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Product Compliance Solutions

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FCC/ISED Test Report

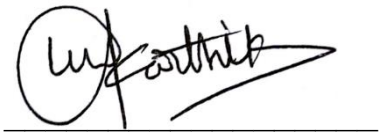
Prepared for: **Garmin International, Inc.**

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

Product: **A04659**

Test Report No: **R20220628-20-E3B**

Approved by:



Mahendra Karthik Vepuri, NCE
EMC Test Engineer,
iNARTE Certified EMC Engineer #EMC-041453-E

DATE: **March 22, 2023**

Total Pages: **126**

REVISION PAGE

Rev. No.	Date	Description
0	19 December 2022	Original – KVepuri Reviewed by KVepuri Prepared by FLane, GLarsen
A	3 January 2023	Page 6 was modified-KV
B	22 March 2023	Section 4.9/ Antenna gain information was removed-KV

CONTENTS

1.0 SUMMARY OF TEST RESULTS

FCC Part 15.247 ☒

The EUT has been tested according to the following specifications:

(1) US Code of Federal Regulations, Title 47, Part 15

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 15.35	Duty Cycle	Pass
FCC Part 15.247(b)(3)	Peak output power	Pass
FCC Part 15.247(a)(2)	Bandwidth	Pass
FCC Part 15.209	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted)	Transmitter Radiated Emissions	Pass
FCC Part 15.247(e)	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d)	Band Edge Measurement	Pass
FCC Part 15.207	Conducted Emissions	Pass

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary and Operating Condition:
Device under test was a rechargeable battery powered transceiver manufactured by Garmin International, Inc.

EUT	A04659
FCC ID:	IPH-04659
EUT Received	21 July 2022
EUT Tested	21 July 2022 - 20 September 2022
Serial No.	3424308878 (Conducted Unit) 3424308866 (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: LACA046 (Representative Power Supply)
Antenna Gain (dBi)	+0.43dBi

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:

The EUT was powered by 5 VDC. It was set to transmit continuously on the 3 different channels of its operating range where available. A ferrite was placed on the charging cable adjacent to the USB-C connector FairRite (0431164951). EUT was investigated with both a short VHF antenna (122mm) and a long VHF antenna (340mm). Data was reported from both.

For 802.11x Transmissions:

Channel	Frequency
Low	2412 MHz
Mid	2437 MHz
High	2462 MHz

Data Rate		
Modulation	**Low**	**High**
802.11b	1Mb	11Mb
802.11g	6Mb	54Mb
802.11n	MCS0	MCS7

These are the only representative channels tested in the frequency range according to FCC Part 15.31. 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
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	Karthik Vepuri	Test Engineer	Review/editing
2	Fox Lane	Test Engineer	Testing and Report
3	Blake Winter	Test Engineer	Testing
4	Grace Larsen	Test Engineer	Testing and Report
5	Ethan Schmidt	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 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)***	N9038A	MY56400083	July 19, 2022	July 19, 2024
Keysight EXA Signal Analyzer**	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A091418-1	July 26, 2022	July 26, 2023
EMCO Horn Antenna**	3115	6416	July 28, 2021	July 28, 2023
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	March 21, 2022	March 21, 2024
8447F POT H64 Preamplifier	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
Trilithic High Pass Filter*	6HC330	23042	March 21, 2022	March 21, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	March 21, 2022	March 21, 2024
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

**2 Year Cal Cycle

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.

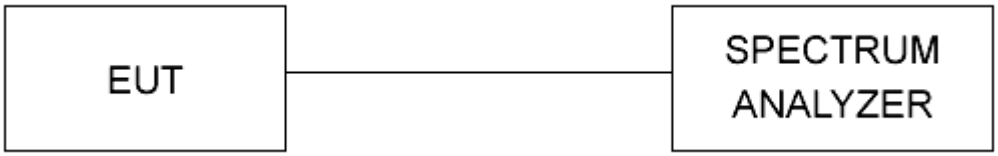


Figure 1 - Bandwidth Measurements Test Setup

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.

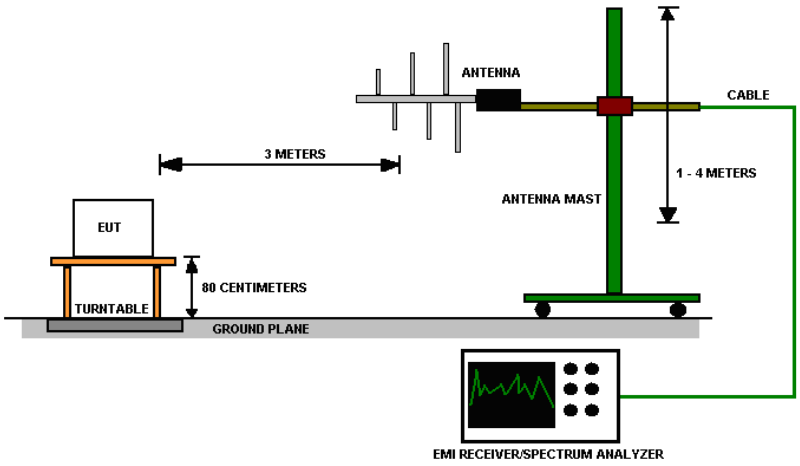


Figure 2 - Radiated Emissions Test Setup

4.0 RESULTS

DTS Radio Measurements, Low Data Rate							
CHANNEL	**Transmitter**	**Occupied Bandwidth (MHz)**	**6 dB Bandwidth (MHz)**	**AVERAGE OUTPUT POWER (dBm)**	**AVERAGE OUTPUT POWER (mW)**	**PSD (dBm)**	**RESULT**
Low	802.11 b	15.16	10.06	17.360	54.450	2.40	PASS
Mid	802.11 b	15.19	10.06	18.290	67.453	3.948	PASS
High	802.11 b	15.26	10.06	18.380	68.865	3.123	PASS
Low	802.11 g	16.99	16.45	16.990	50.003	-6.891	PASS
Mid	802.11 g	17.13	16.51	19.110	81.470	-6.09	PASS
High	802.11 g	17.19	16.55	13.400	21.878	-10.86	PASS
Low	802.11 n	17.59	17.64	15.660	36.813	-8.674	PASS
Mid	802.11 n	17.62	17.61	17.630	57.943	-8.131	PASS
High	802.11 n	17.63	17.64	13.500	22.387	-14.258	PASS
Occupied Bandwidth = N/A; 6 dB Bandwidth Limit = 500 kHz				Peak Output Power Limit = 30 dBm; PSD Limit = 8 dBm			
DTS Radio Measurements, High Data Rate							
CHANNEL	**Transmitter**	**Occupied Bandwidth (MHz)**	**6 dB Bandwidth (MHz)**	**AVERAGE OUTPUT POWER (dBm)**	**AVERAGE OUTPUT POWER (mW)**	**PSD (dBm)**	**RESULT**
Low	802.11 b	14.72	9.04	17.370	54.576	-6.311	PASS
Mid	802.11 b	14.75	9.04	18.350	68.391	-4.813	PASS
High	802.11 b	14.79	8.85	18.440	69.823	-5.058	PASS
Low	802.11 g	16.45	16.54	14.470	27.990	-10.17	PASS
Mid	802.11 g	16.45	16.50	15.020	31.769	-10.353	PASS
High	802.11 g	16.45	16.52	12.450	17.579	-10.592	PASS
Low	802.11 n	17.52	17.67	13.05	20.184	-12.655	PASS
Mid	802.11 n	17.52	17.65	12.48	17.701	-10.765	PASS
High	802.11 n	17.51	17.64	13.19	20.845	-13.188	PASS
Occupied Bandwidth = N/A; 6 dB Bandwidth Limit = 500 kHz				Peak Output Power Limit = 30 dBm; PSD Limit = 8 dBm			

Unrestricted Band-Edge, Low Data Rate							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Relative Highest out of band level (dBuV)**	**Relative Fundamental (dBuV)**	**Delta (dB)**	**Min Delta (dB)**	**Result**
Low	802.11 b	2390.00	81.61	115.65	34.04	30.00	PASS
Low	802.11 g	2390.00	66.63	109.47	42.84	30.00	PASS
Low	802.11 n	2390.00	66.76	108.29	41.53	30.00	PASS
High	802.11 b	2483.50	61.76	114.79	53.02	30.00	PASS
High	802.11 g	2483.50	60.35	104.82	44.47	30.00	PASS
High	802.11 n	2483.50	65.58	104.85	39.27	30.00	PASS

Unrestricted Band-Edge, High Data Rate							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Relative Highest out of band level (dBuV)**	**Relative Fundamental (dBuV)**	**Delta (dB)**	**Min Delta (dB)**	**Result**
Low	802.11 b	2400.00	81.59	116.59	35.00	30.00	PASS
Low	802.11 g	2400.00	71.71	107.39	35.68	30.00	PASS
Low	802.11 n	2400.00	69.41	105.06	35.65	30.00	PASS
High	802.11 b	2483.50	67.13	117.37	50.24	30.00	PASS
High	802.11 g	2483.50	60.63	102.90	42.27	30.00	PASS
High	802.11 n	2483.50	61.27	103.81	42.55	30.00	PASS

Peak Restricted Band-Edge, Low Data Rate							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)**	**Measurement Type**	**Limit (dBuV/m @ 3m)**	**Margin**	**Result**
Low	802.11 b	2390.00	59.60	Peak	73.98	14.38	PASS
Low	802.11 g	2390.00	67.38	Peak	73.98	6.60	PASS
Low	802.11 n	2390.00	67.18	Peak	73.98	6.80	PASS
High	802.11 b	2483.50	61.15	Peak	73.98	12.83	PASS
High	802.11 g	2483.50	68.56	Peak	73.98	5.42	PASS
High	802.11 n	2483.50	66.82	Peak	73.98	7.16	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							
Average Restricted Band-Edge, Low Data Rate							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)**	**Measurement Type**	**Limit (dBuV/m @ 3m)**	**Margin**	**Result**
Low	802.11 b	2390.00	48.46	Average	53.98	5.52	PASS
Low	**802.11 g**	**2390.00**	**53.67**	**Average**	**53.98**	**0.31**	**PASS**
Low	802.11 n	2390.00	53.67	Average	53.98	0.31	PASS
High	802.11 b	2483.50	51.49	Average	53.98	2.49	PASS
High	802.11 g	2483.50	52.28	Average	53.98	1.70	PASS
High	802.11 n	2483.50	53.22	Average	53.98	0.76	PASS
*Limit shown is the average limit taken from FCC Part 15.209							

Peak Restricted Band-Edge, High Data Rate							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)**	**Measurement Type**	**Limit (dBuV/m @ 3m)**	**Margin**	**Result**
Low	802.11 b	2390.00	59.59	Peak	73.98	14.39	PASS
Low	802.11 g	2390.00	69.09	Peak	73.98	4.89	PASS
Low	802.11 n	2390.00	66.91	Peak	73.98	7.07	PASS
High	802.11 b	2483.50	61.37	Peak	73.98	12.62	PASS
High	802.11 g	2483.50	69.98	Peak	73.98	4.01	PASS
High	802.11 n	2483.50	71.13	Peak	73.98	2.85	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							
Average Restricted Band-Edge, High Data Rate							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)**	**Measurement Type**	**Limit (dBuV/m @ 3m)**	**Margin**	**Result**
Low	802.11 b	2390.00	48.66	Average	53.98	5.32	PASS
Low	802.11 g	2390.00	52.00	Average	53.98	1.98	PASS
Low	802.11 n	2390.00	51.06	Average	53.98	2.92	PASS
High	802.11 b	2483.50	50.63	Average	53.98	3.36	PASS
High	802.11 g	2483.50	52.75	Average	53.98	1.23	PASS
High	802.11 n	2483.50	53.29	Average	53.98	0.69	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. Results were all within measurement tolerance.

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 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. The measurements are reported on the graph.

4.4 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:
The highest desired power measured was 7.783 dBm at the fundamental frequency. All other emissions were at least 20 dB lower than the corresponding fundamental frequency. Please note the green line shown in the plots is a reference line, not a limit line.

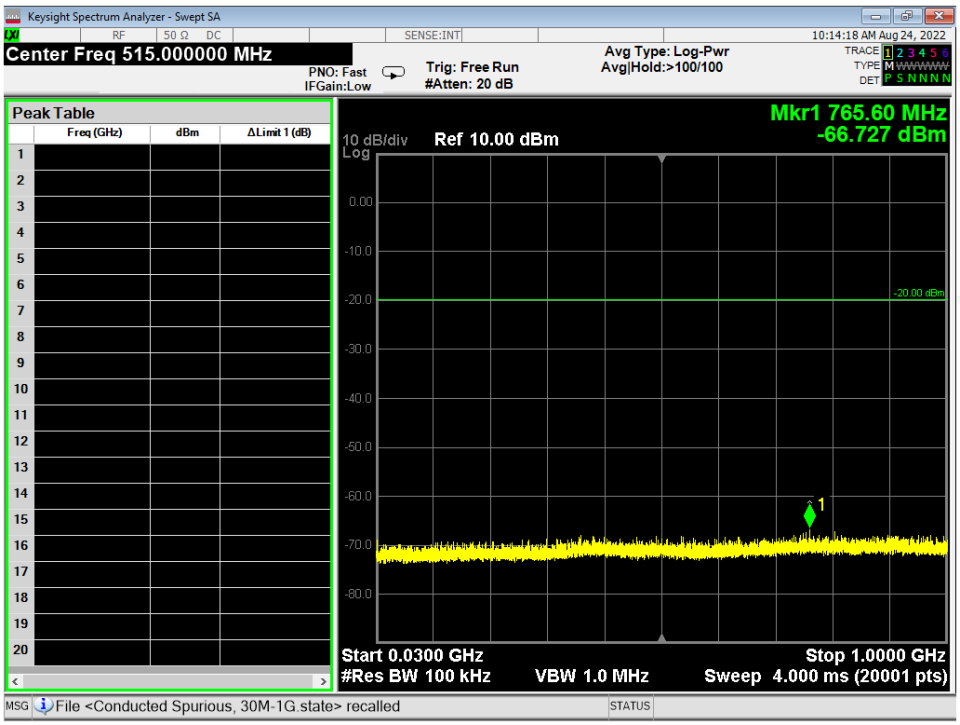


Figure 3 - Radiated Emissions Plot, Wifi B 1MB, 30M – 1G

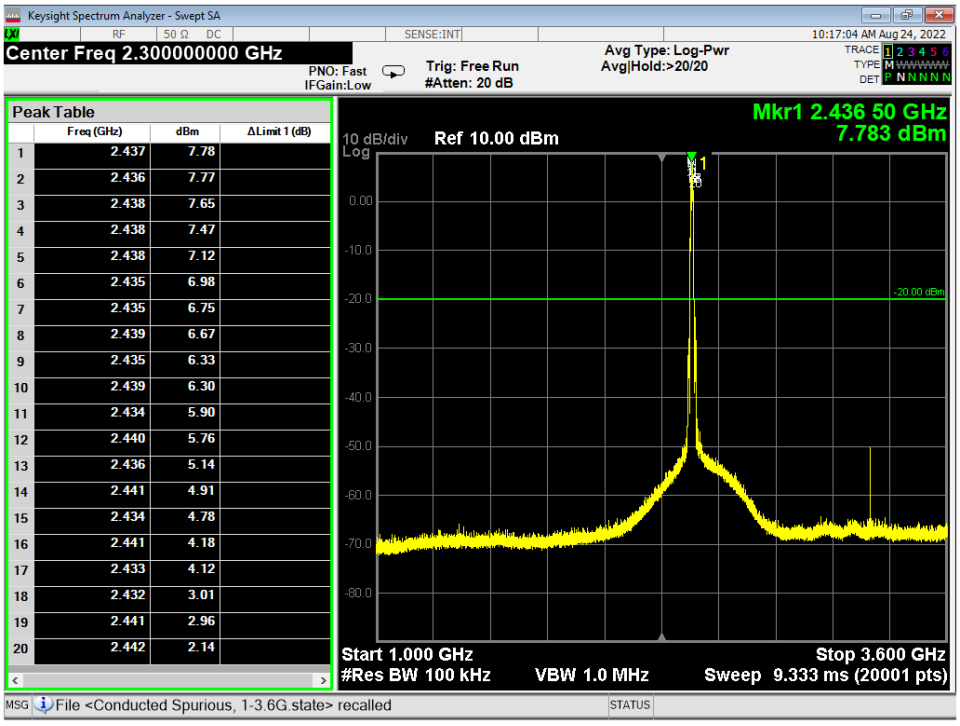


Figure 4 - Radiated Emissions Plot, Wifi B 1MB, 1G – 3.6G

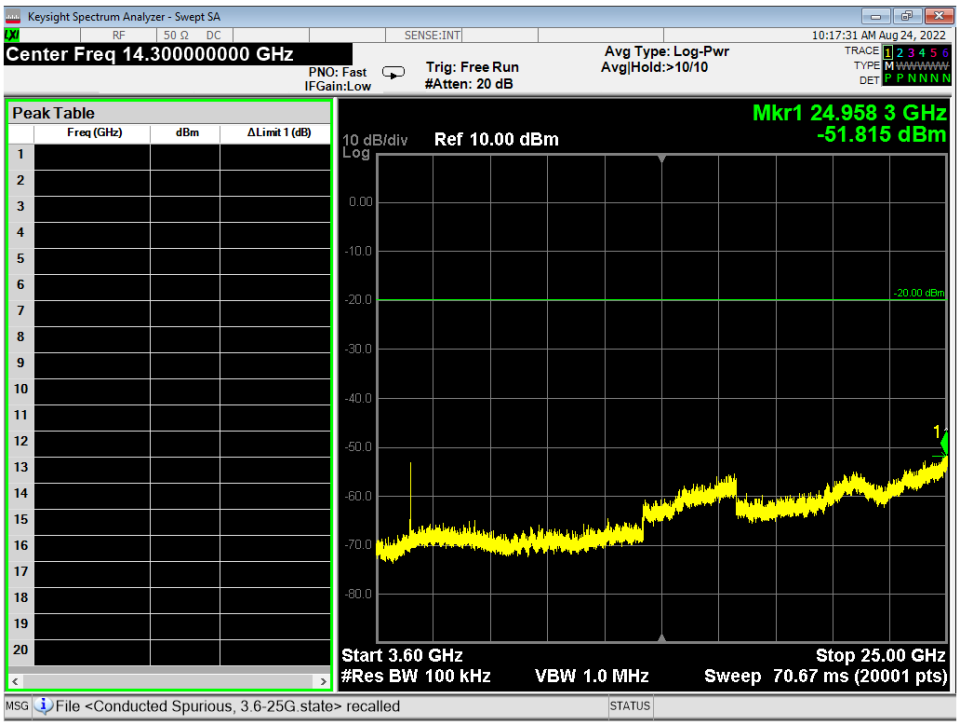


Figure 5 - Radiated Emissions Plot, Wifi B 1MB, 3.6G – 25G

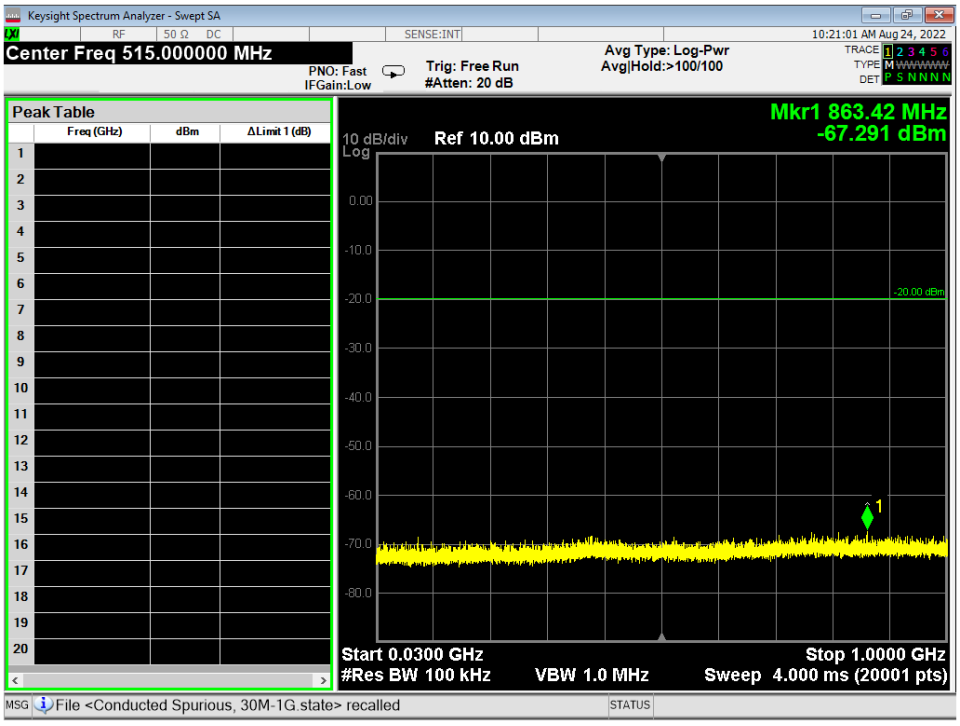


Figure 6 - Radiated Emissions Plot, Wifi G 6MB, 30M – 1G

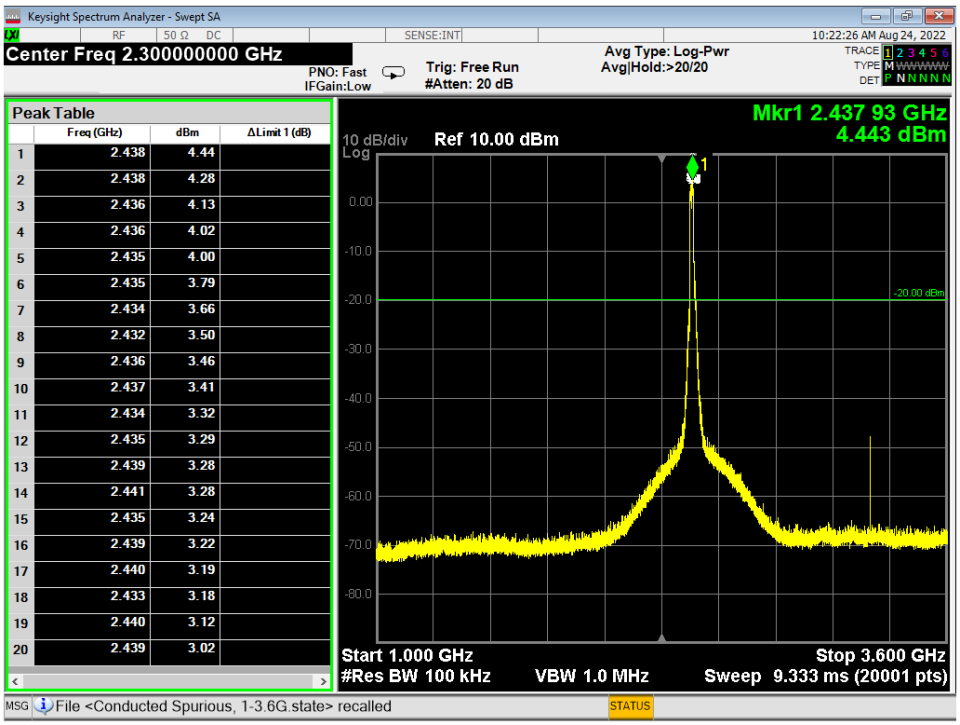


Figure 7 - Radiated Emissions Plot, Wifi G 6MB, 1G – 3.6G

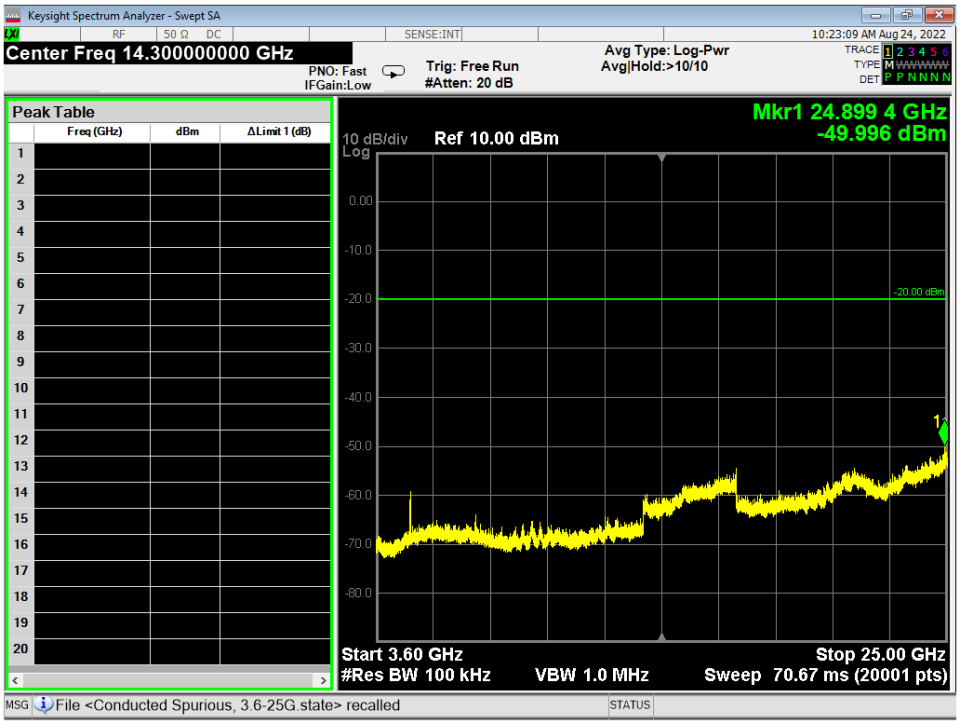


Figure 8 - Radiated Emissions Plot, Wifi G 6MB, 3.6G – 25G

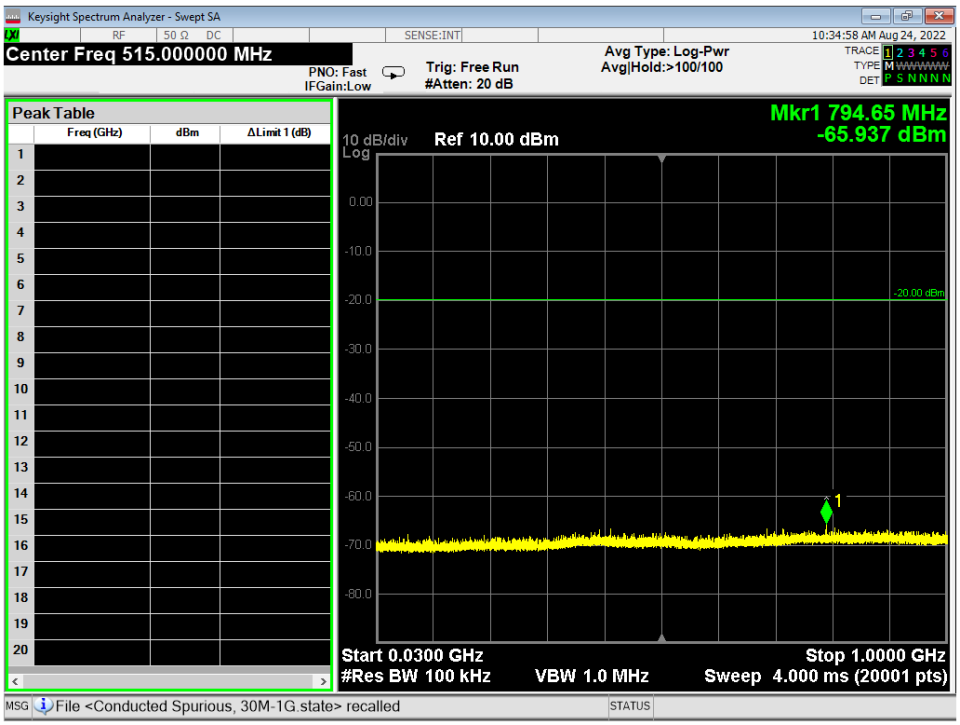


Figure 9 - Radiated Emissions Plot, Wifi N MCS0, 30M – 1G

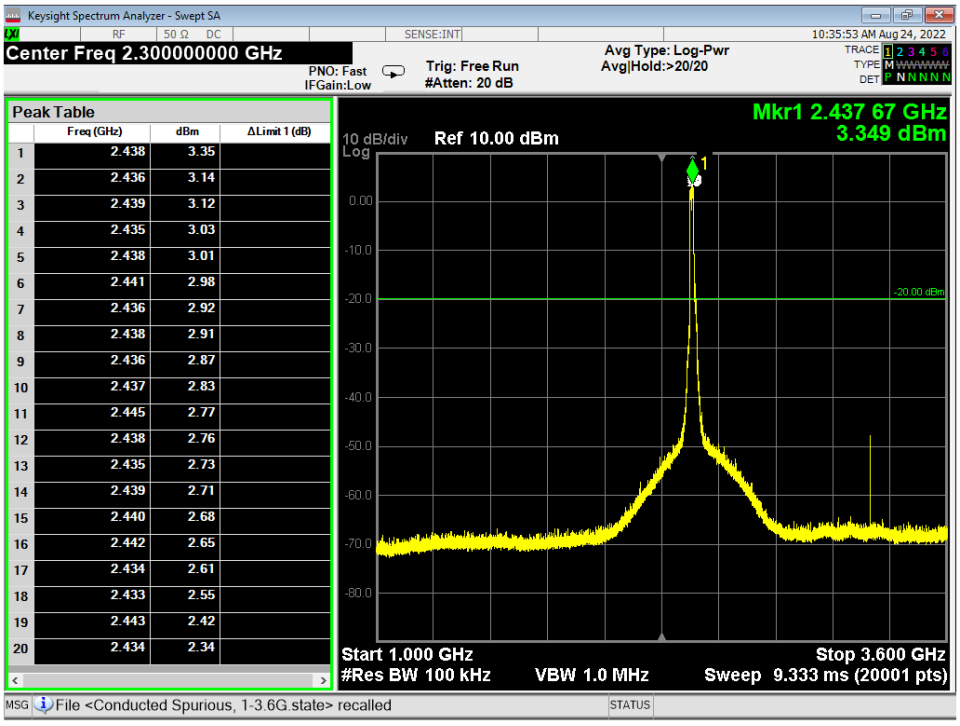


Figure 10 - Radiated Emissions Plot, Wifi N MCS0, 1G – 3.6G

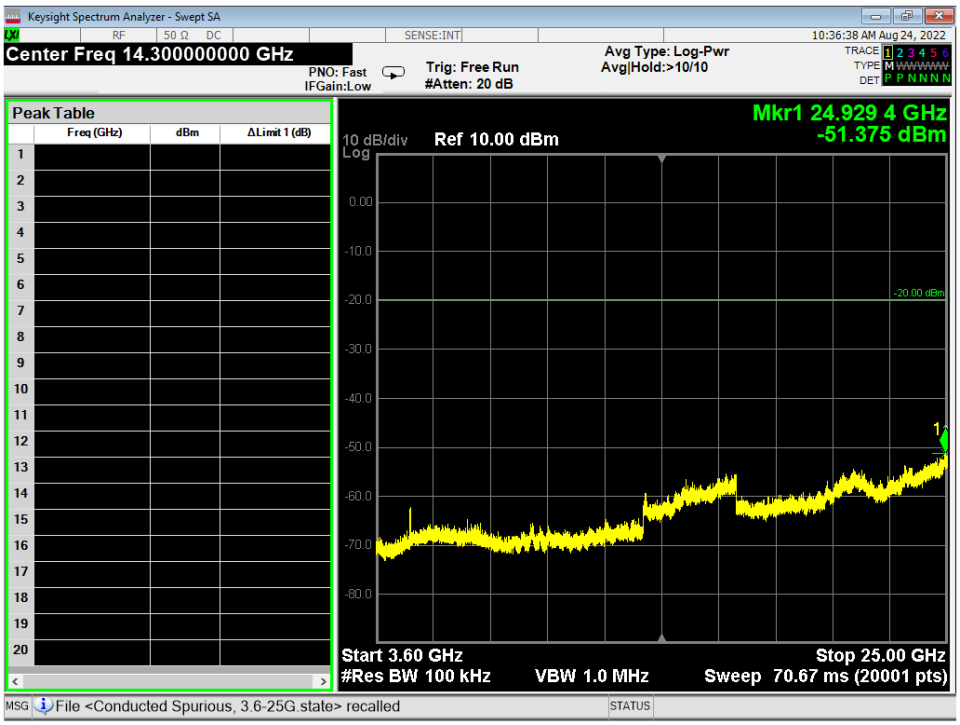


Figure 11 - Radiated Emissions Plot, Wifi N MCS0, 3.6G – 25G

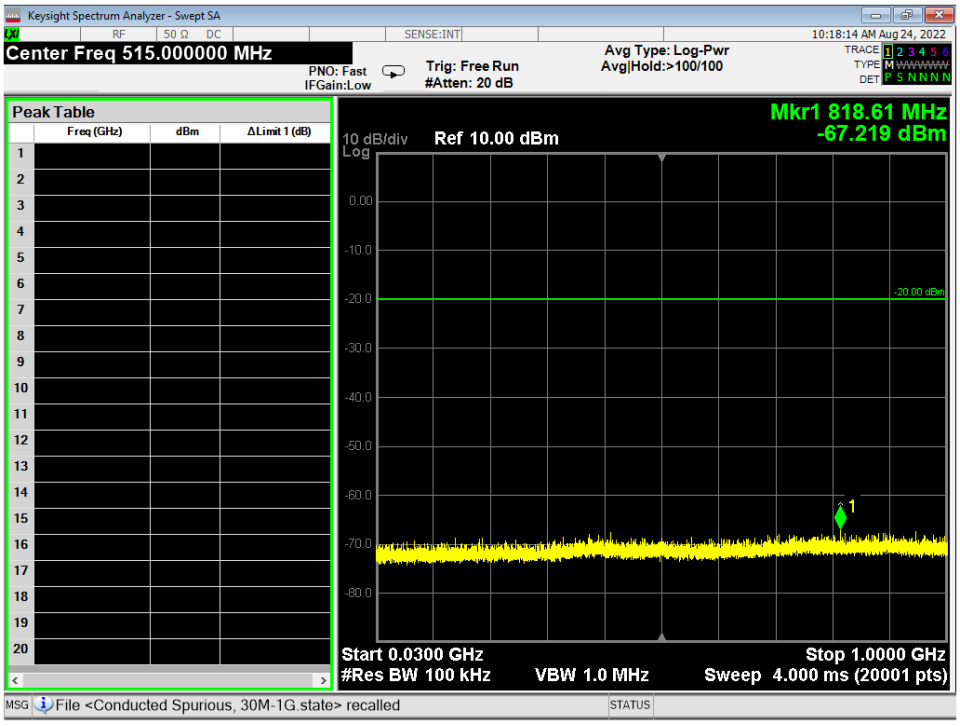


Figure 12 - Radiated Emissions Plot, Wifi B 11MB, 30M – 1G

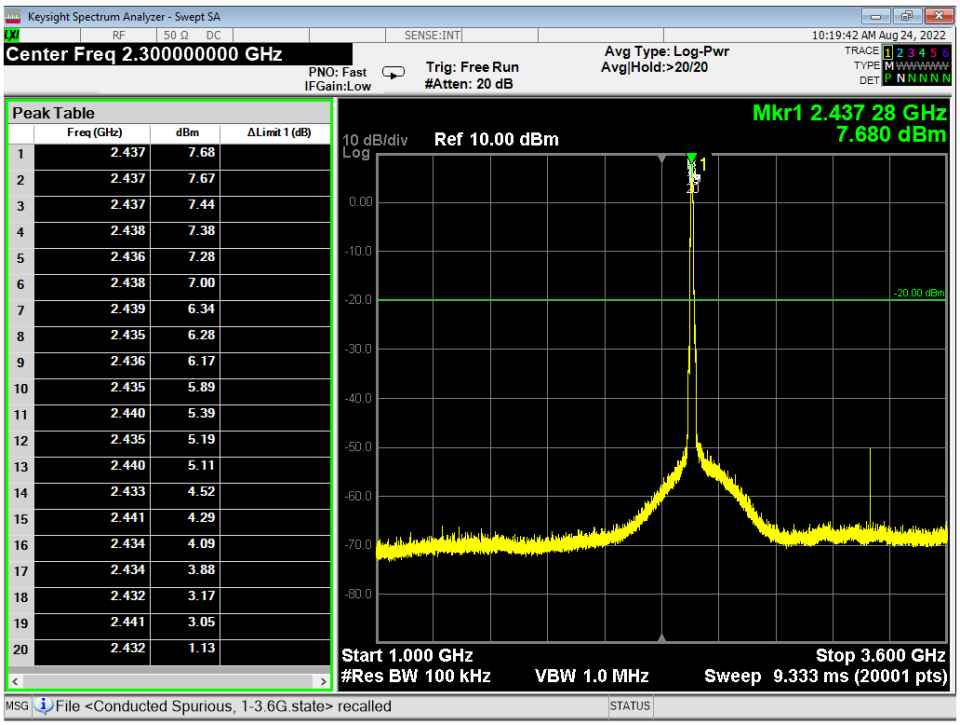


Figure 13 - Radiated Emissions Plot, Wifi B 11MB, 1G – 3.6G

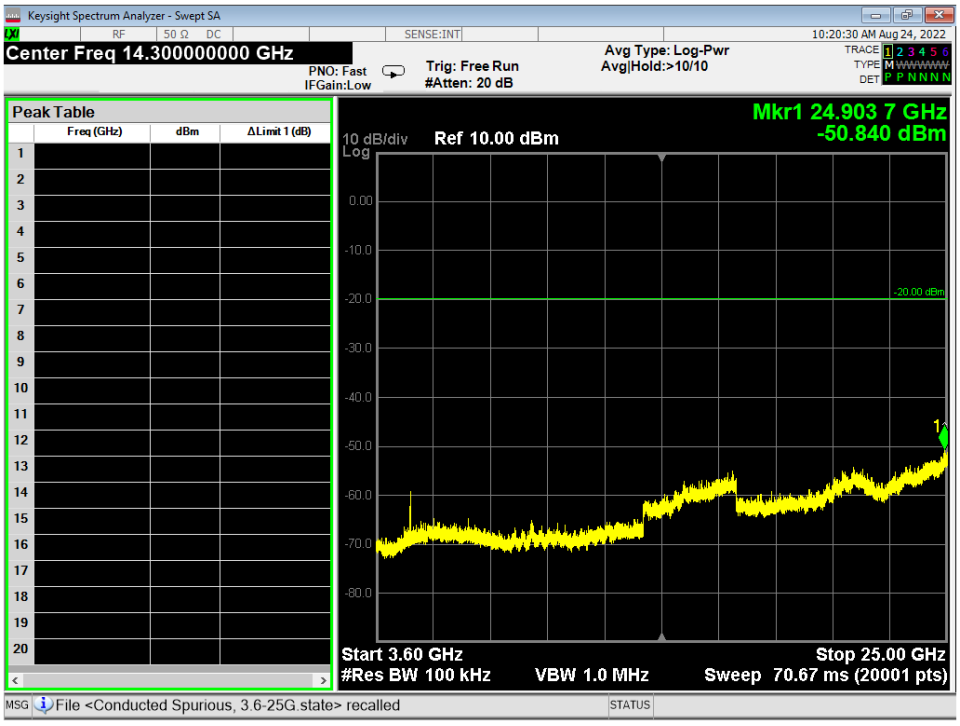


Figure 14 - Radiated Emissions Plot, Wifi B 11MB, 3.6G – 25G

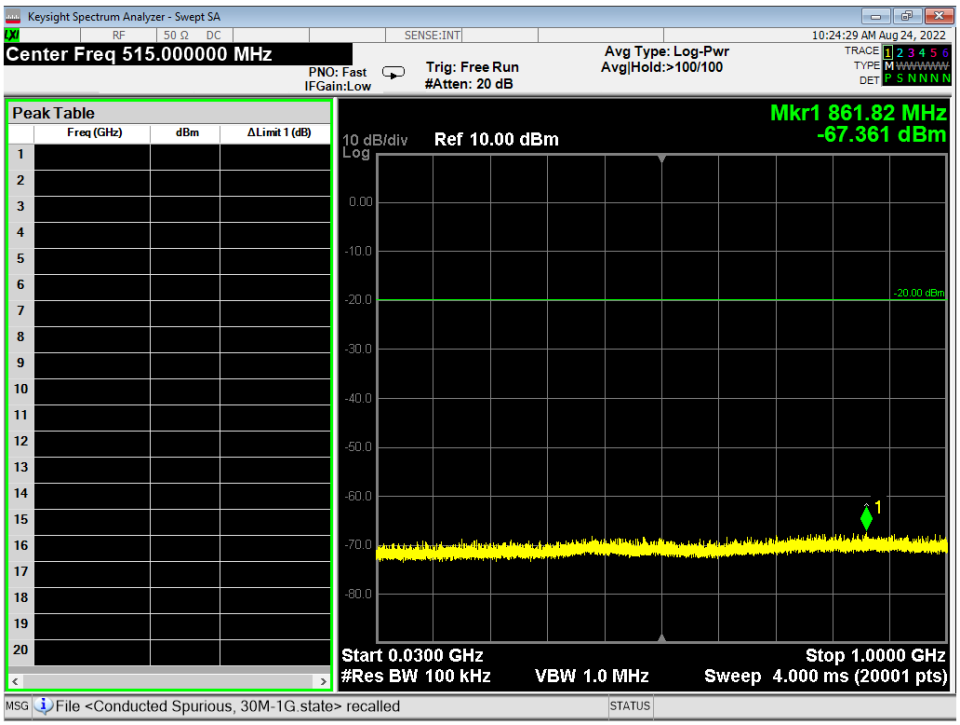


Figure 15 - Radiated Emissions Plot, Wifi G 54MB, 30M – 1G

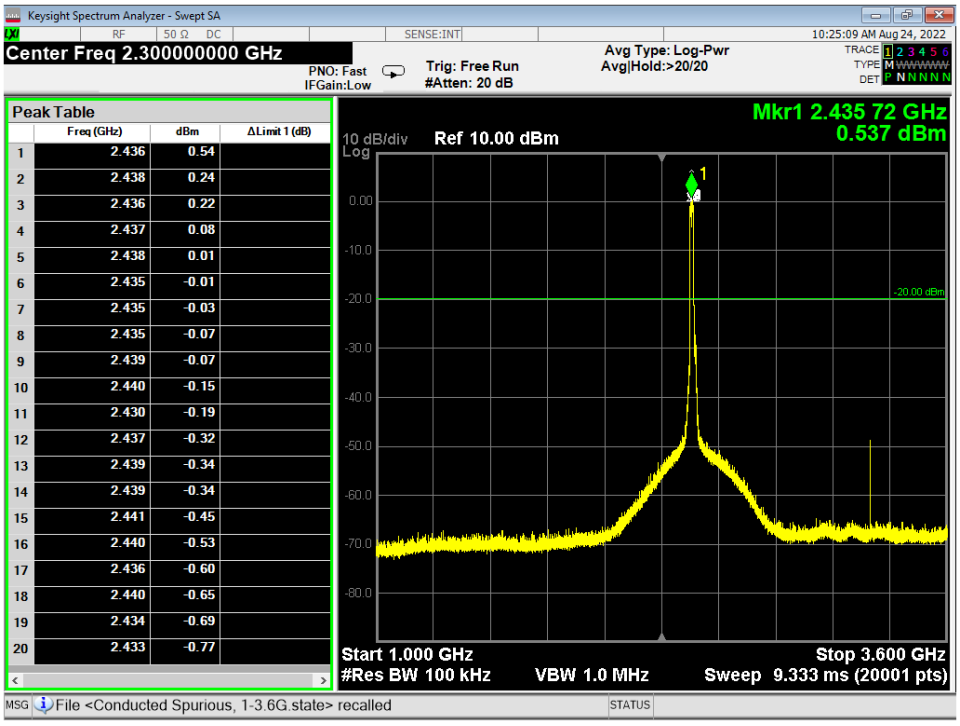


Figure 16 - Radiated Emissions Plot, Wifi G 54MB, 1G – 3.6G

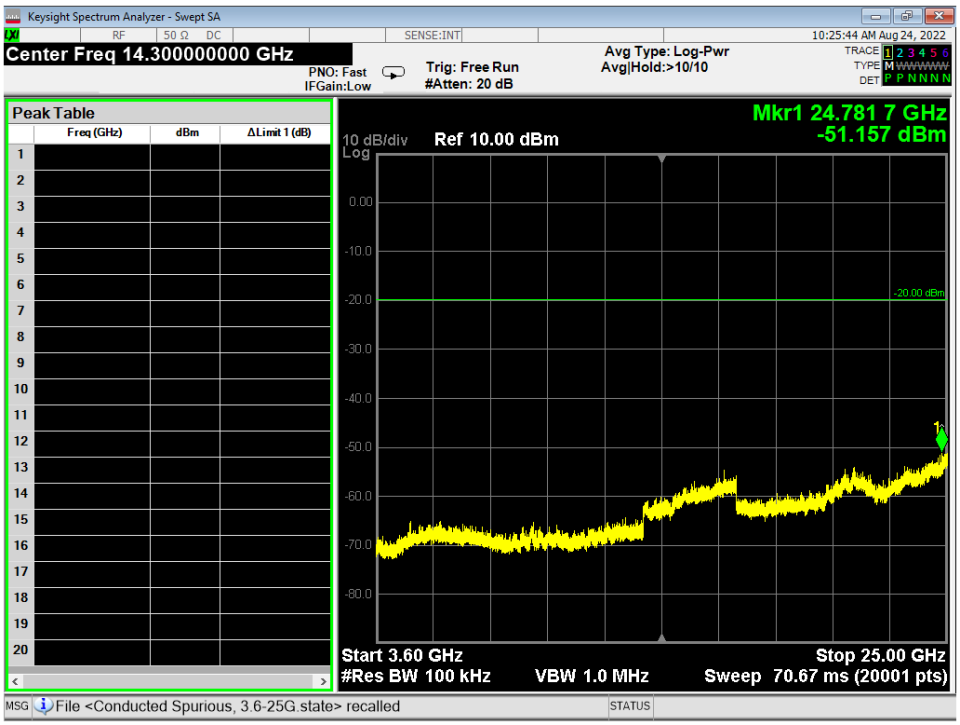


Figure 17 - Radiated Emissions Plot, Wifi G 54MB, 3.6G – 25G

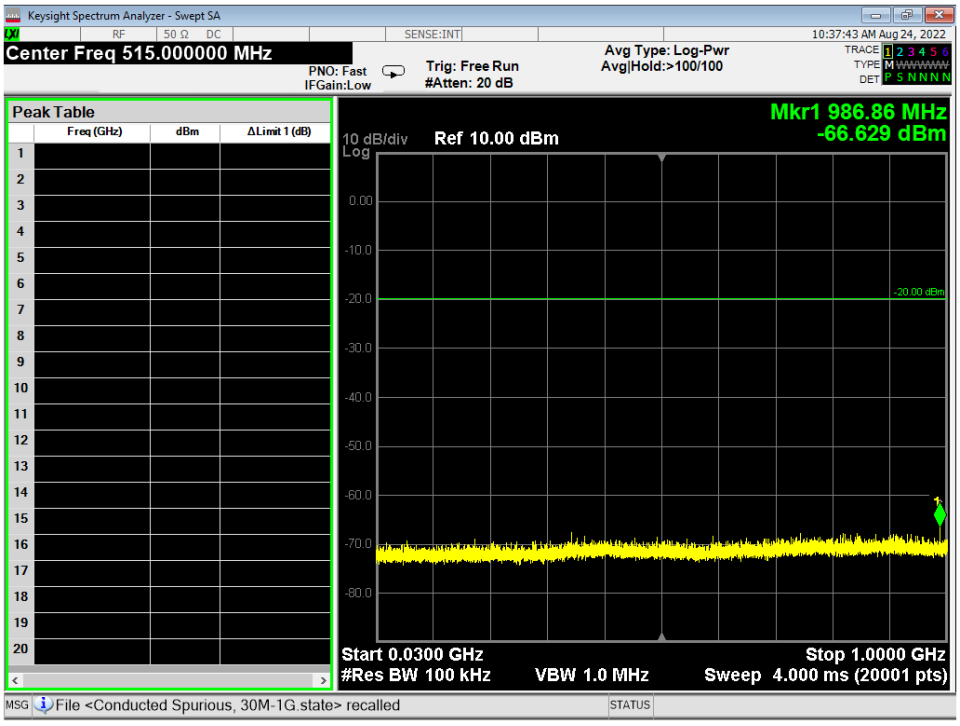


Figure 18 - Radiated Emissions Plot, Wifi N MCS7, 30M – 1G

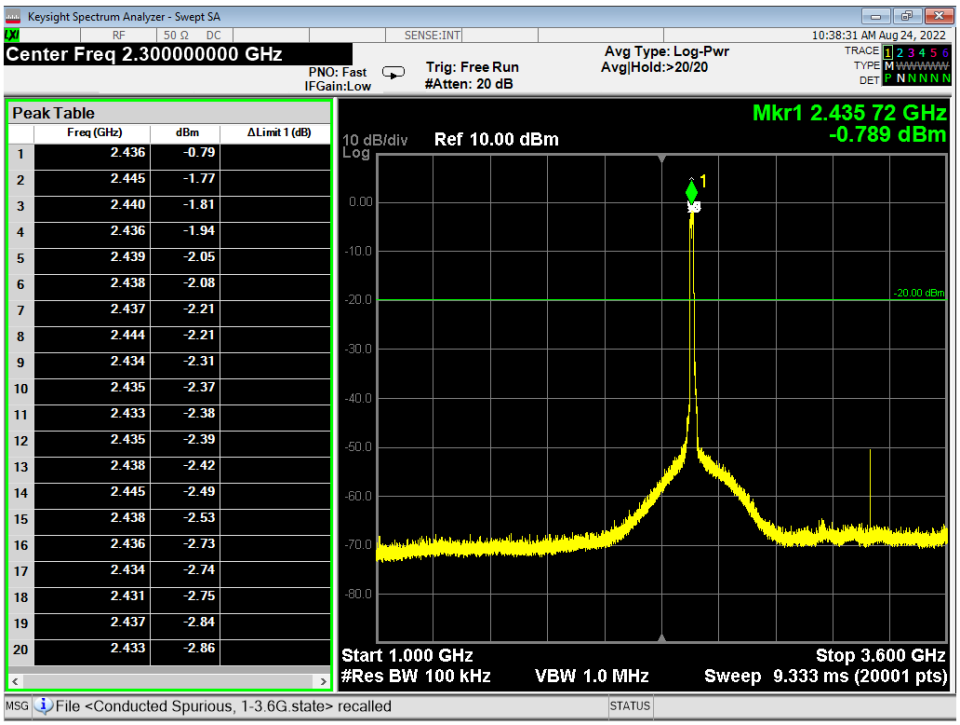


Figure 19 - Radiated Emissions Plot, Wifi N MCS7, 1G – 3.6G

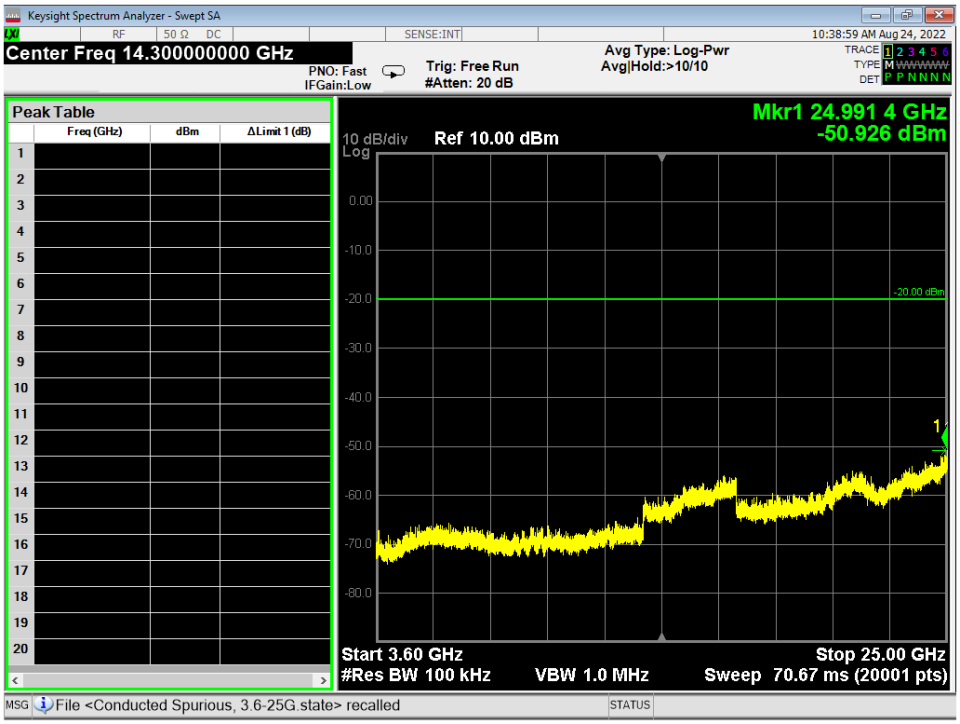


Figure 20 - Radiated Emissions Plot, Wifi N MCS7, 3.6G – 25G

4.5 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:

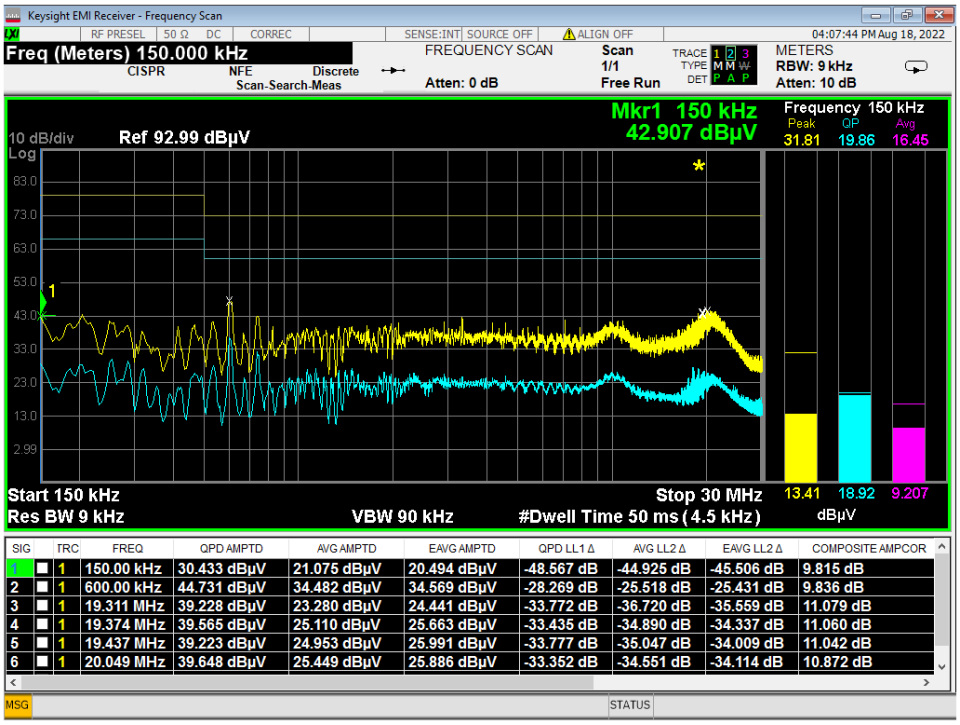


Figure 21 - Conducted Emissions Plot, Line, TX

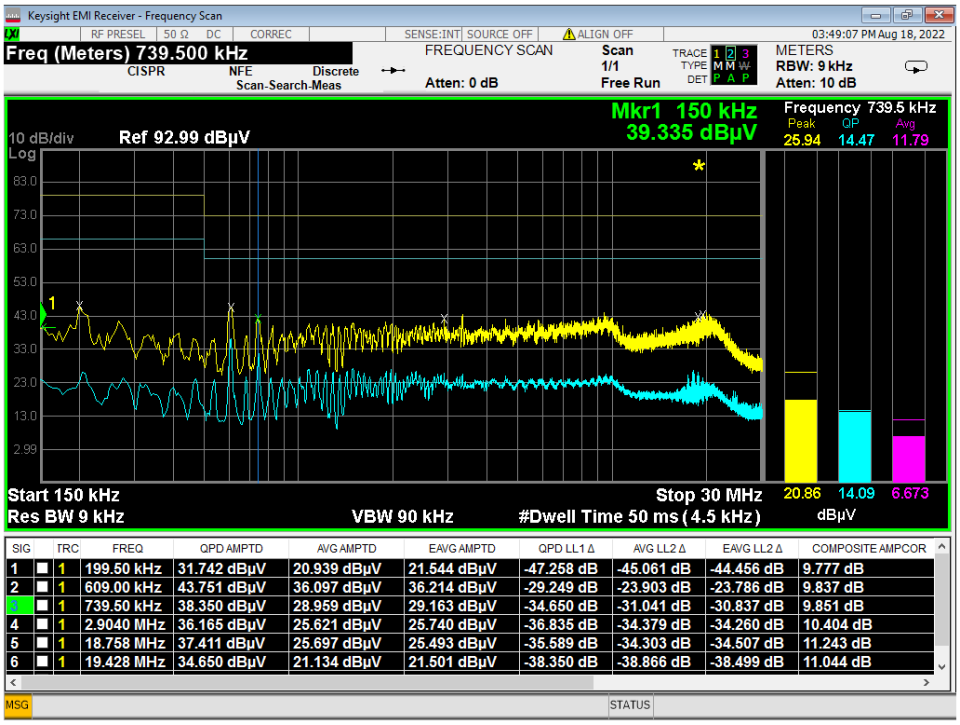


Figure 22 - Conducted Emissions Plot, Neutral, TX

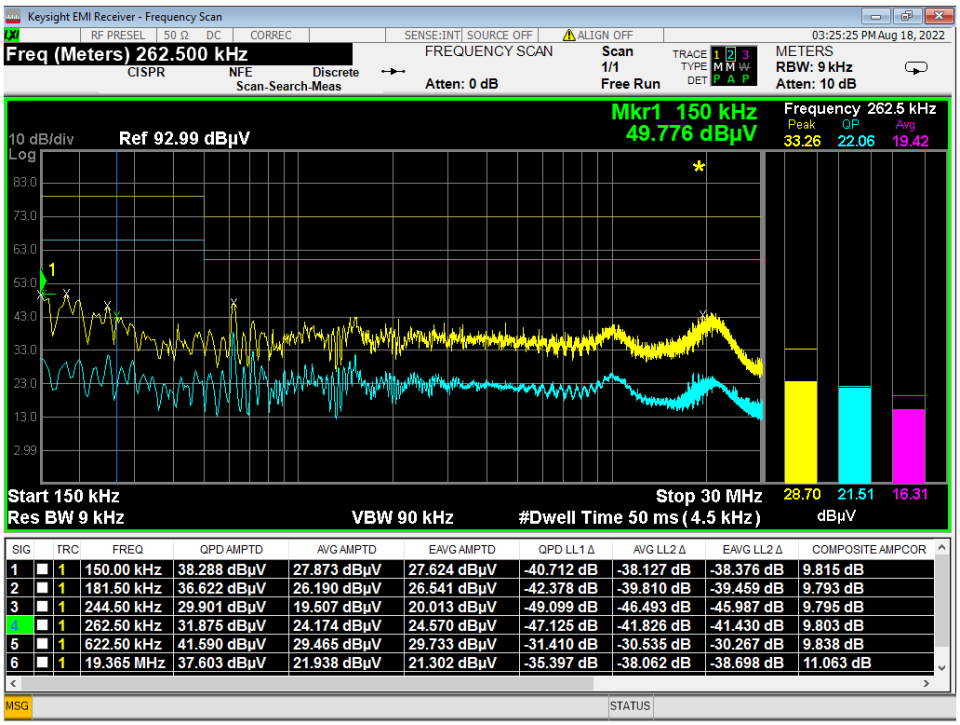


Figure 23 - Conducted Emissions Plot, Line, IDLE

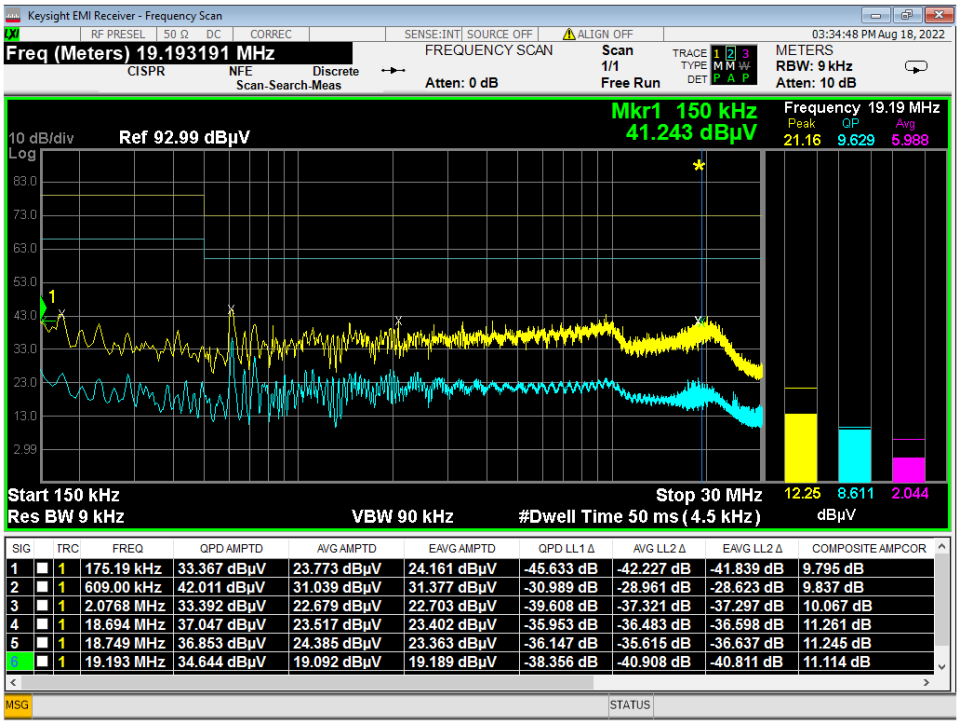


Figure 24 - Conducted Emissions Plot, Neutral, IDLE

4.6 DUTY CYCLE

Test Method:

All Modulations/Transmitters in this report were provided and tested with a duty cycle of >98%

4.7 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 follows:

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:

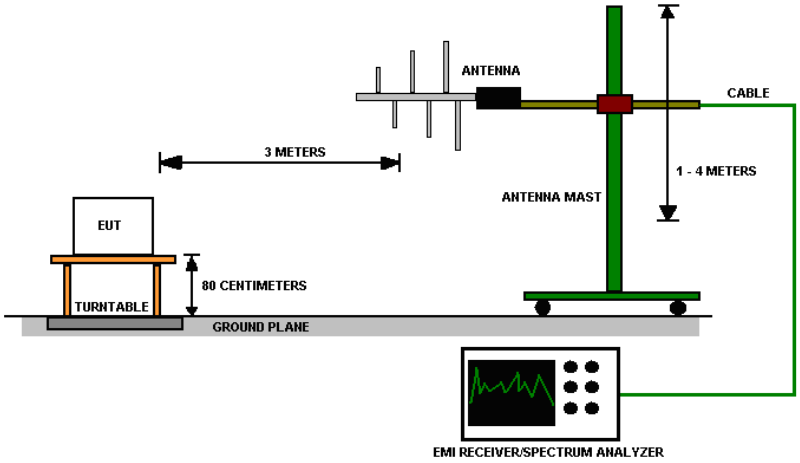


Figure 25 - Radiated Emissions Test Setup

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:

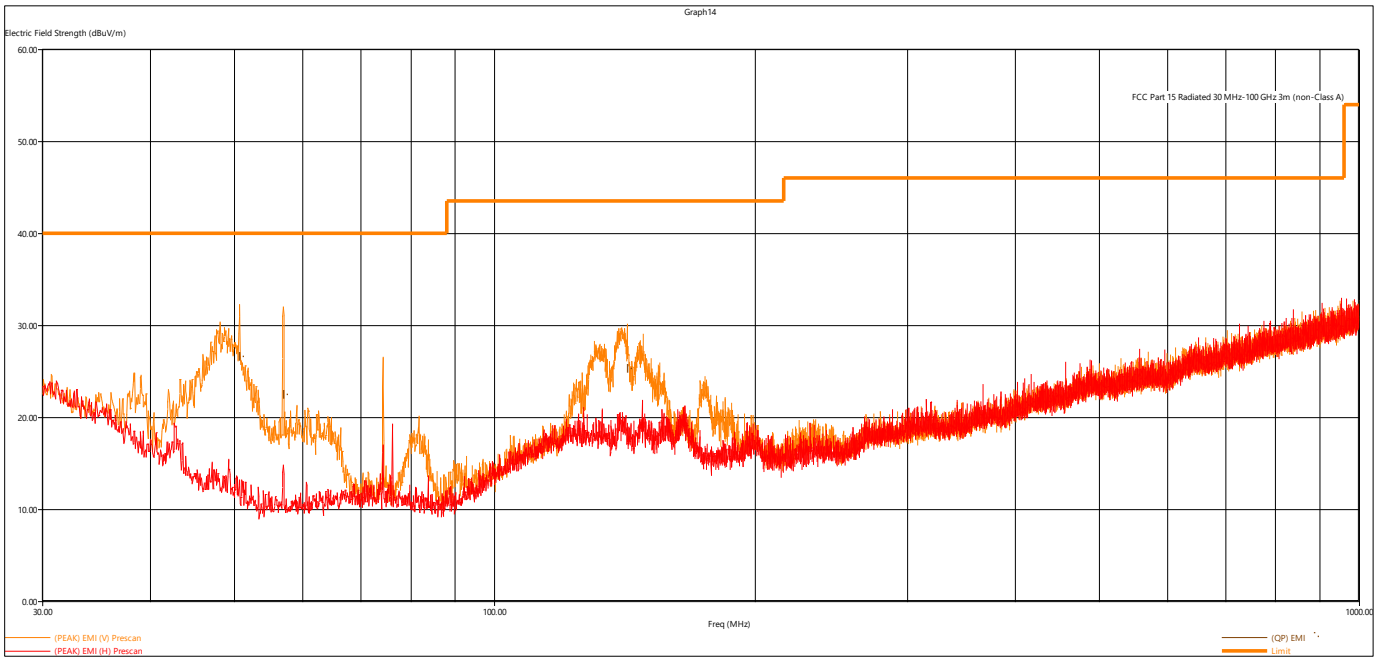


Figure 26 - Radiated Emissions Plot, Receive, Short Antenna

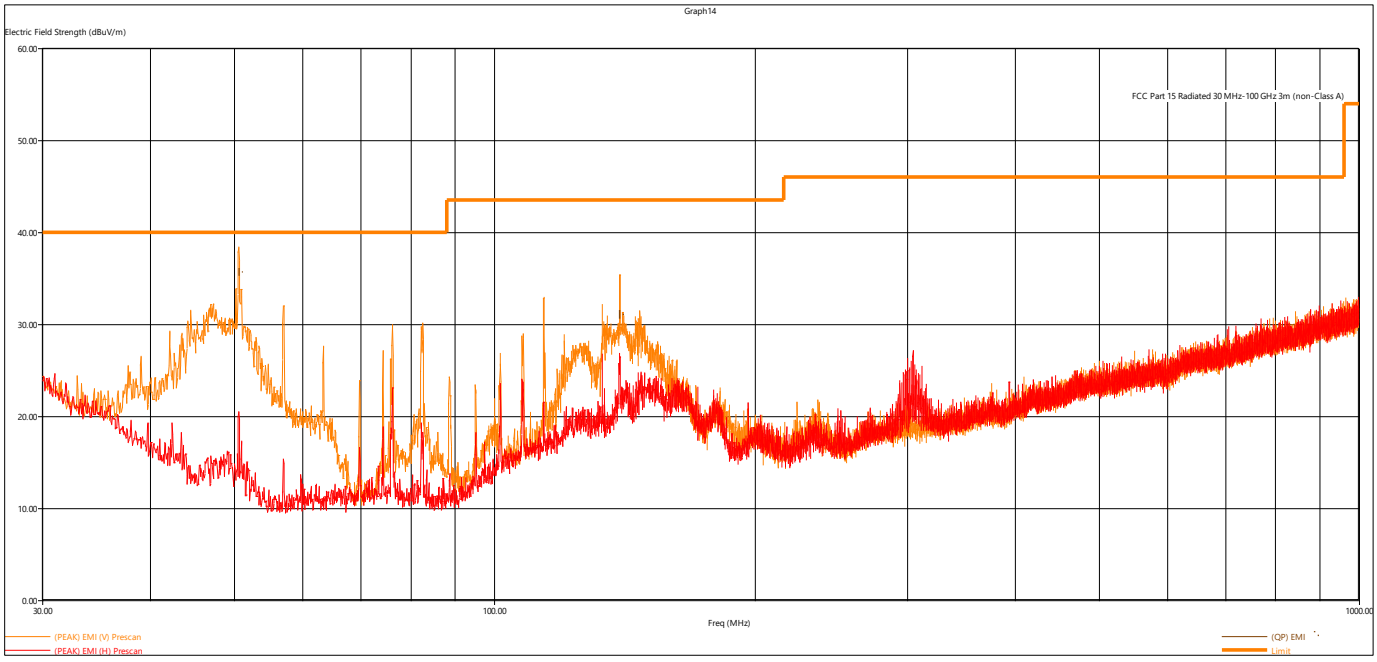


Figure 27 - Radiated Emissions Plot, 802.11b, Low Data Rate, Low Ch, Short Antenna

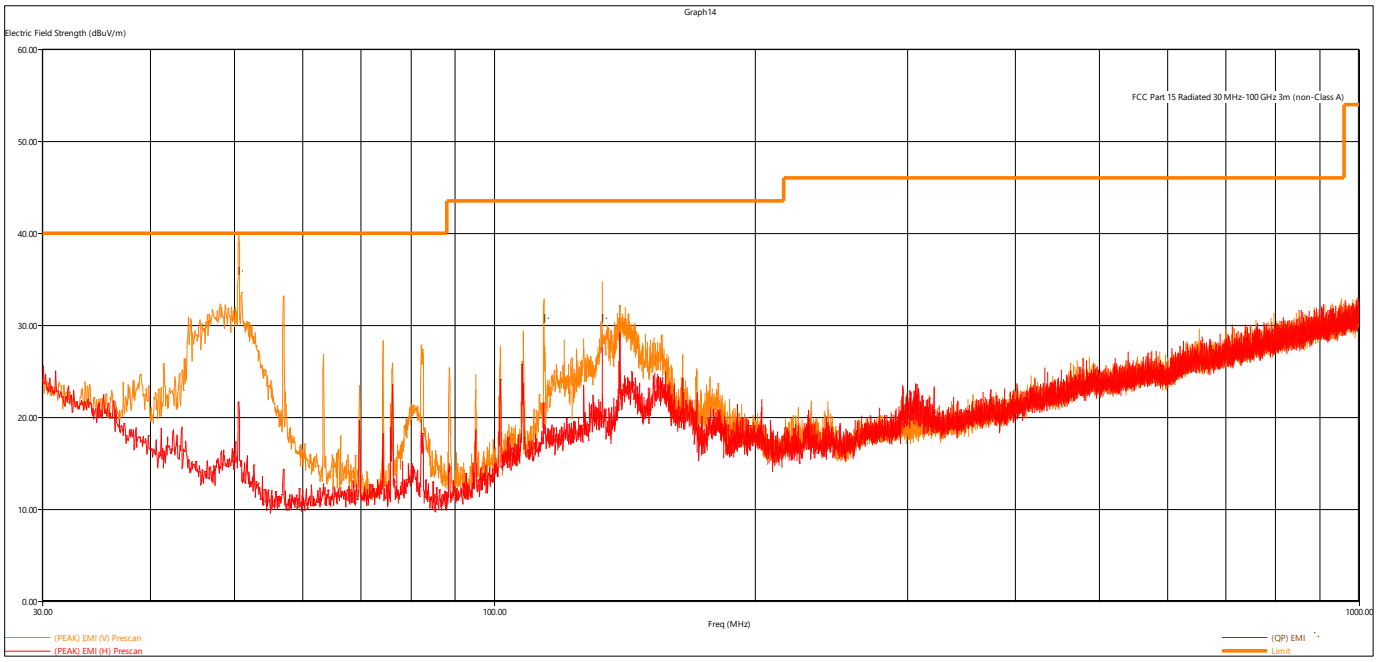


Figure 28 - Radiated Emissions Plot, 802.11g, Low Data Rate, Low Ch, Short Antenna

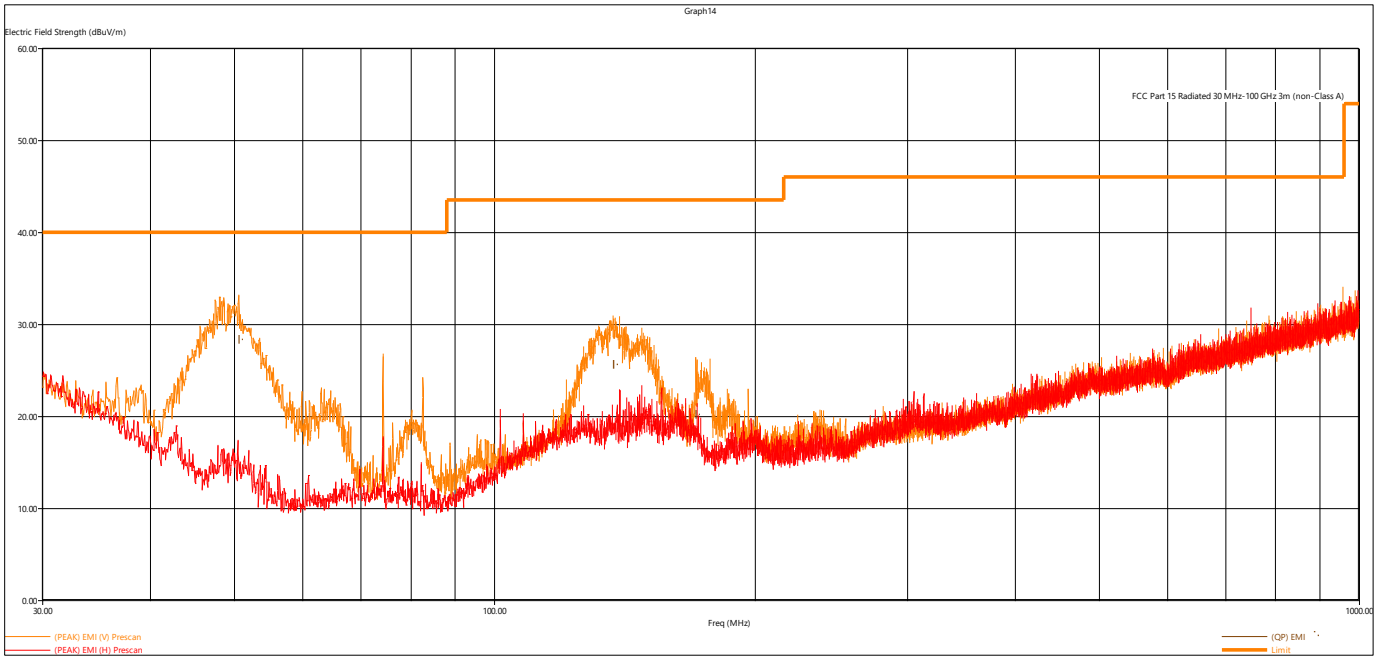


Figure 29 - Radiated Emissions Plot, 802.11n, Low Data Rate, Low Ch, Short Antenna

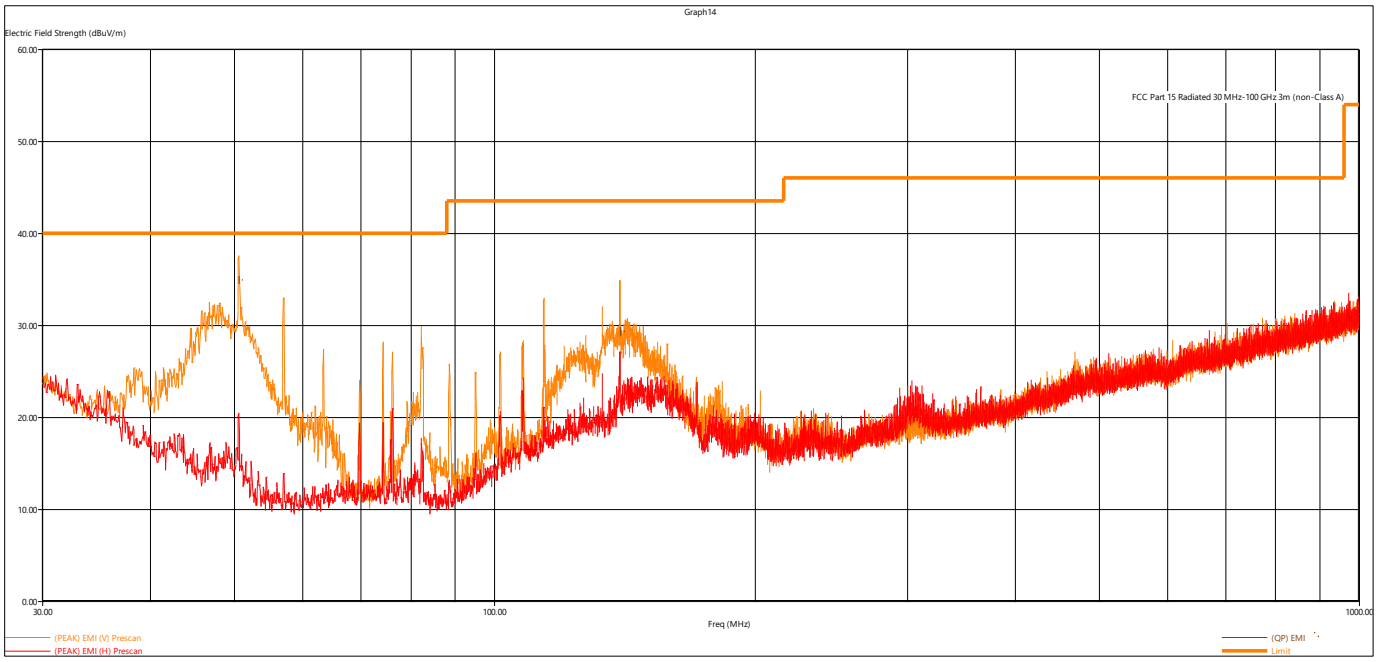


Figure 30 - Radiated Emissions Plot, 802.11b, High Data Rate, Low Ch, Short Antenna

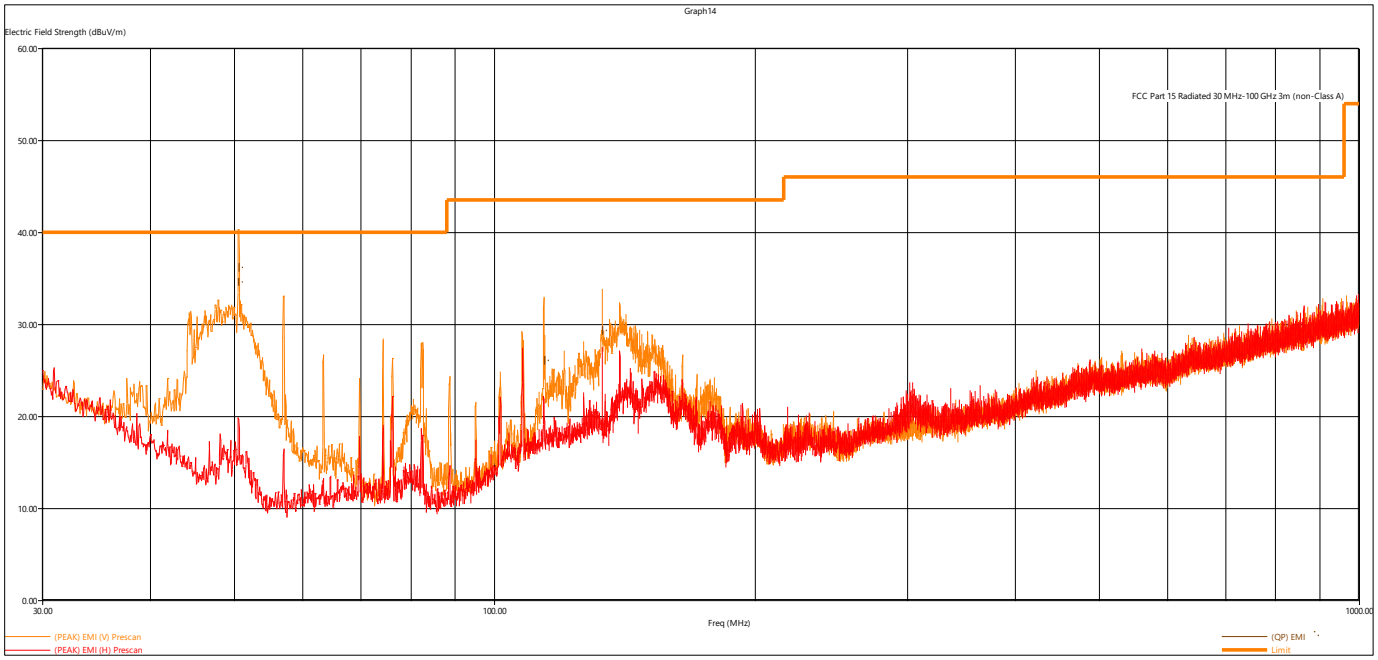


Figure 31 - Radiated Emissions Plot, 802.11g, High Data Rate, Low Ch, Short Antenna

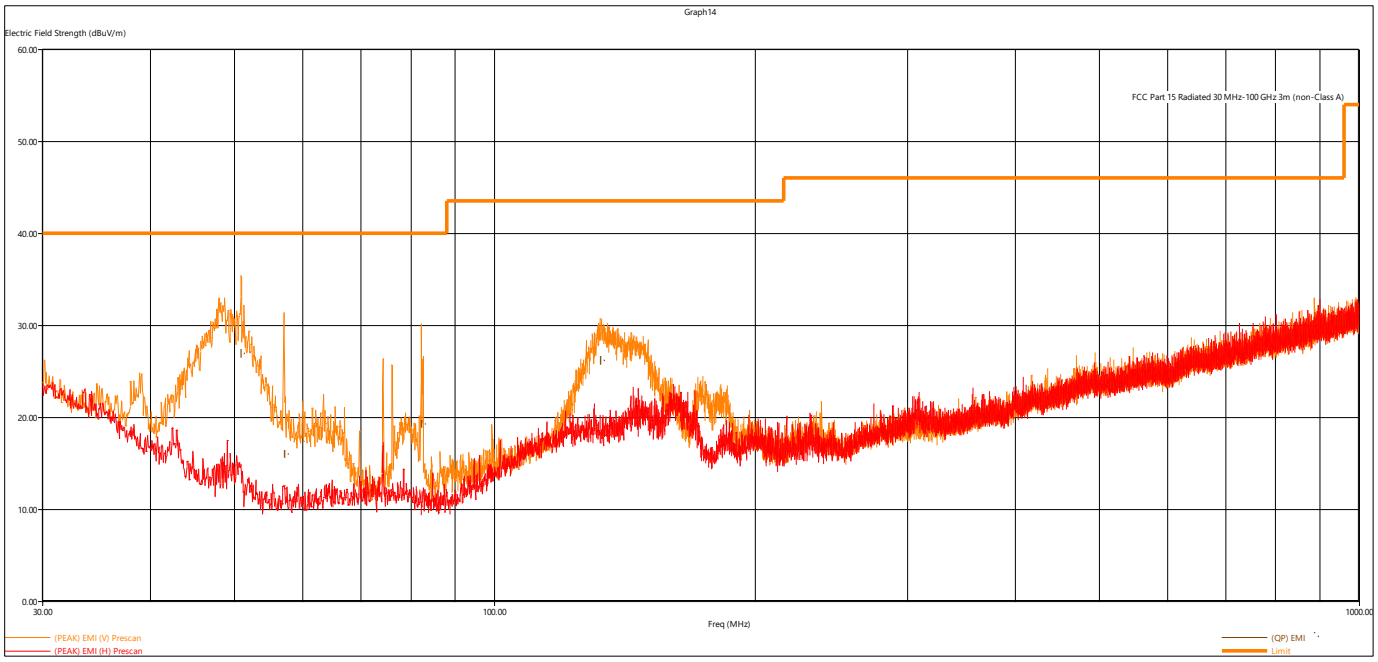


Figure 32 - Radiated Emissions Plot, 802.11n, High Data Rate, Low Ch, Short Antenna

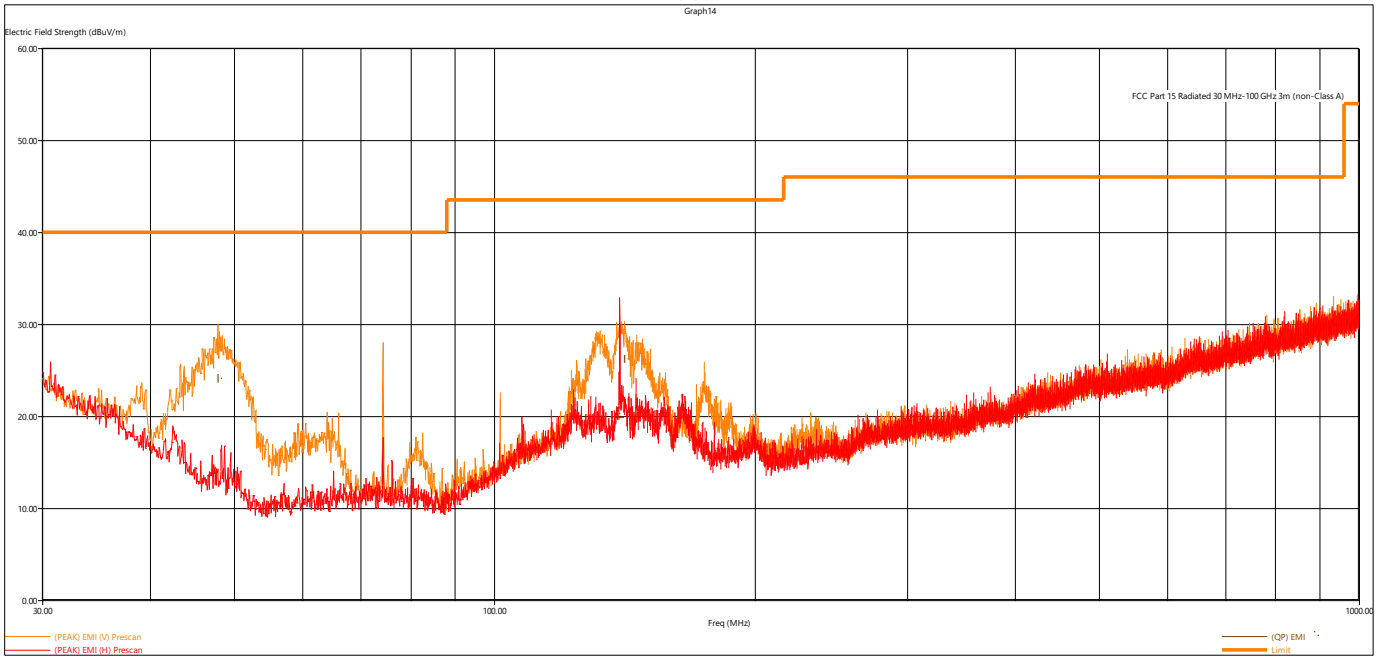


Figure 33 - Radiated Emissions Plot, Receive, Long Antenna

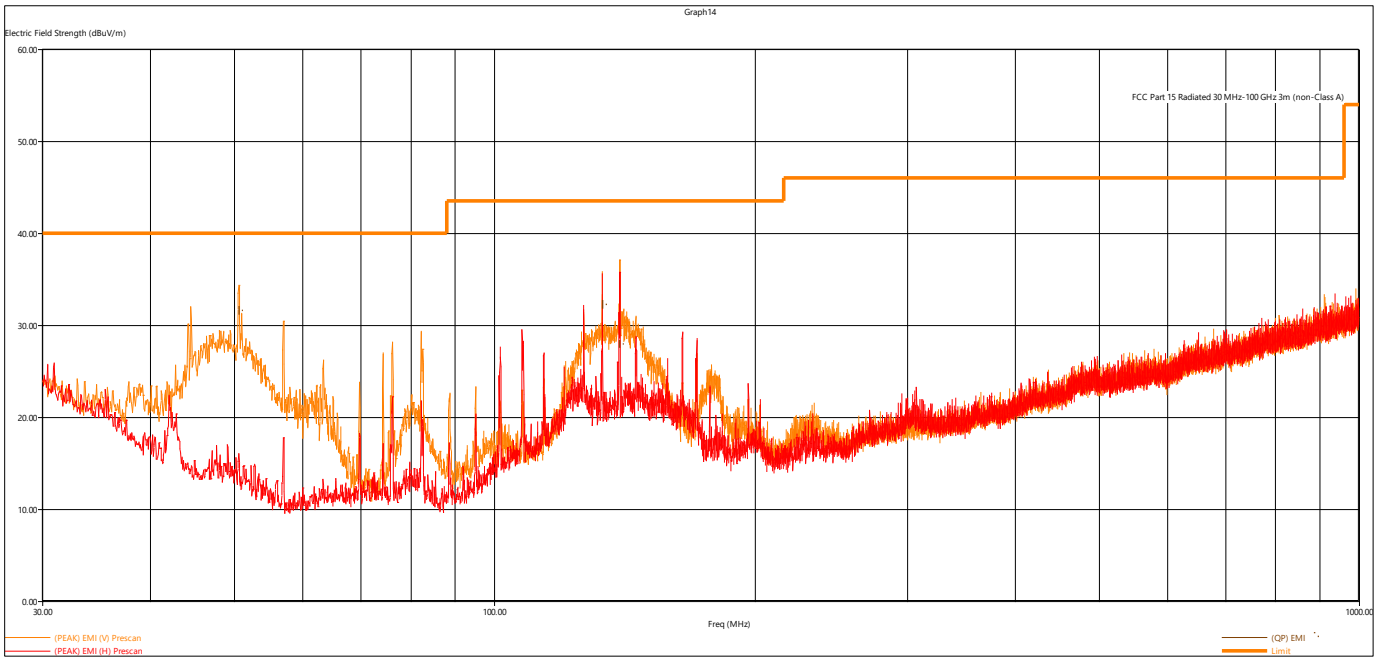


Figure 34 - Radiated Emissions Plot, 802.11b, Low Data Rate, Low Ch, Long Antenna

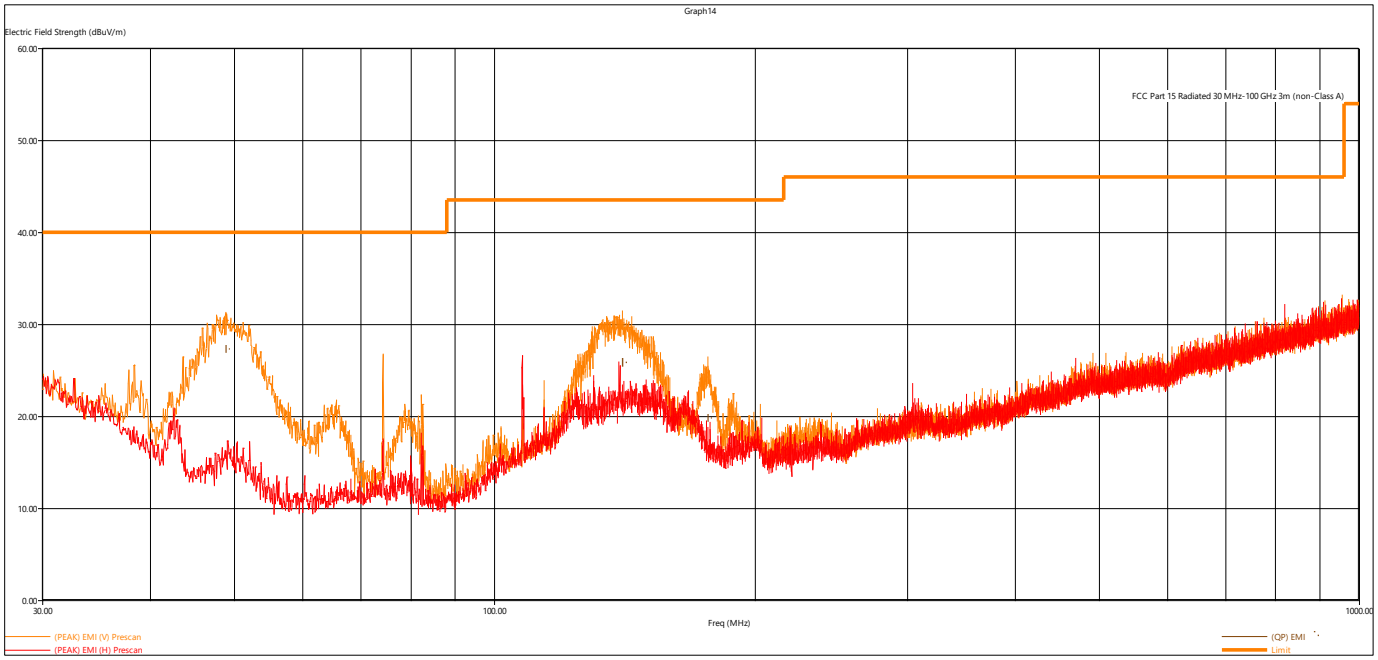


Figure 35 - Radiated Emissions Plot, 802.11g, Low Data Rate, Low Ch, Long Antenna

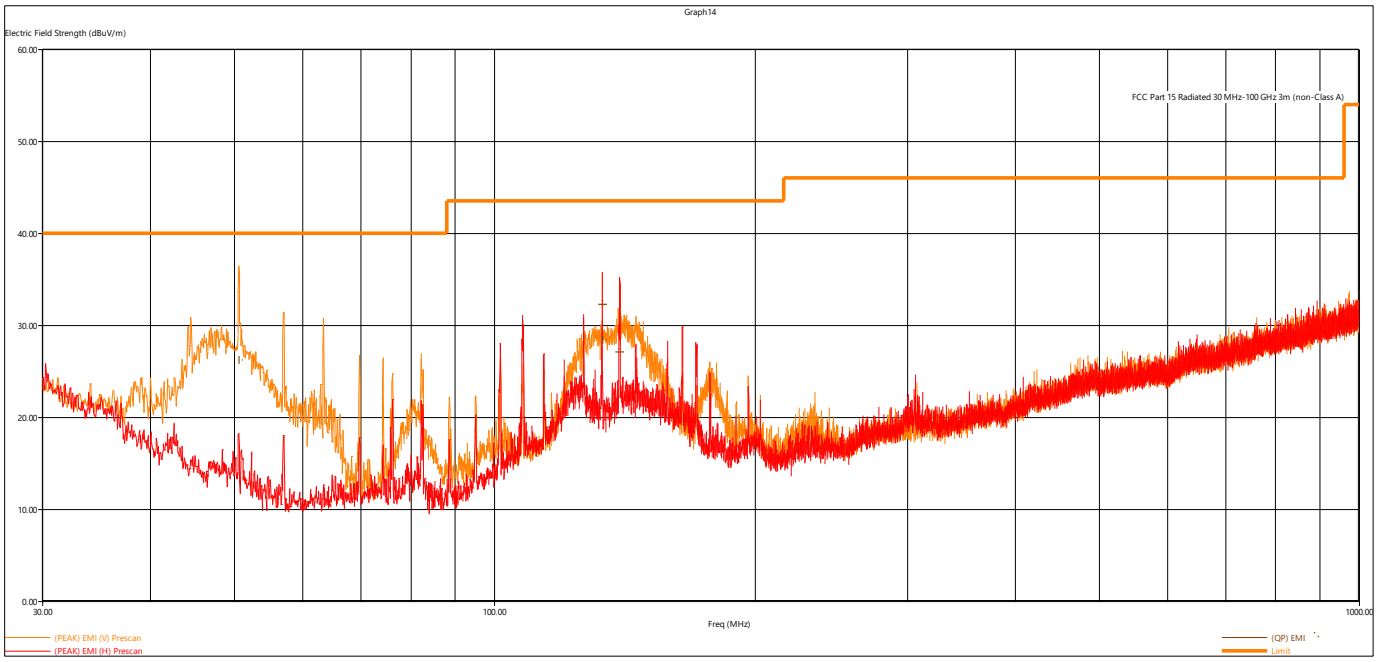


Figure 36 - Radiated Emissions Plot, 802.11n, Low Data Rate, Low Ch, Long Antenna

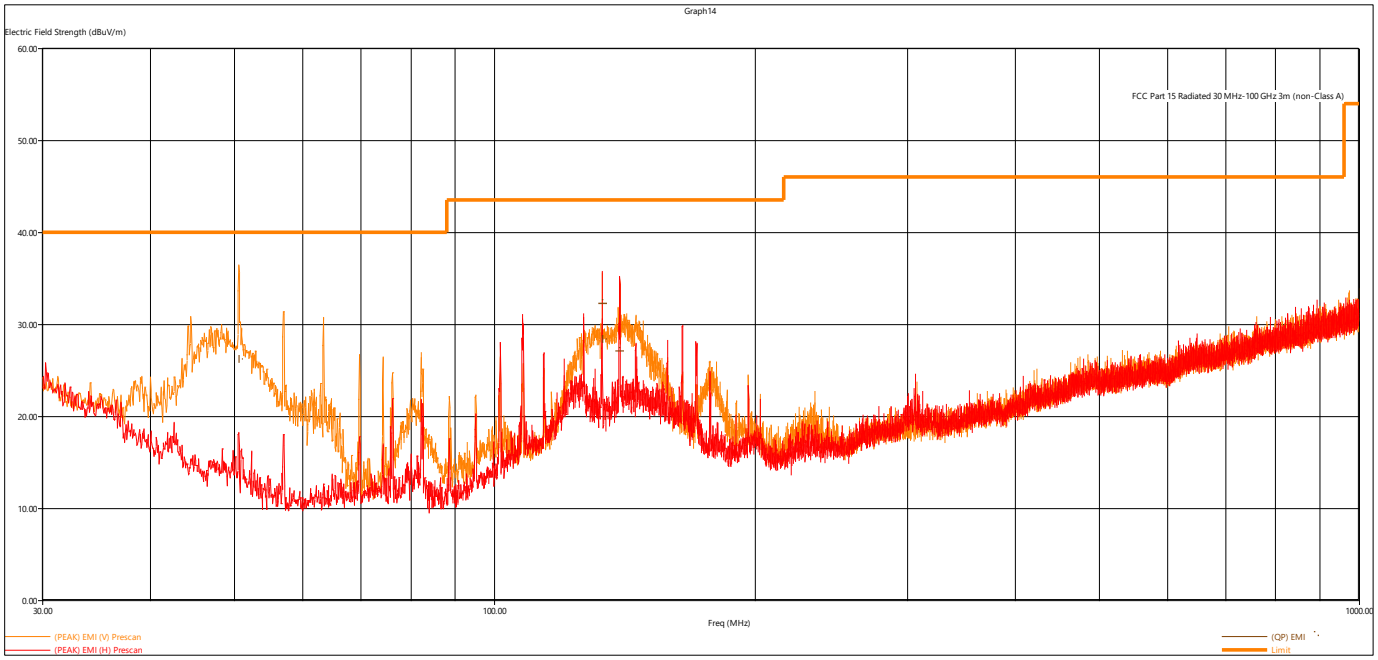


Figure 37 - Radiated Emissions Plot, 802.11b, High Data Rate, Low Ch, Long Antenna

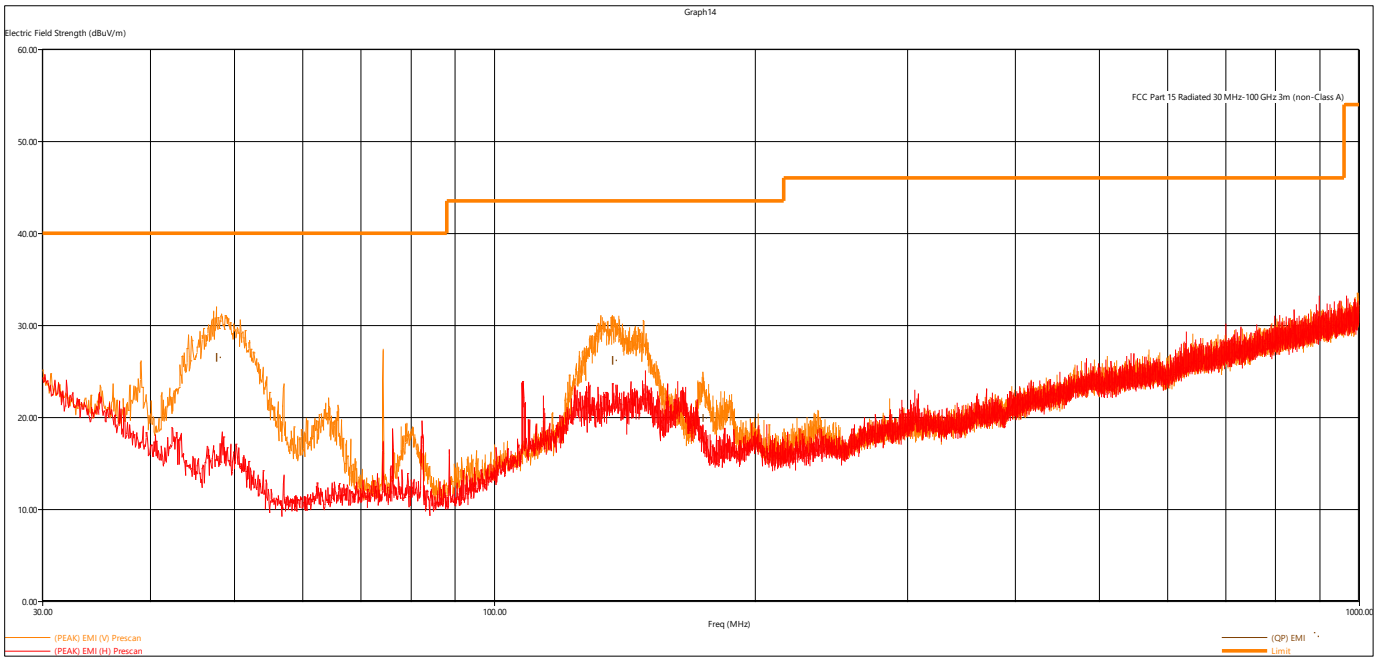


Figure 38 - Radiated Emissions Plot, 802.11g, High Data Rate, Low Ch, Long Antenna

