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FCC/ISED Test Report

Prepared for: **Garmin International Inc.**

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

EUT: **A03518**

Test Report No: **R20190221-21-01B**

Approved by:

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

DATE: **4 August 2019**

Total Pages: **65**

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TESTING LABORATORY
CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	21 June 2019	Original – NJohnson Prepared by KVepuri/CFarrington/FLane
A	26 June 2019	Changed EUT name Includes NCEE Labs report R20190221-21-01 and its amendment in full. -NJ
B	26 June 2019	Includes NCEE Labs report R20190221-21-01A and its amendment in full. -NJ

CONTENTS

1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. The EUT has been tested according to the following specifications:

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 15.35 RSS Gen, Issue 4, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 11.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 4, Section 7.1	Conducted Emissions	Pass

See Section 4 for details on the test methods used for each test.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary

The Equipment Under Test (EUT) was a GMSK and GFSK transceiver manufactured by GARMIN inc.

EUT	A03518
EUT Received	11 April 2019
EUT Tested	11 April 2019- 14 June 2019
Serial No.	3990382611* (conducted unit for ANT); 3990943259a** (conducted unit for BLE); NCEETEST01* (assigned, radiated unit for ANT); NCEETEST02** (assigned, radiated unit for BLE)
Operating Band	2400 – 2483.5 MHz
Device Type	GMSK, GFSK
Power Supply	5 VDC from Garmin (Phi Hong) MN: PSAI10R-050Q (Representative Power Supply)

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

2.2 DESCRIPTION OF TEST MODES

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

Channel	Frequency
Low	2402 MHz
Mid	2440 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 of battery power.

2.3 DESCRIPTION OF SUPPORT UNITS

N/A

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 ± 4%
Temperature of 22 ± 3° 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	Fox Lane	Test Technician	Testing and report
4	Caleb Farrington	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
Rohde & Schwarz Test Receiver	ES126	100037	30 Jan 2018	30 Jan 2020
Keysight EXA Signal Analyzer	N9010A	MY56070862	14 Dec 2018	14 Dec 2020
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2019
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2020
EMCO Horn Antenna	3116	2576	31 Jan 2018	31 Jan 2020
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2020*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2020*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	26 Jul 2018	26 Jul 2019
Rohde & Schwarz Test Software	ES-K1	12575	NA	NA
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2020*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2020*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2020*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2020*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2020*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2020*

*Internal Characterization

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

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Test Method: NA

4.2 OUTPUT POWER

Test Method: ANSI C63.10:

1. Section(s) 11.9.1.1 “RBW ≥ DTS Bandwidth”

Limits of power measurements:
The maximum allowed peak output power is 30 dBm.

Test procedures:
The EUT was connected to a spectrum analyzer directly with a low-loss shielded coaxial cable with 8 MHz RBW and 50 MHz VBW. The intention was to verify that the measurement results were the same as the original filing for this device within the measurement uncertainty of the laboratory.

Deviations from test standard:
No deviation.

Test setup:

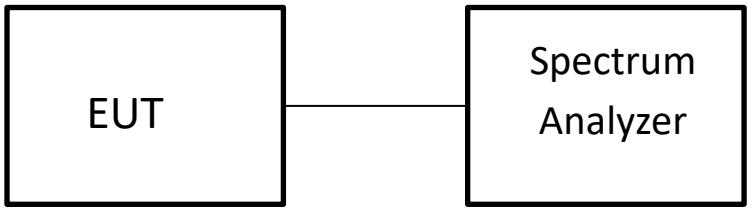

Figure 1 – Peak Output Power Measurements Test Setup

EUT operating conditions:
The EUT was powered by 5 VDC 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 indicated modulation.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	PEAK OUTPUT POWER (mW)	Method	RESULT	Transmitter
Low	2402	8.464	7.021	Conducted	PASS	GMSK
Mid	2440	8.439	6.981	Conducted	PASS	GMSK
High	2480	8.430	6.966	Conducted	PASS	GMSK
Low	2402	9.192	8.302	Conducted	PASS	GFSK
Mid	2440	9.065	8.063	Conducted	PASS	GFSK
High	2480	8.961	7.872	Conducted	PASS	GFSK

Average Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	AVERAGE OUTPUT POWER (dBm)	AVERAGE OUTPUT POWER (mW)	Method	RESULT	Transmitter
Low	2402	7.804	6.031	Conducted	PASS	GMSK
Mid	2440	7.795	6.019	Conducted	PASS	GMSK
High	2480	7.781	5.999	Conducted	PASS	GMSK
Low	2402	8.517	7.107	Conducted	PASS	GFSK
Mid	2440	8.161	6.548	Conducted	PASS	GFSK
High	2480	8.187	6.587	Conducted	PASS	GFSK

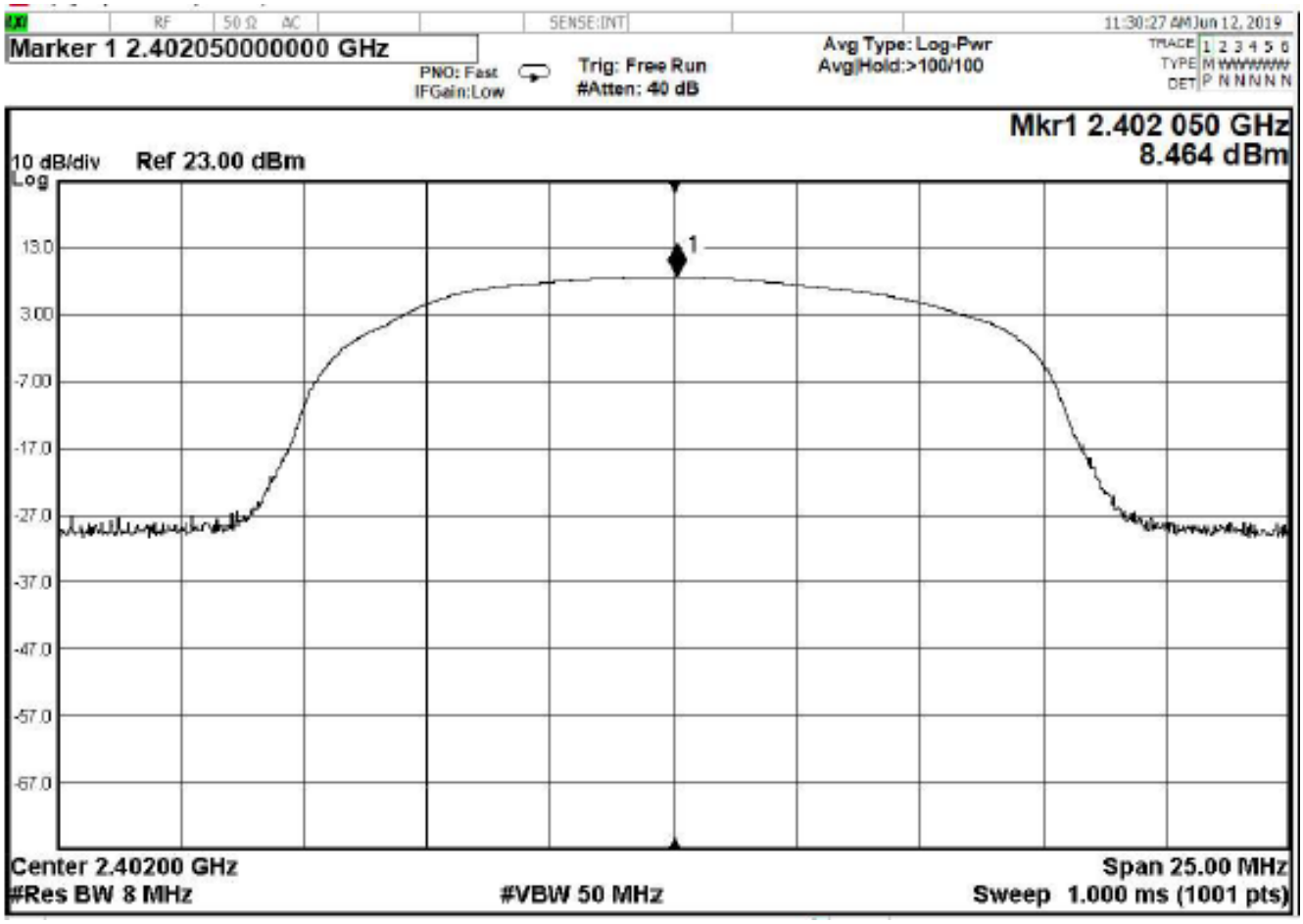

Figure 2 – Peak Output Power, Low Channel, GMSK

Output power = 8.464 dBm

Cable loss was less than 0.1 dB and not included

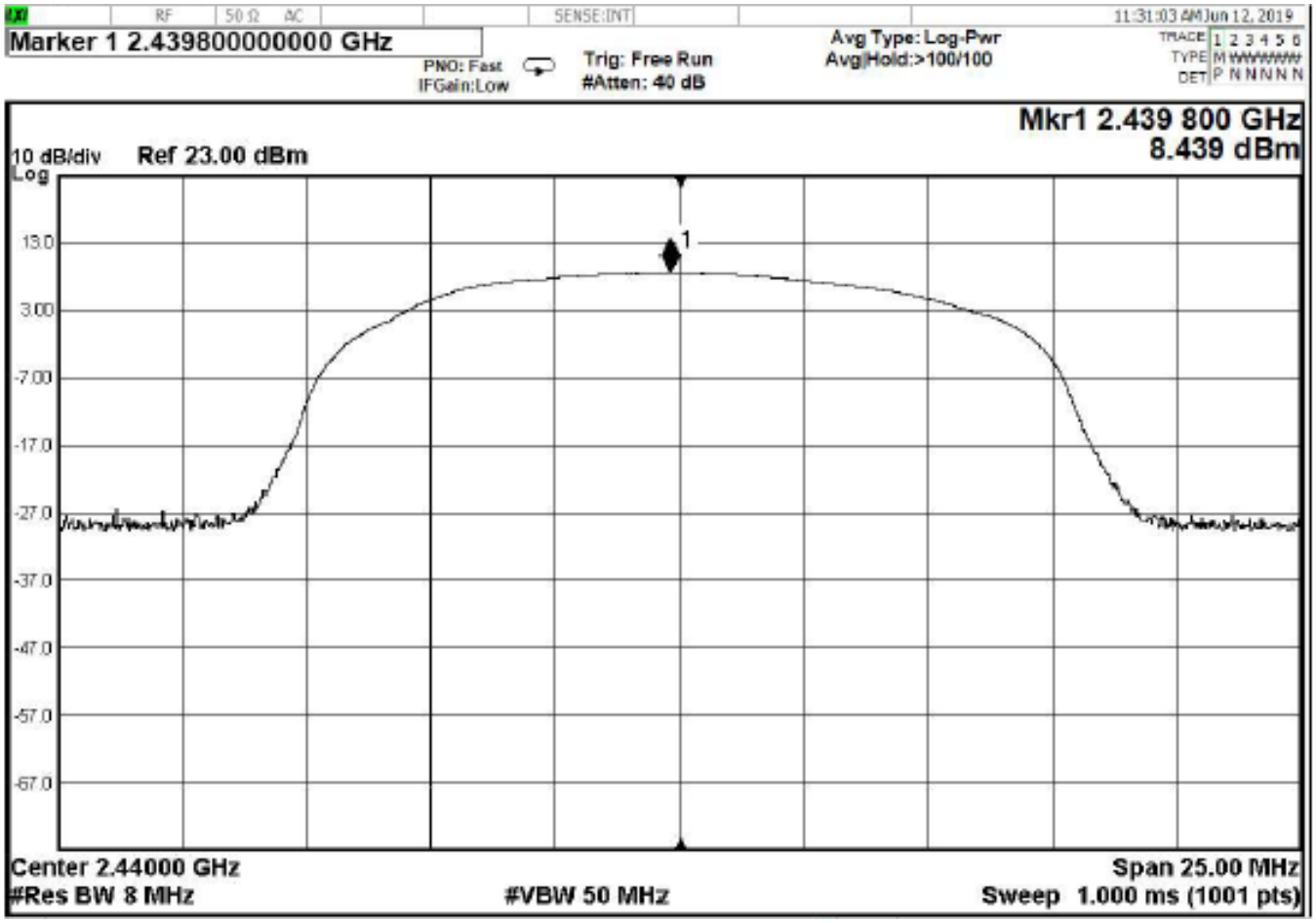

Figure 3 – Peak Output Power, Mid Channel, GMSK

Output power = 8.439 dBm

Cable loss was less than 0.1 dB and not included

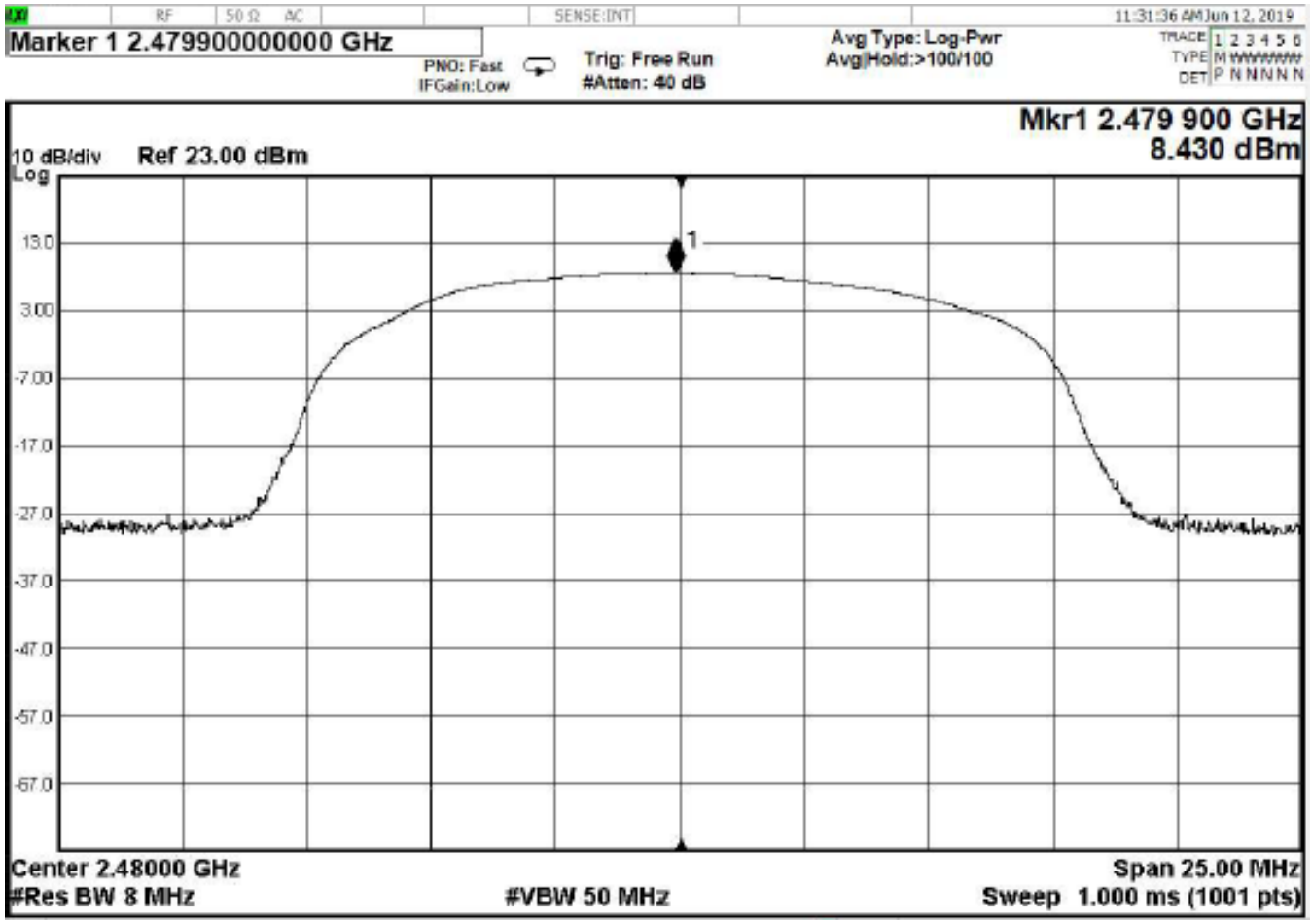

Figure 4 – Peak Output Power, High Channel, GMSK

Output power = 8.430 dBm

Cable loss was less than 0.1 dB and not included

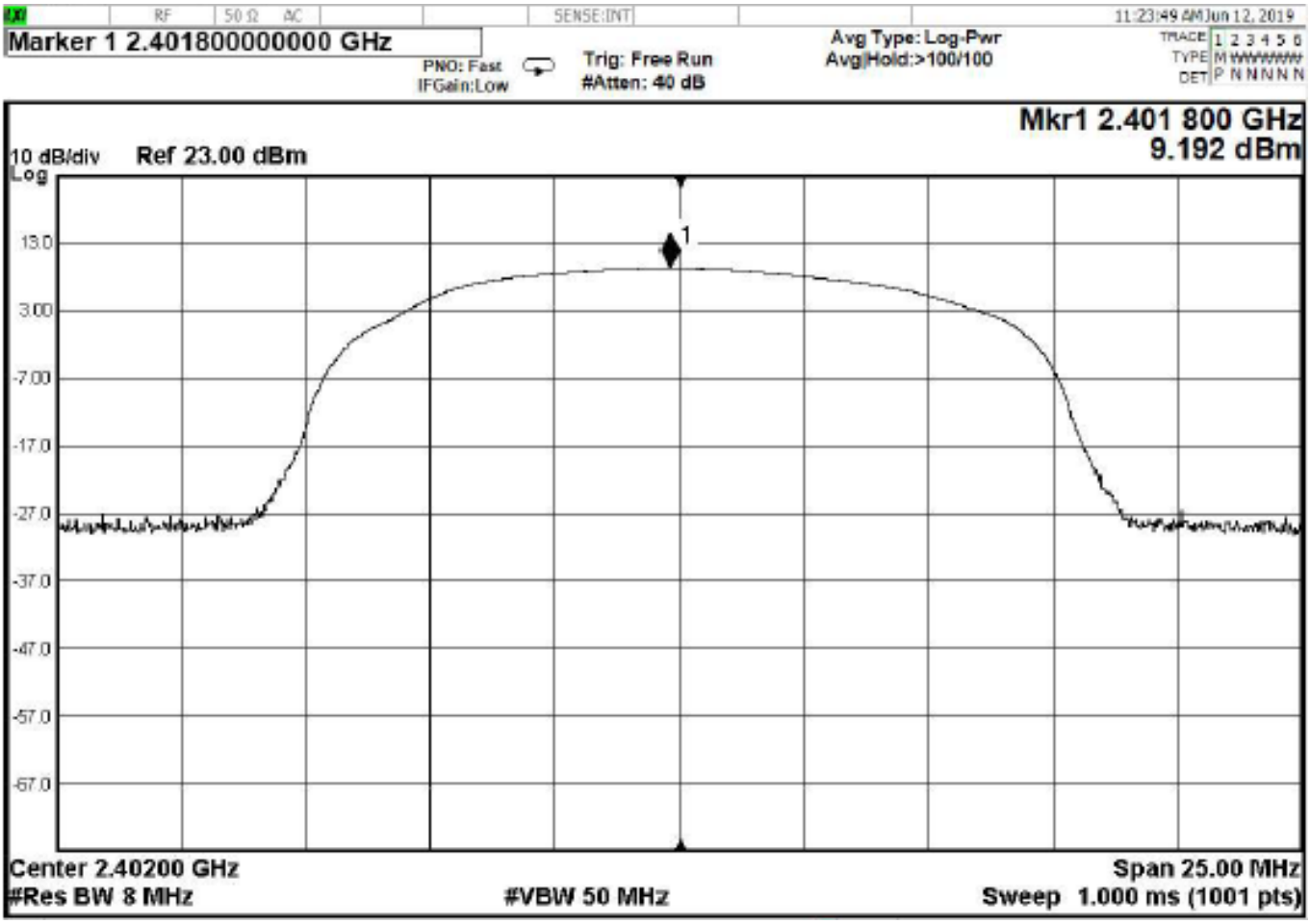

Figure 5 – Peak Output Power, Low Channel, GFSK

Output power = 9.192 dBm

Cable loss was less than 0.1 dB and not include.

