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Amended

FCC/ISED DTS Test Report (802.11)

Prepared for:	**Digital Ally Inc.**
Address:	**9705 Loiret Blvd** **Lenexa, KS 66219, USA**
Product:	**DA_EVO_4G_5**
Test Report No:	**R20190110-20-01A**
Approved By:	 **Nic S. Johnson, NCE** **Technical Manager** **iNARTE Certified EMC Engineer #EMC-003337-NE**
DATE:	**13 June 2019**
Total Pages:	**101**

REVISION PAGE

Rev. No.	Date	Description
0	30 April 2019	Original – NJohnson Prepared by KVepuri/CFarrington
A	13 June 2019	Added a note about intermodulation testing to Section 4.2. Limits and margins were corrected in Table 2 and 6. Includes NCEE Labs report R20190110-20-01 and its amendment in full -NJ

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	NA
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 11.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 4, Section 7.1	Conducted Emissions	NA

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

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was EVO. It features 802.11b, 802.11g and 802.11n modules and has transmit and receives capabilities.

Model	DA_EVO_4G_5
EUT Received	11 March 2019
EUT Tested	11 March 2019 - 25 April 2019
Serial No.	DAEB1D8B8E
Operating Band	2400.0 - 2483.5 GHz
Device Type	802.11b, 802.11g, 802.11n
Power Supply	12 VDC (Marine Battery)

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

1. Cameras x 2: MN: ELP-USBFHD06H-BL36 (SN: 2017120800000200 and 2018112988000200)
2. Digital Ally Monitor: MN:M-35 (SN:10020085)
3. Combo antenna: AW-4C (SN:A1901008100006)

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 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*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	26 Jul 2018	26 Jul 2019
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*

*12 VDC Marine Characterization

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

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

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 (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 limtis 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, 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. In addition to the 802.11 modes of modulation, the licensed module, FCC ID:XPY2AGQN4NNN was set to transmit simultaneously so that any potential intermodulation products could be identified and measured.

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:

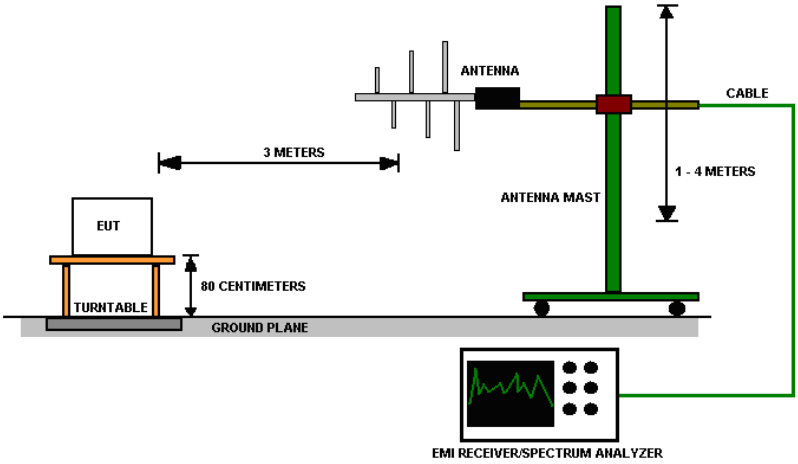

Figure 1 - Radiated Emissions Test Setup

EUT operating conditions
The EUT was powered by 12 VDC Marine battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in 80211b, 80211g and 80211n.

Test results:

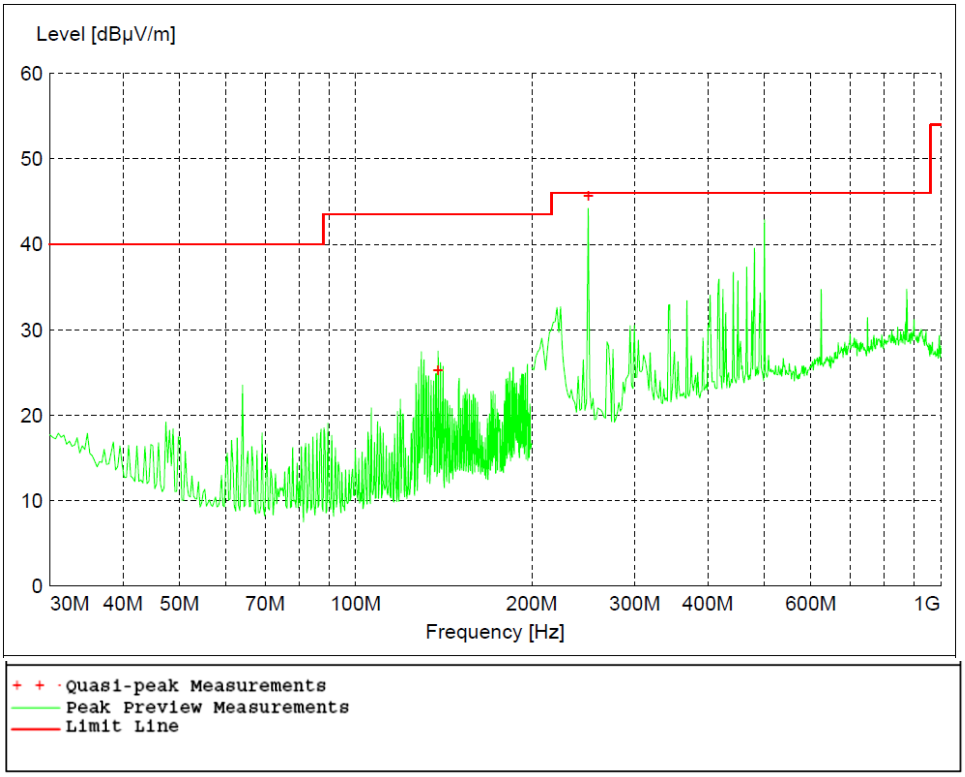

Figure 2 - Radiated Emissions Plot, Receive

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
138.300000	25.26	43.5	18.3	99	212	VERT
250.020000	45.72	46	0.3	119	325	HORI

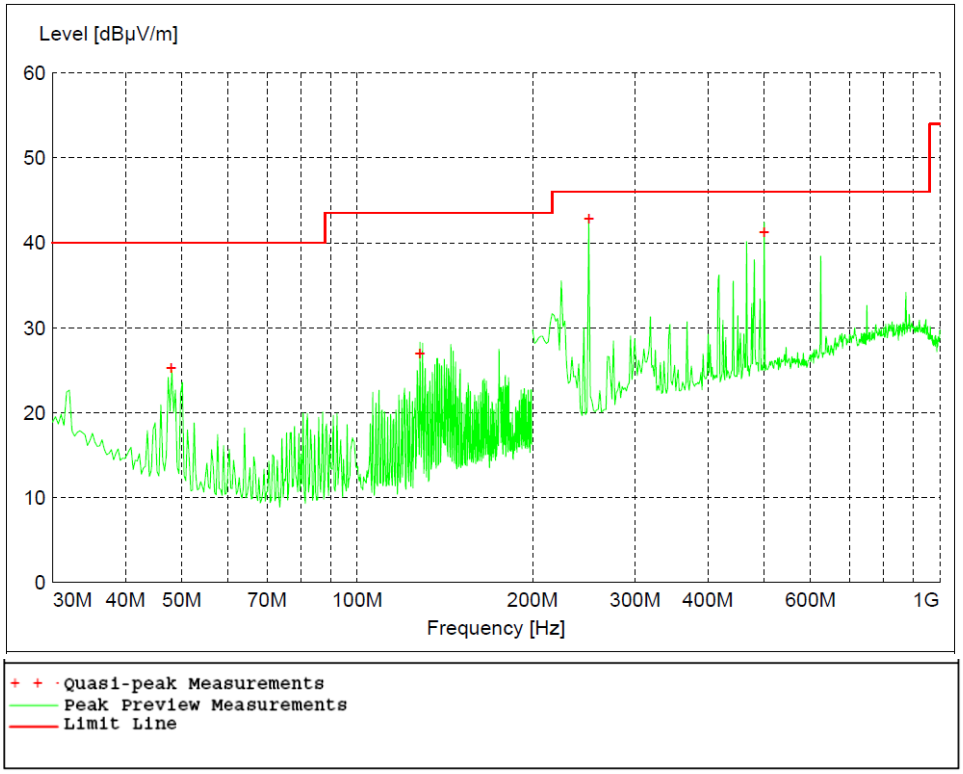

Figure 3 - Radiated Emissions Plot, Low Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
48.000000	25.33	40.0	14.67	223	202	VERT
128.160000	27.00	43.5	16.50	102	211	VERT
250.020000	42.92	46.0	3.08	99	140	VERT
499.980000	41.24	46.0	4.76	101	210	HORI

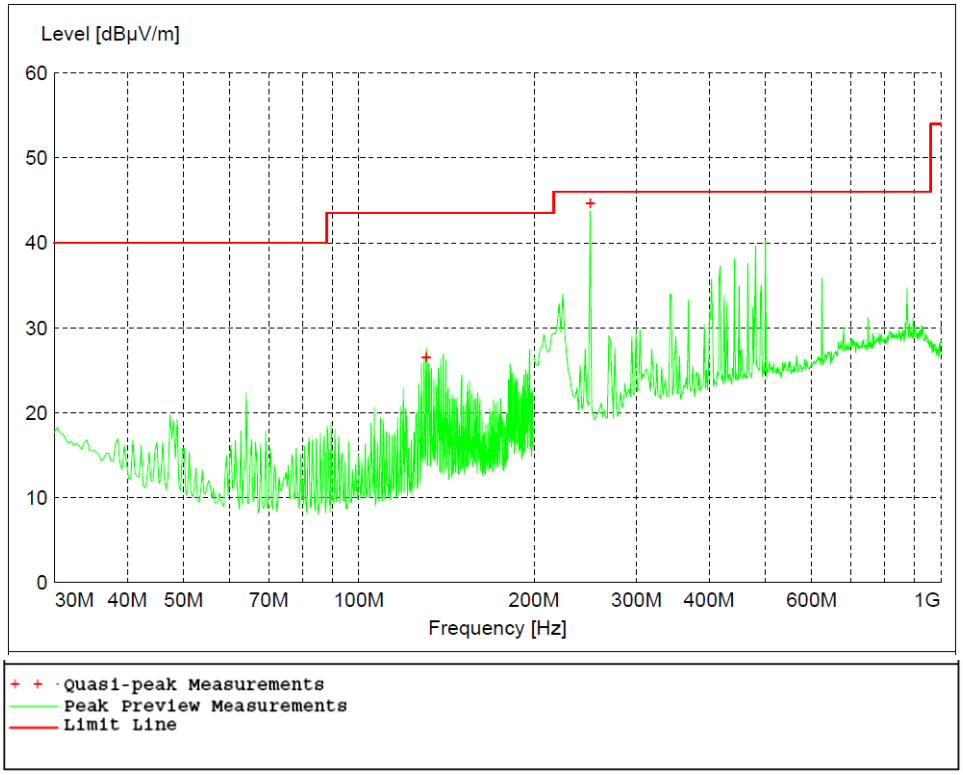

Figure 4 - Radiated Emissions Plot, Mid Channel

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.	
130.620000	26.54	43.50	17.00	100	285	VERT
250.020000	44.72	46.00	1.30	132	329	HORI

