FCC Part 15.247

TEST REPORT

For

Technology Solutions (UK) Ltd

Suite A, Loughborough Technology Centre, Epinal Way, Loughborough, Leicestershire, LE11 3GE, United Kingdom

FCC ID: S6J3117

Report Type:	**Product Type:**
Original Report	RAIN RFID Module

Report Producer : Lynette Wen

Report Number : RXZ230928138RF01

Report Date : 2023-12-26

Reviewed By: Andy Shih

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Revision History

Revision	No.	Report Number	Issue Date	Description	Author/ Revised by
0.0	RXZ230928138	RXZ230928138RF01	2023-12-26	Original Report	Lynette Wen

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1. General Information

1.1. Product Description for Equipment under Test (EUT)

Applicant	Technology Solutions (UK) Ltd
	Suite A, Loughborough Technology Centre, Epinal Way, Loughborough, Leicestershire, LE11 3GE, United Kingdom
Manufacturer	Technology Solutions (UK) Ltd
	Suite A, Loughborough Technology Centre, Epinal Way, Loughborough, Leicestershire, LE11 3GE, United Kingdom
Brand(Trade) Name	TSL
Product (Equipment)	RAIN RFID Module
Main Model Name	3117
Series Model Name	N/A
Frequency Range	902.75 ~ 927.25 MHz
Peak Conducted Output Power	DSB-ASK Mode: 29.80 dBm PR-ASK Mode: 29.88 dBm
Modulation Technique	DSB-ASK PR-ASK
Power Operation (Voltage Range)	☐ AC 120V/60Hz ☐ Adapter: ☐ By AC Power Cord ☐ PoE
	☒ DC Type ☐ Battery ☒ Power Supply DC 5-15 V ☐ External from USB Cable ☐ External DC Adapter
	☐ Host System
Received Date	2023/10/24
Date of Test	2023/11/08 ~ 2023/12/26

*All measurement and test data in this report was gathered from production sample serial number: RXZ230928138-1-1 (Assigned by BACL, New Taipei Laboratory).

1.2. Objective

This report is prepared on behalf of *Technology Solutions (UK) Ltd* in accordance with Part 2, Subpart J, Part 15, Subparts A and C of the Federal Communication Commission's rules.

1.3. Related Submittal(s)/Grant(s)

N/A.

1.4. Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

FCC 558074 D01 15.247 Meas Guidance v05r02.

1.5. Statement

Decision Rule: No, (The test results do not include MU judgment)

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

The determination of the test results does not require consideration of the uncertainty of the measurement, unless the assessment is required by customer agreement, regulation or standard document specification.

Bay Area Compliance Laboratories Corp. (New Taipei Laboratory) is not responsible for the authenticity of the information provided by the applicant that affects the test results.

1.6. Measurement Uncertainty

Parameter		Uncertainty
AC Mains		±2.53 dB
RF output power, conducted		±3.74 dB
Power Spectral Density, conducted		±0.62 dB
Occupied Bandwidth		±0.09 %
Unwanted Emissions, conducted		±1.13 dB
Emissions, radiated	9 kHz~30MHz	±3.54 dB
	30 MHz~1GHz	±4.99 dB
	1 GHz~18 GHz	±7.56 dB
	18 GHz~40 GHz	±5.06 dB
Temperature		±0.79 ℃
Humidity		±0.44 %

Note: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval. Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty

1.7. Environmental Conditions

Test Site	Test Date	Temperature (℃)	Relative Humidity (%)	ATM Pressure (hPa)	Test Engineer
AC Line Conducted Emissions	2023/11/22	22.7	65	1010	Jing
Radiation Spurious Emissions	2023/11/08~2023/12/26	18.3~23.7	61~68	1010	Aaron
Conducted Spurious Emissions	2023/11/13	23.3	56	1010	Jing
20 dB Emission Bandwidth	2023/11/13	23.3	56	1010	Jing
Channel Separation Test	2023/11/13	23.3	56	1010	Jing
Time of Occupancy	2023/11/13	23.3	56	1010	Jing
Quantity of hopping channel	2023/11/13	23.3	56	1010	Jing
Maximum Output Power	2023/11/13	23.3	56	1010	Jing
100 kHz Bandwidth of Frequency Band Edge	2023/11/13	23.3	56	1010	Jing

1.8. Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. (New Taipei Laboratory) to collect test data is located on

☒70, Lane 169, Sec. 2, Datong Road, Xizhi Dist., New Taipei City 22183, Taiwan, R.O.C.

Bay Area Compliance Laboratories Corp. (New Taipei Laboratory) is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 3732) and the FCC designation No.TW3732 under the Mutual Recognition Agreement (MRA) in FCC Test.

2. System Test Configuration

2.1. Description of Test Configuration

For RFID mode, 50 channels are provided to testing:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	902.75	26	915.25
2	903.25	27	915.75
3	903.75	28	916.25
4	904.25	29	916.75
5	904.75	30	917.25
6	905.25	31	917.75
7	905.75	32	918.25
8	906.25	33	918.75
9	906.75	34	919.25
10	907.25	35	919.75
11	907.75	36	920.25
12	908.25	37	920.75
13	908.75	38	921.25
14	909.25	39	921.75
15	909.75	40	922.25
16	910.25	41	922.75
17	910.75	42	923.25
18	911.25	43	923.75
19	911.75	44	924.25
20	912.25	45	924.75
21	912.75	46	925.25
22	913.25	47	925.75
23	913.75	48	926.25
24	914.25	49	926.75
25	914.75	50	927.25

Were tested with channel 1, 26 and 50.

The system was configured for testing in engineering mode, which was provided by manufacturer.

2.2. Equipment Modifications

No modification was made to the EUT.

2.3. EUT Exercise Software

The test software was used “STORM RF Test USB App V1.3.0”

Test Frequency		902.75 MHz	915.25 MHz	927.25 MHz
Power Level Setting	DSB-ASK	2950	2950	2950
	PR-ASK	2950	2950	2950

2.4. Test Mode

Full System (model: 3117) for all test item.

2.5. Support Equipment List and Details

Description	Manufacturer	Model Number
Adapter	TT Electronics	ATS065T-P150
Tablet	Amazon	R2SP8T
Developer Board	TSL	3117B V0.4

2.6. External Cable List and Details

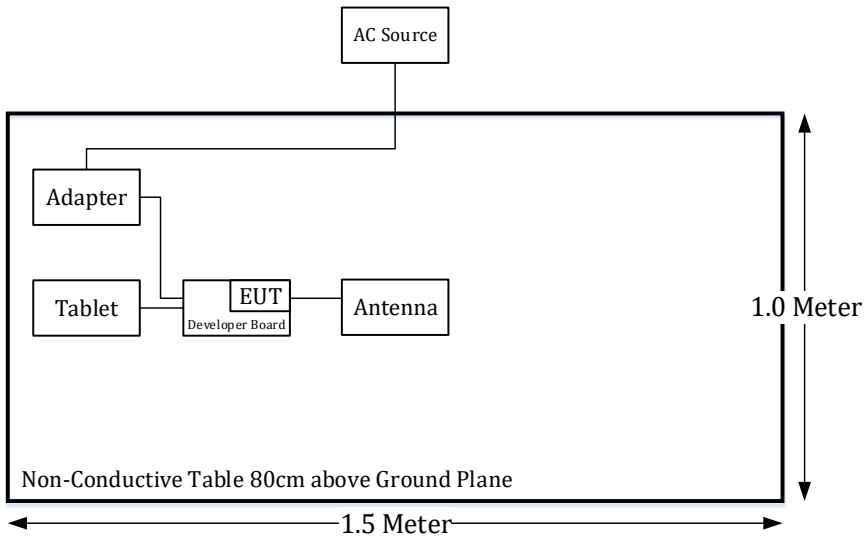
Description	Manufacturer	Model Number
Type-C Cable	PRO-SIGNAL	USB3C-901

2.7. Block Diagram of Test Setup

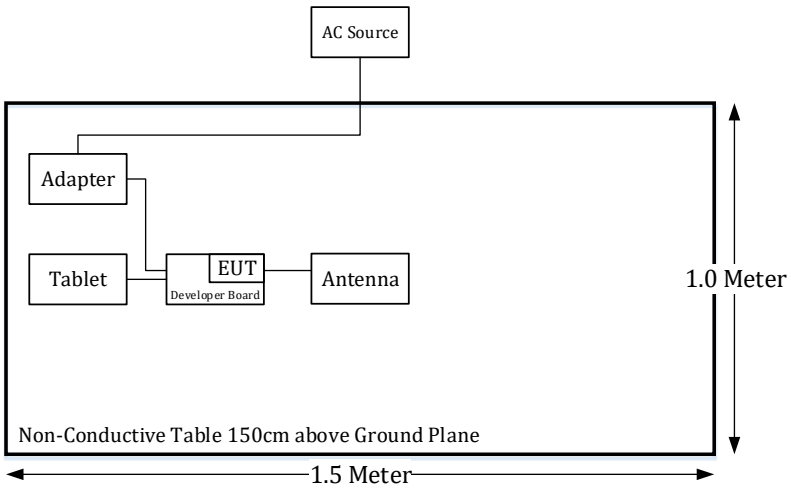
See test photographs attached in annex setup photos for the actual connections between EUT and support equipment.

Radiation:

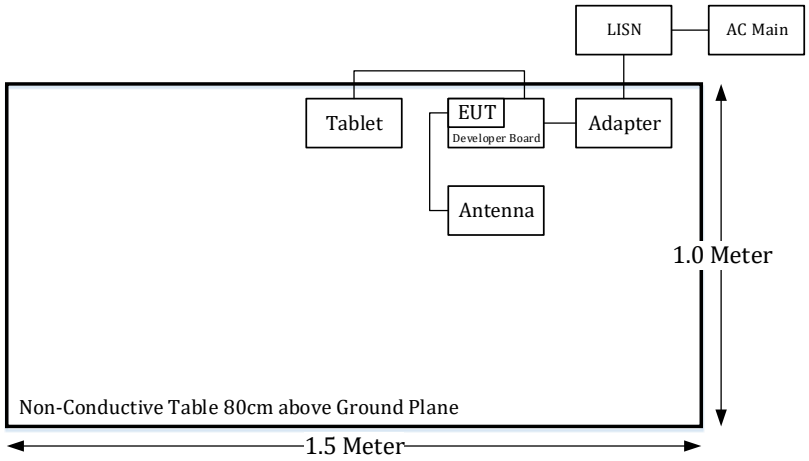
Below 1GHz:



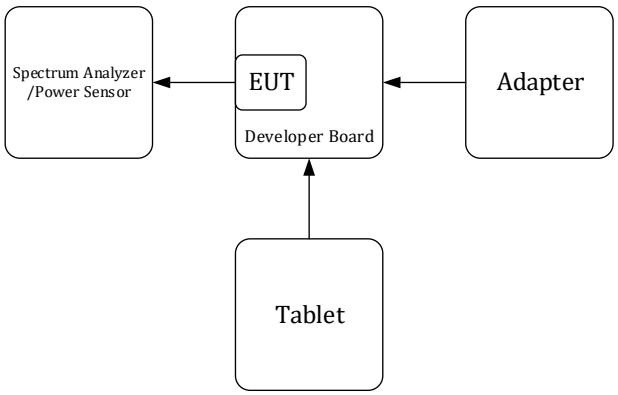
Above 1GHz:



Conduction:



Conducted:



3. Summary of Test Results

FCC Rules	Description of Test	Results
§15.247(i), §1.1307(b)(3)(i)	RF Exposure	Compliance
§15.203	Antenna Requirement	Compliance
§15.207(a)	AC Line Conducted Emissions	Compliance
§15.205, §15.209, §15.247(d)	Spurious Emissions	Compliance
§15.247(a)(1)	20 dB Emission Bandwidth	Compliance
§15.247 (a)(1)	Channel Separation Test	Compliance
§15.247(a)(1)(i)	Time of Occupancy (Dwell Time)	Compliance
§15.247(a)(1)(i)	Quantity of hopping channel Test	Compliance
§15.247(b)(2)	Maximum Peak Output Power	Compliance
§15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliance

4. Test Equipment List and Details

Description	Manufacturer	Model	Serial Number	Calibration Date	Calibration Due Date
AC Line Conduction Room (CON-A)					
LISN	Rohde & Schwarz	ENV216	101612	2023/2/2	2024/2/1
EMI Test Receiver	Rohde & Schwarz	ESW8	100947	2023/5/22	2024/5/20
Pulse Limiter	Rohde & Schwarz	ESH3Z2	TXZEM104	2023/5/18	2024/5/16
RF Cable	EMEC	EM-CB5D	1	2023/6/6	2024/6/4
Software	AUDIX	E3	V9.150826k	N.C.R	N.C.R
Radiation 3M Room (966-A)					
Active Loop Antenna	ETS-Lindgren	6502	35796	2023/3/27	2024/3/25
Bilog Antenna with 6 dB Attenuator	SUNOL SCIENCES & MINI-CIRCUITS	JB6/UNAT-6+	A050115/15542_01	2023/2/2	2024/2/1
Horn Antenna	EMCO	SAS-571	1020	2023/5/18	2024/5/16
Preamplifier	Sonoma	310N	130602	2023/6/16	2024/6/14
Preamplifier	Channel	ERA-100M-18G-01D1748	EC2300051	2023/04/01	2024/03/30
Spectrum Analyzer	Rohde & Schwarz	FSV40	101435	2023/2/1	2024/1/31
EMI Test Receiver	Rohde & Schwarz	ESR3	102099	2023/6/16	2024/6/14
Band-reject filter (902-928MHz)	MICRO-TRONICS	BRC50722	G014	2023/10/2	2024/9/30
Micro flex Cable	UTIFLEX	UFB197C-1-2362-70U-70U	225757-001	2023/1/24	2024/1/23
Coaxial Cable	COMMATE	PEWC	8Dr	2022/12/24	2023/12/23
				2023/12/23	2024/12/22
Coaxial Cable	UTIFLEX	UFB311A-Q-1440-300300	220490-006	2023/1/24	2024/1/23
Coaxial Cable	JUNFLON	J12J102248-00-B-5	AUG-07-15-044	2022/12/24	2023/12/23
				2023/12/23	2024/12/22
Cable	EMC	EMC105-SM-SM-10000	201003	2023/1/24	2024/1/23
Software	AUDIX	E3	18621a	N.C.R	N.C.R
Conducted Room					
Spectrum Analyzer	Rohde & Schwarz	FSV40	101140	2023/2/10	2024/2/9
Cable	UTIFLEX	UFA210A	9435	2023/10/2	2024/9/30
Power Sensor	Boonton	RTP5006	11037	2023/5/23	2024/5/21
Attenuator	MCL	BW-S20W5+	1430	2023/6/6	2024/6/4

***Statement of Traceability:** BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to the SI System of Units via the R.O.C. Center for Measurement Standards of the Electronics Testing Center, Taiwan (ETC) or to another internationally recognized National Metrology Institute (NMI), and were compliant with the current Taiwan Accreditation Foundation (TAF) requirements

5. FCC §15.247(i), §1.1307(b)(3)(i) - RF Exposure

5.1. Applicable Standard

According to subpart 15.247(i)and subpart §1.1310, systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

For single RF sources (i.e., any single fixed RF source, mobile device, or portable device, as defined in paragraph (b)(2) of this section): A single RF source is exempt if:

(A) The available maximum time-averaged power is no more than 1 mW, regardless of separation distance. This exemption may not be used in conjunction with other exemption criteria other than those in paragraph (b)(3)(ii)(A) of this section. Medical implant devices may only use this exemption and that in paragraph (b)(3)(ii)(A);

(B) Or the available maximum time-averaged power or effective radiated power (ERP), whichever is greater, is less than or equal to the threshold Pth (mW) described in the following formula. This method shall only be used at separation distances (cm) from 0.5 centimeters to 40 centimeters and at frequencies from 0.3 GHz to 6 GHz (inclusive). Pth is given by

$$P_{th}\ (\text{mW}) = \begin{cases} ERP_{20\ cm}(d/20\ \text{cm})^x & d \le 20\ \text{cm} \\ ERP_{20\ cm} & 20\ \text{cm} < d \le 40\ \text{cm} \end{cases}$$

Where

$$x = -\log_{10}\left(\frac{60}{ERP_{20\ cm}\sqrt{f}}\right) \text{ and } f \text{ is in GHz;}$$

and

$$ERP_{20\ cm}\ (\text{mW}) = \begin{cases} 2040f & 0.3\ \text{GHz} \le f < 1.5\ \text{GHz} \\ 3060 & 1.5\ \text{GHz} \le f \le 6\ \text{GHz} \end{cases}$$

(C) Or using Table 1 and the minimum separation distance (R in meters) from the body of a nearby person for the frequency (f in MHz) at which the source operates, the ERP (watts) is no more than the calculated value prescribed for that frequency. For the exemption in Table 1 to apply, R must be at least $\lambda/2\pi$, where λ is the free-space operating wavelength in meters. If the ERP of a single RF source is not easily obtained, then the available maximum time-averaged power may be used in lieu of ERP if the physical dimensions of the radiating structure(s) do not exceed the electrical length of $\lambda/4$ or if the antenna gain is less than that of a half-wave dipole (1.64 linear value).

Table 1 to § 1.1307(b)(3)(i)(C) - Single RF Sources Subject to Routine Environmental Evaluation

RF Source frequency (MHz)	Threshold ERP (watts)
0.3-1.34	1,920 R^2.
1.34-30	3,450 R^2/f^2.
30-300	3.83 R^2.
300-1,500	0.0128 R^2f.
1,500-100,000	19.2R^2.

