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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: A04542

Test Report No: R20230109-20-E5C

Approved by:

Fox Lane
EMC Test Engineer

DATE: May 18, 2023

Total Pages: 197

REVISION PAGE

Rev. No.	Date	Description
0	31 March 2023	Issued by FLane Reviewed by FLane Prepared by FLane, GLarsen
A	10 April 2023	Updated Antenna Gain - FL
B	13 April 2023	Corrected FCC/IC ID - FL
C	17 May 2023	Added Channel 12 and 13 Data – ES/FL

CONTENTS

1.0 SUMMARY OF TEST RESULTS

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

FCC Part 15.247

The EUT has been tested according to the following specifications:

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

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

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary and Operating Condition:

EUT	A04542
FCC ID	IPH-04542
IC ID	1792A-04542
EUT Received	13 February 2023
EUT Tested	15 February 2023- 23 March 2023
Serial No.	3436744035 (Radiated Measurements) 3436743817 (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: AQ27A-59CFA GPN: 362-00118-00 (Representative Power Supply)
Antenna Type / Gain (dBi)	-1.88dBi Trace Antenna Antenna Gain value based off Customer provided AUT Report. Results may differ.

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:

Data Rates:

Modulation	Low/High Data rate
802.11b	1MB/11MB
802.11g	6MB/54MB
802.11n	MCS0/MCS7

For 802.11x Transmissions:

Channel	Frequency
Low	2412 MHz
Mid	2437 MHz
High	2462 MHz
12	2467 MHz
13	2472 MHz

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

2.3 DESCRIPTION OF SUPPORT UNITS

None

3.0 LABORATORY AND GENERAL TEST DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

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

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

Environmental conditions varied slightly throughout the tests:
Relative humidity of 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Fox Lane	Test Engineer	Testing and Report
2	Blake Winter	Test Engineer	Testing
3	Grace Larsen	Test Engineer	Testing and Report
4	Ethan Schmidt	Test Technician	Testing and Report

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
EMCO Horn Antenna	3115	6416	July 28, 2021	July 28, 2022
EMCO Horn Antenna***	3116	2576	March 9, 2020	March 9, 2024
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	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.

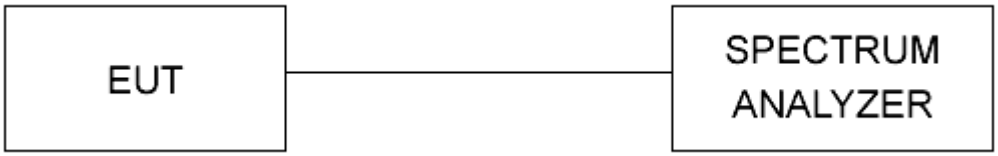


Figure 1 - Bandwidth Measurements Test Setup

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.

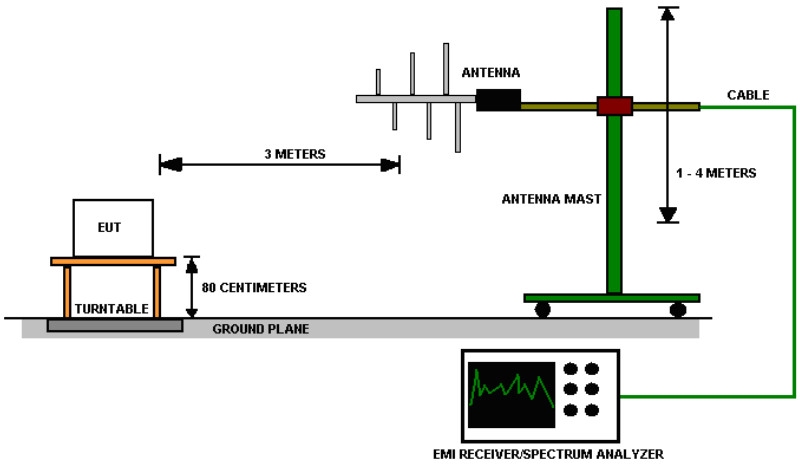


Figure 2 - Radiated Emissions Test Setup

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	14.05	11.17	15.420	34.834	-13.782	PASS
Mid	802.11 b	14.30	12.13	15.860	38.548	-12.105	PASS
High	802.11 b	13.94	11.27	12.500	17.783	-16.591	PASS
12	802.11b	13.971	11.19	14.26	26.669	-17.088	PASS
13	802.11b	13.956	12.21	14.03	25.293	-17.355	PASS
Low	802.11 g	16.94	16.50	10.900	12.303	-13.116	PASS
Mid	802.11 g	17.19	16.54	13.740	23.659	-10.102	PASS
High	802.11 g	17.04	16.48	9.940	9.863	-12.715	PASS
12	802.11g	17.079	16.48	11.68	14.723	-10.576	PASS
13	802.11g	17.063	16.54	11.37	13.709	-13.56	PASS
Low	802.11 n	17.71	17.74	10.600	11.482	-13.404	PASS
Mid	802.11 n	17.73	17.79	13.500	22.387	-11.403	PASS
High	802.11 n	17.78	17.68	9.700	9.333	-13.39	PASS
12	802.11n	17.85	17.76	11.73	14.894	-13.269	PASS
13	802.11n	17.834	17.75	11.36	13.677	-13.832	PASS
Occupied Bandwidth = N/A; 6 dB Bandwidth Limit =500 kHz				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	2400.00	72.40	103.86	31.46	30.00	PASS
Low	802.11 g	2400.00	64.50	99.47	34.97	30.00	PASS
Low	802.11 n	2400.00	64.96	98.99	34.03	30.00	PASS
High	802.11 b	2483.50	58.73	108.31	49.58	30.00	PASS
High	802.11 g	2483.50	60.69	104.36	43.67	30.00	PASS
High	802.11 n	2483.50	59.94	104.63	44.69	30.00	PASS
13	802.11b	2483.50	66.006	109.90	43.89	30.00	PASS
13	802.11g	2483.50	72.409	105.69	33.28	30.00	PASS
13	802.11n	2483.50	70.02	106.49	36.47	30.00	PASS

Radiated 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	53.39	Peak	73.98	20.59	PASS
Low	802.11 g	2390.00	64.08	Peak	73.98	9.90	PASS
Low	802.11 n	2390.00	62.92	Peak	73.98	11.06	PASS
High	802.11 b	2483.50	53.11	Peak	73.98	20.87	PASS
High	802.11 g	2483.50	63.80	Peak	73.98	10.18	PASS
High	802.11 n	2483.50	60.76	Peak	73.98	13.22	PASS
13	802.11 b	2483.50	56.801	Peak	73.98	17.179	PASS
13	802.11 g	2483.50	65.071	Peak	73.98	8.909	PASS
13	802.11 n	2483.50	63.64	Peak	73.98	10.34	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							

Radiated 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	42.40	Average	53.98	11.58	PASS
Low	802.11 g	2390.00	45.48	Average	53.98	8.51	PASS
Low	802.11 n	2390.00	46.63	Average	53.98	7.35	PASS
High	802.11 b	2483.50	42.00	Average	53.98	11.98	PASS
High	802.11 g	2483.50	45.01	Average	53.98	8.97	PASS
High	802.11 n	2483.50	44.80	Average	53.98	9.18	PASS
13	802.11 b	2483.50	47.793	Average	53.98	6.187	PASS
13	802.11 g	2483.50	47.683	Average	53.98	6.297	PASS
13	802.11 n	2483.50	47.83	Average	53.98	6.15	PASS
*Limit shown is the average limit taken from FCC Part 15.209							

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	13.80	11.60	13.480	22.284	-10.928	PASS
Mid	802.11 b	13.92	11.44	15.500	35.481	-9.321	PASS
High	802.11 b	13.83	11.63	12.280	16.904	-12.255	PASS
12	802.11b	13.833	11.62	14.06	25.468	-11.842	PASS
13	802.11b	13.809	11.62	13.71	23.496	-12.265	PASS
Low	802.11 g	16.75	16.48	10.860	12.190	-12.497	PASS
Mid	802.11 g	16.91	16.54	13.690	23.388	-9.735	PASS
High	802.11 g	16.85	16.49	9.910	9.795	-13.504	PASS
12	802.11g	16.841	16.50	11.86	15.346	-12.732	PASS
13	802.11g	16.792	16.51	11.45	13.964	-13.357	PASS
Low	802.11 n	17.81	17.74	10.590	11.455	-13.086	PASS
Mid	802.11 n	17.89	17.76	13.540	22.594	-10.222	PASS
High	802.11 n	17.85	17.69	9.760	9.462	-14.417	PASS
12	802.11n	17.862	17.77	11.74	14.928	-13.259	PASS
13	802.11n	17.836	17.75	11.36	13.677	-14.615	PASS
Occupied Bandwidth = N/A; 6 dB Bandwidth Limit =500 kHz				Output Power Limit = 30 dBm; PSD Limit = 8 dBm			

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	2390.00	74.18	110.14	35.95	30.00	PASS
Low	802.11 g	2390.00	64.76	99.54	34.78	30.00	PASS
Low	802.11 n	2390.00	64.98	98.91	33.93	30.00	PASS
High	802.11 b	2483.50	53.75	108.60	54.85	30.00	PASS
High	802.11 g	2483.50	62.43	106.04	43.61	30.00	PASS
High	802.11 n	2483.50	60.24	102.64	42.40	30.00	PASS
13	802.11b	2483.50	68.38	110.92	42.55	30.00	PASS
13	802.11g	2483.50	71.15	107.31	36.17	30.00	PASS
13	802.11n	2483.50	73.25	107.01	33.76	30.00	PASS

Radiated 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	53.55	Peak	73.98	20.43	PASS
Low	802.11 g	2390.00	63.14	Peak	73.98	10.84	PASS
Low	802.11 n	2390.00	63.93	Peak	73.98	10.05	PASS
High	802.11 b	2483.50	53.72	Peak	73.98	20.26	PASS
High	802.11 g	2483.50	61.76	Peak	73.98	12.22	PASS
High	802.11 n	2483.50	59.80	Peak	73.98	14.18	PASS
13	802.11 b	2483.50	57.396	Peak	73.98	16.584	PASS
13	802.11 g	2483.50	64.256	Peak	73.98	9.724	PASS
13	802.11 n	2483.50	64.936	Peak	73.98	9.044	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							

Radiated 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	41.56	Average	53.98	12.42	PASS
Low	802.11 g	2390.00	45.69	Average	53.98	8.29	PASS
Low	802.11 n	2390.00	46.67	Average	53.98	7.31	PASS
High	802.11 b	2483.50	41.90	Average	53.98	12.08	PASS
High	802.11 g	2483.50	44.44	Average	53.98	9.54	PASS
High	802.11 n	2483.50	45.00	Average	53.98	8.98	PASS
13	802.11 b	2483.50	46.784	Average	53.98	7.196	PASS
13	802.11 g	2483.50	47.449	Average	53.98	6.531	PASS
13	802.11 n	2483.50	47.878	Average	53.98	6.102	PASS
*Limit shown is the average limit taken from FCC Part 15.209							

4.1 OUTPUT POWER

Test Method: Power measurements were performed using ANSI C63.10, Section 11.9.2.2.2.

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

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

Deviations from test standard:
No deviation.

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

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

Test results:

Pass

Comments:

1. All the output power plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are listed in the tables in section 4.0.

4.2 BANDWIDTH

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

Limits of bandwidth measurements:

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

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

Deviations from test standard:
No deviation.

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

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

Test results:

Pass

Comments:

1. All the bandwidth plots can be found in Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are listed in the tables in section 4.0.

4.3 DUTY CYCLE

Test Method:

All Modulations/Transmitters in this report had a duty cycle of >98%

4.4 RADIATED EMISSIONS

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

Limits for radiated emissions measurements:

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

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

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

Test procedures:

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

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

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

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

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

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

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

Test setup:

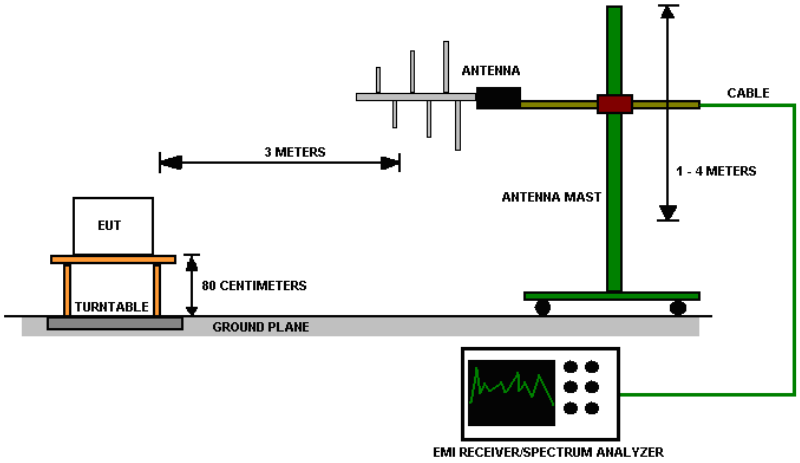


Figure 3 - Radiated Emissions Test Setup

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

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

Deviations from test standard:
No deviation.

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

Test results:

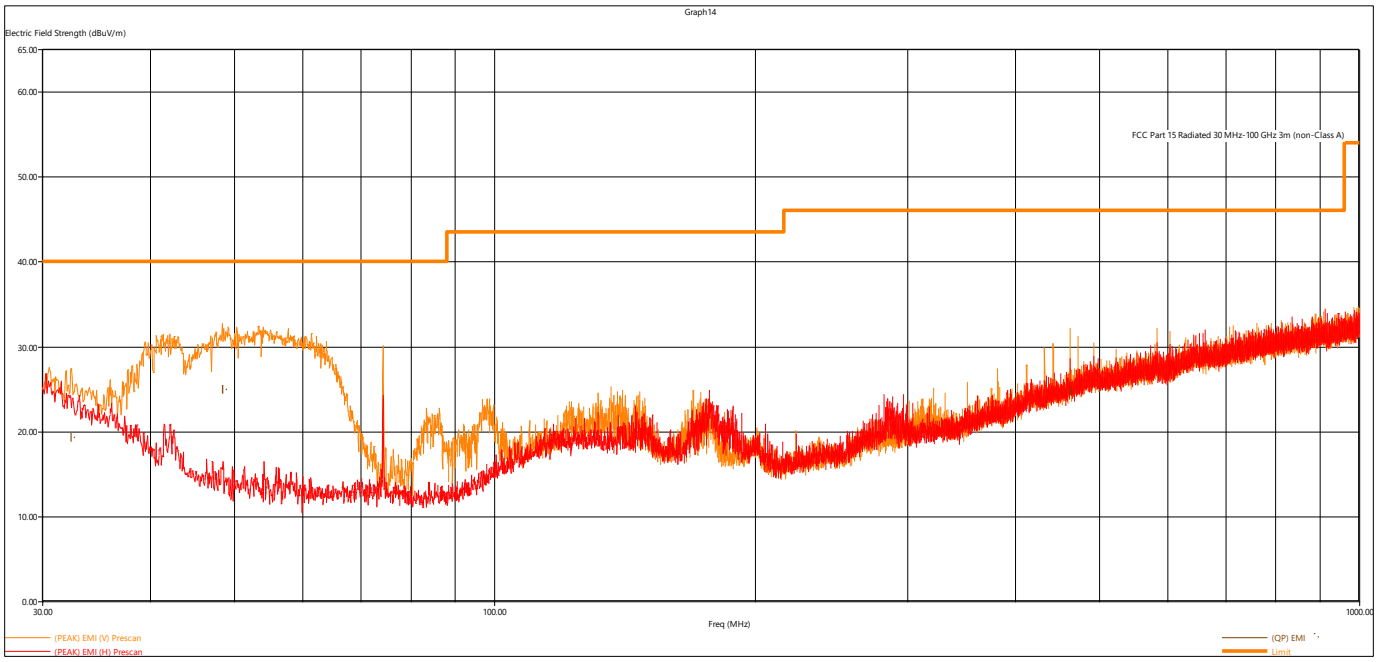


Figure 4 - Radiated Emissions Plot, Receive

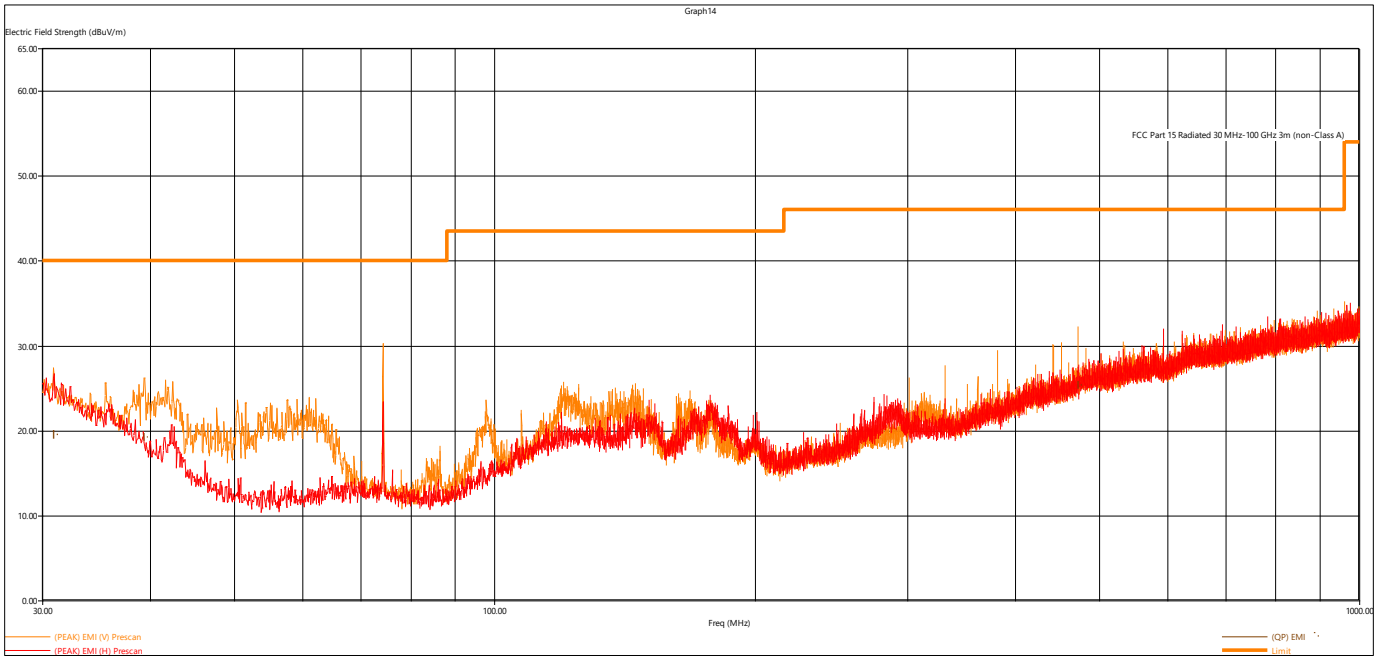


Figure 5 - Radiated Emissions Plot, 802.11b 1MB

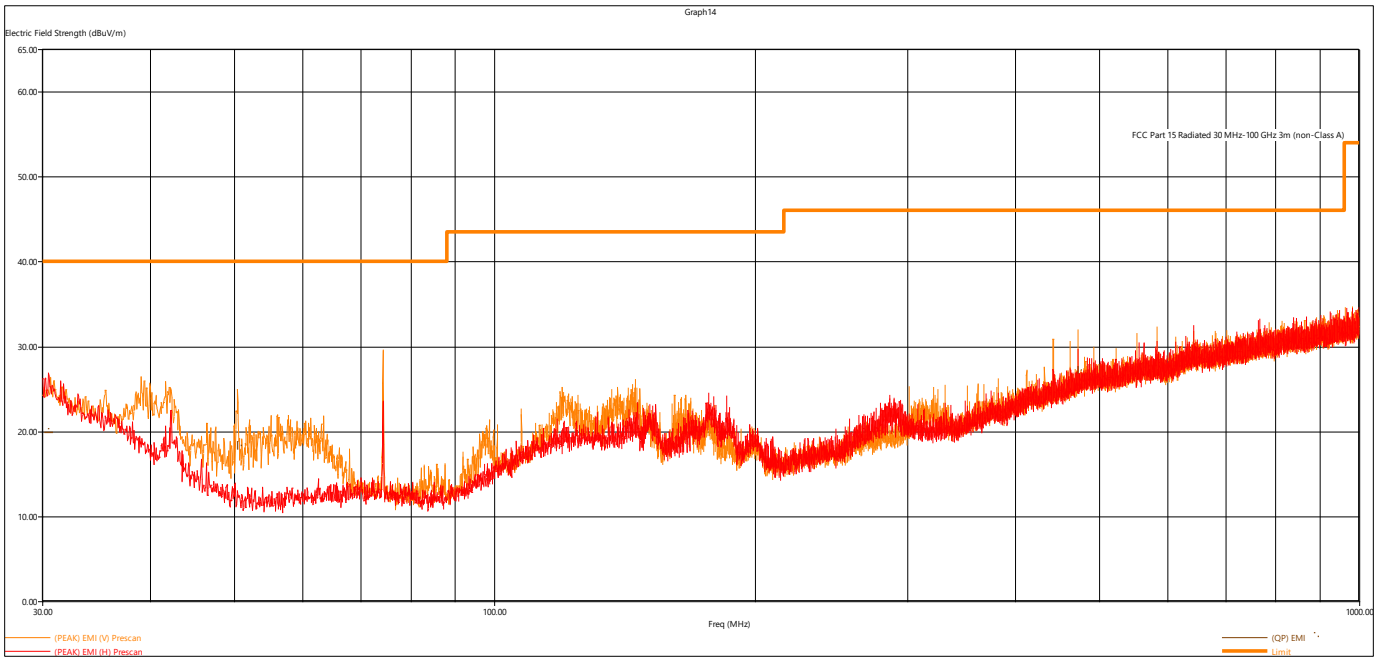


Figure 6 - Radiated Emissions Plot, 802.11b 11MB

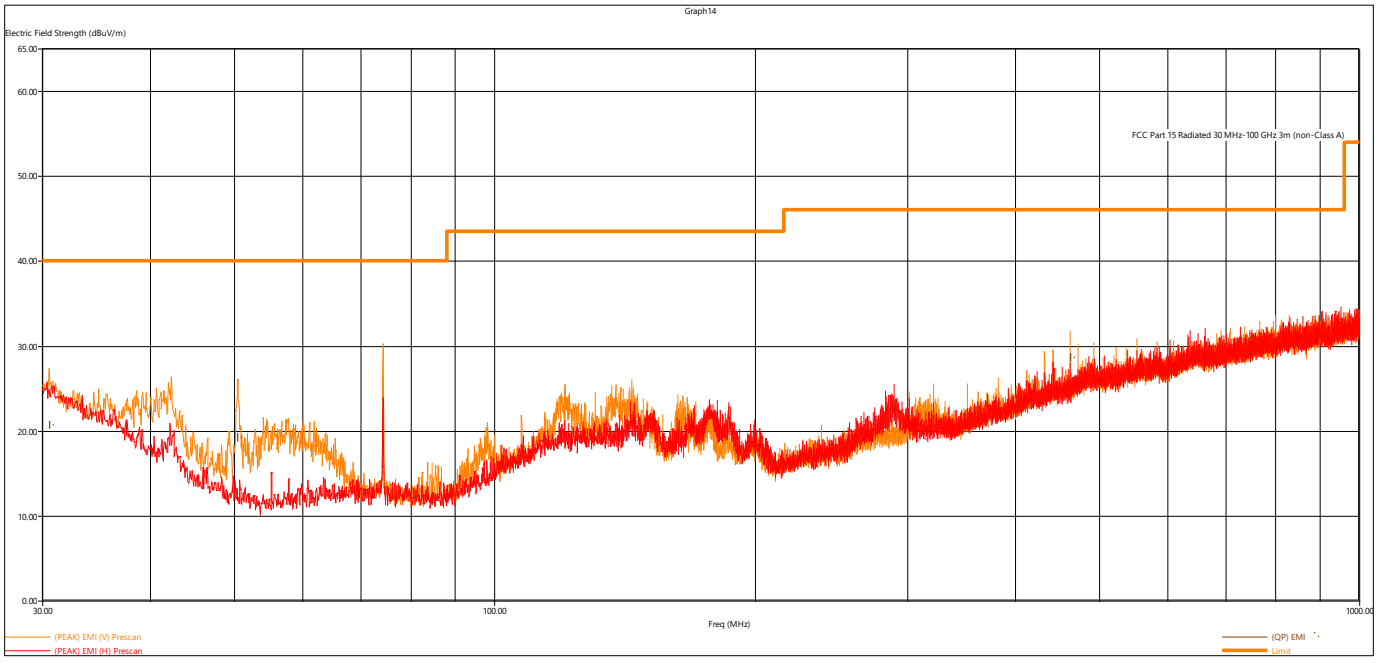


Figure 7 - Radiated Emissions Plot, 802.11g 6MB

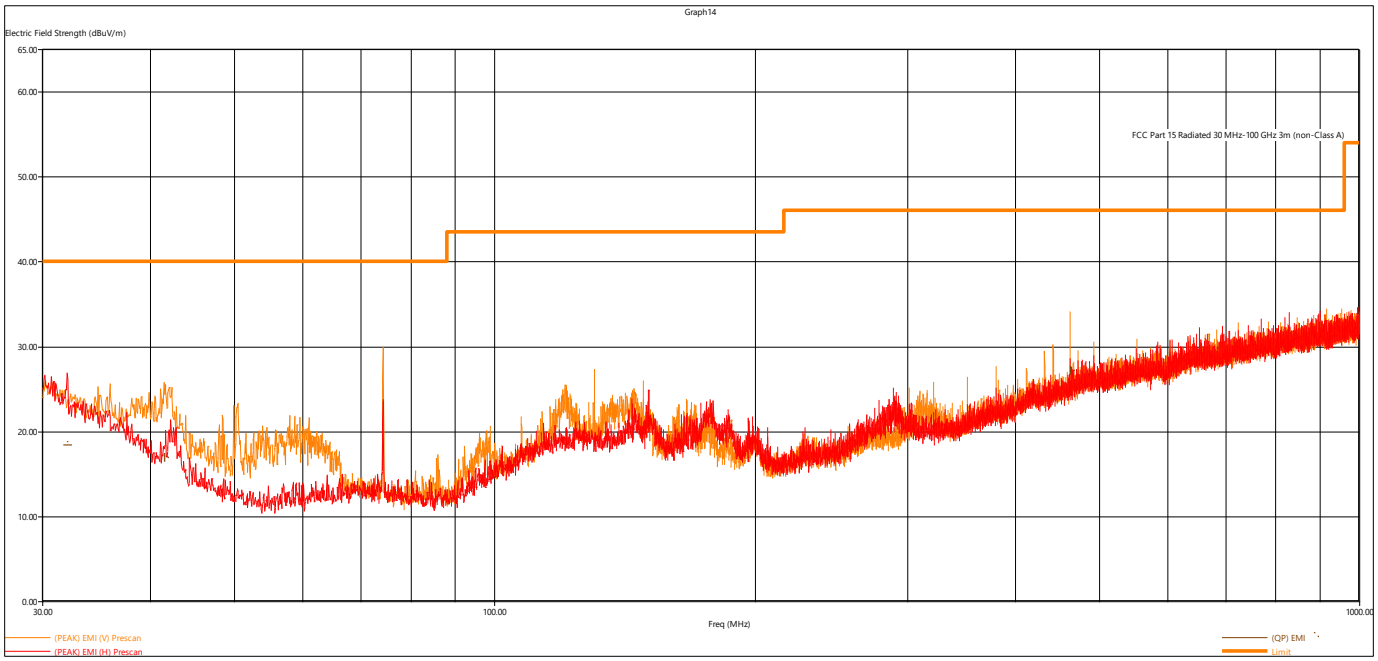


Figure 8 - Radiated Emissions Plot, 802.11g 54MB

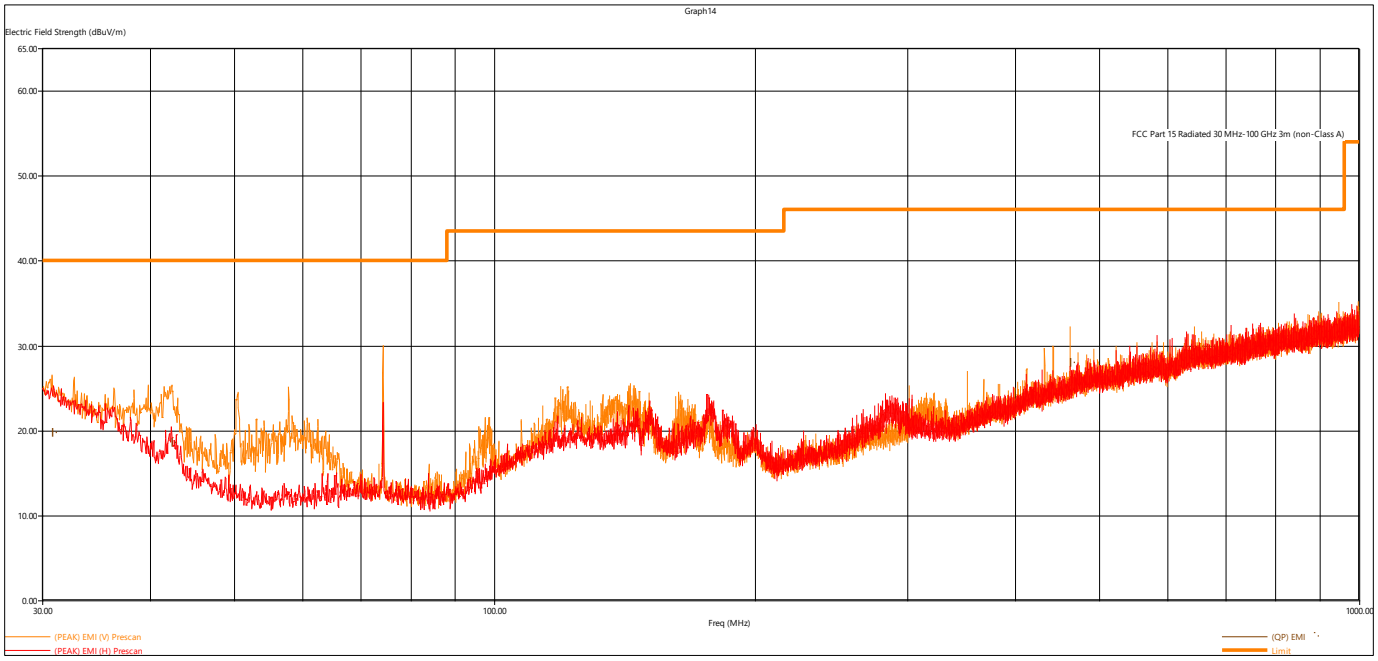


Figure 9 - Radiated Emissions Plot, 802.11n MCS0

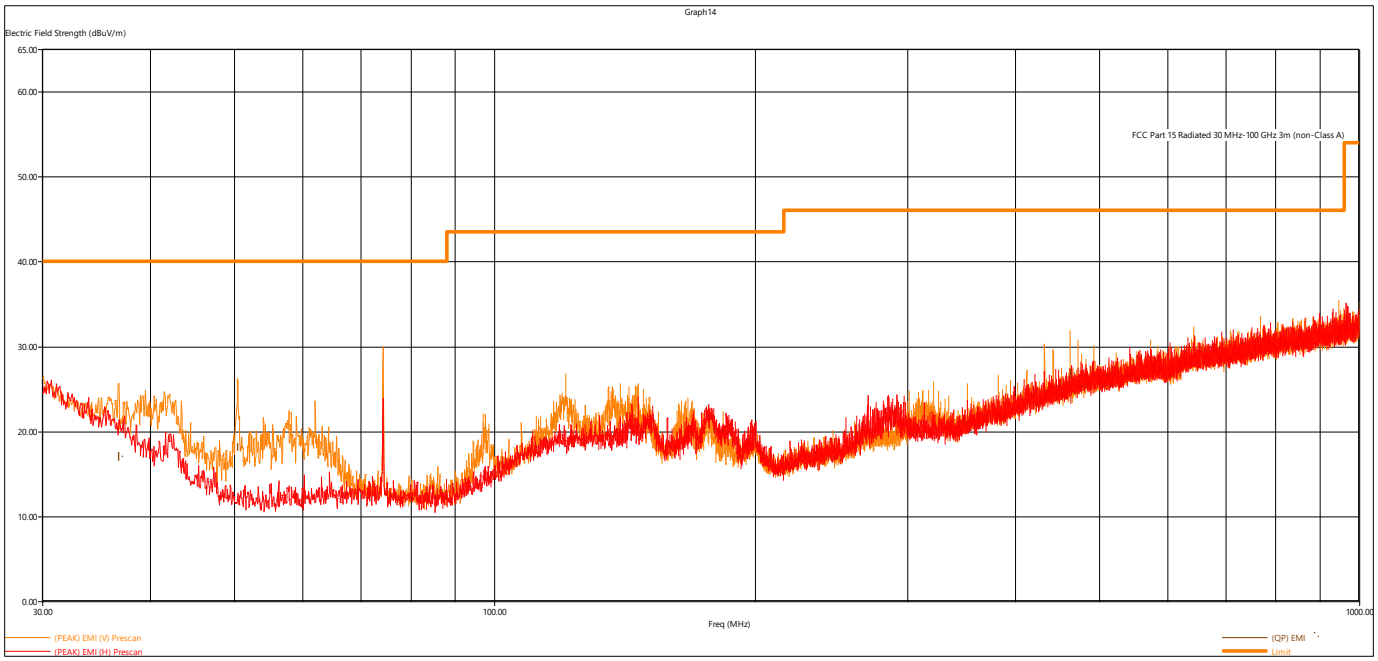


Figure 10 - Radiated Emissions Plot, 802.11n MCS7

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.**			
30.90648	19.48	40.00	20.52	220	3	V	Low	WIFI B 1MB
39.47784	19.23	40.00	20.77	129	360	V	Low	WIFI B 1MB
472.3224	25.28	46.02	20.74	118	196	V	Low	WIFI B 1MB
30.54	19.77	40.00	20.23	355	50	H	Low	WIFI B 11MB
50.49816	18.32	40.00	21.68	117	161	V	Low	WIFI B 11MB
472.36368	27.15	46.02	18.87	113	307	V	Low	WIFI B 11MB
30.51192	20.67	40.00	19.33	117	156	V	Low	WIFI G 6MHz
50.39304	19.1	40.00	20.9	121	164	V	Low	WIFI G 6MHz
462.30336	28.61	46.02	17.41	112	348	V	Low	WIFI G 6MHz
31.99296	18.39	40.00	21.61	186	36	H	Low	WIFI G 54MHz
41.51256	16.83	40.00	23.17	225	169	V	Low	WIFI G 54MHz
462.29688	27.09	46.02	18.93	105	209	V	Low	WIFI G 54MHz
30.85704	19.74	40.00	20.26	109	227	V	Low	WIFI N MCS0
42.30888	18.53	40.00	21.47	222	25	V	Low	WIFI N MCS0
462.31152	27.91	46.02	18.11	112	3	V	Low	WIFI N MCS0
36.52704	17.01	40.00	22.99	167	111	V	Low	WIFI N MCS7
50.32896	18.07	40.00	21.93	133	167	V	Low	WIFI N MCS7
462.27384	26.78	46.02	19.24	115	2	V	Low	WIFI N MCS7
32.3244	19.2	40.00	20.8	196	274	V	Receive	
48.42456	24.92	40.00	15.08	131	217	V	Receive	
462.28032	24.69	46.02	21.33	134	17	V	Receive	

All other measurements were found to be at least 6 dB below the limit. Worst case emissions are reported.