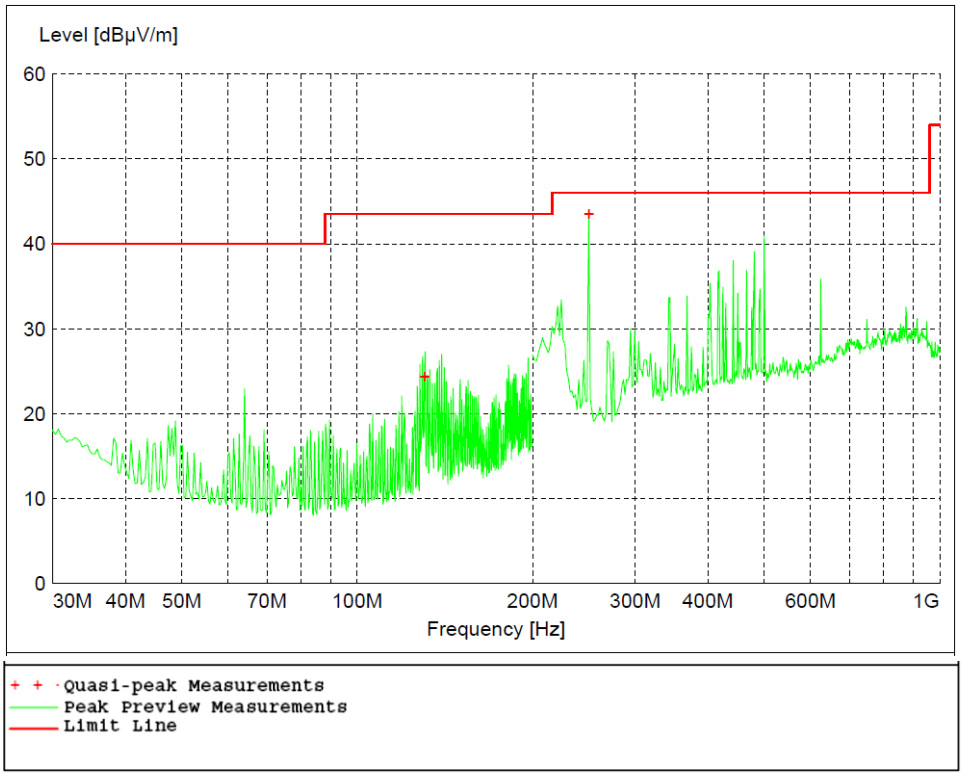

Figure 5 - Radiated Emissions Plot, High Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
130.620000	24.37	43.50	19.20	100	293	VERT
250.020000	43.52	46.00	2.50	119	332	HORI

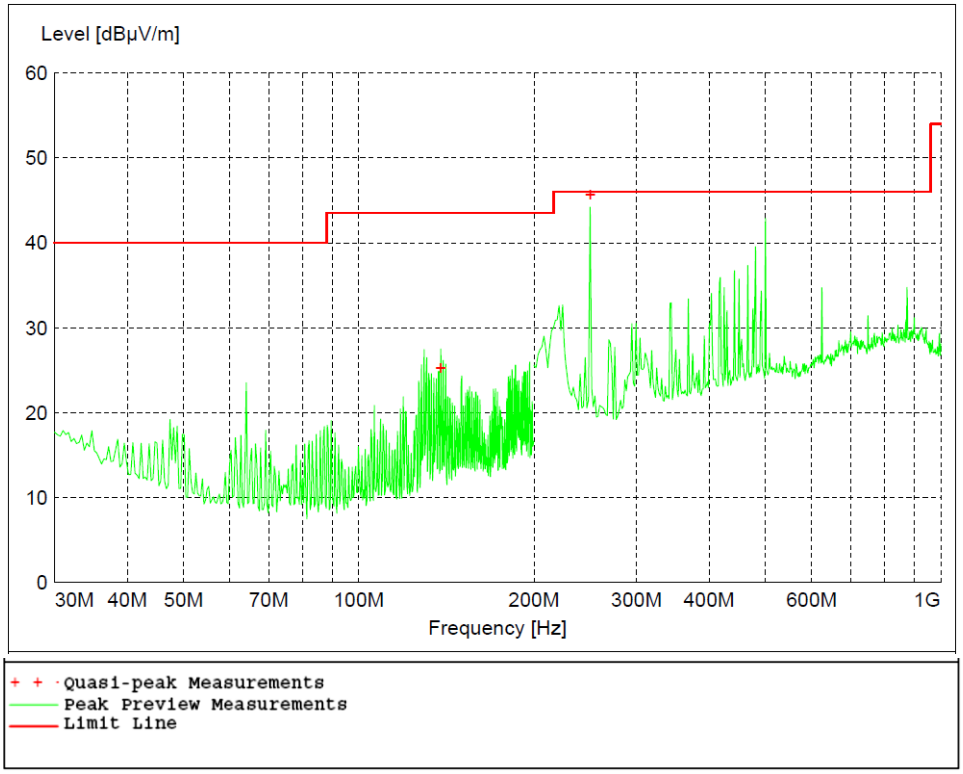

Figure 6 - Radiated Emissions Plot, Receive

Table 5 - Radiated Emissions Quasi-peak and Peak Measurements, Receive, 802.11g

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
138.300000	25.26	43.5	18.3	99	212	VERT
250.020000	45.72	46	0.3	119	325	HORI

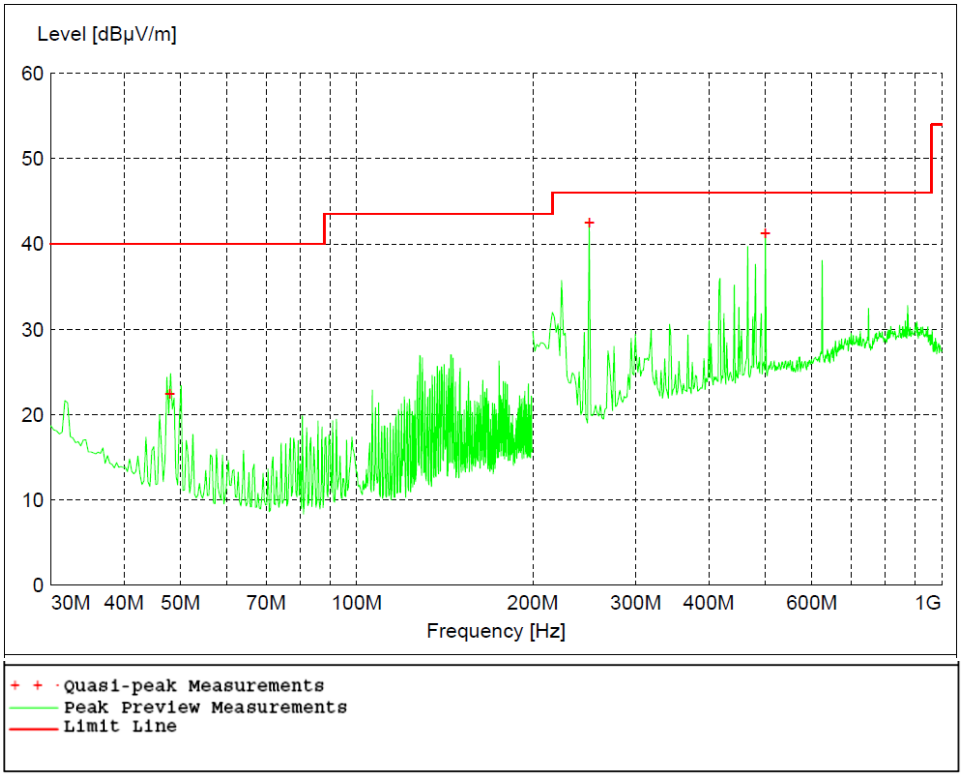

Figure 7 - Radiated Emissions Plot, Low Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
48.000000	22.52	40.0	17.48	216	216	VERT
250.020000	42.59	46.0	3.41	99	143	VERT
499.980000	41.28	46.0	4.72	101	208	HORI

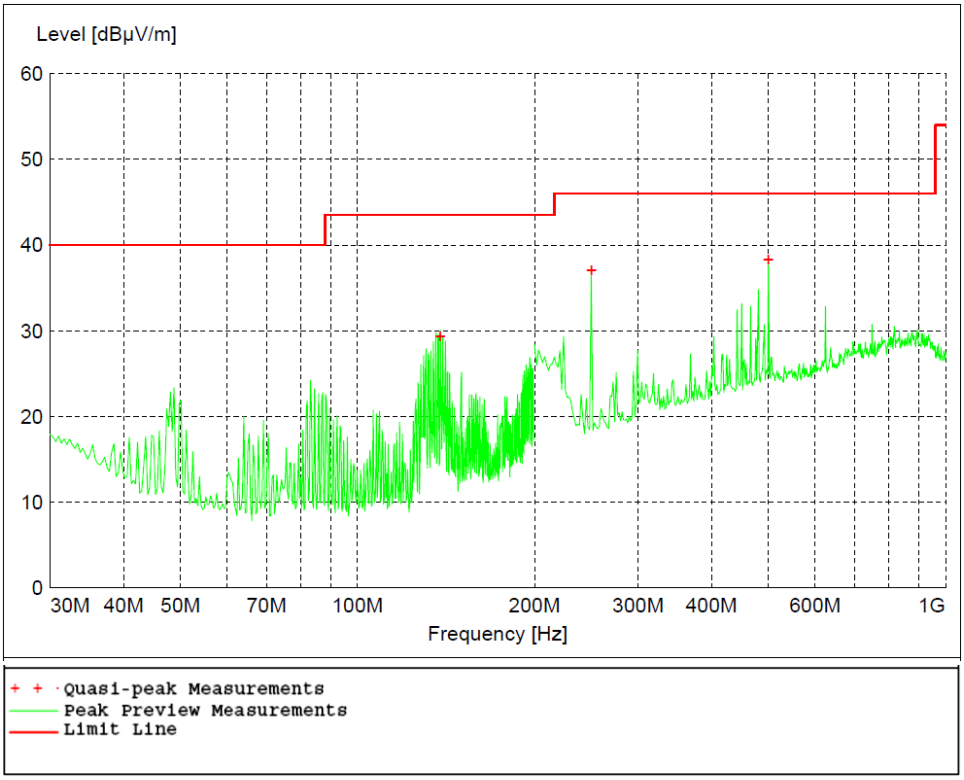

Figure 8 - Radiated Emissions Plot, Mid Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
138.300000	29.43	43.50	14.10	103	226	VERT
250.020000	37.05	46.00	8.90	100	214	VERT
499.980000	38.34	46.00	7.70	193	150	VERT

