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FCC/ISED Test Report

Prepared for: **Garmin International, Inc.**

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

Product: **A04112**

Test Report No: **R20210128-20-E25**

Approved by:

Nic S. Johnson, NCE
Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: **December 17, 2021**

Total Pages: **77**

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REVISION PAGE

Rev. No.	Date	Description
0	17 December 2022	Original – NJohnson Prepared by FLane

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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 (Please see the checked box below for the rule part used):

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(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 11.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 4, Section 7.1	Conducted Emissions	Pass

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary and Operating Condition:

EUT	A04112
EUT Received	9 March 2021
EUT Tested	9 March 2021- 1 December 2021
Serial No.	3379835566 (Conducted Unit) 3378185499 (Conducted Unit) 3378185496 (Radiated Unit)
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:

For ANT and BLE 1MB Transmissions:

Channel	Frequency
Low	2402 MHz
Mid	2440 MHz
High	2480 MHz

For BLE 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	Nic Johnson	Technical Manager	Review/editing
2	Fox Lane	Test Engineer	Testing and report
3	Karthik Vepuri	Test Engineer	Testing and report
4	Grace Larsen	Test Technician	Testing
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
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
TDK Emissions Lab Software	V11.25	700307	NA	NA

*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.

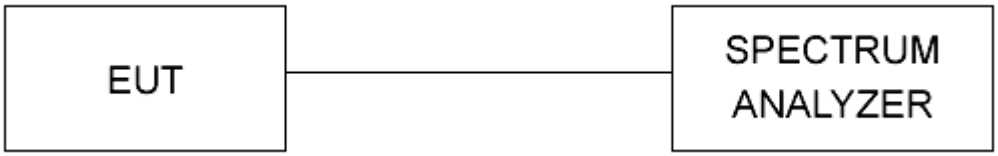


Figure 1 - Bandwidth Measurements Test Setup

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.

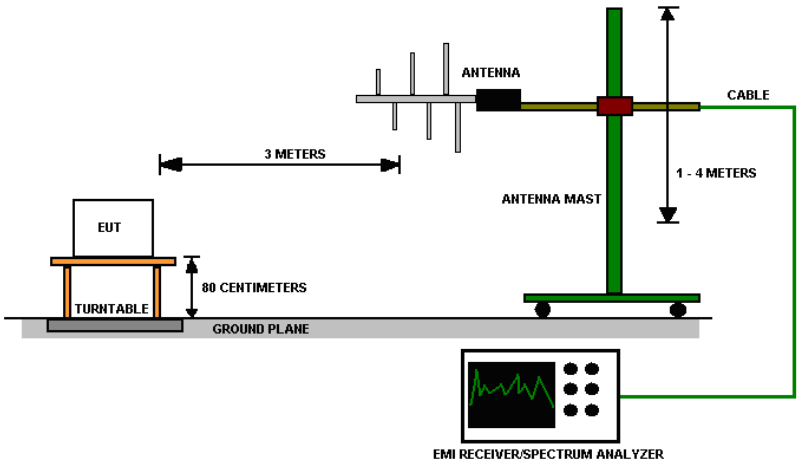


Figure 2 - Radiated Emissions Test Setup

4.0 RESULTS

DTS Radio Measurements							
CHANNEL	Transmitter	Occupied Bandwidth (MHz)	6 dB Bandwidth (MHz)	PEAK OUTPUT POWER (dBm)	PEAK OUTPUT POWER (mW)	PSD (dBm)	RESULT
Low	ANT GFSK	1.8188	0.9277	6.244	4.211	-12.512	PASS
Mid	ANT GFSK	1.6727	0.9327	6.024	4.003	-10.283	PASS
High	ANT GFSK	1.8507	0.9248	6.008	3.988	-12.187	PASS
Low	BLE 1Mb	1.5691	0.7873	4.799	3.019	-12.252	PASS
Mid	BLE 1Mb	1.7393	0.8740	4.951	3.127	-13.129	PASS
High	BLE 1Mb	1.8739	0.8962	4.763	2.994	-12.172	PASS
Low	BLE 2Mb	2.6158	1.4580	5.384	3.455	-12.093	PASS
Mid	BLE 2Mb	2.6878	1.6210	5.286	3.378	-12.718	PASS
High	BLE 2Mb	2.6243	1.4240	5.135	3.262	-12.296	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	BLE 1MB	2390.00	68.62	110.20	41.58	20.00	PASS
Low	BLE 2MB	2390.00	67.07	108.12	41.05	20.00	PASS
Low	ANT GFSK	2390.00	75.17	111.58	36.41	20.00	PASS
High	BLE 1MB	2483.50	58.28	109.84	51.56	20.00	PASS
High	BLE 2MB	2483.50	65.20	108.07	42.87	20.00	PASS
High	ANT GFSK	2483.50	60.15	110.98	50.83	20.00	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	ANT GFSK	2390.00	51.24	Peak	73.98	22.74	PASS
Low	BLE 1MB	2390.00	52.45	Peak	73.98	21.53	PASS
Low	BLE 2MB	2390.00	52.05	Peak	73.98	21.94	PASS
High	ANT GFSK	2483.50	54.51	Peak	73.98	19.47	PASS
High	BLE 1MB	2483.50	60.52	Peak	73.98	13.46	PASS
High	BLE 2MB	2483.50	59.08	Peak	73.98	14.90	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	BLE 1MB	2390.00	39.98	Average	53.98	14.00	PASS
Low	BLE 2MB	2390.00	41.64	Average	53.98	12.35	PASS
Low	ANT GFSK	2390.00	41.13	Average	53.98	12.85	PASS
High	BLE 1MB	2483.50	46.47	Average	53.98	7.51	PASS
High	BLE 2MB	2483.50	51.64	Average	53.98	2.34	PASS
High	ANT GFSK	2483.50	51.05	Average	53.98	2.93	PASS
*Limit shown is the average limit taken from FCC Part 15.209							

4.1 OUTPUT POWER

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 allowed peak 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. The measurements are listed in the tables below.

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.

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:

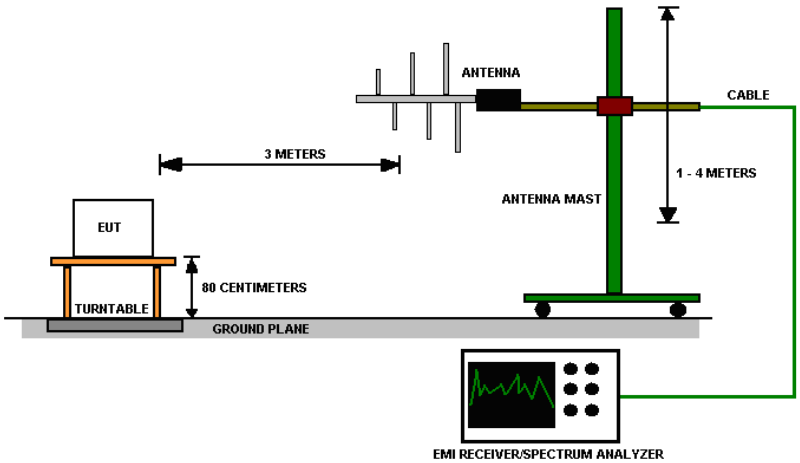


Figure 3 - Radiated Emissions Test Setup

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:

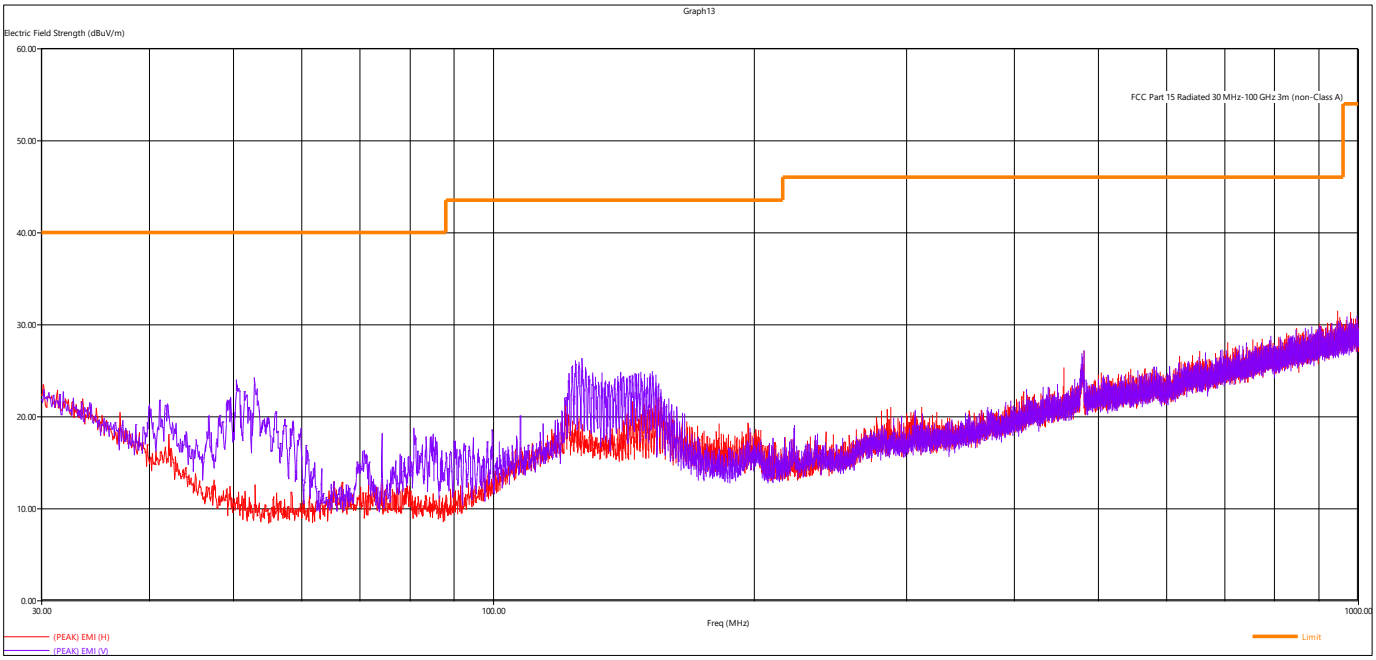


Figure 4 - Radiated Emissions Plot, Receive

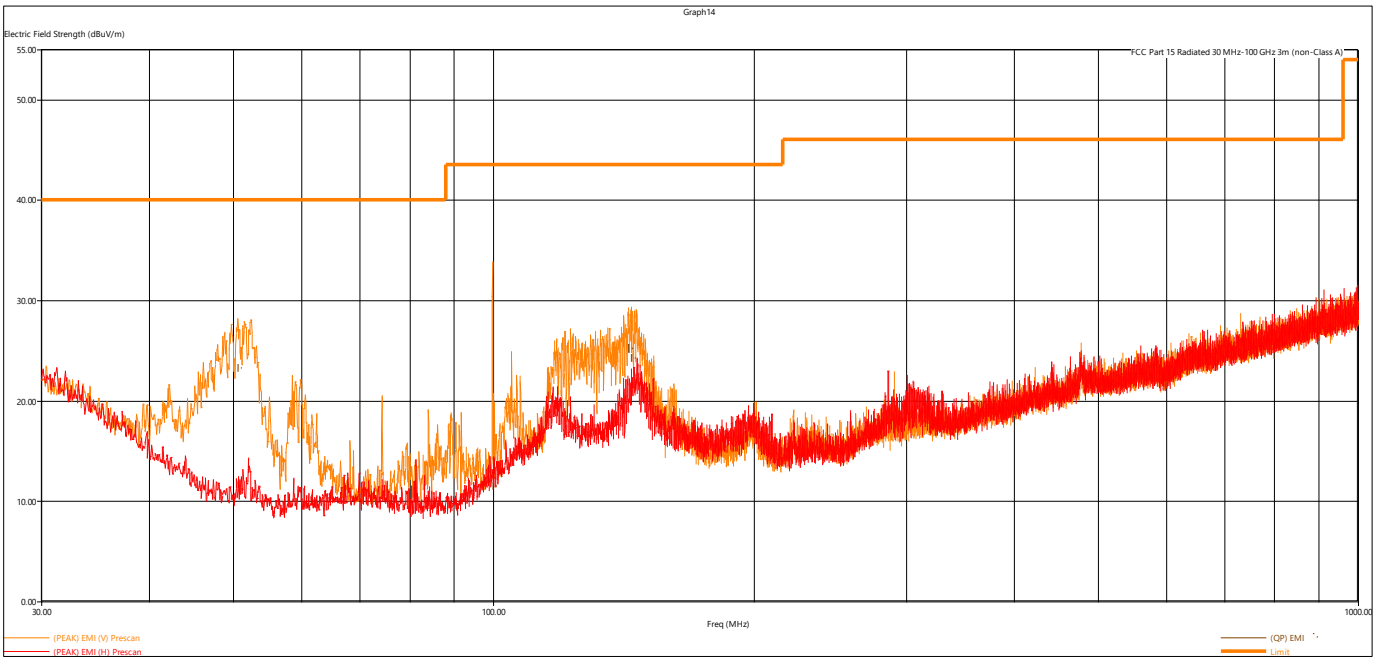


Figure 5 - Radiated Emissions Plot, ANT

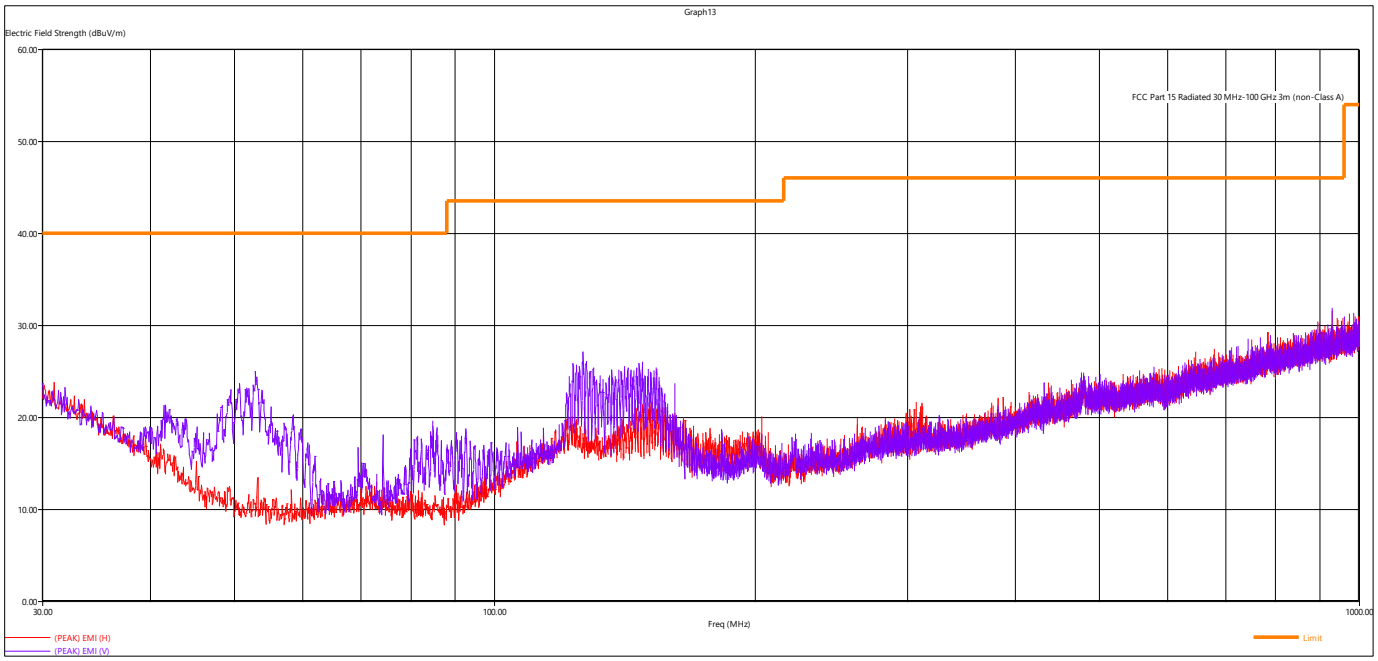


Figure 6 - Radiated Emissions Plot, BLE 1MB

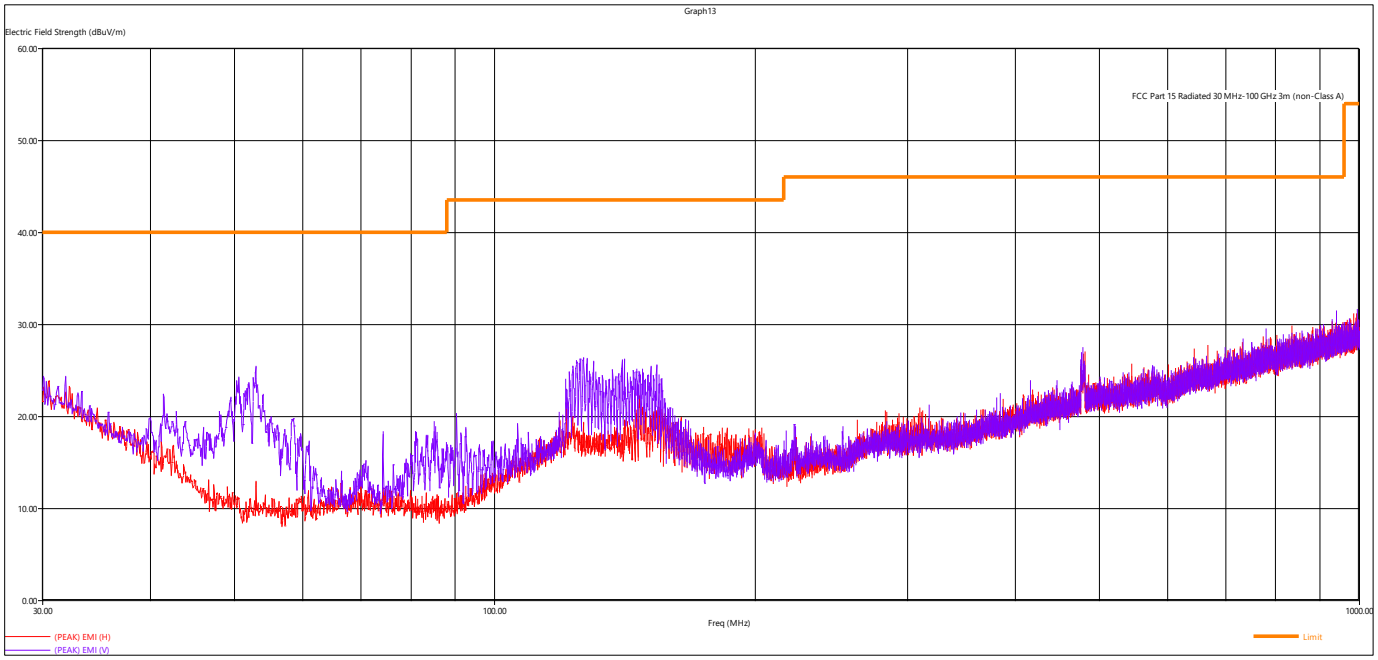


Figure 7 - Radiated Emissions Plot, BLE 2MB

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

Peak Measurements, BLE-ANT								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
2402.190000	100.80	NA	NA	172	162	H	Low	BLE 1MB
2439.776000	100.42	NA	NA	165	161	H	Mid	BLE 1MB
2480.250000	100.01	NA	NA	195	160	H	High	BLE 1MB
7204.812000	51.79	73.98	22.19	452	40	V	Low	BLE 1MB
7206.840000	54.06	73.98	19.92	449	40	V	Low	BLE 1MB
7320.654000	55.07	73.98	18.91	110	0	H	Mid	BLE 1MB
7440.752000	55.58	73.98	18.40	233	287	H	High	BLE 1MB
9919.832000	51.15	73.98	22.83	461	126	H	High	BLE 1MB
2403.590000	100.42	NA	NA	168	163	H	Low	BLE 2MB
2439.450000	96.71	NA	NA	161	163	H	Mid	BLE 2MB
2478.508000	97.49	NA	NA	135	147	V	High	BLE 2MB
7210.686000	54.05	73.98	19.93	264	303	H	Low	BLE 2MB
7213.344000	53.82	73.98	20.16	260	295	H	Low	BLE 2MB
9618.036000	55.36	73.98	18.62	460	34	H	Low	BLE 2MB
7318.564000	56.66	73.98	17.32	483	5	H	Mid	BLE 2MB
7321.282000	55.63	73.98	18.35	121	85	V	Mid	BLE 2MB
7432.450000	59.01	73.98	14.97	387	75	H	High	BLE 2MB
7435.542000	58.26	73.98	15.72	386	75	H	High	BLE 2MB
2401.754000	95.95	NA	NA	297	138	H	Low	GFSK
2439.804000	97.42	NA	NA	110	146	V	Mid	GFSK
2480.178000	97.28	NA	NA	108	146	V	High	GFSK
7206.792000	54.08	73.98	19.90	239	299	H	Low	GFSK
9608.494000	49.82	73.98	24.16	201	218	H	Low	GFSK
7320.658000	54.68	73.98	19.30	145	286	H	Mid	GFSK
9761.250000	51.11	73.98	22.87	108	64	H	Mid	GFSK
7440.842000	55.60	73.98	18.38	115	295	H	High	GFSK

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.
All other emissions found to be at least 6dB below the limit line

Average Measurements, BLE-ANT								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
2402.190000	98.87	NA	NA	172	162	H	Low	BLE 1MB
2439.776000	97.97	NA	NA	165	161	H	Mid	BLE 1MB
2480.250000	97.42	NA	NA	195	160	H	High	BLE 1MB
7204.812000	40.56	53.98	13.42	452	40	V	Low	BLE 1MB
7206.840000	44.90	53.98	9.08	449	40	V	Low	BLE 1MB
7320.654000	47.55	53.98	6.43	110	0	H	Mid	BLE 1MB
7440.752000	47.90	53.98	6.08	233	287	H	High	BLE 1MB
9919.832000	38.99	53.98	14.99	461	126	H	High	BLE 1MB
2403.590000	95.16	NA	NA	168	163	H	Low	BLE 2MB
2439.450000	89.79	NA	NA	161	163	H	Mid	BLE 2MB
2478.508000	91.15	NA	NA	135	147	V	High	BLE 2MB
7210.686000	45.74	53.98	8.24	264	303	H	Low	BLE 2MB
7213.344000	45.38	53.98	8.60	260	295	H	Low	BLE 2MB
9618.036000	45.77	53.98	8.21	460	34	H	Low	BLE 2MB
7318.564000	47.62	53.98	6.36	483	5	H	Mid	BLE 2MB
7321.282000	47.84	53.98	6.14	121	85	V	Mid	BLE 2MB
7432.450000	50.12	53.98	3.86	387	75	H	High	BLE 2MB
7435.542000	49.72	53.98	4.26	386	75	H	High	BLE 2MB
2401.754000	93.20	NA	NA	297	138	H	Low	GFSK
2439.804000	95.35	NA	NA	110	146	V	Mid	GFSK
2480.178000	95.09	NA	NA	108	146	V	High	GFSK
7206.792000	45.55	53.98	8.43	239	299	H	Low	GFSK
9608.494000	39.30	53.98	14.68	201	218	H	Low	GFSK
7320.658000	46.88	53.98	7.10	145	286	H	Mid	GFSK
9761.250000	39.02	53.98	14.96	108	64	H	Mid	GFSK
7440.842000	47.26	53.98	6.72	115	295	H	High	GFSK

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.
All other emissions found to be at least 6dB below the limit line

4.5 CONDUCTED SPURIOUS EMISSIONS

Test Method: ANSI C63.10-2013, Section 7.8.8

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 20dB below the fundamental. 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:

All channels were investigated and worst case was reported.
The highest value measured was 4.940 dBm at the fundamental emissions. All other values were at least 20 dB lower.

