency

Frequency	Reading		Pol.	Factor (dB)	DCCF (dB)	Limits		Result		Margin	
	(dBuV/m)					(dBuV/m)		(dBuV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
4 881.74	N/A	49.17	V	-4.40	-24.78	54.0	74.0	20.0	44.8	34.0	29.2

● High frequency

Frequency (MHz)	Reading		Pol.	Factor (dB)	DCCF (dB)	Limits		Result		Margin	
	(dBuV/m)					(dBuV/m)		(dBuV/m)		(dB)	
	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
4 960.12	N/A	48.21	V	-4.26	-24.78	54.0	74.0	19.2	44.0	34.8	30.1

Note 1: The radiated emissions were investigated 9 kHz to 25 GHz.

Note 2: DCCF(Duty Cycle Correction Factor)

- Time to cycle through all channels = $\Delta t = T \text{ [ms]} \times 20$ minimum hopping channels, where $T = \text{pulse width} = 2.884 \text{ ms}$
- $100 \text{ ms} / \Delta t \text{ [ms]} = H \rightarrow$ Round up to next highest integer, to account for worst case, $H' = 100 / (2.884 \times 20) = 1.73 \approx 2$
- The Worst Case Dwell Time = $T \text{ [ms]} \times H' = 2.884 \text{ ms} \times 2 = 5.77 \text{ ms}$
- $\text{DCCF} = 20 \times \log(\text{The Worst Case Dwell Time} / 100 \text{ ms}) \text{ dB} = 20 \times \log(5.77 / 100) = -24.78 \text{ dB}$

Note 3: Sample Calculation.

Margin = Limit – Result / Peak Result = Peak Reading + TF / Average Result = Peak Reading + TF + DCCF
 TF = Ant factor + Cable Loss + Filter Loss – Amp Gain

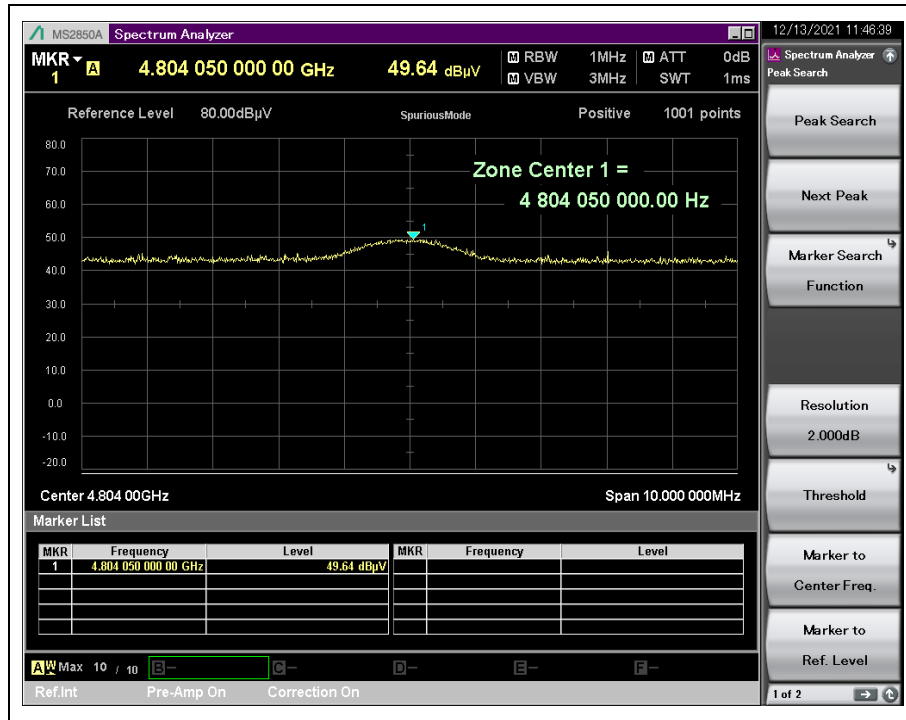
Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
 www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3.7.6 Test Plot for Radiated Spurious Emission

