

AMENDED

FCC/ISED DTS Test Report

Prepared for: Garmin International Inc.

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

Product: A03618

Test Report No: R20181219-20-08B

Approved By:



Nic S. Johnson, NCE

Technical Manager

iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: 12 June 2019

Total Pages: 86

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:	R20181219-20-08	Rev	B
	Prepared for:	Garmin		

REVISION PAGE

Rev. No.	Date	Description
0	23 May 2019	Original – NJohnson Prepared by KVepuri/CFarrington
A	3 June 2019	Re-measured average power Includes NCEE Labs test report R20181219-20-08 and its amendment in full -NJ
B	12 July 2019	Modified test description in Section 4.2 and 4.3 Added detail on calculations to Section 4.5 Includes NCEE Labs test report R20181219-20-08A and its amendment in full -NJ

	Report Number:	R20181219-20-08	Rev	A
	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	Pass

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

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

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

Model	A03618
EUT Received	16 April 2019
EUT Tested	16 April 2019 - 20 May 2019 30 May 2019 (average power)
Serial No.	3988191810 (radiated unit); 3988191793 (conducted unit)
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: PSAL10R-050Q (Representative Power Supply)

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

	Report Number:	R20181219-20-08	Rev	A
	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:	R20181219-20-08	Rev	A
	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:	R20181219-20-08	Rev	A
	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*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	26 Jul 2018	26 Jul 2019
Rohde & Schwarz Test Software	ES-K1	12575	NA	NA
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2020*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2020*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2020*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2020*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2020*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2020*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2020*

*Internal Characterization

Notes:

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

	Report Number:	R20181219-20-08	Rev	A
	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:	R20181219-20-08	Rev	A
	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 ($\mu\text{V/m}$)	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) = $20 * \log * \text{Emission level } (\mu\text{V/m})$.
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

	Report Number:	R20181219-20-08	Rev	A
	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 802.11n mode produced the highest emissions. All final measurements were performed with the EUT transmitting continuously in this mode.
- h. Intermodulation products were investigated by measuring spurious emissions with all three transmitters continuously transmitting. No intermodulation products were found above the labs system sensitivity.

	Report Number:	R20181219-20-08	Rev	A
	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:

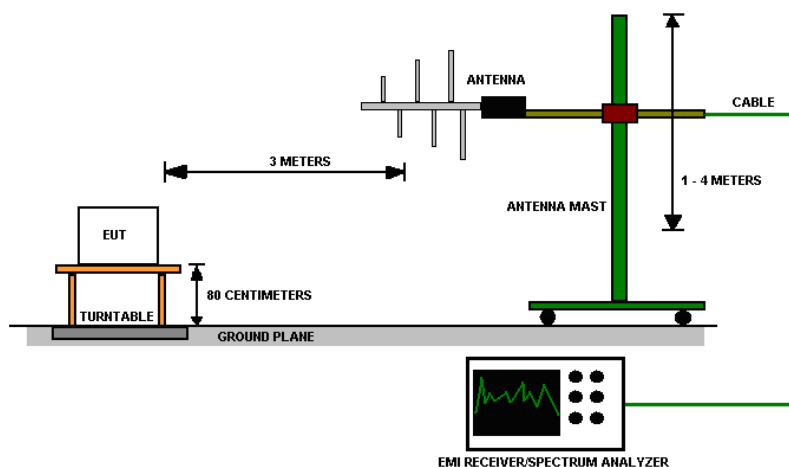


Figure 1 - Radiated Emissions Test Setup

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:

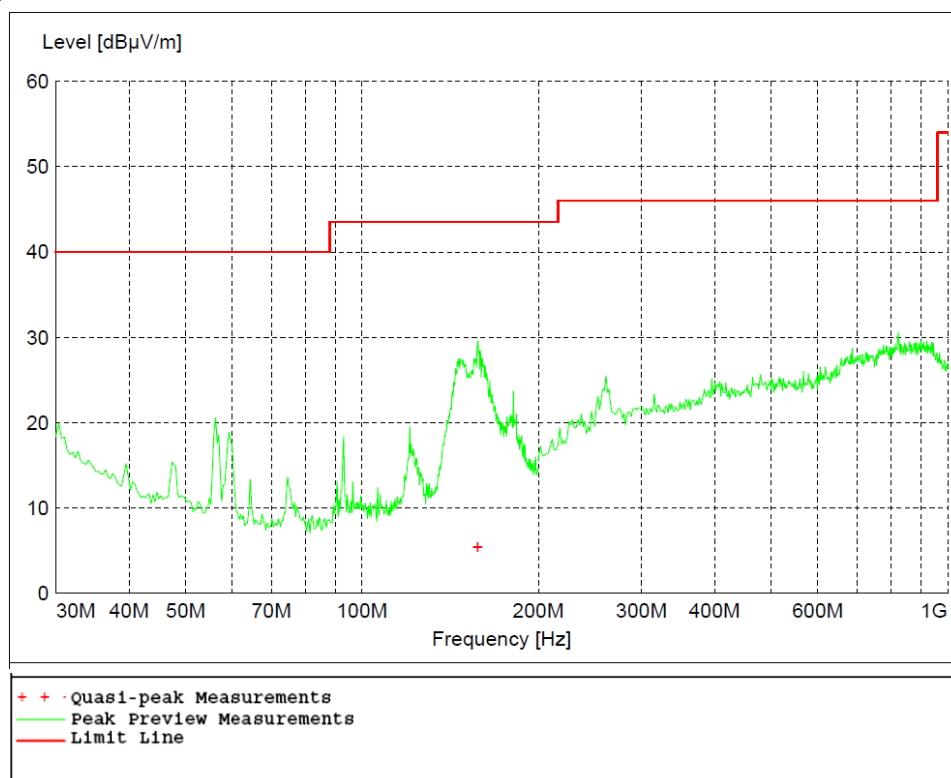


Figure 2 - Radiated Emissions Plot, Receive

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
157.680000	5.49	43.50	38.00	380	210	VERT

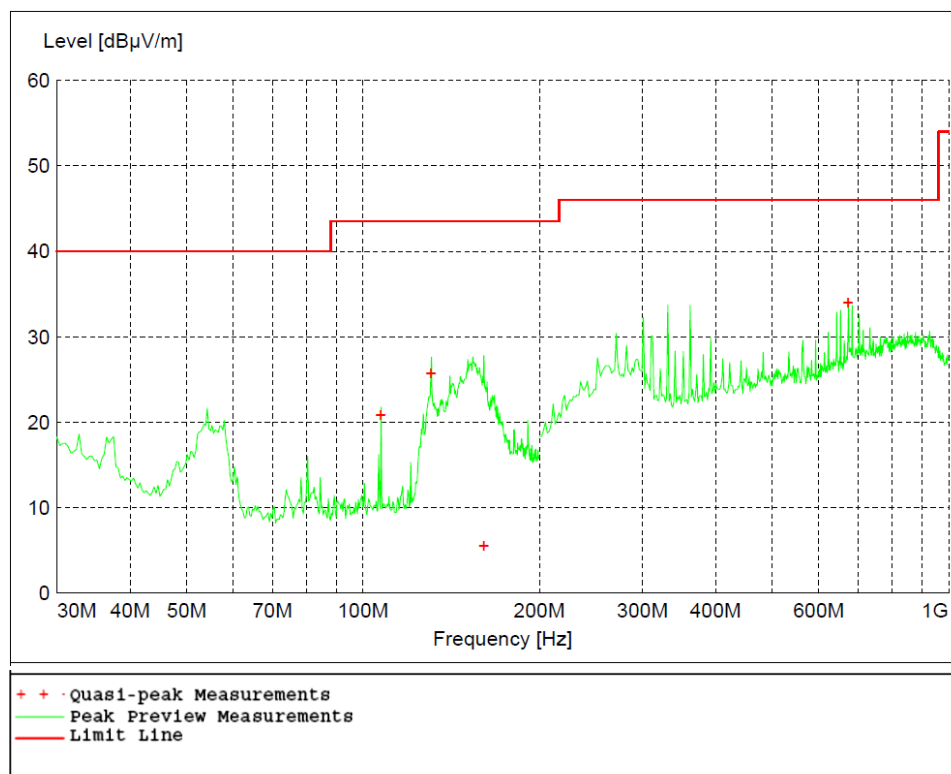


Figure 3 - Radiated Emissions Plot, 802.11b

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
107.220000	20.83	43.50	22.70	100	129	VERT
130.620000	25.72	43.50	17.80	99	84	VERT
160.800000	5.62	43.50	37.90	362	10	HORI
673.320000	34.08	46.00	11.90	136	50	HORI

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

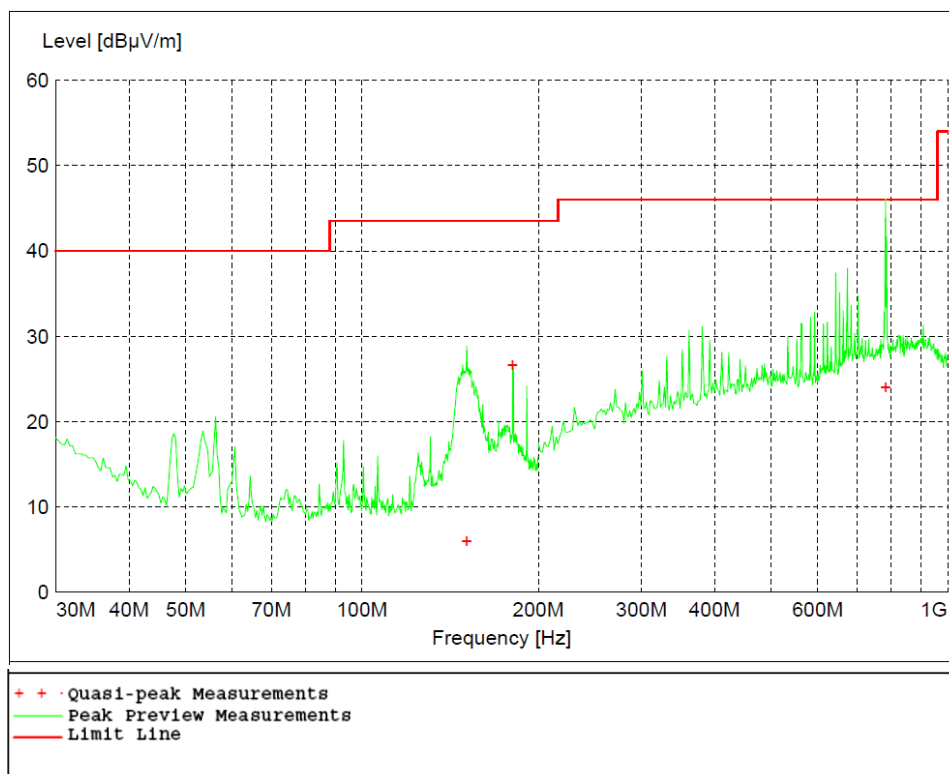


Figure 4 - Radiated Emissions Plot, 802.11g

Table 3 - Radiated Emissions Quasi-peak Measurements, 802.11g

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
151.080000	6.03	43.50	37.50	203	65	VERT
180.900000	26.70	43.50	16.80	100	212	VERT
784.680000	24.05	46.00	22.00	400	15	VERT

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

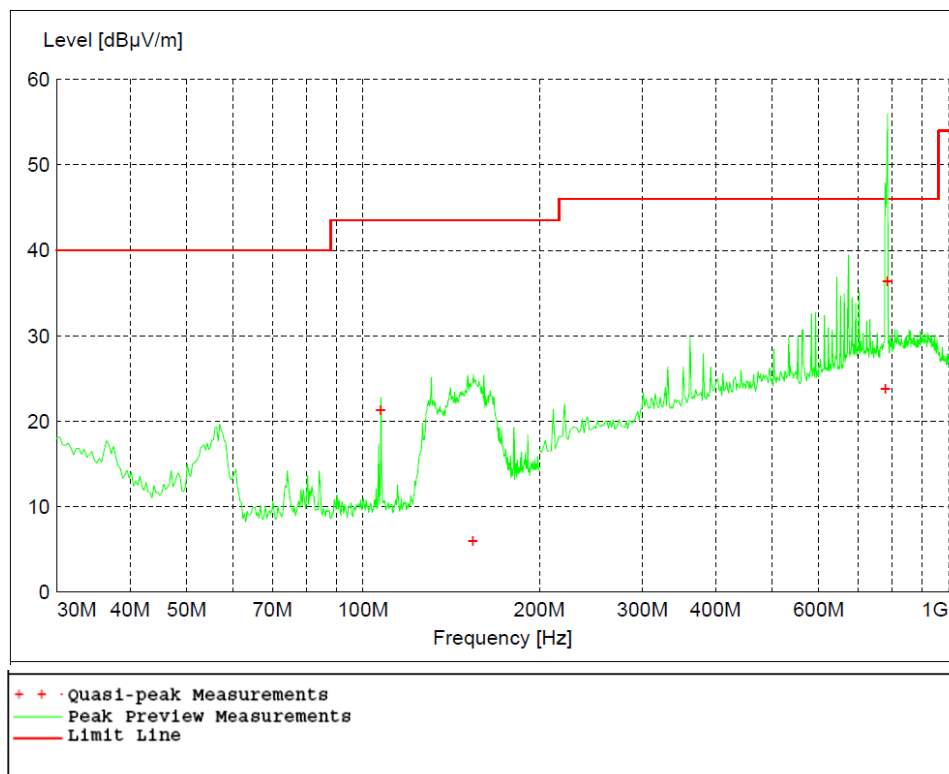


Figure 5 - Radiated Emissions Plot, 802.11n

Table 4 - Radiated Emissions Quasi-peak Measurements, 802.11n

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBμV/m	dBμV/m	dB	cm.	deg.	
107.220000	21.37	43.50	22.10	103	286	VERT
154.140000	6.08	43.50	37.40	142	0	VERT
780.480000	23.78	46.00	22.20	103	231	HORI
785.940000	36.41	46.00	9.60	196	118	HORI

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

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

Table 5 - Radiated Emissions Peak Detector Measurements, 802.11b, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.		
2412.000000	93.84	NA	NA	153	82	HORI	Low
2437.000000	92.89	NA	NA	153	82	HORI	Mid
2462.000000	92.65	NA	NA	153	82	HORI	High
9648.000000	55.41	74.00	18.59	99	245	VERT	Low
9748.000000	55.06	74.00	18.94	99	245	VERT	Mid
9848.000000	54.87	74.00	19.13	99	245	VERT	High

No signals detected above system sensitivity

Table 6 - Radiated Emissions Average Detector Measurements, 802.11b, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.		
2412.000000	84.76	NA	NA	153	82	HORI	Low
2437.000000	83.22	NA	NA	153	82	HORI	Mid
2462.000000	82.02	NA	NA	153	82	HORI	High
9648.000000	50.52	54.00	3.48	99	245	VERT	Low
9748.000000	49.75	54.00	4.25	99	245	VERT	Mid
9848.000000	49.33	54.00	4.67	99	245	VERT	High

No signals detected above system sensitivity

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

Table 7 - Radiated Emissions Peak Measurements, 802.11g, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2412.000000	95.95	NA	NA	153	82	HORI	Low
2437.000000	94.56	NA	NA	153	82	HORI	Mid
2462.000000	93.95	NA	NA	153	82	HORI	High
9648.000000	51.62	74.00	22.38	99	245	VERT	Low
9748.000000	50.78	74.00	23.22	99	245	VERT	Mid
9848.000000	50.25	74.00	23.75	99	245	VERT	High

Table 8 - Radiated Emissions Average Measurements, 802.11g, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2412.000000	82.25	NA	NA	153	82	HORI	Low
2437.000000	81.12	NA	NA	153	82	HORI	Mid
2462.000000	80.50	NA	NA	153	82	HORI	High
9648.000000	41.76	54.00	12.24	99	245	VERT	Low
9748.000000	40.85	54.00	13.15	99	245	VERT	Mid
9848.000000	40.52	54.00	13.48	99	245	VERT	High

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

Table 9 - Radiated Emissions Peak Measurements, 802.11n, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.		
2412.000000	95.68	NA	NA	153	82	HORI	Low
2437.000000	94.42	NA	NA	153	82	HORI	Mid
2462.000000	94.09	NA	NA	153	82	HORI	High
9648.000000	51.92	74.00	22.08	99	245	VERT	Low
9748.000000	51.22	74.00	22.78	99	245	VERT	Mid
9848.000000	50.75	74.00	23.25	99	245	VERT	High
No signals detected above system sensitivity							

Table 10 - Radiated Emissions Average Measurements, 802.11n, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dB μ V/m	dB μ V/m	dB	cm.	deg.		
2412.000000	81.93	NA	NA	153	82	HORI	Low
2437.000000	80.86	NA	NA	153	82	HORI	Mid
2462.000000	80.25	NA	NA	153	82	HORI	High
9648.000000	41.57	54.00	12.43	99	245	VERT	Low
9748.000000	41.12	54.00	12.88	99	245	VERT	Mid
9848.000000	40.98	54.00	13.02	99	245	VERT	High
No signals detected above system sensitivity							

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:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

4.3 OUTPUT POWER

Test Method: ANSI C63.10:

1. Section(s) 11.9.1.2 "Integrated Band Power Method"

Limits of power measurements:

The maximum allowed peak output power is 30 dBm.

Test procedures:

The EUT was connected to a spectrum analyzer directly with a low-loss shielded coaxial cable with 100 MHz RBW and 300 MHz VBW. Power was determined using an integrated channel power measurement.

Deviations from test standard:

No deviation.

Test setup:

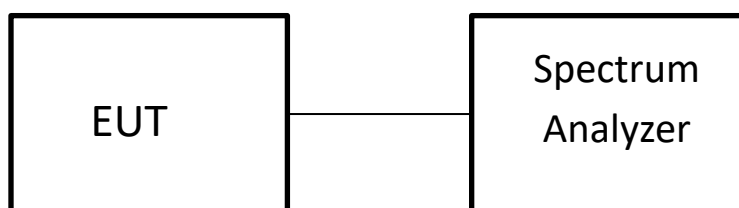


Figure 6 – Peak Output Power Measurements Test Setup

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

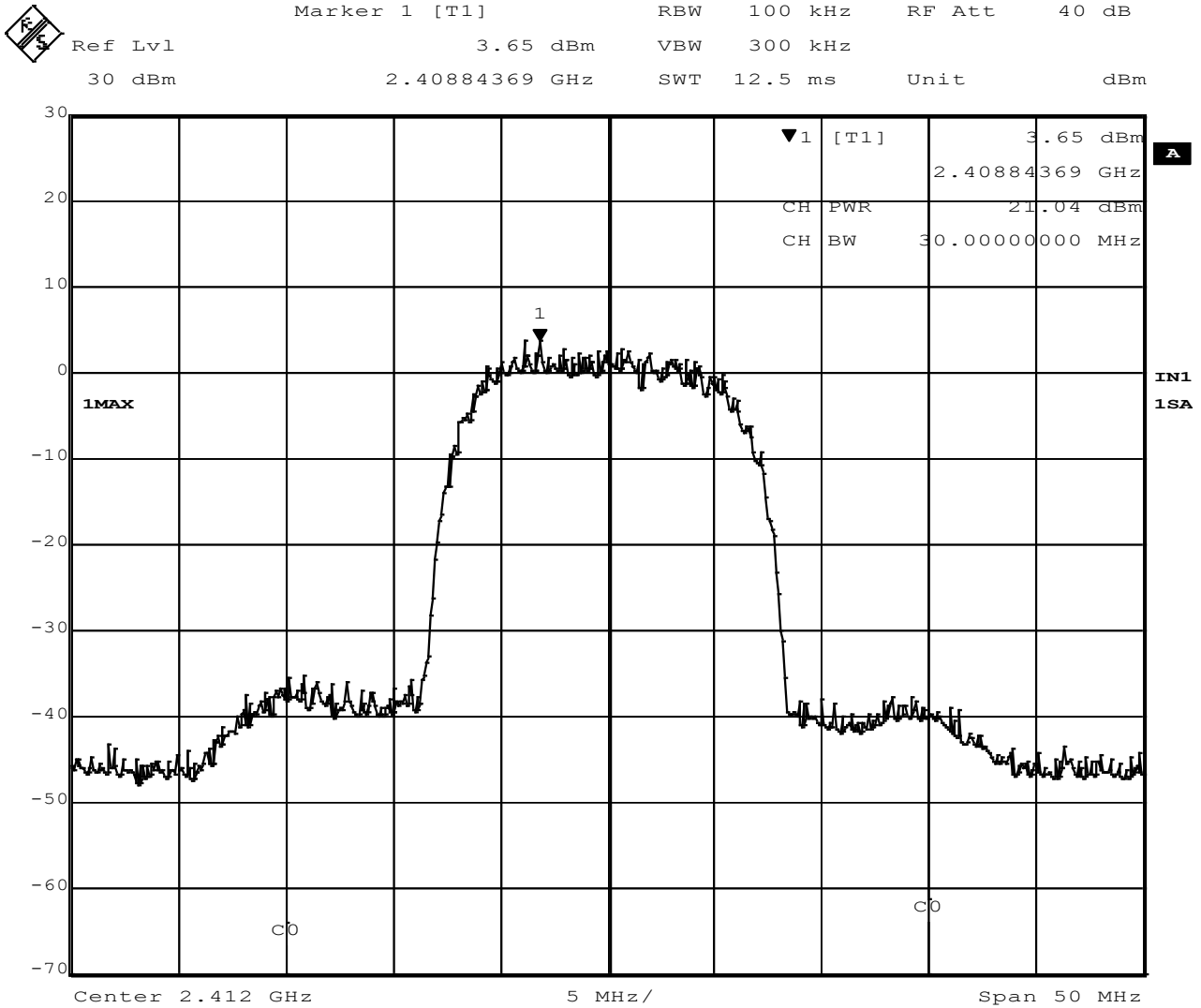
	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	PEAK OUTPUT POWER (dBm) MU = ± 1.1 dB	Method	RESULT
Low	2412	802.11b	21.04	Conducted	PASS
Middle	2437	802.11b	20.07	Conducted	PASS
High	2462	802.11b	19.12	Conducted	PASS
Low	2412	802.11g	21.85	Conducted	PASS
Middle	2437	802.11g	21.46	Conducted	PASS
High	2462	802.11g	21.44	Conducted	PASS
Low	2412	802.11n	20.98	Conducted	PASS
Middle	2437	802.11n	20.13	Conducted	PASS
High	2462	802.11n	18.85	Conducted	PASS

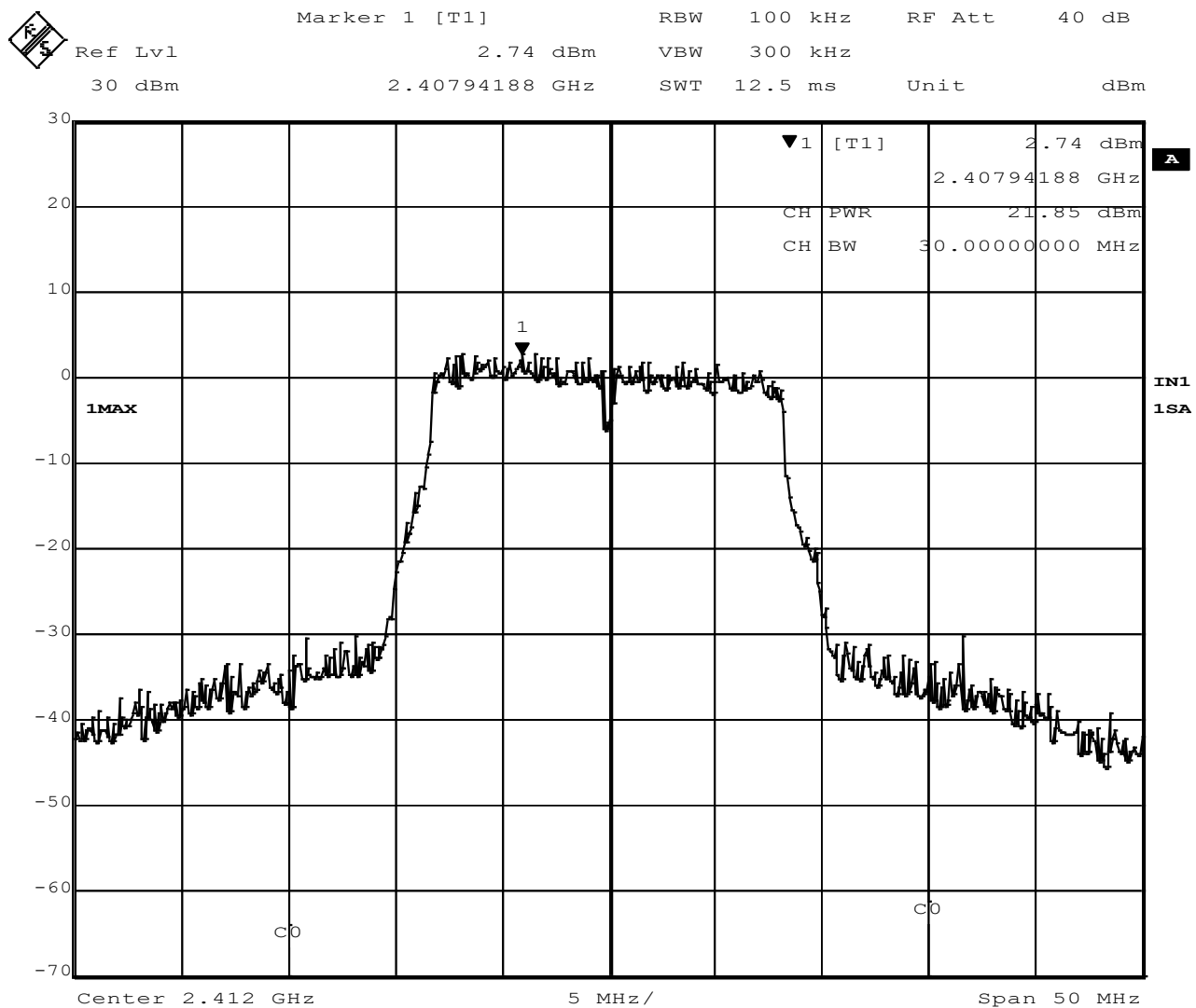
Average Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	Average OUTPUT POWER (dBm) MU = ± 1.37	Method	RESULT
Low	2412	802.11b	12.36	Conducted	PASS
Middle	2437	802.11b	11.58	Conducted	PASS
High	2462	802.11b	11.11	Conducted	PASS
Low	2412	802.11g	13.15	Conducted	PASS
Middle	2437	802.11g	12.71	Conducted	PASS
High	2462	802.11g	12.68	Conducted	PASS
Low	2412	802.11n	12.85	Conducted	PASS
Middle	2437	802.11n	12.63	Conducted	PASS
High	2462	802.11n	12.40	Conducted	PASS