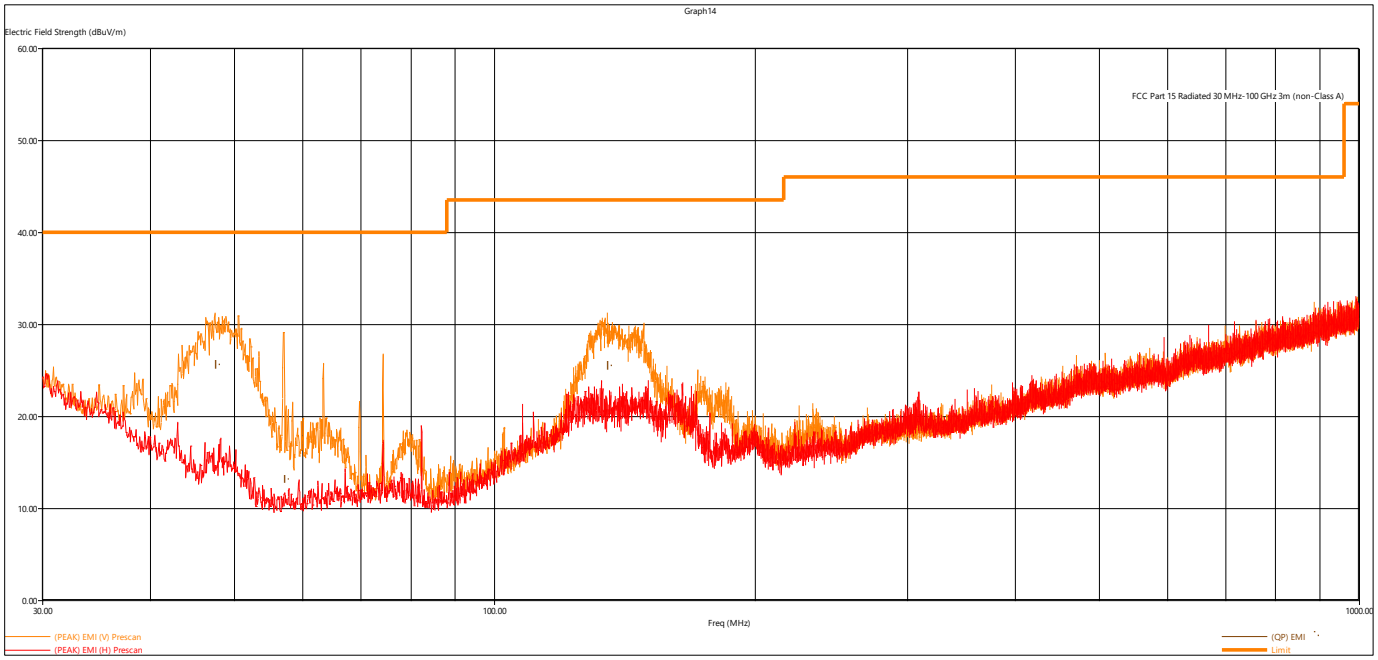


Figure 39 - Radiated Emissions Plot, 802.11n, High Data Rate, Low Ch, Long Antenna

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 = Limit value - Emission level

Quasi-Peak Measurements, Short Antenna									
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**	**Data Rate**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**				
50.53248	35.65	40.00	4.35	112	229	V	Low	802.11b	Low
139.3536	31.02	43.52	12.5	171	166	V	Low	802.11b	Low
50.57856	34.87	40.00	5.13	127	61	V	Low	802.11b	High
139.5787	29.33	43.52	14.19	109	133	V	Low	802.11b	High
50.51496	35.87	40.00	4.13	113	353	V	Low	802.11g	Low
113.8442	30.71	43.52	12.81	118	87	V	Low	802.11g	Low
133.2324	30.67	43.52	12.85	123	153	V	Low	802.11g	Low
50.53248	34.52	40.00	5.48	121	340	V	Low	802.11g	High
50.55528	36.06	40.00	3.94	124	272	V	Low	802.11g	High
114.0034	26.00	43.52	17.52	120	70	V	Low	802.11g	High
133.1287	29.28	43.52	14.24	164	157	V	Low	802.11g	High
49.27824	27.86	40.00	12.14	106	261	V	Low	802.11n	Low
138.0595	26.41	43.52	17.11	105	77	V	Low	802.11n	Low
171.8815	15.88	43.52	27.64	305	360	V	Low	802.11n	Low
50.93712	26.84	40.00	13.16	99	0	V	Low	802.11n	High
57.18768	15.96	40.00	24.04	138	233	V	Low	802.11n	High
82.23768	19.18	40.00	20.82	121	216	V	Low	802.11n	High
132.48	26.08	43.52	17.44	103	301	V	Low	802.11n	High
50.54928	26.56	40.00	13.44	127	271	V	RX		
56.90832	22.43	40.00	17.57	163	336	V	RX		
142.1422	25.21	43.52	18.31	118	76	V	RX		

All other measurements found to be at least 6dB below the limit line

Quasi-Peak Measurements, Long Antenna									
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**	**Data Rate**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**				
50.55384	31.54	40.00	8.46	107	38	V	Low	802.11b	Low
133.1496	32.16	43.52	11.36	106	188	V	Low	802.11b	Low
139.4124	27.9	43.52	15.62	159	137	V	Low	802.11b	Low
133.1448	32.15	43.52	11.37	218	79	H	Low	802.11b	High
139.3865	27.03	43.52	16.49	198	75	H	Low	802.11b	High
50.59032	26.17	40.00	13.83	123	50	V	Low	802.11b	High
133.1064	28.35	43.52	15.17	147	154	V	Low	802.11b	High
48.8604	27.25	40.00	12.75	110	229	V	Low	802.11g	Low
140.2934	25.75	43.52	17.77	137	101	V	Low	802.11g	Low
176.4235	19.78	43.52	23.74	116	88	V	Low	802.11g	Low
47.62656	26.42	40.00	13.58	110	265	V	Low	802.11g	High
136.6452	26.07	43.52	17.45	105	168	V	Low	802.11g	High
173.9957	19.87	43.52	23.65	108	312	V	Low	802.11g	High
139.3752	20.36	43.52	23.16	295	73	H	Low	802.11n	Low
47.88672	26.76	40.00	13.24	104	279	V	Low	802.11n	Low
136.4066	26.34	43.52	17.18	108	131	V	Low	802.11n	Low
47.4732	25.56	40.00	14.44	111	192	V	Low	802.11n	High
56.84232	13.11	40.00	26.89	199	293	V	Low	802.11n	High
134.8524	25.47	43.52	18.05	108	124	V	Low	802.11n	High
139.3452	19.81	43.52	23.71	202	52	H	RX		
47.796	24.03	40.00	15.97	105	193	V	RX		
50.55384	31.54	40.00	8.46	107	38	V	RX		

All other measurements found to be at least 6dB below the limit line

Peak Measurements, 802.11x									
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**	**Data Rate**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**				
2411.112000	107.45	NA	NA	146.00	359.00	H	Low	802.11b	Low
2436.136000	107.92	NA	NA	173.00	3.00	H	Mid	802.11b	Low
2461.224000	107.51	NA	NA	204.00	5.00	H	High	802.11b	Low
2435.084000	111.25	NA	NA	133.00	345.00	H	Mid	802.11g	Low
2438.310000	111.00	NA	NA	133.00	348.00	H	Mid	802.11n	Low
4823.360000	44.75	73.98	29.23	196.00	43.00	H	Low	802.11b	Low
7236.586000	46.94	73.98	27.04	442.00	112.00	H	Low	802.11b	Low
4873.958000	44.08	73.98	35.9	197.00	62.00	H	Mid	802.11b	Low
4923.924000	45.23	73.98	28.75	129.00	341.00	H	High	802.11b	Low
4870.500000	52.75	73.98	21.23	126.00	62.00	H	Mid	802.11g	Low
4880.260000	43.87	73.98	30.11	459.00	56.00	H	Mid	802.11n	Low
4924.154000	42.79	73.98	16.19	130.00	352.00	H	Mid	802.11n	Low
2413.544000	109.91	NA	NA	128.00	347.00	H	High	802.11b	High
2416.810000	106.79	NA	NA	205.00	352.00	H	Low	802.11g	Low
2410.502000	107.97	NA	NA	255.00	352.00	H	Low	802.11g	High
2413.958000	105.47	NA	NA	208.00	341.00	H	Low	802.11n	Low
2461.450000	103.92	NA	NA	183.00	356.00	H	Low	802.11n	High
2460.930000	106.27	NA	NA	197.00	346.00	H	High	802.11n	Low
2459.860000	104.43	NA	NA	374.00	352.00	H	High	802.11n	High
2459.970000	105.78	NA	NA	238.00	360.00	H	High	802.11g	Low
4819.224000	57.20	73.98	16.78	281.00	360.00	V	High	802.11g	High
4923.872000	52.79	73.98	21.19	453.00	355.00	V	High	802.11g	Low

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

Average Measurements, 802.11x									
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**	**Data Rate**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**				
2411.112000	104.64	NA	NA	146.00	359	H	Low	802.11b	Low
2436.136000	105.23	NA	NA	173.00	3.00	H	Mid	802.11b	Low
2461.224000	104.87	NA	NA	204.00	5.00	H	High	802.11b	Low
2435.084000	102.22	NA	NA	133.00	345.00	H	Mid	802.11g	Low
2438.310000	101.63	NA	NA	133.00	348.00	H	Mid	802.11n	Low
4823.360000	29.79	53.98	24.19	196.00	43.00	H	Low	802.11b	Low
7236.586000	33.41	53.98	20.57	442.00	112.00	H	Low	802.11b	Low
4873.958000	29.84	53.98	24.14	197.00	62.00	H	Mid	802.11b	Low
4923.924000	30.97	53.98	23.01	129.00	341.00	H	High	802.11b	Low
4870.500000	38.79	53.98	15.19	126.00	62.00	H	Mid	802.11g	Low
4880.260000	30.43	53.98	23.55	459.00	56.00	H	Mid	802.11n	Low
4924.154000	29.29	53.98	9.19	130.00	352.00	H	High	802.11b	High
2413.544000	100.89	NA	NA	128.00	347.00	H	Low	802.11g	Low
2416.810000	96.84	NA	NA	205.00	352.00	H	Low	802.11g	High
2410.502000	98.69	NA	NA	255.00	352.00	H	Low	802.11n	Low
2413.958000	95.32	NA	NA	208.00	341.00	H	Low	802.11n	High
2461.450000	94.96	NA	NA	183.00	356.00	H	High	802.11n	Low
2460.930000	95.50	NA	NA	197.00	346.00	H	High	802.11n	High
2459.860000	94.91	NA	NA	374.00	352.00	H	High	802.11g	Low
2459.970000	95.40	NA	NA	238.00	360.00	H	High	802.11g	High
4819.224000	43.74	53.98	10.24	281.00	360.00	V	High	802.11g	Low
4923.872000	38.24	53.98	15.74	453.00	355.00	V	High	802.11n	High

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

4.8 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. The limit shown in the graph accounts for the antenna gain of the device.

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

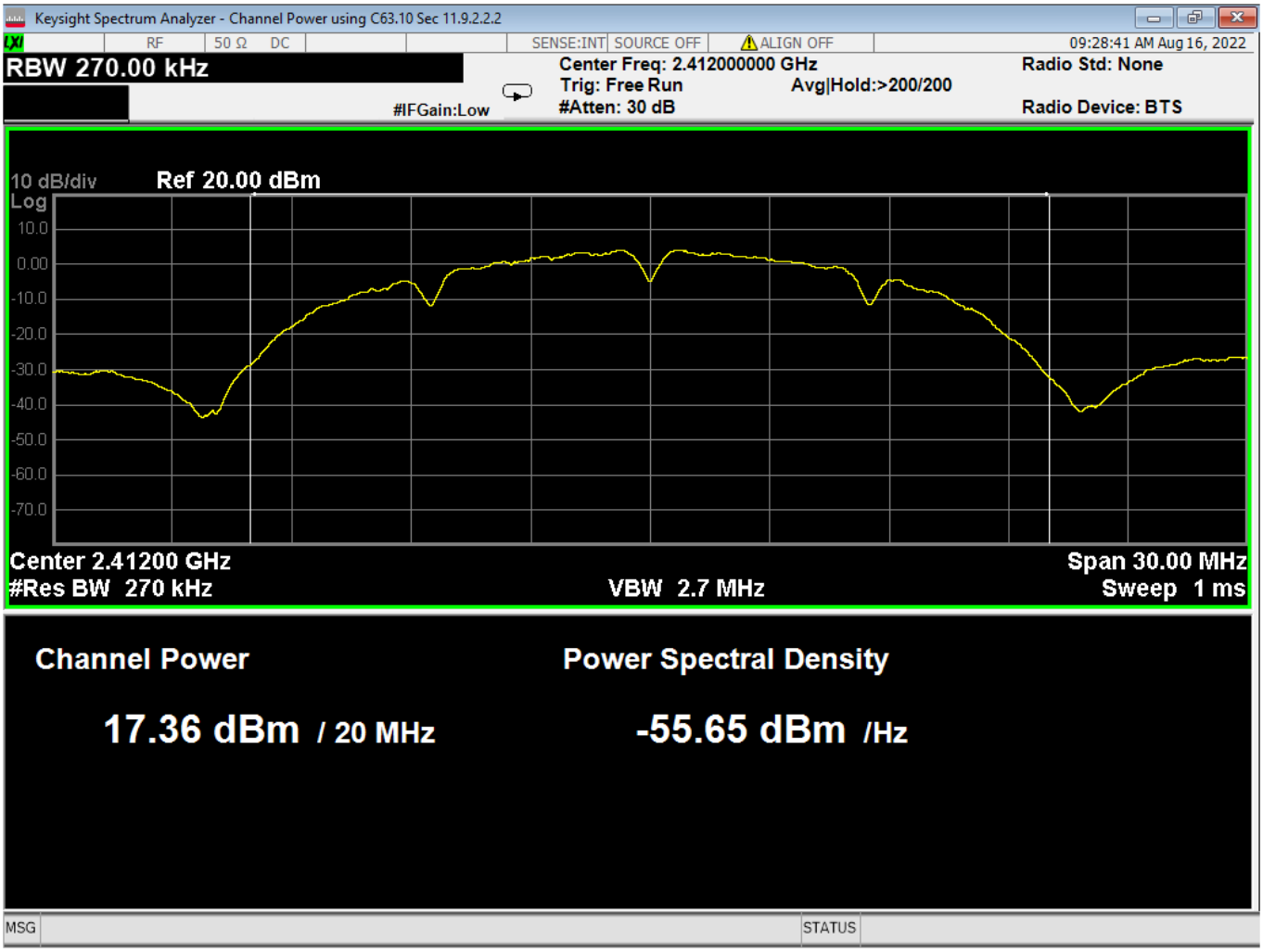
APPENDIX B – MEASUREMENT UNCERTAINTY

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

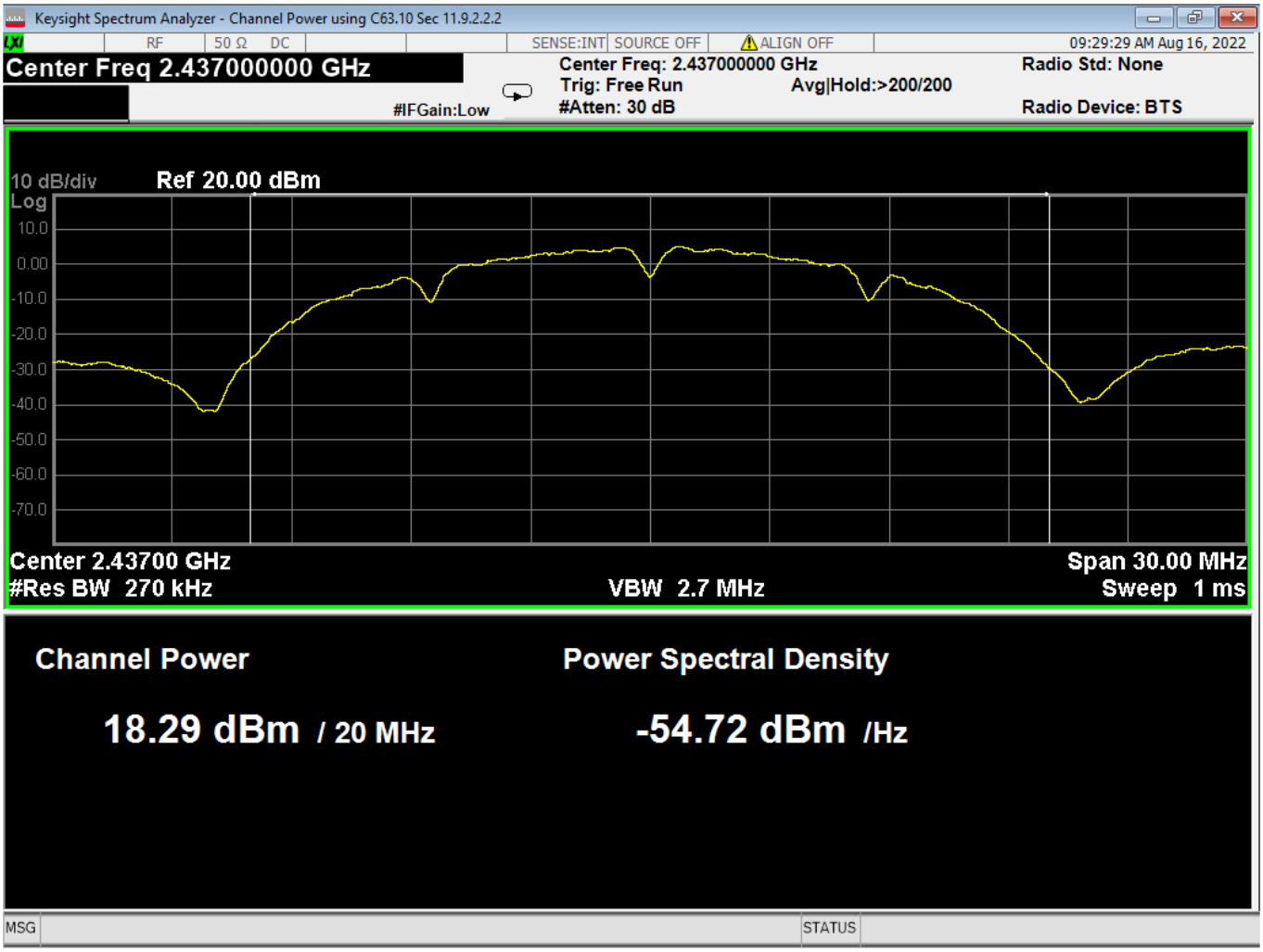
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	150kHz – 30MHz	±3.03

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

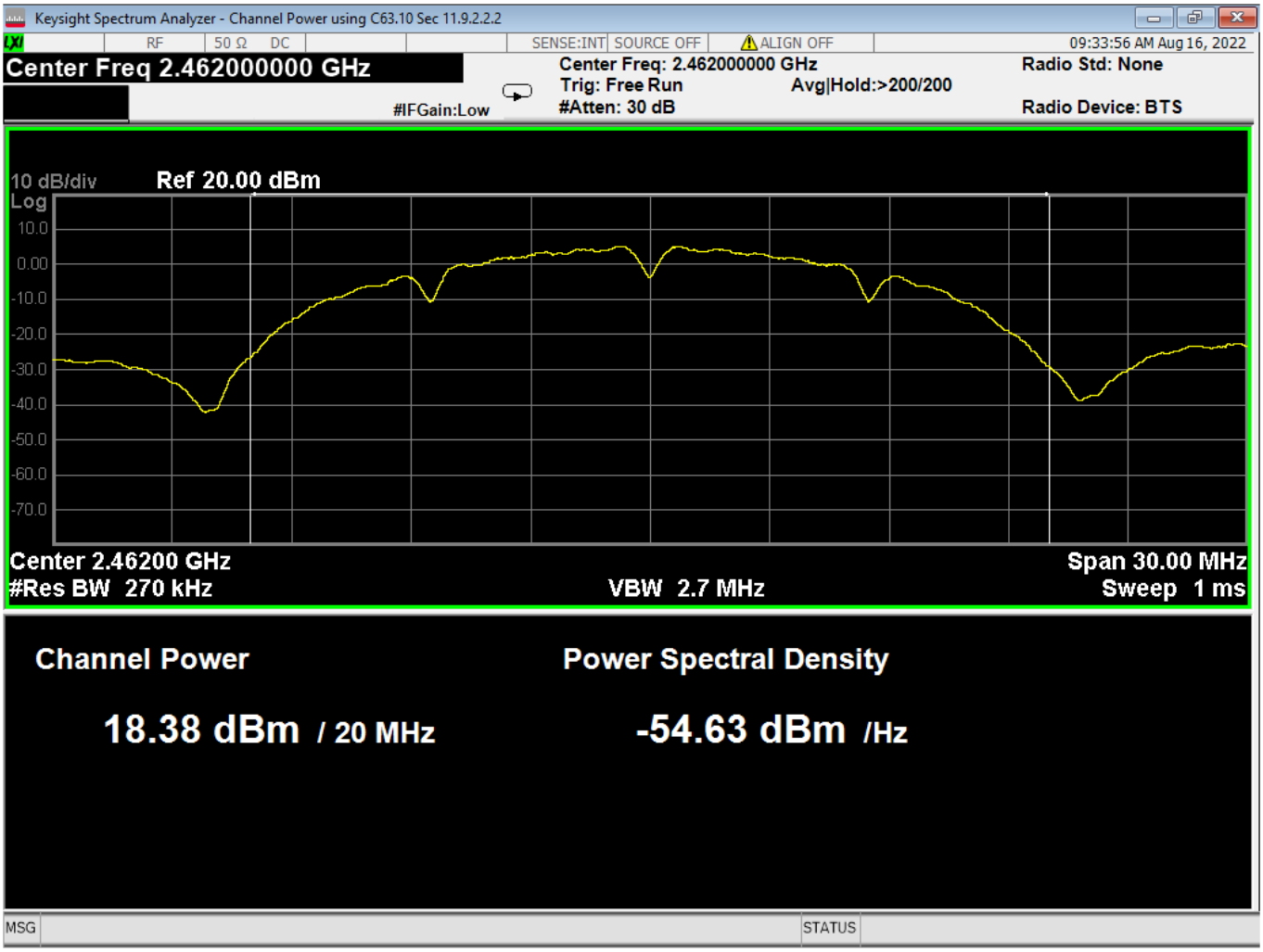
APPENDIX C – GRAPHS AND TABLES



01 Average Power, Low, Wifi B, Low Data Rate



02 Average Power, Mid, Wifi B, Low Data Rate



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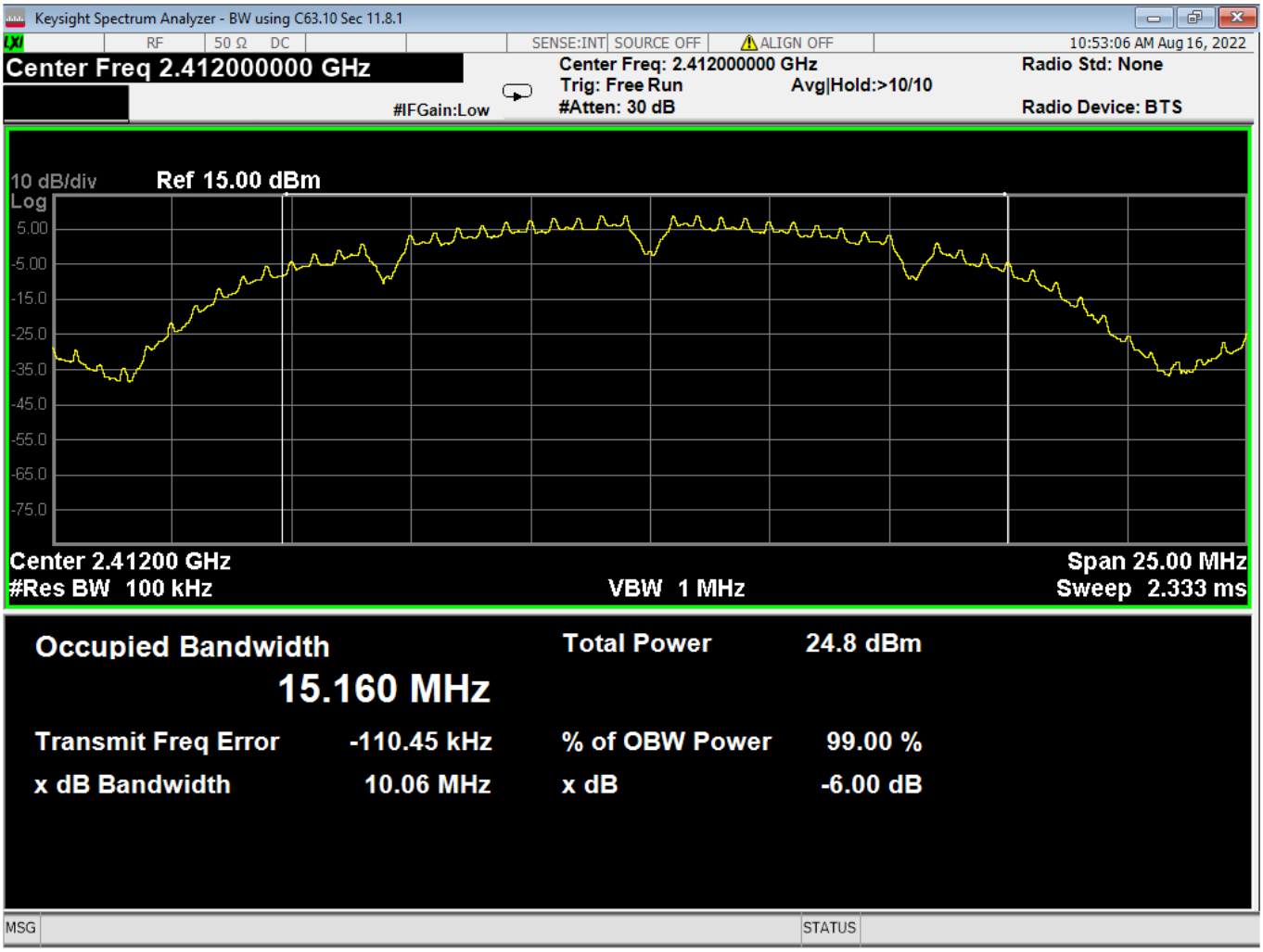

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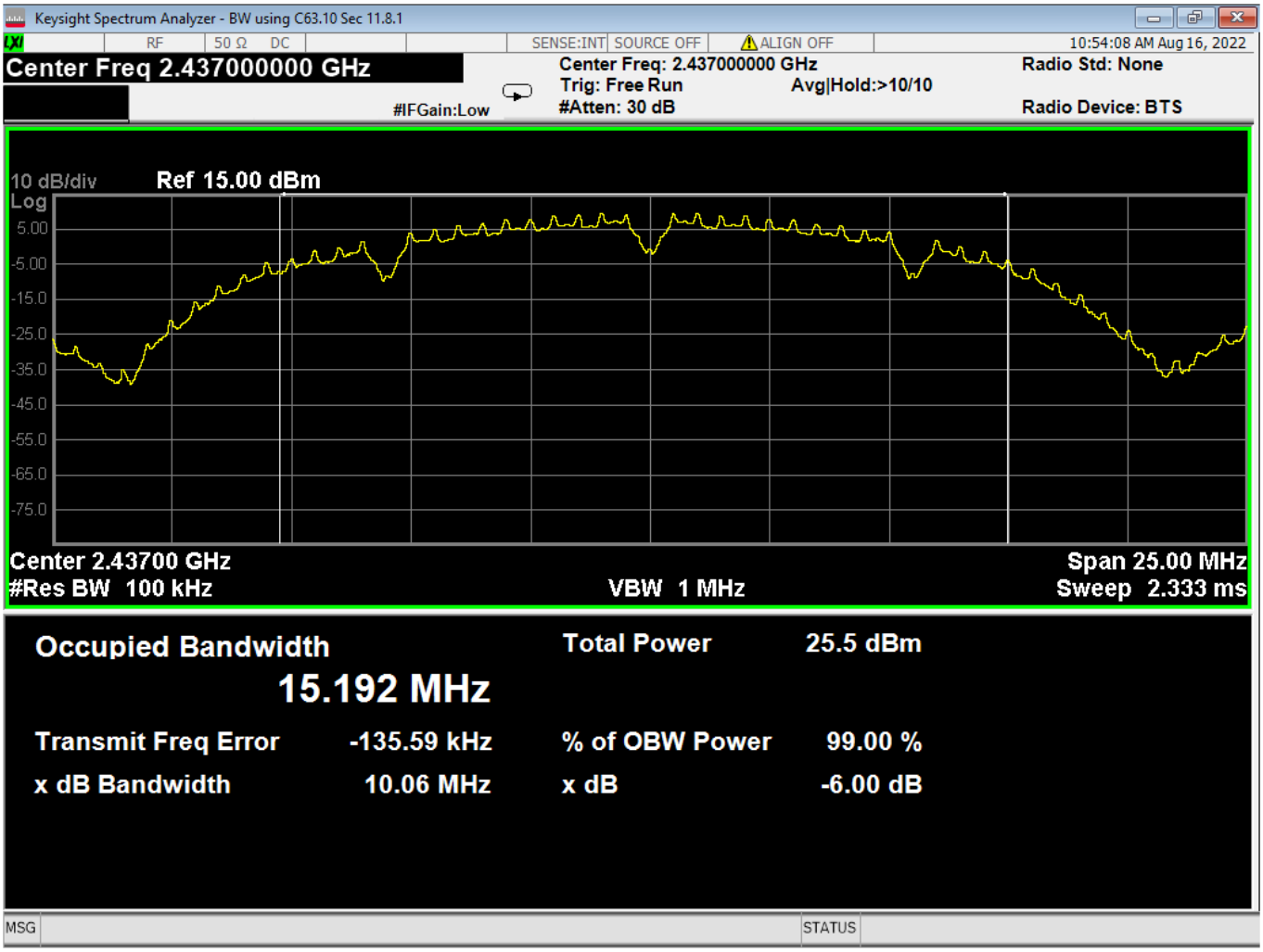

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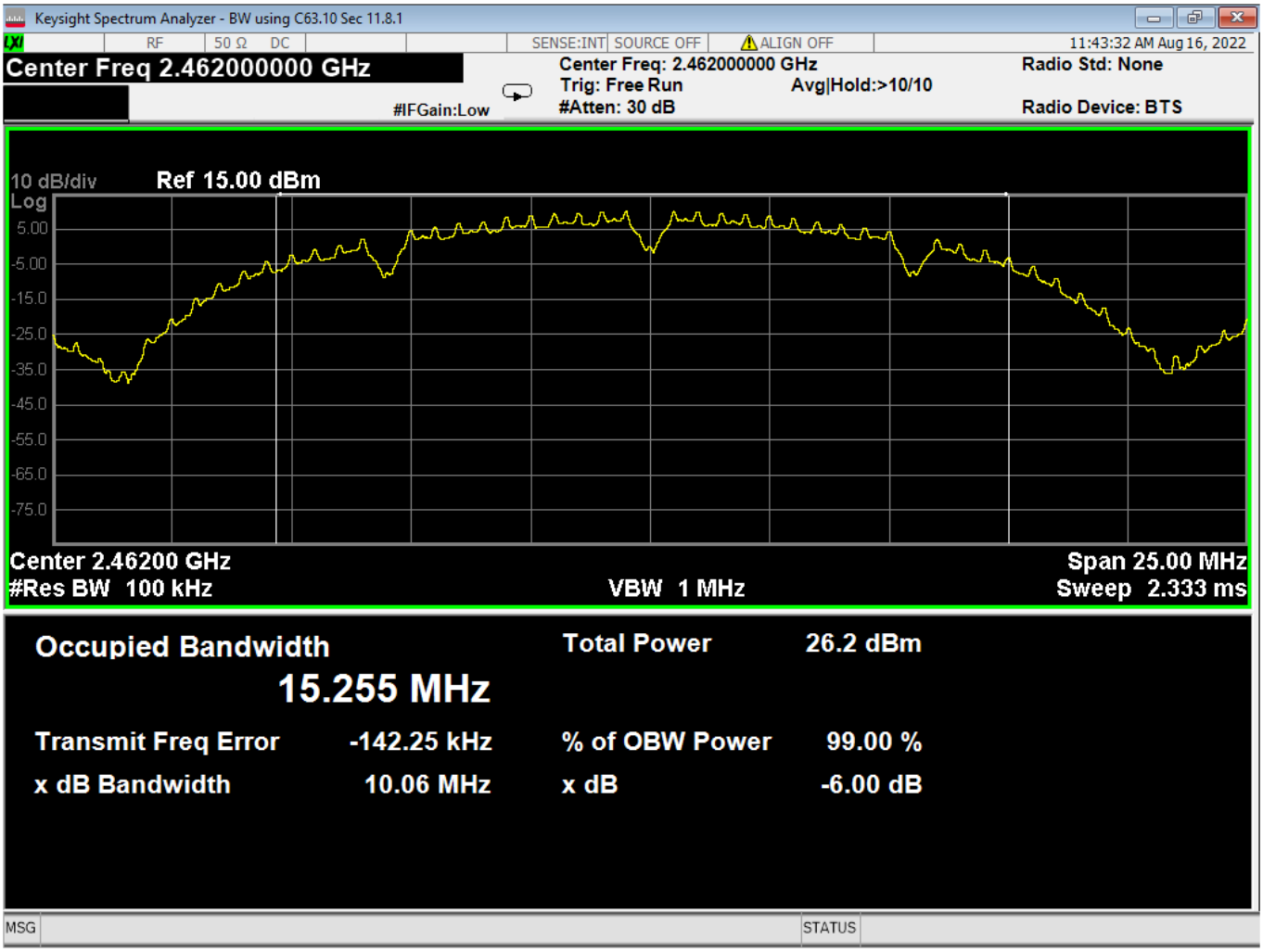

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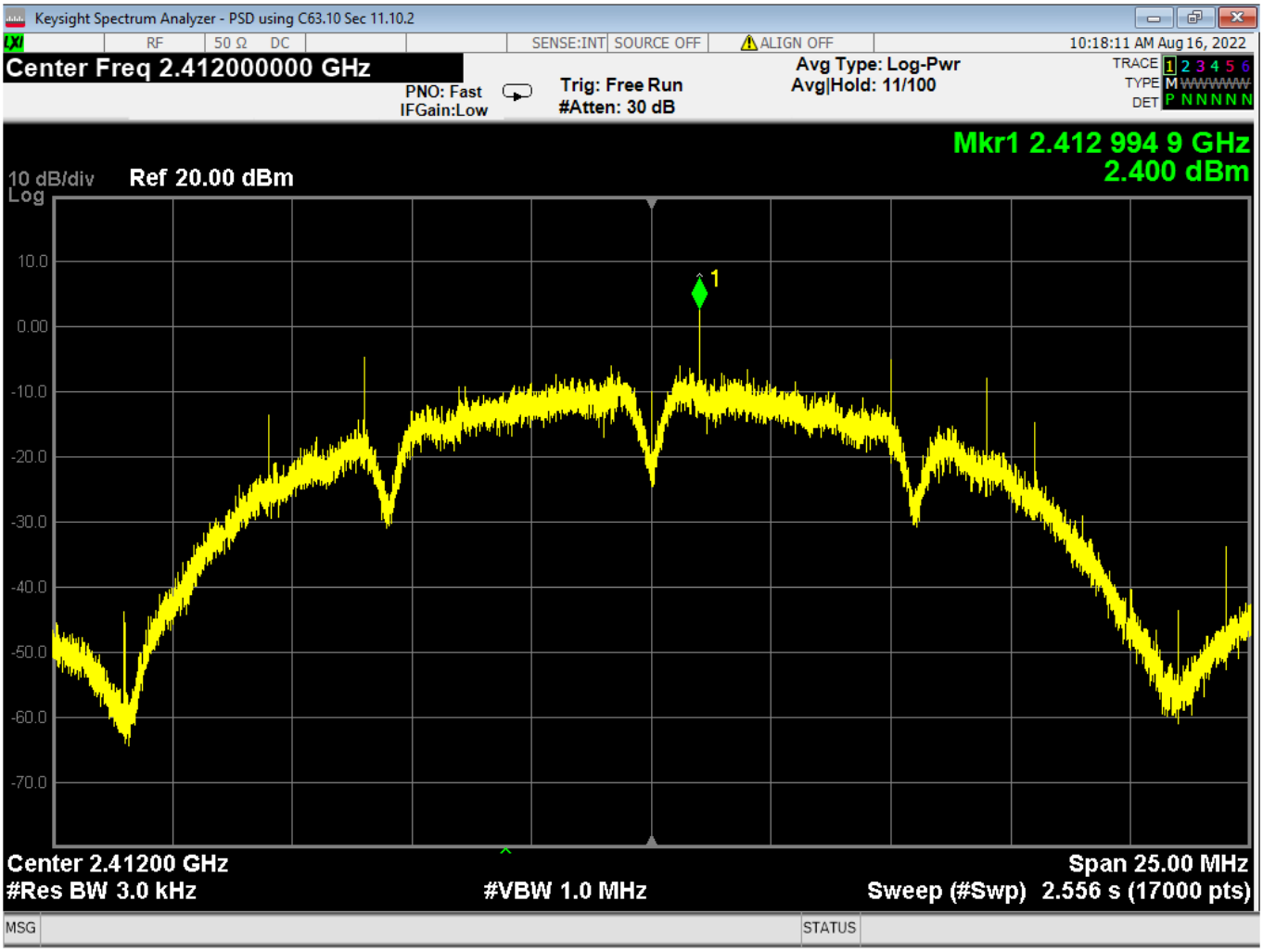

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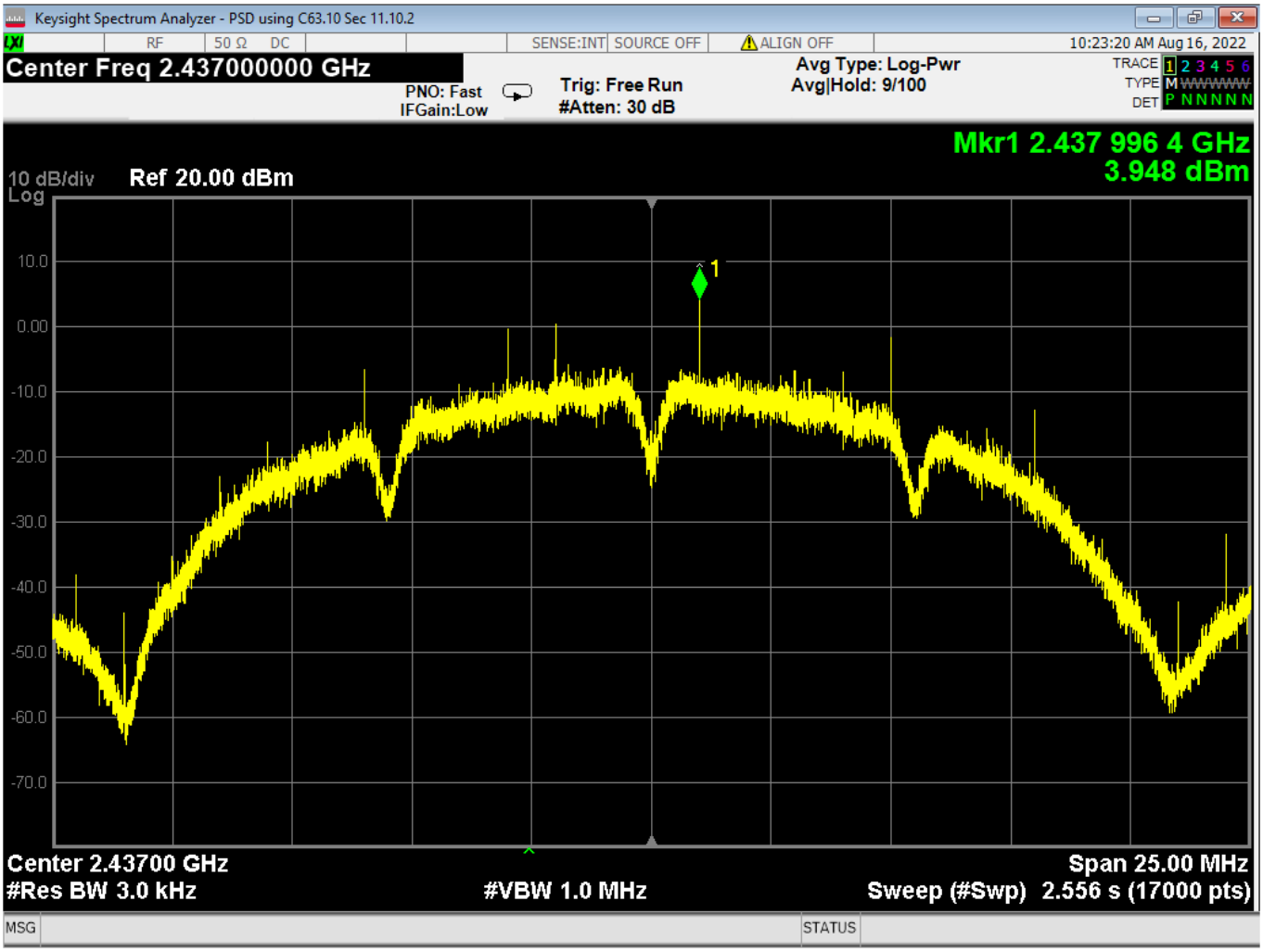

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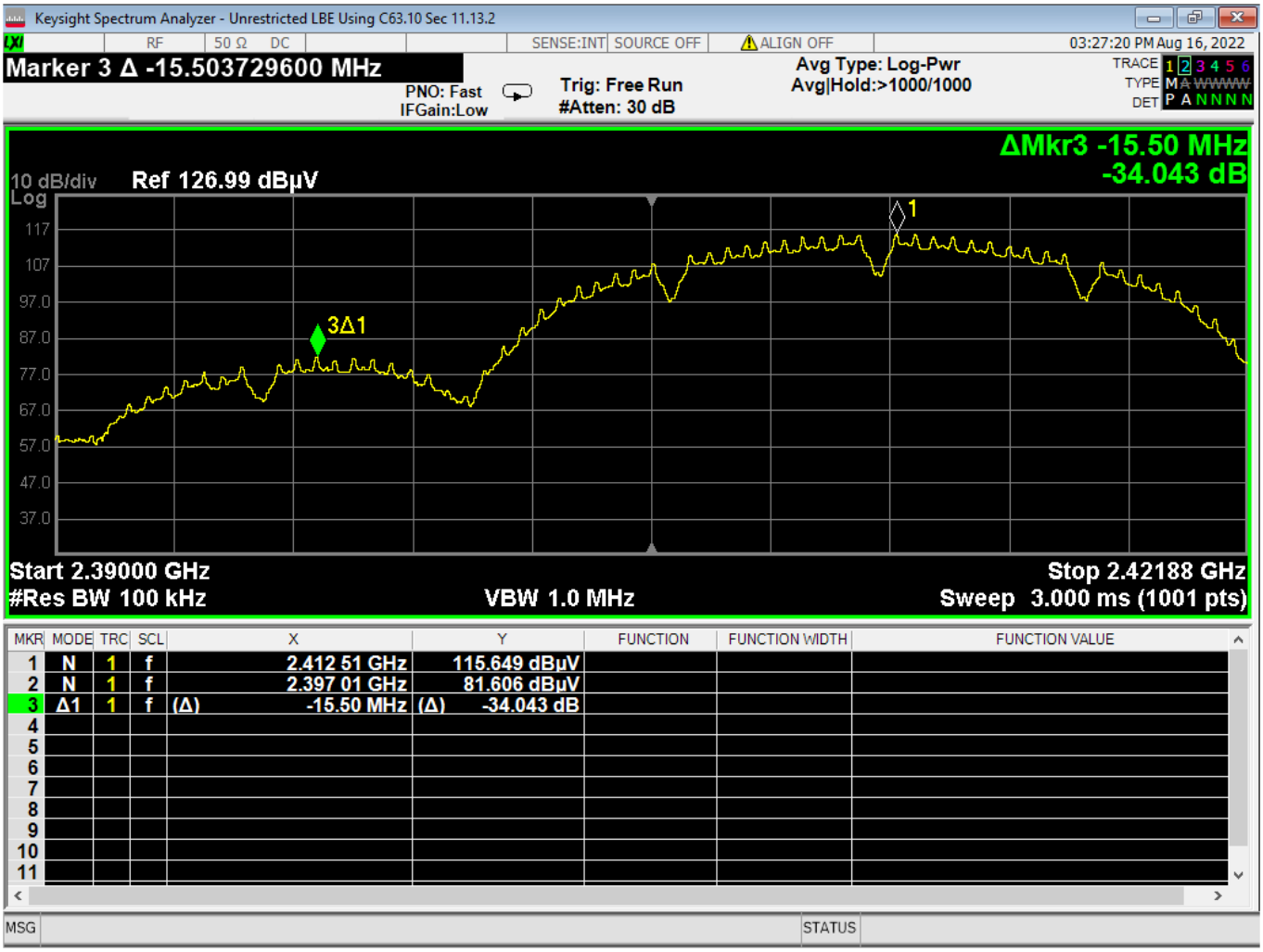
09 PSD, High, Wifi B, Low Data Rate



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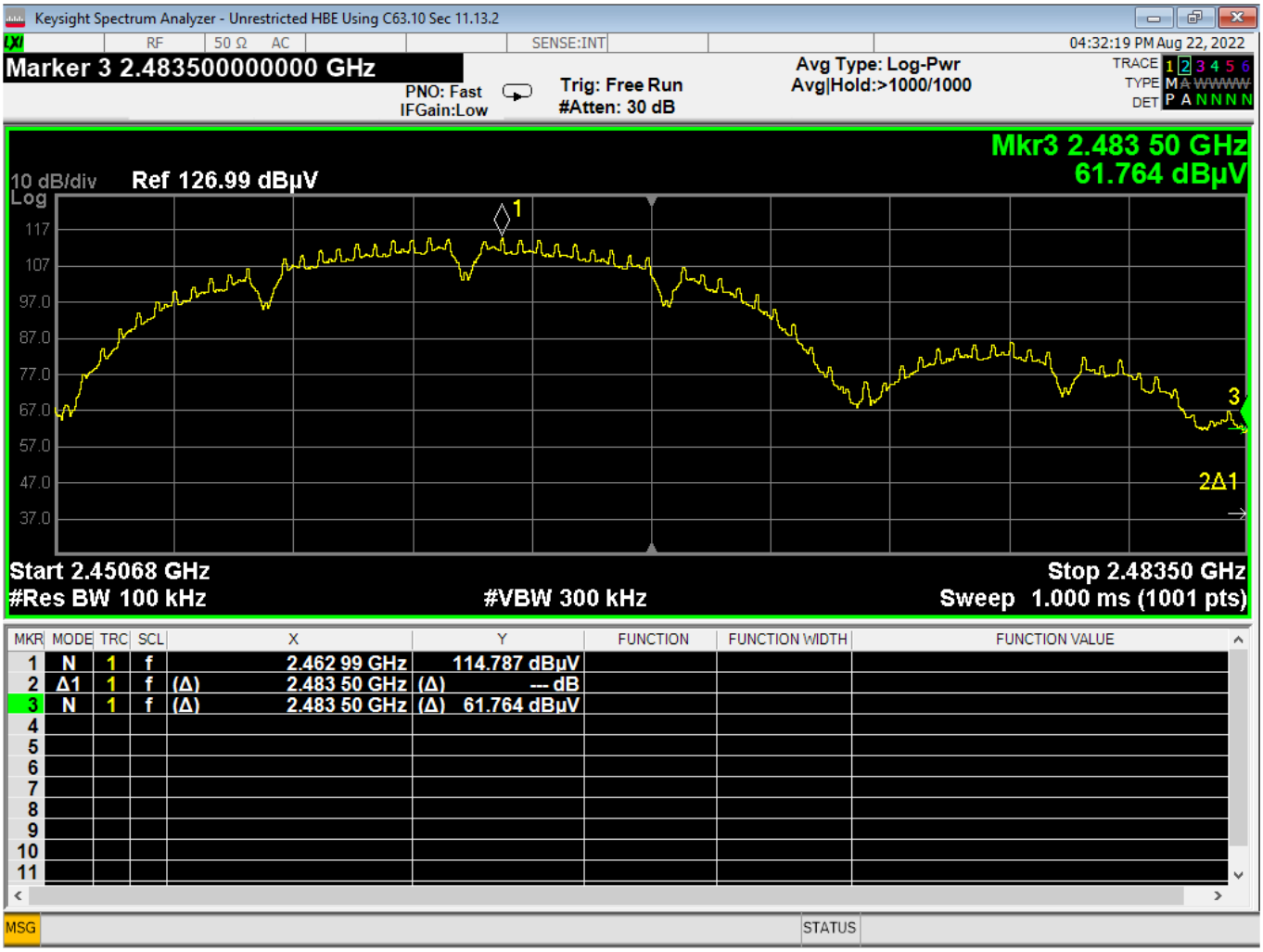

