FCC PART 15.247
TEST REPORT

For

Seeed Technology Co., Ltd

9F, G3 Building, TCL International E City, Zhongshanyuan Road, Nanshan District, Shenzhen, China

FCC ID: Z4T-RETERMINAL

Report Type:	**Product Type:**
Original Report	reTerminal with Raspberry Pi Compute Module CM4X

Report Number: SZNS210706-27597E-00A

Report Date: 2021-08-23

Reviewed By: Candy Li, RF Engineer

Prepared By: Shenzhen Accurate Technology Co., Ltd.
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Note: This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "★".

Shenzhen Accurate Technology Co., Ltd. is not responsible for the authenticity of any test data provided by the applicant. Data included from the applicant that may affect test results are marked with an asterisk '*'. Customer model name, addresses, names, trademarks etc. are not considered data.

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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	reTerminal with Raspberry Pi Compute Module CM4X
Trademark	Seeed Studio
Tested Model	reTerminal - CM4X
Frequency Range	Bluetooth: 2402~2480MHz
Maximum conducted Peak output power	Bluetooth: -6.36dBm
Modulation Technique	Bluetooth: GFSK, π/4-DQPSK, 8DPSK
Antenna Specification*	Ant 0 FPC Antenna: 3.76dBi Ant 1 PCB Antenna: 3.5dBi Ant 2 External Antenna: 2dBi (provided by the applicant)
Voltage Range	DC 5V from adapter.
Date of Test	2021-08-07 to 2021-08-09
Sample serial number	SZNS210706-27597E-RF-S1
Received date	2021-07-06
Sample/EUT Status	Good condition

Note: This product has three types of configuration about antenna for different customer market, and End User can change the configuration files to select antenna used via Windows System, which will not change RF parameter and always only one antenna was used.

Objective

This test report is in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commission rules.

The tests were performed in order to determine compliance with FCC Part 15, Subpart C, section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

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.

For Radiated Emissions testing, please refer to DA 00-705 Released March 30, 2000, Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

All emissions measurement was performed at Shenzhen Accurate Technology Co., Ltd. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement Uncertainty

Parameter		Uncertainty
Occupied Channel Bandwidth		5%
RF output power, conducted		0.73dB
Unwanted Emission, conducted		1.6dB
Emissions, Radiated	30MHz - 1GHz	4.28dB
	1GHz - 18GHz	4.98dB
	18GHz - 26.5GHz	5.06dB
Temperature		1℃
Humidity		6%
Supply voltages		0.4%

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.

Test Facility

The test site used by Shenzhen Accurate Technology Co., Ltd. to collect test data is located on the 1/F., Building A, Changyuan New Material Port, Science & Industry Park, Nanshan District, Shenzhen, Guangdong, P.R. China.

The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No.: 708358, the FCC Designation No.: CN1189. Accredited by American Association for Laboratory Accreditation (A2LA) The Certificate Number is 429 7.01.

Listed by Innovation, Science and Economic Development Canada (ISEDC), the Registration Number is 5077A-2.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The system was configured for testing in an engineering mode and support modes as below, which provided by manufacturer.

Modulation	Packet Type (Maximum Payload)	Data Rate (Mbps)
GFSK	DH5	1
π/4-DQPSK	2DH5	2
8DPSK	3DH5	3

EUT Exercise Software

"Windows PowerShell" software was used to test, which provided by manufacturer.

The device was tested with the Power level is default*.

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

Support Equipment List and Details

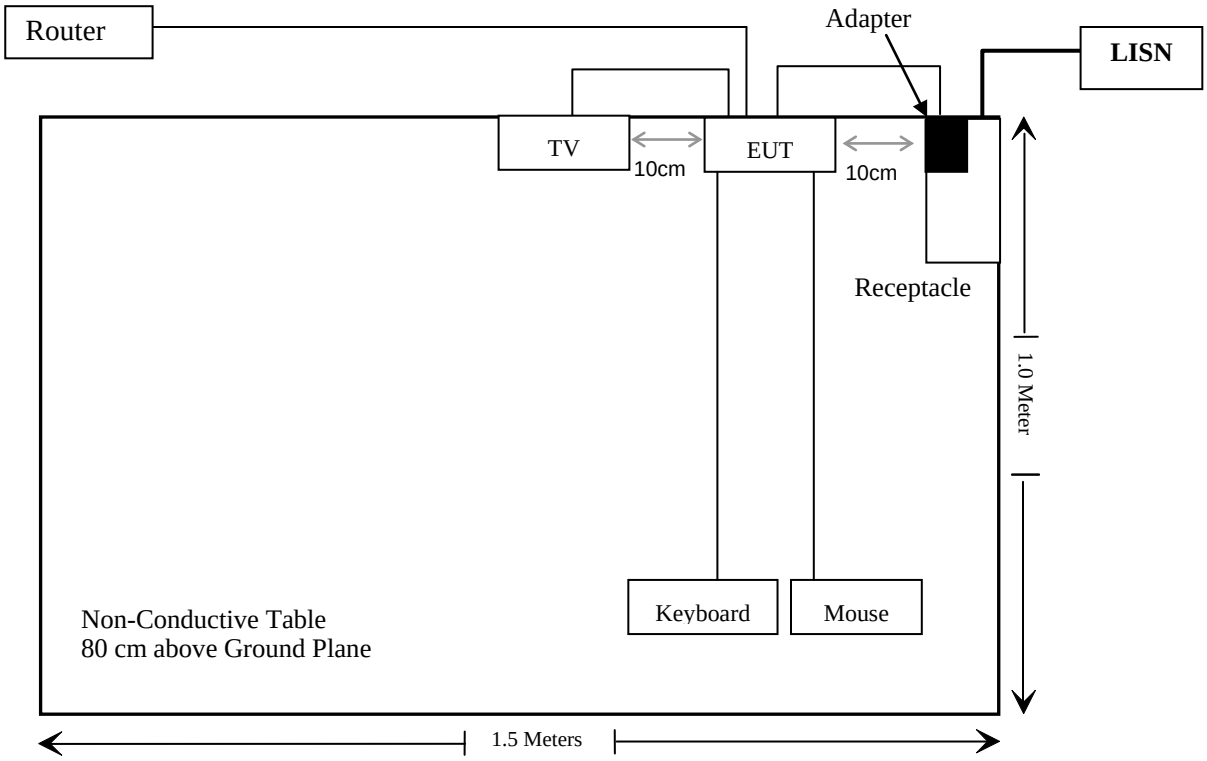
Manufacturer	Description	Model	Serial Number
HUAWEI	Wireless ADSL Router	WS5100	DLJ7S18609013316 10
PENGSHENGYE	Adapter	PSYC0504000	Unknown
XIAOMI	TV	L43M5-ES	25131/114100057334
DELL	Keyboard	L100	CN0RH66658985C018C
DELL	Mouse	MOC5UG	Unknown
SANBAODE	Ferrite Core	740408	Unknown
SANBAODE	Ferrite Core	740421	Unknown
SANBAODE	Ferrite Core	740408	Unknown
SANBAODE	Ferrite Core	740408	Unknown
SANBAODE	Ferrite Core	740415	Unknown
SCI	Ferrite Core	SCRC-130A	Unknown
SCI	Ferrite Core	SCRC-100	Unknown
DONGYANG	Ferrite Core	DYR-2928-160A	Unknown
SCI	Ferrite Core	SCRC-130A	Unknown

External I/O Cable

Cable Description	Length (m)	From Port	To
Unshielded Detachable USB Cable	1.0	Adapter	EUT
Unshielded Detachable HDMI Cable	1.2	TV	EUT
Unshielded Detachable USB Cable	1.5	EUT	Mouse
Unshielded Detachable USB Cable	1.5	EUT	Keyboard
Unshielded Detachable RJ45 Cable	3	Router	EUT

Block Diagram of Test Setup

For conducted emission:



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
FCC §15.247 (i), §2.1091	Maximum Permissible Exposure(MPE)	Compliance
§15.203	Antenna Requirement	Compliance
§15.207(a)	AC Line Conducted Emissions	Compliance
§15.205, §15.209 & §15.247(d)	Radiated Emissions	Compliance
§15.247(a)(1)	20 dB Emission Bandwidth & 99% Occupied Bandwidth	Compliance
§15.247(a)(1)	Channel Separation Test	Compliance
§15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	Compliance
§15.247(a)(1)(iii)	Quantity of hopping channel Test	Compliance
§15.247(b)(1)	Peak Output Power Measurement	Compliance
§15.247(d)	Band edges	Compliance

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Conducted Emissions Test					
Rohde& Schwarz	Test Receiver	ESPI3	100396	2020/12/24	2021/12/23
R & S	L.I.S.N.	ENV216	101314	2020/12/25	2021/12/24
Anritsu Corp	50Ω Coaxial Switch	MP59B	6200506474	2020/12/25	2021/12/24
Unknown	RF Coaxial Cable	N-2m	No.2	2020/12/25	2021/12/24
Radiated Emissions Test					
Rohde&Schwarz	Test Receiver	ESR	101817	2020/12/24	2021/12/23
Rohde & Schwarz	Spectrum Analyzer	FSV-40	101495	2020/12/24	2021/12/23
A.H. Systems, inc.	Preamplifier	PAM-0118P	531	2021/07/08	2022/07/07
SONOMA INSTRUMENT	Amplifier	310 N	186131	2020/12/25	2021/12/24
Schwarzbeck	HORN ANTENNA	BBHA9170	9170-359	2020/01/05	2023/01/04
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2020/11/28	2021/11/27
Schwarzbeck	Bilog Antenna	VULB9163	9163-323	2020/01/04	2023/01/03
Schwarzbeck	Horn Antenna	BBHA9120D	9120D-1067	2020/01/05	2023/01/04
Unknown	RF Coaxial Cable	N-5m	No.3	2020/12/25	2021/12/24
Unknown	RF Coaxial Cable	N-5m	No.4	2020/12/25	2021/12/24
Unknown	RF Coaxial Cable	N-1m	No.5	2020/12/25	2021/12/24
Unknown	RF Coaxial Cable	N-1m	No.6	2020/12/25	2021/12/24
RF Conducted Test					
Rohde&Schwarz	Spectrum Analyzer	FSV40	101495	2020/12/24	2021/12/23
Rohde & Schwarz	Open Switch and Control Unit	OSP120 +OSP-B157	101244 + 100866	2020/12/24	2021/12/23

*** Statement of Traceability:** Shenzhen Accurate Technology Co., Ltd. attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC §15.247 (i) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart 15.247 (i) and subpart 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

Limits for General Population/Uncontrolled Exposure

Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	**Electric Field Strength (V/m)**	**Magnetic Field Strength (A/m)**	**Power Density (mW/cm^2)**	**Averaging Time (Minutes)**
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

Result

Calculated Formulary:

Predication of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

S = power density (in appropriate units, e.g. mW/cm^2)
P = power input to the antenna (in appropriate units, e.g., mW).
G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain.
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

Frequency (MHz)	**Antenna Gain**		**Tune up conducted power**		**Evaluation Distance (cm)**	**Power Density (mW/cm^2)**	**MPE Limit (mW/cm^2)**
	(dBi)	**(numeric)**	**(dBm)**	**(mW)**			
2402-2480	3.76	2.38	-6	0.25	20	0.0001	1

Result: No Standalone SAR test is required.

FCC §15.203 – ANTENNA REQUIREMENT

Applicable Standard

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

Antenna Connector Construction

The EUT has three types of configuration about antenna, which was permanently attached or used a unique connector, and the maximum antenna gain is 3.76dBi, fulfill the requirement of this section. Please refer to the EUT photos.

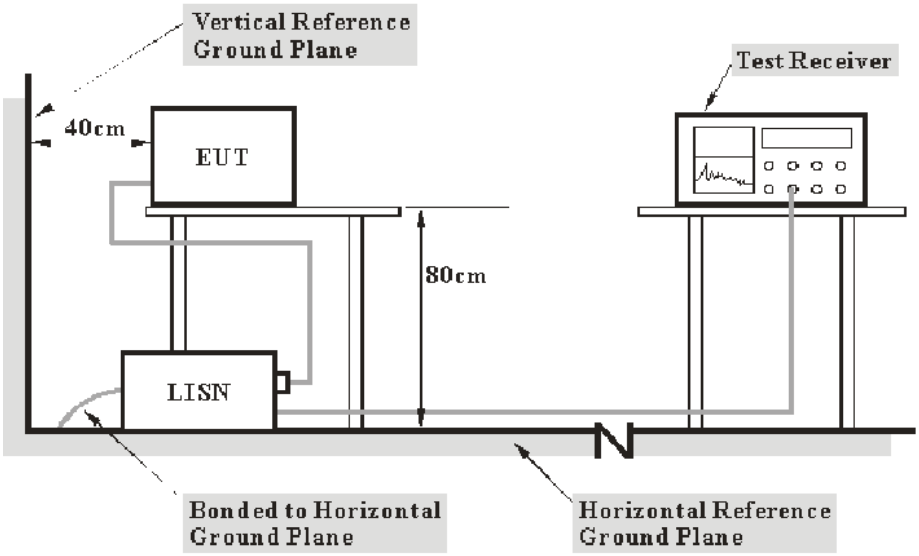
Result: Compliance.

FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a)

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 measurement procedure of EUT setup is according with ANSI C63.10-2013. The related limit was specified in FCC Part 15.207.

The spacing between the peripherals was 10 cm.

EMI Test Receiver Setup

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

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

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

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

Transd Factor & Margin Calculation

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

Transd Factor = LISN VDF + Cable Loss

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 = Limit – level
Level= reading level+ Transd Factor

Test Data

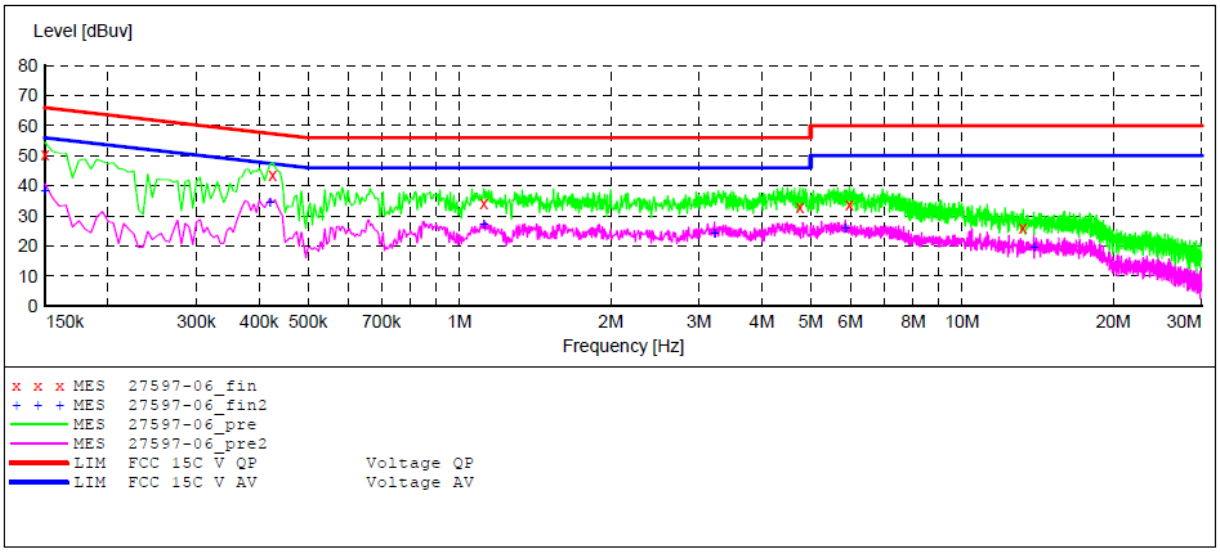
Environmental Conditions

Temperature:	24 ℃
Relative Humidity:	48 %
ATM Pressure:	101.0 kPa

The testing was performed by Fan Yang on 2021-08-09.

EUT operation mode: Transmitting (the worst case for Ant 2, 8DPSK Mode, Middle channel)

AC 120V/60 Hz, Line



MEASUREMENT RESULT: "27597-06_fin"

2021-8-9 05:28

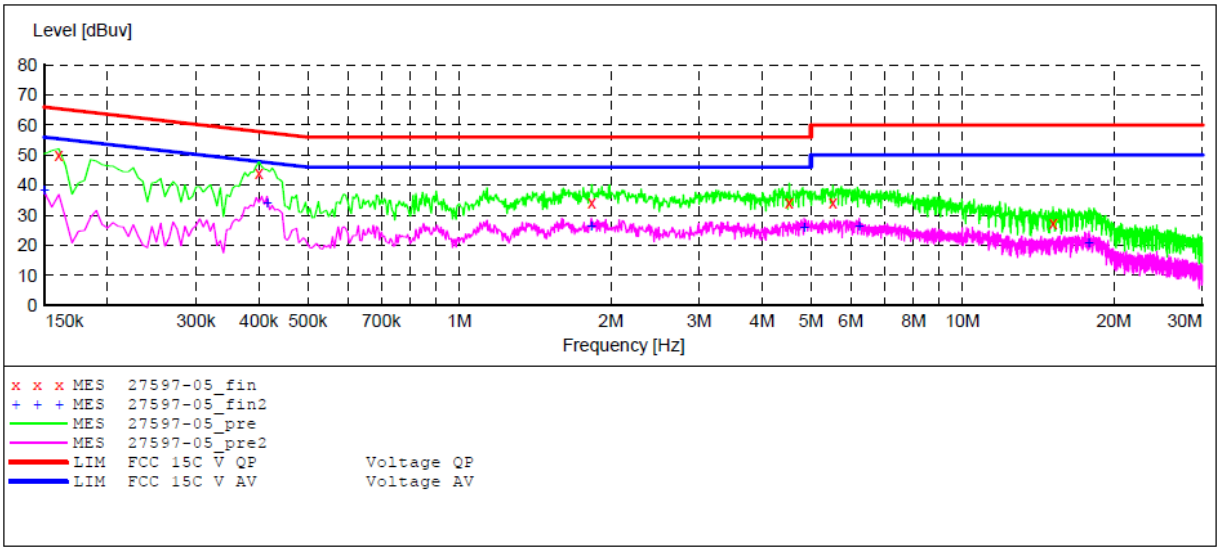
Frequency MHz	Level dBuv	Transd dB	Limit dBuv	Margin dB	Detector	Line	PE
0.150000	50.60	10.8	66	15.4	QP	L1	GND
0.425000	43.50	11.0	57	13.5	QP	L1	GND
1.120000	34.10	11.2	56	21.9	QP	L1	GND
4.760000	32.80	11.4	56	23.2	QP	L1	GND
5.970000	33.60	11.5	60	26.4	QP	L1	GND
13.225000	26.20	11.6	60	33.8	QP	L1	GND

MEASUREMENT RESULT: "27597-06_fin2"

2021-8-9 05:28

Frequency MHz	Level dBuv	Transd dB	Limit dBuv	Margin dB	Detector	Line	PE
0.150000	38.50	10.8	56	17.5	AV	L1	GND
0.420000	34.10	11.0	47	12.9	AV	L1	GND
1.120000	27.20	11.2	46	18.8	AV	L1	GND
3.220000	24.50	11.4	46	21.5	AV	L1	GND
5.860000	26.10	11.5	50	23.9	AV	L1	GND
13.900000	19.80	11.6	50	30.2	AV	L1	GND

AC 120V/60 Hz, Neutral



MEASUREMENT RESULT: "27597-05_fin"

2021-8-9 05:26

Frequency MHz	Level dBuv	Transd dB	Limit dBuv	Margin dB	Detector	Line	PE
0.160000	49.40	10.8	66	15.6	QP	N	GND
0.400000	44.30	11.0	58	13.7	QP	N	GND
1.835000	34.40	11.2	56	21.6	QP	N	GND
4.530000	34.20	11.4	56	21.8	QP	N	GND
5.530000	34.20	11.5	60	25.8	QP	N	GND
15.150000	27.50	11.6	60	32.5	QP	N	GND

MEASUREMENT RESULT: "27597-05_fin2"

2021-8-9 05:26

Frequency MHz	Level dBuv	Transd dB	Limit dBuv	Margin dB	Detector	Line	PE
0.150000	38.30	10.8	56	17.7	AV	N	GND
0.415000	34.90	11.0	48	13.1	AV	N	GND
1.830000	26.70	11.2	46	19.3	AV	N	GND
4.850000	26.20	11.4	46	19.8	AV	N	GND
6.240000	26.70	11.5	50	23.3	AV	N	GND
17.850000	20.90	11.7	50	29.1	AV	N	GND

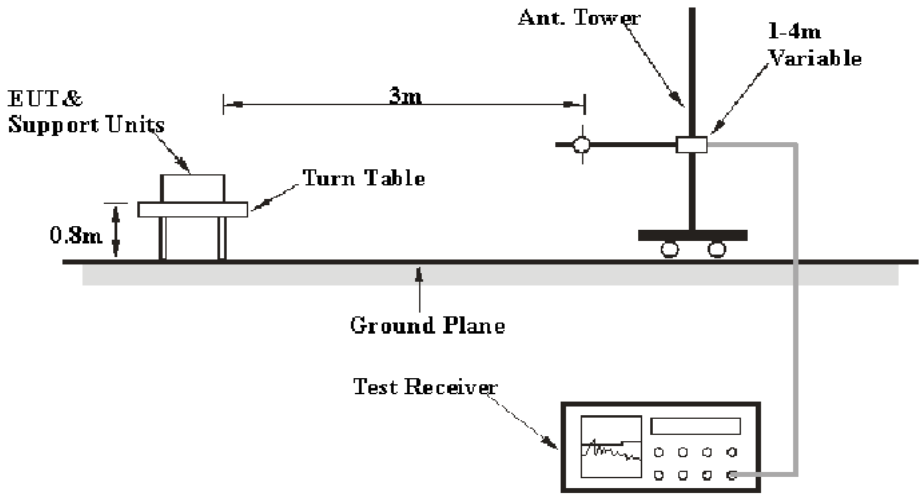
FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

Applicable Standard

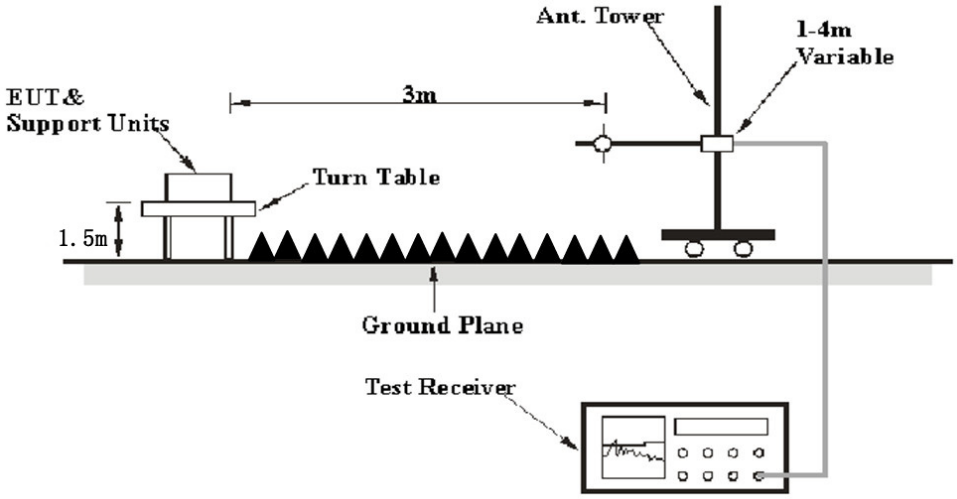
FCC §15.205; §15.209; §15.247(d)

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission tests were performed in the 3 meters, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209 and FCC 15.247 limits.

