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FCC/ISED Test Report

Prepared for: **Garmin International Inc.**

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

Product: **A03671**

Test Report No: **R20181015-21-01B**

Approved by:

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

DATE: **15 February 2019**

Total Pages: **38**

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	29 December 2018	Original – NJohnson Prepared by KVepuri/ CFarrington
A	11 February 2019	Added 15.249(a) limits to data in Section 4.2 Results for Section 4.3 and 4.4 were changed to N/A because they were for informational purposes only. 2483.5 MHz band edge measurement was repeated. -Includes NCEE Labs report R20181015-21-01 and its amendment in full -NJ
B	15 February 2018	Table 15 was corrected Bandedge result table was corrected to match plots Includes NCEE Labs report R20181015-21-01A and its amendment in full -NJ

CONTENTS

TABLES OF FIGURES

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1.0 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

(1) US Code of Federal Regulations, Title 47, Part 15
(2) ISED RSS-Gen, Issue 5
(3) ISED RSS-210, Issue 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	Pass	Meets the requirement of the limit.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary

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

EUT	A03671
EUT Received	2018 December 4
EUT Tested	2018 December 4 –19 2019 February 11 (2483.5 MHz band edge measurement only)
Serial No.	NCEE1 (Assigned)
Operating Band	2400 – 2483.5 MHz
Device Type	GMSK
Power Supply	YI Power Adapter (5 VDC output) MN: A8-501000 (Power supply used was a representative power supply only)

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 and external USB power. The worse-case emissions were produced while running off of USB power, so results from this mode are presented.

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	Report review and editing
1	Karthik Vepuri	Test Engineer	Testing and report
1	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 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.

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 (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 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.

g. The EUT was maximized in all 3 orthogonal axis. 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:

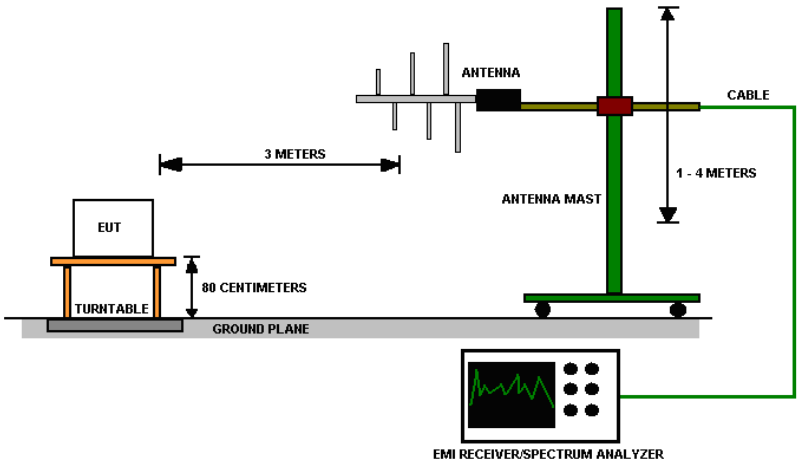

Figure 1 - Radiated Emissions Test Setup

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

Test results:

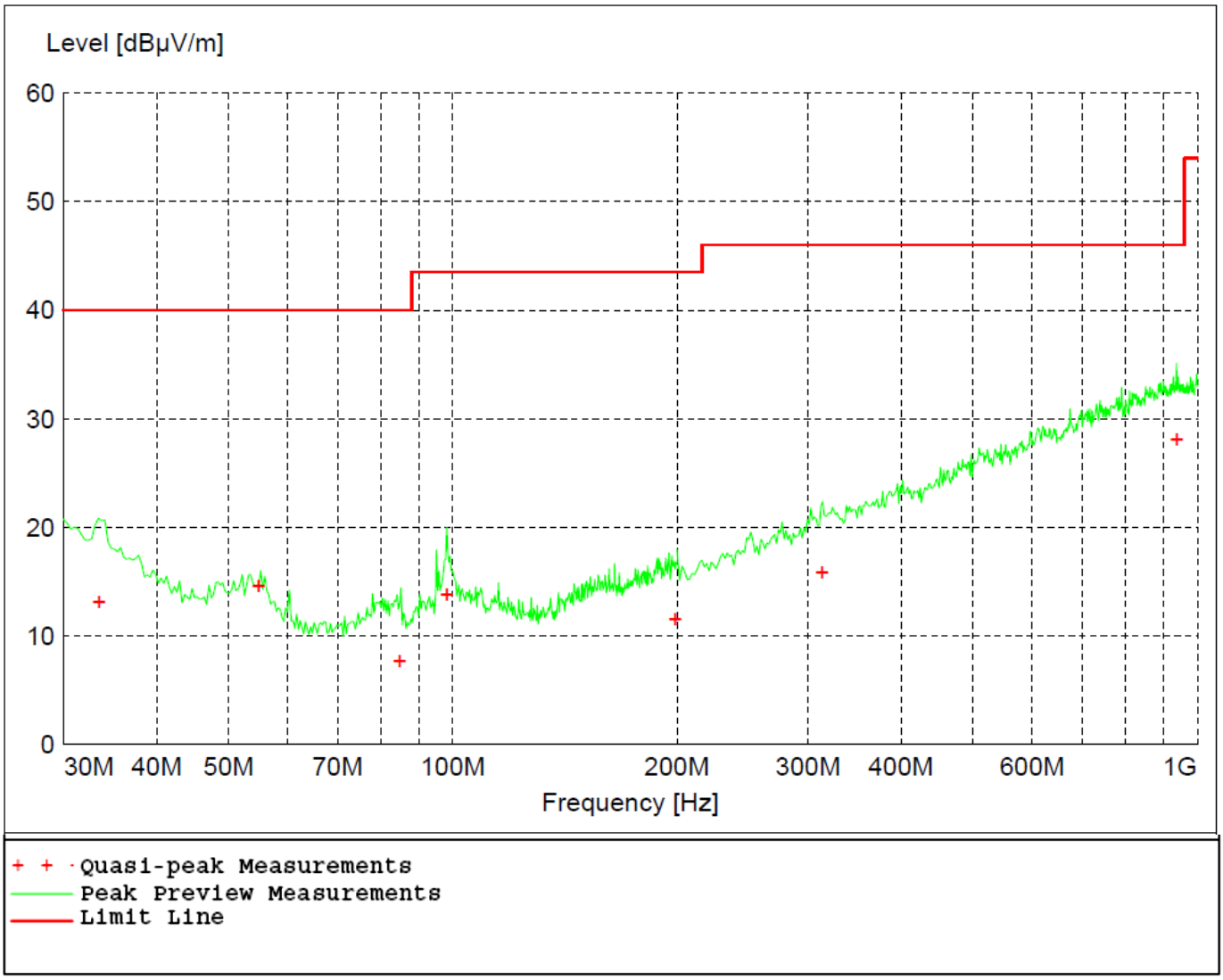

Figure 2 - Radiated Emissions Plot, Receive, GMSK

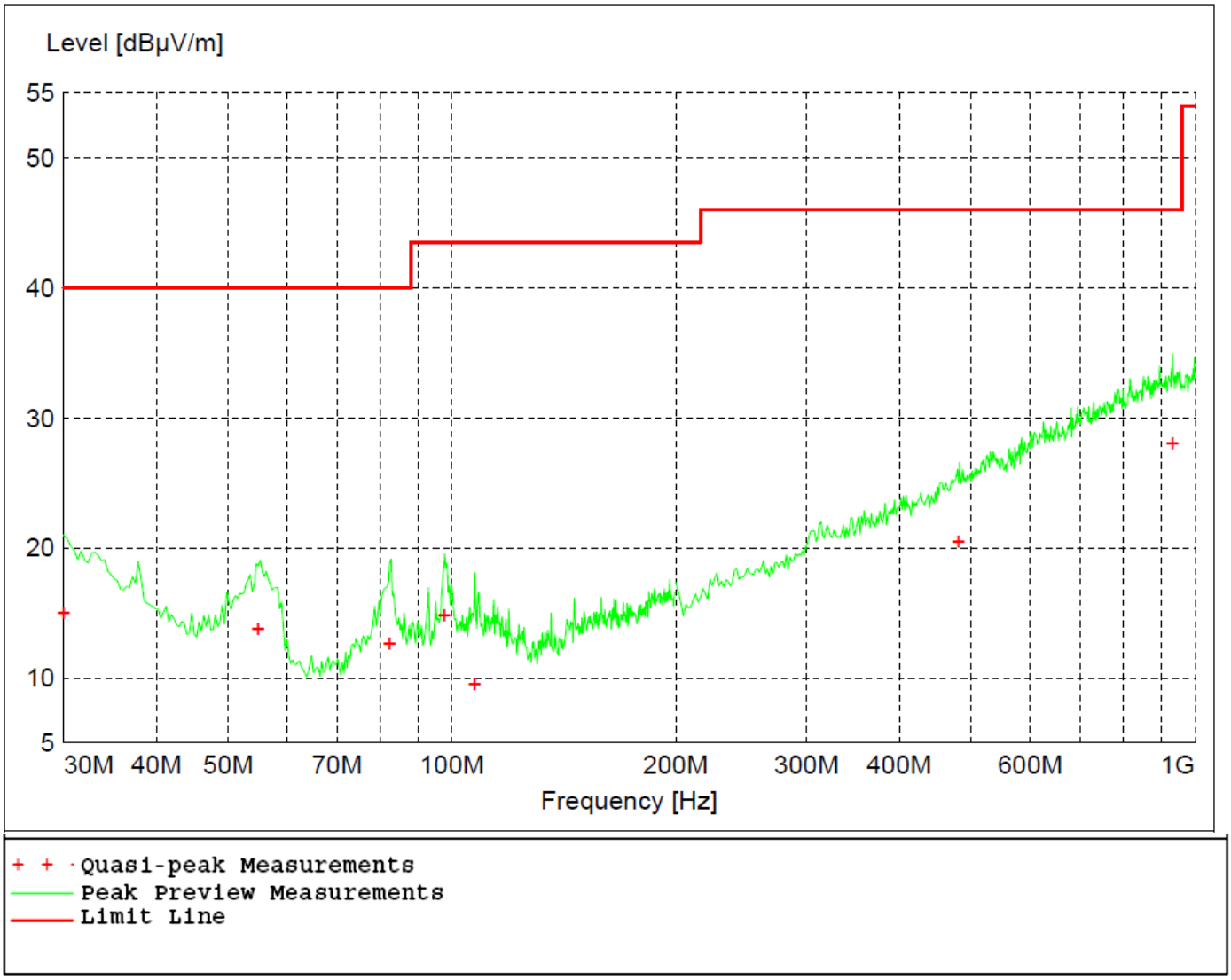

Figure 3 - Radiated Emissions Plot, Low Channel, GMSK

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.060000	15.08	40.00	24.90	143	51	VERT
54.840000	13.77	40.00	26.20	129	207	VERT
82.440000	12.69	40.00	27.30	112	319	VERT
97.740000	14.81	43.50	28.70	377	39	VERT
107.280000	9.53	43.50	34.00	120	65	VERT
480.600000	20.52	46.00	25.50	247	75	HORI
933.180000	28.06	46.00	17.90	370	147	VERT

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

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2402.000000	91.41	93.98	2.57	98	4	HORI
4803.600000	43.54	54.00	10.50	206	360	HORI