5.2. RF Exposure Evaluation Result

Project info

RFID

Band	Freq (MHz)	Tune-up Power (dBm)	Ant Gain + Cable Loss (dBi)	Distances (mm)	Tune-up Power (mW)	ERP (dBm)	ERP (mW)
DSB-ASK	902.75	30	-0.3	200	1000.00	27.55	568.85
PR-ASK	902.75	30	-0.3	200	1000.00	27.55	568.85

Cable loss is 0.3 dB

§ 1.1307(b)(3)(i)(A) and (C) method is not applicable.

§ 1.1307(b)(3)(i)(B)

Band	Freq (MHz)	Pth (mW)	X	ERP 20cm (mW)	Result Option B
DSB-ASK	902.75	1841.61	1.465	1841.61	exempt
PR-ASK	902.75	1841.61	1.465	1841.61	exempt

The available maximum time-averaged power or effective radiated power (ERP), whichever is greater

This method shall only be used at separation distances (cm) from 0.5 centimeters to 40 centimeters and at frequencies from 0.3 GHz to 6 GHz (inclusive).

Result: The device compliant the SAR-Based Exemption at 20cm distances.

6. FCC §15.203 – Antenna Requirements

6.1. Applicable Standard

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 user of a standard antenna jack or electrical connector is prohibited.

And according to FCC 47 CFR section 15.247 (b), if the transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna does not exceed 6dBi.

6.2. Antenna Information

Manufacturer	Model	Type	Antenna Gain	Cable Loss
TSL	ANT016015	Panel Antenna	0 dBi	0.3 dB

The antenna is connected to the EUT using a unique type of connector.

Result: Compliance

7. FCC §15.207(a) – AC Line Conducted Emissions

7.1. Applicable Standard

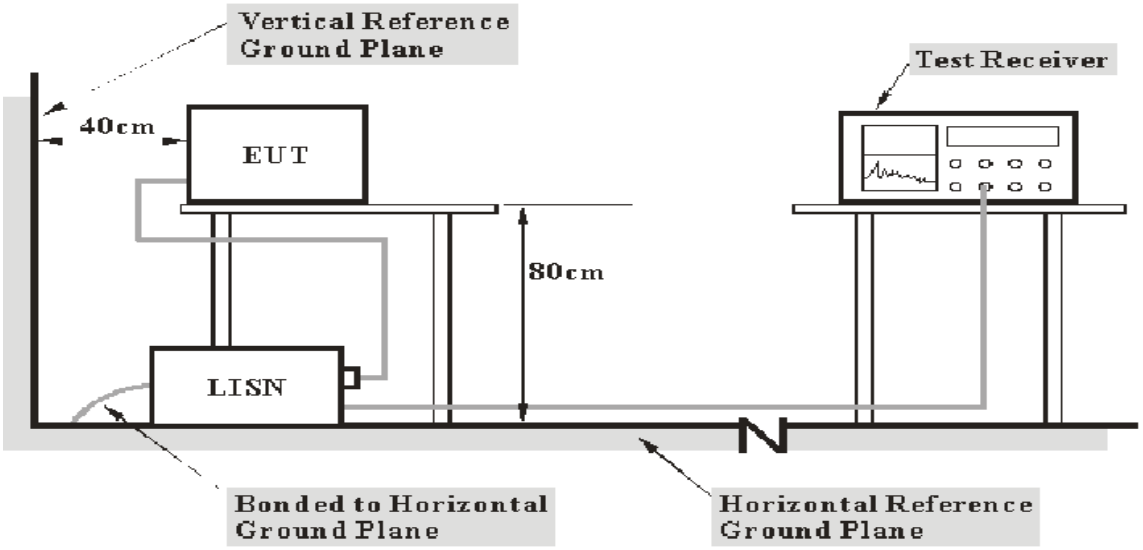
According to §15.207

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 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 Note 1	56 to 46 Note 1
0.5-5	56	46
5-30	60	50

Note 1: Decreases with the logarithm of the frequency.

7.2. EUT Setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.207 limits.

7.3. EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150kHz to 30MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations

Frequency Range	IF B/W
150kHz – 30MHz	9kHz

7.4. Test Procedure

During the conducted emission test, the adapter was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All data was recorded in the Quasi-peak and average detection mode.

7.5. Corrected Factor & Margin Calculation

The factor is calculated by adding LISN/ISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

The “Over Limit” column of the following data tables indicates the degree of compliance with the applicable limit. For example, an over limit of -7 dB means the emission is 7 dB below the limit. The equation for Over Limit calculation is as follows:

Over Limit = Result – Limit Line

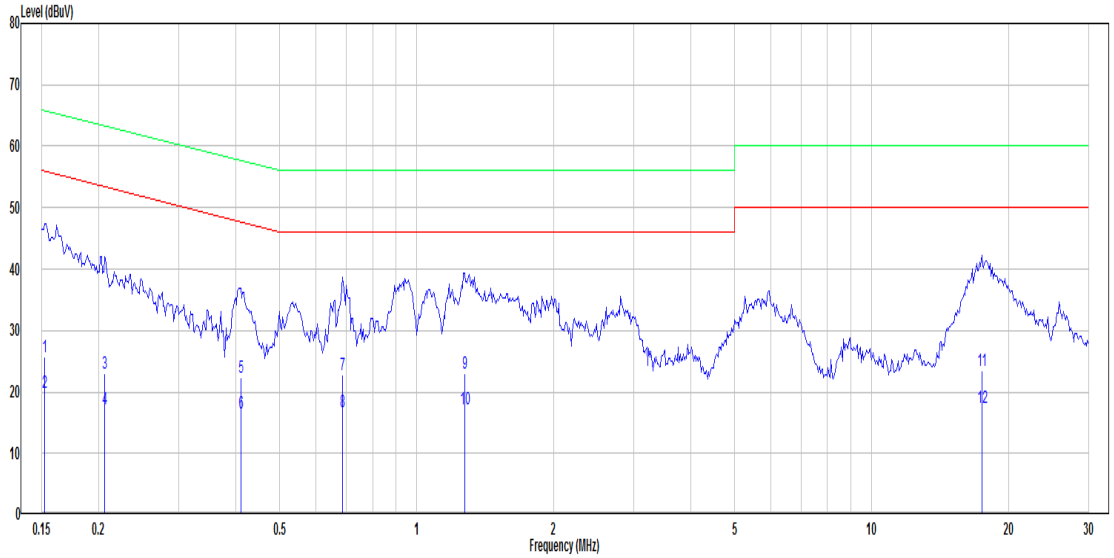
7.6. Test Results

Test Mode: Transmitting

DSB-ASK

(Worst case is low channel)

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark	Phase
	(MHz)	dBuV	Factor(dB)	dBuV	dBuV	(dB)		
1	0.152	6.17	19.50	25.67	55.87	-30.20	QP	Line
2	0.152	0.29	19.50	19.79	65.87	-46.08	Average	Line
3	0.206	3.56	19.49	23.05	53.36	-30.31	QP	Line
4	0.206	-2.31	19.49	17.18	63.36	-46.18	Average	Line
5	0.410	2.83	19.58	22.41	47.64	-25.23	QP	Line
6	0.410	-2.95	19.58	16.63	57.64	-41.01	Average	Line
7	0.686	3.08	19.71	22.79	46.00	-23.21	QP	Line
8	0.686	-2.89	19.71	16.82	56.00	-39.18	Average	Line
9	1.276	3.10	19.93	23.03	46.00	-22.97	QP	Line
10	1.276	-2.68	19.93	17.25	56.00	-38.75	Average	Line
11	17.475	3.10	20.37	23.47	50.00	-26.53	QP	Line
12	17.475	-2.88	20.37	17.49	60.00	-42.51	Average	Line

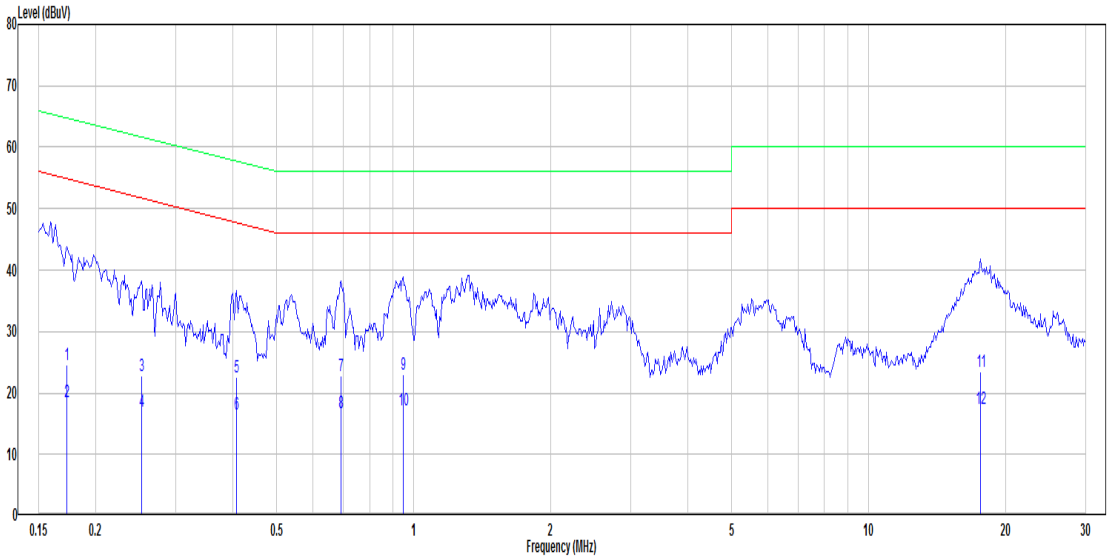
Note:

Result = Reading + Factor

Over Limit = Result – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark	Phase
	(MHz)	dBuV	Factor(dB)	dBuV	dBuV	(dB)		
1	0.173	5.00	19.50	24.50	54.81	-30.31	QP	Neutral
2	0.173	-0.98	19.50	18.52	64.81	-46.29	Average	Neutral
3	0.252	3.31	19.52	22.83	51.69	-28.86	QP	Neutral
4	0.252	-2.59	19.52	16.93	61.69	-44.76	Average	Neutral
5	0.408	2.92	19.59	22.51	47.68	-25.17	QP	Neutral
6	0.408	-2.95	19.59	16.64	57.68	-41.04	Average	Neutral
7	0.694	3.02	19.72	22.74	46.00	-23.26	QP	Neutral
8	0.694	-2.90	19.72	16.82	56.00	-39.18	Average	Neutral
9	0.948	3.28	19.85	23.13	46.00	-22.87	QP	Neutral
10	0.948	-2.53	19.85	17.32	56.00	-38.68	Average	Neutral
11	17.661	3.00	20.44	23.44	50.00	-26.56	QP	Neutral
12	17.661	-2.94	20.44	17.50	60.00	-42.50	Average	Neutral

Note:

Result = Reading + Factor

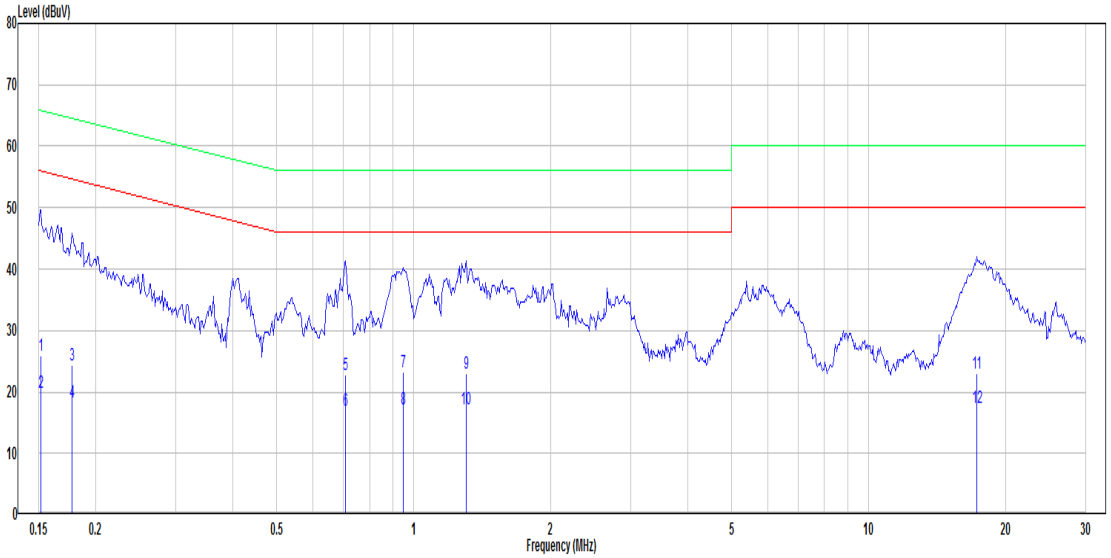
Over Limit = Result – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

PR-ASK

(Worst case is low channel)

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark	Phase
	(MHz)	dBuV	Factor(dB)	dBuV	dBuV	(dB)		
1	0.152	6.33	19.50	25.83	55.91	-30.08	QP	Line
2	0.152	0.43	19.50	19.93	65.91	-45.98	Average	Line
3	0.178	4.77	19.49	24.26	54.59	-30.33	QP	Line
4	0.178	-1.08	19.49	18.41	64.59	-46.18	Average	Line
5	0.708	3.04	19.73	22.77	46.00	-23.23	QP	Line
6	0.708	-2.85	19.73	16.88	56.00	-39.12	Average	Line
7	0.948	3.30	19.84	23.14	46.00	-22.86	QP	Line
8	0.948	-2.55	19.84	17.29	56.00	-38.71	Average	Line
9	1.303	3.19	19.93	23.12	46.00	-22.88	QP	Line
10	1.303	-2.80	19.93	17.13	56.00	-38.87	Average	Line
11	17.291	2.75	20.36	23.11	50.00	-26.89	QP	Line
12	17.291	-3.03	20.36	17.33	60.00	-42.67	Average	Line

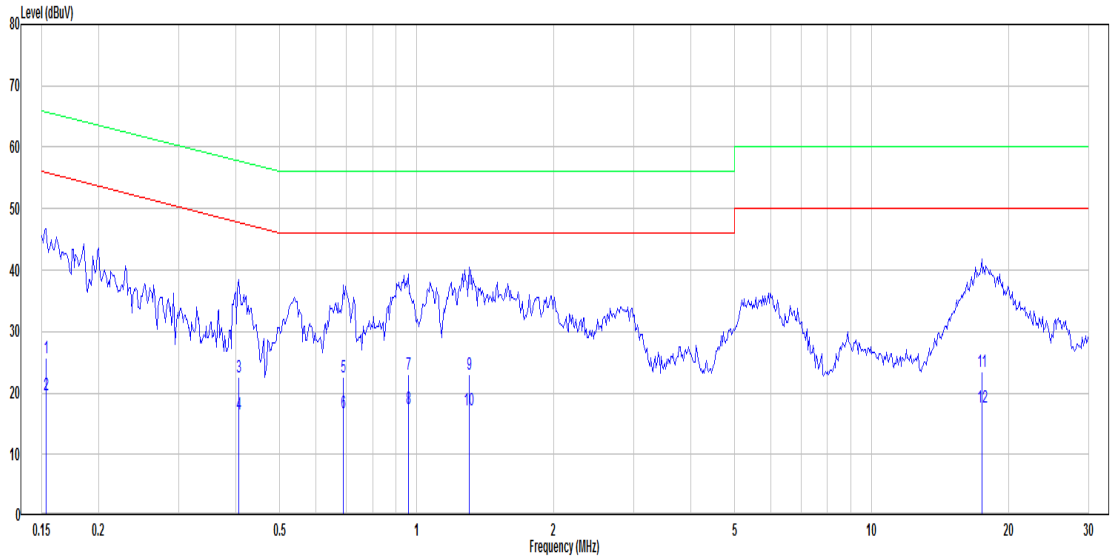
Note:

Result = Reading + Factor

Over Limit = Result – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark	Phase
	(MHz)	dBuV	Factor(dB)	dBuV	dBuV	(dB)		
1	0.153	6.16	19.50	25.66	55.82	-30.16	QP	Neutral
2	0.153	0.23	19.50	19.73	65.82	-46.09	Average	Neutral
3	0.406	2.87	19.59	22.46	47.73	-25.27	QP	Neutral
4	0.406	-2.96	19.59	16.63	57.73	-41.10	Average	Neutral
5	0.690	2.96	19.72	22.68	46.00	-23.32	QP	Neutral
6	0.690	-2.87	19.72	16.85	56.00	-39.15	Average	Neutral
7	0.958	3.23	19.85	23.08	46.00	-22.92	QP	Neutral
8	0.958	-2.52	19.85	17.33	56.00	-38.67	Average	Neutral
9	1.303	3.11	19.93	23.04	46.00	-22.96	QP	Neutral
10	1.303	-2.70	19.93	17.23	56.00	-38.77	Average	Neutral
11	17.475	3.05	20.43	23.48	50.00	-26.52	QP	Neutral
12	17.475	-2.85	20.43	17.58	60.00	-42.42	Average	Neutral

Note:

Result = Reading + Factor

Over Limit = Result – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

8. FCC §15.209, §15.205 , §15.247(d) – Spurious Emissions

8.1. Applicable Standard

As per FCC §15.35(d): Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1MHz.

