

## FCC/ISED Test Report

**Prepared for:** Garmin International Inc.

**Address:** 1200 E. 151<sup>st</sup> Street  
Olathe, Kansas, 66062, USA

**Product:** A03711

**Test Report No:** R20181004-20-03B

**Approved by:**



**Nic S. Johnson, NCE**

Technical Manager

iNARTE Certified EMC Engineer #EMC-003337-NE

**DATE:** 28 December 2018

**Total Pages:** 54

*The Nebraska Center for Excellence in Electronics (NCEE) authorizes the above named company to reproduce this report provided it is reproduced in its entirety for use by the company's employees only. Any use that a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. NCEE accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. This report applies only to the items tested.*

	Report Number:	R201810004-20-03B	Rev	B
	Prepared for:	Garmin		

**REVISION PAGE**

Rev. No.	Date	Description
0	18 December 2018	Original – NJohnson Prepared by NJohnson
A	20 December 2018	Changed modulation description -NJ
B	28 December 2018	Removed any reference to a USB connection. The device has no USB connection and powers only off of a disposable coin cell. -NJ  Includes NCEE Labs report R20181010-20-03A and its amendment in full.



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

## CONTENTS

Revision Page .....	2
Tables of Figures .....	4
1.0 Summary of test results.....	5
2.0 EUT Description .....	6
2.1 Equipment under test .....	6
2.2 Description of test modes .....	7
2.3 Description of support units.....	7
3.0 Laboratory description .....	8
3.1 Laboratory description.....	8
3.2 Test personnel.....	8
3.3 Test equipment.....	9
4.0 Detailed results .....	10
4.1 Duty Cycle.....	10
4.2 Radiated emissions .....	11
4.3 Peak Output Power .....	30
4.4 Bandwidth .....	37
4.5 Band edges.....	45
Appendix A: Sample Calculation .....	51
Appendix B – Measurement Uncertainty.....	53
REPORT END.....	54



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

## TABLES OF FIGURES

Figure Number	Page
Figure 1 - Radiated Emissions Test Setup .....	13
Figure 2 - Radiated Emissions Plot, Receive, GFSK .....	14
Figure 3 - Radiated Emissions Plot, Receive, GMSK.....	16
Figure 4 - Radiated Emissions Plot, Low Channel, GFSK .....	18
Figure 5 - Radiated Emissions Plot, Mid Channel, GFSK .....	20
Figure 6 - Radiated Emissions Plot, High Channel .....	22
Figure 7 - Radiated Emissions Plot, Low Channel, GMSK.....	24
Figure 8 - Radiated Emissions Plot, Mid Channel, GMSK .....	26
Figure 9 - Radiated Emissions Plot, High Channel, GMSK.....	28
Figure 10 – Output Power, Low Channel, GMSK.....	31
Figure 11 – Output Power, Mid Channel, GMSK.....	32
Figure 12 – Output Power, High Channel, GMSK .....	33
Figure 13 - Output Power, Low Channel, GFSK .....	34
Figure 14 - Output Power, Mid Channel, GFSK .....	35
Figure 15 - Output Power, High Channel, GFSK.....	36
Figure 16 - Bandwidth Measurements Test Setup .....	38
Figure 17 – Occupied Bandwidth, Low Channel, GMSK.....	39
Figure 18 - Occupied Bandwidth, Mid Channel, GMSK .....	40
Figure 19 - Occupied Bandwidth, High Channel, GMSK.....	41
Figure 20 – Occupied Bandwidth, Low Channel, GFSK.....	42
Figure 21 - Occupied Bandwidth, Mid Channel, GFSK .....	43
Figure 22 - Occupied Bandwidth, High Channel, GFSK.....	44
Figure 24 - Band Edge, Low Channel, GMSK.....	47
Figure 25 – Restricted Band Edge, High Channel, GMSK .....	48
Figure 28 –Band Edge, Low Channel, GFSK.....	49
Figure 29 – Band Edge Measurement, High Channel, GFSK.....	50



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

## 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	Informational Purpose Only
FCC 15.209 RSS-Gen, 7.1	Receiver Radiated Emissions	Pass	Meets the requirement of the limit.
NA	Minimum Bandwidth	N/A	Informational Purpose Only
NA	Maximum Peak Output Power	N/A	Informational Purpose Only
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 RSS-Gen, 8.9 RSS-249, 5.5	Band Edge Measurement	Pass	Meets the requirement of the limit.
FCC 15.207 RSS-Gen. 8.8	Conducted AC Emissions	NA	No provisions for connection to AC mains



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

## 2.0 EUT DESCRIPTION

### 2.1 EQUIPMENT UNDER TEST

#### Summary

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

EUT	A03711
EUT Received	2018 October 20 2018 December 14 (conducted measurement sample)
EUT Tested	2018 Nov 6 – 11 2018 Dec 17 (conducted measurements only)
Serial No.	16825 (integrated antenna) 61899 (SMA connector in place of antenna)
Operating Band	2400 – 2483.5 MHz
Device Type	GMSK, GFSK
Power Supply	CR2032 3V battery, disposable. There are no provisions for recharging or connecting an external power source.

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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

## 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.

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



#### 3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Nic Johnson	Technical Manager	All testing

**Notes:**

All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

### 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 2019*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2019*
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 2019*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2019*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2019*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2019*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2019*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2019*

\*Internal Characterization

**Notes:**

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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

## 4.0 DETAILED RESULTS

### 4.1 DUTY CYCLE

**Test Method:** ANSI C63.10-2013, Section 7.5

Not required.

## 4.2 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.



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**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 variaGMSK-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.

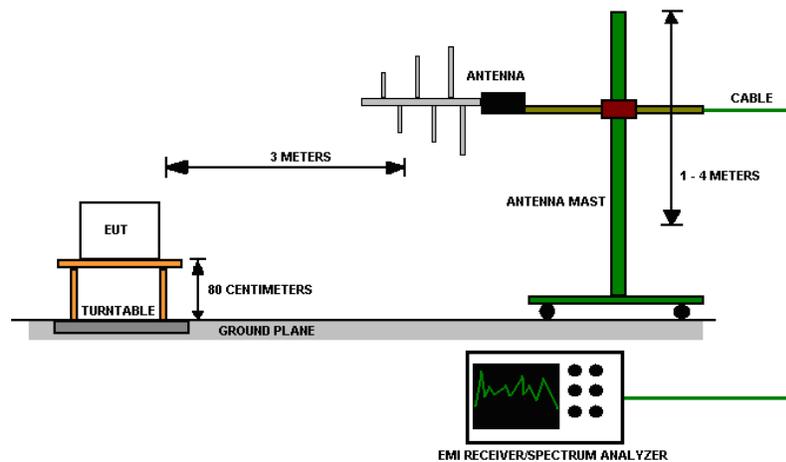
**NOTE:**

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.

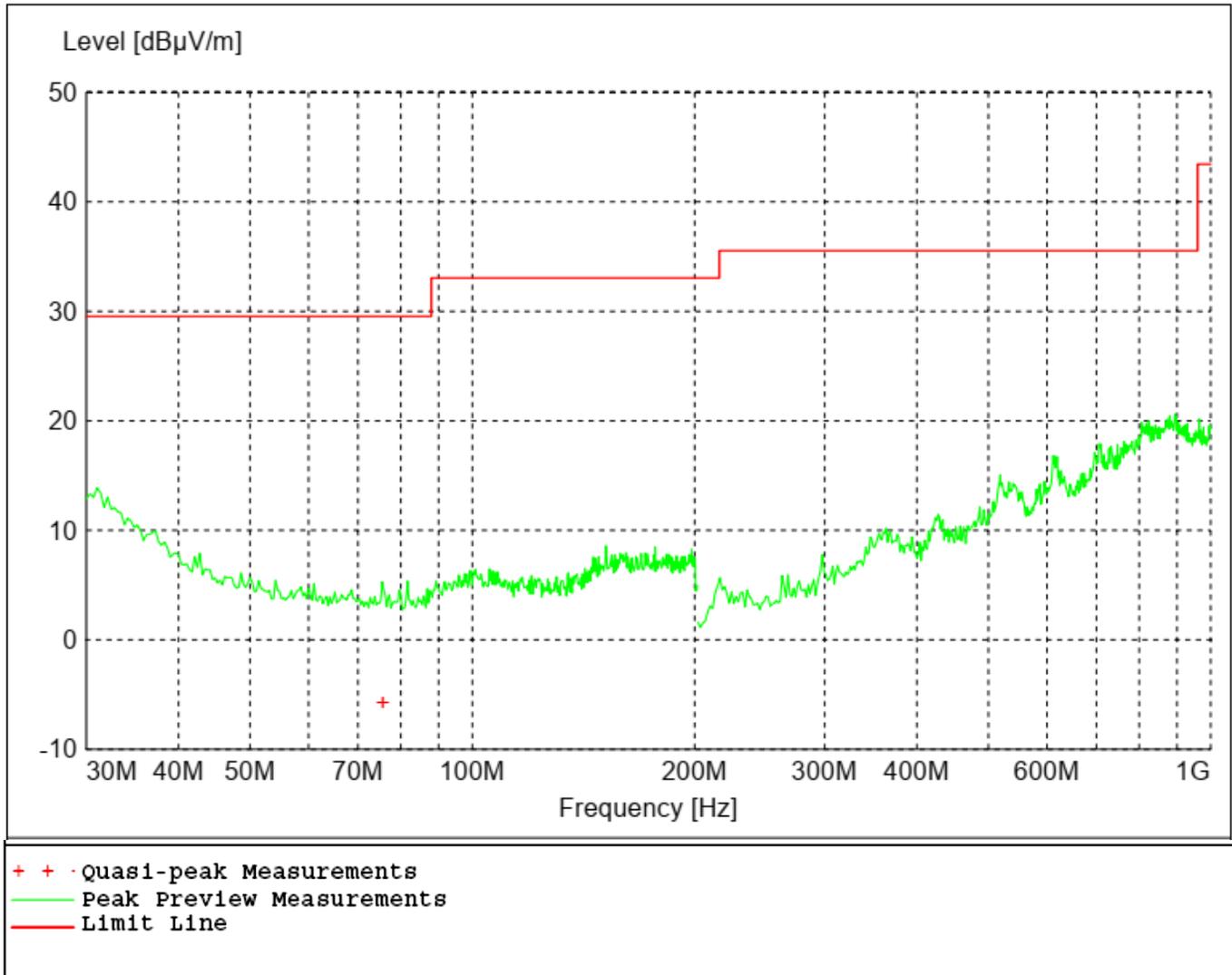
**Test setup:**


**Figure 1 - Radiated Emissions Test Setup**

**EUT operating conditions**

The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest and highest frequency channels.

**Test results:**



**Figure 2 - Radiated Emissions Plot, Receive, 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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**Table 1 - Radiated Emissions Quasi-peak Measurements, Receive, GFSK**

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.		
75.660000	-5.73	29.5	35.3	249.0	96	H	Y

**Table 2 - Radiated Emissions Peak Measurement vs Average Limits, Receive, GFSK**

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.		
1003.500000	43.86	54.00	10.14	130.0	229	V	Y

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

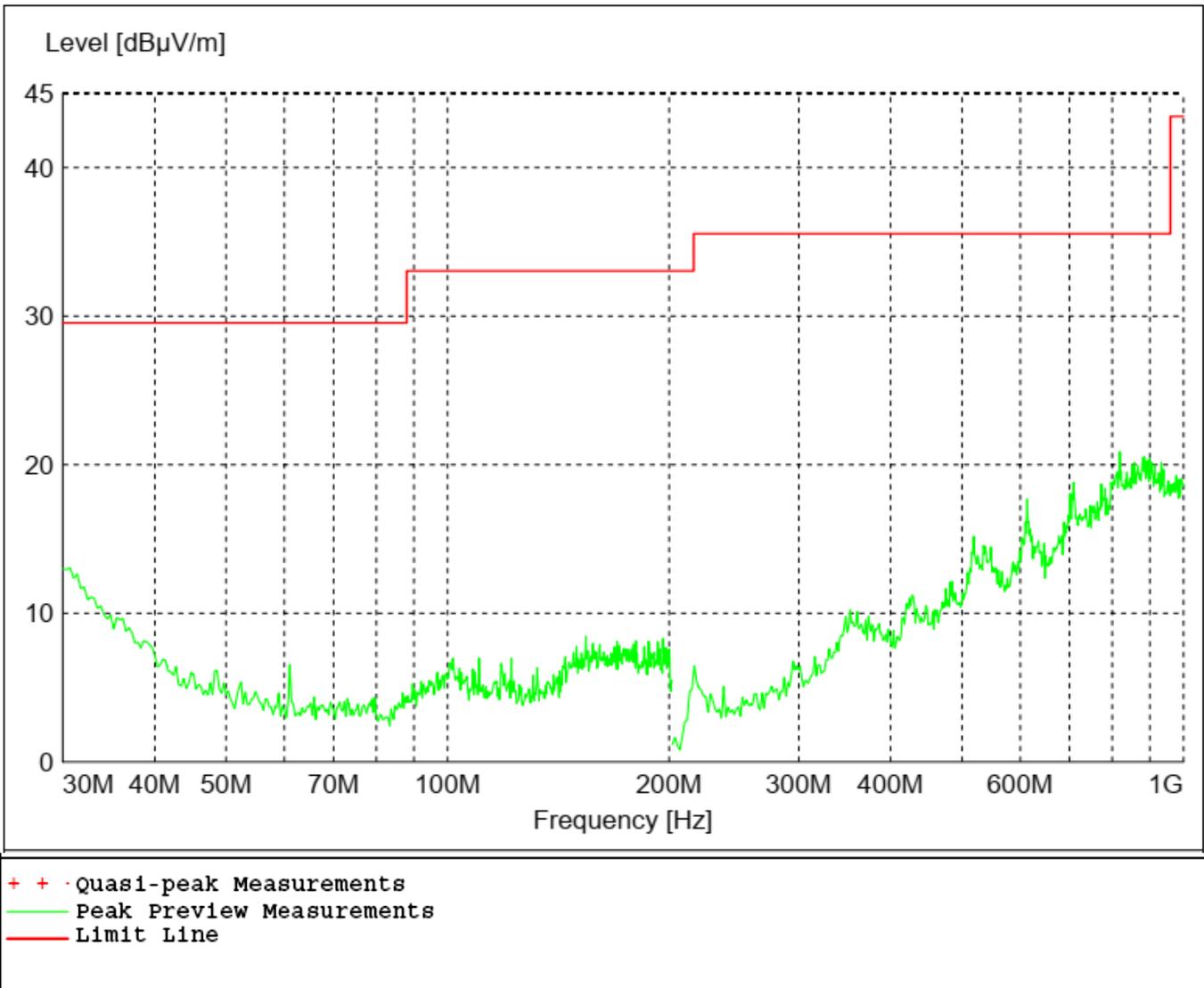


Figure 3 - Radiated Emissions Plot, Receive, GMSK

**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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**Table 3 - Radiated Emissions Quasi-peak Measurements, Receive, GMSK**

