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FCC/ISED Test Report

Prepared for: Garmin International, Inc.

Address: 1200 E. 151st Street
Olathe, Kansas, 66062, USA

Product: A04244

Test Report No: R20211006-20-E1B

Approved by:

Nic Johnson, NCE
Techncial Manager
iNARTE Certified EMC Engineer

DATE: May 12, 2022

Total Pages: 58

REVISION PAGE

Rev. No.	Date	Description
0	1 March 2022	Original – KVepuri Reviewed by KVepuri/NJohnson Prepared by GLarsen and FLane
A	9 May 2022	Added Comment to Section 4.5 Corrected occupied bandwidth data
B	12 May 2022	Increased conducted spurious delta requirement to 30dB -NJ

CONTENTS

1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section:

FCC Part 15.247

The EUT has been tested according to the following specifications:

(1) US Code of Federal Regulations, Title 47, Part 15
(2) ISED RSS-Gen, Issue 5
(3) ISED RSS-247, Issue 2

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(b)(3) RSS-247 Issue 2 Section 5.4(d)	Peak output power	Pass
FCC Part 15.247(a)(2) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 5, Section 7.3	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 5, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(e) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 5.5	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 5, Section 8.8	Conducted Emissions	Pass

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary and Operating Condition:

EUT	A04244
EUT Received	5 November 2021
EUT Tested	9 November 2021- 17 February 2022
Serial No.	3388323232 (Radiated Measurements) 3388323409 (Conducted Measurements) 3388323355 (Conducted Measurements)
Operating Band	2400 – 2483.5 MHz
Device Type	☒ GMSK ☒ GFSK ☐ BT BR ☐ BT EDR 2MB ☐ BT EDR 3MB ☐ 802.11x
Power Supply / Voltage	Internal Battery/ 5VDC Charger: Garmin (Phi Hong) MN: PSAI10R-050Q (Representative Power Supply)

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

GFSK GMSK 1MB Transmissions:

Channel	Frequency
Low	2402 MHz
Mid	2440 MHz
High	2480 MHz

GMSK 2MB Transmissions:

Channel	Frequency
Low	2404 MHz
Mid	2440 MHz
High	2478 MHz

These are the only representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

2.3 DESCRIPTION OF SUPPORT UNITS

None

3.0 LABORATORY AND GENERAL TEST DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Fox Lane	Test Engineer	Testing and Report
2	Karthik Vepuri	Test Engineer	Review/Editing and Report
3	Blake Winter	Test Engineer	Testing
4	Grace Larsen	Test Technician	Testing and report
5	Samuel Probst	Test Technician	Testing
6	Matthew Emory	Test Technician	Testing

Notes: All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)	N9038A	MY59050109	July 21, 2021	July 21, 2023
Keysight MXE Signal Analyzer (26.5GHz)	N9038A	MY56400083	May 5, 2020	May 5, 2022
Keysight EXA Signal Analyzer	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A091418	July 27, 2021	July 27, 2022
EMCO Horn Antenna	3115	6415	March 16, 2020	March 16, 2022
EMCO Horn Antenna	3116	2576	March 9, 2020	March 9, 2022
Com-Power LISN 50µH / 250µH - 50Ω	LI-220C	20070017	September 22, 2020	September 22, 2022
8447F POT H64 Preamplifier*	8447F POT H64	3113AD4667	February 1, 2021	February 1, 2022
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	April 14, 2020	April 14, 2022
Trilithic High Pass Filter*	6HC330	23042	April 14, 2020	April 14, 2022
ETS – Lindgren- VSWR on 10m Chamber	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber	10m Semi-anechoic chamber-NSA	NCEE-001	October 25, 2019	October 25, 2022
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	April 14, 2020	April 14, 2022
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)**	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)**	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

*Internal Characterization

Notes:
All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMNTS

Measurement type presented in this report (Please see the checked box below):

Conducted ☒

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

Figure 1 - Bandwidth Measurements Test Setup

Radiated ☒

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

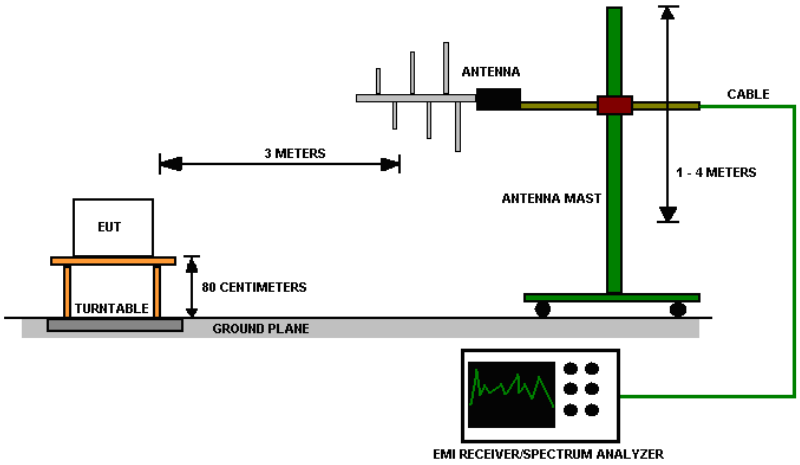


Figure 2 - Radiated Emissions Test Setup

4.0 RESULTS

DTS Radio Measurements							
CHANNEL	**Transmitter**	**Occupied Bandwidth (kHz)**	**6 dB Bandwidth (kHz)**	**AVERAGE OUTPUT POWER (dBm)**	**AVERAGE OUTPUT POWER (mW)**	**PSD (dBm)**	**RESULT**
Low	GFSK	1820.70	947.30	0.850	1.216	-17.115	PASS
Mid	GFSK	1413.80	912.10	3.340	2.158	-11.295	PASS
High	GFSK	1921.00	974.60	-0.780	0.836	-15.791	PASS
Low	GMSK 1Mb	1389.50	782.00	0.280	1.067	-17.203	PASS
Mid	GMSK 1Mb	1764.90	924.20	3.670	2.328	-13.513	PASS
High	GMSK 1Mb	1786.30	907.90	-0.850	0.822	-16.106	PASS
Low	GMSK 2Mb	2800.30	1755.00	3.42	2.198	-14.709	PASS
Mid	GMSK 2Mb	2654.50	1888.00	3.69	2.339	-14.801	PASS
High	GMSK 2Mb	2753.60	1776.00	-0.13	0.971	-18.264	PASS
Occupied Bandwidth = N/A; 6 dB Bandwidth Limit = 500 kHz				Peak Output Power Limit = 30 dBm; PSD Limit = 8 dBm			

Unrestricted Band-Edge							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Relative Highest out of band level (dBuV)**	**Relative Fundamental (dBuV)**	**Delta (dB)**	**Min Delta (dB)**	**Result**
Low	GMSK 1Mb	2400.00	62.70	105.72	43.02	30.00	PASS
Low	GMSK 2Mb	2400.00	66.82	106.60	39.79	30.00	PASS
Low	GFSK	2400.00	63.25	105.64	42.38	30.00	PASS
High	GMSK 1Mb	2483.50	53.79	106.38	52.59	30.00	PASS
High	GMSK 2Mb	2483.50	62.09	102.57	40.48	30.00	PASS
High	GFSK	2483.50	55.78	106.37	50.60	30.00	PASS

Peak Restricted Band-Edge							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)**	**Measurement Type**	**Limit (dBuV/m @ 3m)**	**Margin**	**Result**
Low	GMSK 1Mb	2390.00	52.13	Peak	73.98	21.86	PASS
Low	GMSK 2Mb	2390.00	53.39	Peak	73.98	20.59	PASS
Low	GFSK	2390.00	51.37	Peak	73.98	22.61	PASS
High	GMSK 1Mb	2483.50	55.30	Peak	73.98	18.68	PASS
High	GMSK 2Mb	2483.50	59.41	Peak	73.98	14.57	PASS
High	GFSK	2483.50	54.59	Peak	73.98	19.39	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							

Average Restricted Band-Edge							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)**	**Measurement Type**	**Limit (dBuV/m @ 3m)**	**Margin**	**Result**
Low	GMSK 1Mb	2390.00	40.12	Average	53.98	13.86	PASS
Low	GMSK 2Mb	2390.00	41.71	Average	53.98	12.27	PASS
Low	GFSK	2390.00	40.05	Average	53.98	13.93	PASS
High	GMSK 1Mb	2483.50	45.91	Average	53.98	8.07	PASS
High	GMSK 2Mb	2483.50	50.49	Average	53.98	3.49	PASS
High	GFSK	2483.50	44.74	Average	53.98	9.24	PASS
*Limit shown is the average limit taken from FCC Part 15.209							

4.1 OUTPUT POWER

Test Method: All measurements were performed using the section 11.9.2.2.2 from ANSI C63.10.

Limits of power measurements:
For FCC Part 15.247 Device:
The maximum allowed output power is 30 dBm.

Test procedures:
Details can be found in section 3.4 of this report.

Deviations from test standard:
No deviation.

Test setup:
Details can be found in section 3.4 of this report.

EUT operating conditions:
Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:

1. All the output power plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. Tabulated data is listed in section 4.0.

4.2 BANDWIDTH

Test Method: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

Limits of bandwidth measurements:

For FCC Part 15.247 Device:
The 99% occupied bandwidth is for informational purpose only. The 6dB bandwidth of the signal must be greater than 500 kHz.

Test procedures:
Details can be found in section 3.4 of this report.

Deviations from test standard:
No deviation.

Test setup:
Test setup details can be found in section 3.4 of this report.

EUT operating conditions:
Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:

1. All the bandwidth plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. Tabulated data is listed in section 4.0.

4.3 DUTY CYCLE

Test Method:

All Modulations/transmitters shown have a duty cycle of >98%.

4.4 RADIATED EMISSIONS

Test Method: ANSI C63.10-2013, Section 6.5, 6.6

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (μV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (μV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.
4. The EUT was tested for spurious emissions while running off of battery power and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.

Test procedures:

a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

Test setup:

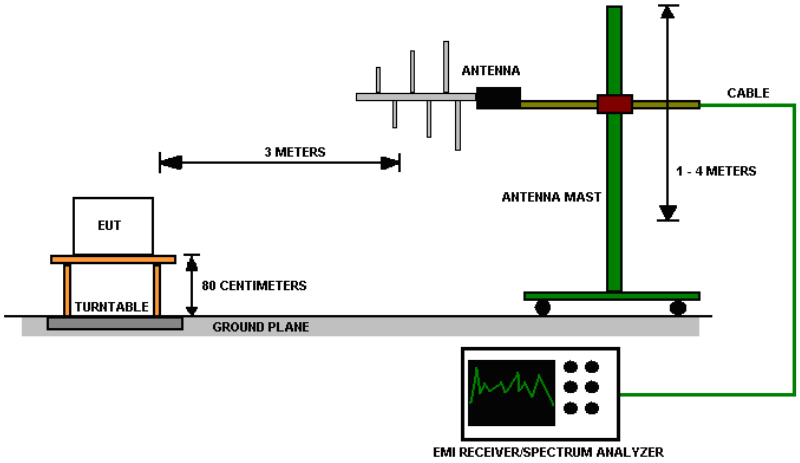


Figure 3 - Radiated Emissions Test Setup

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.

2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

Deviations from test standard:
No deviation.

EUT operating conditions
Details can be found in section 2.1 of this report.

Test results:

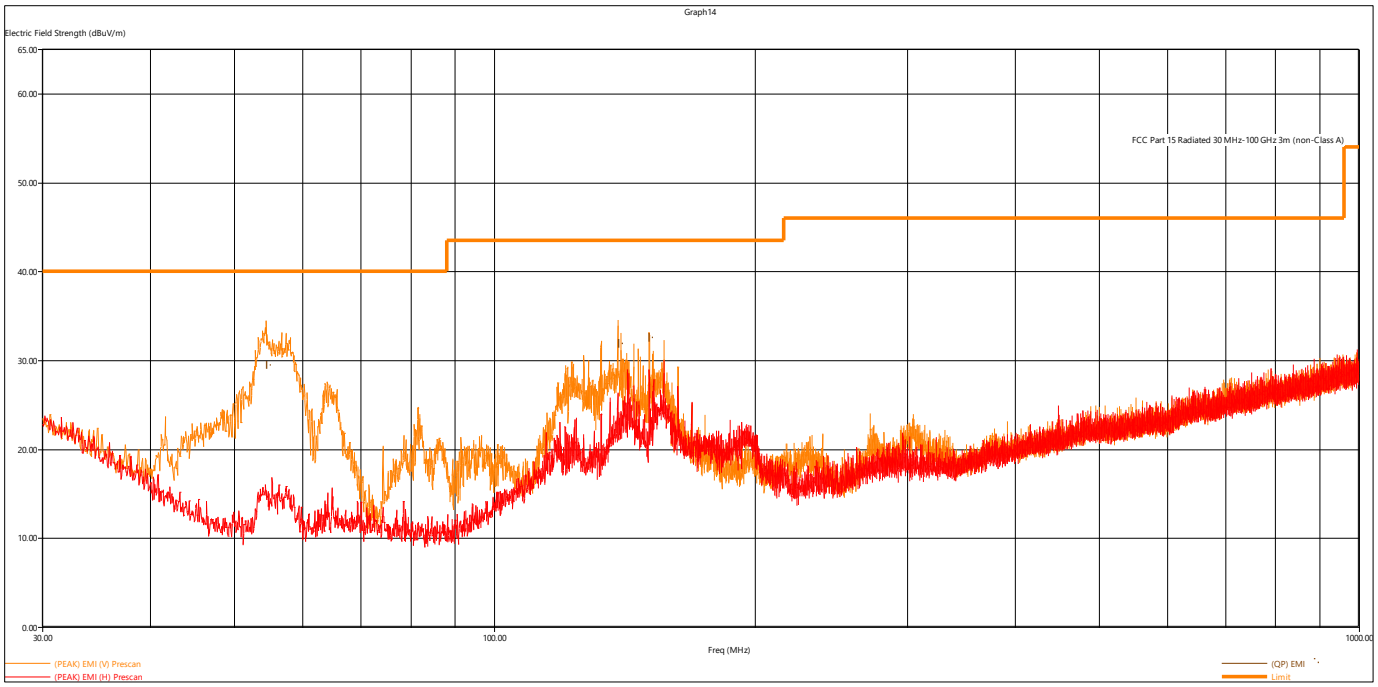


Figure 4 - Radiated Emissions Plot, Receive

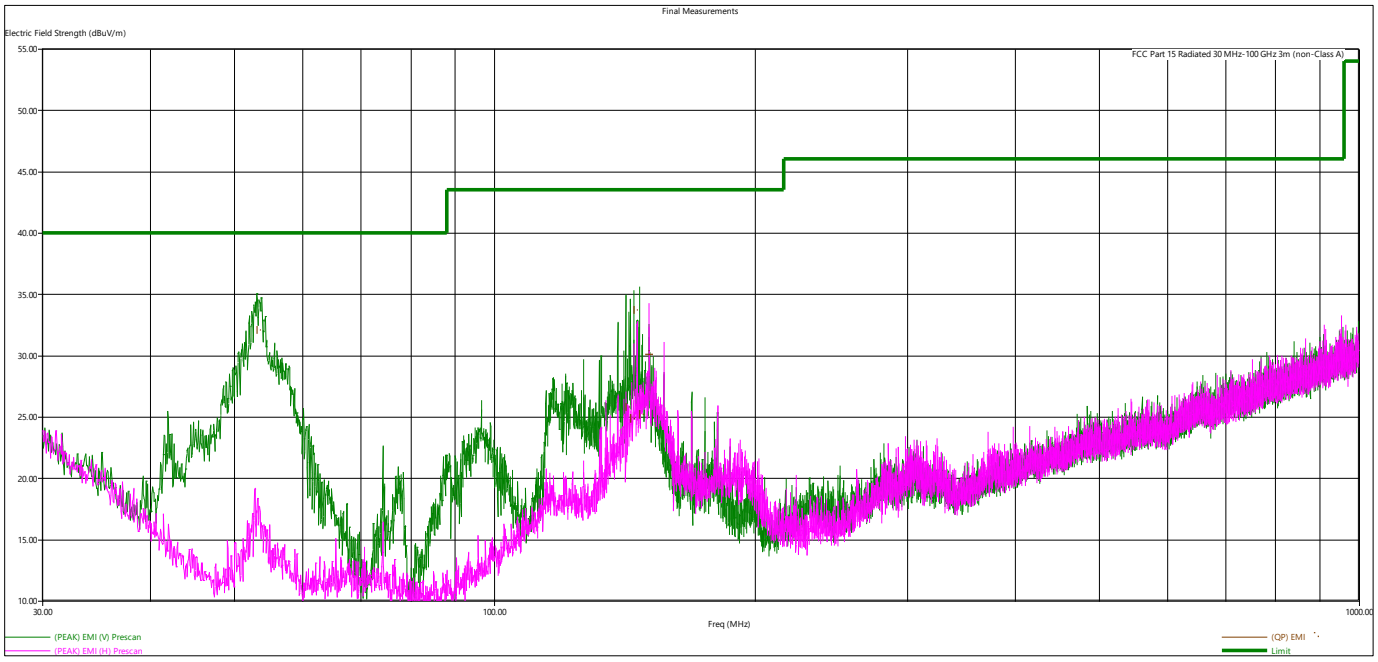


Figure 5 - Radiated Emissions Plot, GFSK

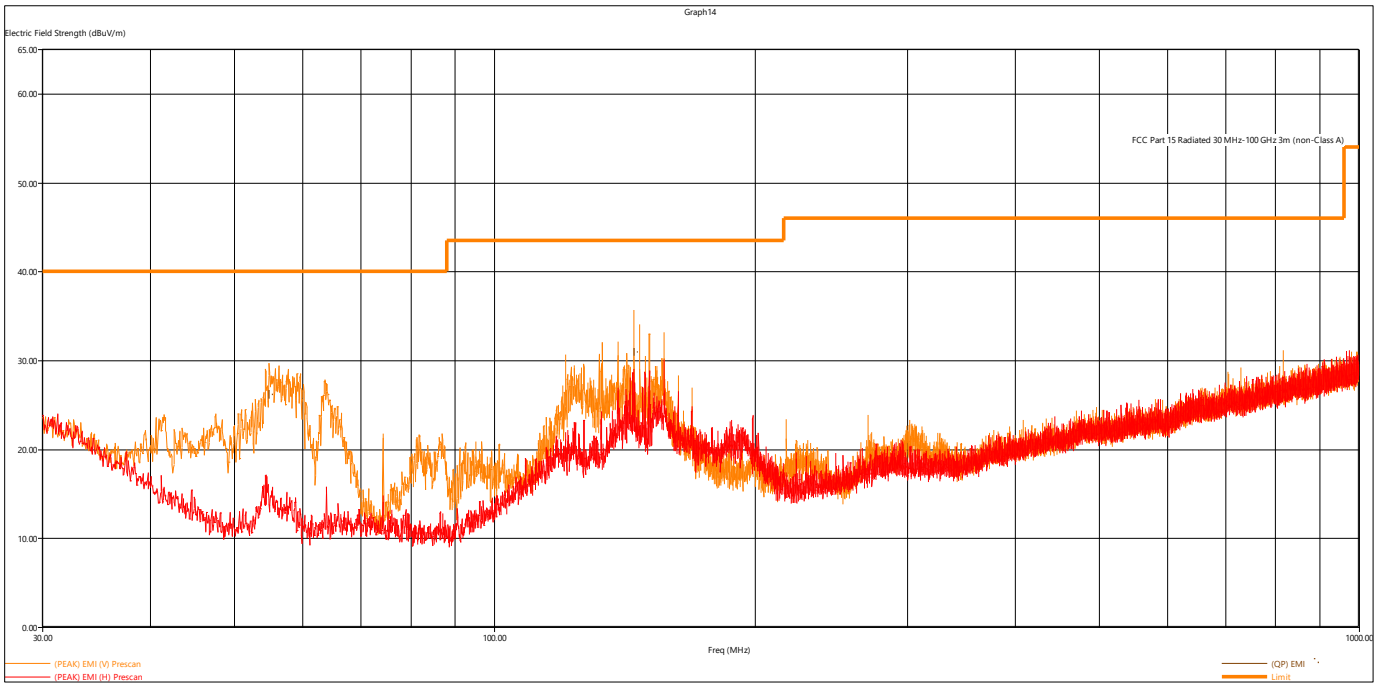


Figure 6 - Radiated Emissions Plot, GMSK 1MB

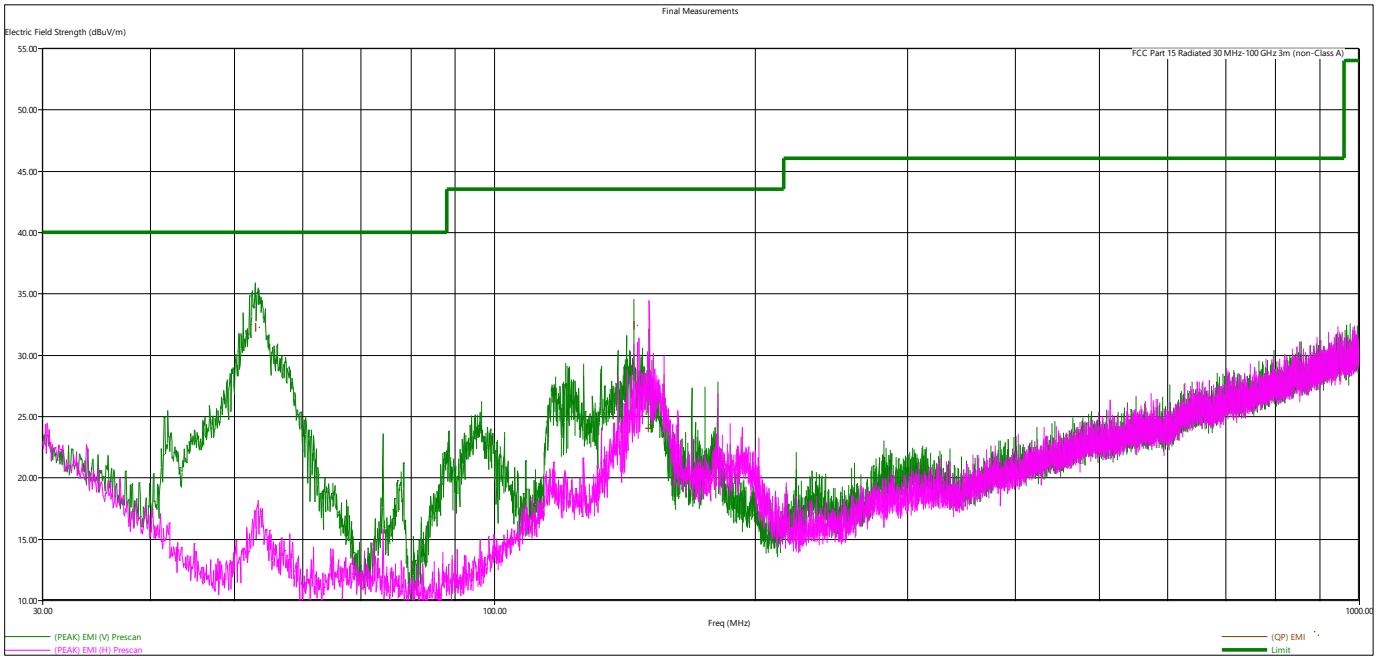


Figure 7 - Radiated Emissions Plot, GMSK 2MB

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

Quasi-Peak Measurements, GMSK-GFSK								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
150.90192	30.02	43.52	13.50	199	359	H	Low	GFSK
53.07696	32.03	40.00	7.97	111	255	V	Low	GFSK
141.73896	25.75	43.52	17.77	147	53	V	Low	GFSK
143.68944	24.80	43.52	18.72	150	88	V	Low	GFSK
144.7968	33.68	43.52	9.84	130	71	V	Low	GFSK
146.92464	25.18	43.52	18.34	178	54	V	Low	GFSK
54.95832	26.13	40.00	13.87	104	356	V	Low	GMSK 1Mb
144.84768	30.89	43.52	12.63	114	77	V	Low	GMSK 1Mb
151.11096	23.92	43.52	19.60	315	332	H	Low	GMSK 2Mb
52.79736	32.23	40.00	7.77	112	286	V	Low	GMSK 2Mb
144.84576	32.35	43.52	11.17	118	94	V	Low	GMSK 2Mb
150.88128	33.04	43.52	10.48	168	178	H	Receive	
53.53752	27.14	40.00	12.86	106	288	V	Receive	
142.08744	23.15	43.52	20.37	136	125	V	Receive	
144.9444	28.68	43.52	14.84	104	88	V	Receive	

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above.
All other measurements were found to be at least 6 dB Below the limit.

Peak Measurements, GMSK-GFSK								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
2401.69	97.31	N/A	N/A	393	95	H	Low	GFSK
2439.622	99.53	N/A	N/A	123	121	H	Mid	GFSK
2480.324	95.82	N/A	N/A	157	121	H	High	GFSK
7204.564	52.79	73.98	21.19	147	187	H	Low	GFSK
7318.73	56.88	73.98	17.10	128	146	H	Mid	GFSK
7438.55	52.75	73.98	21.23	113	143	H	High	GFSK
2402.196	95.84	N/A	N/A	166	52	H	Low	GMSK 1Mb
2440.16	99.44	N/A	N/A	127	122	H	Mid	GMSK 1Mb
2480.198	95.83	N/A	N/A	159	119	H	High	GMSK 1Mb
7321.262	56.01	73.98	17.97	124	180	H	Mid	GMSK 1Mb
7440.774	55.14	73.98	18.84	123	150	H	High	GMSK 1Mb
7204.86	53.76	73.98	20.22	142	183	H	Low	GMSK 1Mb
2401.486	97.10	N/A	N/A	390	94	H	Low	GMSK 2Mb
2439.52	99.31	N/A	N/A	124	121	H	Mid	GMSK 2Mb

2479.53	96.04	N/A	N/A	156	121	H	High	GMSK 2Mb
7213.434	57.04	73.98	16.94	127	190	H	Low	GMSK 2Mb
7321.828	55.92	73.98	18.06	118	145	H	Mid	GMSK 2Mb
7432.572	54.8	73.98	19.18	115	148	H	High	GMSK 2Mb
2420.474	24.48	73.98	49.5	471	302	V	Receive	
2439.928	24.7	73.98	49.28	477	14	V	Receive	

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above.
All other measurements were found to be at least 6 dB Below the limit.

Average Measurements, GMSK-GFSK								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
2401.69	93.74	N/A	N/A	393	95	H	Low	GFSK
2439.622	94.73	N/A	N/A	123	121	H	Mid	GFSK
2480.324	91.64	N/A	N/A	157	121	H	High	GFSK
7204.564	40.21	53.98	13.77	147	187	H	Low	GFSK
7318.73	47.25	53.98	6.73	128	146	H	Mid	GFSK
7438.55	40.94	53.98	13.04	113	143	H	High	GFSK
2402.196	93.31	N/A	N/A	166	52	H	Low	GMSK 1Mb
2440.16	96.65	N/A	N/A	127	122	H	Mid	GMSK 1Mb
2480.198	93.19	N/A	N/A	159	119	H	High	GMSK 1Mb
7321.262	45.49	53.98	8.49	124	180	H	Mid	GMSK 1Mb
7440.774	45.28	53.98	8.70	123	150	H	High	GMSK 1Mb
7204.86	42.55	53.98	11.43	142	183	H	Low	GMSK 1Mb
2401.486	90.52	N/A	N/A	390	94	H	Low	GMSK 2Mb
2439.52	93	N/A	N/A	124	121	H	Mid	GMSK 2Mb
2479.53	89.78	N/A	N/A	156	121	H	High	GMSK 2Mb
7213.434	47.71	53.98	6.27	127	190	H	Low	GMSK 2Mb
7321.828	45.76	53.98	8.22	118	145	H	Mid	GMSK 2Mb
7432.572	43.98	53.98	10.00	115	148	H	High	GMSK 2Mb
2420.474	38.29	53.98	15.69	471	302	V	Receive	
2439.928	38.13	53.98	15.85	477	14	V	Receive	

The EUT was maximized in all 3 orthogonal axes. The worst-case is shown in the plot and table above.
All other measurements were found to be at least 6 dB Below the limit.

4.5 CONDUCTED SPURIOUS EMISSIONS

Test Method: ANSI C63.10-2013, Section 6.7

Limits of spurious emissions:

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 procedures:

The highest emissions level was measured and recorded. All spurious measurements were evaluated to 30dB below the fundamental. More details can be found in section 3.4 of this report.

Deviations from test standard:
Testing was done at 120kHz RBW

Test setup:
Test setup details can be found in section 3.4 of this report.

EUT operating conditions:
Details can be found in section 2.1 of this report.

Test results:
Note that the limit shown on the plots does not apply. The spurious emissions were compared to the peak emission at the fundamental frequency within a 120 kHz band.

