4740 Discovery Drive | Lincoln, NE 68521
tel- 402.323.6233 | tel -888.657.6860 | fax - 402.323.6238
info@nceelabs.com | http://nceelabs.com

FCC/ISED Test Report

Prepared for:	**Garmin International Inc.**
Address:	**1200 E. 151st Street** **Olathe, Kansas, 66062, USA**
Product:	**A03433**
Test Report No:	**R20181107-20-02A**
Approved By:	**Nic S. Johnson, NCE** **Technical Manager** **iNARTE Certified EMC Engineer #EMC-003337-NE**
DATE:	**8 June 2019**
Total Pages:	**89**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	15 May 2019	Original – NJohnson Prepared by KVepuri/CFarrington
A	8 June 2019	Updated Table 12 to include detector Sections 4.3 and 4.6 (p.75) were updated to include an example of the calculations and values used to derive the radiated output power and psd levels reported. Section 4.3 and 4.6 were modified to include calculated conducted values for output power and PSD

CONTENTS

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.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

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

EUT	Transceiver
Model	A03433
EUT Received	22 March 2019
EUT Tested	22 March 2019 - 9 May 2019
Serial No.	NCEETEST1 (assigned)
Operating Band	2400.0 - 2483.5 GHz
Device Type	802.11b, 802.11g, 802.11n
Power Supply	24 VDC (batteries)

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

2.2 DESCRIPTION OF TEST MODES

The EUT operates on, and was tested at the frequencies below:

Channel	Frequency
Low (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

3.0 LABORATORY DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

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

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*

*Internal Characterization

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Duty Cycle: N/A

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 (µV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Note 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 (µV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

Test procedures:

a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements form 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. All 802.11 modes were examined (b, g, n). All final measurements were performed with the EUT transmitting continuously in these mode.

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:

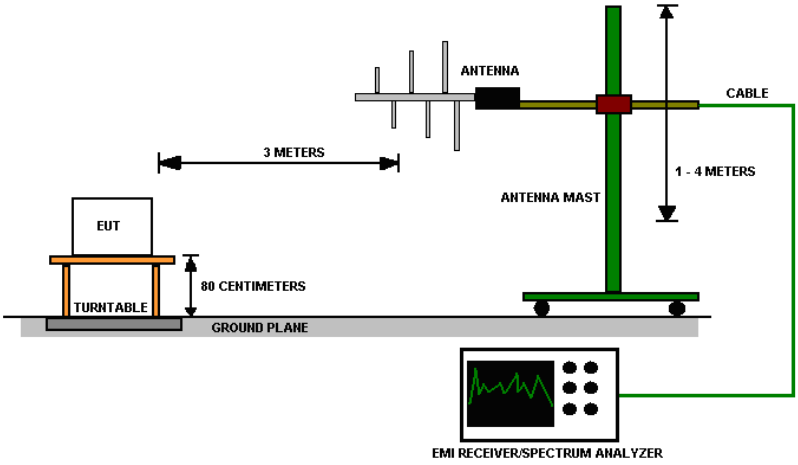

Figure 1 - Radiated Emissions Test Setup

EUT operating conditions
The EUT was powered by 24 VDC 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:

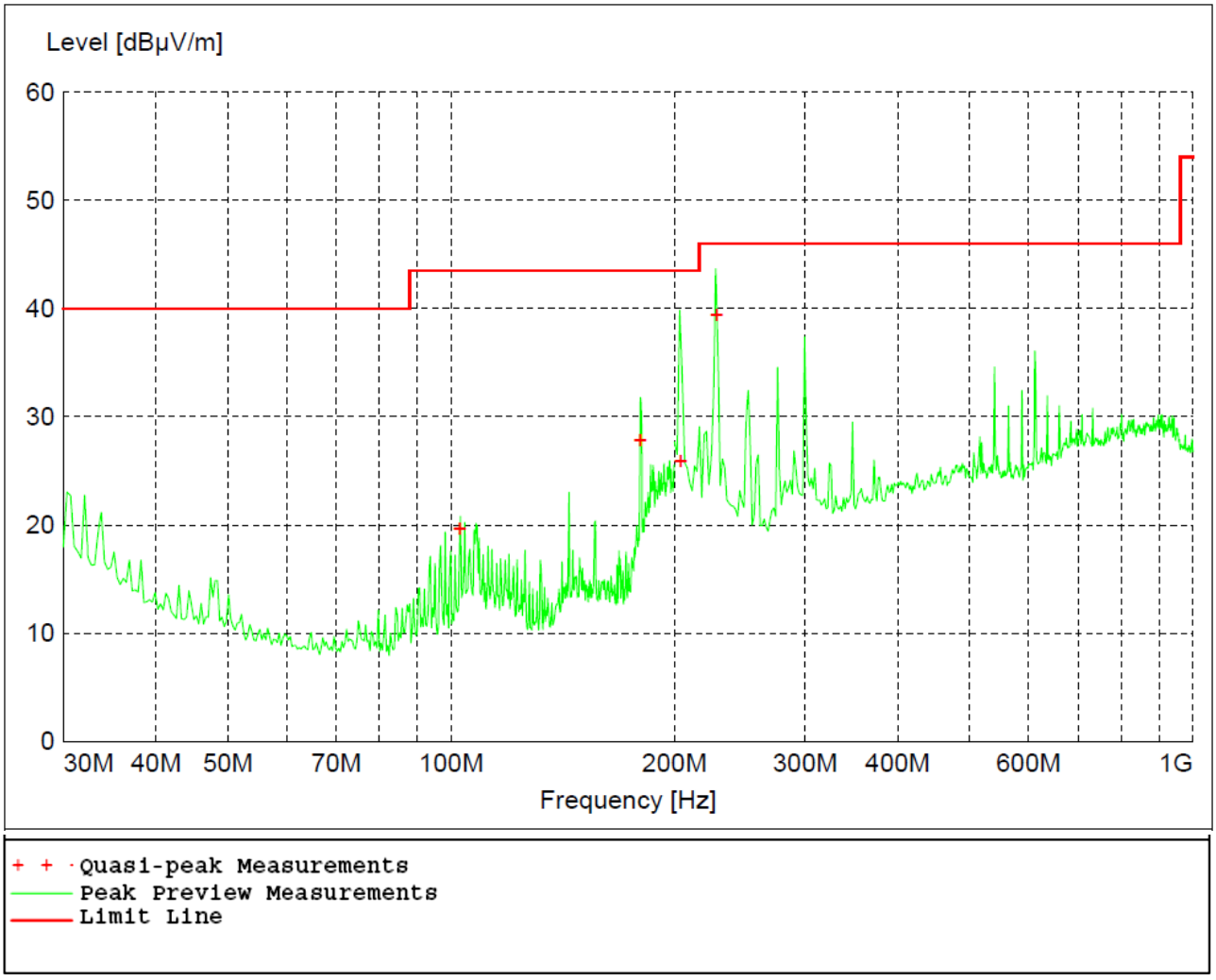

Figure 2 - Radiated Emissions Plot, Receive

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.	
102.780000	19.71	43.50	23.80	102	89	VERT
179.940000	27.86	43.50	15.70	173	360	HORI
204.060000	25.93	43.50	17.60	100	188	HORI
228.000000	39.49	46.00	6.50	223	77	VERT

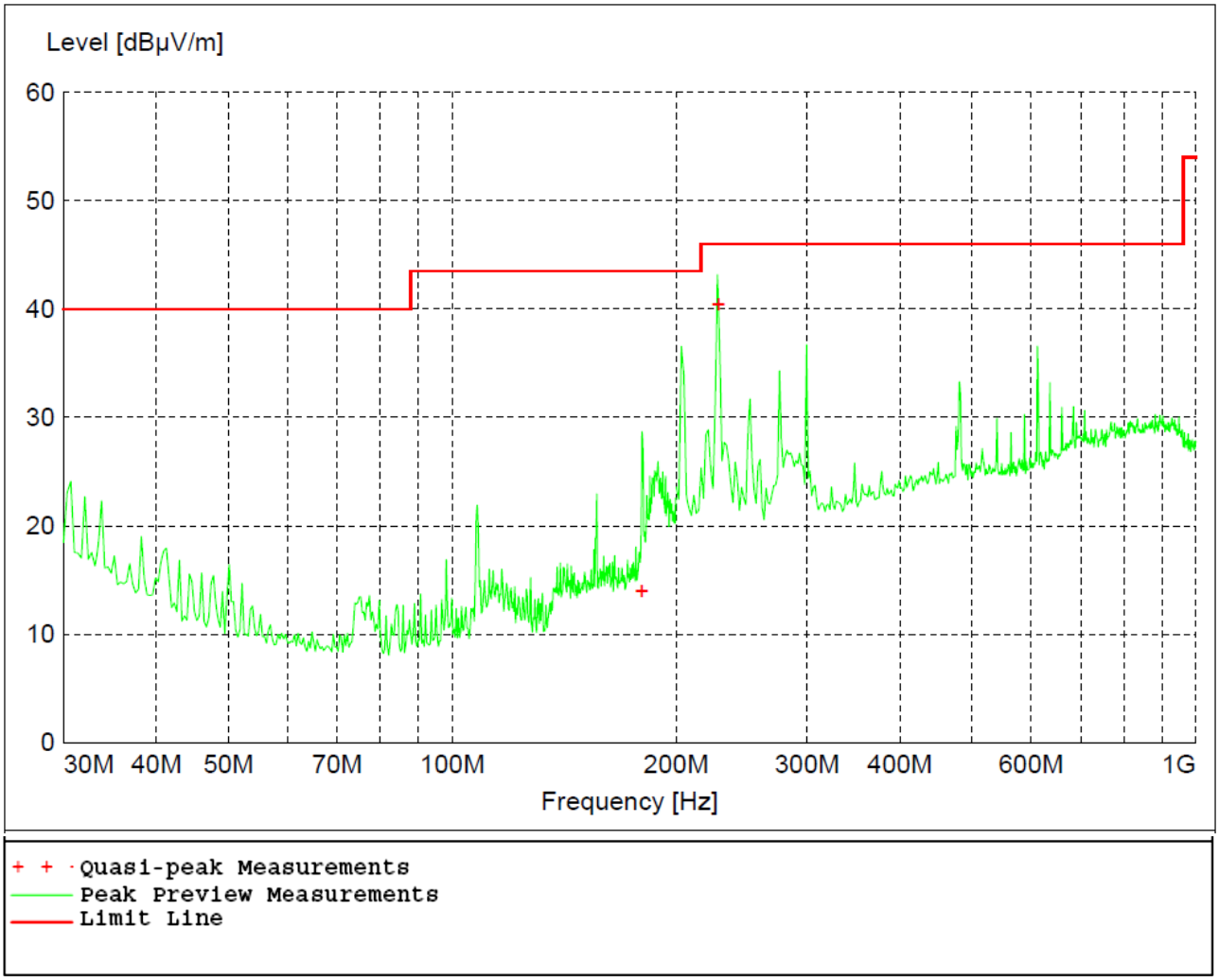

Figure 3 - Radiated Emissions Plot, Low Channel

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.	
179.940000	13.97	43.50	29.60	100	211	VERT
228.000000	40.46	46.00	5.50	217	314	VERT

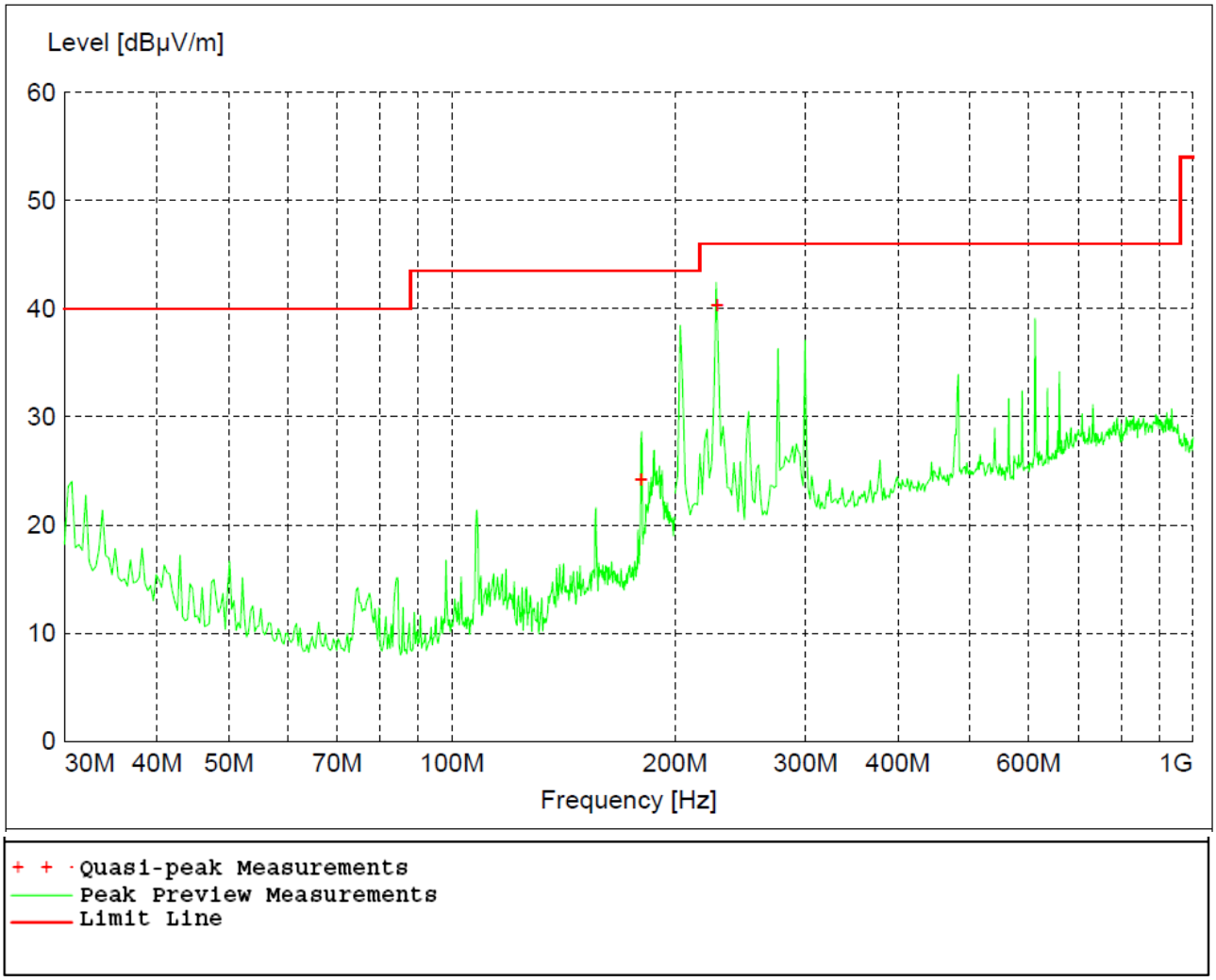

Figure 4 - Radiated Emissions Plot, Mid Channel

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.	
180.000000	24.21	43.50	19.30	100	221	VERT
228.000000	40.36	46.00	5.60	240	314	VERT

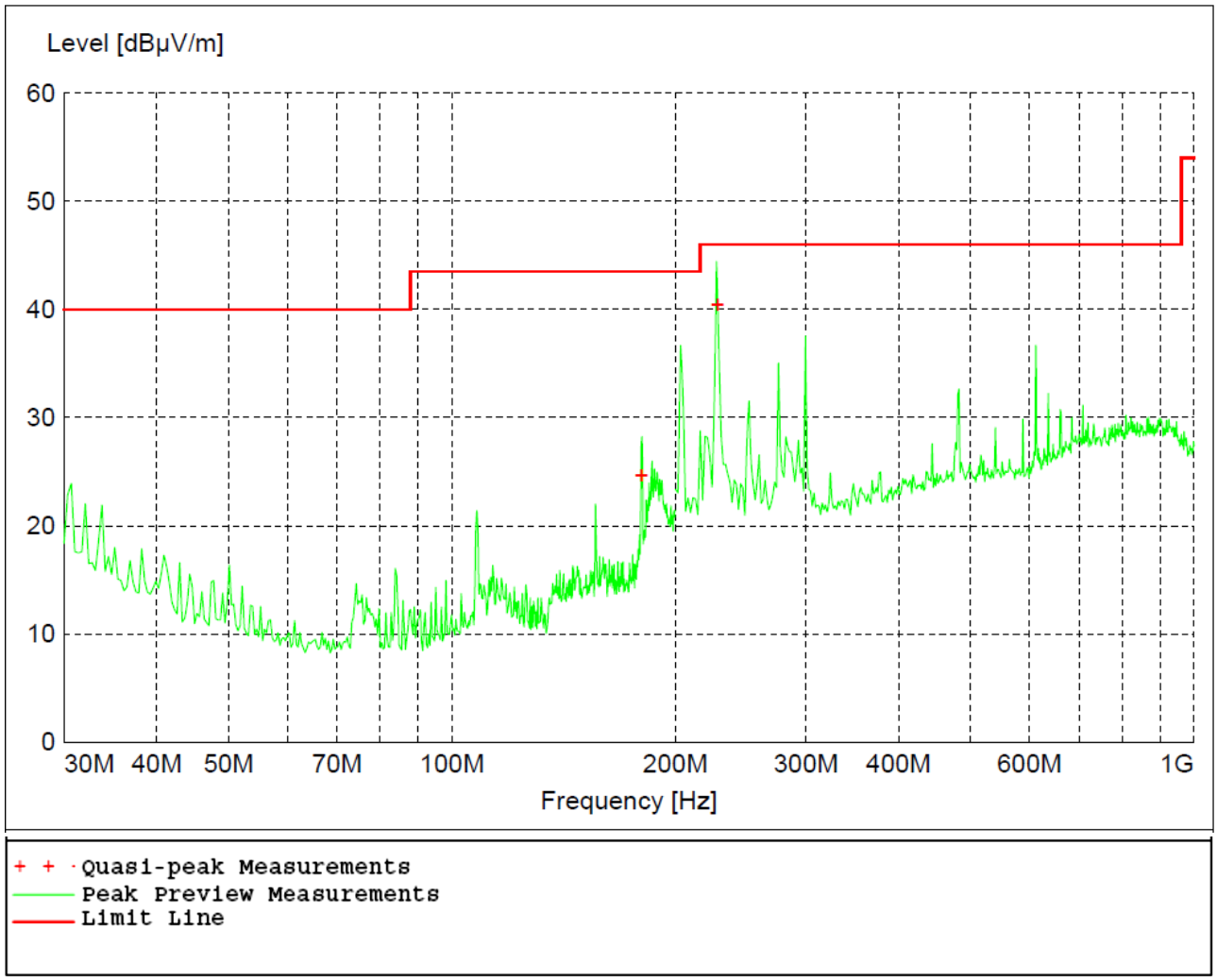

Figure 5 - Radiated Emissions Plot, High Channel

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.	
180.060000	24.63	43.50	18.90	240	299	VERT
228.000000	40.46	46.00	5.50	233	314	VERT

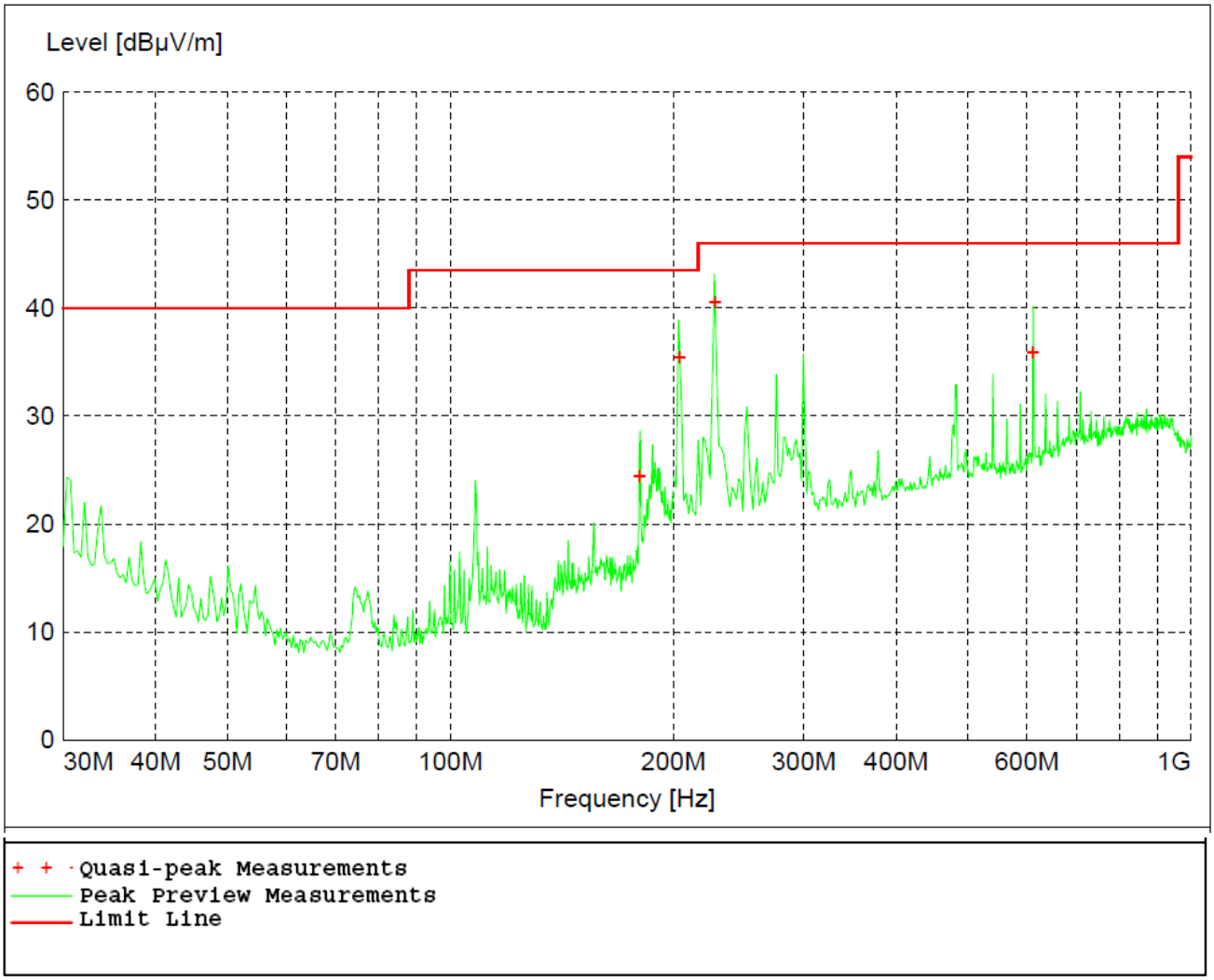

Figure 6 - Radiated Emissions Plot, Low Channel

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.	
180.000000	24.50	43.50	19.00	99	211	VERT
204.060000	35.47	43.50	8.10	99	285	VERT
227.940000	40.60	46.00	5.40	240	310	VERT
612.000000	35.93	46.00	10.10	100	129	VERT

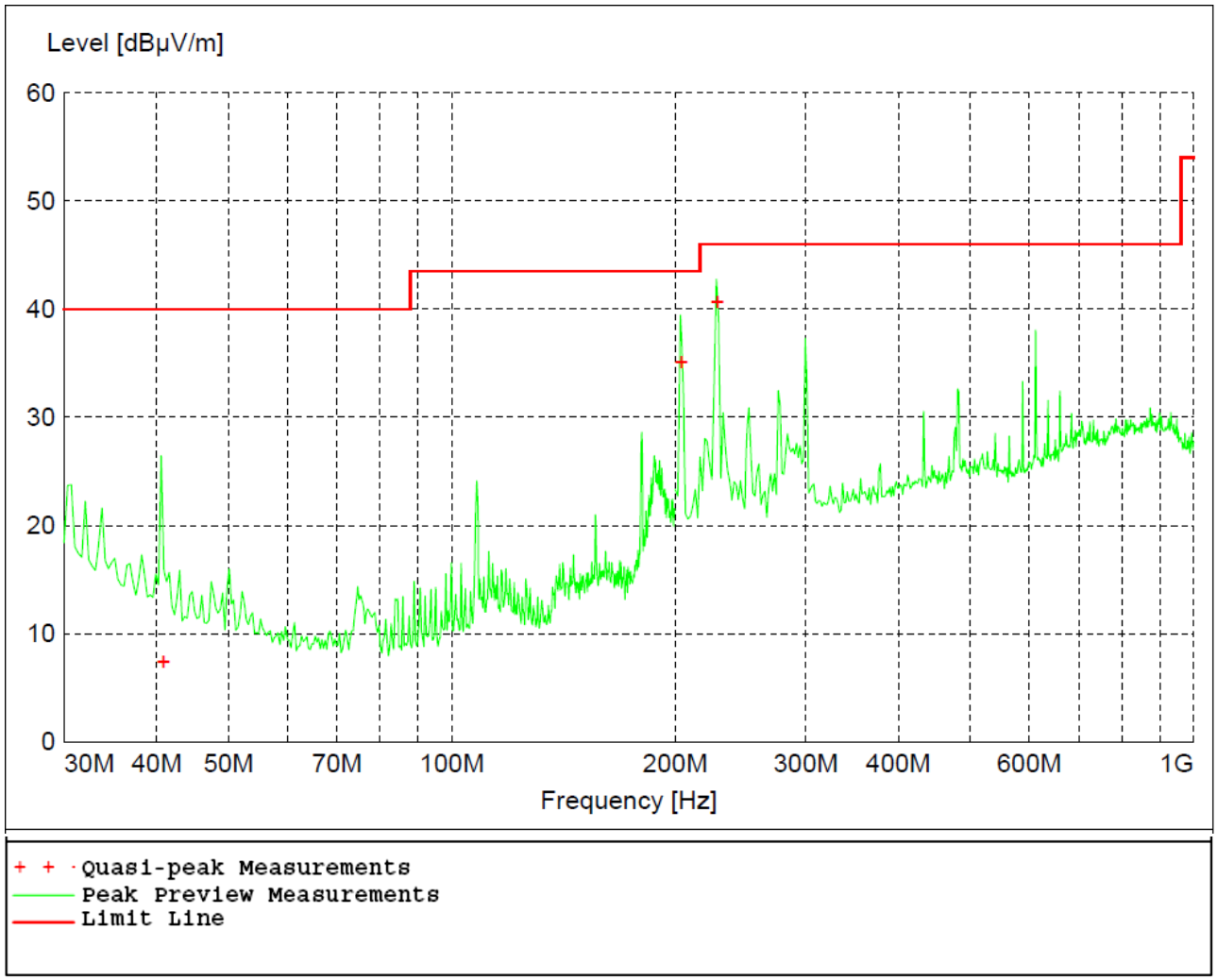

Figure 7 - Radiated Emissions Plot, Mid Channel

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.	
40.860000	7.46	40.00	32.50	165	79	VERT
204.060000	35.12	43.50	8.40	102	294	VERT
228.000000	40.65	46.00	5.40	237	319	VERT

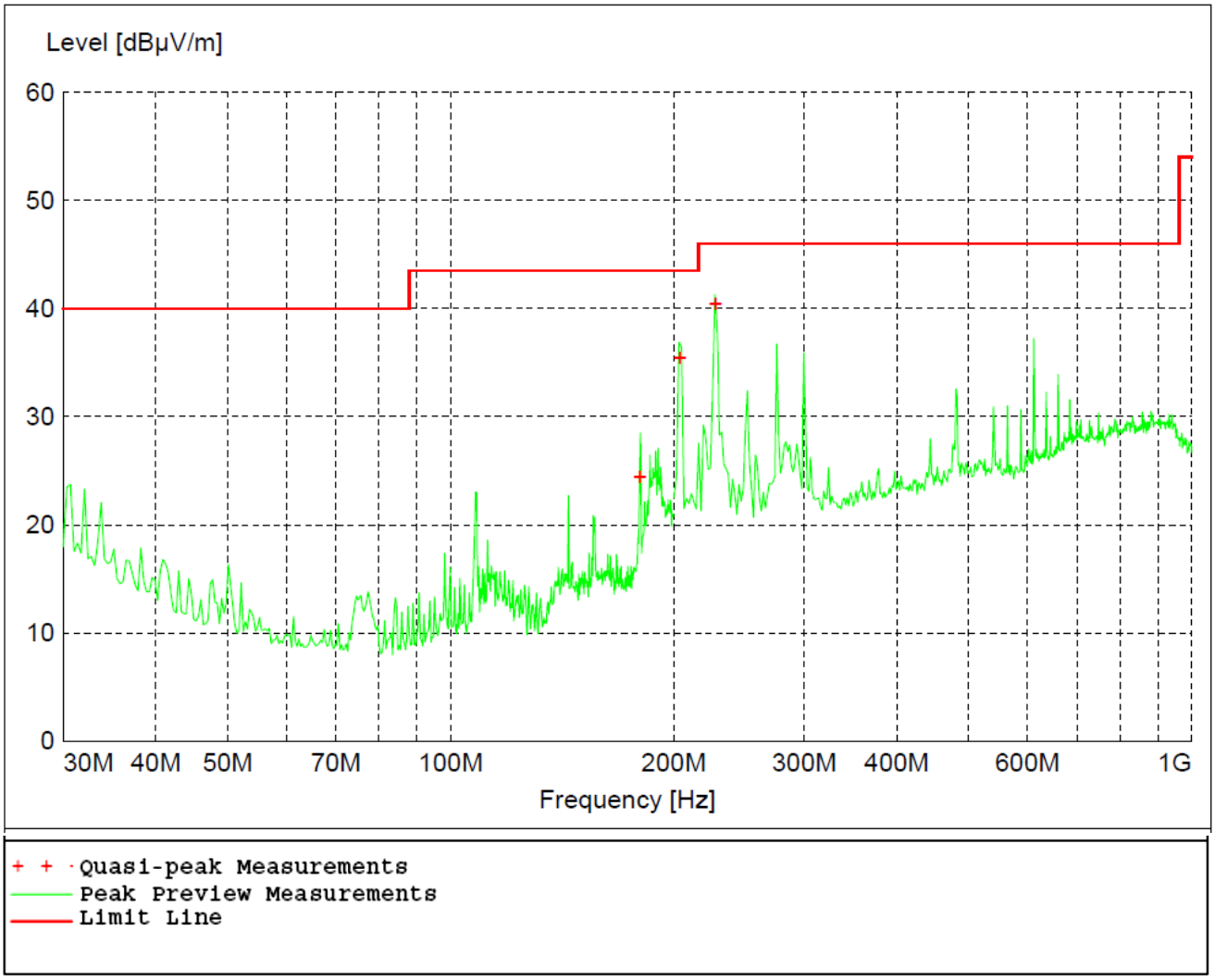

Figure 8 - Radiated Emissions Plot, High Channel

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.	
180.000000	24.50	43.50	19.00	261	301	VERT
204.060000	35.46	43.50	8.10	100	290	VERT
227.940000	40.43	46.00	5.60	230	308	VERT

