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FCC/ISED DXX Test Report

Prepared for: **Garmin International Inc.**

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

Product: **A03587**
B03587

Test Report No: **R20190211-22-02**

Approved by:

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

DATE: **27 March 2019**

Total Pages: **63**

ilac-MRA A2LA ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	27 March 2019	Original – NJohnson Prepared by KVepuri/CFarrington

CONTENTS

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 9

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	N/A	No provisions for connection to AC mains

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary

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

EUT	A03587, 10” model B03587, 12” model
EUT Received	8 March 2019
EUT Tested	8 March 2019- 26 March 2019
Serial No.	146094034018 (12” unit; used for conducted measurements) 146094034059 (12” unit; used for radiated measurements) 146094024091 (10” unit; used for radiated measurements)
Operating Band	2400 – 2483.5 MHz
Device Type	GFSK, GMSK
Power Supply	12VDC

NOTE 1: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

NOTE 2: This report is intended to cover both 10-inch and 12-inch models. However, the report reflects the measurements made on 12 -inch model, as the radio portion of the both the units is identical. Spurious emissions measurements from 30MHz – 1 GHz were performed on both models.

2.2 DESCRIPTION OF TEST MODES

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

Channel	Frequency	Modulation
Low	2402 MHz	GMSK or GFSK
Mid	2440 MHz	GMSK or GFSK
High	2480 MHz	GMSK or GFSK

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

None

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	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 2019
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	25 Jul 2017	25 Jul 2018
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 PEAK OUTPUT POWER

Test Method: N/A

For Informational Purposes only

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

Deviations from test standard:
No deviation.

Test setup:
The field strength was measured by connecting the EUT directly to the spectrum analyzer.
See Section 4.2.

EUT operating conditions:
The EUT was powered by 12 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 GMSK and GFSK.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	PEAK OUTPUT POWER (mW)	Method	RESULT	Transmsitter
1	2402	4.21	2.64	Conducted	PASS	GFSK
2	2440	2.89	1.95	Conducted	PASS	GFSK
3	2480	2.08	1.61	Conducted	PASS	GFSK
1	2402	3.15	2.07	Conducted	PASS	GMSK
2	2440	2.75	1.88	Conducted	PASS	GMSK
3	2480	2.08	1.61	Conducted	PASS	GSMK