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.		
All measured values at least 10 dB below limit							

**Table 4 - Radiated Emissions Peak Measurement vs Average Limits, Receive, GMSK**

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.		
1000.500000	47.96	54.0	6.04	100.0	277	V	Y

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

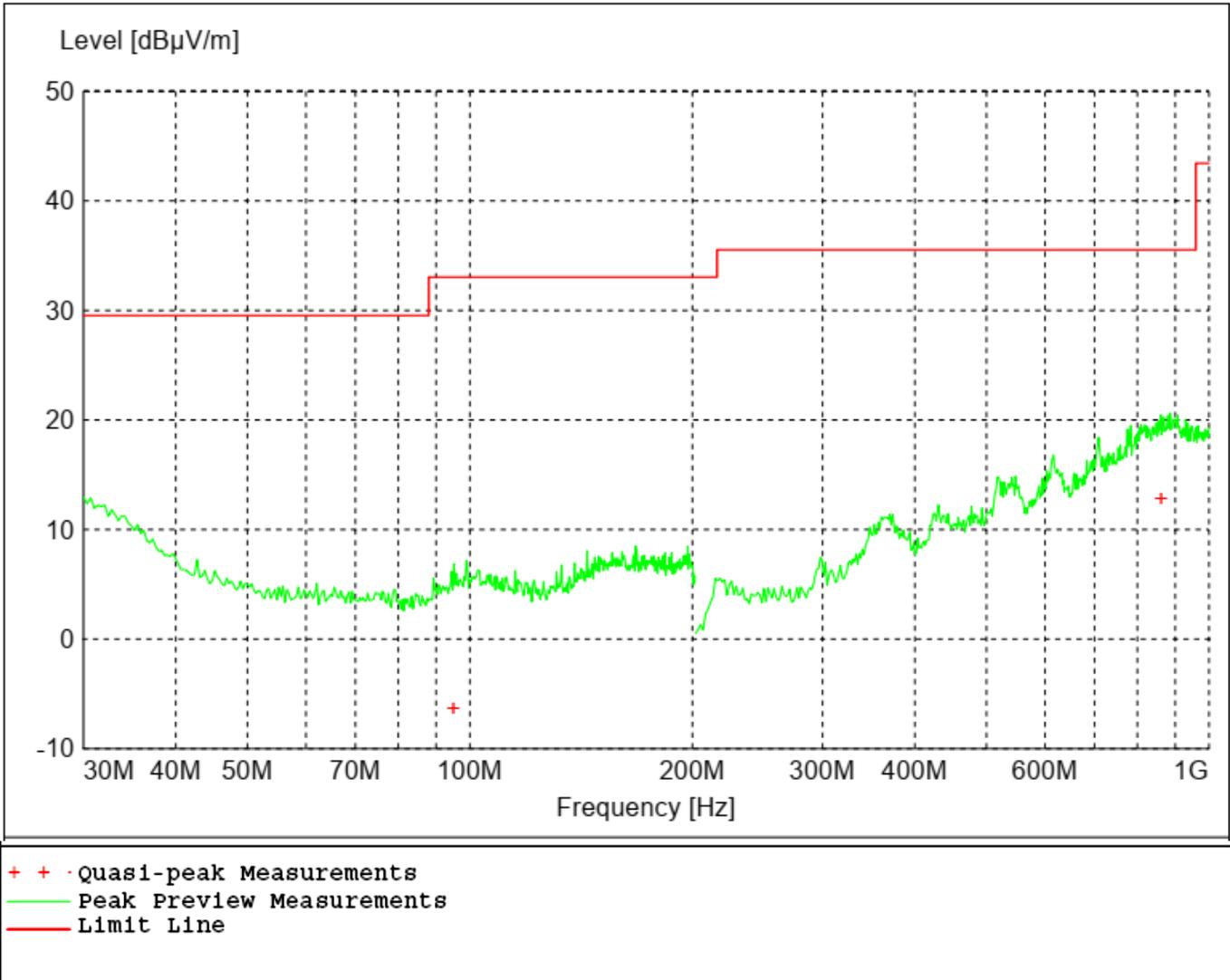


Figure 4 - Radiated Emissions Plot, Low Channel, GFSK

**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 5 - Radiated Emissions Quasi-peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
95.16000	-6.23	33.0	39.3	250.0	333	V	Y
862.240000	12.87	35.5	22.7	101.0	348	V	Y

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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**Table 6 - Radiated Emissions Peak Measurements, Low Channel, GFSK**

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.		
2402.000000	92.04	93.98	1.94	170	114	H	Y
All peak measurements were at least 10 dB below the average limit							

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

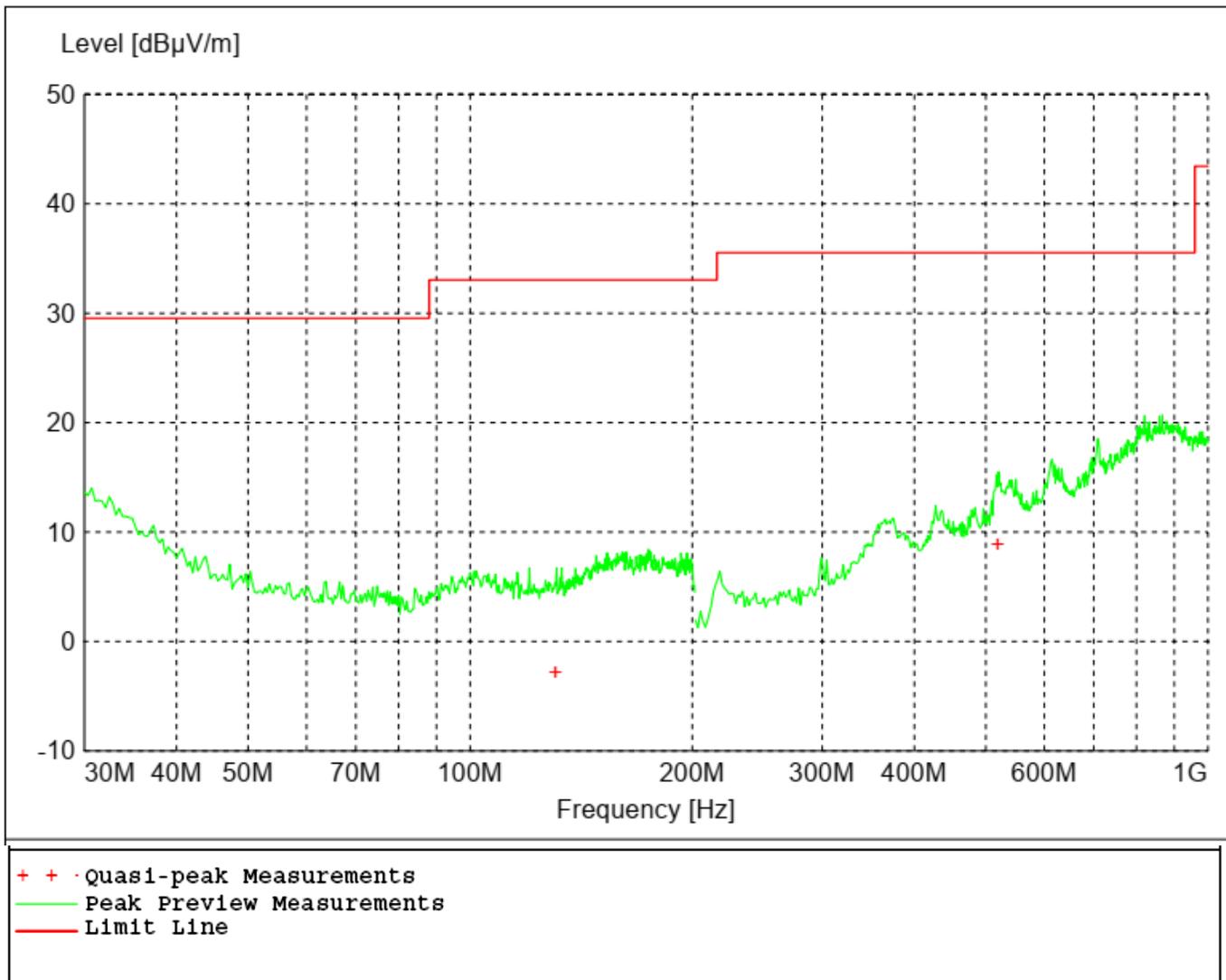


Figure 5 - Radiated Emissions Plot, Mid Channel, GFSK

**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 6 - Radiated Emissions Quasi-peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
130.620000	-2.79	33.0	35.8	99.0	63	H	Y
519.520000	8.89	35.5	26.7	136.0	134	V	Y

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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**Table 7 - Radiated Emissions Peak Measurements, Mid Channel, GFSK**

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.		
2440.000000	93.35	93.98	0.63	153.0	107	H	Y
All peak measurements were at least 10 dB below the average limit							

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

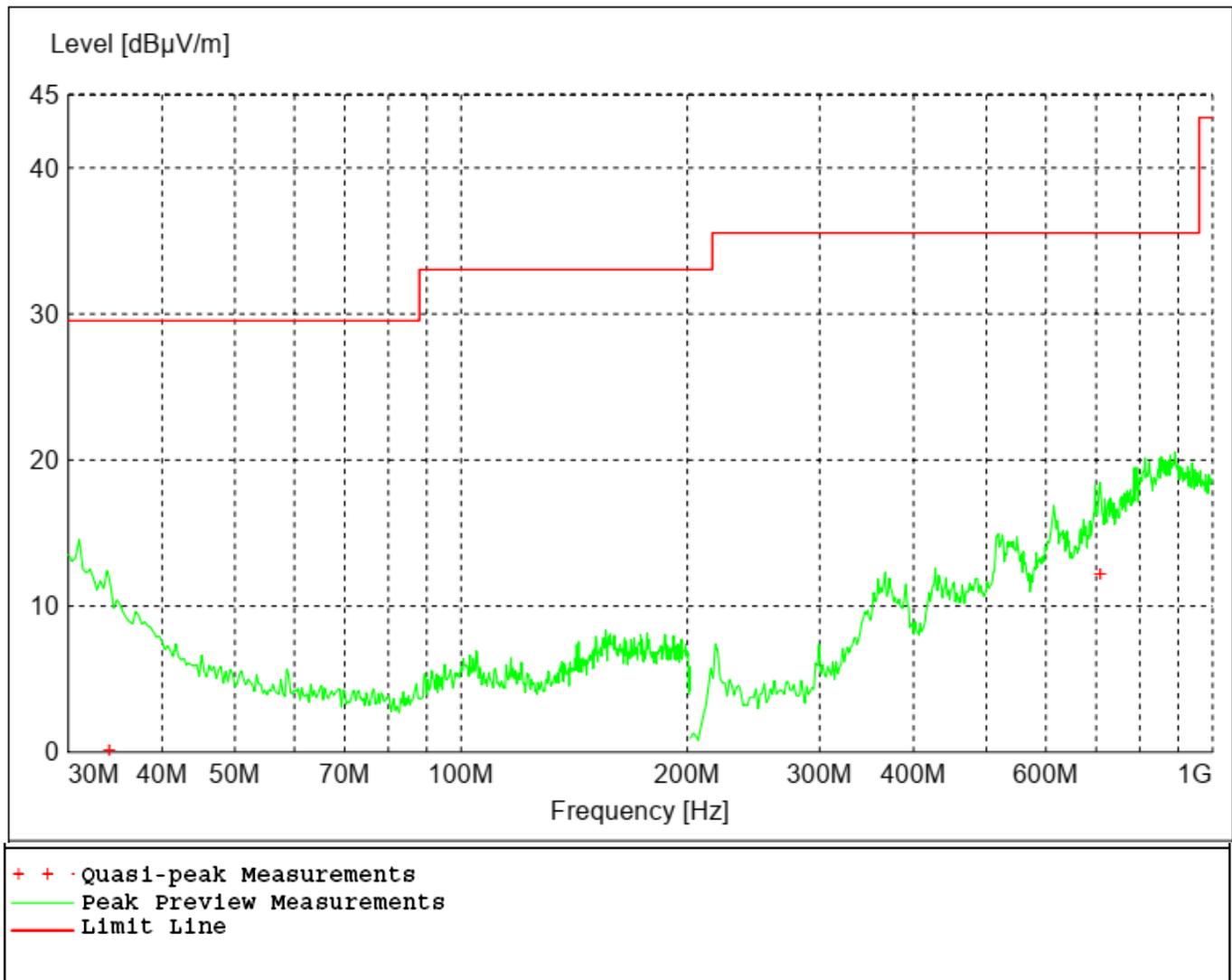


Figure 6 - Radiated Emissions Plot, High Channel

**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 8 - Radiated Emissions Quasi-peak Measurements, High Channel, GFSK**

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
34.080000	0.12	29.5	29.4	286.0	54	H	Y
709.180000	12.18	35.5	23.4	250.0	243	V	Y

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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**Table 9 - Radiated Emissions Peak Measurements, High Channel, GFSK**

Frequency MHz	Level dB $\mu$ V/m	Limit dB $\mu$ V/m	Margin dB	Height cm.	Angle deg.	Pol	Axis
2480.000000	93.83	93.98	0.15	150.0	132	H	Y
All peak measurements were at least 10 dB below the average limit							