As Per FCC §15.205(a) except as show 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	608 – 614	4. 5 – 5. 15
0.495 – 0.505	16.69475 – 16.69525	960 – 1240	5. 35 – 5. 46
2.1735 – 2.1905	16.80425 – 16.80475	1300 – 1427	7.25 – 7.75
4.125 – 4.128	25.5 – 25.67	1435 – 1626.5	8.025 – 8.5
4.17725 – 4.17775	37.5 – 38.25	1645.5 – 1646.5	9.0 – 9.2
4.20725 – 4.20775	73 – 74.6	1660 – 1710	9.3 – 9.5
6.215 – 6.218	74.8 – 75.2	1718.8 – 1722.2	10.6 – 12.7
6.26775 – 6.26825	108 – 121.94	2200 – 2300	13.25 – 13.4
6.31175 – 6.31225	123 – 138	2310 – 2390	14.47 – 14.5
8.291 – 8.294	149.9 – 150.05	2483.5 – 2500	15.35 – 16.2
8.362 – 8.366	156.52475 – 156.52525	2690 – 2900	17.7 – 21.4
8.37625 – 8.38675	156.7 – 156.9	3260 – 3267	22.01 – 23.12
8.41425 – 8.41475	162.0125 –167.17	3.332 – 3.339	23.6 – 24.0
12.29 – 12.293	167.72 – 173.2	3 3458 – 3 358	31.2 – 31.8
12.51975 – 12.52025	240 – 285	3.600 – 4.400	36.43 – 36.5
12.57675 – 12.57725	322 – 335.4		Above 38.6
13.36 – 13.41	399.9 – 410		

As per FCC §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 (micro volts/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

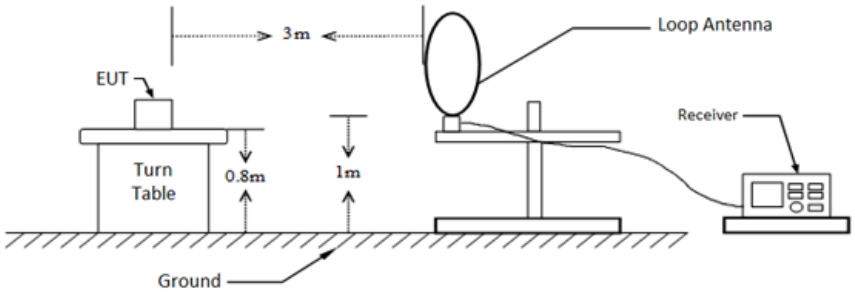
** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this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

As per FCC §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

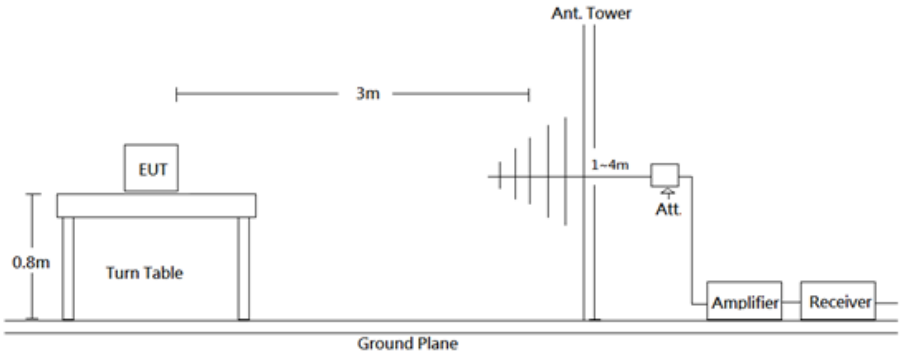
demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 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).

8.2. EUT Setup

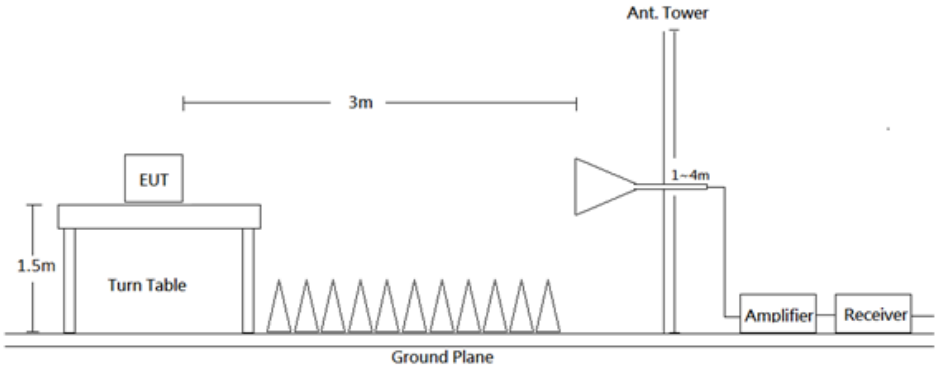
9 kHz - 30 MHz:



30 MHz - 1 GHz:



Above 1 GHz:



Radiated emission tests were performed in the 3 meters chamber test site, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC Part 15.209 and FCC 15.247 Limits.

8.3. EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 9 kHz to 10 GHz. During the radiated emission test, the EMI test receiver was set with the following configurations measurement method 6.3 in ANSI C63.10.

Frequency Range	RBW	VBW	Measurement method
9 -150 kHz	300 Hz	1 kHz	Ave
150 kHz-30 MHz	10 kHz	30 kHz	QP
30-1000 MHz	100 kHz	300 kHz	QP
Above 1 GHz	1 MHz	3 MHz	PK
	1 MHz	10 Hz	Ave

8.4. Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All data was recorded in the Quasi-peak detector mode from 30 MHz to 1 GHz and PK and average detector modes for frequencies above 1 GHz.

8.5. Corrected Factor & Margin Calculation

The Correct Factor is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter Reading. The basic equation is as follows:

Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

The “Margin” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the limit. The equation for margin calculation is as follows:

Margin = Level – Limit

8.6. Test Results

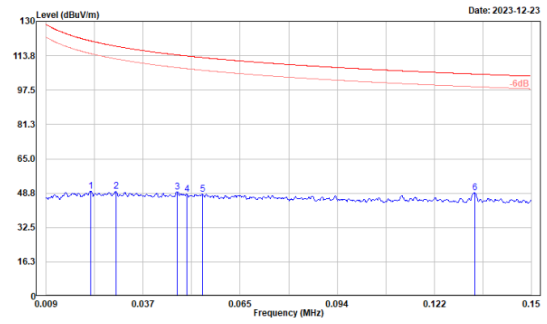
Test Mode: Transmitting

(Pre-scan with three orthogonal axis, and worse case as X axis.)

(Worst case is PR-ASK mode)

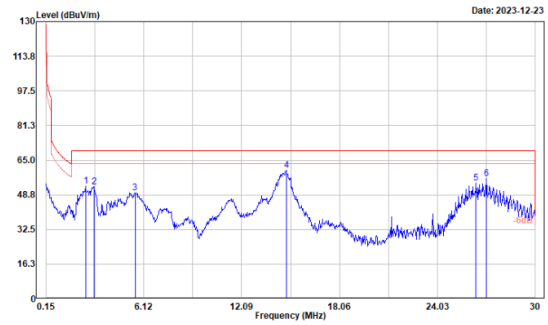
9kHz-30MHz: (Pre-scan with three Antenna orthogonal axis, and worse case as parallel.)

Low Channel / 9kHz-150kHz



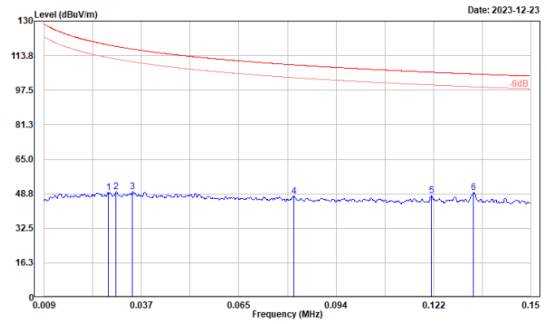
Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
0.022	34.93	14.67	49.60	120.77	-71.17	100	360	Average
0.029	35.71	13.79	49.50	118.27	-68.77	100	35	Average
0.047	36.76	12.64	49.40	114.15	-64.75	100	339	Average
0.050	35.67	12.61	48.28	113.64	-65.36	100	67	Average
0.054	36.08	12.16	48.24	112.89	-64.65	100	140	Average
0.134	37.75	11.39	49.14	105.09	-55.95	100	26	Average

Low Channel / 150kHz-30MHz



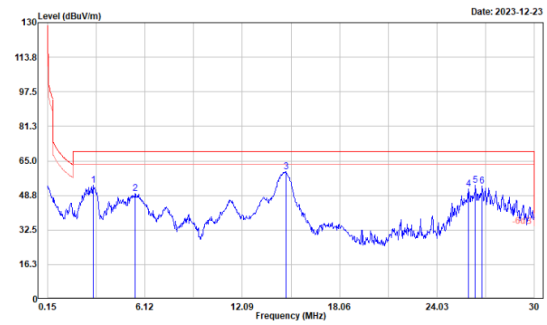
Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
2.568	42.30	10.58	52.88	69.54	-16.66	100	262	QP
3.075	42.00	10.47	52.47	69.54	-17.07	100	0	QP
5.583	38.50	11.35	49.85	69.54	-19.69	100	85	QP
14.806	48.65	11.51	60.16	69.54	-9.38	100	93	QP
26.388	42.44	11.72	54.16	69.54	-15.38	100	342	QP
27.015	44.46	11.74	56.20	69.54	-13.34	100	254	QP

Middle Channel / 9kHz-150kHz



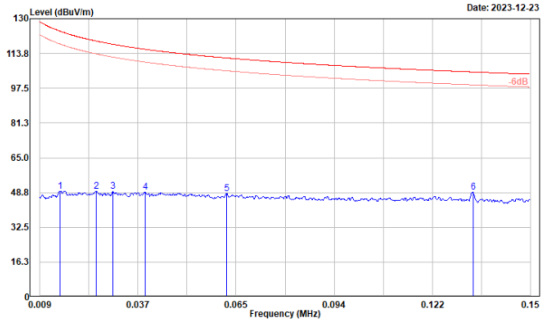
Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
0.028	35.36	14.00	49.36	118.78	-69.42	100	1	Average
0.030	35.82	13.73	49.55	118.10	-68.55	100	360	Average
0.035	36.38	13.24	49.62	116.81	-67.19	100	360	Average
0.081	36.42	11.29	47.71	109.40	-61.69	100	360	Average
0.121	36.45	11.33	47.78	105.93	-58.15	100	274	Average
0.133	37.82	11.39	49.21	105.10	-55.89	100	22	Average

Middle Channel / 150kHz-30MHz



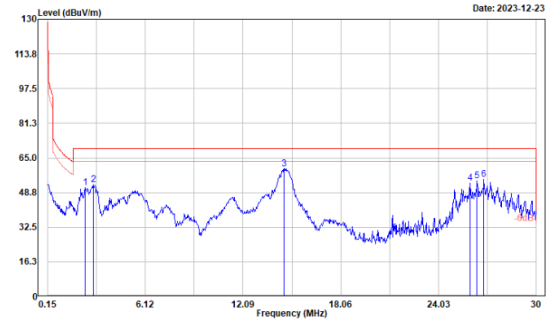
Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
2.926	43.00	10.48	53.48	69.54	-16.06	100	147	QP
5.523	38.31	11.29	49.60	69.54	-19.94	100	39	QP
14.777	48.31	11.51	59.82	69.54	-9.72	100	3	QP
25.970	40.23	11.71	51.94	69.54	-17.60	100	321	QP
26.388	41.87	11.72	53.59	69.54	-15.95	100	280	QP
26.806	41.36	11.72	53.08	69.54	-16.46	100	283	QP

High Channel / 9kHz-150kHz



Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
0.015	33.57	15.88	49.45	124.13	-74.68	100	360	Average
0.025	35.09	14.28	49.37	119.57	-70.20	100	322	Average
0.030	35.45	13.71	49.16	118.06	-68.90	100	24	Average
0.039	36.09	12.79	48.88	115.71	-66.83	100	217	Average
0.063	36.63	11.57	48.20	111.66	-63.46	100	354	Average
0.134	37.45	11.39	48.84	105.09	-56.25	100	24	Average

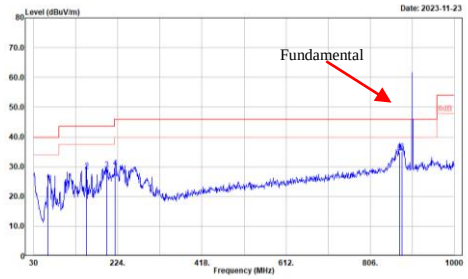
High Channel / 150kHz-30MHz



Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
2.448	40.43	10.62	51.05	69.54	-18.49	100	169	QP
2.956	42.01	10.47	52.48	69.54	-17.06	100	0	QP
14.597	48.41	11.51	59.92	69.54	-9.62	100	70	QP
25.970	41.43	11.71	53.14	69.54	-16.40	100	335	QP
26.388	42.41	11.72	54.13	69.54	-15.41	100	219	QP
26.806	43.35	11.72	55.07	69.54	-14.47	100	38	QP

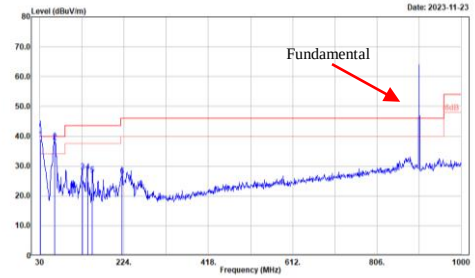
30MHz-1GHz:

Low Channel Horizontal



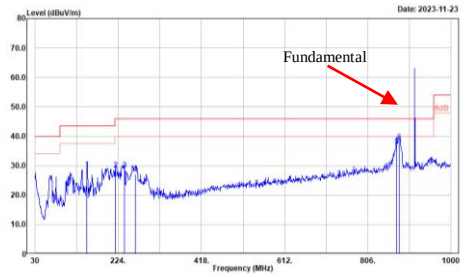
Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
62.980	40.69	-16.23	24.46	40.00	-15.54	100	55	QP
152.220	39.02	-10.49	28.53	43.50	-14.97	100	96	QP
198.780	39.34	-10.27	29.07	43.50	-14.43	100	76	QP
217.210	42.05	-12.32	29.73	46.00	-16.27	100	205	QP
873.900	33.62	1.35	34.97	46.00	-11.03	100	348	QP
879.720	33.63	1.42	35.05	46.00	-10.95	100	359	QP

Low Channel Vertical



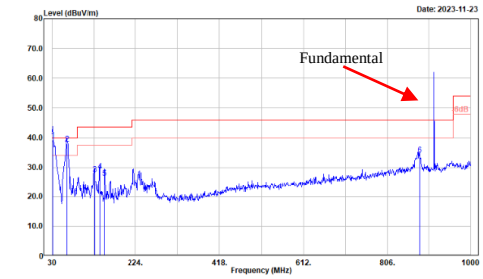
Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
30.970	42.98	-3.87	39.11	40.00	-0.89	100	149	QP
63.950	54.14	-16.03	38.11	40.00	-1.89	100	34	QP
127.970	37.77	-9.57	28.20	43.50	-15.30	100	61	QP
139.610	38.21	-10.10	28.11	43.50	-15.39	100	117	QP
151.250	37.48	-10.40	27.08	43.50	-16.42	100	149	QP
219.150	38.94	-12.22	26.72	46.00	-19.28	100	161	QP

Middle Channel Horizontal



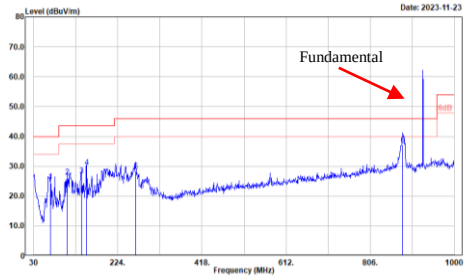
Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
151.250	39.22	-10.40	28.82	43.50	-14.68	100	99	QP
218.180	40.92	-12.27	28.65	46.00	-17.35	100	196	QP
238.550	39.93	-11.38	28.55	46.00	-17.45	100	220	QP
263.770	37.11	-9.92	27.19	46.00	-18.81	100	106	QP
872.930	35.38	1.34	36.72	46.00	-9.28	100	0	QP
879.720	36.75	1.42	38.17	46.00	-7.83	100	359	QP

Middle Channel Vertical



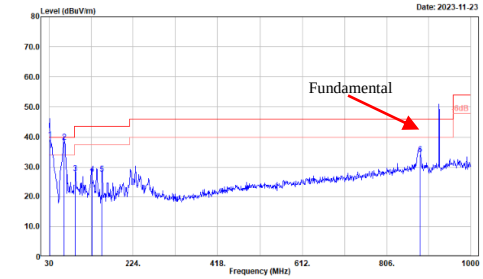
Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
31.940	43.71	-4.45	39.26	40.00	-0.74	100	116	QP
63.950	54.00	-16.03	37.97	40.00	-2.03	100	51	QP
127.970	37.30	-9.57	27.73	43.50	-15.77	100	55	QP
139.610	38.96	-10.10	28.86	43.50	-14.64	100	116	QP
151.250	36.85	-10.40	26.45	43.50	-17.05	100	116	QP
881.660	32.65	1.51	34.16	46.00	-11.84	100	342	QP

High Channel Horizontal



Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
68.800	40.64	-15.81	24.83	40.00	-15.17	100	133	QP
107.600	38.07	-11.61	26.46	43.50	-17.04	100	99	QP
139.610	37.03	-10.10	26.93	43.50	-16.57	100	111	QP
152.220	40.17	-10.49	29.68	43.50	-13.82	100	111	QP
265.710	38.08	-9.73	28.35	46.00	-17.65	100	99	QP
880.690	35.67	1.46	37.13	46.00	-8.87	100	0	QP

High Channel Vertical



Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
30.970	43.17	-3.87	39.30	40.00	-0.70	100	83	QP
63.950	54.32	-16.03	38.29	40.00	-1.71	100	75	QP
90.140	43.64	-15.61	28.03	43.50	-15.47	100	132	QP
127.970	37.31	-9.57	27.74	43.50	-15.76	100	1	QP
151.250	38.05	-10.40	27.65	43.50	-15.85	100	132	QP
883.600	32.56	1.59	34.15	46.00	-11.85	100	301	QP

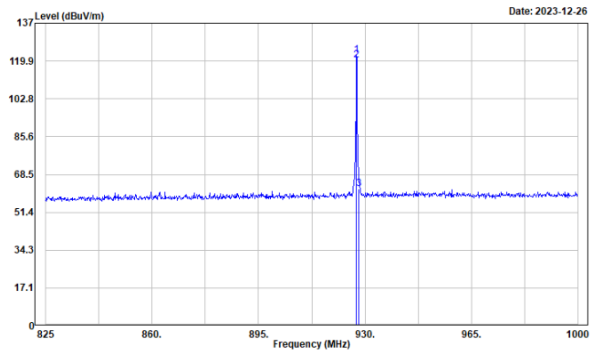
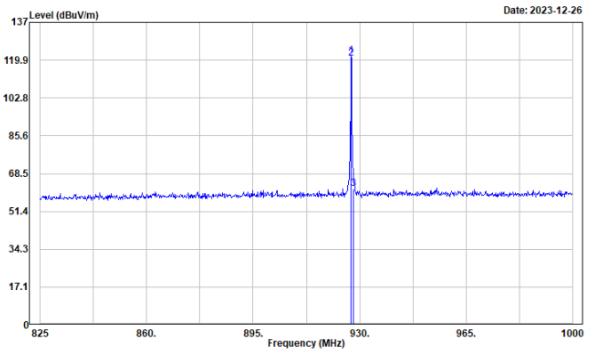
Level = Reading + Factor.