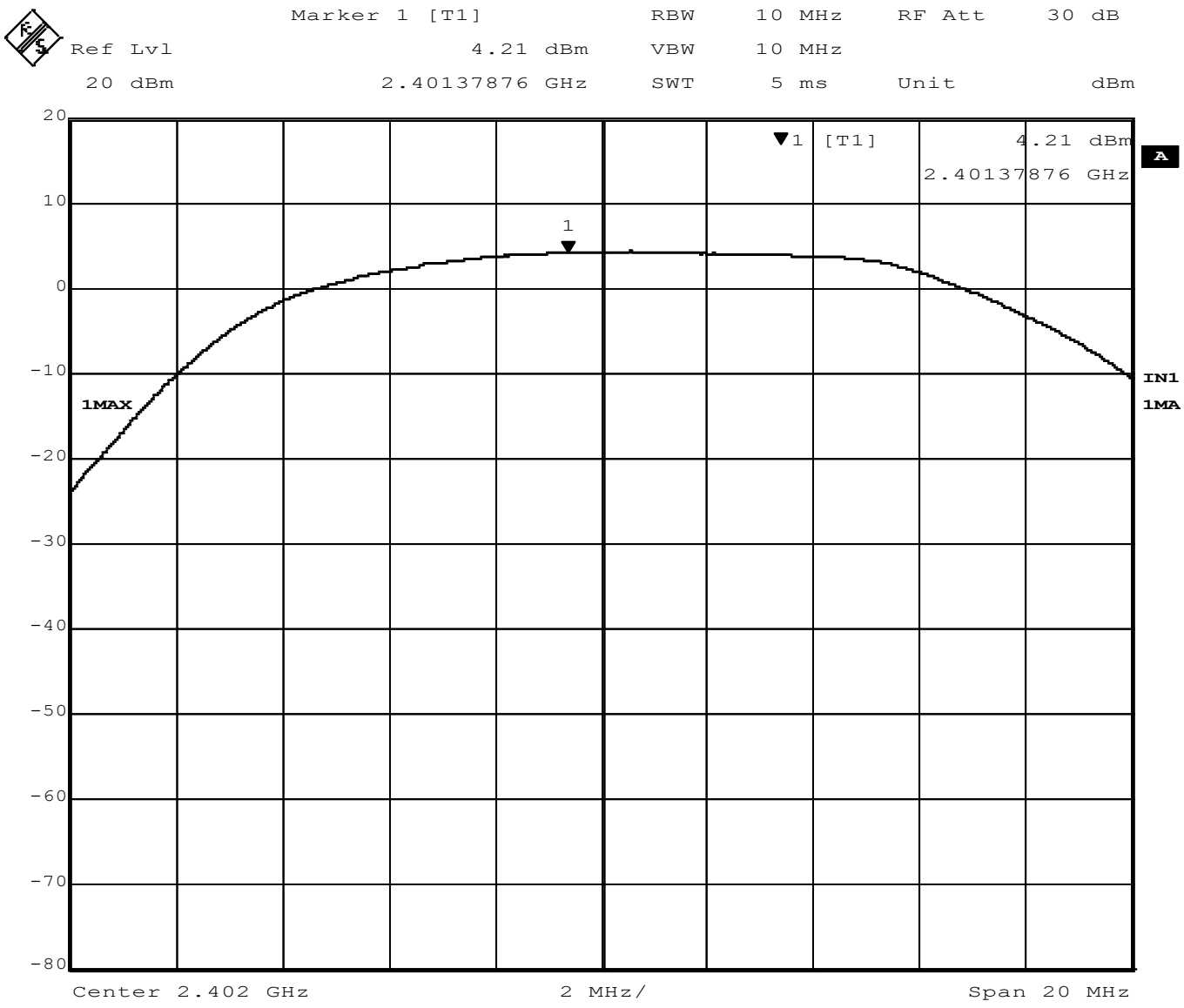

Figure 1 – Output Power, Low Channel, GFSK

Output power 4.21 dBm

Cable loss was less than 0.1 dB and not included

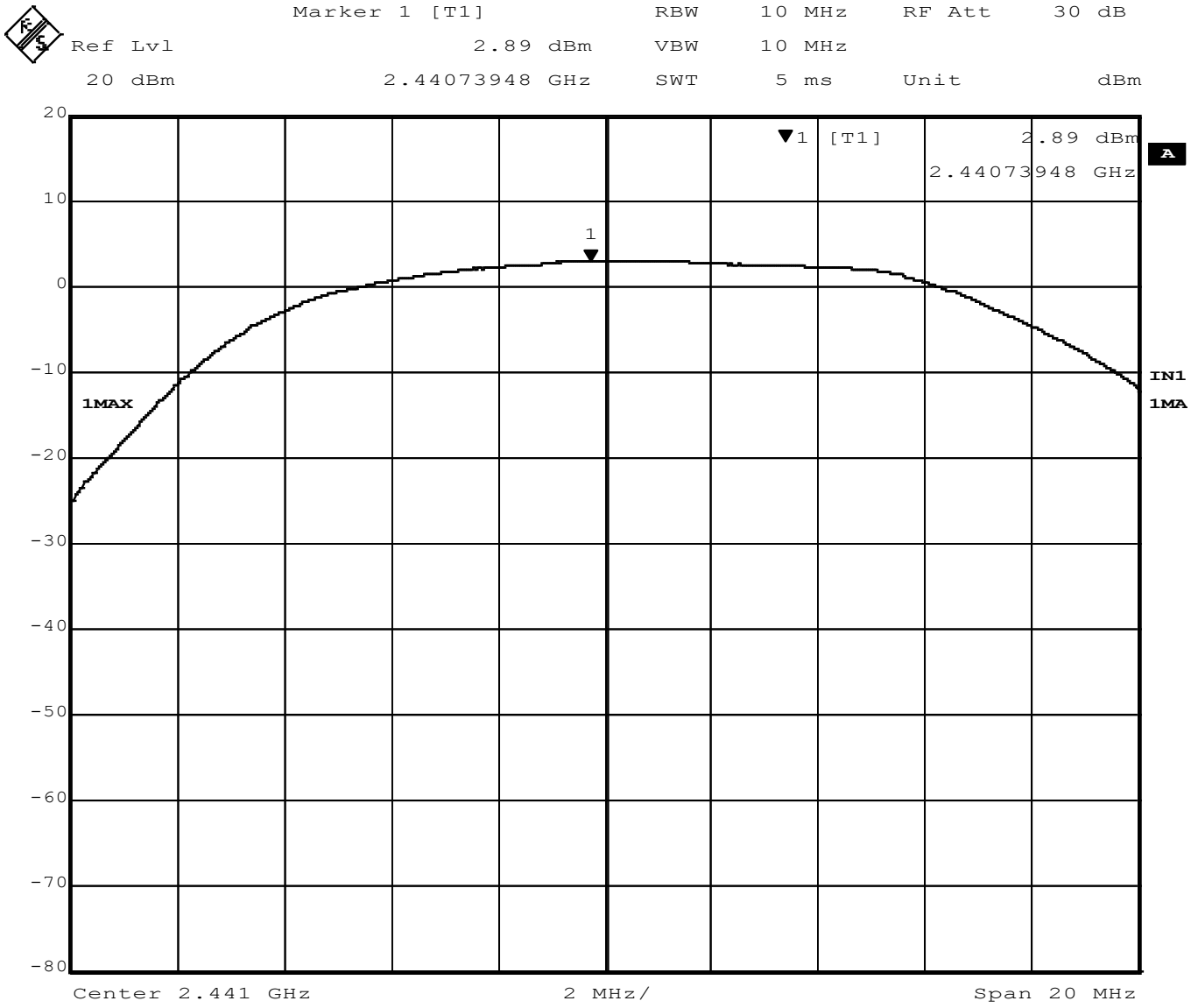

Figure 2 – Output Power, Mid Channel, GFSK

Output power = 2.89 dBm

Cable loss was less than 0.1 dB and not included

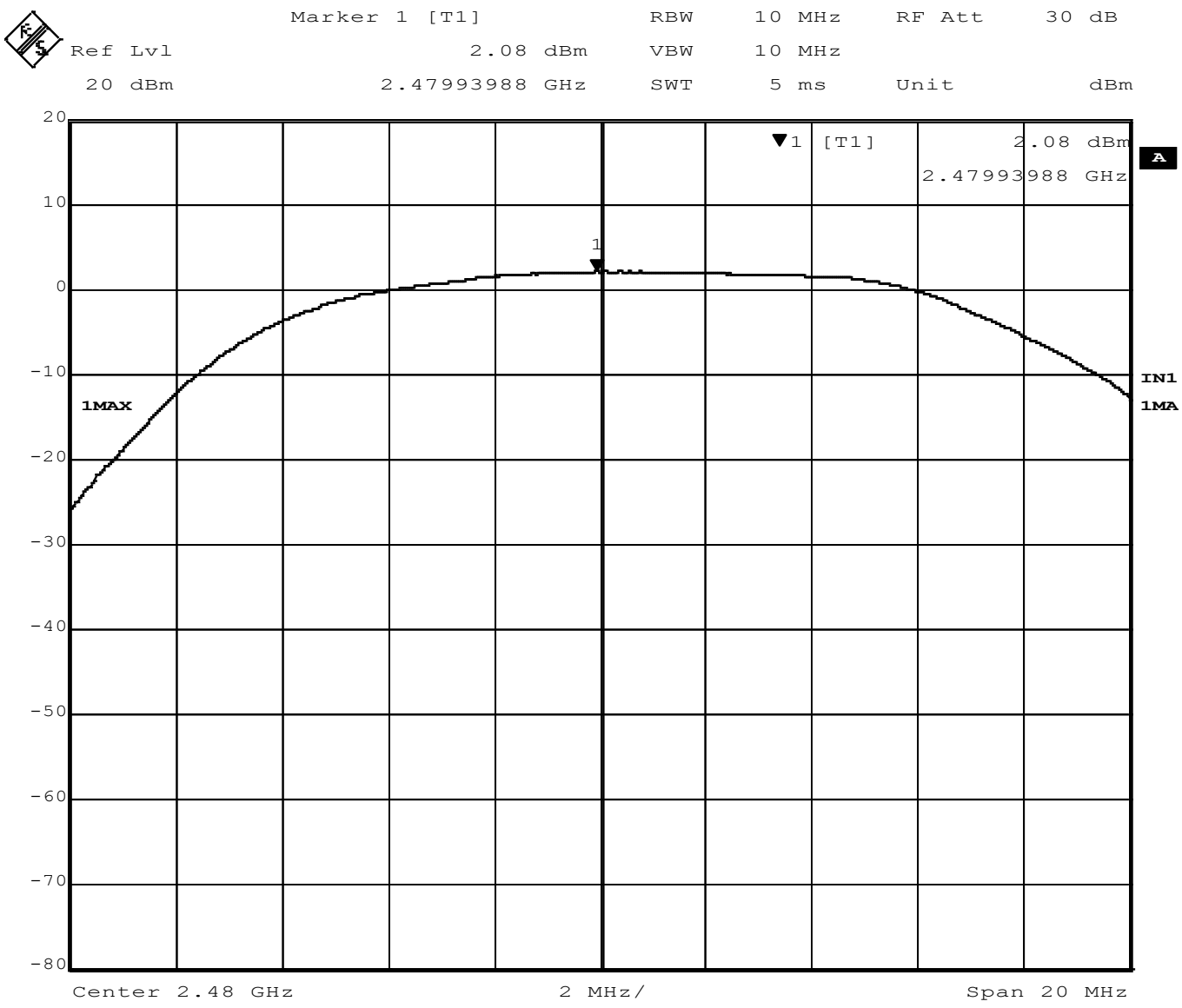

Figure 3 – Output Power, High Channel, GFSK

Output power = 2.08 dBm

Cable loss was less than 0.1 dB and not included

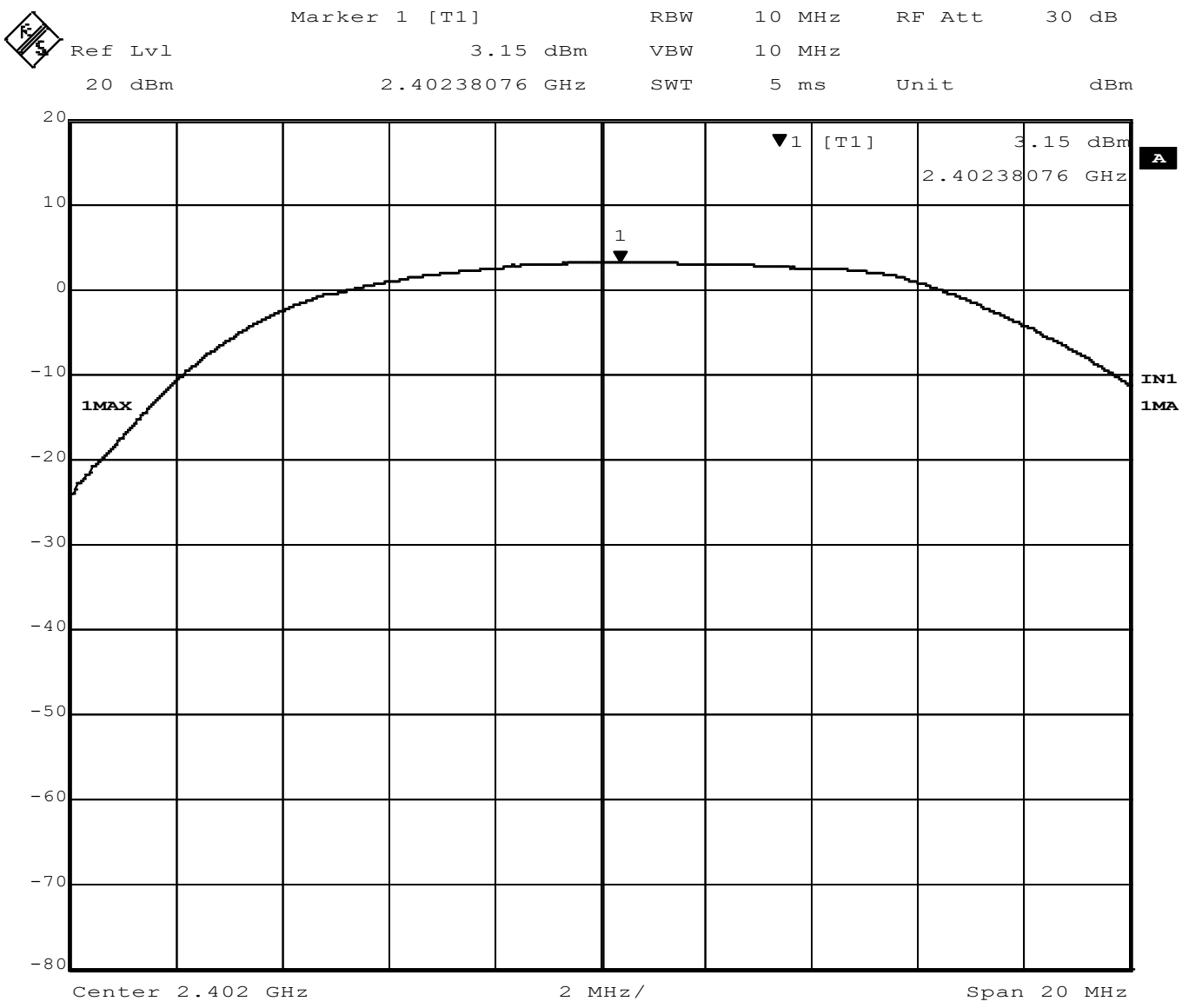

Figure 4 - Output Power, Low Channel, GMSK

Output power = 3.15 dBm

Cable loss was less than 0.1 dB and not included

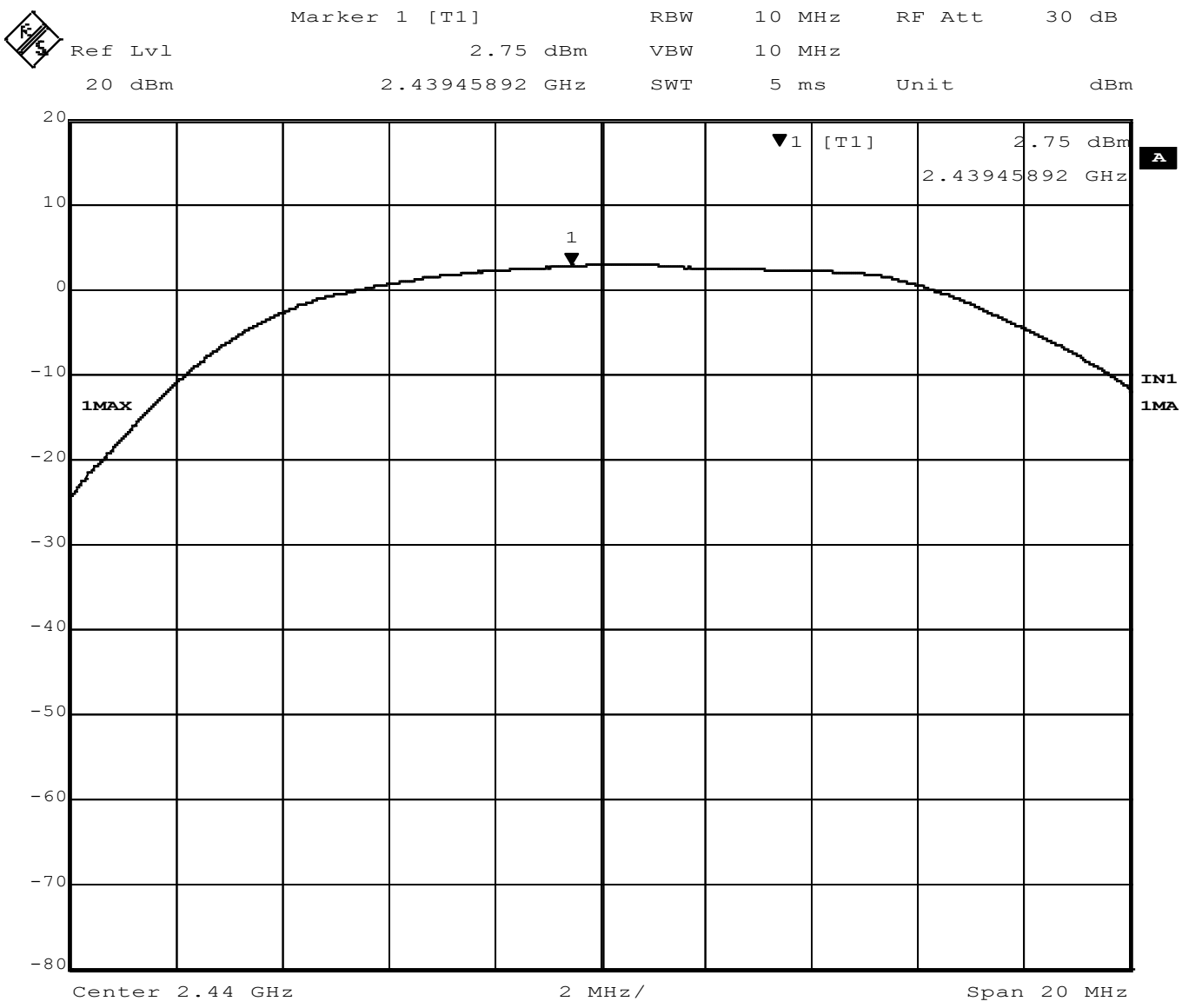

Figure 5 - Output Power, Mid Channel, GMSK

Output power = 2.75 dBm

Cable loss was less than 0.1 dB and not included

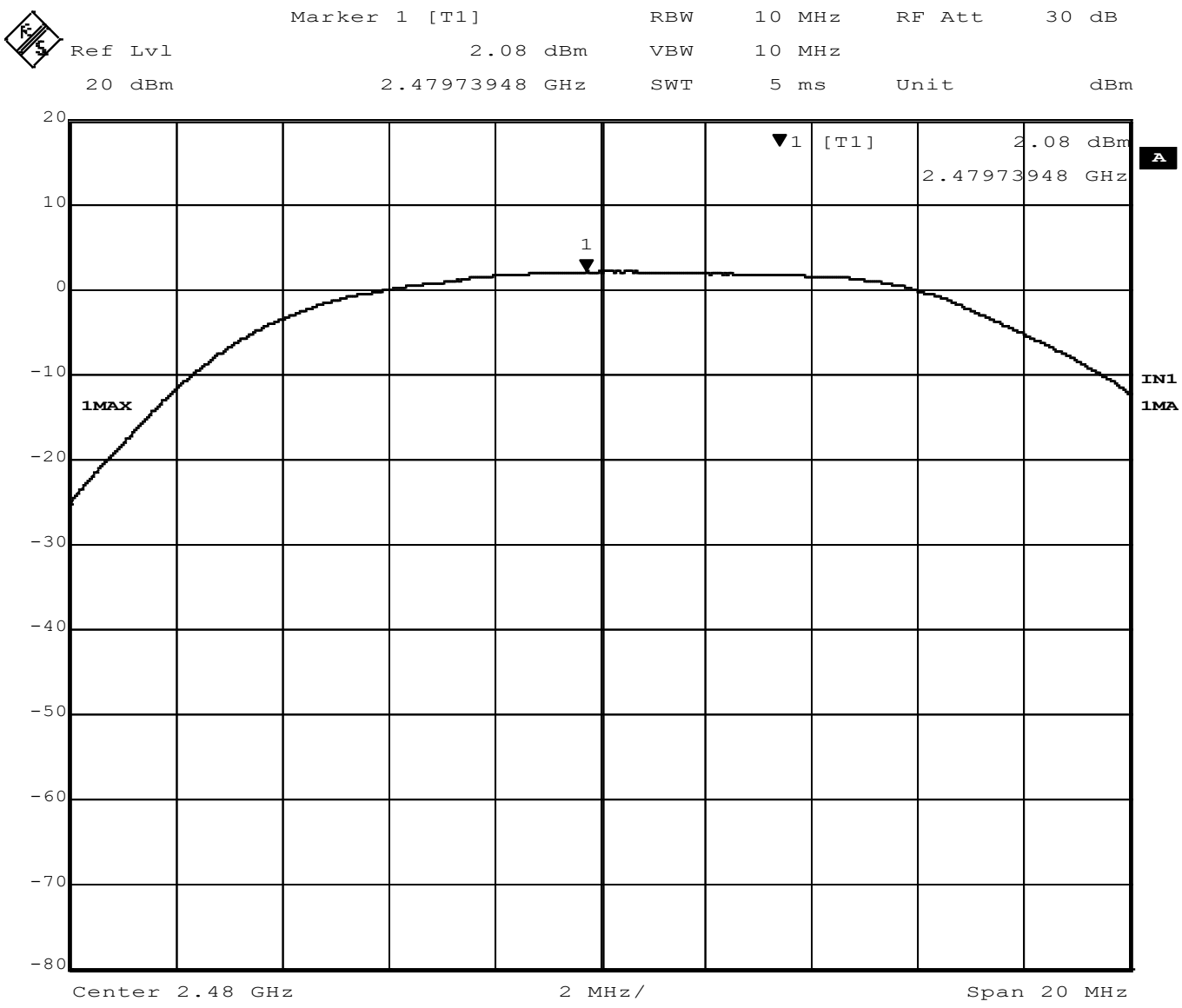

Figure 6 - Output Power, High Channel, GMSK

Output power = 2.08 dBm

Cable loss was less than 0.1 dB and not included

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 connected to the spectrum analyzer directly with a low-loss shielded coaxial cable

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 7 - Bandwidth Measurements Test Setup

EUT operating conditions:
The EUT was powered by 12 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 GMSK and GFSK.

Test results:

Occupied Bandwidth

CHANNEL	Mode	CHANNEL FREQUENCY (MHz)	OBW (KHz)	RESULT
Low	GFSK	2402	967.9	PASS
Mid	GFSK	2440	961.9	PASS
High	GFSK	2480	961.9	PASS
Low	GMSK	2402	1058.0	PASS
Mid	GMSK	2440	1058.0	PASS
High	GMSK	2480	1064.0	PASS

