

TEST REPORT

of

FCC Part 15 Subpart C §15.247

FCC ID: TQ8-VCSA0ZZZXX

Equipment Under Test : Car Infotainment System
Model Name : VCSA0ZZZXX
Variant Model Name(s) : Refer to page 4
Applicant : HYUNDAI MOBIS CO., LTD.
Manufacturer : Hyundai Mobis Co., Ltd.
Date of Receipt : 2025.12.04
Date of Test(s) : 2025.12.08 ~ 2026.05.08
Date of Issue : 2026.05.21

In the configuration tested, the EUT complied with the standards specified above. This test report does not assure KOLAS accreditation.

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- 2) The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received.
- 3) This test report cannot be reproduced, except in full, without prior written permission of the Company.
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We are responsible for all the information of this test report except for the data(※) provided by the customer.

Tested by:



Dave Kim

Technical
Manager:



Jinhyoung Cho

SGS Korea Co., Ltd. Gunpo Laboratory

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1. General Information

1.1 Testing Laboratory

SGS Korea Co., Ltd. (Gunpo Laboratory)

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- Designation number: KR0150

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1.2. Details of Applicant

Applicant : HYUNDAI MOBIS CO., LTD.

Address : 203, Teheran-ro Gangnam-gu Seoul South Korea, 135-977

Contact Person : Choe, Seung-hoon

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1.3. Details of Manufacturer

Company : Hyundai Mobis Co., Ltd.

Address : 203, Teheran-ro, Gangnam-gu, Seoul, 06141, Republic of Korea

1.4. Description of EUT

Kind of Product	Car Infotainment System
Model Name	VCSA0ZZZXX
Variant Model Names	VCS40ZZZXX, VCS50ZZZXX, VCS60ZZZXX, VCS80ZZZXX, VCS90ZZZXX, VCSA0ZZZAN, VCS40ZZZAN, VCS50ZZZAN, VCS60ZZZAN, VCS80ZZZAN, VCS90ZZZAN, VCSA0ZZZKN, VCS40ZZZKN, VCS50ZZZKN, VCS60ZZZKN, VCS80ZZZKN, VCS90ZZZKN, VCSA0ZZZFN, VCS40ZZZFN, VCS50ZZZFN, VCS60ZZZFN, VCS80ZZZFN, VCS90ZZZFN
Serial Number	Conducted: C-0001 Radiated: R-0001
Power Supply	DC 14.4 V
Frequency Range	2 402 MHz ~ 2 480 MHz (Bluetooth)
Modulation Technique	GFSK, $\pi/4$ DQPSK, 8DPSK
Number of Channels	79 channels (Bluetooth)
Antenna Type	Ant.1: PCB Pattern Antenna Ant.2: PCB Pattern Antenna Ant.3: PCB Pattern Antenna
Antenna Gain*	Ant. 1 BT&BLE: 2 402 MHz ~ 2 480 MHz: 3.90 dB i WLAN5: 5 180 MHz ~ 5 240 MHz: 2.80 dB i 5 745 MHz ~ 5 805 MHz: 0.40 dB i
	Ant. 2 BT&BLE: 2 402 MHz ~ 2 480 MHz: 2.70 dB i WLAN5: 5 180 MHz ~ 5 240 MHz: 2.00 dB i 5 745 MHz ~ 5 805 MHz: 3.70 dB i
	Ant. 3 WLAN2: 2 412 MHz ~ 2 462 MHz: -0.20 dB i WLAN5: 5 180 MHz ~ 5 240 MHz: 3.90 dB i 5 745 MHz ~ 5 805 MHz: 2.00 dB i
H/W Version	1.0
S/W Version	1.0

1.5. Information about the FHSS characteristics:

1.5.1. Pseudorandom Frequency Hopping Sequence

The channel is represented by a pseudo-random hopping sequence hopping through the 79 RF channels. The hopping sequence is unique for the piconet and is determined by the Bluetooth device address of the master; the phase in the hopping sequence is determined by the Bluetooth clock of the master. The channel is divided into time slots where each slot corresponds to an RF hop frequency. Consecutive hops correspond to different RF hop frequencies. The nominal hop rate is 1 600 hops/s.

1.5.2. Equal Hopping Frequency Use

The channels of this system will be used equally over the long-term distribution of the hopsets.

1.5.3. Example of a 79 hopping sequence in data mode:

02, 05, 31, 24, 20, 10, 43, 36, 30, 23, 40, 06, 21, 50, 44, 09, 71, 78, 01, 13, 73, 07, 70, 72, 35, 62, 42, 11, 41, 08, 16, 29, 60, 15, 34, 61, 58, 04, 67, 12, 22, 53, 57, 18, 27, 76, 39, 32, 17, 77, 52, 33, 56, 46, 37, 47, 64, 49, 45, 38, 69, 14, 51, 26, 79, 19, 28, 65, 75, 54, 48, 03, 25, 66, 05, 16, 68, 74, 59, 63, 55

1.5.4. System Receiver Input Bandwidth

Each channel bandwidth is 1 MHz.

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

1.5.5. Equipment Description

15.247(a) (1) that the Rx input bandwidths shift frequencies in synchronization with the transmitted signals.

15.247(g): In accordance with the Bluetooth Industry Standard, the system is designed to comply with all of the regulations in Section 15.247 when the transmitter is presented with a continuous data (or information) system.

15.247(h): In accordance with the Bluetooth Industry Standard, the system does not coordinate its channels selection/ hopping sequence with other frequency hopping systems for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters.

1.6. Test Equipment List

Equipment	Manufacturer	Model	S/N	Cal. Date	Cal. Interval	Cal. Due
Signal Generator	R&S	SMA100B	106887	10/20/2025	Annual	10/20/2026
Spectrum Analyzer ¹⁾	R&S	FSV30	101004	12/18/2024 12/17/2025	Annual	12/18/2025 12/17/2026
Spectrum Analyzer	Agilent	N9020A	MY53421758	09/10/2025	Annual	09/10/2026
Spectrum Analyzer	Agilent	N9030A	US51350132	12/03/2025	Annual	12/03/2026
DC Power Supply	Agilent	U8002A	MY50020026	12/02/2025	Annual	12/02/2026
Bluetooth Tester	TESCOM	TC-3000C	3000C000560	09/10/2025	Annual	09/10/2026
Directional Coupler	KRYTAR	152613	122660	07/02/2025	Annual	07/02/2026
Bridge Coupler	MARKI MICROWAVE INC	CBR16-0012	1542	05/15/2025	Annual	05/15/2026
Power Sensor	R&S	NRP-Z81	100669	05/24/2025	Annual	05/24/2026
Preamplifier	H.P.	8447F	2944A03909	08/07/2025	Annual	08/07/2026
Preamplifier ²⁾	TESTEK	TK-PA1840H	130016	03/13/2025 03/06/2026	Annual	03/13/2026 03/06/2027
Signal Conditioning Unit ³⁾	R&S	SCU-18F	100959	07/13/2023 01/05/2026	Annual	07/13/2024 01/05/2027
EMI Test Receiver ⁴⁾	R&S	ESU26	100109	01/13/2025 01/21/2026	Annual	01/13/2026 01/21/2027
High Pass Filter	Wainwright Instrument GmbH	WHKX3.0/18G-10SS	21	06/17/2025	Annual	06/17/2026
High Pass Filter	Wainwright Instrument GmbH	WHNX7.5/26.5G-6SS	15	06/09/2025	Annual	06/09/2026
Low Pass Filter	MINI-CIRCUITS	NLP-1200+	V8979400903-1	05/23/2025	Annual	05/23/2026
Loop Antenna	Schwarzbeck Mess-Elektronik	FMZB 1519	1519-039	10/01/2025	Biennial	10/01/2027
Bilog Antenna	Schwarzbeck Mess-Elektronik	VULB9163	01126	03/05/2025	Biennial	03/05/2027
Horn Antenna ⁵⁾	R&S	HF906	100326	02/24/2025 03/03/2026	Annual	02/24/2026 03/03/2027
Horn Antenna	Schwarzbeck Mess-Elektronik	BBHA 9170	9170-540	12/05/2025	Annual	12/05/2026
Turn Table	Innco systems GmbH	DS 1200 S	N/A	N.C.R.	N/A	N.C.R.
Controller	Innco systems GmbH	CONTROLLER CO3000-4P	CO3000/963/3833 0516/L	N.C.R.	N/A	N.C.R.
Antenna Mast	Innco systems GmbH	MA4640-XP-ET	MA4640/536/3833 0516/L	N.C.R.	N/A	N.C.R.
Anechoic Chamber	SY Corporation	L x W x H (9.6 m x 6.4 m x 6.6 m)	N/A	N.C.R.	N/A	N.C.R.
Coaxial Cable ⁶⁾	SENSORVIEW	NMST-13A26-NMST-5 m	TPC2402190004	10/13/2025 04/17/2026	Semi-Annual	04/13/2026 10/17/2026
Coaxial Cable ⁶⁾	SENSORVIEW	NMST-13A26-NMST-10 m	TPC2402190001	10/13/2025 04/17/2026	Semi-Annual	04/13/2026 10/17/2026
Coaxial Cable ⁷⁾	RFONE	PL360P-292M292M-1.5M-A	20200324002	10/10/2025 04/10/2026	Semi-Annual	04/10/2026 10/10/2026
Coaxial Cable ⁷⁾	RADIALL	TESTPRO 3	182287	10/10/2025 04/10/2026	Semi-Annual	04/10/2026 10/10/2026
Coaxial Cable ⁷⁾	RADIALL	TESTPRO 3	182284	10/10/2025 04/10/2026	Semi-Annual	04/10/2026 10/10/2026

Note;

- 1) The equipment was not used for testing during the period from 12/15/2025 to 12/19/2025
- 2) The equipment was not used for testing during the period from 03/03/2026 to 03/09/2026
- 3) The equipment was used for testing only after its calibration was completed on 01/05/2026
- 4) The equipment was not used for testing during the period from 01/13/2026 to 01/22/2026
- 5) The equipment was not used for testing during the period from 02/24/2026 to 03/05/2026
- 6) The equipment was not used for testing during the period from 04/12/2026 to 04/17/2026
- 7) The equipment was not used for testing during the period from 04/09/2026 to 04/10/2026

1.7. Summary of Test Results

The EUT has been tested according to the following specifications:

APPLIED STANDARD: FCC Part15 Subpart		
Section	Test Item(s)	Result
15.205(a) 15.209 15.247(d)	Transmitter Radiated Spurious Emissions and Conducted Spurious Emission	Pass
15.247(a)(1)	20 dB Bandwidth and 99 % Bandwidth	Pass
15.247(a)(1) 15.247(b)(1)	Maximum Peak Conducted Output Power	Pass
15.247(a)(1)	Carrier Frequency Separation	Pass
15.247(a)(1)(iii)	Number of Hopping Frequencies	Pass
15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	Pass
15.207	AC Power Line Conducted Emission	N/A ¹⁾

Note;

- 1) The AC power line test was not performed because the EUT use battery power for operation and which do not operate from the AC power lines.

1.8. Test Procedure(s)

The measurement procedures described in the American National Standard of Procedure for Compliance Testing of Unlicensed Wireless Devices (ANSI C63.10-2020), as well as the guidance provided in KDB 558074 D01 15.247 Meas Guidance v05r02, were used in the measurement of the DUT.

