

FCC/ISED Test Report

Prepared for: Garmin International Inc.

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

Product: A03626

Test Report No: R20191022-26-02A

Approved by:



Nic S. Johnson, NCE

Technical Manager

iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: 17 April 2020

Total Pages: 64

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REVISION PAGE

Rev. No.	Date	Description
0	27 March 2020	Original – NJohnson Prepared by KVepuri/CFarrington/FLane
A	17 April 2020	Updated calibration table. Includes NCEE Labs report R20191022-26-02 and its amendment in full. -NJ



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1.0 SUMMARY OF TEST RESULTS

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-210, Issue 10

SUMMARY			
Requirement	Test Type and Limit	Result	Remark
FCC 15.203	Unique Antenna Requirement	Pass	PCB Antenna
FCC 15.35 RSS-Gen, 6.10	Duty cycle of pulsed emissions	N/A	Not required
NA	Maximum Peak Output Power	N/A	Informational Purpose Only
NA	Minimum Bandwidth	N/A	Informational Purpose Only
FCC 15.209 RSS-Gen, 7.1	Receiver Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.209 RSS-Gen, 8.9 RSS-210 A1.2 FCC 15.249(a)	Transmitter Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.209, 15.205, 15.249(d) RSS-Gen, 8.9 RSS-210, 5.5	Band Edge Measurement	Pass	Meets the requirement of the limit.
FCC 15.207 RSS-Gen. 8.8	Conducted AC Emissions	Pass	Meets the requirement of the limit.



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2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

EUT	A03626
EUT Received	25 November 2019
EUT Tested	25 November 2019- 6 March 2020
Serial No.	3322745536
Operating Band	2400 – 2483.5 MHz
Device Type	BT BR (GFSK), BT EDR 2MB, BT EDR 2MB, GFSK
Power Supply	Internal Battery/ Charger: Garmin (Phi Hong) MN: LAC046

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



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2.2 DESCRIPTION OF TEST MODES

The EUT operates on, and was tested at the frequencies below:

Channel	Frequency
Low	2402 MHz
Mid	2441 MHz
High	2480 MHz

These are the only three 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.

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on the lowest, middle and highest frequency channels.

The EUT was tested for spurious emissions while running off battery power.

2.3 DESCRIPTION OF SUPPORT UNITS

None

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3.0 LABORATORY 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 $35 \pm 4\%$
Temperature of $22 \pm 3^\circ$ Celsius



3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Nic Johnson	Technical Manager	Review/editing
2	Karthik Vepuri	Test Engineer	Testing and report
3	Caleb Farrington	Test Engineer	Testing and report
4	Fox Lane	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.

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3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer	N9038A	MY59050109	23 Apr 2019	23 Apr 2021
Keysight EXA Signal Analyzer	N9010A	MY56070862	14 Dec 2018	14 Dec 2020
Rohde & Schwarz Test Receiver	ES126	100037	30 Jan 2018	30 Jan 2021
SunAR RF Motion	JB1	A082918-1	15 Oct 2018	15 Oct 2020
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2021
EMCO Horn Antenna	3116	2576	26 Jan 2018	26 Jan 2021
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2021*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2021*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	26 Jul 2018	26 Jul 2019
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2021*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2021*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2021*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2021*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2021*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2021*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2021*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2021*

*Internal Characterization

Notes:

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



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4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Test Method: NA

4.2 PEAK OUTPUT POWER

Test Method: N/A

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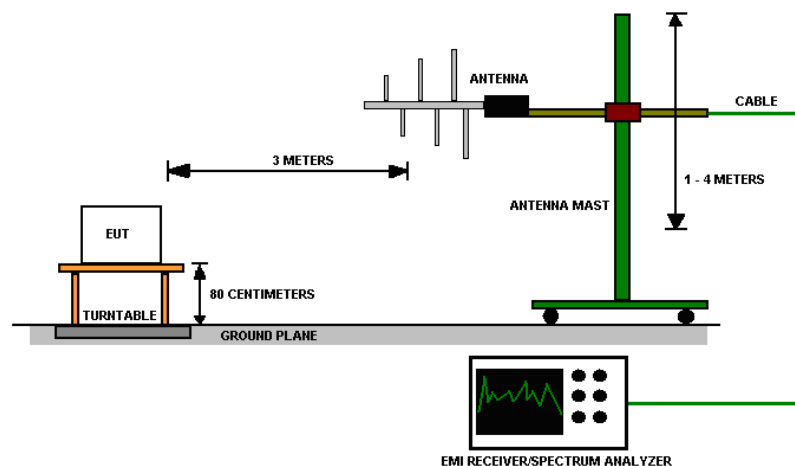
Test procedures:

1. The EUT was measured at a distance of 3 meters.
2. The resolution bandwidth was set to 8 MHz and the video bandwidth was set to 50 MHz to capture the signal. The analyzer used a peak detector in max hold mode.

Deviations from test standard:

No deviation.

Test setup:



EUT operating conditions:

The EUT was powered by internal battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in each operating mode.

Test results:



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Peak EIRP Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP PEAK OUTPUT POWER (dBm)	EIRP PEAK OUTPUT POWER (mW)	METHOD	RESULT	TRANSMITTER
Low	2402	2.712	1.867	Conducted	PASS	BT BR
Mid	2441	4.771	3.000	Conducted	PASS	BT BR
High	2480	8.628	7.291	Conducted	PASS	BT BR
Low	2402	2.016	1.591	Conducted	PASS	BT EDR 2MB
Mid	2441	4.375	2.738	Conducted	PASS	BT EDR 2MB
High	2480	8.103	6.461	Conducted	PASS	BT EDR 2MB
Low	2402	2.047	1.602	Conducted	PASS	BT EDR 3MB
Mid	2441	4.143	2.596	Conducted	PASS	BT EDR 3MB
High	2480	8.198	6.604	Conducted	PASS	BT EDR 3MB
Low	2402	2.836	1.921	Conducted	PASS	GFSK
Mid	2441	5.130	3.258	Conducted	PASS	GFSK
High	2480	8.986	7.918	Conducted	PASS	GFSK

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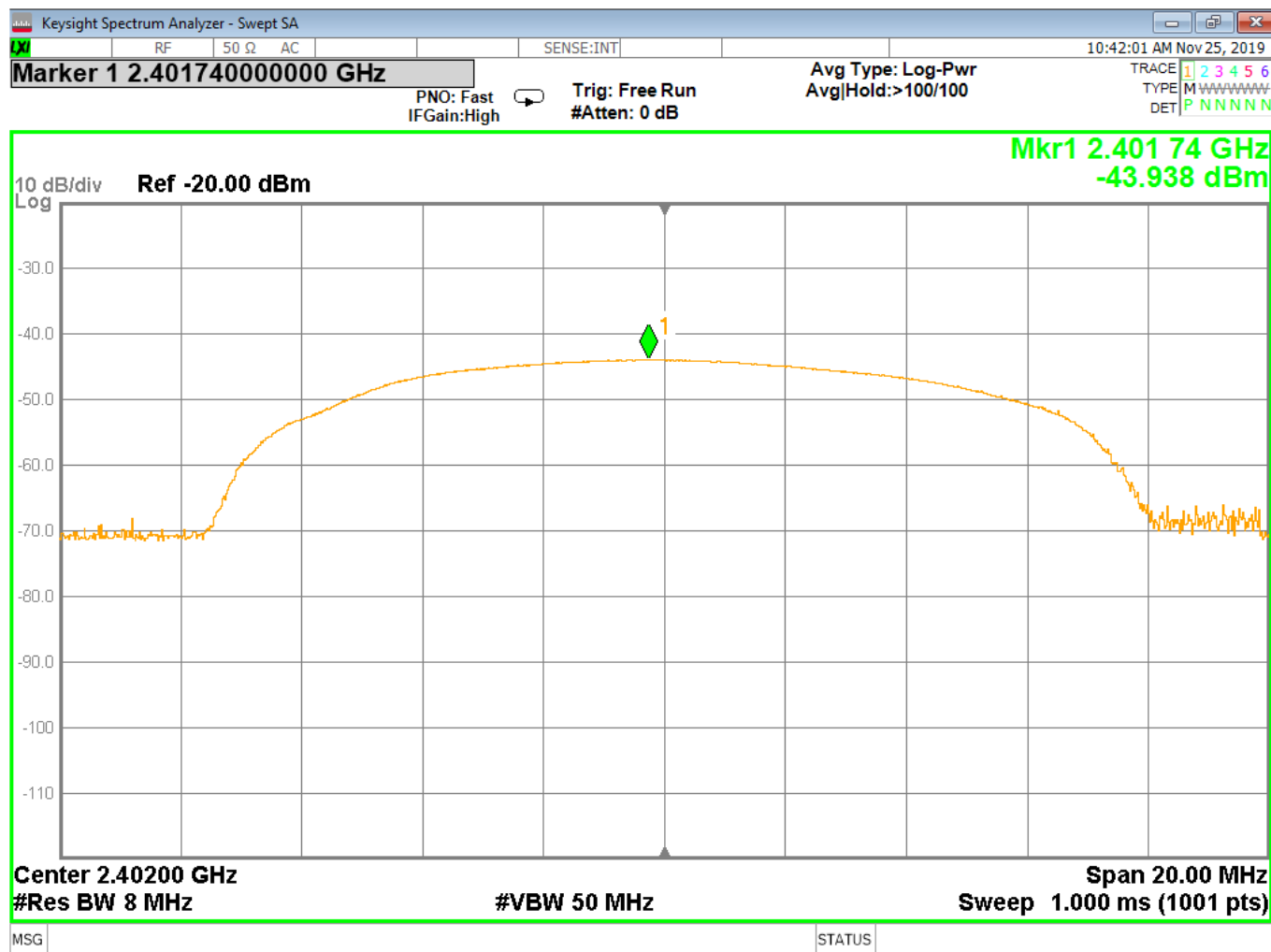


Figure 1 – Output Power, Low Channel, BT BR (GFSK)

$$\text{EIRP Peak Output Power} = -43.938 + 107 - 95.23 + \text{AF} + \text{CL} = 2.712$$

$$\text{Output power} = -43.938 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

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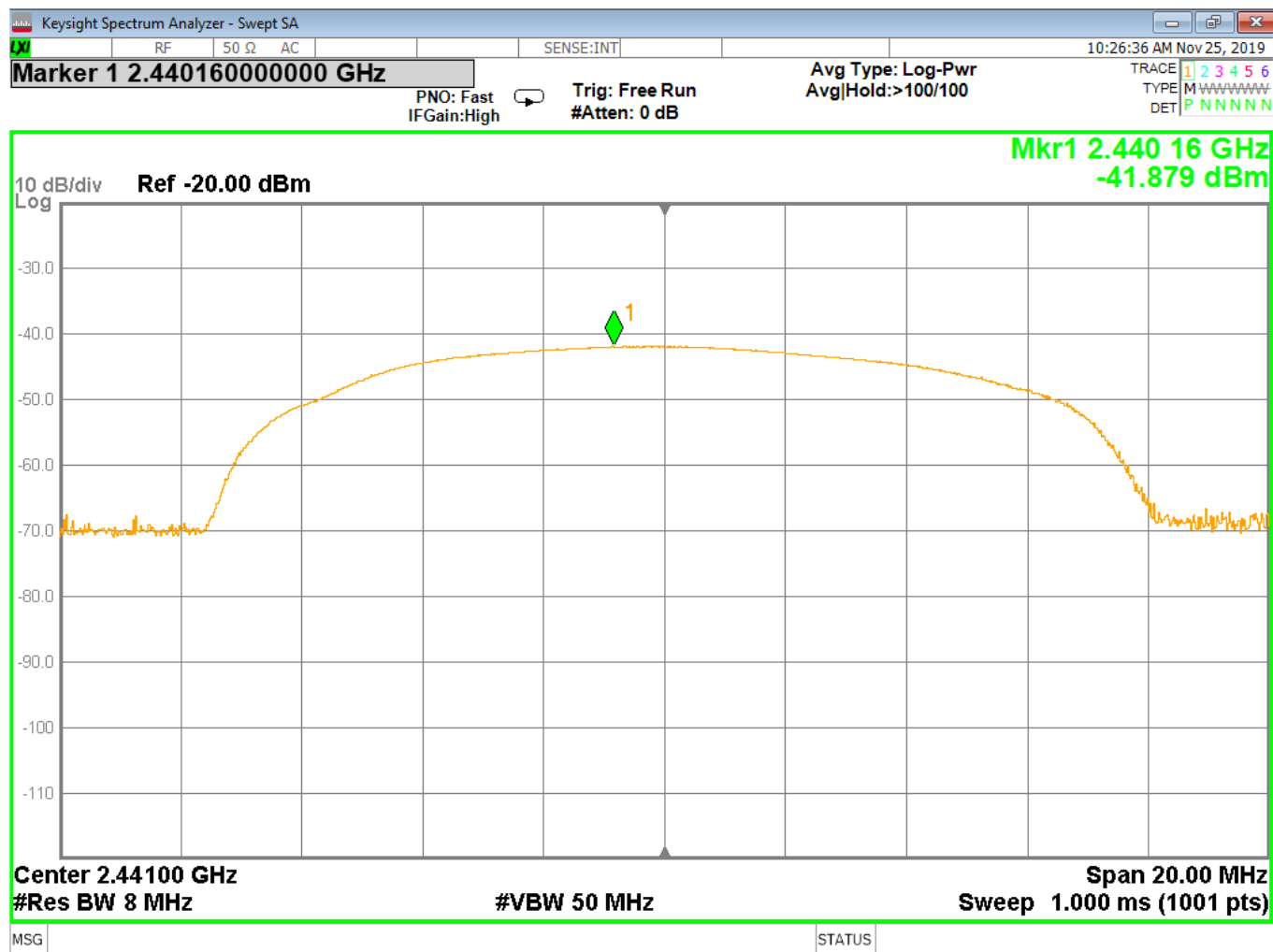


Figure 2 – Output Power, Mid Channel, BT BR (GFSK)

$$\text{EIRP Peak Output Power} = -41.879 + 107 - 95.23 + \text{AF} + \text{CL} = 4.771$$

$$\text{Output power} = -41.879 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

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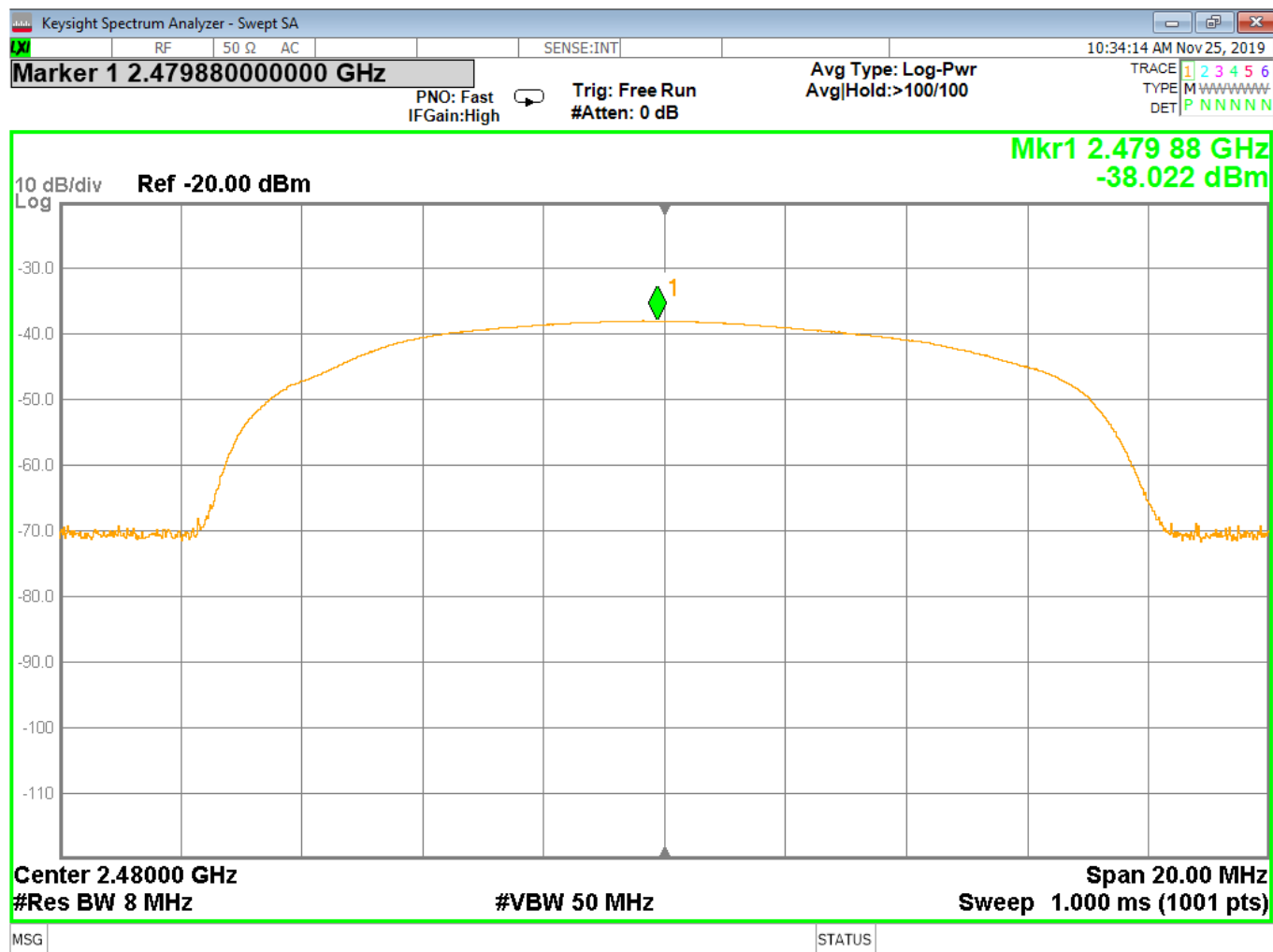


Figure 3 – Output Power, High Channel, BT BR (GFSK)

$$\text{EIRP Peak Output Power} = -38.022 + 107 - 95.23 + \text{AF} + \text{CL} = 8.628$$

$$\text{Output power} = -38.022 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

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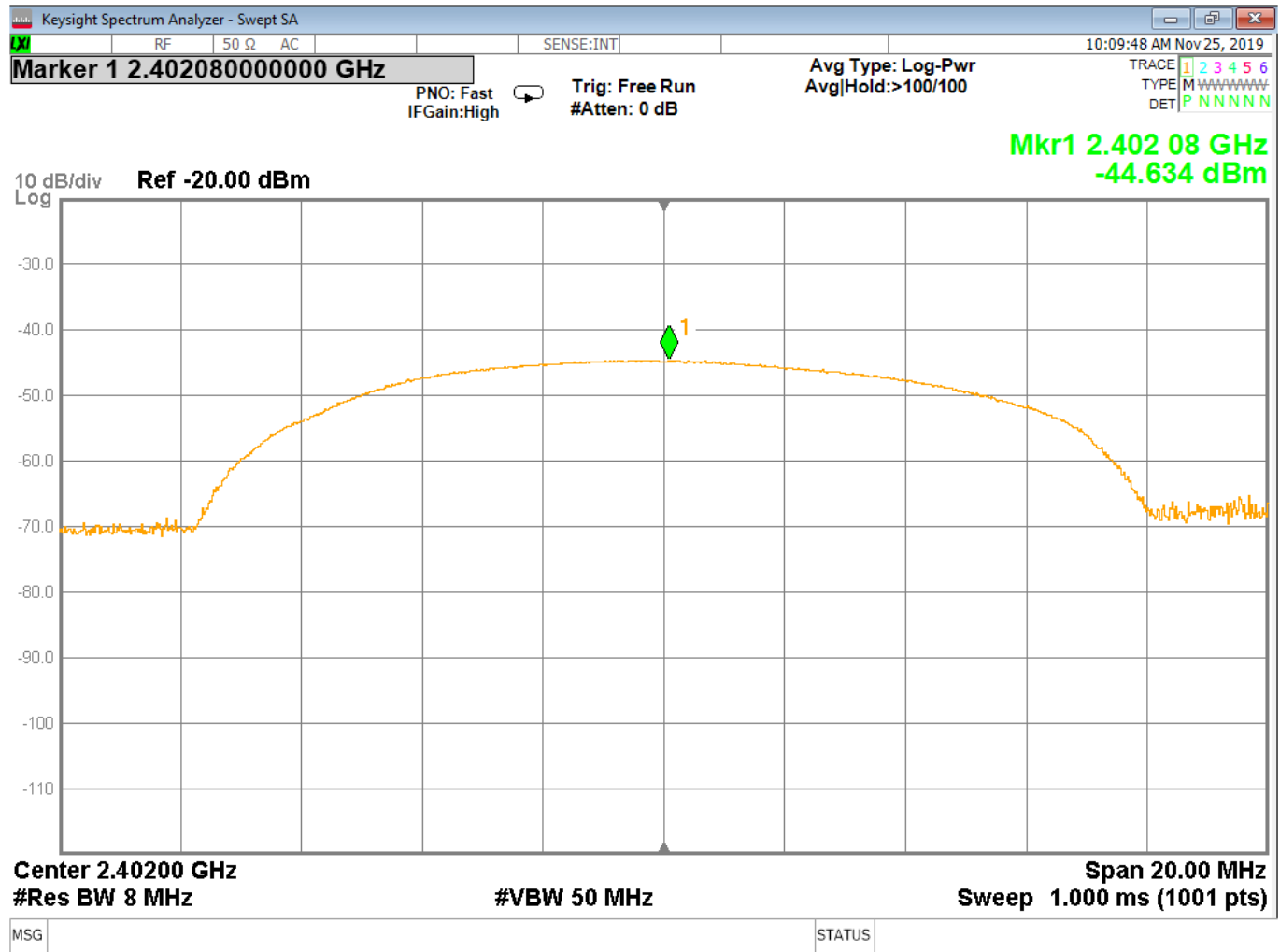