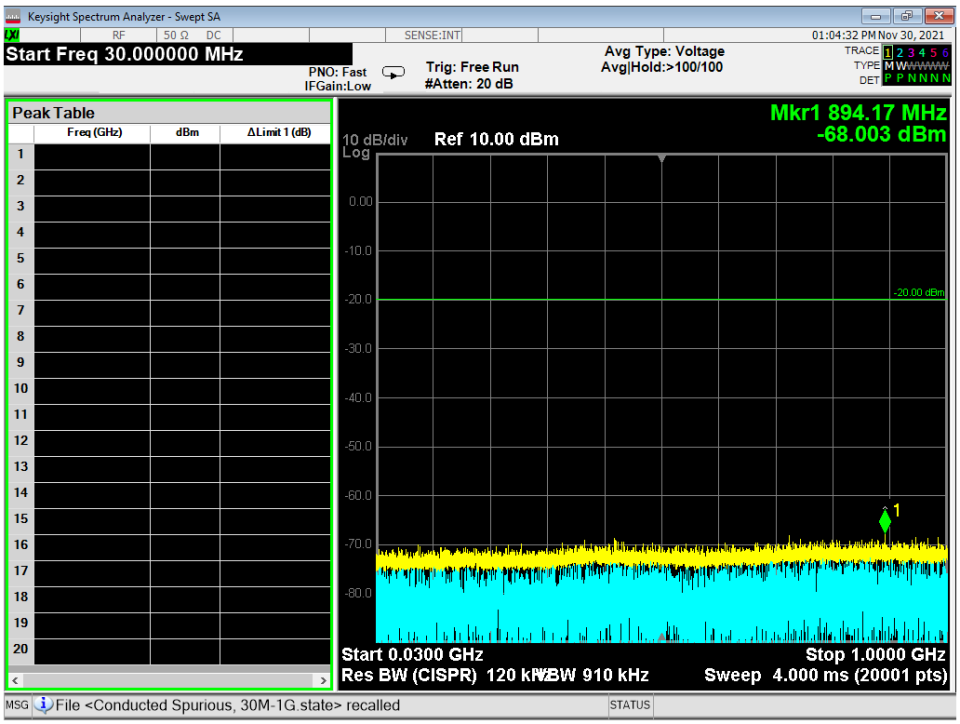


Figure 8 - Radiated Emissions Plot, ANT, 30M – 1G

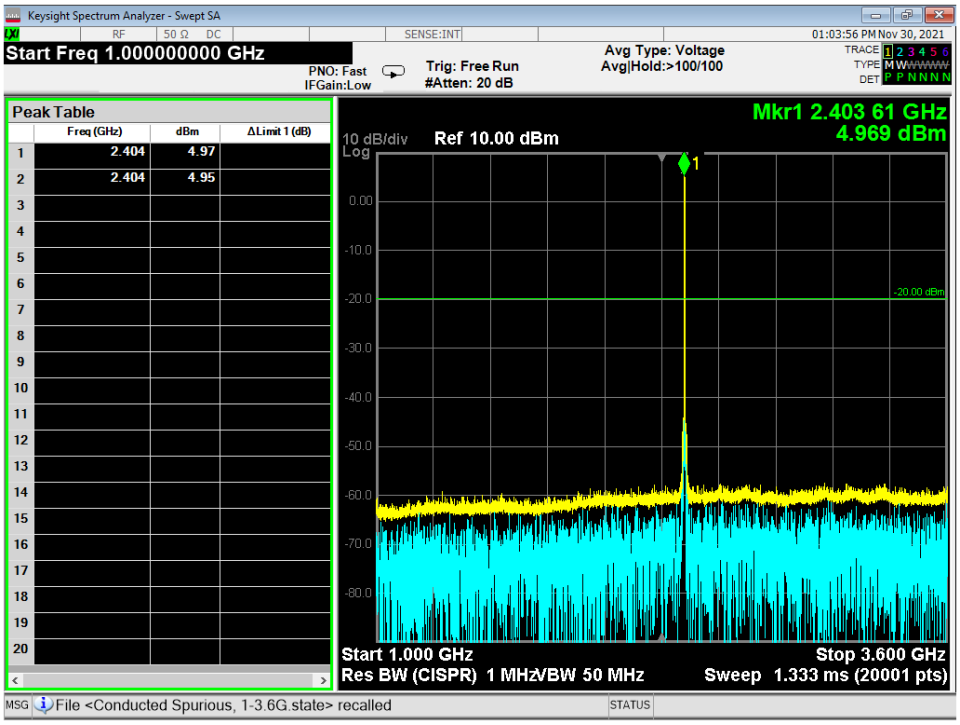


Figure 9 - Radiated Emissions Plot, ANT, 1G – 3.6G

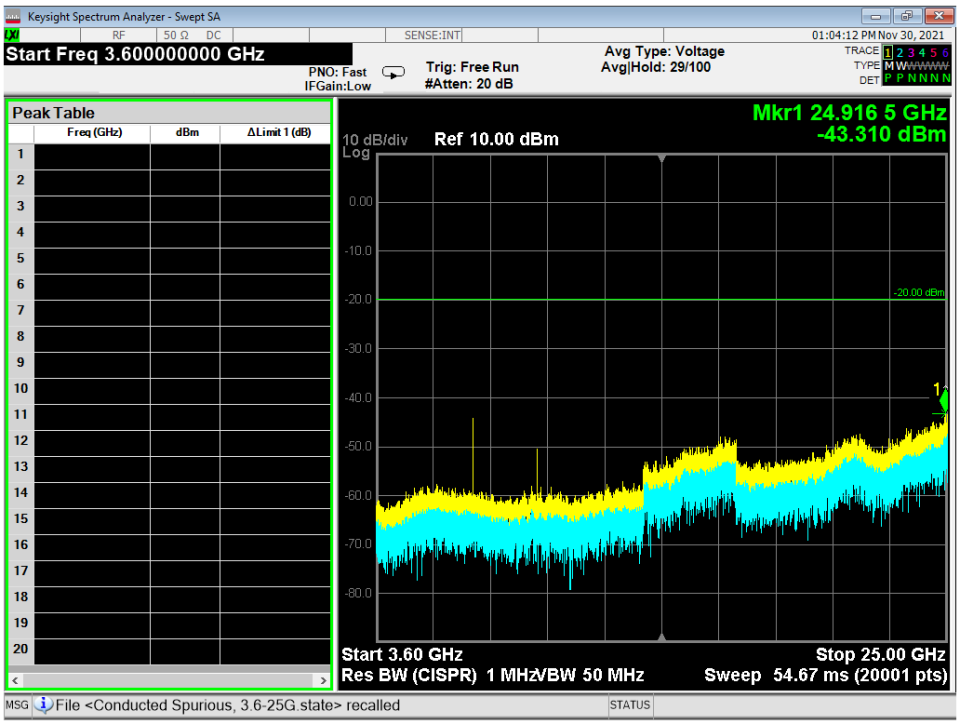


Figure 10 - Radiated Emissions Plot, ANT, 3.6G – 25G

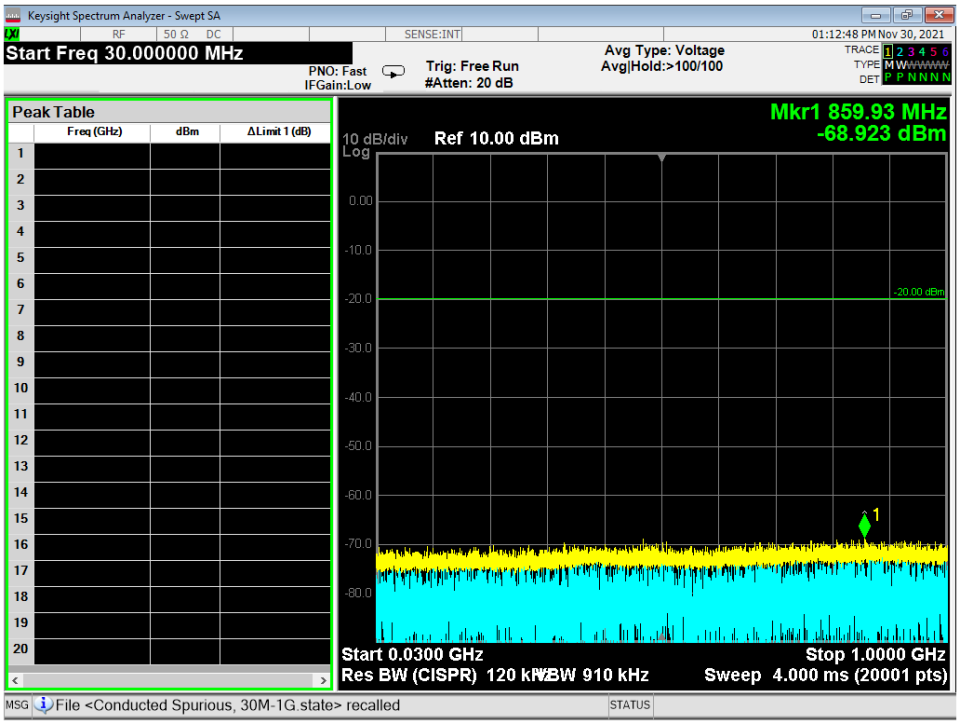


Figure 11 - Radiated Emissions Plot, BLE 1MB, 30M – 1G

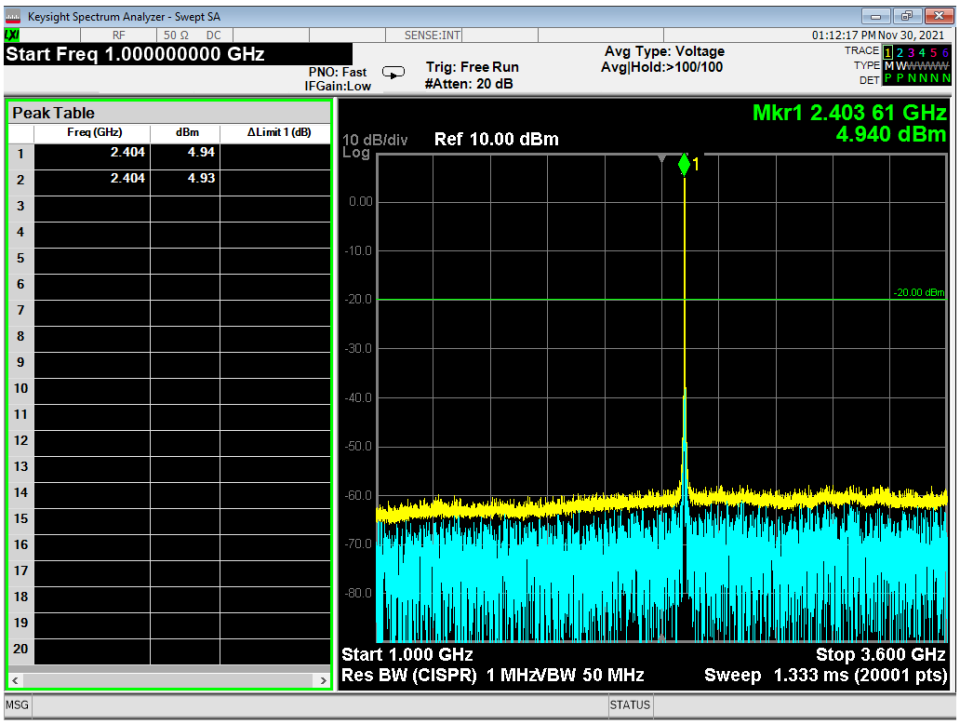


Figure 12 - Radiated Emissions Plot, BLE 1MB, 1G – 3.6G

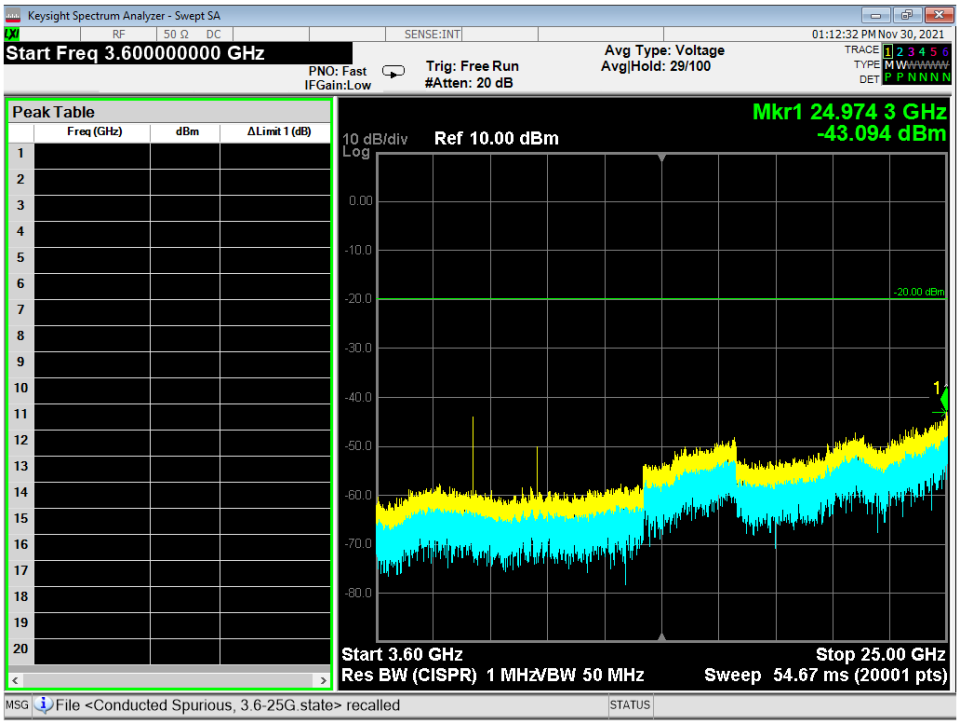


Figure 13 - Radiated Emissions Plot, BLE 1MB, 3.6G – 25G

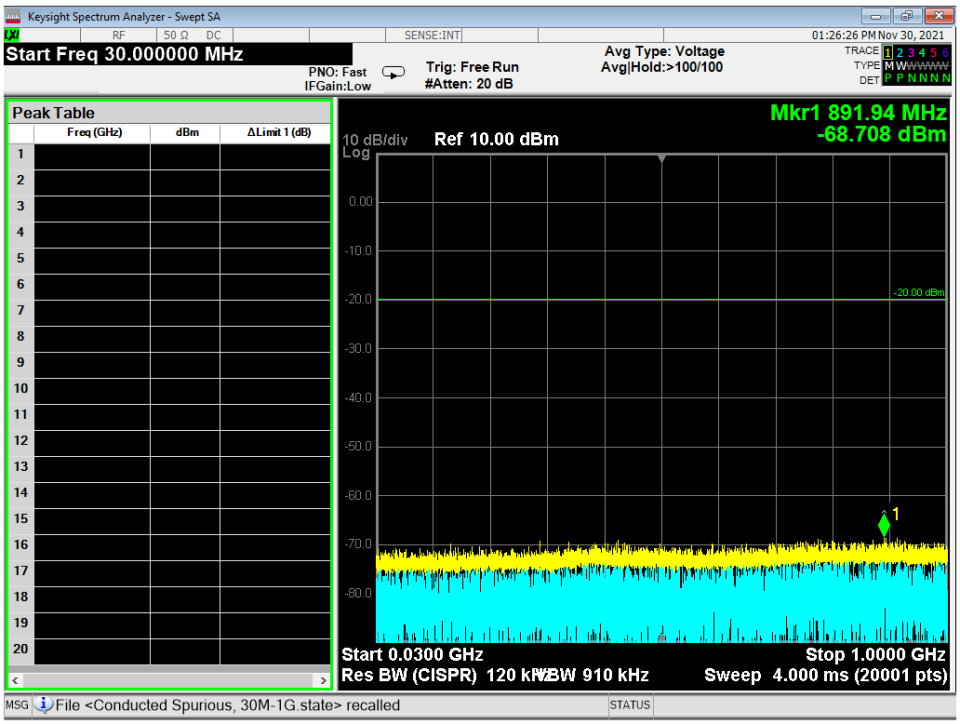


Figure 14 - Radiated Emissions Plot, BLE 2MB, 30M – 1G

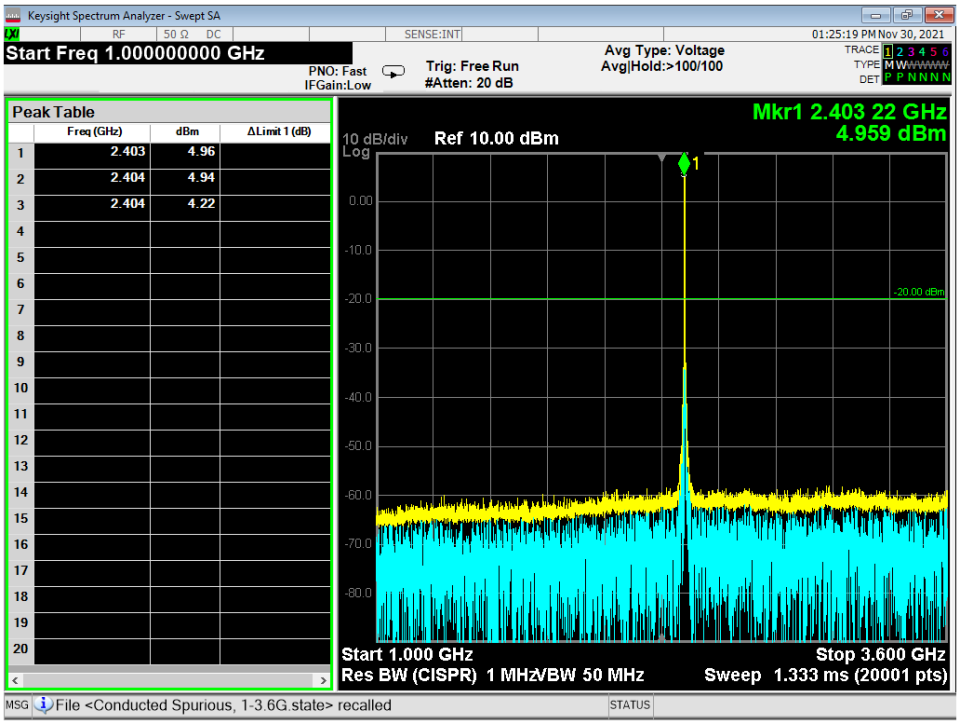


Figure 15 - Radiated Emissions Plot, BLE 2MB, 1G – 3.6G

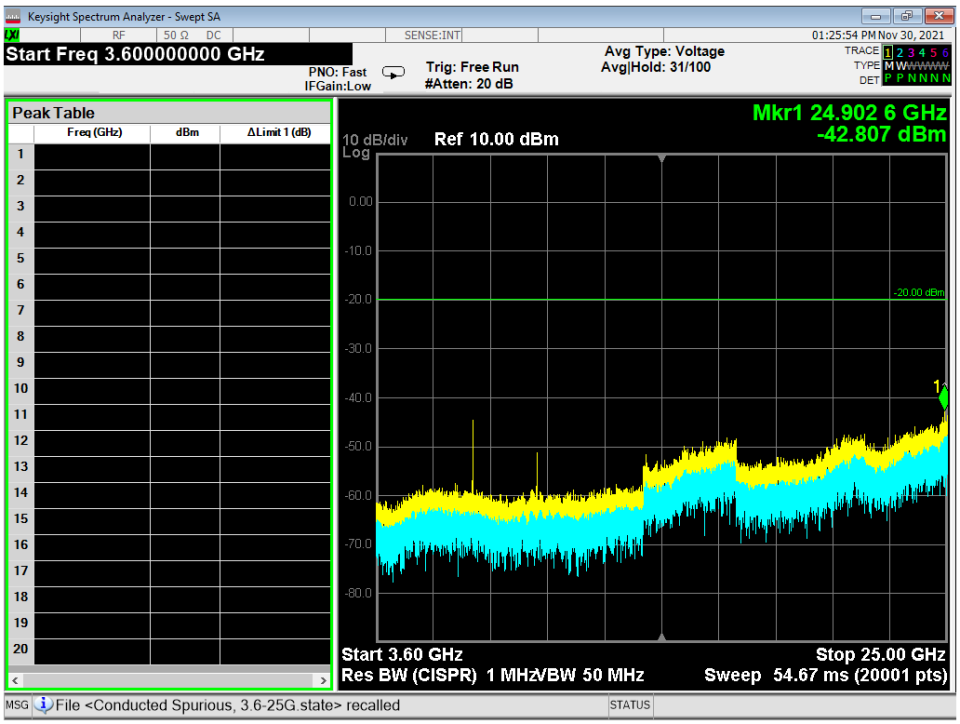


Figure 16 - Radiated Emissions Plot, BLE 2MB, 3.6G – 25G

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 15.249 Device:
Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.
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. If the device falls under FCC Part 15.249 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 50 dB between peak and the band edge.
4. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209. The limit shown in the graph accounts for the antenna gain of the device.

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:

4. All the Power Spectral Density (PSD) plots can be found in the Appendix C.
5. All the measurements were found to be compliant.
6. The measurements are reported on the graph.

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.

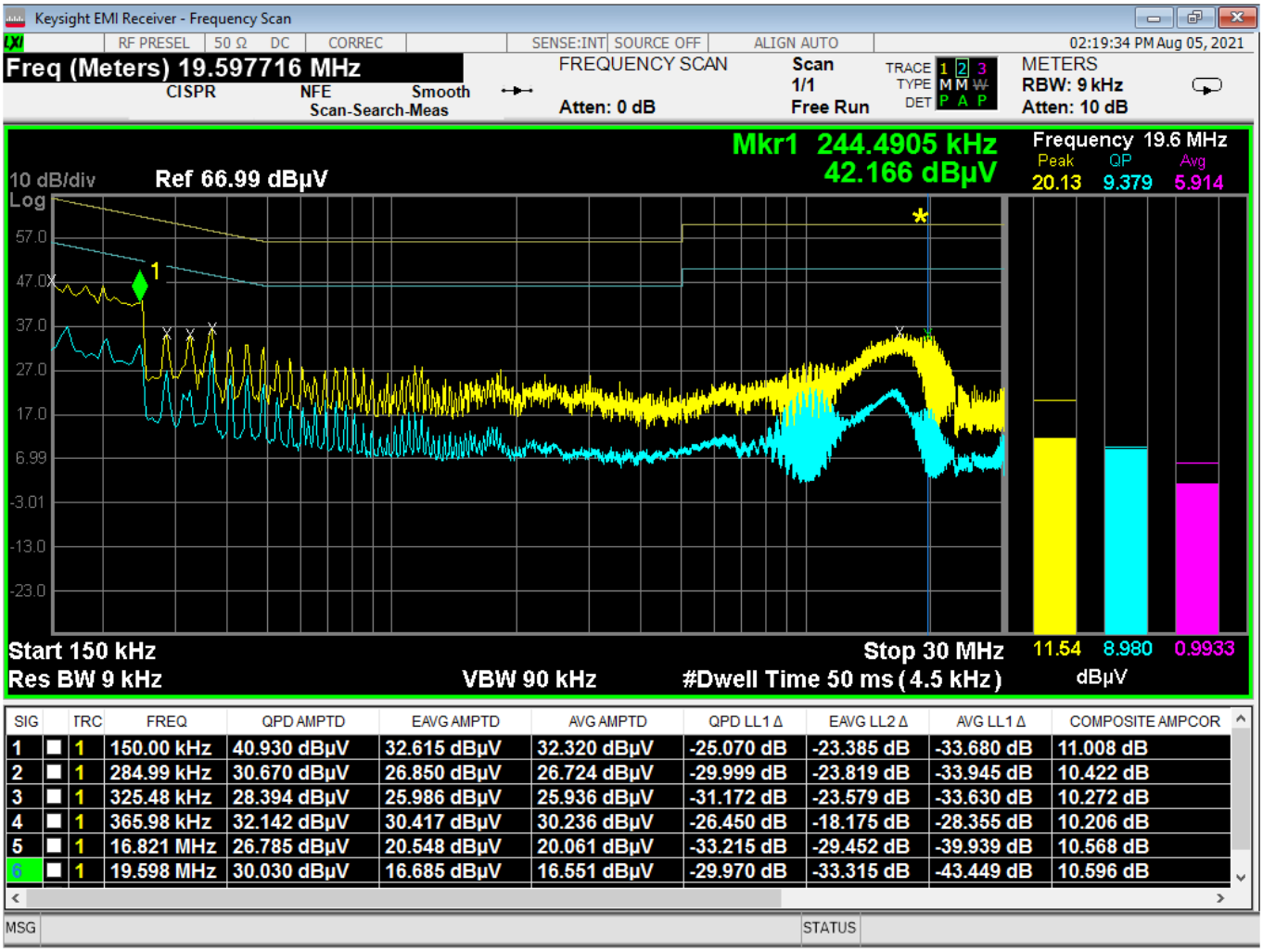
Test Procedures:

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

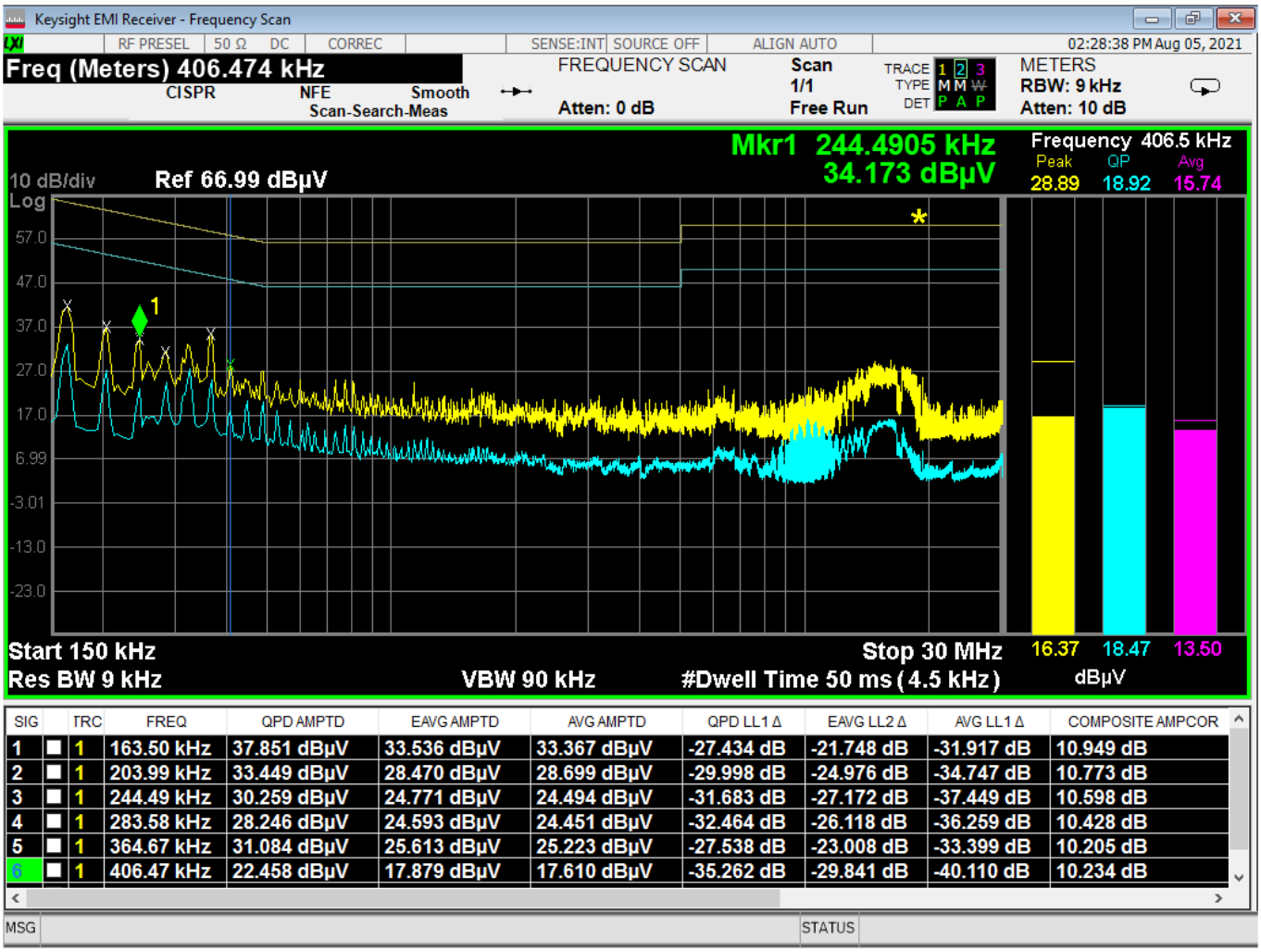
EUT operating conditions:
Details can be found in section 2.1 of this report.
.