1.9. Sample Calculation

Where relevant, the following sample calculation is provided:

1.9.1. Conducted Test

Offset value (dB) = Directional coupler (dB) + Cable loss (dB)

1.9.2. Radiation Test

Field strength level (dB μ V/m) = Measured level (dB μ V) + Antenna factor (dB/m) + Cable loss (dB) - Amplifier gain (dB) + Duty factor (dB)

1.10. Information of power setting and software for test

- The operating software of the EUT has an integrated test interface and transmits at its maximum rated output power setting.

1.11. Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Parameter	Uncertainty	
Maximum Peak Conducted Output Power	0.35 dB	
99 % Bandwidth	4.95 kHz	
20 dB Bandwidth	4.57 kHz	
Conducted Spurious Emission	0.89 dB	
Time of Occupancy	0.01 ms	
Radiated Emission, 9 kHz to 30 MHz	H	3.60 dB
	V	3.60 dB
Radiated Emission, below 1 GHz	H	5.50 dB
	V	5.10 dB
Radiated Emission, above 1 GHz	H	3.50 dB
	V	3.40 dB

All measurement uncertainty values are shown with a coverage factor $k = 2$ to indicate a 95 % level of confidence.

1.12. Test Report Revision

Revision	Report Number	Date of Issue	Description
0	F690501-RF-RTL006993	2026.05.21	Initial

1.13. Description of variant model

Model Name		DMB / DAB	HUD	HUD	Internal AMP 4ch	Internal AMP 2ch	Internal AMP 1ch	External AMP	RVM / SVM	Built-in Cam	ICMU	ICMC (cargo view)
Basic Model	VCSA0ZZZX	○	○	○	○	○	○	○	○	○	○	○
Variant Model	VCS40ZZZX		X	X	○	X	X	X	○	○	○	X
	VCS50ZZZX		X	X	○	○	○	X	○	○	○	X
	VCS60ZZZX		X	X	X	X	X	○	○	○	○	X
	VCS80ZZZX		○	○	○	○	○	X	○	○	○	X
	VCS90ZZZX		○	○	X	X	X	○	○	○	○	X
	VCSA0ZZZAN	X	○	○	○	○	○	○	○	○	○	○
	VCS40ZZZAN		X	X	○	X	X	X	○	○	○	X
	VCS50ZZZAN		X	X	○	○	○	X	○	○	○	X
	VCS60ZZZAN		X	X	X	○	○	○	○	○	○	X
	VCS80ZZZAN		○	○	○	○	○	X	○	○	○	X
	VCS90ZZZAN		○	○	X	○	○	○	○	○	○	X
	VCSA0ZZZKN		○	○	○	○	○	○	○	○	○	○
	VCS40ZZZKN		X	X	○	X	X	X	○	○	○	X
	VCS50ZZZKN		X	X	○	○	○	X	○	○	○	X
	VCS60ZZZKN		X	X	X	○	○	○	○	○	○	X
	VCS80ZZZKN		○	○	○	○	○	X	○	○	○	X
	VCS90ZZZKN		○	○	X	○	○	○	○	○	○	X
	VCSA0ZZZFN		○	○	○	○	○	○	○	○	○	○
	VCS40ZZZFN		X	X	○	X	X	X	○	○	○	X
	VCS50ZZZFN		X	X	○	○	○	X	○	○	○	X
	VCS60ZZZFN		X	X	X	○	○	○	○	○	○	X
	VCS80ZZZFN		○	○	○	○	○	X	○	○	○	X
	VCS90ZZZFN		○	○	X	○	○	○	○	○	○	X

Note;

- The all test items performed with basic model

1.14. Device Capabilities

Mode	SISO			CDD / MIMO
	Ant. 1	Ant. 2	Ant. 3	Ant. 1 + Ant. 2
Bluetooth Low Energy	○	○	X	X
Bluetooth	○	○	X	X
WLAN 2 GHz	X	X	○	X
WLAN 5 GHz	○	○	○	○

Note;

- The EUT has three ports and supports MIMO operation only for ANT 1+2 in the WLAN 5GHz band, while IEEE 802.11a operates in SISO mode only.
- The EUT supported PHY 1M only For Bluetooth Low Energy.

1.15. Descriptions of Test Mode

Preliminary tests were performed in different data rates and recorded the RF output power in the following table:

Ant. 1

Mode	Data Rate (Mbps)	Packet Type	Frequency (MHz)	RF Peak Output Power (dB m)
GFSK	1	DH1	2 480	1.91
		DH3		<u>1.91</u>
		DH5		1.84
$\pi/4$ DQPSK	2	DH1	2 480	2.58
		DH3		<u>2.89</u>
		DH5		2.83
8DPSK	3	DH1	2 480	3.17
		DH3		<u>3.36</u>
		DH5		3.21

Note;

For transmitter radiated spurious emissions, conducted spurious emission, carrier frequency separation and number of hopping frequencies, GFSK / DH3 and 8DPSK / 3DH3 are tested as worst condition.

For 20 dB bandwidth and maximum peak conducted output power, GFSK / DH3, $\pi/4$ DQPSK / 2DH3 and 8DPSK / 3DH3 are tested as worst condition.

For Time of Occupancy, GFSK / DH5 and 8DPSK / 3DH5 are tested as worst condition.

Ant. 2

Mode	Data Rate (Mbps)	Packet Type	Frequency (MHz)	RF Peak Output Power (dB m)
GFSK	1	DH1	2 480	<u>2.34</u>
		DH3		2.27
		DH5		2.27
$\pi/4$ DQPSK	2	DH1	2 480	3.74
		DH3		3.80
		DH5		<u>4.09</u>
8DPSK	3	DH1	2 480	4.20
		DH3		<u>4.38</u>
		DH5		4.35

Note;

For transmitter radiated spurious emissions, conducted spurious emission, carrier frequency separation and number of hopping frequencies, GFSK / DH1 and 8DPSK / 3DH3 are tested as worst condition.

For 20 dB bandwidth and maximum peak conducted output power, GFSK / DH1, $\pi/4$ DQPSK / 2DH5 and 8DPSK / 3DH3 are tested as worst condition.

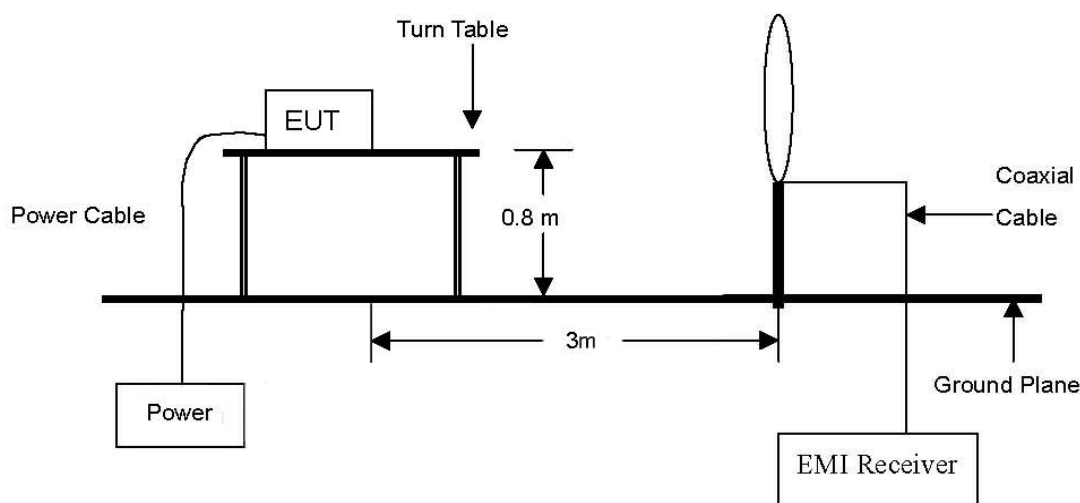
For Time of Occupancy, GFSK / DH5 and 8DPSK / 3DH5 are tested as worst condition.

2. Transmitter Radiated Spurious Emissions and Conducted Spurious Emissions

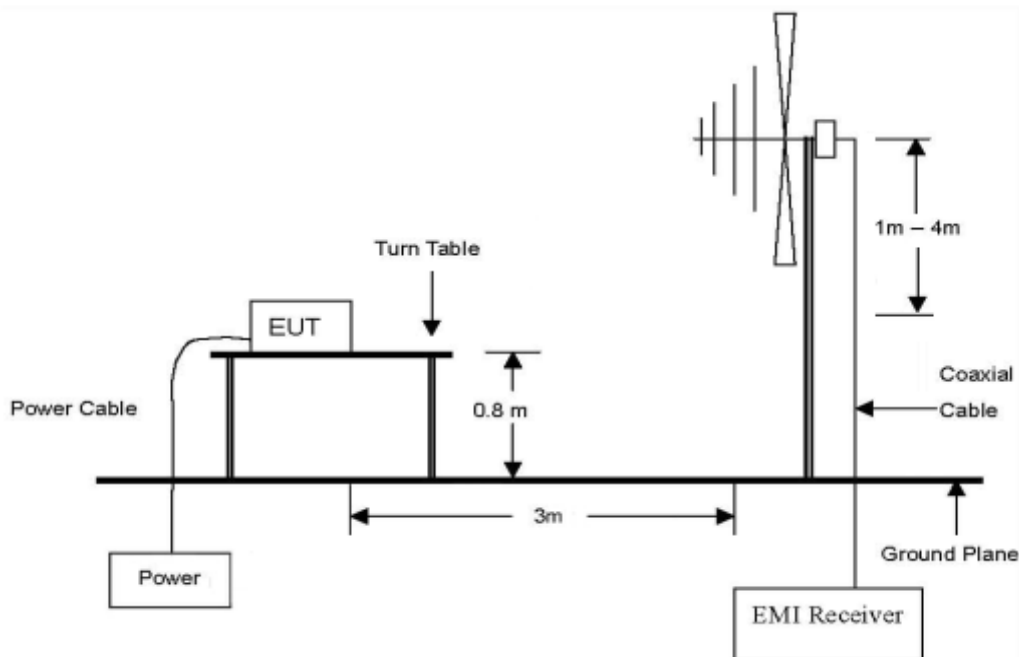
2.1. Test Setup

2.1.1. Transmitter Radiated Spurious Emissions

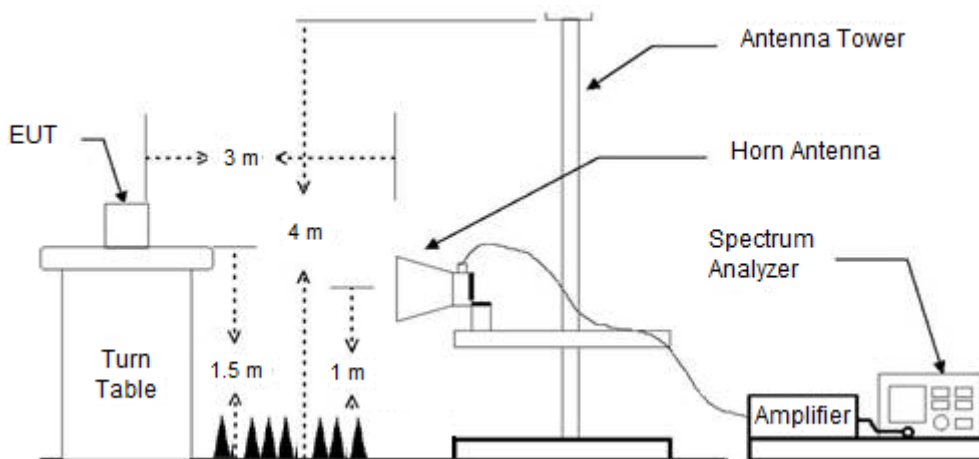
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz.