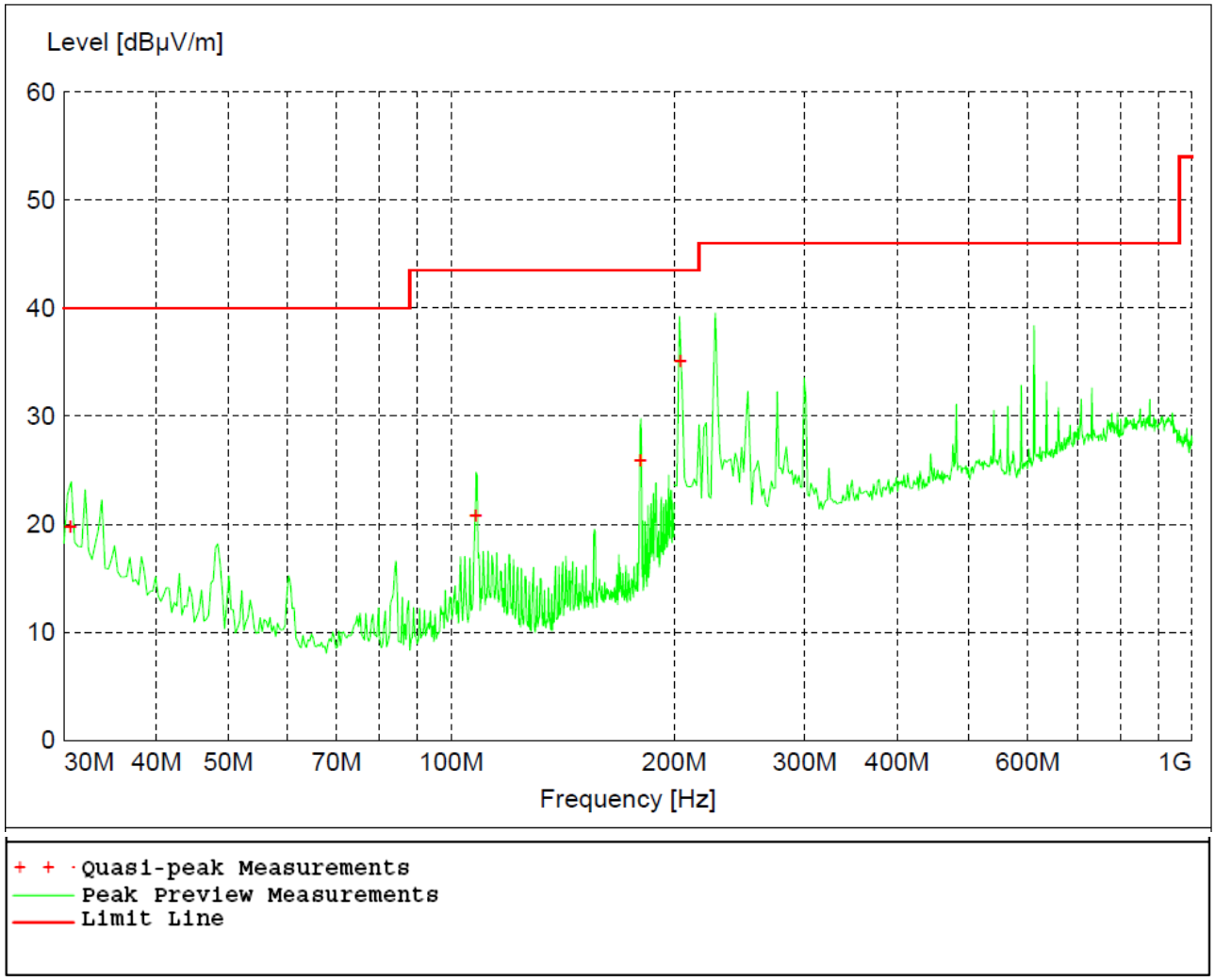

Figure 9 - Radiated Emissions Plot, Low Channel

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.	
30.660000	19.78	40.00	20.20	99	177	VERT
108.000000	20.76	43.50	22.80	100	54	VERT
180.000000	25.96	43.50	17.60	179	360	HORI
204.060000	35.10	43.50	8.40	139	360	HORI

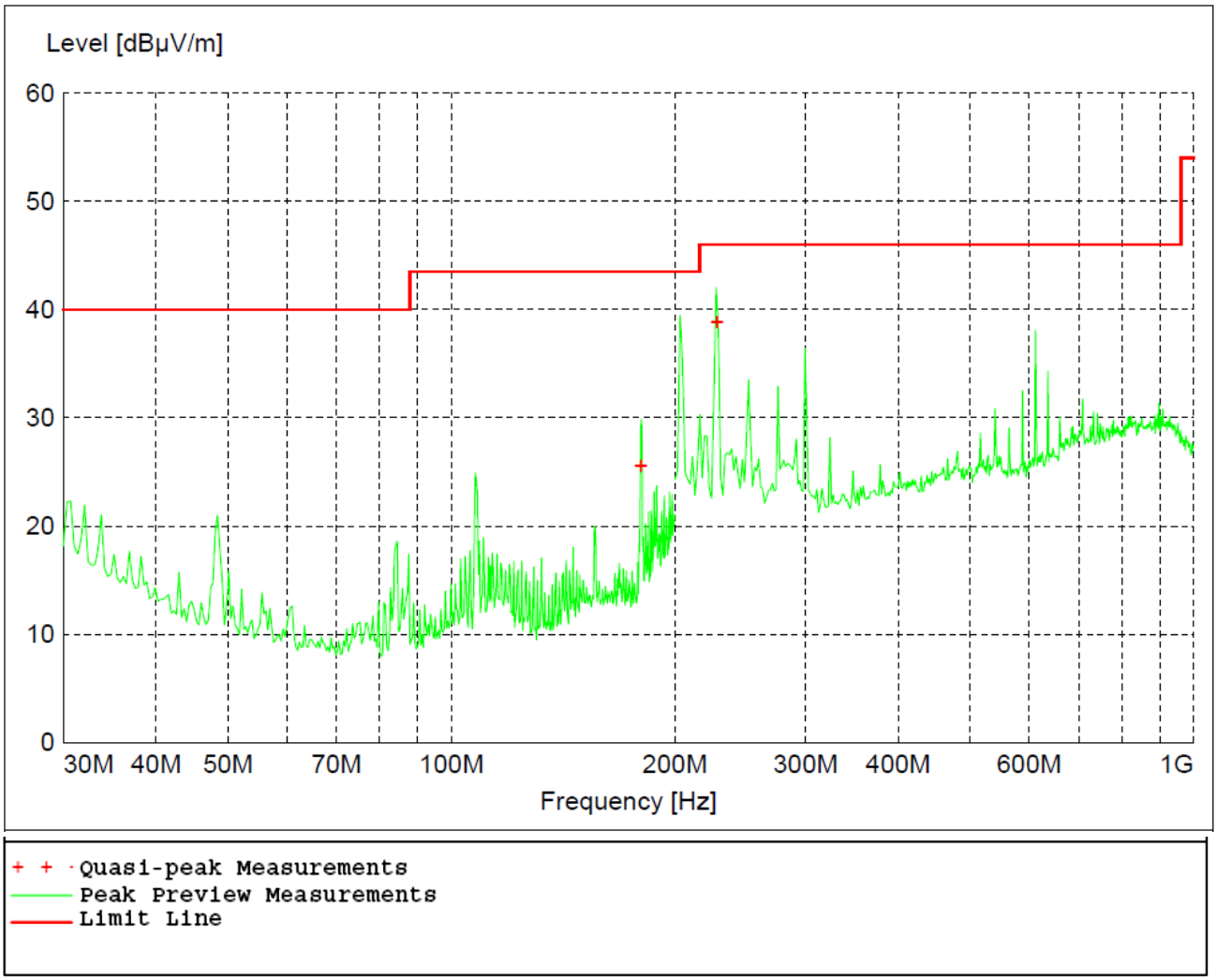

Figure 10 - Radiated Emissions Plot, Mid Channel

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.	
180.000000	25.56	43.50	18.00	176	14	HORI
228.060000	38.89	46.00	7.10	251	62	VERT

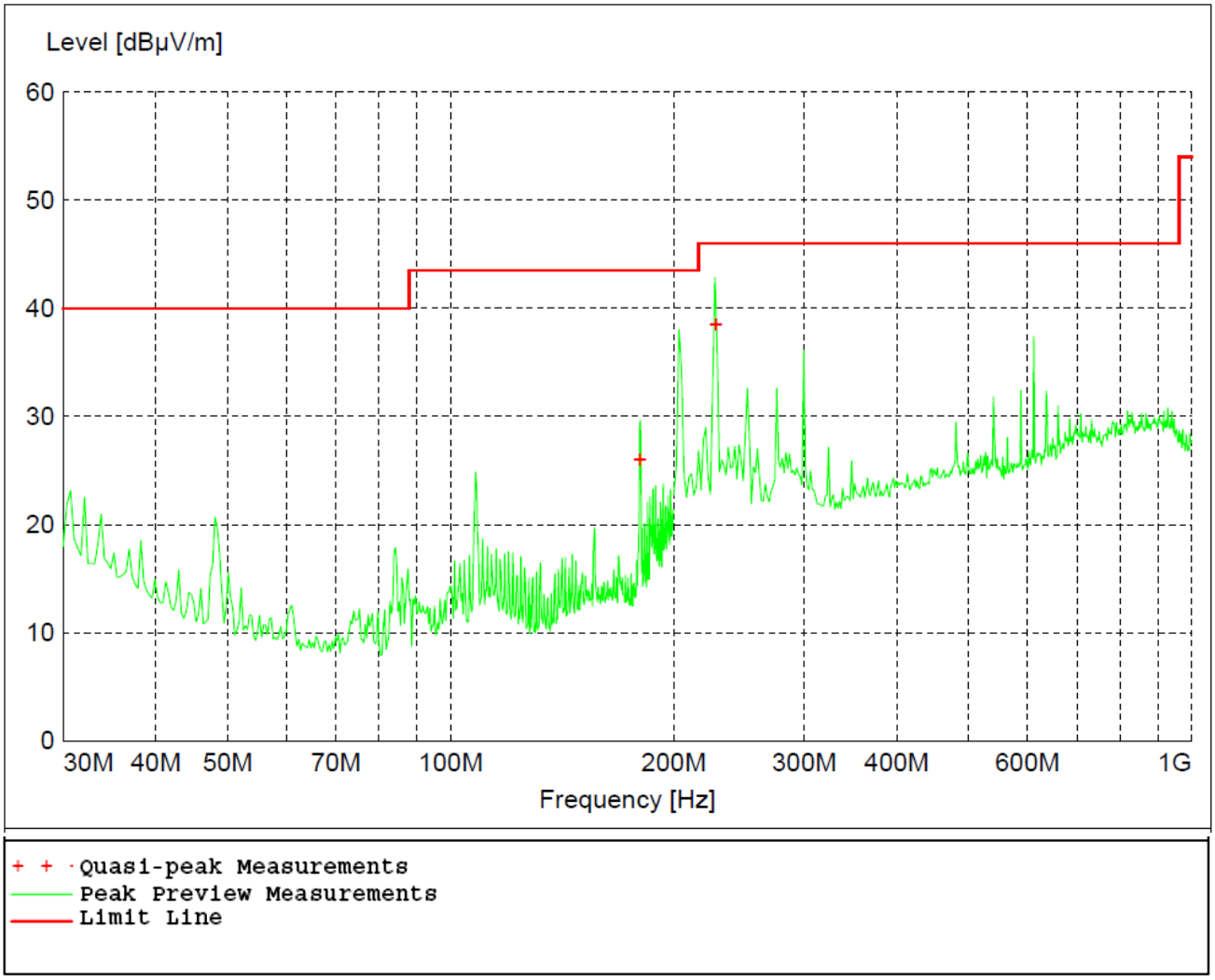

Figure 11 - Radiated Emissions Plot, High Channel

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.	
180.000000	26.03	43.50	17.50	170	0	HORI
228.000000	38.57	46.00	7.40	263	60	VERT

Table 11 - Radiated Emissions Measurements, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode	Detector
MHz	dBµV/m			cm.	deg.		802.11	
2412.000000	87.28	NA	NA	100	228	HORI	n	AV
4824.400000	33.82	54.00	20.18	237	126	HORI	n	AV
2412.000000	104.10	NA	NA	100	228	HORI	n	PK
4824.400000	50.31	74.00	23.69	237	126	HORI	n	PK
2437.000000	92.10	NA	NA	106	228	HORI	n	AV
4877.000000	30.60	54.00	23.40	123	189	HORI	n	AV
2437.000000	108.56	NA	NA	106	228	HORI	n	PK
4877.000000	49.82	74.00	24.18	123	189	HORI	n	PK
2462.000000	87.93	NA	NA	150	192	VERT	n	AV
4917.400000	31.27	54.00	22.73	378	13	HORI	n	AV
2462.000000	105.37	NA	NA	150	192	VERT	n	PK
4917.400000	44.89	74.00	29.11	378	13	HORI	n	PK
2412.000000	88.89	NA	NA	210	285	VERT	g	AV
4824.000000	37.80	54.00	16.20	220	43	VERT	g	AV
7235.800000	40.40	54.00	13.60	251	109	HORI	g	AV
2412.000000	103.51	NA	NA	210	285	VERT	g	PK
4824.000000	52.25	74.00	21.75	220	43	VERT	g	PK
7235.800000	53.94	74.00	20.06	251	109	HORI	g	PK
2437.000000	85.70	NA	NA	274	67	HORI	g	AV
4878.000000	38.09	54.00	15.91	157	202	VERT	g	AV
2437.000000	91.70	NA	NA	274	67	HORI	g	PK
4878.000000	54.38	74.00	19.62	157	202	VERT	g	PK
2462.000000	87.40	NA	NA	200	288	VERT	g	AV
4917.000000	31.07	54.00	22.93	160	150	VERT	g	AV
2462.000000	102.67	NA	NA	200	288	VERT	g	PK
4917.000000	44.25	74.00	29.75	160	150	VERT	g	PK

Table 12 - Radiated Emissions Measurements, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode	Detector
MHz	dBµV/m			cm.	deg.		802.11	
2412.000000	99.58	NA	NA	197	0	VERT	b	PK
4824.000000	39.06	54.00	14.94	137	172	VERT	b	AV
2412.000000	109.75	NA	NA	197	0	VERT	b	PK
4824.000000	52.50	74.00	21.50	137	172	VERT	b	PK
4874.000000	42.11	54.00	11.89	190	280	VERT	b	AV
2437.000000	109.77	NA	NA	221	355	VERT	b	PK
4874.000000	55.00	74.00	19.00	190	280	VERT	b	PK
2462.000000	98.55	NA	NA	200	0	VERT	b	PK
4924.000000	40.82	54.00	13.18	177	155	VERT	b	AV
2462.000000	108.29	NA	NA	200	0	VERT	b	PK
4924.000000	49.25	74.00	24.75	177	155	VERT	b	PK
No other signals were detected above system sensitivity and were at least 10 dB below the applicable limits.								

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.
5. All 3 possible 802.11 modes were tested. The highest of each is presented in the tables.

4.3 PEAK OUTPUT POWER

Test Method: ANSI C63.10:
1. Section(s) 11.9.1.2

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

Test procedures:
All measurements were taken at a distance of 3m from the EUT. The EUT was maximized in all 3 orthogonal positions. The measurement was done with 1 MHz RBW and 3 MHz VBW and Channel power setting on spectrum analyzer was used.

Deviations from test standard:
No deviation.

Test setup:

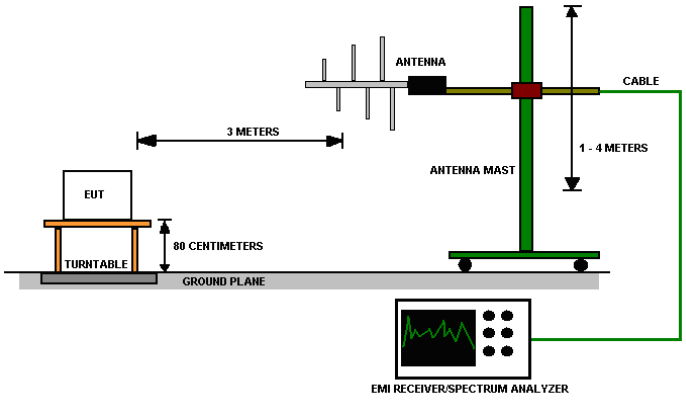

Figure 12 – Peak Output Power Measurements Test Setup

EUT operating conditions:
The EUT was powered by 24 VDC 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.

Radiated SA reading + 107 + CL + AF - 95.23 – AG(conducted only) = Output power (EIRP or conducted)

AG – Antenna gain = 3.9 dBi
CL = cable loss = 7.60 dB
AF = antenna factor = 28.30 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	PEAK EIRP OUTPUT POWER (dBm) MU = ±1.1 dB	PEAK CONDUCTED* OUTPUT POWER (dBm) MU = ±1.1 dB	Method	RESULT
Low	2412	802.11b	24.45	20.55	Radiated	PASS
Middle	2437	802.11b	25.42	21.52	Radiated	PASS
High	2462	802.11b	23.47	19.57	Radiated	PASS
Low	2412	802.11g	23.64	19.74	Radiated	PASS
Middle	2437	802.11g	28.03	24.13	Radiated	PASS
High	2462	802.11g	21.88	17.98	Radiated	PASS
Low	2412	802.11n	21.18	17.28	Radiated	PASS
Middle	2437	802.11n	26.56	22.66	Radiated	PASS
High	2462	802.11n	21.83	17.93	Radiated	PASS

Average Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	Average EIRP OUTPUT POWER (dBm) MU = ±1.37	PEAK CONDUCTED* OUTPUT POWER (dBm) MU = ±1.1 dB	Method	RESULT
Low	2412	802.11b	19.20	15.3	Radiated	PASS
Middle	2437	802.11b	20.17	16.27	Radiated	PASS
High	2462	802.11b	17.94	14.04	Radiated	PASS
Low	2412	802.11g	16.10	12.2	Radiated	PASS
Middle	2437	802.11g	20.42	16.52	Radiated	PASS
High	2462	802.11g	14.20	10.3	Radiated	PASS
Low	2412	802.11n	13.17	9.27	Radiated	PASS
Middle	2437	802.11n	18.73	14.83	Radiated	PASS
High	2462	802.11n	13.92	10.02	Radiated	PASS

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:
All measurements were taken at a distance of 3m from the EUT. The EUT was maximized in all 3 orthogonal positions. 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:
See Section 4.3

EUT operating conditions:
The EUT was powered by 24 VDC 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	13.477
Middle	2437	802.11b	13.427
High	2462	802.11b	13.477
Low	2412	802.11g	17.585
Middle	2437	802.11g	17.585
High	2462	802.11g	17.585
Low	2412	802.11n	17.715
Middle	2437	802.11n	17.615
High	2462	802.11n	17.675

6dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	6 dB BW (MHz)
Low	2412	802.11b	8.417
Middle	2437	802.11b	8.367
High	2462	802.11b	8.166
Low	2412	802.11g	17.685
Middle	2437	802.11g	17.635
High	2462	802.11g	17.385
Low	2412	802.11n	17.234
Middle	2437	802.11n	17.555
High	2462	802.11n	16.894