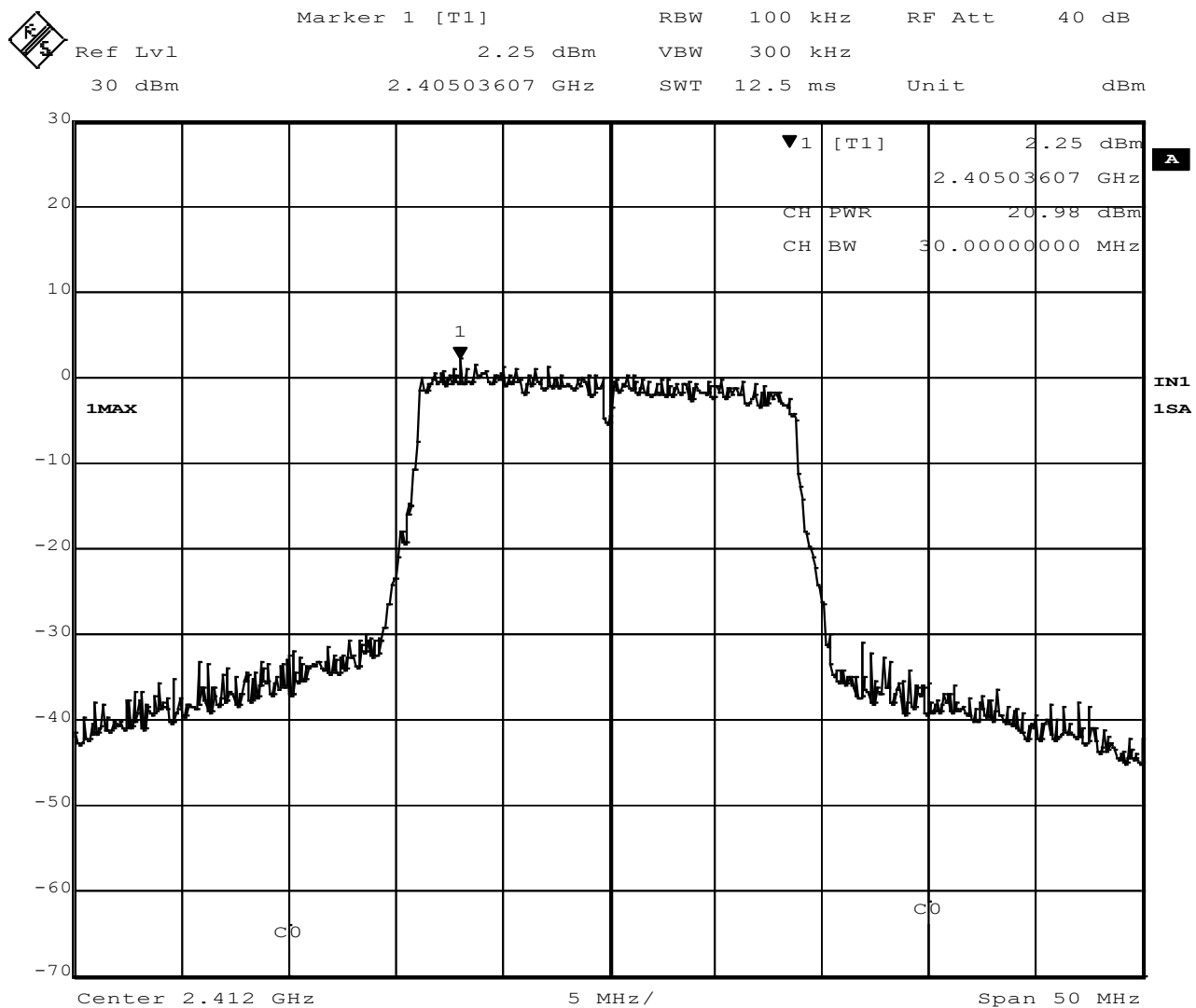
Date: 19.MAR.2019 09:10:05

Figure 7 – Highest Measured Peak Output Power, 802.11b



Date: 19.MAR.2019 09:18:35

Figure 8 – Highest Measured Peak Output Power, 802.11g



Date: 19.MAR.2019 09:33:10

Figure 9 – Highest Measured Peak Output Power, 802.11n

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

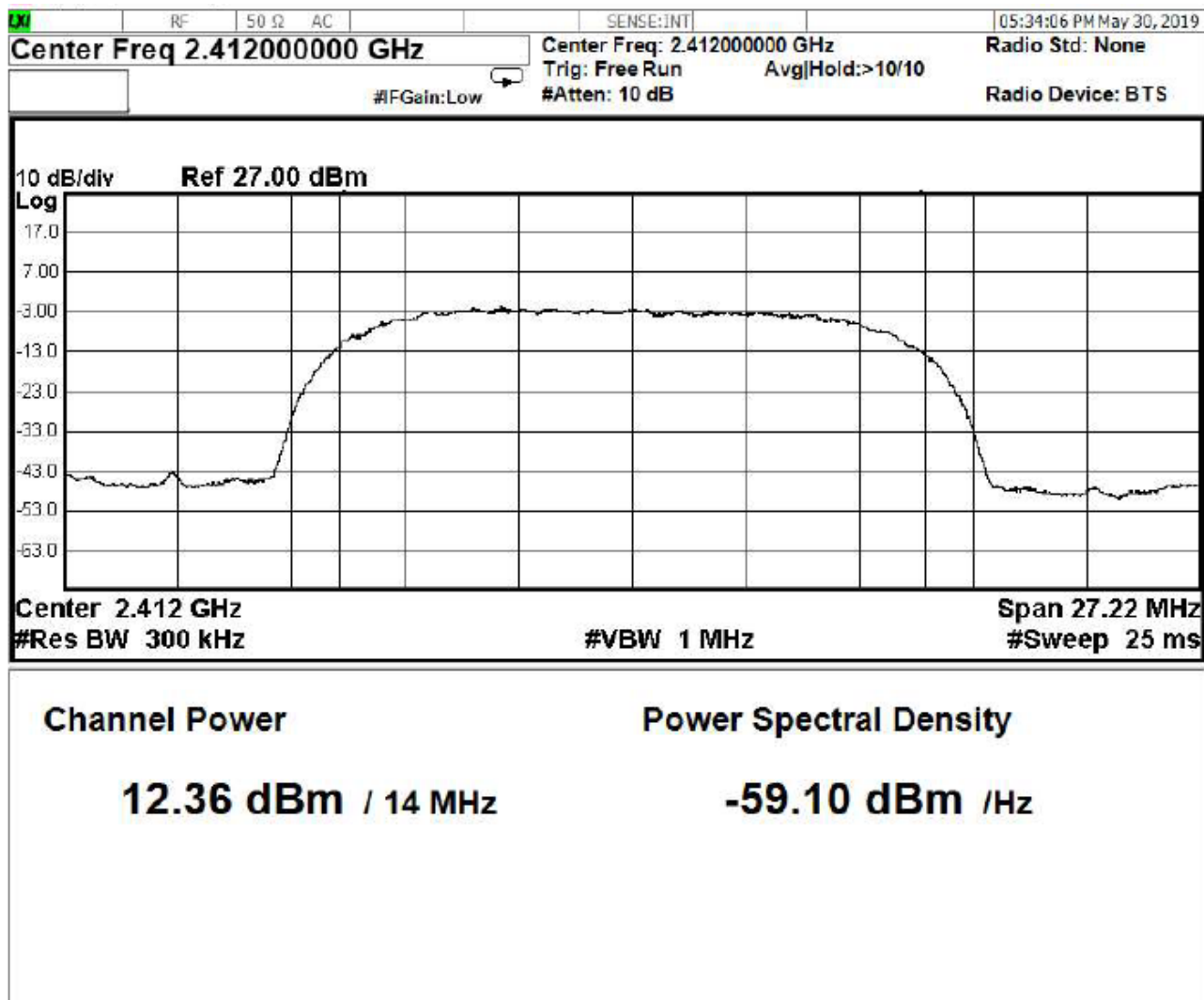


Figure 10 – Highest Measured Average Output Power, 802.11b

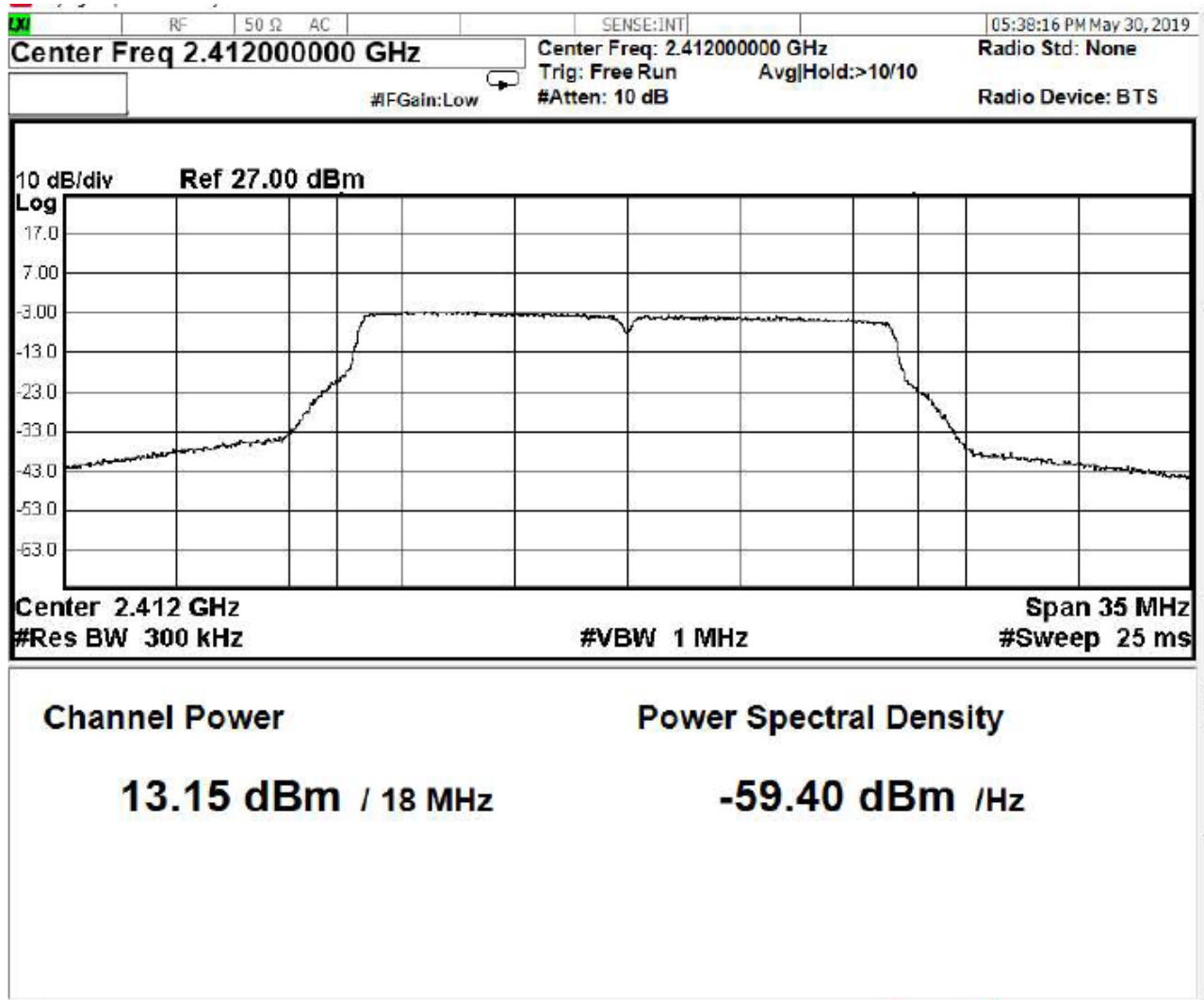


Figure 11 – Highest Measured Average Output Power, 802.11g

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

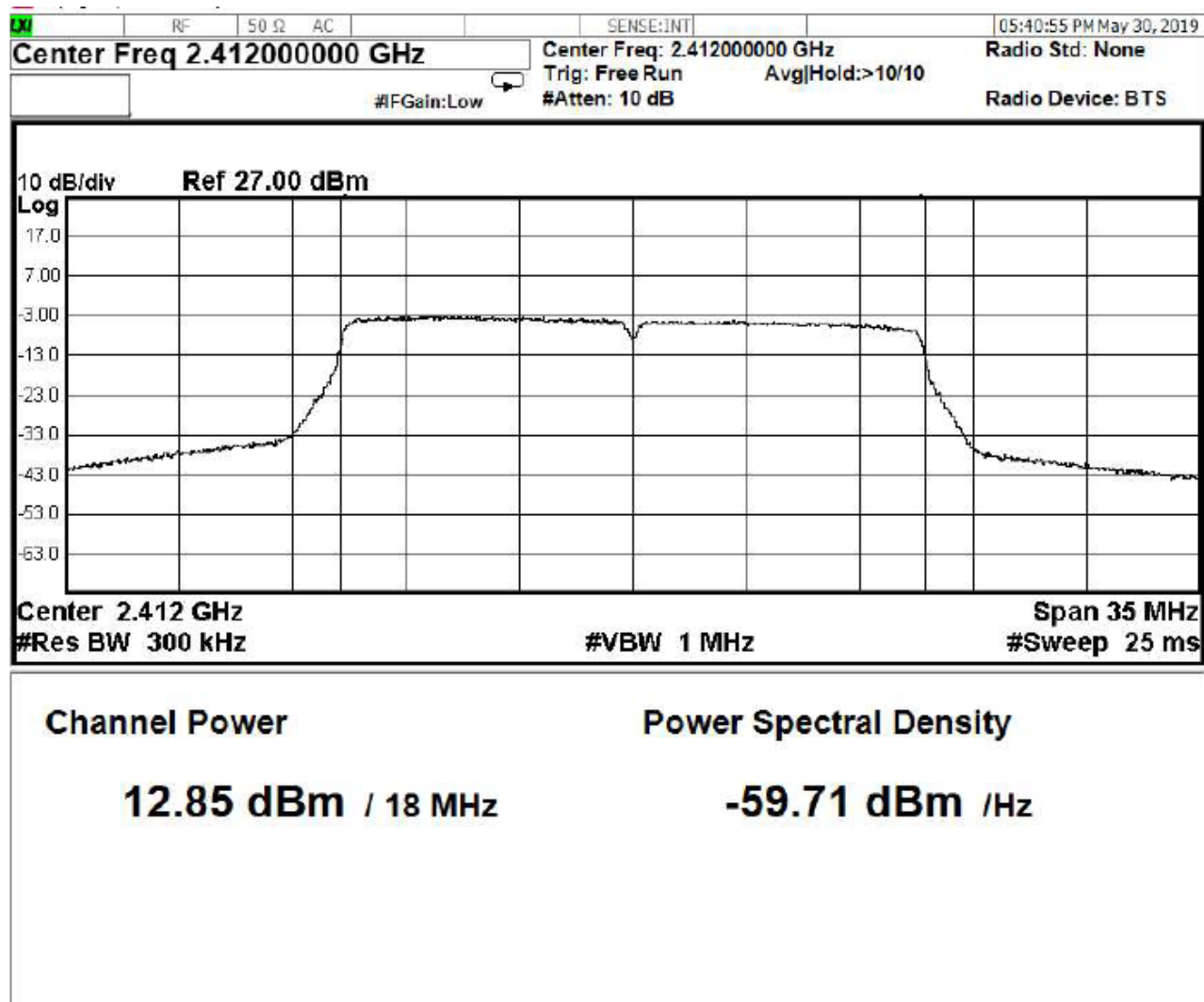


Figure 12 – Highest Measured Average Output Power, 802.11n

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..

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

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:

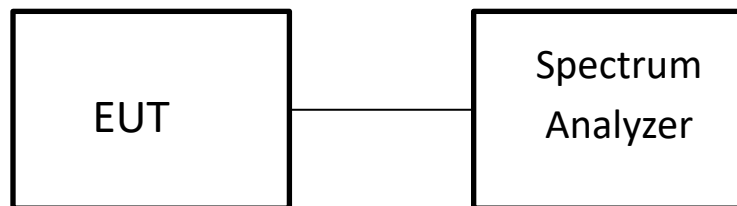


Figure 13 – Peak Output Power Measurements Test Setup

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:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

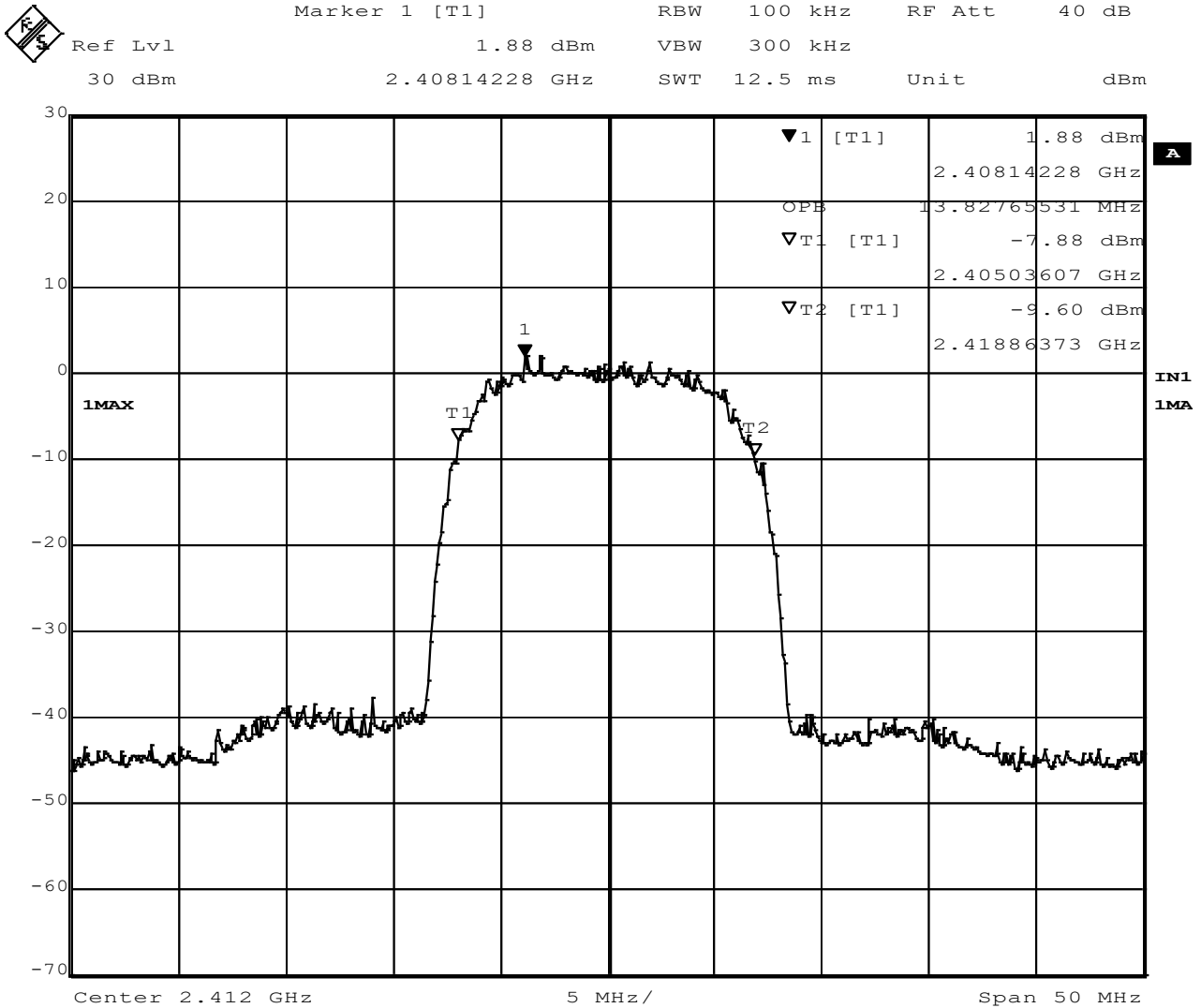
Test results:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	99% Occupied BW (MHz)
Low	2412	802.11b	13.83
Middle	2437	802.11b	13.83
High	2462	802.11b	13.83
Low	2412	802.11g	16.53
Middle	2437	802.11g	16.53
High	2462	802.11g	16.53
Low	2412	802.11n	17.74
Middle	2437	802.11n	17.74
High	2462	802.11n	17.74

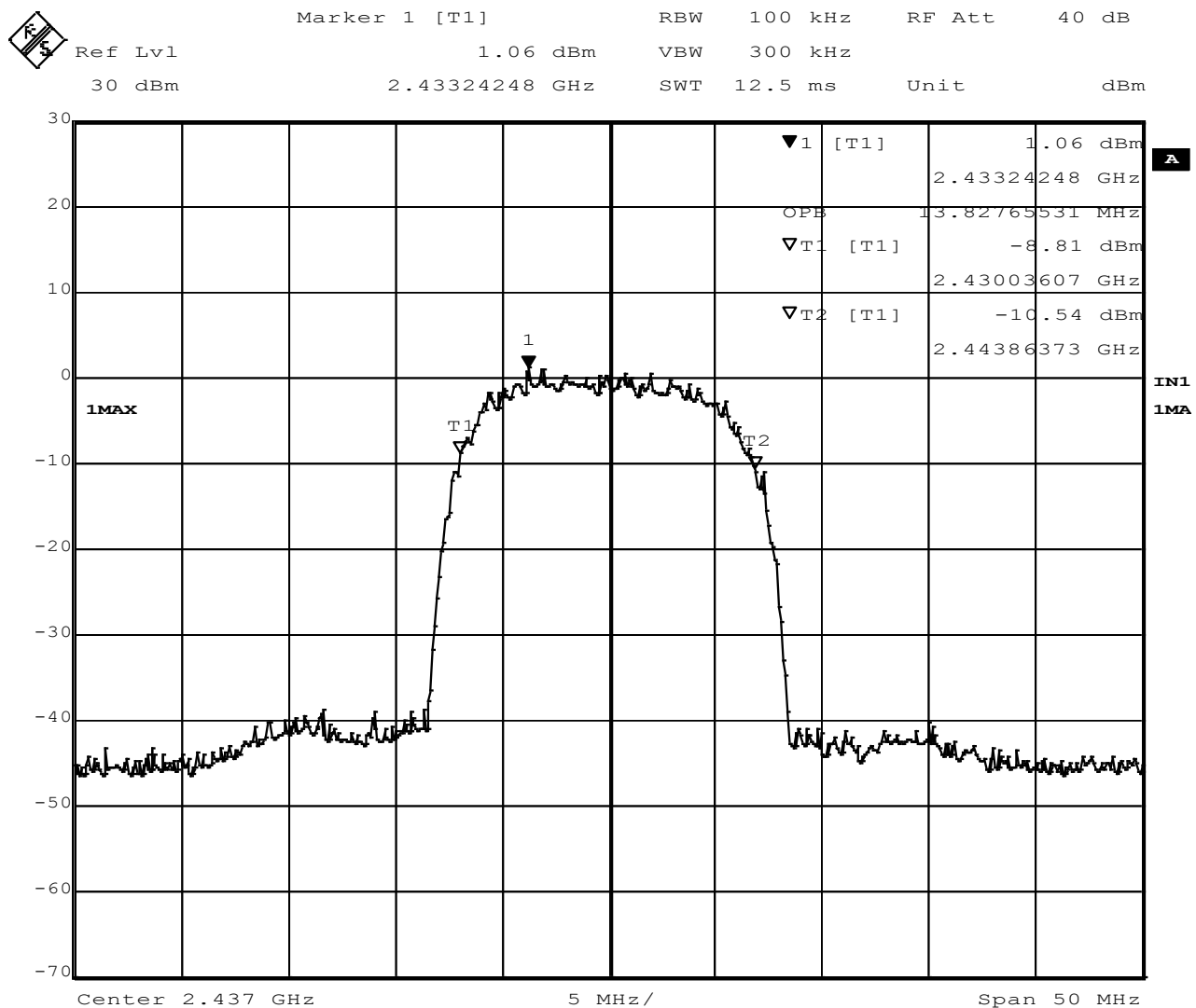
6dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	6 dB BW (MHz)
Low	2412	802.11b	11.62
Middle	2437	802.11b	11.70
High	2462	802.11b	11.62
Low	2412	802.11g	16.51
Middle	2437	802.11g	16.51
High	2462	802.11g	16.51
Low	2412	802.11n	17.72
Middle	2437	802.11n	17.72
High	2462	802.11n	17.72