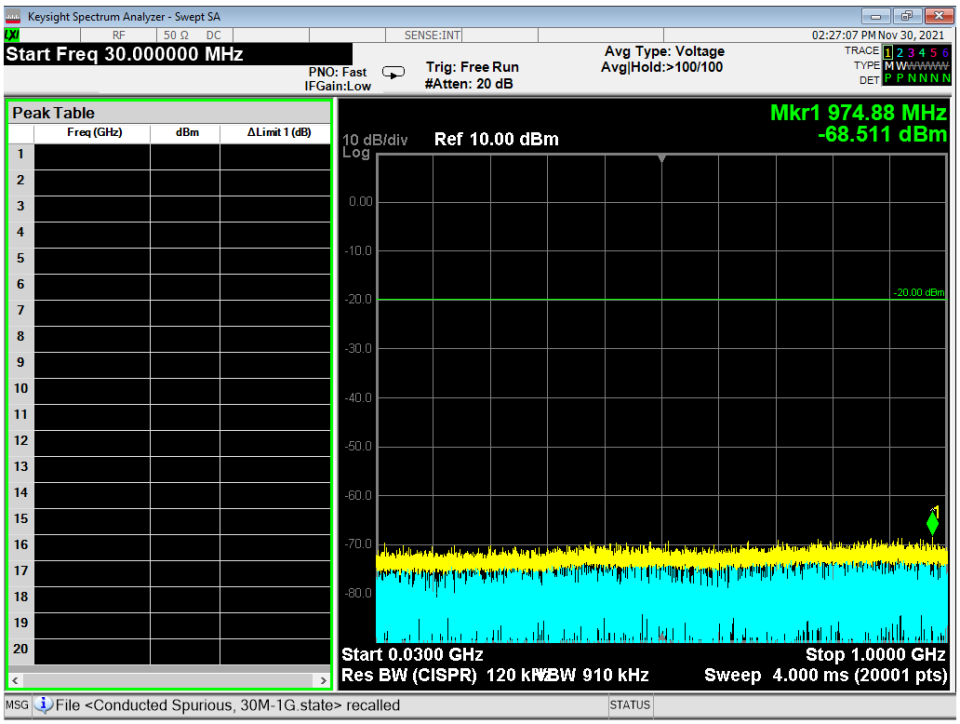


Figure 8 - Radiated Emissions Plot, GFSK, 30MHz – 1GHz, Low

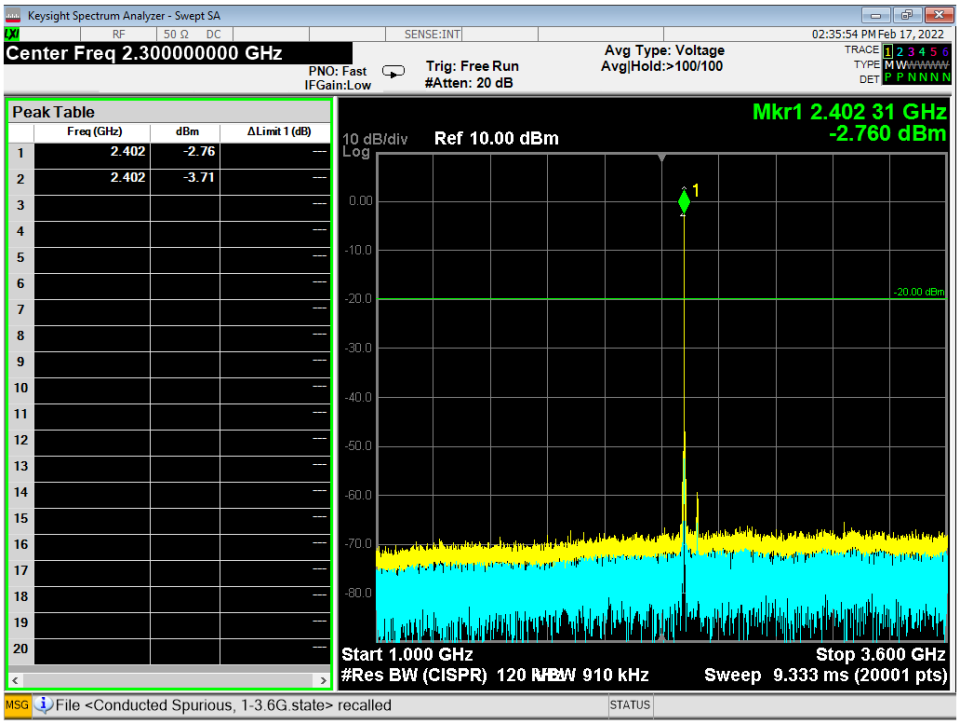


Figure 9 - Radiated Emissions Plot, GFSK, 1GHz – 3.6GHz, Low

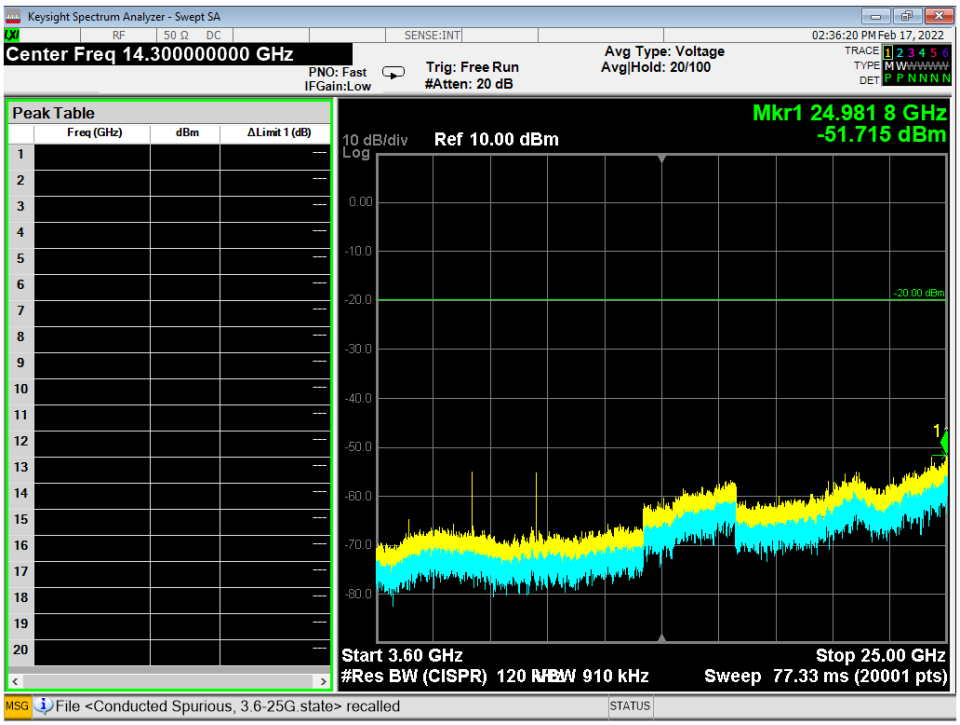


Figure 10 - Radiated Emissions Plot, GFSK, 3.6GHz – 25GHz, Low

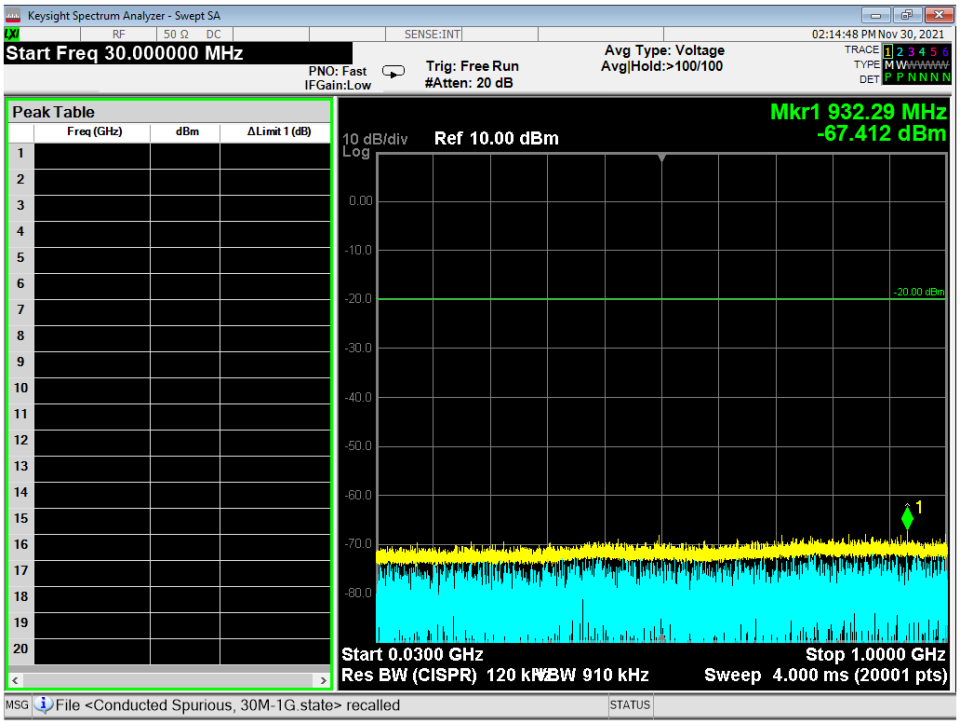


Figure 11 - Radiated Emissions Plot, GMSK 1MB, 30MHz – 1GHz, Low

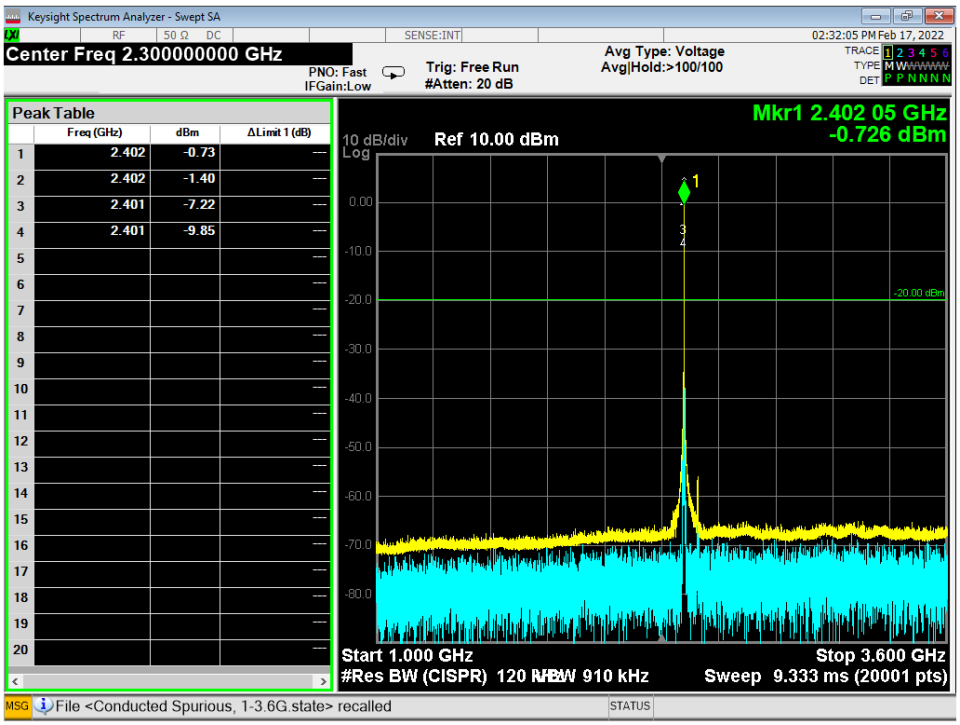


Figure 12 - Radiated Emissions Plot, GMSK 1MB, 1GHz – 3.6GHz, Low

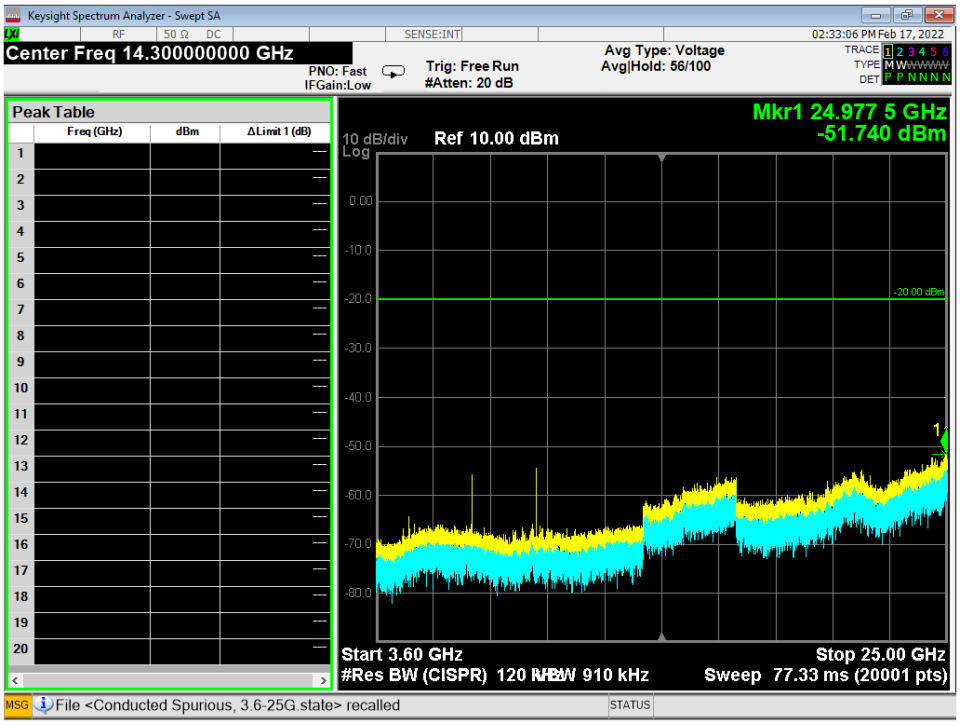


Figure 13 - Radiated Emissions Plot, GMSK 1MB, 3.6GHz – 25GHz, Low

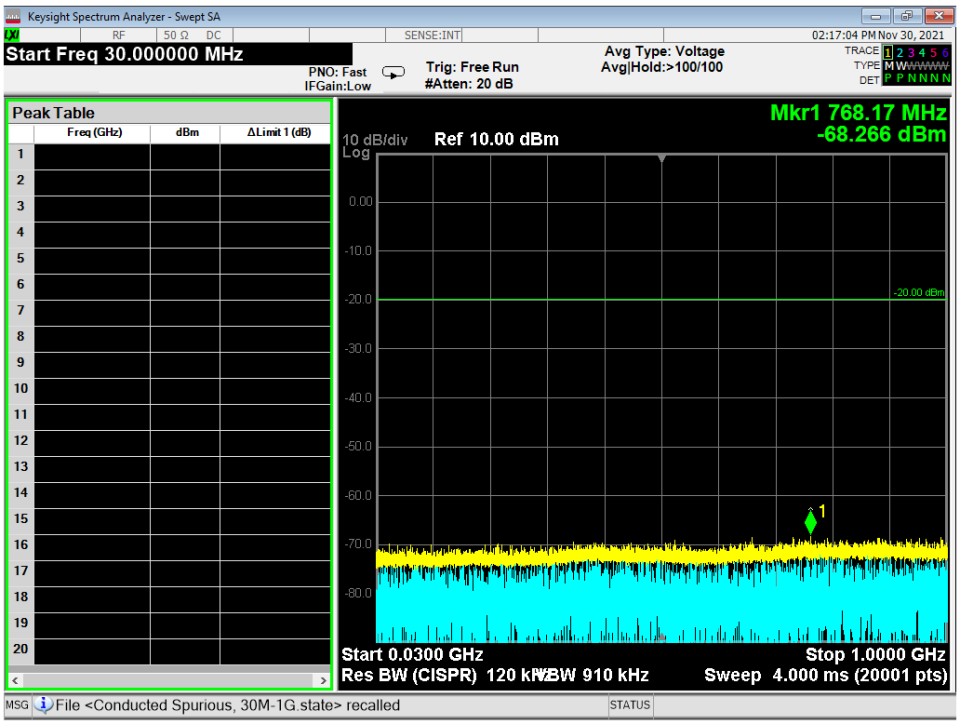


Figure 14 - Radiated Emissions Plot, GMSK 2MB, 30MHz – 1GHz, Low

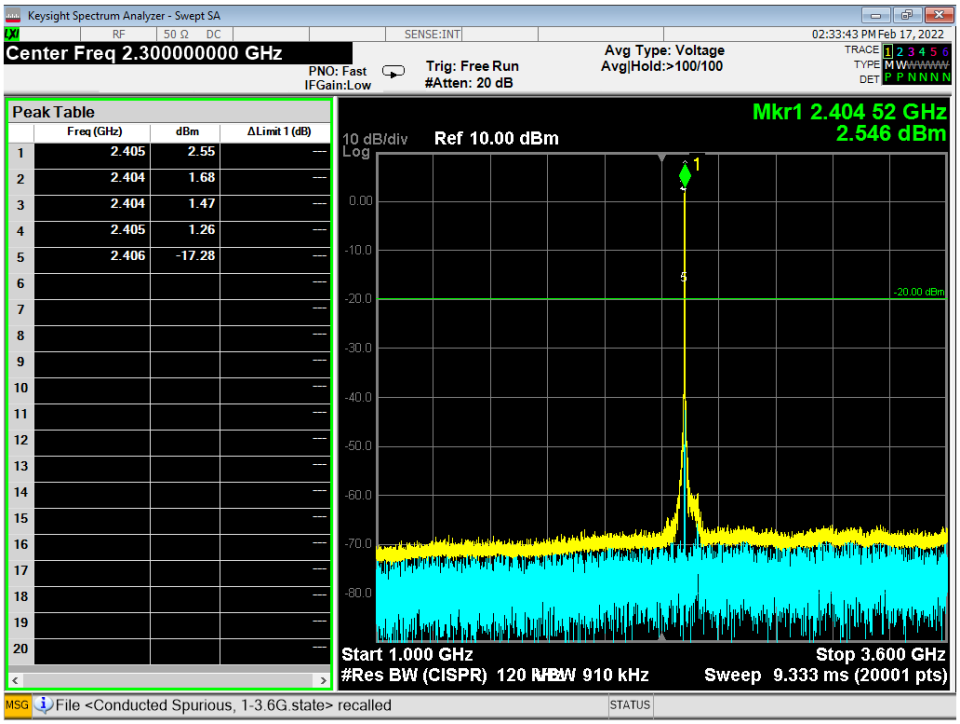


Figure 15 - Radiated Emissions Plot, GMSK 2MB, 1GHz – 3.6GHz, Low

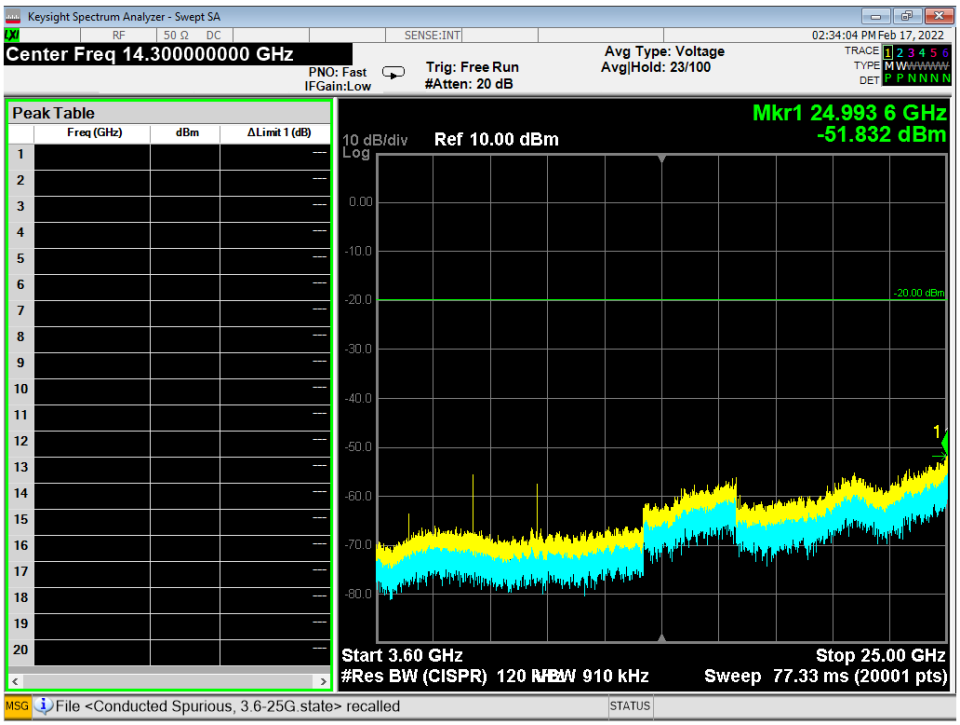


Figure 16 - Radiated Emissions Plot, GMSK 2MB, 3.6GHz – 25GHz, Low

4.6 BAND EDGES

Test Method: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

Limits of band-edge measurements:
For FCC Part 15.247 Device:
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 procedures:

The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

Deviations from test standard:
No deviation.

Test setup:
Test setup details can be found in section 3.4 of this report.

EUT operating conditions:
Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:

1. All the band edge plots can be found in the Appendix C.
2. If the device falls under FCC Part 15.247 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 20 dB between peak and the band edge.
3. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209.
4. Tabulated data is listed in section 4.0.

4.7 POWER SPECTRAL DENSITY

Test Method: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

Limits of power measurements:

For FCC Part 15.247 Device:
The maximum PSD allowed is 8 dBm.

Test procedures:
Details can be found in section 3.4 of this report.

Deviations from test standard:
No deviation.

Test setup:
Details can be found in section 3.4 of this report.

EUT operating conditions:
Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:

1. All the Power Spectral Density (PSD) plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. Tabulated data is listed in section 4.0.

4.8 CONDUCTED AC MAINS EMISSIONS

Test Method: ANSI C63.10-2013, Section(s) 6.2

Limits for conducted emissions measurements:

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

Notes:
1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

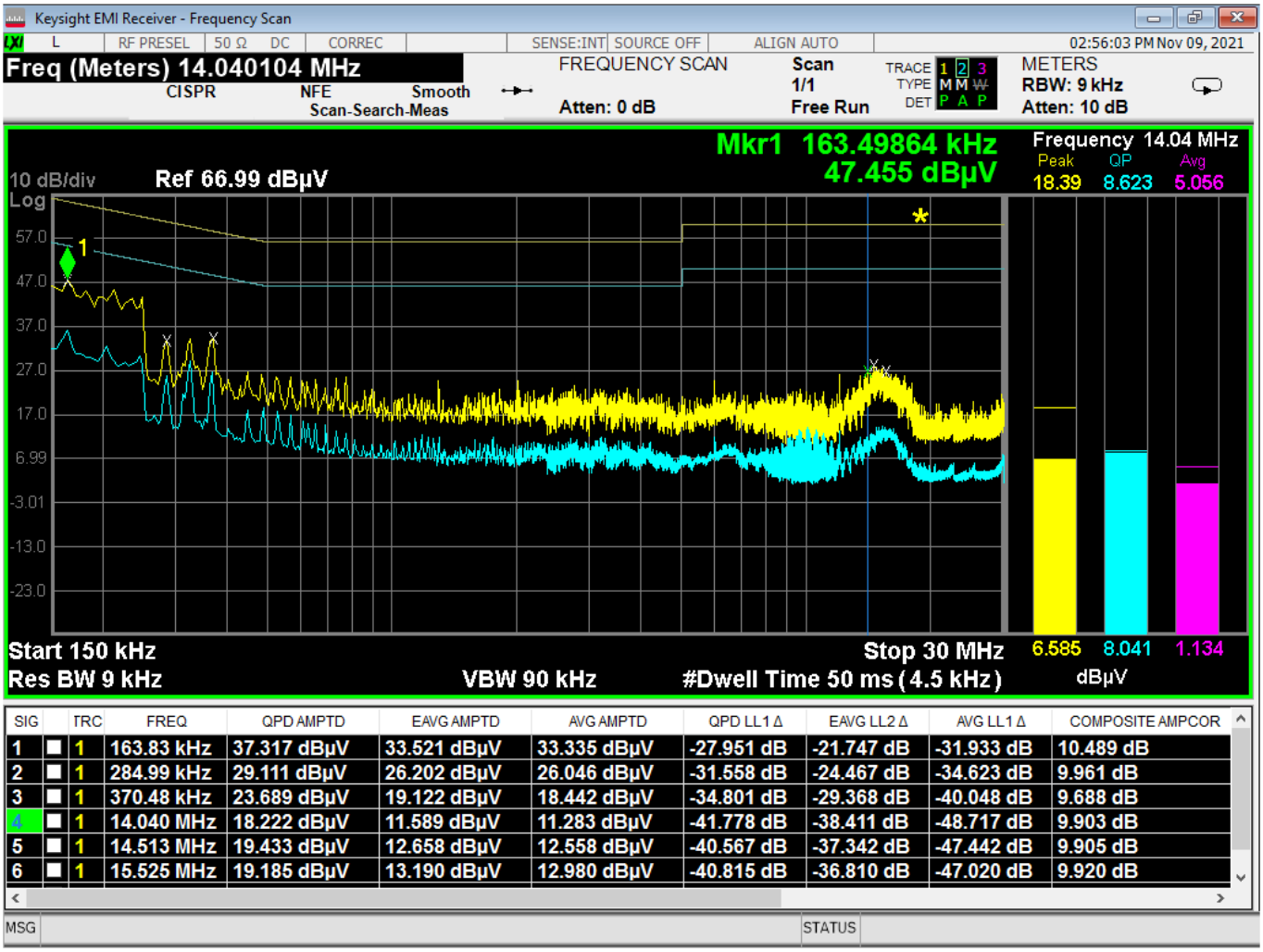
Test Procedures:

a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
d. Results were compared to the 15.207 limits.

Deviation from the test standard:
No deviation

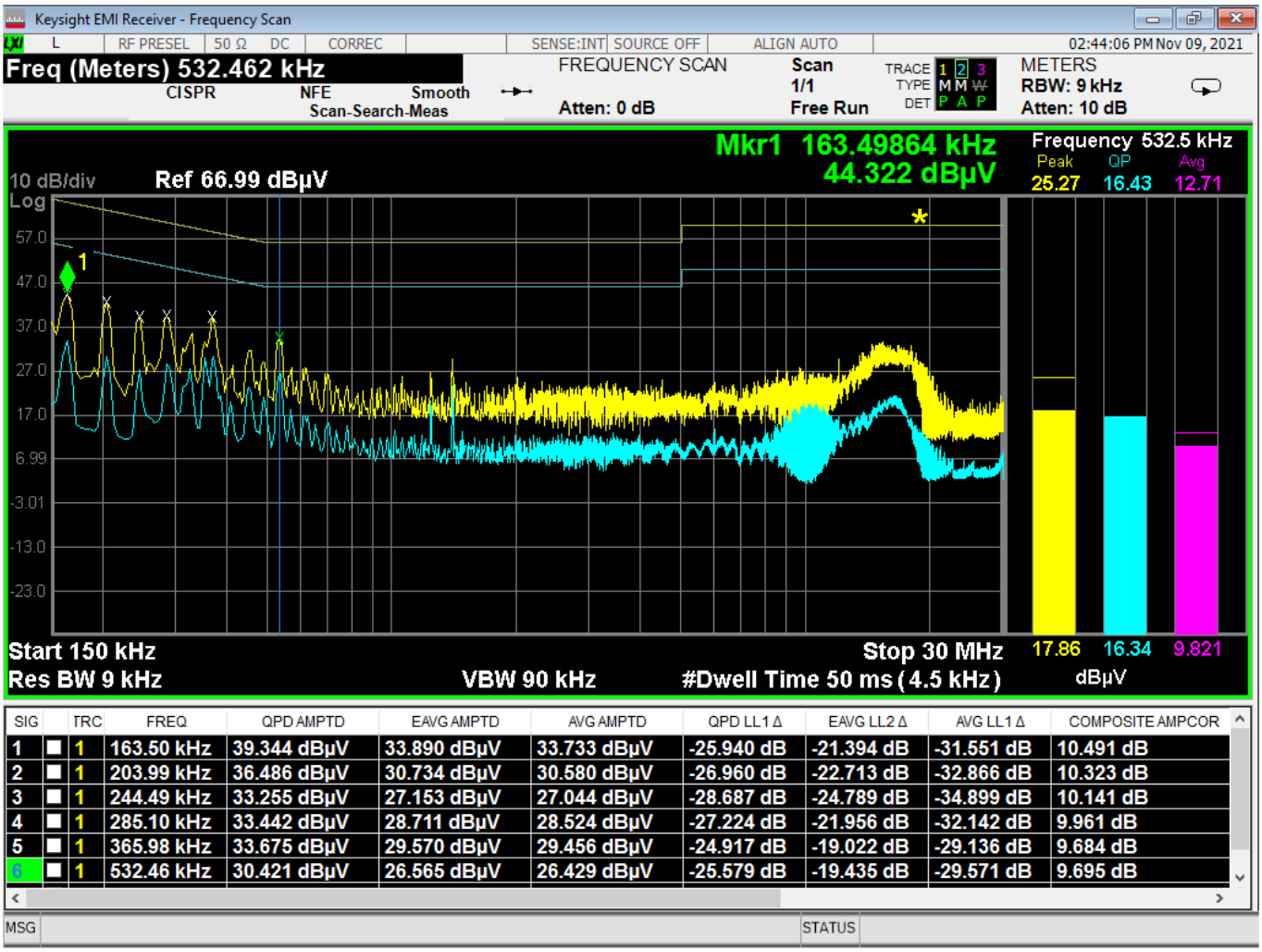
EUT operating conditions:
Details can be found in section 2.1 of this report.