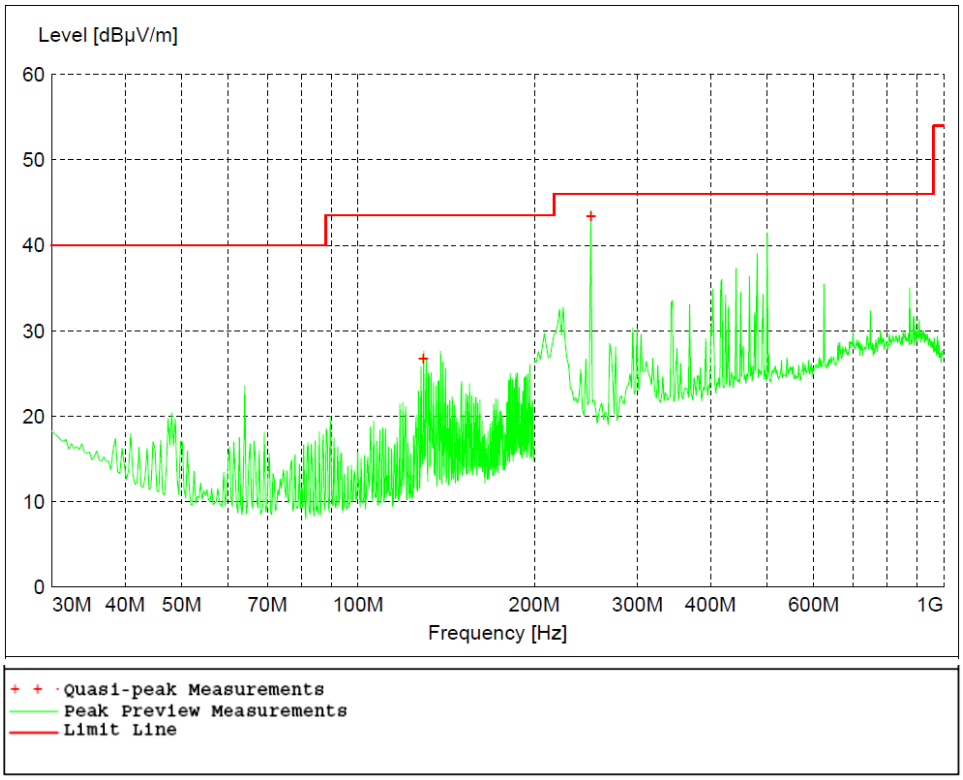

Figure 9 - Radiated Emissions Plot, High Channel

Table 8 - Radiated Emissions Quasi-peak Measurements, High Channel, 802.11g

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
129.360000	26.82	43.50	16.70	100	231	VERT
250.020000	43.44	46.00	2.60	129	329	HORI

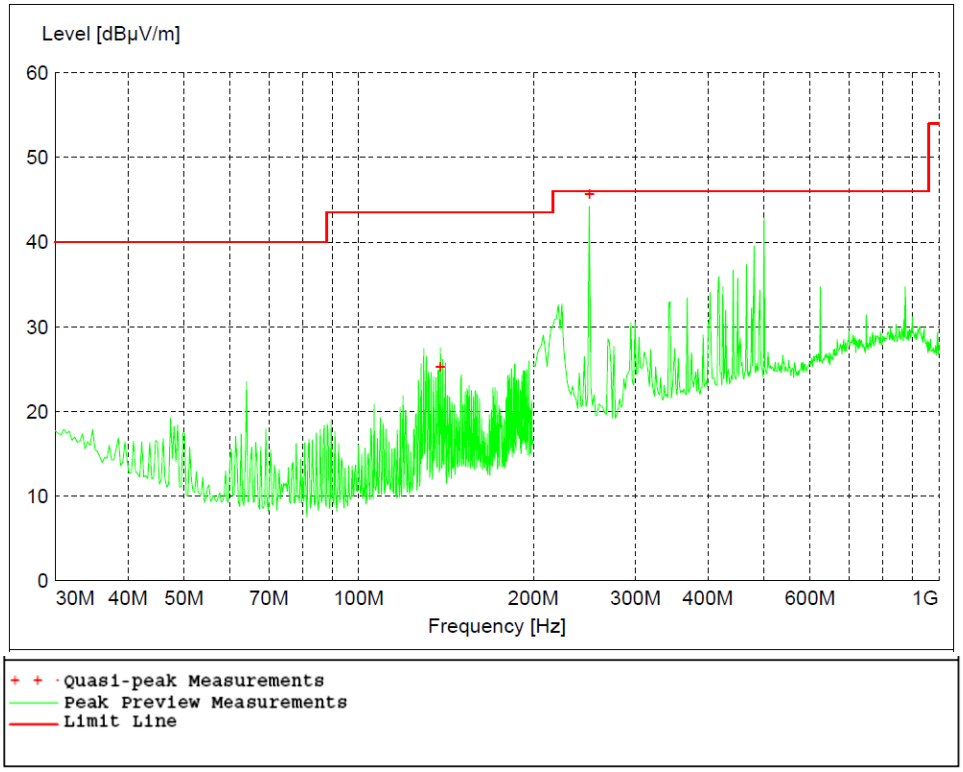

Figure 10 - Radiated Emissions Plot, Receive

Table 9 - Radiated Emissions Quasi-peak and Peak Measurements, Receive, 802.11n

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
138.300000	25.26	43.50	18.3	99	212	VERT
250.020000	45.72	46.00	0.30	119	325	HORI

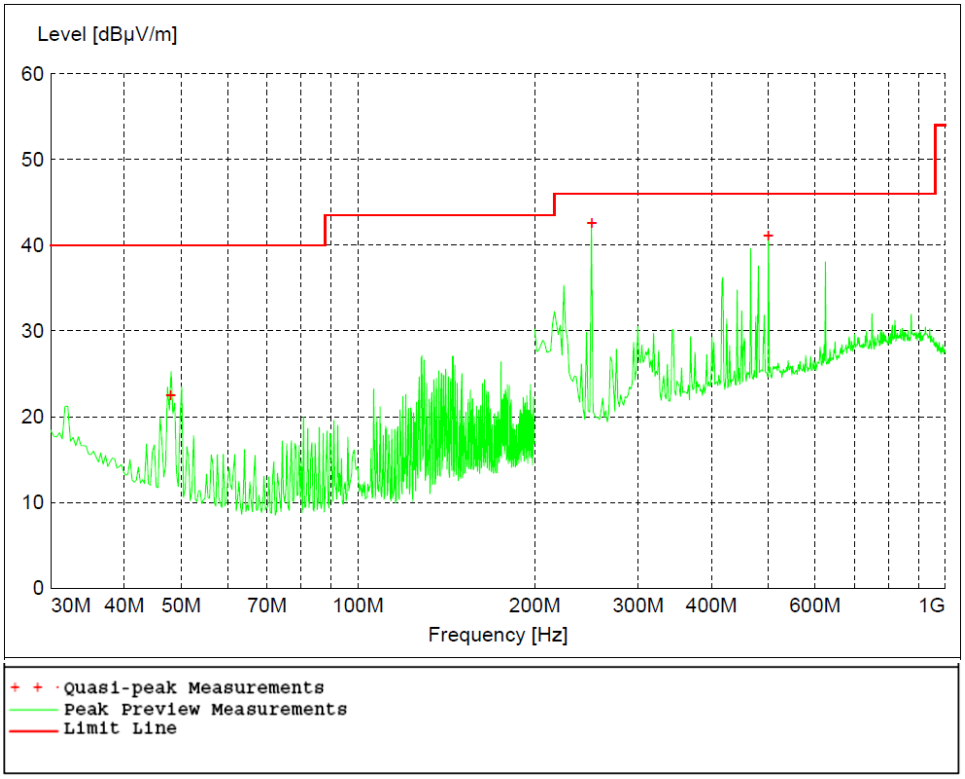

Figure 11 - Radiated Emissions Plot, Low Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
48.000000	22.52	40.00	17.50	206	157	VERT
250.020000	42.62	46.00	3.40	100	139	VERT
499.980000	41.14	46.00	4.90	100	205	HORI

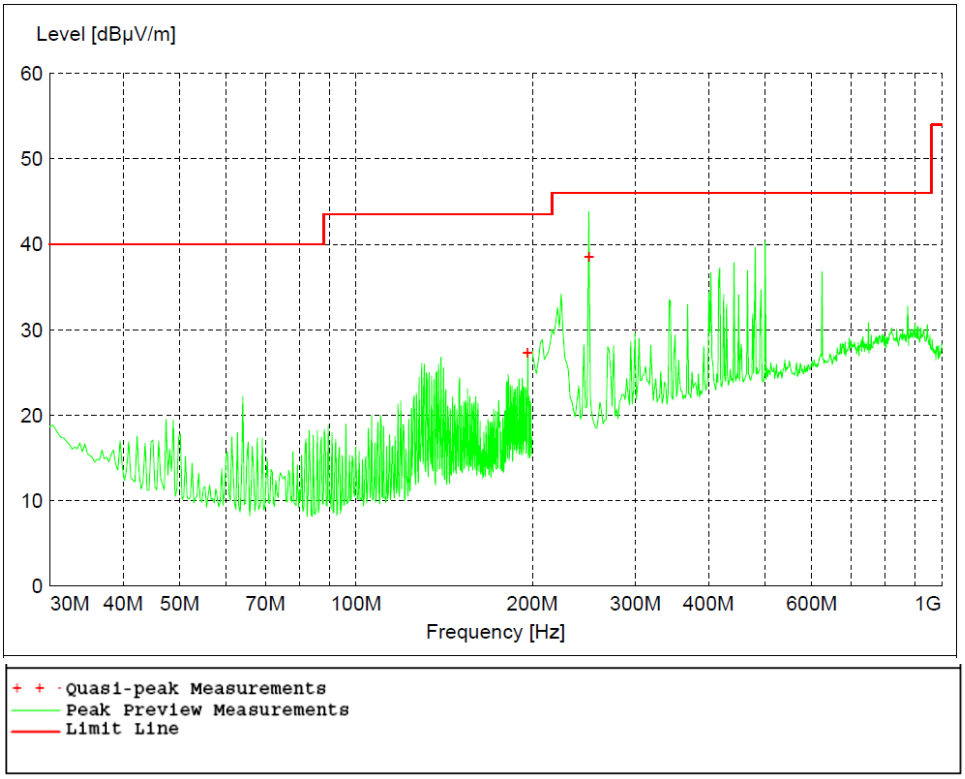

Figure 12 - Radiated Emissions Plot, Mid Channel

Table 11 - Radiated Emissions Quasi-peak Measurements, Mid Channel, 802.11n

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
196.320000	27.31	43.50	16.20	102	293	VERT
250.020000	38.56	46.00	7.40	130	334	HORI