7179.200000	44.29	54.00	9.70	168	67	HORI

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

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

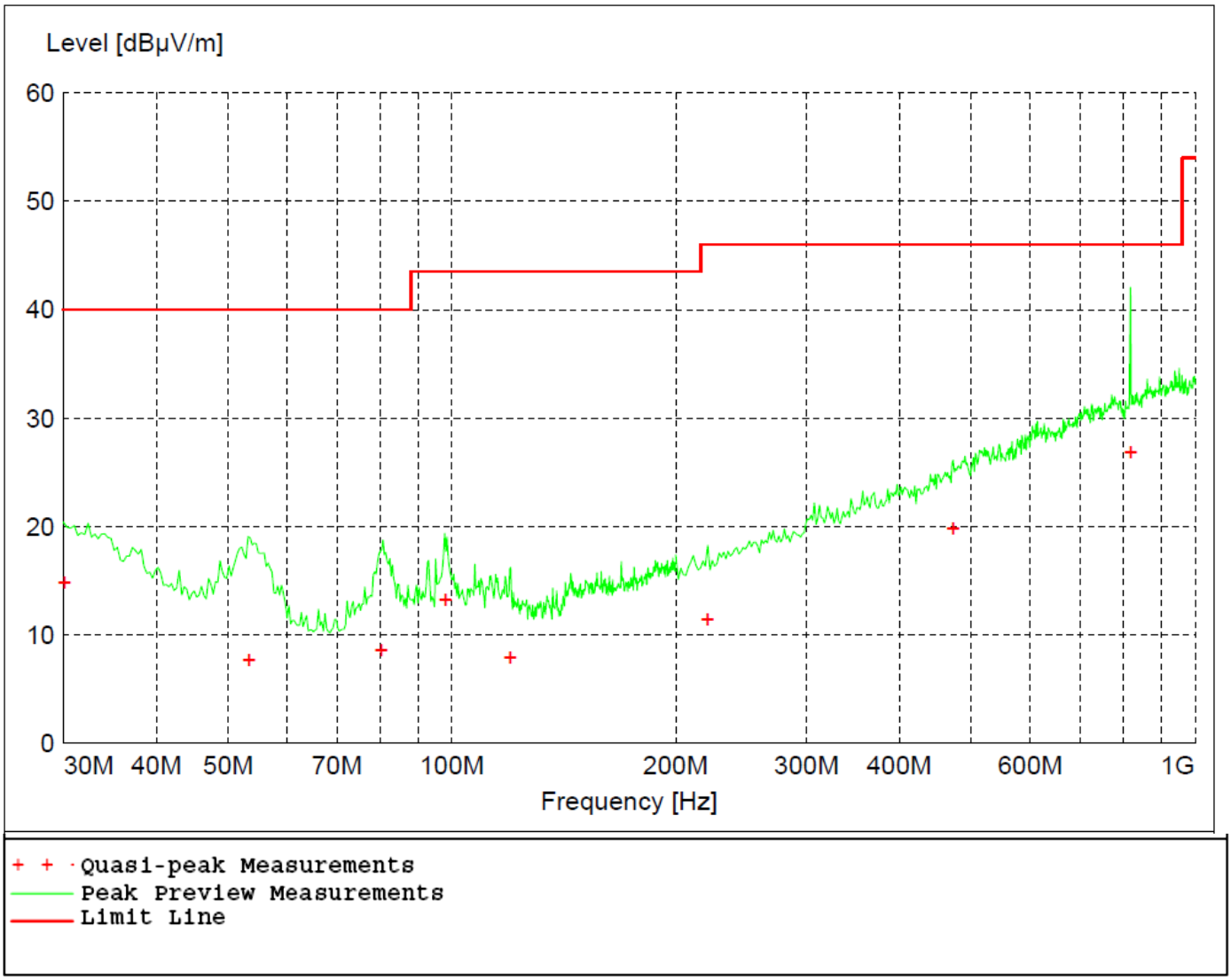

Figure 4 - Radiated Emissions Plot, Mid Channel, GMSK

Table 12 - Radiated Emissions Quasi-peak Measurements, Mid Channel, GMSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.120000	14.88	40.00	25.10	131	163	HORI
53.340000	7.68	40.00	32.30	384	31	VERT
80.400000	8.61	40.00	31.40	99	0	VERT
98.100000	13.31	43.50	30.20	384	46	VERT
119.820000	7.99	43.50	35.50	104	0	VERT
220.860000	11.48	46.00	34.50	99	0	HORI
472.680000	19.83	46.00	26.20	295	0	VERT
820.200000	26.85	46.00	19.20	196	76	VERT