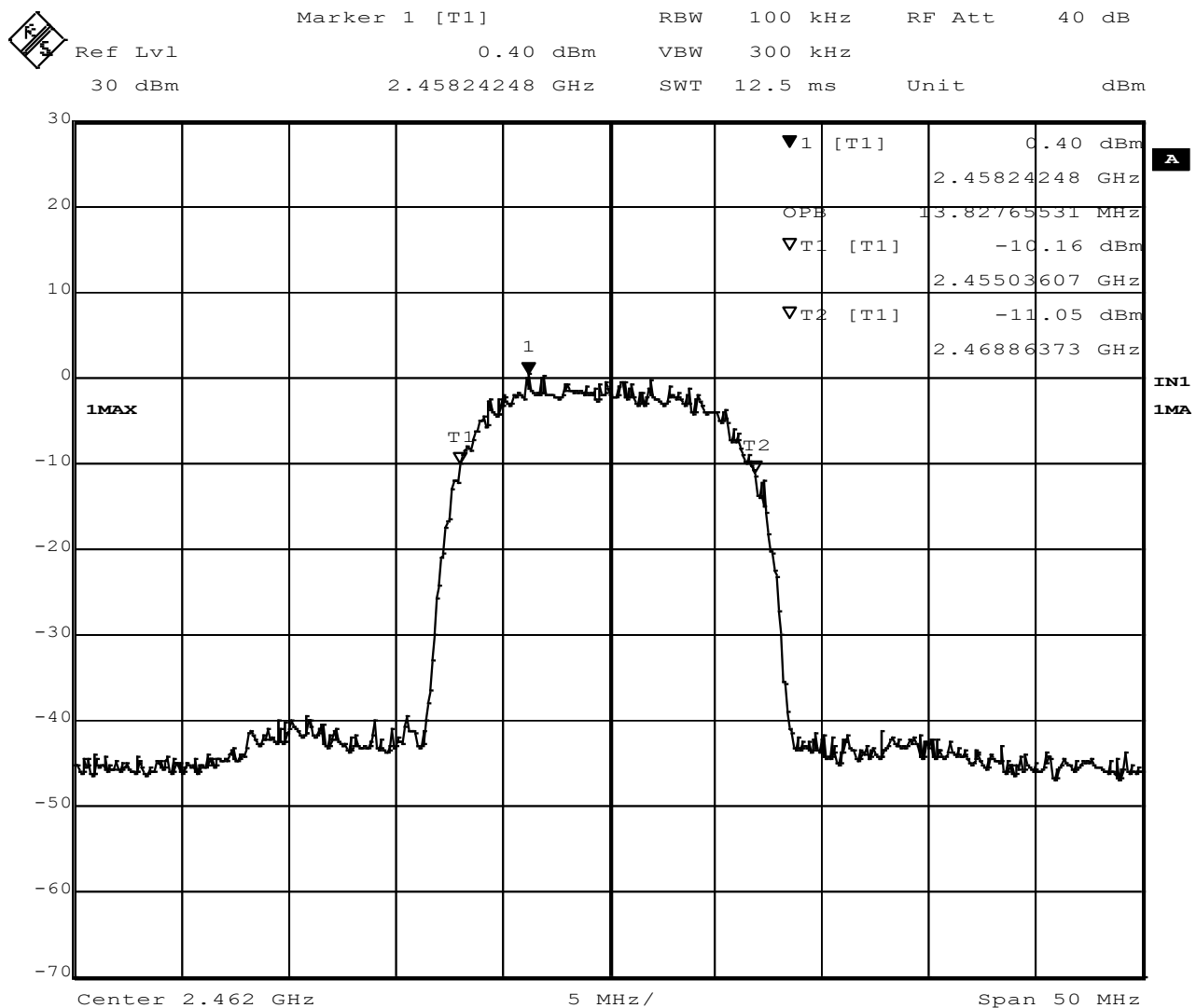
Date: 19.MAR.2019 16:33:08

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



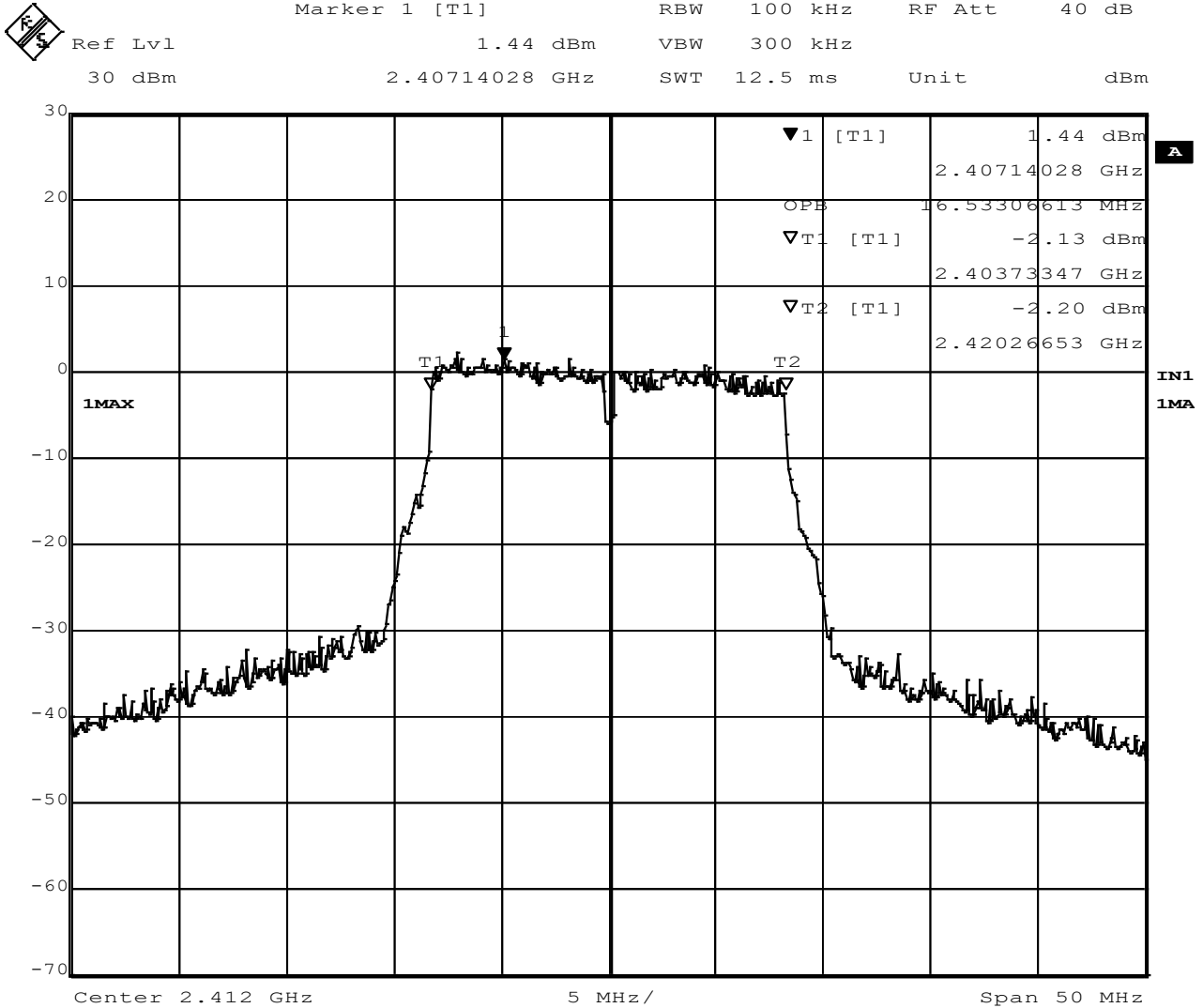
Date: 19.MAR.2019 16:34:16

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



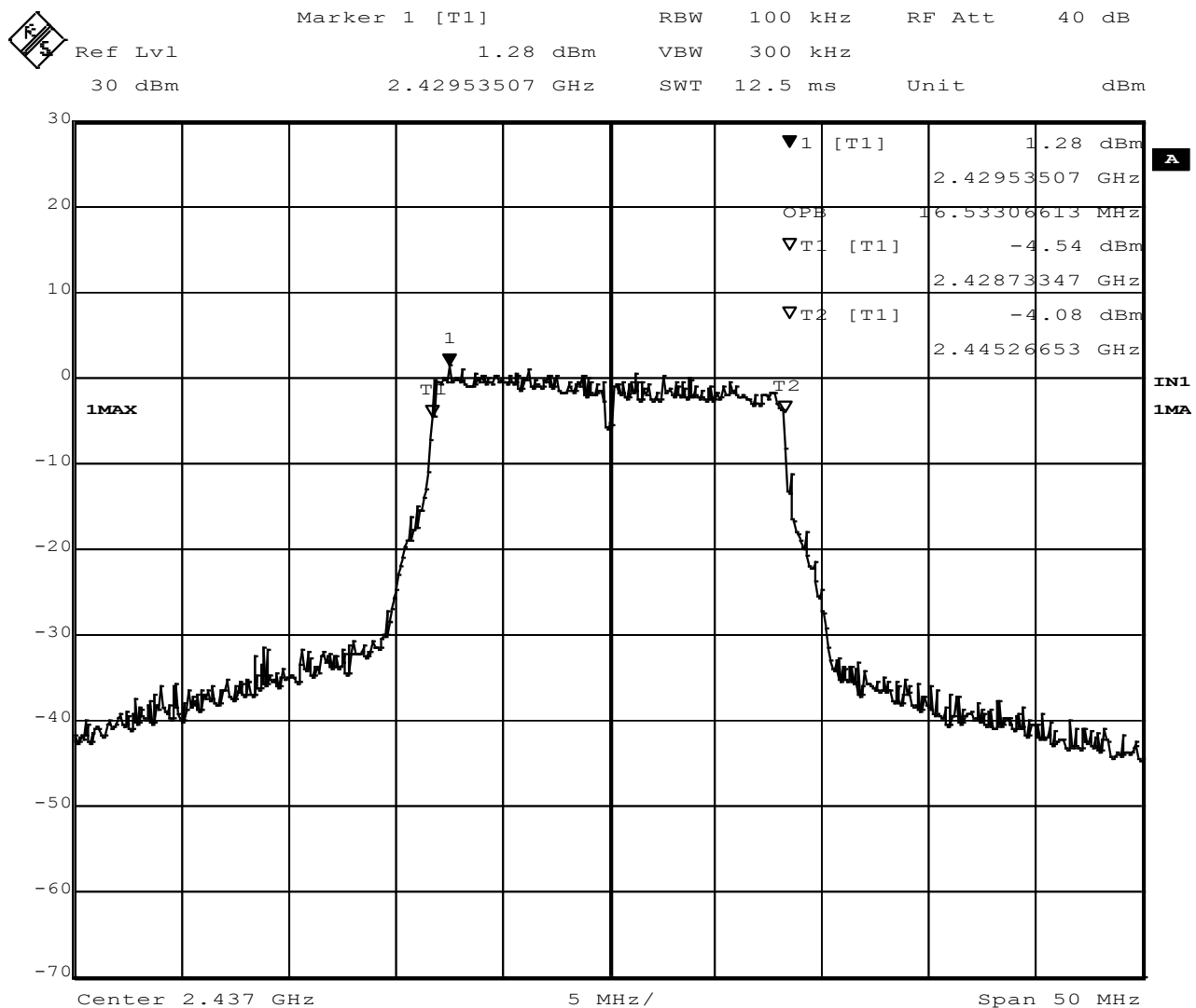
Date: 19.MAR.2019 16:35:10

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



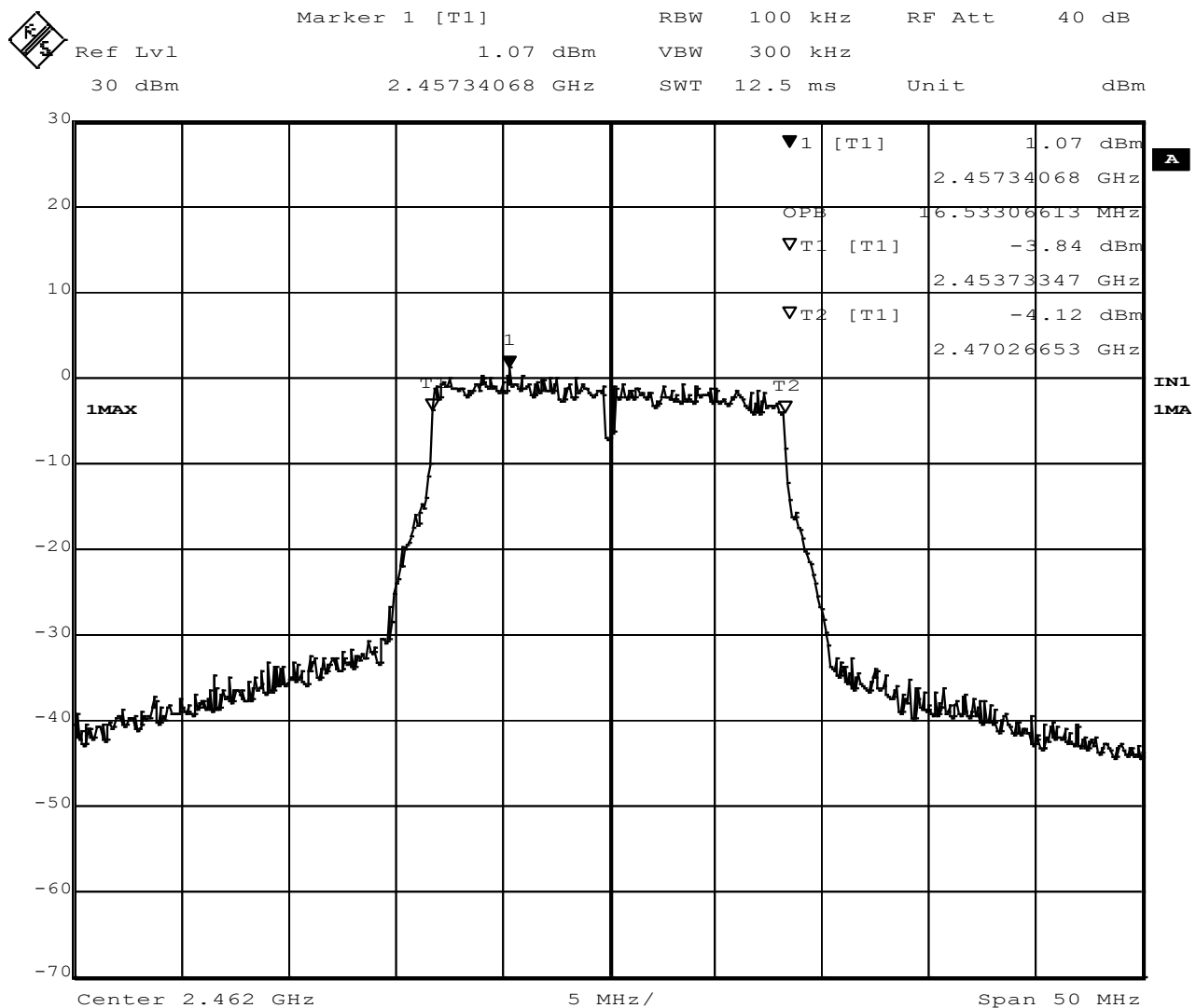
Date: 19.MAR.2019 16:36:32

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



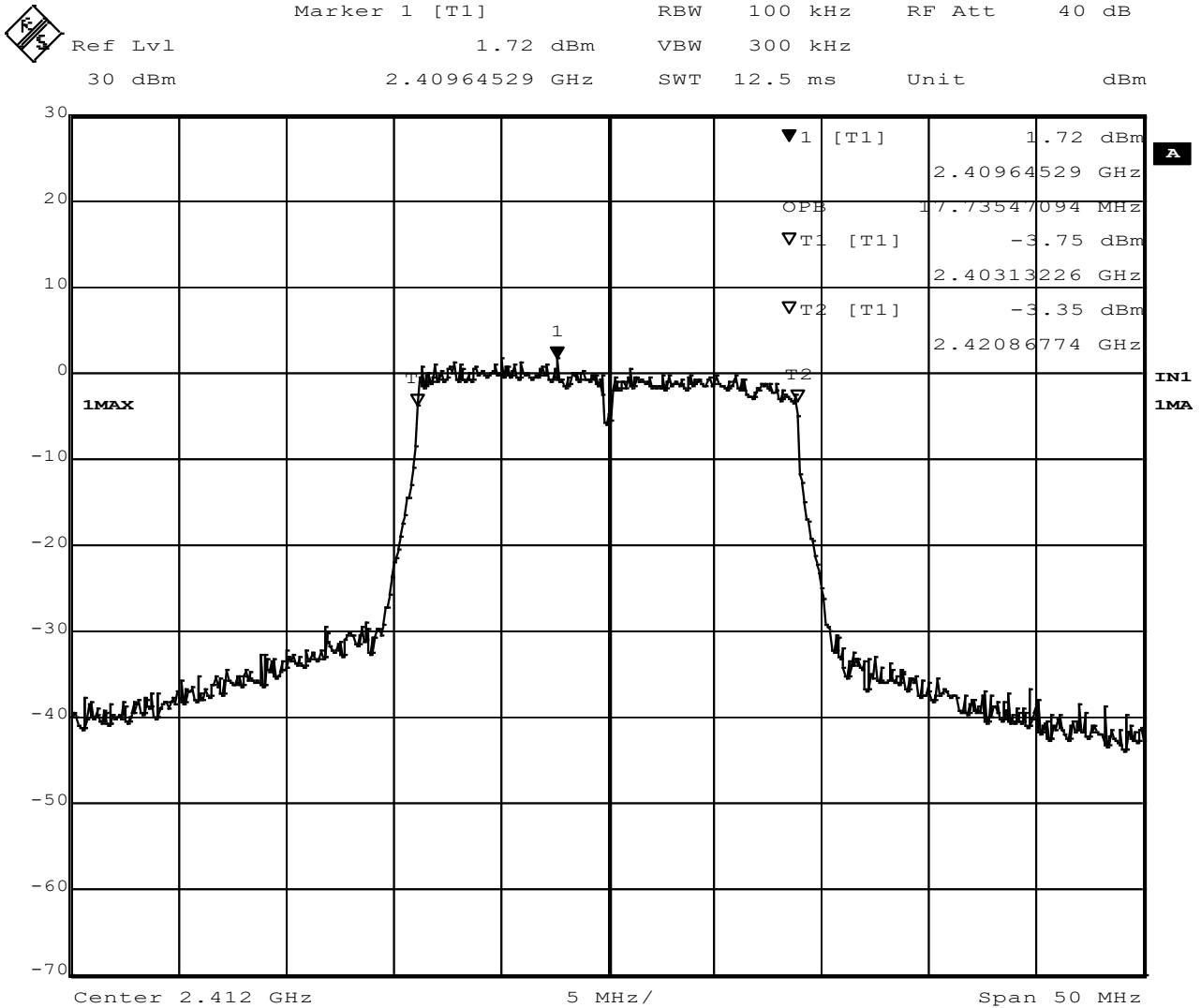
Date: 19.MAR.2019 16:37:00

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



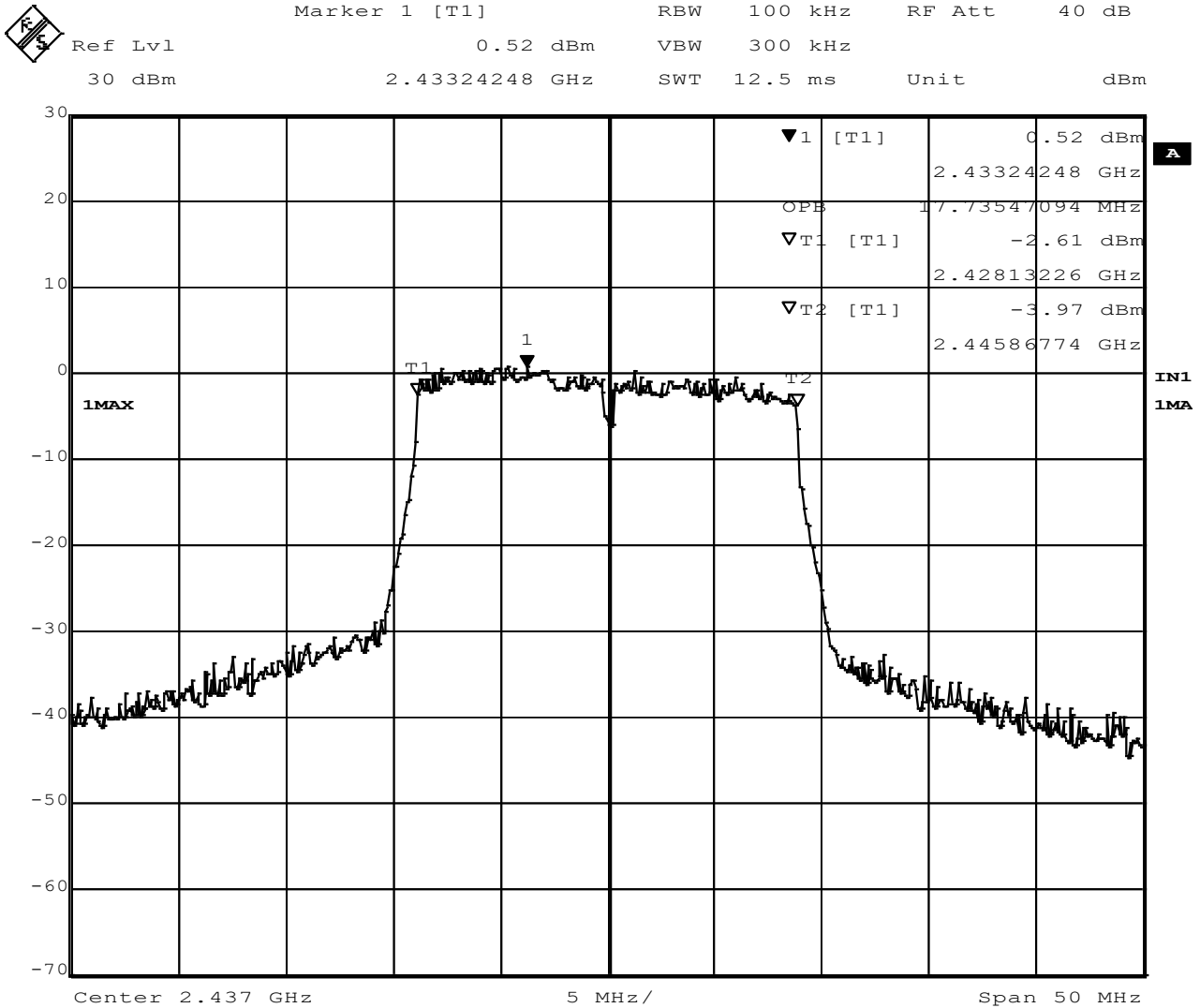
Date: 19.MAR.2019 16:35:45

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



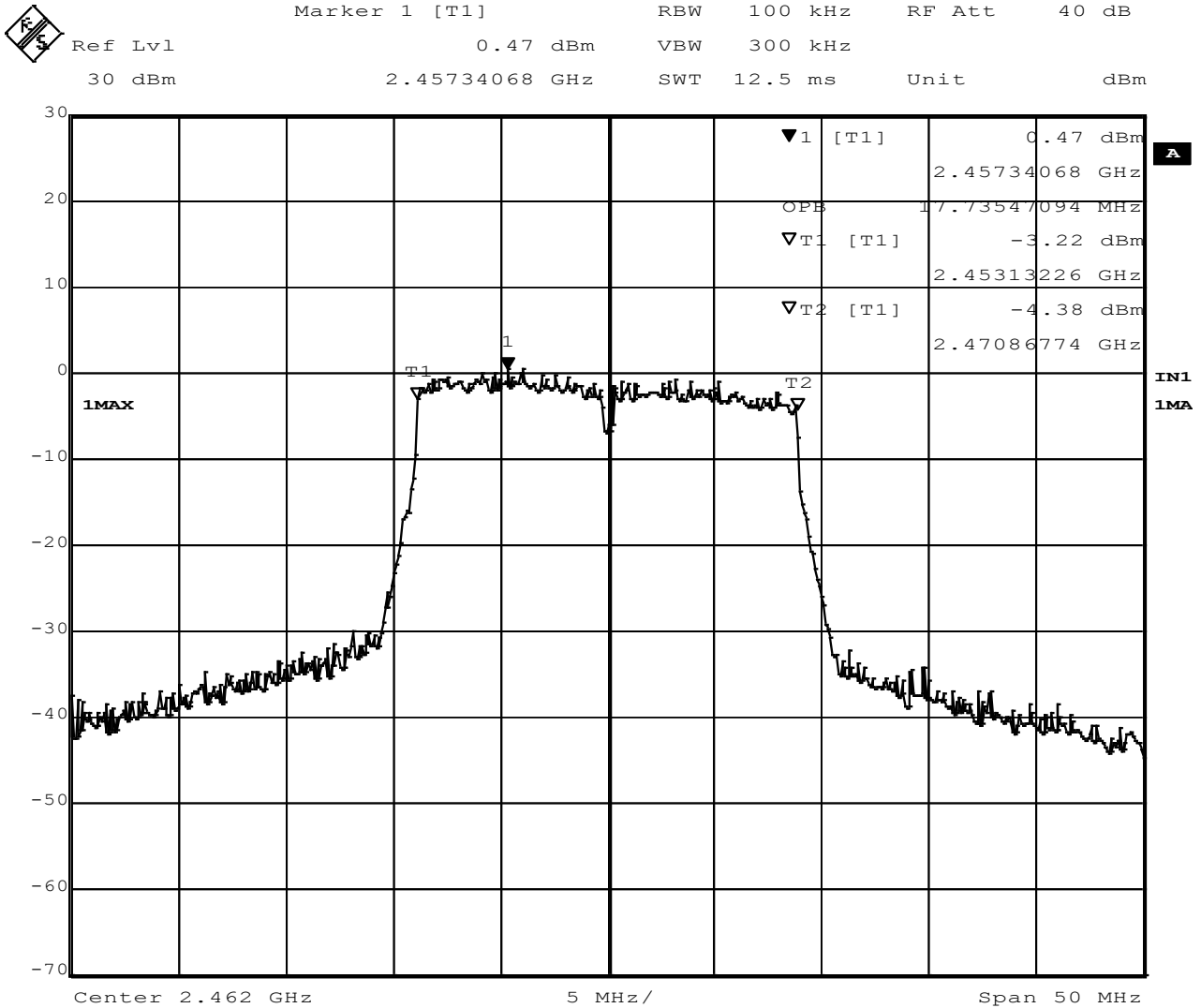
Date: 19.MAR.2019 16:38:30

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



Date: 19.MAR.2019 16:39:03

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



Date: 19.MAR.2019 16:37:54

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



Marker 1 [T1] RBW 100 kHz RF Att 20 dB
Ref Lvl 103.12 dBμV VBW 300 kHz
117 dBμV 2.40819238 GHz SWT 10 ms Unit dBμV

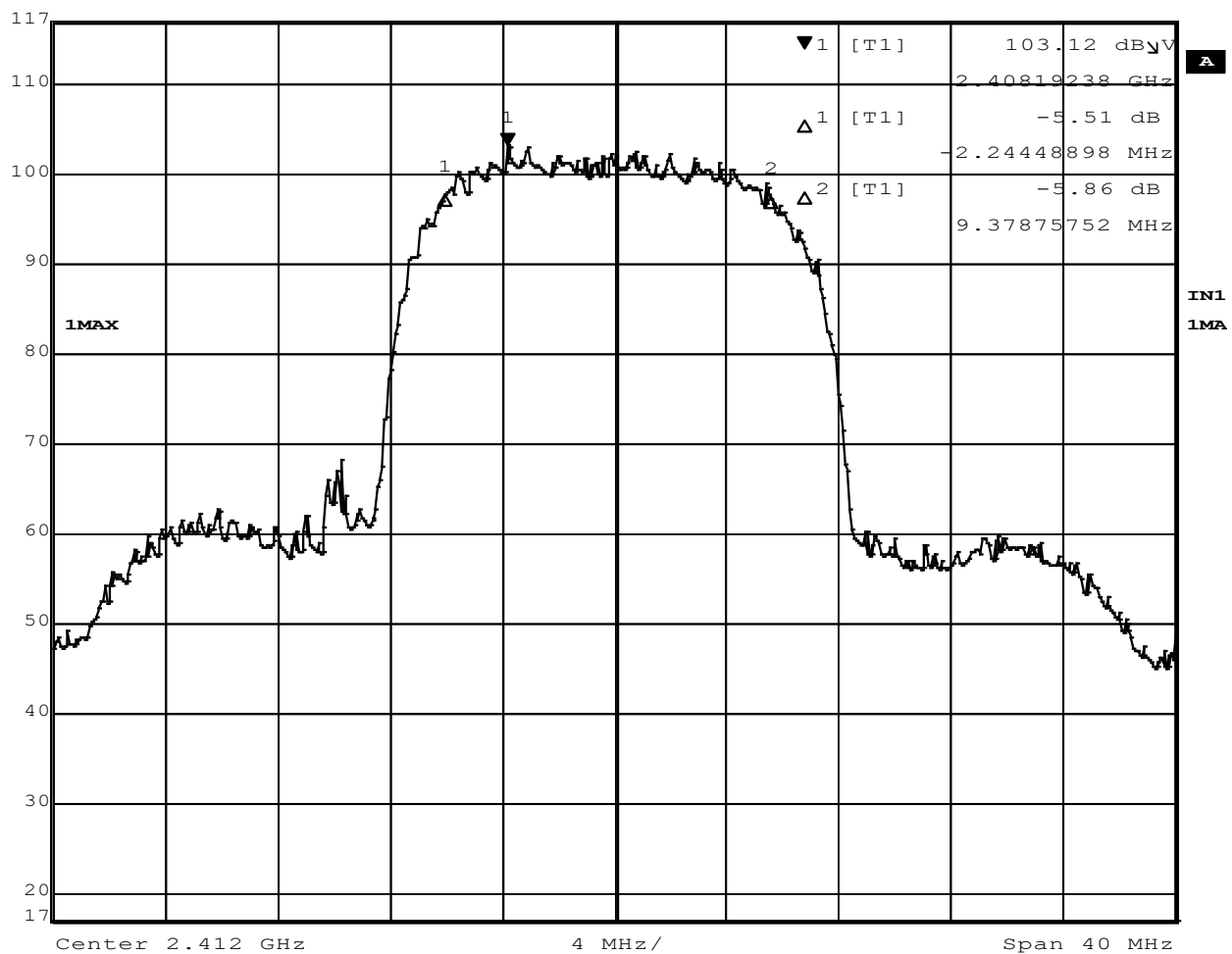


Figure 23 - 6dB Bandwidth, Low Channel, 802.11b



Marker 1 [T1] RBW 100 kHz RF Att 20 dB
 Ref Lvl 102.09 dBμV VBW 300 kHz
 117 dBμV 2.43319238 GHz SWT 10 ms Unit dBμV

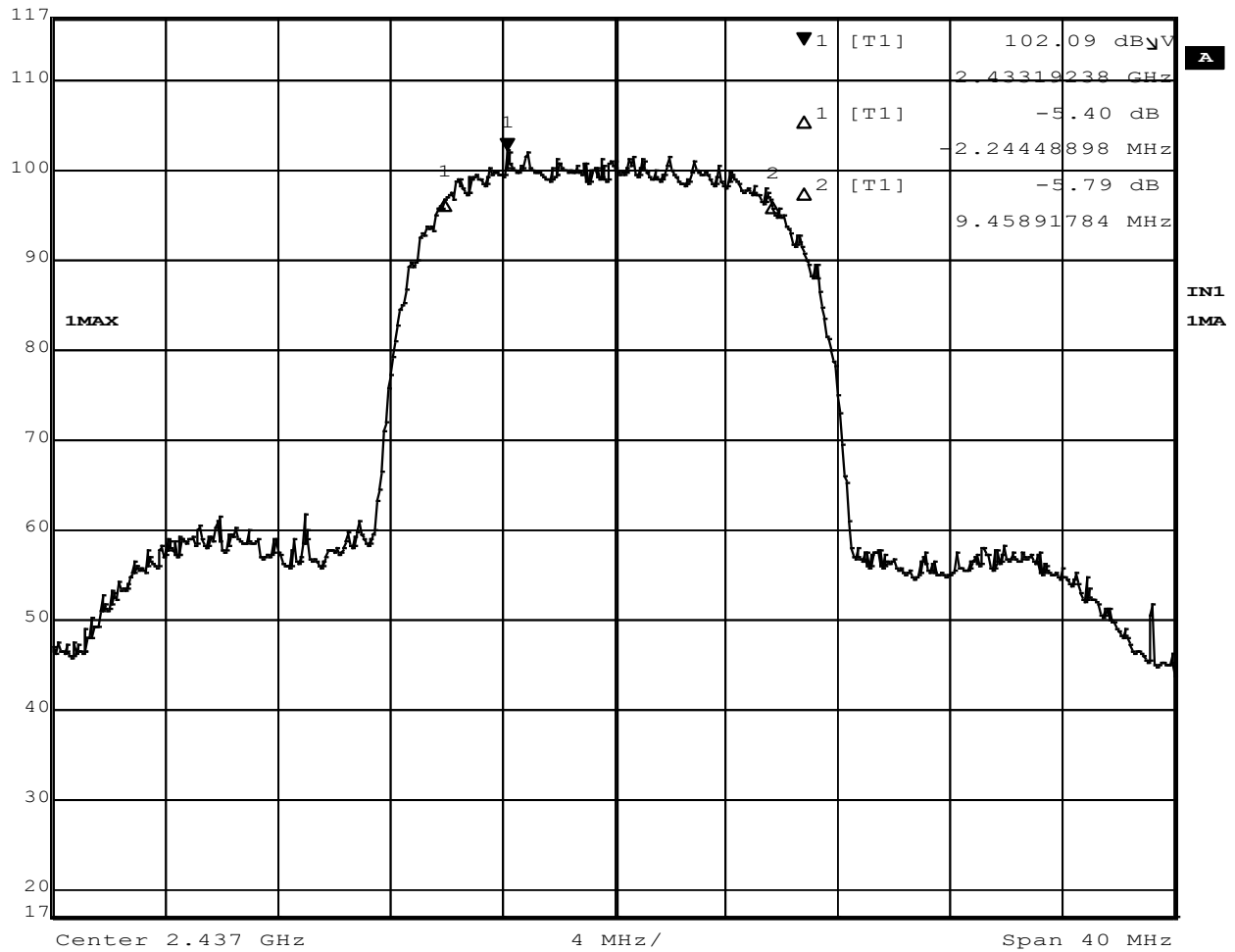


Figure 24 - 6dB Bandwidth, Mid Channel, 802.11b

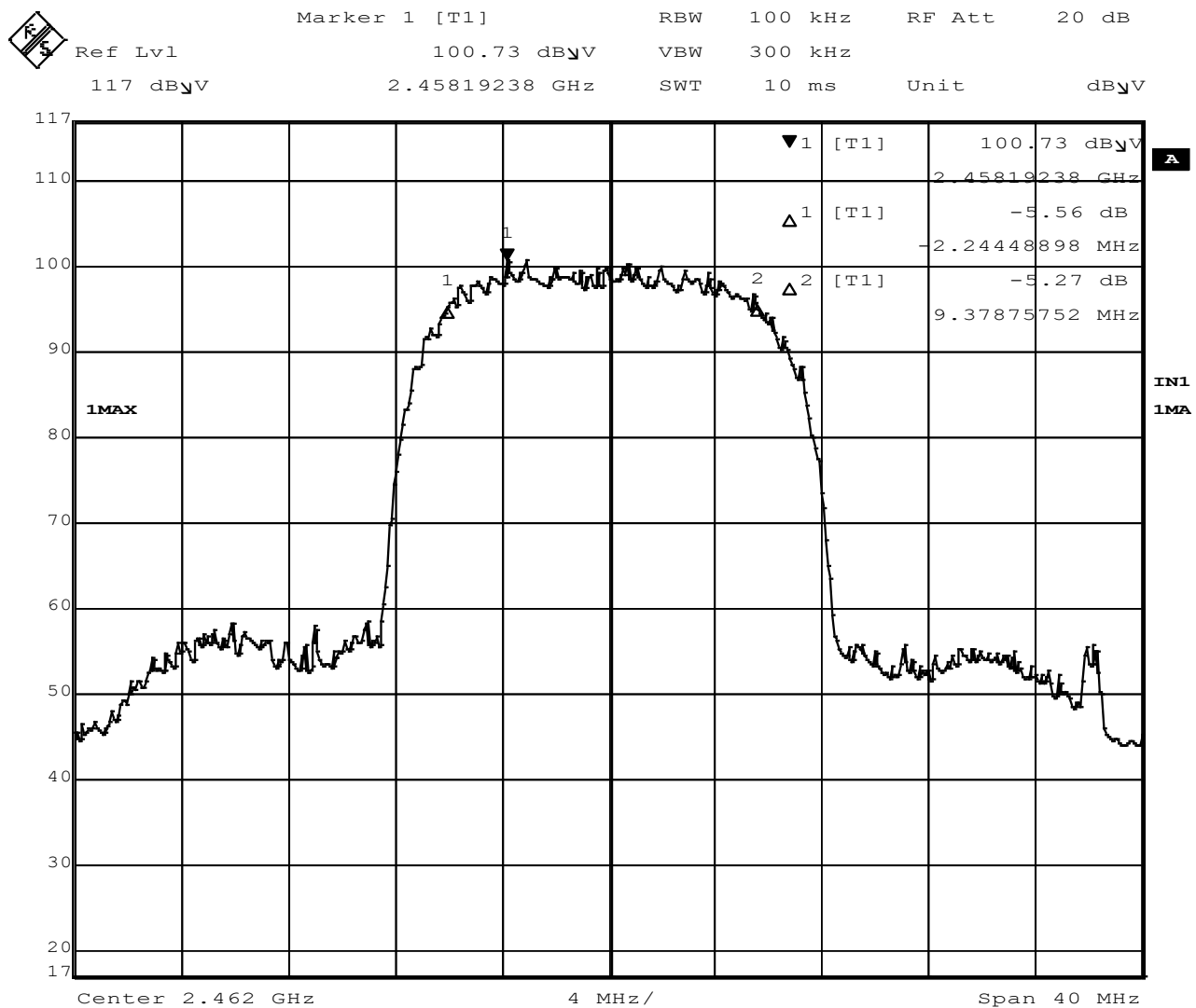


Figure 25 - 6dB Bandwidth, High Channel, 802.11b



Marker 1 [T1] RBW 100 kHz RF Att 20 dB
Ref Lvl 102.48 dBμV VBW 300 kHz
117 dBμV 2.40490581 GHz SWT 10 ms Unit dBμV

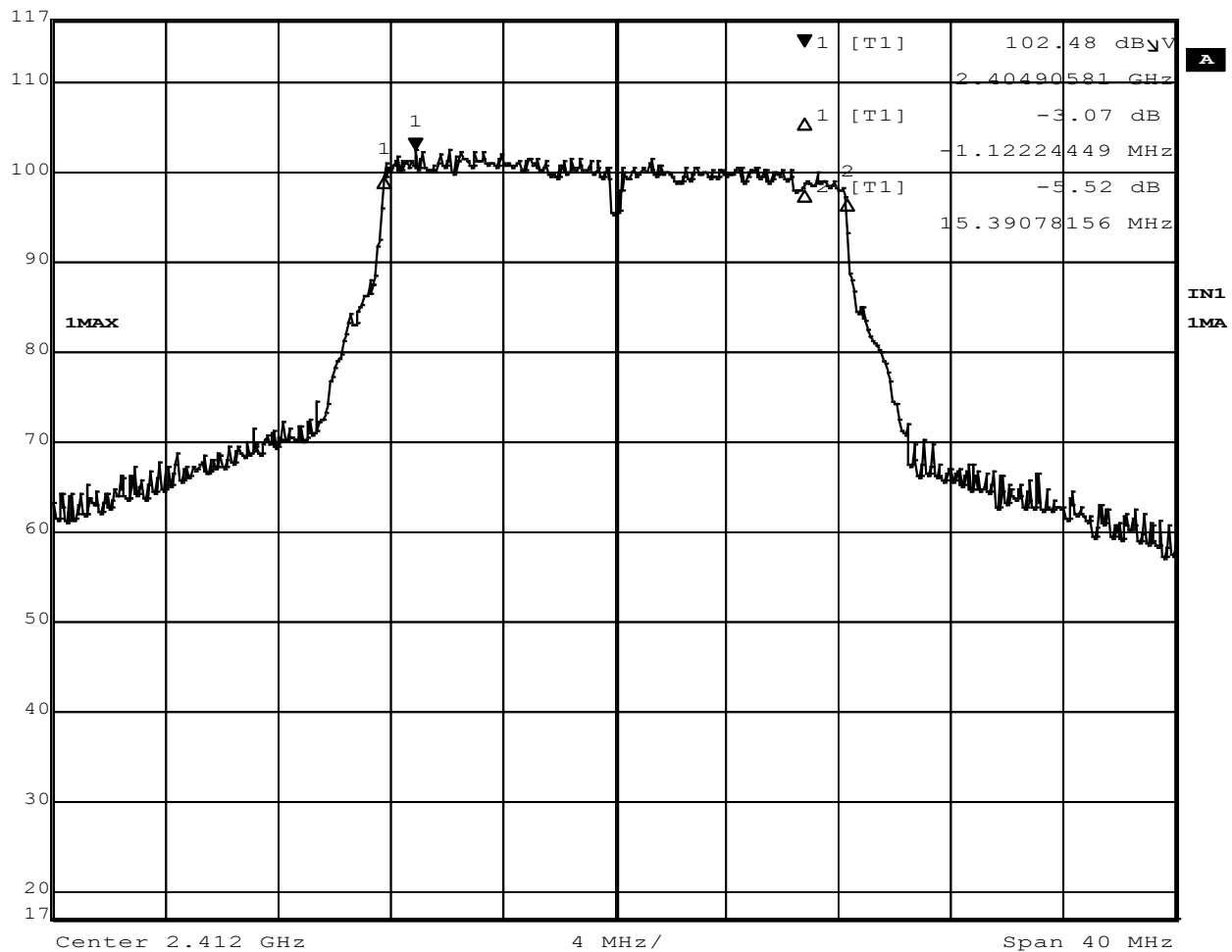


Figure 26 - 6dB Bandwidth, Low Channel, 802.11g



Marker 1 [T1] RBW 100 kHz RF Att 20 dB
Ref Lvl 101.77 dBμV VBW 300 kHz
117 dBμV 2.43207014 GHz SWT 10 ms Unit dBμV