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

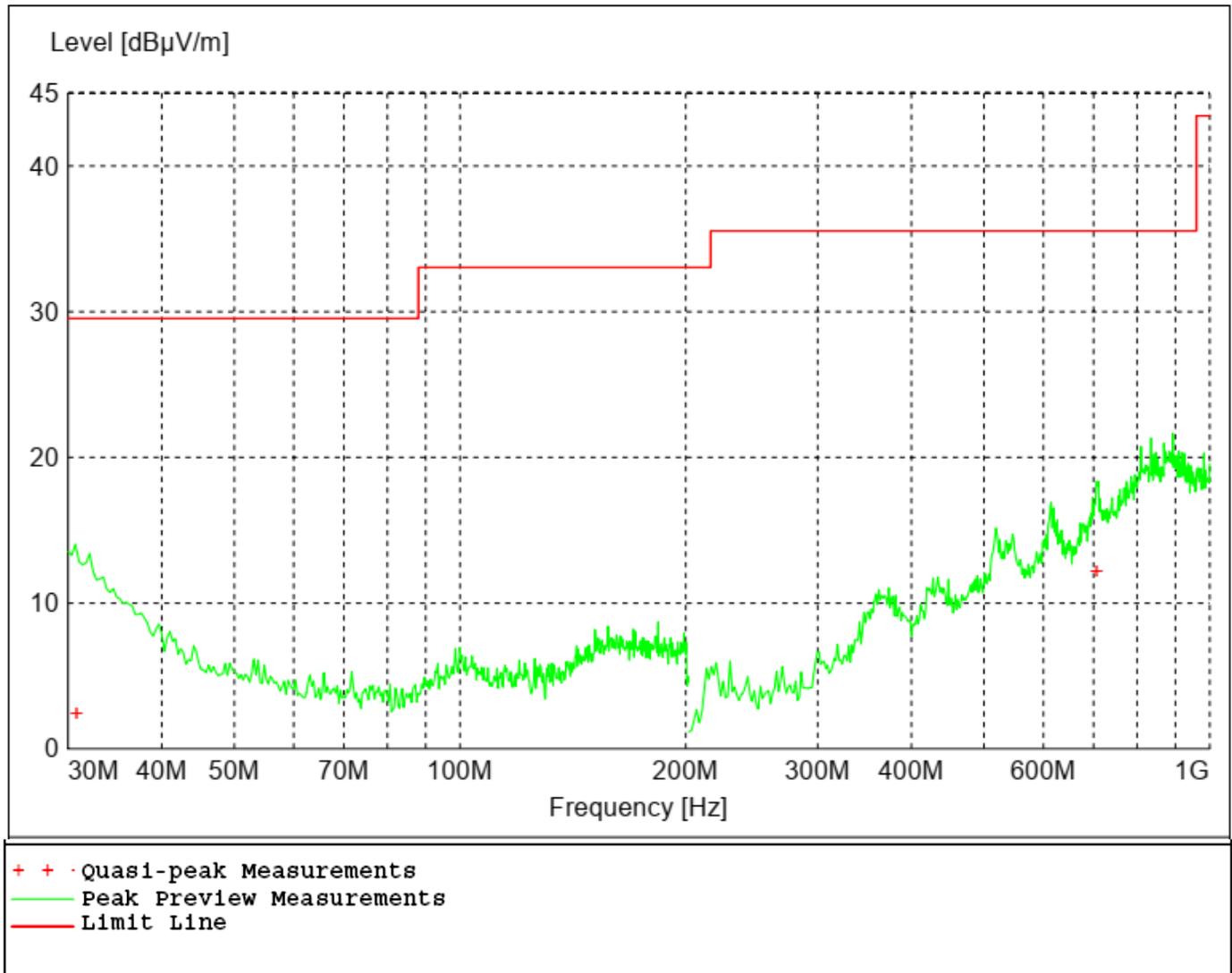


Figure 7 - Radiated Emissions Plot, Low Channel, GMSK

**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 10 - Radiated Emissions Quasi-peak Measurements, Low Channel, GMSK

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
30.840000	2.50	29.5	27.0	272.0	174	H	Y
708.040000	12.17	25.1	23.4	350.0	28	V	Y

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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**Table 11 - Radiated Emissions Peak Measurements, Low Channel, GMSK**

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.		
2402.000000	92.30	93.98	1.68	234.0	122	H	Y
All peak measurements were at least 10 dB below the average limit							

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

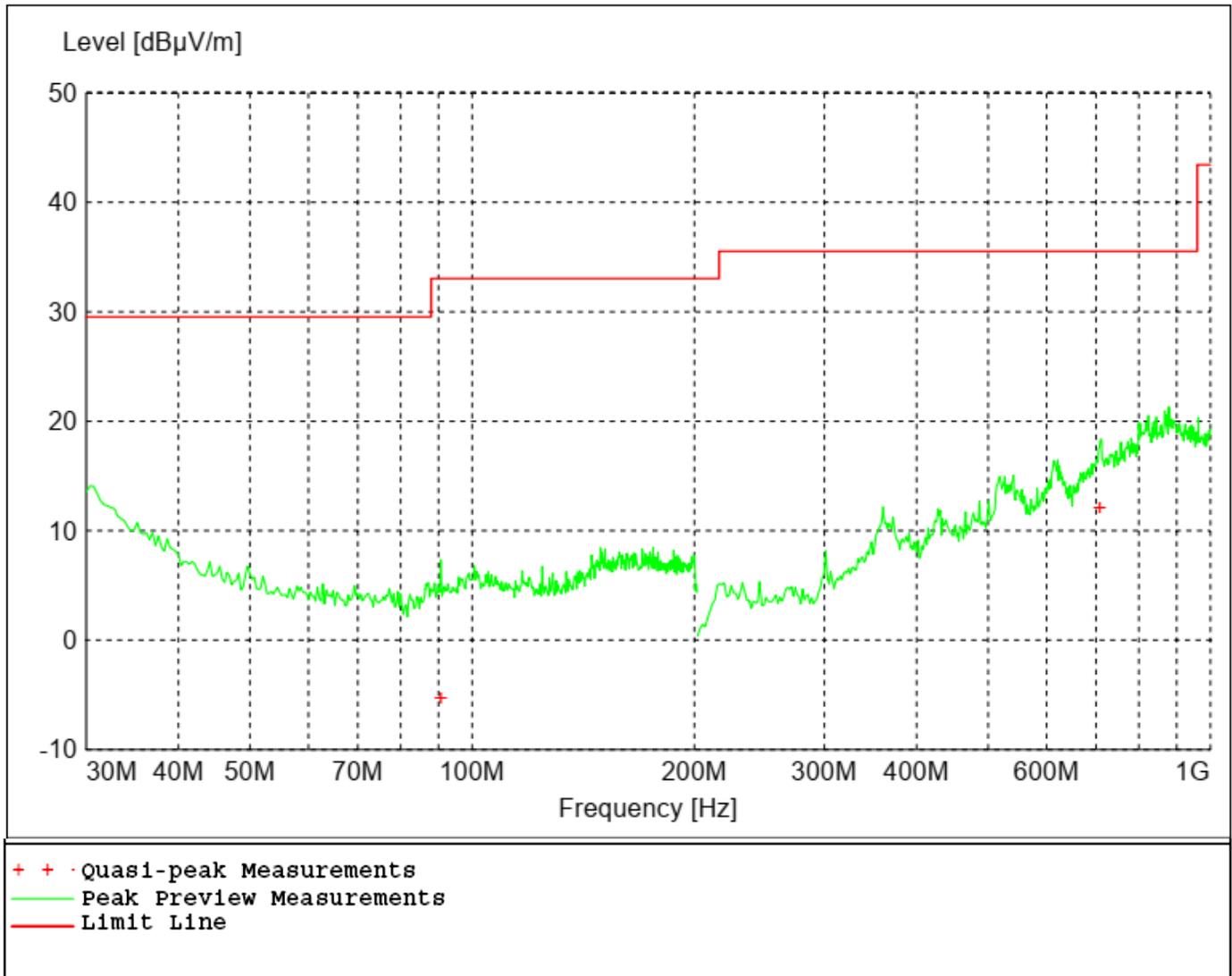


Figure 8 - Radiated Emissions Plot, Mid Channel, GMSK

**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 12 - Radiated Emissions Quasi-peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
90.720000	-5.27	33.0	38.3	349.0	248	H	Y
709.06000	12.15	35.5	23.4	142.0	34	V	Y

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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**Table 13 - Radiated Emissions Peak Measurements, Low Channel, GMSK**

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.		
2440.000000	92.83	93.98	1.15	100	113	H	Y
All peak measurements were at least 10 dB below the average limit							

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

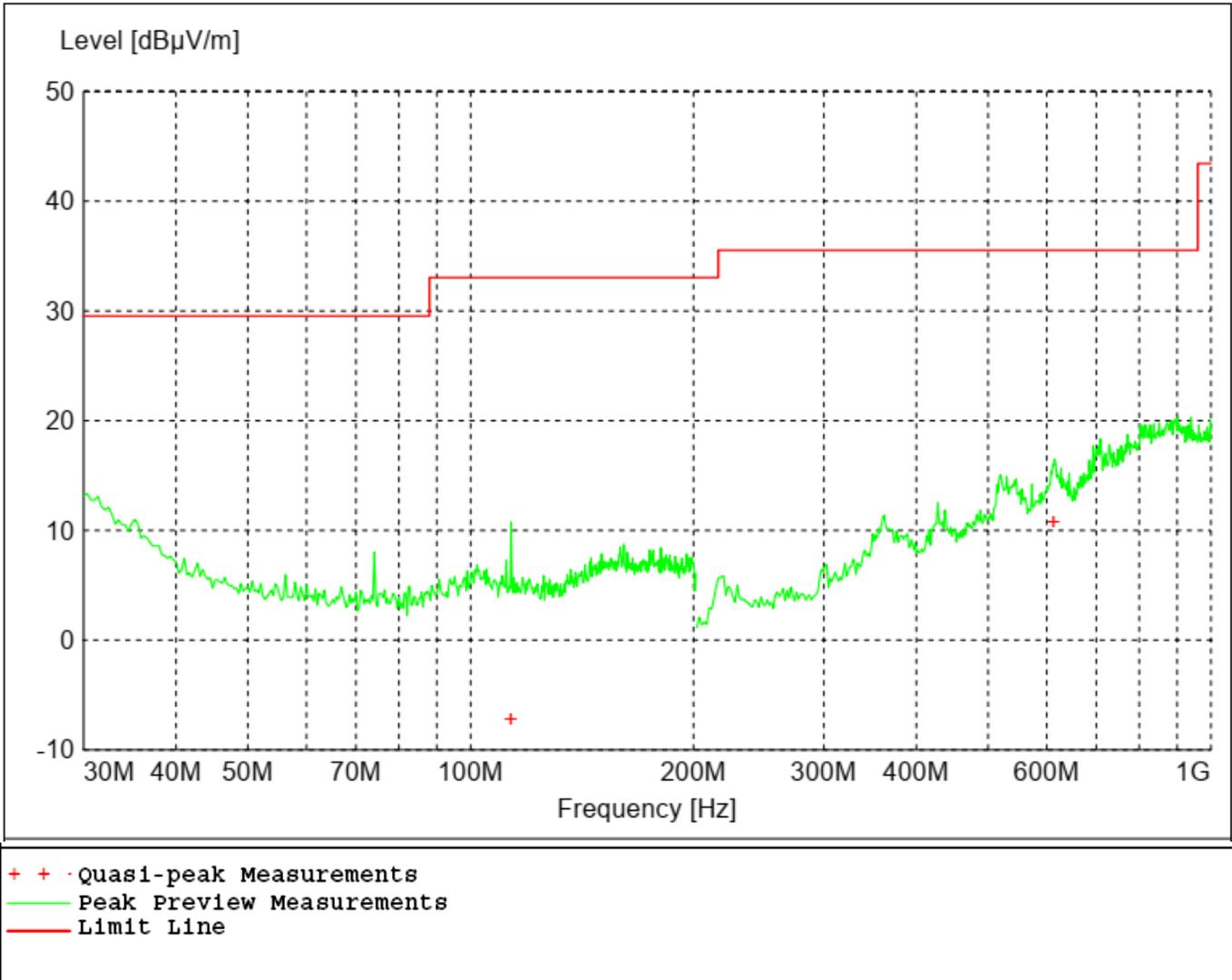


Figure 9 - Radiated Emissions Plot, High Channel, GMSK

**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 14 - Radiated Emissions Quasi-peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
113.400000	-7.19	33.0	40.2	101.0	354	V	Y
613.960000	10.78	35.5	24.8	306.0	157	V	Y

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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**Table 15 - Radiated Emissions Peak Measurements, Low Channel, GMSK**

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dB $\mu$ V/m	dB $\mu$ V/m	dB	cm.	deg.		
2480.000000	84.98	93.98	9.00	105.0	107	H	Y
All peak measurements were at least 10 dB below the average limit							

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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

### 4.3 PEAK OUTPUT POWER

**Test Method:** N/A

EIRP was calculated from field strength measurements using ANSI C63.10-2013, Annex G, Equation G.1. The field strength was measured at a 3m distance and maximized. Test from ANSI C63.10-2013, Section 11.9.1.1 was used as a reference.

For Informational Purposes only

**Test procedures:**

All measurements were taken at a distance of 3m from the EUT.

The EUT was maximized in all 3 orthogonal positions in a similar manner as described in Section 4.2. The power was measured using a 10 MHz RBW.

**Deviations from test standard:**

No deviation.

**Test setup:**

See Section 4.2.