- GFSK _ Low frequency

Spurious – Peak

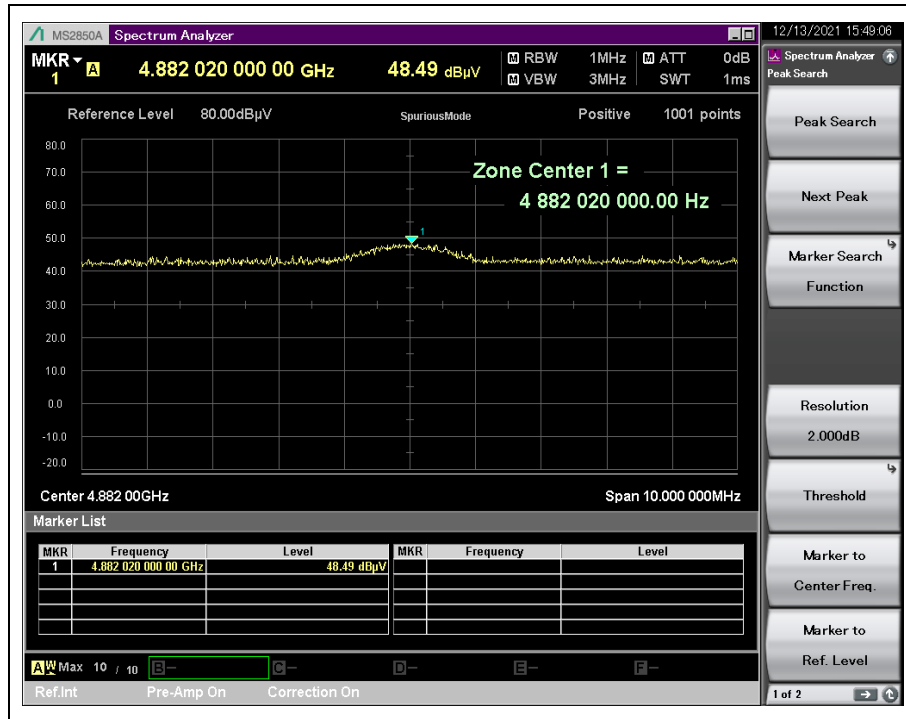


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

- GFSK _ Middle frequency

Spurious – Peak

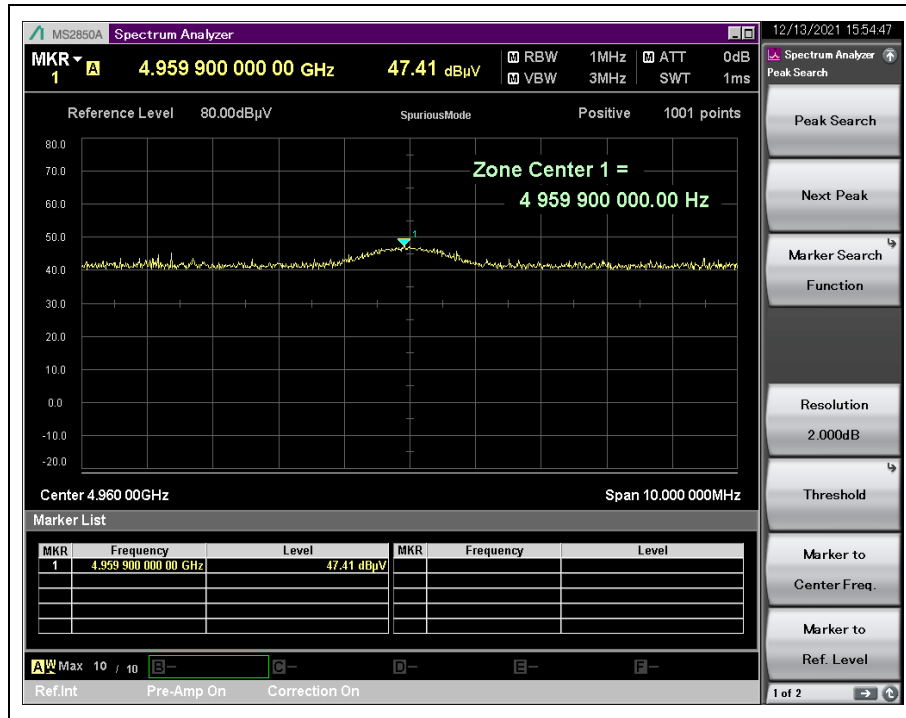


Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

- GFSK _ High frequency

Spurious – Peak

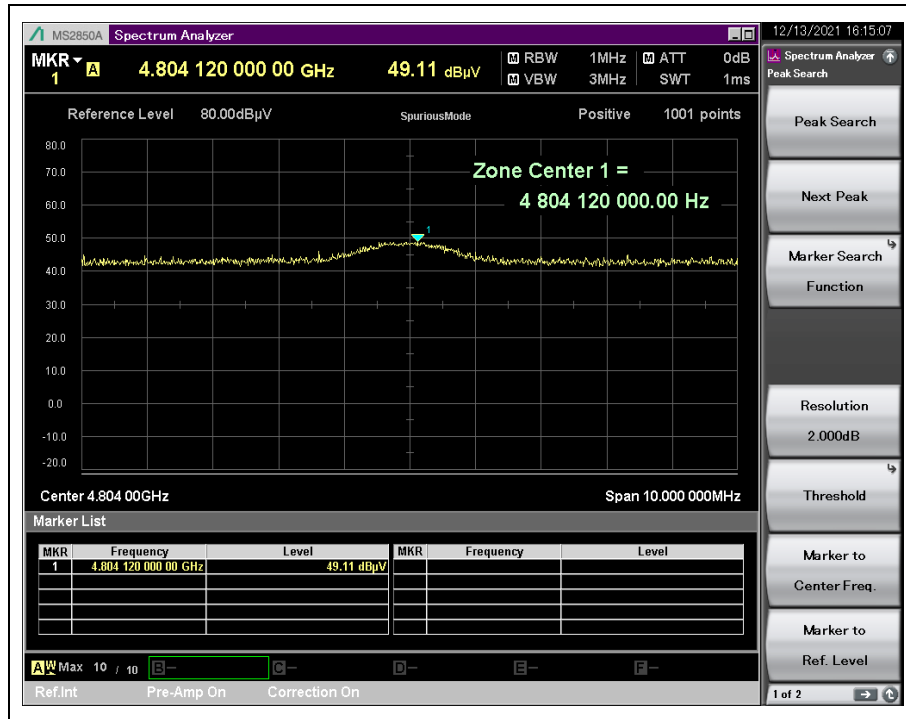


Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

- 8DPSK _ Low frequency

Spurious – Peak

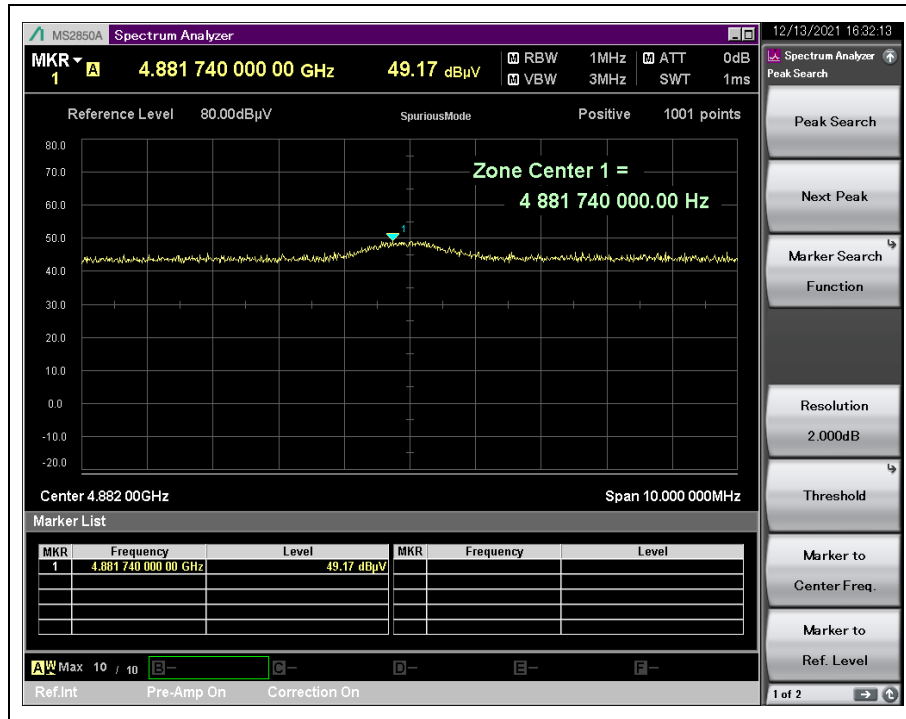


Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

- 8DPSK _ Middle frequency

Spurious – Peak

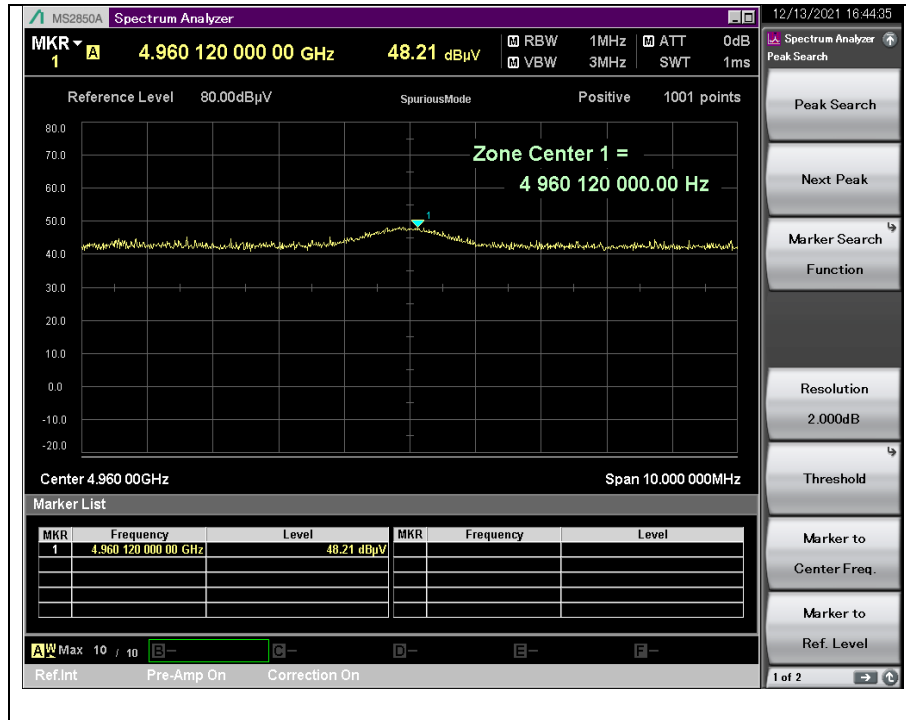


Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

- 8DPSK _ High frequency

Spurious – Peak



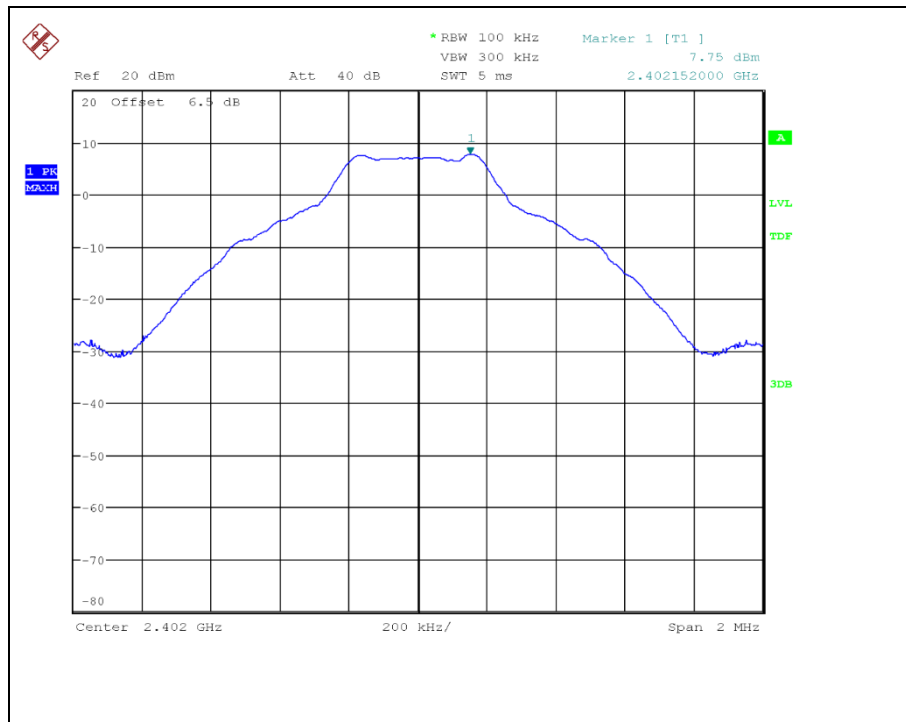
Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