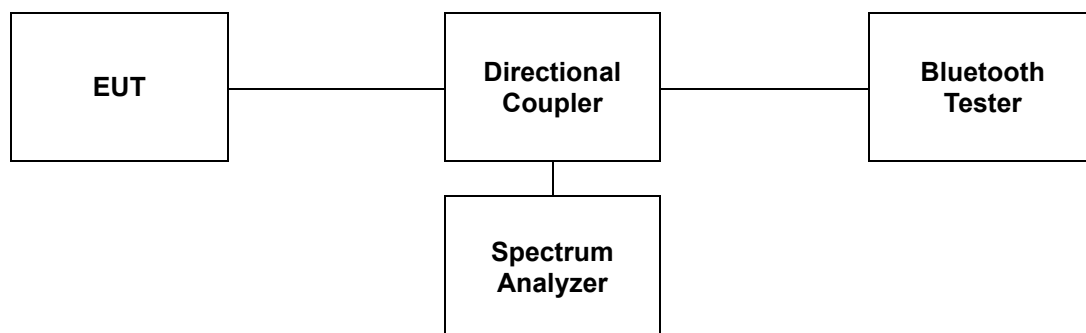
The diagram below shows the test setup that is utilized to make the measurements for emission from 30 MHz to 1 GHz.



The diagram below shows the test setup that is utilized to make the measurements for emission. The spurious emissions were investigated from 1 GHz to the 10th harmonic of the highest fundamental frequency or 40 GHz, whichever is lower.



2.1.2. Conducted Spurious Emissions



2.2. 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 §15.209(a) is not required. In addition, radiated emission 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)).

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

Frequency (MHz)	Field Strength ($\mu\text{V/m}$)	Measurement Distance (Meters)
0.009-0.490	2 400/F(kHz)	300
0.490-1.705	24 000/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.

2.3. Test Procedures

Radiated emissions from the EUT were measured in accordance with sections 11.11 & 11.12 of ANSI C63.10-2020.

2.3.1. Test Procedures for emission below 30 MHz

1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
2. Then antenna is a loop antenna is fixed at one meter above the ground to determine the maximum value of the field strength. Both parallel and perpendicular of the antenna are set to make the measurement.
3. For each suspected emission, the EUT was arranged to its worst case and then the table was turned from 0 degrees to 360 degrees to find the maximum reading.
4. The test-receiver system was set to average or quasi peak detect function and Specified Bandwidth with Maximum Hold Mode.

2.3.2. Test Procedures for emission from above 30 MHz

1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter anechoic chamber test site below 1 GHz and 1.5 meter above the ground at a 3 meter anechoic chamber test site above 1 GHz. 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 3 meter away from the interference-receiving antenna.
3. The antenna is a bi-log antenna, a horn 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.
4. 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.
5. For measurements below 1 GHz resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.
6. For measurements Above 1 GHz resolution bandwidth is set to 1 MHz, the video bandwidth is set to 3 MHz for peak measurements.

2.3.3. Test Procedures for Average measurements

Radiated emissions for average measurements were according to section 7.8.8.2 of ANSI C63.10-2020

Where average measurements of an emission are required it is permitted to determine the average value over 100 ms after accounting for the maximum dwell time per 1 MHz in any 100 ms period. The dwell time in any 100 ms period can include multiple hops on that frequency for devices which have a short dwell time.

The maximum dwell time per 1 MHz does need to account for cases where the channel spacing is less than the 1 MHz measurement bandwidth and for cases where the occupied bandwidth exceeds the channel spacing and the channels overlap. The maximum dwell time per 1 MHz is determined as follows:

Maximum dwell time per 1 MHz = dwell time per 100 ms per channel × (channel separation correction + overlapping channel correction) where:

- Channel separation correction = $[1 / \text{channel separation (MHz)}]$ for channel separation < 1 MHz, and = 1 for channel separation ≥ 1 MHz, as determined using the procedures of 7.8.2. If the average measurements are performed on the Nth harmonic, the channel separation value is N times the separation at the fundamental frequency.
- Overlapping channel correction = 0 when the 20 dB channel bandwidth < channel separation and 1 for when the 20 dB channel bandwidth > channel separation.

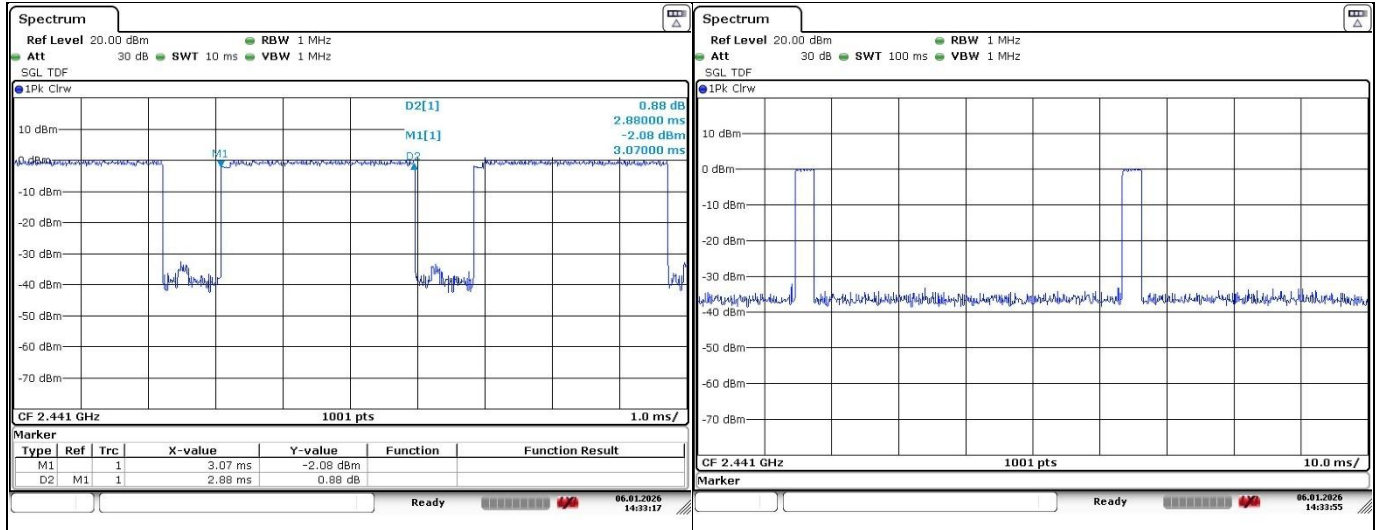
The average value may be determined as follows:

- a) From the peak value of the emission: The measured peak value in dB μ V/m is corrected by $20 \log(\text{maximum dwell time in 100 ms} / 100)$.
- b) From the average value of the emission: When the average value has been measured with the device continuously transmitting (100% duty cycle) the measured average value in dB μ V/m is corrected by $X \log(\text{maximum dwell time in 100 ms} / 100)$ where X = 10 if using an rms-average power detector (with output data in power terms) and X = 20 if using a linear voltage average detector (with output data in voltage terms).

- Ant. 1

on time on Channel

dwelt time per 100 ms per channel



In AFH mode, the minimum hopping frequencies are 20, to get the longest dwell time 3DH5 packet is observed.

the period to have 3DH5 packet completing one hopping sequence is $2.88 \text{ ms} \times 20 \text{ channels} = 57.60 \text{ ms}$

There cannot be 2 complete hopping sequences within 100 ms period, considering the random hopping behavior, maximum 2 hops can be possibly observed within the period. $[100 \text{ ms} / 57.60 \text{ ms}] = 2 \text{ hops}$

Thus, the possible dwell time per 100 ms per channel:

$$2.88 \text{ ms} \times 2 = 5.76 \text{ ms}$$

For the 3DH5, the channel separation is 1 MHz, Channel separation correction = 1

For the 3DH5, 20 dB channel bandwidth > channel separation, Overlapping channel correction = 1

Maximum dwell time in 100 ms = dwell time per 100 ms per channel $\times$ (channel separation correction + overlapping channel correction)

$$5.76 \text{ ms} \times (1 + 1) = 11.52 \text{ ms}$$

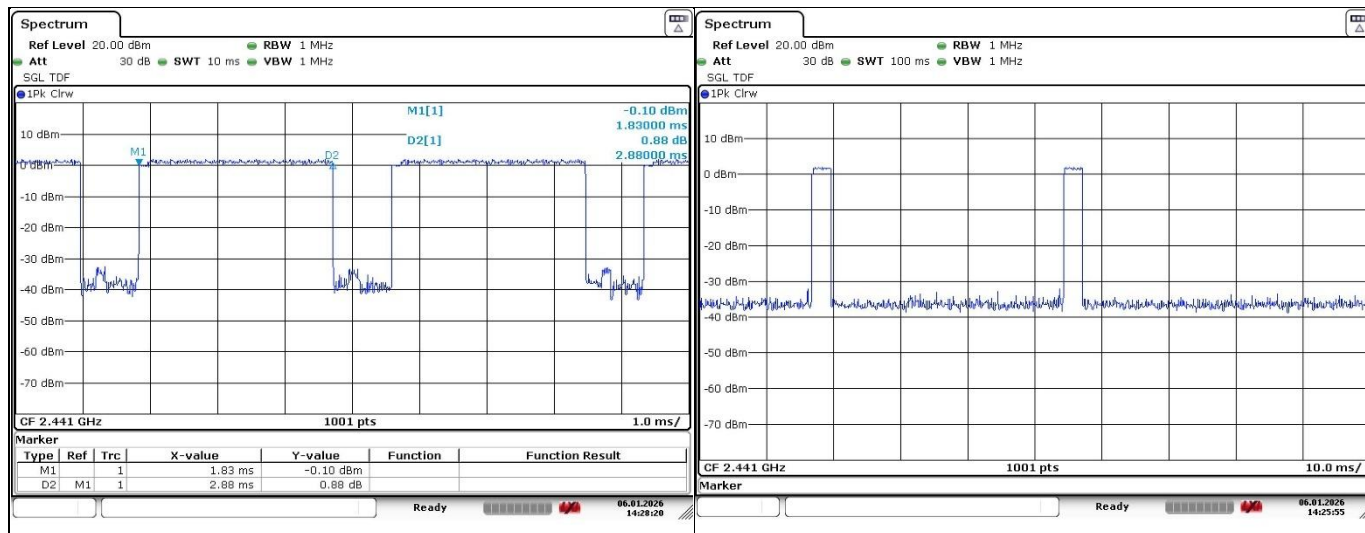
Correction factor for average value is follow:

$$20 \times \log (11.52 \text{ ms}/100 \text{ ms}) = -18.77 \text{ dB}$$

- Ant. 2

on time on Channel

dwelt time per 100 ms per channel



In AFH mode, the minimum hopping frequencies are 20, to get the longest dwell time 3DH5 packet is observed.

the period to have 3DH5 packet completing one hopping sequence is $2.88 \text{ ms} \times 20 \text{ channels} = 57.60 \text{ ms}$

There cannot be 2 complete hopping sequences within 100 ms period, considering the random hopping behavior, maximum 2 hops can be possibly observed within the period. $[100 \text{ ms} / 57.60 \text{ ms}] = 2 \text{ hops}$

Thus, the possible dwell time per 100 ms per channel:

$$2.88 \text{ ms} \times 2 = 5.76 \text{ ms}$$

For the 3DH5, the channel separation is 1 MHz, Channel separation correction = 1

For the 3DH5, 20 dB channel bandwidth > channel separation, Overlapping channel correction = 1

Maximum dwell time in 100 ms = dwell time per 100 ms per channel $\times$ (channel separation correction + overlapping channel correction)

$$5.76 \text{ ms} \times (1 + 1) = 11.52 \text{ ms}$$

Correction factor for average value is follow:

$$20 \times \log (11.52 \text{ ms}/100 \text{ ms}) = -18.77 \text{ dB}$$

2.3.4. Test Procedures for Conducted Spurious Emissions

2.3.4.1. Band-edge Compliance of RF Conducted Emissions

The transmitter output was connected to the spectrum analyzer.