Figure 4 – Output Power, Low Channel, BT EDR 2MB

$$\text{EIRP Peak Output Power} = -44.634 + 107 - 95.23 + \text{AF} + \text{CL} = 2.016$$

$$\text{Output power} = -44.634 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

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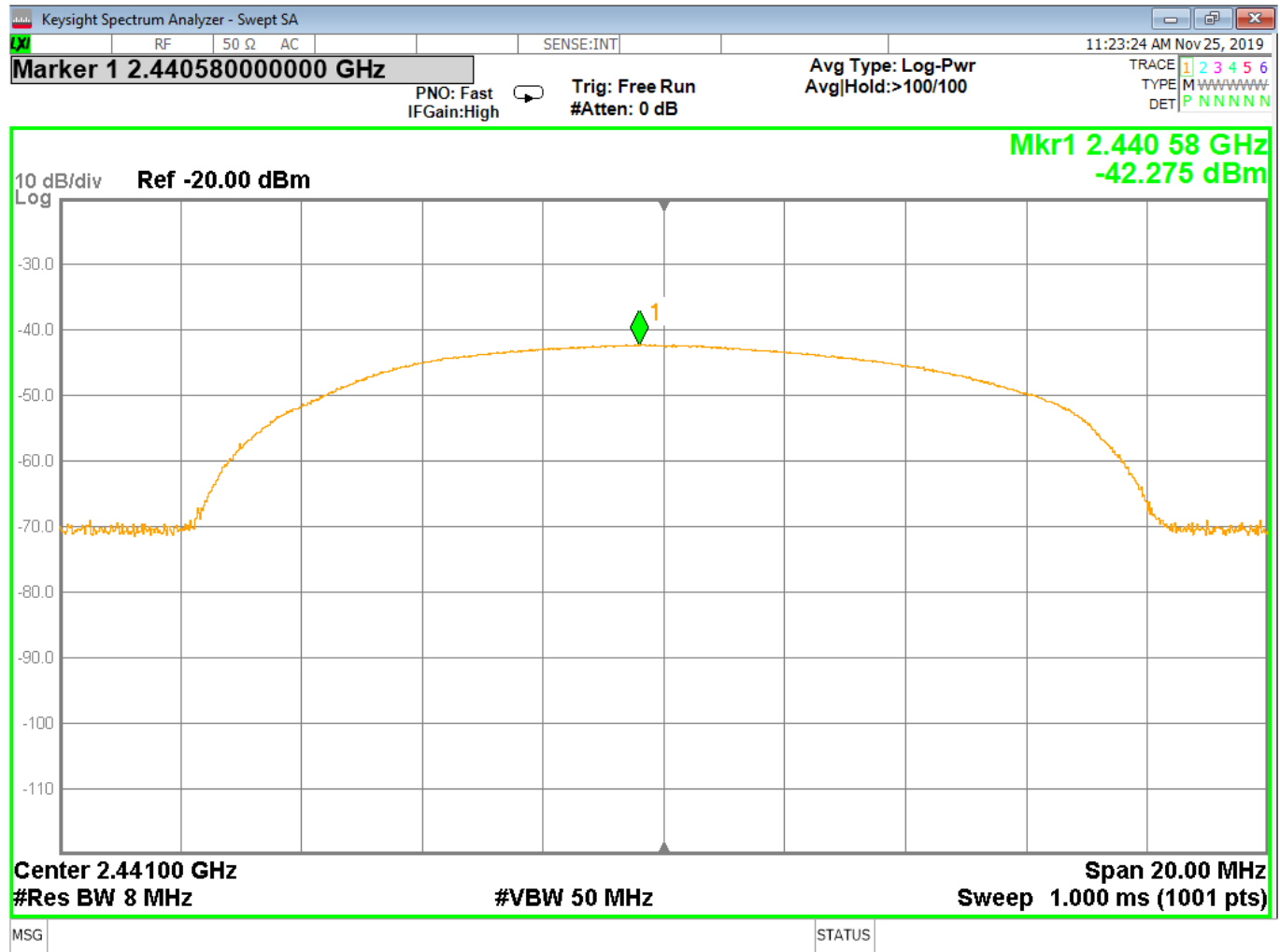


Figure 5 – Output Power, Mid Channel, BT EDR 2MB

$$\text{EIRP Peak Output Power} = -42.275 + 107 - 95.23 + \text{AF} + \text{CL} = 4.375$$

$$\text{Output power} = -42.275 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

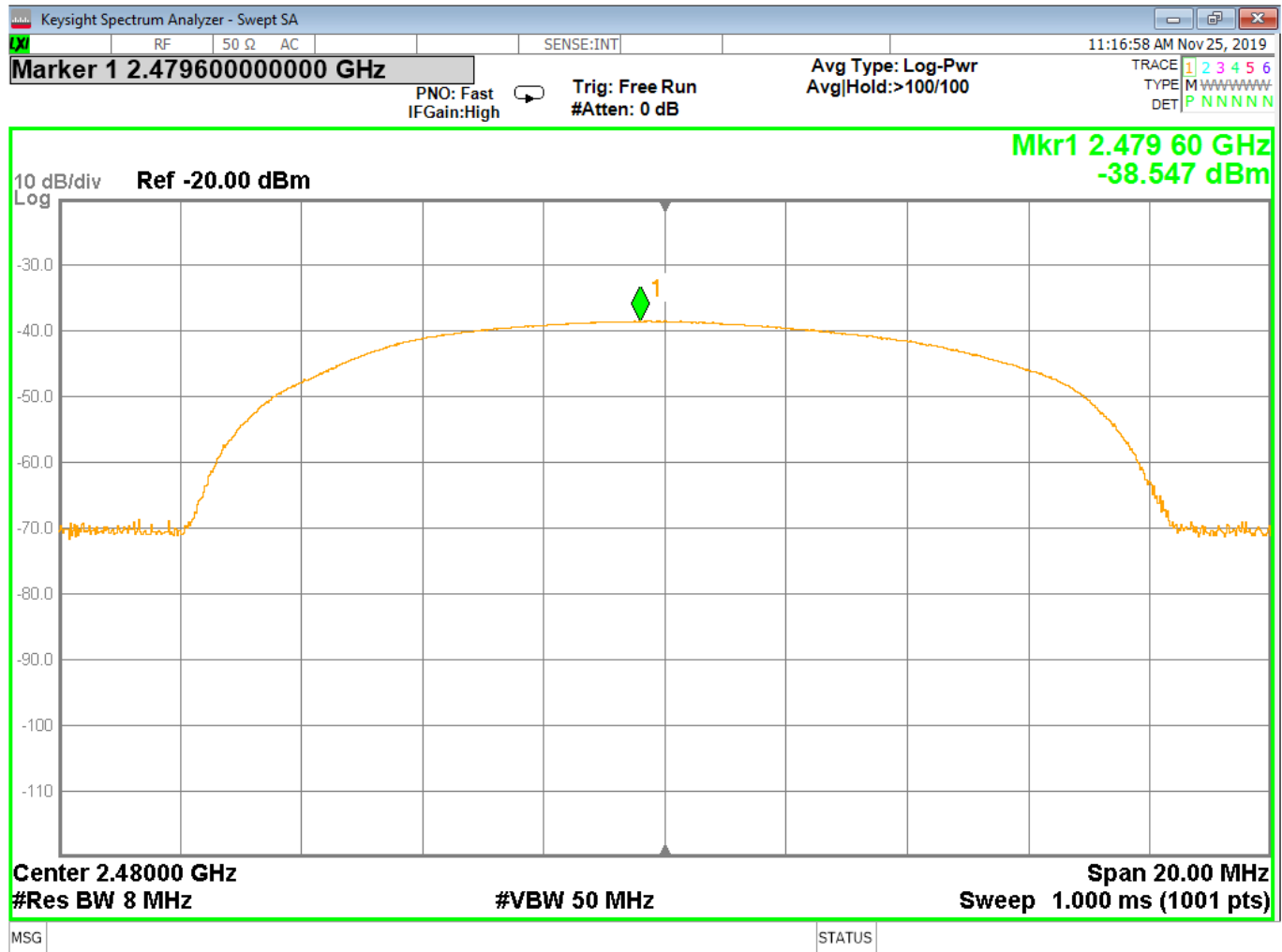


Figure 6 – Output Power, High Channel, BT EDR 2MB

$$\text{EIRP Peak Output Power} = -38.547 + 107 - 95.23 + \text{AF} + \text{CL} = 8.103$$

$$\text{Output power} = -38.547 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

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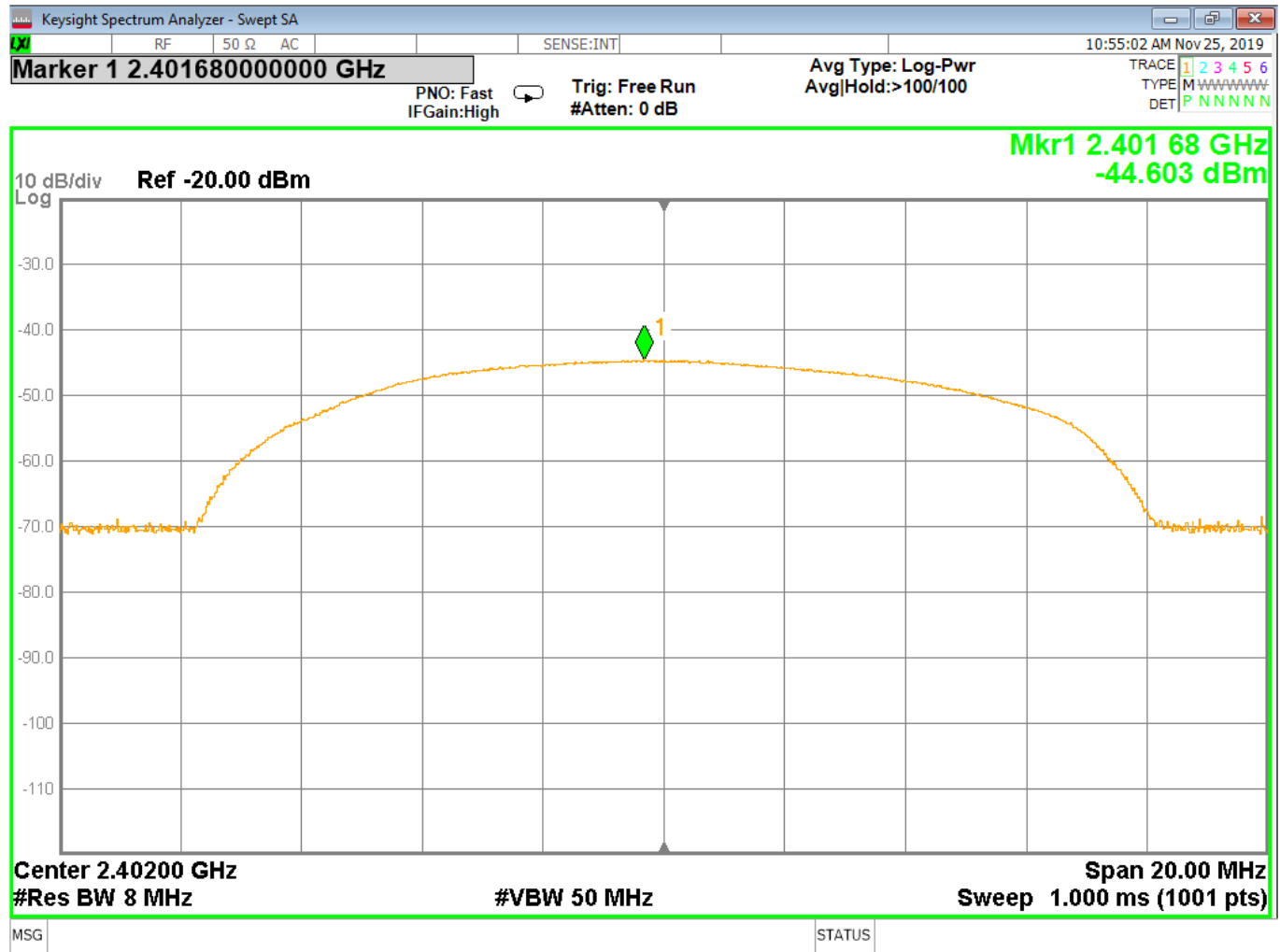


Figure 7 – Output Power, Low Channel, BT EDR 3MB

$$\text{EIRP Peak Output Power} = -44.603 + 107 - 95.23 + \text{AF} + \text{CL} = 2.047$$

$$\text{Output power} = -44.603 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

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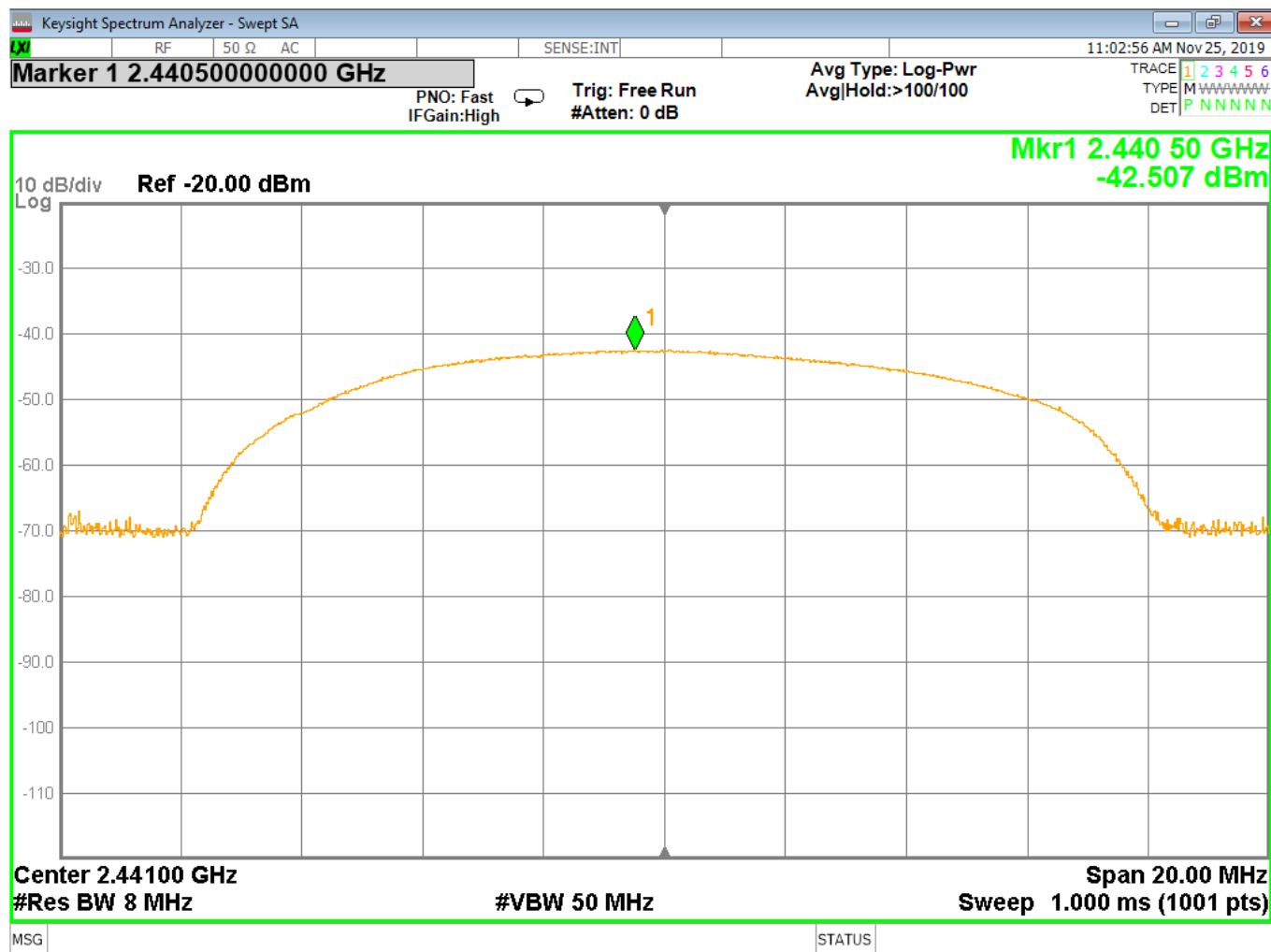


Figure 8 – Output Power, Mid Channel, BT EDR 3MB

$$\text{EIRP Peak Output Power} = -42.507 + 107 - 95.23 + \text{AF} + \text{CL} = 4.143$$

$$\text{Output power} = -42.507\text{dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

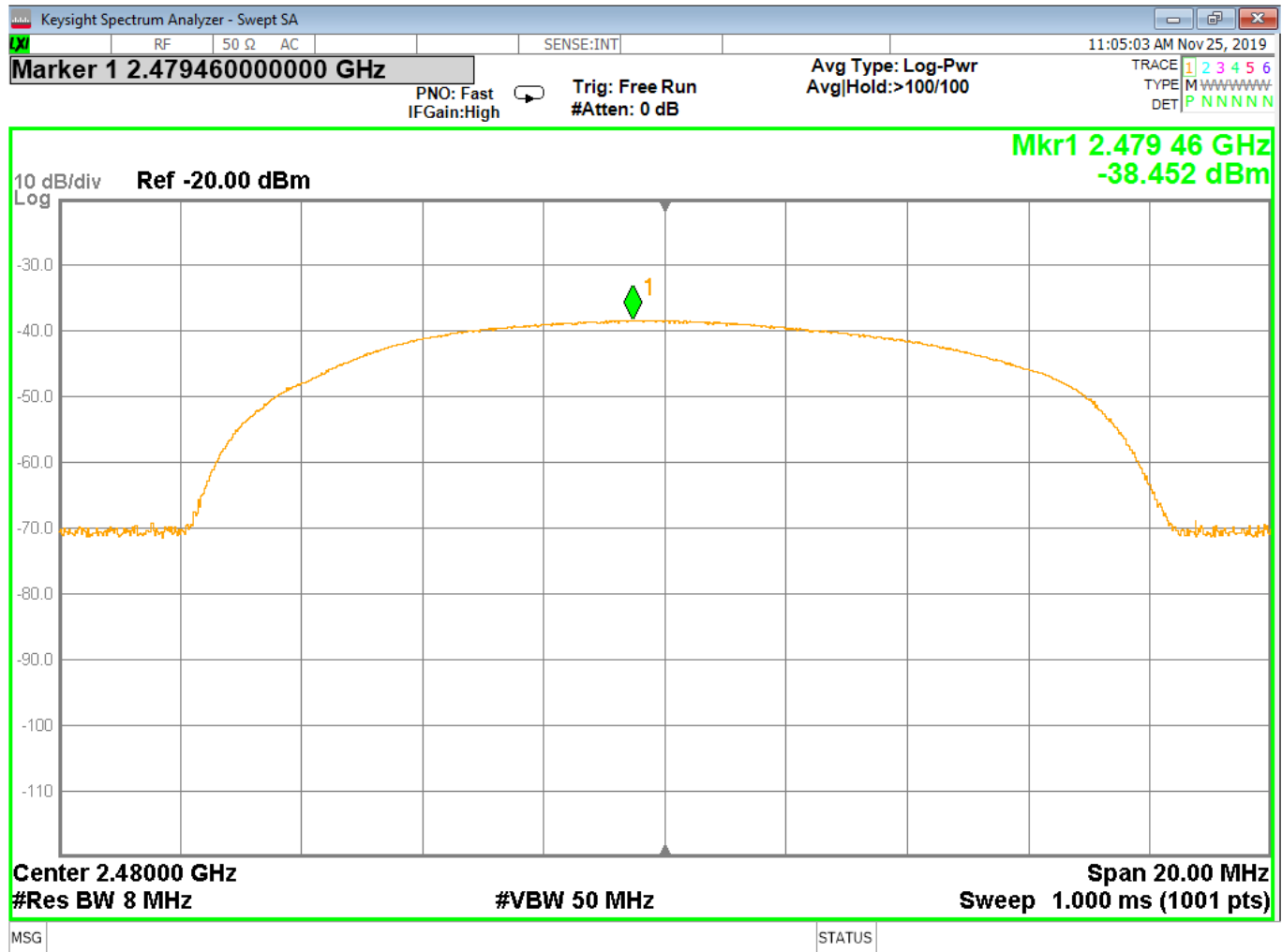


Figure 9 – Output Power, High Channel, BT EDR 3MB

$$\text{EIRP Peak Output Power} = -38.452 + 107 - 95.23 + \text{AF} + \text{CL} = 8.198$$

$$\text{Output power} = -38.452 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