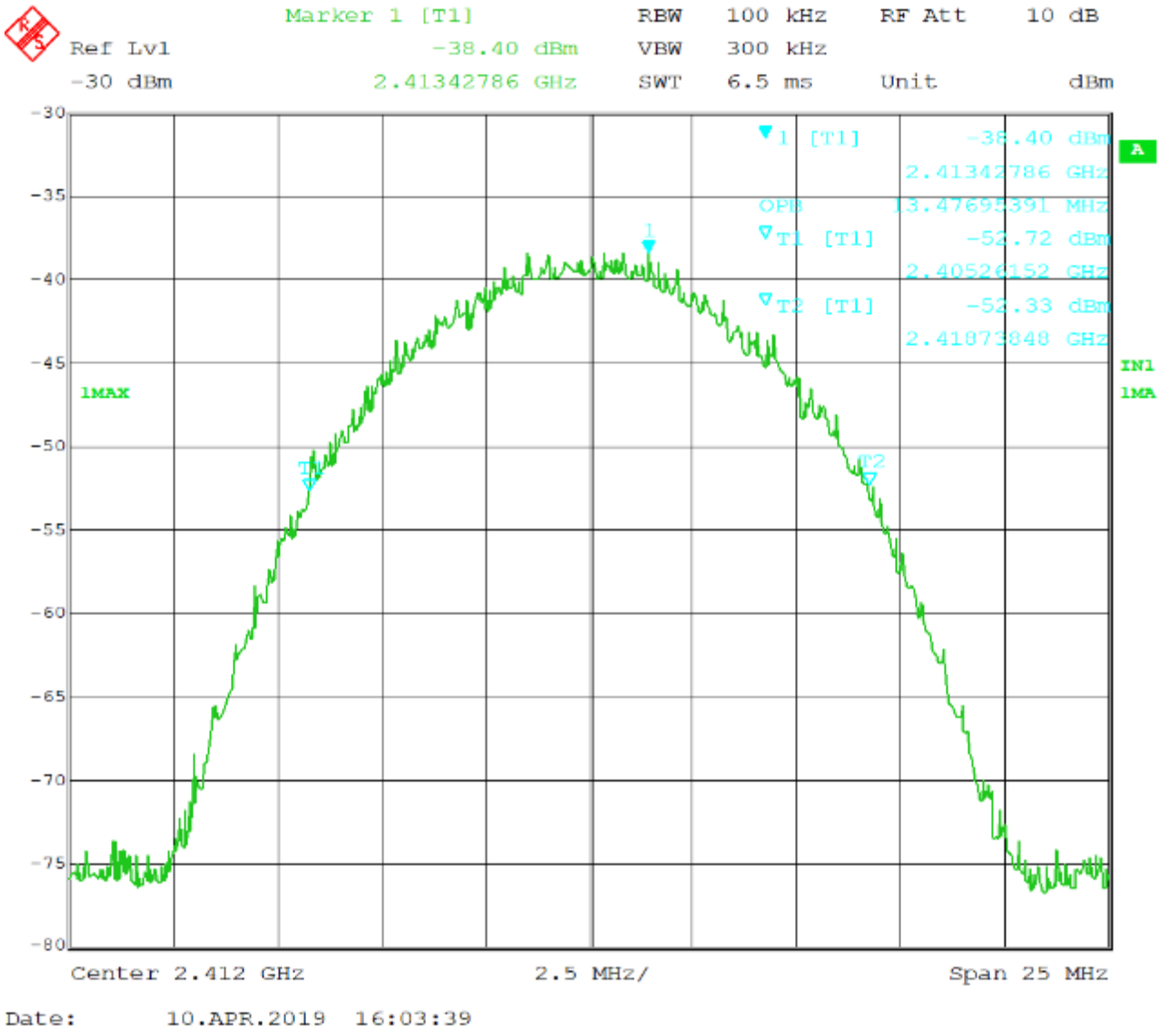

Figure 13 - 99% Occupied Bandwidth, Low Channel, 802.11b

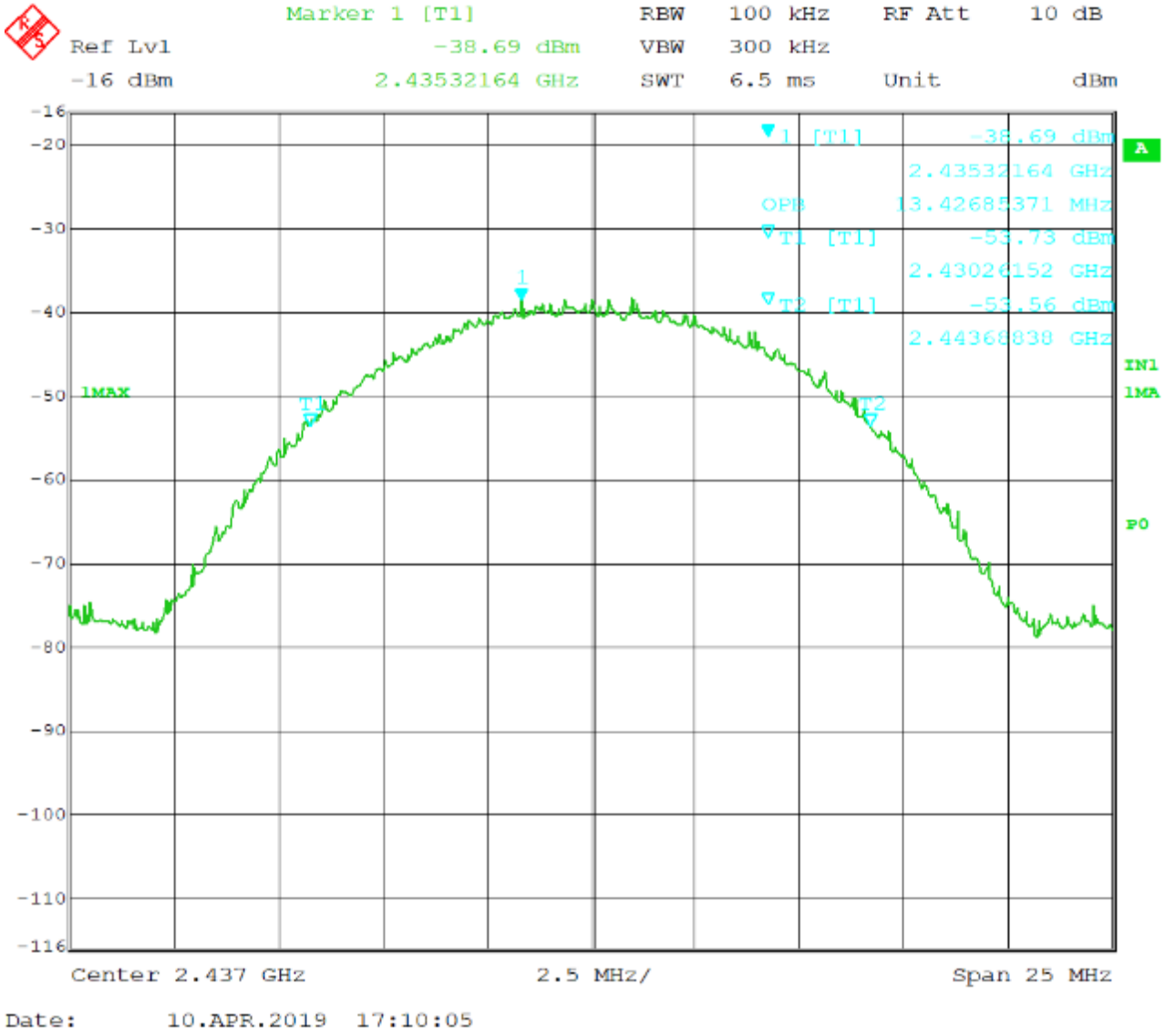

Figure 14 - 99% Occupied Bandwidth, Mid Channel, 802.11b

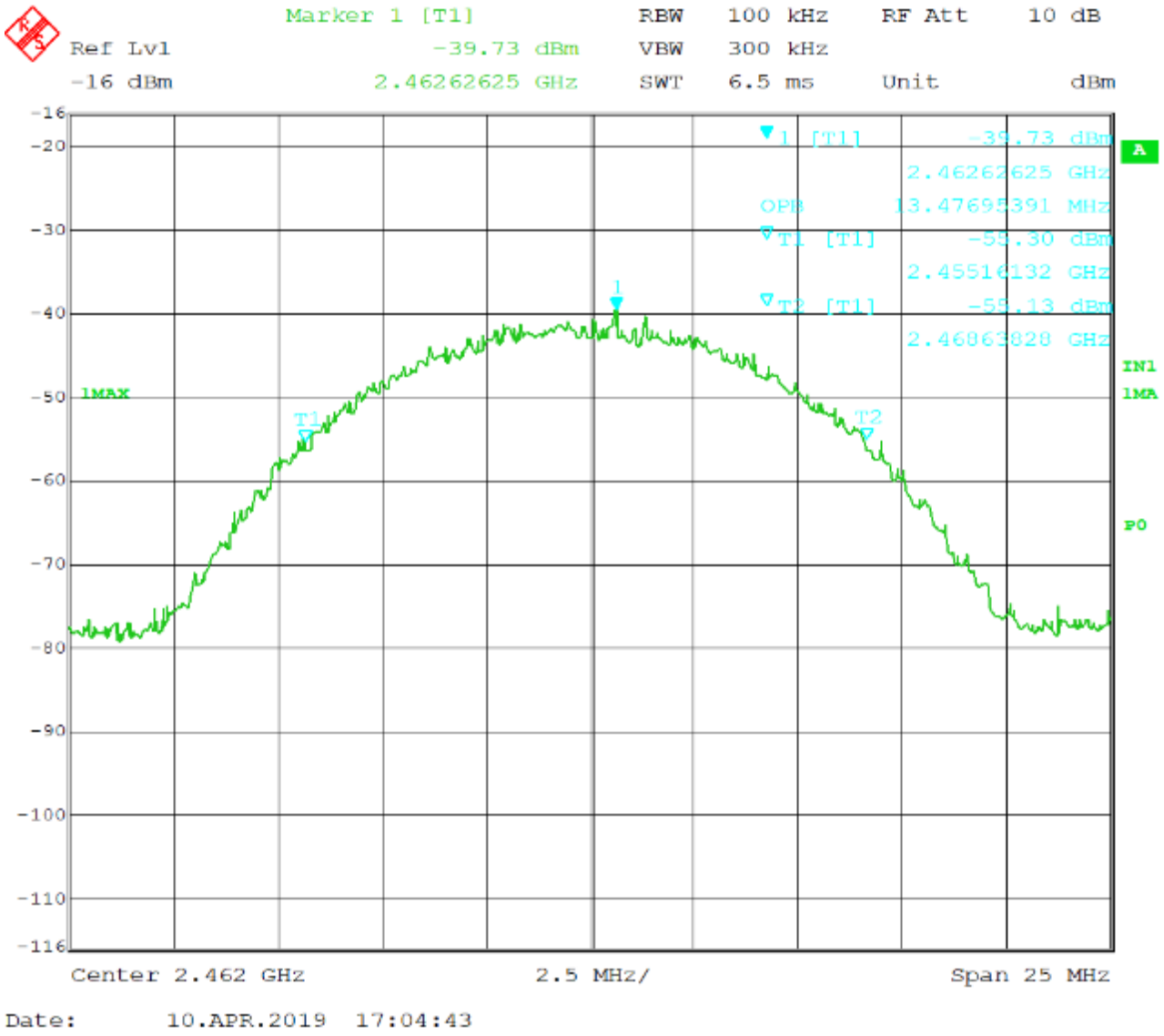

Figure 15 - 99% Occupied Bandwidth, High Channel, 802.11b

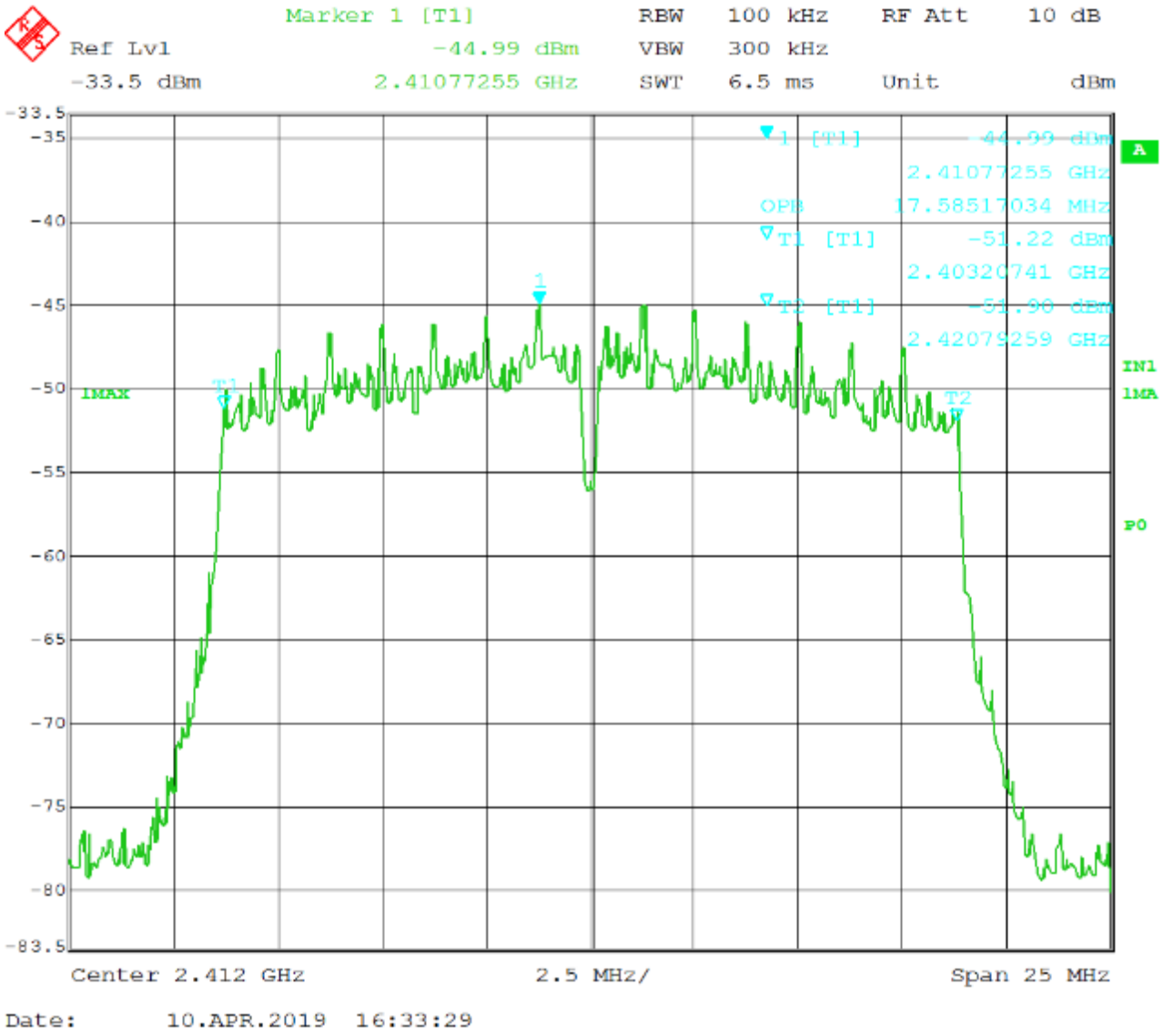

Figure 16 - 99% Occupied Bandwidth, Low Channel, 802.11g

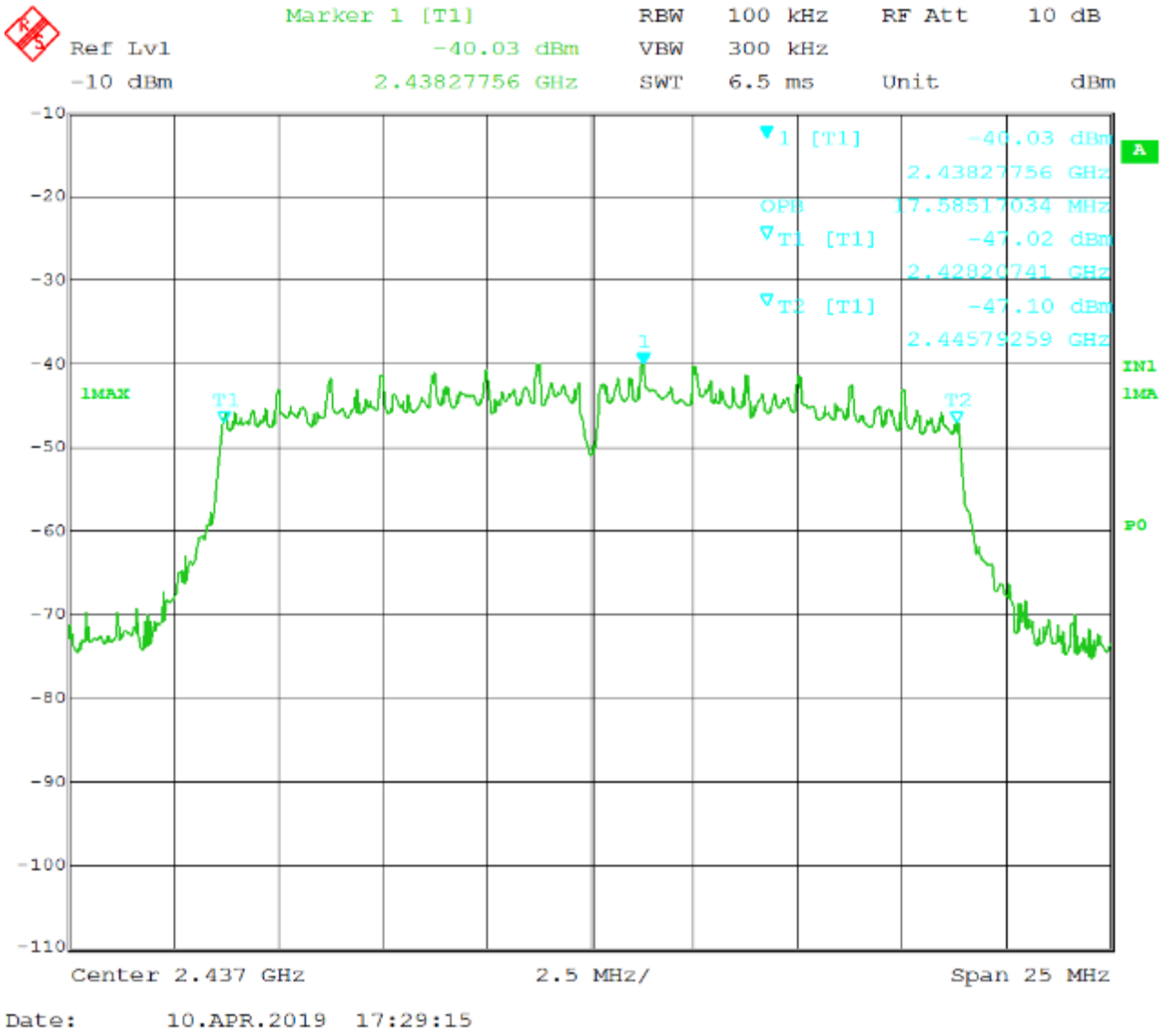

Figure 17 - 99% Occupied Bandwidth, Mid Channel, 802.11g

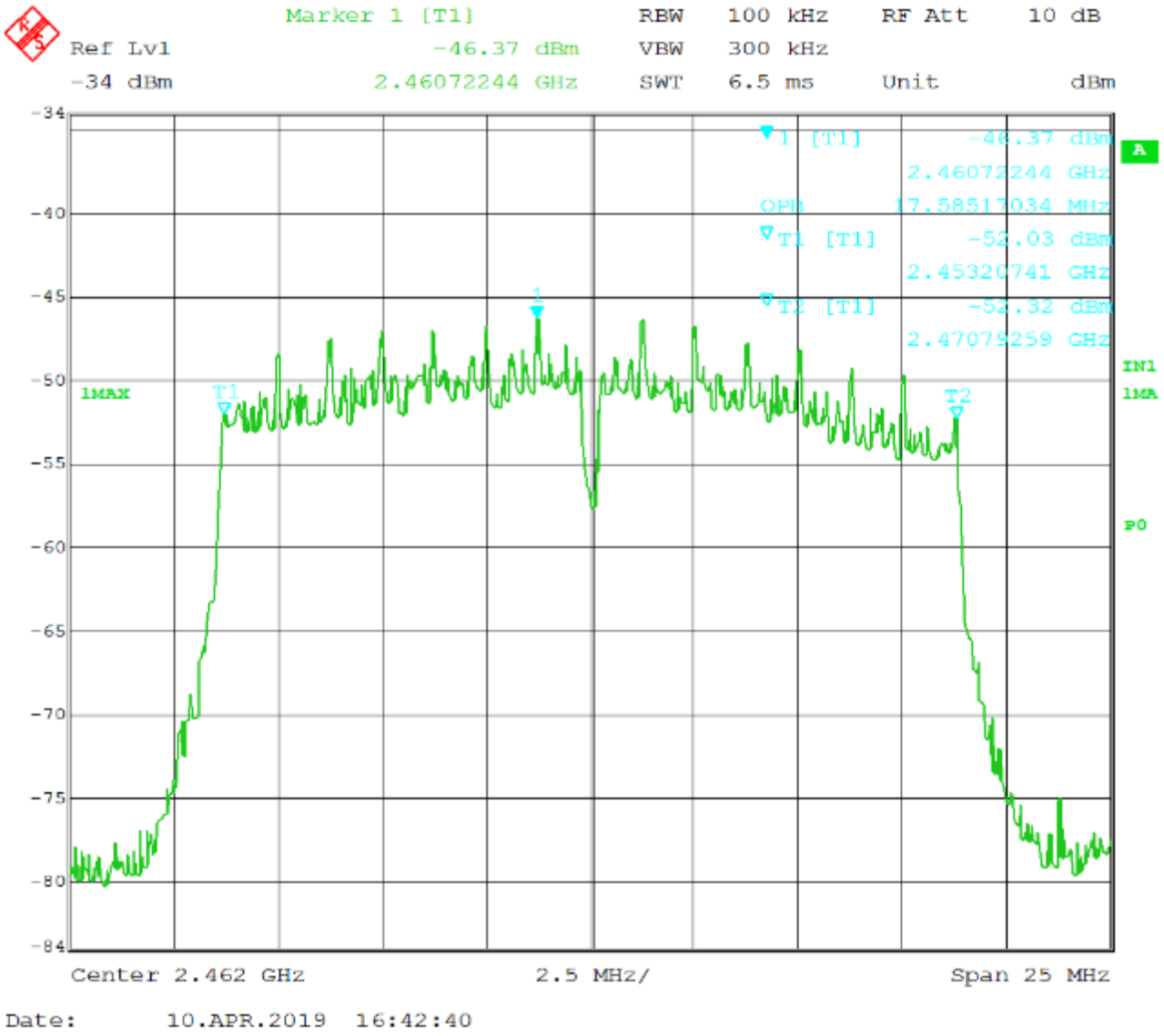

Figure 18 - 99% Occupied Bandwidth, High Channel, 802.11g

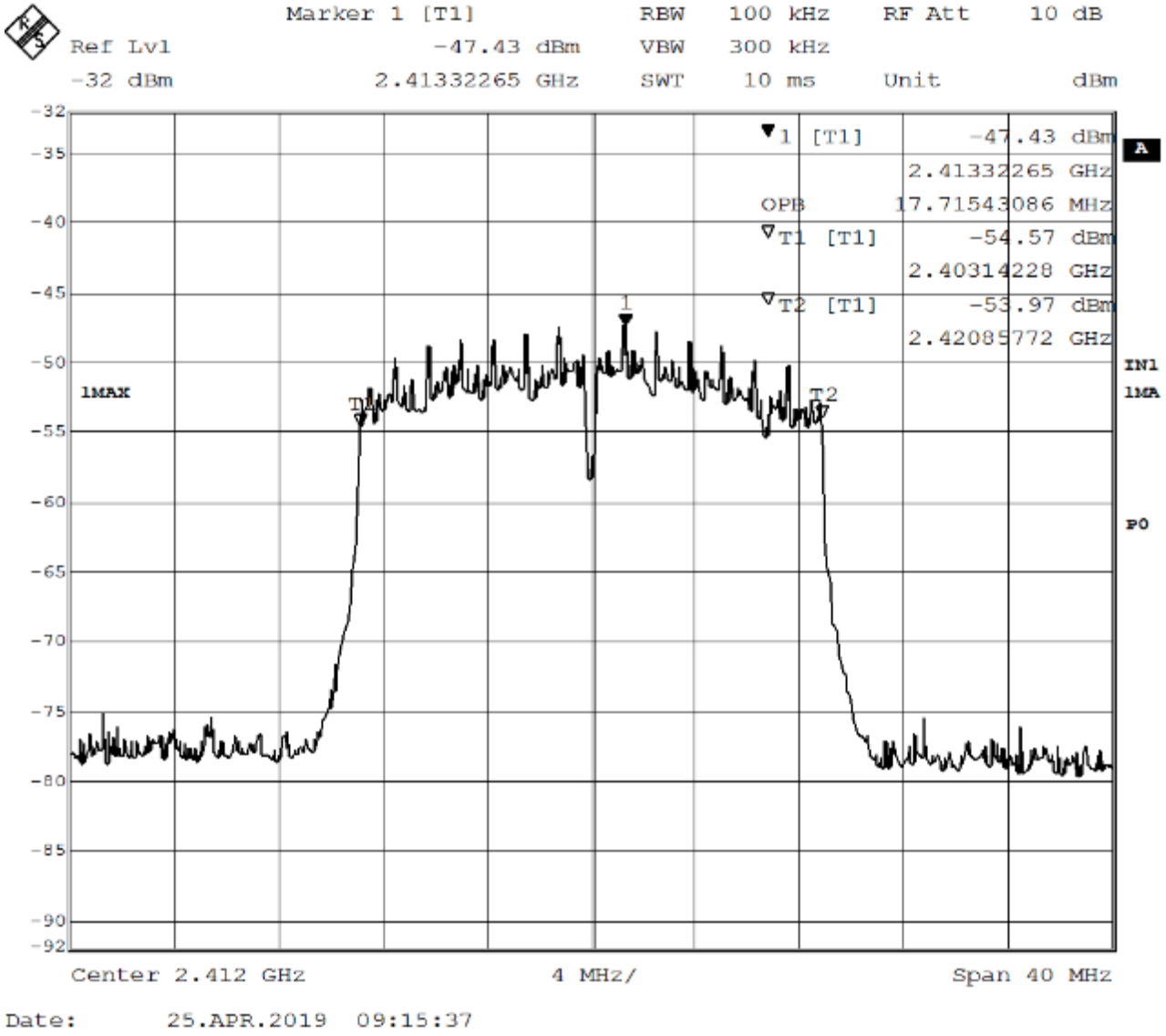

Figure 19 - 99% Occupied Bandwidth, Low Channel, 802.11n

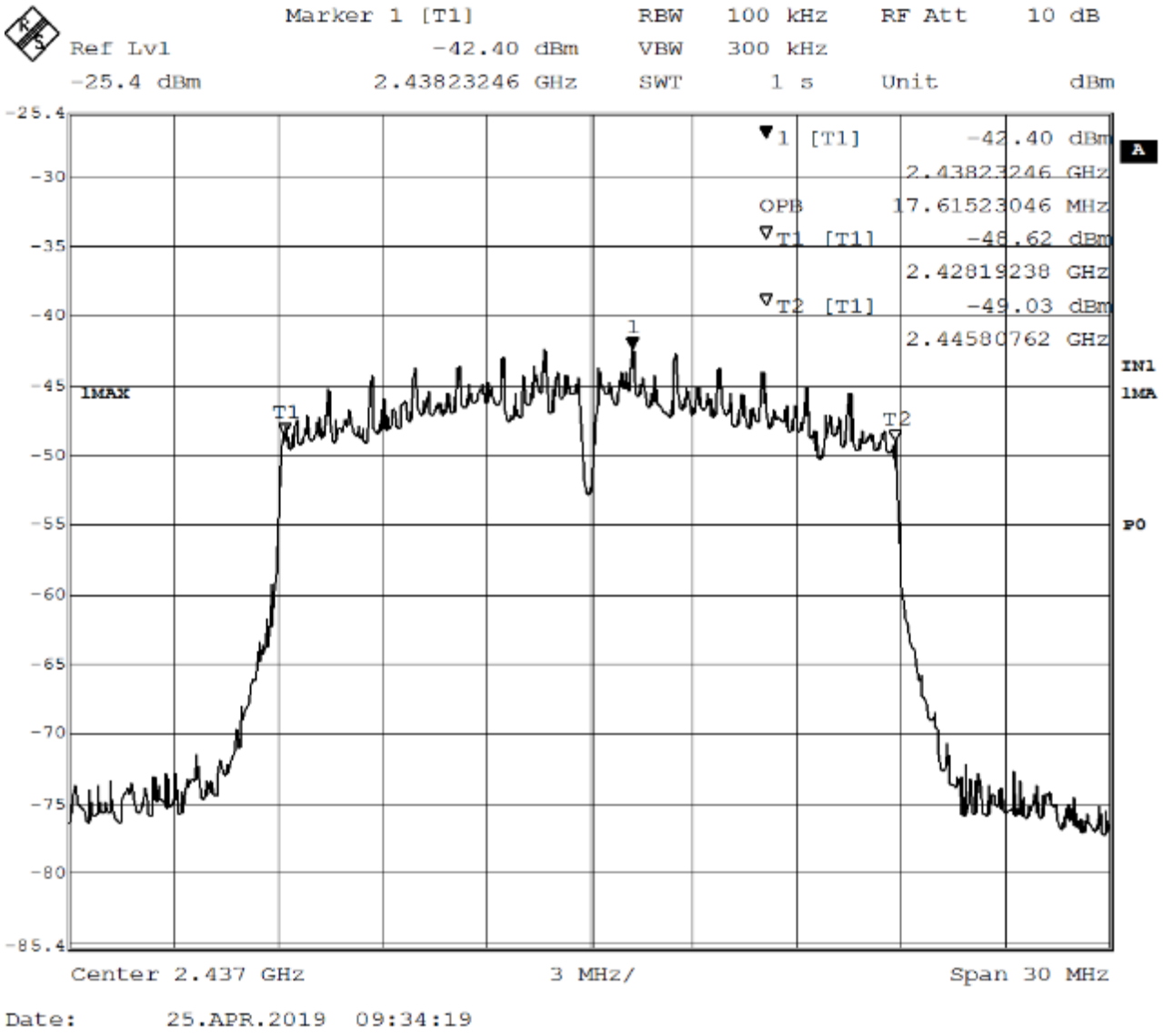

Figure 20 - 99% Occupied Bandwidth, Mid Channel, 802.11n

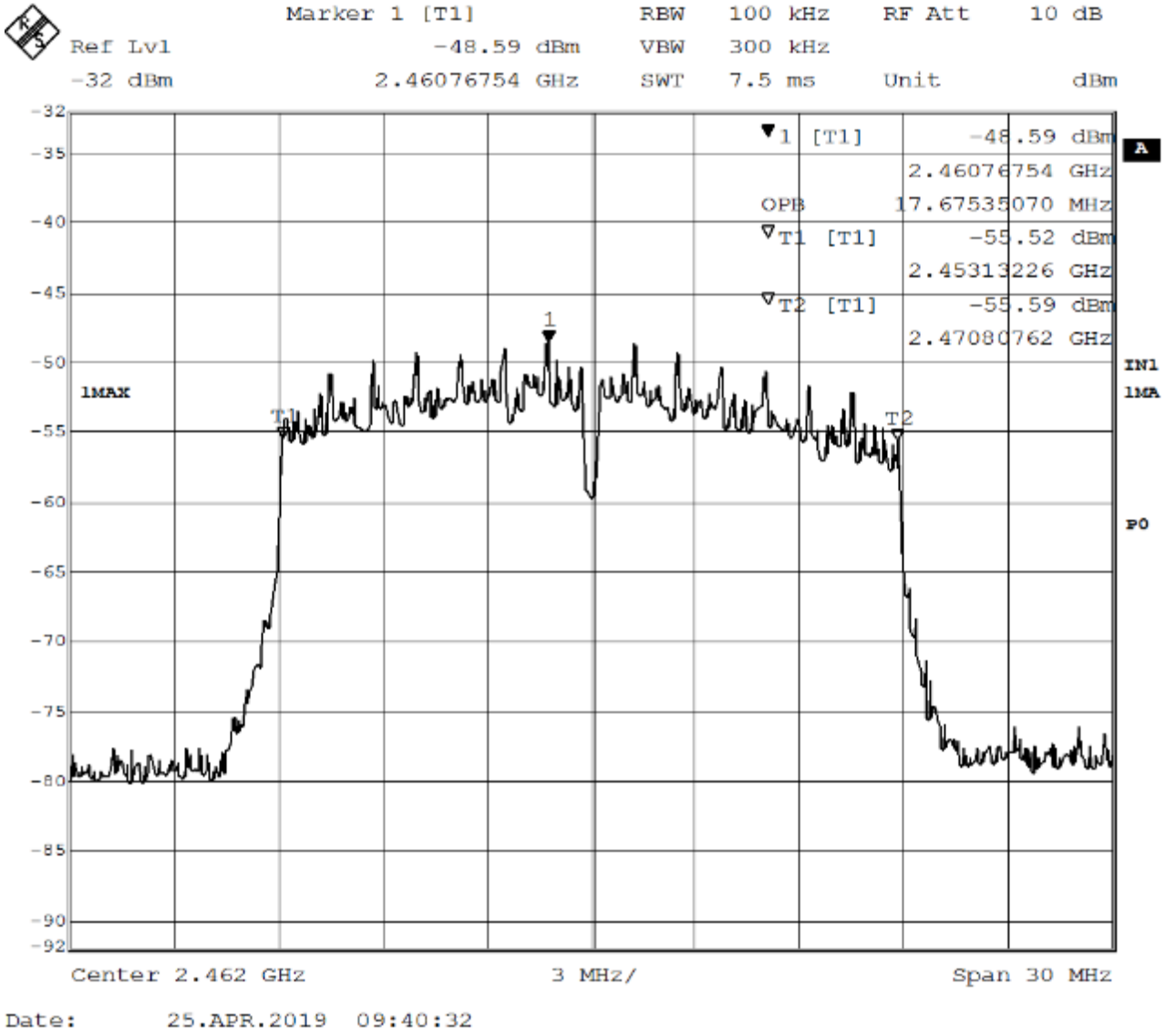

Figure 21 - 99% Occupied Bandwidth, High Channel, 802.11n

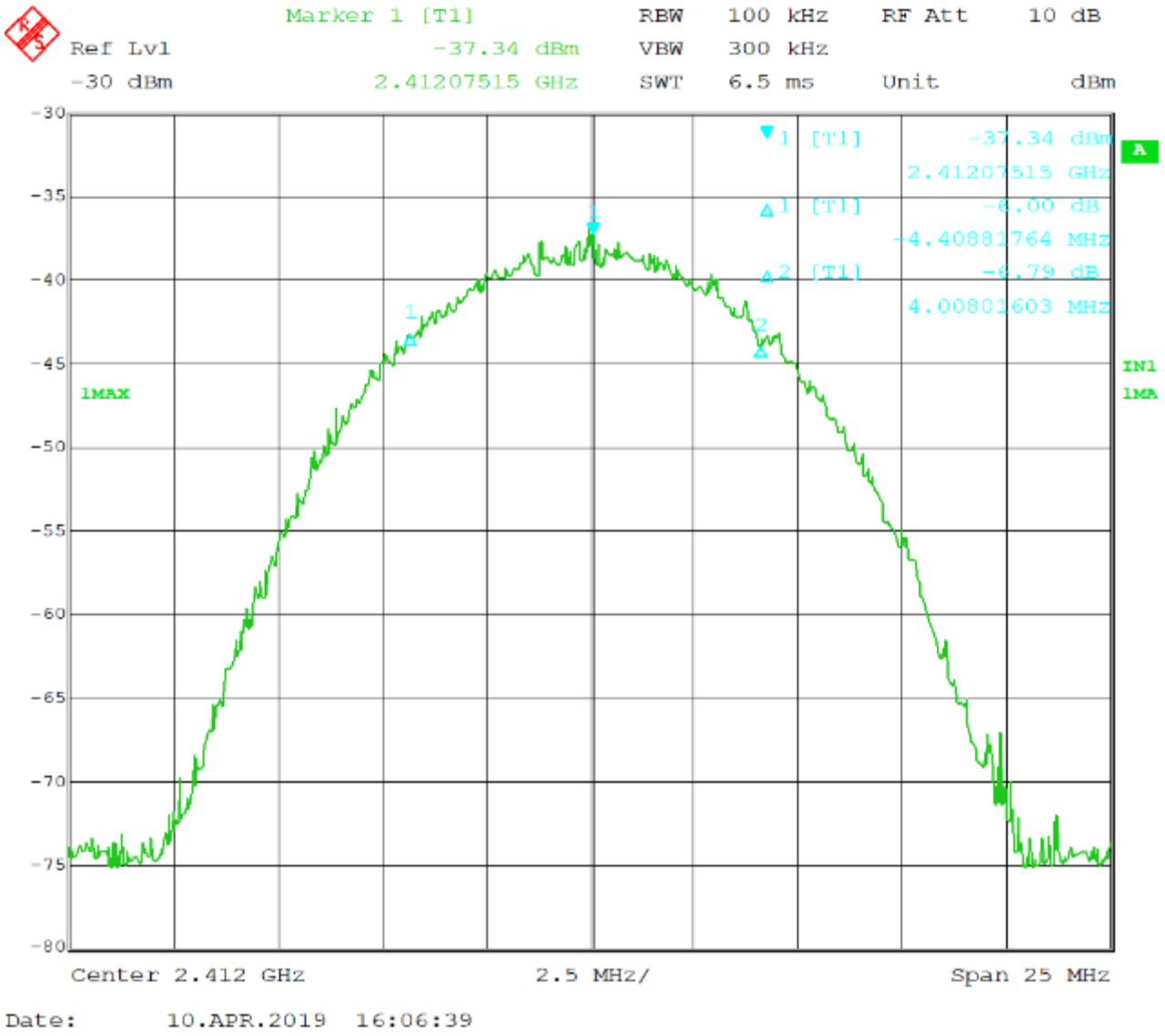

Figure 22 - 6dB Bandwidth, Low Channel, 802.11b

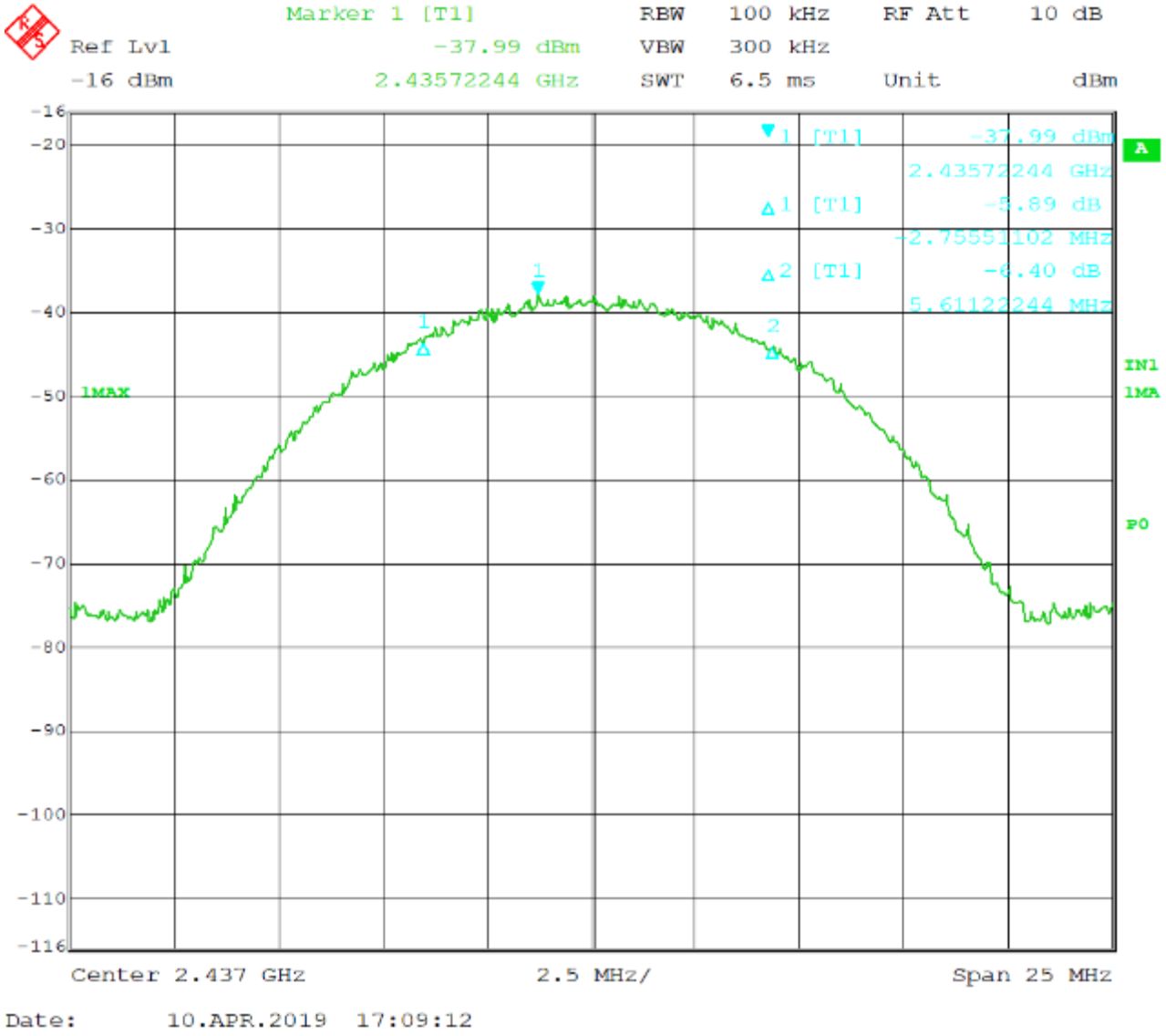

Figure 23 - 6dB Bandwidth, Mid Channel, 802.11b

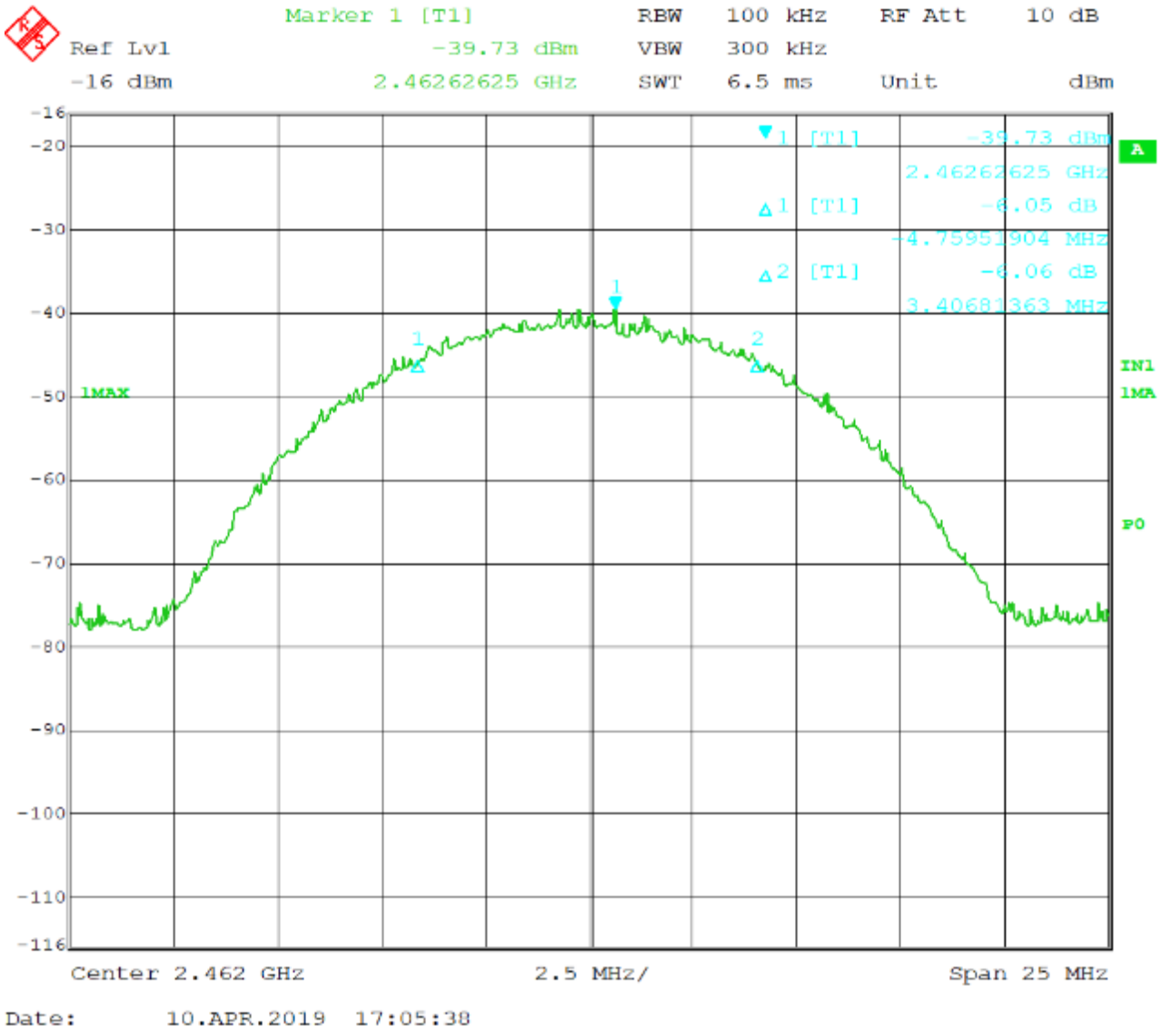

Figure 24 - 6dB Bandwidth, High Channel, 802.11b

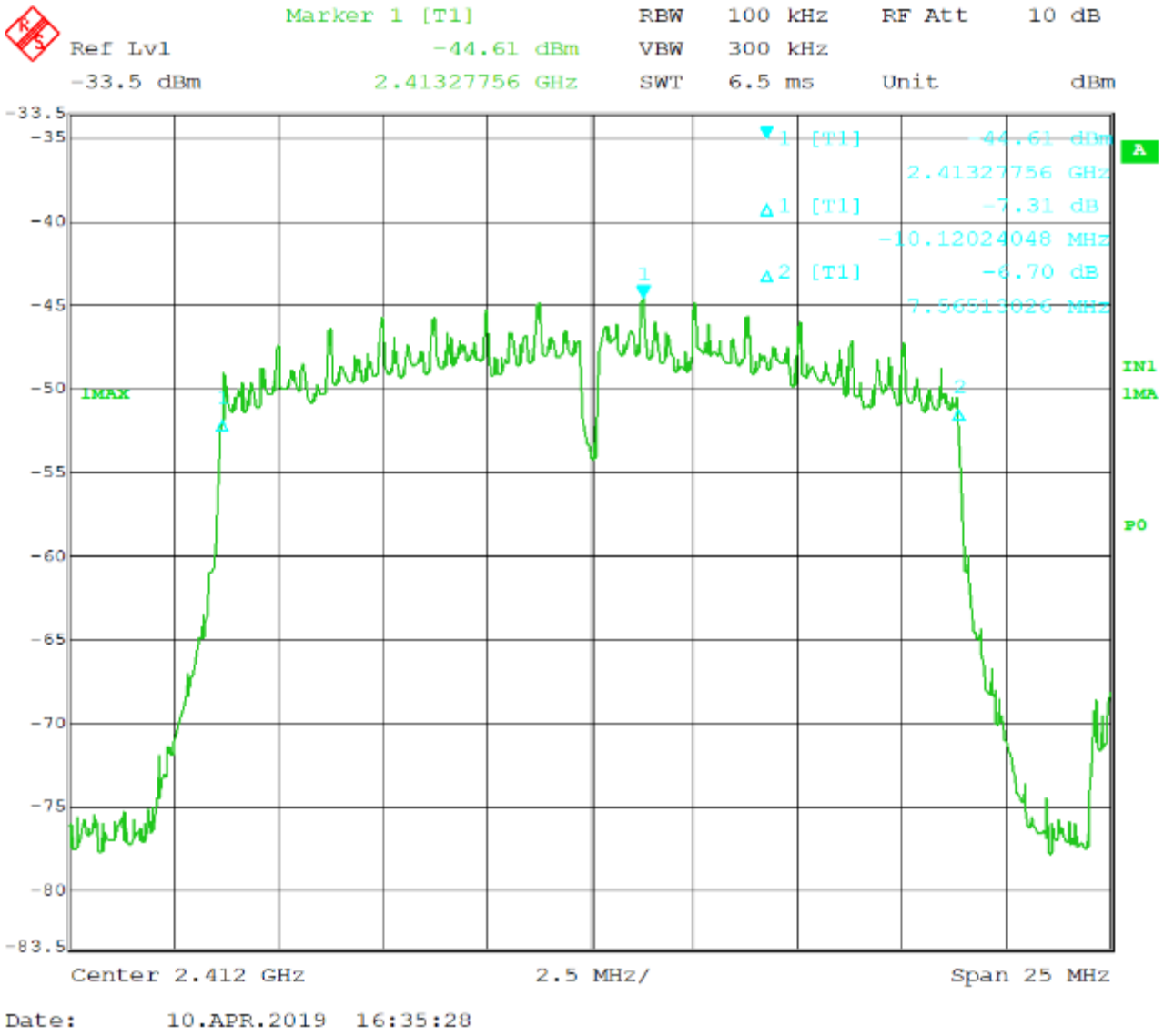