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 which fall outside of the authorized band of operation.

RBW $\geq$ 100 kHz

VBW = 300 kHz

Sweep = auto

Detector function = peak

Trace = max hold

2.3.4.2. Spurious RF Conducted Emissions

The transmitter output was connected to the spectrum analyzer.

RBW = 1 MHz

VBW = 3 MHz

Sweep = auto

Detector function = peak

Trace = max hold

2.3.4.3. TDF function

- For plots showing conducted spurious emissions from 9 kHz to 25 GHz, all path loss of wide frequency range was investigated and compensated to spectrum analyzer as TDF function.

So, the reading values shown in plots were final result.

2.4. Test Results

Ambient temperature : (23 ± 1) °C
Relative humidity : 47 %

2.4.1. Radiated Spurious Emission below 1 000 MHz

The frequency spectrum from 9 kHz to 1 000 MHz was investigated.

Ant. 1

Radiated Emissions			Ant.	Correction (dB/m)	Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.		Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
Below 30.00	Not detected	-	-	-	-	-	-
above 30.00	Not detected	-	-	-	-	-	-

Remark;

- Spurious emissions for all channels and modes were investigated and almost the same below 1 GHz.
- Test from 30 MHz to 1 000 MHz was performed using the software of ELEKTRA(V5.02) from Rohde & Schwarz GmbH & Co. KG.
- Reported spurious emissions are in **EDR / 3DH3 / High channel** as worst case among other modes and channels.
- Radiated spurious emission measurement as below.
(Actual = Reading + Correction)
(Correction = Antenna Factor + AMP Factor + Cable Loss)
- According to §15.31(o), emission levels are not report much lower than the limits by over 20 dB.

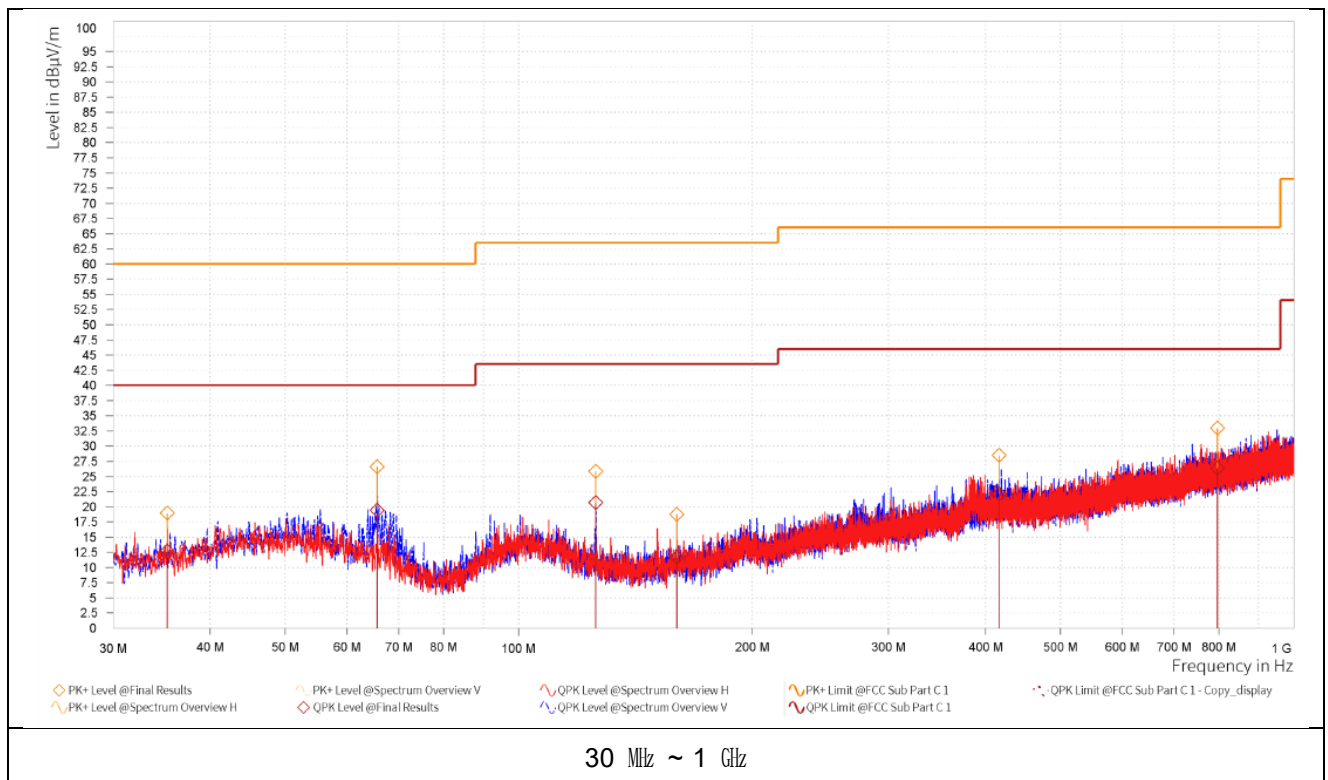
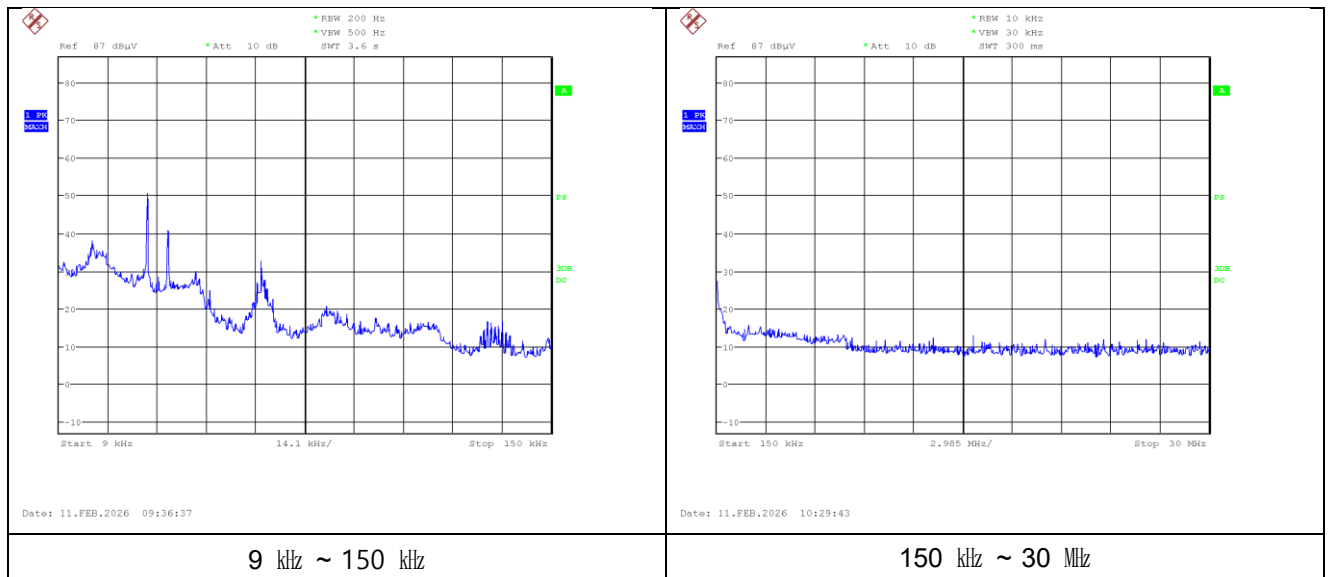
Ant. 2

Radiated Emissions			Ant.	Correction (dB/m)	Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.		Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
Below 30.00	Not detected	-	-	-	-	-	-
above 30.00	Not detected	-	-	-	-	-	-

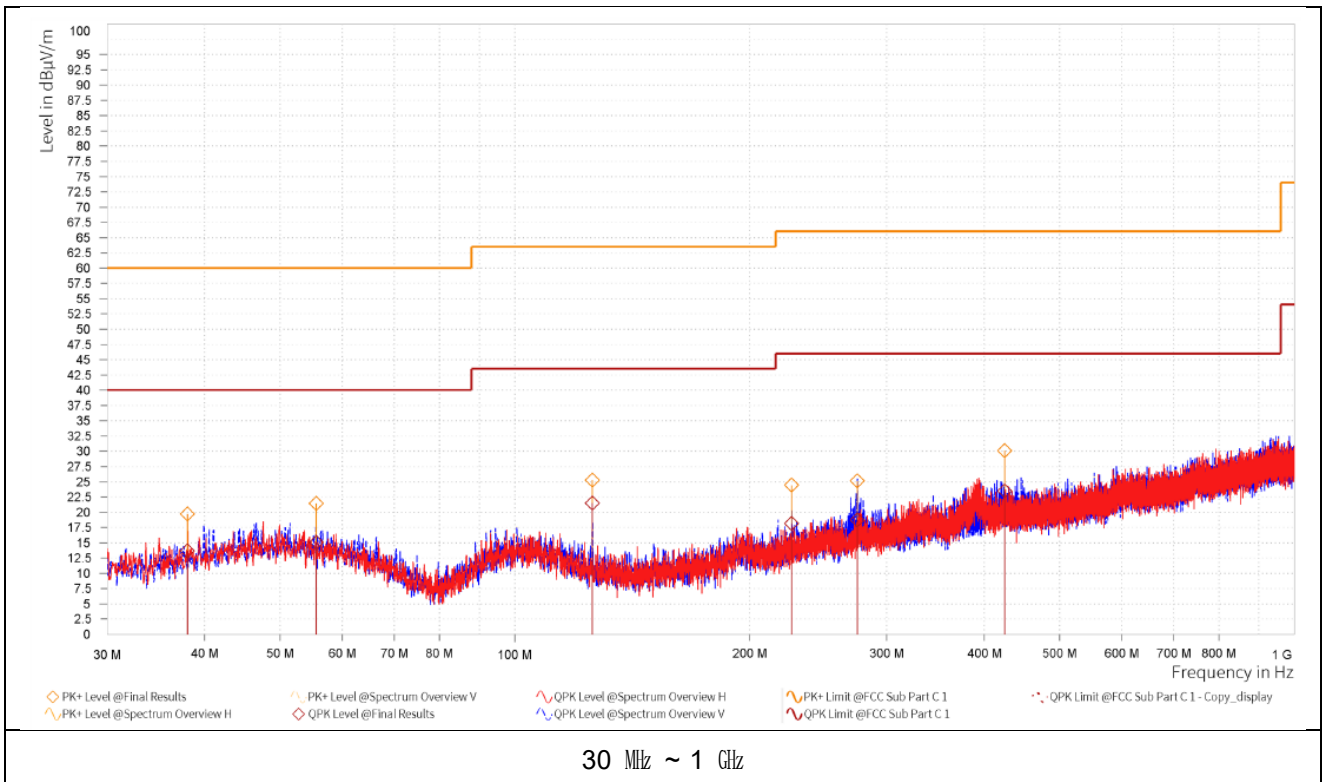
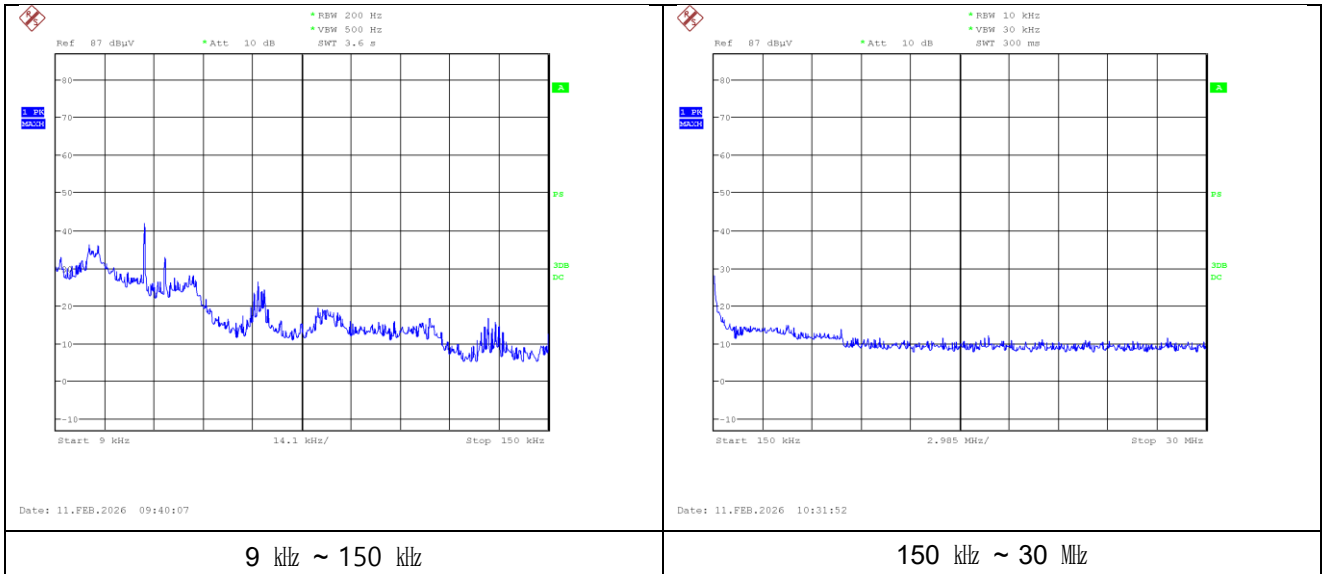
Remark;

