

## FCC/ISED Test Report

**Prepared for:** Garmin International Inc.

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

**Product:** A03556


**Test Report No:** R20190123-20-02D

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

**DATE:** 20 May 2019


**Total Pages:** 91

*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:	R20190123-20-02	Rev	D
	Prepared for:	Garmin		

**REVISION PAGE**

Rev. No.	Date	Description
0	24 April 2019	Original – NJohnson Prepared by KVeपुरi/CFarrington
A	15 May 2019	Updated output power to state that power meter was used. Corrected band edge values.
B	16 May 2019	Added new output power measurements completed with a repaired SMA connector.
C	17 May 2019	Replaced output power measurements with new measurements performed with calibrated power meter and sensor.
D	20 May 2019	Added peak power measurements using peak power detector.

	Report Number:	R20181130-20-02	Rev	D
	Prepared for:	Garmin		

**CONTENTS**

**Revision Page..... 2**

**1.0 Summary of test results..... 4**

**2.0 EUT Description ..... 5**

**2.1 Equipment under test.....5**

**2.2 Description of test modes .....6**

**2.3 Description of support units .....6**

**3.0 Laboratory description ..... 7**

**3.1 Laboratory description .....7**

**3.2 Test Personnel .....7**

**3.3 Test equipment .....8**

**4.0 Detailed results ..... 9**

**4.1 Duty Cycle .....9**

**4.2 Radiated emissions .....10**

**4.3 Output Power .....24**

**4.4 Bandwidth .....26**

**4.5 Bandedges .....46**


**4.6 Power Spectral Density .....74**

**4.7 Conducted AC Mains Emissions.....85**

**Appendix A: Sample Calculation ..... 88**

**Appendix B – Measurement Uncertainty ..... 90**

**REPORT END..... 91**


	Report Number:	R20181130-20-02	Rev	D
	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	N/A
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 11.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 4, Section 7.1	Conducted Emissions	Pass

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

	Report Number:	R20181130-20-02	Rev	D
	Prepared for:	Garmin		


## 2.0 EUT DESCRIPTION

### 2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a GPS from Garmin. It features 802.11b, 802.11g, 802.11n, GFSK and GMSK modules and has transmit and receives capabilities.

EUT	Portable transceiver
Model	A03556
EUT Received	22 March 2019
EUT Tested	22 March 2019 - 24 April 2019, 16 May 2019 (average power measurements)
Serial No.	3985900303bw00 (used for radiate tests); 3985900336bw00 (used for conducted tests)
Operating Band	2400.0 - 2483.5 GHz
Device Type	802.11b, 802.11g, 802.11n
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:	R20181130-20-02	Rev	D
	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)	2412
Middle (Channel 6)	2437
High (Channel 11)	2462

As well as the following modes:


WIFI Mode
802.11b
802.11g
802.11n (HT20)

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:	R20181130-20-02	Rev	D
	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 and Caleb Farrington of NCEE Labs. The results were reviewed by Nic Johnson.


	Report Number:	R20181130-20-02	Rev	D
	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 2020
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2019
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2020
EMCO Horn Antenna	3116	2576	31 Jan 2018	31 Jan 2020
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2020*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2020*
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2020*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2020*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2020*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2020*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2020*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2020*
Rohde & Schwarz power meter	NRVD	036029/012	07 Aug 2018	07 Aug 2019
Rohde & Schwarz power sensor	URV5-Z2	836416/022	07 Aug 2018	07 Aug 2019
Tektronix Avg/Peak/Pulse USB Power Meter	PSM4110	11C944	02/22/2019	02/22/2020

\*Internal Characterization




	Report Number:	R20181130-20-02	Rev	D
	Prepared for:	Garmin		

## 4.0 DETAILED RESULTS

### 4.1 DUTY CYCLE

Duty Cycle measurements were not conducted as the EUT is capable of continuous transmission.

	Report Number:	R20181130-20-02	Rev	D
	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 non-restricted 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 ( $\mu\text{V/m}$ )	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3


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

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

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


**NOTE:**

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 \* log \* Emission level ( $\mu\text{V/m}$ ).
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:	R20181130-20-02	Rev	D
	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.
- g. All 802.11 modes were examined (b, g, n, HT20) and it was found the 802.11 n mode produced the highest emissions. All final measurements were performed with the EUT transmitting continuously in this mode.

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

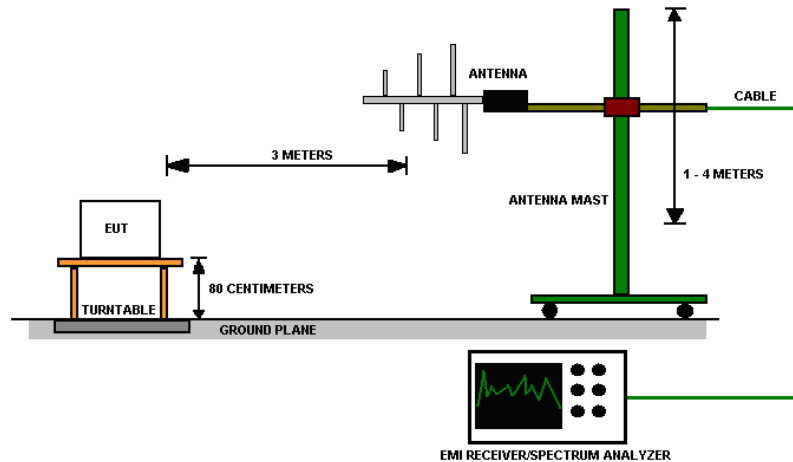
**NOTE:**

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 80211b, 80211g and 80211n.

**Test results:**

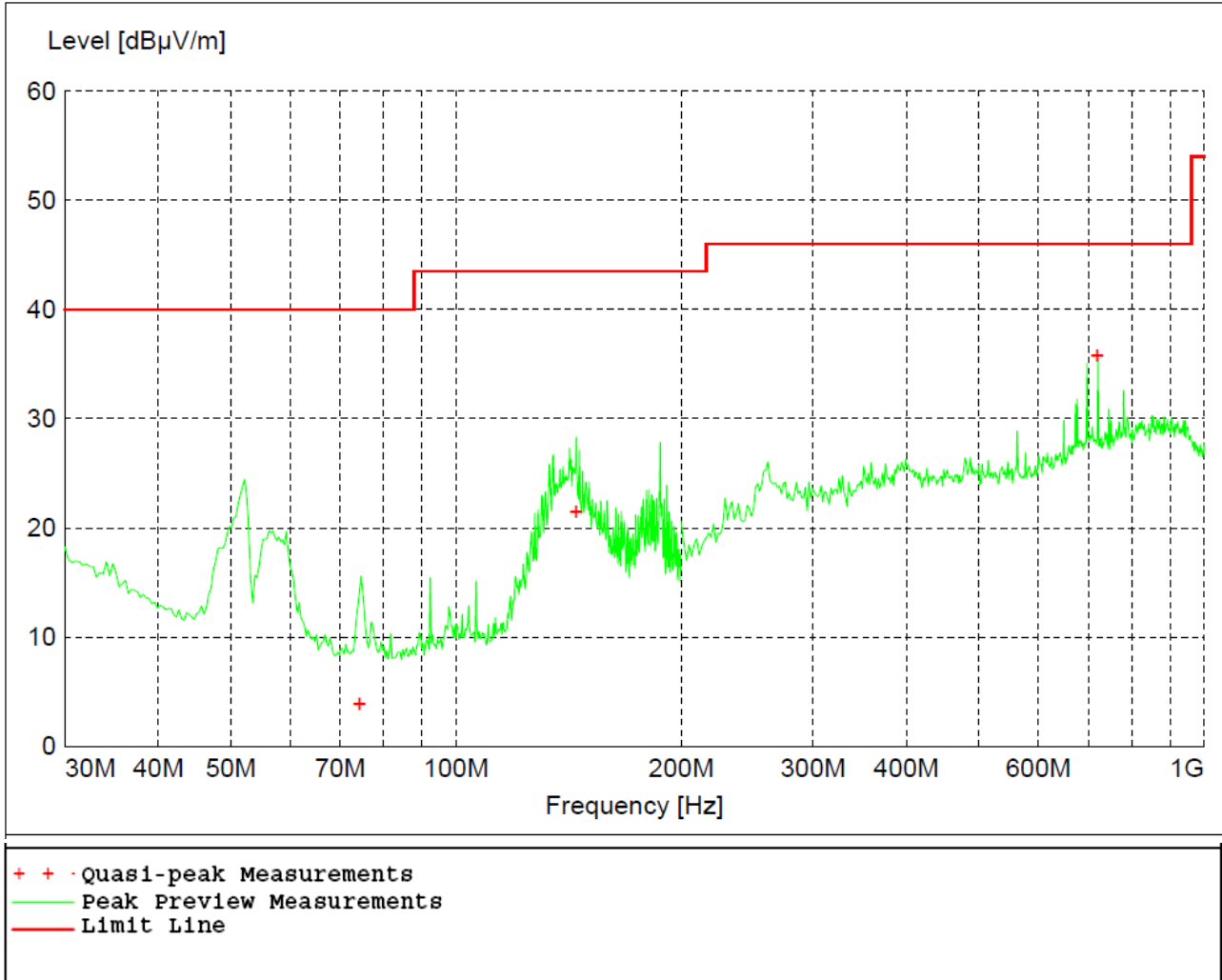


Figure 2 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak and Peak Measurements, Receive, 802.11b

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
74.340000	3.90	40.00	36.10	400	16	VERT
144.780000	21.49	43.50	22.00	100	245	VERT
720.000000	35.78	46.00	10.20	121	304	HORI

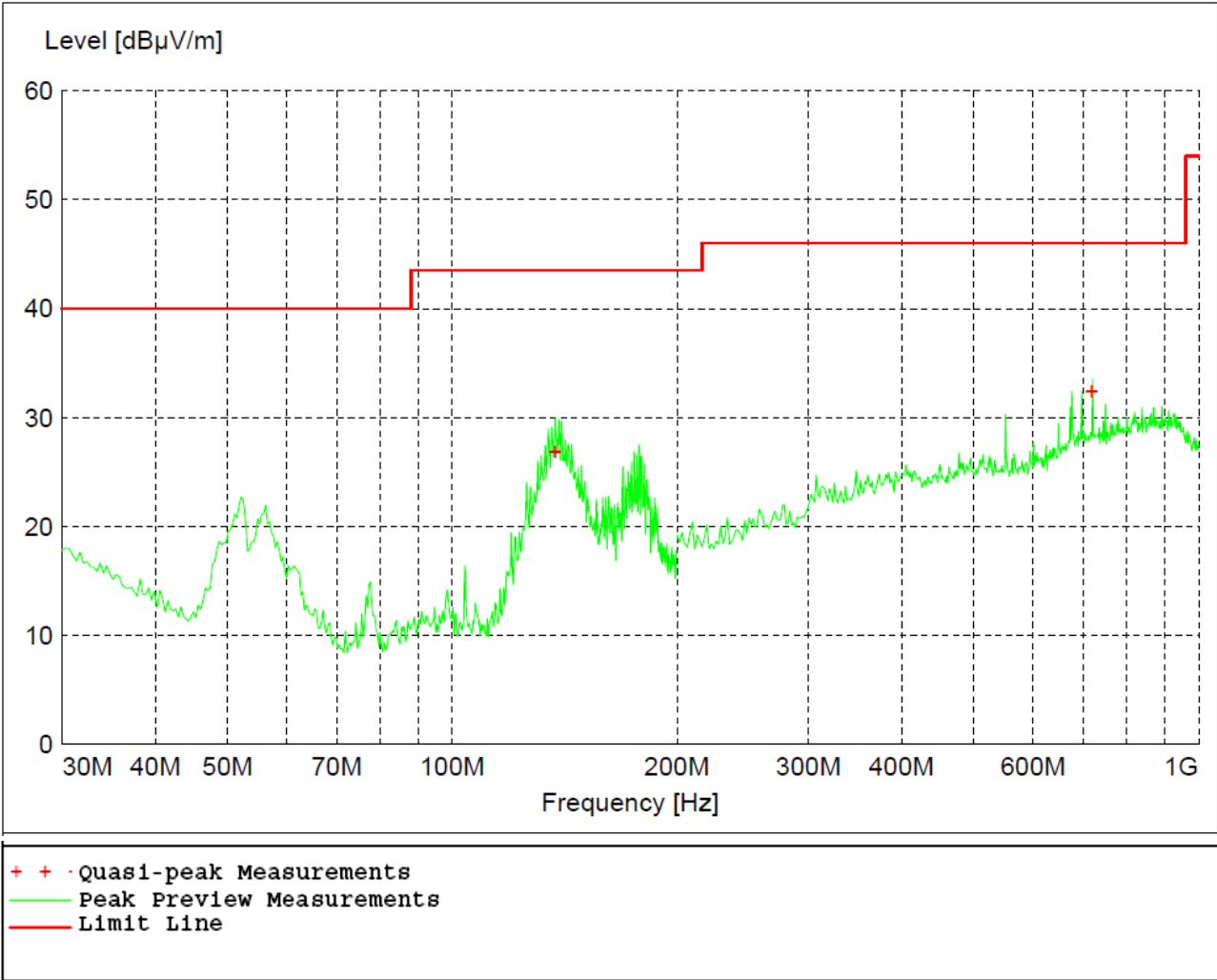


Figure 3 - Radiated Emissions Plot, Low Channel

Table 2 - Radiated Emissions Quasi-peak Measurements, Low Channel, 802.11b

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
137.400000	26.93	43.50	16.60	102	162	VERT
720.000000	32.42	46.00	13.60	100	299	VERT

All modulations were measured for receive mode and 802.11b was found to produce the highest emissions, although all odes were similar within 2 dB.

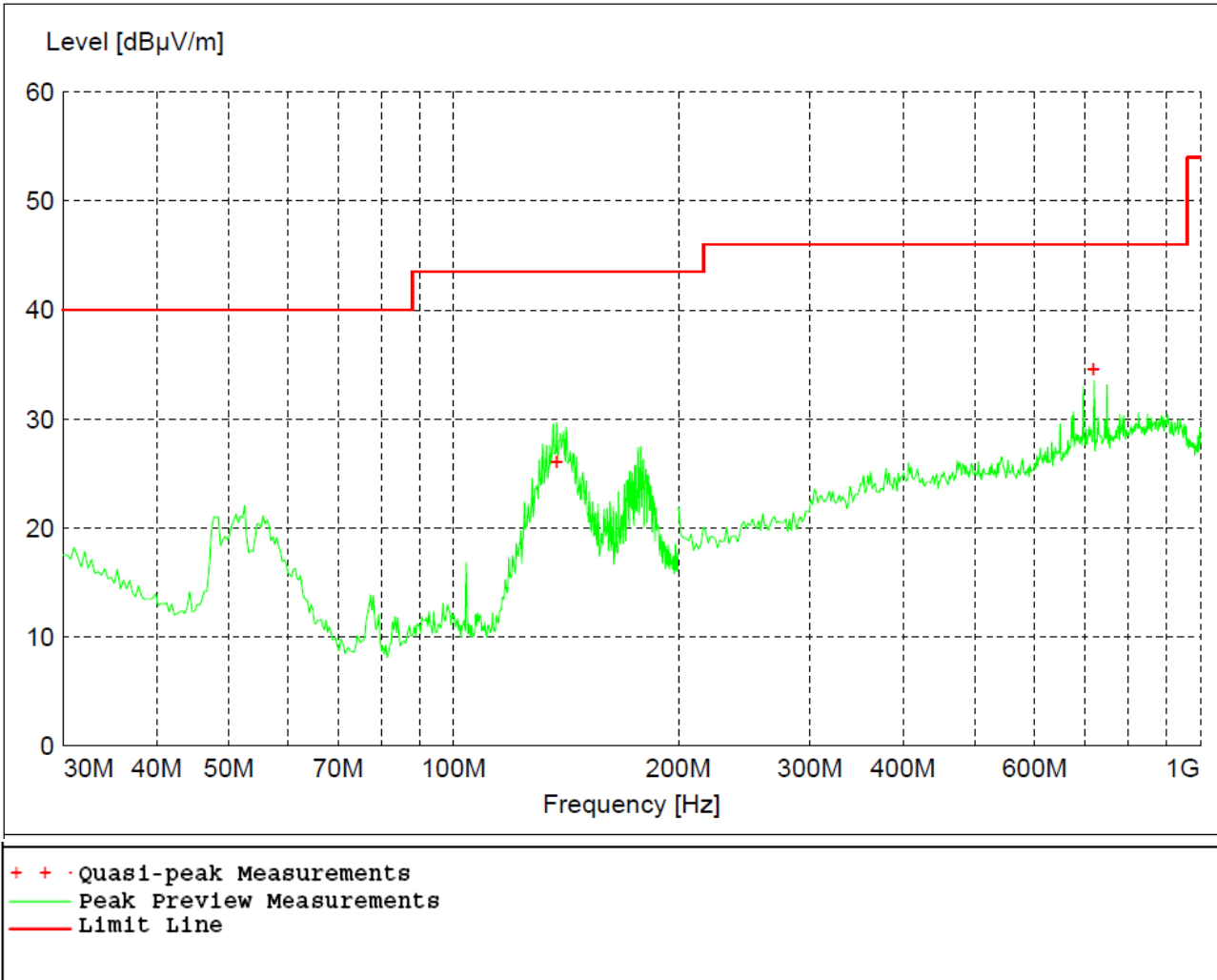


Figure 4 - Radiated Emissions Plot, Mid Channel

Table 3 - Radiated Emissions Quasi-peak Measurements, Mid Channel, 802.11b

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
137.460000	26.05	43.50	17.50	100	123	VERT
720.000000	34.57	46.00	11.40	217	221	HORI

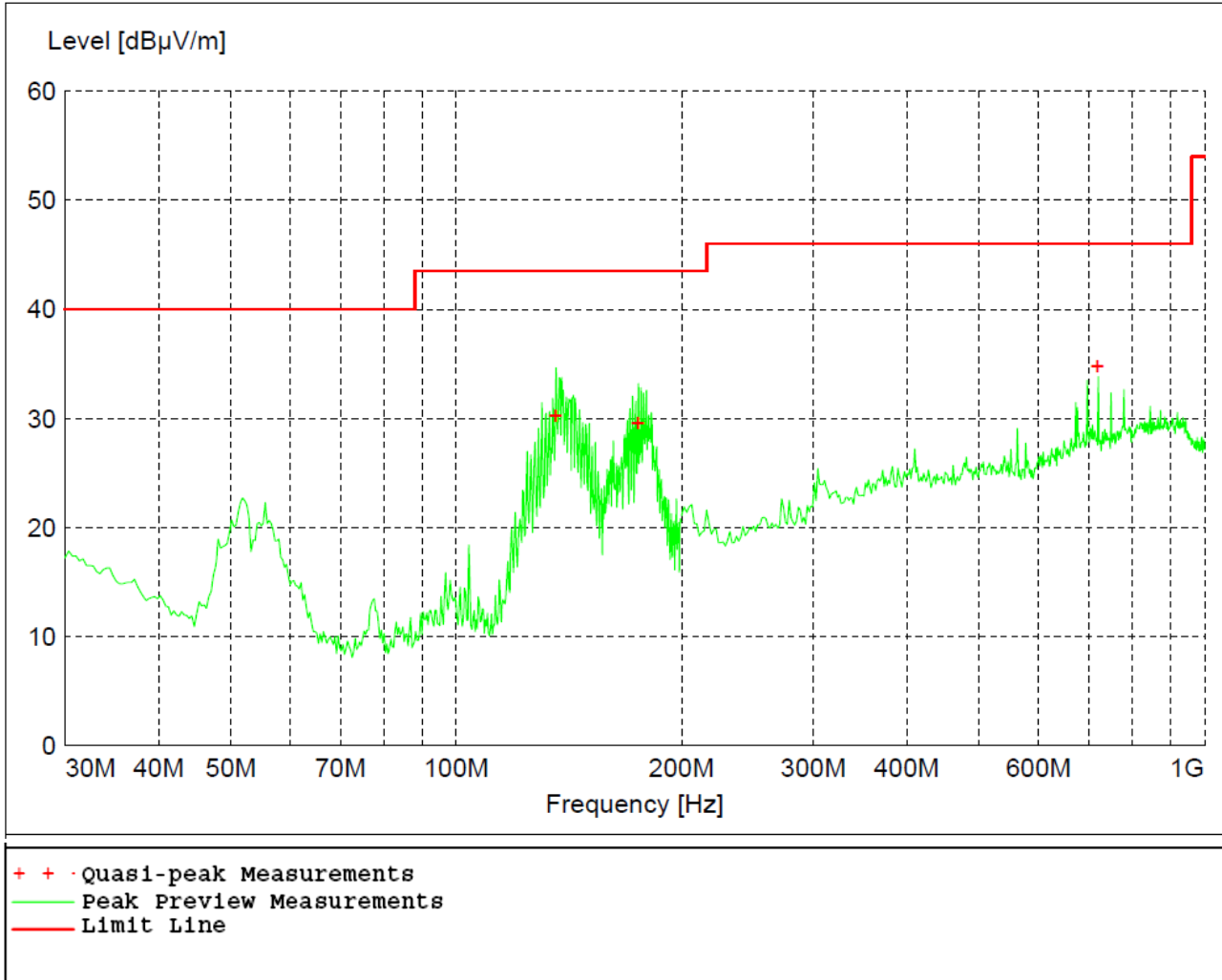


Figure 5 - Radiated Emissions Plot, High Channel

Table 4 - Radiated Emissions Quasi-peak Measurements, High Channel, 802.11b

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
135.720000	30.25	43.50	13.30	100	158	VERT
174.960000	29.56	43.50	14.00	100	163	VERT
720.000000	34.77	46.00	11.20	216	221	HORI



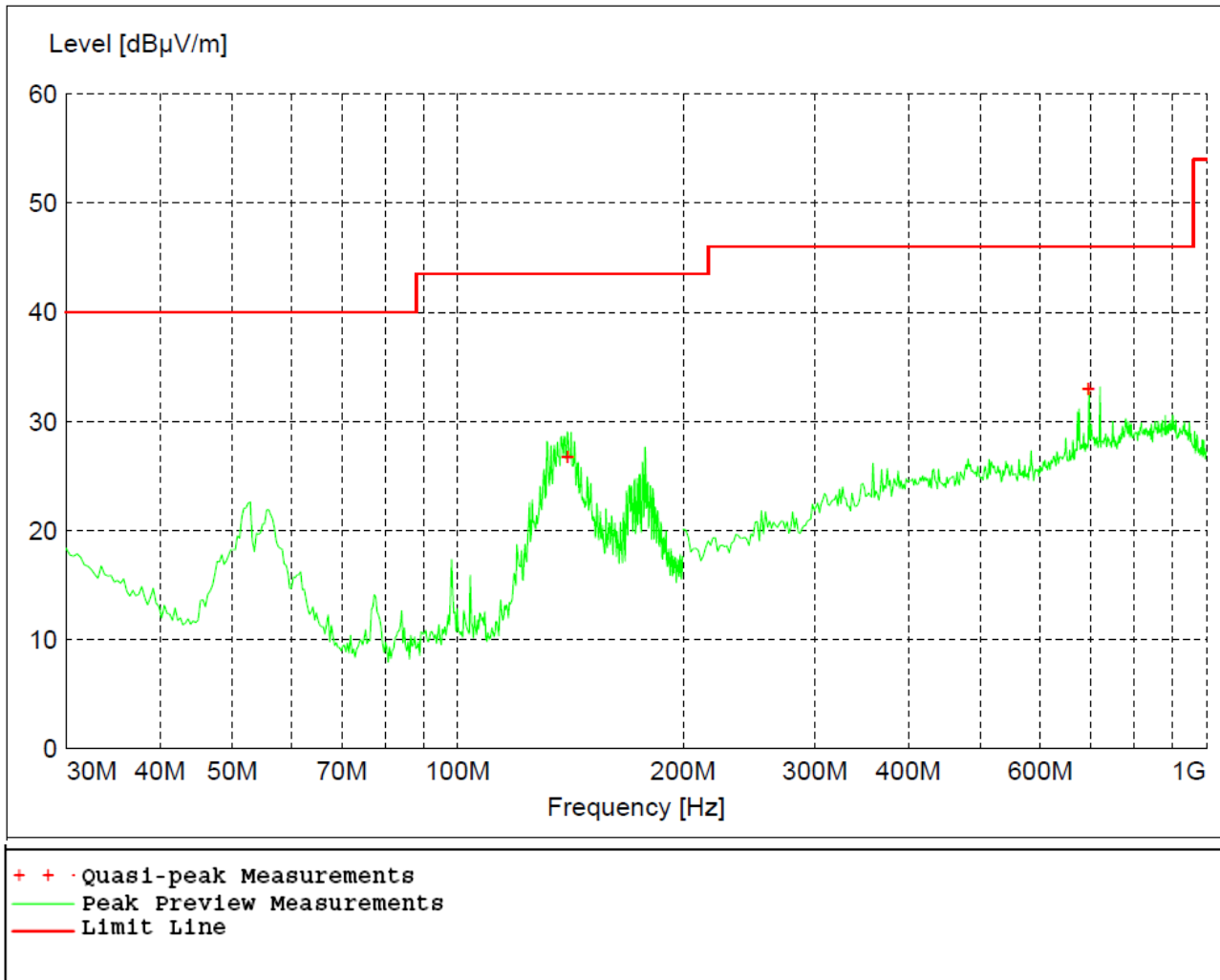


Figure 6 - Radiated Emissions Plot, Low Channel

Table 5 - Radiated Emissions Quasi-peak Measurements, Low Channel, 802.11g

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
140.280000	26.73	43.50	16.80	100	147	VERT
696.000000	33.02	46.00	13.00	206	143	VERT

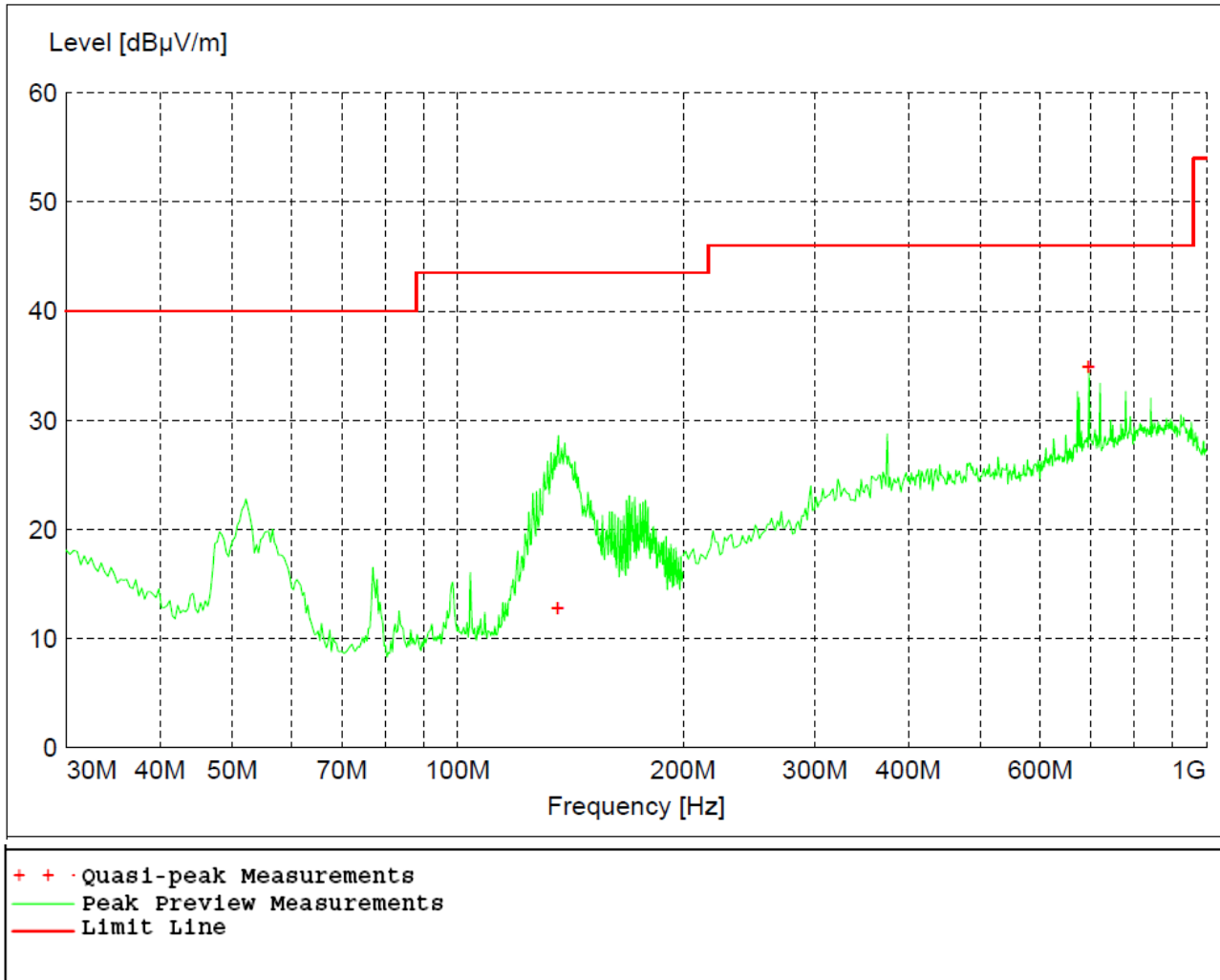


Figure 7 - Radiated Emissions Plot, Mid Channel

Table 6 - Radiated Emissions Quasi-peak Measurements, Mid Channel, 802.11g

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
136.020000	12.89	43.50	30.60	100	182	VERT
696.000000	34.98	46.00	11.00	100	290	VERT

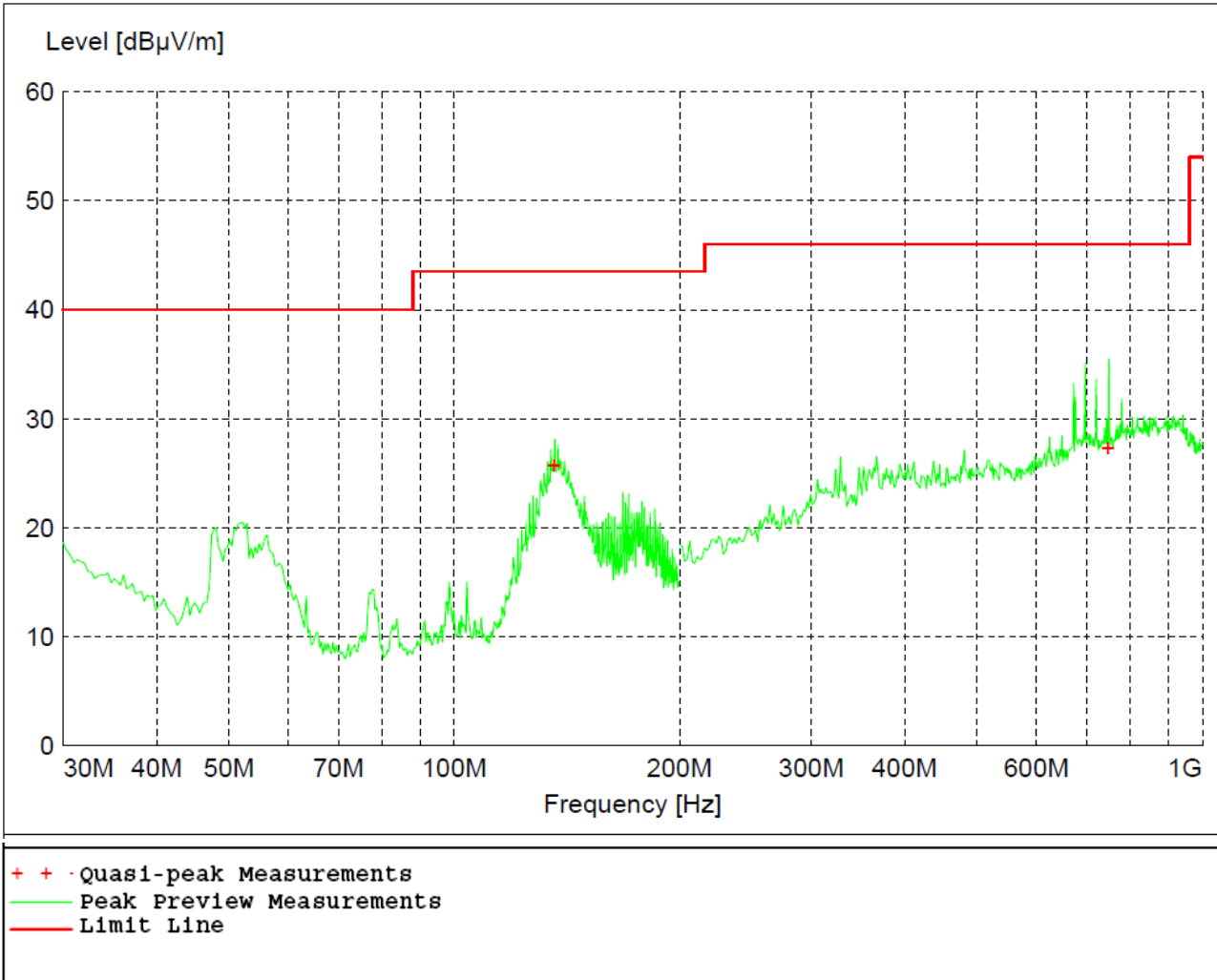


Figure 8 - Radiated Emissions Plot, High Channel

Table 7 - Radiated Emissions Quasi-peak Measurements, High Channel, 802.11g

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
136.020000	25.71	43.50	17.80	100	187	VERT
748.800000	27.31	46.00	18.70	119	0	HORI