Figure 25 - 6dB Bandwidth, Low Channel, 802.11g

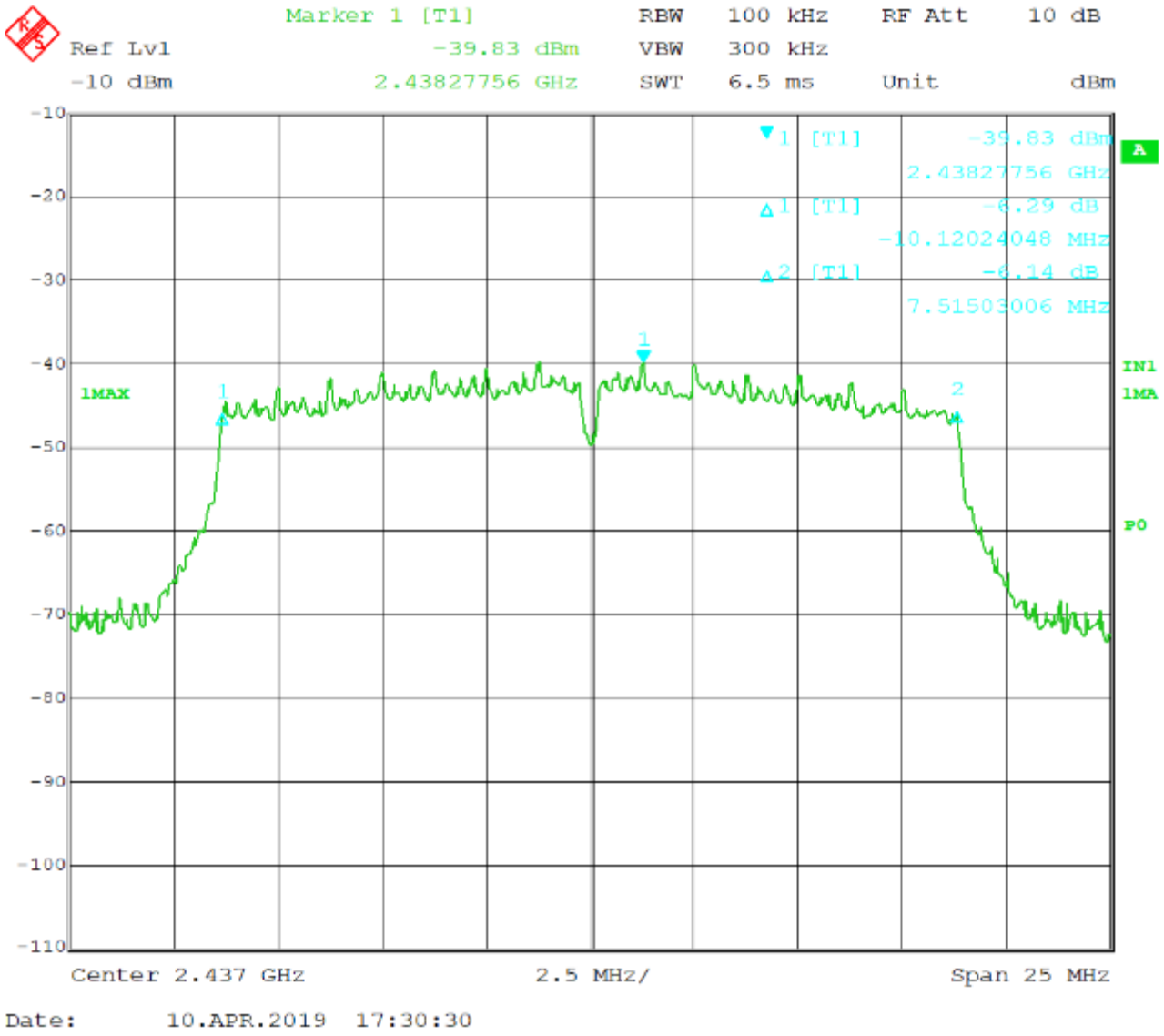

Figure 26 - 6dB Bandwidth, Mid Channel, 802.11g

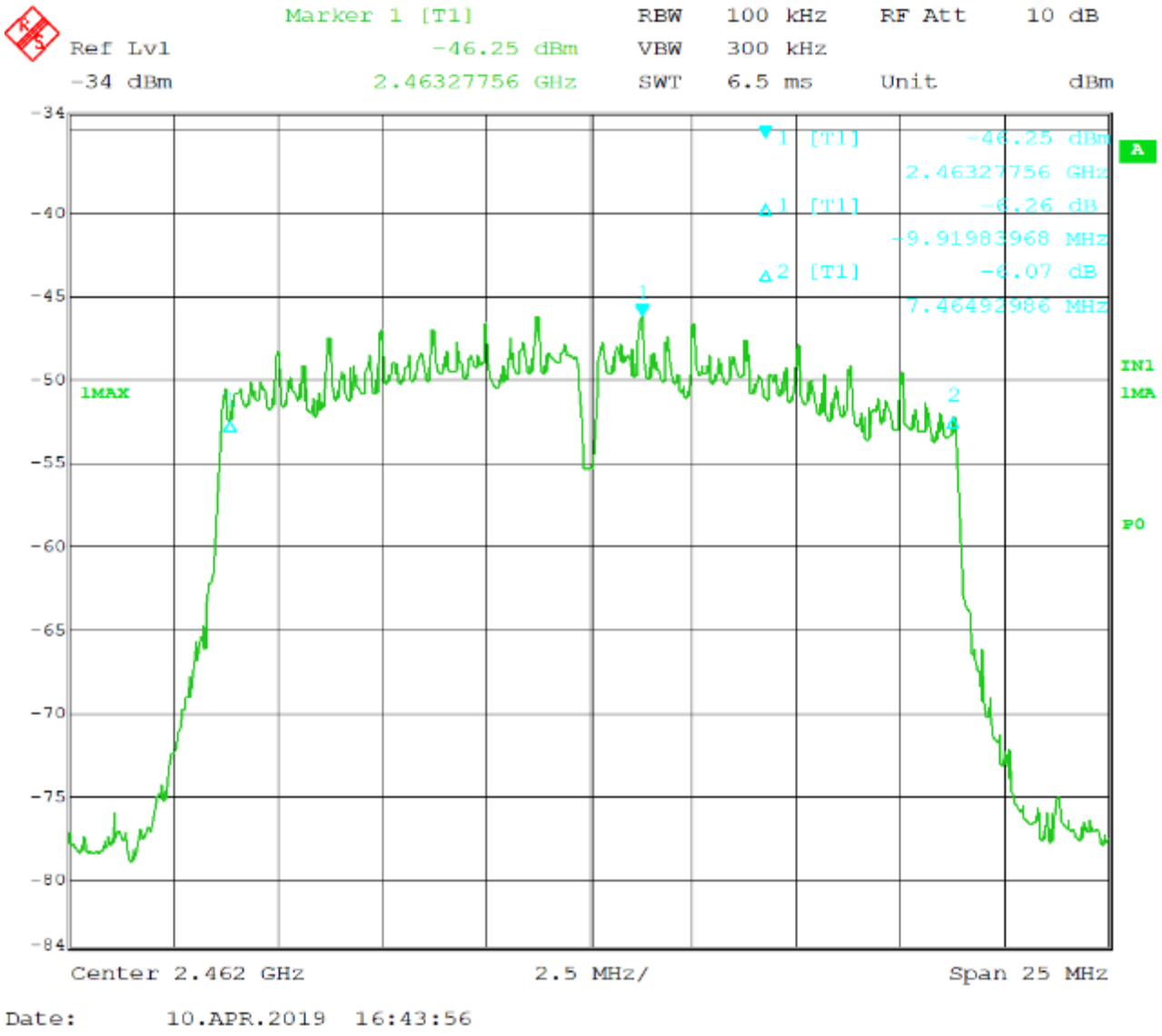

Figure 27 - 6dB Bandwidth, High Channel, 802.11g

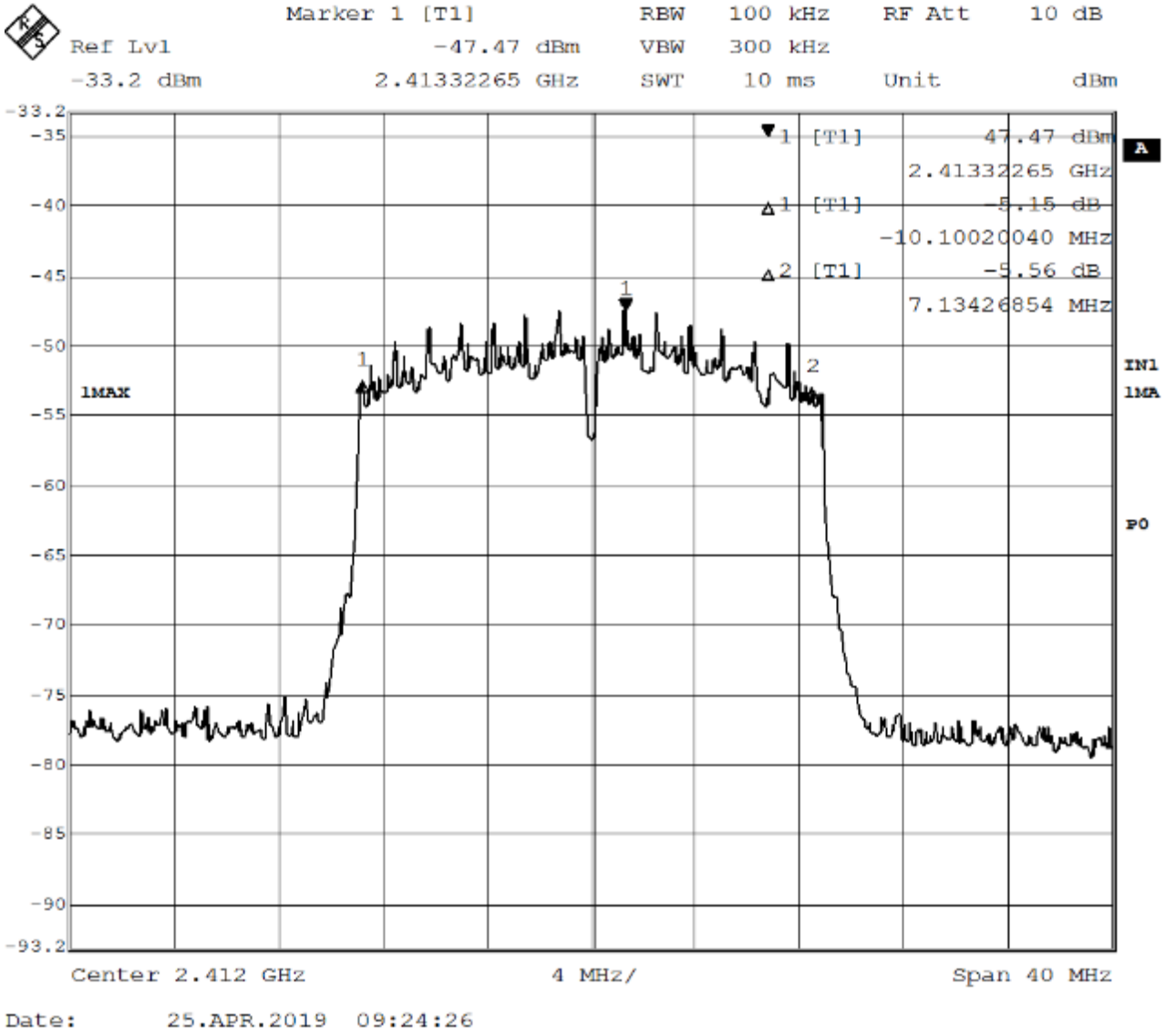

Figure 28 - 6dB Bandwidth, Low Channel, 802.11n

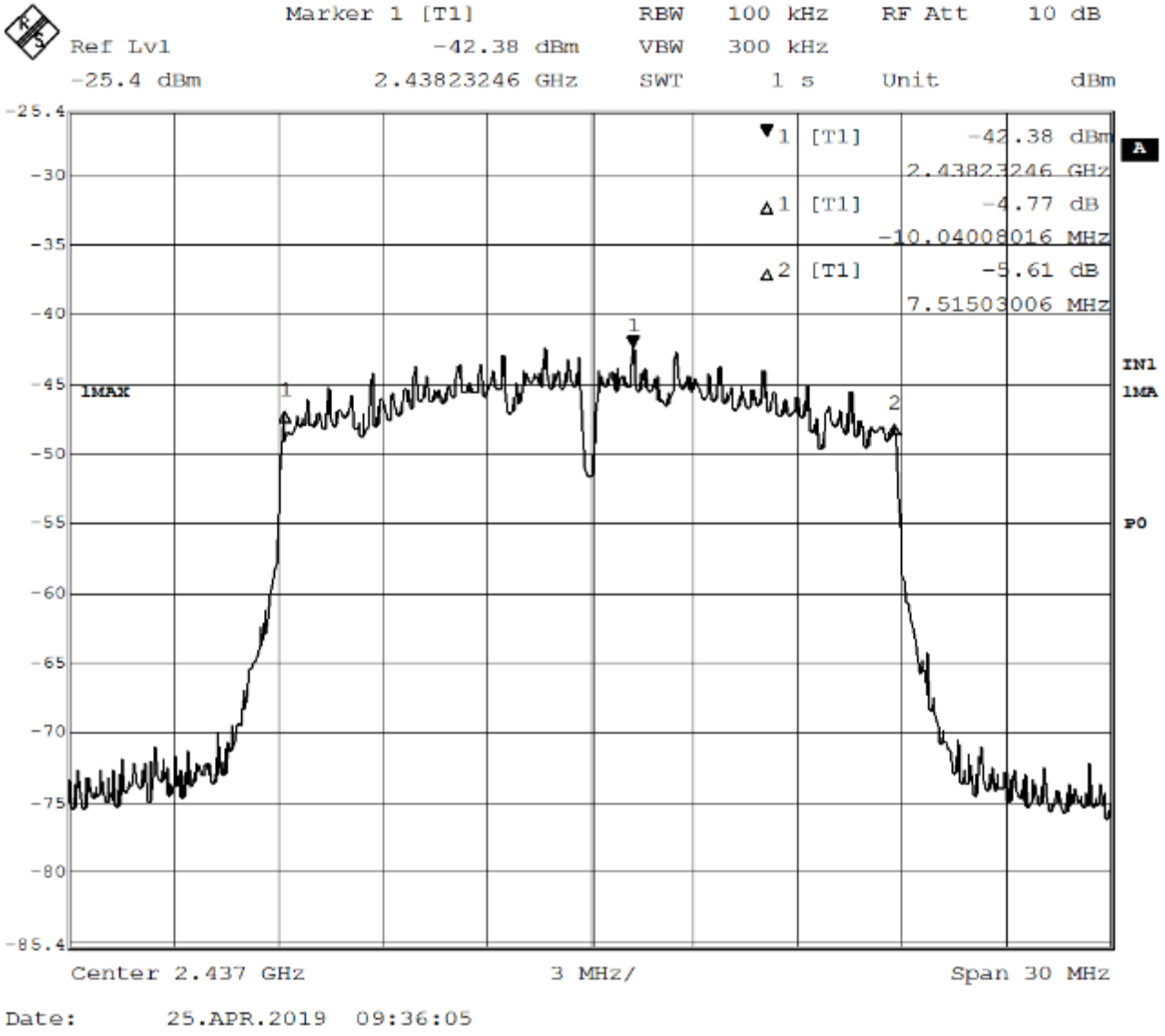

Figure 29 - 6dB Bandwidth, Mid Channel, 802.11n

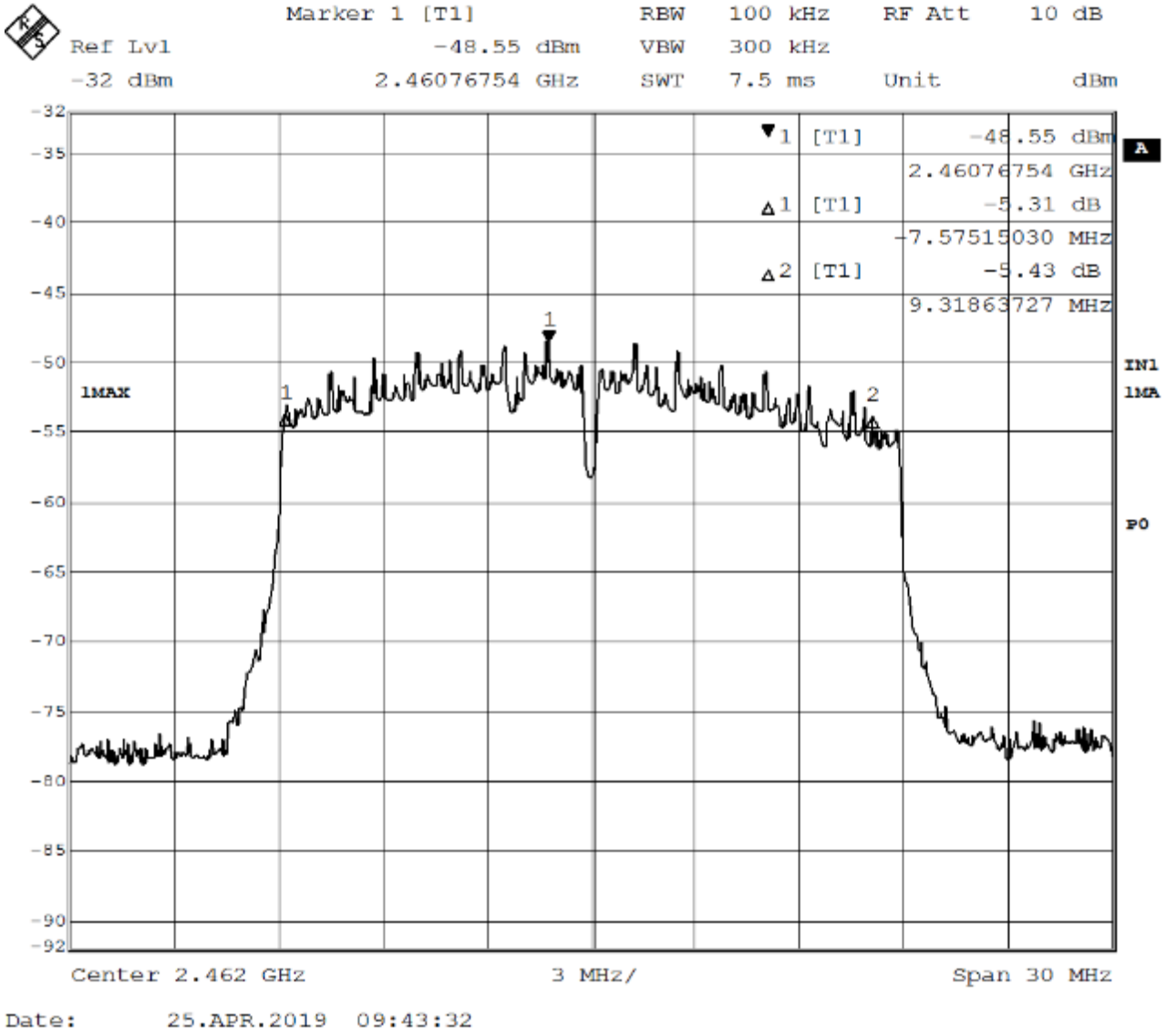

Figure 30 - 6dB Bandwidth, High Channel, 802.11n

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 24 VDC 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:

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)	-75.16	-39.50	35.66	20	PASS
1	2390.0 (Unrestricted, Average)	-88.44	-47.23	41.21	20	PASS
11	2483.5 (Unrestricted, Peak)	-75.52	-39.93	35.59	20	PASS
11	2483.5 (Unrestricted, Average)	-106.91	-48.37	58.54	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)	-48.35	-48.35	27.12	-21.23	0	PASS
1	2340.0 (Restricted, Average)	-56.45	-56.45	15.22	-41.23	0	PASS
11	2483.5 (Restricted, Peak)	-48.16	-48.16	26.93	-21.23	0	PASS
11	2483.5 (Restricted, Average)	-58.01	-58.01	16.78	-41.23	0	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

