

FCC/ISED DTS Test Report (GMSK)

Prepared for: Garmin International Inc.

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

Product: A03525

Test Report No: R20181130-20-04B

Approved By:



Nic S. Johnson, NCE


Technical Manager

iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: 9 April 2019


Total Pages: 49

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:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

REVISION PAGE

Rev. No.	Date	Description
0	30 January 2019	Original – NJohnson Prepared by KVepuri/CFarrington
A	28 March 2019	Added average detector measurements to spurious emissions results Includes NCEE Labs test report R20181130-20-04 and its amendment in full -NJ
B	9 April 2019	Peak measurement at second harmonic in Table 9 was corrected. Original data was reviewed. Includes NCEE Labs test report R20181130-20-04A and its amendment in full -NJ

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

CONTENTS

Revision Page..... 2

Tables of Figures 4

Table of Tables..... 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 20

4.4 Bandwidth 25

4.5 Bandedges 33


4.6 Power Spectral Density 39

4.7 Conducted AC Mains Emissions 44

Appendix A: Sample Calculation 46

Appendix B – Measurement Uncertainty 48

REPORT END..... 49


	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

TABLES OF FIGURES

Figure Number	Page
Figure 1 - Radiated Emissions Test Setup.....	13
Figure 2 - Radiated Emissions Plot, Receive.....	14
Figure 3 - Radiated Emissions Plot, Low Channel.....	15
Figure 4 - Radiated Emissions Plot, Mid Channel.....	16
Figure 5 - Radiated Emissions Plot, High Channel.....	17
Figure 6 – Peak Output Power Measurements Test Setup	20
Figure 7 – Peak Output Power, Low Channel, GFSK.....	22
Figure 8 – Peak Output Power, Mid Channel, GFSK	23
Figure 9 – Peak Output Power, High Channel, GFSK.....	24
Figure 10 – Peak Output Power Measurements Test Setup	25
Figure 11 - 99% Occupied Bandwidth, Low Channel, GFSK	27
Figure 12 - 99% Occupied Bandwidth, Mid Channel, GFSK	28
Figure 13 - 99% Occupied Bandwidth, High Channel, GFSK	29
Figure 14 - 6dB Bandwidth, Low Channel, GFSK.....	30
Figure 15 - 6dB Bandwidth, Mid Channel, GFSK.....	31
Figure 16 - 6dB Bandwidth, High Channel, GFSK.....	32
Figure 17 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak.....	35
Figure 18 - Band-edge Measurement, Low Channel, Fundamental, Peak	36
Figure 19 - Band-edge Measurement, High Channel, Restricted Frequency, Peak.....	37
Figure 20 - Band-edge Measurement, High Channel, Fundamental, Peak	38
Figure 21 - Power Spectral Density, Low Channel	41
Figure 22 - Power Spectral Density, Mid Channel	42
Figure 23 - Power Spectral Density, High Channel.....	43
Figure 24 - Conducted Emissions Plot.....	45

TABLE OF TABLES

Table Number	Page
Table 1 - Radiated Emissions Quasi-peak and Peak Measurements, Receive	14
Table 2 - Radiated Emissions Quasi-peak Measurements, Low Channel	15
Table 3 - Radiated Emissions Quasi-peak Measurements, Mid Channel	16
Table 4 - Radiated Emissions Quasi-peak Measurements, High Channel	17
Table 5 - Radiated Emissions Peak Detector Measurements, Low Channel	18
Table 6 - Radiated Emissions Average Detector Measurements, Low Channel.....	18
Table 7 - Radiated Emissions Peak Detector Measurements, Middle Channel	18
Table 8 - Radiated Emissions Average Detector Measurements, Middle Channel	18
Table 9 - Radiated Emissions Peak Detector Measurements, High Channel.....	19
Table 10 - Radiated Emissions Average Detector Measurements, High Channel.....	19


	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

1.0 SUMMARY OF TEST RESULTS

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

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

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

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		


2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a portable transceiver. This report covers GMSK modulation certified under FCC Part 15.247 and ISSED RSS-247 as a DTS device.

Model	A03525
EUT Received	20 December 2018
EUT Tested	20 December 2018 - 30 January 2019
Serial No.	NCEETEST1 (assigned)
Operating Band	2400.0 - 2483.5 GHz
Device Type	Bluetooth Classic GFSK
Antenna	Trace Antenna
Power Supply	Internal Battery/ Charger: Garmin (Phi Hong) MN: PSAI10R-050Q

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

	Report Number:	R20181130-20-04	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 (Channel 1)	2402
Middle (Channel 6)	2440
High (Channel 11)	2480

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, highest and one channel in the middle.

2.3 DESCRIPTION OF SUPPORT UNITS

NA

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

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


All testing was performed by Karthik Vepuri of NCEE Labs. The results were reviewed by Nic Johnson.

	Report Number:	R20181130-20-04	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*
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*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	26 Jul 2018	26 Jul 2019

*Internal Characterization

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		


4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Test Method: NA

Maximum duty cycle declared by the manufacturer = 75 ms per 100 ms window

Duty cycle correction factor = $20 \cdot \log((75)/100) = -2.50$ dB

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10:2013:

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

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH ($\mu\text{V}/\text{m}$)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3


Note about requirement from FCC Part 15.247(d) and RSS-247, Section 5.5:

In addition to the limits shown above, all emissions were also required to be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. All measurements were performed with a 1 MHz bandwidth, but the bandwidth conversion from 1 MHz to 100 kHz would be equally applied to the highest emission and the spurious emissions, so it would not effect the delta measurement.

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


NOTE:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level ($\mu\text{V}/\text{m}$).
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:	R20181130-20-04	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 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.

	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		

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:

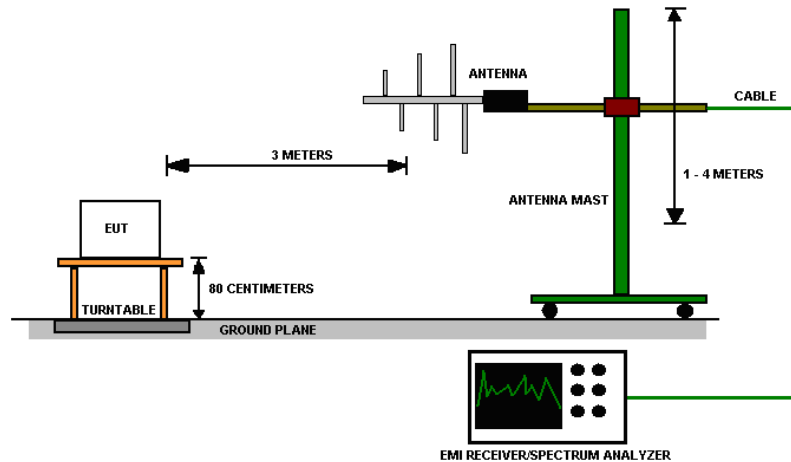


Figure 1 - Radiated Emissions Test Setup

EUT operating conditions

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



Report Number: R20181130-20-04

Rev

B

Prepared for: Garmin

Test results:

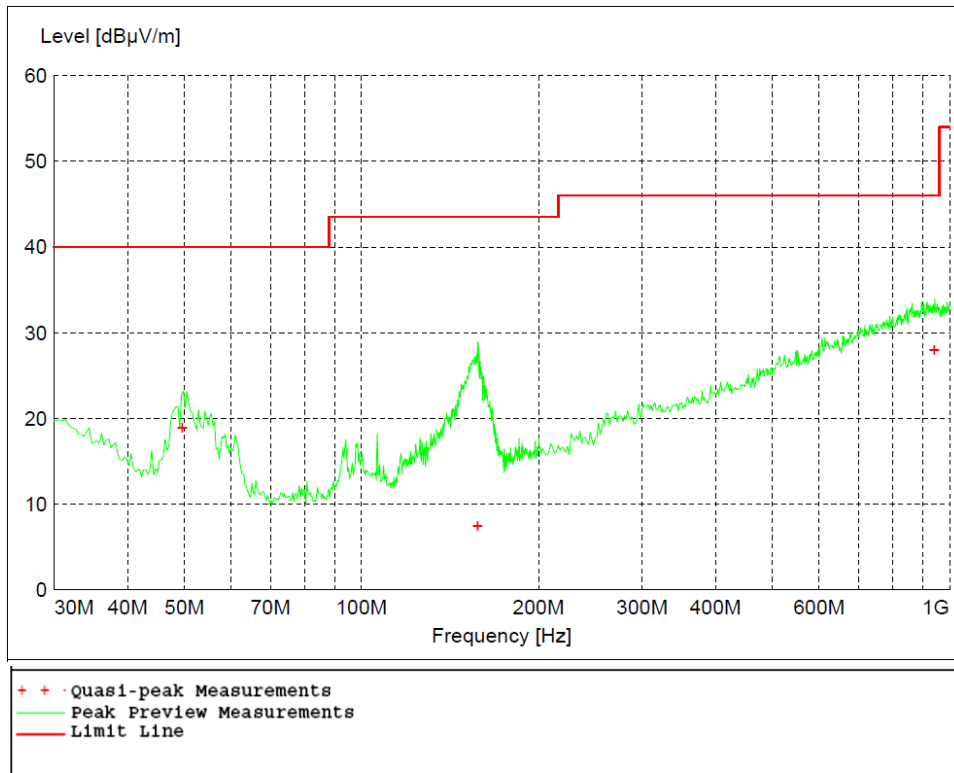


Figure 2 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak and Peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
49.560000	18.98	40.00	21.00	100	236	VERT
157.560000	7.50	43.50	36.00	354	318	HORI
942.420000	28.00	46.00	18.00	100	310	VERT