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

Table 13 - Radiated Emissions Peak Measurements, Mid Channel, GMSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2442.000000	91.56	93.98	2.42	N/A	N/A	N/A
4883.000000	46.07	54.00	7.90	158	57	HORI
7313.400000	43.58	54.00	10.40	301	0	HORI

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

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

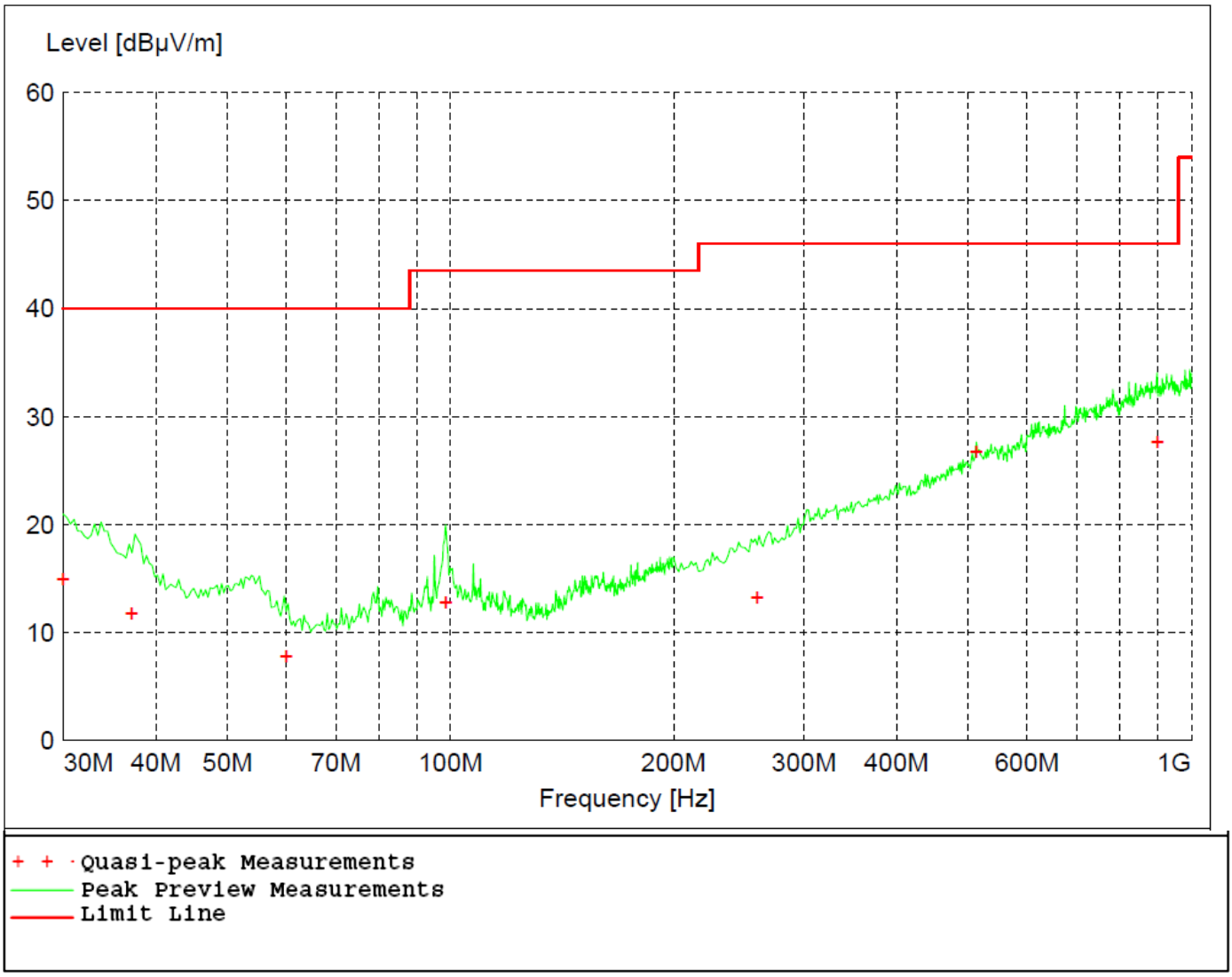

Figure 5 - Radiated Emissions Plot, High Channel, GMSK

Table 14 - Radiated Emissions Quasi-peak Measurements, High Channel, GMSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.000000	14.96	40.00	25.00	264	312	HORI
37.140000	11.85	40.00	28.20	100	331	VERT
60.000000	7.78	40.00	32.20	99	285	VERT
98.580000	12.78	43.50	30.70	377	119	VERT
259.560000	13.26	46.00	32.70	391	274	HORI
512.940000	26.73	46.00	19.30	354	16	HORI
900.480000	27.70	46.00	18.30	356	266	VERT

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

Table 15 - Radiated Emissions Peak Measurements, High Channel, GMSK

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2480.000000	92.67	93.98	1.31	335	204	VERT
4965.800000	43.74	54.00	10.30	152	324	HORI
7439.200000	48.80	54.00	5.20	305	192	VERT

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

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

4.3 PEAK OUTPUT POWER

Test Method: ANSI C63.10, Section(s) 11.9.1.1

Limits of peak power measurements:

For Informational Purposes only

Test procedures:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable with 10 MHz RBW and 10 MHz VBW. The RBW was set to a value larger than the DTS bandwidth.

Deviations from test standard:
No deviation.