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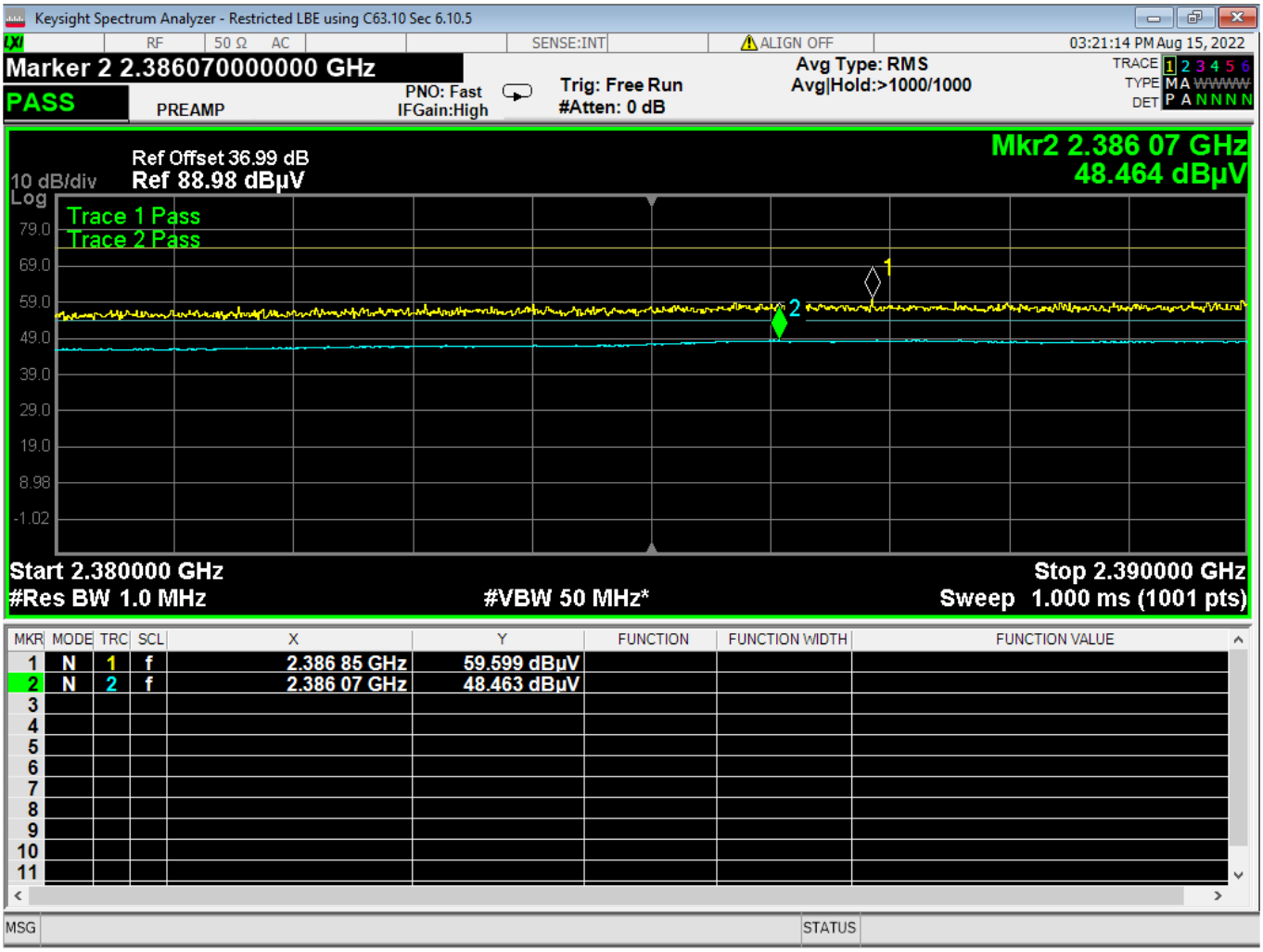

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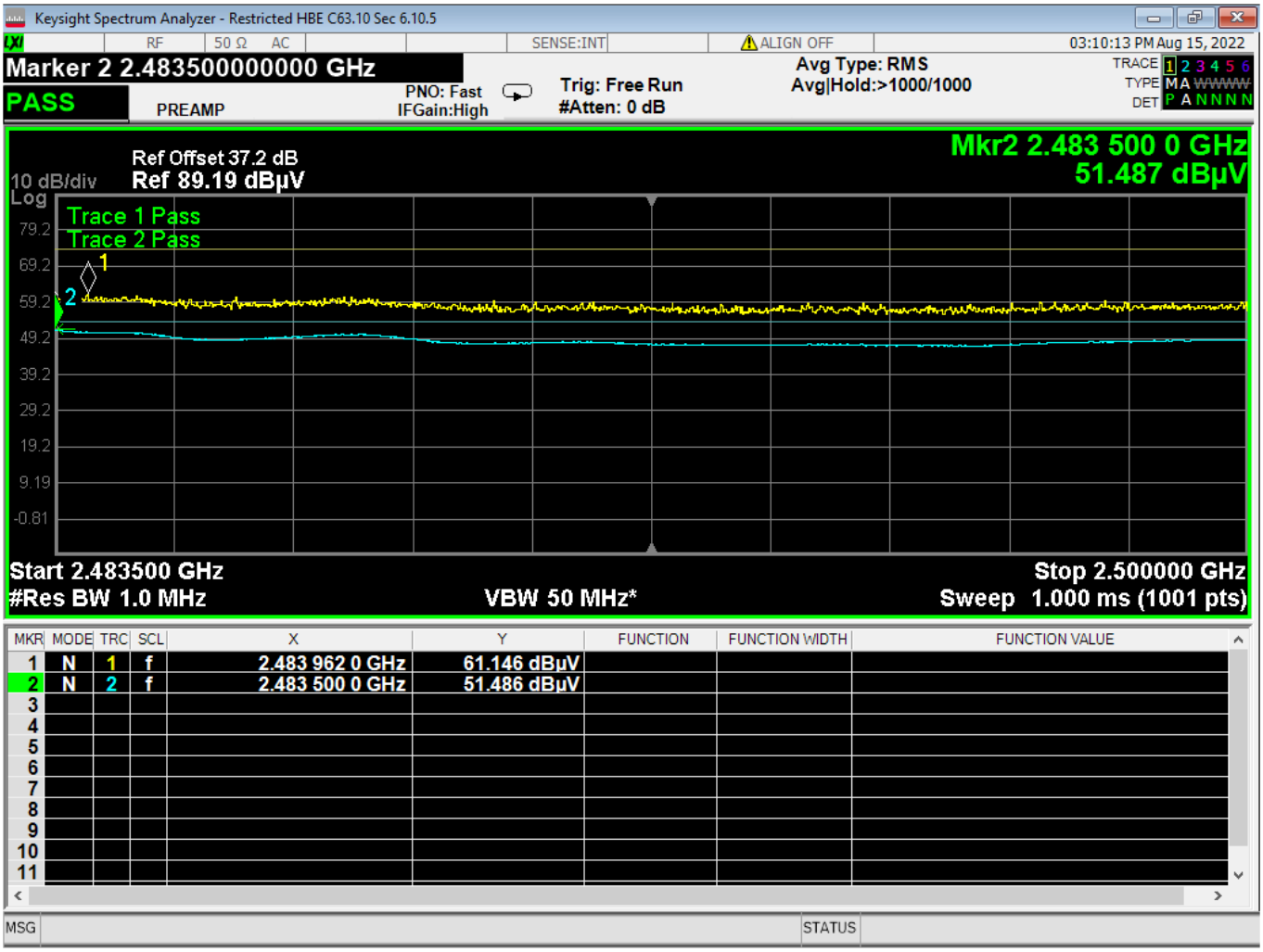

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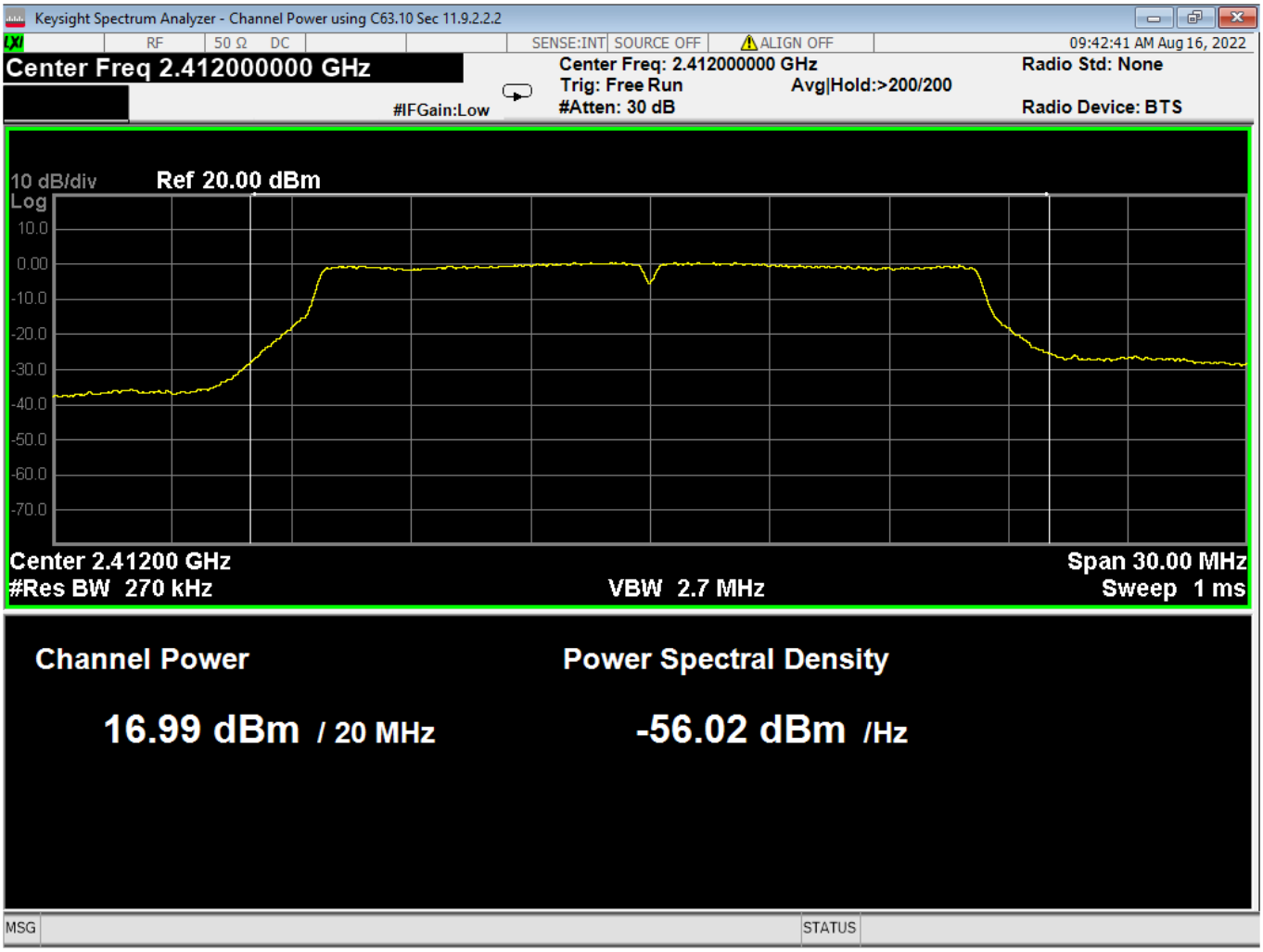

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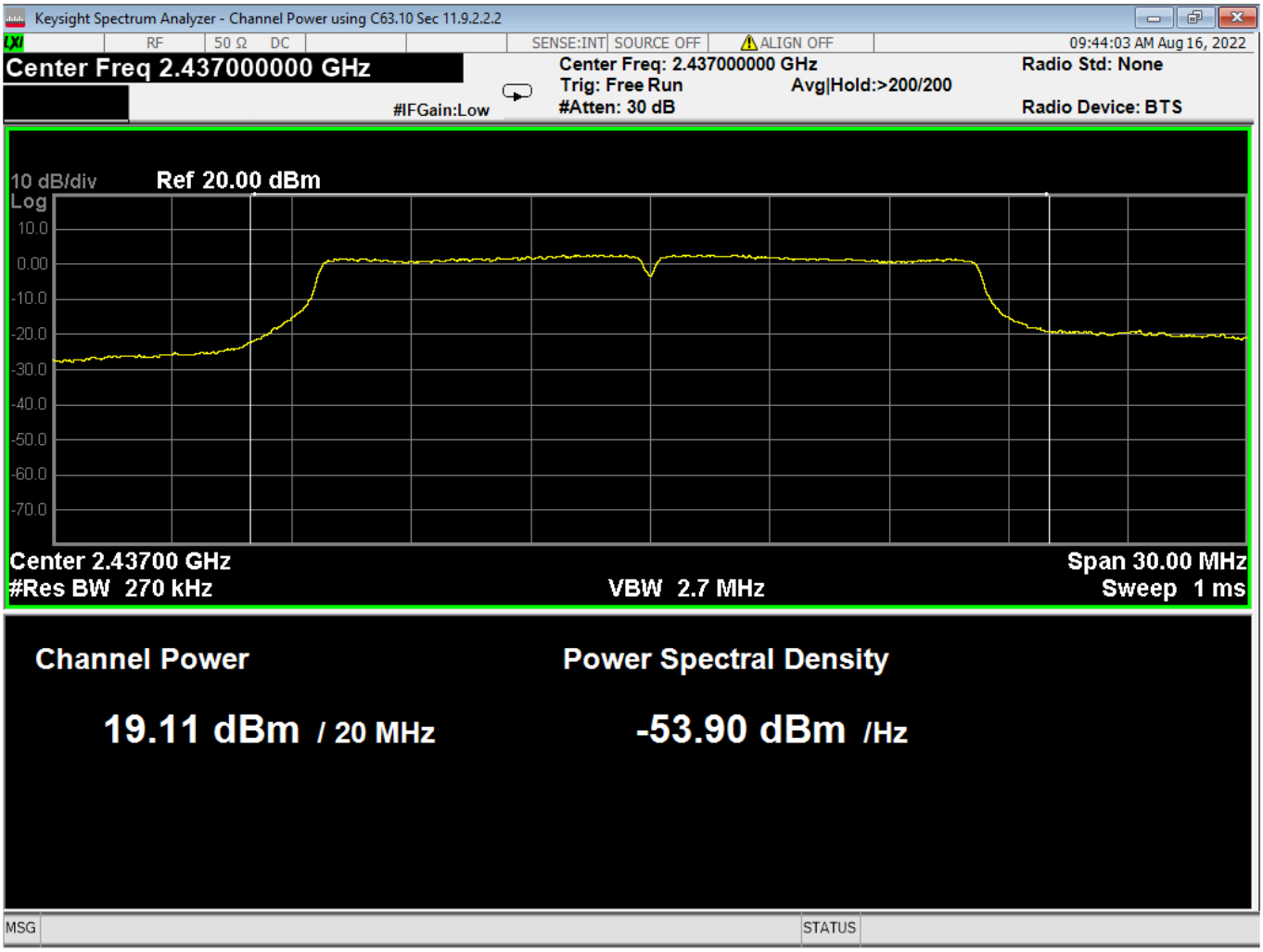

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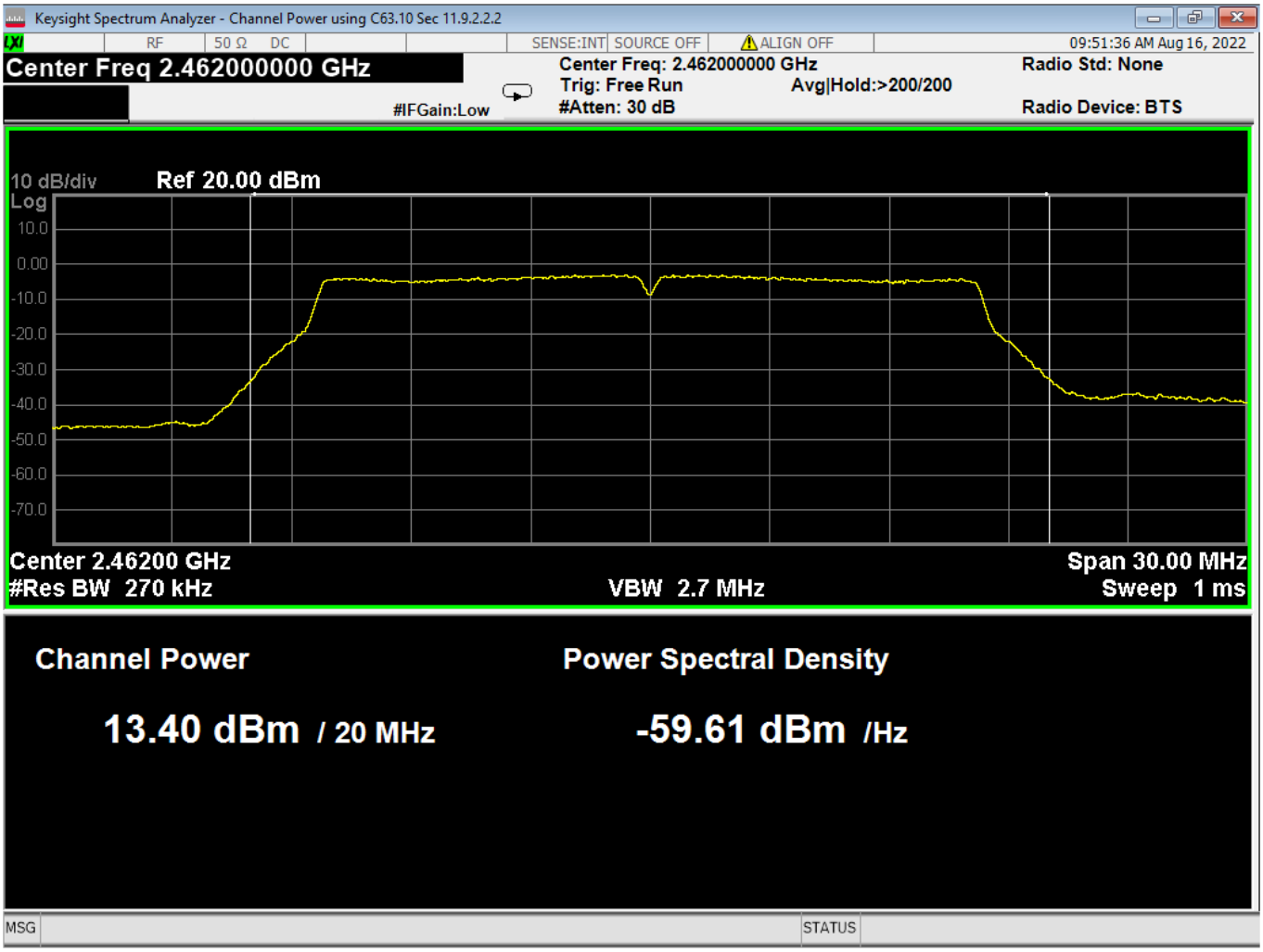

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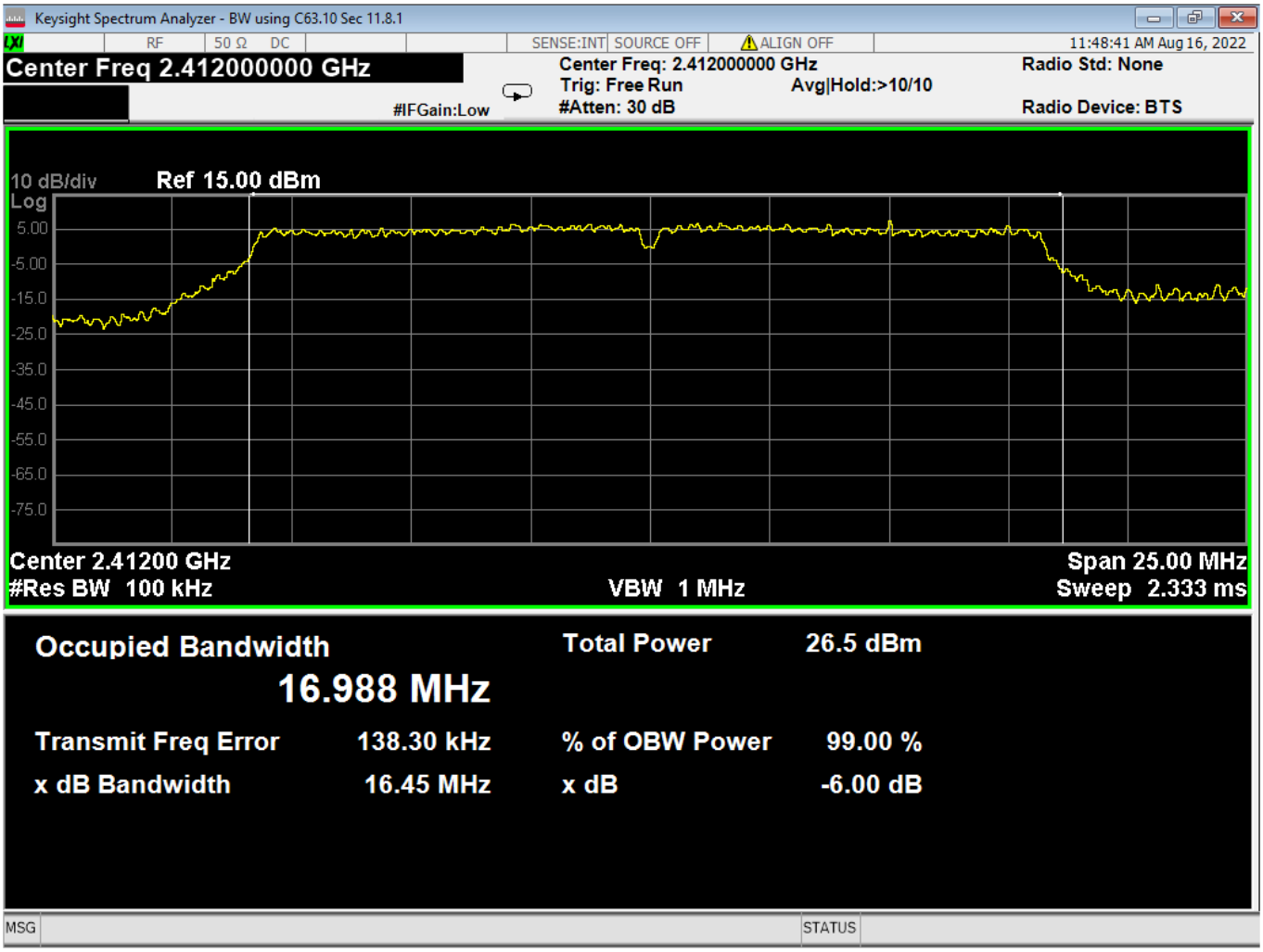

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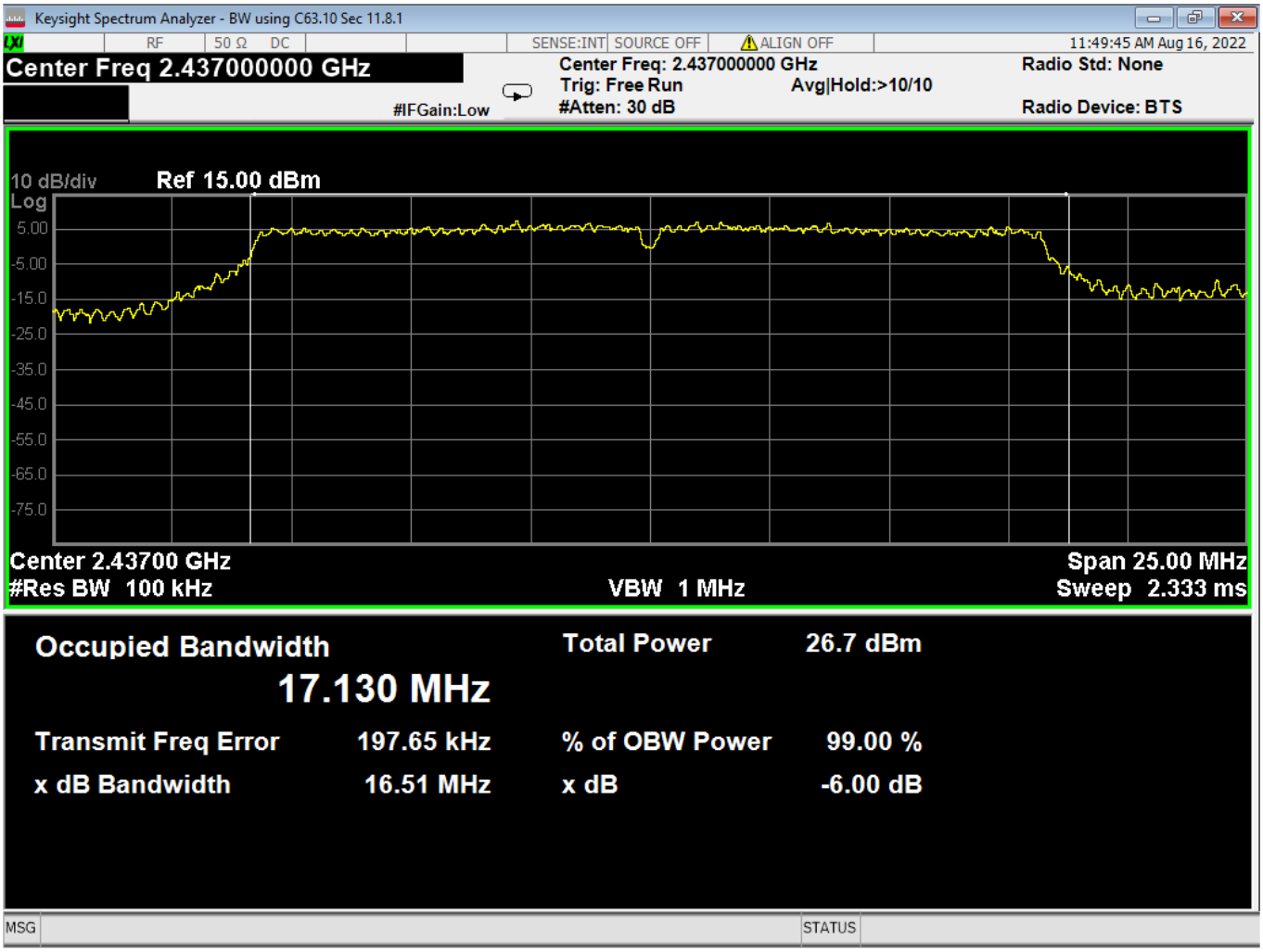

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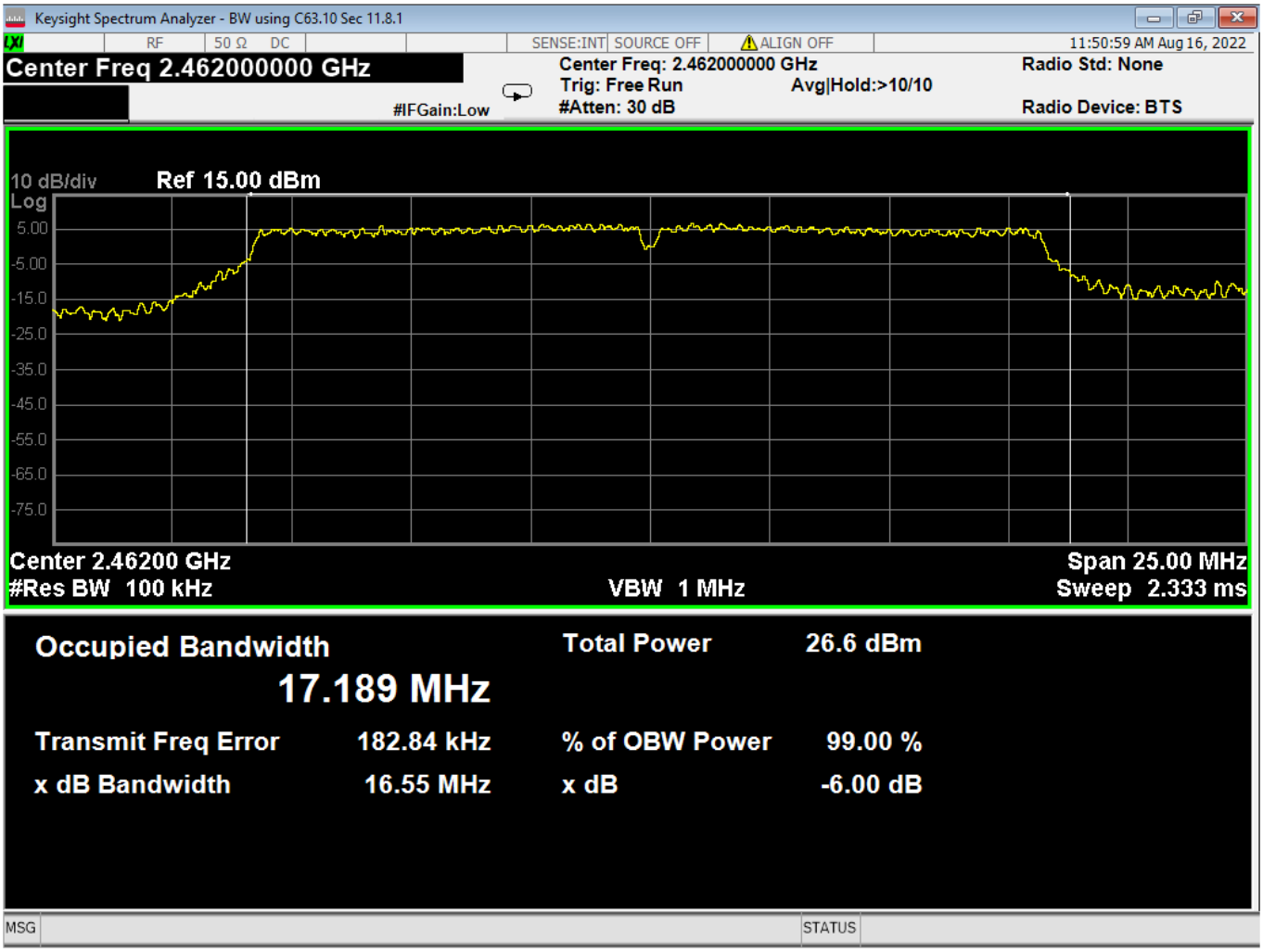

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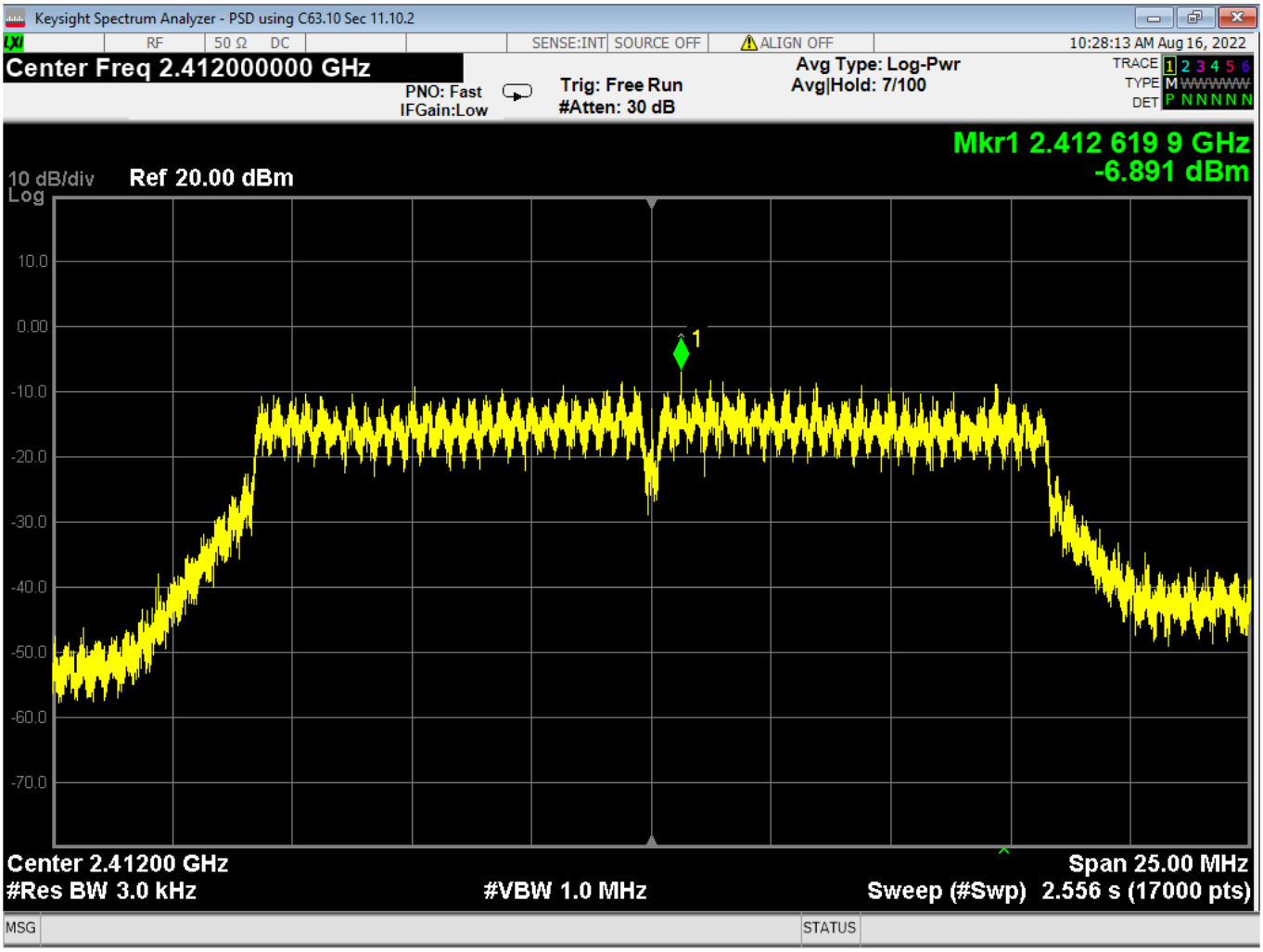

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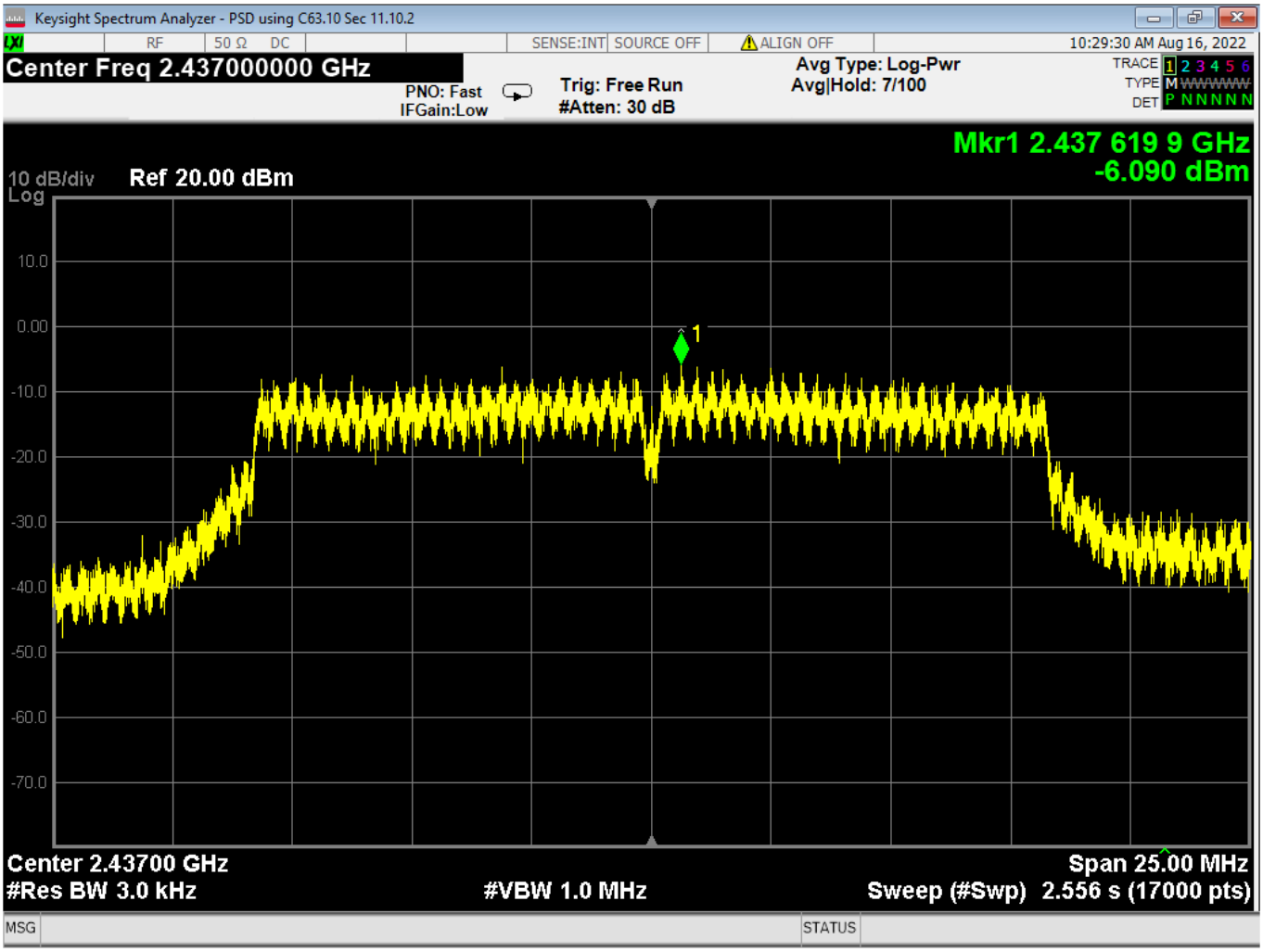

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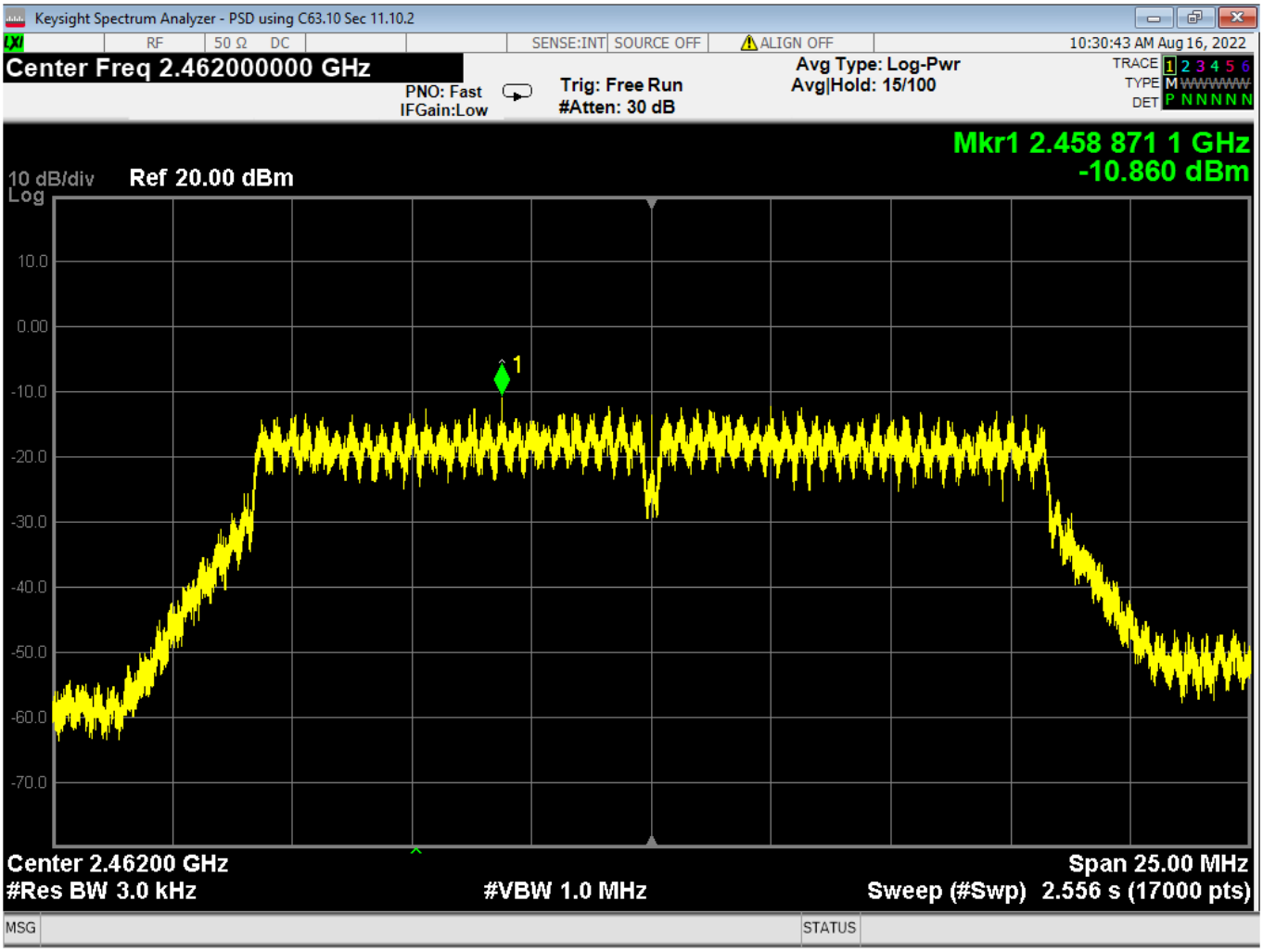

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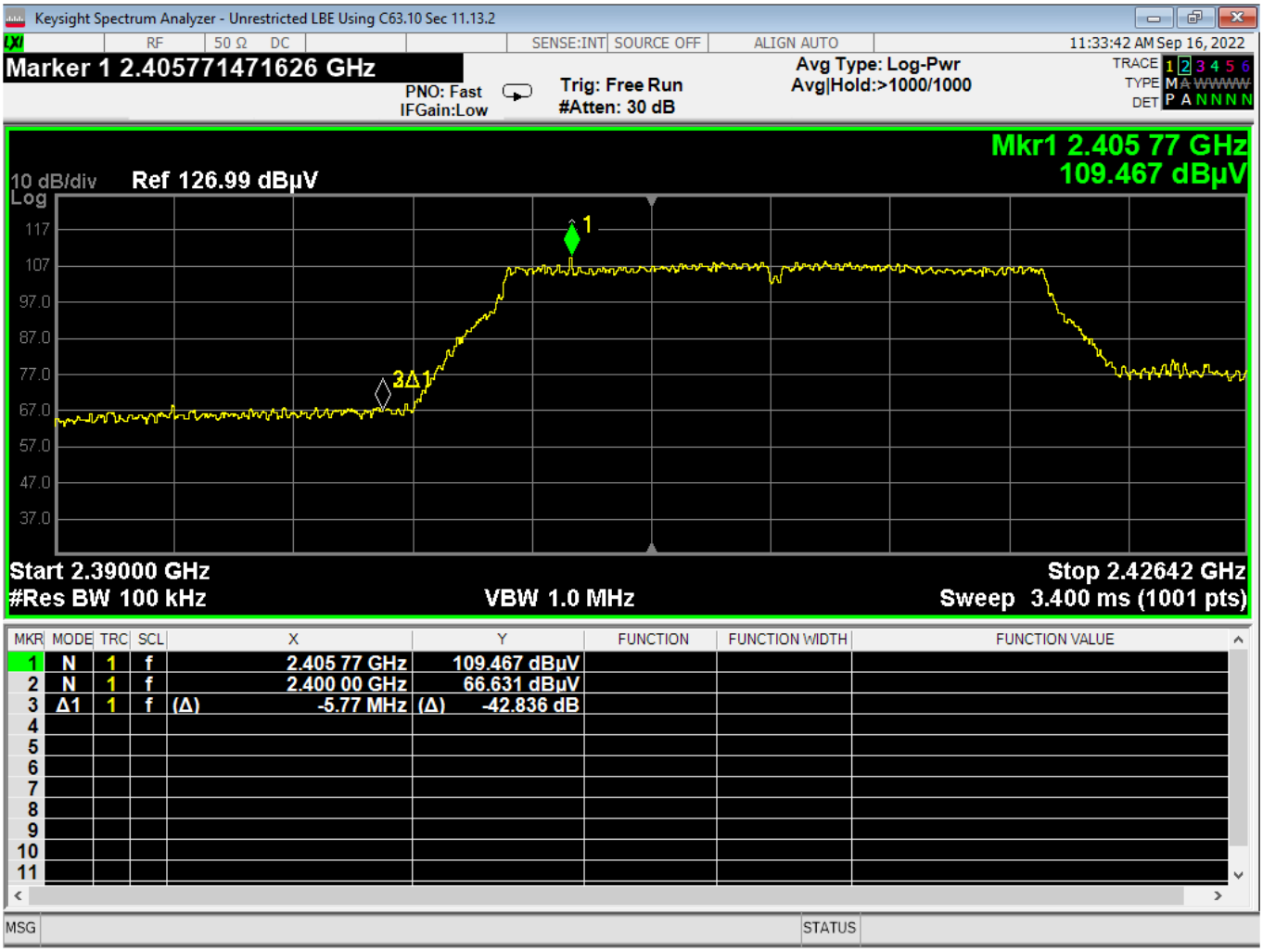

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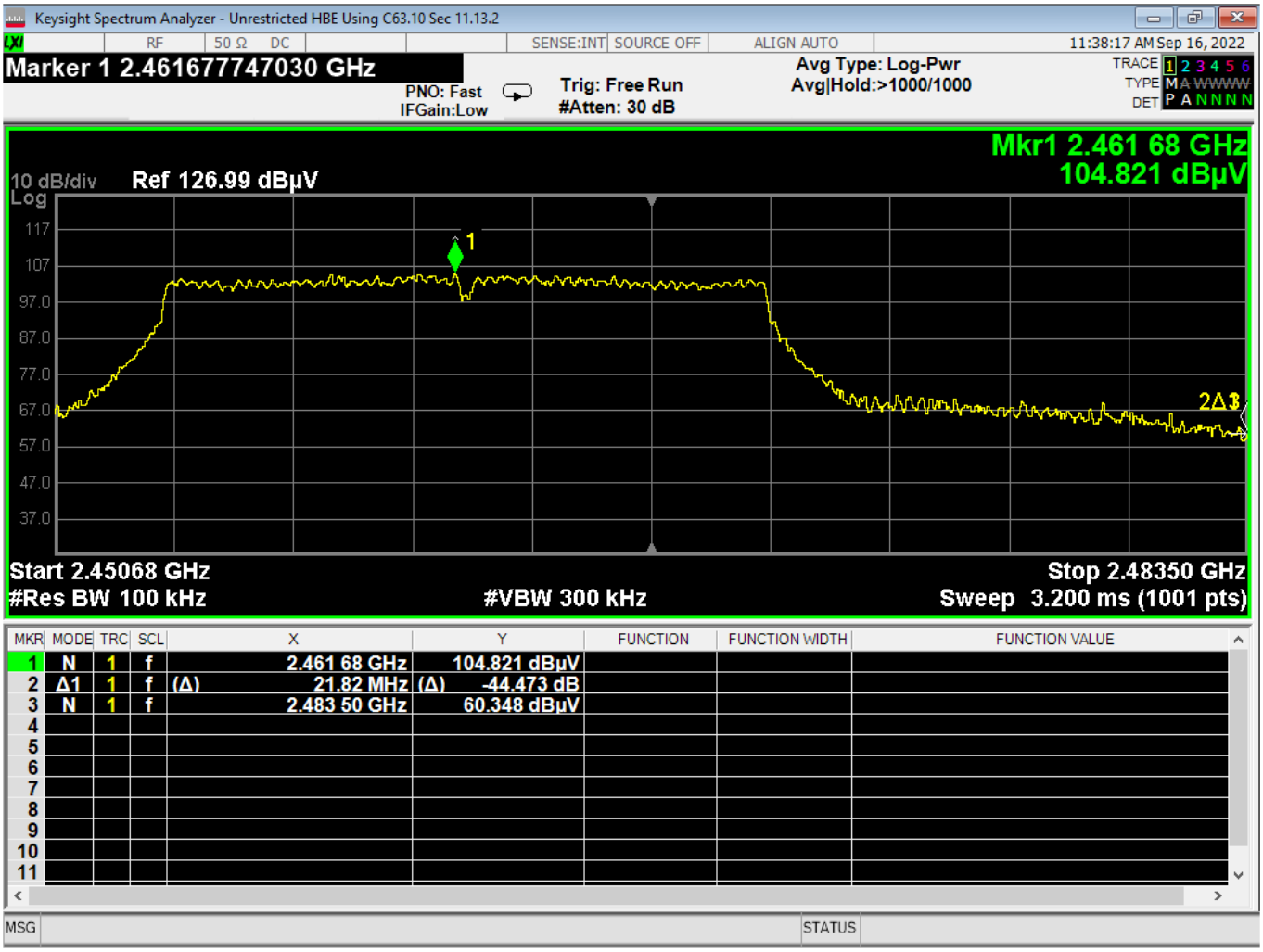

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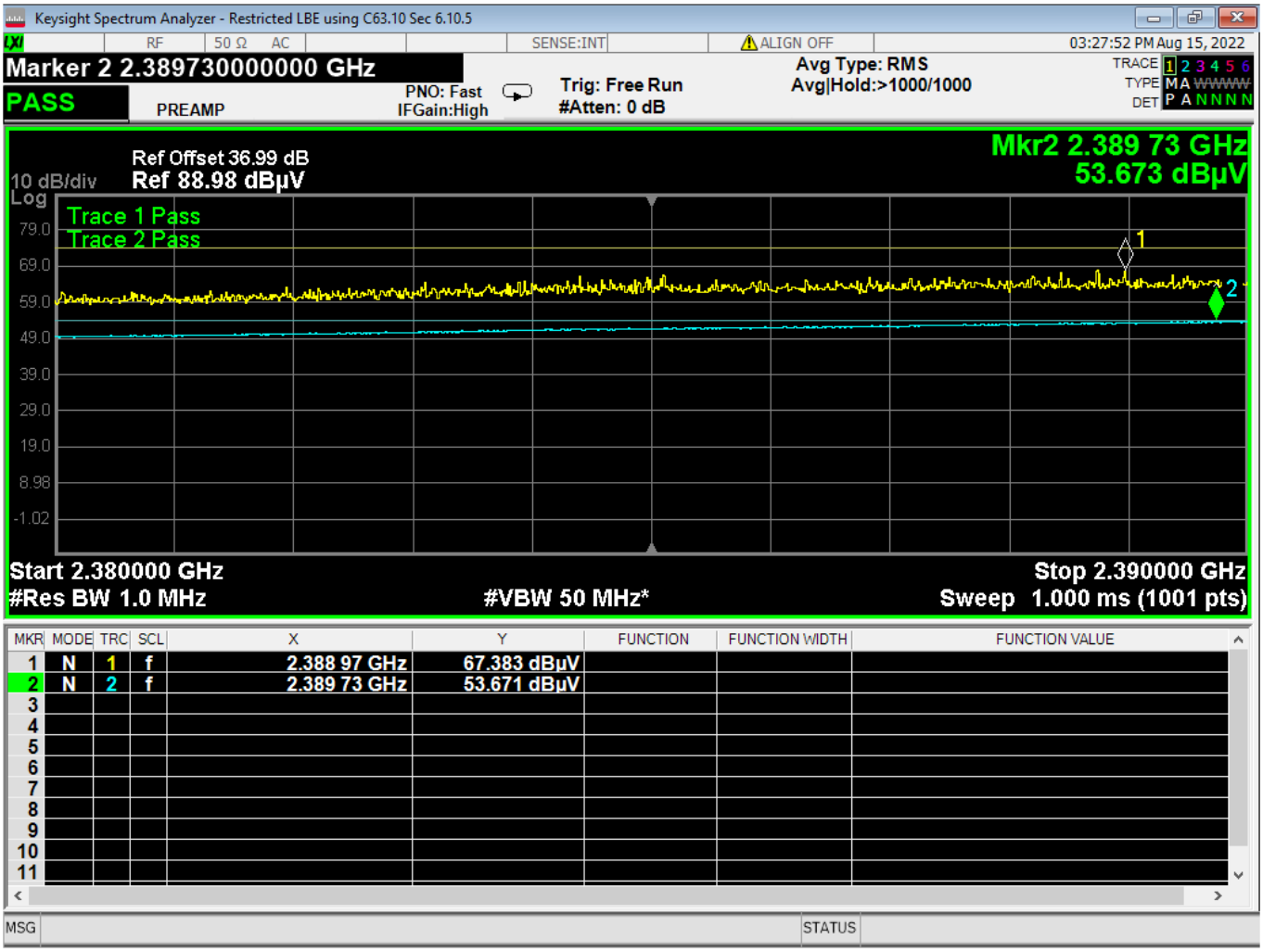