Test Results:



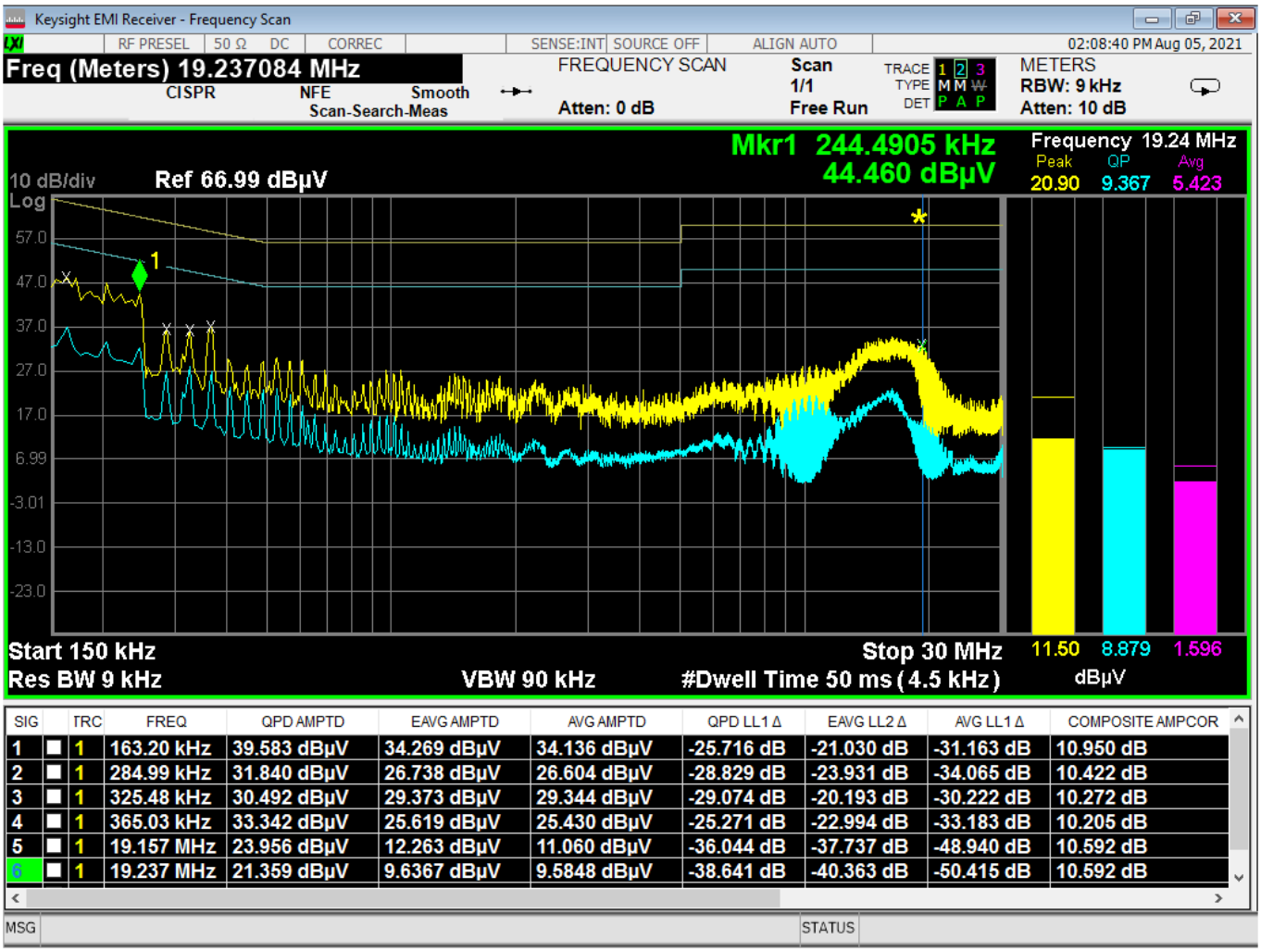
SIG		TRC	FREQ	QPD AMPTD	EAVG AMPTD	AVG AMPTD	QPD LL1 Δ	EAVG LL2 Δ	AVG LL1 Δ	COMPOSITE AMPCOR
1	■	1	150.00 kHz	40.930 dBµV	32.615 dBµV	32.320 dBµV	-25.070 dB	-23.385 dB	-33.680 dB	11.008 dB
2	■	1	284.99 kHz	30.670 dBµV	26.850 dBµV	26.724 dBµV	-29.999 dB	-23.819 dB	-33.945 dB	10.422 dB
3	■	1	325.48 kHz	28.394 dBµV	25.986 dBµV	25.936 dBµV	-31.172 dB	-23.579 dB	-33.630 dB	10.272 dB
4	■	1	365.98 kHz	32.142 dBµV	30.417 dBµV	30.236 dBµV	-26.450 dB	-18.175 dB	-28.355 dB	10.206 dB
5	■	1	16.821 MHz	26.785 dBµV	20.548 dBµV	20.061 dBµV	-33.215 dB	-29.452 dB	-39.939 dB	10.568 dB
6	■	1	19.598 MHz	30.030 dBµV	16.685 dBµV	16.551 dBµV	-29.970 dB	-33.315 dB	-43.449 dB	10.596 dB

Figure 17 - Conducted Emissions Plot, Line, TX



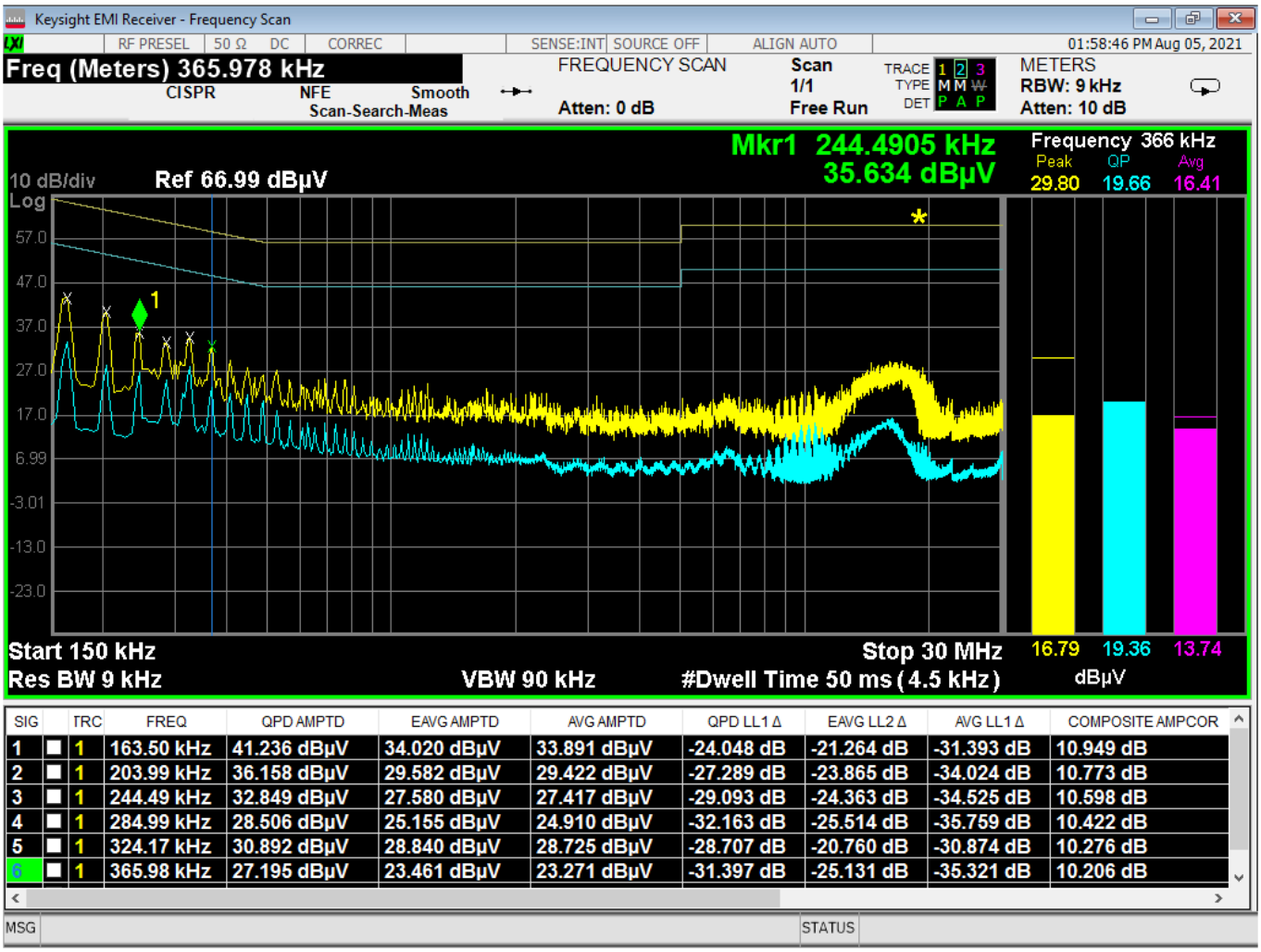
SIG		TRC	FREQ	QPD AMPTD	EAVG AMPTD	AVG AMPTD	QPD LL1 Δ	EAVG LL2 Δ	AVG LL1 Δ	COMPOSITE AMPCOR
1	■	1	163.50 kHz	37.851 dBµV	33.536 dBµV	33.367 dBµV	-27.434 dB	-21.748 dB	-31.917 dB	10.949 dB
2	■	1	203.99 kHz	33.449 dBµV	28.470 dBµV	28.699 dBµV	-29.998 dB	-24.976 dB	-34.747 dB	10.773 dB
3	■	1	244.49 kHz	30.259 dBµV	24.771 dBµV	24.494 dBµV	-31.683 dB	-27.172 dB	-37.449 dB	10.598 dB
4	■	1	283.58 kHz	28.246 dBµV	24.593 dBµV	24.451 dBµV	-32.464 dB	-26.118 dB	-36.259 dB	10.428 dB
5	■	1	364.67 kHz	31.084 dBµV	25.613 dBµV	25.223 dBµV	-27.538 dB	-23.008 dB	-33.399 dB	10.205 dB
6	■	1	406.47 kHz	22.458 dBµV	17.879 dBµV	17.610 dBµV	-35.262 dB	-29.841 dB	-40.110 dB	10.234 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	163.20 kHz	39.583 dBµV	34.269 dBµV	34.136 dBµV	-25.716 dB	-21.030 dB	-31.163 dB	10.950 dB
2	■	1	284.99 kHz	31.840 dBµV	26.738 dBµV	26.604 dBµV	-28.829 dB	-23.931 dB	-34.065 dB	10.422 dB
3	■	1	325.48 kHz	30.492 dBµV	29.373 dBµV	29.344 dBµV	-29.074 dB	-20.193 dB	-30.222 dB	10.272 dB
4	■	1	365.03 kHz	33.342 dBµV	25.619 dBµV	25.430 dBµV	-25.271 dB	-22.994 dB	-33.183 dB	10.205 dB
5	■	1	19.157 MHz	23.956 dBµV	12.263 dBµV	11.060 dBµV	-36.044 dB	-37.737 dB	-48.940 dB	10.592 dB
6	■	1	19.237 MHz	21.359 dBµV	9.6367 dBµV	9.5848 dBµV	-38.641 dB	-40.363 dB	-50.415 dB	10.592 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	163.50 kHz	41.236 dBµV	34.020 dBµV	33.891 dBµV	-24.048 dB	-21.264 dB	-31.393 dB	10.949 dB
2	■	1	203.99 kHz	36.158 dBµV	29.582 dBµV	29.422 dBµV	-27.289 dB	-23.865 dB	-34.024 dB	10.773 dB
3	■	1	244.49 kHz	32.849 dBµV	27.580 dBµV	27.417 dBµV	-29.093 dB	-24.363 dB	-34.525 dB	10.598 dB
4	■	1	284.99 kHz	28.506 dBµV	25.155 dBµV	24.910 dBµV	-32.163 dB	-25.514 dB	-35.759 dB	10.422 dB
5	■	1	324.17 kHz	30.892 dBµV	28.840 dBµV	28.725 dBµV	-28.707 dB	-20.760 dB	-30.874 dB	10.276 dB
6	■	1	365.98 kHz	27.195 dBµV	23.461 dBµV	23.271 dBµV	-31.397 dB	-25.131 dB	-35.321 dB	10.206 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

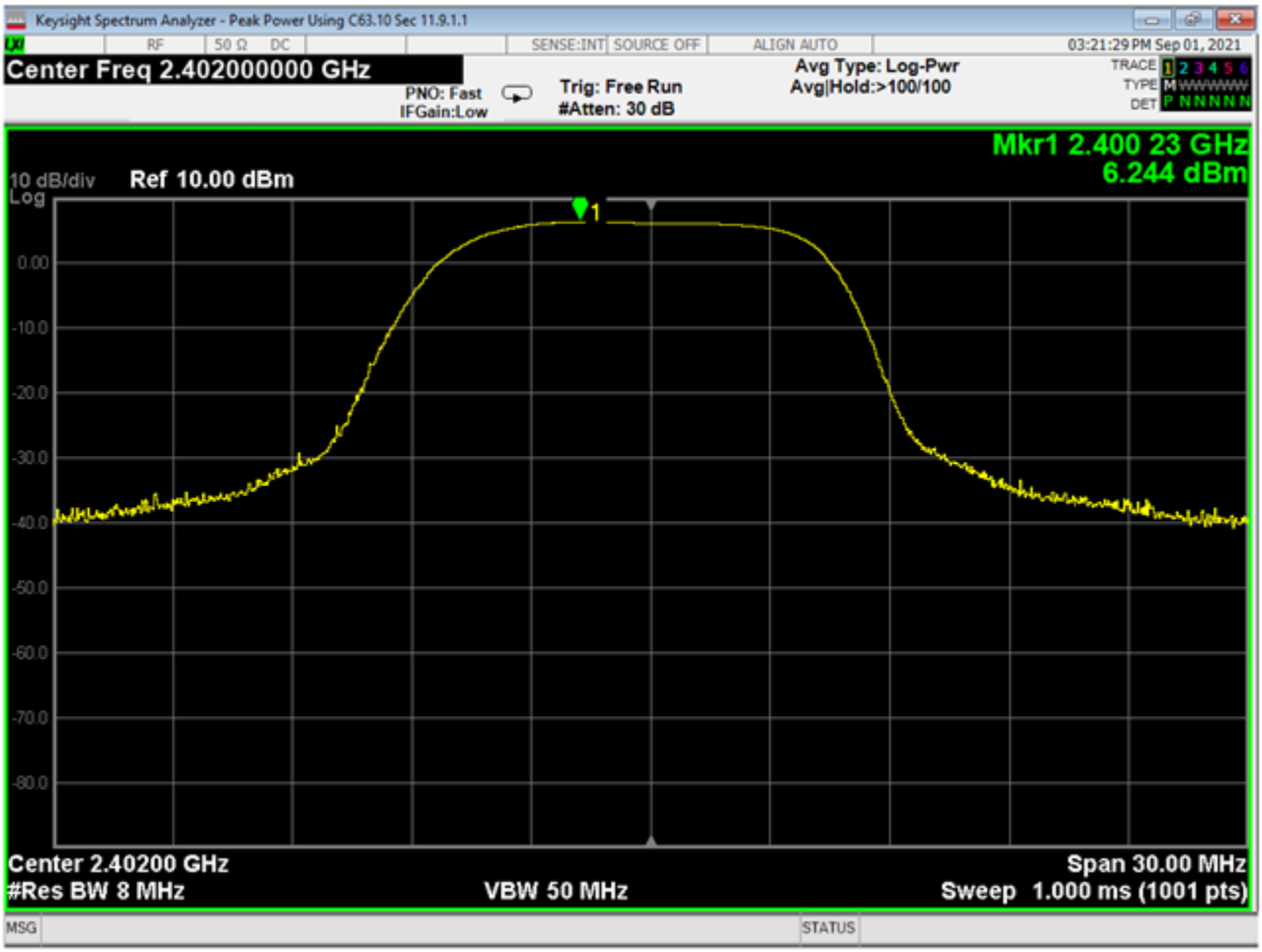
APPENDIX B – MEASUREMENT UNCERTAINTY

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

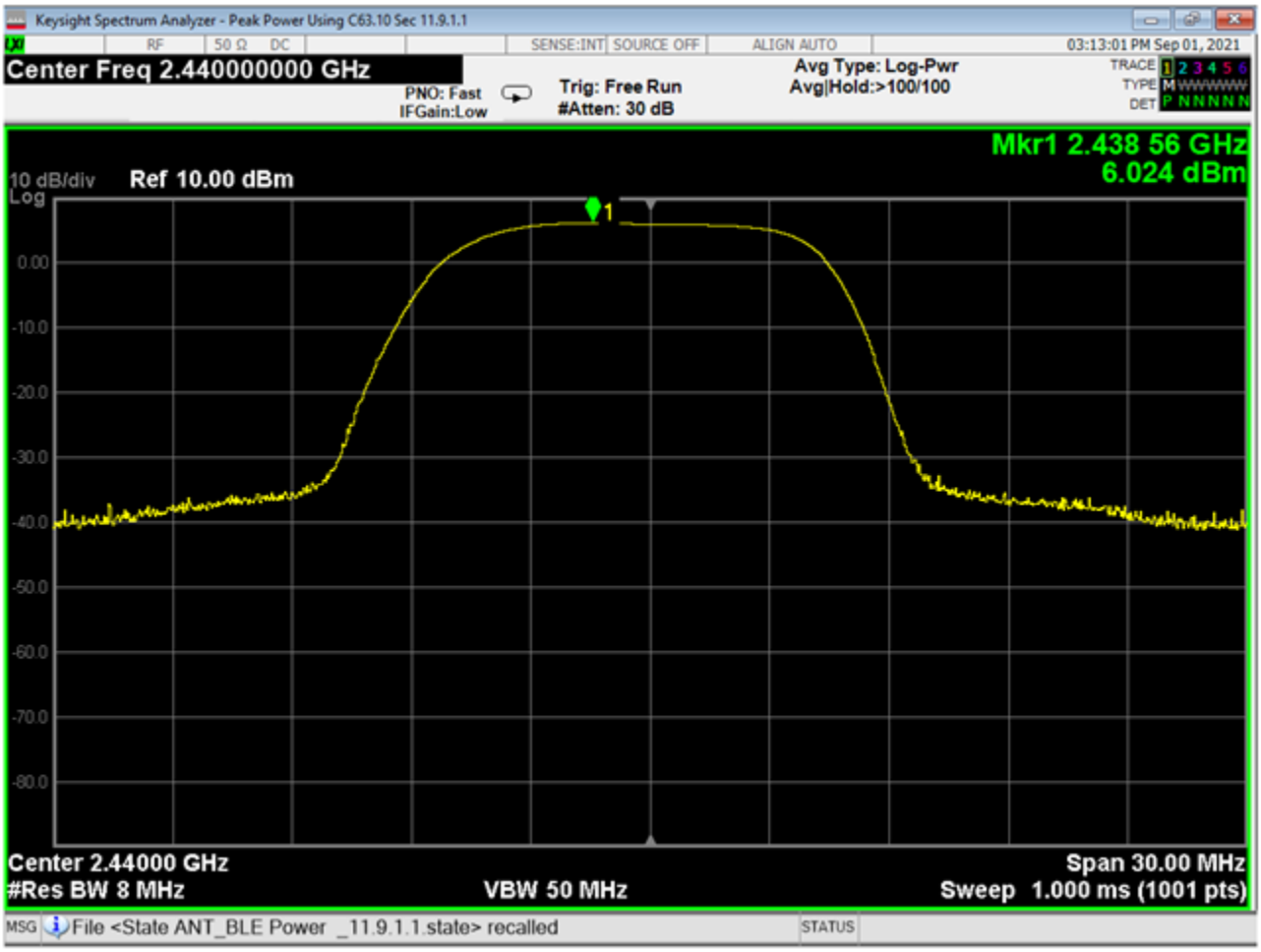
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB

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

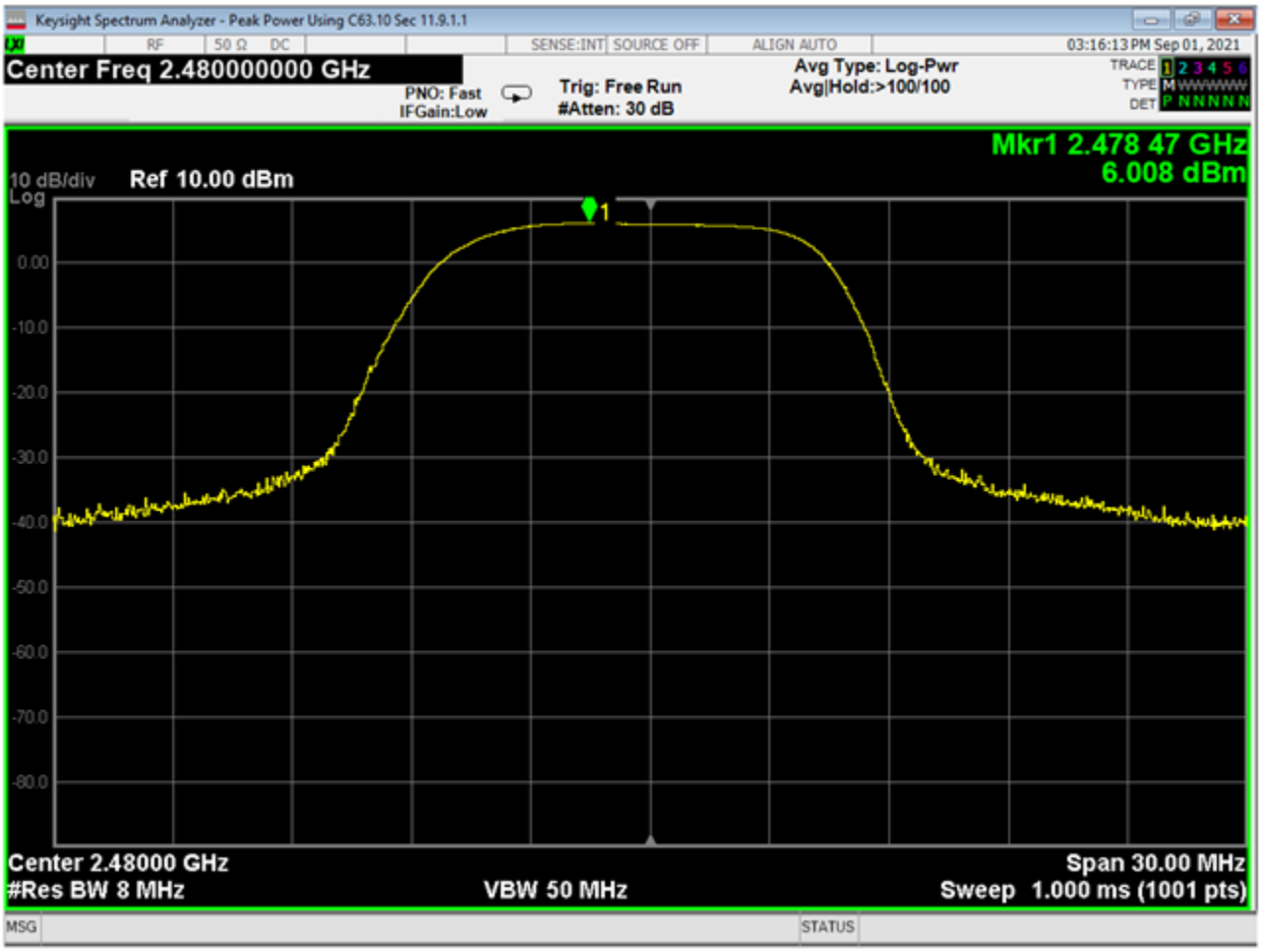
APPENDIX C – GRAPHS AND TABLES



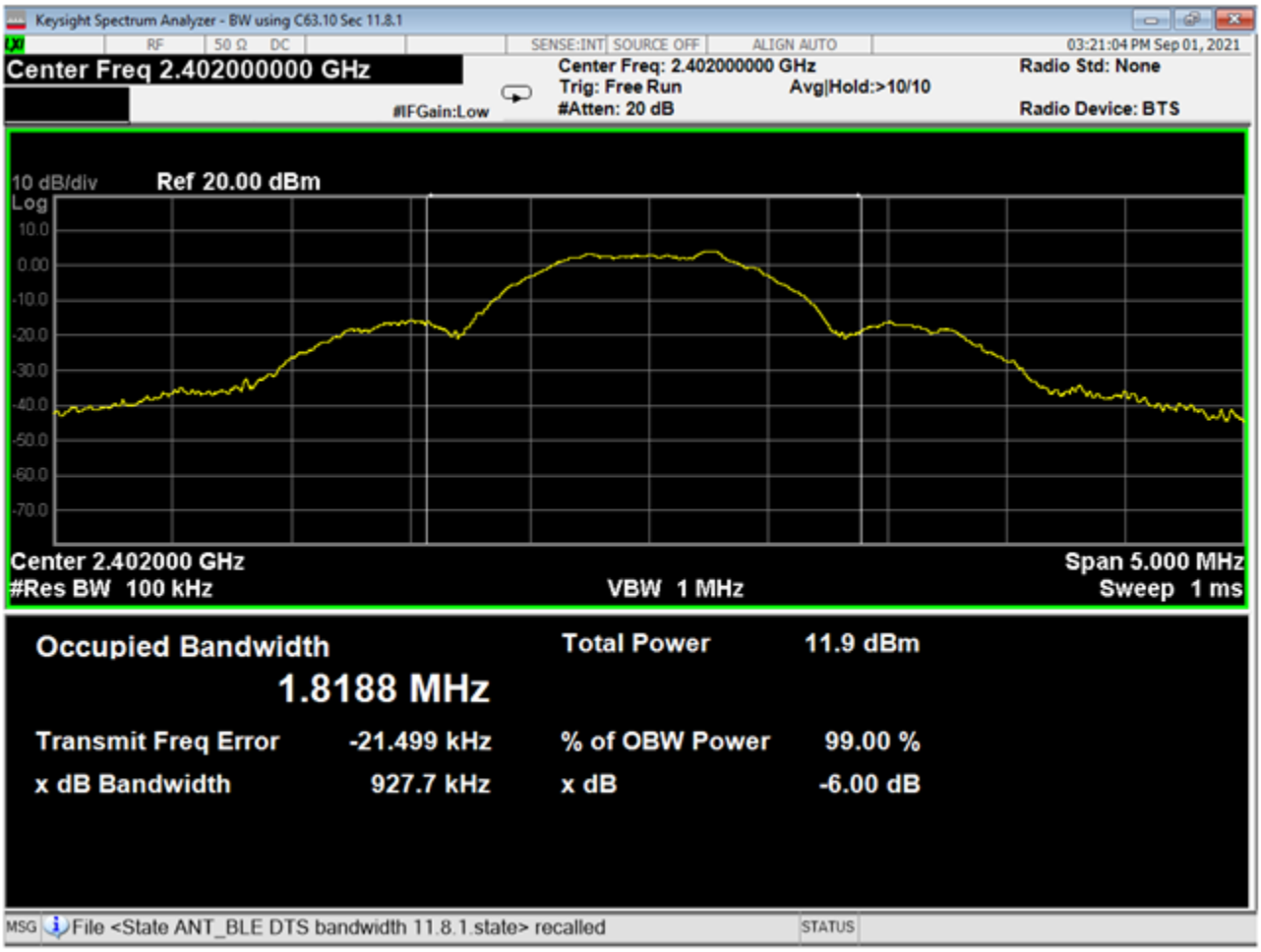
01 PWR, Low, ANT



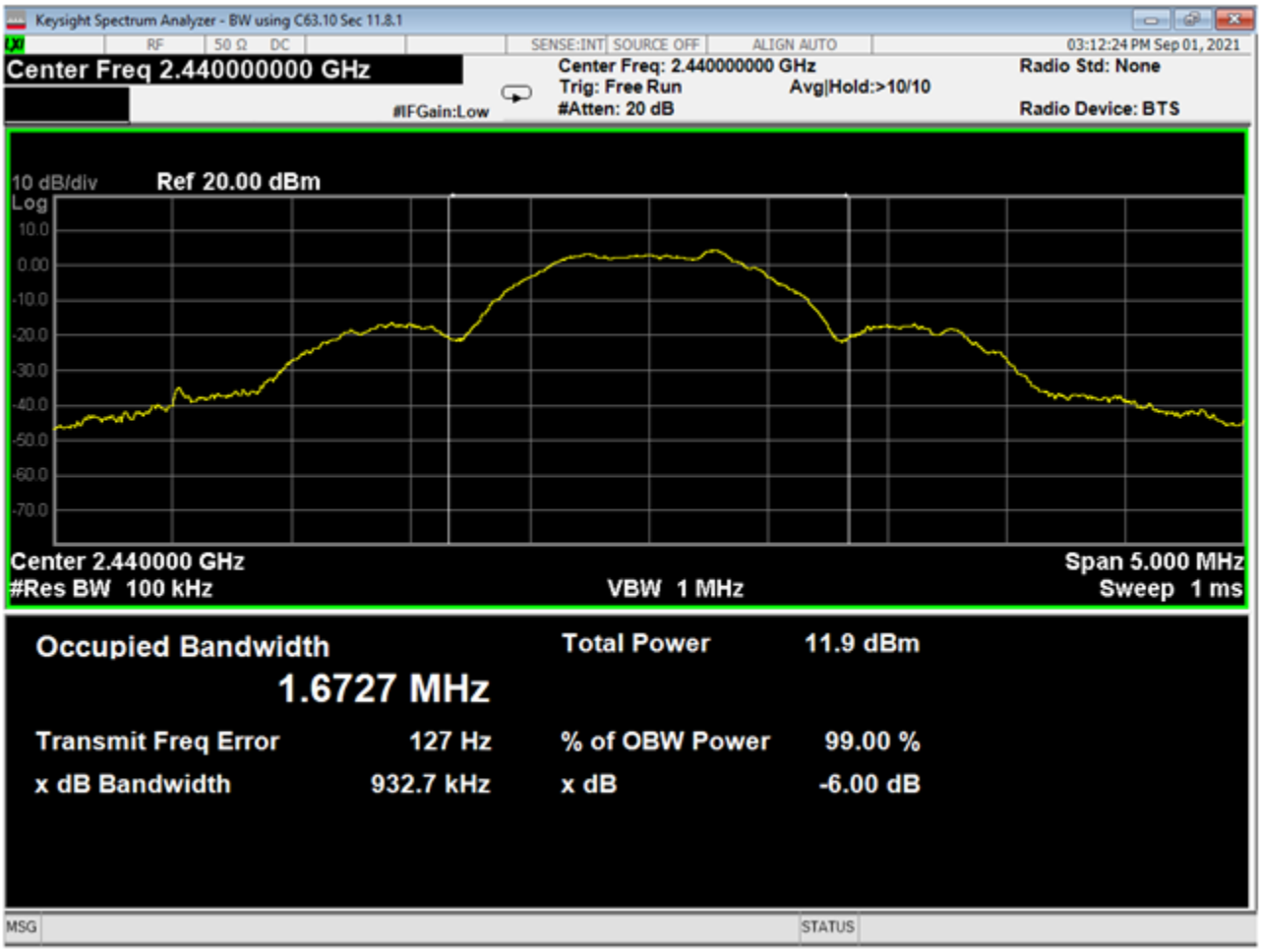
02 PWR, Mid, ANT



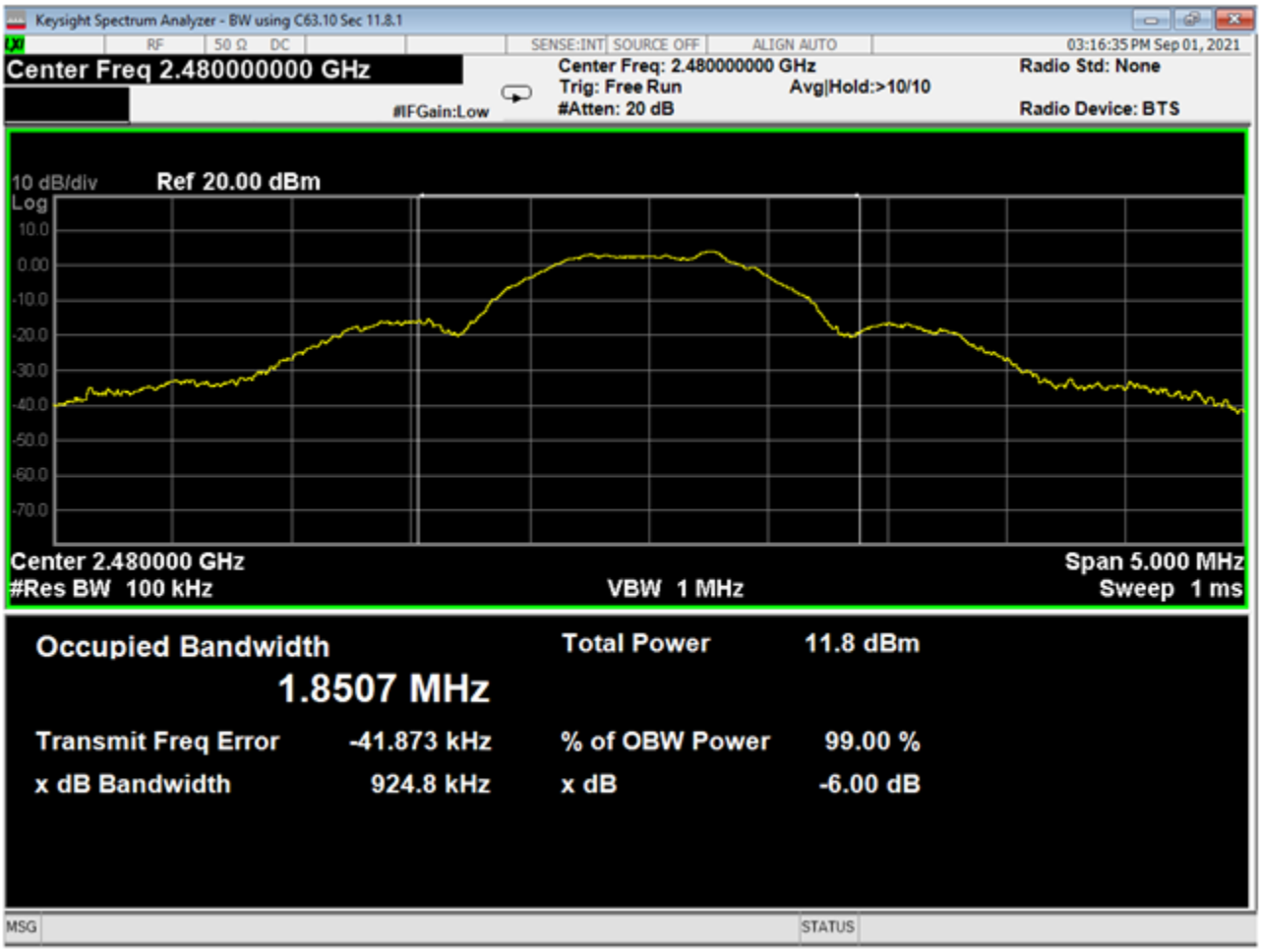
03 PWR, High, ANT



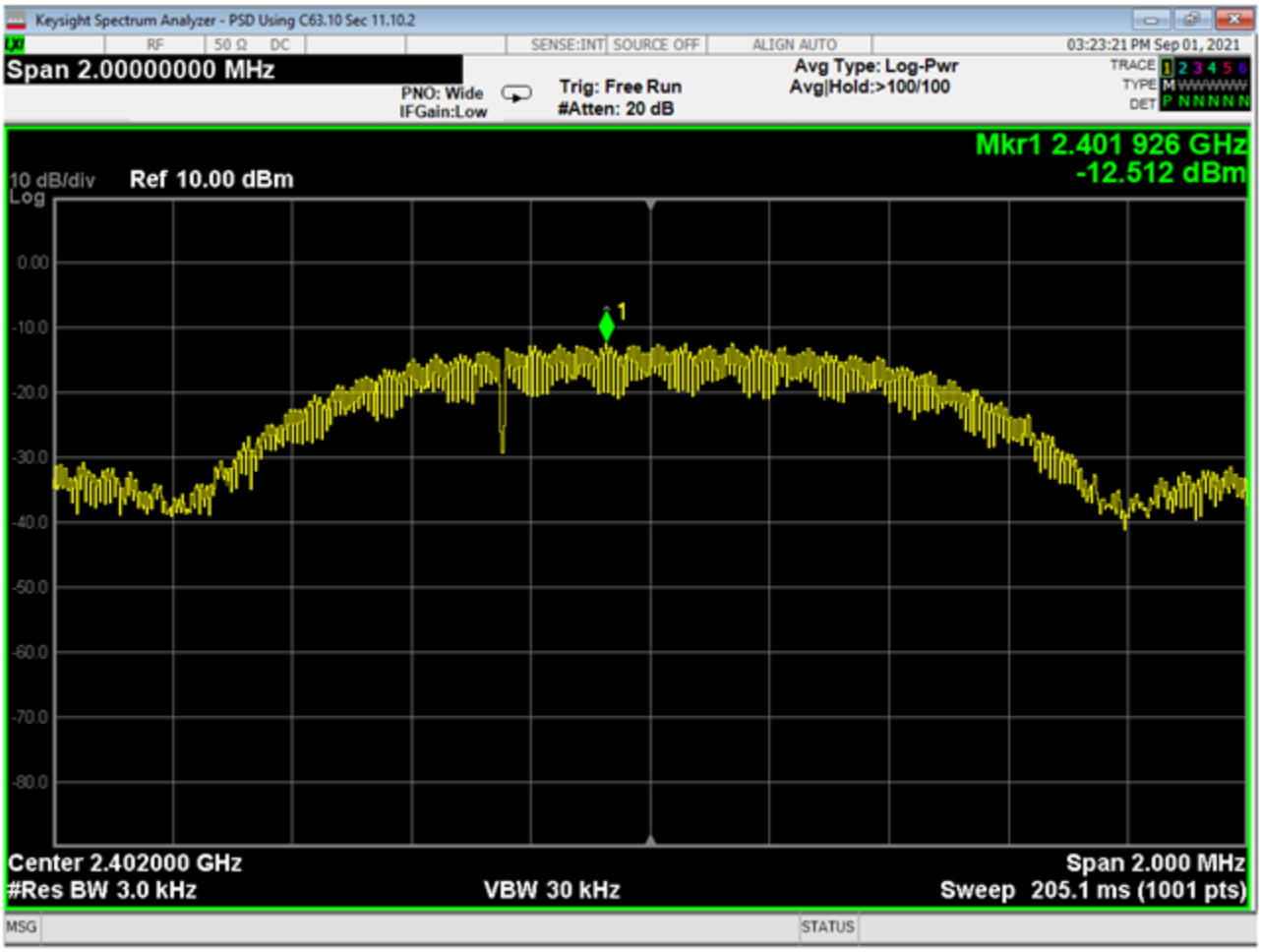
04 OBW 6dB, Low, ANT



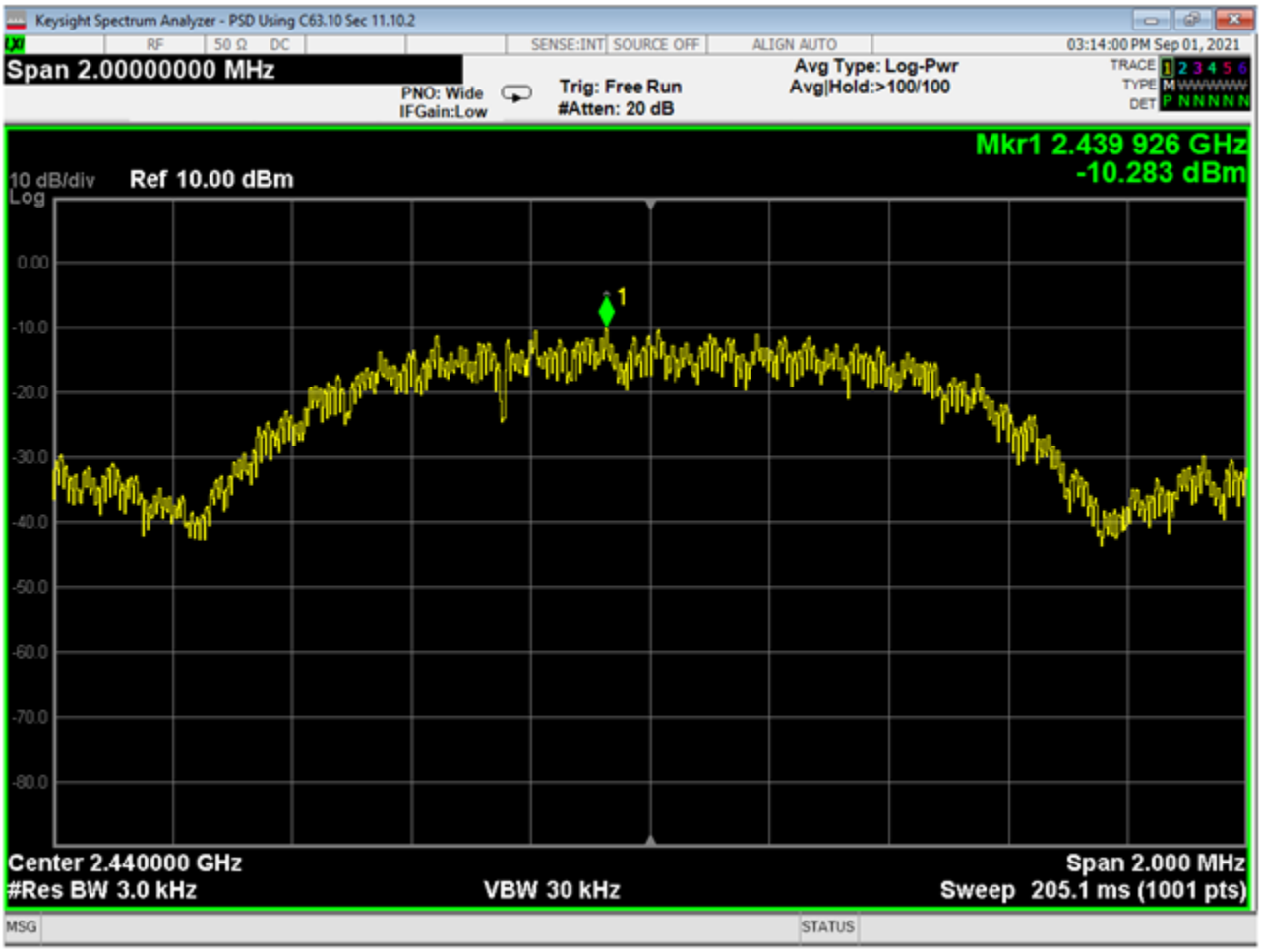
05 OBW 6dB, Mid, ANT



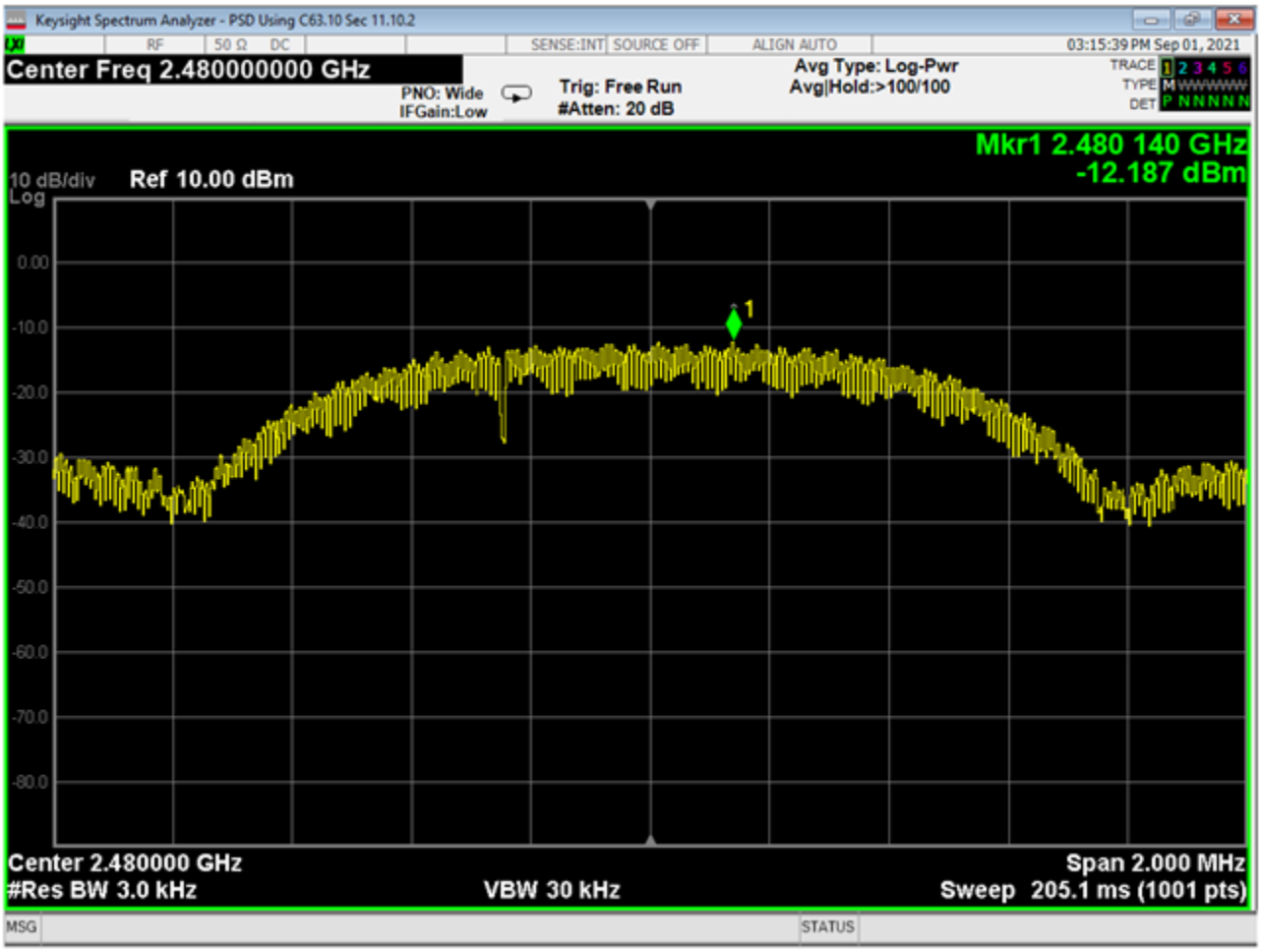
06 OBW 6dB, High, ANT



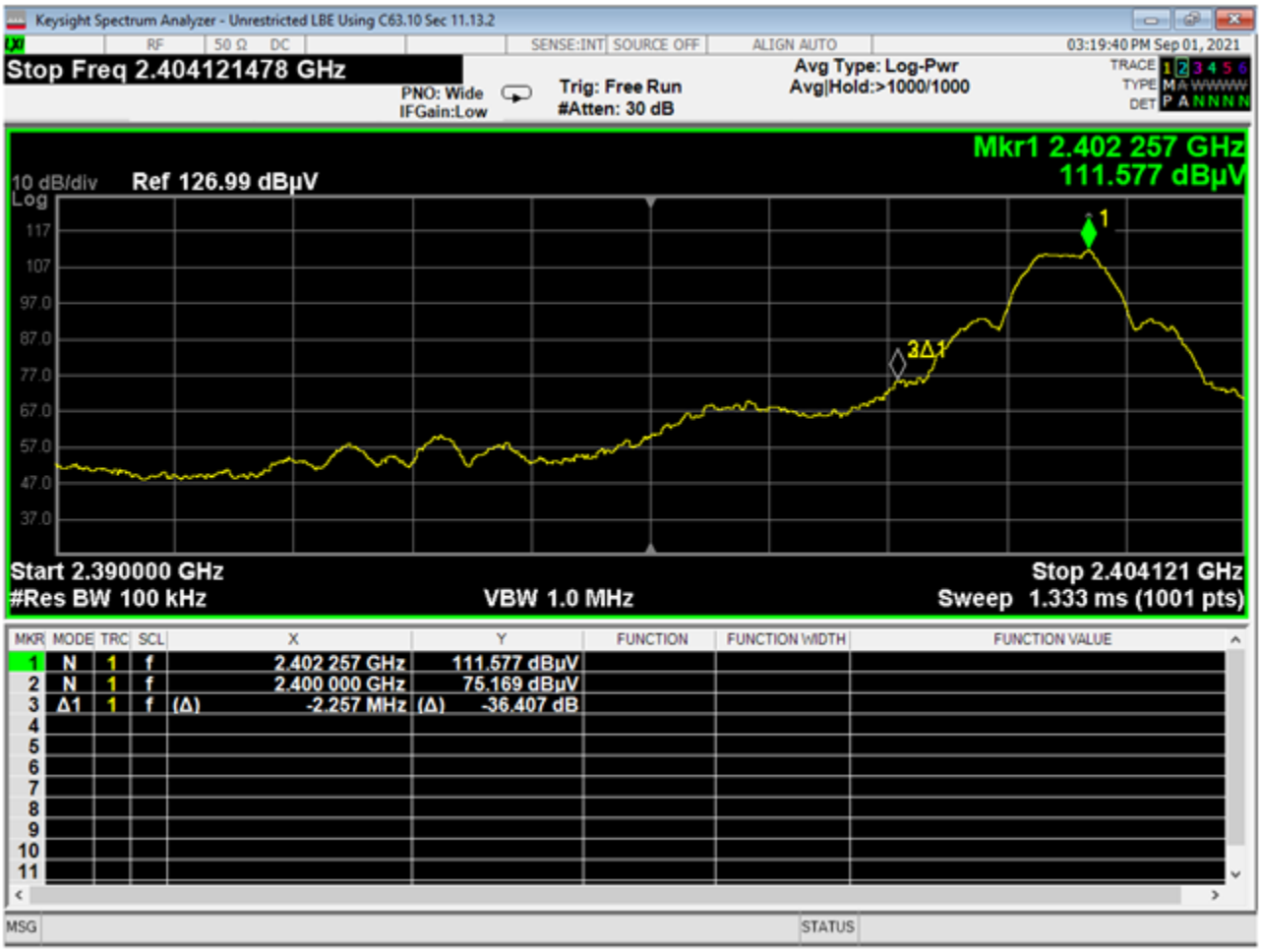
07 PSD, Low, ANT