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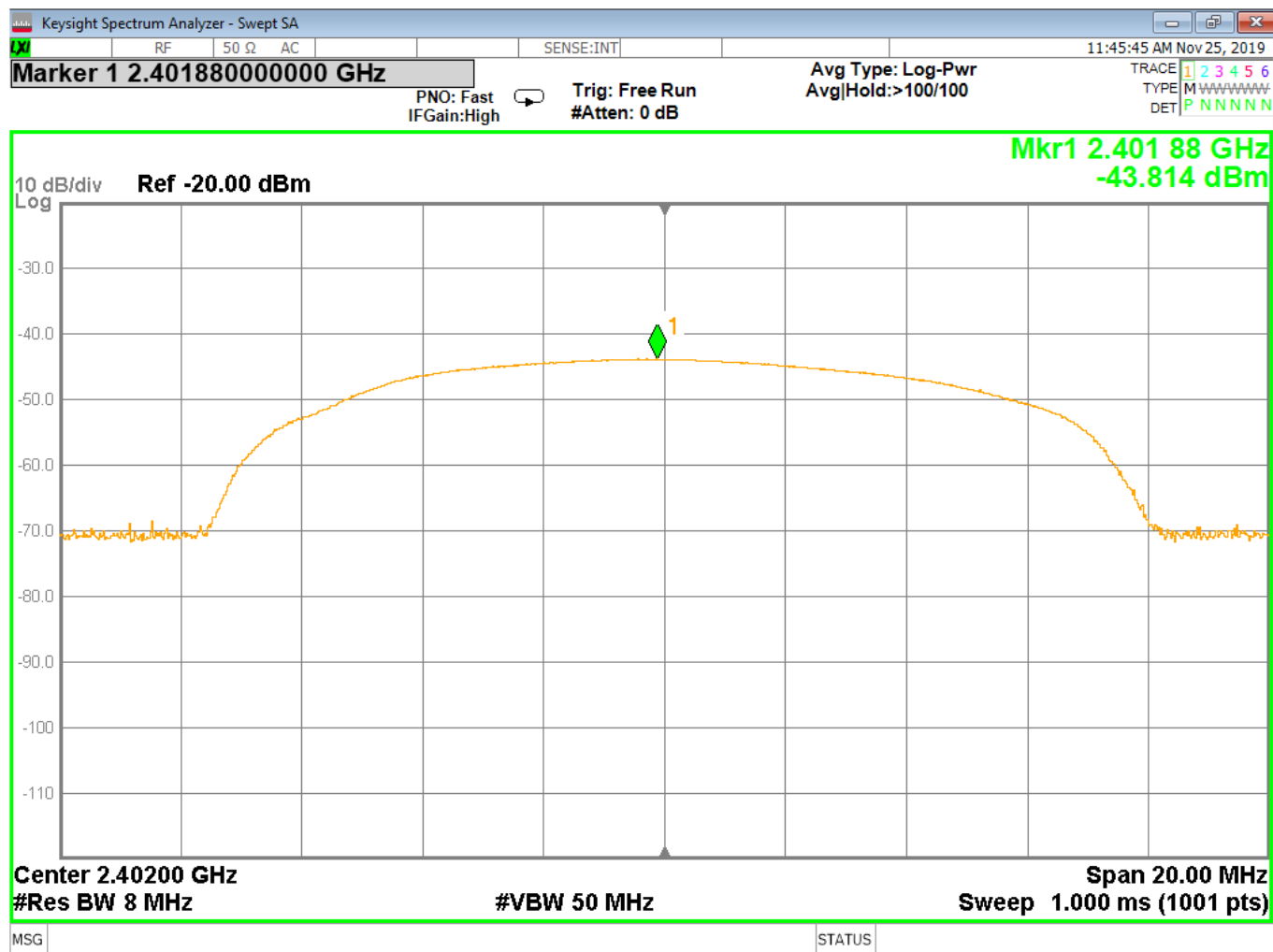


Figure 10 – Output Power, Low Channel, GFSK

$$\text{EIRP Peak Output Power} = -43.814 + 107 - 95.23 + \text{AF} + \text{CL} = 2.836$$

$$\text{Output power} = -43.814 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

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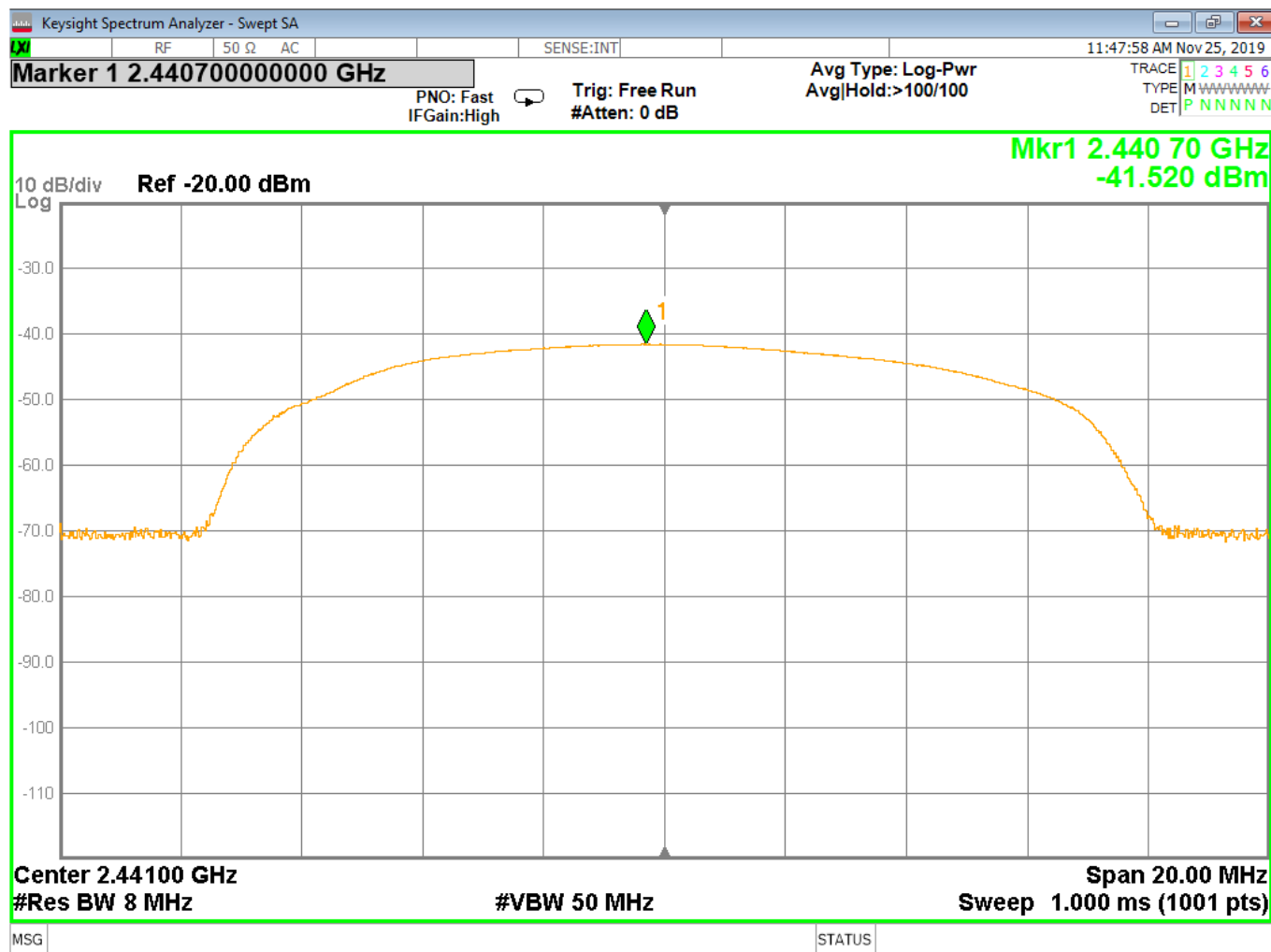


Figure 11 – Output Power, Mid Channel, GFSK

$$\text{EIRP Peak Output Power} = -41.520 + 107 - 95.23 + \text{AF} + \text{CL} = 5.130$$

$$\text{Output power} = -41.520 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

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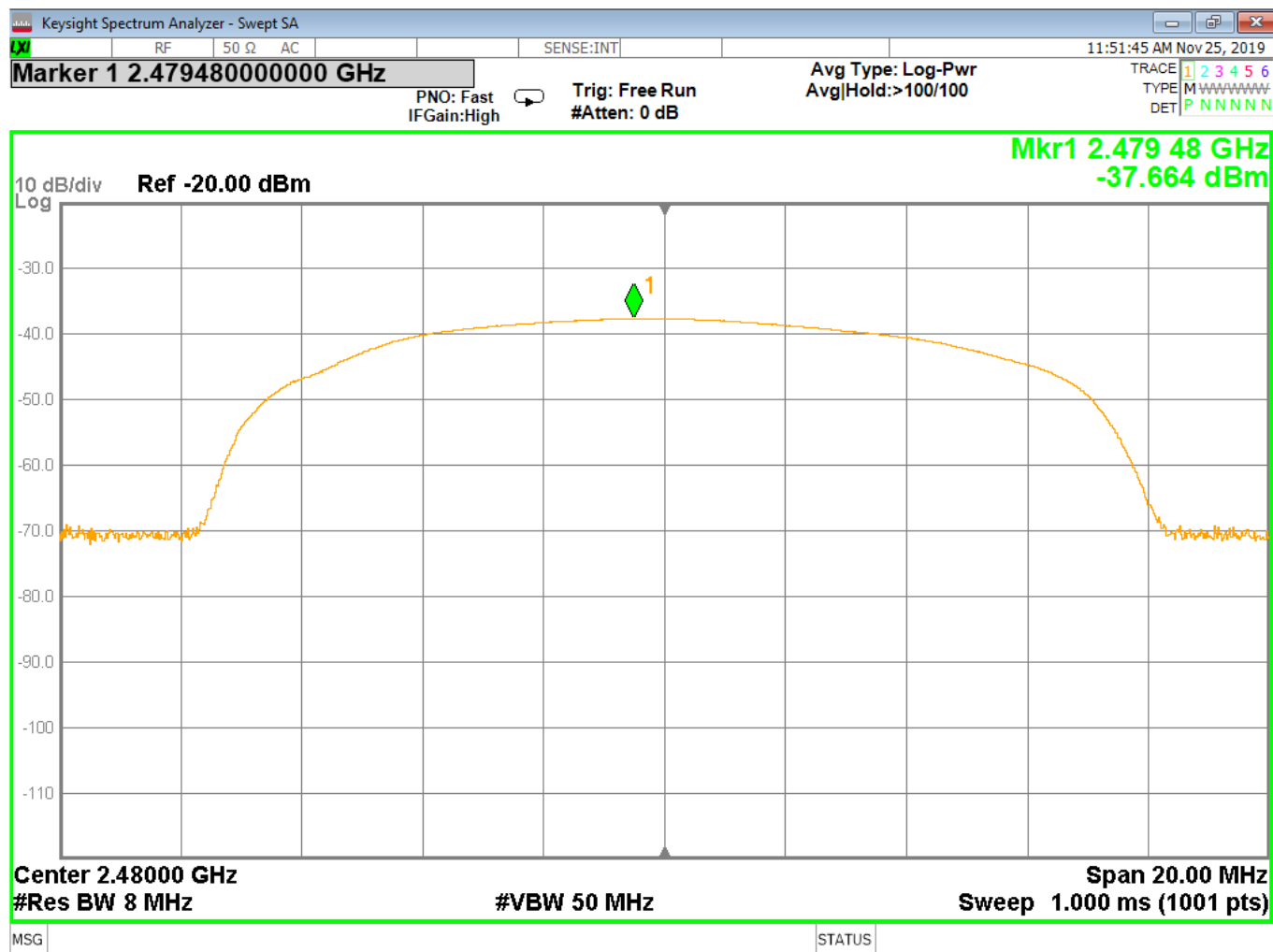


Figure 12 – Output Power, High Channel, GFSK

$$\text{EIRP Peak Output Power} = -37.664 + 107 - 95.23 + \text{AF} + \text{CL} = 8.968$$

$$\text{Output power} = -37.664 \text{ dBm}$$

$$\text{AF} = \text{Antenna Factor} = 28.36$$

$$\text{CL} = \text{Cable Loss} = 6.52$$

4.3 BANDWIDTH

Test Method: ANSI C63.10-2013, Section(s) 6.9.2

Limits of bandwidth measurements:

For Informational Purposes only

Test procedures:

1. The EUT was measured at a distance of 3 meters.
2. The resolution bandwidth was set to 100 kHz and the video bandwidth was set to 300 kHz to capture the signal. The analyzer used a peak detector in max hold mode.
3. The Occupied Bandwidth is defined as the bandwidth of which is higher than peak power minus 20dB.

Test setup:

The field strength was measured by connecting the EUT directly to the spectrum analyzer.

Deviations from test standard:

No deviation.

Test setup:

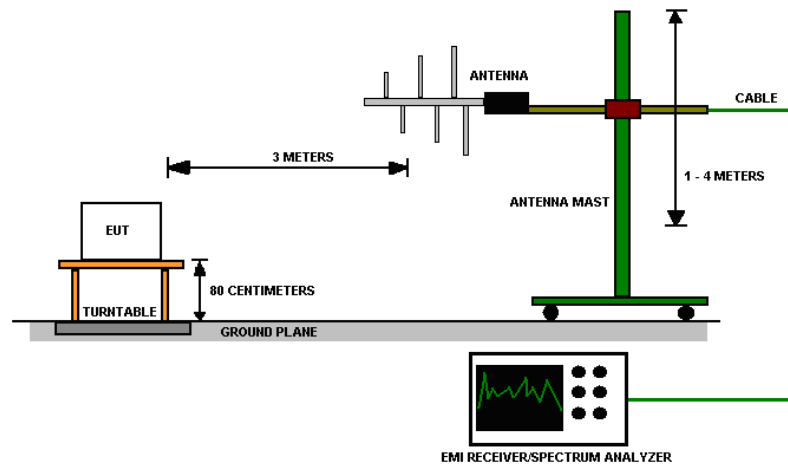


Figure 13 - Bandwidth Measurements Test Setup

EUT operating conditions:

The EUT was powered by internal battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in each of its operating modes.



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Test results:**Occupied Bandwidth**

CHANNEL	Mode	CHANNEL FREQUENCY (MHz)	OBW (KHz)
Low	BT BR	2402	820.980
Mid	BT BR	2441	819.080
High	BT BR	2480	818.720
Low	BT EDR 2MB	2402	1160.900
Mid	BT EDR 2MB	2441	1160.300
High	BT EDR 2MB	2480	1160.100
Low	BT EDR 3MB	2402	1187.200
Mid	BT EDR 3MB	2441	1187.100
High	BT EDR 3MB	2480	1186.800
Low	GFSK	2402	842.16
Mid	GFSK	2441	839.93
High	GFSK	2480	841.27

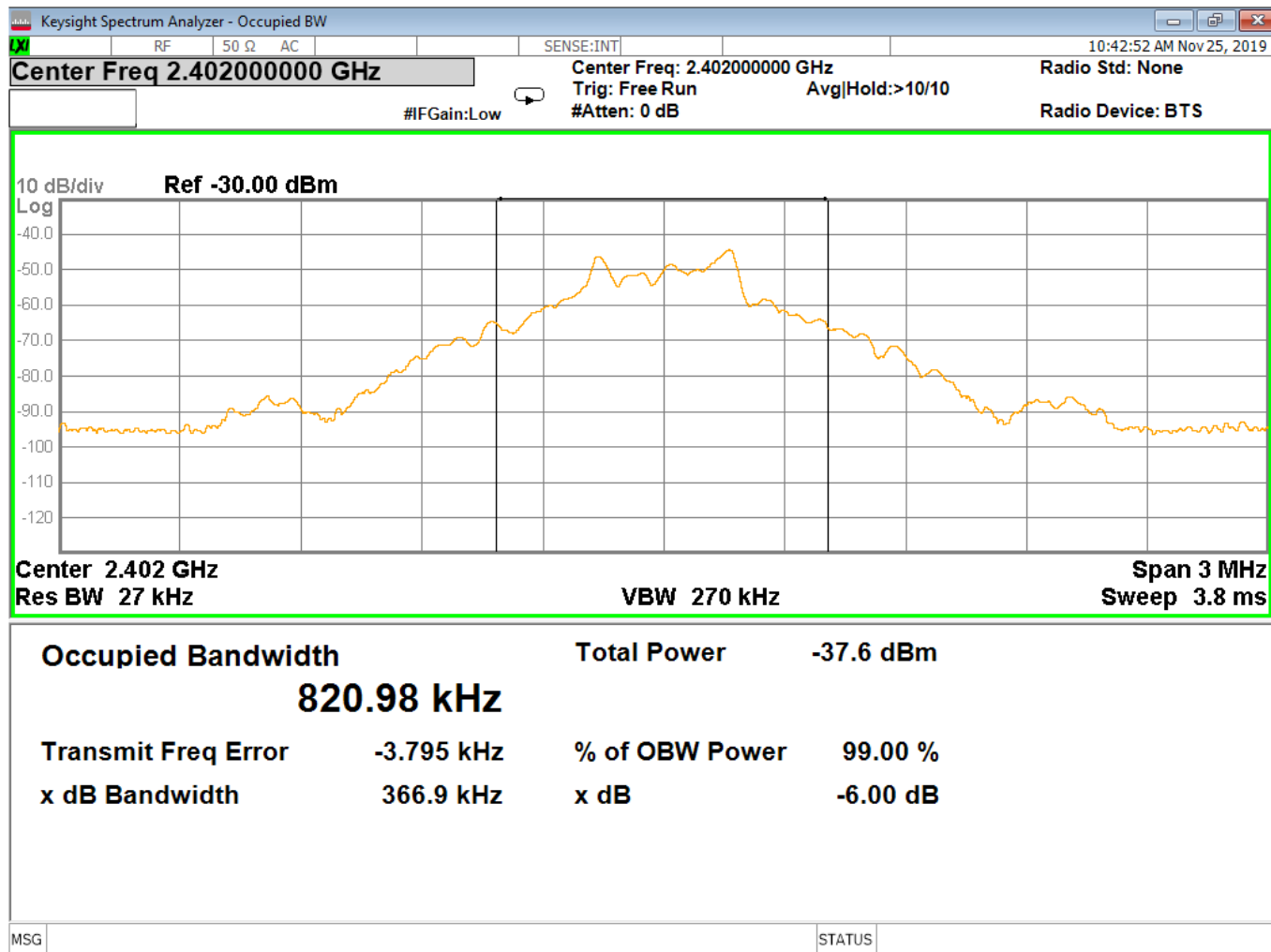


Figure 14 – Occupied Bandwidth, Low Channel, BT BR (GFSK)

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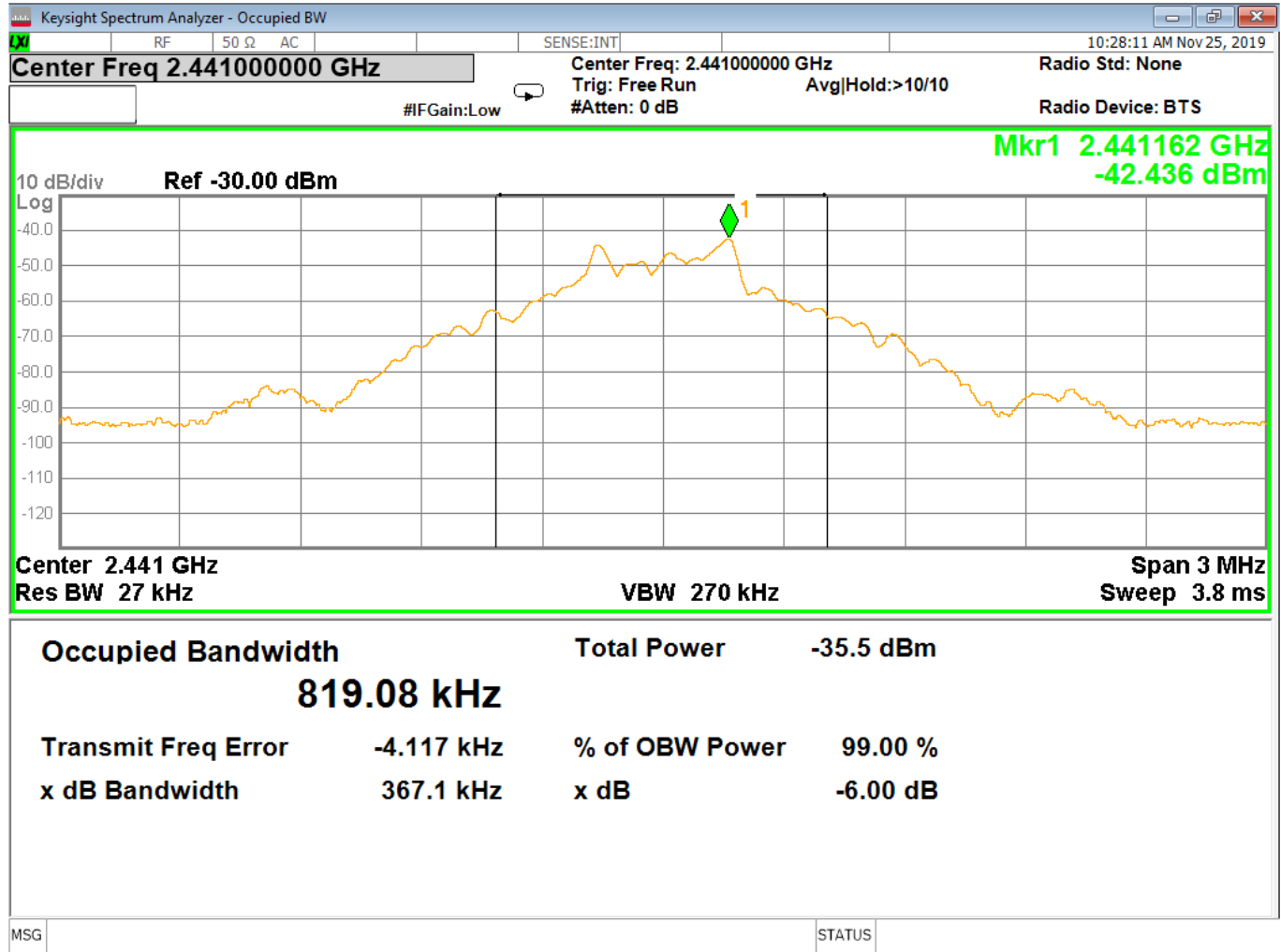