Peak Measurements, 802.11x								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	Modulation
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
2409.25	97.25	73.98	NA	242	166	H	Low	WIFI B 1MB
4824.004	57.44	73.98	16.54	185	359	H	Low	WIFI B 1MB
2434.216	98.2	73.98	NA	236	167	H	Mid	WIFI B 1MB
4873.926	59.47	73.98	14.51	141	134	V	Mid	WIFI B 1MB
2459.268	95.32	73.98	NA	231	168	H	High	WIFI B 1MB
4924.026	56.53	73.98	17.45	276	199	H	High	WIFI B 1MB
2412.98	99.29	73.98	NA	241	167	H	Low	WIFI B 11MB
4824.192	56.56	73.98	17.42	303	176	H	Low	WIFI B 11MB
2433.514	101.76	73.98	NA	235	168	H	Mid	WIFI B 11MB
4875.05	56.11	73.98	17.87	144	151	V	Mid	WIFI B 11MB
2460.814	98.12	73.98	NA	227	168	H	High	WIFI B 11MB
4922.812	54.09	73.98	19.89	162	151	V	High	WIFI B 11MB
2411.202	97.01	73.98	NA	243	163	H	Low	WIFI G 6MHz
4825.532	54.8	73.98	19.18	303	5	H	Low	WIFI G 6MHz
2431.63	100.34	73.98	NA	241	162	H	Mid	WIFI G 6MHz
4873.73	57.52	73.98	16.46	173	103	H	Mid	WIFI G 6MHz
2456.664	98.08	73.98	NA	226	167	H	High	WIFI G 6MHz
4921.006	53.38	73.98	20.6	144	3	H	High	WIFI G 6MHz
2405.734	97.7	73.98	NA	390	163	H	Low	WIFI G 54MHz
9648.43	55.05	73.98	18.93	376	66	H	Low	WIFI G 54MHz
4818.832	53.04	73.98	20.94	264	29	V	Low	WIFI G 54MHz
2434.29	100.48	73.98	NA	202	161	H	Mid	WIFI G 54MHz
4874	59.88	73.98	14.1	135	260	H	Mid	WIFI G 54MHz
2455.374	98.74	73.98	NA	237	167	H	High	WIFI G 54MHz
4924	55.88	73.98	18.1	111	270	H	High	WIFI G 54MHz
2409.596	99.03	73.98	NA	241	171	H	Low	WIFI N MCS0
4824	56.29	73.98	17.69	100	260	H	Low	WIFI N MCS0
2432.572	101.34	73.98	NA	234	162	H	Mid	WIFI N MCS0
4874	57.52	73.98	16.46	139	160	H	Mid	WIFI N MCS0
2458.324	98.23	73.98	NA	364	175	H	High	WIFI N MCS0
4924	54.85	73.98	19.13	195	180	H	High	WIFI N MCS0
2408.376	97.21	73.98	NA	193	188	H	Low	WIFI N MCS7
4824	54.55	73.98	19.43	245	345	H	Low	WIFI N MCS7
2430.812	101.18	73.98	NA	377	181	H	Mid	WIFI N MCS7
4874	57.15	73.98	16.83	235	345	H	Mid	WIFI N MCS7
2455.472	97.28	73.98	NA	371	182	H	High	WIFI N MCS7
4924	55.06	73.98	18.92	140	350	H	High	WIFI N MCS7

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

Average Measurements, 802.11x								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Modulation**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			
2409.25	94.14	53.98	NA	242	166	H	Low	WIFI B 1MB
4824.004	50.02	53.98	3.96	185	359	H	Low	WIFI B 1MB
2434.216	95.15	53.98	NA	236	167	H	Mid	WIFI B 1MB
4873.926	**52.00**	**53.98**	**1.98**	**141**	**134**	**V**	**Mid**	**WIFI B 1MB**
2459.268	92.18	53.98	NA	231	168	H	High	WIFI B 1MB
4924.026	48.30	53.98	5.68	276	199	H	High	WIFI B 1MB
2412.98	91.04	53.98	NA	241	167	H	Low	WIFI B 11MB
4824.192	36.89	53.98	17.09	303	176	H	Low	WIFI B 11MB
2433.514	93.75	53.98	NA	235	168	H	Mid	WIFI B 11MB
4875.05	39.80	53.98	14.18	144	151	V	Mid	WIFI B 11MB
2460.814	90.51	53.98	NA	227	168	H	High	WIFI B 11MB
4922.812	37.93	53.98	16.05	162	151	V	High	WIFI B 11MB
2411.202	86.72	53.98	NA	243	163	H	Low	WIFI G 6MHz
4825.532	34.30	53.98	19.68	303	5	H	Low	WIFI G 6MHz
2431.63	89.70	53.98	NA	241	162	H	Mid	WIFI G 6MHz
4873.73	37.88	53.98	16.1	173	103	H	Mid	WIFI G 6MHz
2456.664	87.35	53.98	NA	226	167	H	High	WIFI G 6MHz
4921.006	33.43	53.98	20.55	144	3	H	High	WIFI G 6MHz
2405.734	85.50	53.98	NA	390	163	H	Low	WIFI G 54MHz
9648.43	47.96	53.98	6.02	376	66	H	Low	WIFI G 54MHz
4818.832	34.04	53.98	19.94	264	29	V	Low	WIFI G 54MHz
2434.29	88.62	53.98	NA	202	161	H	Mid	WIFI G 54MHz
4874	40.23	53.98	13.75	135	260	H	Mid	WIFI G 54MHz
2455.374	86.93	53.98	NA	237	167	H	High	WIFI G 54MHz
4924	36.91	53.98	17.07	111	270	H	High	WIFI G 54MHz
2409.596	87.08	53.98	NA	241	171	H	Low	WIFI N MCS0
4824	37.03	53.98	16.95	100	260	H	Low	WIFI N MCS0
2432.572	89.65	53.98	NA	234	162	H	Mid	WIFI N MCS0
4874	38.34	53.98	15.64	139	160	H	Mid	WIFI N MCS0
2458.324	86.38	53.98	NA	364	175	H	High	WIFI N MCS0
4924	35.67	53.98	18.31	195	180	H	High	WIFI N MCS0
2408.376	85.23	53.98	NA	193	188	H	Low	WIFI N MCS7
4824	35.72	53.98	18.26	245	345	H	Low	WIFI N MCS7
2430.812	88.76	53.98	NA	377	181	H	Mid	WIFI N MCS7
4874	37.92	53.98	16.06	235	345	H	Mid	WIFI N MCS7
2455.472	85.91	53.98	NA	371	182	H	High	WIFI N MCS7
4924	35.89	53.98	18.09	140	350	H	High	WIFI N MCS7

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

4.5 CONDUCTED SPURIOUS EMISSIONS

Test Method: ANSI C63.10-2013, Section 6.7
Limits of spurious emissions:
From FCC Part 15.247:
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

Test procedures:

The highest emissions level was measured and recorded. All spurious measurements were evaluated to 30dB below the fundamental. More details can be found in section 3.4 of this report. The line shown in the plots is a reference line placed at -20dBm.

Deviations from test standard:
None.

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:
Data rates and channels were investigated, and worst case was reported, no emissions exceeded the limits.
There was no distinguishable difference between low and high data rate.

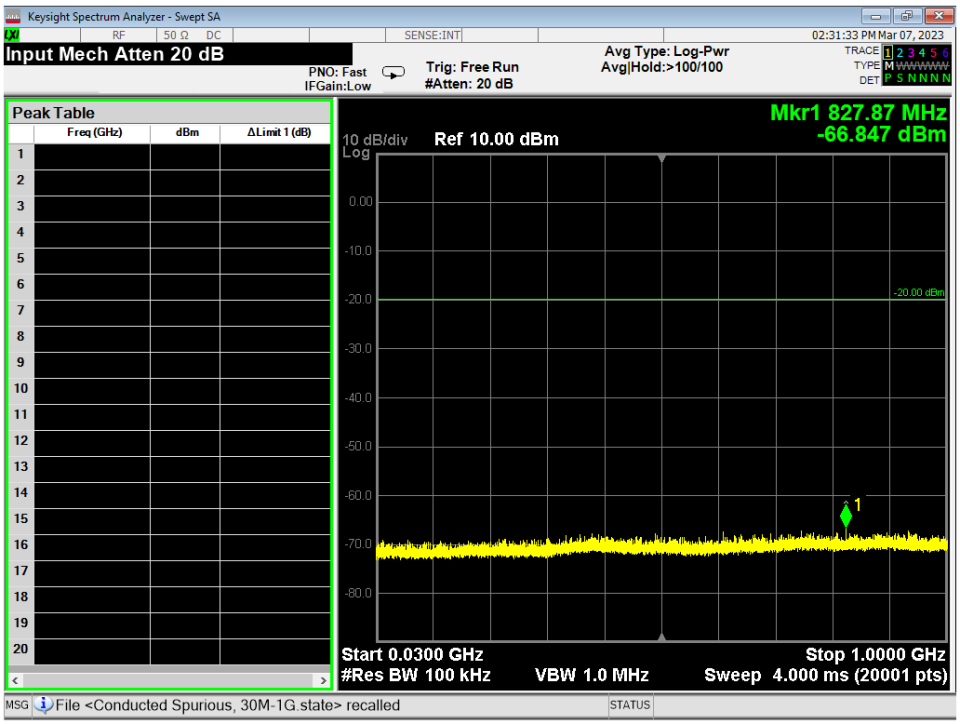


Figure 11 - Radiated Emissions Plot, WIFI 802.11b, 30M – 1G, Mid

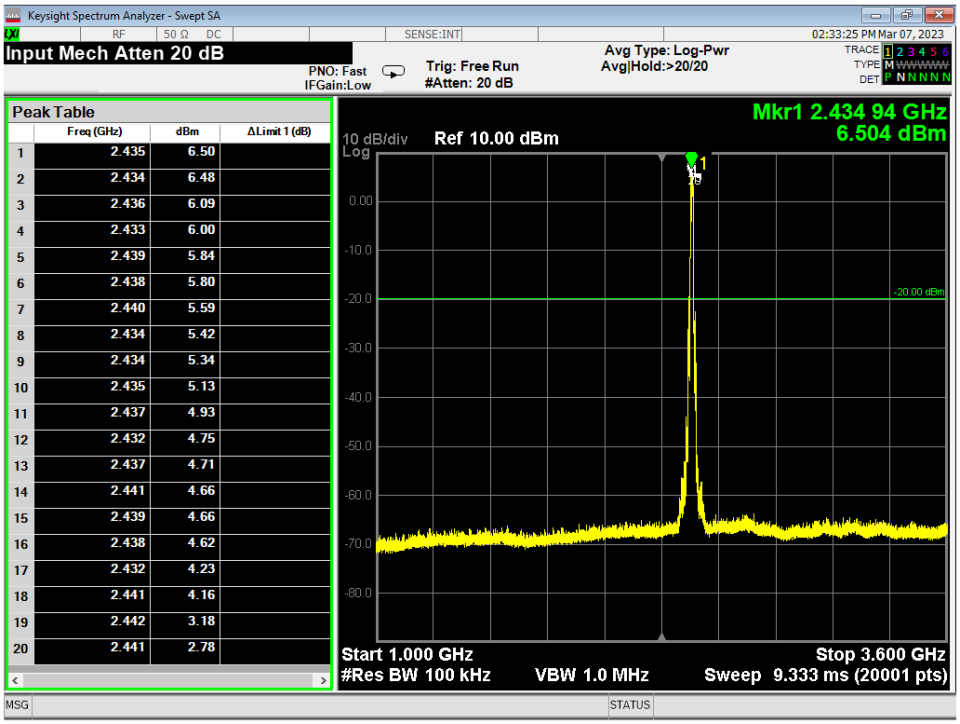


Figure 12 - Radiated Emissions Plot, WIFI 802.11b, 1G – 3.6G, Mid

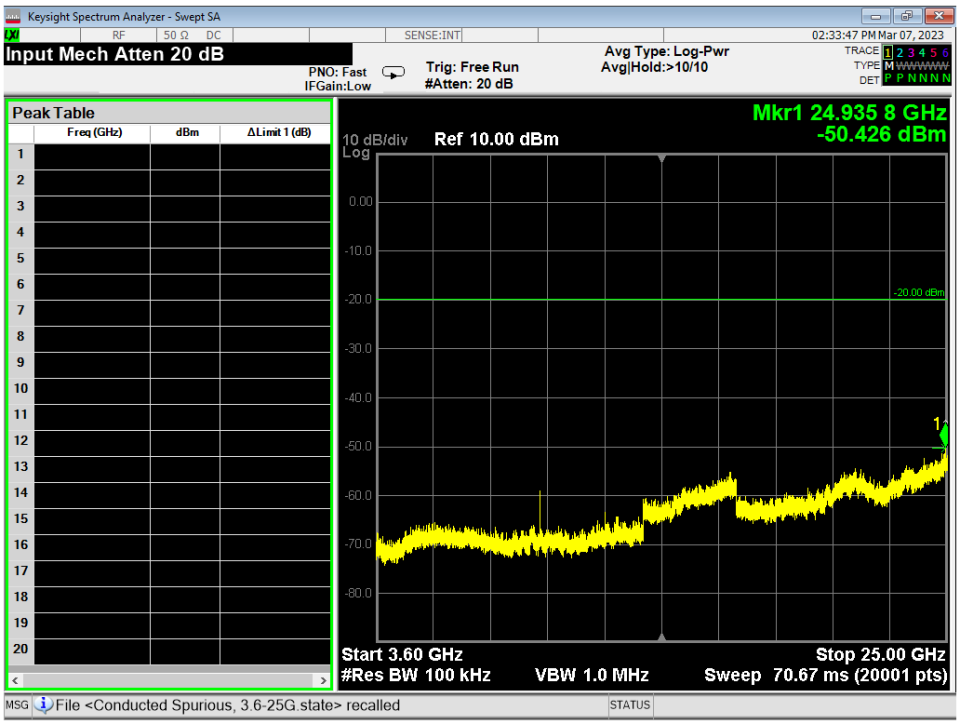


Figure 13 - Radiated Emissions Plot, WIFI 802.11b, 3.6G – 25G, Mid

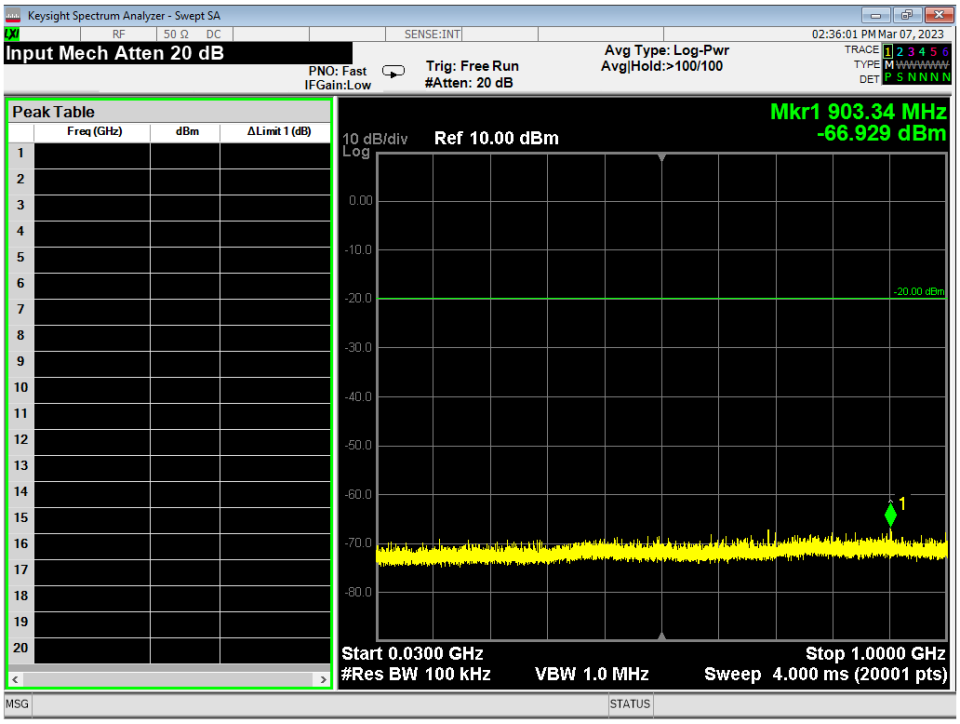


Figure 14 - Radiated Emissions Plot, WIFI 802.11g, 30M – 1G, Mid

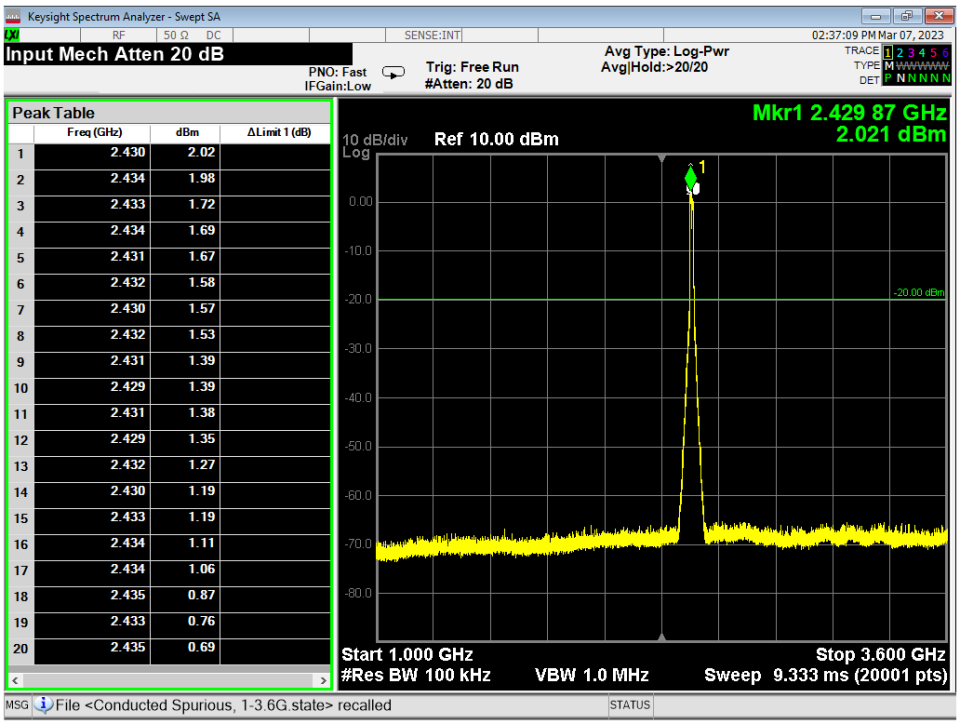


Figure 15 - Radiated Emissions Plot, WIFI 802.11g, 1G – 3.6G, Mid

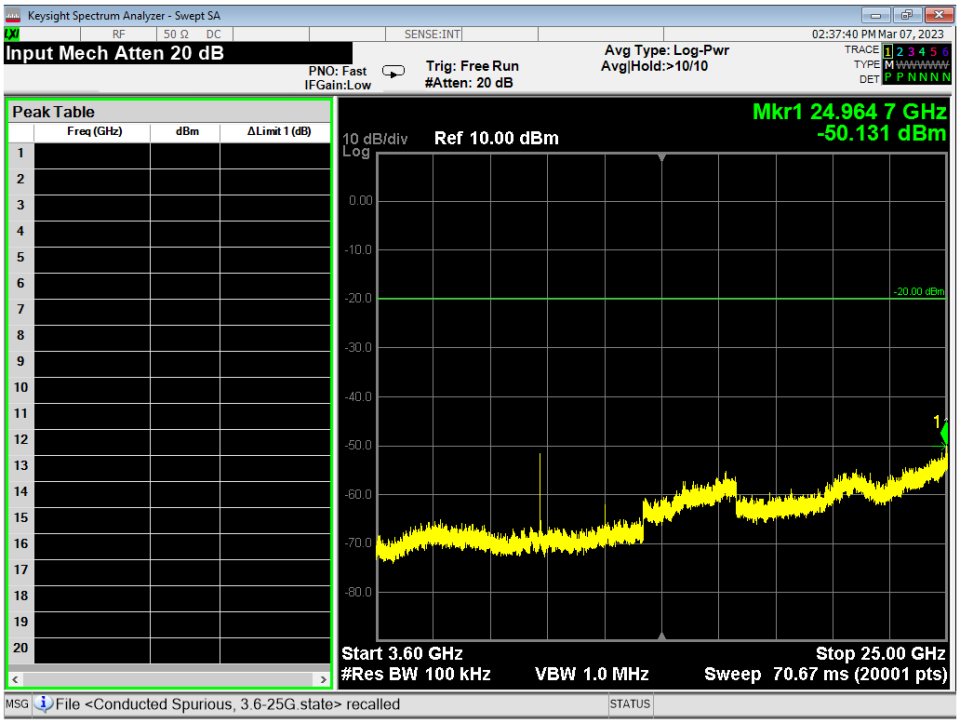


Figure 16 - Radiated Emissions Plot, WIFI 802.11g, 3.6G – 25G, Mid

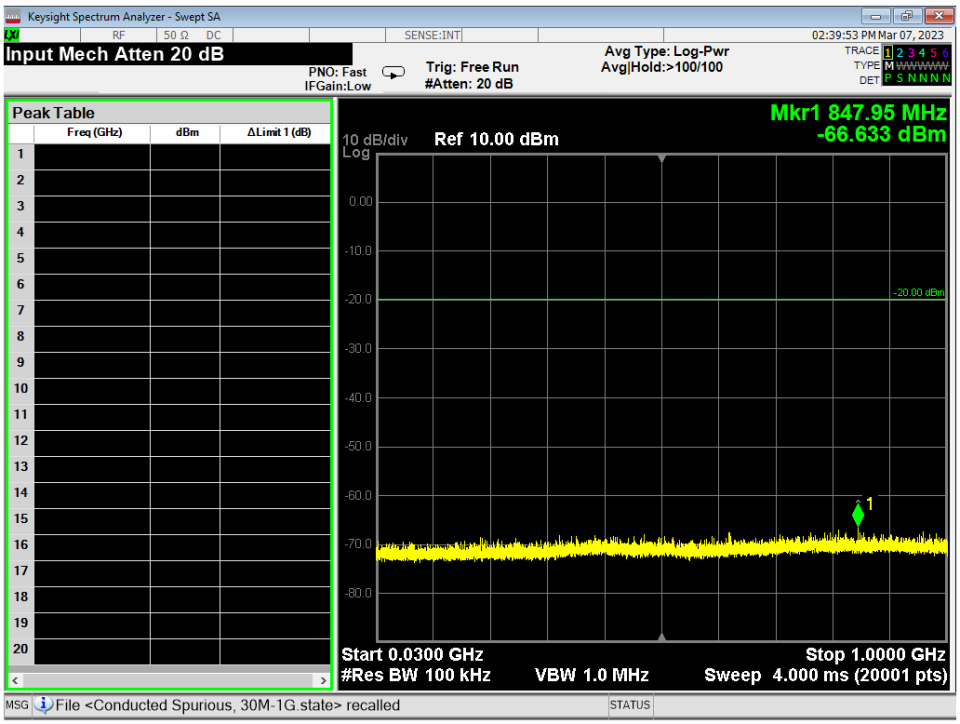


Figure 17 - Radiated Emissions Plot, WIFI 802.11n, 30M – 1G, Mid

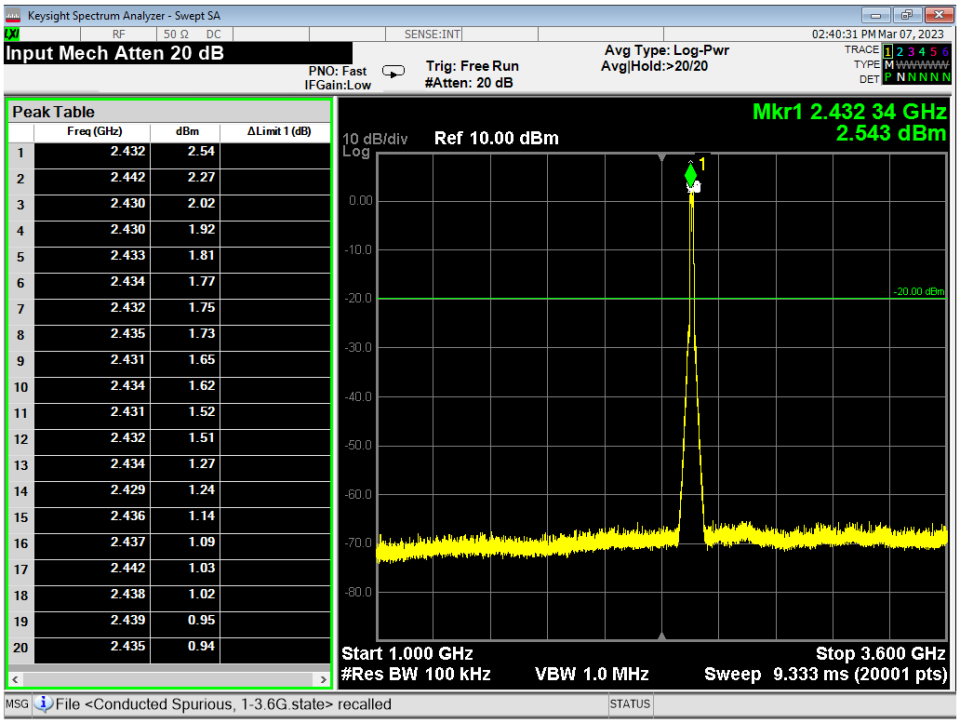


Figure 18 - Radiated Emissions Plot, WIFI 802.11n, 1G – 3.6G, Mid

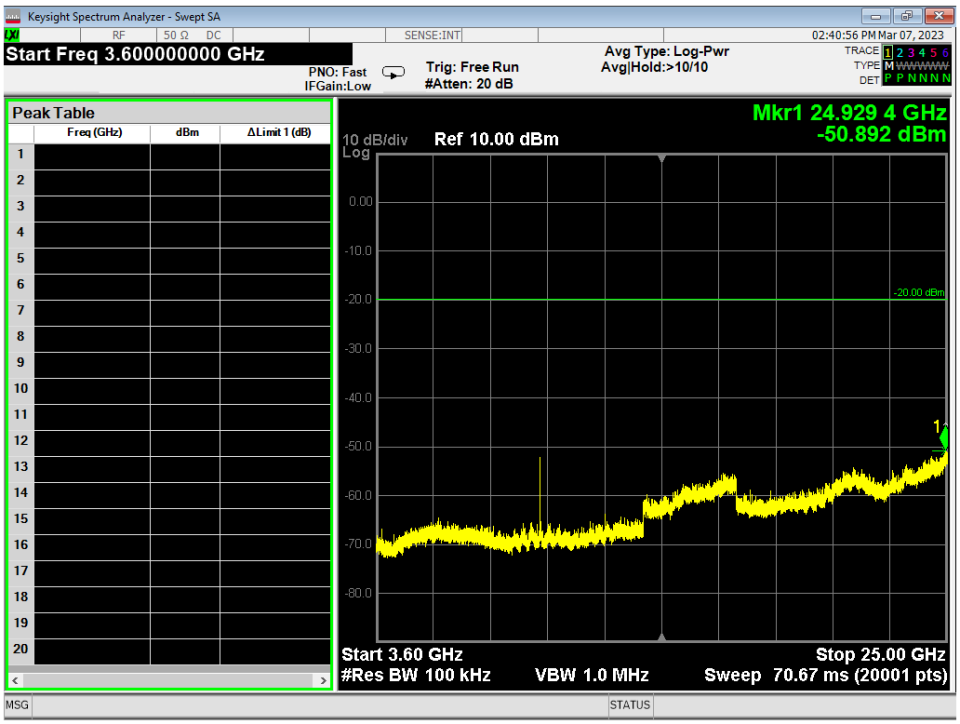


Figure 19 - Radiated Emissions Plot, WIFI 802.11n, 3.6G – 25G, Mid

4.6 BAND EDGES

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

Limits of band-edge measurements:
For FCC Part 15.247 Device:
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c))

Test procedures:

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

Deviations from test standard:
No deviation.

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

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

Test results:

Pass

Comments:

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

4.7 POWER SPECTRAL DENSITY

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

Limits of power measurements:

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

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

Deviations from test standard:
No deviation.

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

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

Test results:

Pass

Comments:

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. The measurements are listed in the tables in section 4.0.

4.8 CONDUCTED AC MAINS EMISSIONS

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

Limits for conducted emissions measurements:

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

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

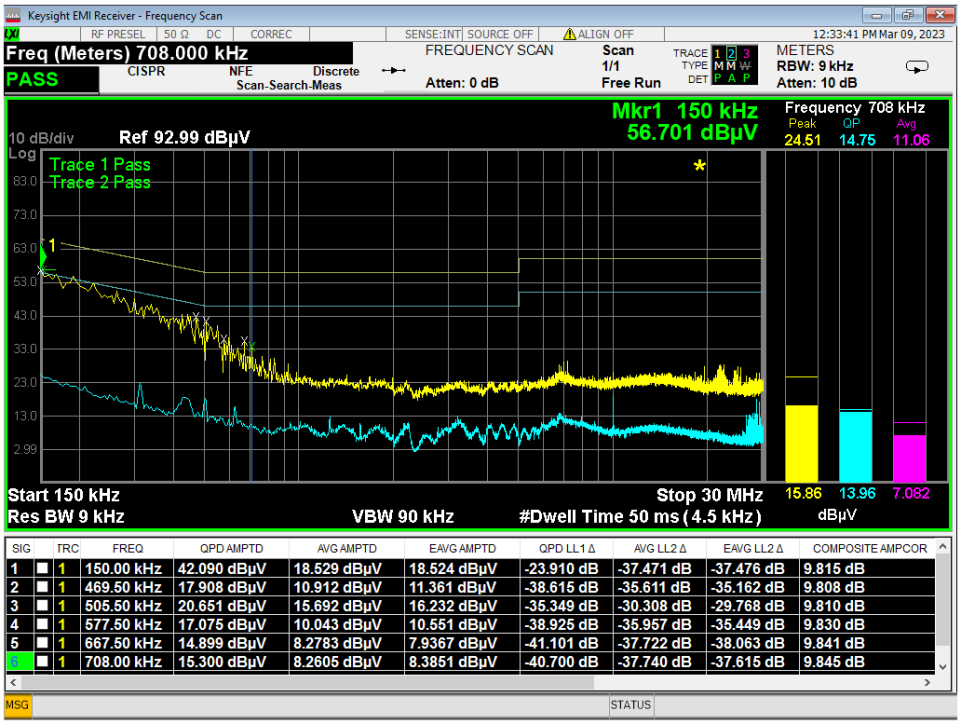
Test Procedures:

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

Deviation from the test standard:
No deviation

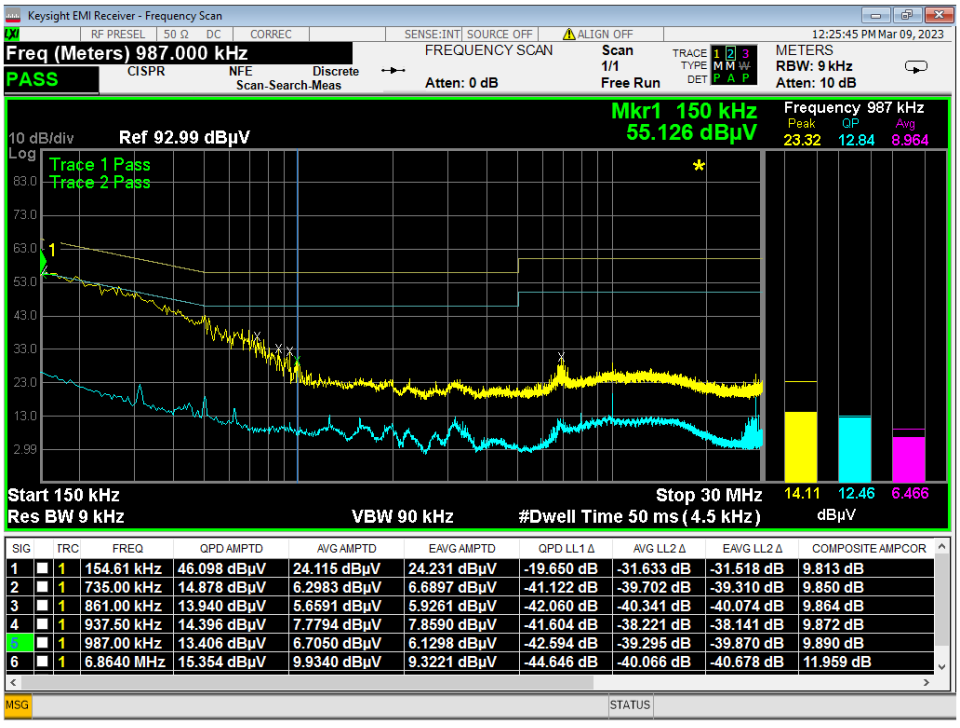
EUT operating conditions:
Details can be found in section 2.1 of this report.

Test Results:



SIG	TRC	FREQ	QPD AMPTD	AVG AMPTD	EAVG AMPTD	QPD LL1 Δ	AVG LL2 Δ	EAVG LL2 Δ	COMPOSITE AMPCOR
1	1	150.00 kHz	42.090 dBµV	18.529 dBµV	18.524 dBµV	-23.910 dB	-37.471 dB	-37.476 dB	9.815 dB
2	1	469.50 kHz	17.908 dBµV	10.912 dBµV	11.361 dBµV	-38.615 dB	-35.611 dB	-35.162 dB	9.808 dB
3	1	505.50 kHz	20.651 dBµV	15.692 dBµV	16.232 dBµV	-35.349 dB	-30.308 dB	-29.768 dB	9.810 dB
4	1	577.50 kHz	17.075 dBµV	10.043 dBµV	10.551 dBµV	-38.925 dB	-35.957 dB	-35.449 dB	9.830 dB
5	1	667.50 kHz	14.899 dBµV	8.2783 dBµV	7.9367 dBµV	-41.101 dB	-37.722 dB	-38.063 dB	9.841 dB
6	1	708.00 kHz	15.300 dBµV	8.2605 dBµV	8.3851 dBµV	-40.700 dB	-37.740 dB	-37.615 dB	9.845 dB

Figure 20 - Conducted Emissions Plot, Line, TX



SIG	TRC	FREQ	QPD AMPTD	AVG AMPTD	EAVG AMPTD	QPD LL1 Δ	AVG LL2 Δ	EAVG LL2 Δ	COMPOSITE AMPCOR
1	1	154.61 kHz	46.098 dBµV	24.115 dBµV	24.231 dBµV	-19.650 dB	-31.633 dB	-31.518 dB	9.813 dB
2	1	735.00 kHz	14.878 dBµV	6.2983 dBµV	6.6897 dBµV	-41.122 dB	-39.702 dB	-39.310 dB	9.850 dB
3	1	861.00 kHz	13.940 dBµV	5.6591 dBµV	5.9261 dBµV	-42.060 dB	-40.341 dB	-40.074 dB	9.864 dB
4	1	937.50 kHz	14.396 dBµV	7.7794 dBµV	7.8590 dBµV	-41.604 dB	-38.221 dB	-38.141 dB	9.872 dB
5	1	987.00 kHz	13.406 dBµV	6.7050 dBµV	6.1298 dBµV	-42.594 dB	-39.295 dB	-39.870 dB	9.890 dB
6	1	6.8640 MHz	15.354 dBµV	9.9340 dBµV	9.3221 dBµV	-44.646 dB	-40.066 dB	-40.678 dB	11.959 dB

Figure 21 - Conducted Emissions Plot, Neutral, TX

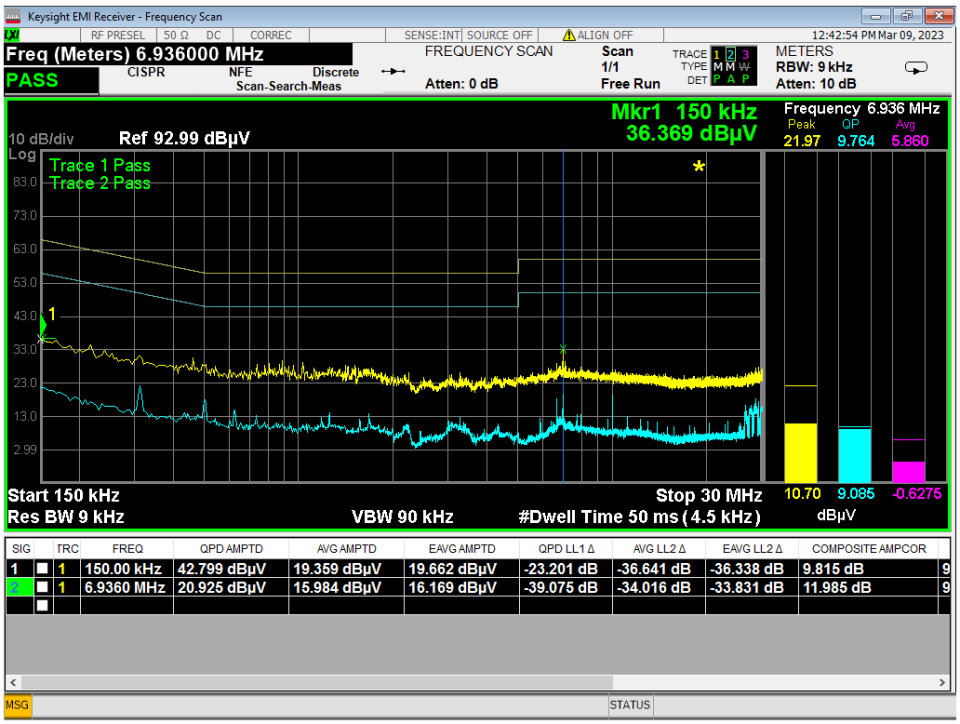


Figure 22 - Conducted Emissions Plot, Line, IDLE

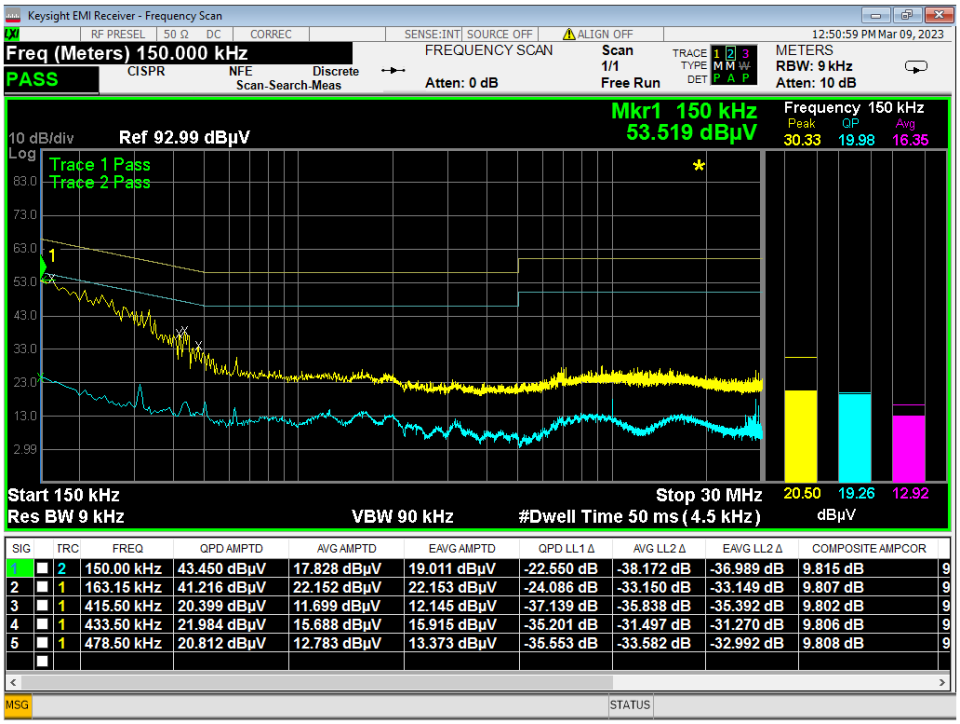


Figure 23 - Conducted Emissions Plot, Neutral, IDLE

APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

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

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

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

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

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

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

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

EIRP Calculations

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

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

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

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

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

Gain = 1 (numeric gain for isotropic radiator)