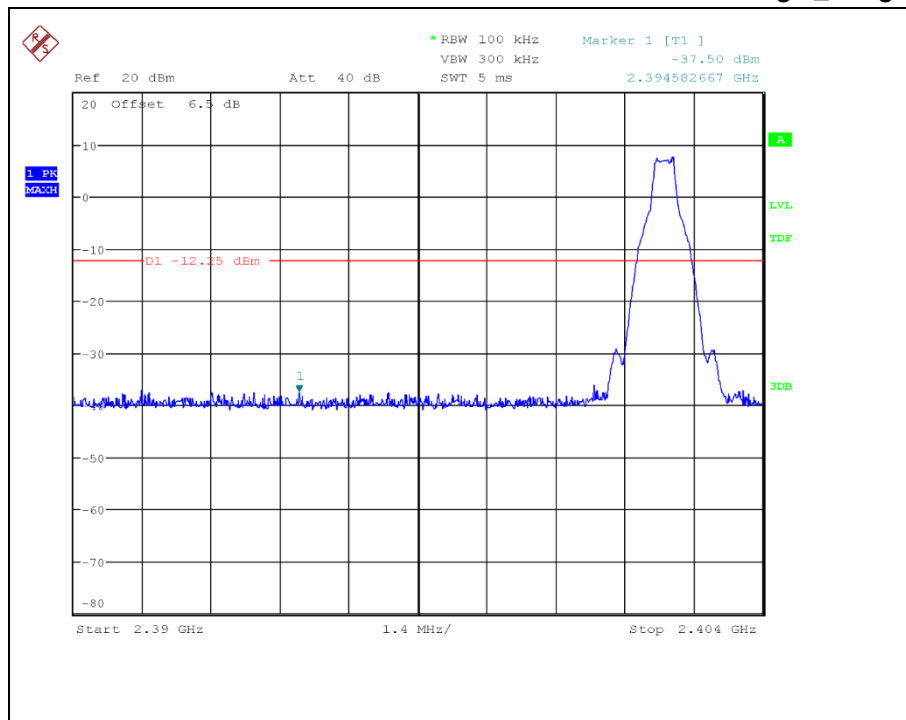
3.3.7.7 Test Plot for Conducted Spurious Emission

- GFSK _ Low frequency

Reference



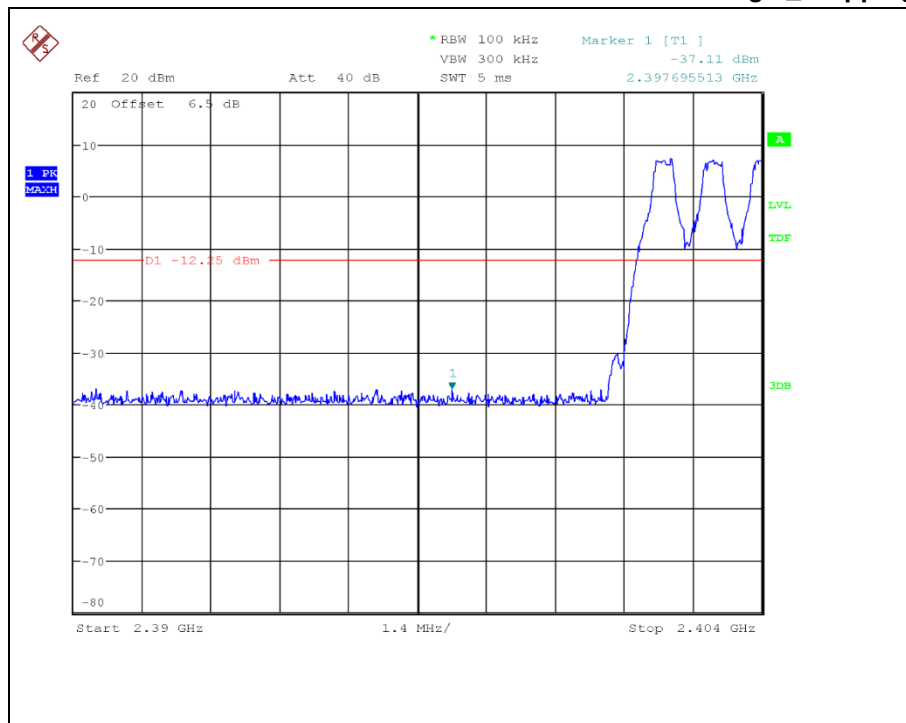
Bandedge _ Single



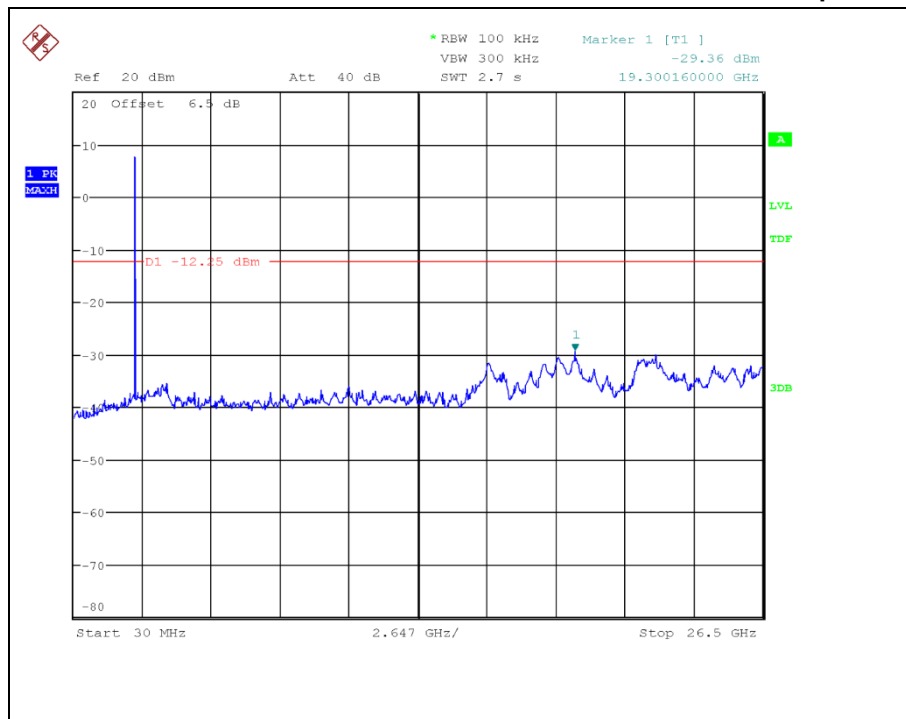
Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