Margin = Level – Limit.

Factor = Antenna Factor + Cable Loss – Amplifier Gain.

(Worst case is PR-ASK mode high channel)

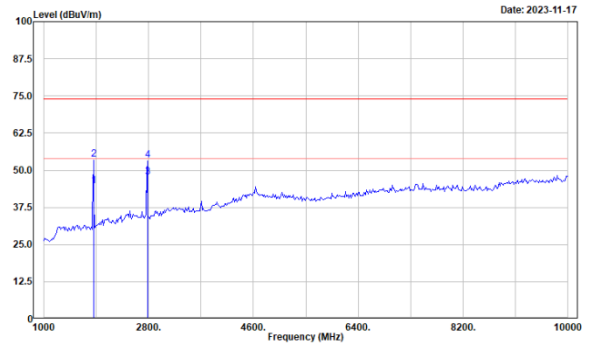
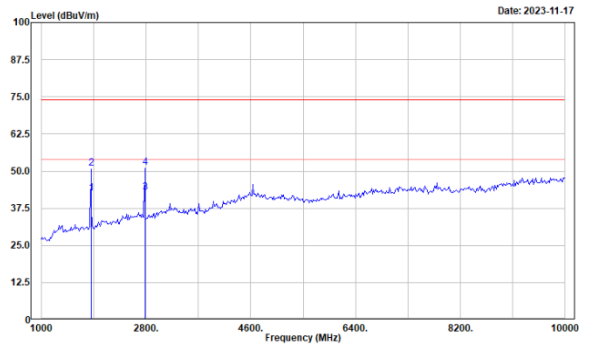
Band-Edge

Horizontal	Vertical
	

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
927.250	120.10	2.35	122.45			100	7	Peak
927.250	118.09	2.35	120.44			100	7	QP
928.000	59.58	2.38	61.96	100.44	-38.48	100	7	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
927.250	119.46	2.35	121.81			100	341	Peak
927.250	118.31	2.35	120.66			100	341	QP
928.000	59.33	2.38	61.71	100.66	-38.95	100	341	QP

1GHz-10GHz:

Horizontal	Vertical
	

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB	dBuV	dBuV	dB	(cm)	(°)	
1854.500	58.21	-13.62	44.59	54.00	-9.41	144	84	Average
1854.500	67.37	-13.62	53.75	74.00	-20.25	144	84	Peak
2781.750	57.71	-10.07	47.64	54.00	-6.36	105	84	Average
2781.750	63.32	-10.07	53.25	74.00	-20.75	105	84	Peak

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB	dBuV	dBuV	dB	(cm)	(°)	
1854.500	56.23	-13.62	42.61	54.00	-11.39	223	41	Average
1854.500	64.60	-13.62	50.98	74.00	-23.02	223	41	Peak
2781.750	52.85	-10.07	42.78	54.00	-11.22	197	359	Average
2781.750	61.33	-10.07	51.26	74.00	-22.74	197	359	Peak

Above 1GHz

DSB-ASK Mode:

Low channel

Horizontal

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
902.000	59.13	1.90	61.03	101.78	-40.75	100	316	QP
902.750	121.56	1.90	123.46			100	316	Peak
902.750	119.88	1.90	121.78			100	316	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1805.500	47.79	-14.00	33.79	54.00	-20.21	135	77	Average
1805.500	63.39	-14.00	49.39	74.00	-24.61	135	77	Peak
2708.250	50.38	-9.79	40.59	54.00	-13.41	130	247	Average
2708.250	63.03	-9.79	53.24	74.00	-20.76	130	247	Peak

Vertical

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
902.000	59.99	1.90	61.89	102.78	-40.89	100	342	QP
902.750	122.42	1.90	124.32			100	342	Peak
902.750	120.88	1.90	122.78			100	342	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1805.500	47.02	-14.00	33.02	54.00	-20.98	147	152	Average
1805.500	59.68	-14.00	45.68	74.00	-28.32	147	152	Peak
2708.250	42.98	-9.79	33.19	54.00	-20.81	178	144	Average
2708.250	55.06	-9.79	45.27	74.00	-28.73	178	144	Peak

Middle channel

Horizontal

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
915.250	120.43	1.98	122.41			100	354	Peak
915.250	118.70	1.98	120.68			100	354	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1830.500	50.78	-13.80	36.98	54.00	-17.02	183	116	Average
1830.500	63.98	-13.80	50.18	74.00	-23.82	183	116	Peak
2745.750	50.80	-9.96	40.84	54.00	-13.16	107	120	Average
2745.750	61.90	-9.96	51.94	74.00	-22.06	107	120	Peak

Vertical

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
915.250	121.15	1.98	123.13			100	317	Peak
915.250	119.37	1.98	121.35			100	317	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1830.500	49.11	-13.80	35.31	54.00	-18.69	105	24	Average
1830.500	59.85	-13.80	46.05	74.00	-27.95	105	24	Peak
2745.750	45.37	-9.96	35.41	54.00	-18.59	149	9	Average
2745.750	56.77	-9.96	46.81	74.00	-27.19	149	9	Peak

High channel

Horizontal

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
927.250	119.84	2.35	122.19			100	6	Peak
927.250	117.98	2.35	120.33			100	6	QP
928.000	59.96	2.38	62.34	100.33	-37.99	100	6	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1854.500	54.36	-13.62	40.74	54.00	-13.26	129	12	Average
1854.500	66.46	-13.62	52.84	74.00	-21.16	129	12	Peak
2781.750	52.35	-10.07	42.28	54.00	-11.72	153	269	Average
2781.750	62.11	-10.07	52.04	74.00	-21.96	153	269	Peak

Vertical

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
927.250	119.84	2.35	122.19			100	11	Peak
927.250	118.03	2.35	120.38			100	11	QP
928.000	59.41	2.38	61.79	100.38	-38.59	100	11	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1854.500	51.89	-13.62	38.27	54.00	-15.73	225	37	Average
1854.500	63.52	-13.62	49.90	74.00	-24.10	225	37	Peak
2781.750	49.49	-10.07	39.42	54.00	-14.58	231	2	Average
2781.750	59.77	-10.07	49.70	74.00	-24.30	231	2	Peak

Level = Reading + Factor.

Margin = Level – Limit.

Factor = Antenna Factor + Cable Loss – Amplifier Gain.

PR-ASK Mode:

Low channel

Horizontal

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
902.000	59.46	1.90	61.36	100.90	-39.54	100	310	QP
902.750	120.21	1.90	122.11			100	310	Peak
902.750	119.00	1.90	120.90			100	310	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1805.500	51.09	-14.00	37.09	54.00	-16.91	143	125	Average
1805.500	62.90	-14.00	48.90	74.00	-25.10	143	125	Peak
2708.250	54.92	-9.79	45.13	54.00	-8.87	131	264	Average
2708.250	63.01	-9.79	53.22	74.00	-20.78	131	264	Peak

Vertical

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
902.000	59.86	1.90	61.76	102.44	-40.68	100	310	QP
902.750	121.70	1.90	123.60			100	310	Peak
902.750	120.54	1.90	122.44			100	310	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1805.500	50.34	-14.00	36.34	54.00	-17.66	149	167	Average
1805.500	58.36	-14.00	44.36	74.00	-29.64	149	167	Peak
2708.250	43.37	-9.79	33.58	54.00	-20.42	160	214	Average
2708.250	53.45	-9.79	43.66	74.00	-30.34	160	214	Peak

Middle channel

Horizontal

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
915.250	120.11	1.98	122.09			100	340	Peak
915.250	119.08	1.98	121.06			100	340	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1830.500	53.76	-13.80	39.96	54.00	-14.04	143	86	Average
1830.500	63.94	-13.80	50.14	74.00	-23.86	143	86	Peak
2745.750	55.23	-9.96	45.27	54.00	-8.73	110	204	Average
2745.750	62.28	-9.96	52.32	74.00	-21.68	110	204	Peak

Vertical

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
915.250	120.47	1.98	122.45			100	310	Peak
915.250	119.26	1.98	121.24			100	310	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1830.500	52.64	-13.80	38.84	54.00	-15.16	191	31	Average
1830.500	60.83	-13.80	47.03	74.00	-26.97	191	31	Peak
2745.750	48.06	-9.96	38.10	54.00	-15.90	229	18	Average
2745.750	56.85	-9.96	46.89	74.00	-27.11	229	18	Peak

High channel

Horizontal

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
927.250	120.10	2.35	122.45			100	7	Peak
927.250	118.09	2.35	120.44			100	7	QP
928.000	59.58	2.38	61.96	100.44	-38.48	100	7	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1854.500	58.21	-13.62	44.59	54.00	-9.41	144	84	Average
1854.500	67.37	-13.62	53.75	74.00	-20.25	144	84	Peak
2781.750	57.71	-10.07	47.64	54.00	-6.36	105	84	Average
2781.750	63.32	-10.07	53.25	74.00	-20.75	105	84	Peak

Vertical

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
927.250	119.46	2.35	121.81			100	341	Peak
927.250	118.31	2.35	120.66			100	341	QP
928.000	59.33	2.38	61.71	100.66	-38.95	100	341	QP

Freq.	Reading	Factor	Level	Limit	Margin	Height	Degree	Remark
MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	(cm)	(°)	
1854.500	56.23	-13.62	42.61	54.00	-11.39	223	41	Average
1854.500	64.60	-13.62	50.98	74.00	-23.02	223	41	Peak
2781.750	52.85	-10.07	42.78	54.00	-11.22	197	359	Average
2781.750	61.33	-10.07	51.26	74.00	-22.74	197	359	Peak

Level = Reading + Factor.

Margin = Level – Limit.

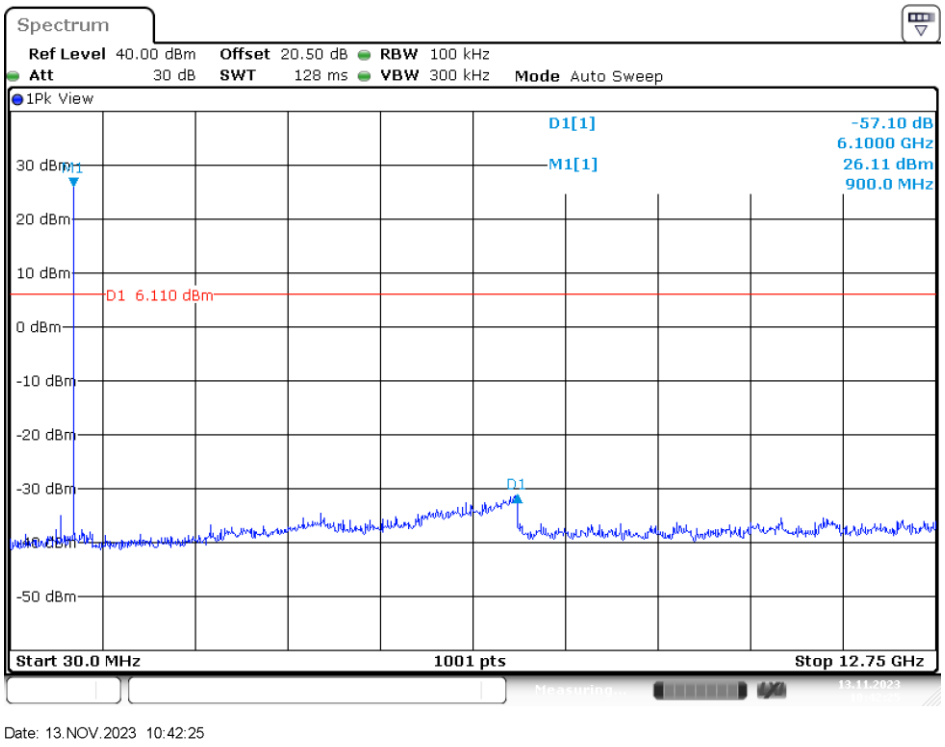
Factor = Antenna Factor + Cable Loss – Amplifier Gain.

Conducted Spurious Emissions:

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
DSB-ASK Mode				
Low	902.75	57.10	≥ 20	PASS
Mid	915.25	58.64	≥ 20	PASS
High	927.25	58.66	≥ 20	PASS
PR-ASK Mode				
Low	902.75	59.03	≥ 20	PASS
Mid	915.25	59.38	≥ 20	PASS
High	927.25	59.18	≥ 20	PASS

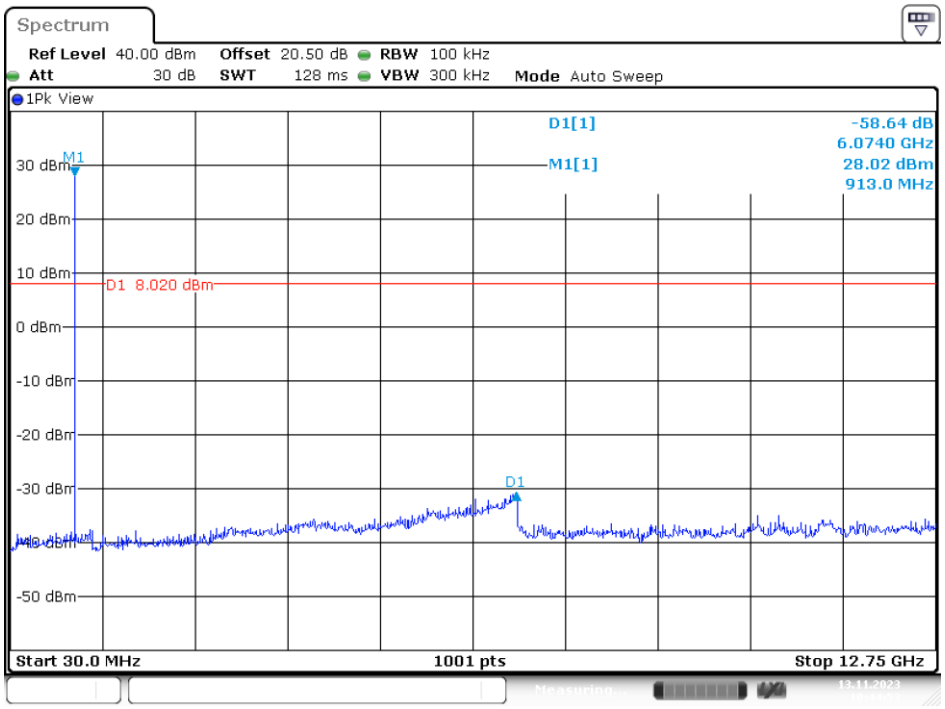
DSB-ASK Mode

Low Channel



Date: 13.NOV.2023 10:42:25

Middle Channel



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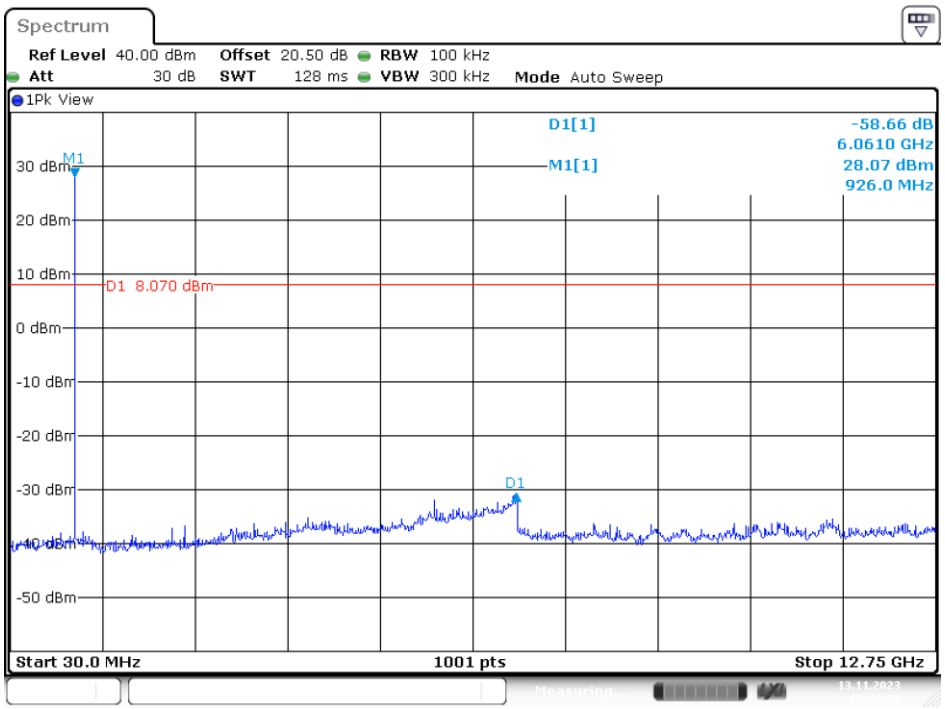
High Channel