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

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

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

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

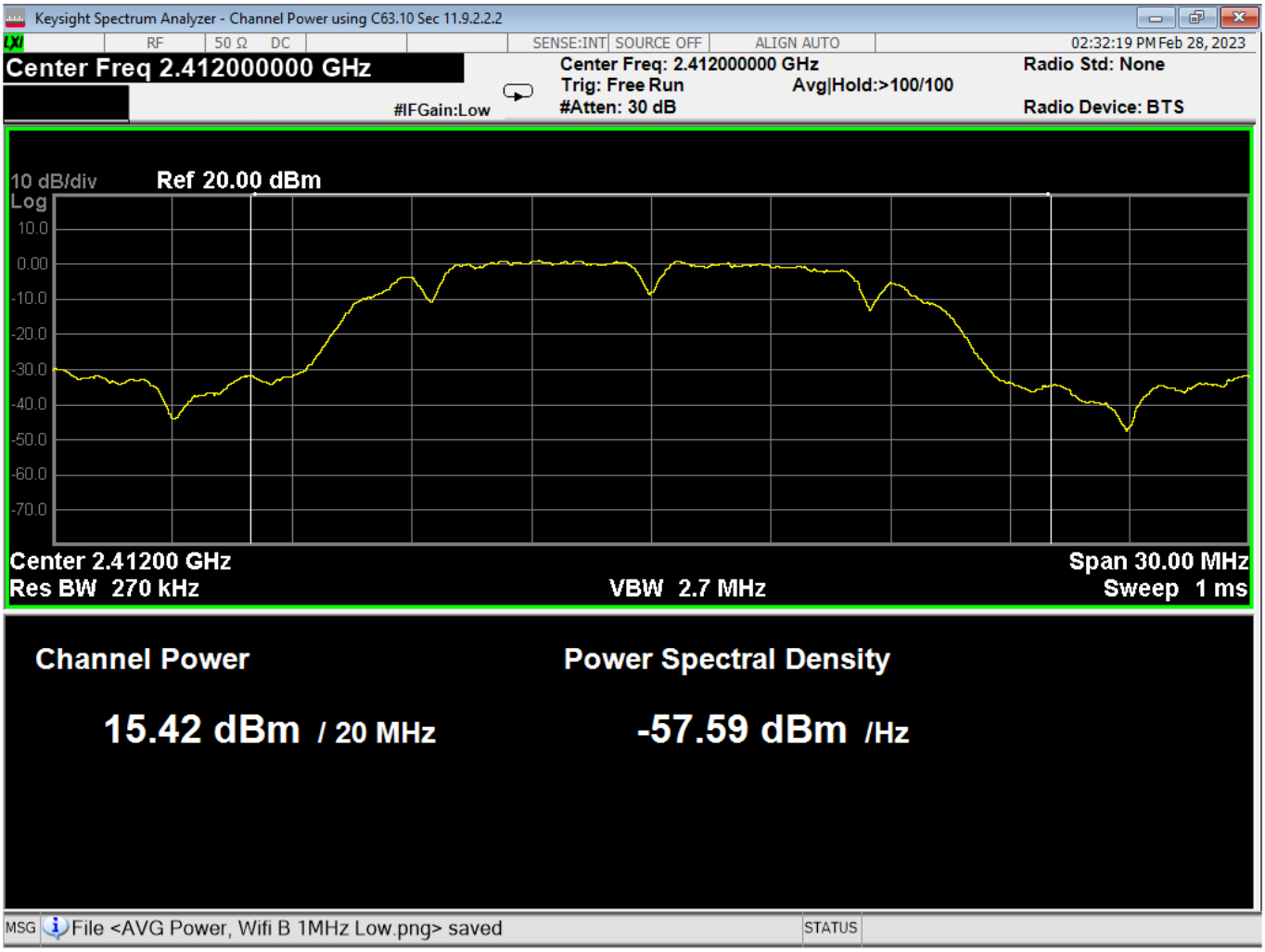
APPENDIX B – MEASUREMENT UNCERTAINTY

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

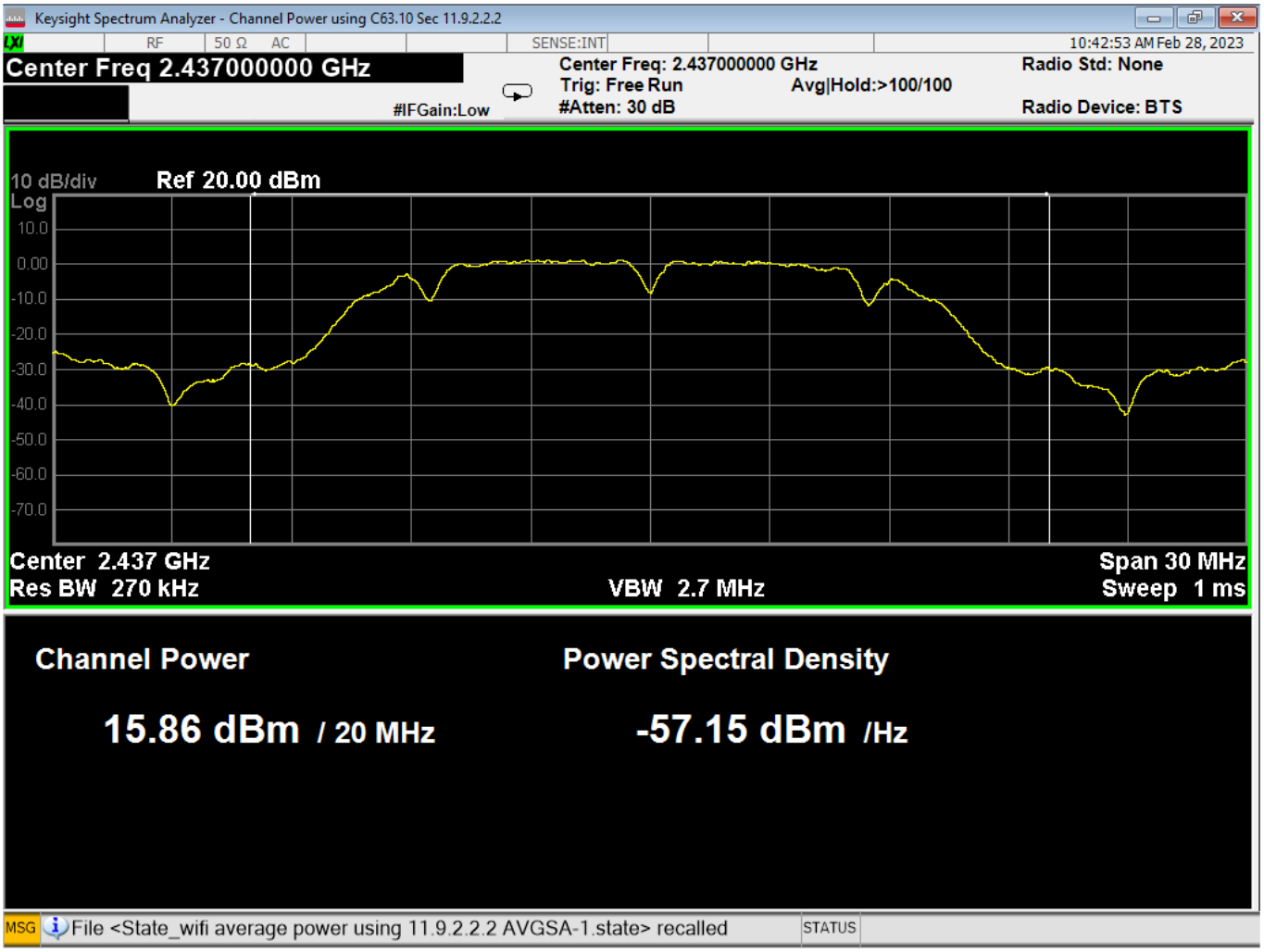
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03

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

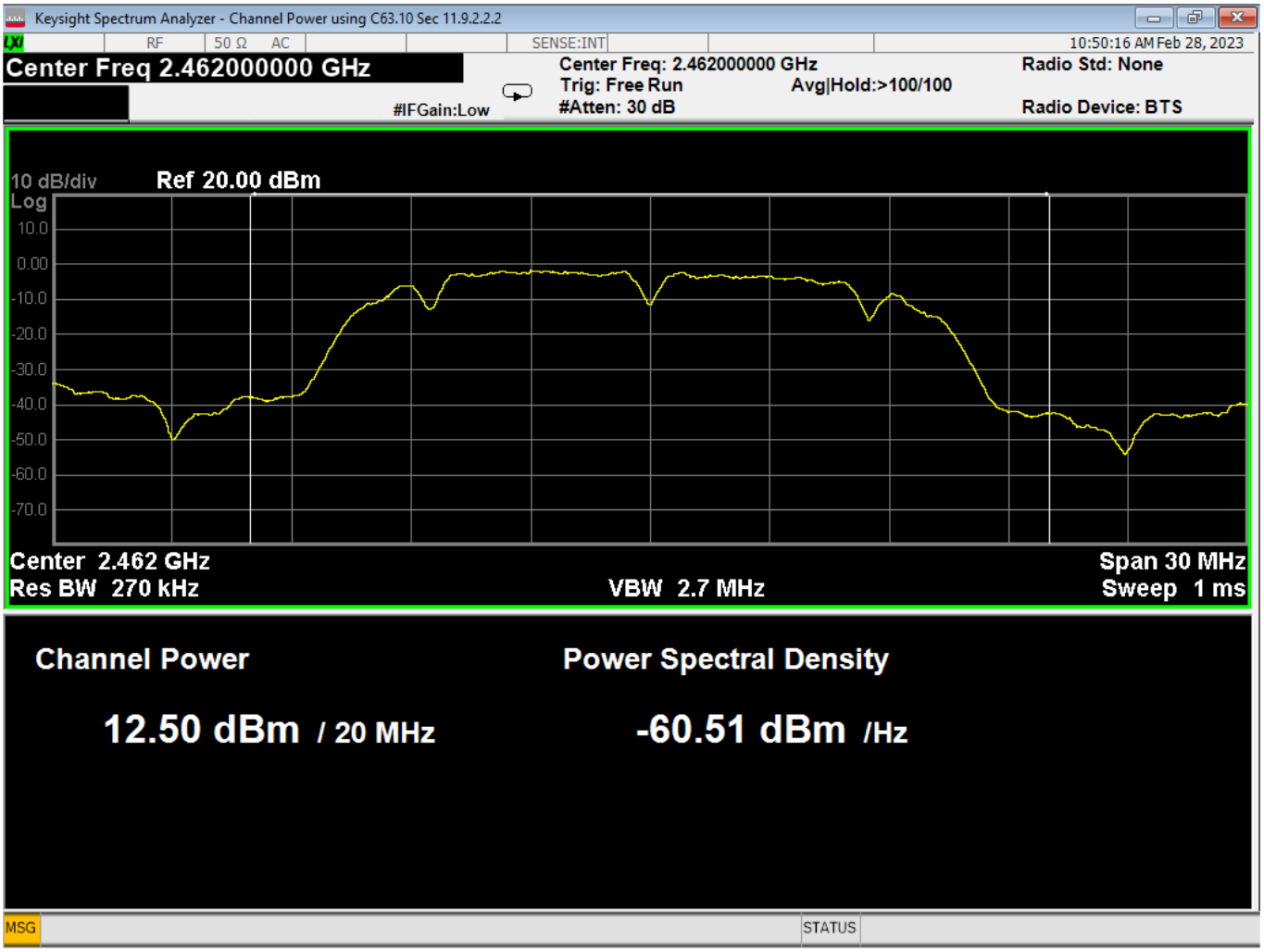
APPENDIX C – GRAPHS AND TABLES



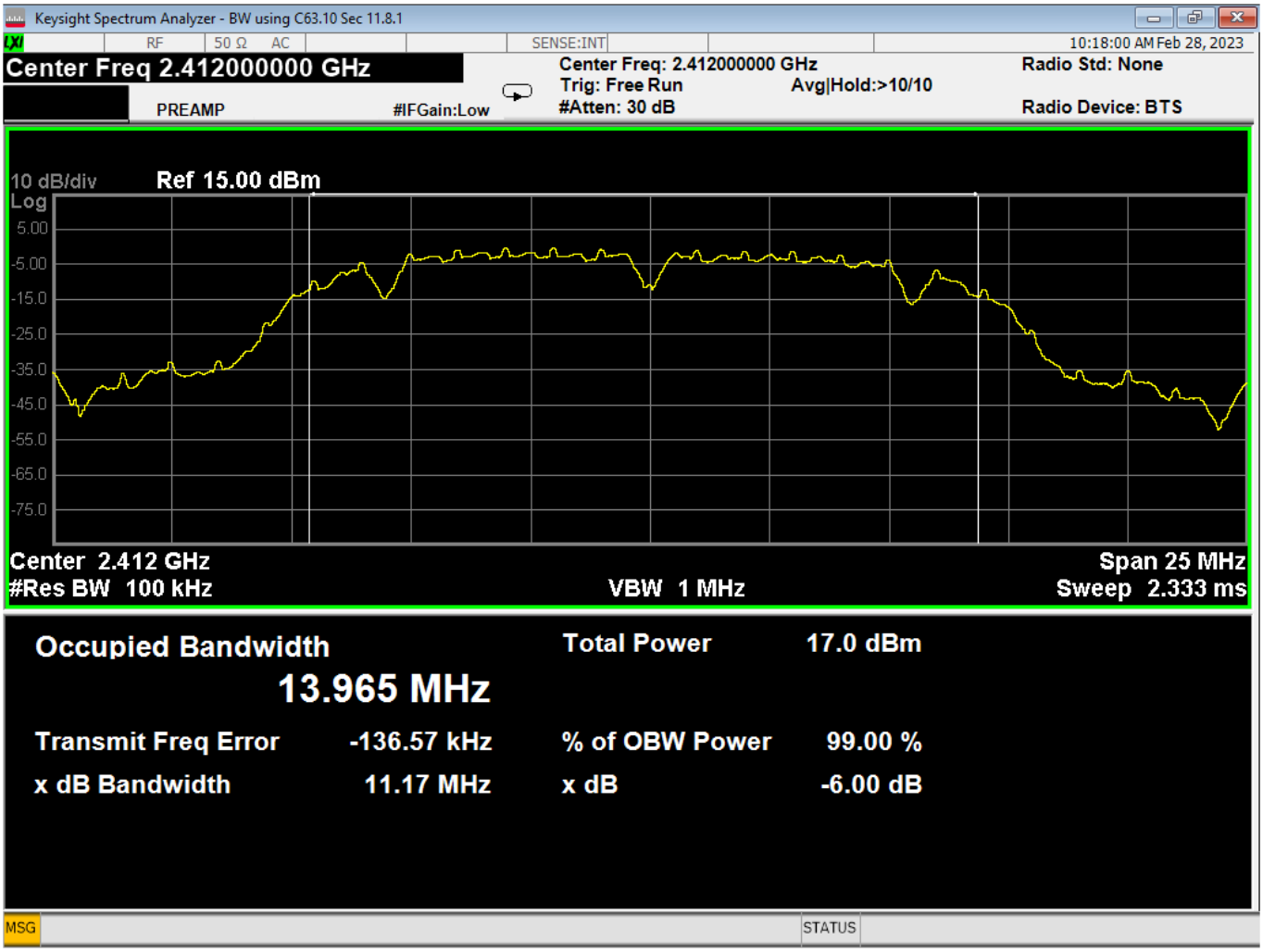
01 Average Power, Low, Wifi B, Low Data Rate



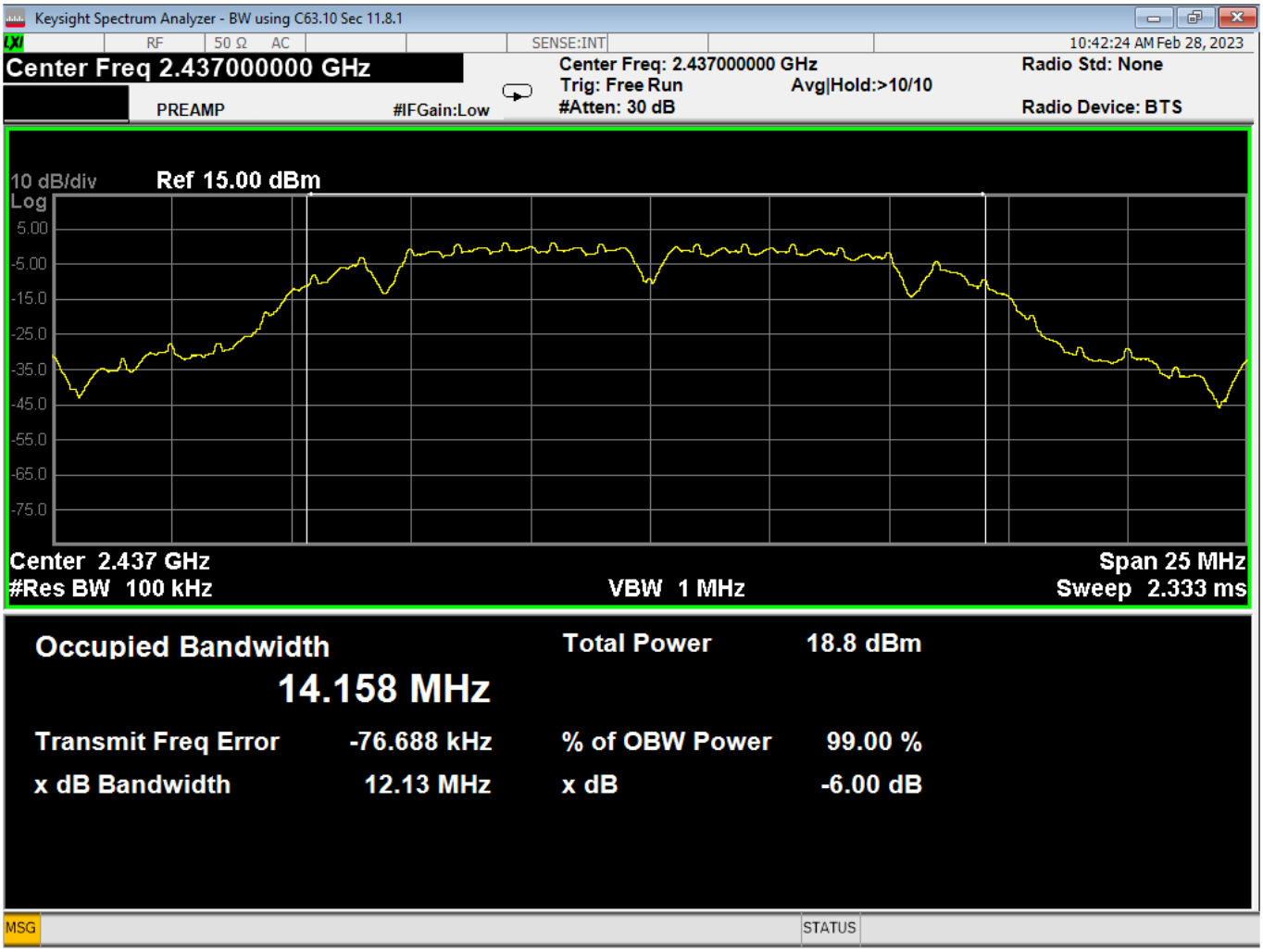
02 Average Power, Mid, Wifi B, Low Data Rate



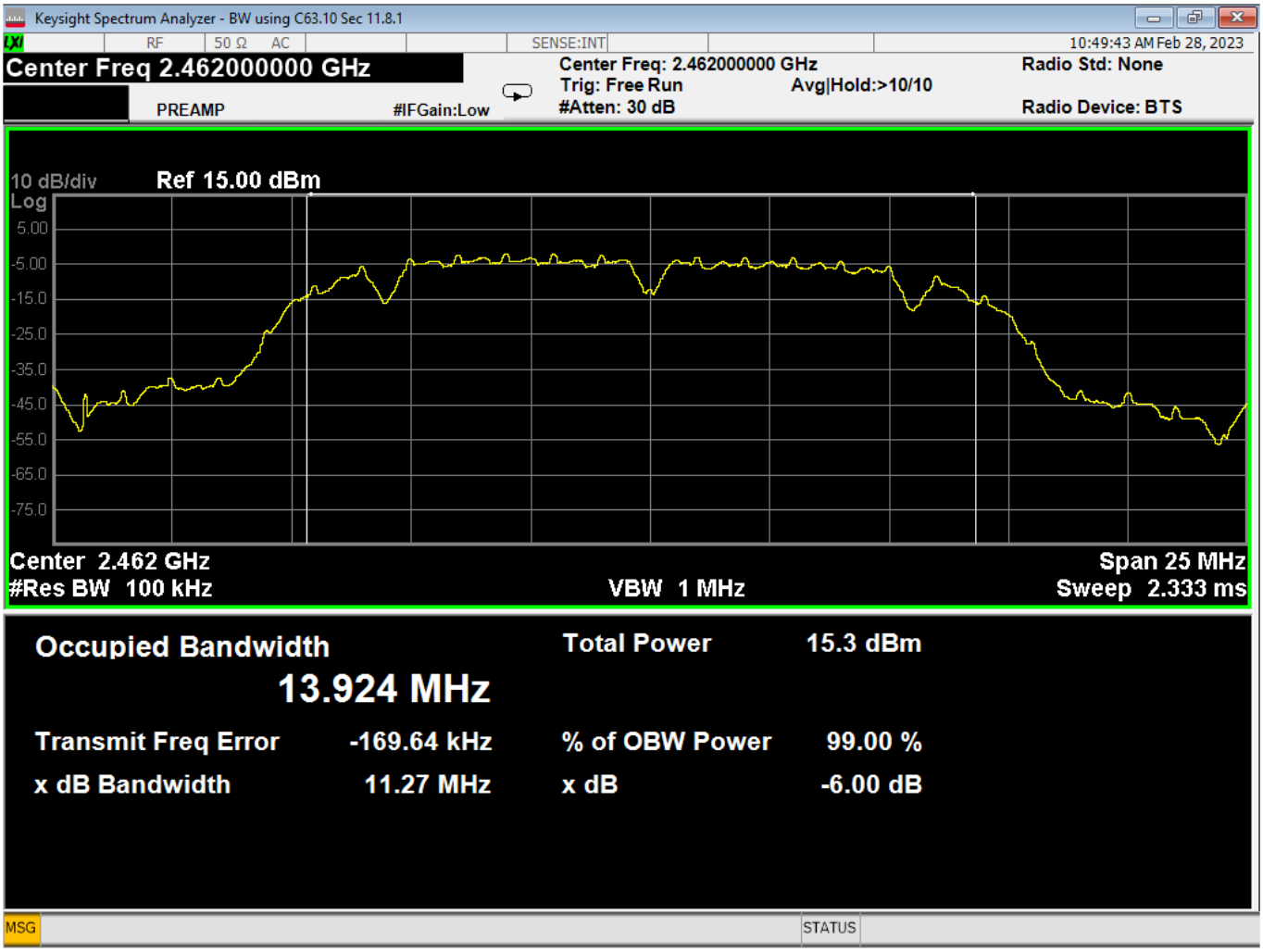
03 Average Power, High, Wifi B, Low Data Rate



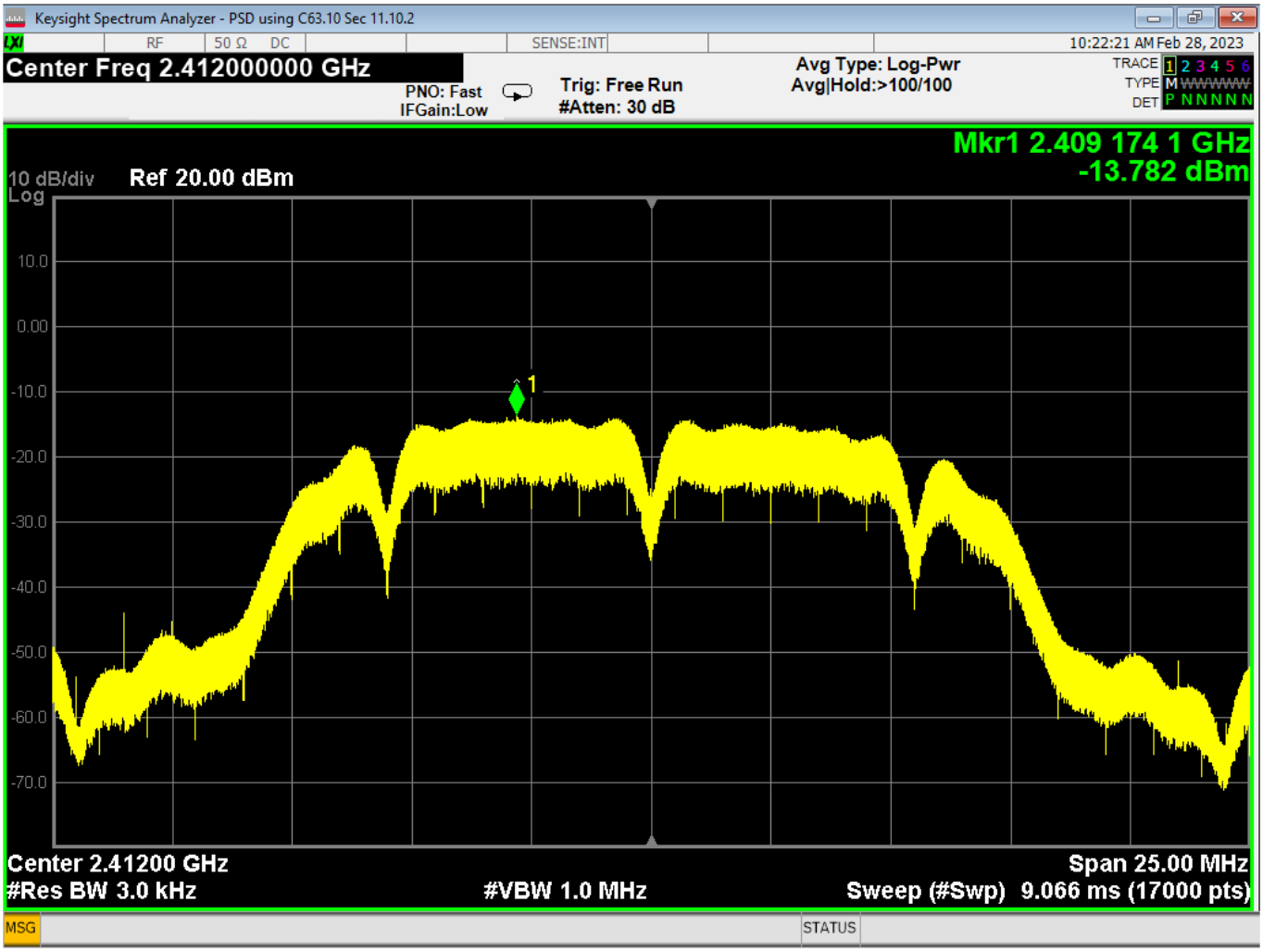
04 6dB Bandwidth, Low, Wifi B, Low Data Rate



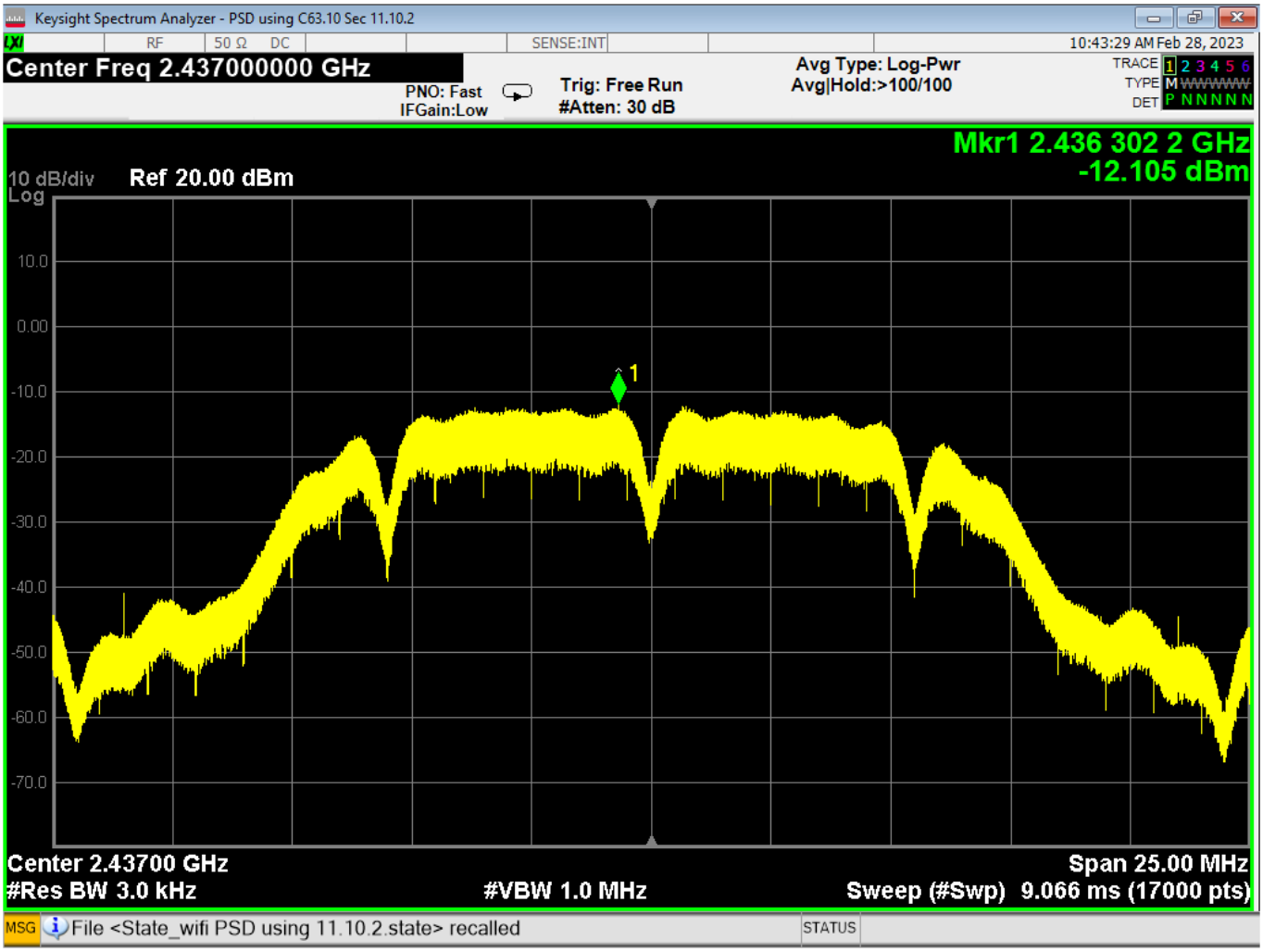
05 6dB Bandwidth, Mid, Wifi B, Low Data Rate



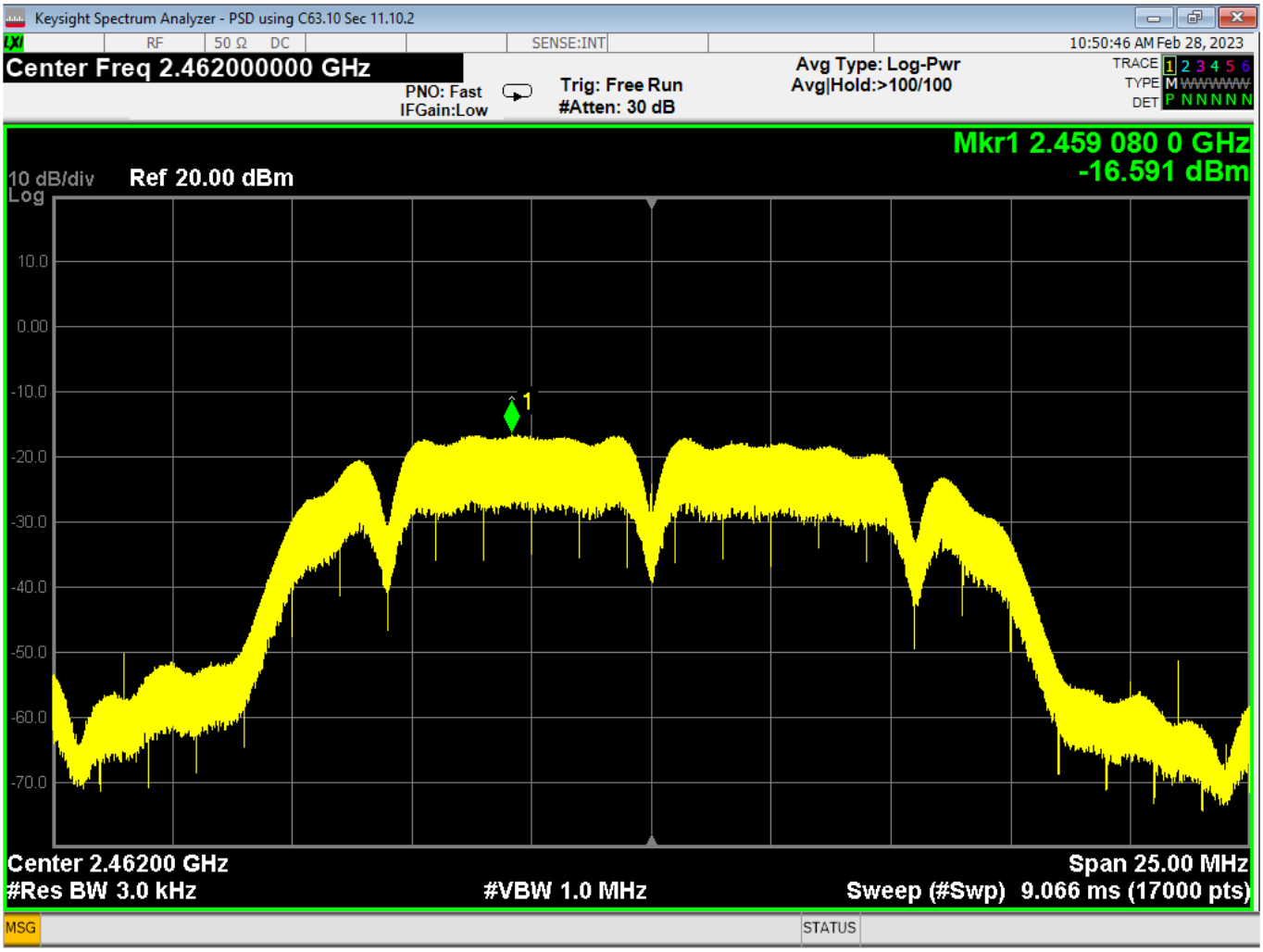
06 6dB Bandwidth, High, Wifi B, Low Data Rate