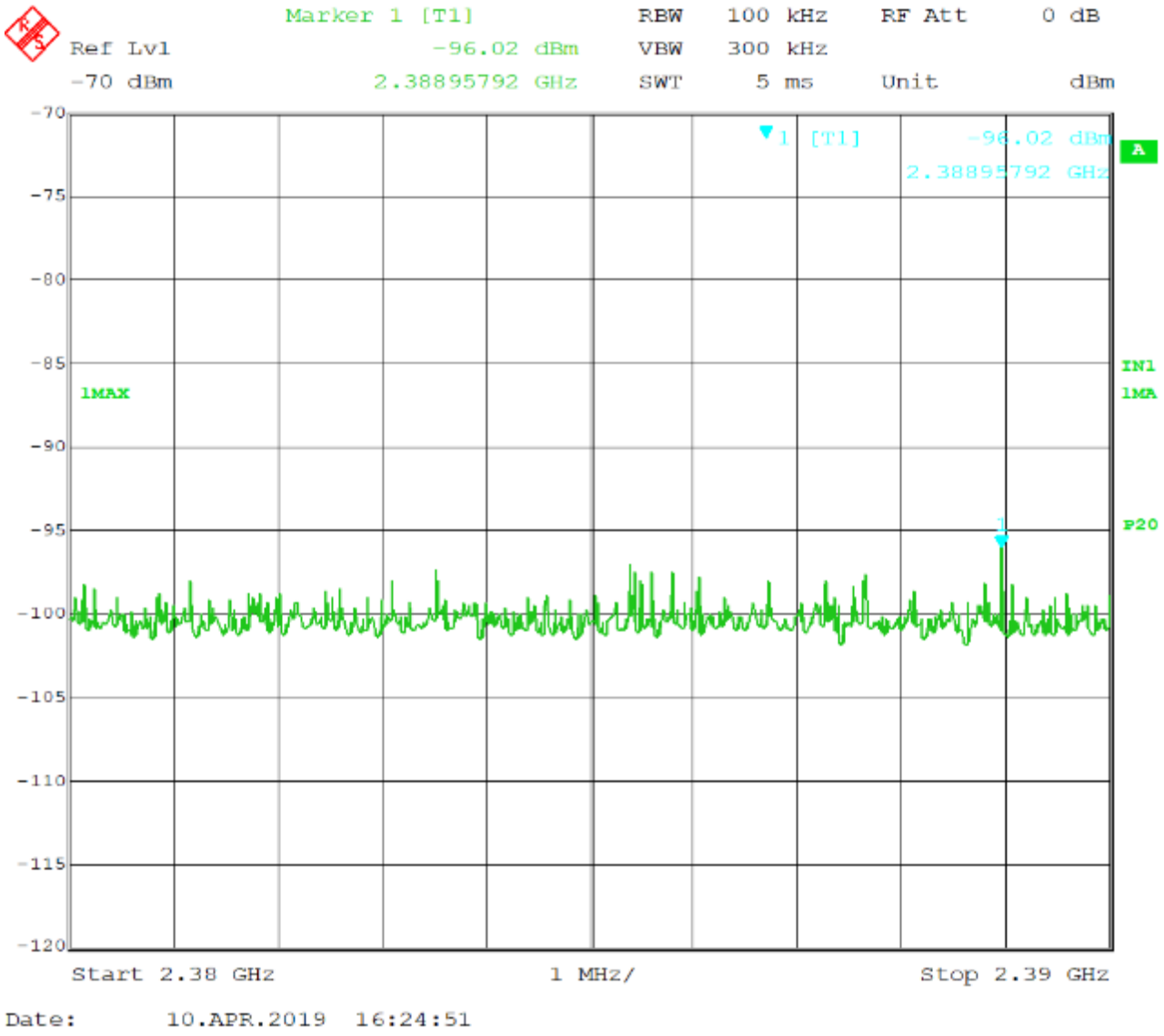

Figure 31 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

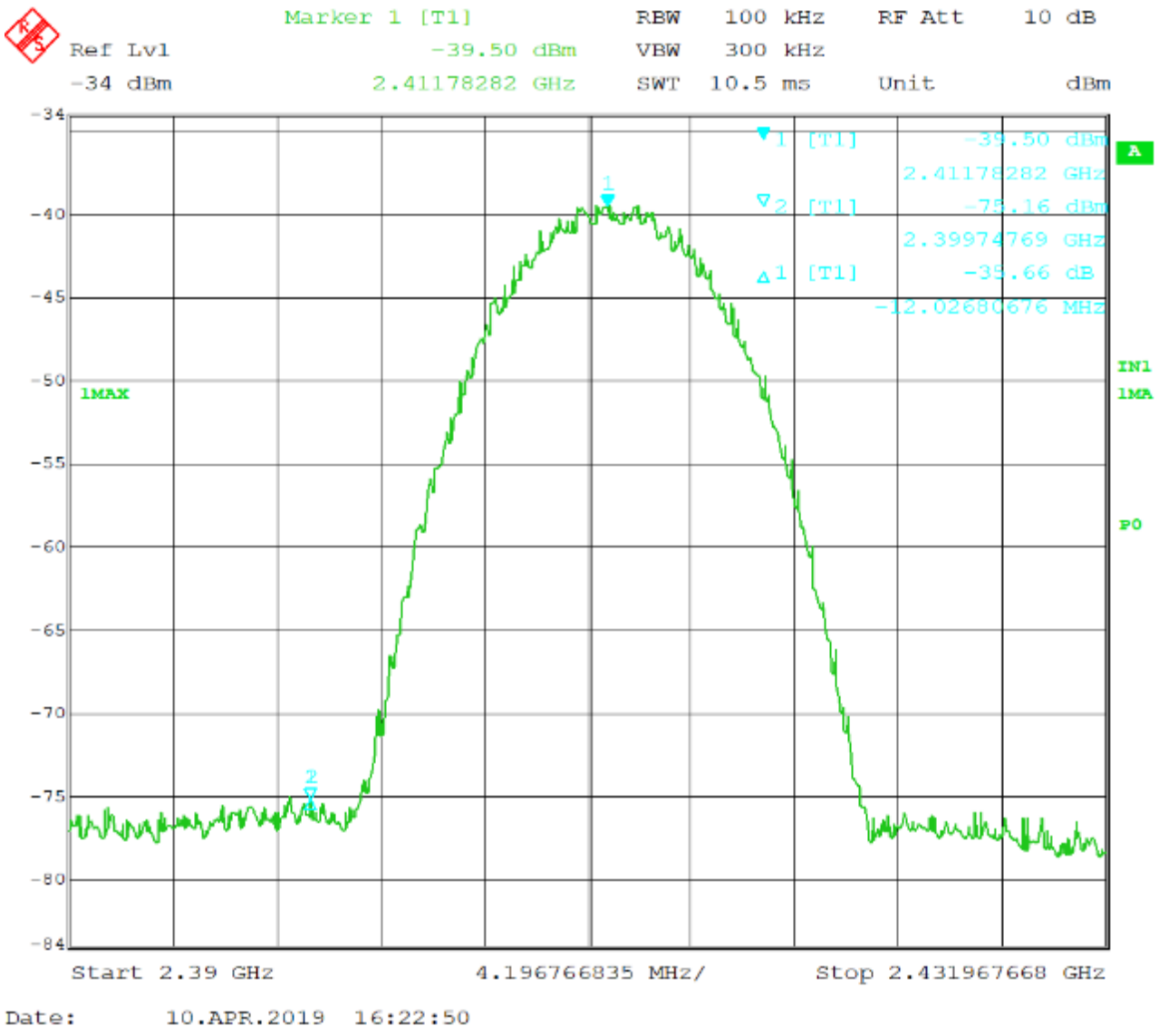

Figure 32 - Band-edge Measurement, Low Channel, Fundamental, Peak

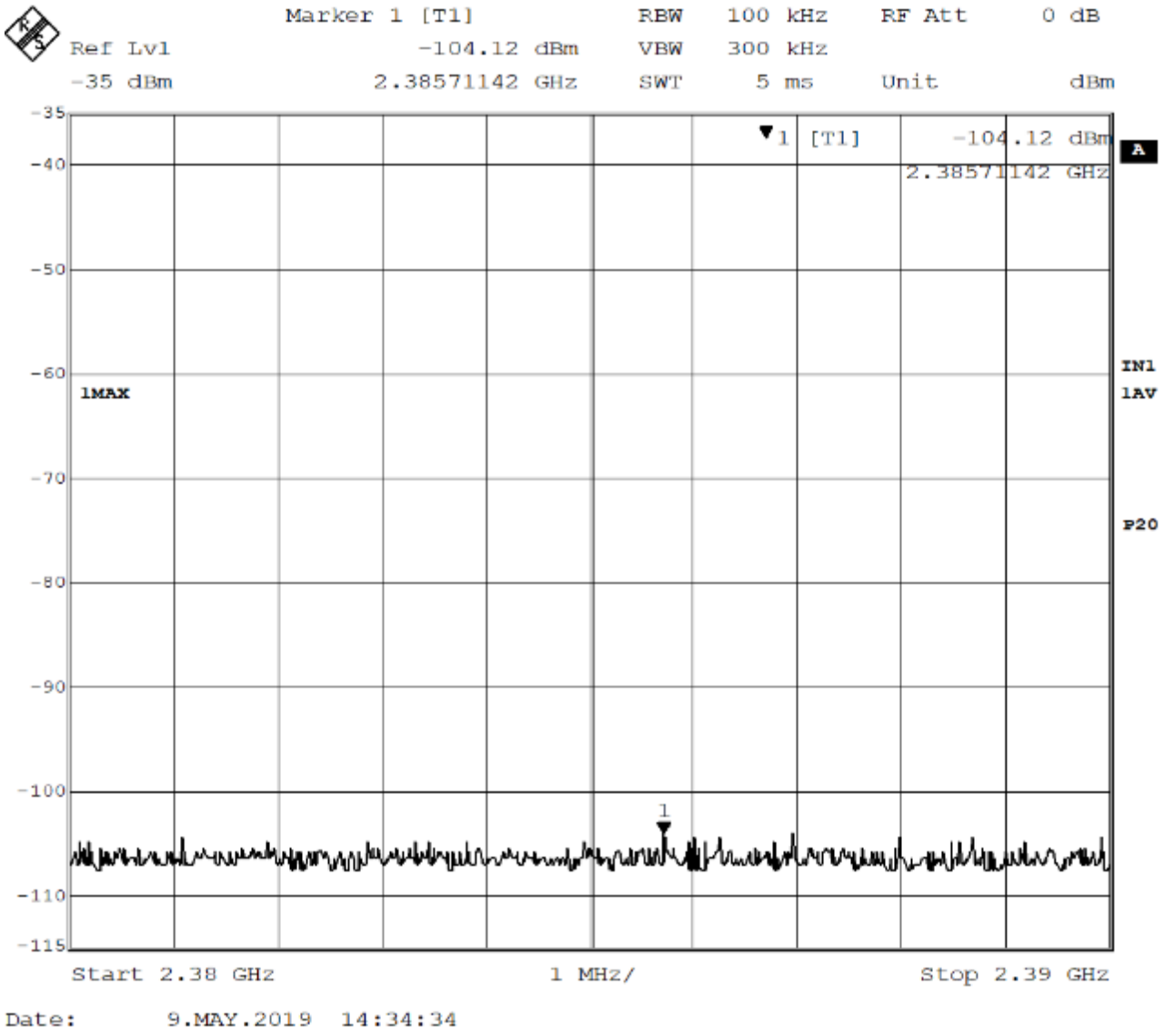

Figure 33 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

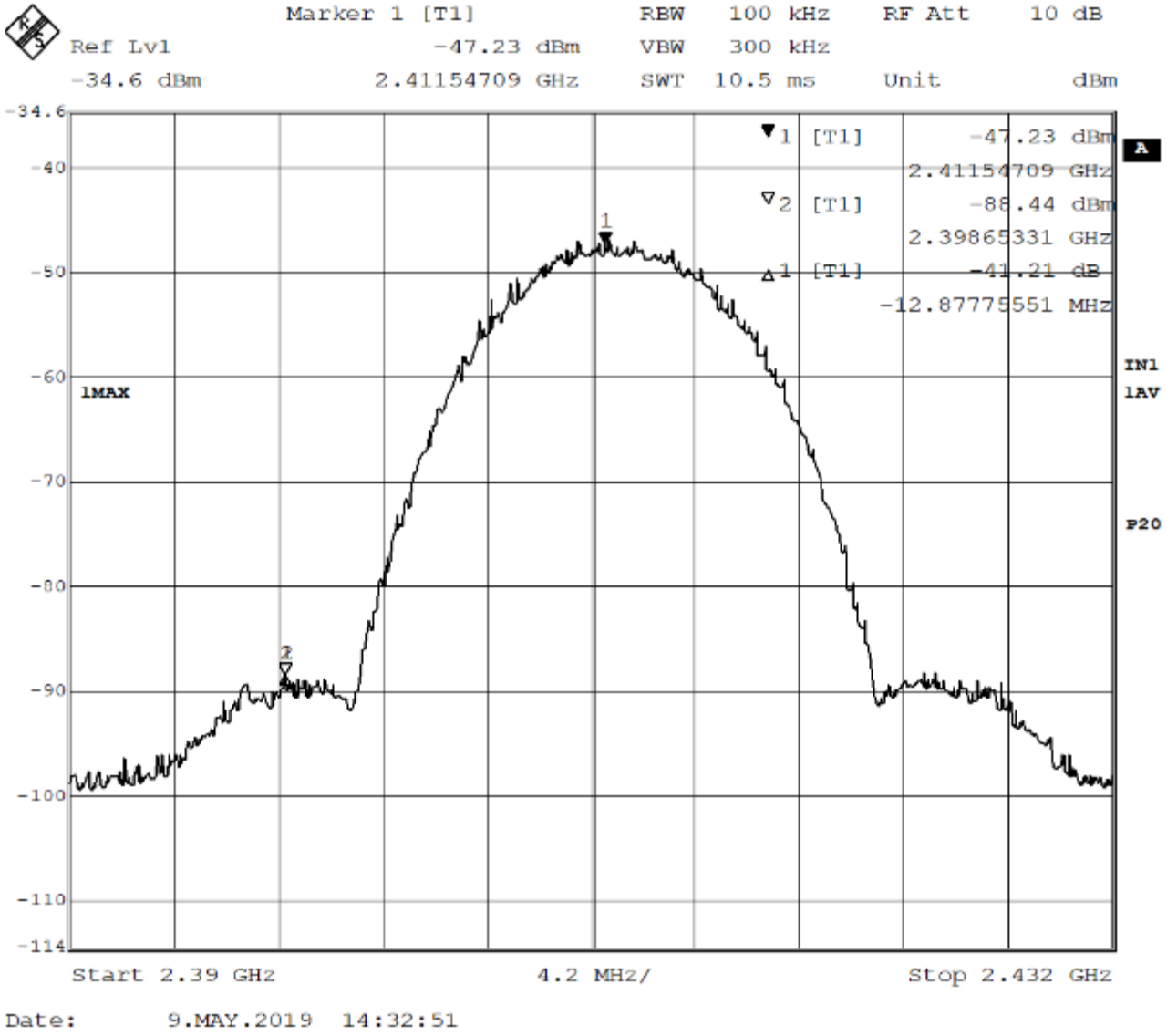

Figure 34 - Band-edge Measurement, Low Channel, Fundamental, Average

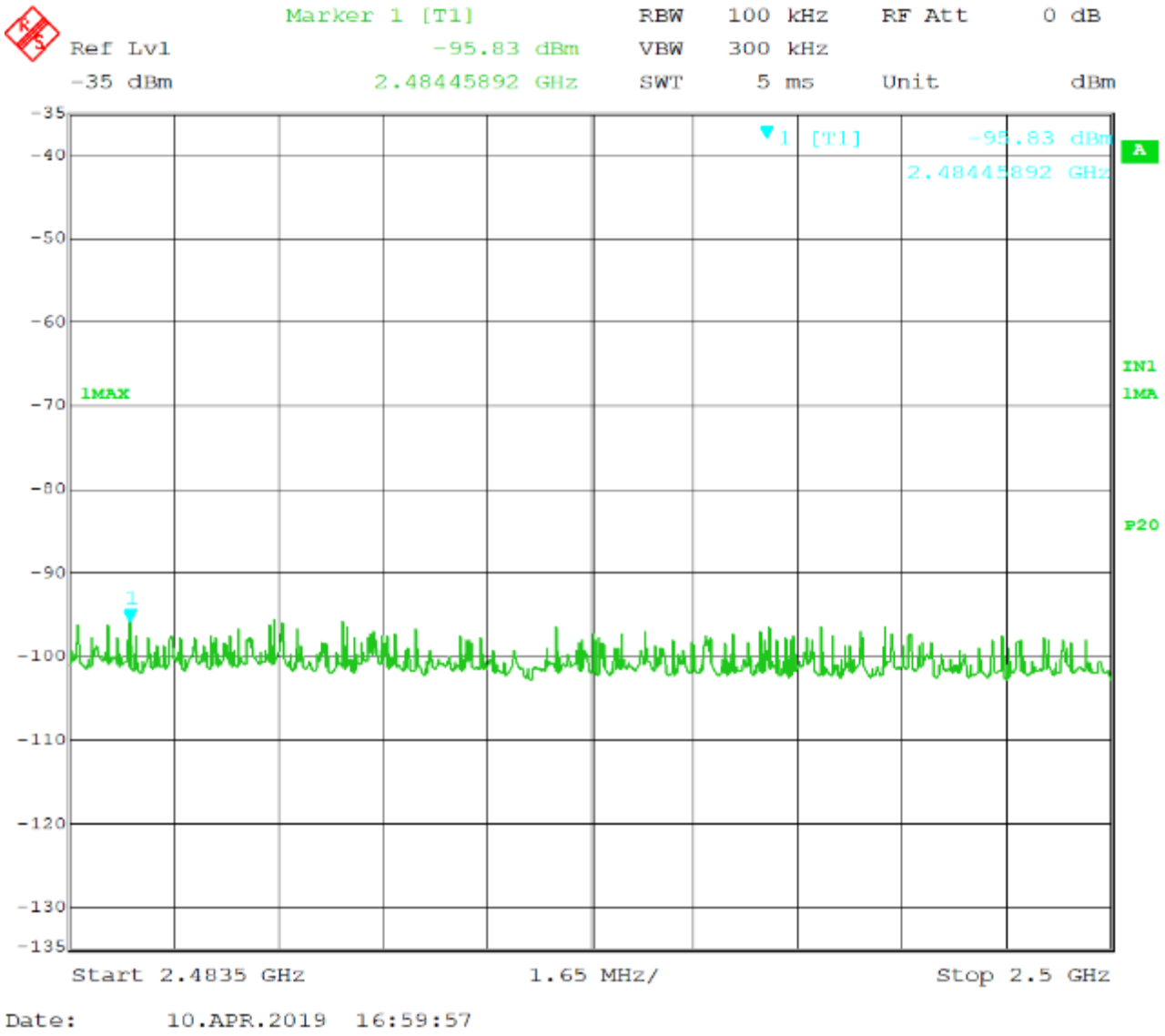

Figure 35 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

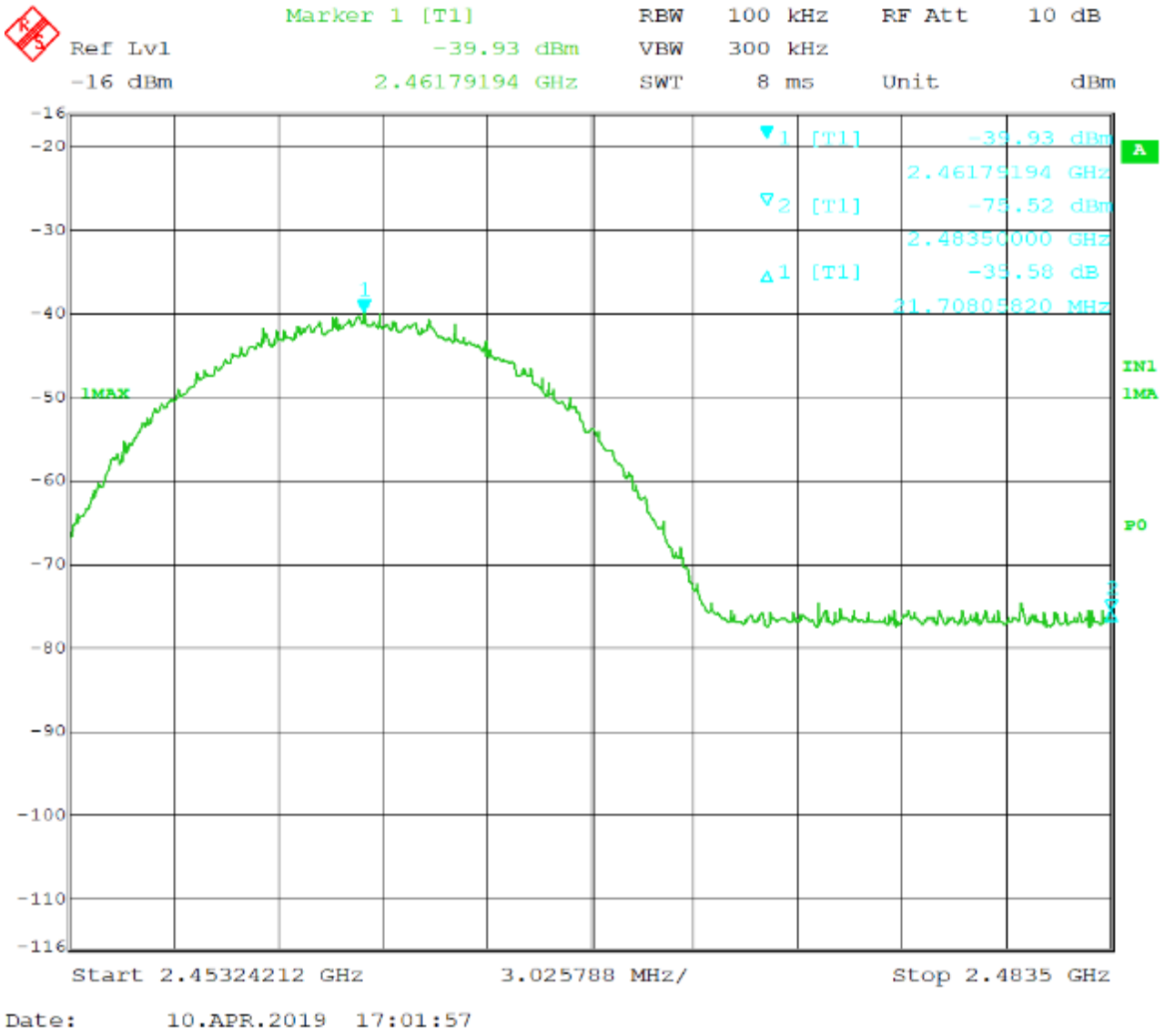

Figure 36 - Band-edge Measurement, High Channel, Fundamental, Peak

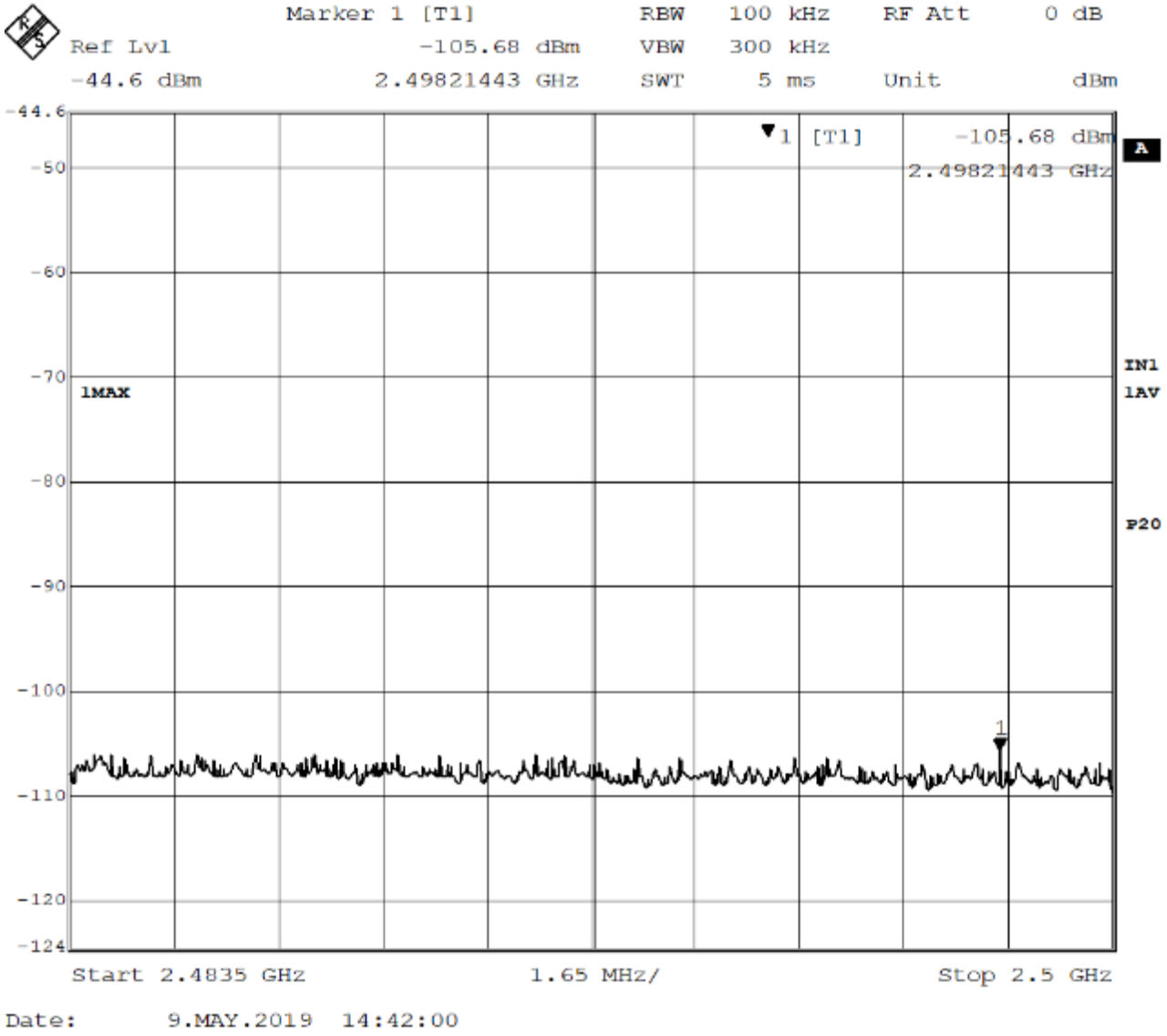

Figure 37 - Band-edge Measurement, High Channel, Restricted Frequency, Average

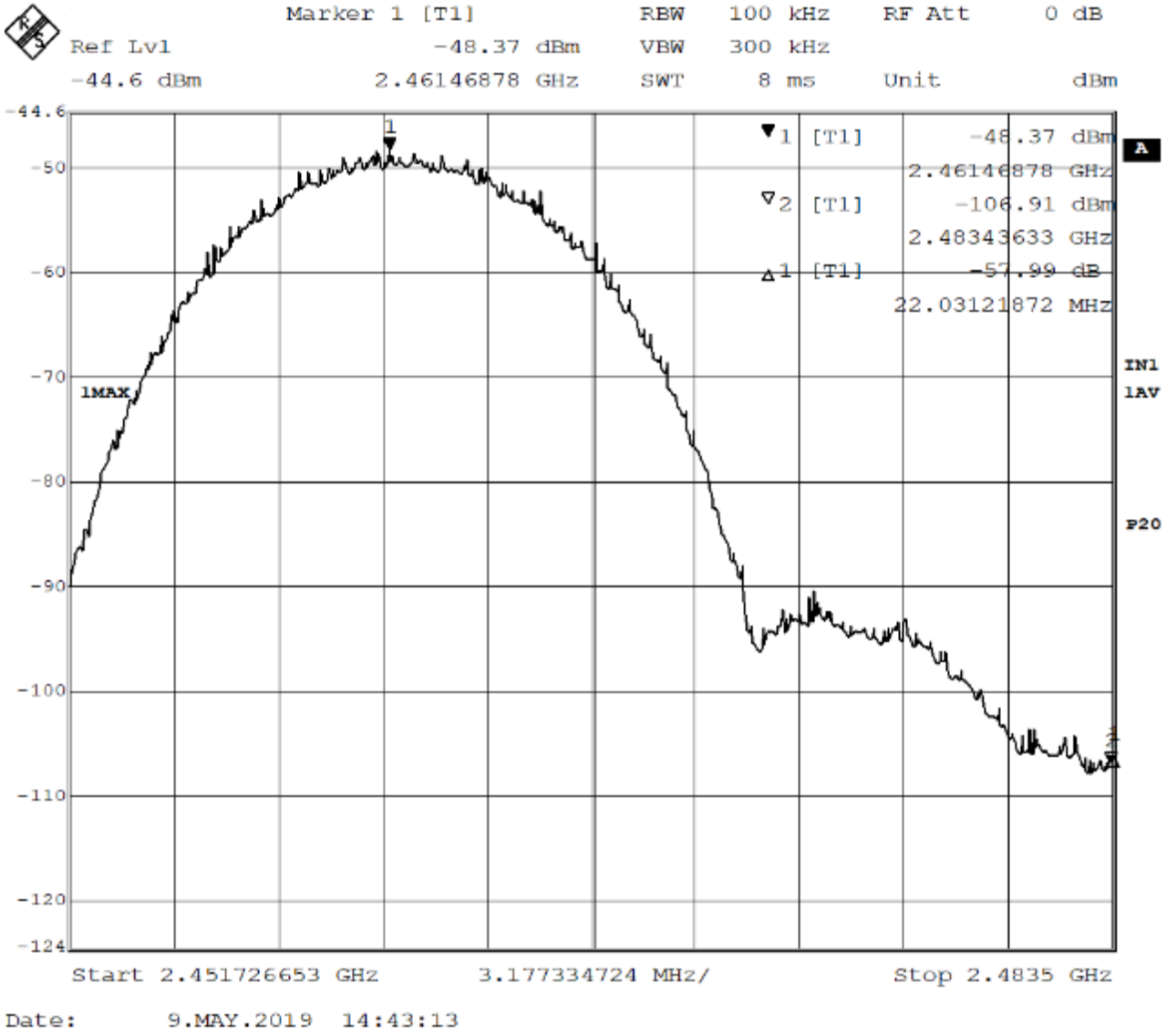

Figure 38 - Band-edge Measurement, High Channel, Fundamental, Average

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)	-75.39	-44.93	30.46	20	PASS
1	2390.0 (Unrestricted, Average)	-92.72	-52.49	40.23	20	PASS
11	2483.5 (Unrestricted, Peak)	-76.21	-46.35	29.86	20	PASS
11	2483.5 (Unrestricted, Average)	-101.94	-53.78	48.16	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)	-38.98	-38.98	17.75	-21.23	0	PASS
1	2340.0 (Restricted, Average)	-54.60	-54.60	13.37	-41.23	0	PASS
11	2483.5 (Restricted, Peak)	-38.54	-38.54	17.31	-21.23	0	PASS
11	2483.5 (Restricted, Average)	-53.41	-53.41	12.18	-41.23	0	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