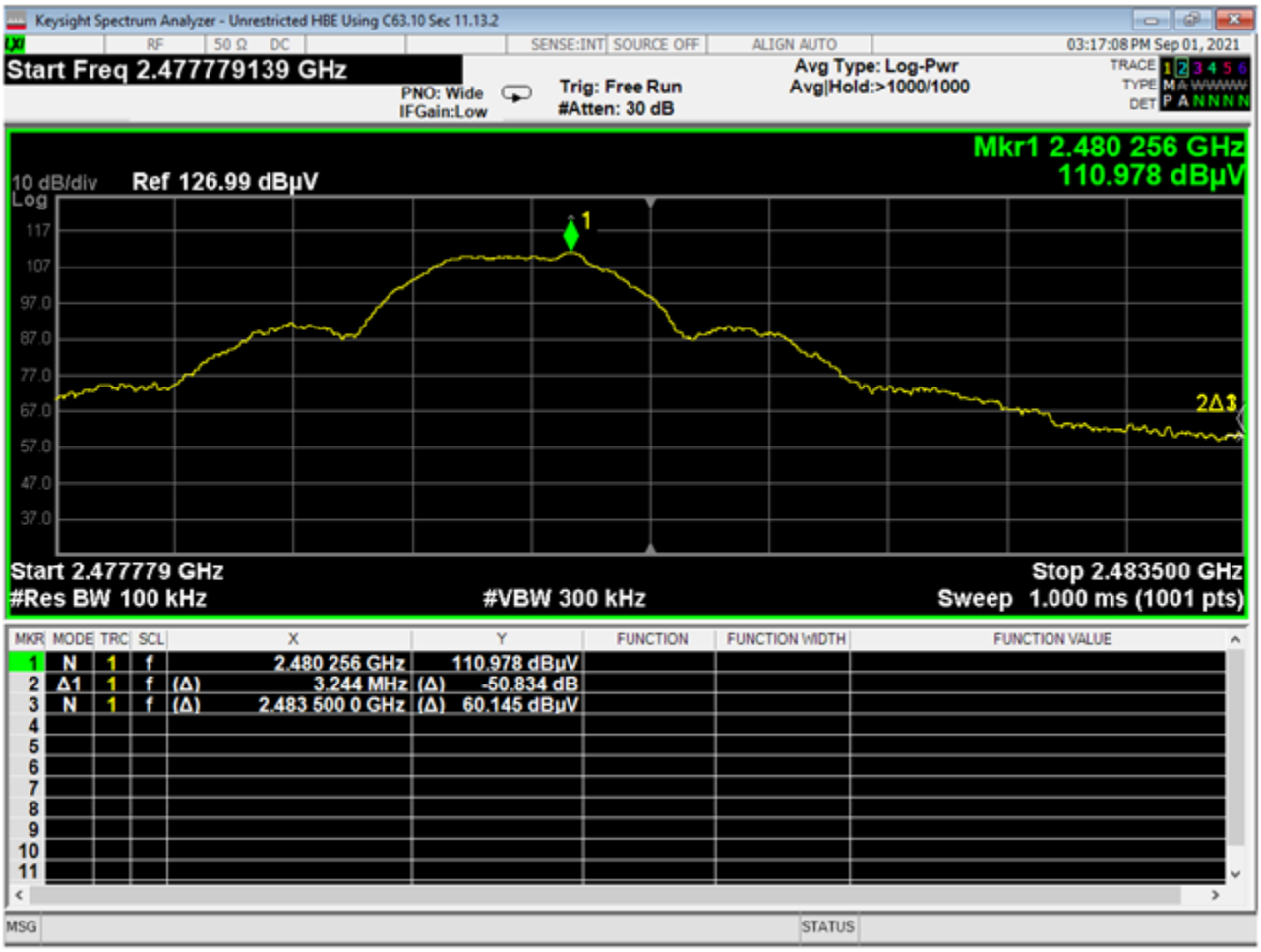
08 PSD, Mid, ANT



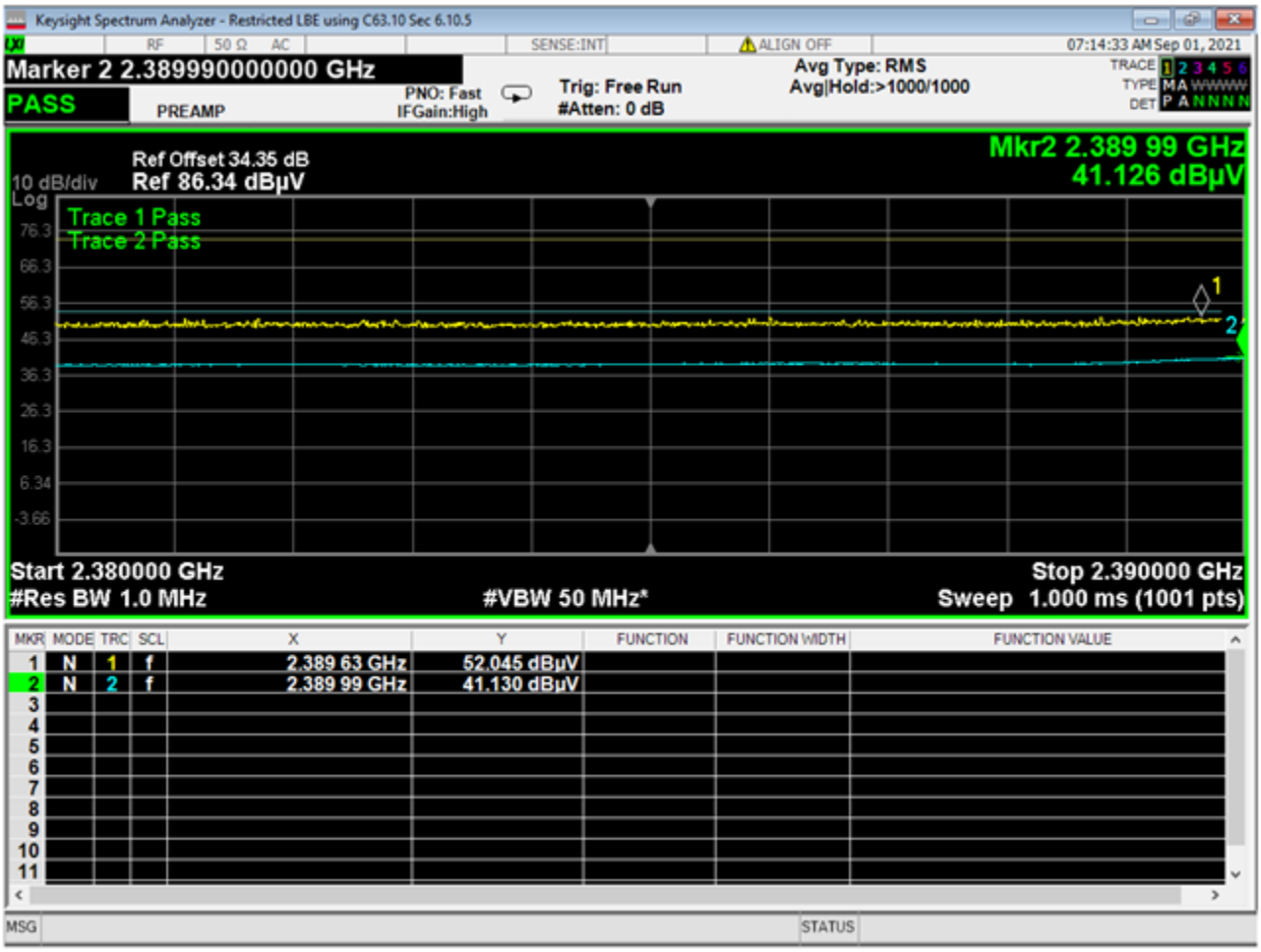
09 PSD, High, ANT



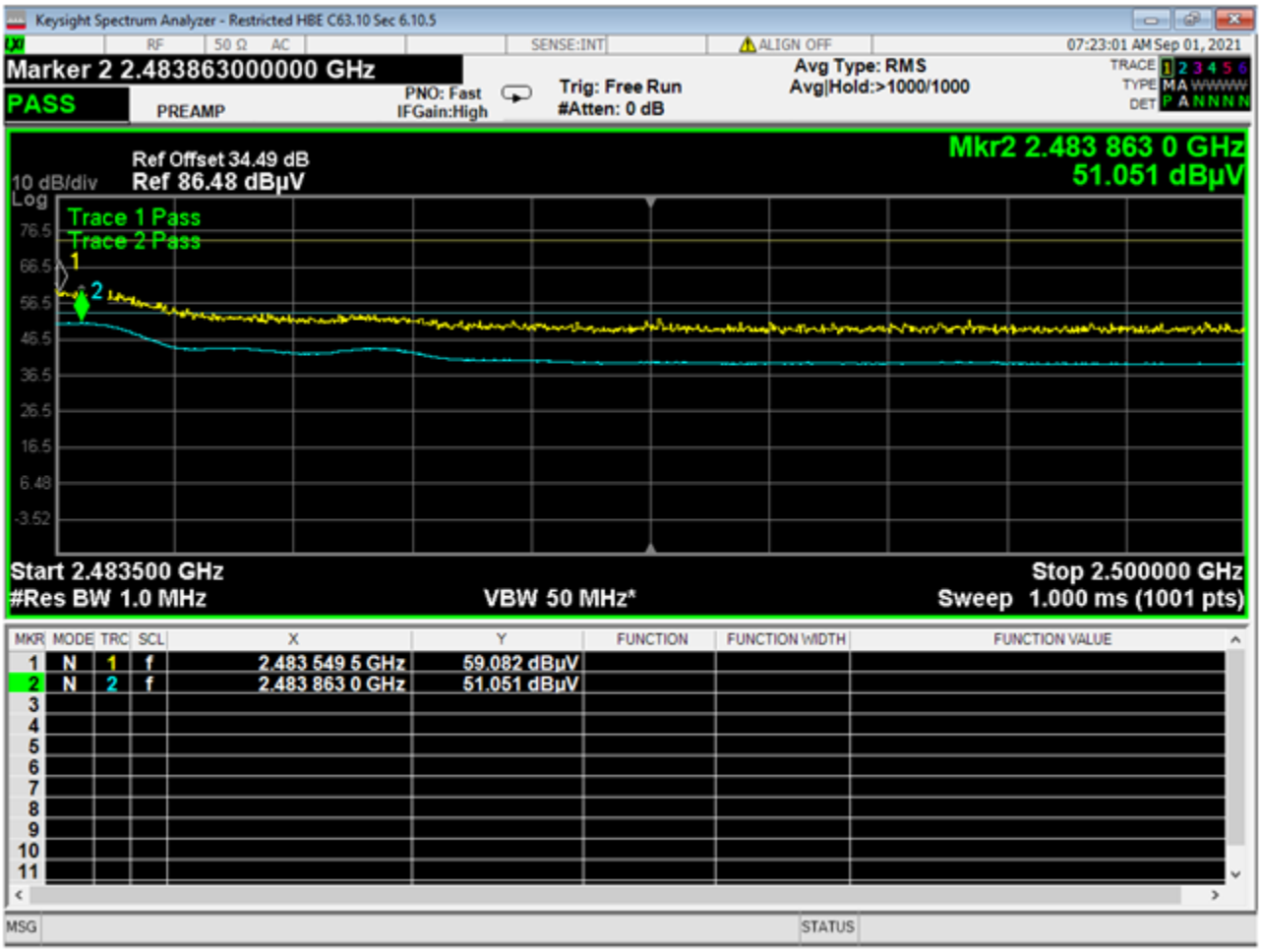
10 Lower Bandedge, Unrestricted, ANT



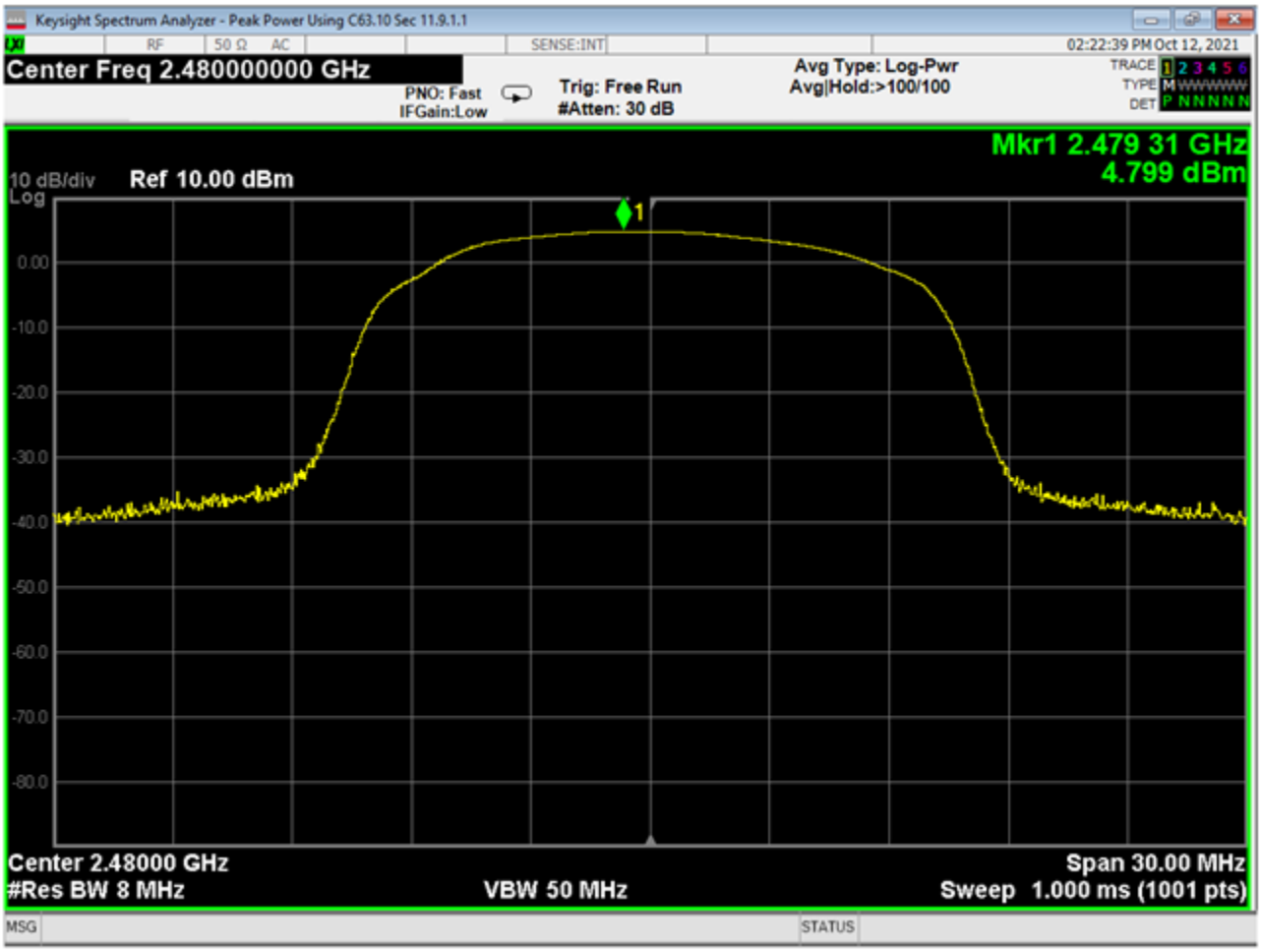
11 Higher Bandedge, Unrestricted, ANT



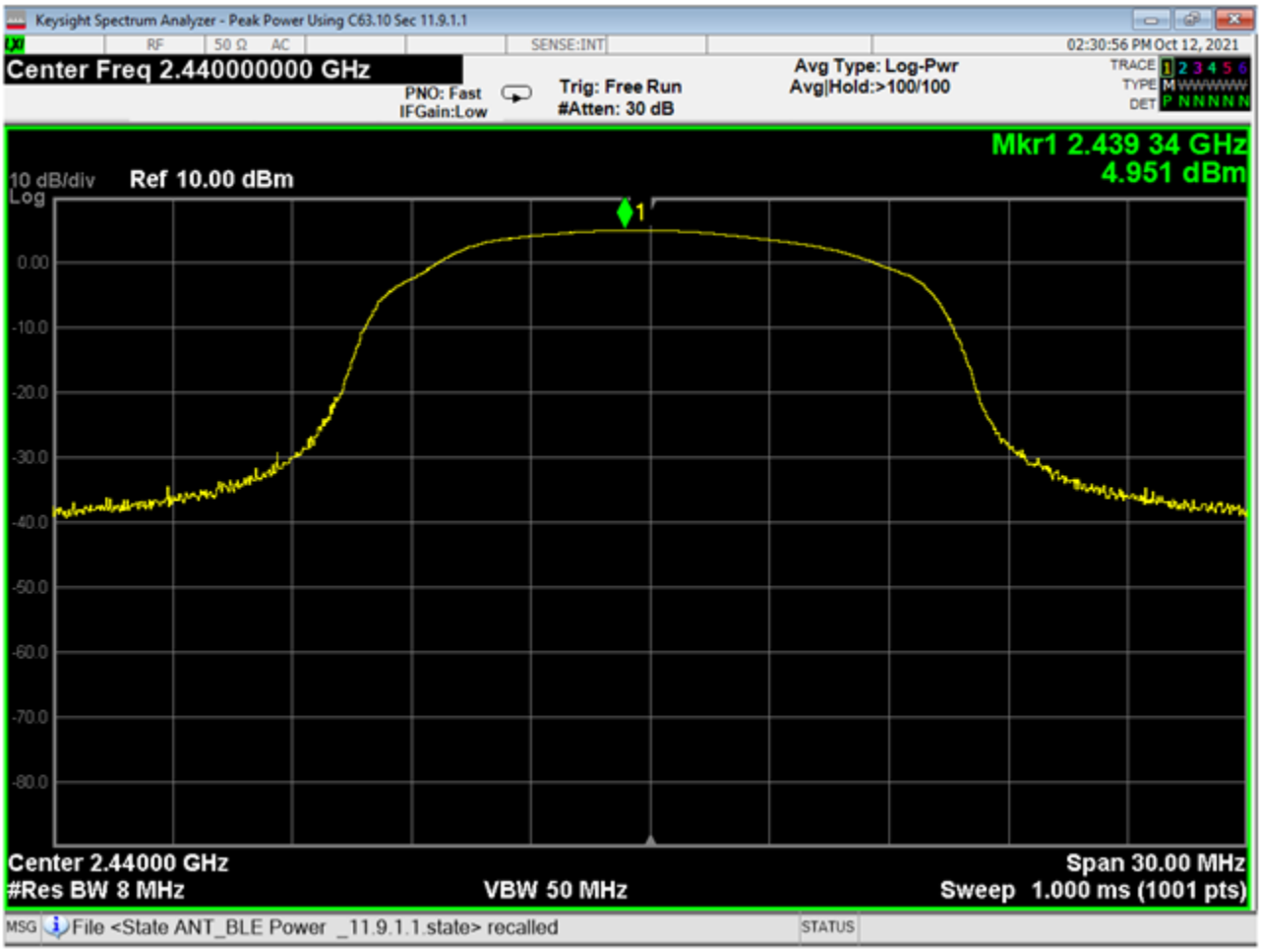
12 Lower Bandedge, Restricted, ANT



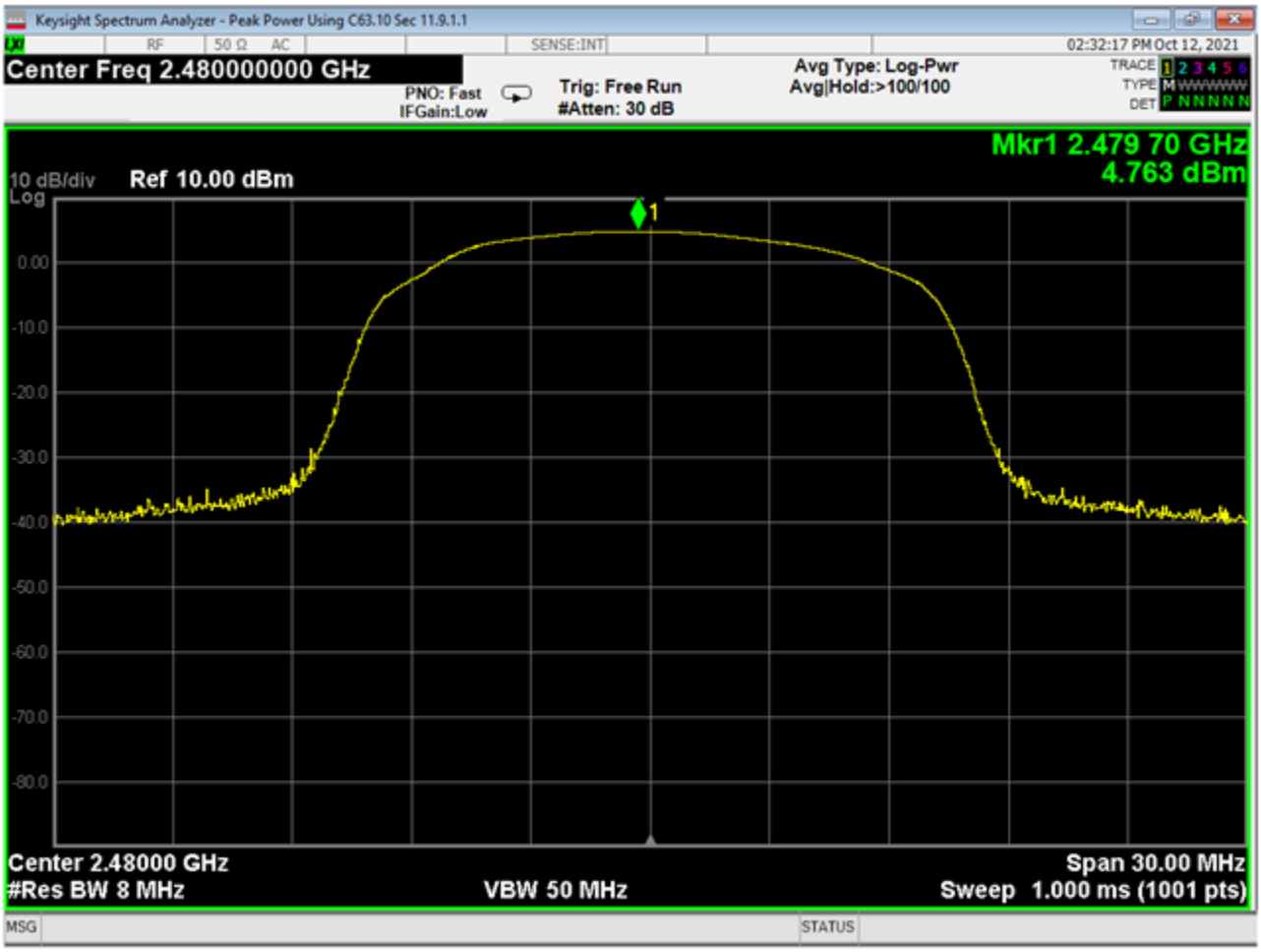
13 Higher Bandedge, Restricted, ANT



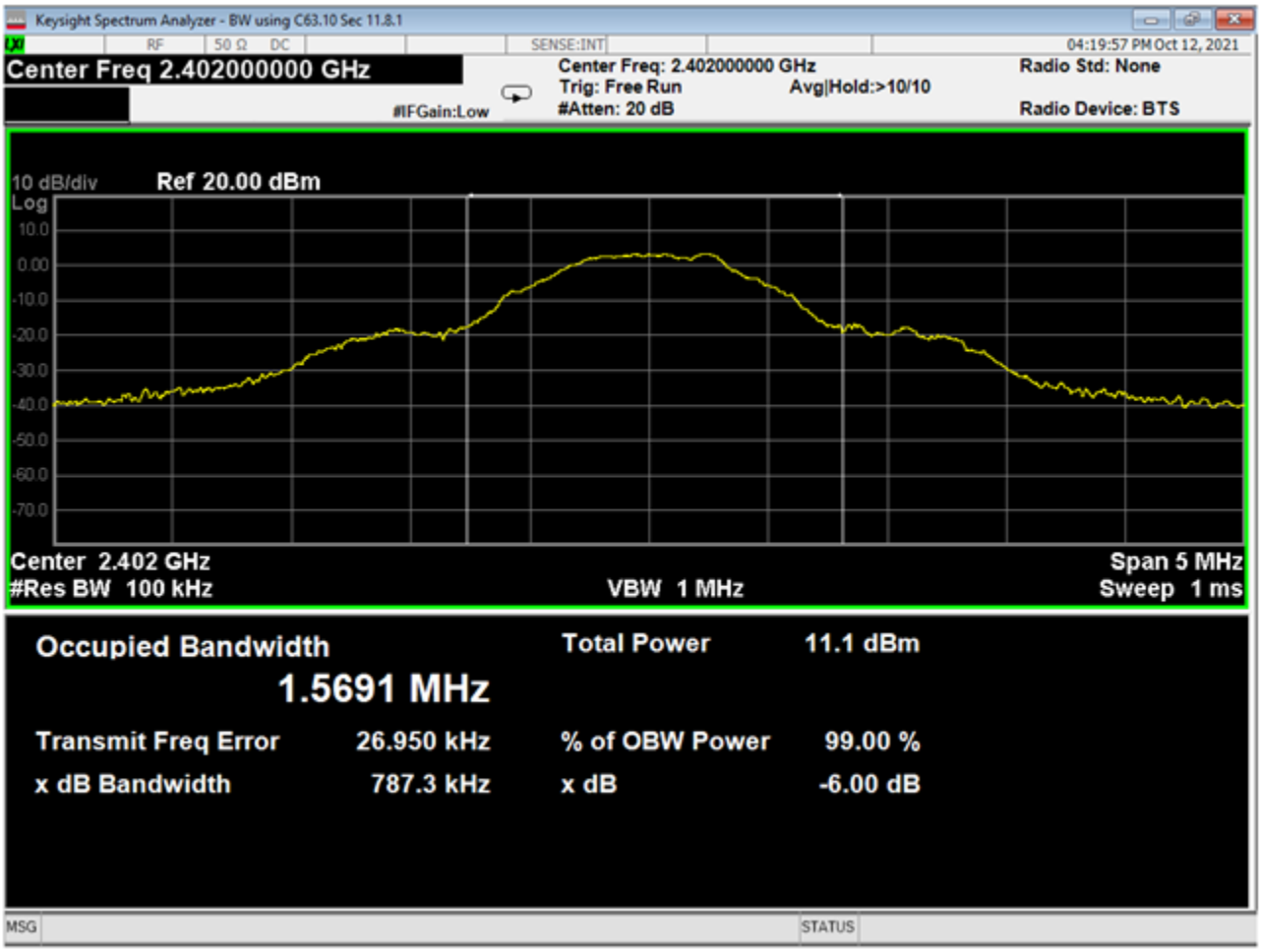
14 Power, Low, BLE 1MB



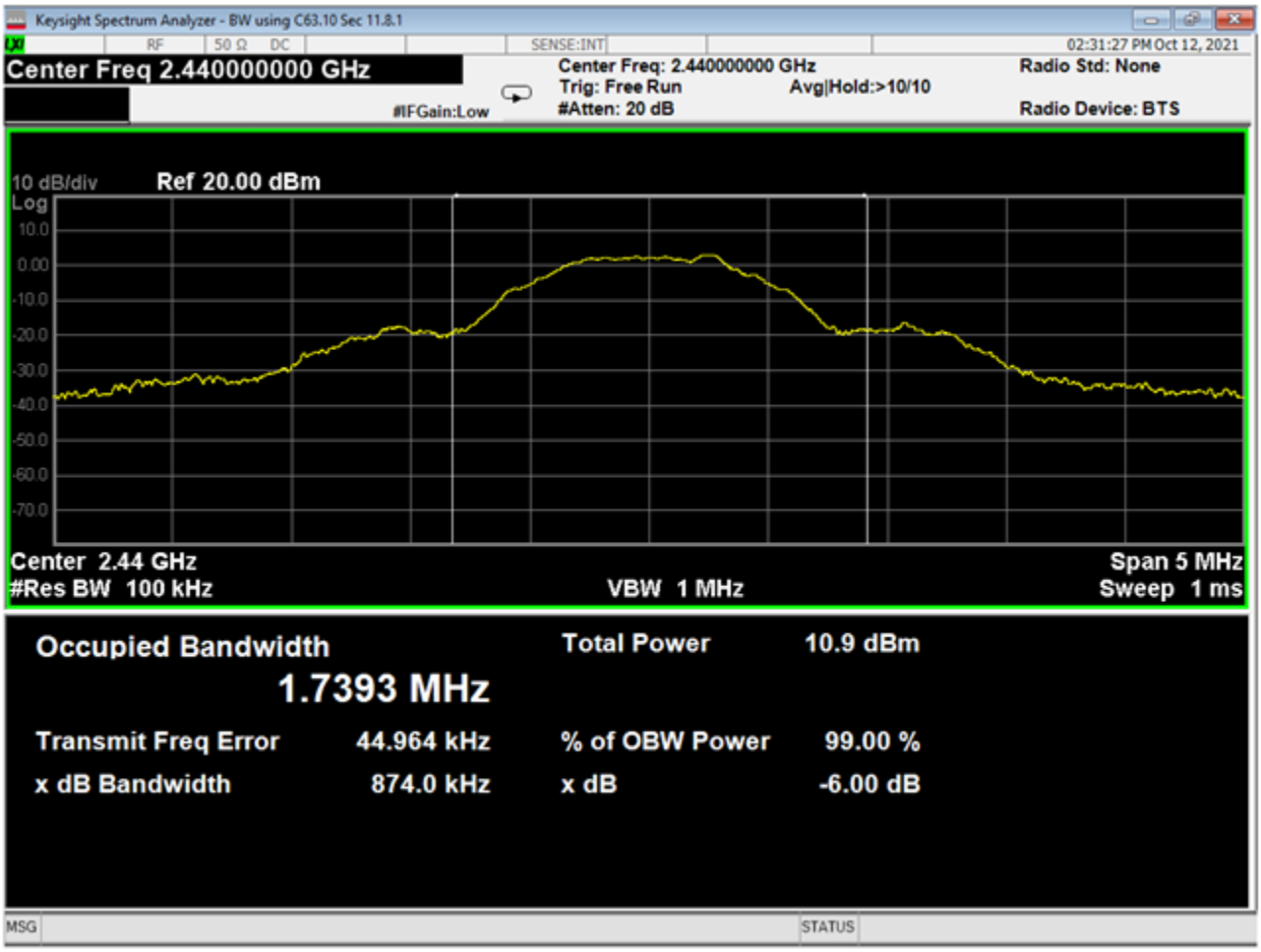
15 Power, Mid, BLE 1MB