EMI Test Receiver & Spectrum Analyzer Setup

The EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Measurement
30 MHz – 1000 MHz	100 kHz	300 kHz	120 kHz	QP
Above 1 GHz	1 MHz	3 MHz	/	PK
	1 MHz	10 Hz	/	Average

Test Procedure

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

All final data was recorded in Quasi-peak detection mode for frequency range of 30 MHz -1 GHz and peak and Average detection modes for frequencies above 1 GHz.

Factor & Margin Calculation

The 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:

Factor = Meter Reading + 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 -7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

Margin = Result-Limit
Result = Reading + Factor

Test Data

Environmental Conditions

Temperature:	24 ℃
Relative Humidity:	48 %
ATM Pressure:	101.0 kPa

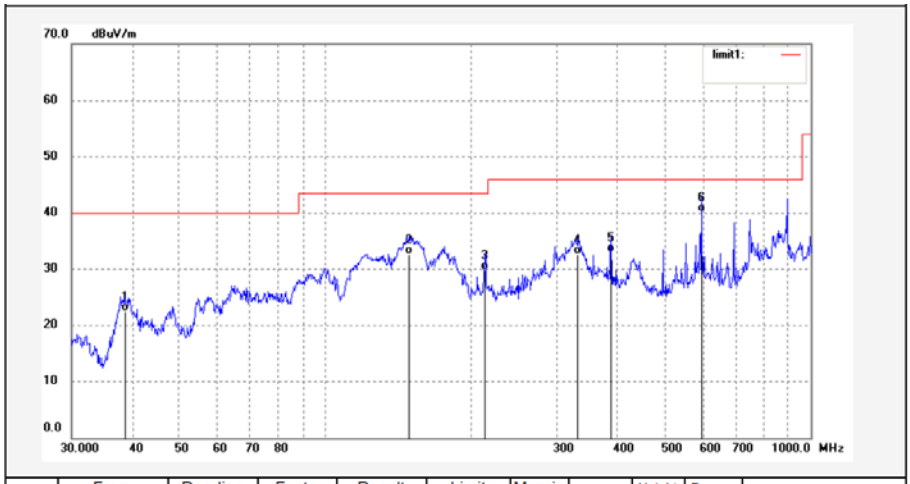
The testing was performed by Fan Yang on 2021-08-07.

EUT operation mode: Transmitting

(Scan with GFSK, π/4-DQPSK, 8DPSK mode, the worst case is 8DPSK Mode)

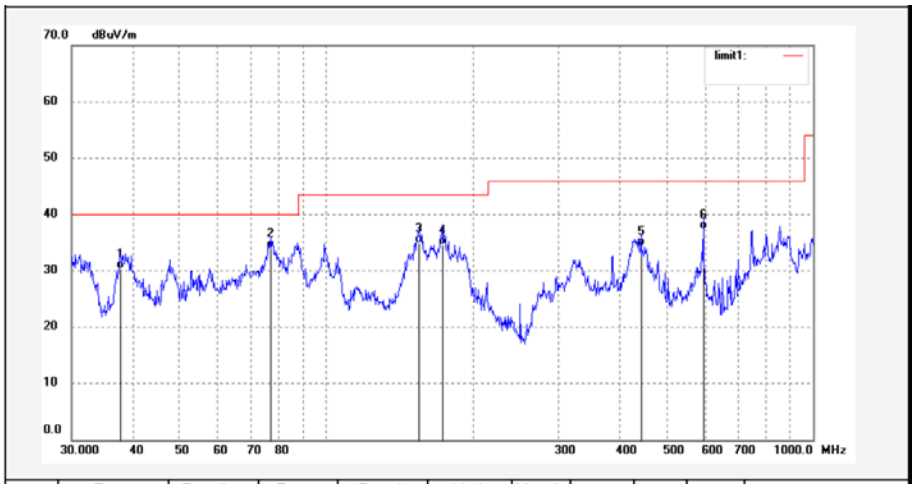
30MHz-1GHz: *(worst case for Ant 2, 8DPSK Mode, Middle channel)*

Horizontal:



No.	Freq. (MHz)	Reading (dBuV)	Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Degree (deg.)	Remark
1	38.6160	41.15	-18.69	22.46	40.00	-17.54	QP			
2	148.9625	52.79	-20.07	32.72	43.50	-10.78	QP			
3	213.0149	47.17	-17.31	29.86	43.50	-13.64	QP			
4	331.3546	46.45	-13.75	32.70	46.00	-13.30	QP			
5	387.9920	45.90	-12.85	33.05	46.00	-12.95	QP			
6	595.1326	48.04	-7.91	40.13	46.00	-5.87	QP			

Vertical



No.	Freq. (MHz)	Reading (dBuV)	Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Degree (deg.)	Remark
1	37.8121	46.10	-15.70	30.40	40.00	-9.60	QP			
2	77.0502	55.47	-21.51	33.96	40.00	-6.04	QP			
3	155.3642	54.88	-19.98	34.90	43.50	-8.60	QP			
4	173.2050	53.28	-18.68	34.60	43.50	-8.90	QP			
5	443.2943	45.28	-10.86	34.42	46.00	-11.58	QP			
6	595.1326	45.29	-7.91	37.38	46.00	-8.62	QP			

Above 1GHz:

Ant 0:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/QP/Ave.		Height (m)	Polar (H/V)				
Low Channel (2402 MHz)									
2310	45.51	PK	168	1.0	H	-6.84	38.67	74	35.33
2310	45.25	PK	22	1.5	V	-6.84	38.41	74	35.59
2390	45.97	PK	291	1.5	H	-6.44	39.53	74	34.47
2390	46.31	PK	47	1.2	V	-6.44	39.87	74	34.13
4804	39.72	PK	190	1.8	H	2.81	42.53	74	31.47
4804	39.84	PK	20	2.1	V	2.81	42.65	74	31.35
Middle Channel (2441 MHz)									
4882	41.69	PK	155	1.3	H	3.04	44.73	74	29.27
4882	41.22	PK	138	2.1	V	3.04	44.26	74	29.74
High Channel (2480 MHz)									
2483.5	46.02	PK	321	1.5	H	-5.96	40.06	74	33.94
2483.5	46.09	PK	71	2.1	V	-5.96	40.13	74	33.87
2500	46.91	PK	348	1.0	H	-5.88	41.03	74	32.97
2500	47.81	PK	207	1.8	V	-5.88	41.93	74	32.07
4960	40.34	PK	4	1.0	H	3.29	43.63	74	30.37
4960	39.43	PK	23	1.7	V	3.29	42.72	74	31.28

Ant 1:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/QP/Ave.		Height (m)	Polar (H/V)				
Low Channel (2402 MHz)									
2310	45.78	PK	327	1.3	H	-6.84	38.94	74	35.06
2310	45.74	PK	47	2.1	V	-6.84	38.90	74	35.1
2390	46.31	PK	231	2.2	H	-6.44	39.87	74	34.13
2390	46.67	PK	193	1.8	V	-6.44	40.23	74	33.77
4804	39.97	PK	245	1.9	H	2.81	42.78	74	31.22
4804	40.29	PK	184	1.2	V	2.81	43.10	74	30.9
Middle Channel (2441 MHz)									
4882	41.86	PK	170	1.9	H	3.04	44.90	74	29.1
4882	41.68	PK	129	1.6	V	3.04	44.72	74	29.28
High Channel (2480 MHz)									
2483.5	46.38	PK	175	1.5	H	-5.96	40.42	74	33.58
2483.5	46.36	PK	236	1.0	V	-5.96	40.40	74	33.6
2500	47.01	PK	347	1.6	H	-5.88	41.13	74	32.87
2500	47.97	PK	49	1.0	V	-5.88	42.09	74	31.91
4960	40.80	PK	90	1.2	H	3.29	44.09	74	29.91
4960	39.55	PK	341	1.1	V	3.29	42.84	74	31.16

Ant 2:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/QP/Ave.		Height (m)	Polar (H/V)				
Low Channel (2402 MHz)									
2310	45.62	PK	76	1.5	H	-6.84	38.78	74	35.22
2310	45.60	PK	192	1.9	V	-6.84	38.76	74	35.24
2390	46.43	PK	229	1.6	H	-6.44	39.99	74	34.01
2390	46.55	PK	51	1.8	V	-6.44	40.11	74	33.89
4804	40.15	PK	318	2.2	H	2.81	42.96	74	31.04
4804	40.13	PK	166	1.2	V	2.81	42.94	74	31.06
Middle Channel (2441 MHz)									
4882	41.93	PK	321	2.1	H	3.04	44.97	74	29.03
4882	41.63	PK	260	1.5	V	3.04	44.67	74	29.33
High Channel (2480 MHz)									
2483.5	46.45	PK	149	2.0	H	-5.96	40.49	74	33.51
2483.5	46.26	PK	66	1.9	V	-5.96	40.30	74	33.7
2500	47.26	PK	69	2.2	H	-5.88	41.38	74	32.62
2500	47.89	PK	225	1.1	V	-5.88	42.01	74	31.99
4960	40.48	PK	275	2.1	H	3.29	43.77	74	30.23
4960	39.52	PK	193	1.8	V	3.29	42.81	74	31.19

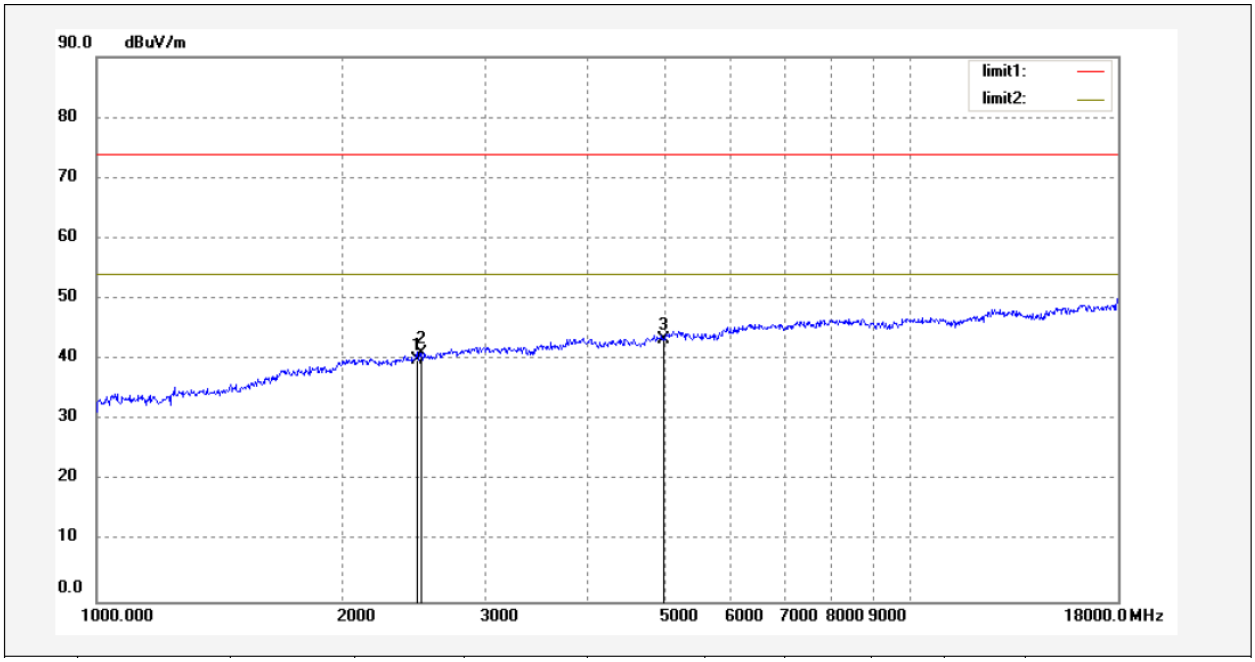
Note:
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
Corrected Amplitude = Corrected Factor + Reading
Margin = Limit - Corrected. Amplitude
The other spurious emission which is in the noise floor level was not recorded.
The test result of peak was less than the limit of average, so just peak value were recorded.

1-18GHz

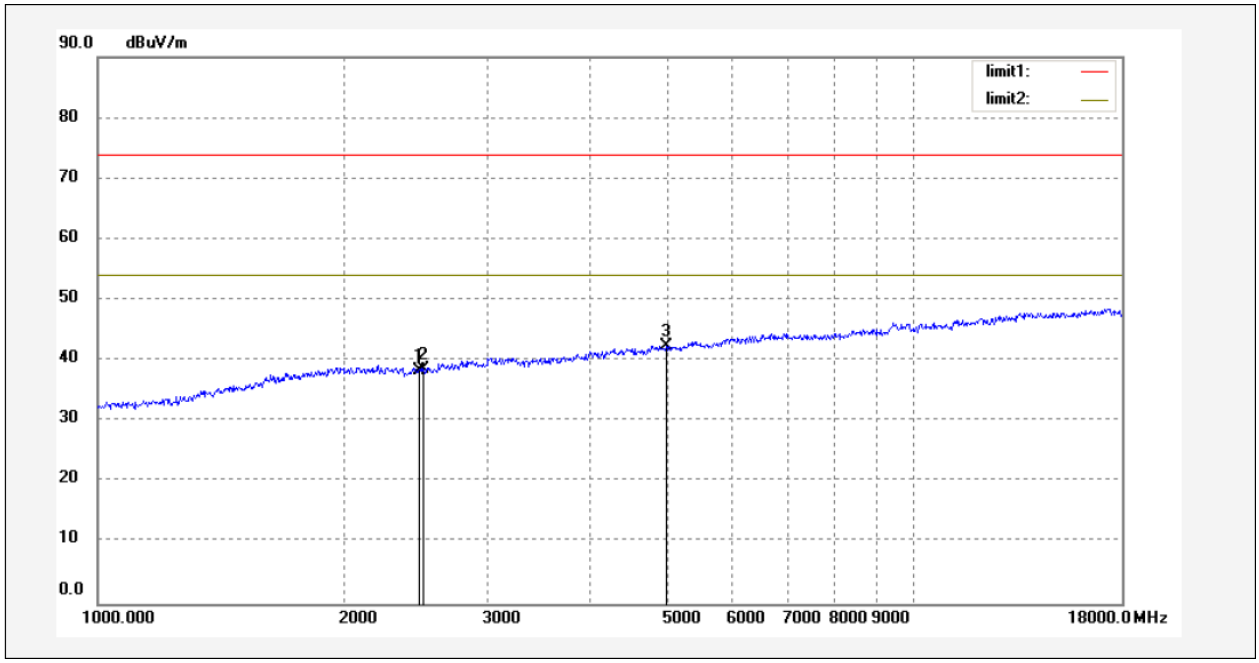
Pre-scan for Peak, Ant 0

Low Channel

Horizontal:



Vertical:

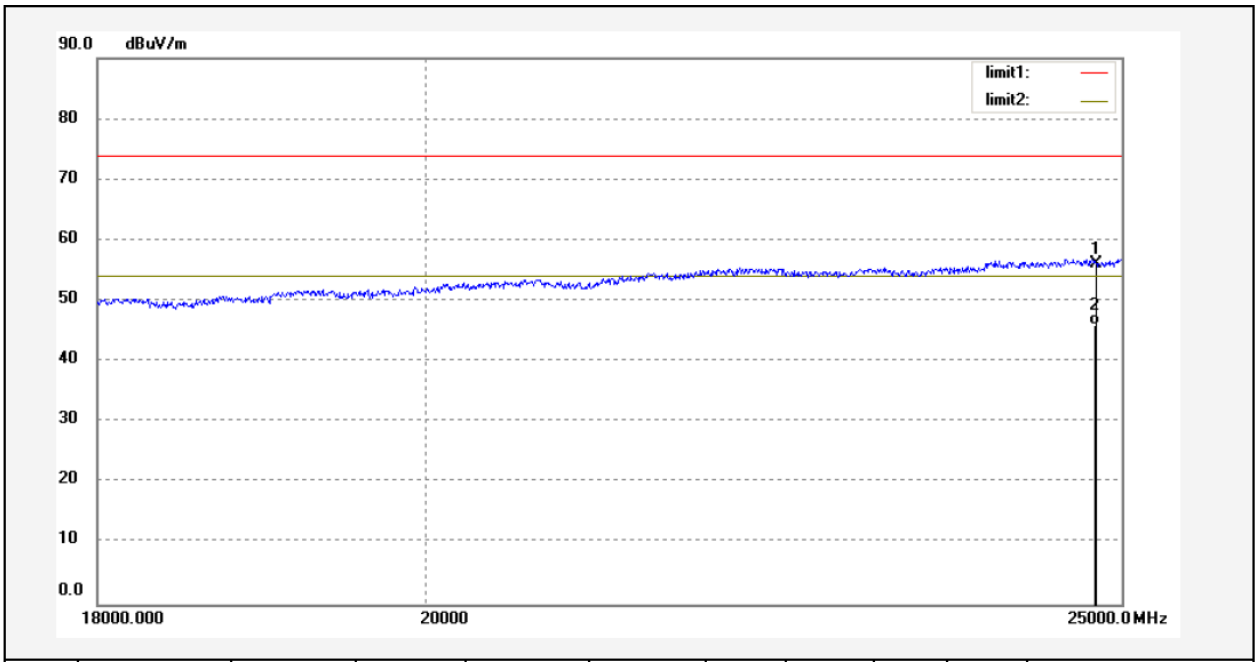


18-25GHz

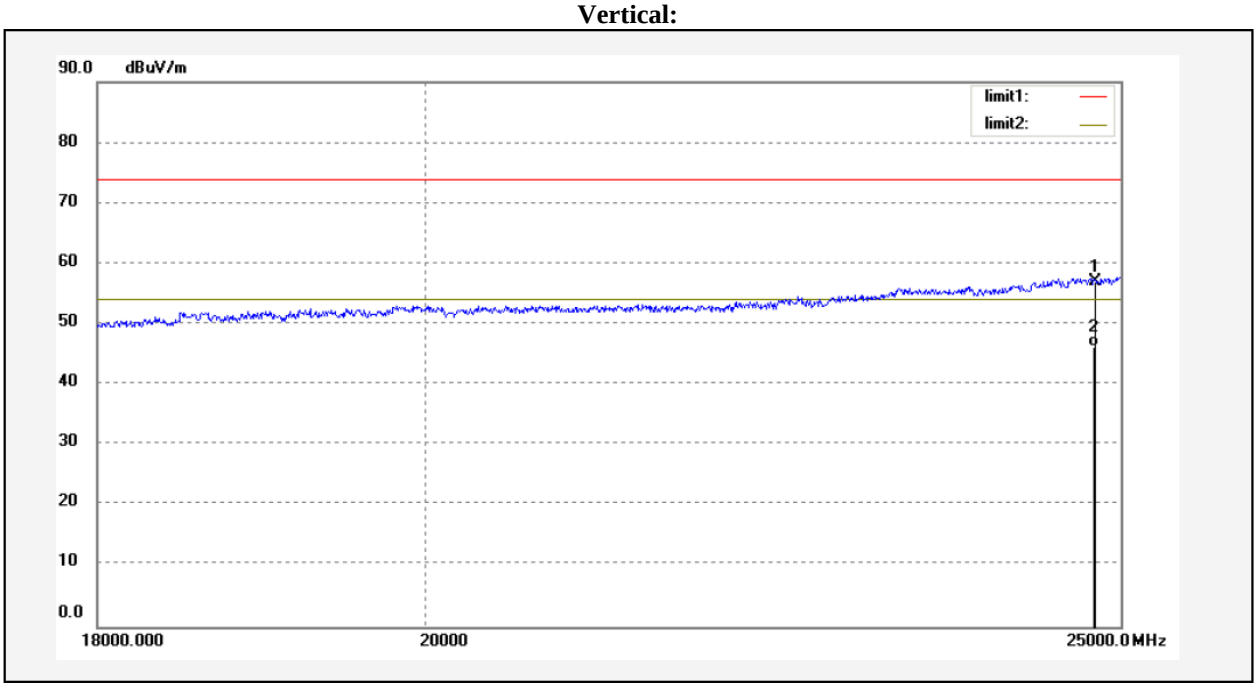
Pre-scan for Peak, Ant 0

Low Channel

Horizontal:



Vertical:



FCC §15.247(a) (1)-CHANNEL SEPARATION TEST

Applicable Standard

Frequency hopping systems shall have hoping 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.

