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FCC/ISED Test Report

Prepared for: Garmin International, Inc.

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

Product: A04624

Test Report No: R20220615-20-E2A

Approved by:

Nic Johnson
Technical Manager

DATE: January 27, 2023

Total Pages: 141

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ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	15 December 2022	Issued by FLane Reviewed by KVepuri Prepared by FLane
A	27 January 2023	Corrected IC number

CONTENTS

1.0 SUMMARY OF TEST RESULTS

This report is a class 1 permissive change to FCCID: IPH-A4624. Manufacturer declares devices are electrically similar. The device tested was AA4624 and worst-case spurious emissions were compared on the A04624 to ensure compliance.

FCC Part 15.247 ☒

The EUT has been tested according to the following specifications:

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

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

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary and Operating Condition:

Note that the device that was tested included a certified module as well. The device that is the focus of this report will have this module depopulated, with no other modifications. Spots-check were performed on the device with the module depopulated to include worse-case spurious emissions as well as output power to ensure the results were within 1 dB.

EUT	A04624
IC	1792A-A0624
FCC ID	IPH-04624
EUT Received	29 August 2022
EUT Tested	5 September 2022- 28 October 2022
Serial No.	3426363242 (Radiated Measurements) 3426363123 (Conducted Measurements)
Operating Band	2400 – 2483.5 MHz
Device Type	☐ GMSK ☐ GFSK ☐ BT BR ☐ BT EDR 2MB ☐ BT EDR 3MB ☒ 802.11x
Power Supply / Voltage	Internal Battery / 5VDC Charger: Garmin (Phi Hong) Model: LACA046 GPN: 362-00112-00 (Representative Power Supply)
Antenna Type / Gain (dBi)	Trace Antenna -3.29 dBi

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.

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 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

The following power table was used for the entirety of testing:

802.11x Power Table			
Modulation	**Low**	**Mid**	**High**
802.11b	42	42	42
802.11g	33	42	33
802.11n	32	42	32

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	Nic Johnson	Technical Manager	Review/editing
2	Fox Lane	Test Engineer	Testing/Review 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	A082918-1	July 26, 2022	July 26, 2023
ETS EMCO Red Horn Antenna	3115	00218655	July 21, 2022	July 21, 2023
Com-Power LISN, Single Phase**	LI-220C	20070017	July 18, 2022	July 18, 2024
8447F POT H64 Preamplifier*	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	August 22, 2022	August 22, 2024
Trilithic High Pass Filter*	6HC330	23042	March 21, 2022	March 21, 2024
ETS – Lindgren- VSWR on 10m Chamber***	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber*	10m Semi-anechoic chamber-NSA	NCEE-001	May 25, 2022	May 25, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)*	MFR-57500	90-195-040	August 22, 2022	August 22, 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.

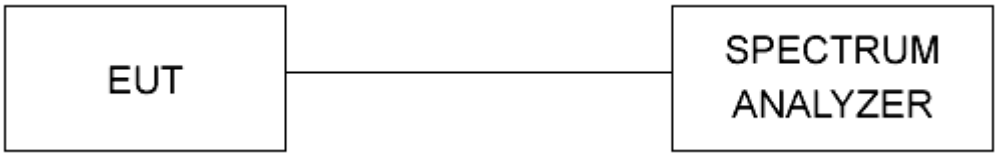


Figure 1 - Bandwidth Measurements Test Setup

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.

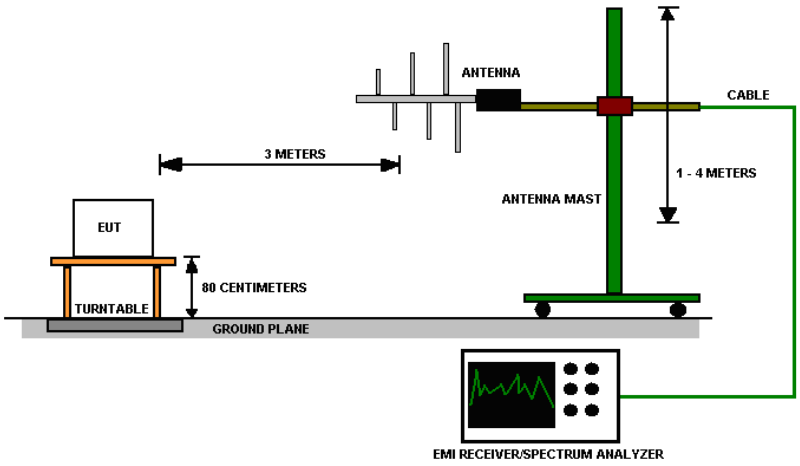


Figure 2 - Radiated Emissions Test Setup

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	15.19	10.06	15.380	34.514	0.755	PASS
Mid	802.11 b	15.19	10.06	15.010	31.696	0.595	PASS
High	802.11 b	15.49	10.06	16.740	47.206	2.226	PASS
Low	802.11 g	16.76	16.46	13.940	24.774	-9.423	PASS
Mid	802.11 g	16.96	16.50	15.530	35.727	-8.139	PASS
High	802.11 g	16.88	16.50	14.120	25.823	-8.951	PASS
Low	802.11 n	17.599	17.63	13.5	22.387	-11.124	PASS
Mid	802.11 n	17.616	17.65	14.38	27.416	-9.951	PASS
High	802.11 n	17.634	17.63	13.3	21.380	-11.155	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	14.73	8.94	14.770	29.992	-7.901	PASS
Mid	802.11 b	14.70	9.01	14.700	29.512	-8.107	PASS
High	802.11 b	14.88	9.04	16.510	44.771	-6.363	PASS
Low	802.11 g	16.58	16.53	11.150	13.032	-12.525	PASS
Mid	802.11 g	16.57	16.51	10.750	11.885	-13.459	PASS
High	802.11 g	16.60	16.52	10.770	11.940	-13.149	PASS
Low	802.11 n	17.56	17.53	5.340	3.420	-14.501	PASS
Mid	802.11 n	17.53	17.66	5.030	3.184	-14.683	PASS
High	802.11 n	17.54	17.65	5.130	3.258	-15.051	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	80.71	113.34	32.64	30.00	PASS
Low	802.11 g	2390.00	75.71	108.24	32.53	30.00	PASS
Low	802.11 n	2390.00	77.28	108.59	31.31	30.00	PASS
High	802.11 b	2483.50	59.89	114.74	54.85	30.00	PASS
High	802.11 g	2483.50	77.17	108.87	31.69	30.00	PASS
High	802.11 n	2483.50	77.23	108.03	30.80	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	80.52	113.41	32.89	30.00	PASS
Low	802.11 g	2400.00	74.01	106.45	32.45	30.00	PASS
Low	802.11 n	2400.00	70.78	104.99	34.21	30.00	PASS
High	802.11 b	2483.50	69.88	114.87	44.99	30.00	PASS
High	802.11 g	2483.50	66.50	105.53	39.03	30.00	PASS
High	802.11 n	2483.50	65.16	104.94	39.78	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	55.56	Peak	73.98	18.42	PASS
Low	802.11 g	2390.00	66.01	Peak	73.98	7.97	PASS
Low	802.11 n	2390.00	60.50	Peak	73.98	13.48	PASS
High	802.11 b	2483.50	55.08	Peak	73.98	18.90	PASS
High	802.11 g	2483.50	70.36	Peak	73.98	3.63	PASS
High	802.11 n	2483.50	69.30	Peak	73.98	4.68	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	44.84	Average	53.98	9.14	PASS
Low	802.11 g	2390.00	52.91	Average	53.98	1.07	PASS
Low	**802.11 n**	**2390.00**	**53.71**	**Average**	**53.98**	**0.27**	**PASS**
High	802.11 b	2483.50	43.84	Average	53.98	10.14	PASS
High	802.11 g	2483.50	53.05	Average	53.98	0.93	PASS
High	802.11 n	2483.50	53.09	Average	53.98	0.89	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	56.16	Peak	73.98	17.82	PASS
Low	802.11 g	2390.00	64.71	Peak	73.98	9.28	PASS
Low	802.11 n	2390.00	63.53	Peak	73.98	10.45	PASS
High	802.11 b	2483.50	54.81	Peak	73.98	19.17	PASS
High	802.11 g	2483.50	60.85	Peak	73.98	13.13	PASS
High	802.11 n	2483.50	58.20	Peak	73.98	15.78	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	44.84	Average	53.98	9.14	PASS
Low	802.11 g	2390.00	48.97	Average	53.98	5.01	PASS
Low	802.11 n	2390.00	47.50	Average	53.98	6.48	PASS
High	802.11 b	2483.50	43.38	Average	53.98	10.60	PASS
High	802.11 g	2483.50	45.57	Average	53.98	8.41	PASS
High	802.11 n	2483.50	44.27	Average	53.98	9.71	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:

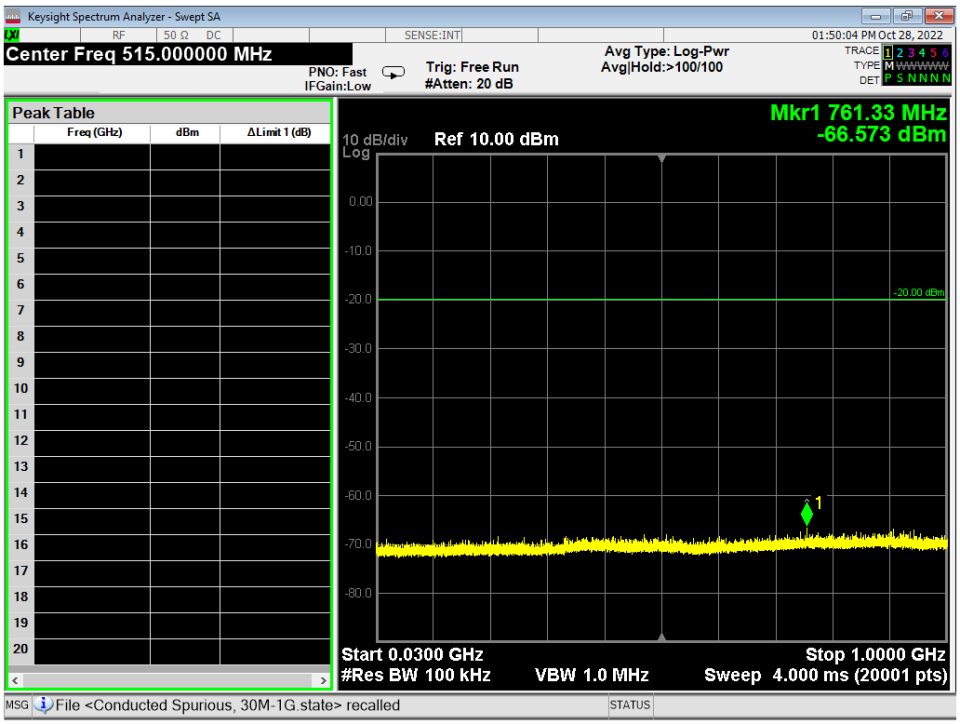


Figure 3 - Conducted Emissions Plot, Wifi B 1MB, 30M – 1G

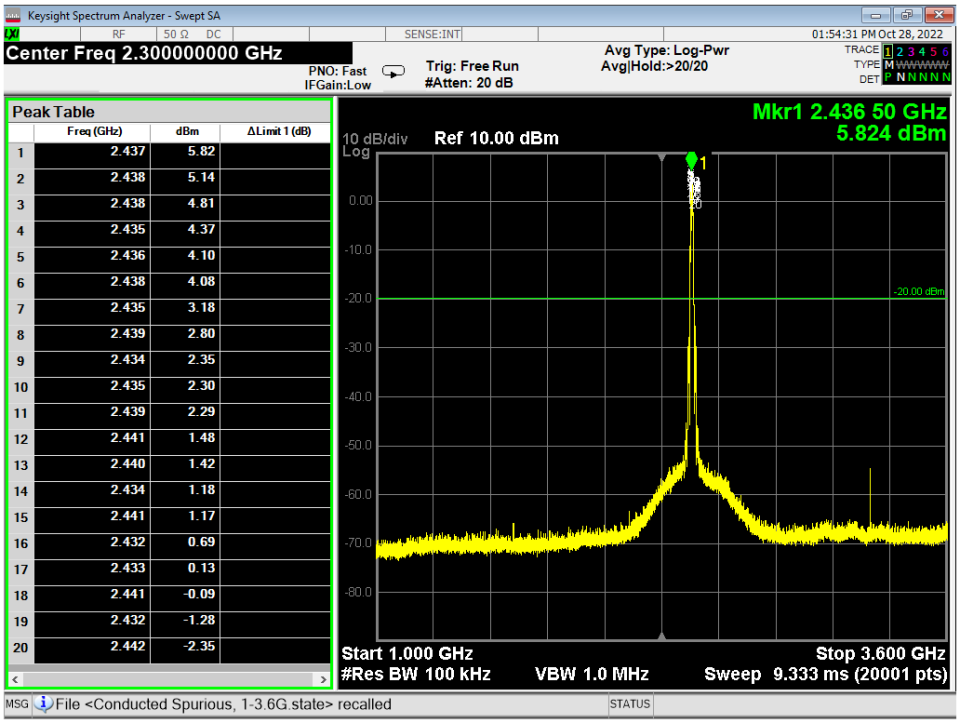


Figure 4 - Conducted Emissions Plot, Wifi B 1MB, 1G – 3.6G

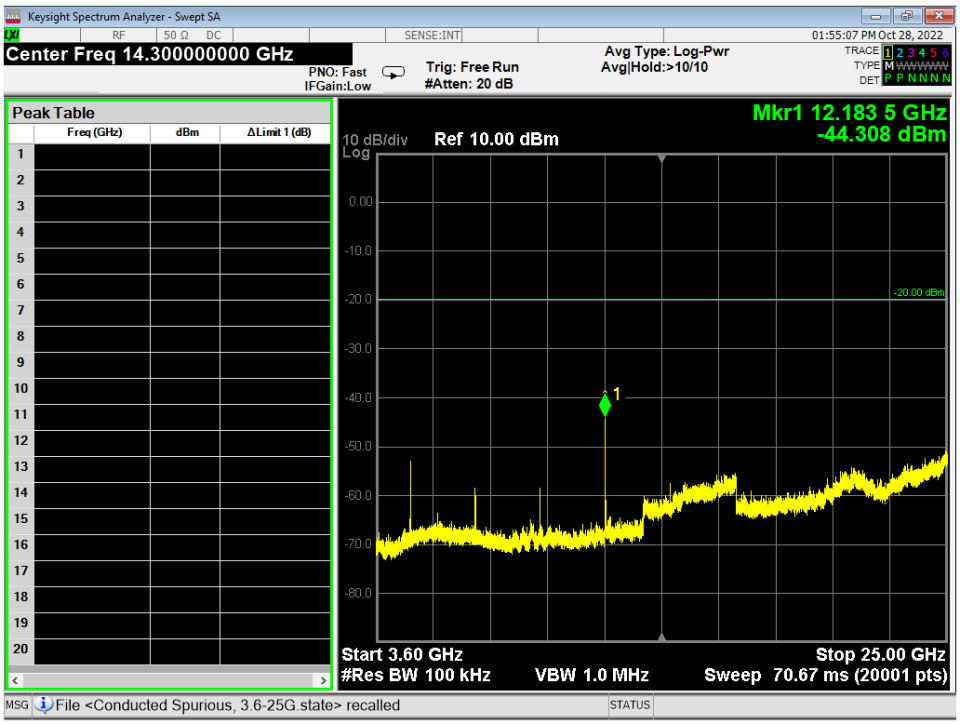


Figure 5 - Conducted Emissions Plot, Wifi B 1MB, 3.6G – 25G

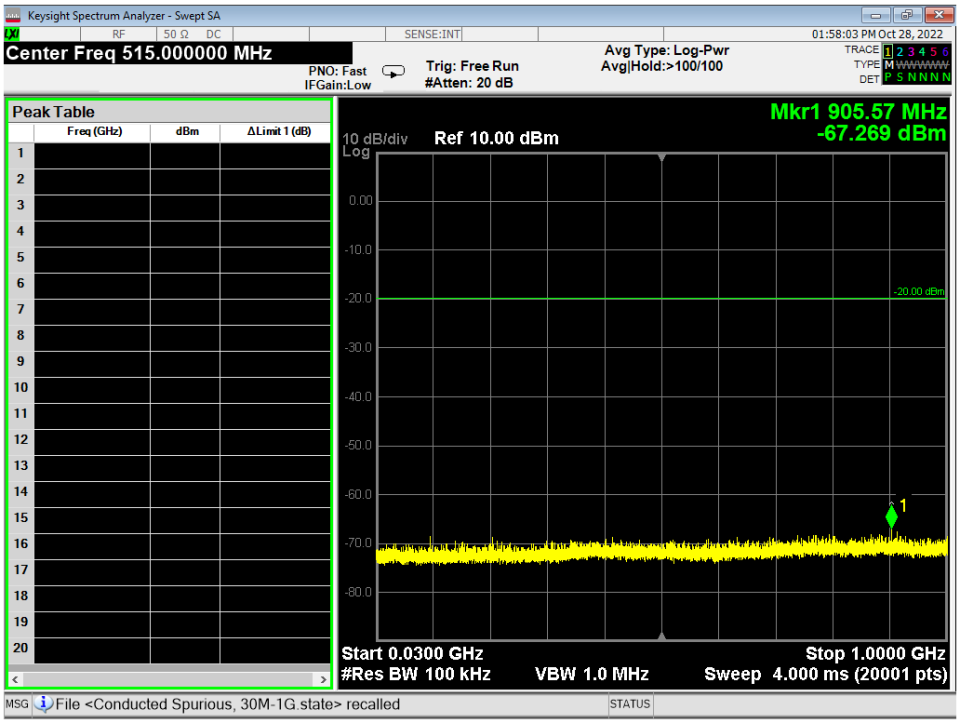


Figure 6 - Conducted Emissions Plot, Wifi G 6MB, 30M – 1G

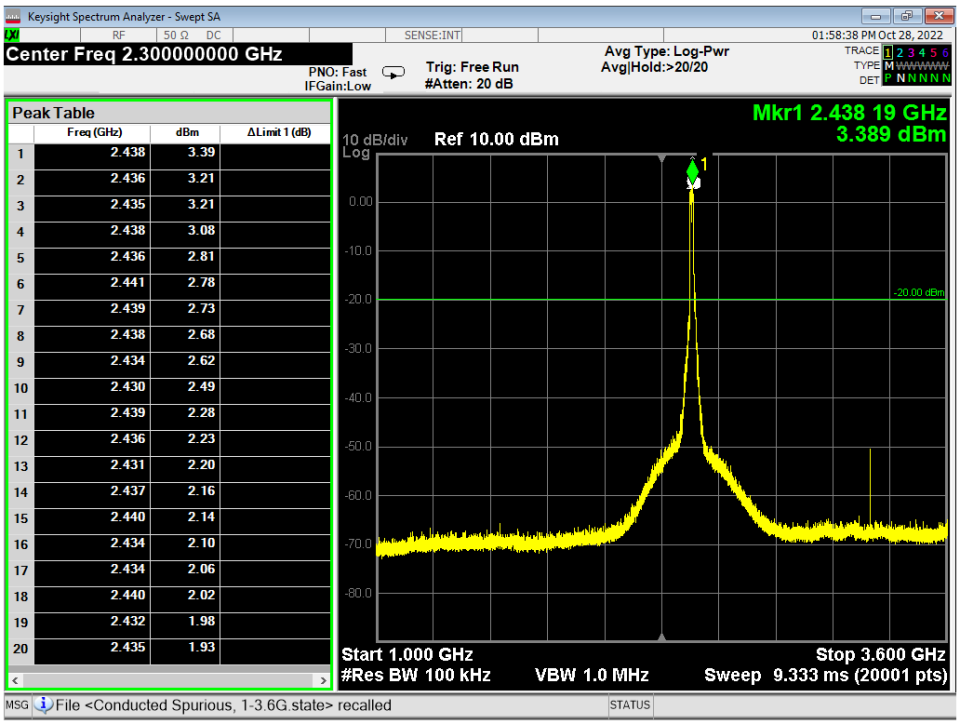


Figure 7 - Conducted Emissions Plot, Wifi G 6MB, 1G – 3.6G

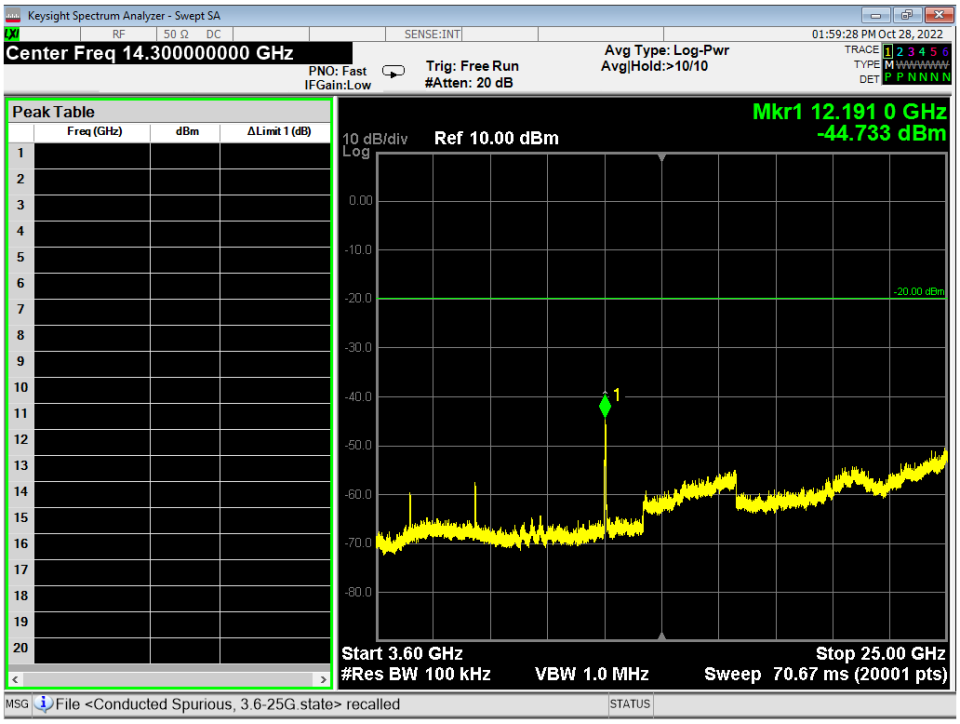


Figure 8 - Conducted Emissions Plot, Wifi G 6MB, 3.6G – 25G

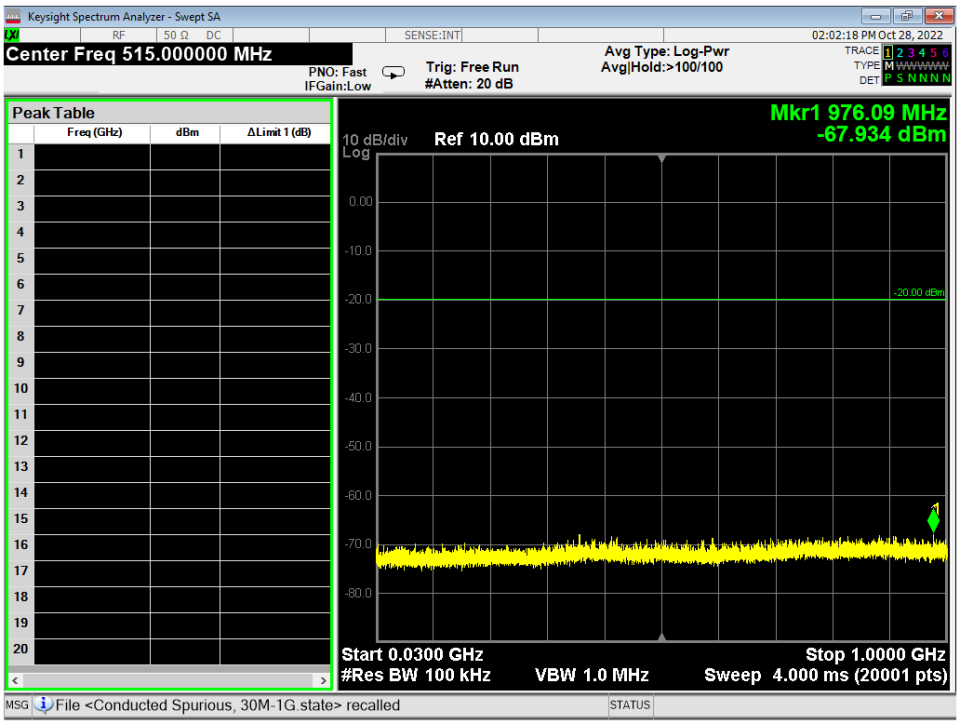


Figure 9 - Conducted Emissions Plot, Wifi N MCS0, 30M – 1G

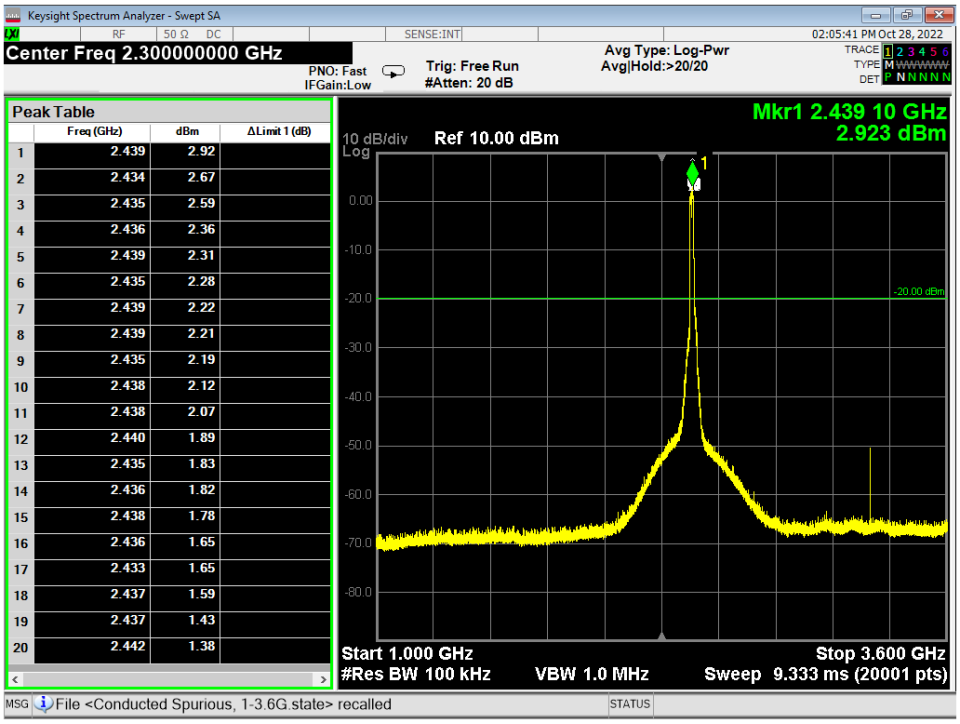


Figure 10 - Conducted Emissions Plot, Wifi N MCS0, 1G – 3.6G

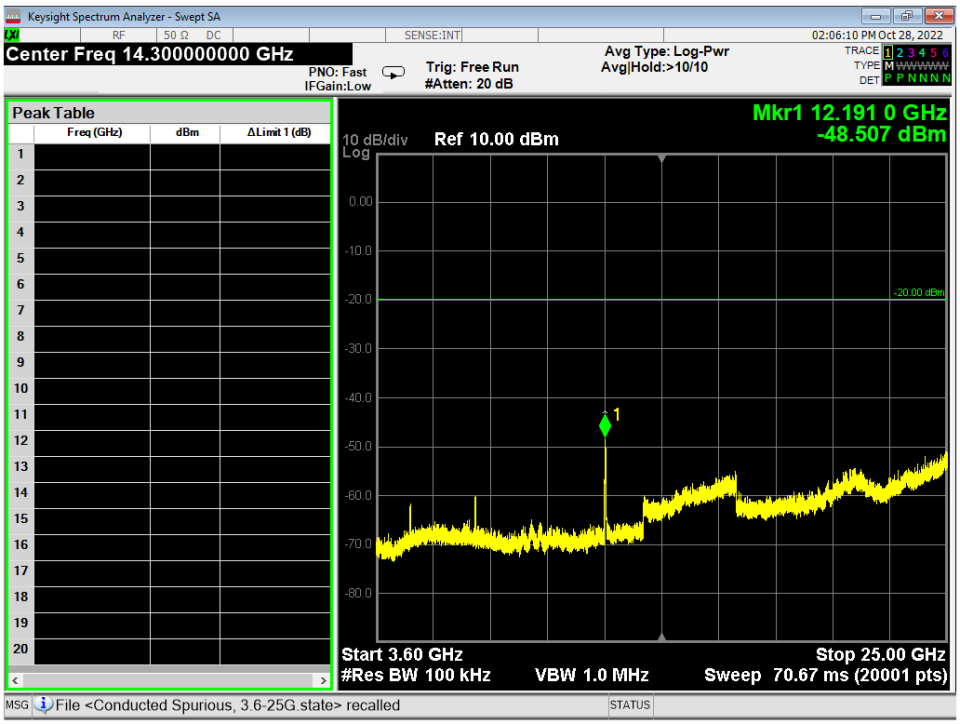


Figure 11 - Conducted Emissions Plot, Wifi N MCS0, 3.6G – 25G

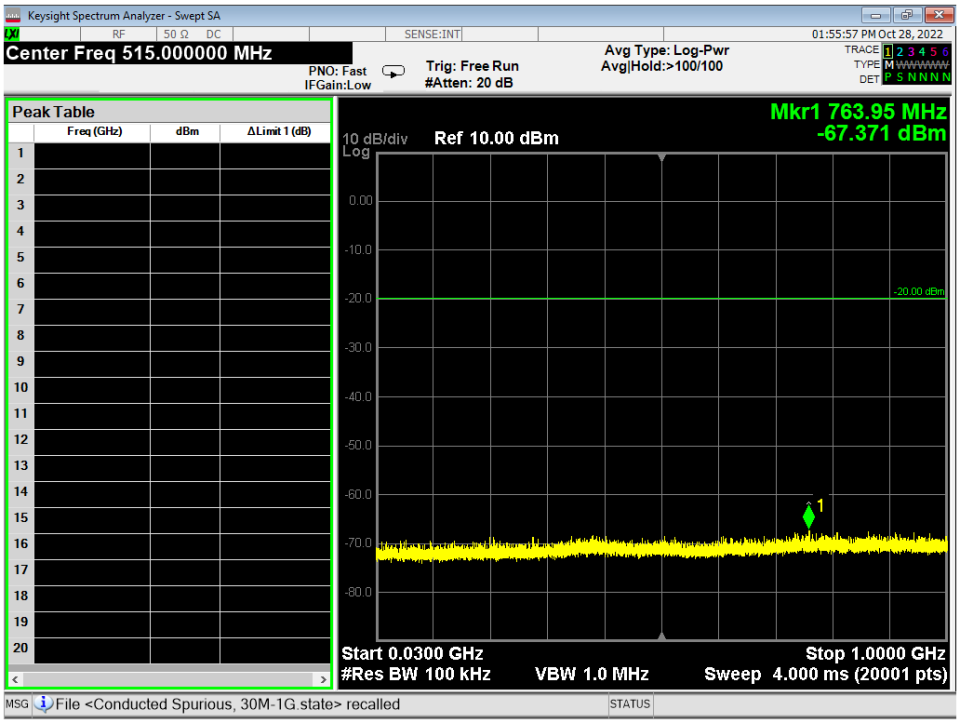


Figure 12 - Conducted Emissions Plot, Wifi B 11MB, 30M – 1G

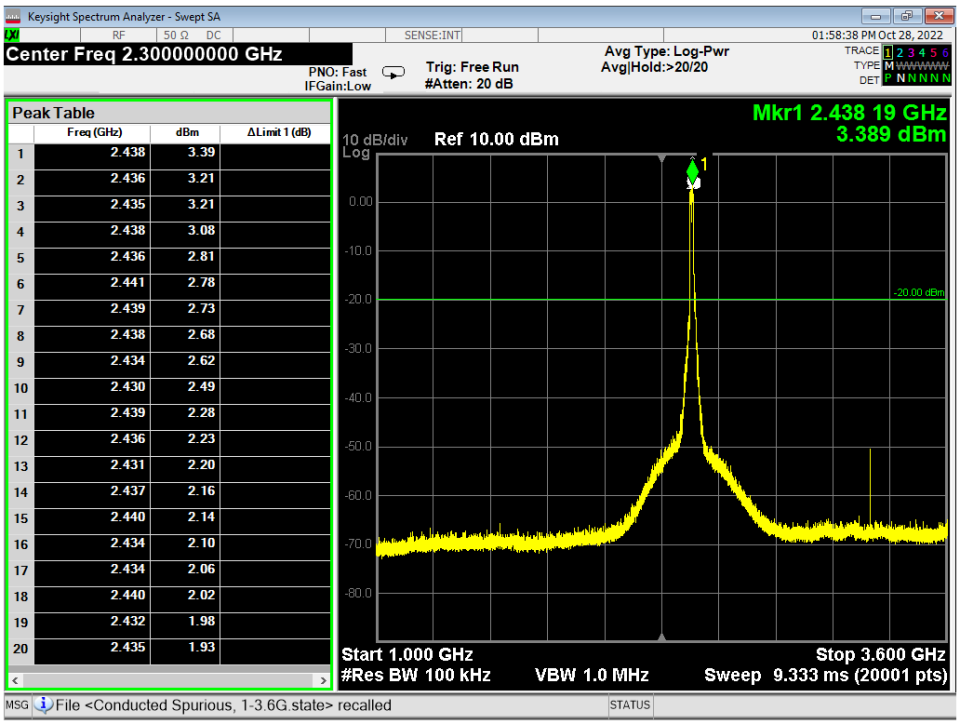


Figure 13 - Conducted Emissions Plot, Wifi B 11MB, 1G – 3.6G

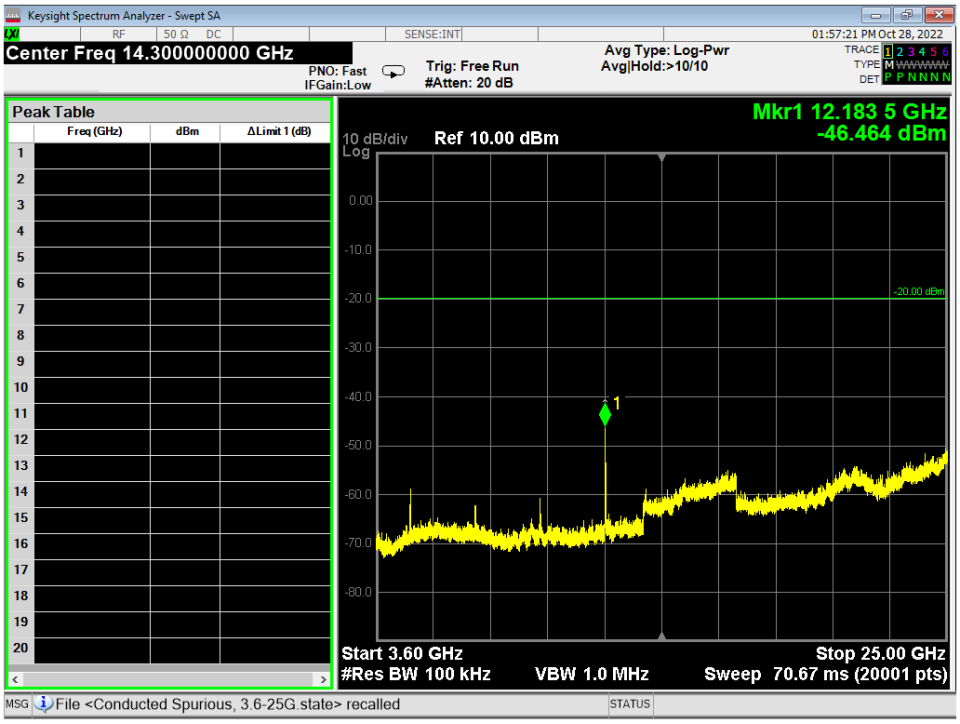


Figure 14 - Conducted Emissions Plot, Wifi B 11MB, 3.6G – 25G

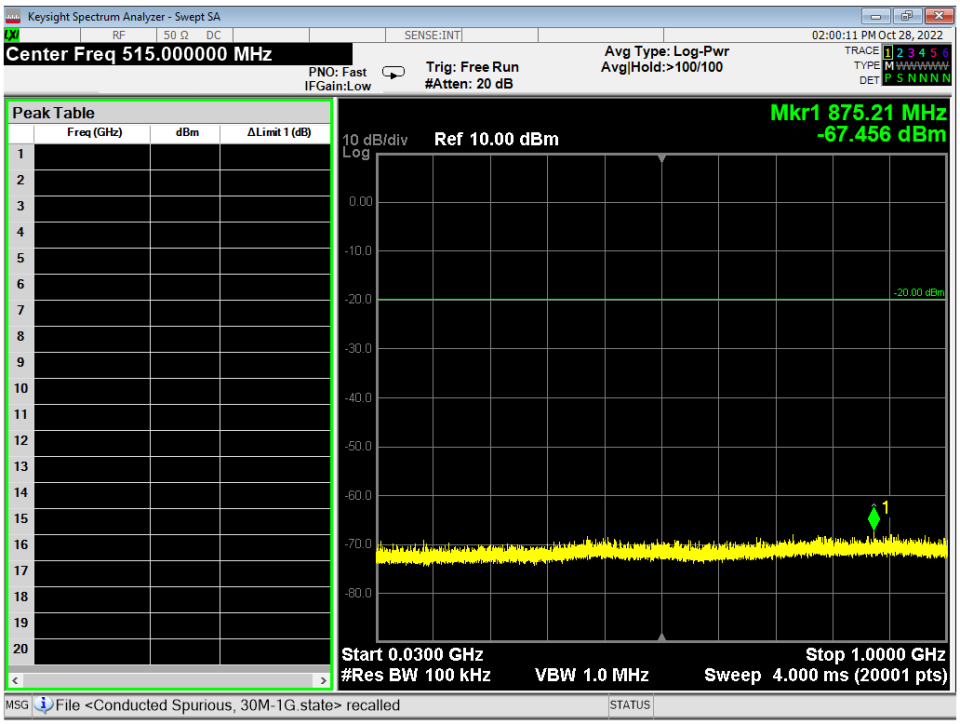


Figure 15 - Conducted Emissions Plot, Wifi G 54MB, 30M – 1G

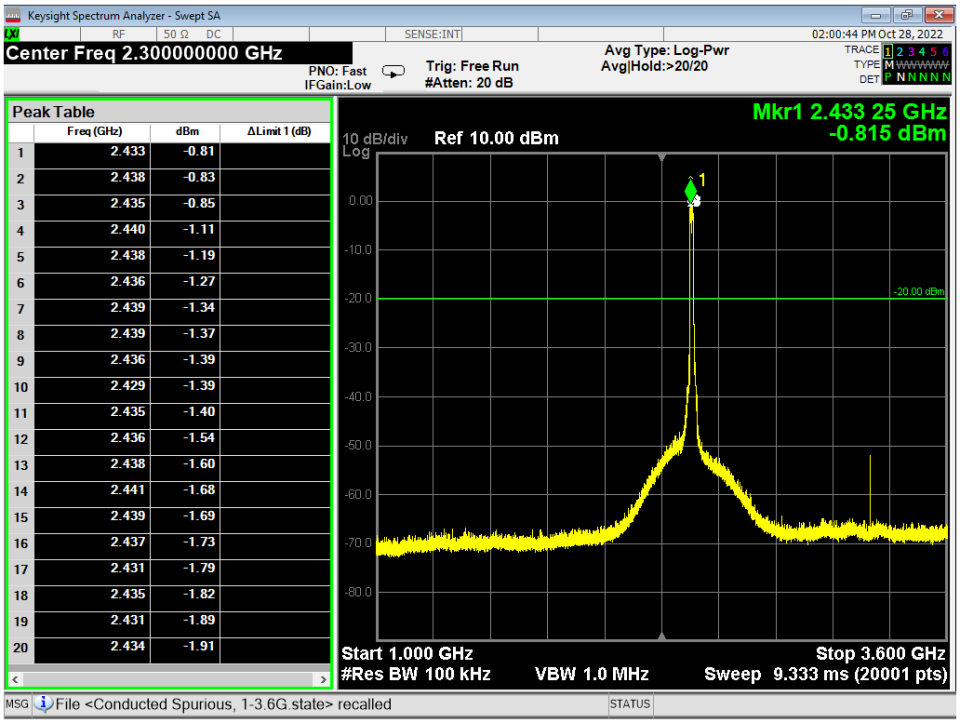


Figure 16 - Conducted Emissions Plot, Wifi G 54MB, 1G – 3.6G

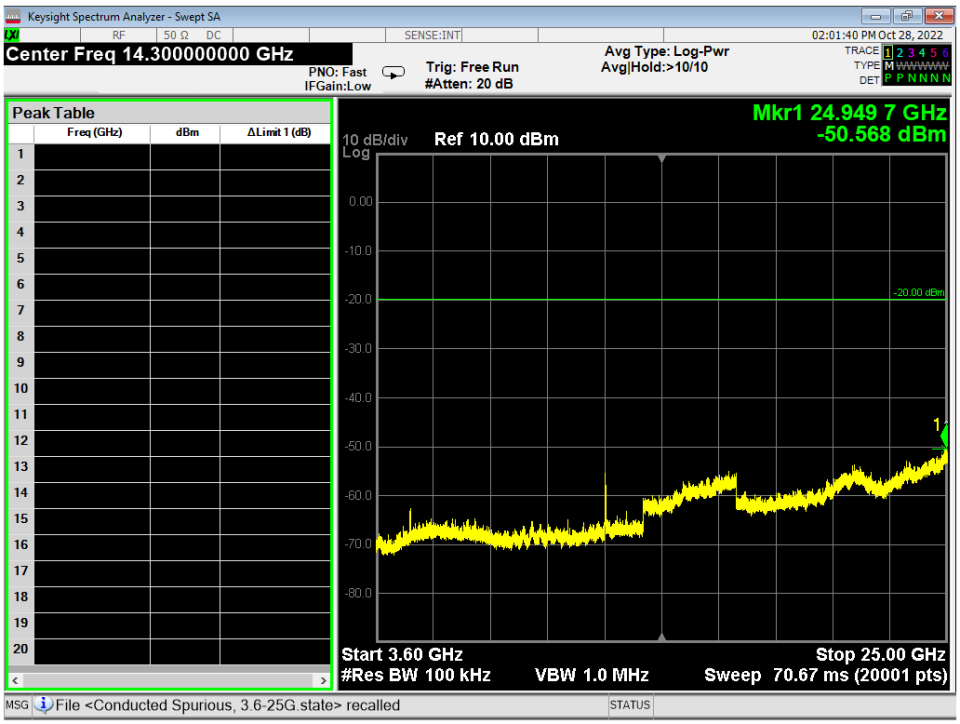


Figure 17 - Conducted Emissions Plot, Wifi G 54MB, 3.6G – 25G

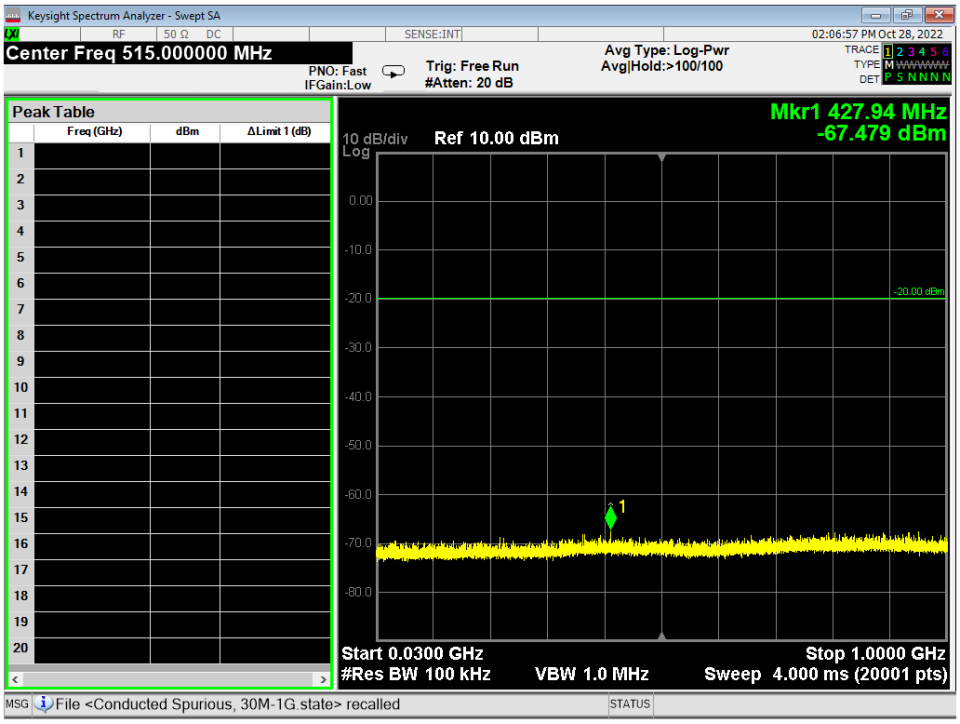


Figure 18 - Conducted Emissions Plot, Wifi N MCS7, 30M – 1G

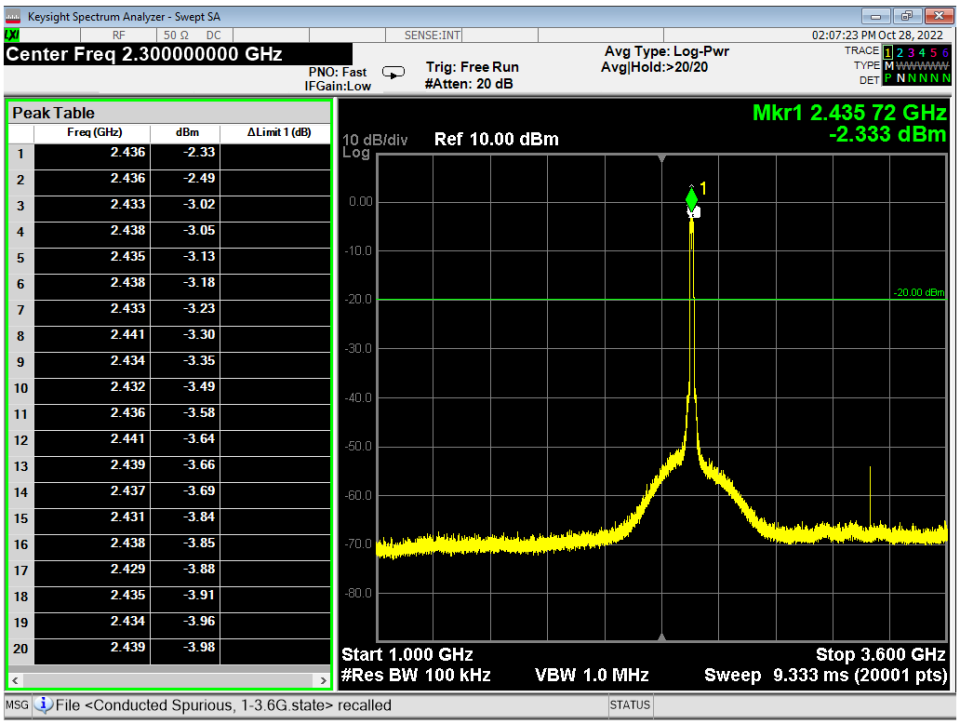


Figure 19 - Conducted Emissions Plot, Wifi N MCS7, 1G – 3.6G

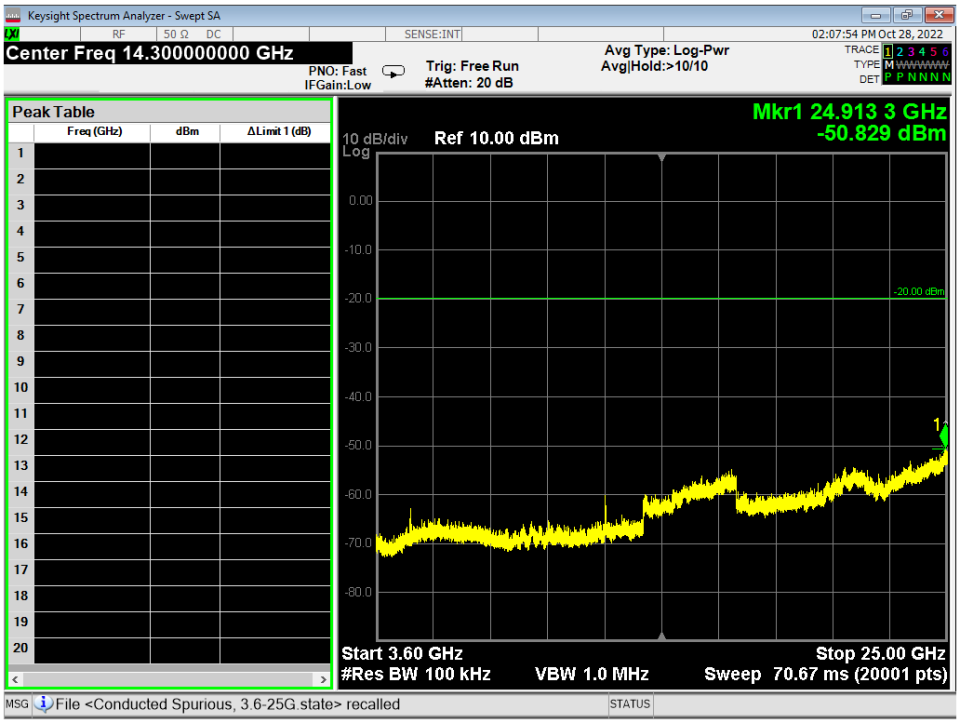


Figure 20 - Conducted Emissions Plot, Wifi N MCS7, 3.6G – 25G

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:

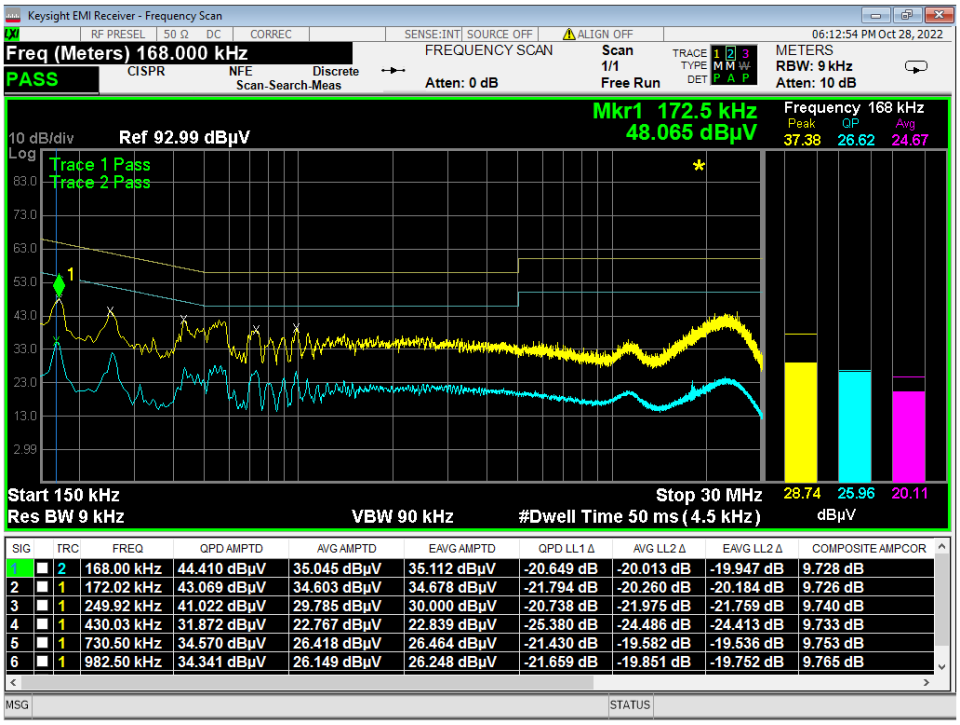


Figure 21 - Conducted Emissions Plot, Line, TX

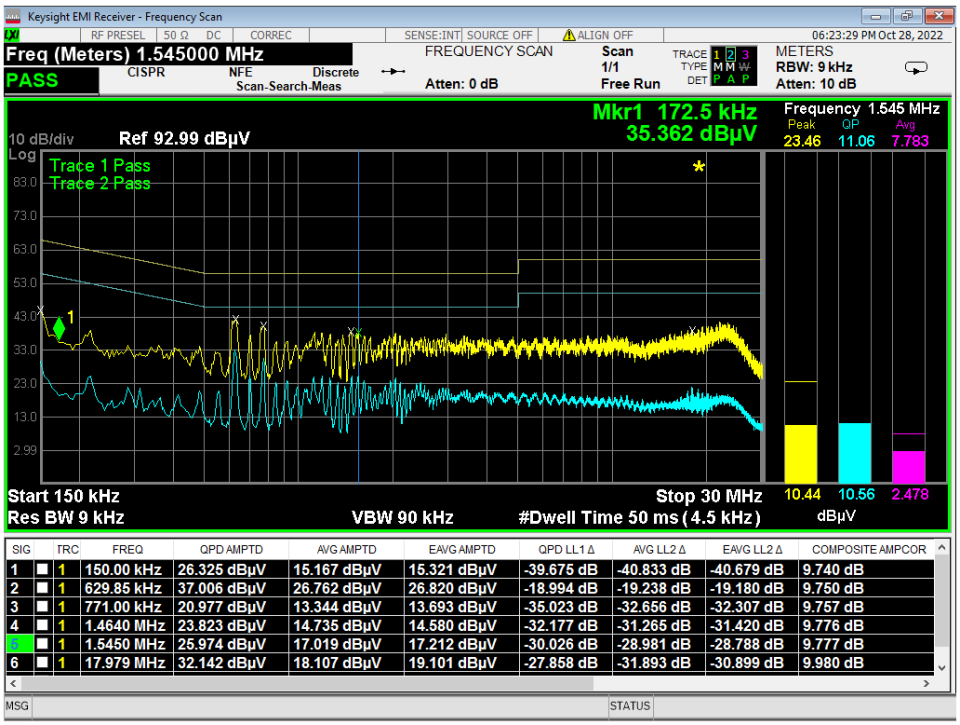


Figure 22 - Conducted Emissions Plot, Neutral, TX

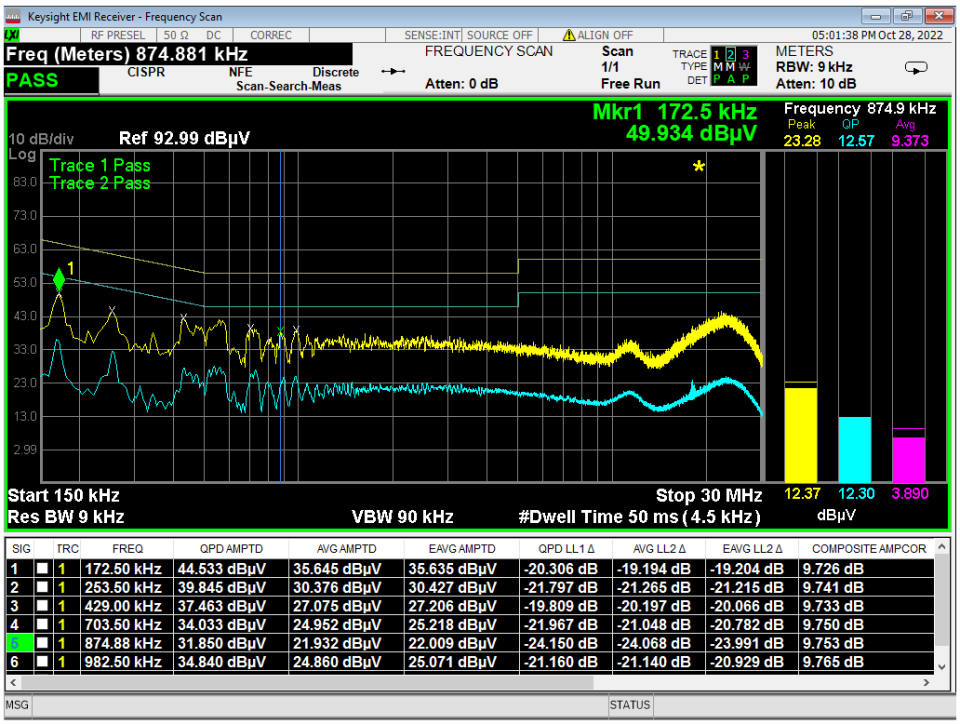


Figure 23 - Conducted Emissions Plot, Line, IDLE

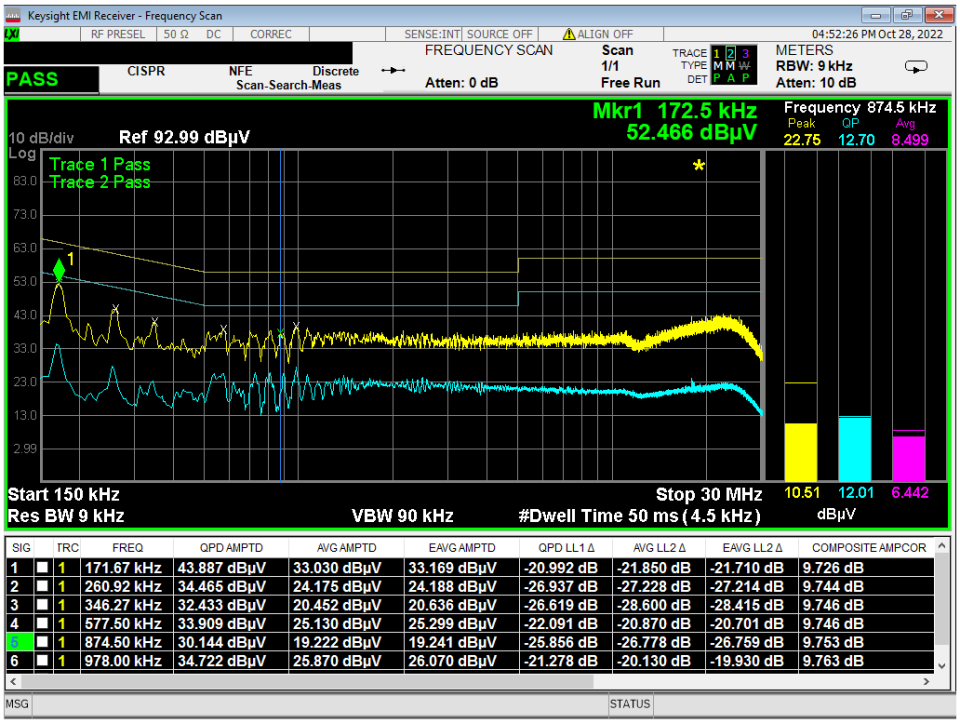


Figure 24 - Conducted Emissions Plot, Neutral, IDLE

4.6 DUTY CYCLE

Test Method:

All Modulations/Transmitters in this report had 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 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:

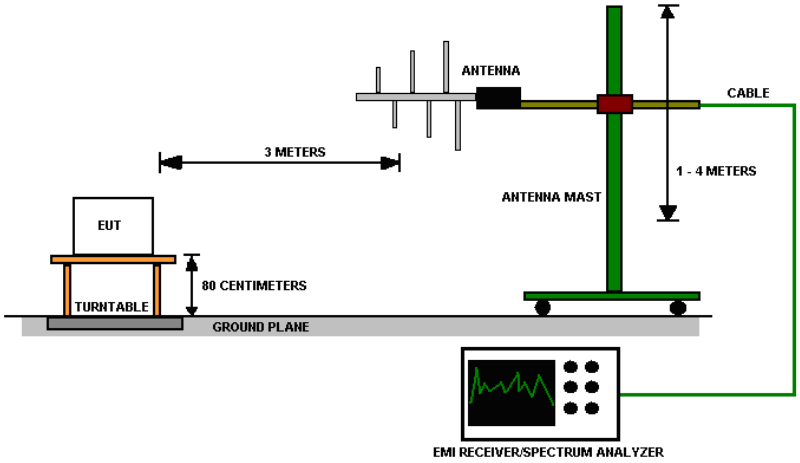


Figure 25 - Radiated Emissions Test Setup

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:

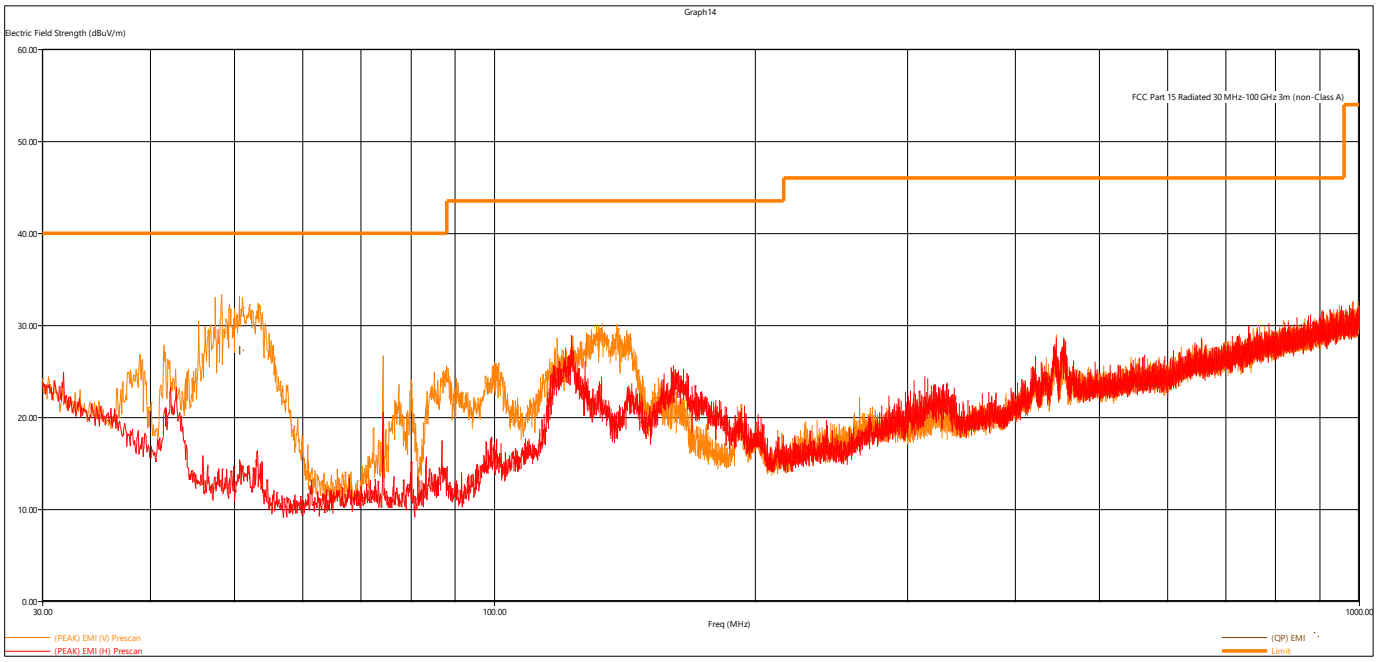


Figure 26 - Radiated Emissions Plot, Receive

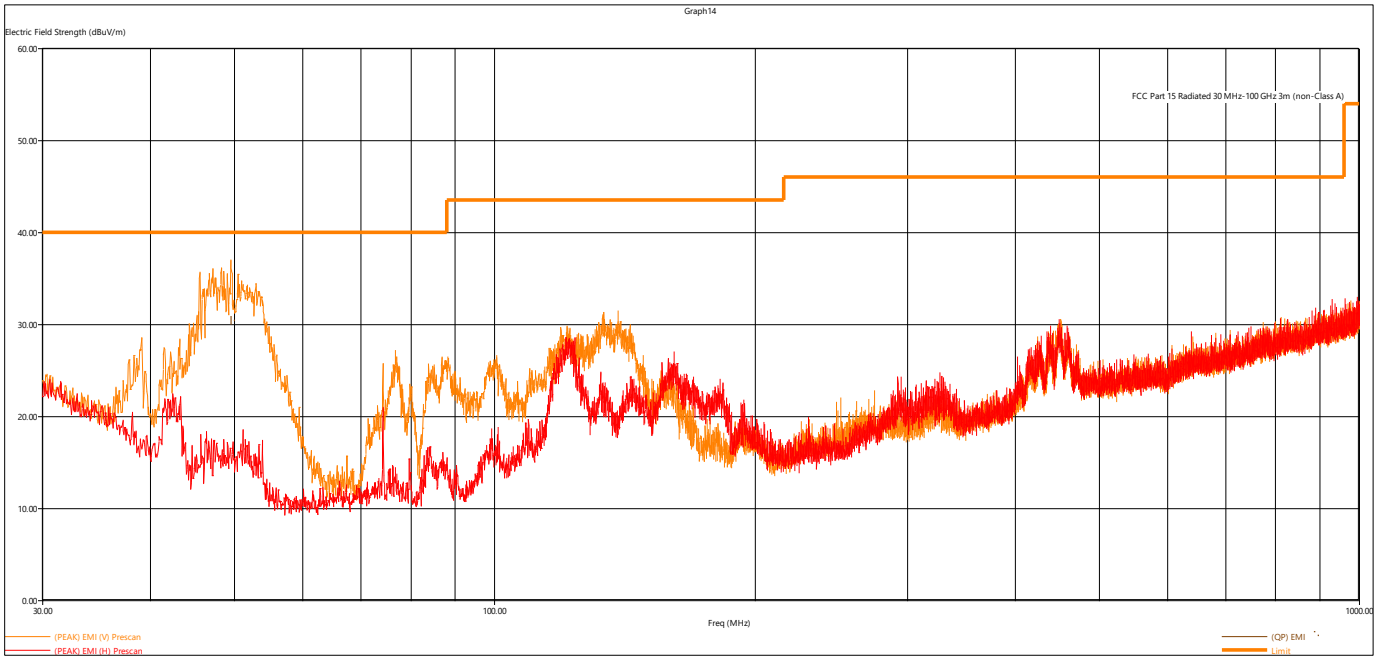


Figure 27 - Radiated Emissions Plot, 802.11b, Low Data Rate

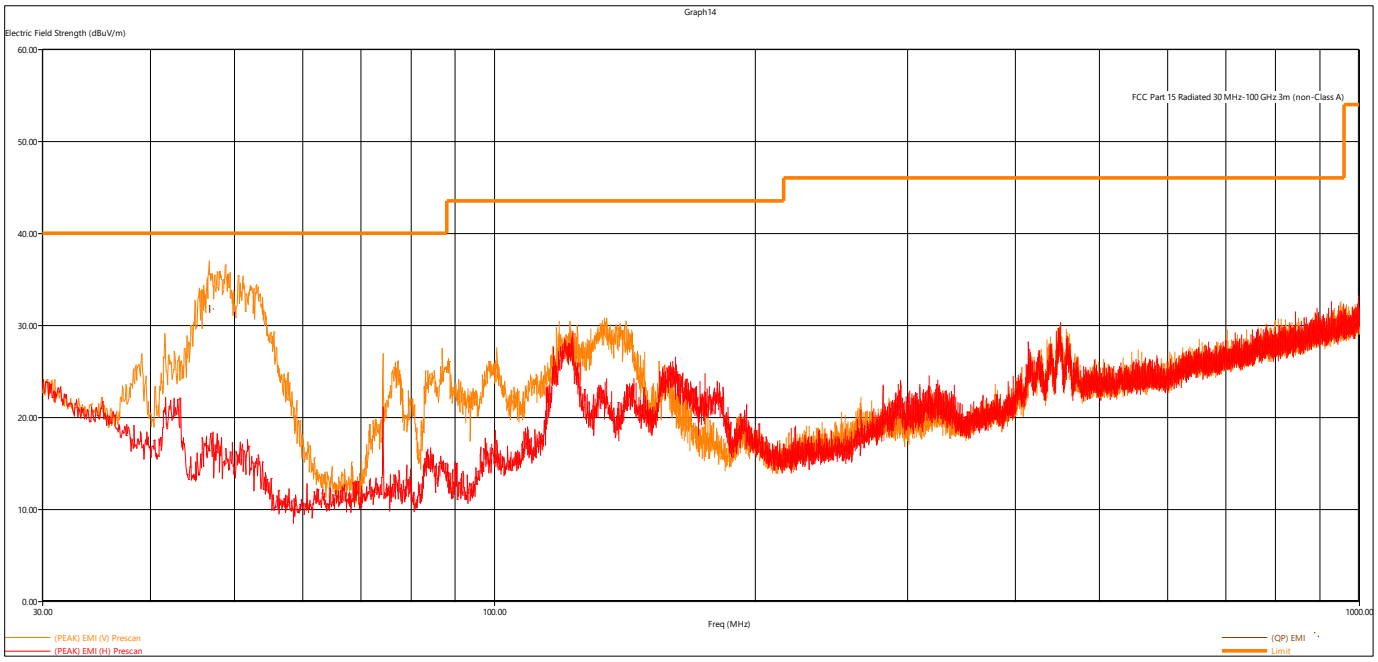


Figure 28 - Radiated Emissions Plot, 802.11g, Low Data Rate

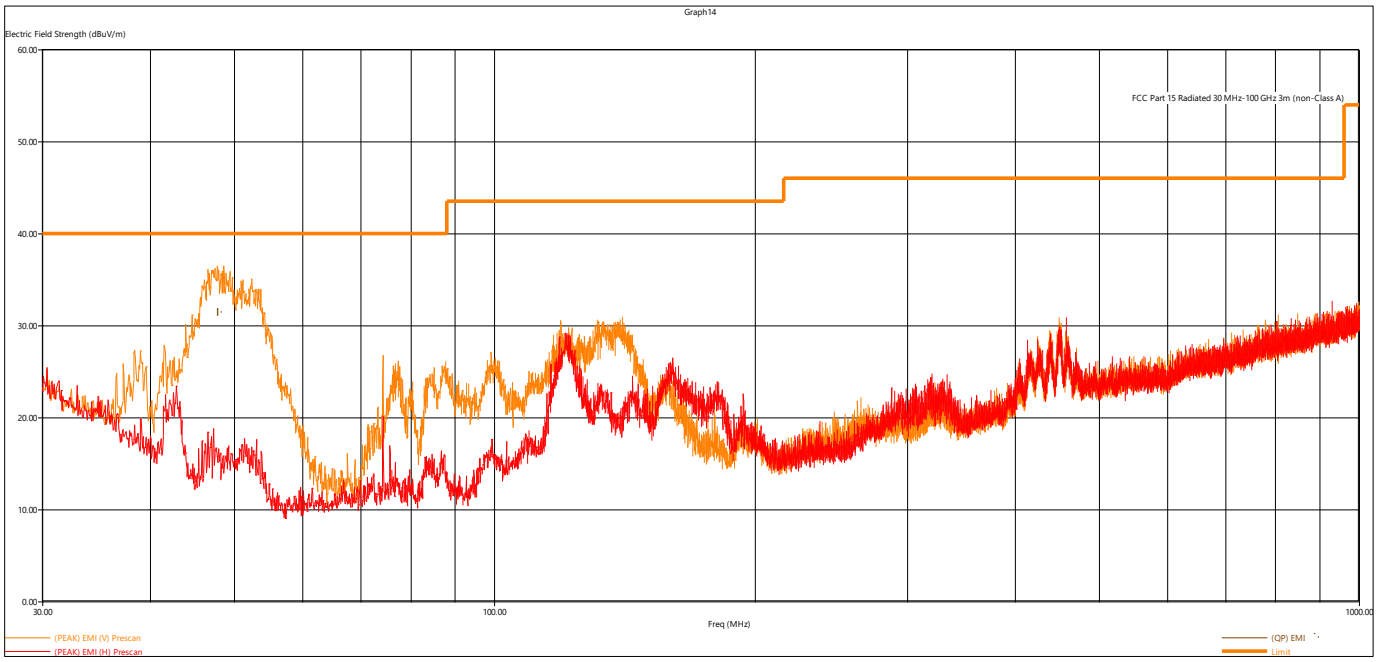


Figure 29 - Radiated Emissions Plot, 802.11n, Low Data Rate

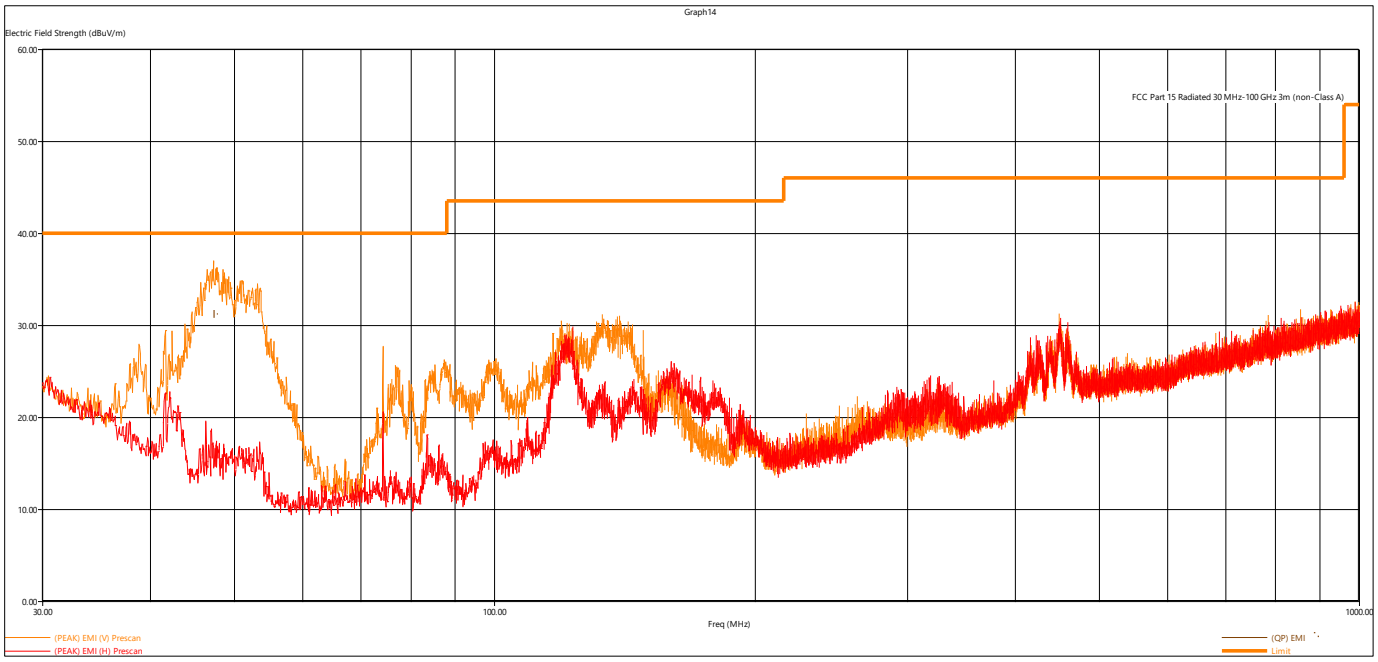


Figure 30 - Radiated Emissions Plot, 802.11b, High Data Rate

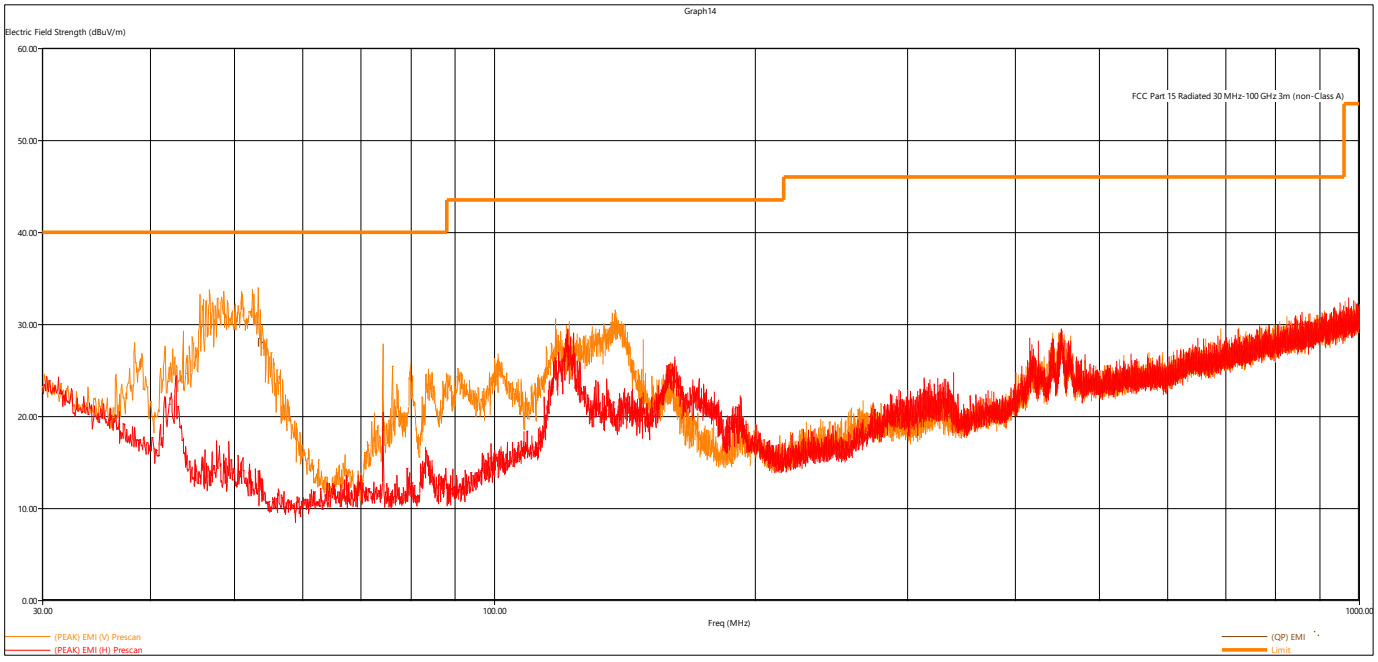


Figure 31 - Radiated Emissions Plot, 802.11g, High Data Rate

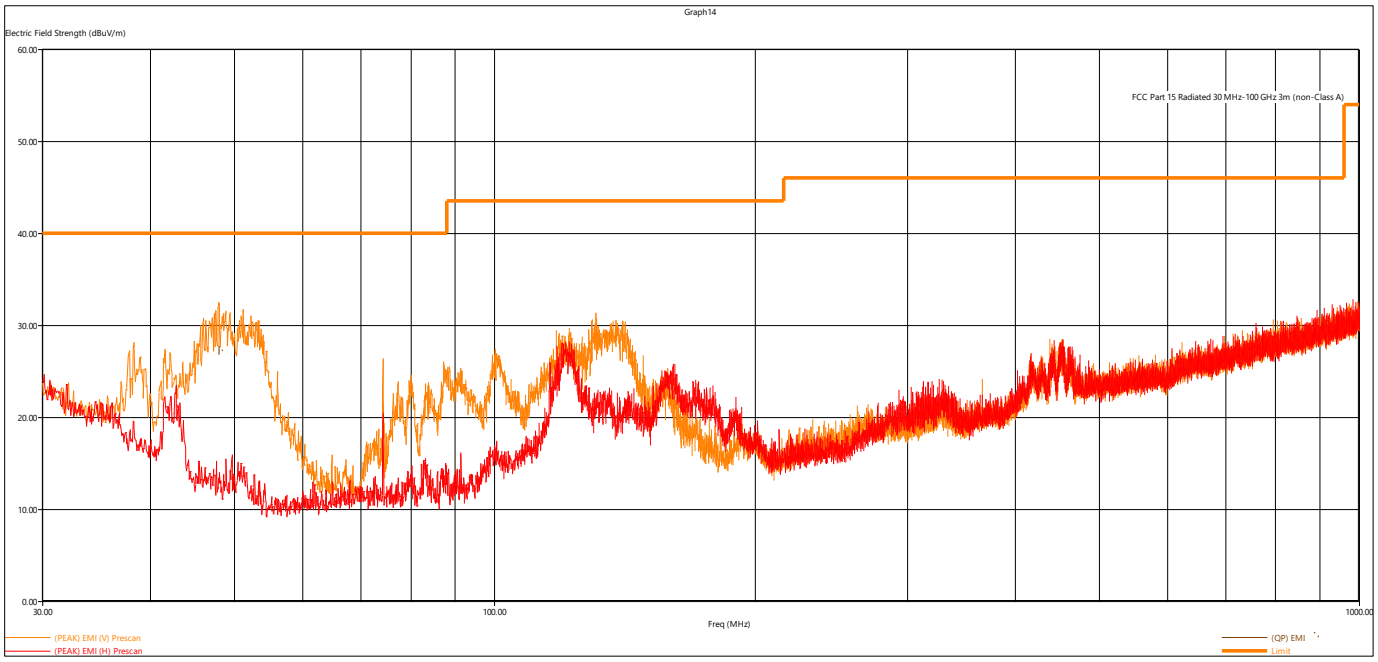


Figure 32 - Radiated Emissions Plot, 802.11n, High Data Rate

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, 802.11x								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
49.538160	30.35	40.00	9.65	106.00	22.00	V	Low	WIFI B 1MB
47.420640	31.15	40.00	8.85	111.00	298.00	V	Low	WIFI B 11MB
46.832640	31.71	40.00	8.29	112.00	321.00	V	Low	WIFI G 6MHz
53.470560	27.97	40.00	12.03	108.00	24.00	V	Low	WIFI G 54MHz
47.860080	31.44	40.00	8.56	106.00	314.00	V	Low	WIFI N MCS0
47.778960	27.20	40.00	12.80	116.00	316.00	V	Low	WIFI N MCS7
50.845200	27.22	40.00	12.78	116.00	39.00	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**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
2411.116000	98.80	NA	NA	170	189	H	Low	WIFI B 1MB
2436.094000	98.98	NA	NA	125	32	H	Mid	WIFI B 1MB
2461.082000	99.48	NA	NA	211	183	H	High	WIFI B 1MB
2412.346000	102.40	NA	NA	169	188	H	Low	WIFI B 11MB
2436.234000	103.61	NA	NA	134	186	H	Mid	WIFI B 11MB
2461.218000	103.96	NA	NA	209	185	H	High	WIFI B 11MB
2410.898000	99.74	NA	NA	146	25	H	Low	WIFI G 6MHz
2435.156000	103.46	NA	NA	158	188	H	Mid	WIFI G 6MHz
2459.818000	101.41	NA	NA	278	177	H	High	WIFI G 6MHz
2412.520000	98.85	NA	NA	203	185	H	Low	WIFI G 54MHz
2435.178000	98.97	NA	NA	163	29	H	Mid	WIFI G 54MHz
2461.174000	97.94	NA	NA	112	181	H	High	WIFI G 54MHz
2409.936000	101.28	NA	NA	396	297	H	Low	WIFI N MCS0
2434.892000	102.73	NA	NA	206	32	H	Mid	WIFI N MCS0
2461.230000	100.04	NA	NA	192	20	H	High	WIFI N MCS0
2410.754000	98.43	NA	NA	397	299	H	Low	WIFI N MCS7
2435.420000	96.46	NA	NA	161	26	H	Mid	WIFI N MCS7
2461.472000	96.96	NA	NA	237	18	H	High	WIFI N MCS7

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**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
2411.116000	95.93	NA	NA	170	189	H	Low	WIFI B 1MB
2436.094000	96.02	NA	NA	125	32	H	Mid	WIFI B 1MB
2461.082000	96.47	NA	NA	211	183	H	High	WIFI B 1MB
2412.346000	94.91	NA	NA	169	188	H	Low	WIFI B 11MB
2436.234000	95.49	NA	NA	134	186	H	Mid	WIFI B 11MB
2461.218000	95.83	NA	NA	209	185	H	High	WIFI B 11MB
2410.898000	90.60	NA	NA	146	25	H	Low	WIFI G 6MHz
2435.156000	94.23	NA	NA	158	188	H	Mid	WIFI G 6MHz
2459.818000	91.36	NA	NA	278	177	H	High	WIFI G 6MHz
2412.520000	87.77	NA	NA	203	185	H	Low	WIFI G 54MHz
2435.178000	88.19	NA	NA	163	29	H	Mid	WIFI G 54MHz
2461.174000	88.13	NA	NA	112	181	H	High	WIFI G 54MHz
2409.936000	91.44	NA	NA	396	297	H	Low	WIFI N MCS0
2434.892000	93.01	NA	NA	206	32	H	Mid	WIFI N MCS0
2461.230000	90.78	NA	NA	192	20	H	High	WIFI N MCS0
2410.754000	87.65	NA	NA	397	299	H	Low	WIFI N MCS7
2435.420000	85.80	NA	NA	161	26	H	Mid	WIFI N MCS7
2461.472000	85.94	NA	NA	237	18	H	High	WIFI N MCS7

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.

4.9 ANTENNA GAIN

Test procedures:
Device's conducted power was measured then then same measurement was repeated on a radiated sample at 3m test distance and converted to E.I.R.P.

Test setup:
Details can be found in section 2.1 of this report.

EUT operating conditions:
Details can be found in section 2.1 and 2.2 of this report.

Test results:

Antenna Gain:
Radiated Average power – Conducted Average Power = Antenna gain
12.24 dBm – 15.53 dBm = **-3.29 dBi**

Comments:

1. Since antenna gain was negative, conducted values were compared to the limit as if it has 0dBm gain for worst case

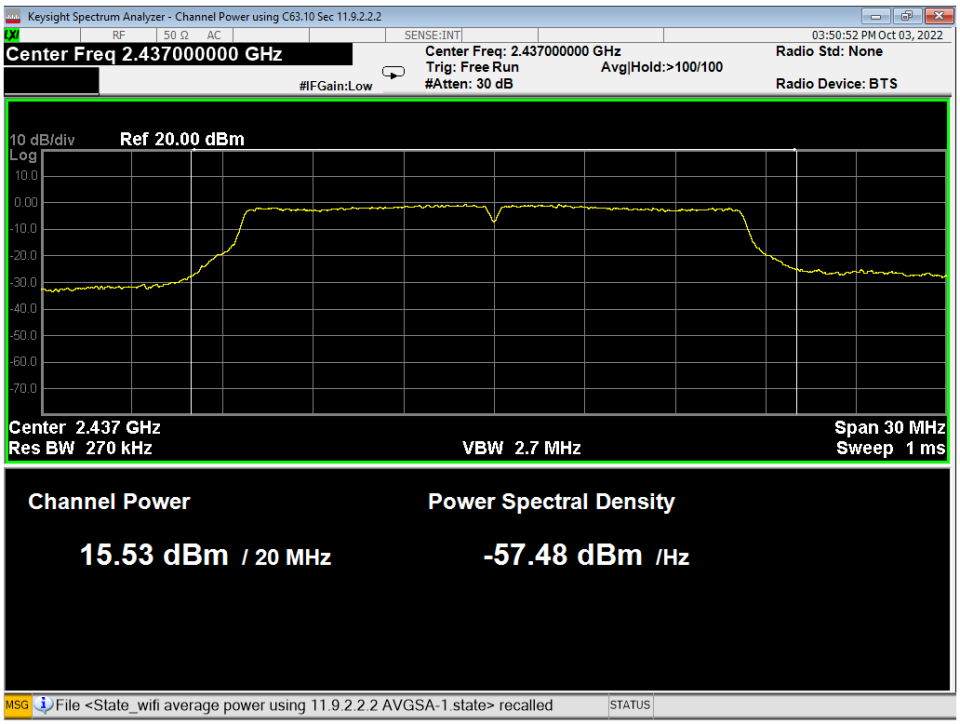


Figure 33 – Conducted Average Power Measurement, 802.11g 6MB

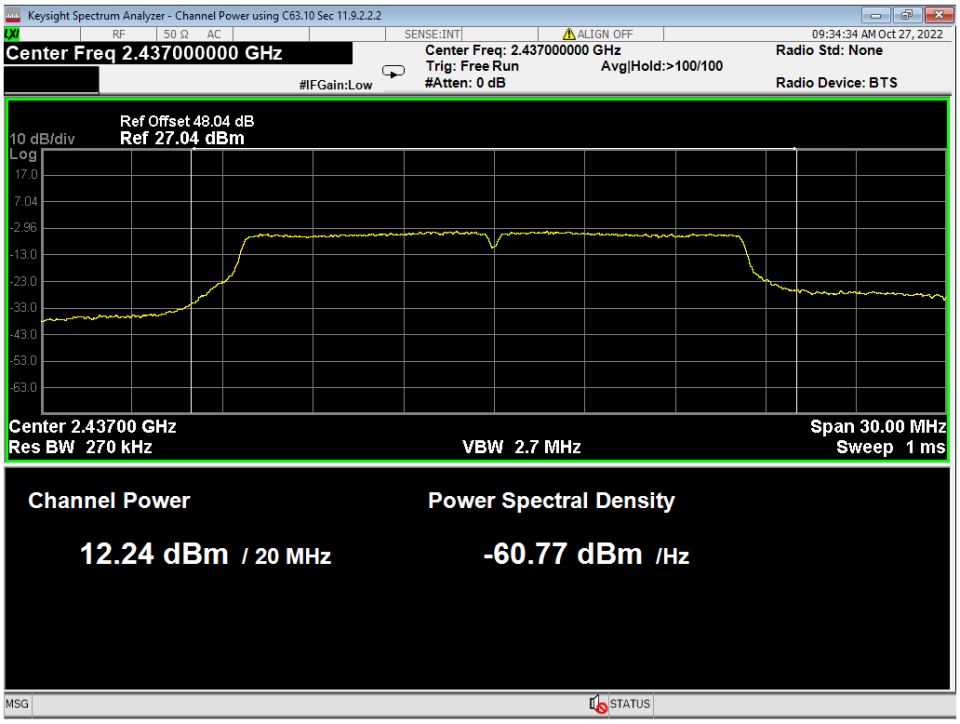


Figure 34 – Radiated Average Power Measurement, 802.11g 6MB

Reference offset includes EIRP conversion and corrections

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

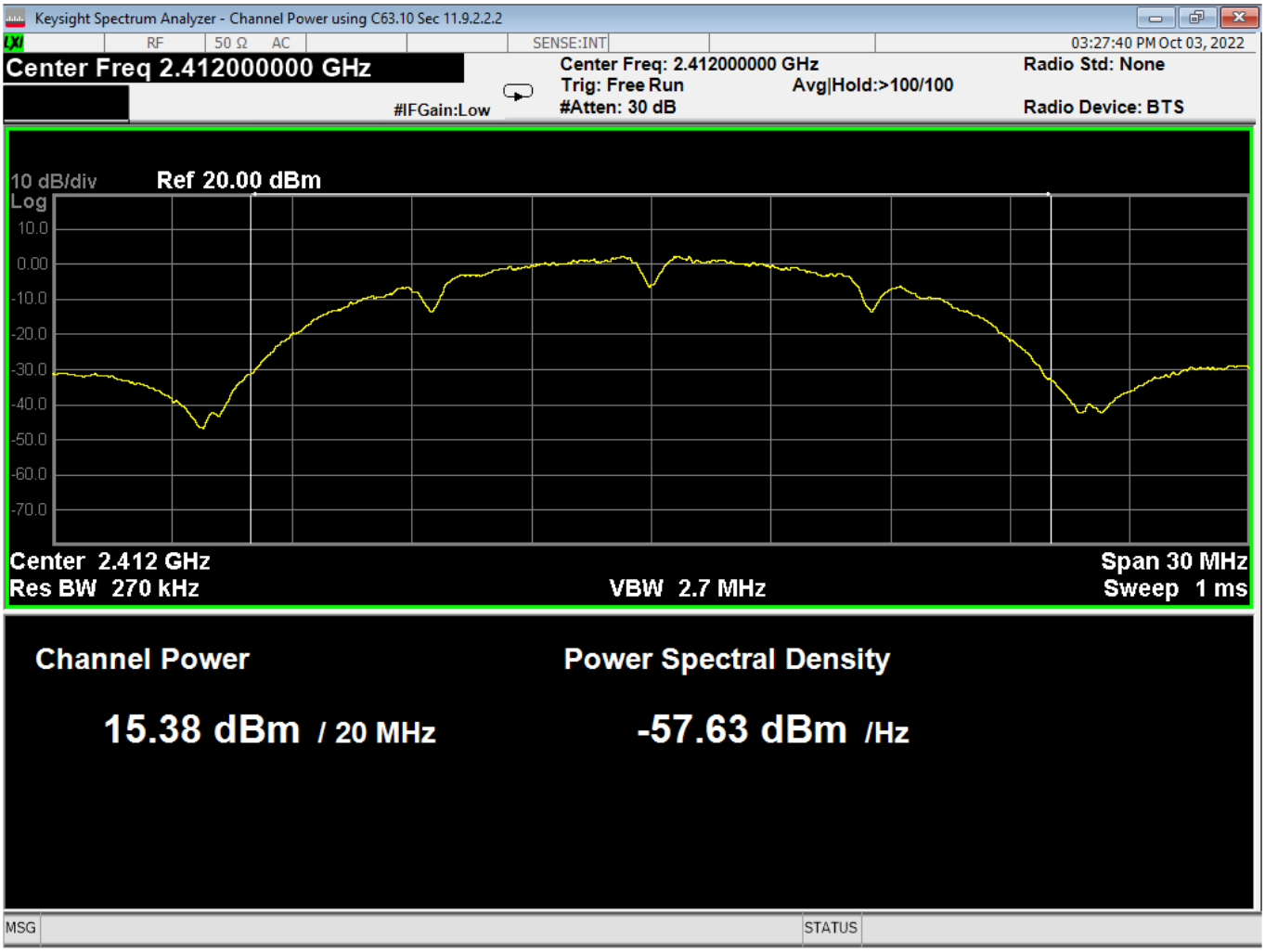
APPENDIX B – MEASUREMENT UNCERTAINTY

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

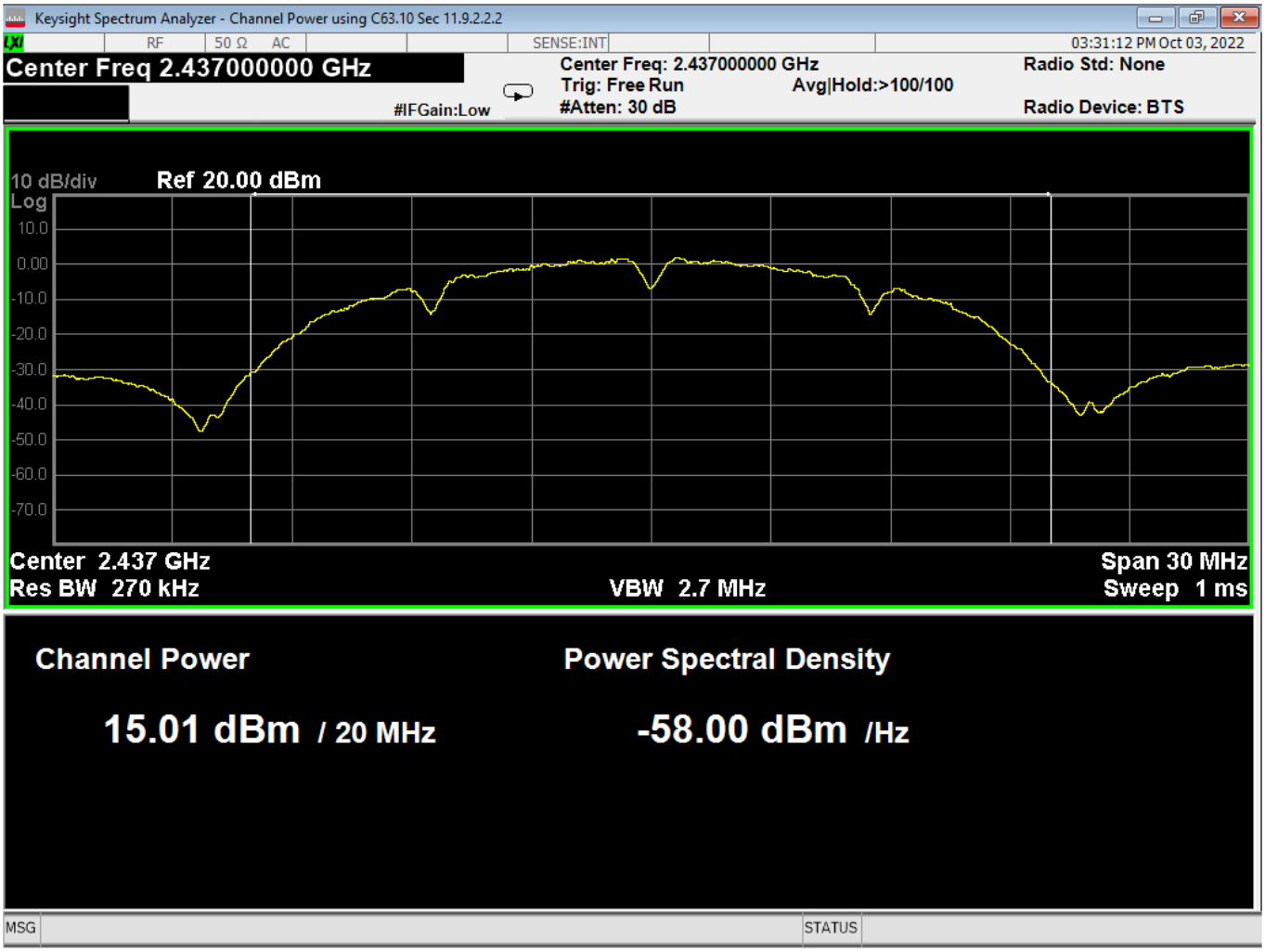
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	150kHz – 30MHz	±3.03

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

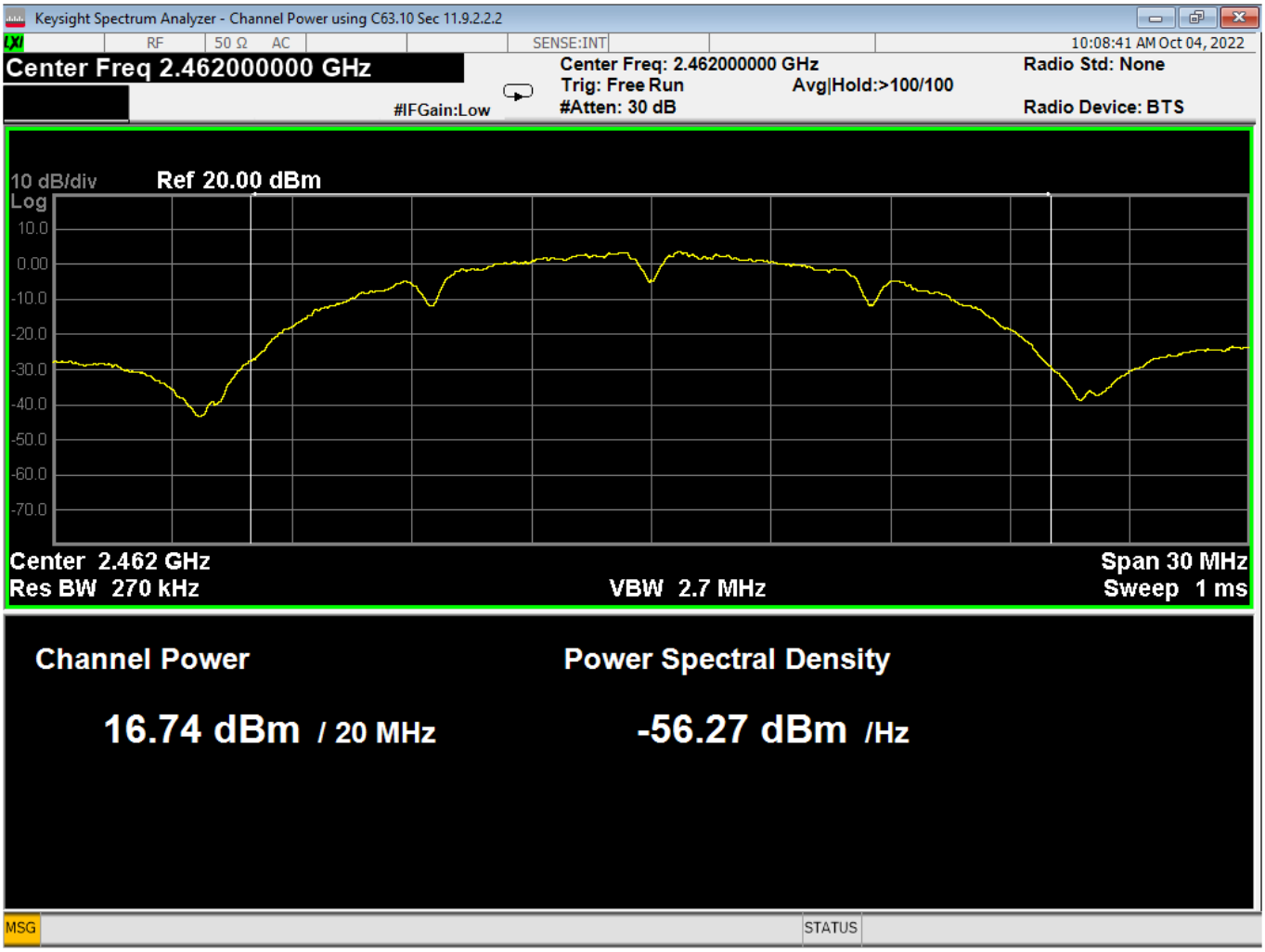
APPENDIX C – GRAPHS AND TABLES



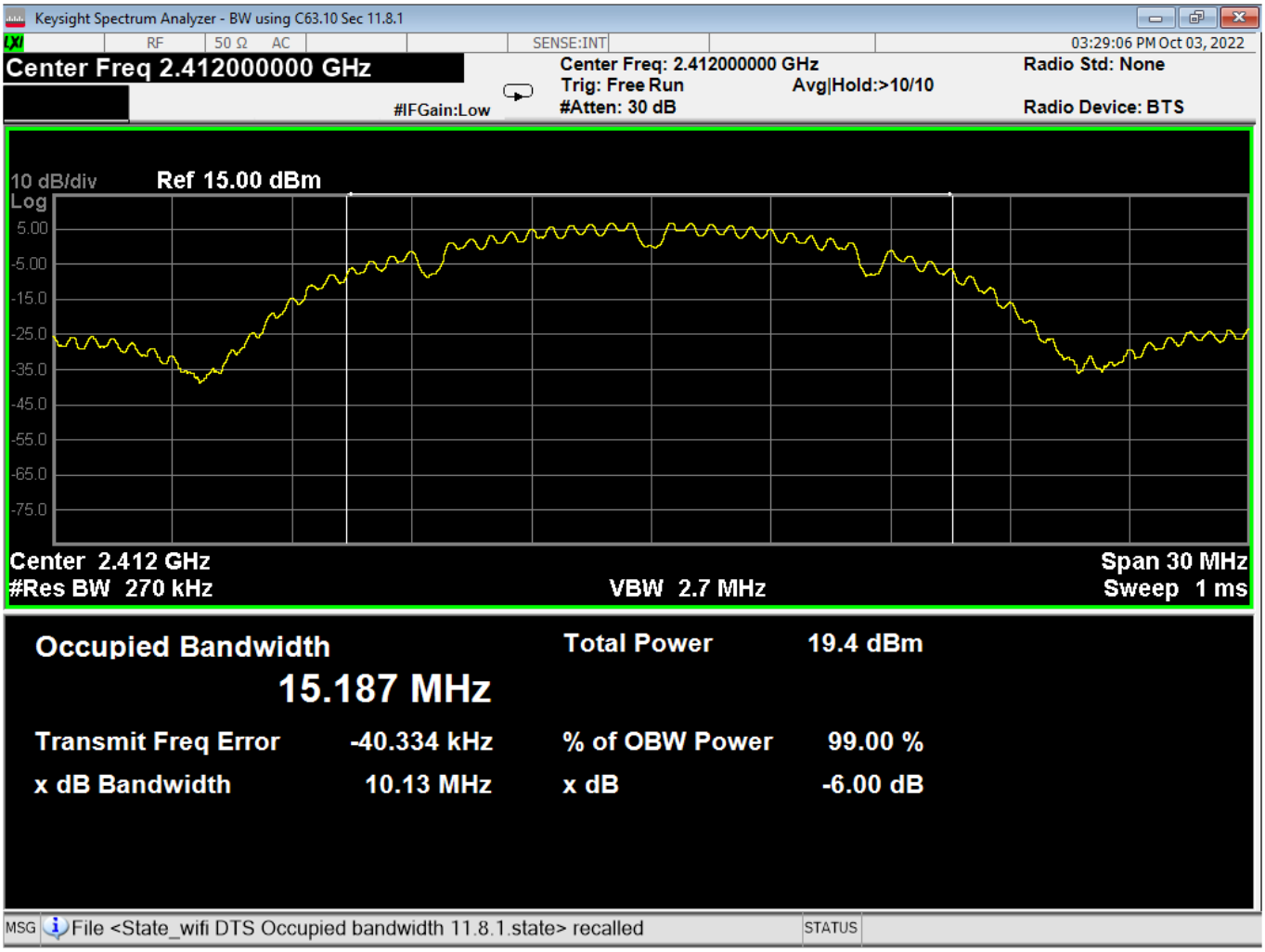
01 Average Power, Low, Wifi B, Low Data Rate



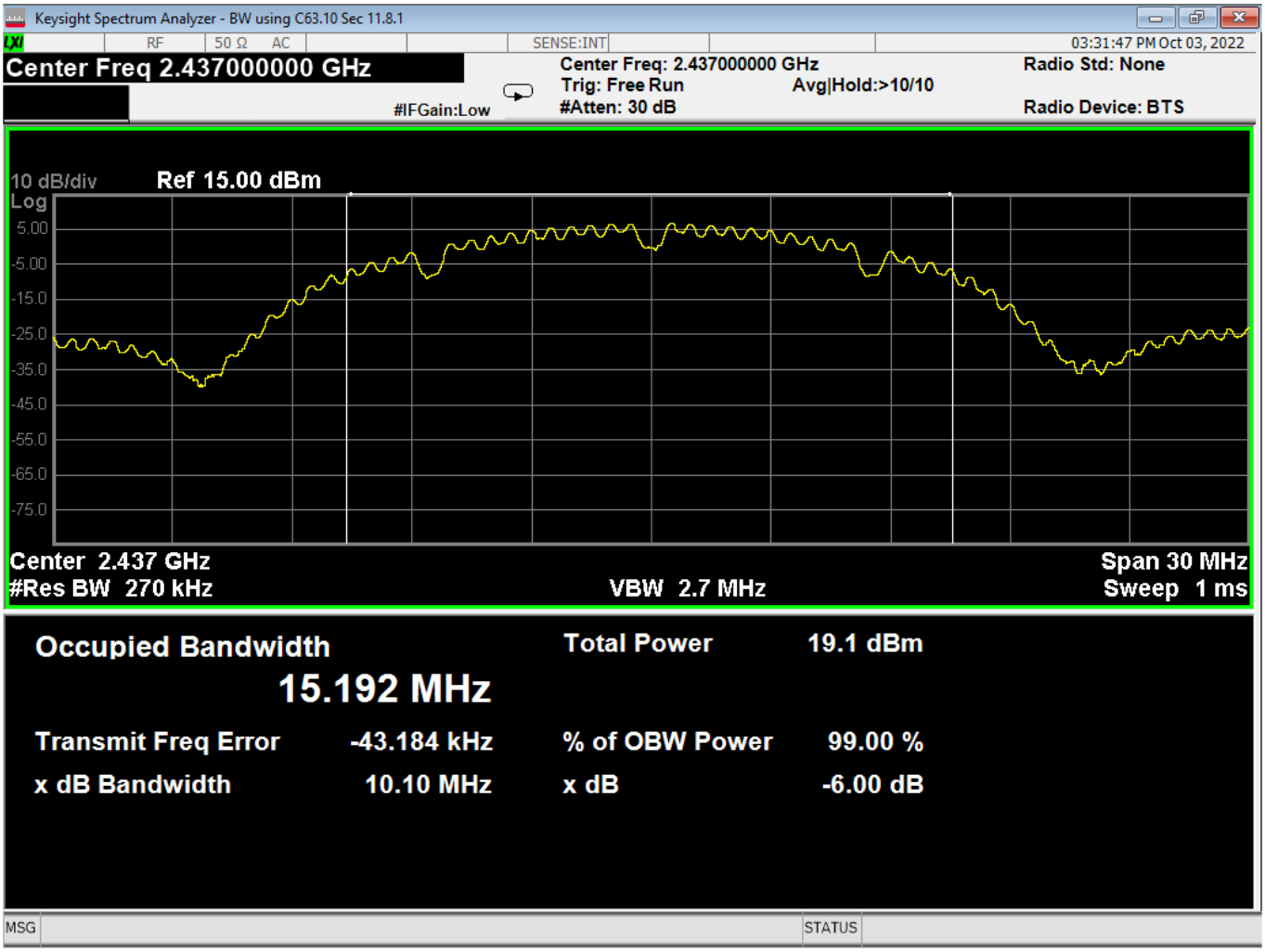
02 Average Power, Mid, Wifi B, Low Data Rate



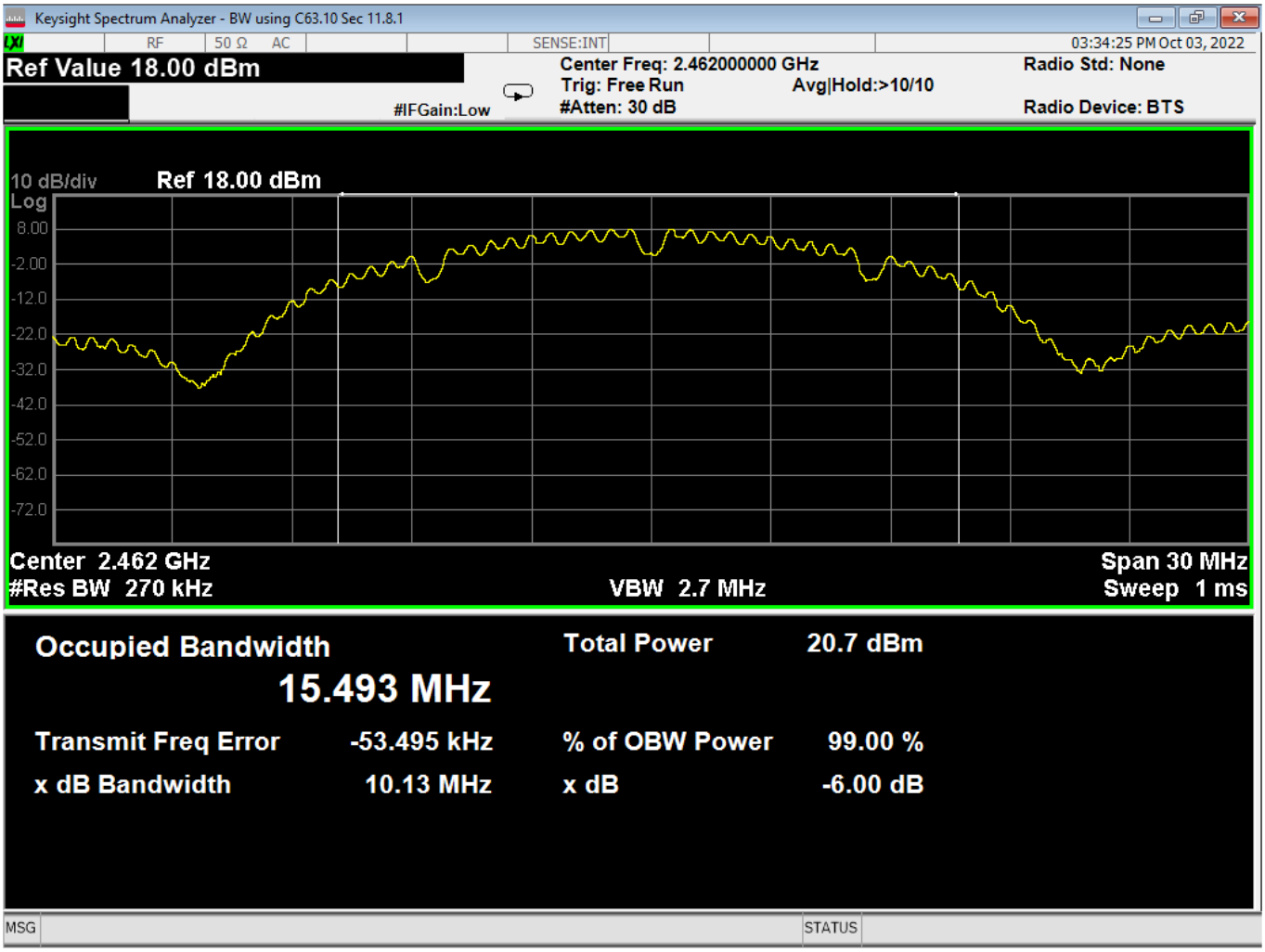
03 Average Power, High, Wifi B, Low Data Rate