Test setup:

Figure 6 - 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 and highest frequency channel.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	PEAK OUTPUT POWER (mW)	Method	RESULT	Transmsitter
1	2402	2.89	1.95	Conducted	N/A	GMSK
2	2441	2.99	1.99	Conducted	N/A	GMSK
3	2480	3.13	2.06	Conducted	N/A	GMSK

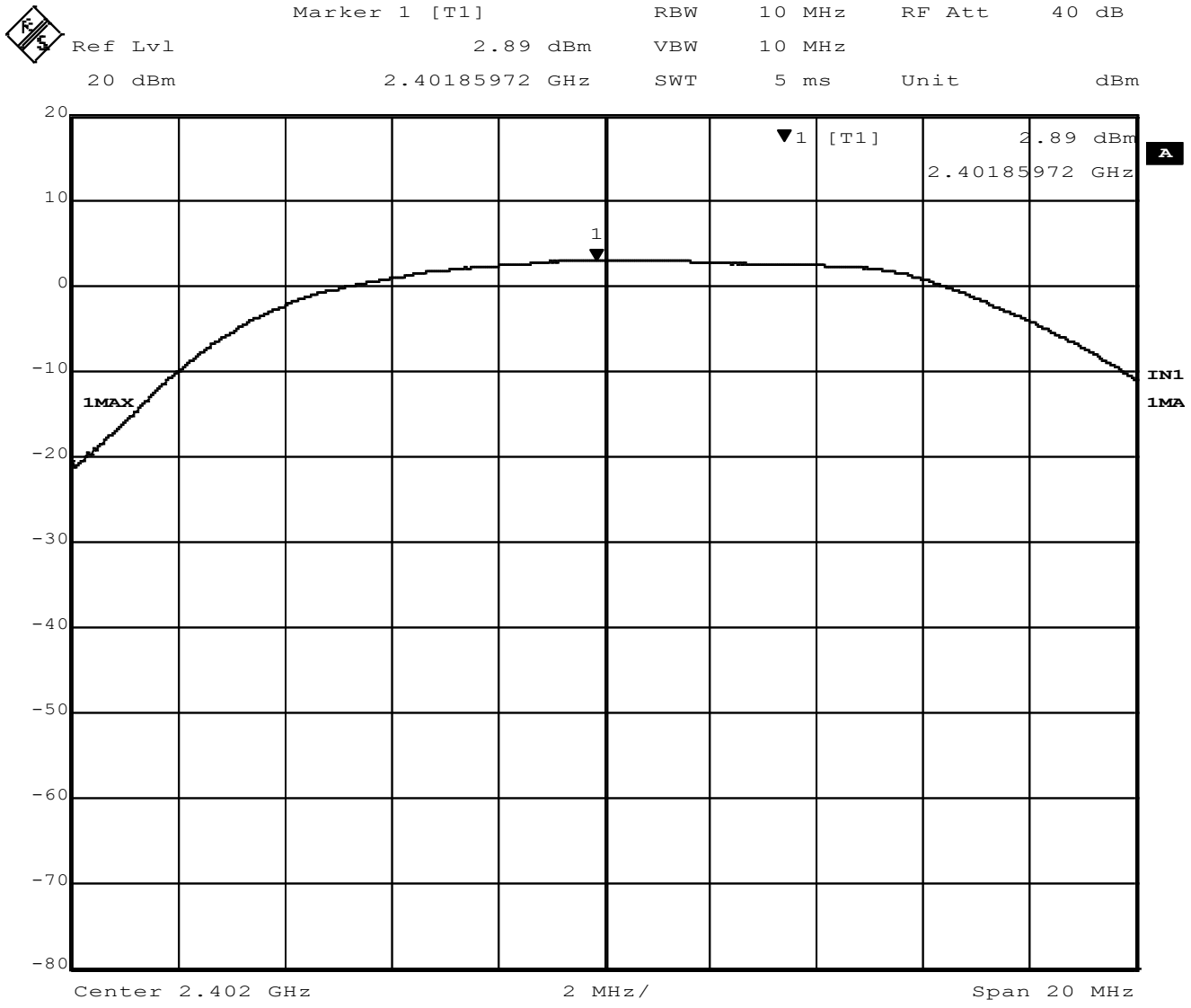

Figure 7 – Output Power, Low Channel, GMSK

Output power 2.89 dBm

Cable loss was less than 0.1 dB and not included

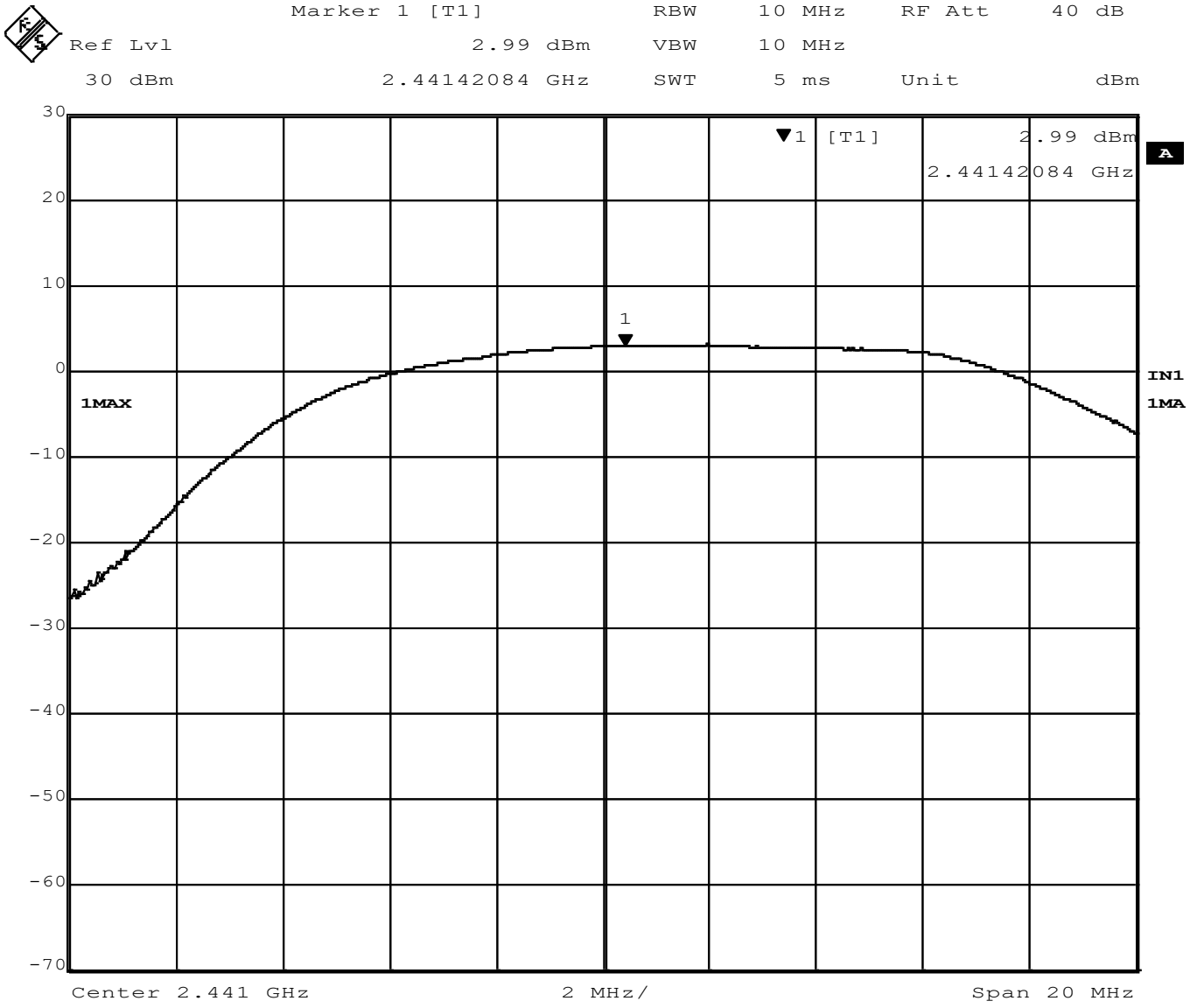

Figure 8 – Output Power, Mid Channel, GMSK

Output power = 2.99 dBm

Cable loss was less than 0.1 dB and not included

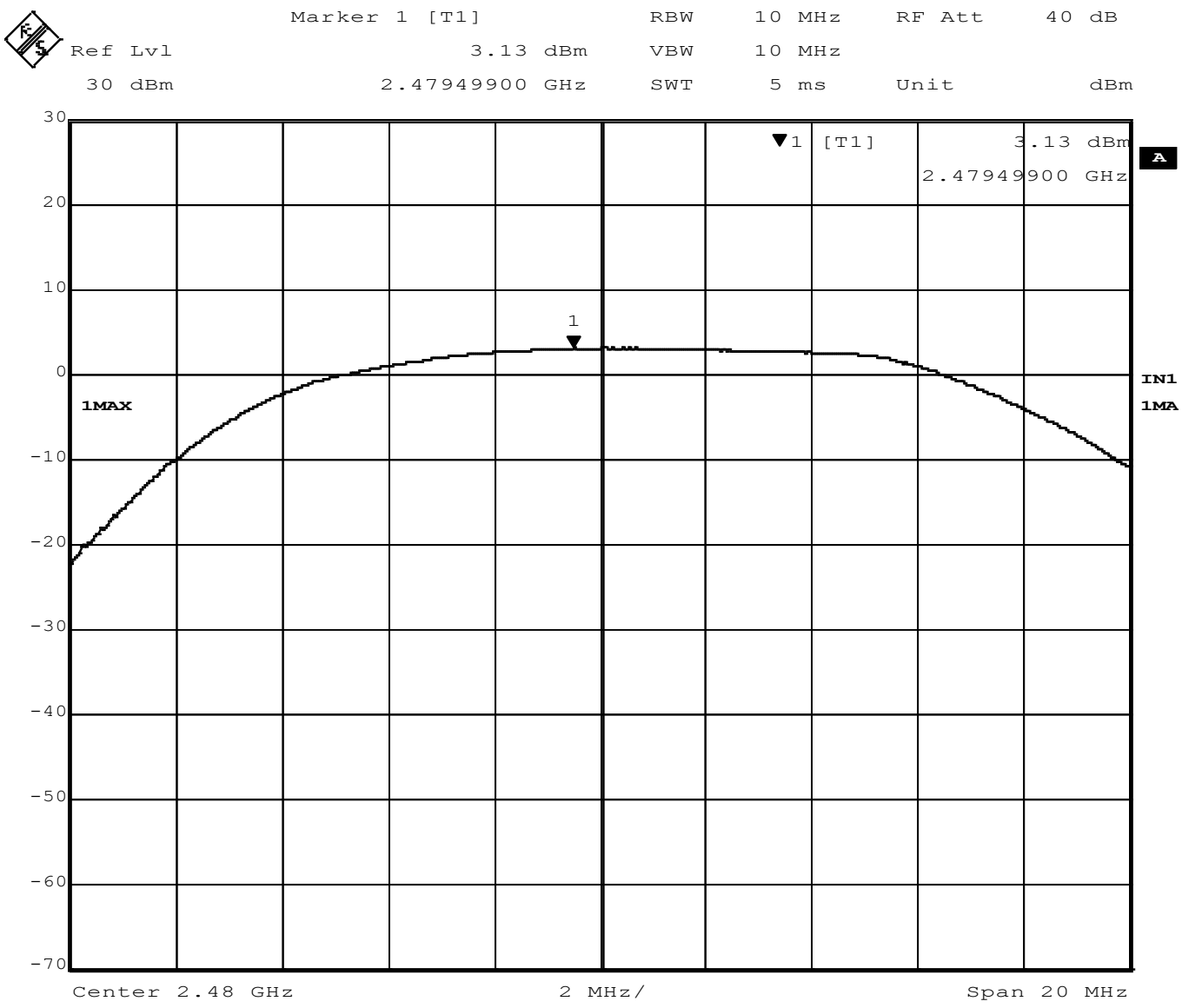

Figure 9 – Output Power, High Channel, GMSK