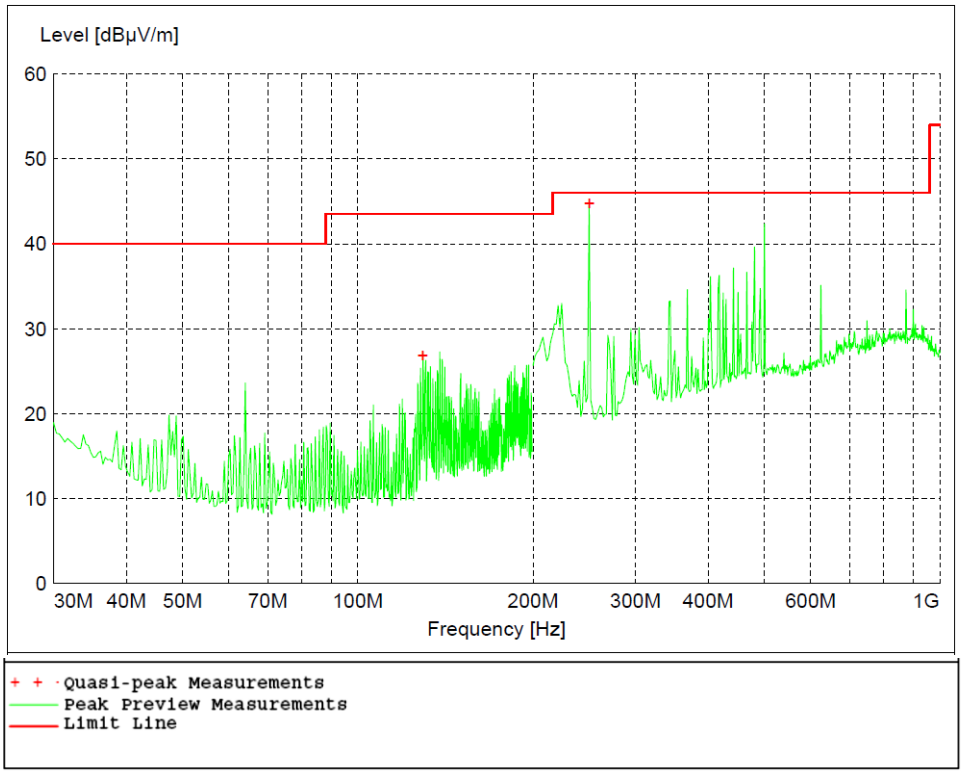

Figure 13 - Radiated Emissions Plot, High Channel

Table 12 - Radiated Emissions Quasi-peak Measurements, High Channel, 802.11n

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
129.360000	26.83	43.50	16.70	99	224	VERT
250.020000	44.78	46.00	1.20	122	334	HORI

Table 13 - Radiated Emissions Peak Detector Measurements, Low Channel, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
2412.000000	104.61	NA	NA	258	175	HORI	b
4824.000000	51.15	74.00	22.85	217	216	HORI	b
7236.000000	49.43	74.00	24.57	99	119	VERT	b
2412.000000	102.14	NA	NA	257	175	HORI	g
4825.600000	43.46	74.00	30.54	120	45	VERT	g
2412.000000	103.04	NA	NA	167	166	HORI	n
4919.800000	44.13	74.00	29.87	159	251	HORI	n
No signals detected above system sensitivity							

Table 14 - Radiated Emissions Average Detector Measurements, Low Channel, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
2412.000000	95.93	NA	NA	258	175	HORI	b
4824.000000	37.61	54.00	16.39	217	216	HORI	b
7236.000000	35.37	54.00	18.63	99	119	VERT	b
2412.000000	90.09	NA	NA	257	175	HORI	g
4825.600000	29.61	54.00	24.39	120	45	VERT	g
2412.000000	90.74	NA	NA	167	166	HORI	n
4919.800000	31.25	54.00	22.75	159	251	HORI	n
No signals detected above system sensitivity							

Table 15 - Radiated Emissions Peak Measurements, Middle Channel, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
2437.000000	106.12	NA	NA	163	166	HORI	b
4874.000000	44.44	74.00	29.56	177	219	HORI	b
7312.600000	55.22	74.00	18.78	119	126	VERT	b
2437.000000	103.52	NA	NA	163	165	HORI	g
4873.400000	43.68	74.00	30.32	103	4	VERT	g
7311.200000	51.80	74.00	22.20	107	121	VERT	g
2437.000000	102.42	NA	NA	143	157	VERT	n
4885.000000	45.40	74.00	28.60	156	326	HORI	n
7311.600000	52.31	74.00	21.69	136	126	VERT	n

Table 16 - Radiated Emissions Average Measurements, Middle Channel, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
2437.000000	97.19	NA	NA	163	166	HORI	b
4874.000000	30.68	54.00	23.32	177	219	HORI	b
7312.600000	42.57	54.00	11.43	119	126	VERT	b
2437.000000	91.01	NA	NA	163	165	HORI	g
4873.400000	29.89	54.00	24.11	103	4	VERT	g
7311.200000	38.00	54.00	16.00	107	121	VERT	g
2437.000000	89.85	NA	NA	143	157	VERT	n
4885.000000	31.22	54.00	22.78	156	326	HORI	n
7311.600000	38.46	54.00	15.54	136	126	VERT	n

Table 17 - Radiated Emissions Peak Measurements, High Channel, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
2462.000000	105.12	NA	NA	117	158	VERT	b
4924.000000	54.69	74.00	19.31	133	116	HORI	b
7386.000000	46.70	74.00	27.30	100	82	VERT	b
2462.000000	102.42	NA	NA	117	157	VERT	g
4928.600000	44.12	74.00	29.88	221	270	HORI	g
7387.200000	50.80	74.00	23.20	100	207	VERT	g
2462.000000	96.95	NA	NA	174	339	VERT	n
5966.600000	46.90	74.00	27.10	126	107	VERT	n
No signals detected above system sensitivity							

Table 18 - Radiated Emissions Average Measurements, High Channel, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
2462.000000	96.12	NA	NA	117	158	VERT	b
4924.000000	41.48	54.00	12.52	133	116	HORI	b
7386.000000	32.87	54.00	21.13	100	82	VERT	b
2462.000000	90.38	NA	NA	117	157	VERT	g
4928.600000	30.83	54.00	23.17	221	270	HORI	g
7387.200000	36.89	54.00	17.11	100	207	VERT	g
2462.000000	83.57	NA	NA	174	339	VERT	n
5966.600000	32.66	54.00	21.34	126	107	VERT	n
2462.000000	96.12	NA	NA	117	158	VERT	n
No signals detected above system sensitivity							

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) 11.9.2.2.2

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

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

Deviations from test standard:
No deviation.

Test setup:

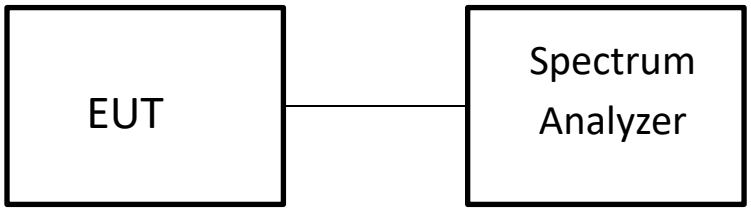

Figure 14 – Peak Output Power Measurements Test Setup

EUT operating conditions:
The EUT was powered by 12 VDC Marine 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

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	PEAK OUTPUT POWER (dBm) MU = ±1.1 dB	Method	RESULT
Low	2412	802.11b	28.33*	Conducted	PASS
Middle	2437	802.11b	28.14*	Conducted	PASS
High	2462	802.11b	28.13*	Conducted	PASS
Low	2412	802.11g	27.92*	Conducted	PASS
Middle	2437	802.11g	28.09*	Conducted	PASS
High	2462	802.11g	27.98*	Conducted	PASS
Low	2412	802.11n	28.06*	Conducted	PASS
Middle	2437	802.11n	28.36*	Conducted	PASS
High	2462	802.11n	27.87*	Conducted	PASS

*0.5 dB of cable loss was added as the plots don't reflect the corrected value.