**EUT operating conditions:**

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

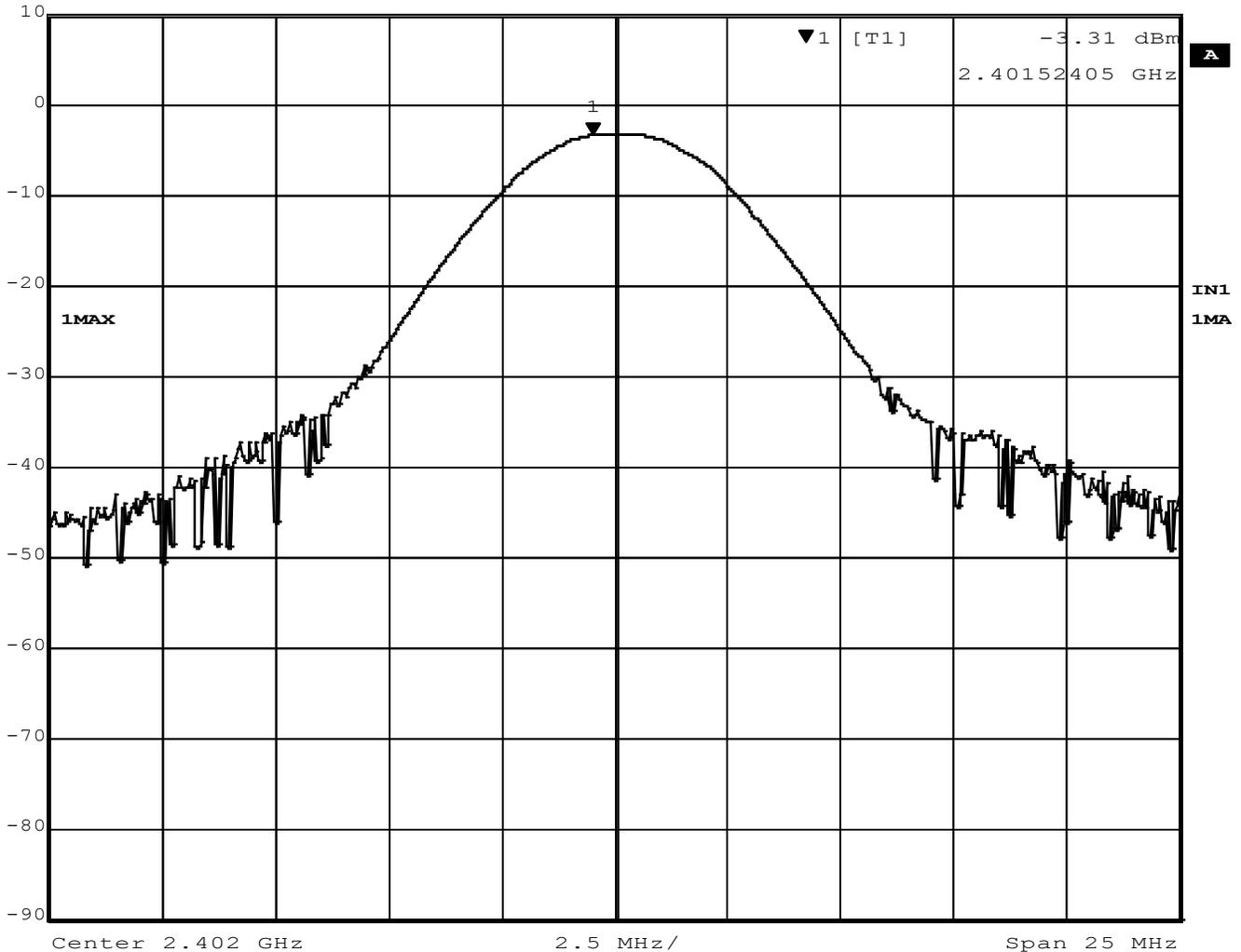
**Test results:**

**Peak Output Power**

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	PEAK OUTPUT POWER (mW)	Method	RESULT	Transmitter
1	2402	-3.31	0.467	Conducted	PASS	GMSK
2	2441	-2.81	0.524	Conducted	PASS	GMSK
3	2480	-3.20	0.479	Conducted	PASS	GMSK
1	2402	-3.05	0.495	Conducted	PASS	GFSK
2	2441	-2.81	0.524	Conducted	PASS	GFSK
3	2480	-3.07	0.493	Conducted	PASS	GFSK



Marker 1 [T1]      RBW      3 MHz      RF Att      20 dB  
 Ref Lvl      -3.31 dBm      VBW      10 MHz  
 10 dBm      2.40152405 GHz      SWT      5 ms      Unit      dBm



Date: 17.DEC.2018 14:41:58

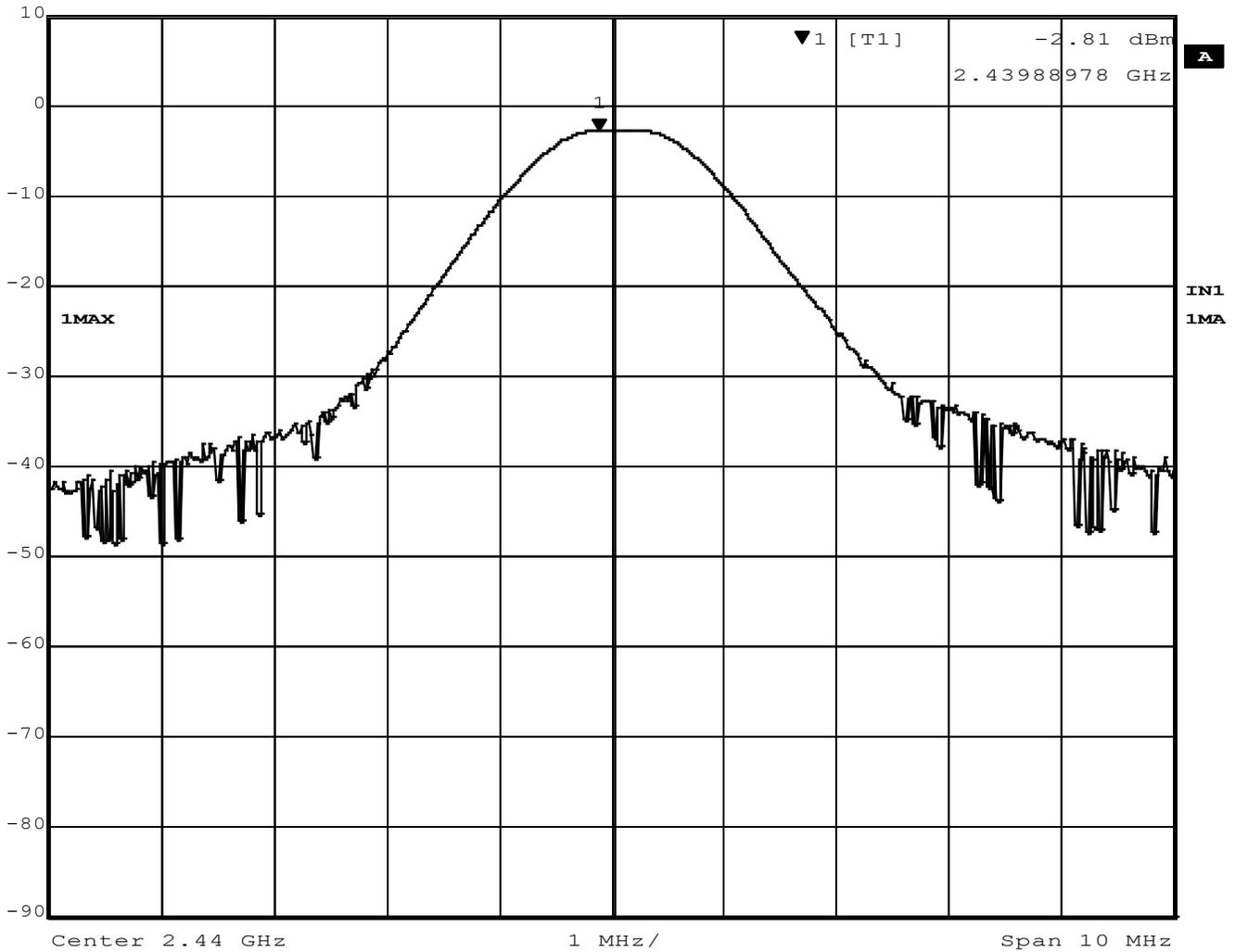
**Figure 10 – Output Power, Low Channel, GMSK**

Output power -3.31 dBm

Cable loss was less than 0.1 dB and not included



Marker 1 [T1]	RBW	1 MHz	RF Att	30 dB
Ref Lvl	-2.81 dBm	VBW	3 MHz	
10 dBm	2.43988978 GHz	SWT	5 ms	Unit dBm



Date: 17.DEC.2018 13:07:01

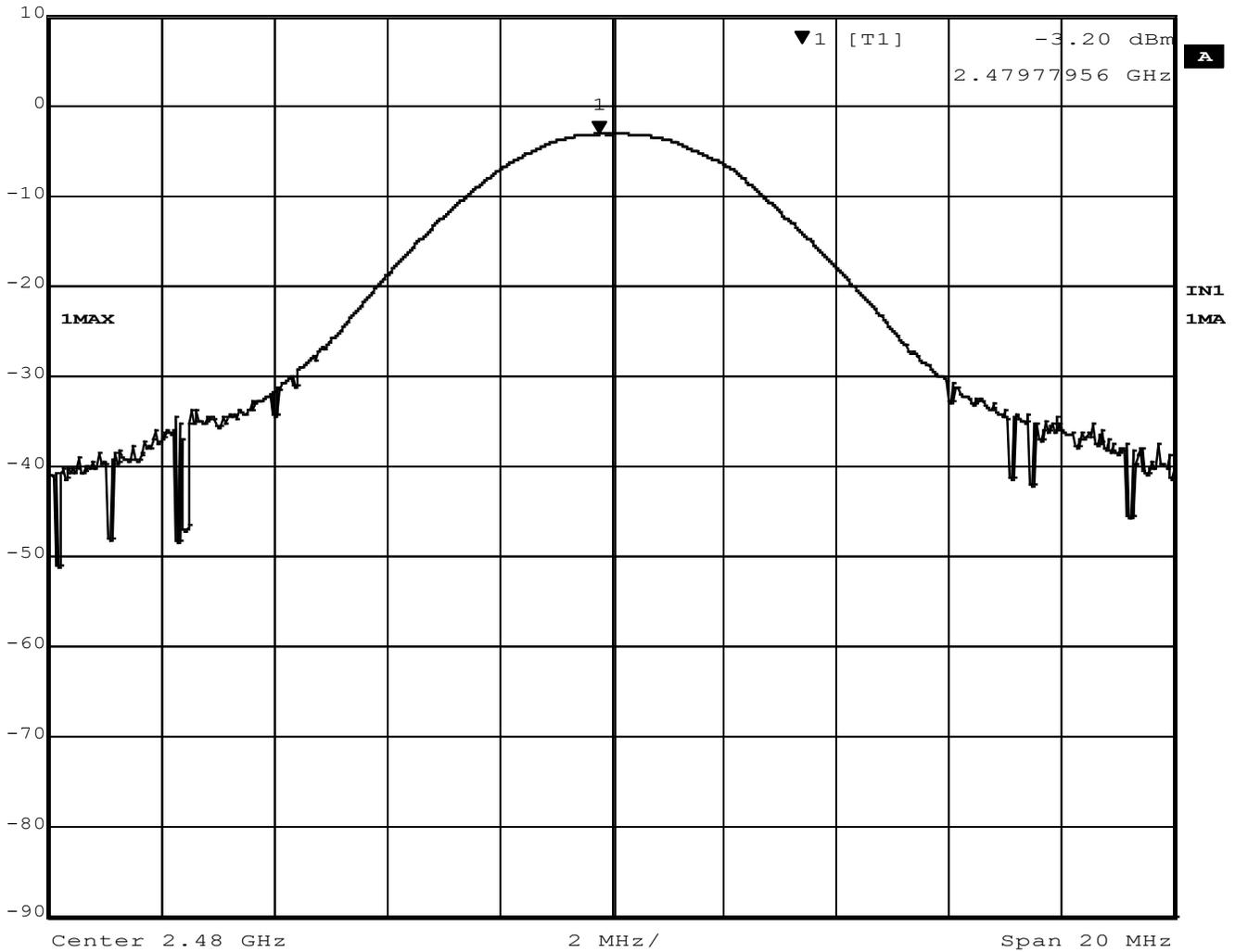
**Figure 11 – Output Power, Mid Channel, GMSK**

Output power = -2.81 dBm

Cable loss was less than 0.1 dB and not included



Marker 1 [T1]	RBW	3 MHz	RF Att	20 dB
Ref Lvl	-3.20 dBm	VBW	10 MHz	
10 dBm	2.47977956 GHz	SWT	5 ms	Unit dBm