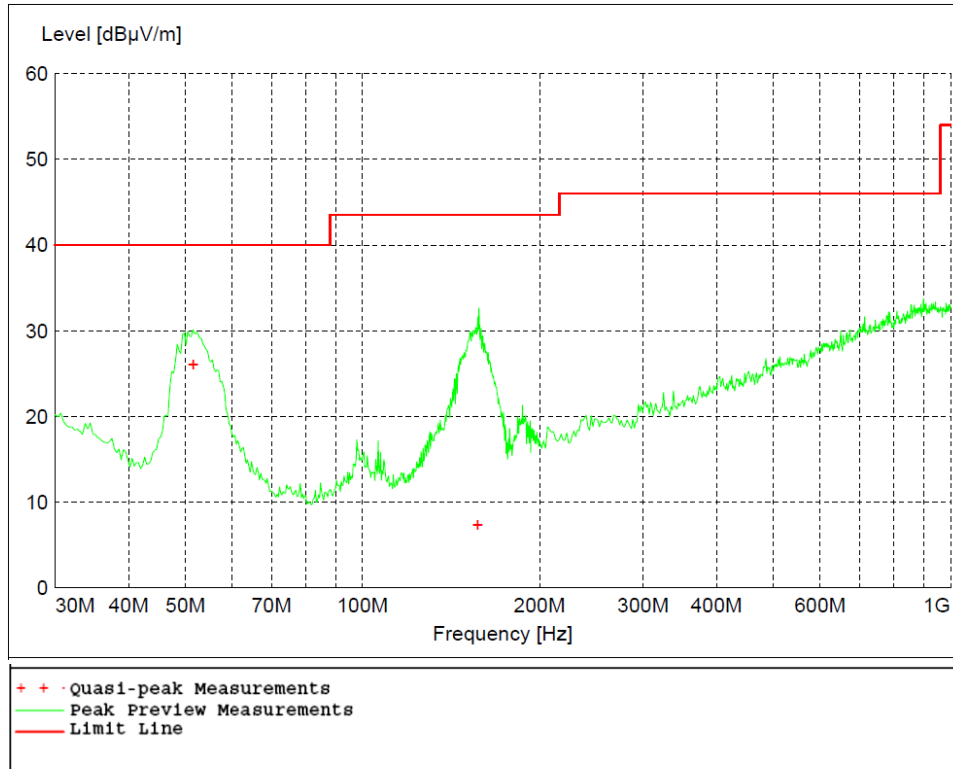


Figure 3 - Radiated Emissions Plot, Low Channel

Table 2 - Radiated Emissions Quasi-peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
51.600000	26.04	40.00	14.00	100	255	VERT
157.080000	7.42	43.50	36.10	377	360	HORI

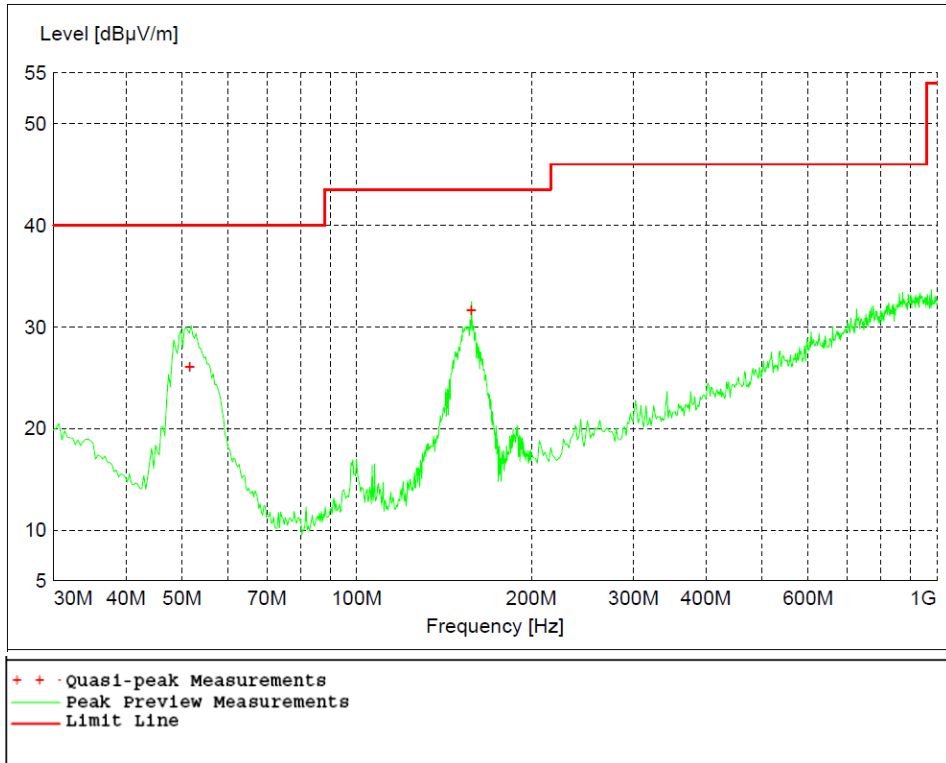



Figure 4 - Radiated Emissions Plot, Mid Channel

Table 3 - Radiated Emissions Quasi-peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
51.540000	26.09	40.00	13.90	98	313	VERT
157.680000	31.66	43.50	11.90	217	353	HORI

	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		

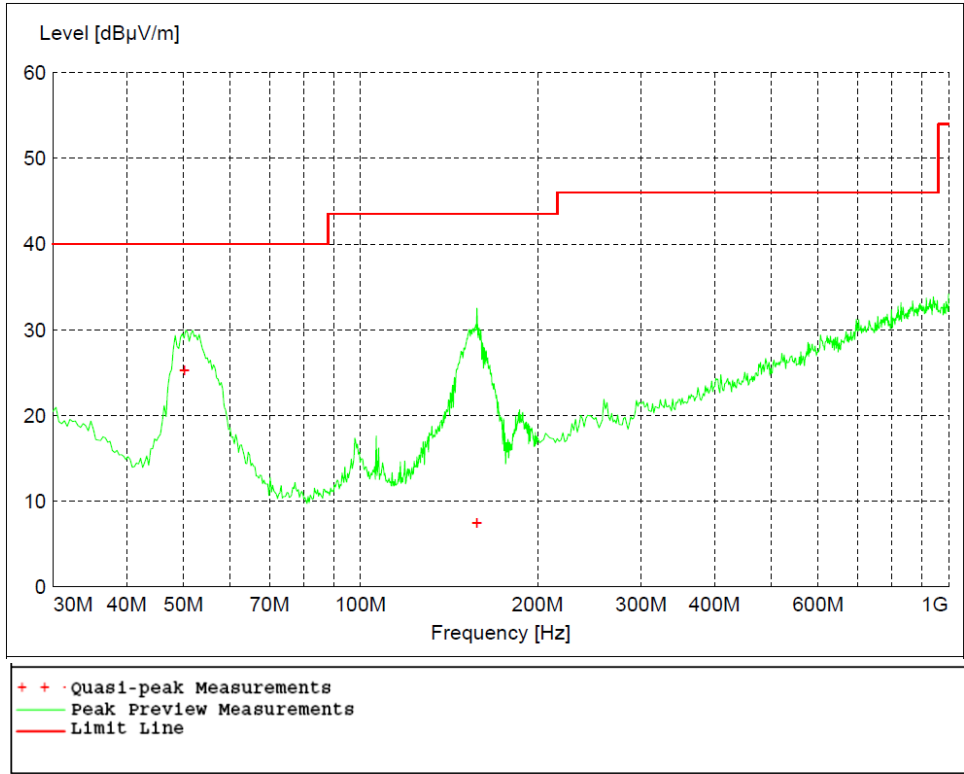


Figure 5 - Radiated Emissions Plot, High Channel

Table 4 - Radiated Emissions Quasi-peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
50.220000	25.28	40.00	14.70	100	299	VERT
157.800000	7.50	43.50	36.00	399	18	HORI


	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		

Table 5 - Radiated Emissions Peak Detector Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.	
2402.000000	104.02	N/A	N/A	129	194	HORI
4804.400000*	67.49	74.00	6.51	157	142	VERT
7205.400000	60.08	74.00	13.92	167	126	VERT
9607.400000	60.78	74.00	13.22	167	233	HORI

Table 6 - Radiated Emissions Average Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.	
2402.000000	101.52	N/A	N/A	129	194	HORI
4804.400000*	51.81	54.00	2.19	157	142	VERT
7205.400000*	42.17	54.00	11.83	167	126	VERT
9607.400000*	47.27	54.00	6.73	167	233	HORI

All measurements are calculated by applying the 2.5 dB duty cycle correction factor to the peak measurements. *In these cases, the duty cycle correction was added to measurements performed with an average detector.

Table 7 - Radiated Emissions Peak Measurements, Middle Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.	
2440.000000	106.21	N/A	N/A	231	185	HORI
4879.600000	61.57	74.00	12.43	140	198	VERT
7319.400000	46.63	74.00	27.37	101	120	VERT

Table 8 - Radiated Emissions Average Measurements, Middle Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.	
2440.000000	103.71	N/A	N/A	231	185	HORI
4879.600000*	51.73	54.00	2.27	140	198	VERT
7319.400000	44.13	54.00	9.87	101	120	VERT

All measurements are calculated by applying the 2.5 dB duty cycle correction factor to the peak measurements. *In these cases, the duty cycle correction was added to measurements performed with an average detector.