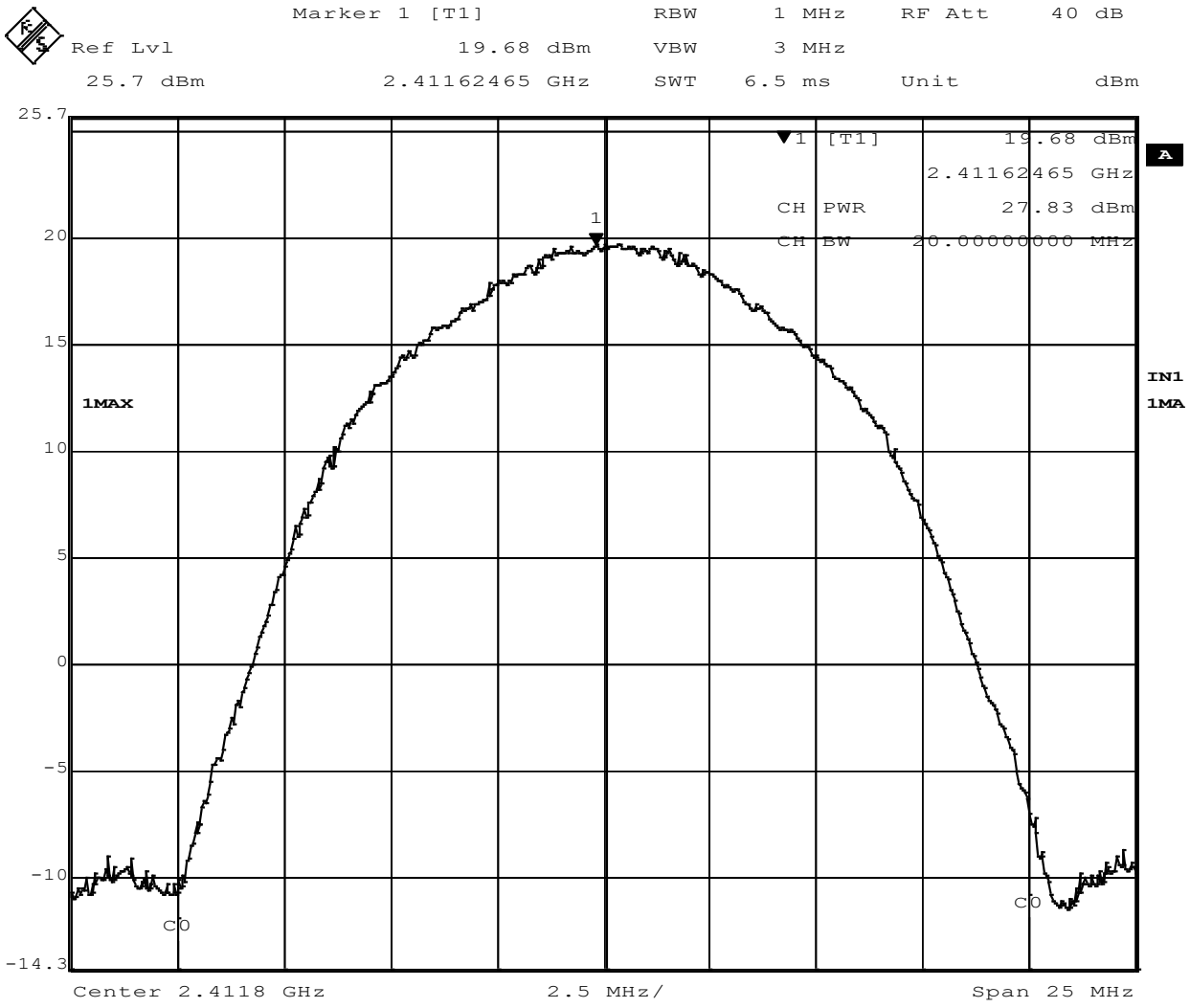

Figure 15 – Peak Power Measurement, Low Channel, 802.11b

Worst case was determined to be 11 Mbps for 802.11b

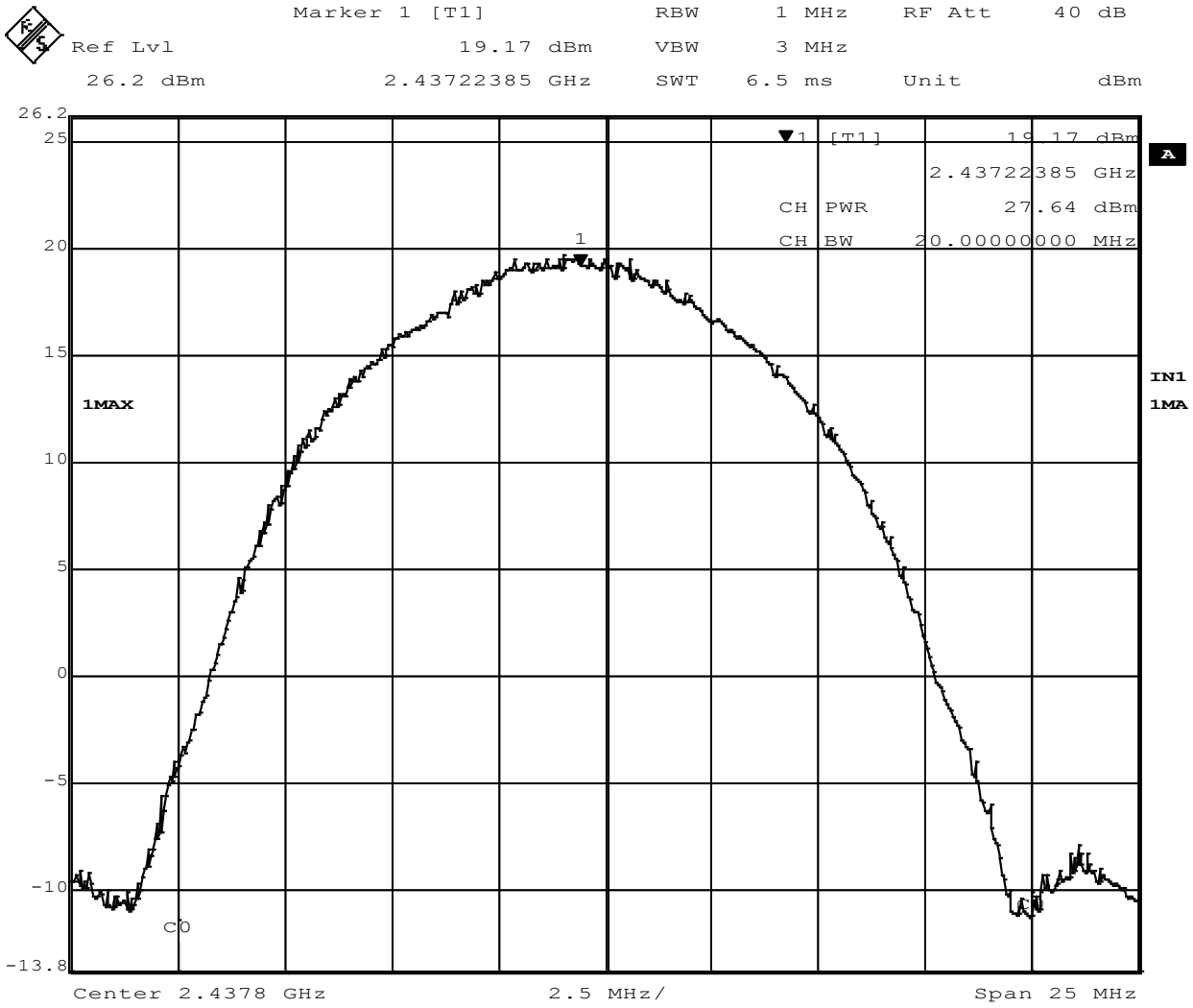

Figure 16 - Peak Power Measurement, Mid Channel, 802.11b

Worst case was determined to be 11 Mbps for 802.11b

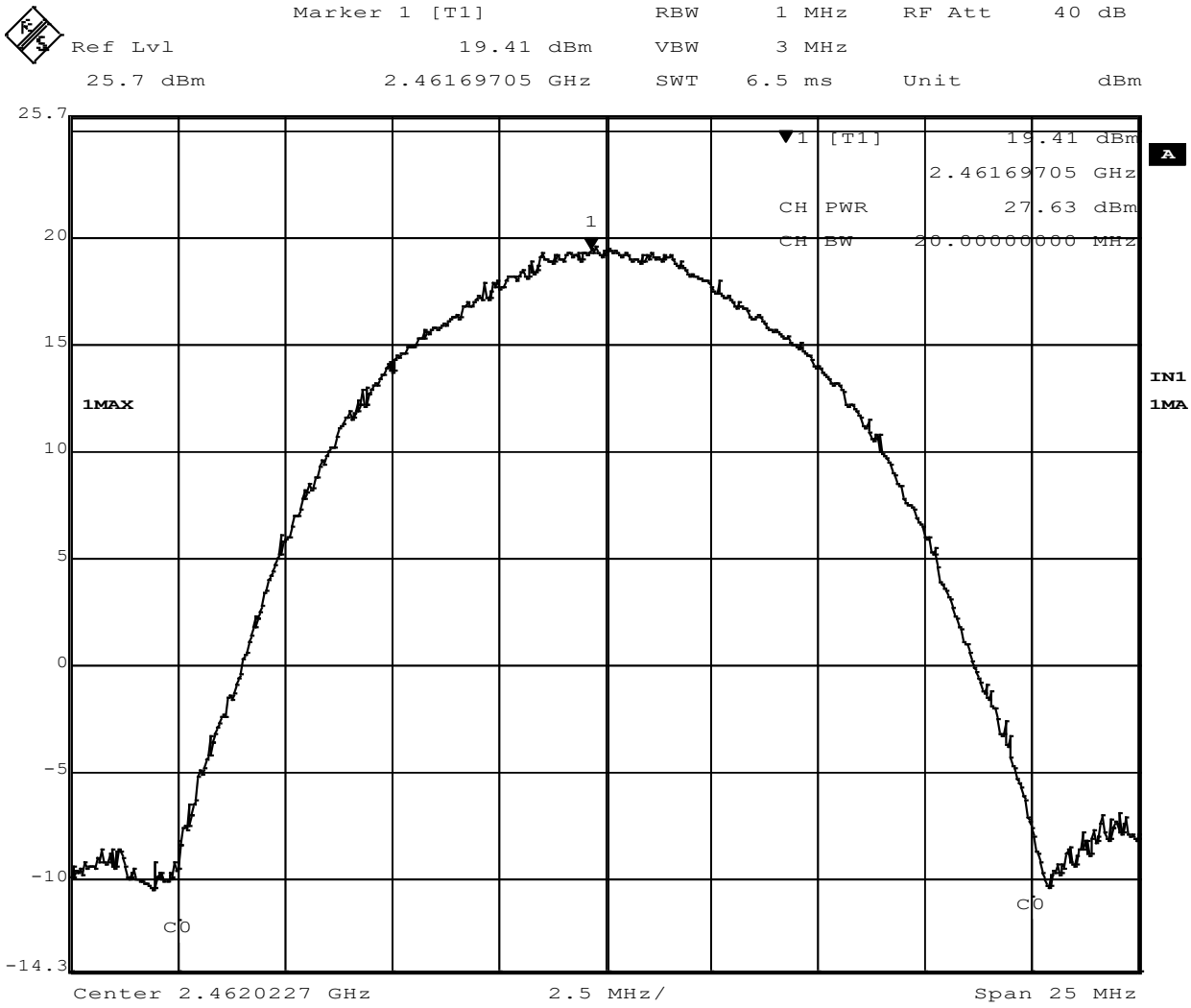

Figure 17 - Peak Power Measurement, High Channel, 802.11b

Worst case was determined to be 11 Mbps for 802.11b