- Spurious emissions for all channels and modes were investigated and almost the same below 1 GHz.
- Test from 30 MHz to 1 000 MHz was performed using the software of ELEKTRA(V5.02) from Rohde & Schwarz GmbH & Co. KG.
- Reported spurious emissions are in **EDR / 3DH3 / High channel** as worst case among other modes and channels.
- Radiated spurious emission measurement as below.
(Actual = Reading + Correction)
(Correction = Antenna Factor + AMP Factor + Cable Loss)
- According to §15.31(o), emission levels are not report much lower than the limits by over 20 dB.

- Test plots



Ant. 2



2.4.2. Radiated Spurious Emission above 1 000 MHz

The frequency spectrum above 1 000 MHz was investigated. All reading values are peak values.

- Ant. 1

Operating Mode: GFSK

A. Low Channel (2 402 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	DF (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
*2 310.00	14.02	Peak	V	27.94	7.33	-	49.29	74.00	24.71
*2 310.00	-	Average	-	-	-	-18.77	30.52	54.00	23.48
*2 385.03	15.89	Peak	V	28.17	7.55	-	51.61	74.00	22.39
*2 385.03	-	Average	-	-	-	-18.77	32.84	54.00	21.16
*2 390.00	14.20	Peak	V	28.18	7.59	-	49.97	74.00	24.03
*2 390.00	-	Average	-	-	-	-18.77	31.20	54.00	22.80

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

B. Middle Channel (2 441 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

C. High Channel (2 480 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	DF (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
*2 483.50	22.93	Peak	V	28.34	7.58	-	58.85	74.00	15.15
*2 483.50	-	Average	-	-	-	-18.77	40.08	54.00	13.92
*2 483.54	23.30	Peak	V	28.34	7.58	-	59.22	74.00	14.78
*2 483.54	-	Average	-	-	-	-18.77	40.45	54.00	13.55
*2 500.00	14.70	Peak	V	28.50	7.74	-	50.94	74.00	23.06
*2 500.00	-	Average	-	-	-	-18.77	32.17	54.00	21.83

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

Operating Mode: 8DPSK

A. Low Channel (2 402 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	DF (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
*2 310.00	14.61	Peak	V	27.94	7.33	-	49.88	74.00	24.12
*2 310.00	-	Average	-	-	-	-18.77	31.11	54.00	22.89
*2 353.13	15.37	Peak	V	28.11	7.32	-	50.80	74.00	23.20
*2 353.13	-	Average	-	-	-	-18.77	32.03	54.00	21.97
*2 390.00	13.72	Peak	V	28.18	7.59	-	49.49	74.00	24.51
*2 390.00	-	Average	-	-	-	-18.77	30.72	54.00	23.28

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

B. Middle Channel (2 441 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

C. High Channel (2 480 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	DF (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
*2 483.50	22.79	Peak	V	28.34	7.58	-	58.71	74.00	15.29
*2 483.50	-	Average	-	-	-	-18.77	39.94	54.00	14.06
*2 483.54	23.03	Peak	V	28.34	7.58	-	58.95	74.00	15.05
*2 483.54	-	Average	-	-	-	-18.77	40.18	54.00	13.82
*2 500.00	13.82	Peak	V	28.50	7.74	-	50.06	74.00	23.94
*2 500.00	-	Average	-	-	-	-18.77	31.29	54.00	22.71

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

Remark;

1. “*” means the restricted band.
2. Measuring frequencies from 1 GHz to the 10th harmonic of highest fundamental frequency.
3. Radiated emissions measured in frequency above 1 000 MHz were made with an instrument using peak/average detector mode.
4. Actual = Reading + AF + CL + (DF) or Reading + AF + AMP + CL + (DF).
5. According to § 15.31(o), emission levels are not reported much lower than the limits by over 20 dB.
6. The maximized peak measured value complies with the average limit, to perform an average measurement is unnecessary.

- Ant. 2

Operating Mode: GFSK

A. Low Channel (2 402 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	DF (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
*2 310.00	13.24	Peak	V	27.94	7.33	-	48.51	74.00	25.49
*2 310.00	-	Average	-	-	-	-18.77	29.74	54.00	24.26
*2 341.23	15.65	Peak	V	28.06	7.29	-	51.00	74.00	23.00
*2 341.23	-	Average	-	-	-	-18.77	32.23	54.00	21.77
*2 390.00	13.84	Peak	V	28.18	7.59	-	49.61	74.00	24.39
*2 390.00	-	Average	-	-	-	-18.77	30.84	54.00	23.16

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

B. Middle Channel (2 441 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

C. High Channel (2 480 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	DF (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
*2 483.50	21.91	Peak	V	28.34	7.58	-	57.83	74.00	16.17
*2 483.50	-	Average	-	-	-	-18.77	39.06	54.00	14.94
*2 483.56	22.40	Peak	V	28.34	7.58	-	58.32	74.00	15.68
*2 483.56	-	Average	-	-	-	-18.77	39.55	54.00	14.45
*2 500.00	17.96	Peak	V	28.50	7.74	-	54.20	74.00	19.80
*2 500.00	-	Average	-	-	-	-18.77	35.43	54.00	18.57

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

Operating Mode: 8DPSK

A. Low Channel (2 402 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	DF (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
*2 310.00	13.41	Peak	V	27.94	7.33	-	48.68	74.00	25.32
*2 310.00	-	Average	-	-	-	-18.77	29.91	54.00	24.09
*2 336.28	14.70	Peak	V	28.05	7.29	-	50.04	74.00	23.96
*2 336.28	-	Average	-	-	-	-18.77	31.27	54.00	22.73
*2 390.00	15.03	Peak	V	28.18	7.59	-	50.80	74.00	23.20
*2 390.00	-	Average	-	-	-	-18.77	32.03	54.00	21.97

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

B. Middle Channel (2 441 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dB μ V)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

C. High Channel (2 480 MHz)

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	CL (dB)	DF (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
*2 483.50	21.87	Peak	V	28.34	7.58	-	57.79	74.00	16.21
*2 483.50	-	Average	-	-	-	-18.77	39.02	54.00	14.98
*2 483.53	21.57	Peak	V	28.34	7.58	-	57.49	74.00	16.51
*2 483.53	-	Average	-	-	-	-18.77	38.72	54.00	15.28
*2 500.00	18.46	Peak	V	28.50	7.74	-	54.70	74.00	19.30
*2 500.00	-	Average	-	-	-	-18.77	35.93	54.00	18.07

Radiated Emissions			Ant.	Correction Factors			Total	Limit	
Frequency (MHz)	Reading (dBμV)	Detect Mode	Pol.	AF (dB/m)	AMP+CL (dB)	DF (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)
Above 1 000.00	Not detected	-	-	-	-	-	-	-	-

Remark;

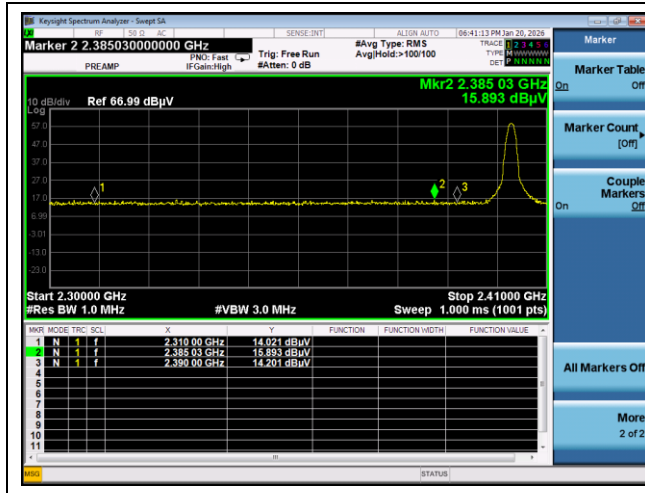
1. “*” means the restricted band.
2. Measuring frequencies from 1 GHz to the 10th harmonic of highest fundamental frequency.
3. Radiated emissions measured in frequency above 1 000 MHz were made with an instrument using peak/average detector mode.
4. Actual = Reading + AF + CL + (DF) or Reading + AF + AMP + CL + (DF).
5. According to § 15.31(o), emission levels are not reported much lower than the limits by over 20 dB.
6. The maximized peak measured value complies with the average limit, to perform an average measurement is unnecessary.