Test Procedure

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

Test Data

Environmental Conditions

Temperature:	24 ℃
Relative Humidity:	48 %
ATM Pressure:	101.0 kPa

The testing was performed by Fan Yang on 2021-08-08.

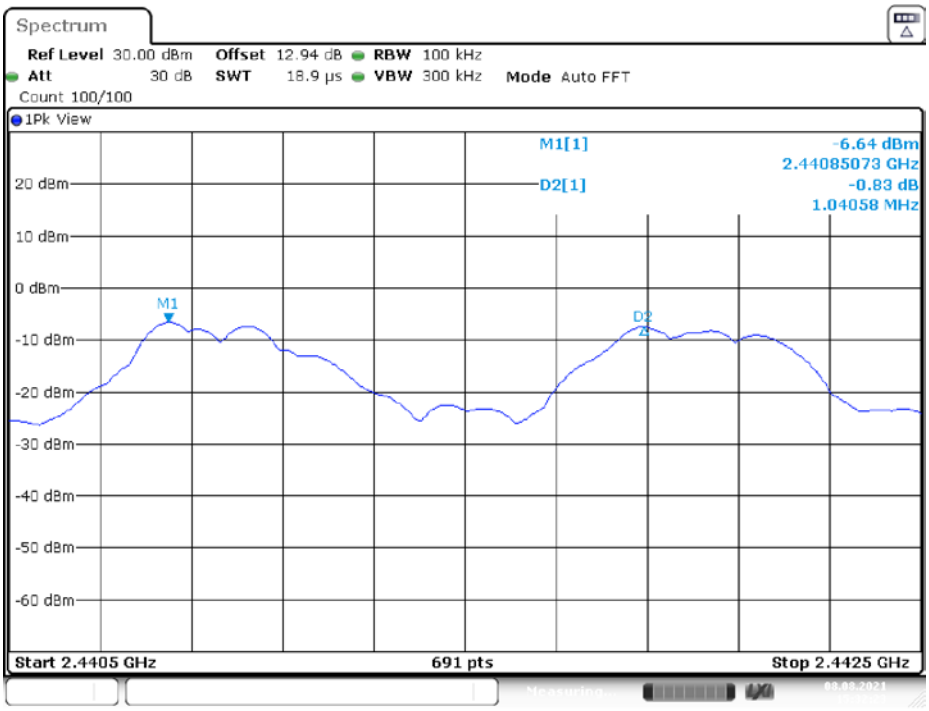
EUT operation mode: Transmitting

Test Result: Compliant.

Test Mode	Channel	Result[MHz]	Limit[MHz]	Verdict
DH5	Hop	1.041	>=0.634	PASS
2DH5	Hop	1.003	>=0.906	PASS
3DH5	Hop	1	>=0.884	PASS

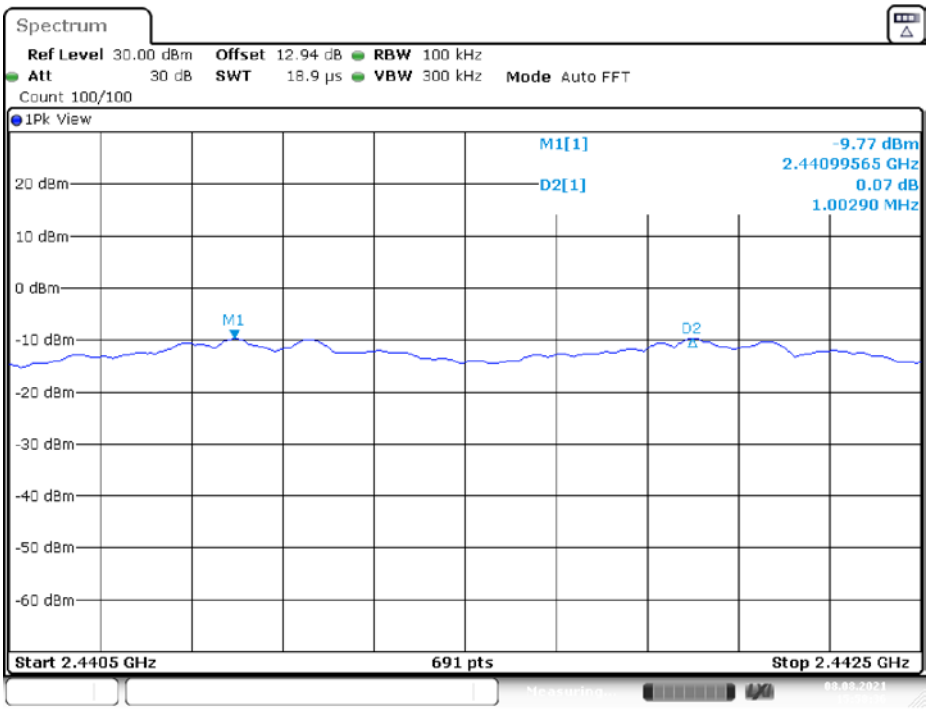
Please refer to the below plots:

DH5_Hop



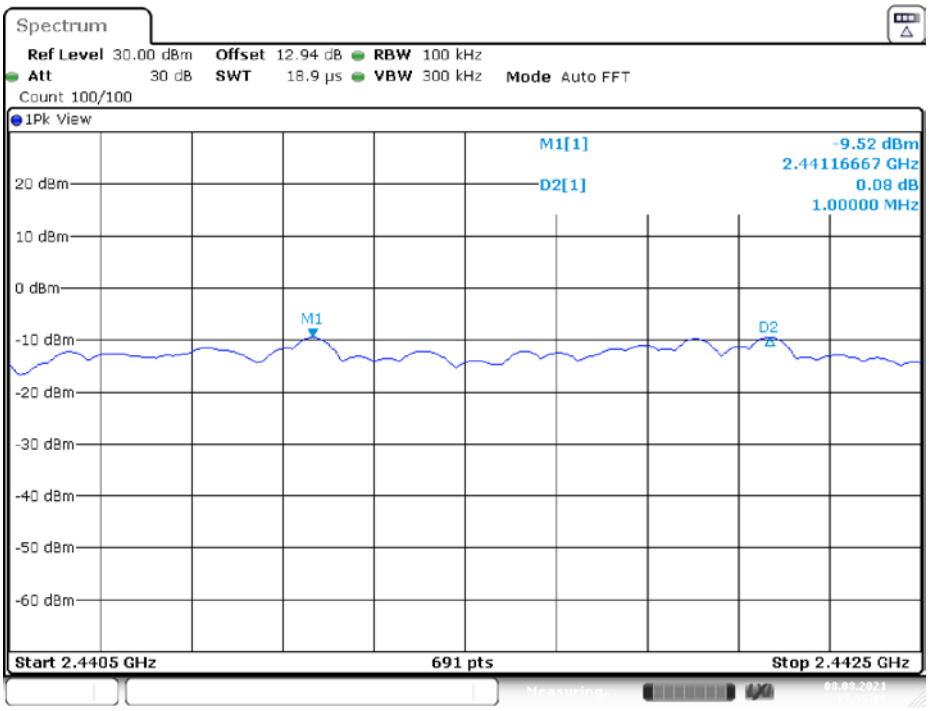
Date: 8.AUG.2021 15:32:24

2DH5_Hop



Date: 8.AUG.2021 15:58:37

3DH5_Hop


Spectrum
Ref Level 30.00 dBm Offset 12.94 dB RBW 100 kHz
Att 30 dB SWT 18.9 µs VBW 300 kHz Mode Auto FFT
Count 100/100
1Pk View
M1[1] -9.52 dBm
2.44116667 GHz
D2[1] 0.08 dB
1.00000 MHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
M1
D2
Start 2.4405 GHz
691 pts
Stop 2.4425 GHz
Date: 8.AUG.2021 15:55:20

FCC §15.247(a) (1) – 20 dB EMISSION BANDWIDTH & 99% OCCUPIED BANDWIDTH

Applicable Standard

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.

Test Procedure

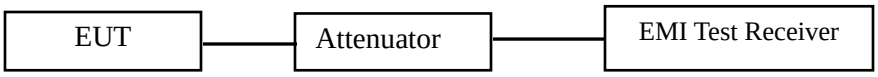
The following conditions shall be observed for measuring the occupied bandwidth and 20 dB bandwidth:
• The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

• The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

• The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / 20 dB bandwidth if the device is not transmitting continuously.

• The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / 20 dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.
For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).



Test Data

Environmental Conditions

Temperature:	24 ℃
Relative Humidity:	48 %
ATM Pressure:	101.0 kPa

The testing was performed by Fan Yang on 2021-08-08.

EUT operation mode: Transmitting

Test Result: Compliant.

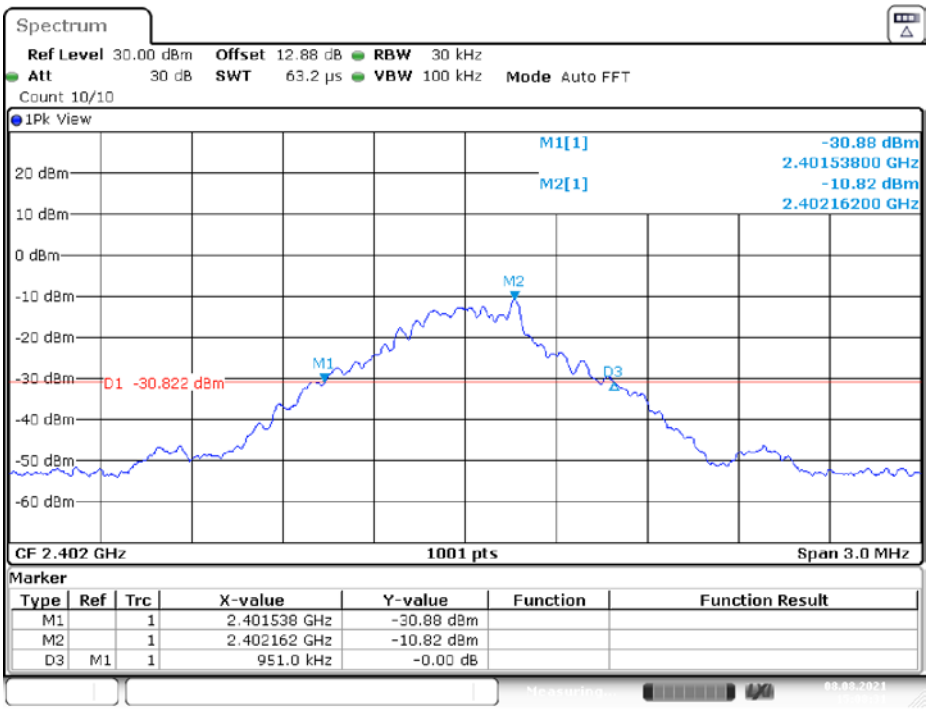
Test Mode	Channel[MHz]	20db EBW[MHz]	Limit[MHz]	Verdict
DH5	2402	0.951	---	PASS
	2441	0.951	---	PASS
	2480	0.948	---	PASS
2DH5	2402	1.359	---	PASS
	2441	1.356	---	PASS
	2480	1.359	---	PASS
3DH5	2402	1.326	---	PASS
	2441	1.323	---	PASS
	2480	1.326	---	PASS

Test Mode	Channel[MHz]	99% Occupied Bandwidth [MHz]	Limit[MHz]	Verdict
DH5	2402	0.932	---	PASS
	2441	0.929	---	PASS
	2480	0.929	---	PASS
2DH5	2402	1.22	---	PASS
	2441	1.217	---	PASS
	2480	1.217	---	PASS
3DH5	2402	1.217	---	PASS
	2441	1.214	---	PASS
	2480	1.217	---	PASS

Please refer to the below plots:

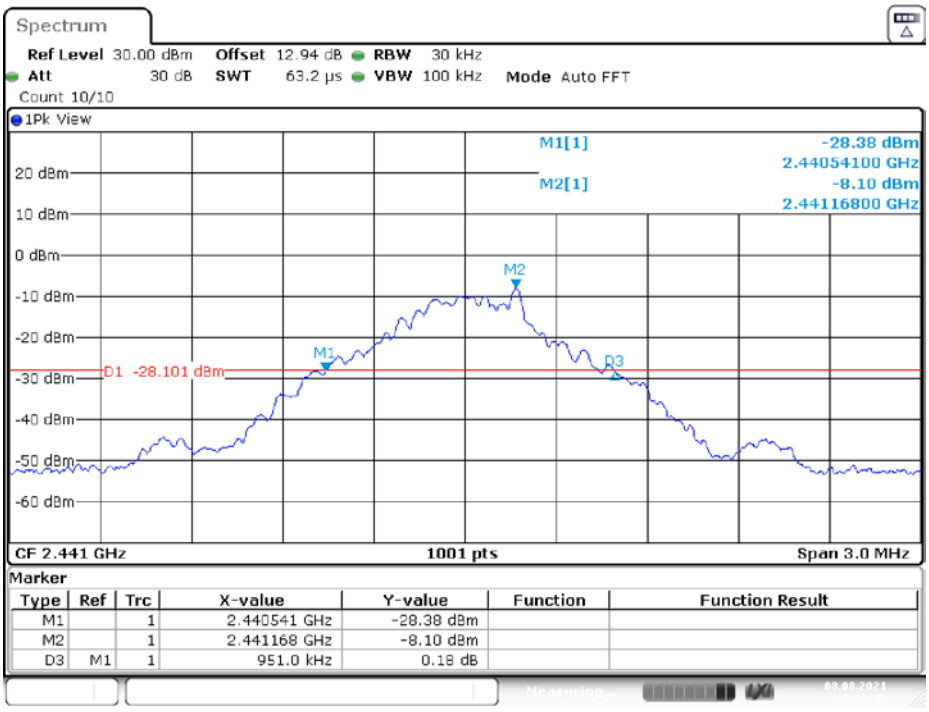
20 dB EMISSION BANDWIDTH

DH5_2402MHz



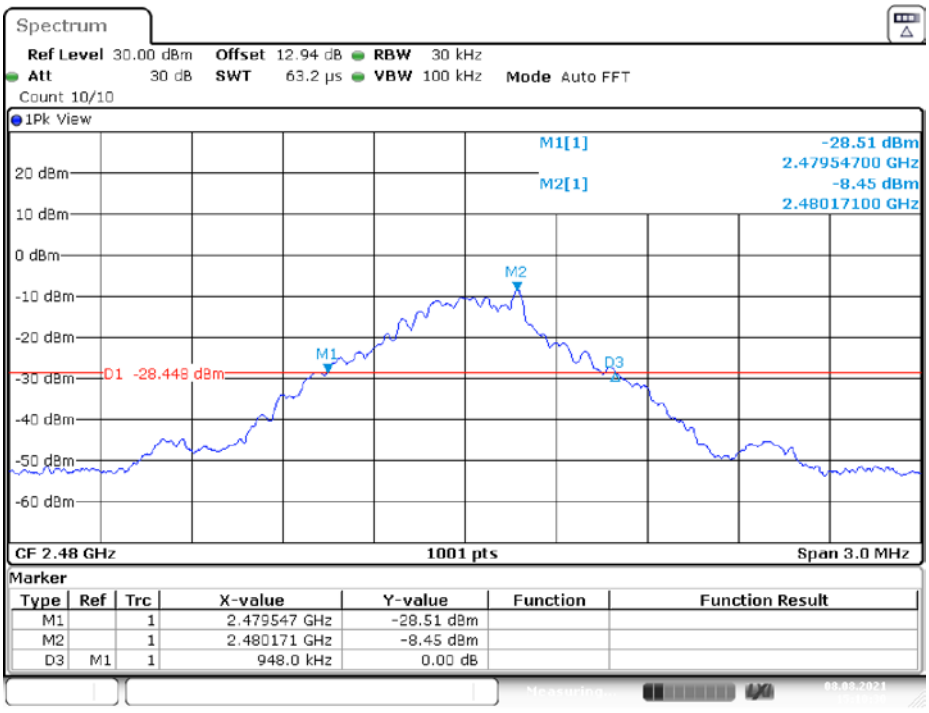
Date: 8.AUG.2021 15:08:31

DH5_2441MHz



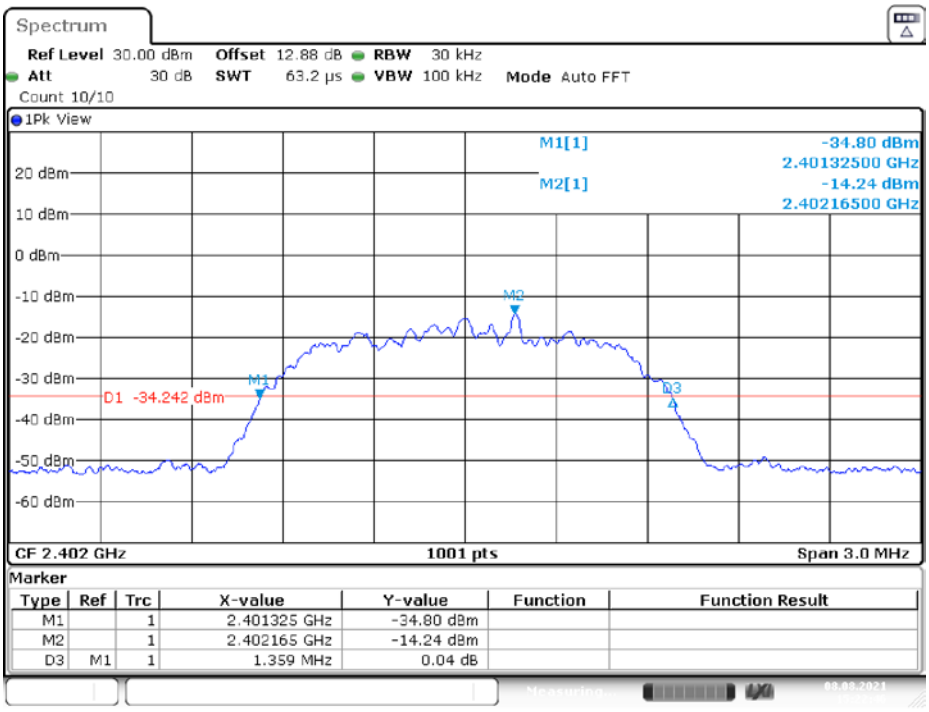
Date: 8.AUG.2021 15:09:37

DH5_2480MHz



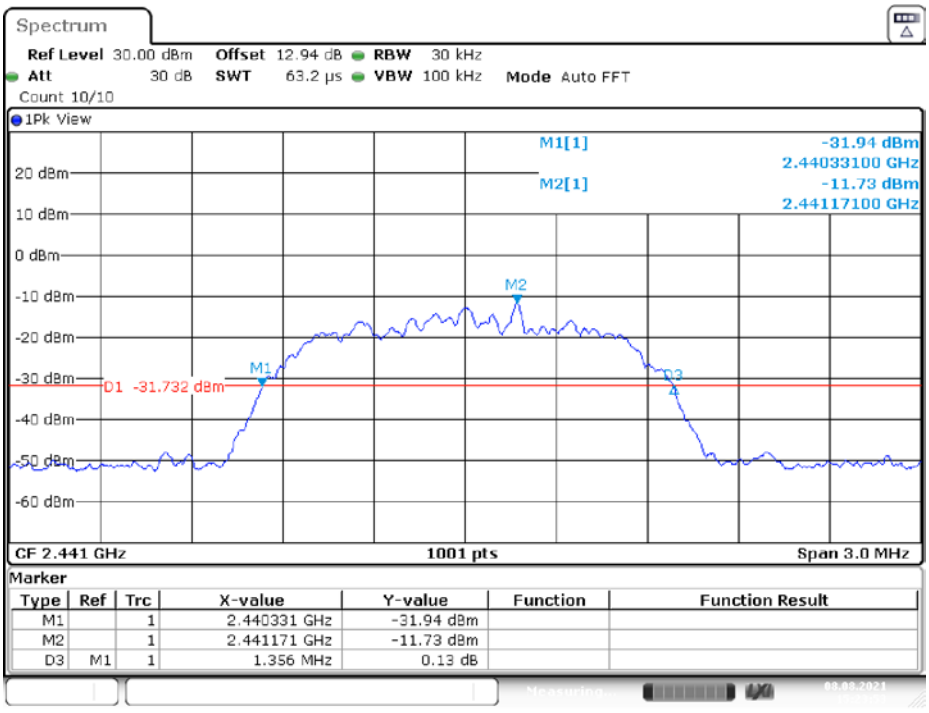
Date: 8.AUG.2021 15:10:31

2DH5_2402MHz



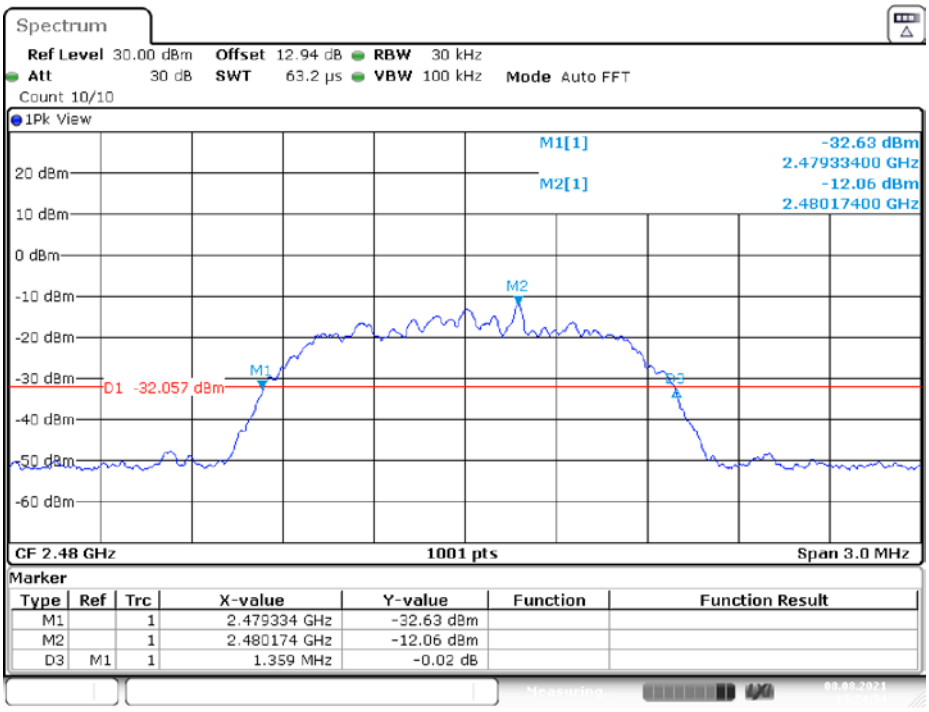
Date: 8.AUG.2021 15:22:46

2DH5_2441MHz



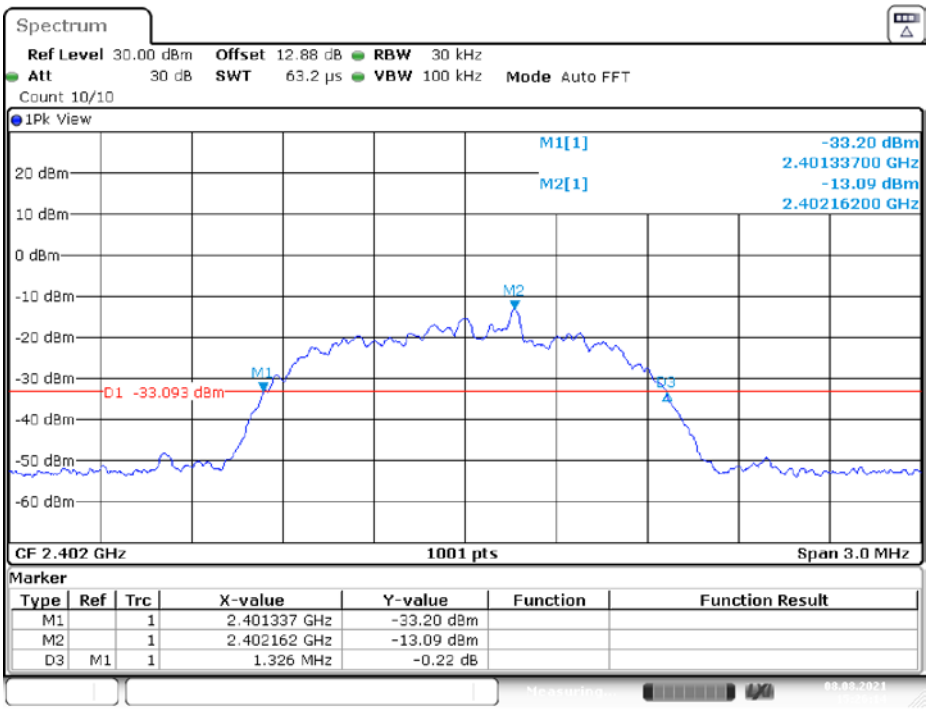
Date: 8.AUG.2021 15:23:53

2DH5_2480MHz



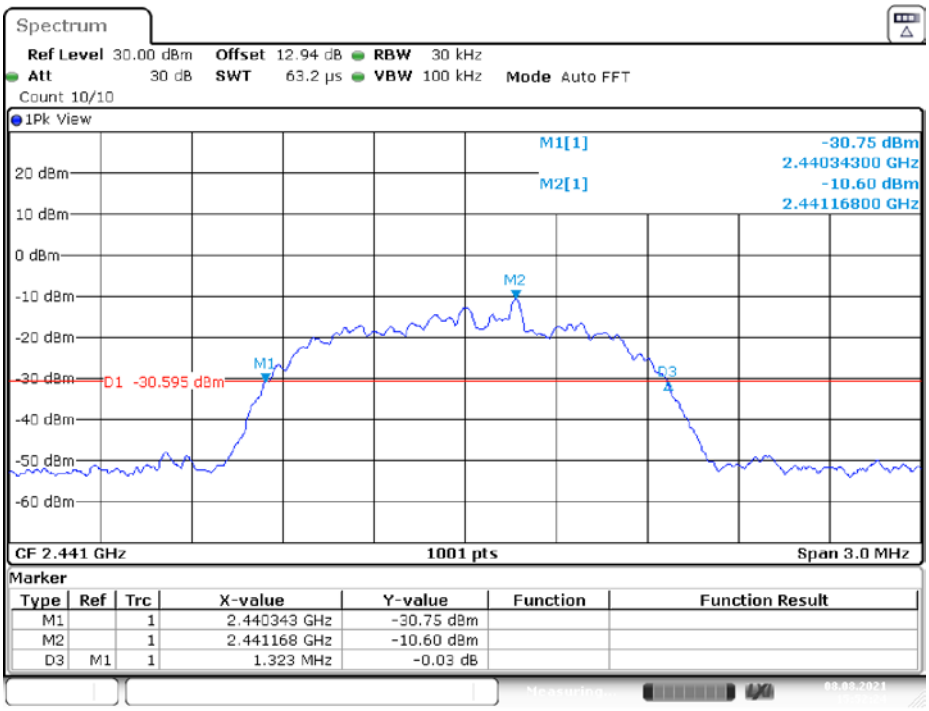
Date: 8.AUG.2021 15:24:55

3DH5_2402MHz



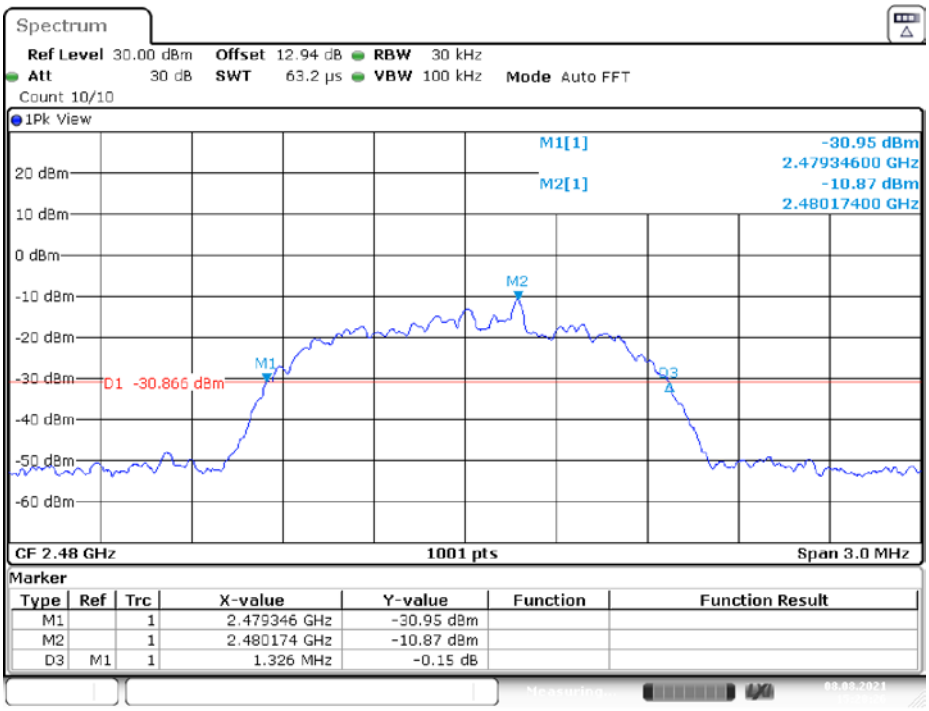
Date: 8.AUG.2021 15:26:14

3DH5_2441MHz



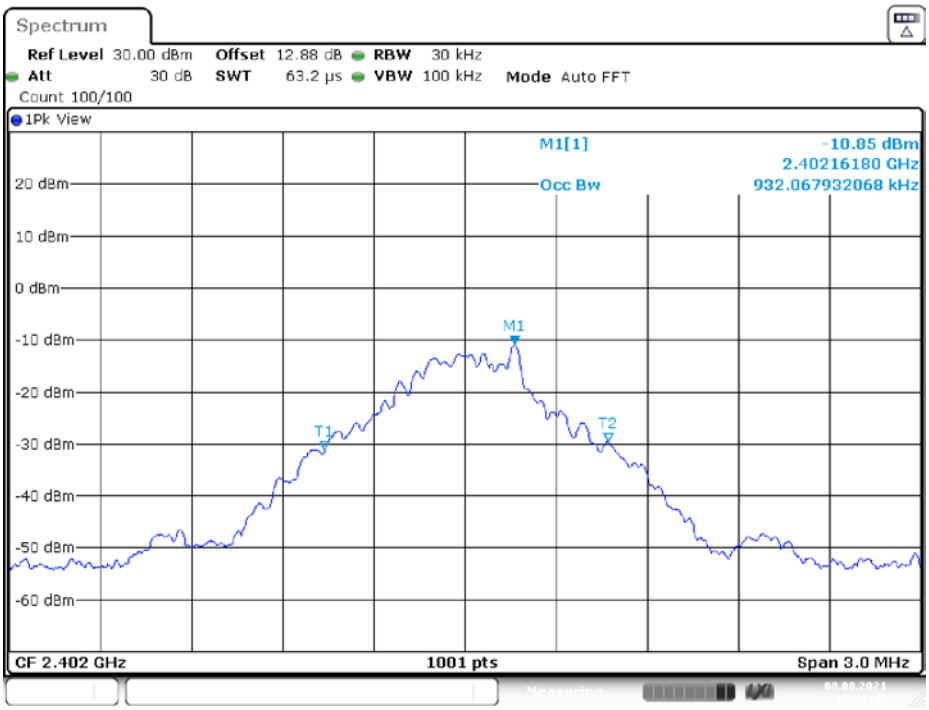
Date: 8.AUG.2021 15:52:25

3DH5_2480MHz



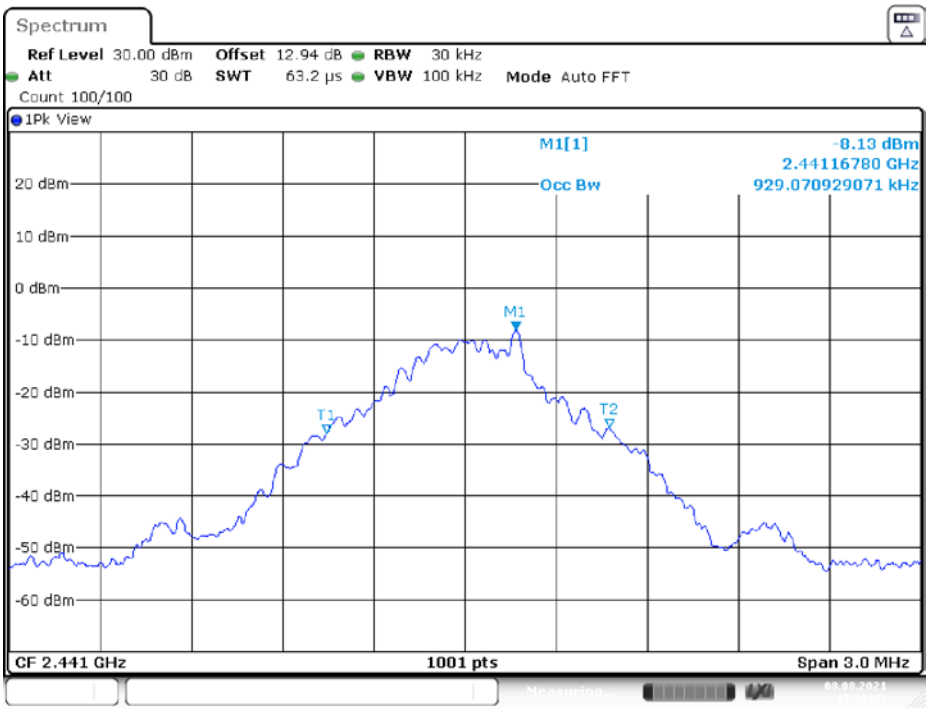
99% OCCUPIED BANDWIDTH

DH5_2402MHz



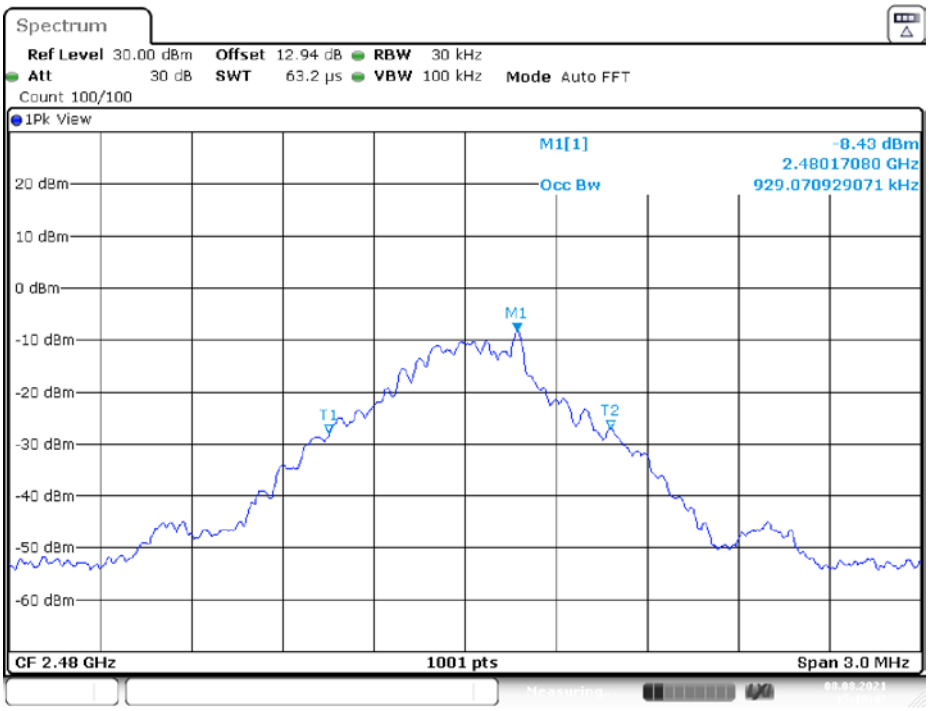
Date: 8.AUG.2021 15:08:48

DH5_2441MHz



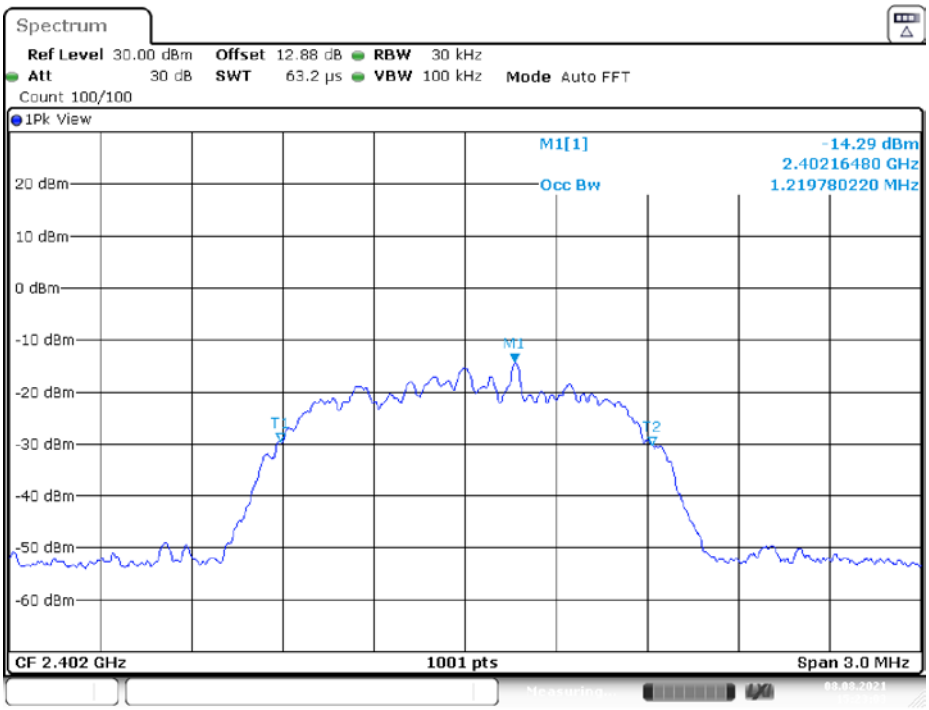
Date: 8.AUG.2021 15:09:54

DH5_2480MHz



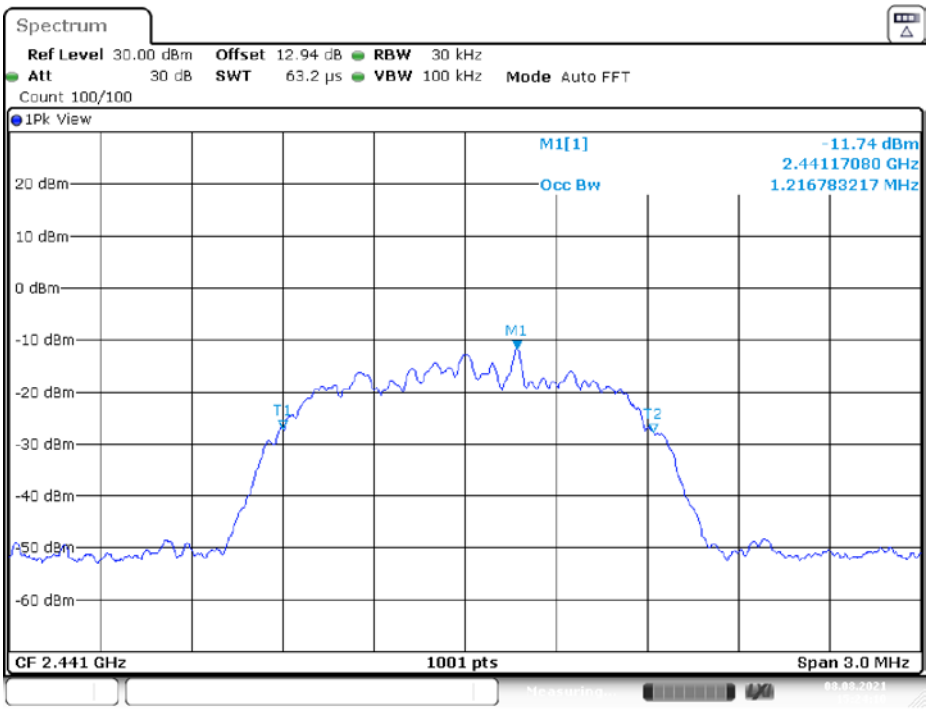
Date: 8.AUG.2021 15:10:48

2DH5_2402MHz



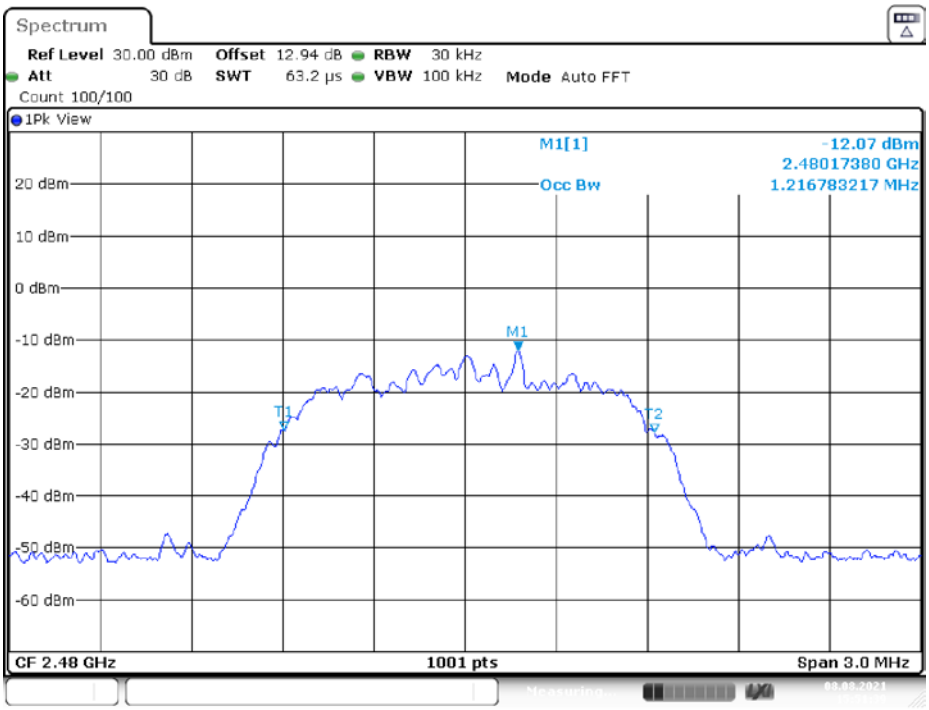
Date: 8.AUG.2021 15:23:03

2DH5_2441MHz



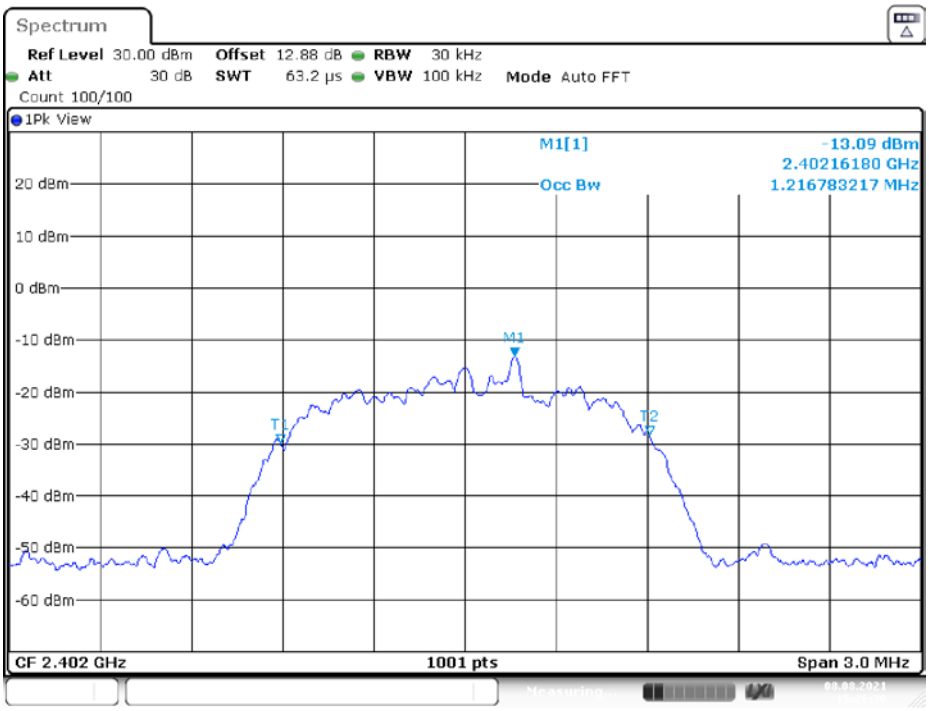
Date: 8.AUG.2021 15:24:10

2DH5_2480MHz



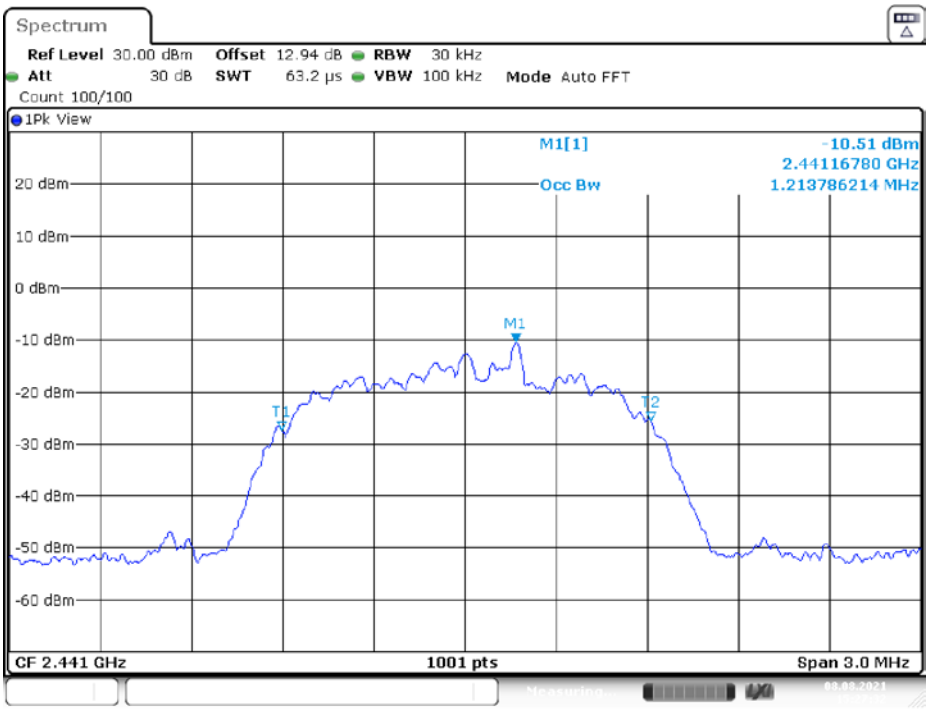
Date: 8.AUG.2021 15:51:40

3DH5_2402MHz



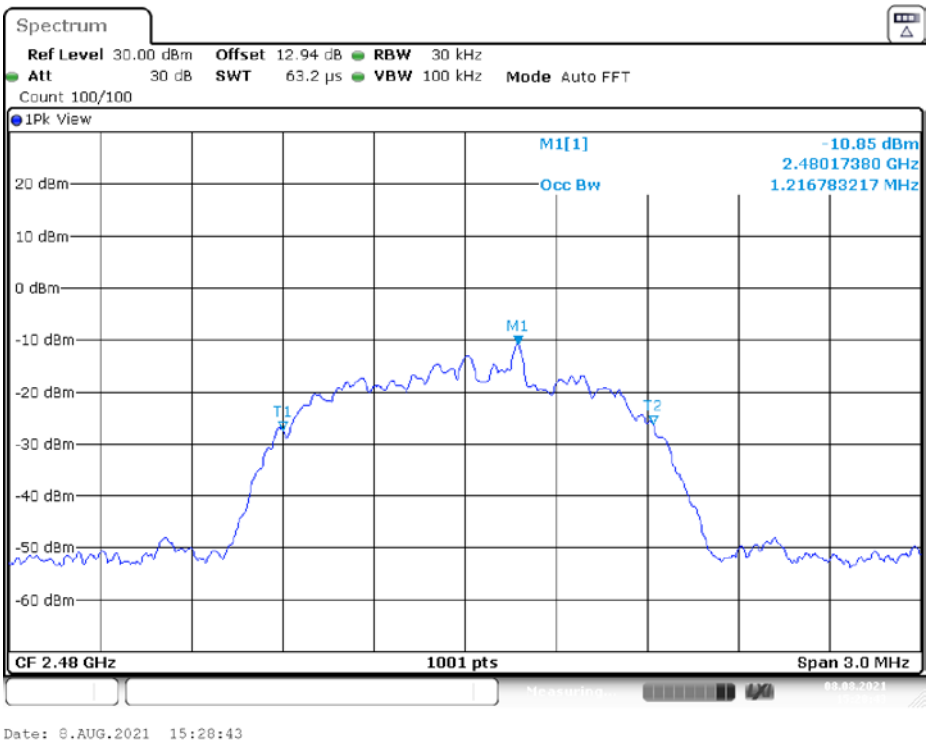
Date: 8.AUG.2021 15:26:31

3DH5_2441MHz



Date: 8.AUG.2021 15:27:33

3DH5_2480MHz



FCC §15.247(a) (1) (iii)-QUANTITY OF HOPPING CHANNEL TEST