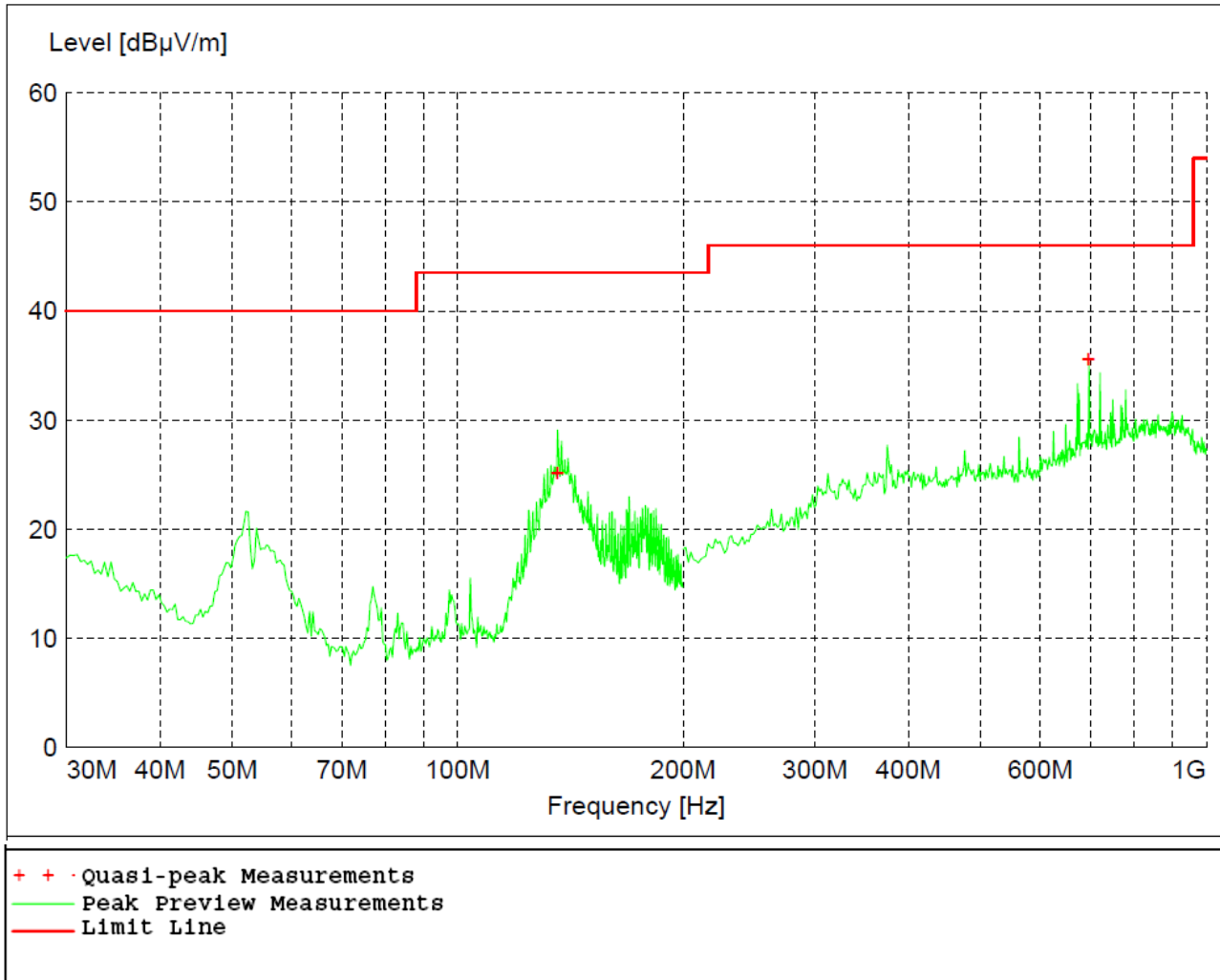


Figure 9 - Radiated Emissions Plot, Low Channel

Table 8 - Radiated Emissions Quasi-peak Measurements, Low Channel, 802.11n

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
135.960000	25.21	43.50	18.30	100	183	VERT
696.000000	35.64	46.00	10.40	100	241	VERT

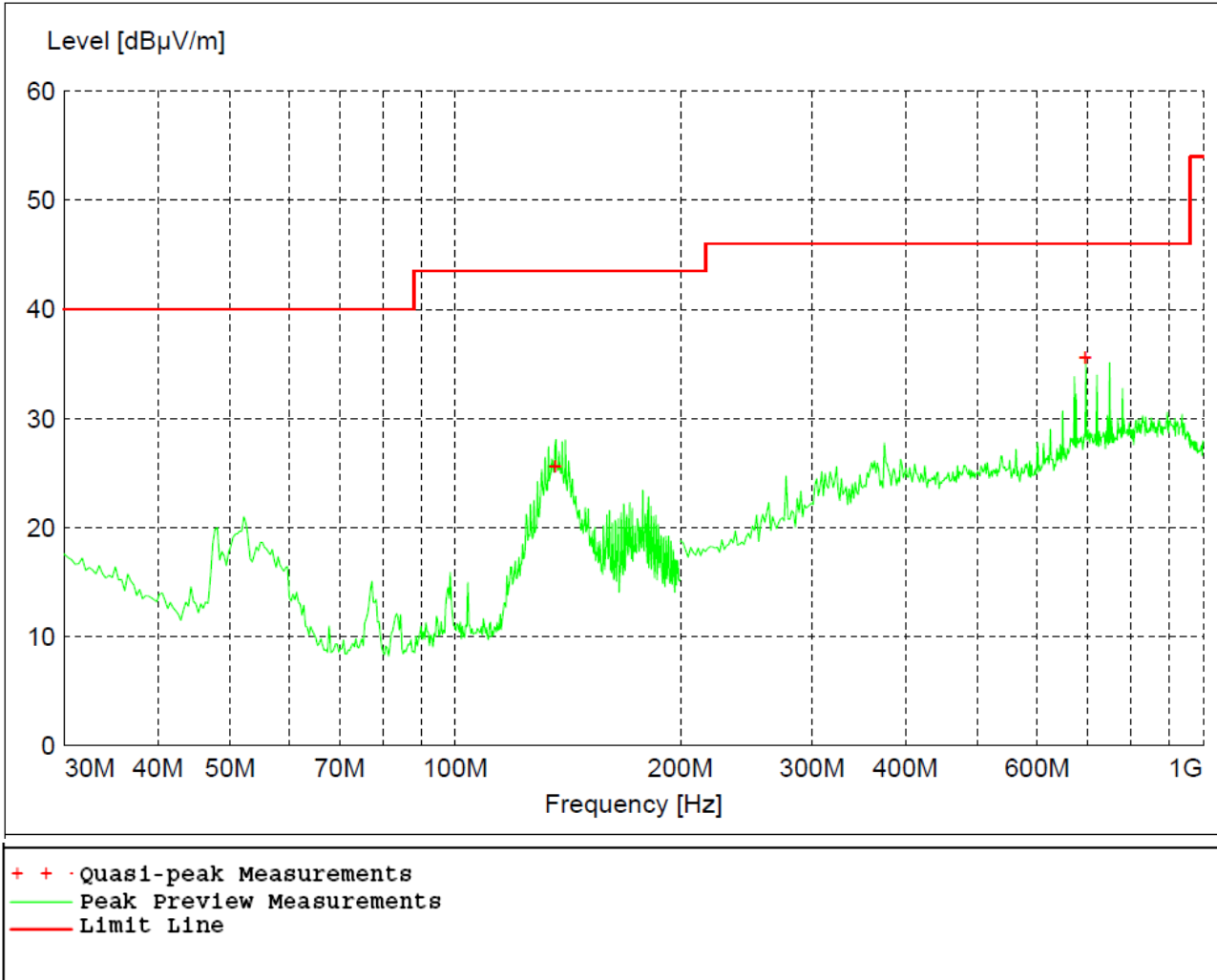


Figure 10 - Radiated Emissions Plot, Mid Channel

Table 9 - Radiated Emissions Quasi-peak Measurements, Mid Channel, 802.11n

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
136.080000	25.62	43.50	17.90	99	197	VERT
696.000000	35.64	46.00	10.40	99	246	VERT

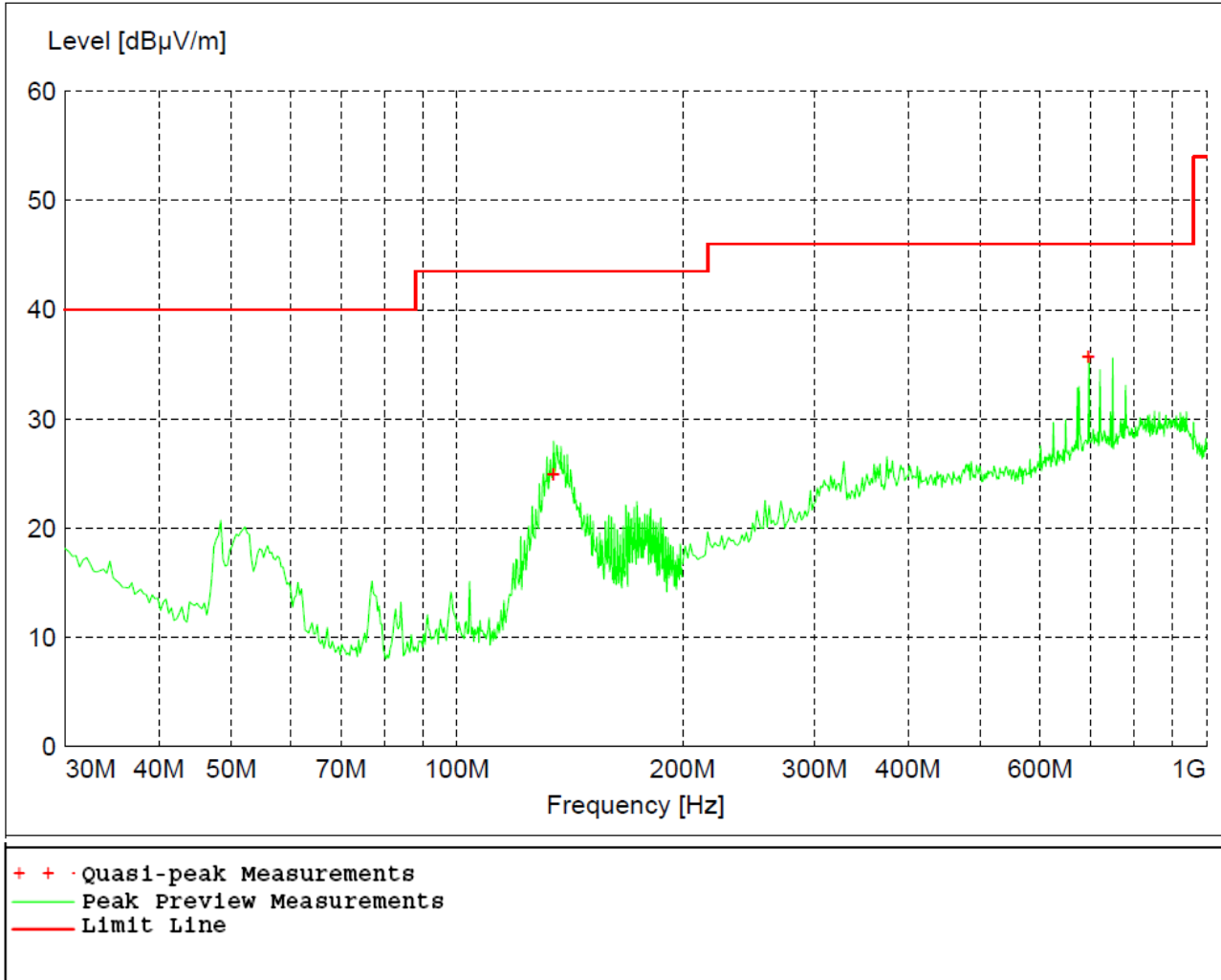


Figure 11 - Radiated Emissions Plot, High Channel

Table 10 - Radiated Emissions Quasi-peak Measurements, High Channel, 802.11n

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
134.580000	24.97	43.50	18.60	100	147	VERT
696.000000	35.79	46.00	10.20	100	246	VERT



	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

Table 11 - Radiated Emissions Measurements, 1-26 GHz

Frequency	Peak Level	Average Level	Height	Angle	Pol	Mode
MHz	dB $\mu$ V/m	dB $\mu$ V/m	cm.	deg.		802.11
2412.000000	100.65	90.92	197	27	Horizontal	b
2437.000000	101.78	91.85	197	27	Horizontal	b
2462.000000	99.90	89.94	197	27	Horizontal	b
2412.000000	97.82	83.44	197	27	Horizontal	g
2437.000000	101.73	86.99	197	27	Horizontal	g
2462.000000	99.12	84.32	197	27	Horizontal	g
2412.000000	98.40	81.54	197	27	Horizontal	n
2437.000000	101.49	90.78	197	27	Horizontal	n
2462.000000	98.13	82.78	197	27	Horizontal	n
No other signals were detected above system sensitivity and were at least 10 dB below the applicable limits.						

**REMARKS:**

1. Emission level (dB $\mu$ V/m) = Raw Value (dB $\mu$ 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:	R20181130-20-02	Rev	D
	Prepared for:	Garmin		

### 4.3 OUTPUT POWER

**Test Method:** ANSI C63.10:  
 1. Section(s) 11.9.2.3.1, 11.9.1.3

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

**Test procedures:**  
 The EUT was connected to peak and true average power meter.

**Deviations from test standard:**  
 No deviation.

**Test setup:**

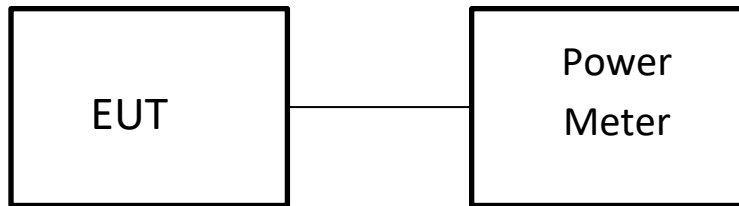



Figure 12 – Peak Output Power Measurements Test Setup

**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  $\pm 1.1$  dB and average power is  $\pm 1.37$  dB



	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		


**Peak Output Power**

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	PEAK OUTPUT POWER (dBm) MU = ±1.1 dB	Method	RESULT
Low	2412	802.11b	21.71	Conducted	PASS
Middle	2437	802.11b	19.96	Conducted	PASS
High	2462	802.11b	20.12	Conducted	PASS
Low	2412	802.11g	17.93	Conducted	PASS
Middle	2437	802.11g	19.19	Conducted	PASS
High	2462	802.11g	16.84	Conducted	PASS
Low	2412	802.11n	17.55	Conducted	PASS
Middle	2437	802.11n	19.48	Conducted	PASS
High	2462	802.11n	16.80	Conducted	PASS

**Average Output Power**

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	Average OUTPUT POWER (dBm) MU = ±1.37	Method	RESULT
Low	2412	802.11b	16.96	Conducted	PASS
Middle	2437	802.11b	17.31	Conducted	PASS
High	2462	802.11b	17.39	Conducted	PASS
Low	2412	802.11g	16.15	Conducted	PASS
Middle	2437	802.11g	18.11	Conducted	PASS
High	2462	802.11g	16.75	Conducted	PASS
Low	2412	802.11n	16.06	Conducted	PASS
Middle	2437	802.11n	17.97	Conducted	PASS
High	2462	802.11n	16.56	Conducted	PASS

All measurements include 0.1 dB of cable loss.

	Report Number:	R20181130-20-02	Rev	D
	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:**

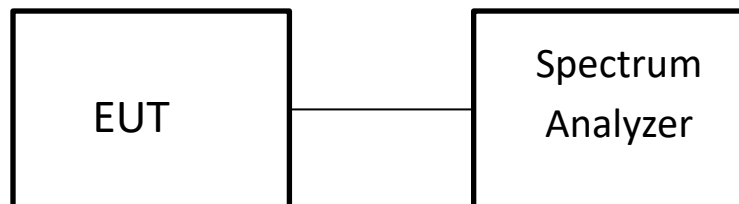



Figure 13 – Peak Output Power Measurements Test Setup

	Report Number: R20181130-20-02	Rev	D
	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)	WIFI Type	99% Occupied BW (MHz)
Low	2412	802.11b	14.028
Middle	2437	802.11b	13.948
High	2462	802.11b	14.028
Low	2412	802.11g	16.754
Middle	2437	802.11g	17.234
High	2462	802.11g	16.673
Low	2412	802.11n	17.796
Middle	2437	802.11n	17.956
High	2462	802.11n	17.796

**6dB Bandwidth**

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	6 dB BW (MHz)
Low	2412	802.11b	8.81
Middle	2437	802.11b	8.40
High	2462	802.11b	8.48
Low	2412	802.11g	16.34
Middle	2437	802.11g	16.34
High	2462	802.11g	16.34
Low	2412	802.11n	16.98
Middle	2437	802.11n	16.98
High	2462	802.11n	16.42