- Test plots

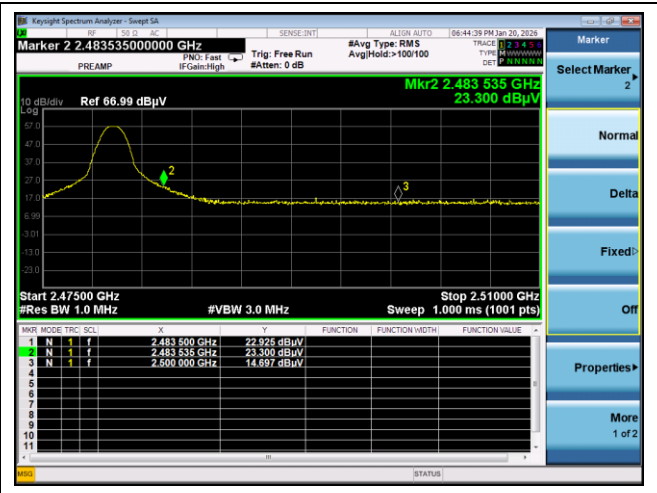
Ant. 1

Mode: GFSK

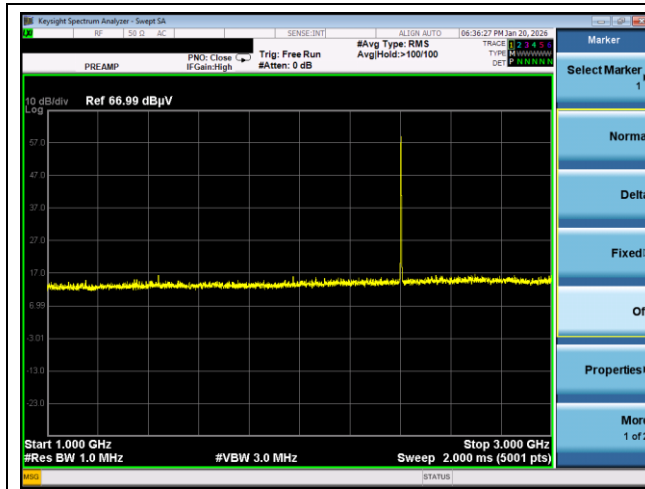
Low channel band edge (Peak)



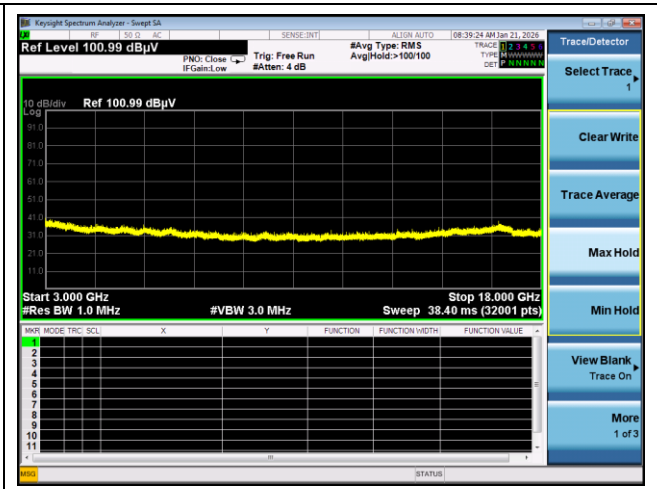
High channel band edge (Peak)



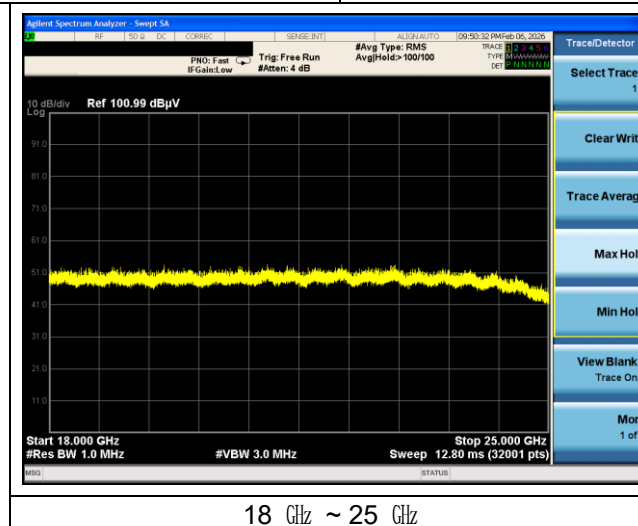
Radiated Spurious Emissions



1 GHz ~ 3 GHz



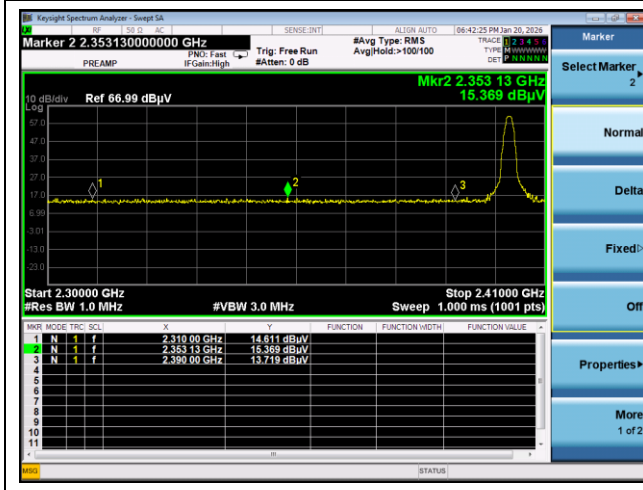
3 GHz ~ 18 GHz



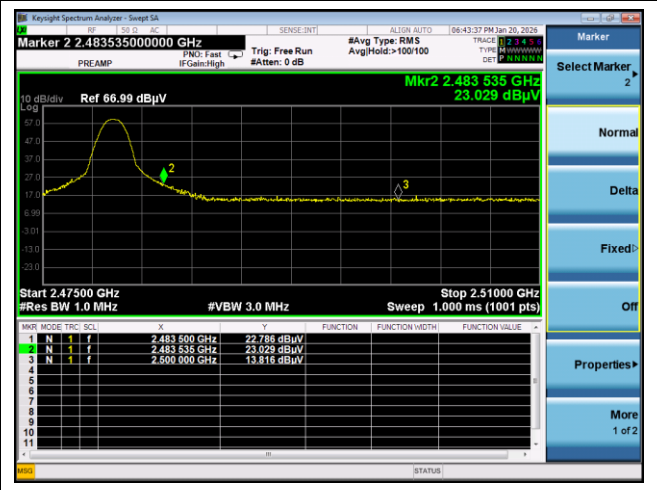
18 GHz ~ 25 GHz

Mode: 8DPSK

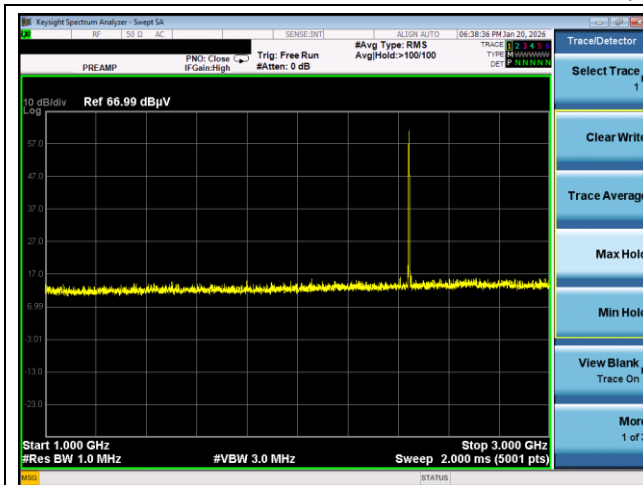
Low channel band edge (Peak)



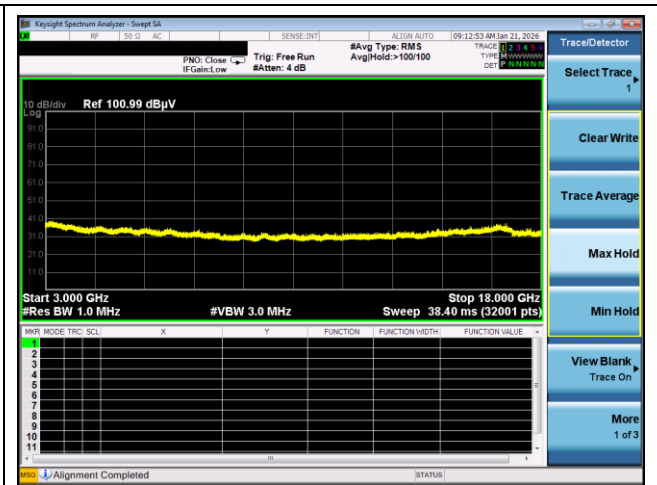
High channel band edge (Peak)



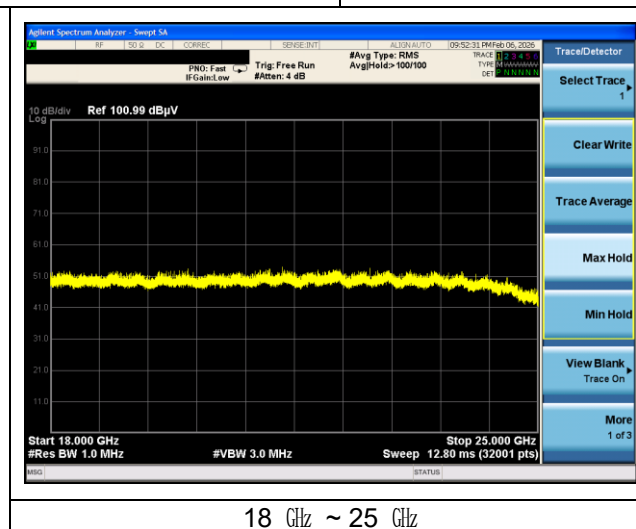
Radiated Spurious Emissions



1 GHz ~ 3 GHz



3 GHz ~ 18 GHz

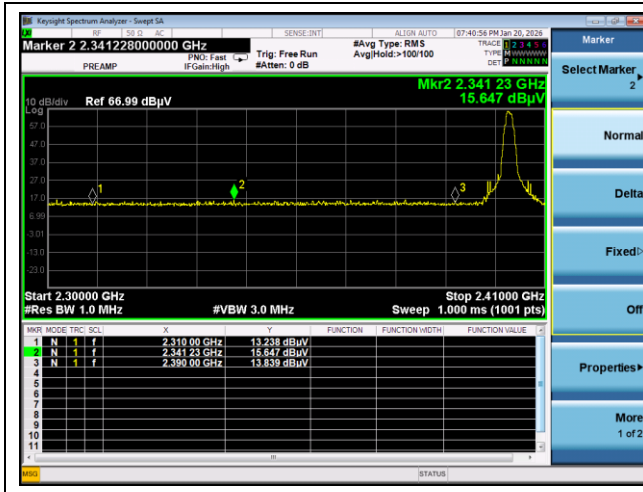


18 GHz ~ 25 GHz

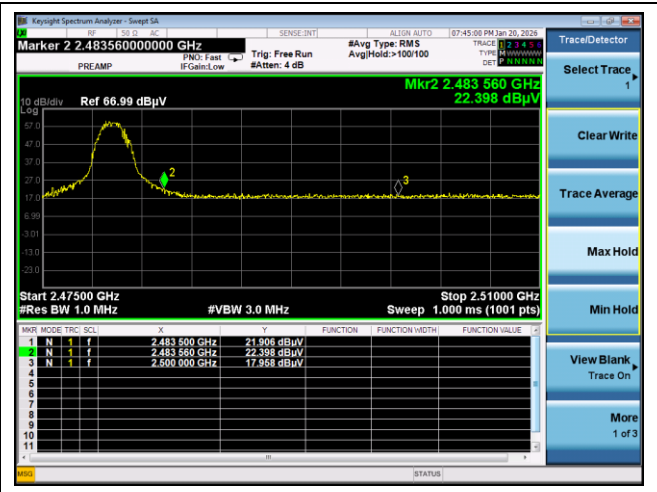
Ant. 2

Mode: GFSK

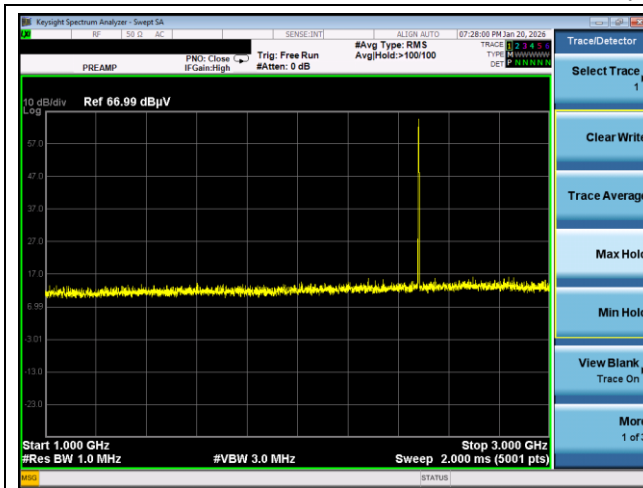
Low channel band edge (Peak)