	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

Table 9 - Radiated Emissions Peak Detector Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.	
2480.000000	104.14	N/A	N/A	220	184	HORI
4959.600000	60.10	74.00	23.83	127	17	VERT
7439.400000	47.23	74.00	26.77	142	130	VERT
9919.200000	52.43	74.00	21.57	115	234	HORI


Table 10 - Radiated Emissions Average Detector Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.	
2480.000000	101.64	N/A	N/A	220	184	HORI
4959.600000	51.10	54.00	2.19	127	17	VERT
7439.400000	44.73	54.00	9.27	142	130	VERT
9919.200000	49.93	54.00	4.07	115	234	HORI

All measurements are calculated by applying the 2.5 dB duty cycle correction factor to the peak measurements. *In these cases, the duty cycle correction was added to measurements performed with an average detector.

REMARKS:

1. Emission level (dB μ V/m) = Raw Value (dB μ V) + 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.
5. All 3 possible 802.11 modes were tested. The highest of each is presented in the tables.

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

4.3 PEAK OUTPUT POWER

Test Method: ANSI C63.10:

1. Section(s) 11.9.2.3 “Measurement using a power meter (PM)”

Limits of power measurements:

The maximum allowed peak output power is 30 dBm.

Test procedures:

The EUT was connected to an RF power meter directly with a low-loss shielded coaxial cable with 10 MHz RBW and 10 MHz VBW. The intention was to verify that the measurement results were the same as the original filing for this device within the measurement uncertainty of the laboratory.

Deviations from test standard:

No deviation.

Test setup:

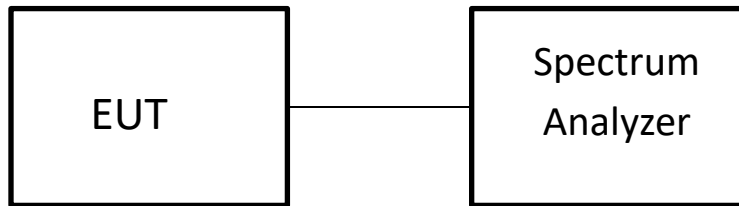



Figure 6 – Peak Output Power Measurements Test Setup

EUT operating conditions:

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


Test results:

The uncertainty for conducted peak power measurements is ± 1.1 dB and average power is ± 1.37 dB

	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm) MU = ±1.1 dB	Method	RESULT
Low	2402	14.72	Conducted	PASS
Middle	2440	13.15	Conducted	PASS
High	2480	12.35	Conducted	PASS

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

4.4 BANDWIDTH

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

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

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

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

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

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

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

Deviations from test standard:
No deviation

Test setup:

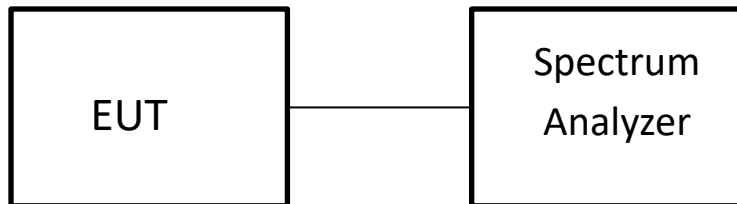



Figure 10 – Peak Output Power Measurements Test Setup

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

EUT operating conditions:

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

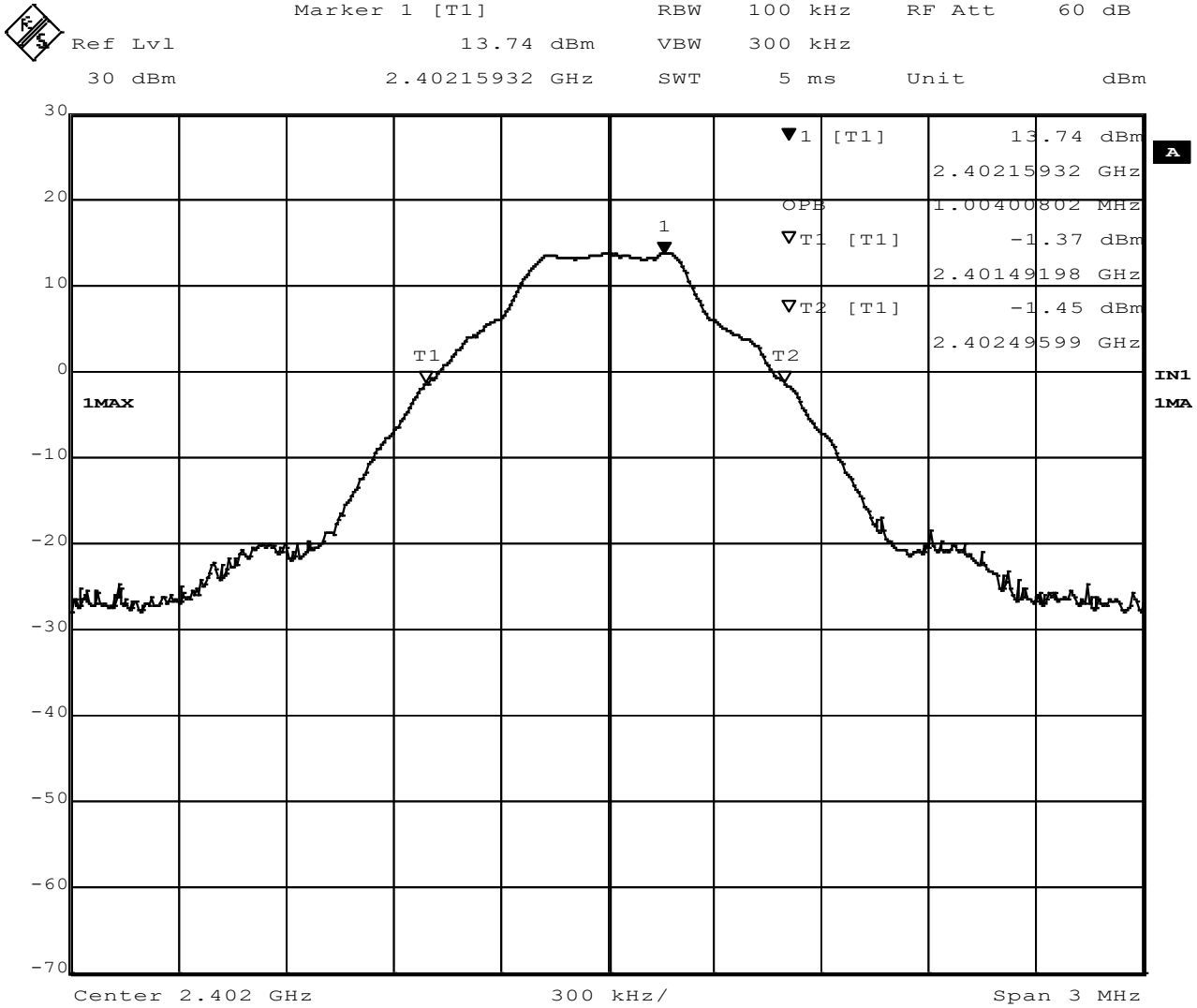
Test results:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (MHz)
Low	2402	1.00
Middle	2440	1.13
High	2480	0.99


6dB Bandwidth

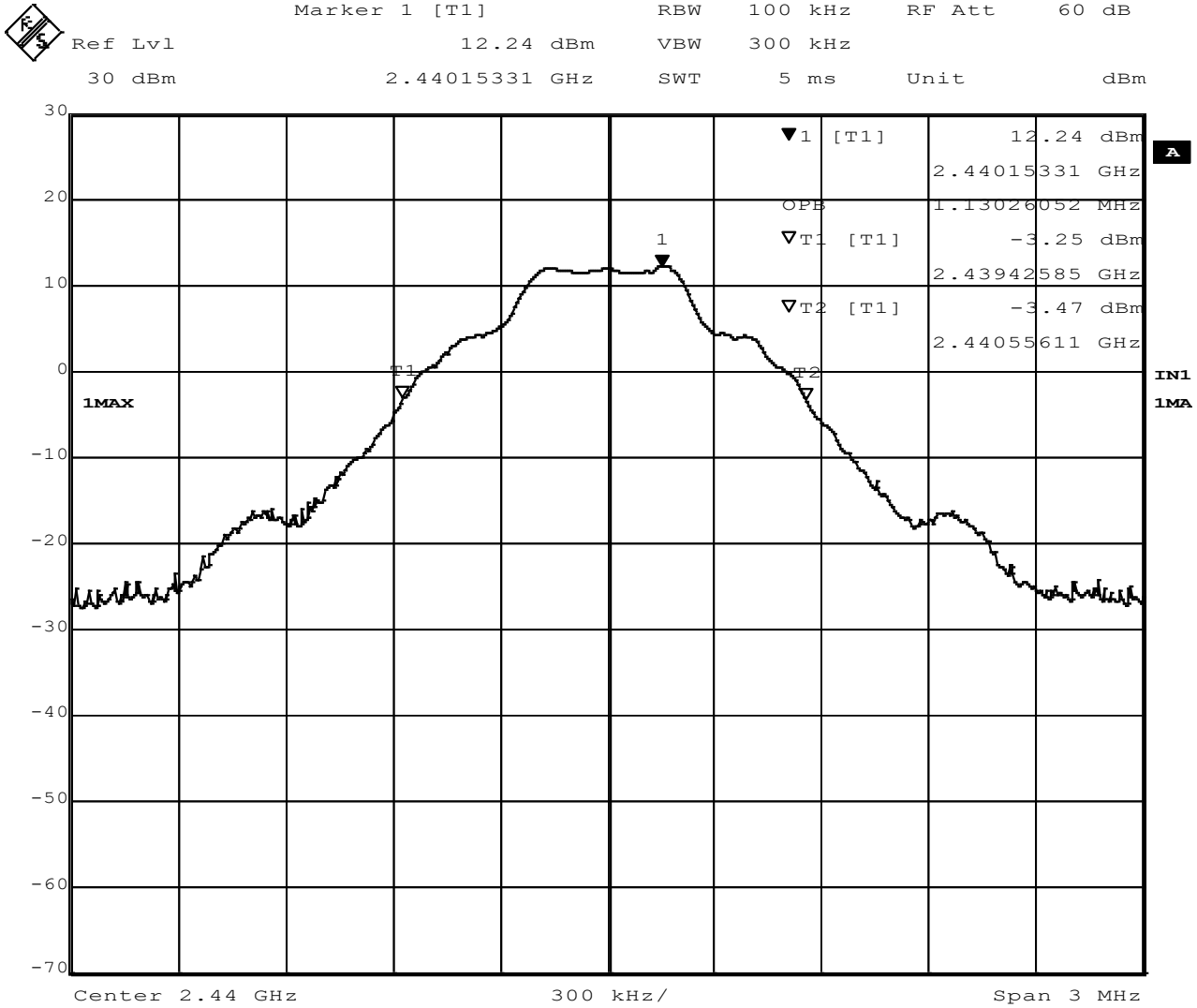
CHANNEL	CHANNEL FREQUENCY (MHz)	6 dB BW (kHz)
Low	2402	547.1
Middle	2440	541.1
High	2480	541.1