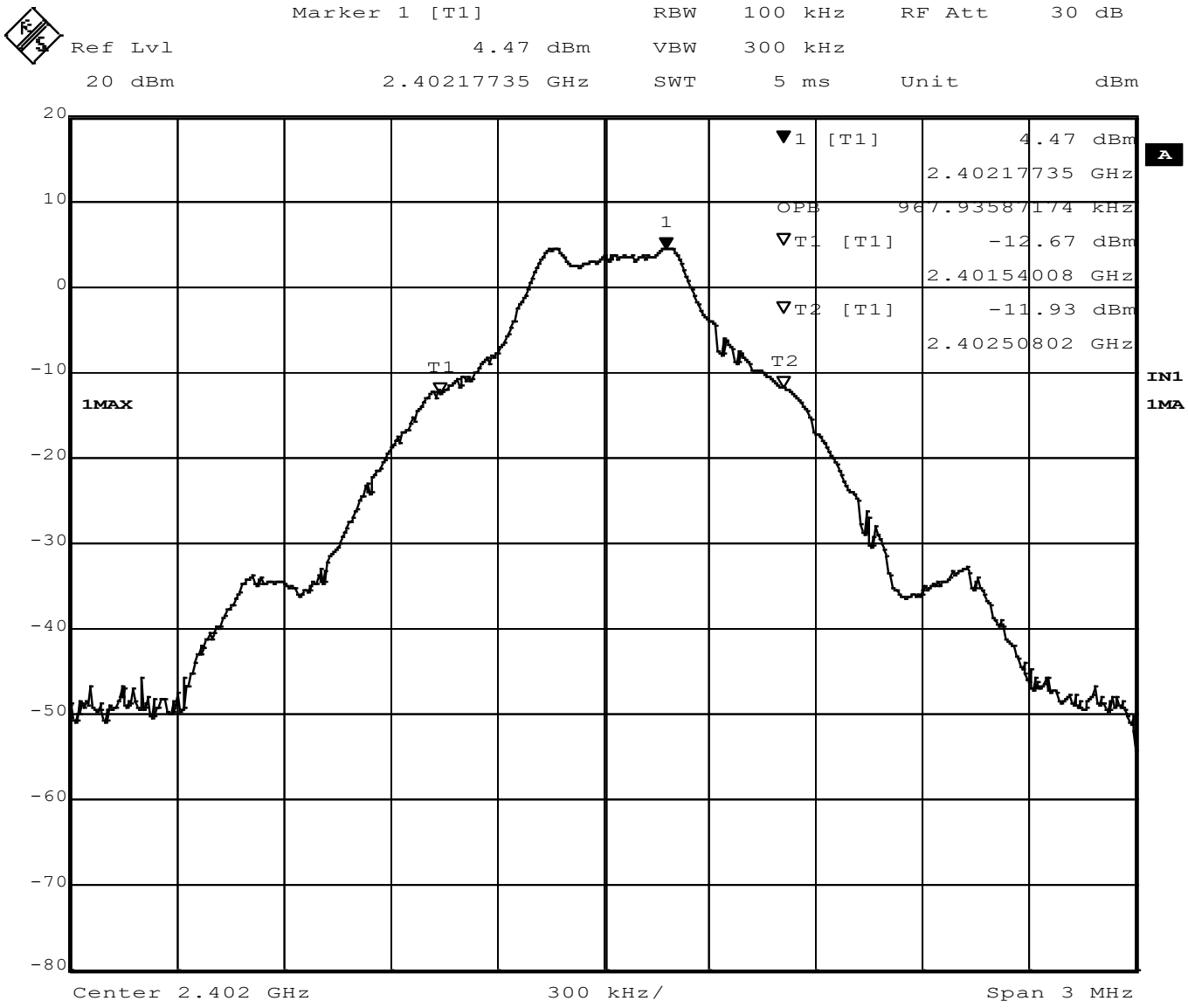

Figure 8 – Occupied Bandwidth, Low Channel, GFSK

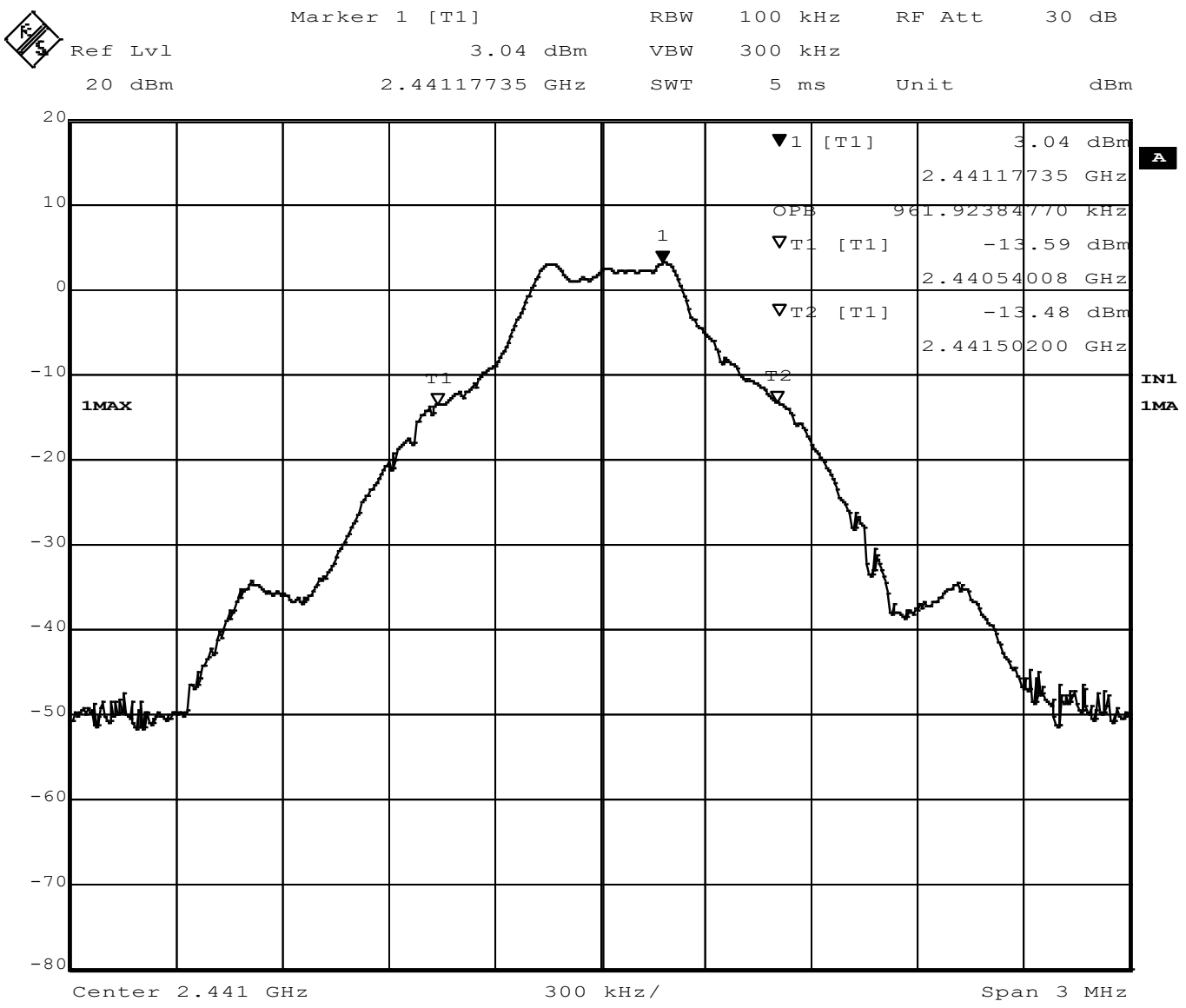

Figure 9 - Occupied Bandwidth, Mid Channel, GFSK

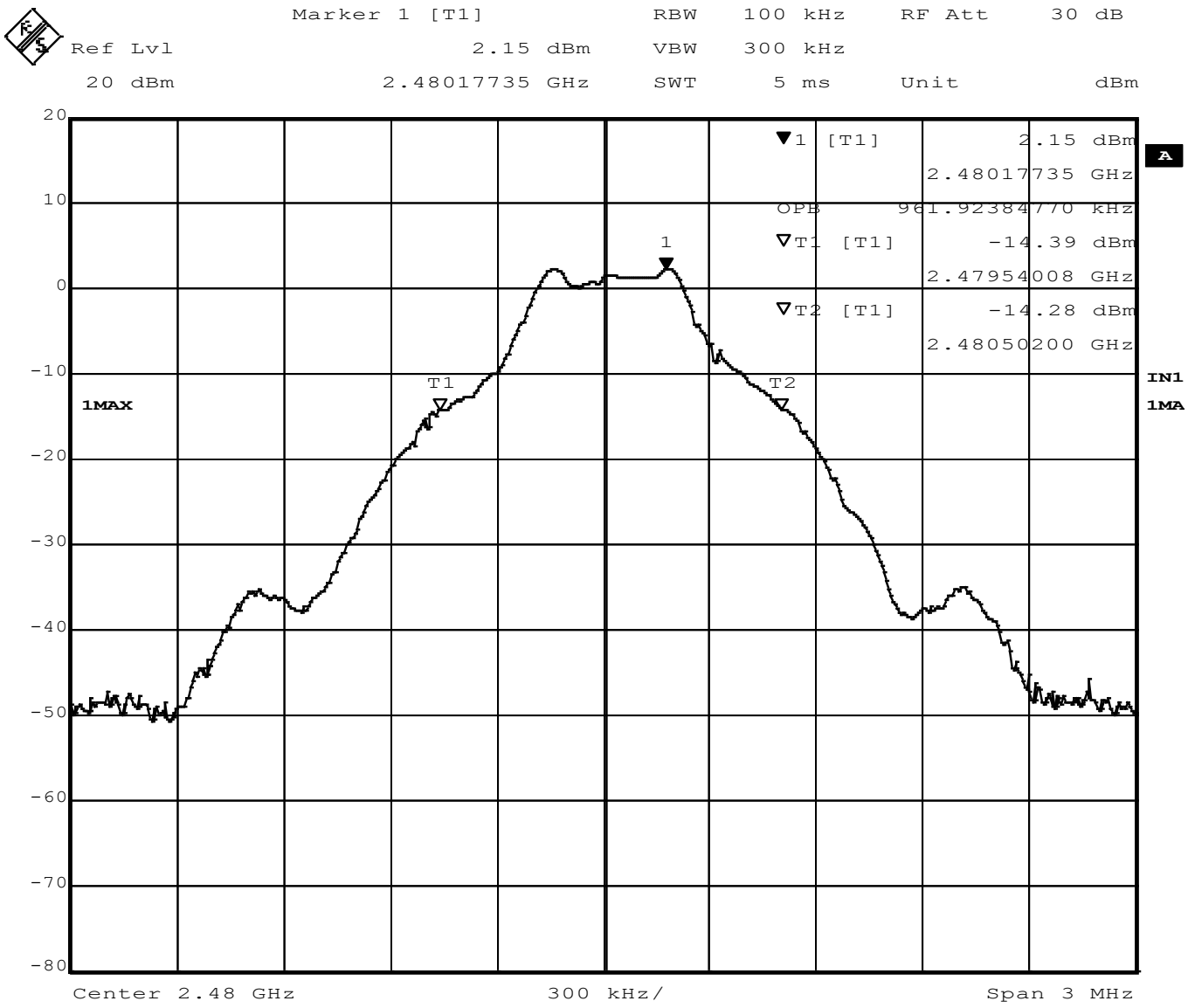

Figure 10 - Occupied Bandwidth, High Channel, GFSK

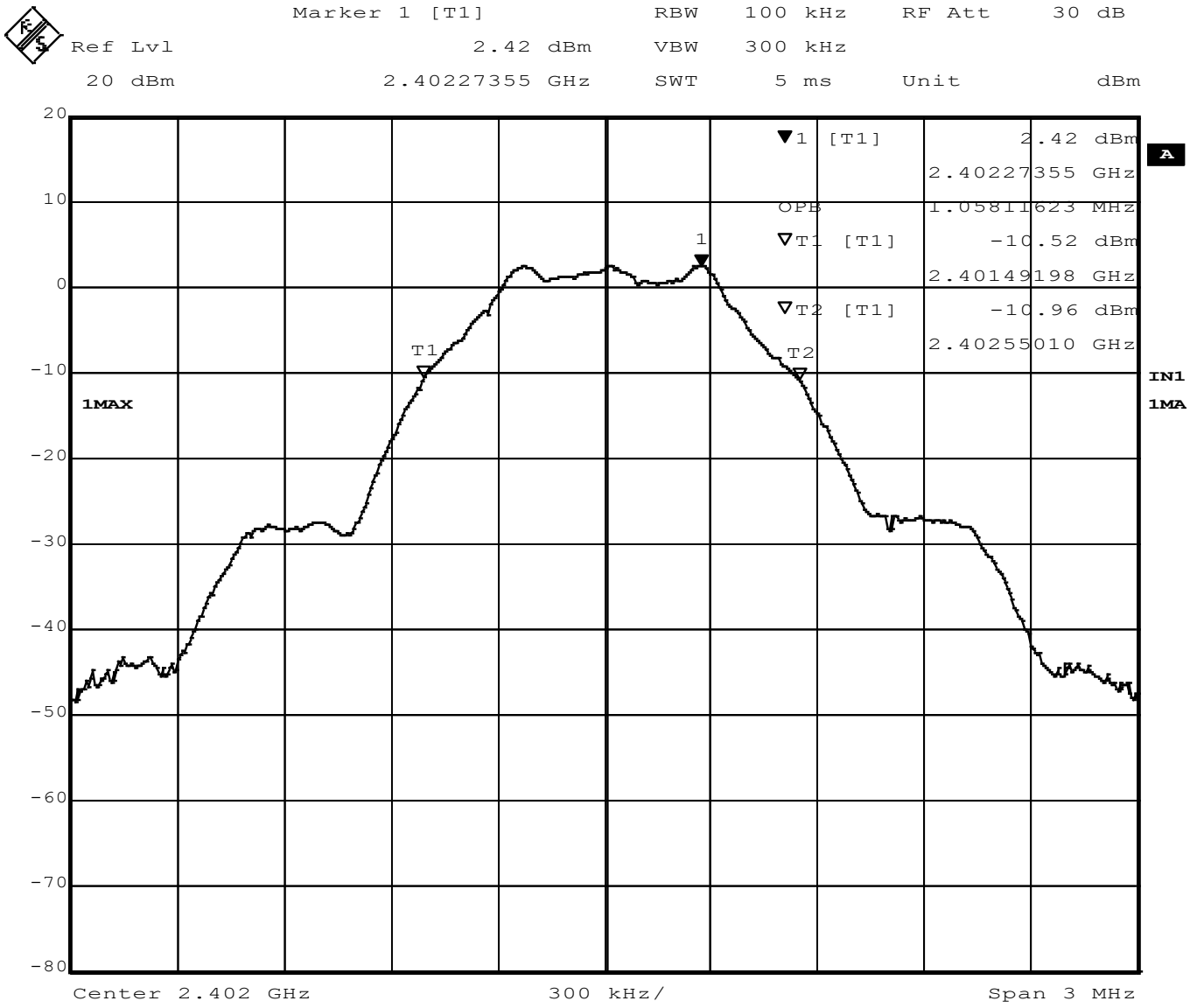

Figure 11 – Occupied Bandwidth, Low Channel, GMSK

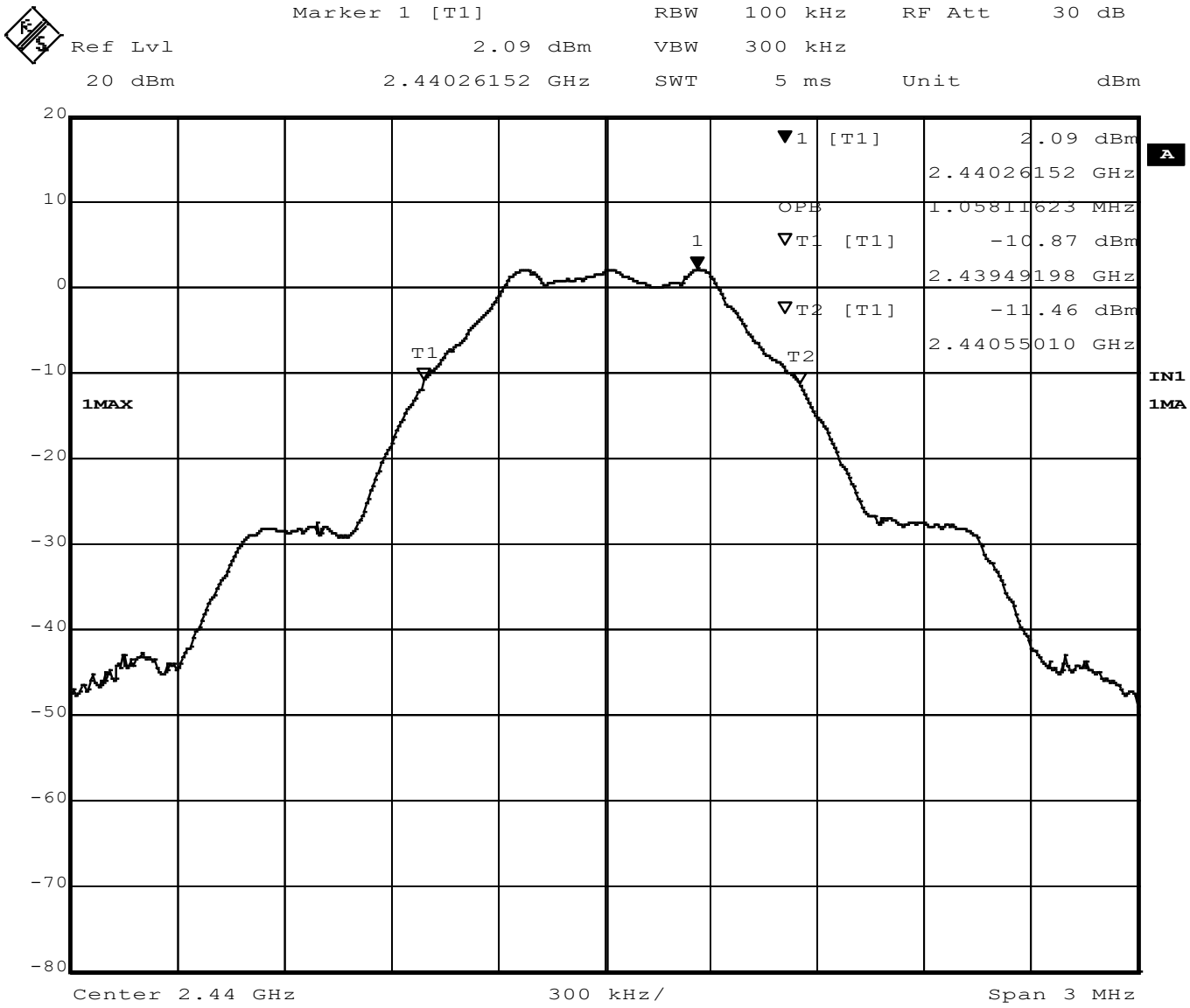

Figure 12 - Occupied Bandwidth, Mid Channel, GMSK

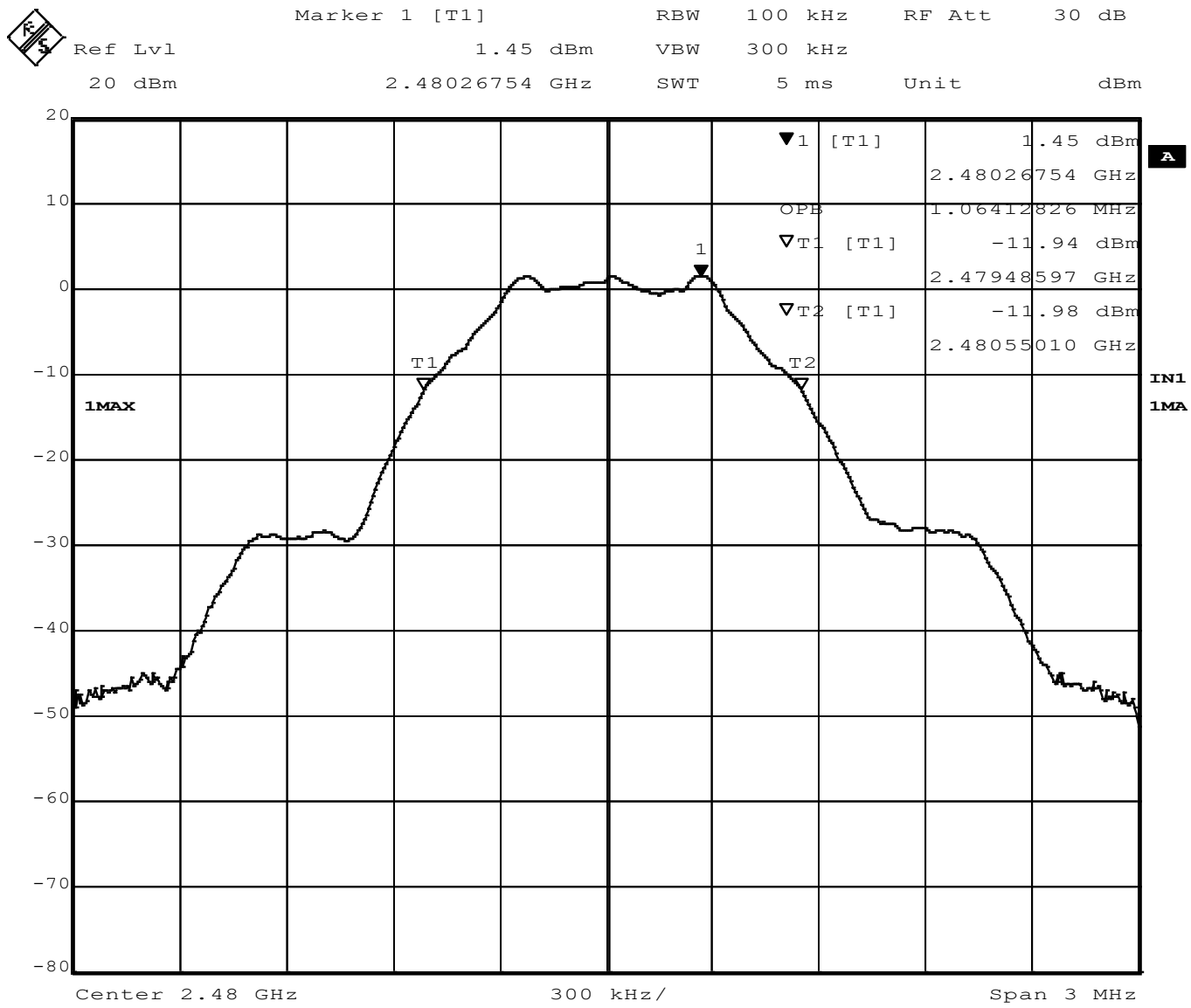

Figure 13 - Occupied Bandwidth, High Channel, GMSK

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:

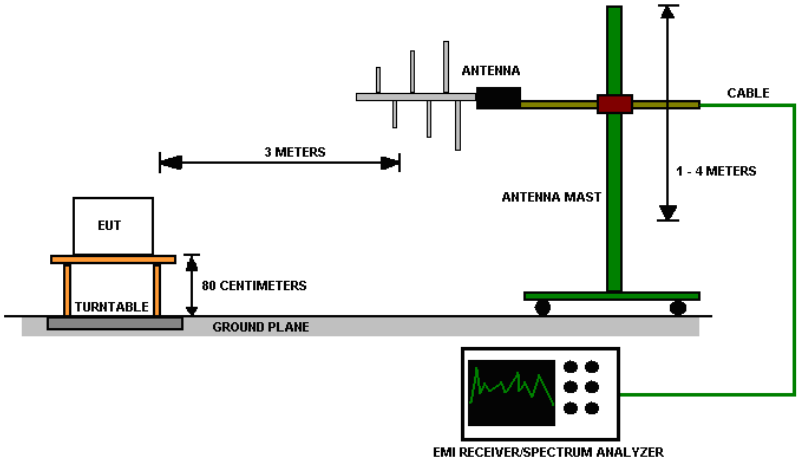

Figure 14 - Radiated Emissions Test Setup

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
The EUT was powered by 12 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 GMSK and GFSK.

Test results:

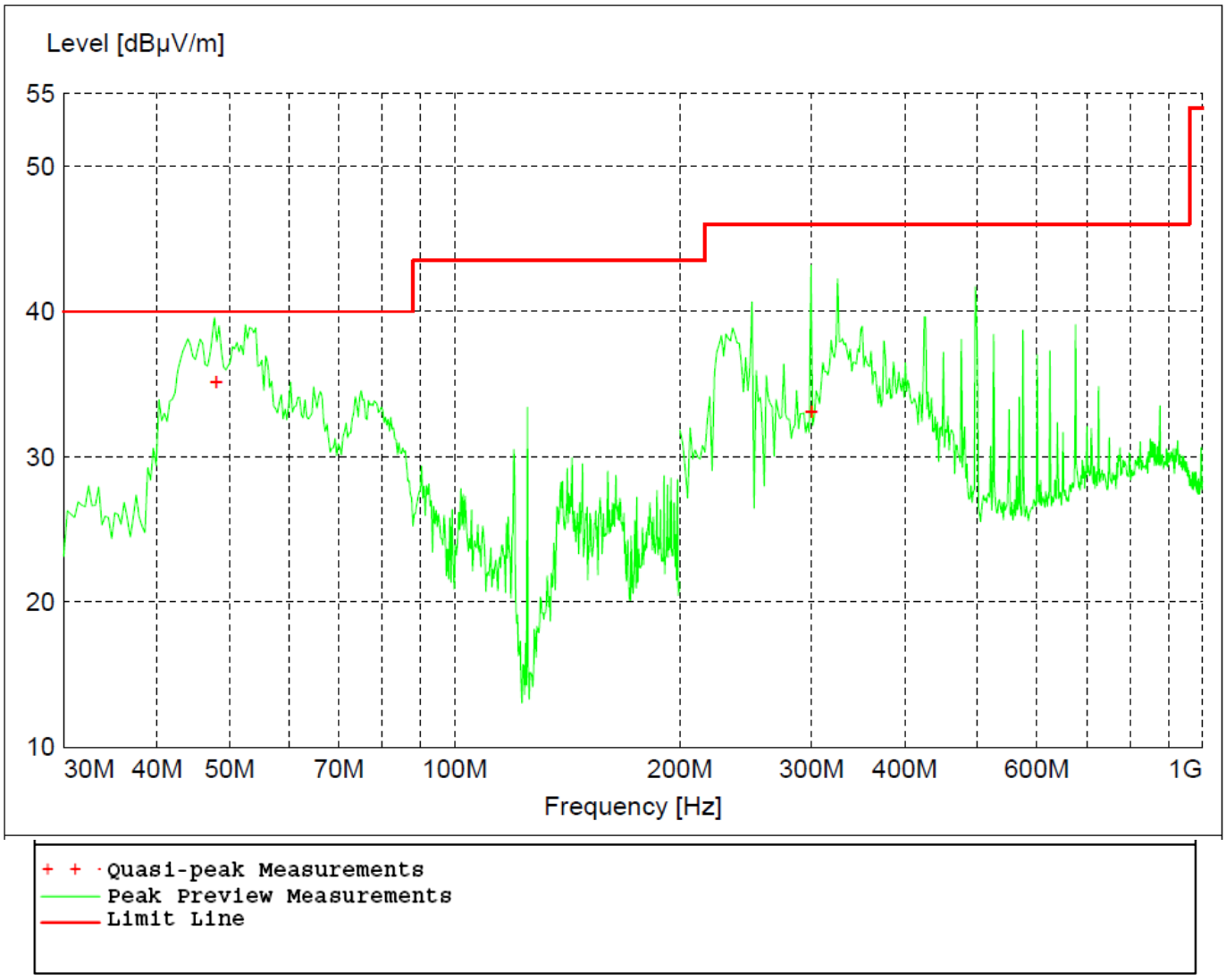

Figure 15 - Radiated Emissions Plot, Receive, 12 Inch Unit

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, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
48.000000	35.15	40.00	4.80	99	214	VERT
300.000000	33.12	46.00	12.90	99	238	HORI

Table 2 - Radiated Emissions Peak Measurement, Receive, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1745.000000	34.13	54.00	19.90	372	358	VERT
4870.000000	43.51	54.00	10.50	98	274	VERT
5777.400000	41.21	54.00	12.80	100	187	VERT
7312.000000	46.11	54.00	7.90	217	147	VERT

Peak measurements were compared with average limits and found to be compliant, average values not shown.