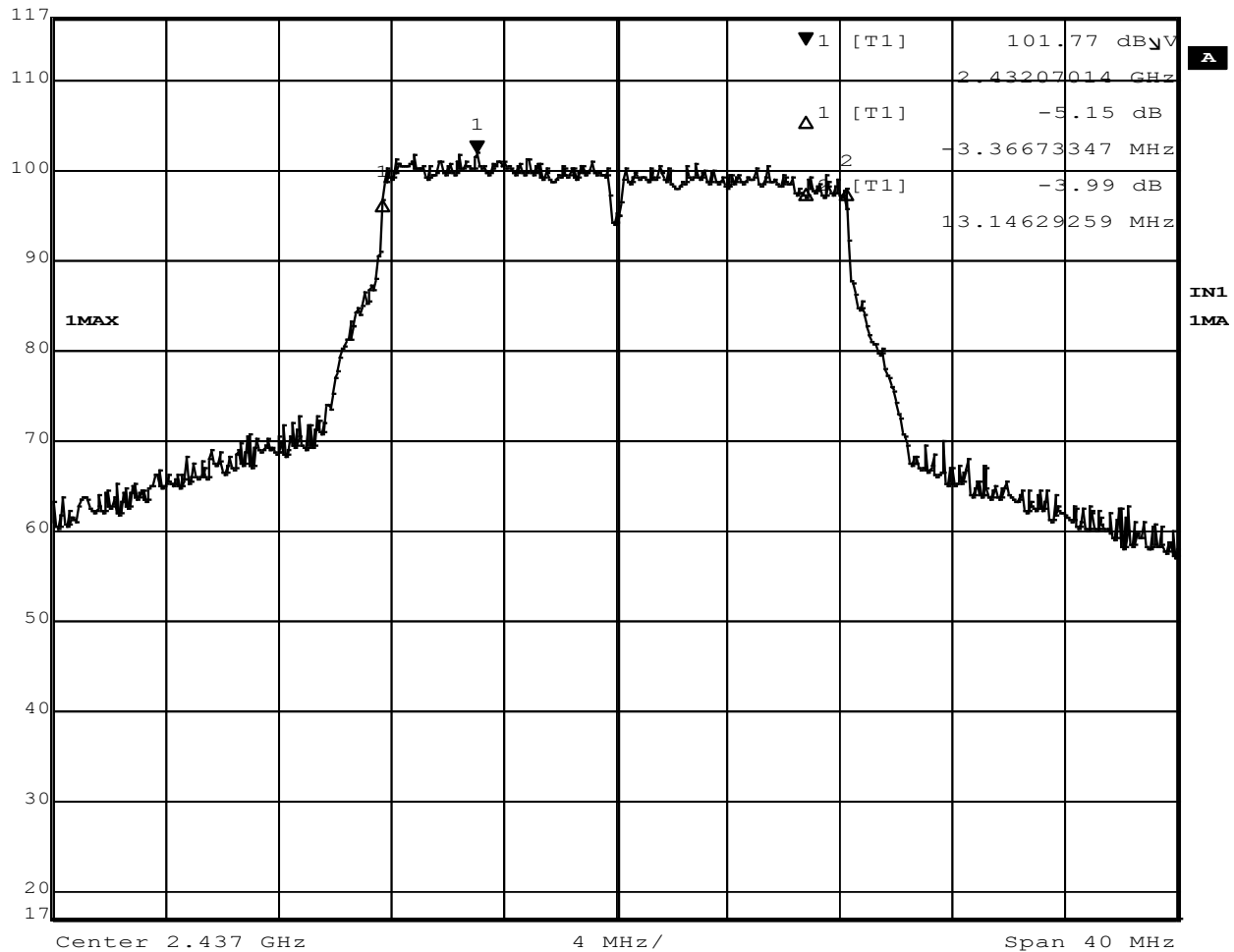


Figure 27 - 6dB Bandwidth, Mid Channel, 802.11g



Marker 1 [T1] RBW 100 kHz RF Att 20 dB
 Ref Lvl 101.44 dBμV VBW 300 kHz
 117 dBμV 2.45650902 GHz SWT 10 ms Unit dBμV

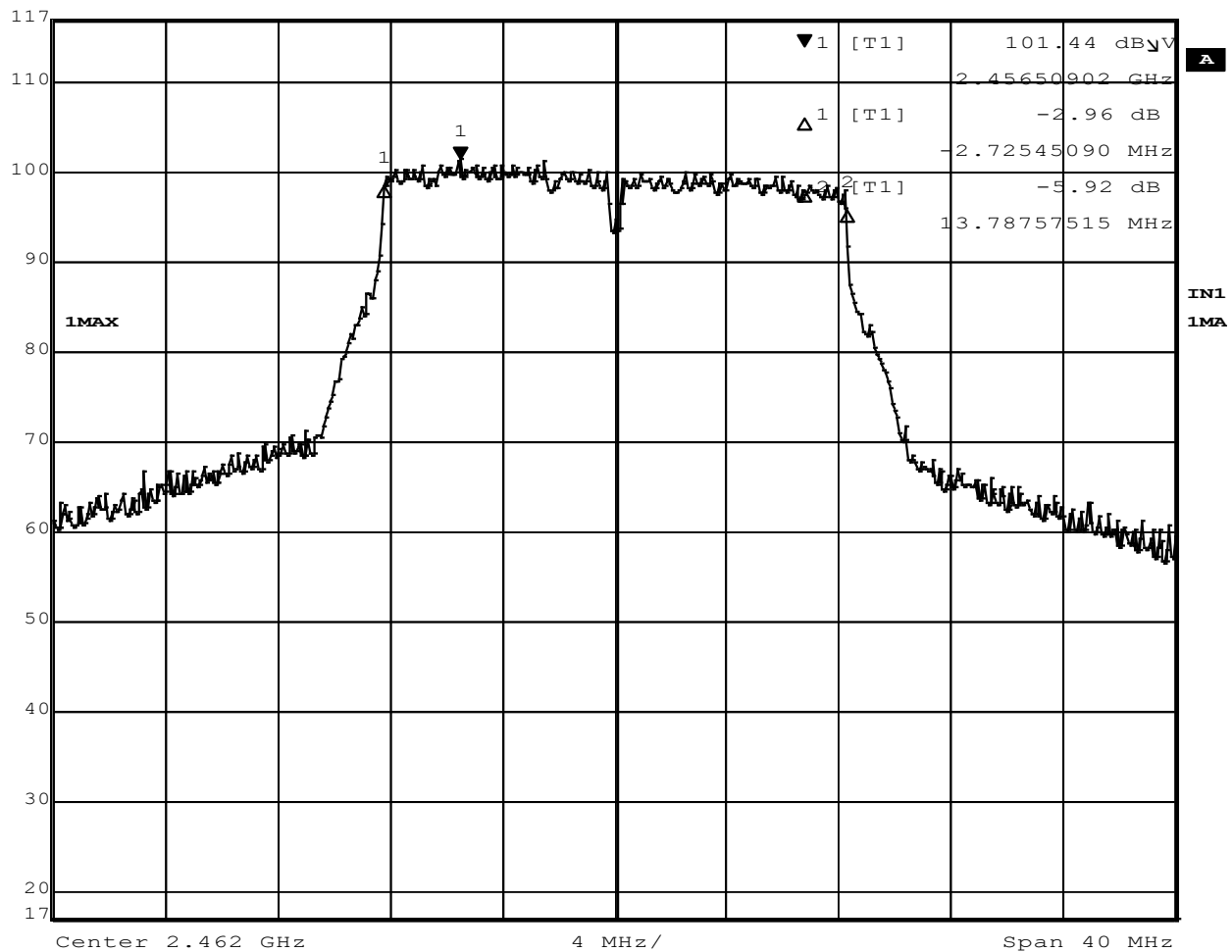


Figure 28 - 6dB Bandwidth, High Channel, 802.11g

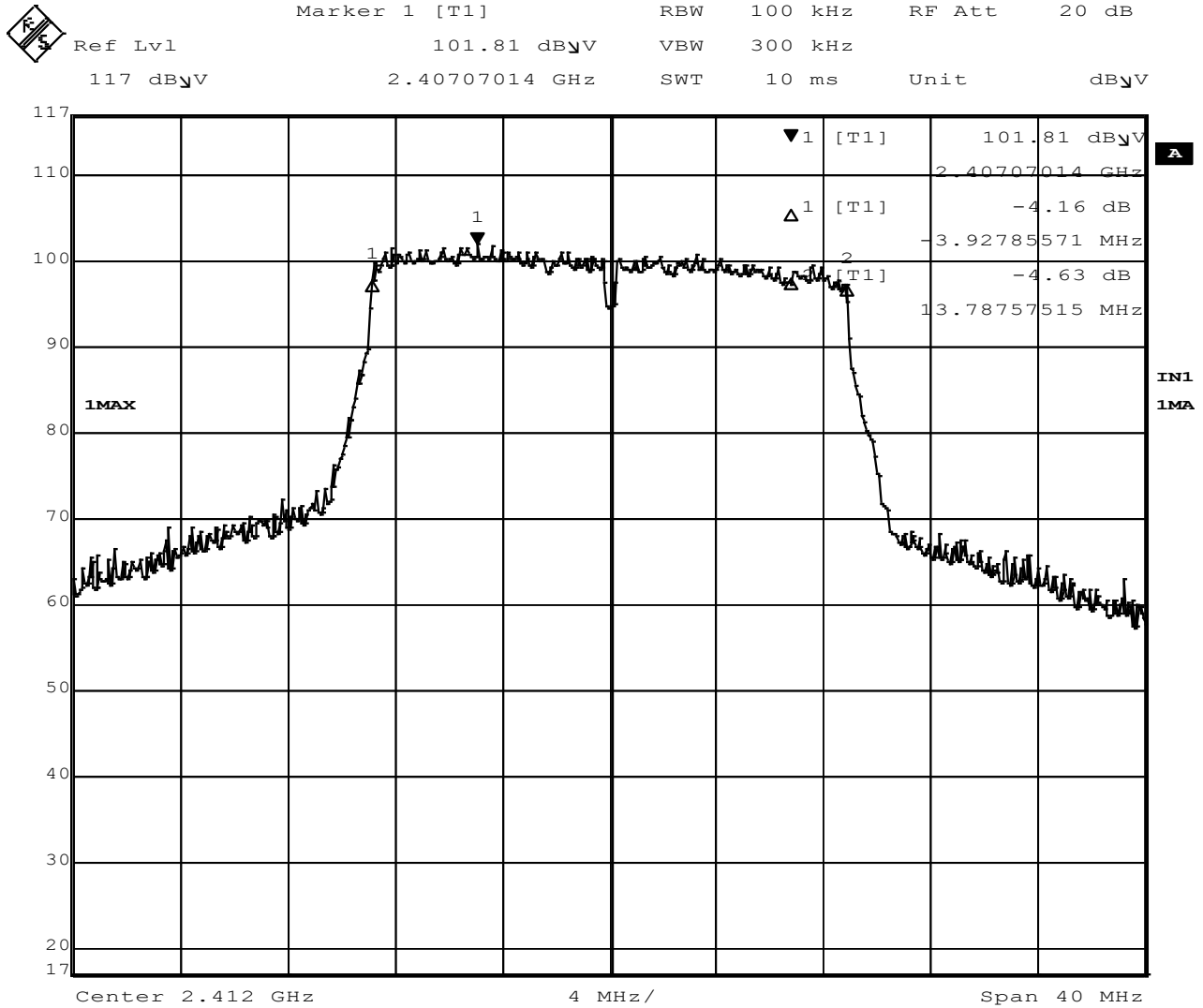


Figure 29 - 6dB Bandwidth, Low Channel, 802.11n

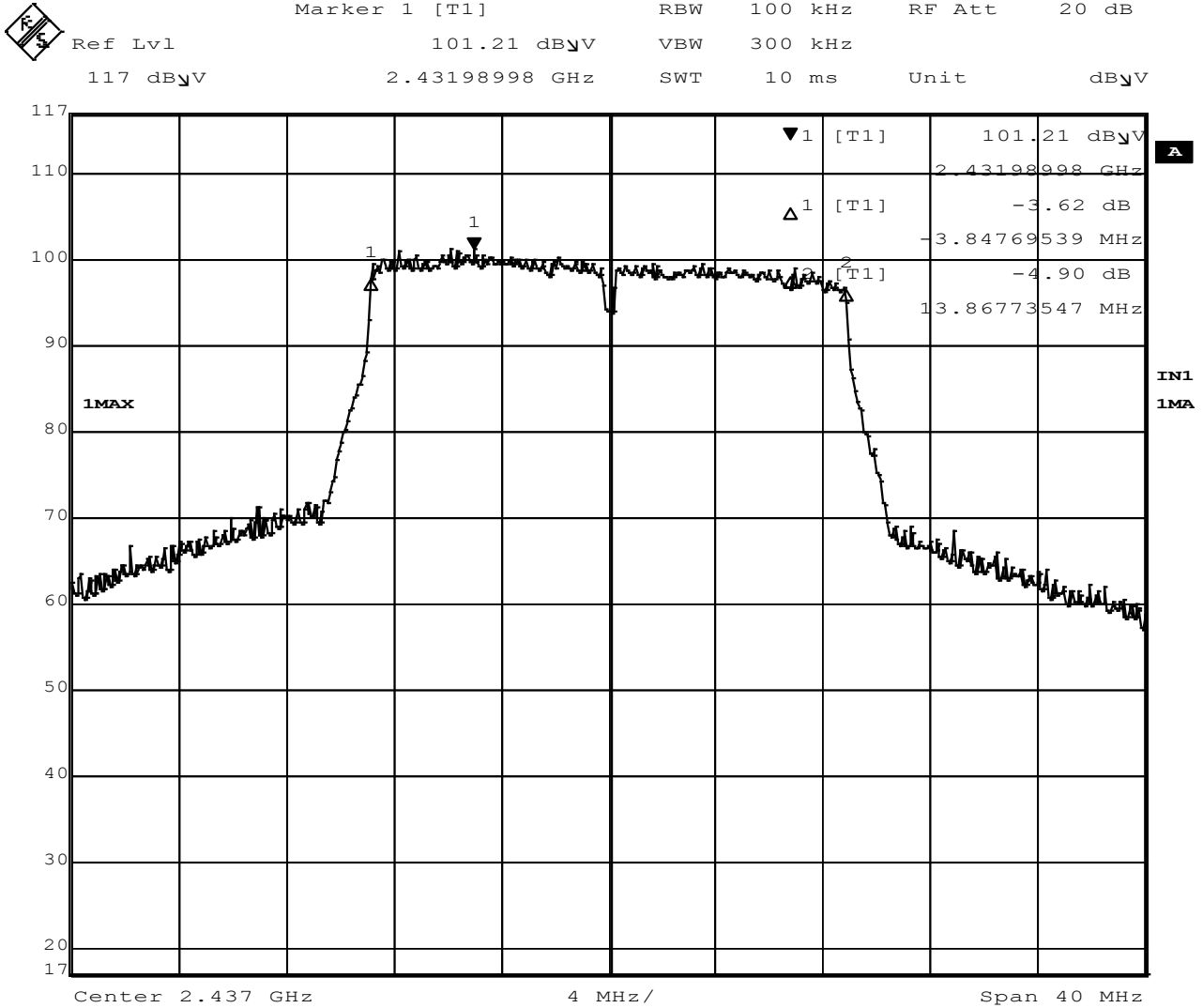


Figure 30 - 6dB Bandwidth, Mid Channel, 802.11n

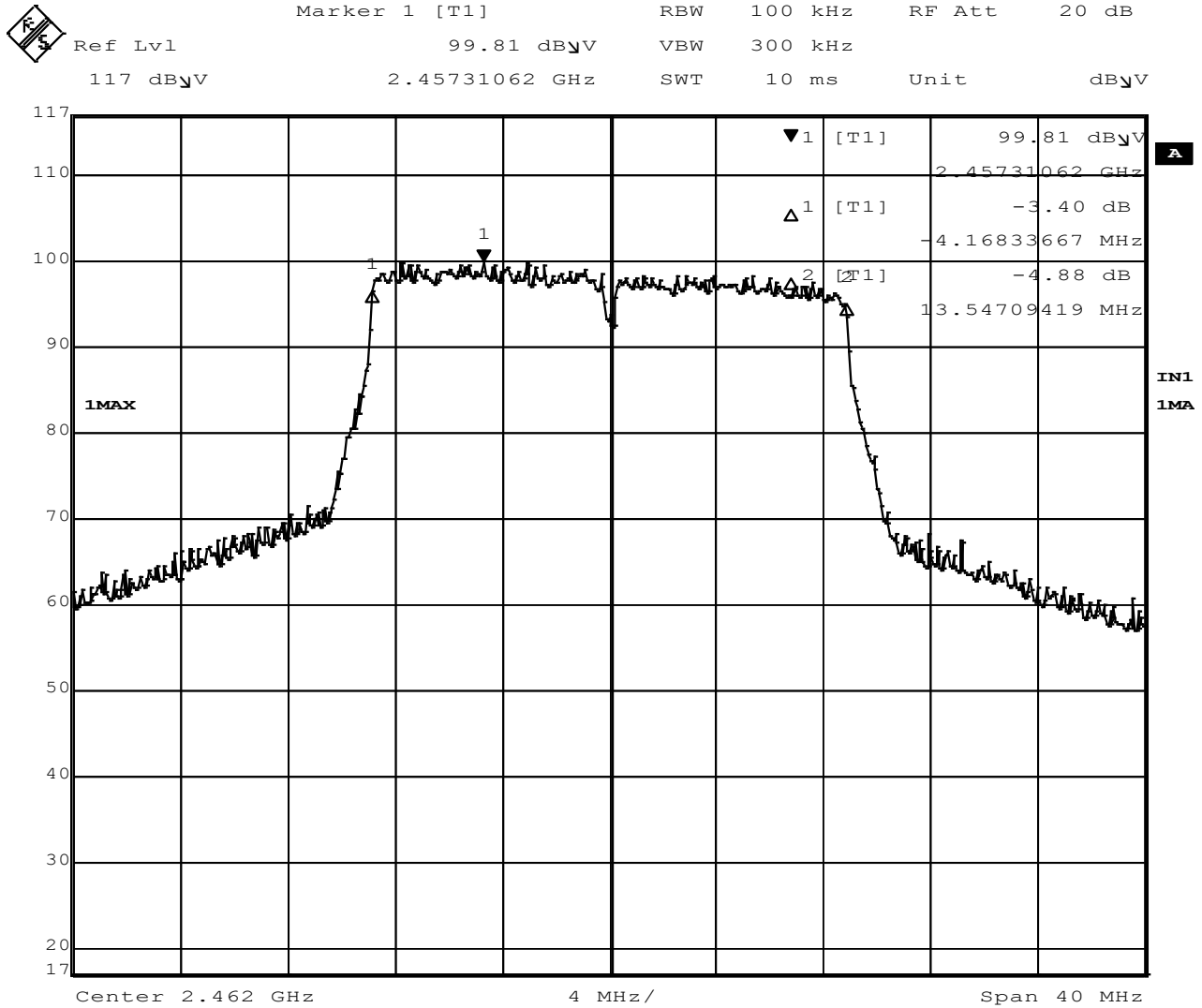


Figure 31 - 6dB Bandwidth, High Channel, 802.11n

	Report Number:	R20181219-20-08	Rev	A
	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:	R20181219-20-08	Rev	A
	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)	-50.33	-10.24	40.09	20	PASS
1	2390.0 (Unrestricted, Average)	-55.74	-13.97	41.77	20	PASS
11	2483.5 (Unrestricted, Peak)	-71.58	-12.6	58.98	20	PASS
11	2483.5 (Unrestricted, Average)	-78.00	-15.81	62.19	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Limit* (dBm)	Gain (dBi)	Margin	Result
1	2340.0 (Restricted, Peak)	-69.82	-69.82	-21.23	0	48.59	PASS
1	2340.0 (Restricted, Average)	-76.38	-76.38	-41.23	0	35.15	PASS
11	2483.5 (Restricted, Peak)	-69.68	-69.68	-21.23	0	48.45	PASS
11	2483.5 (Restricted, Average)	-73.14	-73.14	-41.23	0	31.91	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

Part 15.209 Peak Limit = 74.00 dBμV/m

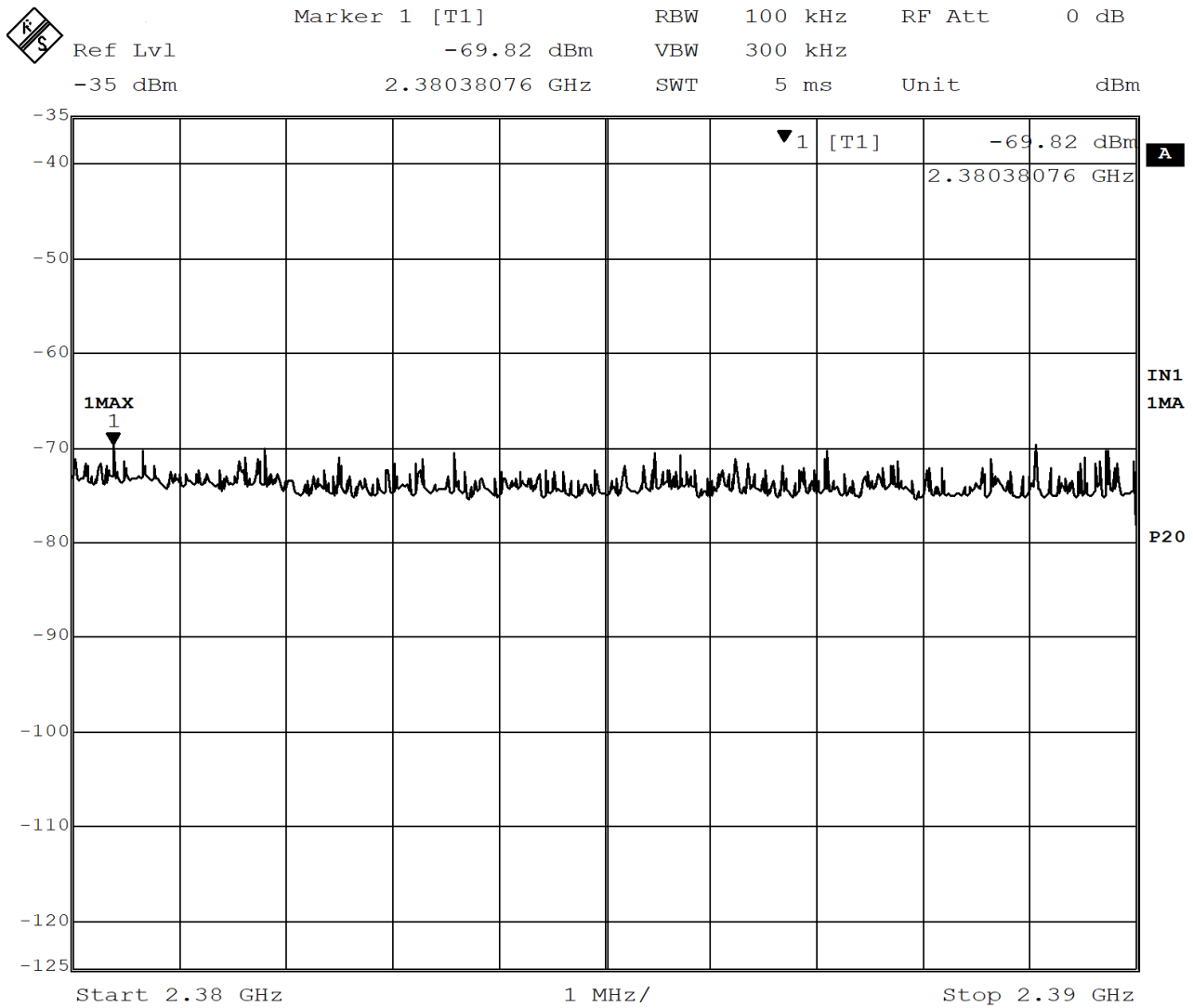
Part 15.209 Average Limit = 54.00 dBμV/m

$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS_{3m}(dB\mu V/m) - 95.23$

Peak Limit (delta) = 74.00 dBμV/m – 95.23 = -21.23dBm

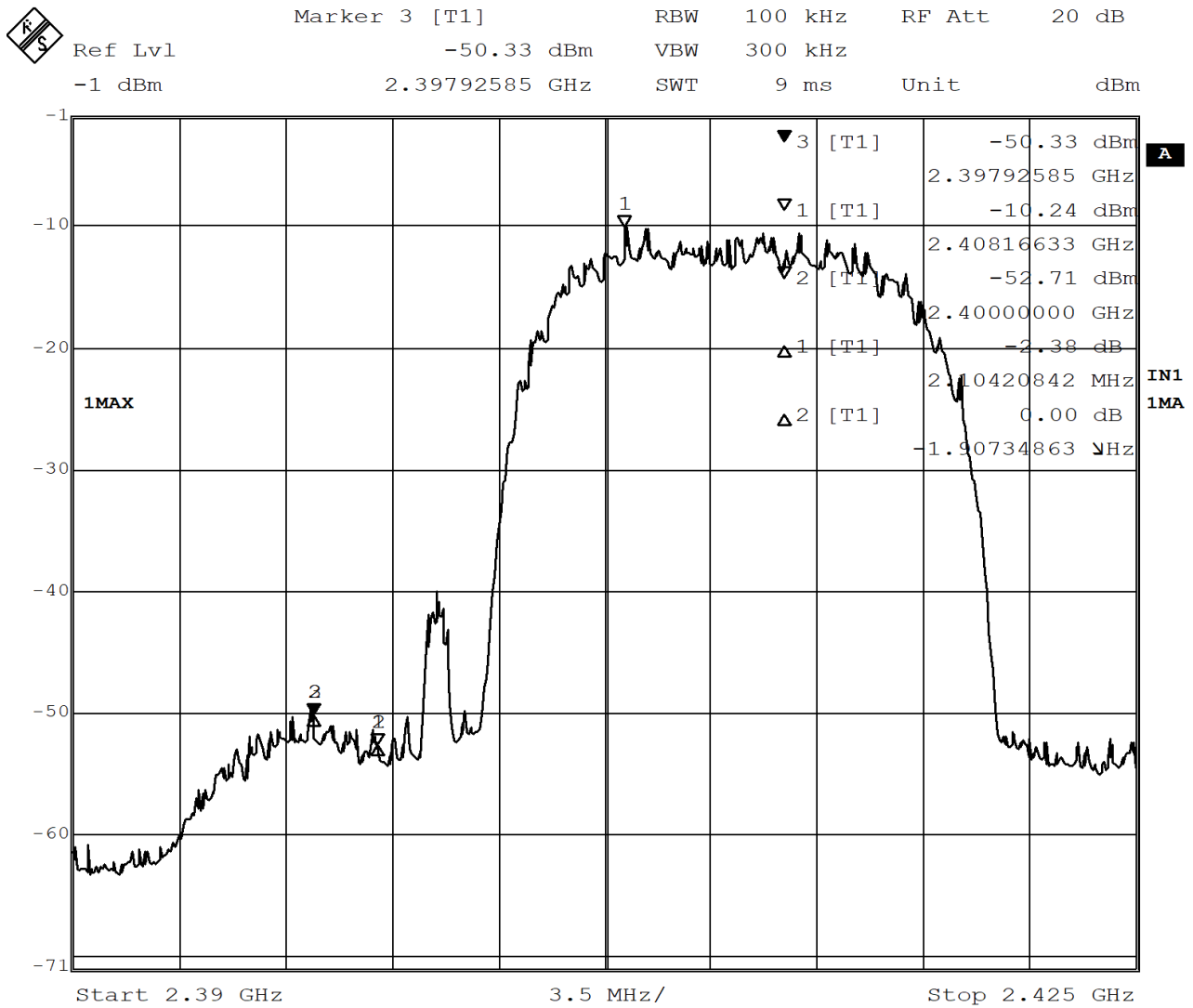
Average Limit (delta) = 54.00 dBμV/m – 95.23 = -41.23dBm

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



Date: 21.MAY.2019 08:10:08

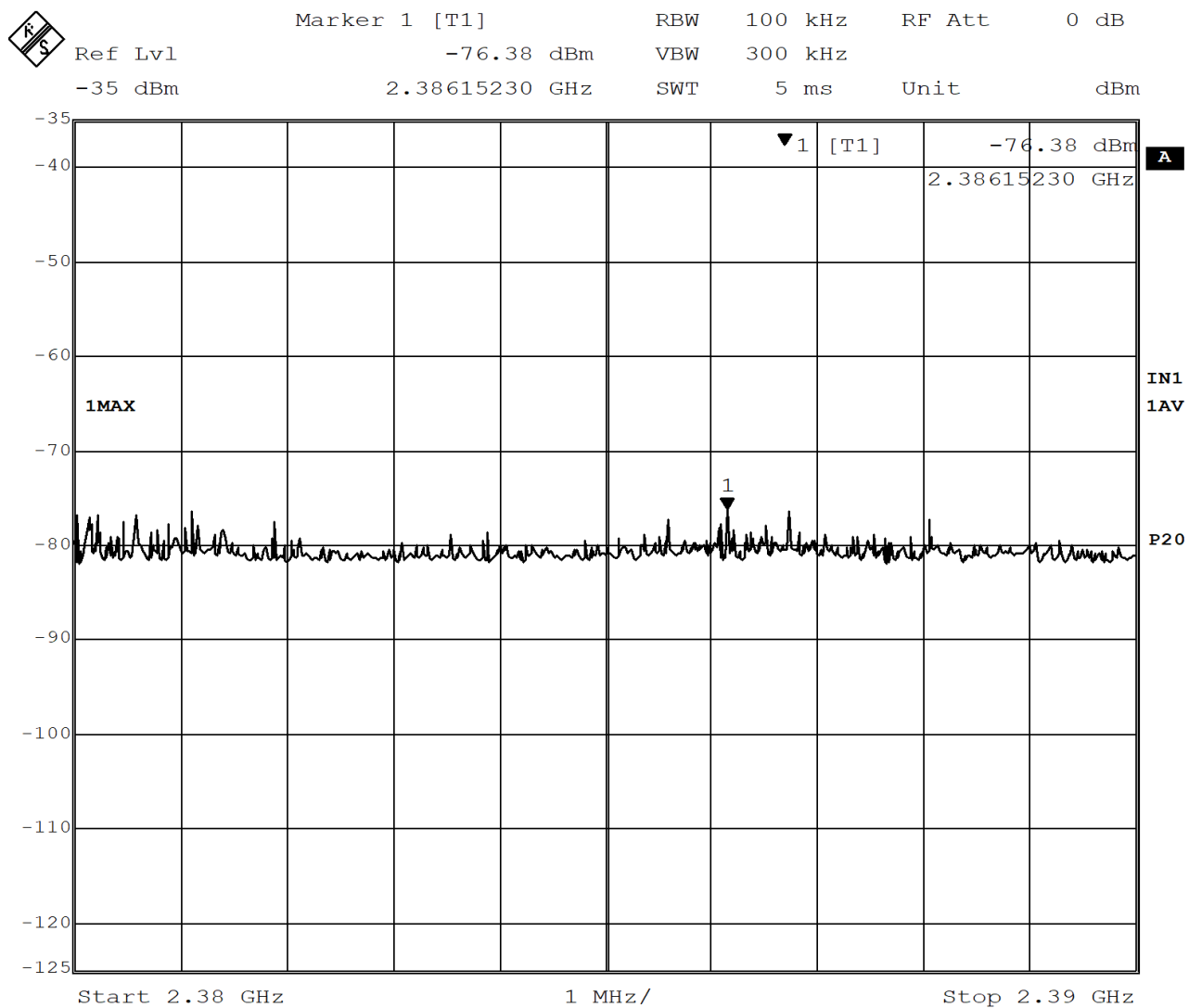
Figure 32 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak