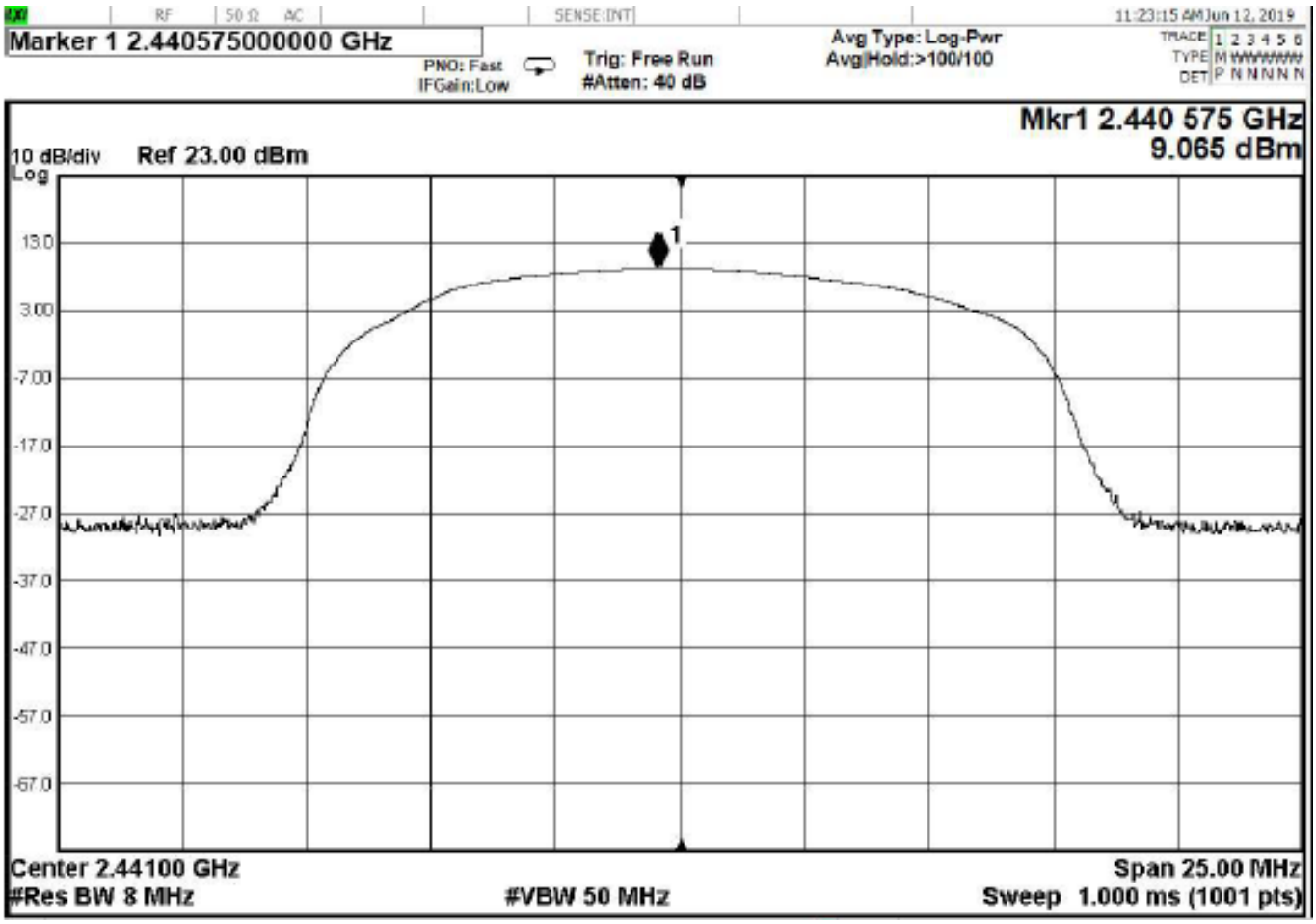

Figure 6 – Peak Output Power, Mid Channel, GFSK

Output power = 9.065 dBm

Cable loss was less than 0.1 dB and not included

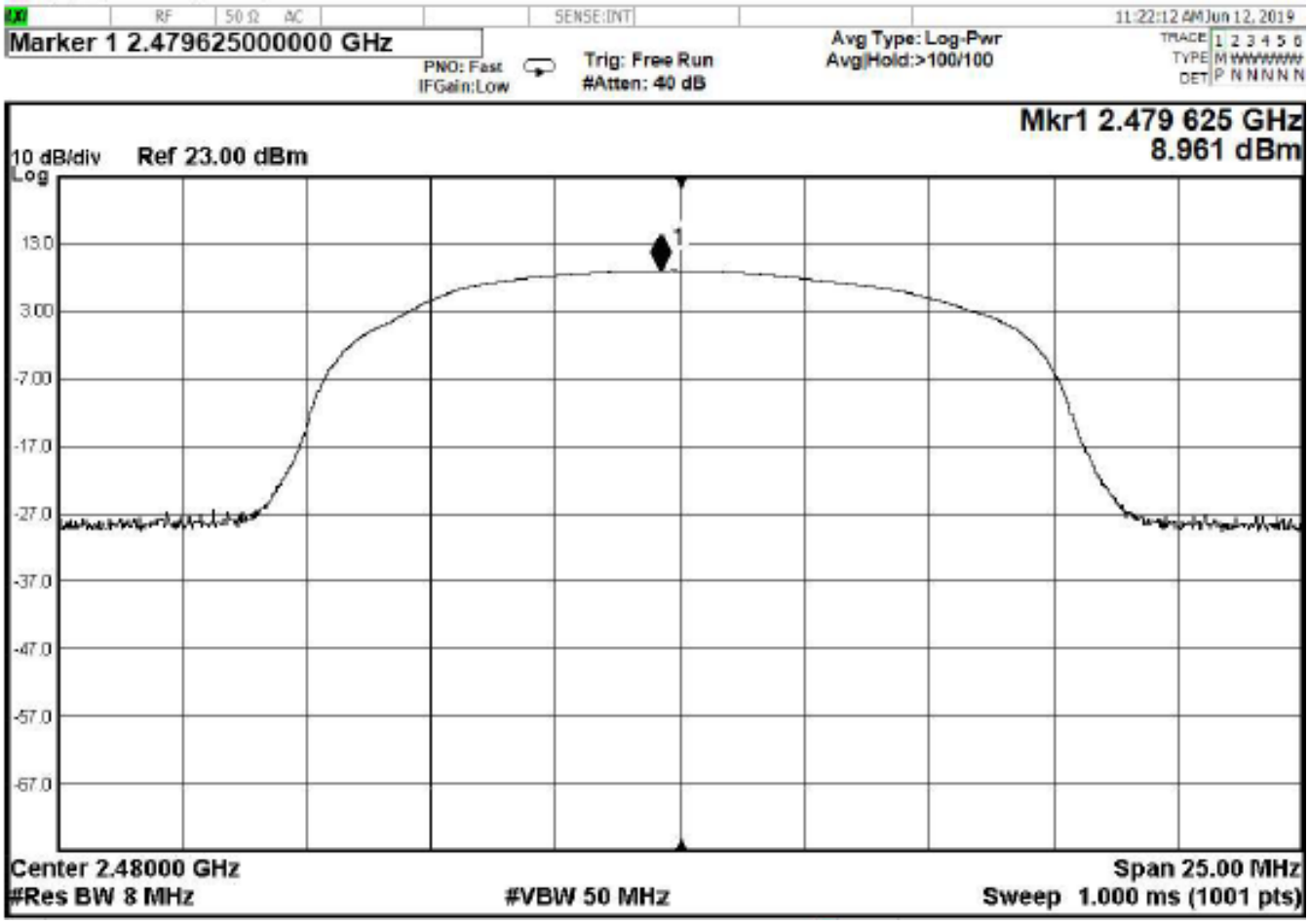

Figure 7 – Peak Output Power, High Channel, GFSK

Output power = 8.961 dBm

Cable loss was less than 0.1 dB and not included

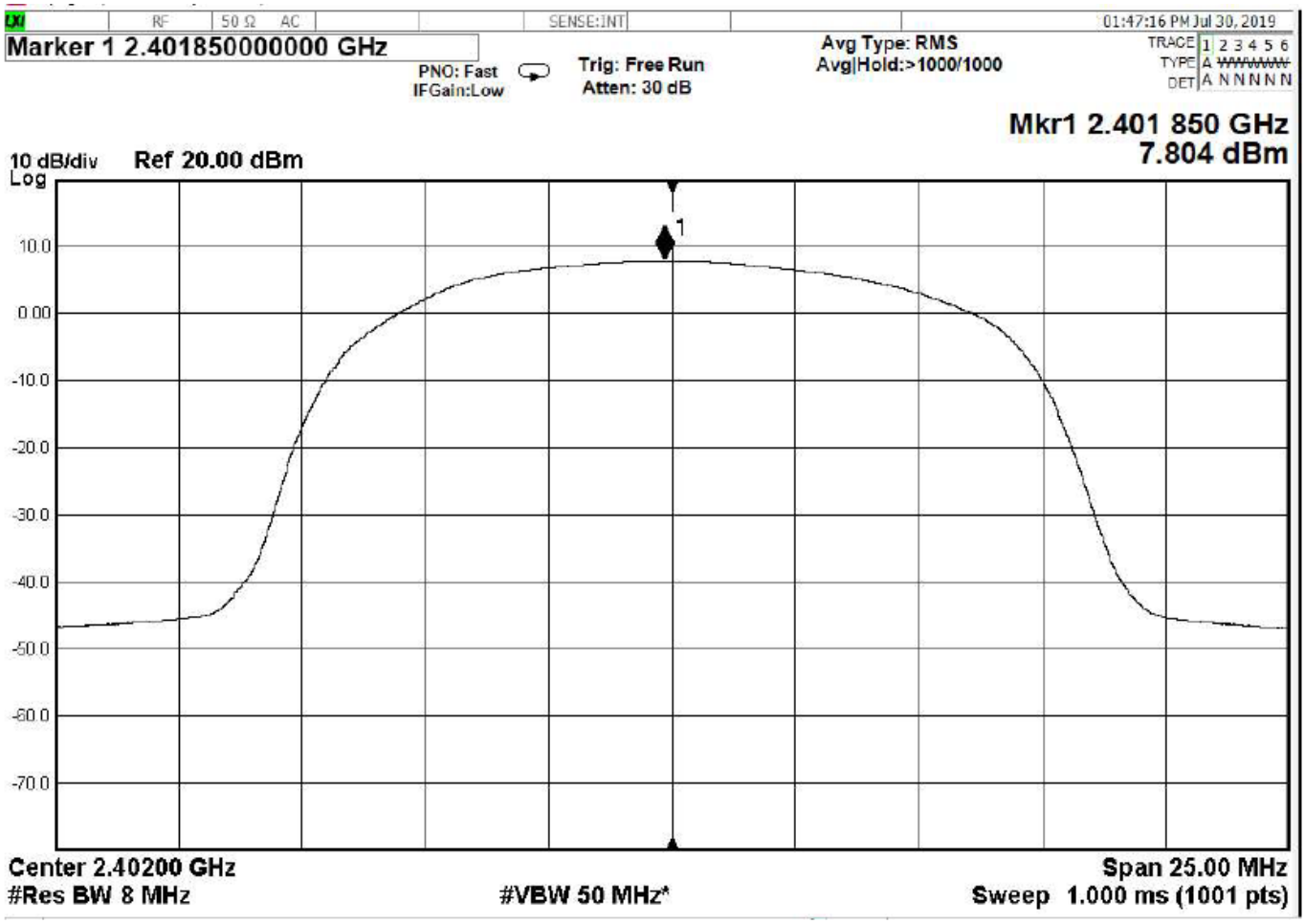

Figure 8 – Average Output Power, Low Channel, GMSK

Output power = 7.804 dBm

Cable loss was less than 0.1 dB and not included

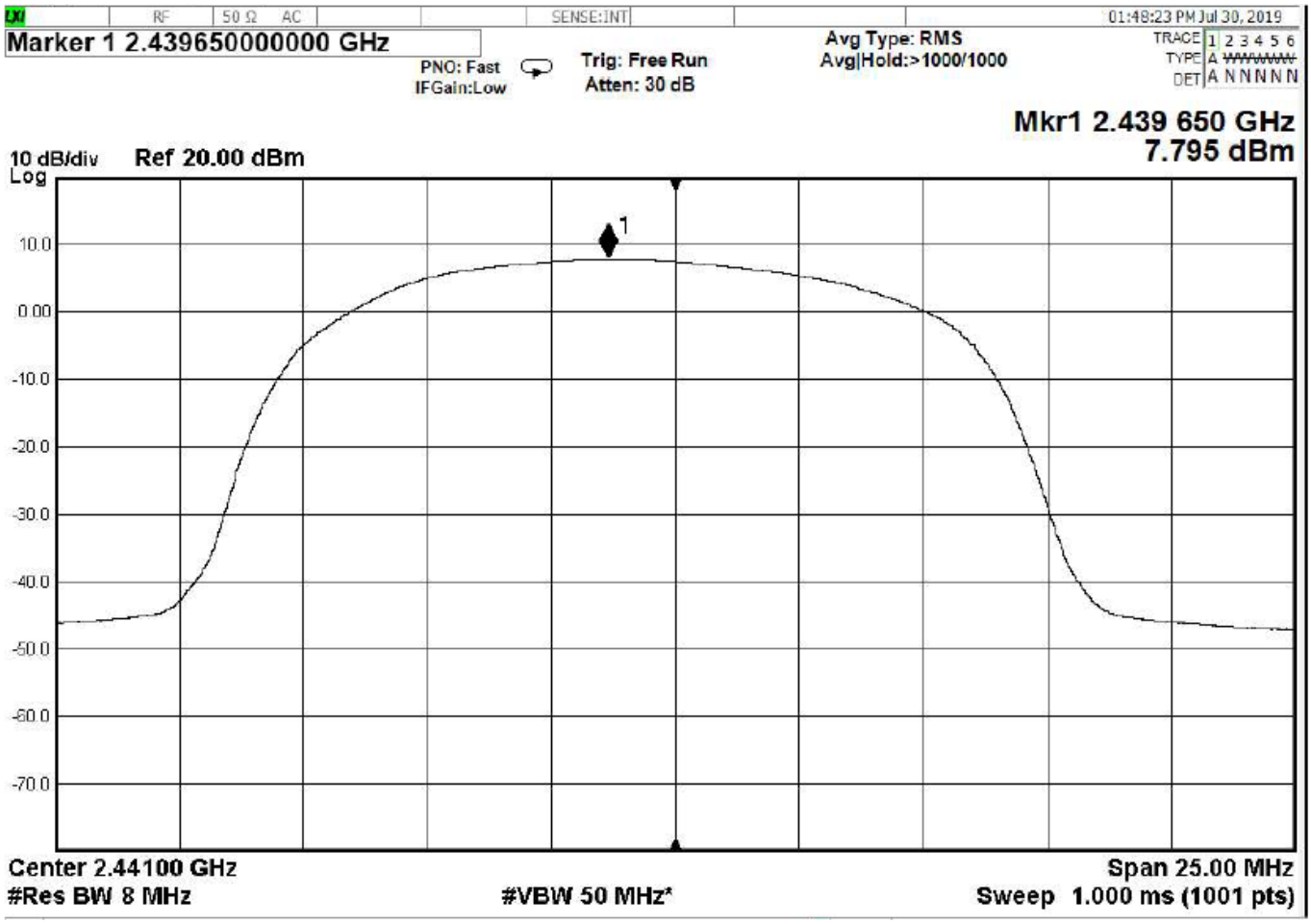

Figure 9 – Average Output Power, Mid Channel, GMSK

Output power = 7.795 dBm

Cable loss was less than 0.1 dB and not included

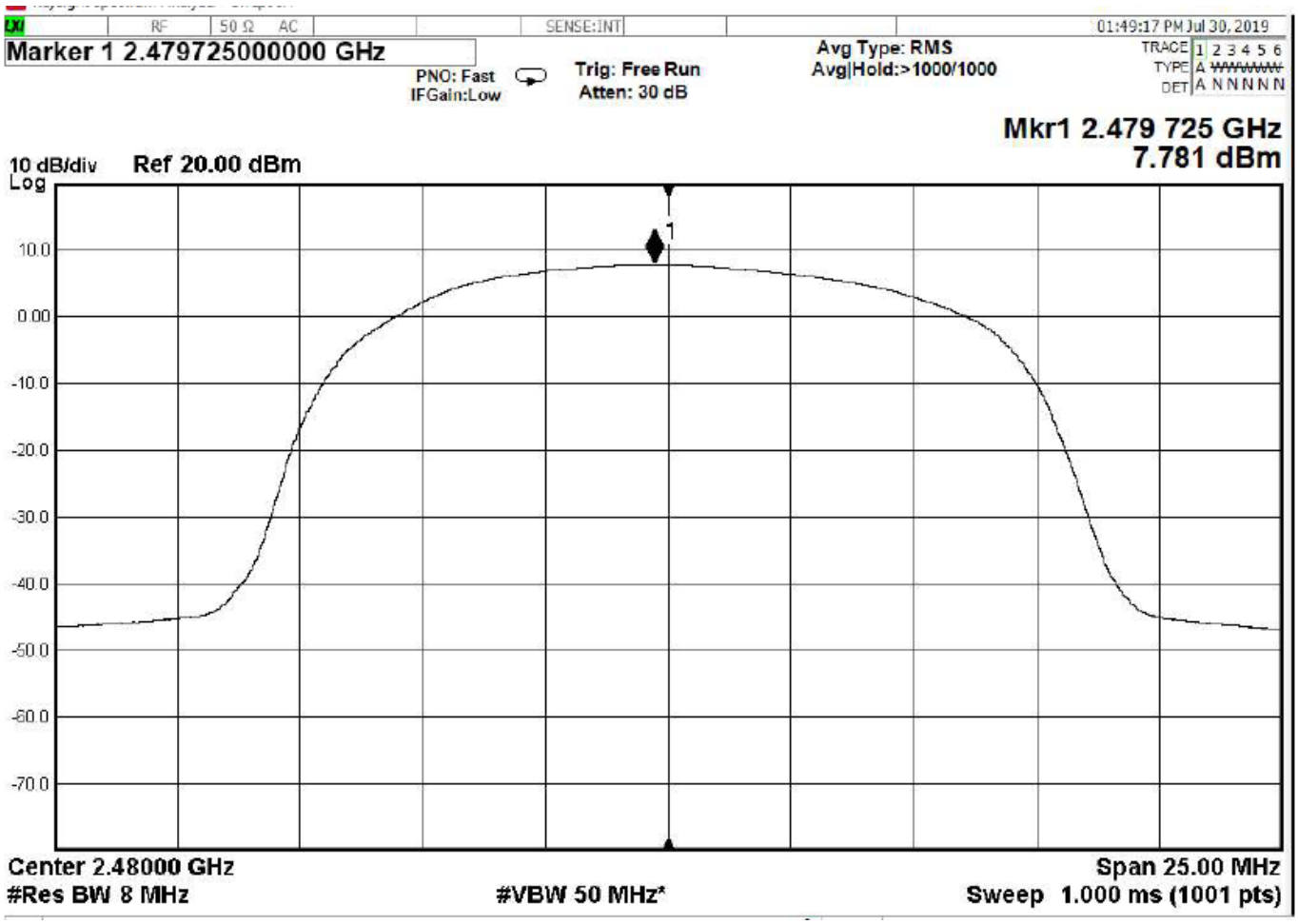

Figure 10 – Average Output Power, High Channel, GMSK

Output power = 7.781 dBm

Cable loss was less than 0.1 dB and not included

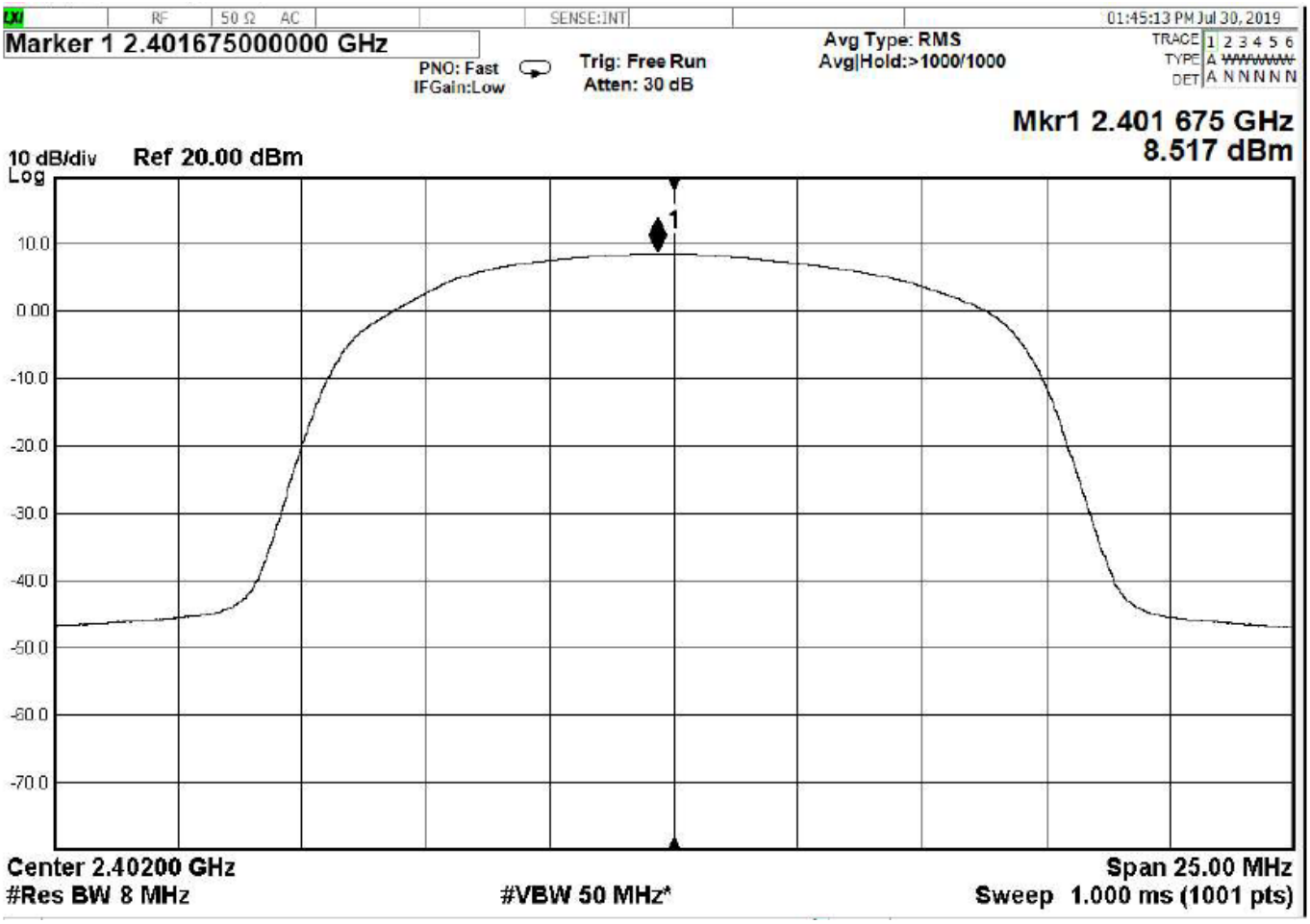

Figure 11 – Average Output Power, Low Channel, GFSK

Output power = 8.517 dBm

Cable loss was less than 0.1 dB and not include.