Applicable Standard

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

Test Procedure

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.

Test Data

Environmental Conditions

Temperature:	24 ℃
Relative Humidity:	48 %
ATM Pressure:	101.0 kPa

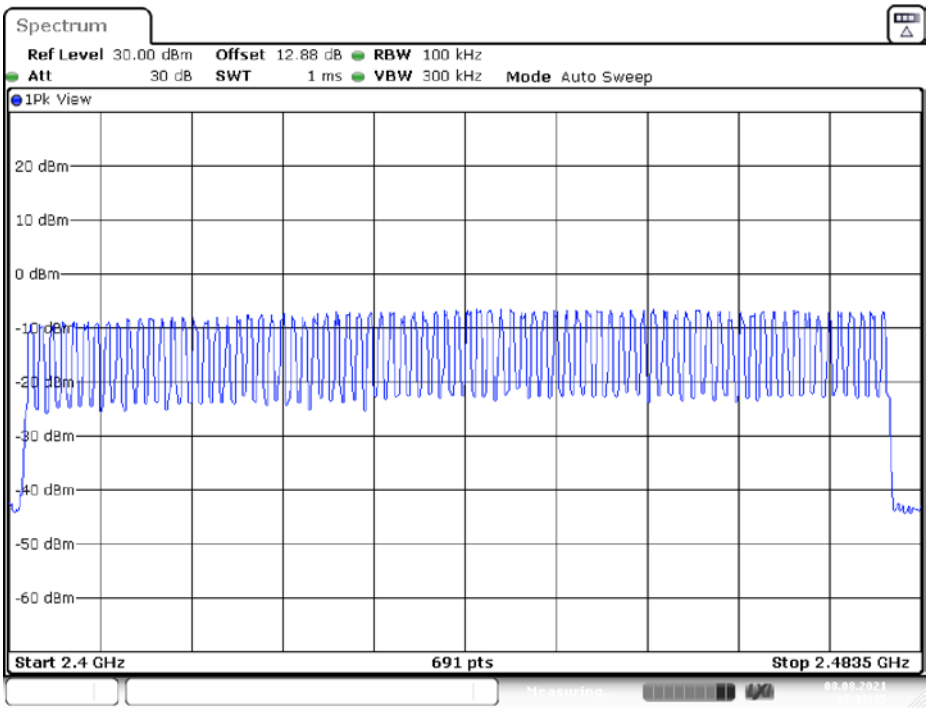
The testing was performed by Fan Yang on 2021-08-08.

EUT operation mode: Transmitting

Test Result: Compliant.

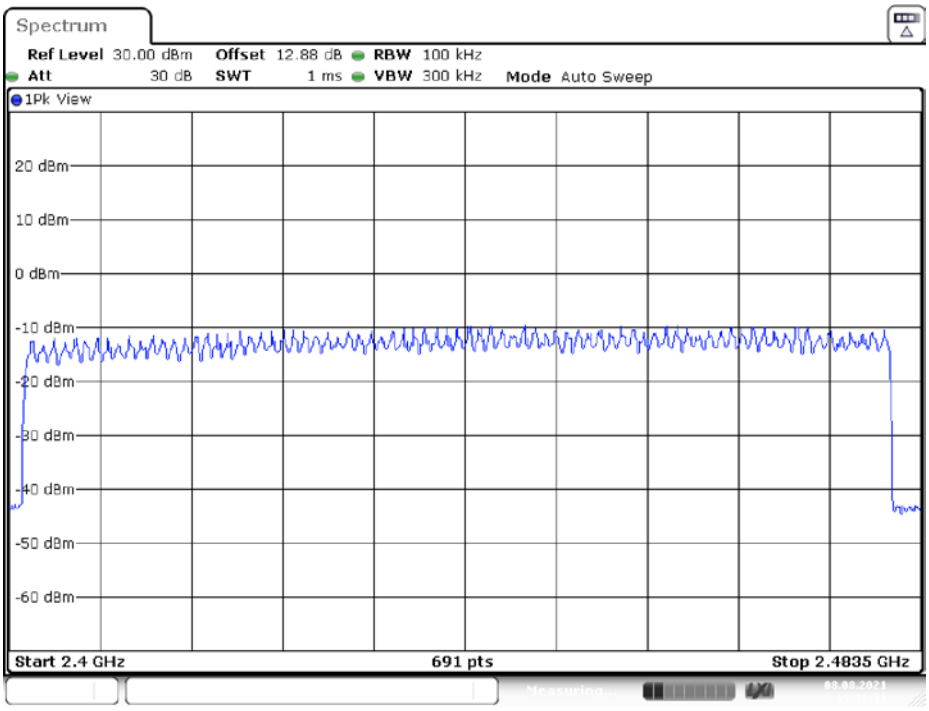
TestMode	Channel	Result[Num]	Limit[Num]	Verdict
DH5	Hop	79	>=15	PASS
2DH5	Hop	79	>=15	PASS
3DH5	Hop	79	>=15	PASS

DH5_Hop



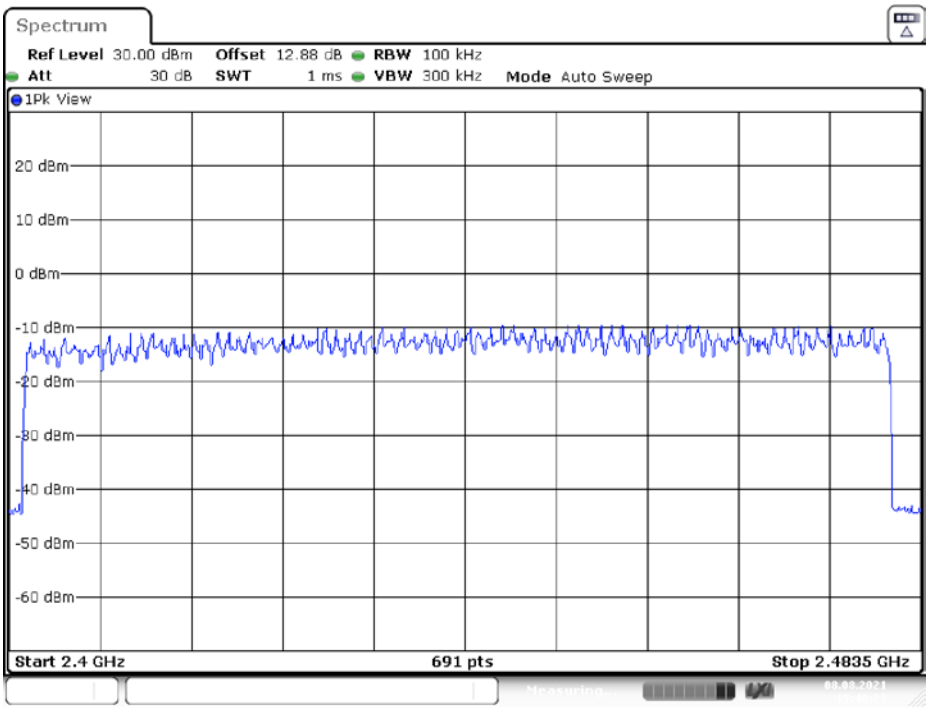
Date: 8.AUG.2021 15:33:35

2DH5_Hop



Date: 8.AUG.2021 15:36:32

3DH5_Hop


Spectrum
Ref Level 30.00 dBm Offset 12.88 dB RBW 100 kHz
Att 30 dB SWT 1 ms VBW 300 kHz Mode Auto Sweep
1Pk View
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
Start 2.4 GHz
691 pts
Stop 2.4835 GHz
Date: 8.AUG.2021 15:40:24

FCC §15.247(a) (1) (iii) - TIME OF OCCUPANCY (DWELL TIME)

Applicable Standard

Frequency hopping systems in the 2400-2483.5 MHz shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

Test Procedure

1. The EUT was worked in channel hopping.
2. Set the RBW to: 1MHz.
3. Set the VBW ≥ 3×RBW.
4. Set the span to 0Hz.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Recorded the time of single pulses

Test Data

Environmental Conditions

Temperature:	24 ℃
Relative Humidity:	48 %
ATM Pressure:	101.0 kPa

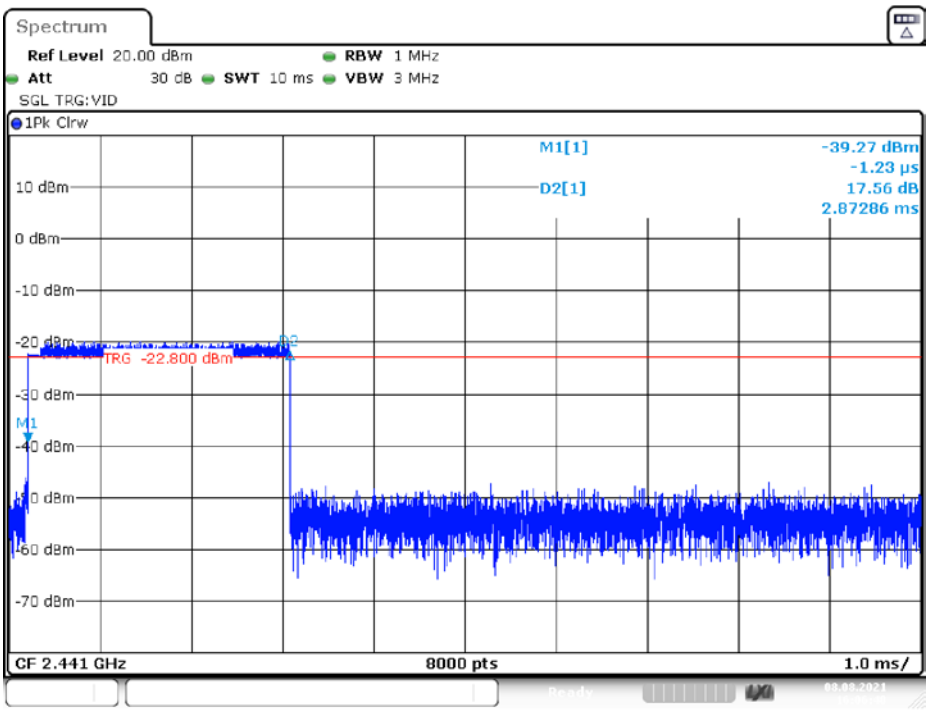
The testing was performed by Fan Yang on 2021-08-08.