Date: 21.MAY.2019 08:01:43

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

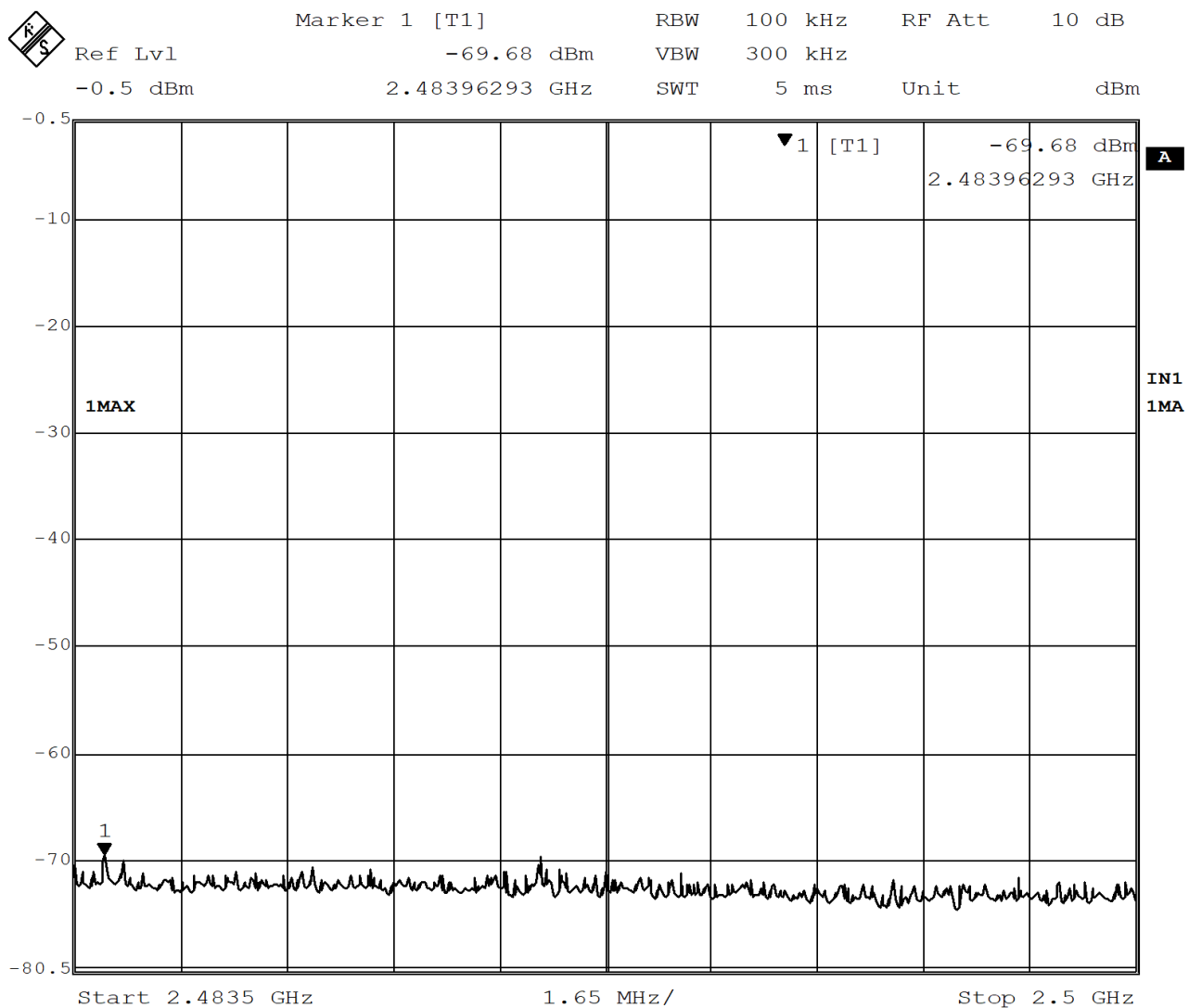
	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



Date: 21.MAY.2019 08:09:24

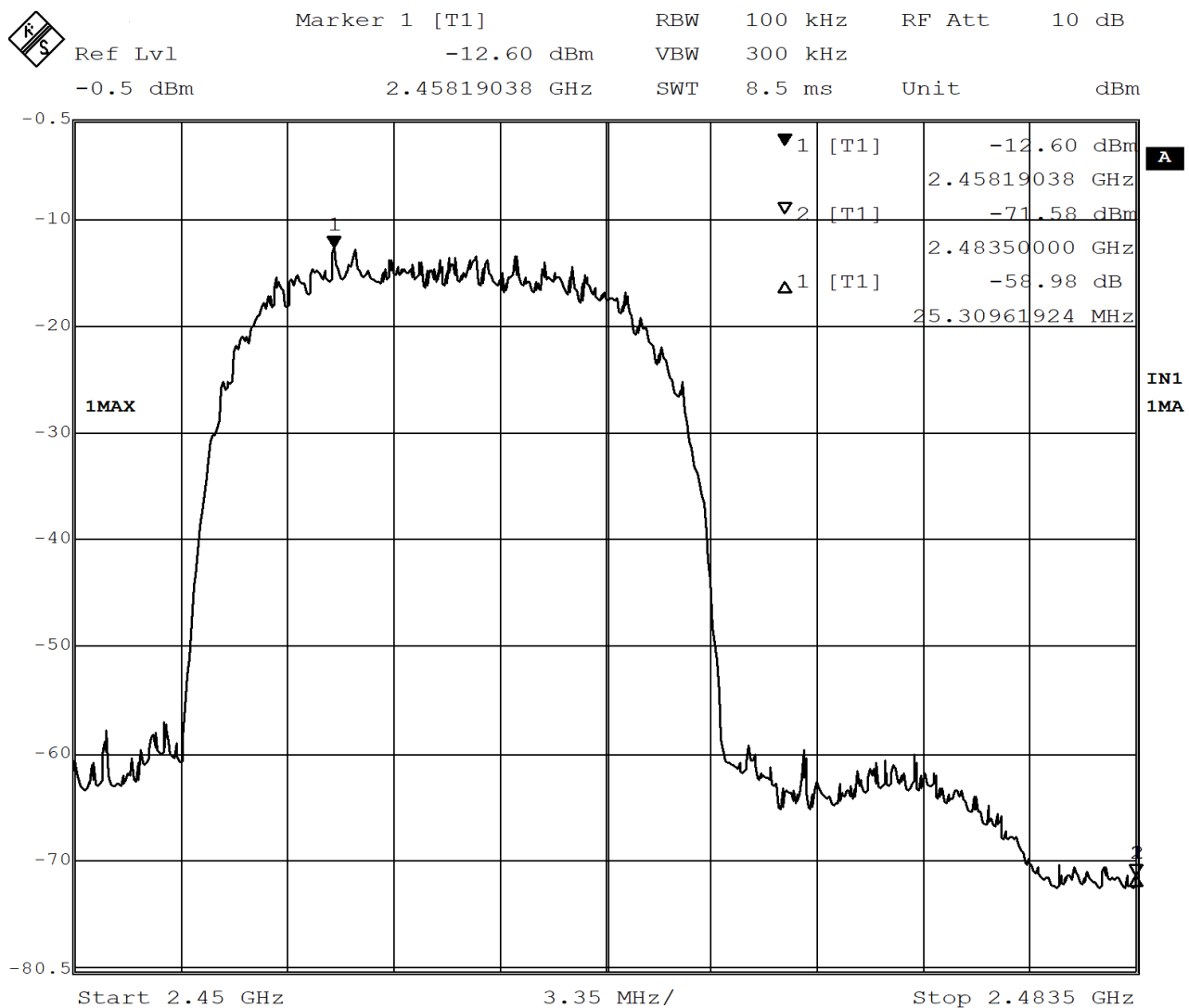
Figure 34 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



Date: 21.MAY.2019 08:36:34

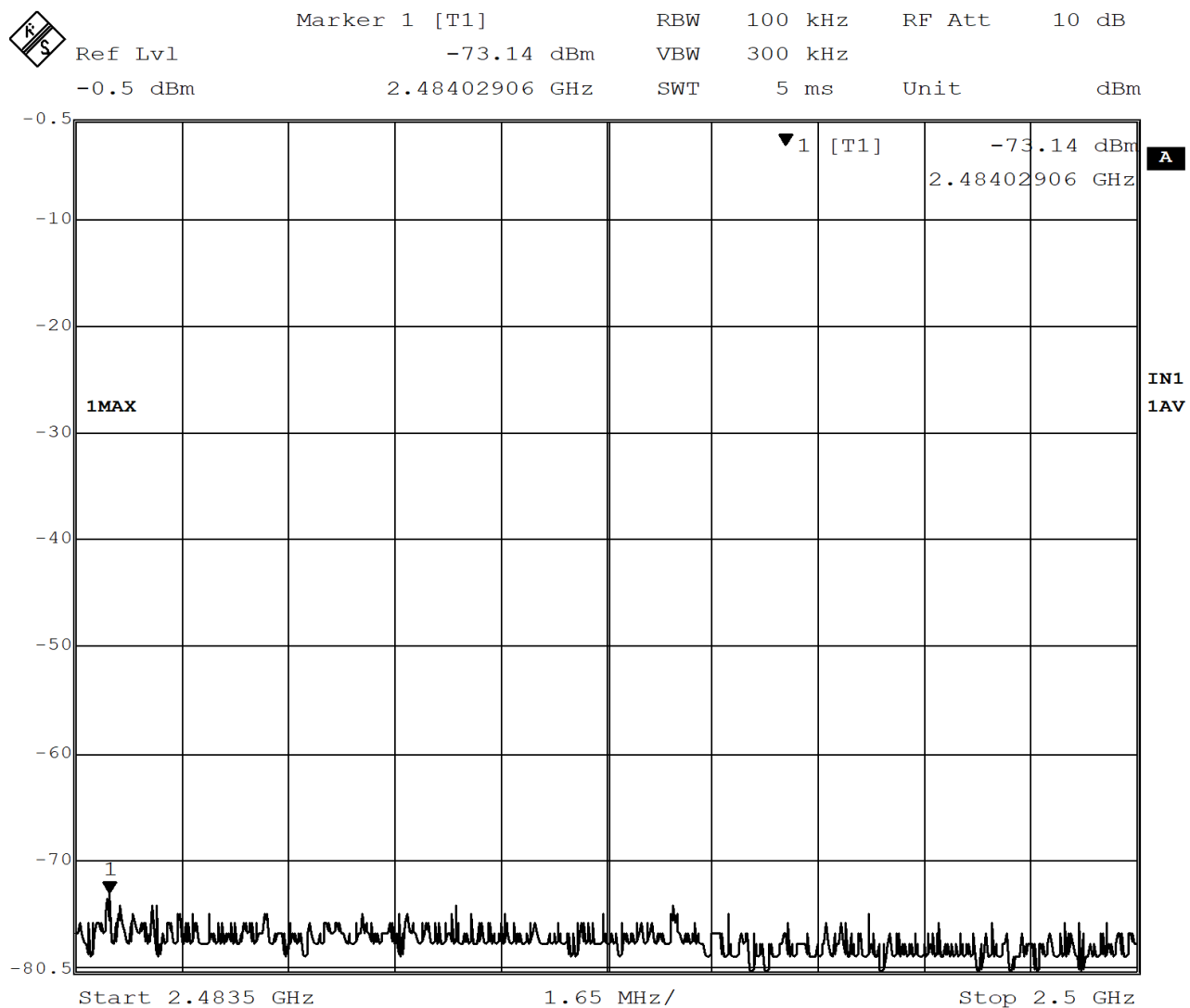
Figure 36 - Band-edge Measurement, High Channel, Restricted Frequency, Peak



Date: 21.MAY.2019 08:38:52

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

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

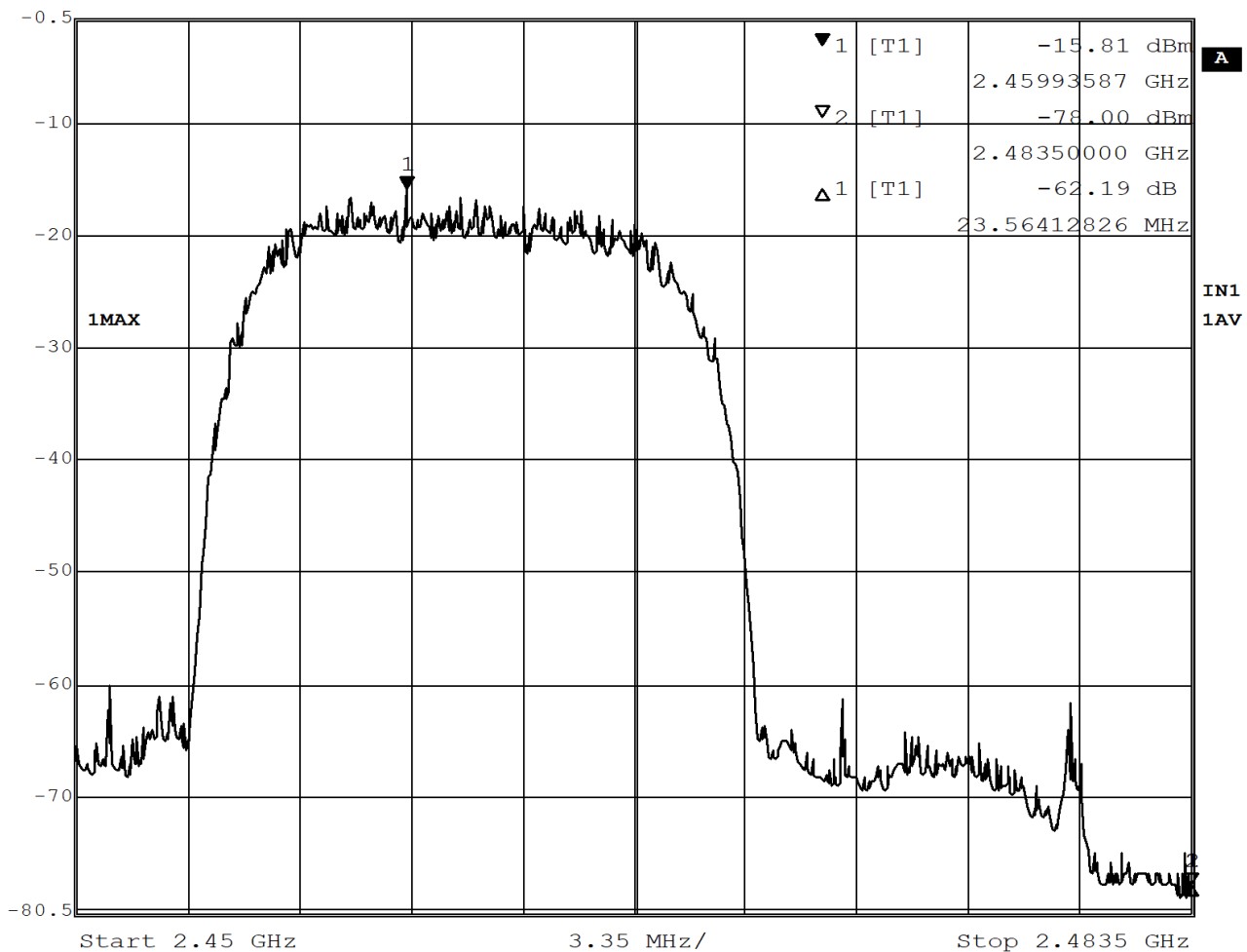


Date: 21.MAY.2019 08:37:15

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



Marker 1 [T1] RBW 100 kHz RF Att 10 dB
Ref Lvl -15.81 dBm VBW 300 kHz
-0.5 dBm 2.45993587 GHz SWT 8.5 ms Unit dBm



Date: 21.MAY.2019 08:38:12

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

	Report Number:	R20181219-20-08	Rev	A
	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)	-42.17	-10.43	31.74	20	PASS
1	2390.0 (Unrestricted, Average)	-46.85	-14.44	32.41	20	PASS
11	2483.5 (Unrestricted, Peak)	-59.03	-12.28	46.75	20	PASS
11	2483.5 (Unrestricted, Average)	-64.02	-14.62	49.40	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Limit* (dBm)	Gain (dBi)	Margin	Result
1	2340.0 (Restricted, Peak)	-53.53	-53.53	-21.23	0	32.30	PASS
1	2340.0 (Restricted, Average)	-54.55	-54.55	-41.23	0	13.32	PASS
11	2483.5 (Restricted, Peak)	-53.69	-53.69	-21.23	0	32.46	PASS
11	2483.5 (Restricted, Average)	-59.67	-59.67	-41.23	0	18.44	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

Part 15.209 Peak Limit = 74.00 dBμV/m

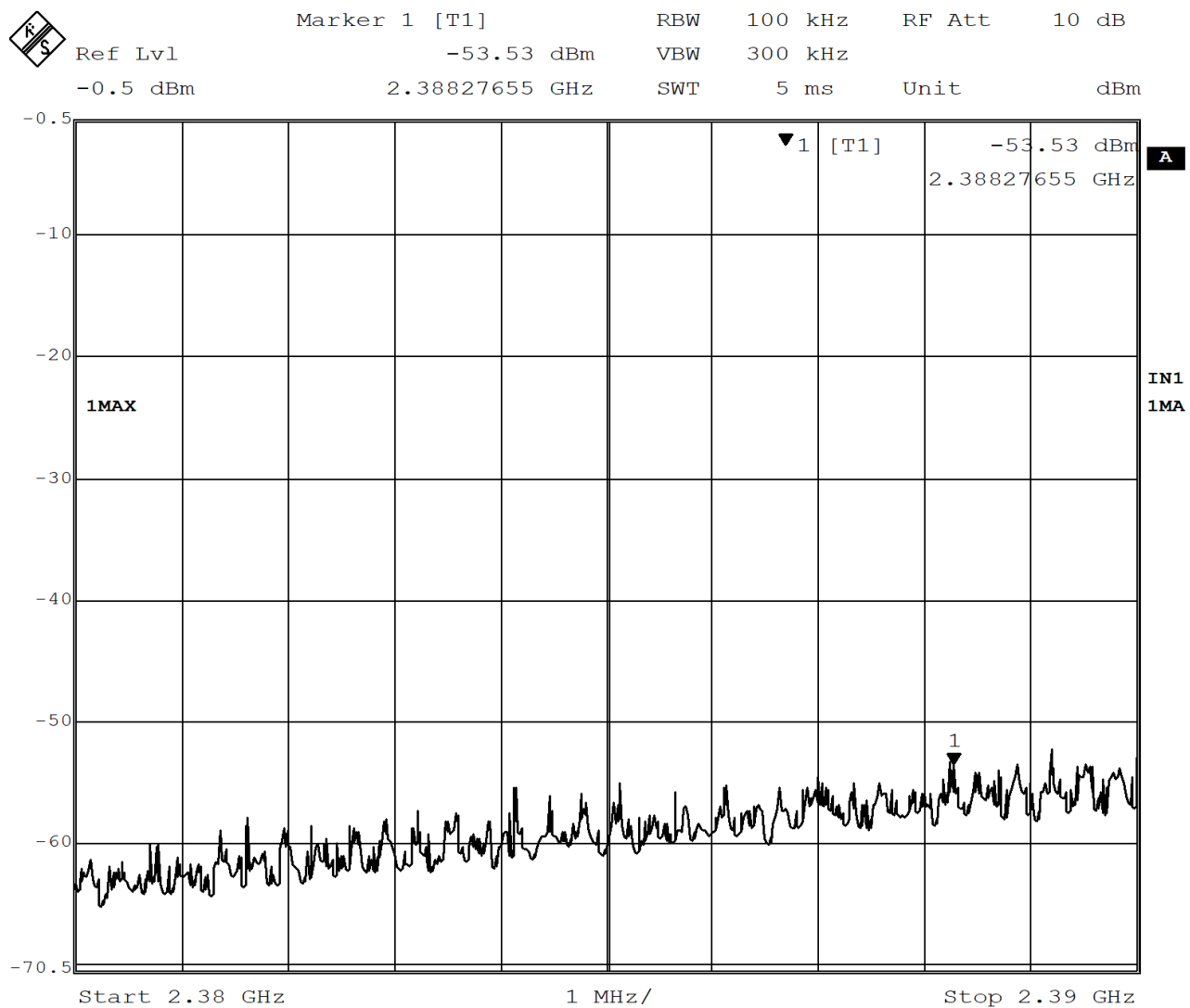
Part 15.209 Average Limit = 54.00 dBμV/m

EIRP(dBm) = FS(dBμV/m) – 10(log 10⁹)+ 10log[0.3] = FS(dBμV/m) - 95.23

Peak Limit (delta) = 74.00 dBμV/m – 95.23 = -21.23dBm

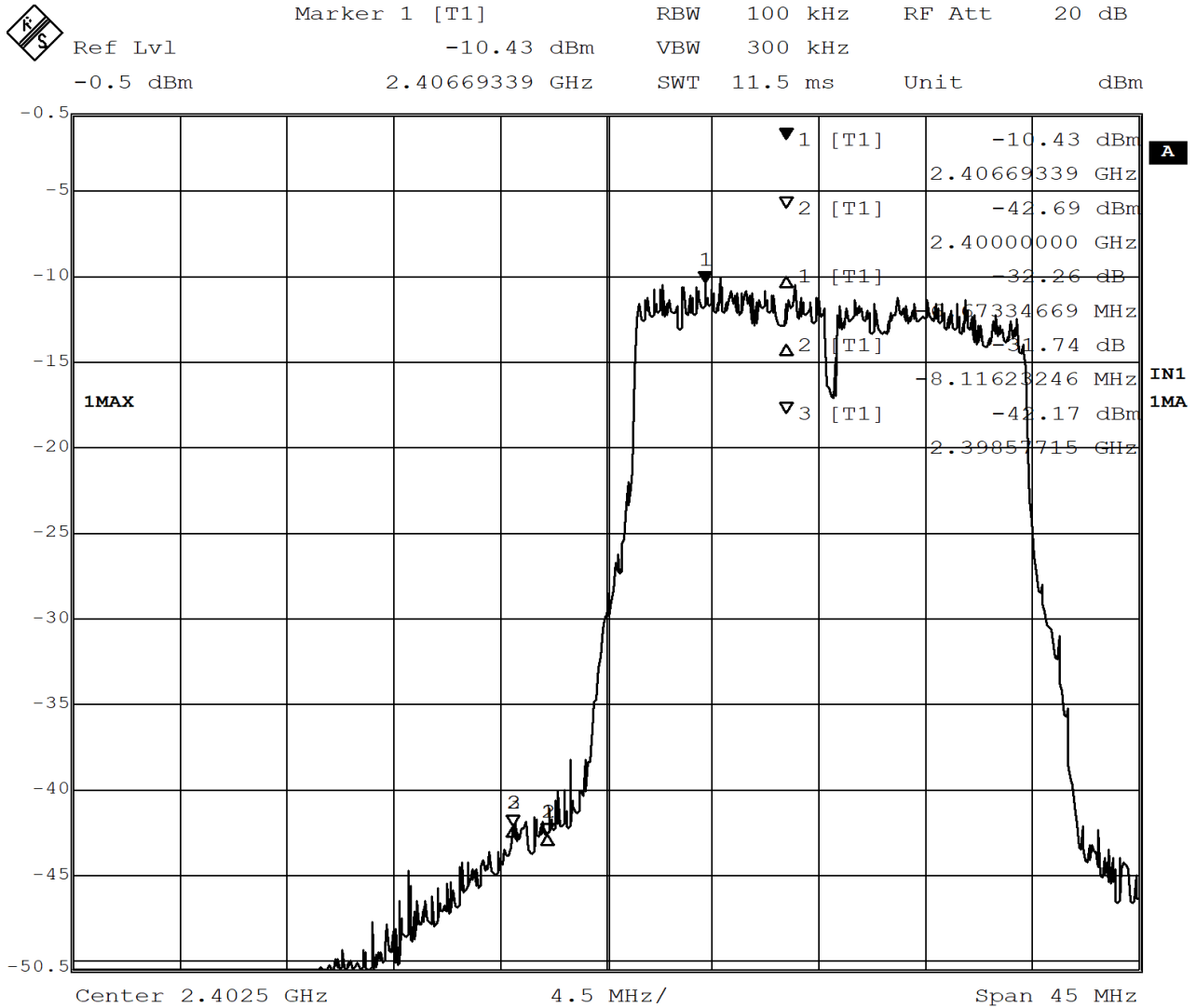
Average Limit (delta) = 54.00 dBμV/m – 95.23 = -41.23dBm

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



Date: 21.MAY.2019 08:28:23

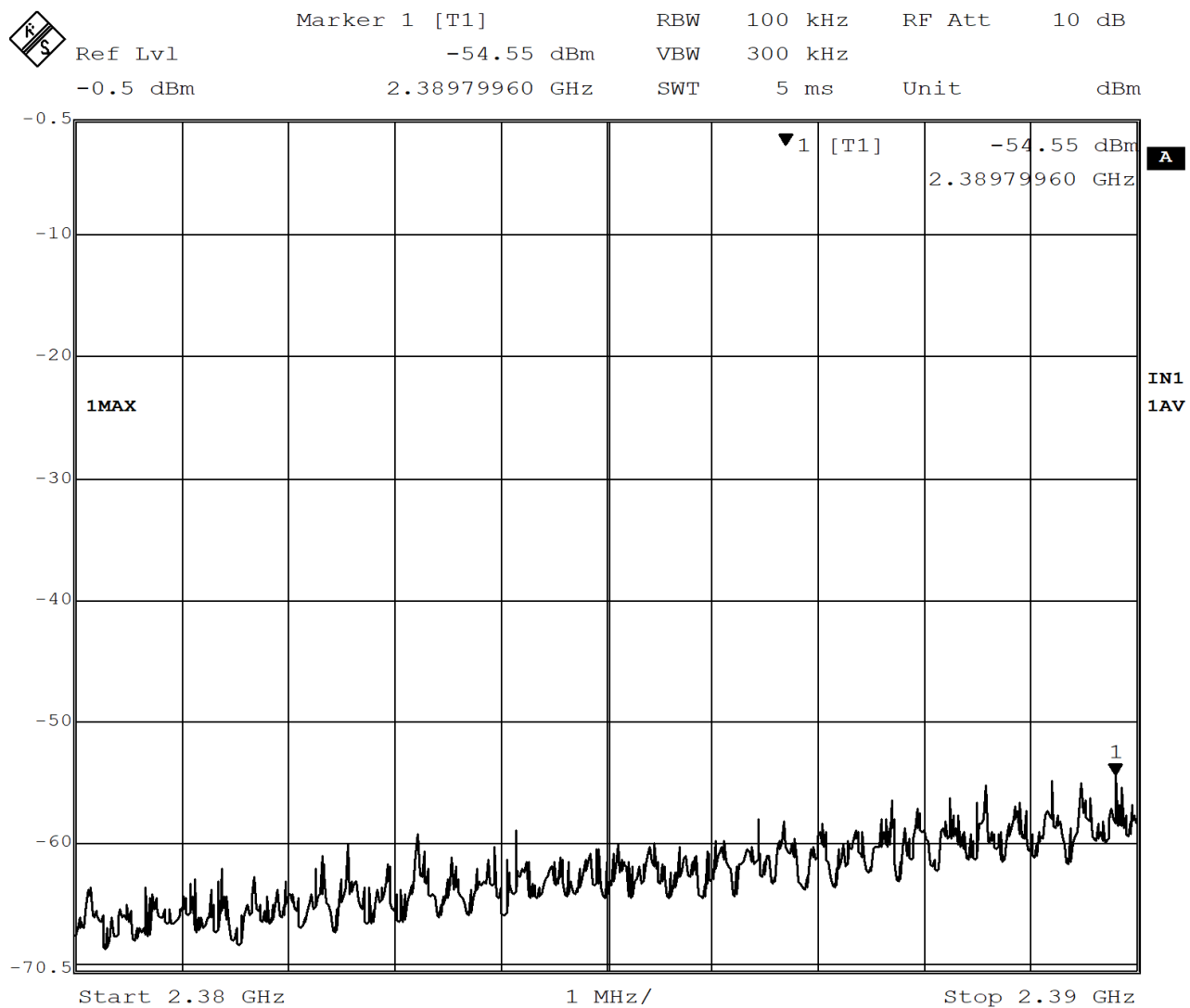
Figure 40 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak



Date: 21.MAY.2019 08:25:19

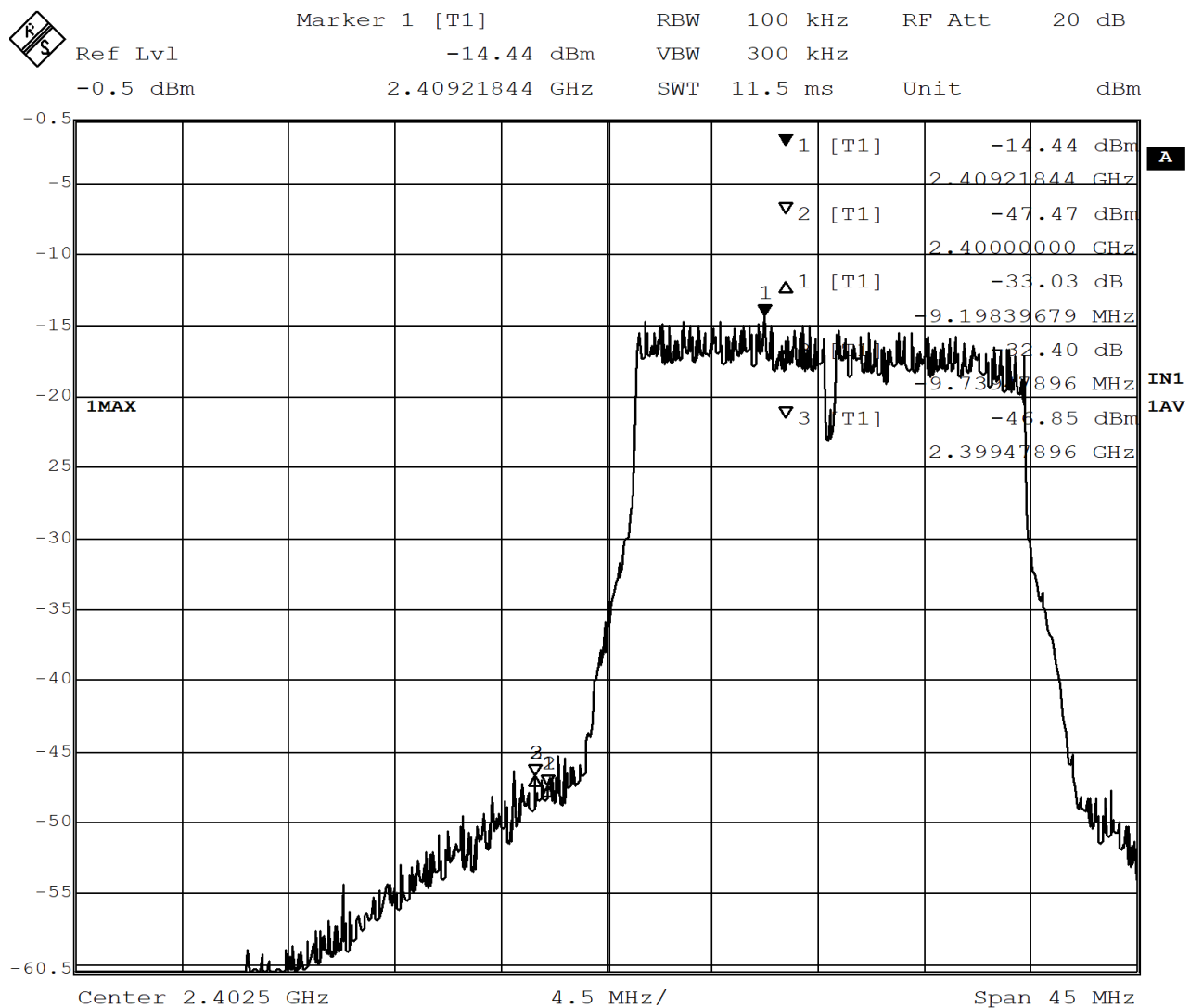
Figure 41 - Band-edge Measurement, Low Channel, Fundamental, Peak

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



Date: 21.MAY.2019 08:27:48

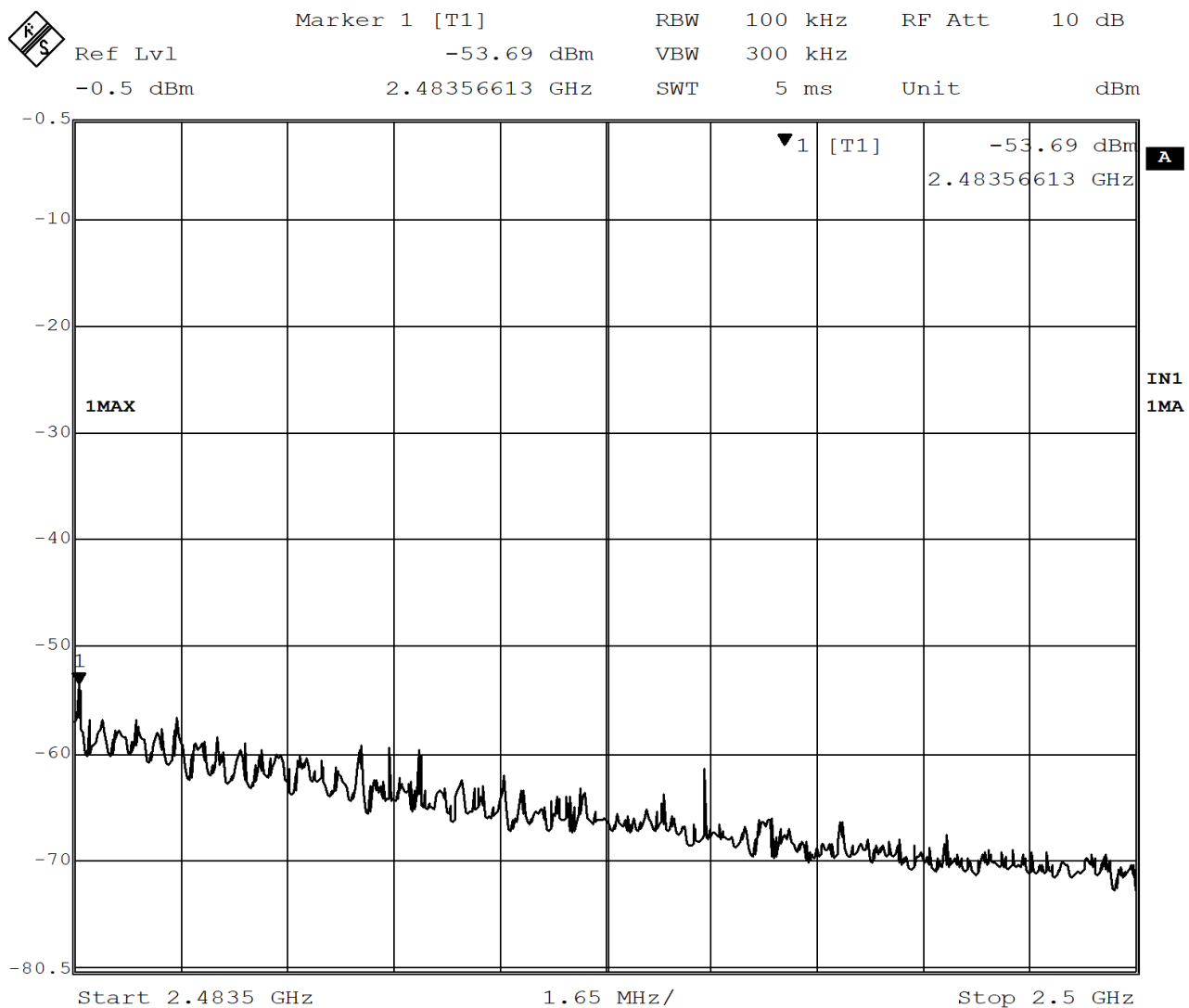
Figure 42 - Band-edge Measurement, Low Channel, Restricted Frequency, Average



Date: 21.MAY.2019 08:26:33

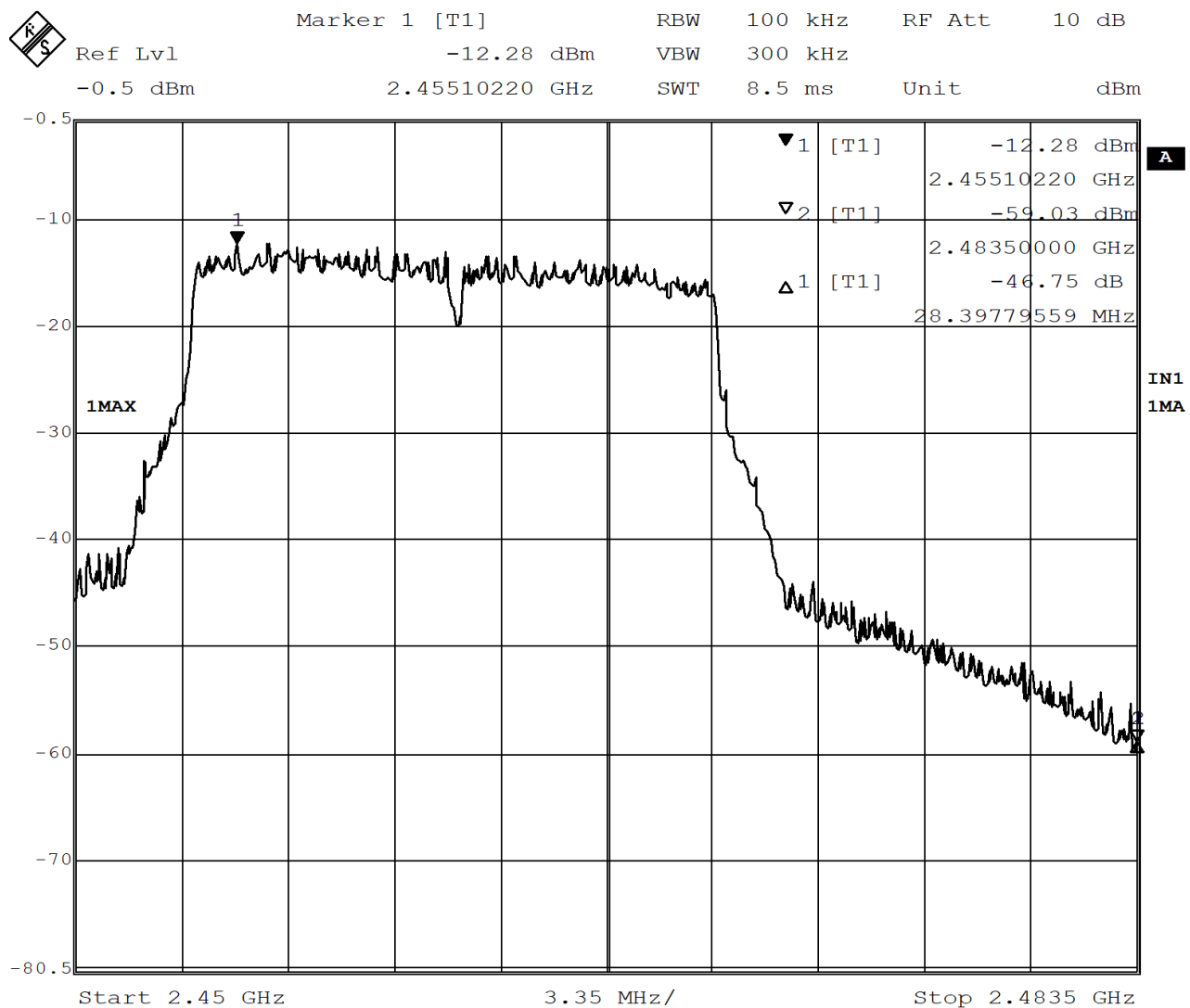
Figure 43 - Band-edge Measurement, Low Channel, Fundamental, Average

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



Date: 21.MAY.2019 08:29:30

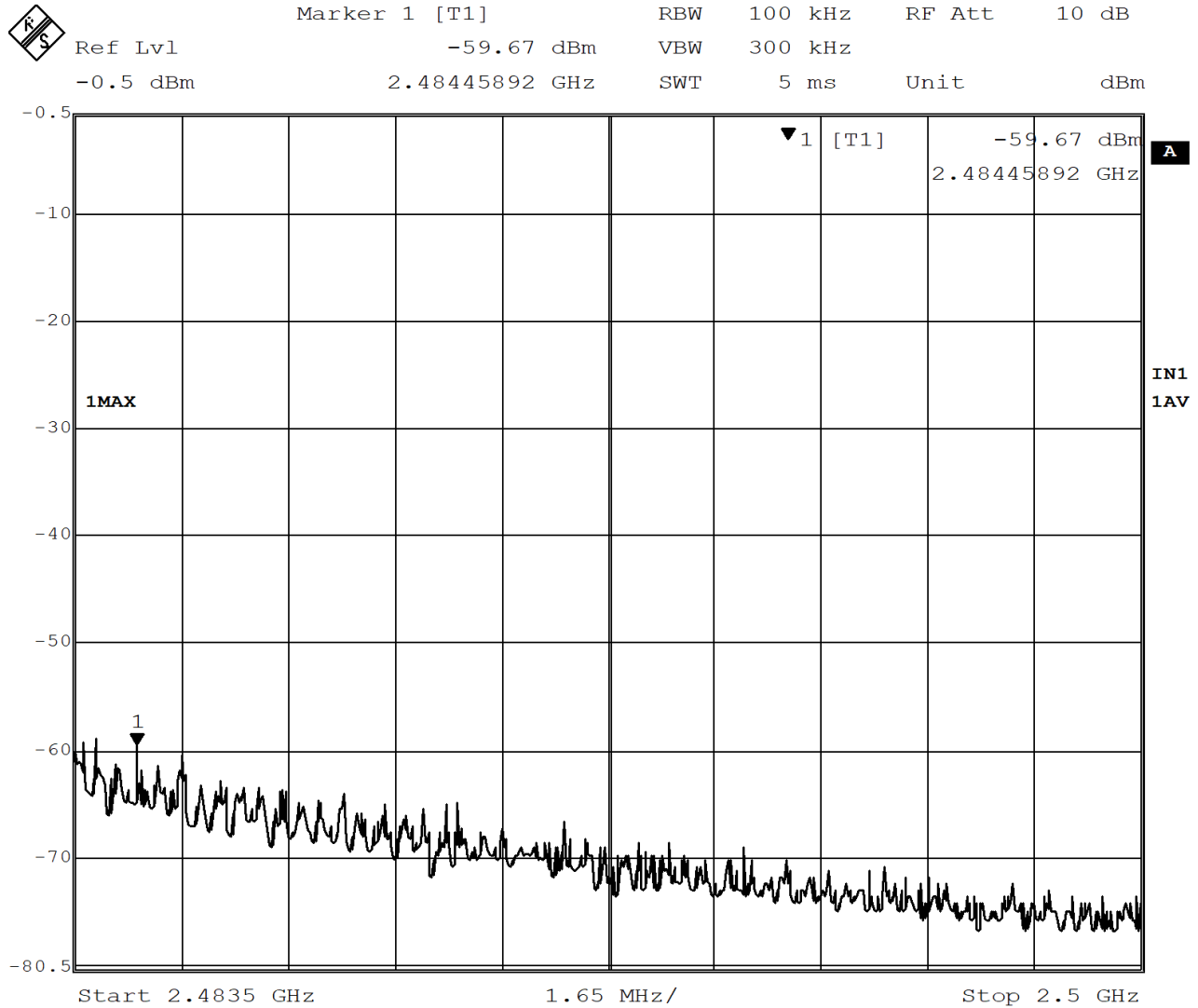
Figure 44 - Band-edge Measurement, High Channel, Restricted Frequency, Peak



Date: 21.MAY.2019 08:31:47

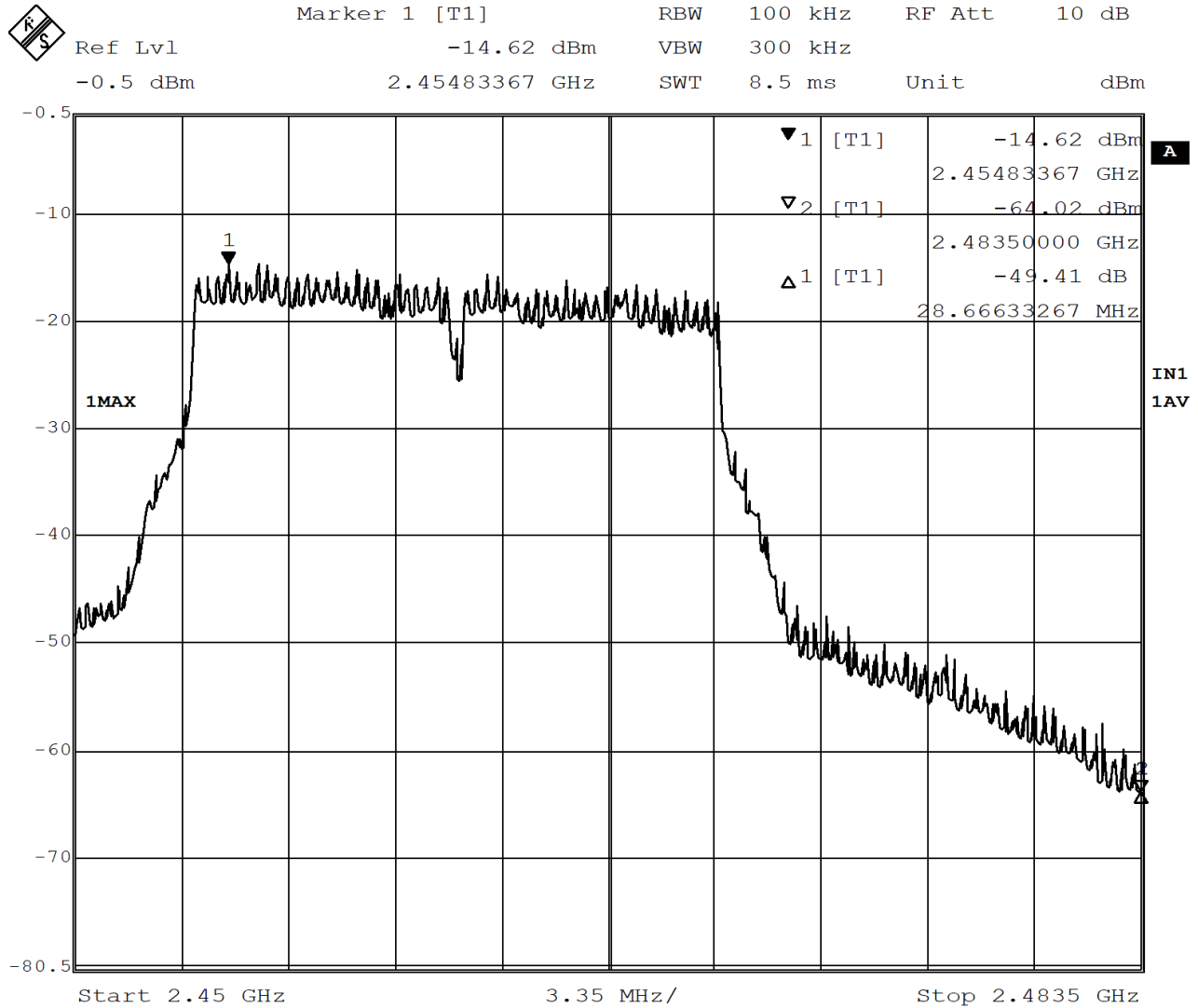
Figure 45 - Band-edge Measurement, High Channel, Fundamental, Peak

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



Date: 21.MAY.2019 08:30:07

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



Date: 21.MAY.2019 08:31:10

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

	Report Number:	R20181219-20-08	Rev	A
	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)	-41.47	-11.44	30.03	20	PASS
1	2390.0 (Unrestricted, Average)	-47.86	-14.97	32.89	20	PASS
11	2483.5 (Unrestricted, Peak)	-57.81	-11.90	45.91	20	PASS
11	2483.5 (Unrestricted, Average)	-62.09	-15.44	46.65	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Limit* (dBm)	Gain** (dBi)	Margin	Result
1	2340.0 (Restricted, Peak)	-71.70	-71.70	-21.23	0	50.47	PASS
1	2340.0 (Restricted, Average)	-73.39	-73.39	-41.23	0	32.16	PASS
11	2483.5 (Restricted, Peak)	-54.67	-54.67	-21.23	0	33.44	PASS
11	2483.5 (Restricted, Average)	-56.45	-56.45	-41.23	0	15.22	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

Part 15.209 Peak Limit = 74.00 dBμV/m

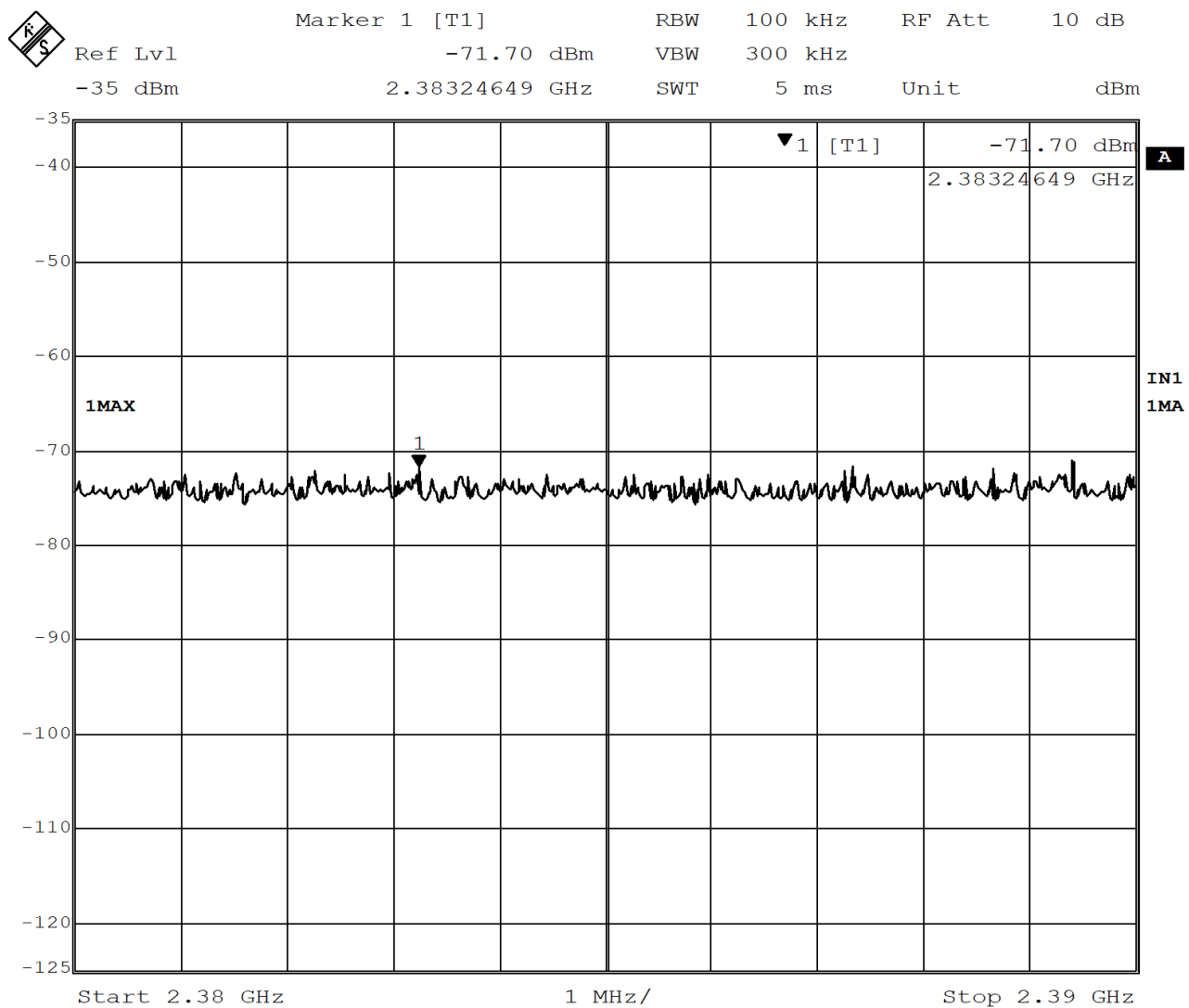
Part 15.209 Average Limit = 54.00 dBμV/m

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

Peak Limit (delta)= 74.00 dBμV/m – 95.23 = -21.23dBm

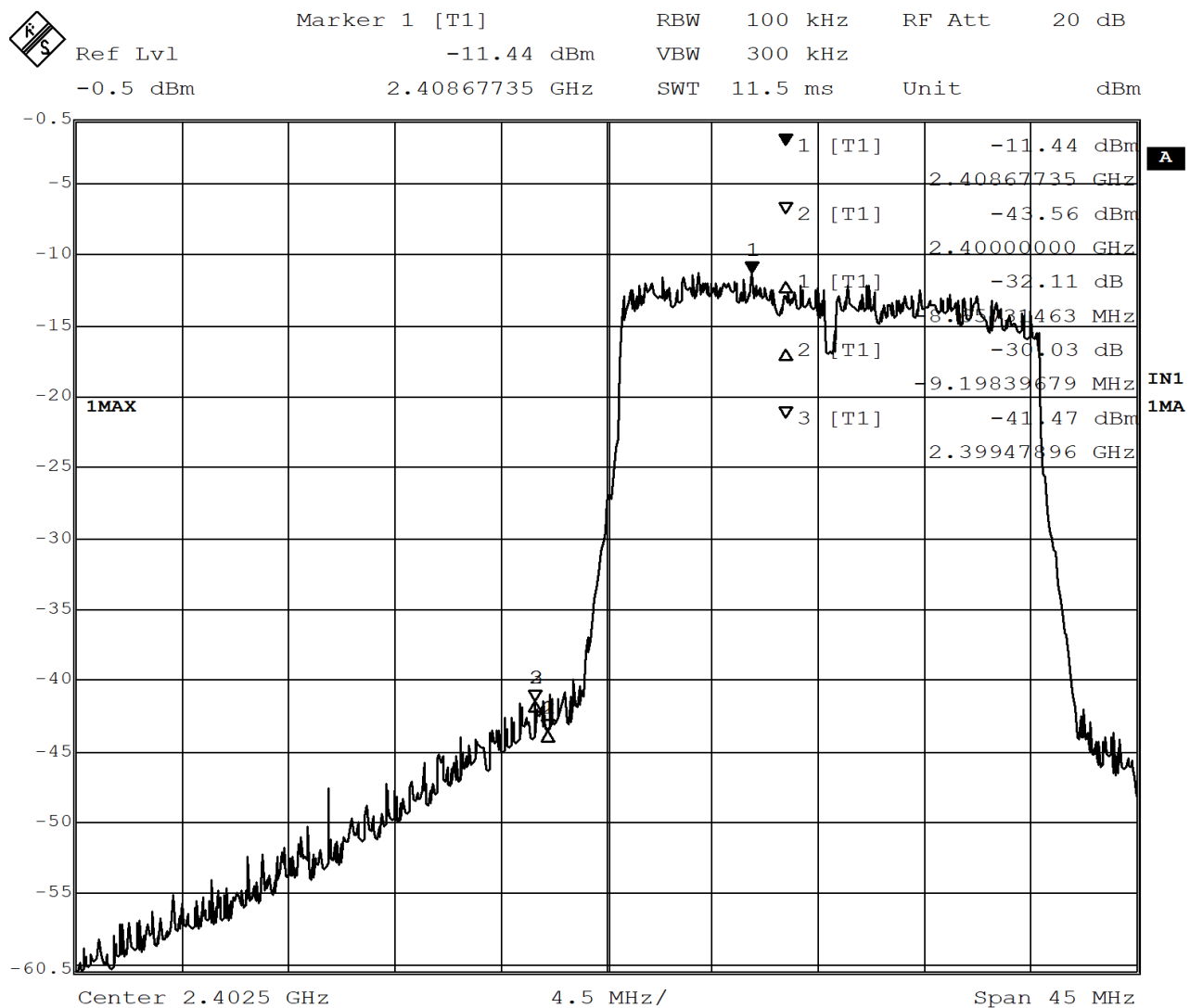
Average Limit (delta) = 54.00 dBμV/m – 95.23 = -41.23dBm