Date: 8.JAN.2019 10:19:48

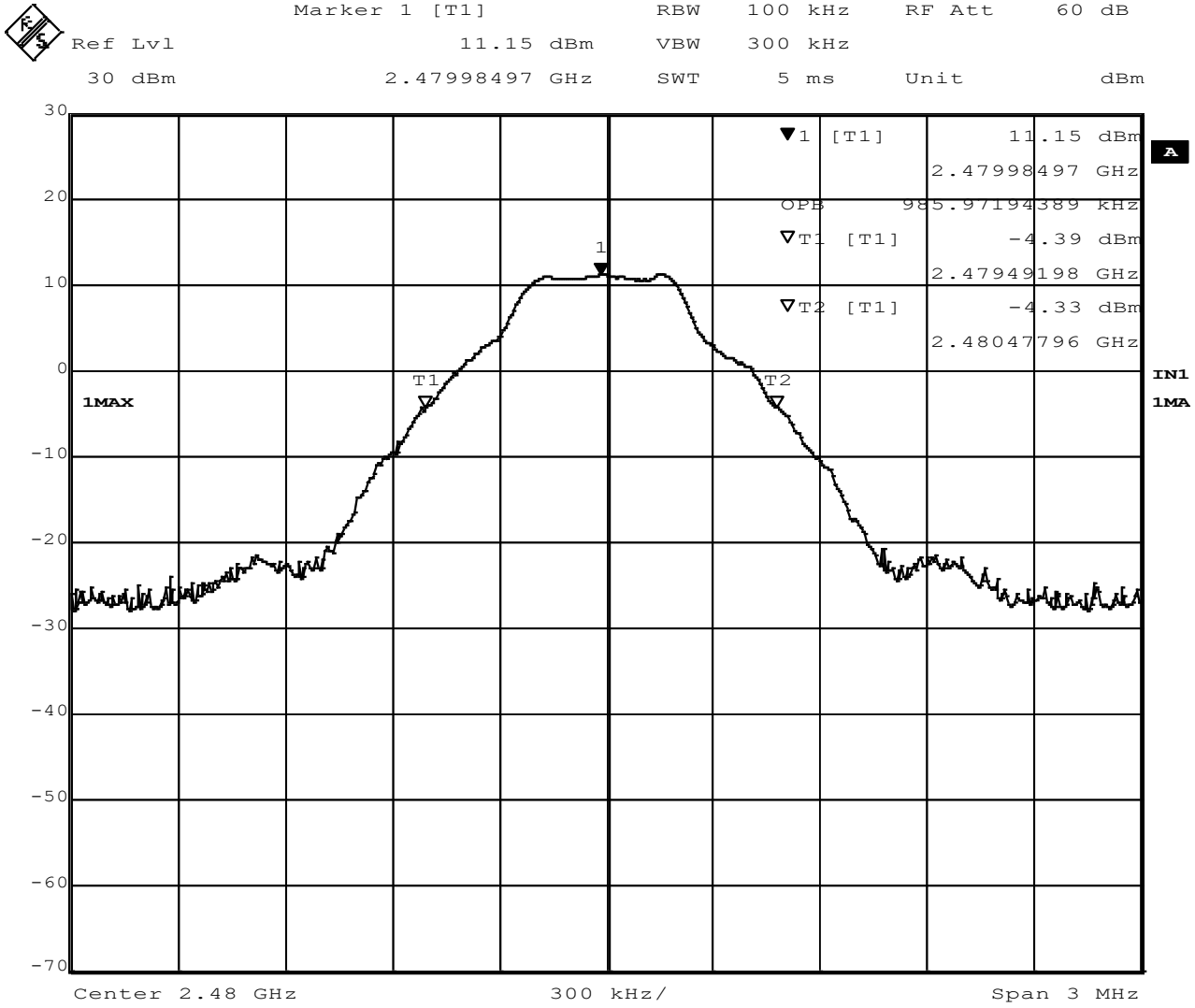
Figure 11 - 99% Occupied Bandwidth, Low Channel, GFSK

	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		




Date: 8.JAN.2019 10:49:06

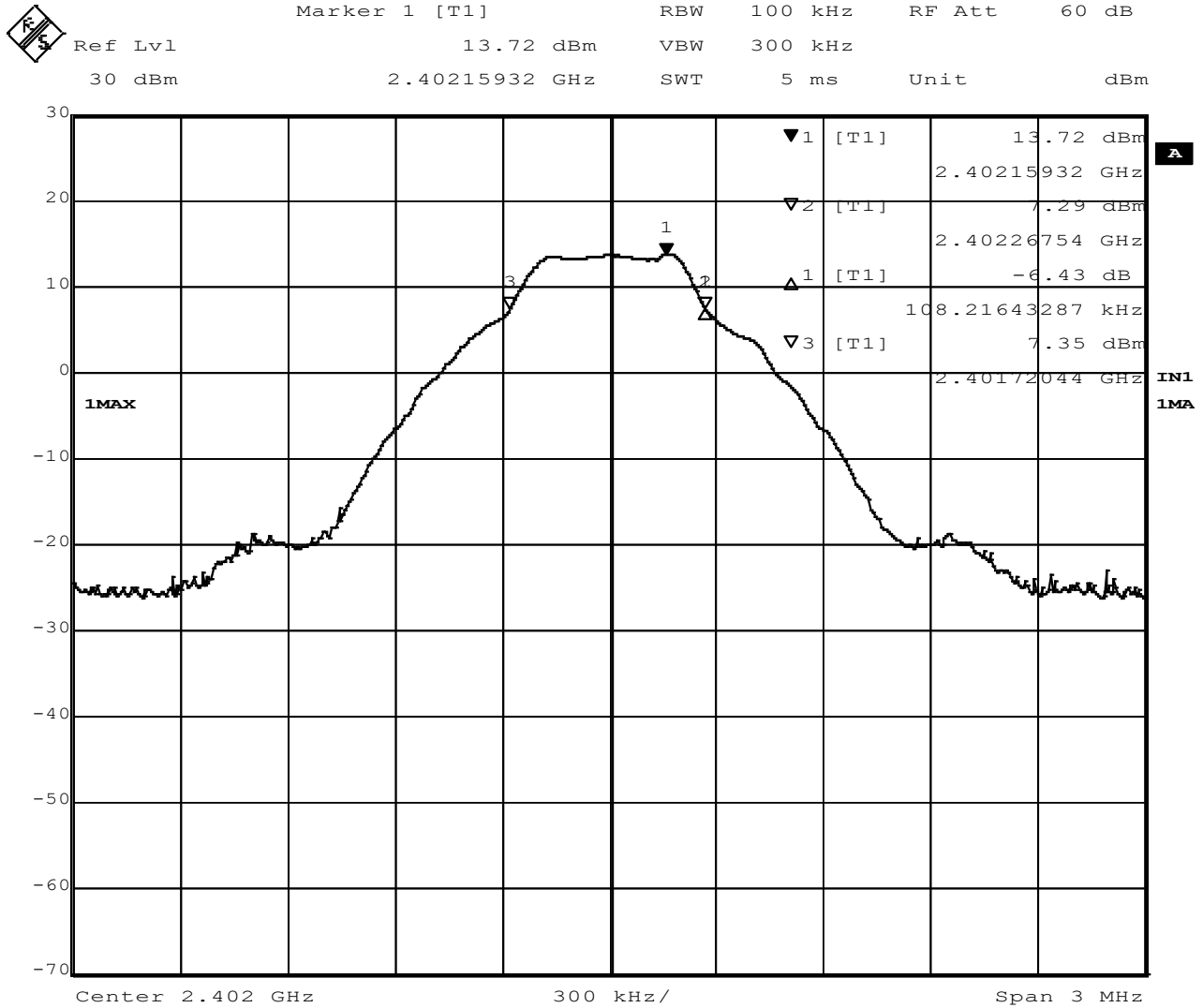
Figure 12 - 99% Occupied Bandwidth, Mid Channel, GFSK