Figure 15 - Occupied Bandwidth, Mid Channel, BT BR (GFSK)

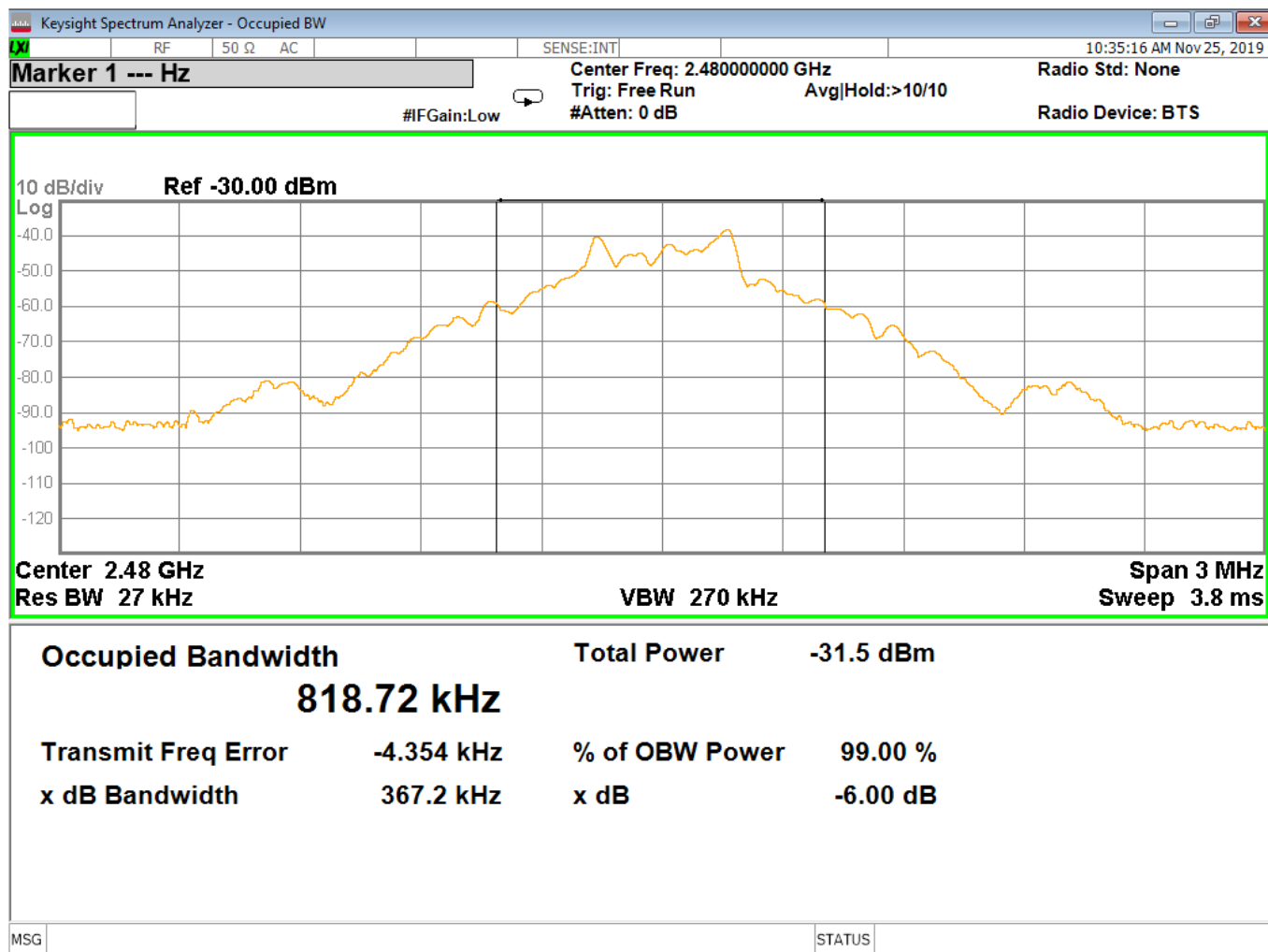


Figure 16 - Occupied Bandwidth, High Channel, BT BR (GFSK)

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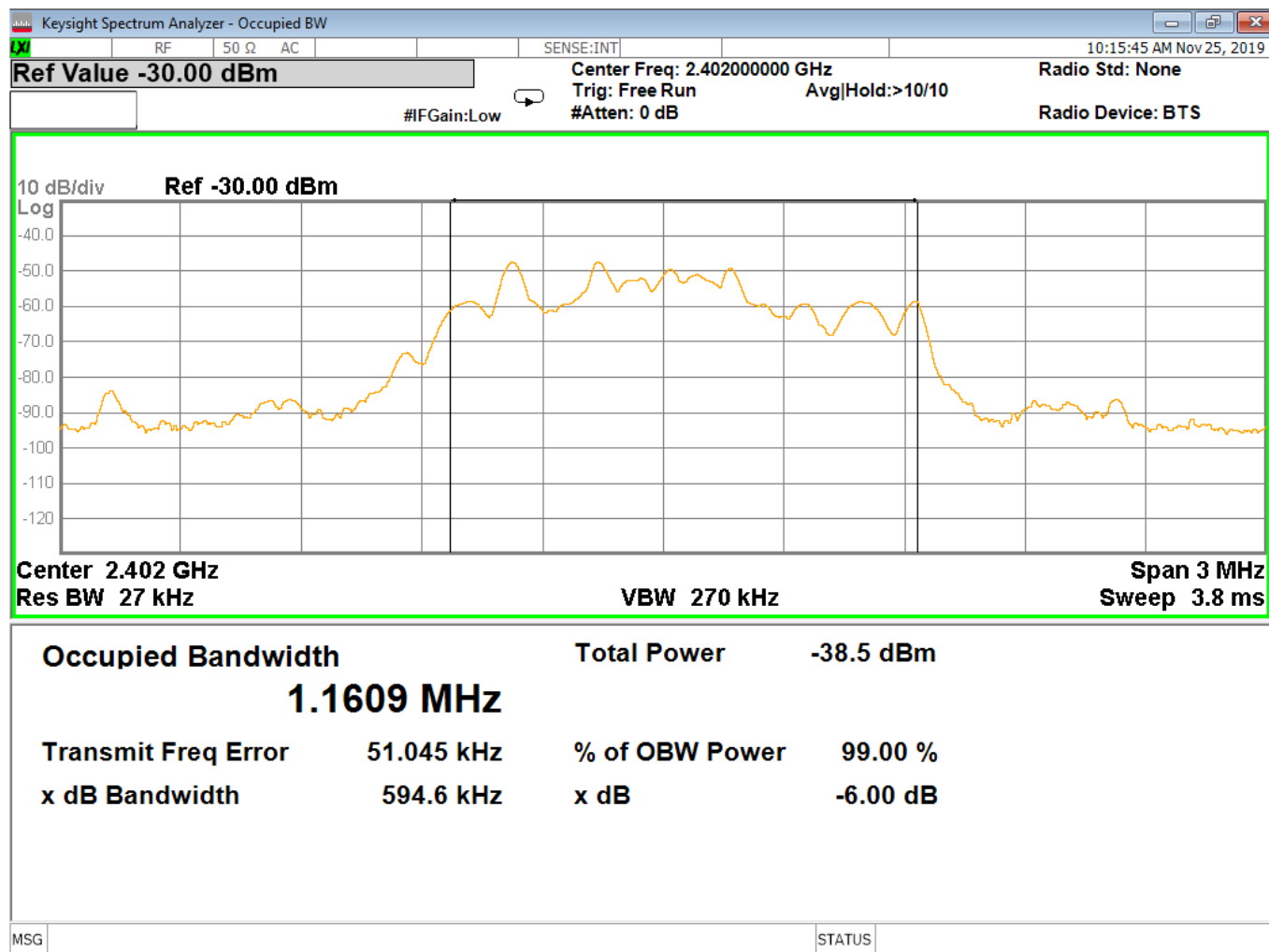


Figure 17 – Occupied Bandwidth, Low Channel, BT EDR 2MB

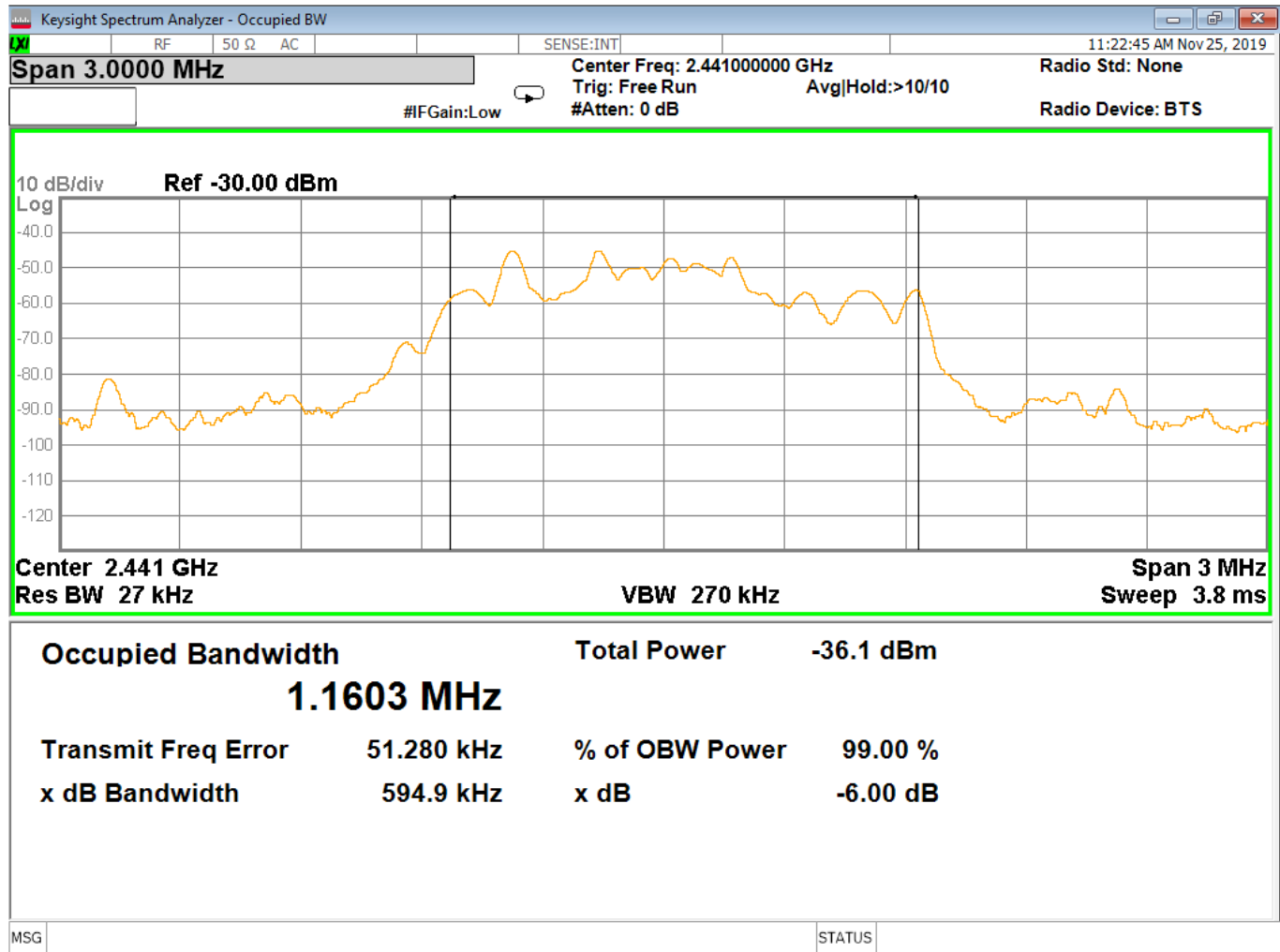


Figure 18 - Occupied Bandwidth, Mid Channel, BT EDR 2MB

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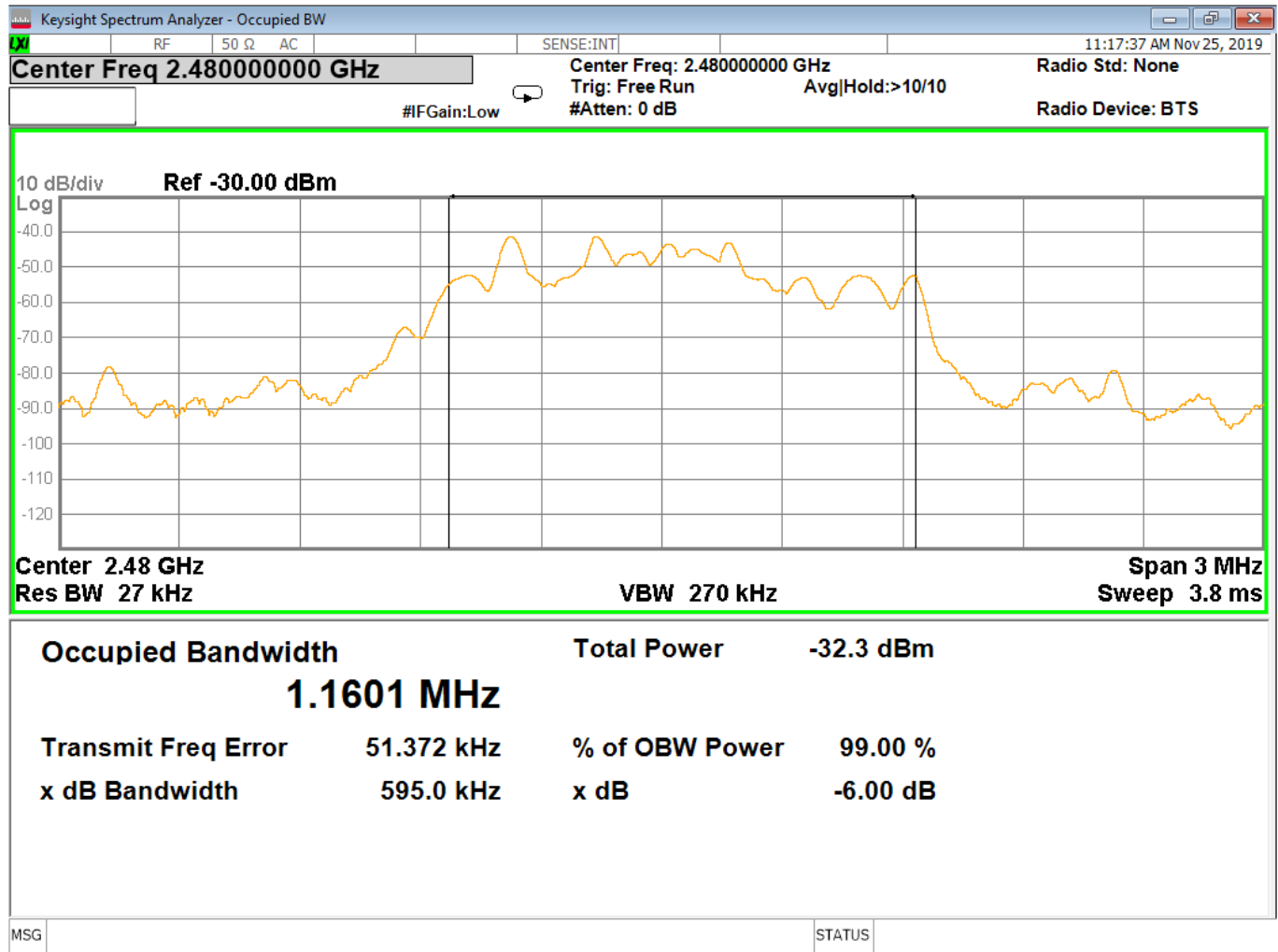


Figure 19 - Occupied Bandwidth, High Channel, BT EDR 2MB

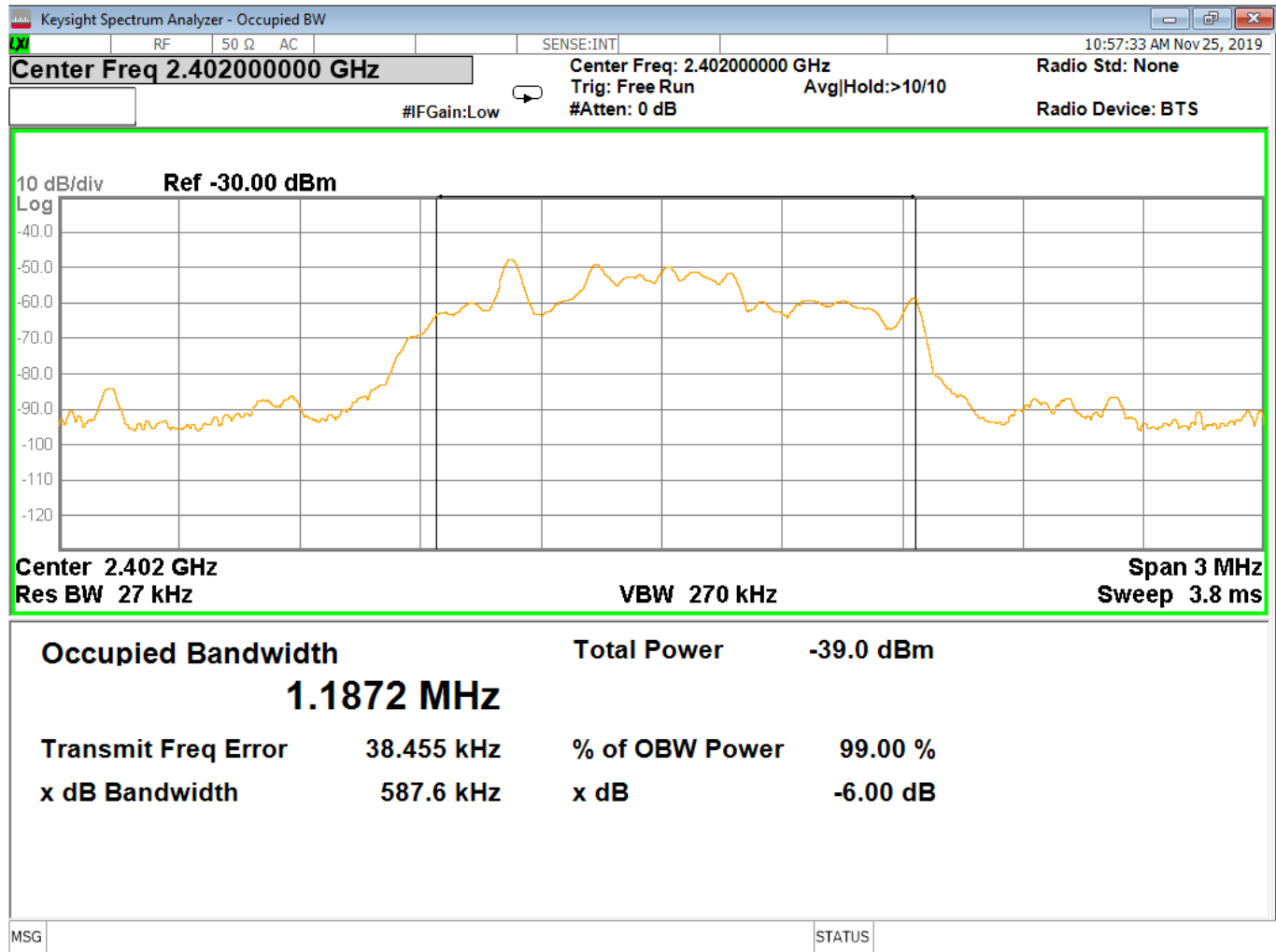


Figure 20 – Occupied Bandwidth, Low Channel, BT EDR 3MB

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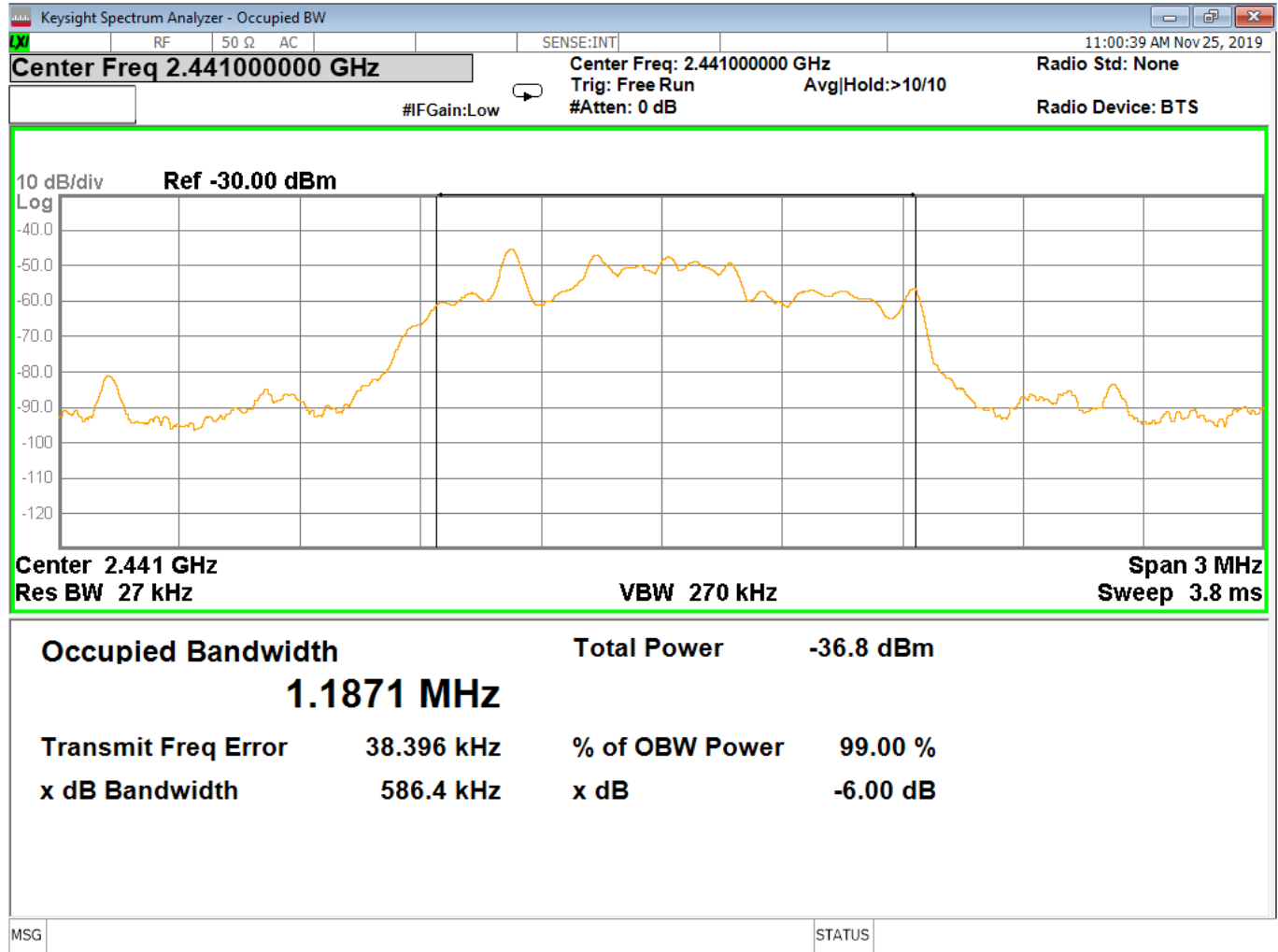