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

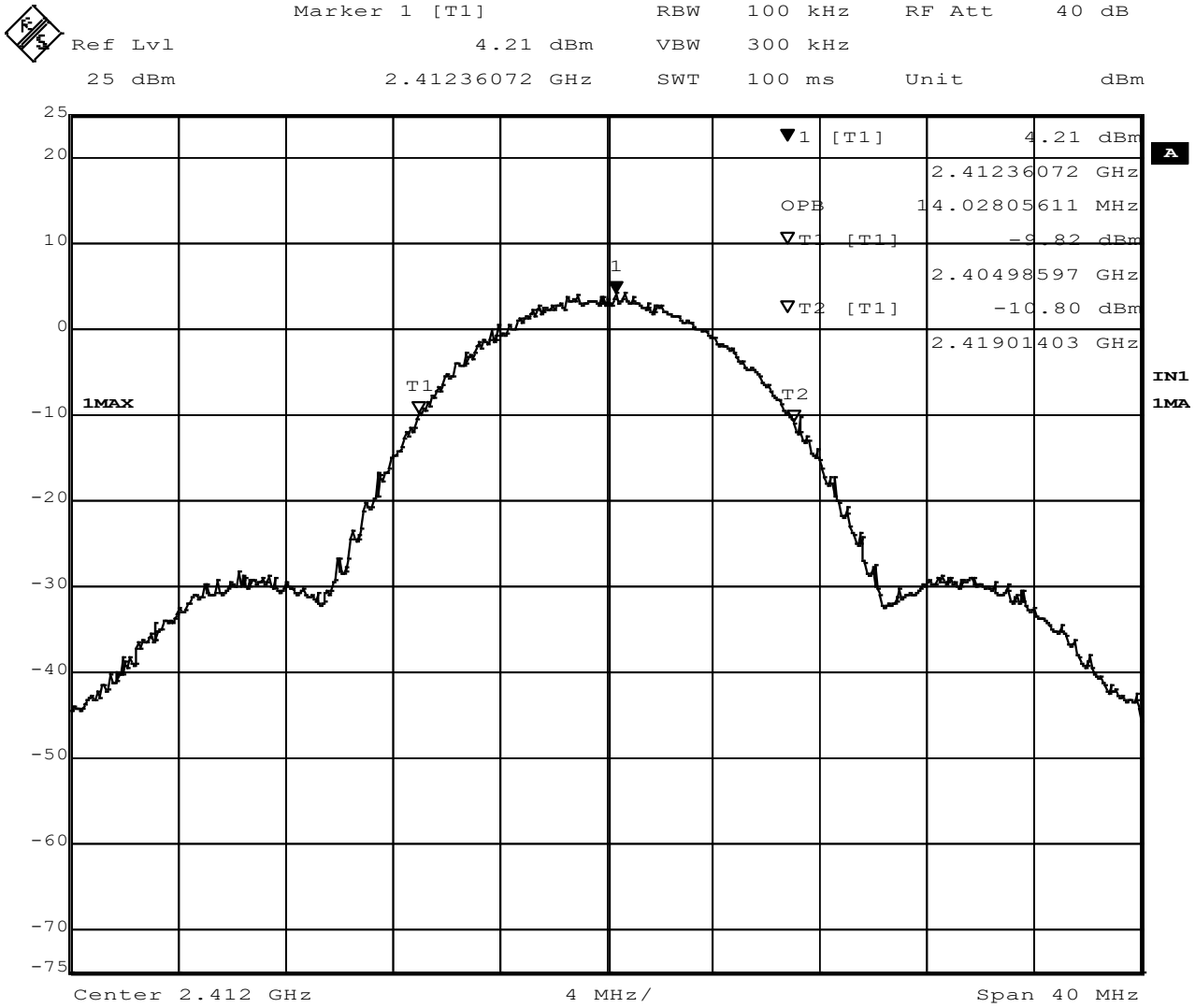



Figure 14 - 99% Occupied Bandwidth, Low Channel, 802.11b

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

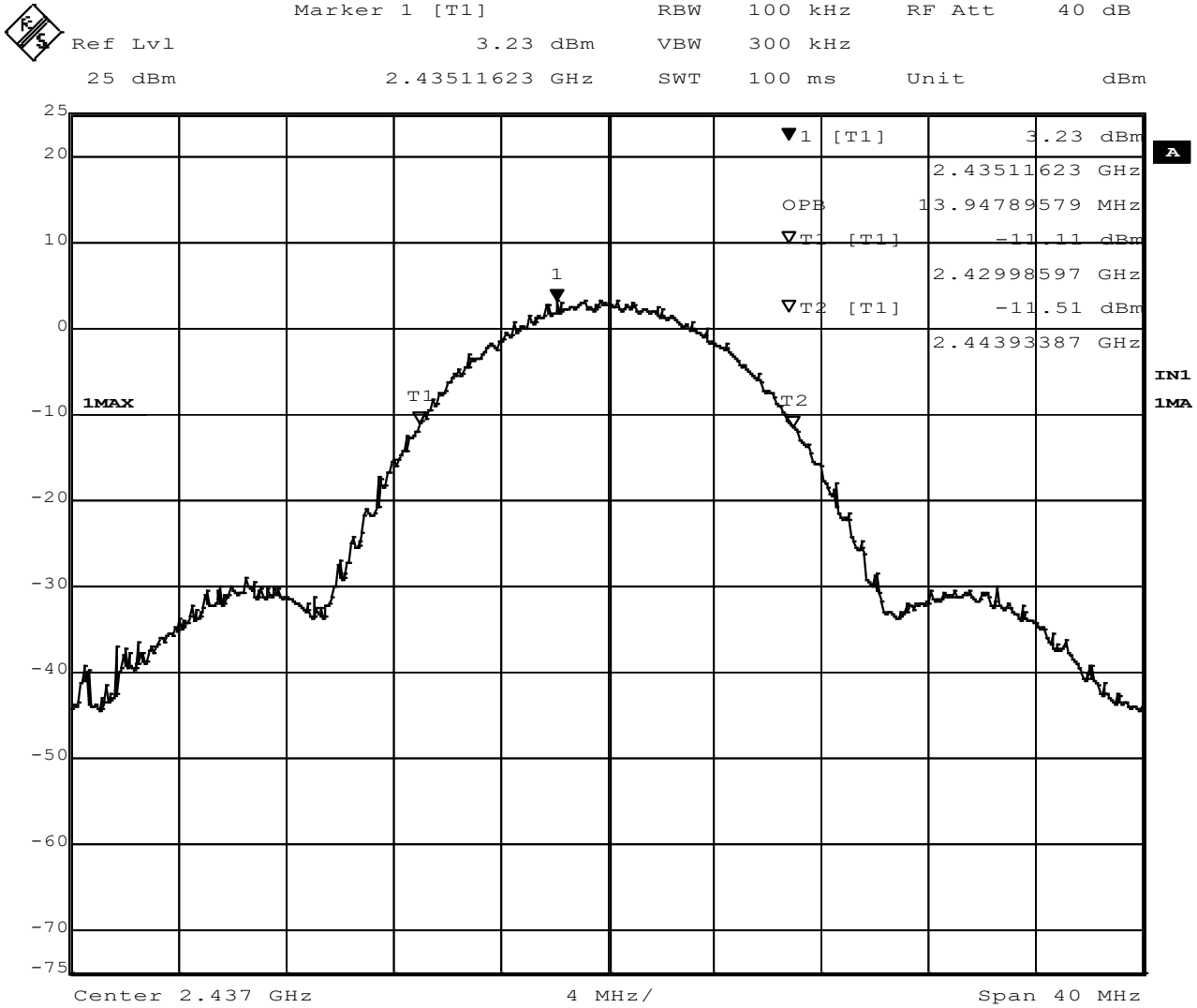



Figure 15 - 99% Occupied Bandwidth, Mid Channel, 802.11b

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

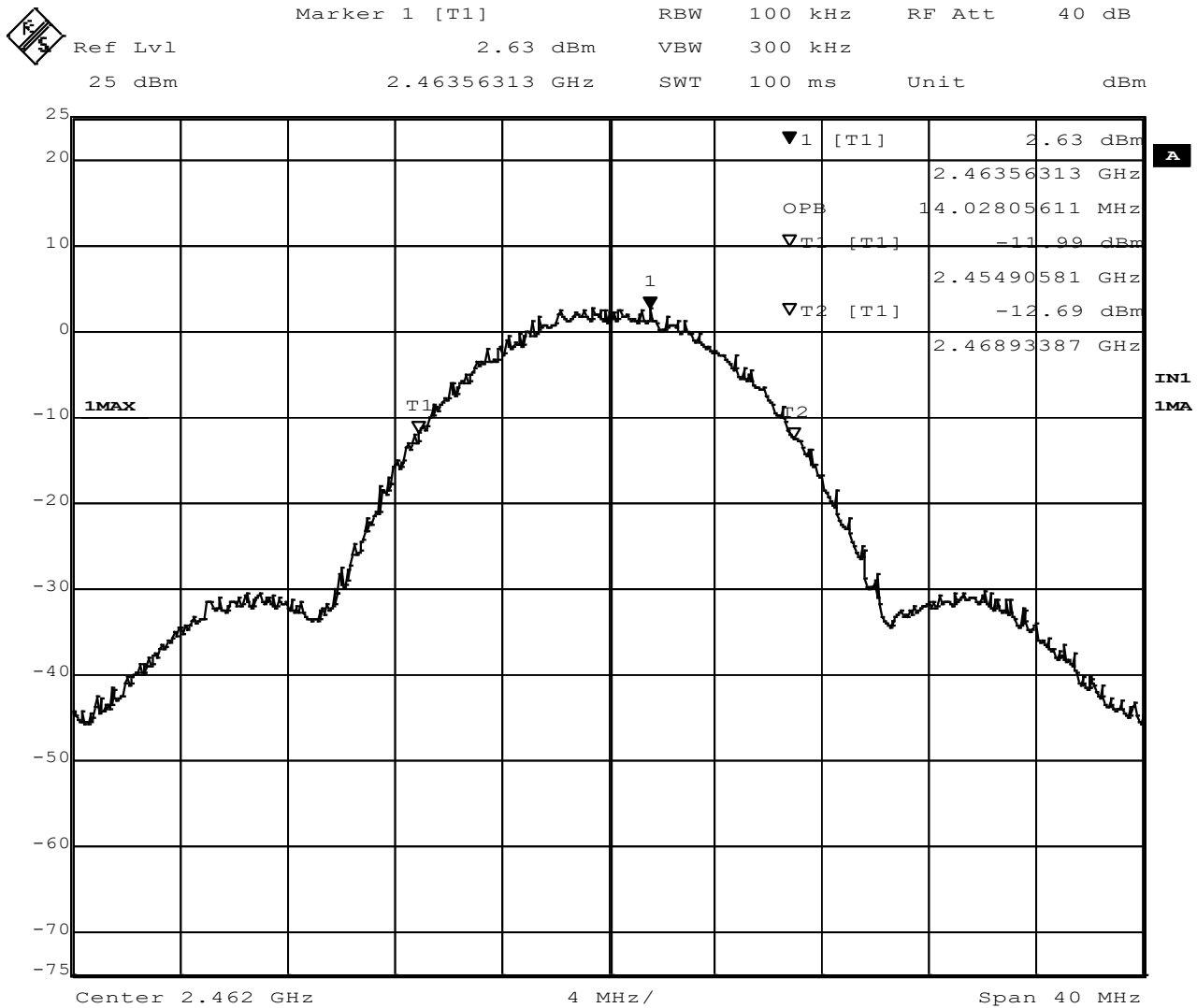



Figure 16 - 99% Occupied Bandwidth, High Channel, 802.11b

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

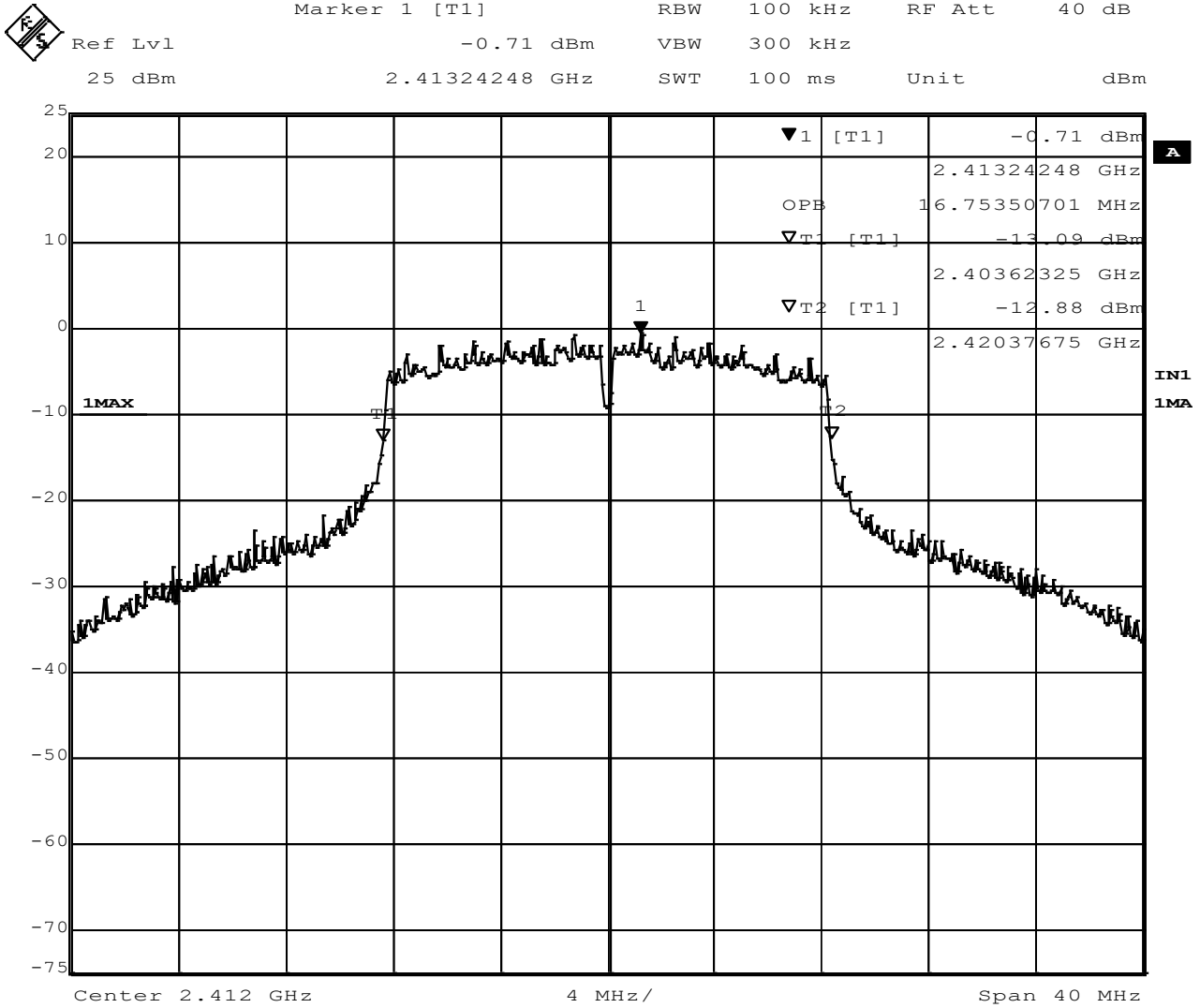


Figure 17 - 99% Occupied Bandwidth, Low Channel, 802.11g

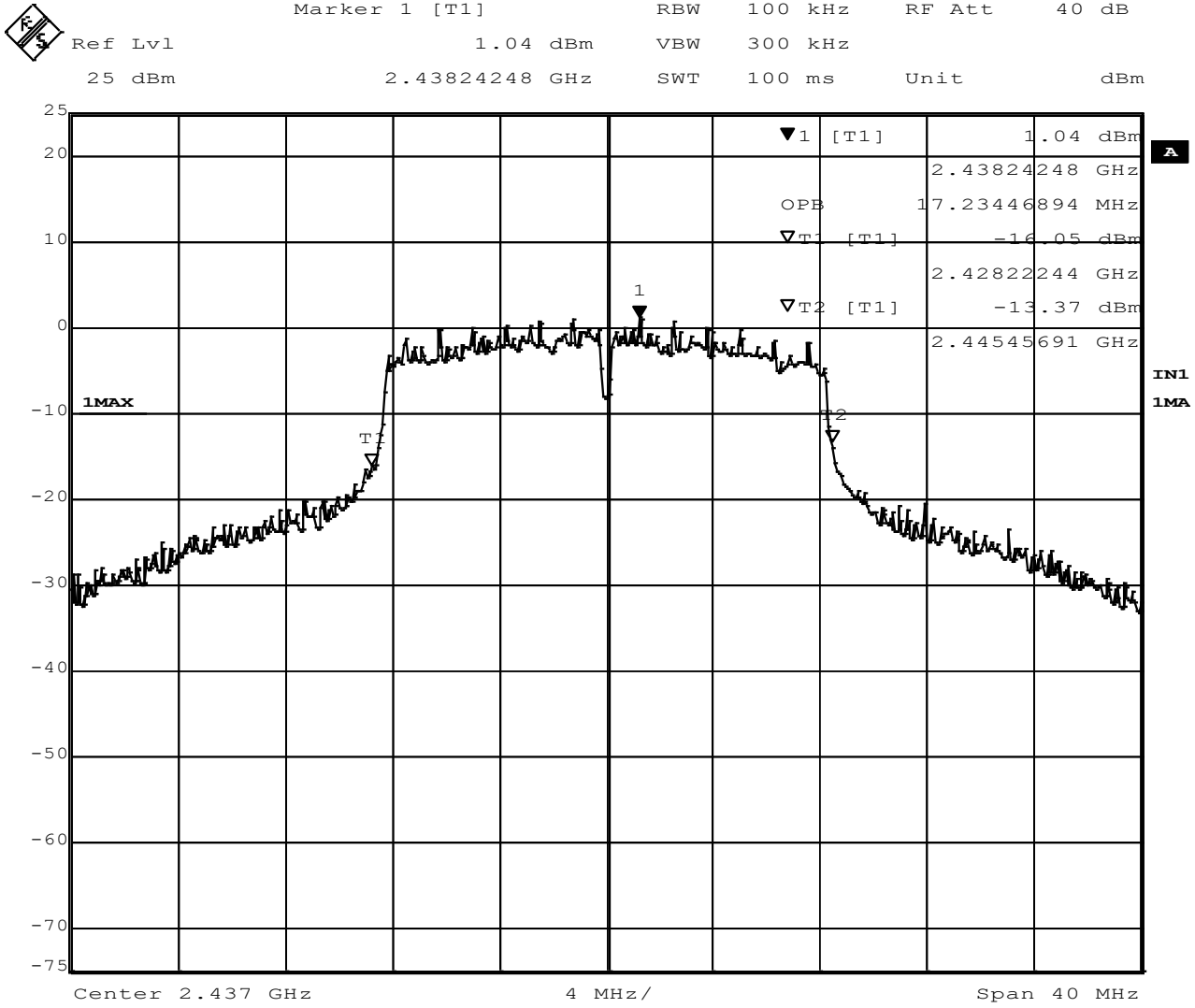



Figure 18 - 99% Occupied Bandwidth, Mid Channel, 802.11g



	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

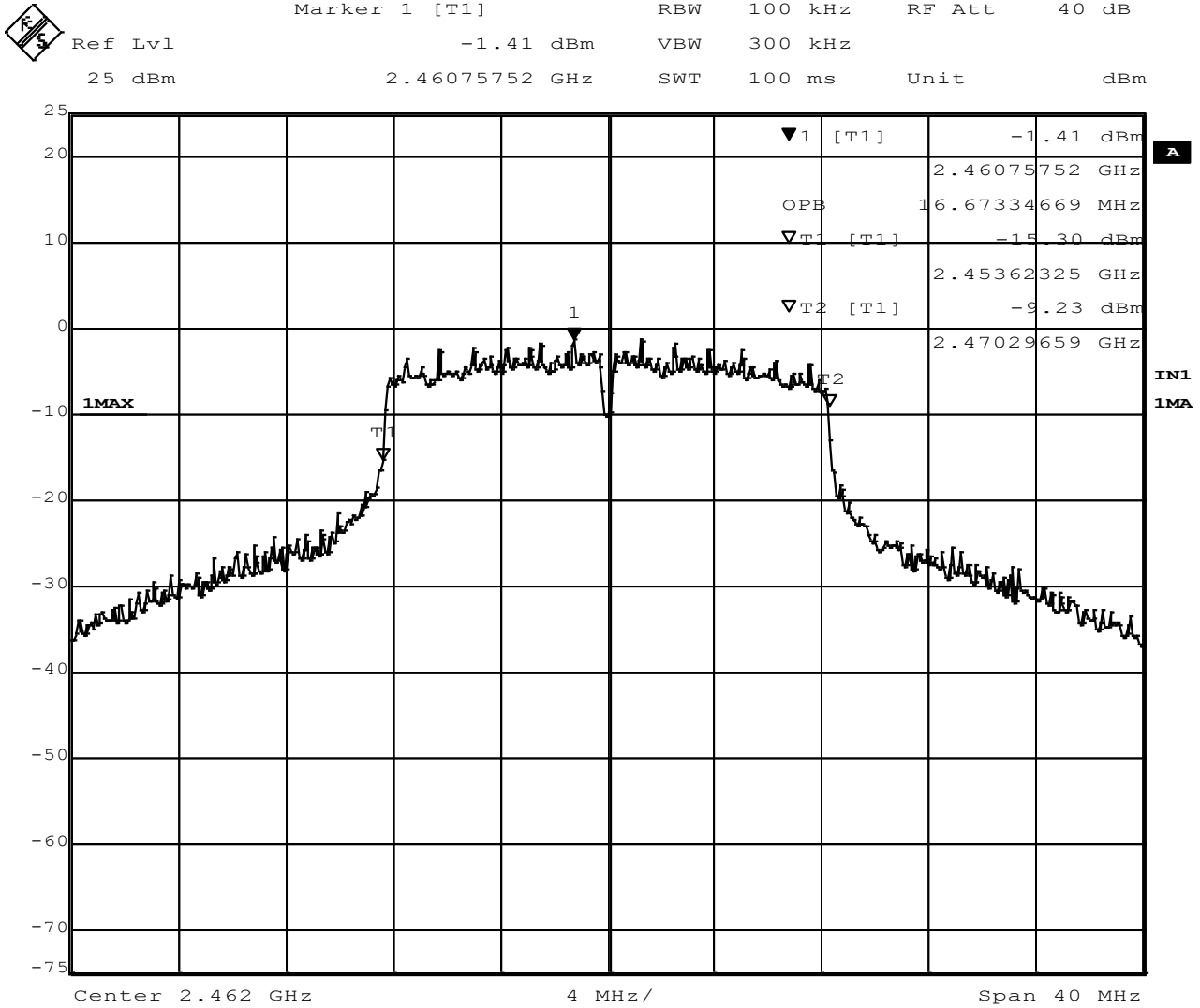



Figure 19 - 99% Occupied Bandwidth, High Channel, 802.11g

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

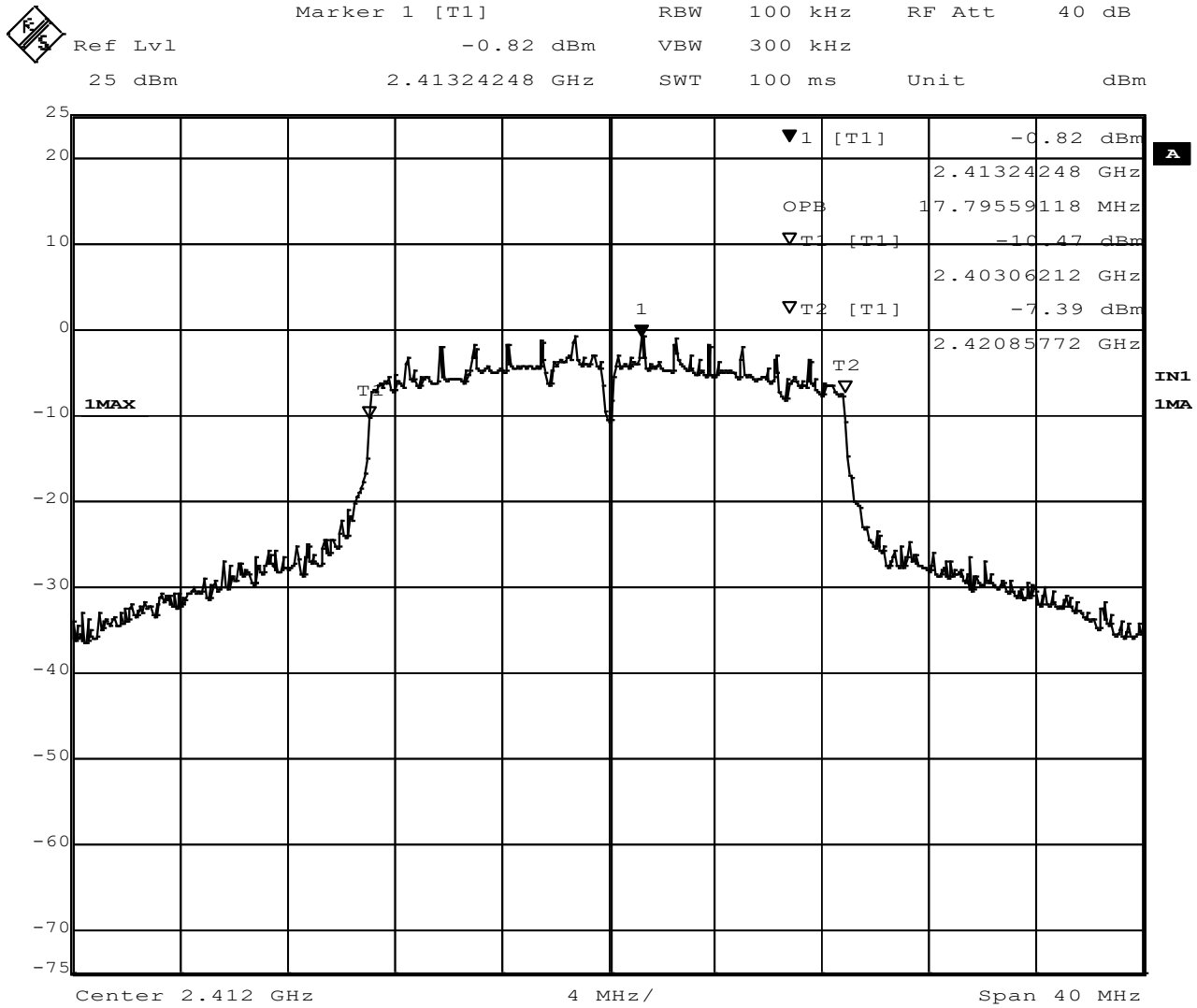



Figure 20 - 99% Occupied Bandwidth, Low Channel, 802.11n

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

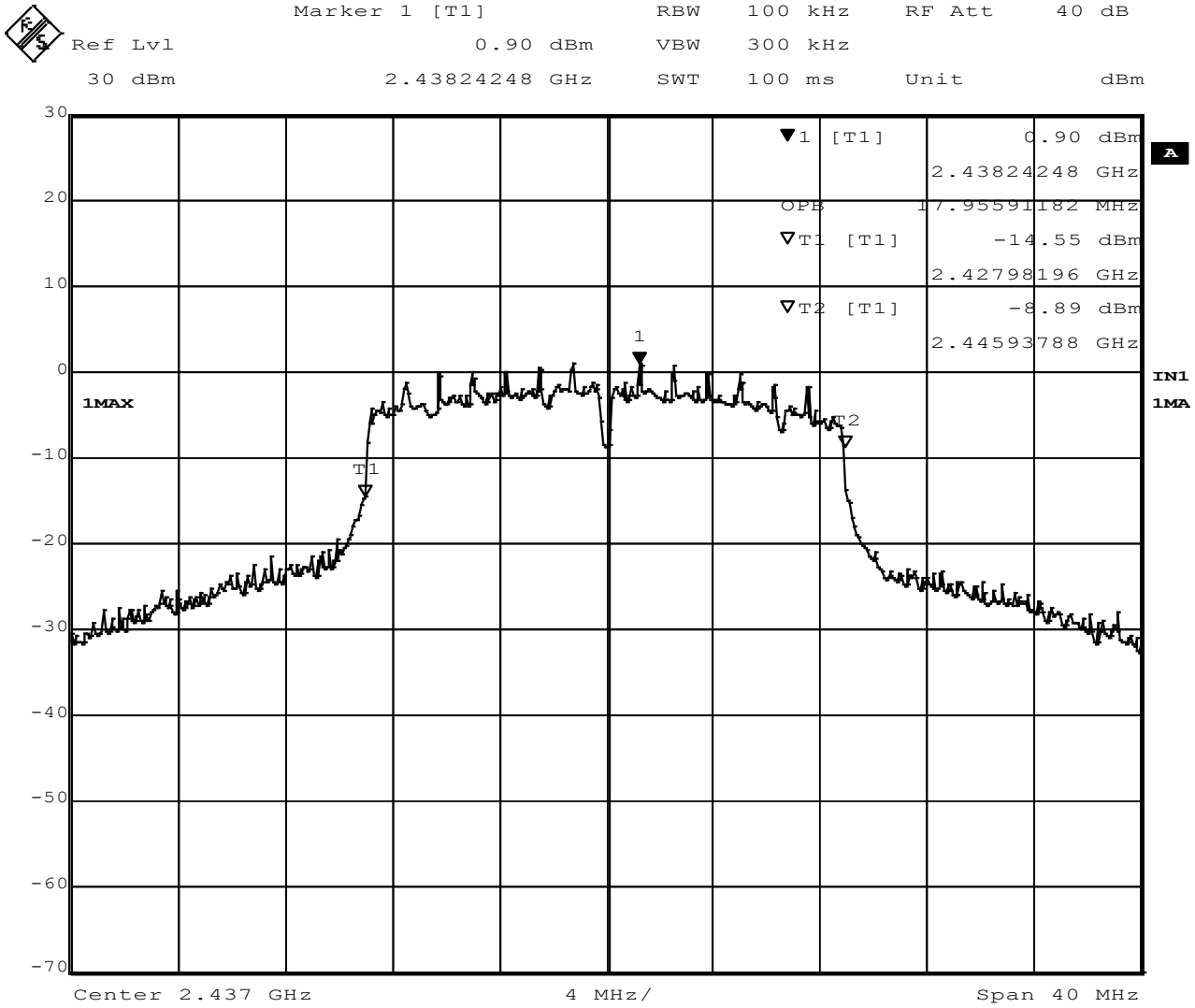



Figure 21 - 99% Occupied Bandwidth, Mid Channel, 802.11n

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

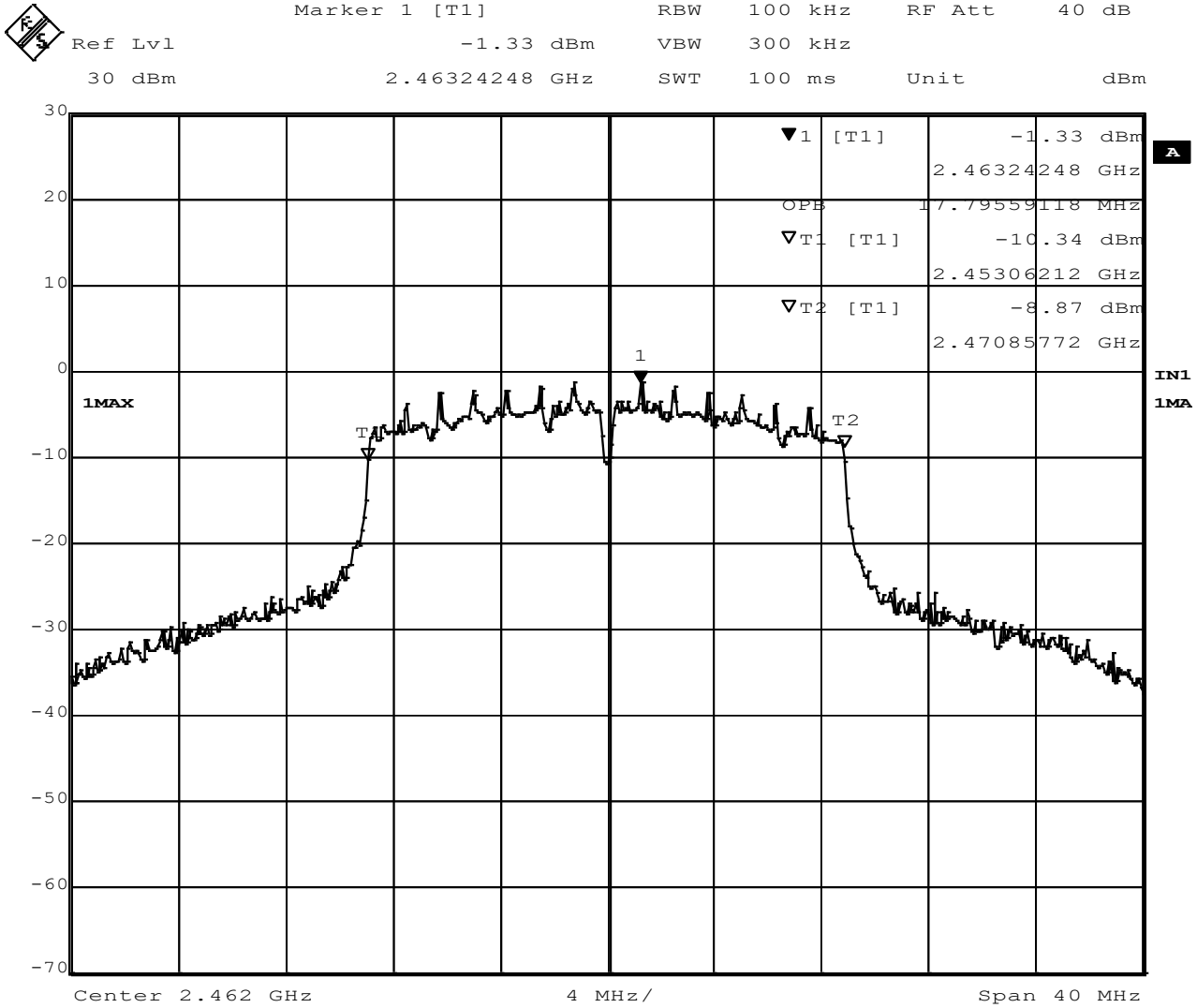


Figure 22 - 99% Occupied Bandwidth, High Channel, 802.11n

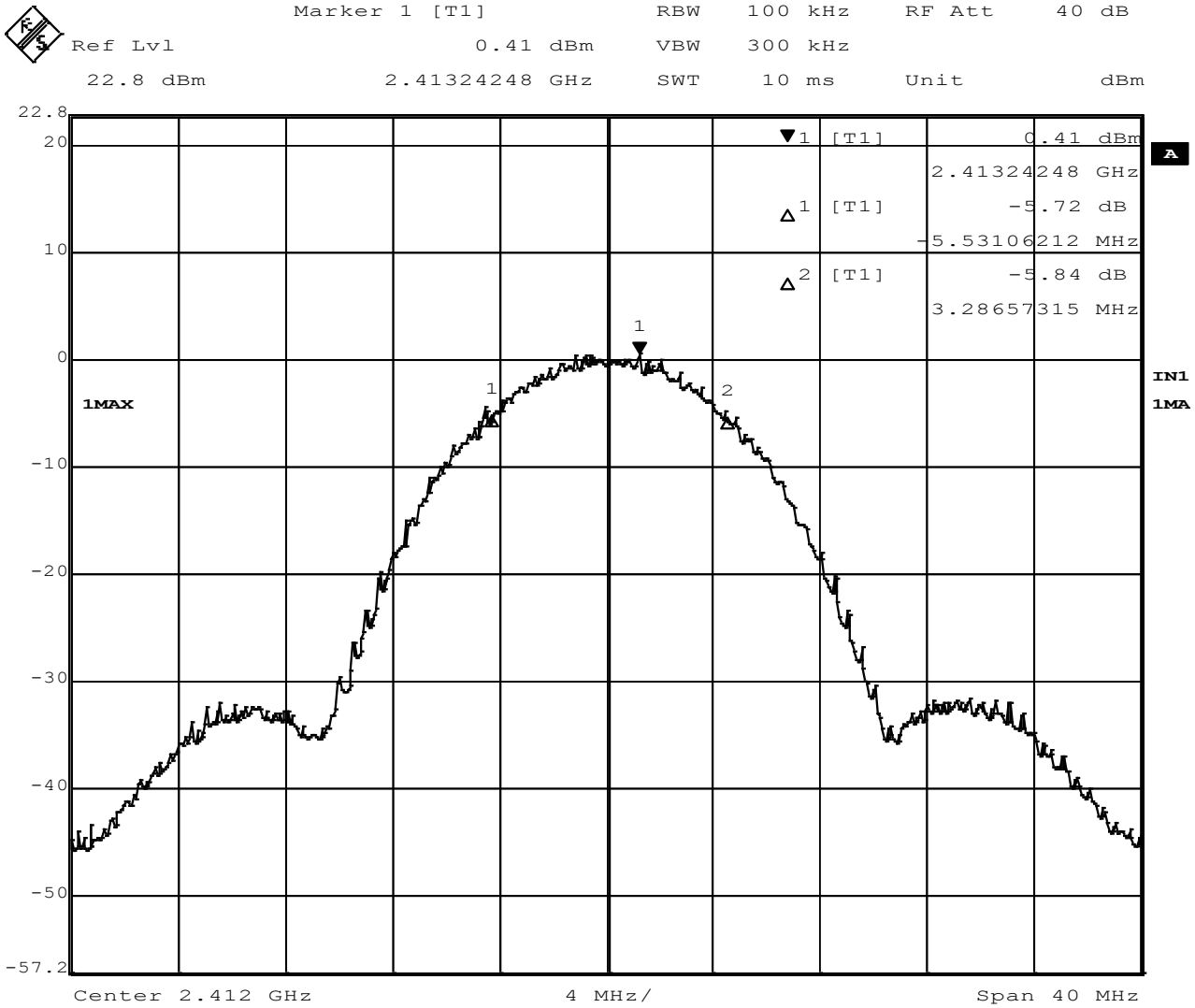



Figure 23 - 6dB Bandwidth, Low Channel, 802.11b

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

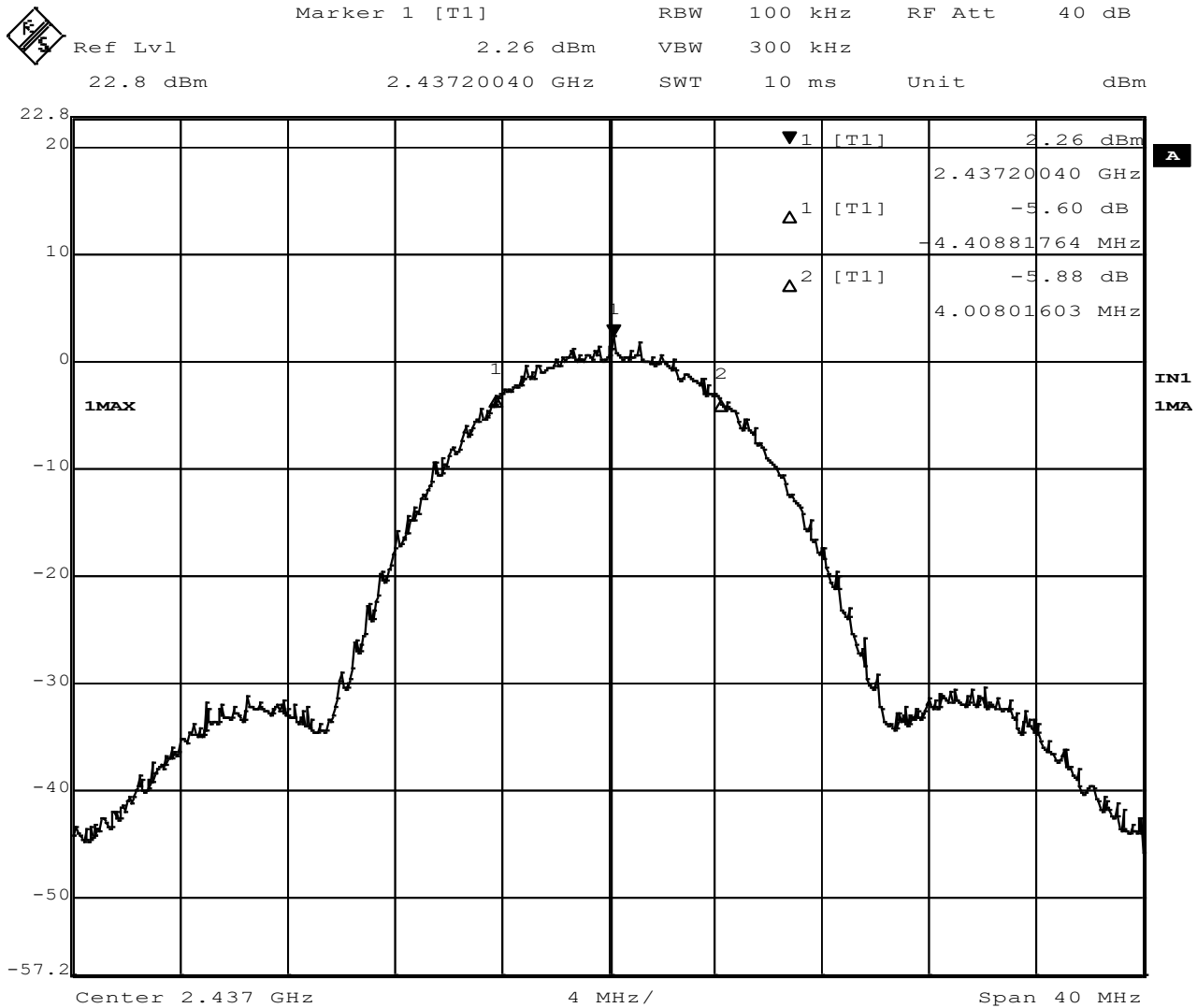



Figure 24 - 6dB Bandwidth, Mid Channel, 802.11b

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