Date: 17.DEC.2018 14:00:06

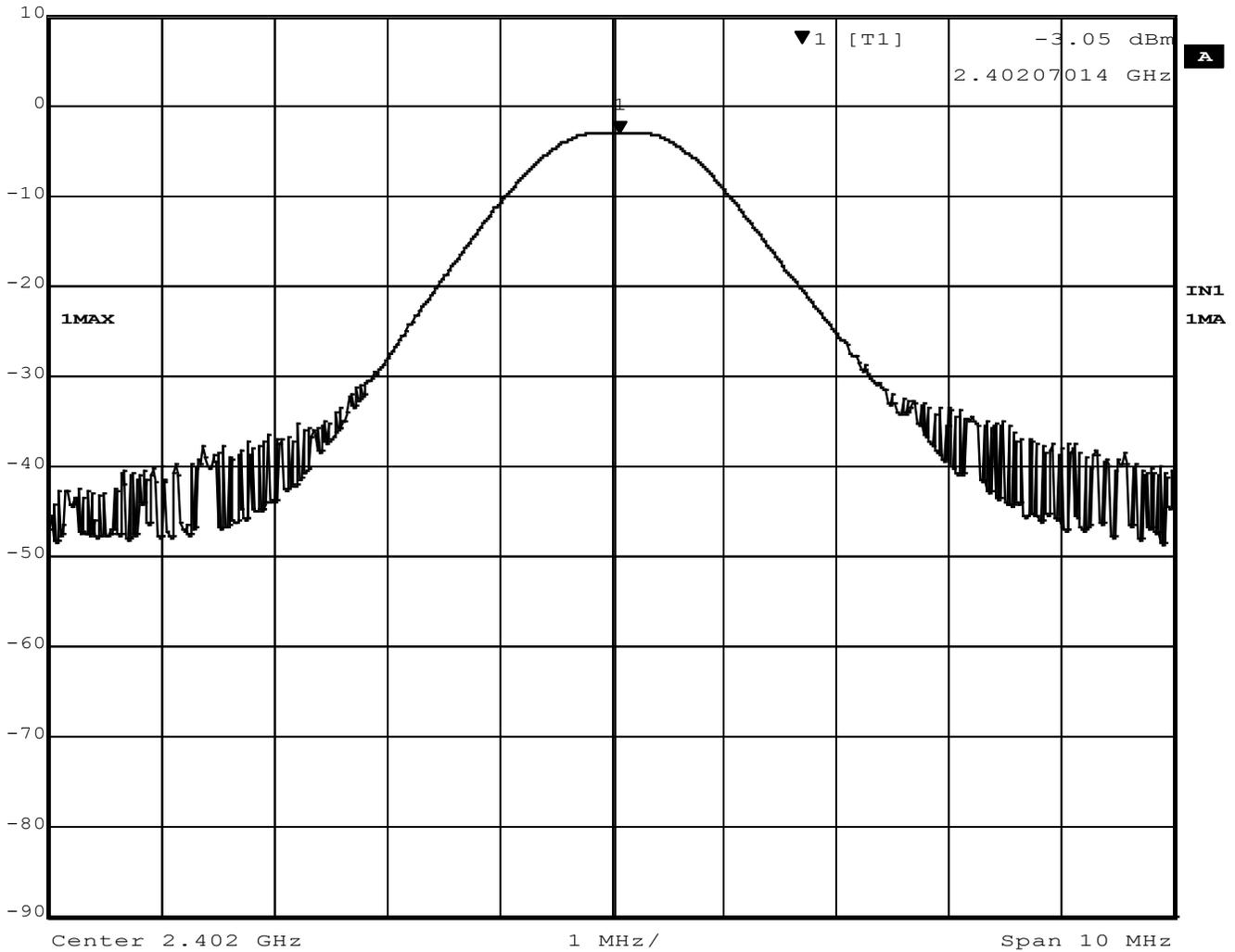
**Figure 12 – Output Power, High Channel, GMSK**

Output power = -3.20 dBm

Cable loss was less than 0.1 dB and not included



Ref Lvl	Marker 1 [T1]	RBW	1 MHz	RF Att	30 dB
10 dBm	-3.05 dBm	VBW	3 MHz		
	2.40207014 GHz	SWT	5 ms	Unit	dBm



Date: 17.DEC.2018 13:00:47

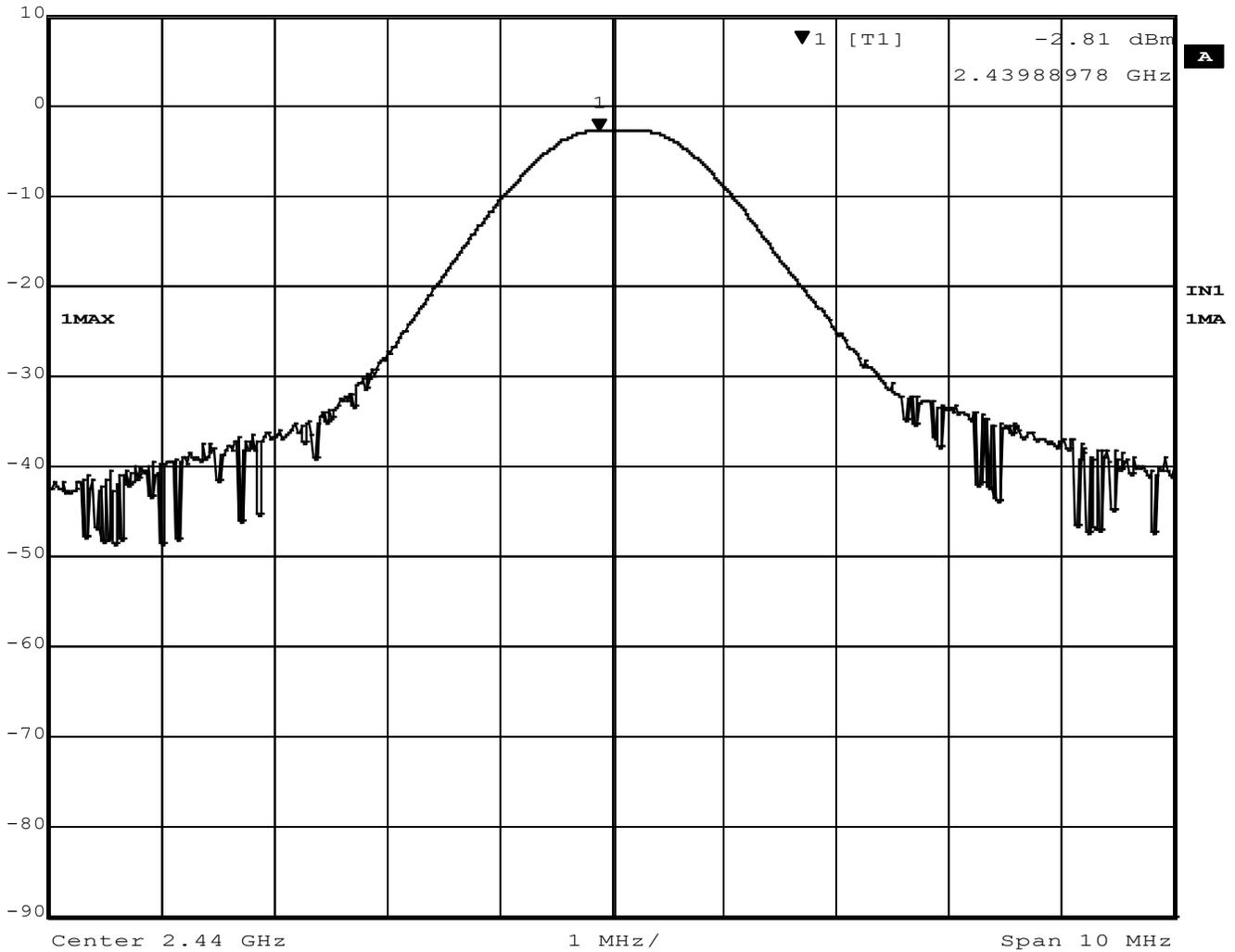
**Figure 13 - Output Power, Low Channel, GFSK**

Output power = -3.05 dBm

Cable loss was less than 0.1 dB and not included



Marker 1 [T1]	RBW	1 MHz	RF Att	30 dB
Ref Lvl	-2.81 dBm	VBW	3 MHz	
10 dBm	2.43988978 GHz	SWT	5 ms	Unit dBm



Date: 17.DEC.2018 13:07:01

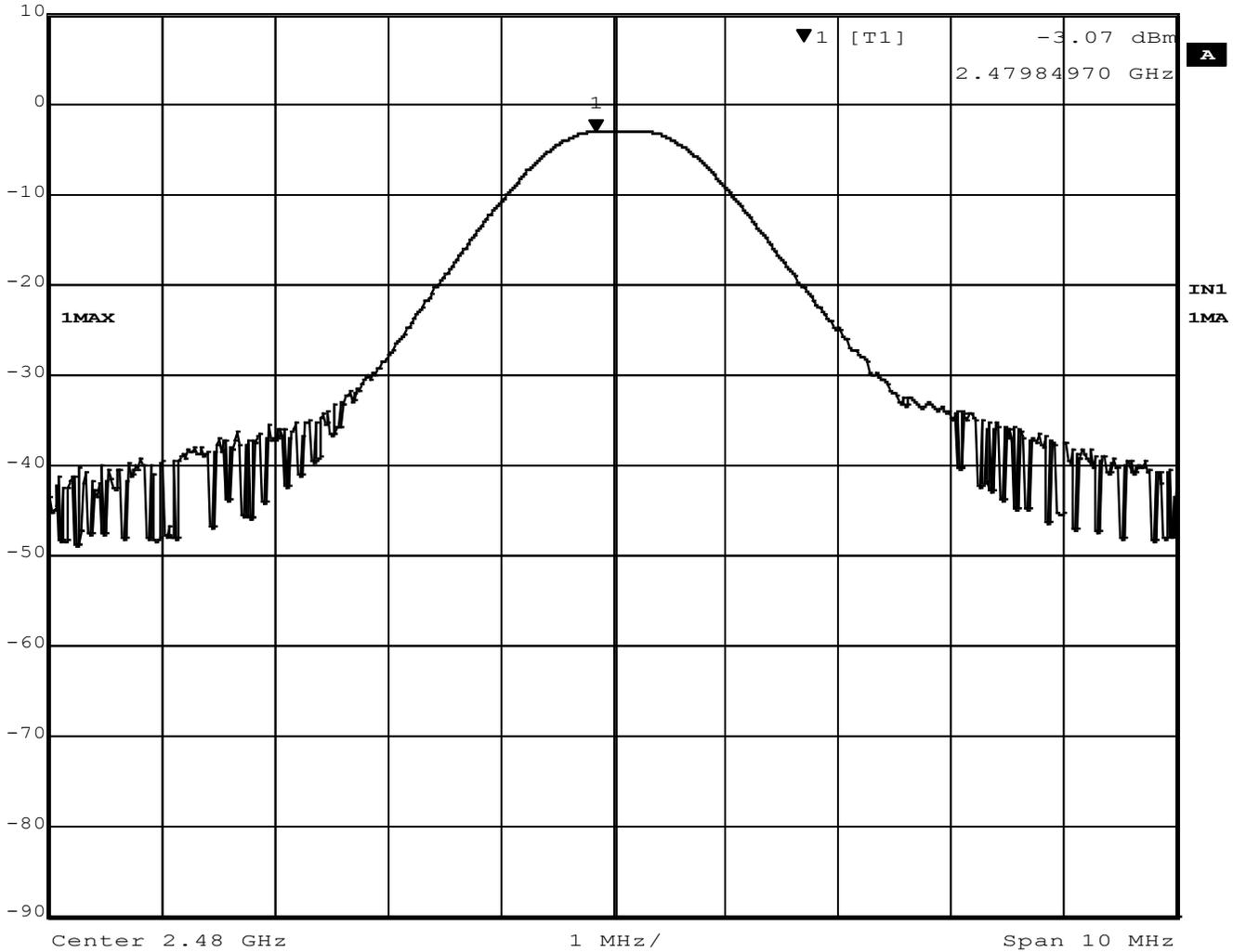
**Figure 14 - Output Power, Mid Channel, GFSK**

Output power = -2.81 dBm

Cable loss was less than 0.1 dB and not included



Marker 1 [T1]	RBW	1 MHz	RF Att	30 dB
Ref Lvl	-3.07 dBm	VBW	3 MHz	
10 dBm	2.47984970 GHz	SWT	5 ms	Unit dBm



Date: 17.DEC.2018 13:12:37

**Figure 15 - Output Power, High Channel, GFSK**

Output power = -3.07 dBm

Cable loss was less than 0.1 dB and not included



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

#### 4.4 BANDWIDTH

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

**Limits of bandwidth measurements:**

For Informational Purposes only

**Test procedures:**

Bandwidth measurement was taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 3 kHz RBW and 10 kHz VBW.

The Occupied Bandwidth is defined as the bandwidth of which is higher than peak power minus 20dB.

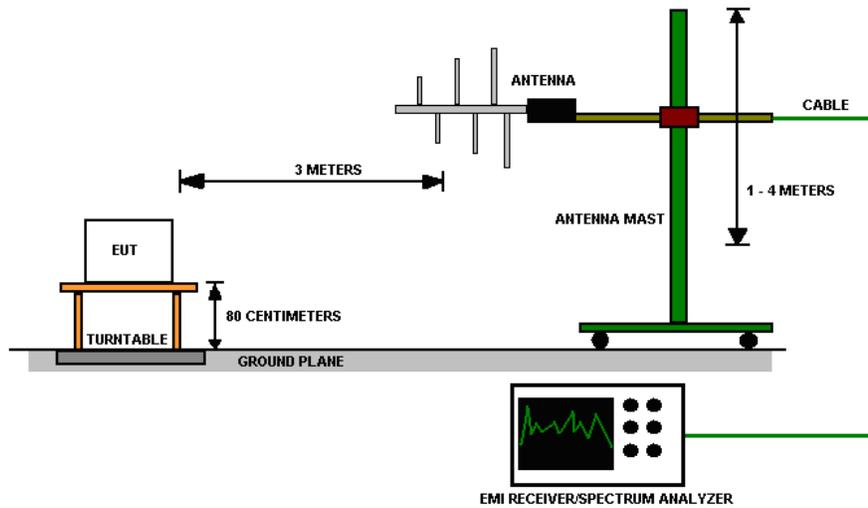
**Test setup:**

All the measurements were done at 3m test distance while an operator was trying to activate the hopping sequence manually. See Section 4.3 for more details.

**Deviations from test standard:**

No deviation.