Test Results:



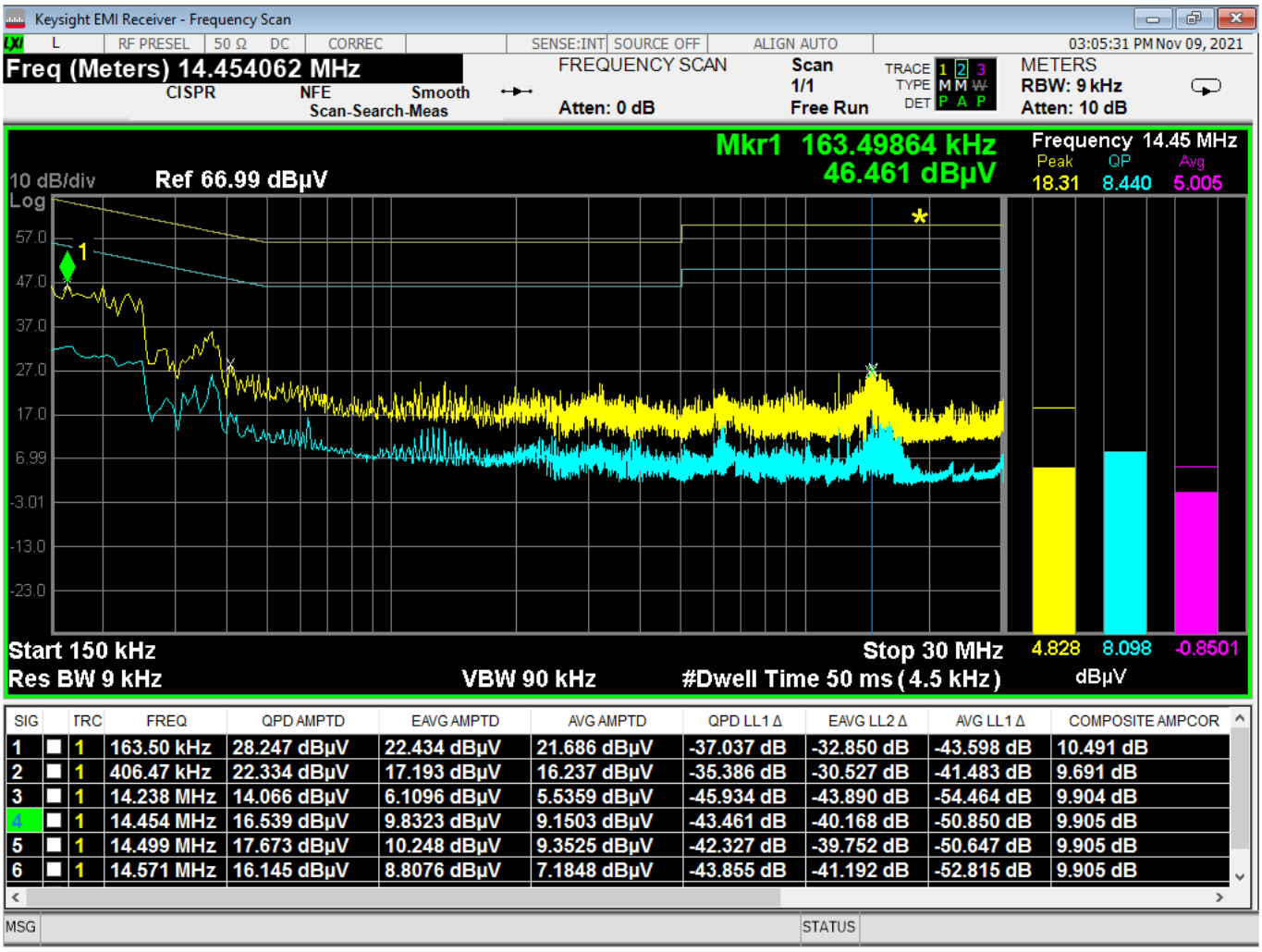
SIG		TRC	FREQ	QPD AMPTD	EAVG AMPTD	AVG AMPTD	QPD LL1 Δ	EAVG LL2 Δ	AVG LL1 Δ	COMPOSITE AMPCOR
1	■	1	163.83 kHz	37.317 dBµV	33.521 dBµV	33.335 dBµV	-27.951 dB	-21.747 dB	-31.933 dB	10.489 dB
2	■	1	284.99 kHz	29.111 dBµV	26.202 dBµV	26.046 dBµV	-31.558 dB	-24.467 dB	-34.623 dB	9.961 dB
3	■	1	370.48 kHz	23.689 dBµV	19.122 dBµV	18.442 dBµV	-34.801 dB	-29.368 dB	-40.048 dB	9.688 dB
4	■	1	14.040 MHz	18.222 dBµV	11.589 dBµV	11.283 dBµV	-41.778 dB	-38.411 dB	-48.717 dB	9.903 dB
5	■	1	14.513 MHz	19.433 dBµV	12.658 dBµV	12.558 dBµV	-40.567 dB	-37.342 dB	-47.442 dB	9.905 dB
6	■	1	15.525 MHz	19.185 dBµV	13.190 dBµV	12.980 dBµV	-40.815 dB	-36.810 dB	-47.020 dB	9.920 dB

Figure 17 - Conducted Emissions Plot, Line, TX



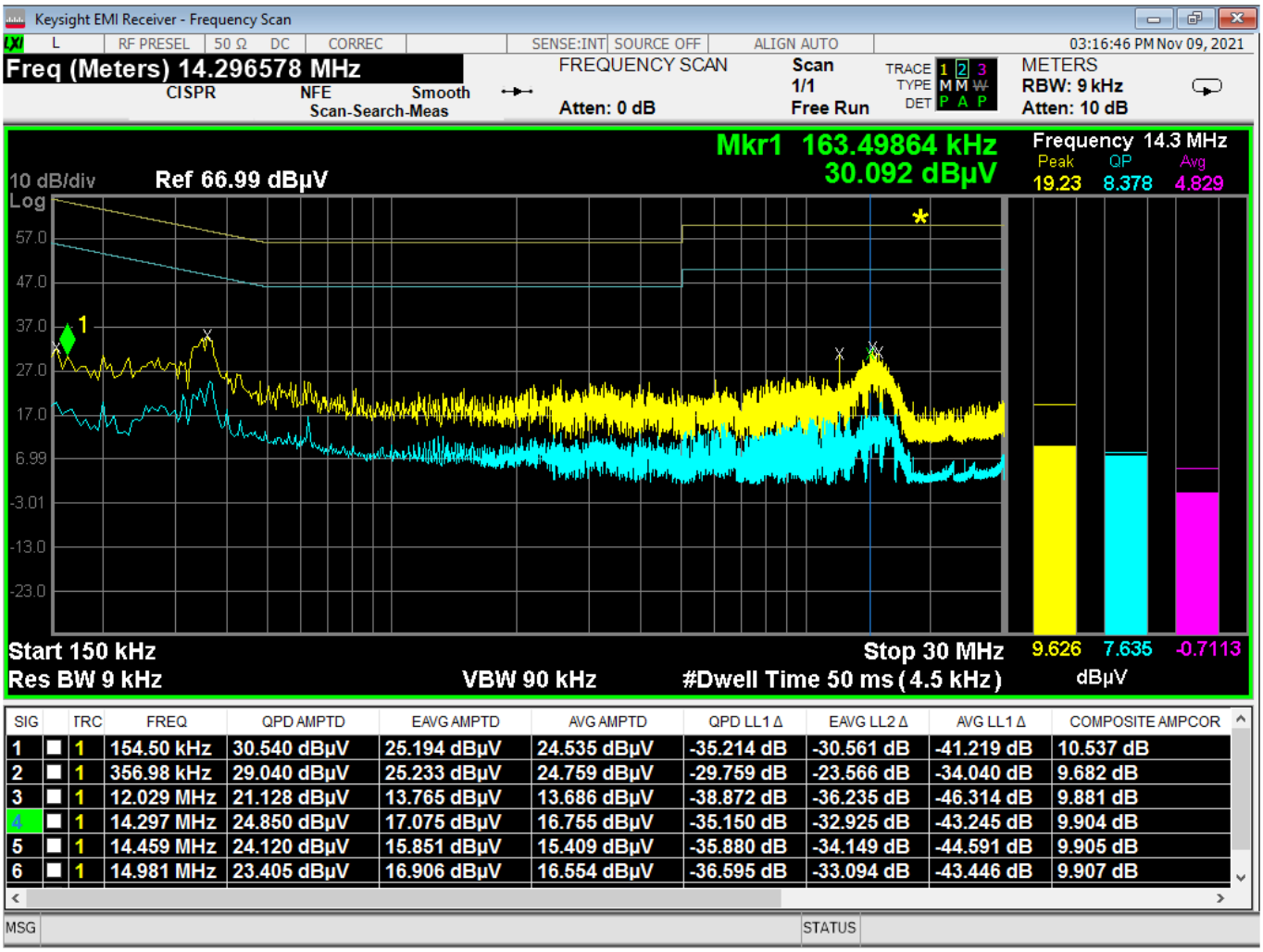
SIG	TRC	FREQ	QPD AMPTD	EAVG AMPTD	AVG AMPTD	QPD LL1 Δ	EAVG LL2 Δ	AVG LL1 Δ	COMPOSITE AMPCOR
1	1	163.50 kHz	39.344 dBµV	33.890 dBµV	33.733 dBµV	-25.940 dB	-21.394 dB	-31.551 dB	10.491 dB
2	1	203.99 kHz	36.486 dBµV	30.734 dBµV	30.580 dBµV	-26.960 dB	-22.713 dB	-32.866 dB	10.323 dB
3	1	244.49 kHz	33.255 dBµV	27.153 dBµV	27.044 dBµV	-28.687 dB	-24.789 dB	-34.899 dB	10.141 dB
4	1	285.10 kHz	33.442 dBµV	28.711 dBµV	28.524 dBµV	-27.224 dB	-21.956 dB	-32.142 dB	9.961 dB
5	1	365.98 kHz	33.675 dBµV	29.570 dBµV	29.456 dBµV	-24.917 dB	-19.022 dB	-29.136 dB	9.684 dB
6	1	532.46 kHz	30.421 dBµV	26.565 dBµV	26.429 dBµV	-25.579 dB	-19.435 dB	-29.571 dB	9.695 dB

Figure 18 - Conducted Emissions Plot, Neutral, TX



SIG	TRC	FREQ	QPD AMPTD	EAVG AMPTD	AVG AMPTD	QPD LL1 Δ	EAVG LL2 Δ	AVG LL1 Δ	COMPOSITE AMPCOR
1	1	163.50 kHz	28.247 dBµV	22.434 dBµV	21.686 dBµV	-37.037 dB	-32.850 dB	-43.598 dB	10.491 dB
2	1	406.47 kHz	22.334 dBµV	17.193 dBµV	16.237 dBµV	-35.386 dB	-30.527 dB	-41.483 dB	9.691 dB
3	1	14.238 MHz	14.066 dBµV	6.1096 dBµV	5.5359 dBµV	-45.934 dB	-43.890 dB	-54.464 dB	9.904 dB
4	1	14.454 MHz	16.539 dBµV	9.8323 dBµV	9.1503 dBµV	-43.461 dB	-40.168 dB	-50.850 dB	9.905 dB
5	1	14.499 MHz	17.673 dBµV	10.248 dBµV	9.3525 dBµV	-42.327 dB	-39.752 dB	-50.647 dB	9.905 dB
6	1	14.571 MHz	16.145 dBµV	8.8076 dBµV	7.1848 dBµV	-43.855 dB	-41.192 dB	-52.815 dB	9.905 dB

Figure 19 - Conducted Emissions Plot, Line, IDLE



SIG	TRC	FREQ	QPD AMPTD	EAVG AMPTD	AVG AMPTD	QPD LL1 Δ	EAVG LL2 Δ	AVG LL1 Δ	COMPOSITE AMPCOR
1	1	154.50 kHz	30.540 dBµV	25.194 dBµV	24.535 dBµV	-35.214 dB	-30.561 dB	-41.219 dB	10.537 dB
2	1	356.98 kHz	29.040 dBµV	25.233 dBµV	24.759 dBµV	-29.759 dB	-23.566 dB	-34.040 dB	9.682 dB
3	1	12.029 MHz	21.128 dBµV	13.765 dBµV	13.686 dBµV	-38.872 dB	-36.235 dB	-46.314 dB	9.881 dB
4	1	14.297 MHz	24.850 dBµV	17.075 dBµV	16.755 dBµV	-35.150 dB	-32.925 dB	-43.245 dB	9.904 dB
5	1	14.459 MHz	24.120 dBµV	15.851 dBµV	15.409 dBµV	-35.880 dB	-34.149 dB	-44.591 dB	9.905 dB
6	1	14.981 MHz	23.405 dBµV	16.906 dBµV	16.554 dBµV	-36.595 dB	-33.094 dB	-43.446 dB	9.907 dB

Figure 20 - Conducted Emissions Plot, Neutral, IDLE

APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:
FS = RA + AF – (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

AV is calculated by the taking the 20*log(T_{on}/100) where T_{on} is the maximum transmission time in any 100ms window.

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]^2 / 30

Power (watts) = 10^[Power (dBm)/10] / 1000

Voltage (dBµV) = Power (dBm) + 107 (for 50Ω measurement systems)

Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator)

Conversion from 3m field strength to EIRP (d=3):

EIRP = [FS(V/m) x d^2]/30 = FS [0.3] for d = 3

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = FS(dBµV/m) - 95.23

10log(10^9) is the conversion from micro to milli

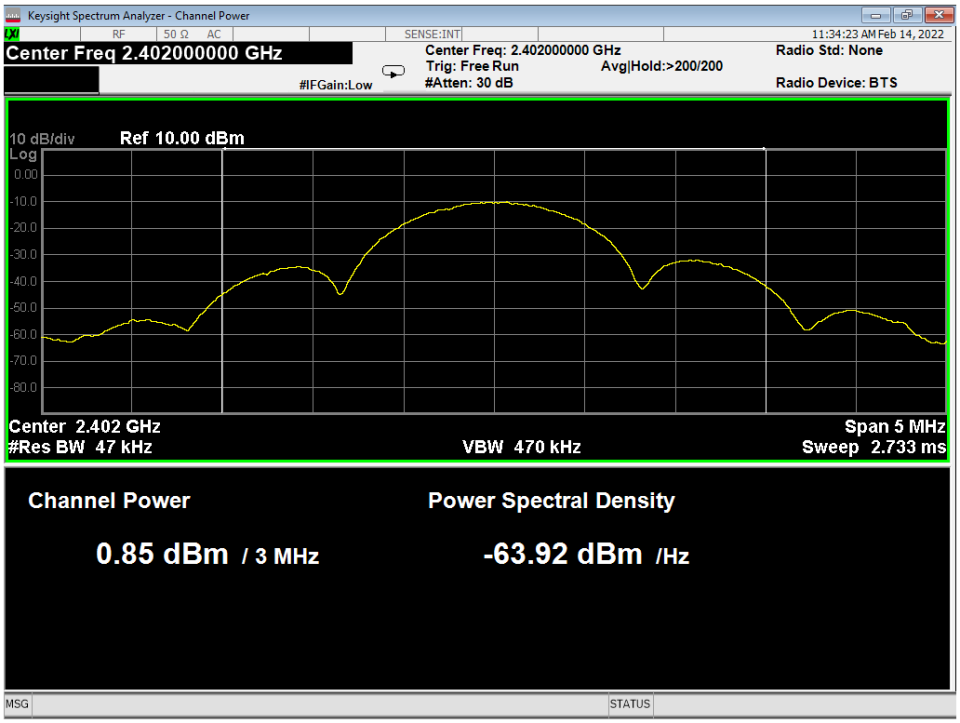
APPENDIX B – MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

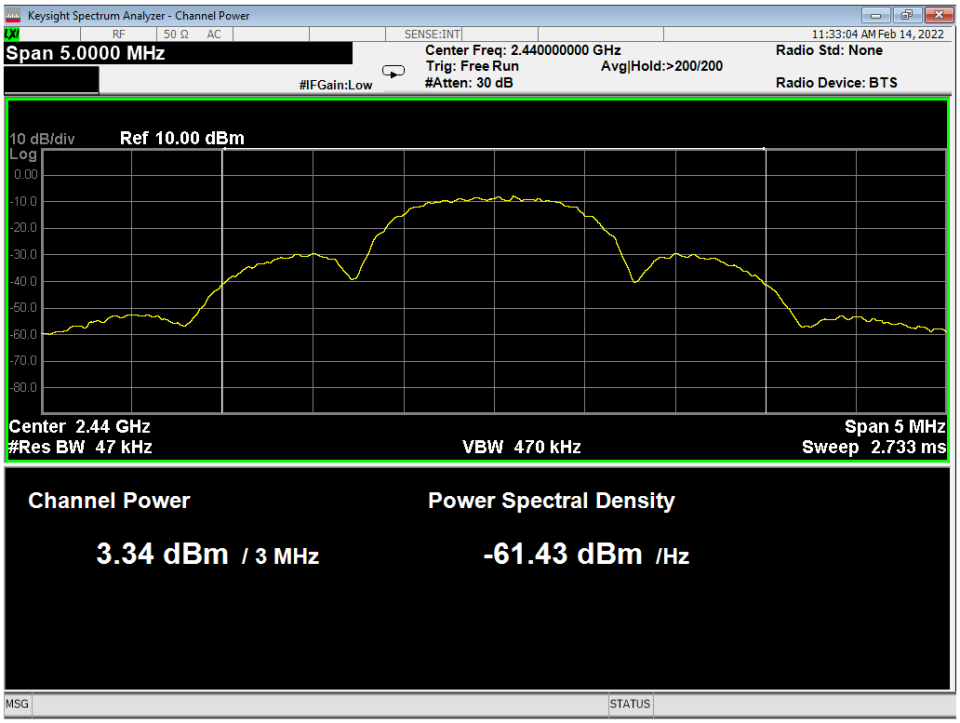
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB

Expanded uncertainty values are calculated to a confidence level of 95%.