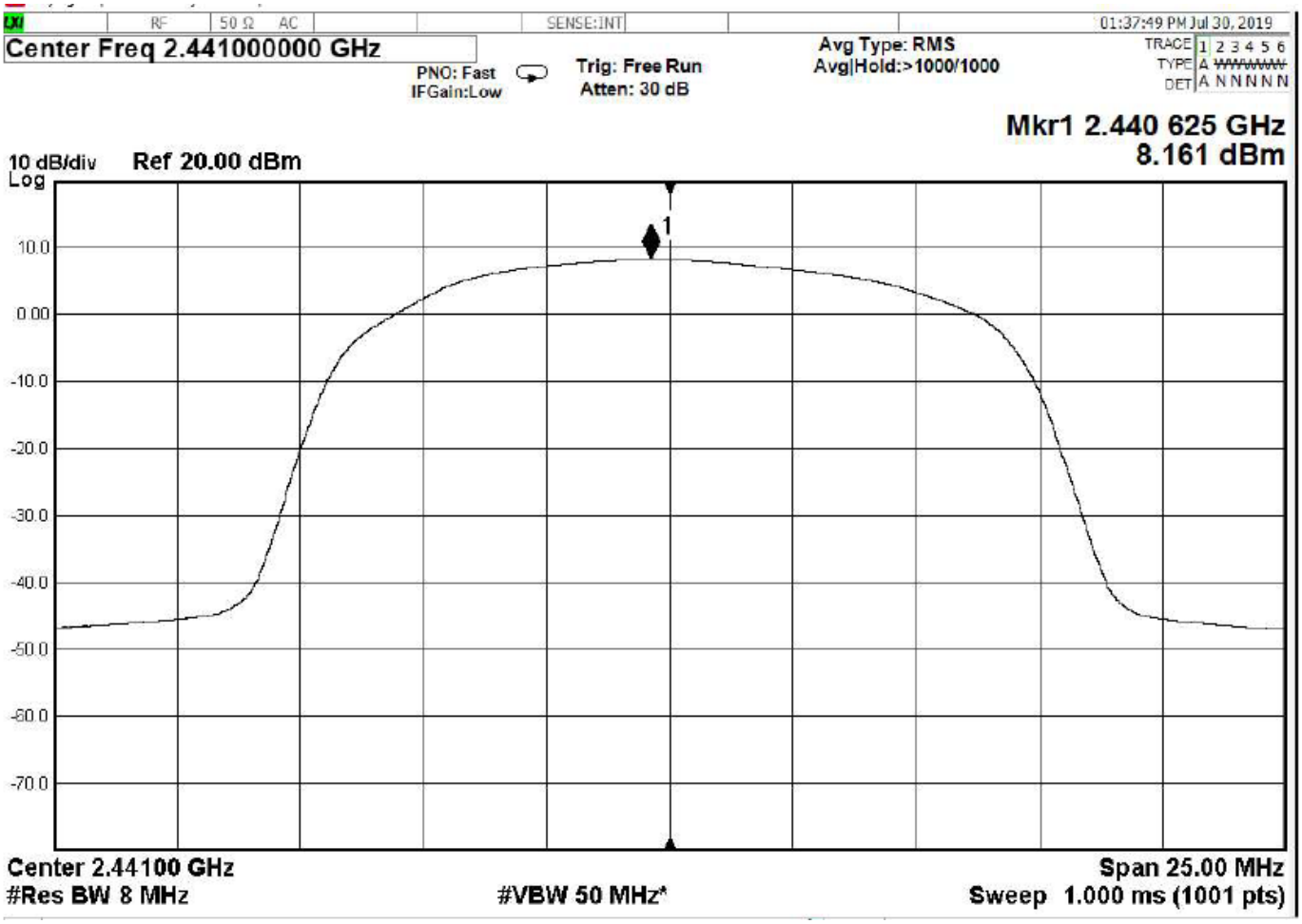

Figure 12 – Average Output Power, Mid Channel, GFSK

Output power = 8.161 dBm

Cable loss was less than 0.1 dB and not included

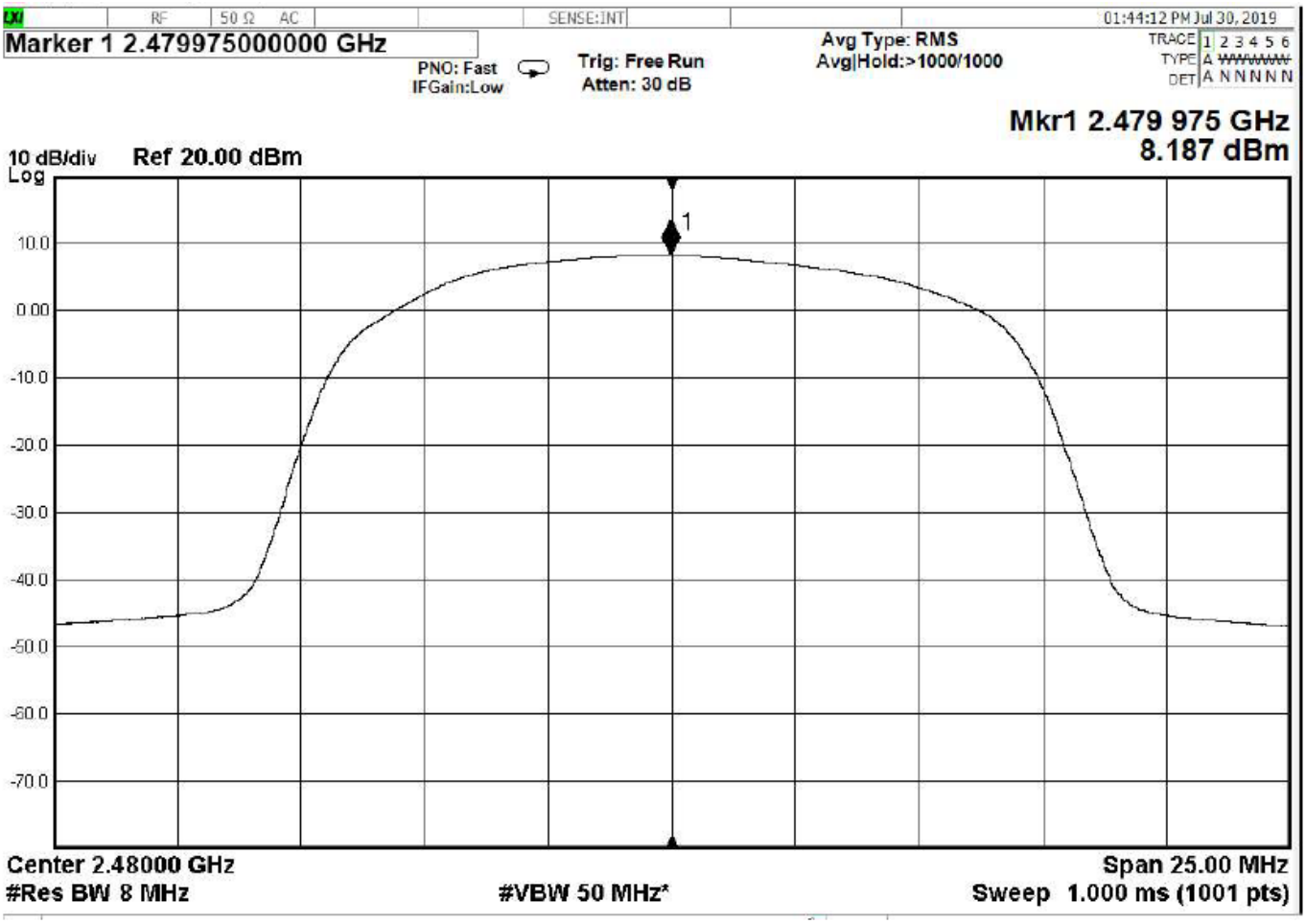

Figure 13 – Average Output Power, High Channel, GFSK

Output power = 8.187 dBm

Cable loss was less than 0.1 dB and not included

4.3 BANDWIDTH

Test Method: ANSI C63.10,
1. Section(s) 11.8.1 “DTS Bandwidth, Option 1”

Limits of bandwidth measurements:
The 99% occupied bandwidth is displayed.

The 6dB bandwidth of the signal must be greater than 500 kHz.

Test procedures:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 300 kHz VBW.

The 99% occupied is defined as the bandwidth at which 99% of the signal power is found. This corresponds to 20dB down from the maximum power level. The maximum power was measured with the largest resolution bandwidth possible (10MHz) and this value was recorded. The signal was then captured with a 1 MHz resolution bandwidth and the frequencies where the measurements were 20dB below the maximum power were marked. The bandwidth between these frequencies was recorded as the 99% occupied bandwidth.

The 6 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 6dB.

For peak output power measurements, the EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable with 3 MHz RBW and 10 MHz VBW.

Deviations from test standard:
No deviation

Test setup:

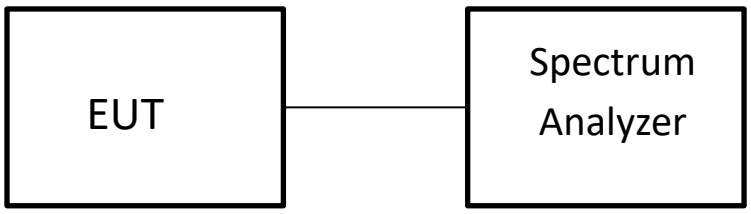

Figure 14 – Peak Output Power Measurements Test Setup

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 indicated modulation.

Test results:

Occupied Bandwidth

CHANNEL	Mode	CHANNEL FREQUENCY (MHz)	OBW (KHz)	RESULT
Low	GMSK	2402	2047.70	PASS
Mid	GMSK	2440	2053.40	PASS
High	GMSK	2480	2057.50	PASS
Low	GFSK	2402	1829.90	PASS
Mid	GFSK	2440	1831.10	PASS
High	GFSK	2480	1833.20	PASS

6dB Bandwidth

CHANNEL	Mode	CHANNEL FREQUENCY (MHz)	OBW (KHz)	RESULT
Low	GMSK	2402	1140.00	PASS
Mid	GMSK	2440	1141.00	PASS
High	GMSK	2480	1147.00	PASS
Low	GFSK	2402	817.20	PASS
Mid	GFSK	2440	820.30	PASS
High	GFSK	2480	815.40	PASS