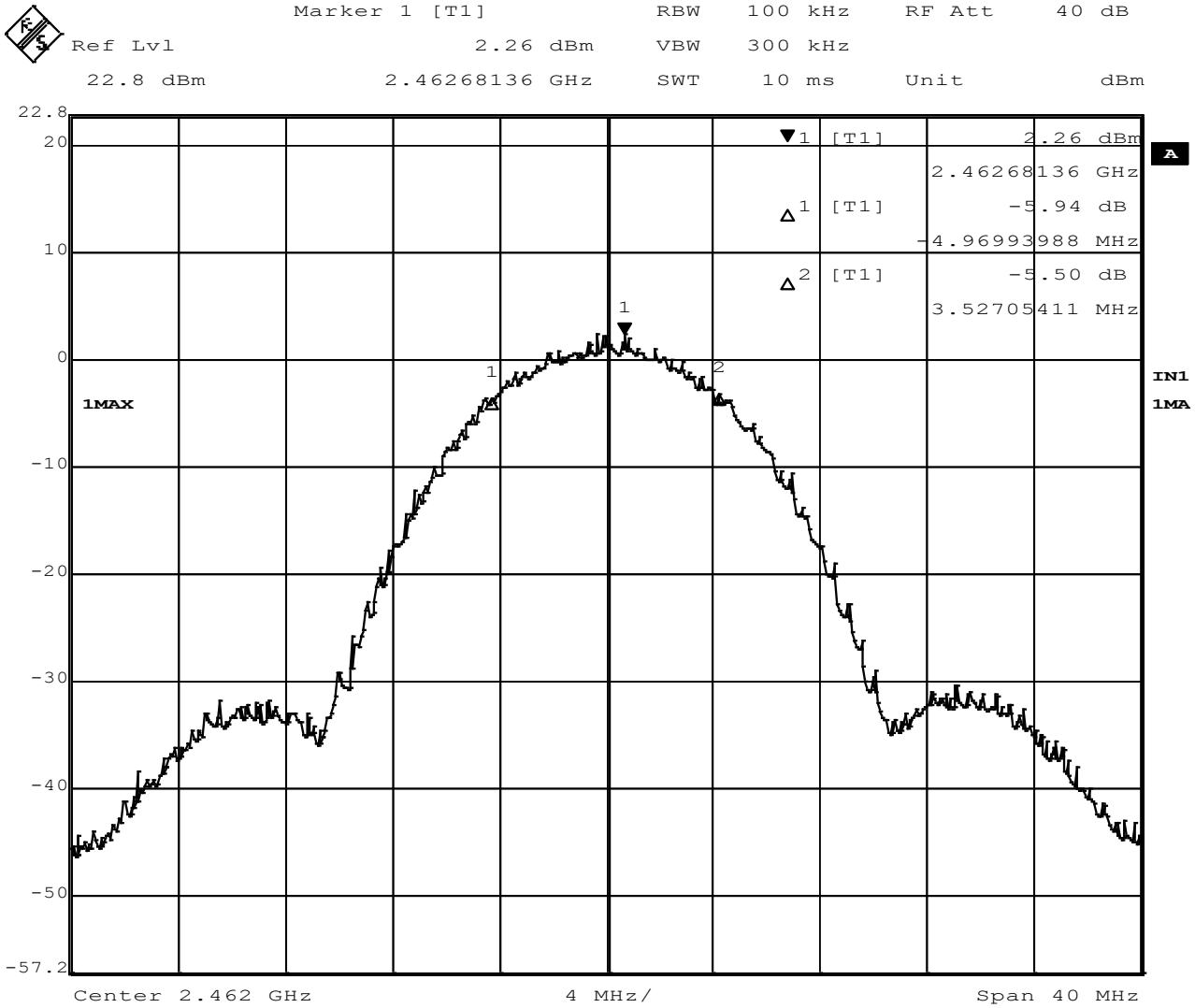


Figure 25 - 6dB Bandwidth, High Channel, 802.11b

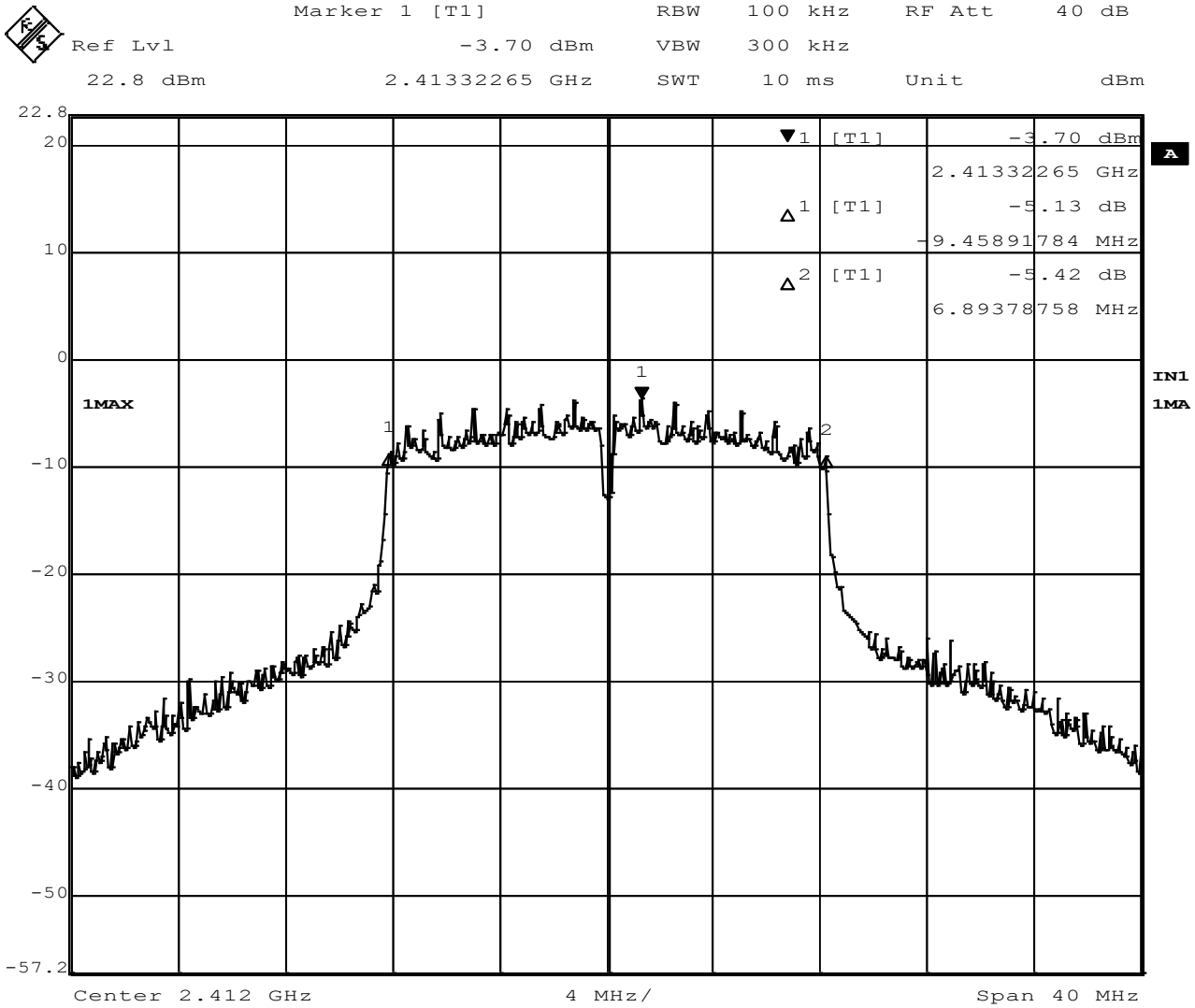



Figure 26 - 6dB Bandwidth, Low Channel, 802.11g



	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

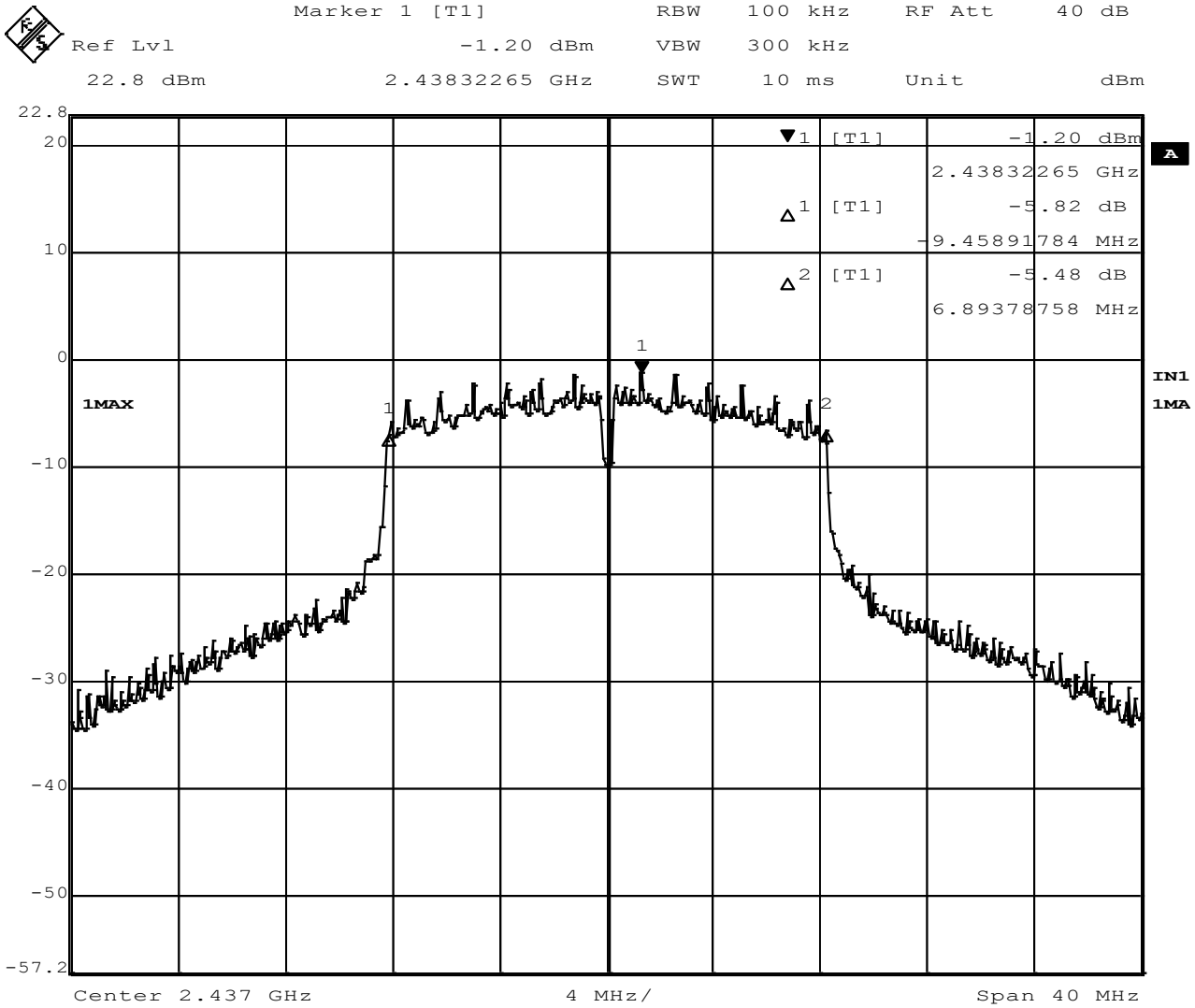


Figure 27 - 6dB Bandwidth, Mid Channel, 802.11g

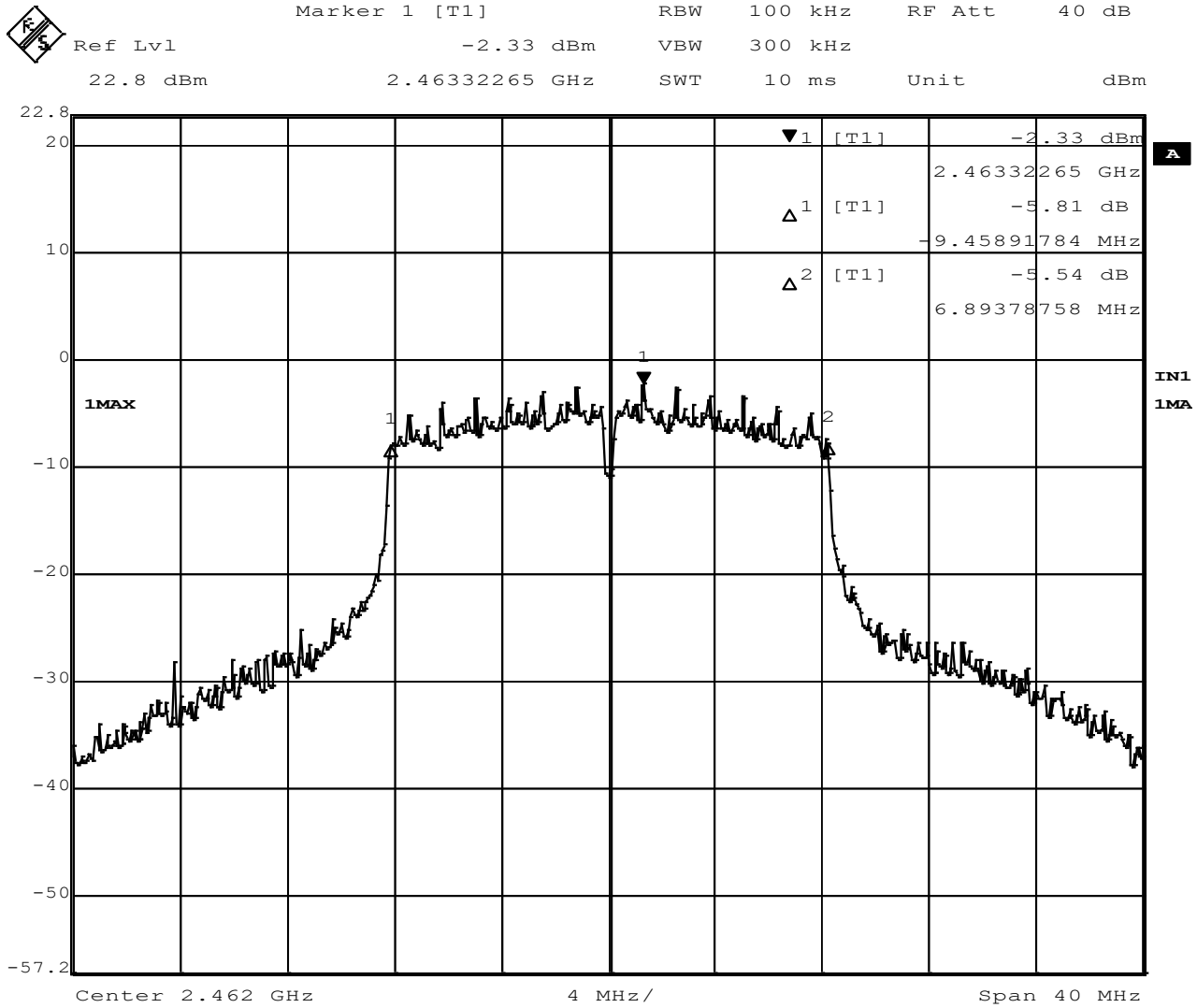



Figure 28 - 6dB Bandwidth, High Channel, 802.11g

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

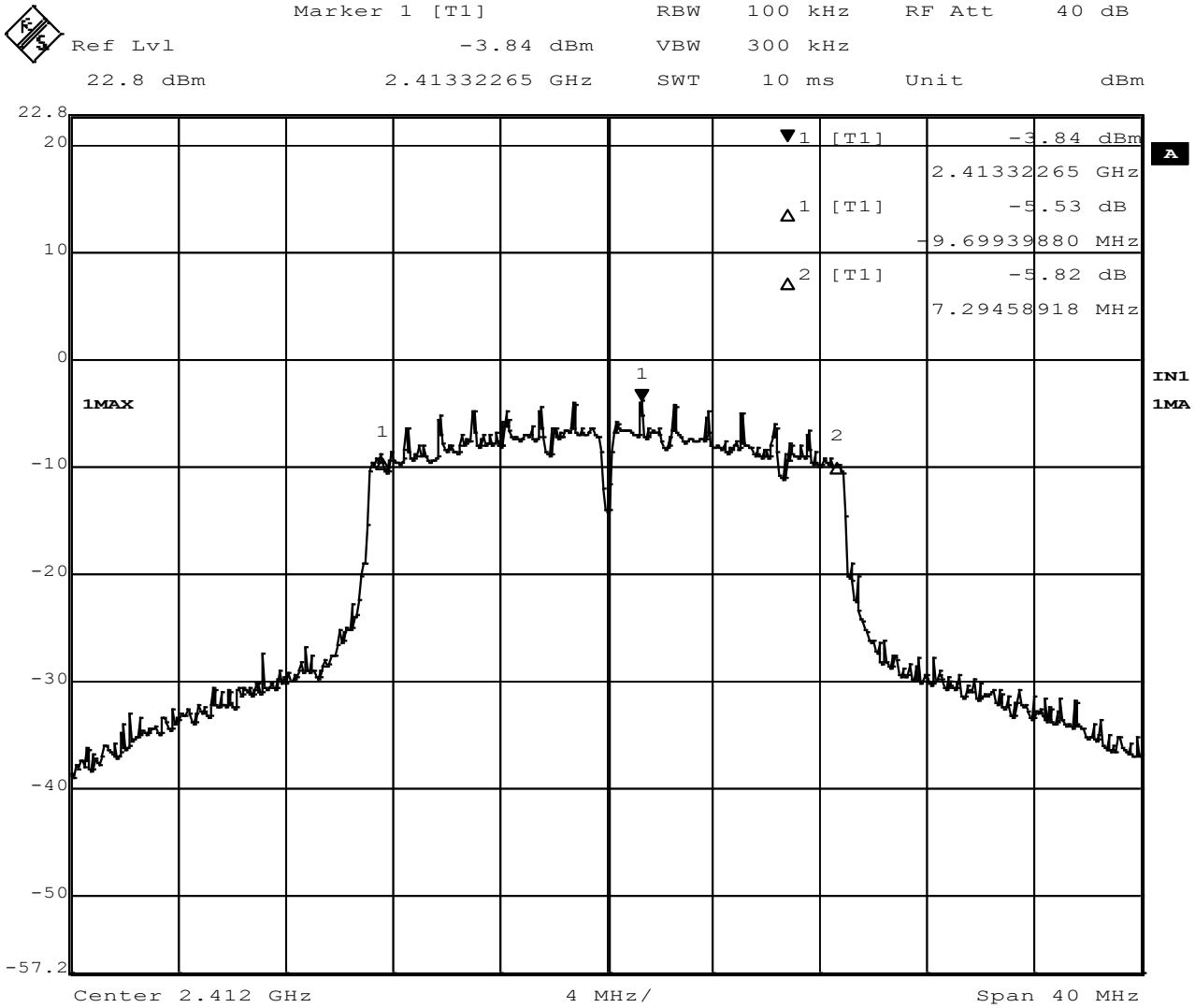



Figure 29 - 6dB Bandwidth, Low Channel, 802.11n

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

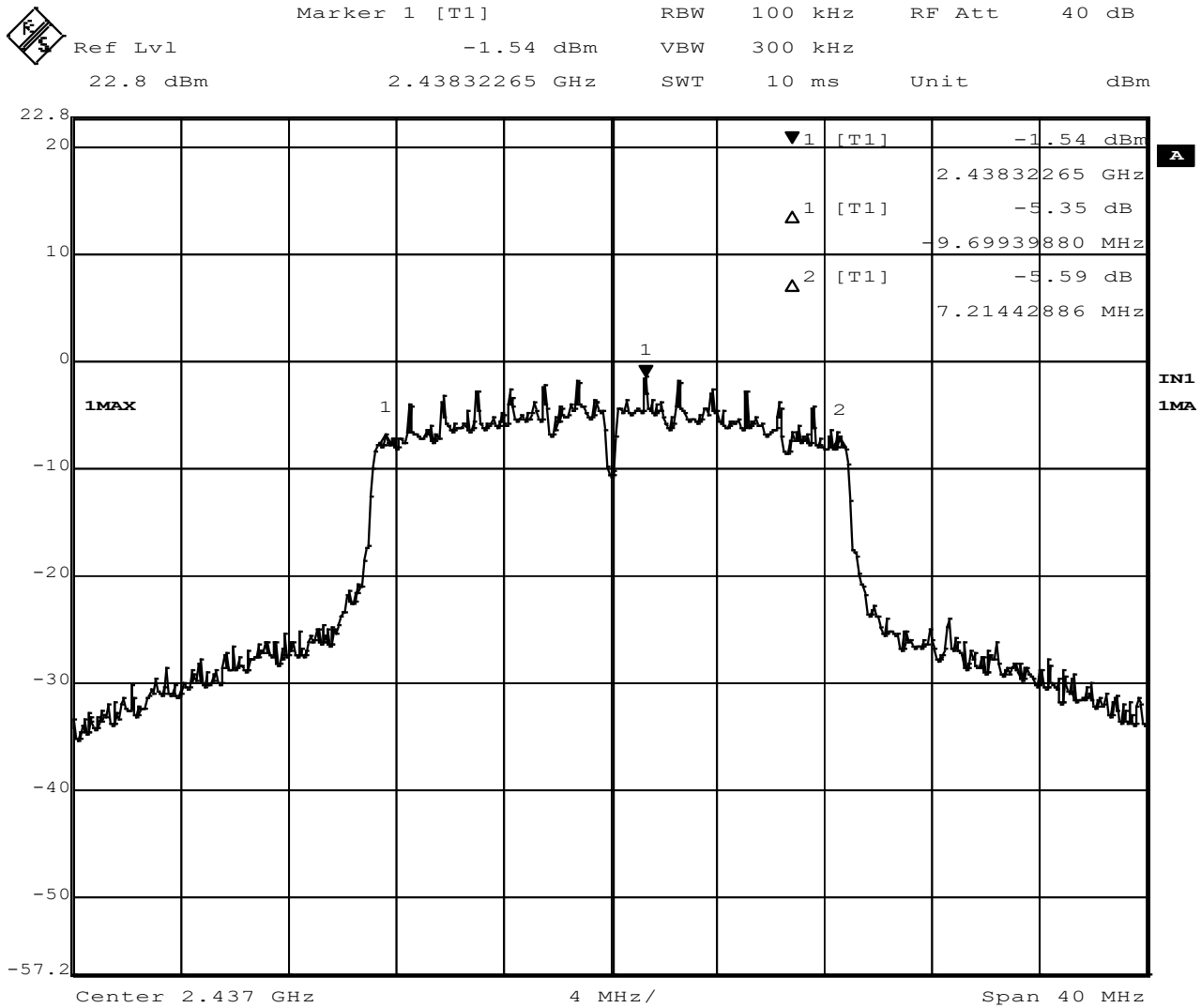


Figure 30 - 6dB Bandwidth, Mid Channel, 802.11n

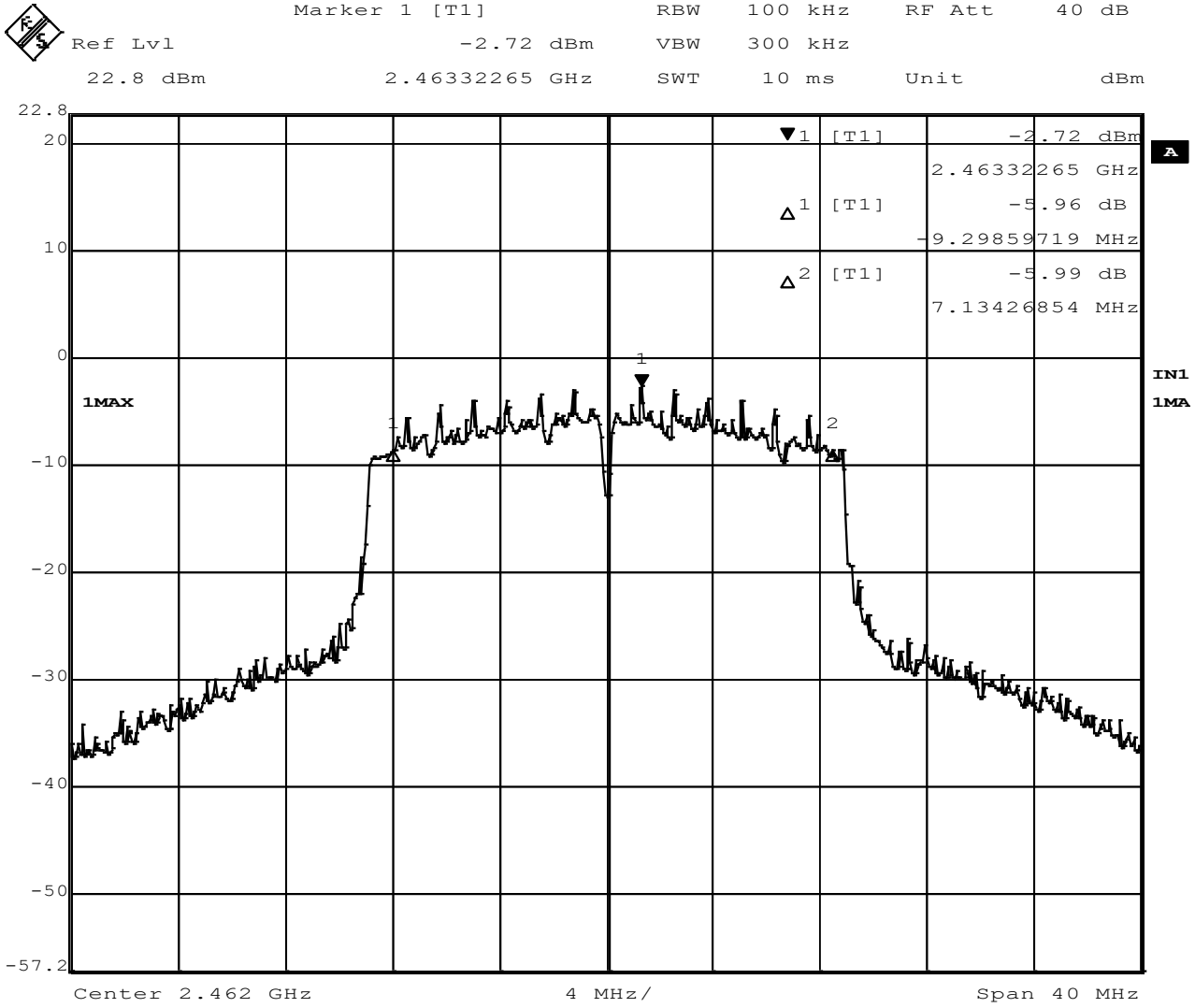



Figure 31 - 6dB Bandwidth, High Channel, 802.11n

	Report Number:	R20181130-20-02	Rev	D
	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:	R20181130-20-02	Rev	D
	Prepared for:	Garmin		

**Test results:**

Highest Out of Band Emissions, 802.11b


CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1	2390.0 (Unrestricted, Peak)	-30.19	3.24	33.43	20	PASS
1	2390.0 (Unrestricted, Average)	-36.72	-3.26	33.46	20	PASS
11	2483.5 (Unrestricted, Peak)	-58.12	2.51	60.63	20	PASS
11	2483.5 (Unrestricted, Average)	-65.57	-3.15	62.42	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Margin	Limit* (dBm)	Gain (dBi)	Result
1	2340.0 (Restricted, Peak)	-49.17	-49.17	27.94	-21.23	0.00	PASS
1	2340.0 (Restricted, Average)	-58.30	-58.30	17.07	-41.23	0.00	PASS
11	2483.5 (Restricted, Peak)	-53.28	-53.28	32.05	-21.23	0.00	PASS
11	2483.5 (Restricted, Average)	-58.98	-58.98	17.75	-41.23	0.00	PASS