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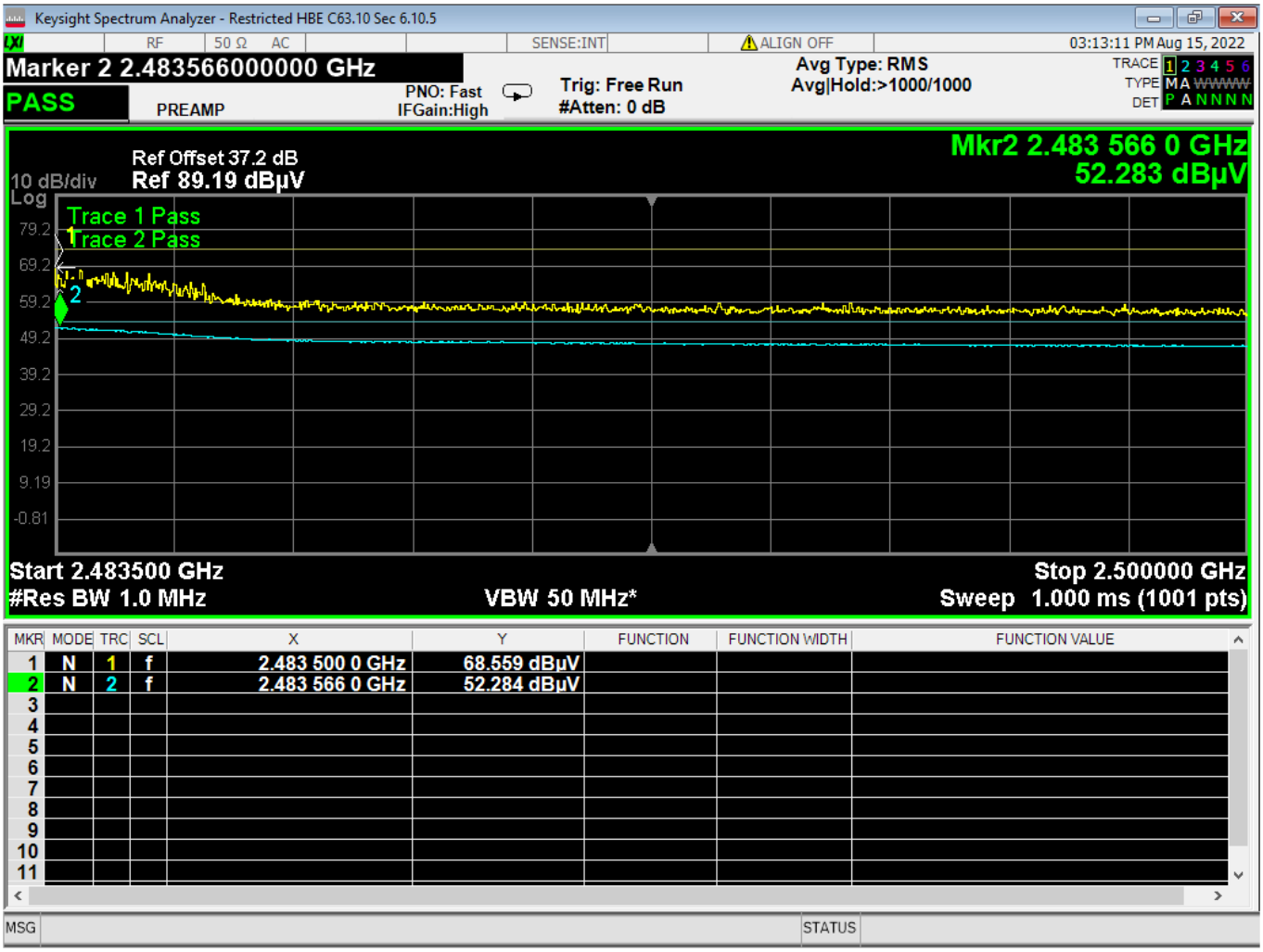

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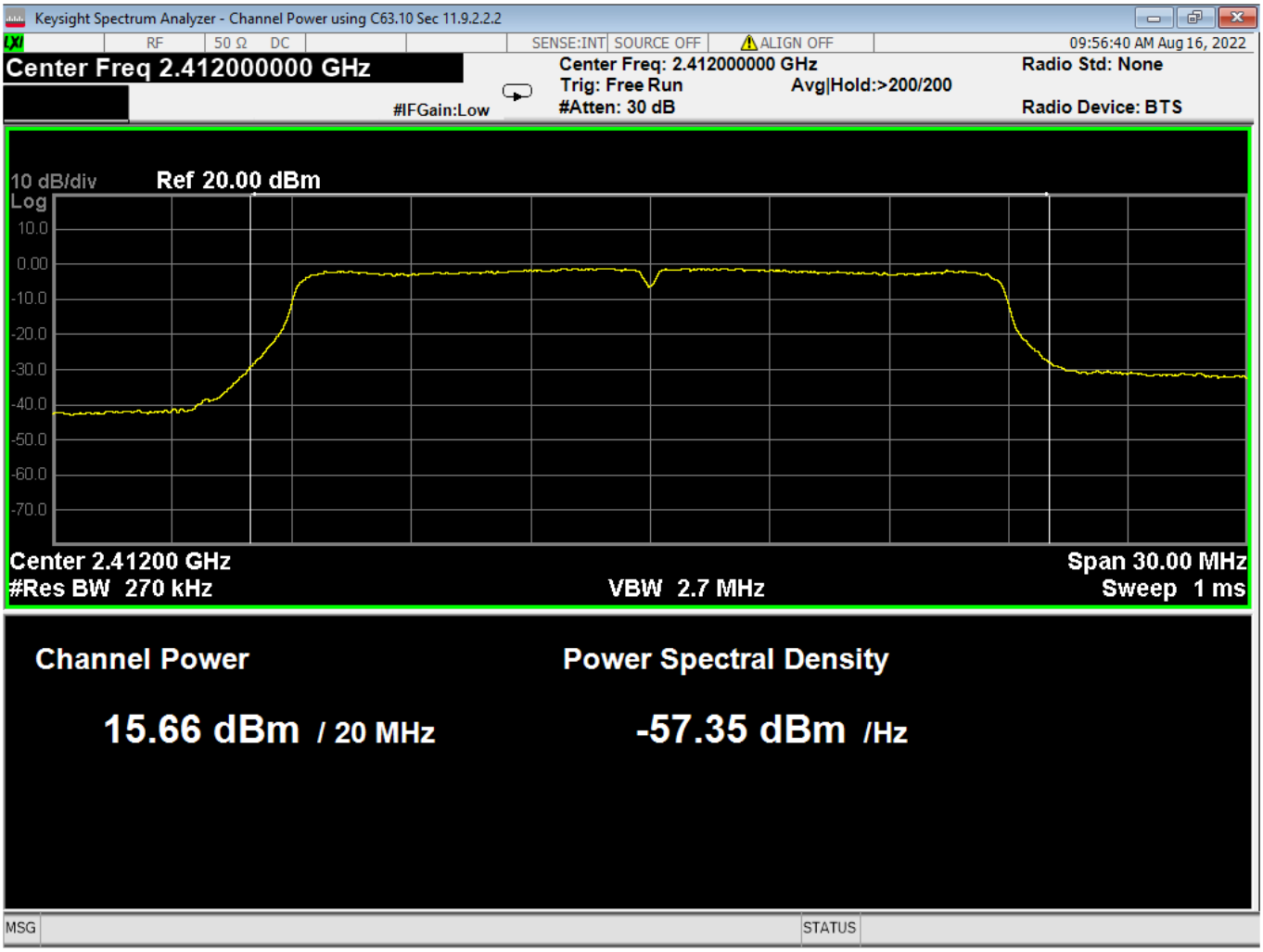

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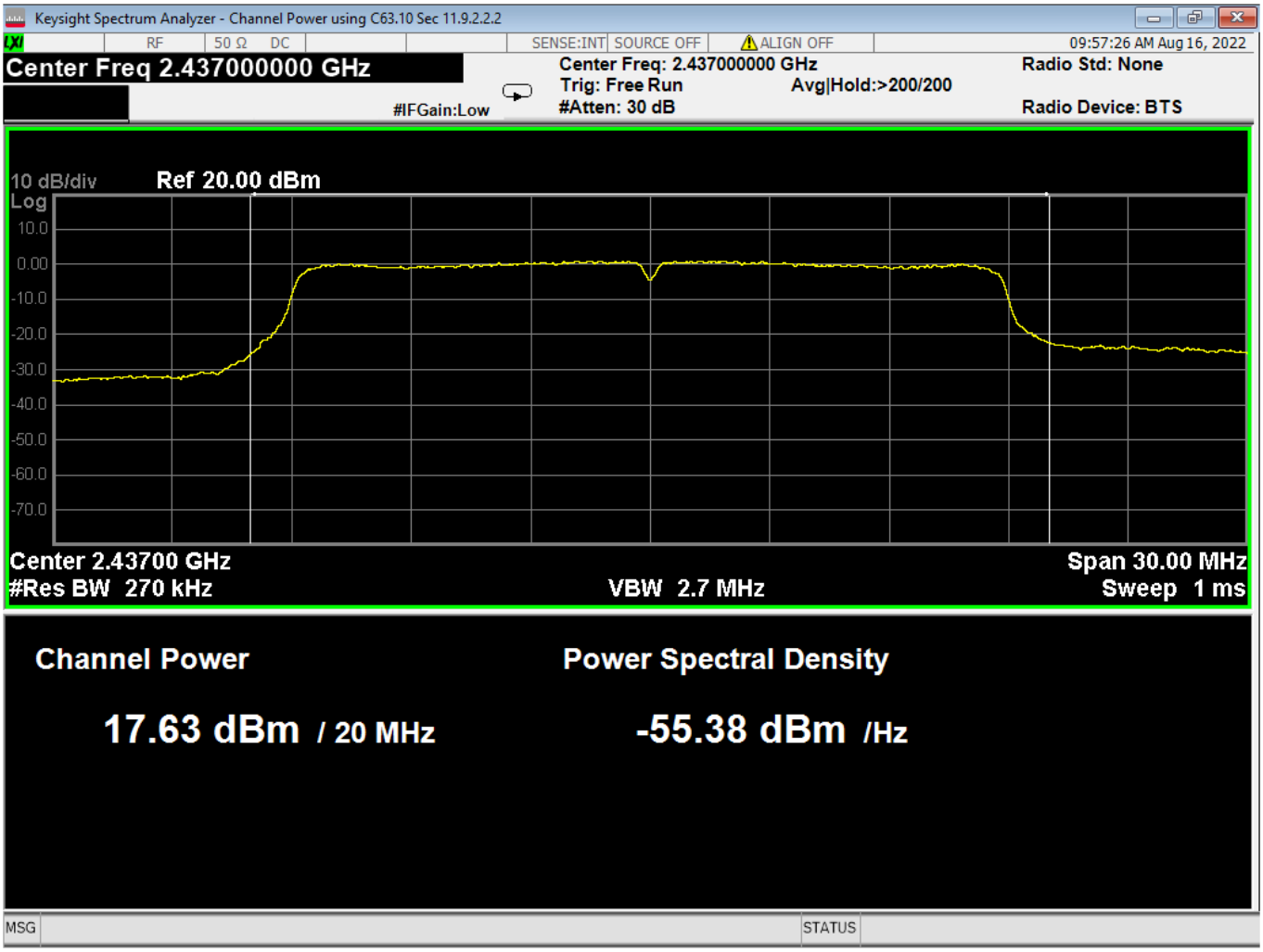

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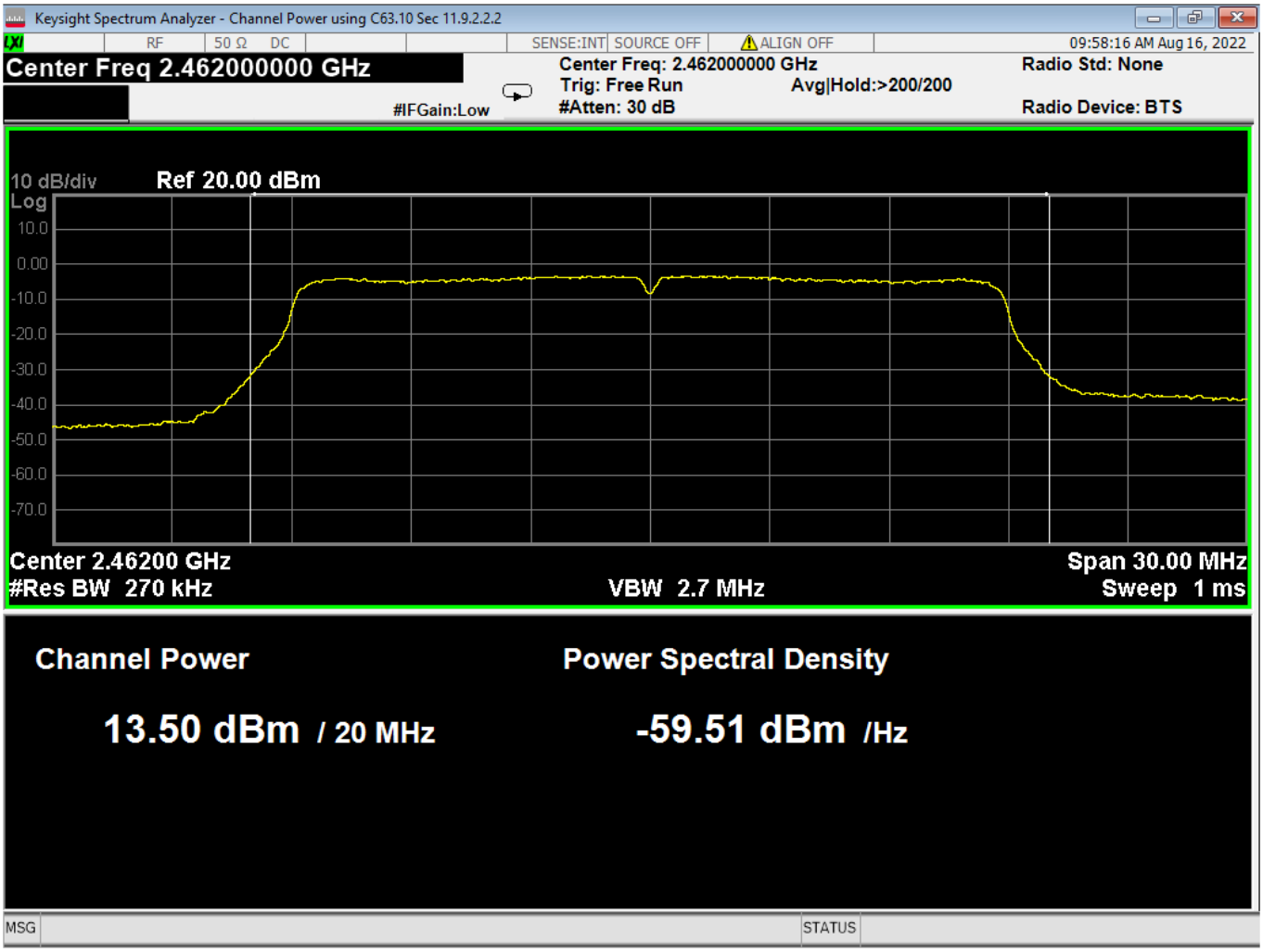

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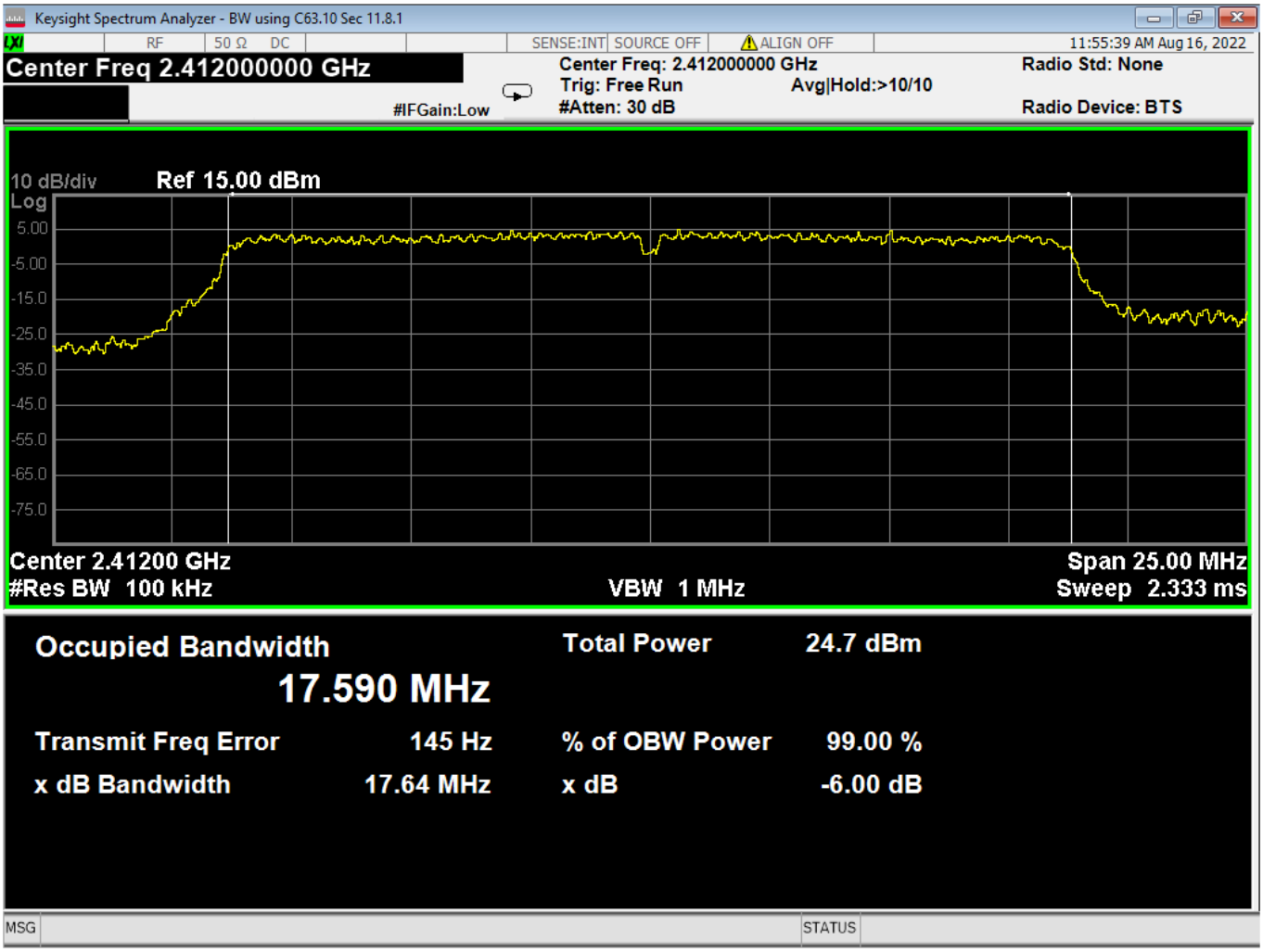

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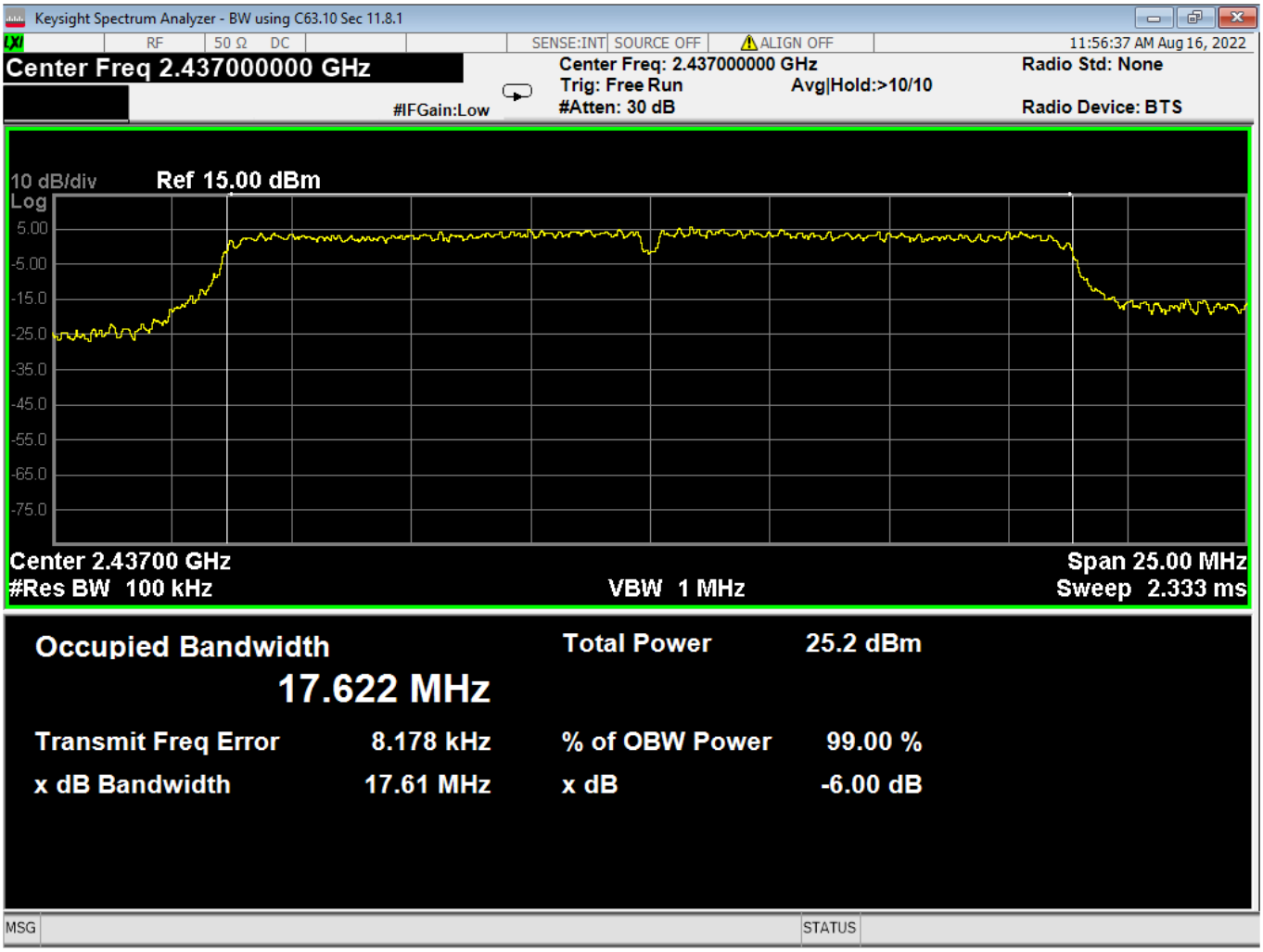

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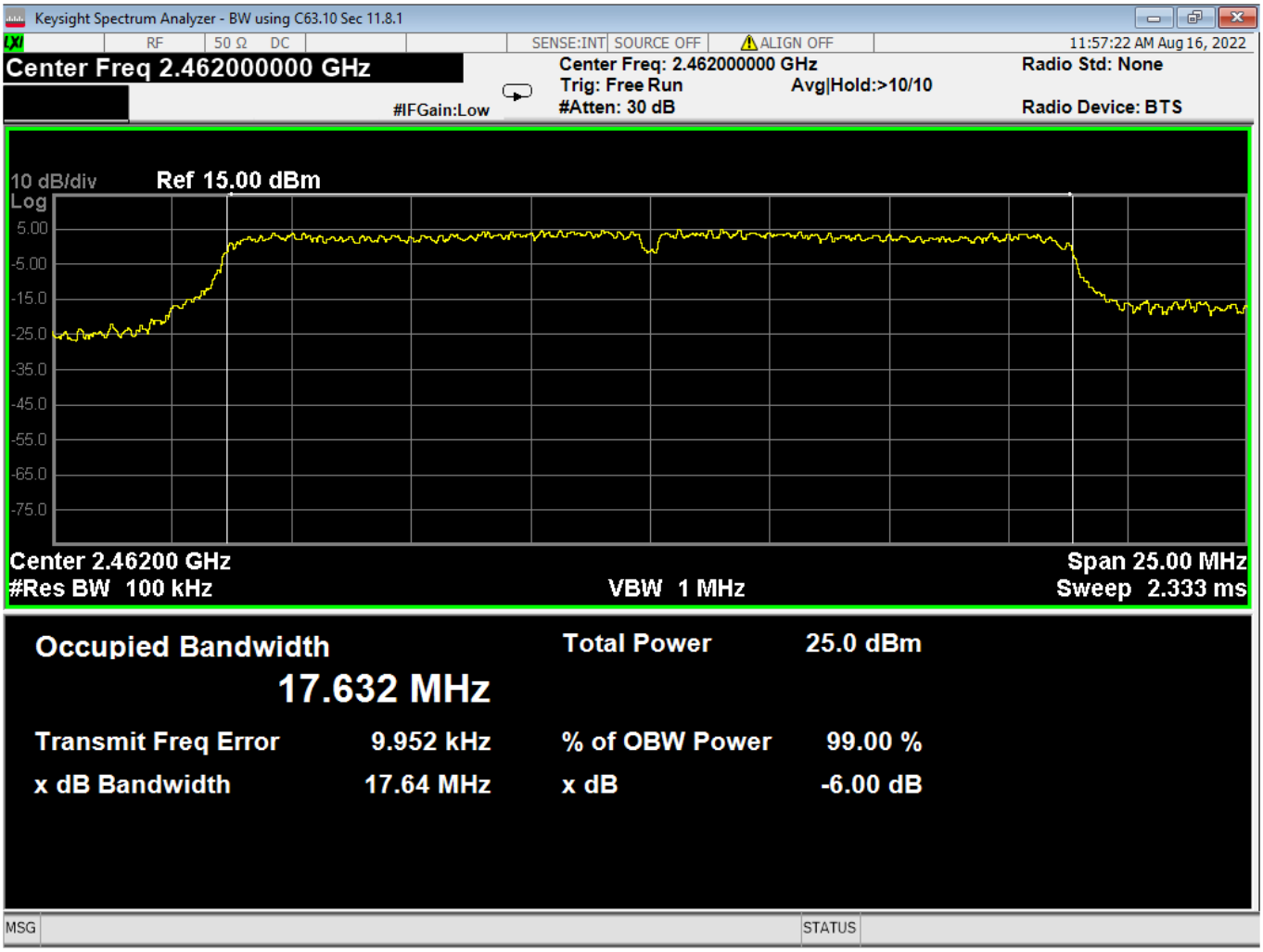

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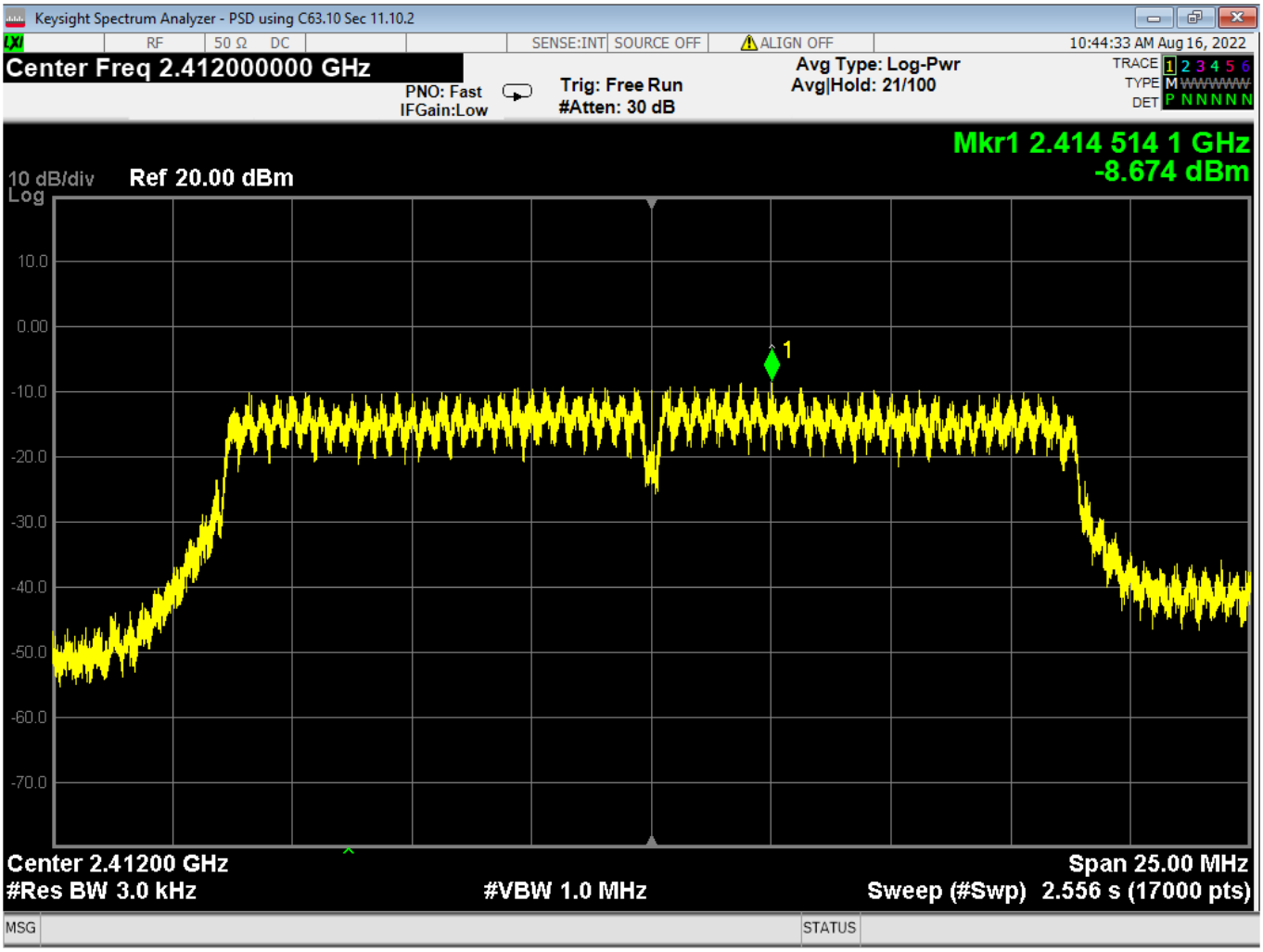

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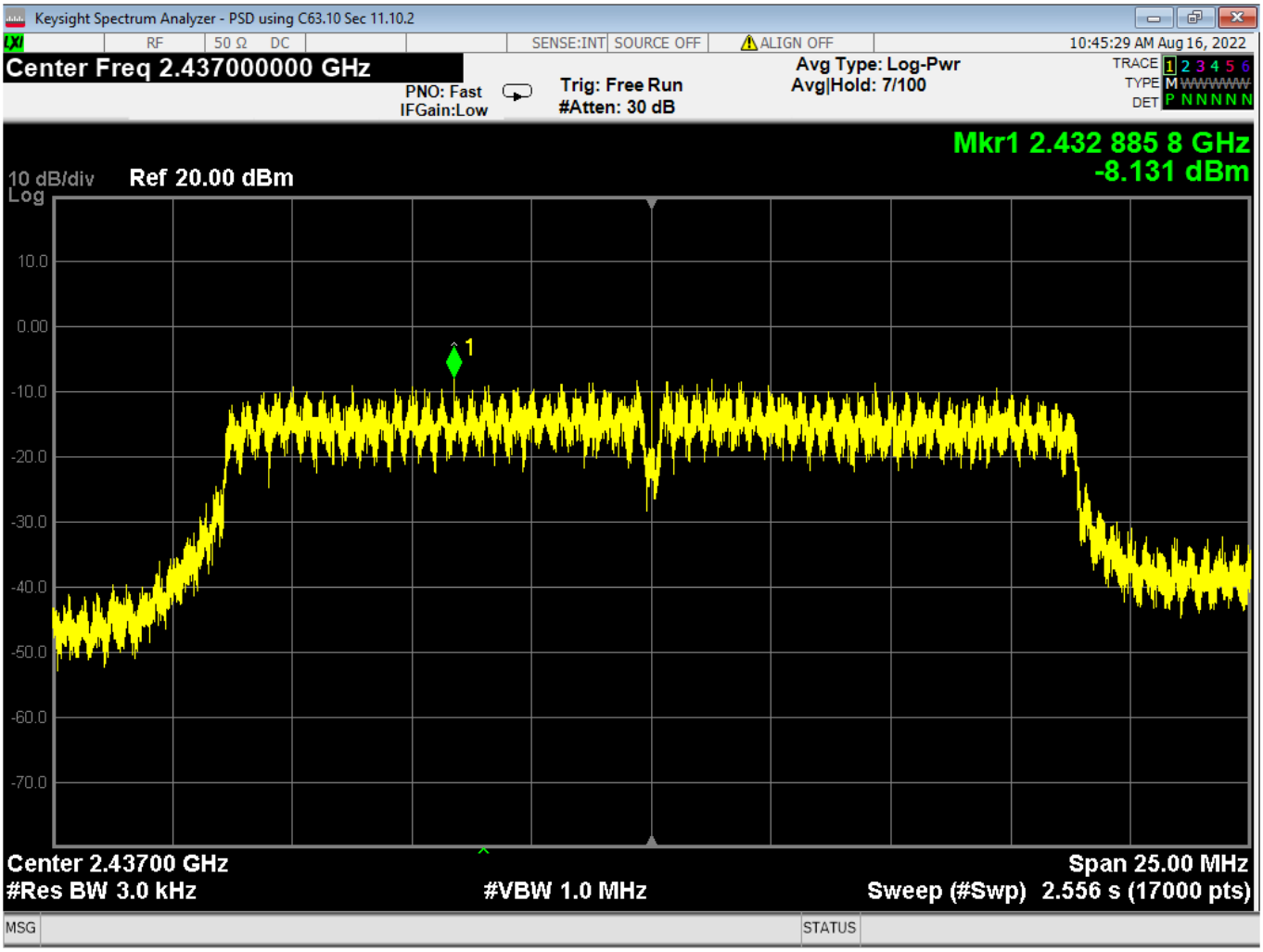

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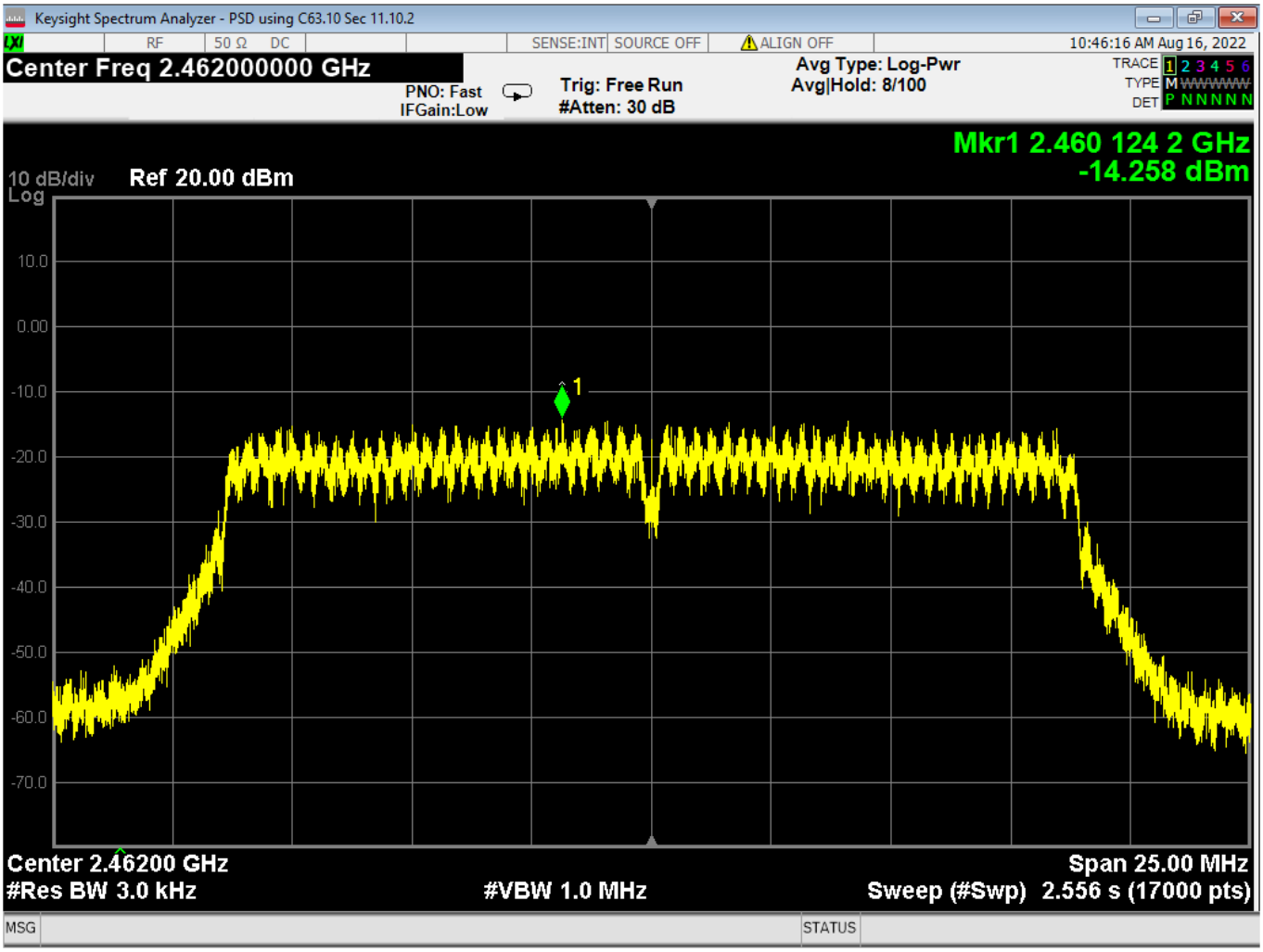

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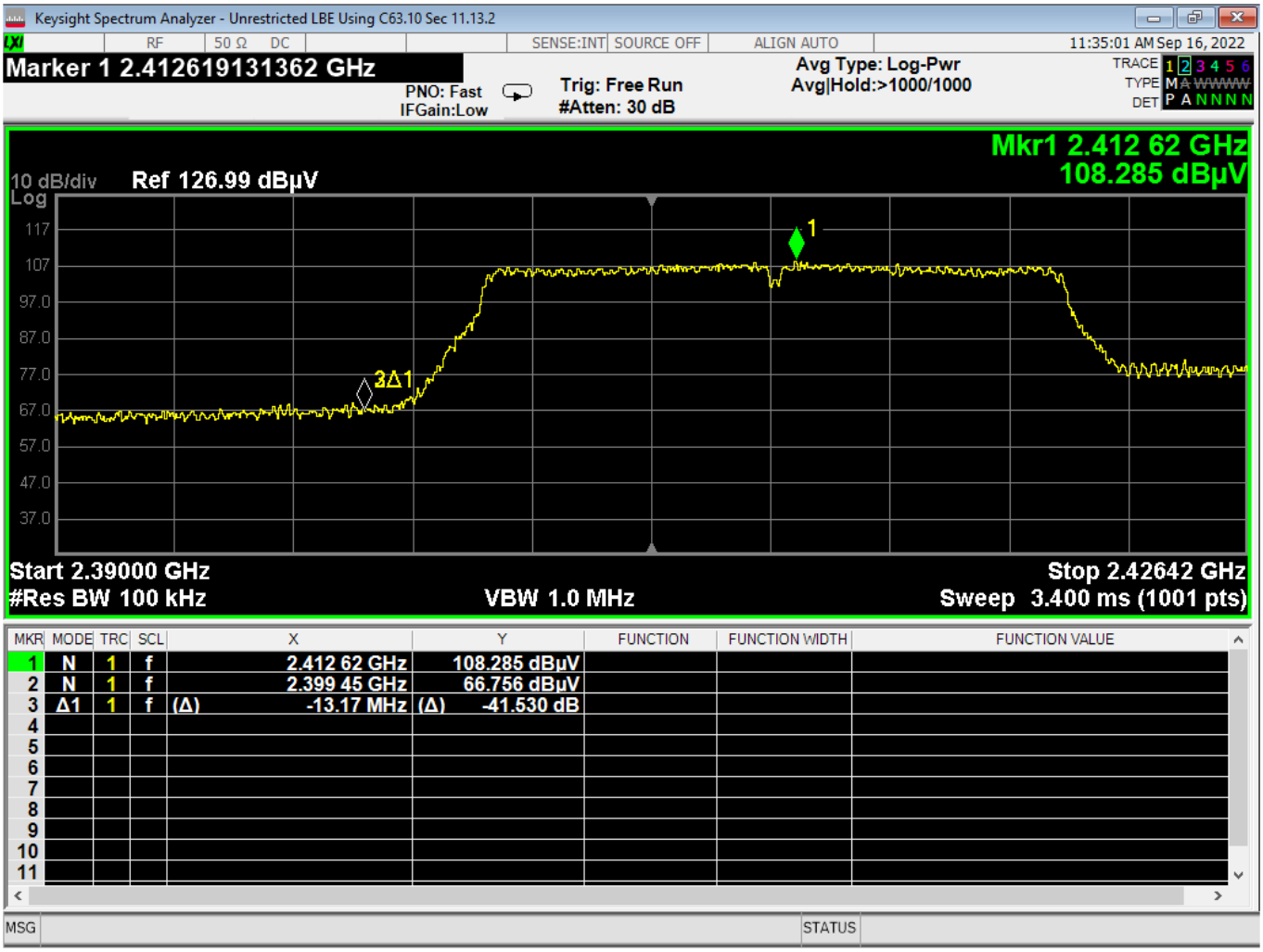

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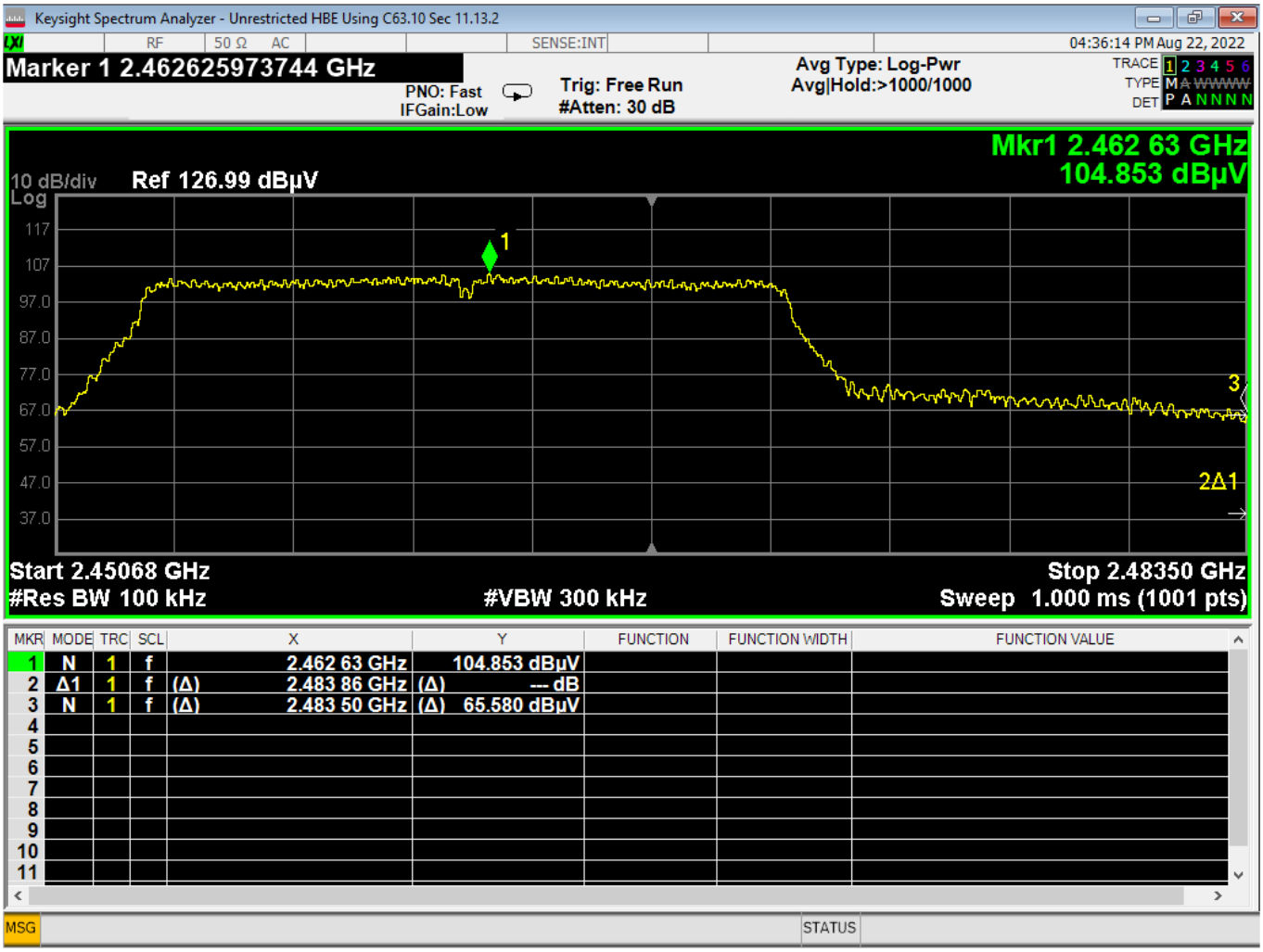

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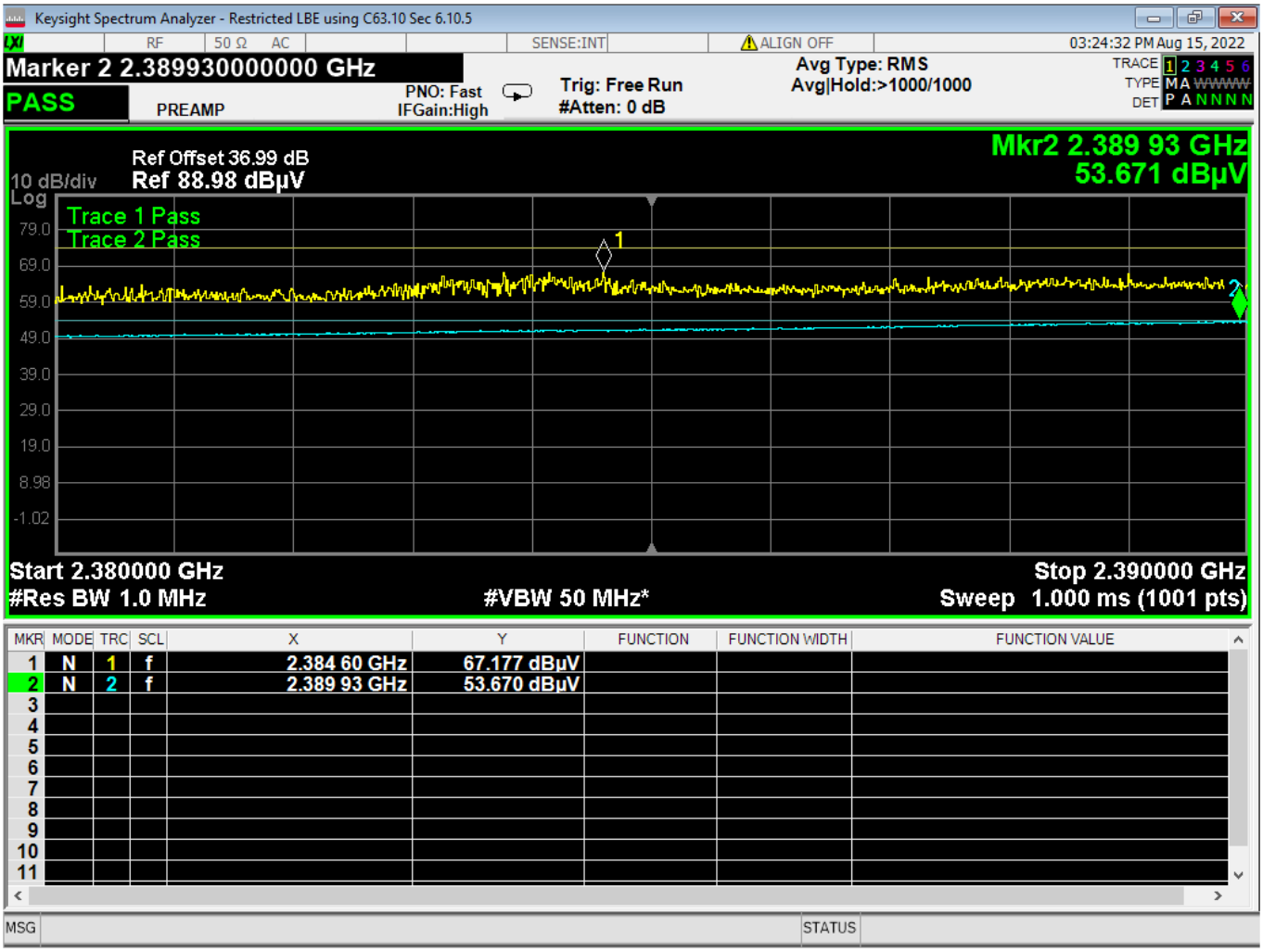