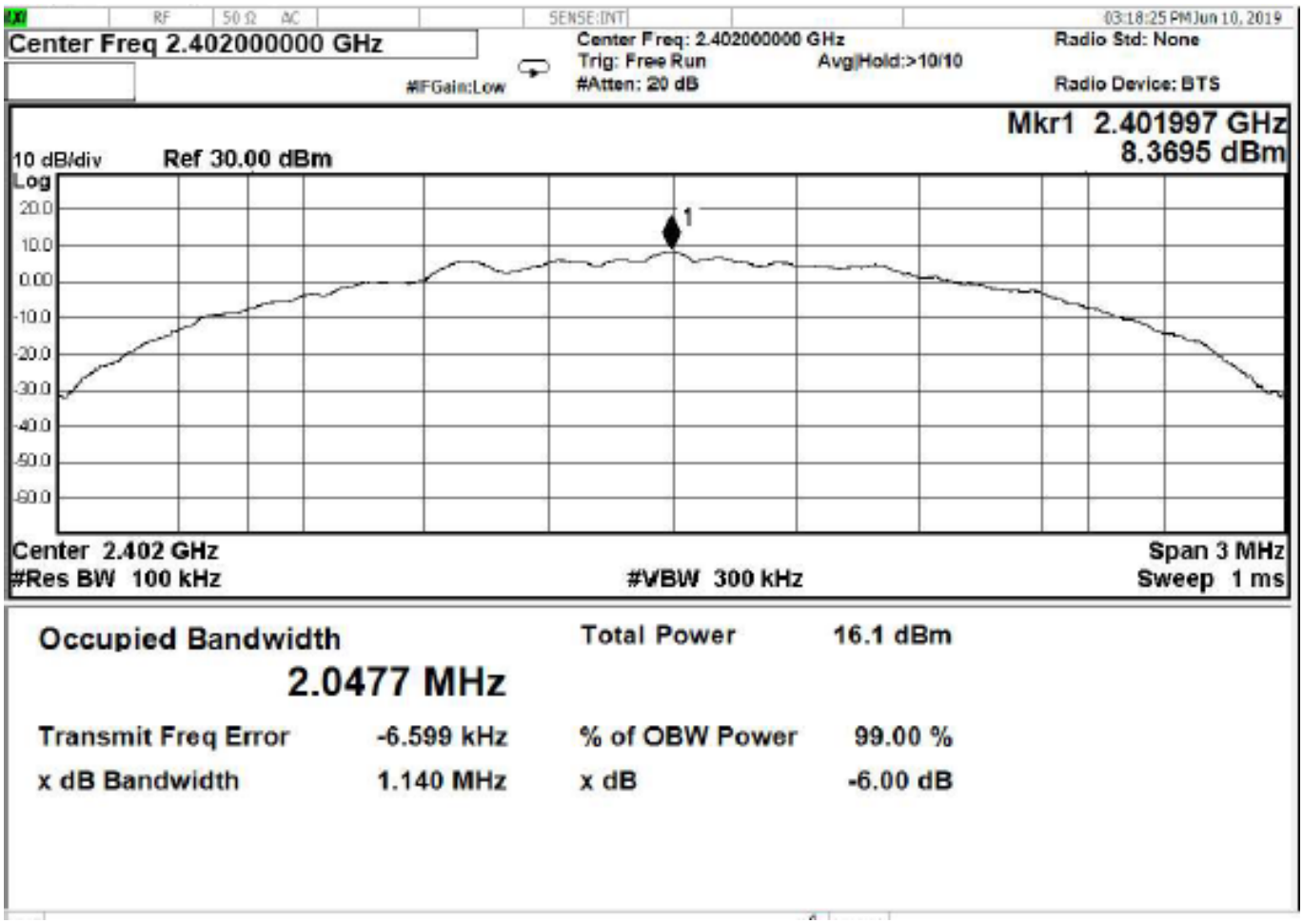

Figure 15 – Occupied Bandwidth and 6dB Bandwidth, Low Channel, GMSK

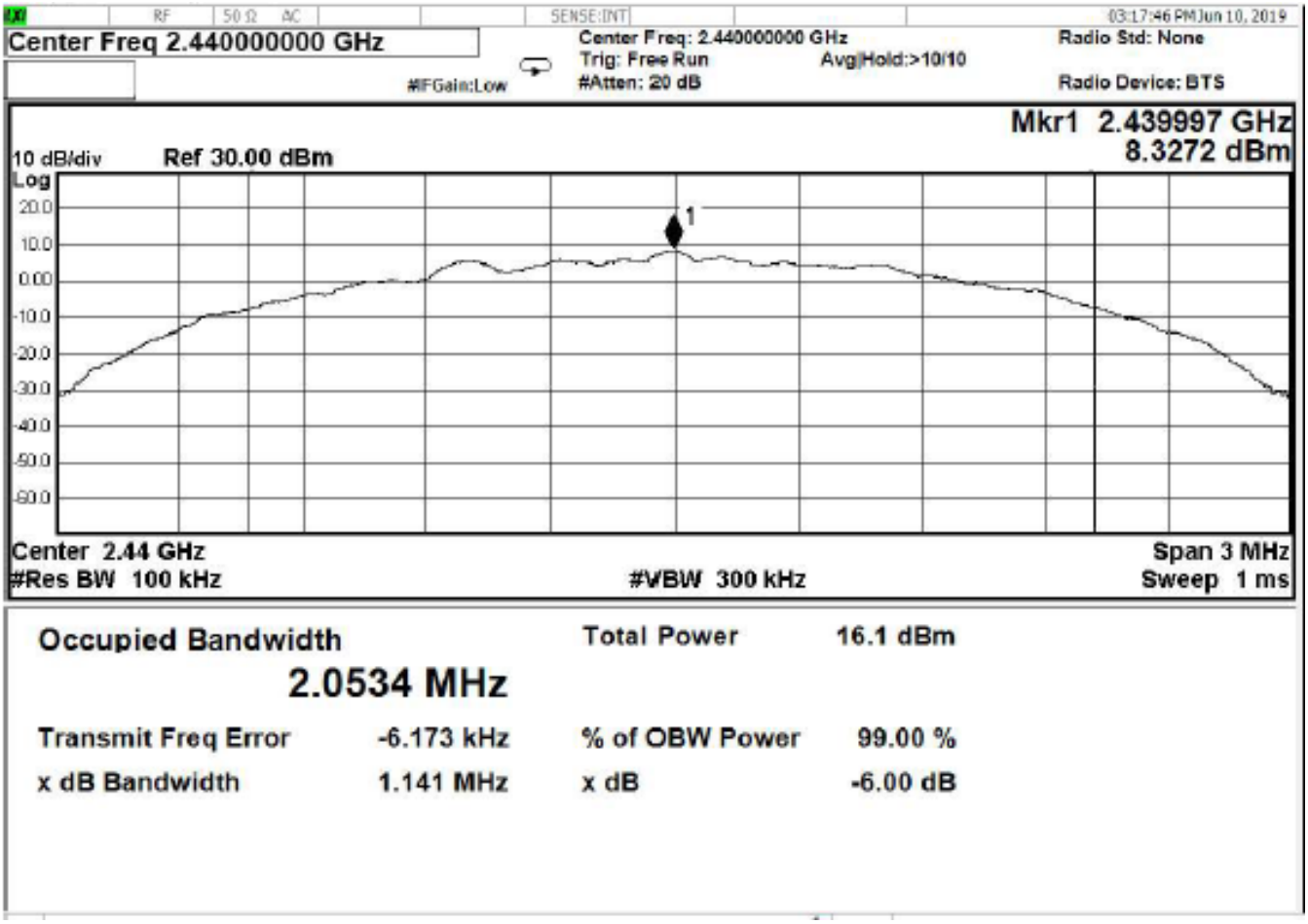

Figure 16 - Occupied Bandwidth and 6dB Bandwidth, Mid Channel, GMSK

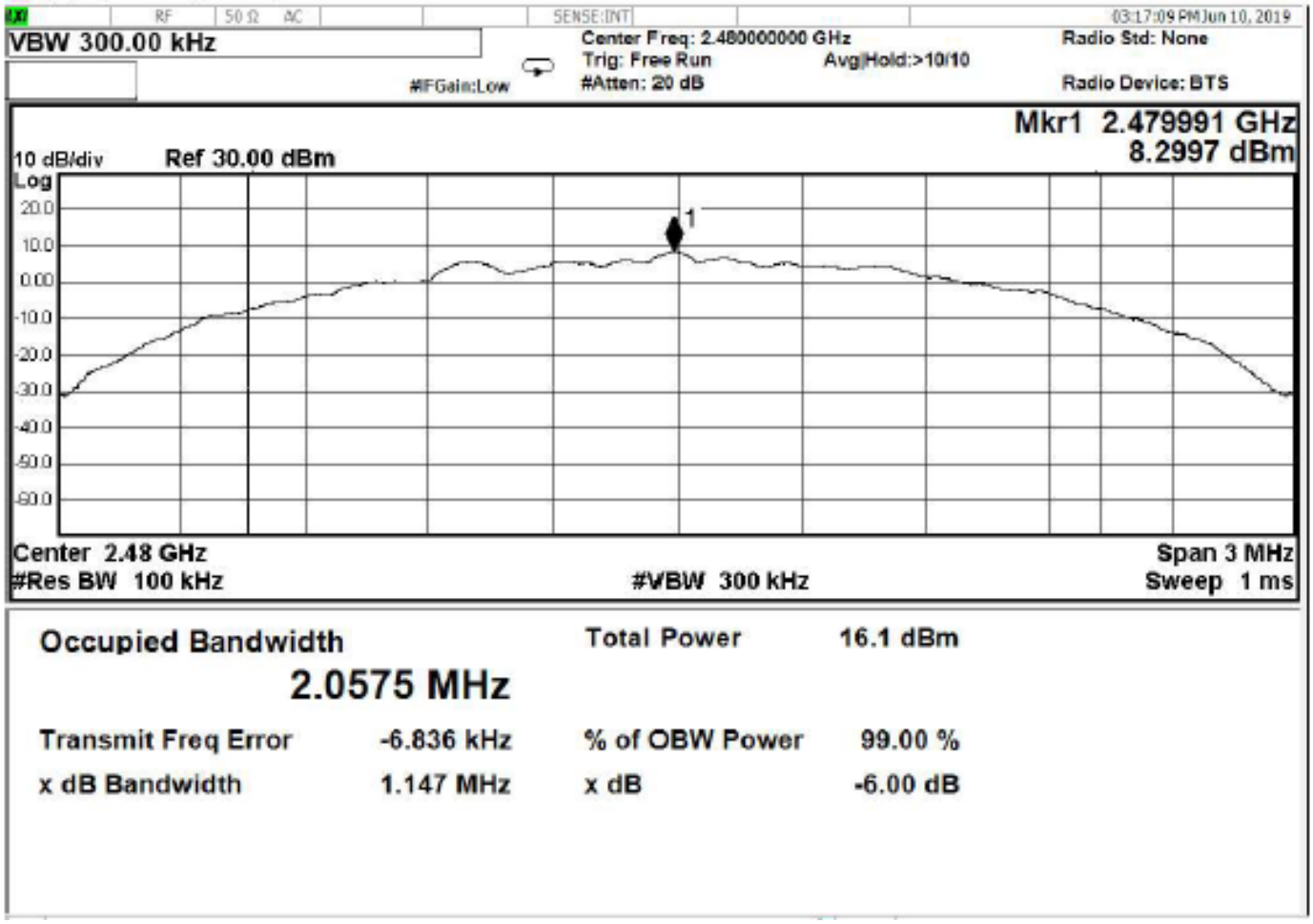

Figure 17 - Occupied Bandwidth and 6dB Bandwidth, High Channel, GMSK

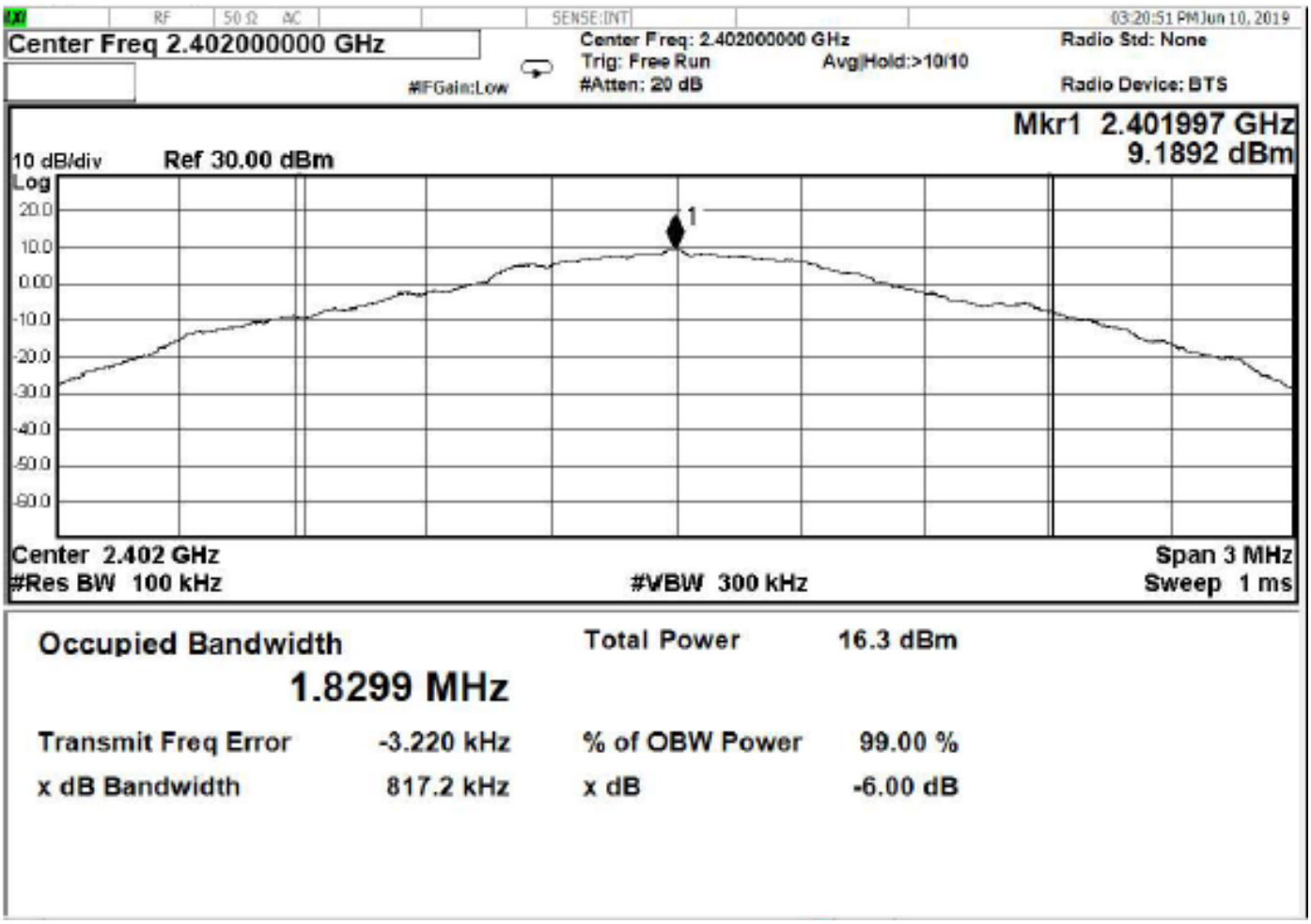

Figure 18 – Occupied Bandwidth and 6dB Bandwidth, Low Channel, GFSK

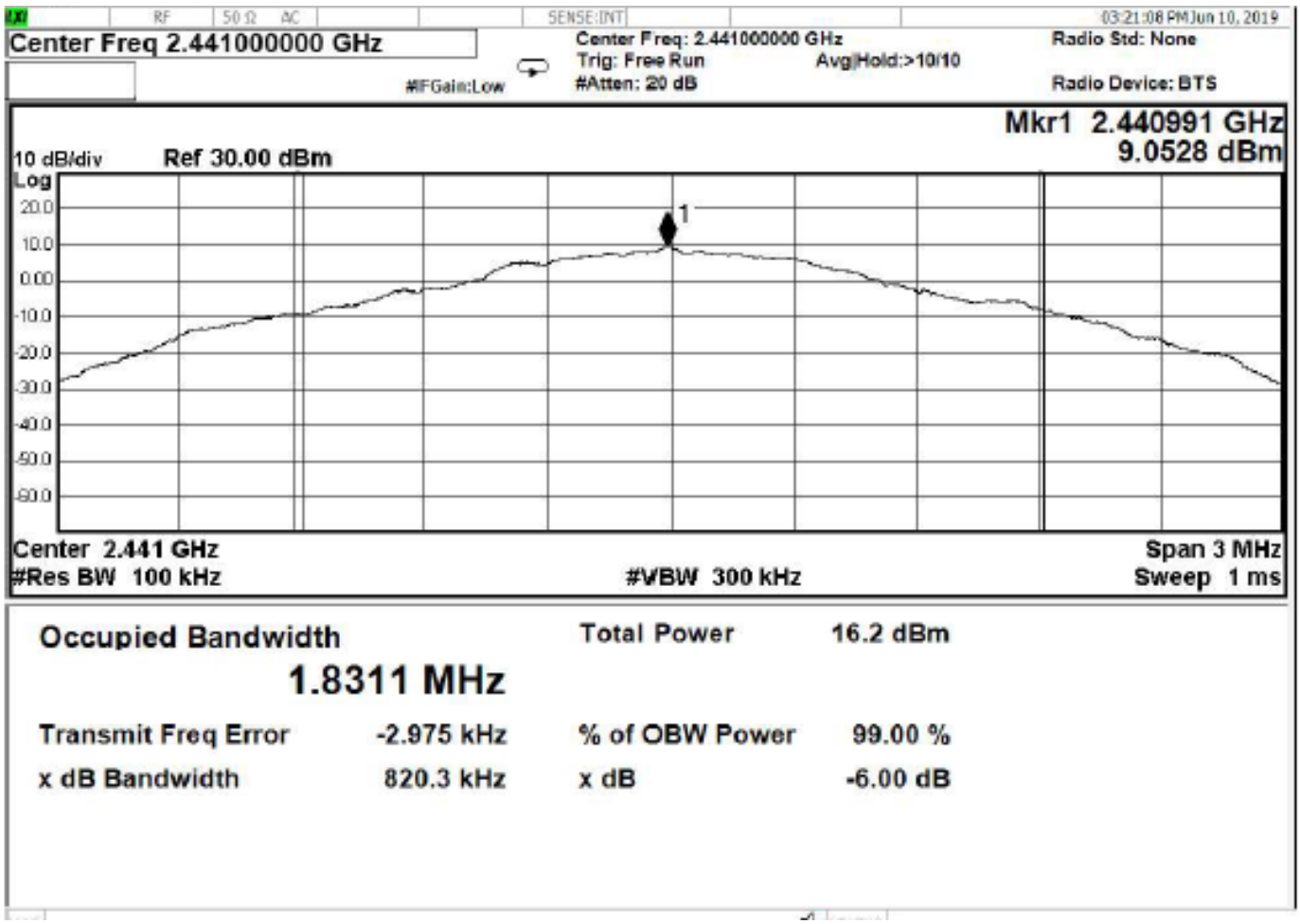

Figure 19 - Occupied Bandwidth and 6dB Bandwidth, Mid Channel, GFSK

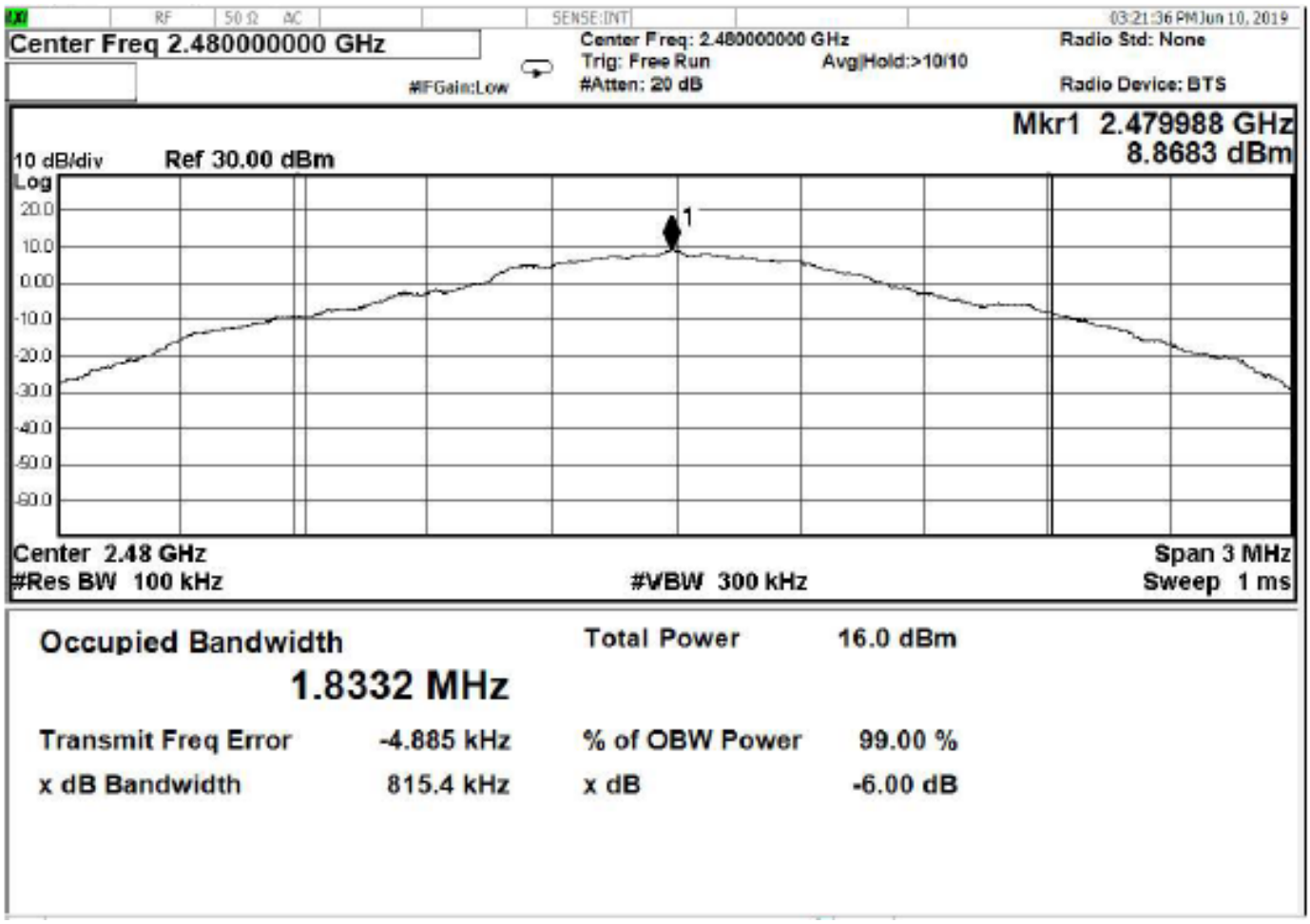

Figure 20 - Occupied Bandwidth and 6dB Bandwidth, High Channel, GFSK

4.4 RADIATED EMISSIONS

Test Method: ANSI C63.10:2013:

1. Section 6.5, “Radiated emissions from unlicensed wireless devices in the frequency range of 30 MHz to 1000 MHz”
2. Section 6.6, “Radiated emissions from unlicensed wireless devices above 1 GHz”
3. Section 11.11, “Measurement in nonrestricted frequency bands”
4. Section 11.12, “Emissions in restricted bands”

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 about requirement from FCC Part 15.247(d) and RSS-247, Section 5.5:
In addition to the limits shown above, all emissions were also required to be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. All measurements were performed with a 1 MHz bandwidth, but the bandwidth conversion from 1 MHz to 100 kHz would be equally applied to the highest emission and the spurious emissions, so it would not affect the delta measurement.

Since the fundamental emissions was at least 20 dB over the spurious emissions limits from 15.209 and all spurious emissions were below the 15.209 limit, this requirement was met.

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.

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 form 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.

All 802.11 modes were examined (b, g, n, HT20) and it was found the 802.11n mode produced the highest emissions. All final measurements were performed with the EUT transmitting continuously in this mode.

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.

Test setup:

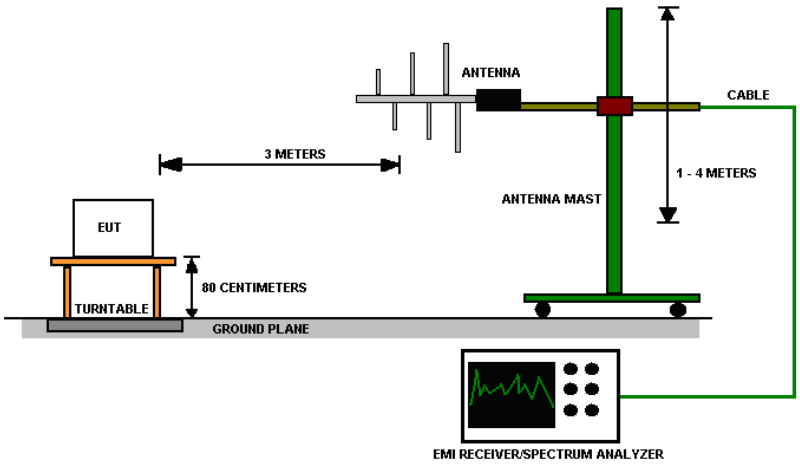

Figure 21 - Radiated Emissions Test Setup

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 indicated modulation.