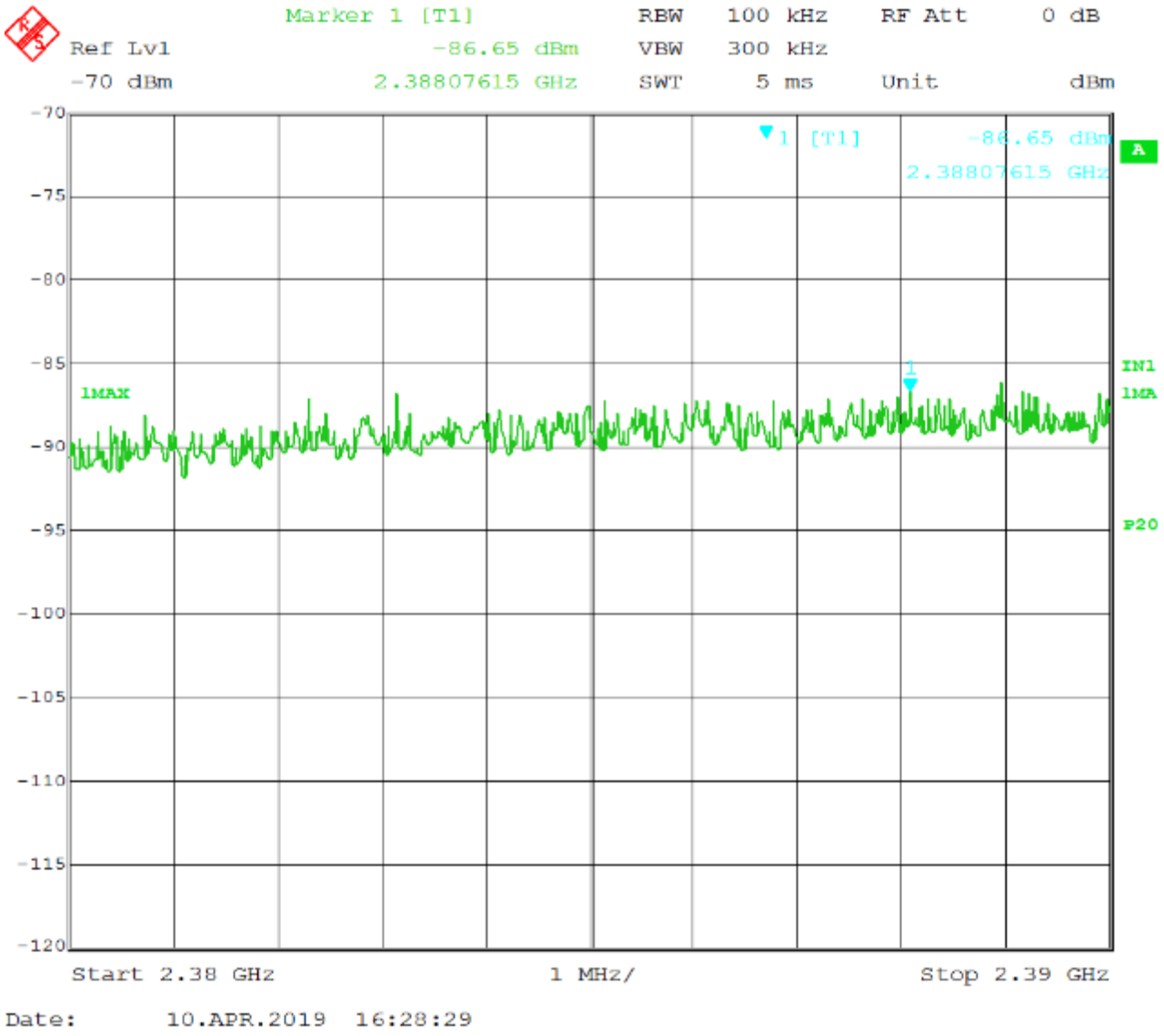

Figure 39 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

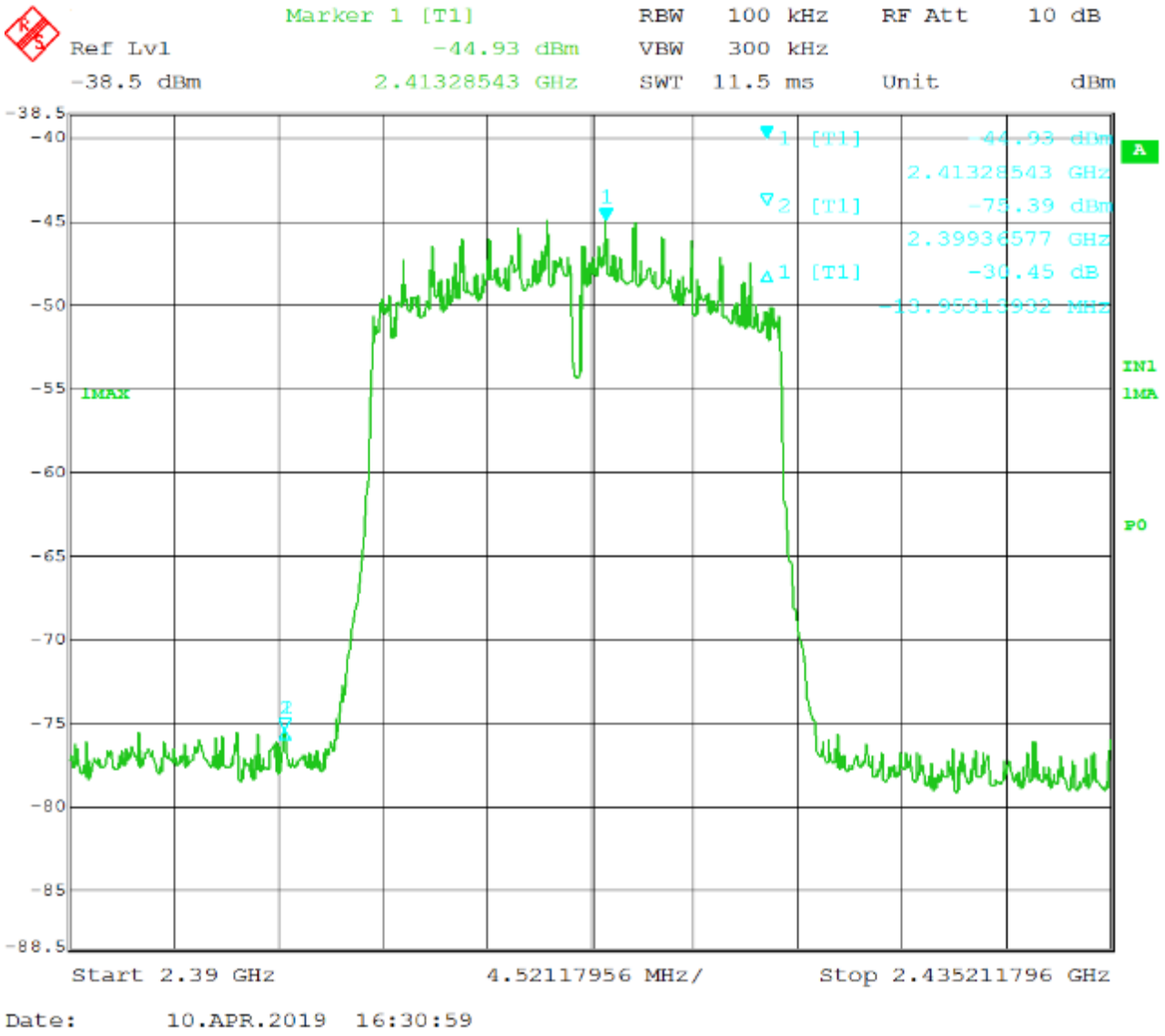

Figure 40 - Band-edge Measurement, Low Channel, Fundamental, Peak

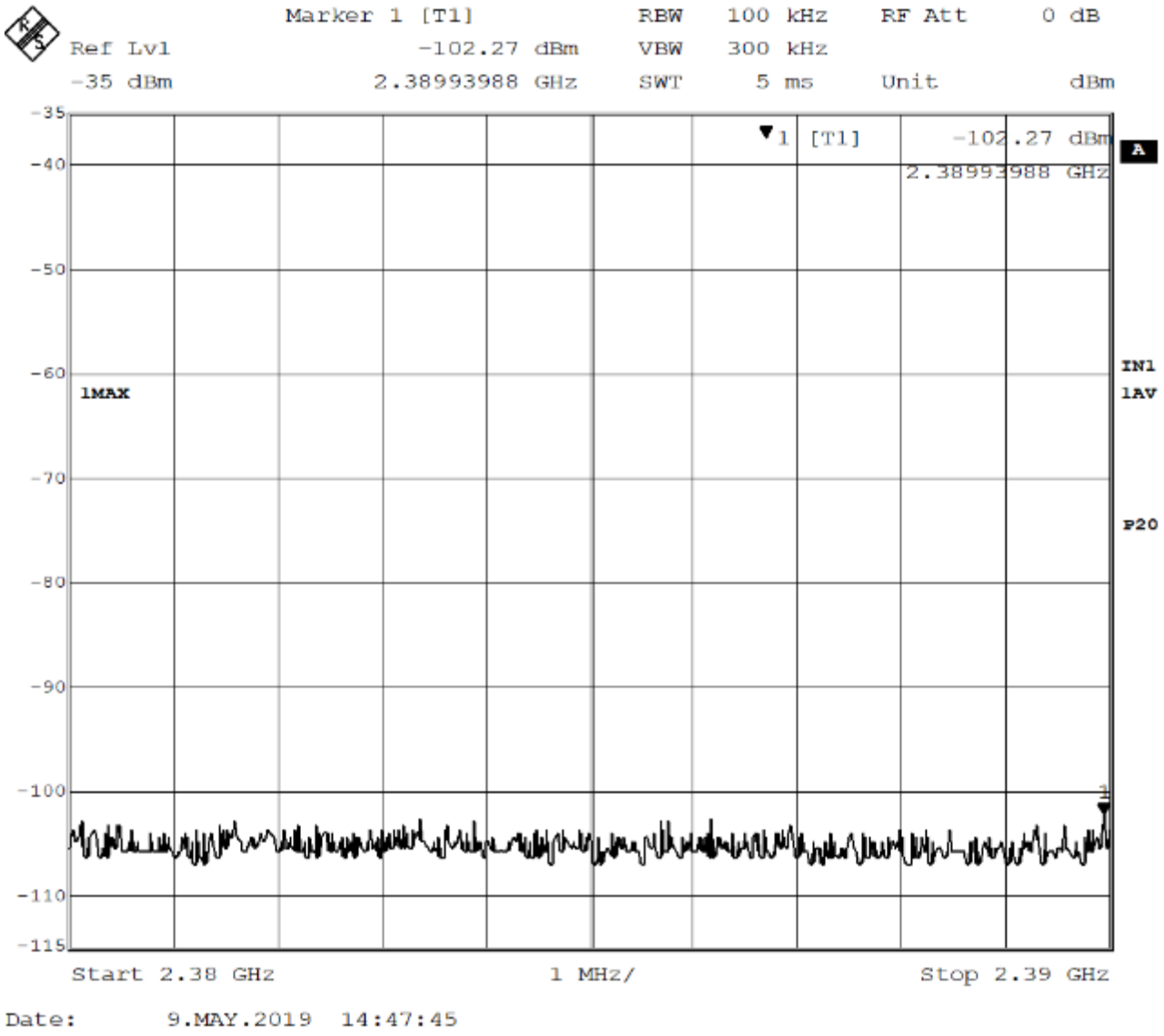

Figure 41 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

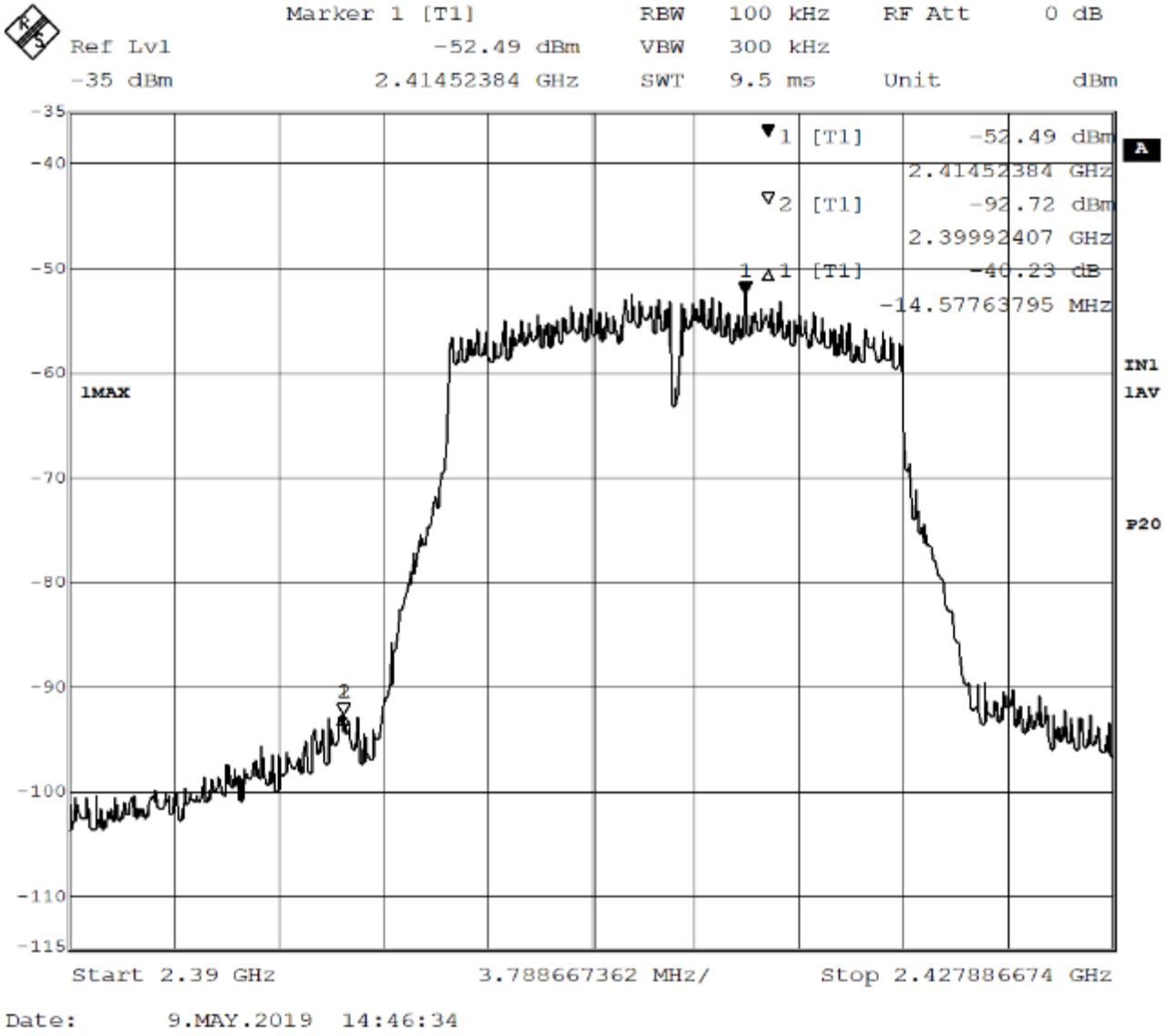

Figure 42 - Band-edge Measurement, Low Channel, Fundamental, Average

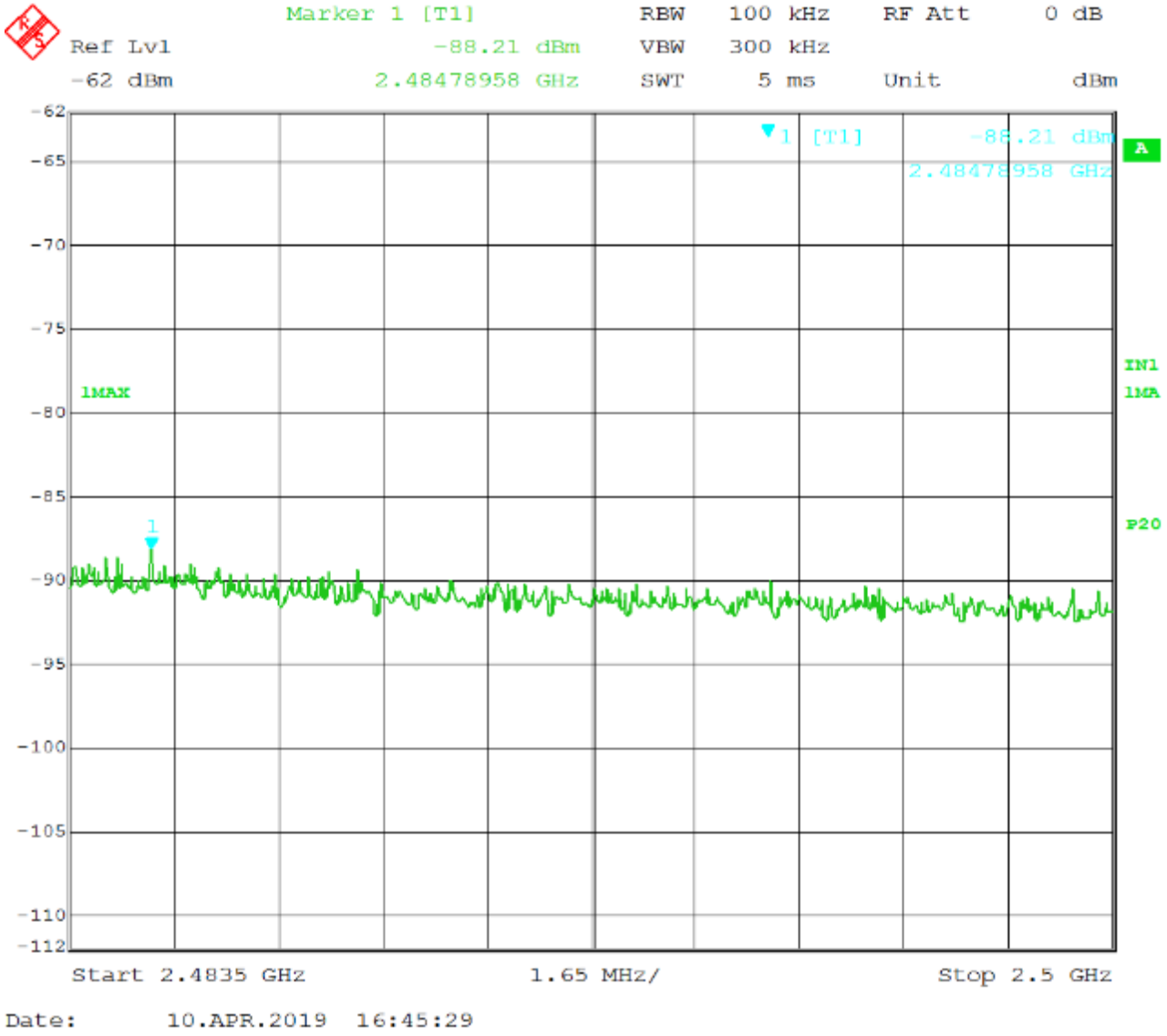

Figure 43 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

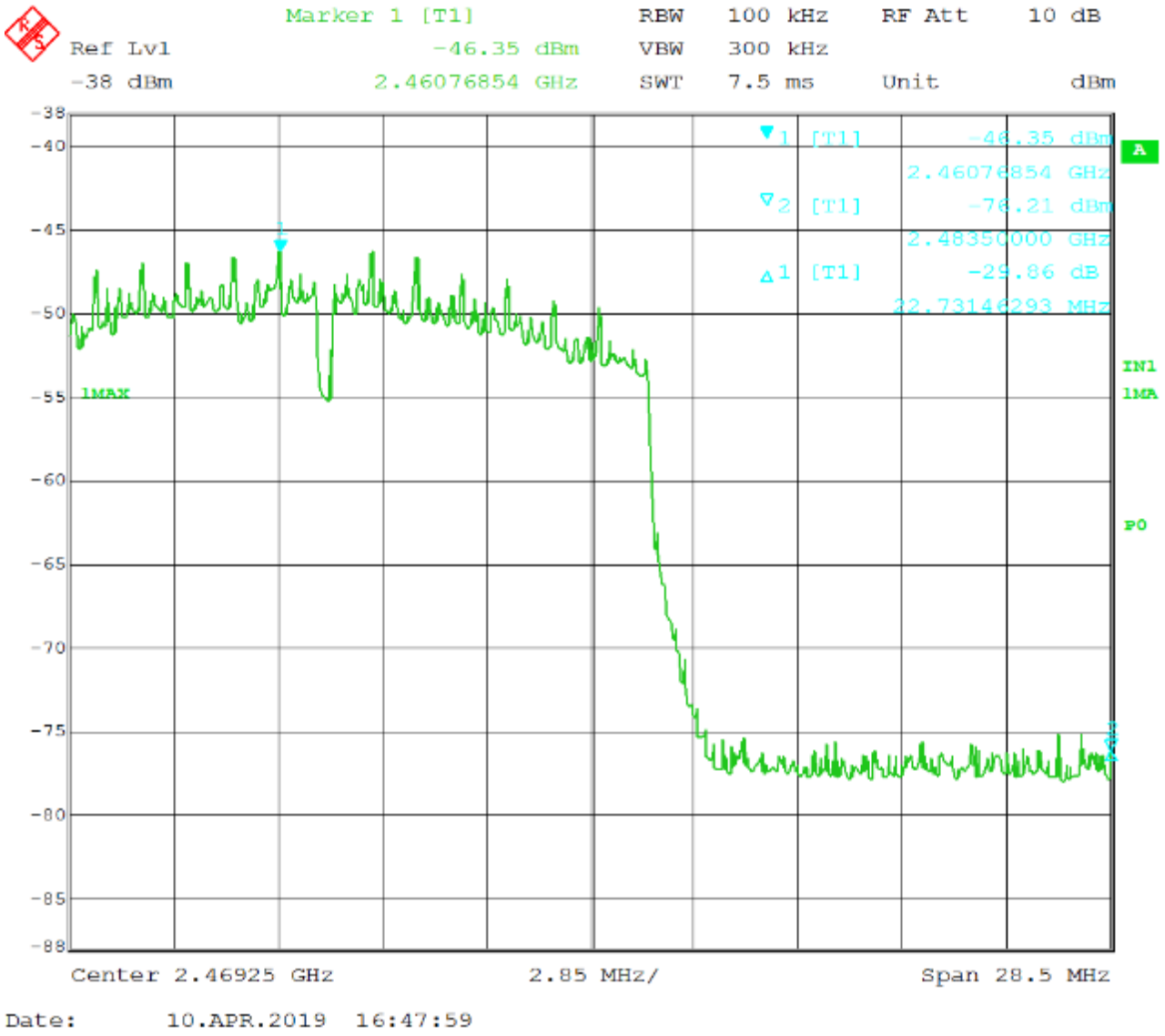

Figure 44 - Band-edge Measurement, High Channel, Fundamental, Peak

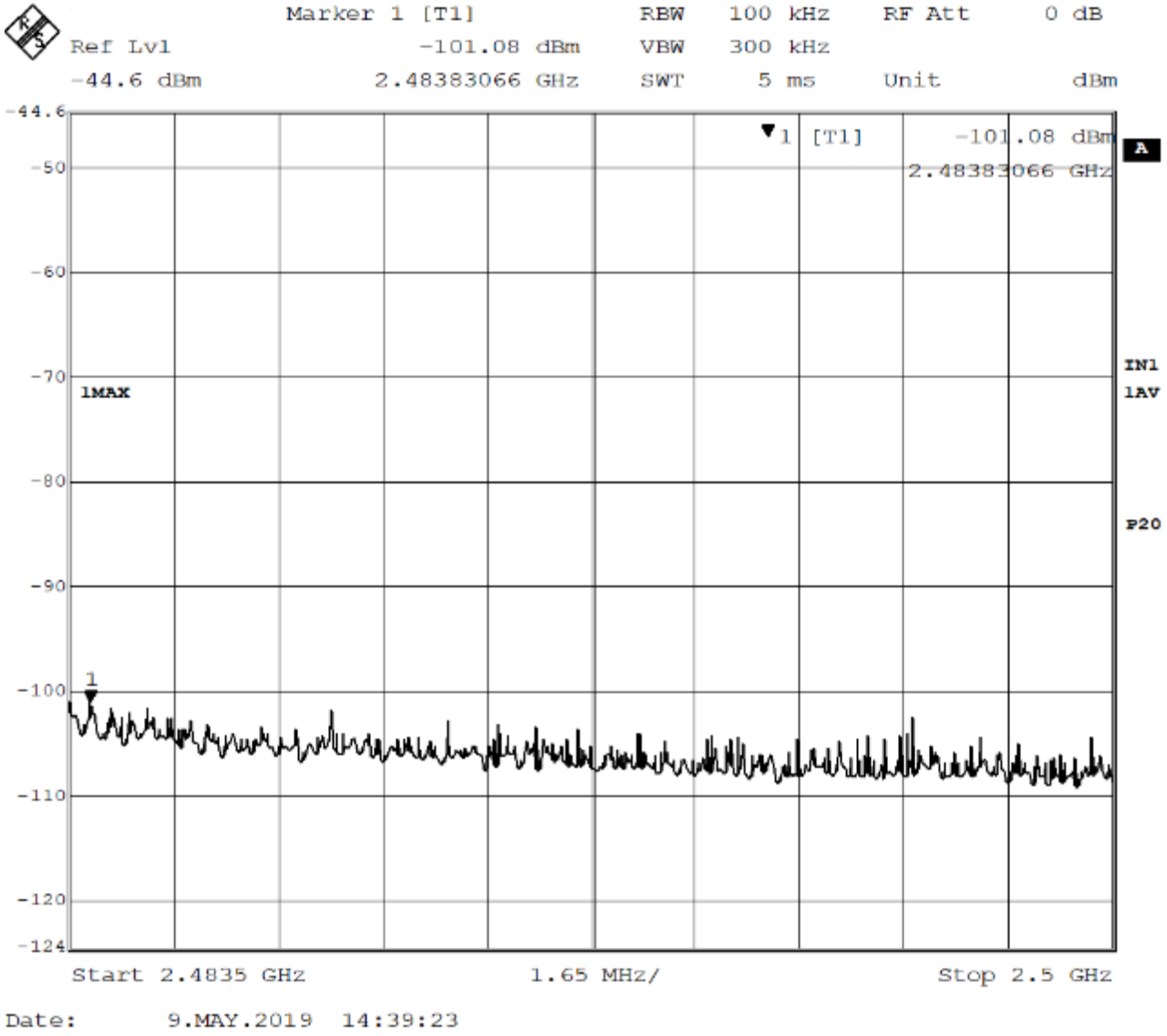

Figure 45 - Band-edge Measurement, High Channel, Restricted Frequency, Average

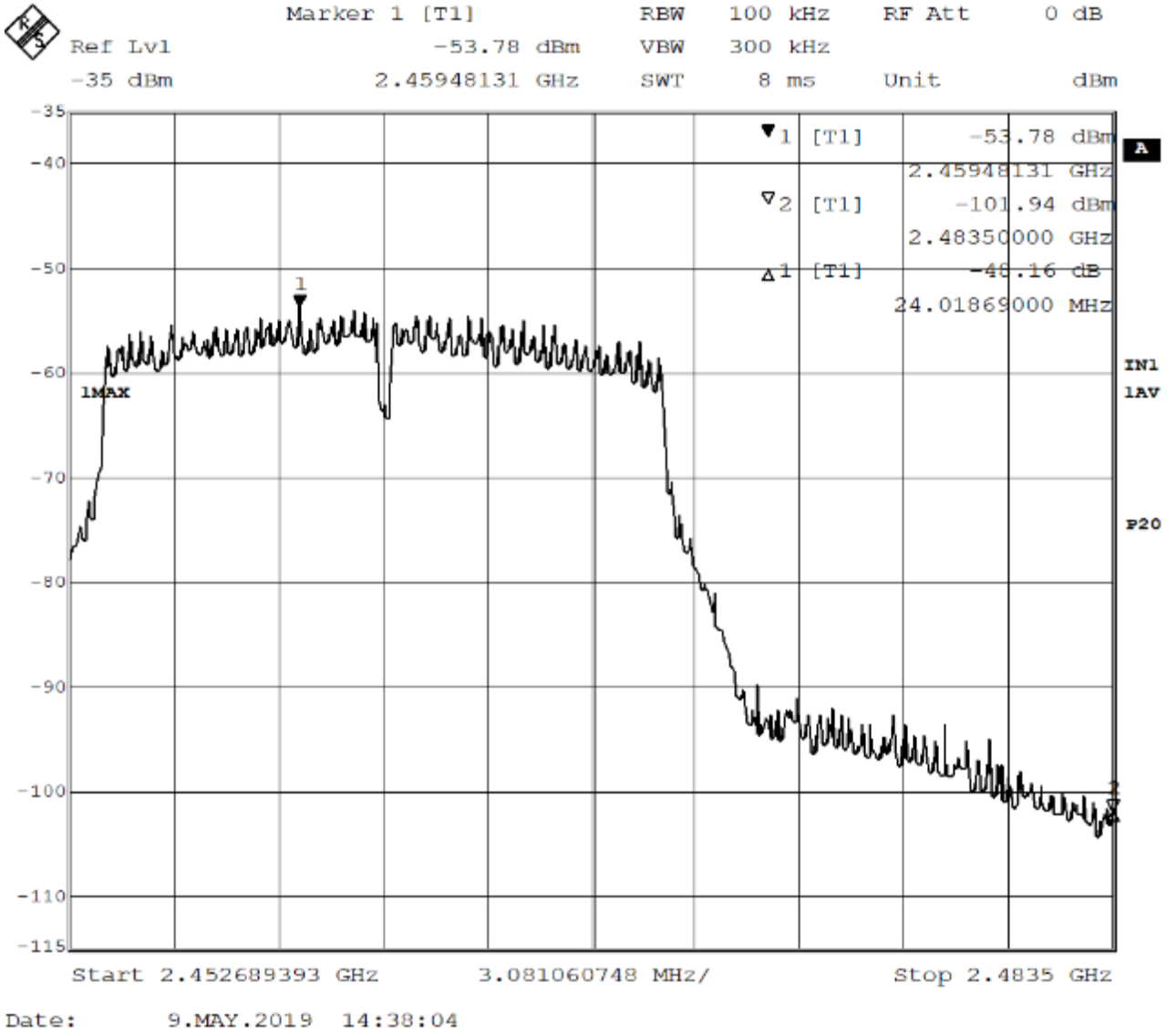

Figure 46 - Band-edge Measurement, High Channel, Fundamental, Average

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)	-76.07	-47.39	28.68	20	PASS
1	2390.0 (Unrestricted, Average)	-87.48	-60.17	27.31	20	PASS
11	2483.5 (Unrestricted, Peak)	-75.37	-48.62	26.75	20	PASS
11	2483.5 (Unrestricted, Average)	-87.98	-61.71	26.27	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)	-50.62	-50.62	29.39	-21.23	0	PASS
1	2340.0 (Restricted, Average)	-62.83	-62.83	21.60	-41.23	0	PASS
11	2483.5 (Restricted, Peak)	-43.31	-43.31	22.08	-21.23	0	PASS
11	2483.5 (Restricted, Average)	-61.62	-61.62	20.39	-41.23	0	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