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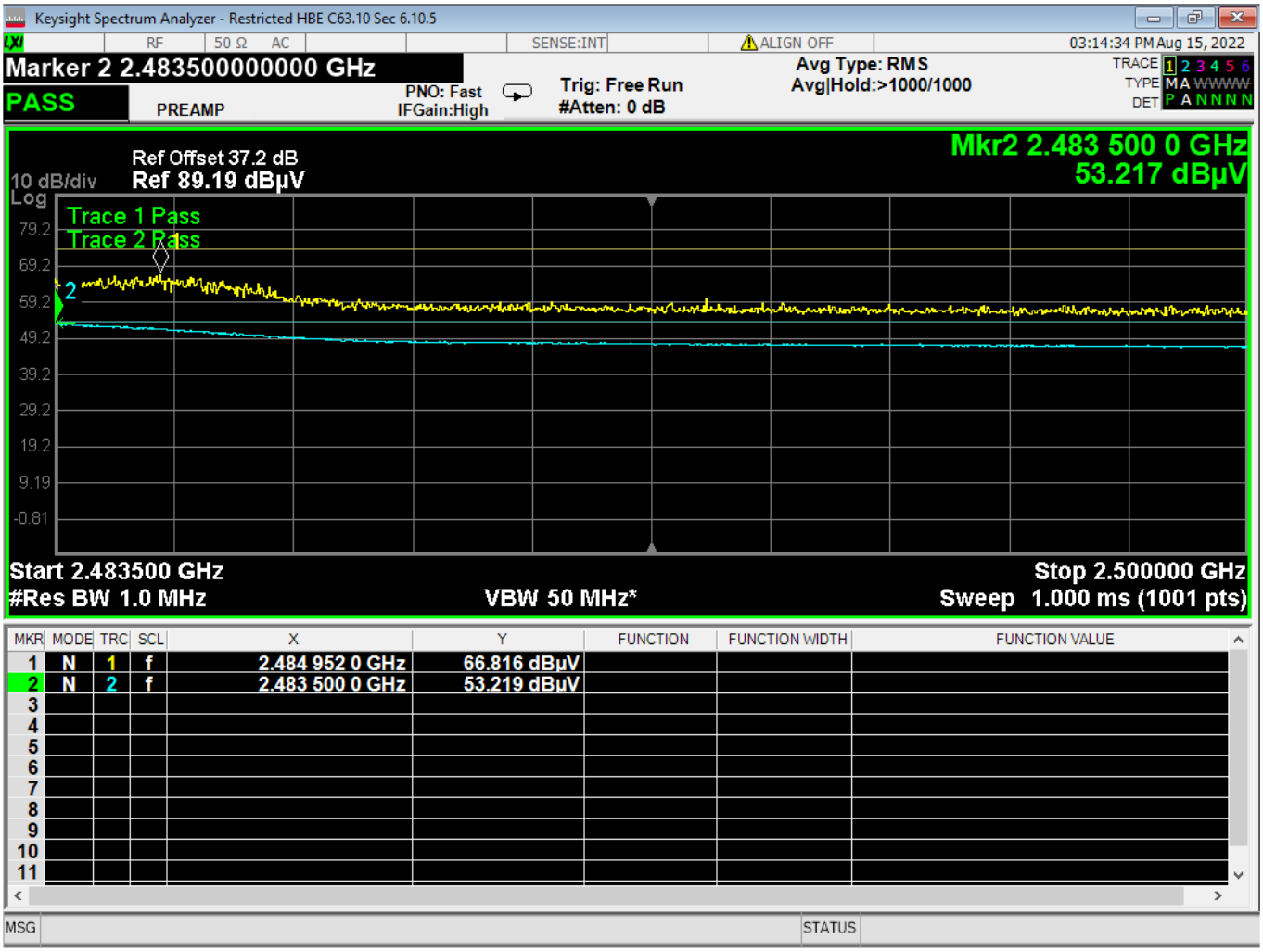

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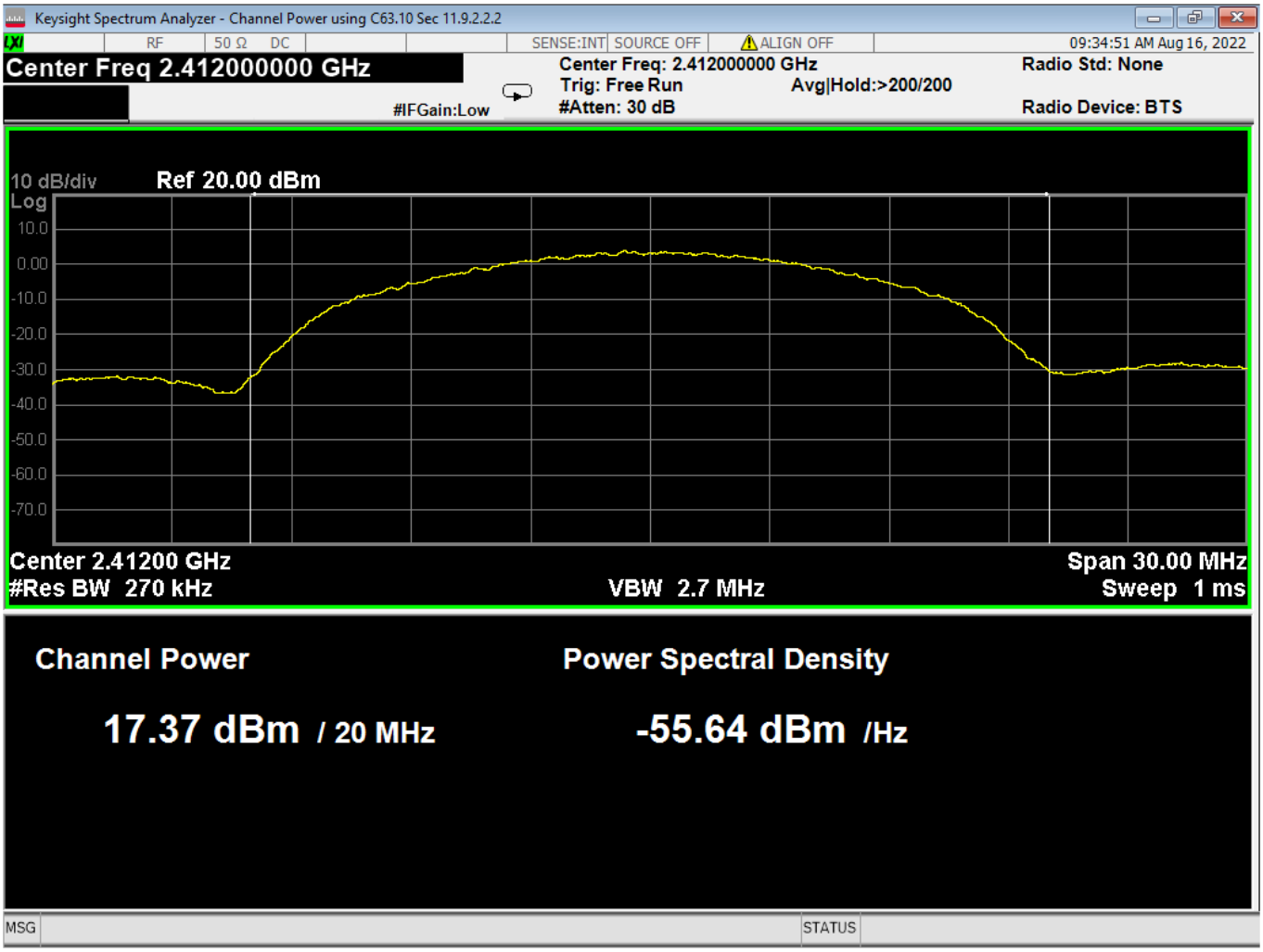
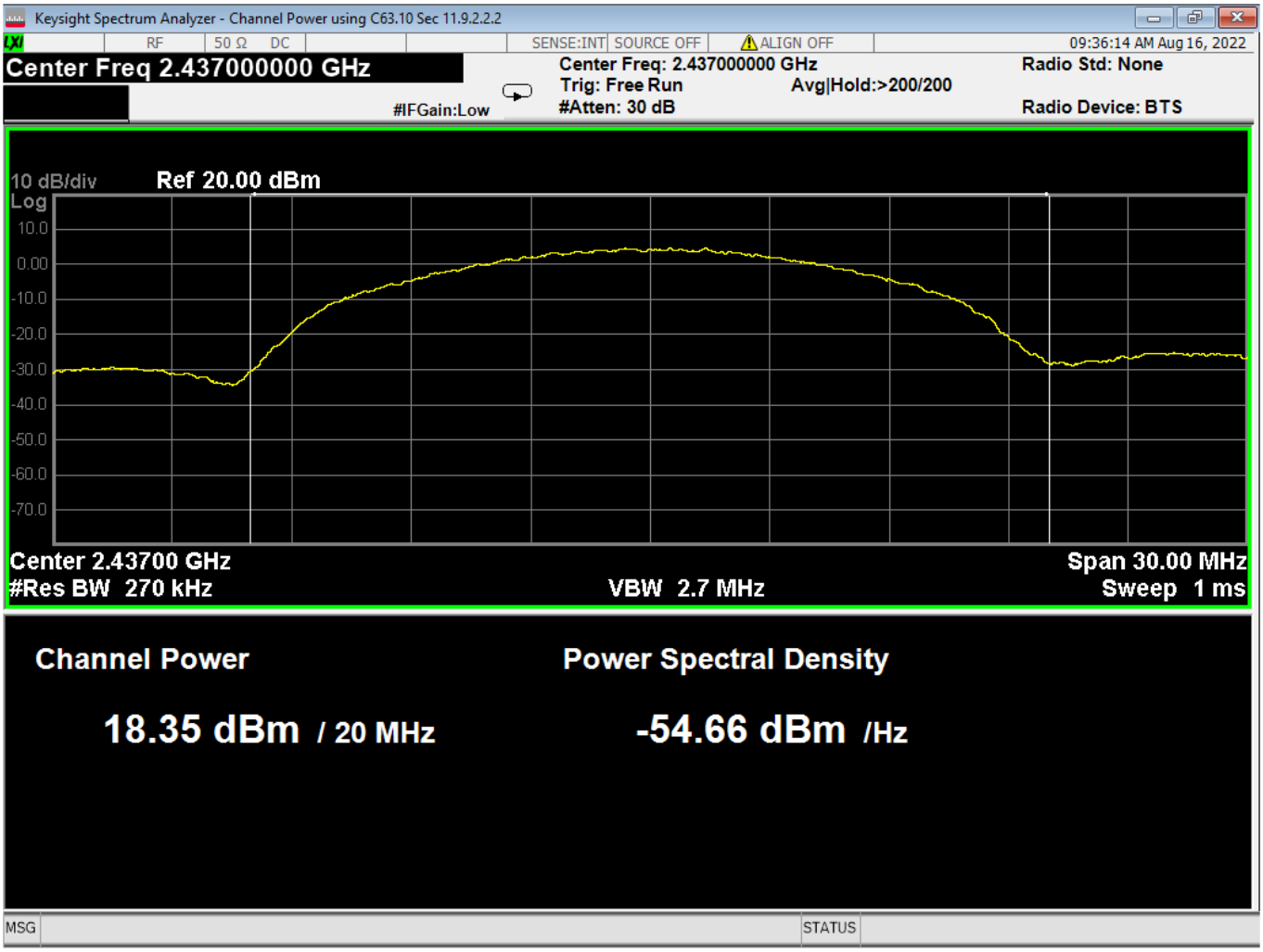
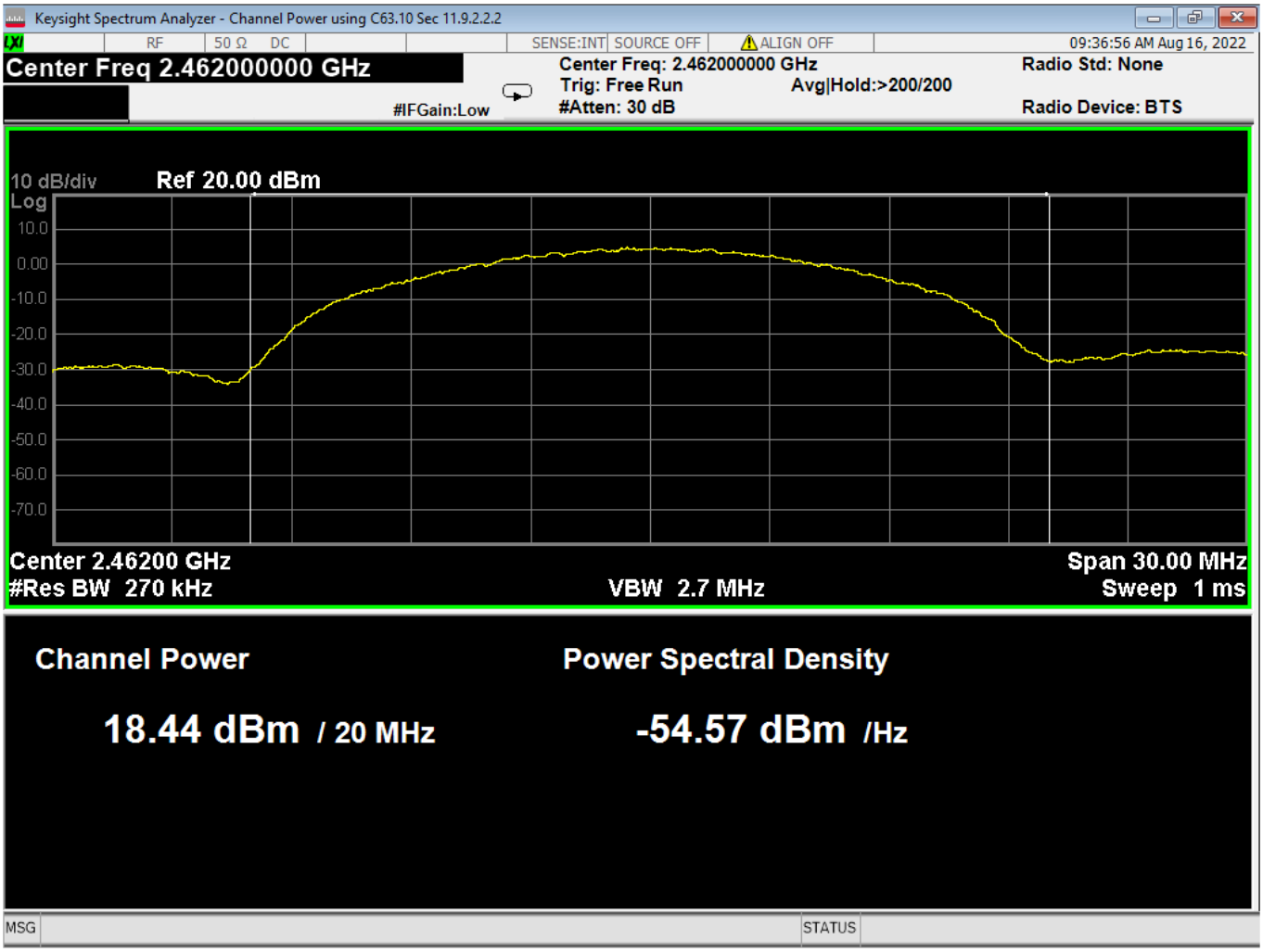


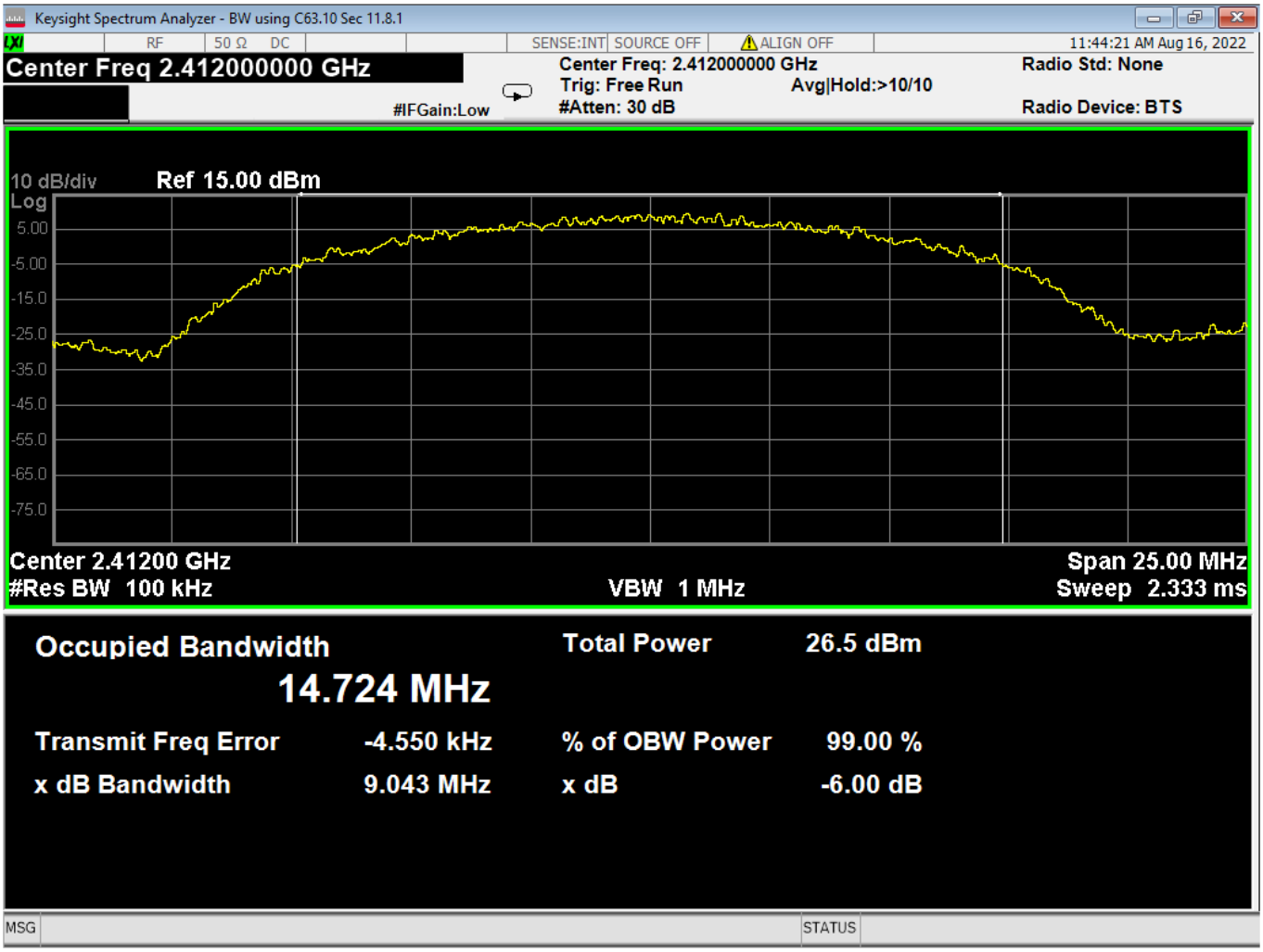
40 Average Power, Low, Wifi B, High Data Rate



41 Average Power, Mid, Wifi B, High Data Rate



42 Average Power, High, Wifi B, High Data Rate



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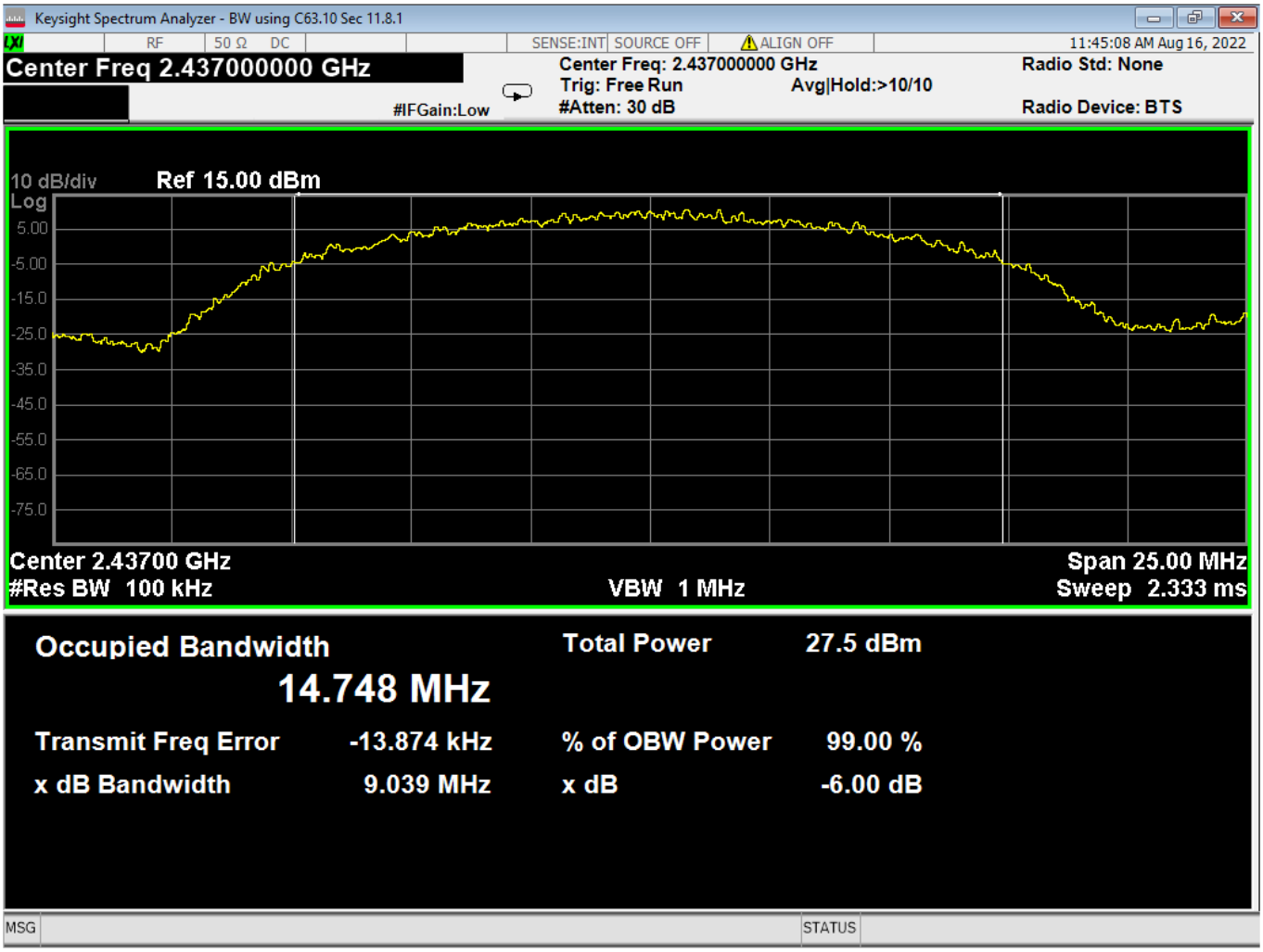

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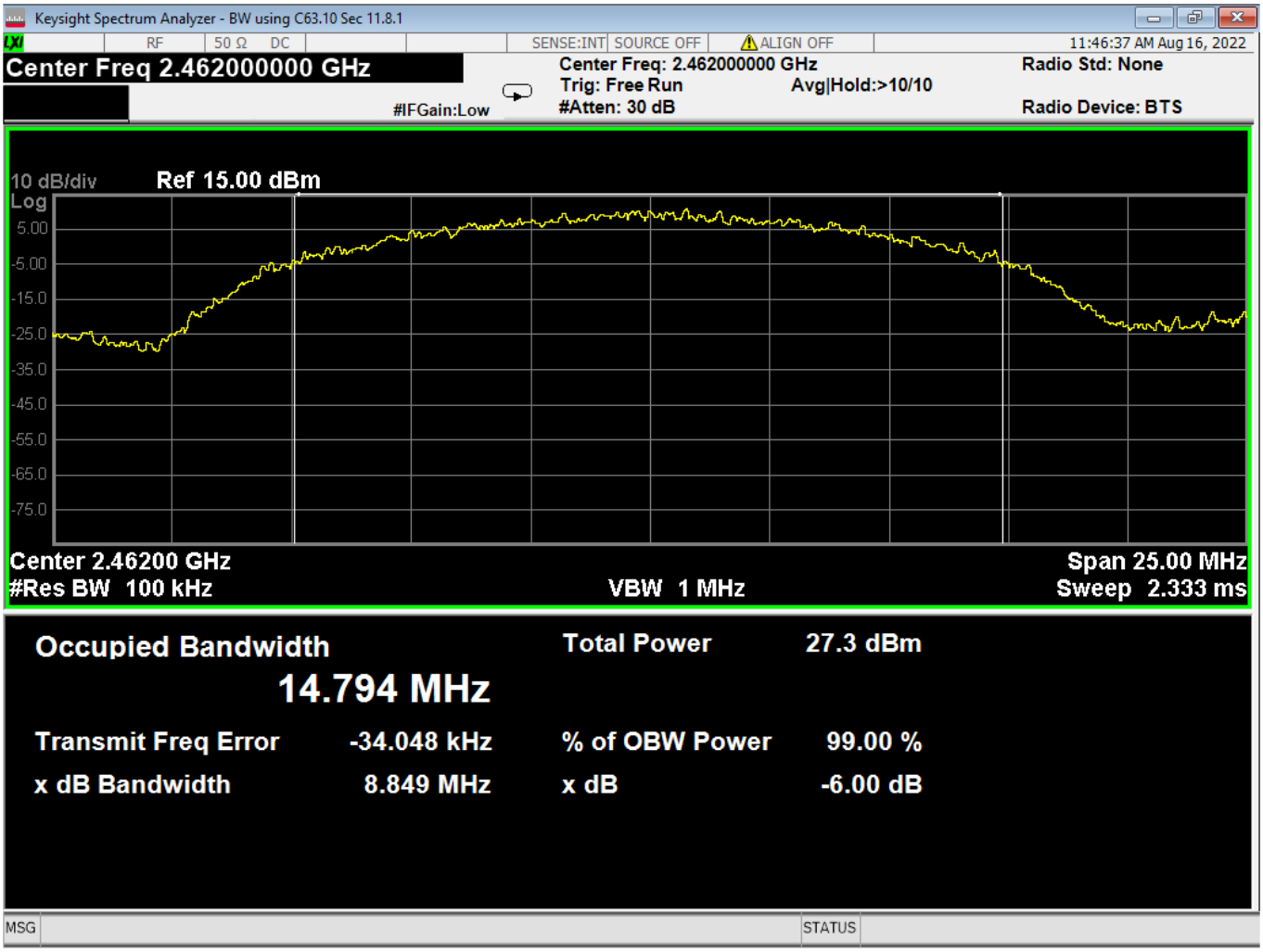

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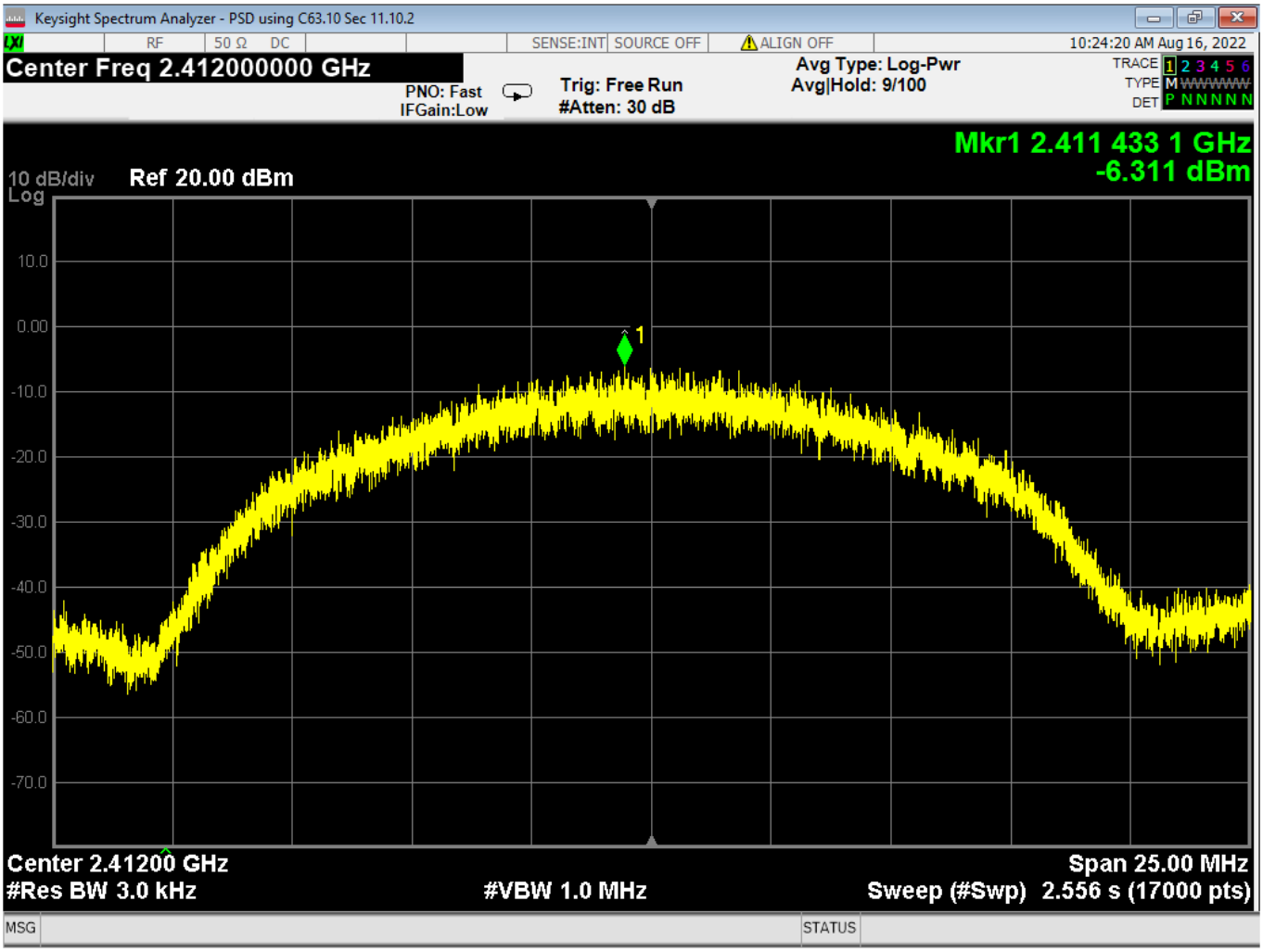
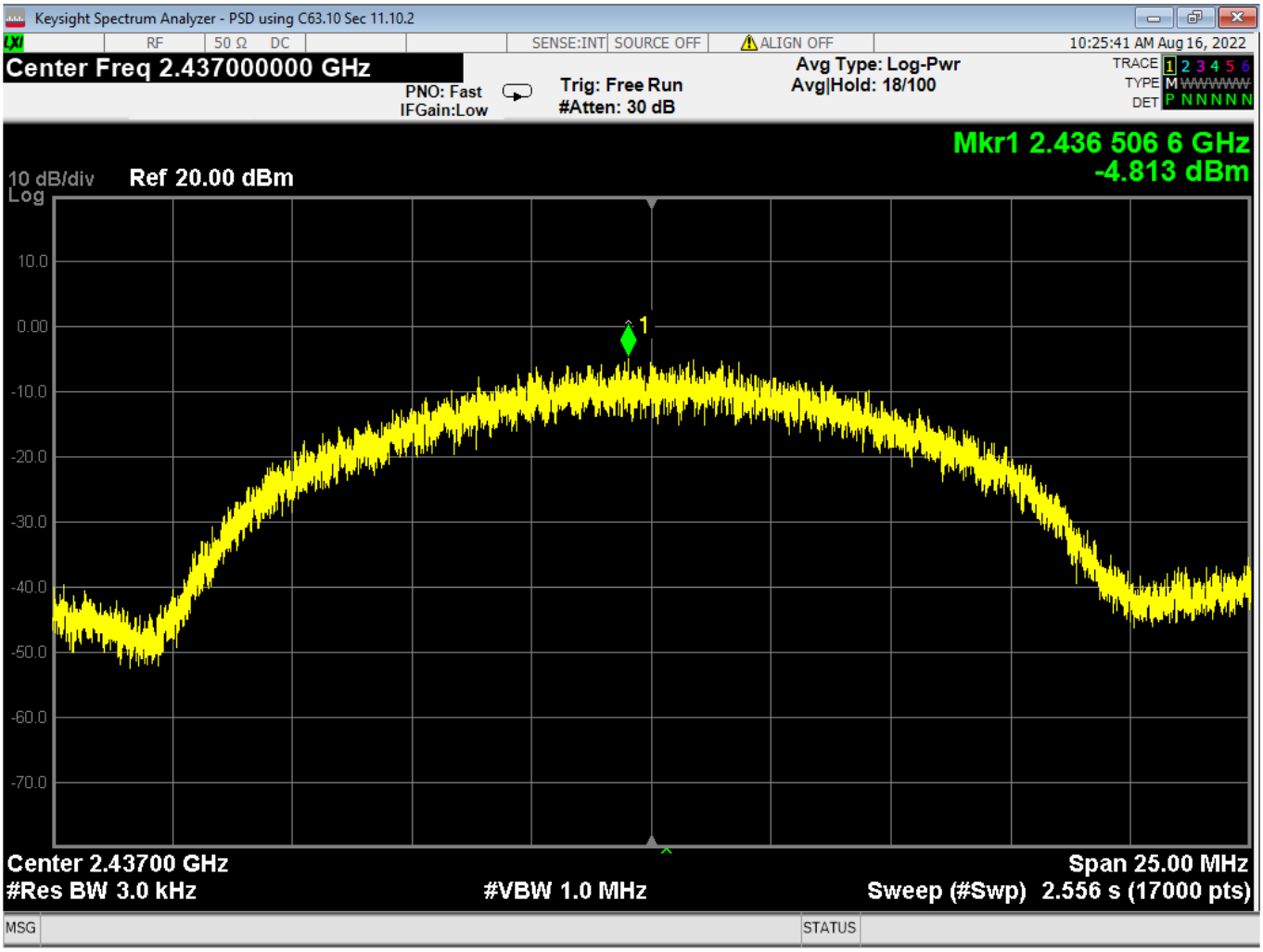
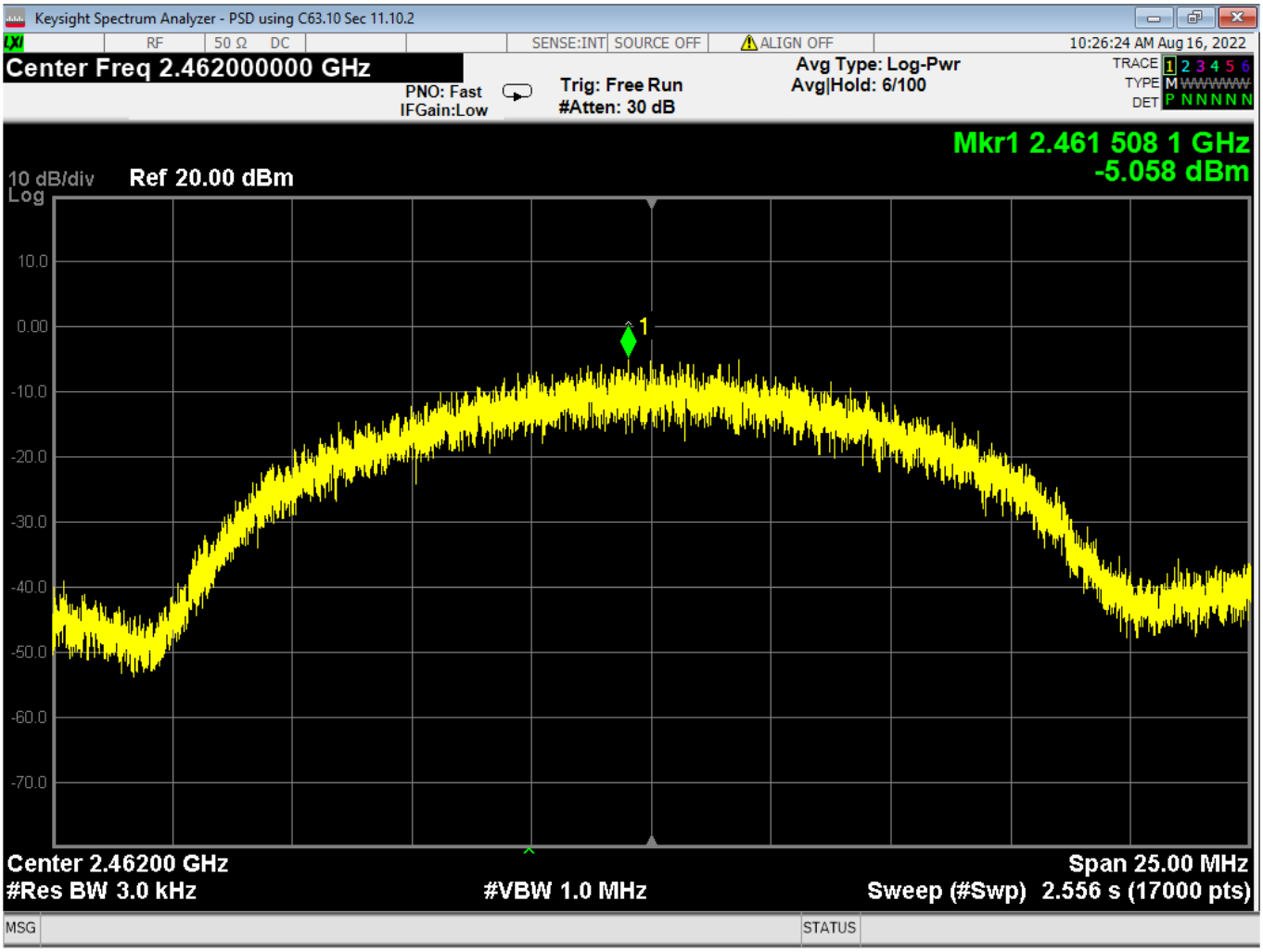


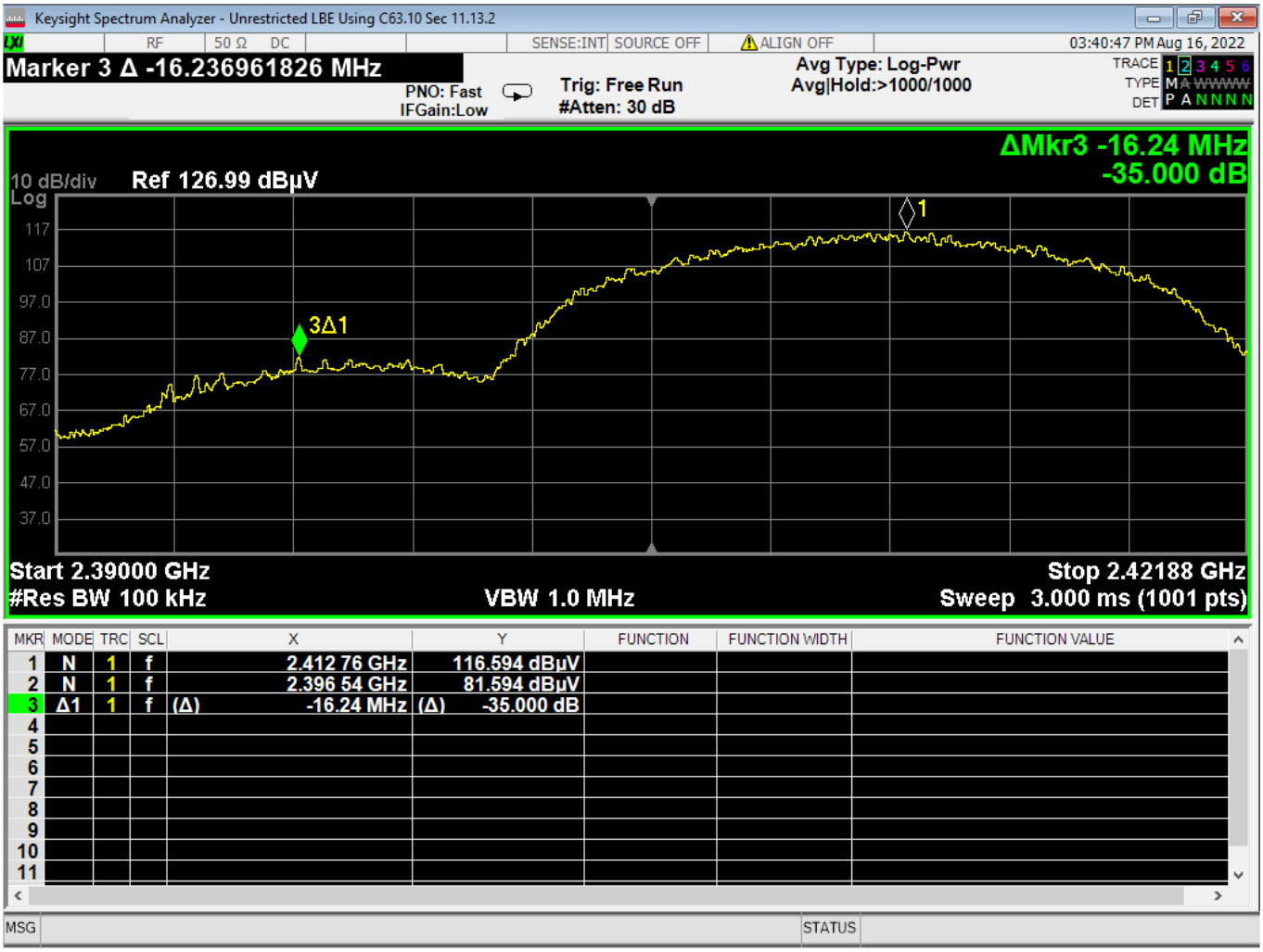
46 PSD, Low, Wifi B, High Data Rate



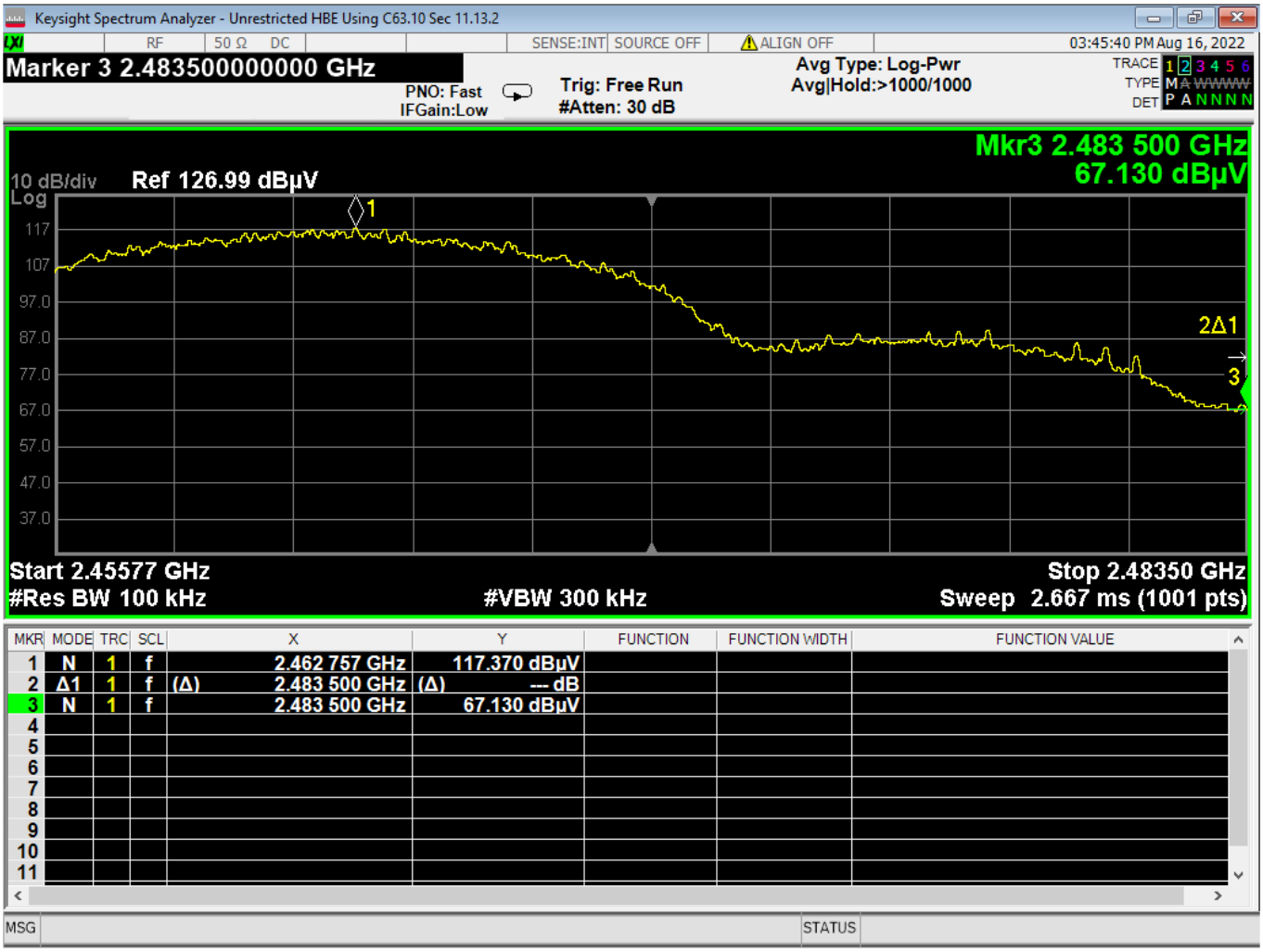
47 PSD, Mid, Wifi B, High Data Rate



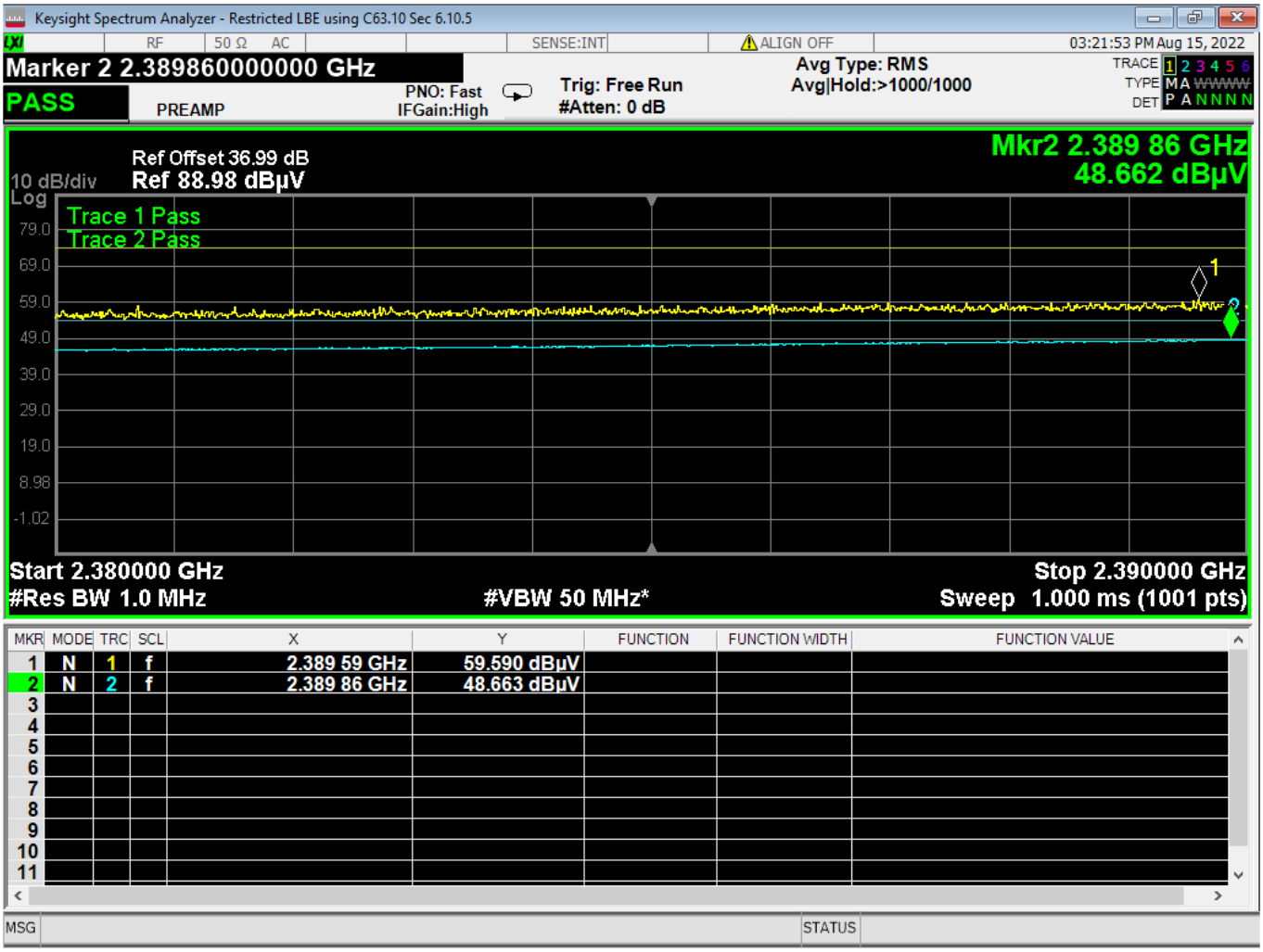
48 PSD, High, Wifi B, High Data Rate



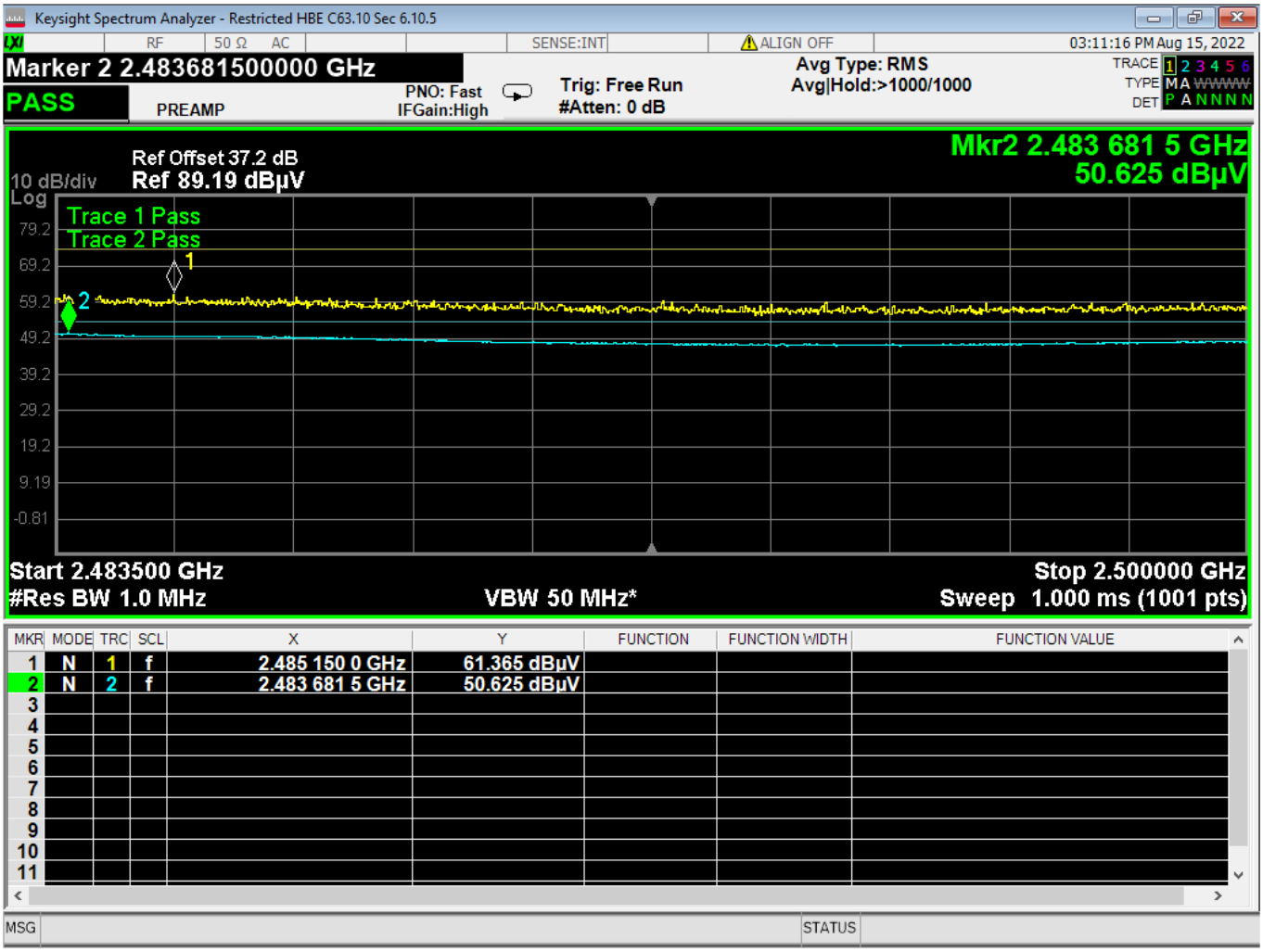
49 Lower Bandedge, Unrestricted, Wifi B, High Data Rate