Bandedge _ Hopping



Spurious

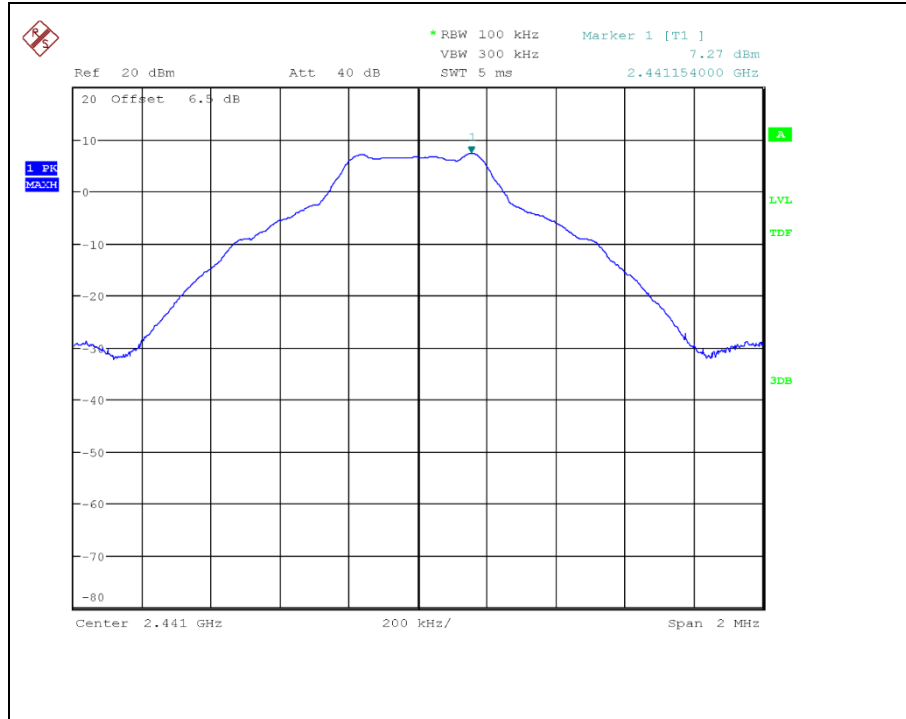


Test Repot No.: NW2201-F001

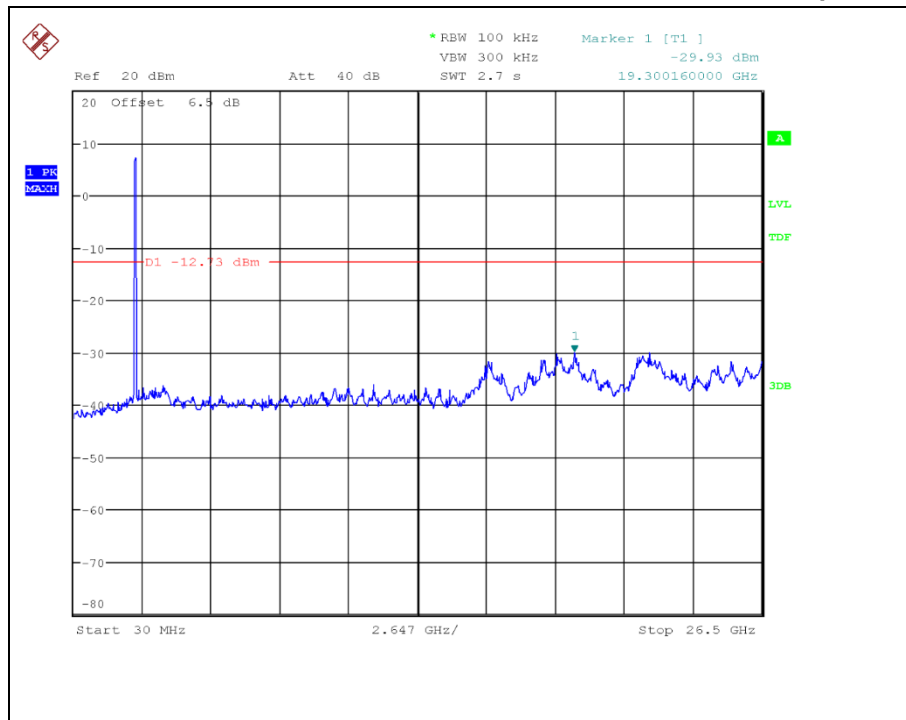
211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

- GFSK _ Middle frequency

Reference



Spurious

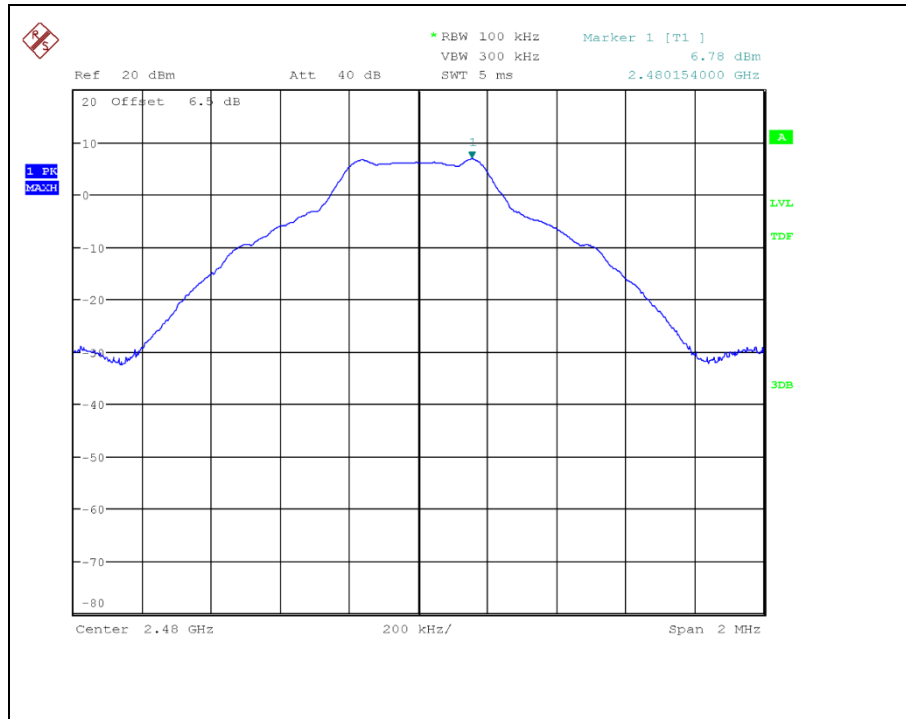


Test Report No.: NW2201-F001

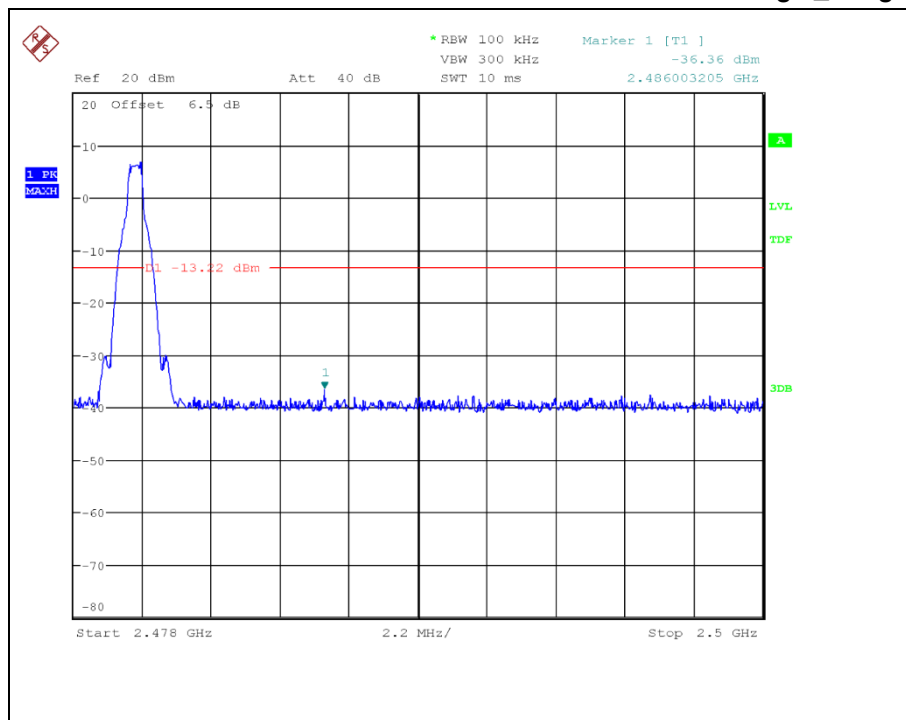
211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