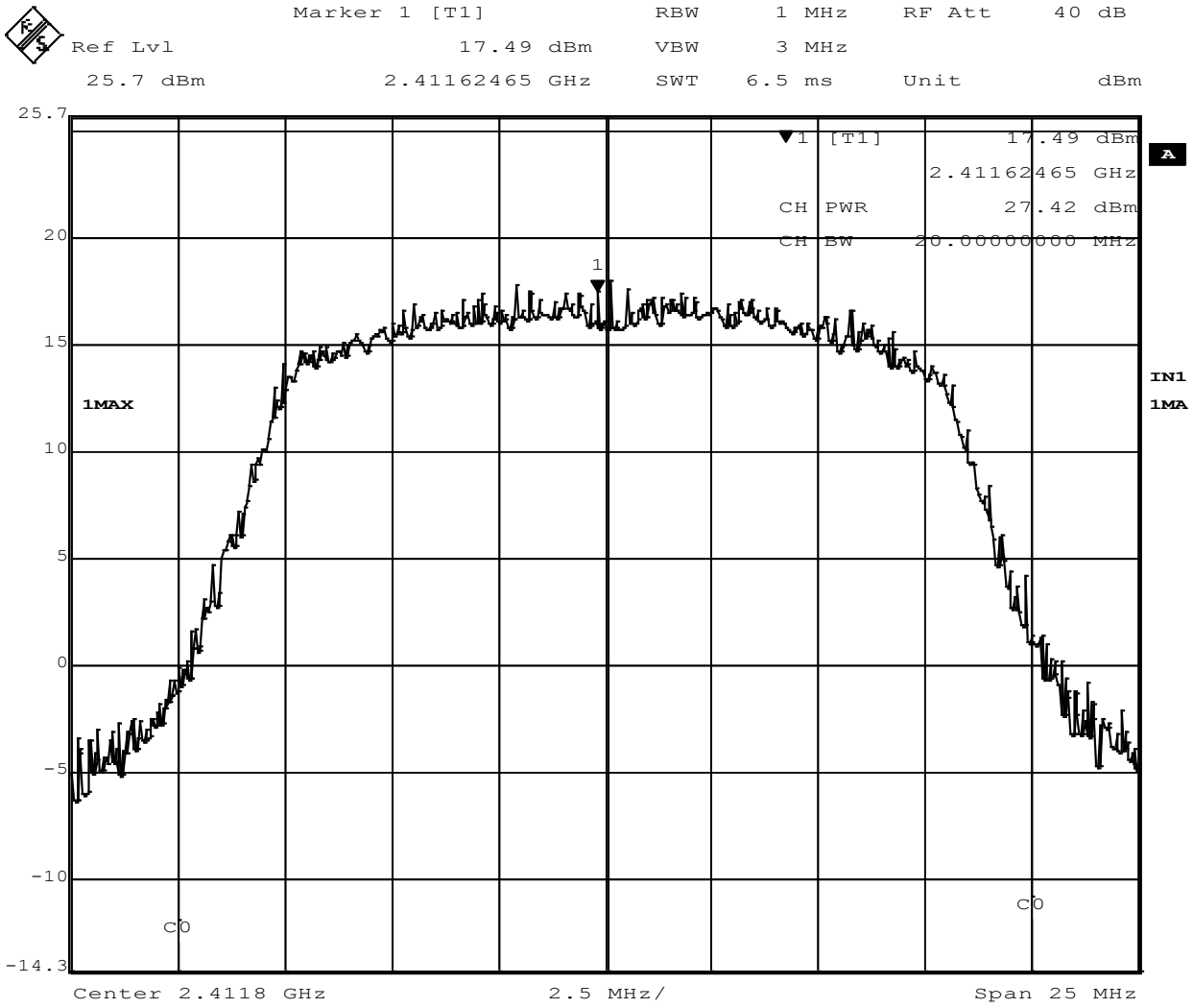

Figure 18 – Peak Power Measurement, Low Channel, 802.11g

Worst case was determined to be 54 Mbps for 802.11g

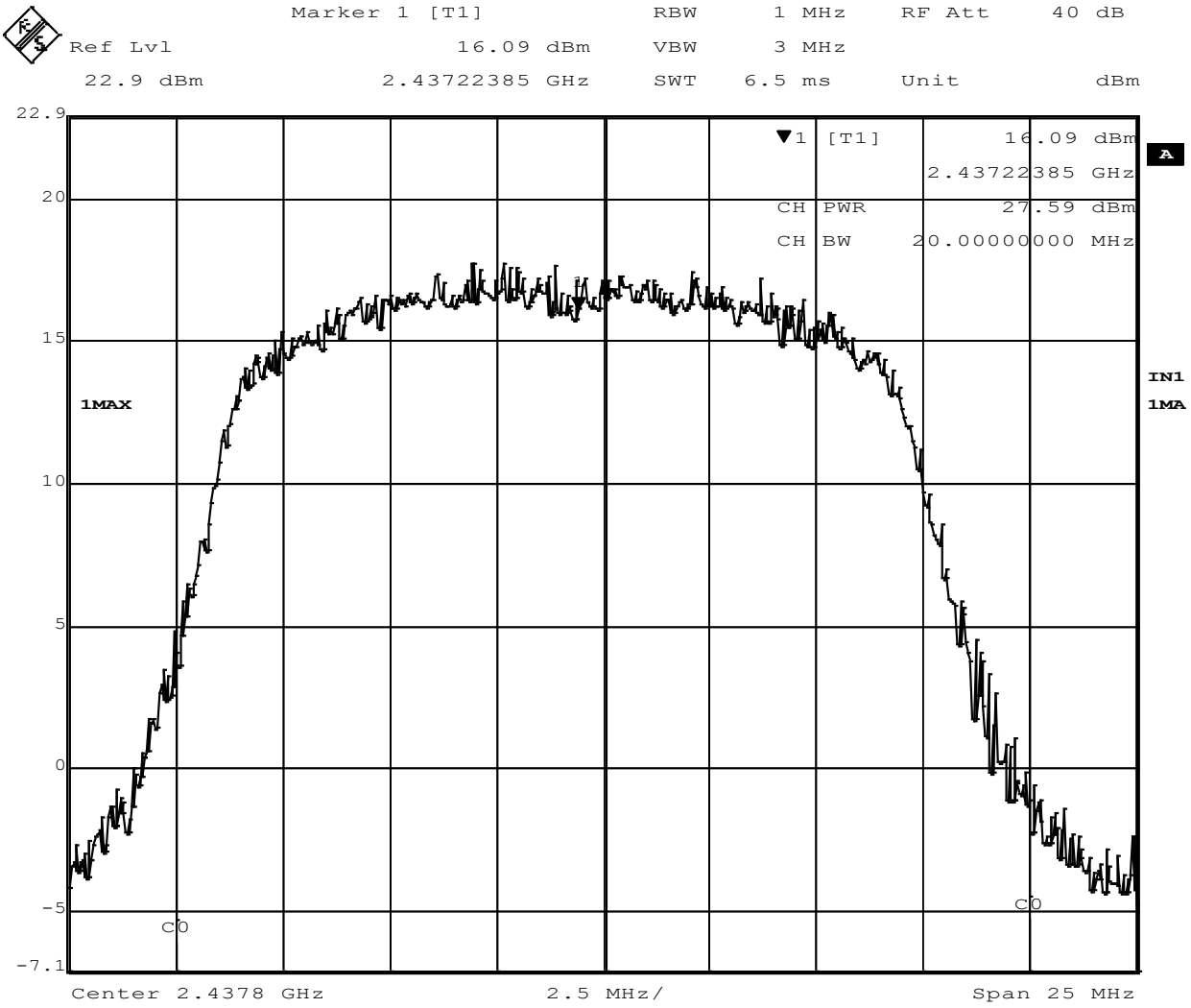

Figure 19 - Peak Power Measurement, Mid Channel, 802.1g

Worst case was determined to be 54 Mbps for 802.11g

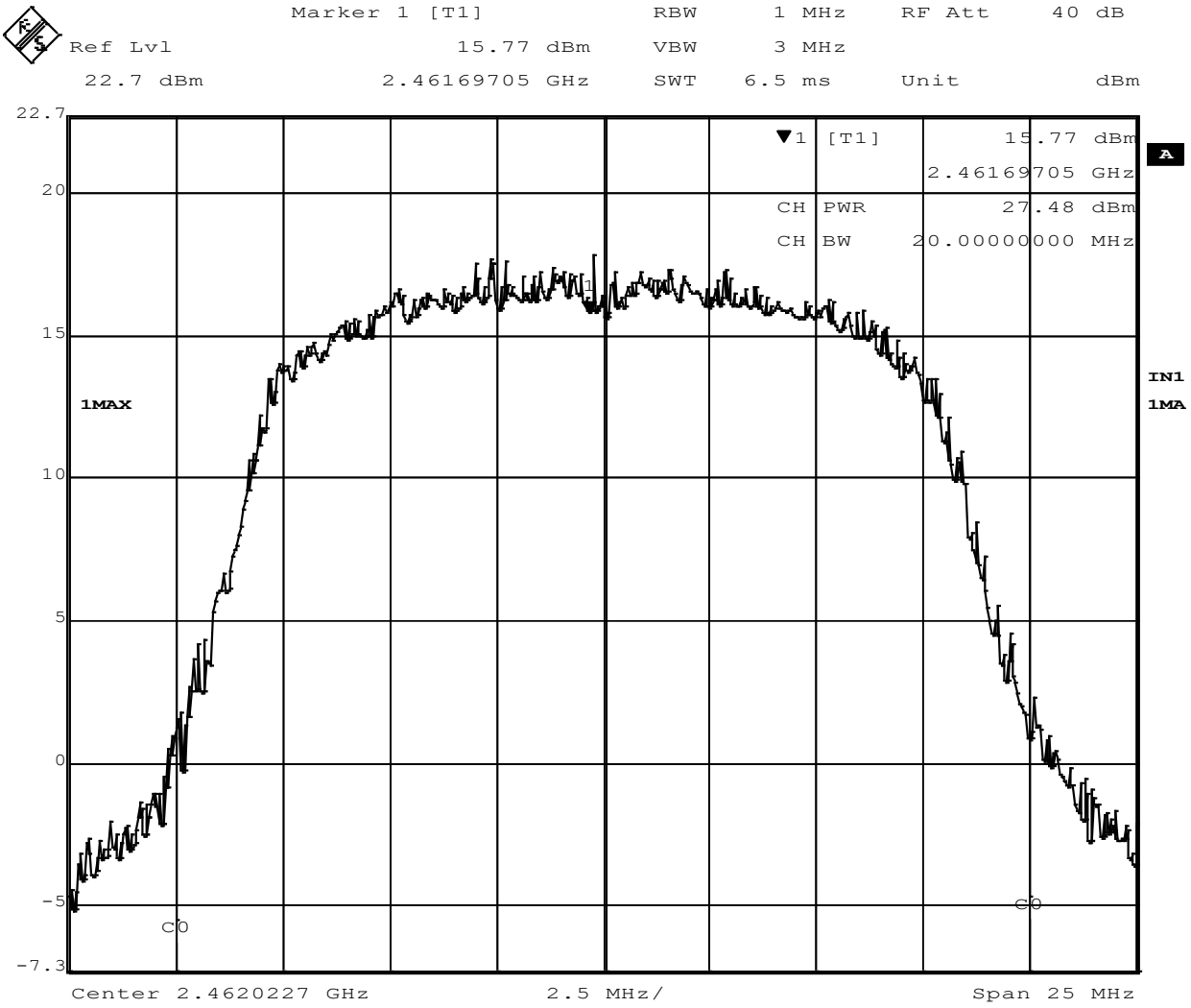

Figure 20 - Peak Power Measurement, High Channel, 802.11g

Worst case was determined to be 54 Mbps for 802.11g

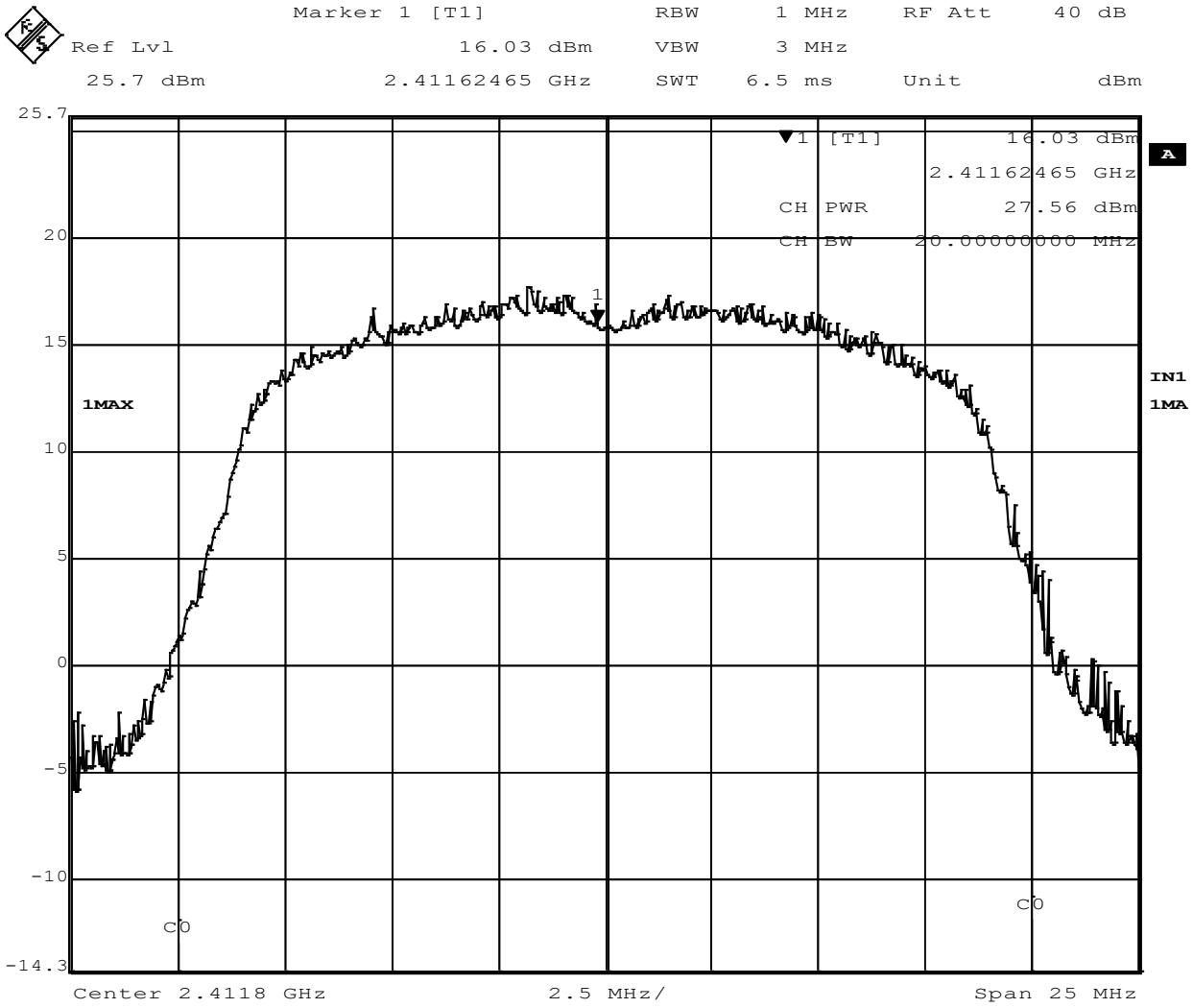