Test results:

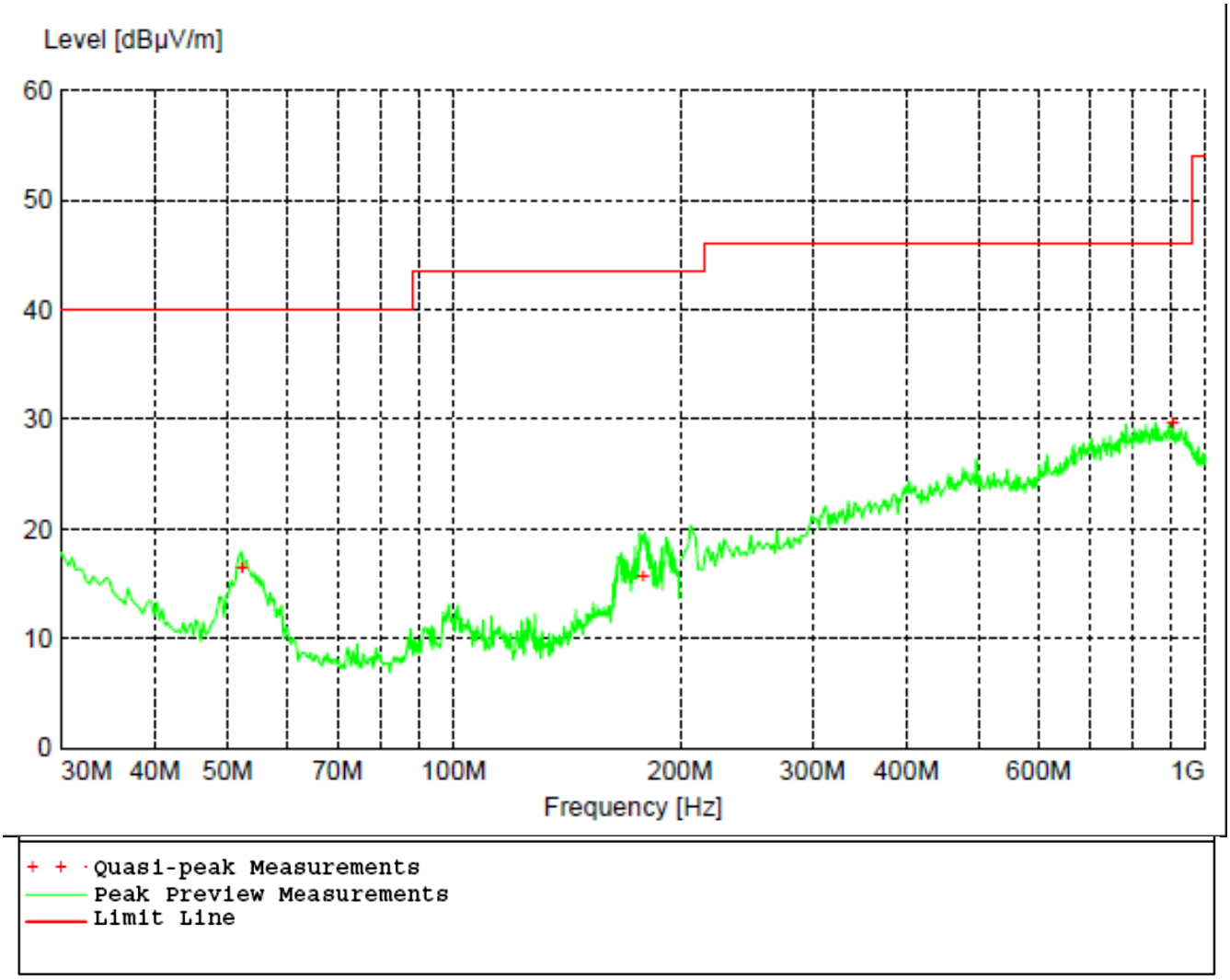

Figure 22 - Radiated Emissions Plot, Receive, GMSK

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 1 - Radiated Emissions Quasi-peak Measurements, Receive, GMSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
52.320000	16.32	40	23.68	102	271	VERT
178.560000	15.58	43.5	27.92	100	72	VERT
904.860000	29.59	46.00	16.41	143	3	VERT

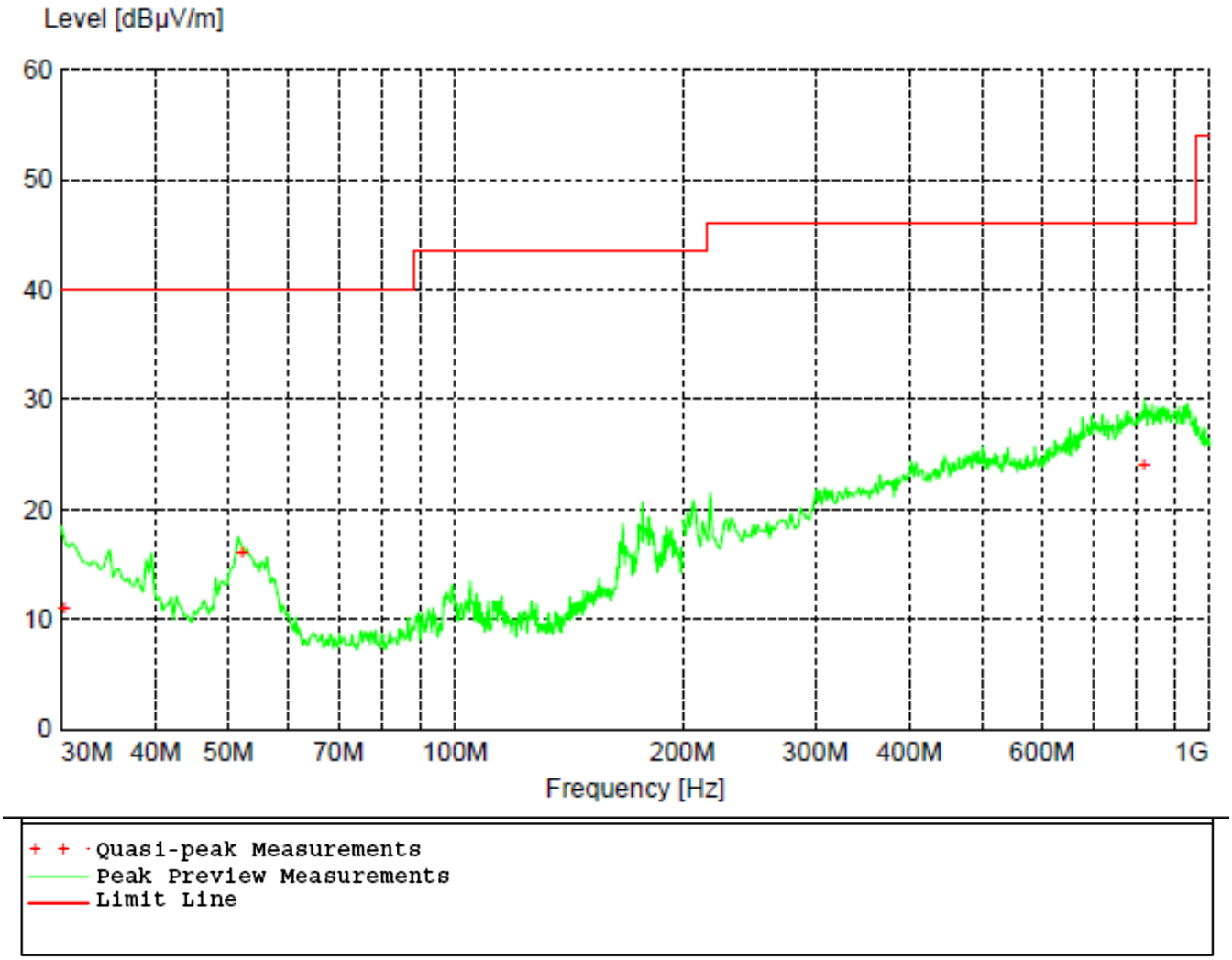

Figure 23 - Radiated Emissions Plot, Receive, GFSK

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, Receive GFSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.300000	10.95	40.00	29.05	101	158	HORI
52.140000	16.09	40.00	23.91	99	258	VERT
819.060000	23.89	46.00	22.11	170	0	HORI

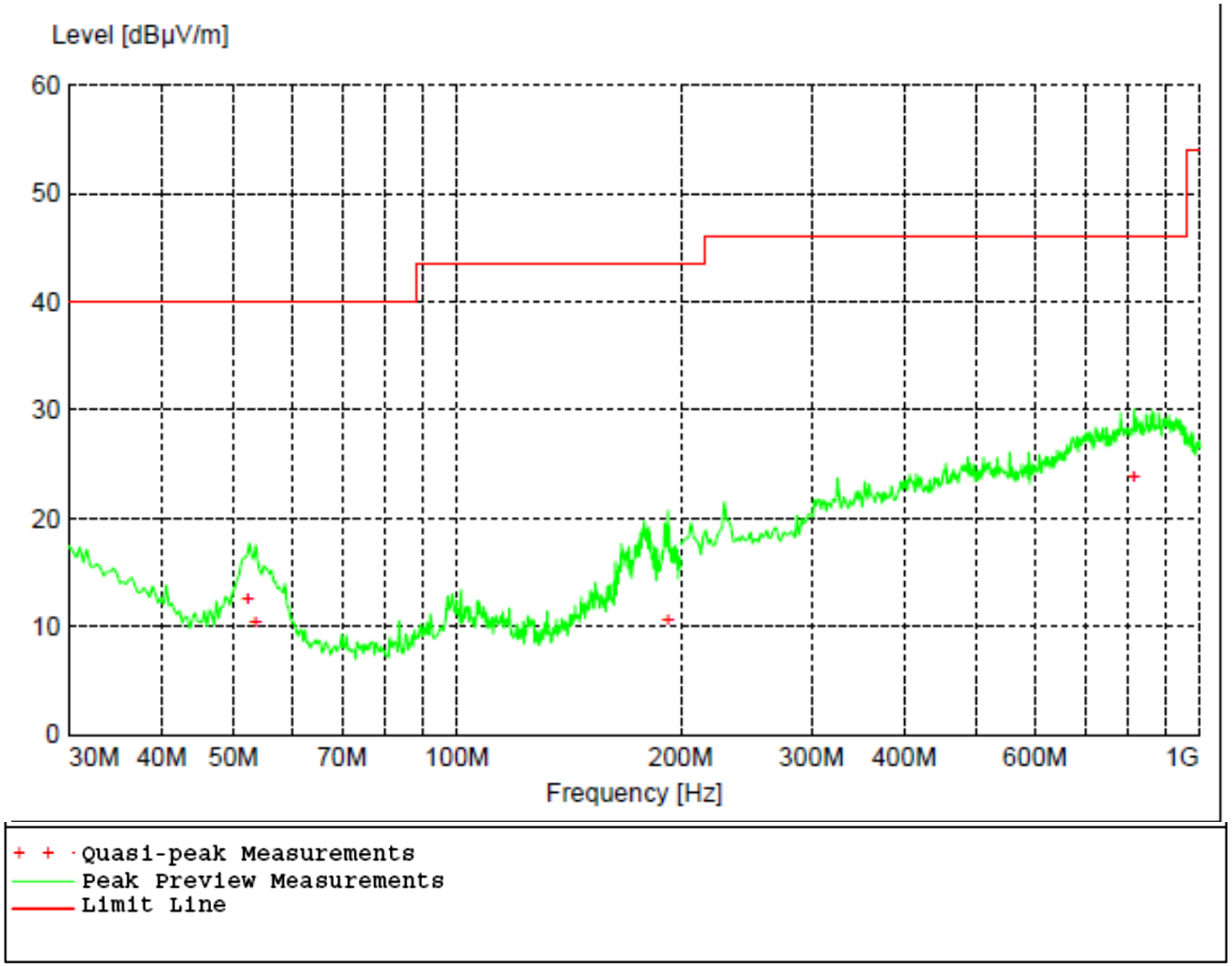

Figure 24 - Radiated Emissions Plot, GMSK

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, GMSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
52.260000	12.54	40	27.46	99	245	VERT
53.580000	10.33	40	29.67	198	360	VERT
192.240000	10.62	43.5	32.88	100	67	VERT
816.300000	23.84	46.00	22.16	176	155	HORI

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

Table 4 - Radiated Emissions Average Measurements, GMSK

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2402.000000	99.93	NA	NA	152	195	HORI	Low
2440.000000	98.33	NA	NA	152	195	HORI	Mid
2480.000000	99.72	NA	NA	152	195	HORI	High
4803.000000	29.12	54.00	24.88	100	140	HORI	Low
7207.400000	46.30	54.00	7.70	126	349	HORI	Low
7318.400000	45.45	54.00	8.55	187	334	HORI	Mid
7438.400000	42.41	54.00	11.59	99	12	VERT	High

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

Table 5 - Radiated Emissions Peak Measurements, GMSK

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2402.000000	103.97	NA	NA	152	195	HORI	Low
2440.000000	102.88	NA	NA	152	195	HORI	Mid
2480.000000	101.02	NA	NA	152	195	HORI	High
4803.000000	42.23	74.00	31.77	100	140	HORI	Low
7207.400000	56.60	74.00	17.40	126	349	HORI	Low
7318.400000	56.75	74.00	17.25	187	334	HORI	Mid
7438.400000	54.07	74.00	19.93	99	12	VERT	High

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

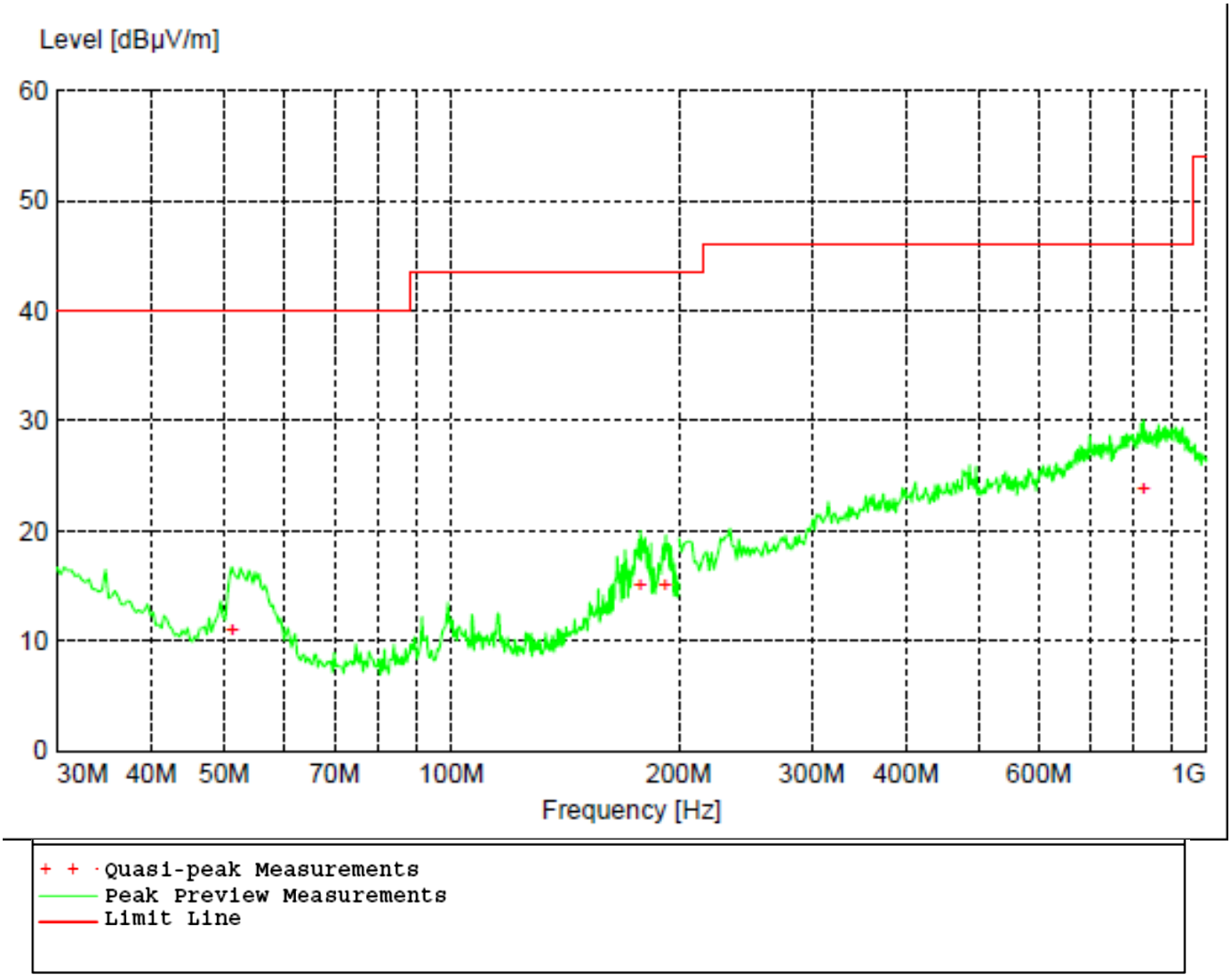

Figure 25 - Radiated Emissions Plot, GFSK

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 6 - Radiated Emissions Quasi-peak Measurements, GFSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
51.300000	10.94	40.00	29.06	101	273	VERT
177.900000	15.14	43.5	28.36	100	58	VERT
191.880000	15.02	43.50	28.48	99	84	VERT
826.740000	23.73	46.00	22.27	186	359	VERT

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

Table 7 - Radiated Emissions Average Measurements, GFSK

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2402.000000	99.93	NA	NA	152	195	HORI	Low
2440.000000	99.10	NA	NA	152	195	HORI	Mid
2480.000000	97.34	NA	NA	152	195	HORI	High
4810.000000	29.40	54.00	24.60	288	0	HORI	Mid
7207.000000	33.89	54.00	20.11	122	339	HORI	Low
7322.800000	46.15	54.00	20.30	180	355	HORI	Mid
7441.000000	46.20	54.00	7.80	100	339	HORI	High

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

Table 8 - Radiated Emissions Peak Measurements, GFSK

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2402.000000	104.16	NA	NA	152	195	HORI	Low
2440.000000	103.65	NA	NA	152	195	HORI	Mid
2480.000000	102.14	NA	NA	152	195	HORI	High
4810.000000	42.97	74.00	31.03	288	0	HORI	Mid
7207.000000	47.33	74.00	26.67	122	339	HORI	Low
7322.800000	56.99	74.00	17.01	180	355	HORI	Mid
7441.000000	55.58	74.00	18.42	100	339	HORI	High

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

4.5 BAND EDGES

Test Method: ANSI C63.10:

1. Section 6.10.5 (used for restricted bands)
2. Section 11.13.2 “Marker-delta method” (for unrestricted bands)
3. Section 11.11, “Measurement in unrestricted frequency bands”

Limits of band edge measurements:
For emissions outside of the allowed band of operation (2400.0MHz – 2480.0MHz), the emission level needs to be 20dB 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 tested in the same method as described in section *4.4 - Bandwidth*. The resolution bandwidth was set to 100 kHz and video bandwidth to 300 kHz the EMI receiver was used to scan from the band edge to the fundamental frequency with a quasi-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.

Deviations from test standard:
No deviation.

Test setup:
See Section 4.3

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 indicated modulation.

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, Restricted	GMSK	2390	-56.361	8.250	64.611	29.97	PASS
High, Restricted	GMSK	4835	-47.067	8.231	55.298	27.02	PASS
Low, Unrestricted	GMSK	2400	-25.386	8.250	33.636	20	PASS
High, Unrestricted	GMSK	4835	-47.475	8.231	55.706	20	PASS

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

From Section 4.2

Fundamental peak field strength at Low Channel GMSK = 103.97 dBµV/m
Fundamental peak field strength at High Channel GMSK = 101.02 dBµV/m

Low Channel minimum delta GMSK = 103.97 – 74.0 dBµV/m = 29.97 dBc
High Channel minimum delta GMSK = 101.02 – 74.0 dBµV/m = 27.02 dBc

FCC Part 15.247 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.