EUT operation mode: Transmitting

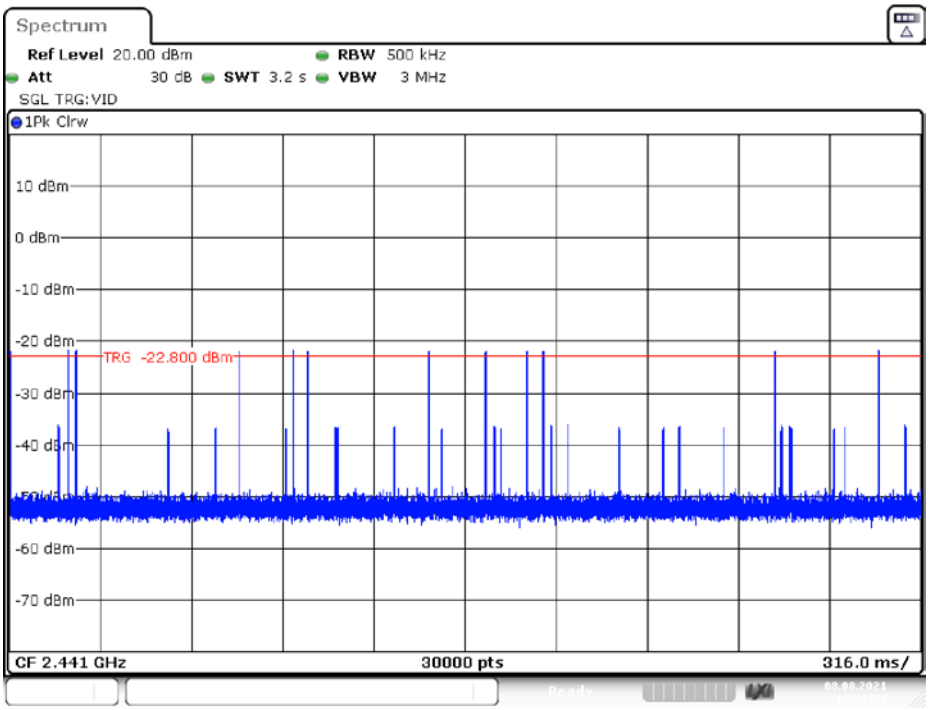
Test Result: Compliant.

Test Mode	Channel	BurstWidth [ms]	TotalHops [Num]	Result[s]	Limit[s]	Verdict
DH5	Hop	2.87	120	0.345	<=0.4	PASS
2DH5	Hop	2.87	60	0.172	<=0.4	PASS
3DH5	Hop	2.87	110	0.316	<=0.4	PASS

DH5_Hop

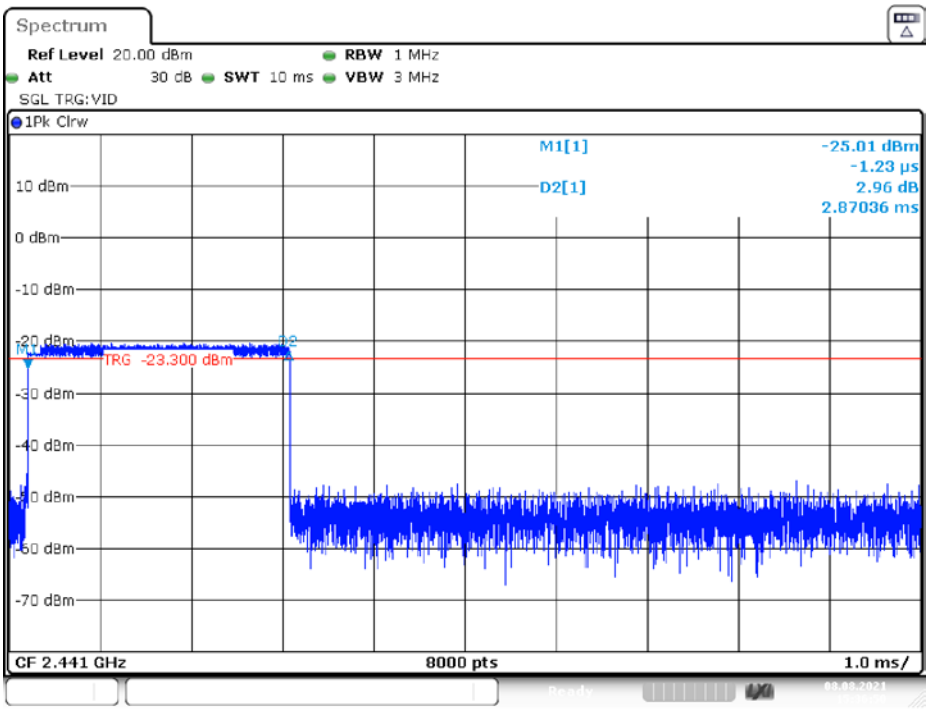


Date: 8.AUG.2021 16:06:49

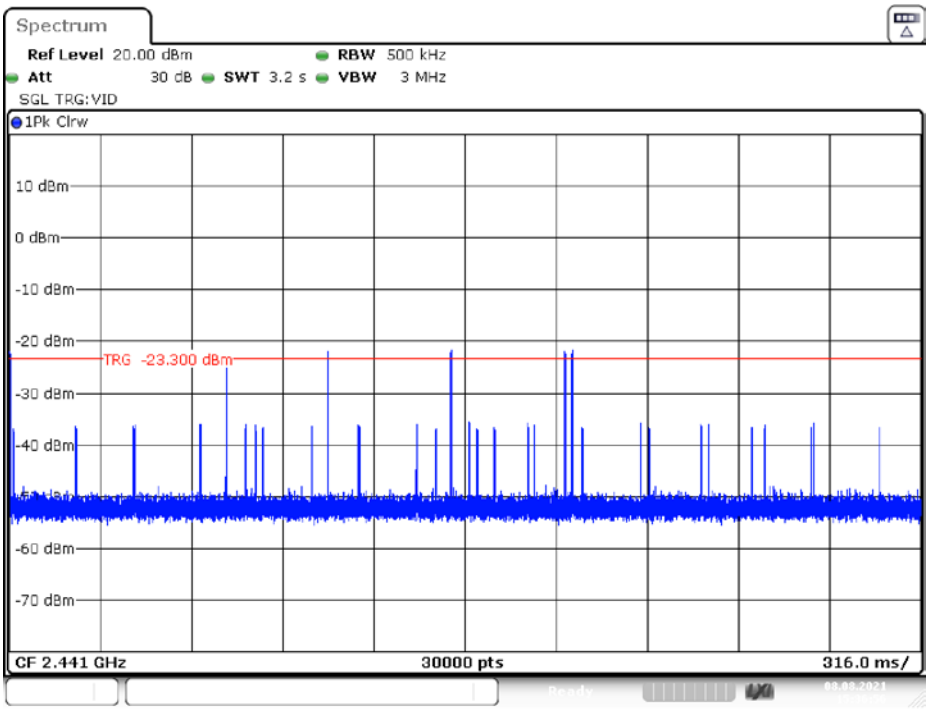


Date: 8.AUG.2021 16:06:54

2DH5_Hop

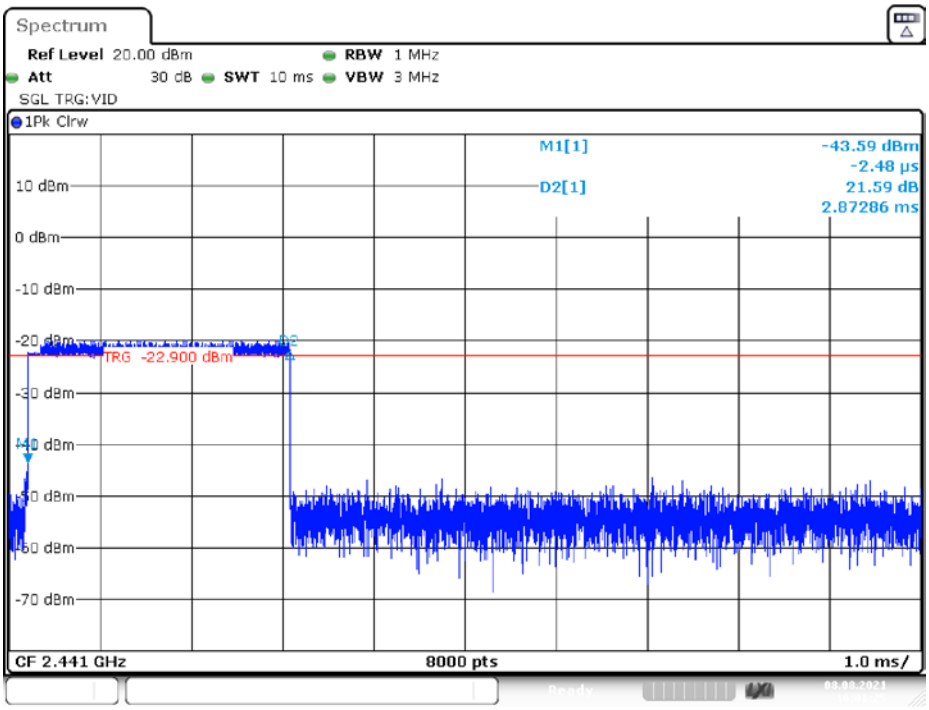


Date: 8.AUG.2021 15:36:51

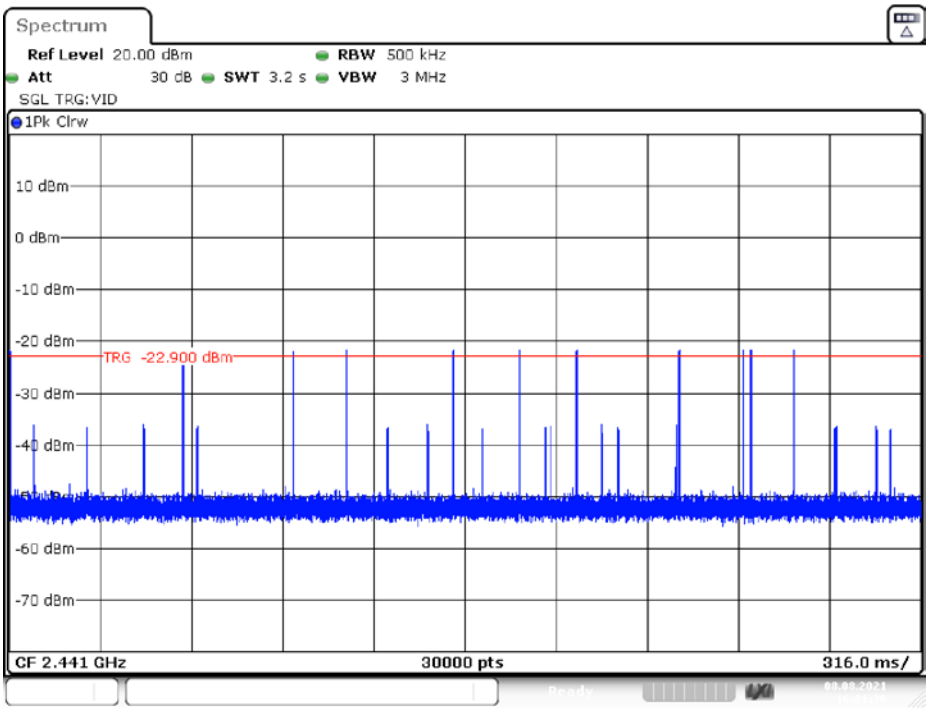


Date: 8.AUG.2021 15:36:56

3DH5_Hop



Date: 8.AUG.2021 16:01:25



Date: 8.AUG.2021 16:01:31

FCC §15.247(b) (1) - PEAK OUTPUT POWER MEASUREMENT

Applicable Standard

According to §15.247(b) (1), for frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. And for all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

Test Procedure

1. Place the EUT on a bench and set in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add a correction factor to the display.

Test Data

Environmental Conditions

Temperature:	24 ℃
Relative Humidity:	48 %
ATM Pressure:	101.0 kPa

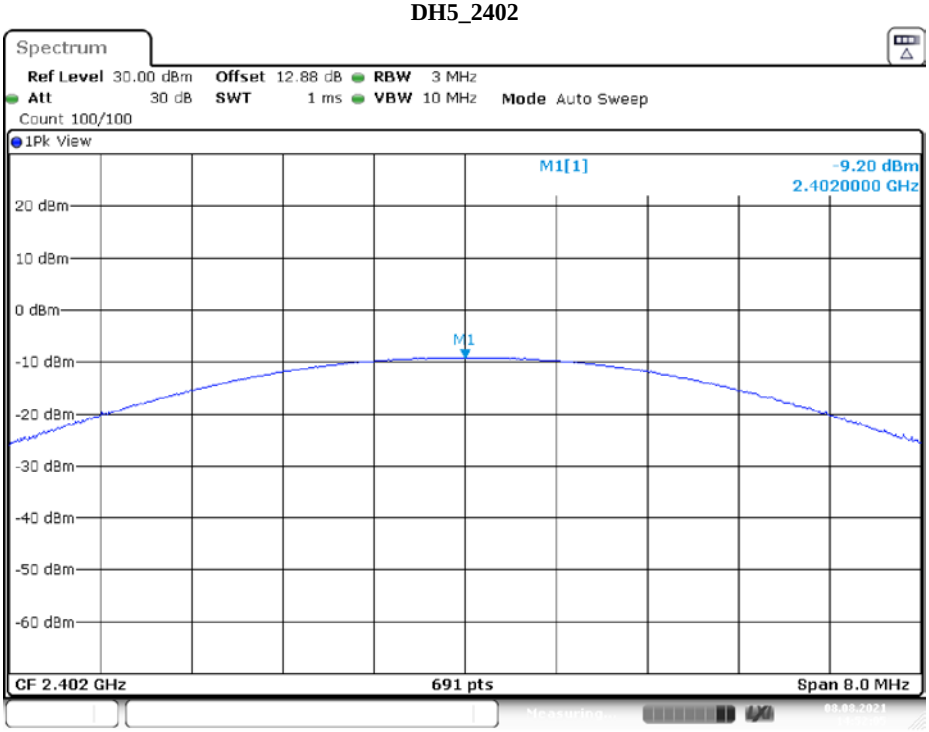
The testing was performed by Fan Yang on 2021-08-08

EUT operation mode: Transmitting

Test Result: Compliant.

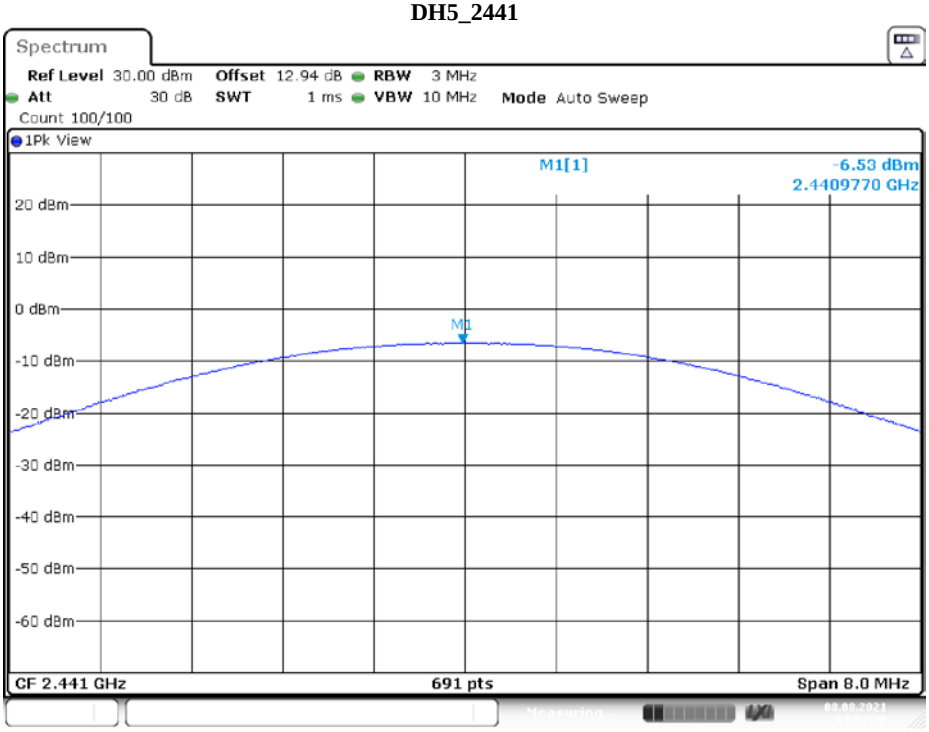
Test Mode	Channel[MHz]	Result[dBm]	Limit[dBm]	Verdict
DH5	2402	-9.2	<=20.97	PASS
	2441	-6.53	<=20.97	PASS
	2480	-6.86	<=20.97	PASS
2DH5	2402	-9.29	<=20.97	PASS
	2441	-6.76	<=20.97	PASS
	2480	-7.05	<=20.97	PASS
3DH5	2402	-8.83	<=20.97	PASS
	2441	-6.36	<=20.97	PASS
	2480	-6.59	<=20.97	PASS