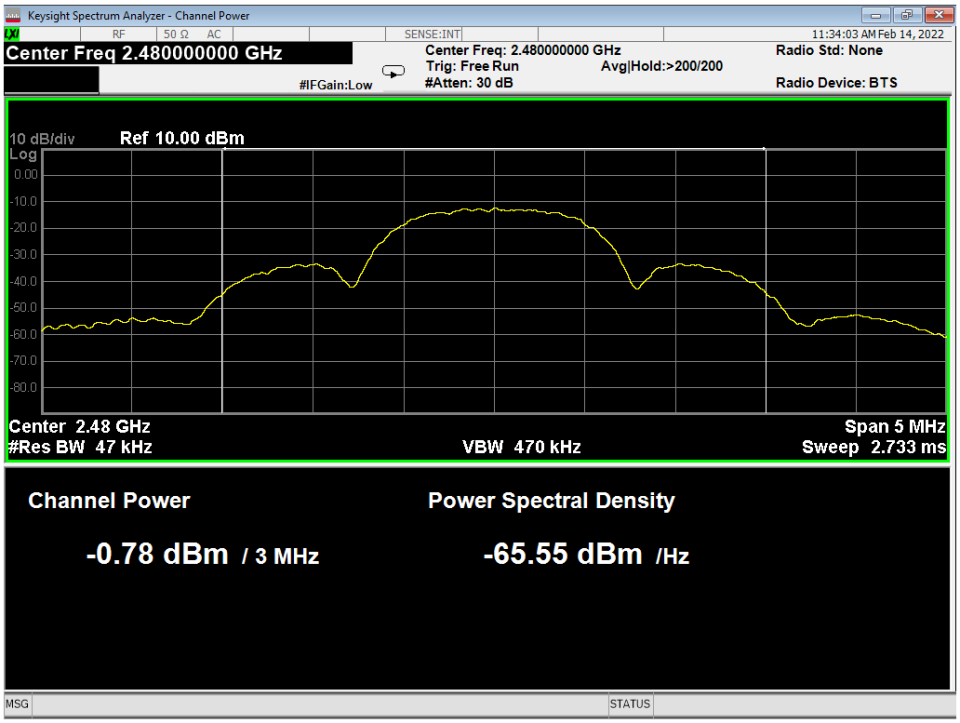
APPENDIX C – GRAPHS AND TABLES



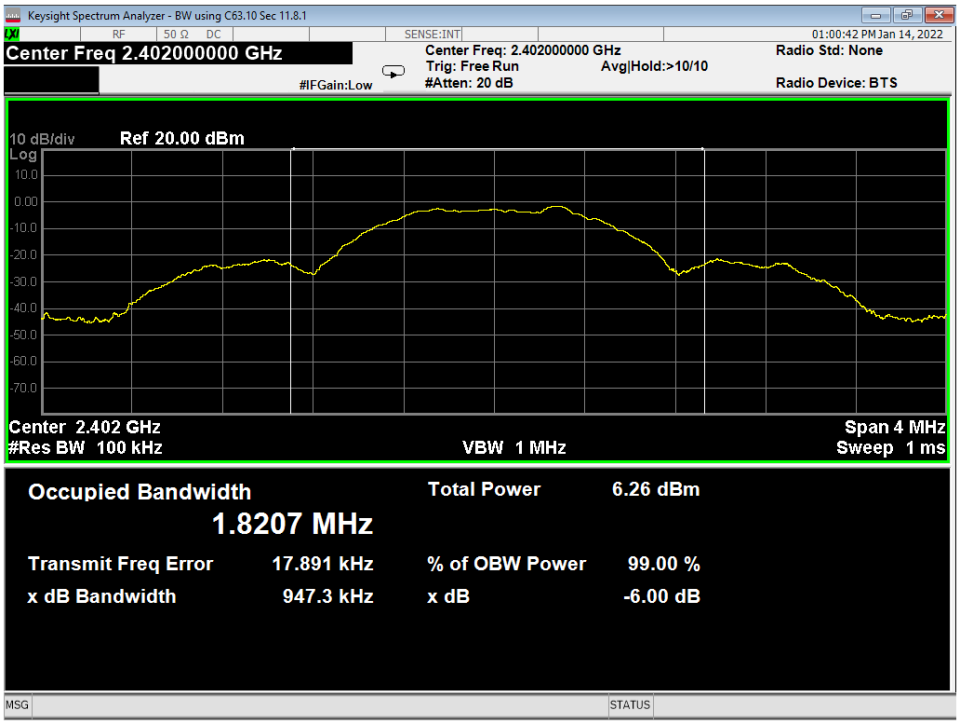
01 Average Power, Low Channel, GFSK



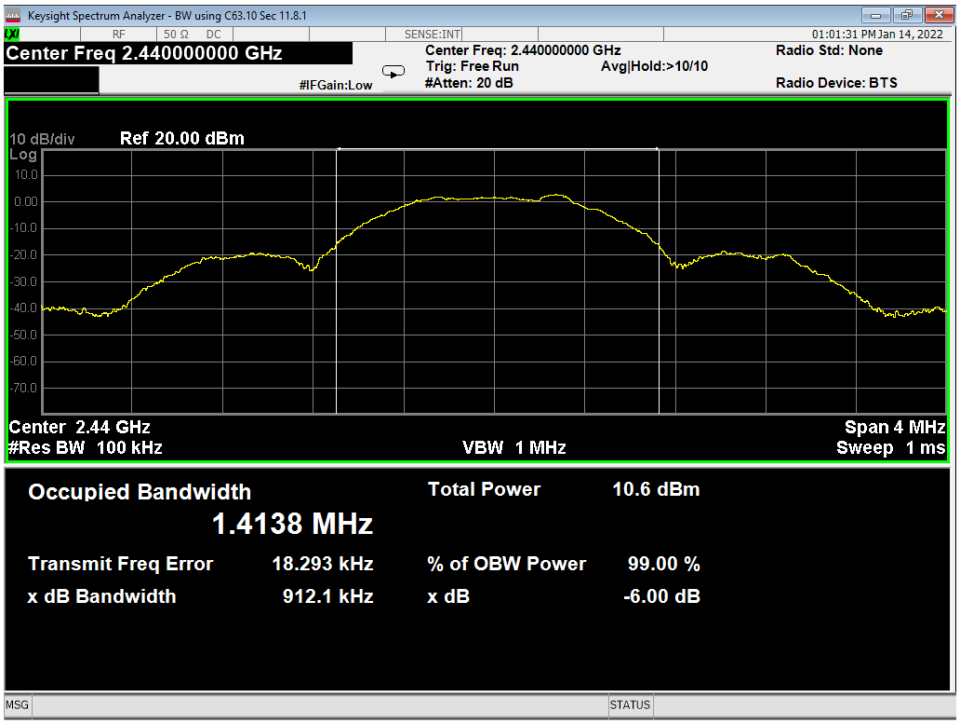
02 Average Power, Mid Channel, GFSK



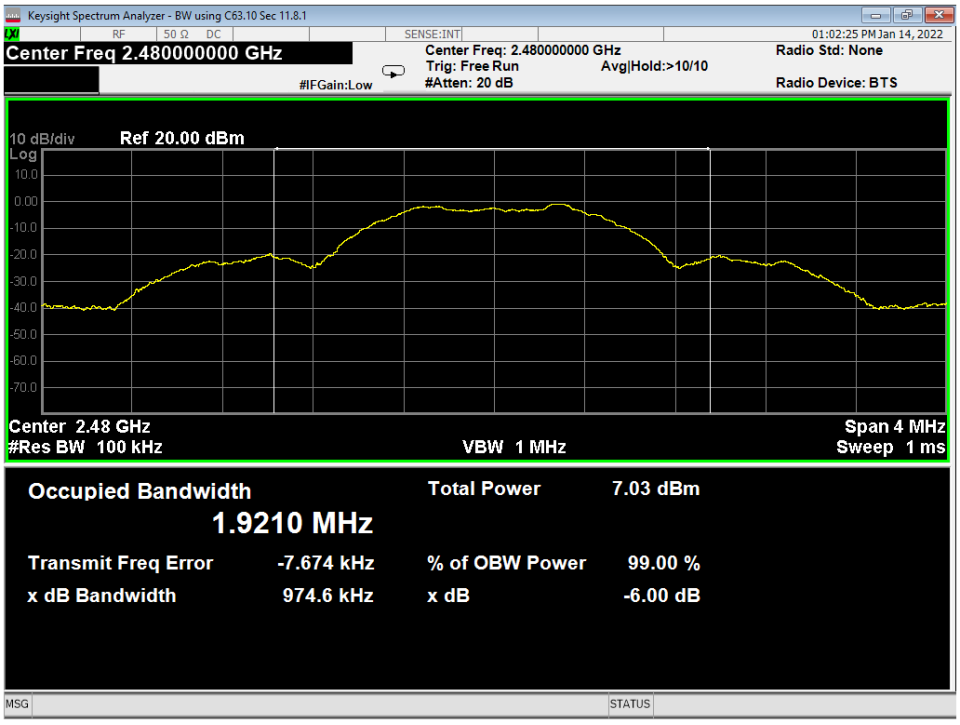
03 Average Power, High Channel, GFSK



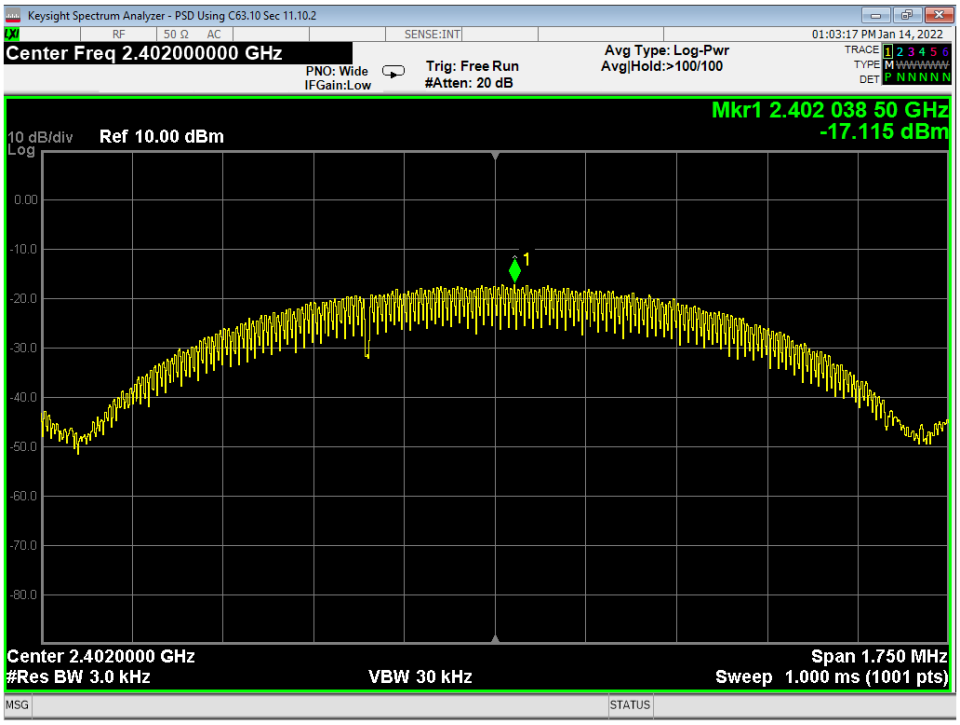
04 OBW-6dB, Low Channel, GFSK



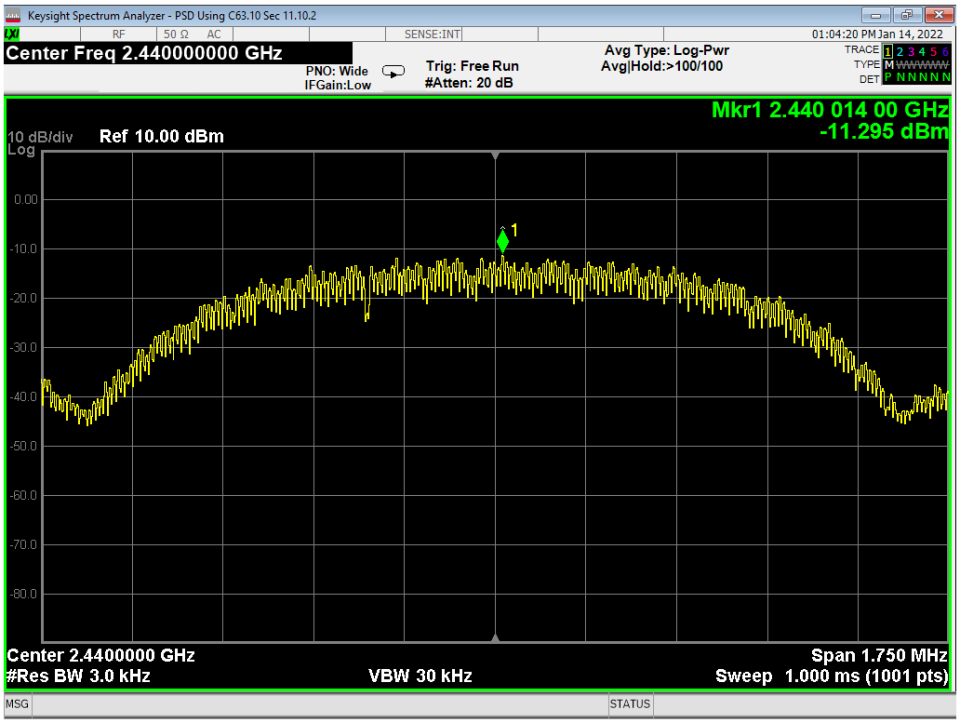
05 OBW-6dB, Mid Channel, GFSK



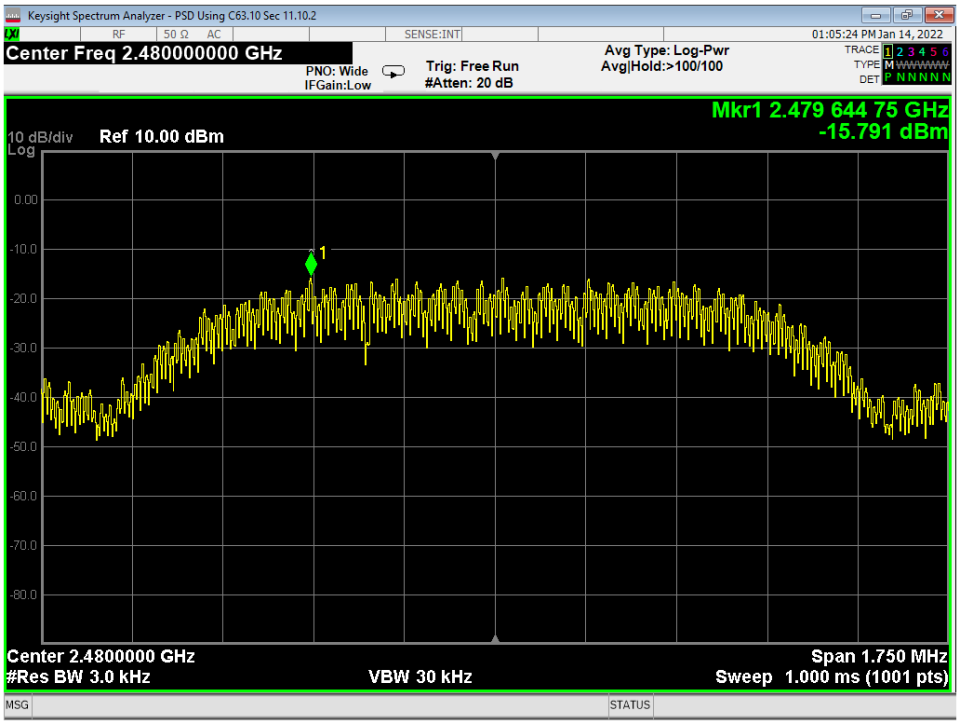
06 OBW-6dB, High Channel, GFSK



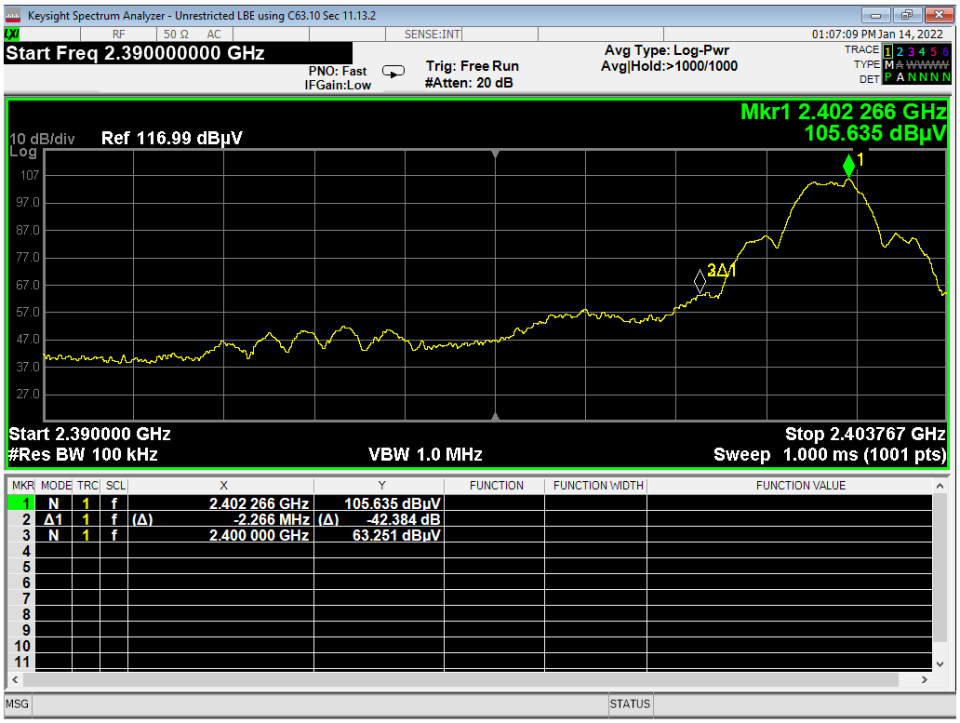
07 PSD, Low Channel, GFSK



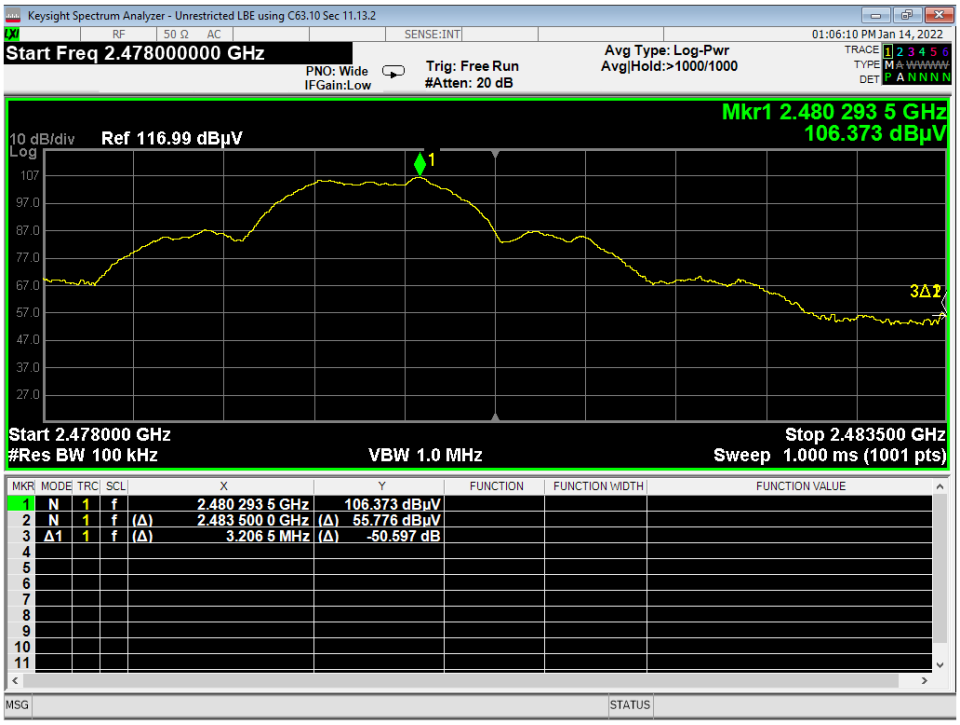