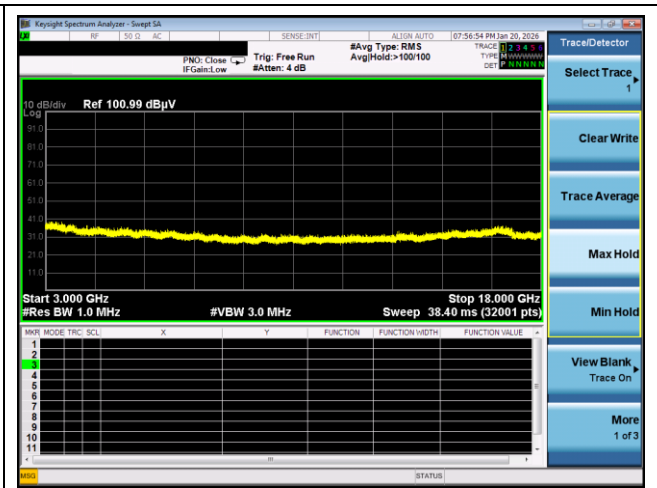
High channel band edge (Peak)



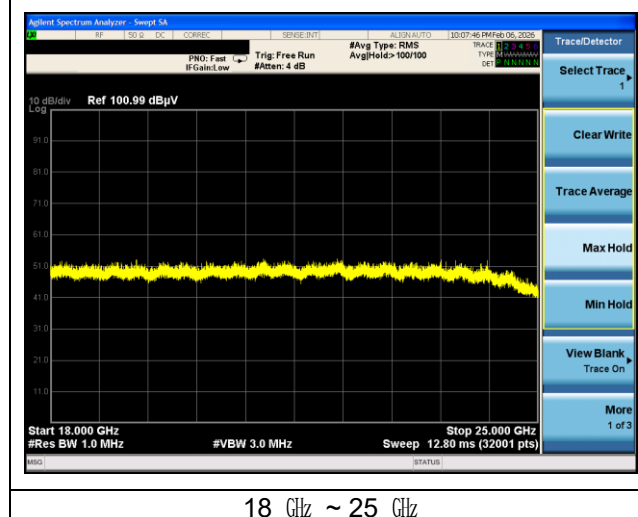
Radiated Spurious Emissions



1 GHz ~ 3 GHz



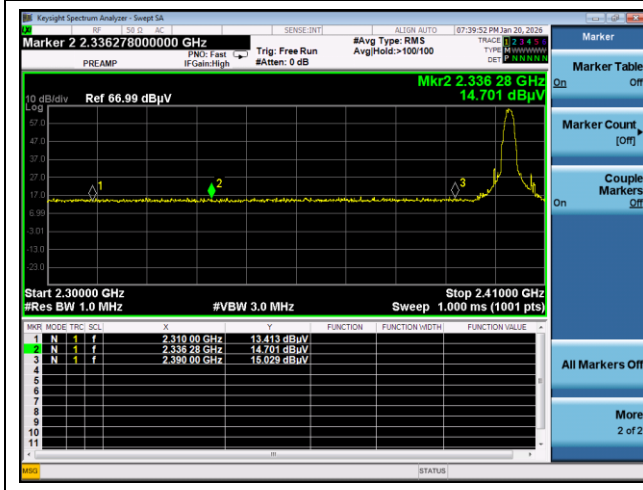
3 GHz ~ 18 GHz



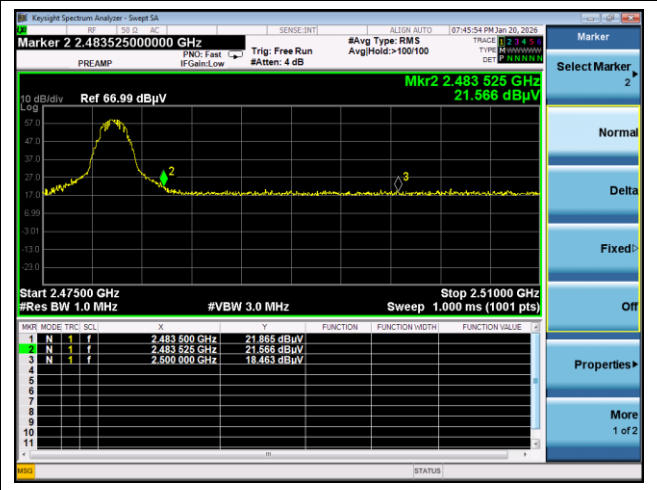
18 GHz ~ 25 GHz

Mode: 8DPSK

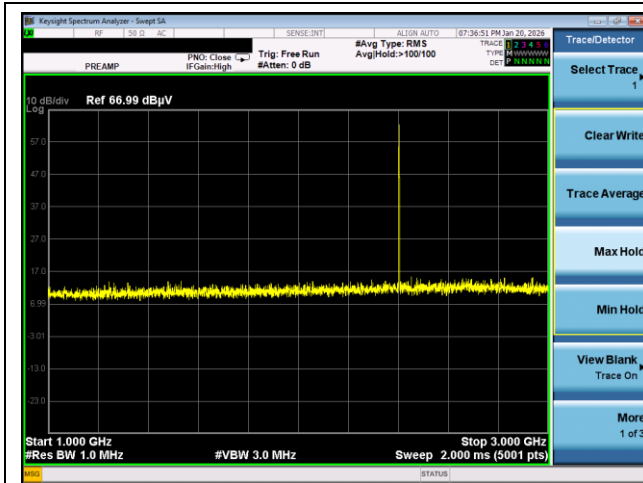
Low channel band edge (Peak)



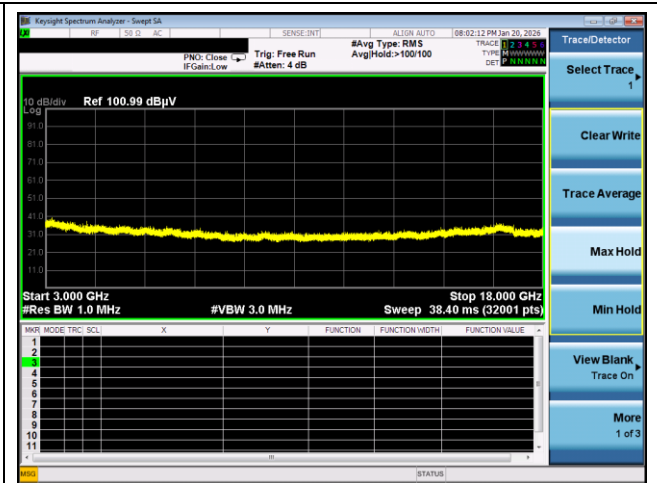
High channel band edge (Peak)