Date: 8.JAN.2019 10:54:06

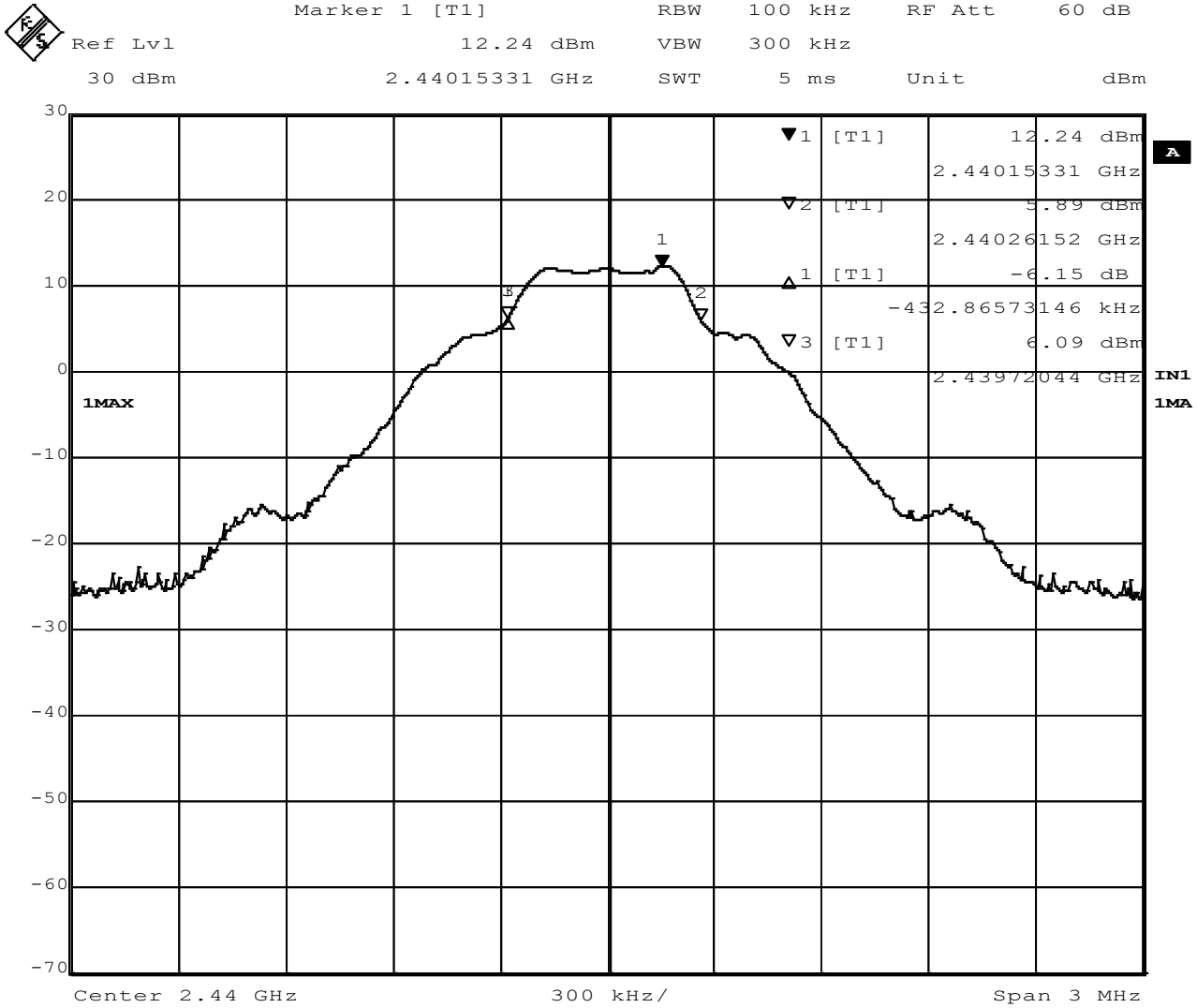
Figure 13 - 99% Occupied Bandwidth, High Channel, GFSK

	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		



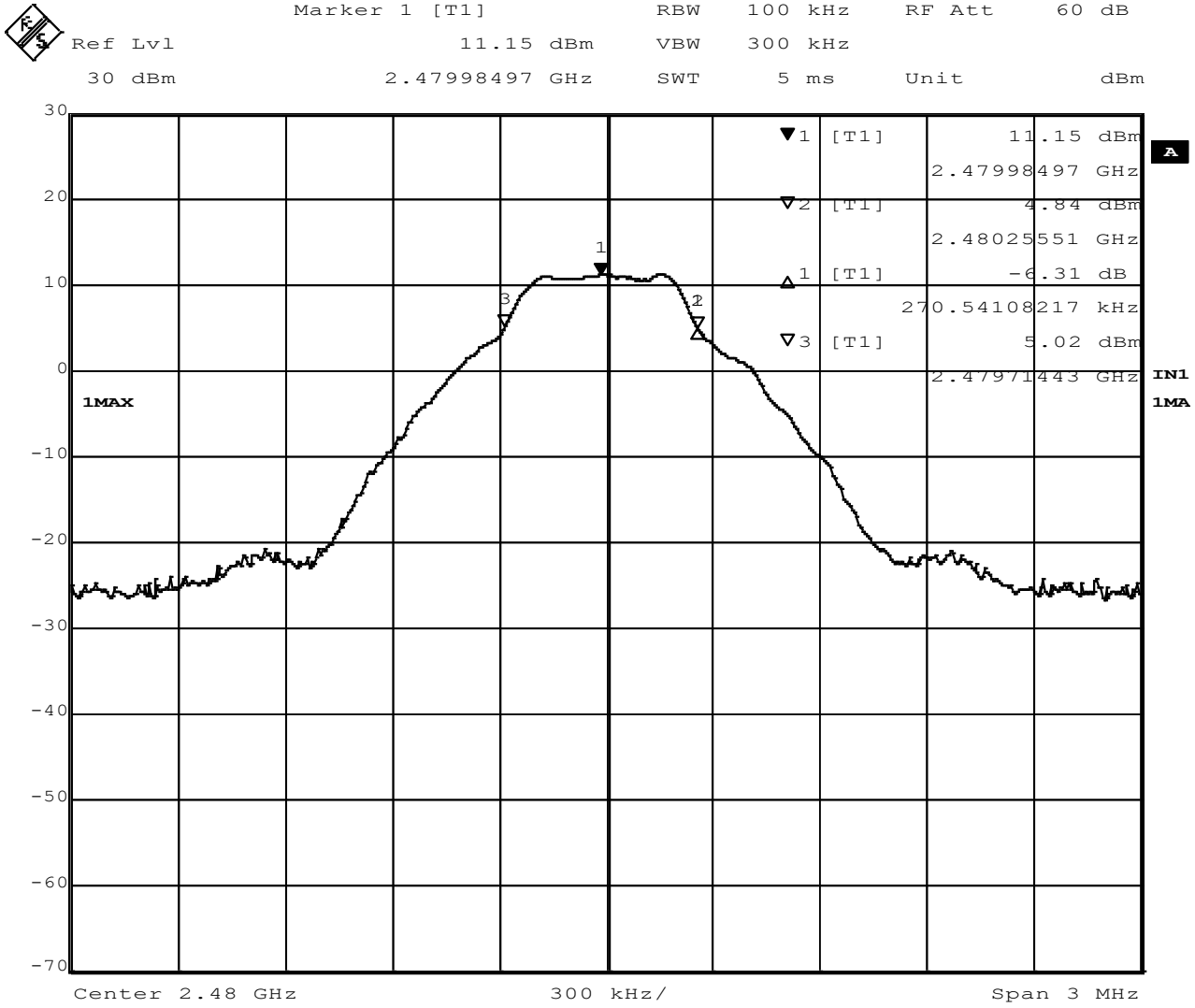
Date: 8.JAN.2019 10:22:08

Figure 14 - 6dB Bandwidth, Low Channel, GFSK




Date: 8.JAN.2019 10:50:09

Figure 15 - 6dB Bandwidth, Mid Channel, GFSK



Date: 8.JAN.2019 10:55:24

Figure 16 - 6dB Bandwidth, High Channel, GFSK

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

4.5 BANDEDGES

Test Method: ANSI C63.10:

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

Limits of bandedge measurements:

For emissions outside of the allowed band of operation (2400.0MHz – 2480.0MHz), the emission level needs to be 20dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

Test procedures:

The EUT was tested in the same method as described in section 4.4 - *Bandwidth*. The resolution bandwidth was set to 100kHz and video bandwidth to 300 kHz 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

EUT operating conditions:

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

	Report Number:	R20181130-20-04	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 (restricted)	GFSK	2390	-43.37	13.71	57.08	32.30	PASS
High, Continuous (restricted)	GFSK	2483.5	-42.46	11.05	53.51	32.42	PASS
Low, Continuous (unrestricted)	GFSK	2400	-25.97	13.71	39.68	20.00	PASS
High, Continuous (unrestricted)	GFSK	2483.5	-27.12	11.05	38.17	20.00	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 = 86.30 dB μ V/m
Fundamental peak field strength at High Channel GFSK = 86.42 dB μ V/m

Low Channel minimum delta GFSK = 86.30 – 54.0 dB μ V/m = 32.30 dBc
High Channel minimum delta GFSK = 86.42 – 54.0 dB μ V/m = 32.42 dBc