08 PSD, Mid Channel, GFSK



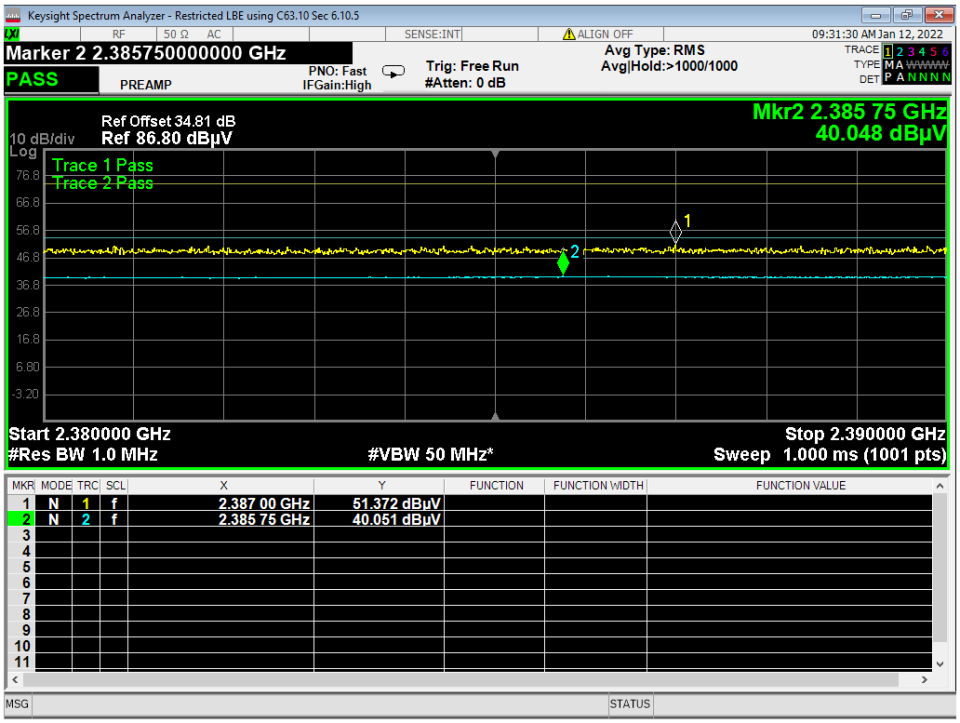
09 PSD, High Channel, GFSK



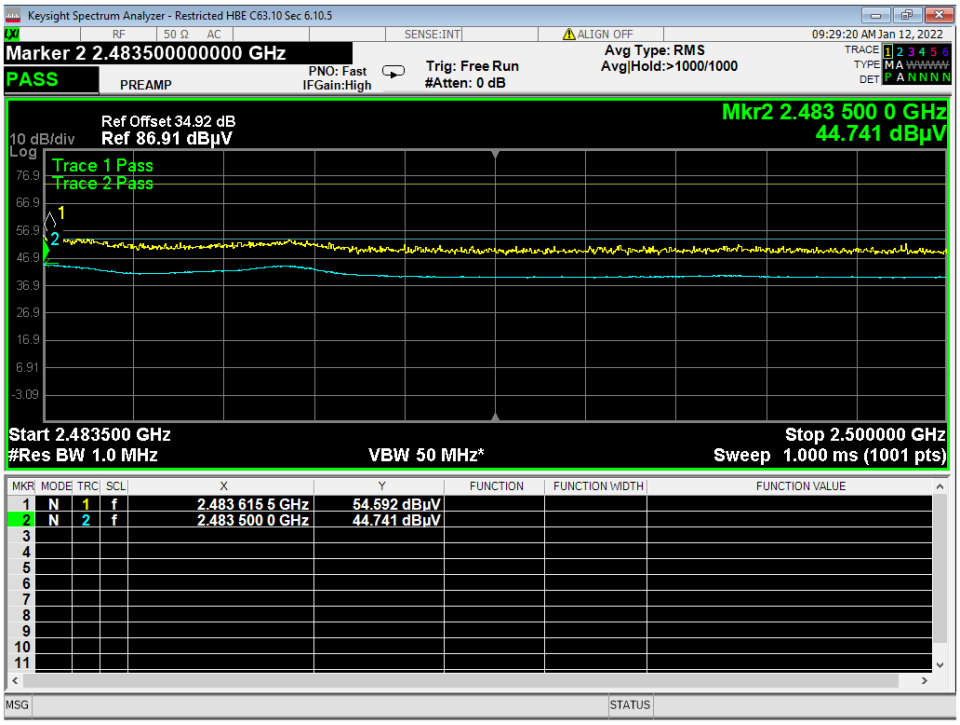
10 Lower Bandedge, Unrestricted, GFSK



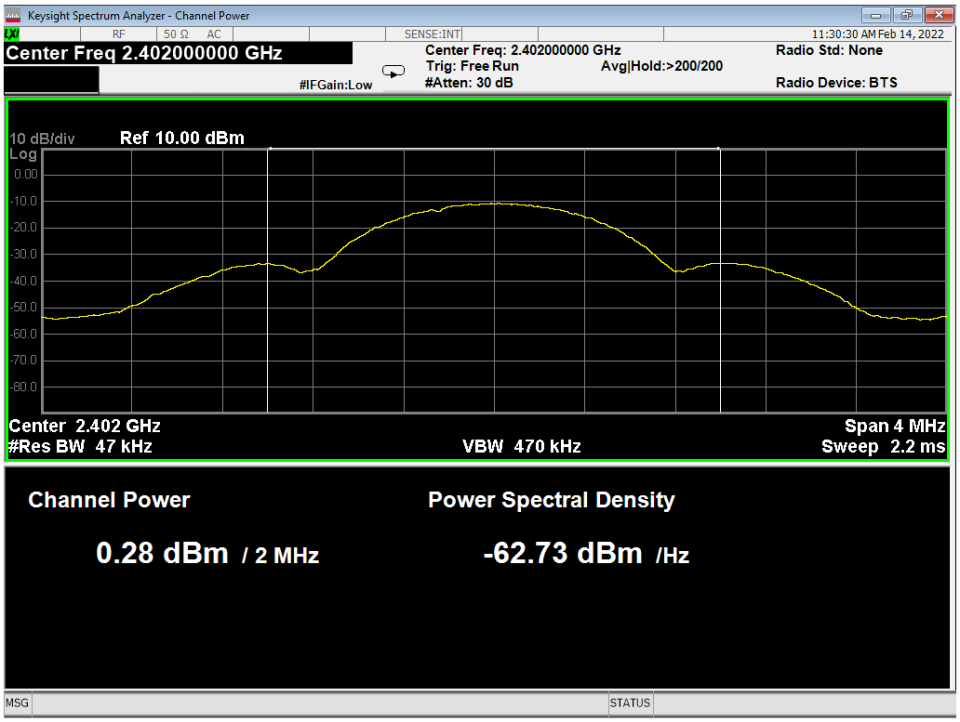
11 Higher Bandedge, Unrestricted, GFSK



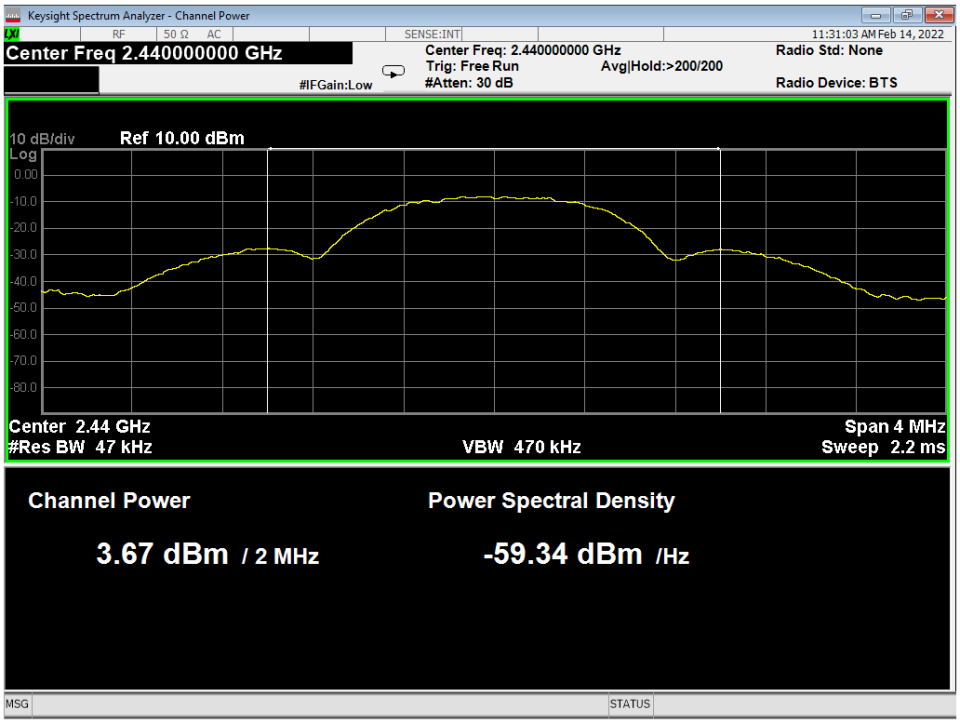
12 Lower Bandedge, Restricted, GFSK



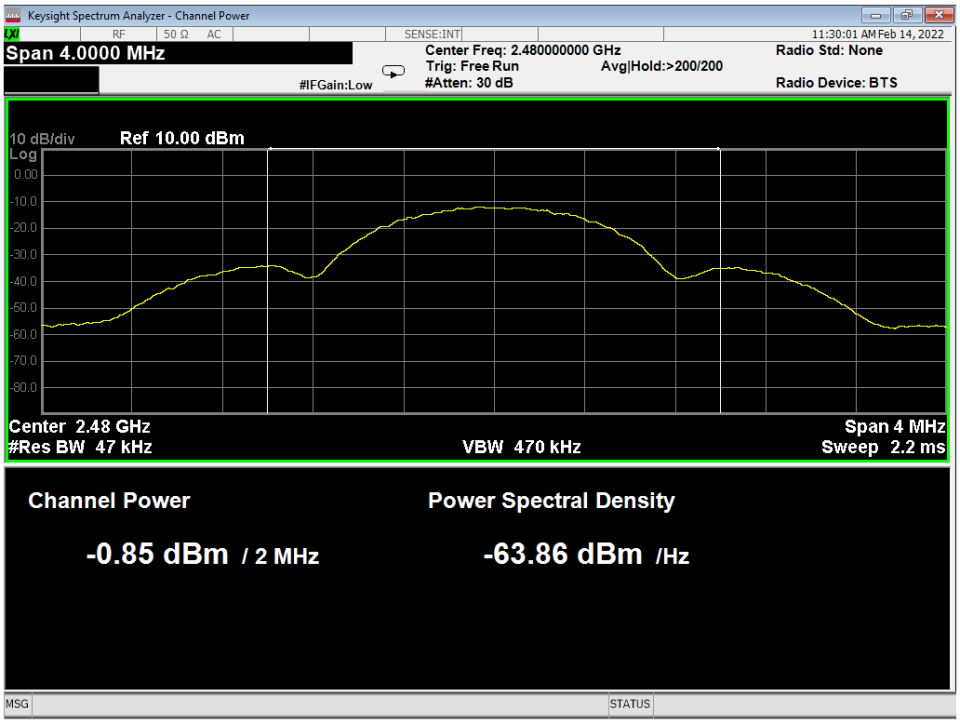
13 Higher Bandedge, Restricted, GFSK



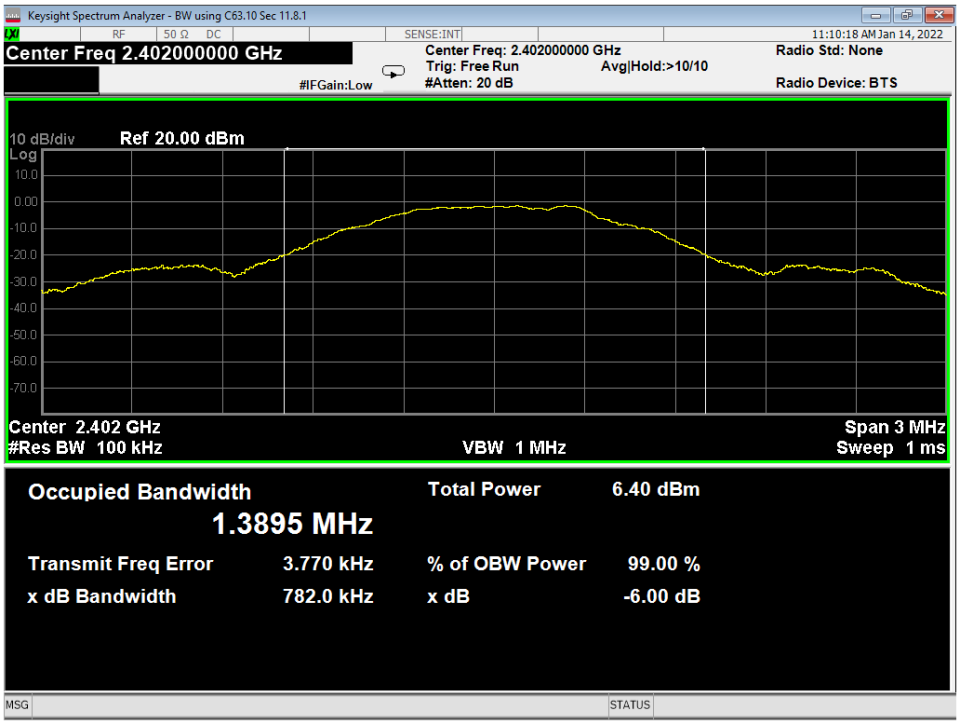
14 Average Power, Low Channel, GMSK 1MB



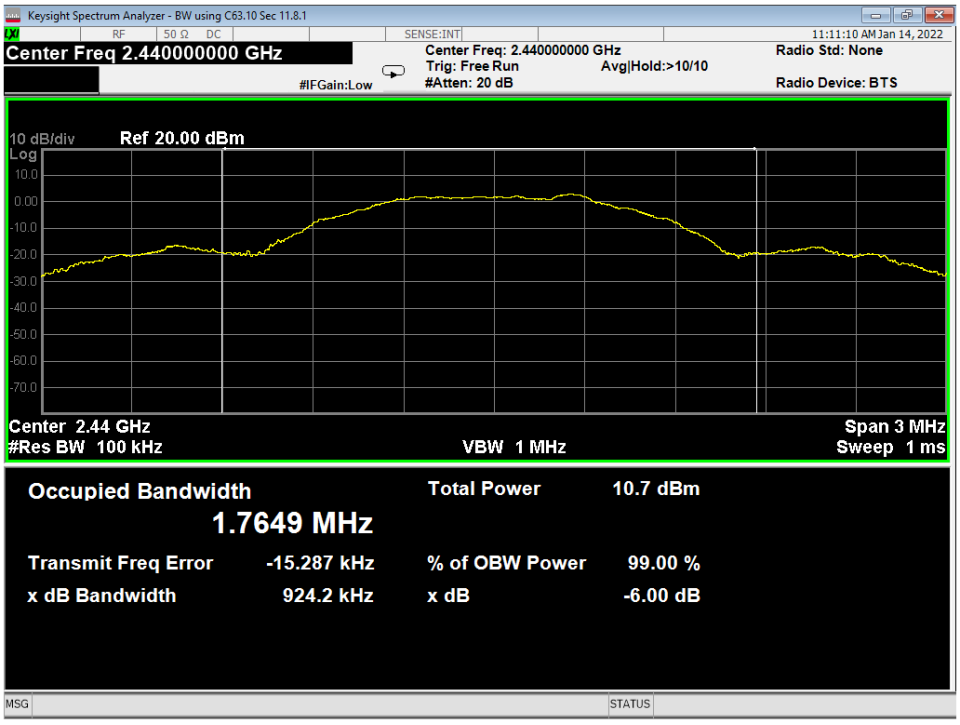
15 Average Power, Mid Channel, GMSK 1MB



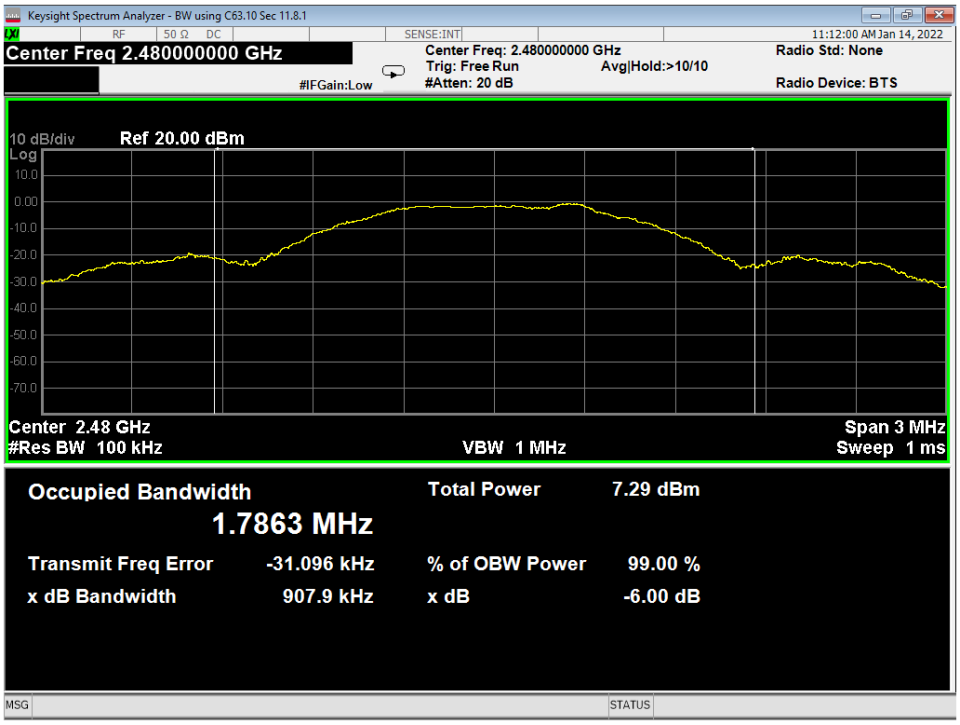
16 Average Power, High Channel, GMSK 1MB