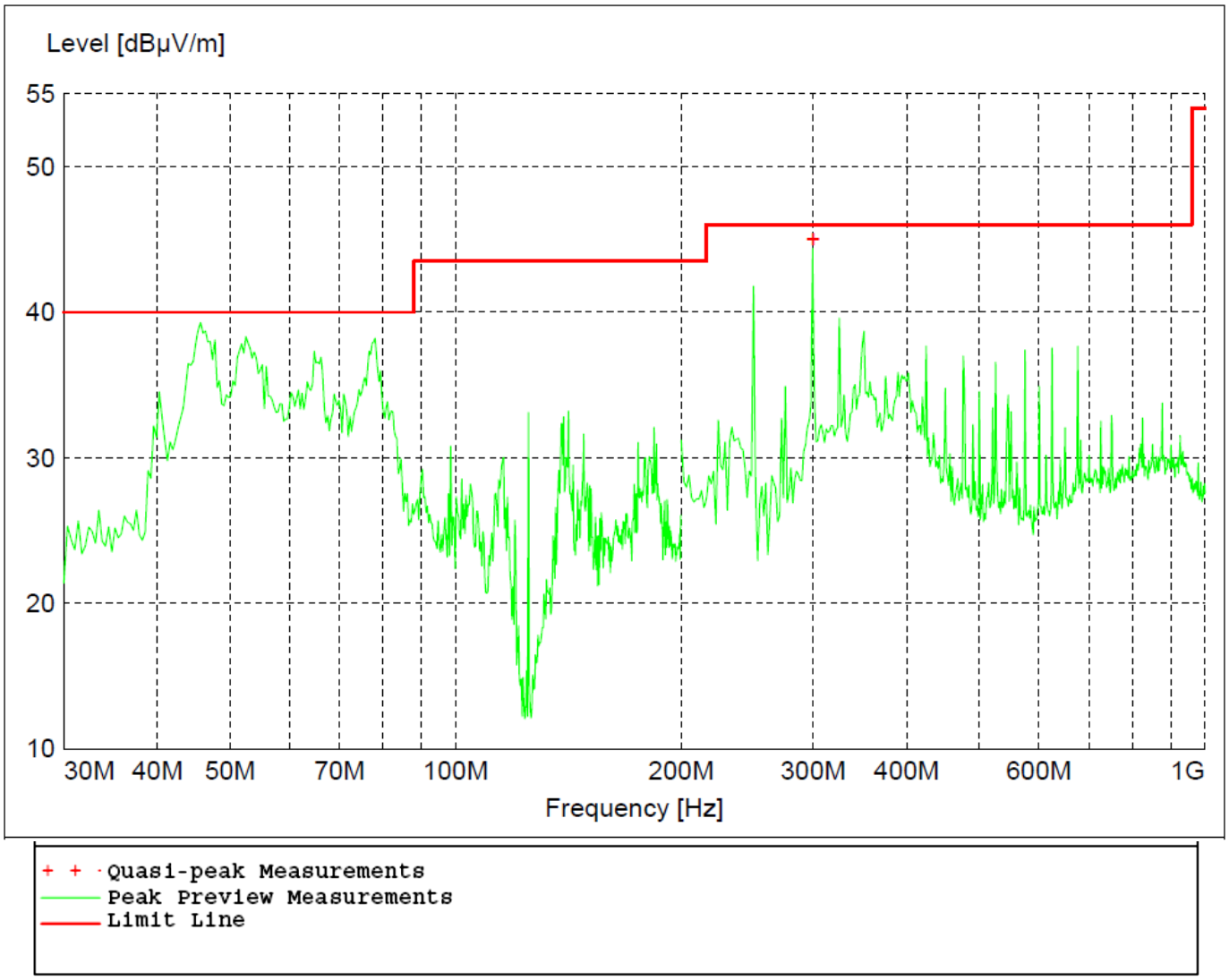

Figure 16 - Radiated Emissions Plot, Receive, 10 Inch Unit

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, Receive, 10 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
300.000000	45.02	46.00	1.00	100	236	HORI

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

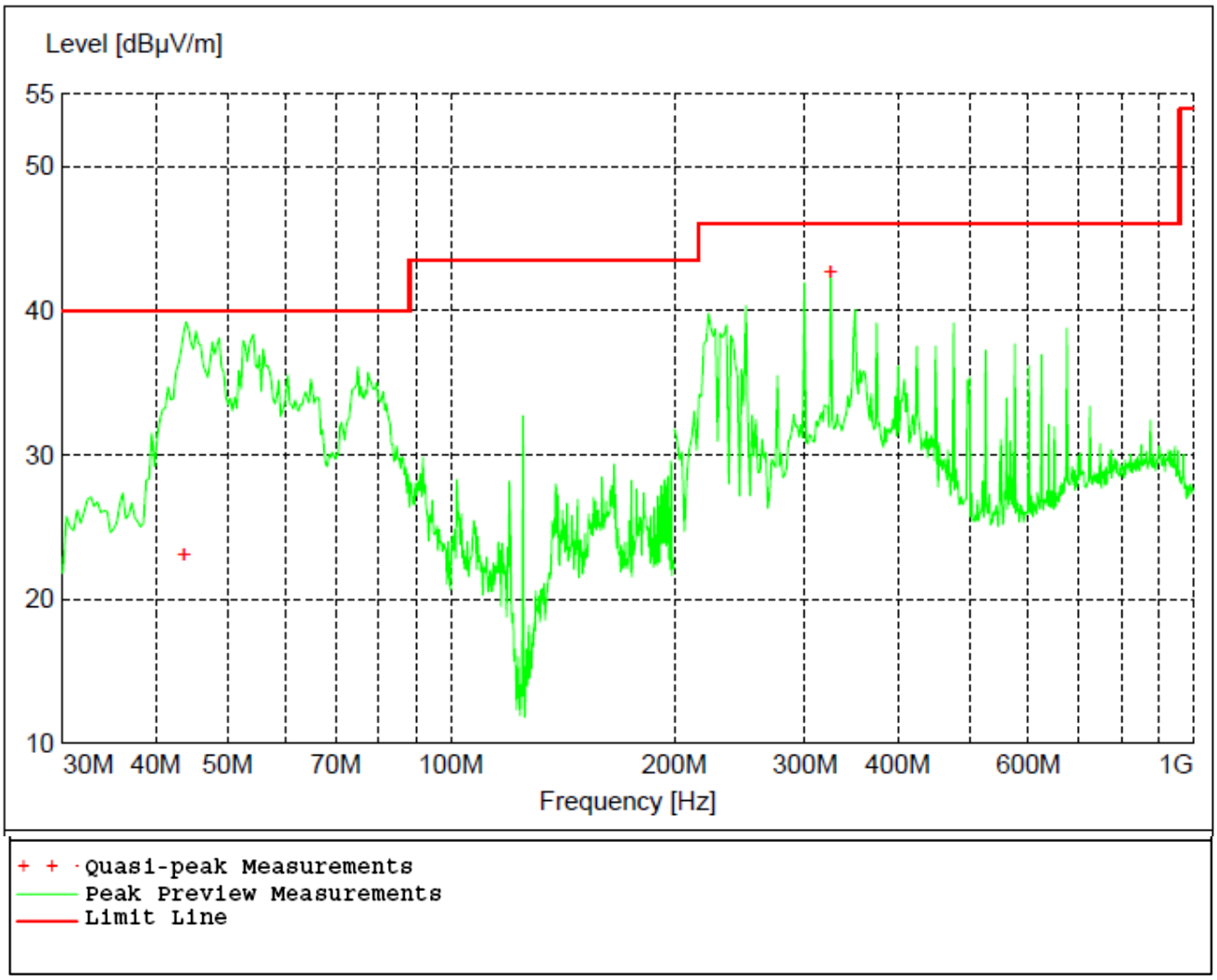

Figure 17 - Radiated Emissions Plot, Low Channel, GMSK, 12 Inch Unit

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, Low Channel, GMSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
43.680000	23.03	40.00	17.00	99.00	356	VERT
325.020000	42.68	46.00	3.30	108.00	199	HORI

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

Table 5 - Radiated Emissions Peak Measurements vs Average Limits, Low Channel, GMSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2402.000000	90.80	94.00	3.20	201	136	HORI
4816.400000	43.21	54.00	10.79	226	353	VERT

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
Peak measurements were compared with average limits and found to be compliant, average values not shown.

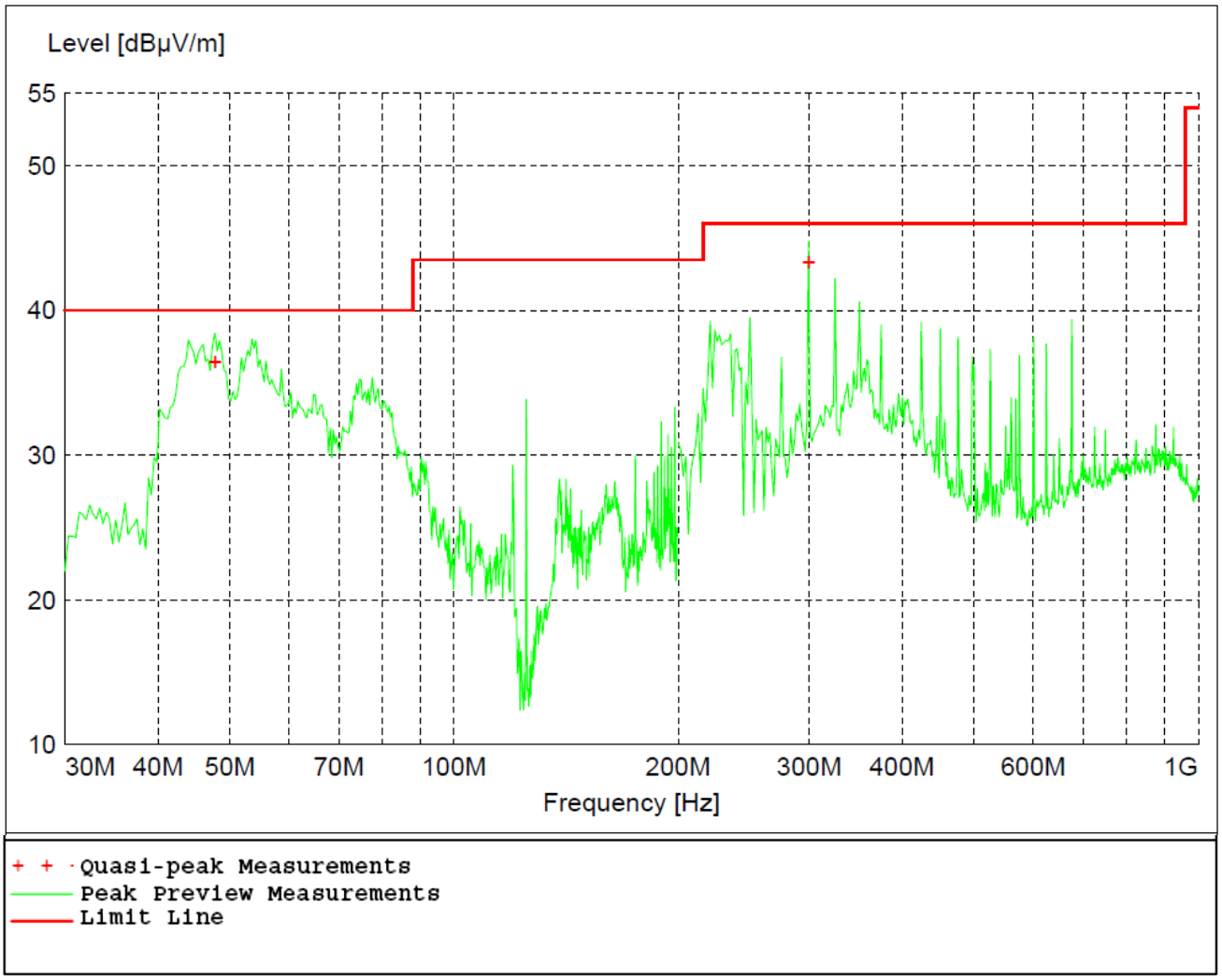

Figure 18 - Radiated Emissions Plot, Mid Channel, GMSK, 12 Inch Unit

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, Mid Channel, GMSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
47.760000	36.49	40.00	3.50	99.00	216	VERT
300.000000	43.37	46.00	2.60	100.00	246	HORI

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

Table 7 - Radiated Emissions Peak Measurements vs Average Limits, Mid Channel, GMSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2440.000000	90.83	94.00	3.17	231	184	HORI
4896.000000	45.43	54.00	8.57	291	246	HORI

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
Peak measurements were compared with average limits and found to be compliant, average values not shown.

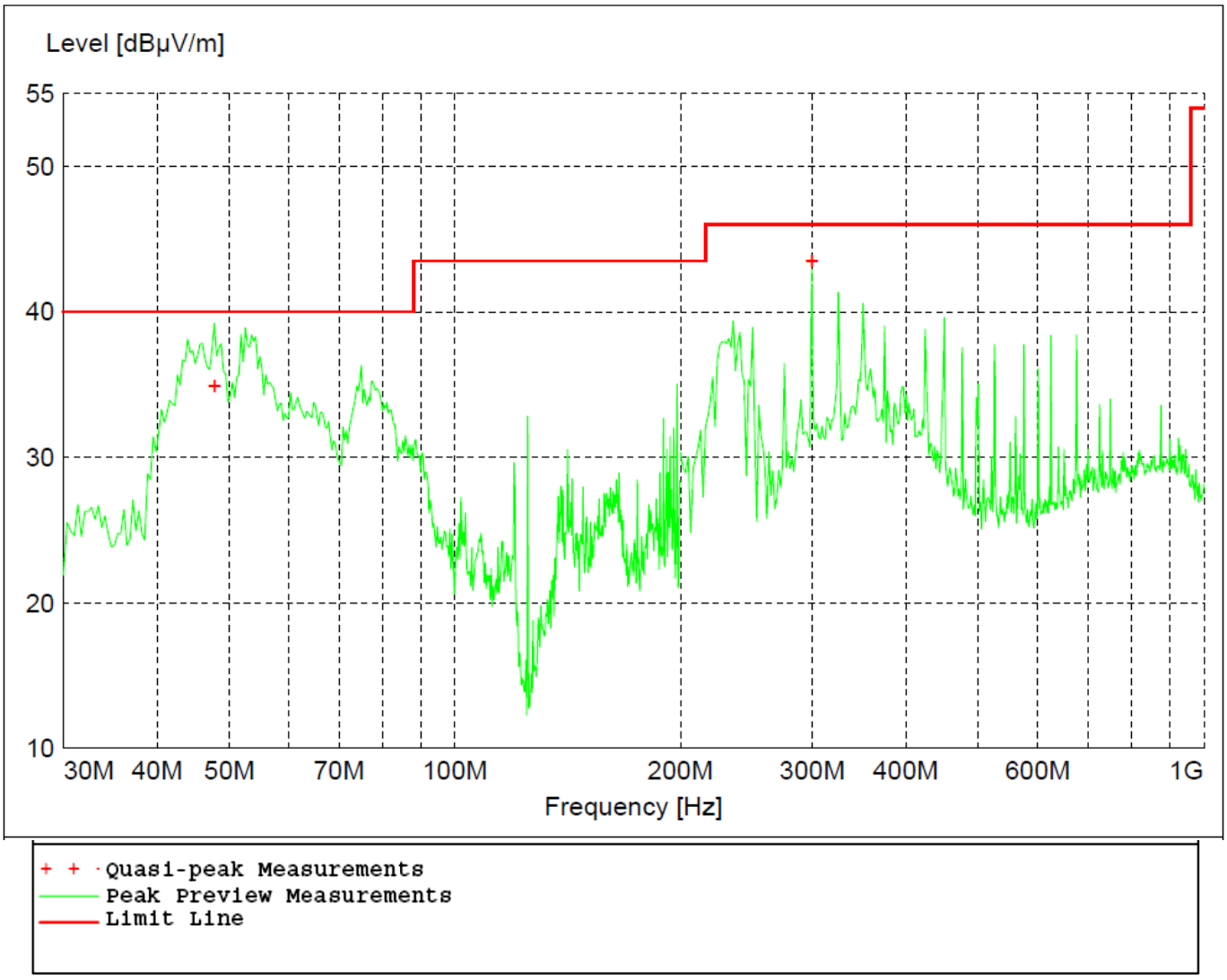

Figure 19 - Radiated Emissions Plot, High Channel, GMSK, 12 Inch Unit

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 8 - Radiated Emissions Quasi-peak Measurements, High Channel, GMSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
47.760000	34.93	40.00	5.10	102.00	280	VERT
300.000000	43.48	46.00	2.50	99.00	241	HORI

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

Table 9 - Radiated Emissions Peak Measurements vs Average Limits, High Channel, GMSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2480.000000	91.42	94.00	2.58	197	191	HORI
4965.000000	42.79	54.00	11.21	103	123	VERT

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
Peak measurements were compared with average limits and found to be compliant, average values not shown.