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



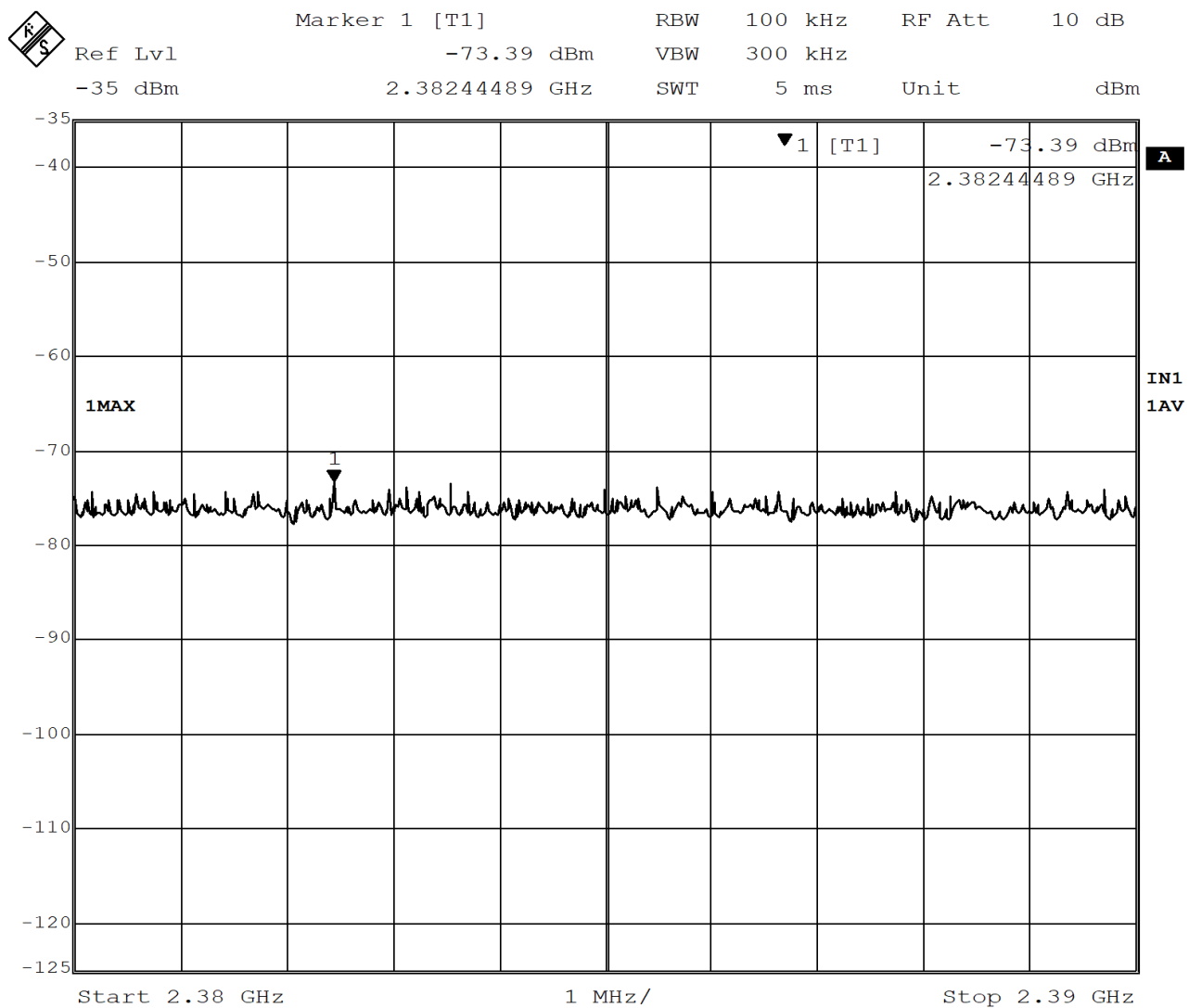
Date: 21.MAY.2019 08:11:50

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



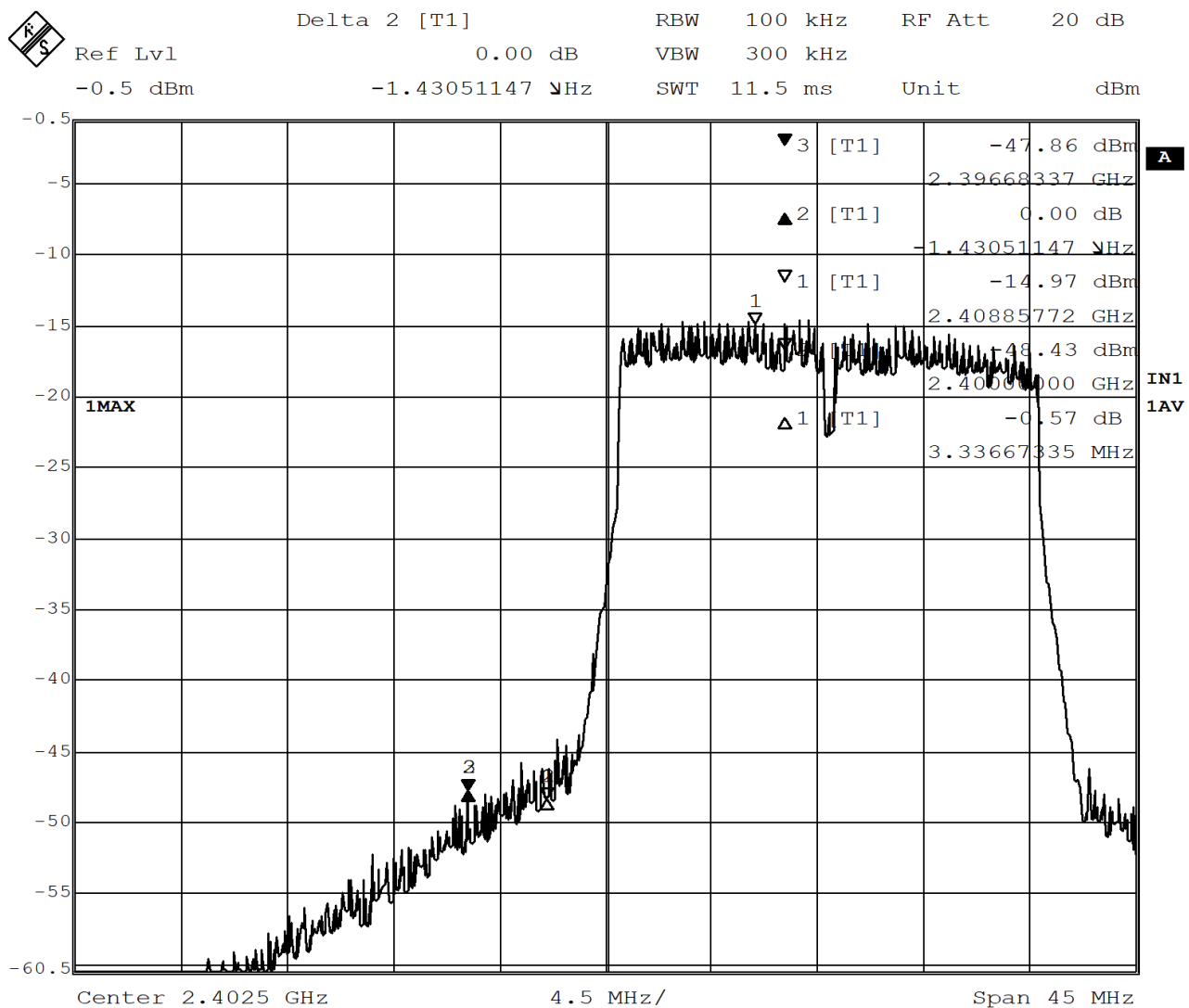
Date: 21.MAY.2019 08:20:40

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



Date: 21.MAY.2019 08:14:02

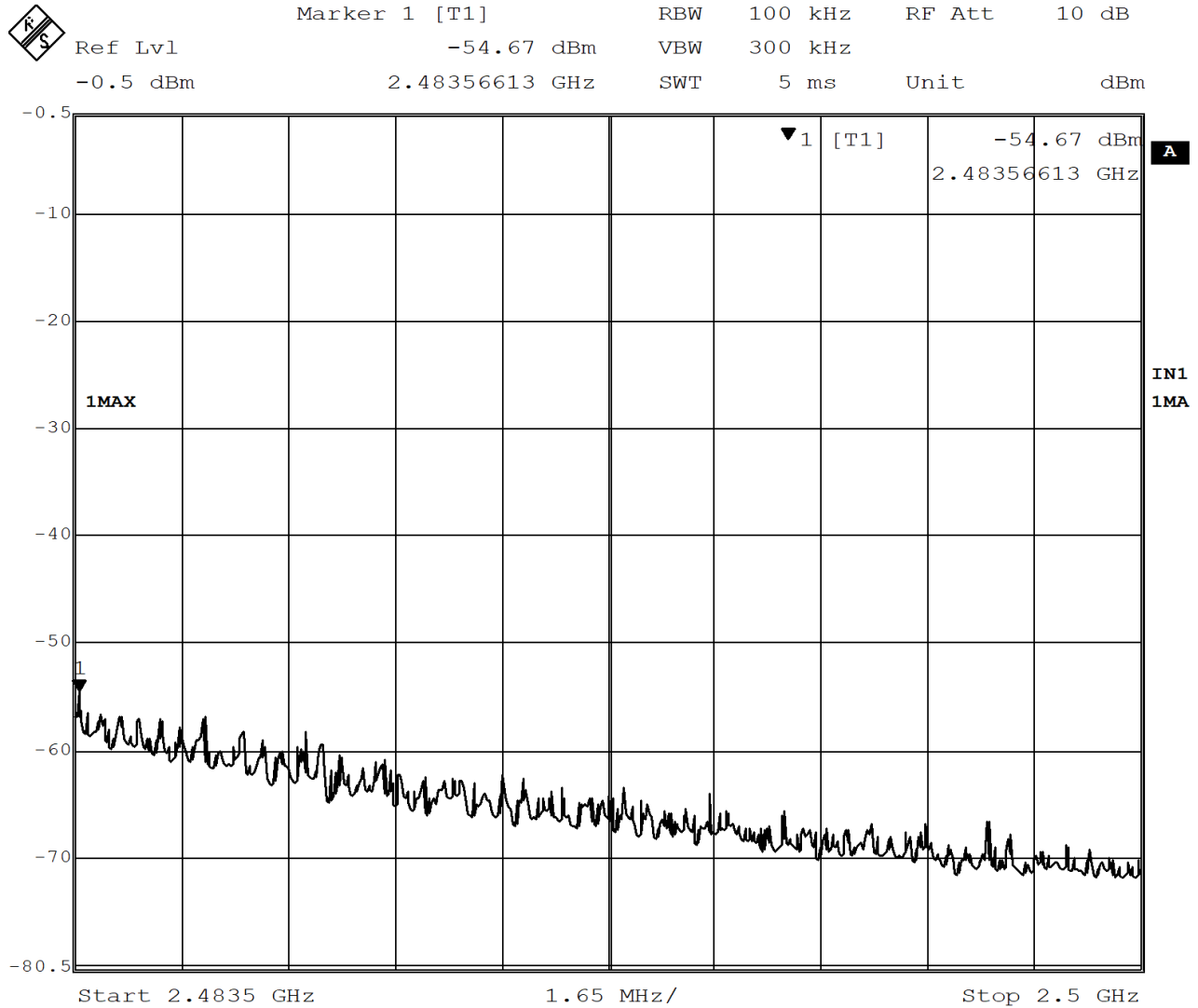
Figure 50 - Band-edge Measurement, Low Channel, Restricted Frequency, Average



Date: 21.MAY.2019 08:19:17

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

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



Date: 21.MAY.2019 08:35:28

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



Marker 1 [T1]

RBW 100 kHz

RF Att 10 dB

Ref Lvl

-11.90 dBm

VBW 300 kHz

-0.5 dBm

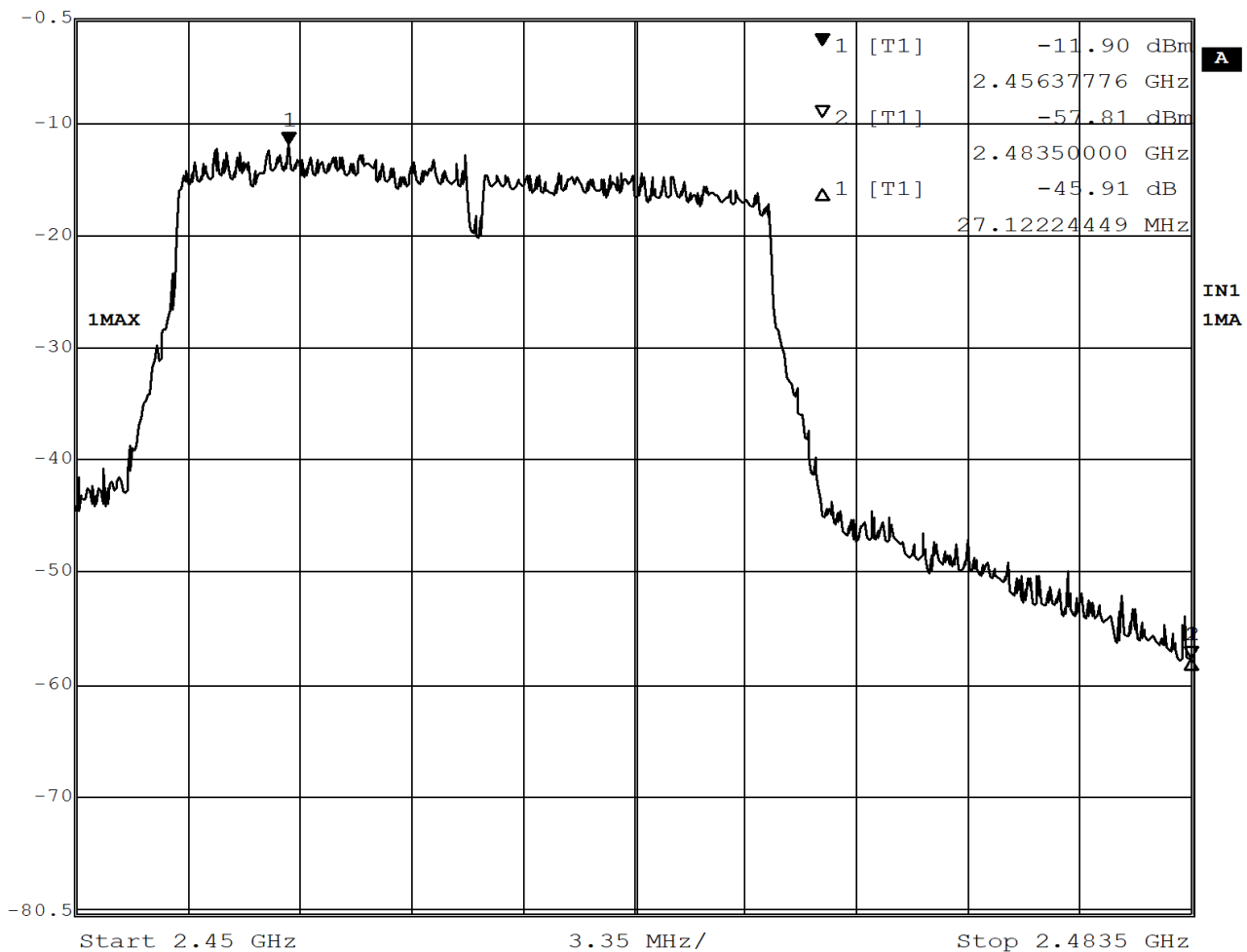
2.45637776 GHz

SWT

8.5 ms

Unit

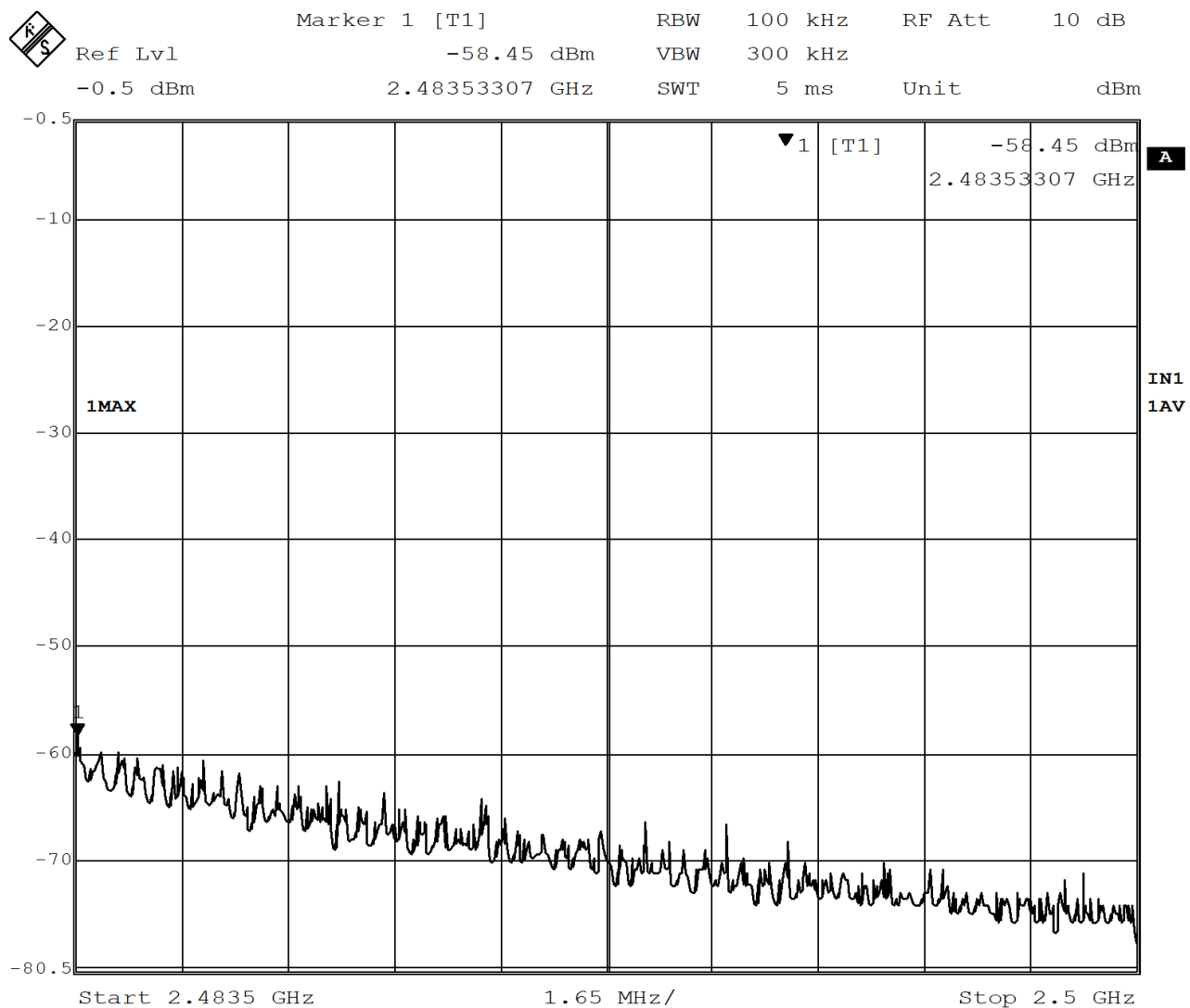
dBm



Date: 21.MAY.2019 08:32:50

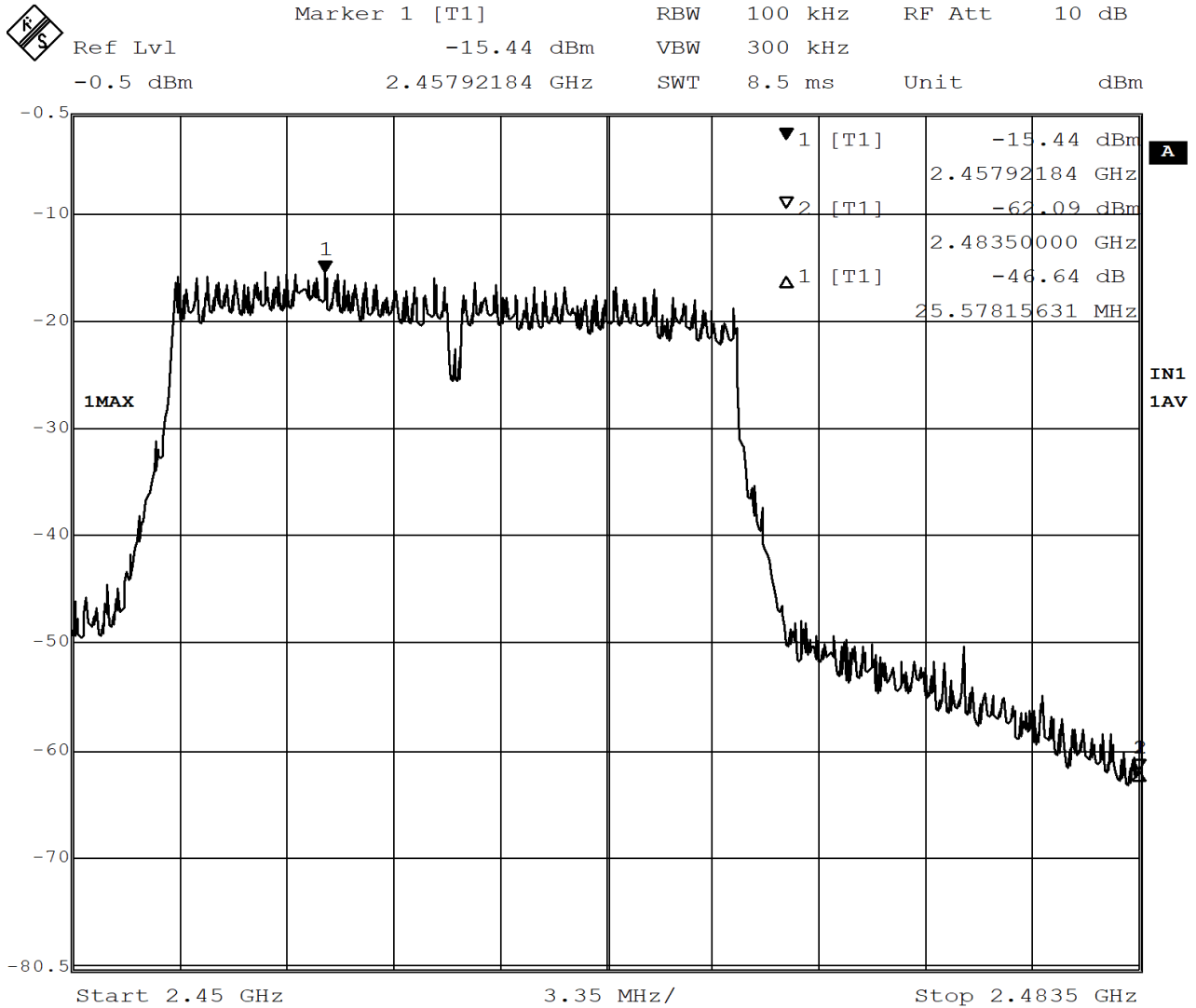
Figure 53 - Band-edge Measurement, High Channel, Fundamental, Peak

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



Date: 21.MAY.2019 08:34:50

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



Date: 21.MAY.2019 08:33:24

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

	Report Number:	R20181219-20-08	Rev	A
	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:

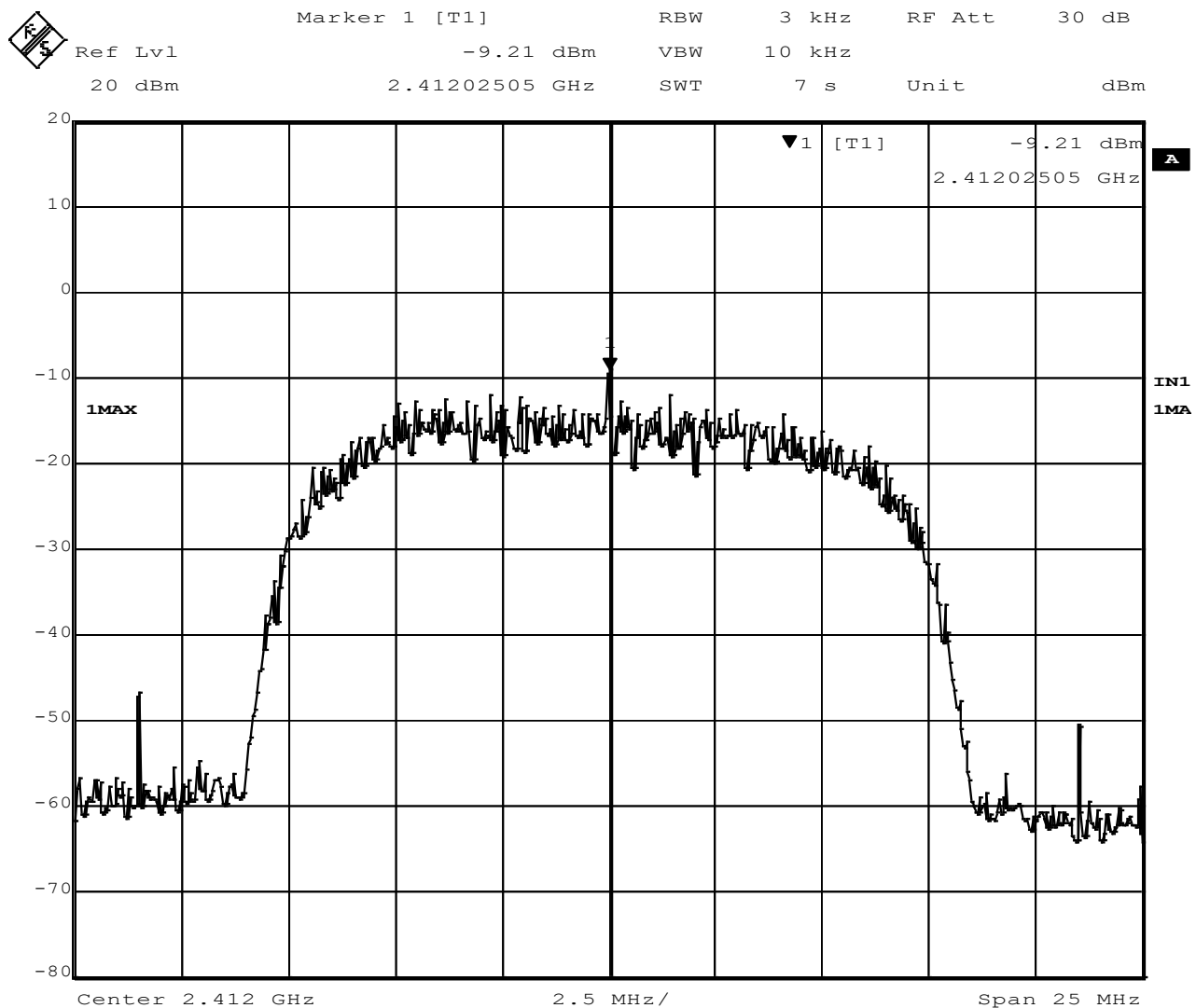
The EUT was powered by internal battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

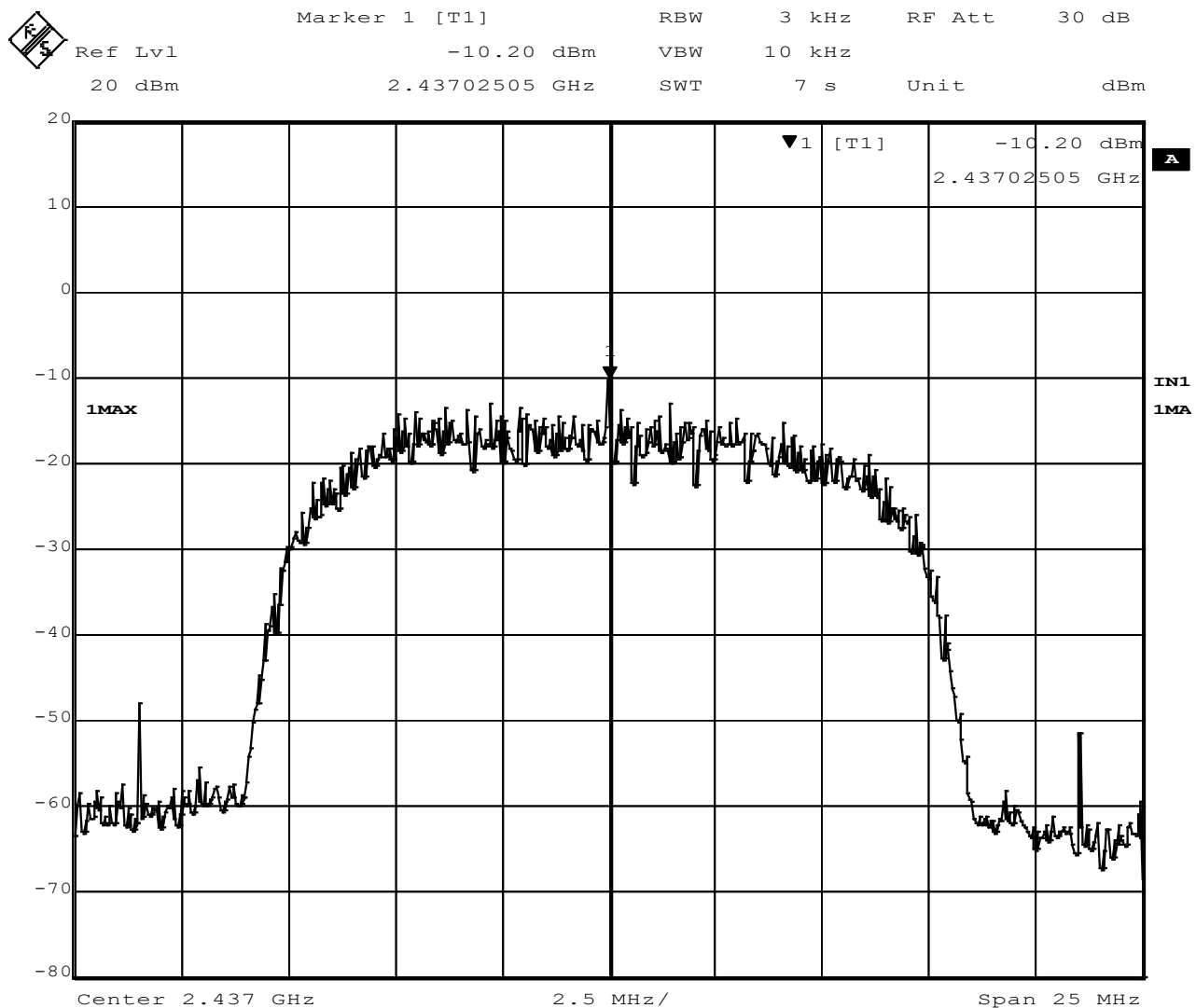
Power Spectral Density

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	PEAK PSD(dBm)	Method	Limit (dBm)	RESULT
Low	2412	802.11b	-9.21	Conducted	8.00	PASS
Middle	2437	802.11b	-10.20	Conducted	8.00	PASS
High	2462	802.11b	-10.92	Conducted	8.00	PASS
Low	2412	802.11g	-10.64	Conducted	8.00	PASS
Middle	2437	802.11g	-10.86	Conducted	8.00	PASS
High	2462	802.11g	-13.47	Conducted	8.00	PASS
Low	2412	802.11n	-11.00	Conducted	8.00	PASS
Middle	2437	802.11n	-11.92	Conducted	8.00	PASS
High	2462	802.11n	-13.14	Conducted	8.00	PASS