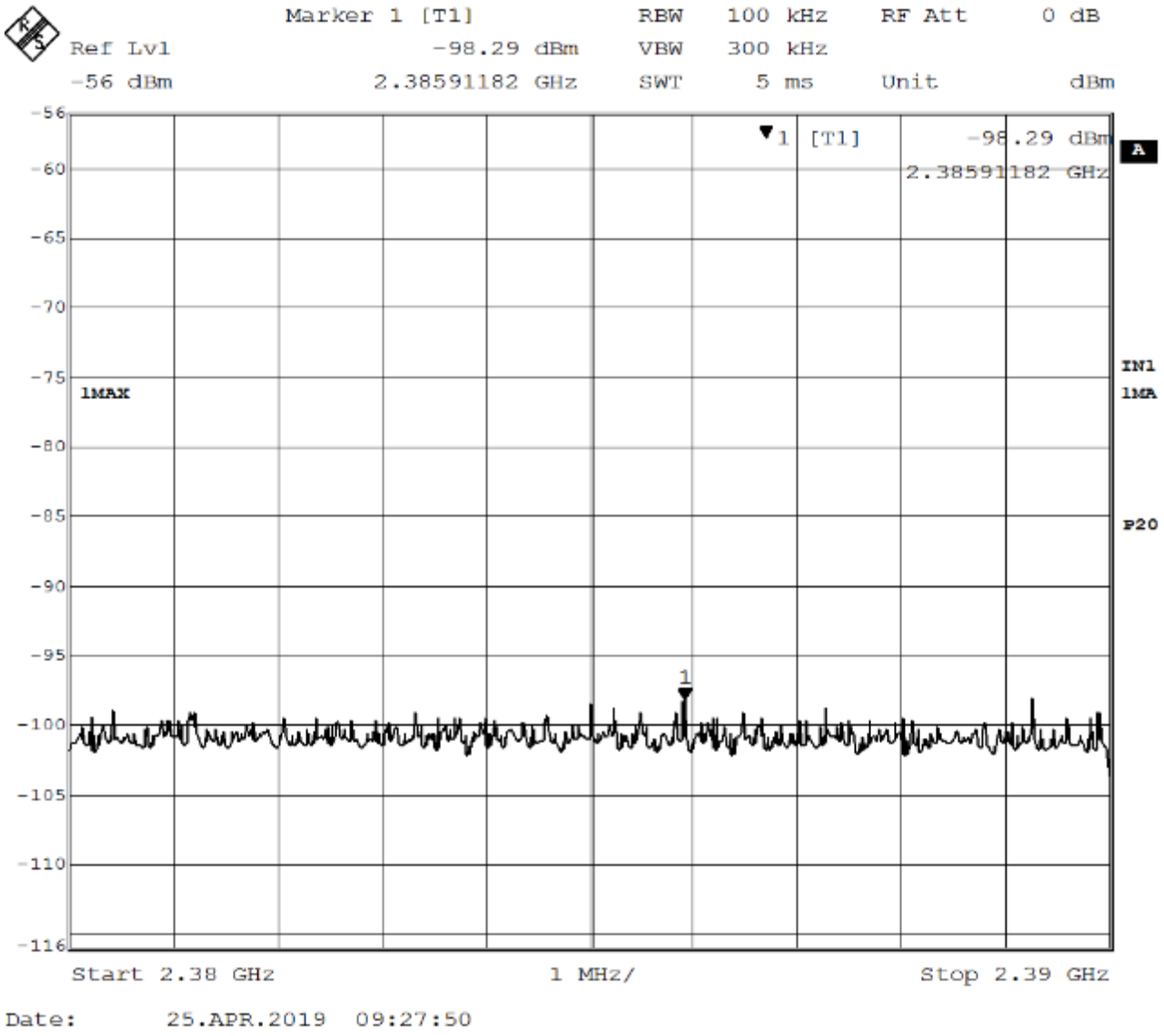

Figure 47 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

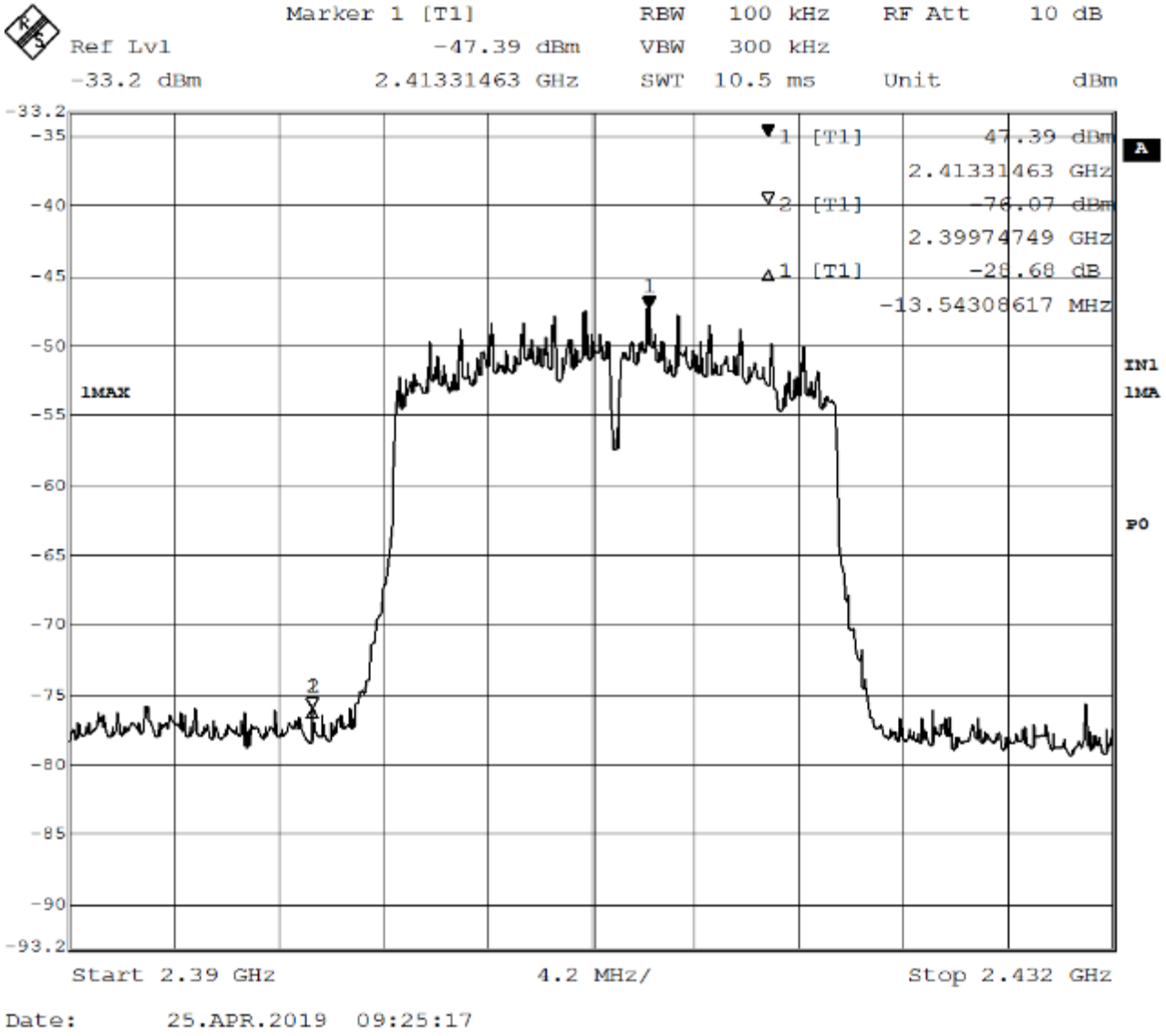

Figure 48 - Band-edge Measurement, Low Channel, Fundamental, Peak

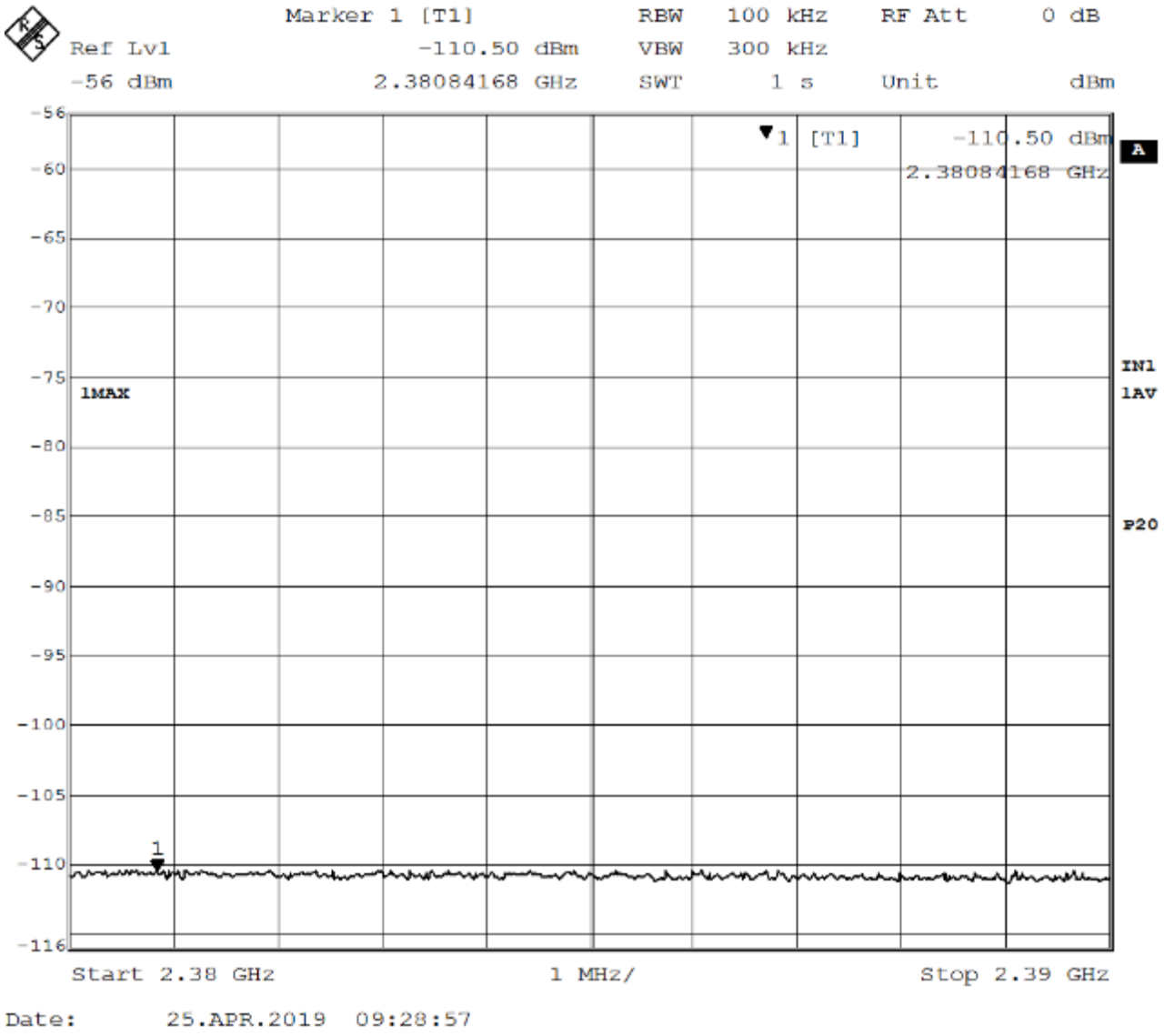

Figure 49 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

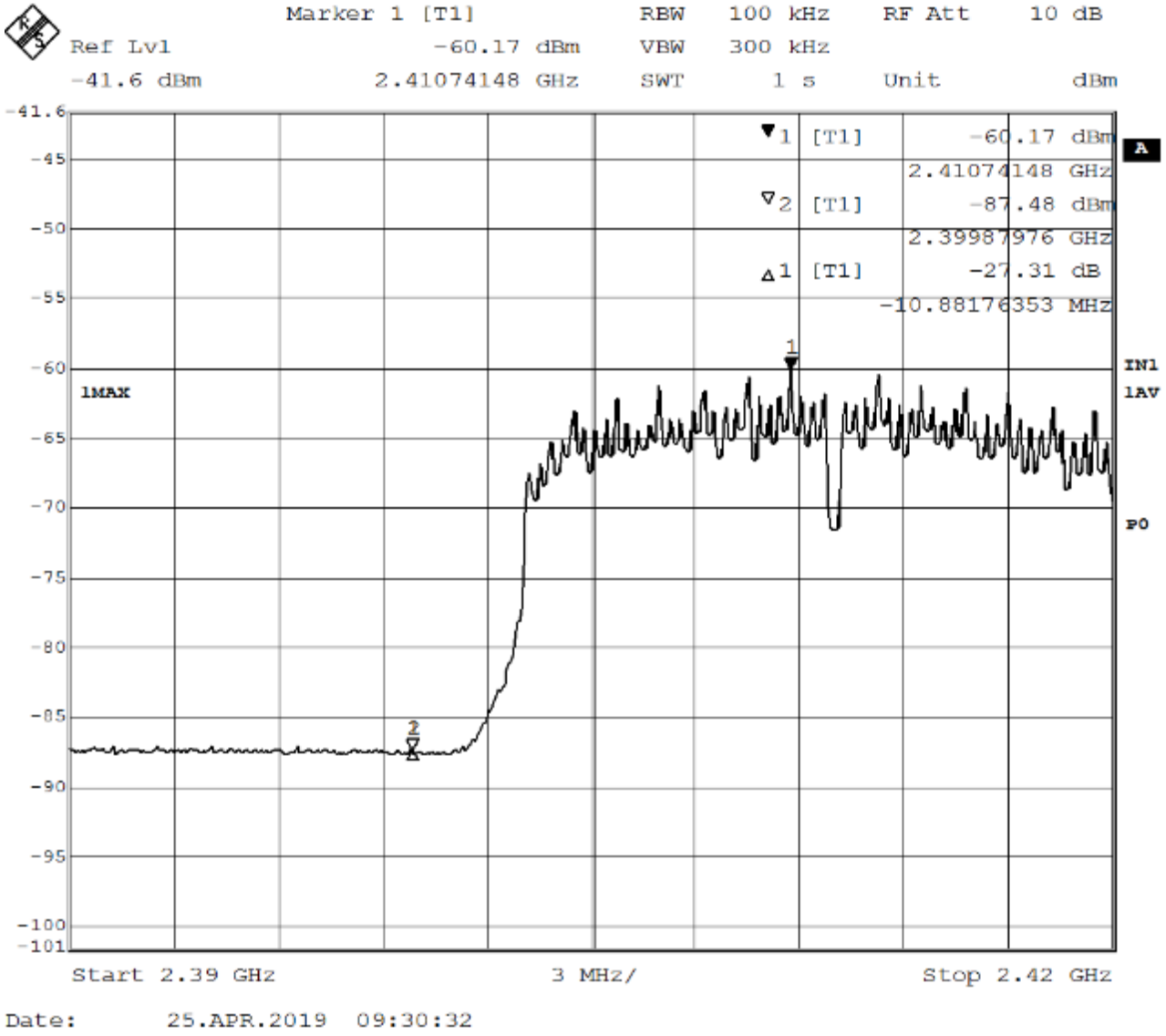

Figure 50 - Band-edge Measurement, Low Channel, Fundamental, Average

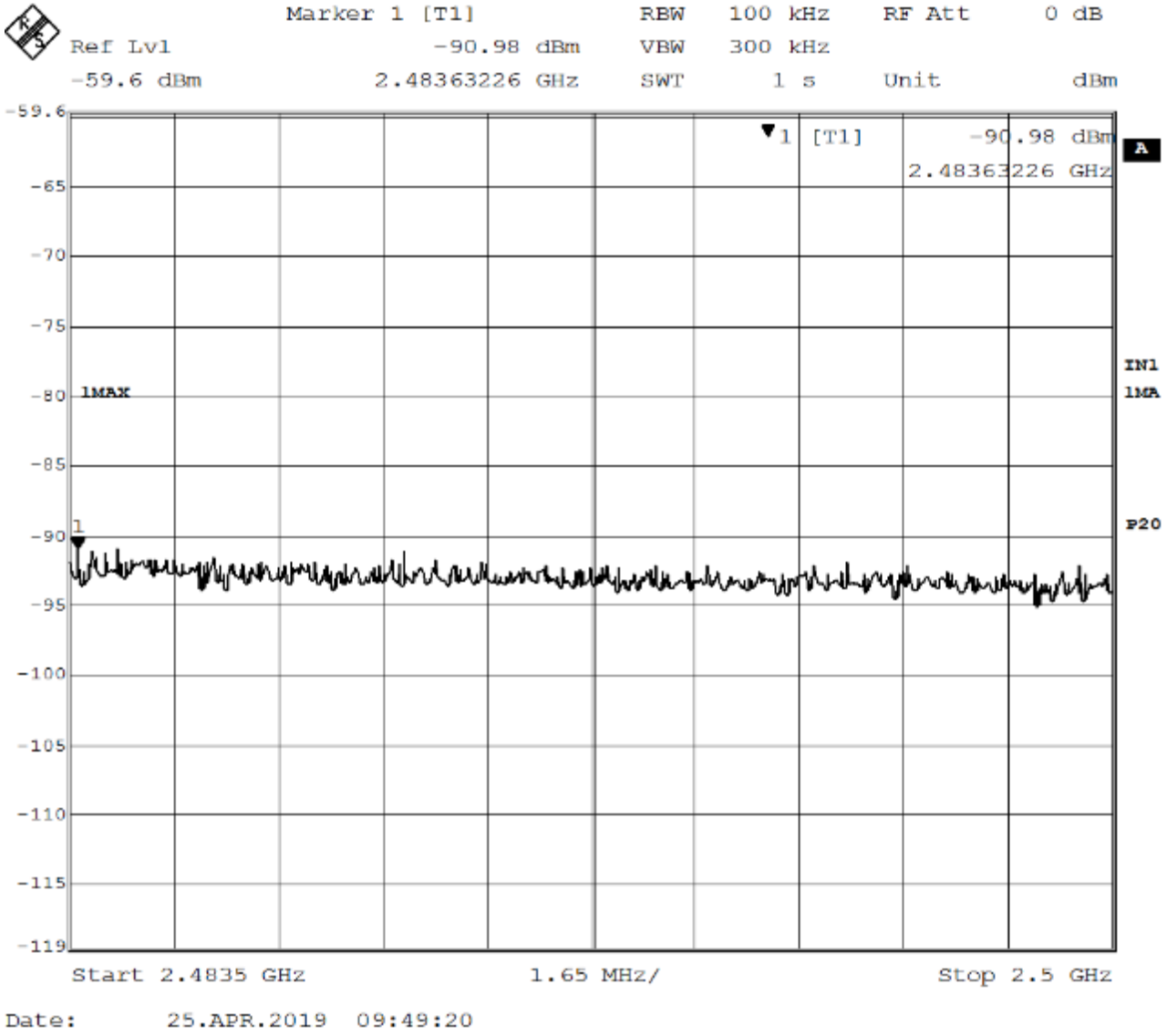

Figure 51 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

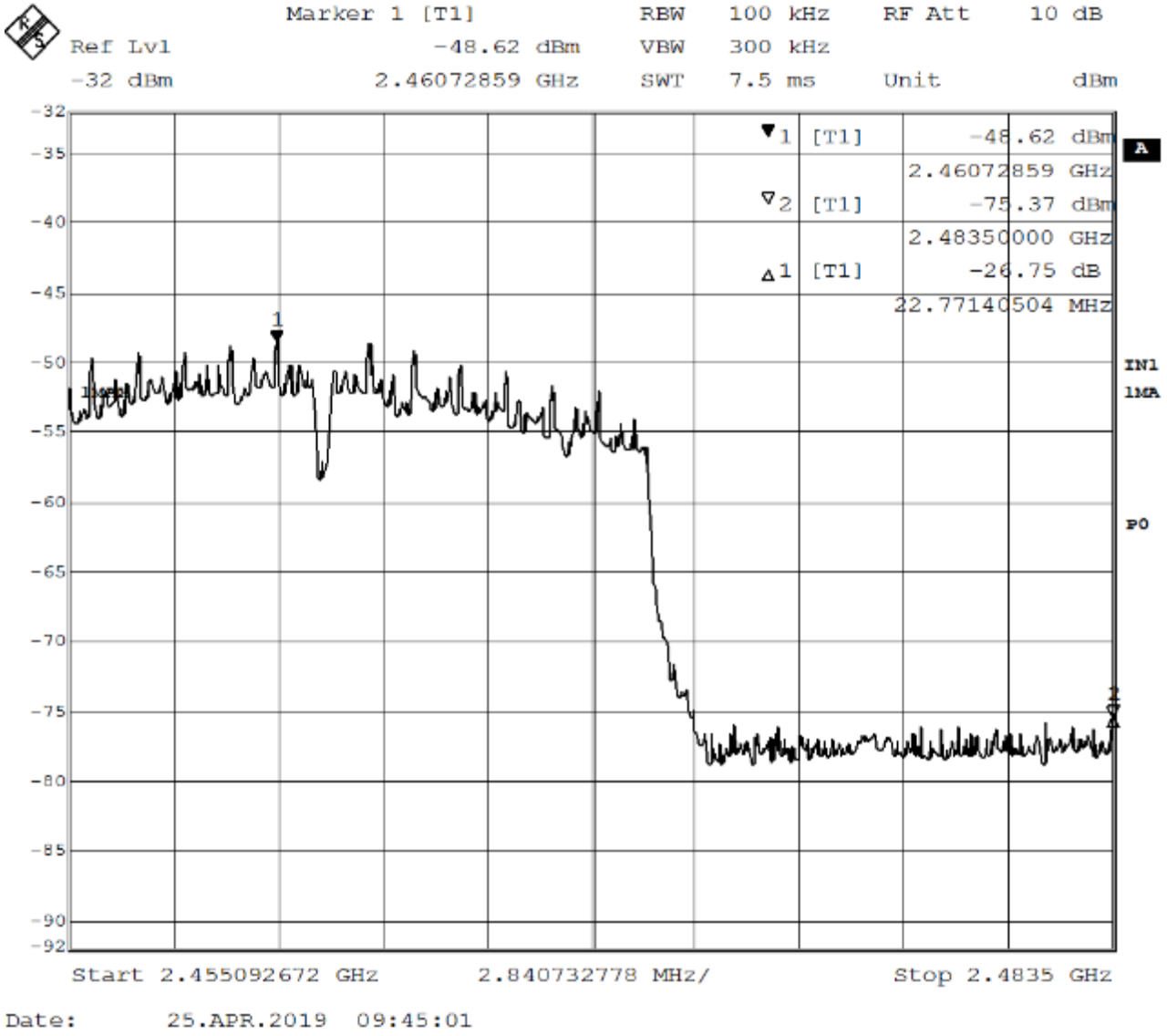

Figure 52 - Band-edge Measurement, High Channel, Fundamental, Peak

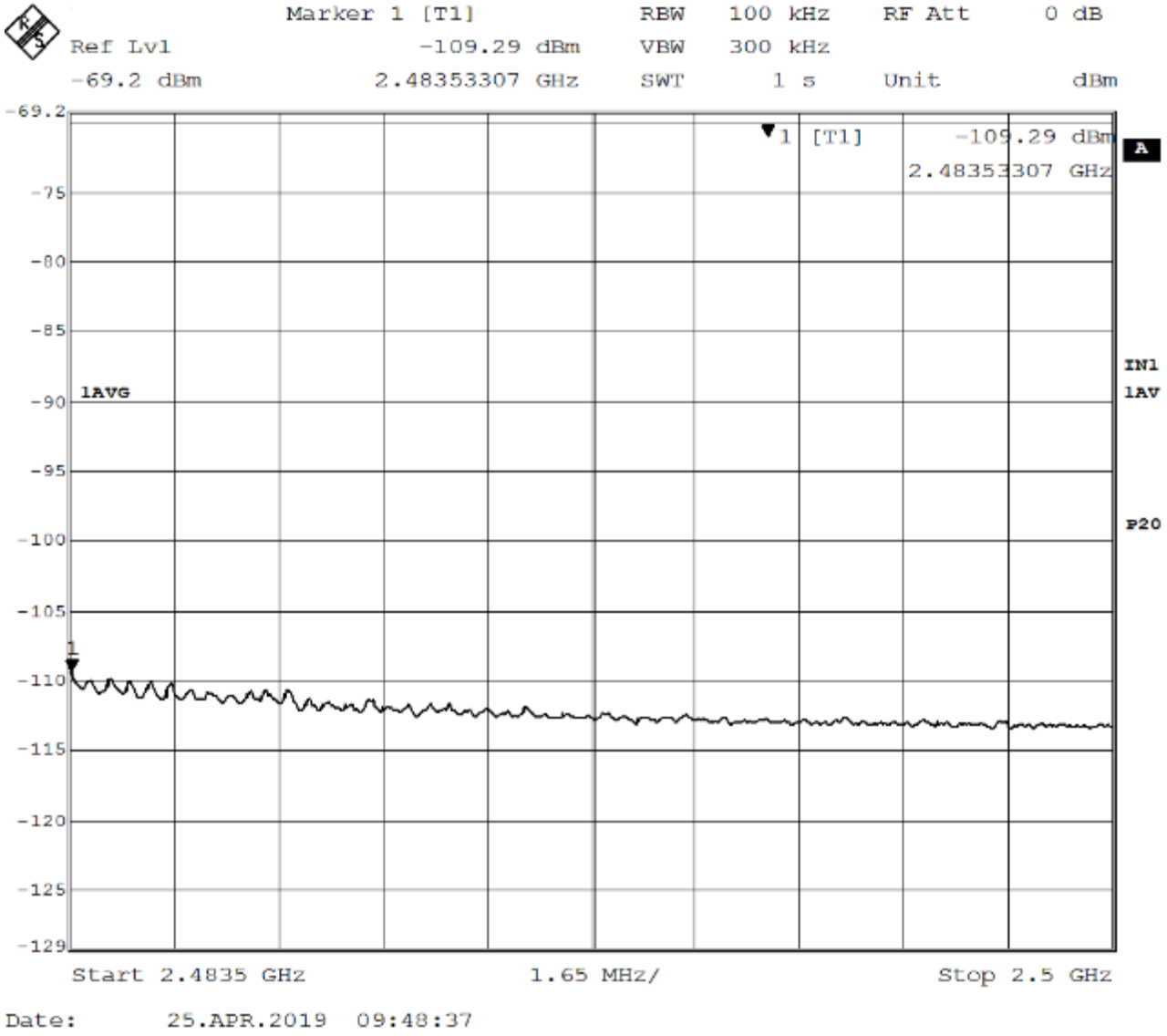

Figure 53 - Band-edge Measurement, High Channel, Restricted Frequency, Average

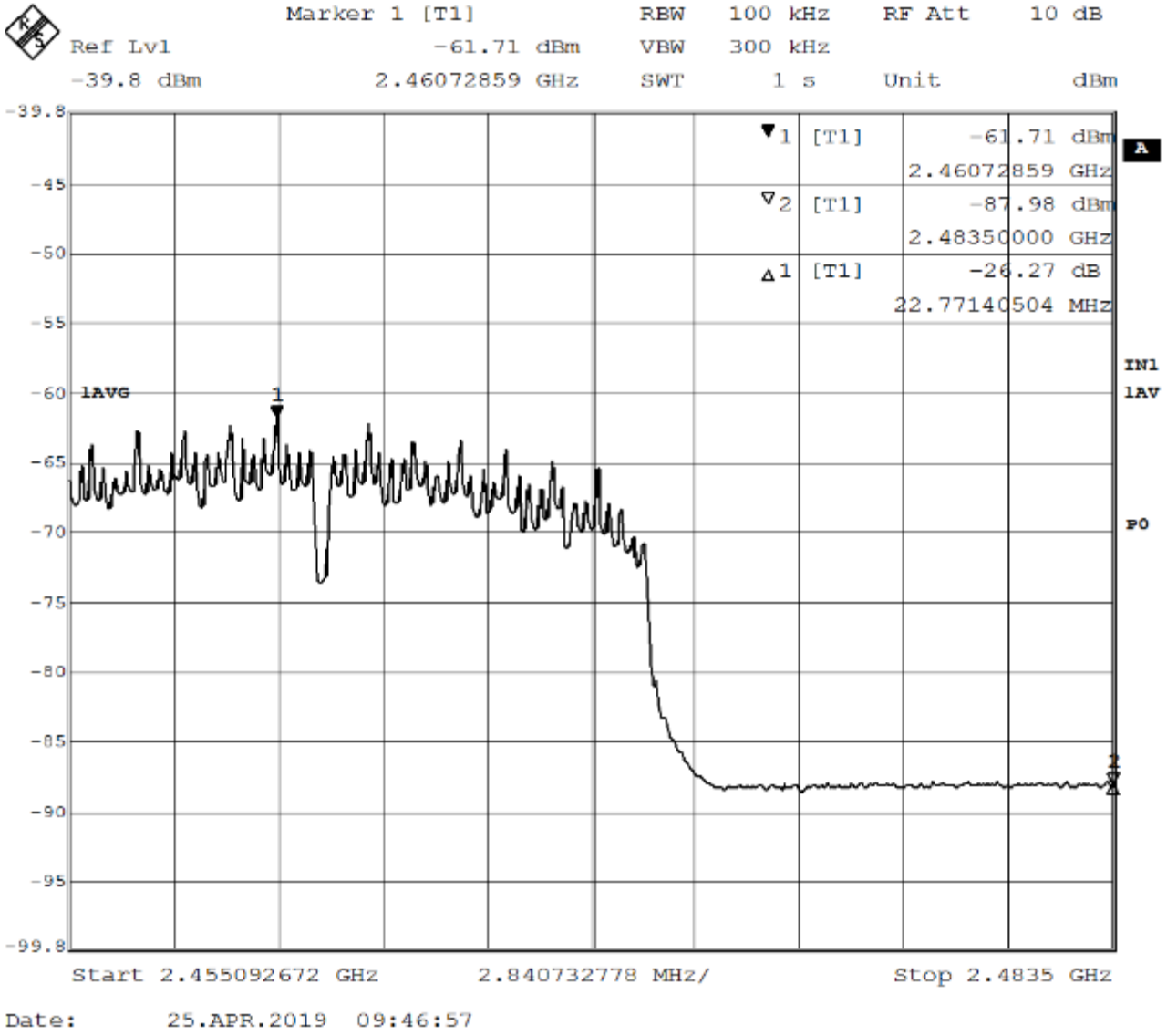

Figure 54 - Band-edge Measurement, High Channel, Fundamental, Average

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. All measurements were taken at a distance of 3m from the EUT. The EUT was maximized in all 3 orthogonal positions.

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:
See Section 4.3

EUT operating conditions:
The EUT was powered by 24 VDC 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:

Power Spectral Density, EIRP

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	EIRP PEAK PSD(dBm)	Conducted PEAK PSD(dBm)	Limit (dBm)	RESULT
Low	2412	802.11b	-5.34	-9.24	8.00	PASS
Middle	2437	802.11b	-5.67	-9.57	8.00	PASS
High	2462	802.11b	-7.57	-11.47	8.00	PASS
Low	2412	802.11g	-13.35	-17.25	8.00	PASS
Middle	2437	802.11g	-8.02	-11.92	8.00	PASS
High	2462	802.11g	-14.46	-18.36	8.00	PASS
Low	2412	802.11n	-15.67	-19.57	8.00	PASS
Middle	2437	802.11n	-10.72	-14.62	8.00	PASS
High	2462	802.11n	-17.04	-20.94	8.00	PASS

Radiated SA reading + 107 + CL + AF - 95.23 – AG(conducted only) = PSD (EIRP or conducted)

AG – Antenna gain = 3.9 dBi
CL = cable loss = 7.60 dB
AF = antenna factor = 28.30 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance

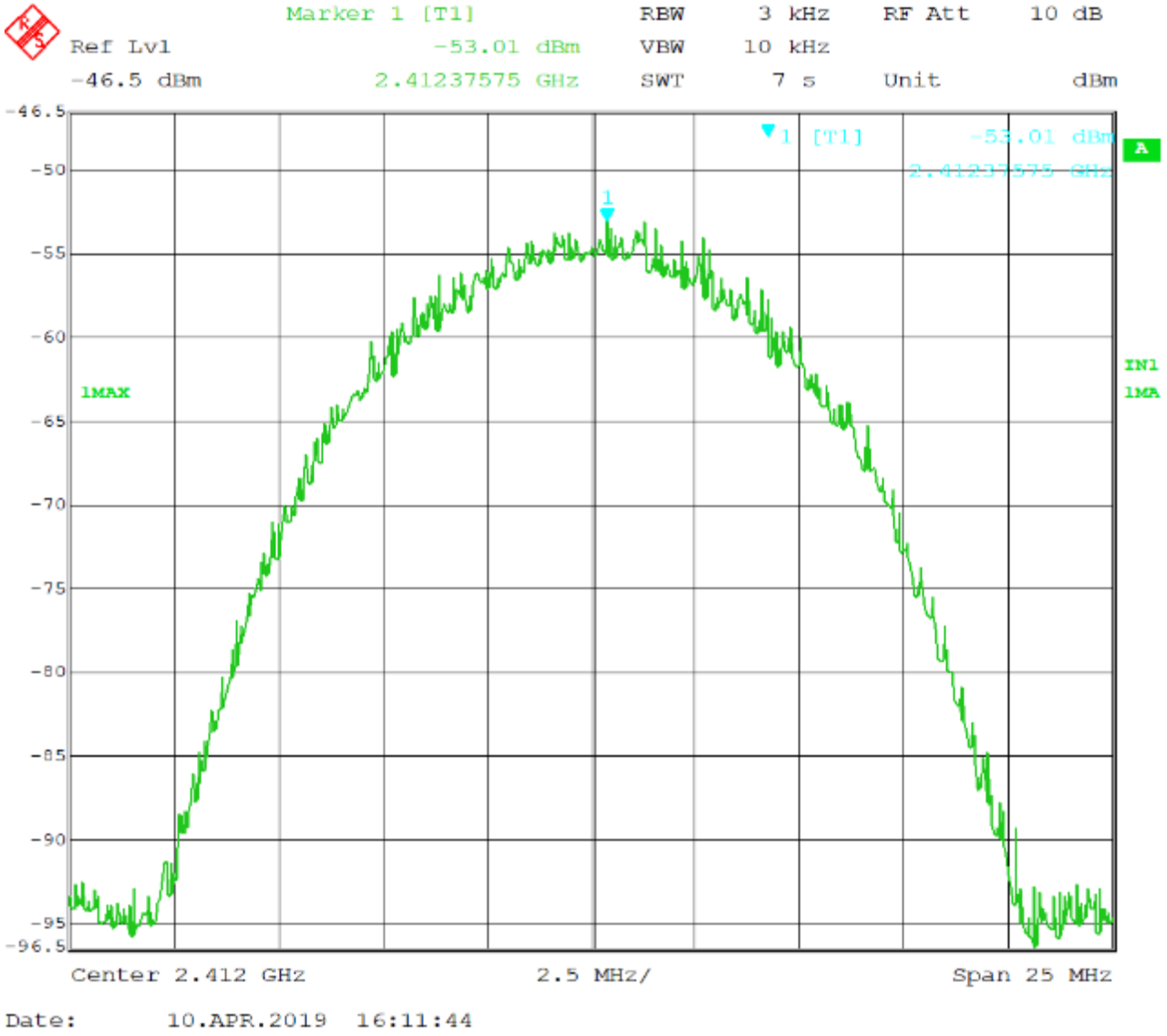

Figure 55 - Power Spectral Density, Low Channel, 802.11b

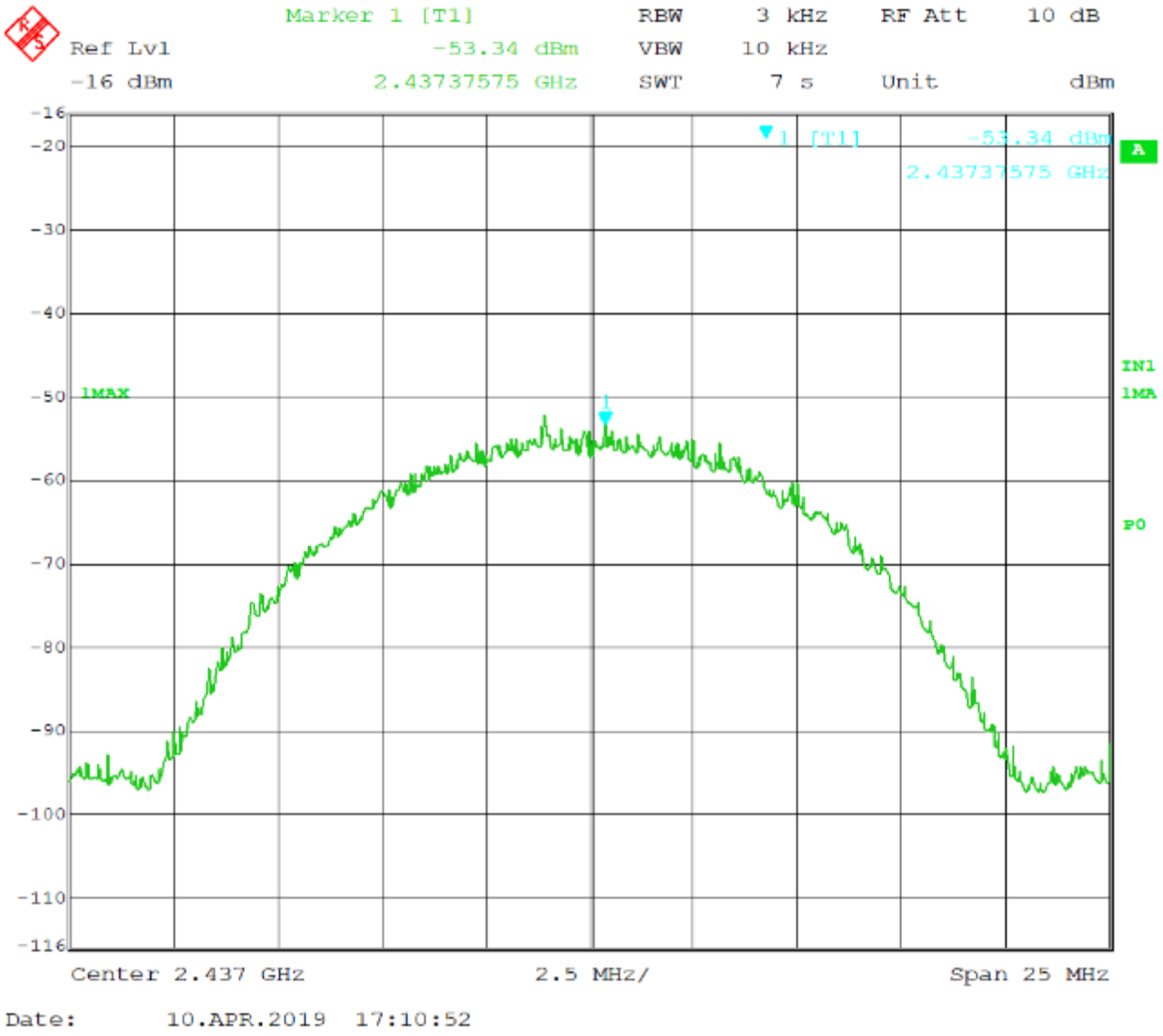

Figure 56 - Power Spectral Density, Mid Channel, 802.11b

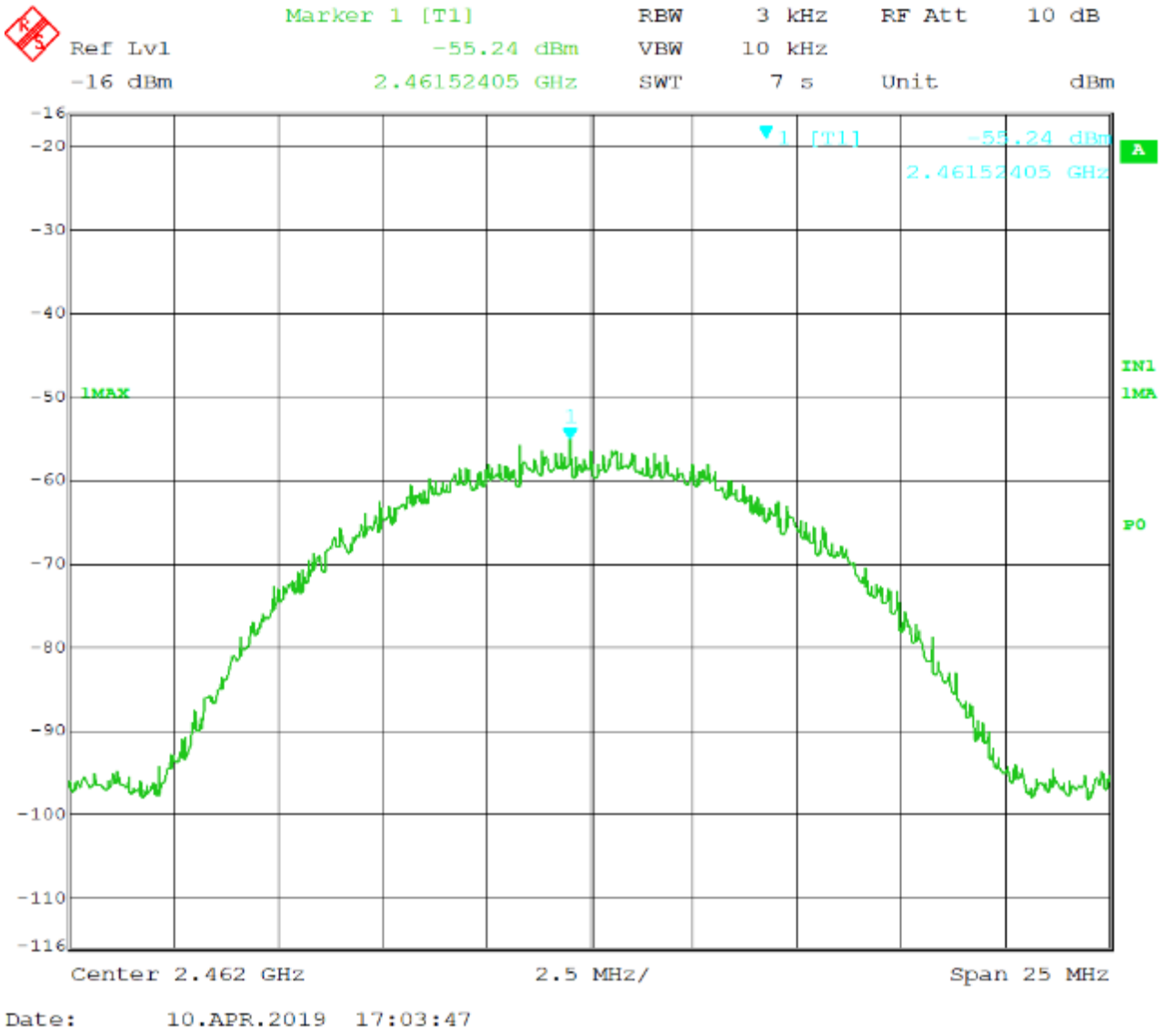

Figure 57 - Power Spectral Density, High Channel, 802.11b

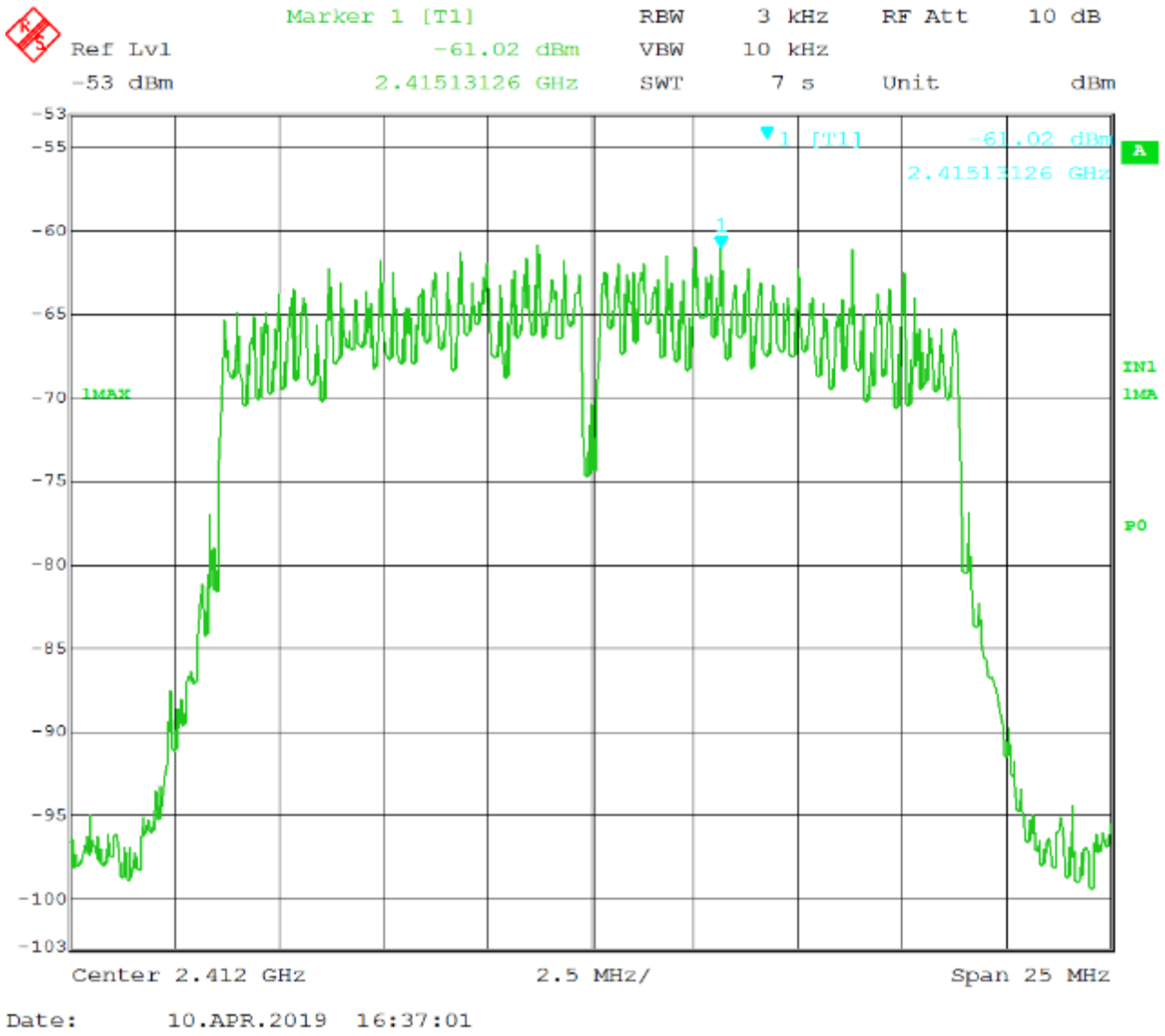

Figure 58 - Power Spectral Density, Low Channel, 802.11g

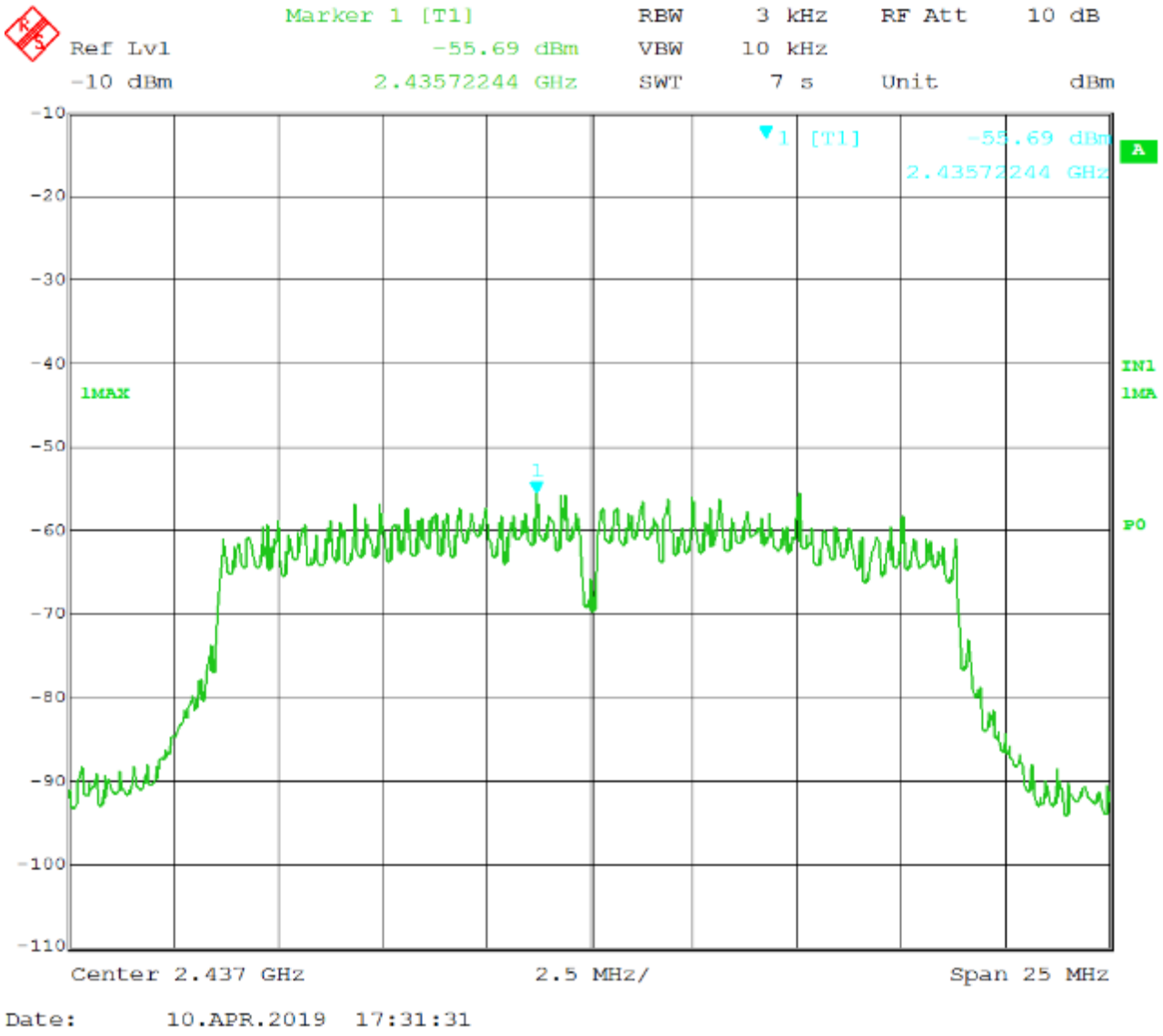

Figure 59 - Power Spectral Density, Mid Channel, 802.11g

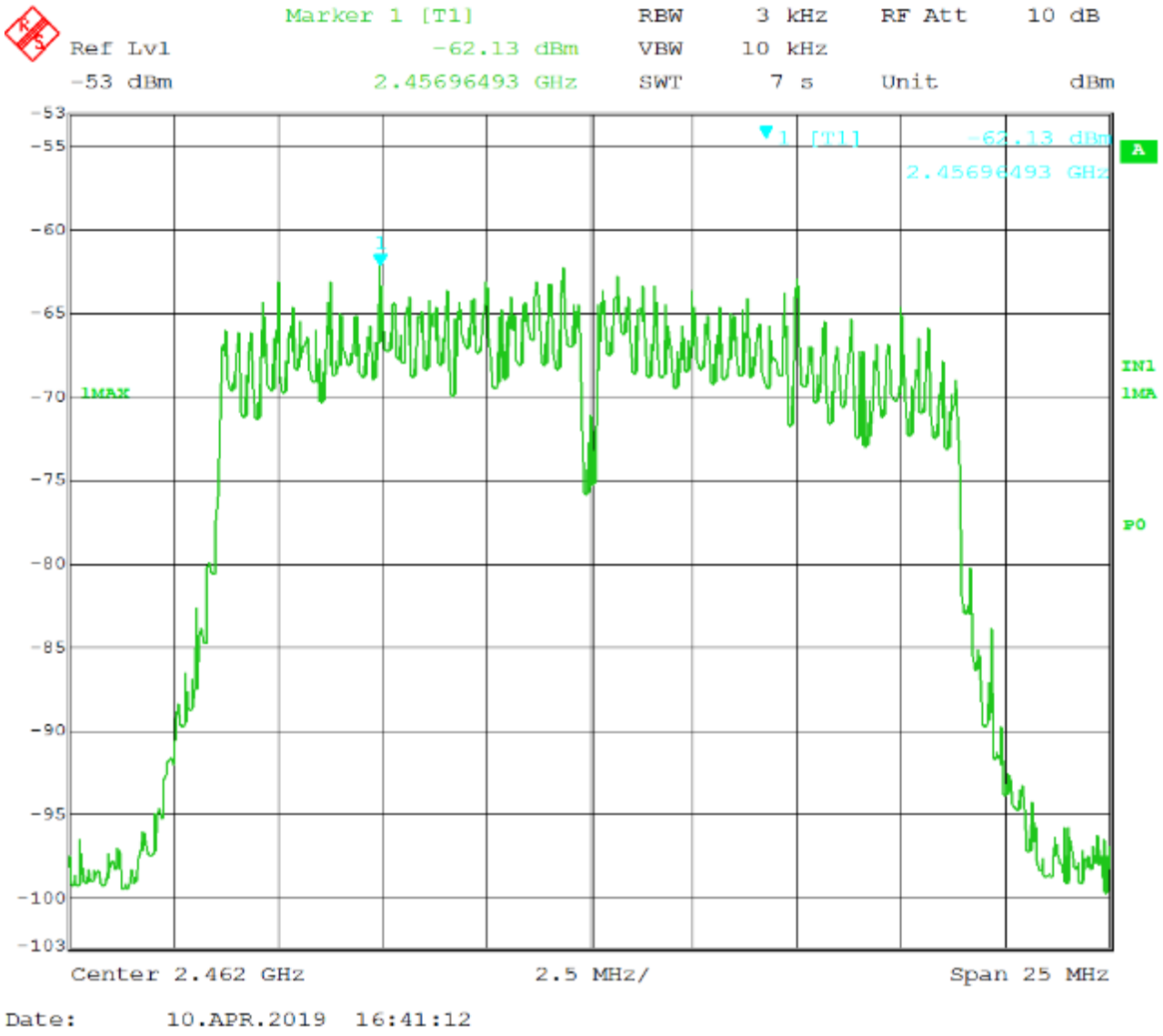

Figure 60 - Power Spectral Density, High Channel, 802.11g

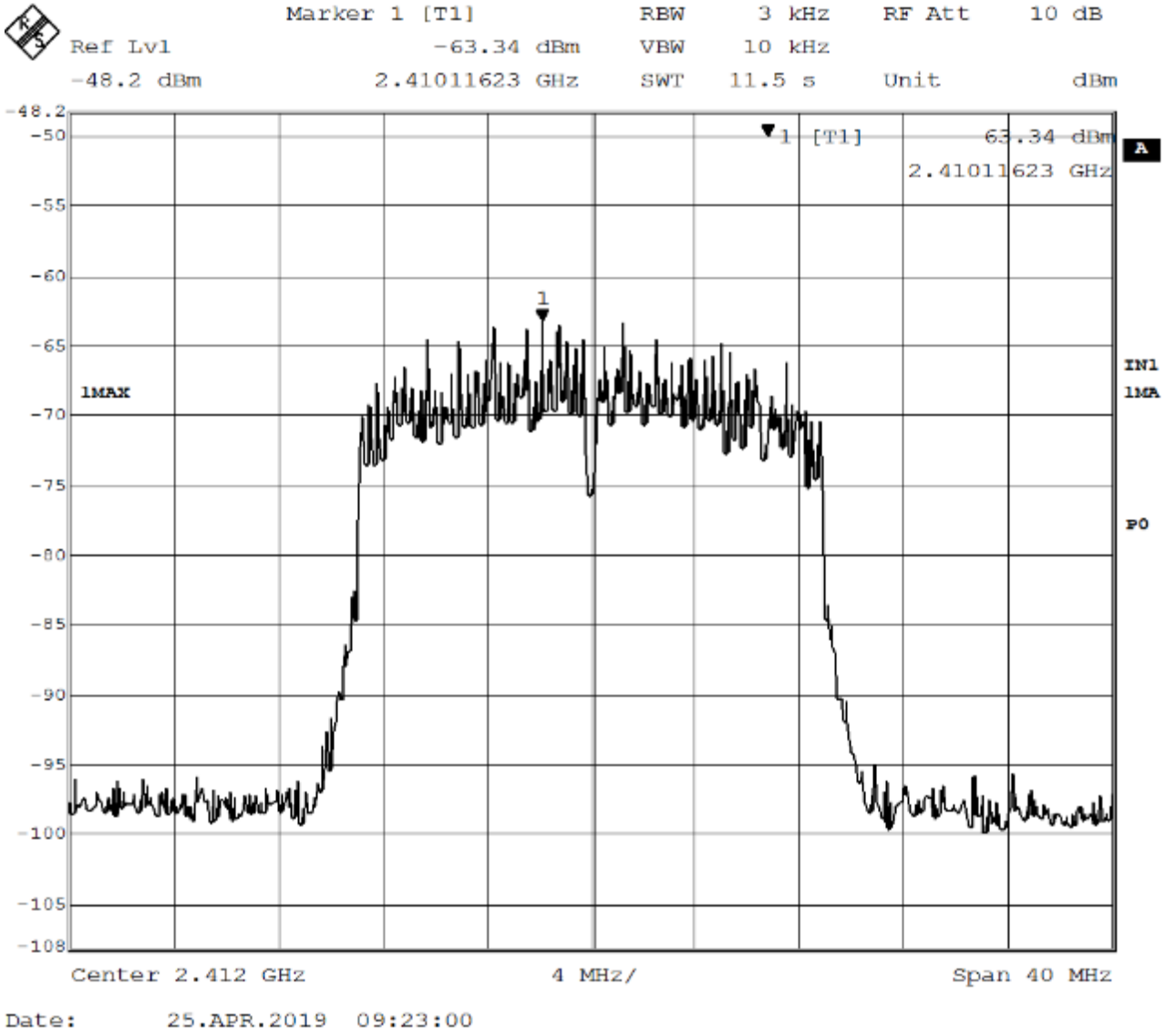

Figure 61 - Power Spectral Density, low Channel, 802.11n

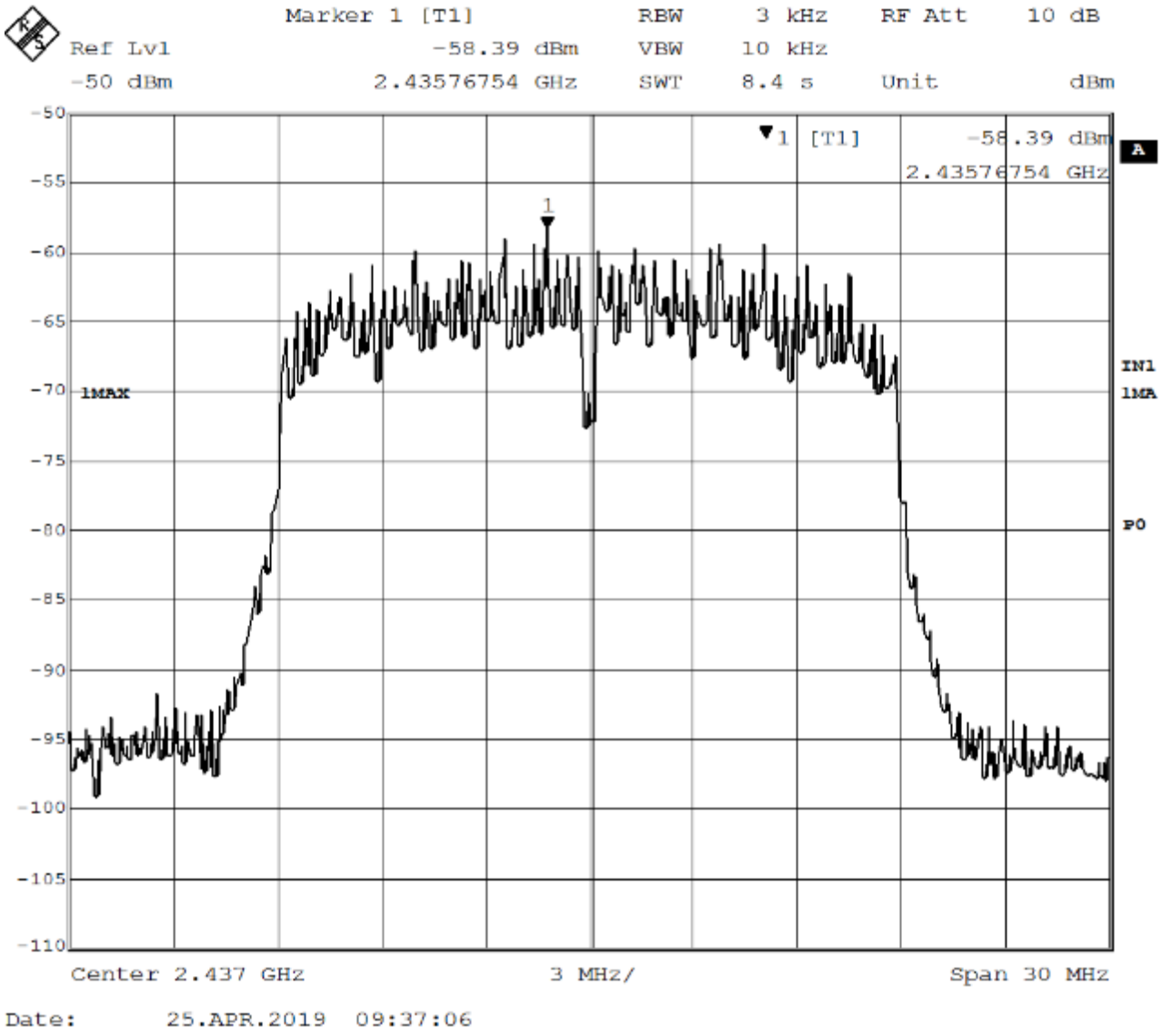

Figure 62 - Power Spectral Density, Mid Channel, 802.11n

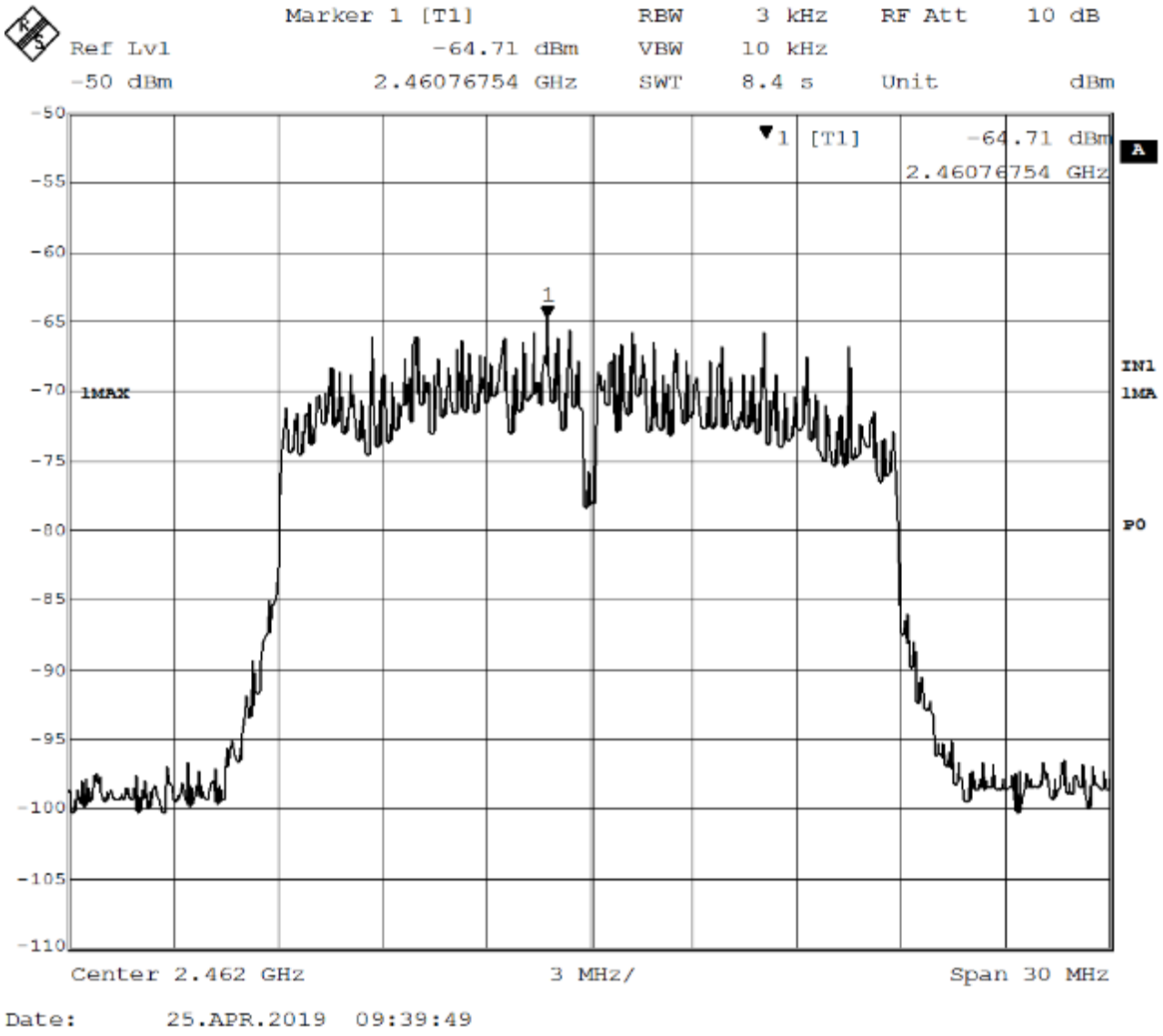

Figure 63 - Power Spectral Density, High Channel, 802.11n

APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:
FS = RA + AF – (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

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

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

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

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

Voltage (dBµV) = Power (dBm) + 107 (for 50Ω measurement systems)

Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator)

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

EIRP = [FS(V/m) x d^2]/30 = FS [0.3] for d = 3

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = FS(dBµV/m) - 95.23

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

APPENDIX B – MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±3.82 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 END