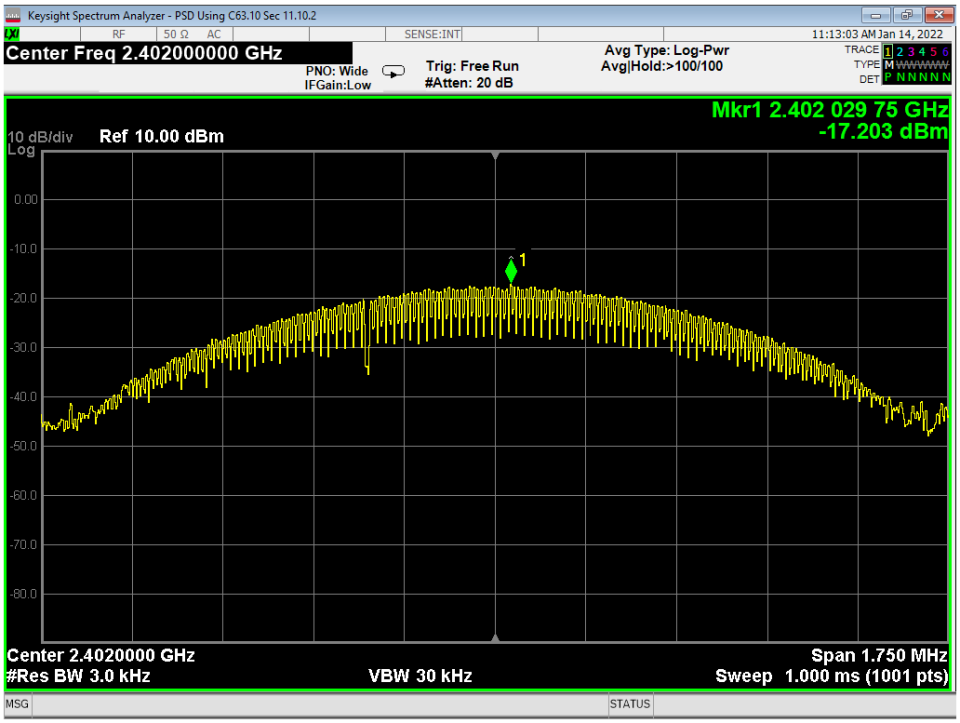
17 Bandwidth, Low Channel, GMSK 1MB



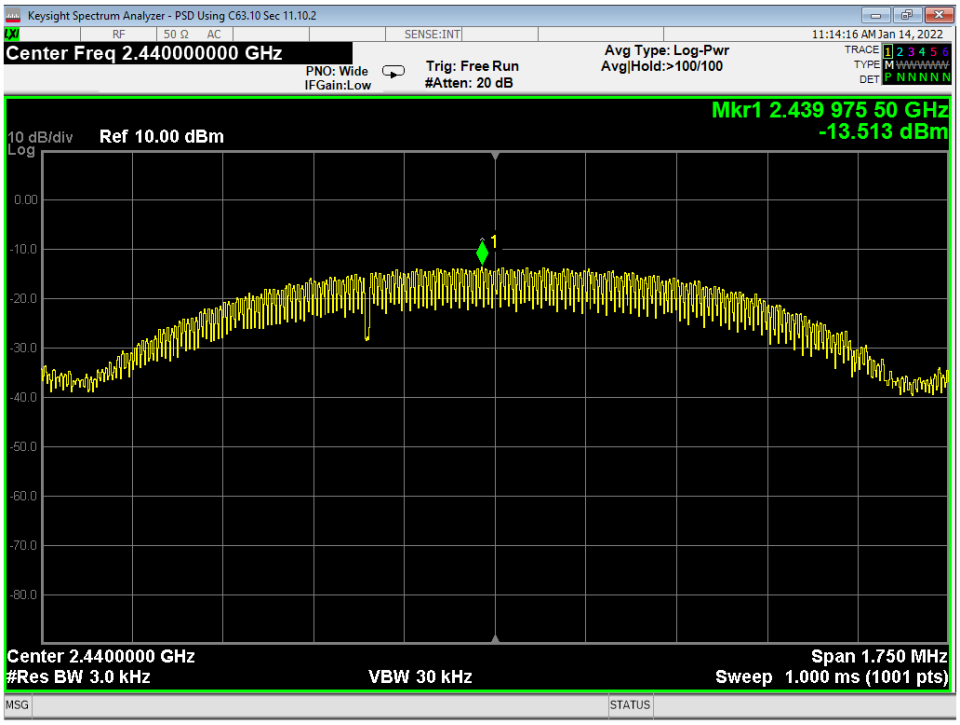
18 Bandwidth, Mid Channel, GMSK 1MB



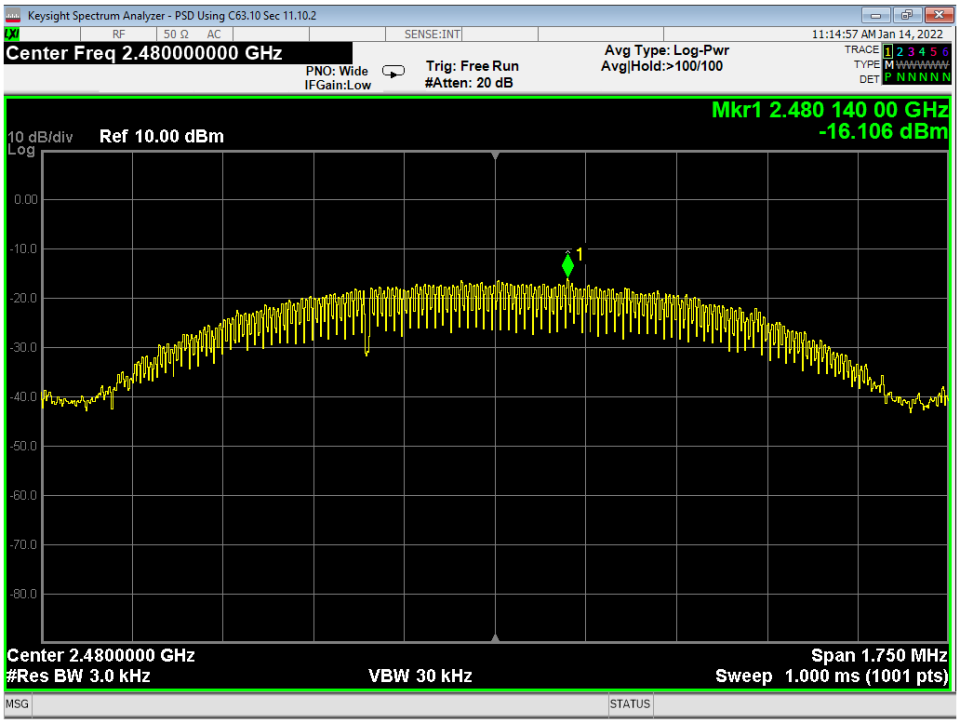
19 Bandwidth, High Channel, GMSK 1MB



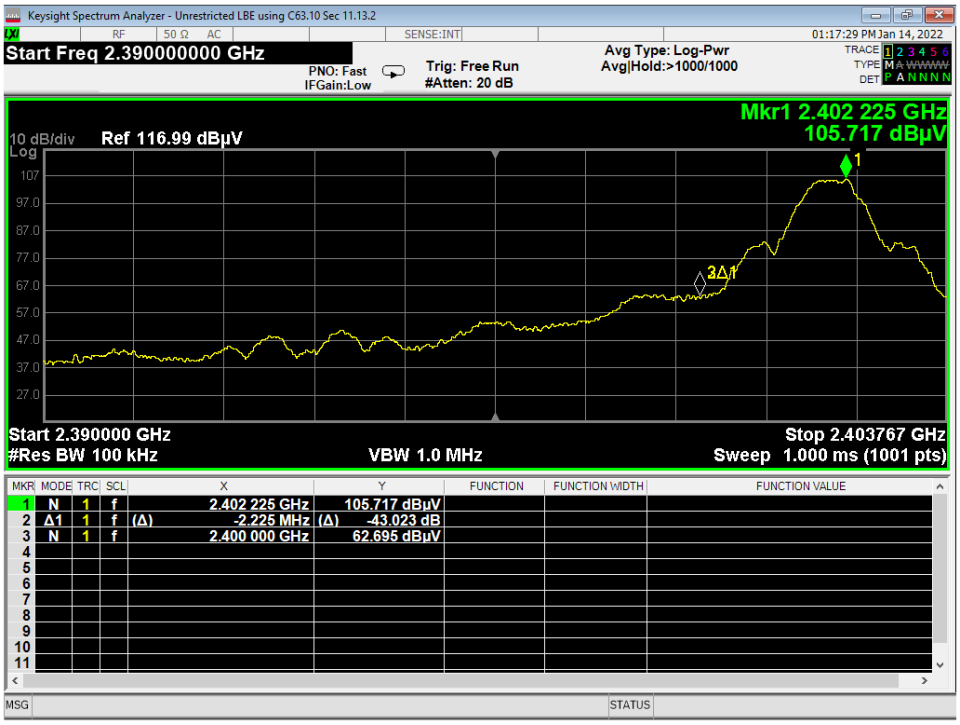
20 PSD, Low Channel, GMSK 1MB



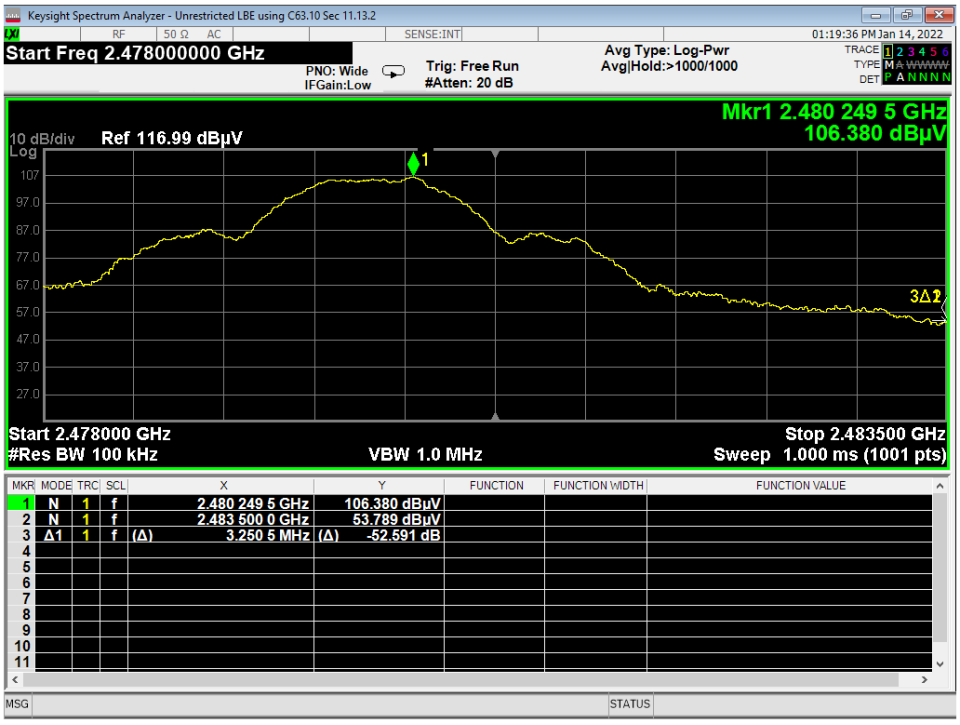
21 PSD, Mid Channel, GMSK 1MB



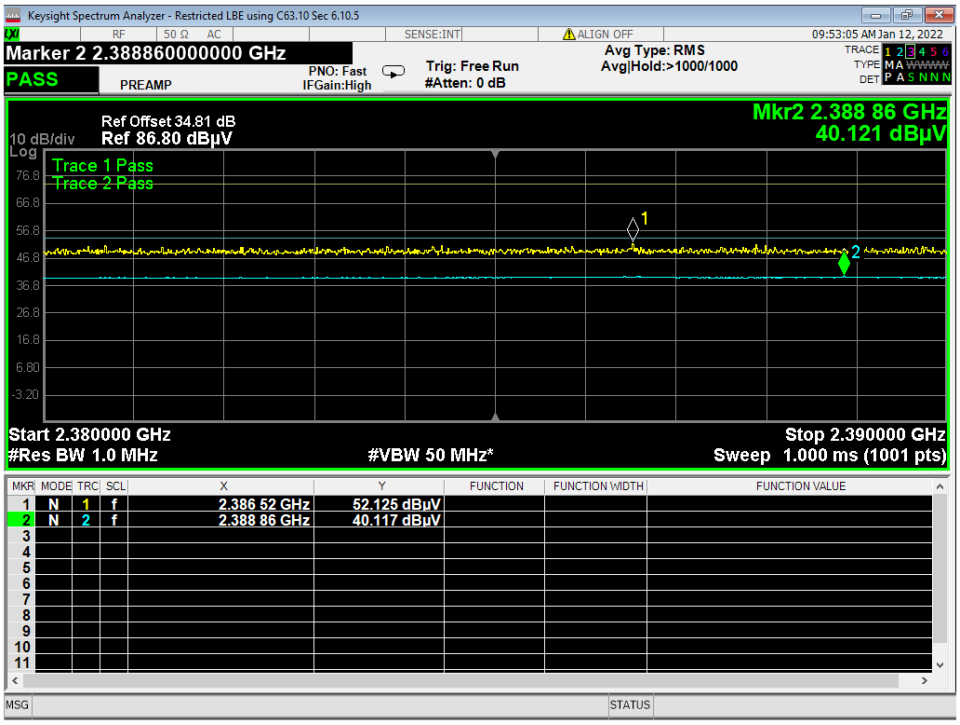
22 PSD, High Channel, GMSK 1MB



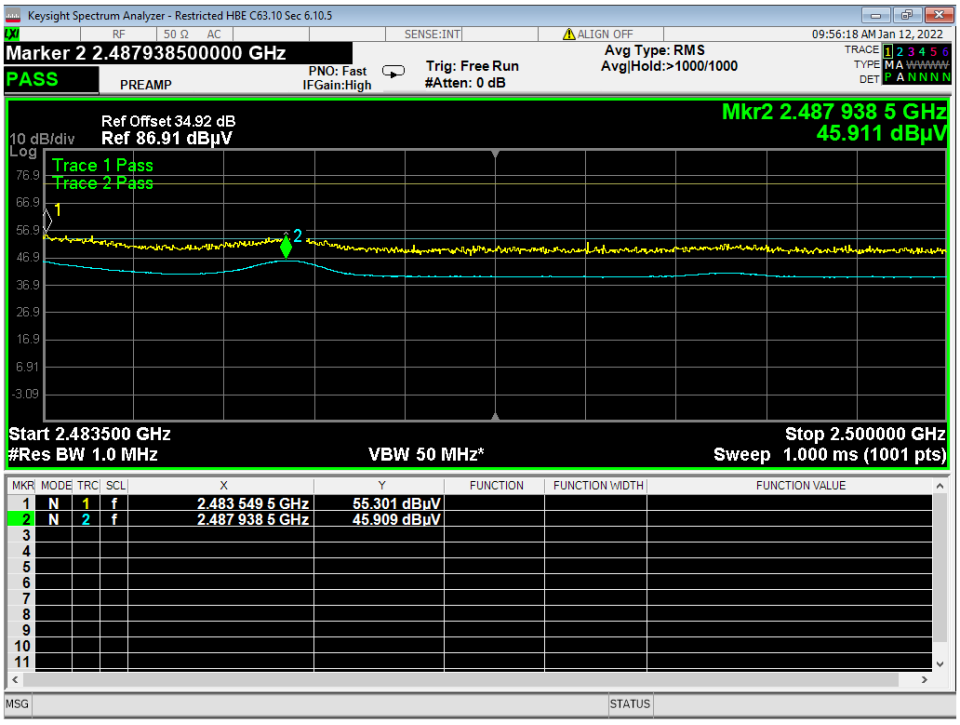
23 LBE, unrestricted GMSK 1MB



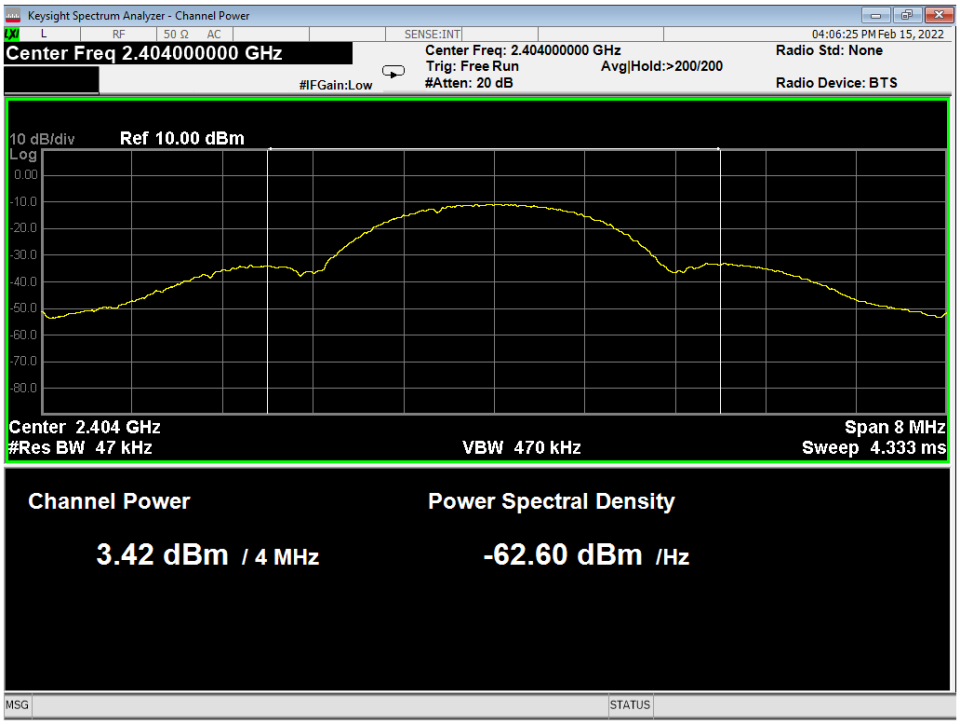
24 HBE, unrestricted GMSK 1MB



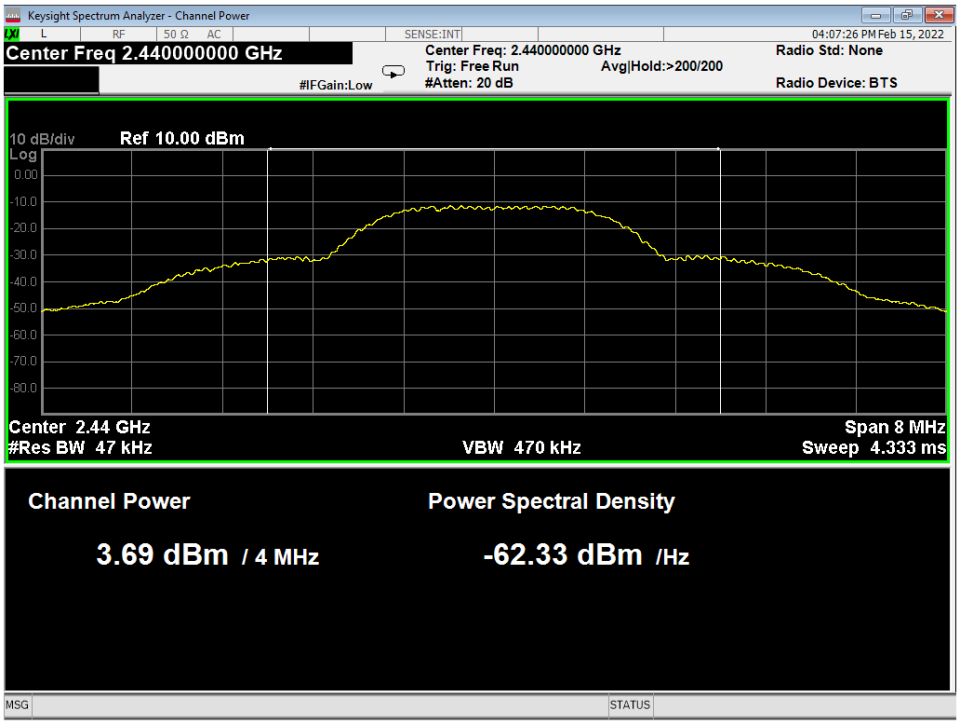
25 LBE, Restricted GMSK 1MB



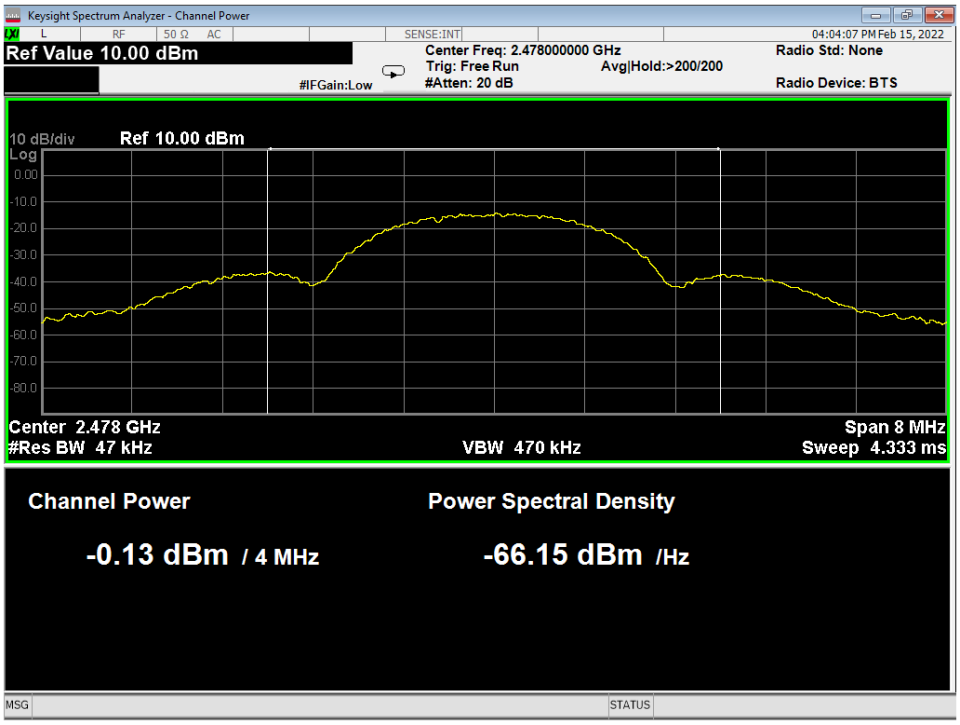
26 HBE, Restricted GMSK 1MB



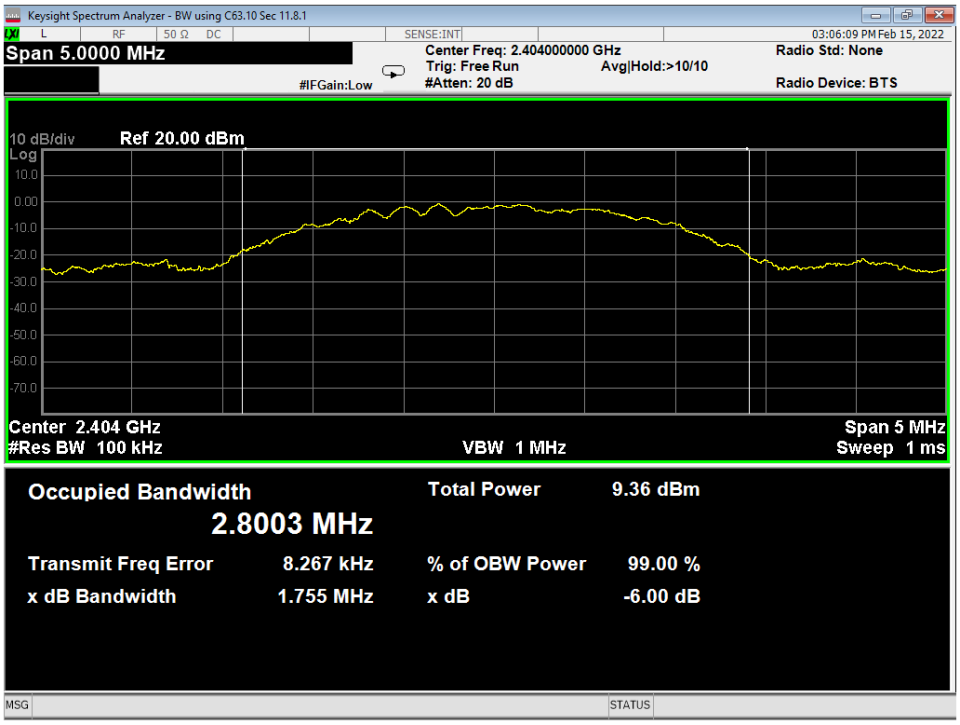
27 Average Power, Low Channel, GMSK 2MB