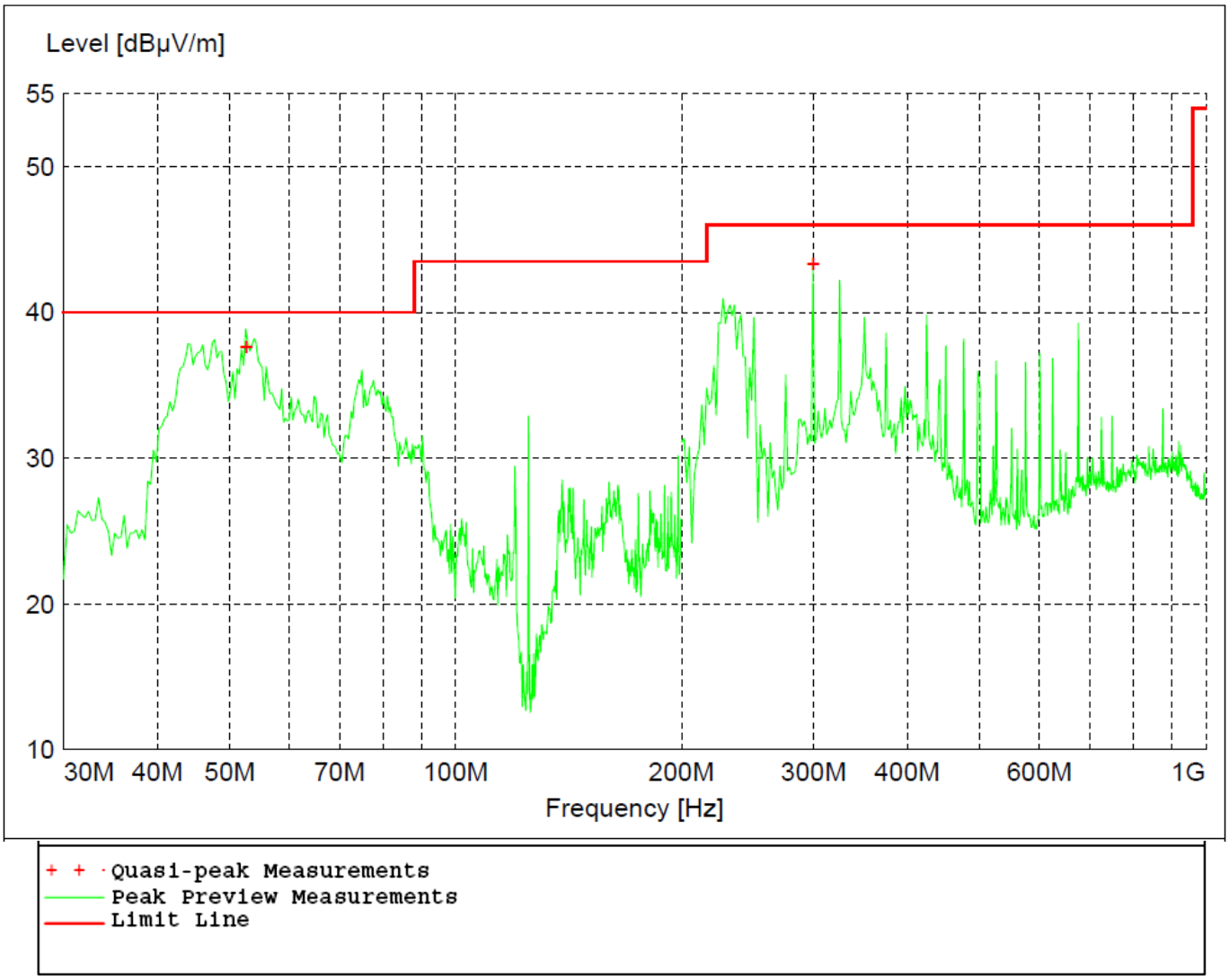

Figure 20 - Radiated Emissions Plot, Low Channel, GFSK, 12 Inch Unit

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 10 - Radiated Emissions Quasi-peak Measurements, Low Channel, GFSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
52.620000	37.61	40.00	2.40	100.00	278	VERT
300.000000	43.36	46.00	2.60	99.00	233	HORI

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

Table 11 - Radiated Emissions Peak Measurements vs Average Limits, Low Channel, GFSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2402.000000	93.32	94.00	0.68	153	216	HORI
4817.000000	43.33	54.00	10.67	342	356	VERT

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
Peak measurements were compared with average limits and found to be compliant, average values not shown.

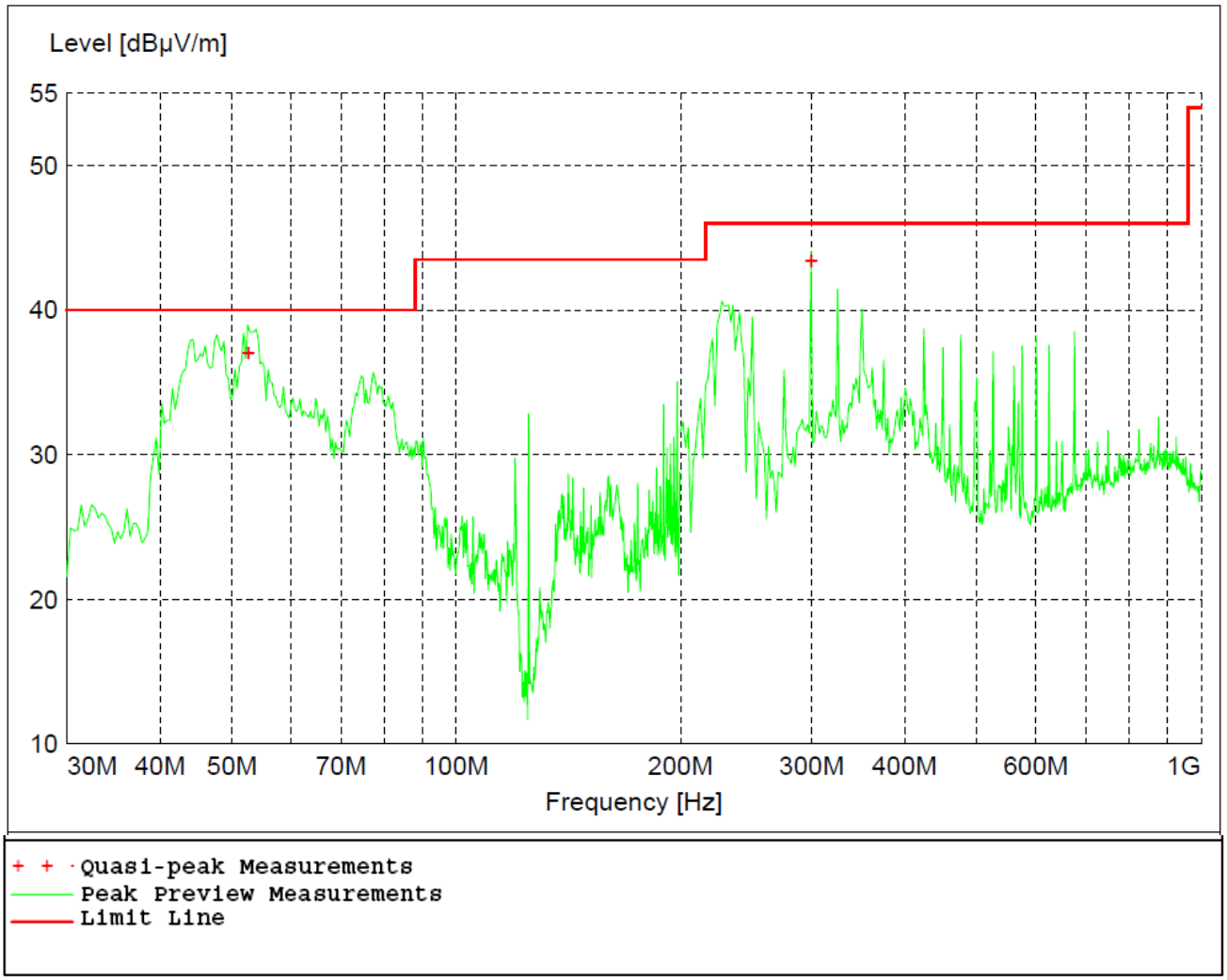

Figure 21 - Radiated Emissions Plot, Mid Channel, GFSK, 12 Inch Unit

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 12 - Radiated Emissions Quasi-peak Measurements, Mid Channel, GFSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
52.620000	37.06	40.00	2.90	133.00	314	VERT
300.000000	43.46	46.00	2.50	100.00	241	HORI

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

Table 13 - Radiated Emissions Peak Measurements vs Average Limits, Mid Channel, GFSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2441.000000	90.96	94.00	3.04	211	194	HORI
2677.000000	74.81	74.00	-0.81	389	360	VERT
4882.400000	45.52	54.00	8.48	281	31	VERT

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
Peak measurements were compared with average limits and found to be compliant, average values not shown.

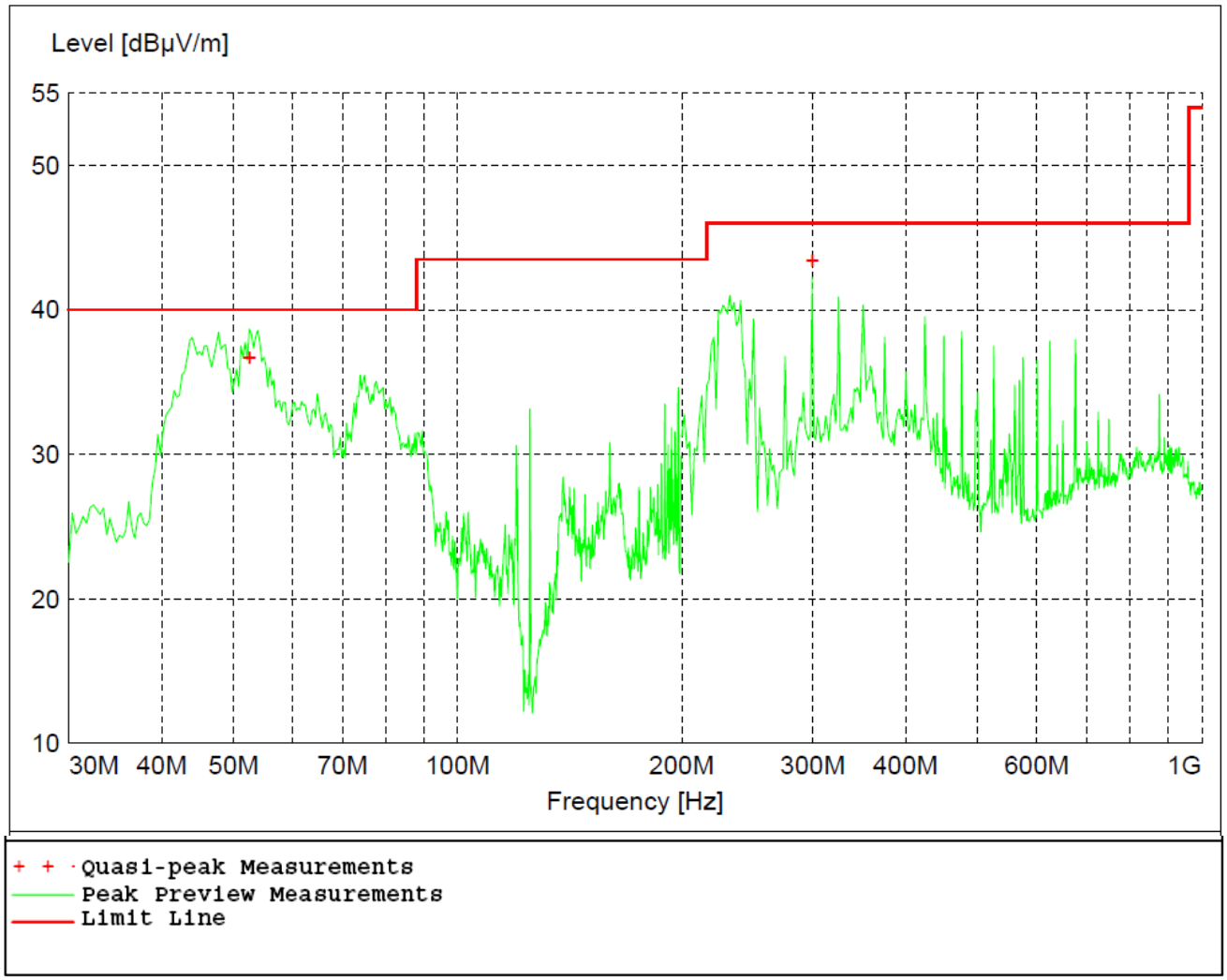

Figure 22 - Radiated Emissions Plot, High Channel, GFSK, 12 Inch Unit

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 14 - Radiated Emissions Quasi-peak Measurements, High Channel, GFSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
52.560000	36.72	40.00	3.30	100.00	319	VERT
300.000000	43.47	46.00	2.50	103.00	237	HORI

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

Table 15 - Radiated Emissions Peak Measurements vs Average Limits, High Channel, GFSK, 12 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2480.000000	90.93	94.00	3.07	200	184	HORI
4951.400000	43.14	54.00	10.86	153	0	HORI

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the table above.
Peak measurements were compared with average limits and found to be compliant, average values not shown.

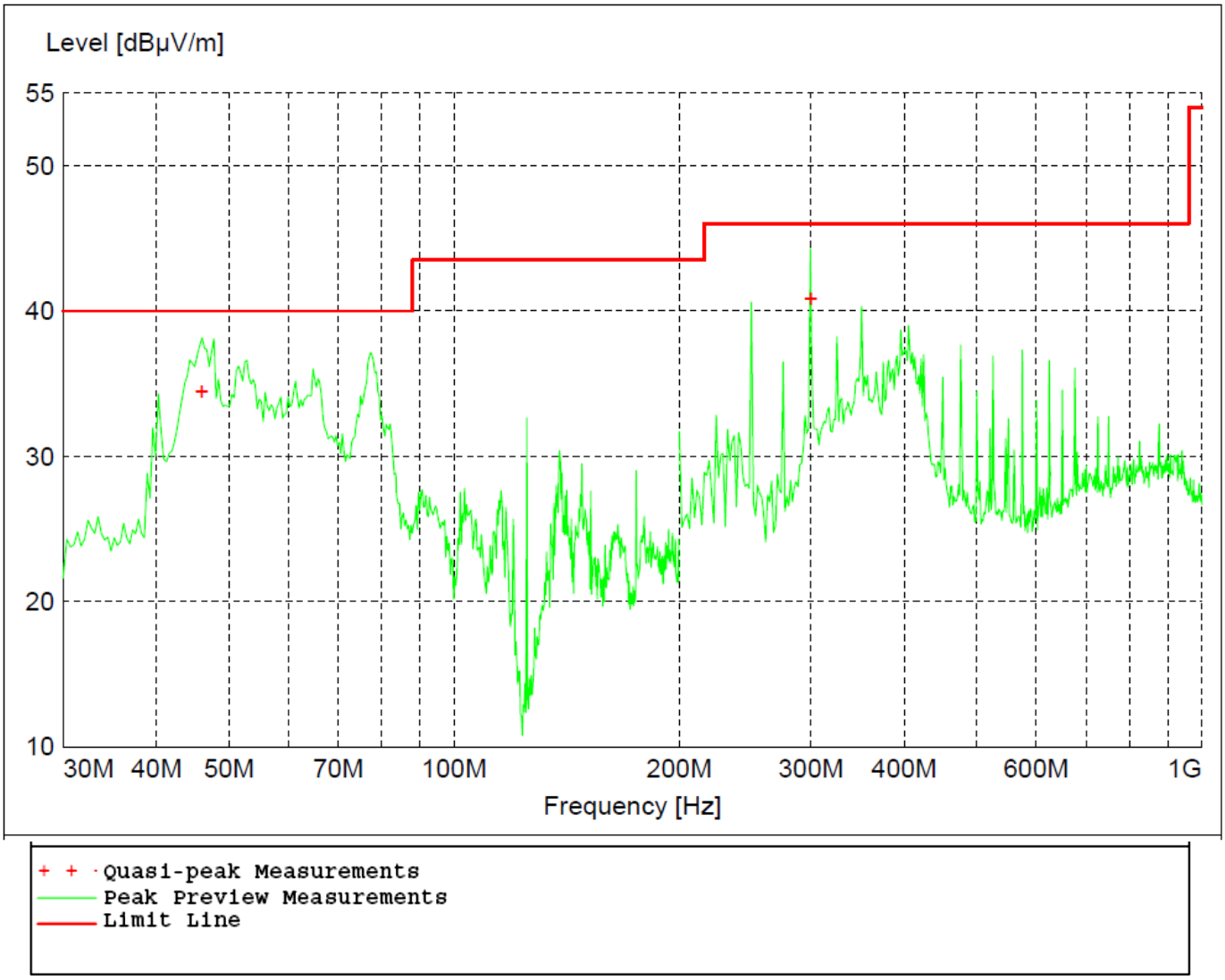

Figure 23 - Radiated Emissions Plot, Low Channel, GMSK, 10 Inch Unit

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 16 - Radiated Emissions Quasi-peak Measurements, Low Channel, GMSK, 10 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
46.020000	34.50	40.00	5.50	100	70	VERT
300.000000	40.87	46.00	5.10	103	223	HORI