Output power = 3.13 dBm

Cable loss was less than 0.1 dB and not included

4.4 BANDWIDTH

Test Method: ANSI C63.10-2013, Section(s) 6.9.3, 11.8.1

Limits of bandwidth measurements:

For Informational Purposes only

Test procedures:
The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 300 kHz VBW. The occupied bandwidth was measured using the spectrum analyzers 99% occupied bandwidth setting.

Test setup:

See Section 4.3 for more details.

Deviations from test standard:
No deviation.

Test setup:

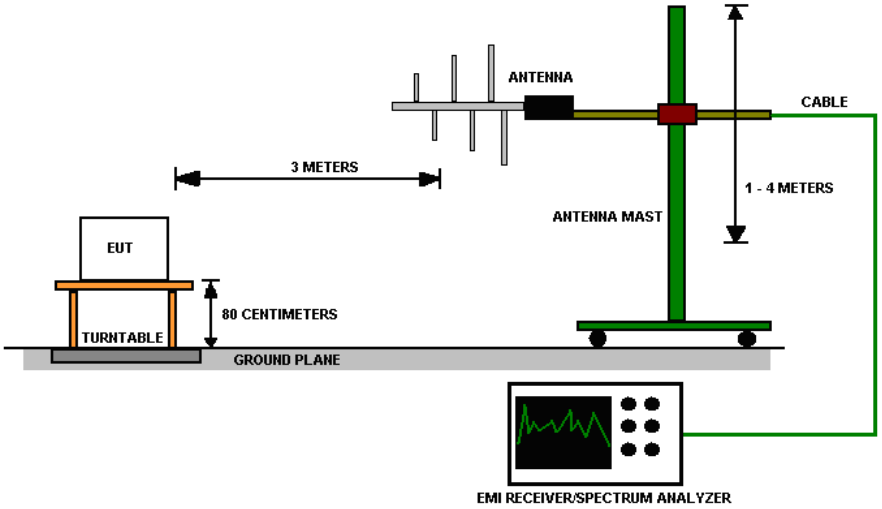

Figure 10 - Bandwidth Measurements Test Setup

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	N/A
Mid	GMSK	2442	1.11	N/A
High	GMSK	2480	1.11	N/A