Figure 21 – Peak Power Measurement, Low Channel, 802.11n

Worst case was determined to be MSC7 for 802.11n

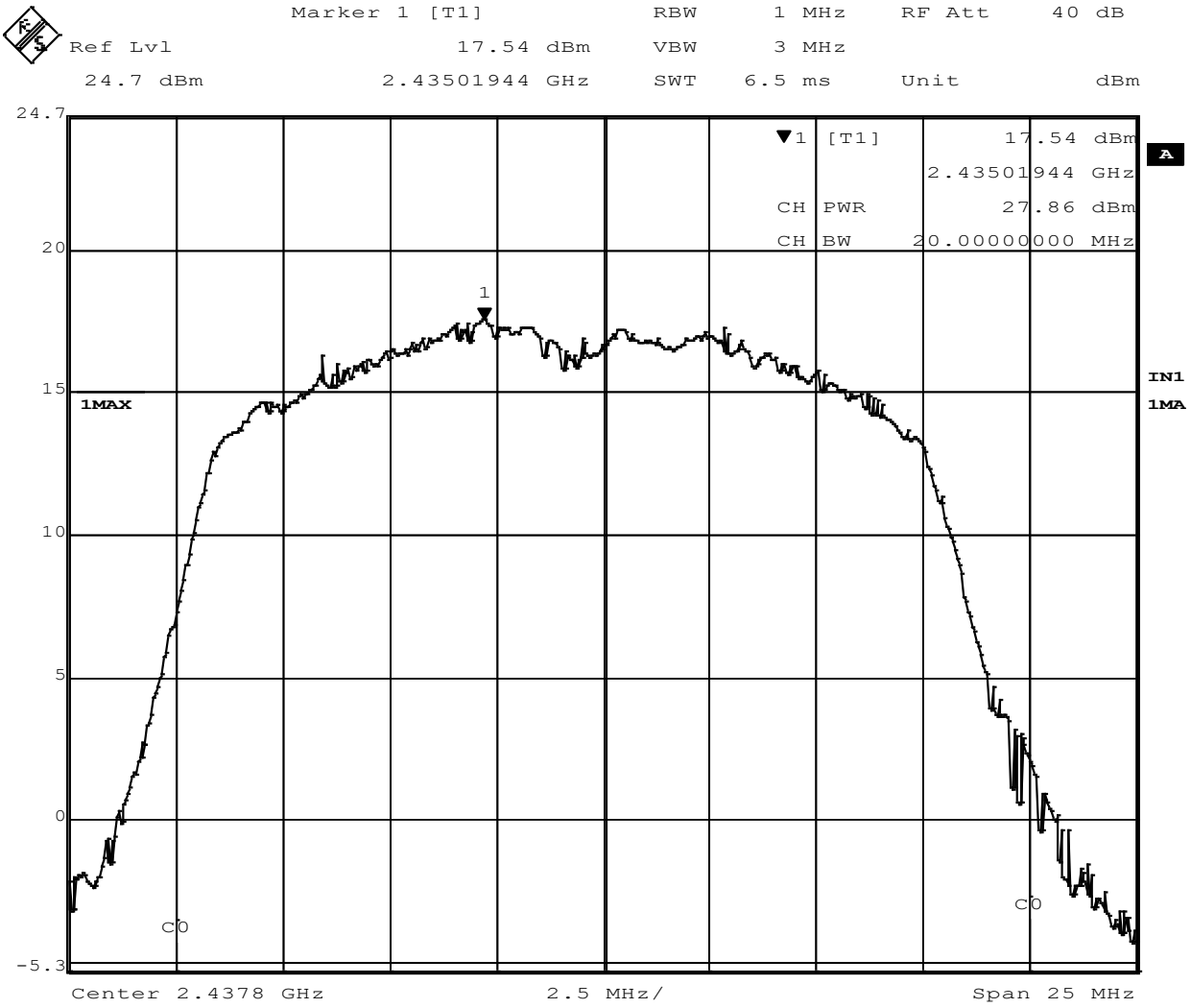

Figure 22 - Peak Power Measurement, Mid Channel, 802.1n

Worst case was determined to be MSC7 for 802.11n

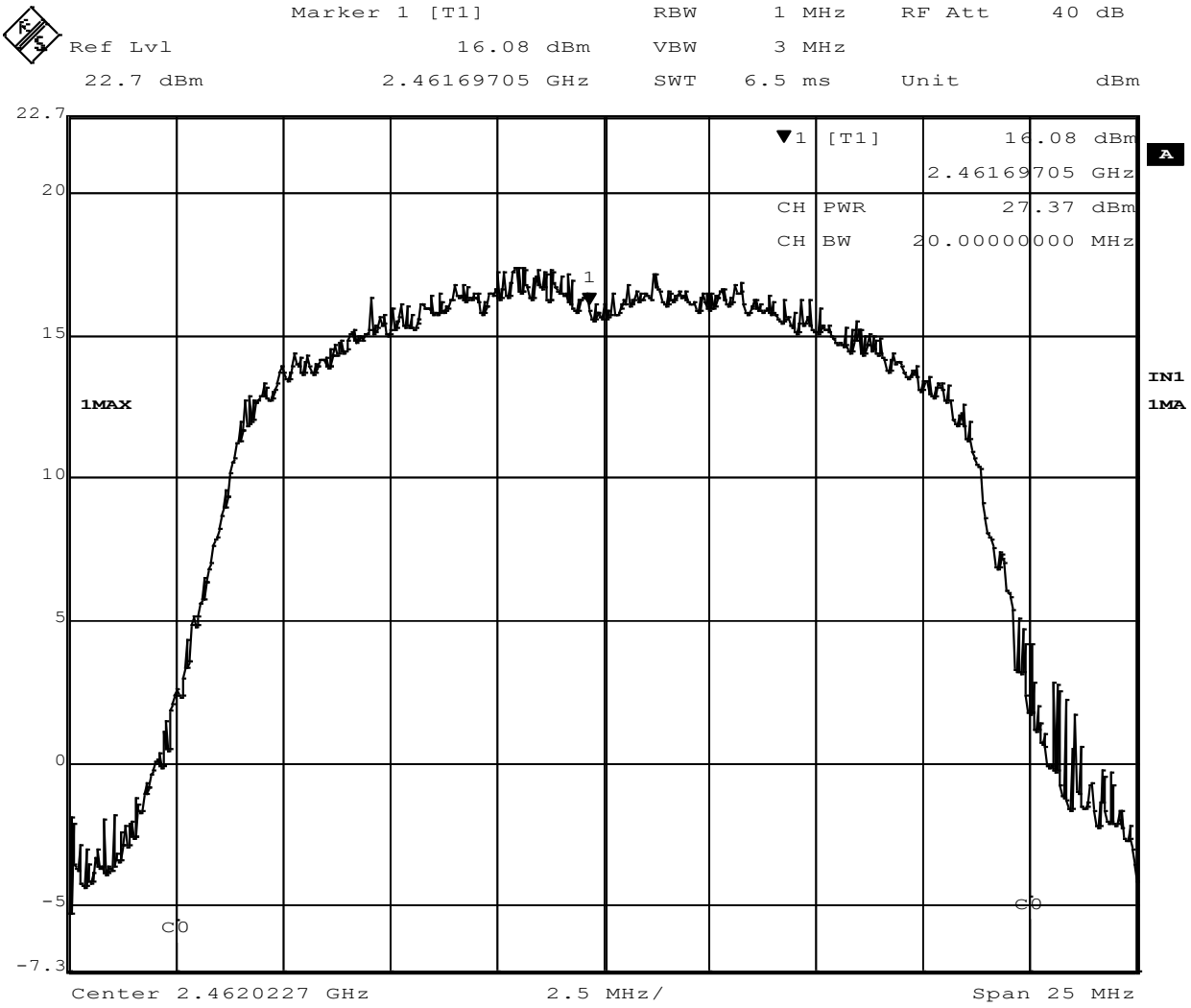

Figure 23 - Peak Power Measurement, High Channel, 802.11n

Worst case was determined to be MSC7 for 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.