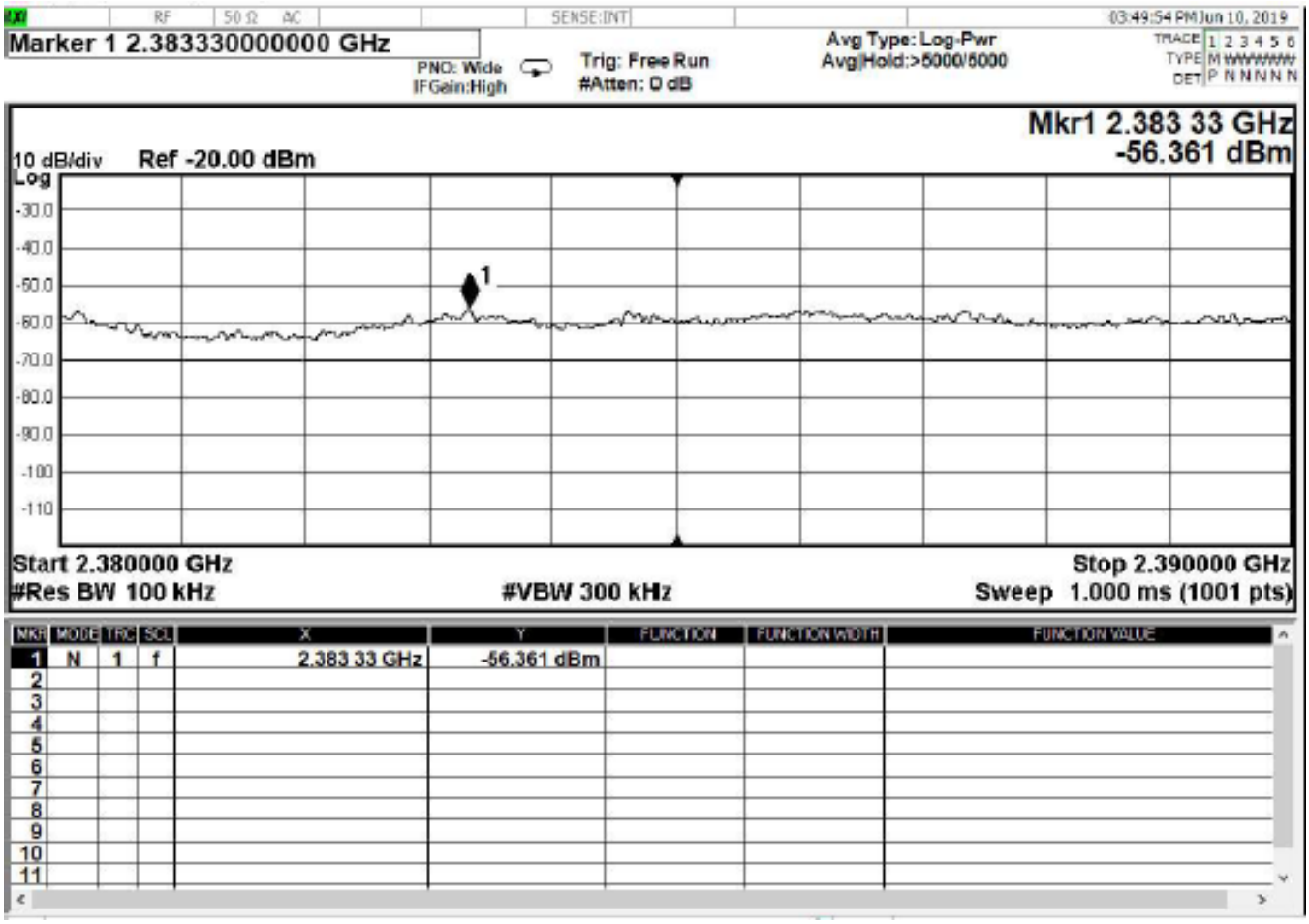

Figure 26 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

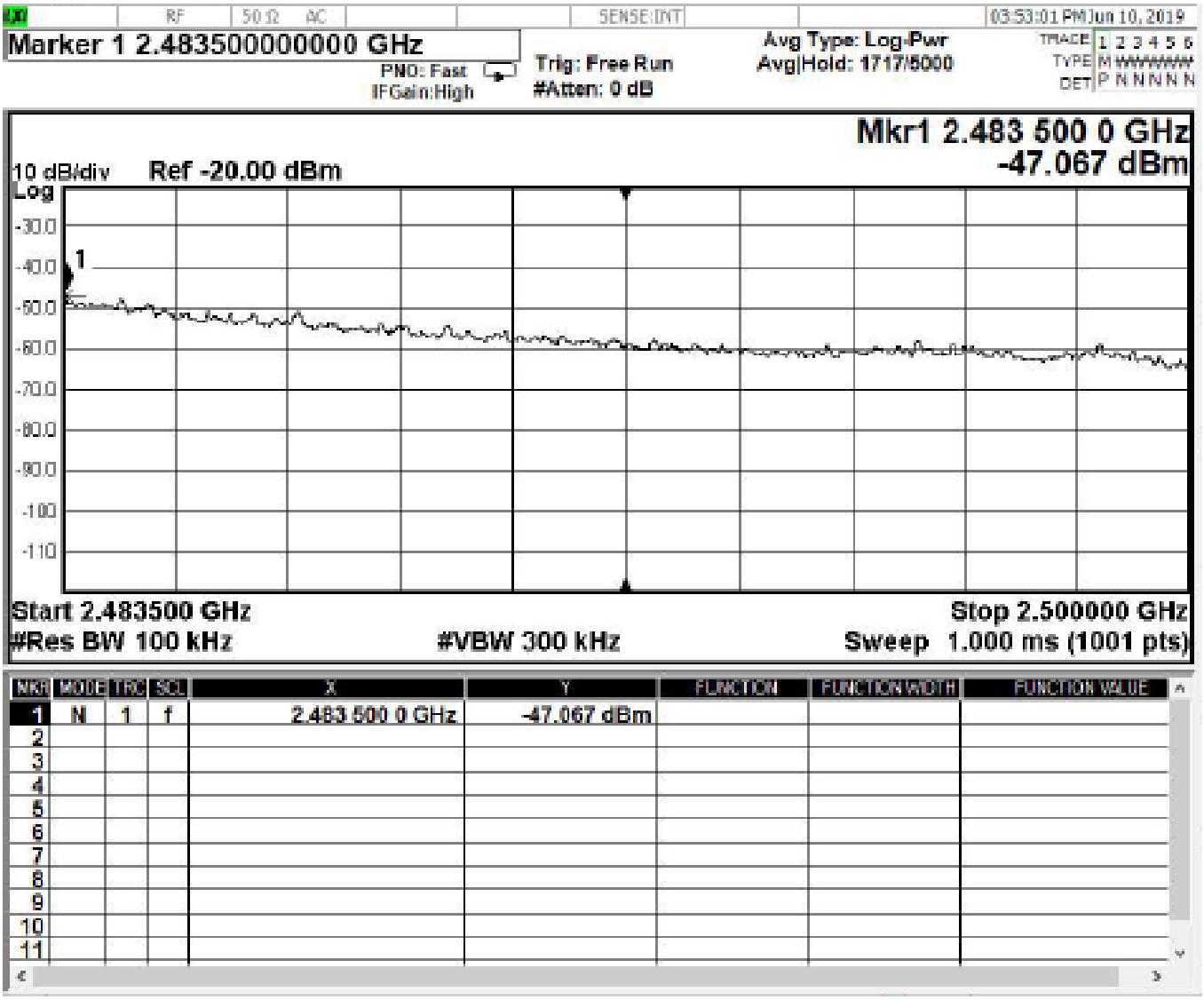

Figure 27 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

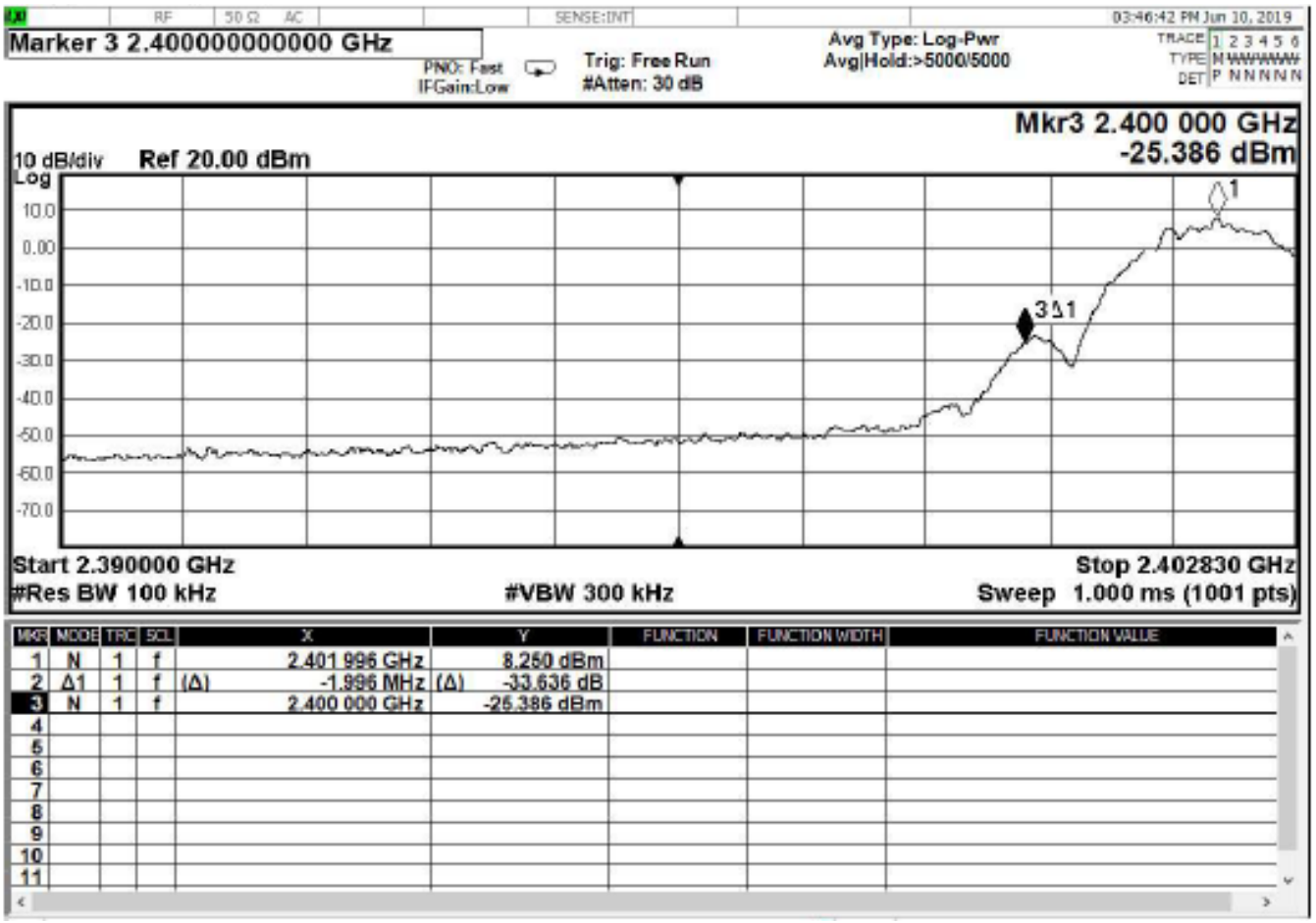

Figure 28 - Band-edge Measurement, Low Channel, Fundamental, Peak

Unrestricted band edge shown in plot

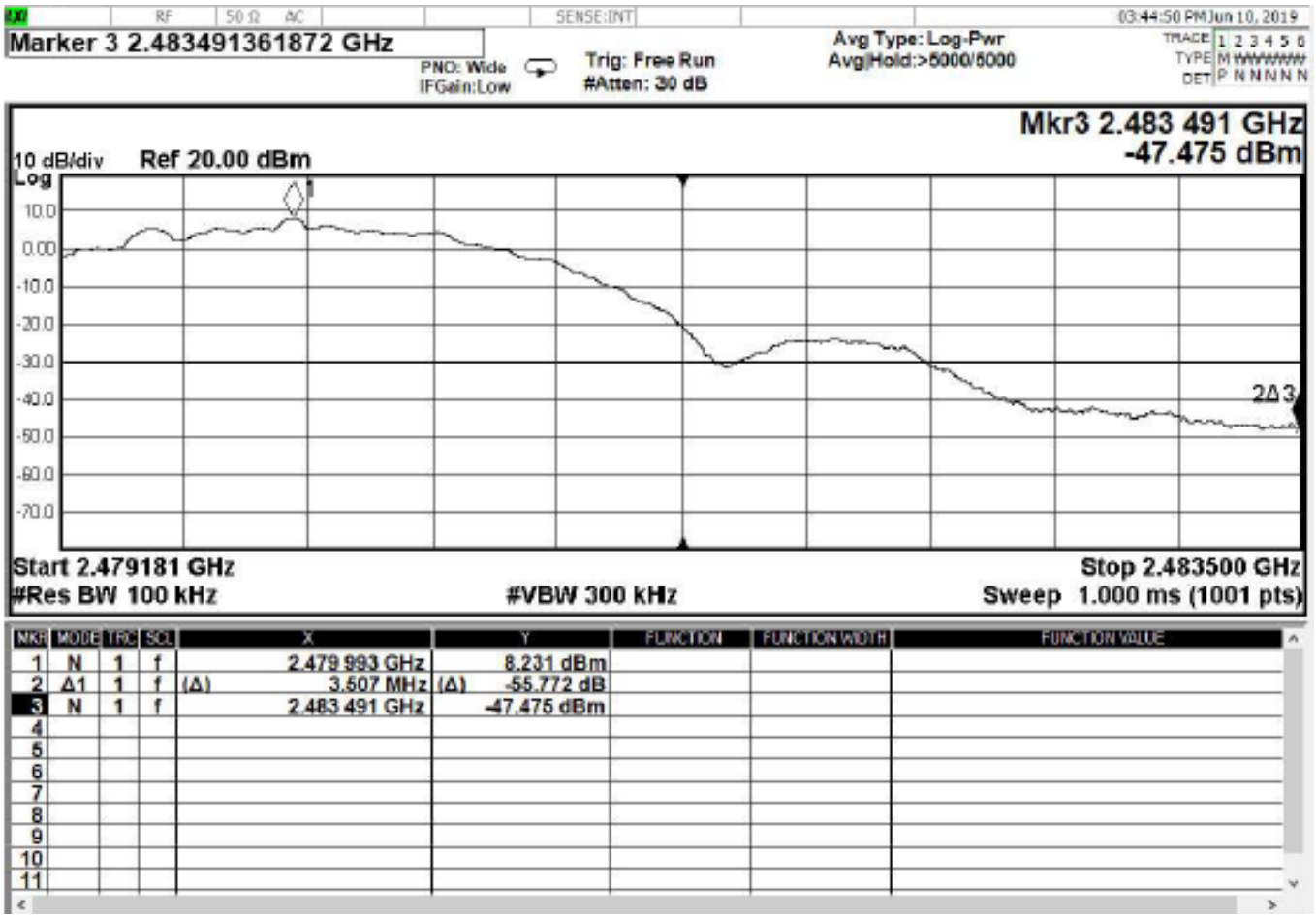

Figure 29 - Band-edge Measurement, High Channel, Fundamental, Peak

Unrestricted band edge shown in plot

CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental dBm	Delta (dB)	Min Delta (dB)	Result
Low, Restricted	GFSK	2390	-56.415	9.012	65.427	30.16	PASS
High, Restricted	GFSK	4835	-48.243	8.741	56.984	28.14	PASS
Low, Unrestricted	GFSK	2400	-30.317	9.012	39.329	20	PASS
High, Unrestricted	GFSK	4835	-48.935	8.741	57.676	20	PASS

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

From Section 4.2

Fundamental peak field strength at Low Channel GFSK = 104.16 dBµV/m
Fundamental peak field strength at High Channel GFSK = 102.14 dBµV/m

Low Channel minimum delta GFSK = 104.16 – 74.0 dBµV/m = 30.16 dBc
High Channel minimum delta GFSK = 102.14 – 74.0 dBµV/m = 28.14 dBc

FCC Part 15.247 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.