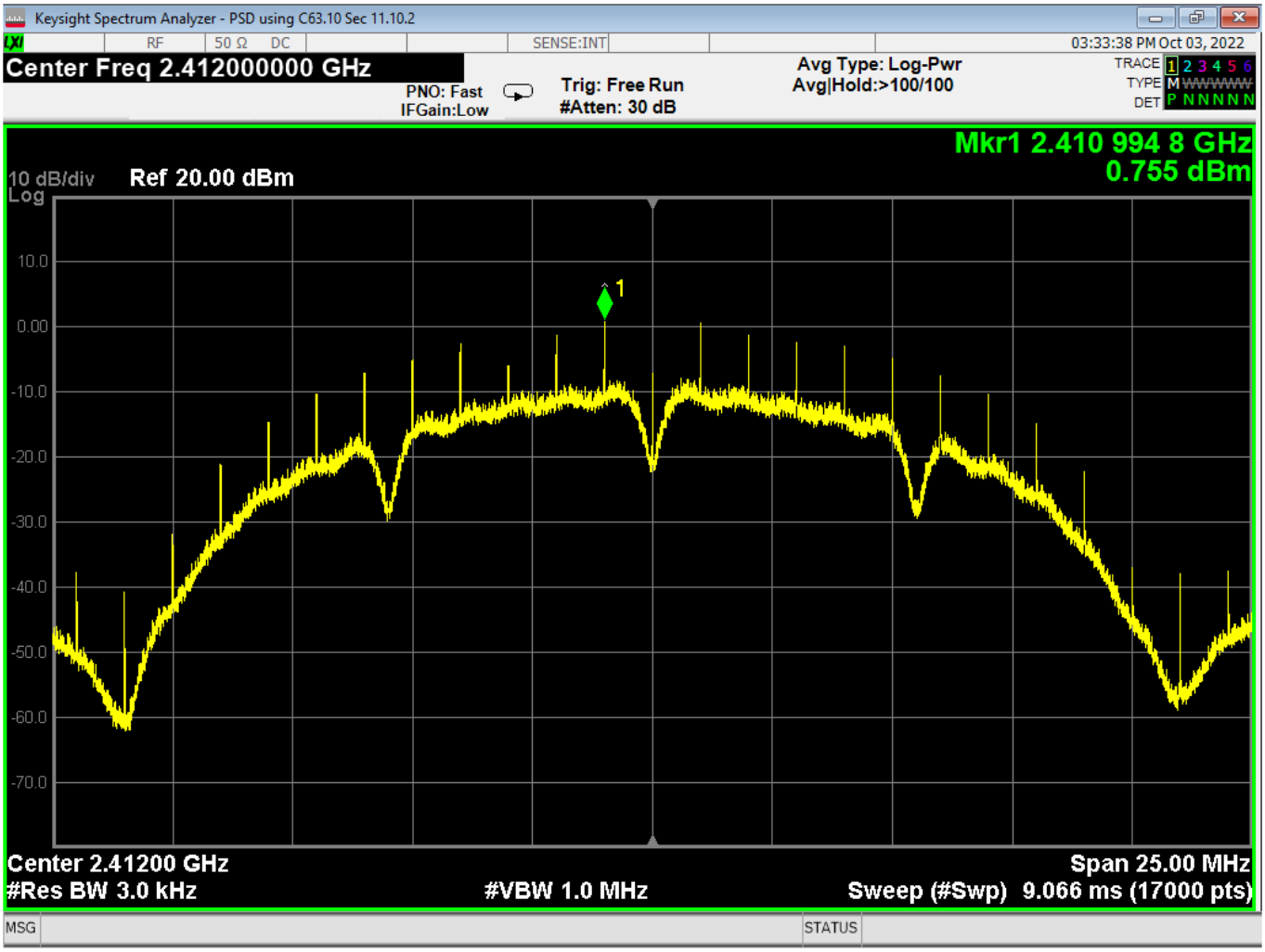
04 Bandwidth, Low, Wifi B, Low Data Rate



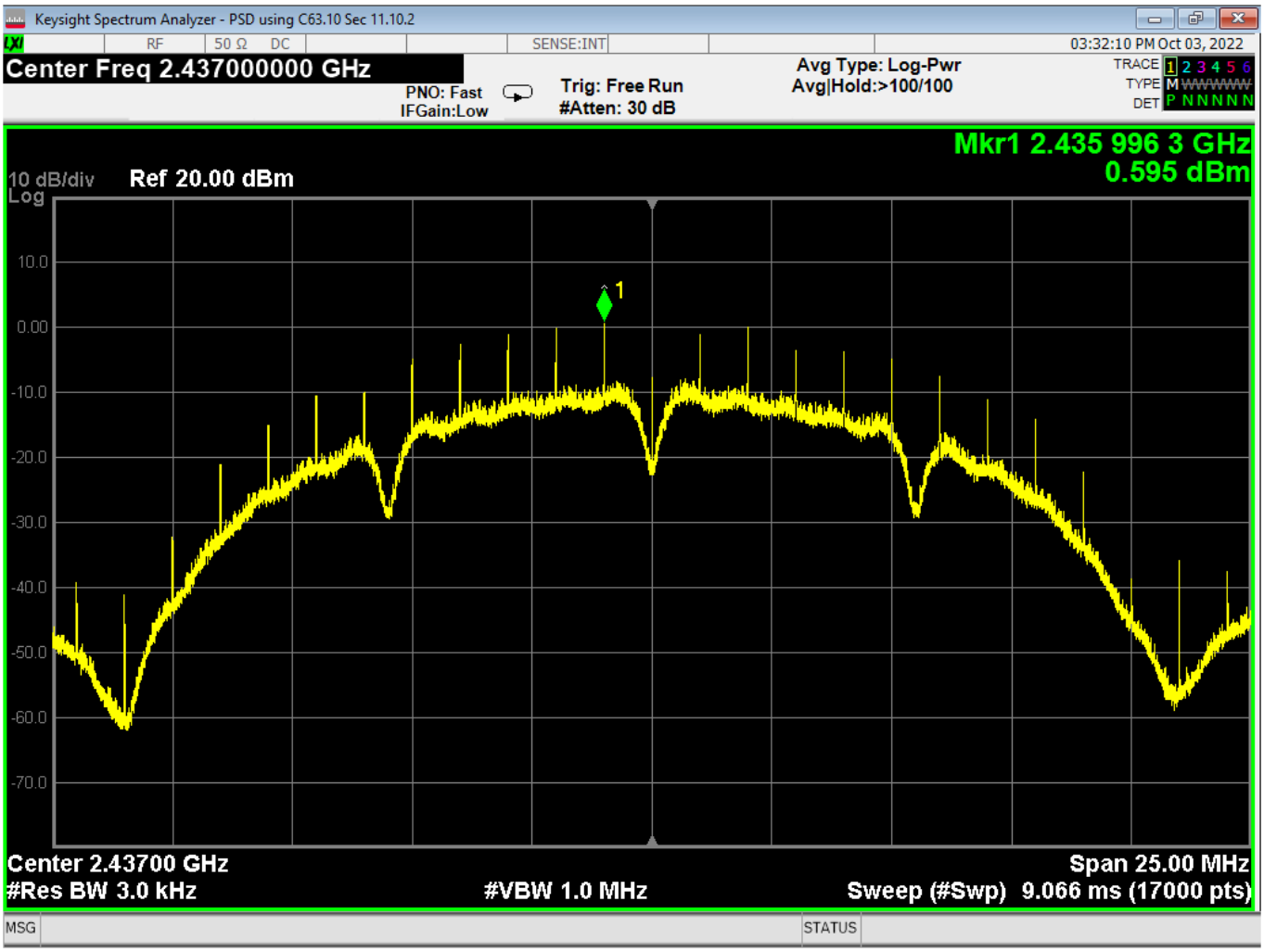
05 Bandwidth, Mid, Wifi B, Low Data Rate



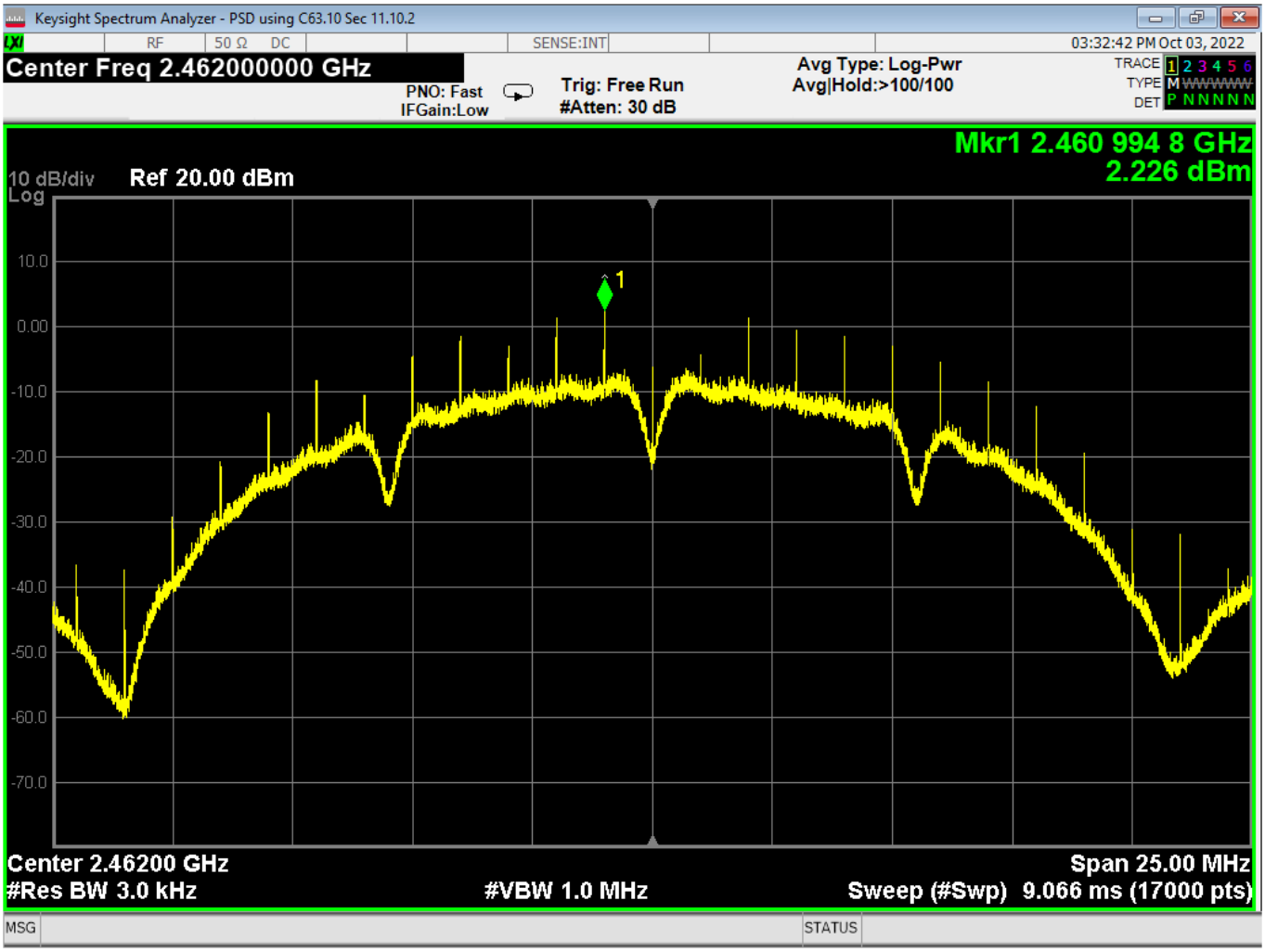
06 Bandwidth, High, Wifi B, Low Data Rate



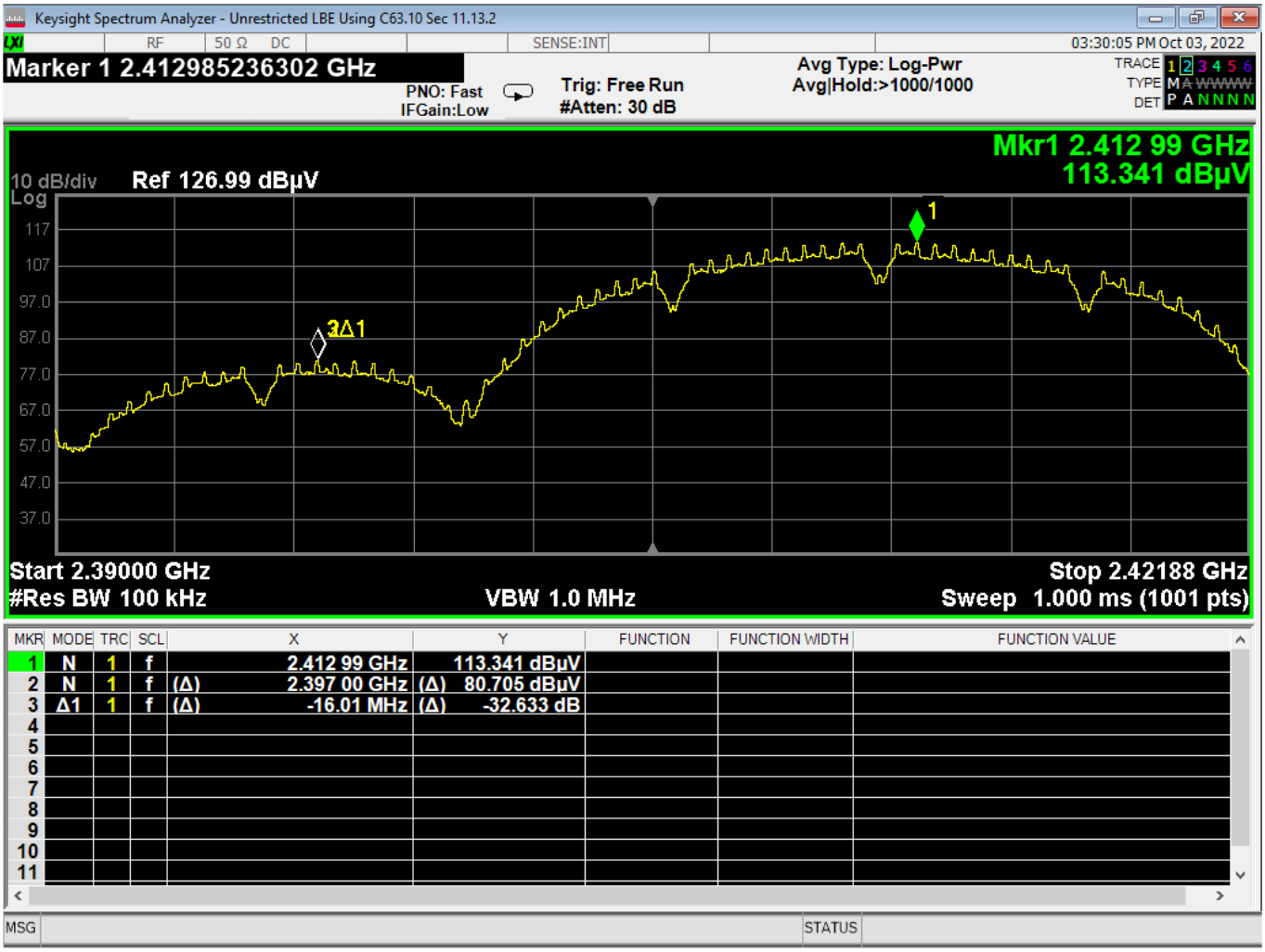
07 PSD, Low, Wifi B, Low Data Rate



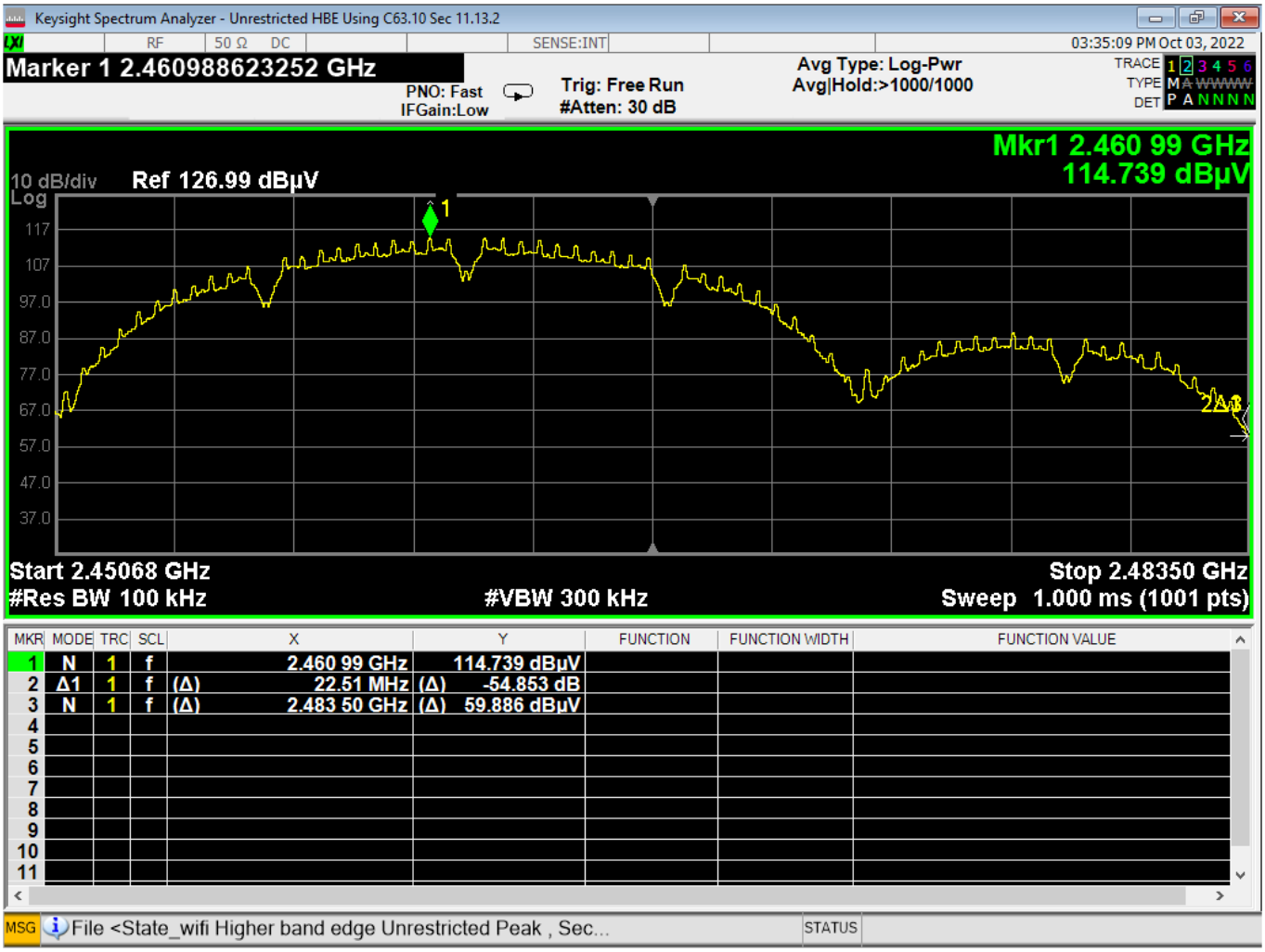
08 PSD, Mid, Wifi B, Low Data Rate



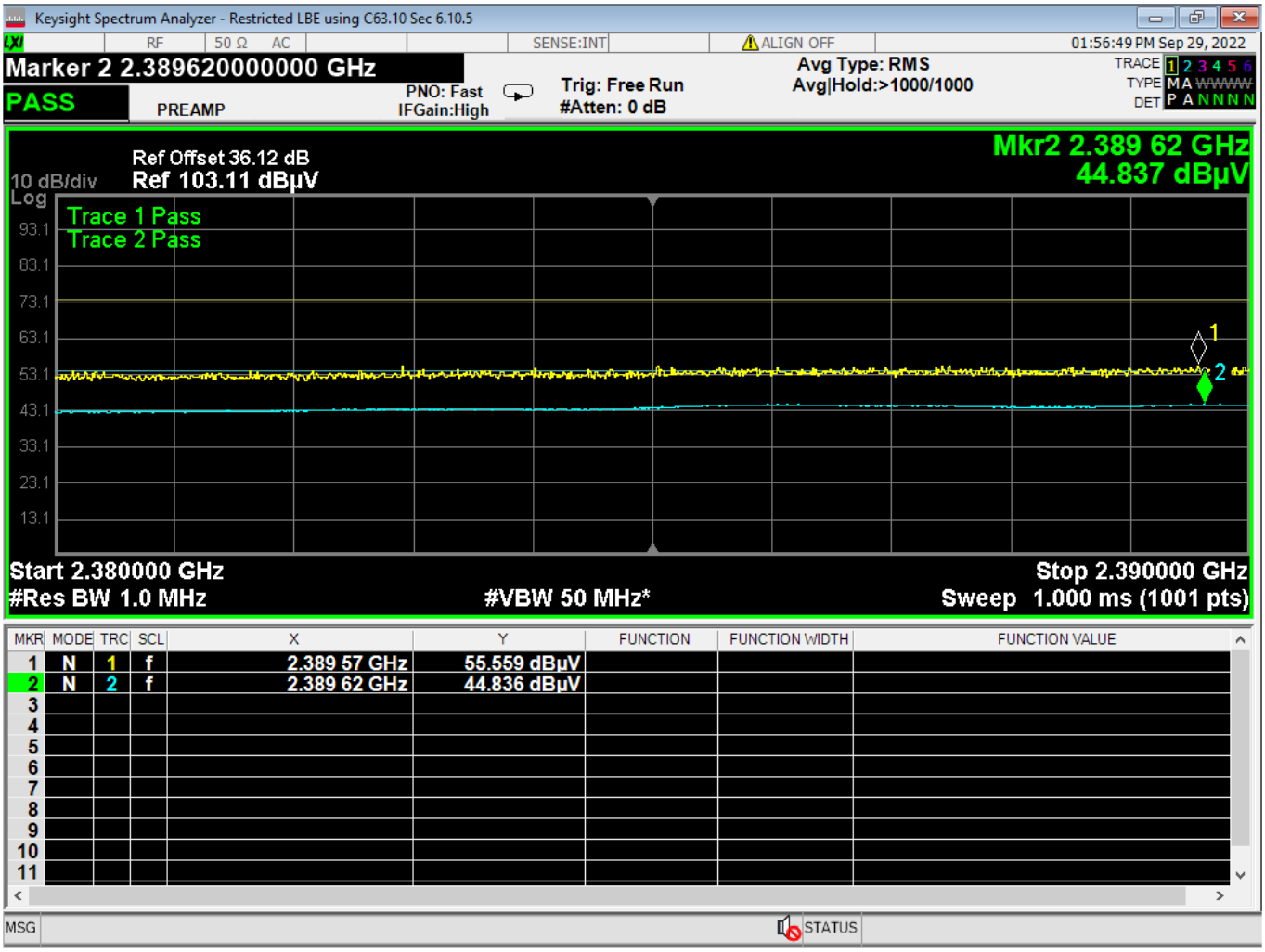
09 PSD, High, Wifi B, Low Data Rate



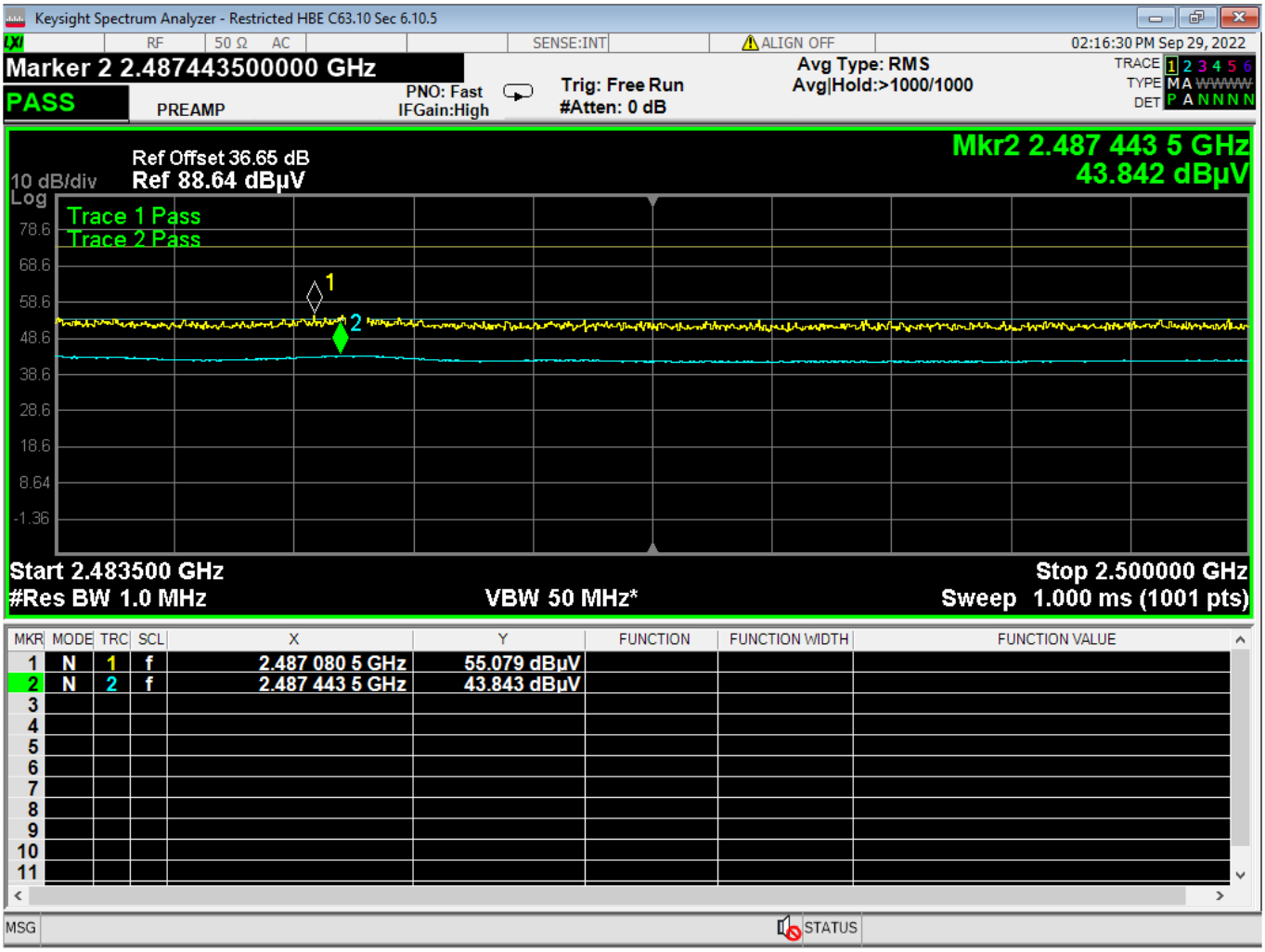
10 Lower Bandedge, Unrestricted, Wifi B, Low Data Rate



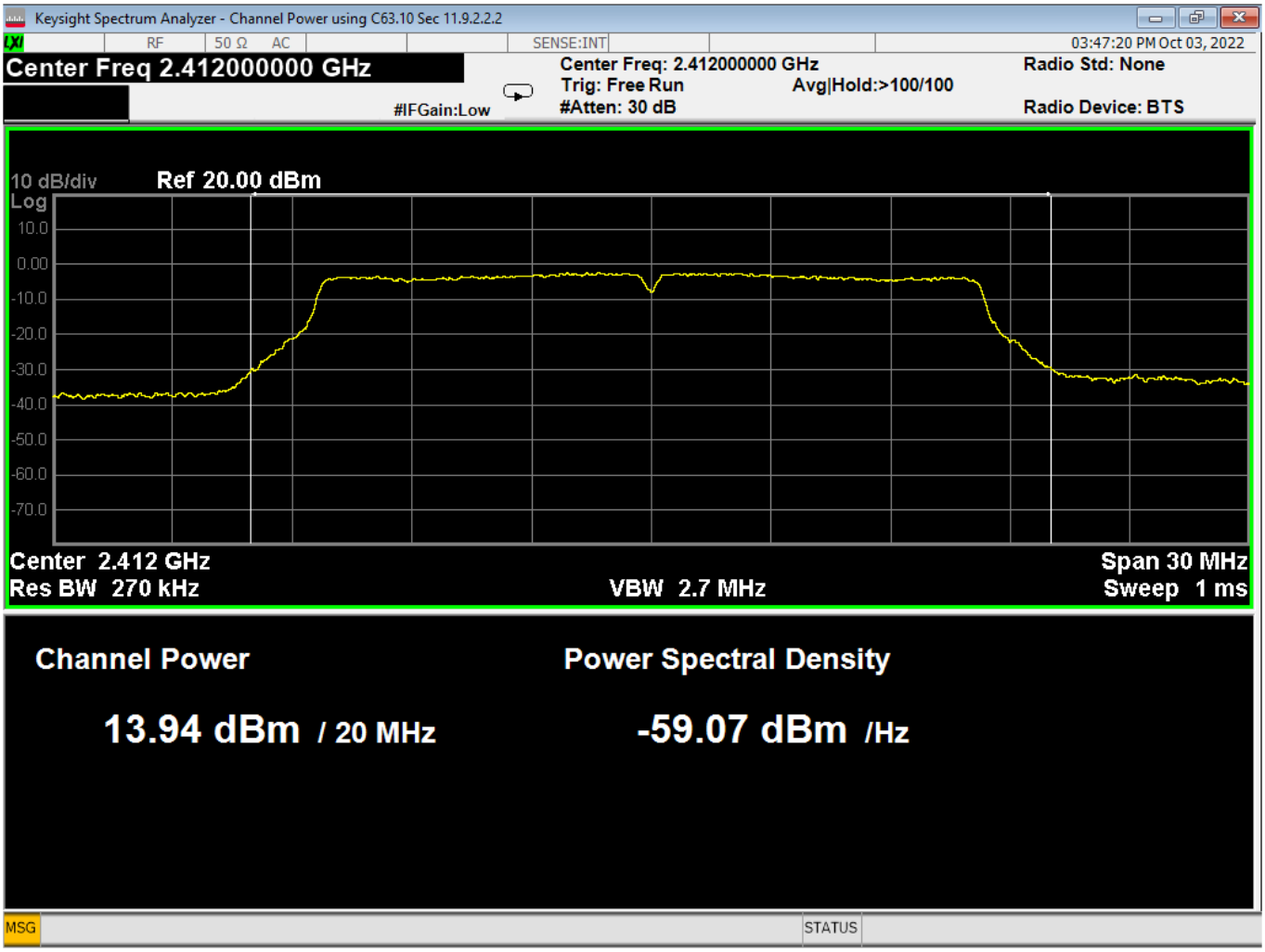
11 Higher Bandedge, Unrestricted, Wifi B, Low Data Rate



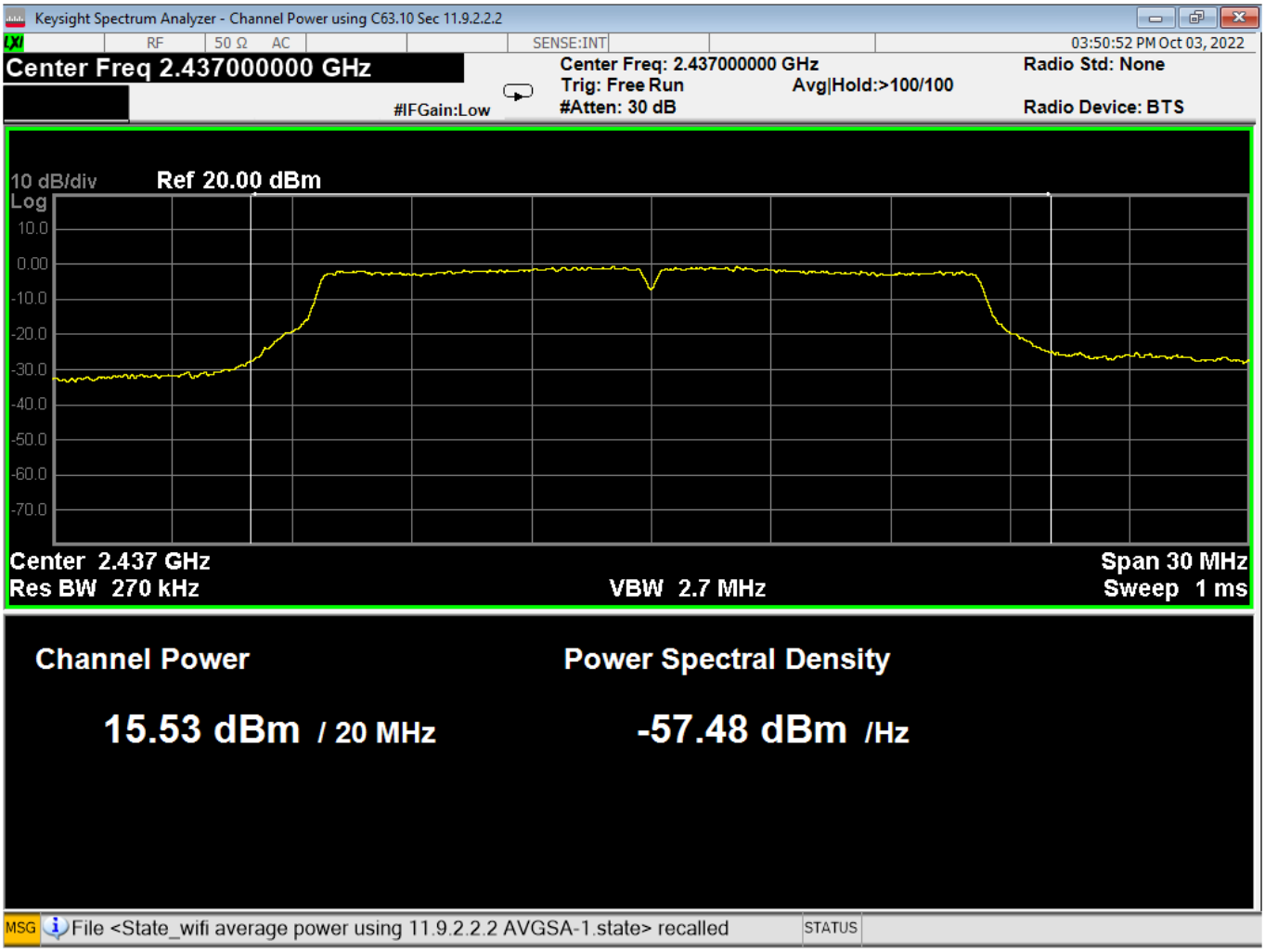
12 Lower Bandedge, Restricted, Wifi B, Low Data Rate



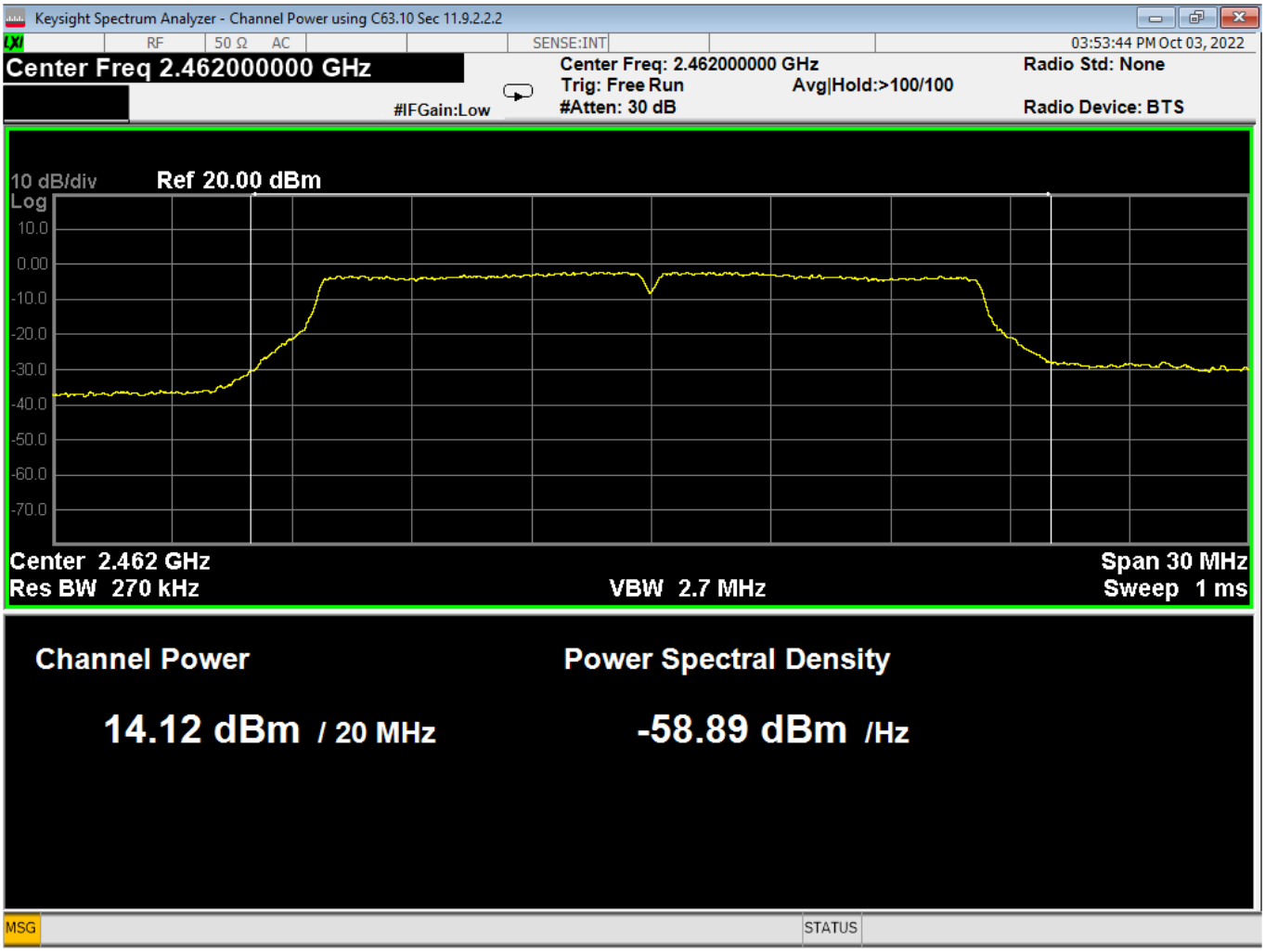
13 Higher Bandedge, Restricted, Wifi B, Low Data Rate



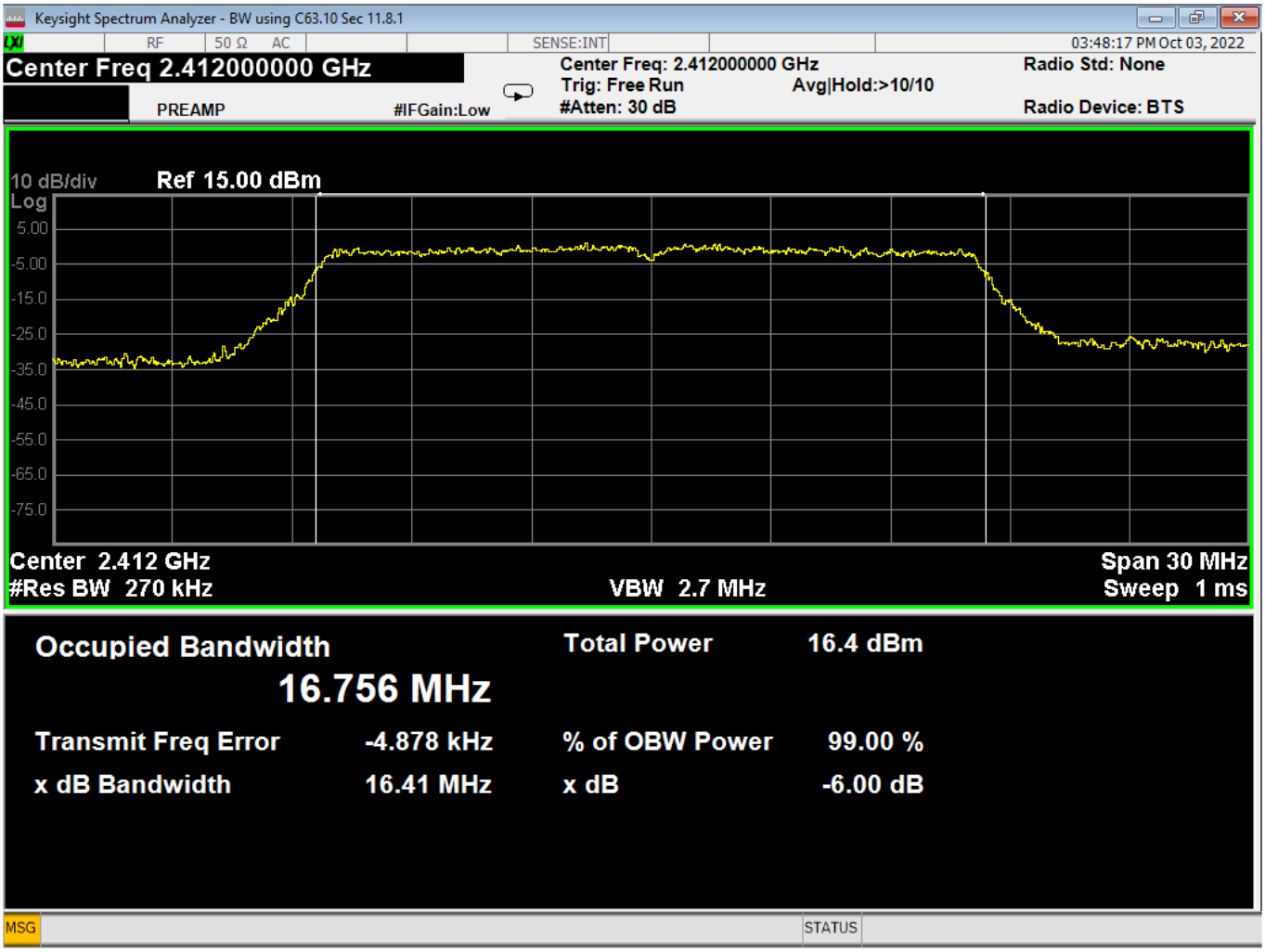
14 Average Power, Low, Wifi G, Low Data Rate



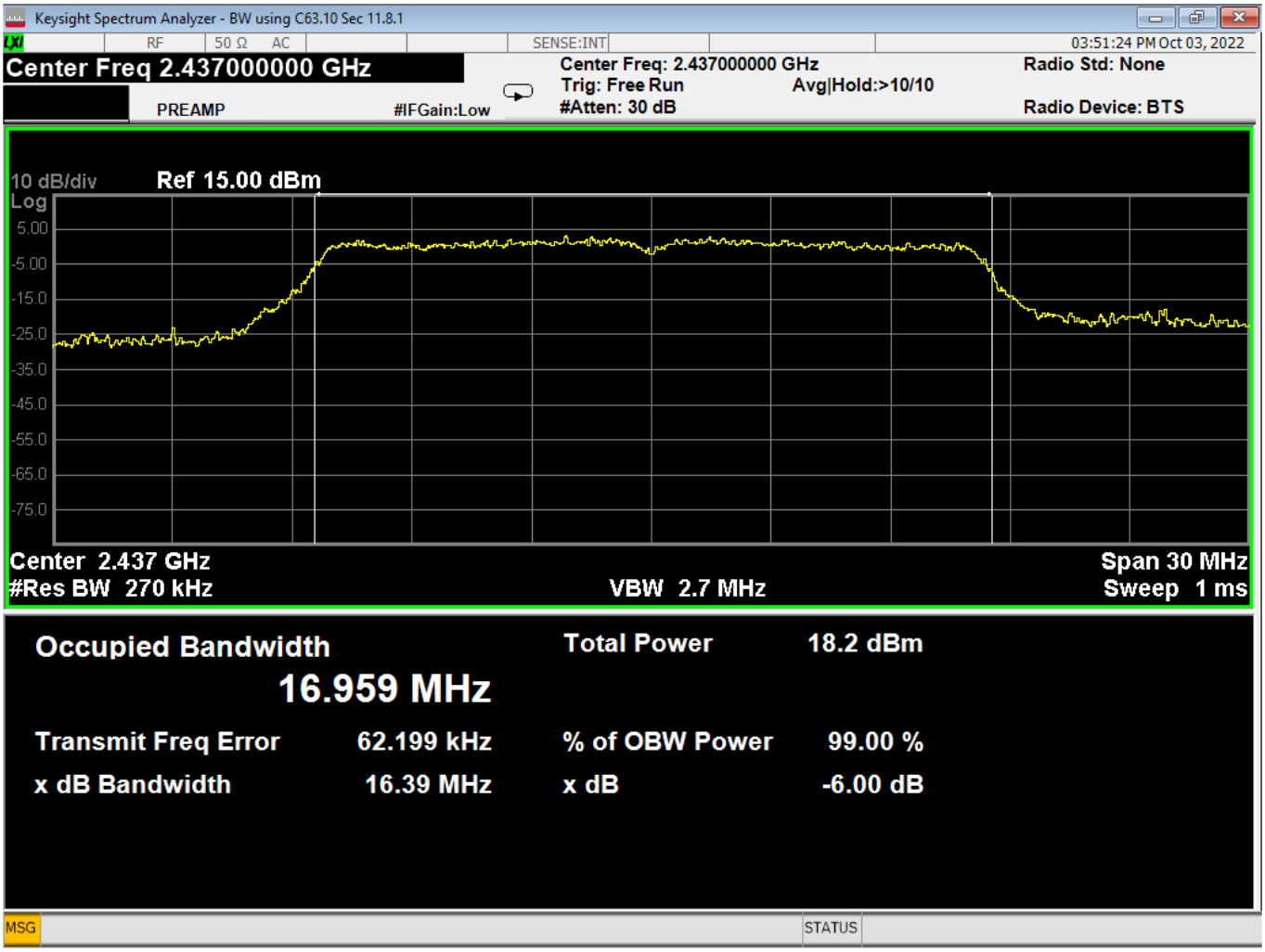
15 Average Power, Mid, Wifi G, Low Data Rate



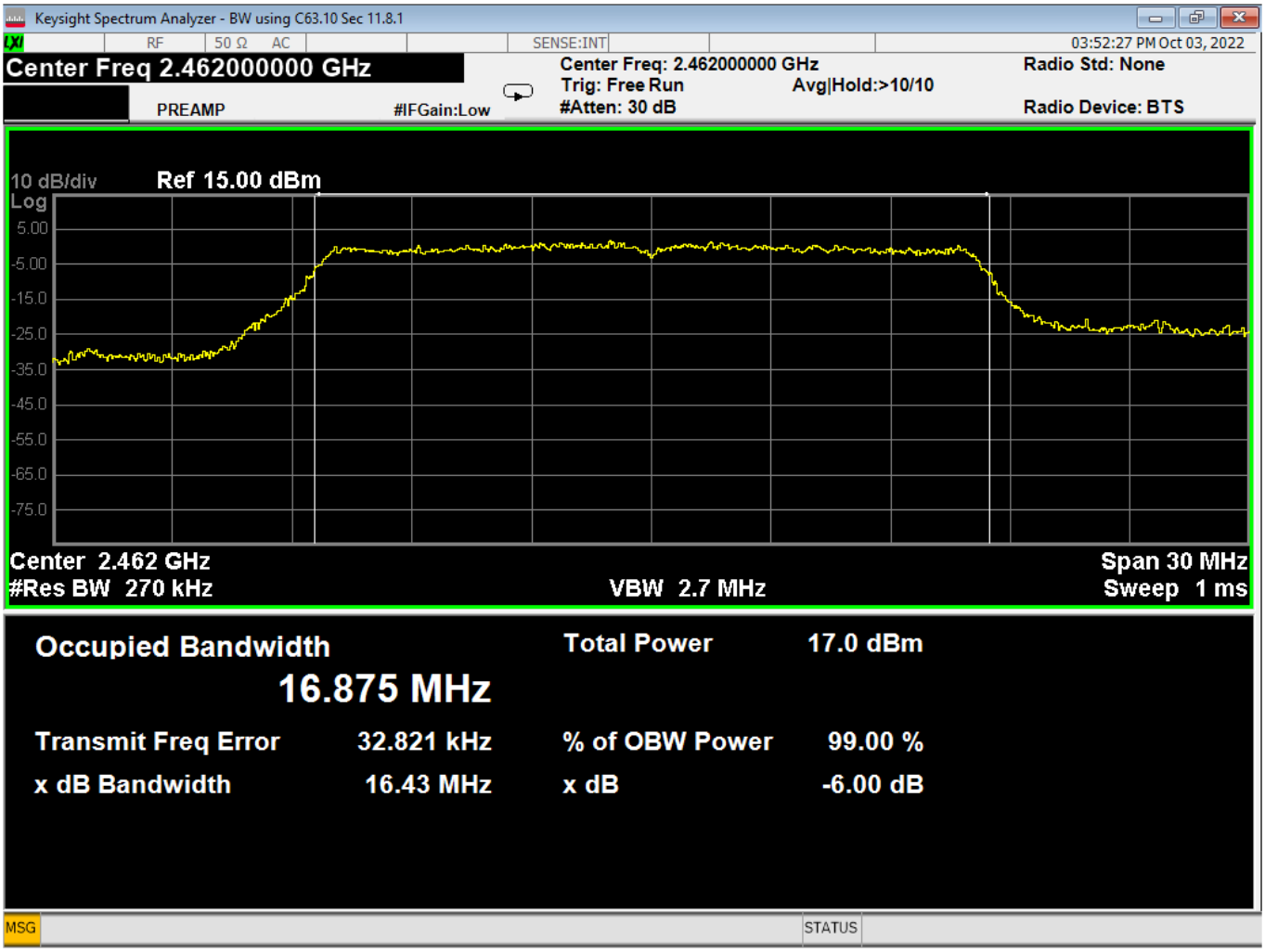
16 Average Power, High, Wifi G, Low Data Rate



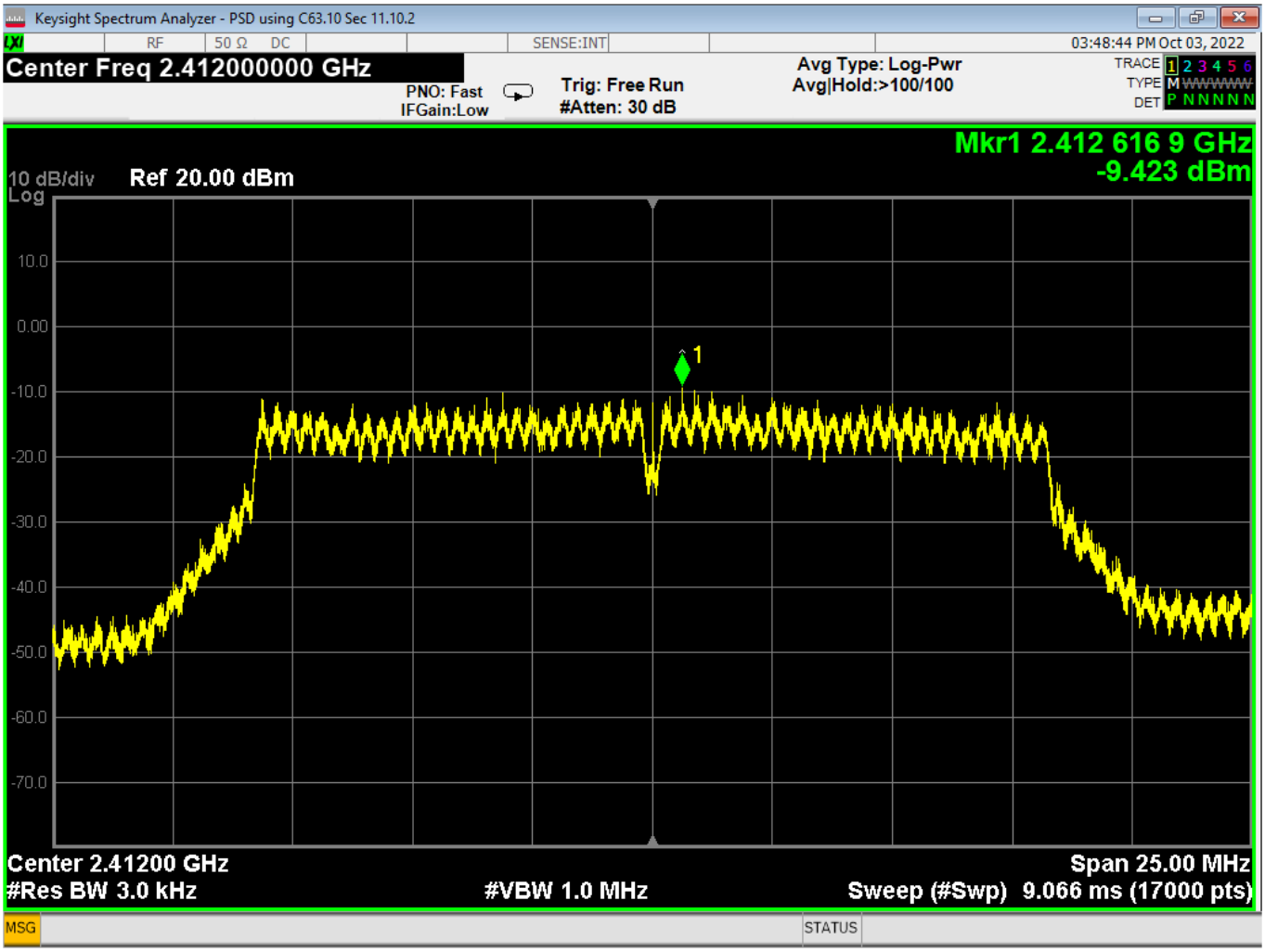
17 Bandwidth, Low, Wifi G, Low Data Rate



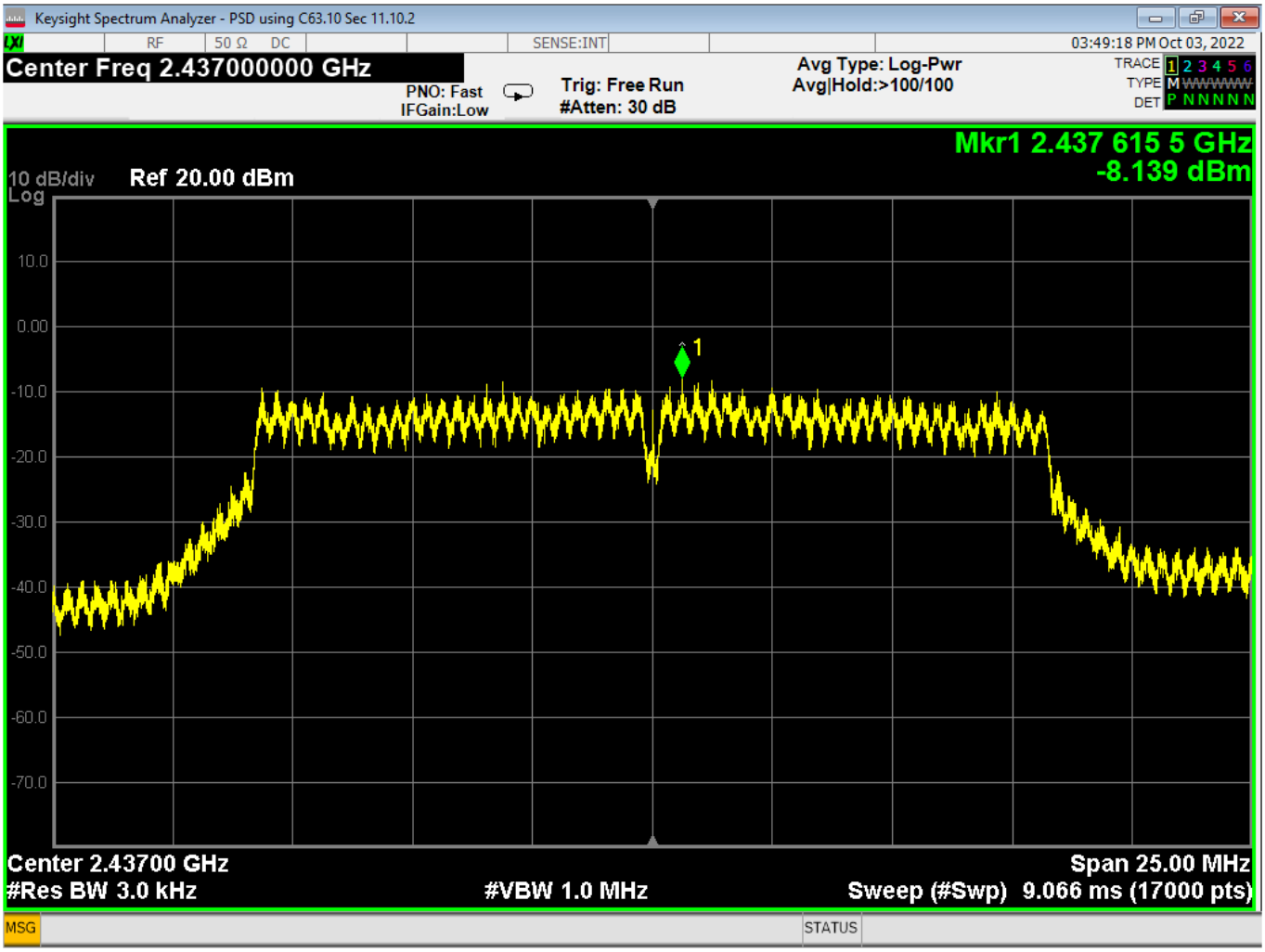
18 Bandwidth, Mid, Wifi G, Low Data Rate