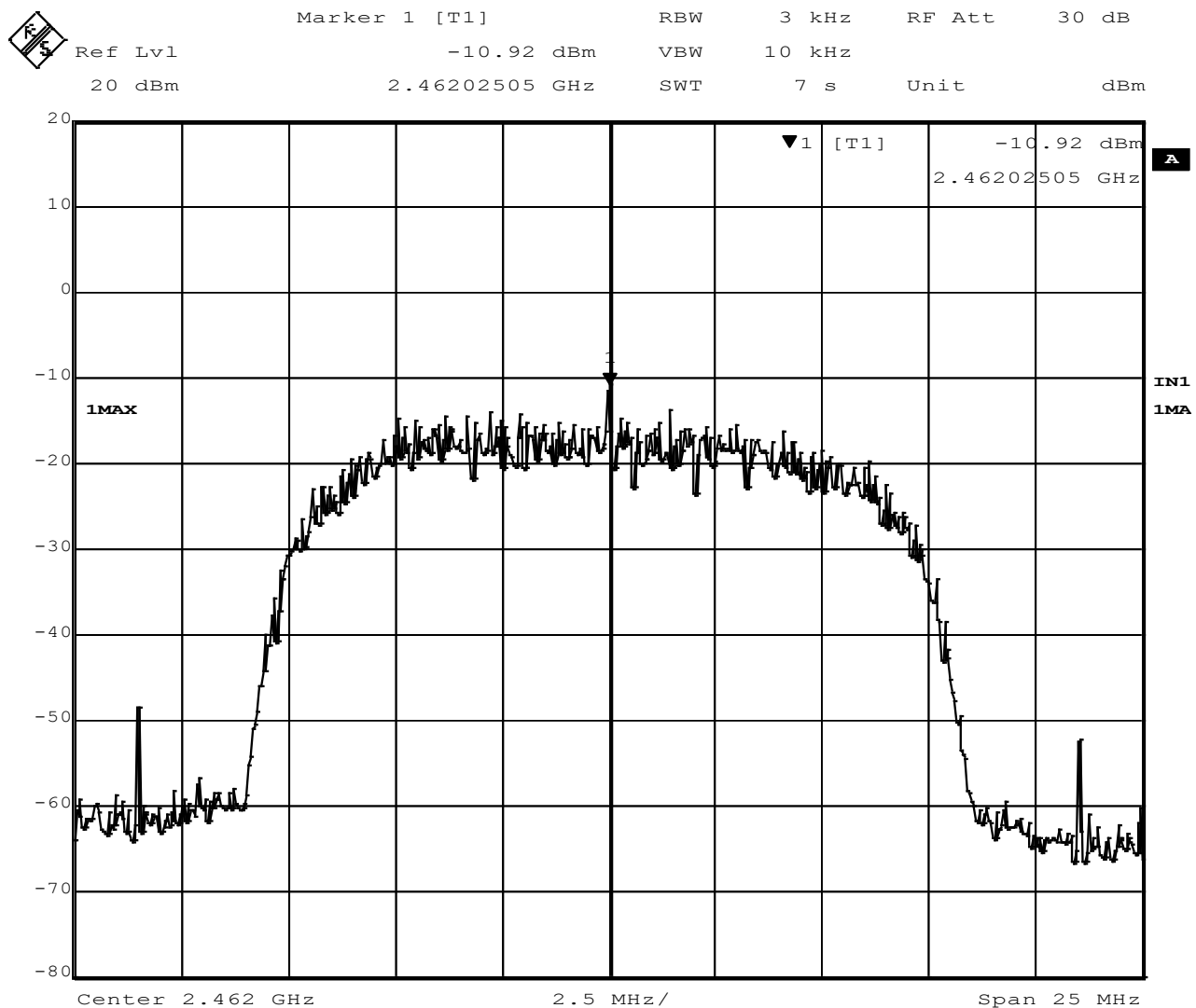
Date: 19.MAR.2019 16:43:33

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



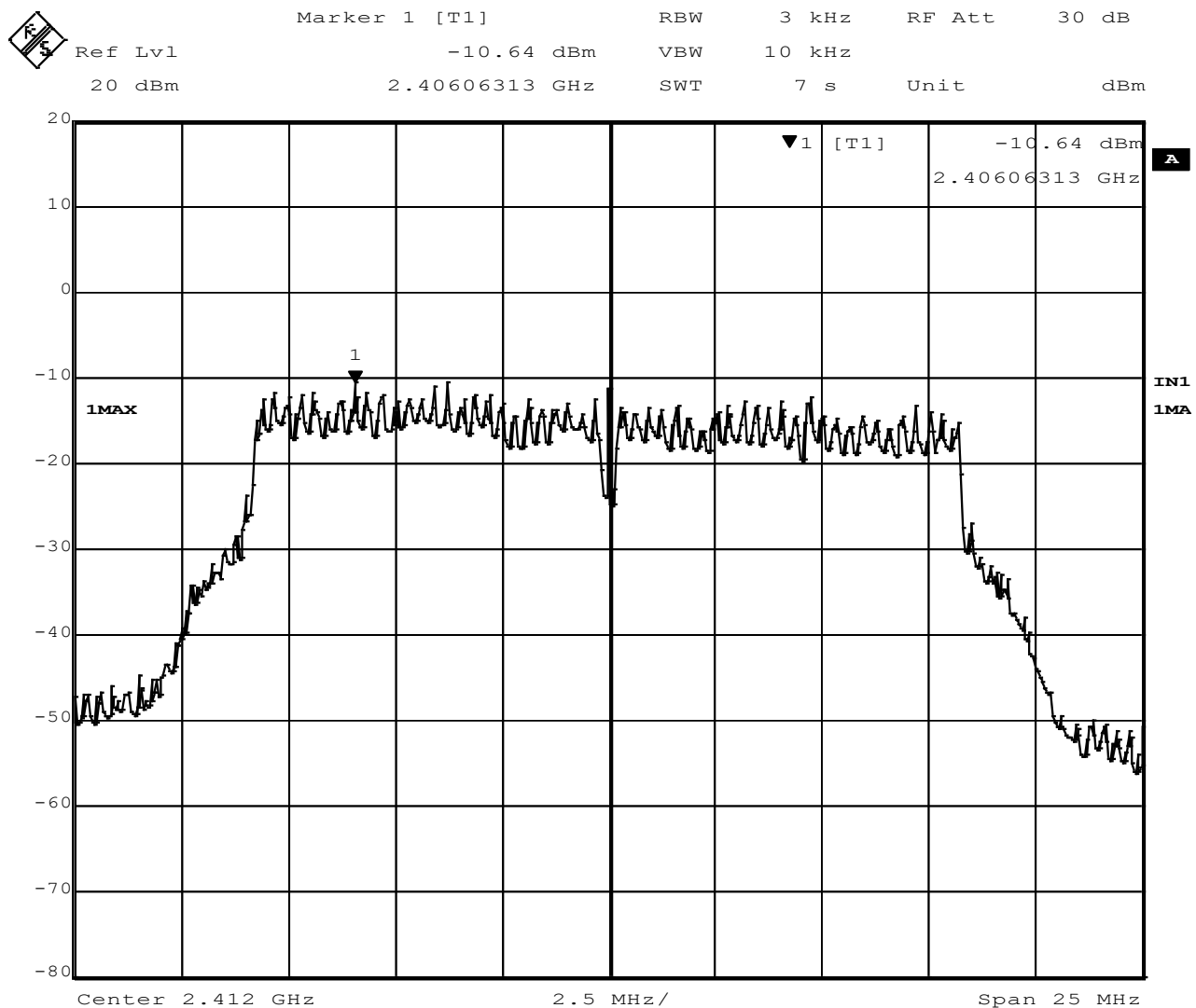
Date: 19.MAR.2019 16:44:29

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



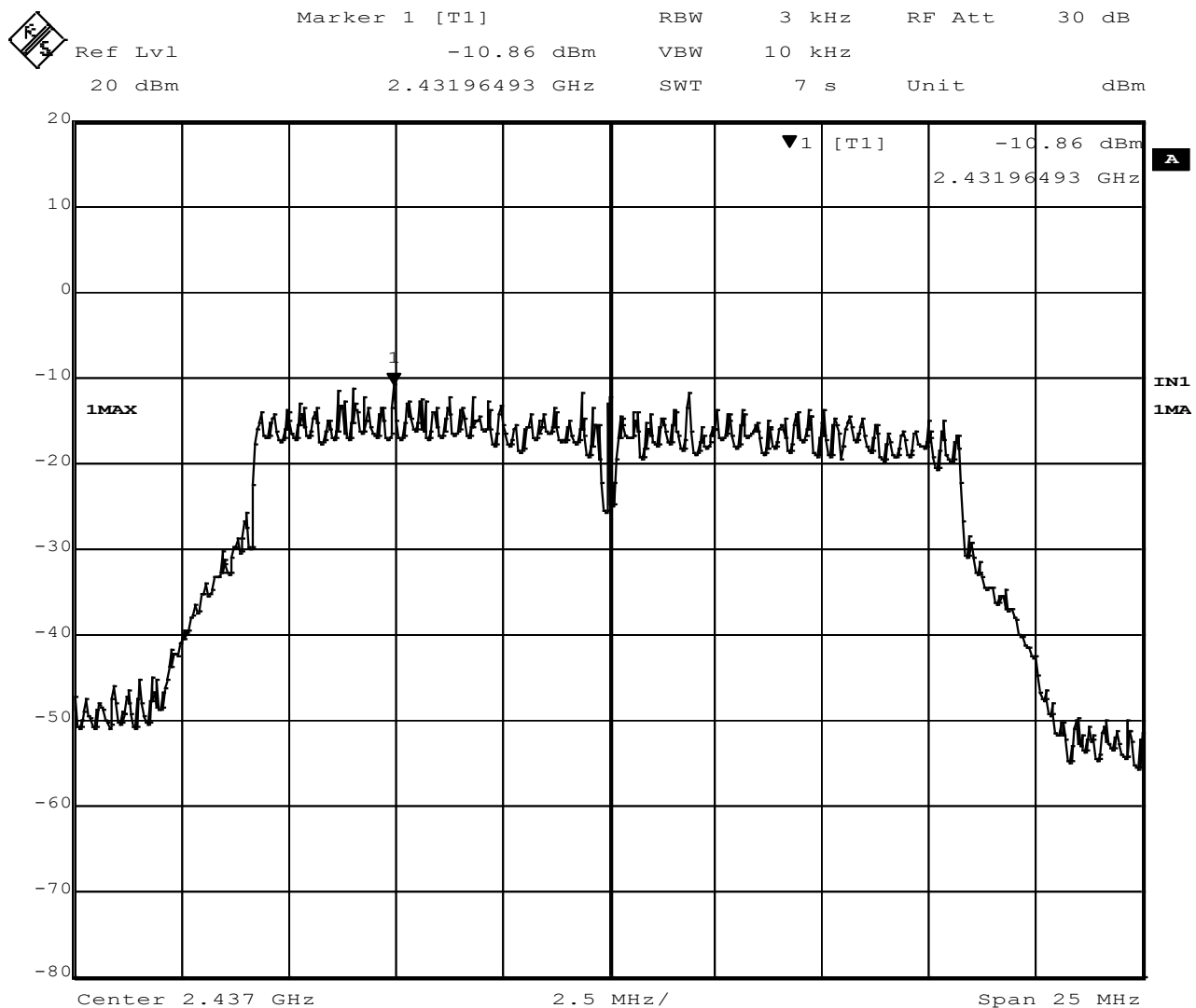
Date: 19.MAR.2019 16:45:02

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



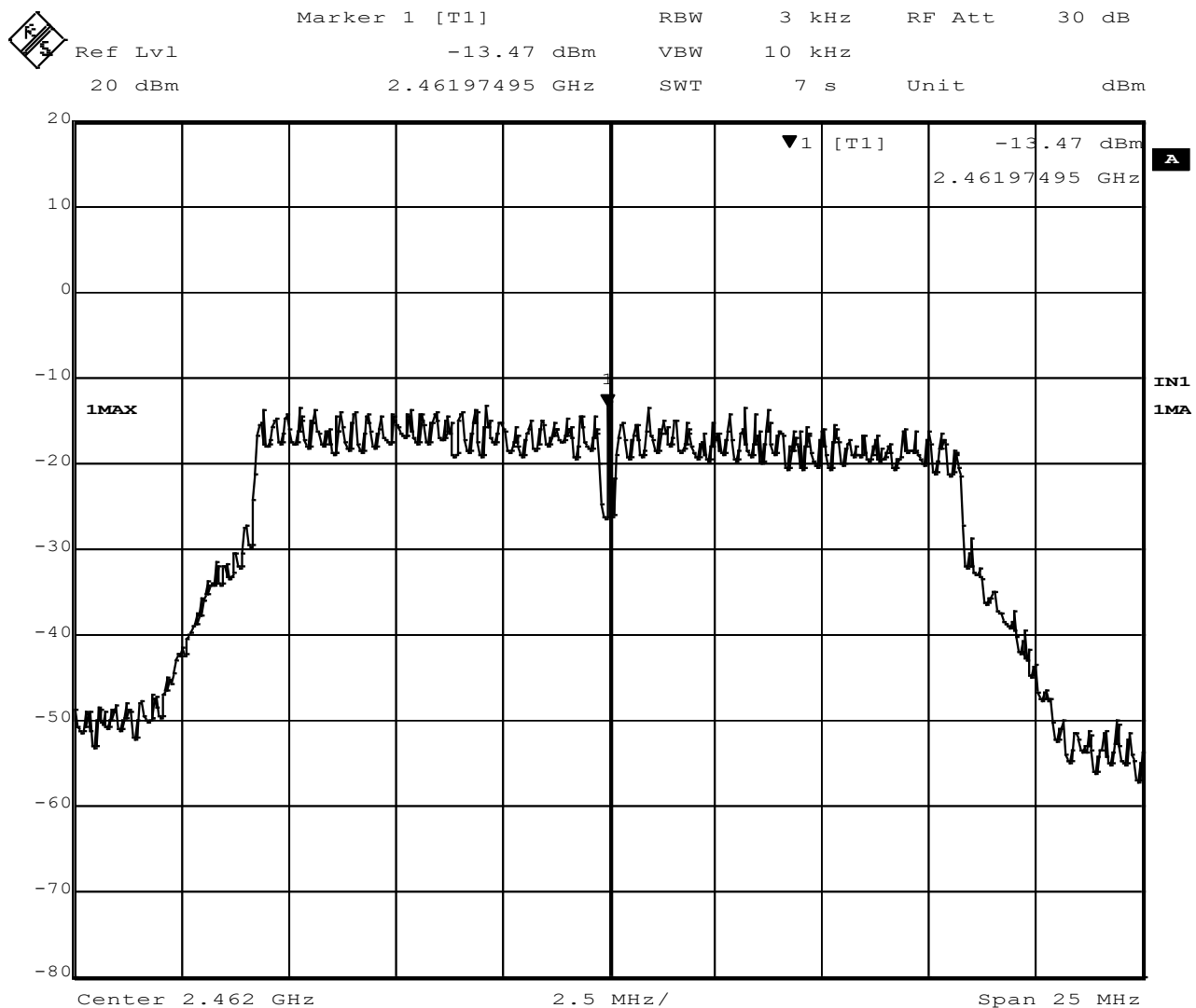
Date: 19.MAR.2019 16:46:19

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



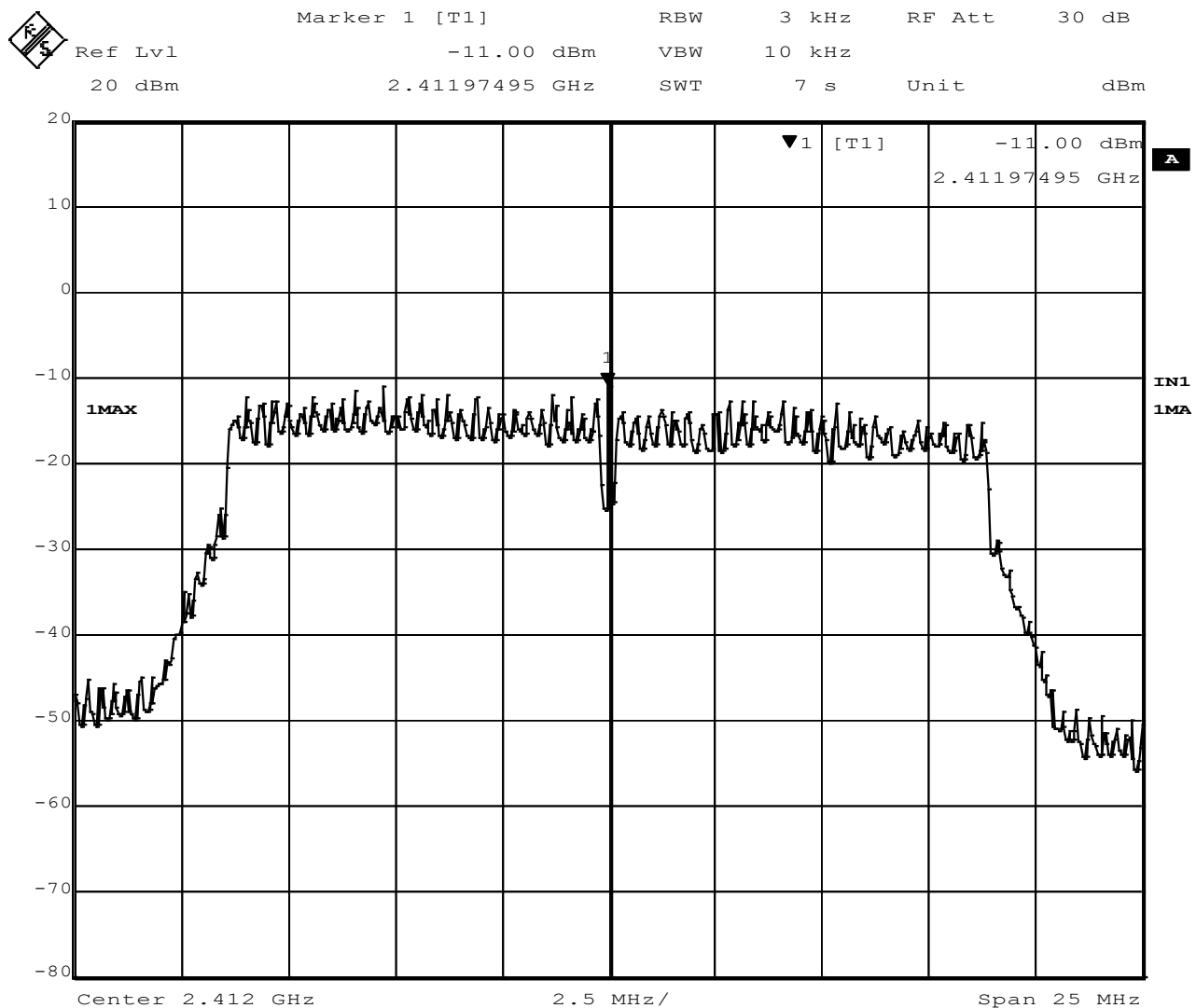
Date: 19.MAR.2019 16:46:57

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



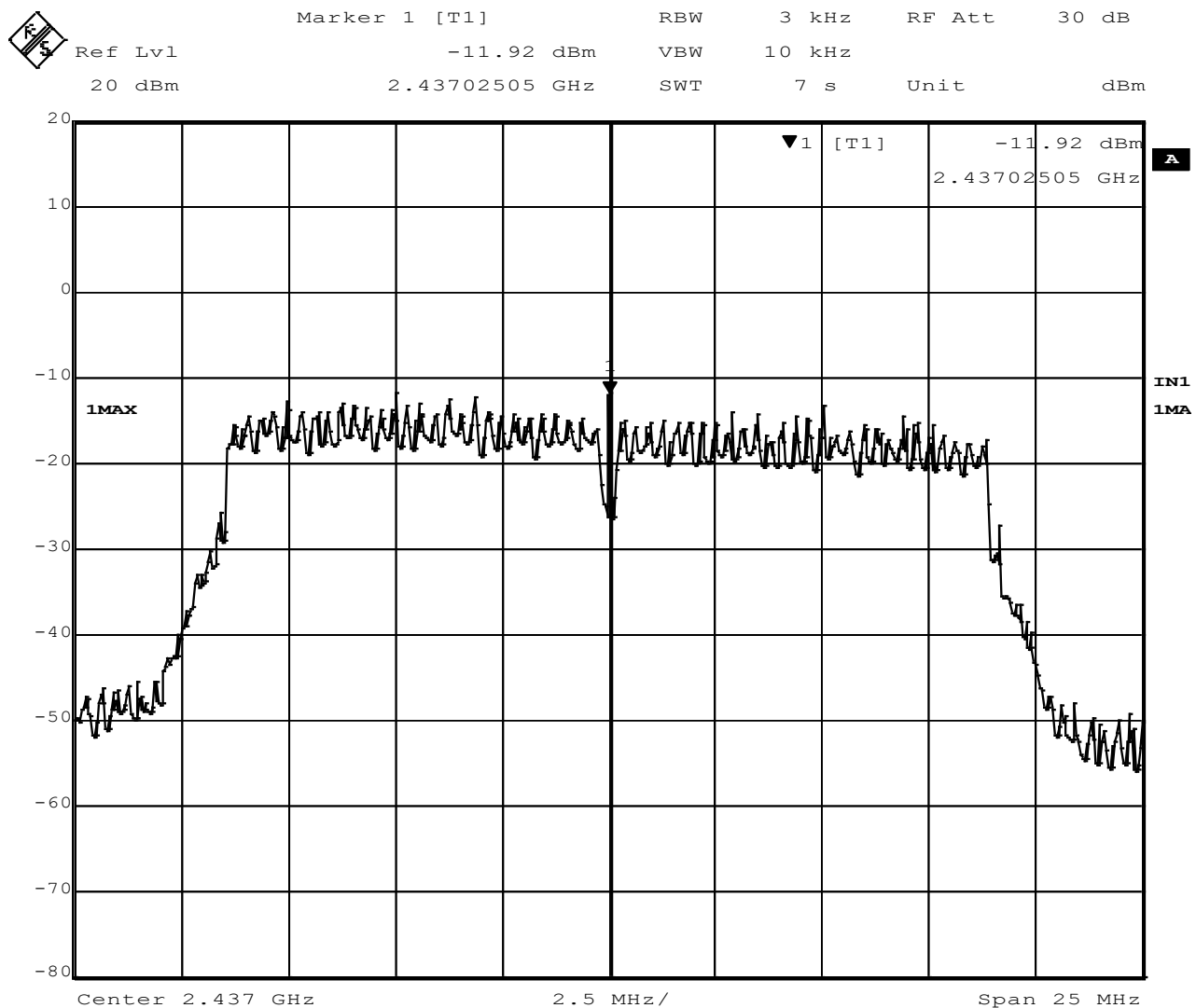
Date: 19.MAR.2019 16:45:36

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



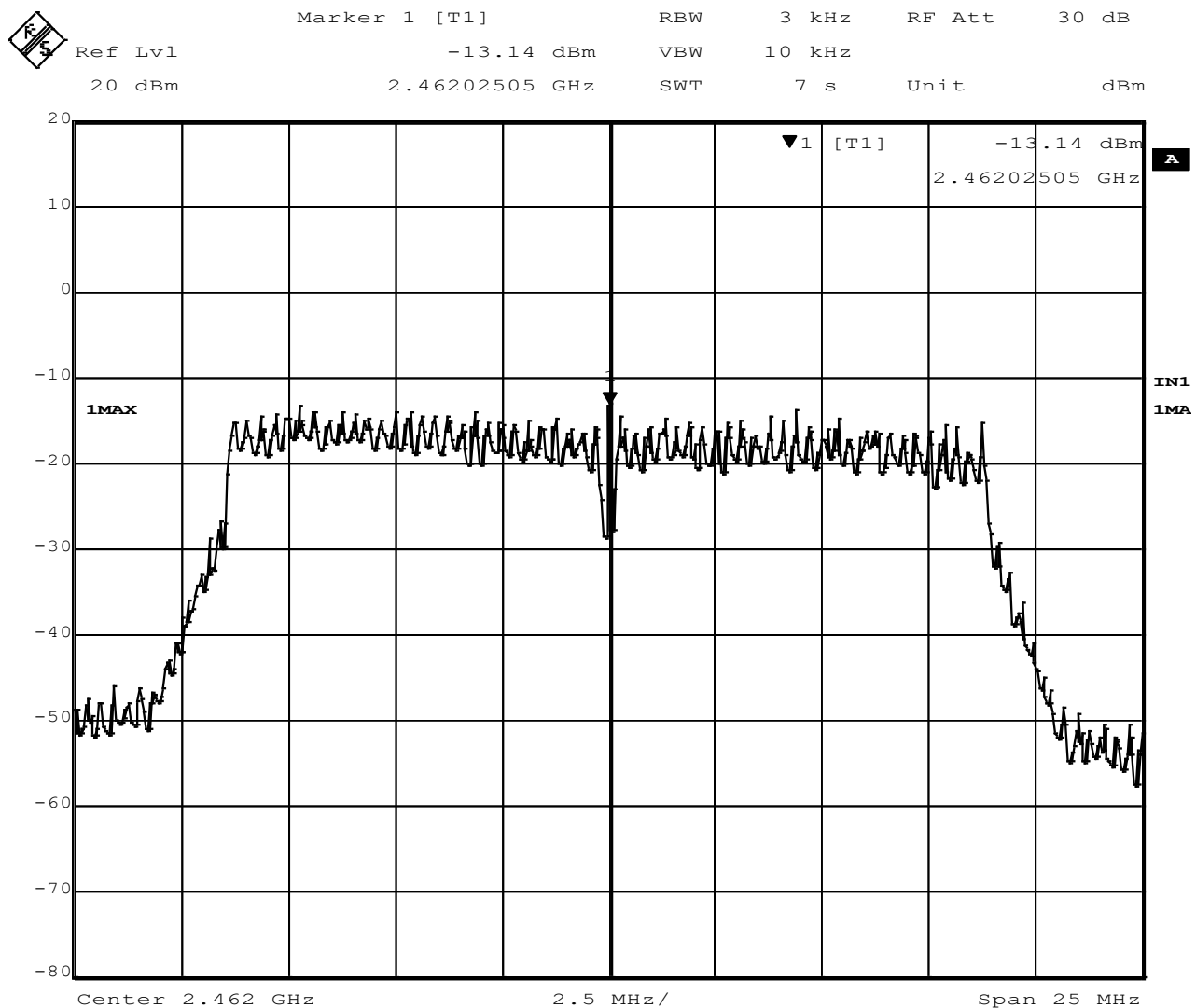
Date: 19.MAR.2019 16:49:02

Figure 62 - Power Spectral Density, Low Channel, 802.11n



Date: 19.MAR.2019 16:50:02

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



Date: 19.MAR.2019 16:48:02

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

	Report Number:	R20181219-20-08	Rev	A
	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.

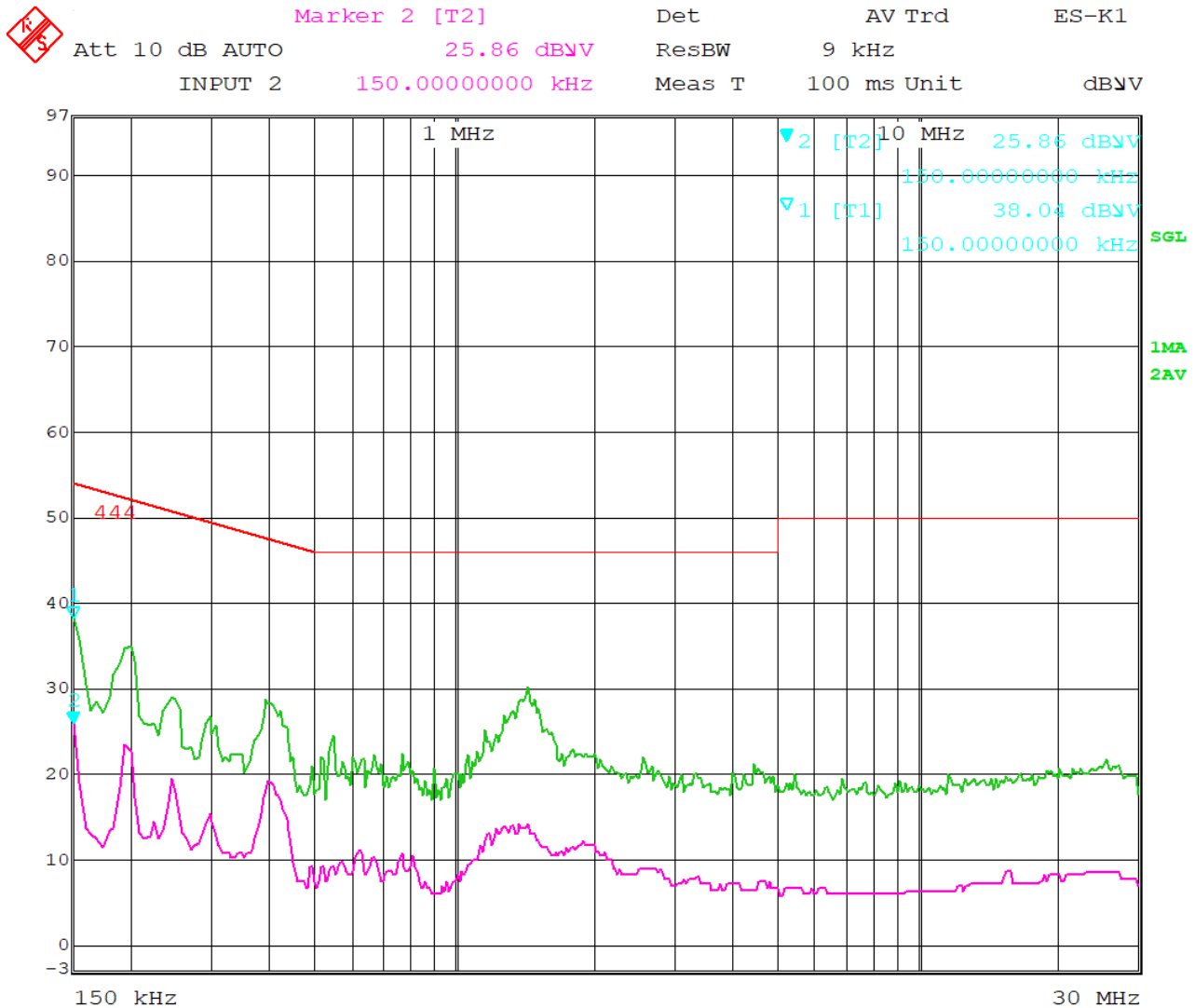
Deviation from the test standard:

No deviation

EUT operating conditions:

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

Test Results:

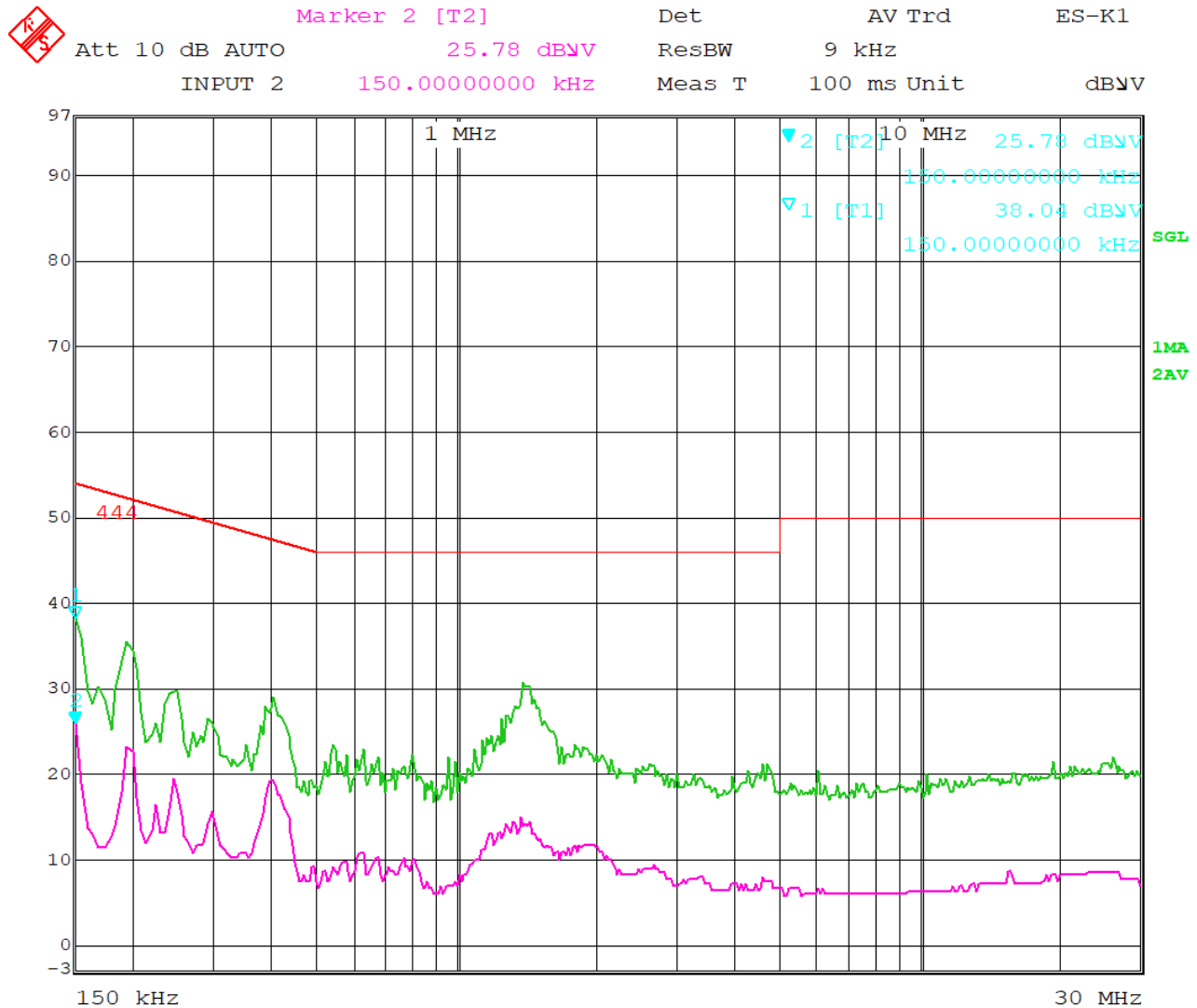


Date: 20.MAY.2019 16:18:13

Figure 65 - Conducted Emissions Plot, Line

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

	Report Number:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		



Date: 20.MAY.2019 16:05:57

. Figure 66 - Conducted Emissions Plot, Neutral

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

	Report Number:	R20181219-20-08	Rev	A
	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 taking the $20 \cdot \log(T_{on}/100)$ where T_{on} is the maximum transmission time in any 100ms window.

	Report Number:	R20181219-20-08	Rev	A
	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:	R20181219-20-08	Rev	A
	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:	R20181219-20-08	Rev	A
	Prepared for:	Garmin		

REPORT END