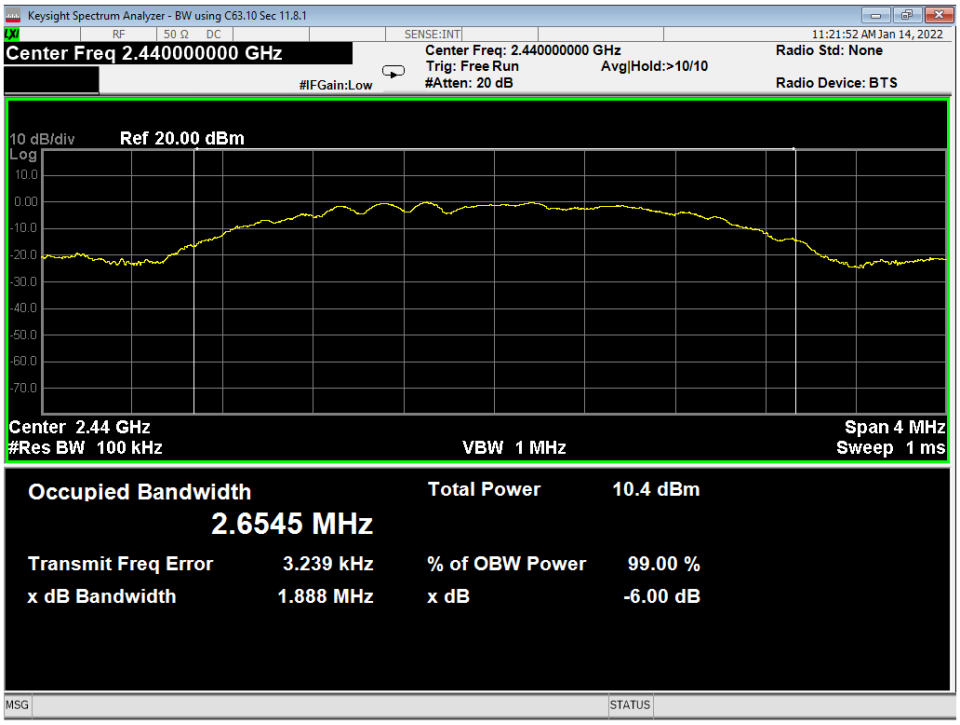
28 Average Power, Mid Channel, GMSK 2MB



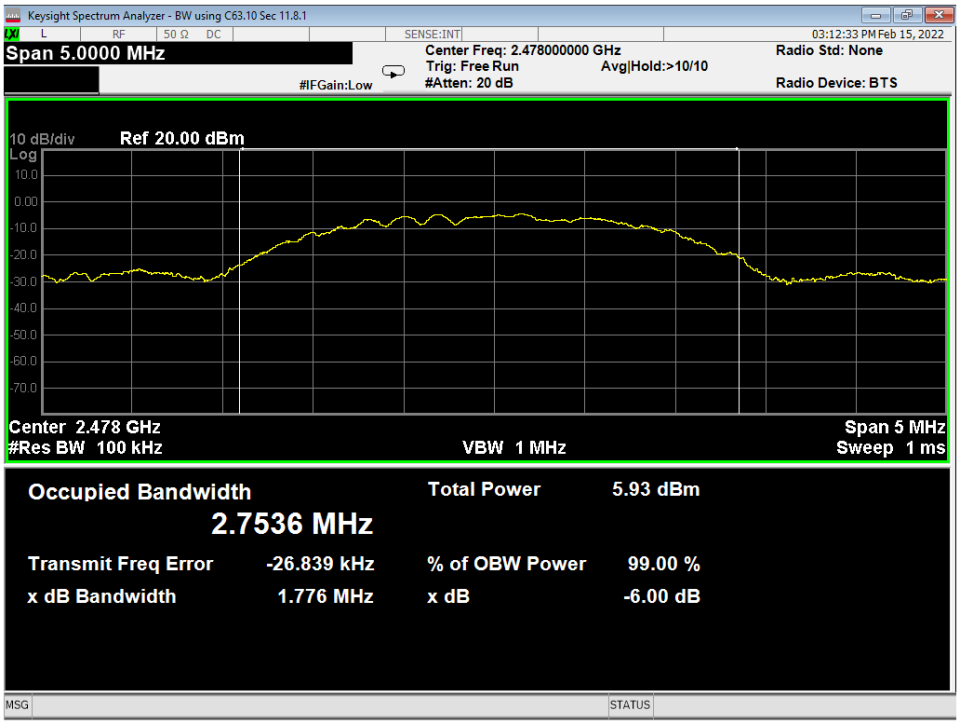
29 Average Power, High Channel, GMSK 2MB



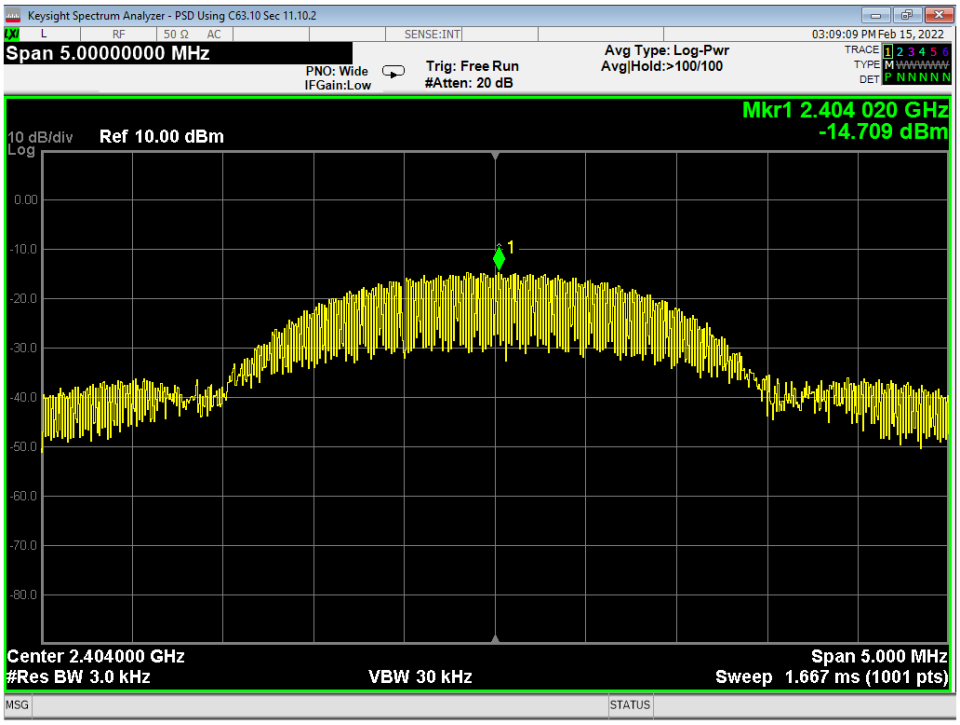
30 OBW-6dB, Low Channel, GMSK 2MB



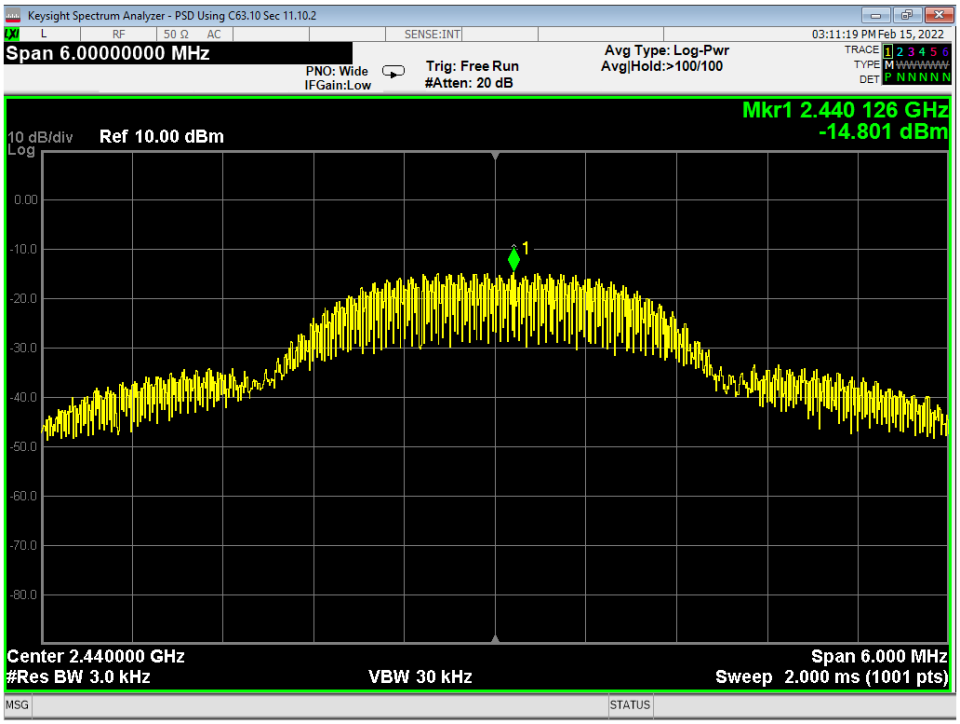
31 OBW-6dB, Mid Channel, GMSK 2MB



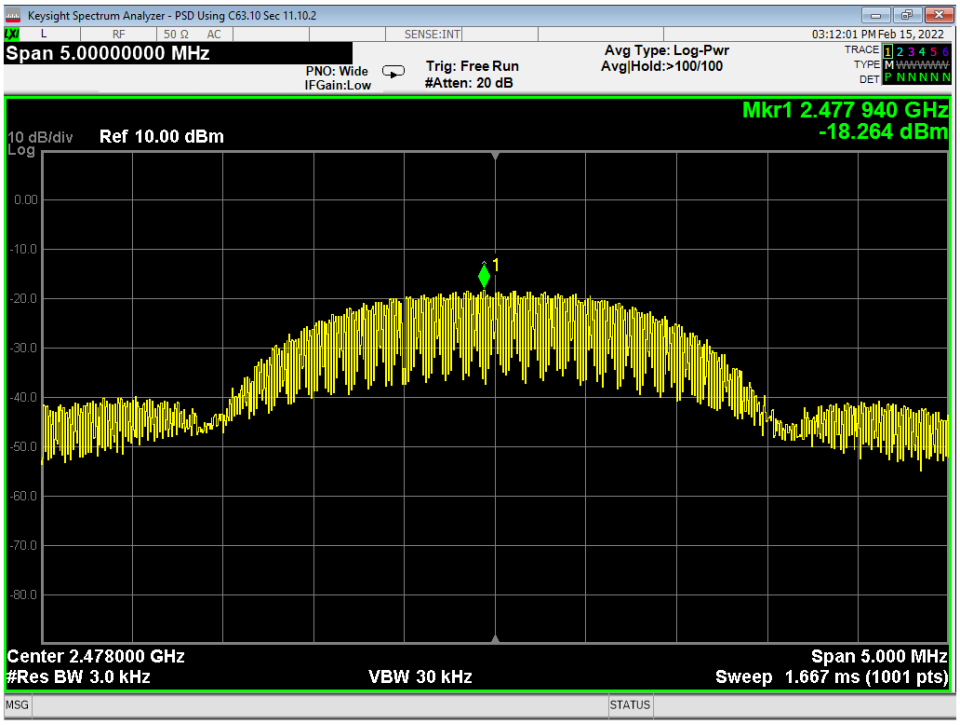
32 OBW-6dB, High Channel, GMSK 2MB



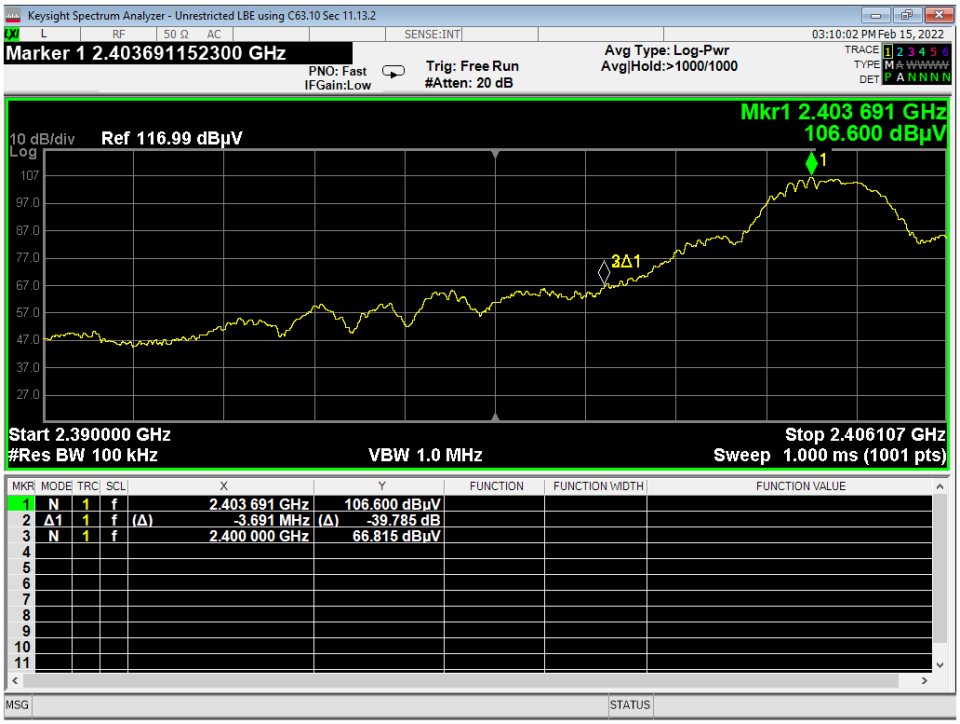
33 PSD, Low Channel, GMSK 2MB



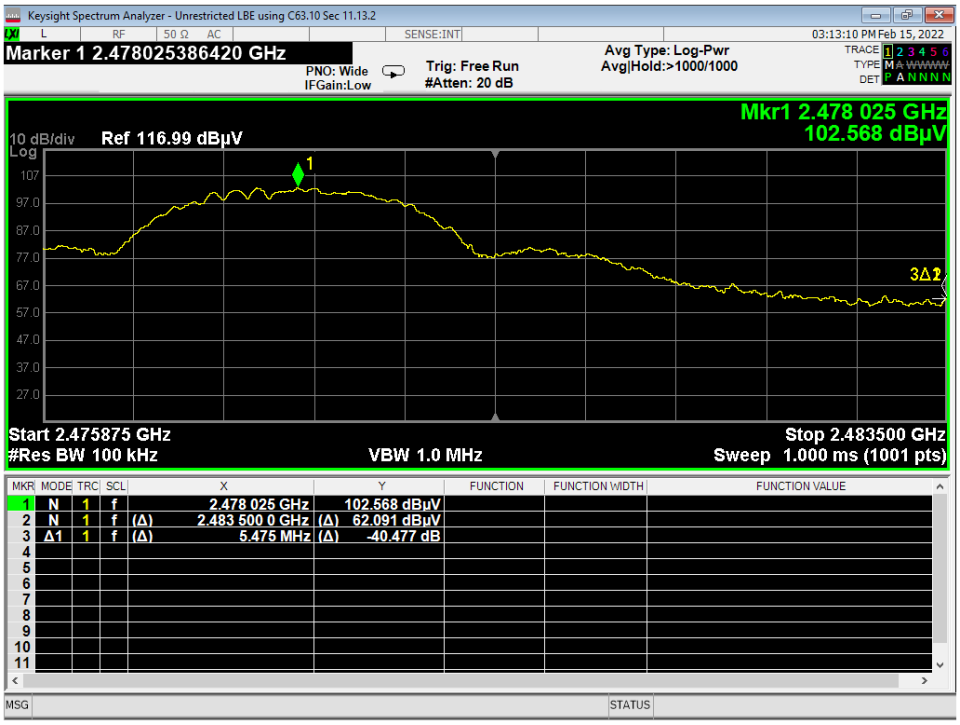
34 PSD, Mid Channel, GMSK 2MB



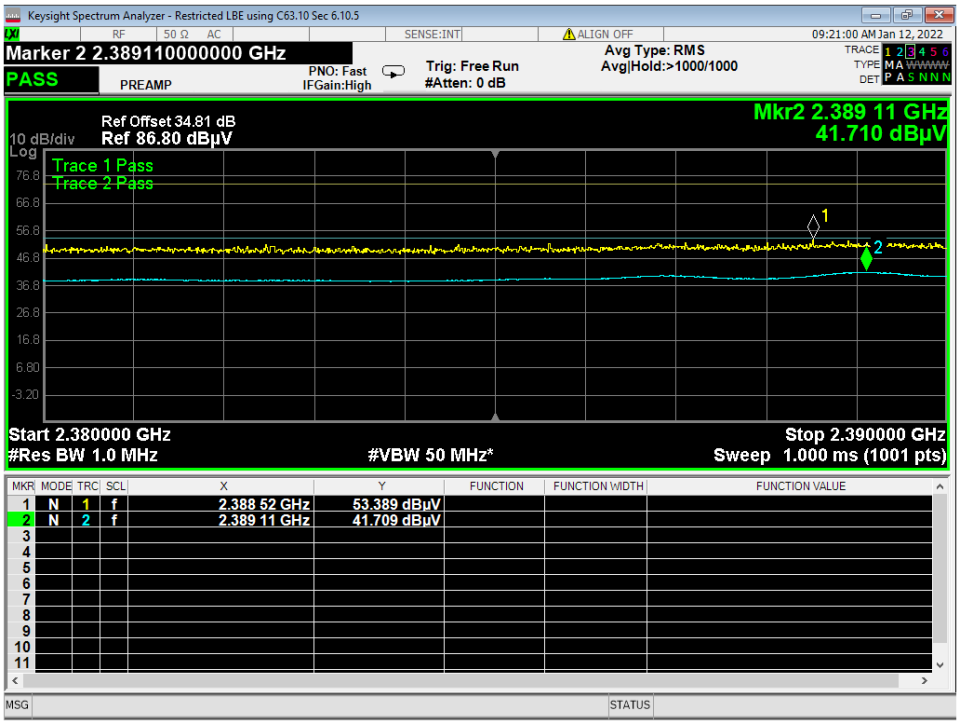
35 PSD, High Channel, GMSK 2MB



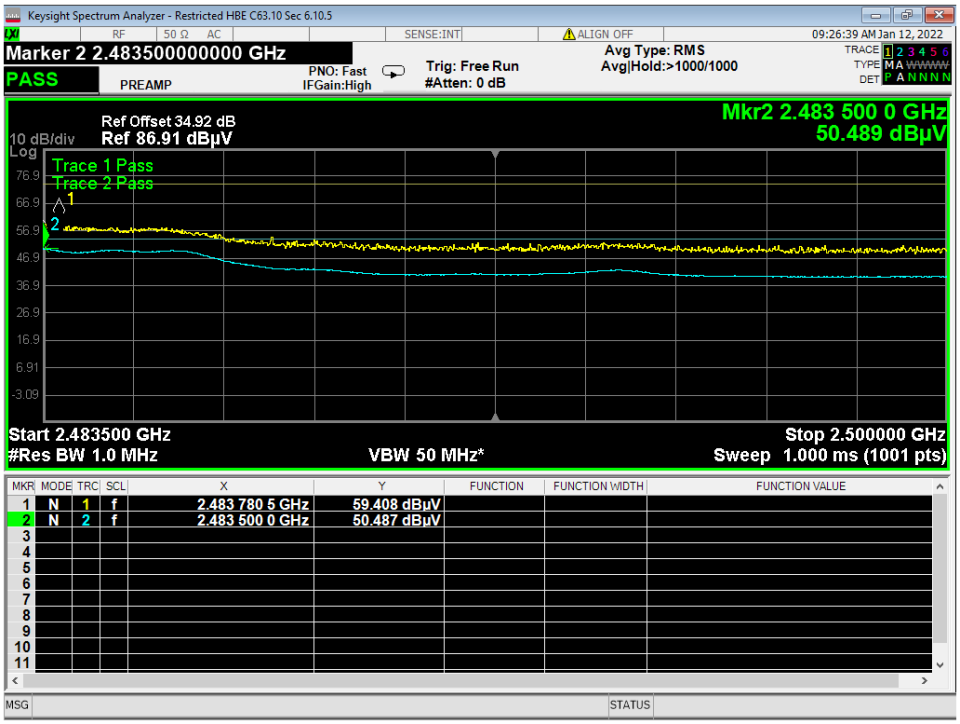
36 Lower Bandedge, Unrestricted, GMSK 2MB



37 Higher Bandedge, Unrestricted, GMSK 2MB



38 Lower Bandedge, Restricted, GMSK 2MB



39 Higher Bandedge, Restricted, GMSK 2MB

REPORT END