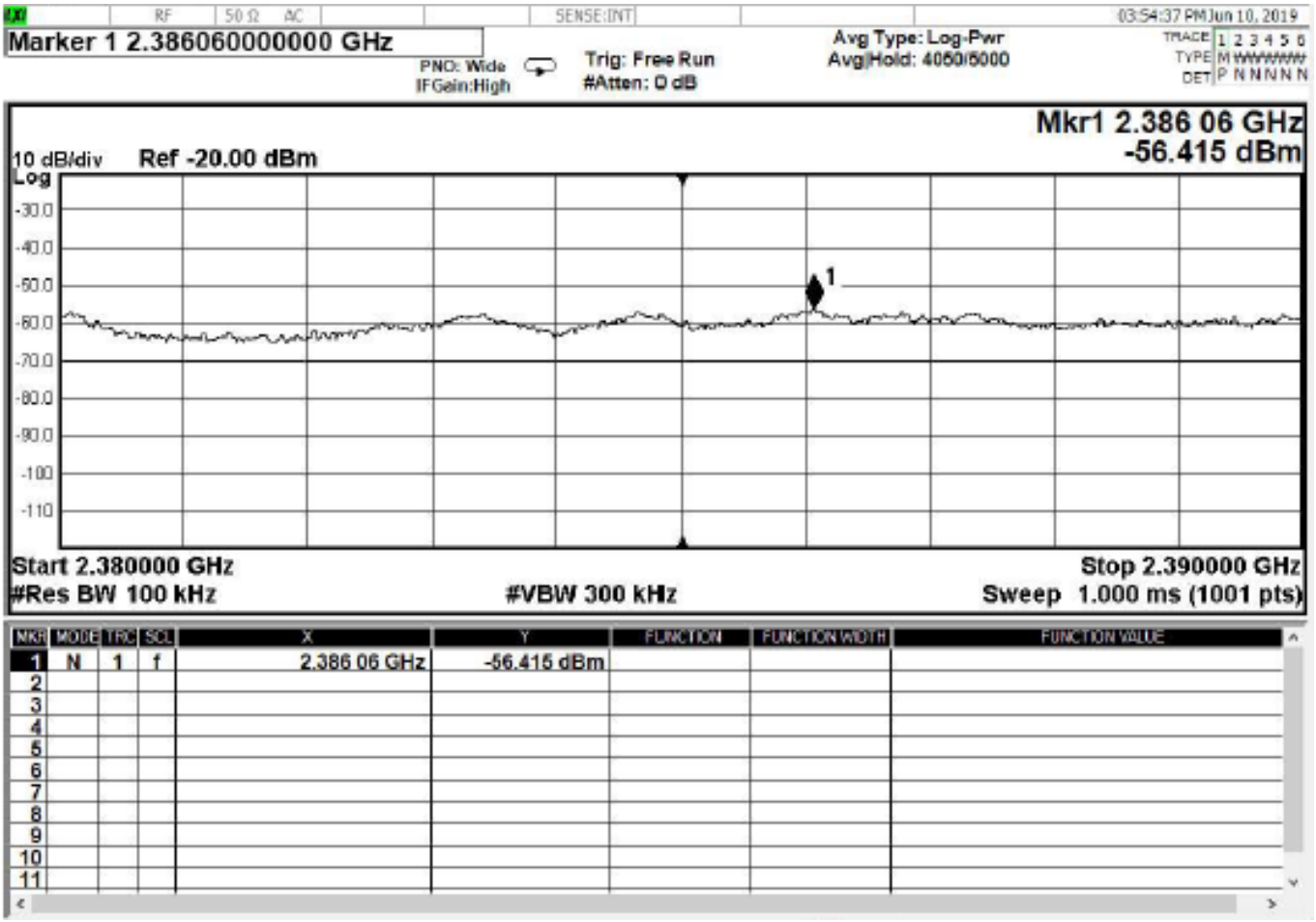

Figure 30 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

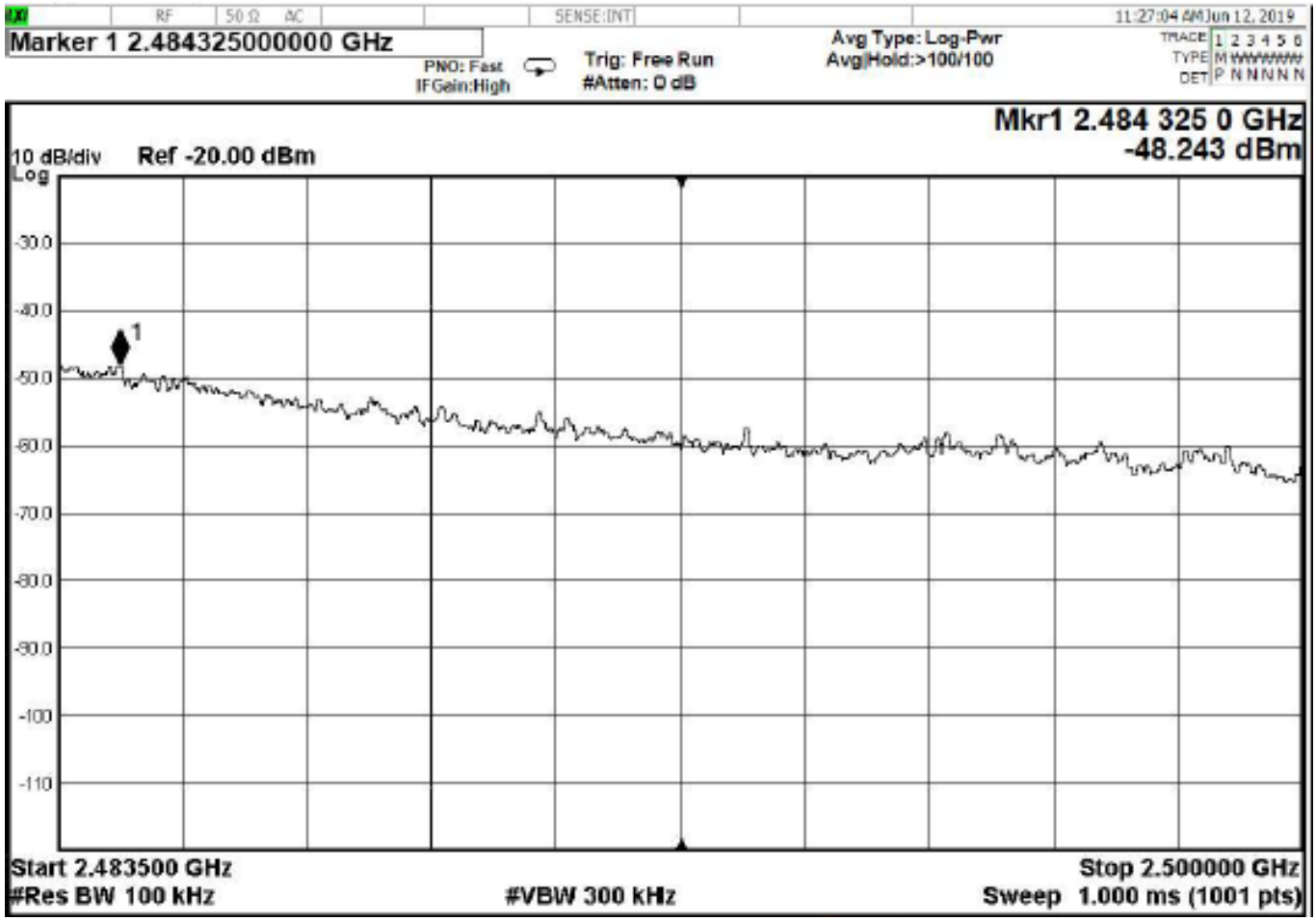

Figure 31 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

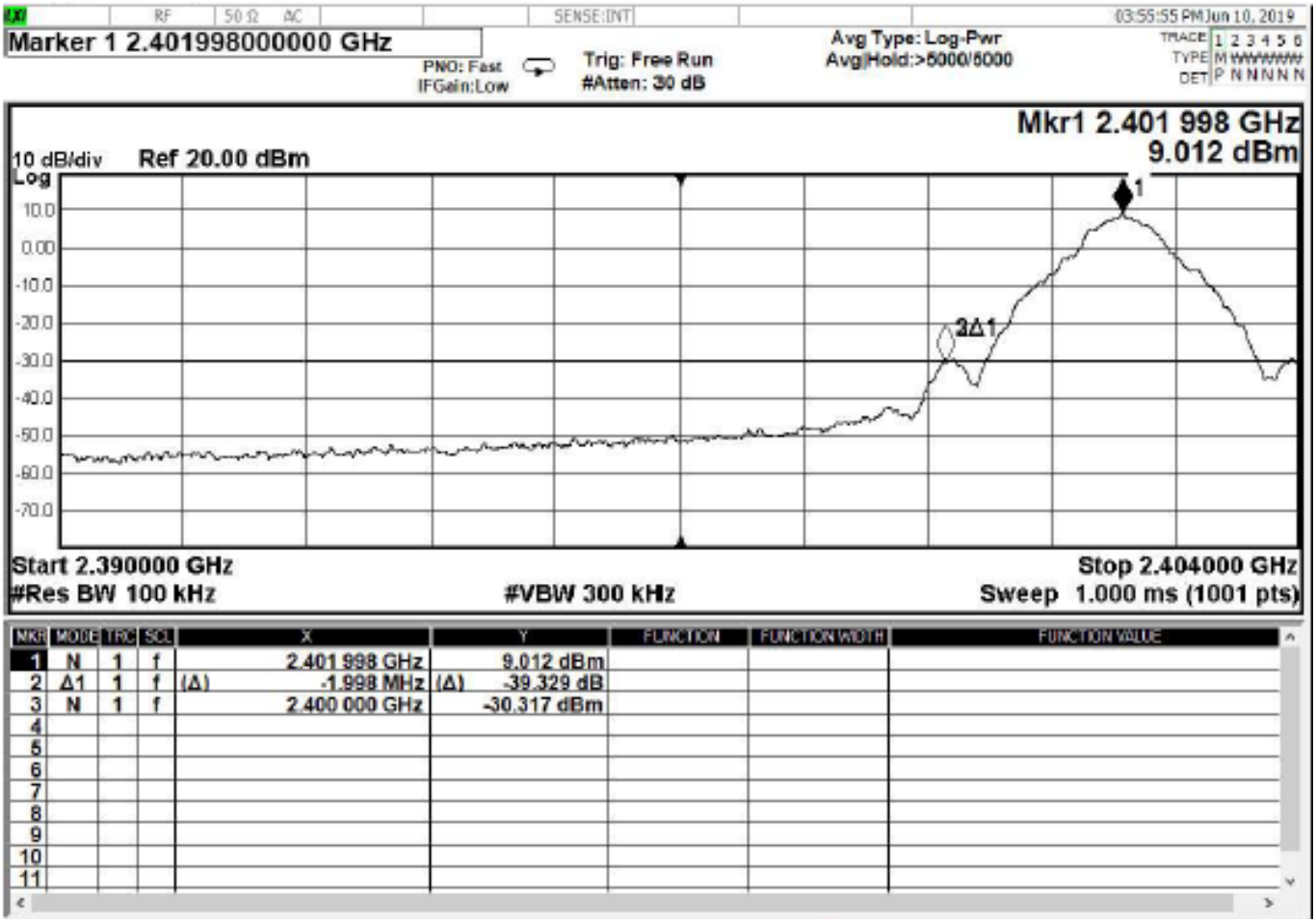

Figure 32 - Band-edge Measurement, Low Channel, Fundamental, Peak

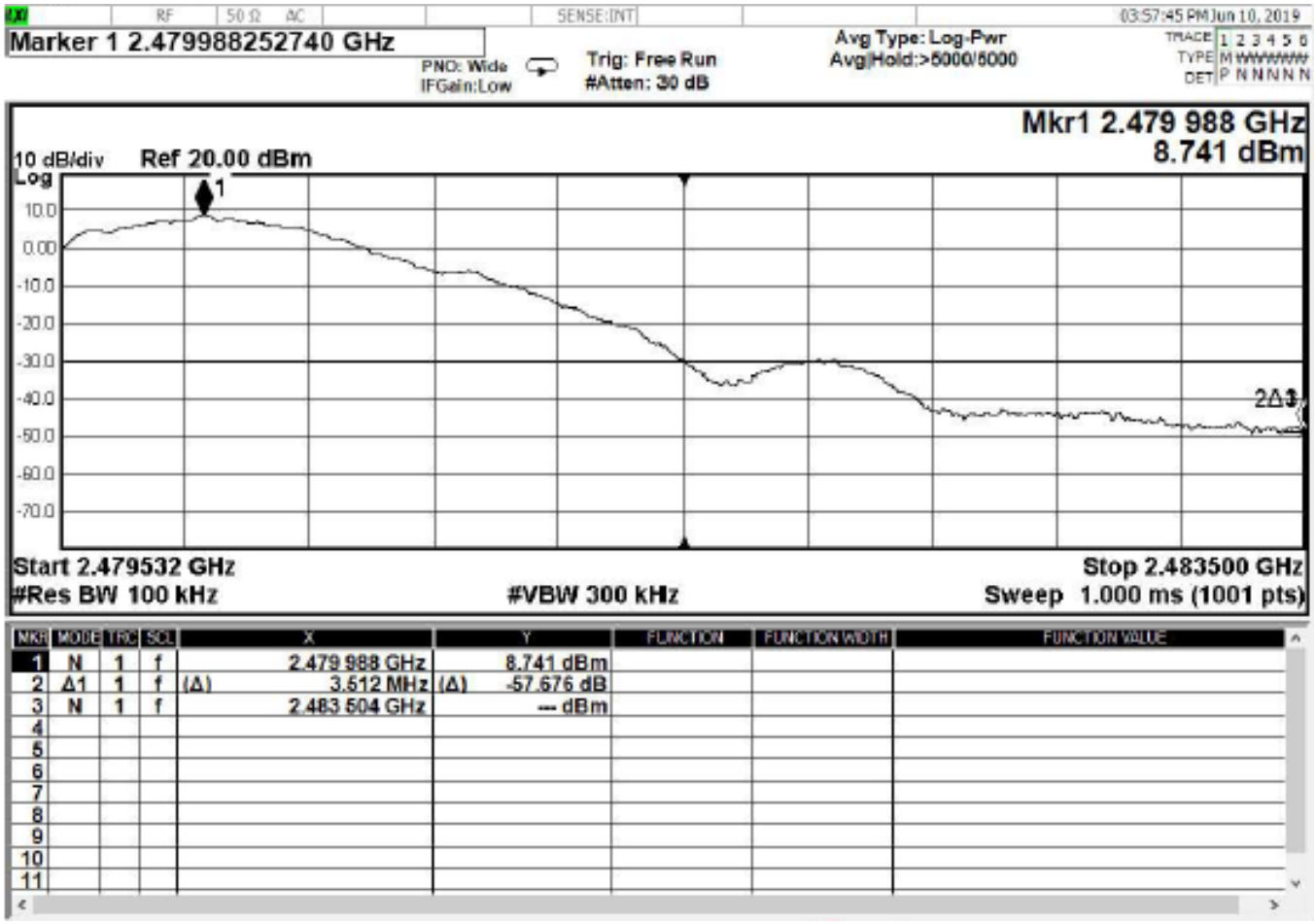

Figure 33 - Band-edge Measurement, High Channel, Fundamental, Peak

4.6 POWER SPECTRAL DENSITY

Test Method: ANSI C63.10,

1. Section 11.10.2 “Method PKPSD (peak PSD)”

Limits of power measurements:
The maximum PSD allowed is 8 dBm.

Test procedures:
1. The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable.

2. The resolution bandwidth was set to 3 kHz and the video bandwidth was set to 10 kHz to capture the signal. The analyzer used a peak detector in max hold mode.

Test setup:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable on a bench top.

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 indicated modulation.

Test results:

Power Spectral Density

CHANNEL	MODE	CHANNEL FREQUENCY (MHz)	PEAK PSD(dBm)	Method	Limit (dBm)	RESULT
Low	GMSK	2402	-8.4651	Conducted	8.00	PASS
Mid	GMSK	2440	-8.265	Conducted	8.00	PASS
High	GMSK	2480	-8.3947	Conducted	8.00	PASS
Low	GFSK	2402	-6.3426	Conducted	8.00	PASS
Mid	GFSK	2440	-6.5104	Conducted	8.00	PASS
High	GFSK	2480	-6.6623	Conducted	8.00	PASS