	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		

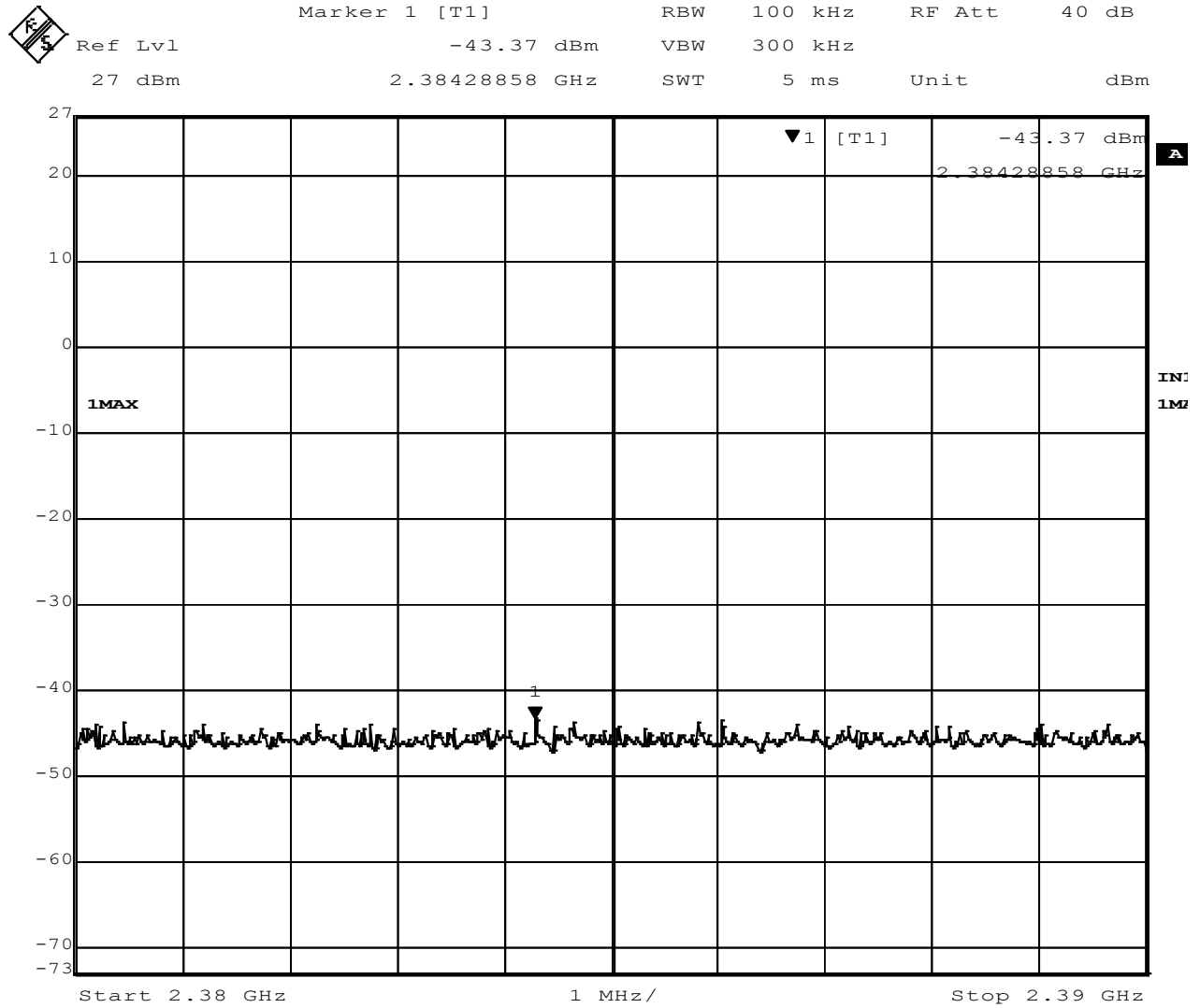

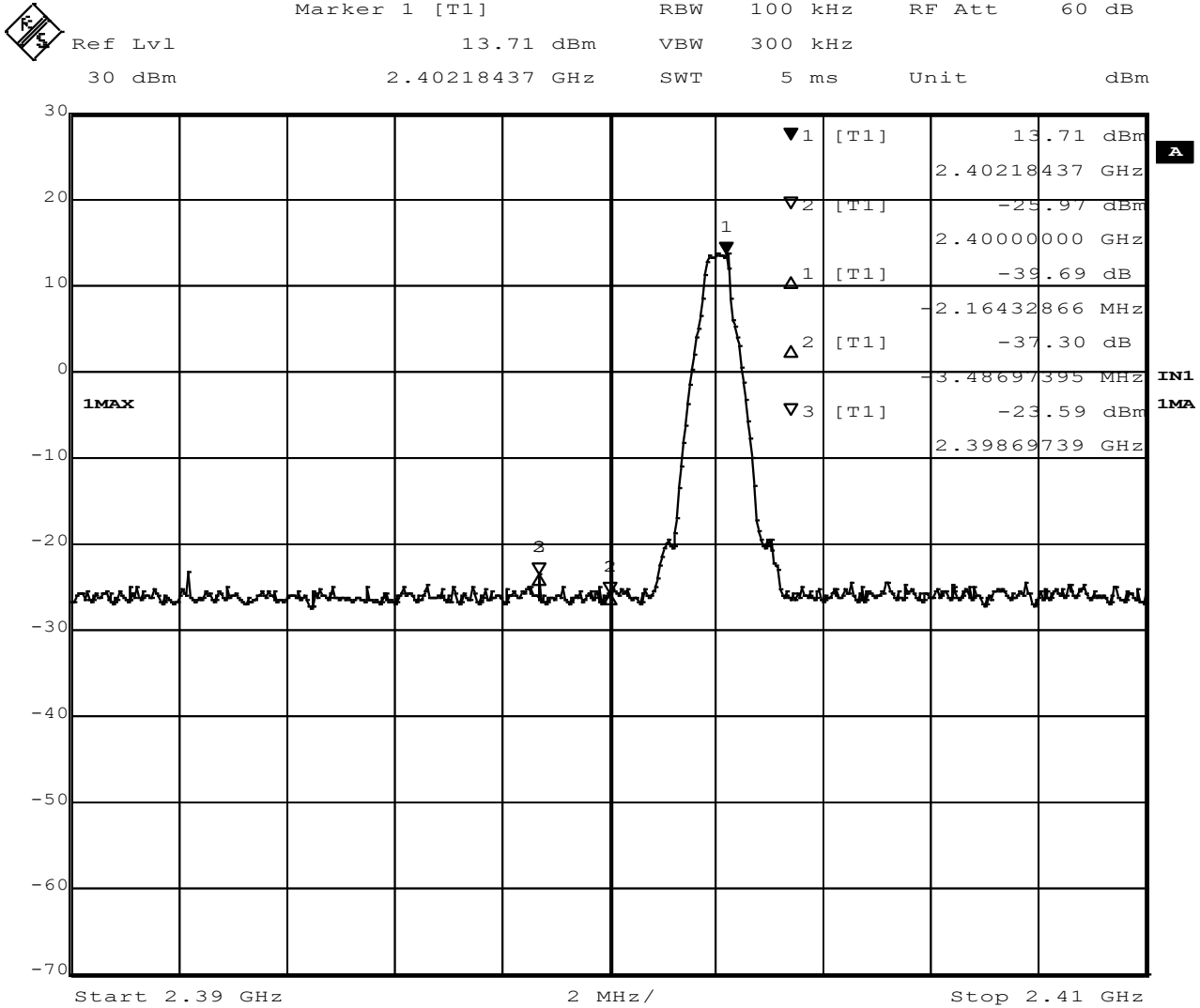



Figure 17 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		



Date: 8.JAN.2019 10:23:45

Figure 18 - Band-edge Measurement, Low Channel, Fundamental, Peak

	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		

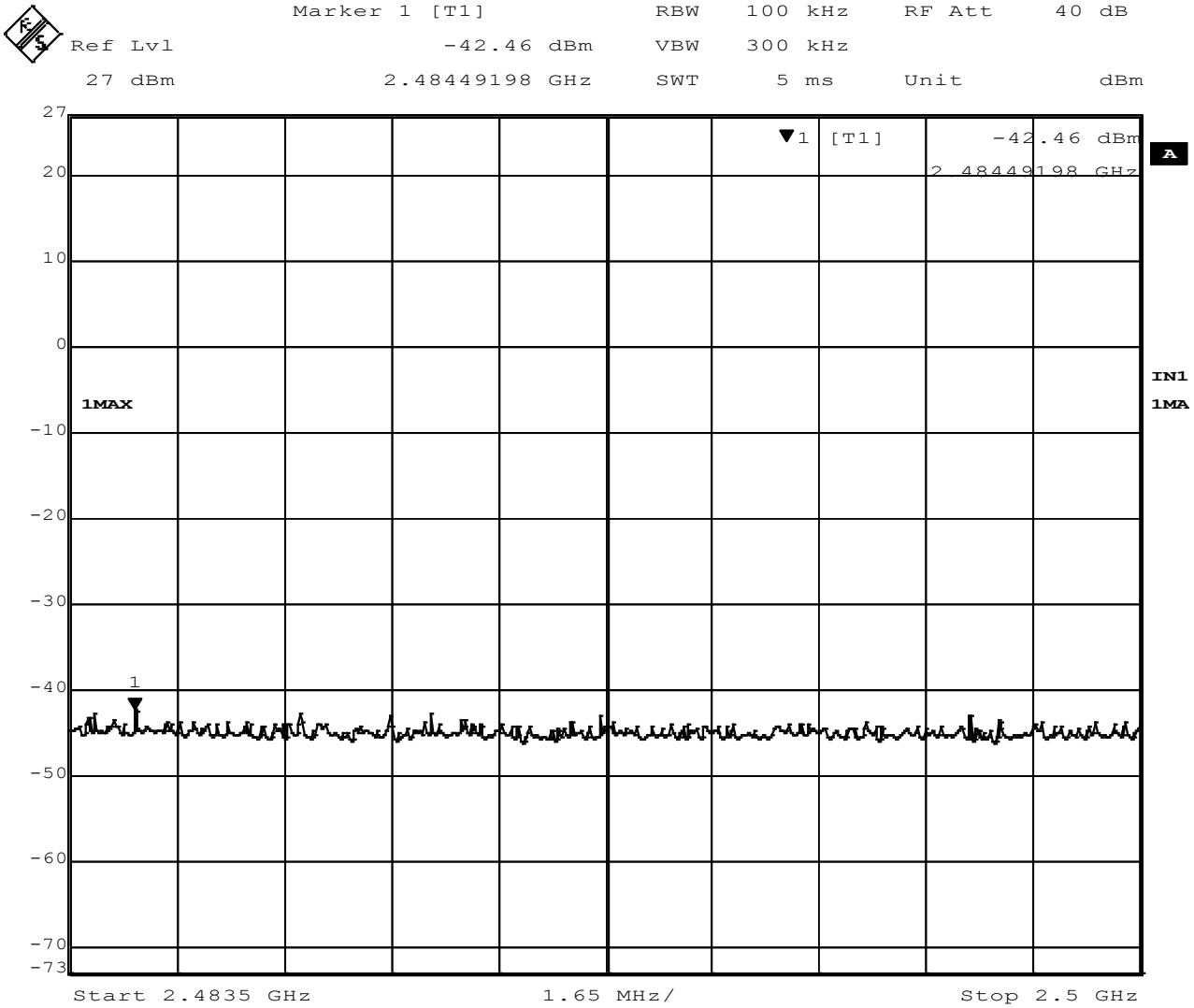
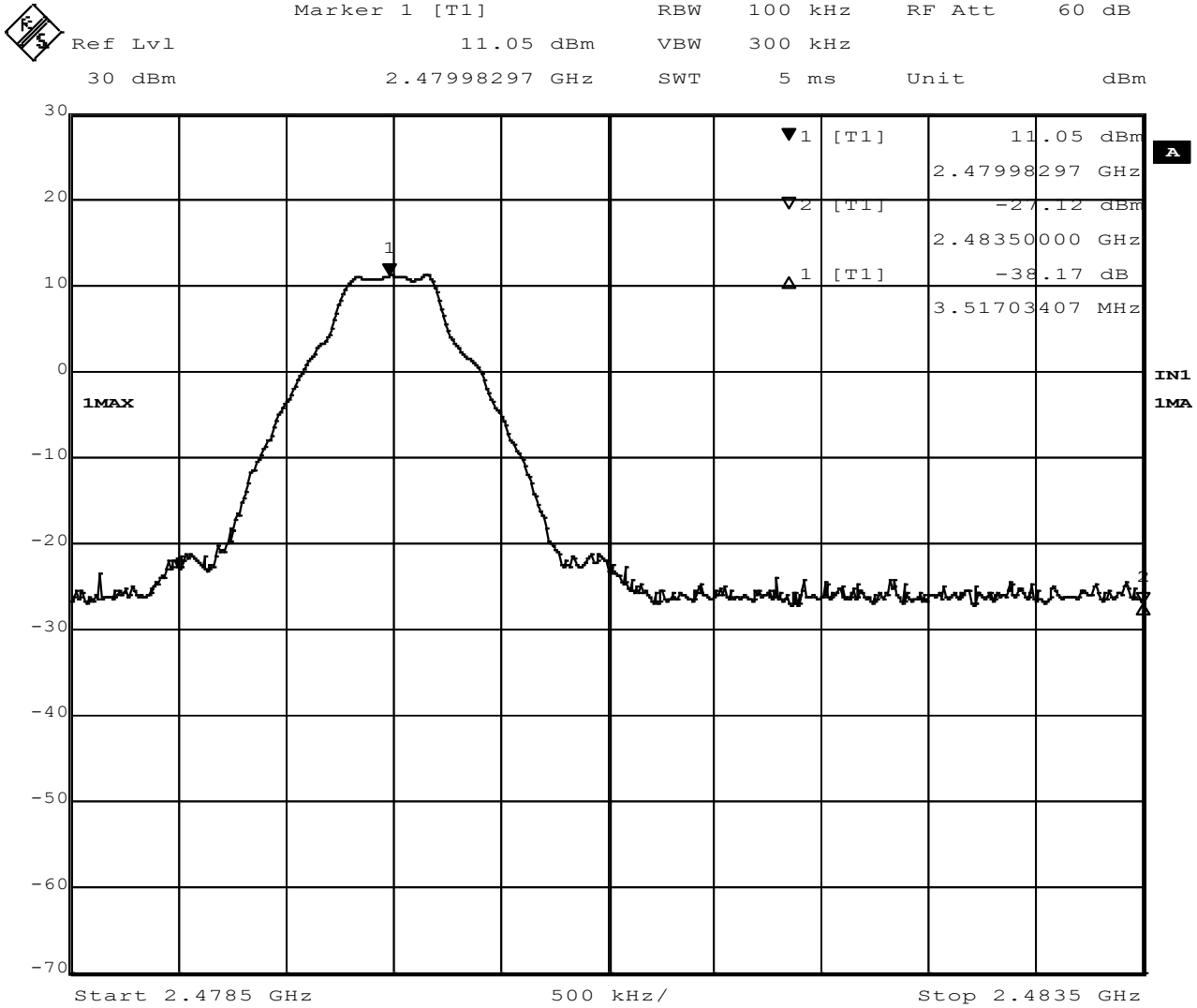



Figure 19 - Band-edge Measurement, High Channel, Restricted Frequency, Peak



Date: 8.JAN.2019 10:56:23

Figure 20 - Band-edge Measurement, High Channel, Fundamental, Peak