Figure 21 - Occupied Bandwidth, Mid Channel, BT EDR 3MB

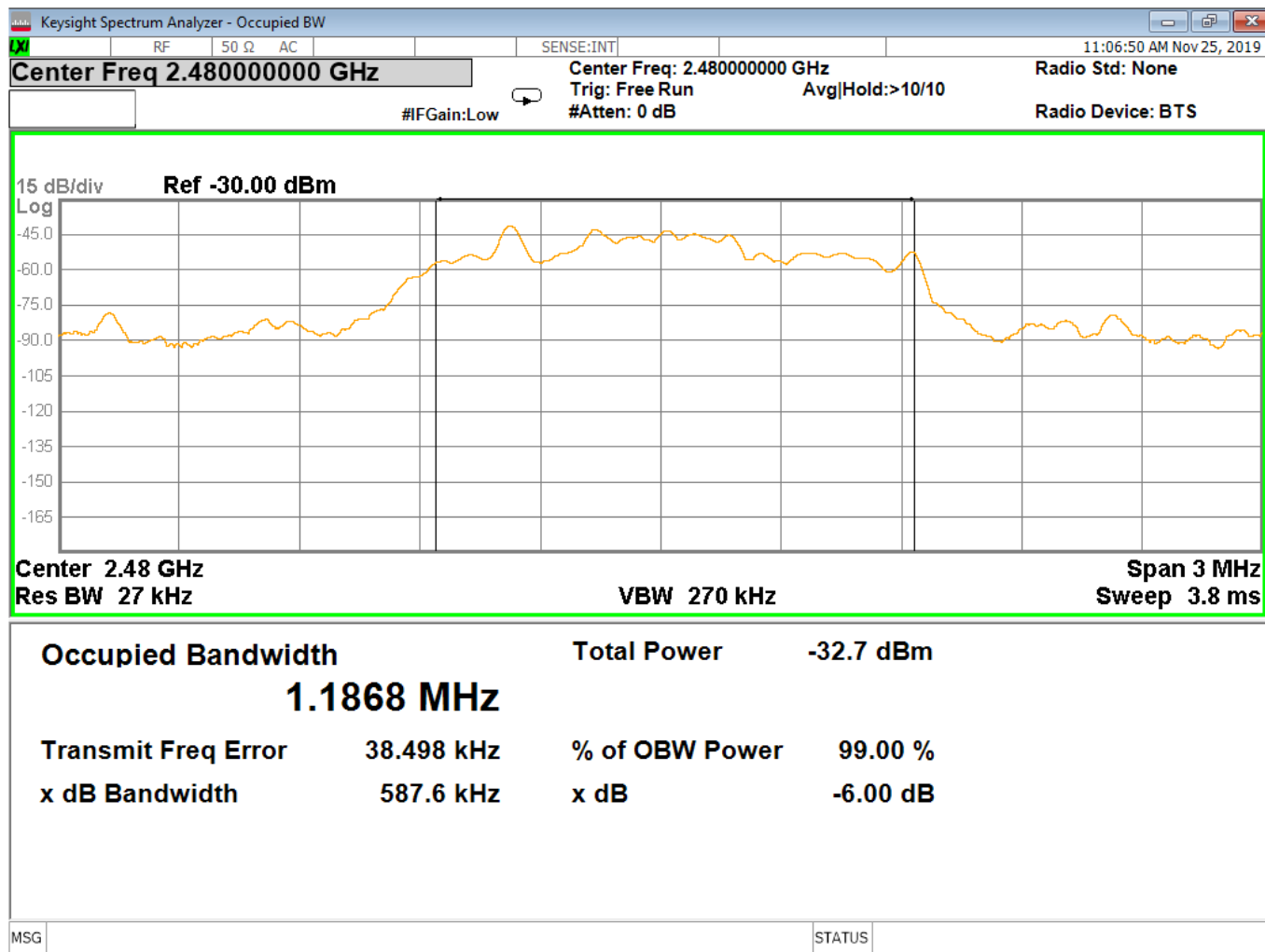


Figure 22 - Occupied Bandwidth, High Channel, BT EDR 3MB

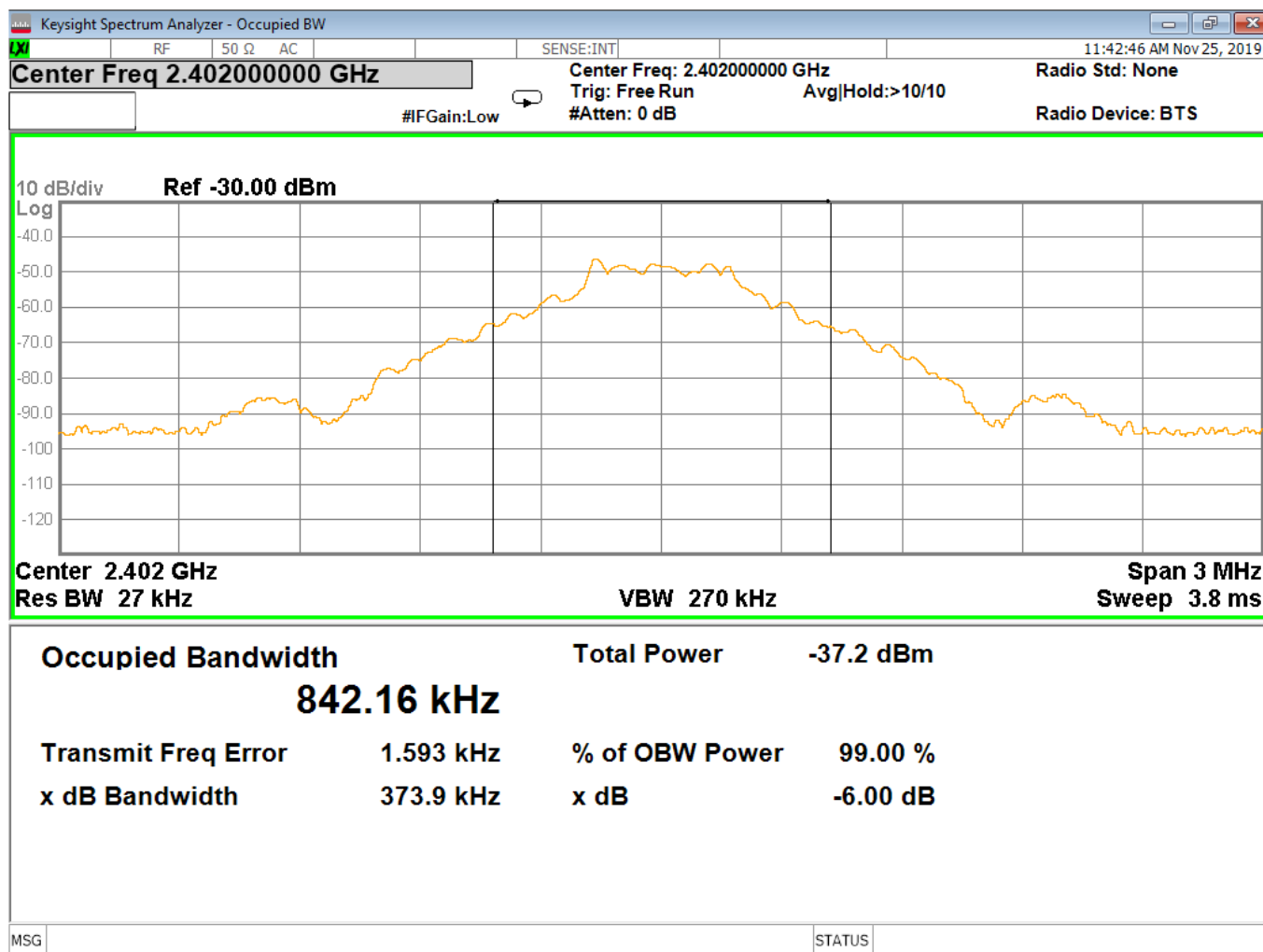


Figure 23 - Occupied Bandwidth, Low Channel, GFSK

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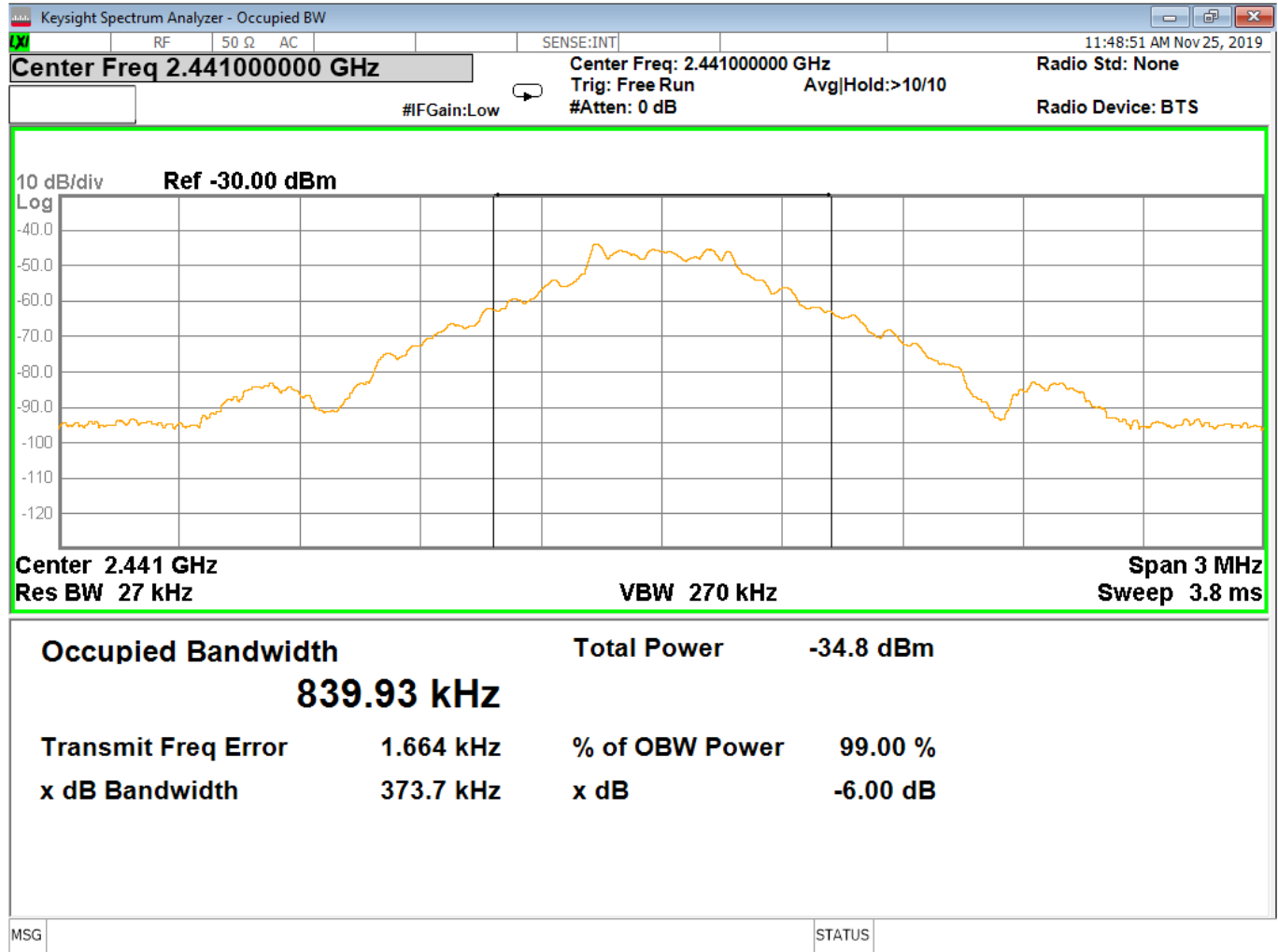


Figure 24 - Occupied Bandwidth, Mid Channel, GFSK

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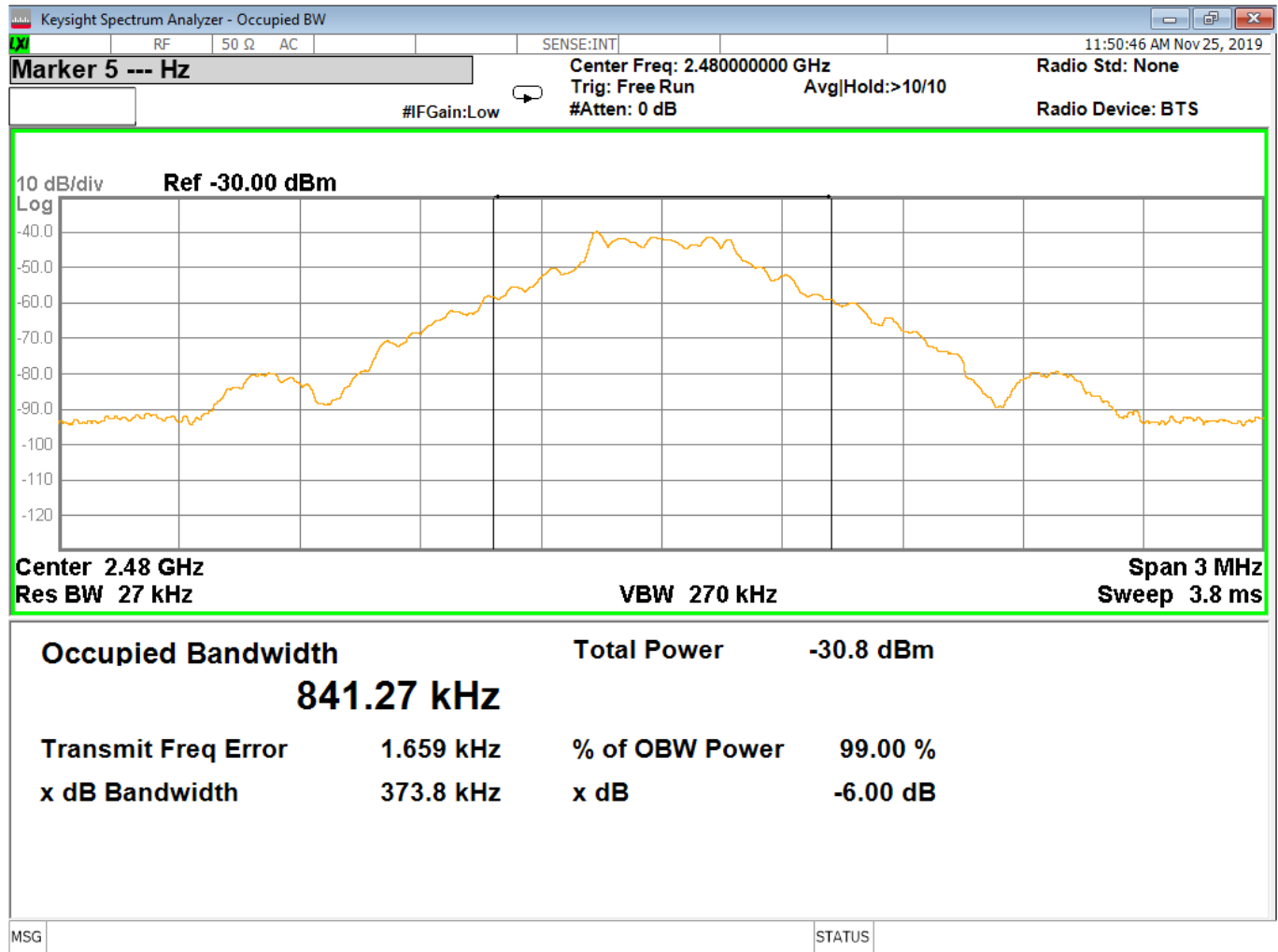


Figure 25 - Occupied Bandwidth, High Channel, GFSK

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 ($\mu\text{V/m}$)	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) = $20 * \log * \text{Emission level } (\mu\text{V/m})$.
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.

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Test procedures:

- 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.
- The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- 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.
- 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.
- 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.
- 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.
- The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

Test setup:

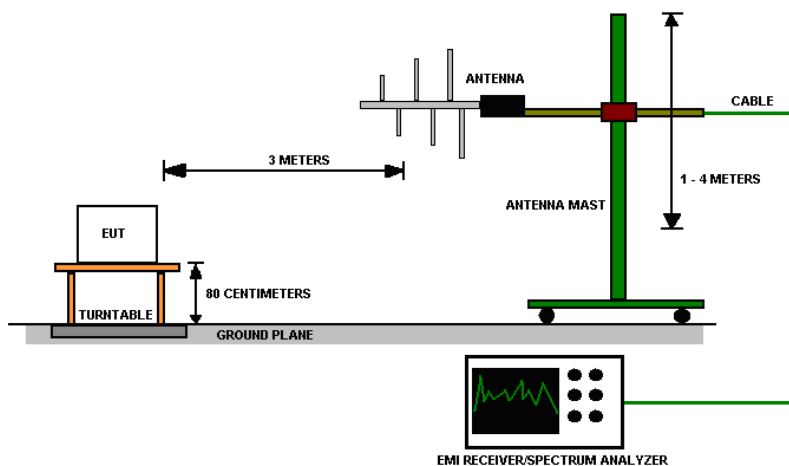


Figure 26 - Radiated Emissions Test Setup



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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

The EUT was powered by internal battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in each of its operating modes.