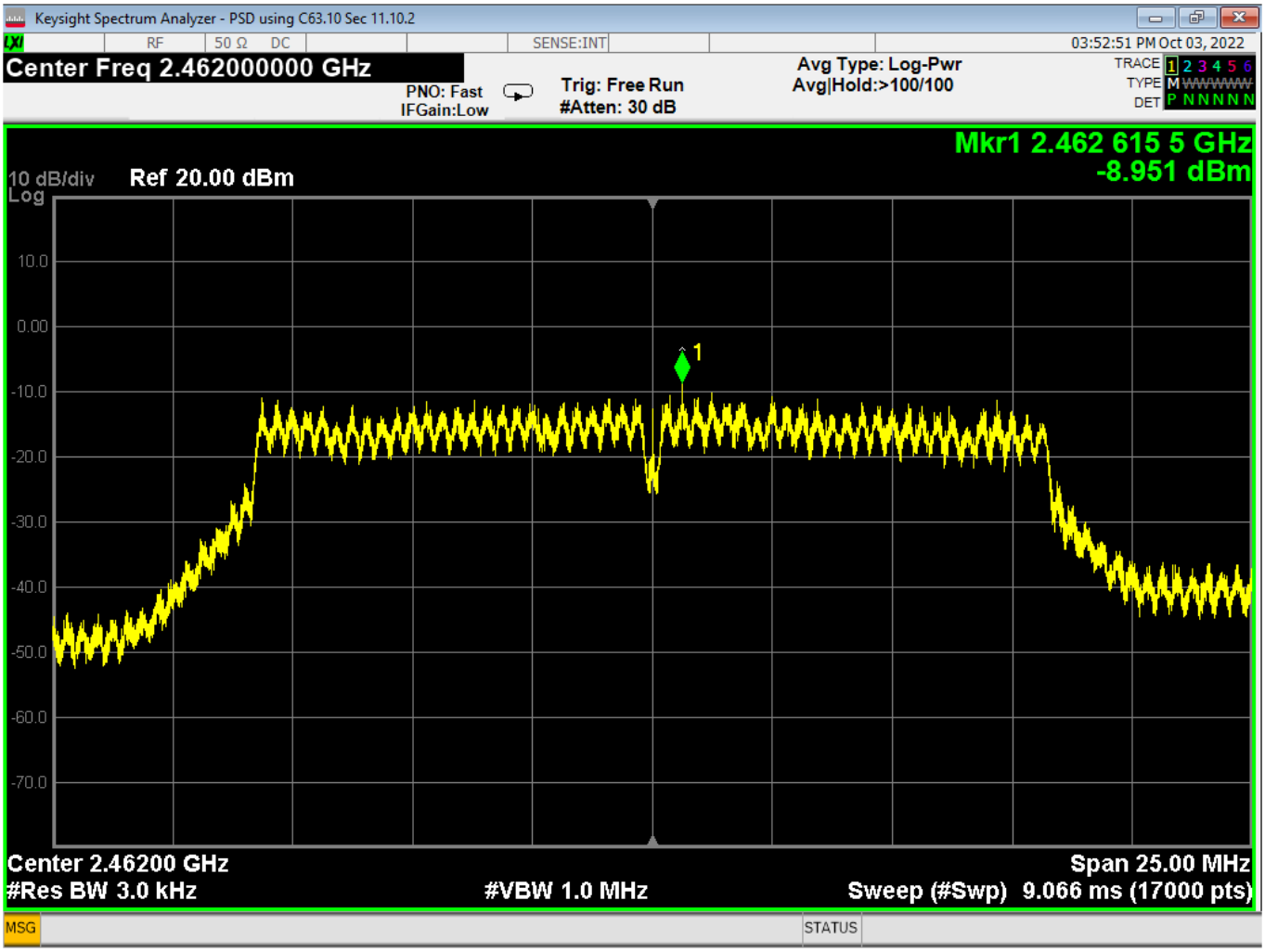
19 Bandwidth, High, Wifi G, Low Data Rate



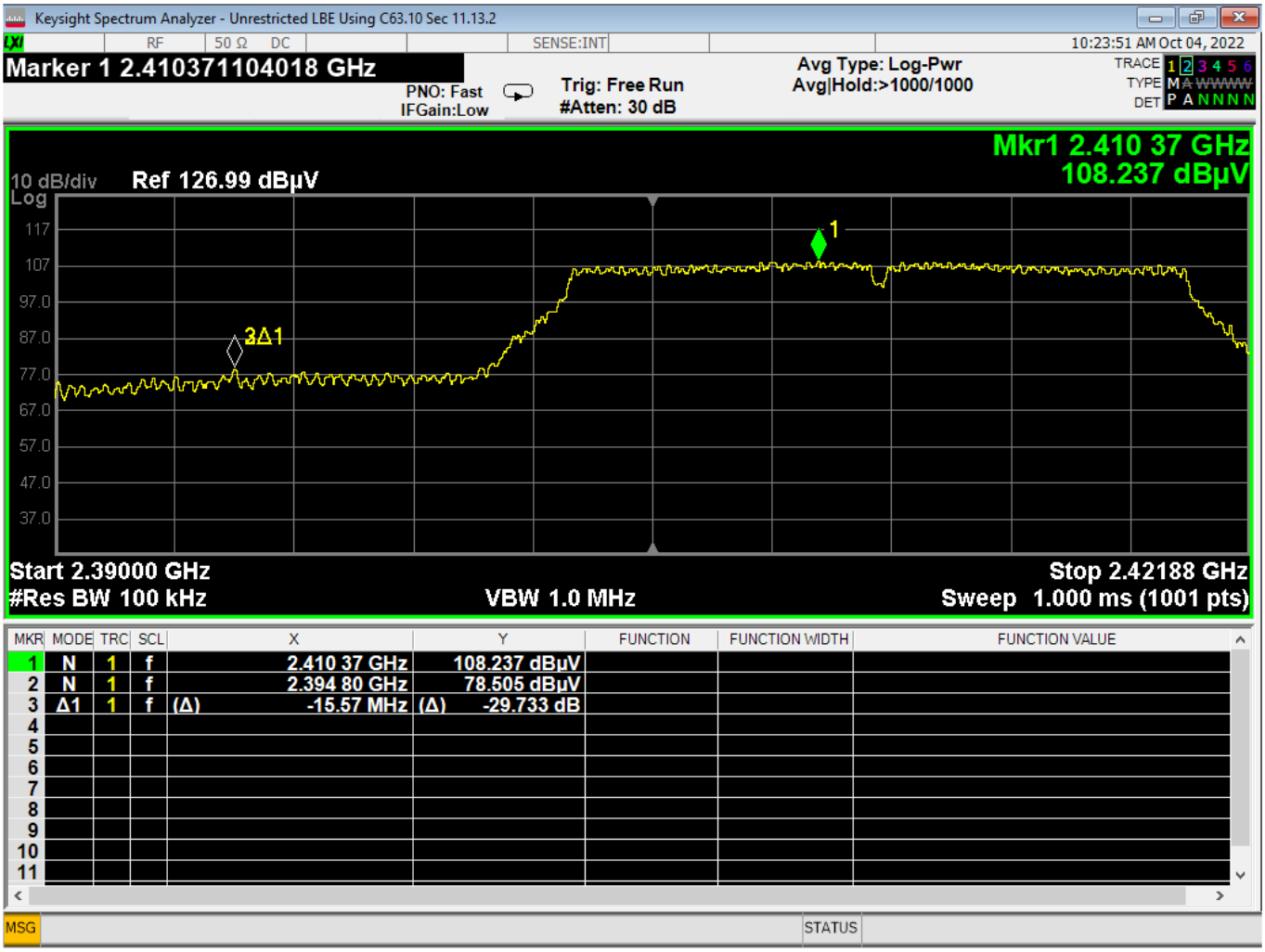
20 PSD, Low, Wifi G, Low Data Rate



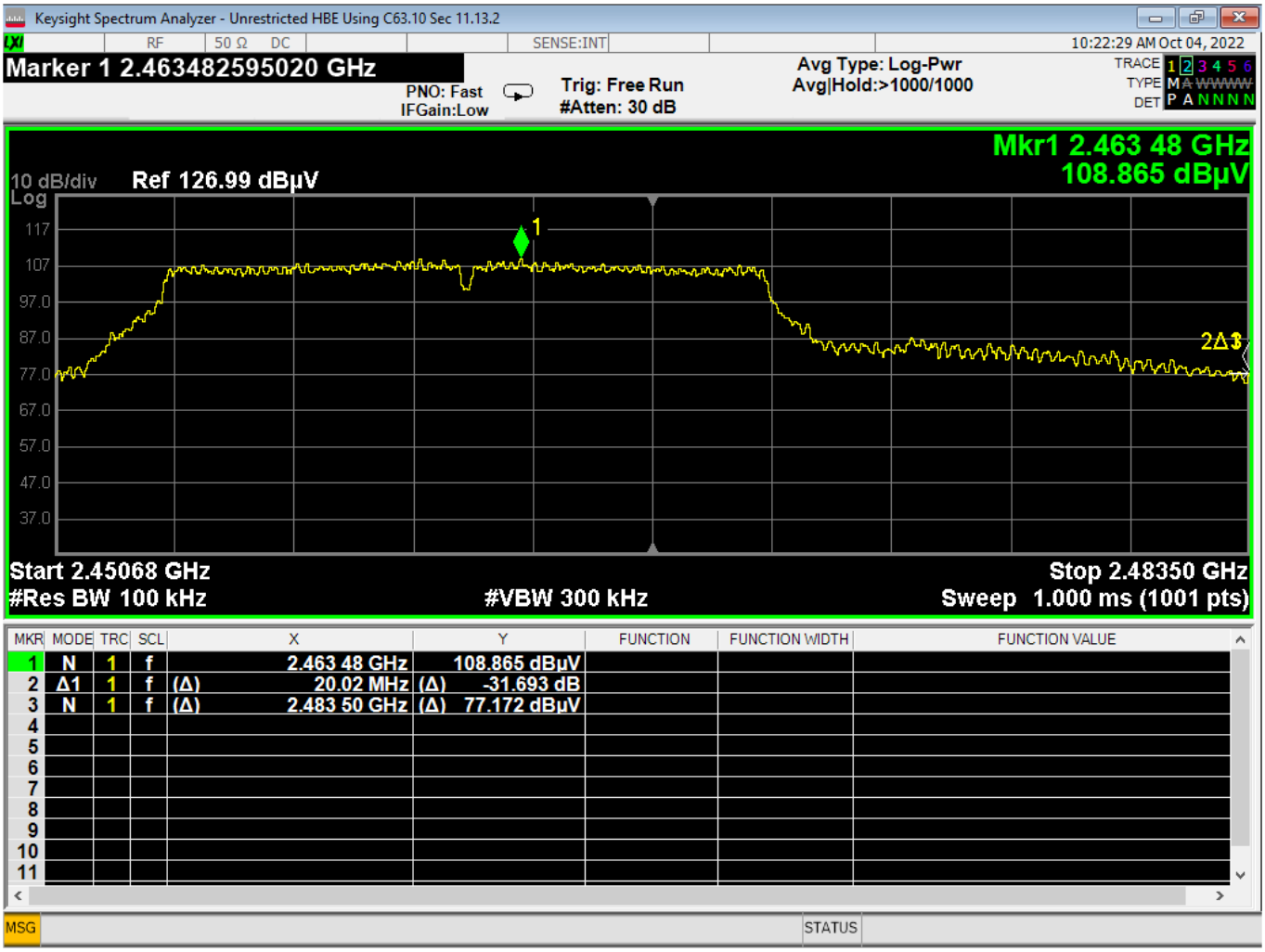
21 PSD, Mid, Wifi G, Low Data Rate



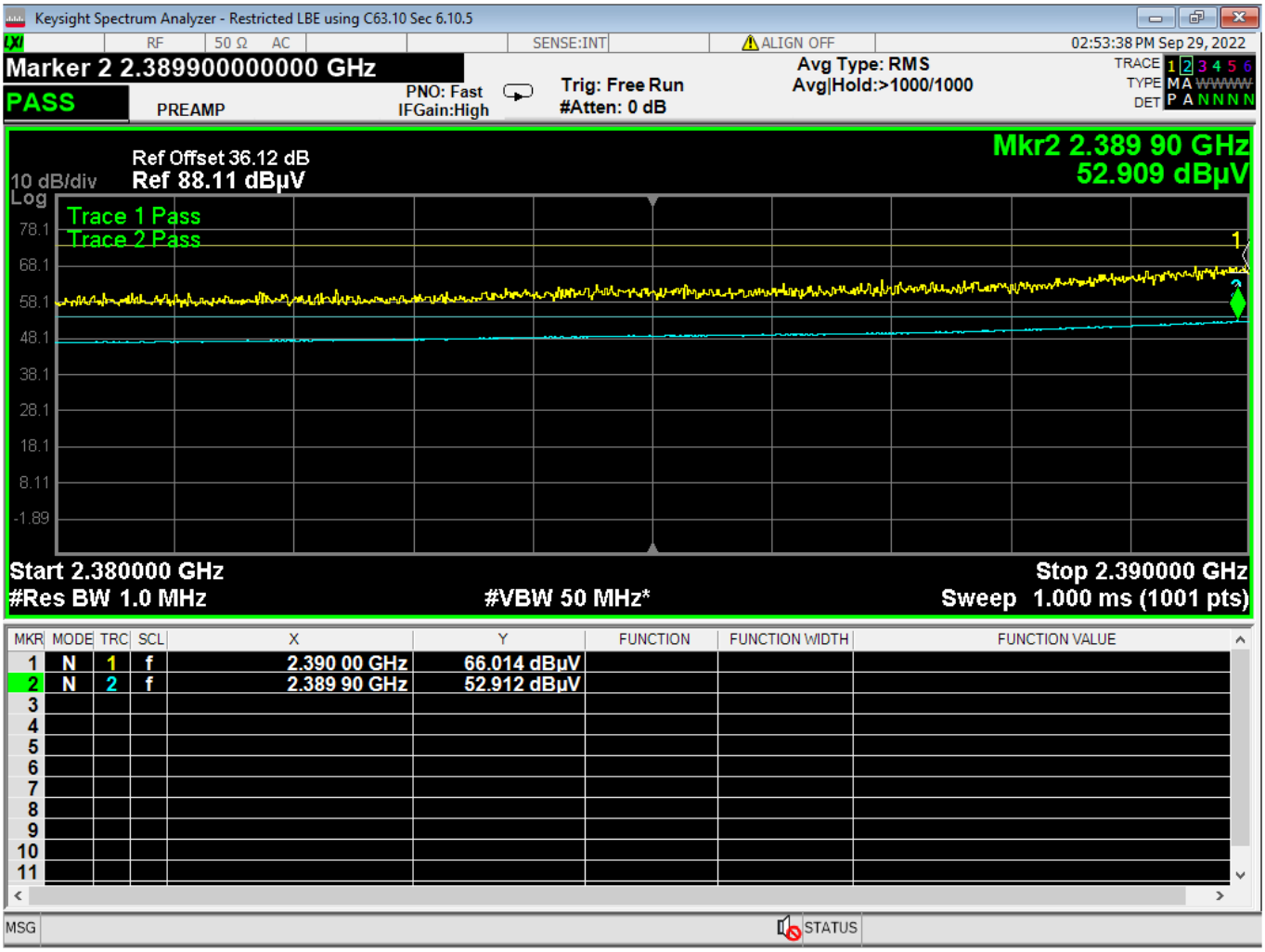
22 PSD, High, Wifi G, Low Data Rate



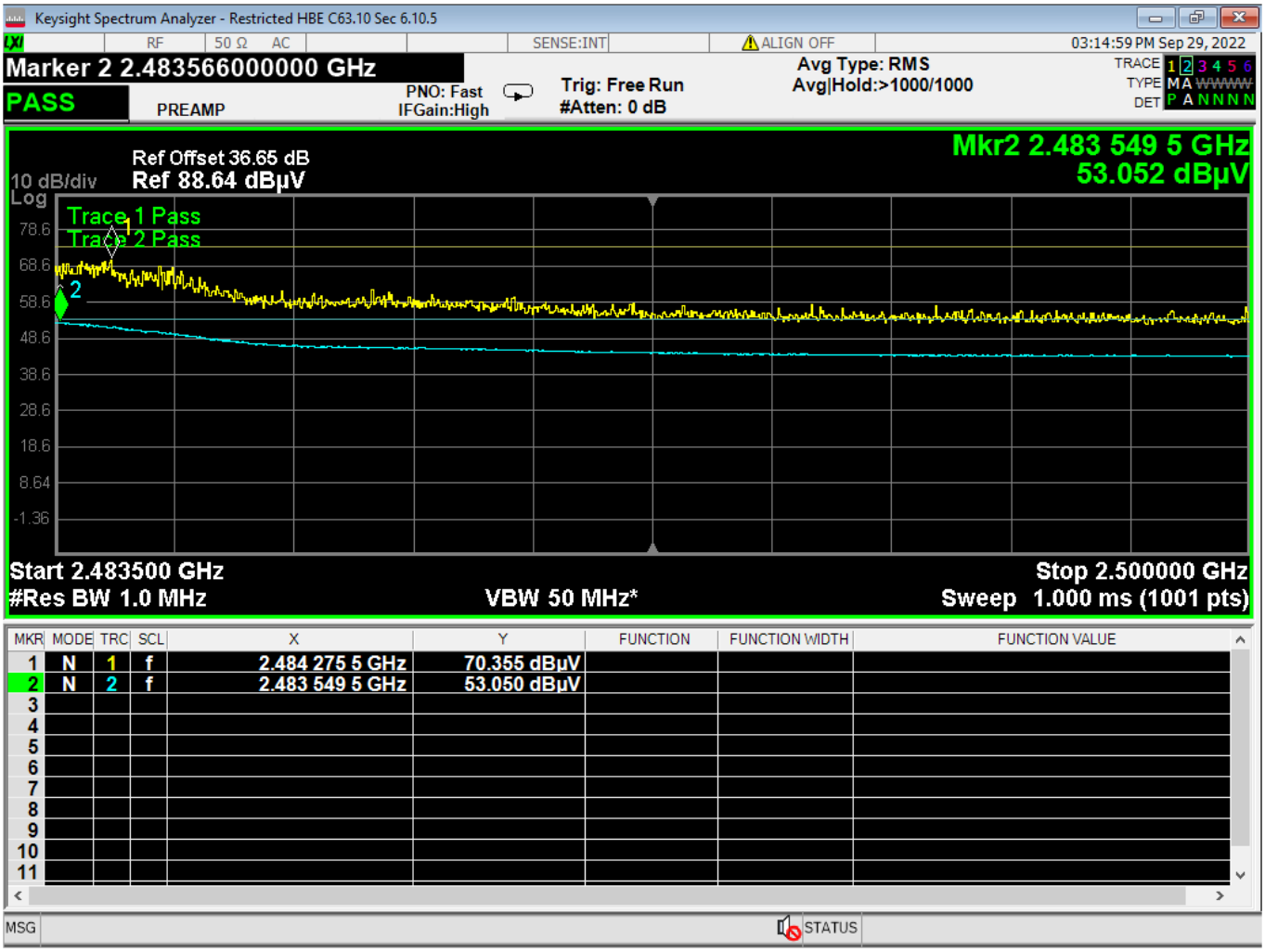
23 Lower Bandedge, Unrestricted, Wifi G, Low Data Rate



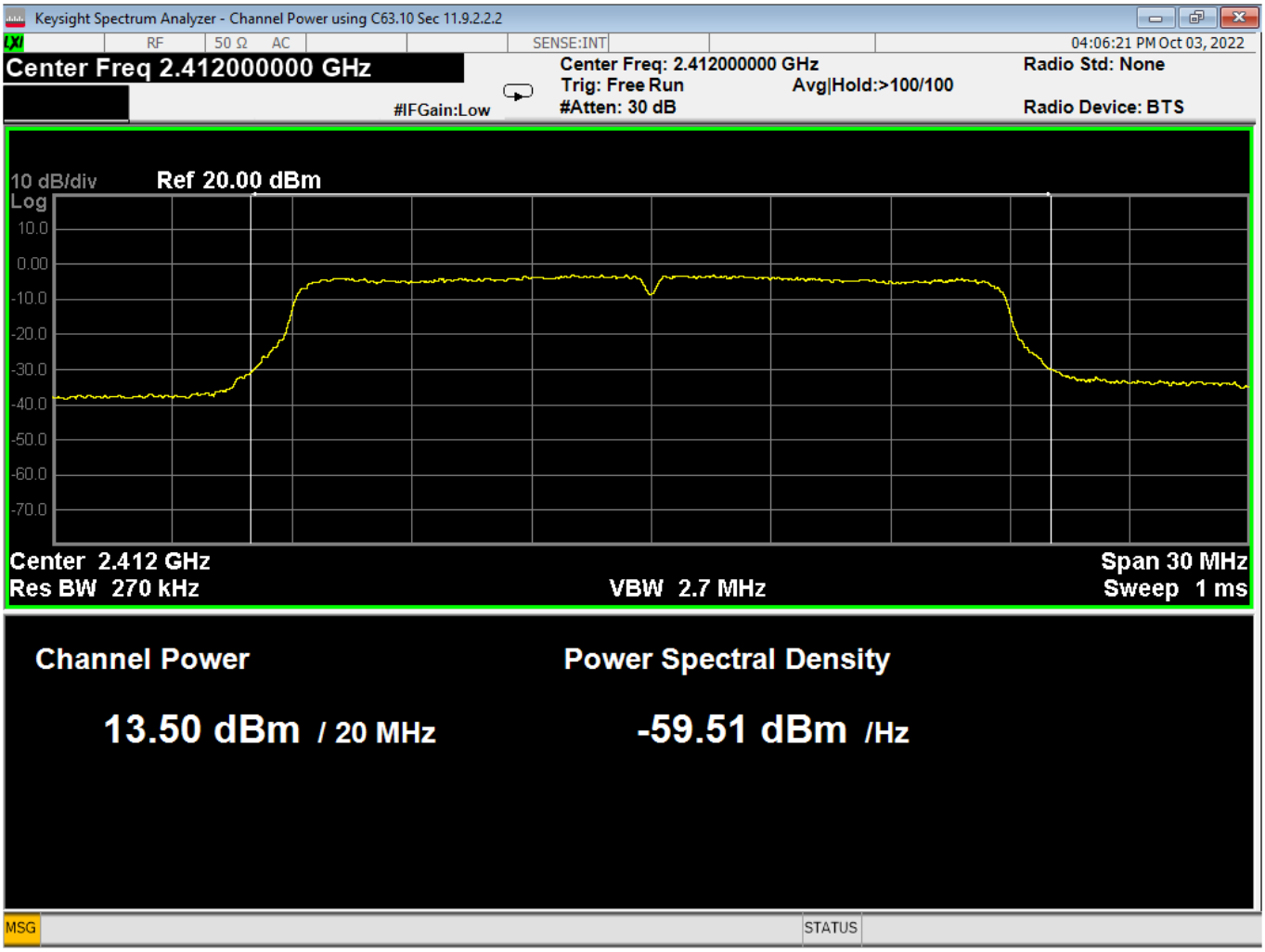
24 Higher Bandedge, Unrestricted, Wifi G, Low Data Rate



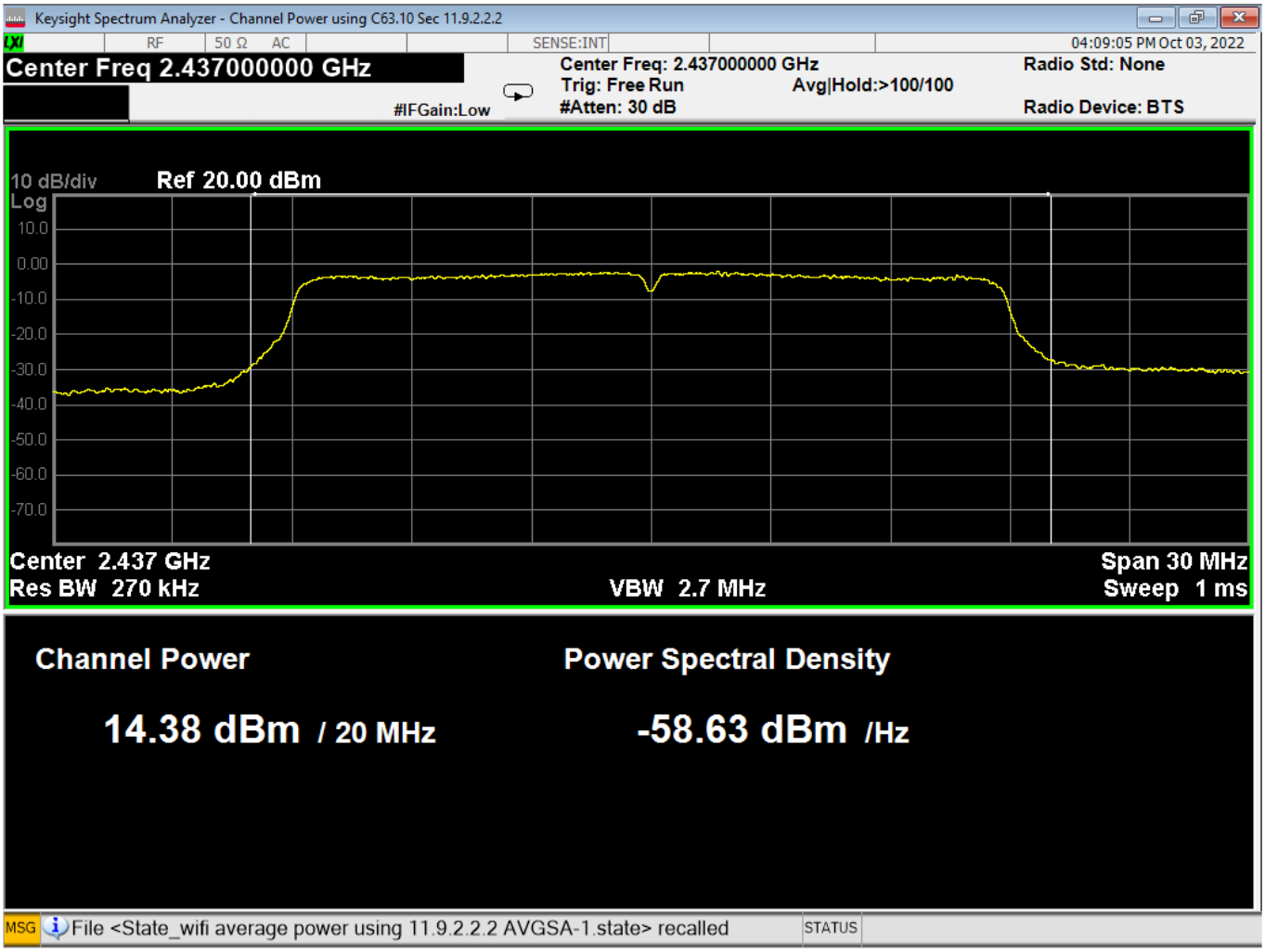
25 Lower Bandedge, Restricted, Wifi G, Low Data Rate



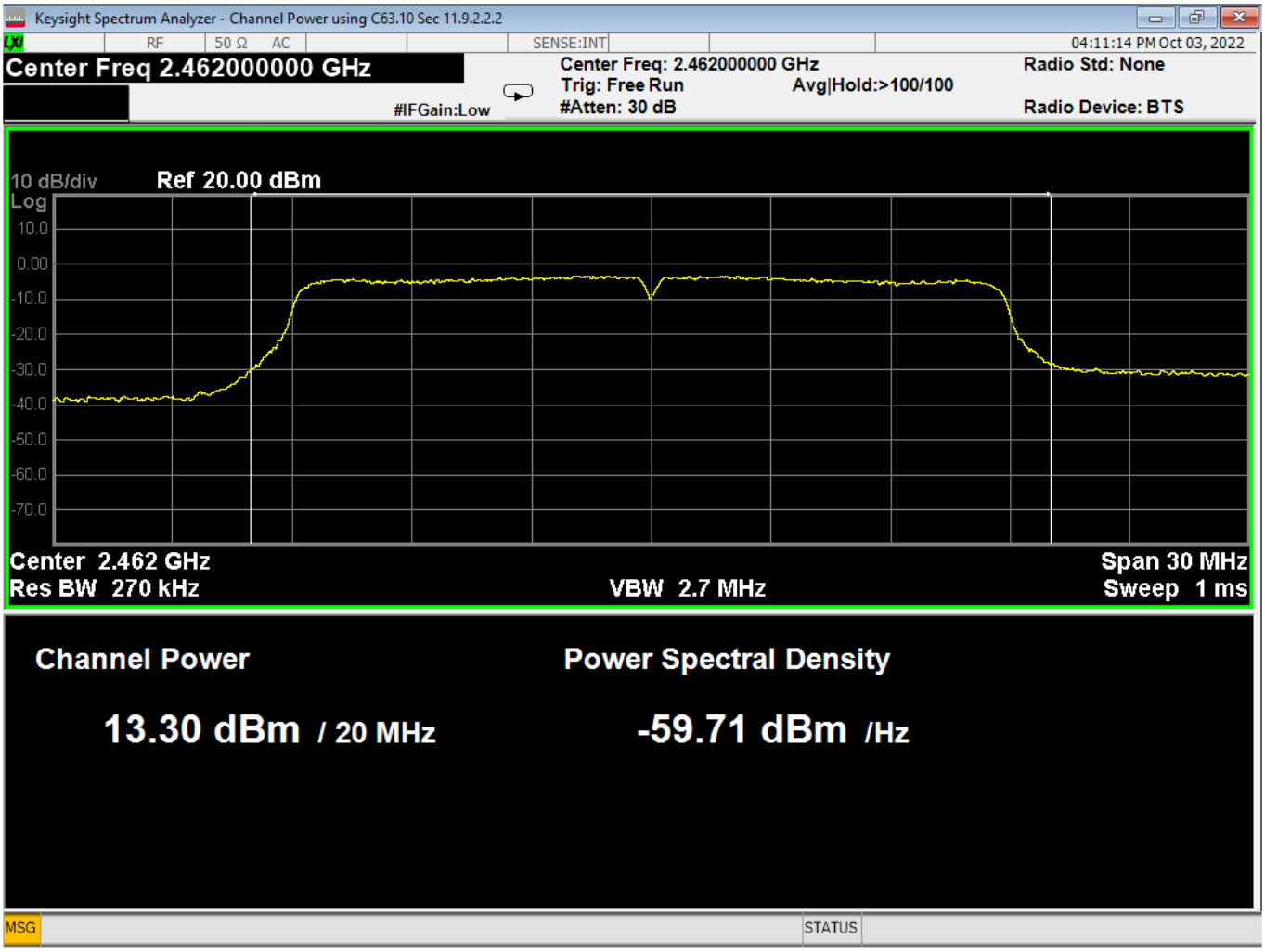
26 Higher Bandedge, Restricted, Wifi G, Low Data Rate



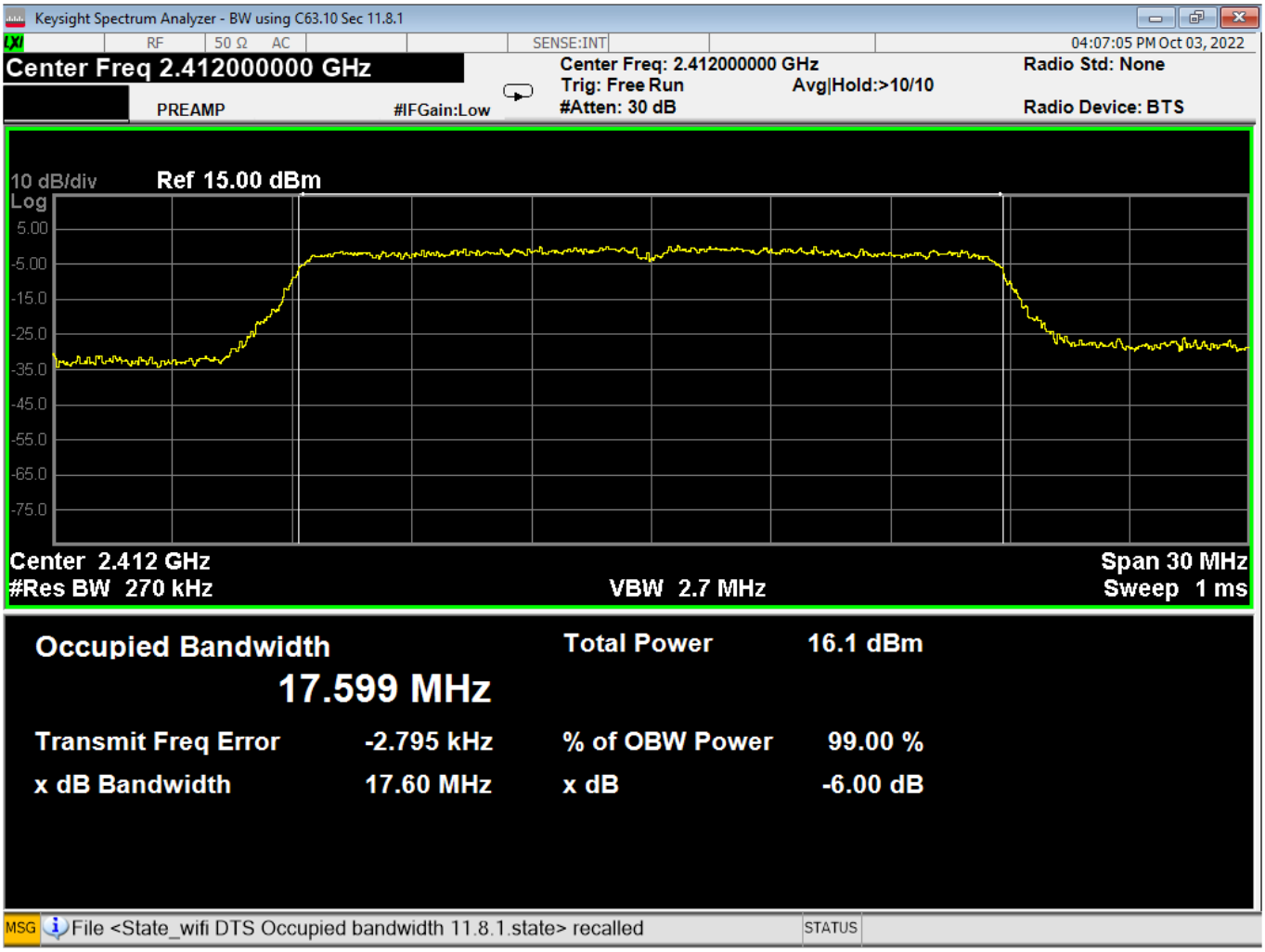
27 Average Power, Low, Wifi N, Low Data Rate



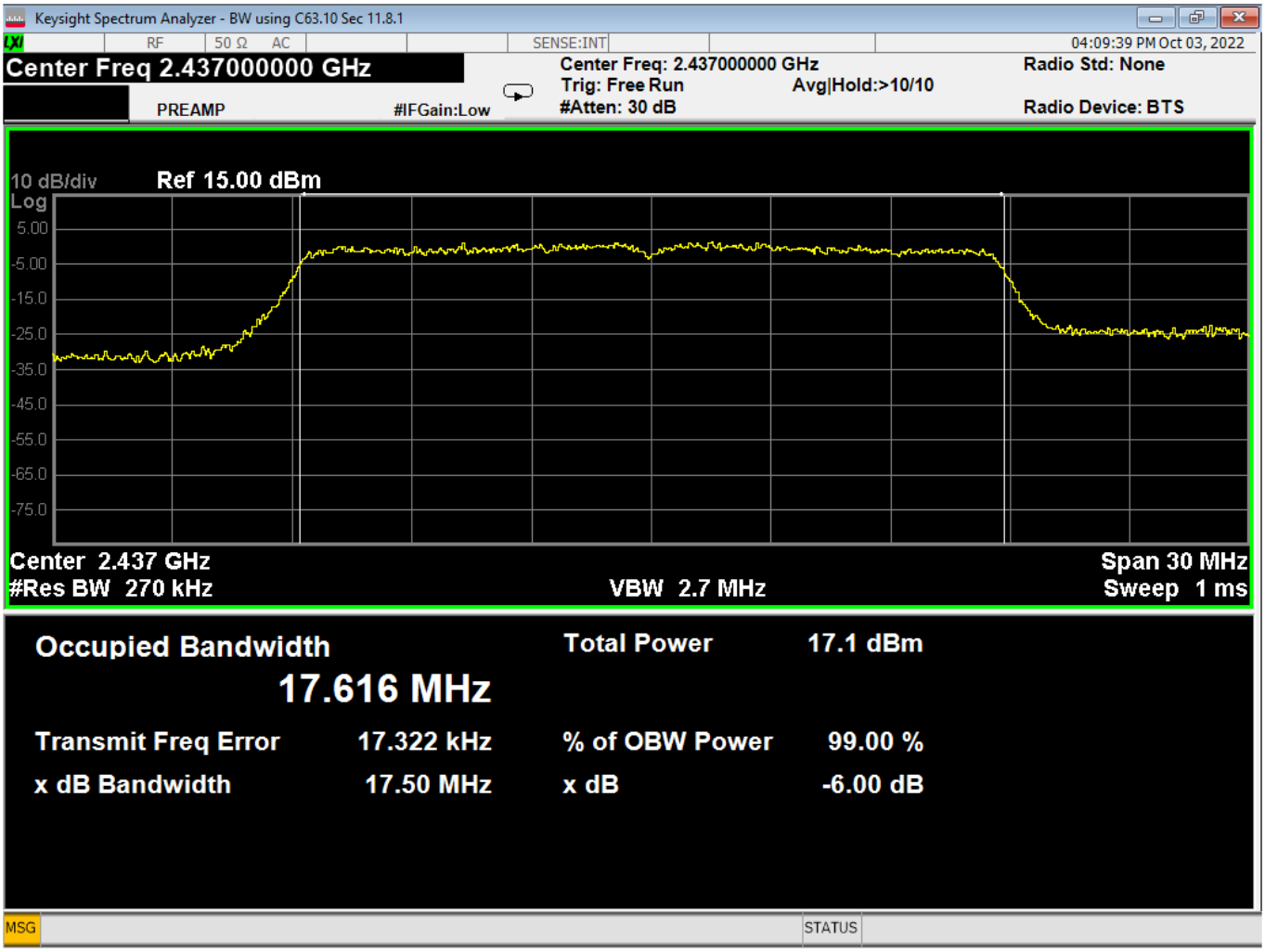
28 Average Power, Mid, Wifi N, Low Data Rate



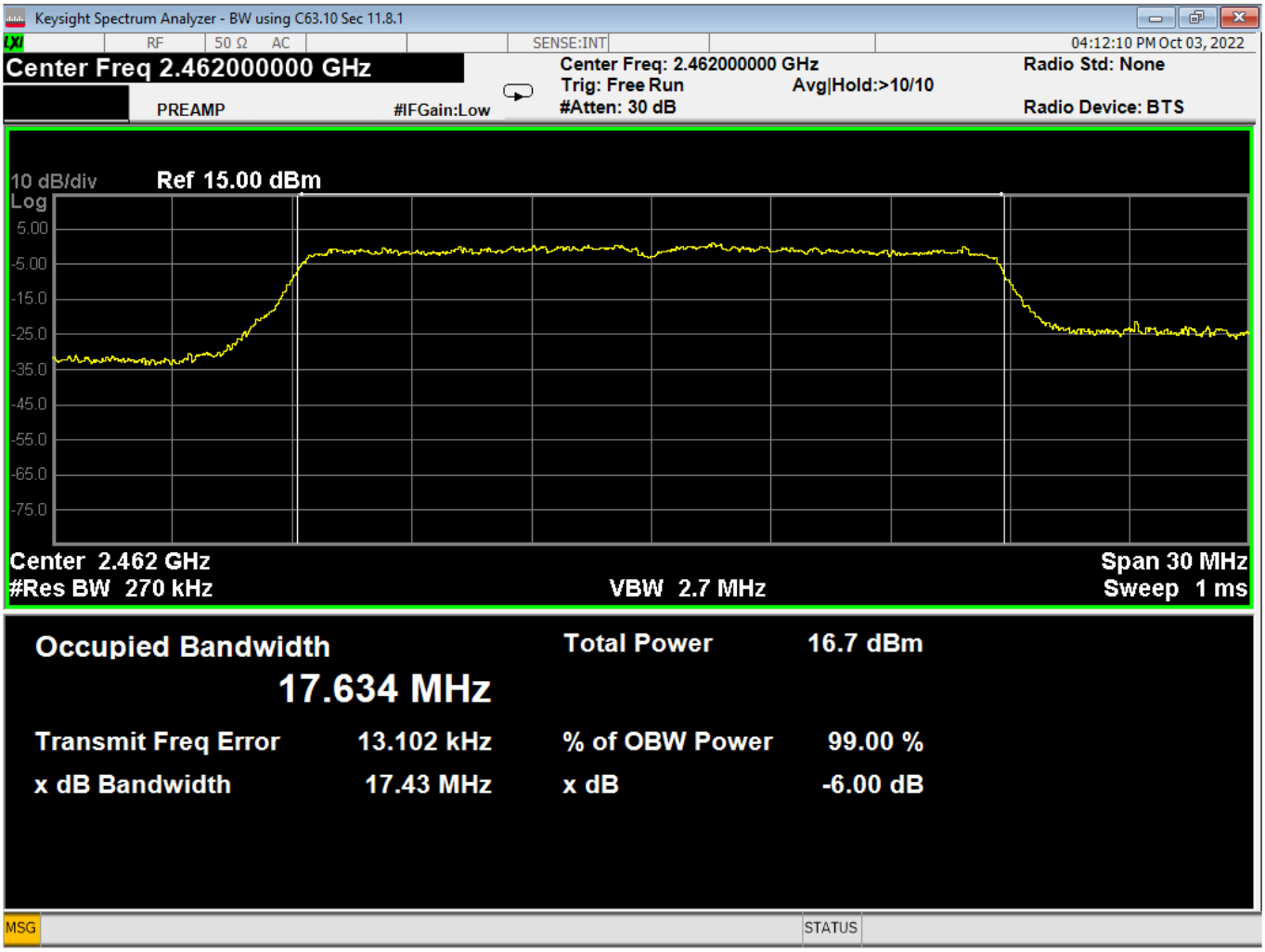
29 Average Power, High, Wifi N, Low Data Rate



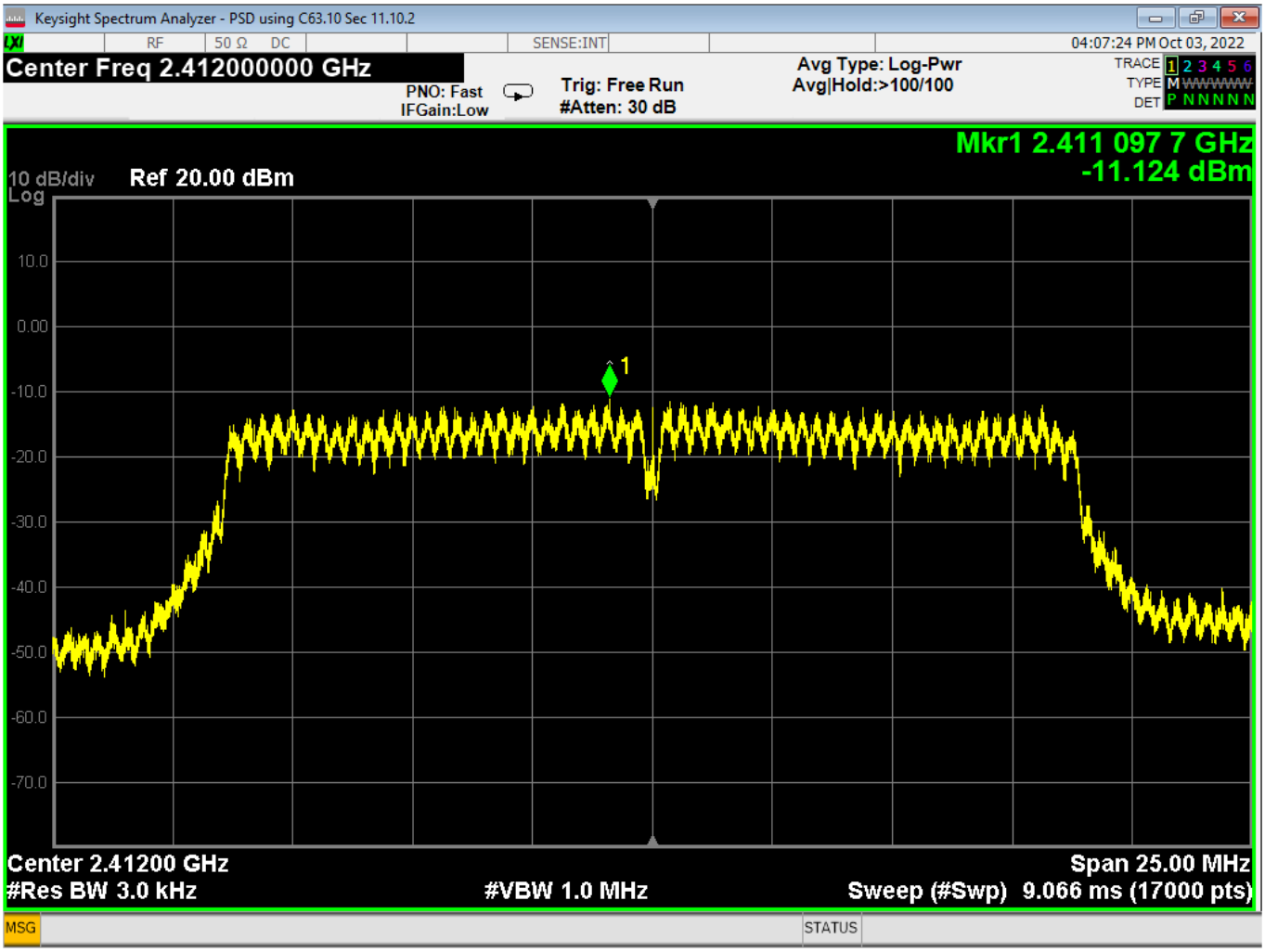
30 Bandwidth, Low, Wifi N, Low Data Rate



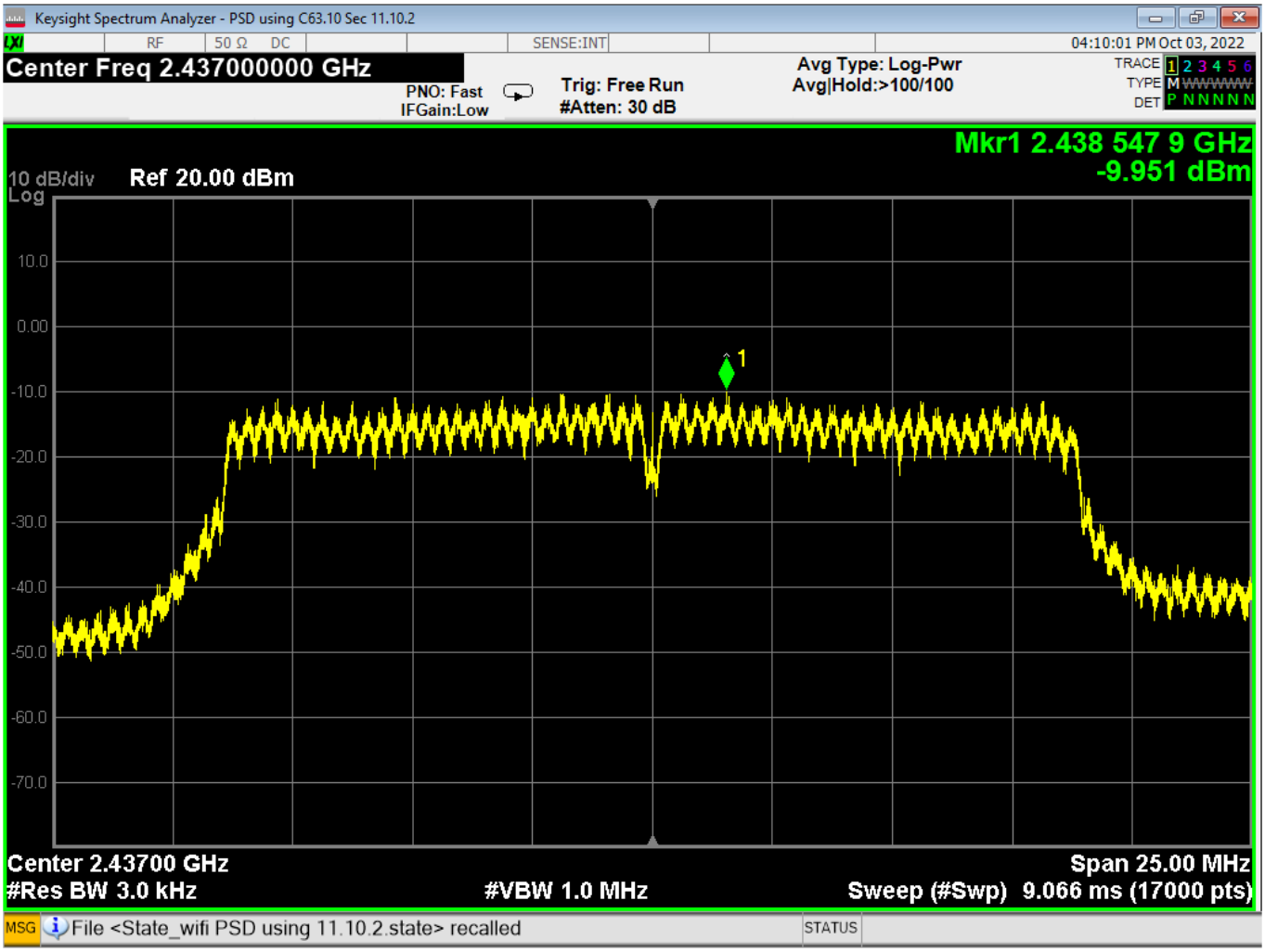
31 Bandwidth, Mid, Wifi N, Low Data Rate



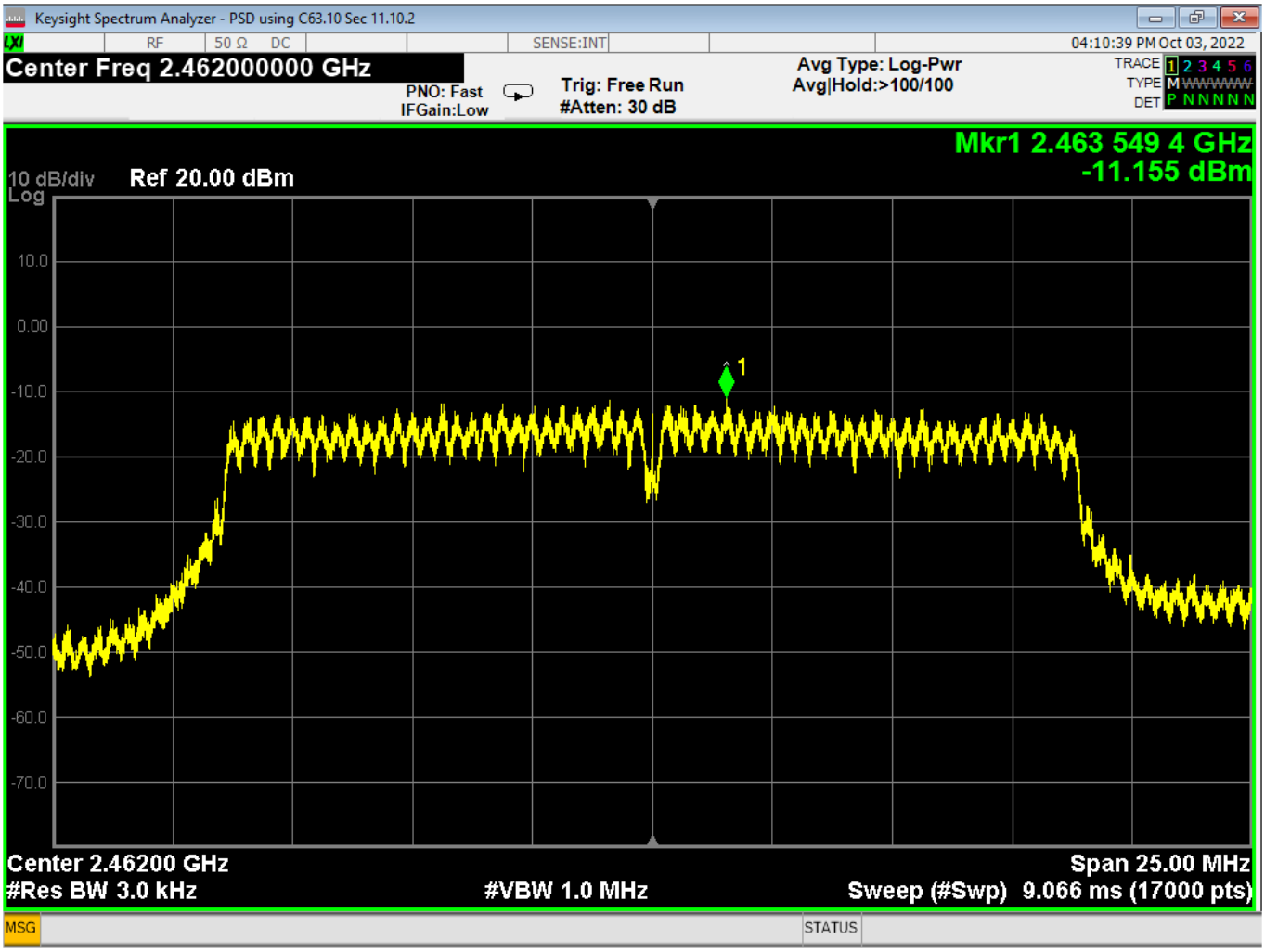
32 Bandwidth, High, Wifi N, Low Data Rate