**Test setup:**



**Figure 16 - Bandwidth Measurements Test Setup**

**EUT operating conditions:**

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

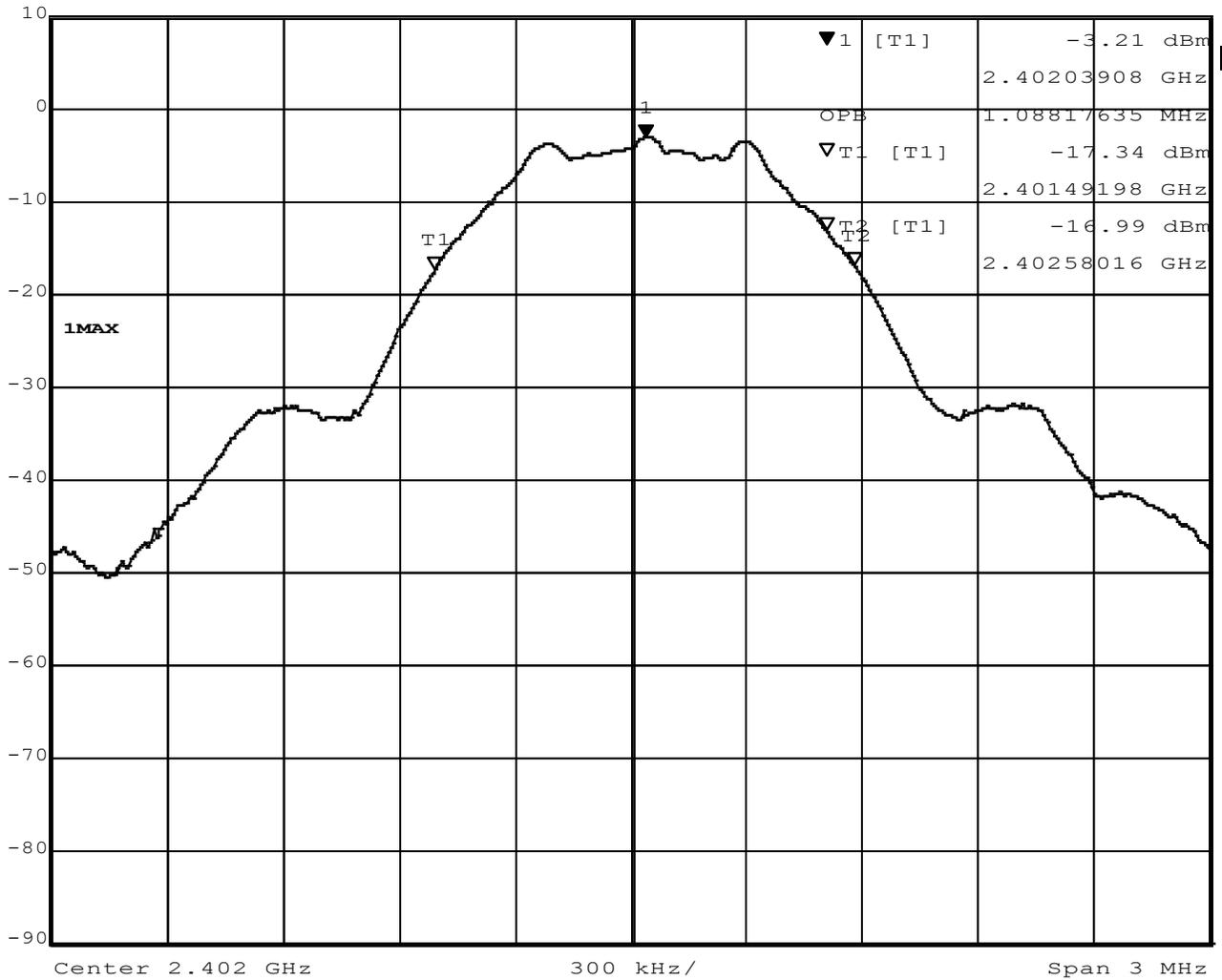
**Test results:**

**Occupied Bandwidth**

CHANNEL	Mode	CHANNEL FREQUENCY (MHz)	OBW (MHz)	RESULT
Low	GMSK	2402	1.09	PASS
Mid	GMSK	2441	1.08	PASS
High	GMSK	2480	1.09	PASS
Low	GFSK	2402	0.992	PASS
Mid	GFSK	2441	0.992	PASS
High	GFSK	2480	0.998	PASS



Marker 1 [T1] RBW 100 kHz RF Att 20 dB  
 Ref Lvl -3.21 dBm VBW 300 kHz  
 10 dBm 2.40203908 GHz SWT 5 ms Unit dBm

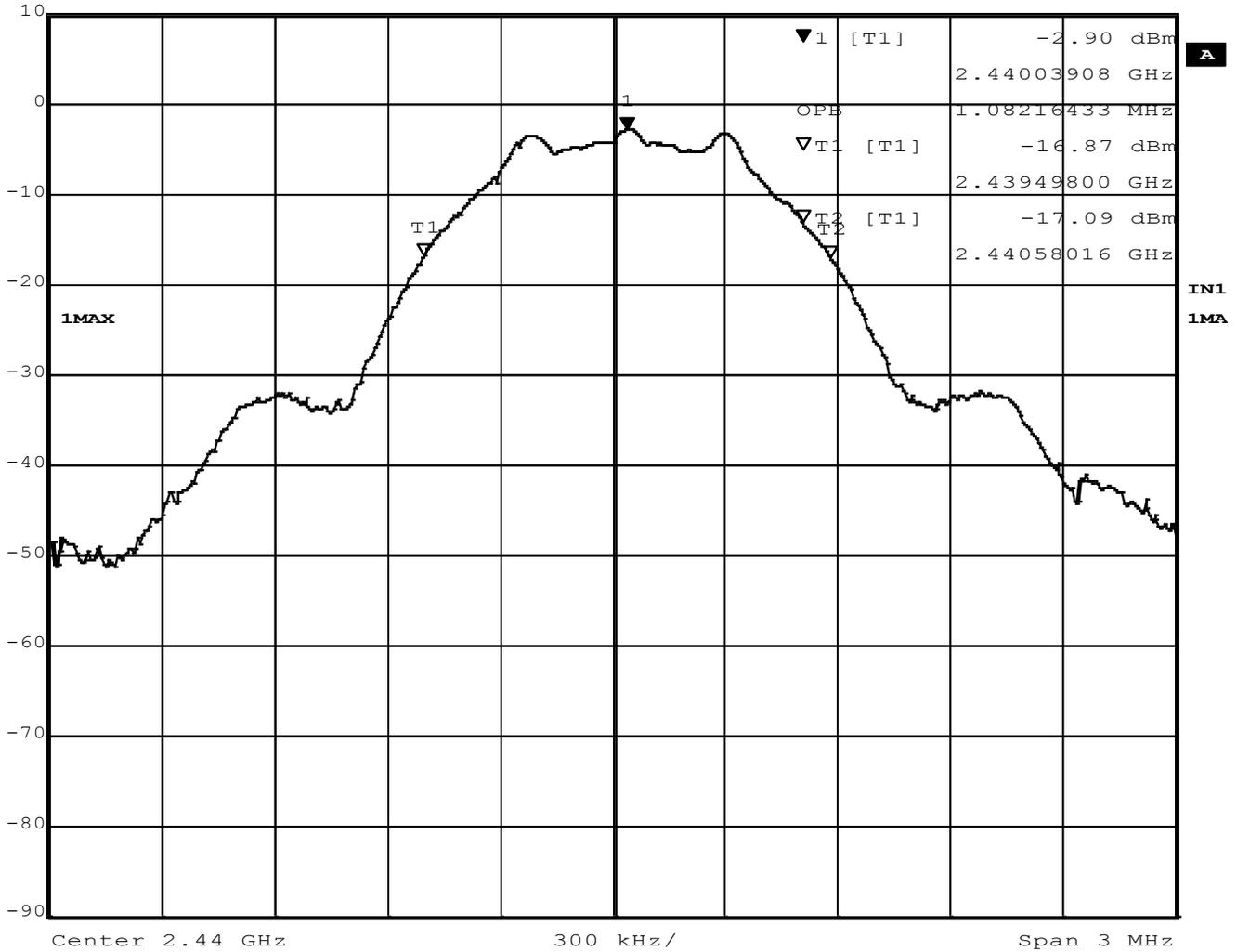


Date: 17.DEC.2018 14:31:50

Figure 17 – Occupied Bandwidth, Low Channel, GMSK



Marker 1 [T1]      RBW 100 kHz      RF Att 20 dB  
 Ref Lvl -2.90 dBm      VBW 300 kHz  
 10 dBm      2.44003908 GHz      SWT 5 ms      Unit dBm

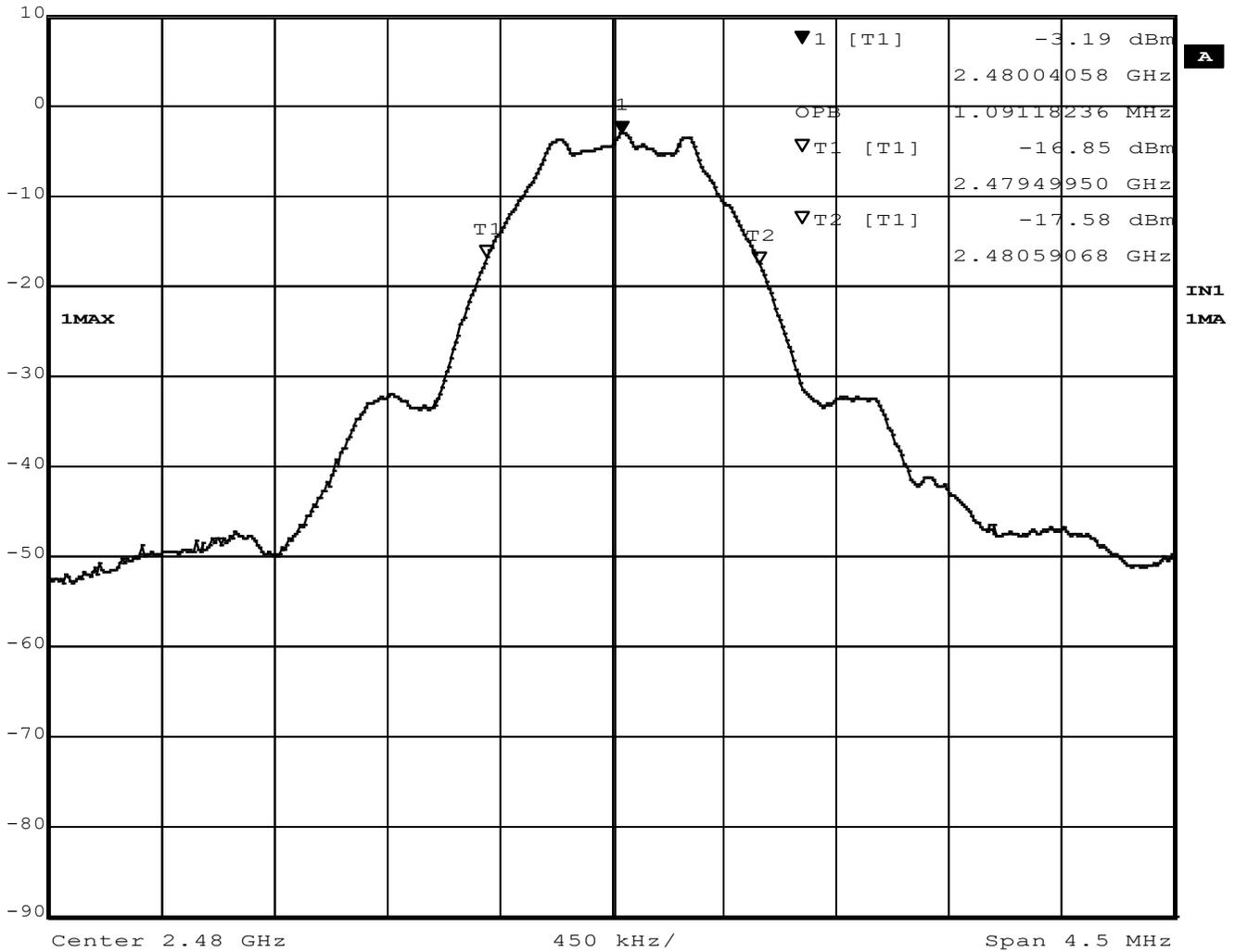


Date: 17.DEC.2018 14:03:36

**Figure 18 - Occupied Bandwidth, Mid Channel, GMSK**



Marker 1 [T1] RBW 100 kHz RF Att 20 dB  
 Ref Lvl -3.19 dBm VBW 300 kHz  
 10 dBm 2.48004058 GHz SWT 5 ms Unit dBm

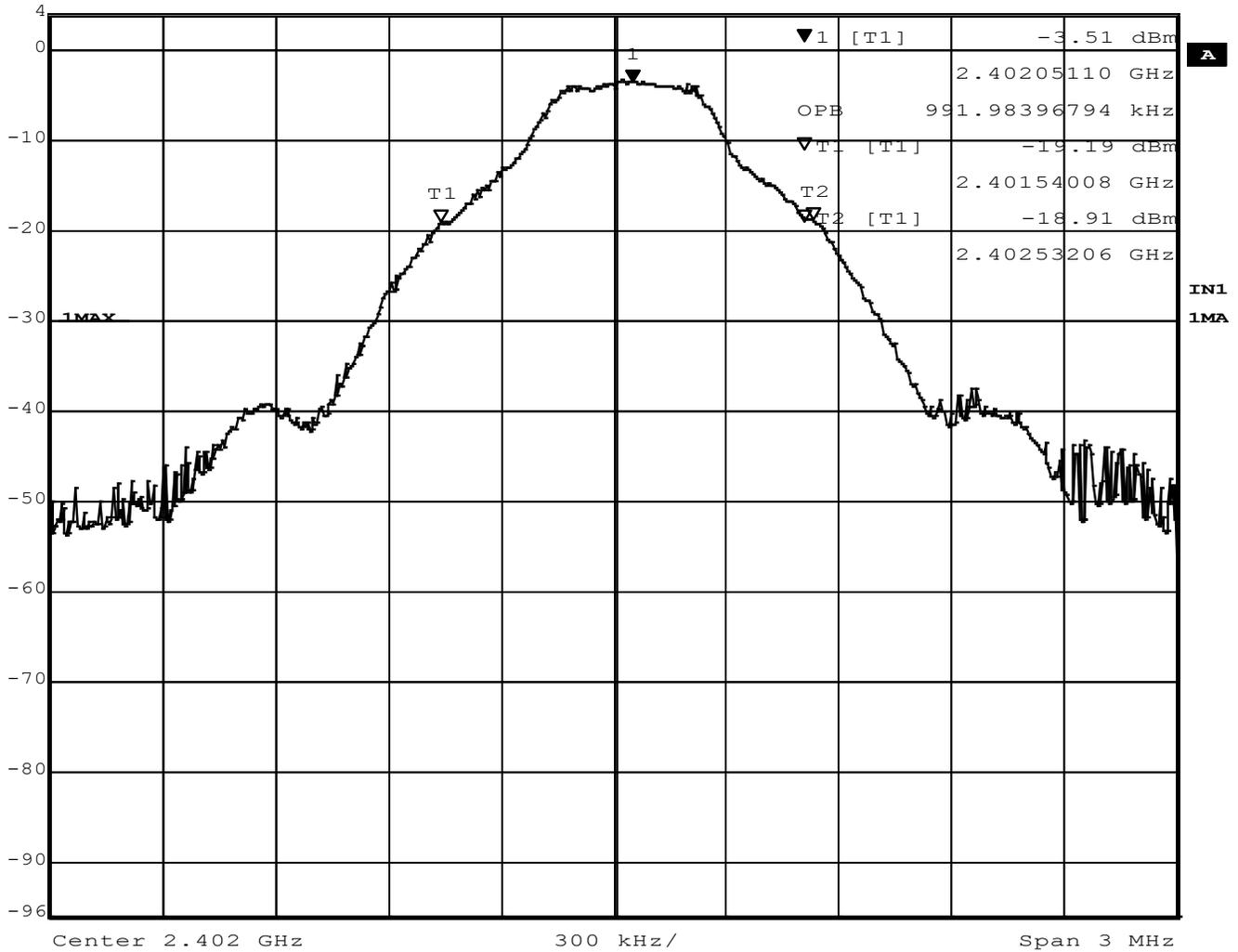


Date: 17.DEC.2018 13:57:57

**Figure 19 - Occupied Bandwidth, High Channel, GMSK**



Marker 1 [T1] RBW 100 kHz RF Att 30 dB  
 Ref Lvl -3.51 dBm VBW 300 kHz  
 4 dBm 2.40205110 GHz SWT 5 ms Unit dBm