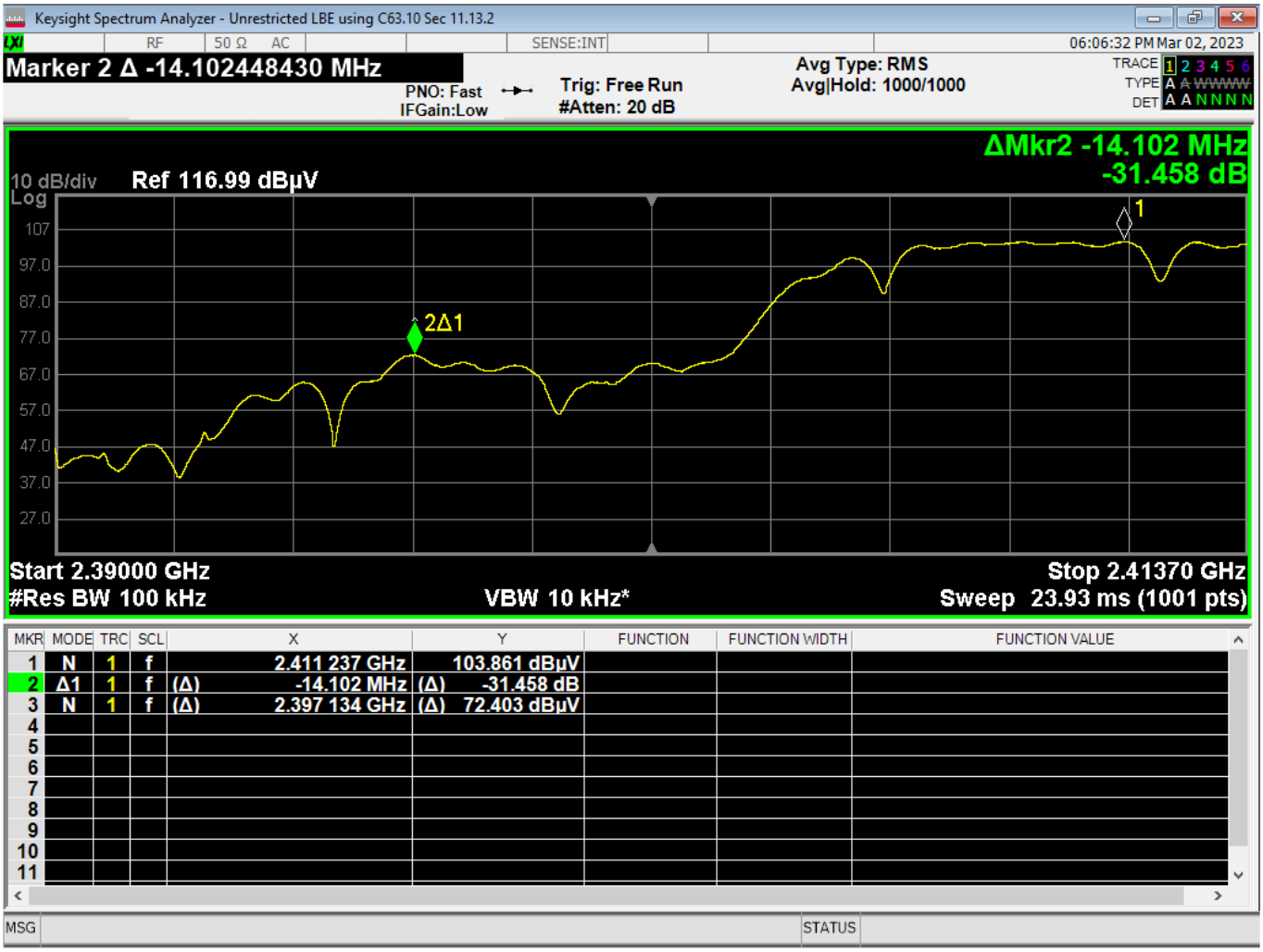
07 PSD, Low, Wifi B, Low Data Rate



08 PSD, Mid, Wifi B, Low Data Rate



09 PSD, High, Wifi B, Low Data Rate



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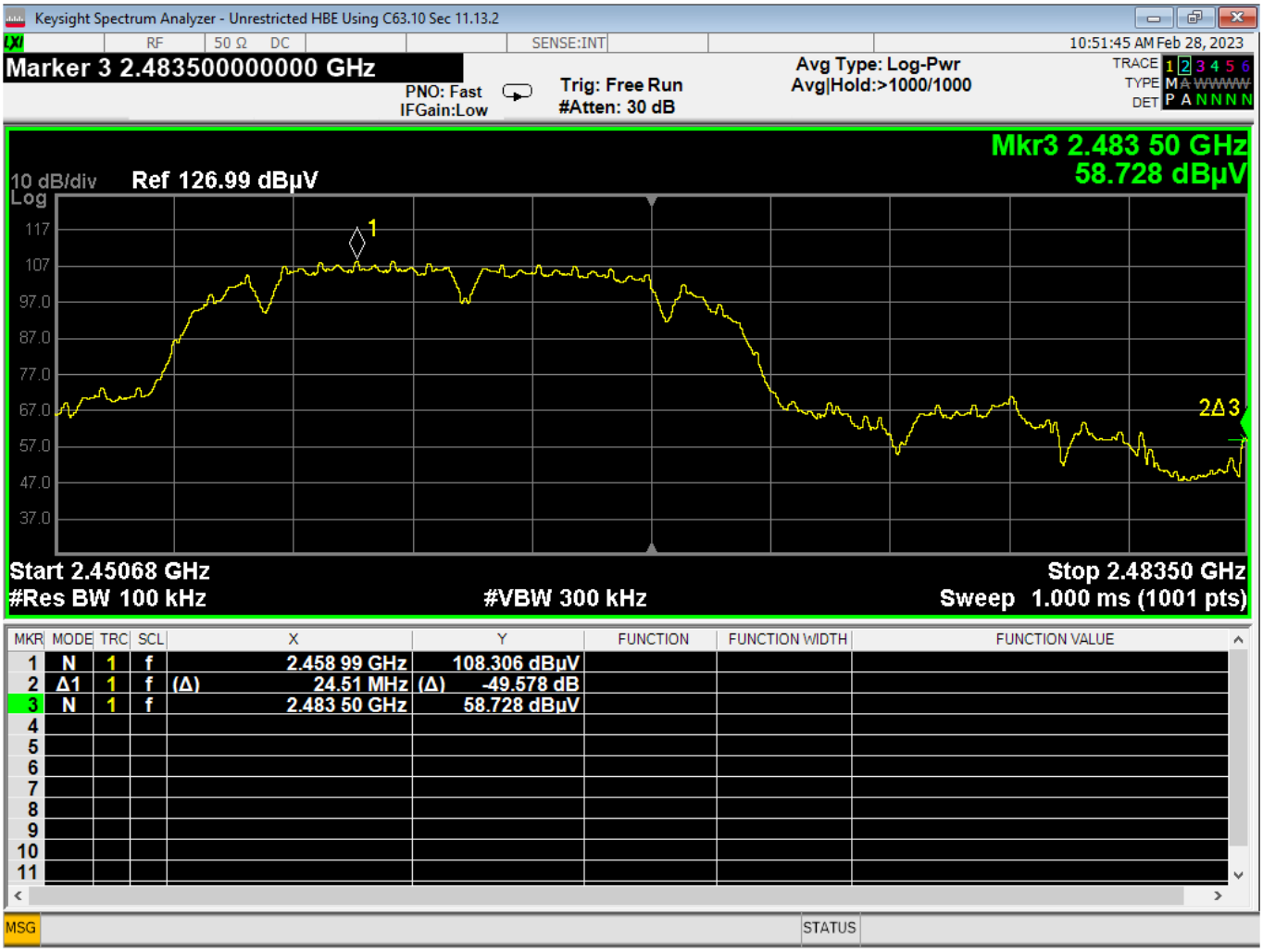
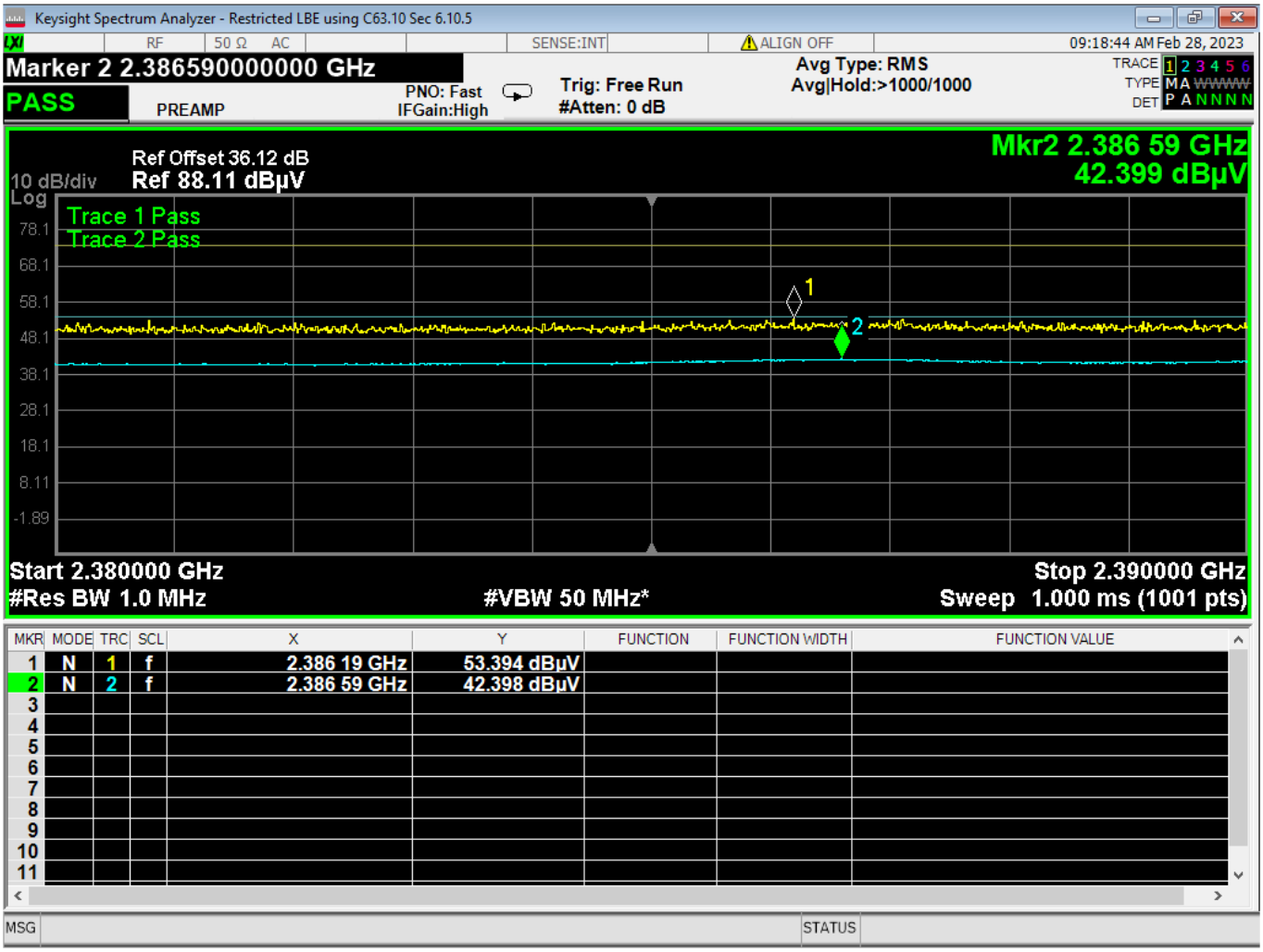


11 Higher Bandedge, Unrestricted, Wifi B, Low Data Rate



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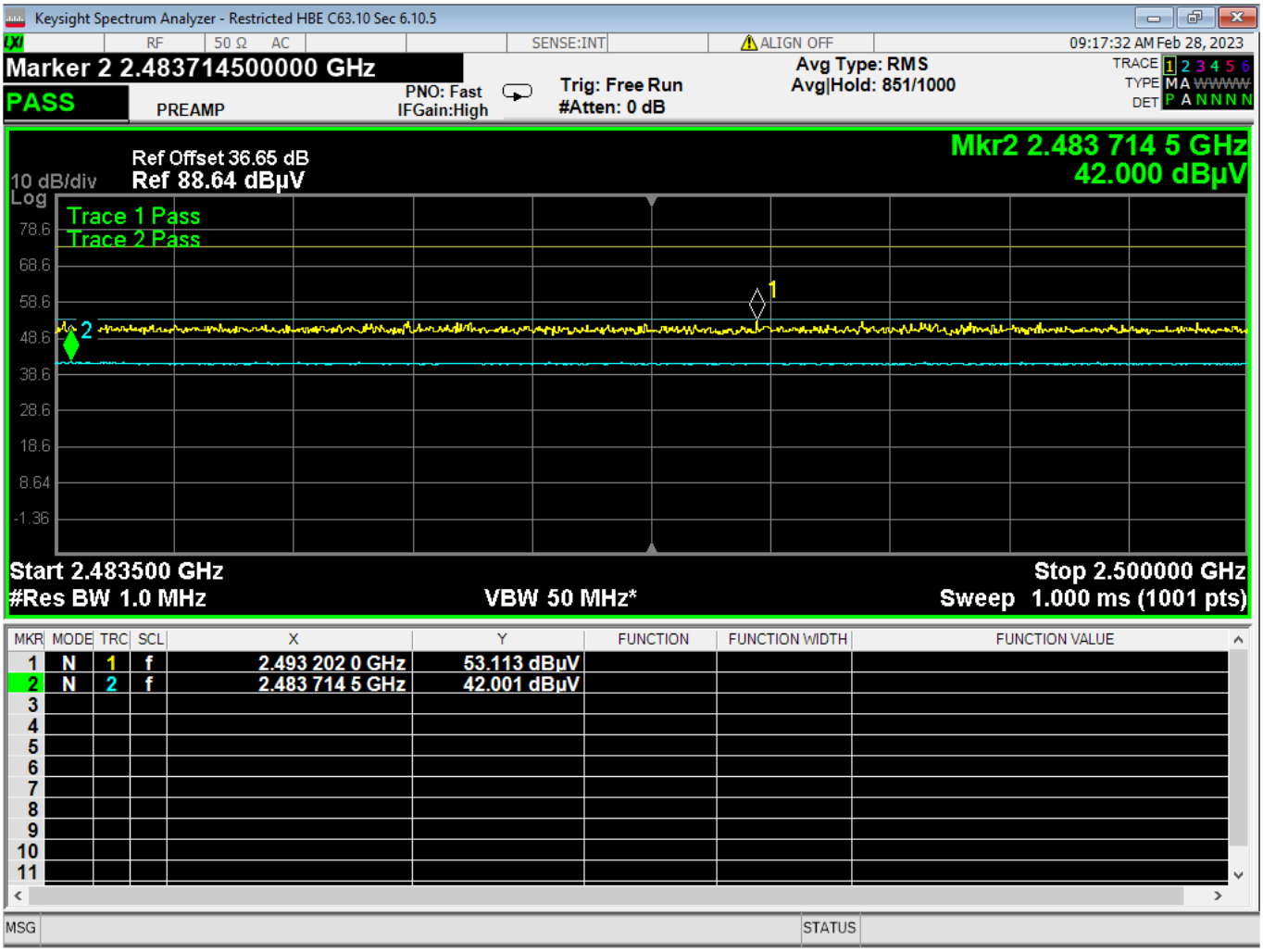

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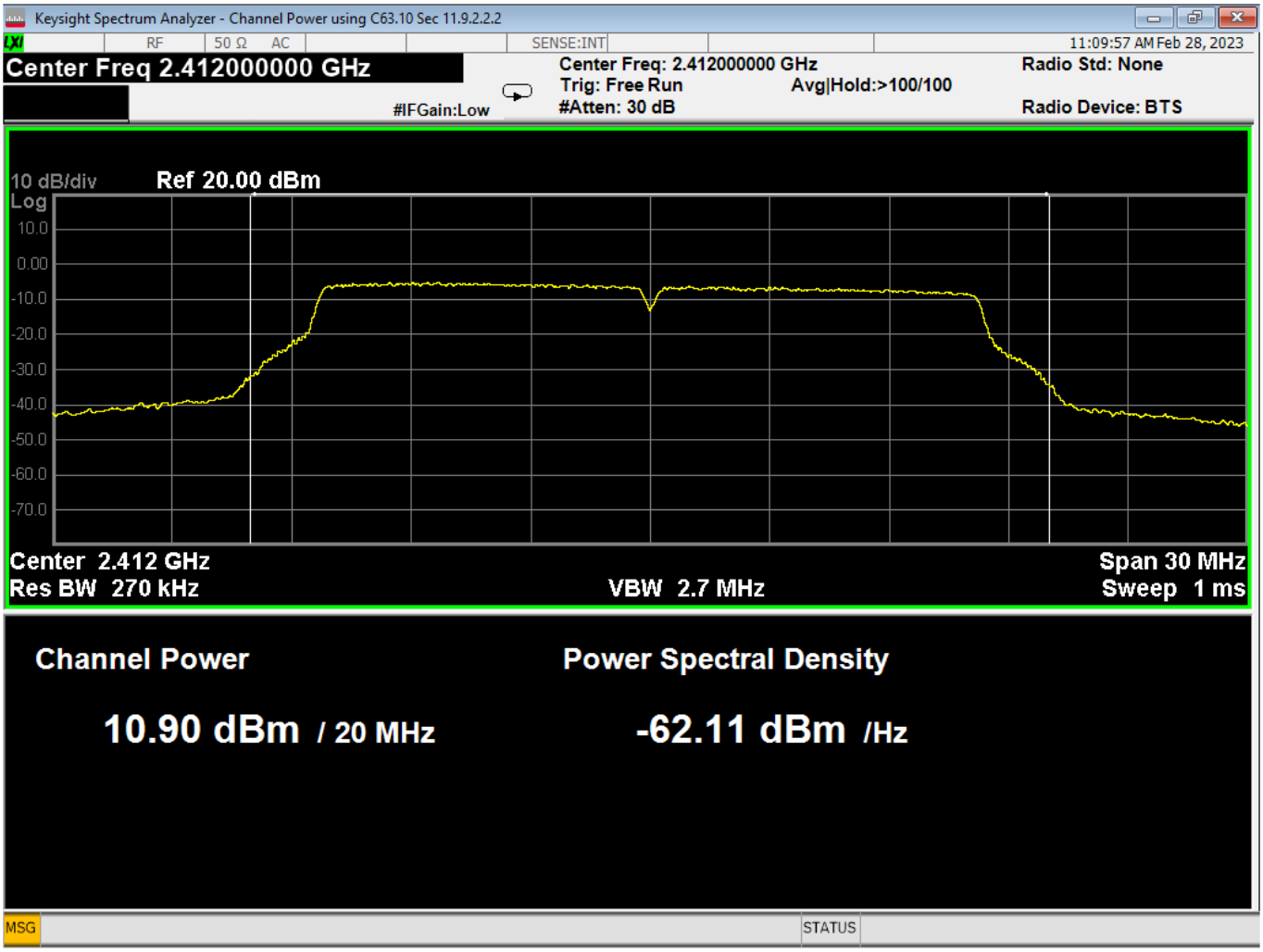

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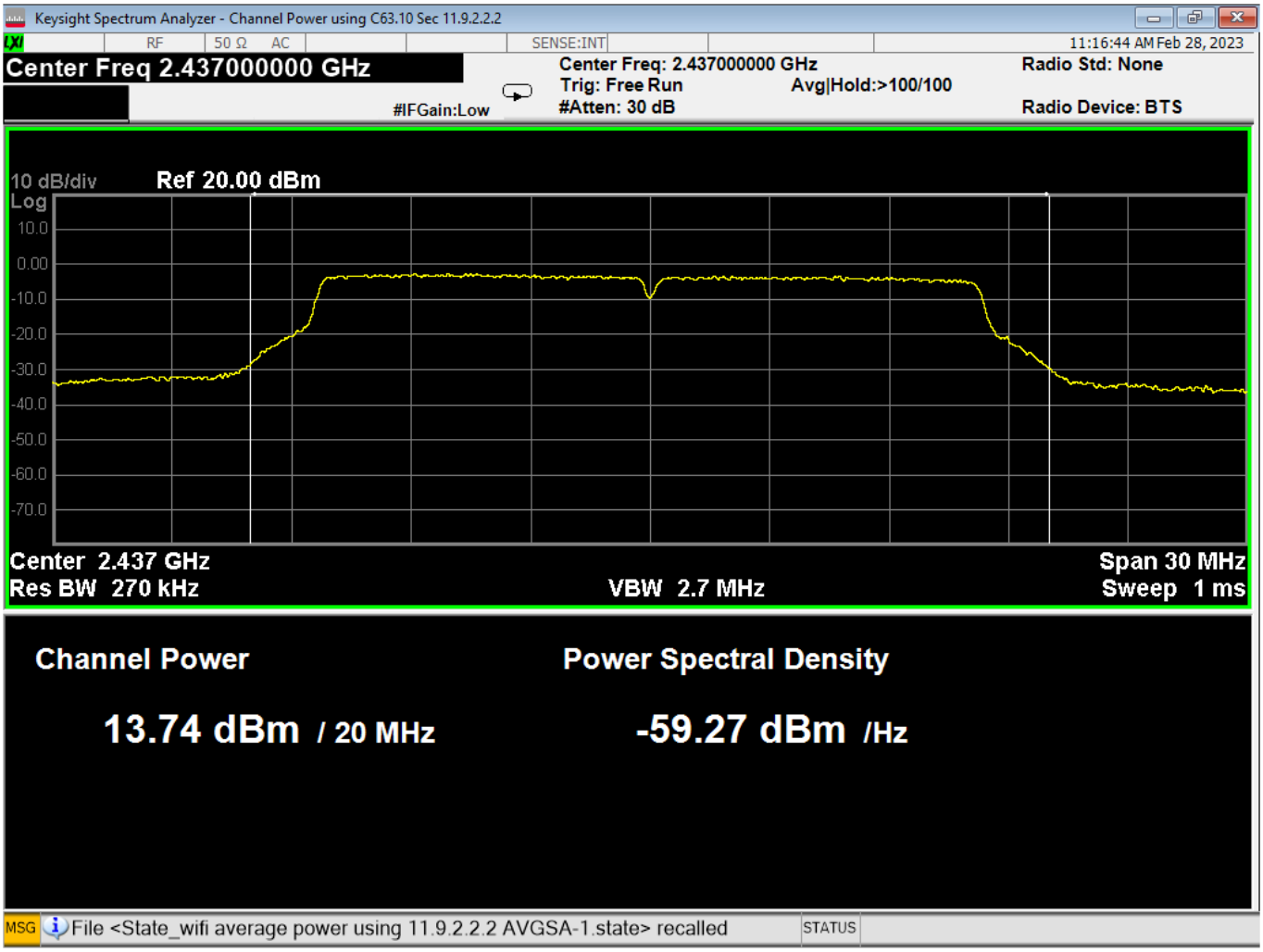

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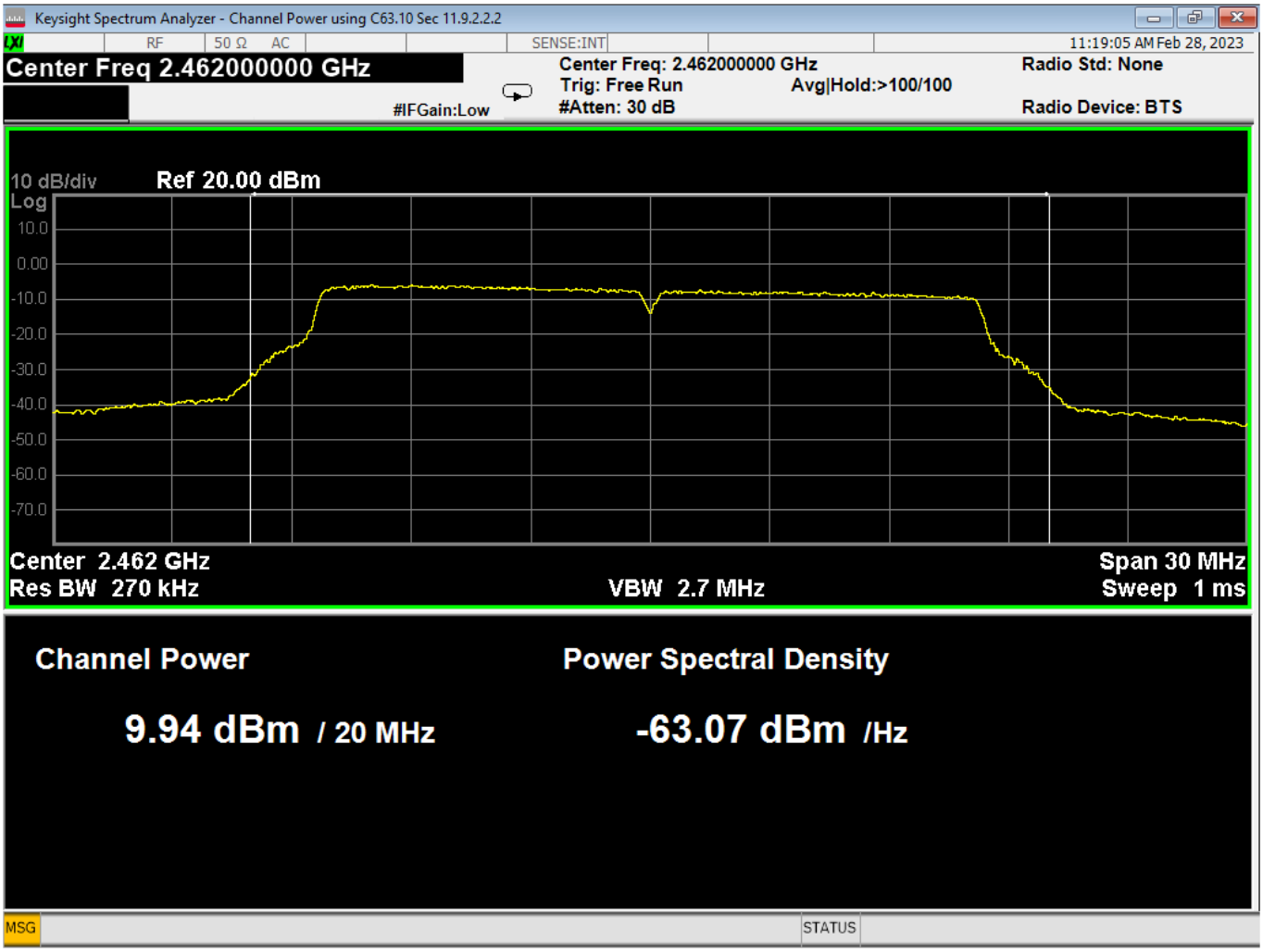
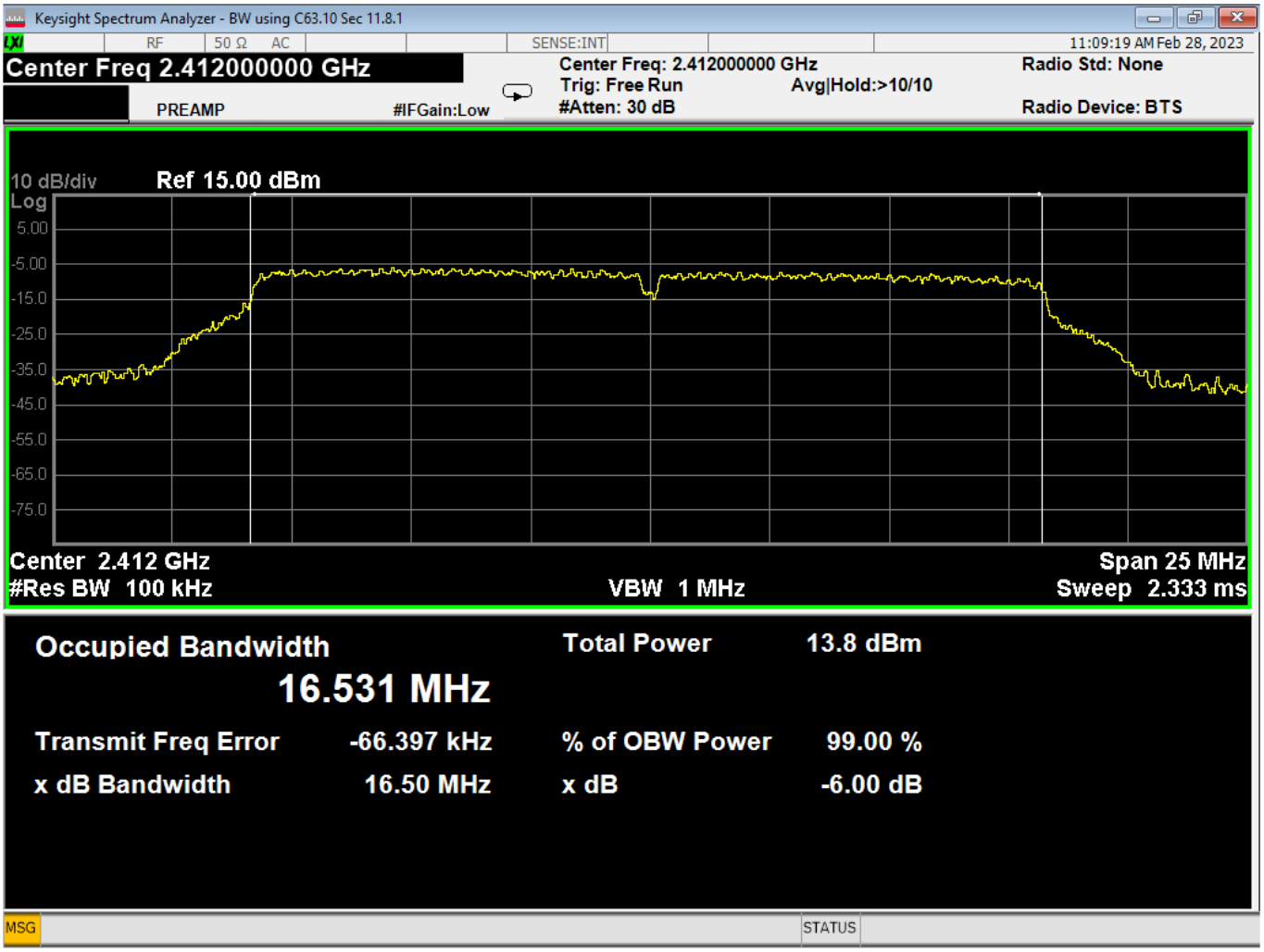
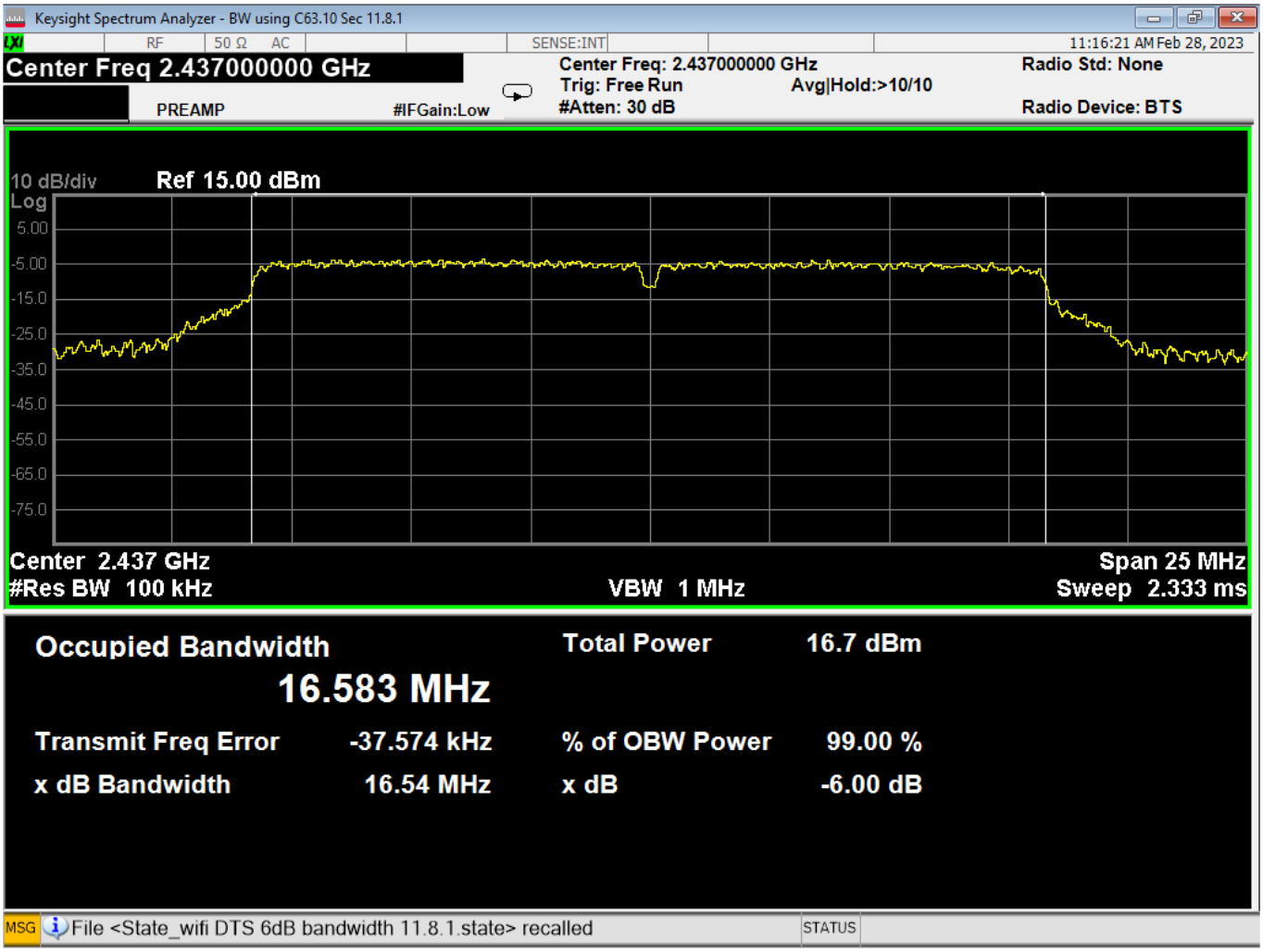


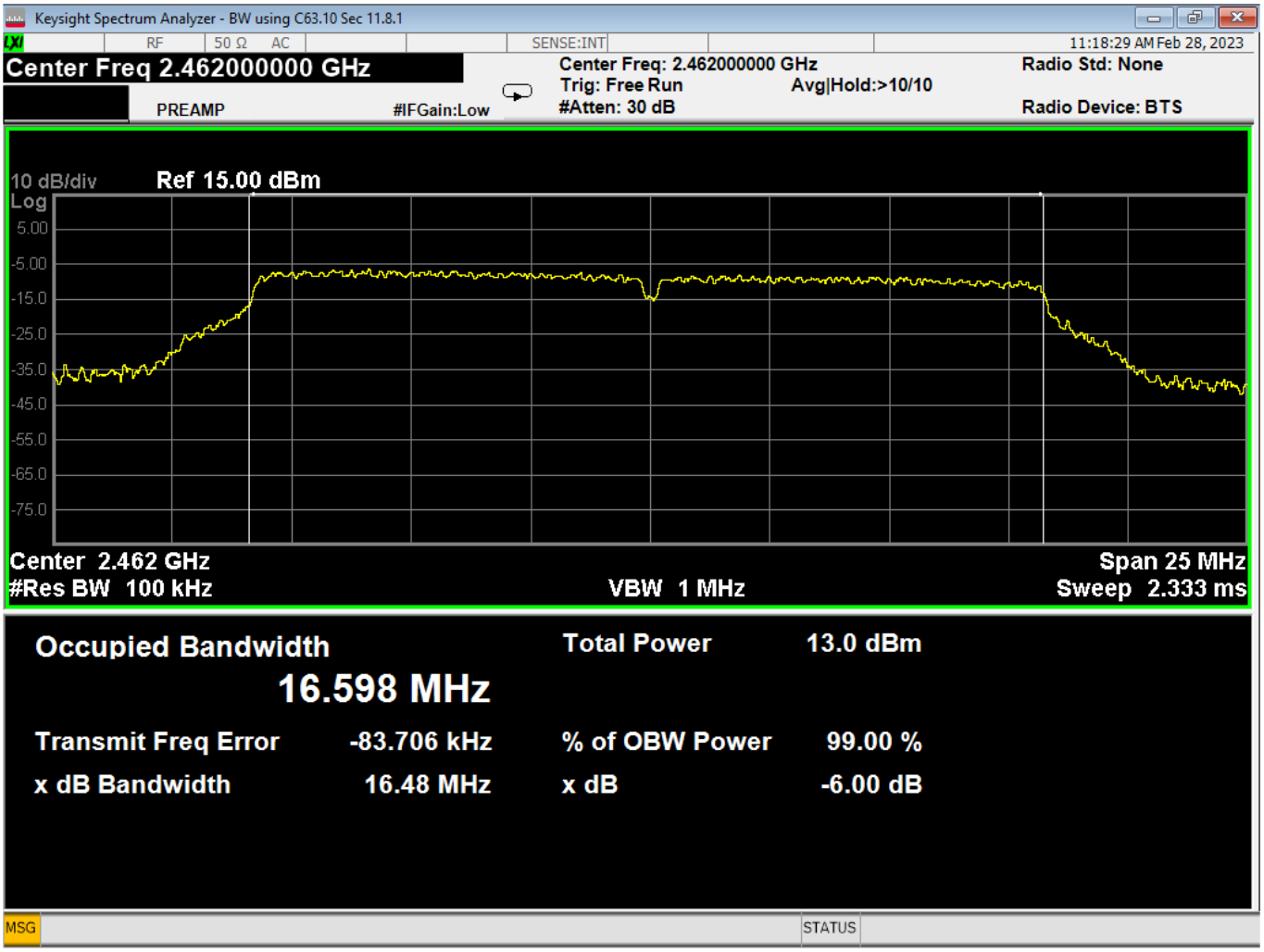
16 Average Power, High, Wifi G, Low Data Rate



17 6dB Bandwidth, Low, Wifi G, Low Data Rate



18 6dB Bandwidth, Mid, Wifi G, Low Data Rate



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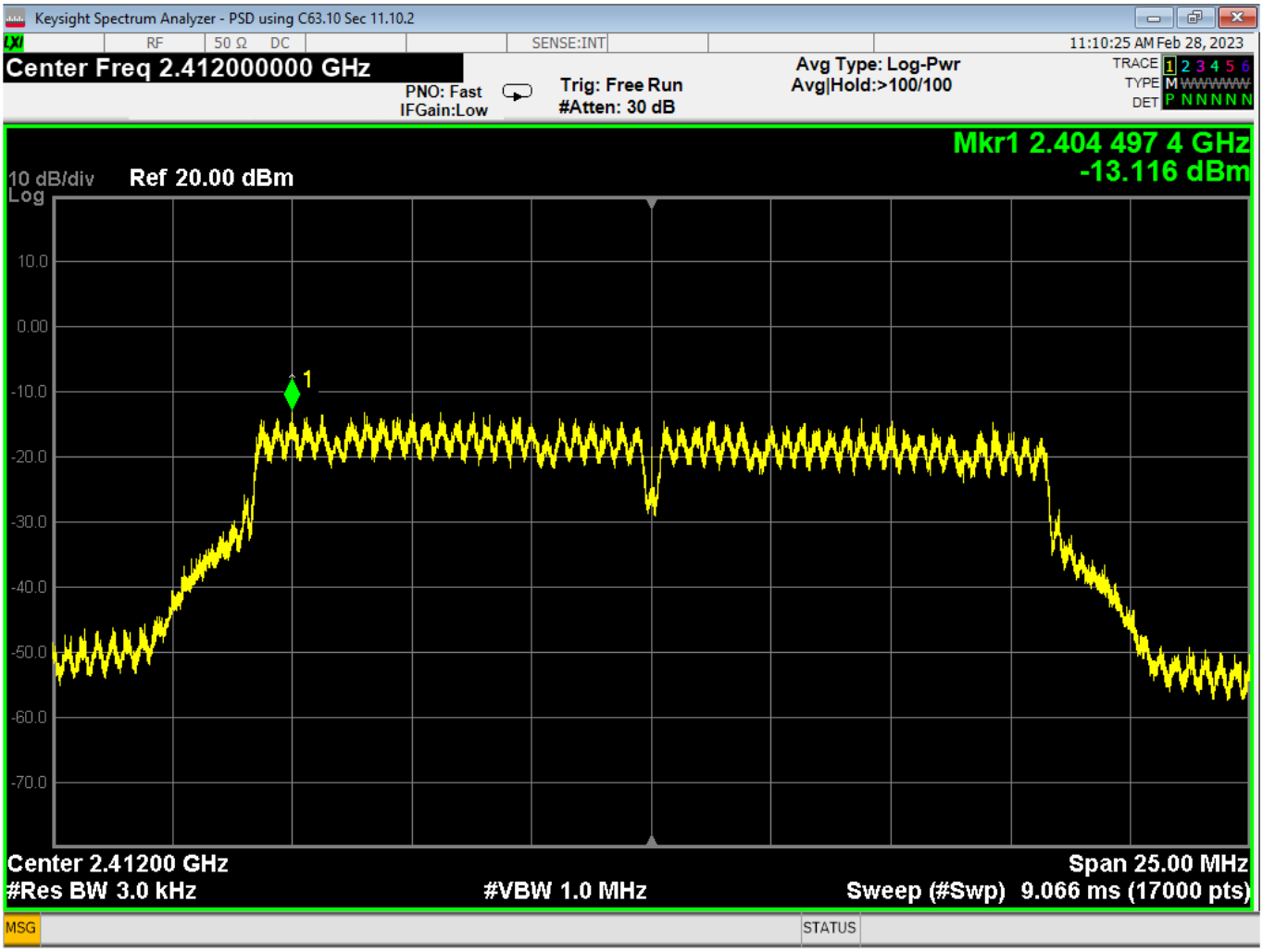