Test results:

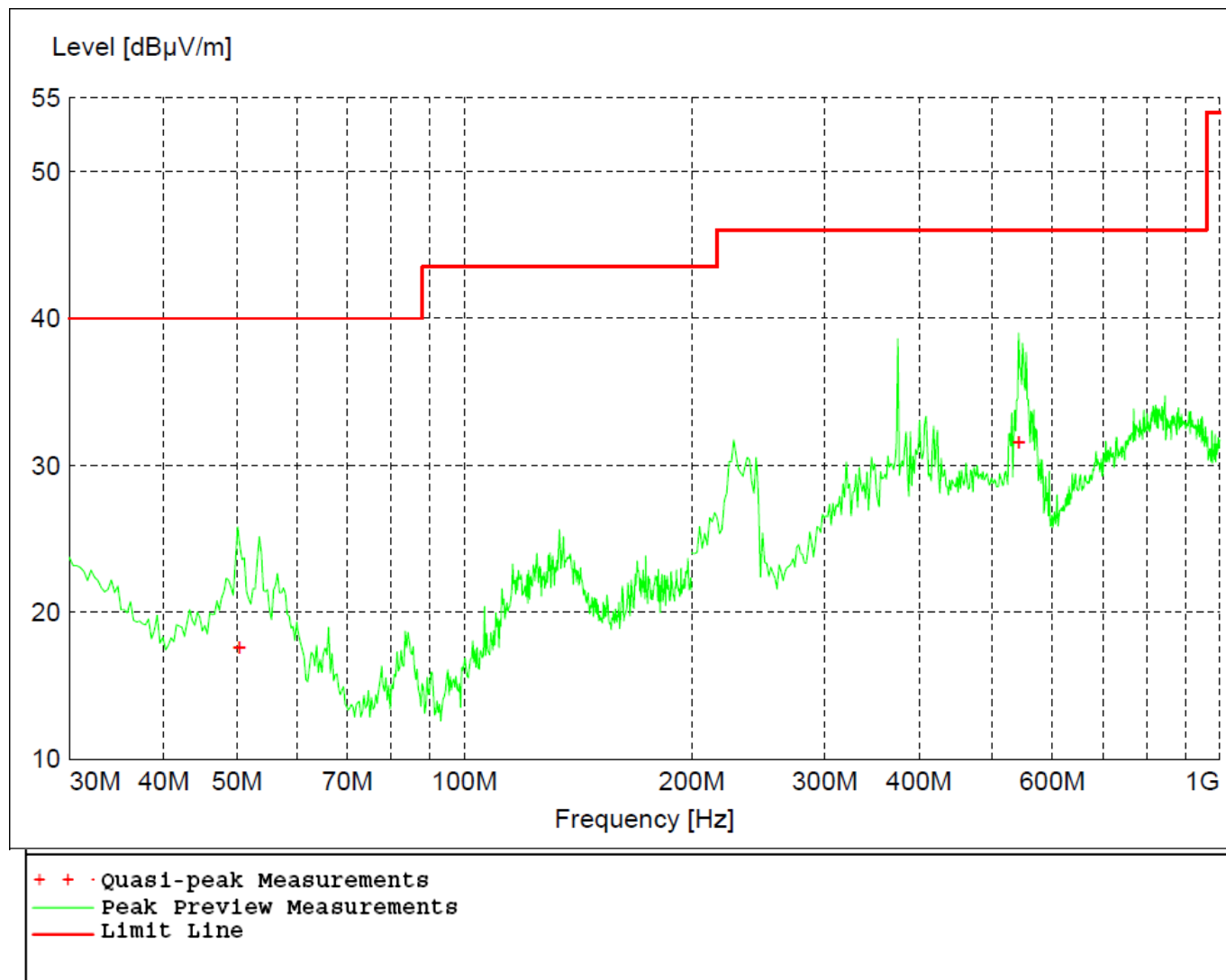


Figure 27 - Radiated Emissions Plot, Receive

REMARKS:

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

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
50.400000	17.64	40	22.4	139	0	VERT
542.520000	31.58	46	14.4	100	9	VERT

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.

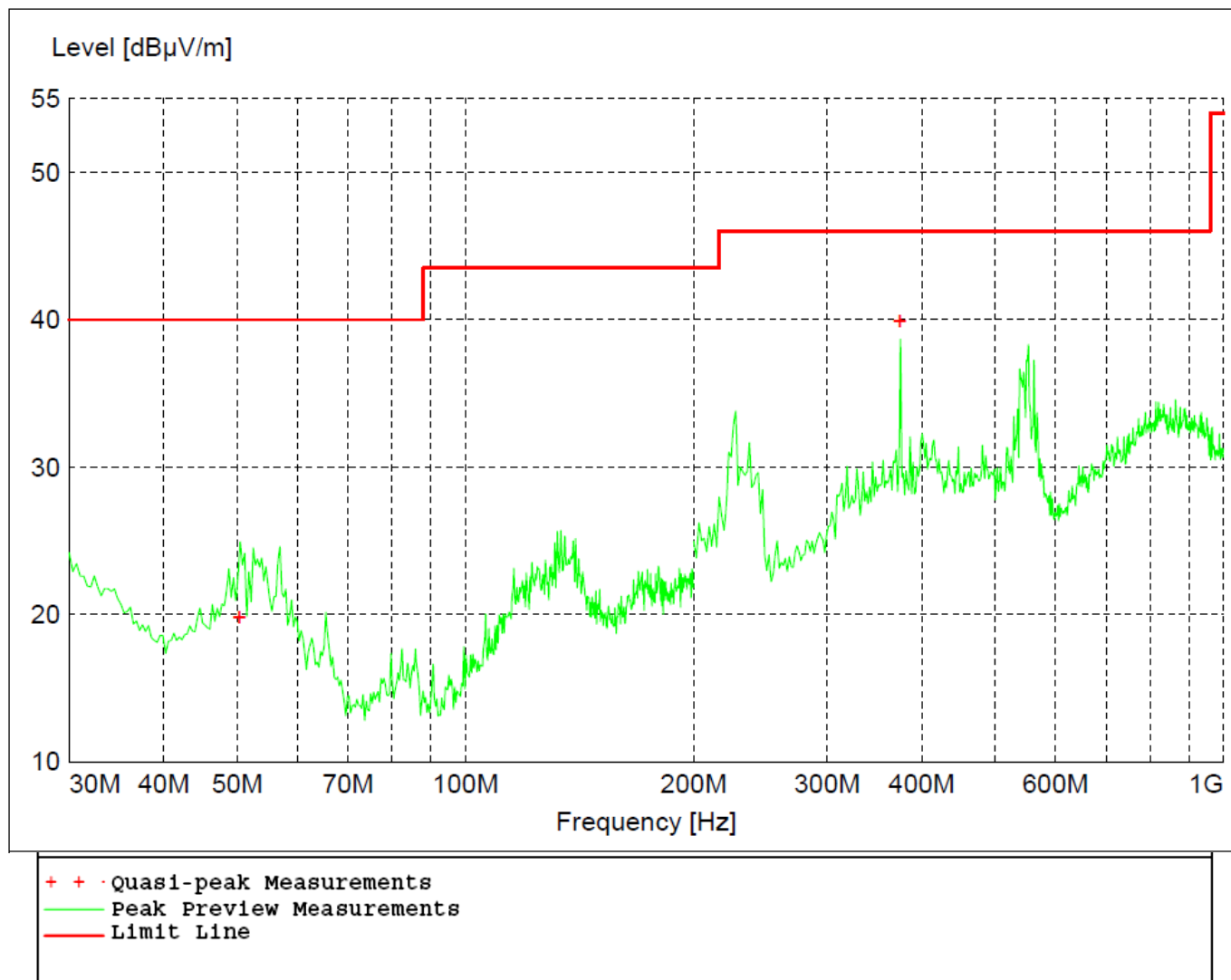


Figure 28 - Radiated Emissions Plot, BT BR

REMARKS:

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

Table 2 - Radiated Emissions Quasi-peak Measurements, BT BR

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
50.340000	19.85	40	20.2	100	38	VERT
374.400000	39.89	46	6.1	190	38	VERT

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.

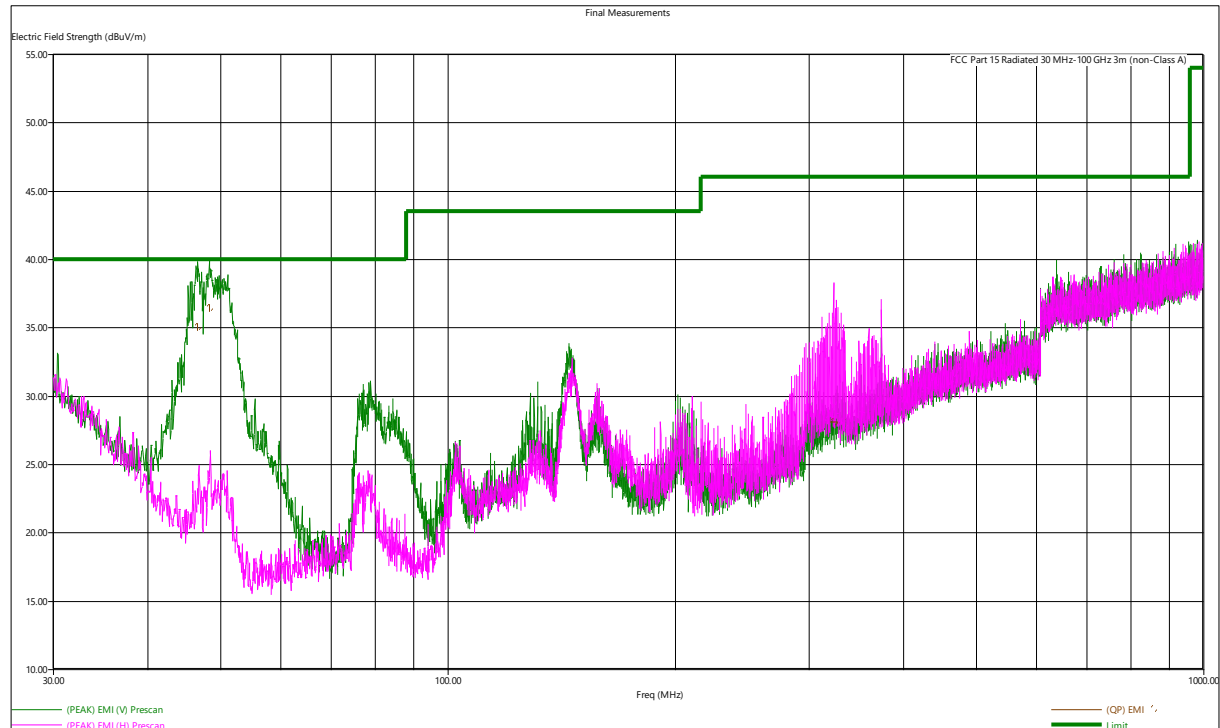


Figure 29 - Radiated Emissions Plot, 2EDR

REMARKS:

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

Table 3 - Radiated Emissions Quasi-peak Measurements, 2EDR

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
323.64	28.07	46.02	17.95	157.00	194.00	H
46.51	35.01	40.00	4.99	107.00	191.00	V
48.13	36.41	40.00	3.59	111.00	251.00	V

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.

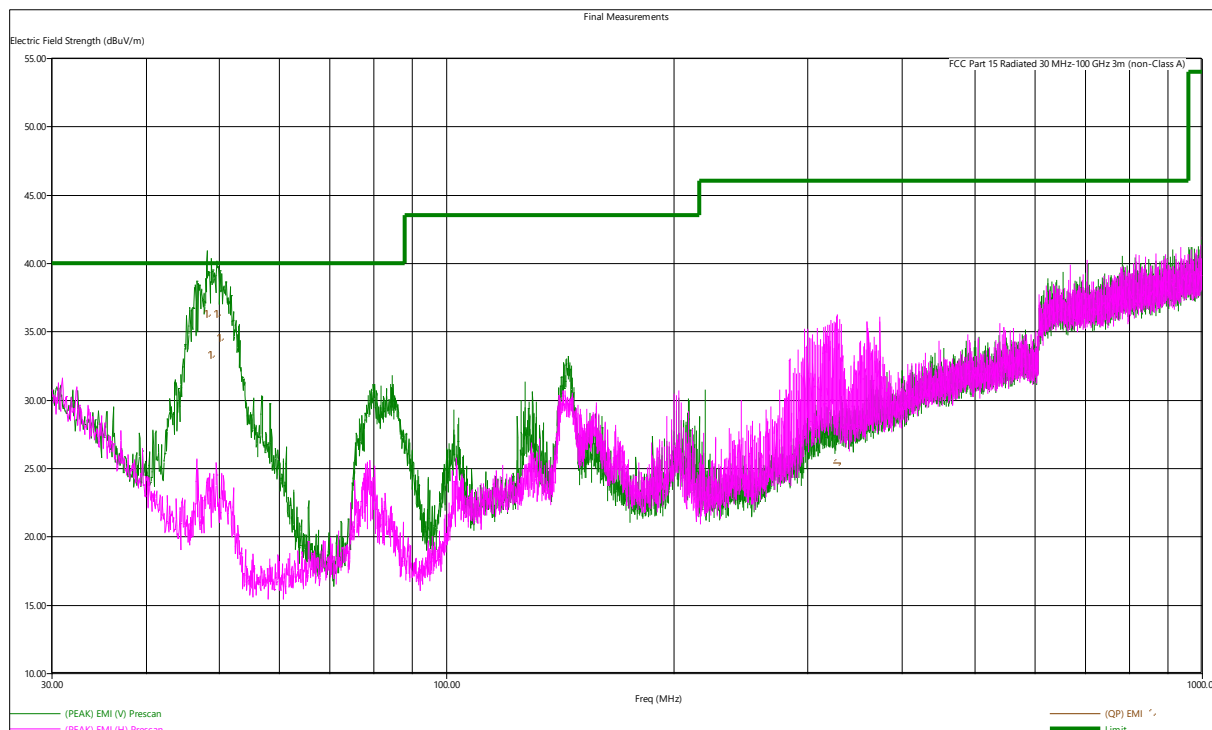


Figure 30 - Radiated Emissions Plot, 3EDR

REMARKS:

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

Table 4 - Radiated Emissions Quasi-peak Measurements, 3EDR

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
328.30	25.38	46.02	20.64	276.00	188.00	H
48.27	36.25	40.00	3.75	107.00	288.00	V
48.93	33.24	40.00	6.76	112.00	210.00	V
49.59	36.22	40.00	3.78	106.00	200.00	V
50.14	34.49	40.00	5.51	114.00	244.00	V

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.

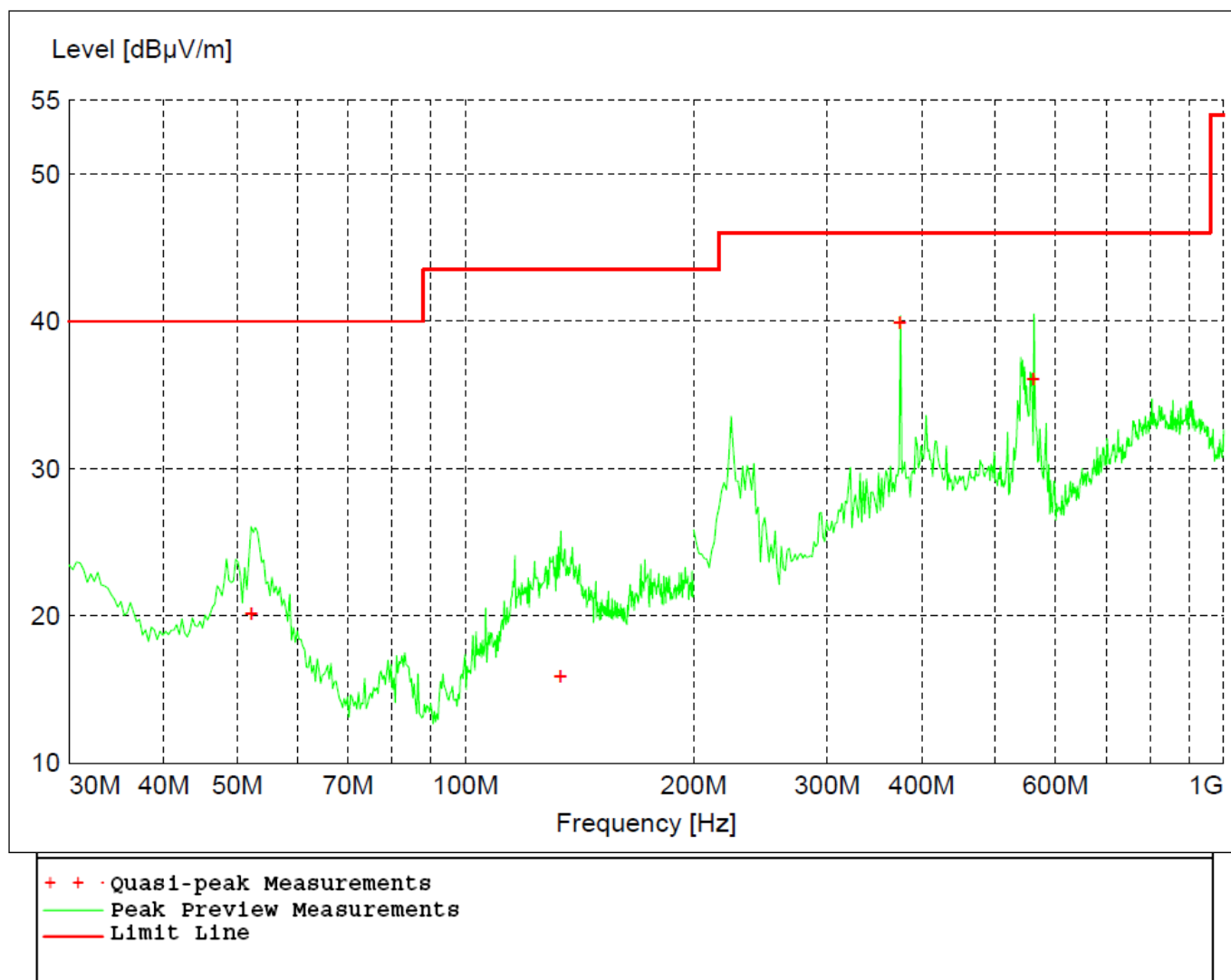


Figure 31 - Radiated Emissions Plot, GFSK

REMARKS:

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

Table 5 - Radiated Emissions Quasi-peak Measurements, GFSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
89.340000	19.81	43.5	23.7	99	253	VERT
107.340000	37.45	43.5	6.1	109	272	VERT
374.400000	38.94	46	7.1	100	312	HORI
547.500000	31.45	46	14.6	100	360	VERT

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.

Table 6 - Radiated Emissions Peak Measurements

Frequency	Level	Limit	Margin	Height	Angle	Pol	Radio
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.		
2402.000000	94.71	114.00	19.29	150	223	H	BTBR
2441.000000	97.65	114.00	16.35	150	223	H	BTBR
2480.000000	100.83	114.00	13.17	150	223	H	BTBR
2402.000000	93.44	114.00	20.56	150	223	H	BT EDR 2MB
2441.000000	95.71	114.00	18.29	150	223	H	BT EDR 2MB
2480.000000	99.31	114.00	14.69	150	223	H	BT EDR 2MB
2402.000000	93.57	114.00	20.43	150	223	H	BT EDR 3MB
2441.000000	95.94	114.00	18.06	150	223	H	BT EDR 3MB
2480.000000	99.81	114.00	14.19	150	223	H	BT EDR 3MB
2402.000000	95.00	114.00	19.00	150	223	H	GFSK
2441.000000	97.12	114.00	16.88	150	223	H	GFSK
2480.000000	101.35	114.00	12.65	150	223	H	GFSK

Table 7 - Radiated Emissions Average Measurements

Frequency	Level	Limit	Margin	Height	Angle	Pol	Radio
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.		
2402.000000	83.77	94.00	10.23	150	223	H	BTBR
2441.000000	86.52	94.00	7.48	150	223	H	BTBR
2480.000000	89.93	94.00	4.07	150	223	H	BTBR
2402.000000	80.07	94.00	13.93	150	223	H	BT EDR 2MB
2441.000000	82.36	94.00	11.64	150	223	H	BT EDR 2MB
2480.000000	86.01	94.00	7.99	150	223	H	BT EDR 2MB
2402.000000	80.19	94.00	13.81	150	223	H	BT EDR 3MB
2441.000000	82.56	94.00	11.44	150	223	H	BT EDR 3MB
2480.000000	86.43	94.00	7.57	150	223	H	BT EDR 3MB
2402.000000	84.21	94.00	9.79	150	223	H	GFSK
2441.000000	86.37	94.00	7.63	150	223	H	GFSK
2480.000000	90.56	94.00	3.44	150	223	H	GFSK

4.5 BAND EDGES

Test Method: ANSI C63.10-2013, Section(s) 6.10.5

Limits of band-edge measurements:

For emissions outside of the allowed band of operation, the emission level needs to be 50dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

Test procedures:

The EUT was measured at a distance of 3 meters. The resolution bandwidth was set to 100 kHz and the EMI receiver was used to scan from the band-edge to the fundamental frequency with a peak detector. 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.

To calculate the level at the band-edge frequencies, the difference between the peak and the band edge level was subtracted from the peak radiated value at the fundamental. This value was compared to the 15.209 radiated limits for compliance.

Deviations from test standard:

No deviation.

Test setup:

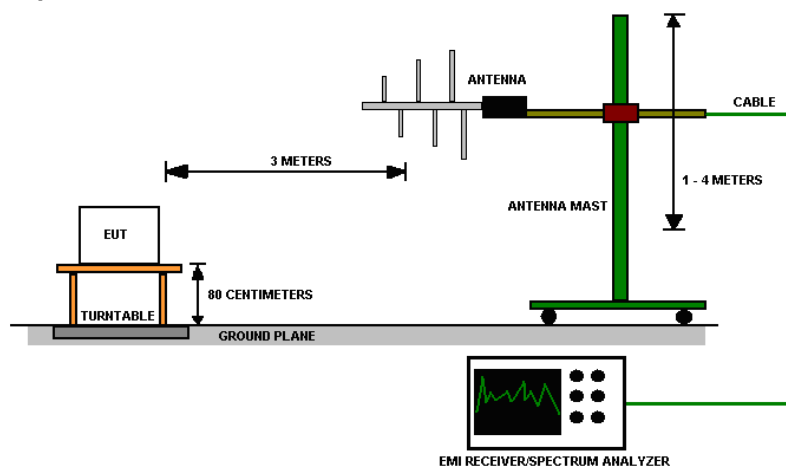


Figure 32 - Bandwidth Measurements Test Setup

EUT operating conditions:

The EUT was powered by internal battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in each of its operating modes.