Corrected Emission level= Highest out of band level +Gain

Margin= Limit-Corrected Emission Level

\*Limits from Part 15.209 in dBm \*\*Antenna gain declared by the manufacturer

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

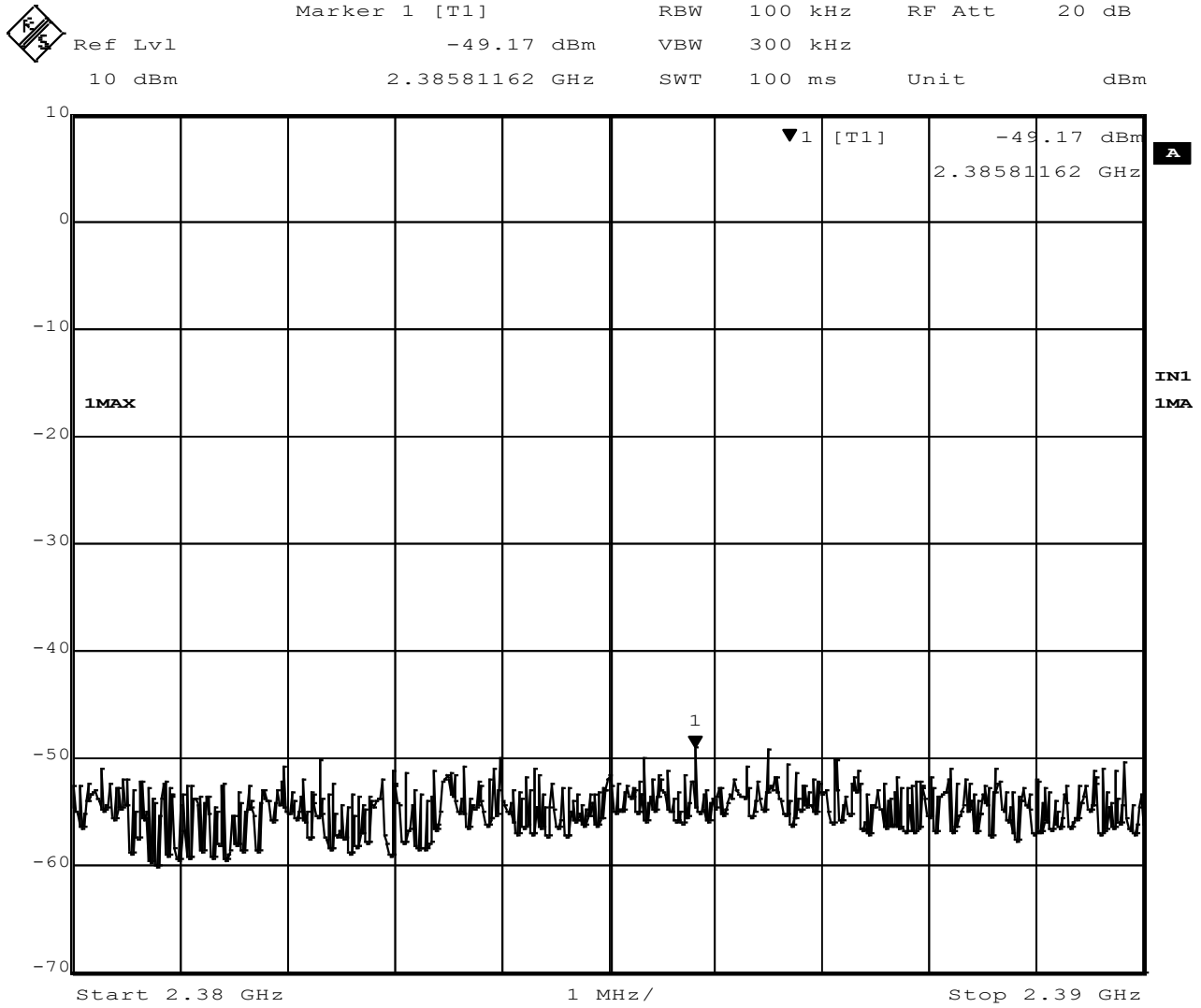



Figure 32 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak



	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

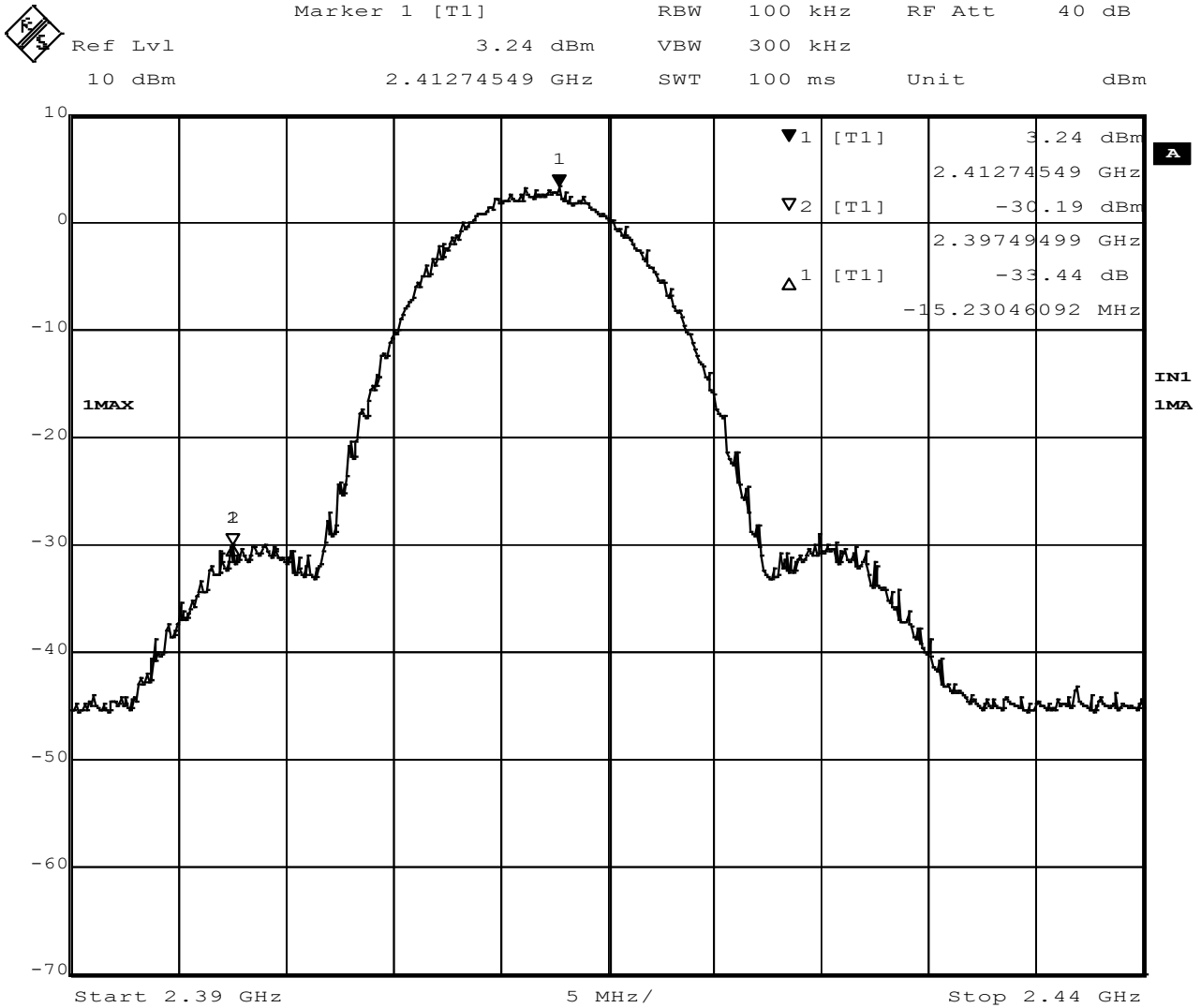



Figure 33 - Band-edge Measurement, Low Channel, Fundamental, Peak

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

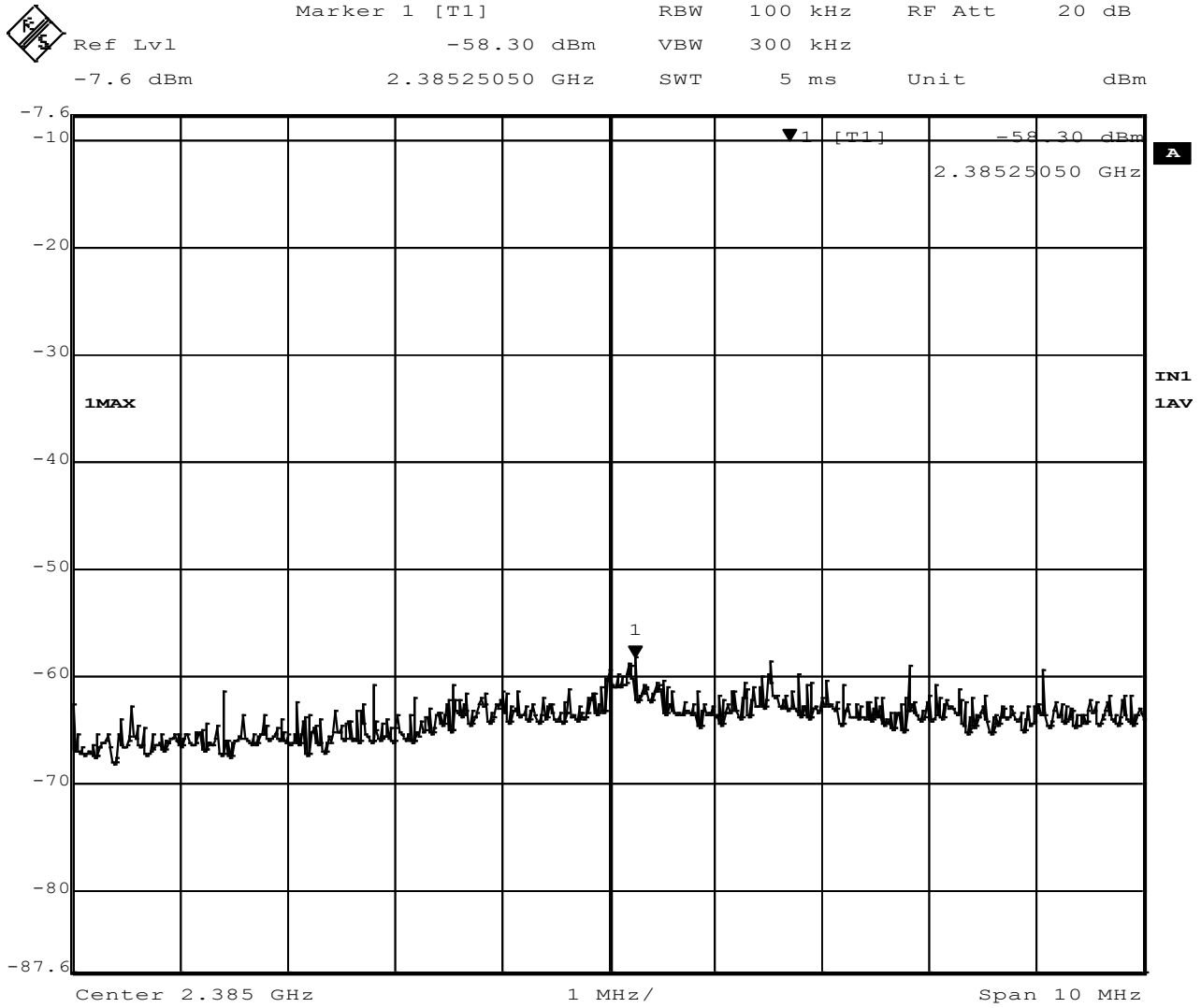


Figure 34 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

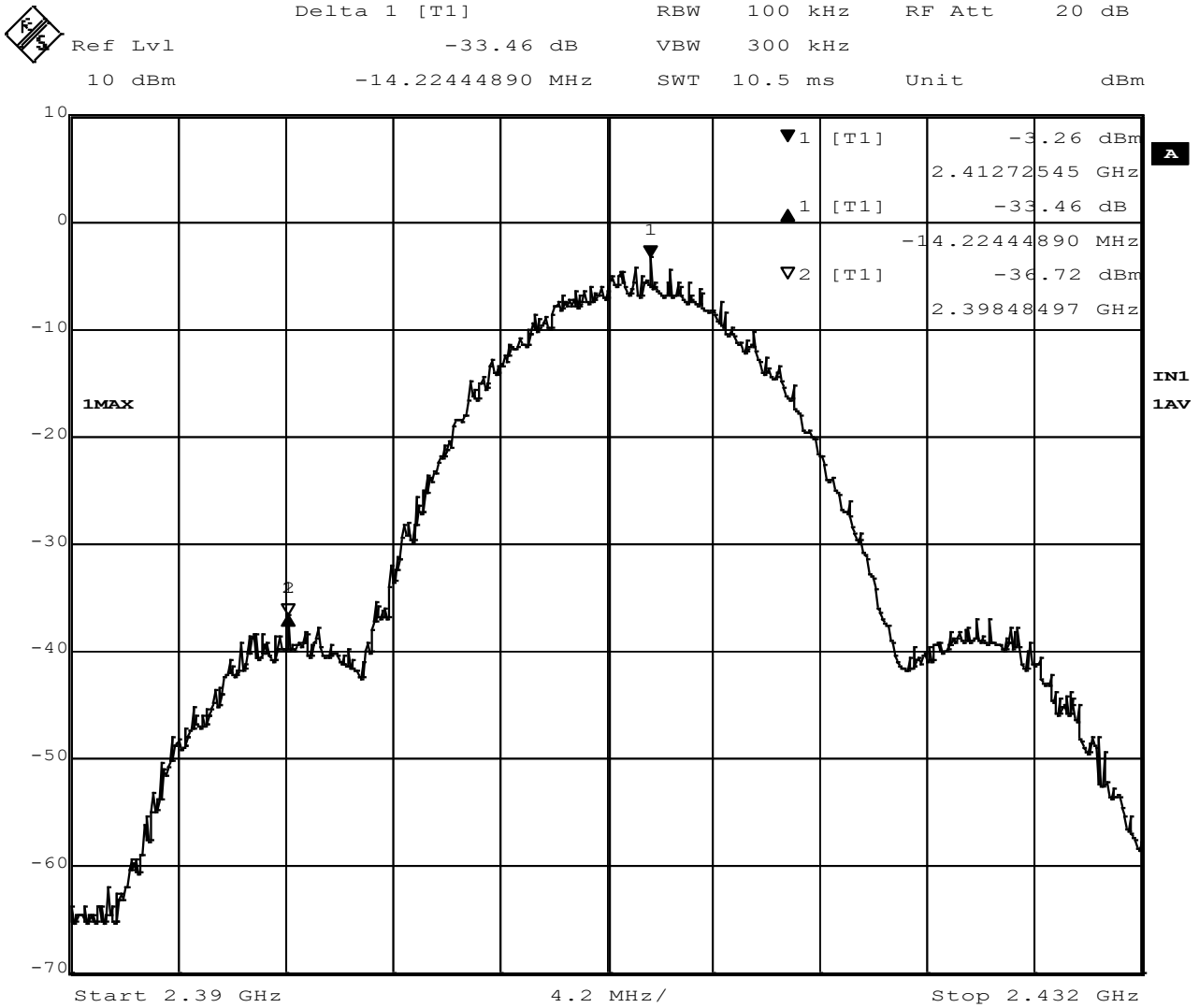



Figure 35 - Band-edge Measurement, Low Channel, Fundamental, Average

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

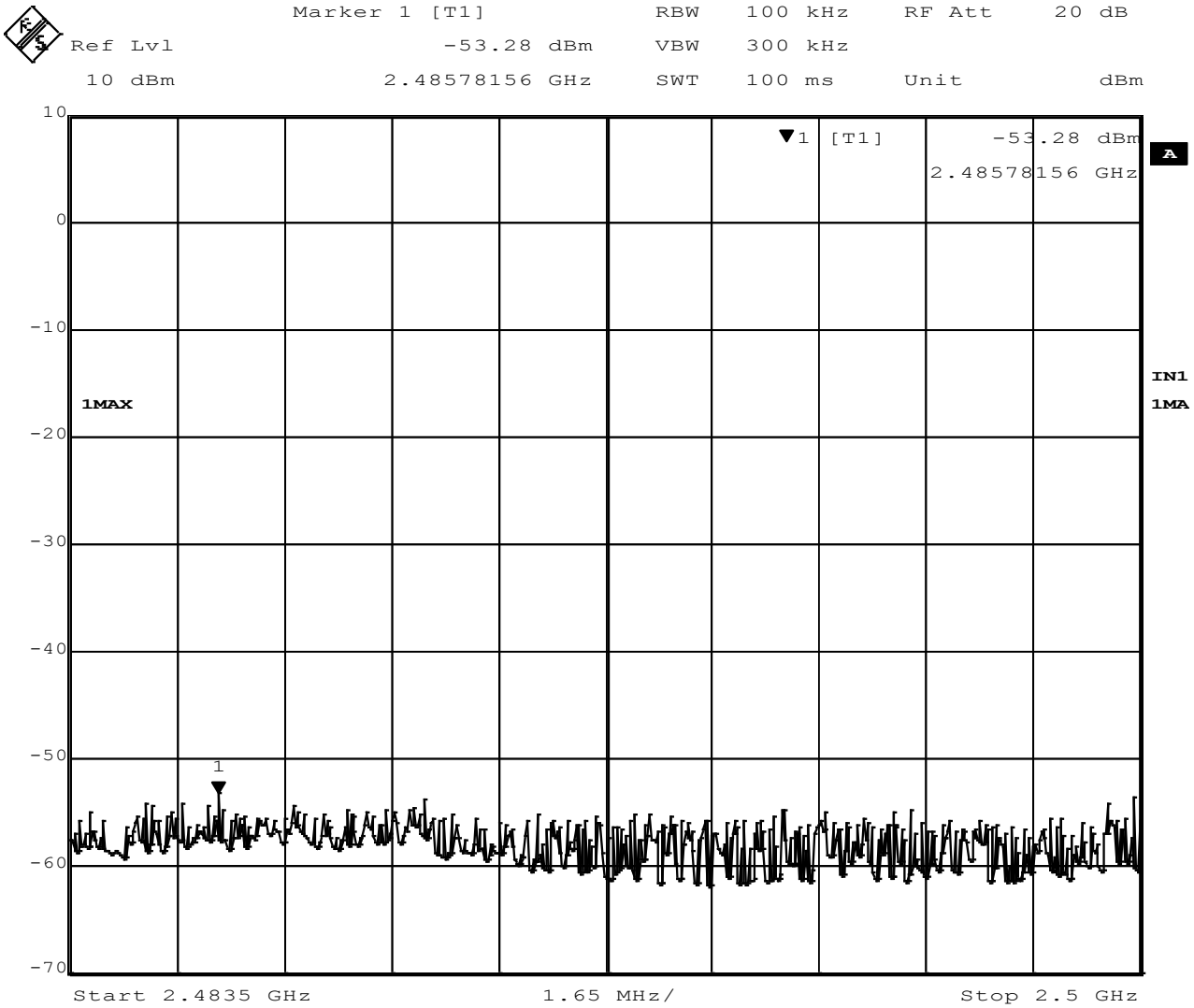


Figure 36 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

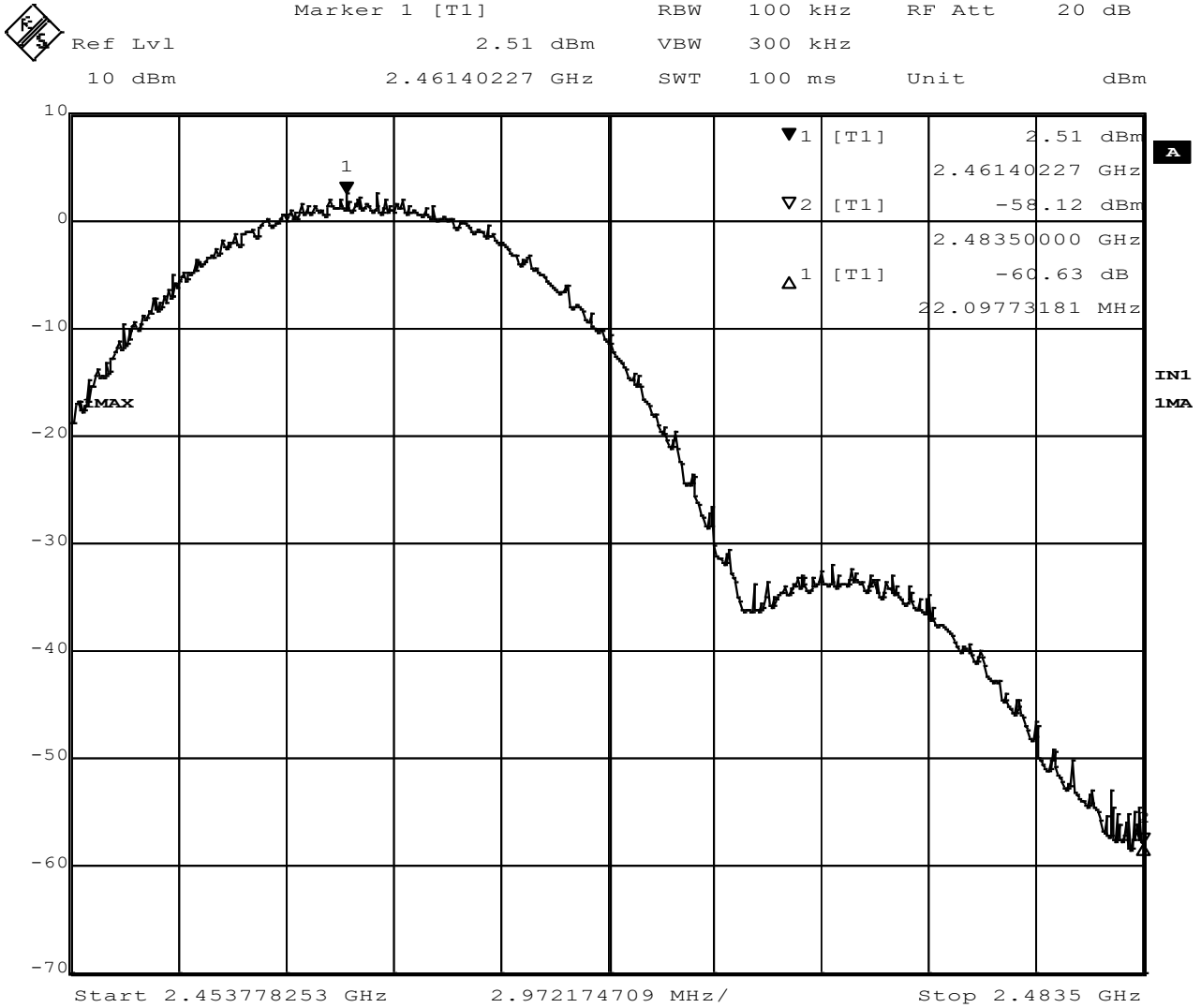



Figure 37 - Band-edge Measurement, High Channel, Fundamental, Peak

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

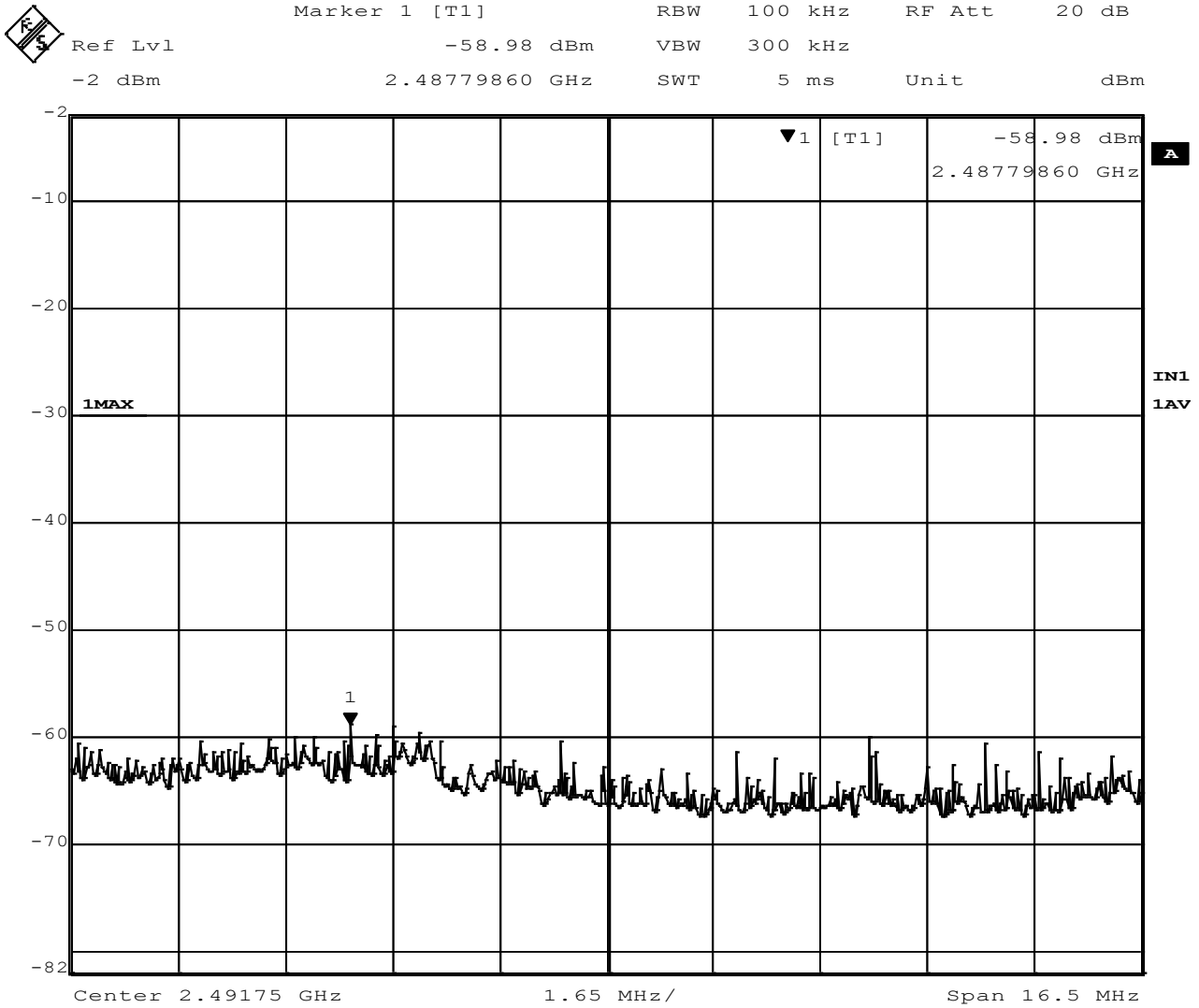


Figure 38 - Band-edge Measurement, High Channel, Restricted Frequency, Average

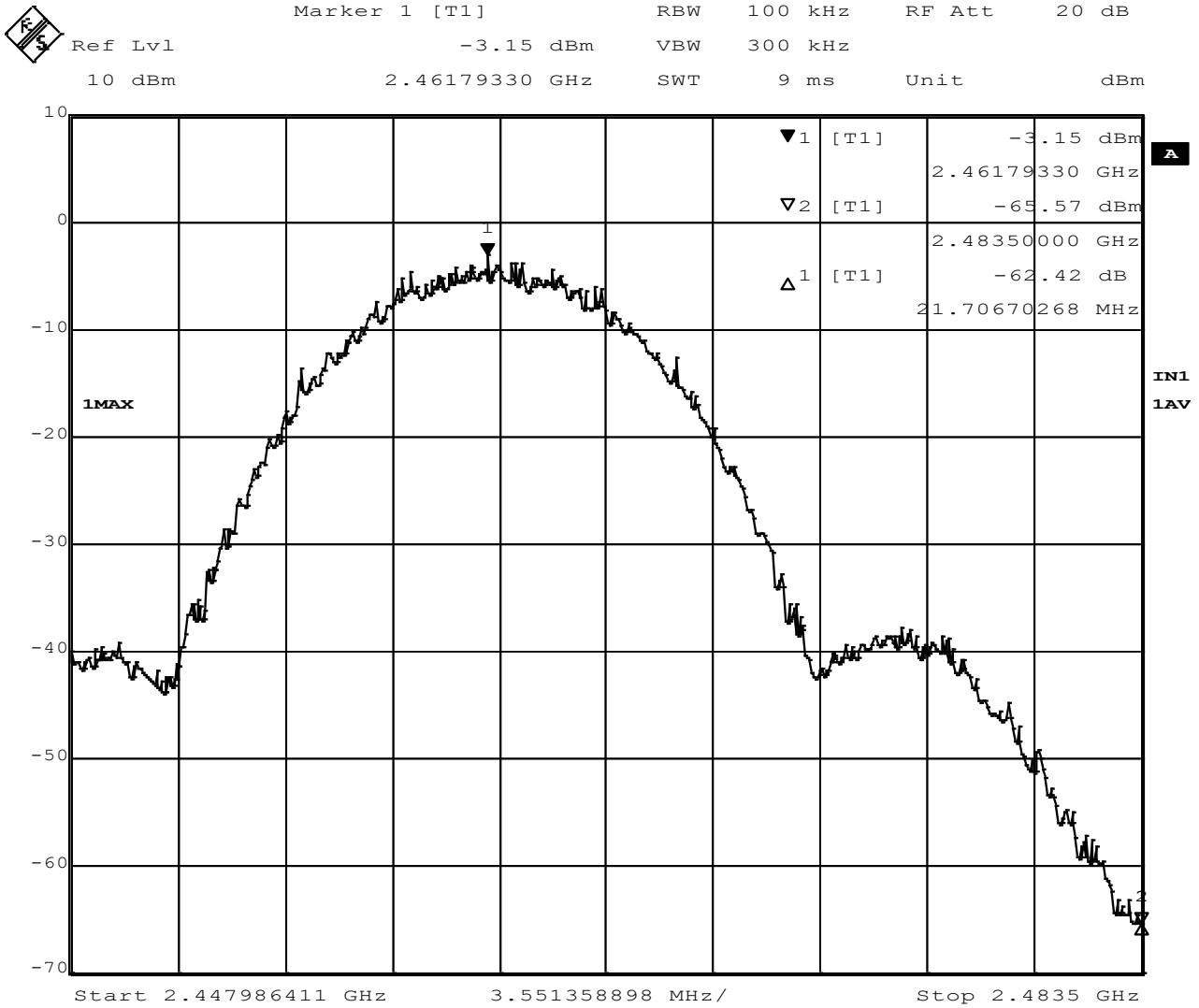



Figure 39 - Band-edge Measurement, High Channel, Fundamental, Average

	Report Number:	R20181130-20-02	Rev	D
	Prepared for:	Garmin		

Highest Out of Band Emissions, 802.11g

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1	2390.0 (Unrestricted, Peak)	-24.59	-0.75	23.84	20	PASS
1	2390.0 (Unrestricted, Average)	-44.47	-17.41	27.06	20	PASS
11	2483.5 (Unrestricted, Peak)	-41.60	-1.82	39.78	20	PASS
11	2483.5 (Unrestricted, Average)	-56.09	-16.22	39.87	20	PASS


CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Margin	Limit* (dBm)	Gain (dBi)	Result
1	2340.0 (Restricted, Peak)	-39.81	-39.81	18.58	-21.23	0.00	PASS
1	2340.0 (Restricted, Average)	-59.47	-59.47	18.24	-41.23	0.00	PASS
11	2483.5 (Restricted, Peak)	-41.13	-41.13	19.9	-21.23	0.00	PASS
11	2483.5 (Restricted, Average)	-54.70	-54.70	13.47	-41.23	0.00	PASS