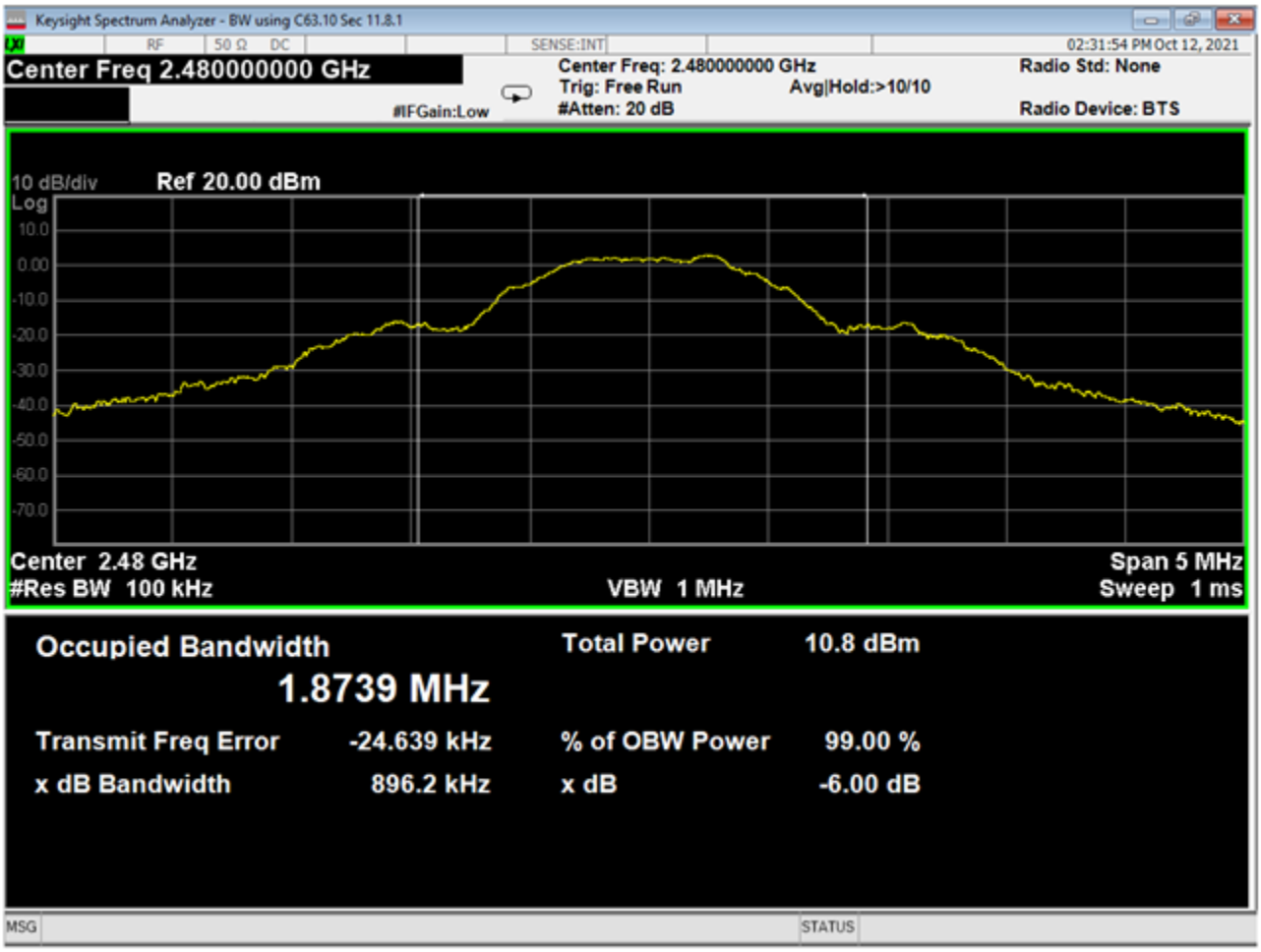
16 Power, High, BLE 1MB



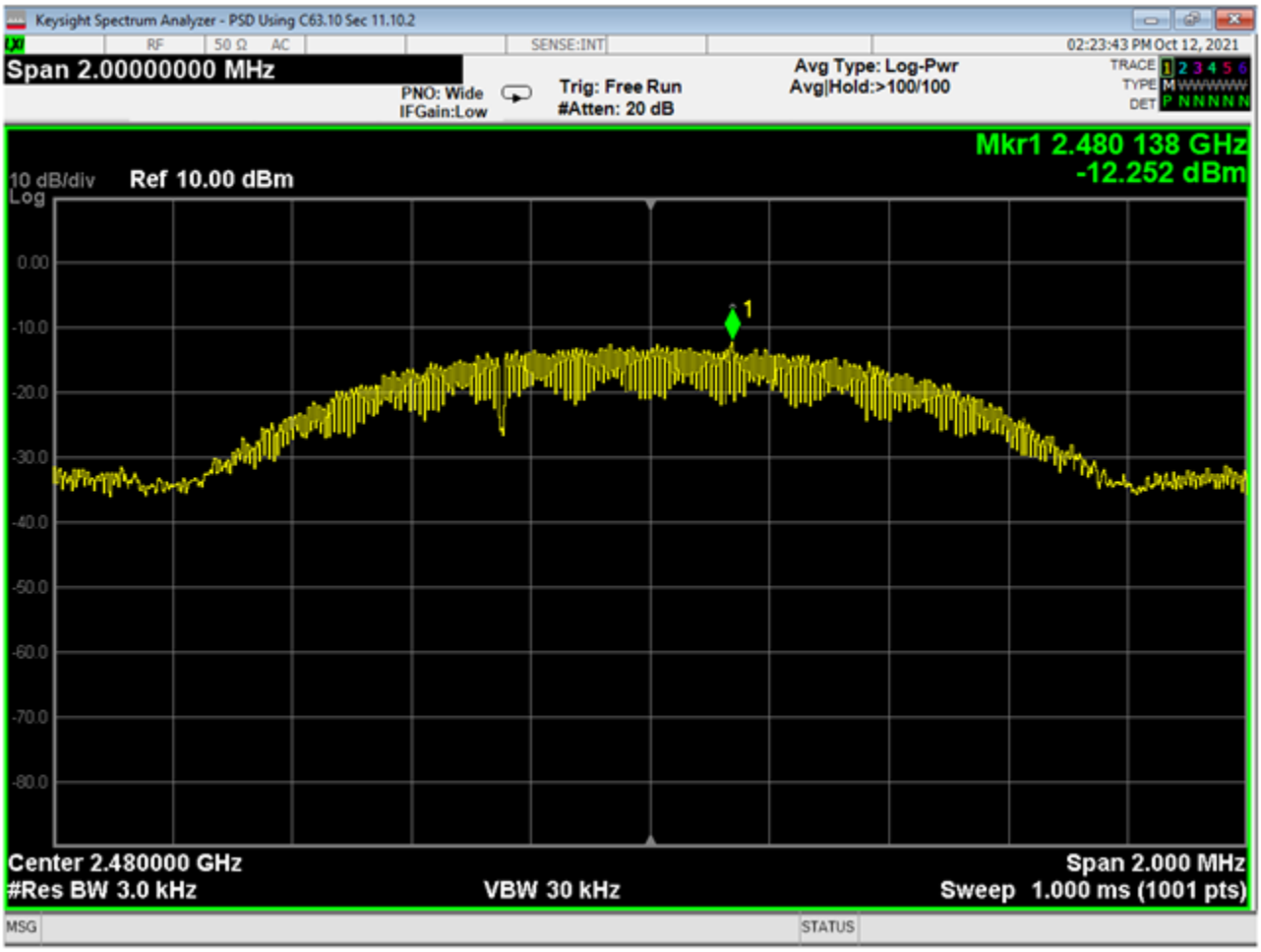
17 OBW-6dB, Low, BLE 1MB



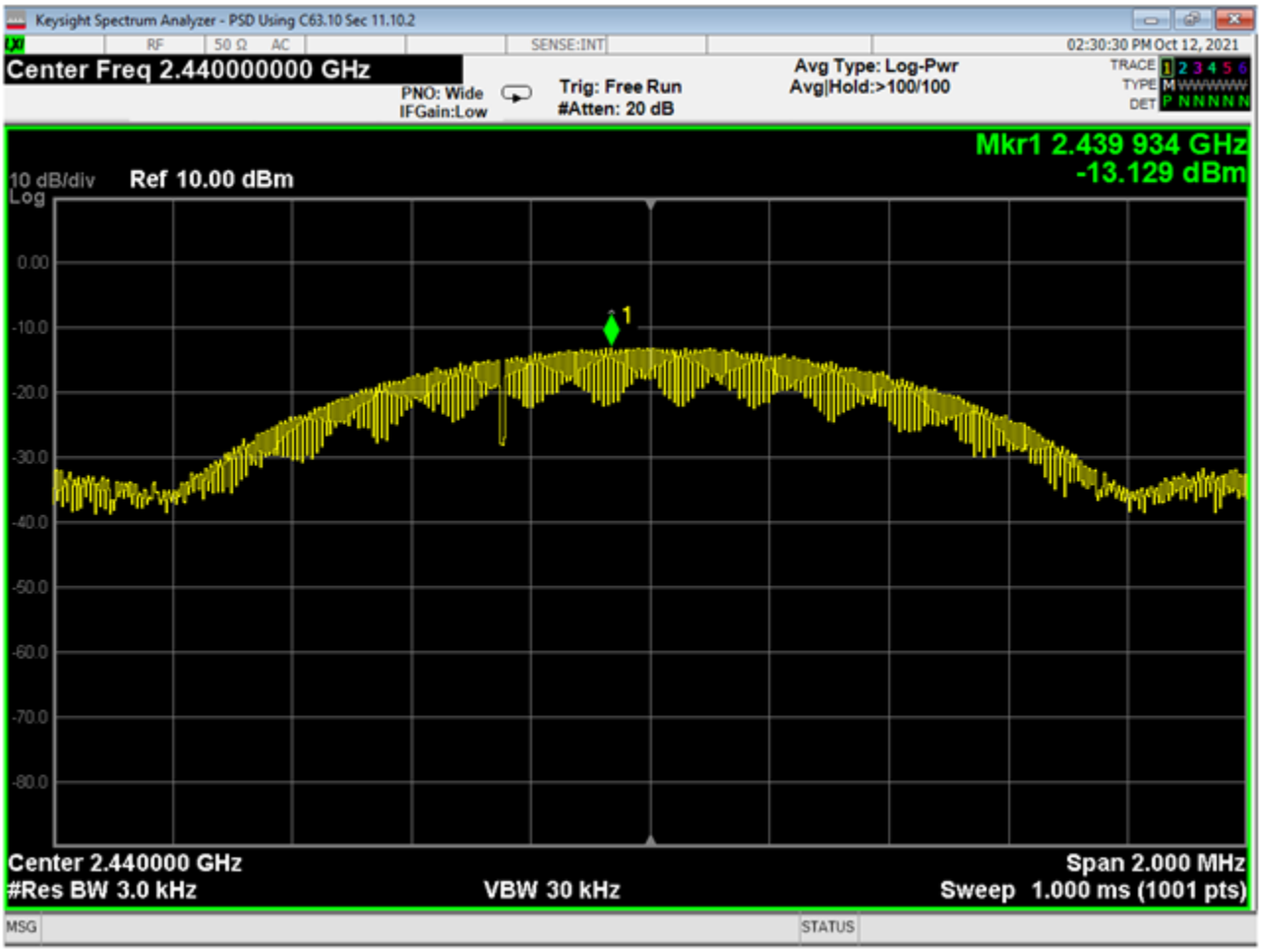
18 OBW-6dB, Mid, BLE 1MB



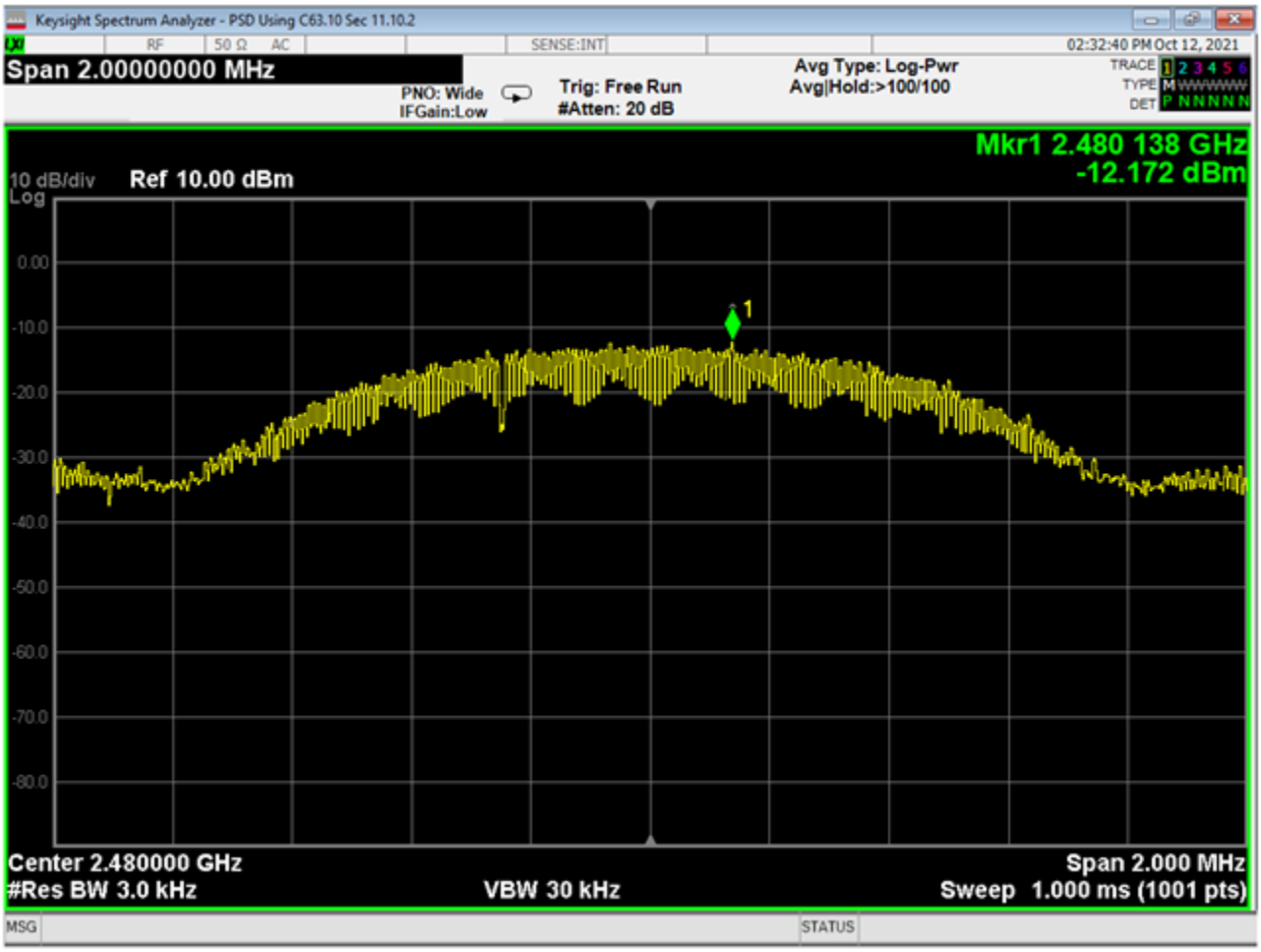
19 OBW-6dB, High, BLE 1MB



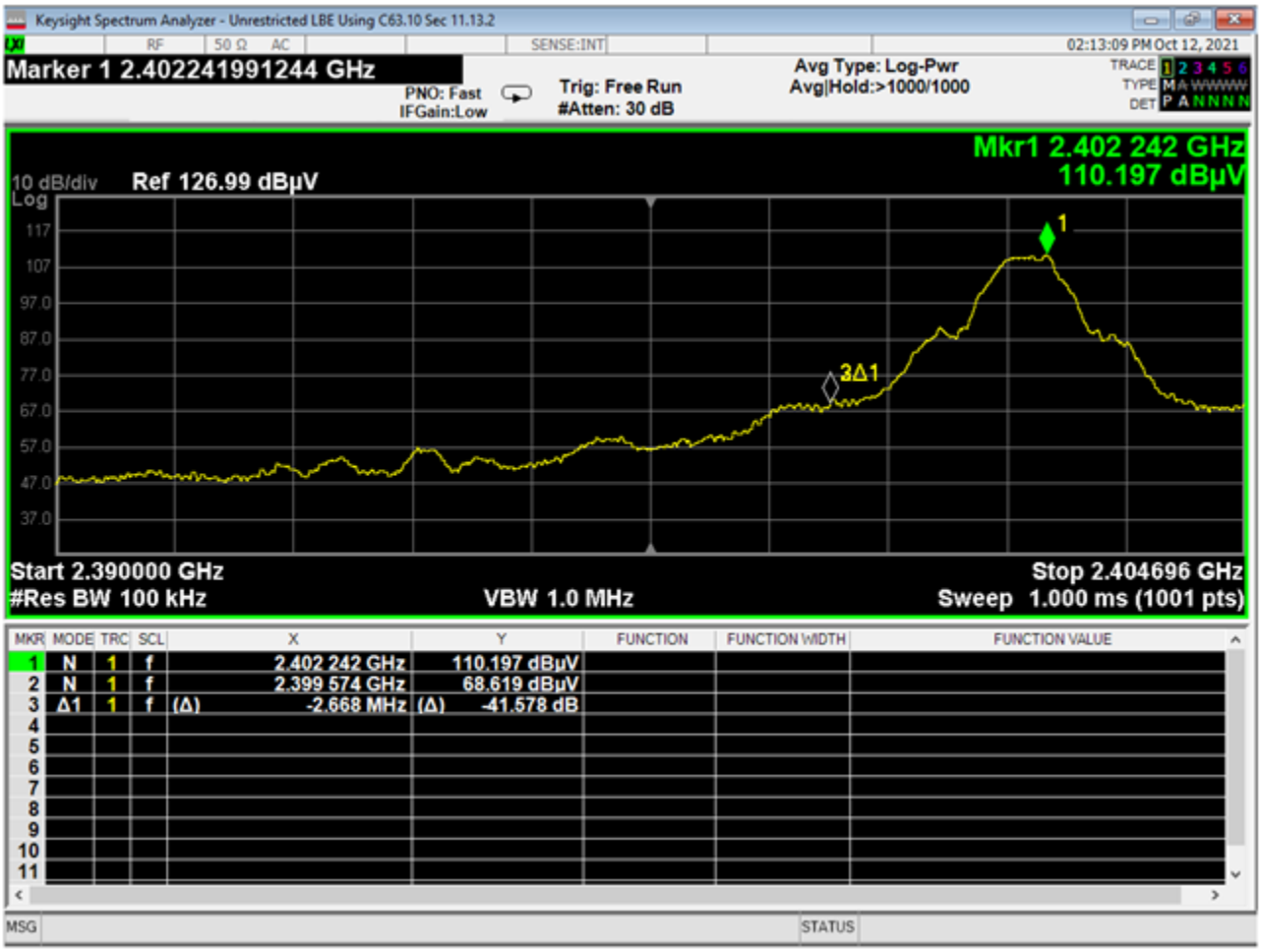
20 PSD, Low, BLE 1MB



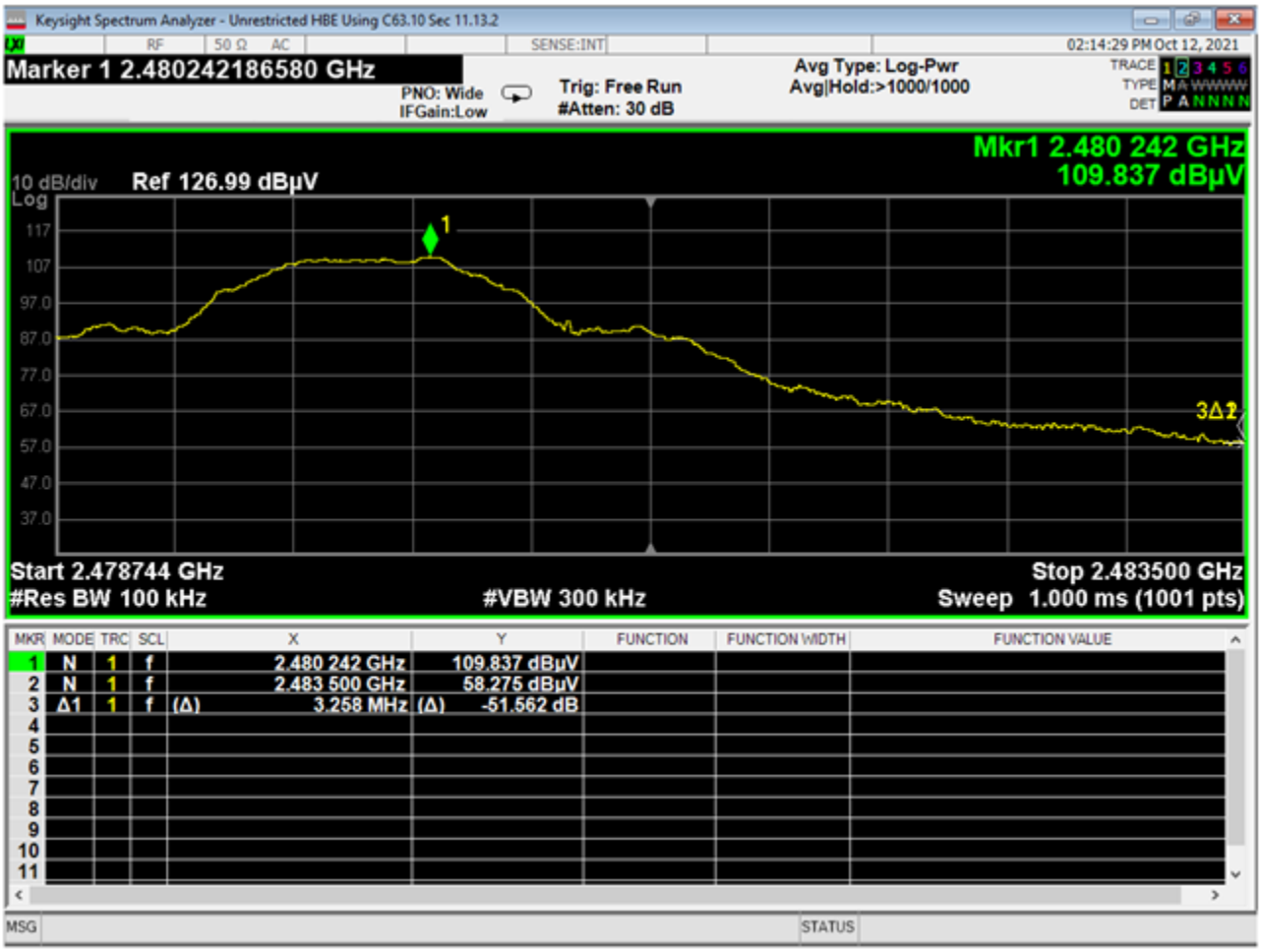
21 PSD, Mid, BLE 1MB



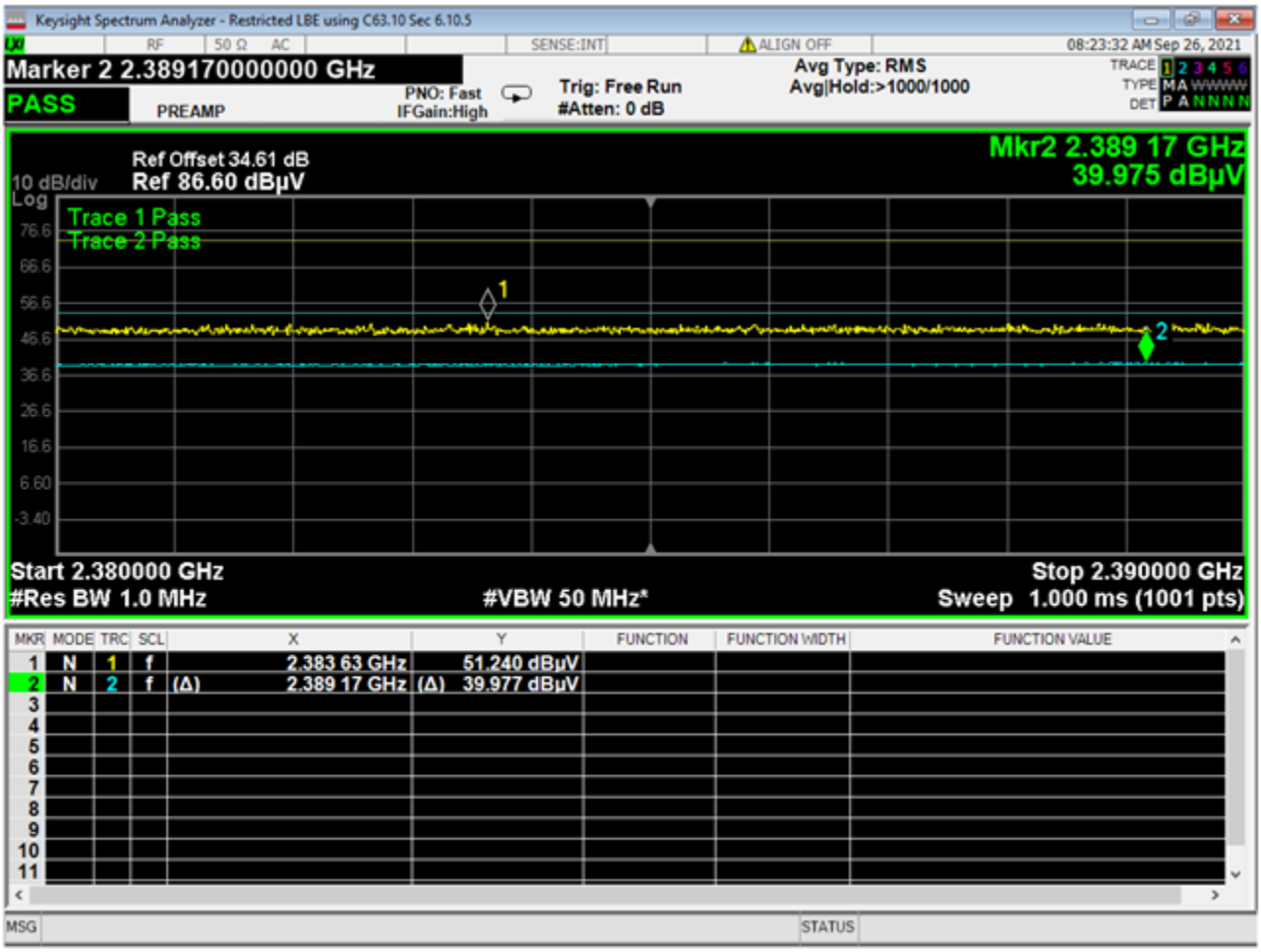
22 PSD, High, BLE 1MB



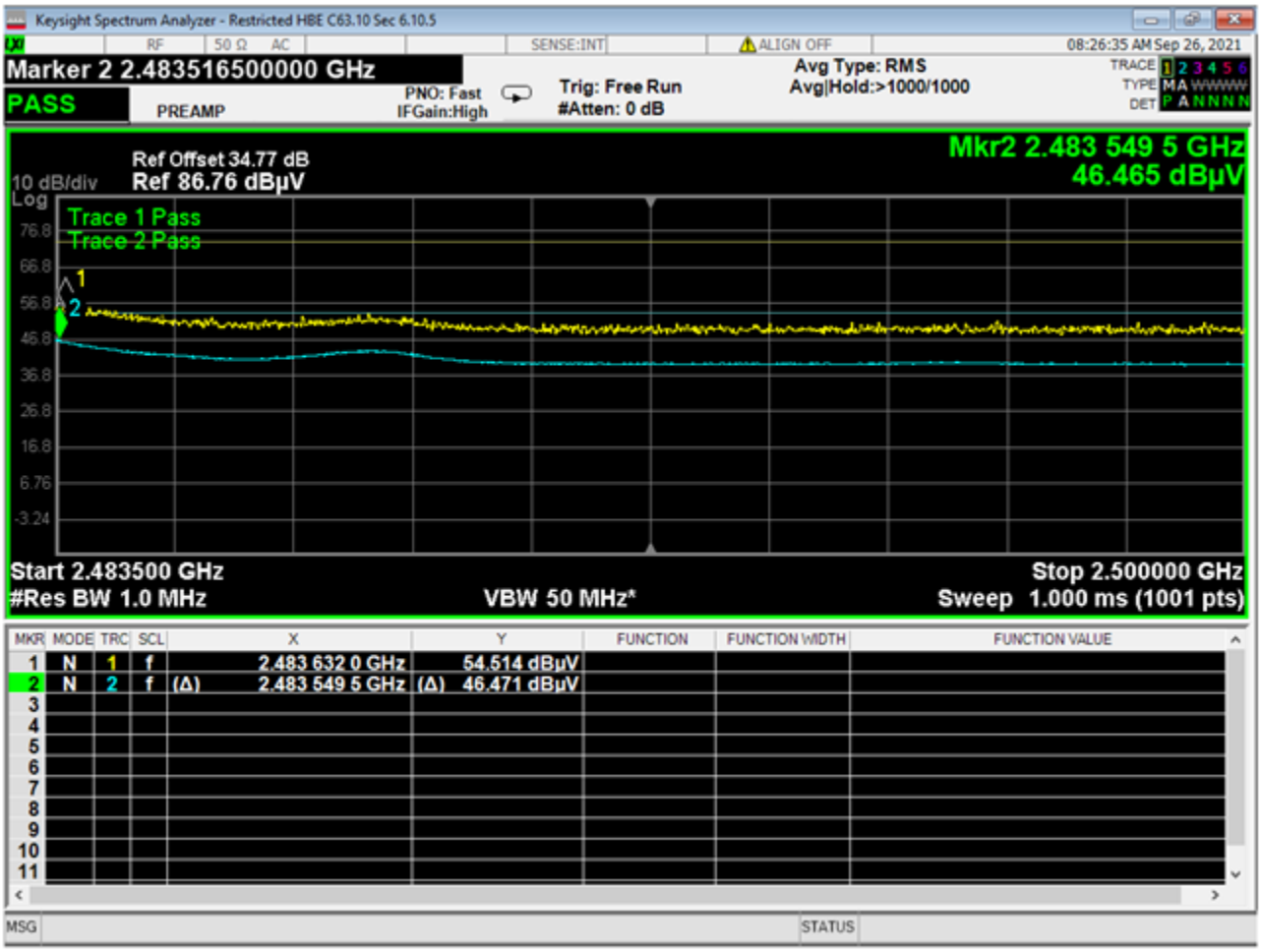
23 Lower Bandedge, Unrestricted, BLE 1MB