- GFSK _ High frequency

Reference



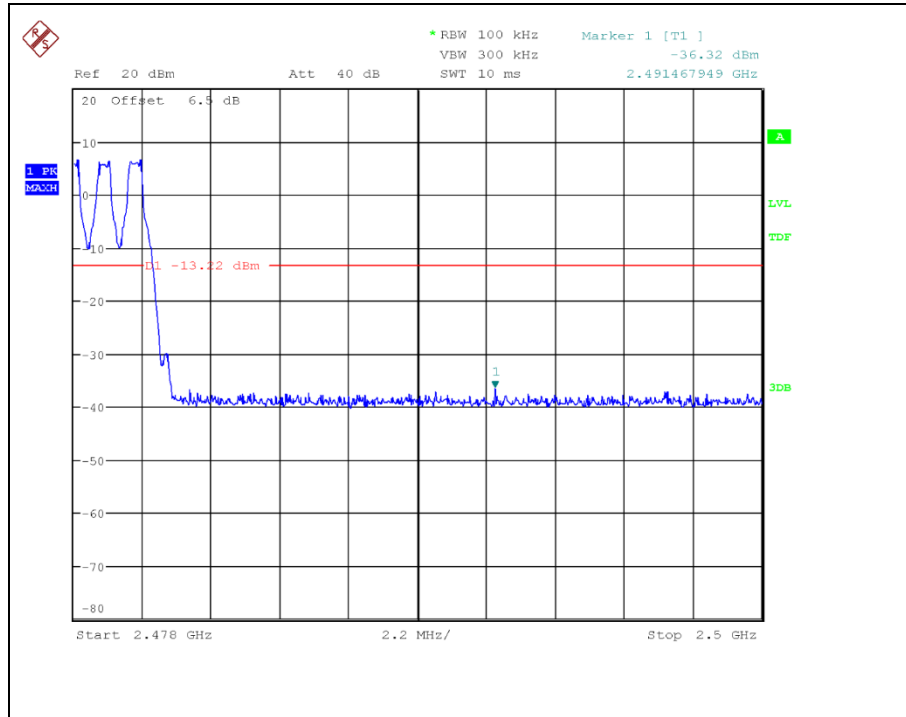
Bandedge _ Single



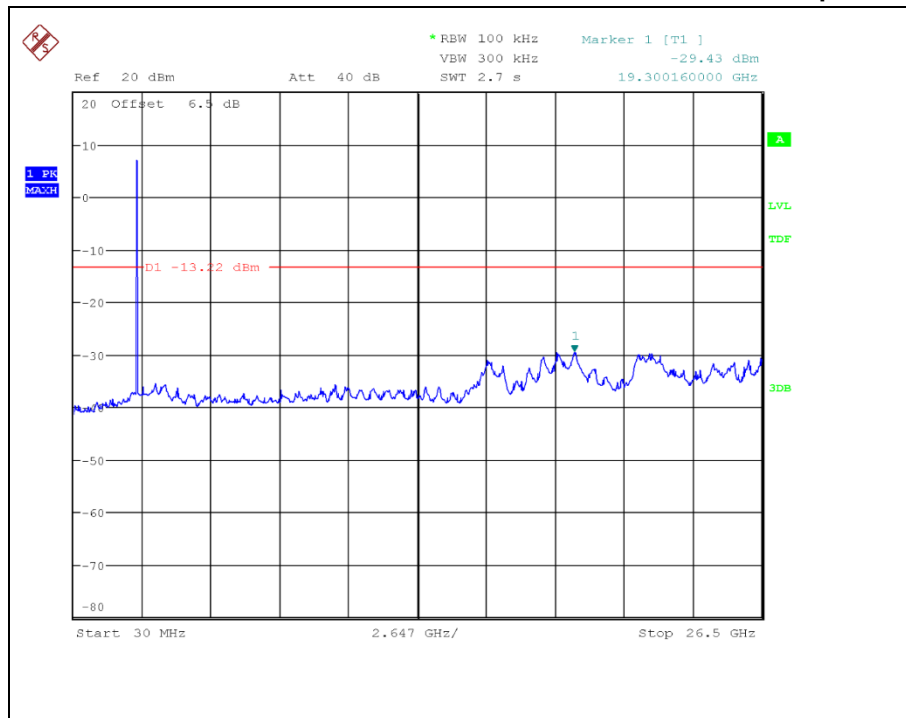
Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

Bandedge _ Hopping



Spurious

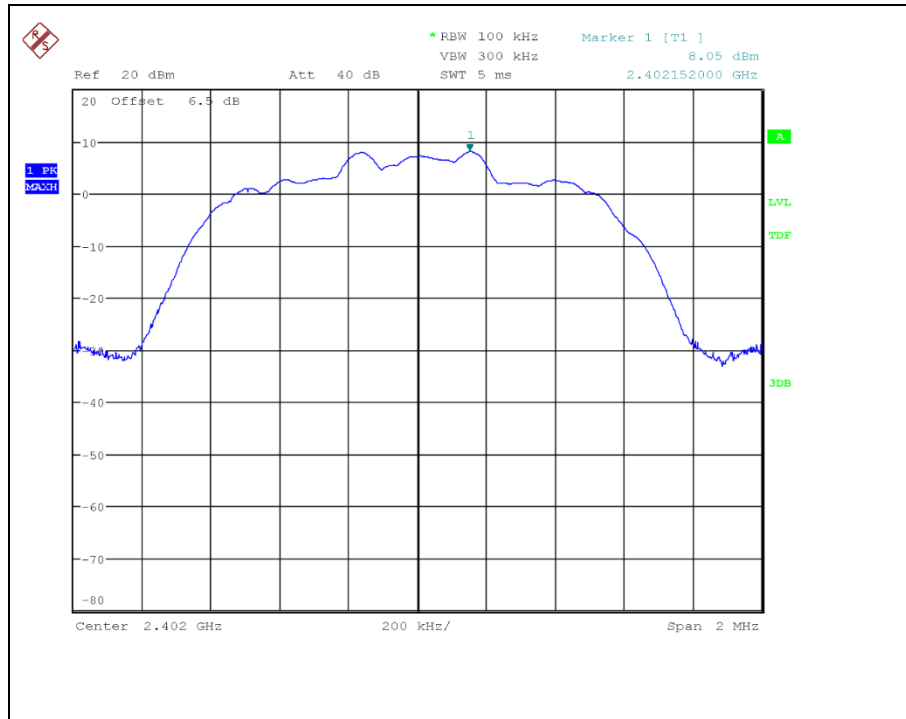


Test Report No.: NW2201-F001

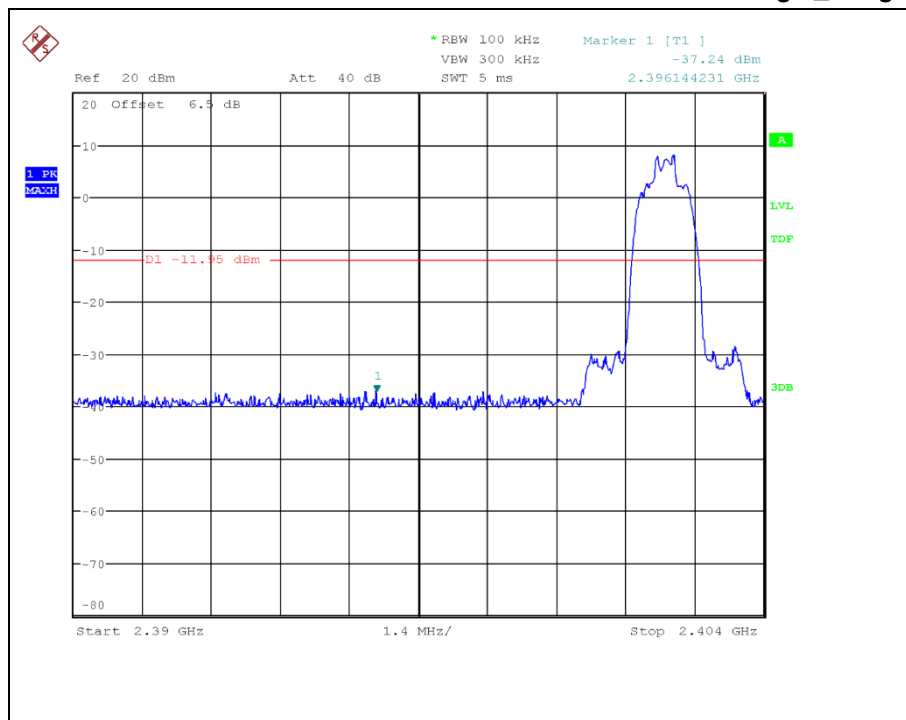
211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