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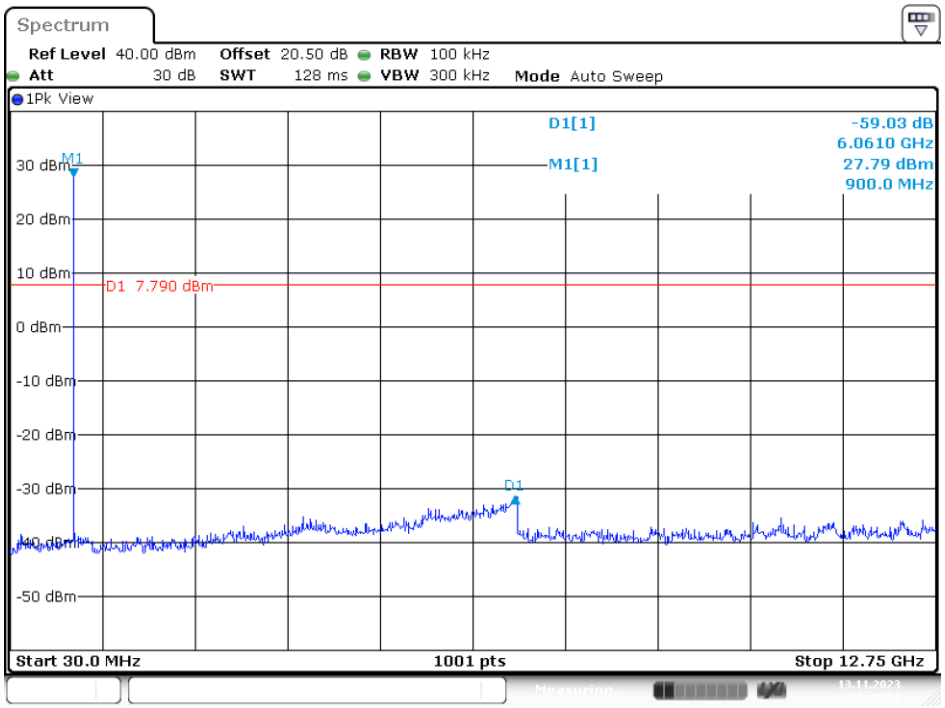
PR-ASK Mode

Low Channel



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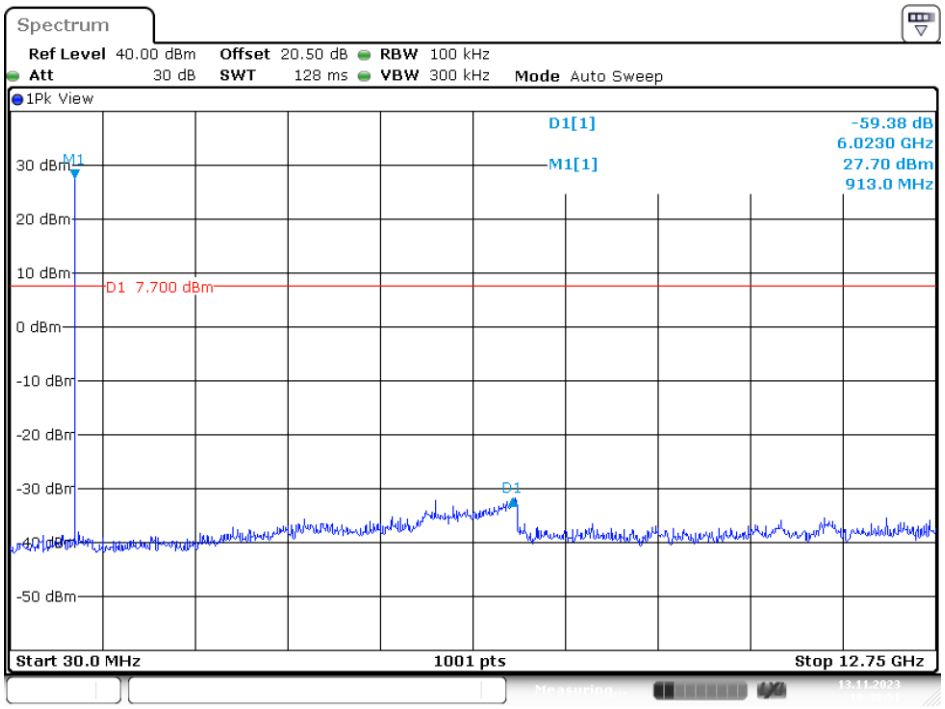
Middle Channel



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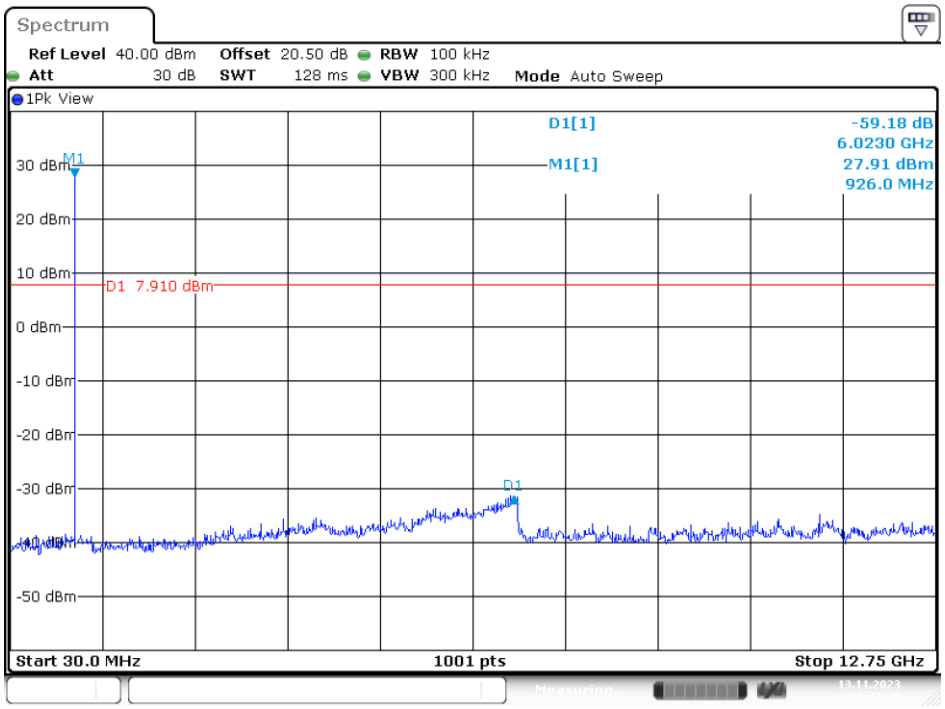
High Channel



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9. FCC §15.247(a)(1) – 20 dB Emission Bandwidth

9.1. Applicable Standard

According to FCC §15.247(a) (1) the maximum 20 dB bandwidth of the hopping channel shall be presented.

9.2. Test Procedure

According to ANSI C63.10-2013 Section 6.9.2

(1) Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
(2) Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
(3) Measure the frequency difference of two frequencies that were attenuated 20 dB from the reference level. Record the frequency difference as the emission bandwidth.
(4) Repeat above procedures until all frequencies measured were complete.

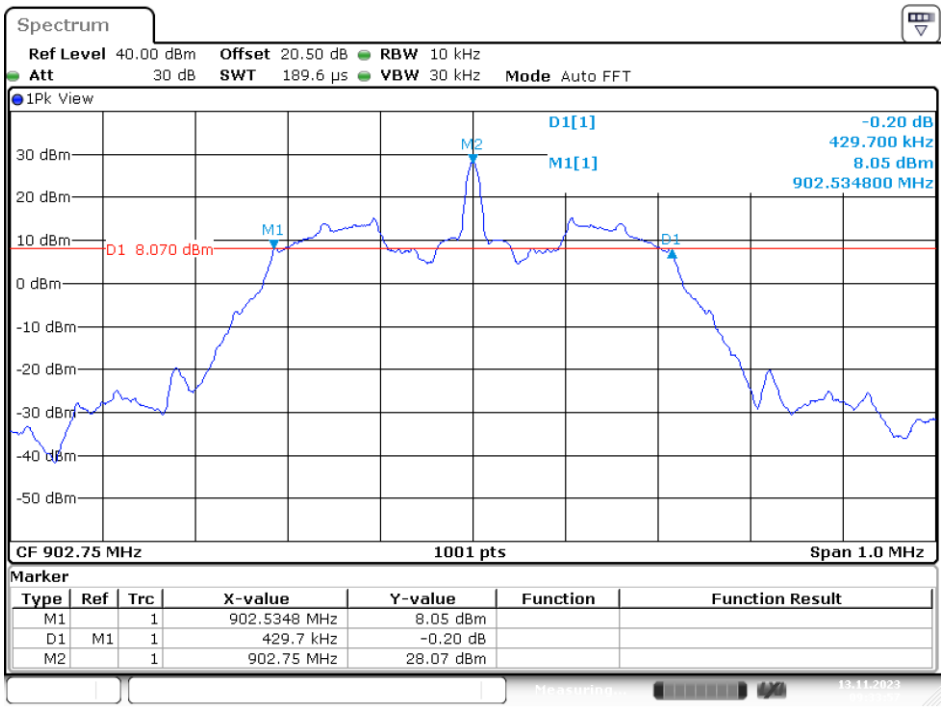
9.3. Test Results

Channel	Frequency (MHz)	20 dBc BW (kHz)	Limit (kHz)	Result
DSB-ASK Mode				
Low	902.75	429.70	<500	Pass
Middle	915.25	431.60	<500	Pass
High	927.25	429.60	<500	Pass
PR-ASK Mode				
Low	902.75	210.80	<500	Pass
Middle	915.25	210.80	<500	Pass
High	927.25	210.80	<500	Pass

Please refer to the following plots

DSB-ASK Mode

Low Channel



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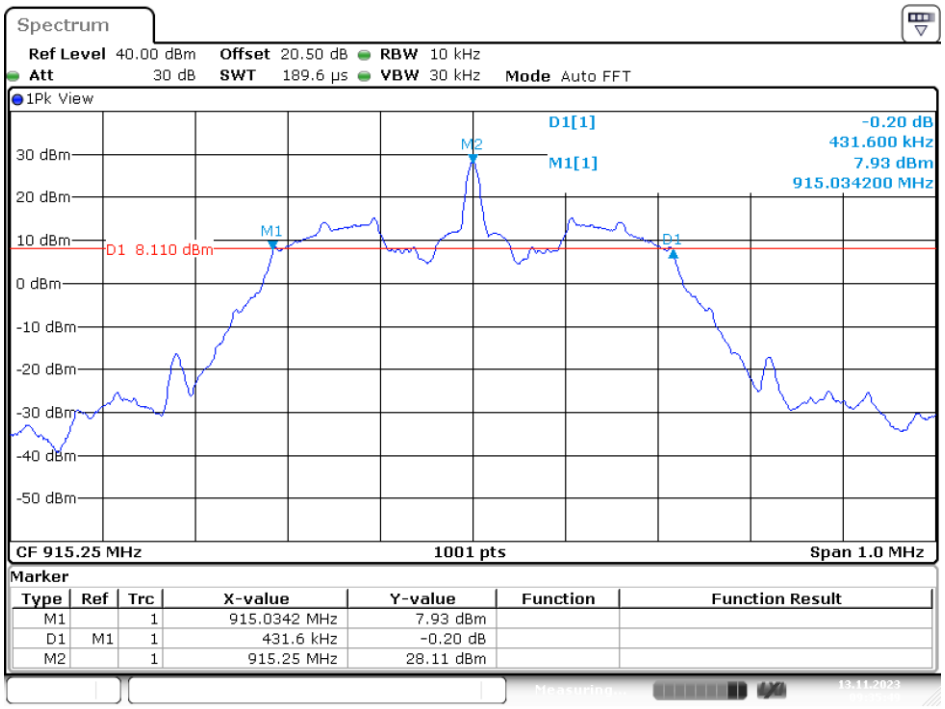
Middle Channel



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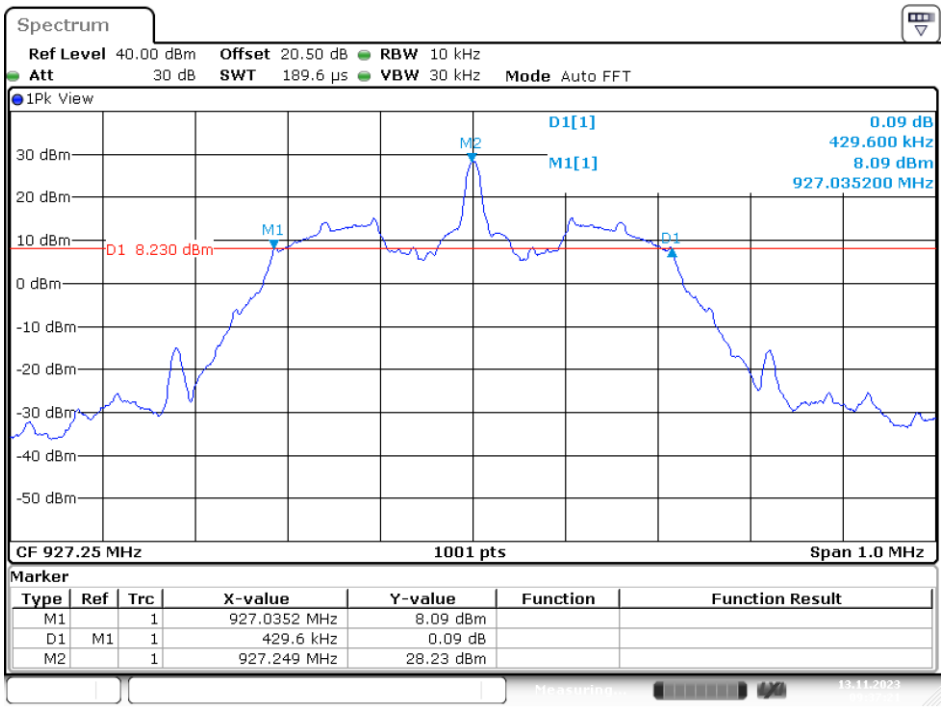
High Channel



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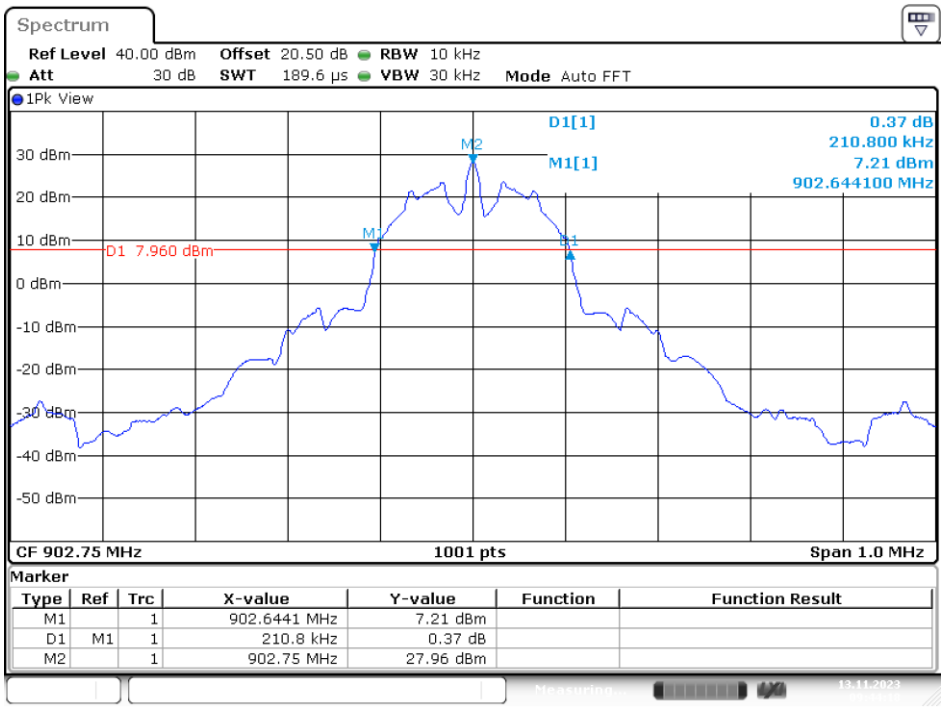
PR-ASK Mode