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

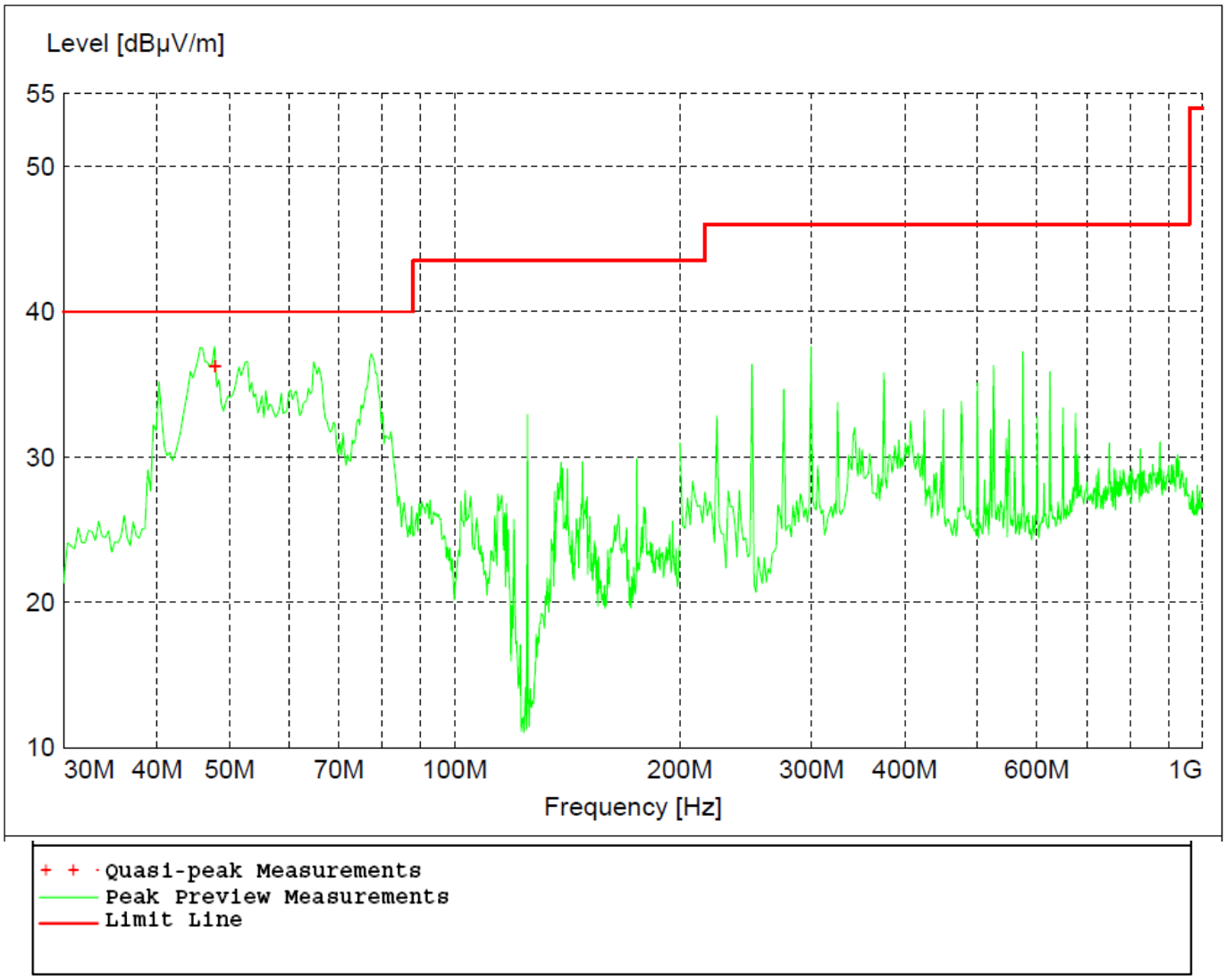

Figure 24 - Radiated Emissions Plot, Mid Channel, GMSK, 10 Inch Unit

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 17 - Radiated Emissions Quasi-peak Measurements, Mid Channel, GMSK, 10 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
47.820000	36.25	40.00	3.70	100	127	VERT

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

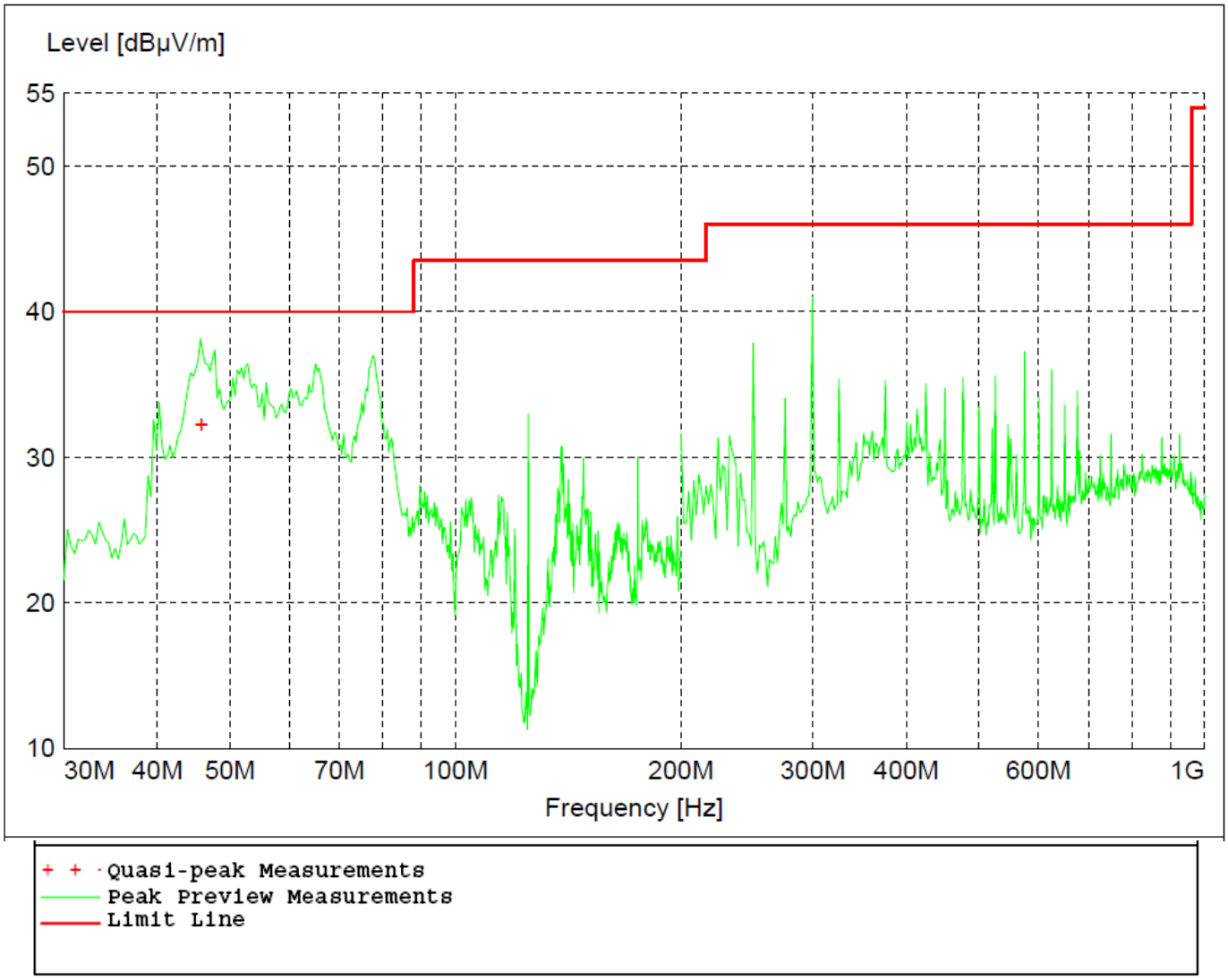

Figure 25 - Radiated Emissions Plot, High Channel, GMSK, 10 Inch Unit

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 18 - Radiated Emissions Quasi-peak Measurements, High Channel, GMSK, 10 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
45.840000	32.26	40.00	7.70	102	227	VERT

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

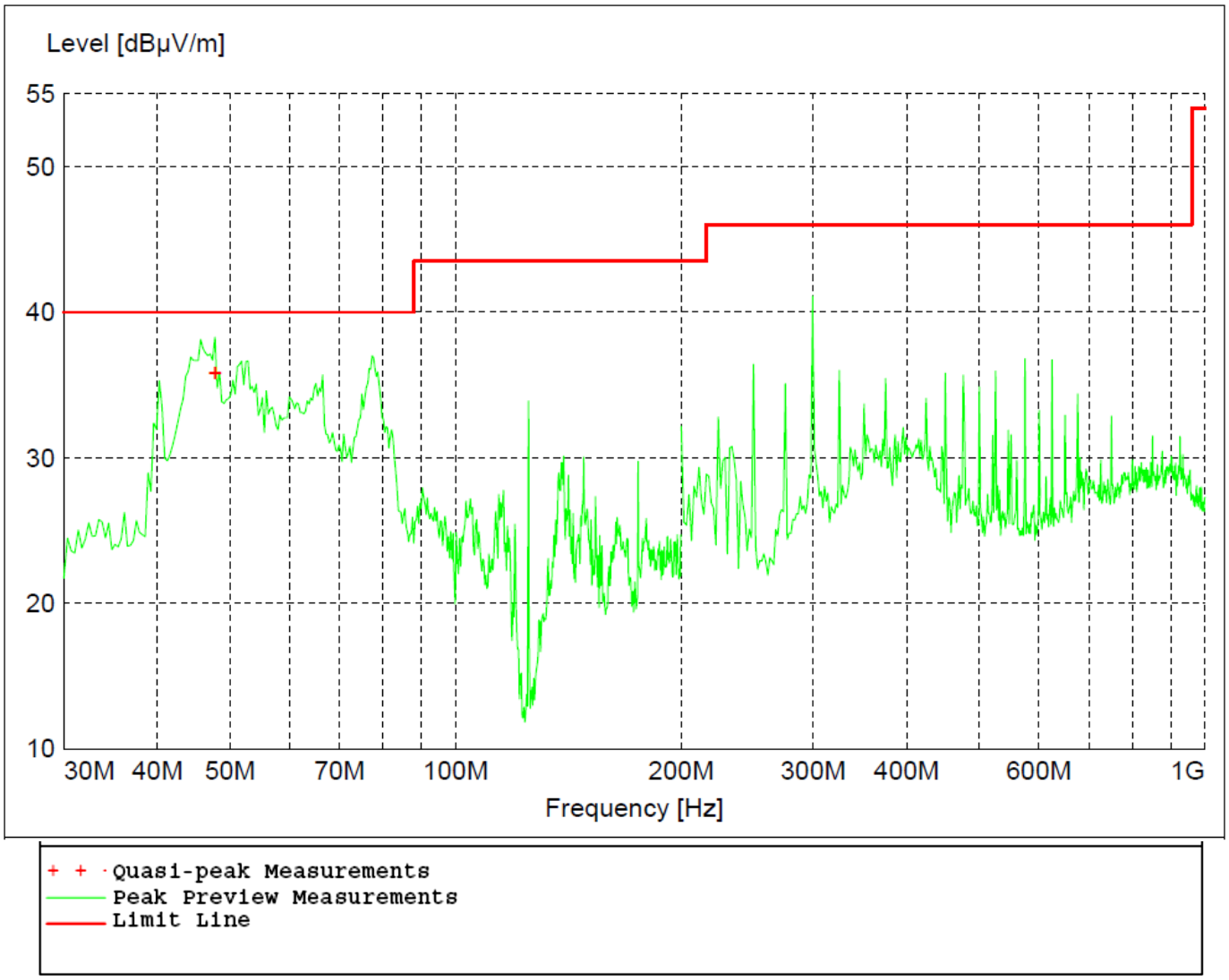

Figure 26 - Radiated Emissions Plot, Low Channel, GFSK, 10 Inch Unit

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 19 - Radiated Emissions Quasi-peak Measurements, Low Channel, GFSK, 10 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
47.760000	35.81	40.00	4.20	99	20	VERT

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

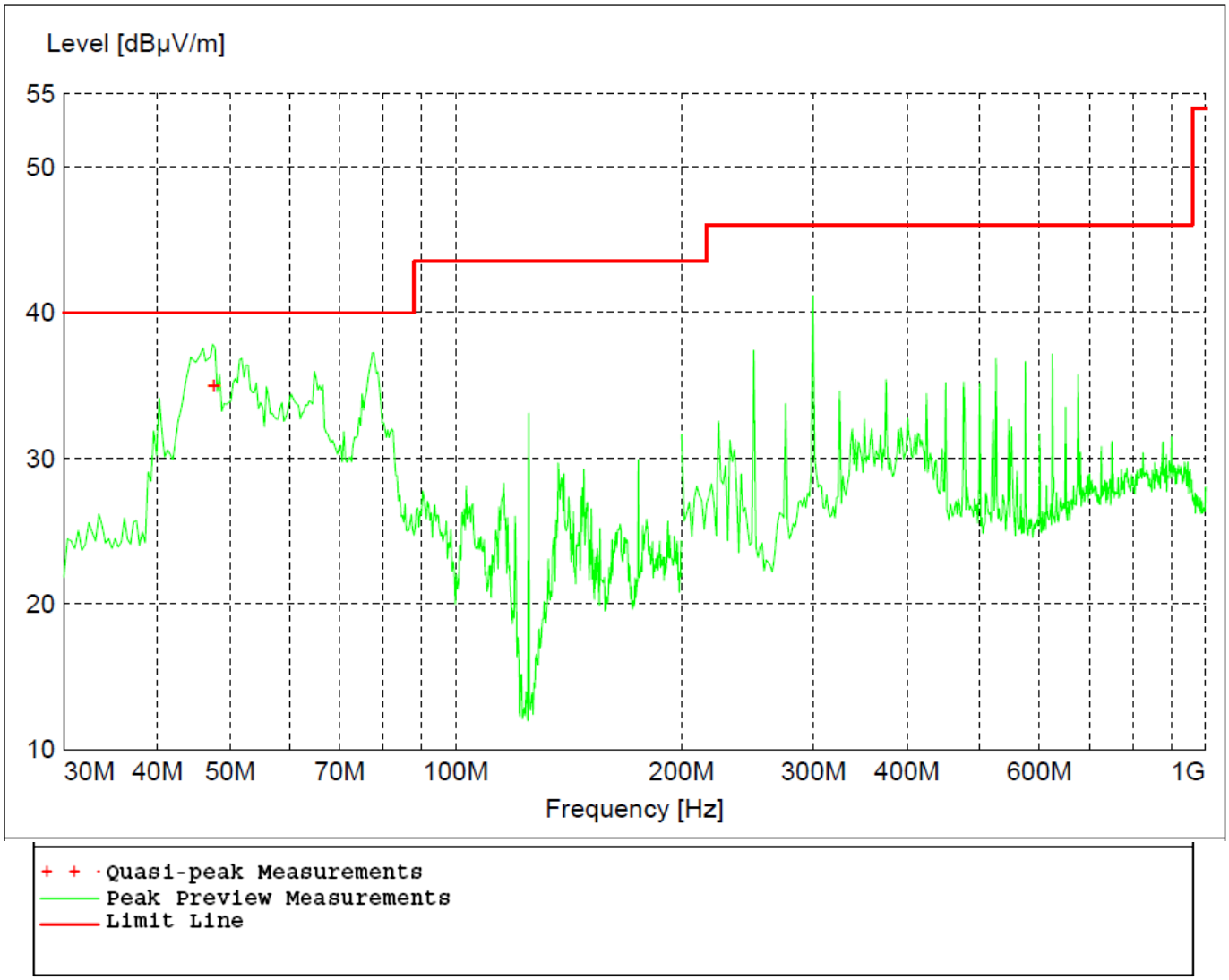

Figure 27 - Radiated Emissions Plot, Mid Channel, GFSK, 10 Inch Unit

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 20 - Radiated Emissions Quasi-peak Measurements, Mid Channel, GFSK, 10 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
47.580000	34.96	40.00	5.00	100	149	VERT