● 8DPSK _ Low frequency

Reference



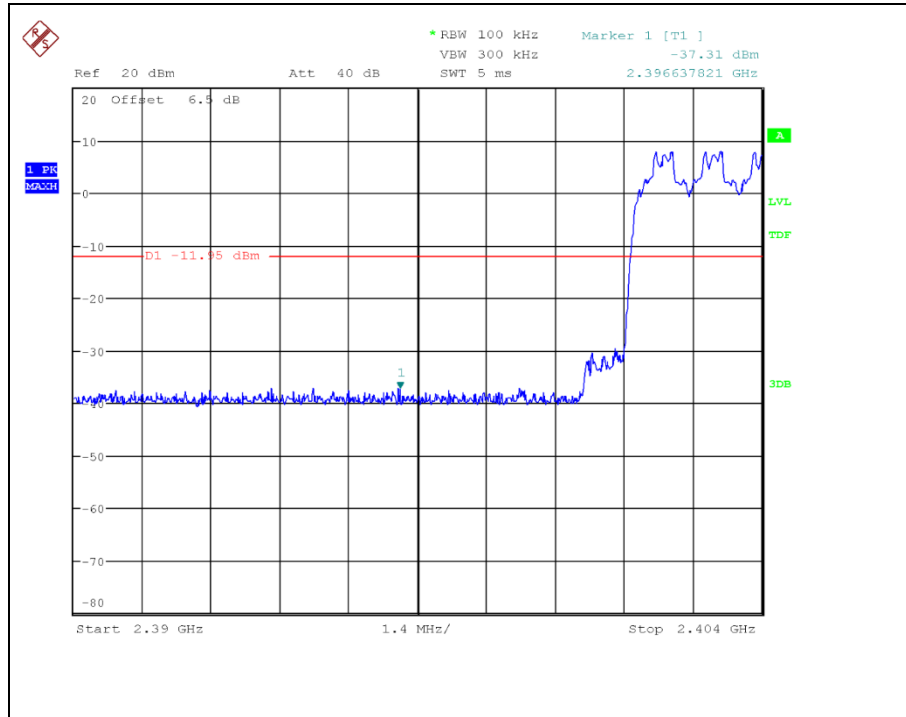
Bandedge _ Single



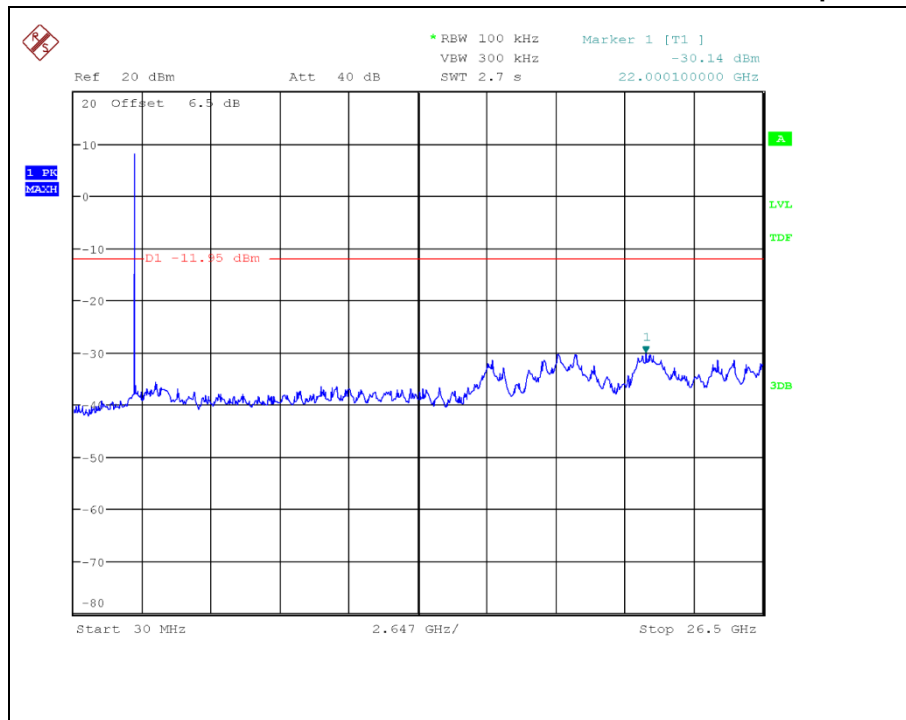
Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

Bandedge _ Hopping



Spurious

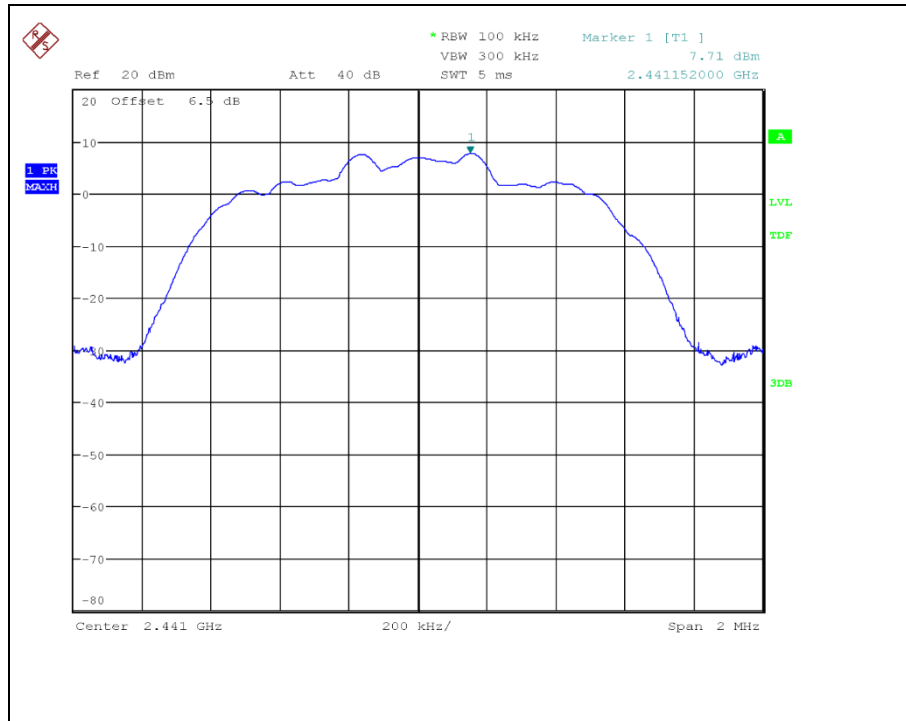


Test Repot No.: NW2201-F001

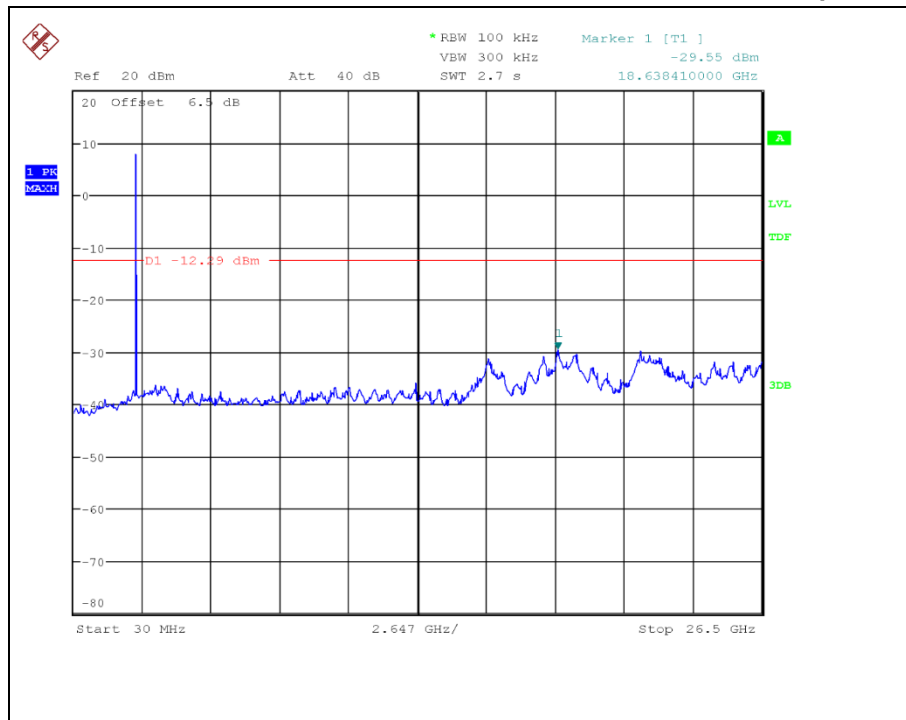
211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