Low Channel



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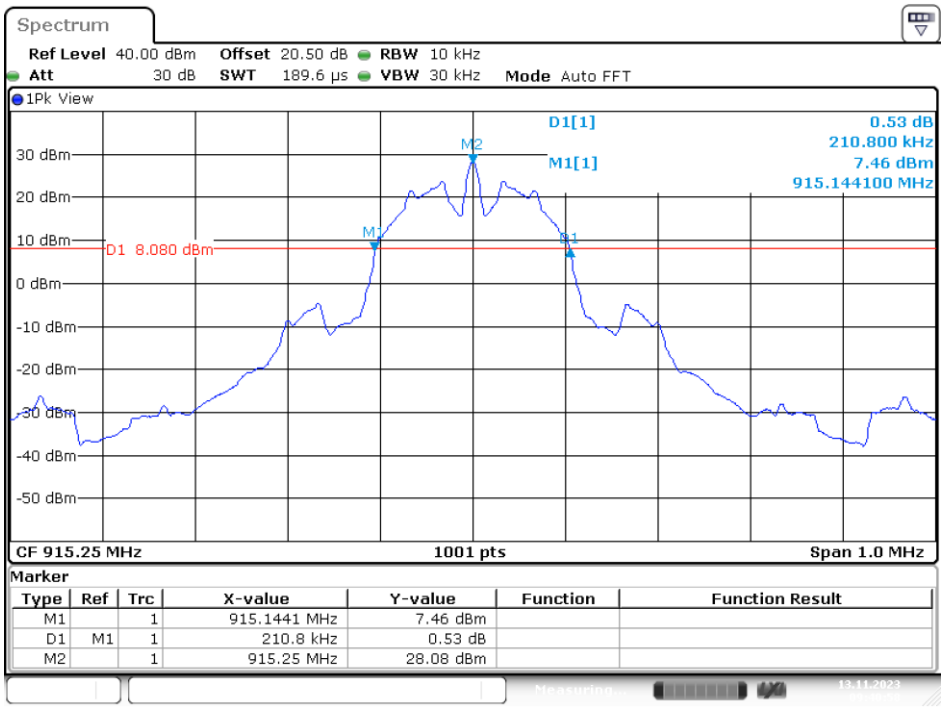
Middle Channel



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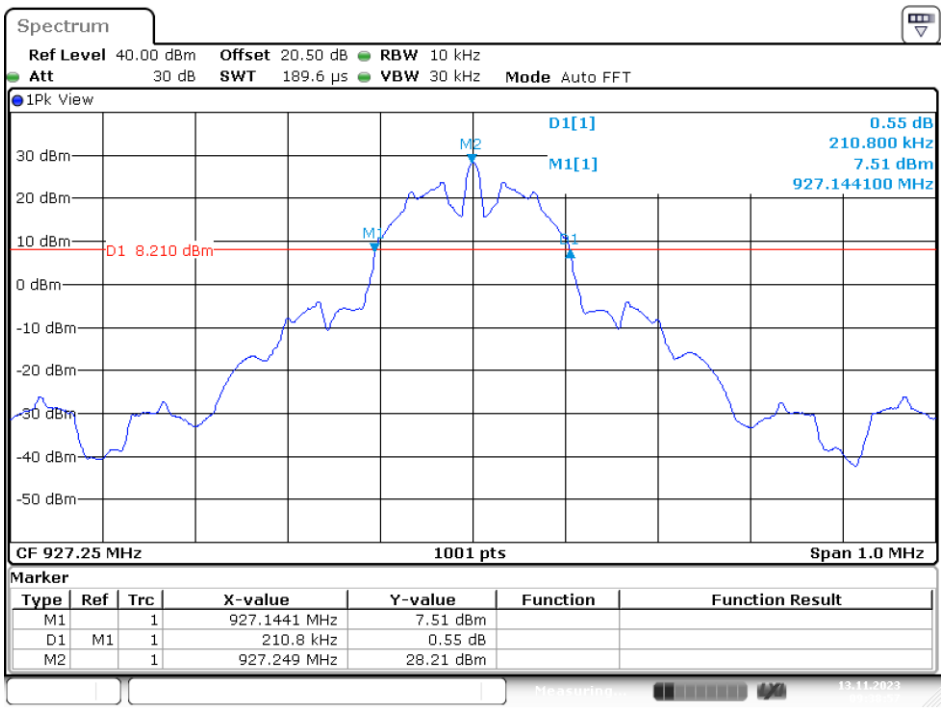
High Channel



Date: 13.NOV.2023 09:38:57

10. FCC §15.247(a)(1) – Channel Separation Test

10.1. Applicable Standard

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

10.2. Test Procedure

According to ANSI C63.10-2013 Section 7.8.2

1. Set the EUT in transmitting mode, max hold the channel.
2. Set the adjacent channel of the EUT and max hold another trace.
3. Measure the channel separation.

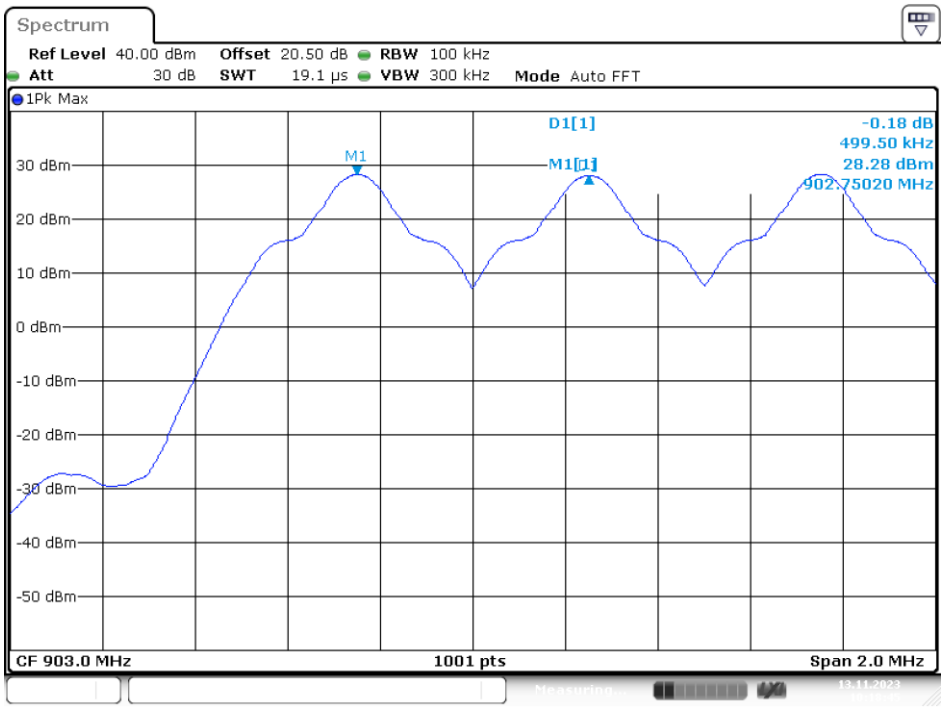
10.3. Test Results

Channel	Frequency (MHz)	Channel Separation (MHz)	20 dBc BW (MHz)	Channel Separation Limit	Result
DSB-ASK Mode					
Low	902.75	499.50	429.70	25 kHz or the 20 dB bandwidth, whichever is greater	Pass
Middle	915.25	499.50	431.60		Pass
High	927.25	499.50	429.60		Pass
PR-ASK Mode					
Low	902.75	499.50	210.80	25 kHz or the 20 dB bandwidth, whichever is greater	Pass
Middle	915.25	499.50	210.80		Pass
High	927.25	499.50	210.80		Pass

Please refer to the following plots.

DSB-ASK Mode

Low Channel



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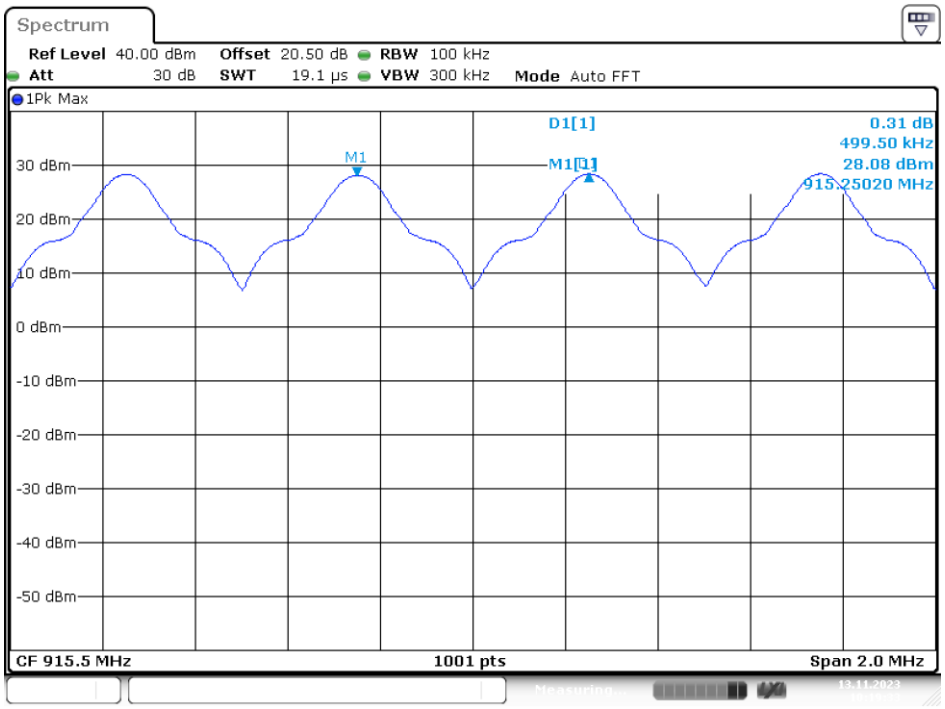
Middle Channel



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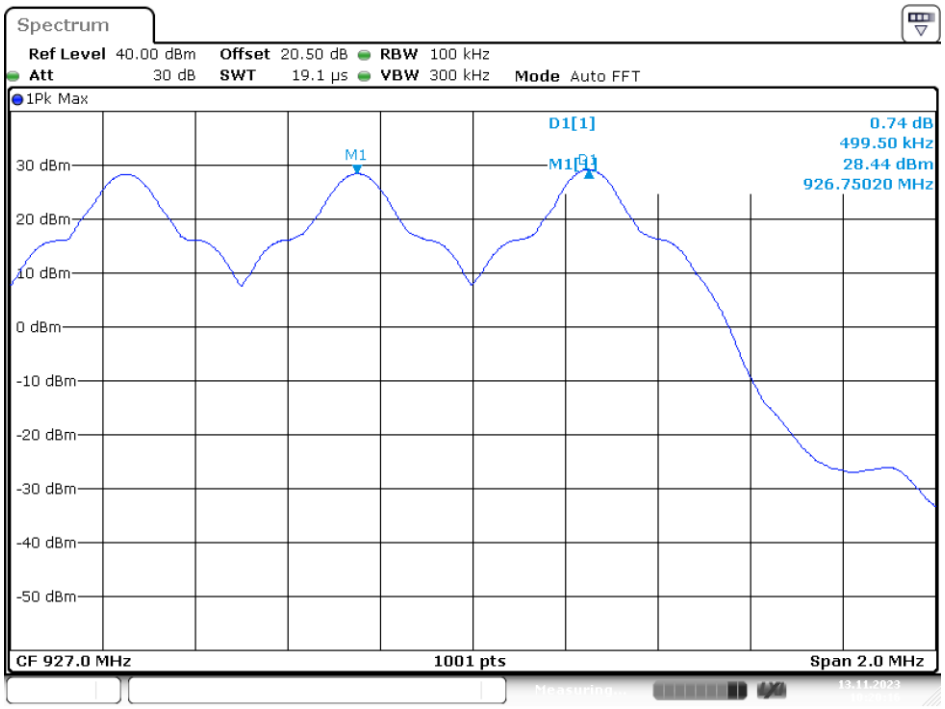
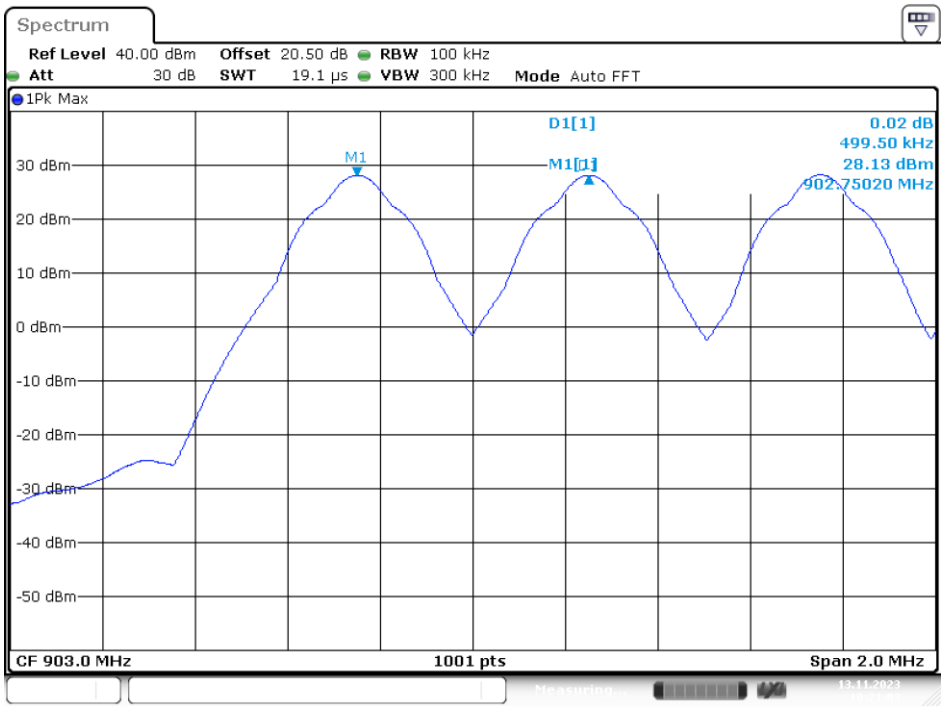
High Channel



Date: 13.NOV.2023 10:20:17

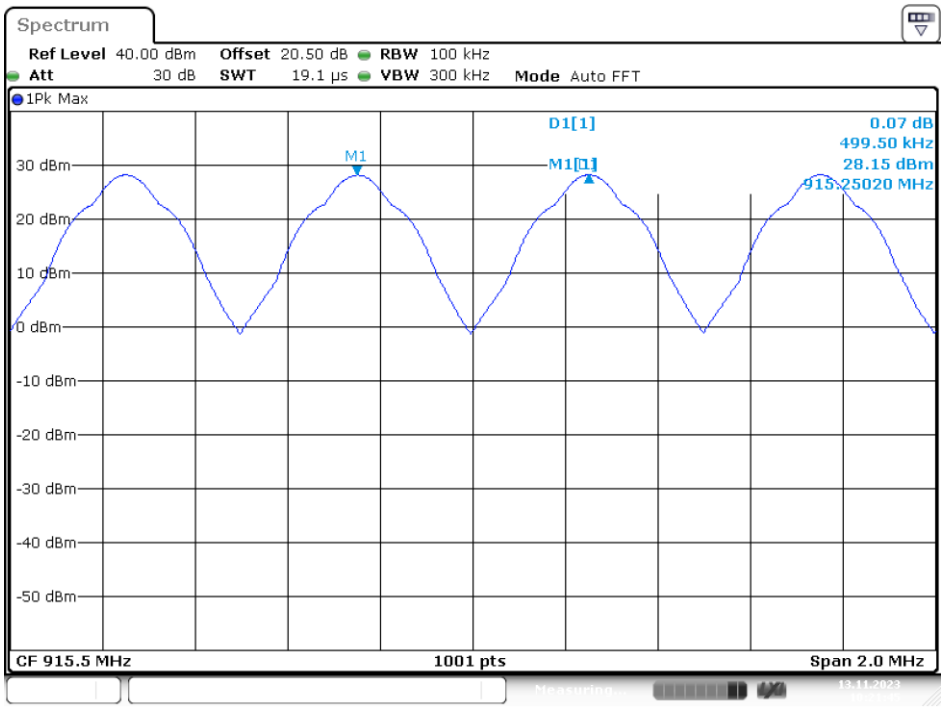
PR-ASK Mode

Low Channel



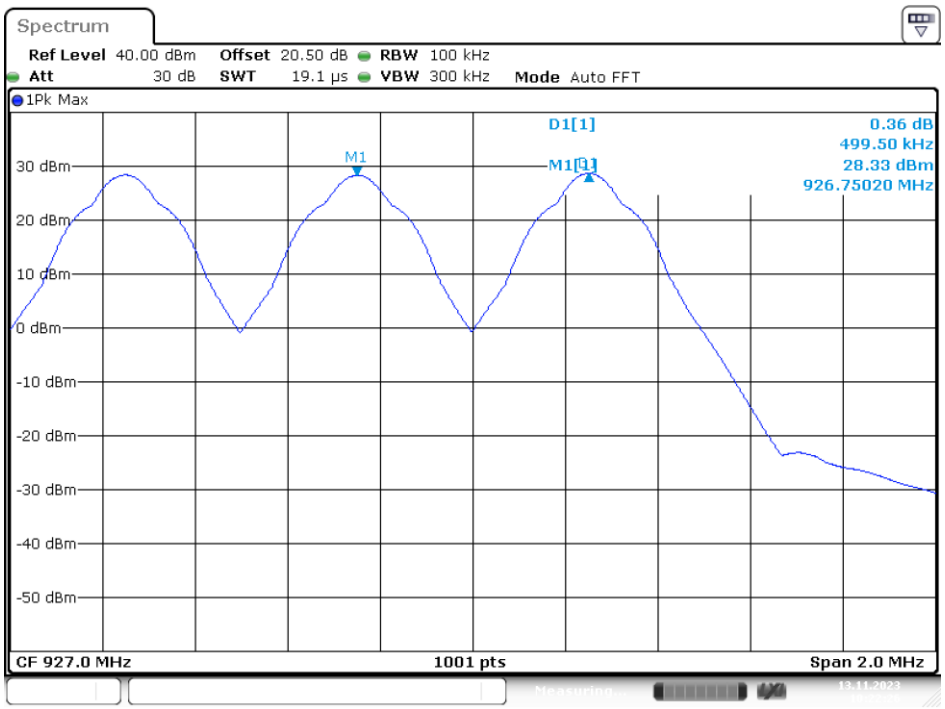
Date: 13.NOV.2023 10:21:03

Middle Channel



Date: 13.NOV.2023 10:21:45

High Channel



Date: 13.NOV.2023 10:22:26

11. FCC§15.247(a)(1)(i) –Time of Occupancy (Dwell Time)

11.1. Applicable Standard

According to FCC §15.247(a) (1) (i).