DH5_2402



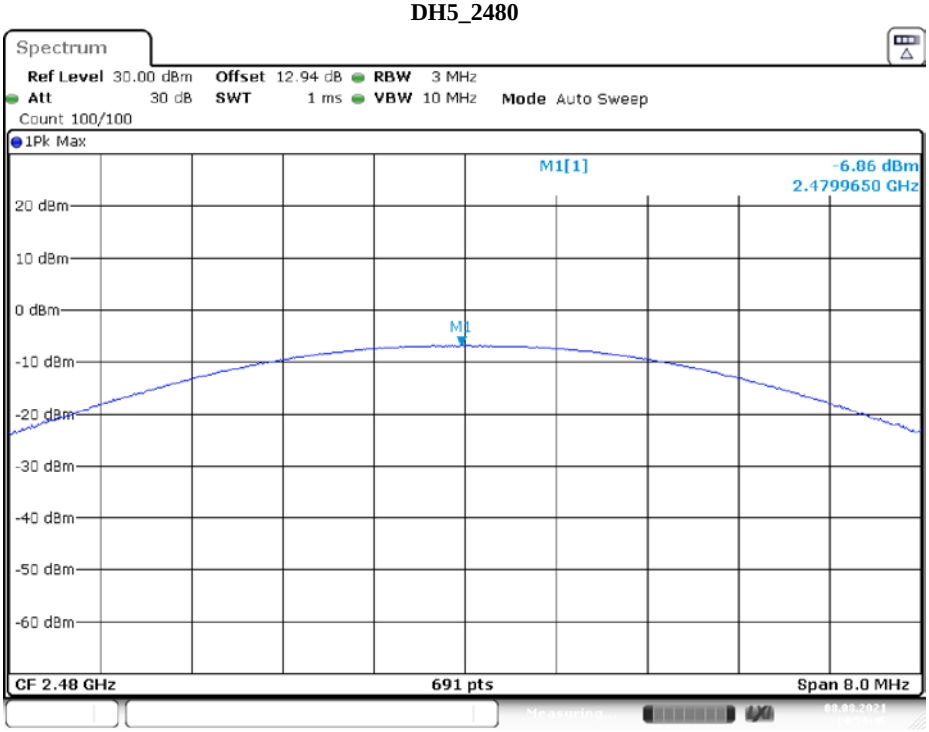
Date: 8.AUG.2021 14:52:06

DH5_2441



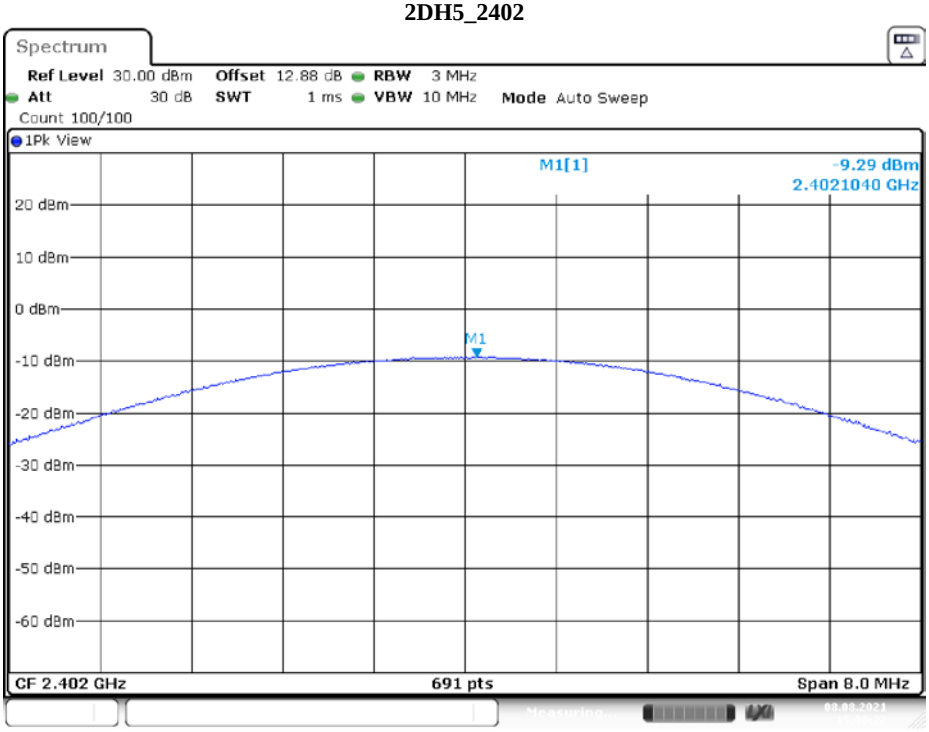
Date: 8.AUG.2021 14:52:28

DH5_2480



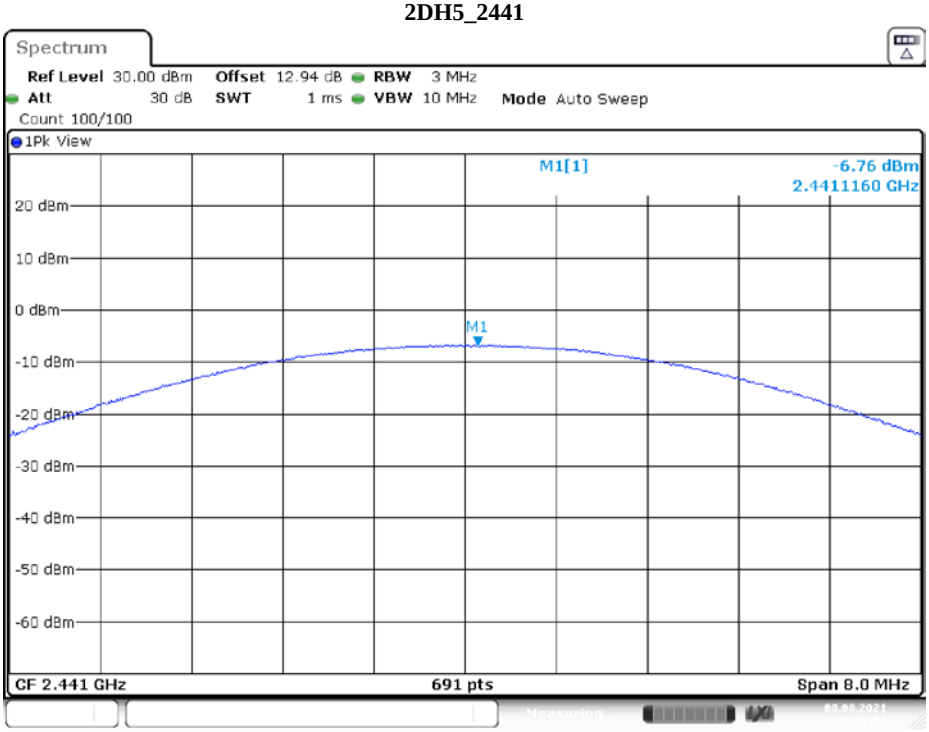
Date: 8.AUG.2021 14:59:47

2DH5_2402



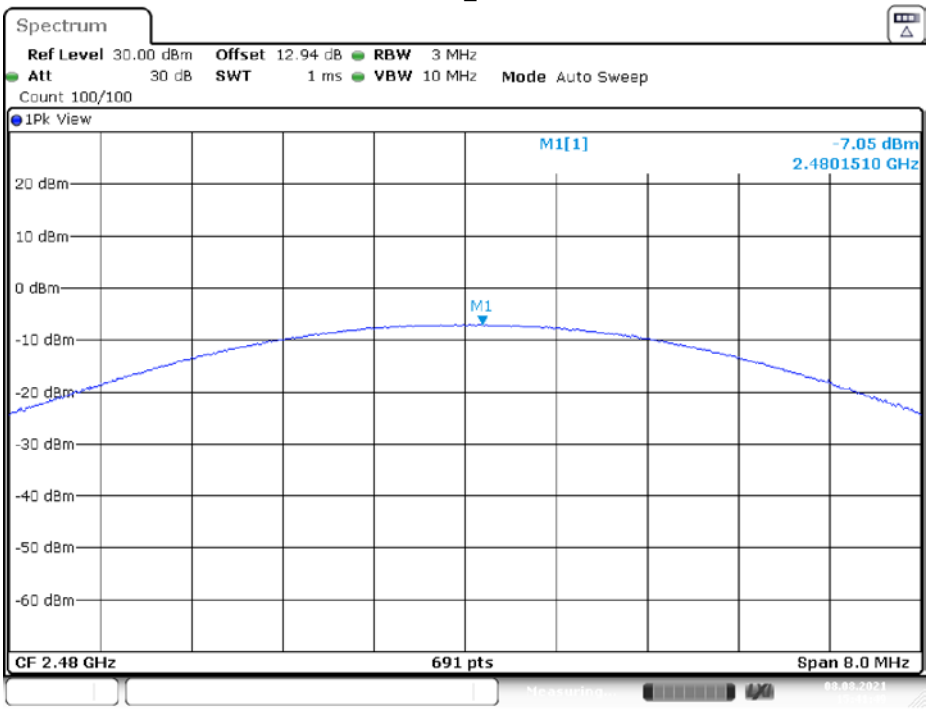
Date: 8.AUG.2021 15:00:22

2DH5_2441



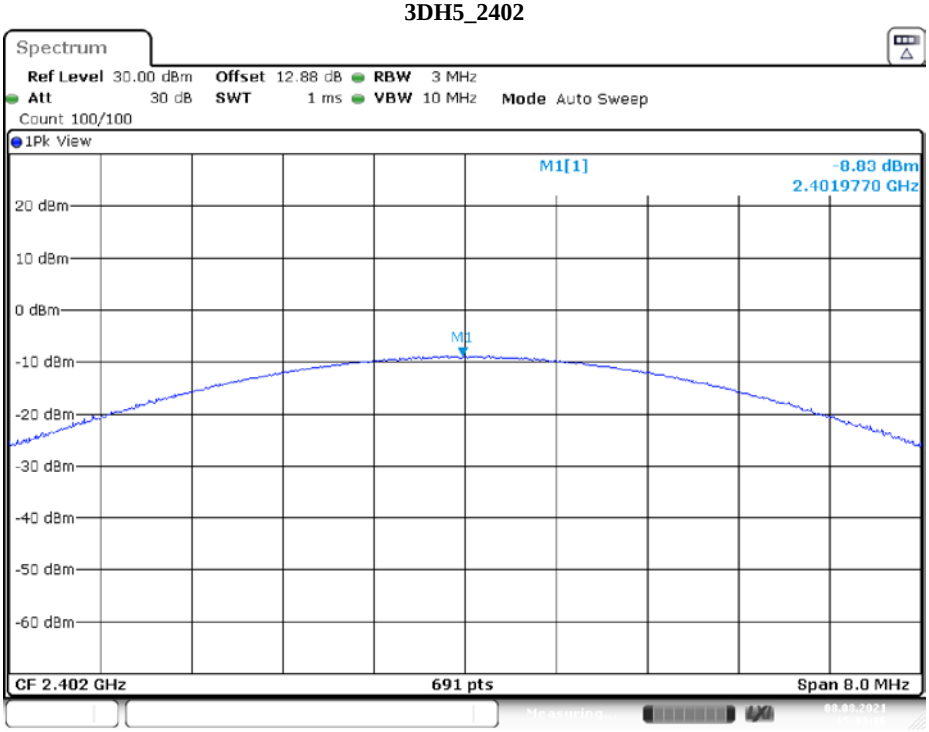
Date: 8.AUG.2021 15:01:03

2DH5_2480



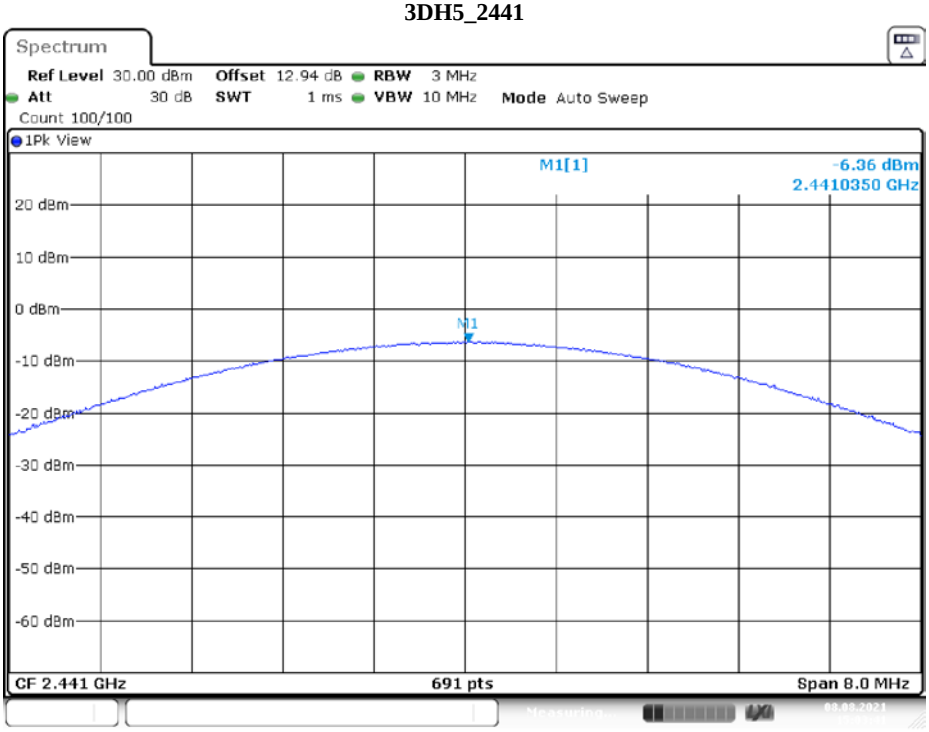
Date: 8.AUG.2021 15:41:50

3DH5_2402



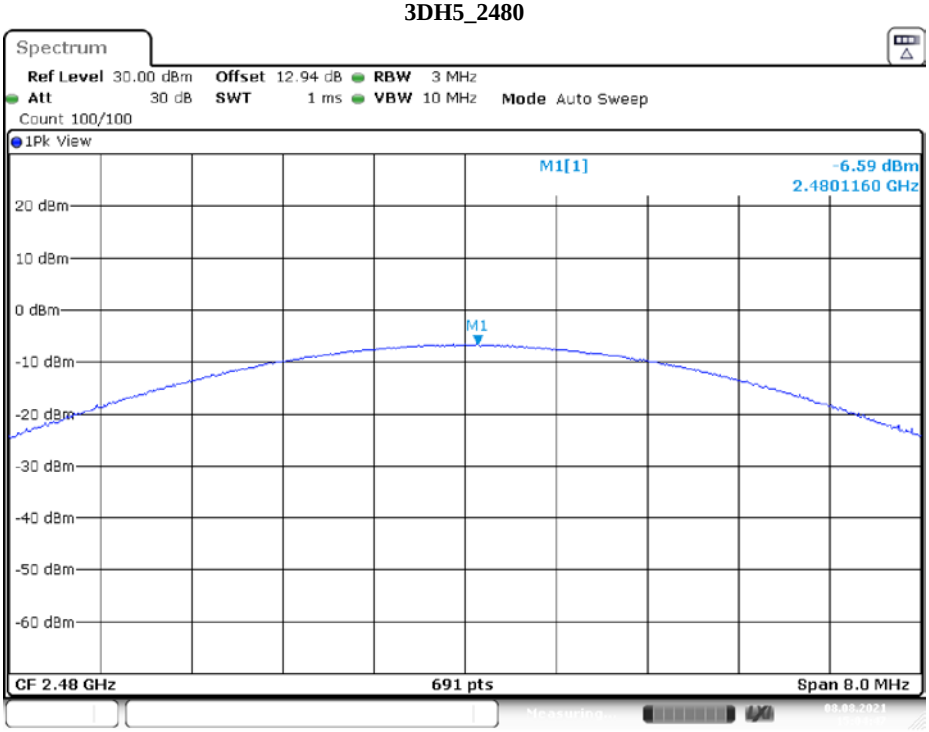
Date: 8.AUG.2021 15:03:16

3DH5_2441



Date: 8.AUG.2021 15:03:42

3DH5_2480


Spectrum
Ref Level 30.00 dBm Offset 12.94 dB RBW 3 MHz
Att 30 dB SWT 1 ms VBW 10 MHz Mode Auto Sweep
Count 100/100
1Pk View
M1[1] -6.59 dBm
2.4801160 GHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
M1
CF 2.48 GHz
691 pts
Span 8.0 MHz
Measuring...
Date: 8.AUG.2021 15:04:48

FCC §15.247(d) - BAND EDGES TESTING

Applicable Standard

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

Test Procedure

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

Test Data

Environmental Conditions

Temperature:	24℃
Relative Humidity:	48 %
ATM Pressure:	101.0 kPa

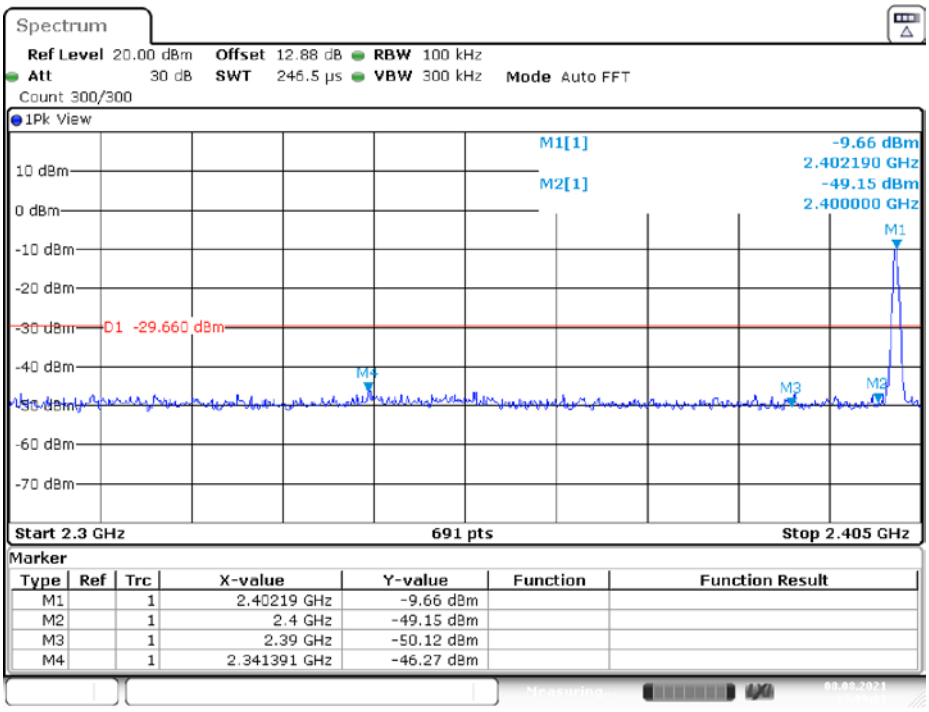
The testing was performed by Fan Yang on 2021-08-08.

EUT operation mode: Transmitting

Test Result: Compliant.

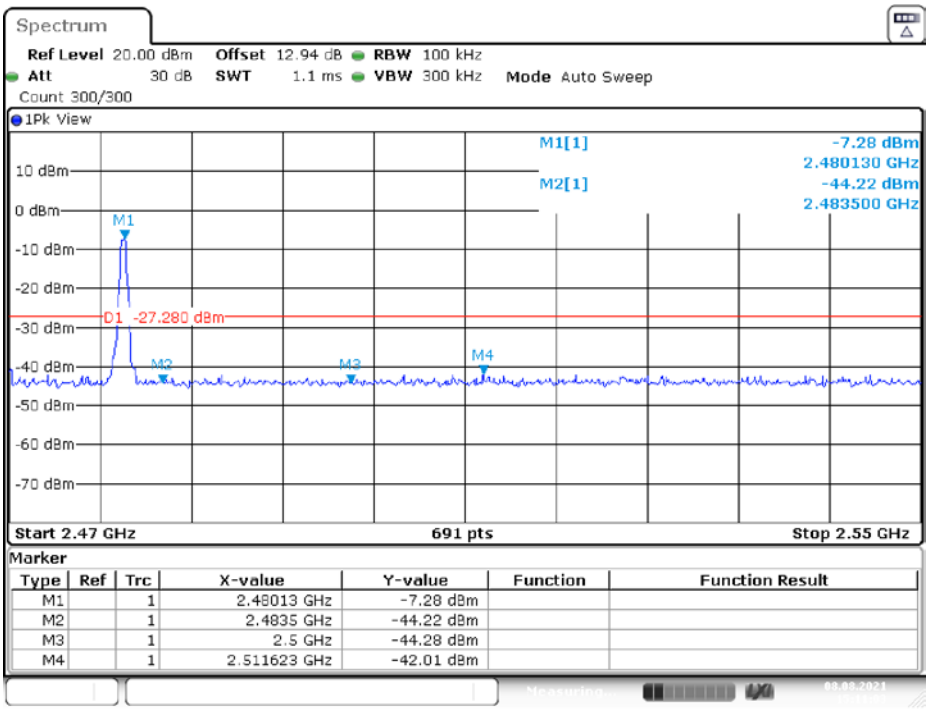
Conducted Band Edge Result:

DH5_Low_2402MHz



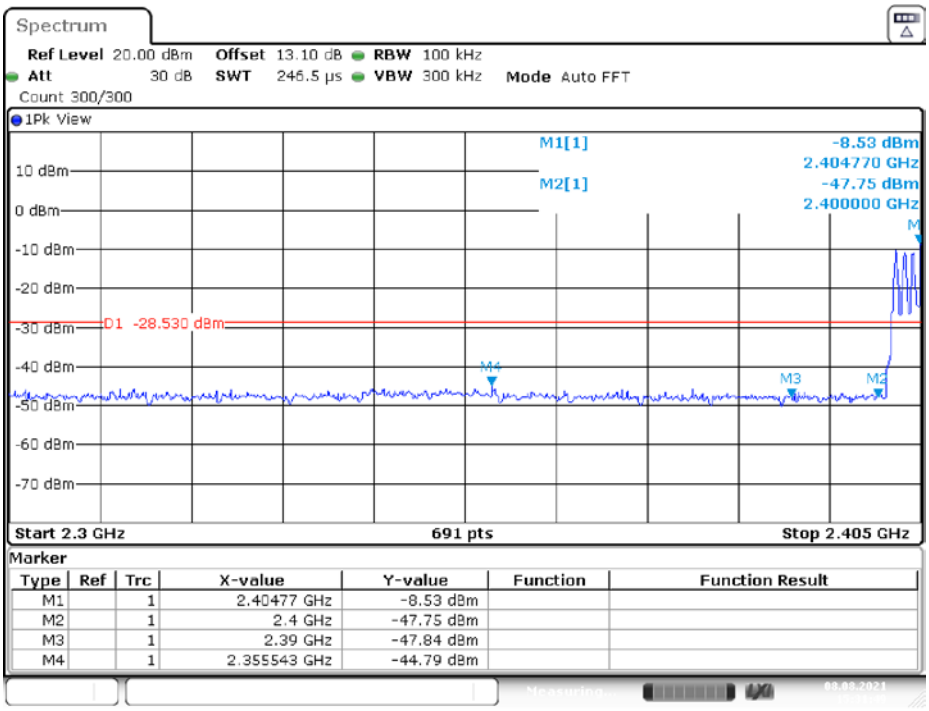
Date: 8.AUG.2021 15:09:03

DH5_High_2480MHz



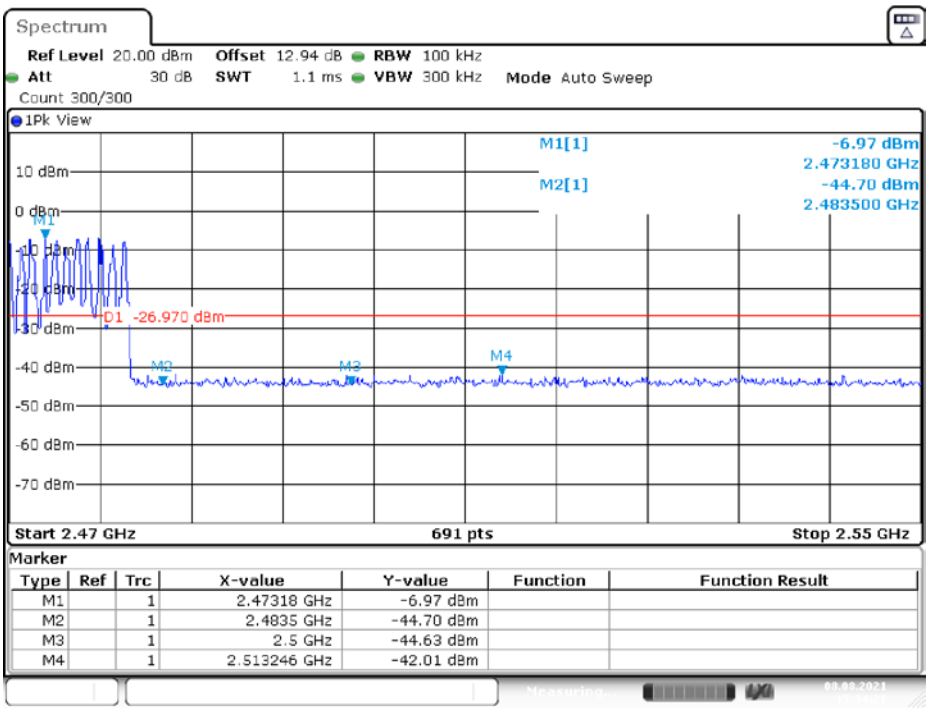
Date: 8.AUG.2021 15:11:03

DH5_Low_Hop_2402MHz



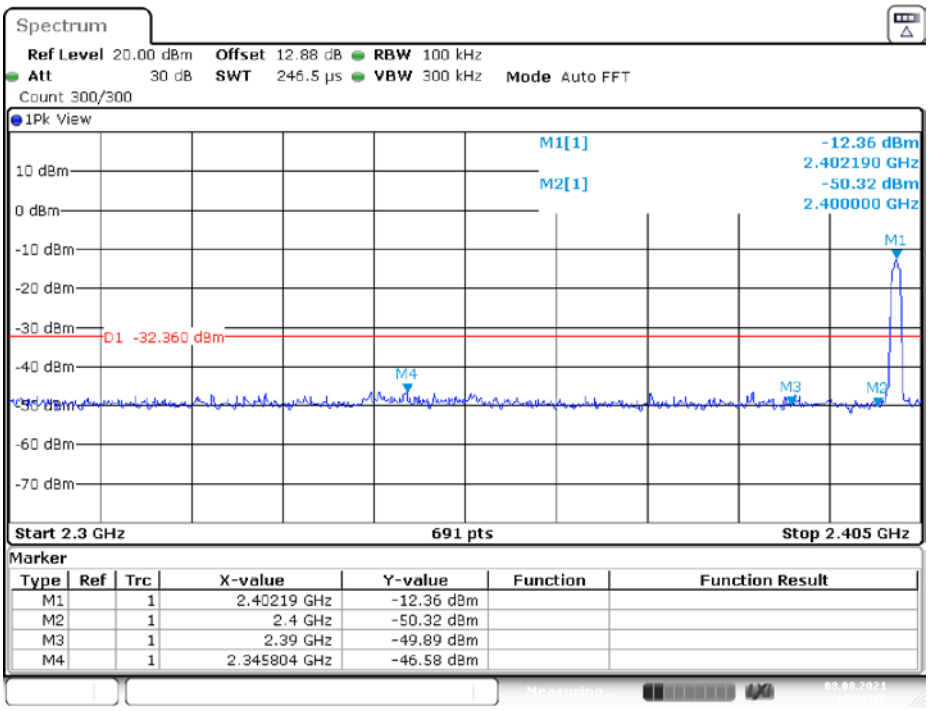
Date: 8.AUG.2021 15:31:49

DH5_High_Hop_2480MHz



Date: 8.AUG.2021 15:34:21

2DH5_Low_2402MHz



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.40219 GHz	-12.36 dBm		
M2		1	2.4 GHz	-50.32 dBm		
M3		1	2.39 GHz	-49.89 dBm		
M4		1	2.345804 GHz	-46.58 dBm		

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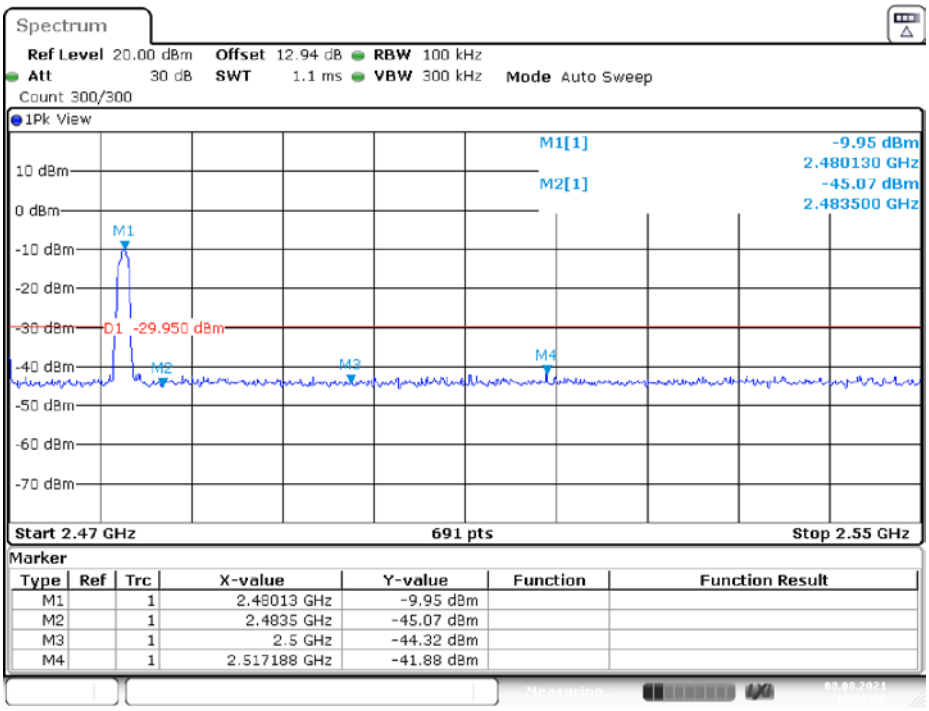
2DH5_High_2480MHz



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.48013 GHz	-9.95 dBm		
M2		1	2.4835 GHz	-45.07 dBm		
M3		1	2.5 GHz	-44.32 dBm		
M4		1	2.517188 GHz	-41.88 dBm		

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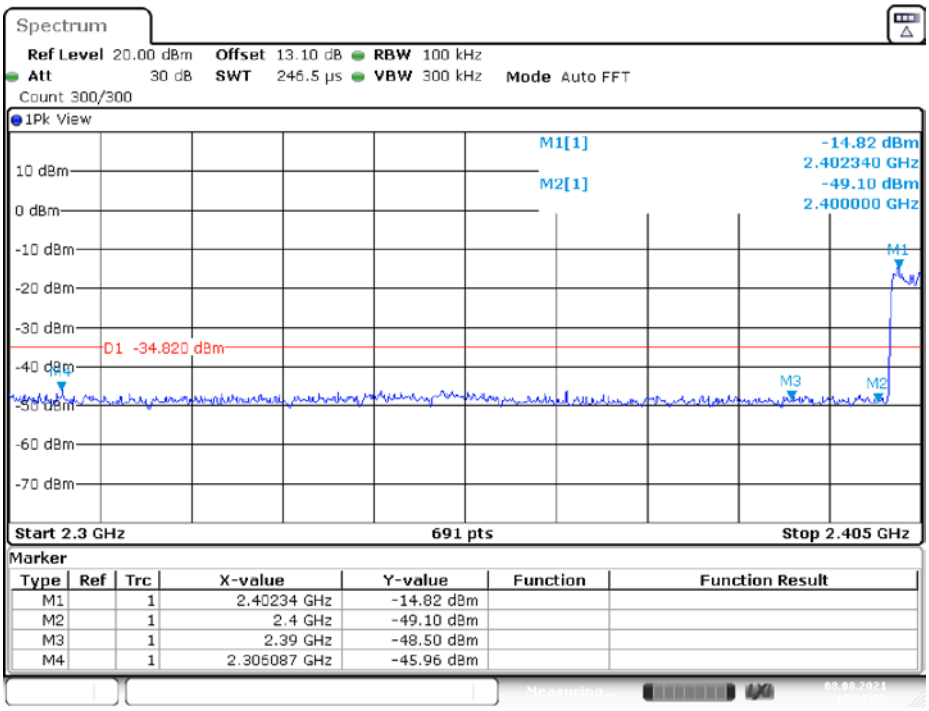
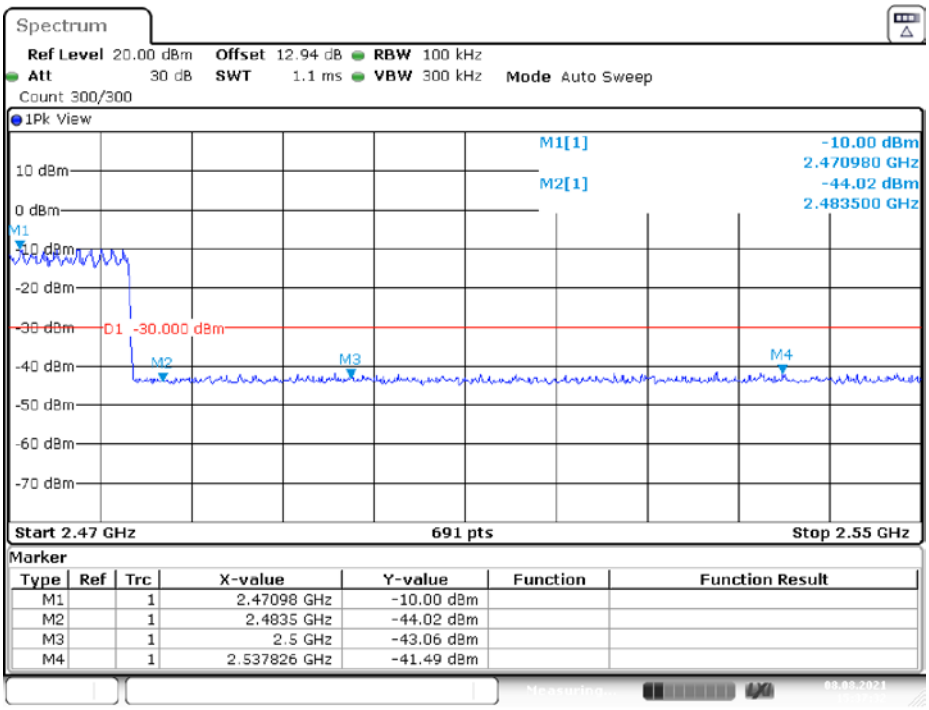
2DH5_Low_Hop_2402MHz



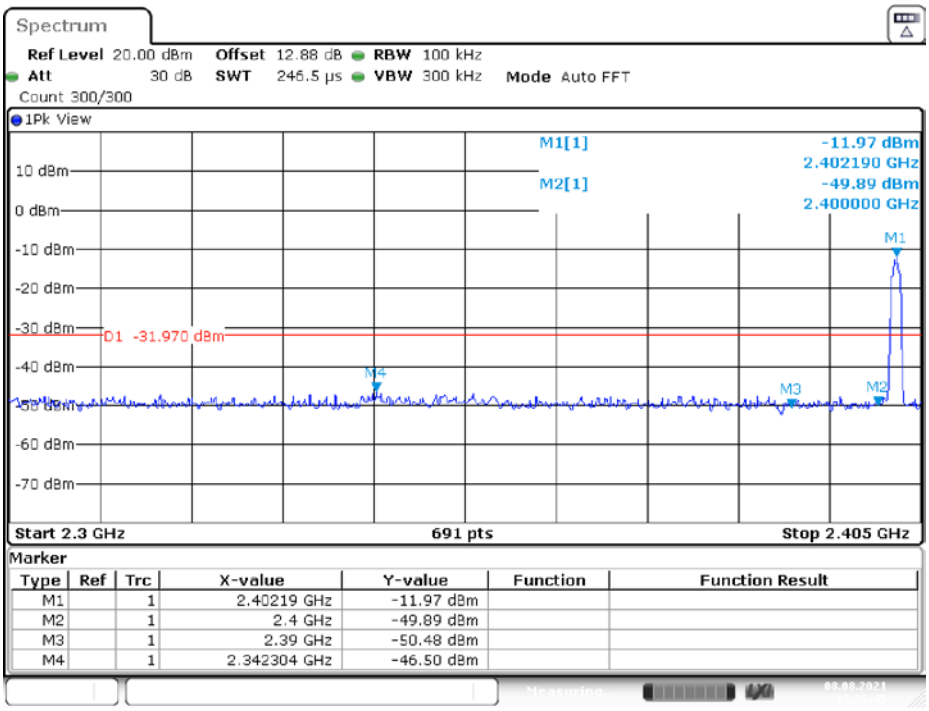
Date: 8.AUG.2021 15:35:05

2DH5_High_Hop_2480MHz



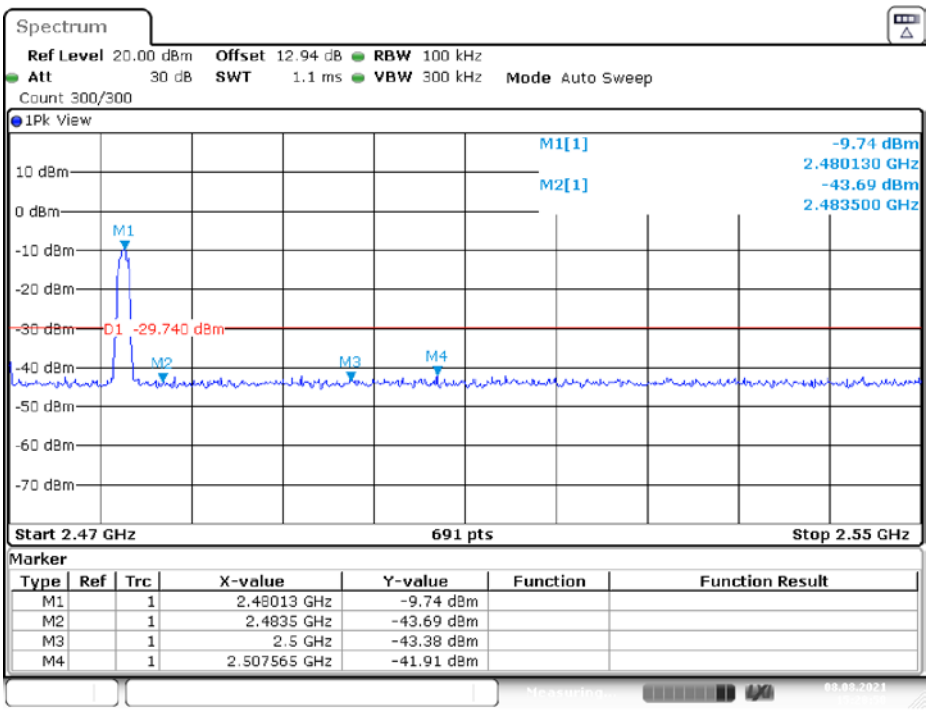
Date: 8.AUG.2021 15:37:32

3DH5_Low_2402MHz



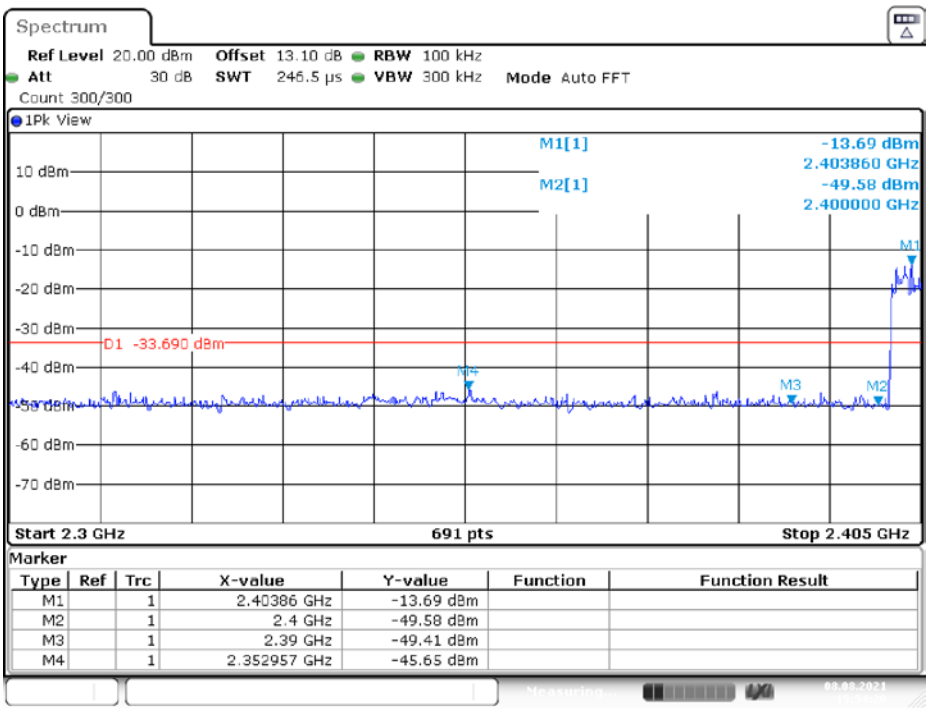
Date: 8.AUG.2021 15:26:46

3DH5_High_2480MHz



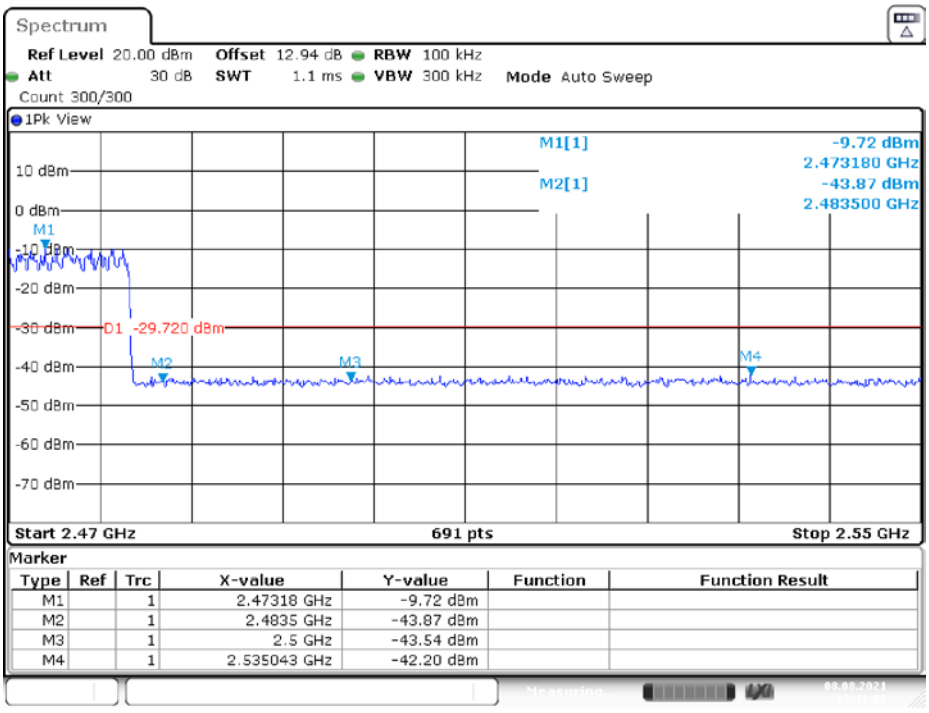
Date: 8.AUG.2021 15:28:58

3DH5_Low_Hop_2402MHz



Date: 8.AUG.2021 15:54:21

3DH5_High_Hop_2480MHz



Date: 8.AUG.2021 15:41:10

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