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

4.6 POWER SPECTRAL DENSITY

Test Method: ANSI C63.10,

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

Limits of power measurements:

The maximum PSD allowed is 8 dBm.

Test procedures:

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

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


Test setup:

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

EUT operating conditions:


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

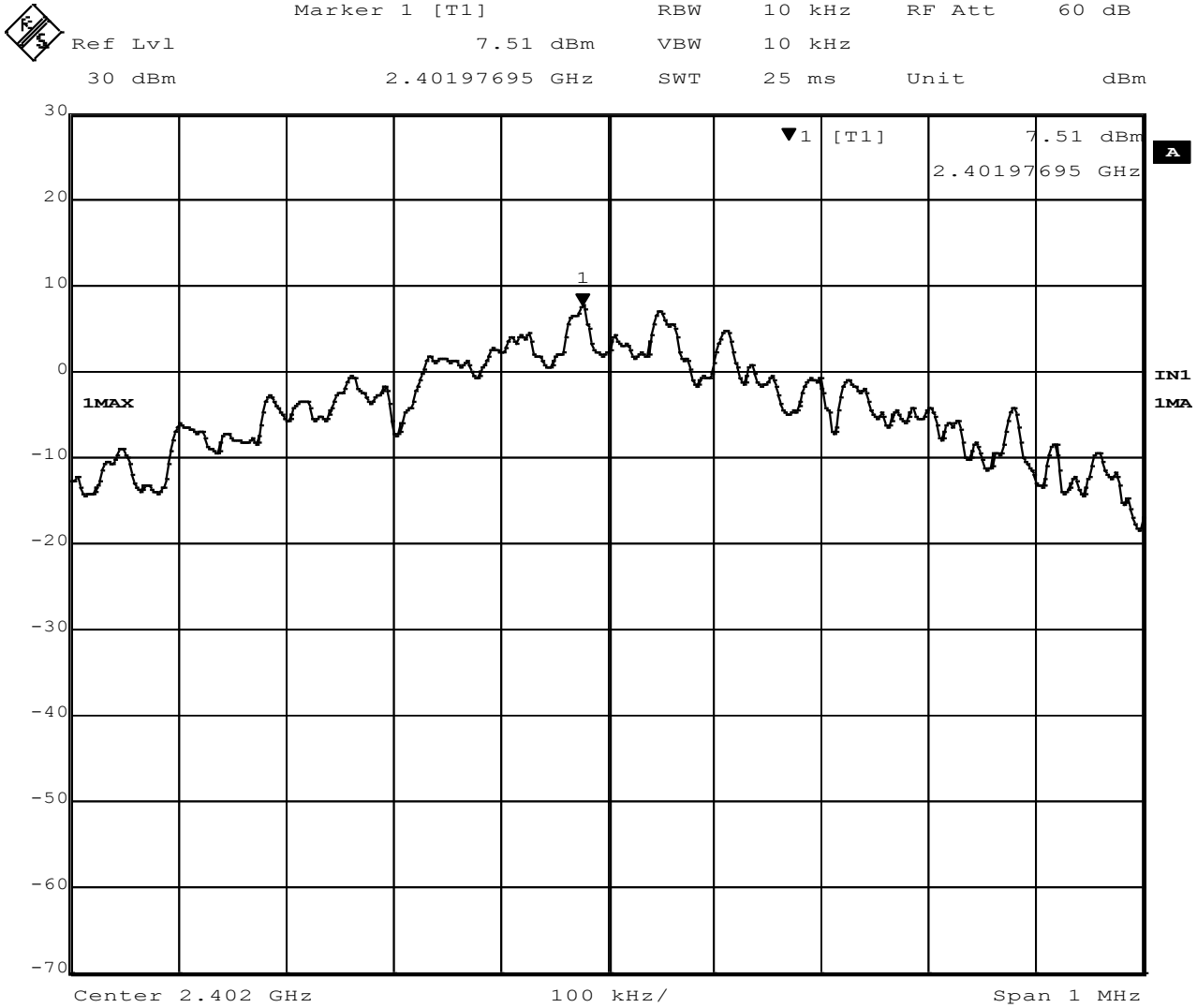
Test results:

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

Power Spectral Density


CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK PSD(dBm)	Method	Limit (dBm)	RESULT
Low	2402	7.51	Conducted	8.00	PASS
Middle	2440	6.63	Conducted	8.00	PASS
High	2480	5.42	Conducted	8.00	PASS

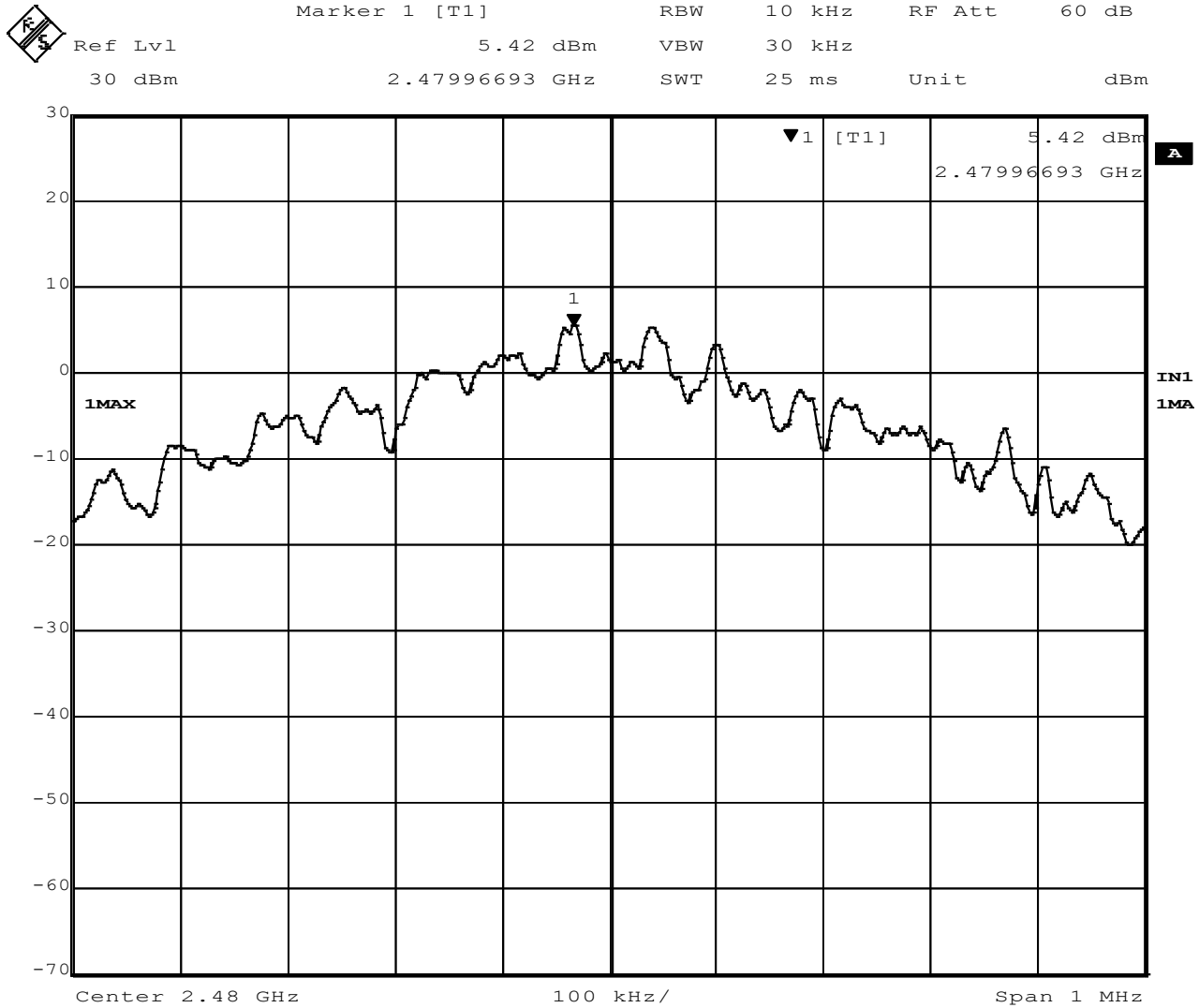
	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		



Date: 8.JAN.2019 10:32:44


Figure 21 - Power Spectral Density, Low Channel

	Report Number: R20181130-20-04	Rev	B
	Prepared for: Garmin		



Date: 8.JAN.2019 10:59:20

Figure 23 - Power Spectral Density, High Channel

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

4.7 CONDUCTED AC MAINS EMISSIONS

Test Method: ANSI C63.10-2013, Section(s) 6.2

Limits for conducted emissions measurements:

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dB μ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

Notes:

1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

Test Procedures:


- a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
- c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
- d. Results were compared to the 15.207 limits.

Deviation from the test standard:

No deviation

EUT operating conditions:

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

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

Test Results:

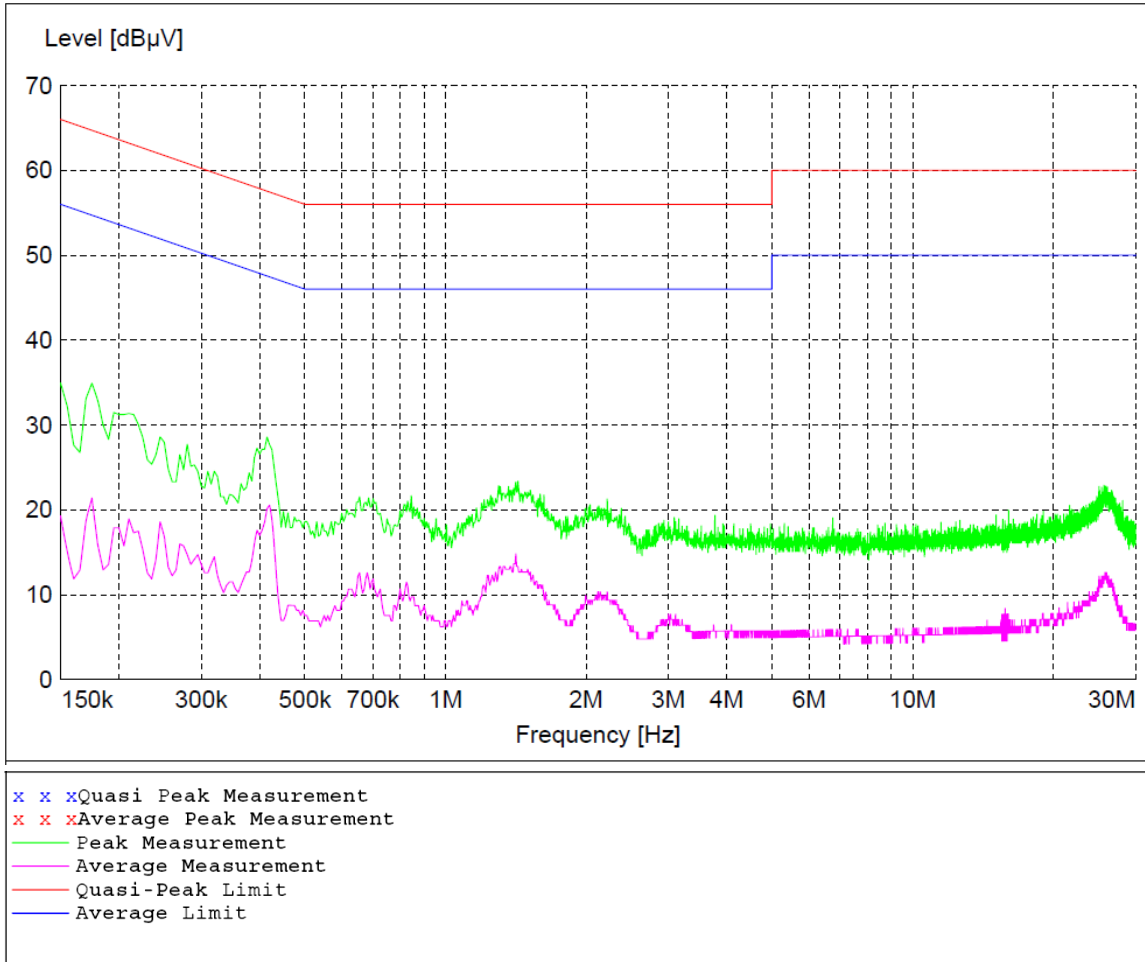



Figure 24 - Conducted Emissions Plot

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.

	Report Number:	R20181130-20-04	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 μ V is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dB μ V/m.

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

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

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

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

	Report Number:	R20181130-20-04	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;

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

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

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

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


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

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

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

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

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

	Report Number:	R20181130-20-04	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 dB
Radiated Emissions, 3m	1GHz - 18GHz	±4.44 dB
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB
Antenna port conducted	9 kHz – 25 GHz	±0.50 dB

Values were calculated per CISPR 16-4-2:2011

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

	Report Number:	R20181130-20-04	Rev	B
	Prepared for:	Garmin		

REPORT END