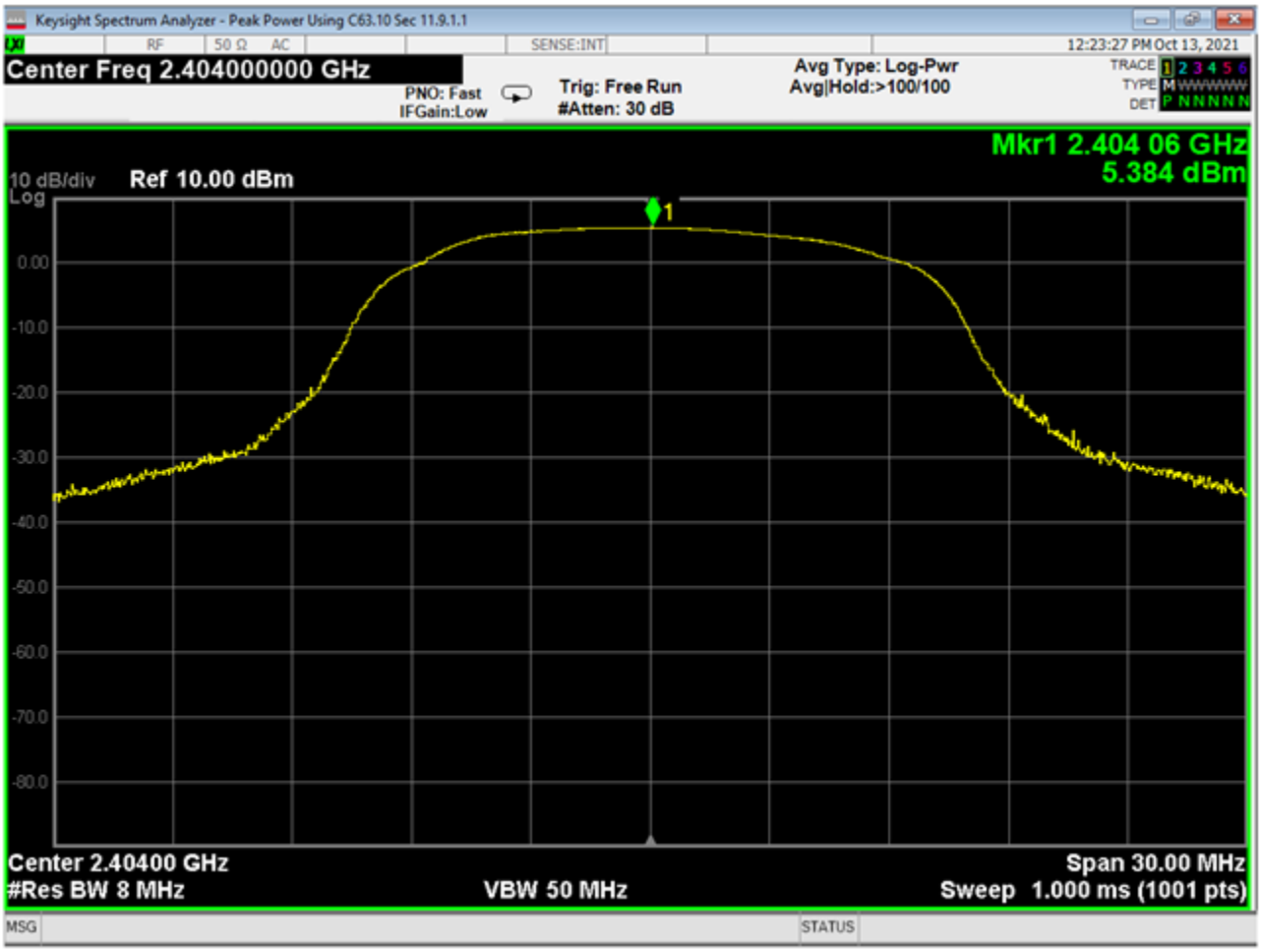
24 Higher Bandedge, Unrestricted, BLE 1MB