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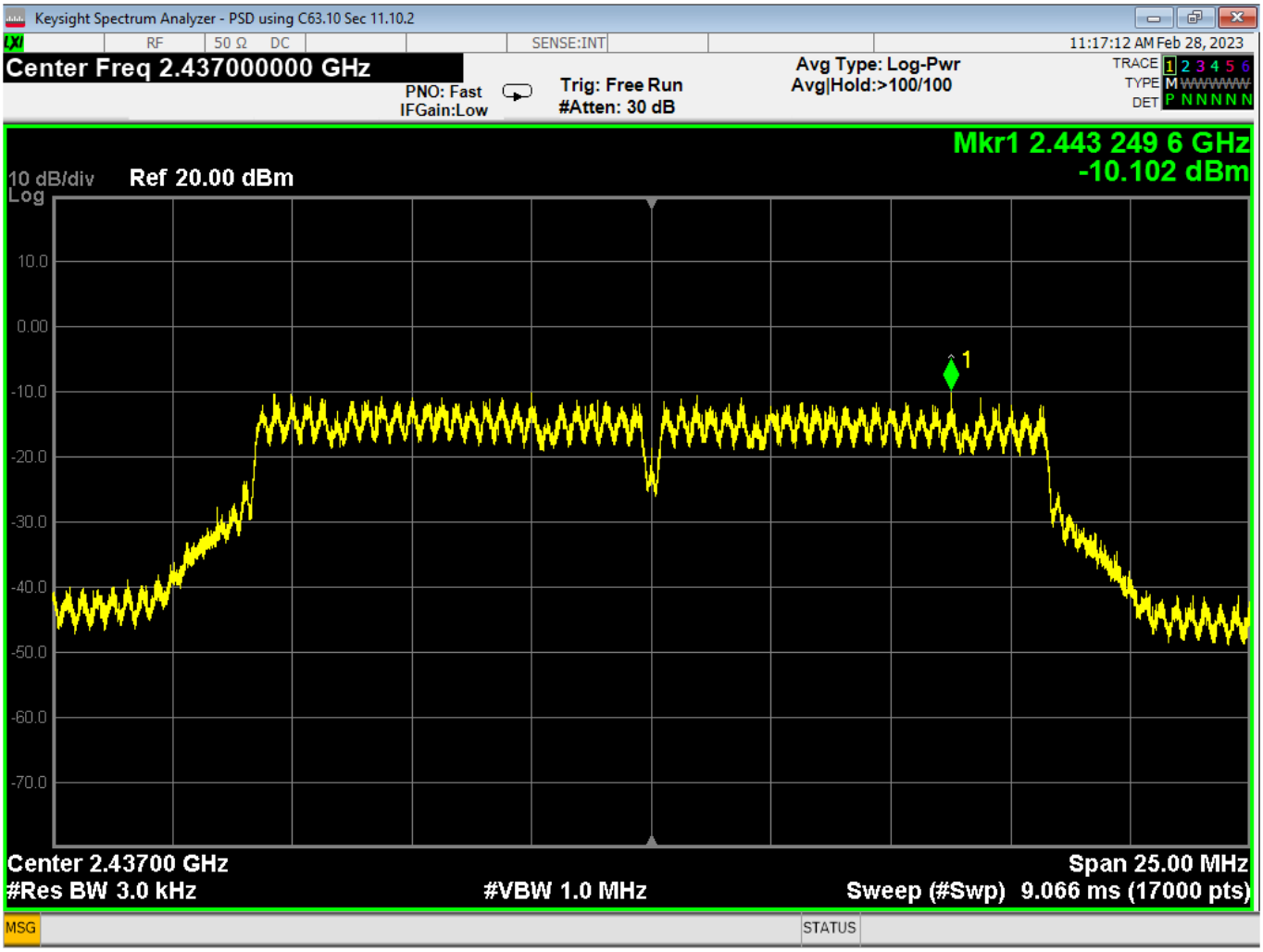

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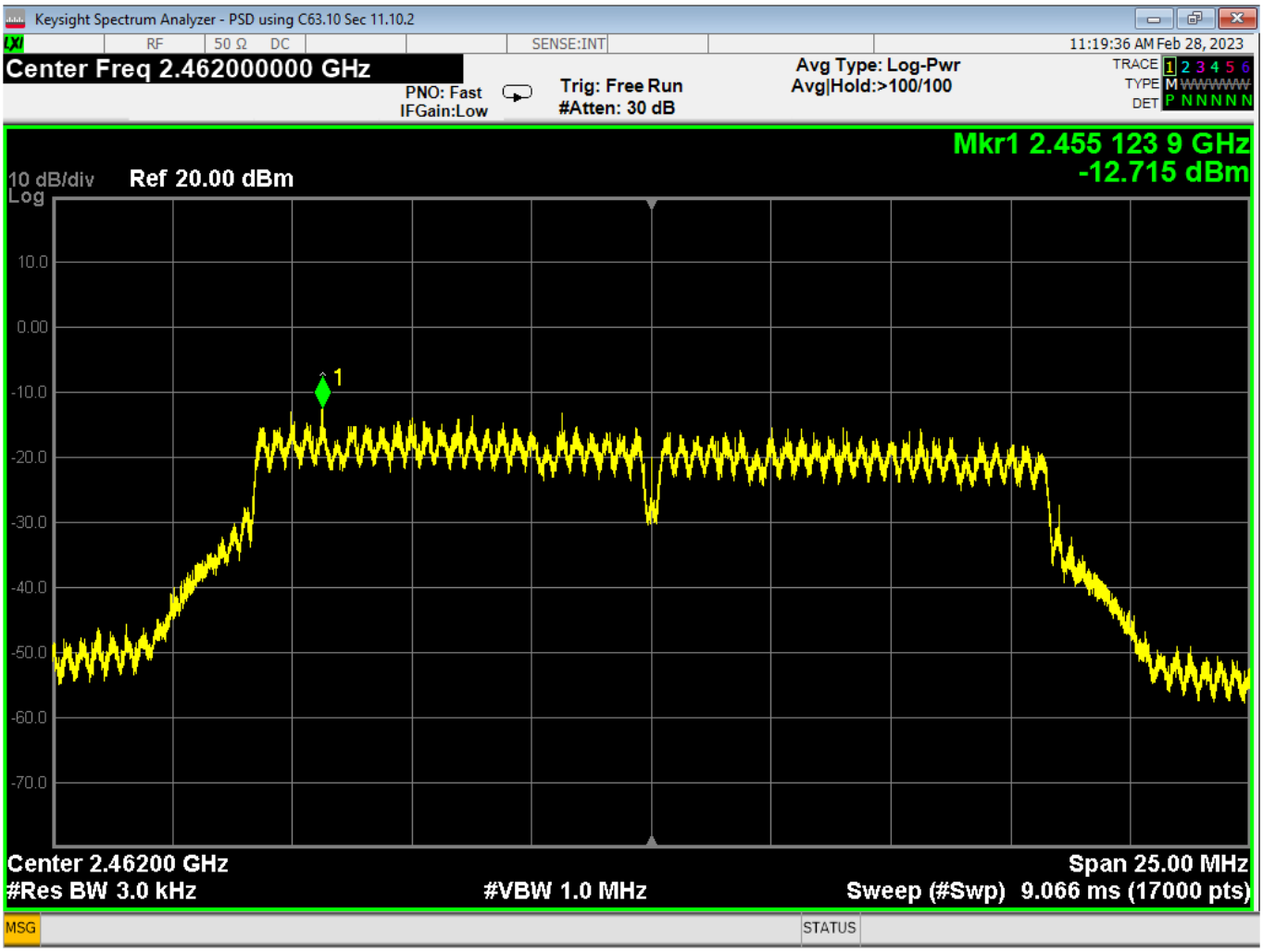

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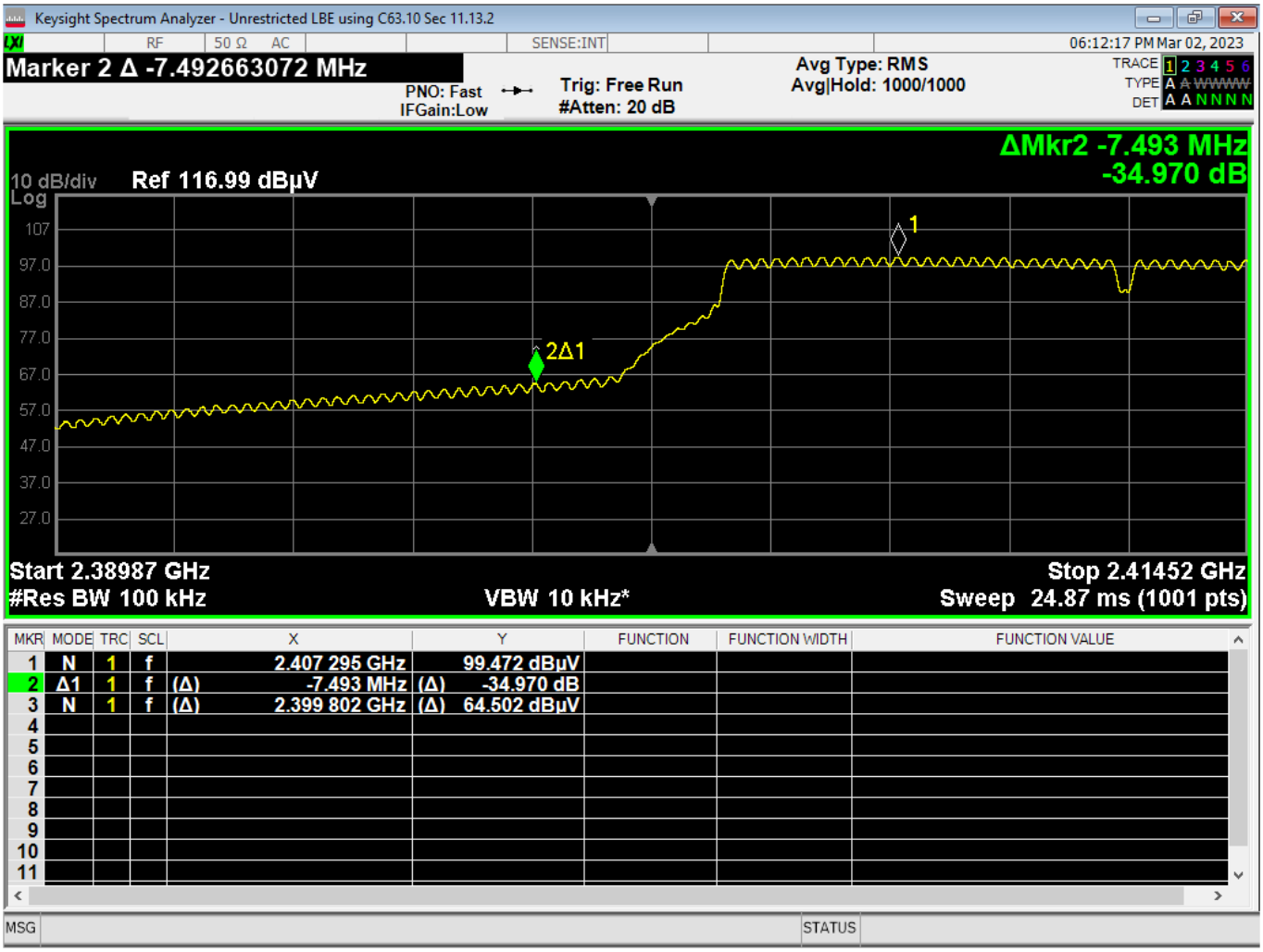

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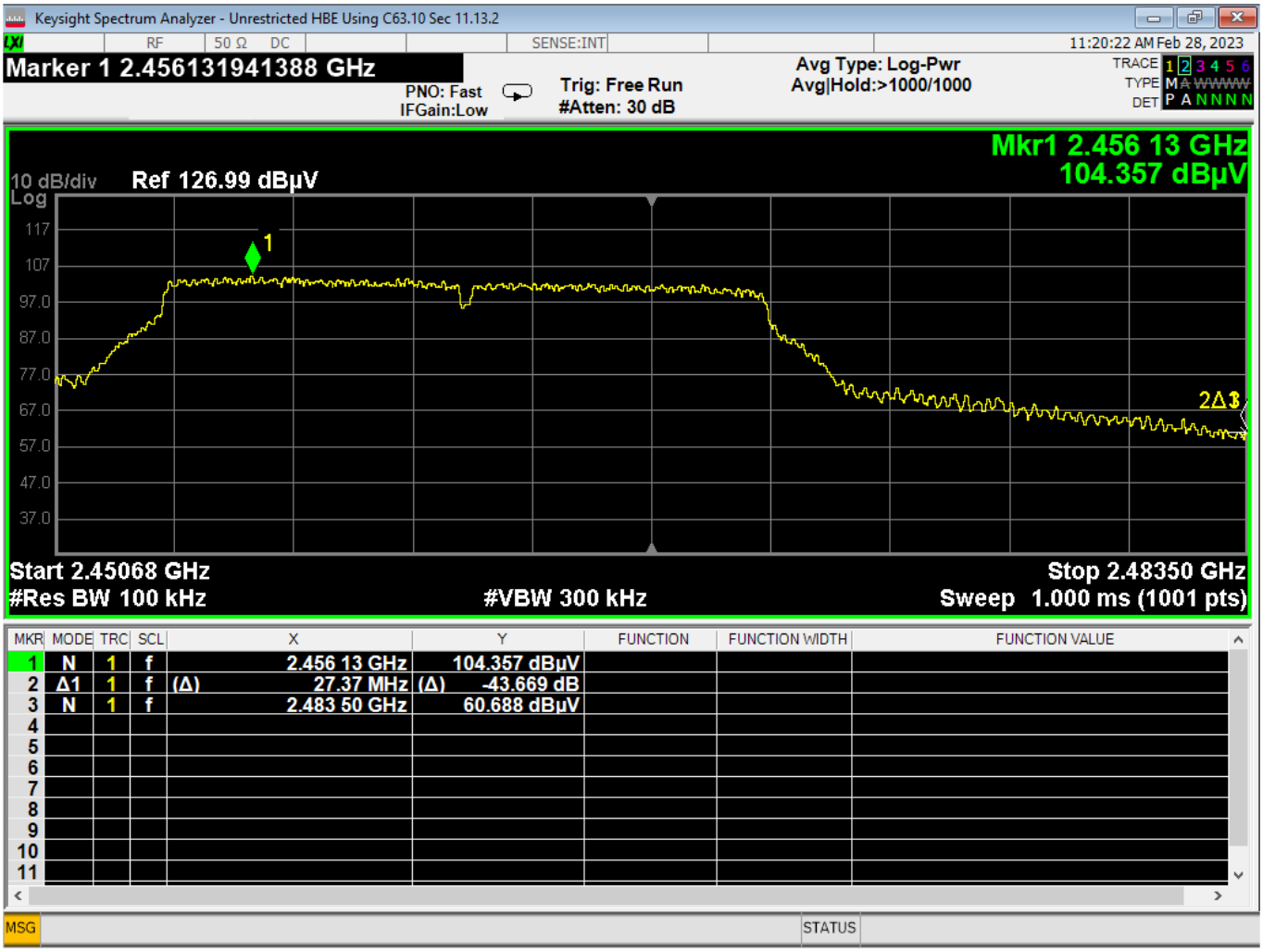

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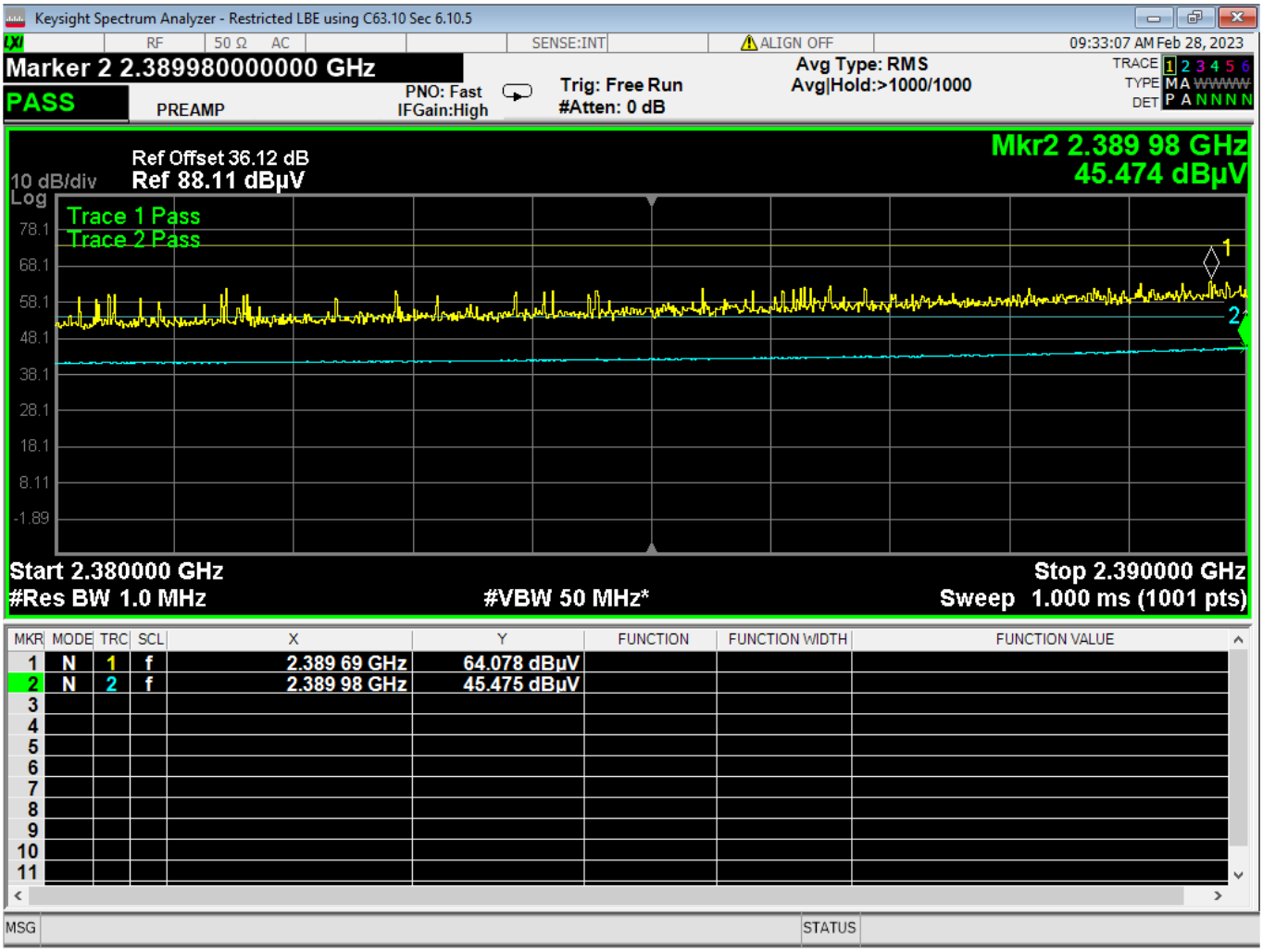

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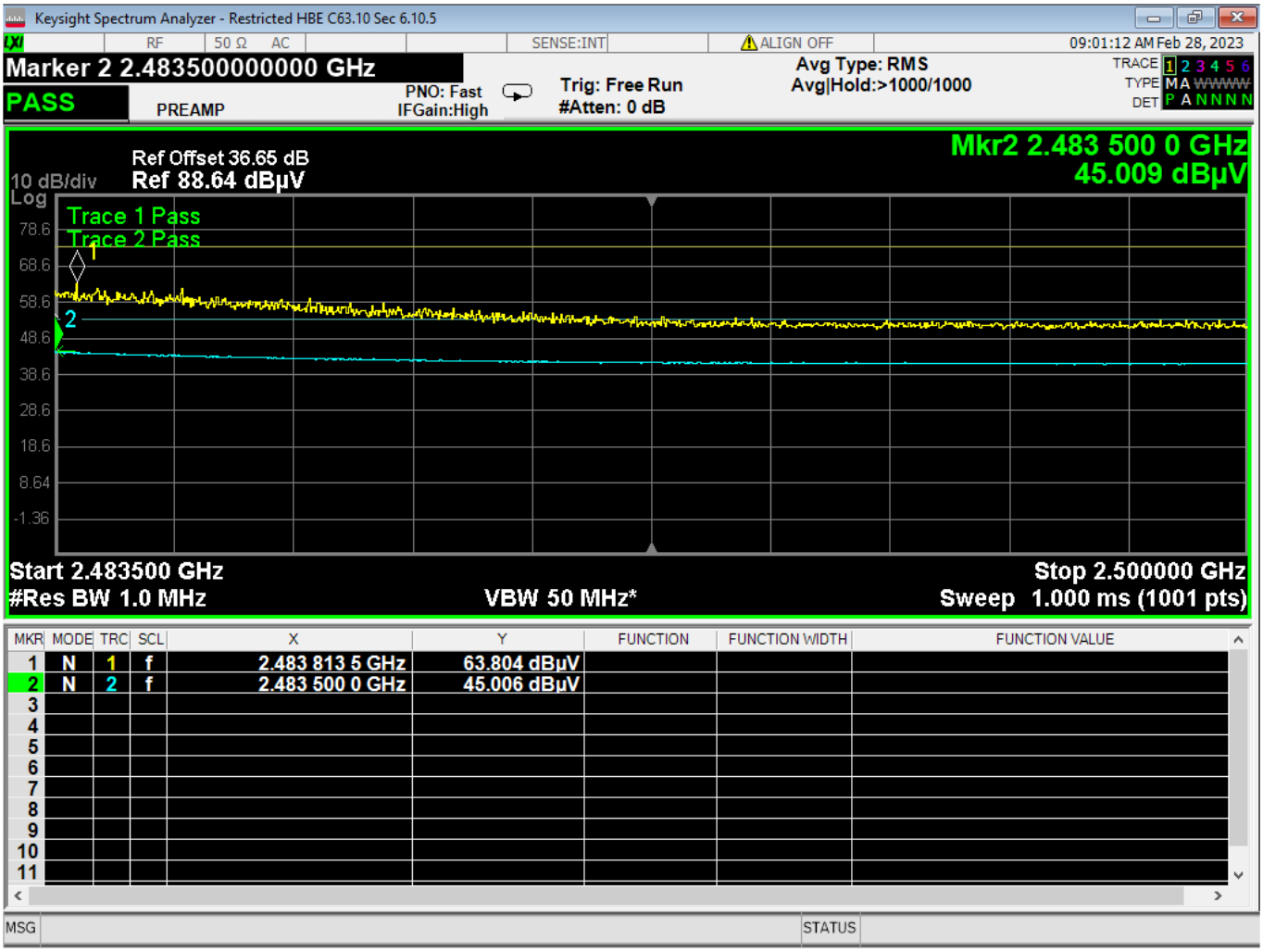

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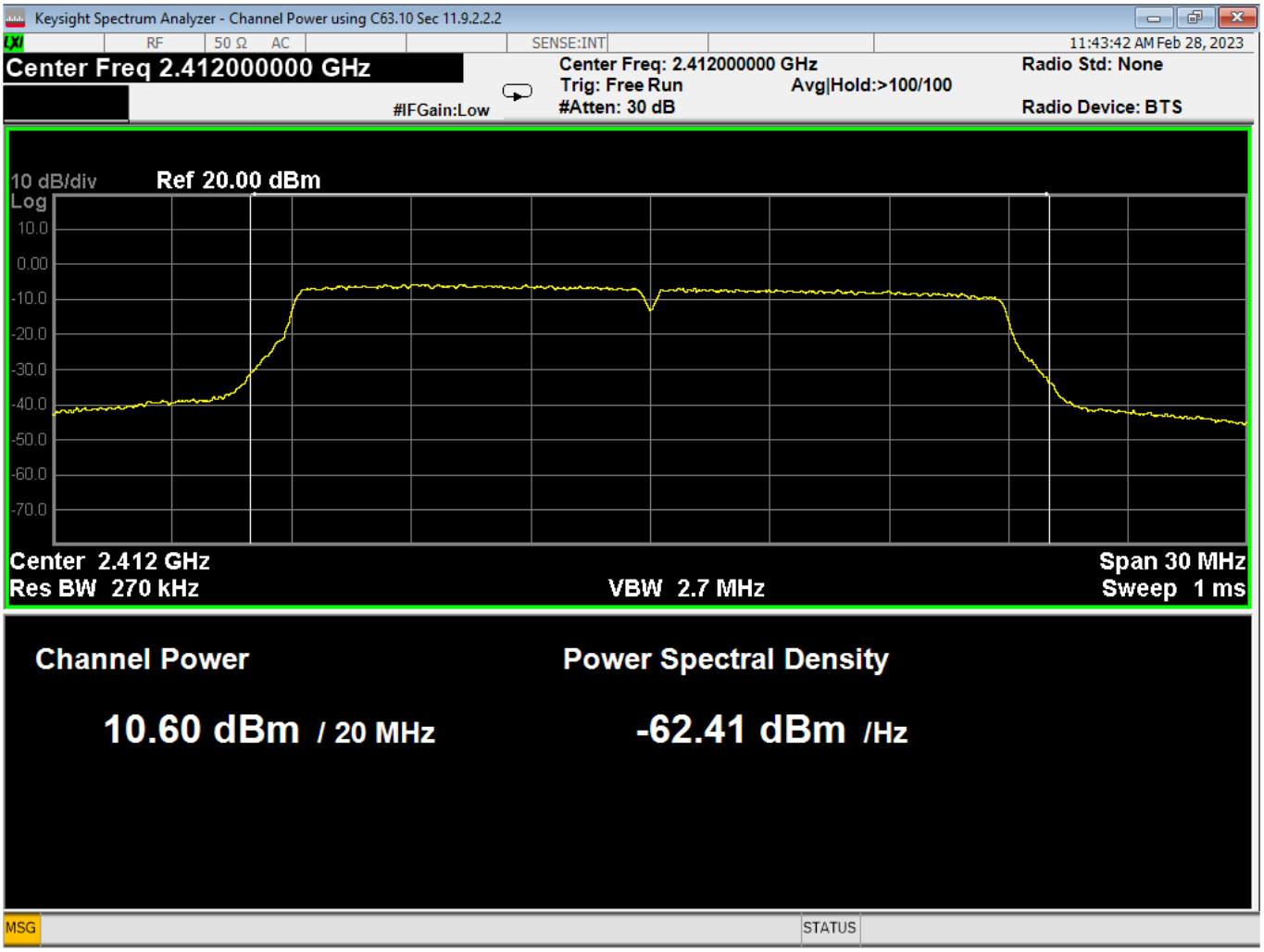

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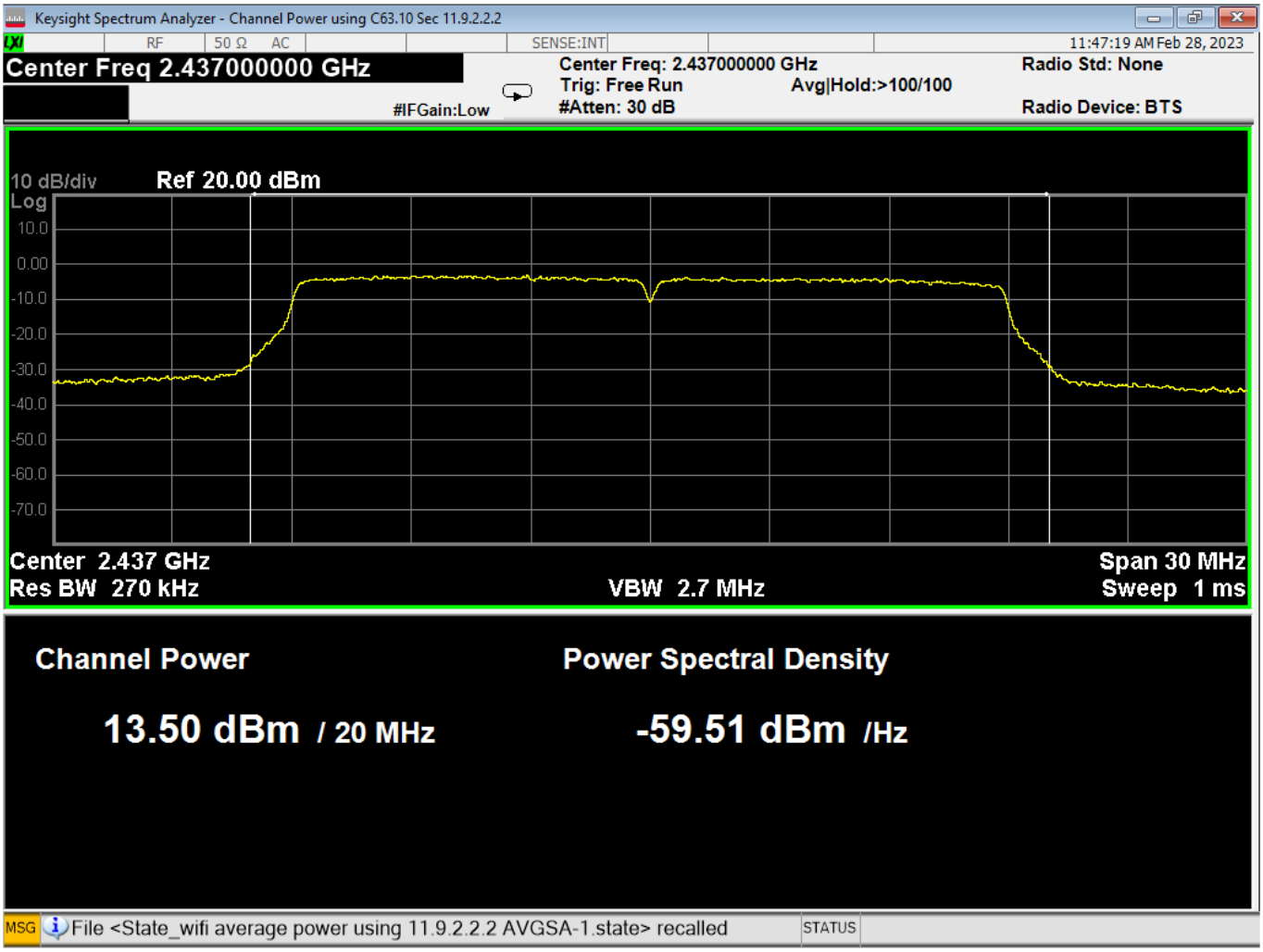

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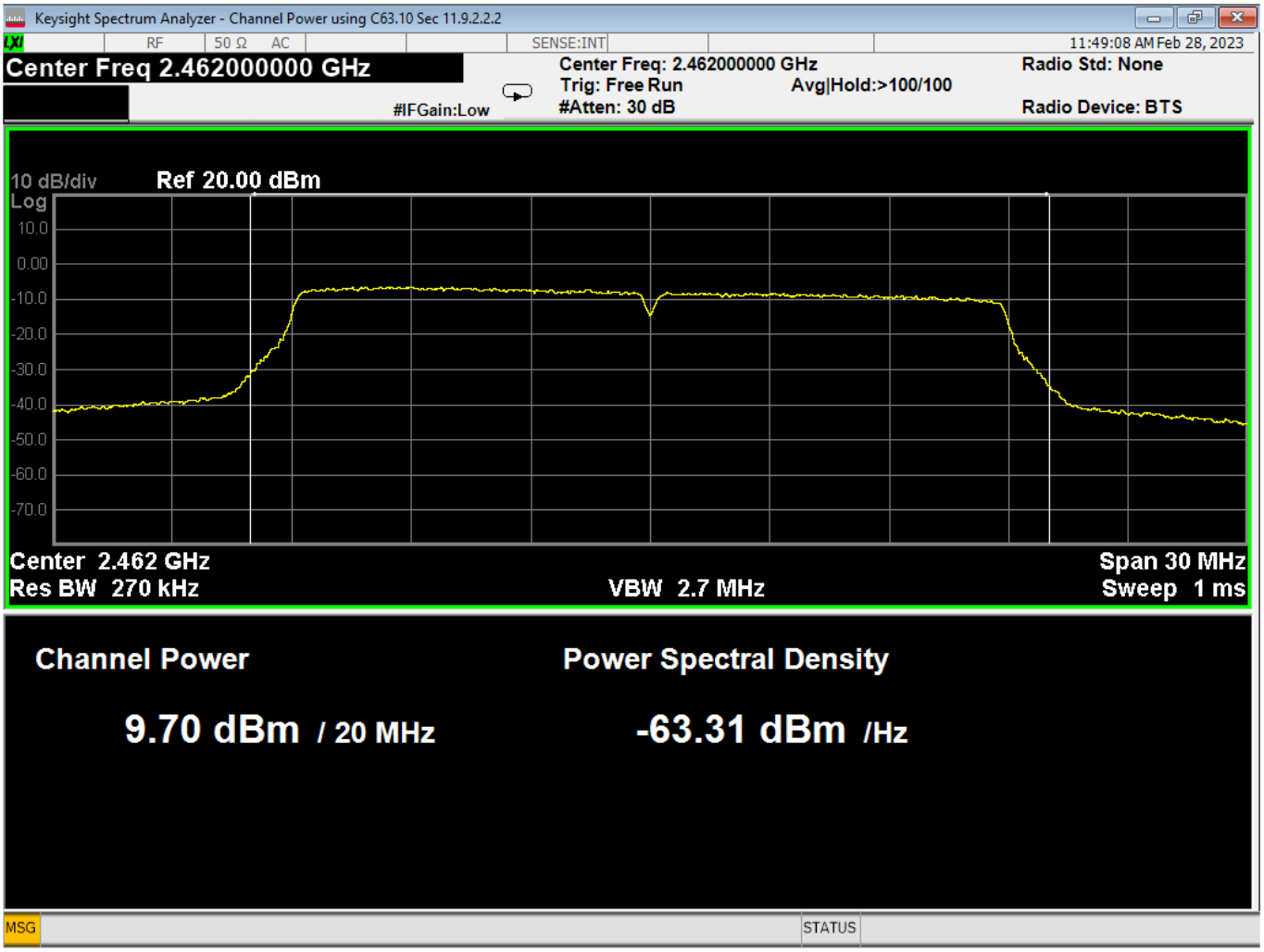

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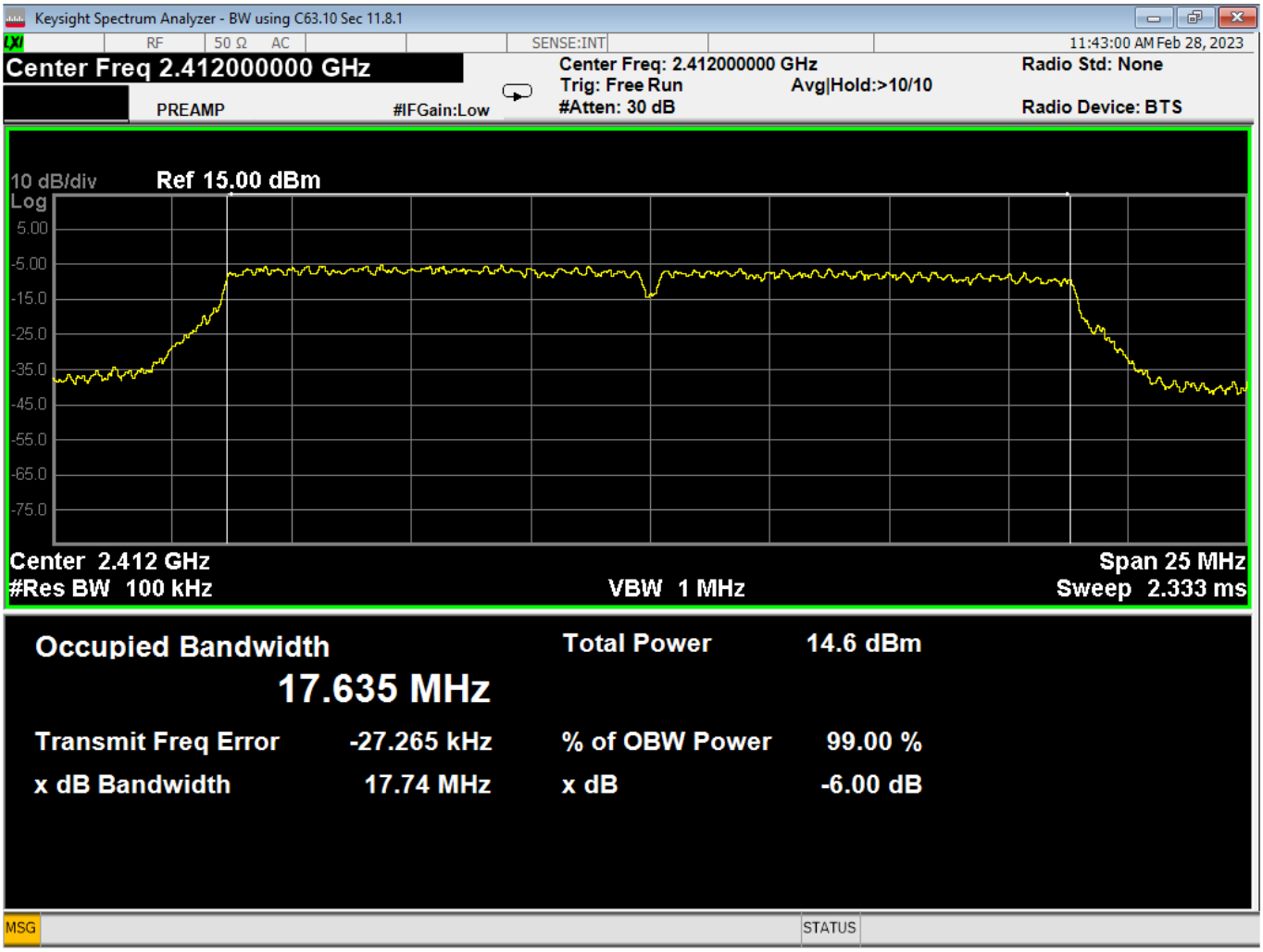
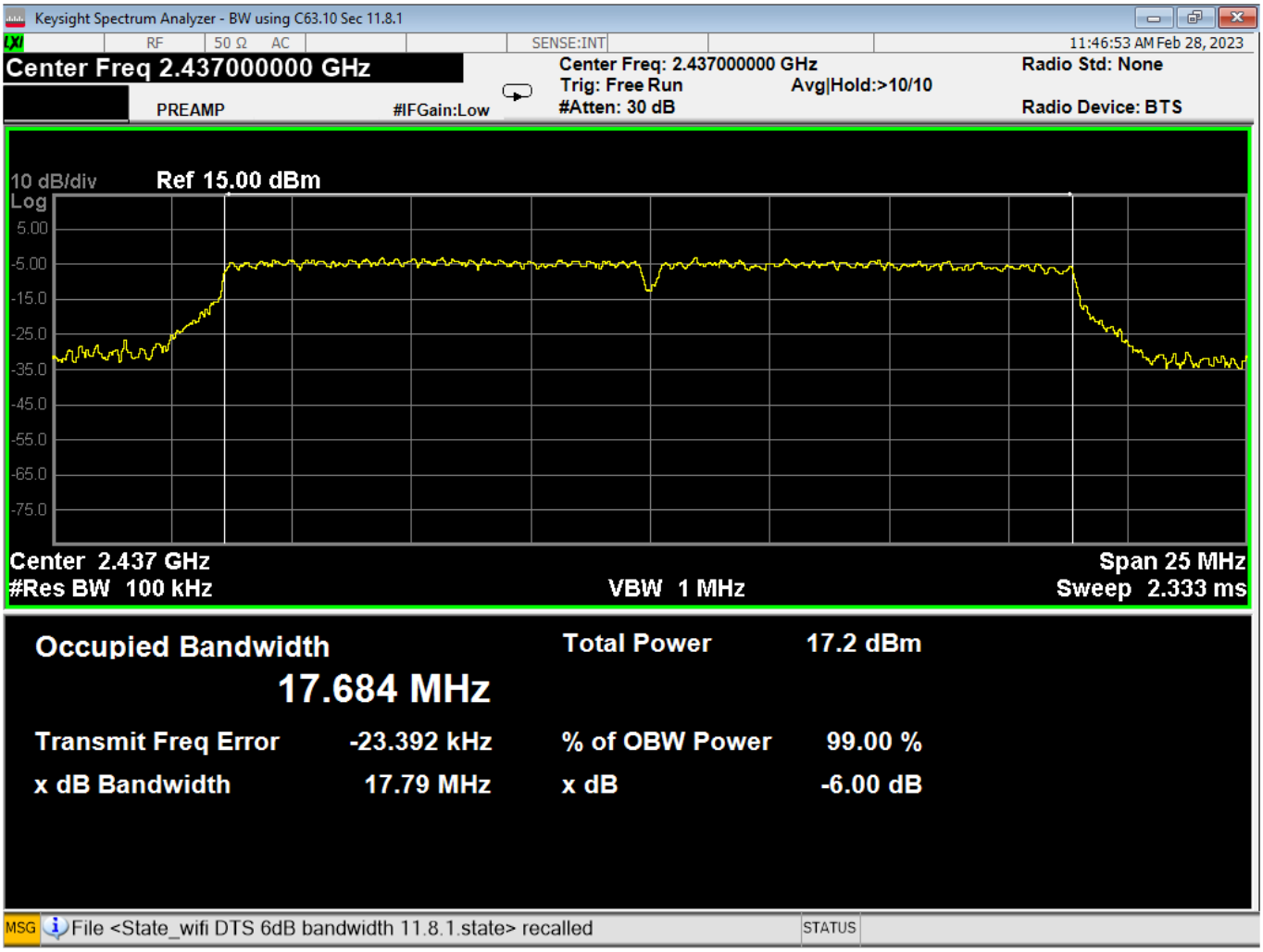