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

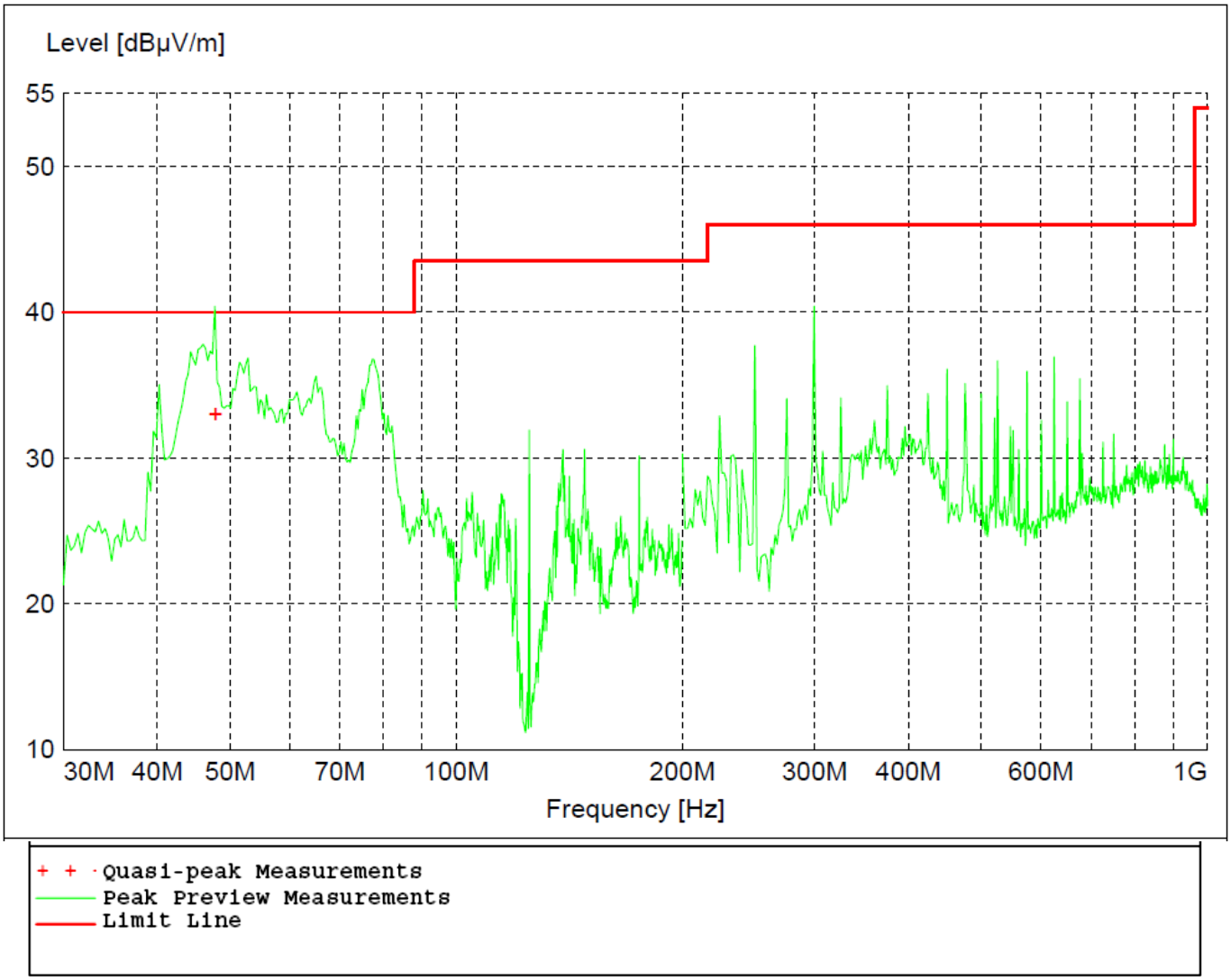

Figure 28 - Radiated Emissions Plot, High Channel, GFSK, 10 Inch Unit

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 21 - Radiated Emissions Quasi-peak Measurements, High Channel, GFSK, 10 Inch Unit

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
47.820000	32.99	40.00	7.00	100	259	VERT

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 C63.10-2013, Section(s) 6.10.5

Limits of bandedge measurements:
For emissions outside of the allowed band of operation, 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:
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 resolution bandwidth was set to 100kHz and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a peak detector. The highest emissions level beyond the bandedge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209.

To calculate the level at the bandedge 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:
The field strength was measured by connecting the EUT directly to the spectrum analyzer.

EUT operating conditions:
The EUT was powered by 12 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 inGMSKand GFSK.

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, Unrestricted	GFSK	2400	-52.57	4.06	56.62	20.00	PASS
Low, Unrestricted	GMSK	2400	-50.70	2.11	52.81	20.00	PASS
High, Unrestricted	GFSK	2483.5	-54.00	2.01	56.01	20.00	PASS
High, Unrestricted	GMSK	2483.5	-54.62	1.07	55.69	20.00	PASS
Low, Restricted	GFSK	2380	-52.82	4.06	56.88	39.32	PASS
Low, Restricted	GMSK	2380	-52.66	2.11	54.77	36.80	PASS
High, Restricted	GFSK	2500	-52.66	2.01	54.67	36.93	PASS
High, Restricted	GMSK	2500	-52.25	1.07	53.32	37.42	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 = 93.32 dBµV/m
Fundamental peak field strength at High Channel GFSK = 90.93 dBµV/m
Fundamental peak field strength at Low Channel GMSK= 90.80 dBµV/m
Fundamental peak field strength at High Channel GMSK= 91.42 dBµV/m

Low Channel minimum delta GFSK = 93.32 – 54.0 dBµV/m = 39.32 dBc
High Channel minimum delta GFSK = 90.93 – 54.0 dBµV/m = 36.93 dBc
Low Channel minimum delta GMSK= 90.80 – 54.0 dBµV/m = 36.80 dBc
High Channel minimum delta GMSK= 91.42 – 54.0 dBµV/m = 37.42 dBc

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.