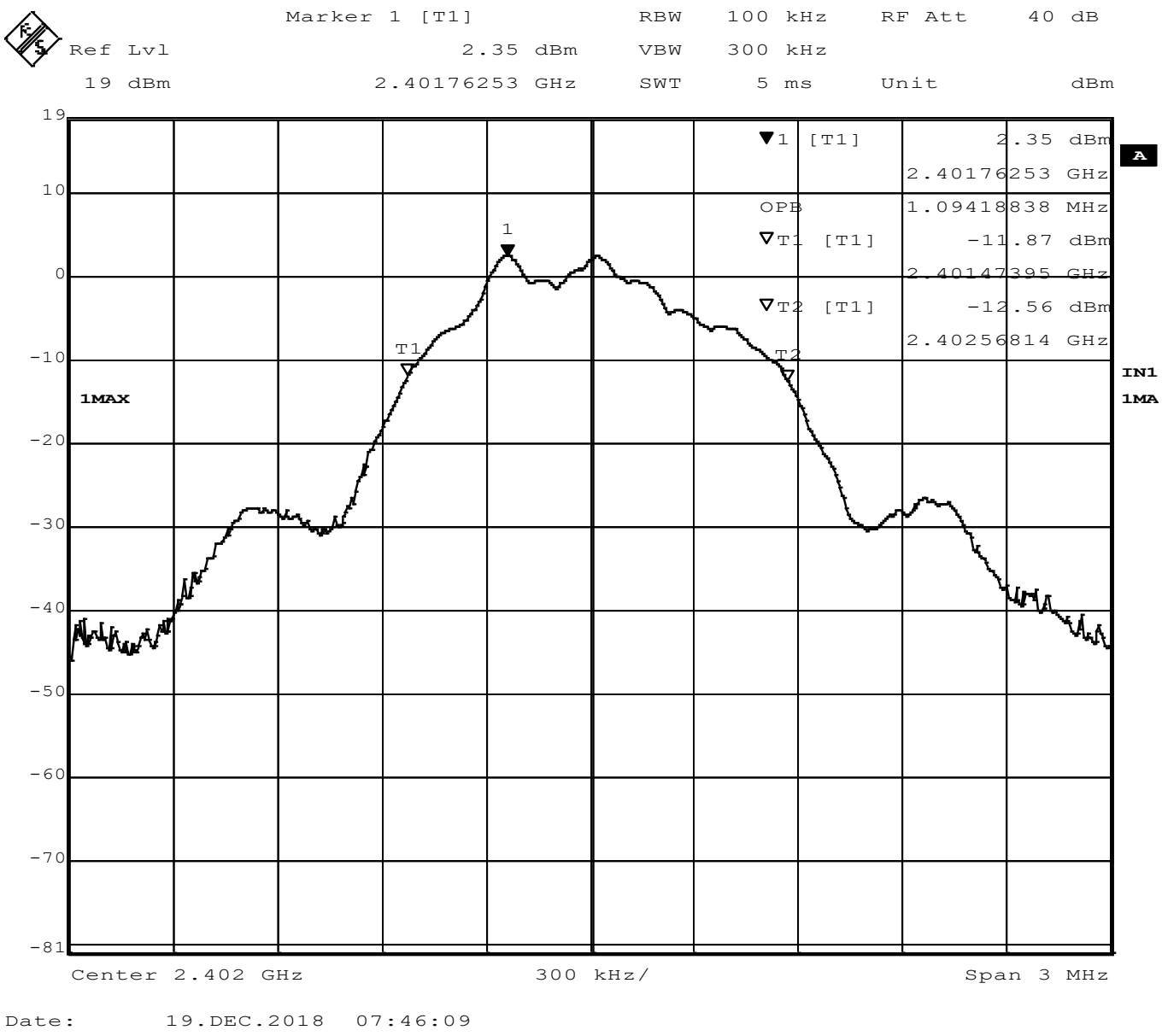

Figure 11 – Occupied Bandwidth, Low Channel, GMSK

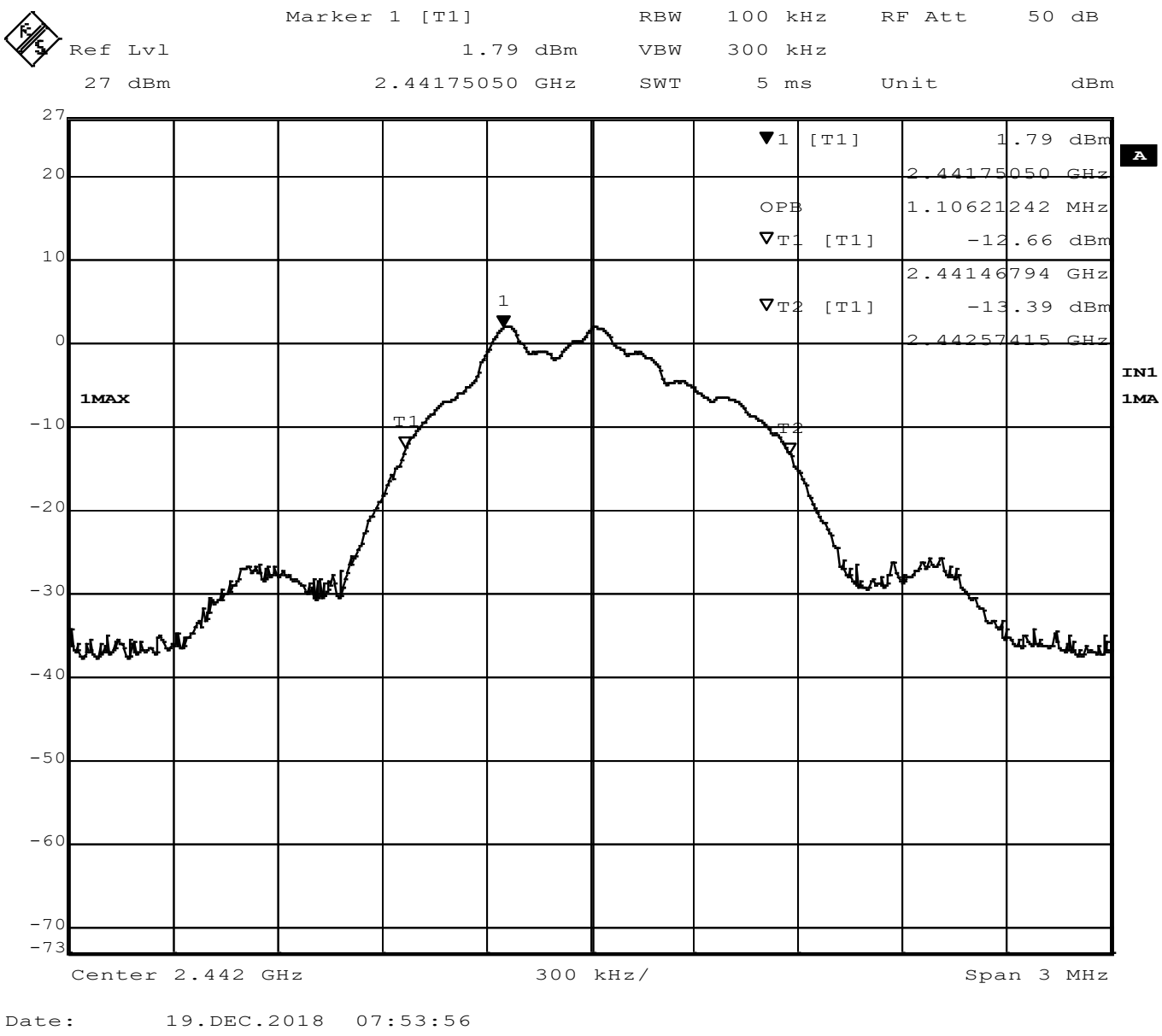

Figure 12 - Occupied Bandwidth, Mid Channel, GMSK

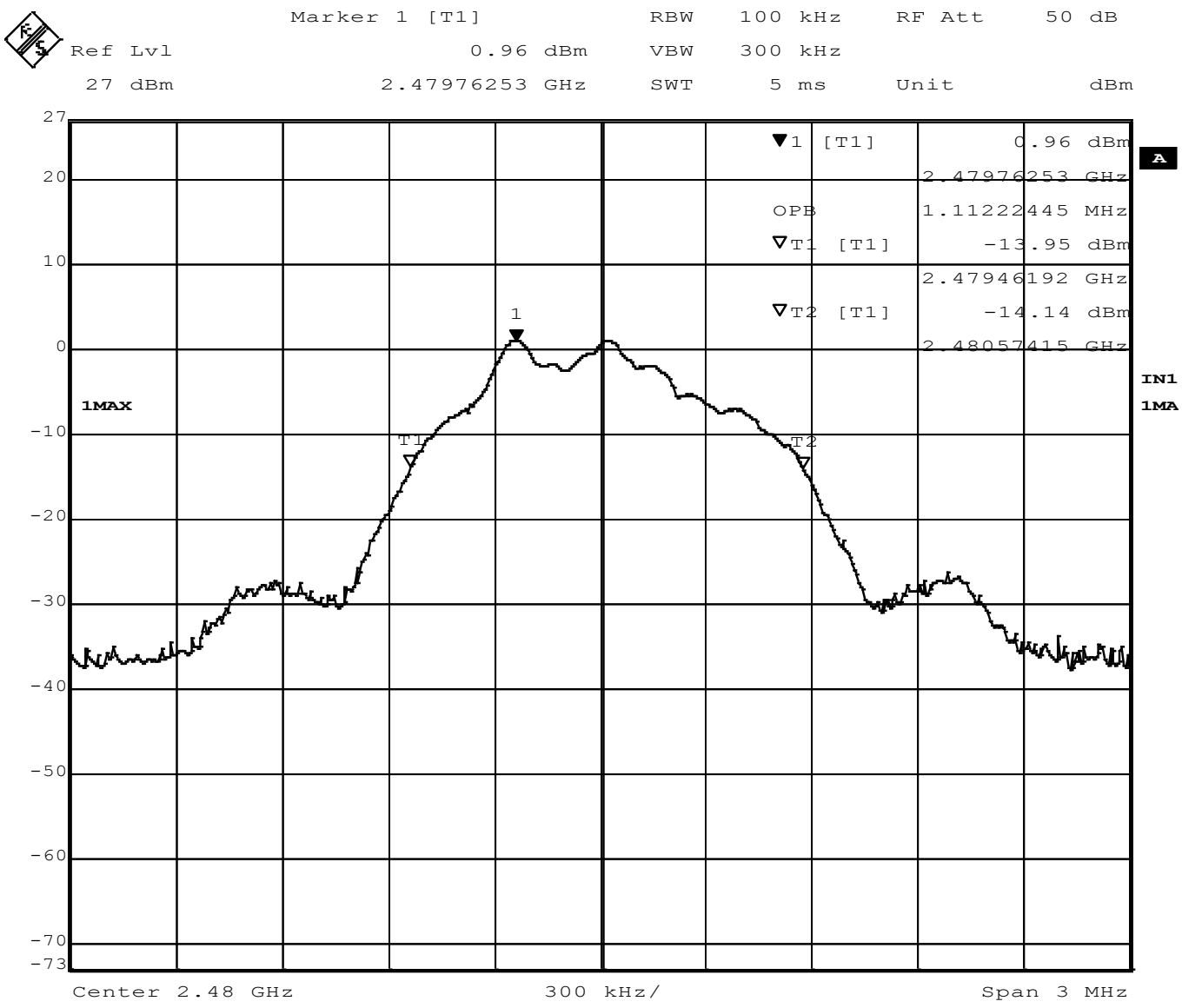

Figure 13 - Occupied Bandwidth, High Channel, GMSK

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 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 EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 100kHz 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:
See Section 4.3 for more details.

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.

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	2400.0	-36.86	2.15	39.01	37.41	PASS
High, Continuous	GMSK	2483.5	-65.77	-10.86	54.91	38.67	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 BLE = 91.41 dBµV/m
Fundamental peak field strength at High Channel BLE = 92.67 dBµV/m

Low Channel minimum delta BLE = 91.41 – 54.0 dBµV/m = 37.41 dBc
High Channel minimum delta BLE = 92.67 – 54.0 dBµV/m = 38.67 dBc