30 6dB Bandwidth, Low, Wifi N, Low Data Rate



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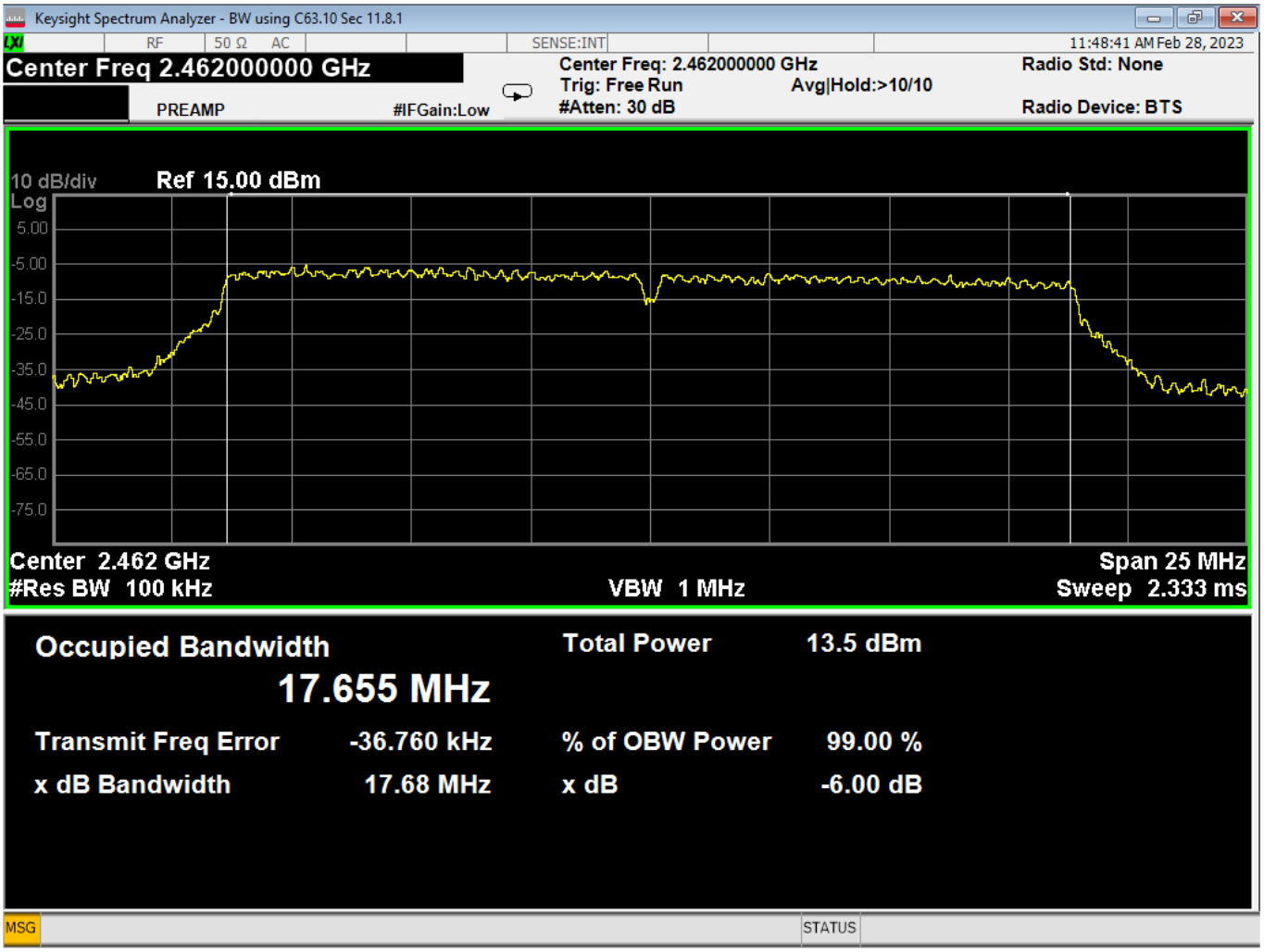
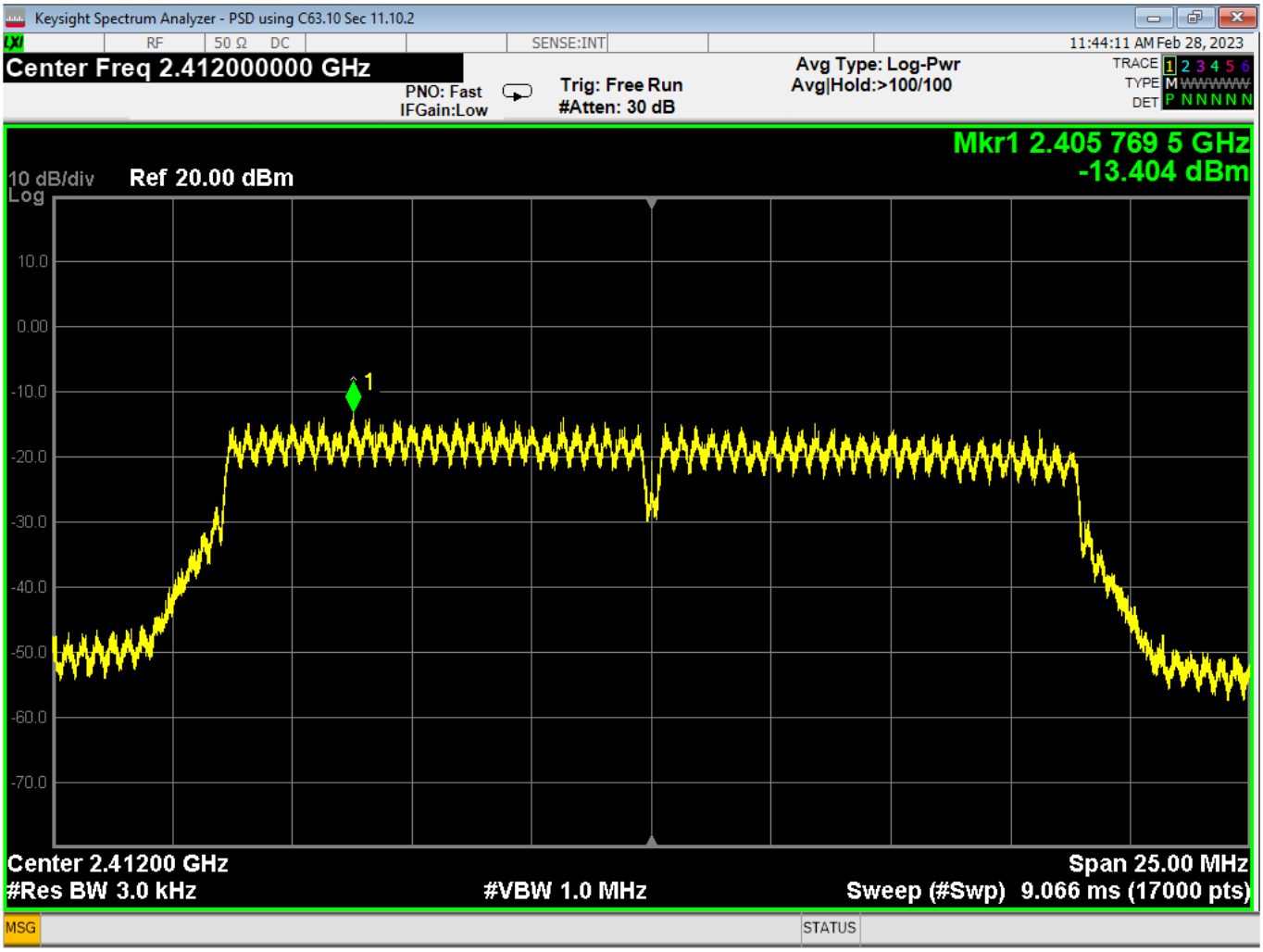
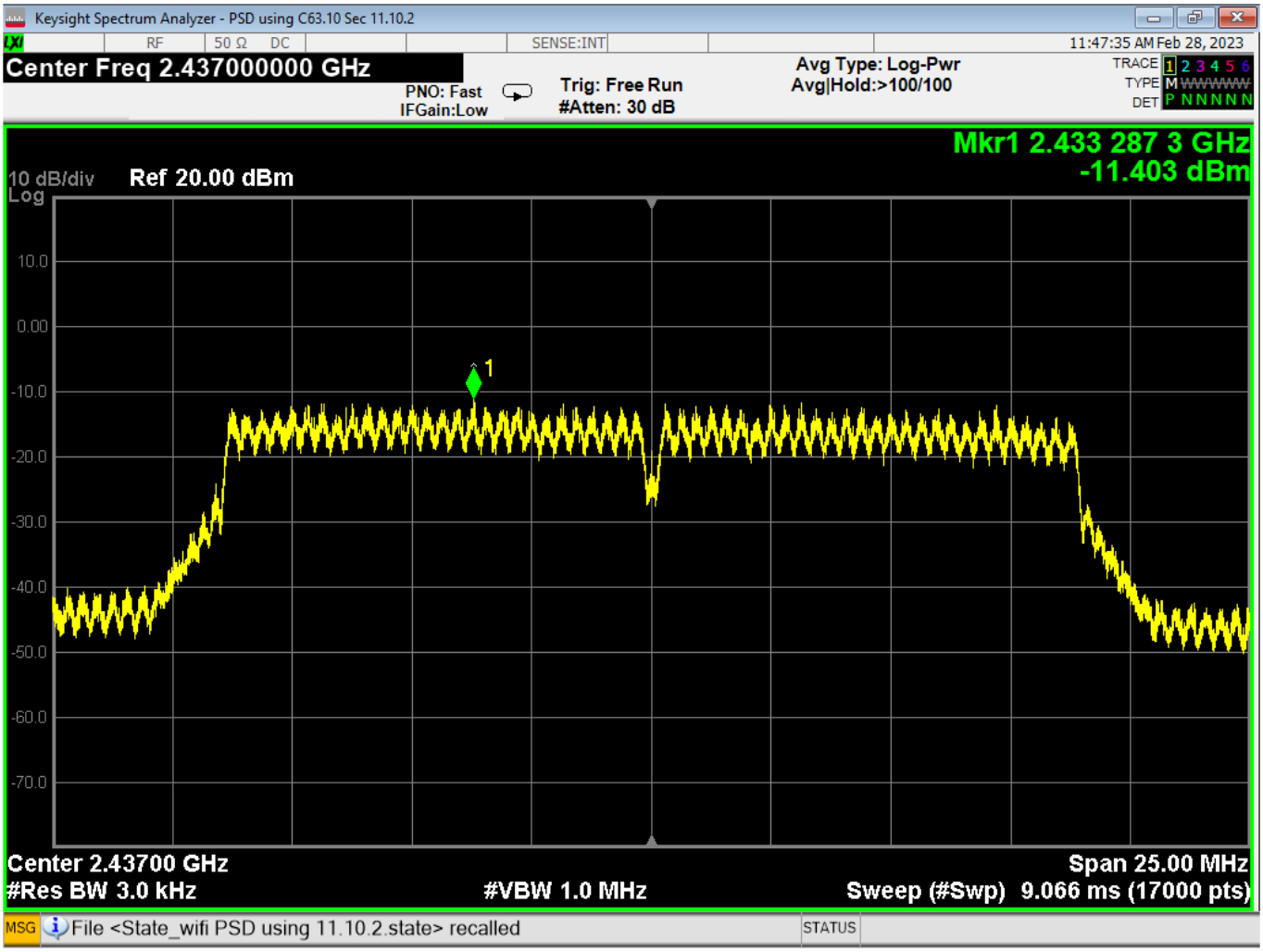


32 6dB Bandwidth, High, Wifi N, Low Data Rate



33 PSD, Low, Wifi N, Low Data Rate



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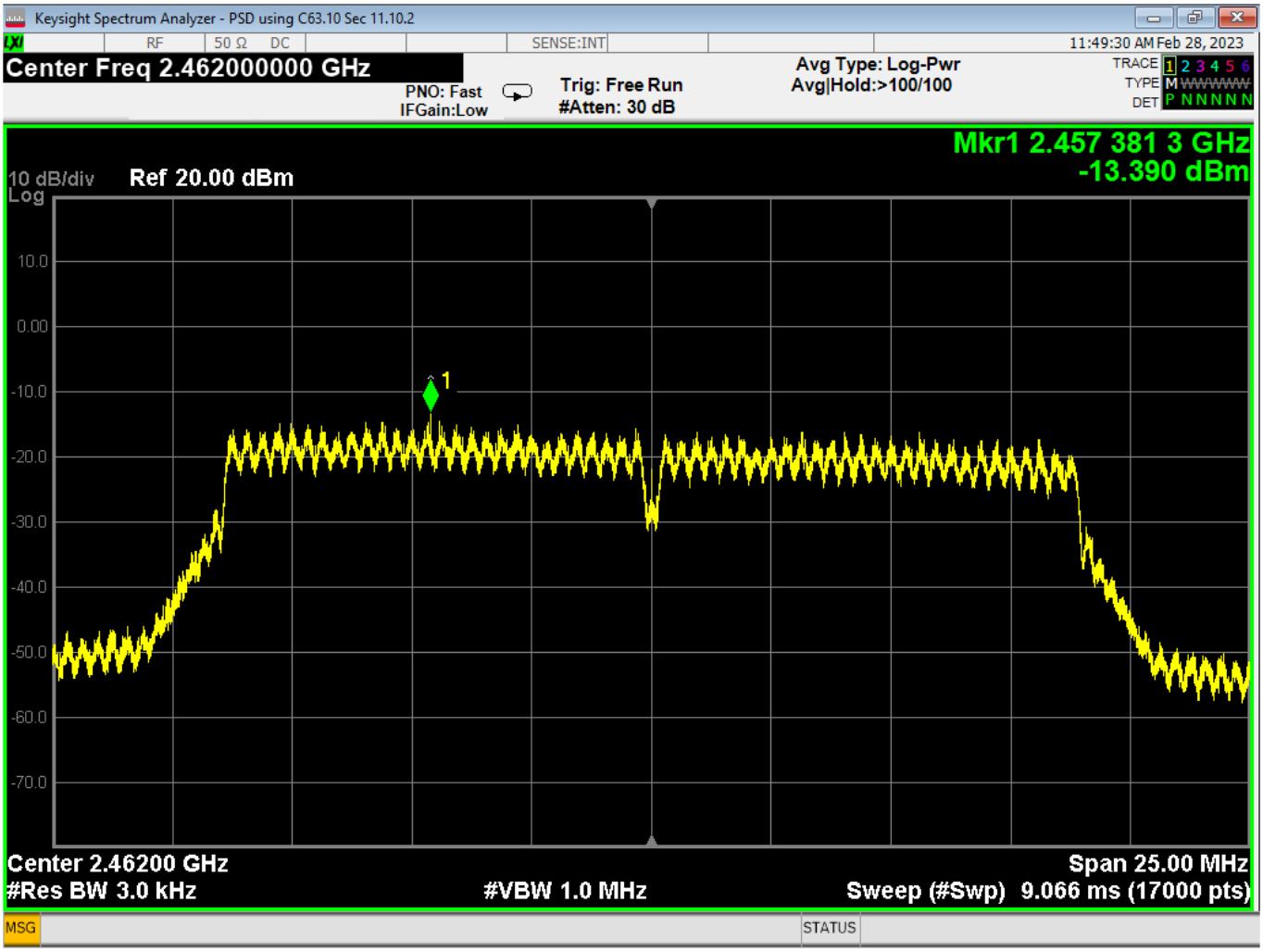

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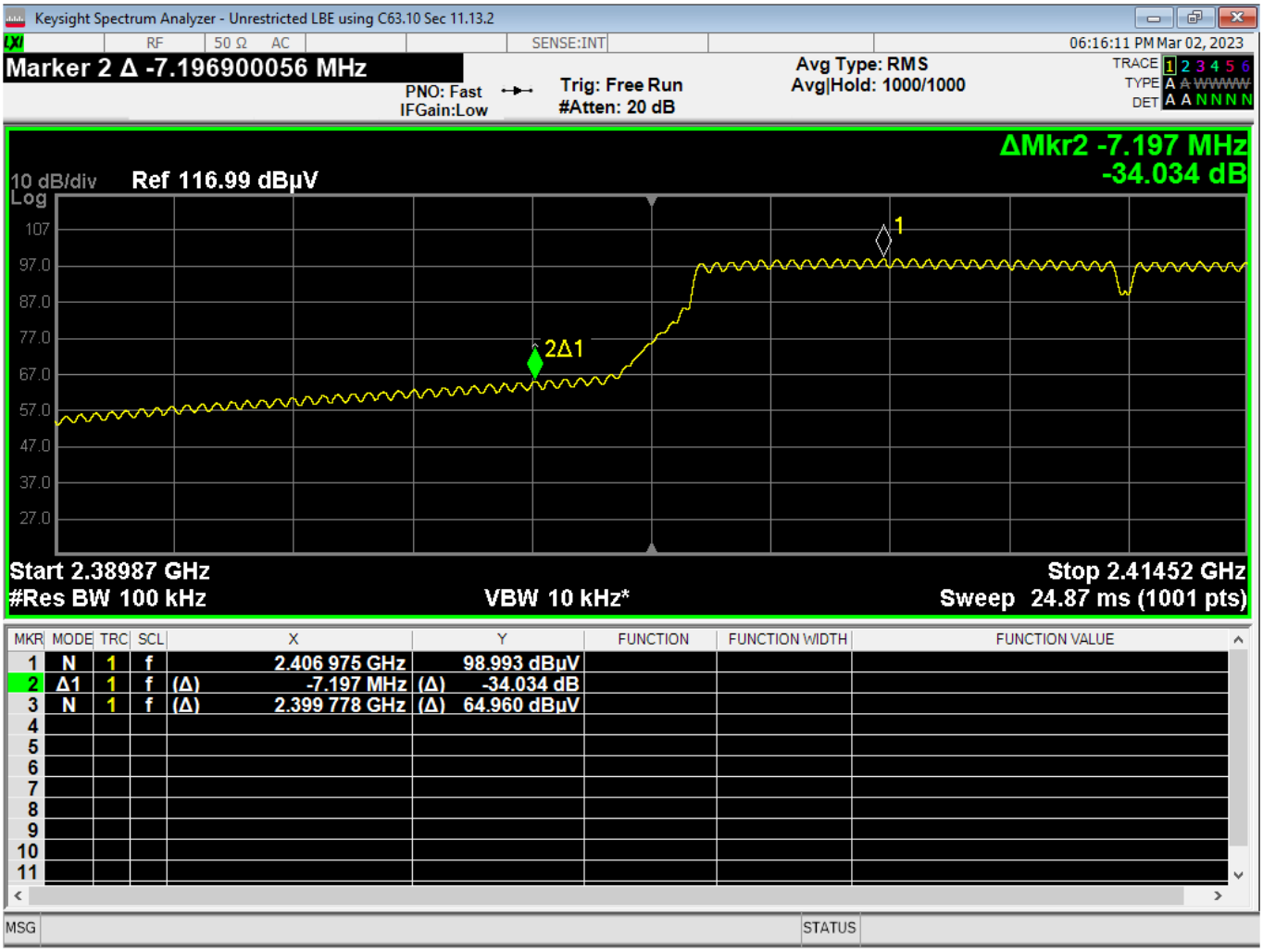
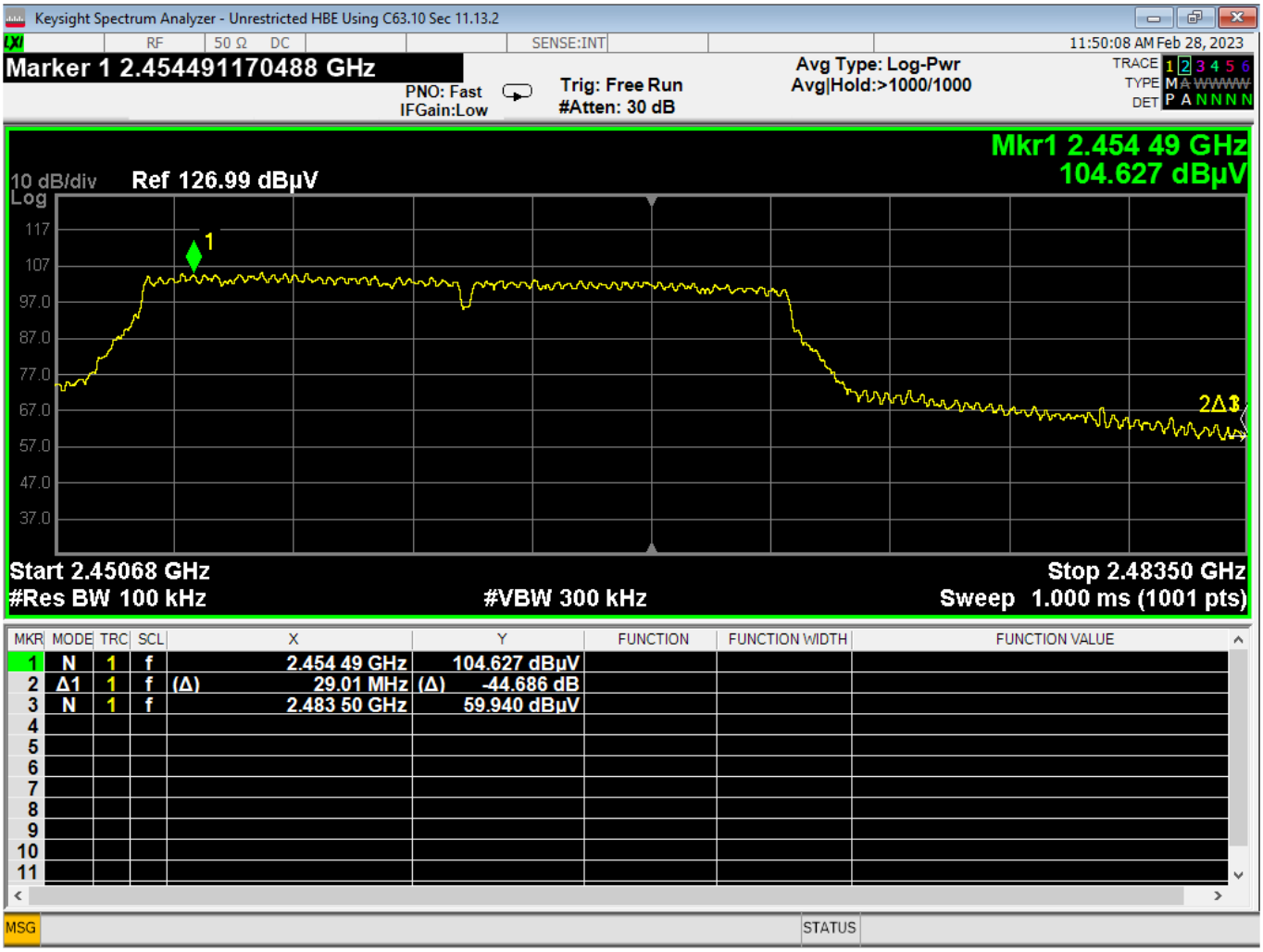


36 Lower Bandedge, Unrestricted, Wifi N, Low Data Rate



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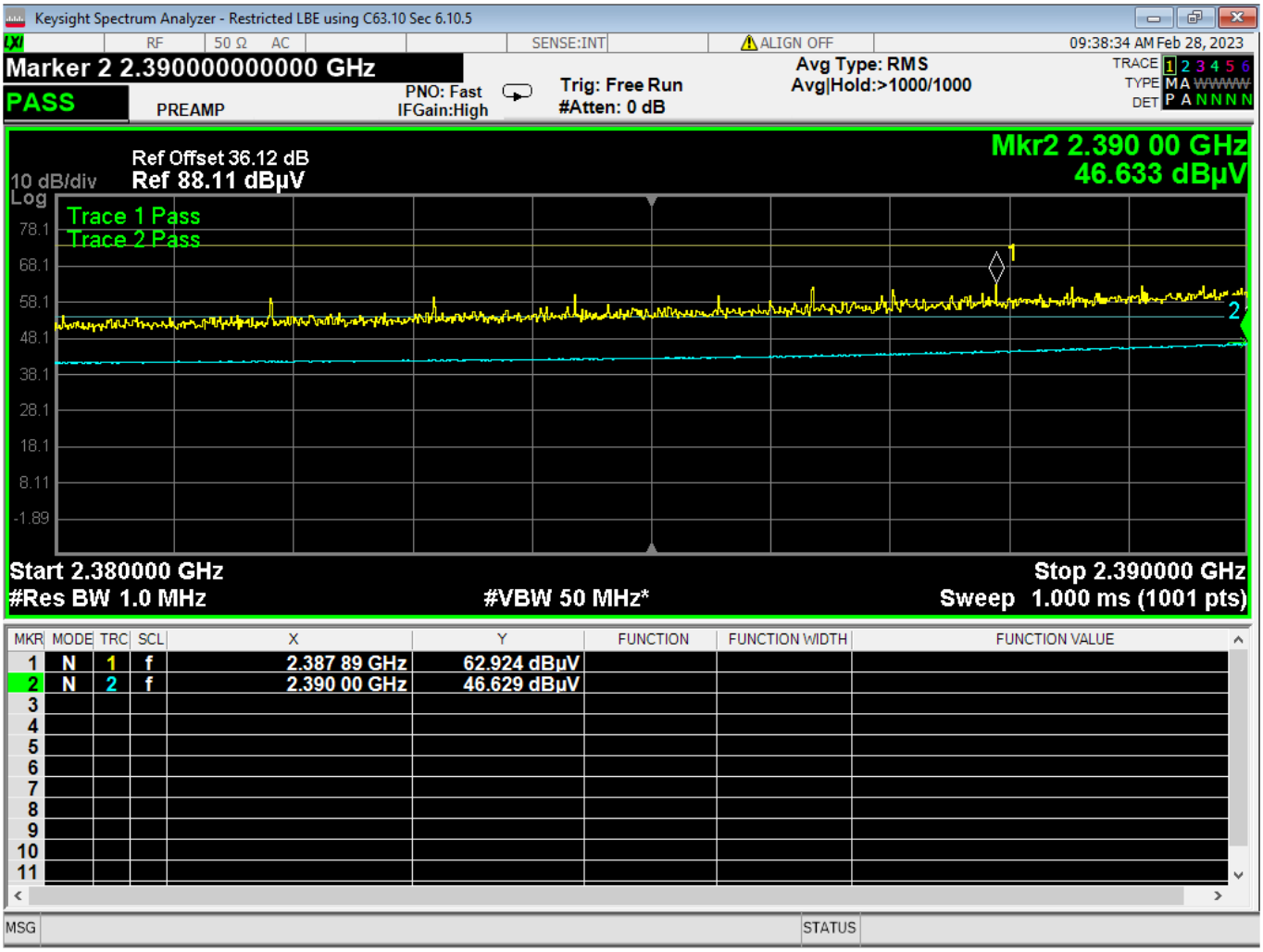
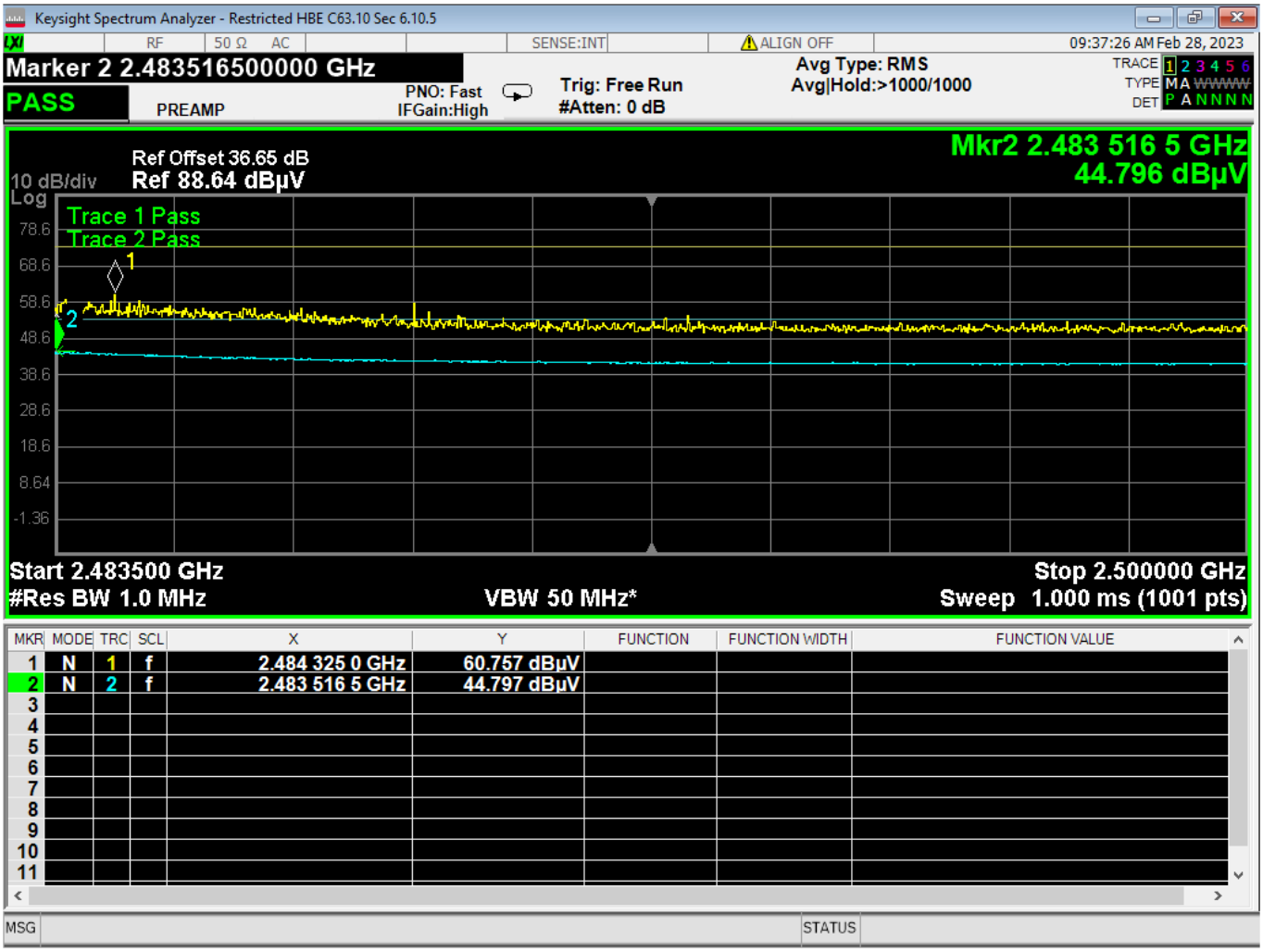
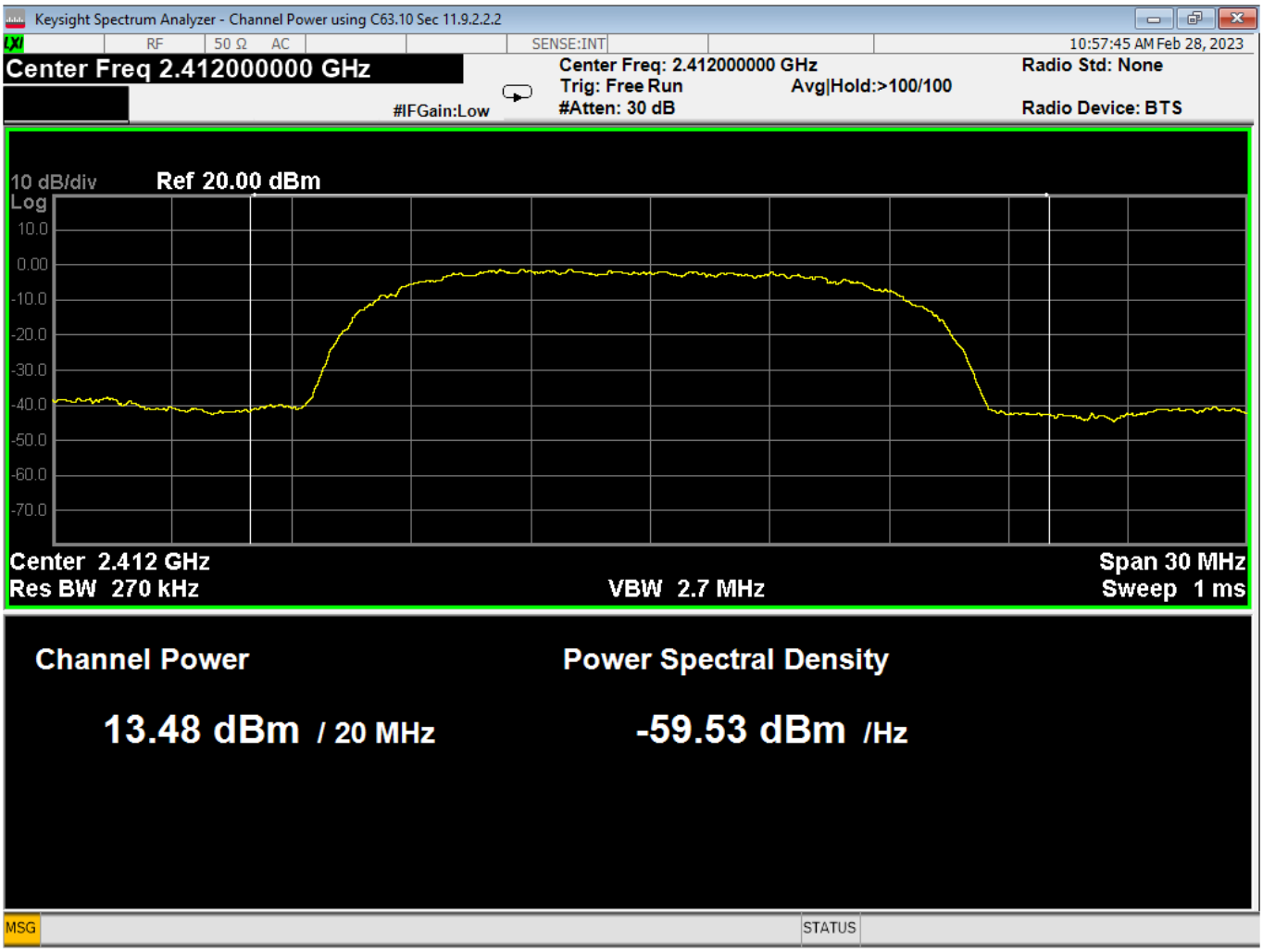