For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

11.2. Test Procedure

According to ANSI C63.10-2013 Section 7.8.4

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

Span = zero span, centered on a hopping channel.

RBW ≤ channel spacing and where possible RBW should be set >> 1/T, where T is the expected dwell time per channel.

Sweep = as necessary to capture the entire dwell time per hopping channel.

Detector function = peak.

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:

(Number of hops in the period specified in the requirements) = (number of hops on spectrum analyzer) x (period specified in the requirements / analyzer sweep time)

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified. 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.

11.3. Test Results

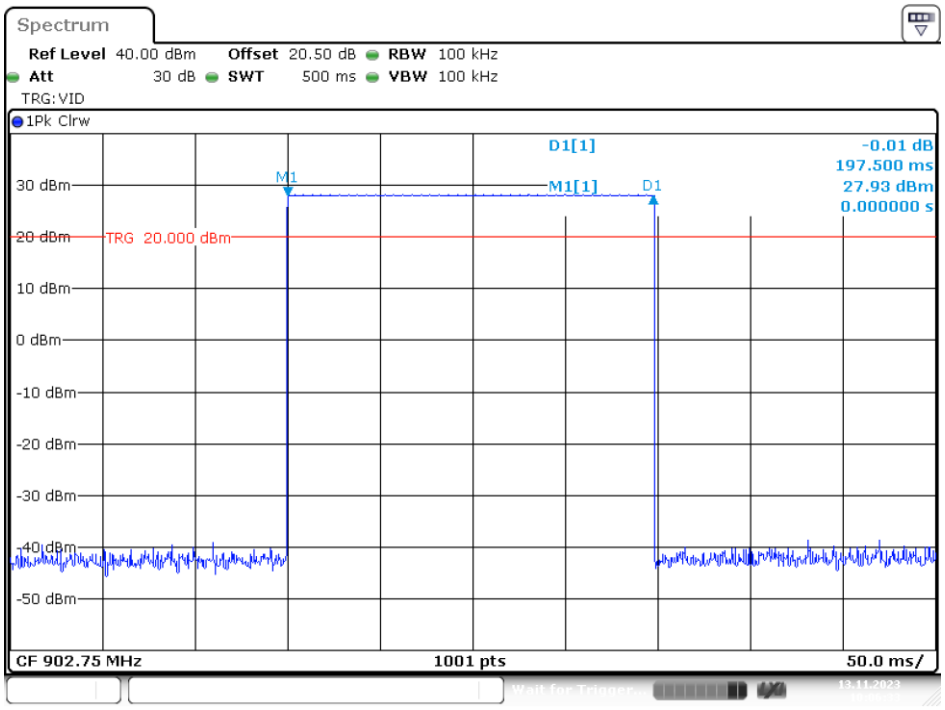
Test mode: DSB-ASK mode / 902.75~927.25MHz					
Pulse Time (ms)	**Hopping Number**	**Period Time (s)**	**Total of Dwell (ms)**	**Limit (ms)**	**Result**
197.50	1	10	197.50	<400	PASS
Test mode: PR-ASK mode / 902.75~927.25MHz					
Pulse Time (ms)	**Hopping Number**	**Period Time (s)**	**Total of Dwell (ms)**	**Limit (ms)**	**Result**
197.5	2	20	395	<400	PASS

Note: Total of Dwell=Pulse Time * Hopping Number

Please refer to the following plots

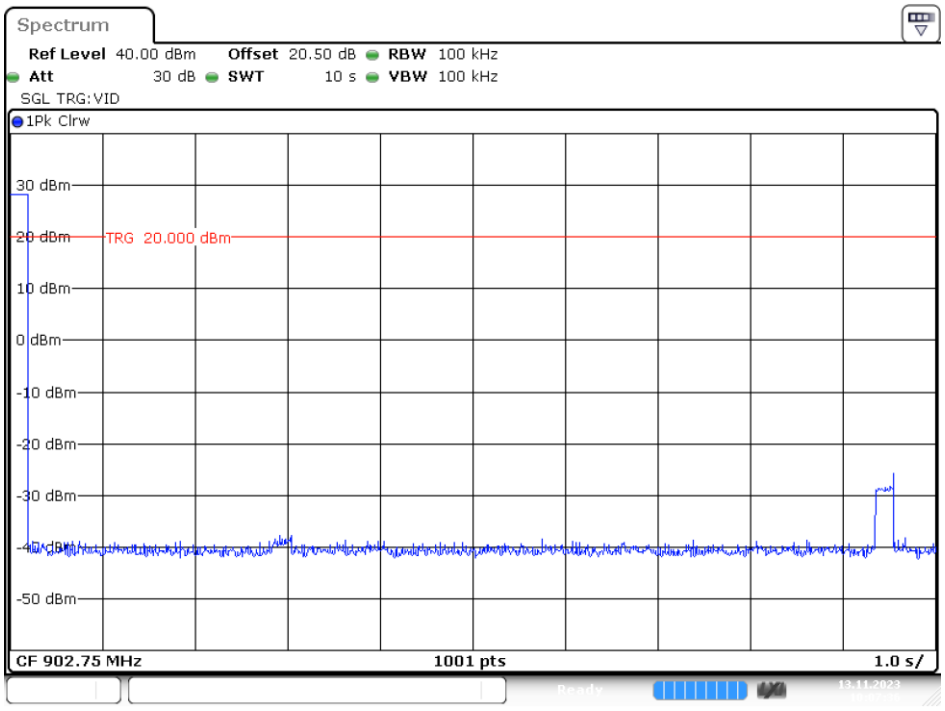
DSB-ASK Mode

Pulse Width



Date: 13.NOV.2023 10:06:33

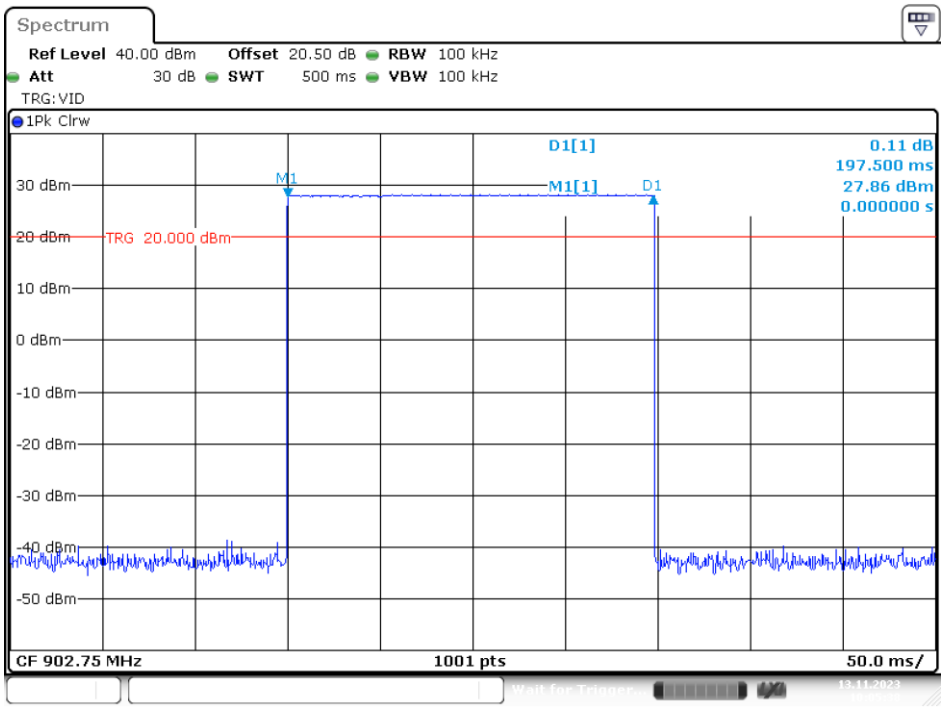
Hopping Number



Date: 13.NOV.2023 10:07:37

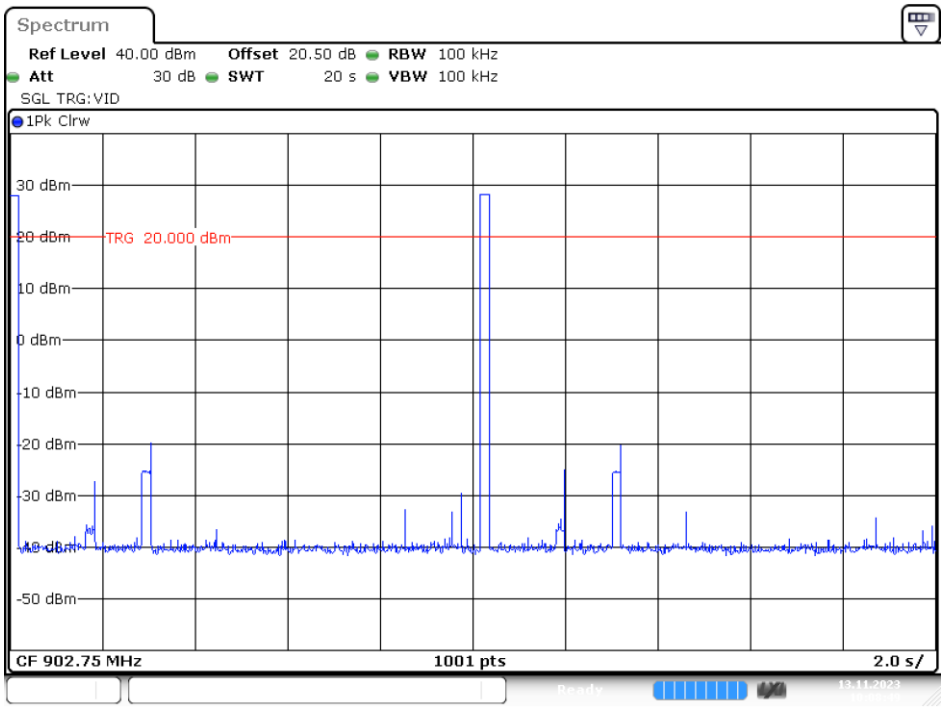
PR-ASK Mode

Pulse Width



Date: 13.NOV.2023 10:05:38

Hopping Number



Date: 13.NOV.2023 10:08:50

12. FCC §15.247(a)(1)(i) –Quantity of hopping channel Test

12.1. Applicable Standard

According to FCC §15.247(a) (1) (i).

For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

12.2. Test Procedure

According to ANSI C63.10-2013 Section 7.8.3

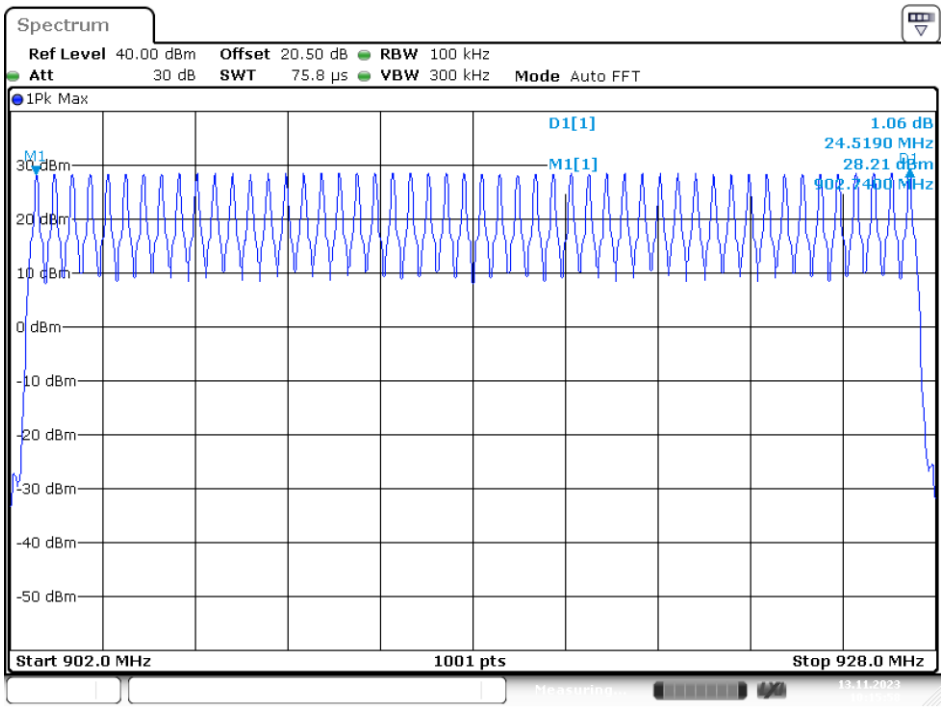
1. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
2. Set the EUT in hopping mode from first channel to last.
3. By using the Max-Hold function record the Quantity of the channel.

12.3. Test Results

Mode	Frequency Range (MHz)	Number of Hopping Channel	Limit	Result
DSB-ASK	902.75~927.25	50	≥25	Compliance
PR-ASK	902.75~927.25	50	≥50	Compliance

Please refer to the following plots

DSB-ASK Mode



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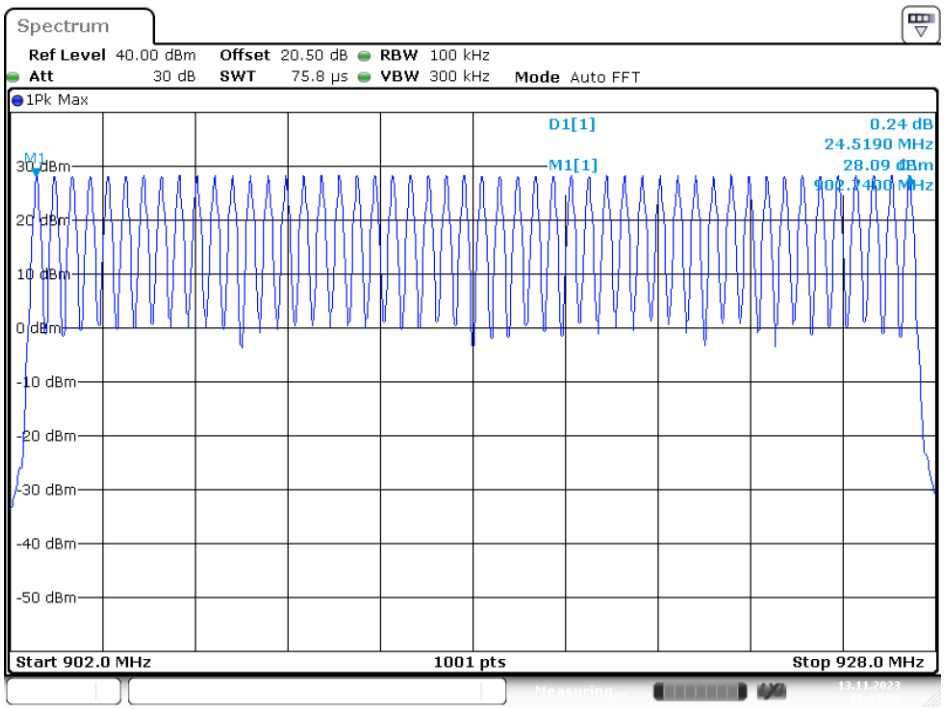
PR-ASK Mode



Date: 13.NOV.2023 10:09:54

13. FCC §15.247(b)(2) – Maximum Output Power

13.1. Applicable Standard

According to FCC §15.247(b) (2).

For frequency hopping systems operating in the 902–928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

13.2. Test Procedure

According to ANSI C63.10-2013 Section 7.8.5

1. Place the EUT on a bench and set it in transmitting mode.

2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to measuring equipment.