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Test results:

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental dBm	Delta (dB)	Min Delta (dB)	Result
Low, Continuous (Restricted)	GFSK	2390 Restricted	-87.819	-44.521	43.298	41.02	PASS
High, Continuous (Restricted)	GFSK	2483.5 Restricted	-88.534	-38.456	50.078	47.37	PASS
Low, Continuous (Restricted)	BT BR	2390 Restricted	-88.56	-44.48	44.08	40.73	PASS
High, Continuous (Restricted)	BT BR	2483.5 Restricted	-88.015	-38.186	49.829	46.85	PASS
Low, Continuous (Restricted)	2EDR	2390 Restricted	-88.234	-45.655	42.579	39.46	PASS
High, Continuous (Restricted)	2EDR	2483.5 Restricted	-88.399	-39.473	48.926	45.33	PASS
Low, Continuous (Restricted)	3EDR	2390 Restricted	-88.377	-45.706	42.671	39.59	PASS
High, Continuous (Restricted)	3EDR	2483.5 Restricted	-88.355	-39.385	48.97	45.83	PASS

*Minimum delta = [highest fundamental peak field strength from Section 4.2] – [Part 15.209 radiated emissions limit.]

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From Section 4.2

CHANNEL	Mode	Peak Field Strength (dBuV/m)	Field Strength Limit (dBuV/m)	Min Delta (dBc)	Result
Low	BT BR	94.71	53.98	40.73	PASS
High	BT BR	100.83	53.98	46.85	PASS
Low	BT EDR 2MB	93.44	53.98	39.46	PASS
High	BT EDR 2MB	99.31	53.98	45.33	PASS
Low	BT EDR 3MB	93.57	53.98	39.59	PASS
High	BT EDR 3MB	99.81	53.98	45.83	PASS
Low	GFSK	95.00	53.98	41.02	PASS
High	GFSK	101.35	53.98	47.37	PASS

FCC Part 15.249 requires the attenuation of all emissions outside of the specified band to be at least 50 dB or below the 15.209 limits, whichever is the lesser. In this case, the 15.209 limits were the lesser and used to show compliance.

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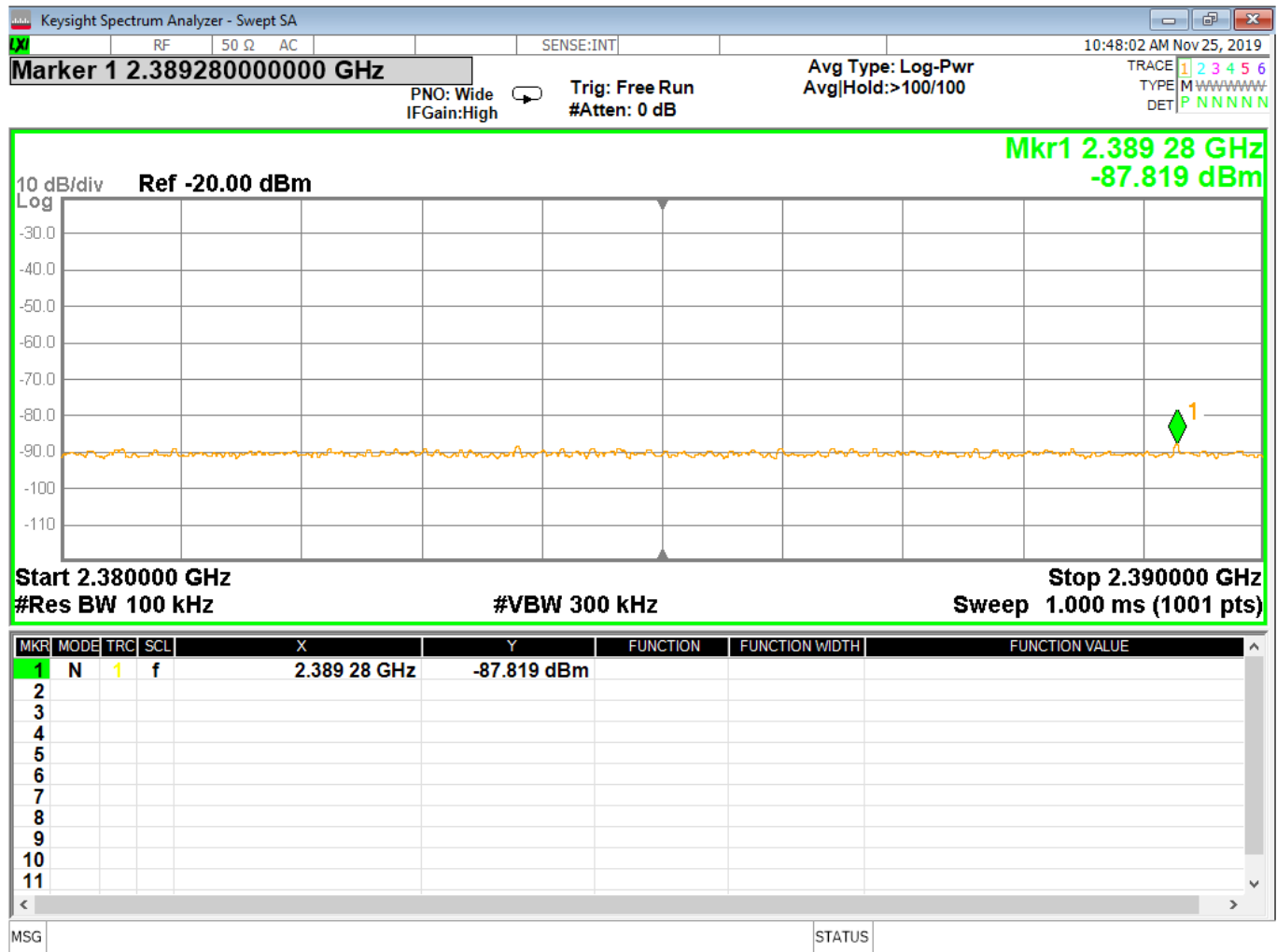


Figure 33 –Band Edge Measurement, Low Channel, Restricted, BT BR



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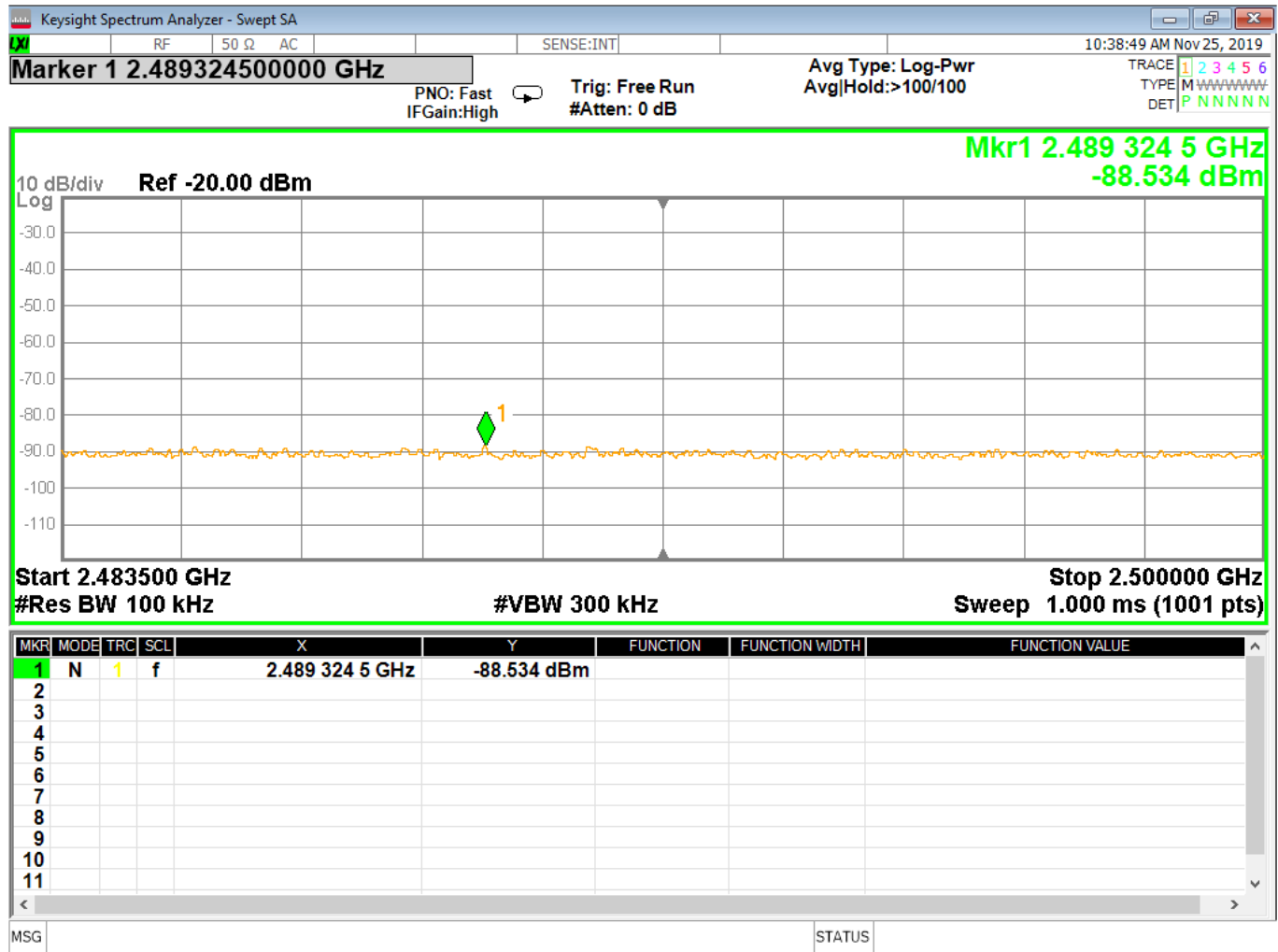


Figure 34 – Band Edge Measurement, High Channel, Restricted, BT BR

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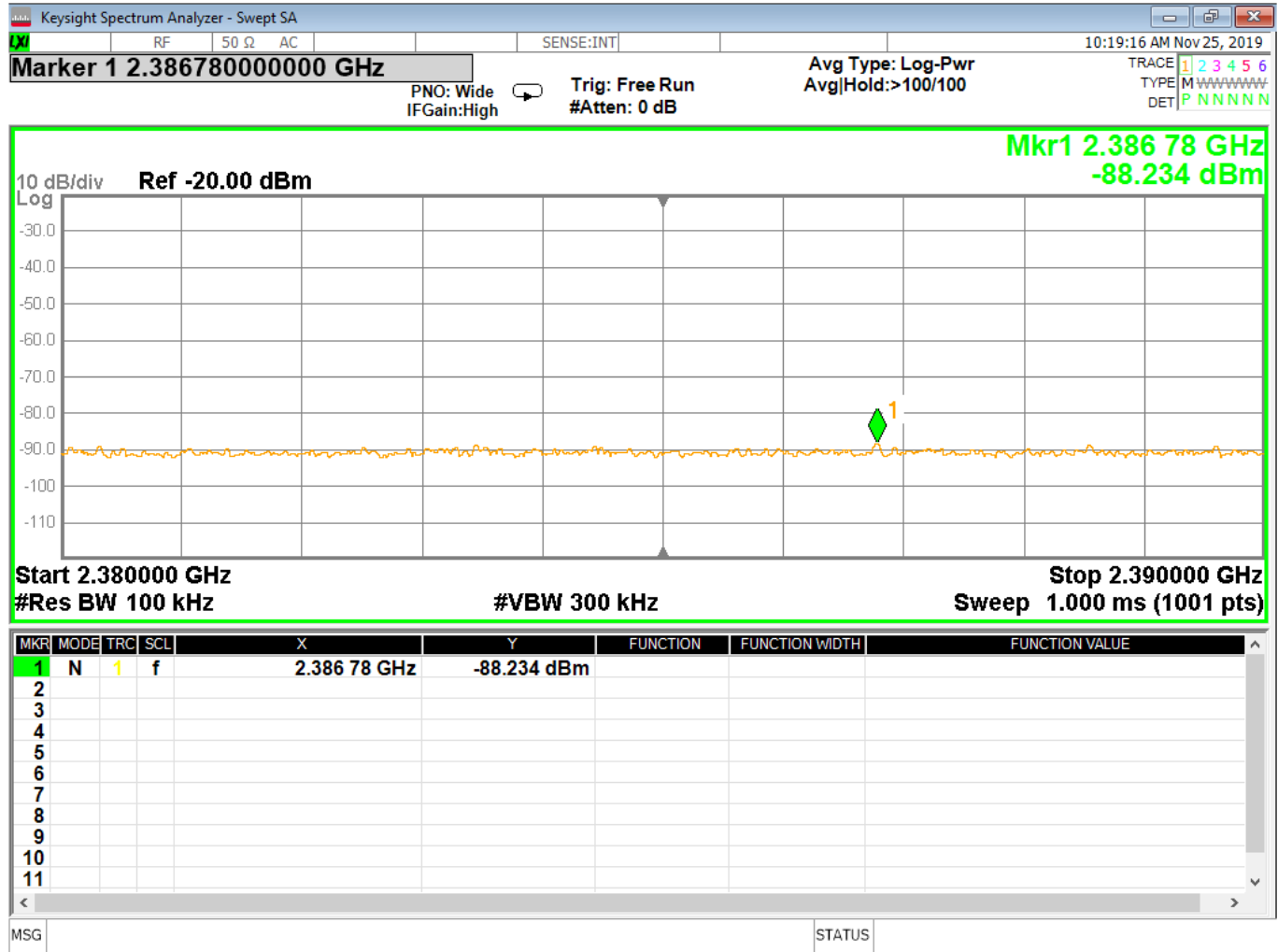


Figure 35 –Band Edge Measurement, Low Channel, Restricted, BT EDR 2MB



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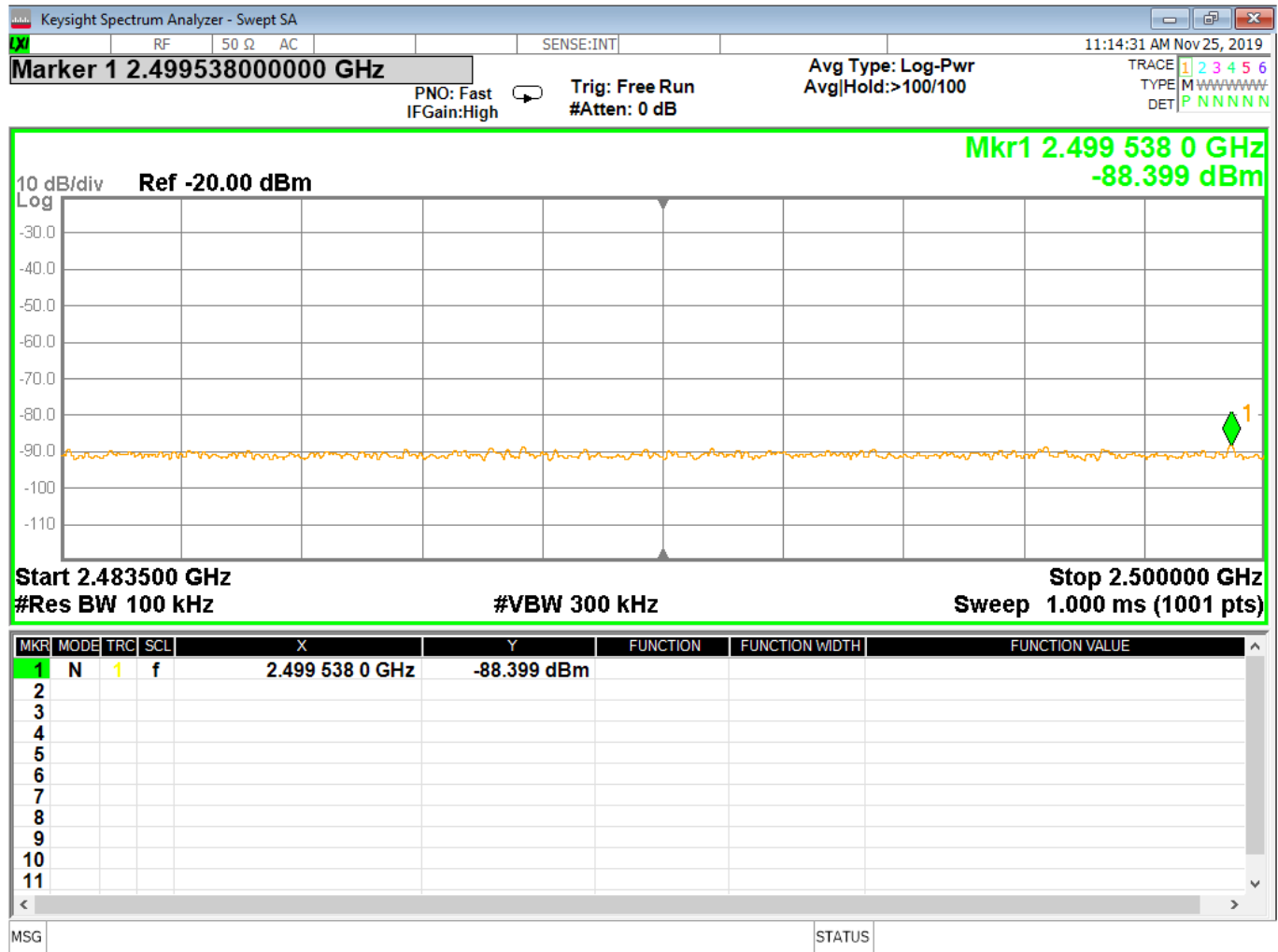


Figure 36 – Band Edge Measurement, High Channel, Restricted, BT EDR 2MB



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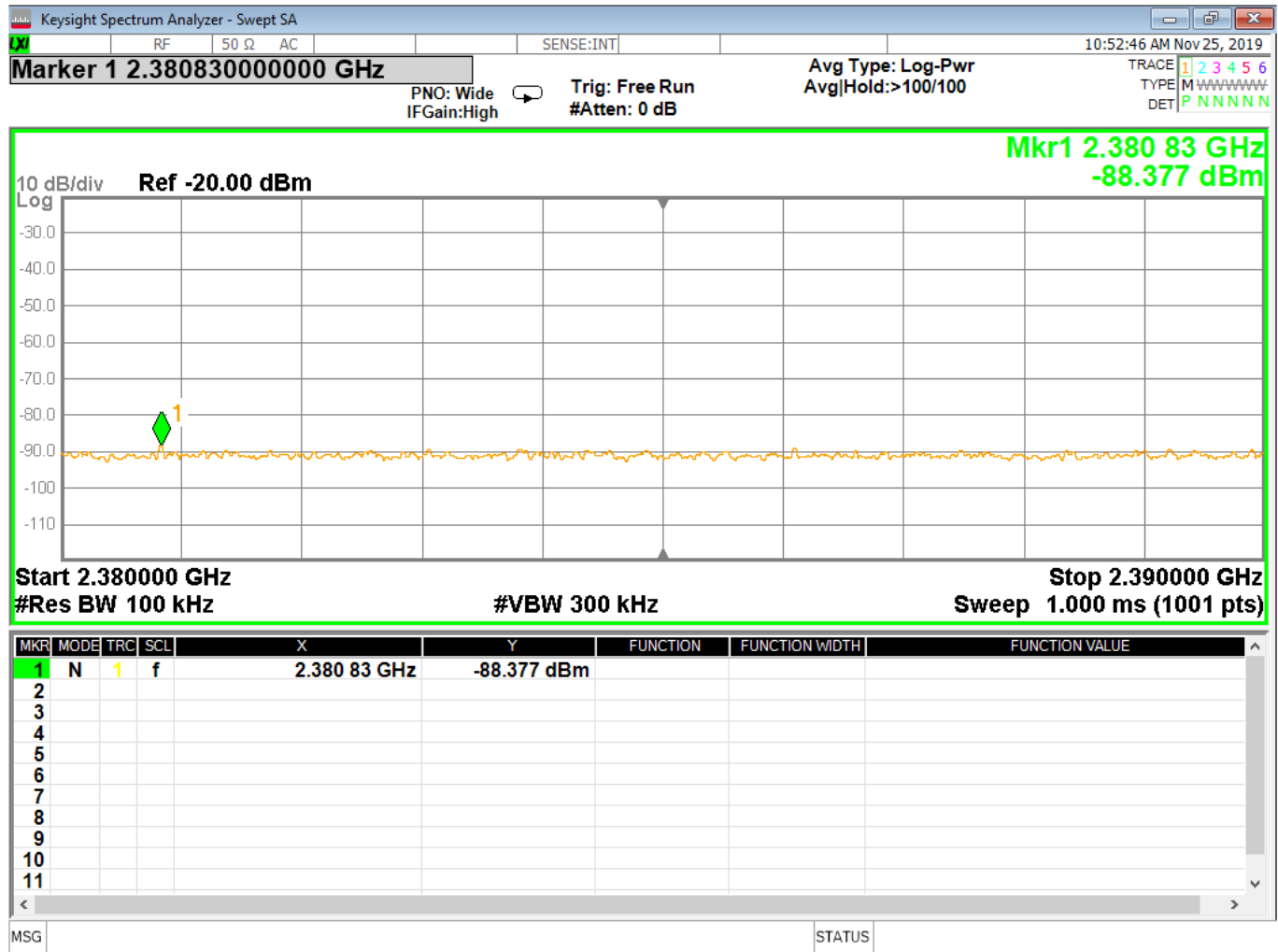