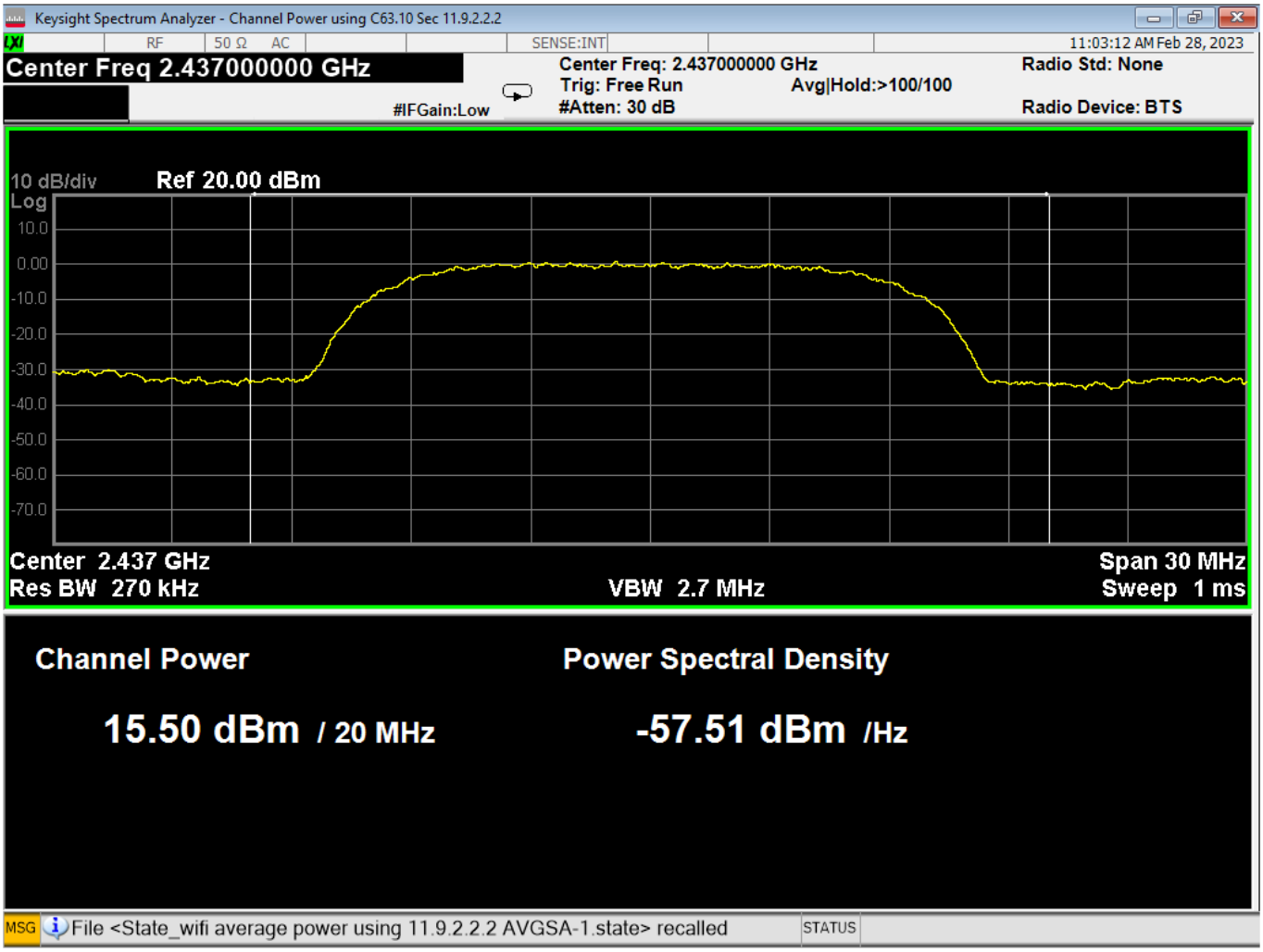
38 Lower Bandedge, Restricted, Wifi N, Low Data Rate



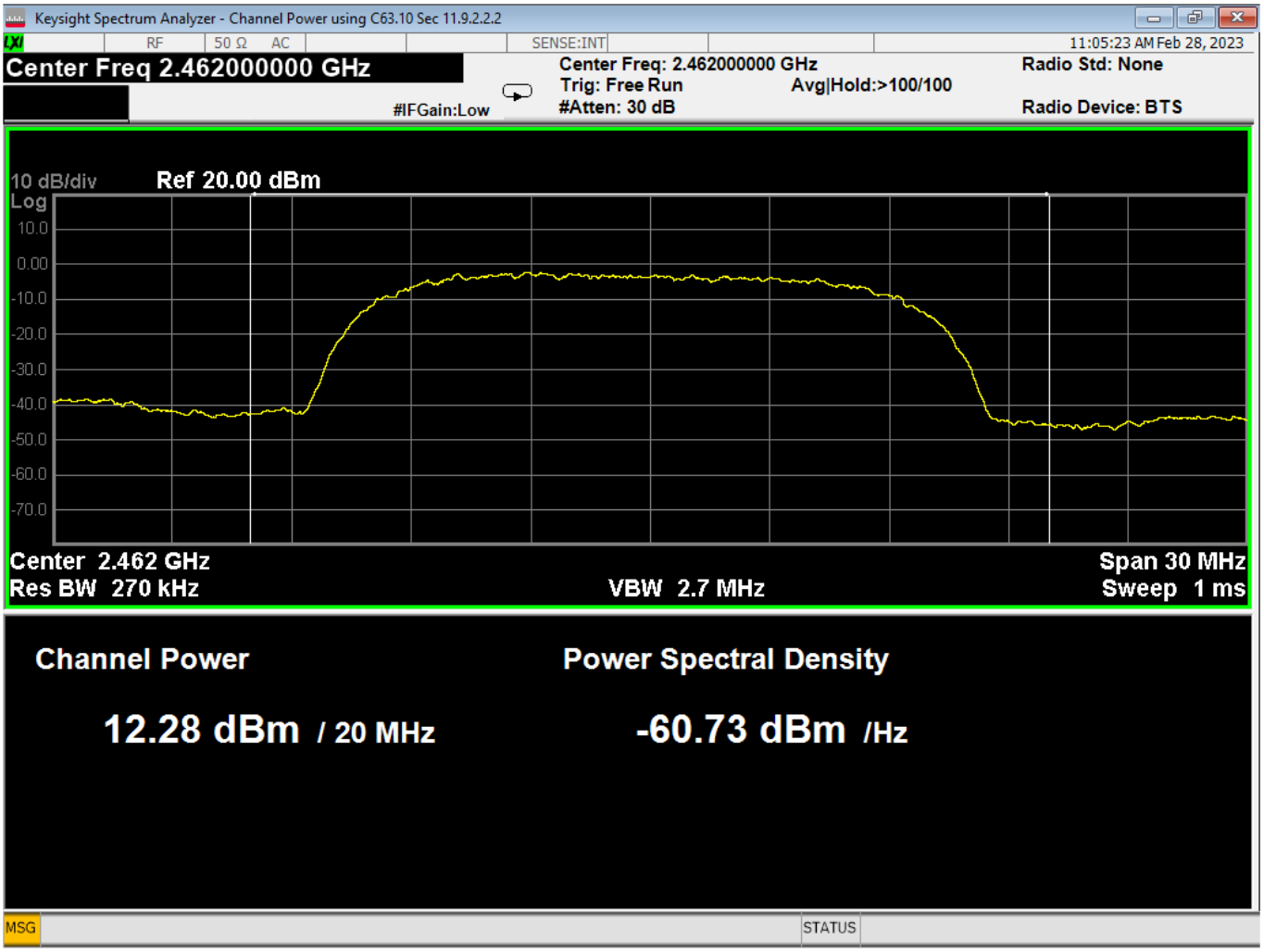
39 Higher Bandedge, Restricted, Wifi N, Low Data Rate



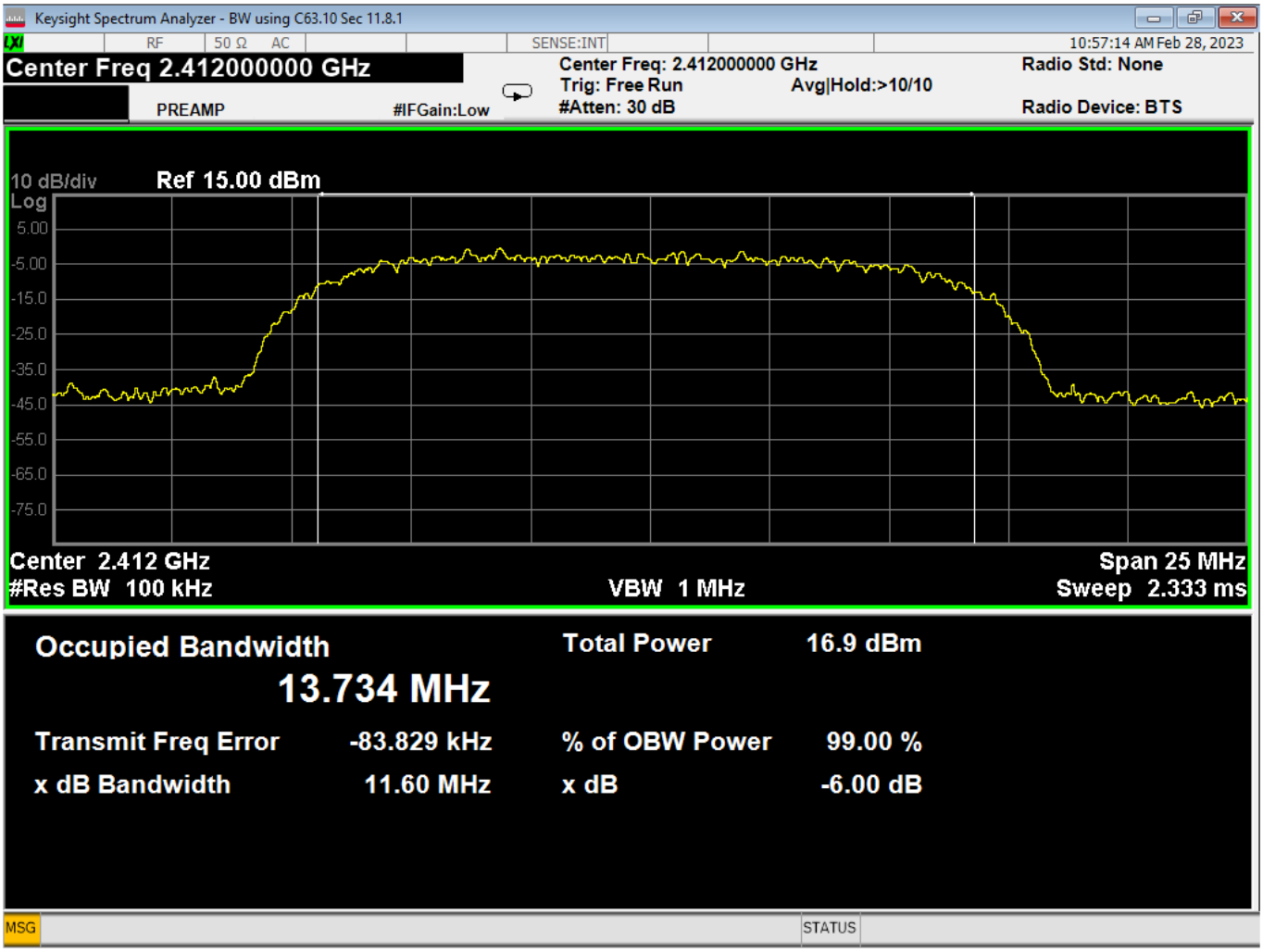
40 Average Power, Low, Wifi B, High Data Rate



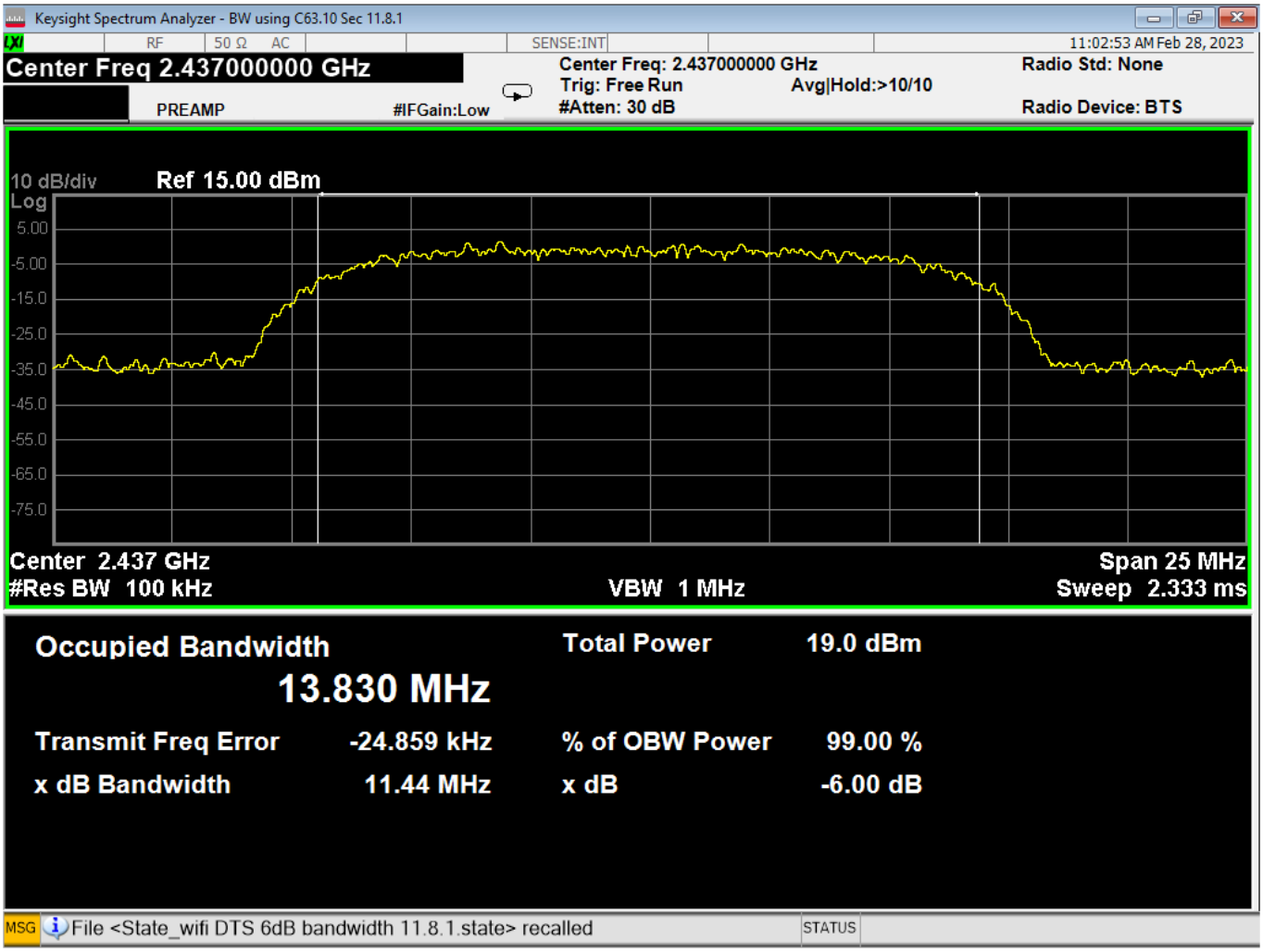
41 Average Power, Mid, Wifi B, High Data Rate



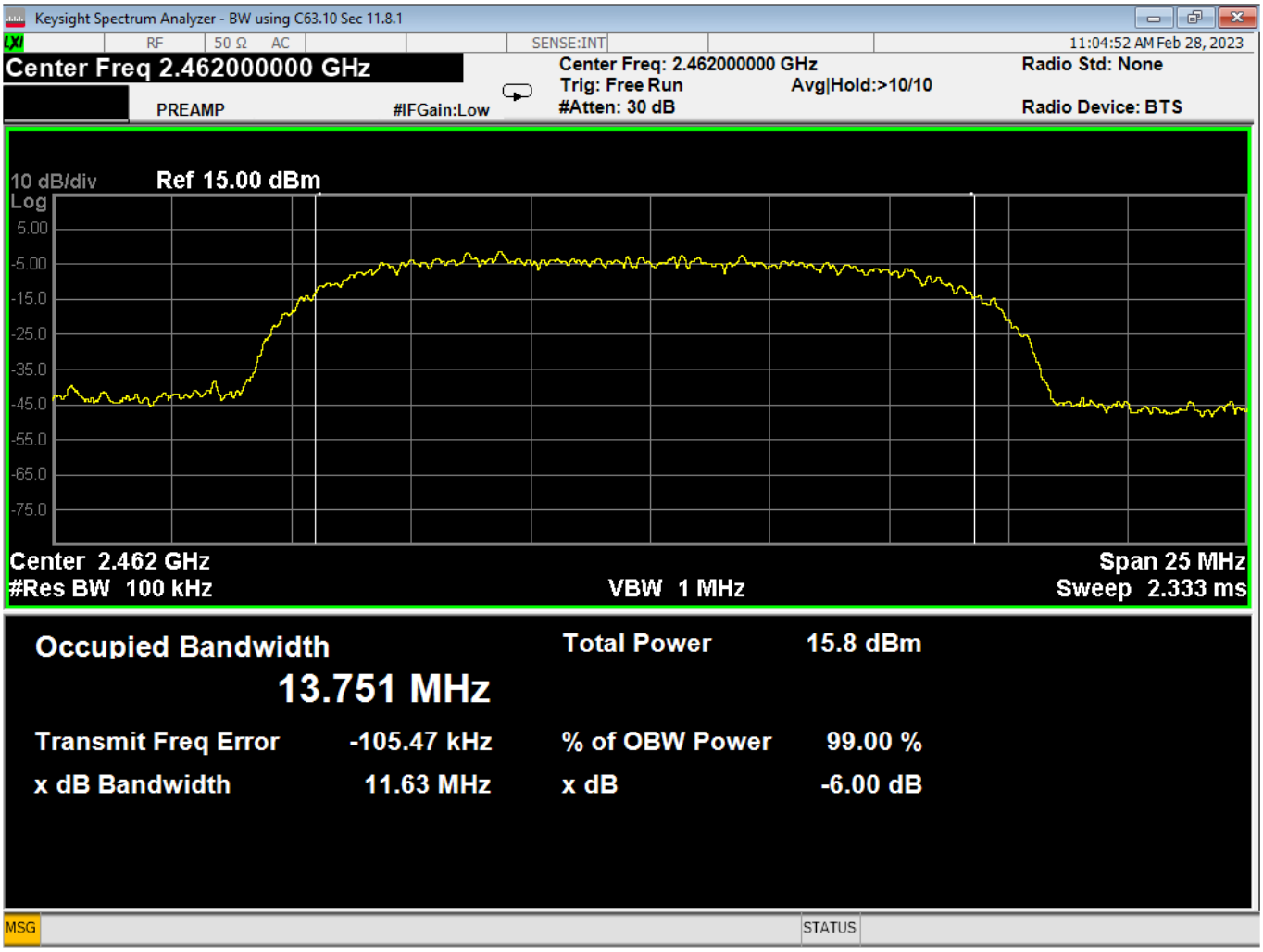
42 Average Power, High, Wifi B, High Data Rate



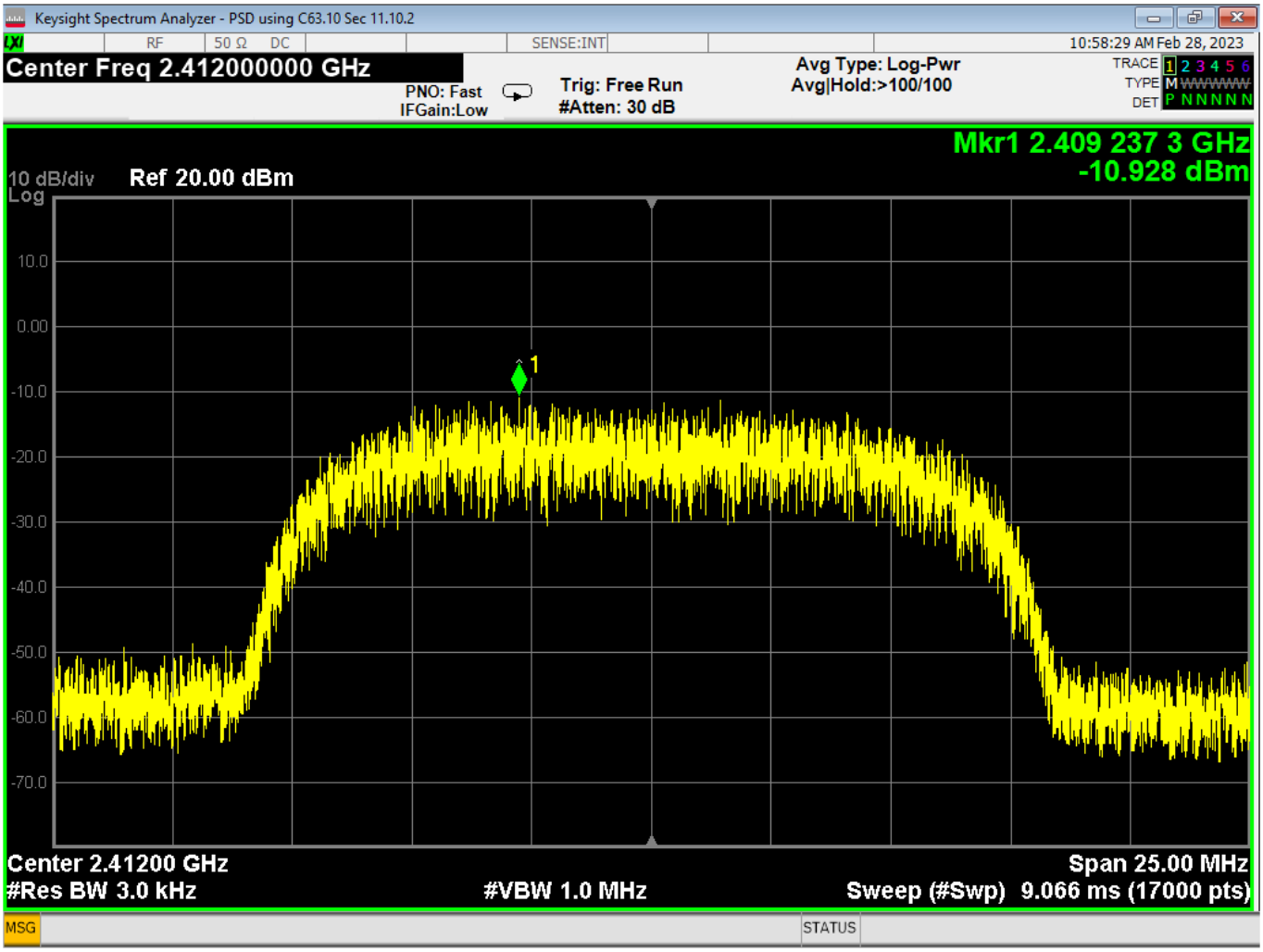
43 6dB Bandwidth, Low, Wifi B, High Data Rate



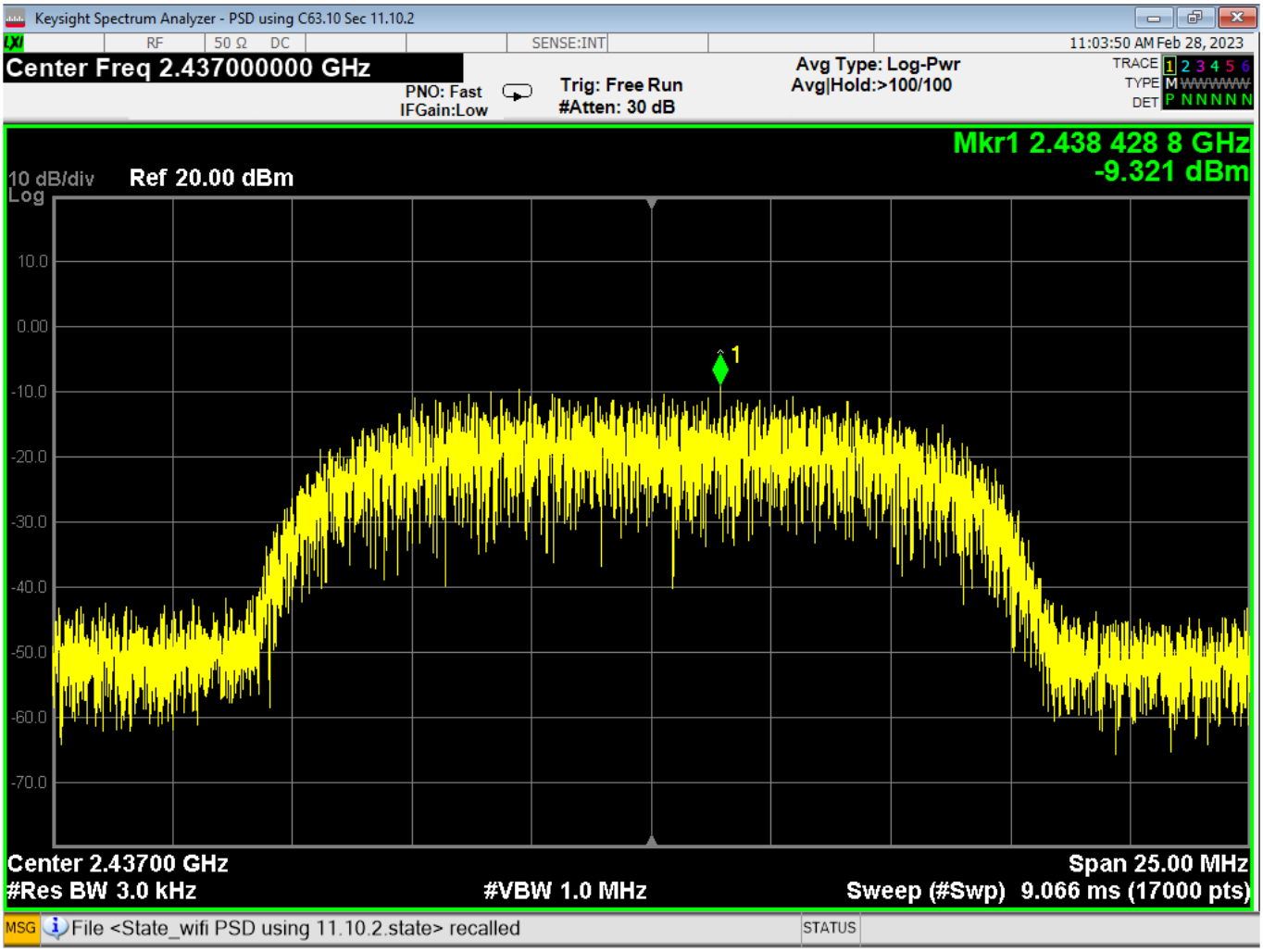
44 6dB Bandwidth, Mid, Wifi B, High Data Rate



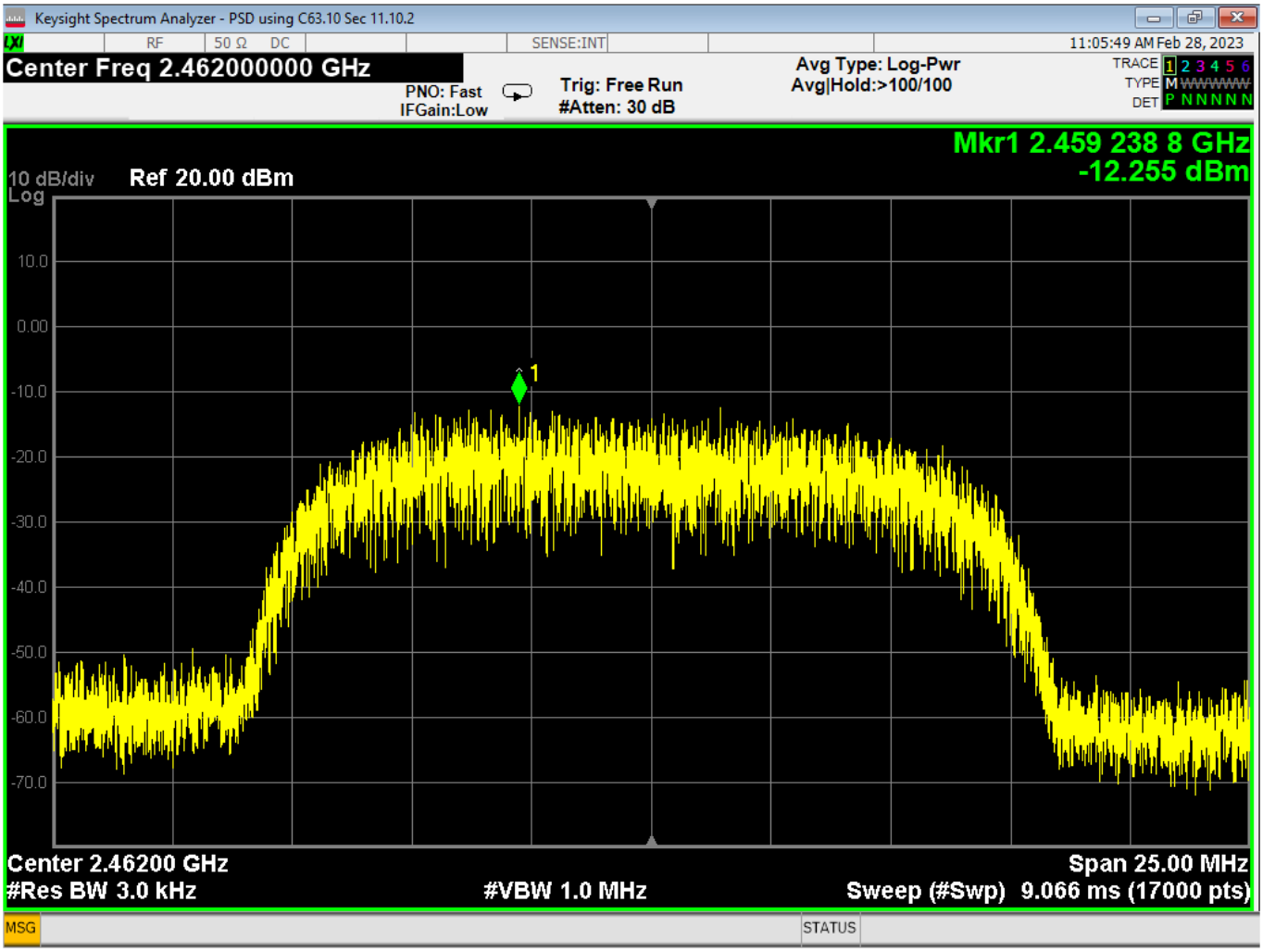
45 6dB Bandwidth, High, Wifi B, High Data Rate