- 8DPSK _ Middle frequency

Reference



Spurious

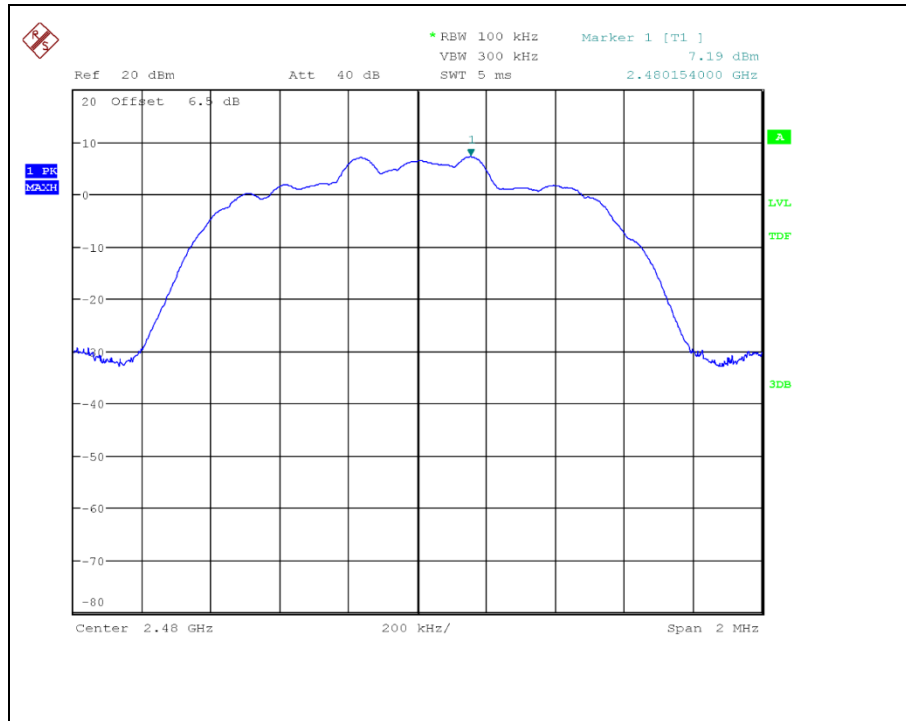


Test Report No.: NW2201-F001

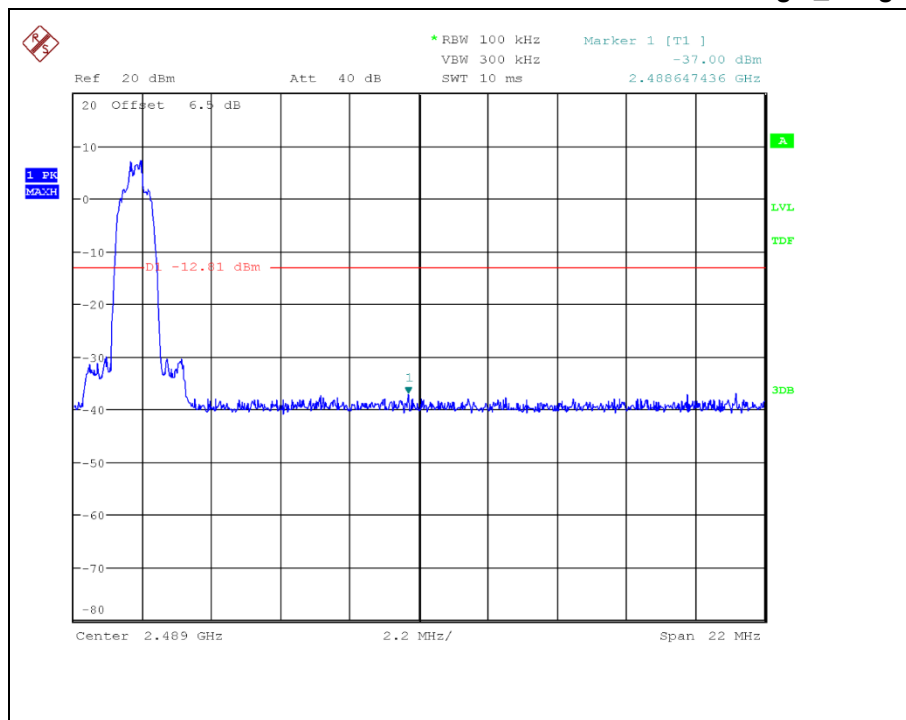
211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

- 8DPSK _ High frequency

Reference



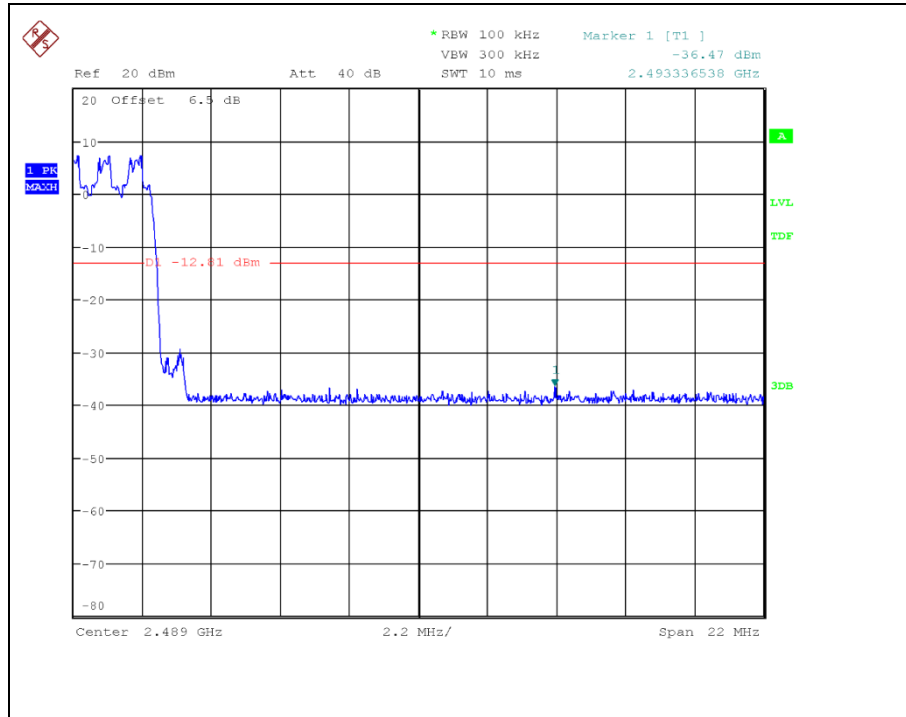
Bandedge _ Single



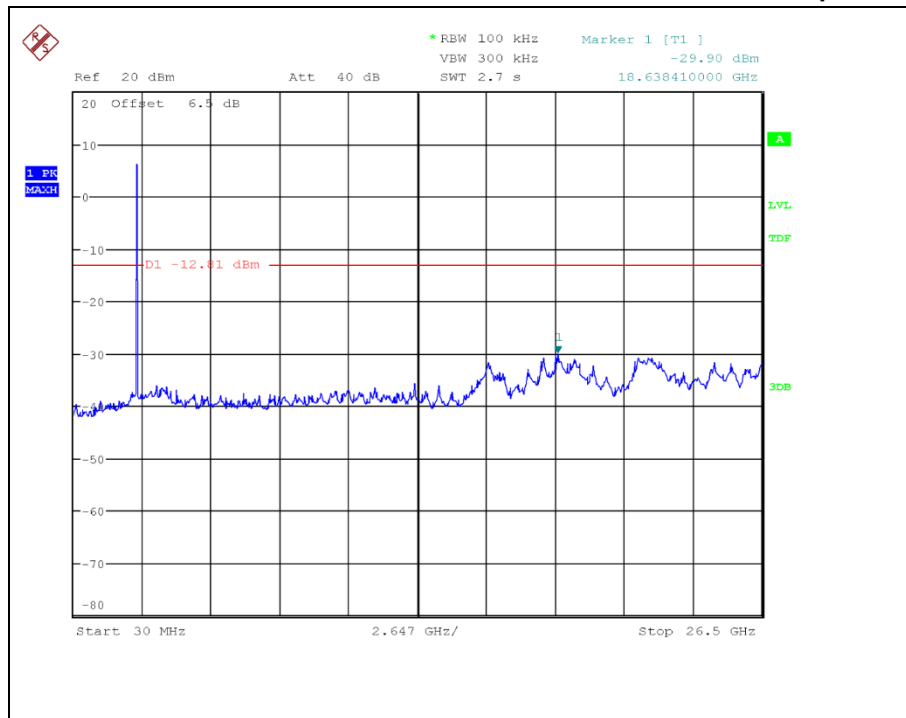
Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

Bandedge _ Hopping



Spurious



Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

3.3.8 Conducted Emission

3.3.8.1 Test Setup

See test photographs for the actual connections between EUT and support equipment.

3.3.8.2 Limit

According to §15.207(a) for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 uH/50 ohm line impedance stabilization network (LISN).

Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequency ranges.

Frequency Range (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15 ~ 0.5	66 to 56 *	56 to 46 *
0.5 ~ 5	56	46
5 ~ 30	60	50

* Decreases with the logarithm of the frequency

3.3.8.3 Test Procedure

Conducted emissions from the EUT were measured according to the ANSI C63.10.

1. The test procedure is performed in a 6.5 m × 3.5 m × 3.5 m (L × W × H) shielded room. The EUT along with its peripherals were placed on a 1.0 m (W) × 1.5 m (L) and 0.8 m in height wooden table and the EUT was adjusted to maintain a 0.4 meter space from a vertical reference plane.
2. The EUT was connected to power mains through a line impedance stabilization network (LISN) which provides 50 ohm coupling impedance for measuring instrument and the chassis ground was bounded to the horizontal ground plane of shielded room.
3. All peripherals were connected to the second LISN and the chassis ground also bounded to the horizontal ground plane of shielded room.
4. The excess power cable between the EUT and the LISN was bundled. The power cables of peripherals were unbundled. All connecting cables of EUT and peripherals were moved to find the maximum emission.

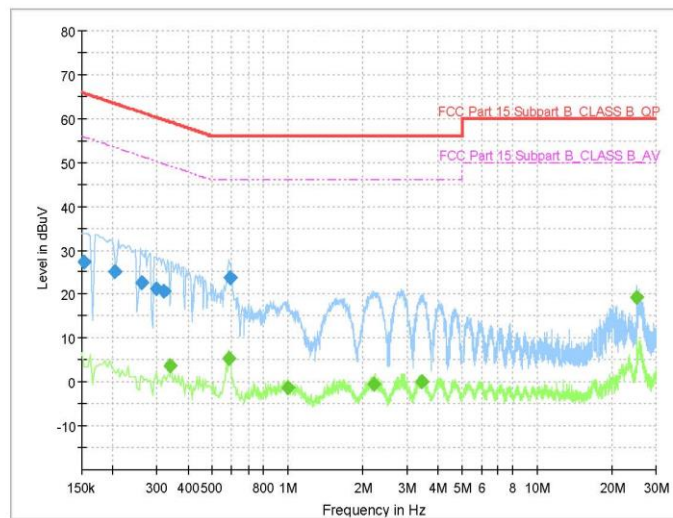
3.3.8.4 Test Result

- AC Line Conducted Emission (Graph)

Test Report

Common Information

Test Model: SP107
Test Standard: FCC Part 15 Subpart B
Test Mode: BT
Test Conditions: AC 120 V, 60 Hz / 24.5 °C, 47.8 % R. H.
Operator Name: JongMyoung, Shin
Comment: LINE
Order Number: -