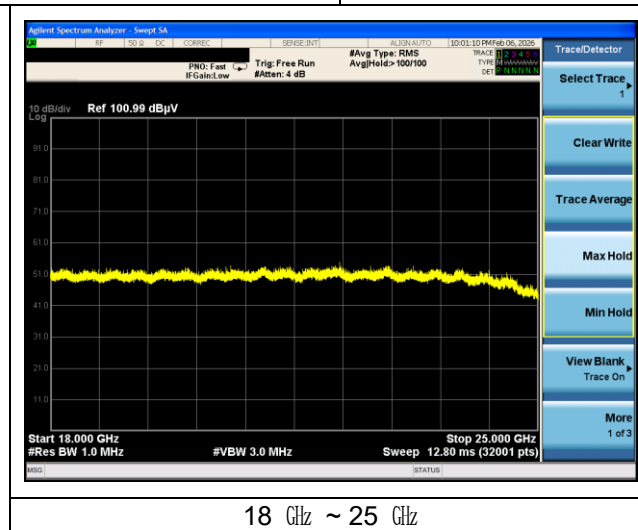
Radiated Spurious Emissions



1 GHz ~ 3 GHz



3 GHz ~ 18 GHz



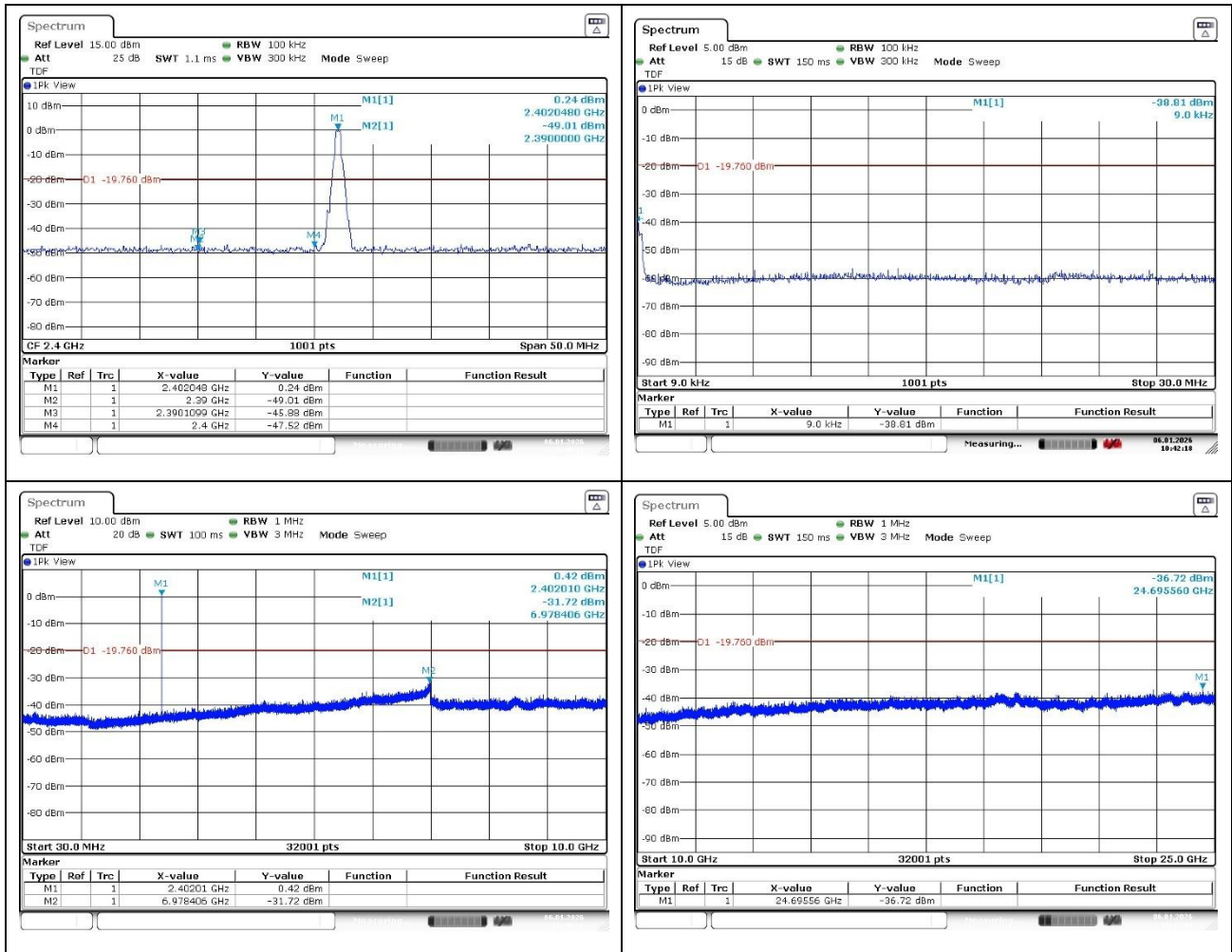
18 GHz ~ 25 GHz

2.4.3. Plot of Conducted Spurious Emissions

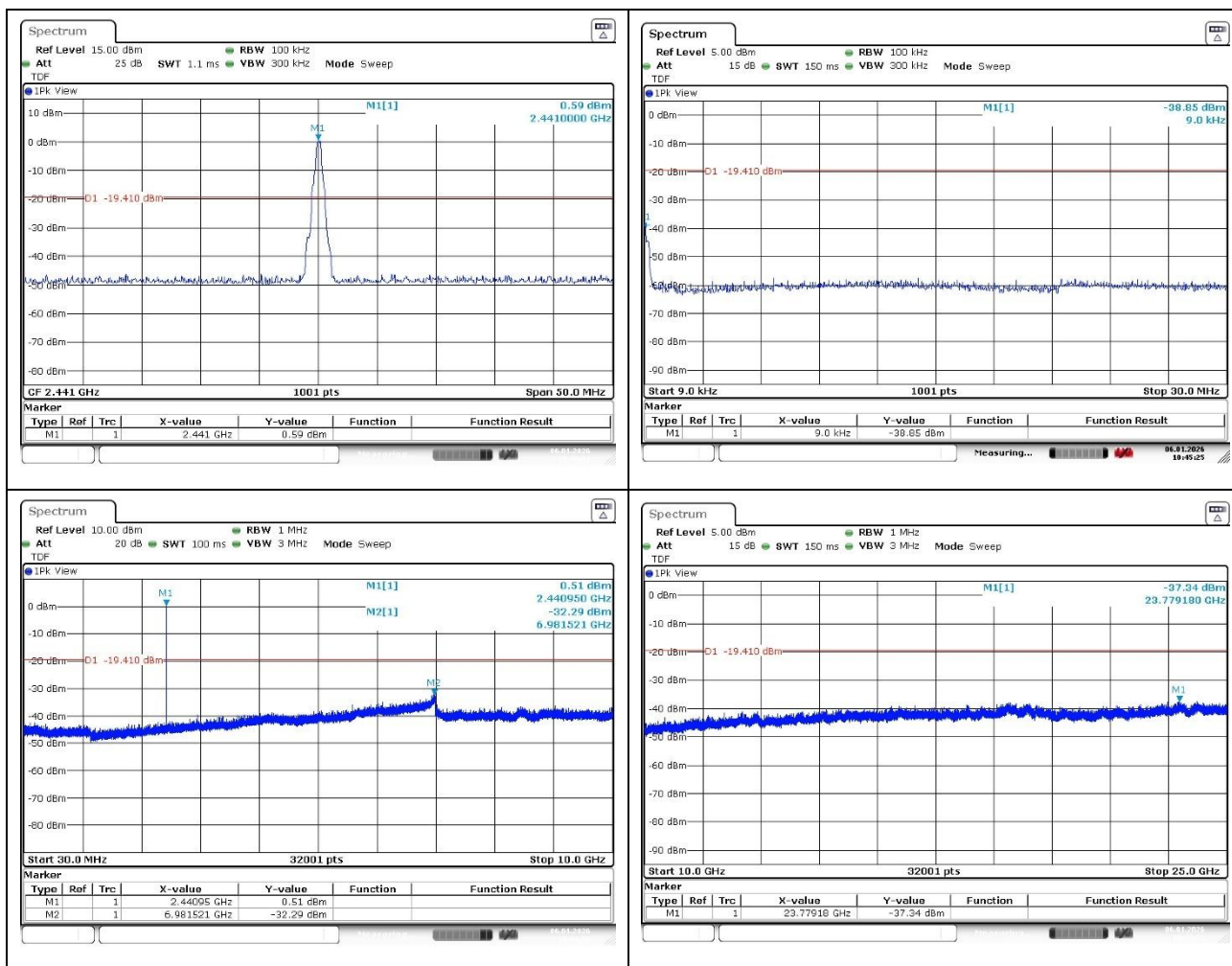
- Ant.1

Mode: GFSK_hopping function turned off

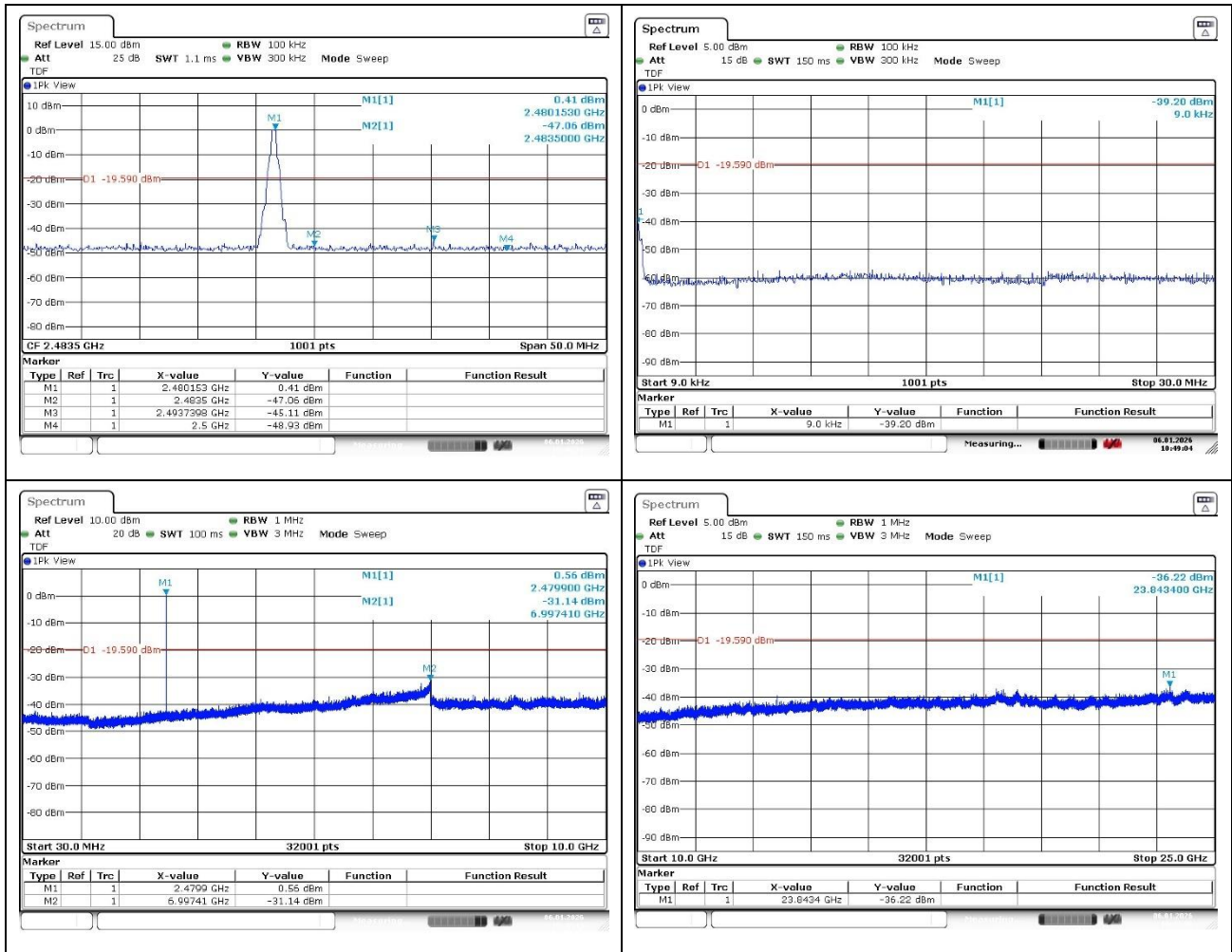
- Low Channel



- Middle Channel



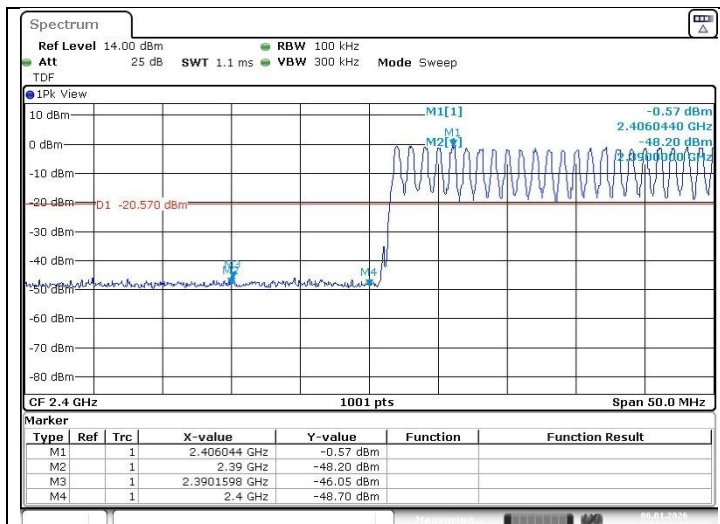
- High Channel



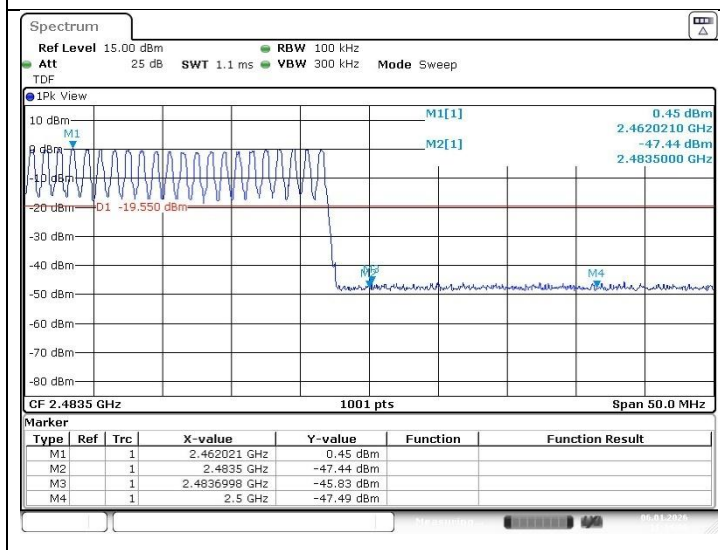
Mode: GFSK_hopping function turned on

Band edge compliance

Low Channel



High Channel



Mode: 8DPSK_hopping function turned off

- Low Channel