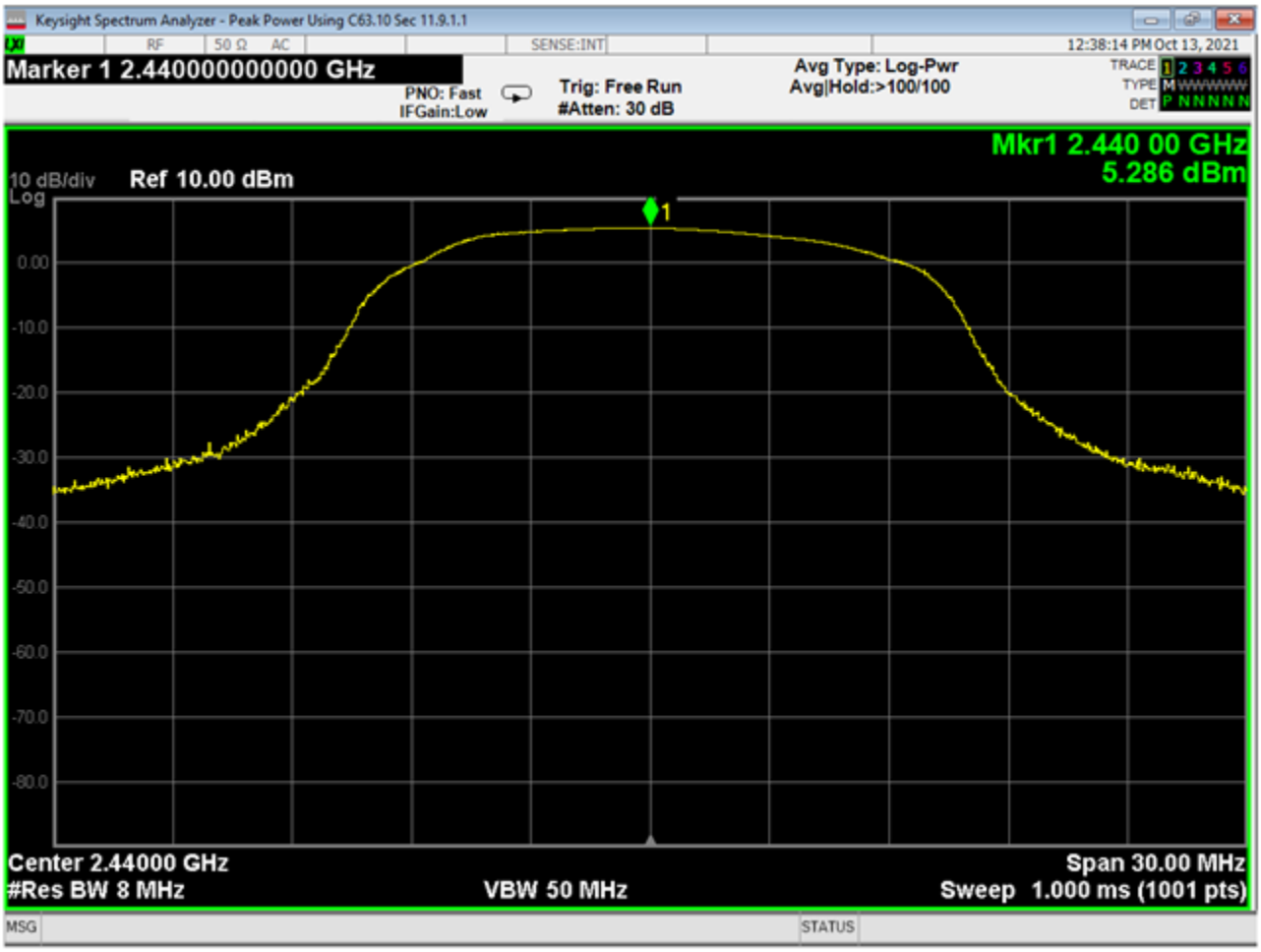
25 Lower Bandedge, Restricted, BLE 1MB



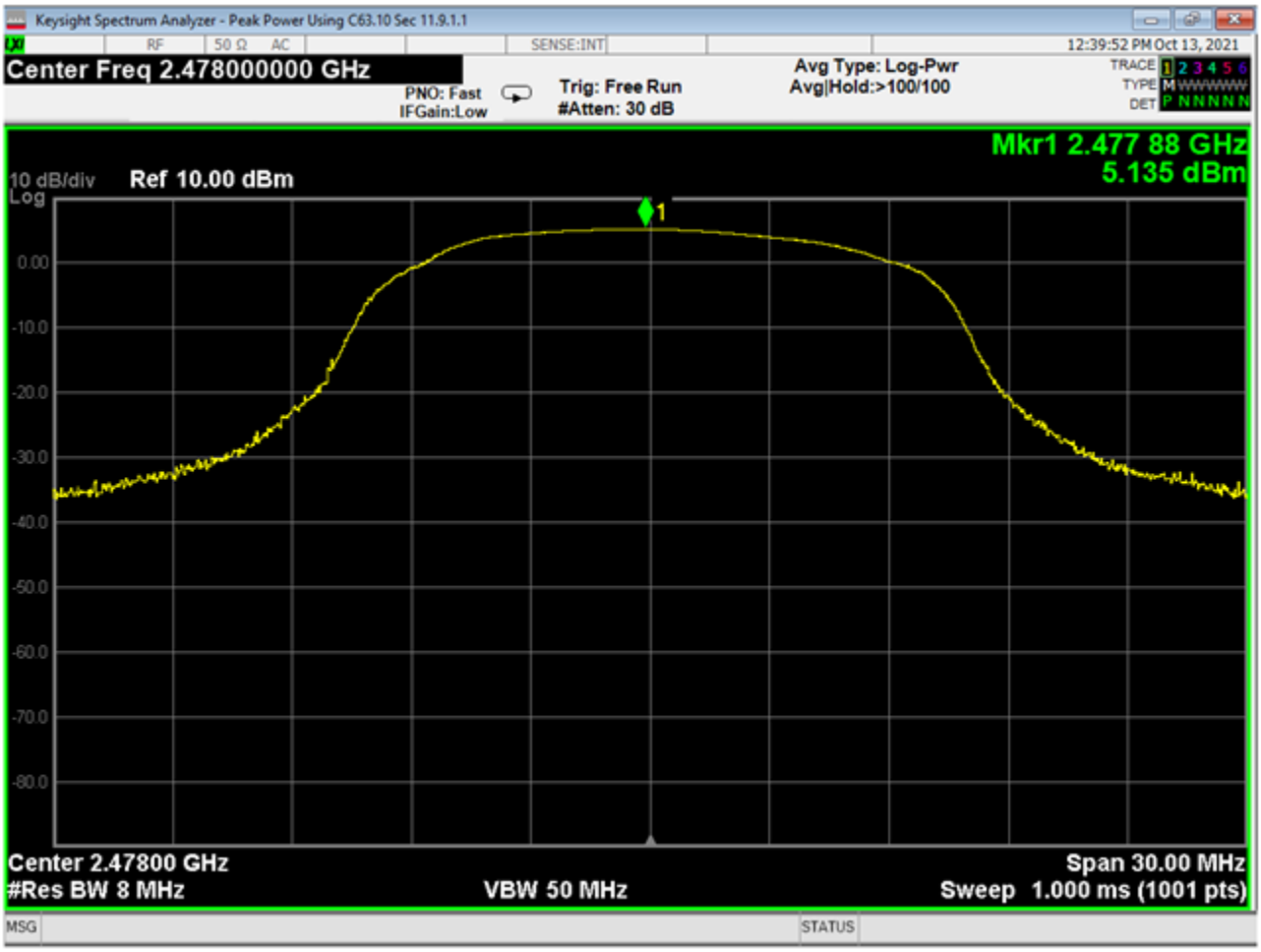
26 Higher Bandedge, Restricted, BLE 1MB



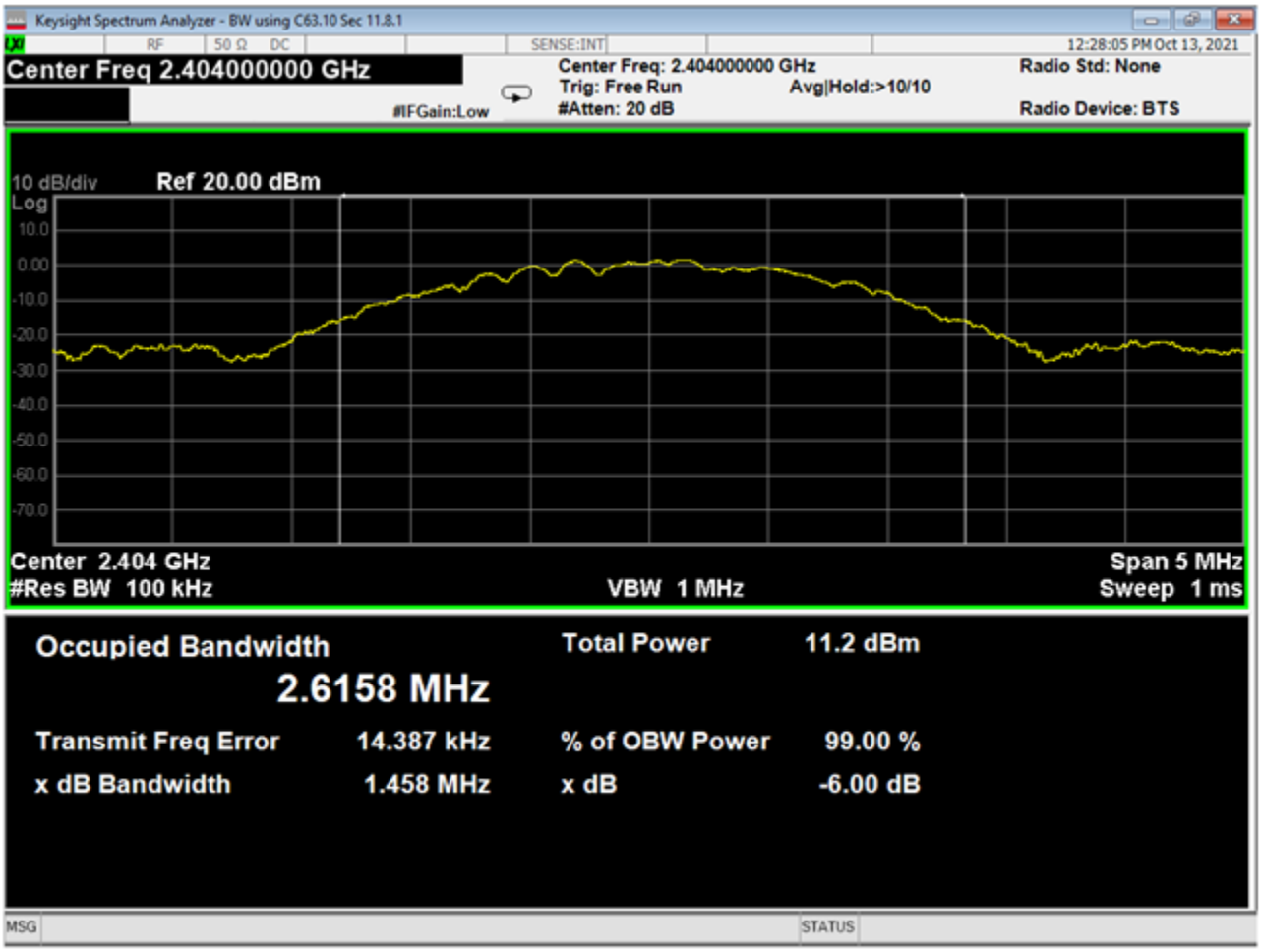
27 Power, Low, BLE 2MB



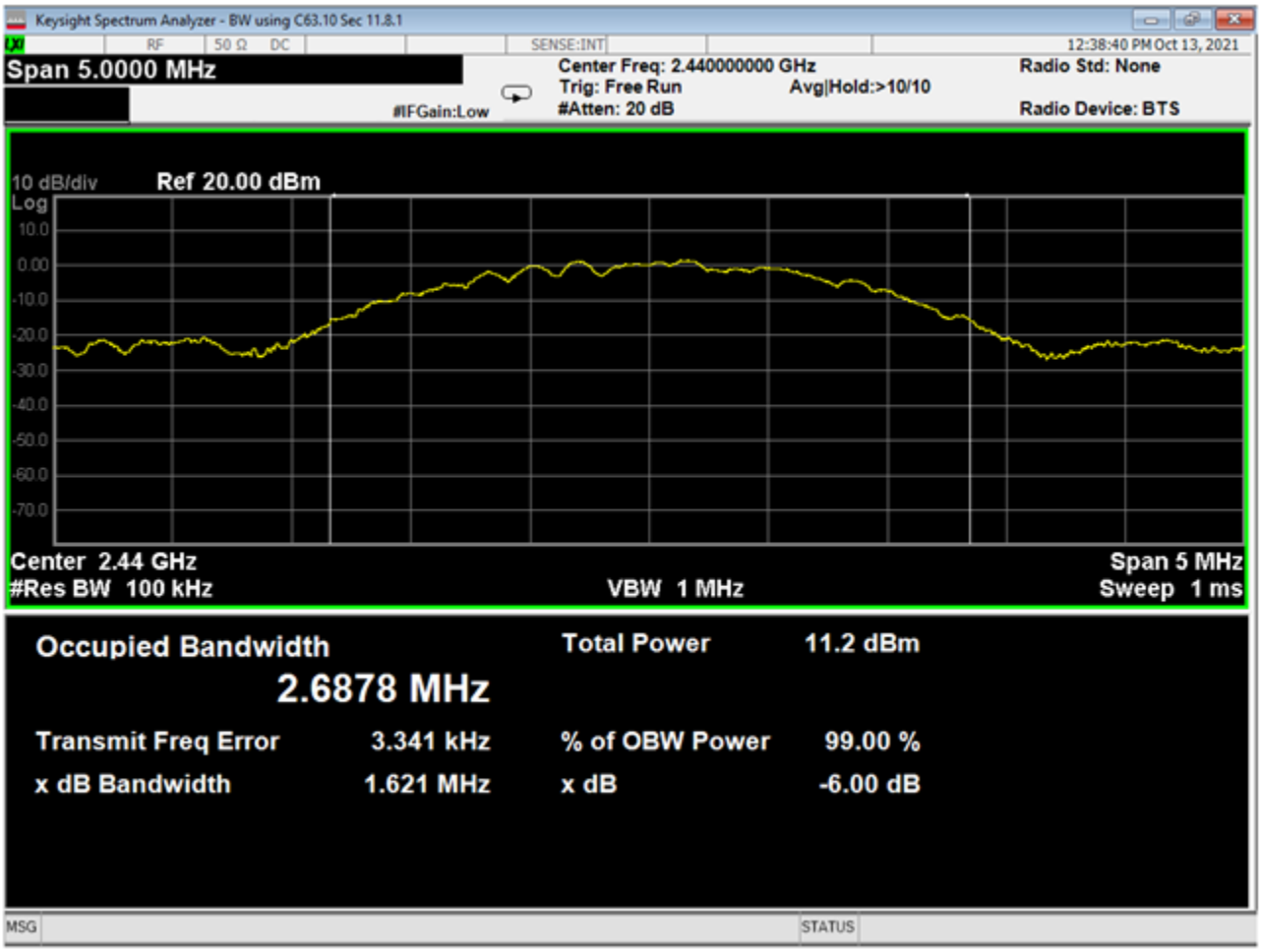
28 Power, Mid, BLE 2MB



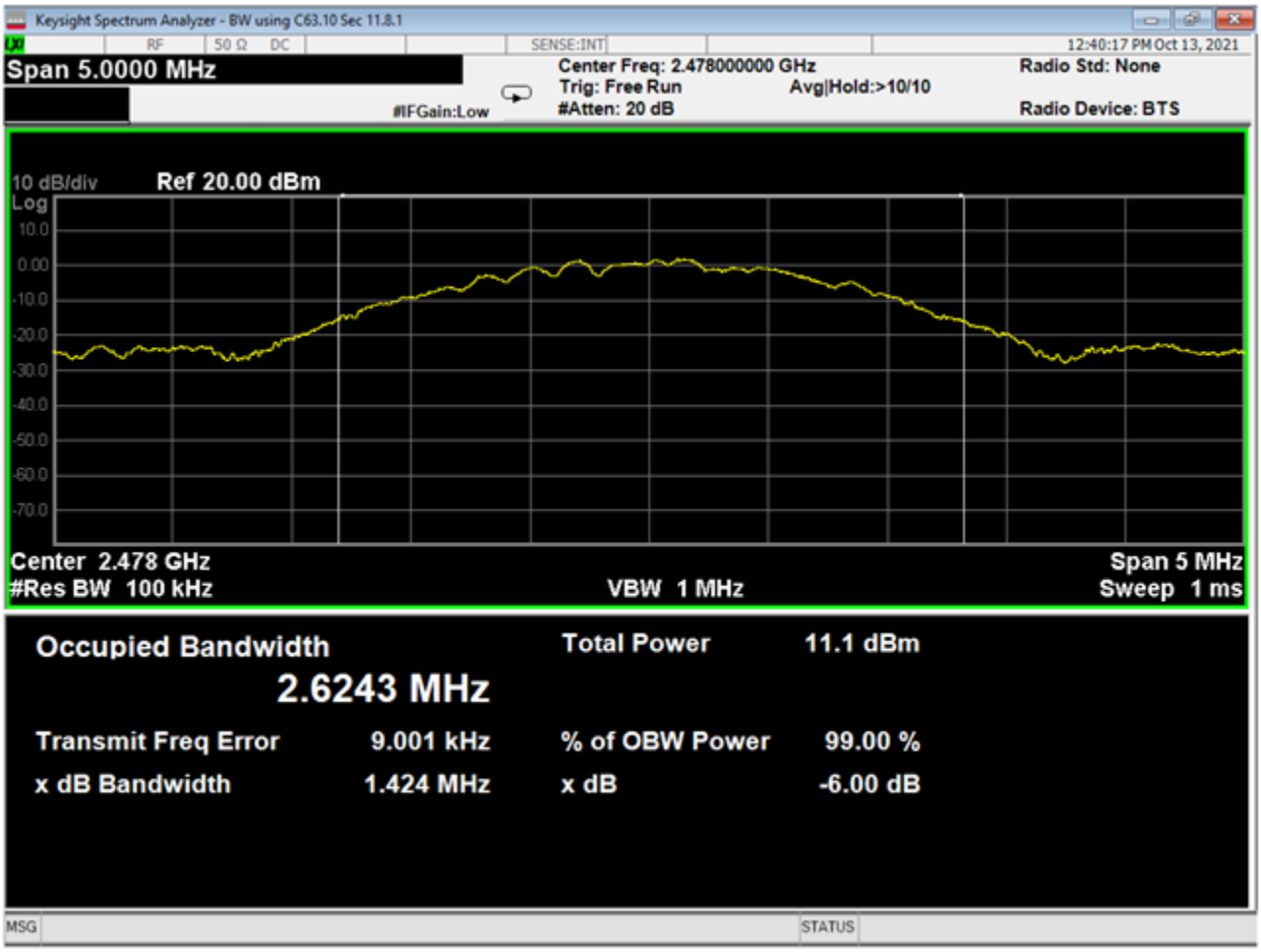
29 Power, High, BLE 2MB



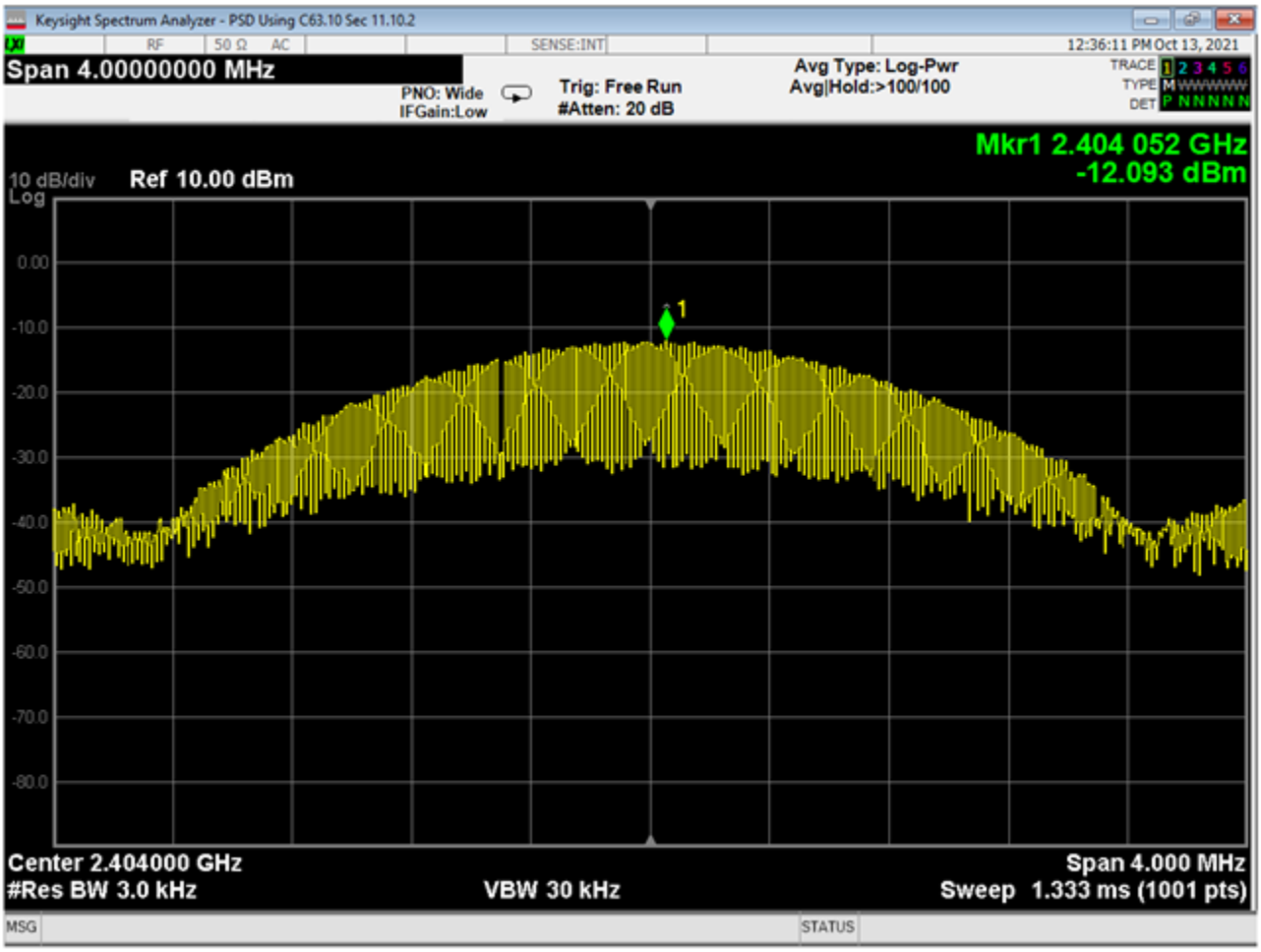
30 OBW-6dB, Low, BLE 2MB



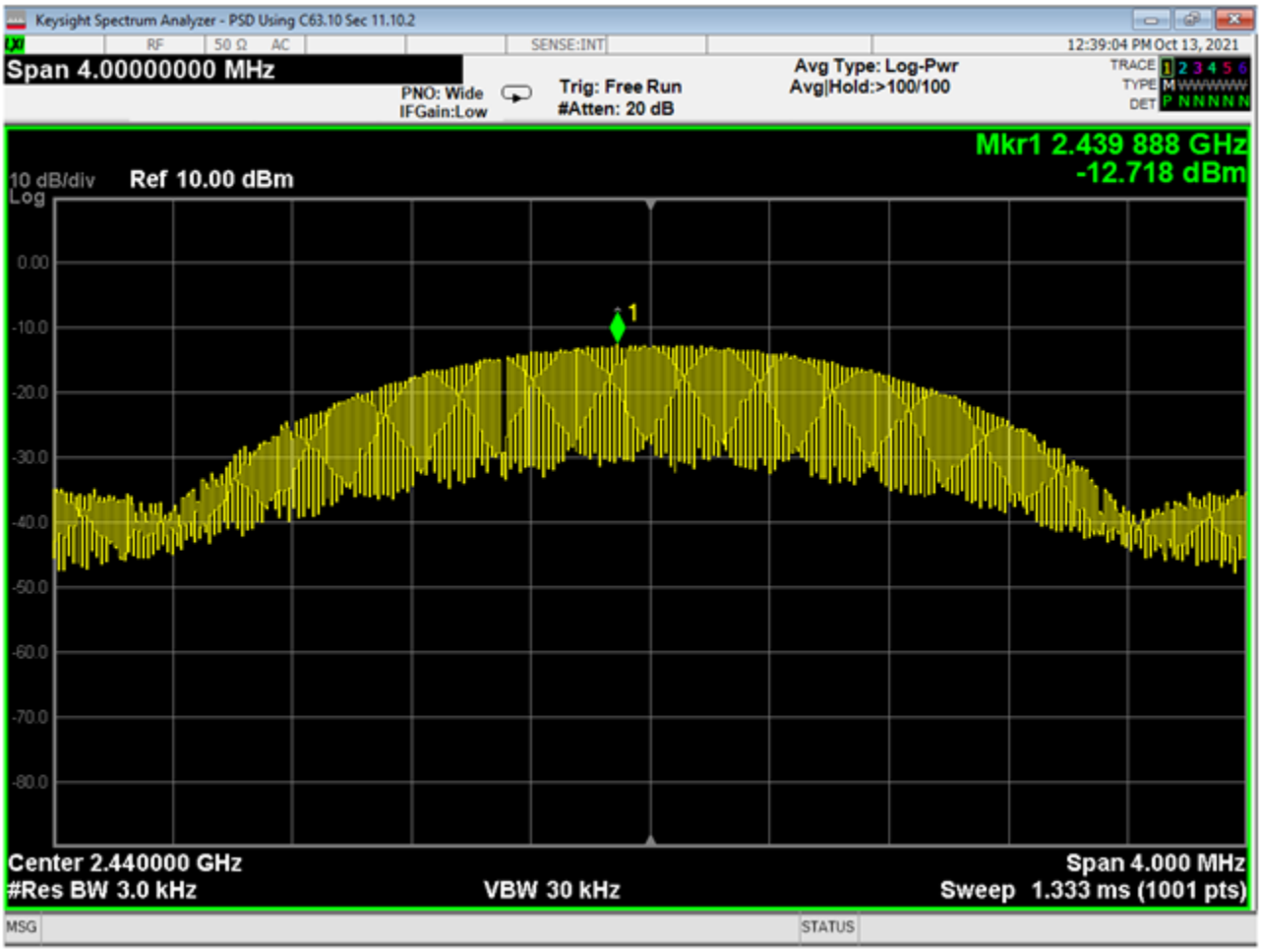
31 OBW-6dB, Mid, BLE 2MB



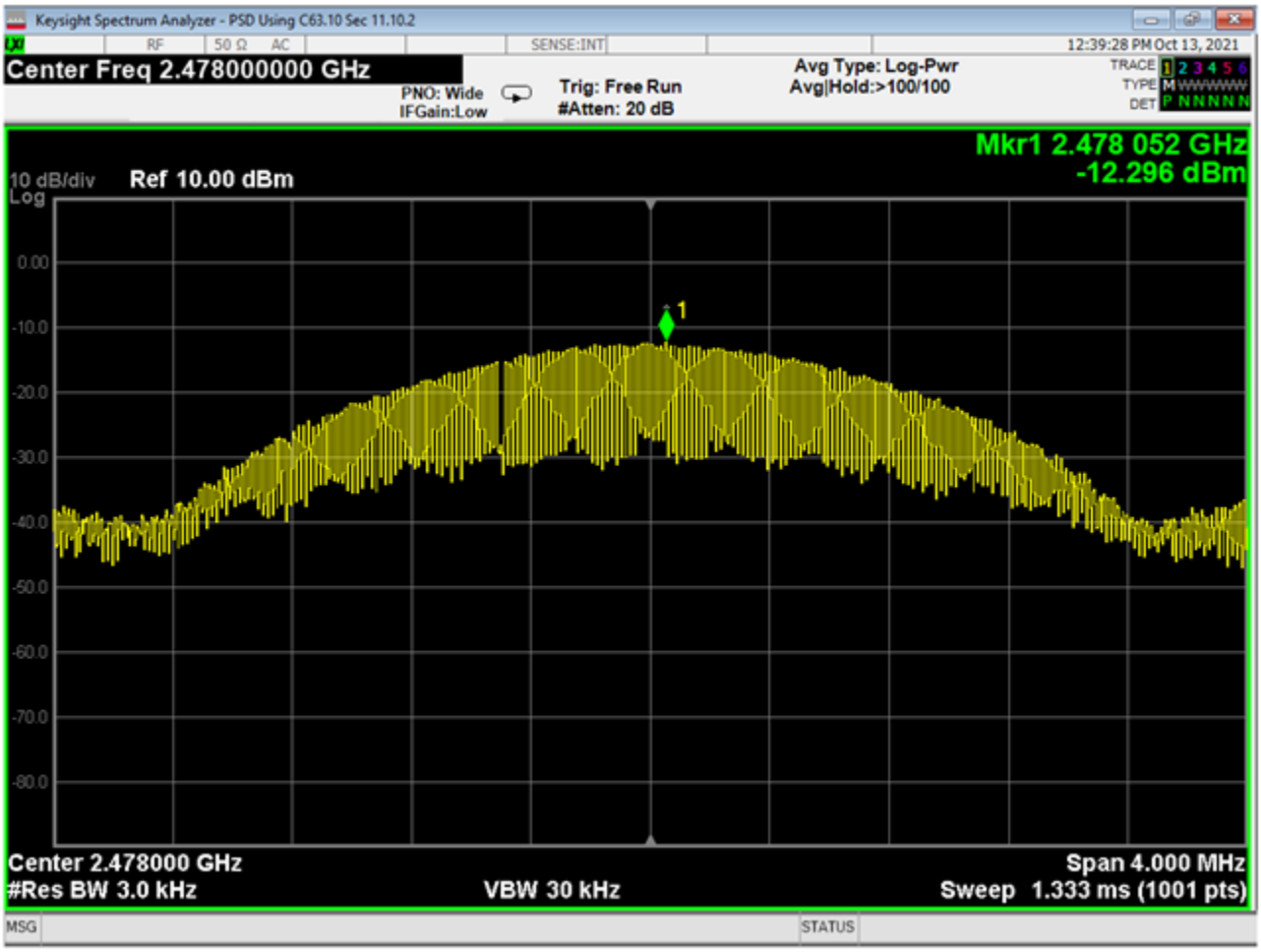
32 OBW-6dB, High, BLE 2MB



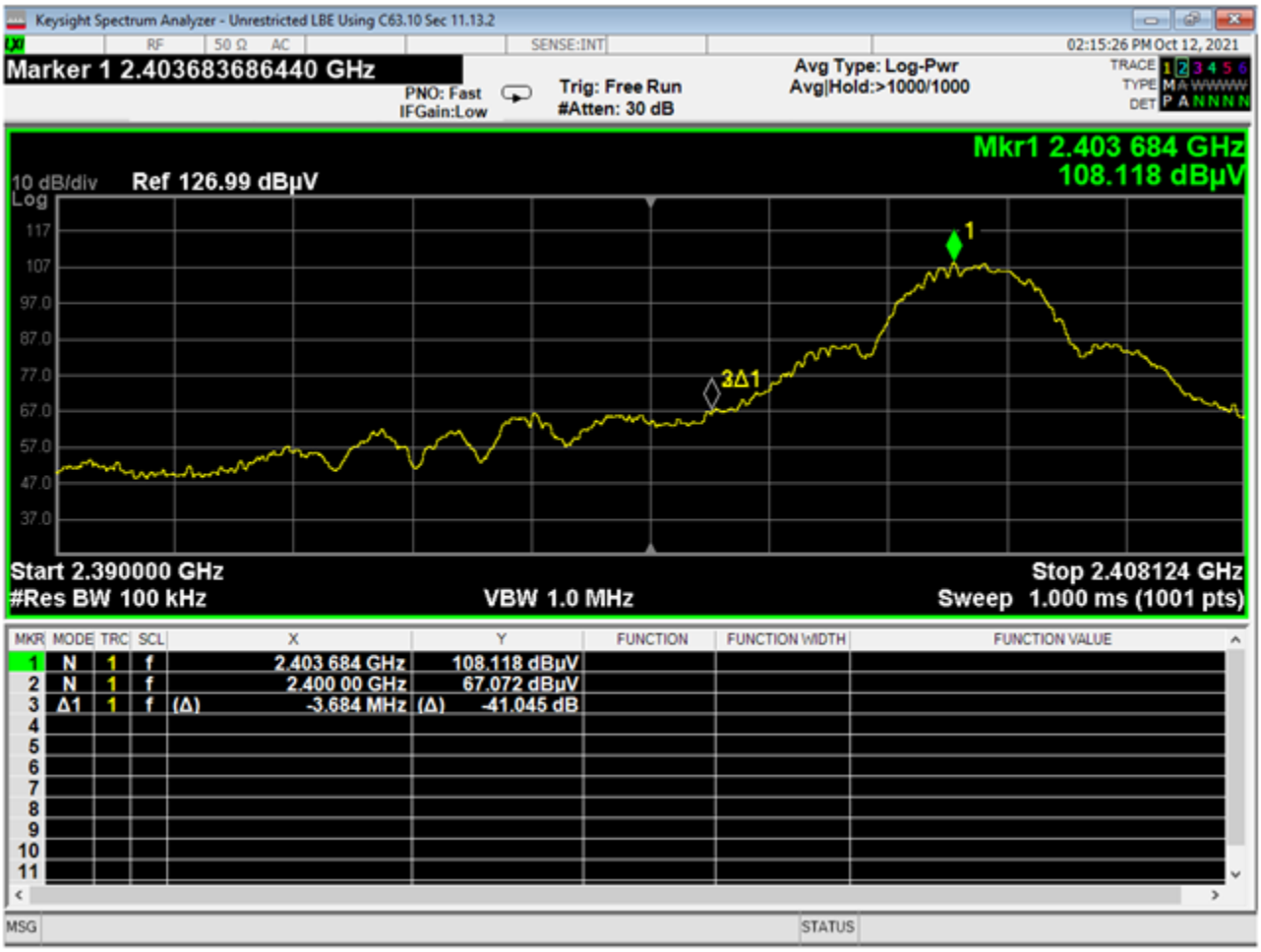
33 PSD, Low, BLE 2MB



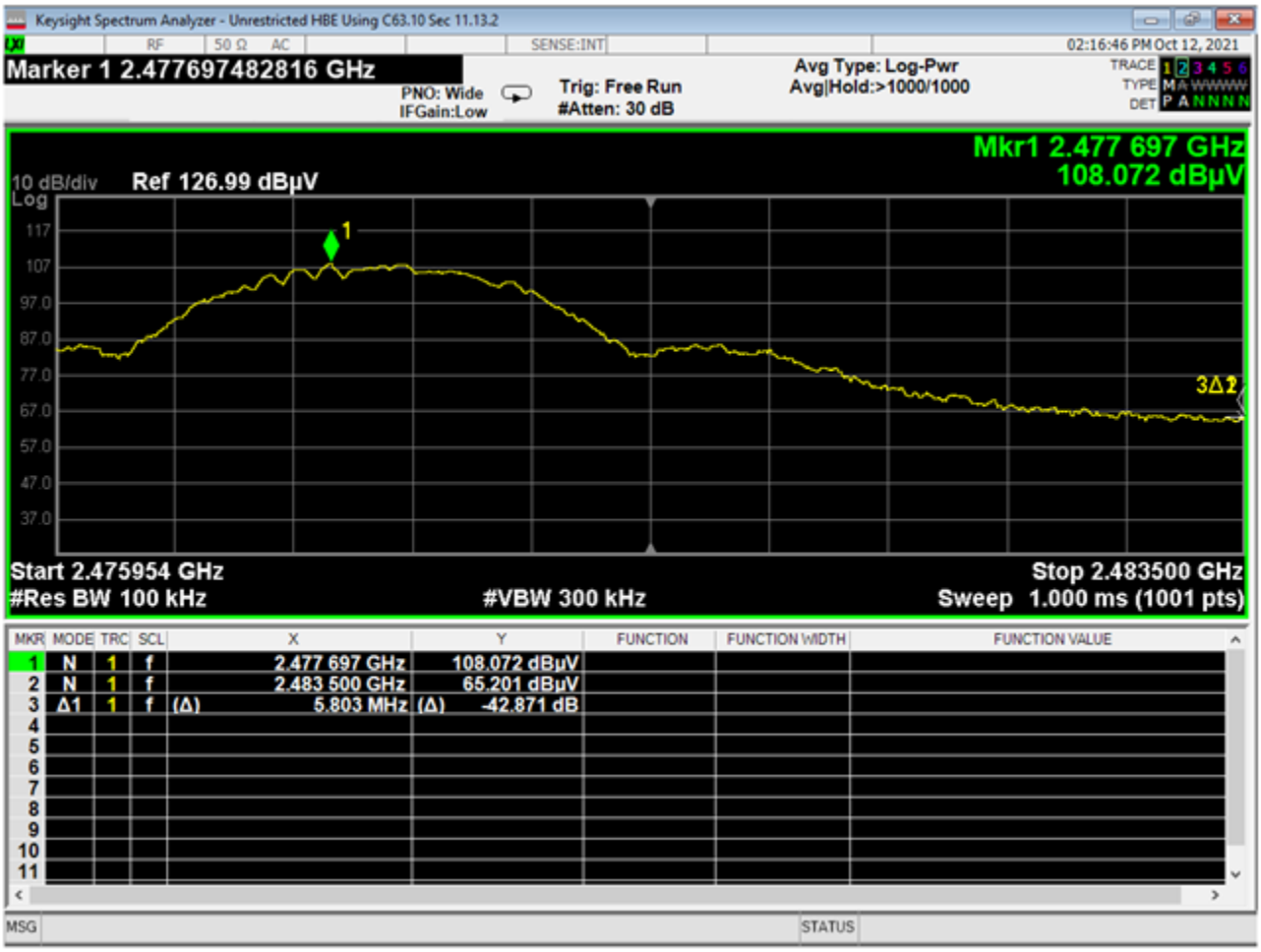
34 PSD, Mid, BLE 2MB



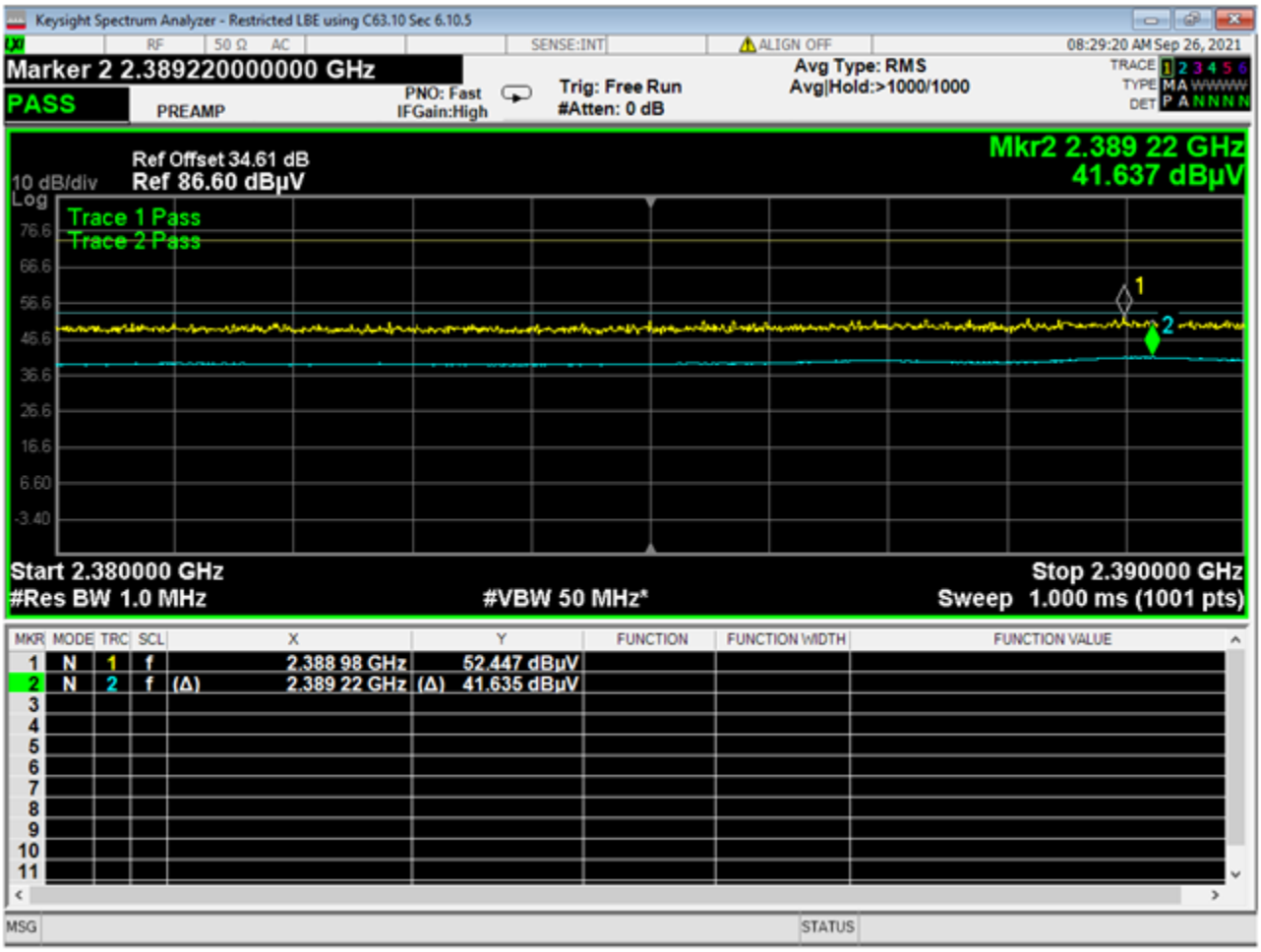
35 PSD, High, BLE 2MB



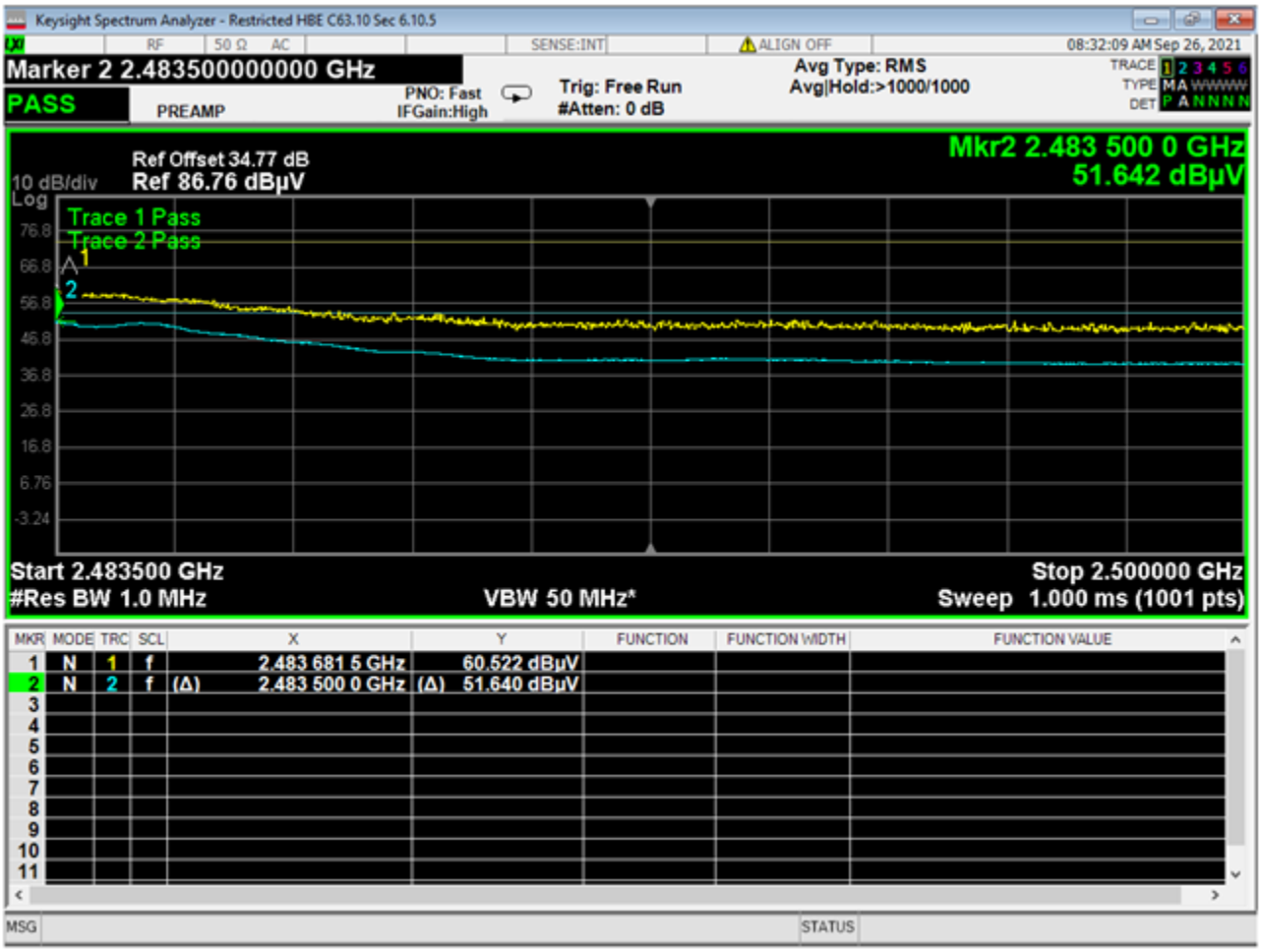
36 Lower Bandedge, Unrestricted, BLE 2MB



37 Lower Bandedge, Unrestricted, BLE 2MB



38 Lower Bandedge, Restricted, BLE 2MB



39 Higher Bandedge, Restricted, BLE 2MB

REPORT END