Figure 37 –Band Edge Measurement, Low Channel, Restricted, BT EDR 3MB



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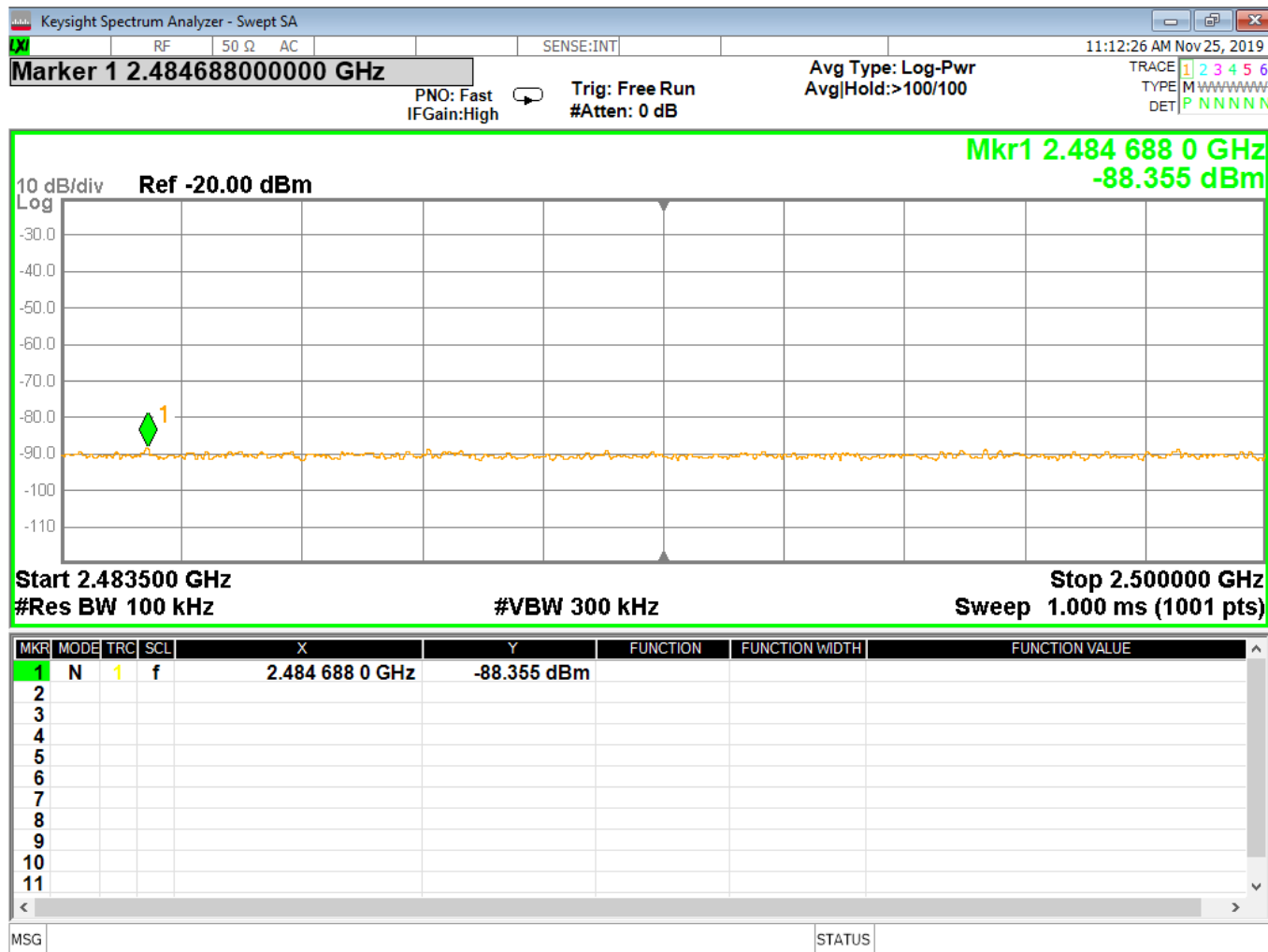


Figure 38 – Band Edge Measurement, High Channel, Restricted, BT EDR 3MB

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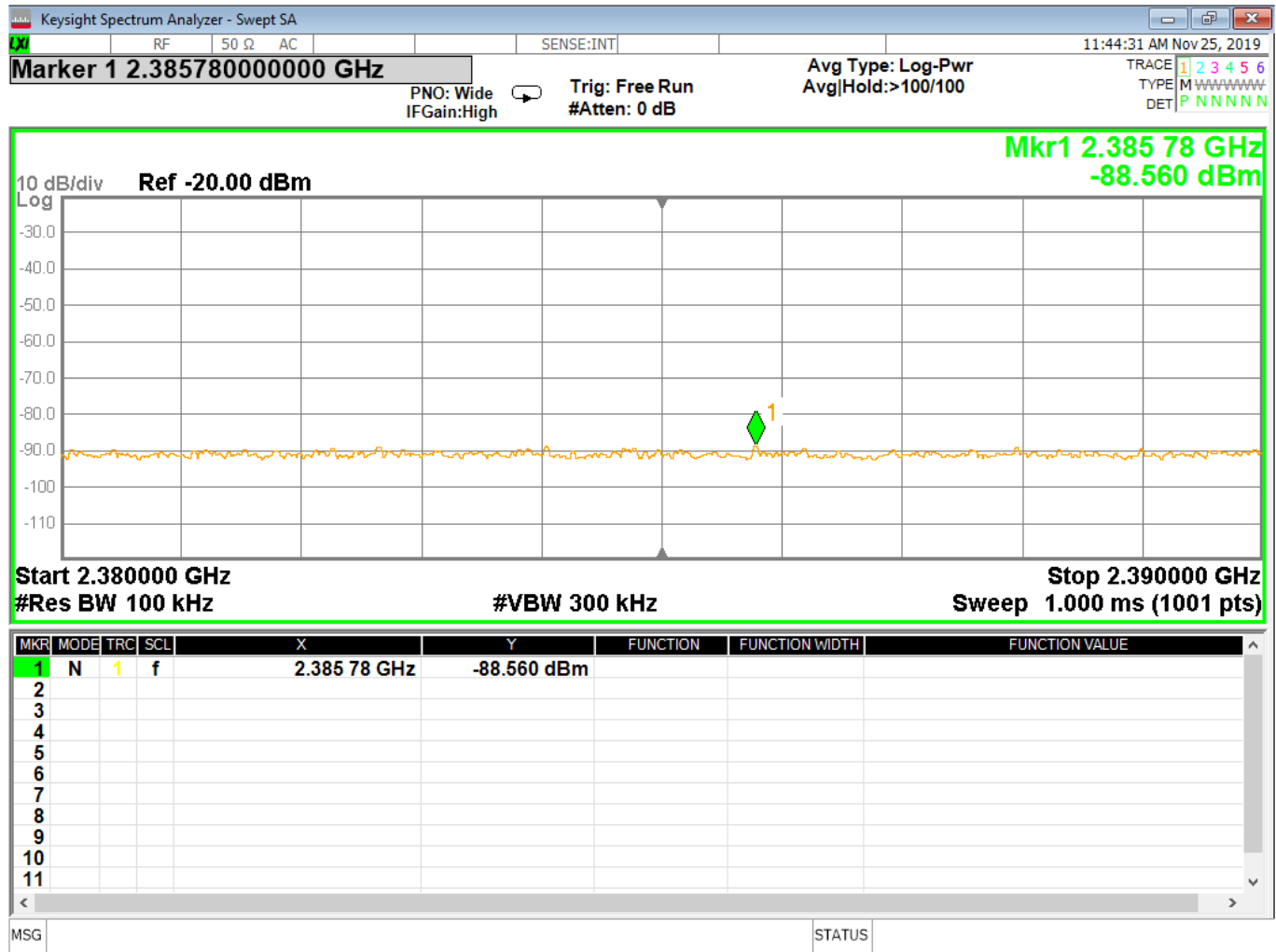


Figure 39 –Band Edge Measurement, Low Channel, Restricted, ANT



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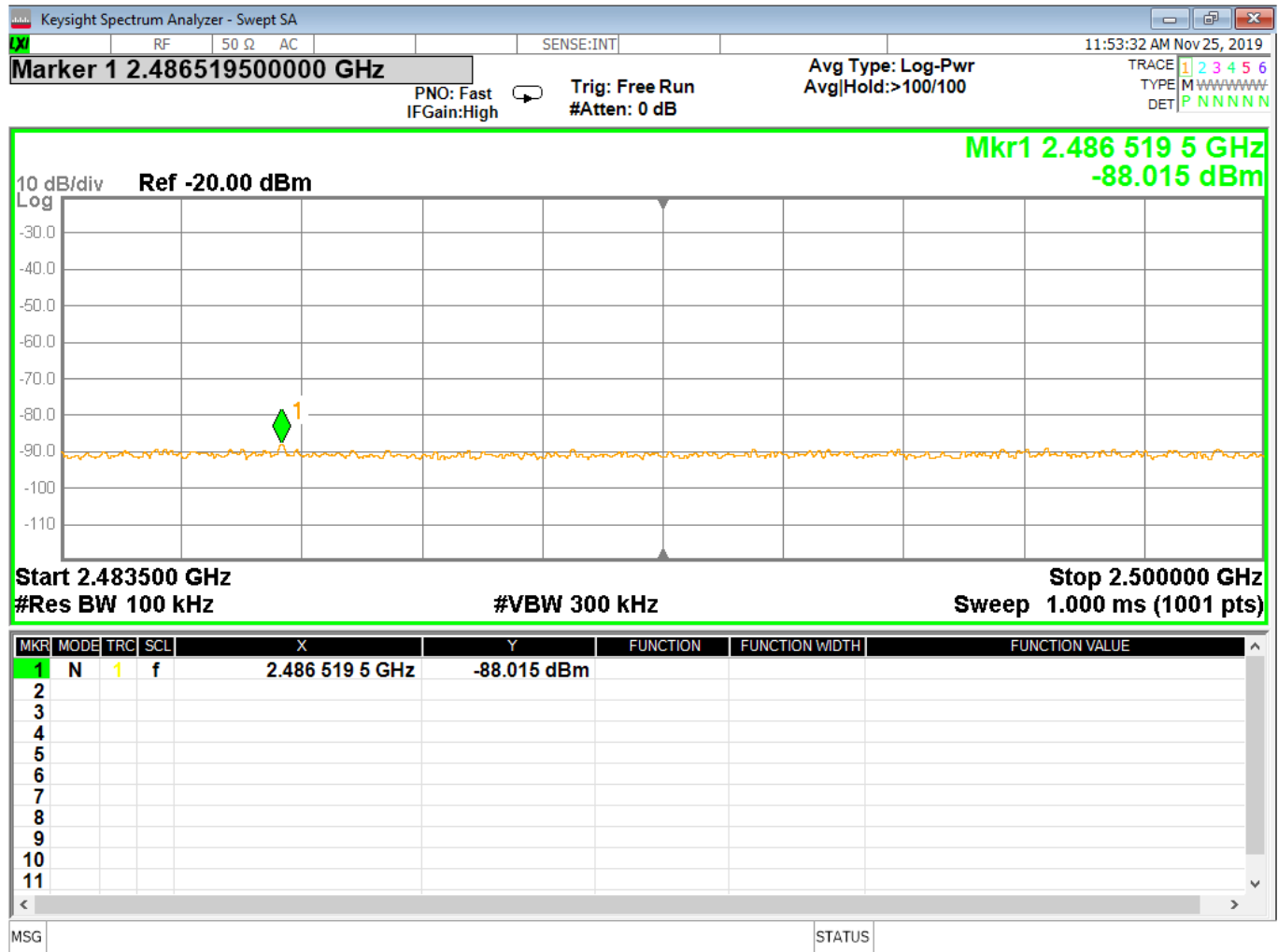


Figure 40 – Band Edge Measurement, High Channel, Restricted, ANT

4.6 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 (dB μ V)	
	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

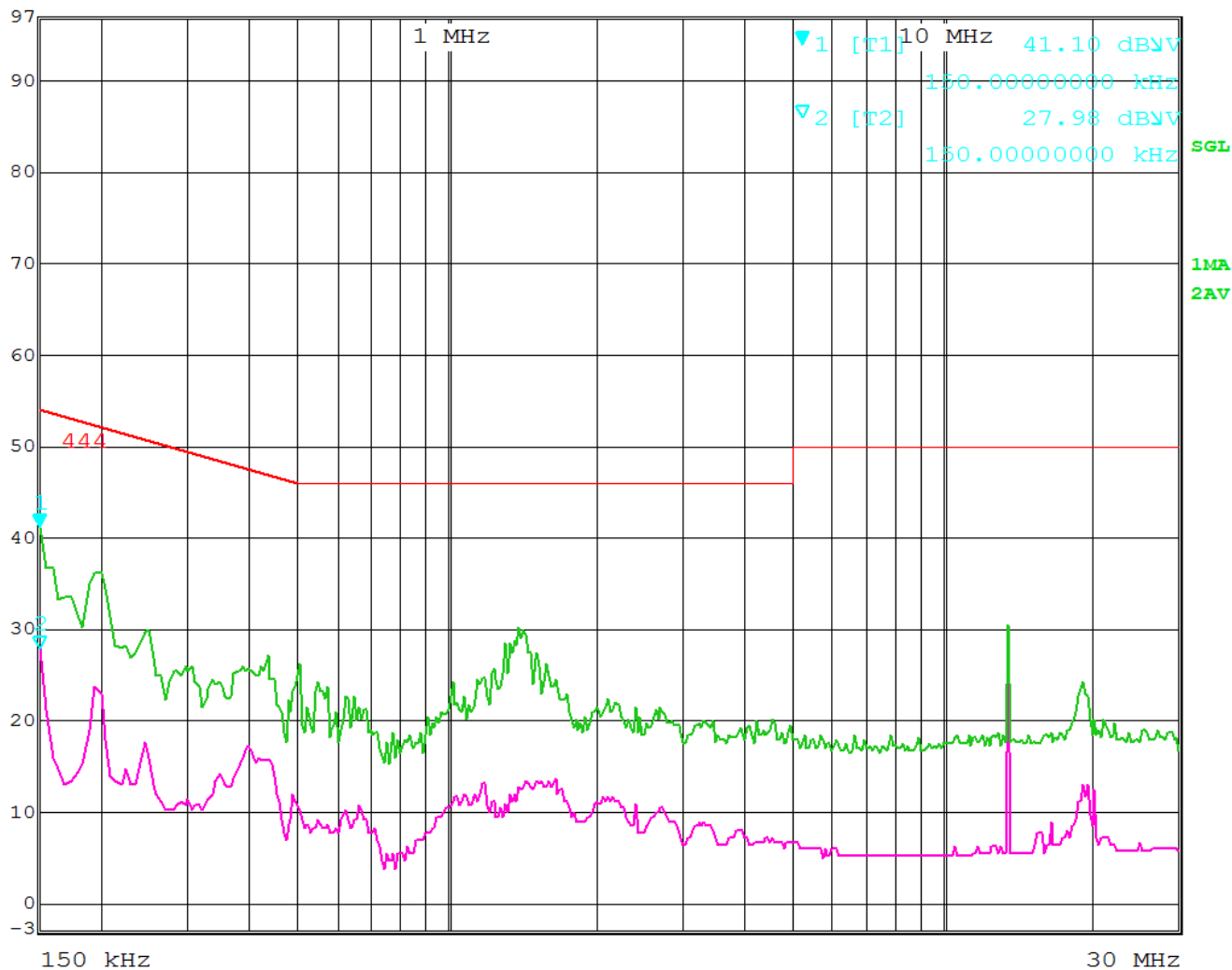
EUT operating conditions:

The EUT was powered by 5 VDC unless specified and set to transmit continuously on the middle channel.

Test Results:



Marker 1 [T1] Det AV Trd ES-K1
Att 10 dB AUTO 41.10 dBV ResBW 9 kHz
INPUT 2 150.0000000 kHz Meas T 100 ms Unit dBV



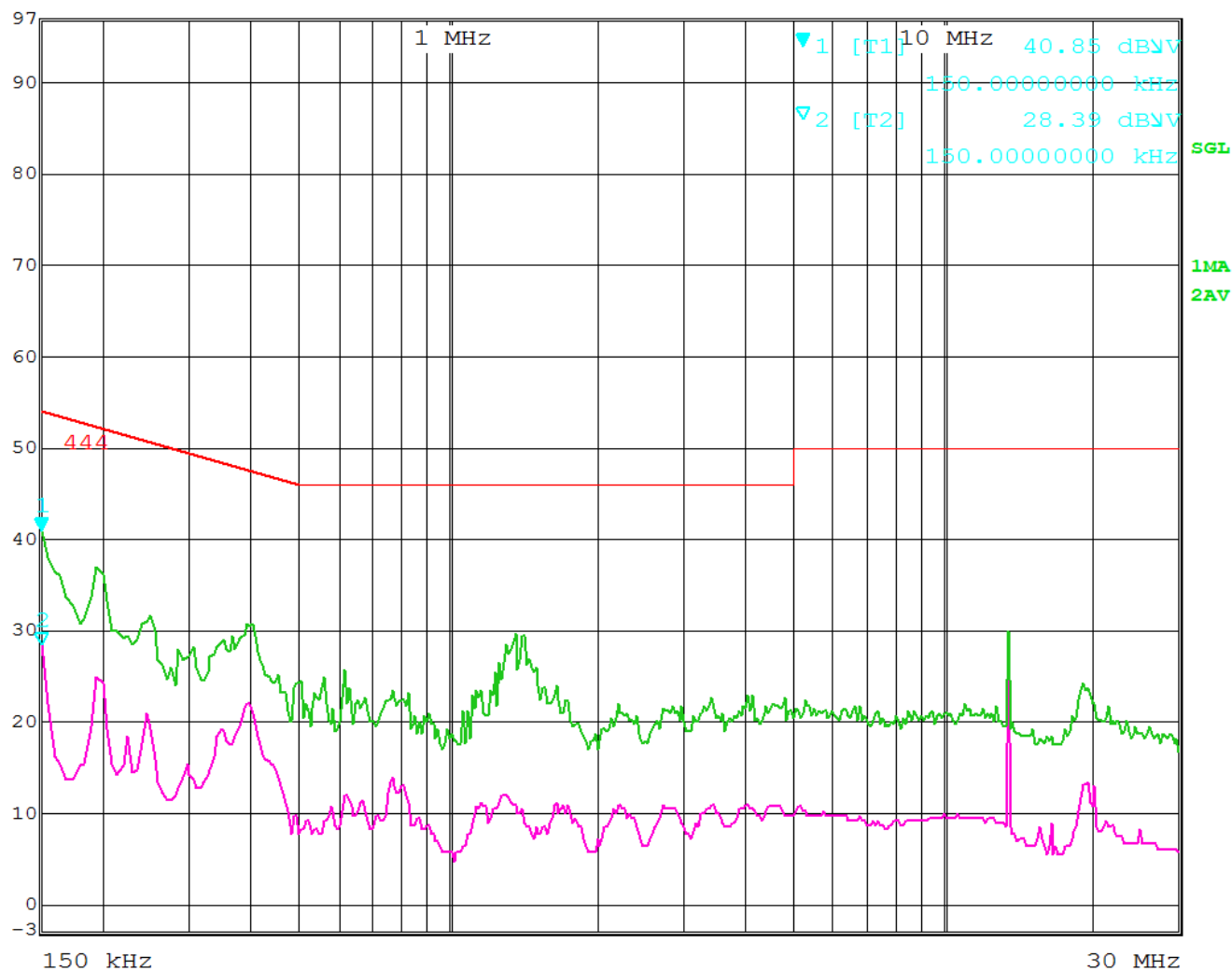
Date: 20.MAY.2019 10:21:56

Figure 41 - Conducted Emissions Plot, Line

All Measurements were found to be at least 10 dB below the limits.



Marker 1 [T1] Det AV Trd ES-K1
 Att 10 dB AUTO 40.85 dBV ResBW 9 kHz
 INPUT 2 150.00000000 kHz Meas T 100 ms Unit dBV



Date: 20.MAY.2019 10:35:18

Figure 42 - Conducted Emissions Plot, Neutral

All Measurements were found to be at least 10 dB below the limits.



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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 dB μ V 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 dB μ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB μ V/m value can be mathematically converted to its corresponding level in μ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm} [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

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



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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;

$$EIRP \text{ (Watts)} = [Field \text{ Strength (V/m)} \times \text{antenna distance (m)}]^2 / 30$$

$$\text{Power (watts)} = 10^{[Power \text{ (dBm)}/10]} / 1000$$

$$\text{Voltage (dB}\mu\text{V)} = \text{Power (dBm)} + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$\text{Field Strength (V/m)} = 10^{[\text{Field Strength (dB}\mu\text{V/m)} / 20]} / 10^6$$

$$\text{Gain} = 1 \text{ (numeric gain for isotropic radiator)}$$

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

$$EIRP = [FS(V/m) \times d^2]/30 = FS [0.3] \quad \text{for } d = 3$$

$$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS(dB\mu V/m) - 95.23$$

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



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APPENDIX B – MEASUREMENT UNCERTAINTY

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

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

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



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