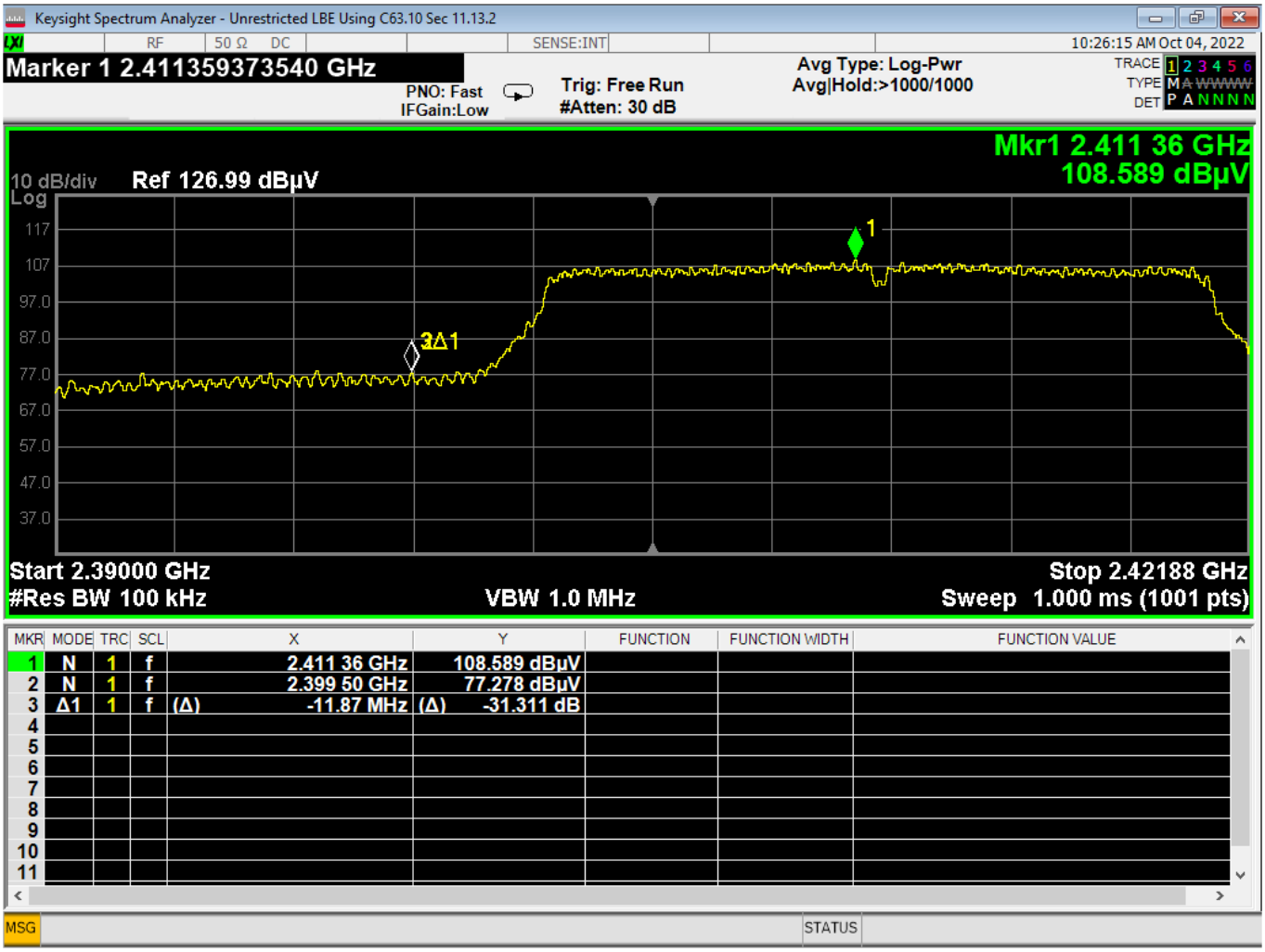
33 PSD, Low, Wifi N, Low Data Rate



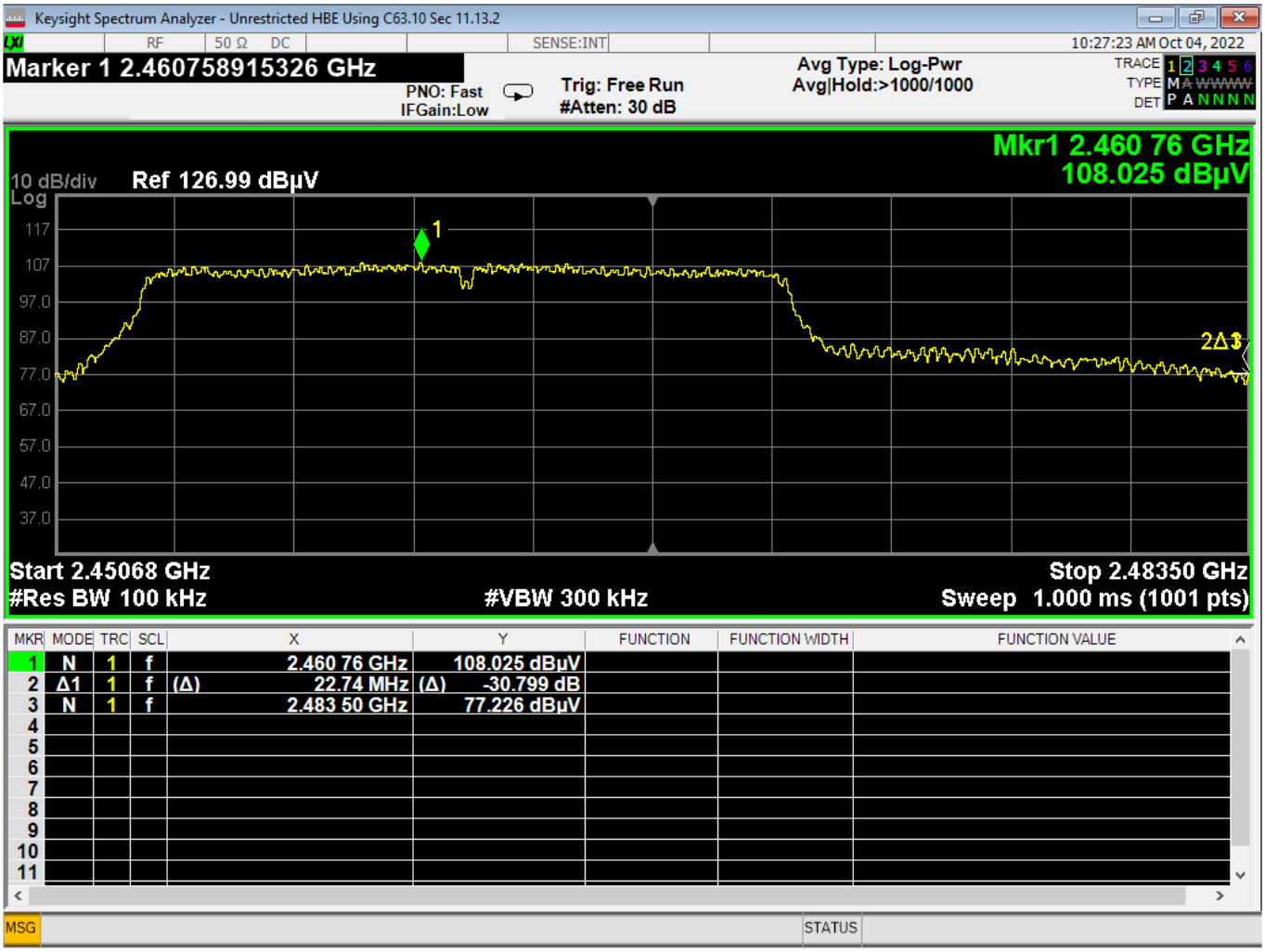
34 PSD, Mid, Wifi N, Low Data Rate



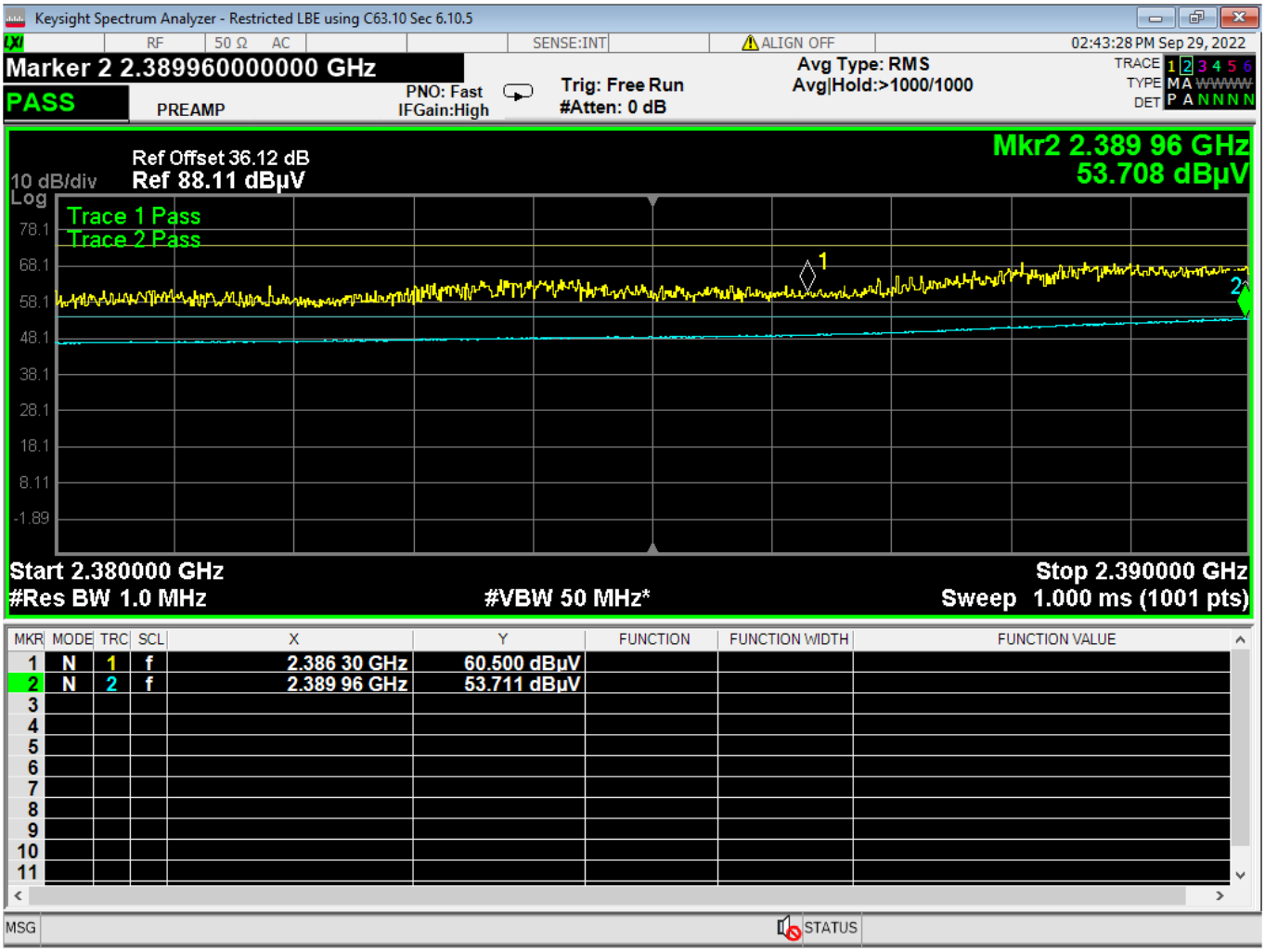
35 PSD, High, Wifi N, Low Data Rate



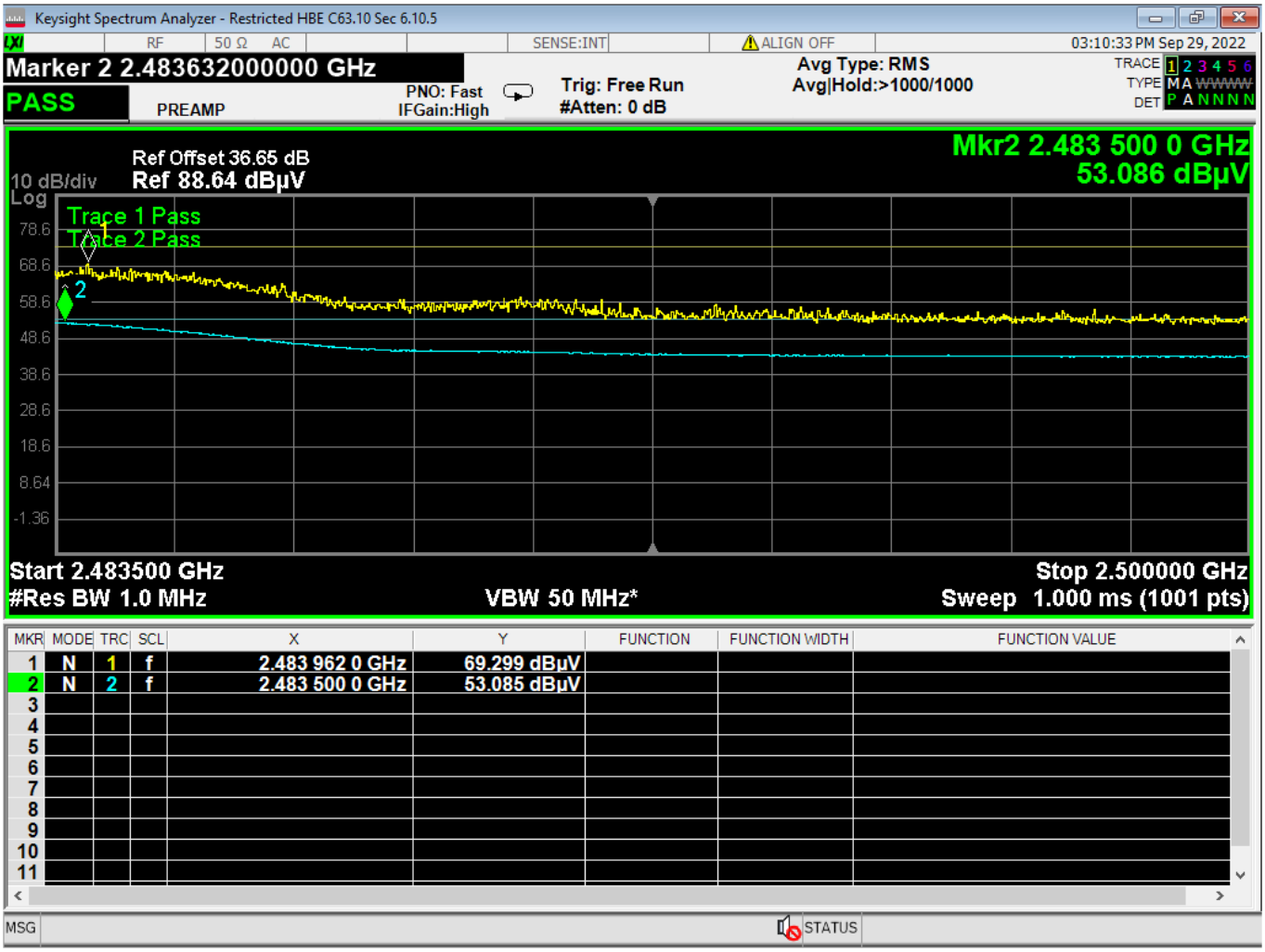
36 Lower Bandedge, Unrestricted, Wifi N, Low Data Rate



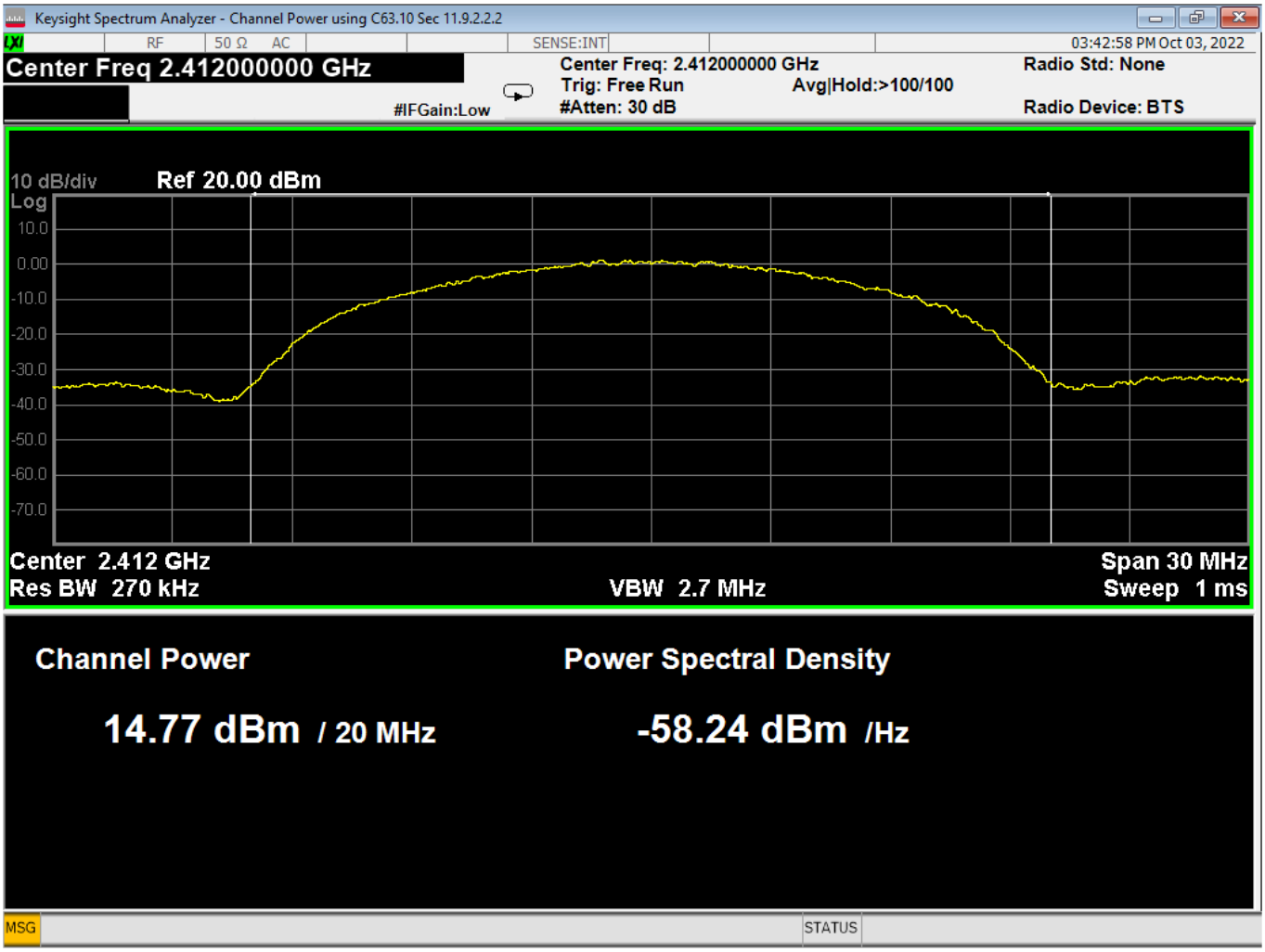
37 Higher Bandedge, Unrestricted, Wifi N, Low Data Rate



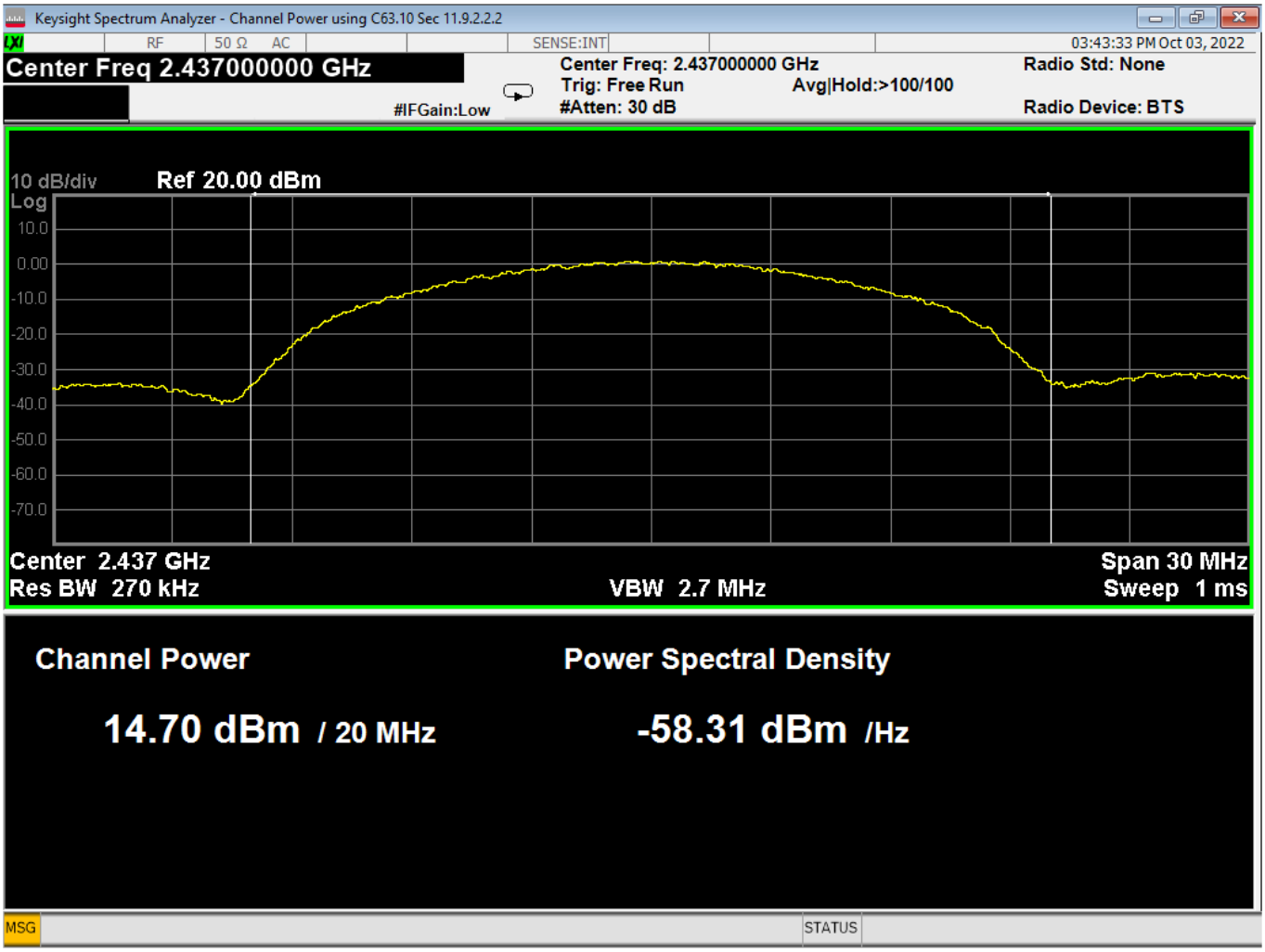
38 Lower Bandedge, Restricted, Wifi N, Low Data Rate



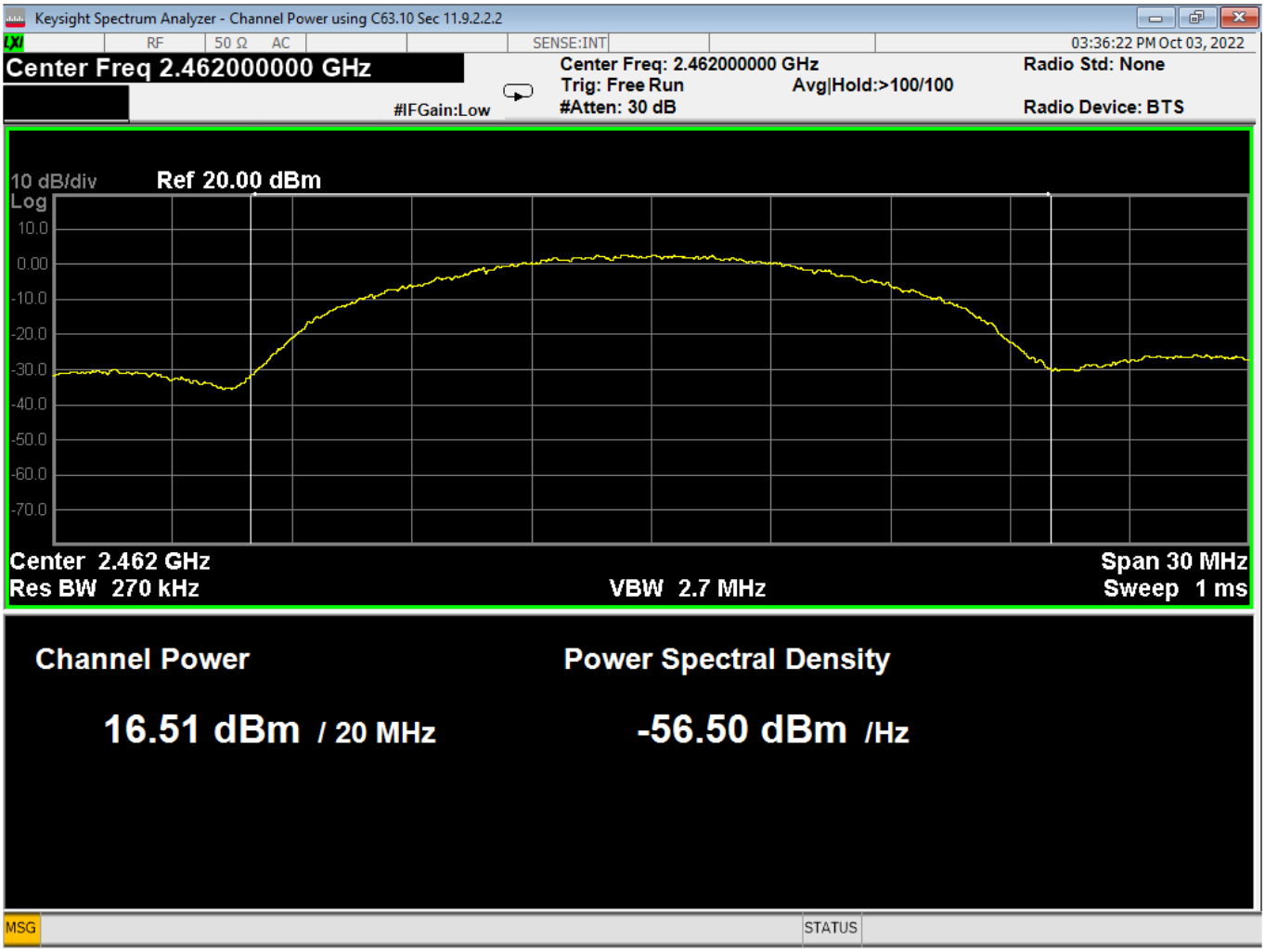
39 Higher Bandedge, Restricted, Wifi N, Low Data Rate



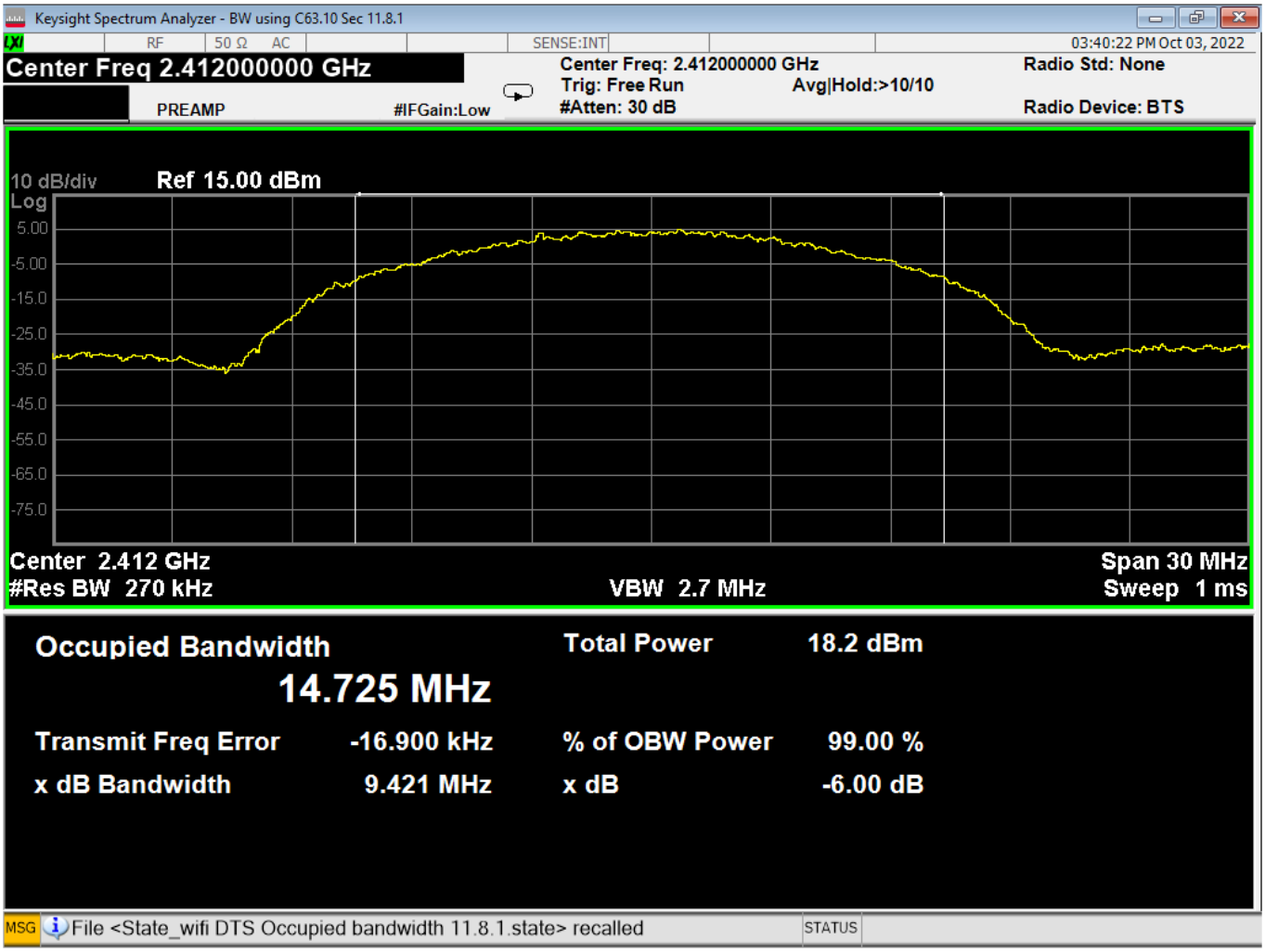
40 Average Power, Low, Wifi B, High Data Rate



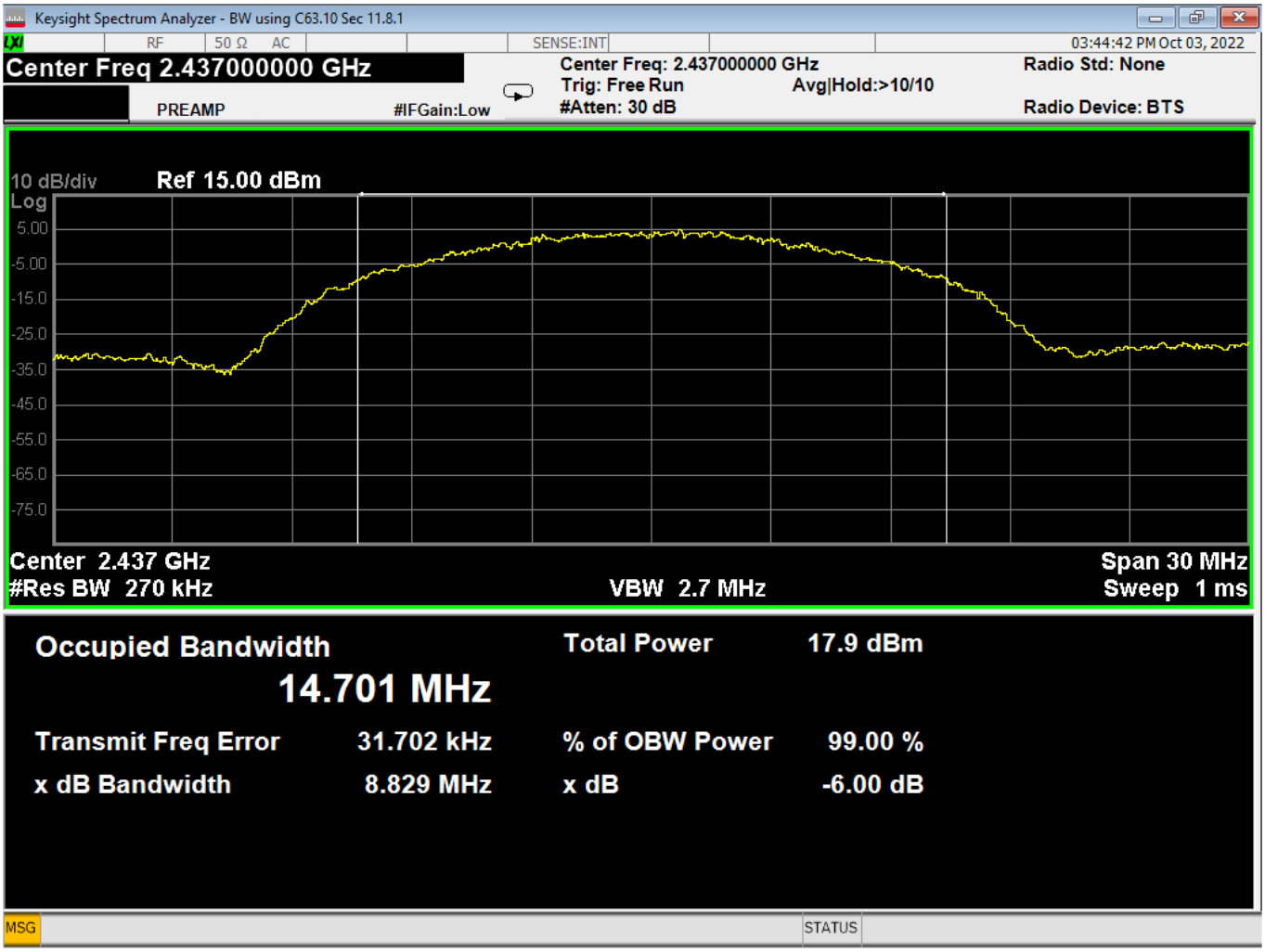
41 Average Power, Mid, Wifi B, High Data Rate



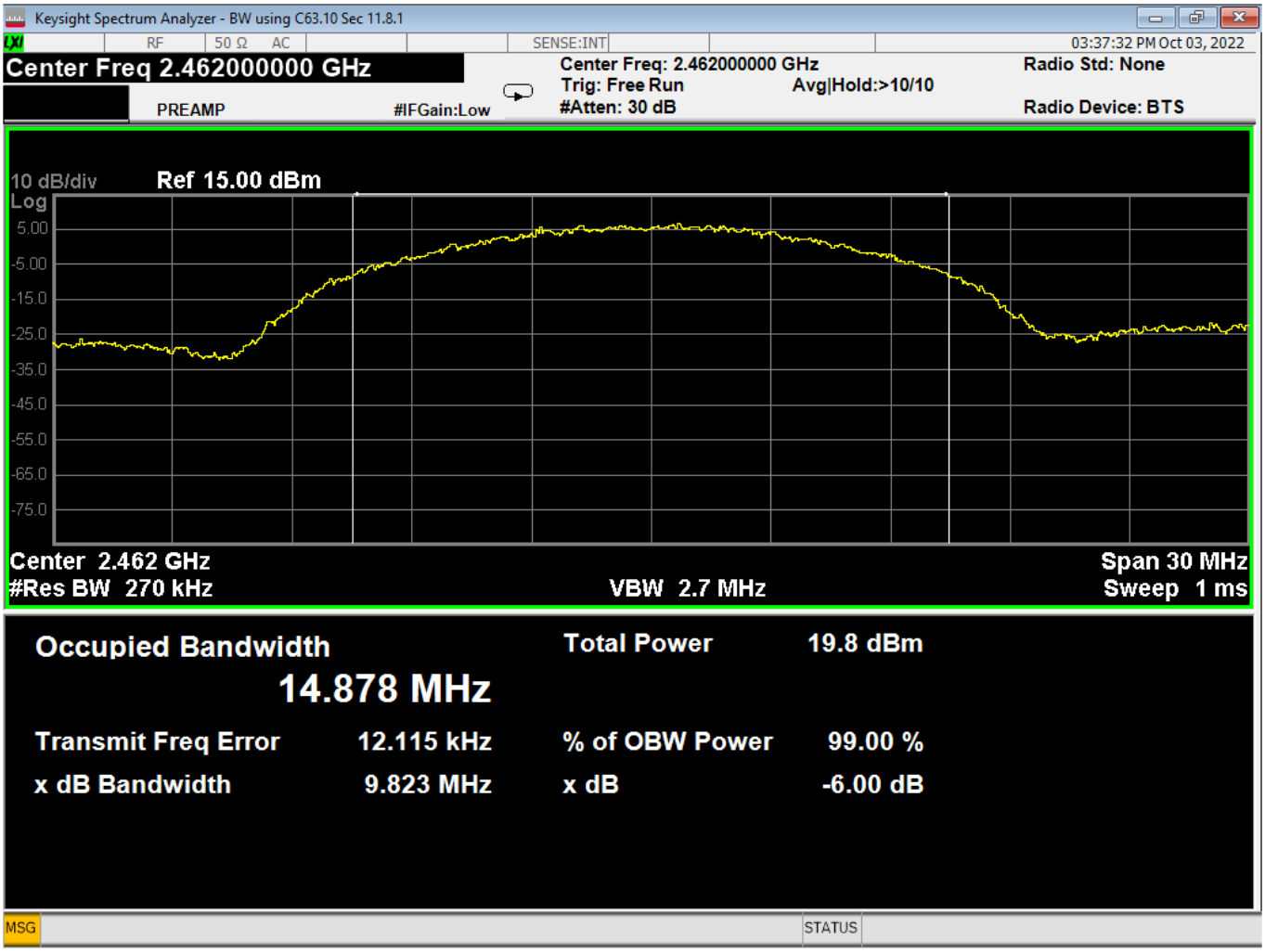
42 Average Power, High, Wifi B, High Data Rate



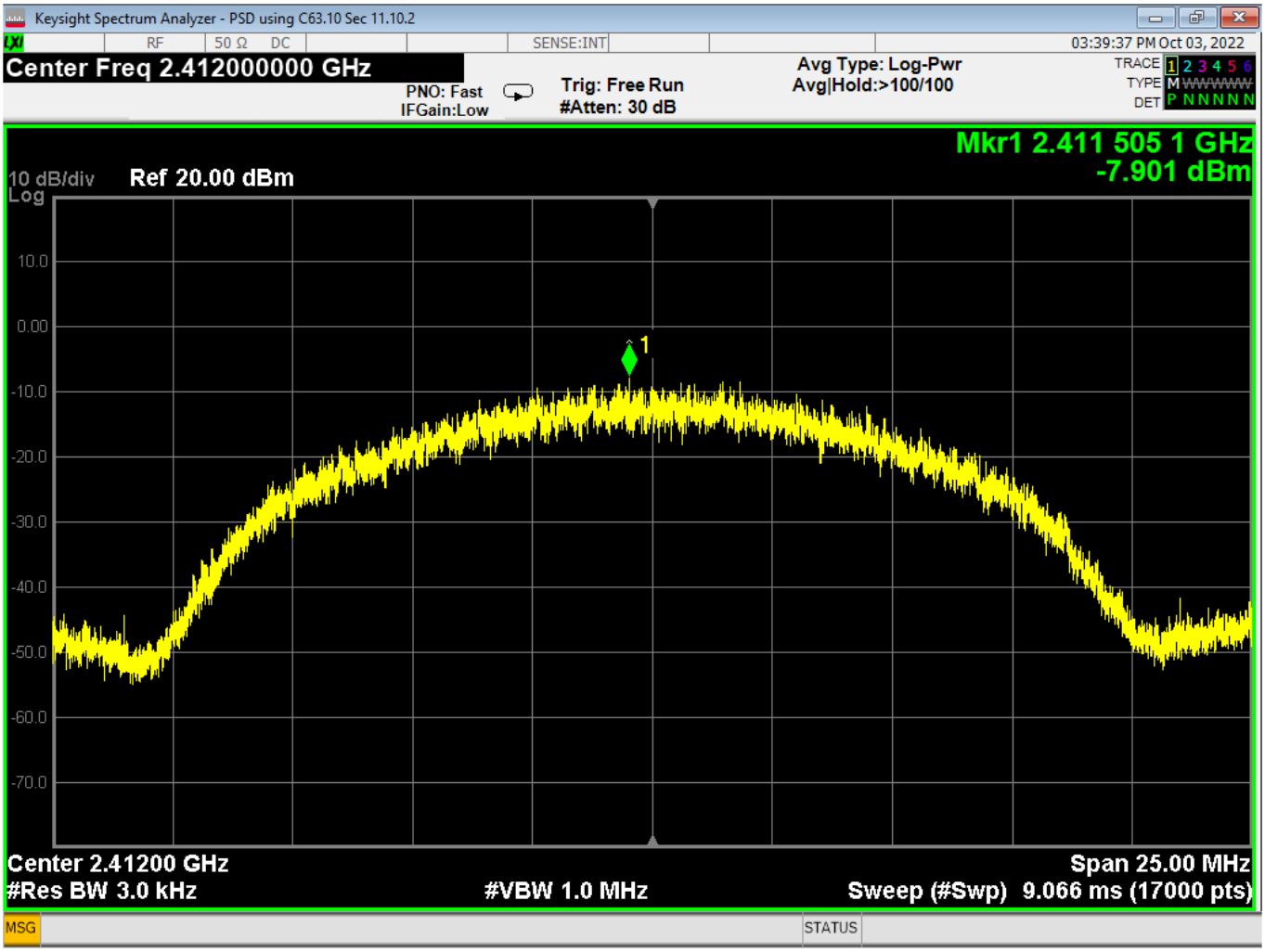
43 Bandwidth, Low, Wifi B, High Data Rate



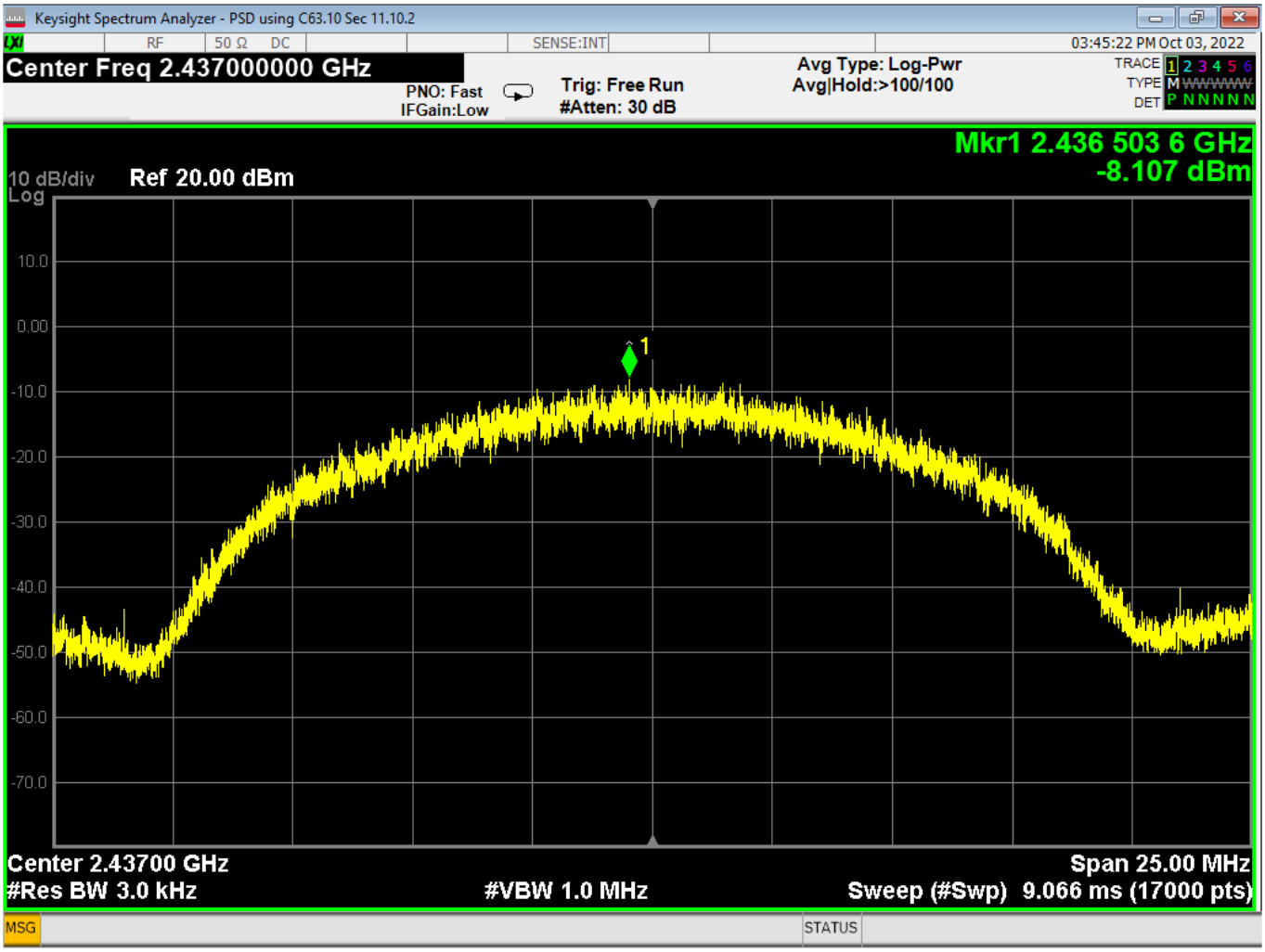
44 Bandwidth, Mid, Wifi B, High Data Rate



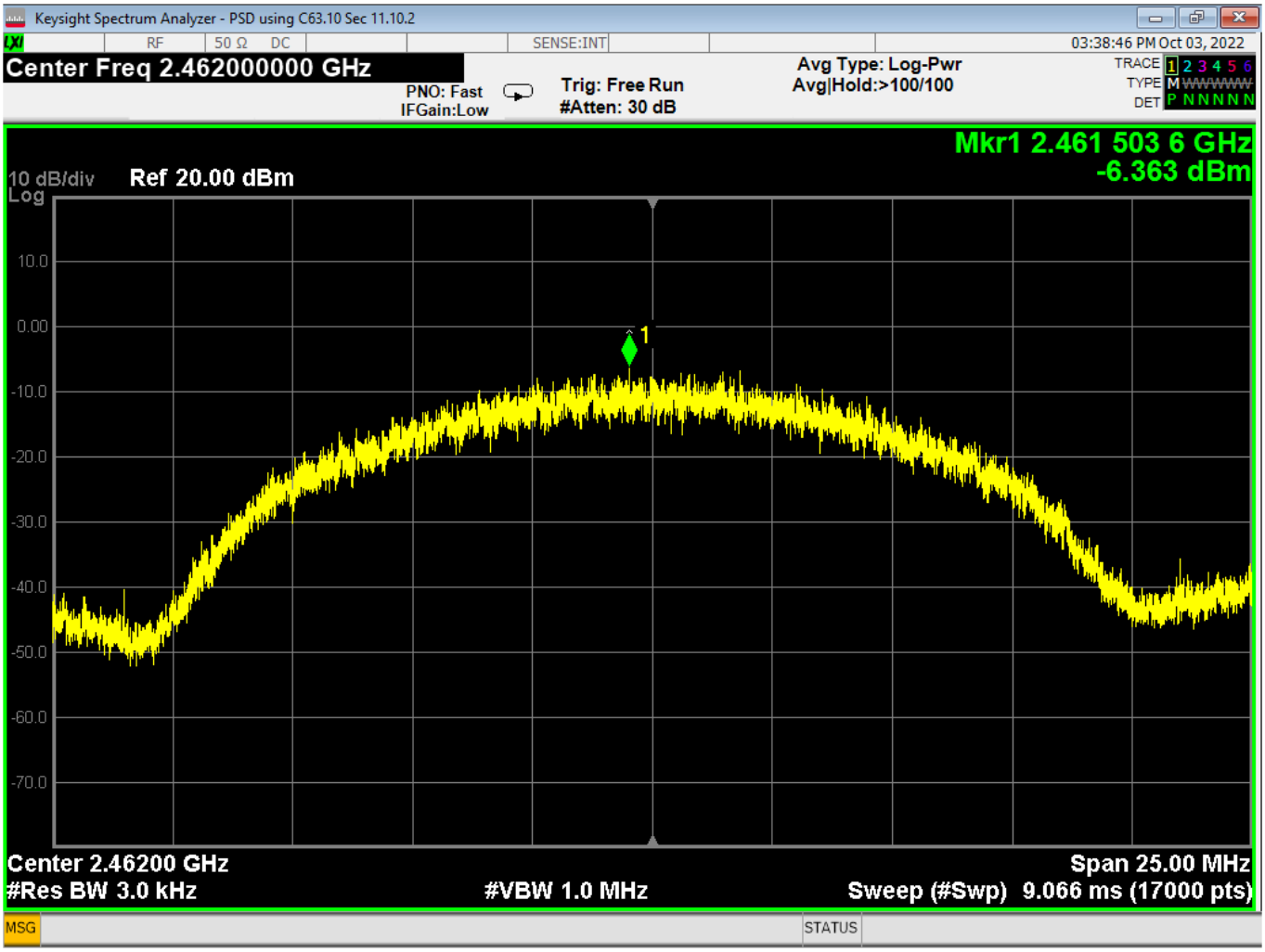
45 Bandwidth, High, Wifi B, High Data Rate



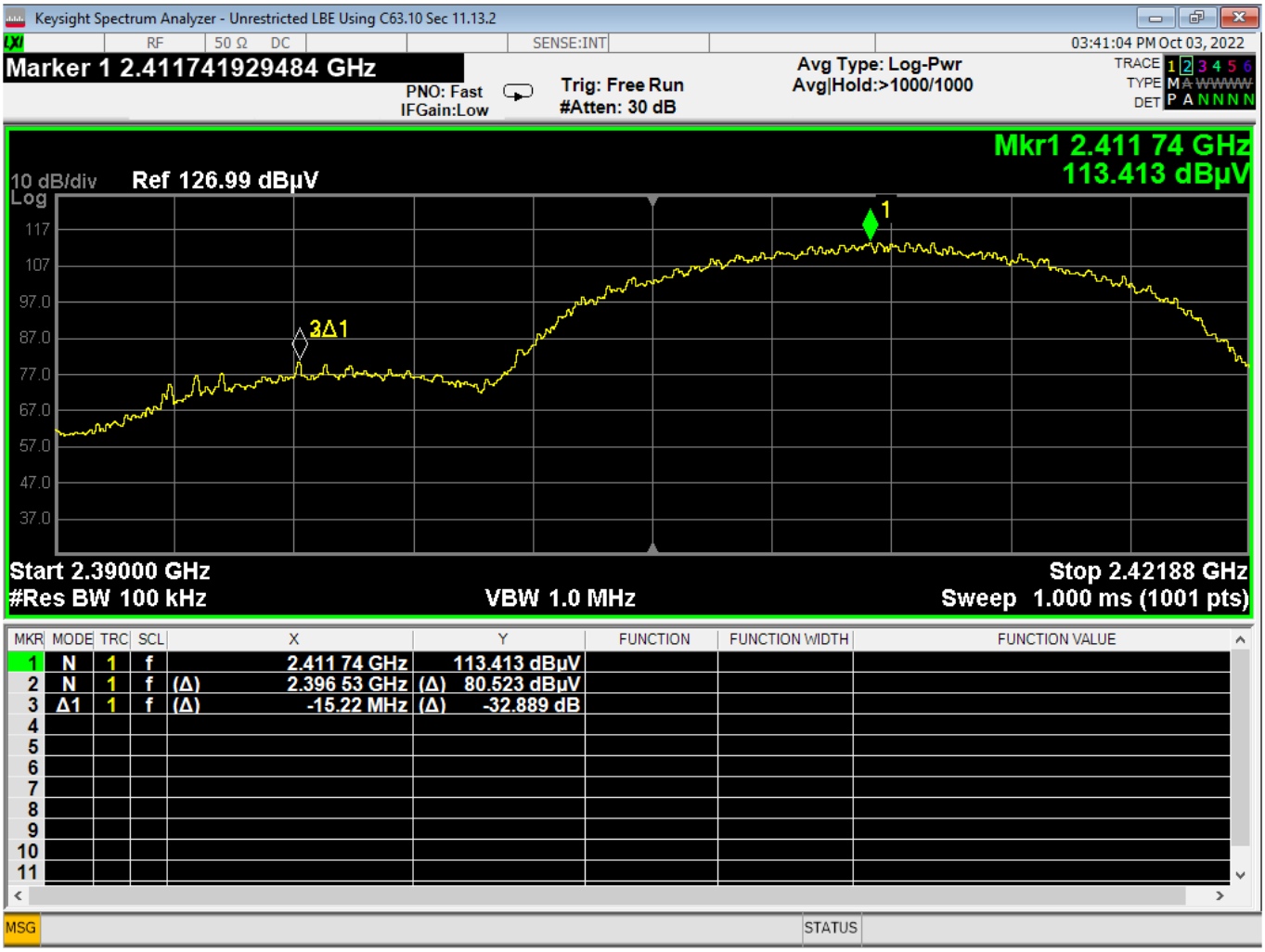
46 PSD, Low, Wifi B, High Data Rate



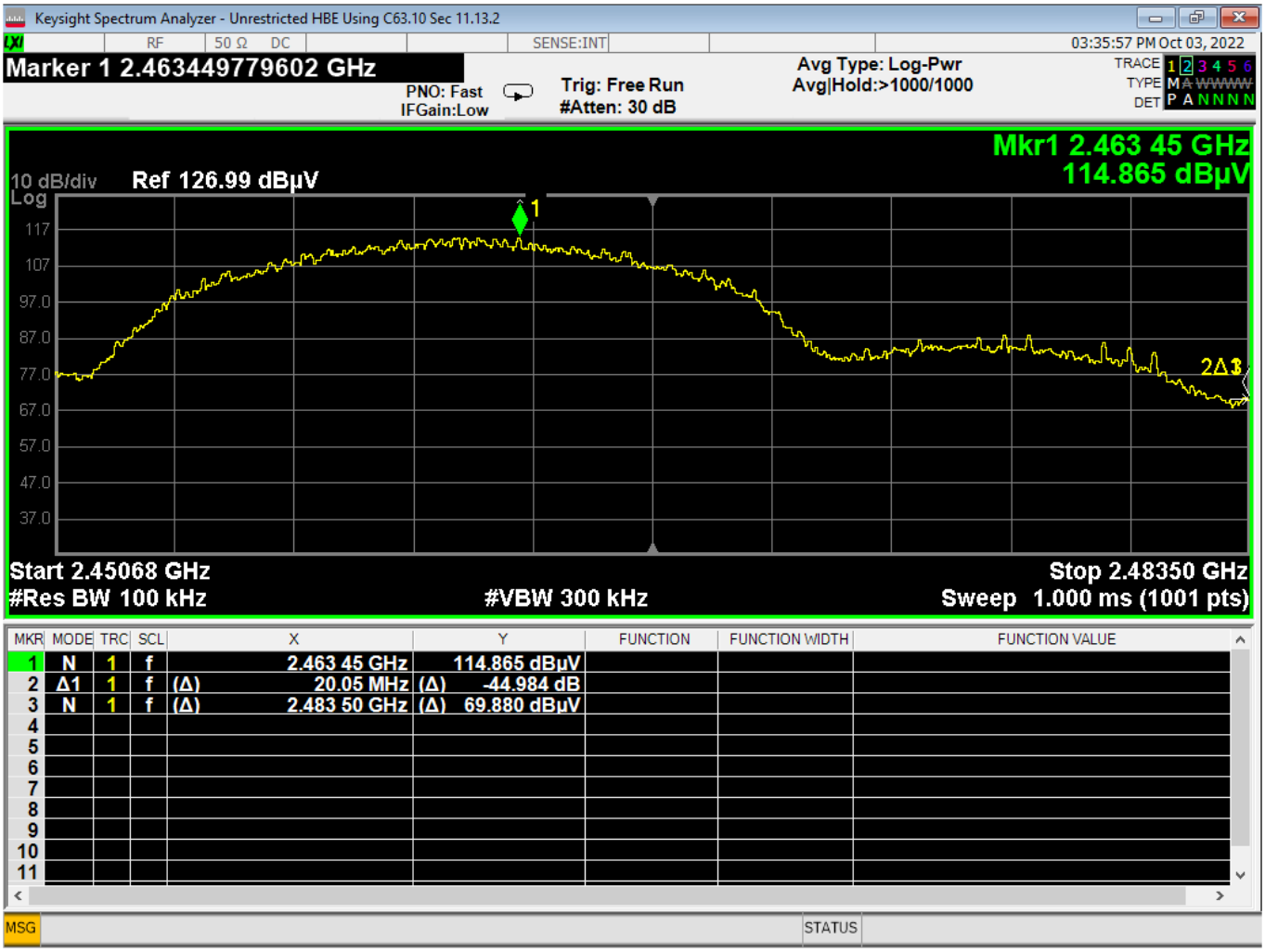
47 PSD, Mid, Wifi B, High Data Rate



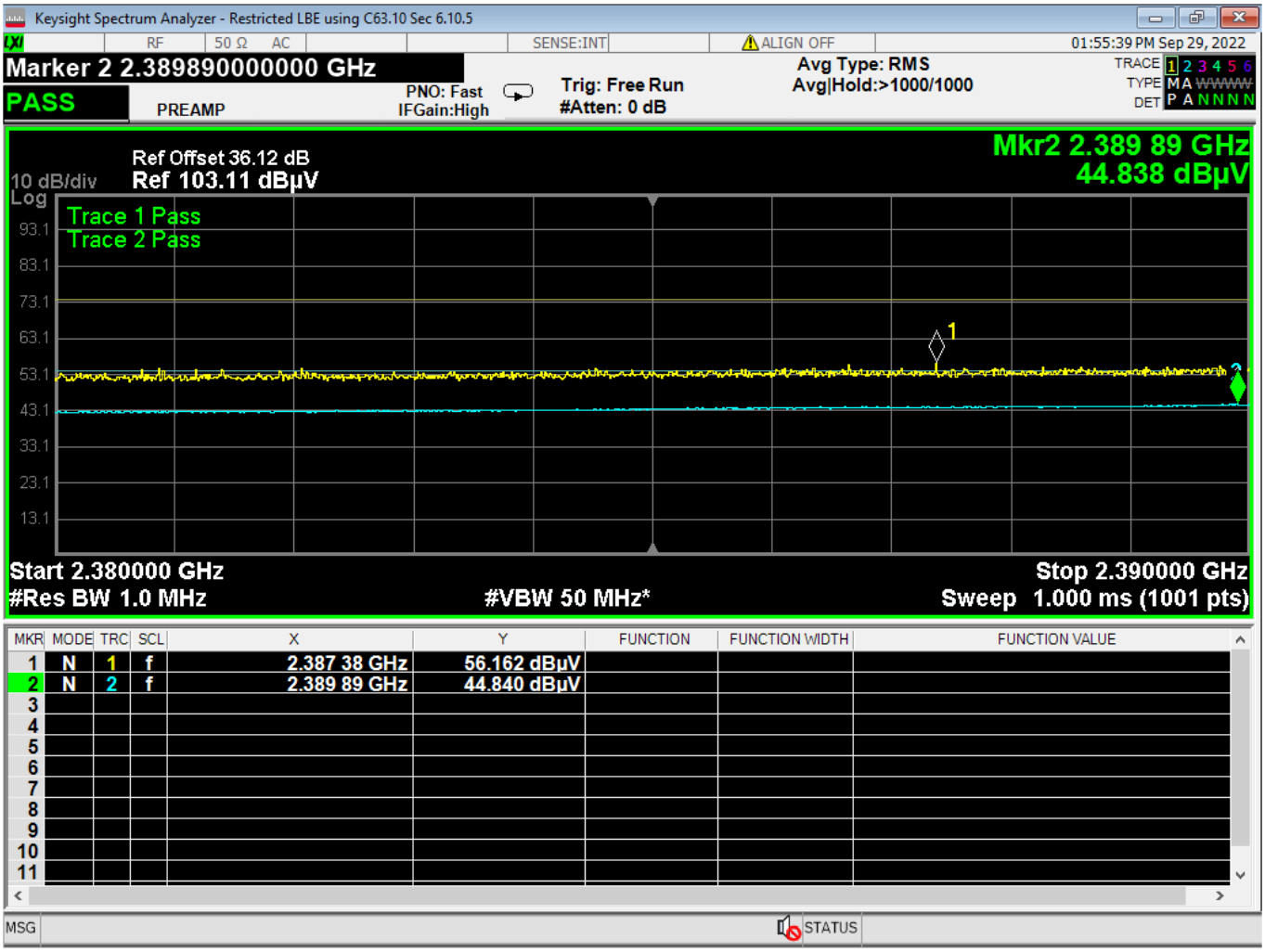
48 PSD, High, Wifi B, High Data Rate



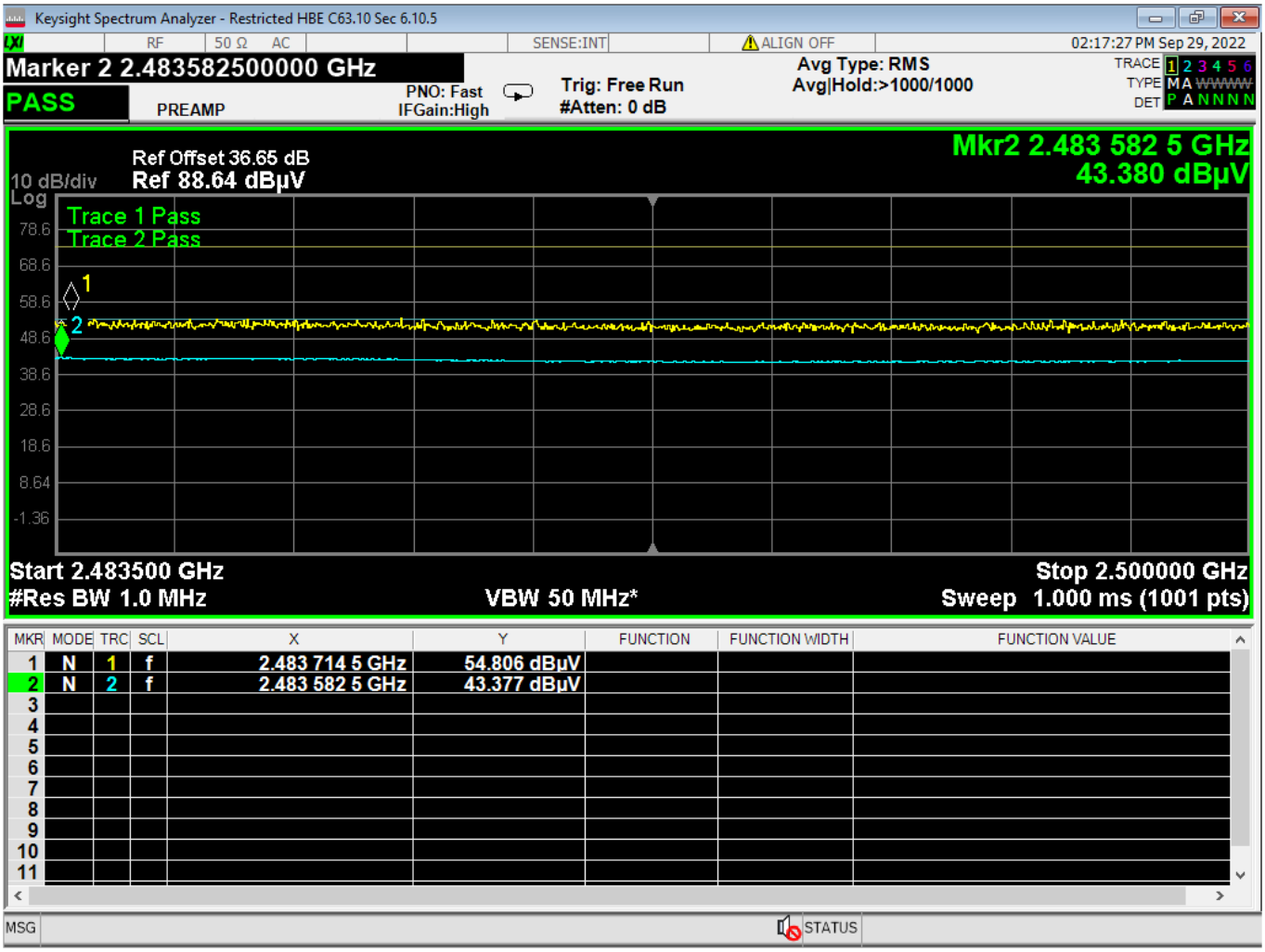
49 Lower Bandedge, Unrestricted, Wifi B, High Data Rate