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

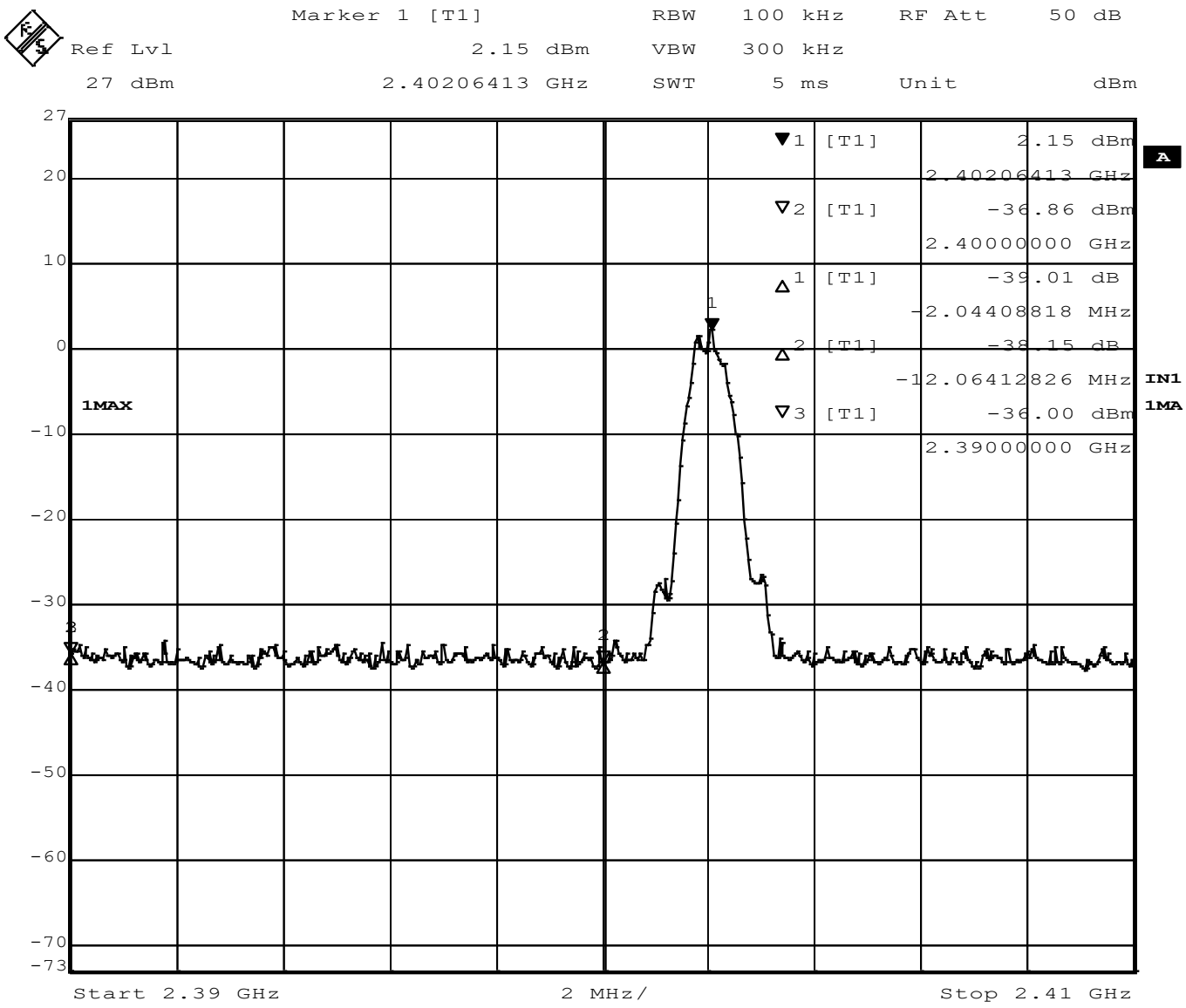

Figure 14 - Band Edge, Low Channel, GMSK

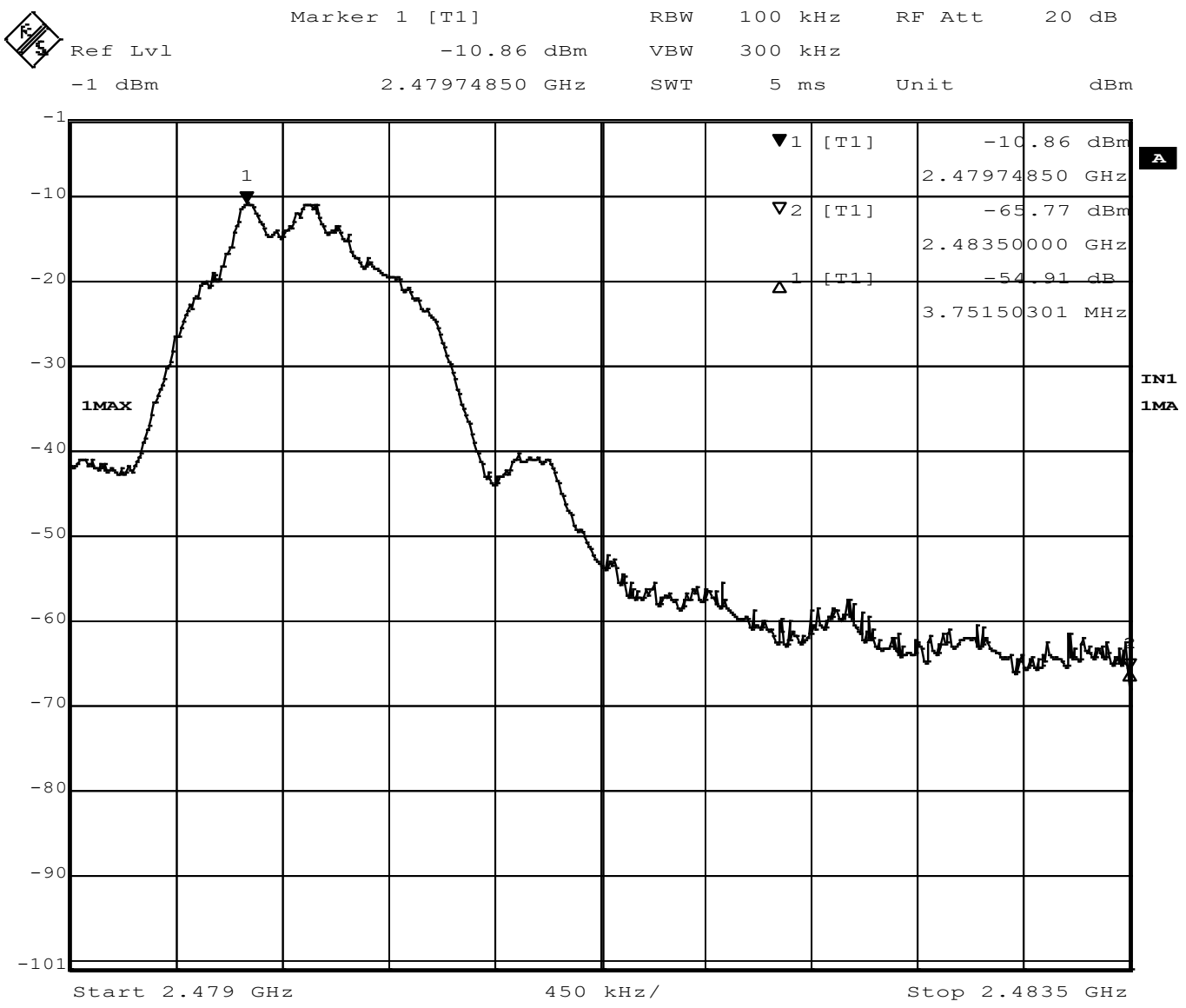

Figure 15 – Restricted Band Edge, High Channel, GMSK

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.

Test Results:

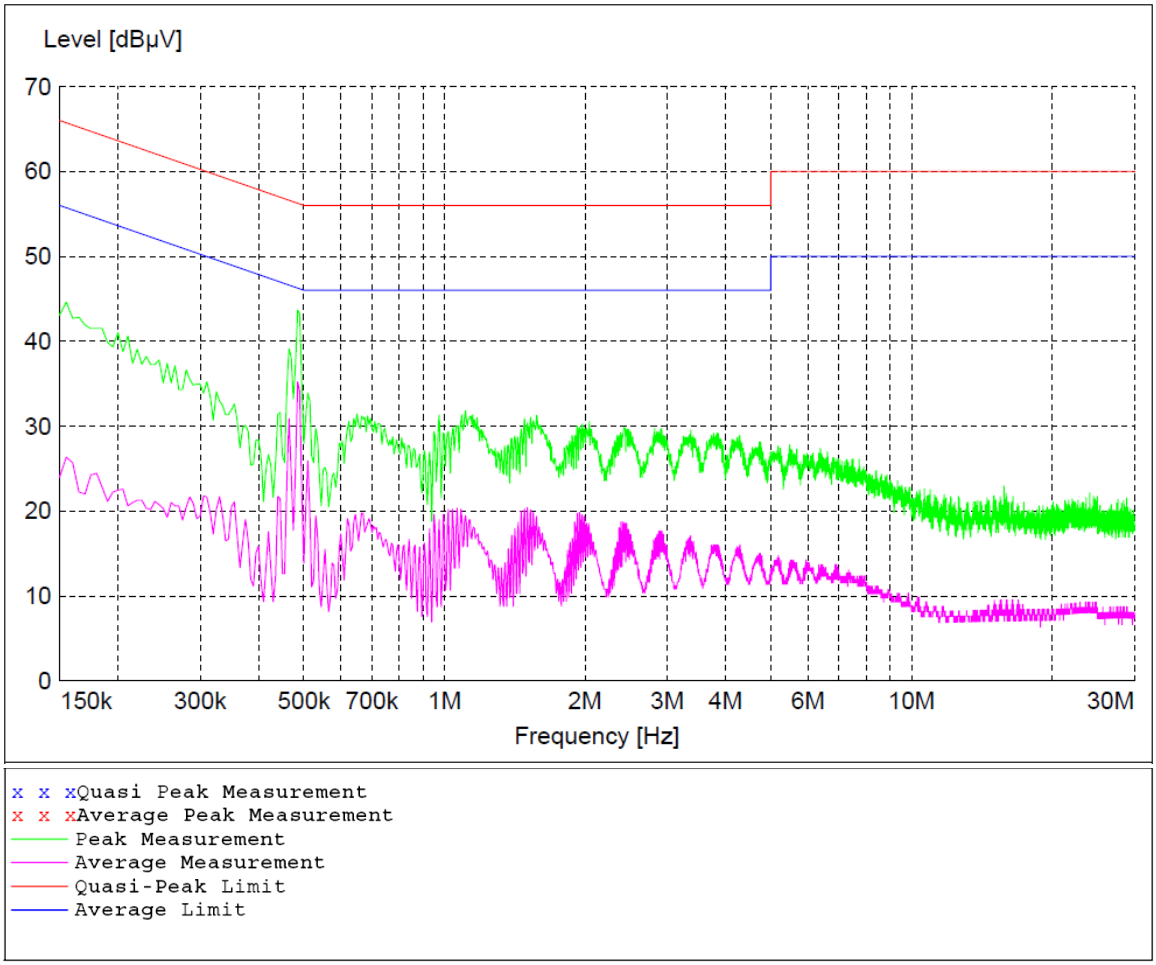

Figure 16 - Conducted Emissions Plot

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

The plot shows the composite maximum value of both the line and neutral conductors. It shows the worse-case at each frequency.

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