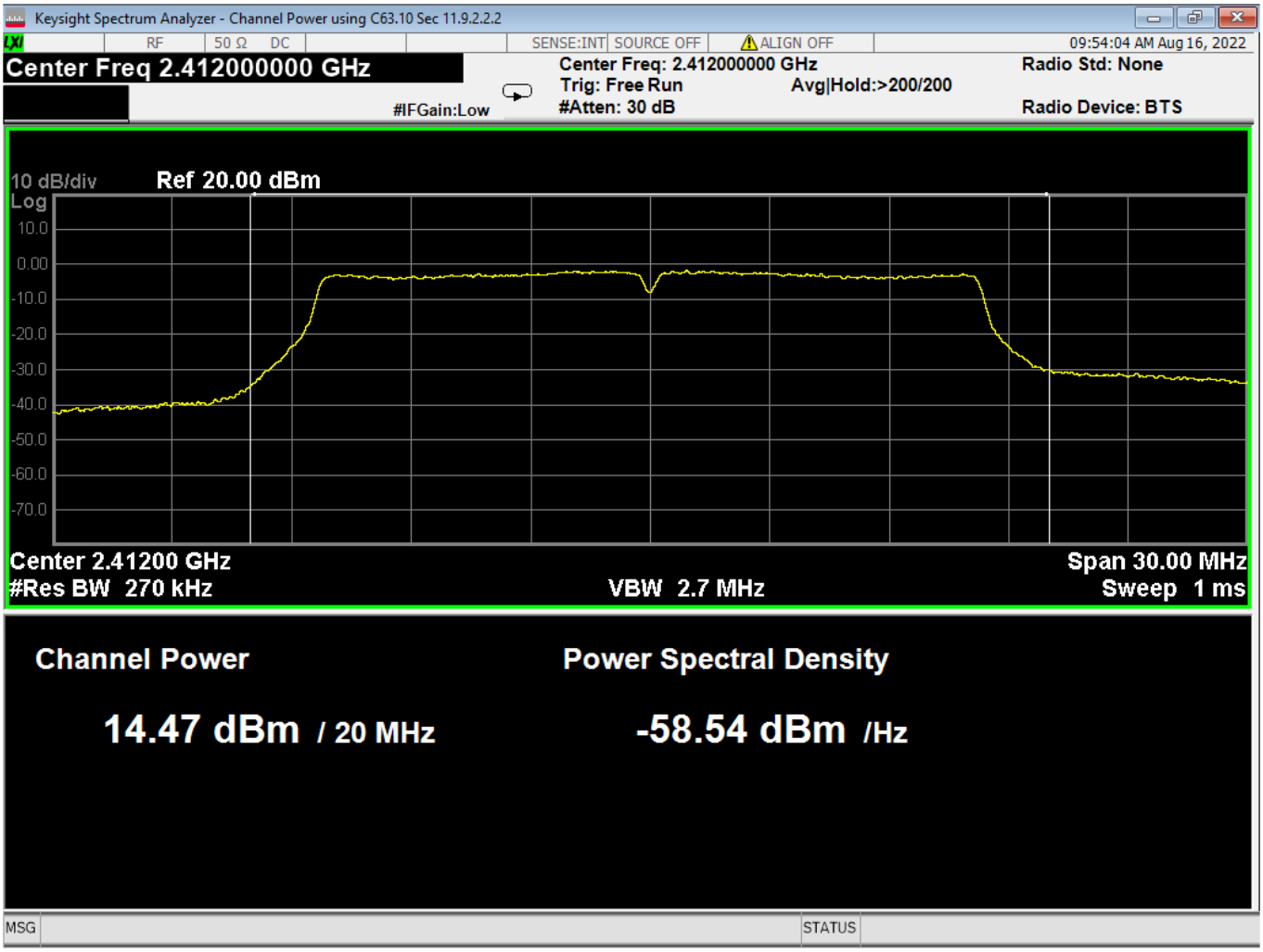
50 Higher Bandedge, Unrestricted, Wifi B, High Data Rate



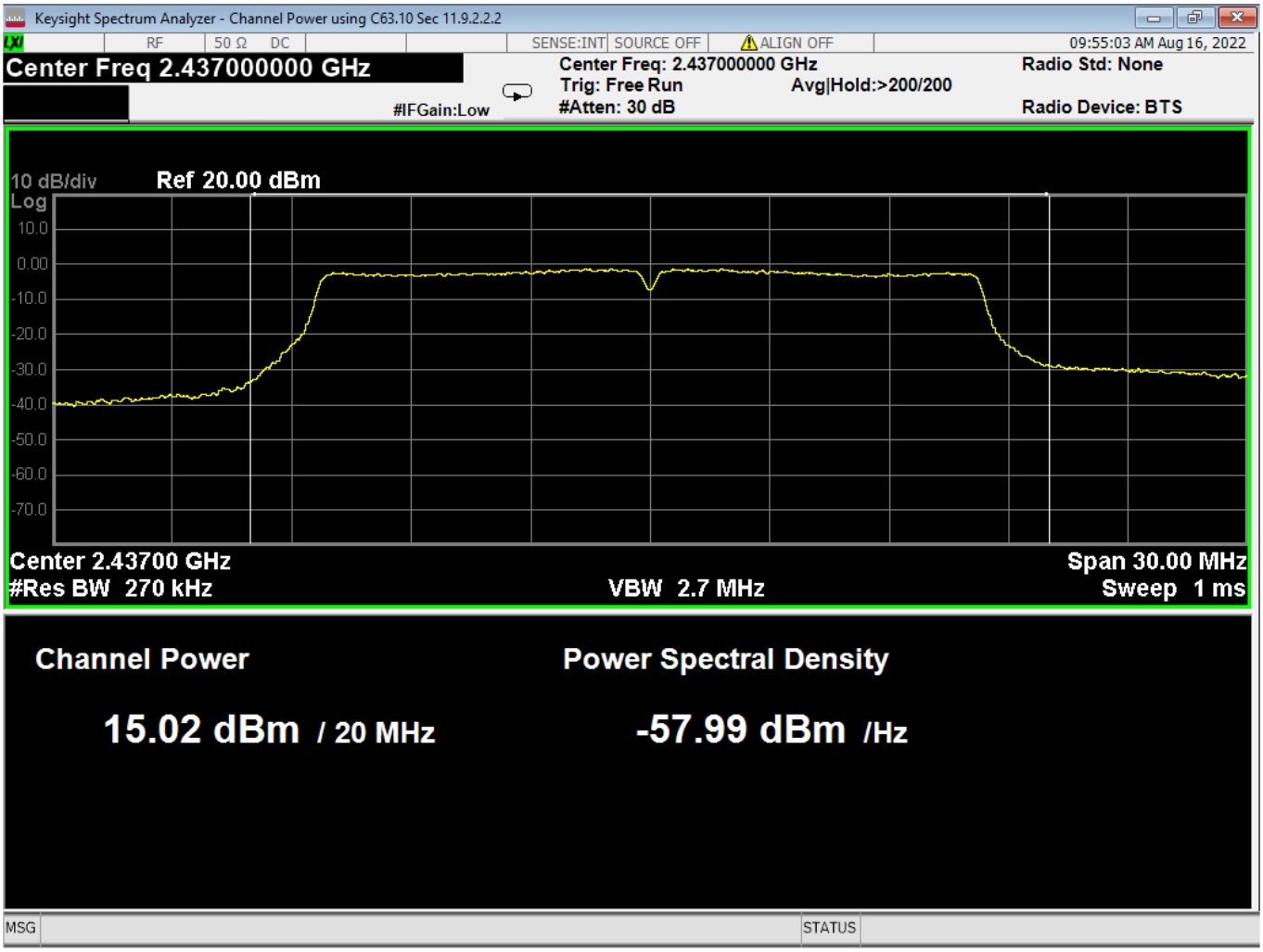
51 Lower Bandedge, Restricted, Wifi B, High Data Rate



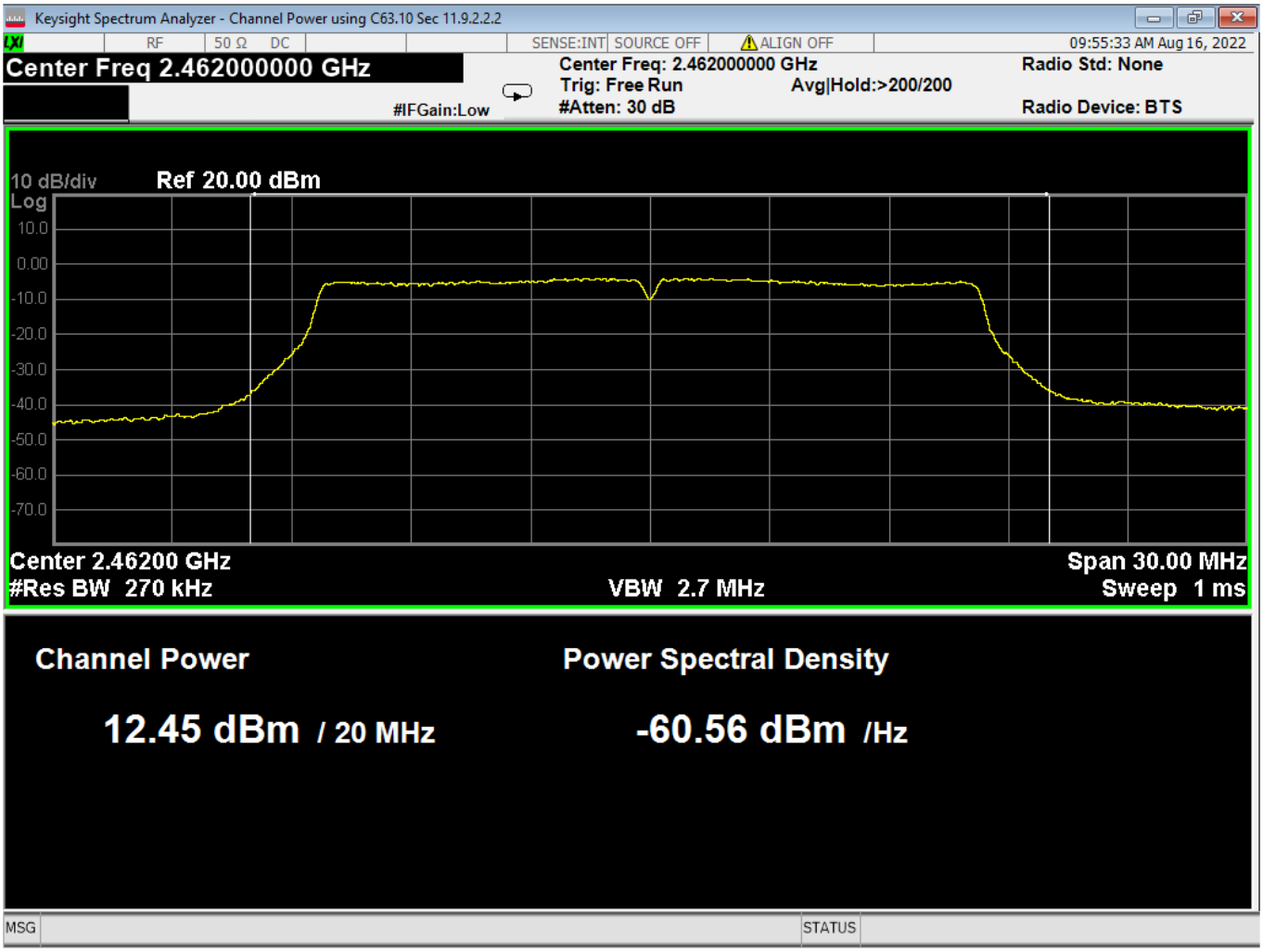
52 Higher Bandedge, Restricted, Wifi B, High Data Rate



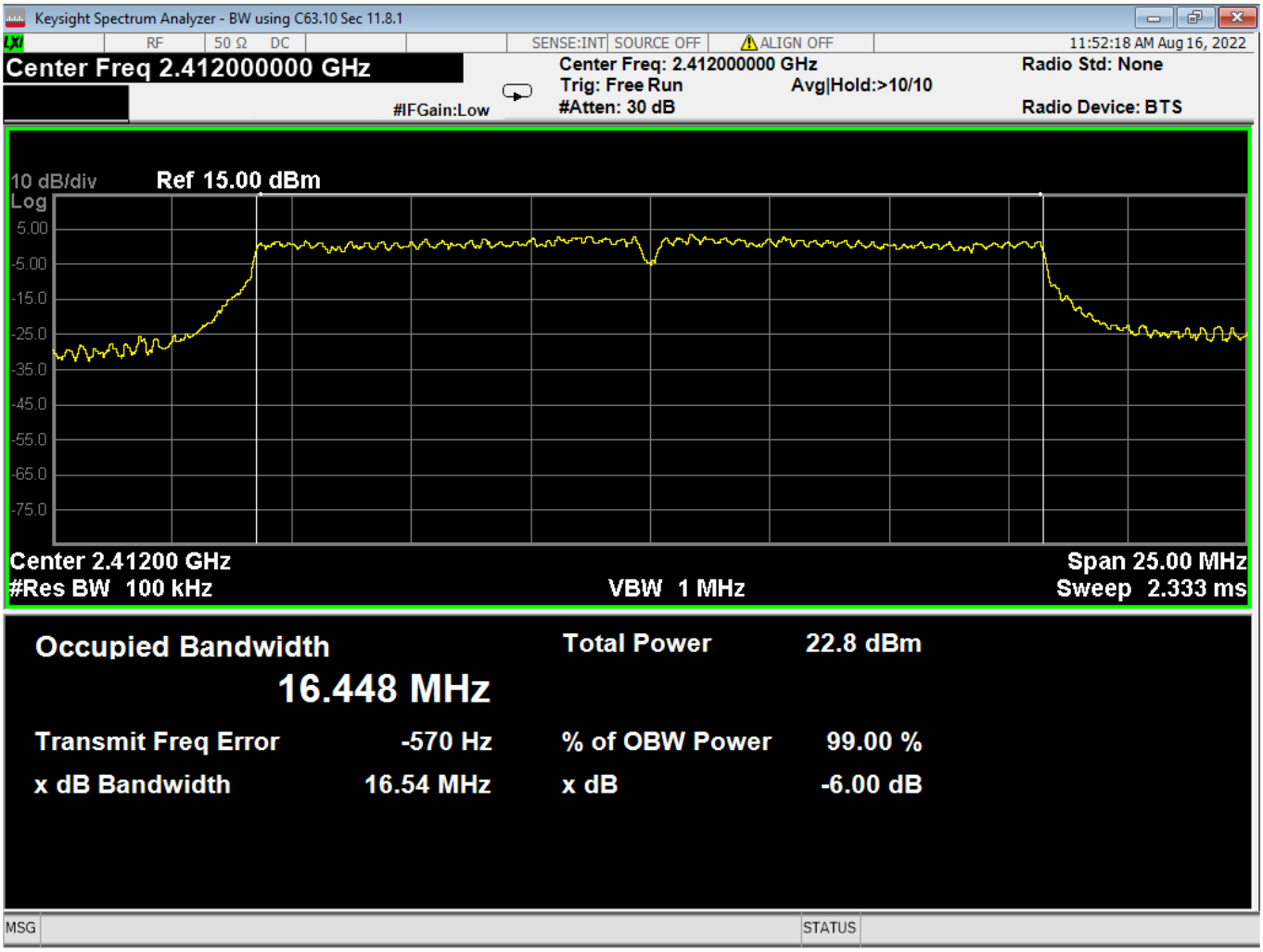
53 Average Power, Low, Wifi G, High Data Rate



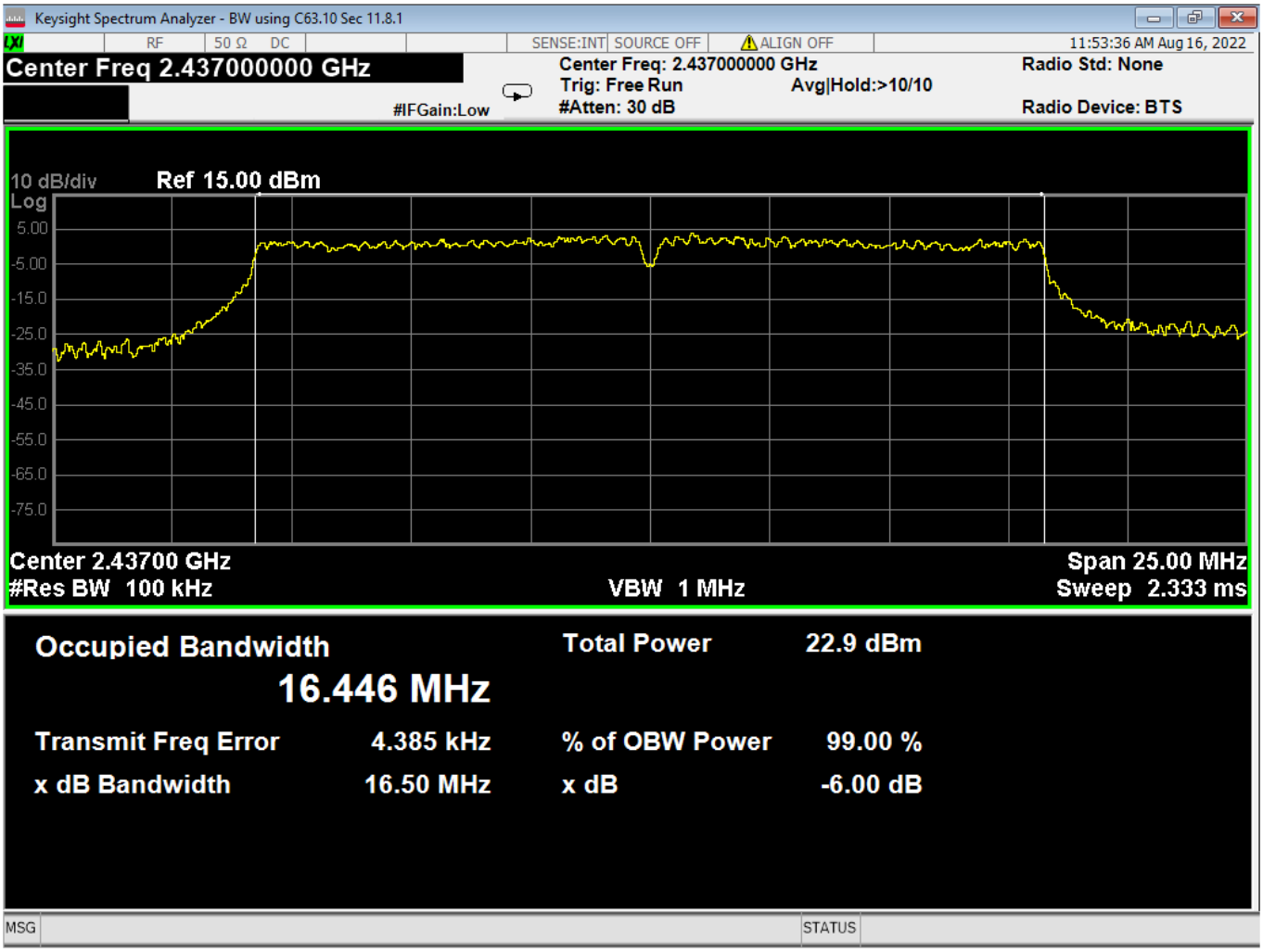
54 Average Power, Mid, Wifi G, High Data Rate



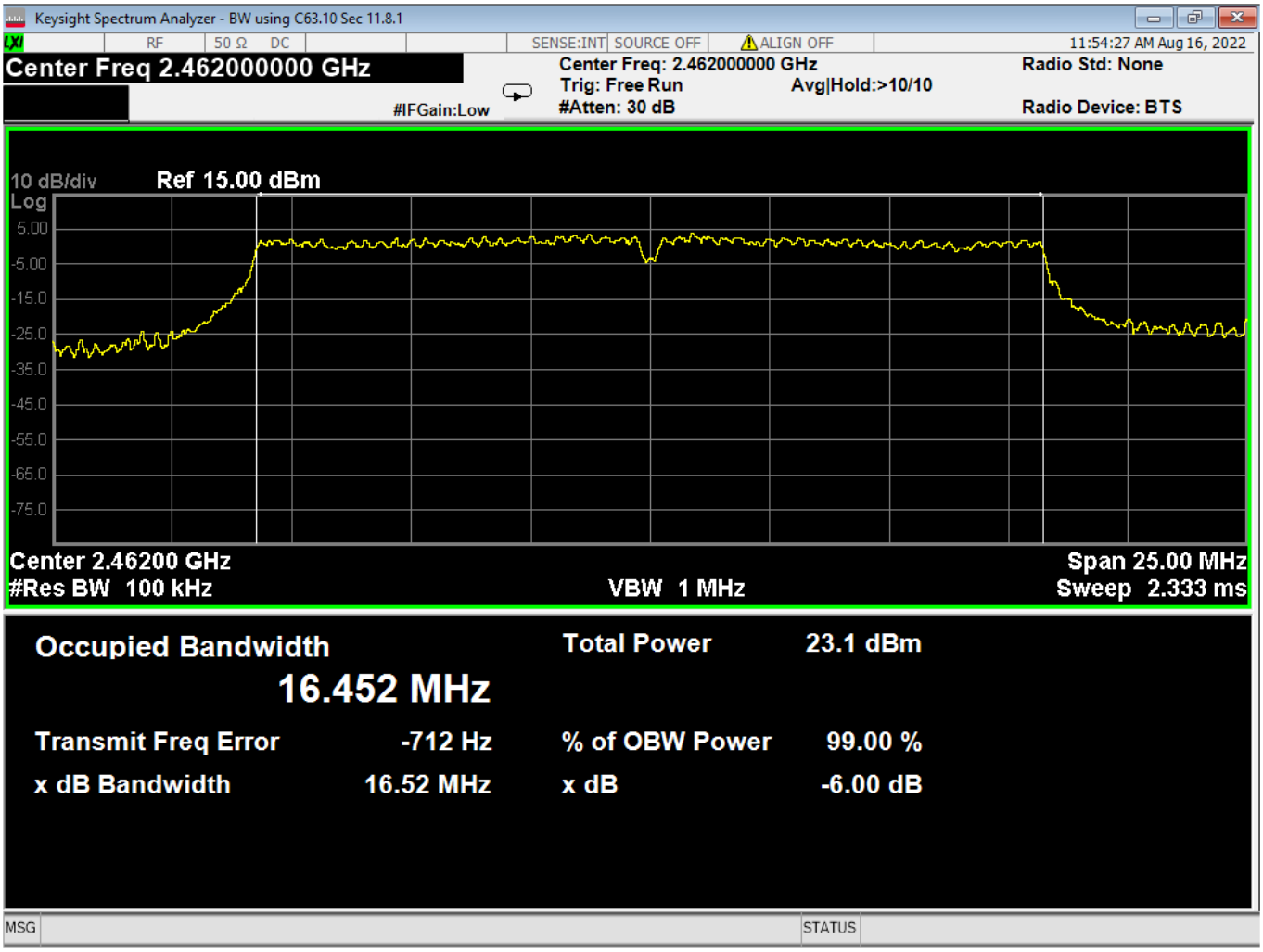
55 Average Power, High, Wifi G, High Data Rate



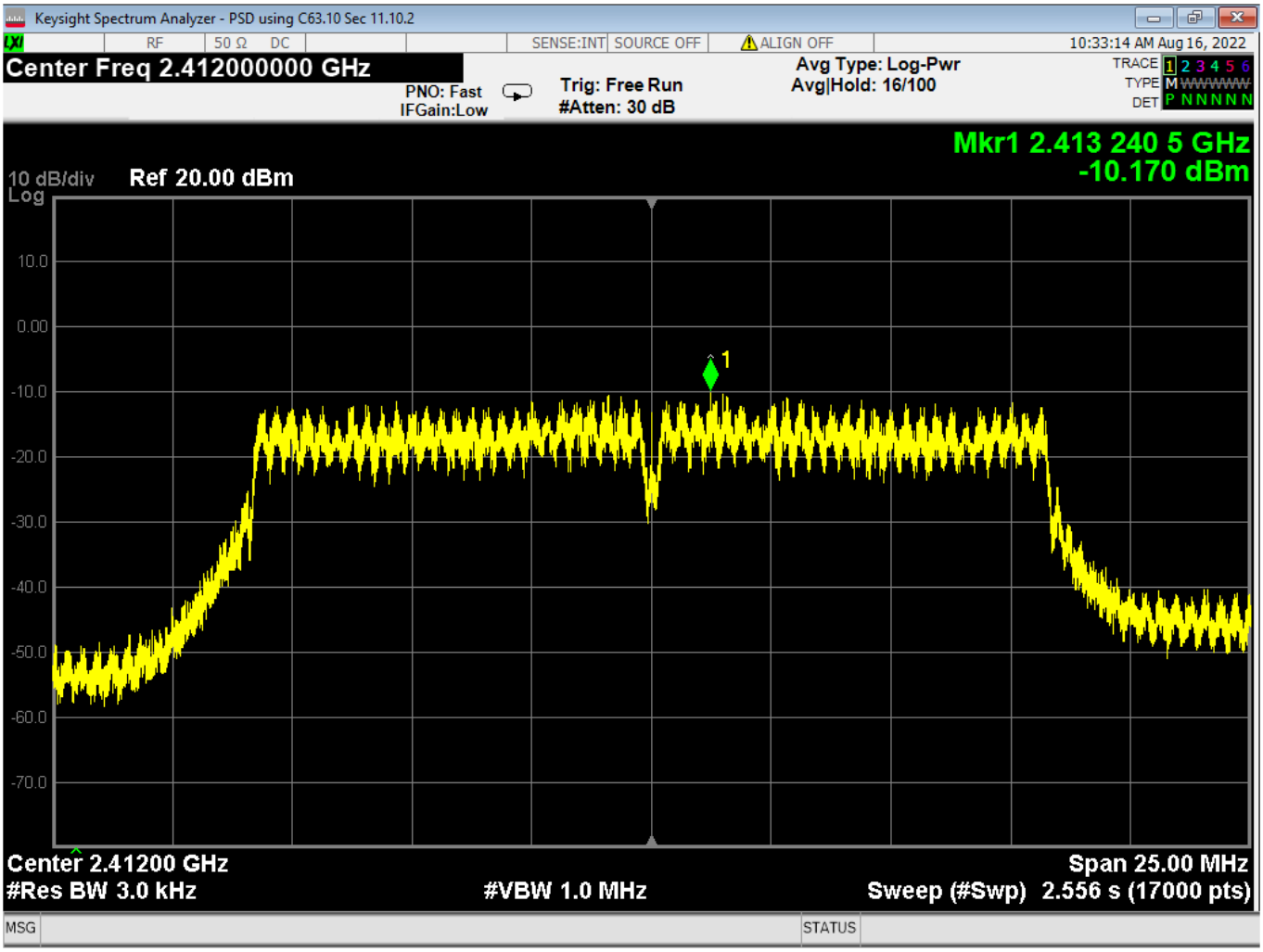
56 Bandwidth, Low, Wifi G, High Data Rate



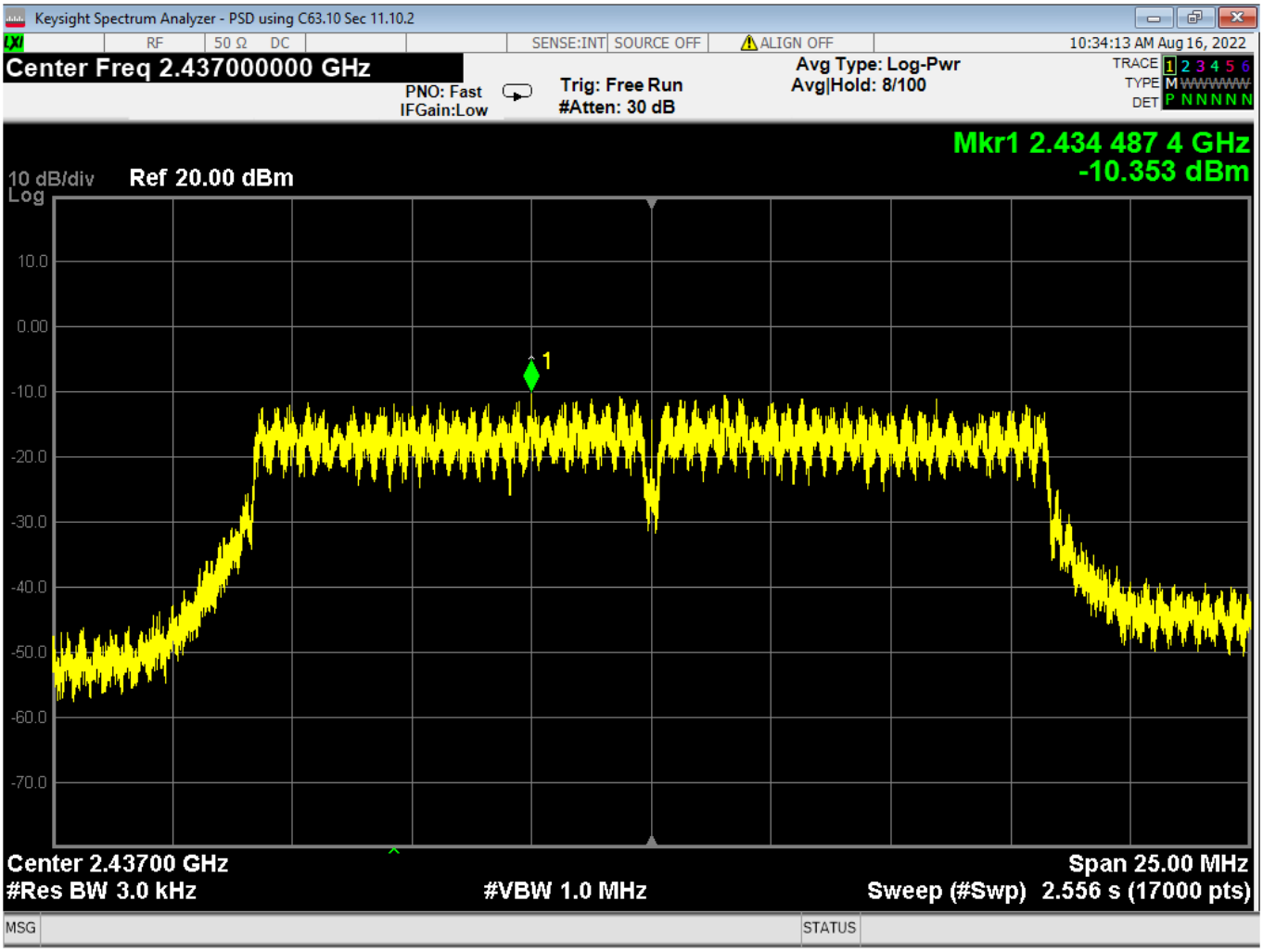
57 Bandwidth, Mid, Wifi G, High Data Rate



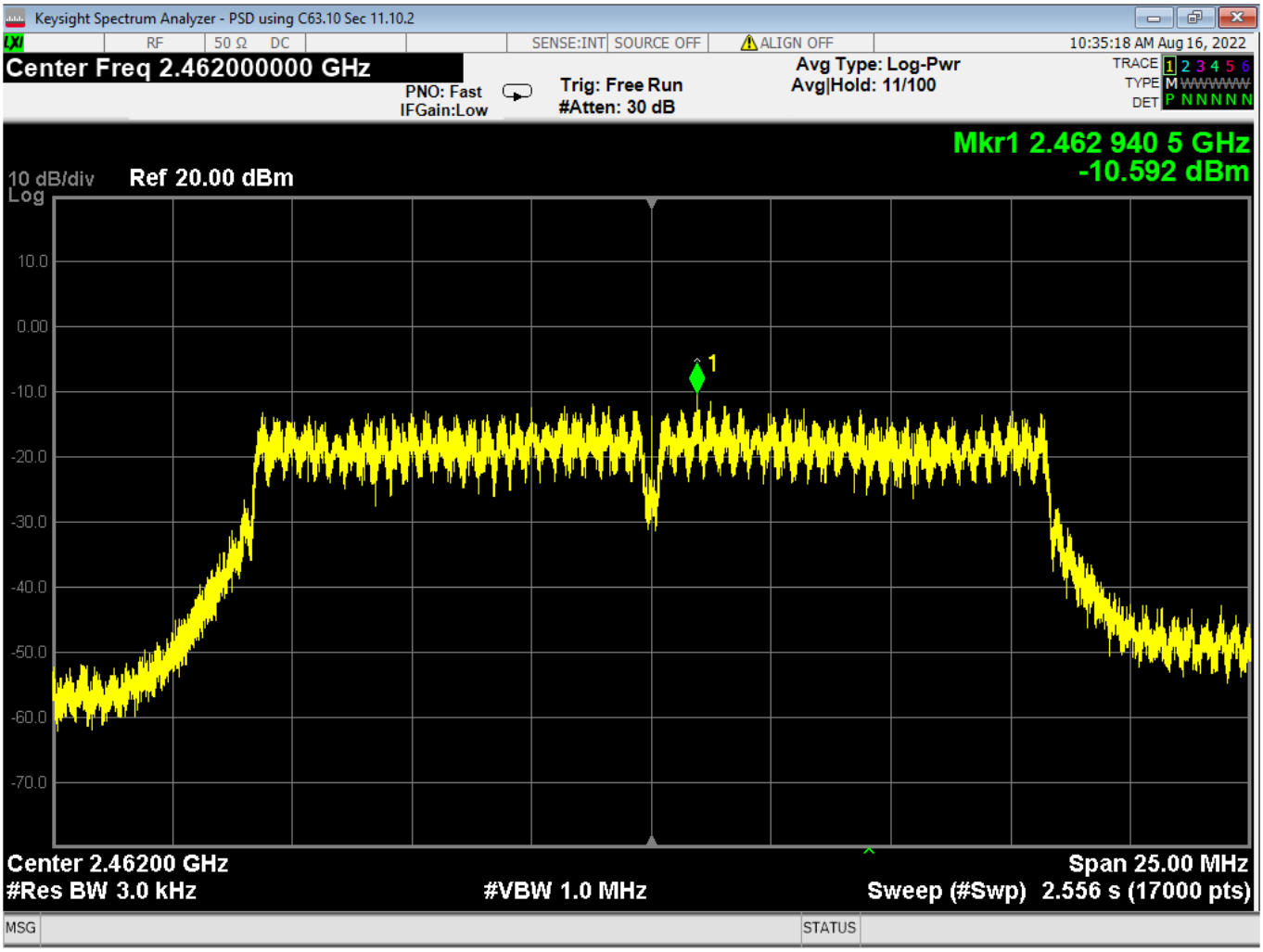
58 Bandwidth, High, Wifi G, High Data Rate



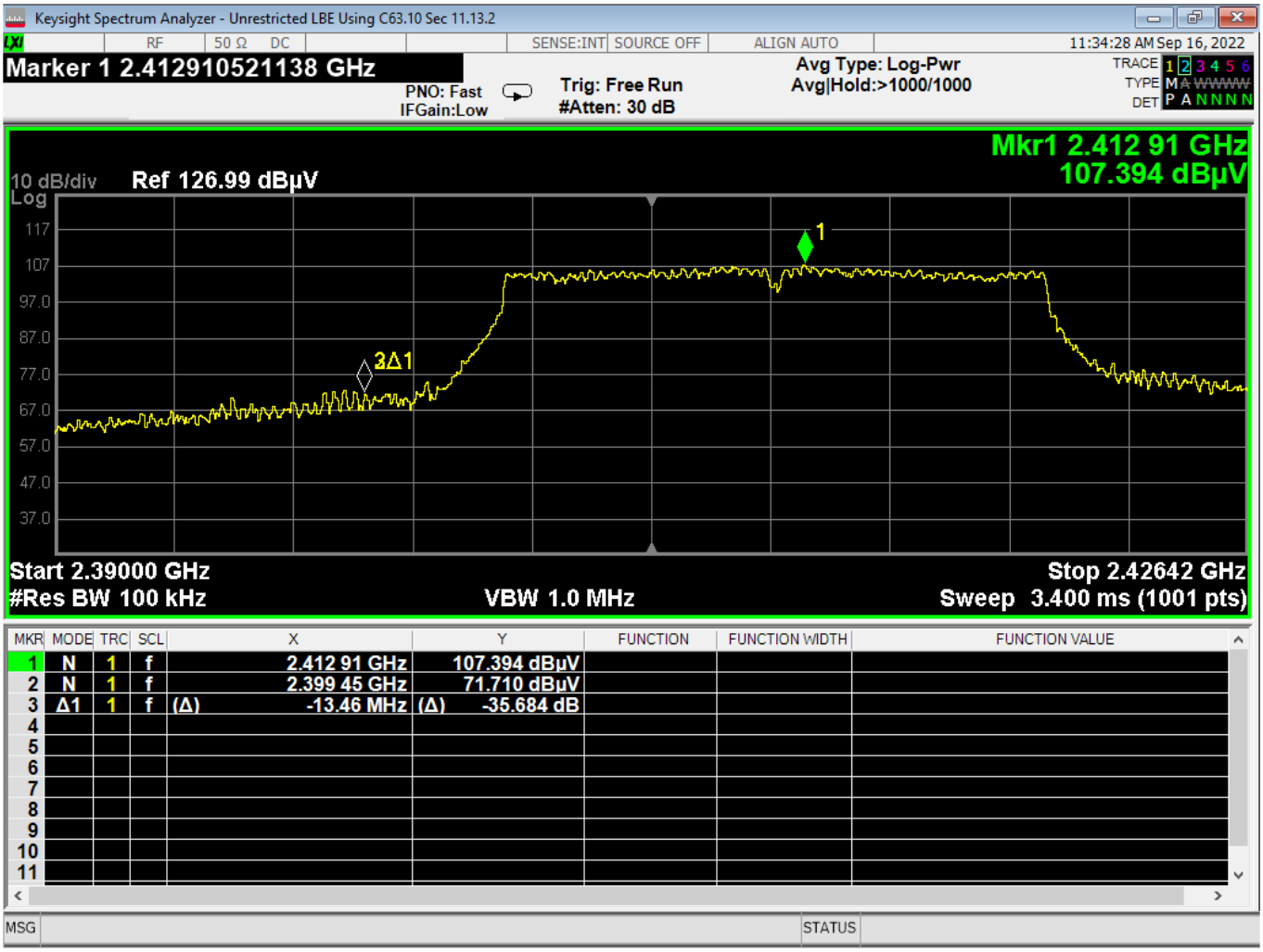
59 PSD, Low, Wifi G, High Data Rate



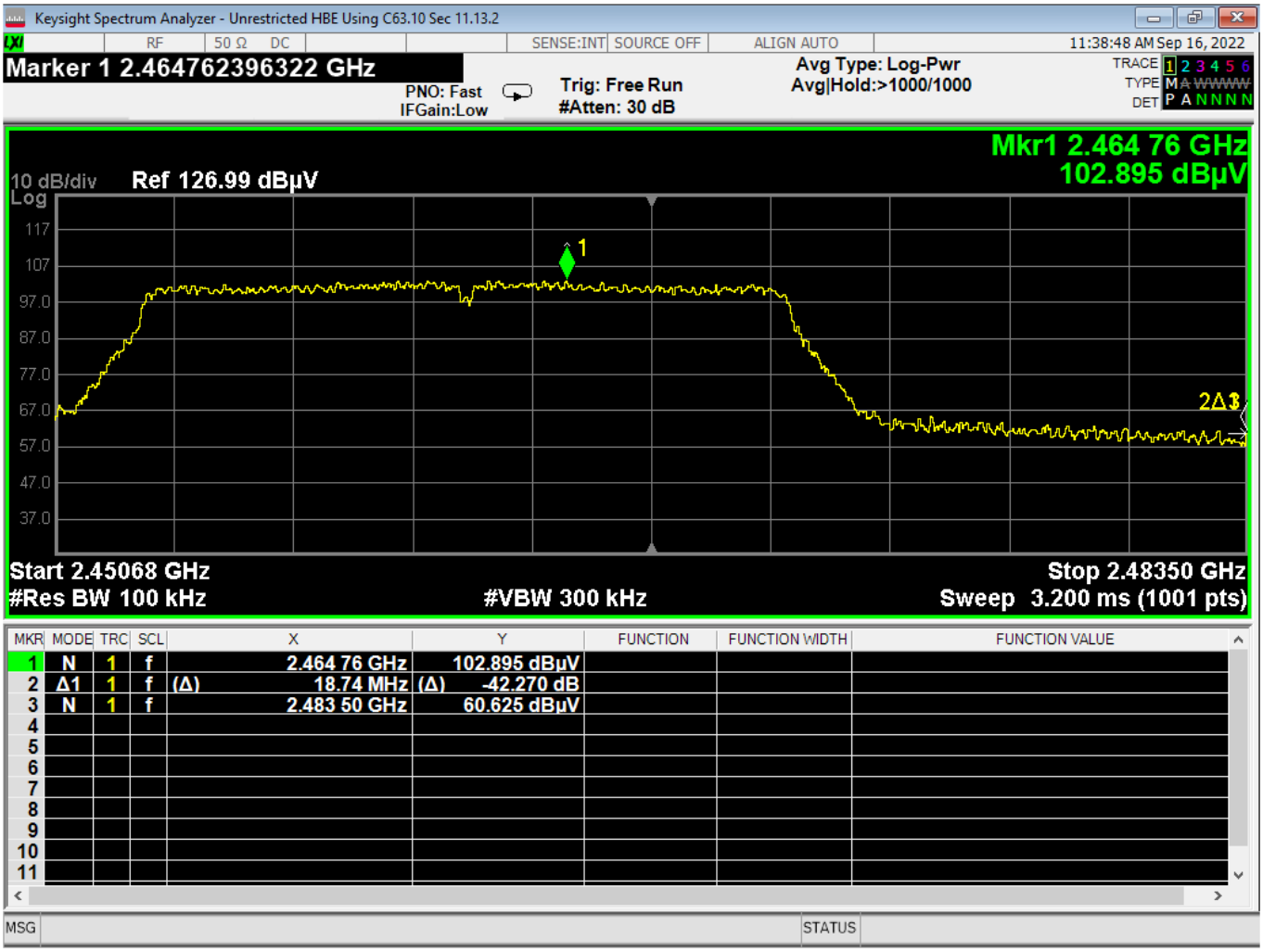
60 PSD, Mid, Wifi G, High Data Rate



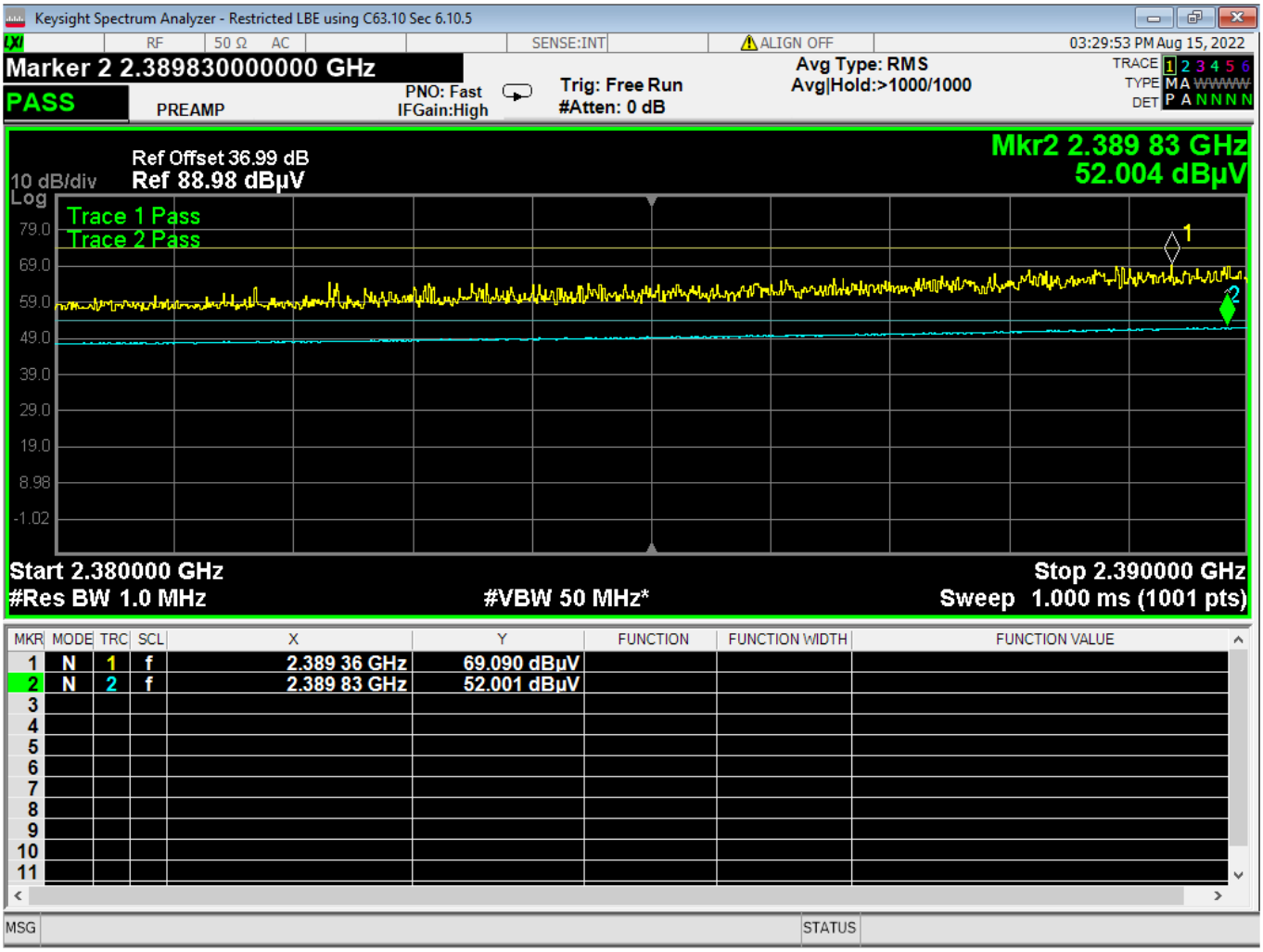
61 PSD, High, Wifi G, High Data Rate



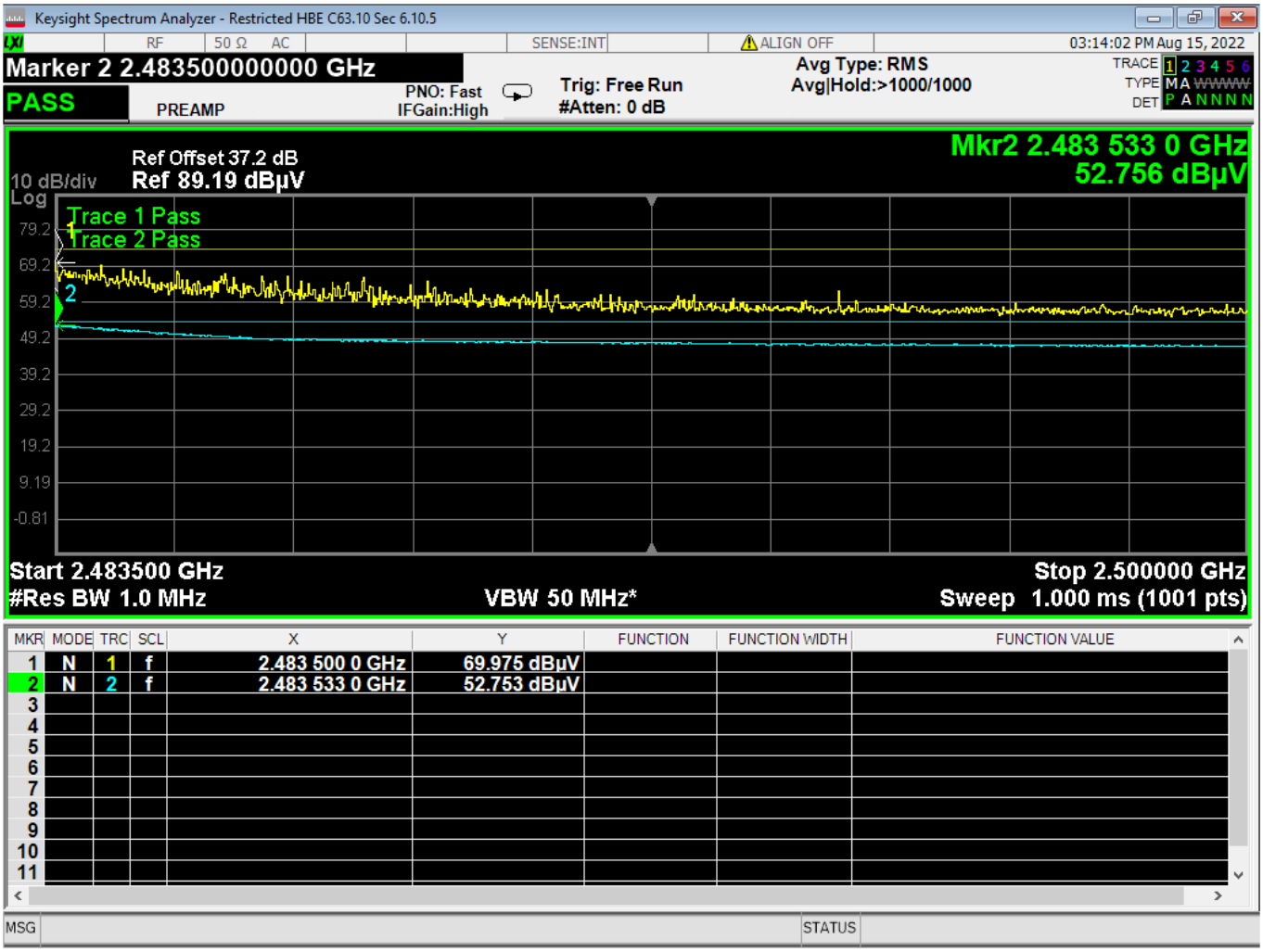
62 Lower Bandedge, Unrestricted, Wifi G, High Data Rate