Corrected Emission level= Highest out of band level +Gain

Margin= Limit-Corrected Emission Level

\*Limits from Part 15.209 in dBm \*\*Antenna gain declared by the manufacturer



	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

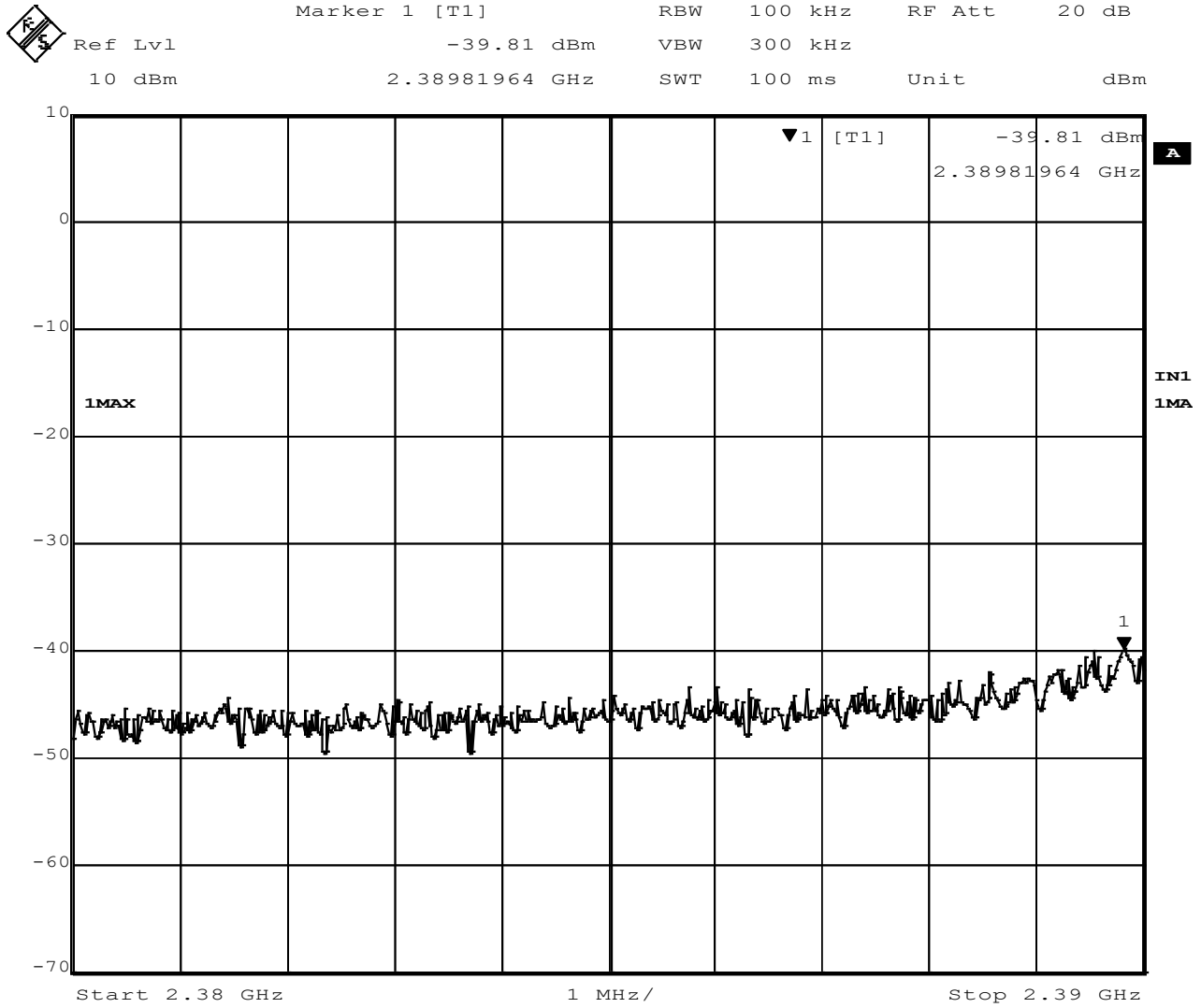



Figure 40 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

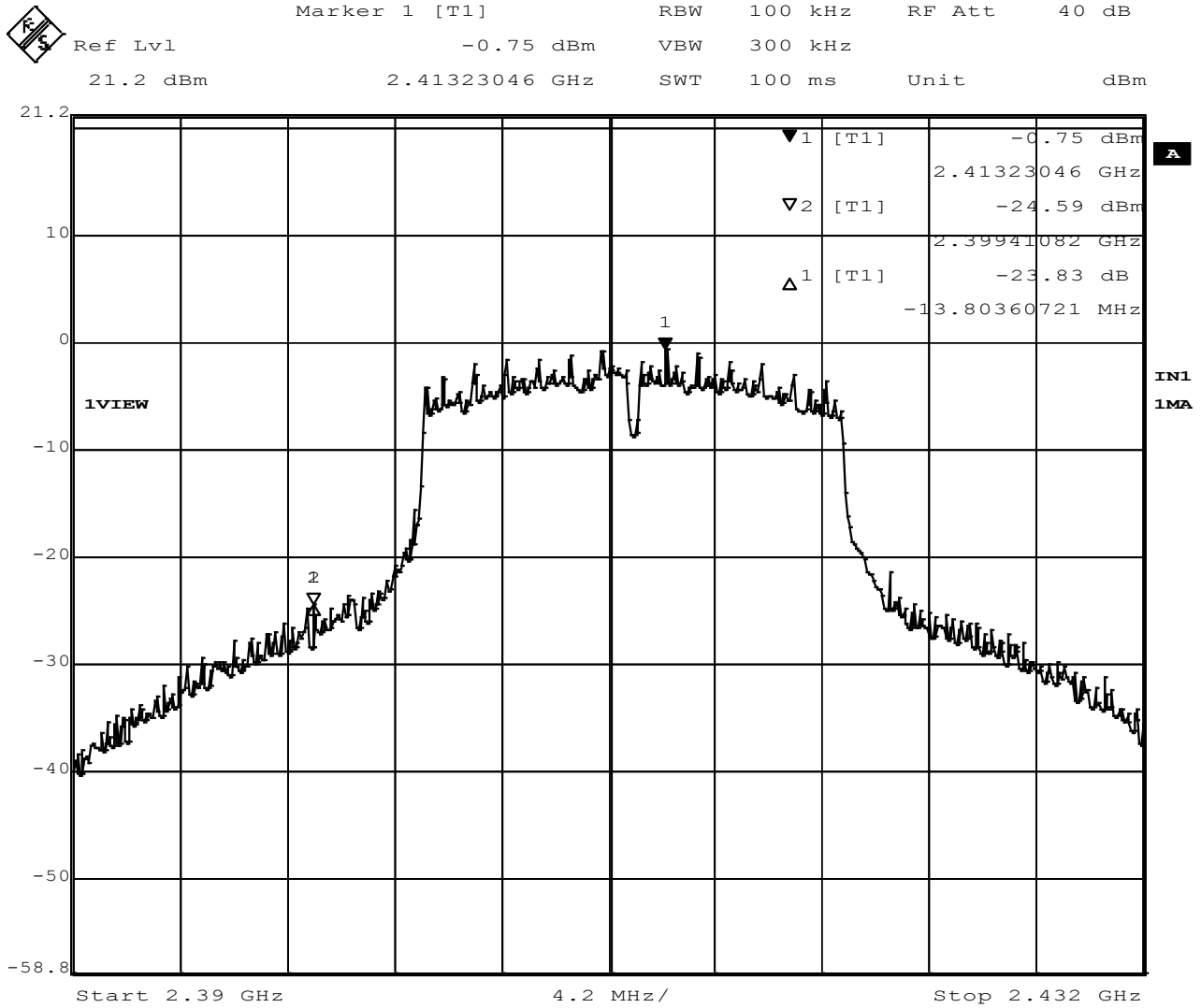



Figure 41 - Band-edge Measurement, Low Channel, Fundamental, Peak

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

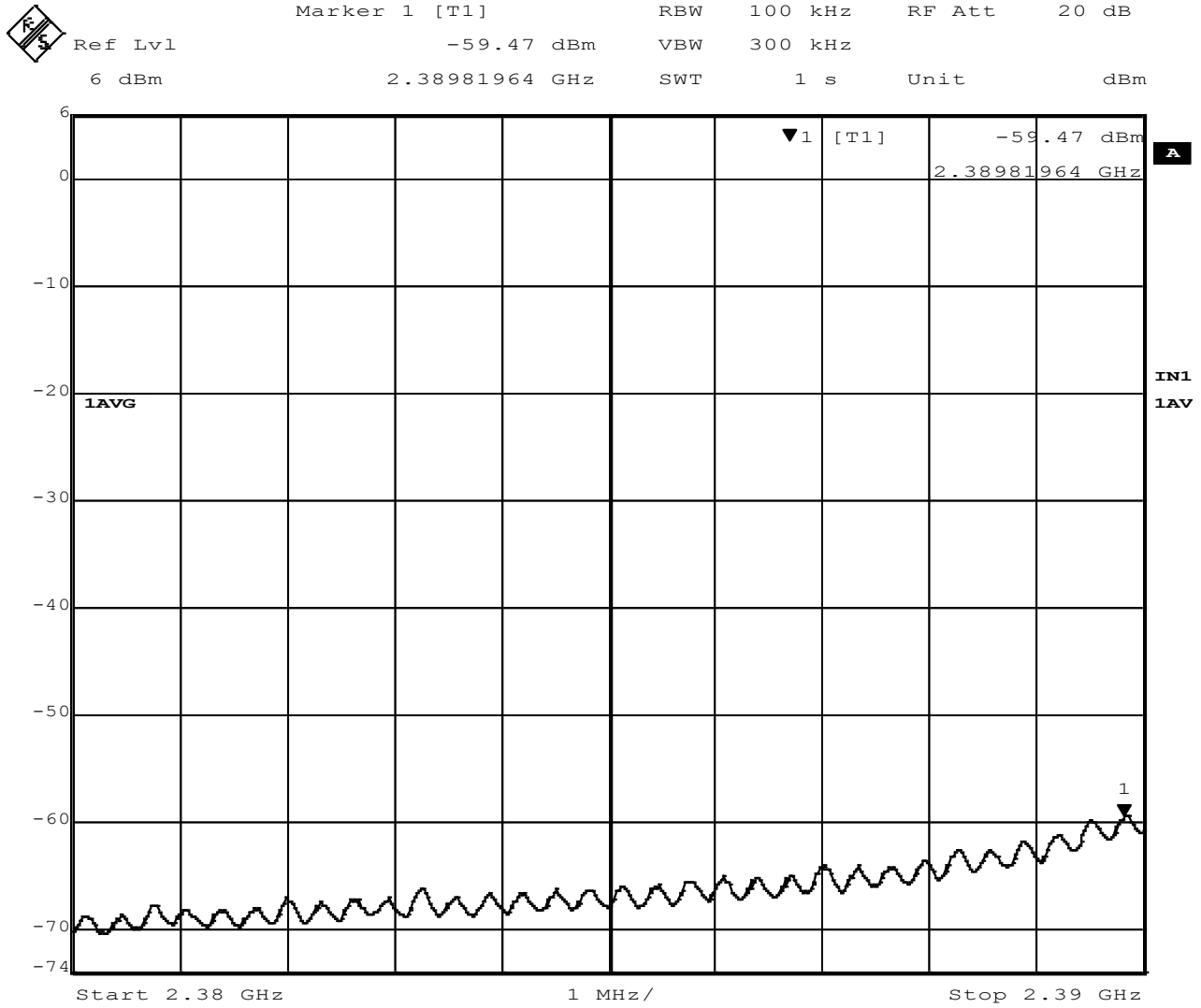



Figure 42 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

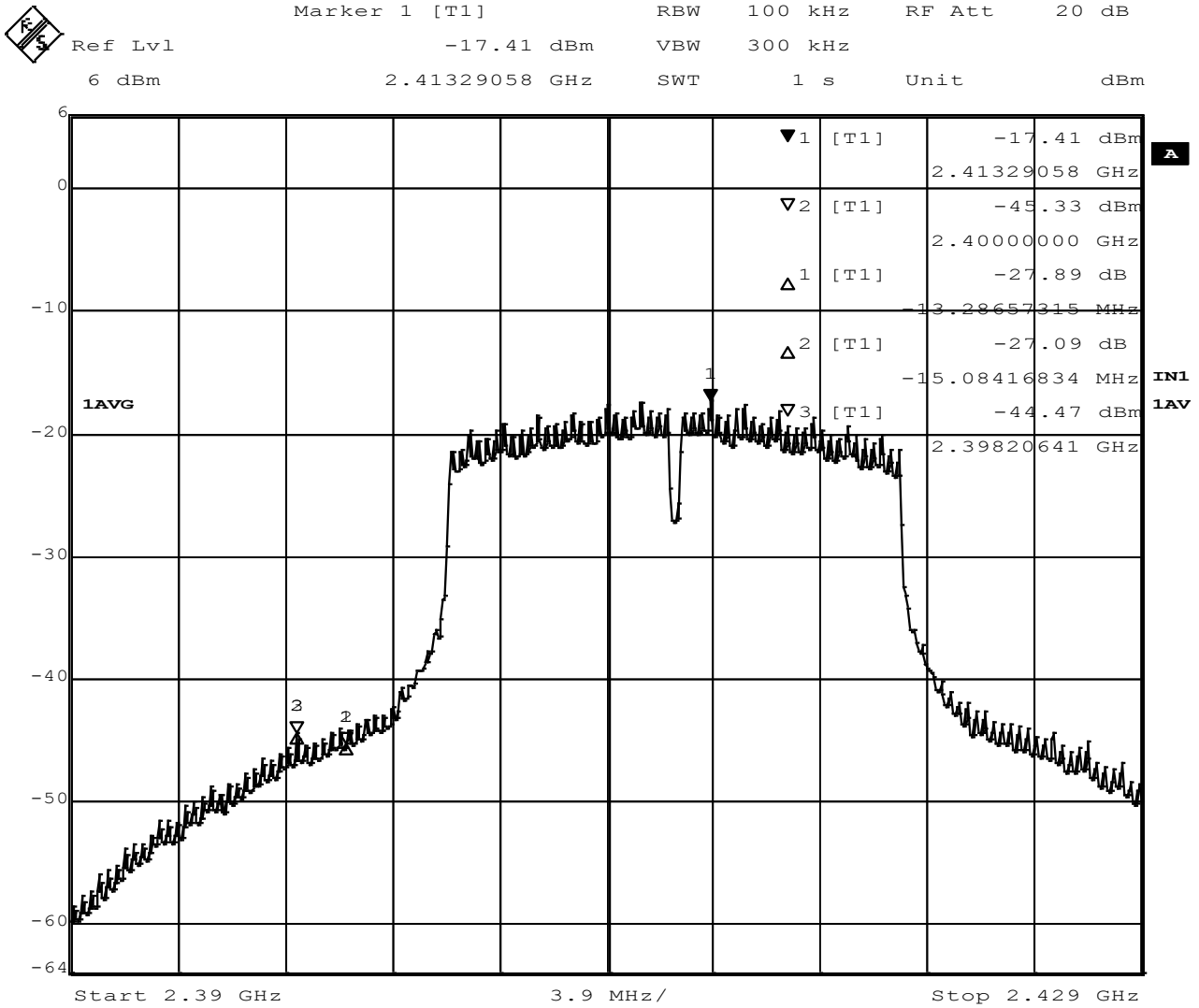



Figure 43 - Band-edge Measurement, Low Channel, Fundamental, Average

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

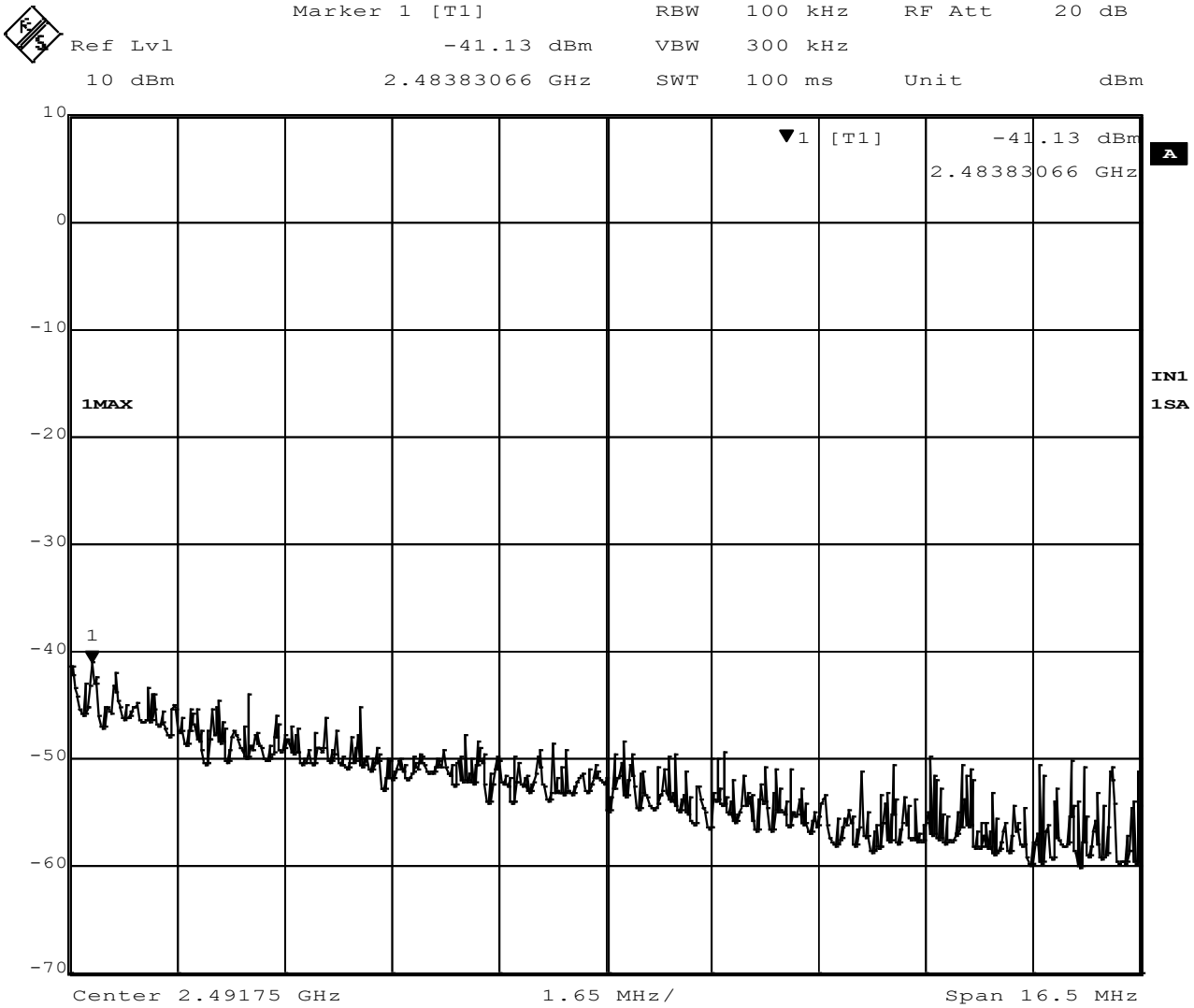



Figure 44 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

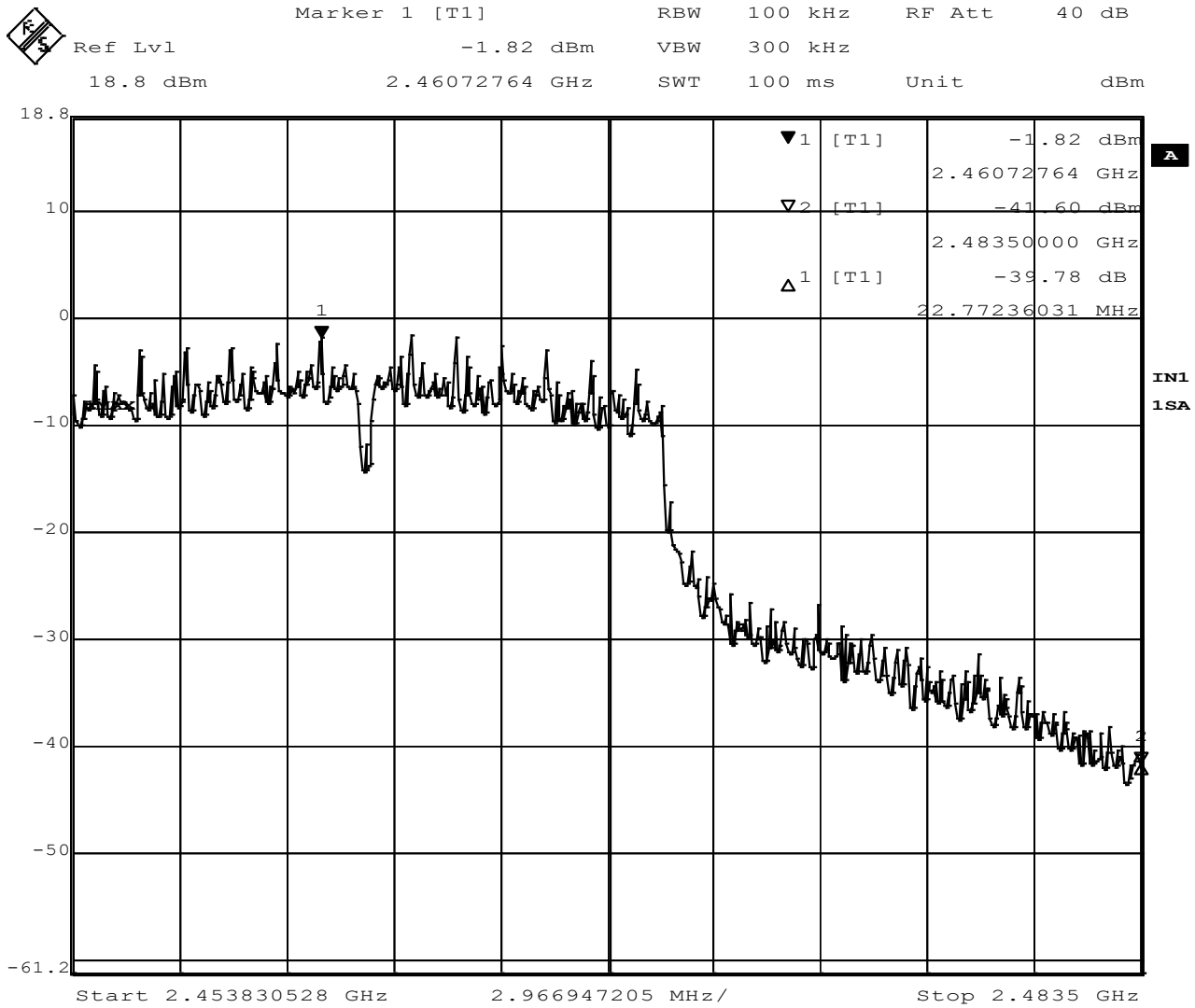



Figure 45 - Band-edge Measurement, High Channel, Fundamental, Peak

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

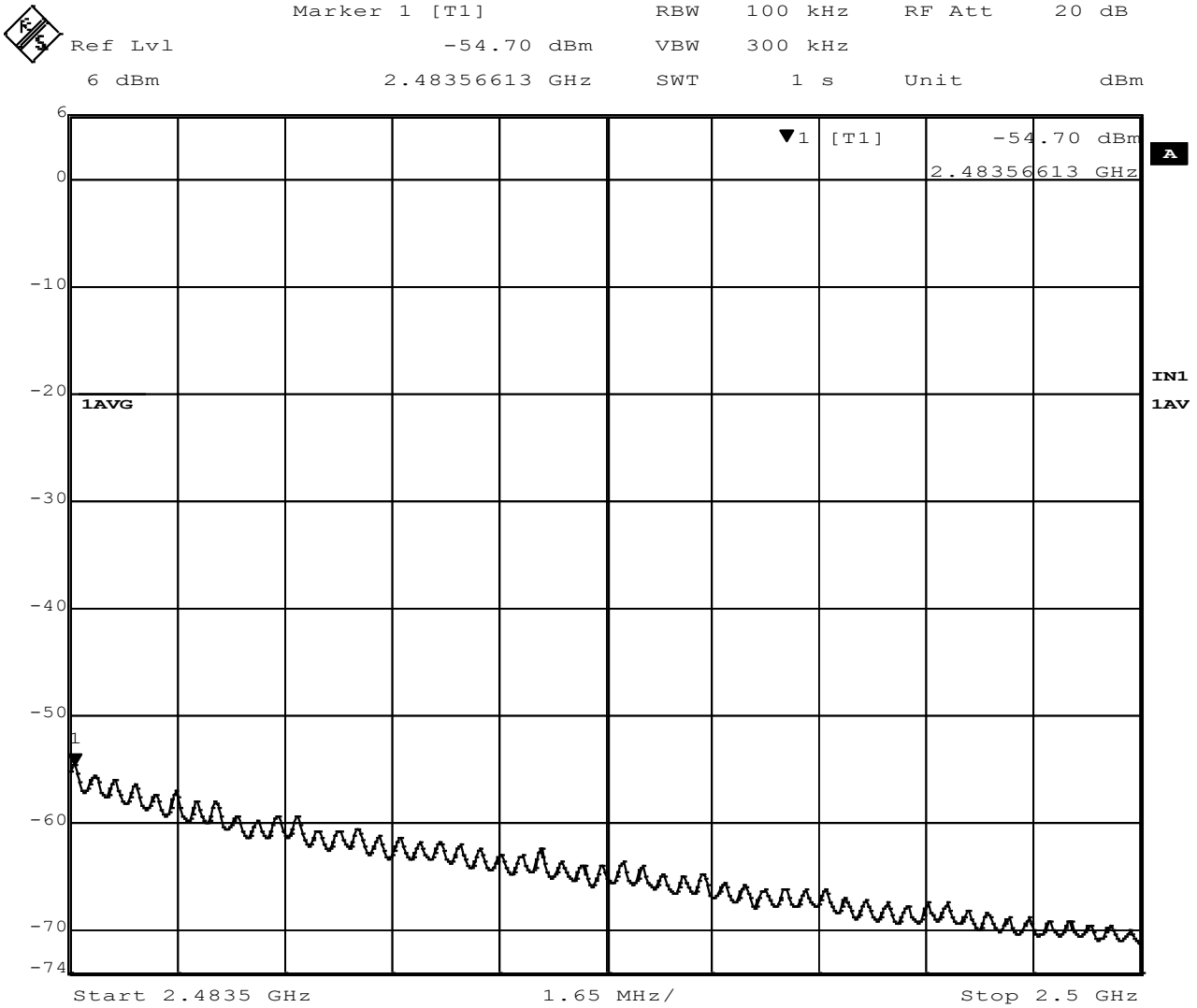



Figure 46 - Band-edge Measurement, High Channel, Restricted Frequency, Average

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

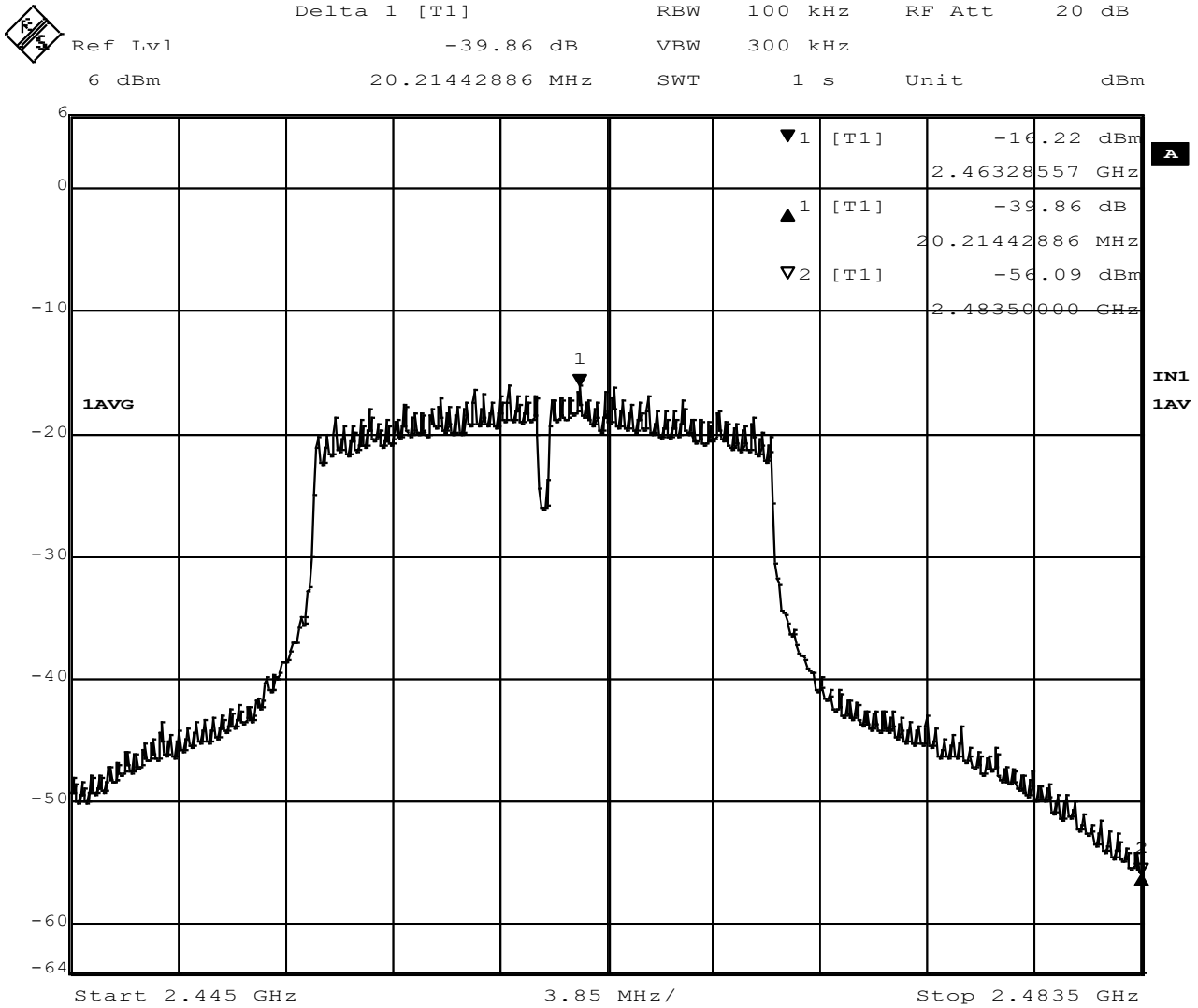



Figure 47 - Band-edge Measurement, High Channel, Fundamental, Average



	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

Highest Out of Band Emissions, 802.11n


CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1	2390.0 (Unrestricted, Peak)	-28.91	-4.13	24.78	20	PASS
1	2390.0 (Unrestricted, Average)	-46.62	-18.69	27.93	20	PASS
11	2483.5 (Unrestricted, Peak)	-40.22	-3.20	37.02	20	PASS
11	2483.5 (Unrestricted, Average)	-40.14	-17.52	22.62	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Margin	Limit* (dBm)	Gain** (dBi)	Result
1	2340.0 (Restricted, Peak)	-40.67	-40.67	19.44	-21.23	0.00	PASS
1	2340.0 (Restricted, Average)	-59.96	-59.96	18.73	-41.23	0.00	PASS
11	2483.5 (Restricted, Peak)	-39.78	-39.78	18.55	-21.23	0.00	PASS
11	2483.5 (Restricted, Average)	-55.90	-55.90	14.67	-41.23	0.00	PASS