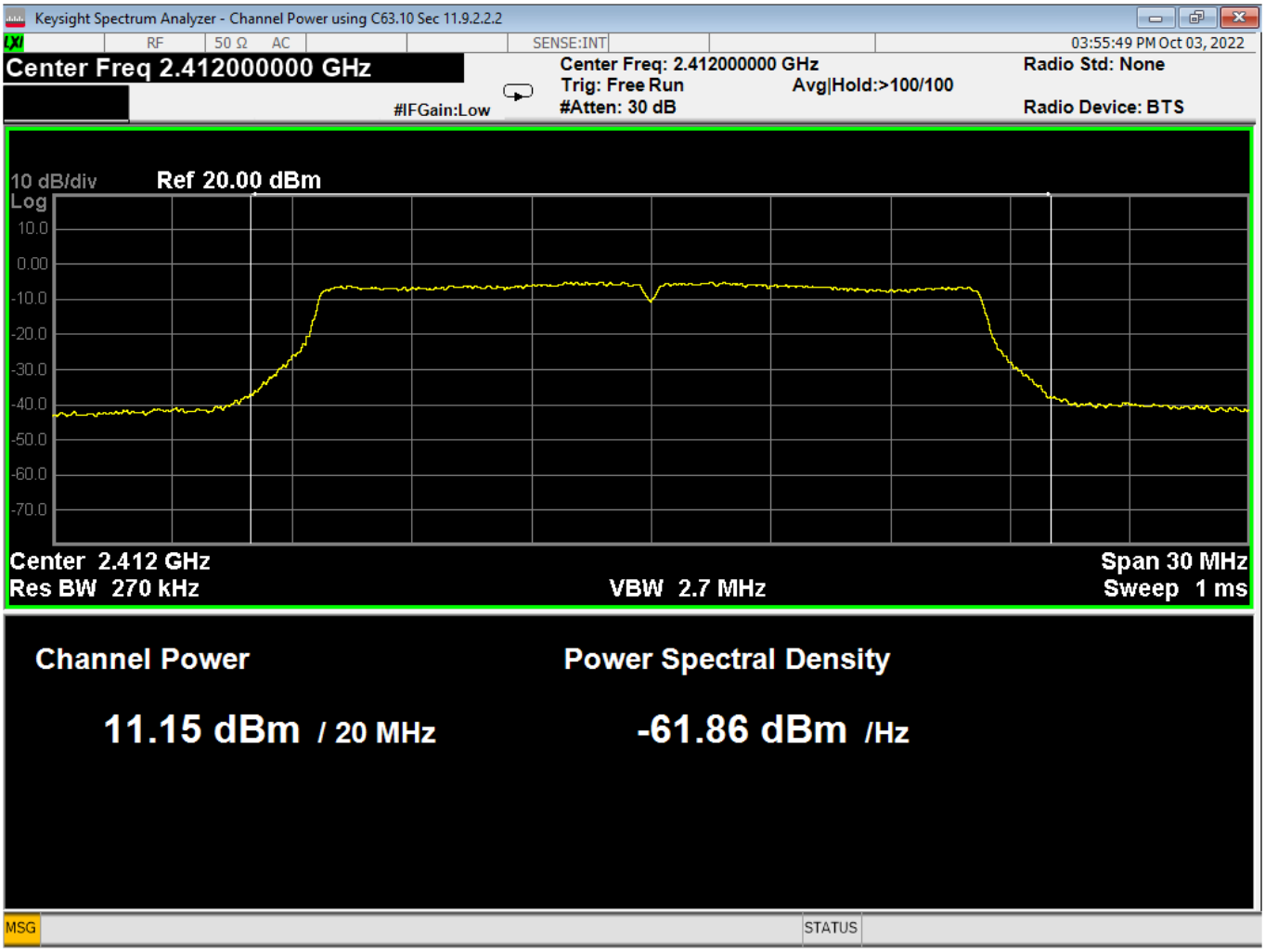
50 Higher Bandedge, Unrestricted, Wifi B, High Data Rate



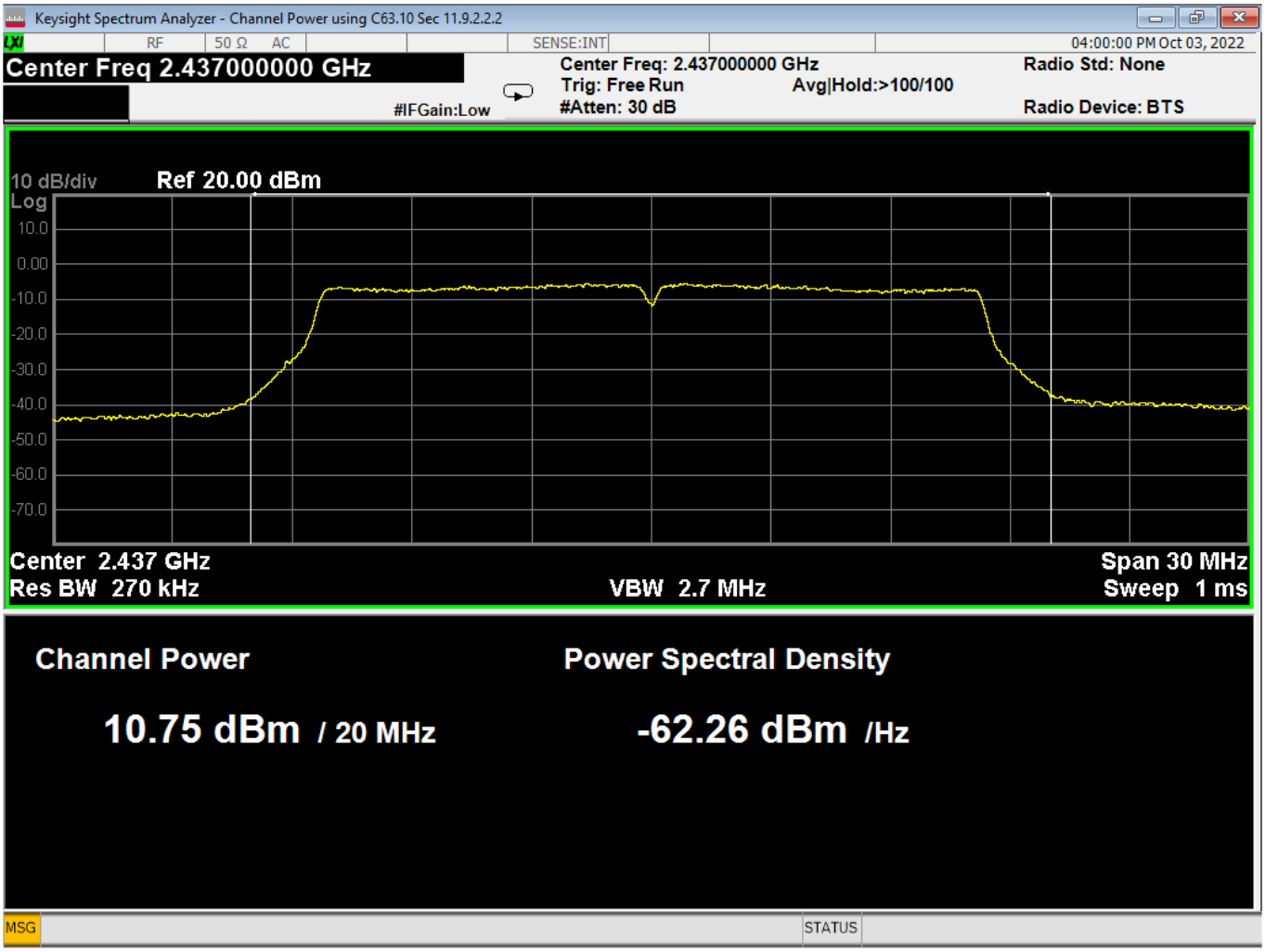
51 Lower Bandedge, Restricted, Wifi B, High Data Rate



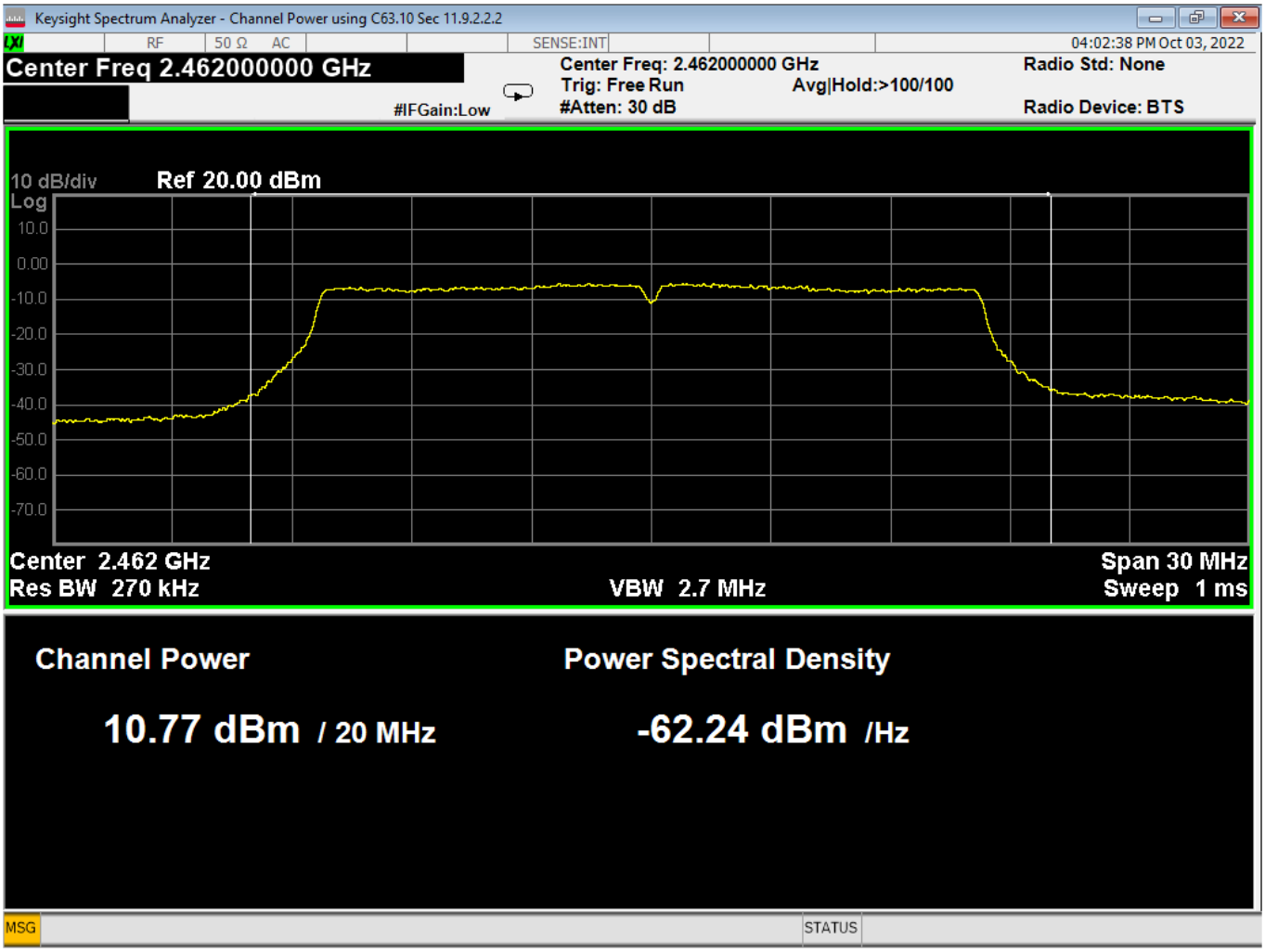
52 Higher Bandedge, Restricted, Wifi B, High Data Rate



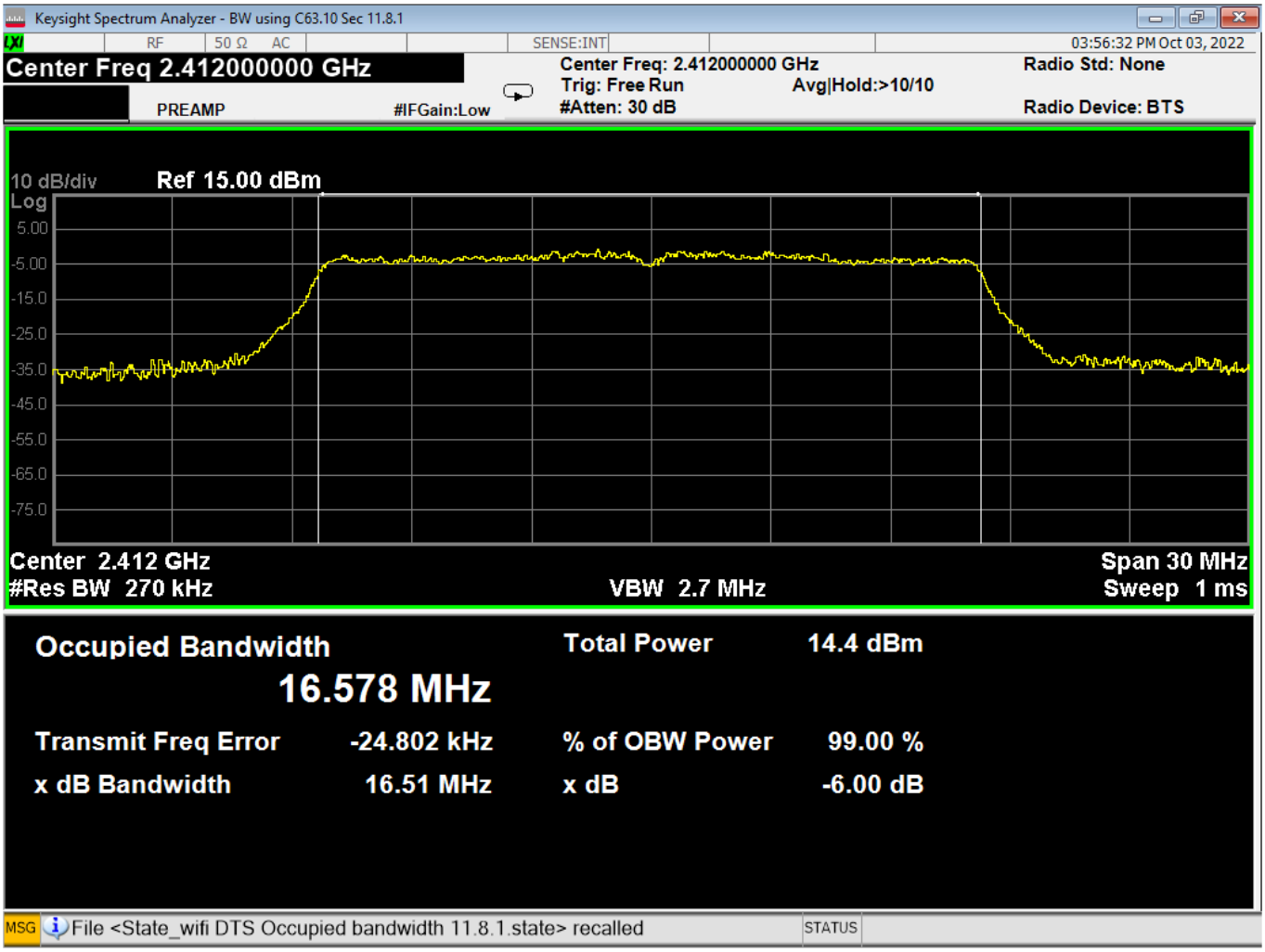
53 Average Power, Low, Wifi G, High Data Rate



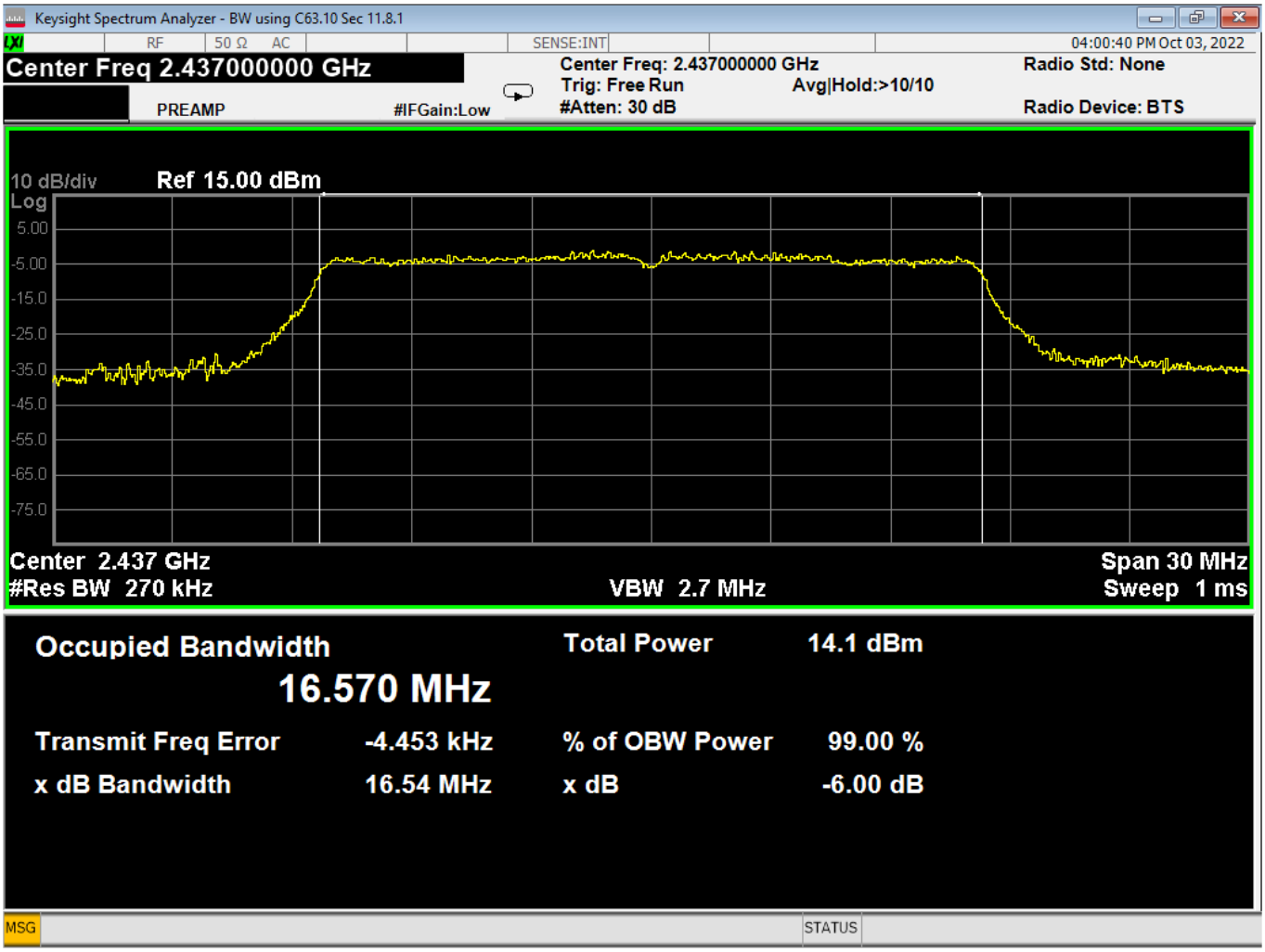
54 Average Power, Mid, Wifi G, High Data Rate



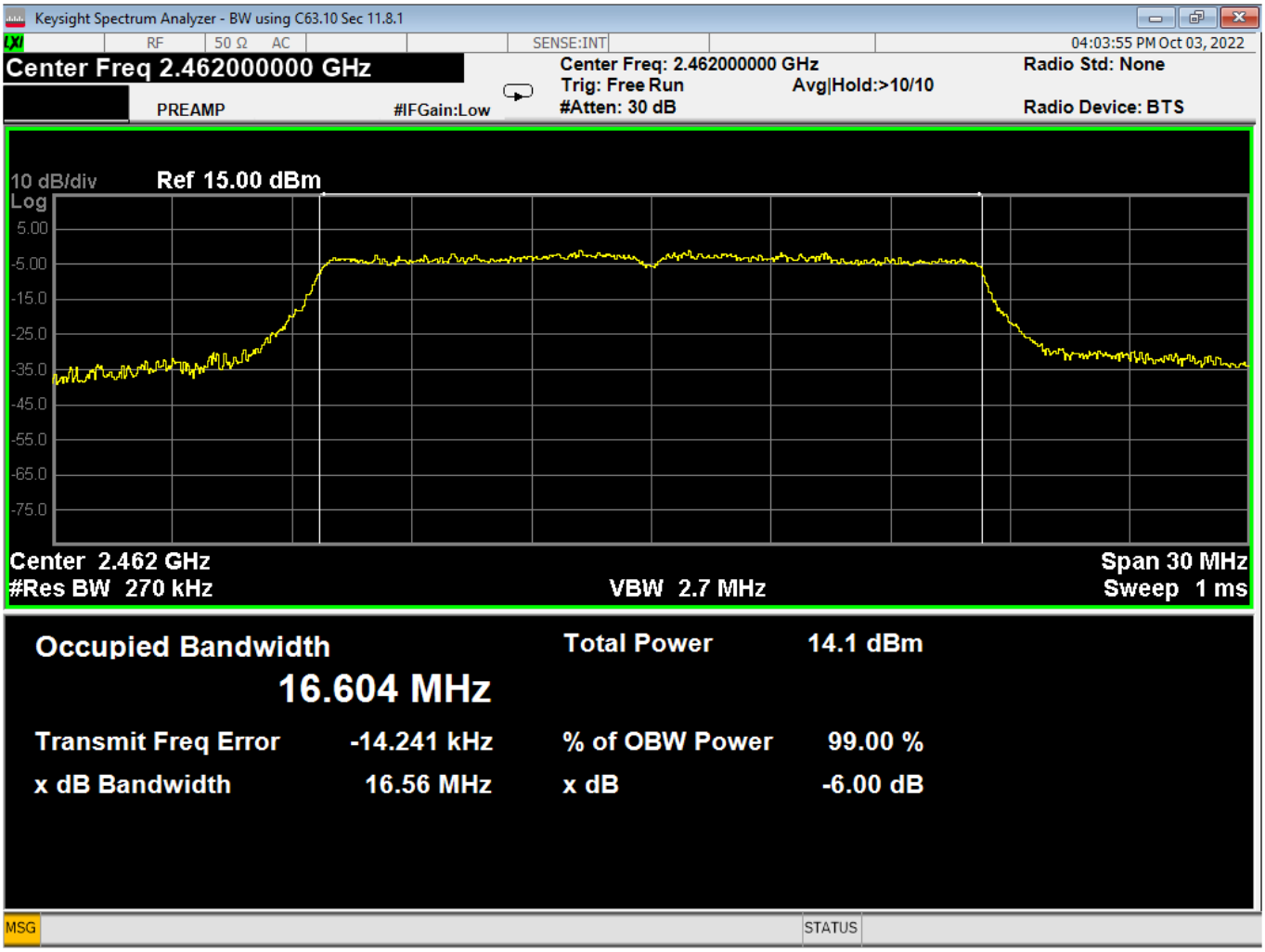
55 Average Power, High, Wifi G, High Data Rate



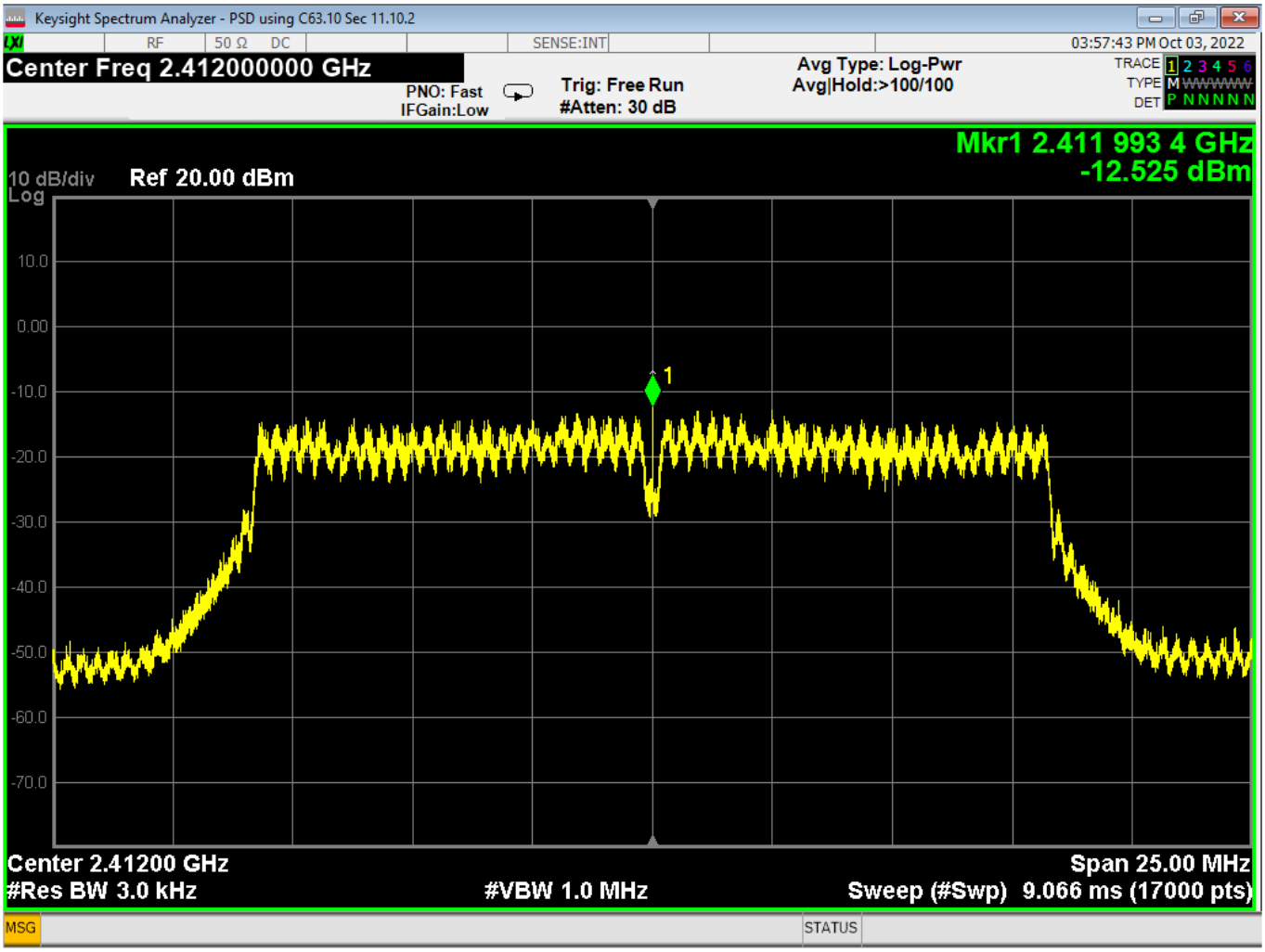
56 Bandwidth, Low, Wifi G, High Data Rate



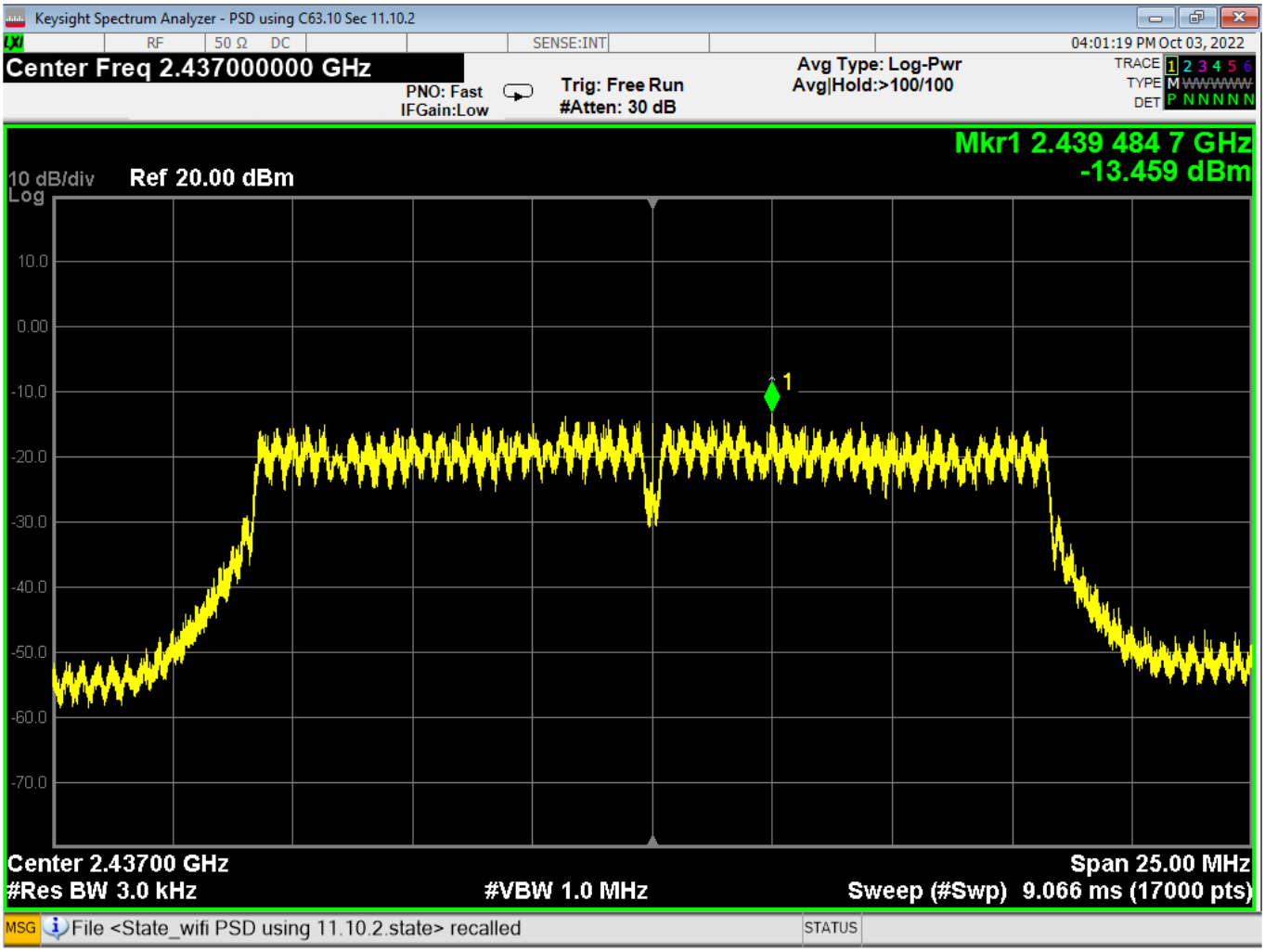
57 Bandwidth, Mid, Wifi G, High Data Rate



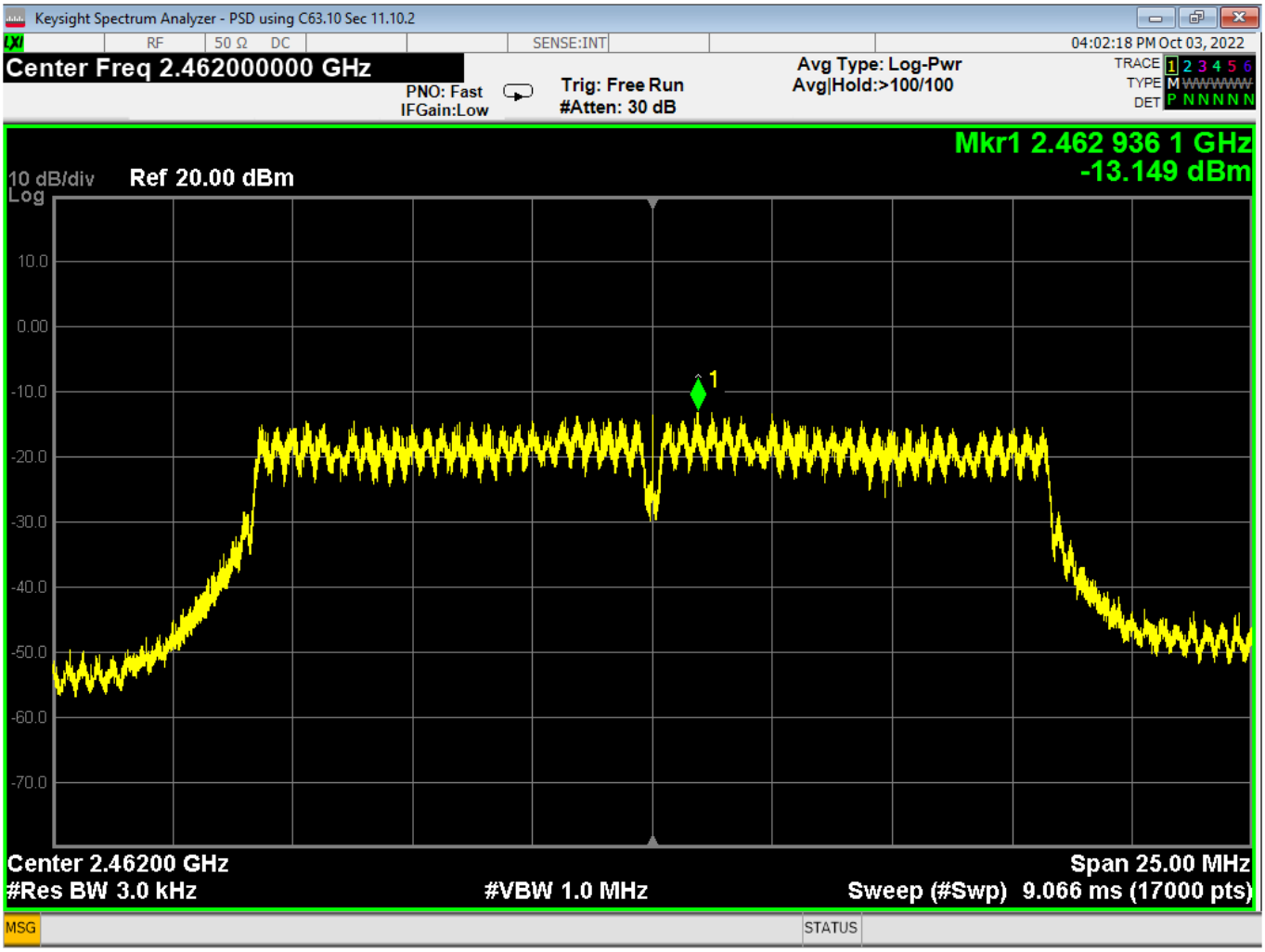
58 Bandwidth, High, Wifi G, High Data Rate



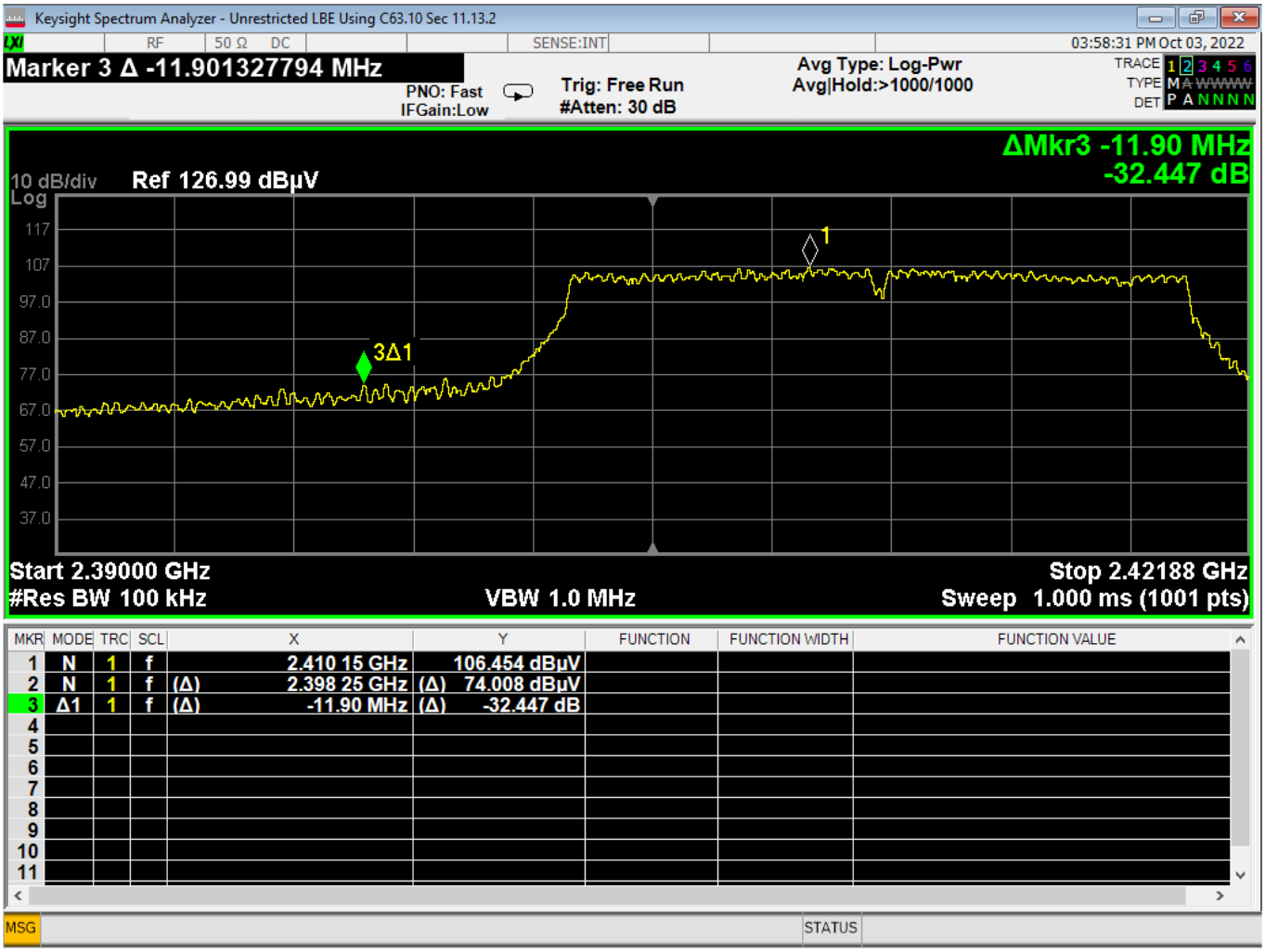
59 PSD, Low, Wifi G, High Data Rate



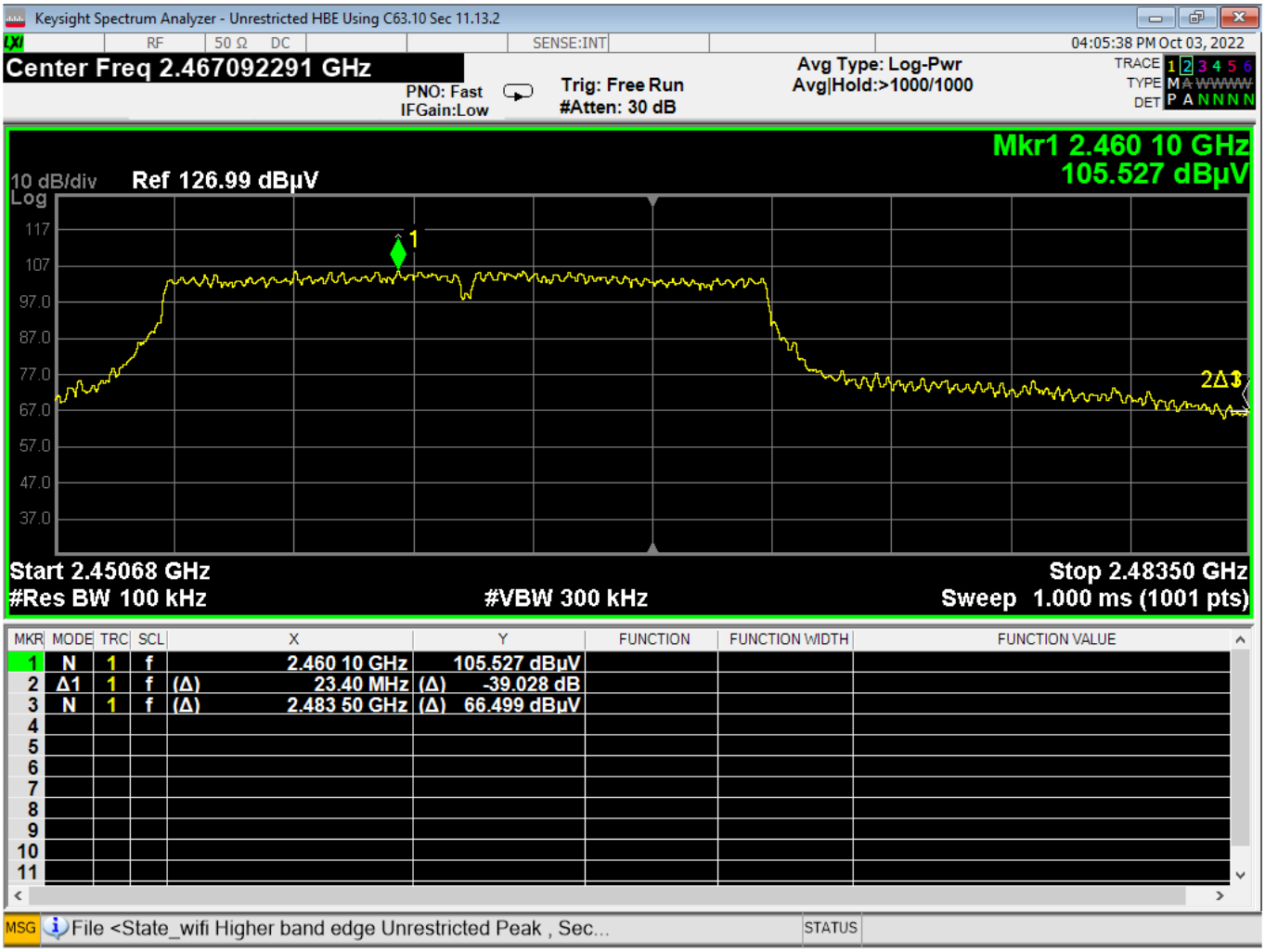
60 PSD, Mid, Wifi G, High Data Rate



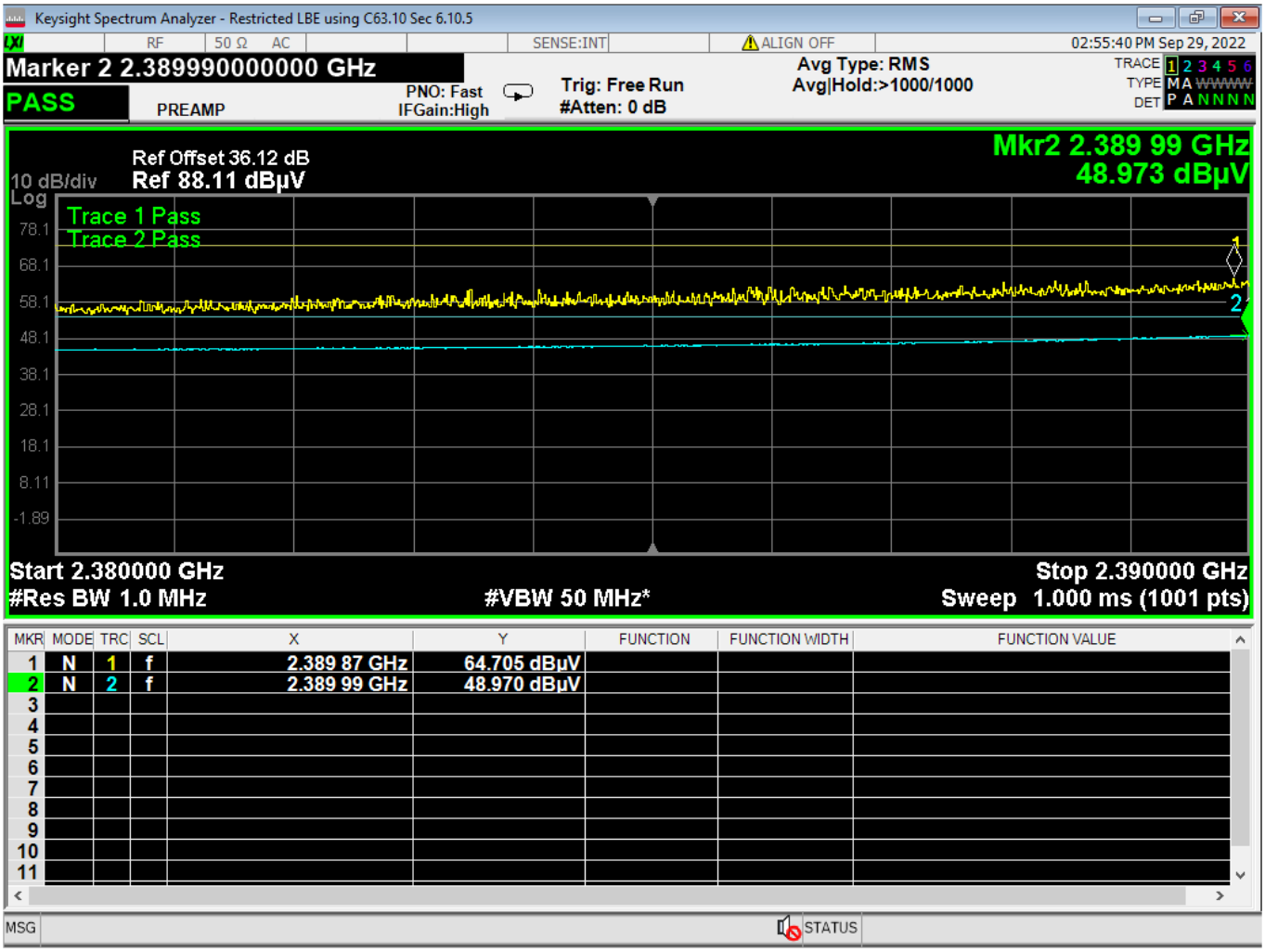
61 PSD, High, Wifi G, High Data Rate



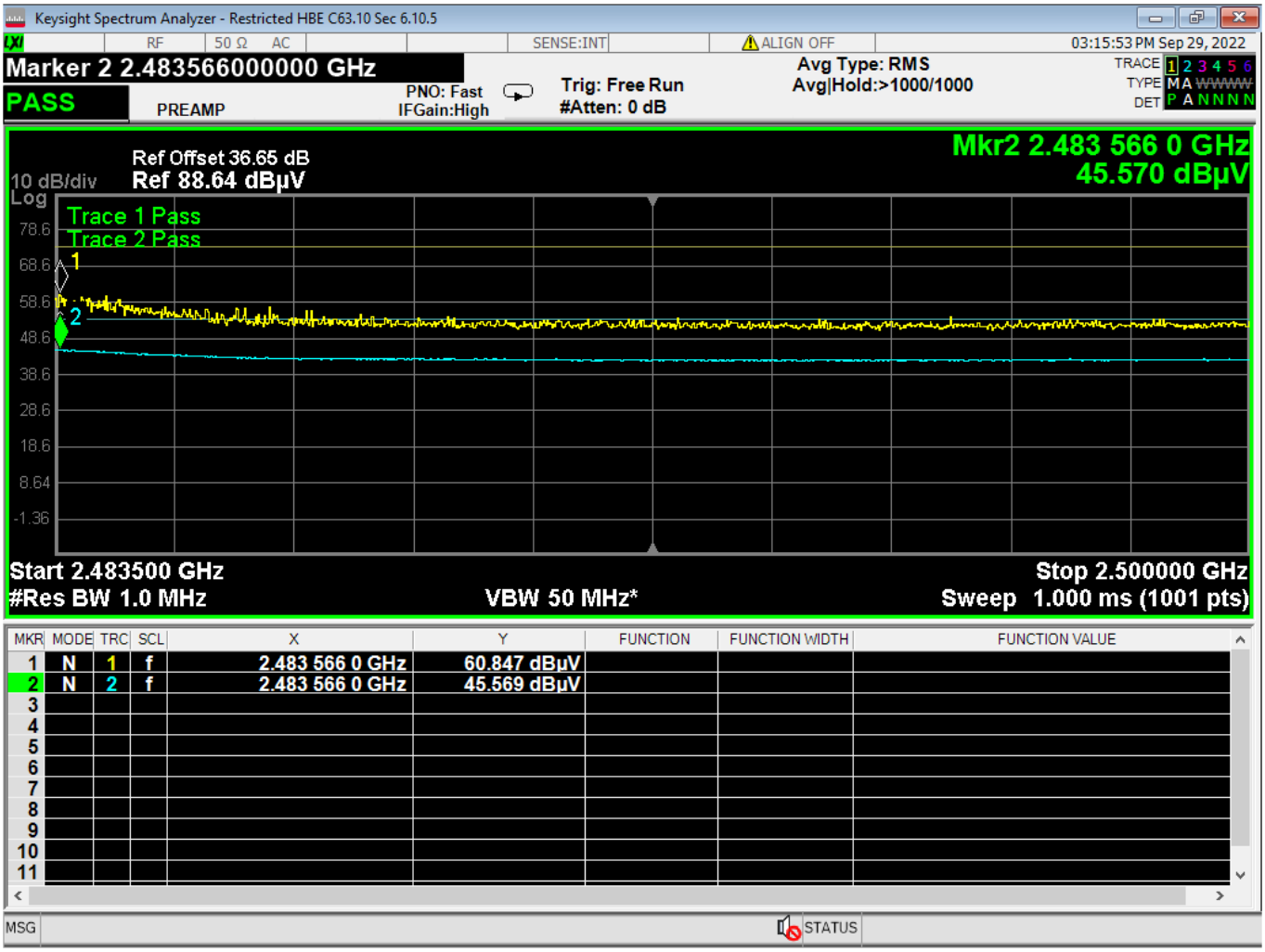
62 Lower Bandedge, Unrestricted, Wifi G, High Data Rate



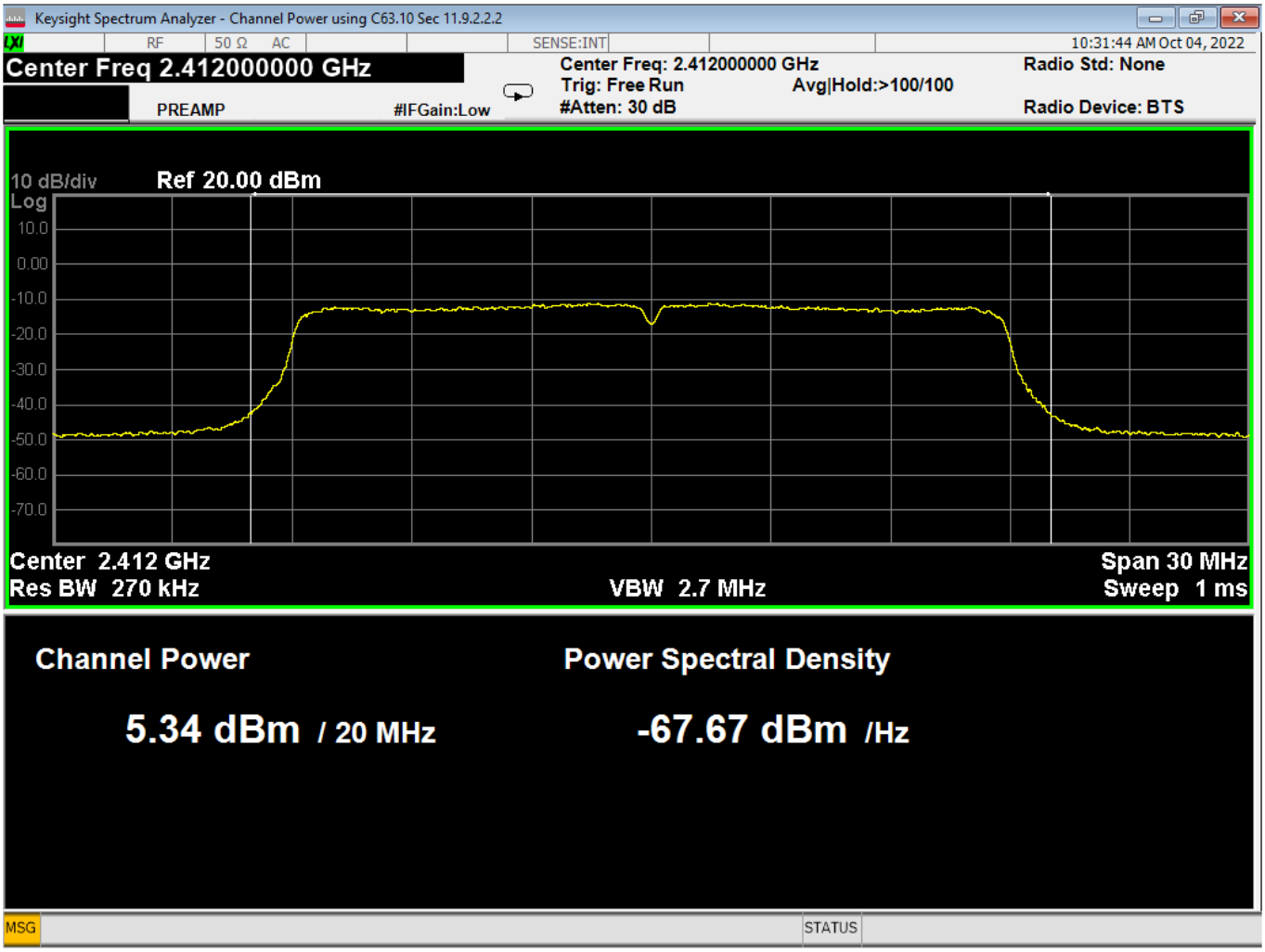
63 Higher Bandedge, Unrestricted, Wifi G, High Data Rate