13.3. Test Results

Channel	Frequency (MHz)	Peak Conducted Output Power		Limit (W)	Result
		(dBm)	(W)		
DSB-ASK Mode					
Low	902.75	29.26	0.843	1	Compliance
Middle	915.25	29.34	0.859	1	Compliance
High	927.25	29.80	0.955	1	Compliance
PR-ASK Mode					
Low	902.75	29.06	0.805	1	Compliance
Middle	915.25	29.14	0.820	1	Compliance
High	927.25	29.88	0.973	1	Compliance

14. FCC §15.247(d) – 100 kHz Bandwidth of Frequency Band Edge

14.1. Applicable Standard

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

14.2. Test Procedure

According to ANSI C63.10-2013 Section 7.8.6

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 = 100 kHz VBW = 300 kHz

Sweep = auto couple

Detector function = peak , Trace = max hold

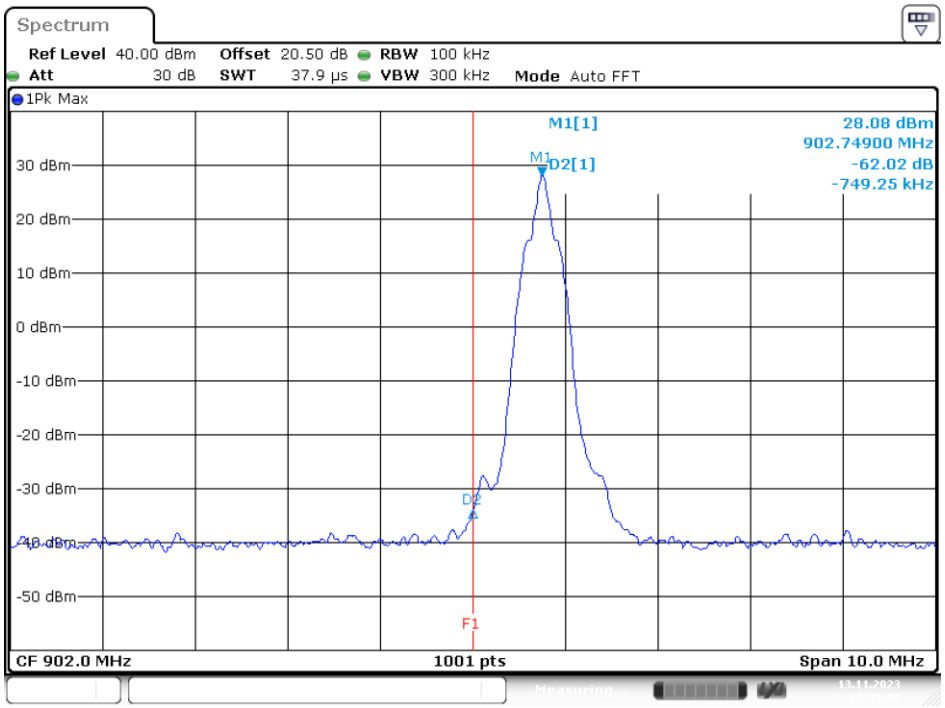
14.3. Test Results

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
DSB-ASK Mode				
Low	902.75	62.02	≥ 20	PASS
High	927.25	62.60	≥ 20	PASS
DSB-ASK Hopping Mode				
Low	902.75	66.58	≥ 20	PASS
High	927.25	65.34	≥ 20	PASS
PR-ASK Mode				
Low	902.75	53.10	≥ 20	PASS
High	927.25	60.40	≥ 20	PASS
PR-ASK Hopping Mode				
Low	902.75	66.21	≥ 20	PASS
High	927.25	63.68	≥ 20	PASS

Please refer to the following plots.

DSB-ASK Mode

Band Edge, CH Low



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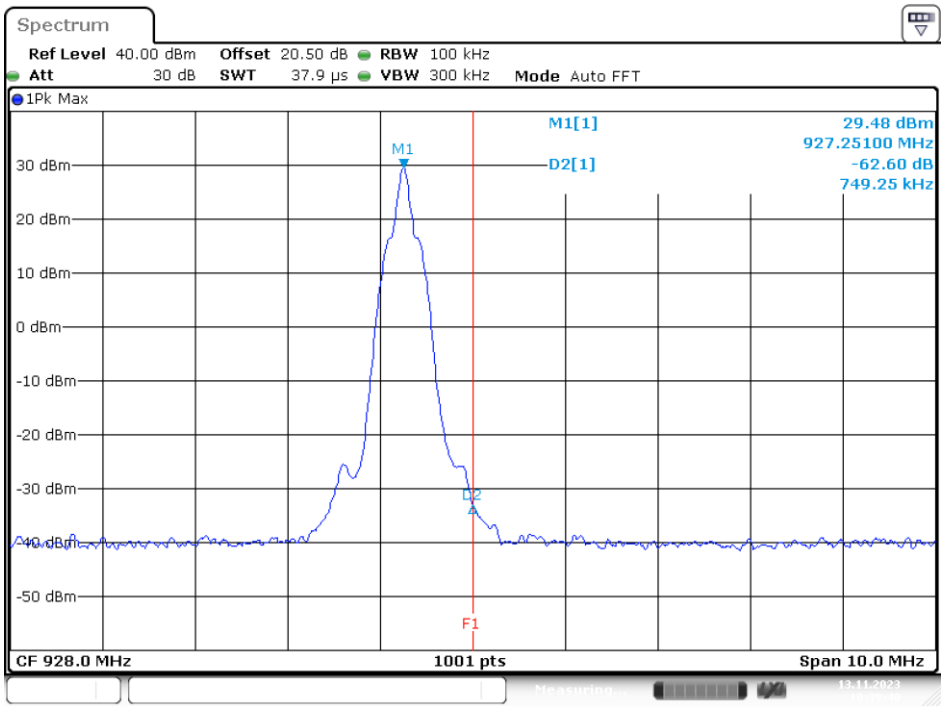
Band Edge, CH High



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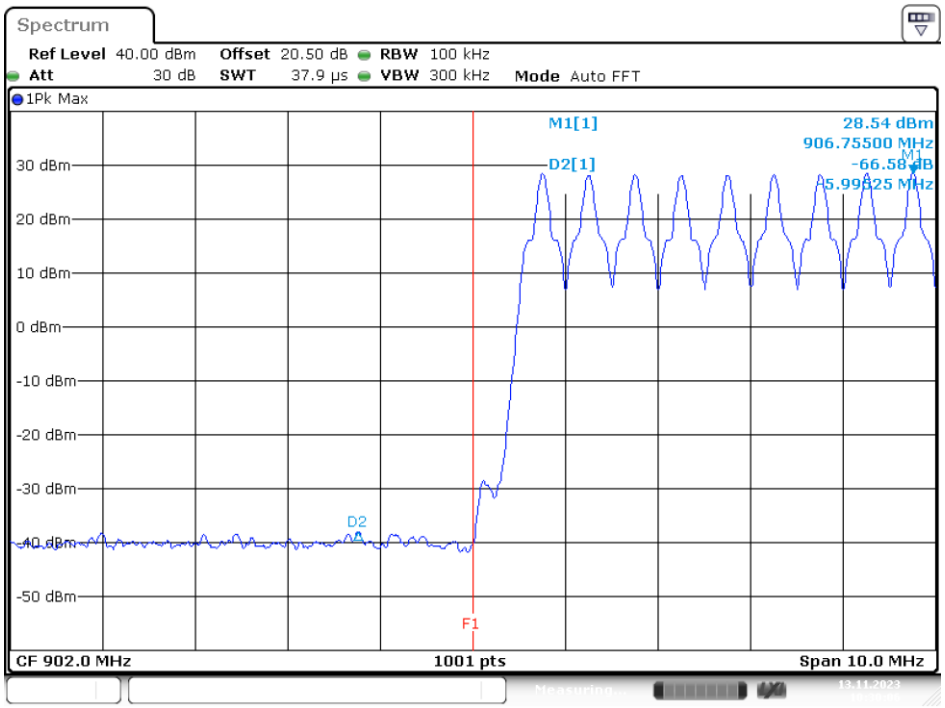
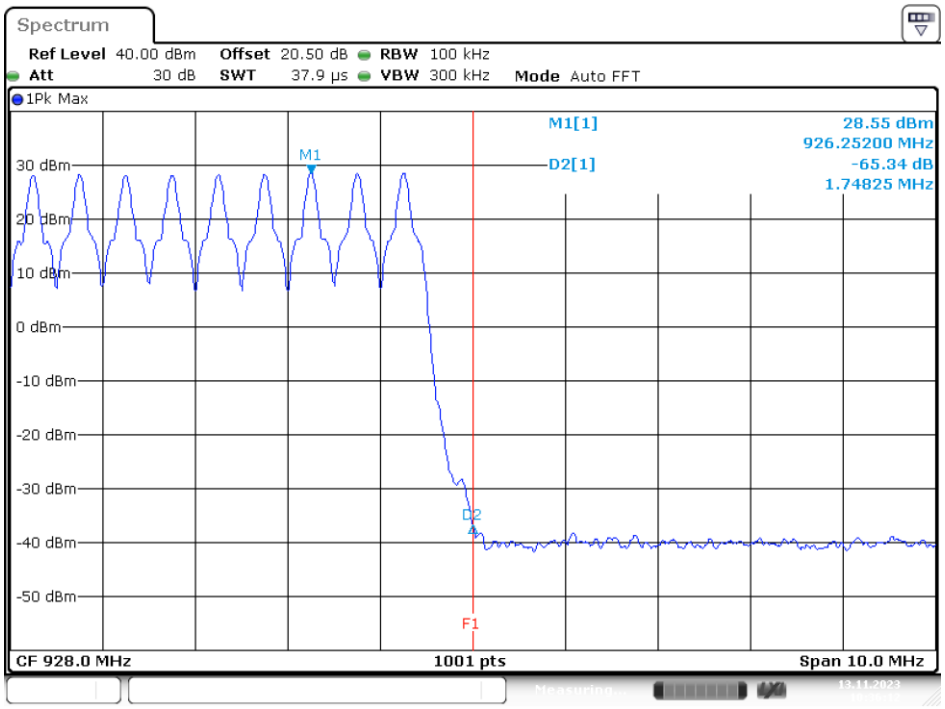
DSB-ASK Hopping Mode

Band Edge, CH Low



Date: 13.NOV.2023 10:30:06

Band Edge, CH High



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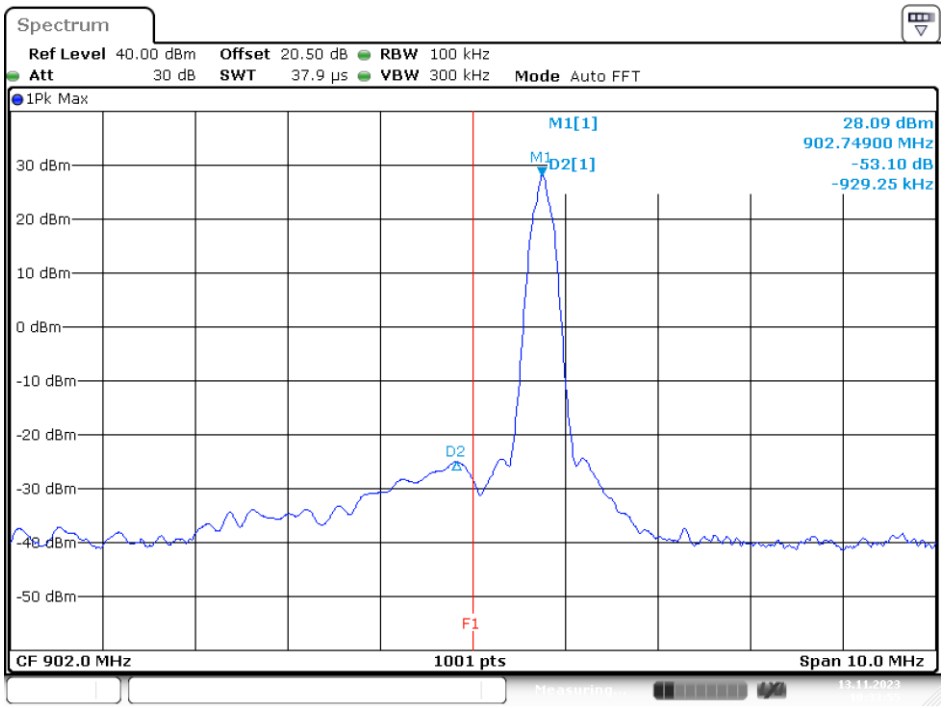
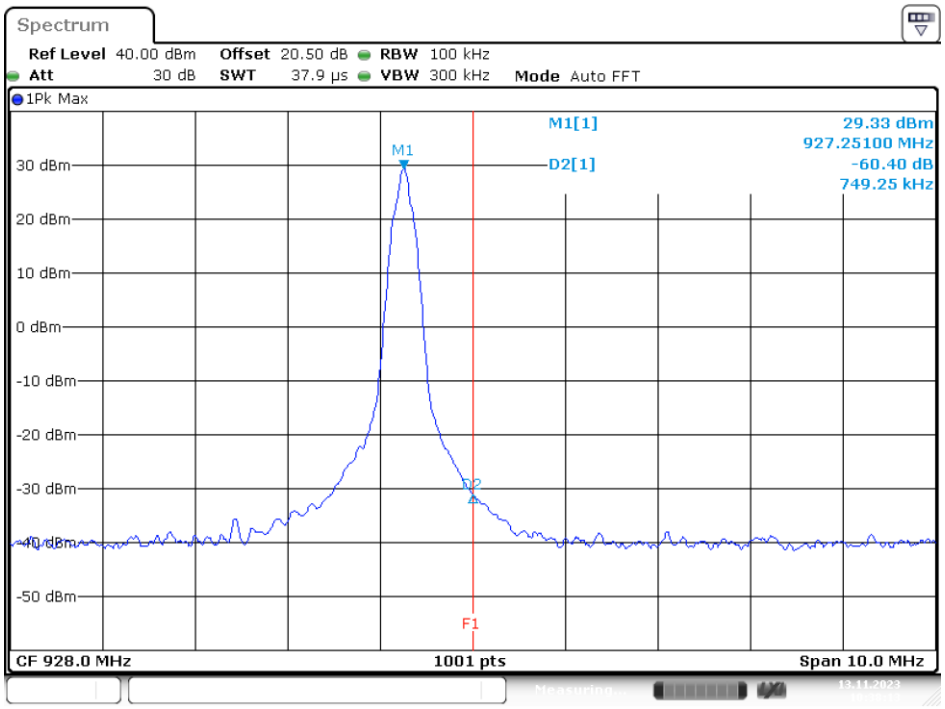
PR-ASK Mode

Band Edge, CH Low



Date: 13.NOV.2023 10:33:55

Band Edge, CH High



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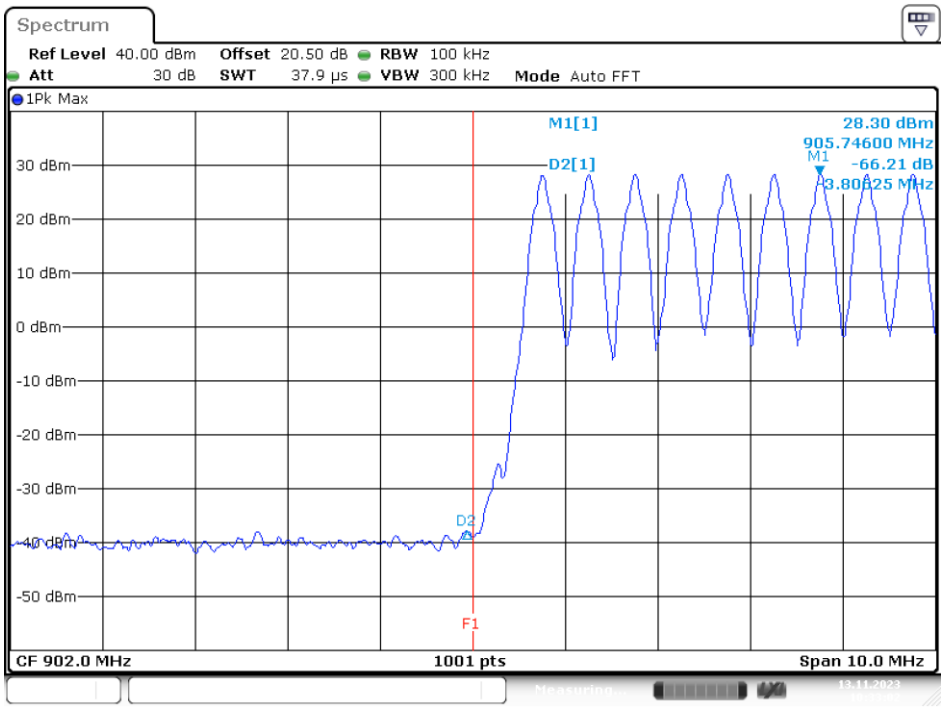
PR-ASK Hopping Mode

Band Edge, CH Low



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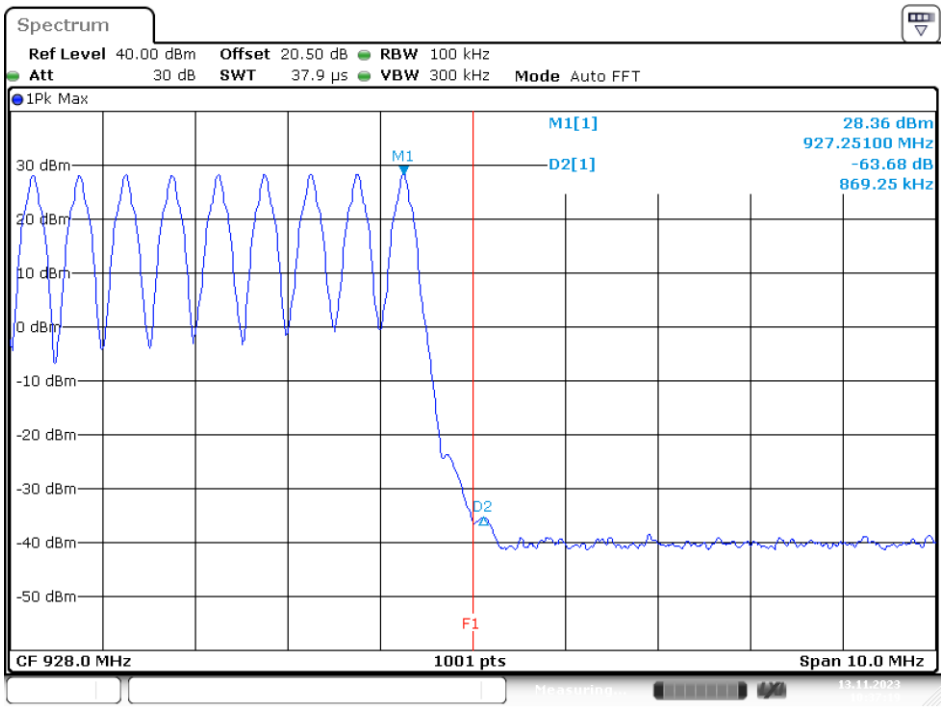
Band Edge, CH High



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