Corrected Emission level= Highest out of band level +Gain

Margin= Limit-Corrected Emission Level

\*Limits from Part 15.209 in dBm \*\*Antenna gain declared by the manufacturer

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

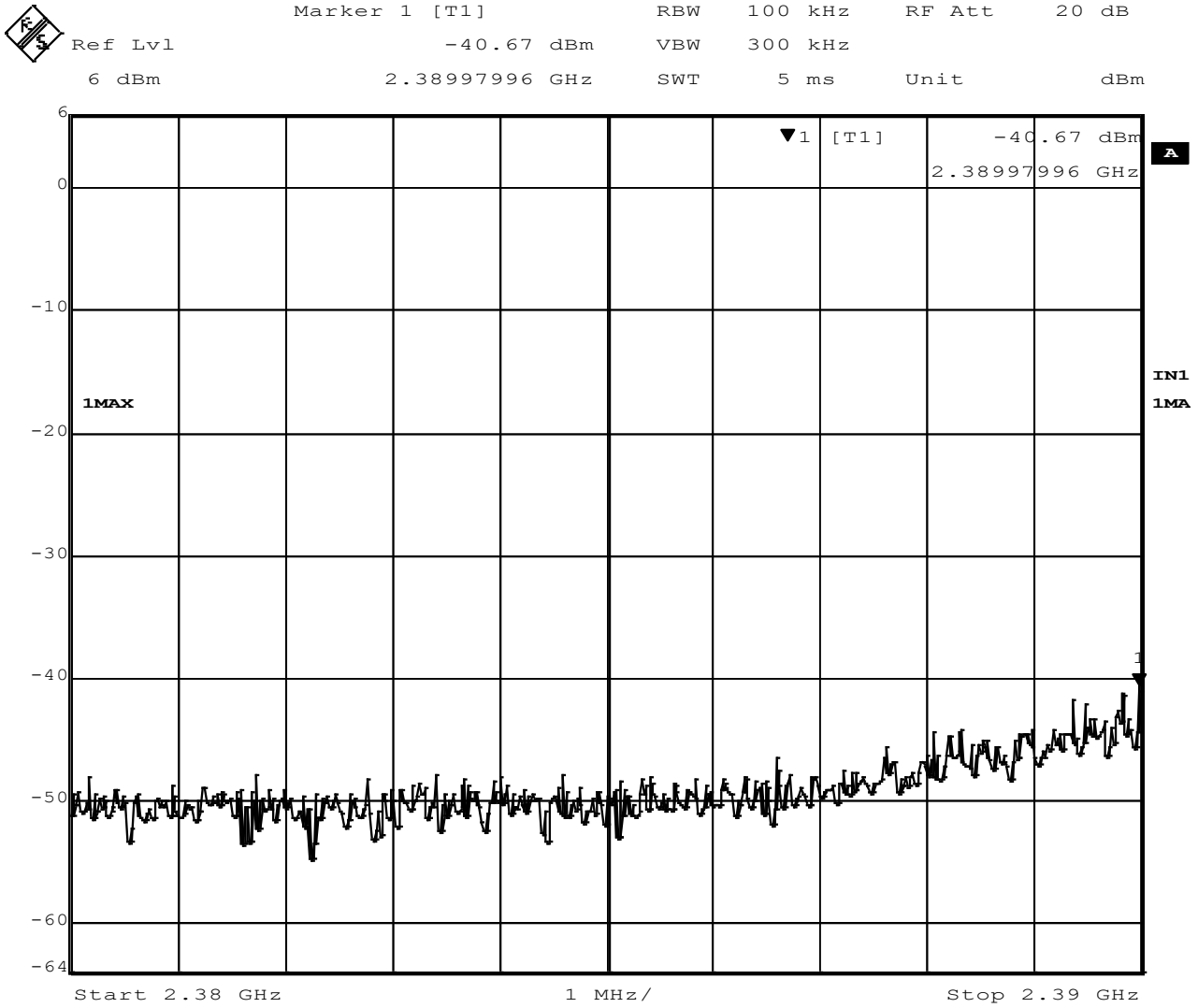


Figure 48 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

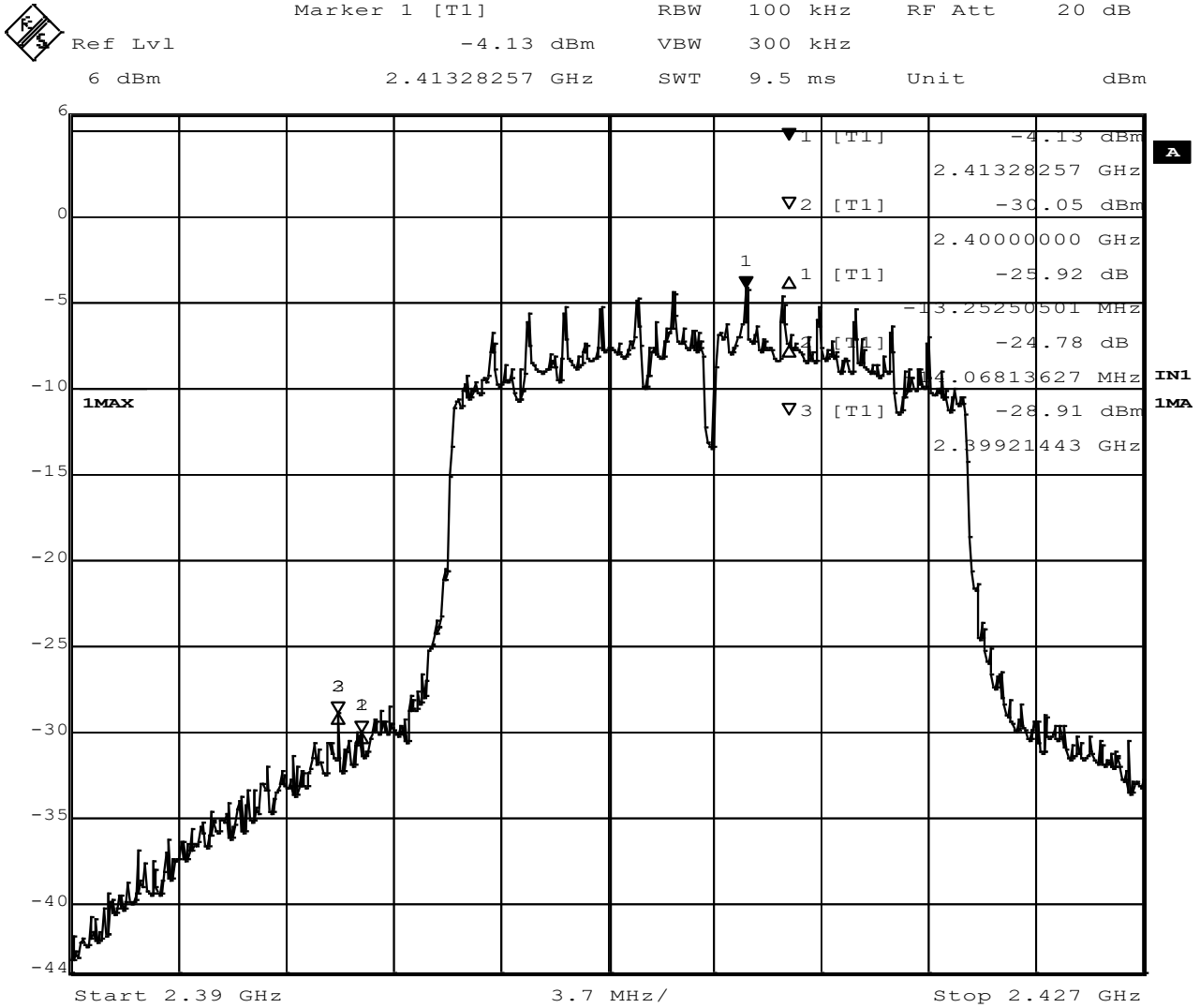



Figure 49 - Band-edge Measurement, Low Channel, Fundamental, Peak

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

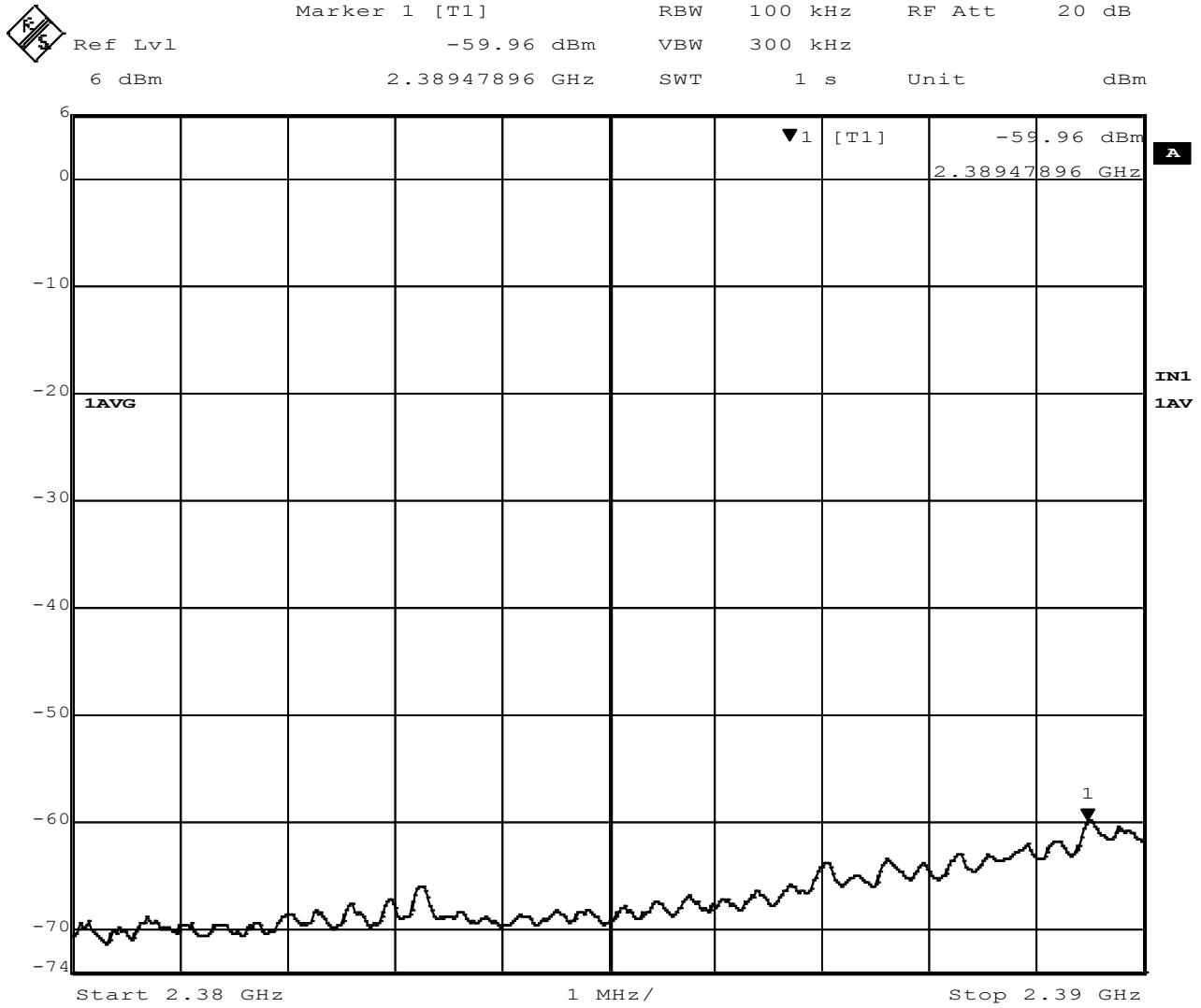



Figure 50 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

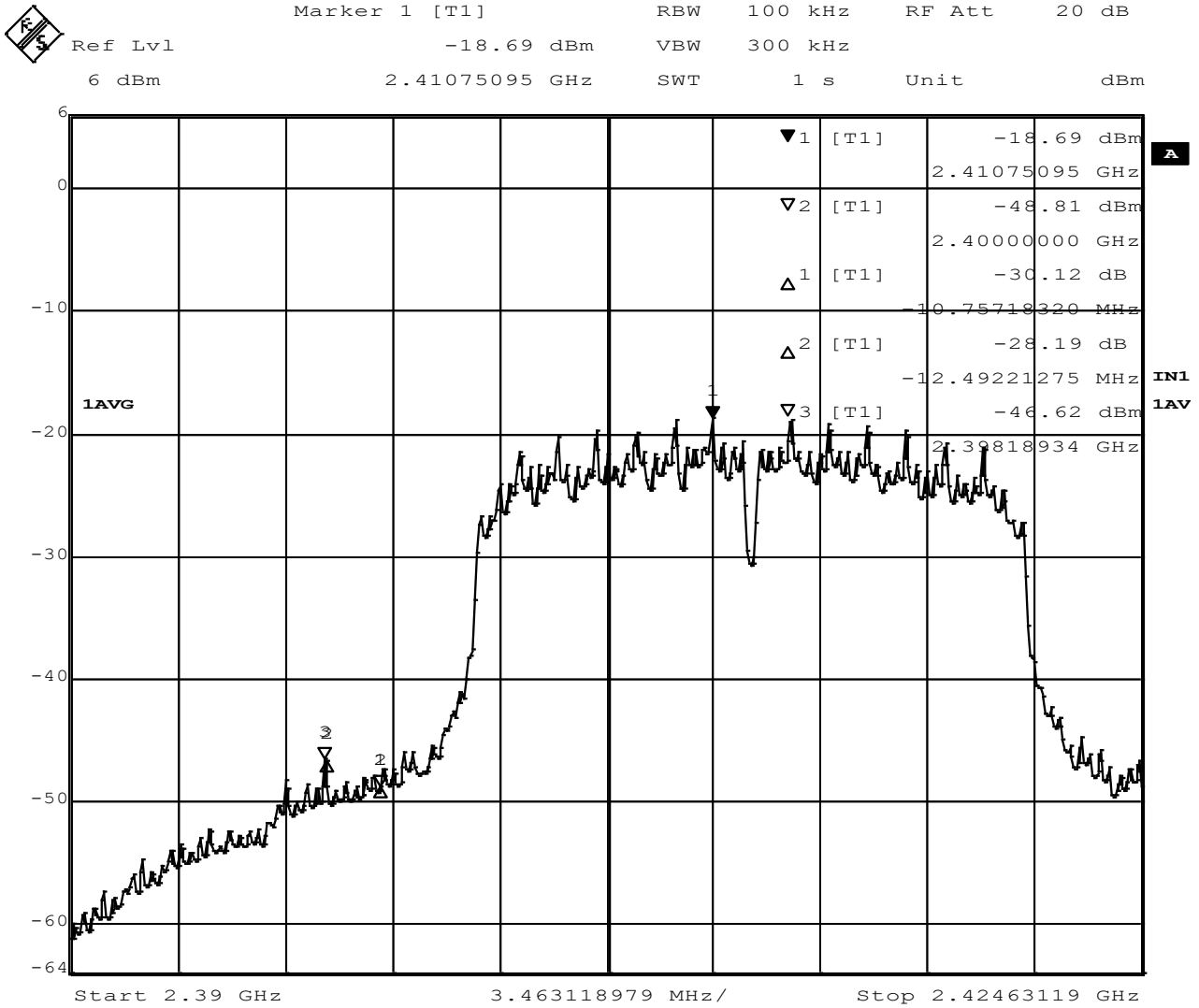



Figure 51 - Band-edge Measurement, Low Channel, Fundamental, Average

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

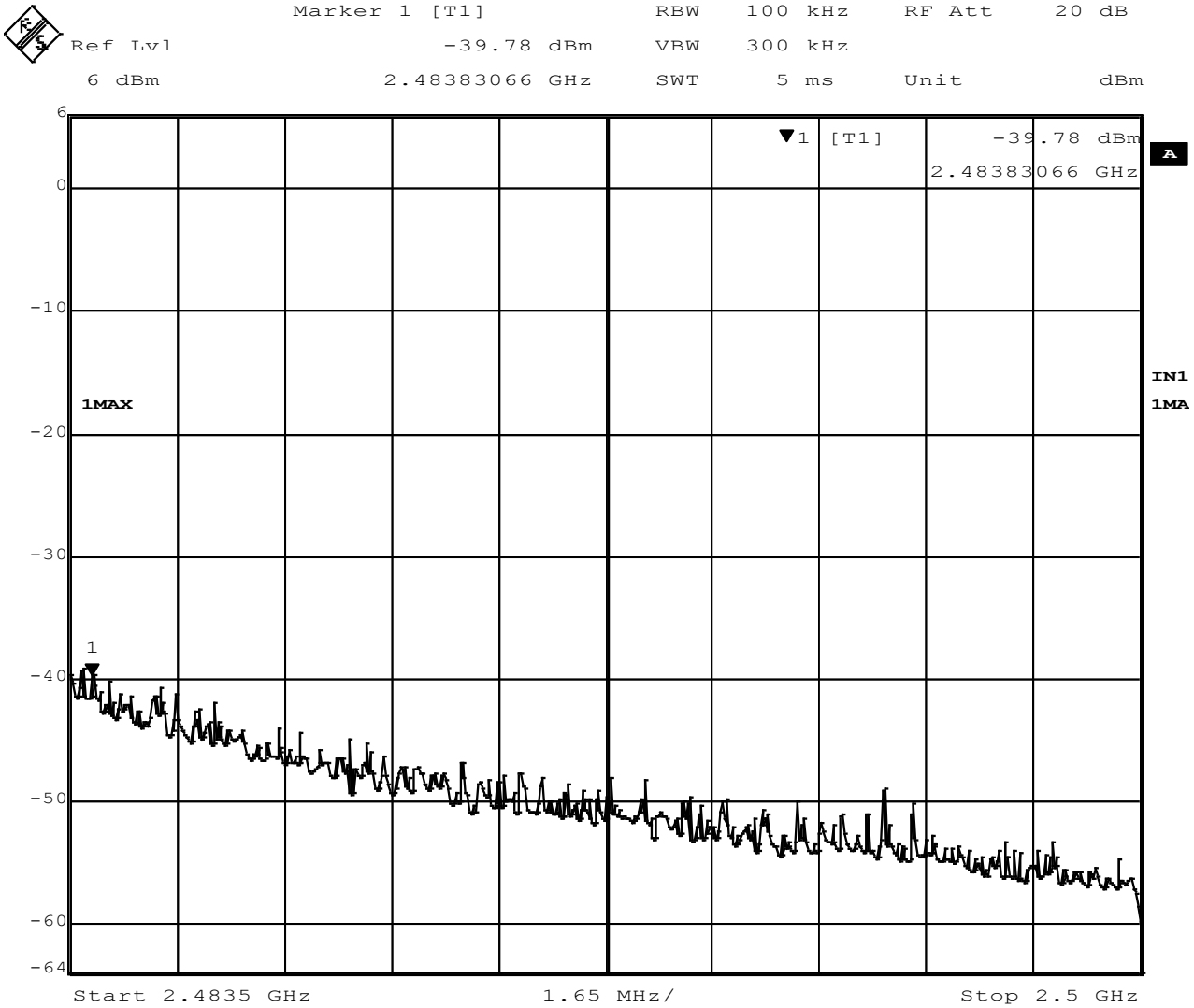



Figure 52 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

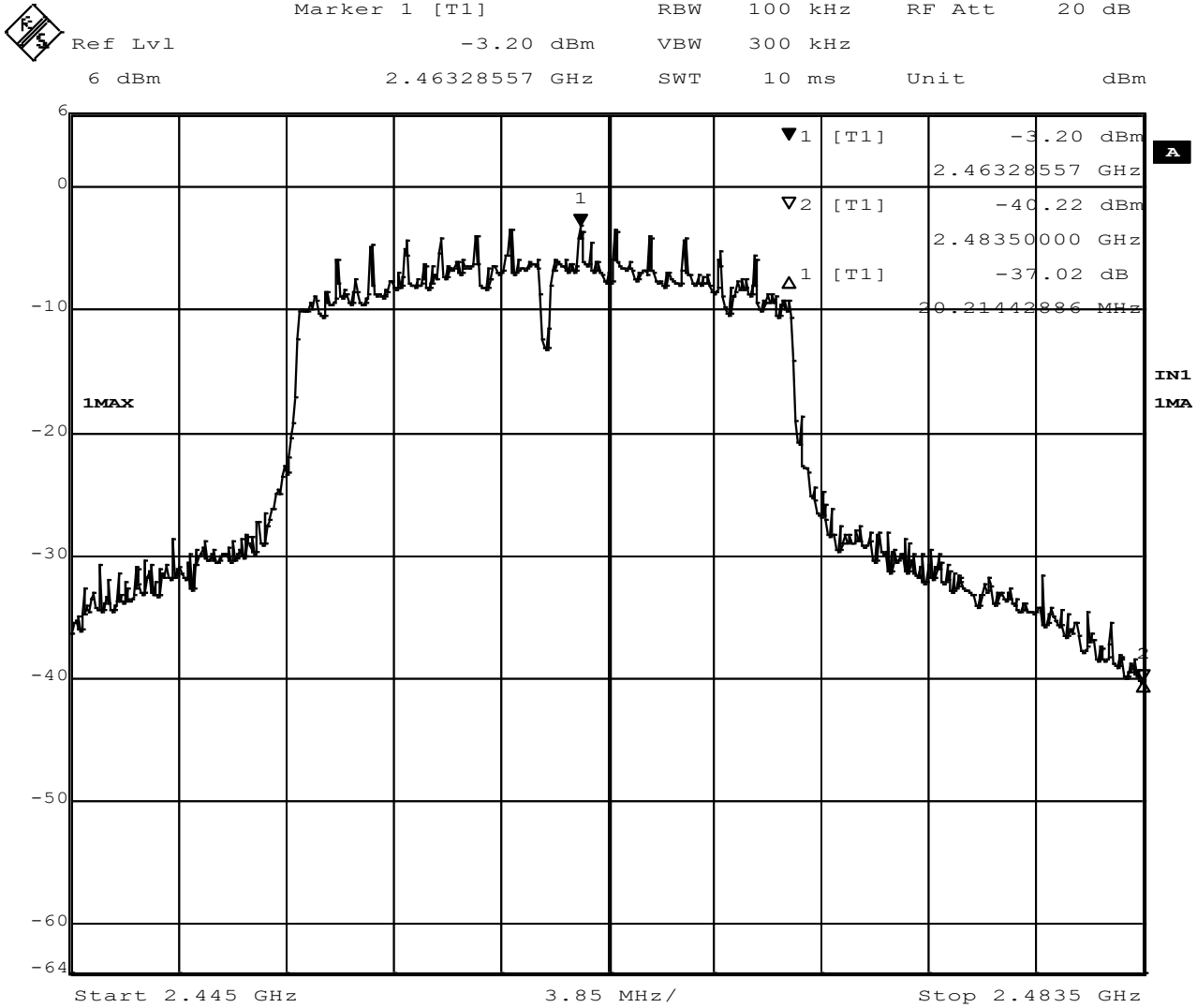



Figure 53 - Band-edge Measurement, High Channel, Fundamental, Peak

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

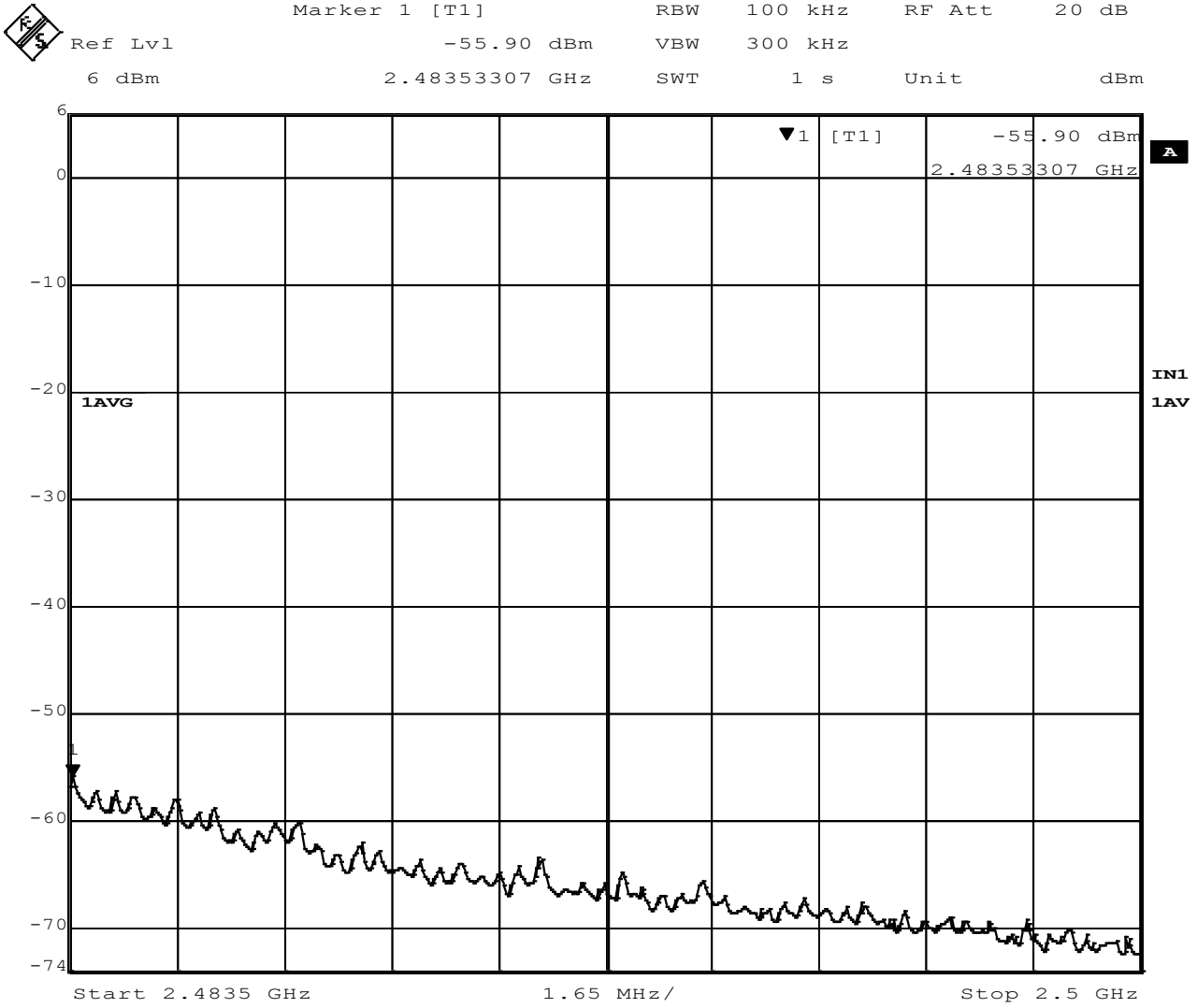



Figure 54 - Band-edge Measurement, High Channel, Restricted Frequency, Average



	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

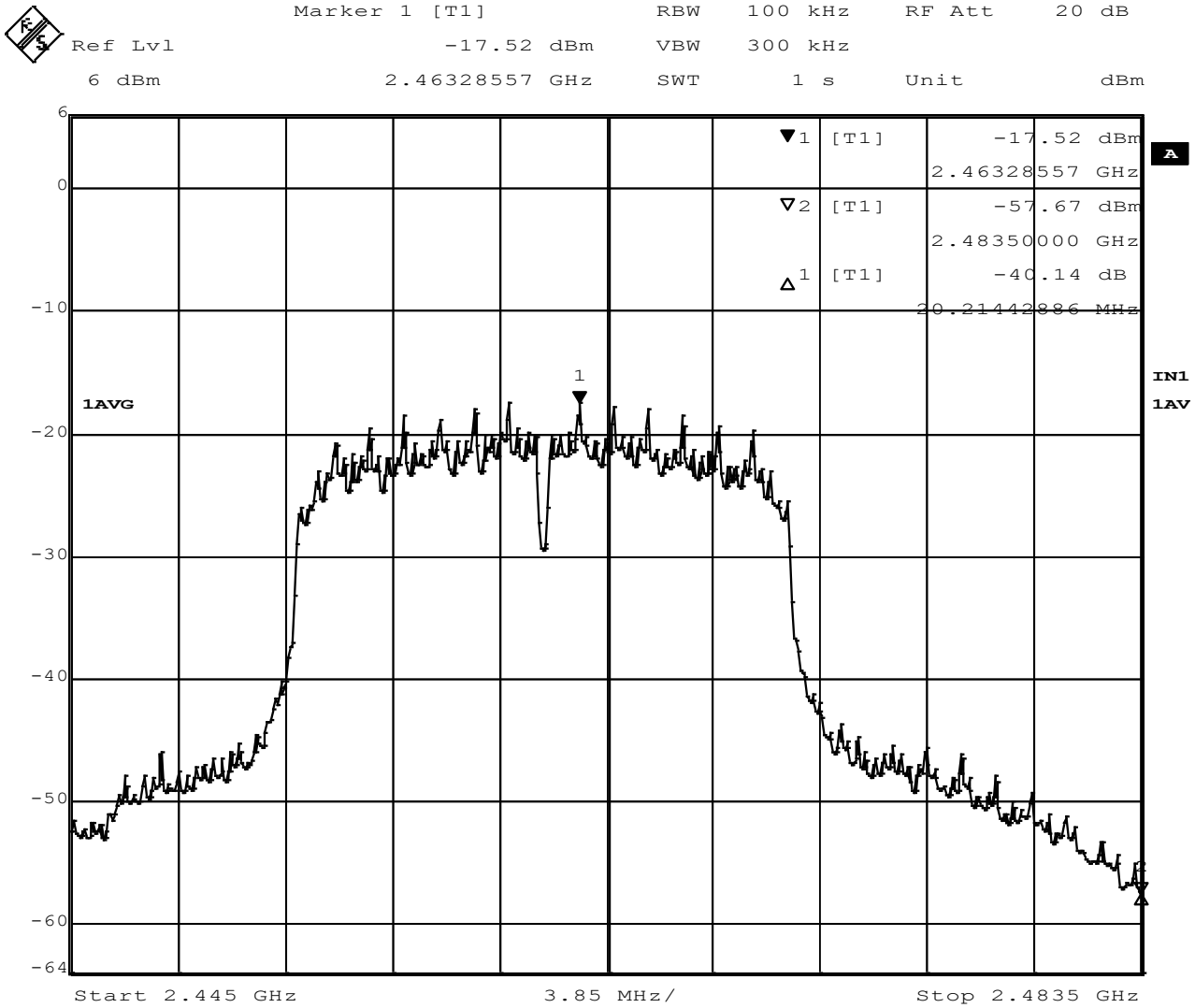



Figure 55 - Band-edge Measurement, High Channel, Fundamental, Average

	Report Number:	R20181130-20-02	Rev	D
	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:	R20181130-20-02	Rev	D
	Prepared for:	Garmin		

**Power Spectral Density**

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	PEAK PSD(dBm)	Method	Limit (dBm)	RESULT
Low	2412	802.11b	-14.96	Conducted	8.00	PASS
Middle	2437	802.11b	-14.51	Conducted	8.00	PASS
High	2462	802.11b	-15.30	Conducted	8.00	PASS
Low	2412	802.11g	-20.04	Conducted	8.00	PASS
Middle	2437	802.11g	-18.19	Conducted	8.00	PASS
High	2462	802.11g	-18.25	Conducted	8.00	PASS
Low	2412	802.11n	-20.47	Conducted	8.00	PASS
Middle	2437	802.11n	-18.28	Conducted	8.00	PASS
High	2462	802.11n	-19.95	Conducted	8.00	PASS