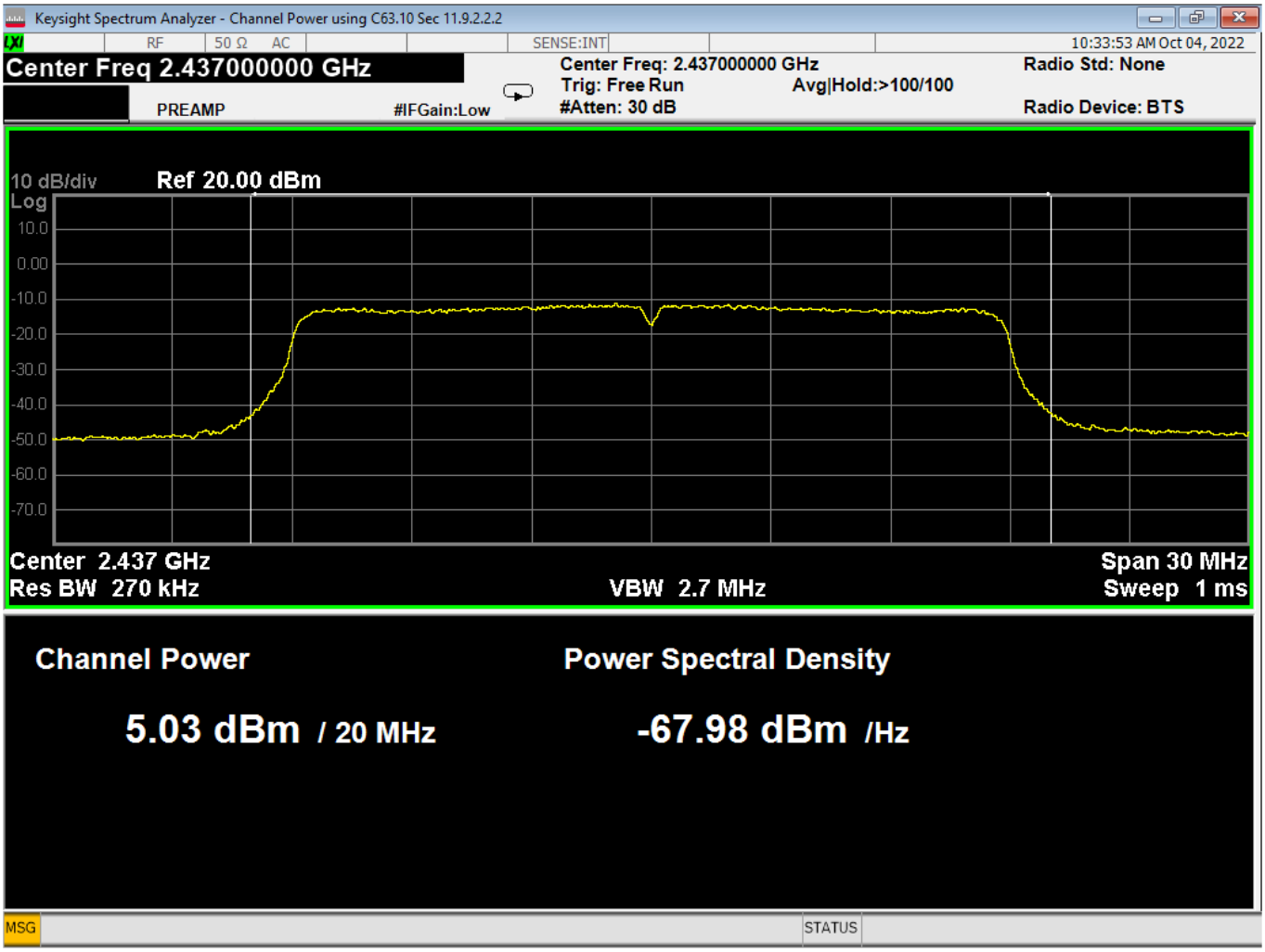
64 Lower Bandedge, Restricted, Wifi G, High Data Rate



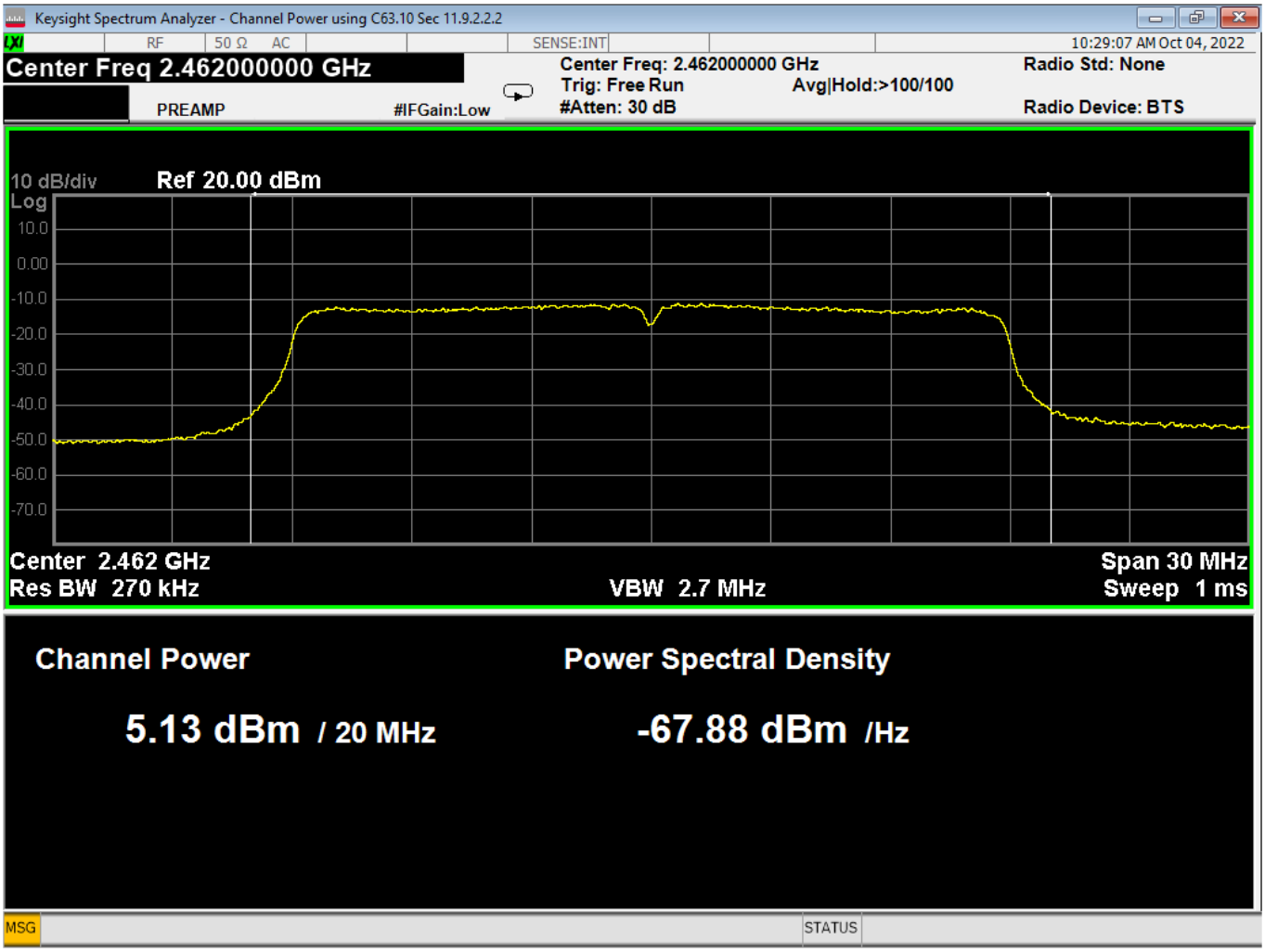
65 Higher Bandedge, Restricted, Wifi G, High Data Rate



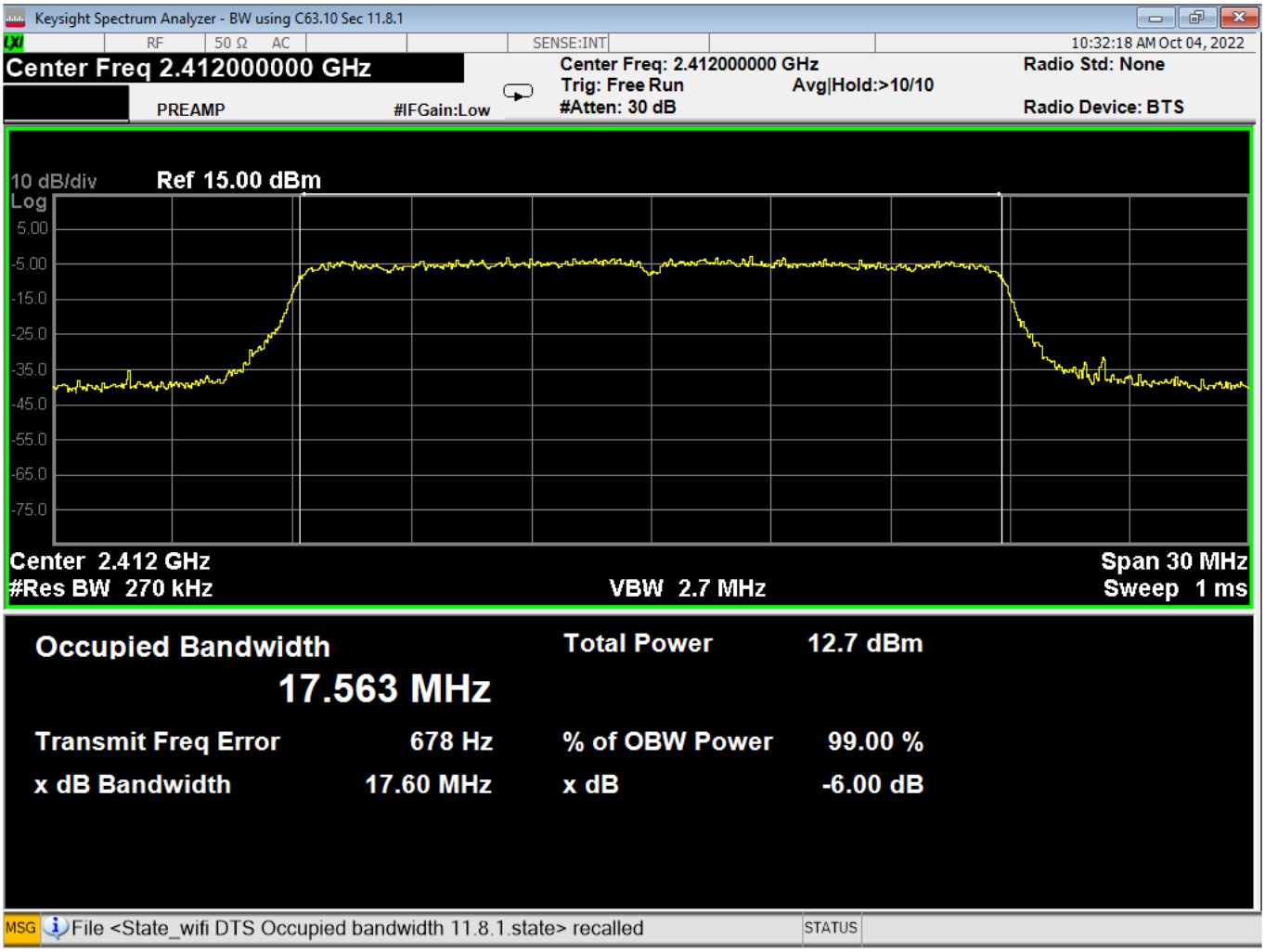
66 Average Power, Low, Wifi N, High Data Rate



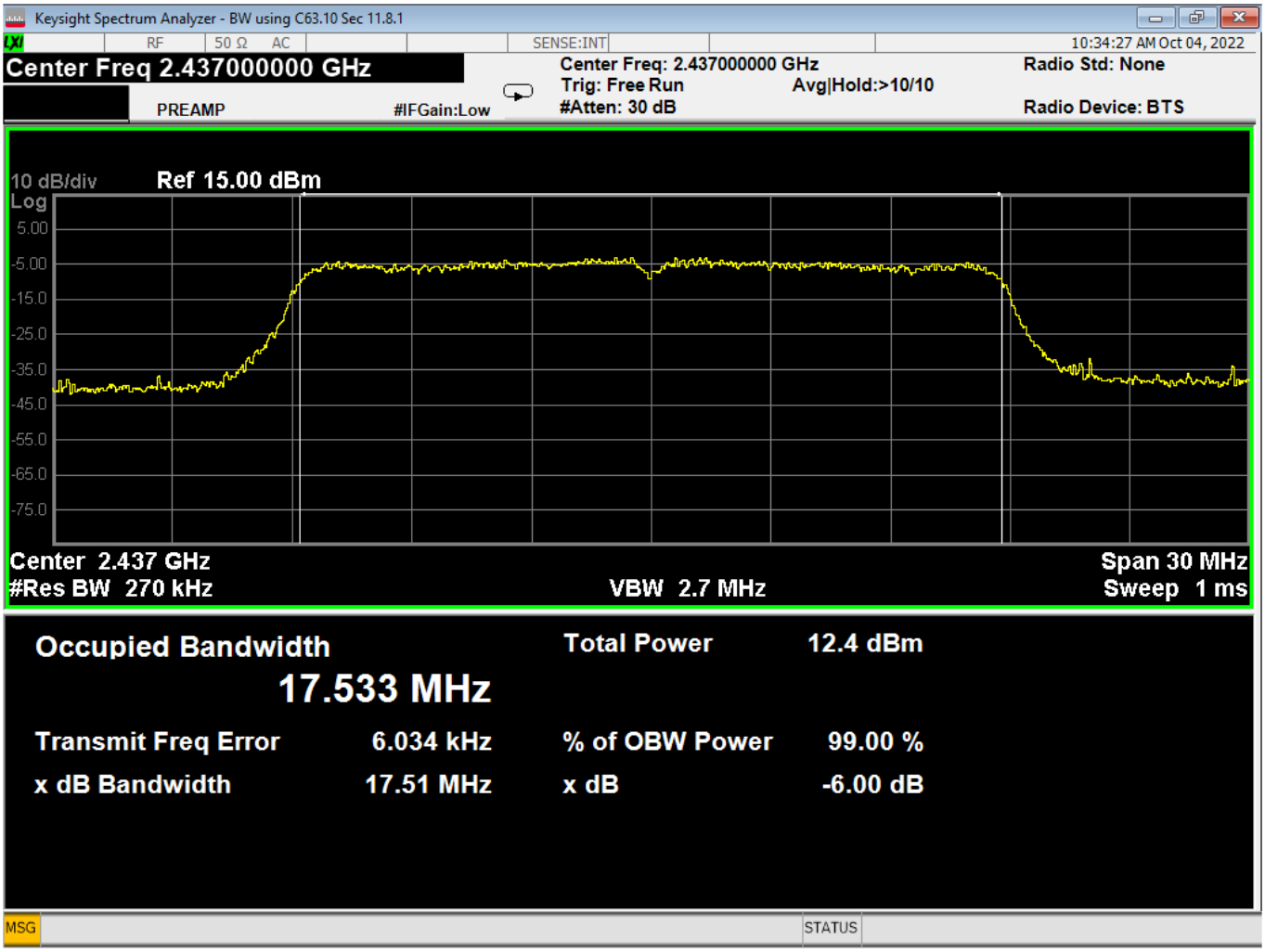
67 Average Power, Mid, Wifi N, High Data Rate



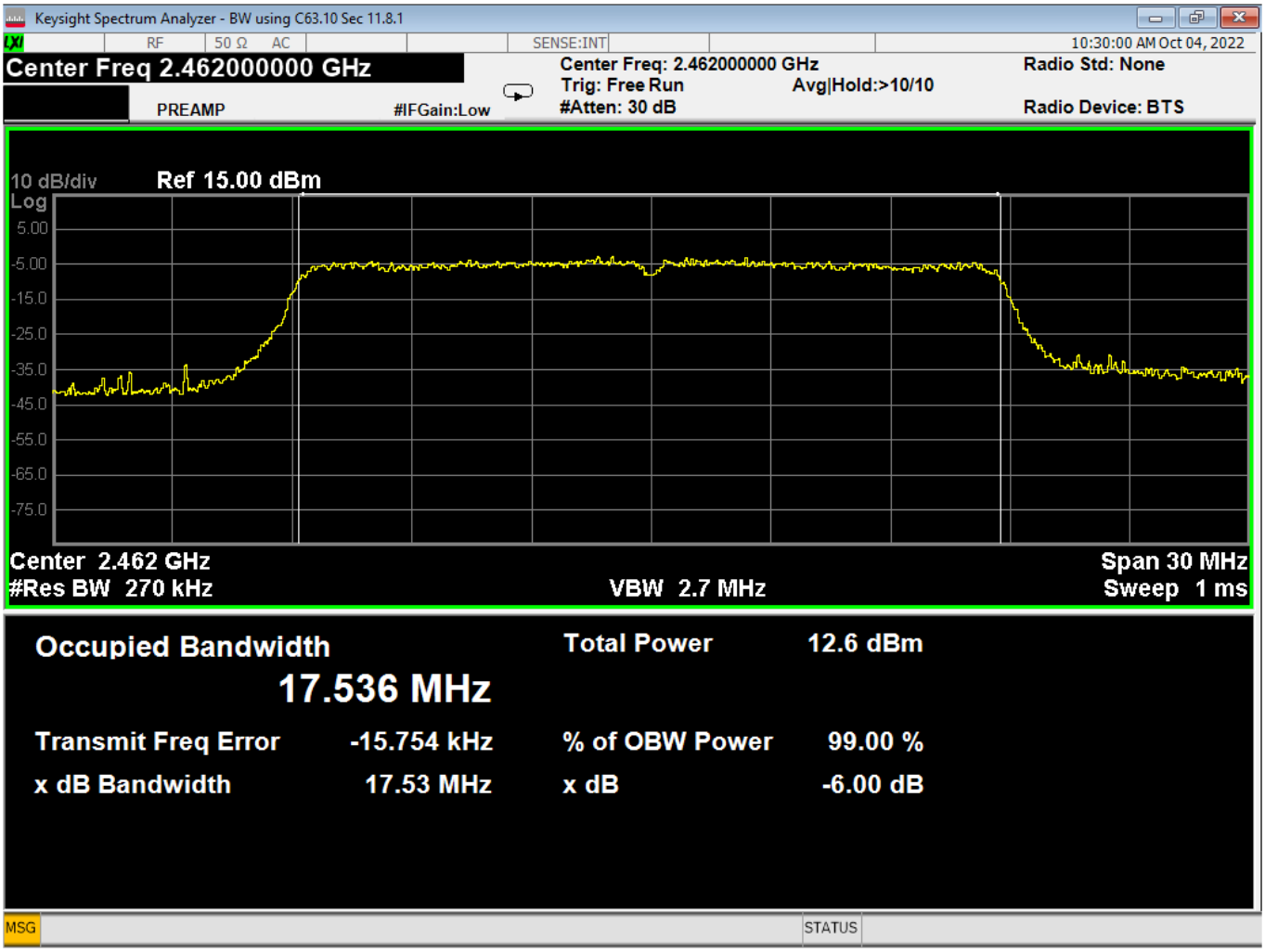
68 Average Power, High, Wifi N, High Data Rate



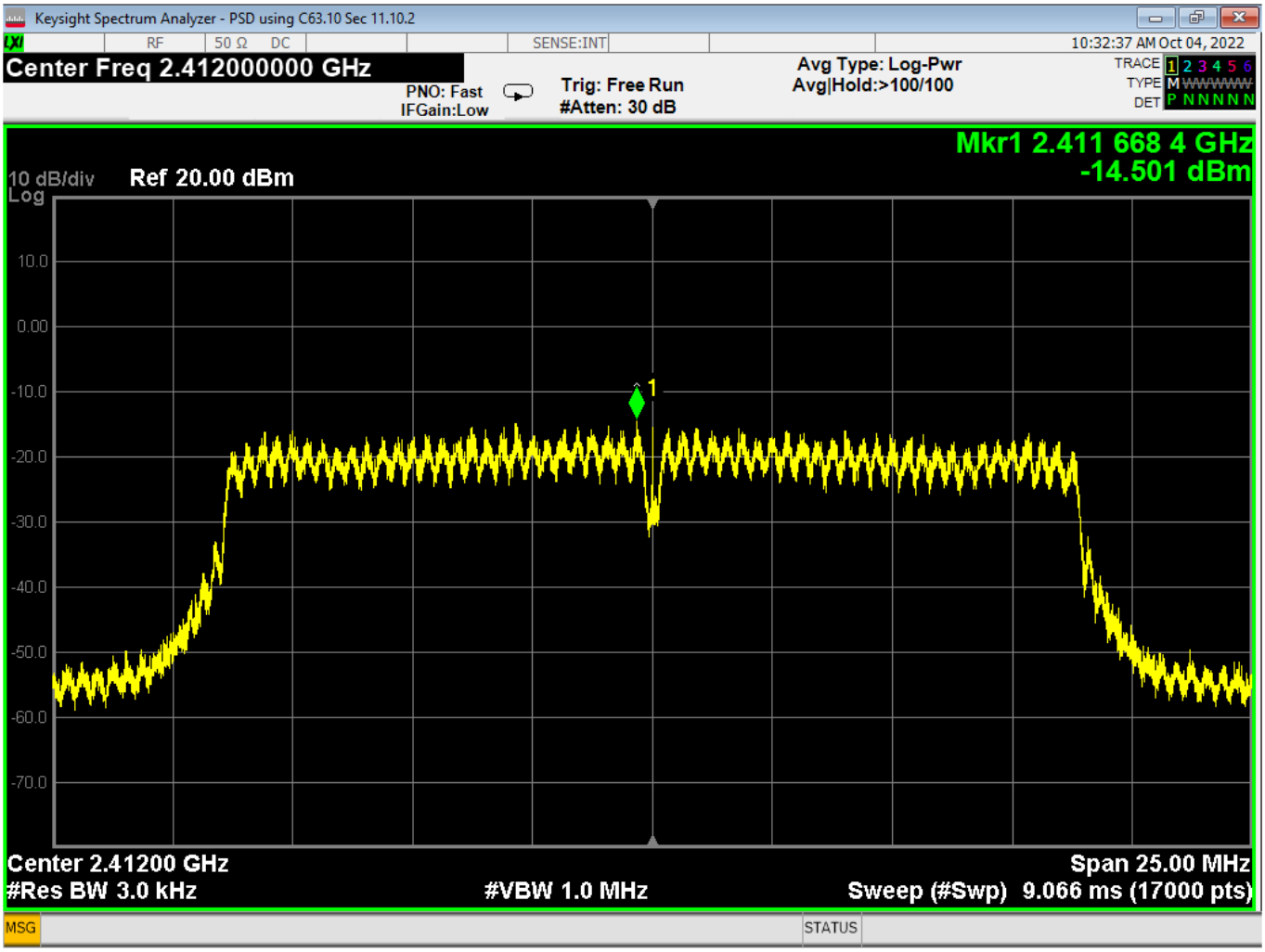
69 Bandwidth, Low, Wifi N, High Data Rate



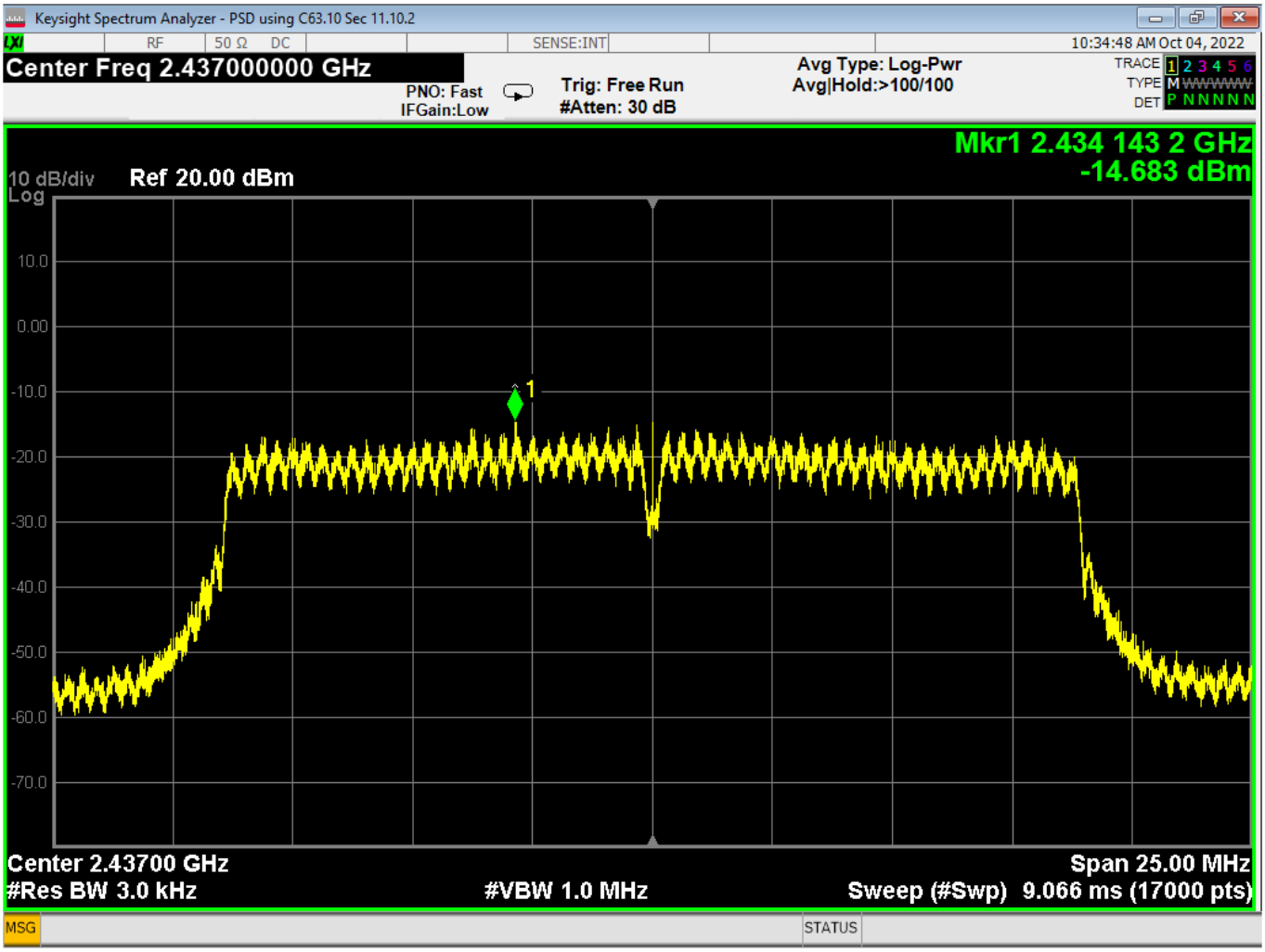
70 Bandwidth, Mid, Wifi N, High Data Rate



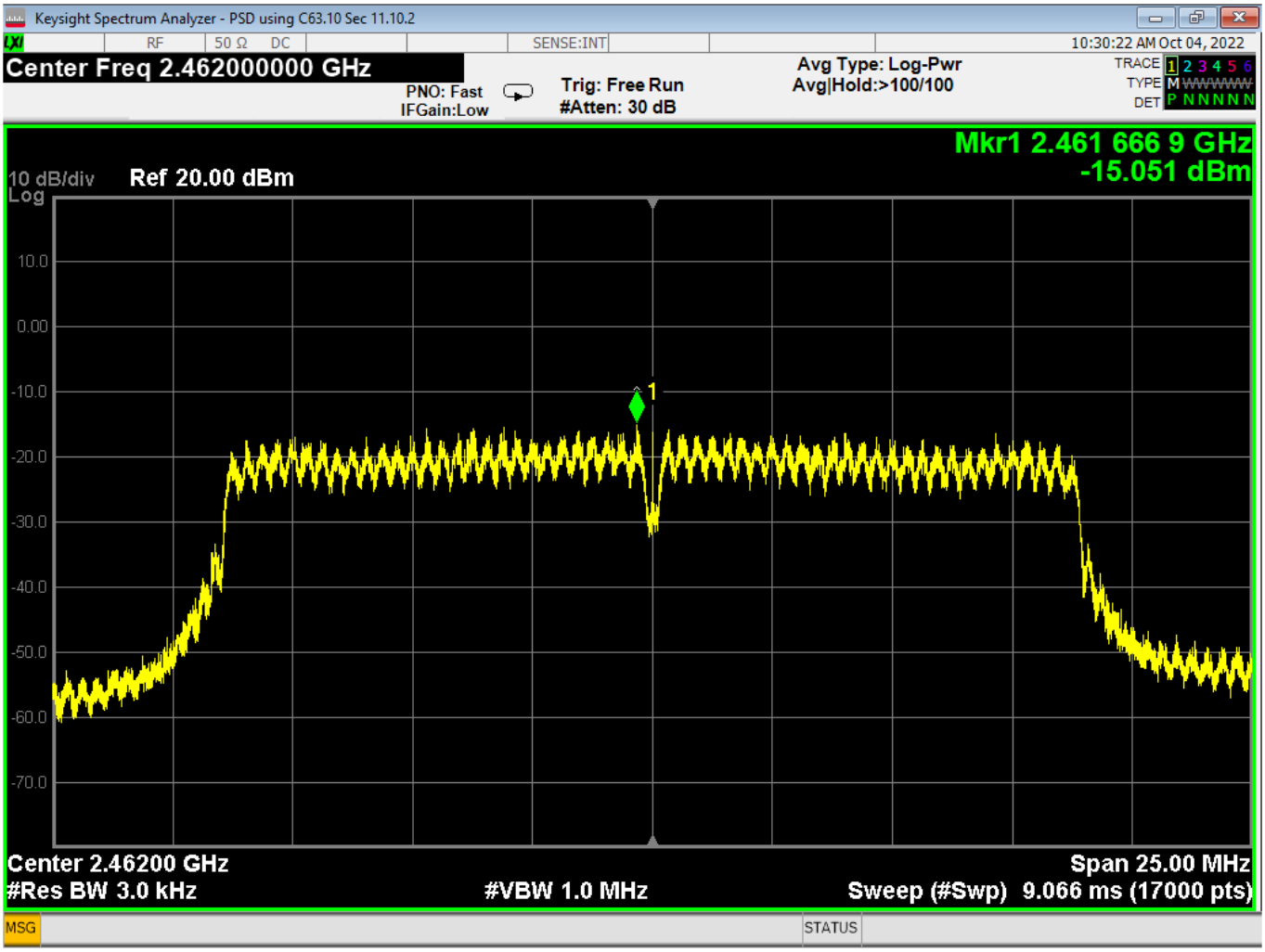
71 Bandwidth, High, Wifi N, High Data Rate



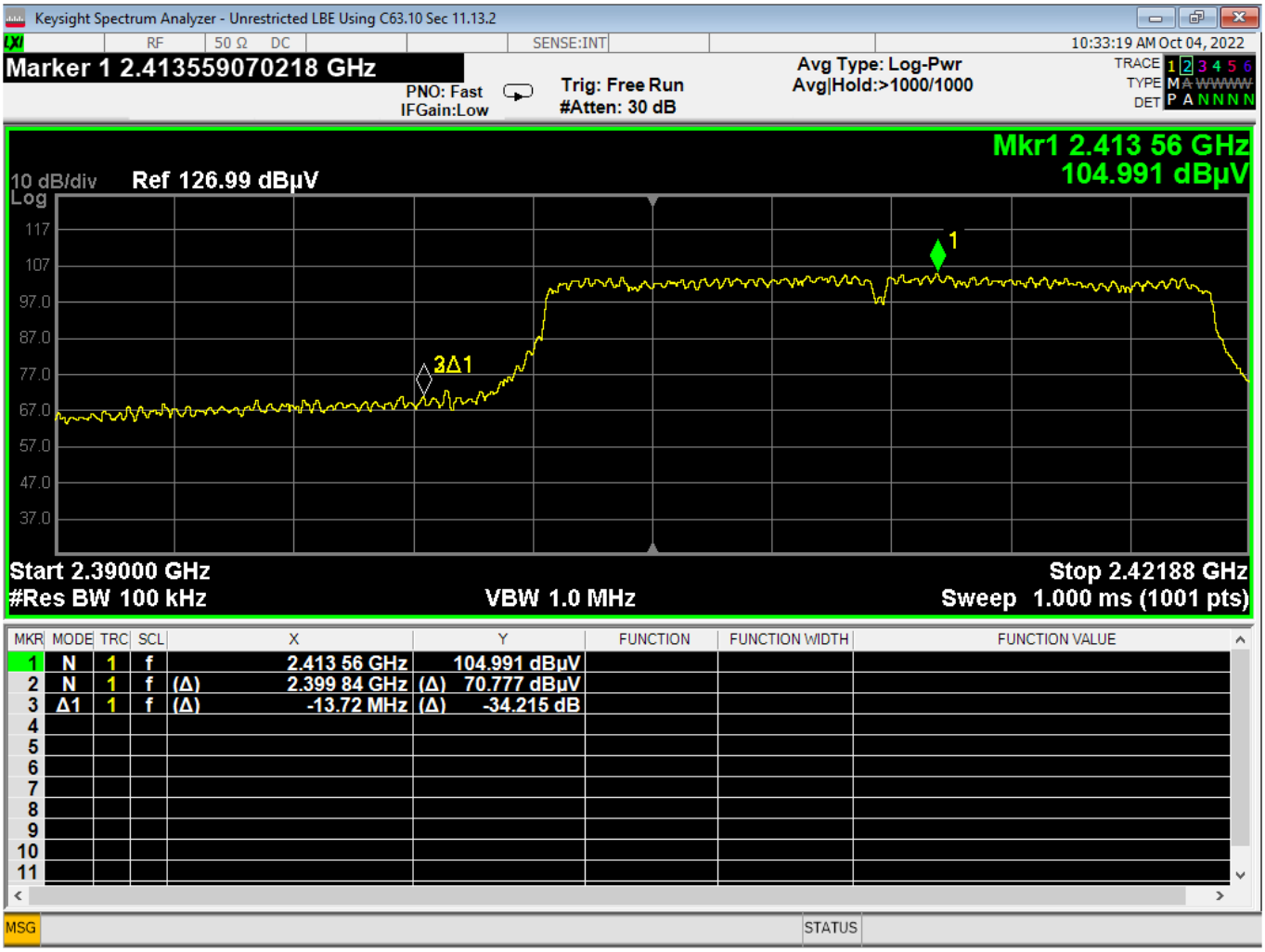
72 PSD, Low, Wifi N, High Data Rate



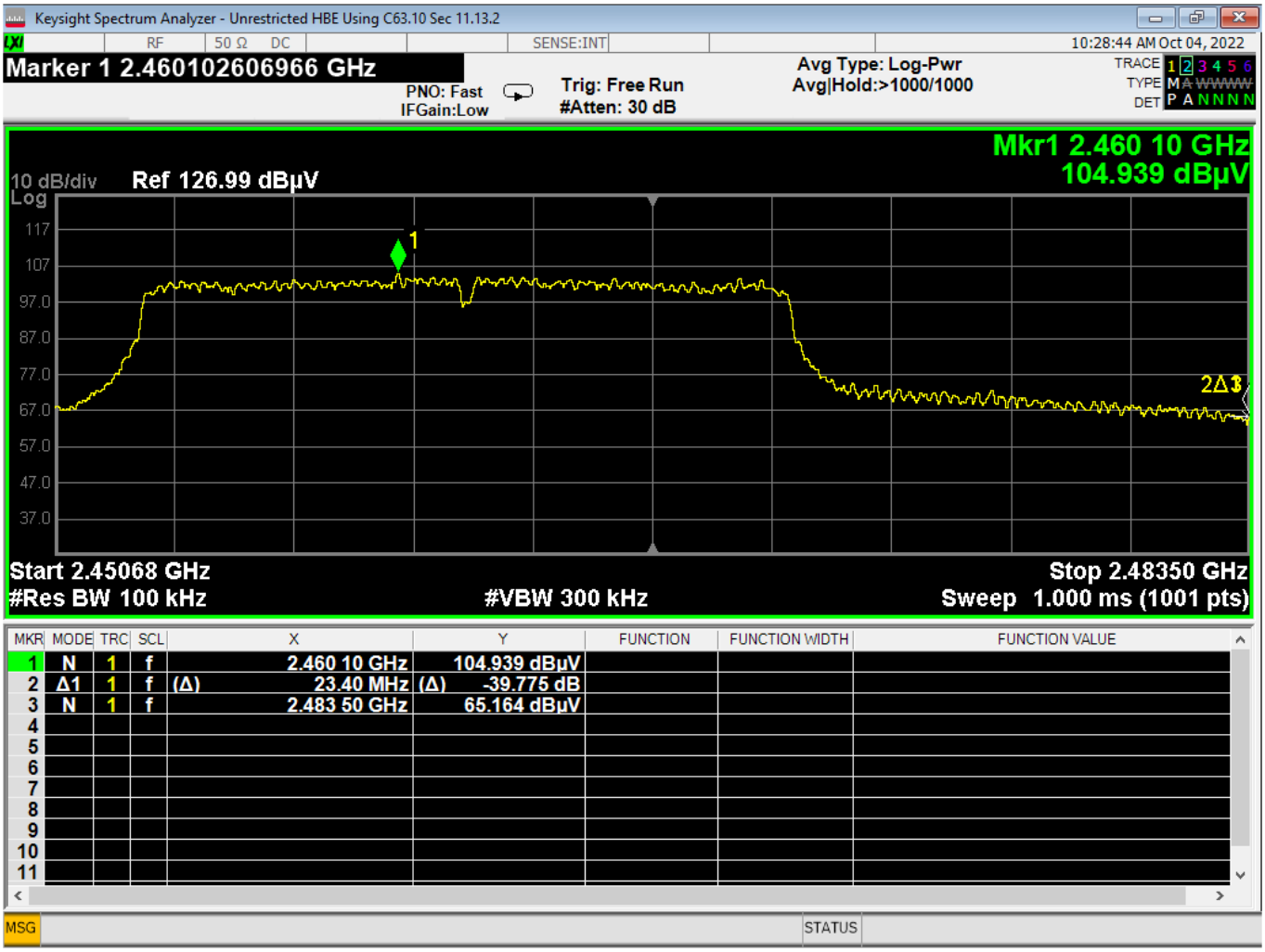
73 PSD, Mid, Wifi N, High Data Rate



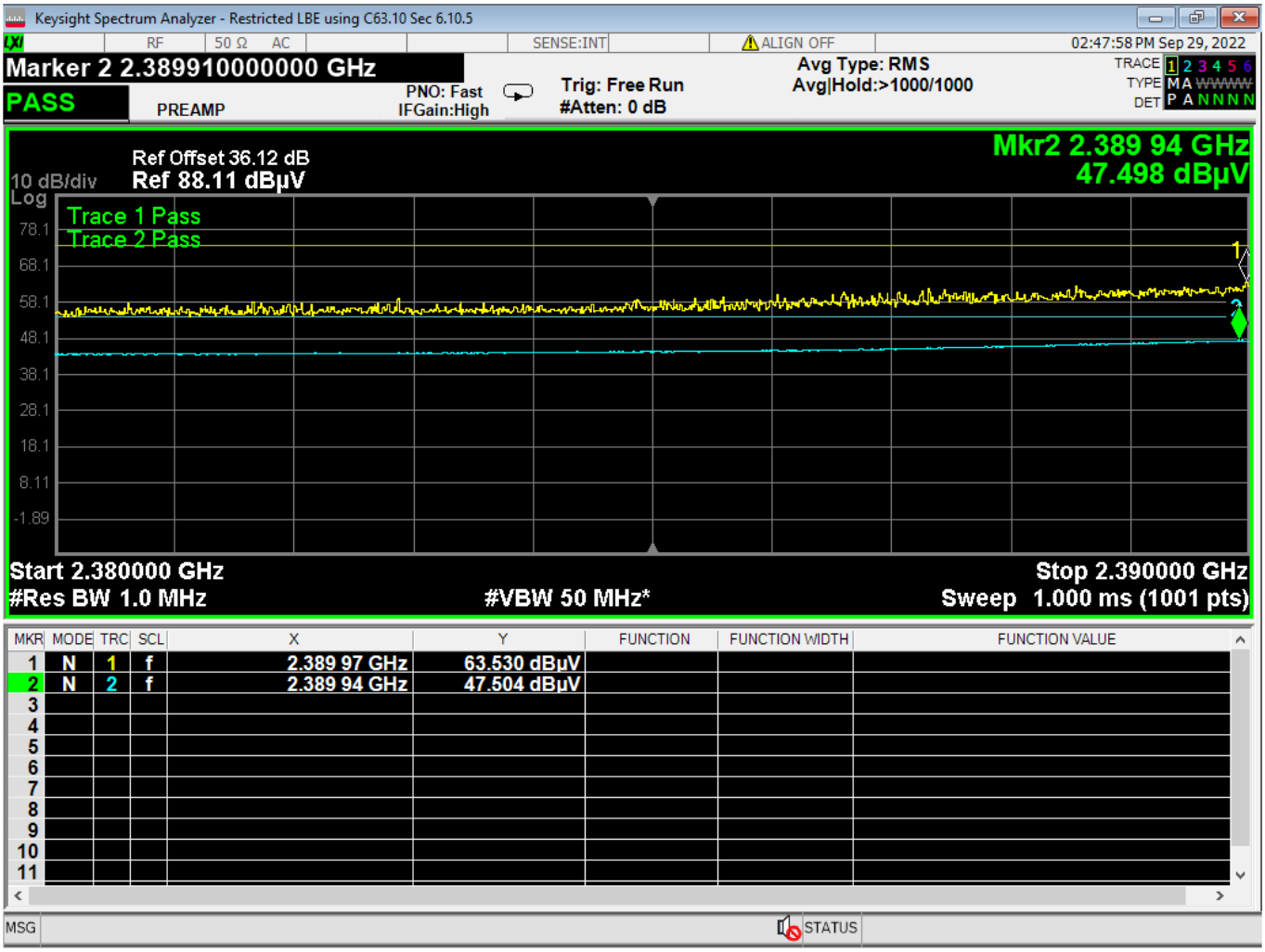
74 PSD, High, Wifi N, High Data Rate



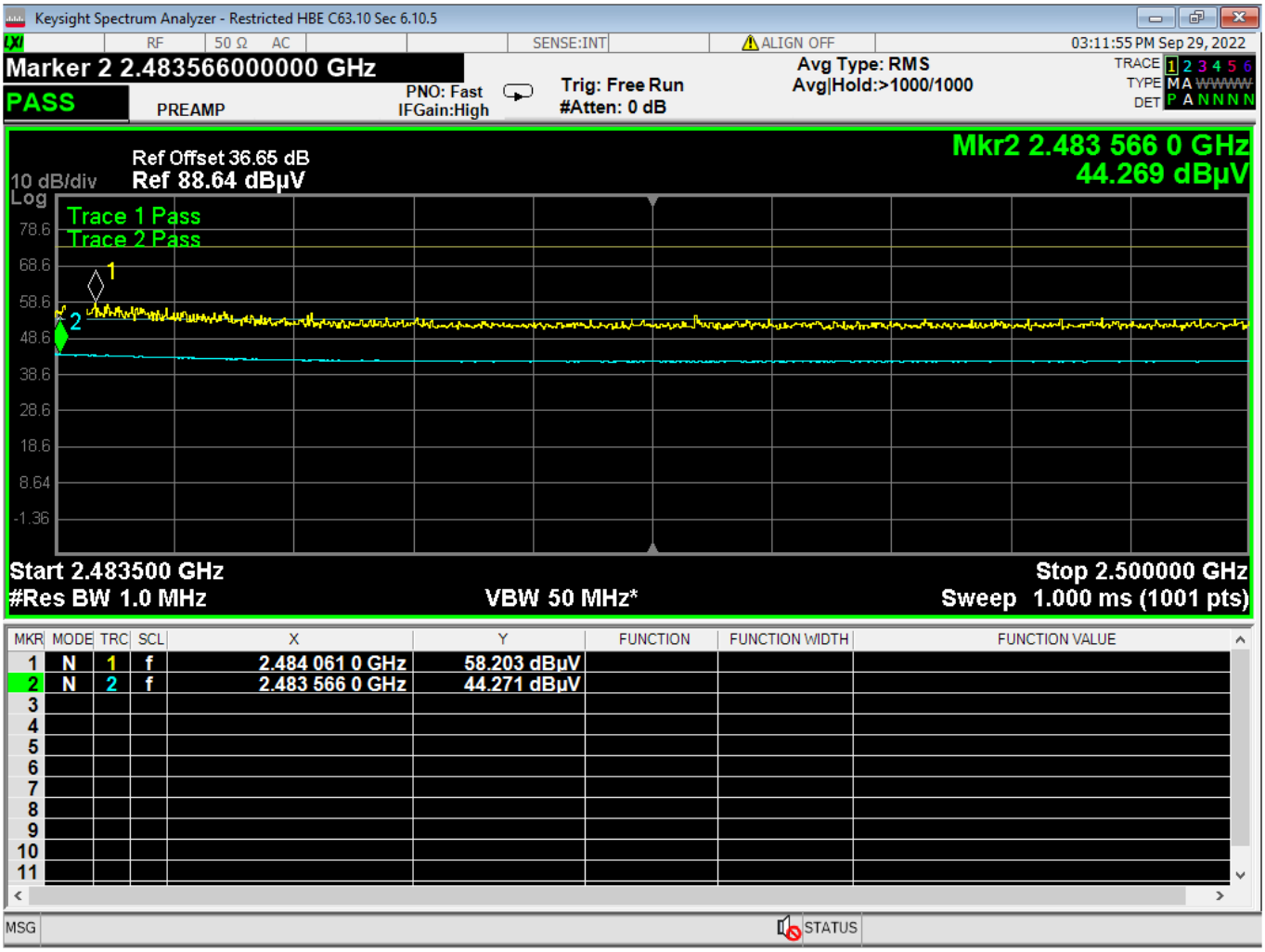
75 Lower Bandedge, Unrestricted, Wifi N, High Data Rate



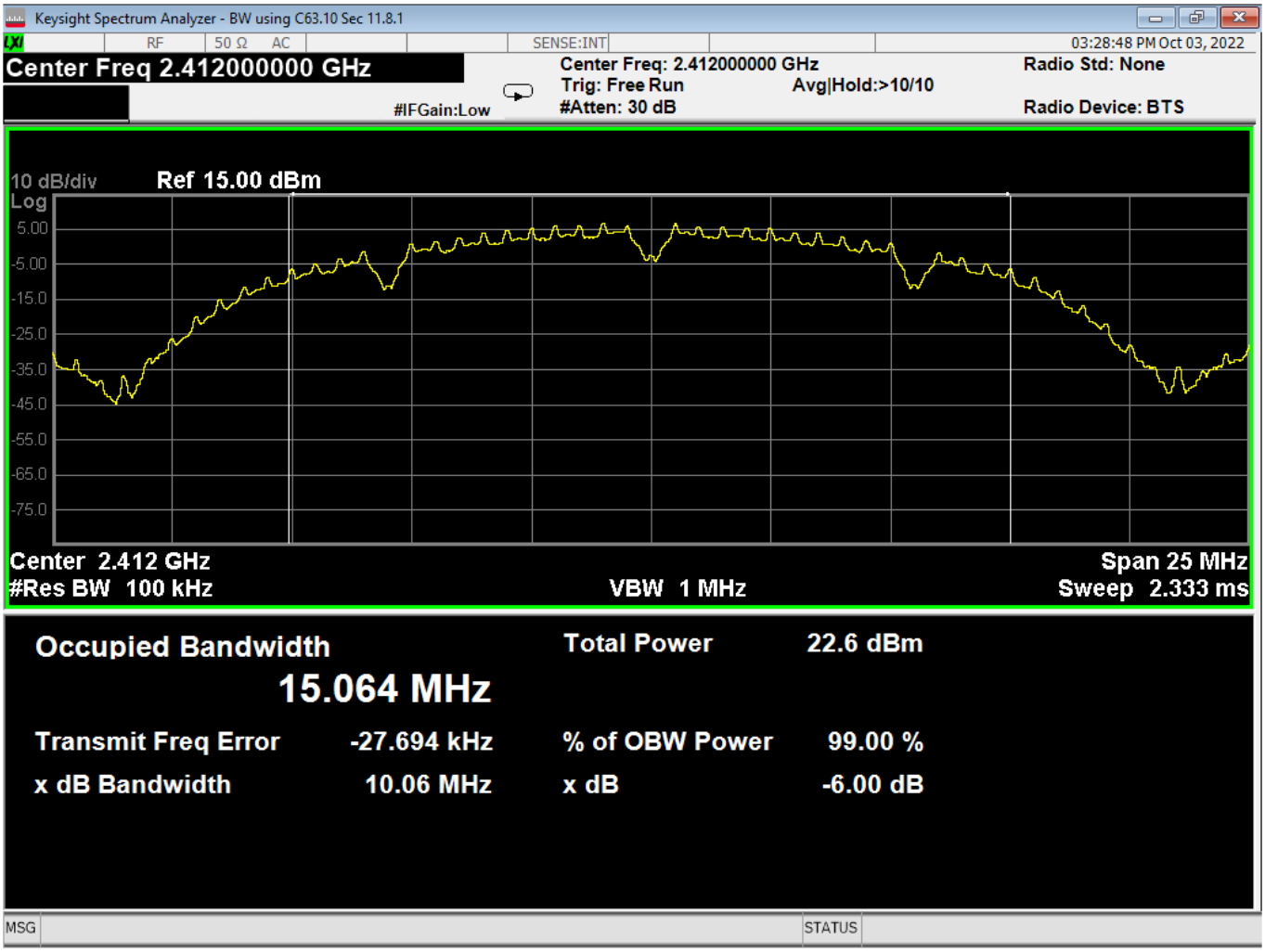
76 Higher Bandedge, Unrestricted, Wifi N, High Data Rate



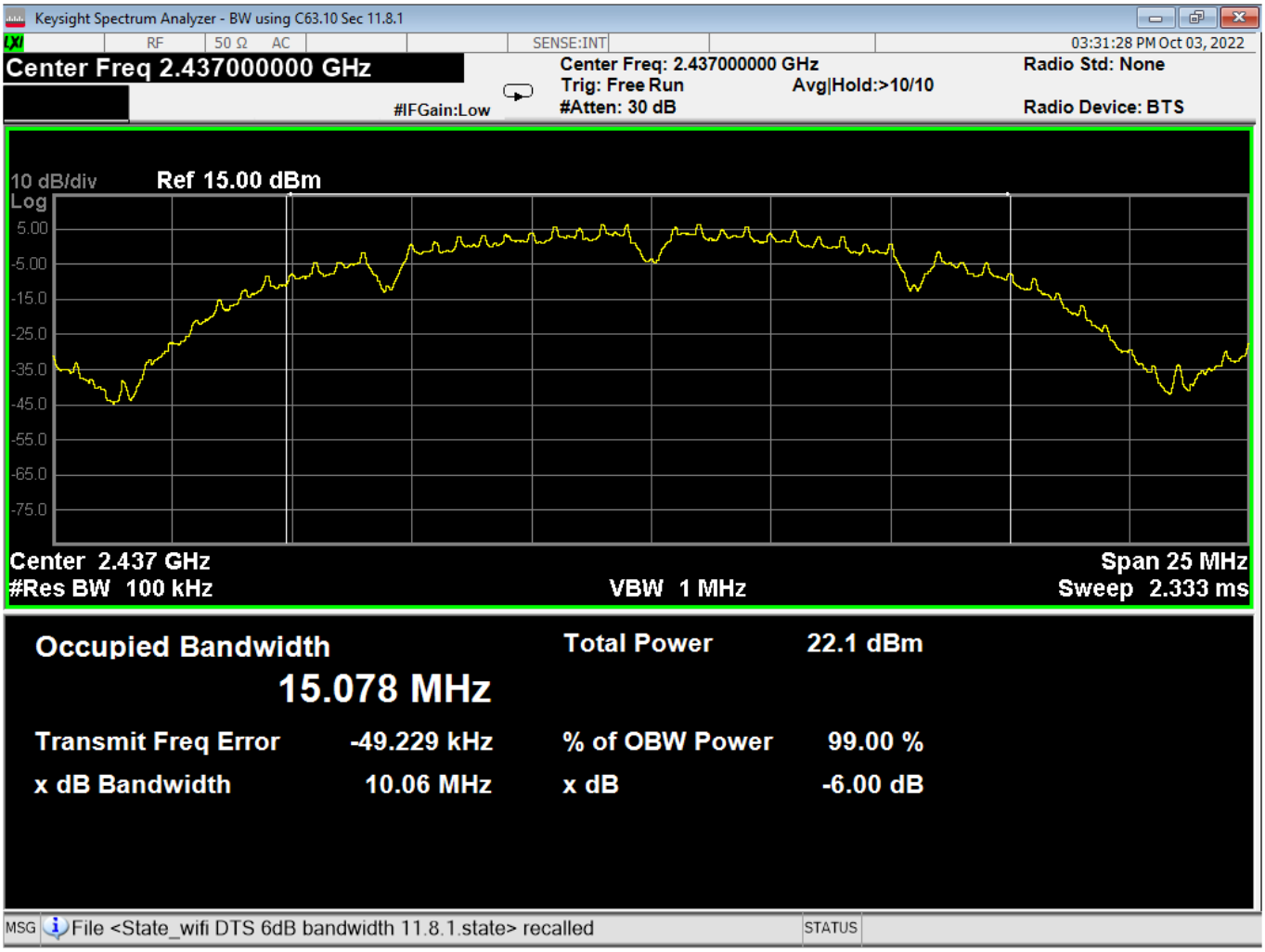
77 Lower Bandedge, Restricted, Wifi N, High Data Rate



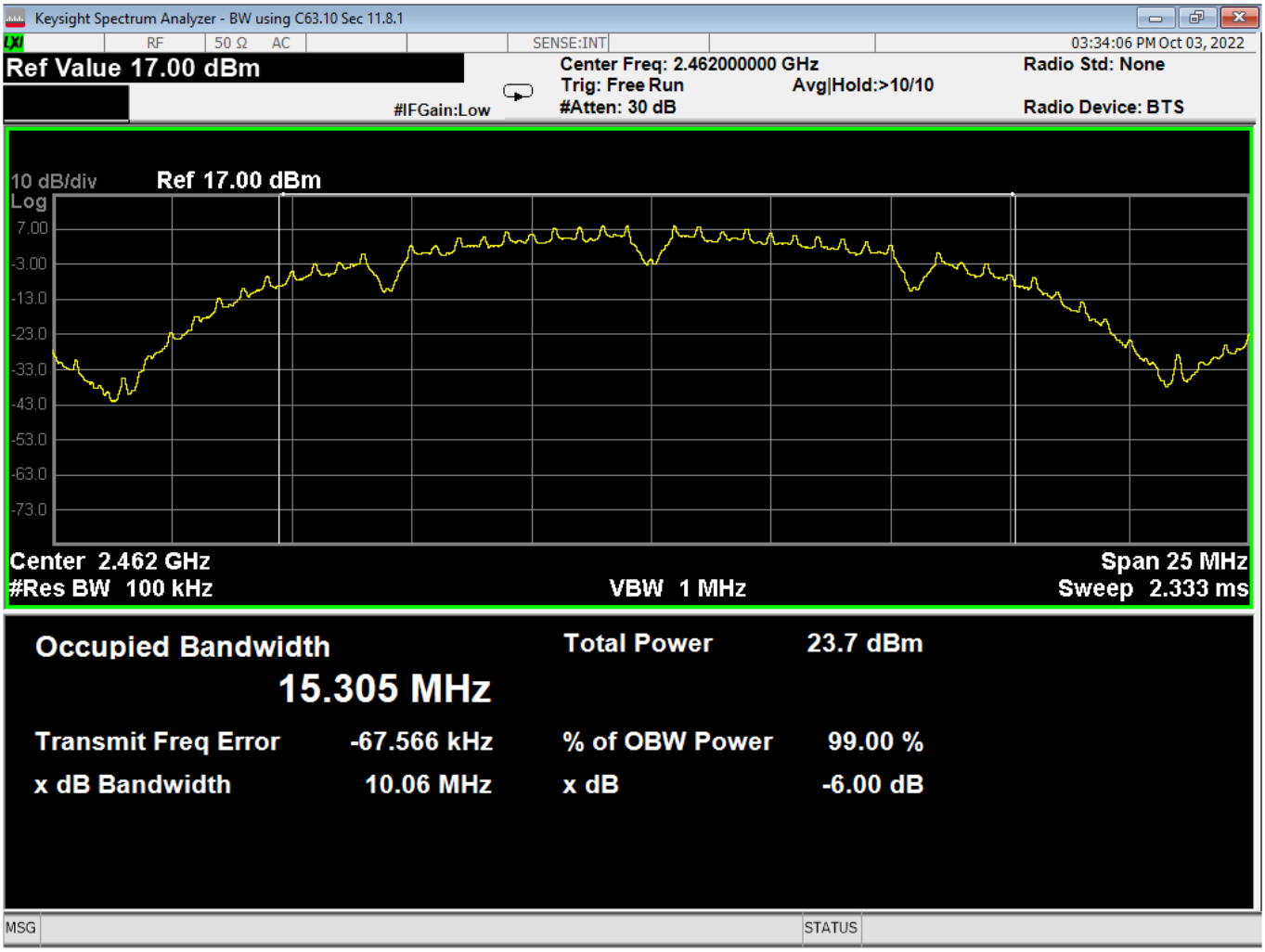
78 Higher Bandedge, Restricted, Wifi N, High Data Rate