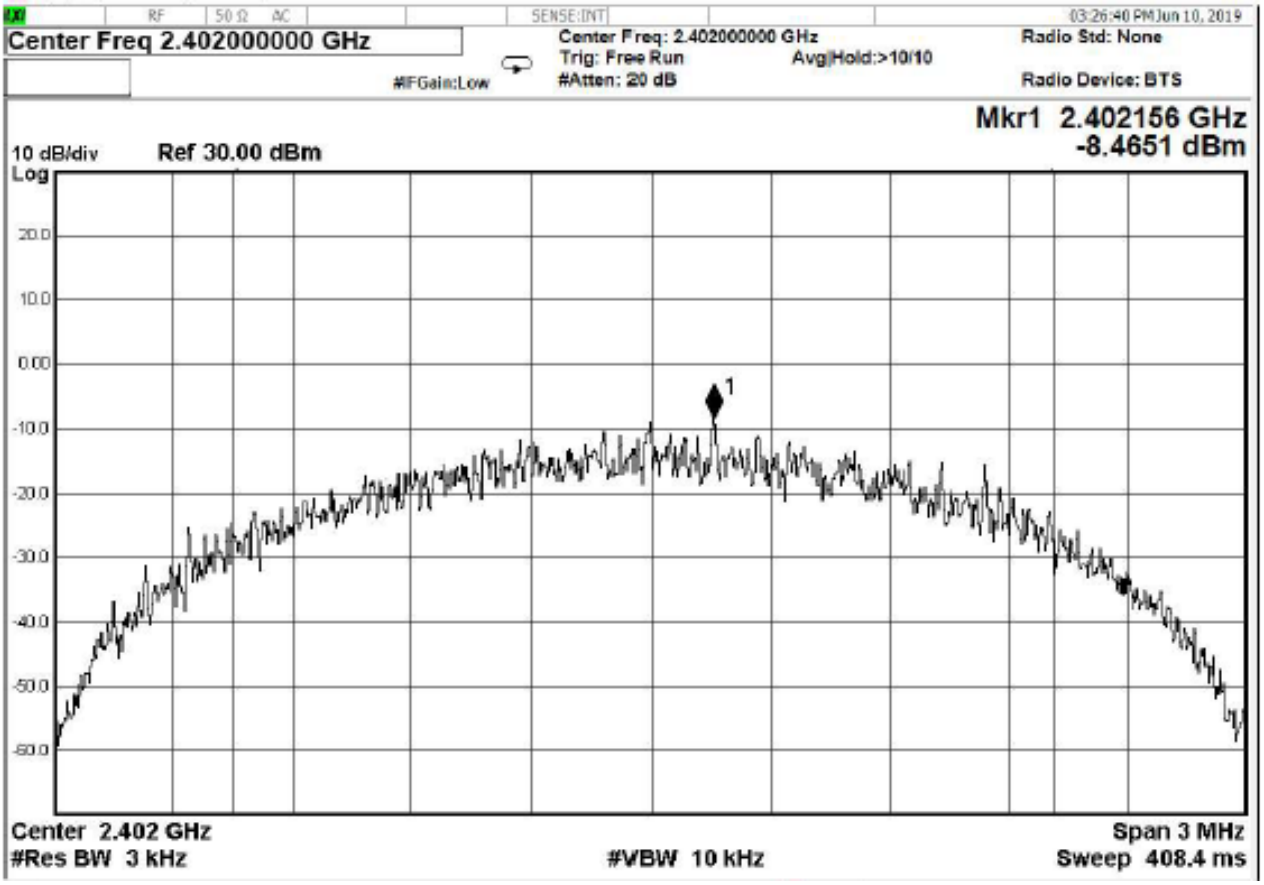

Figure 34 - Power Spectral Density, Low Channel, GMSK

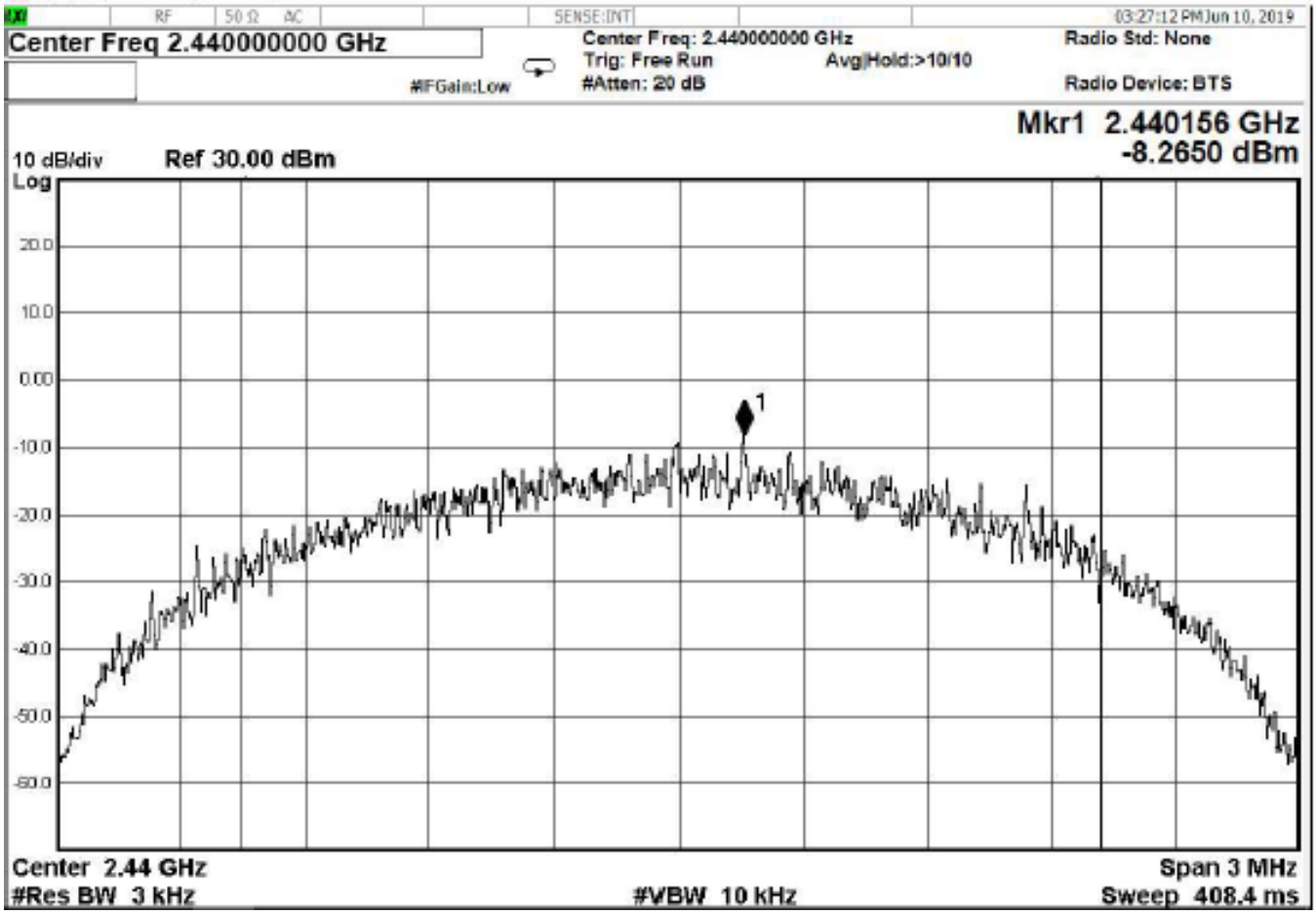

Figure 35 - Power Spectral Density, Mid Channel, GMSK

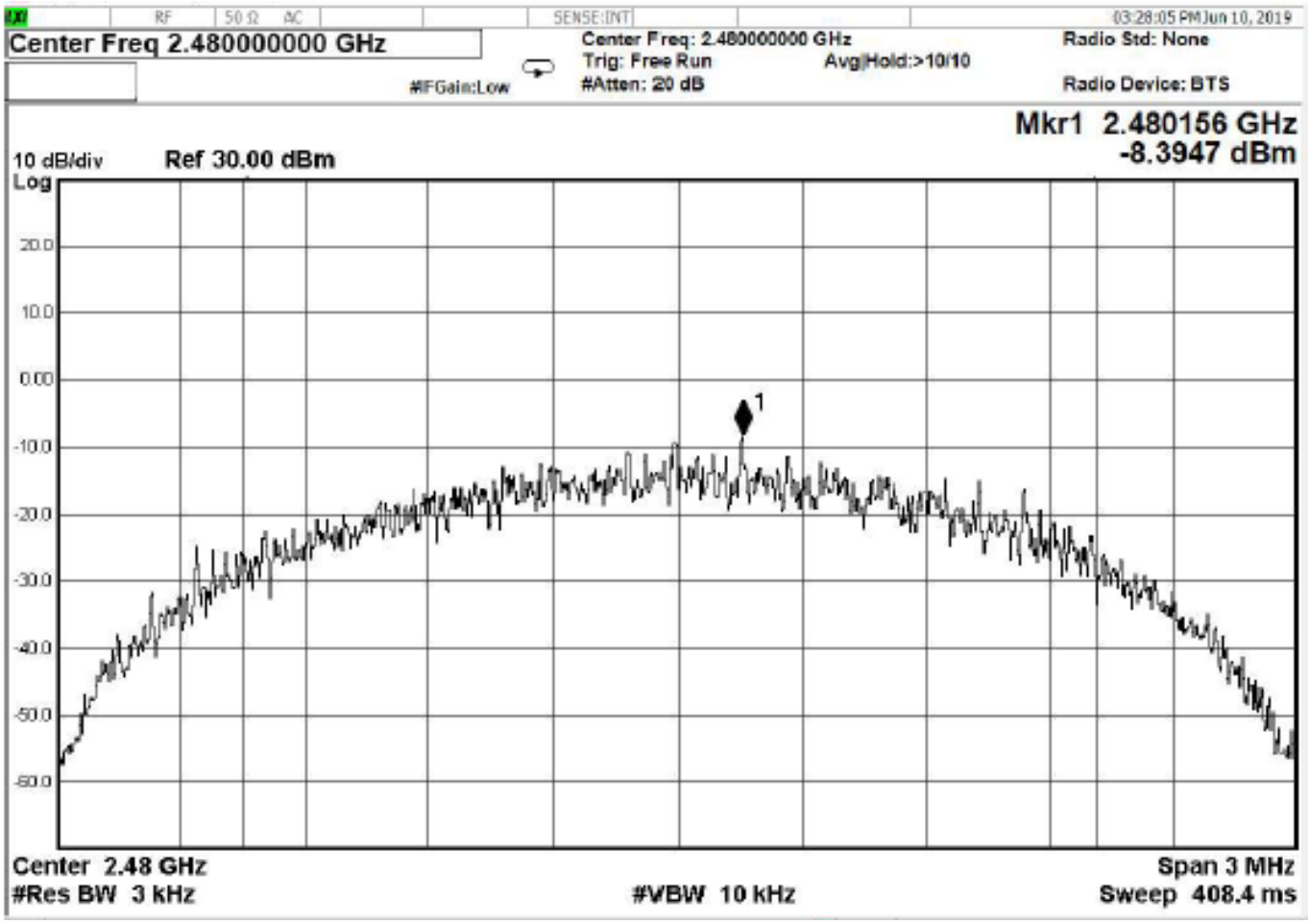

Figure 36 - Power Spectral Density, High Channel, GMSK

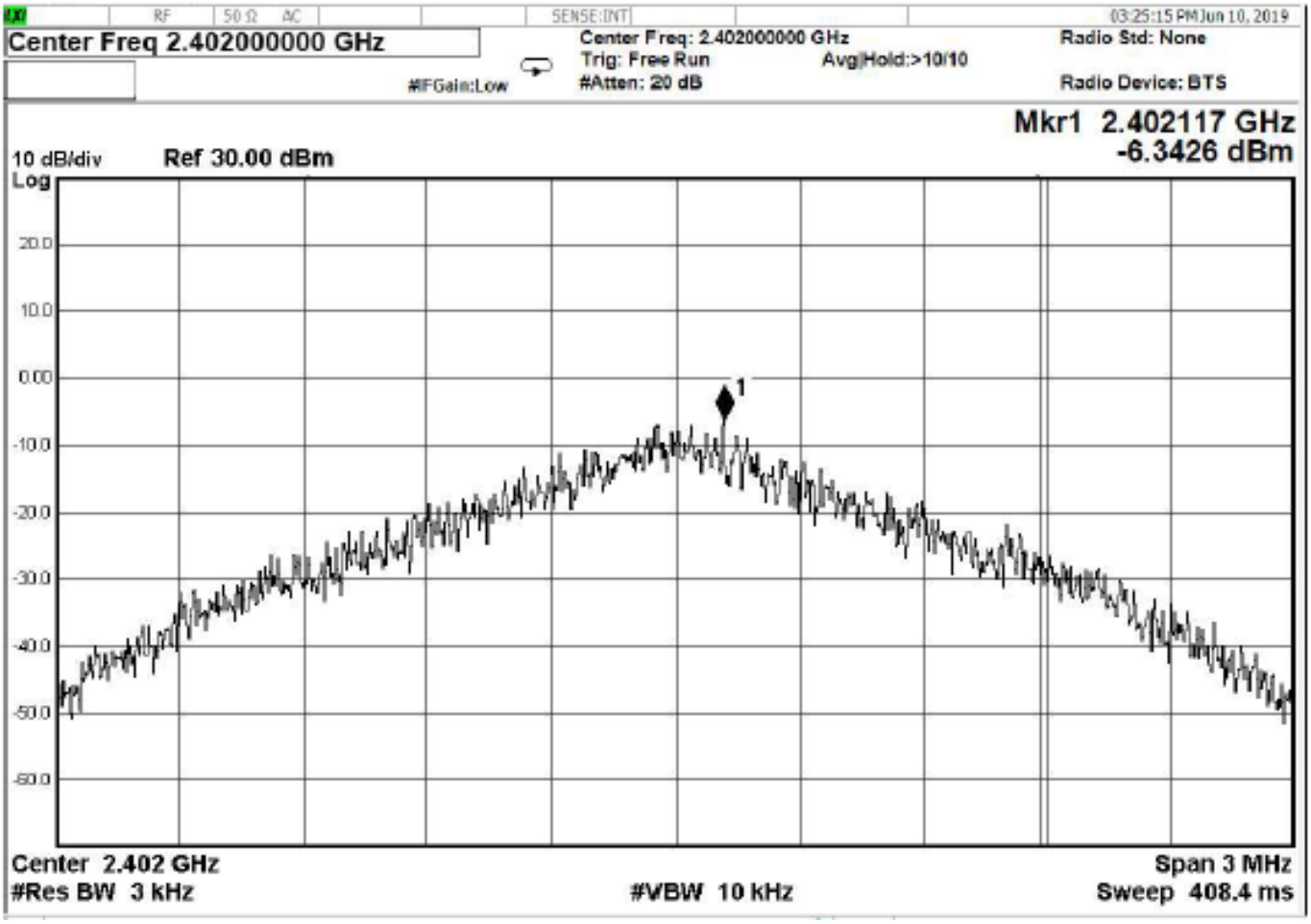

Figure 37 - Power Spectral Density, Low Channel, GFSK

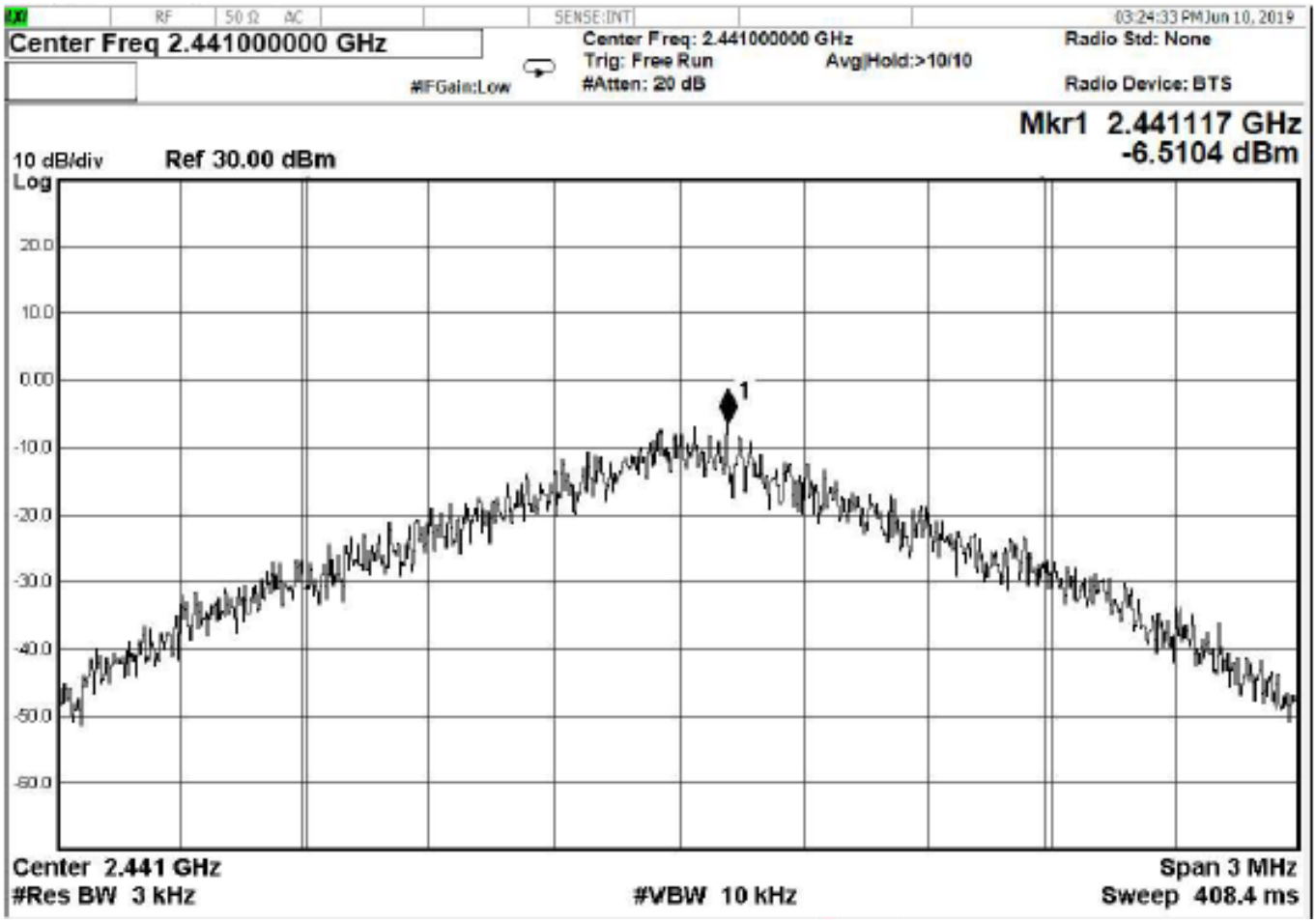

Figure 38 - Power Spectral Density, Mid Channel, GFSK

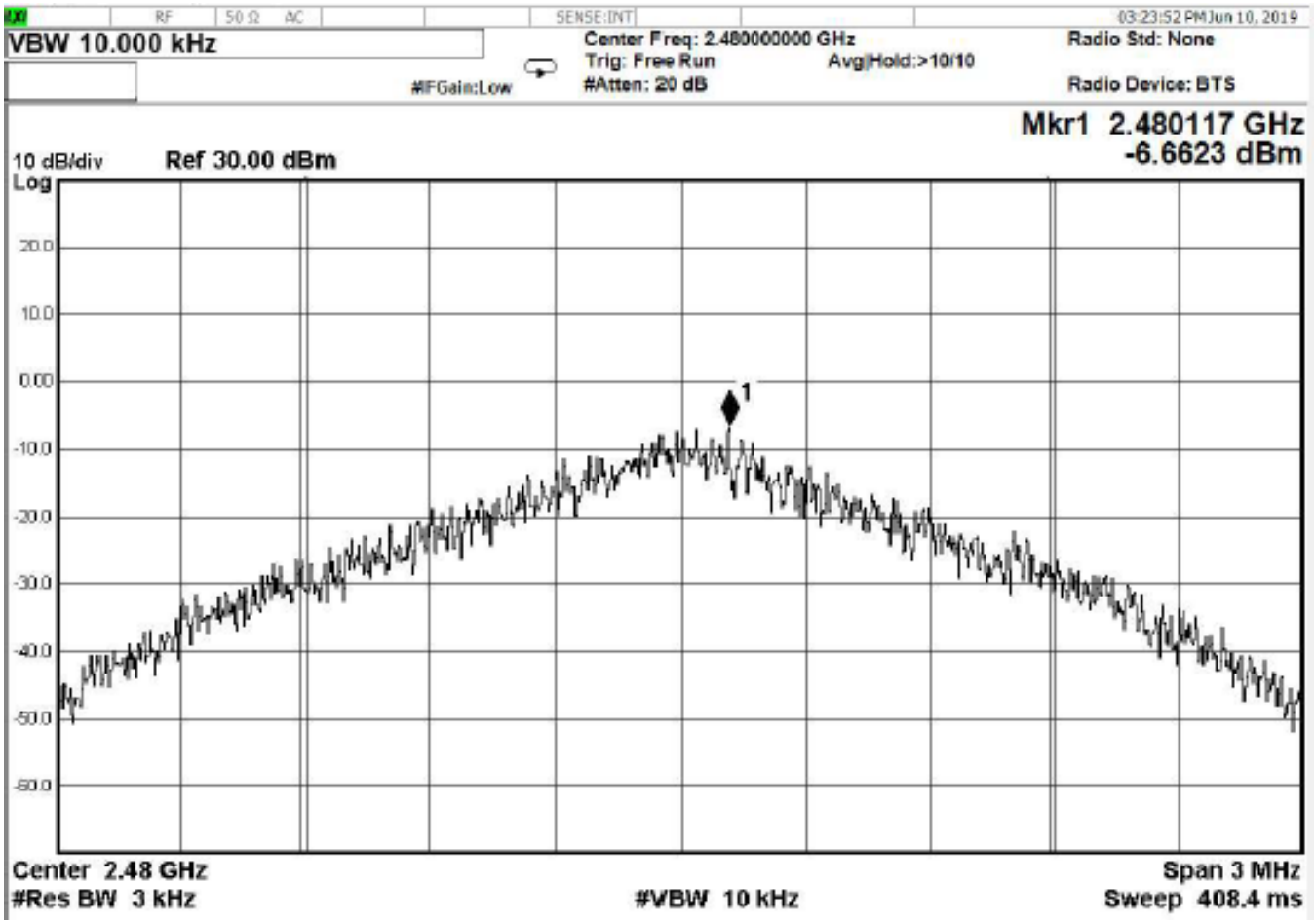

Figure 39 - Power Spectral Density, High Channel, GFSK

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 (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:
The EUT was powered by 5 VDC unless specified and set to transmit continuously on the middle channel of ANT unit.

Test Results:

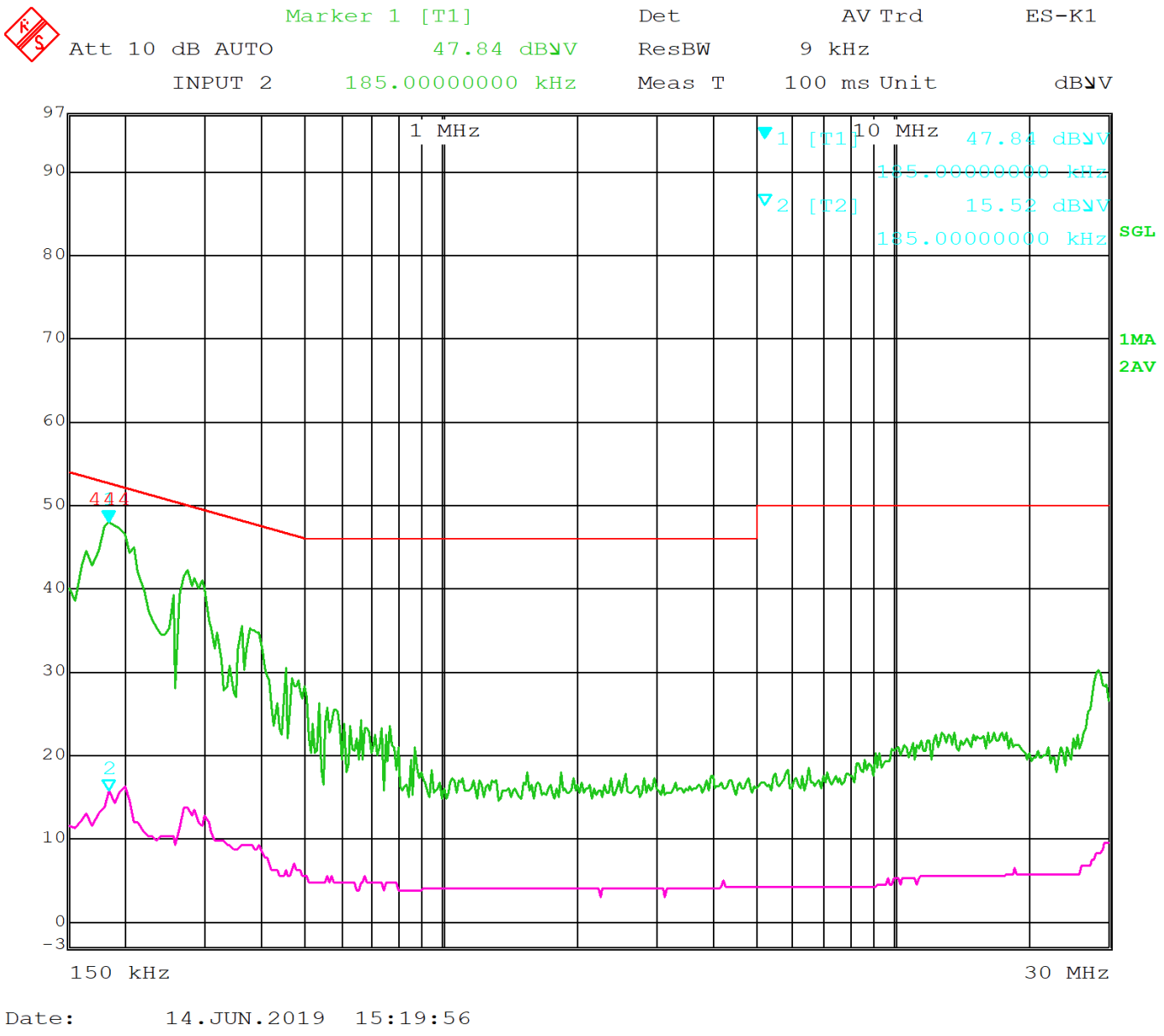

Figure 40 - Conducted Emissions, Line

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

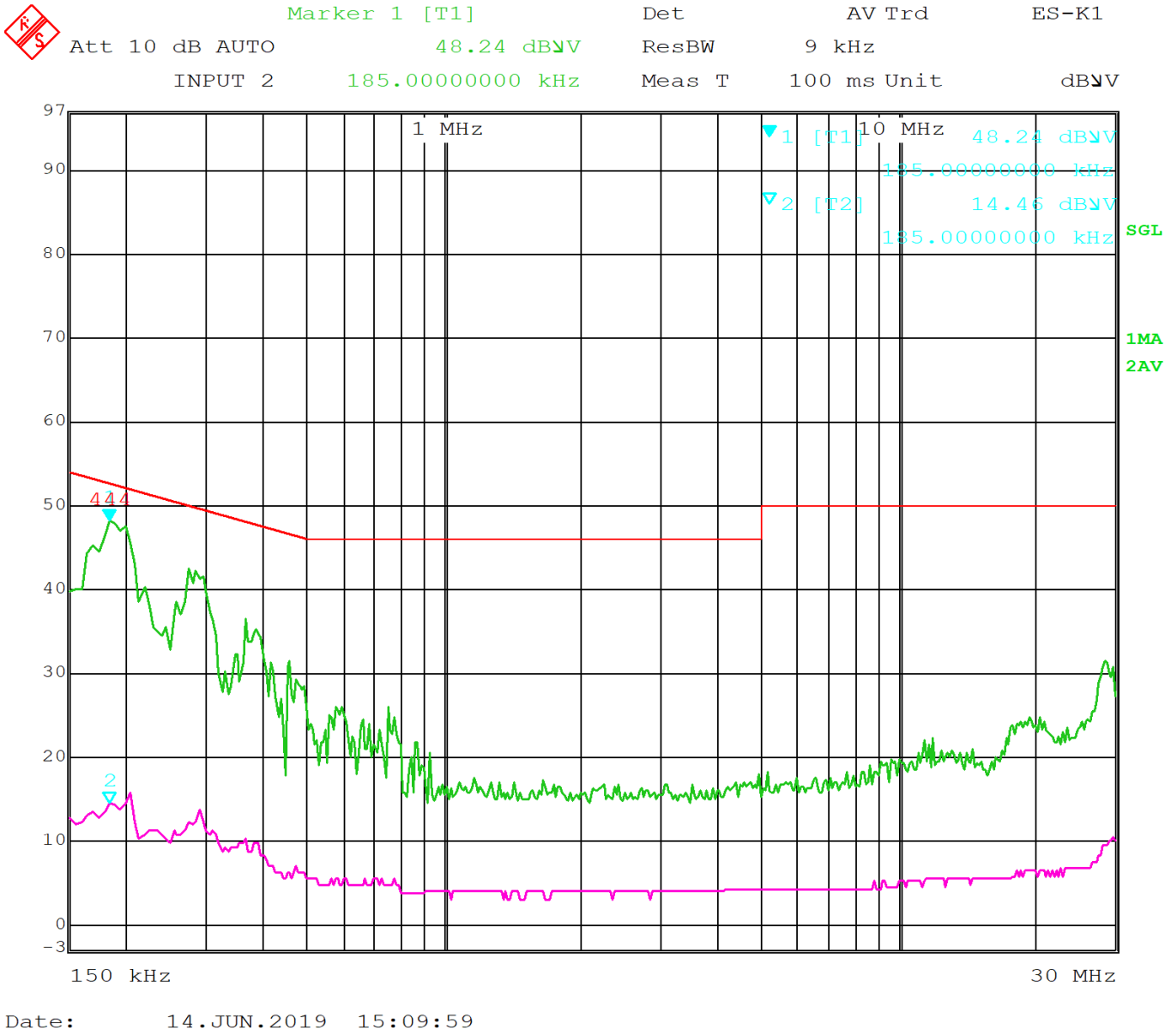

Figure 41 - Conducted Emissions, Neutral

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

APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

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

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

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

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

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

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

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

EIRP Calculations

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

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

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

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

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

Gain = 1 (numeric gain for isotropic radiator)

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

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

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

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

APPENDIX B – MEASUREMENT UNCERTAINTY

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

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

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

REPORT END