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

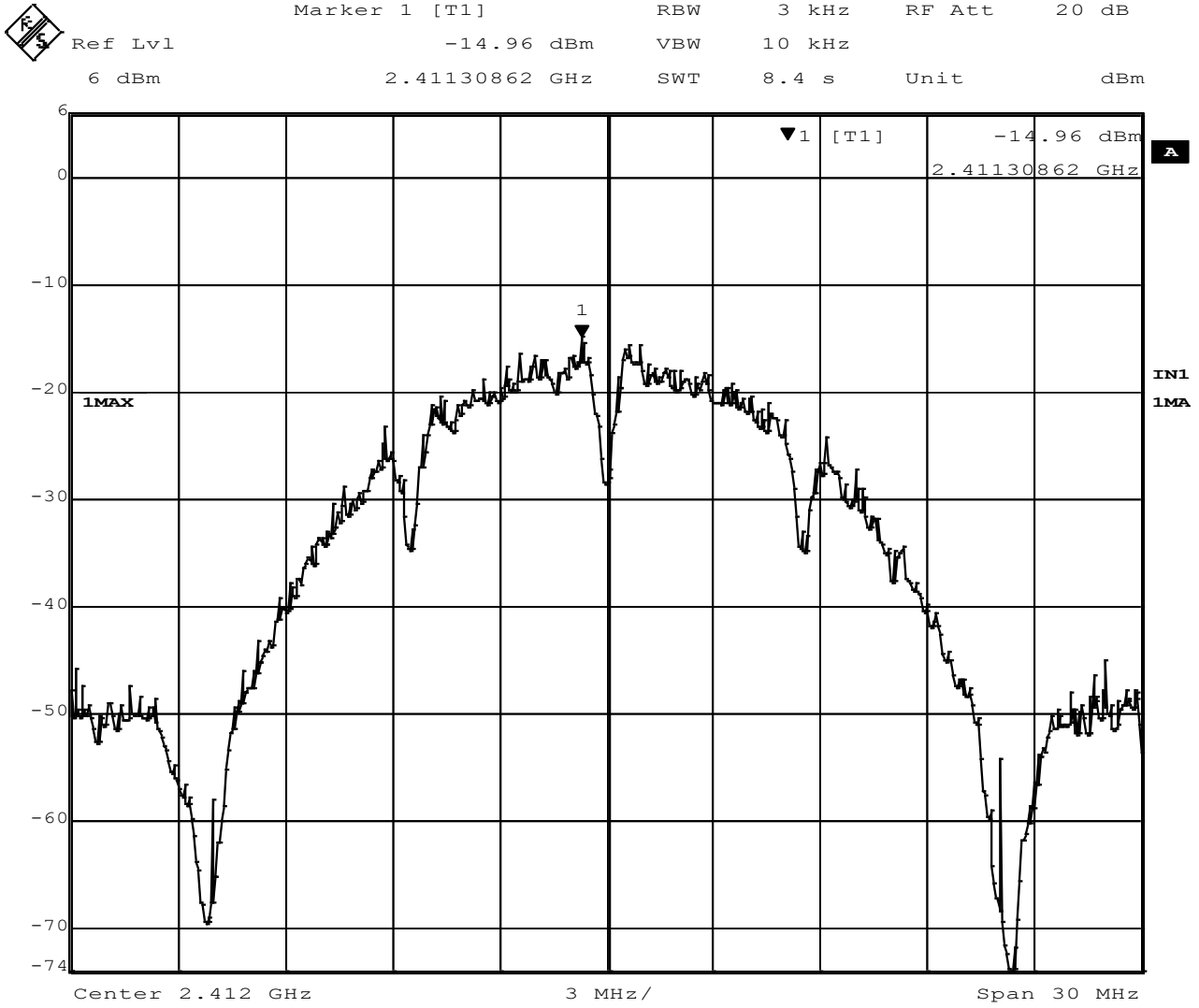



Figure 56 - Power Spectral Density, Low Channel, 802.11b

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

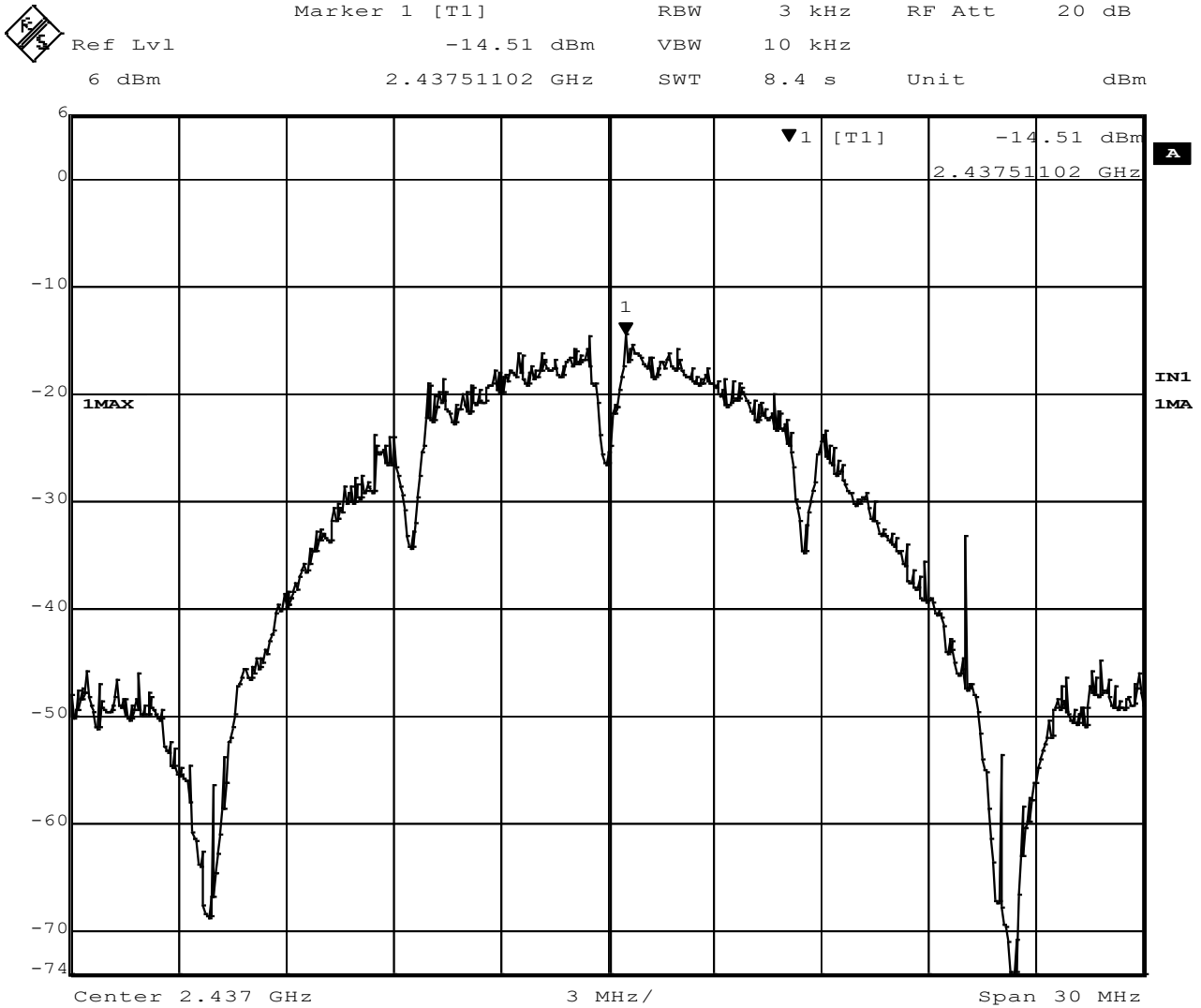



Figure 57 - Power Spectral Density, Mid Channel, 802.11b

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

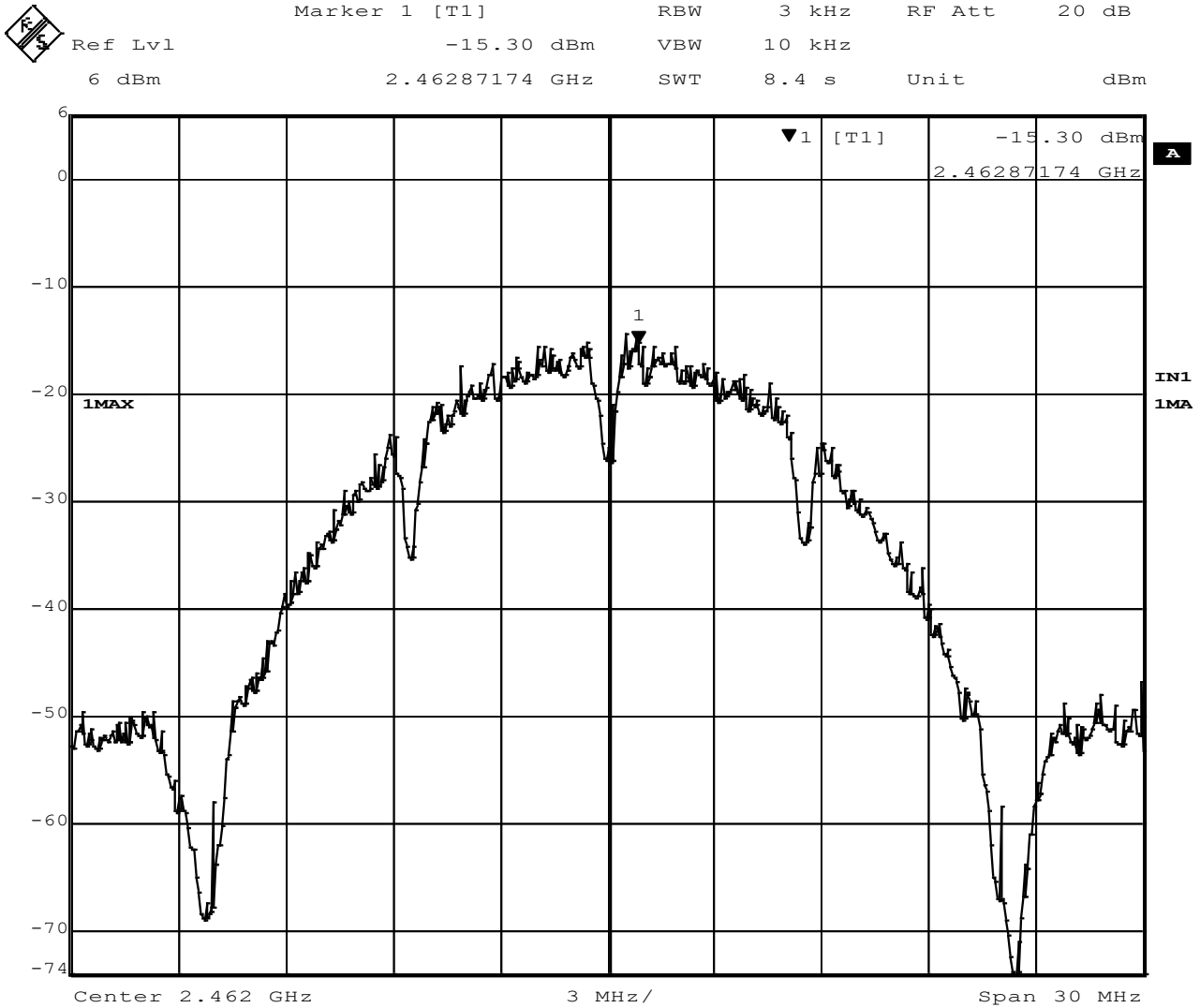



Figure 58 - Power Spectral Density, High Channel, 802.11b

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

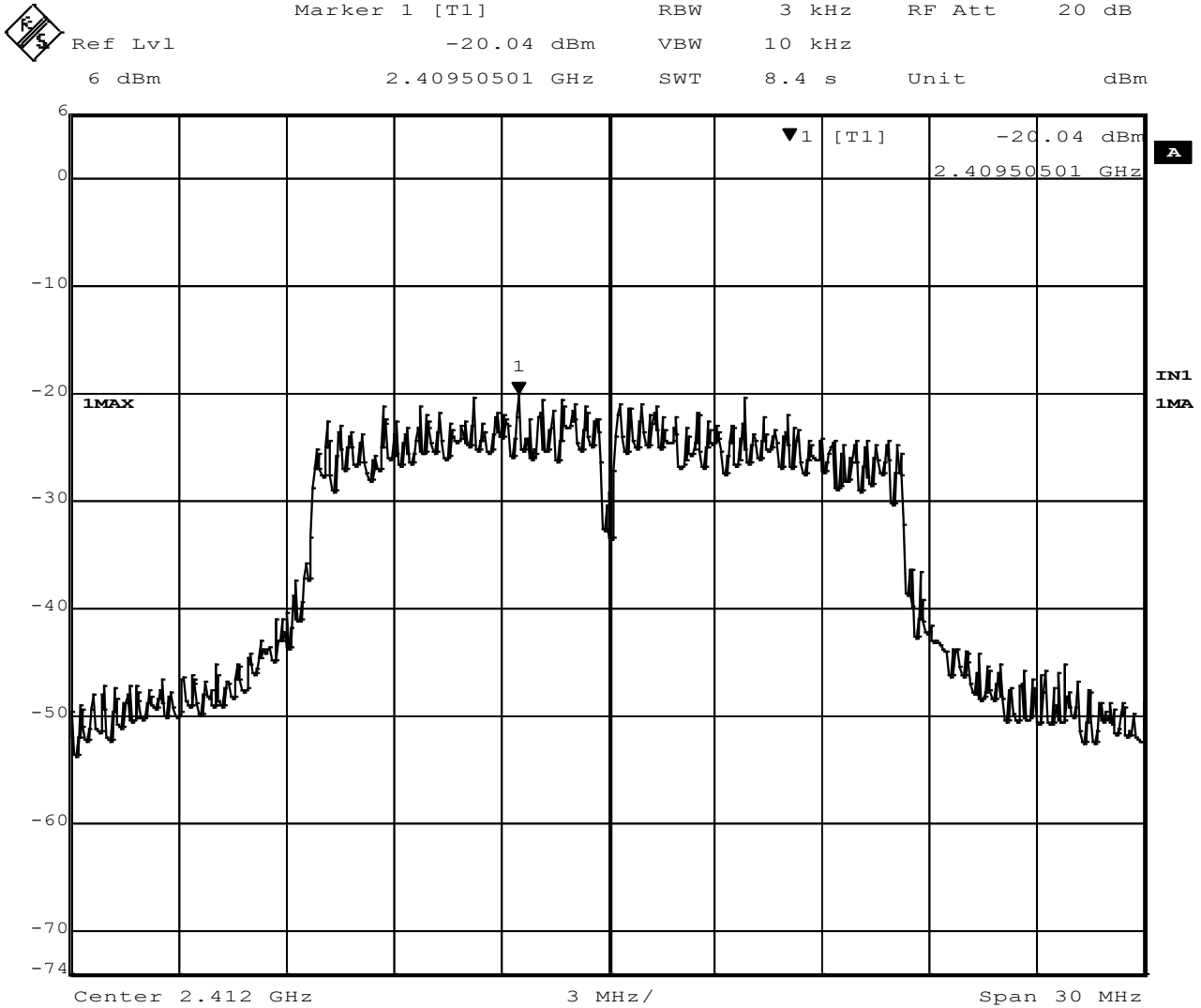



Figure 59 - Power Spectral Density, Low Channel, 802.11g

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

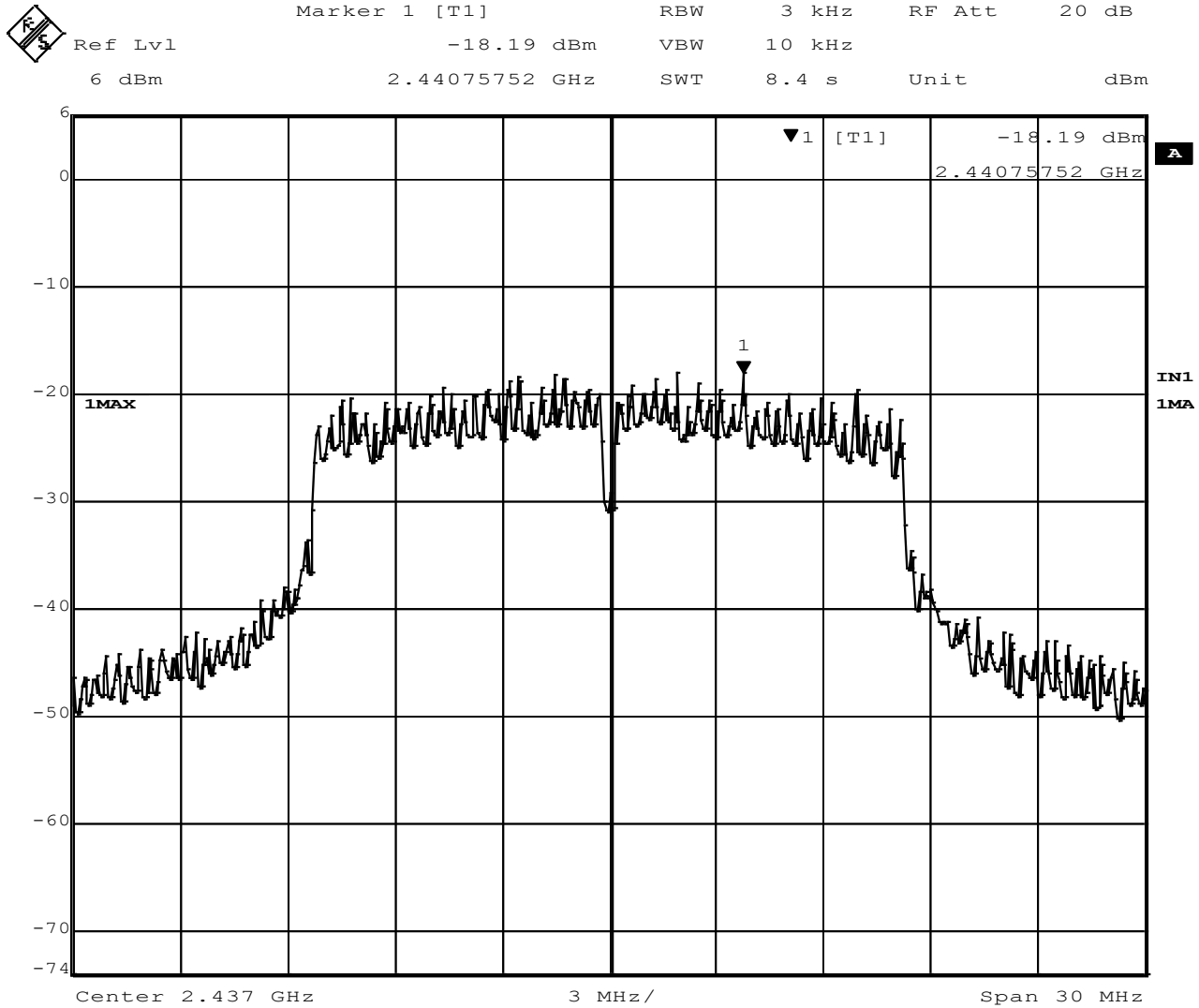



Figure 60 - Power Spectral Density, Mid Channel, 802.11g



	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

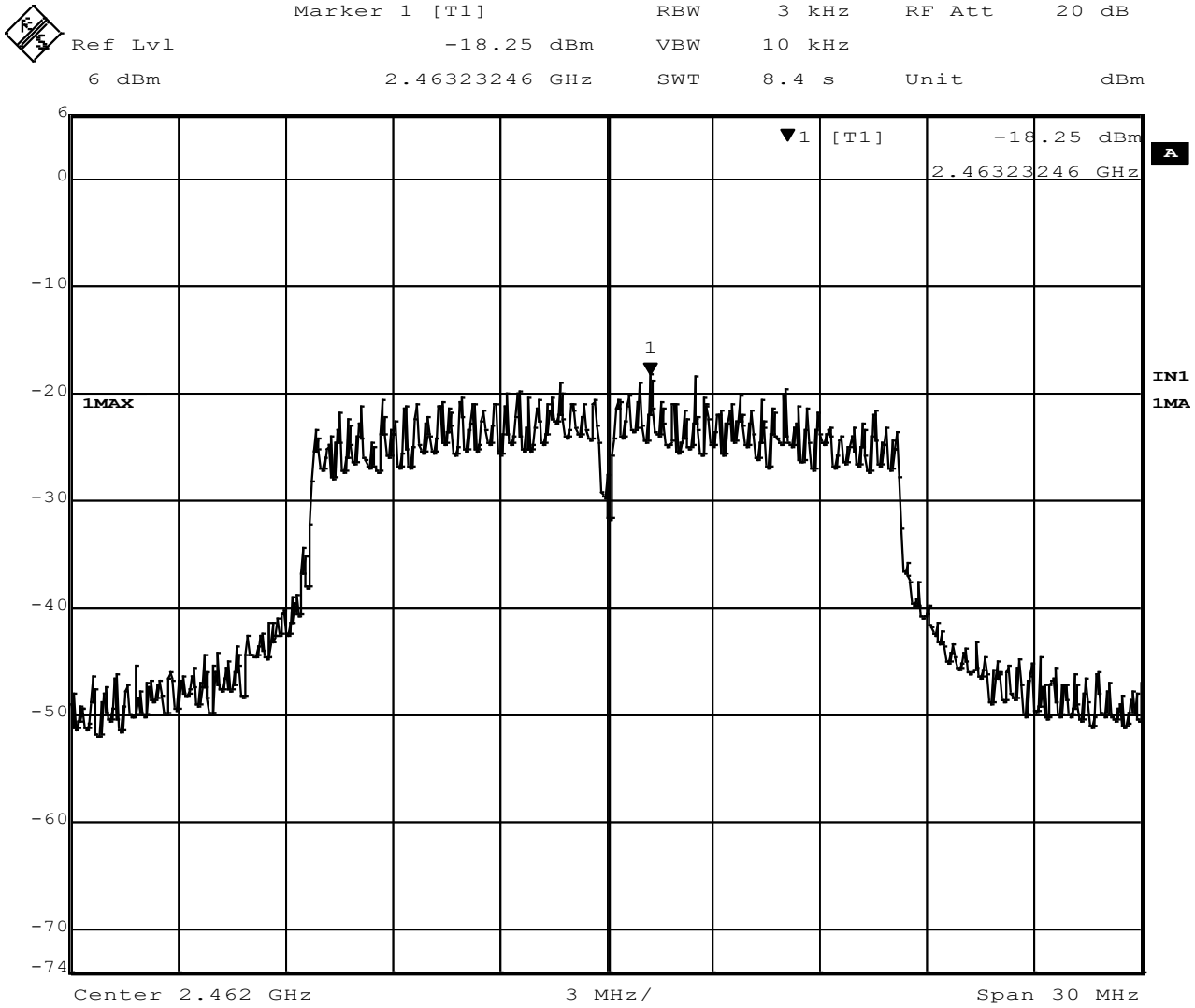



Figure 61 - Power Spectral Density, High Channel, 802.11g



	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

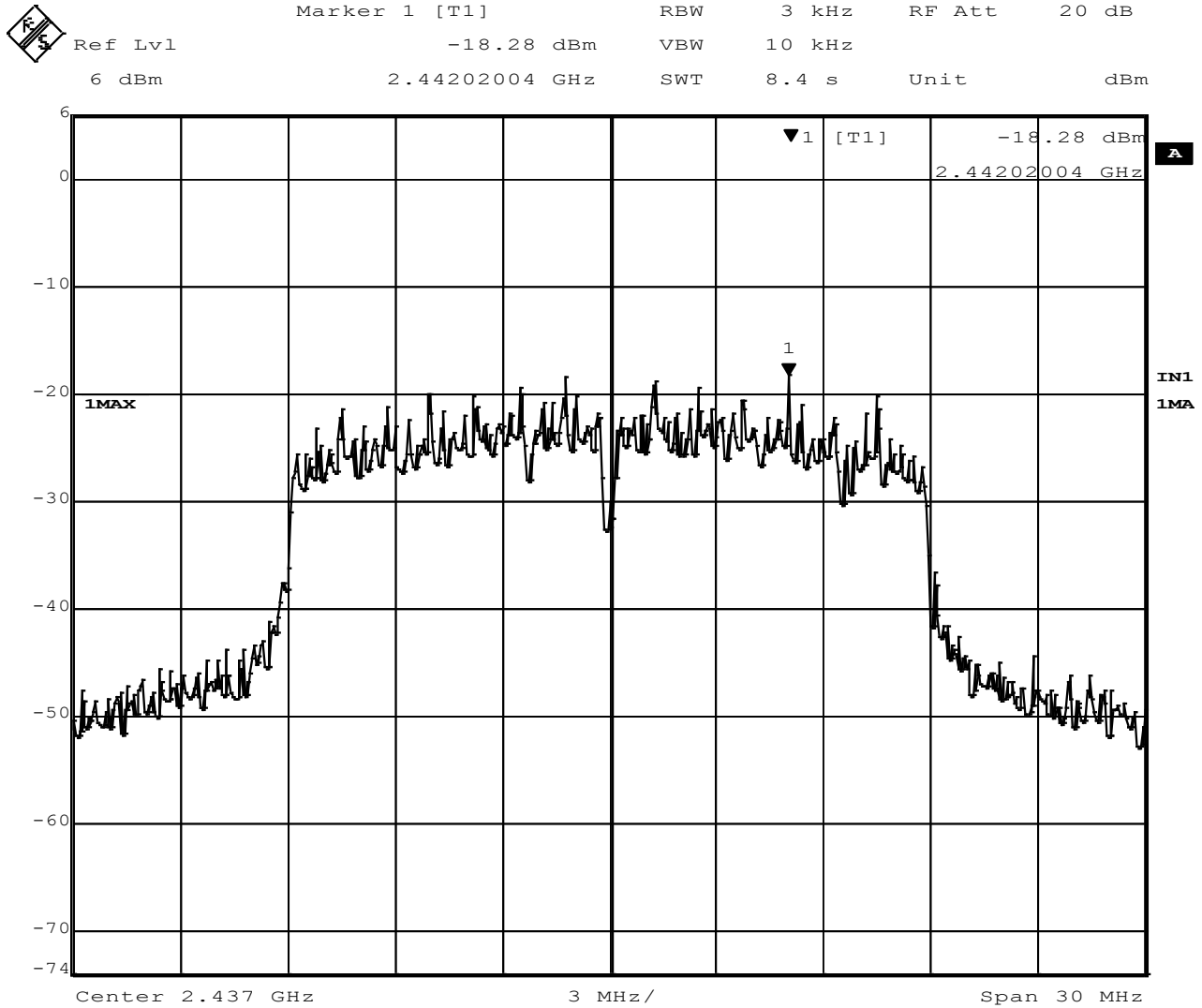



Figure 63 - Power Spectral Density, Mid Channel, 802.11n

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		

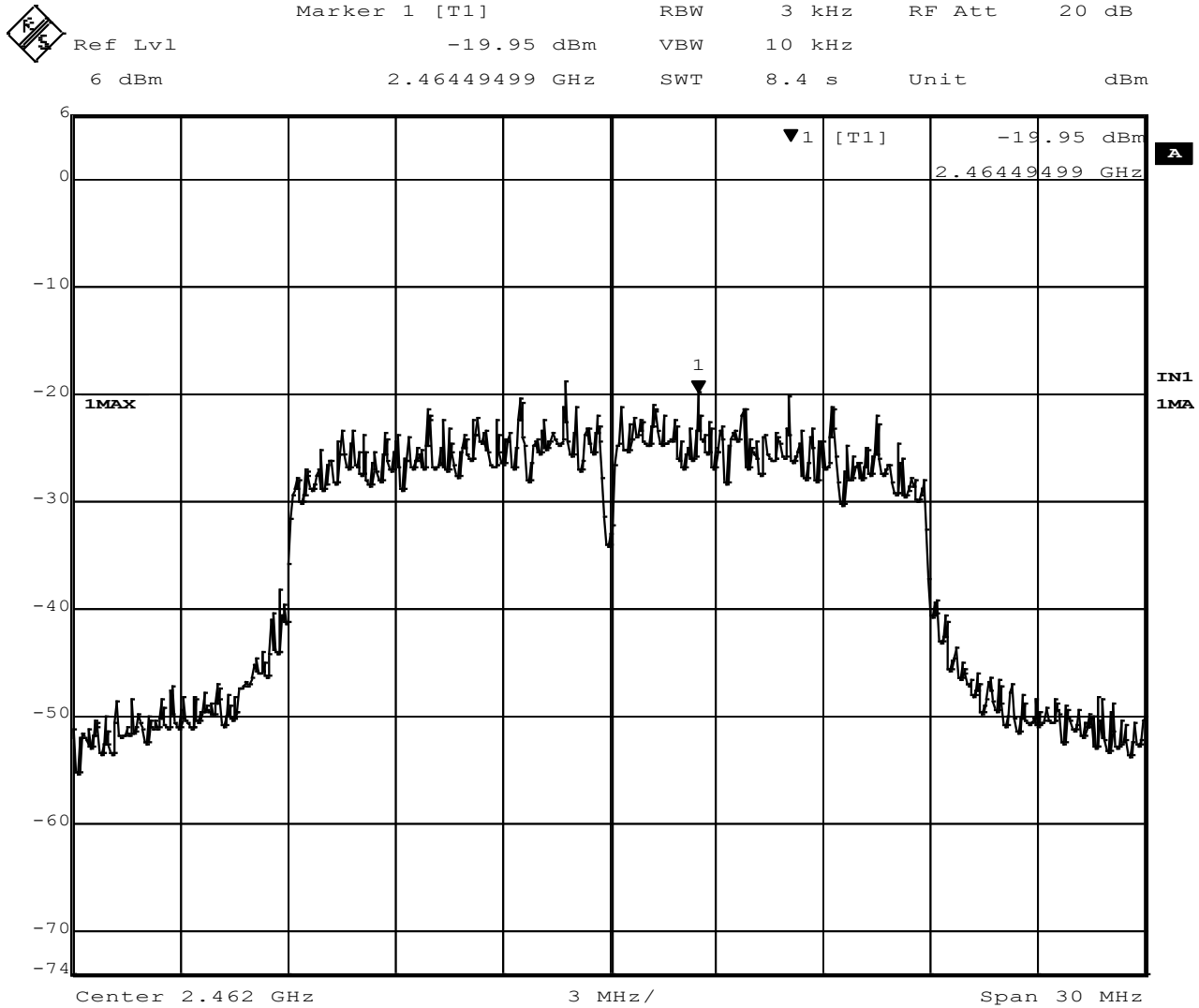



Figure 64 - Power Spectral Density, High Channel, 802.11n

	Report Number:	R20181130-20-02	Rev	D
	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 $\mu$ 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:**

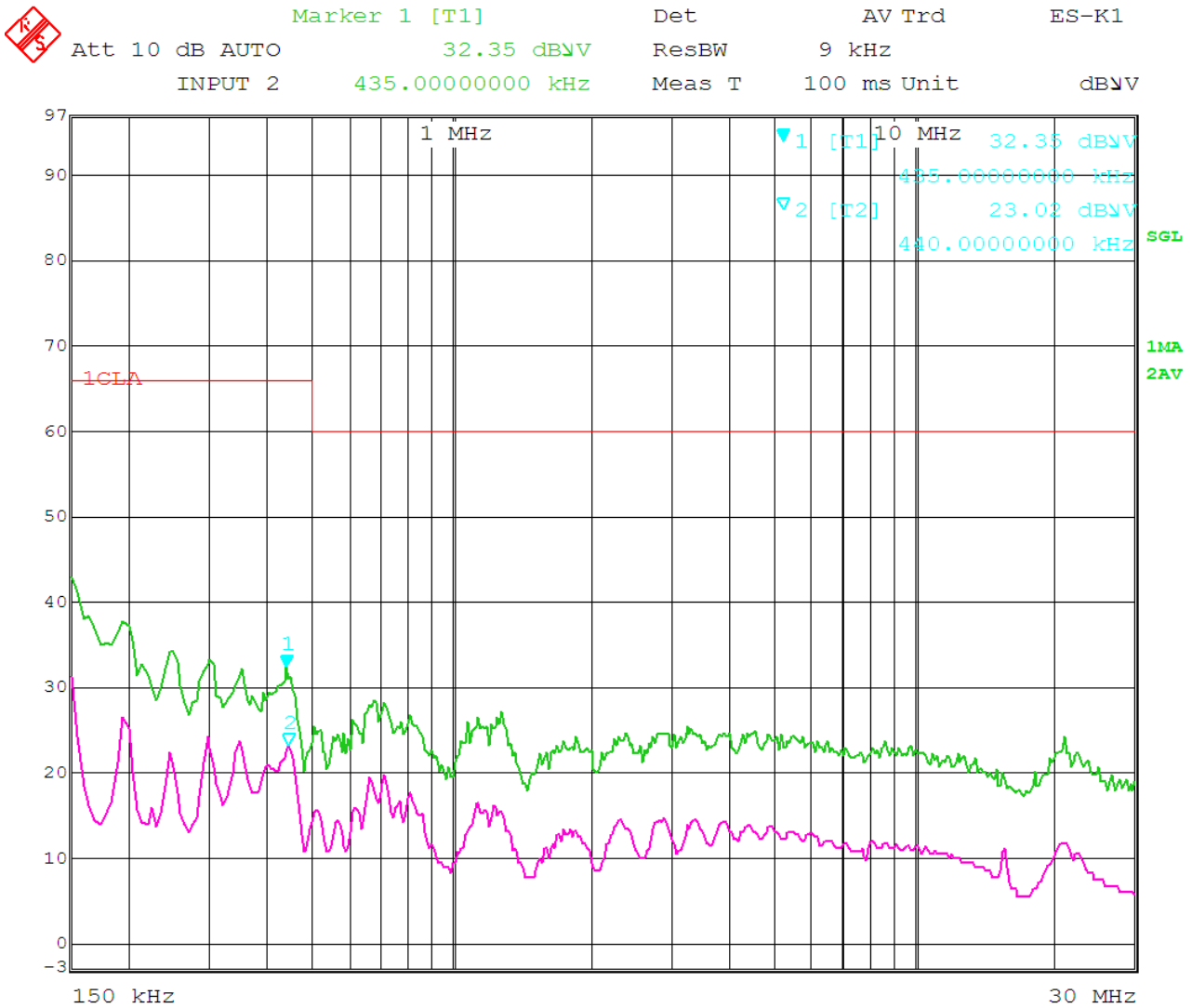
No deviation

**EUT operating conditions:**

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

	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		


**Test Results:**

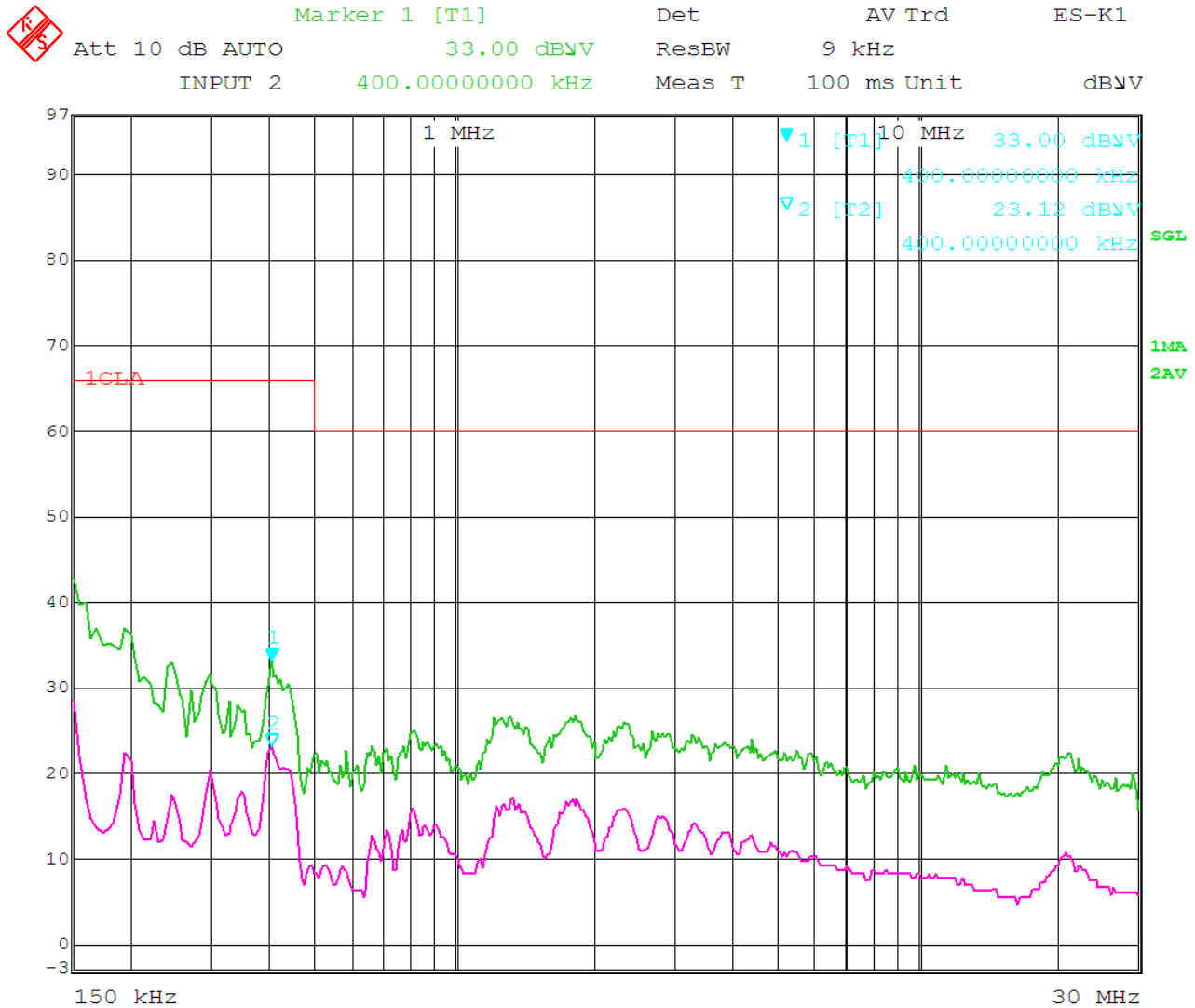


Date: 23.APR.2019 17:22:29

**Figure 65 - Conducted Emissions Plot, L-F**

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


	Report Number: R20181130-20-02	Rev	D
	Prepared for: Garmin		



Date: 23.APR.2019 17:29:27

Figure 66 - Conducted Emissions Plot, L-G

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

	Report Number:	R20181130-20-02	Rev	D
	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:	R20181130-20-02	Rev	D
	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:	R20181130-20-02	Rev	D
	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:	R20181130-20-02	Rev	D
	Prepared for:	Garmin		

REPORT END