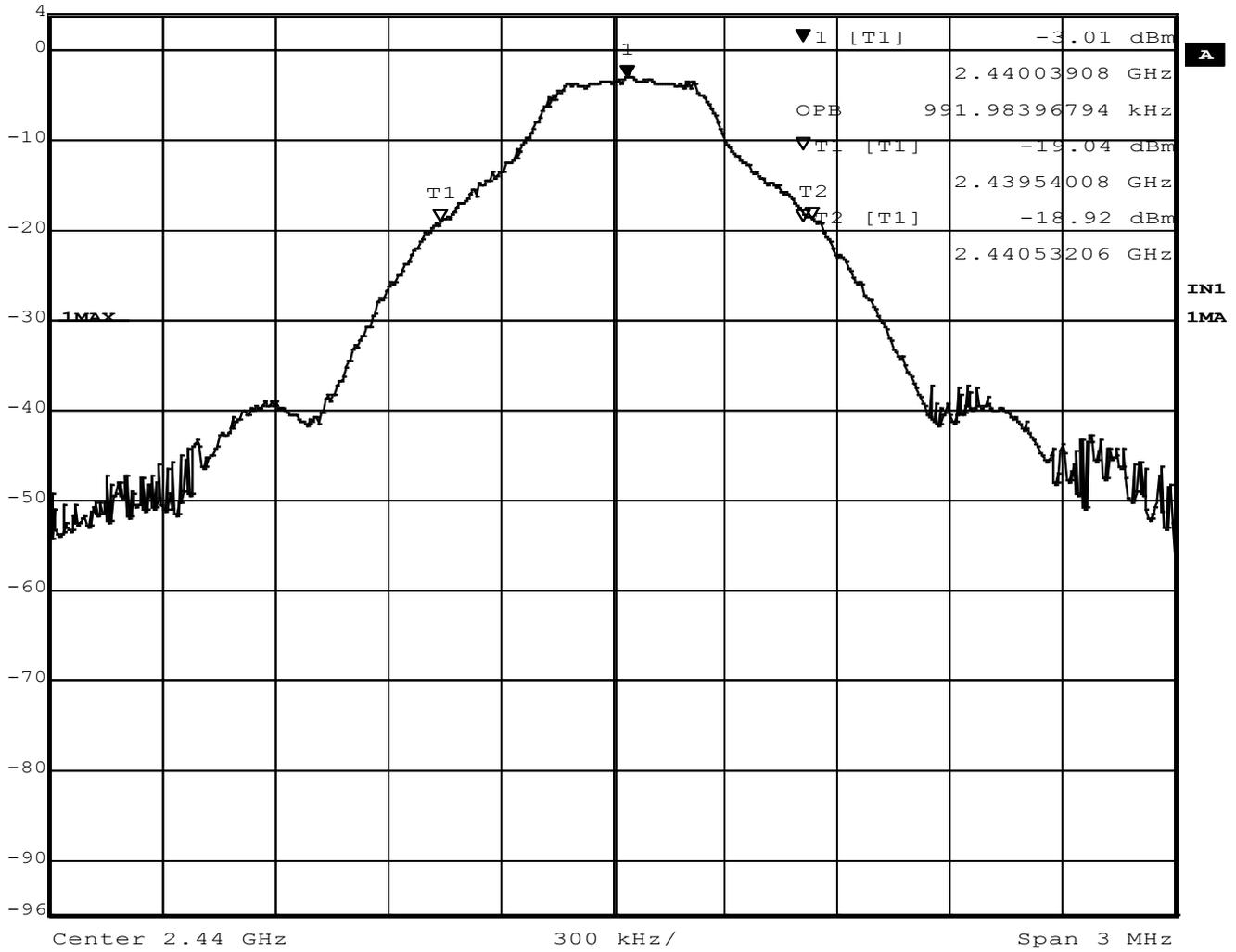


Date: 17.DEC.2018 15:31:23

Figure 20 – Occupied Bandwidth, Low Channel, GFSK



Marker 1 [T1] RBW 100 kHz RF Att 30 dB  
 -3.01 dBm VBW 300 kHz  
 Ref Lvl 4 dBm 2.44003908 GHz SWT 5 ms Unit dBm

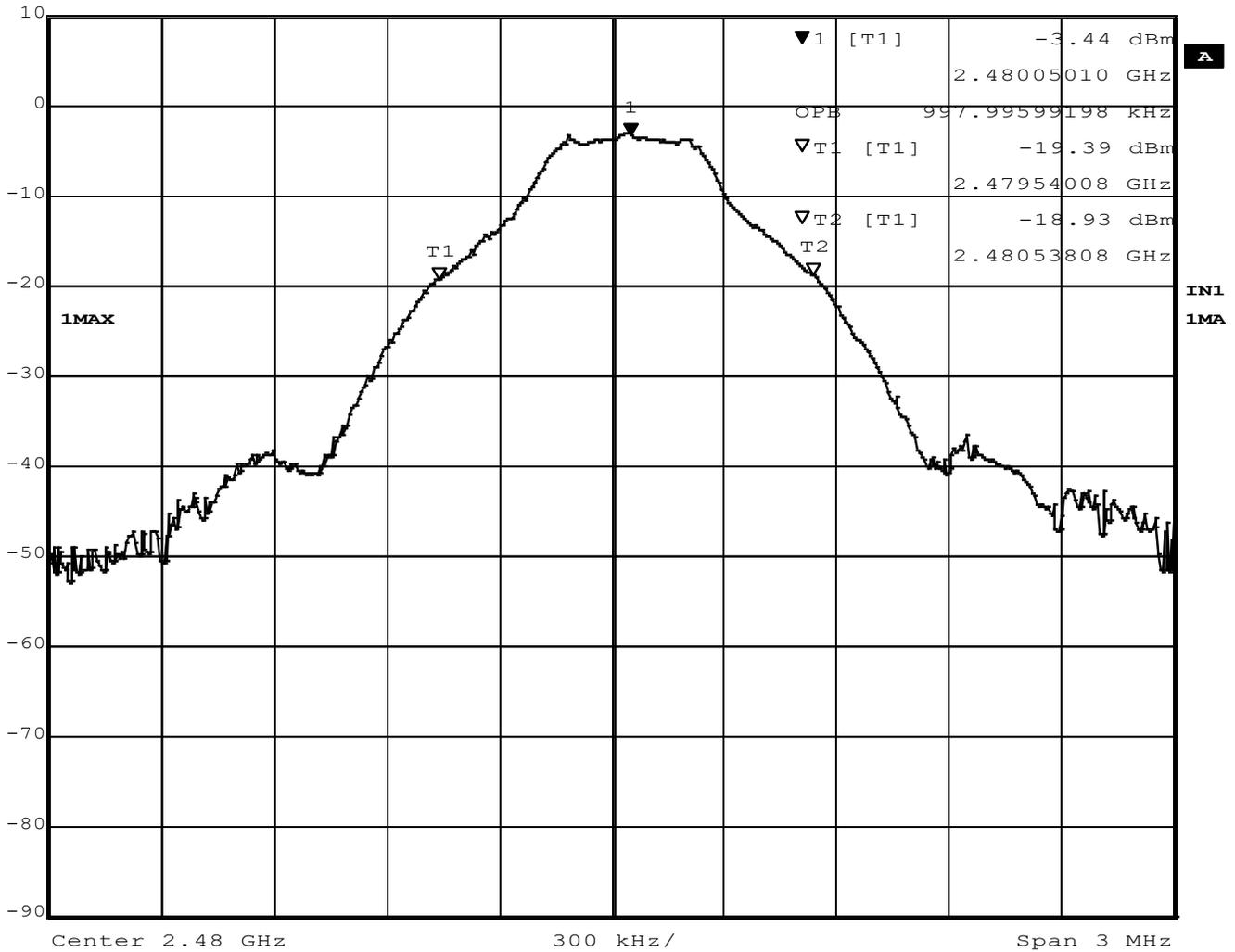


Date: 17.DEC.2018 15:29:29

Figure 21 - Occupied Bandwidth, Mid Channel, GFSK



Marker 1 [T1] RBW 100 kHz RF Att 30 dB  
 Ref Lvl -3.44 dBm VBW 300 kHz  
 10 dBm 2.48005010 GHz SWT 5 ms Unit dBm



Date: 17.DEC.2018 13:37:09

Figure 22 - Occupied Bandwidth, High Channel, GFSK



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

#### 4.5 BAND EDGES

**Test Method:** ANSI C63.10-2013, Section(s) 6.10.6

**Limits of bandedge 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 tested in the same method as described in section 4.4 - *Bandwidth*. The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 30kHz and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a quasi-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.

**Deviations from test standard:**

No deviation.

**Test setup:**

All the measurements were done at 3m test distance while an operator was trying to activate the hopping sequence manually.

**EUT operating conditions:**

The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest frequency channel, and the highest frequency channel.



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**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	GMSK	2400	-49.68	-3.97	45.71	30.13	PASS
Low, Continuous	GFSK	2400	-55.01	-2.94	52.07	30.98	PASS
High, Continuous	GMSK	2483.5	-53.22	-3.24	49.98	35.98	PASS
High, Continuous	GFSK	2483.5	-54.85	-3.16	51.69	37.85	PASS

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

From Section 4.2

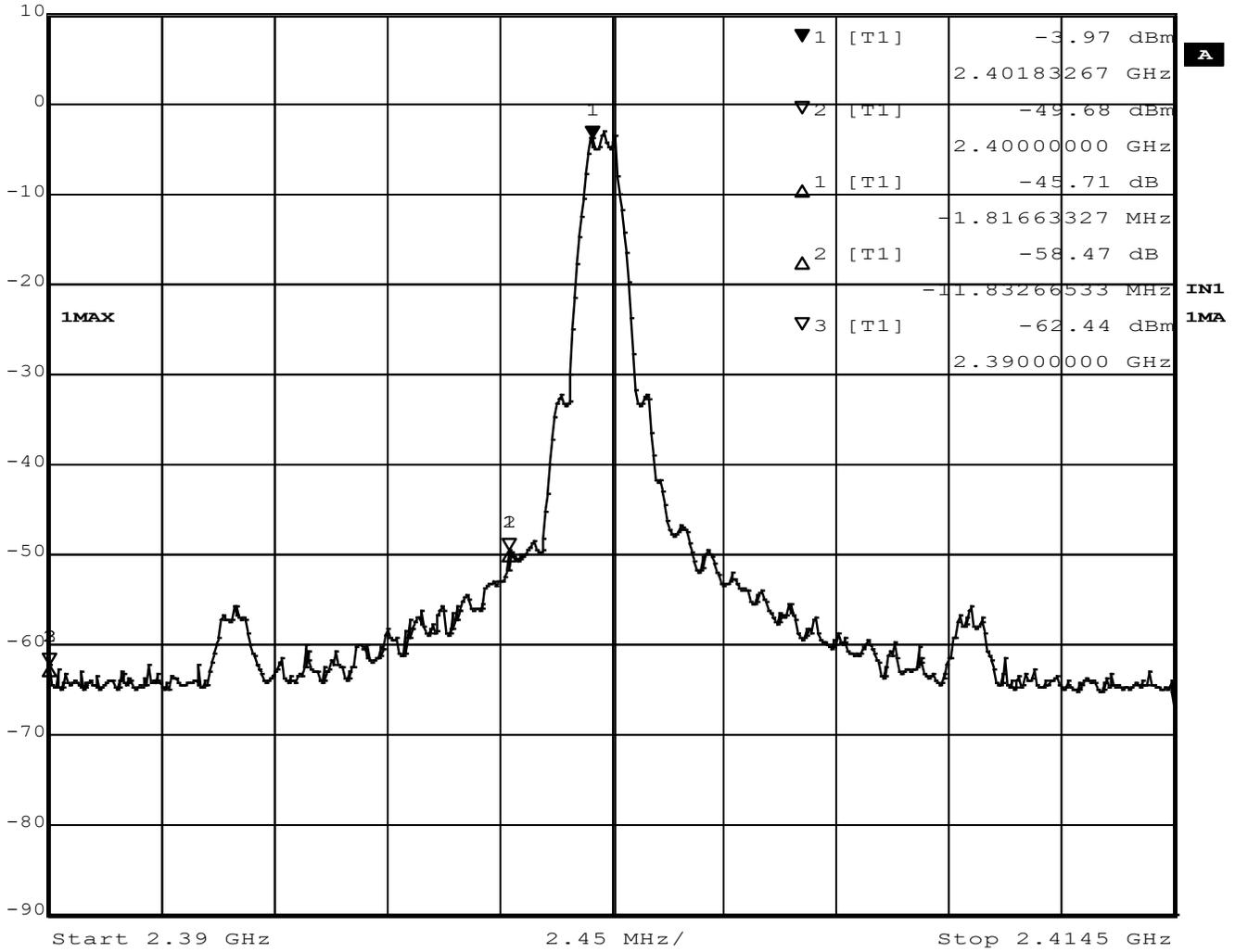
Fundamental peak field strength at Low Channel GMSK = 92.30 dBµV/m  
 Fundamental peak field strength at High Channel GMSK = 92.19 dBµV/m  
 Fundamental peak field strength at Low Channel GFSK = 92.04 dBµV/m  
 Fundamental peak field strength at High Channel GFSK = 93.82 dBµV/m

Low Channel minimum delta GMSK = 92.30 – 54.0 dBµV/m = 30.13 dBc  
 High Channel minimum delta GMSK = 92.19 – 54.0 dBµV/m = 30.98 dBc  
 Low Channel minimum delta GFSK = 92.04 – 54.0 dBµV/m = 35.98 dBc  
 High Channel minimum delta GFSK = 93.82 – 54.0 dBµV/m = 37.85 dBc

Measurements do not include correction factors and are intended to be relative measurements only.