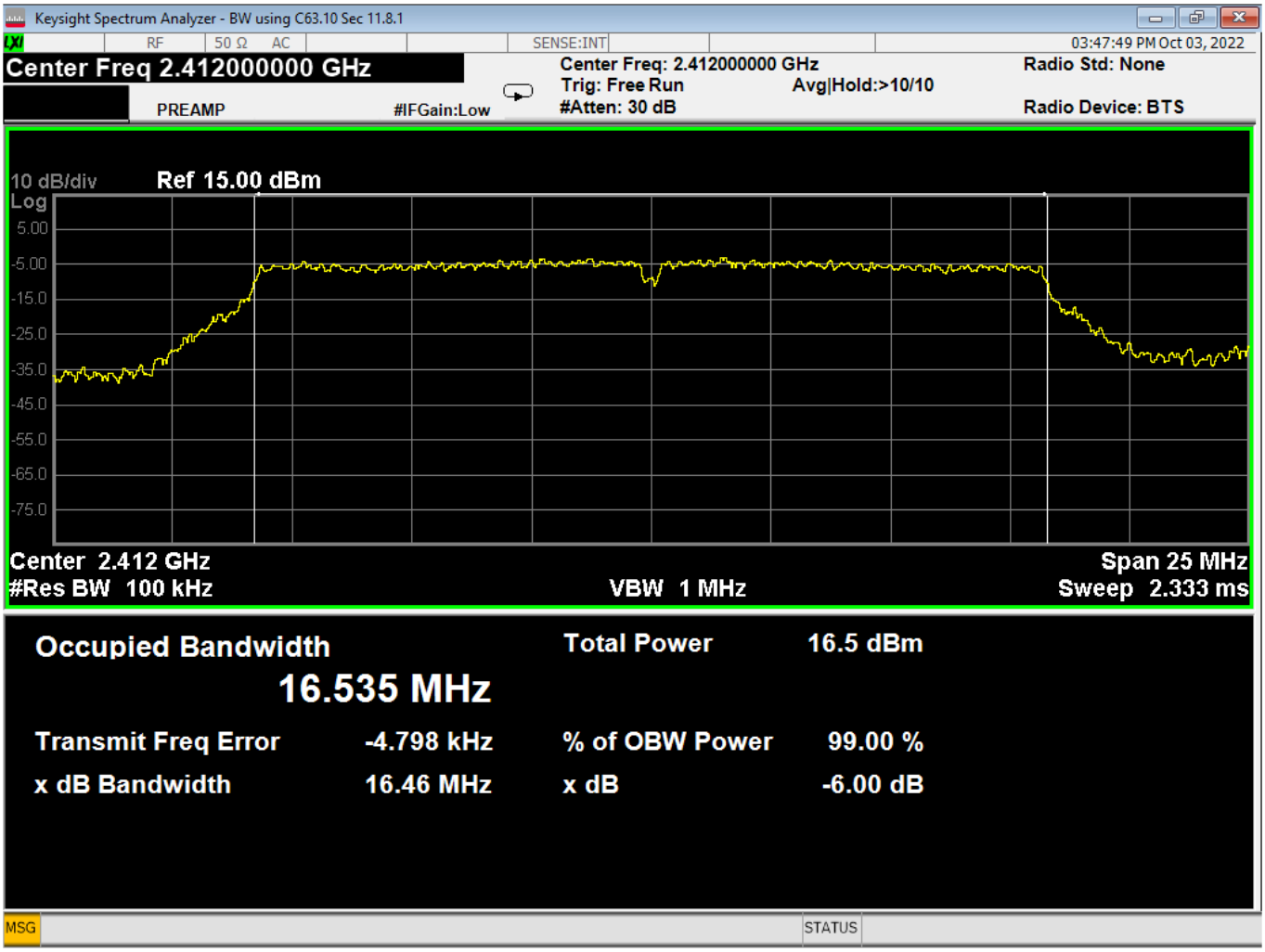
79 6dB Bandwidth, Low, Wifi B, Low Data Rate



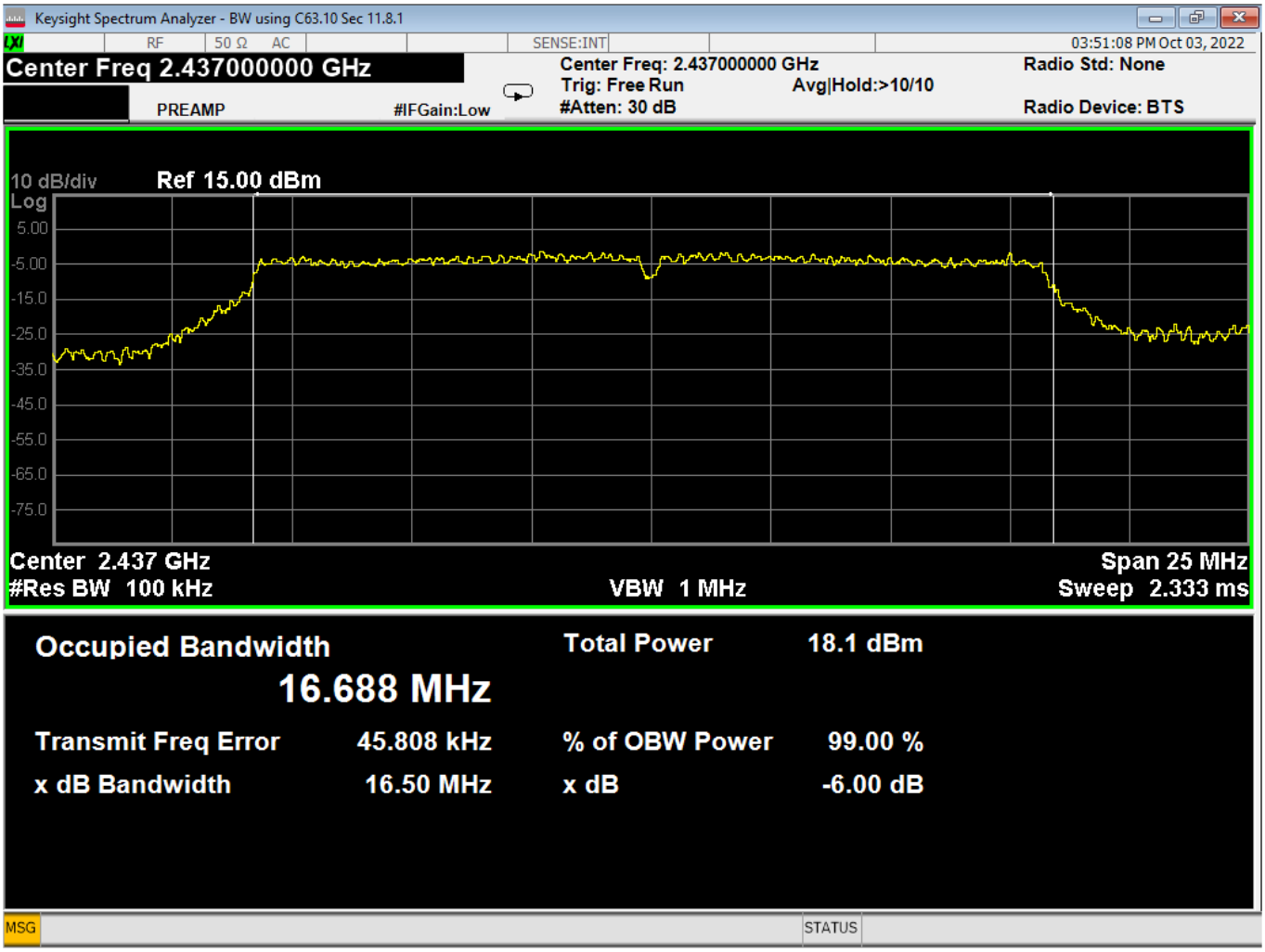
80 6dB Bandwidth, Mid, Wifi B, Low Data Rate



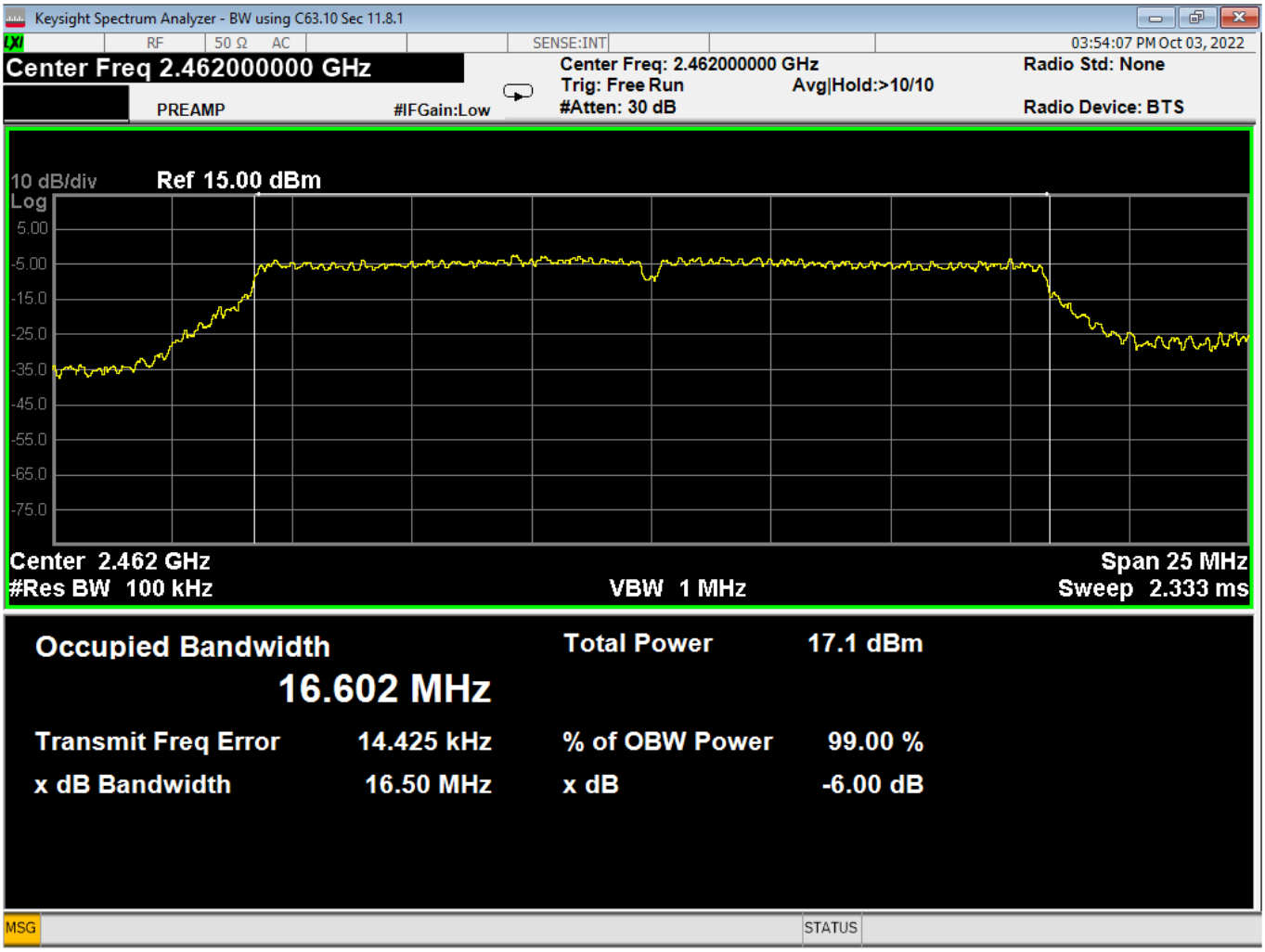
81 6dB Bandwidth, High, Wifi B, Low Data Rate



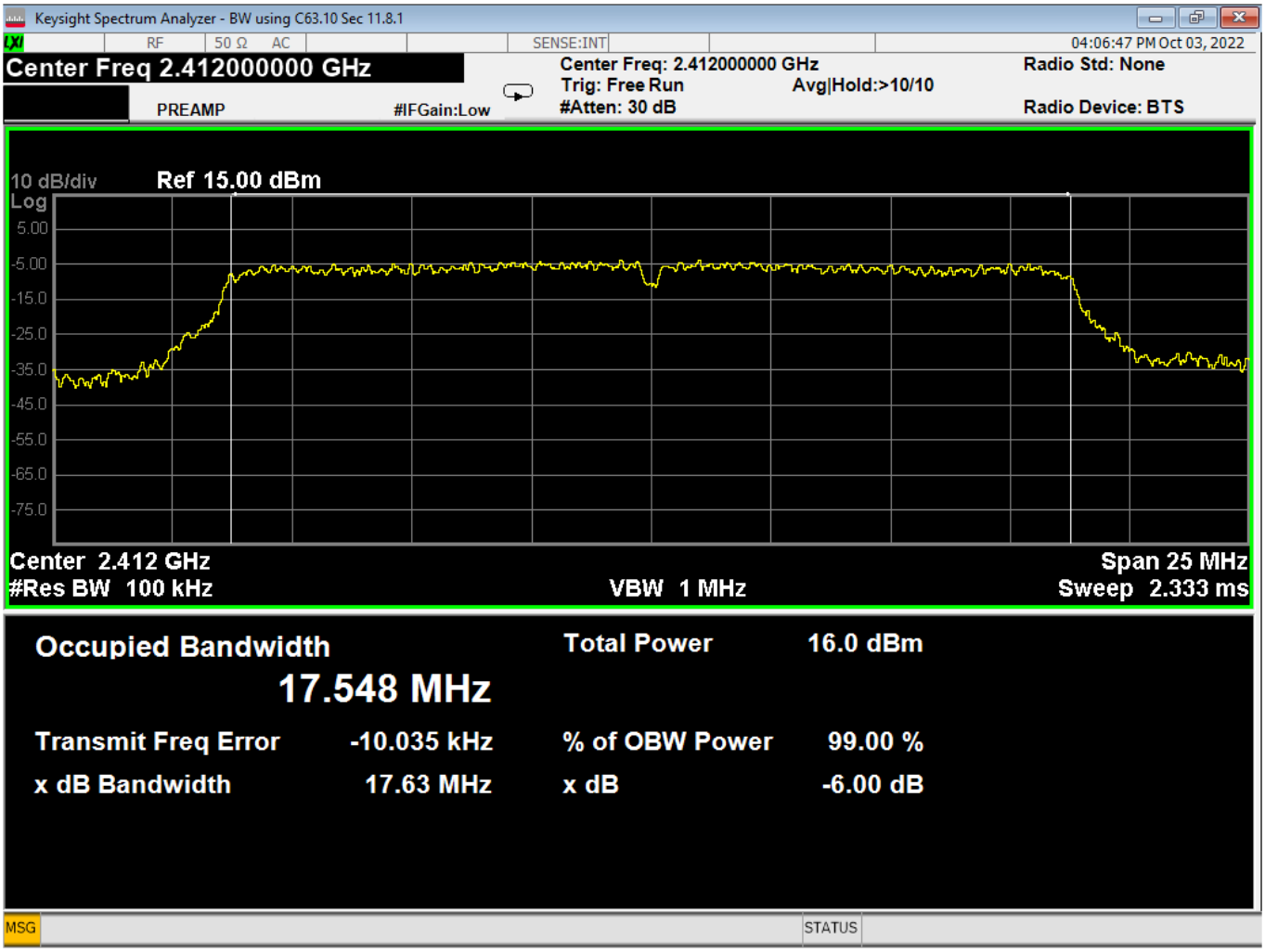
82 6dB Bandwidth, Low, Wifi G, Low Data Rate



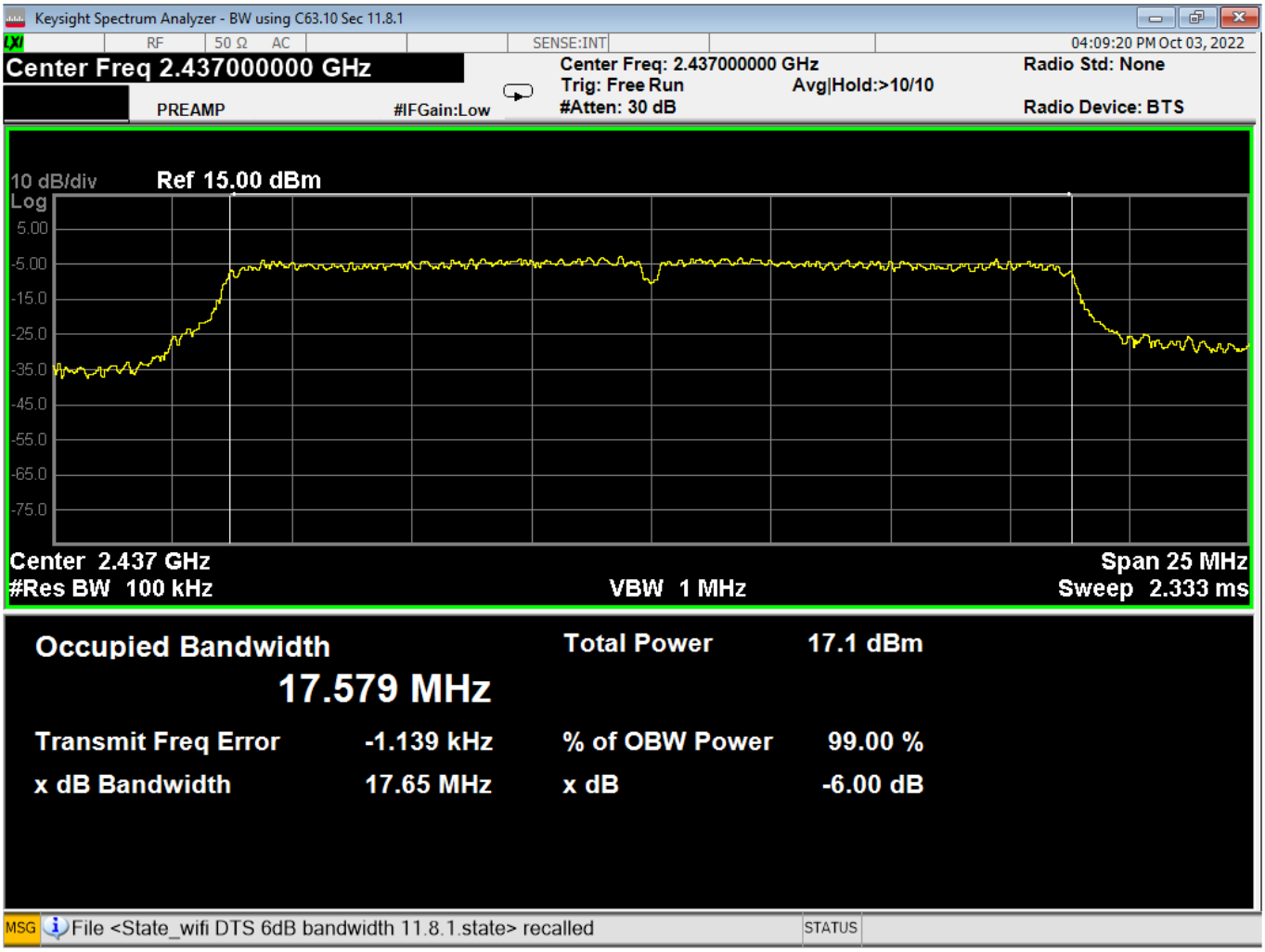
83 6dB Bandwidth, Mid, Wifi G, Low Data Rate



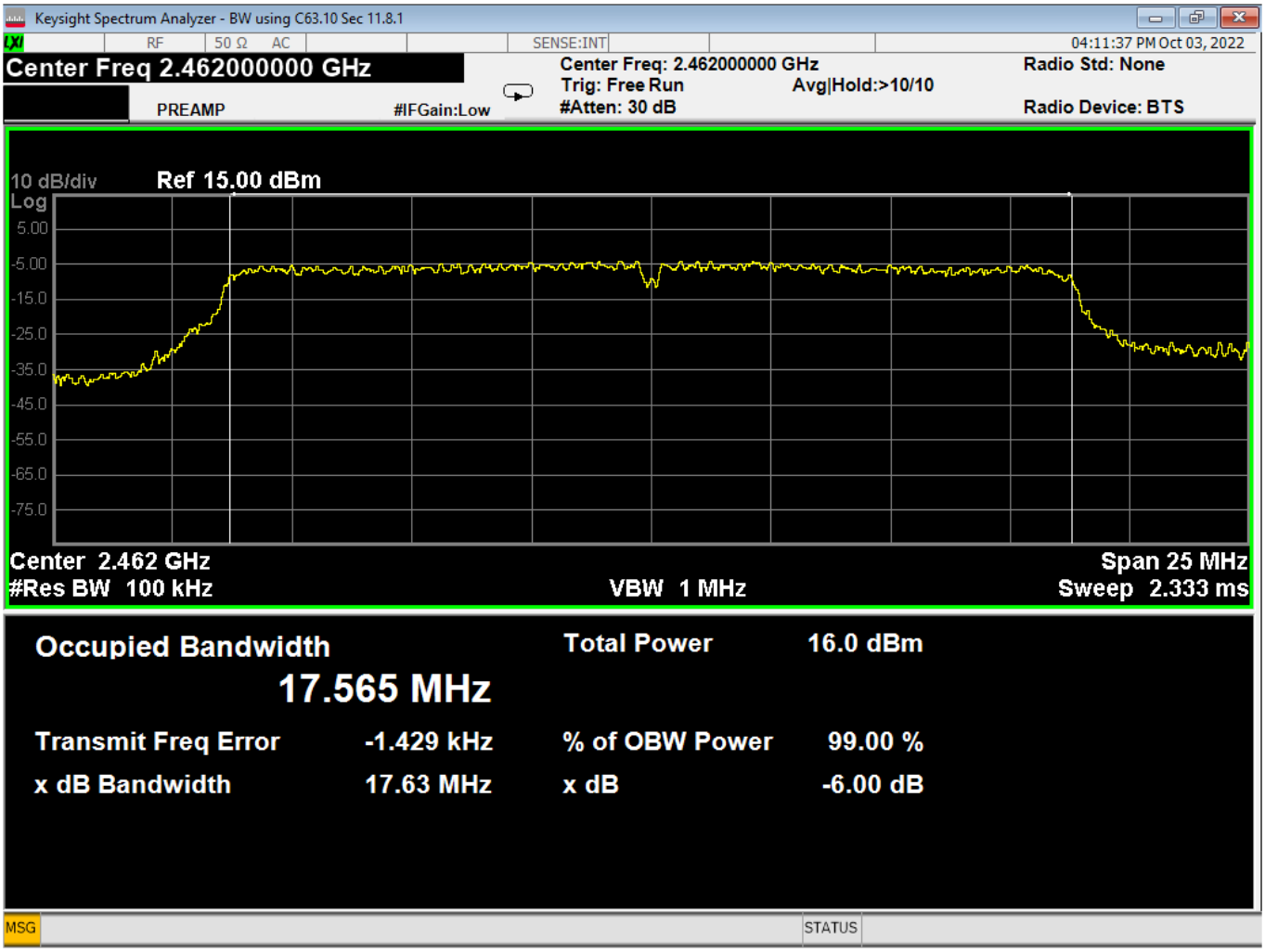
84 6dB Bandwidth, High, Wifi G, Low Data Rate



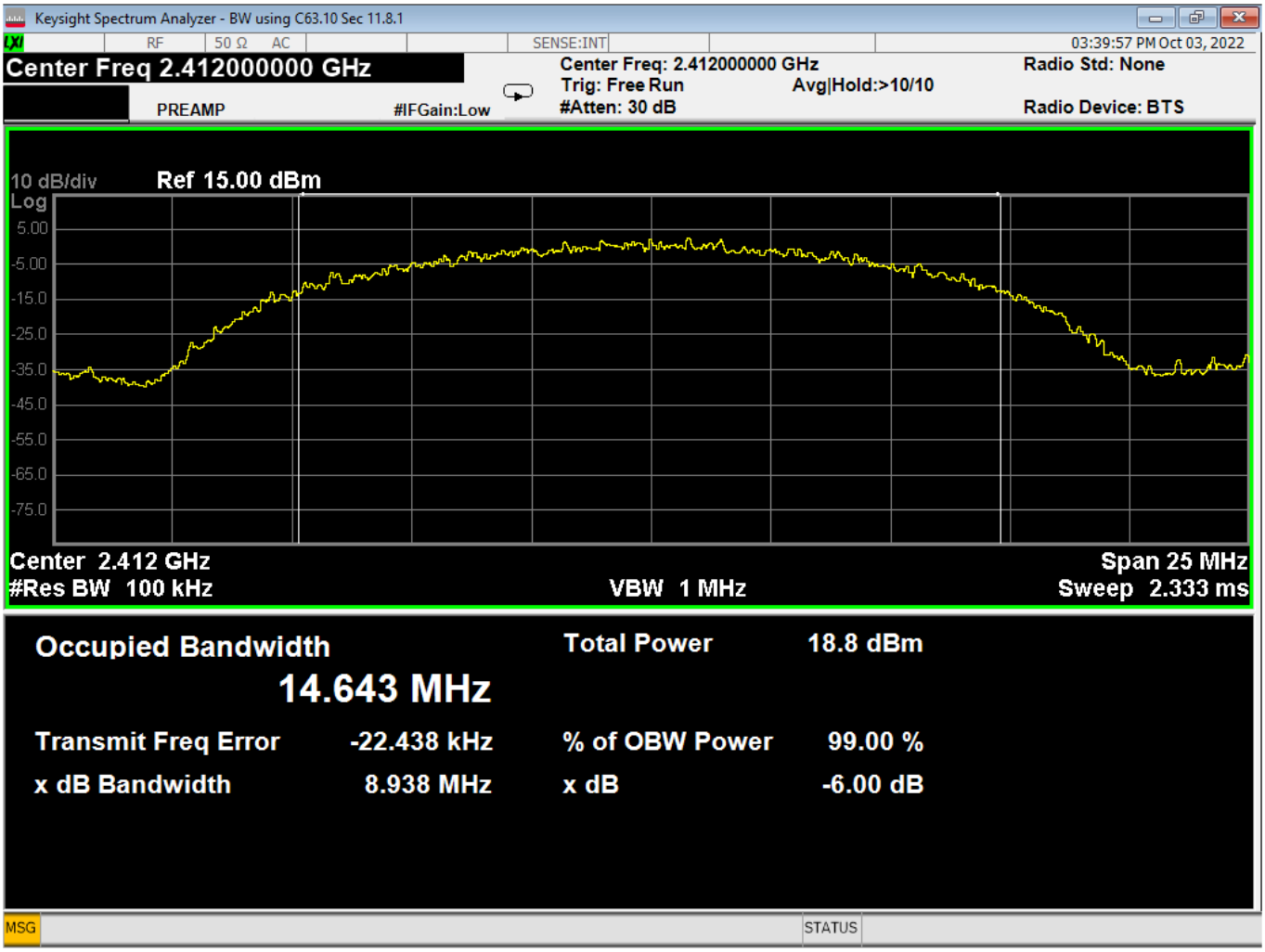
85 6dB Bandwidth, Low, Wifi N, Low Data Rate



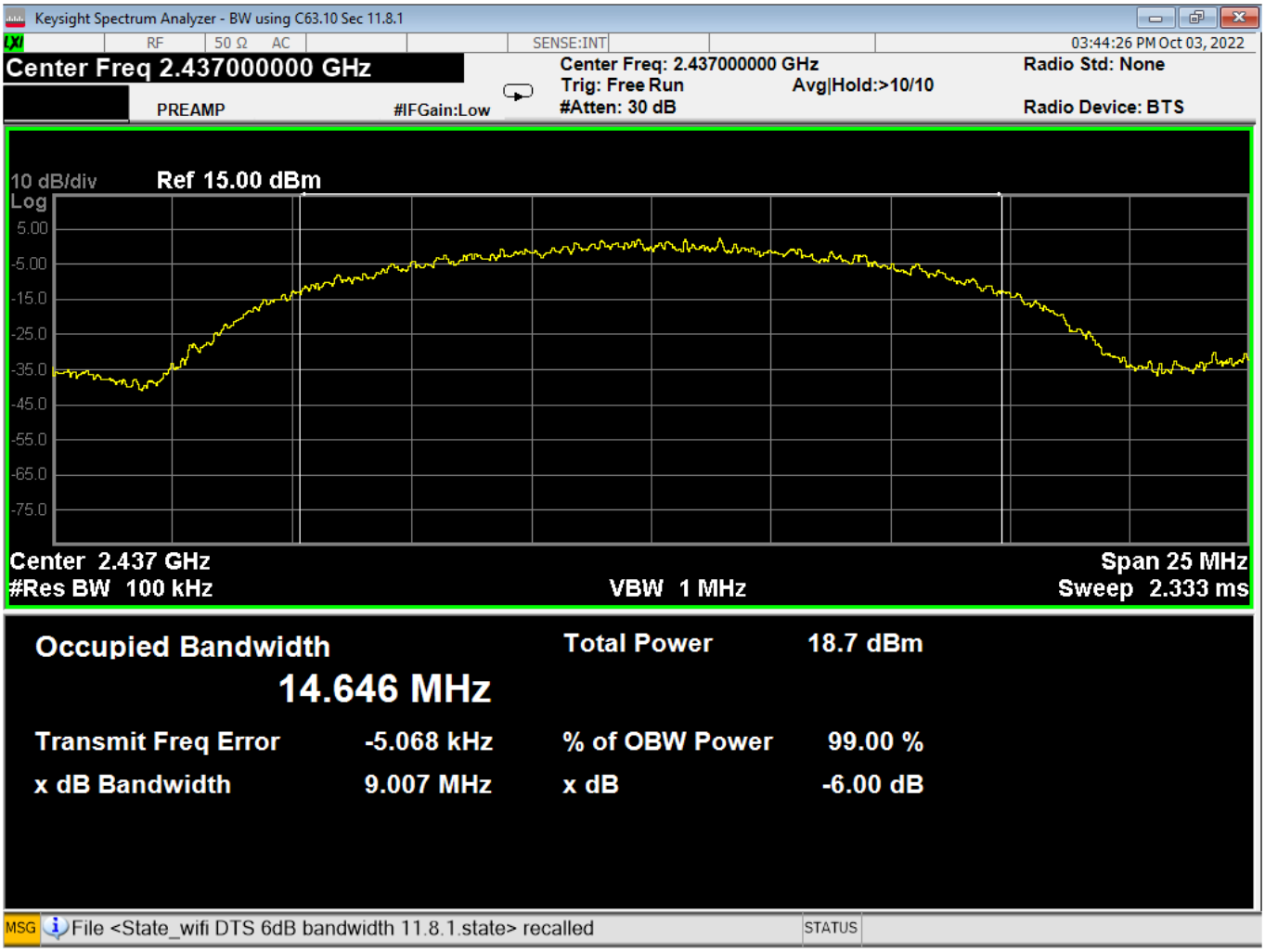
86 6dB Bandwidth, Mid, Wifi N, Low Data Rate



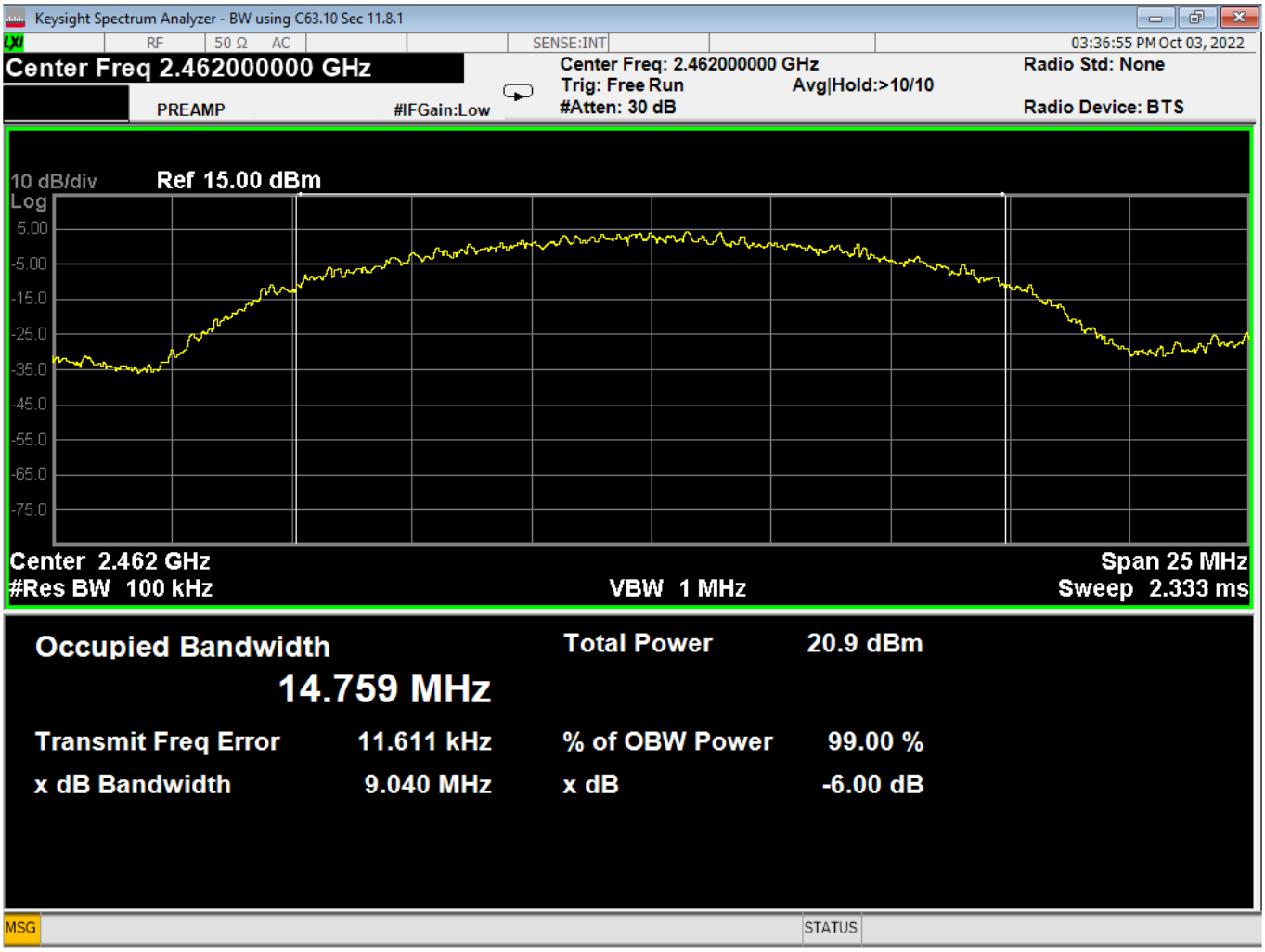
87 6dB Bandwidth, High, Wifi N, Low Data Rate



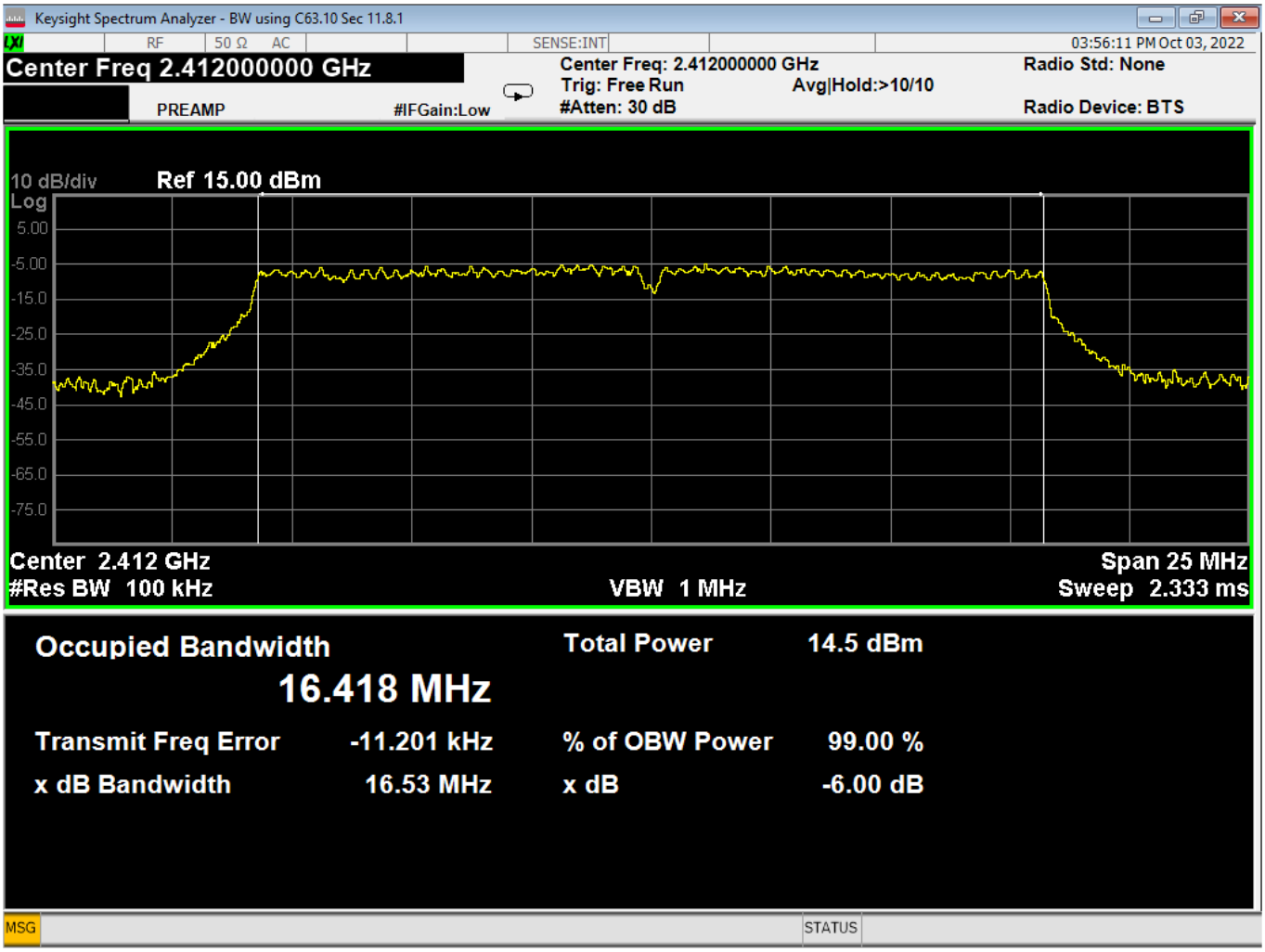
88 6dB Bandwidth, Low, Wifi B, High Data Rate



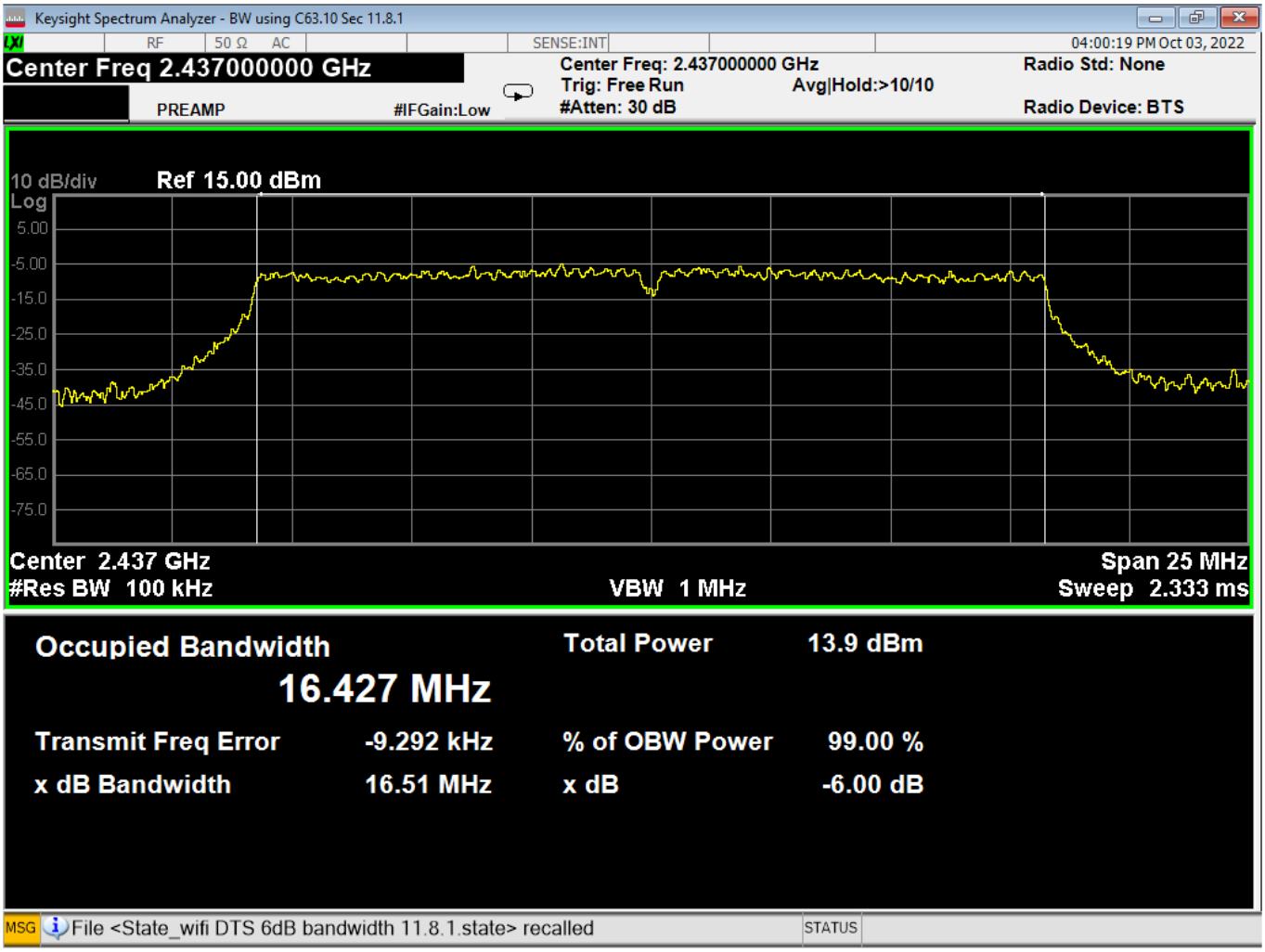
89 6dB Bandwidth, Mid, Wifi B, High Data Rate



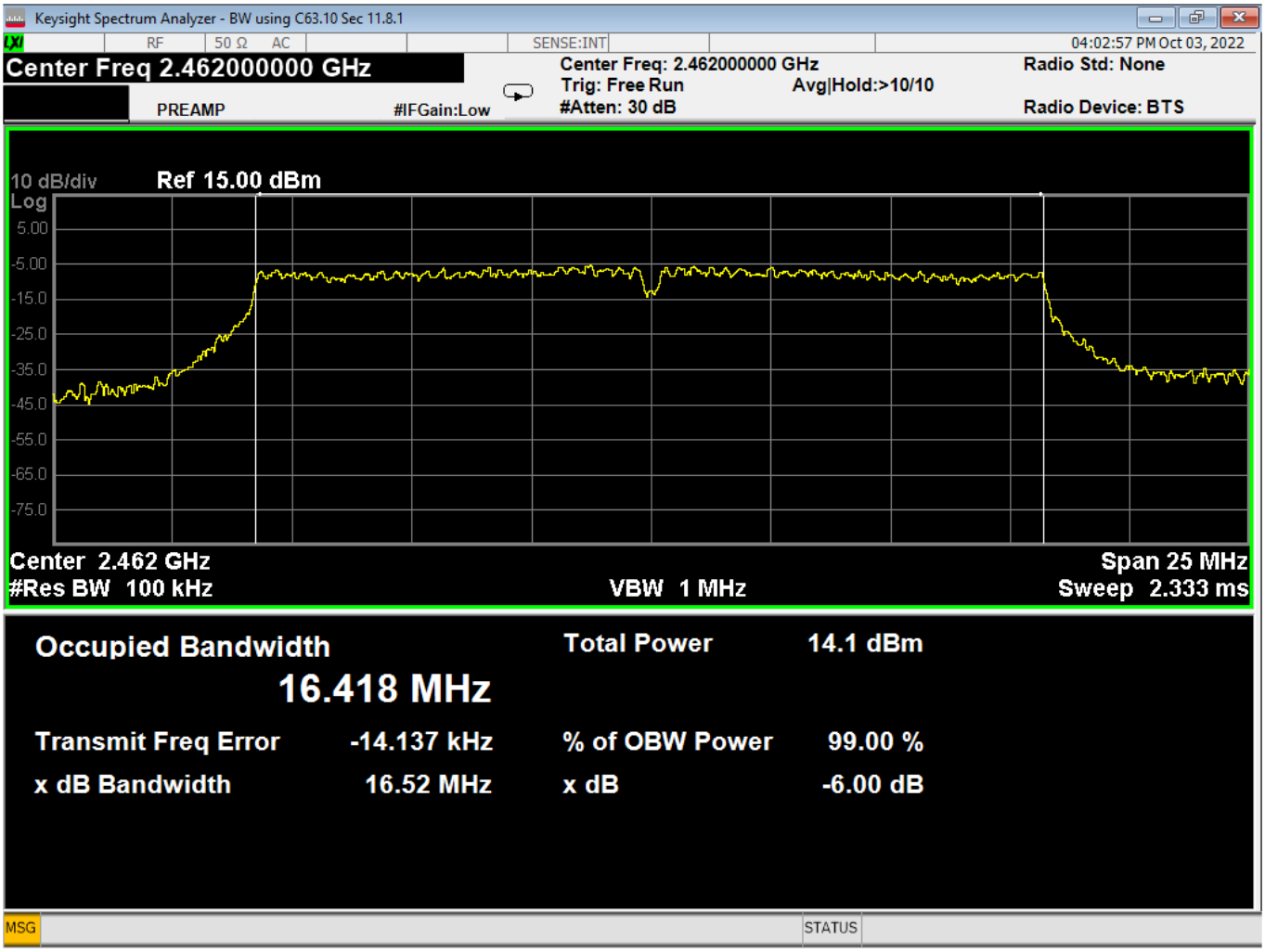
90 6dB Bandwidth, High, Wifi B, High Data Rate



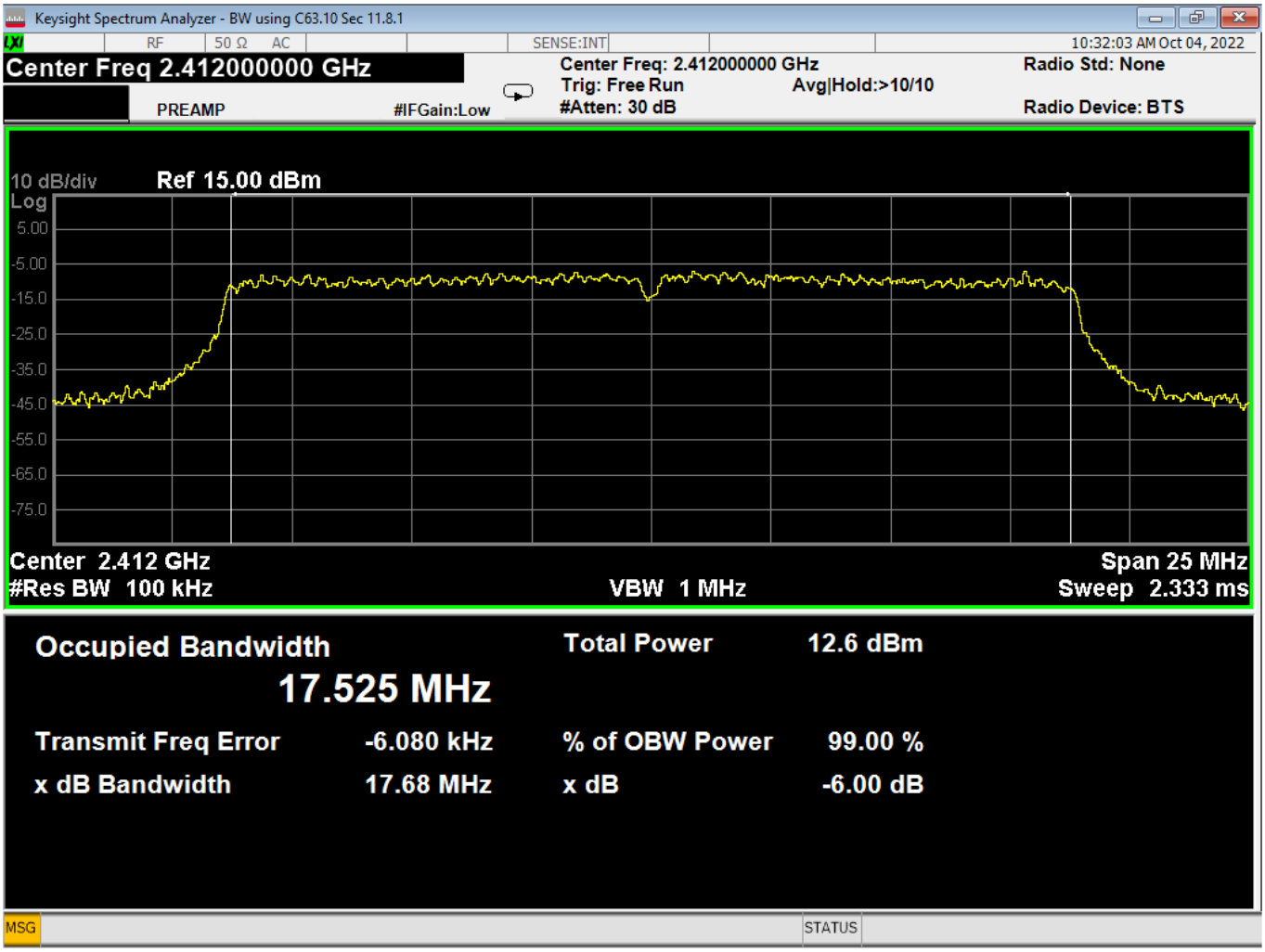
91 6dB Bandwidth, Low, Wifi G, High Data Rate



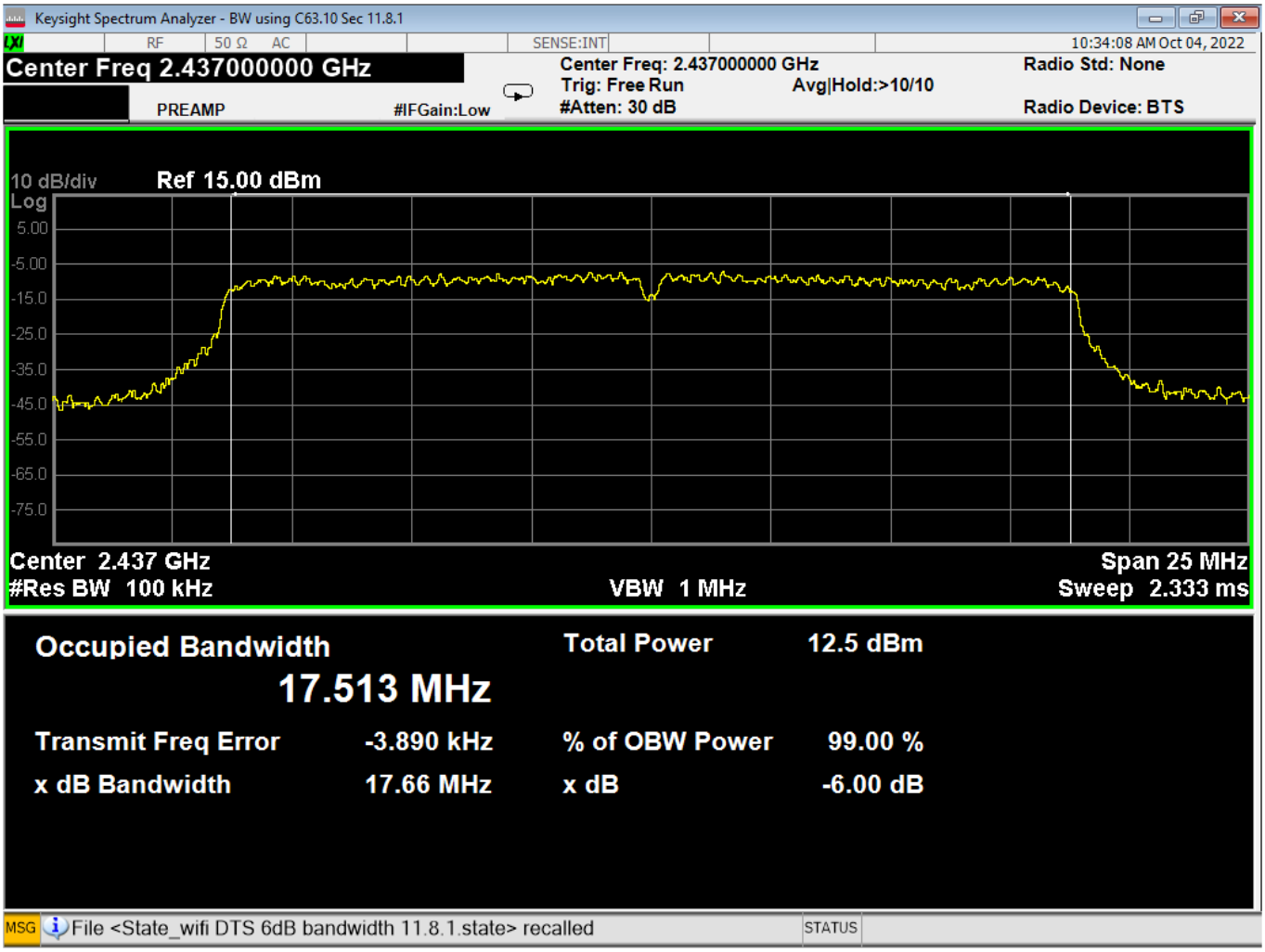
92 6dB Bandwidth, Mid, Wifi G, High Data Rate



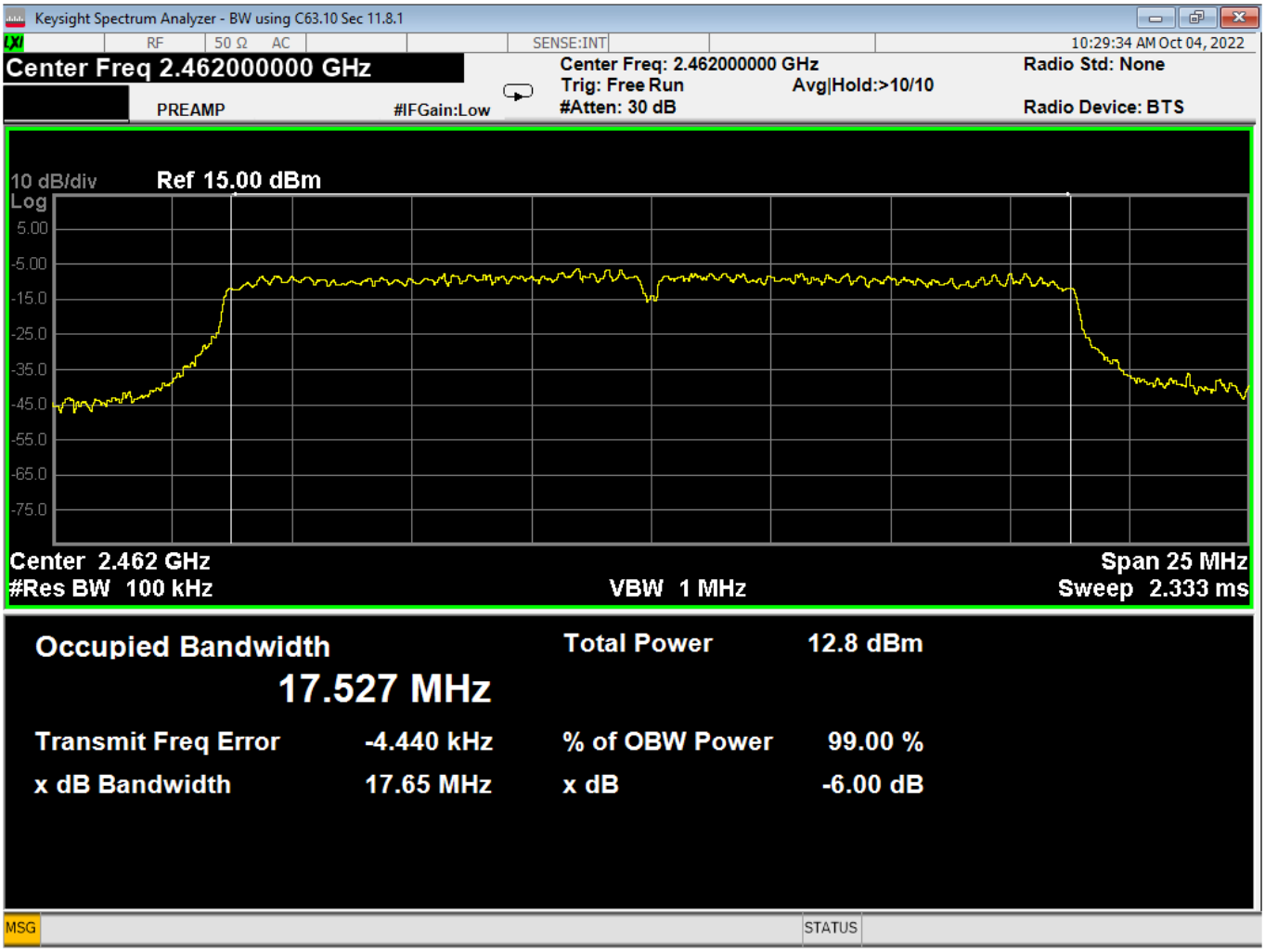
93 6dB Bandwidth, High, Wifi G, High Data Rate



94 6dB Bandwidth, Low, Wifi N, High Data Rate



95 6dB Bandwidth, Mid, Wifi N, High Data Rate



96 6dB Bandwidth, High, Wifi N, High Data Rate

REPORT END