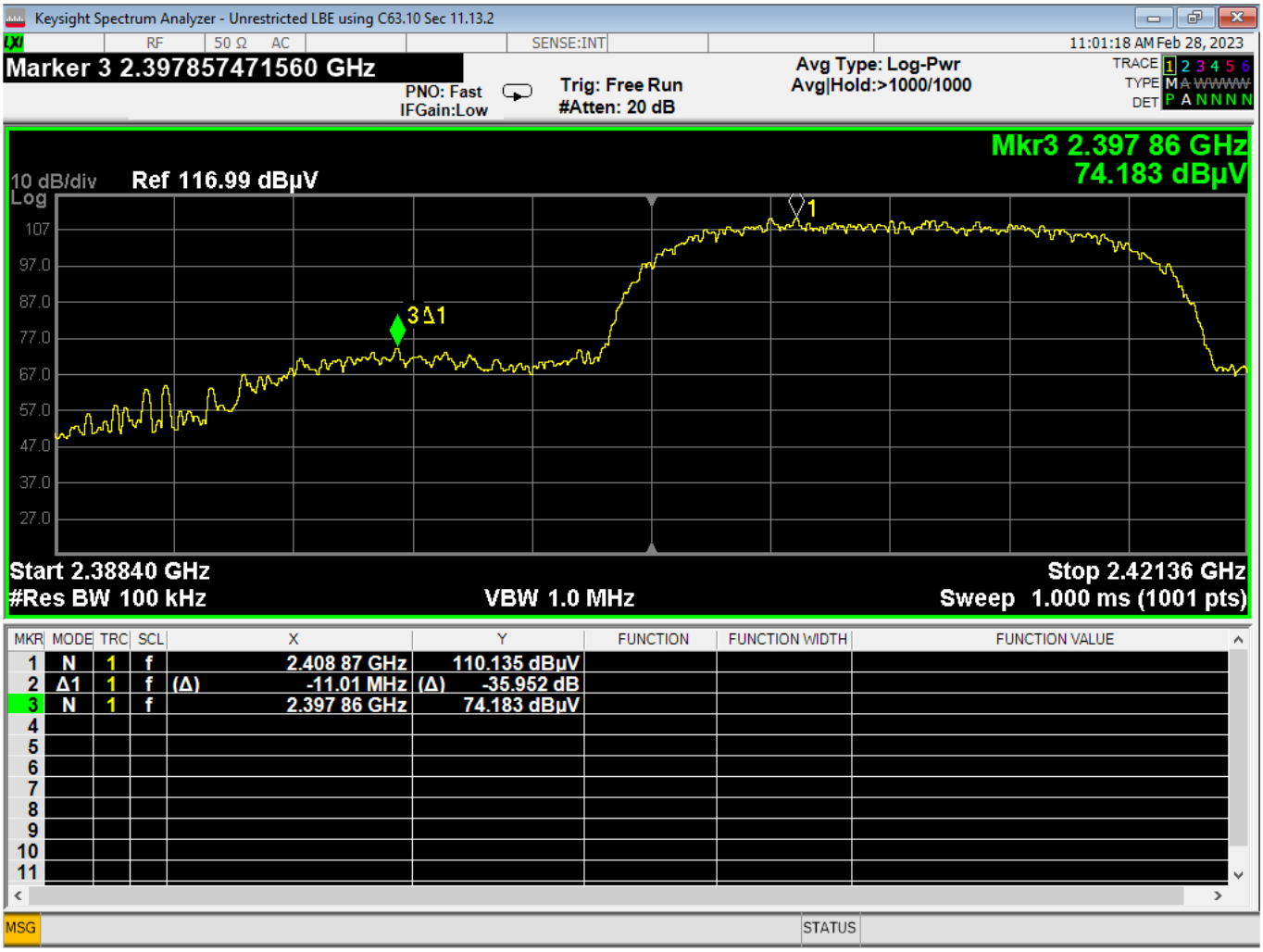
46 PSD, Low, Wifi B, High Data Rate



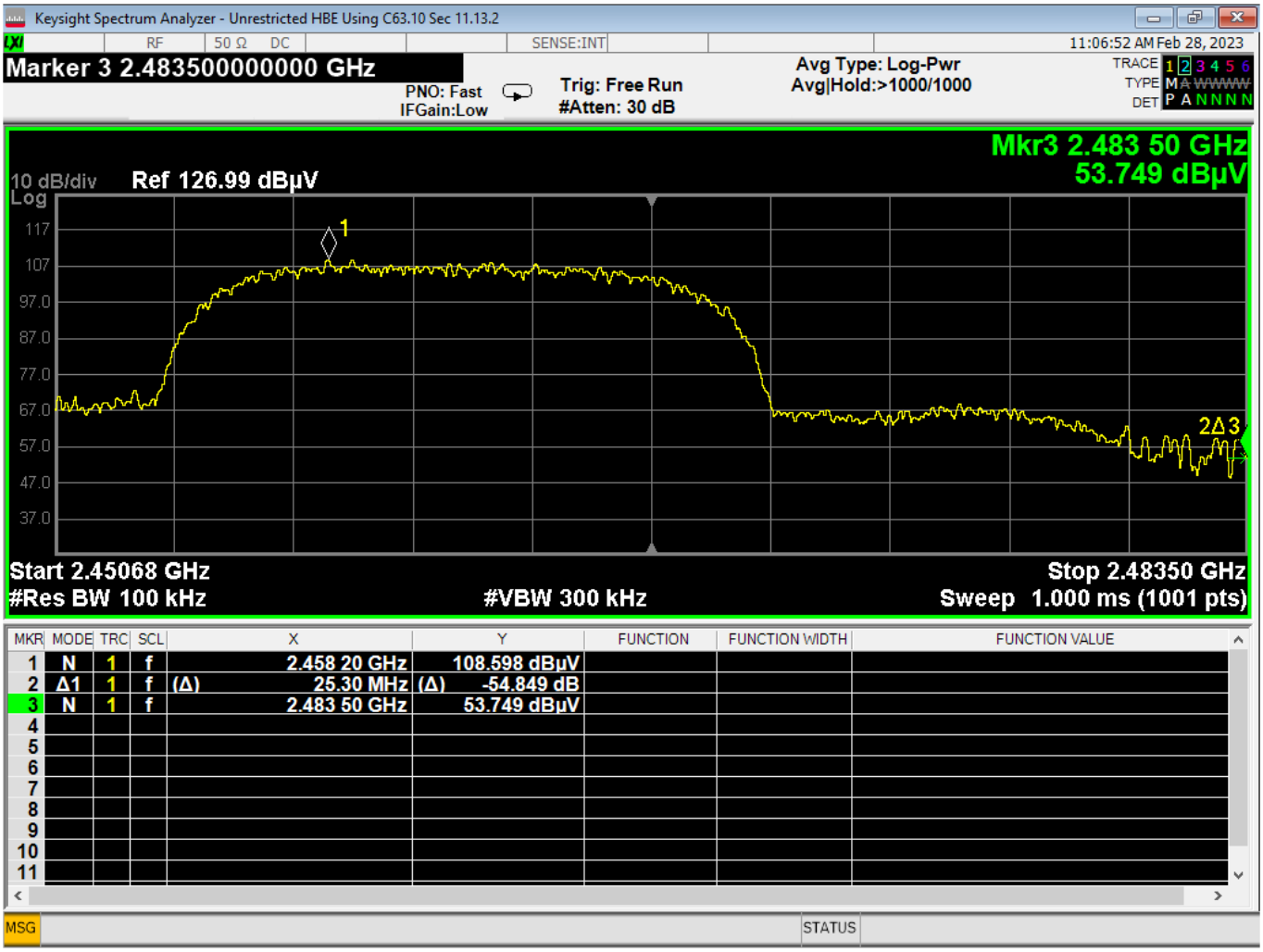
47 PSD, Mid, Wifi B, High Data Rate



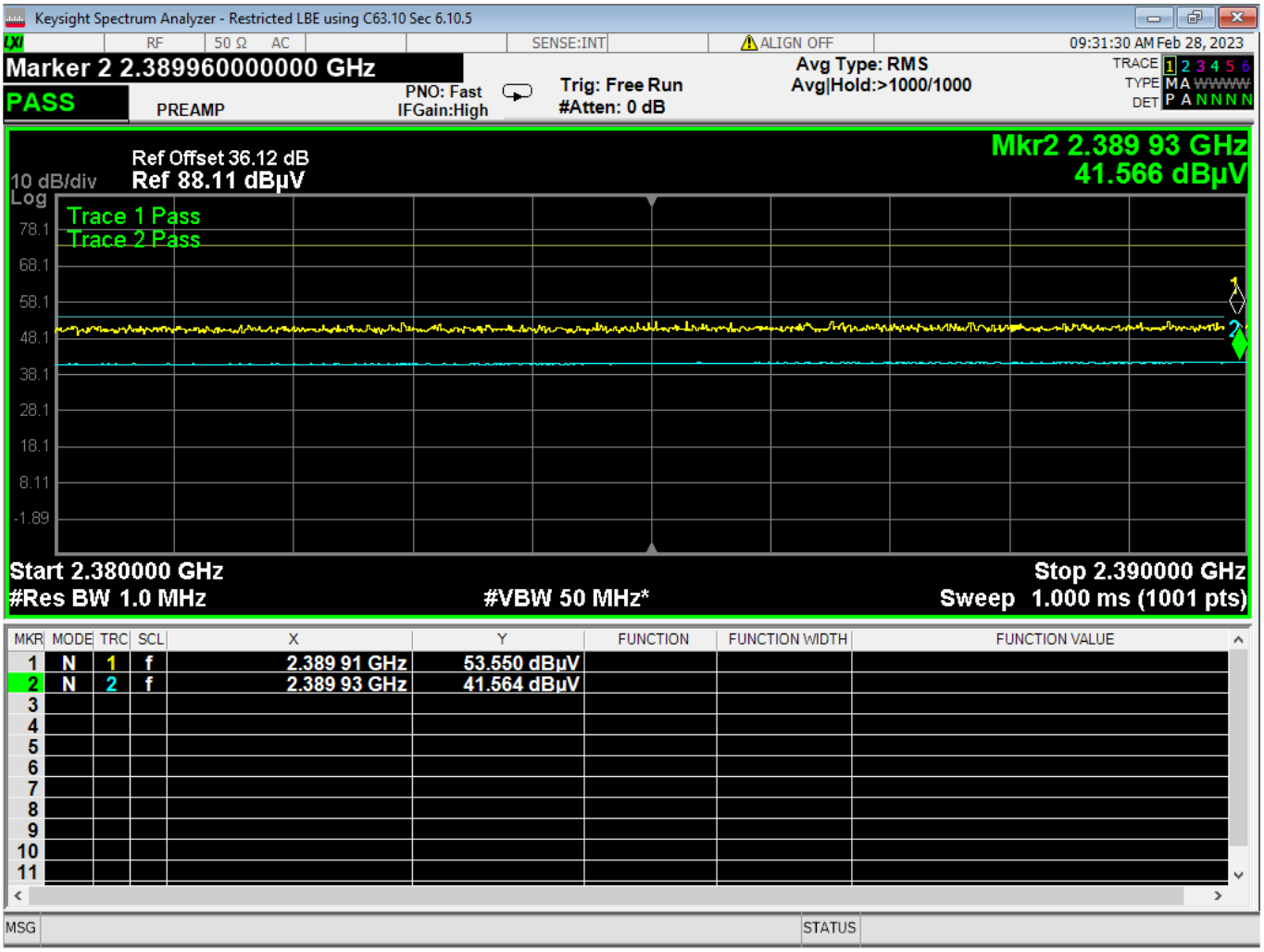
48 PSD, High, Wifi B, High Data Rate



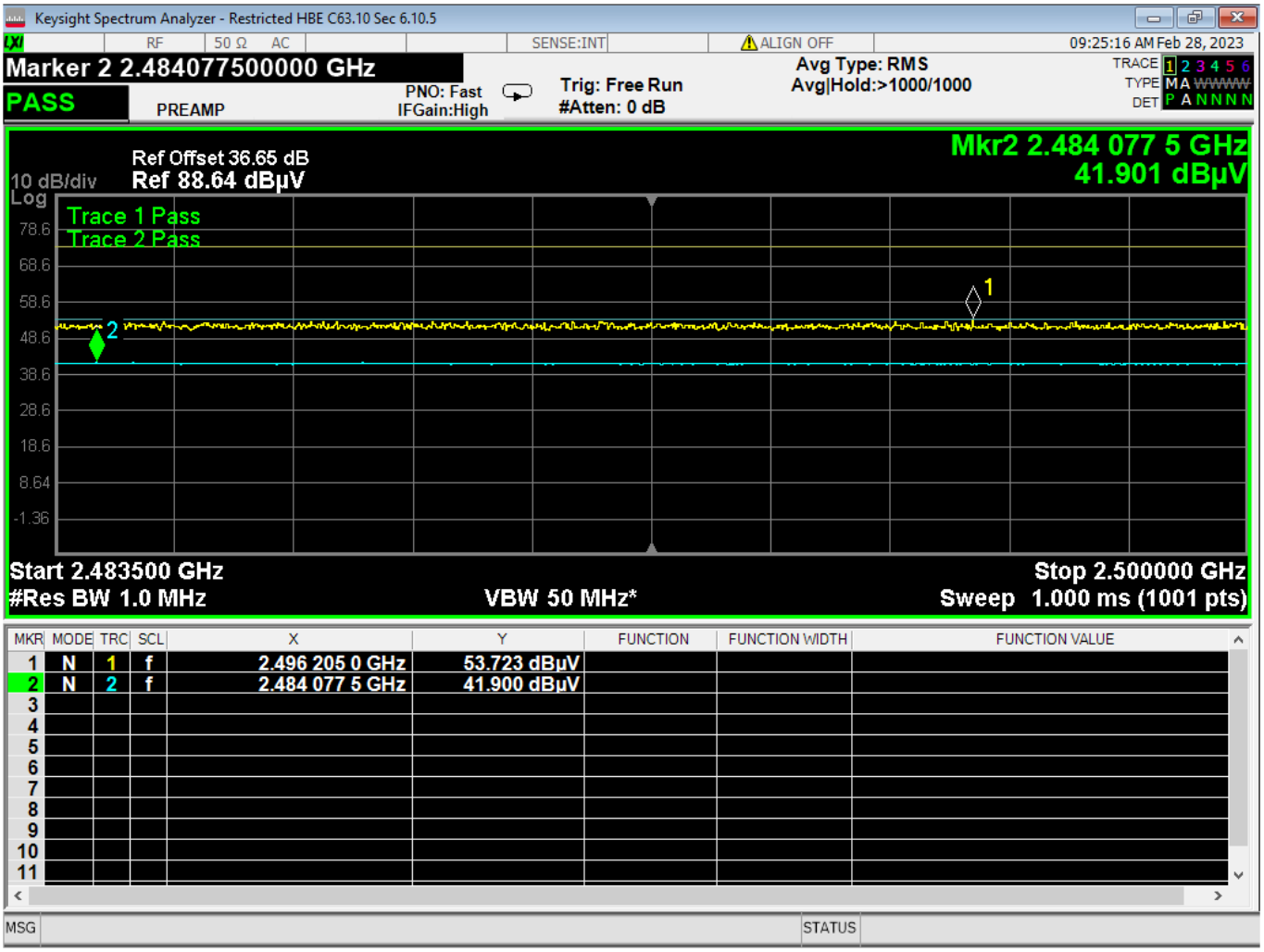
49 Lower Bandedge, Unrestricted, Wifi B, High Data Rate



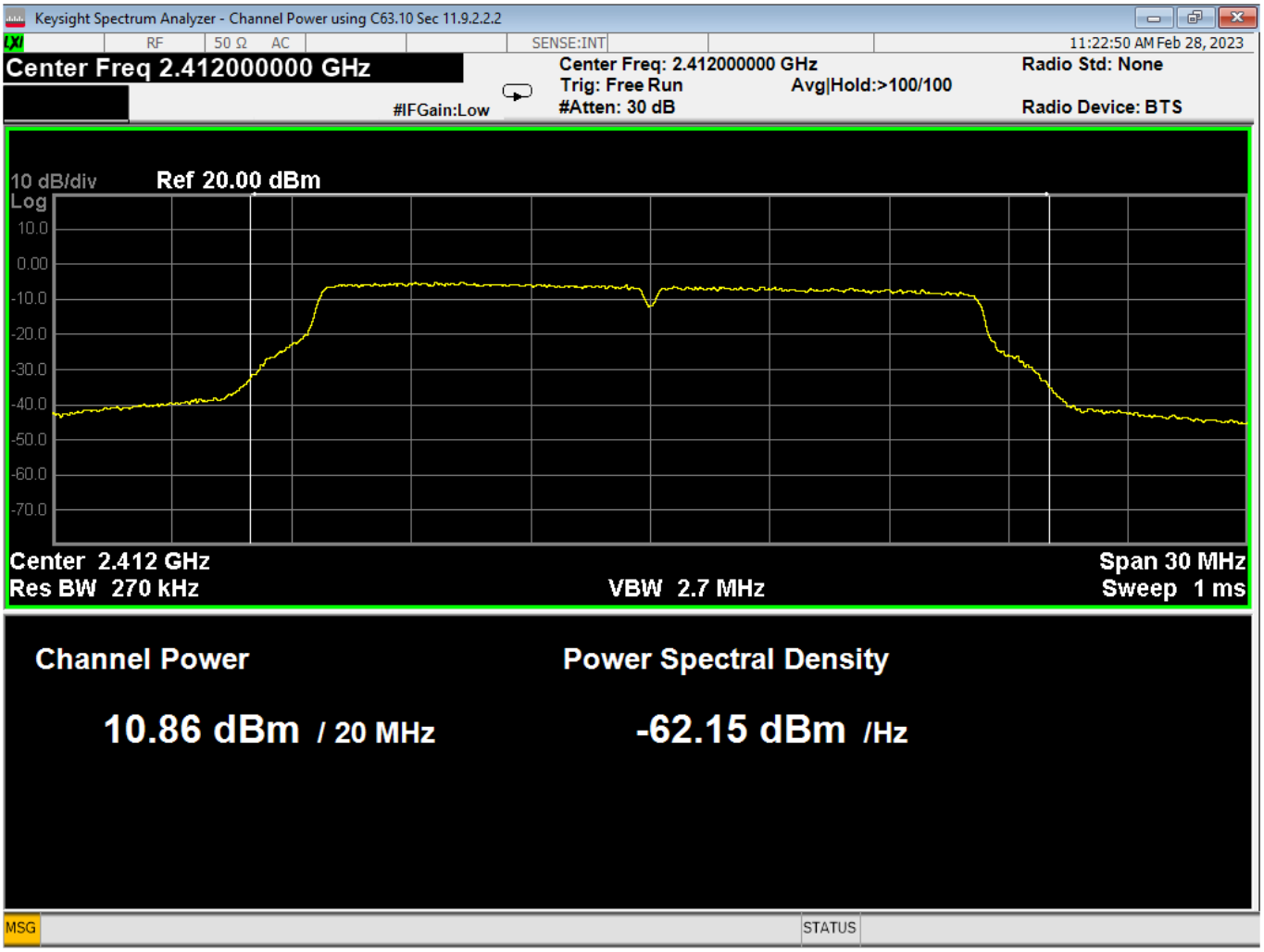
50 Higher Bandedge, Unrestricted, Wifi B, High Data Rate



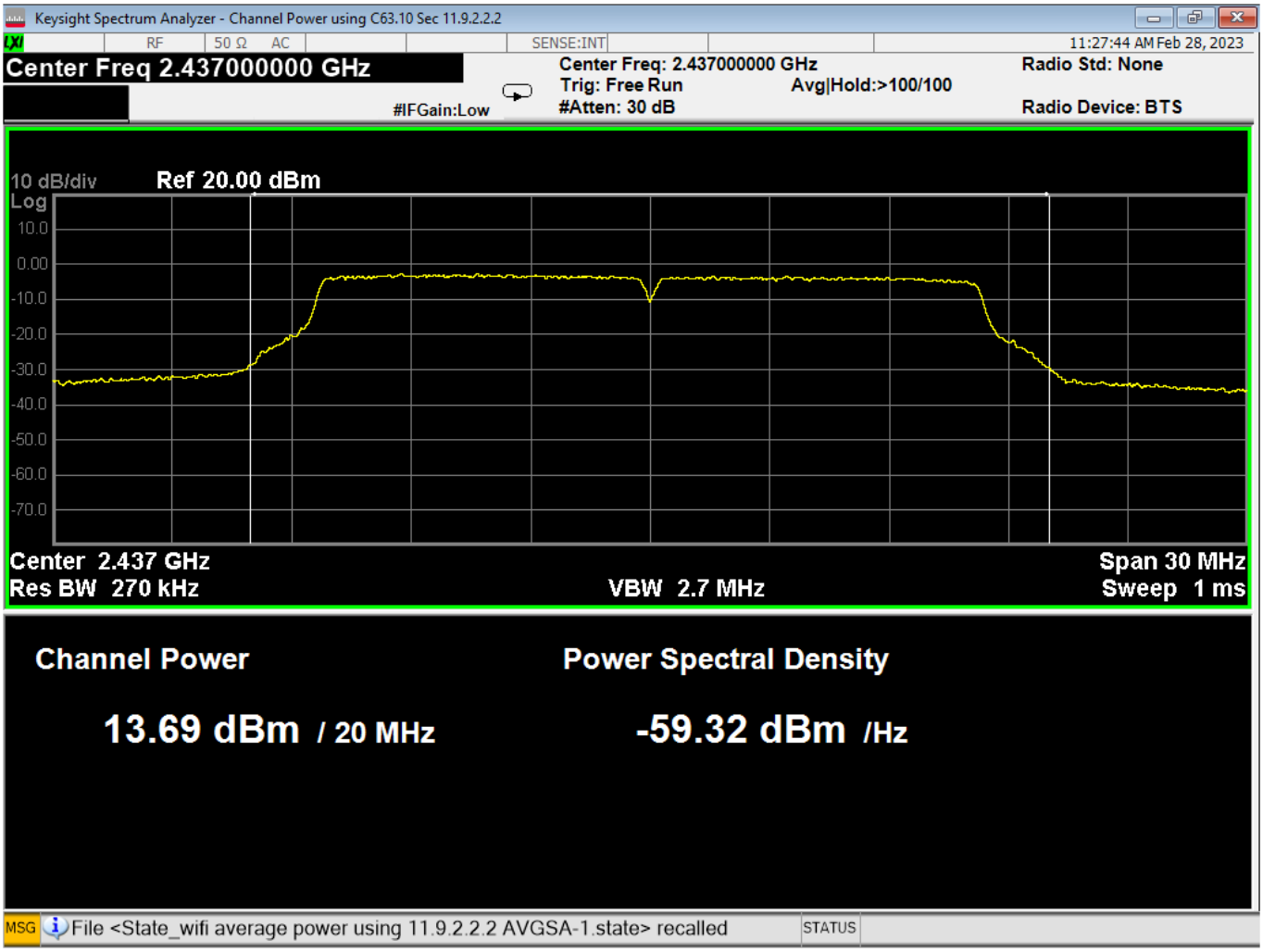
51 Lower Bandedge, Restricted, Wifi B, High Data Rate



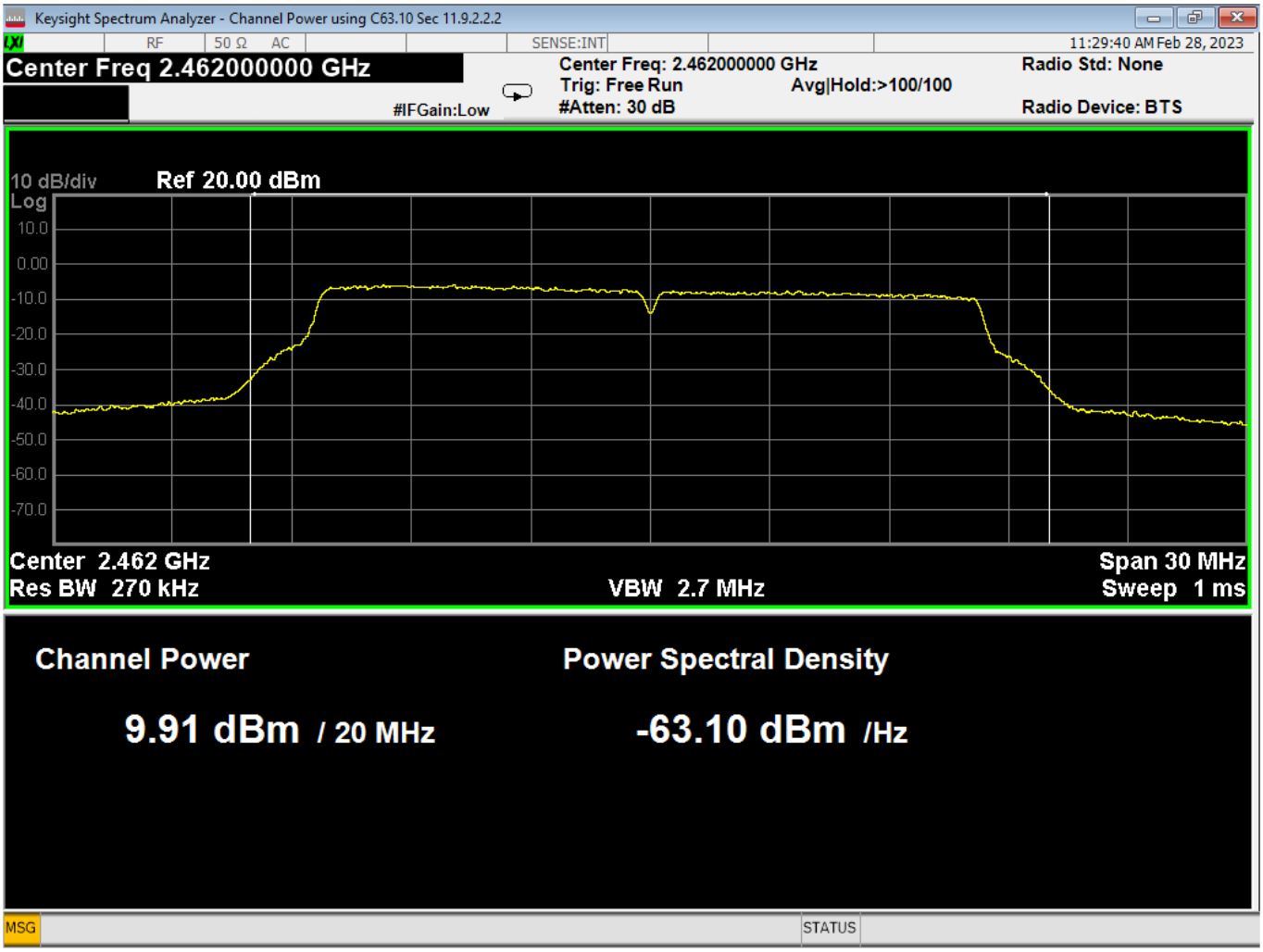
52 Higher Bandedge, Restricted, Wifi B, High Data Rate



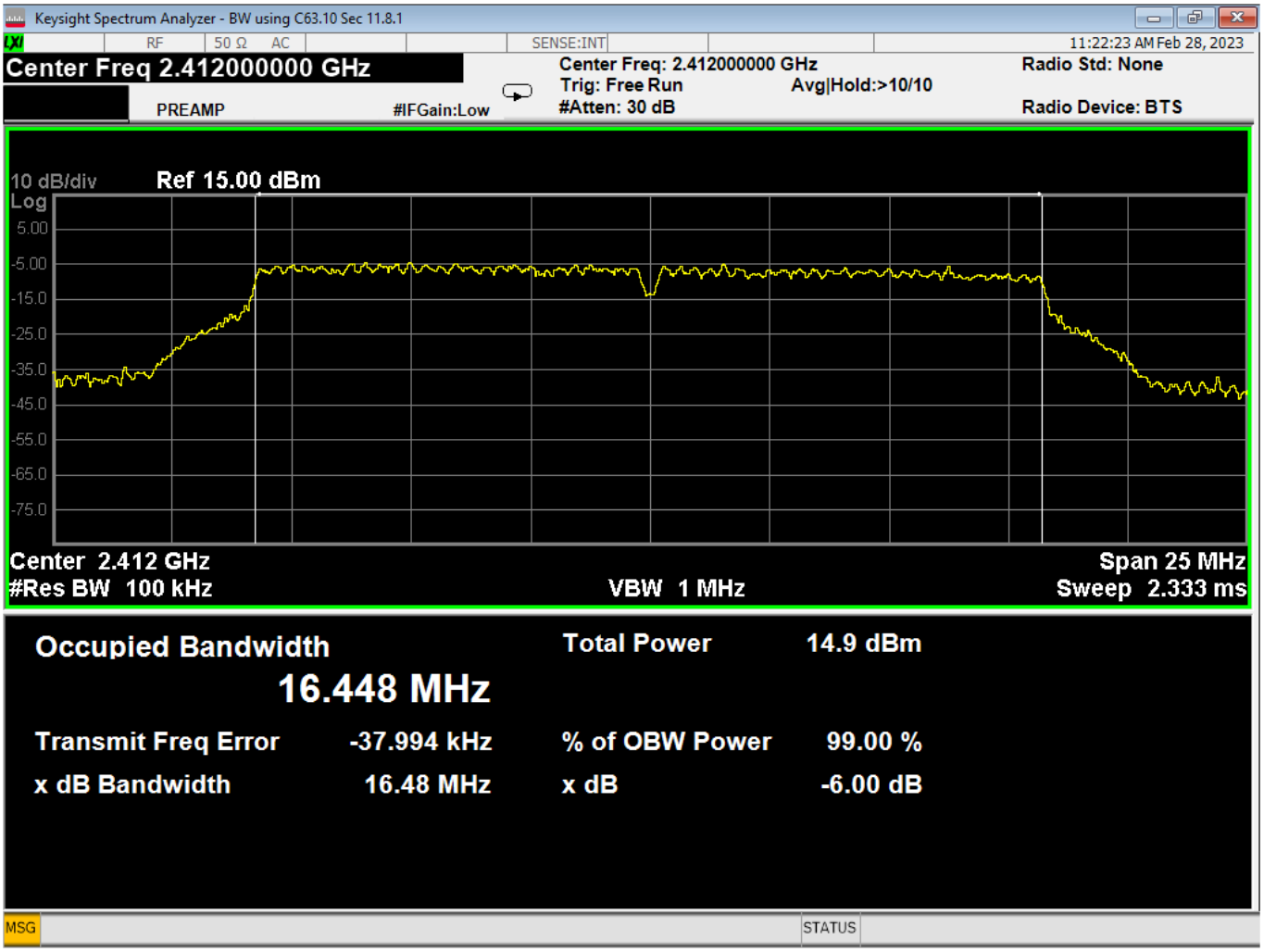
53 Average Power, Low, Wifi G, High Data Rate



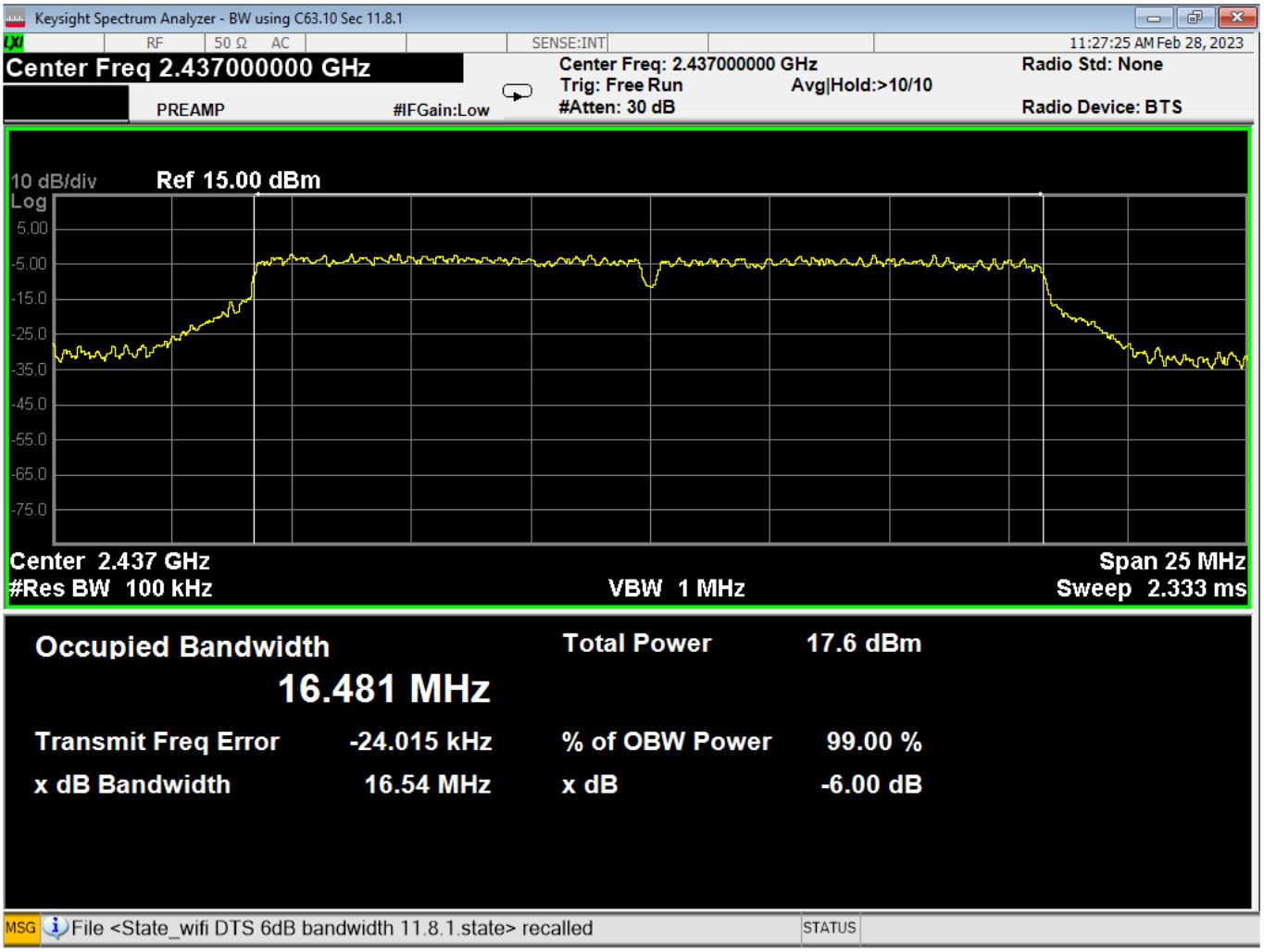
54 Average Power, Mid, Wifi G, High Data Rate



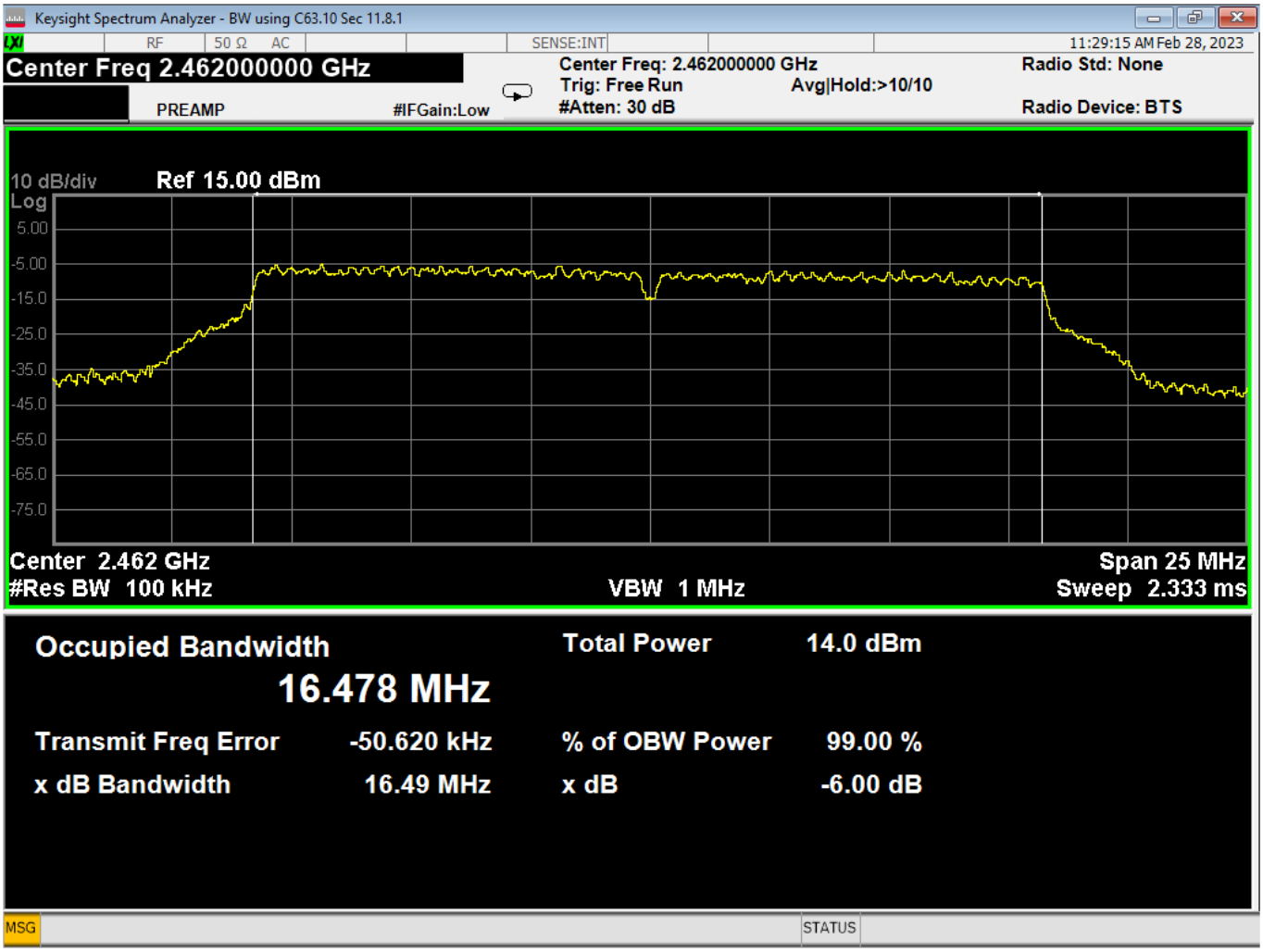
55 Average Power, High, Wifi G, High Data Rate



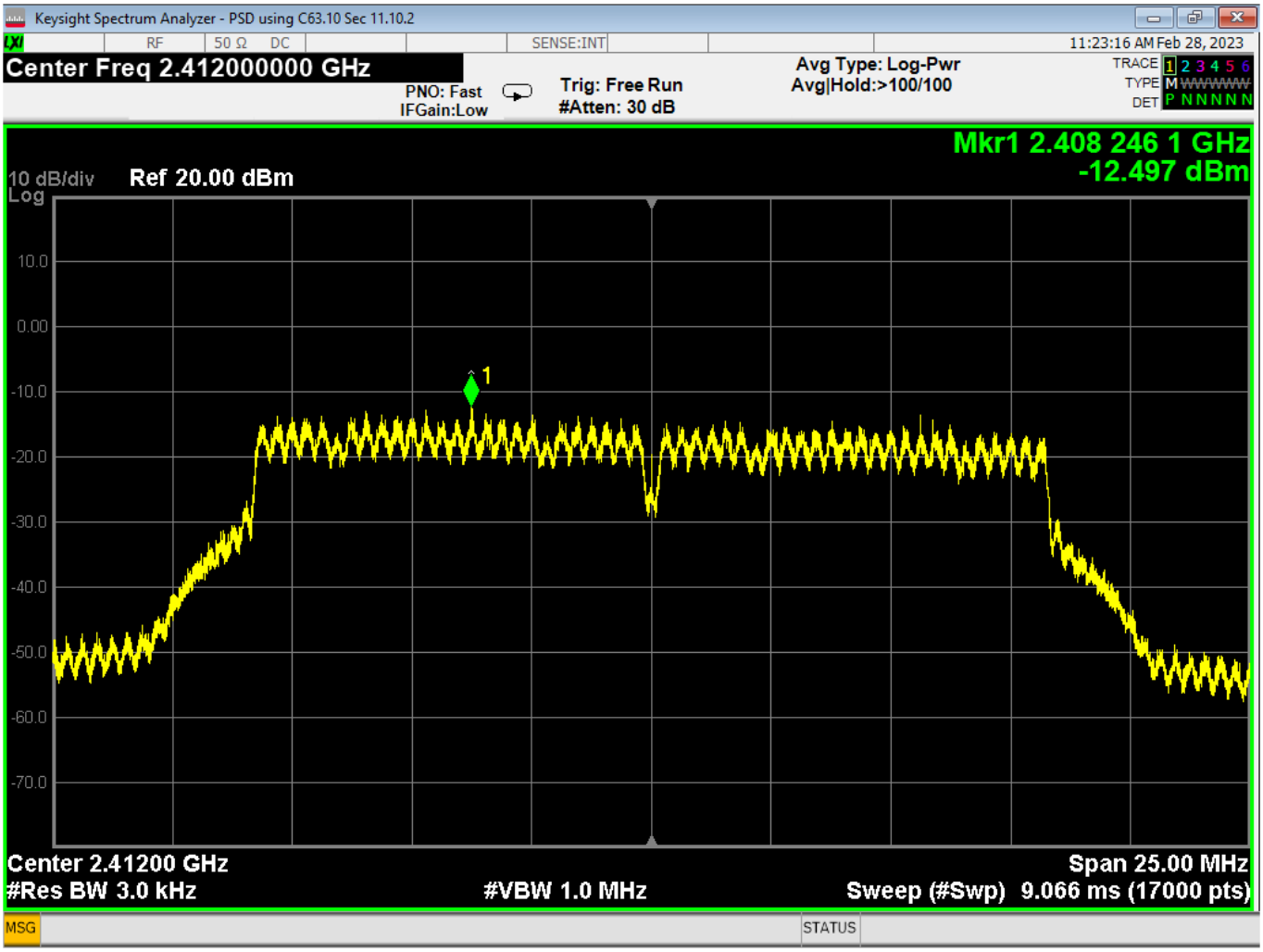
56 6dB Bandwidth, Low, Wifi G, High Data Rate



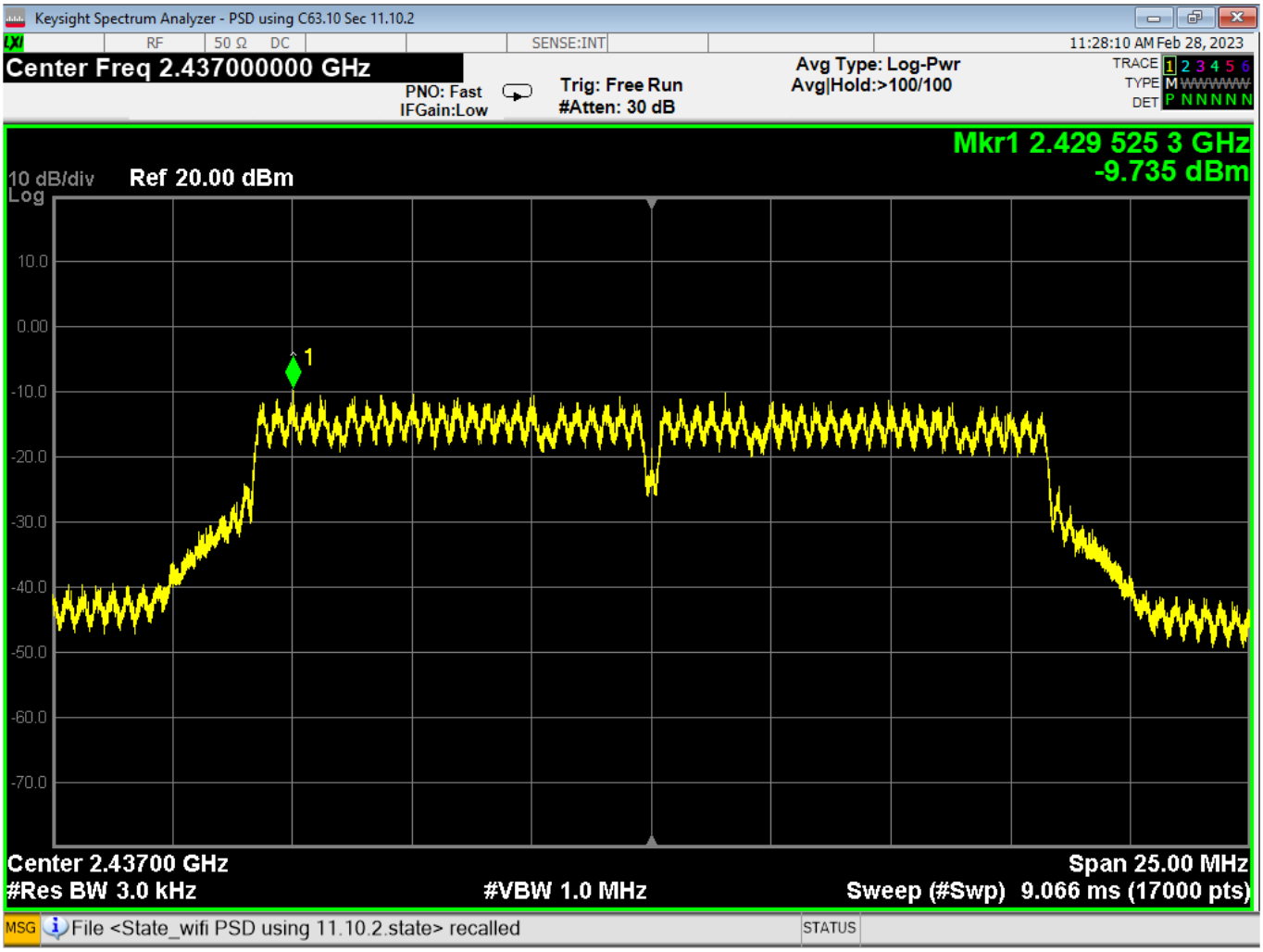
57 6dB Bandwidth, Mid, Wifi G, High Data Rate



58 6dB Bandwidth, High, Wifi G, High Data Rate



59 PSD, Low, Wifi G, High Data Rate



60 PSD, Mid, Wifi G, High Data Rate