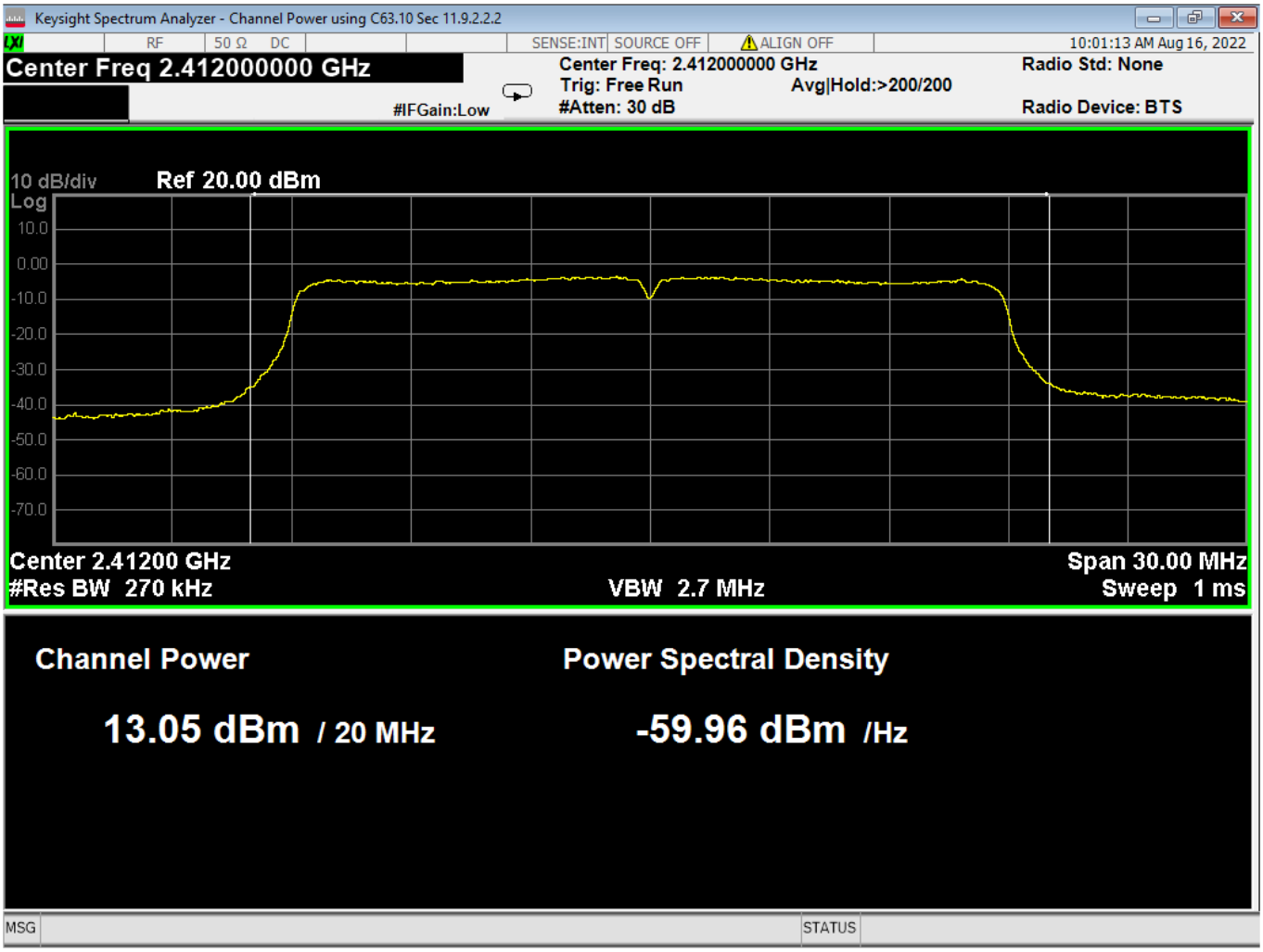
63 Higher Bandedge, Unrestricted, Wifi G, High Data Rate



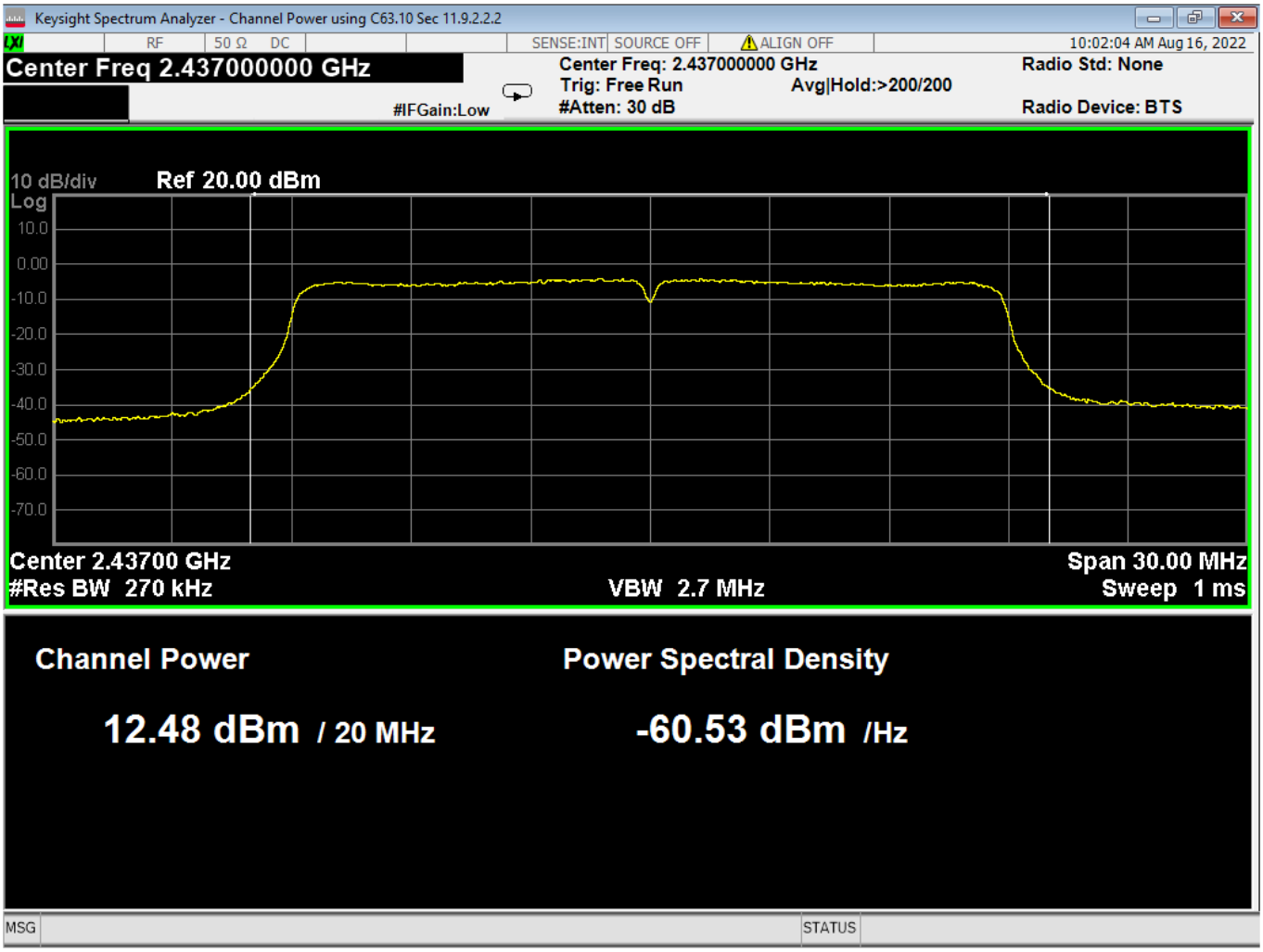
64 Lower Bandedge, Restricted, Wifi G, High Data Rate



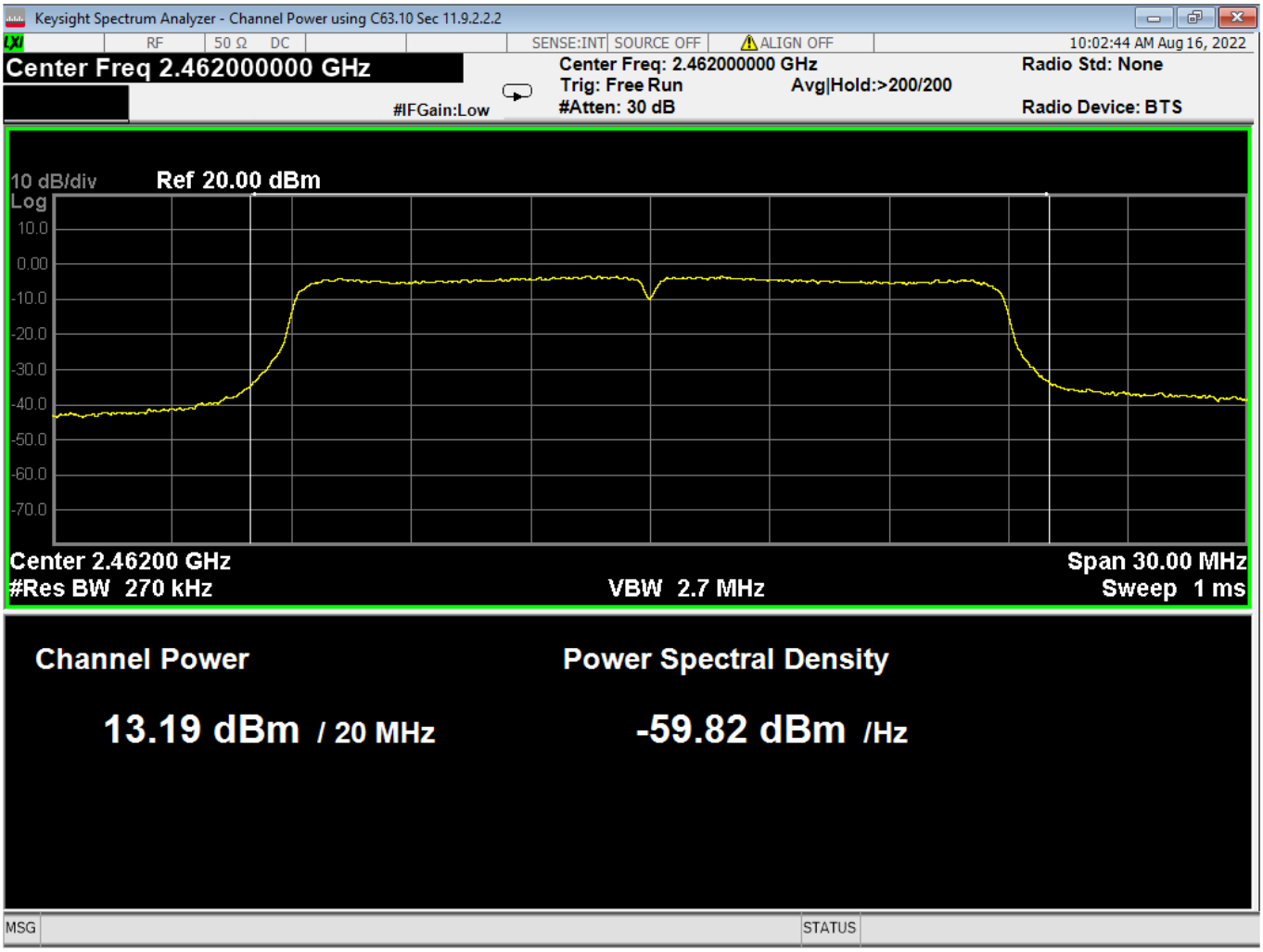
65 Higher Bandedge, Restricted, Wifi G, High Data Rate



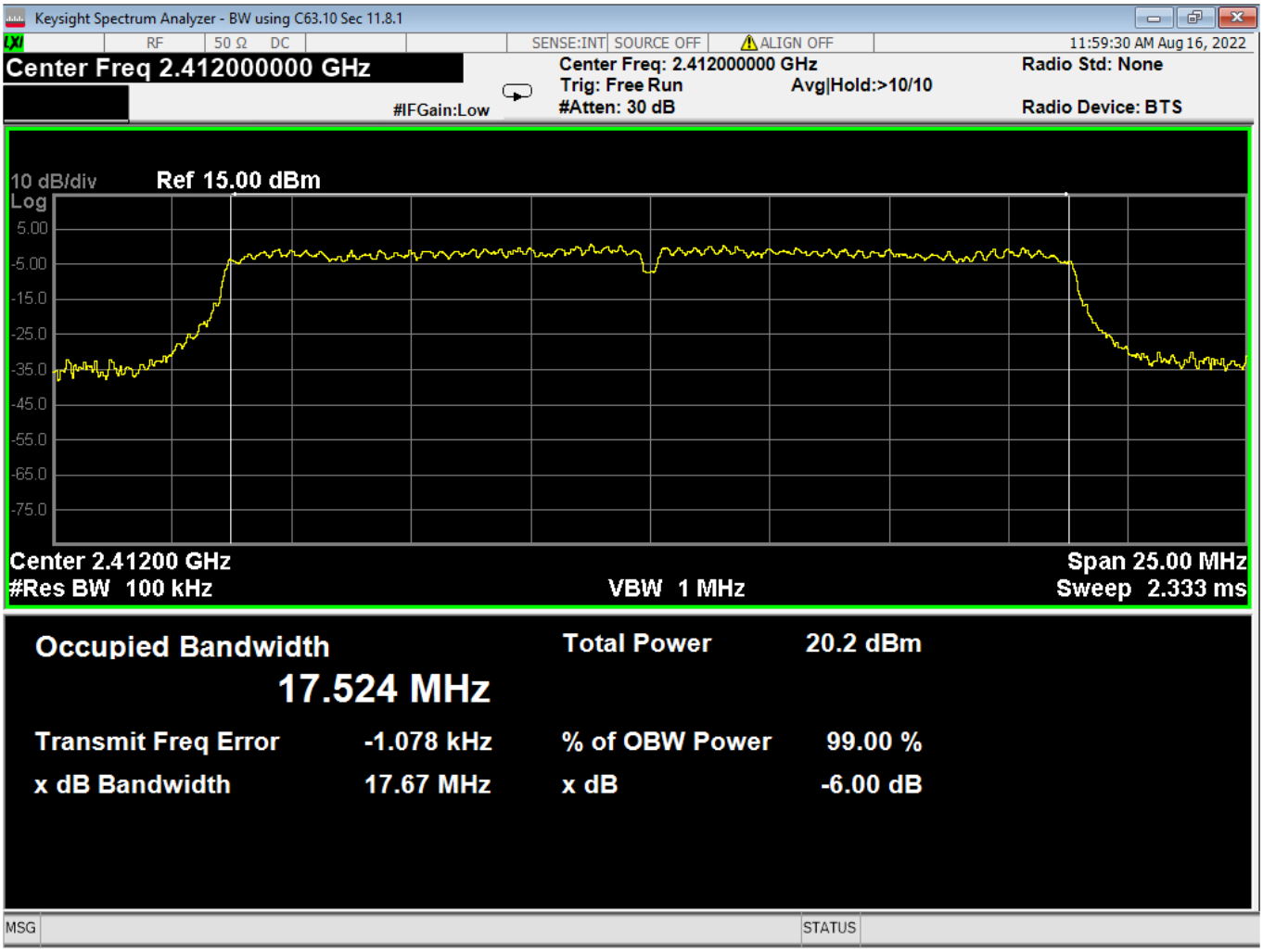
66 Average Power, Low, Wifi N, High Data Rate



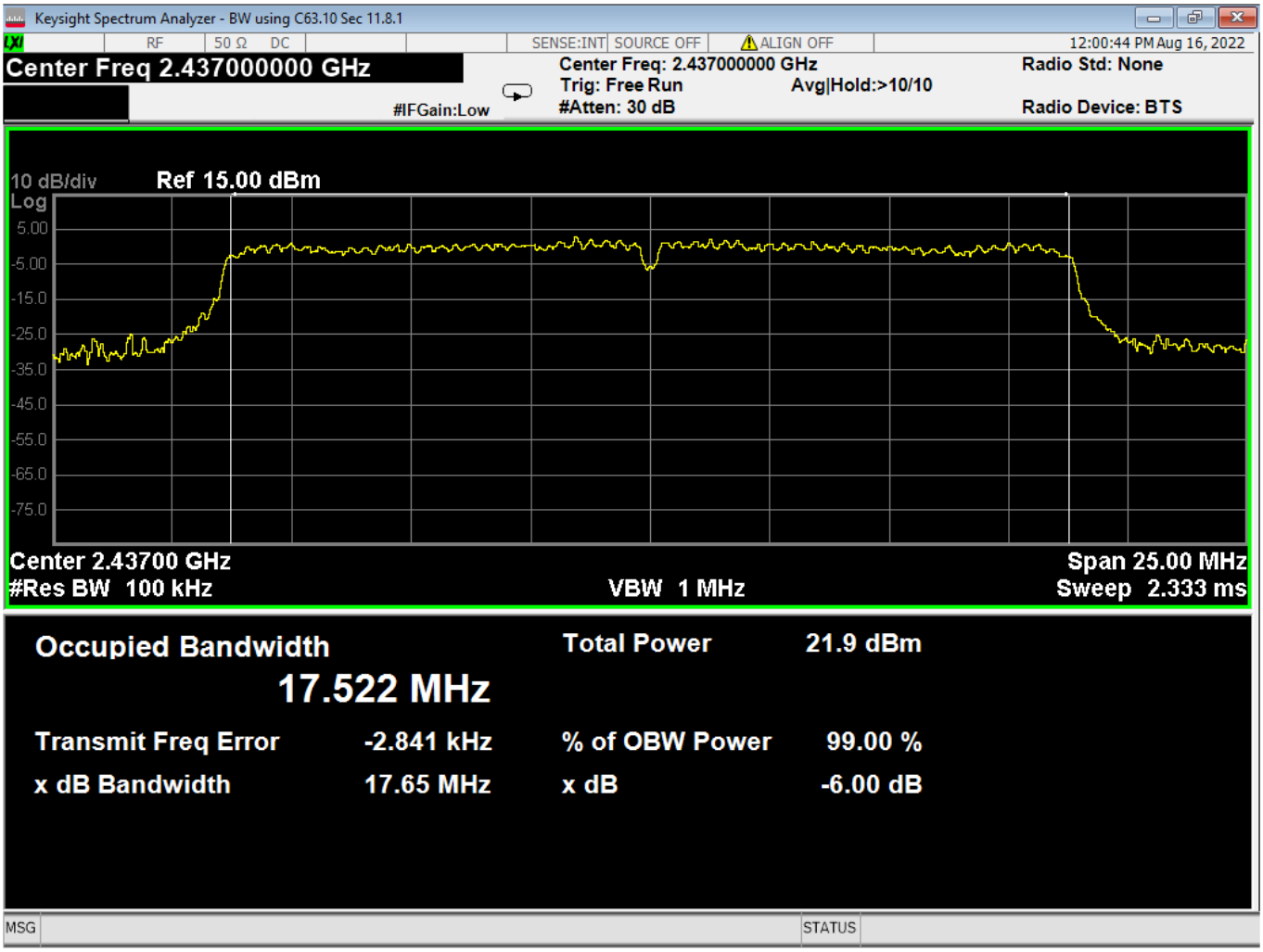
67 Average Power, Mid, Wifi N, High Data Rate



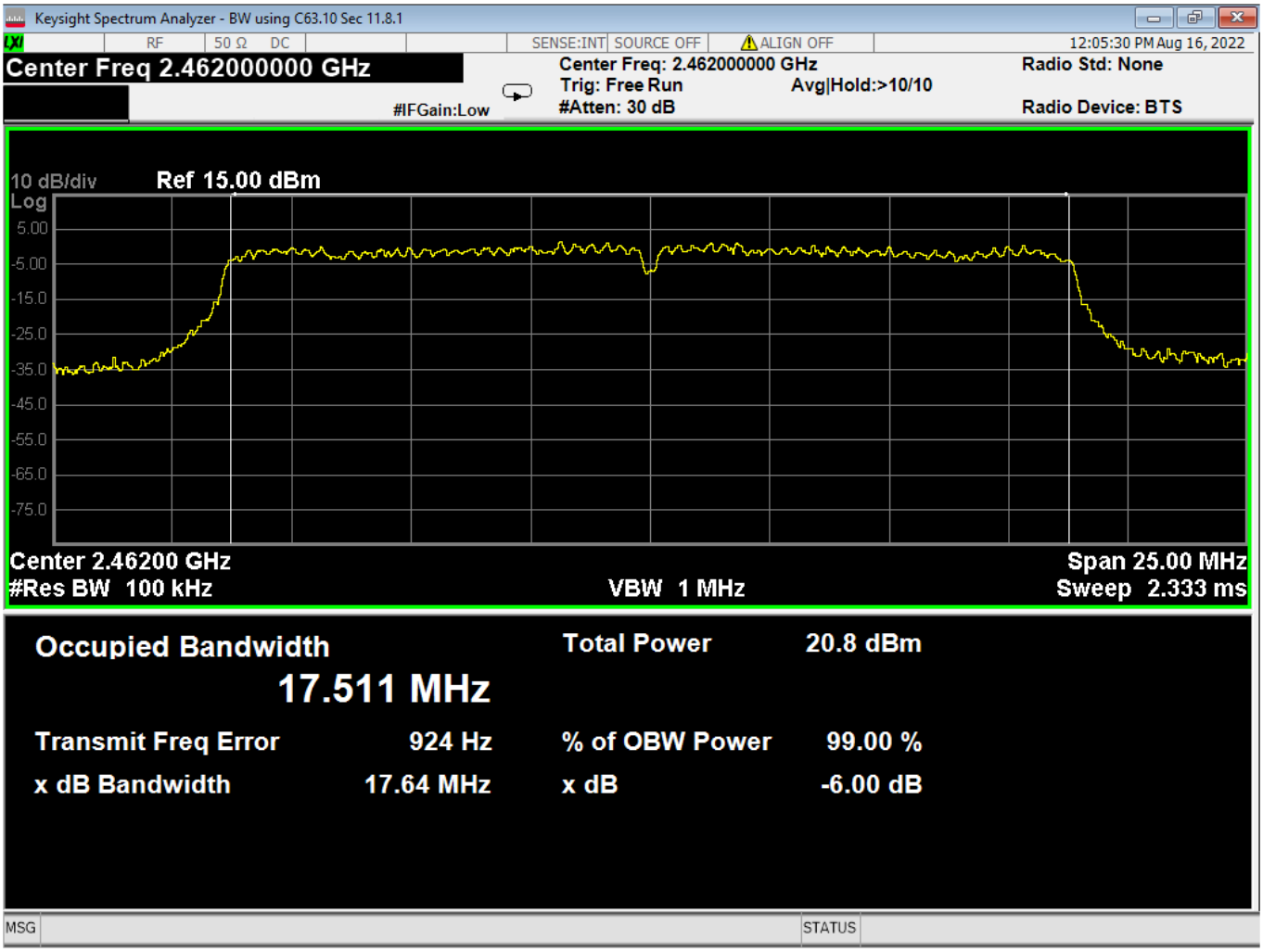
68 Average Power, High, Wifi N, High Data Rate



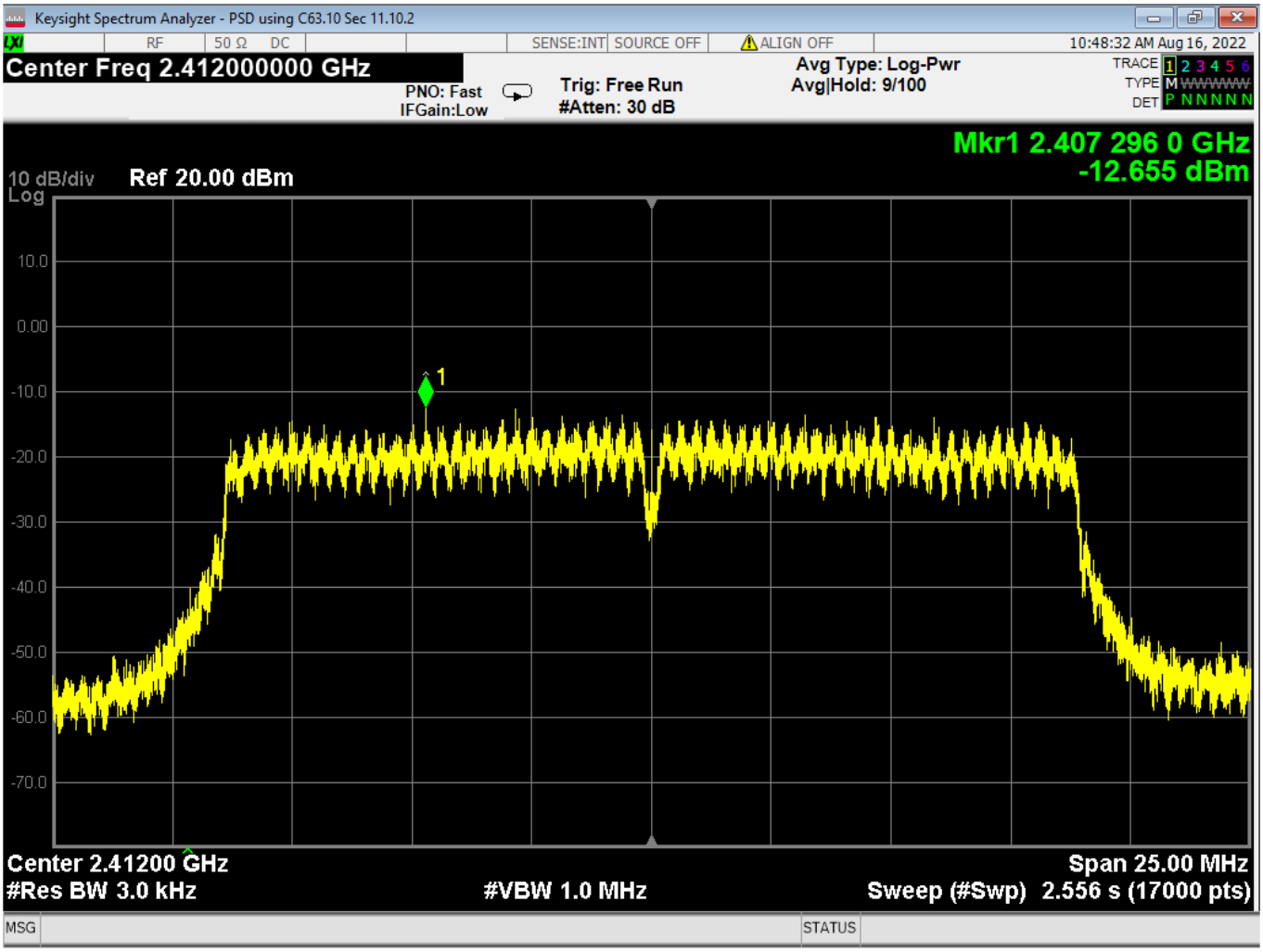
69 Bandwidth, Low, Wifi N, High Data Rate



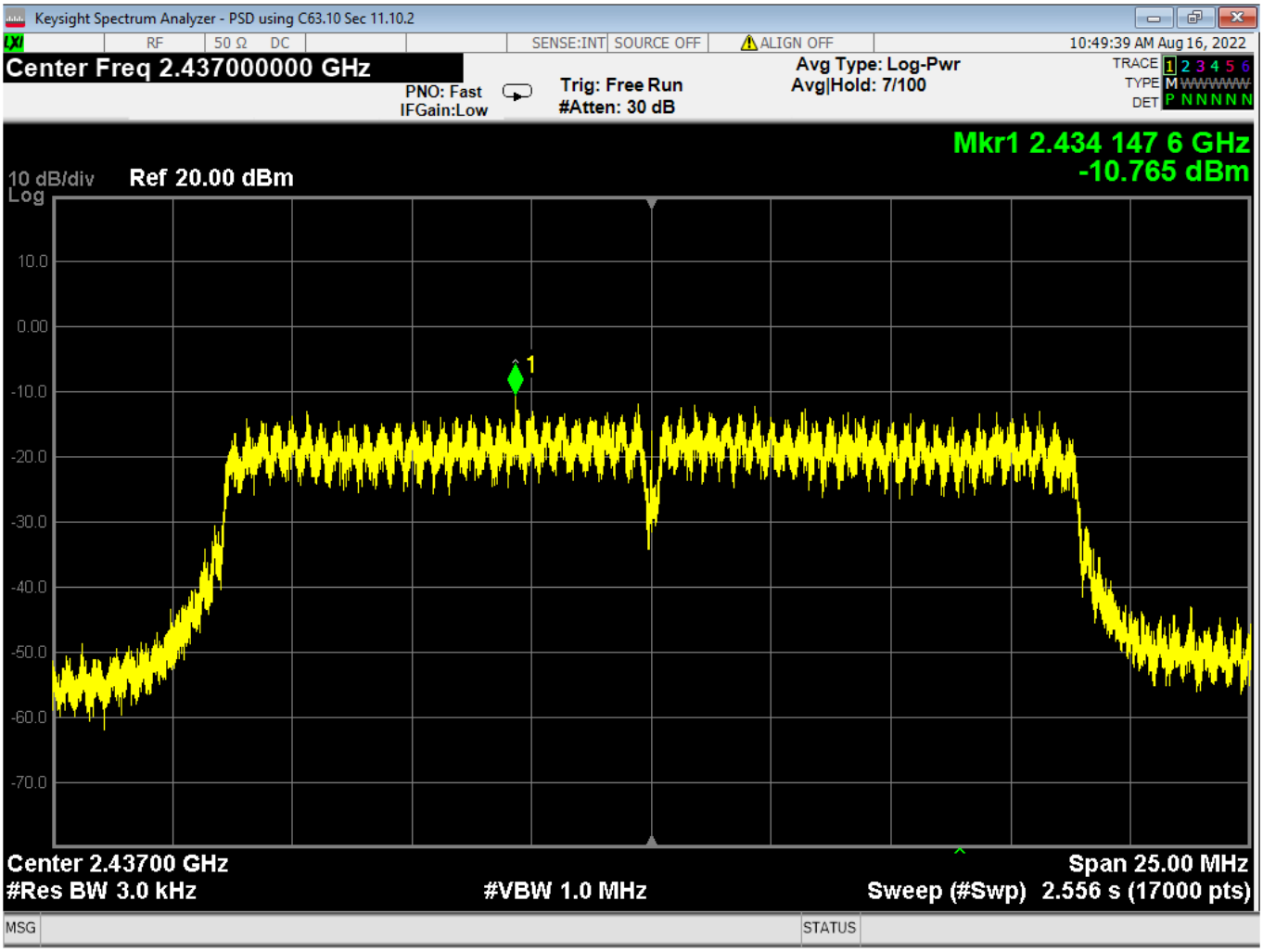
70 Bandwidth, Mid, Wifi N, High Data Rate



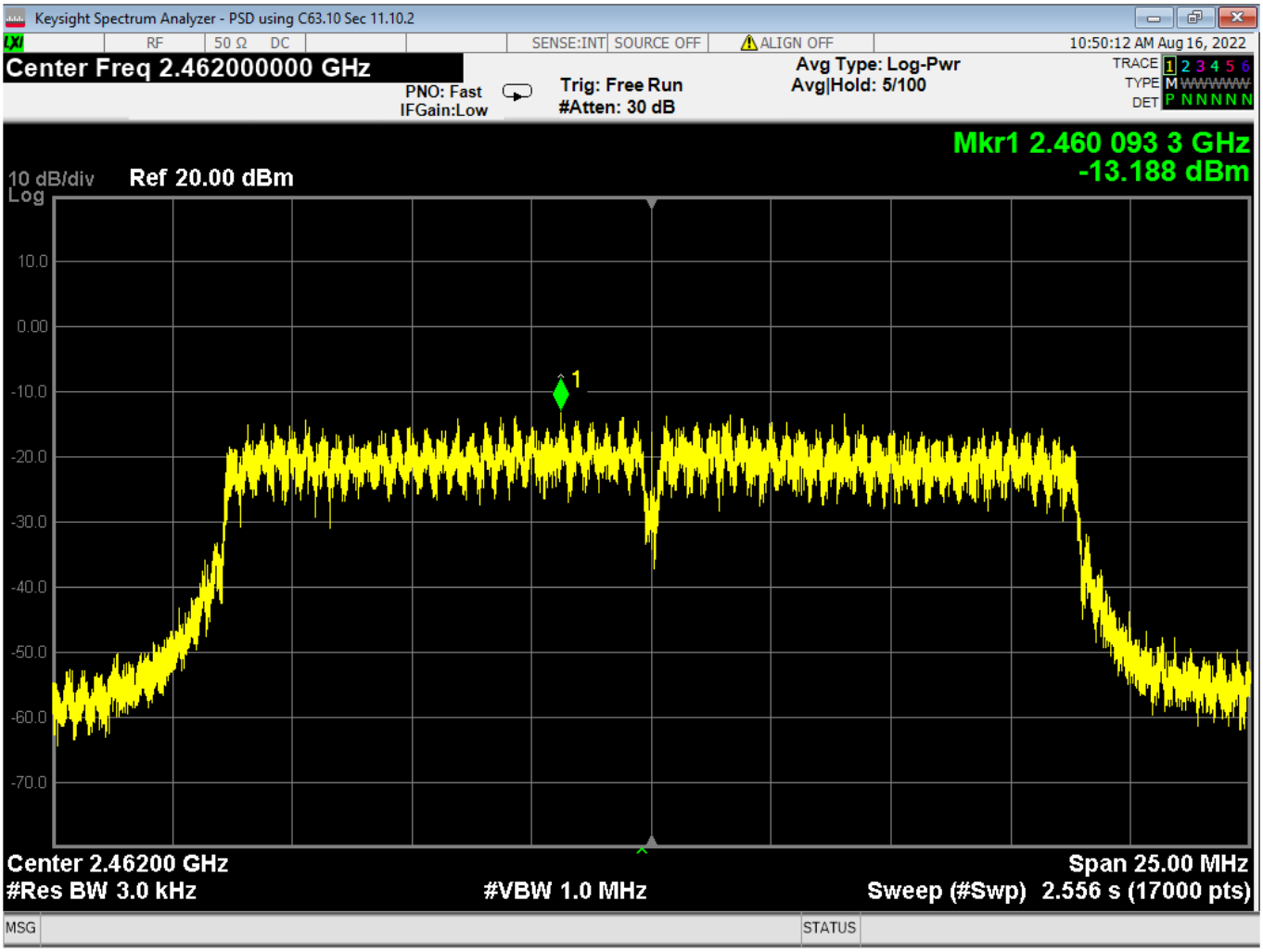
71 Bandwidth, High, Wifi N, High Data Rate



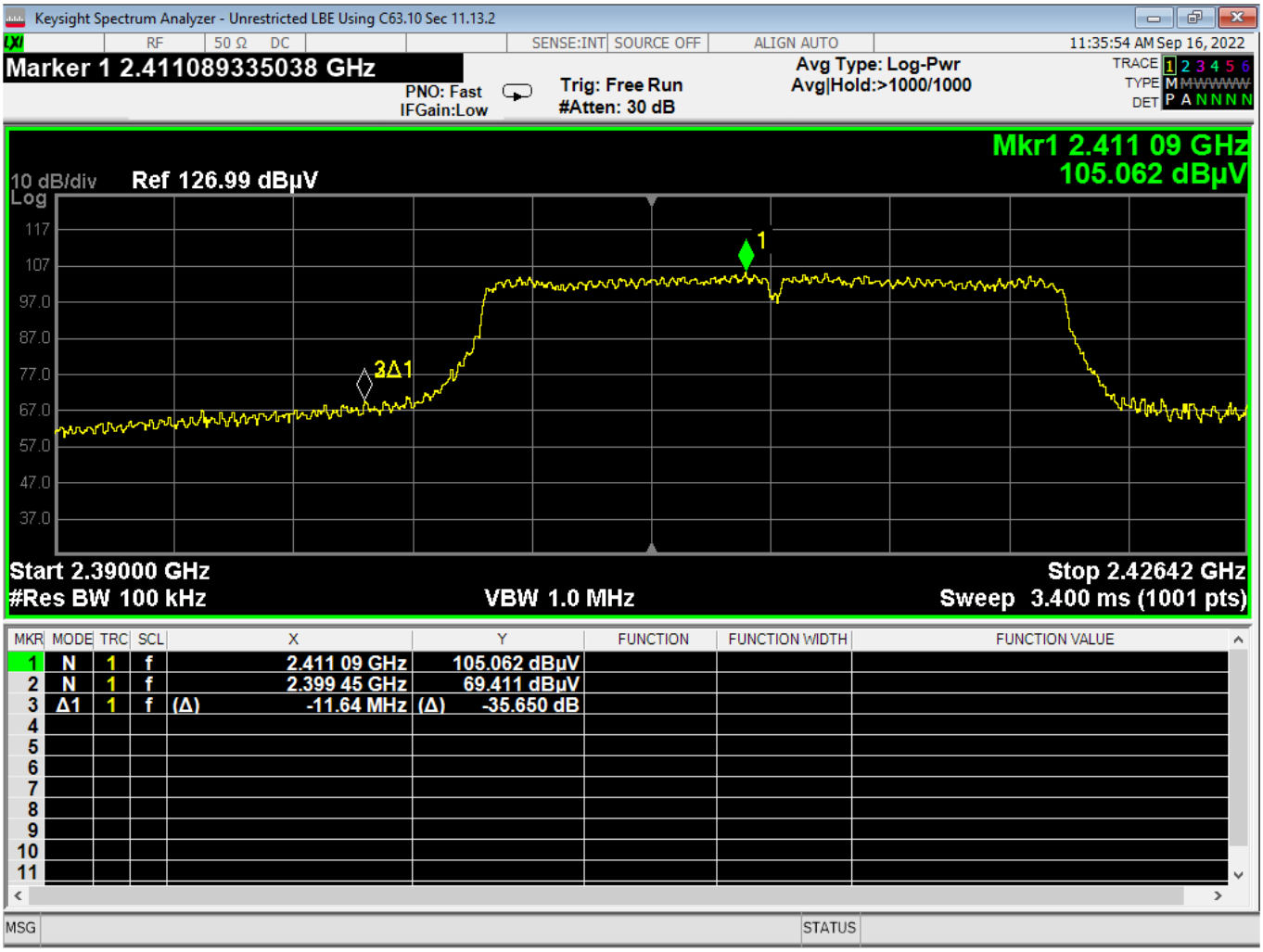
72 PSD, Low, Wifi N, High Data Rate



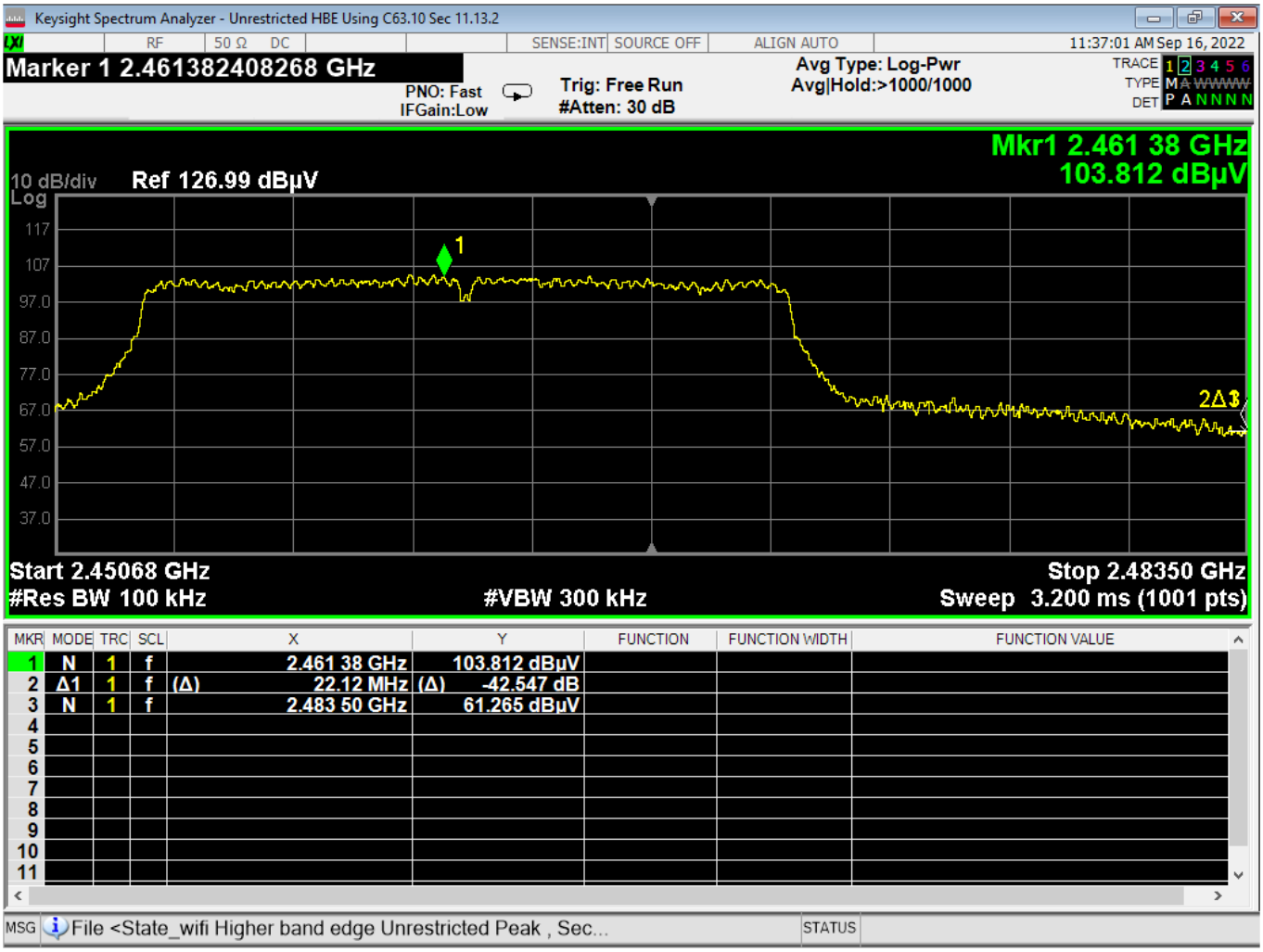
73 PSD, Mid, Wifi N, High Data Rate



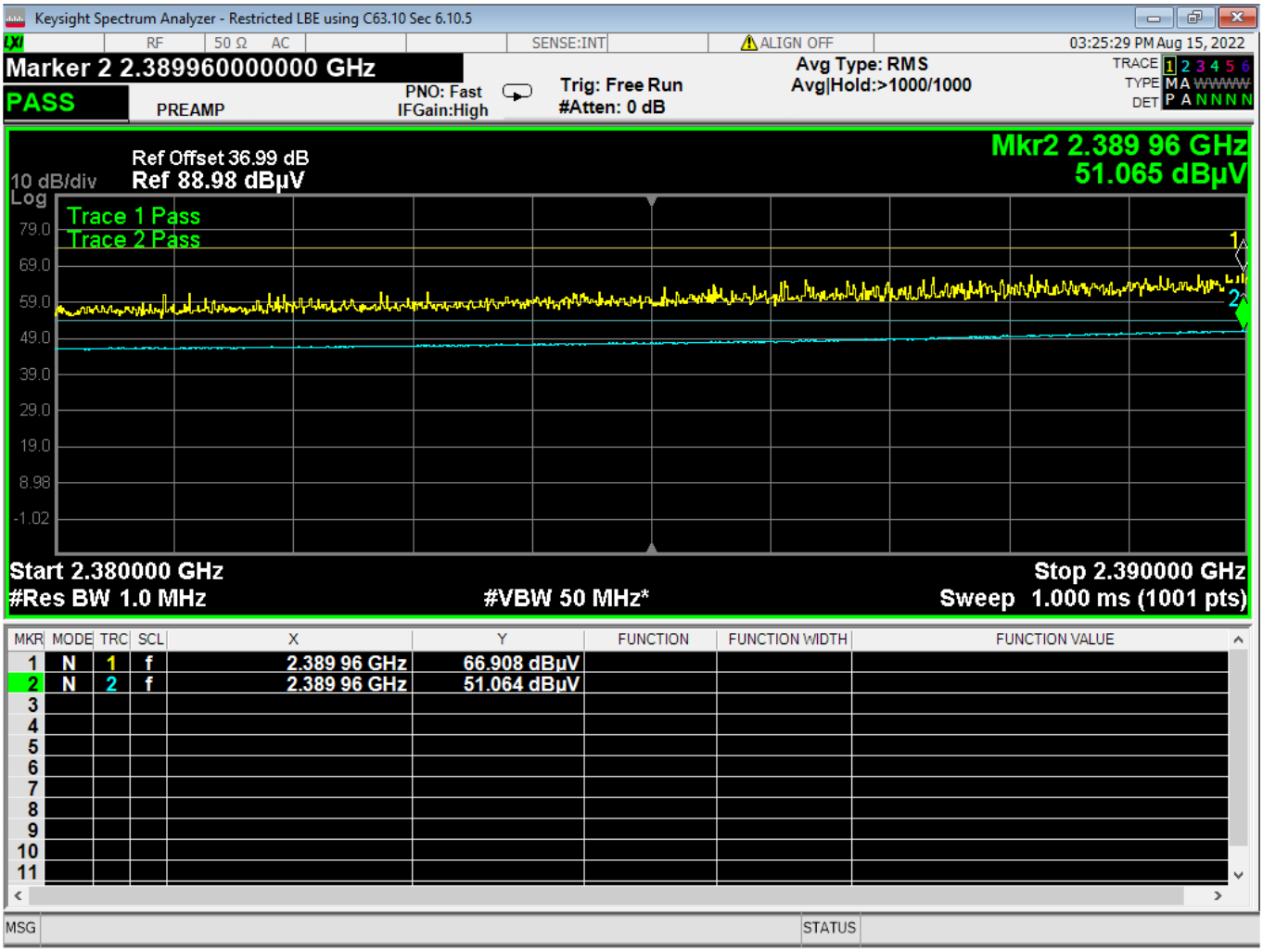
74 PSD, High, Wifi N, High Data Rate



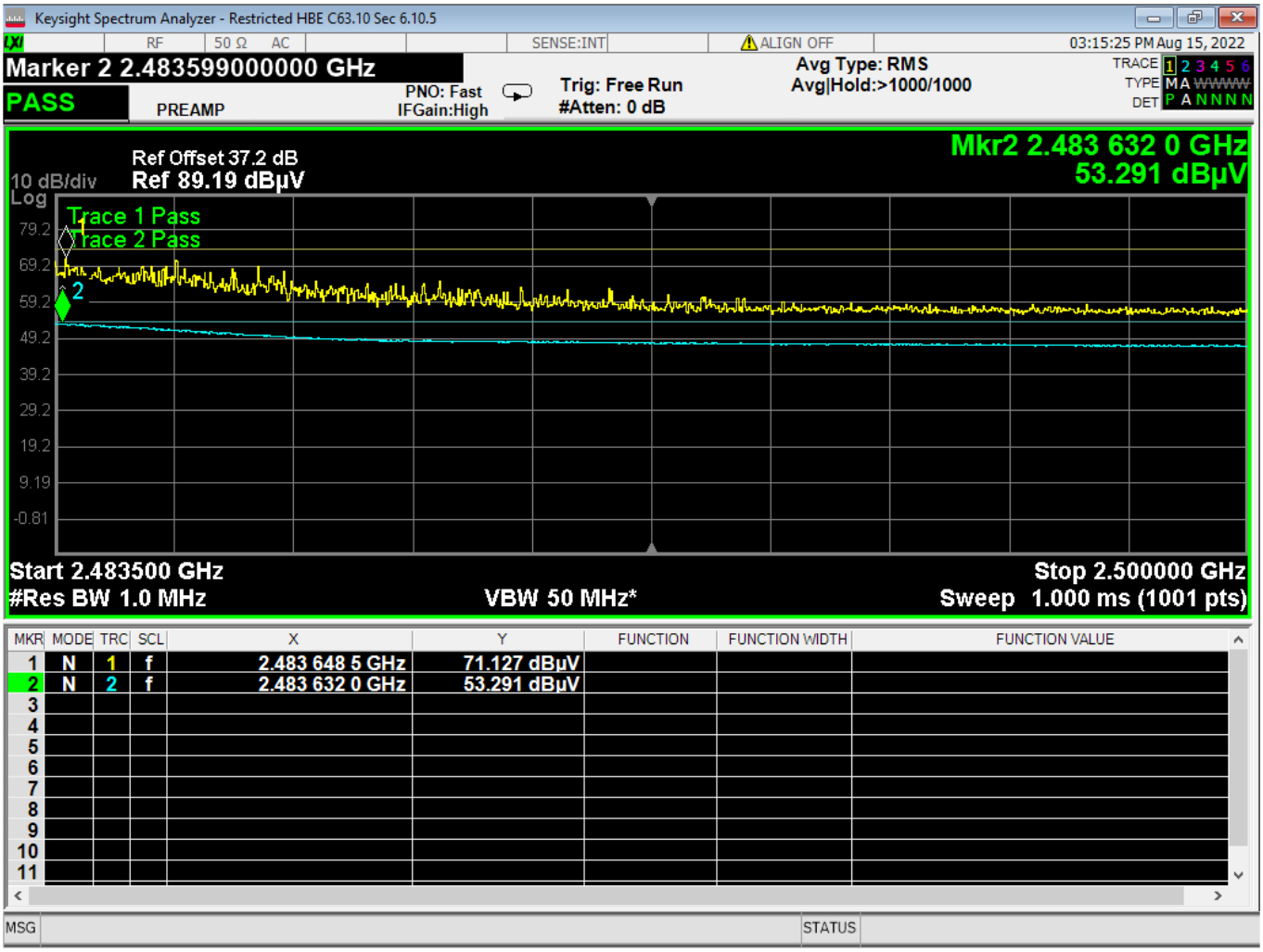
75 Lower Bandedge, Unrestricted, Wifi N, High Data Rate



76 Higher Bandedge, Unrestricted, Wifi N, High Data Rate



77 Lower Bandedge, Restricted, Wifi N, High Data Rate



78 Higher Bandedge, Restricted, Wifi N, High Data Rate

REPORT END