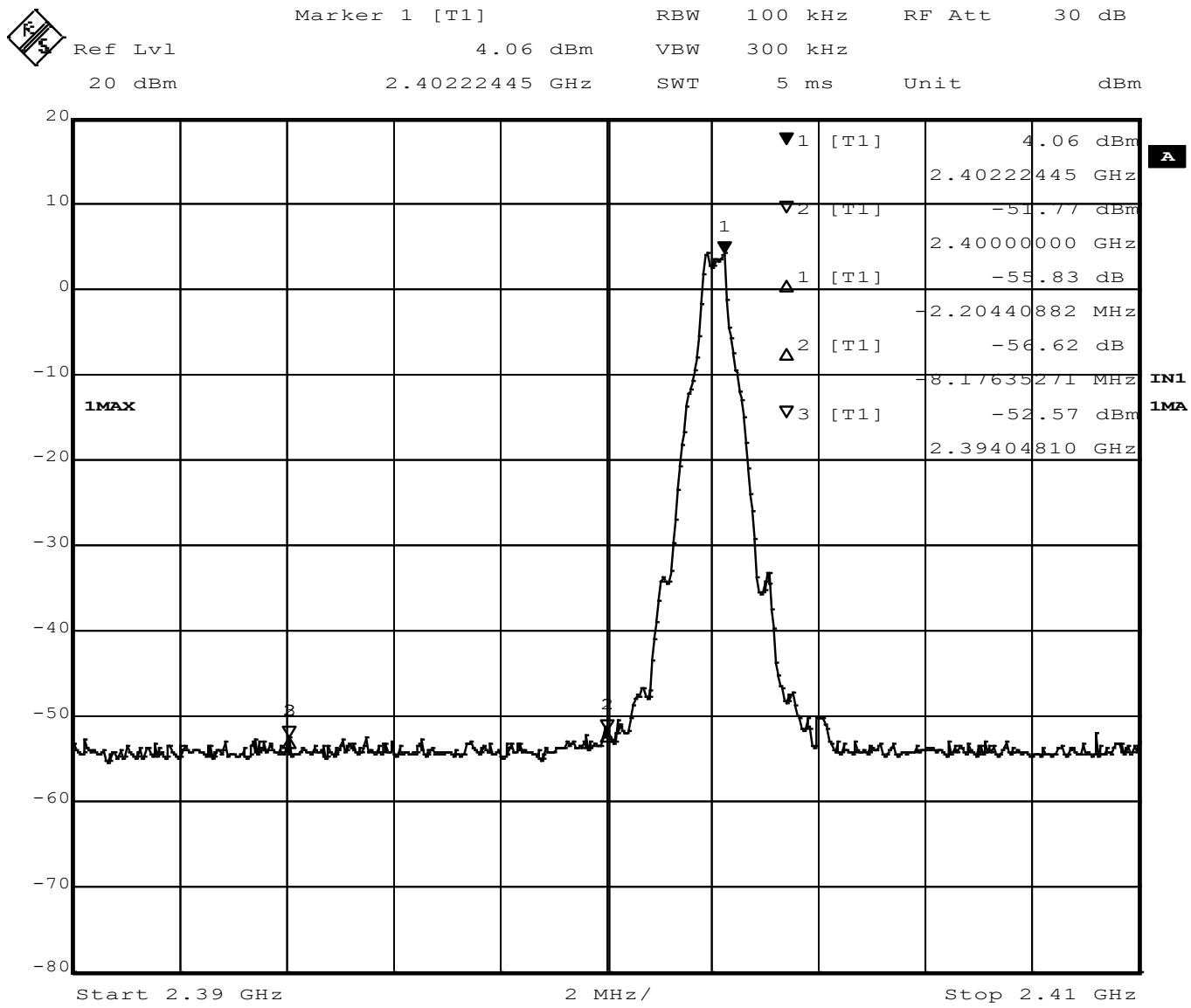

Figure 29 - Band Edge, Low Channel, Unrestricted, GFSK

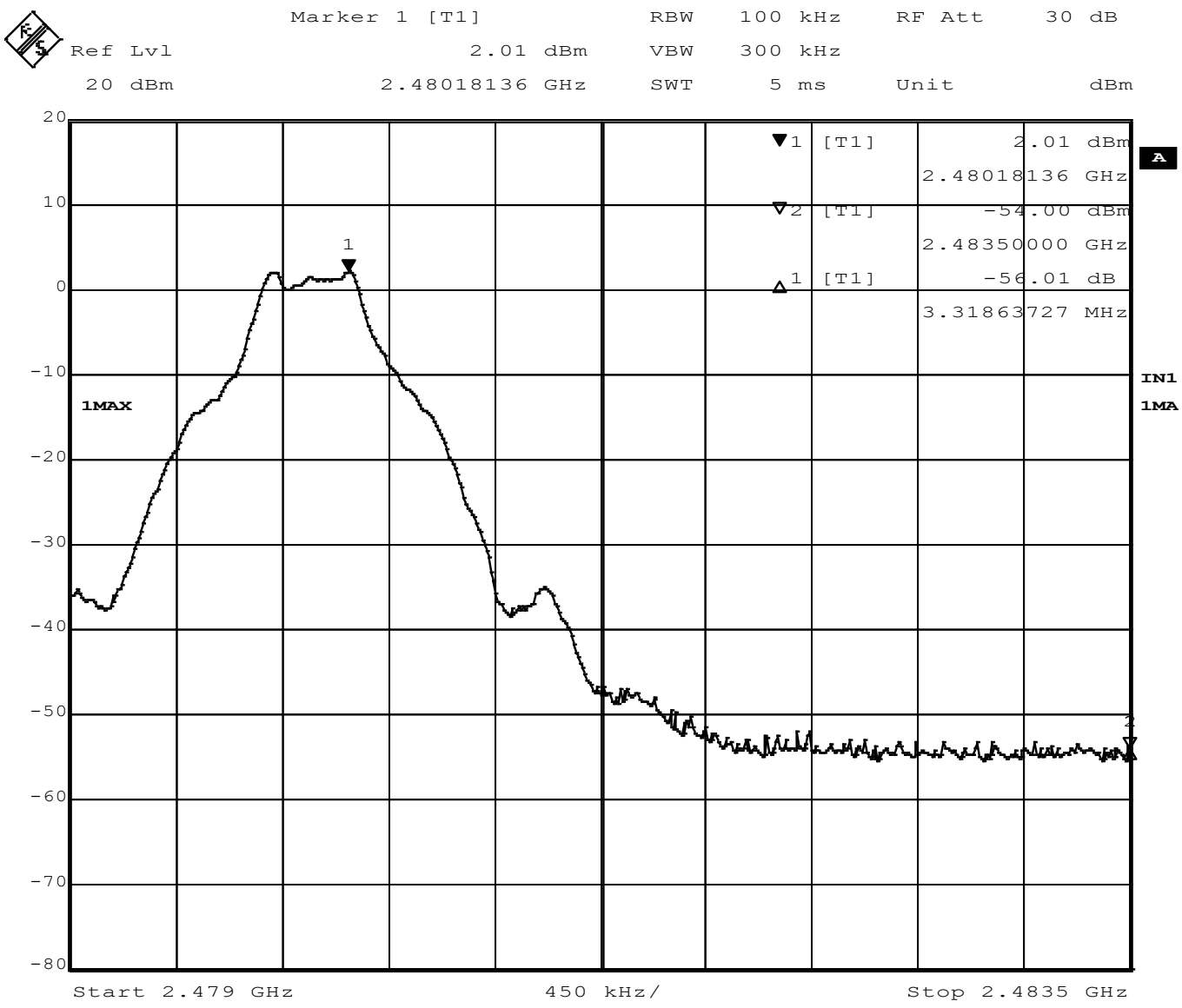

Figure 30 –Band Edge Measurement, High Channel, Unrestricted, GFSK

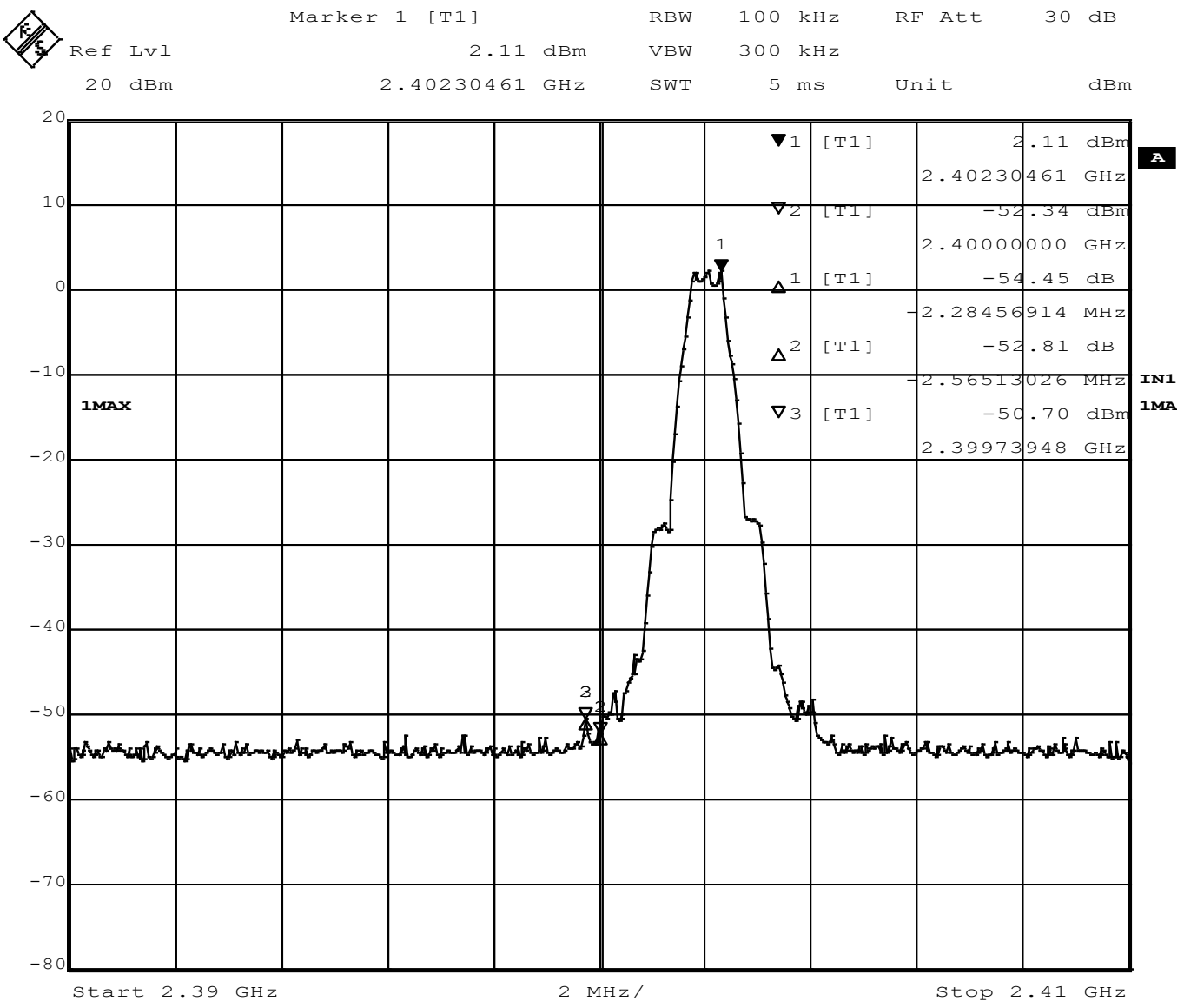

Figure 31 –Band Edge, Low Channel, Unrestricted, GMSK

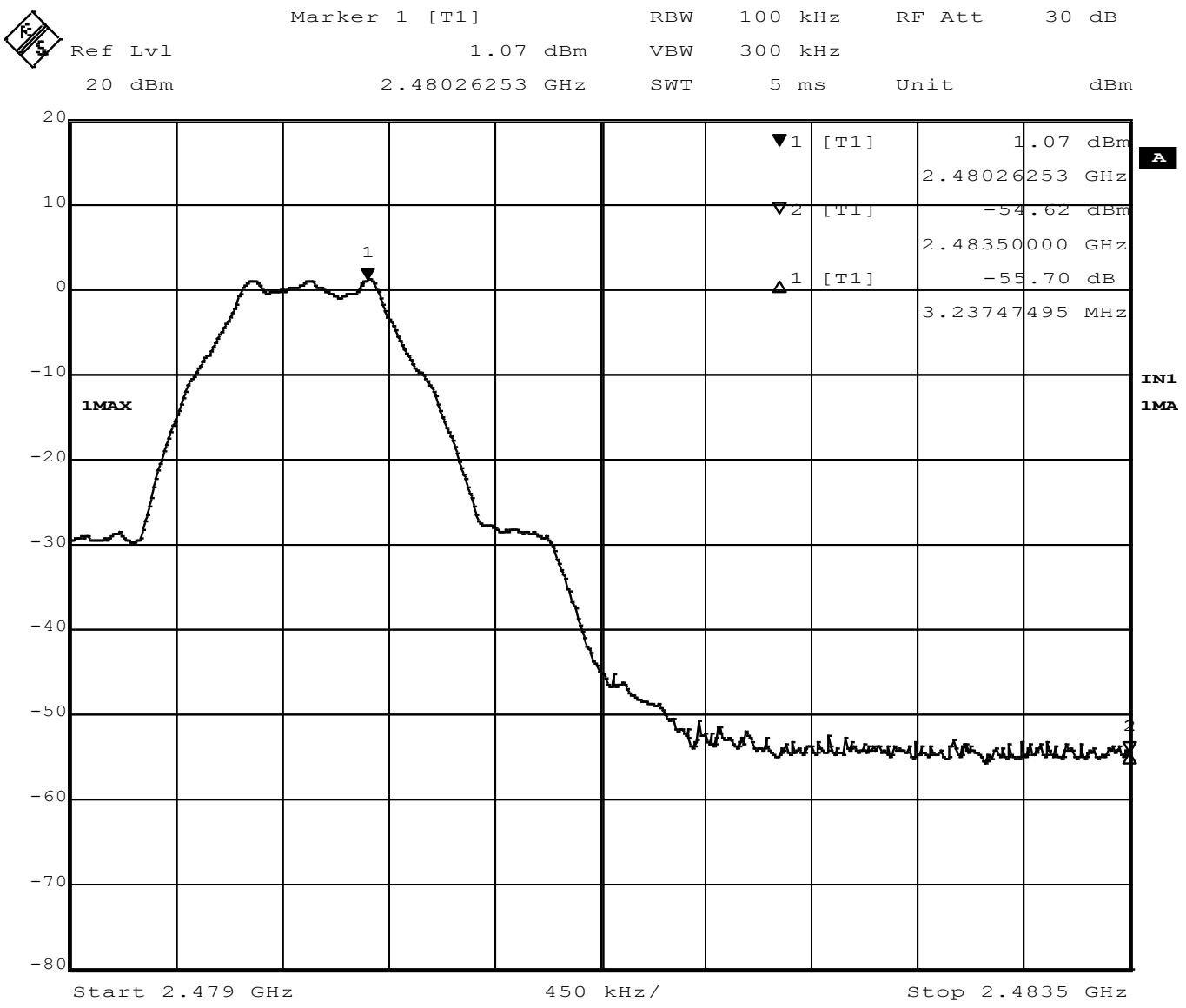

Figure 32 – Band Edge Measurement, High Channel, Unrestricted, GMSK

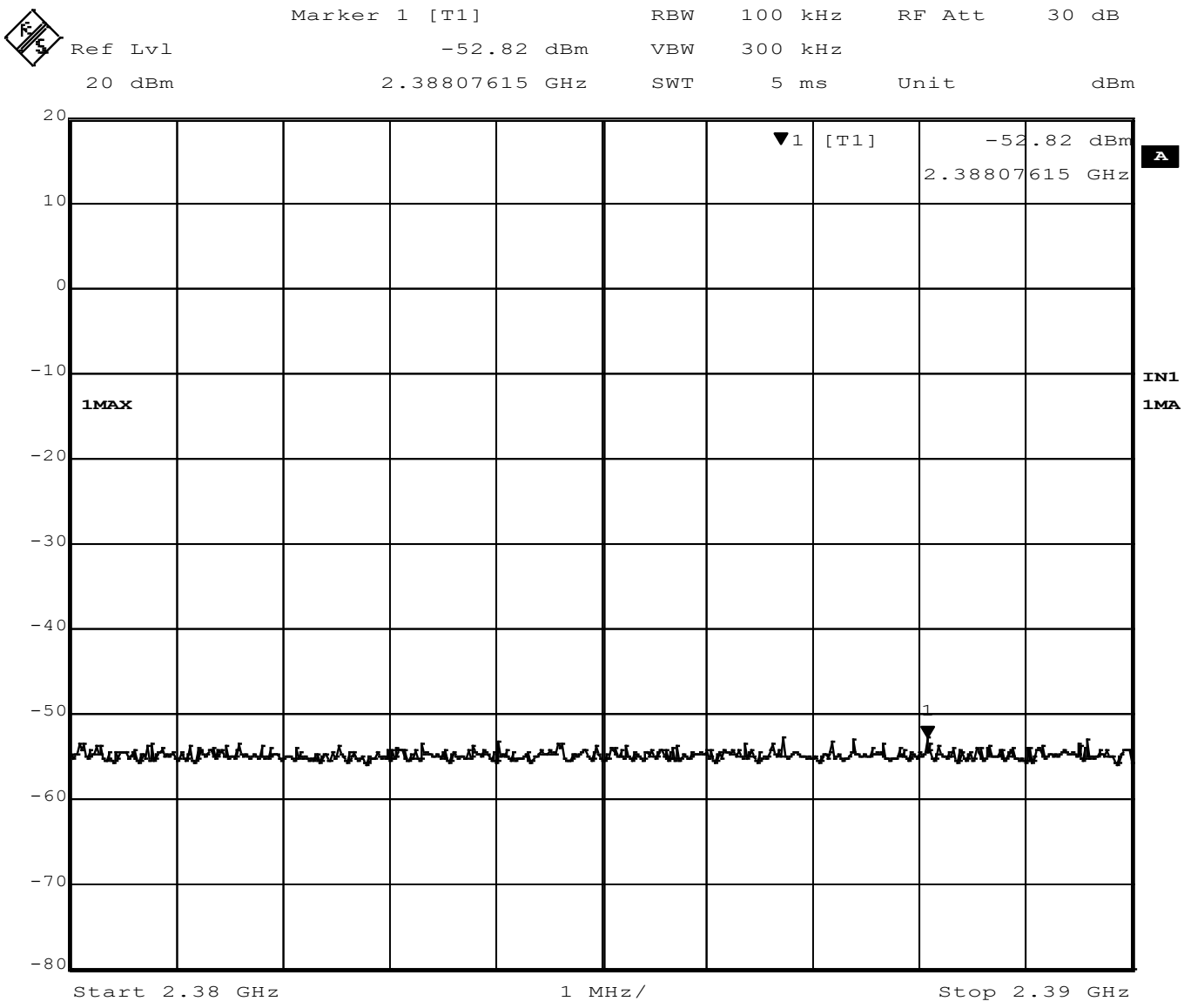

Figure 33 - Band Edge, Low Channel, Restricted, GFSK

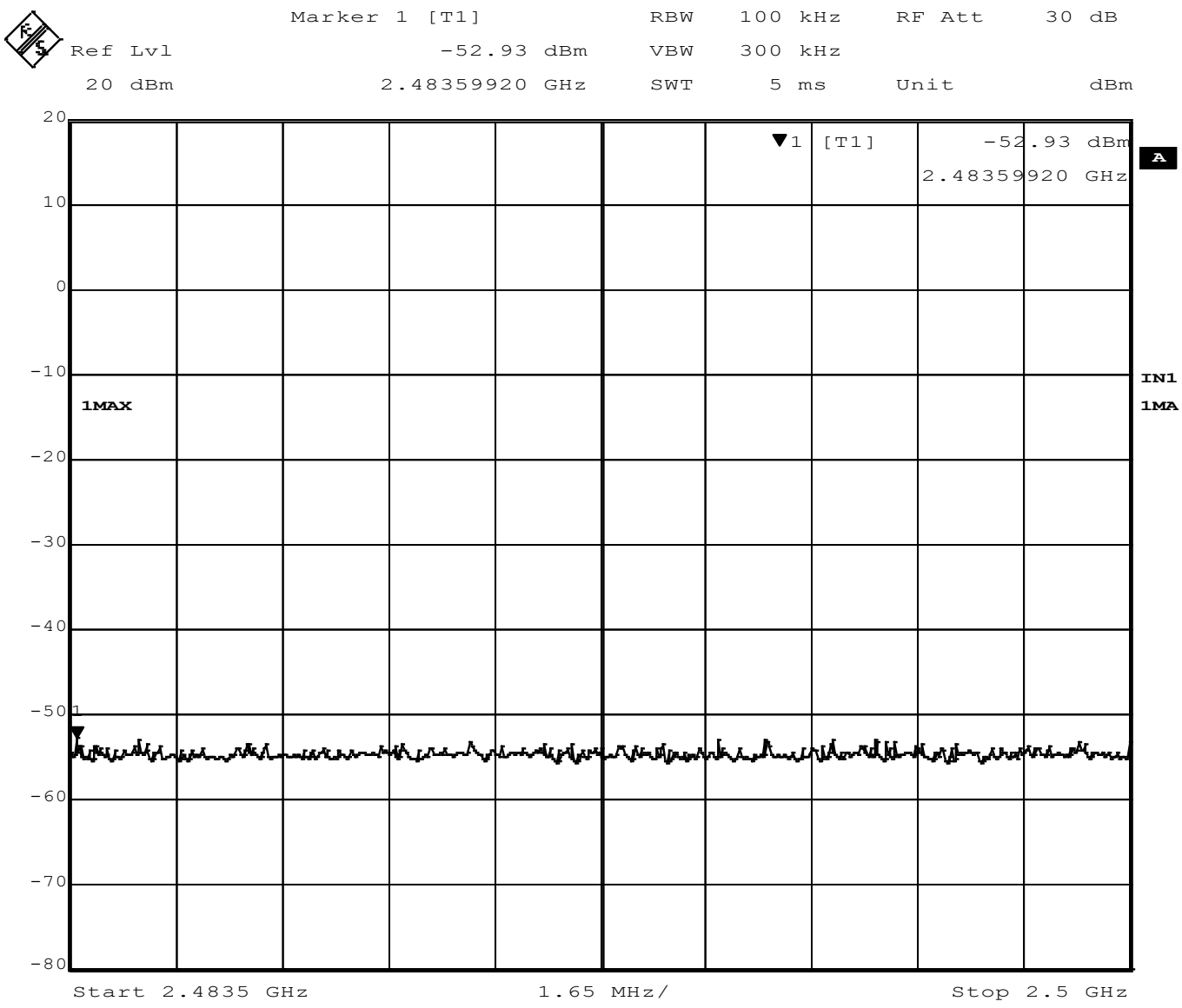

Figure 34 –Band Edge Measurement, High Channel, Restricted, GFSK

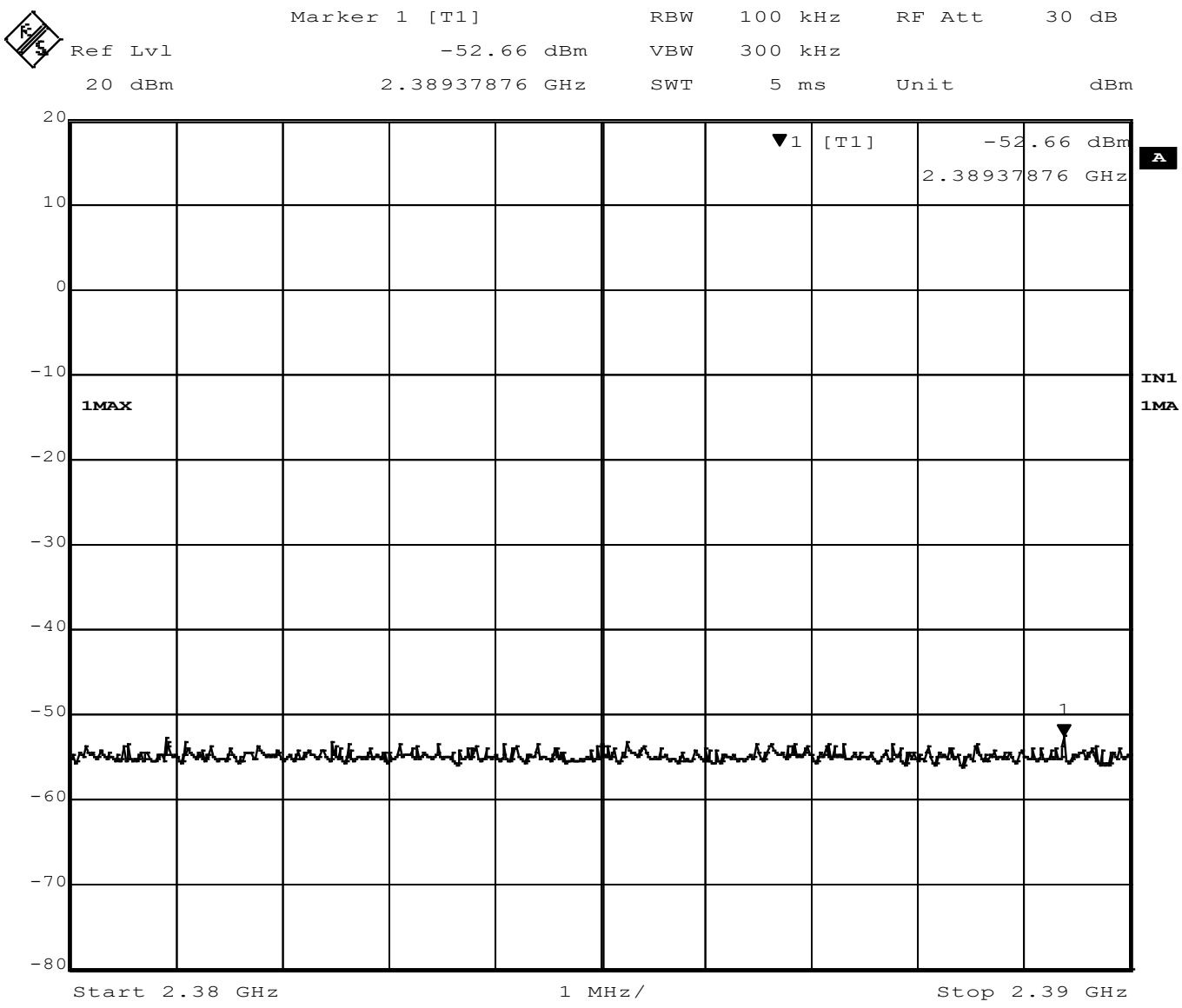

Figure 35 –Band Edge, Low Channel, Restricted, GMSK

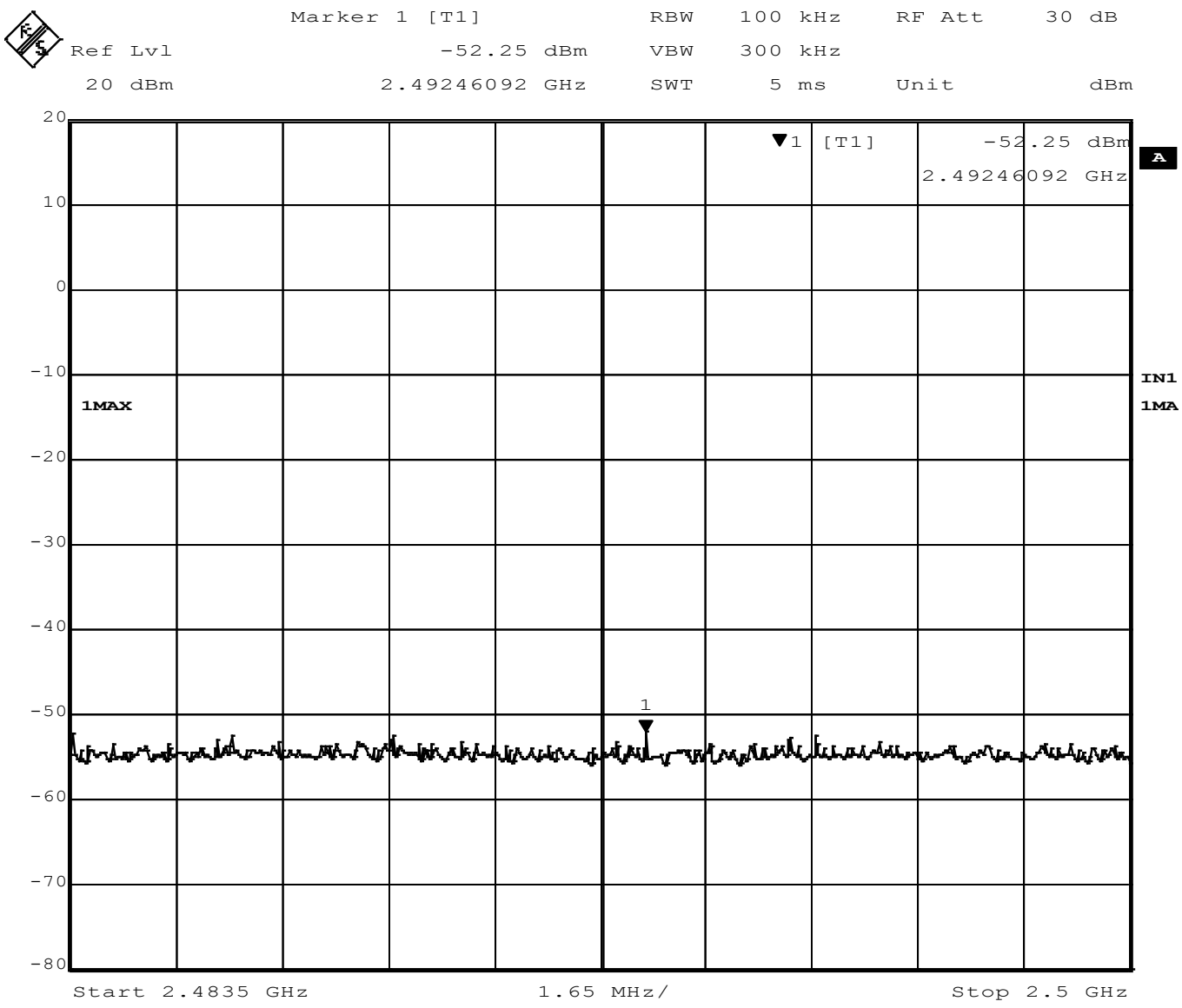

Figure 36 – Band Edge Measurement, High Channel, Restricted, GMSK

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