Final Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.154000	27.43	—	65.78	38.35	1000.0	9.000	L1	10.5
0.204000	25.16	—	63.45	38.29	1000.0	9.000	L1	10.4
0.260000	22.66	—	61.43	38.77	1000.0	9.000	L1	10.4
0.300000	21.29	—	60.24	38.96	1000.0	9.000	L1	10.4
0.320000	20.66	—	59.71	39.05	1000.0	9.000	L1	10.4
0.340000	—	3.80	49.20	45.40	1000.0	9.000	L1	10.4
0.584000	—	5.48	46.00	40.52	1000.0	9.000	L1	10.4
0.588000	23.75	—	56.00	32.25	1000.0	9.000	L1	10.4
1.010000	—	-1.32	46.00	47.32	1000.0	9.000	L1	10.5
2.232000	—	-0.49	46.00	46.49	1000.0	9.000	L1	10.5
3.462000	—	-0.06	46.00	46.06	1000.0	9.000	L1	10.7
25.016000	—	19.23	50.00	30.77	1000.0	9.000	L1	11.9

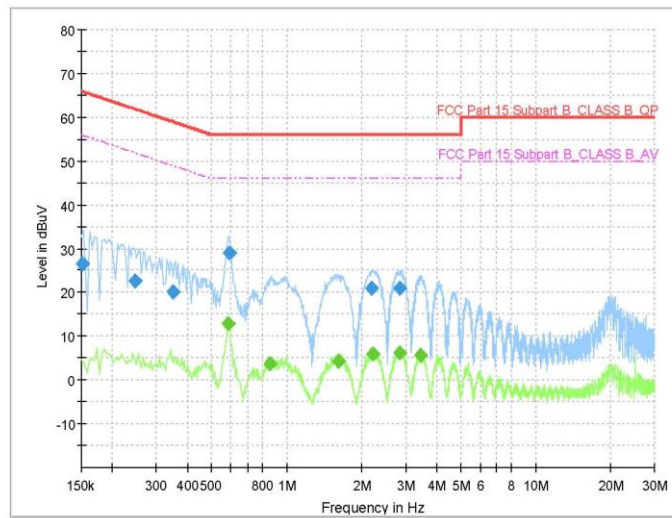
Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

Test Report

Common Information

Test Model: SP107
Test Standard: FCC Part 15 Subpart B
Test Mode: BT
Test Conditions: AC 120 V, 60 Hz / 24.5 °C, 47.8 % R. H.
Operator Name: JongMyoung, Shin
Comment: NEUTRAL
Order Number: -



Final Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.152000	26.50	---	65.89	39.39	1000.0	9.000	N	10.5
0.248000	22.62	---	61.82	39.21	1000.0	9.000	N	10.4
0.352000	20.05	---	58.92	38.87	1000.0	9.000	N	10.4
0.584000	---	12.90	46.00	33.10	1000.0	9.000	N	10.4
0.588000	28.99	---	56.00	27.01	1000.0	9.000	N	10.4
0.856000	---	3.81	46.00	42.19	1000.0	9.000	N	10.5
1.616000	---	4.35	46.00	41.65	1000.0	9.000	N	10.5
2.200000	20.96	---	56.00	35.04	1000.0	9.000	N	10.5
2.230000	---	5.81	46.00	40.19	1000.0	9.000	N	10.5
2.832000	20.81	---	56.00	35.19	1000.0	9.000	N	10.6
2.840000	---	6.08	46.00	39.92	1000.0	9.000	N	10.6
3.444000	---	5.59	46.00	40.41	1000.0	9.000	N	10.7

Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

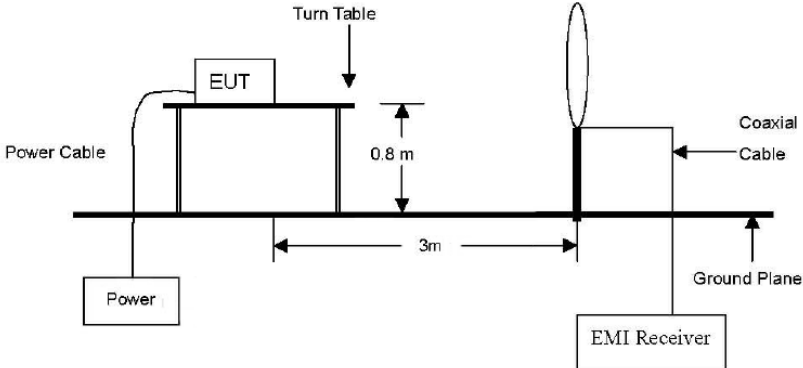
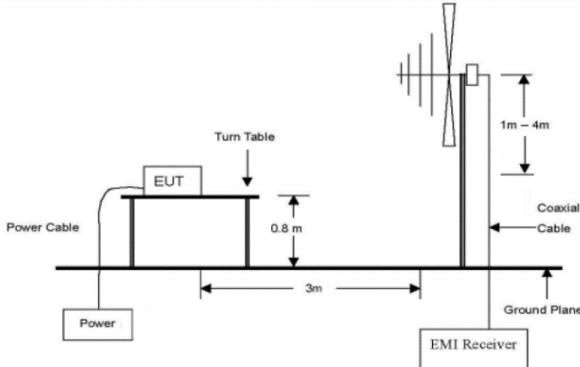
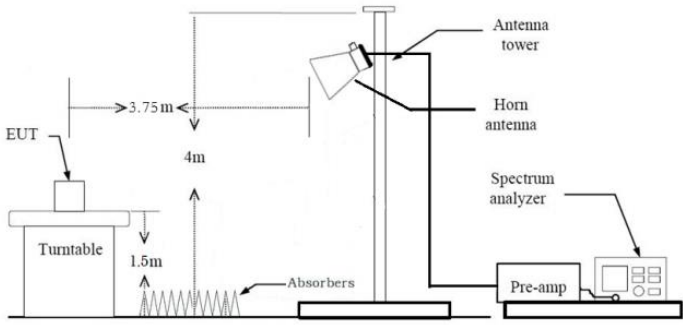
APPENDIX I

TEST SETUP

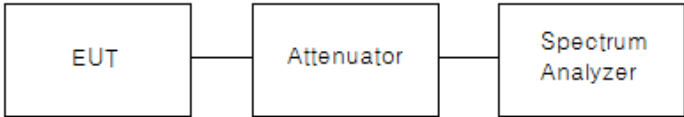
Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

- Radiated Measurement

below 30 MHz	
below 1 GHz	
above 1 GHz	Above 1 GHz 

- Conducted Measurement

Conducted	
-----------	--

Test Report No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

APPENDIX II

TEST EQUIPMENT USED FOR TESTS

Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

	Description	Manufacturer	Serial No.	Model No.	Cal. Date	Next Cal. Date
1	SPECTRUM ANALYZER	R&S	100617	FSP40	2021-03-09	2022-03-09
2	Power supply	GWInstek	EH120798	PST-3202	2021-03-09	2022-03-09
3	Bench-top Type Temperature & Humidity Chamber	ESPEC	92006813	SH-241	2021-09-02	2022-09-02
4	LOOP-ANTENNA	Schwarzbeck	00124	FMZB1519 B	2021-06-01	2023-06-01
5	TRILOG Broadband Antenna	Schwarzbeck	01027	VULB 9168	2021-06-08	2023-06-08
6	Double Ridged Broadband Horn Antenna	Schwarzbeck	02087	BBHA 9120D	2021-06-02	2022-06-02
7	Broadband Horn Antenna	Schwarzbeck	00938	BBHA 9170	2021-06-01	2022-06-01
8	Amplifier	TESTEK	190008-L	TK-PA1840H	2021-05-28	2022-05-28
9	Low Noise Amplifier	LTC MICROWAVE	143	LLA01185025Q	2021-09-03	2022-09-03
10	ATTENUATOR	INMET	279465	40AH2W	2021-07-27	2022-07-27
11	ATTENUATOR	Weinschel	none	WA41/12-30-12	2021-03-09	2022-03-09
12	High Pass Filter	WT Microwave INC	WT210907-1-2	WT-A3289-HS	2021-09-24	2022-09-24
13	LISN	Schwarzbeck	00984	NSLK 8127	2021-05-27	2022-05-27
14	EMI Test Receiver	R&S	102116	ESRP3	2021-05-27	2022-05-27
15	Signal Analyzer	Anritsu	6261745943	MS2850A	2021-12-07	2022-12-07

Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

APPENDIX III

UNCERTAINTY

Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071

Measurement Item	Expanded Uncertainty $U = kU_c (k=2)$
Conducted RF power	0.40 dB
Conducted Spurious Emissions	0.40 dB
Radiated Spurious Emissions	5.16 dB
Conducted Emissions	3.68 dB

Test Repot No.: NW2201-F001

211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, Korea 18511
www.nct.re.kr TEL: +82-31-323-6070 FAX: +82-31-323-6071