Marker 1 [T1] RBW 100 kHz RF Att 20 dB  
 Ref Lvl -3.97 dBm VBW 300 kHz  
 10 dBm 2.40183267 GHz SWT 6.5 ms Unit dBm

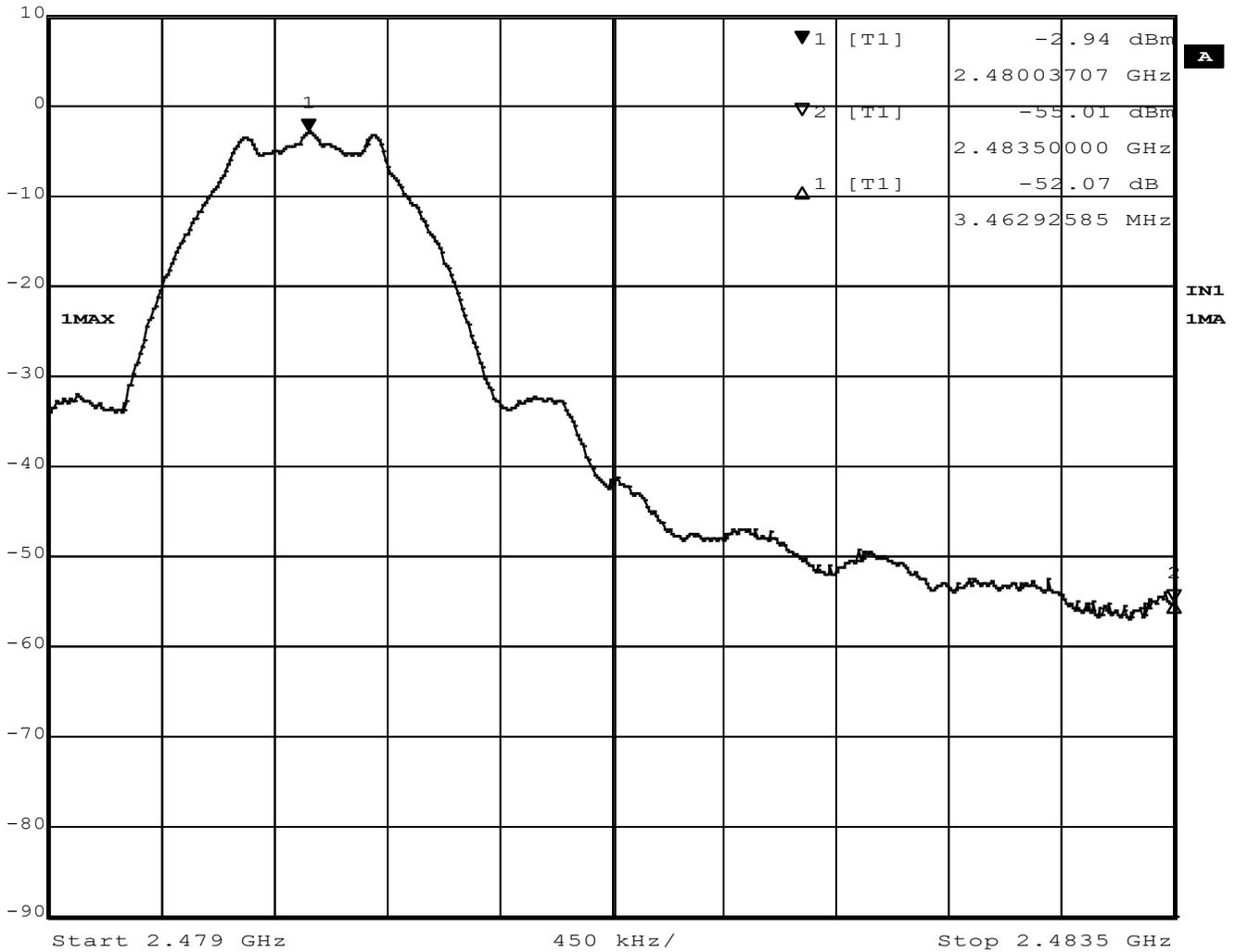


Date: 17.DEC.2018 14:48:14

Figure 23 - Band Edge, Low Channel, GMSK



Marker 1 [T1]      RBW 100 kHz      RF Att 20 dB  
 Ref Lvl      -2.94 dBm      VBW 300 kHz  
 10 dBm      2.48003707 GHz      SWT 5 ms      Unit dBm

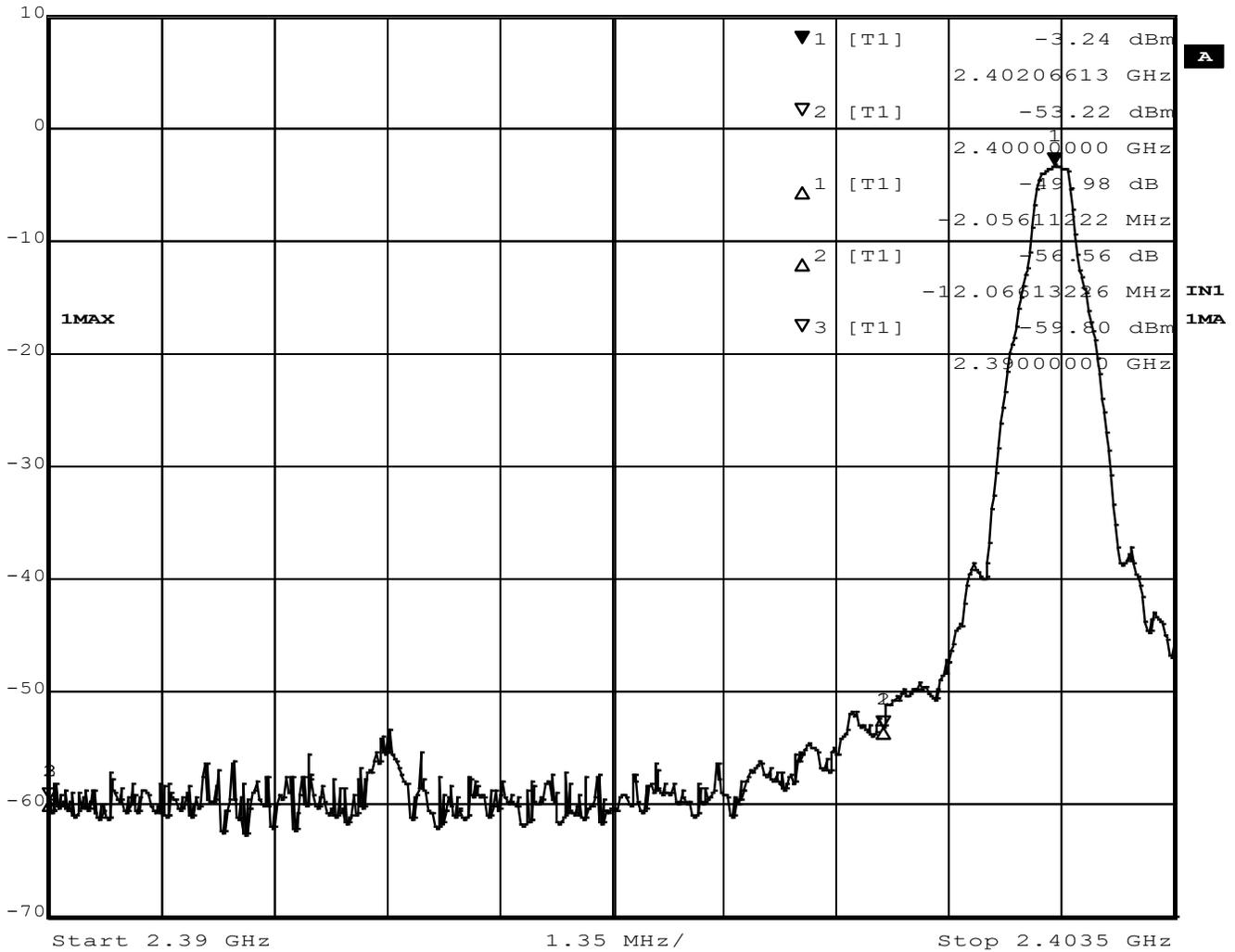


Date: 17.DEC.2018 13:50:01

**Figure 24 – Restricted Band Edge, High Channel, GMSK**



Marker 1 [T1] RBW 100 kHz RF Att 20 dB  
 Ref Lvl -3.24 dBm VBW 300 kHz  
 10 dBm 2.40206613 GHz SWT 5 ms Unit dBm

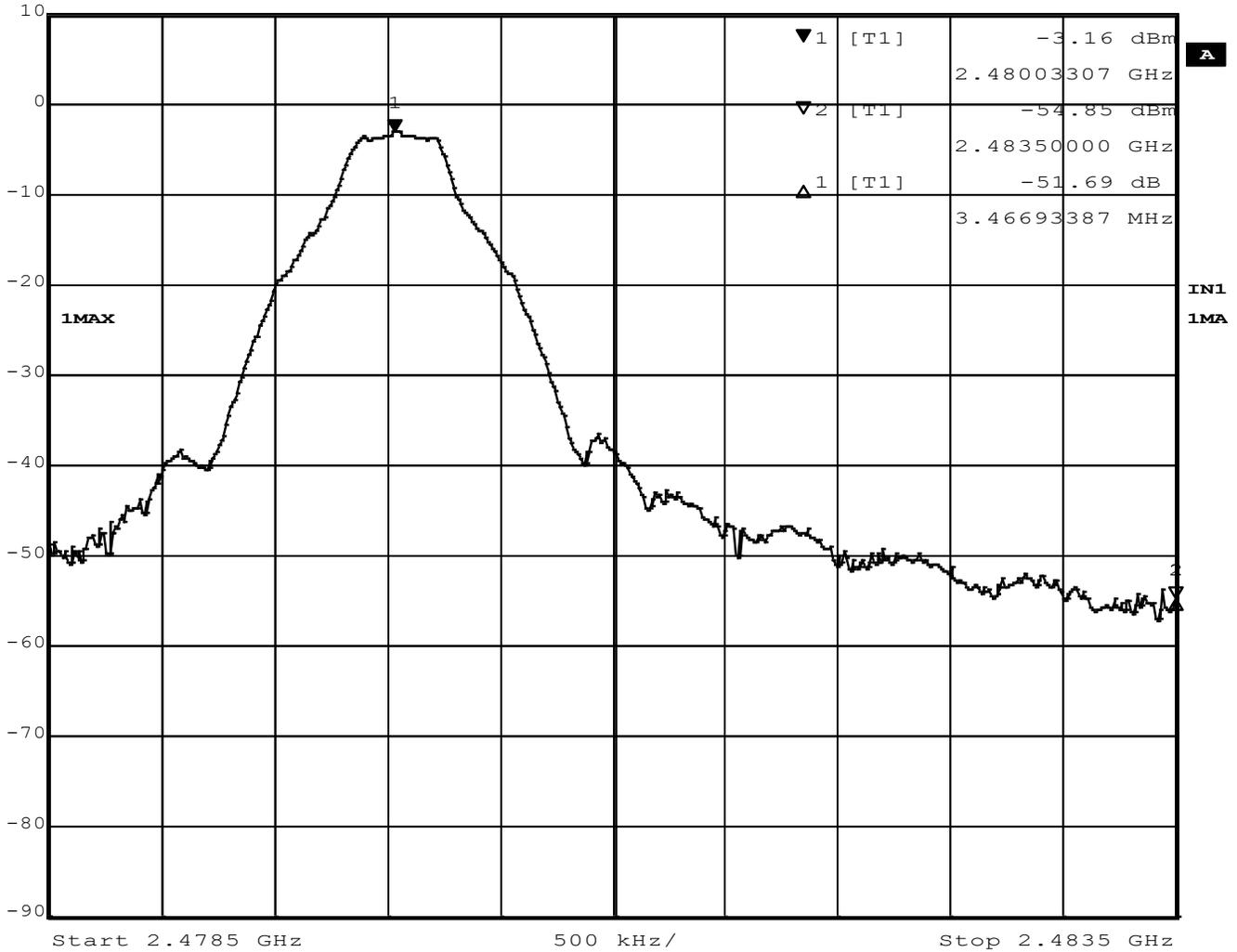


Date: 17.DEC.2018 15:34:08

Figure 25 –Band Edge, Low Channel, GFSK



Marker 1 [T1]      RBW 100 kHz      RF Att 20 dB  
 Ref Lvl -3.16 dBm      VBW 300 kHz  
 10 dBm      2.48003307 GHz      SWT 5 ms      Unit dBm



Date: 17.DEC.2018 13:40:49

Figure 26 – Band Edge Measurement, High Channel, GFSK



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

**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 $\mu$ 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 $\mu$ V/m.

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

The 48.1 dB $\mu$ V/m value can be mathematically converted to its corresponding level in  $\mu$ 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 the taking the  $20 \cdot \log(T_{on}/100)$  where  $T_{on}$  is the maximum transmission time in any 100ms window.



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

### 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;

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

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

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

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

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

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

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

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

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



Report Number:	R20180514-24-01B	Rev	B
Prepared for:	Garmin		

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 Number:

R20180514-24-01B

Rev

B

Prepared for:

Garmin

REPORT END