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:

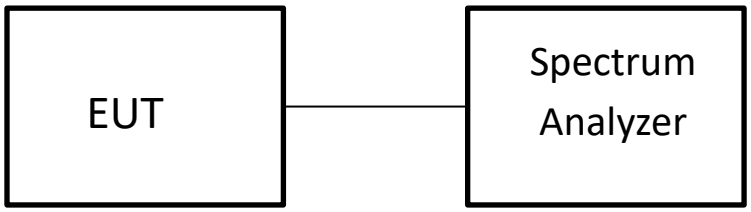

Figure 24 – Peak Output Power Measurements Test Setup

EUT operating conditions:
The EUT was powered by 12 VDC Marine battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	99% Occupied BW (MHz)
Low	2412	802.11b	14.53
Middle	2437	802.11b	14.63
High	2462	802.11b	14.83
Low	2412	802.11g	16.43
Middle	2437	802.11g	16.48
High	2462	802.11g	16.53
Low	2412	802.11n	17.59
Middle	2437	802.11n	17.64
High	2462	802.11n	17.69

6 dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	6 dB BW (MHz)
Low	2412	802.11b	9.30
Middle	2437	802.11b	9.13
High	2462	802.11b	8.65
Low	2412	802.11g	15.08
Middle	2437	802.11g	15.38
High	2462	802.11g	15.44
Low	2412	802.11n	14.54
Middle	2437	802.11n	15.62
High	2462	802.11n	12.08

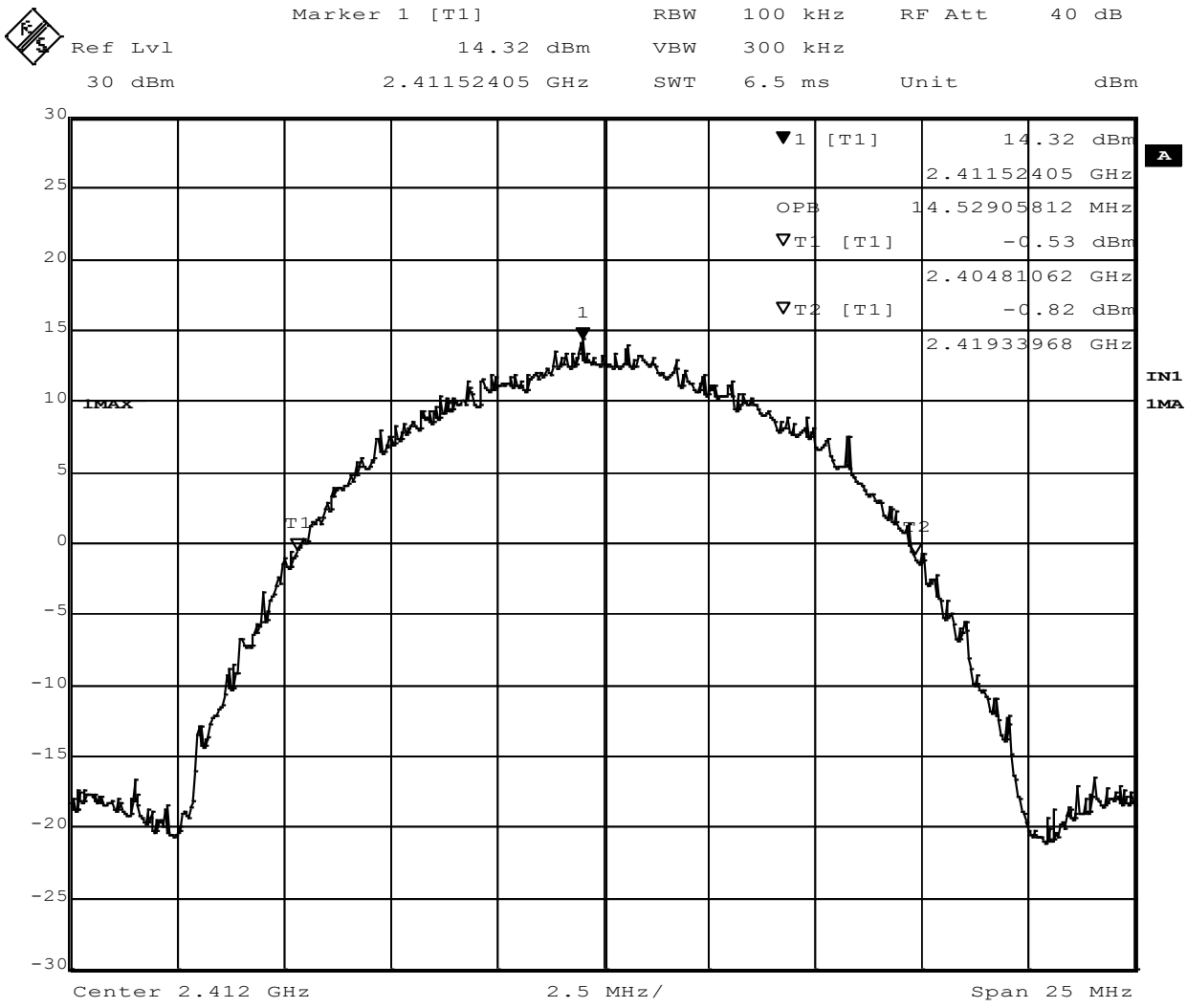

Figure 25 - 99% Occupied Bandwidth, Low Channel, 802.11b

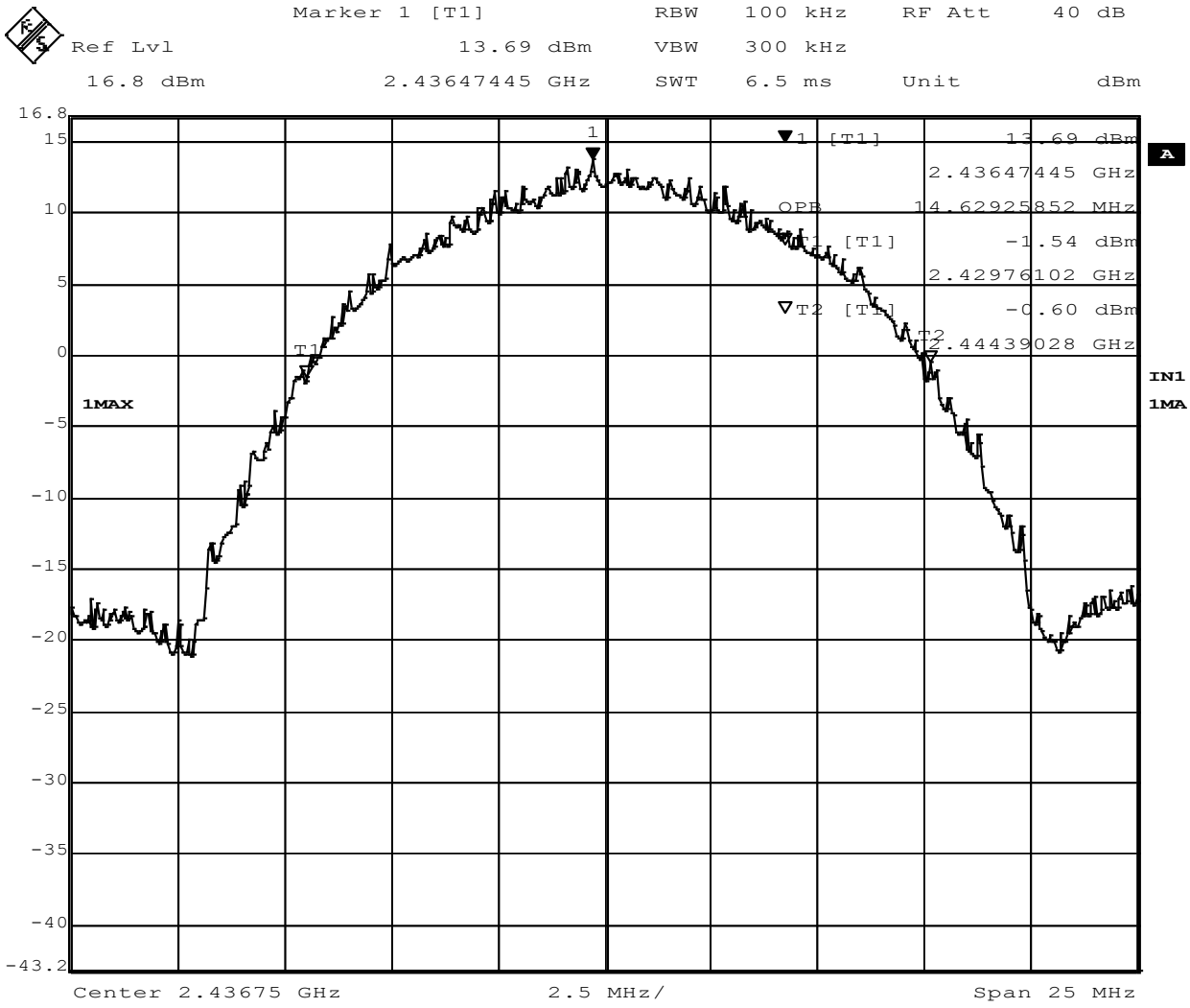

Figure 26 - 99% Occupied Bandwidth, Mid Channel, 802.11b

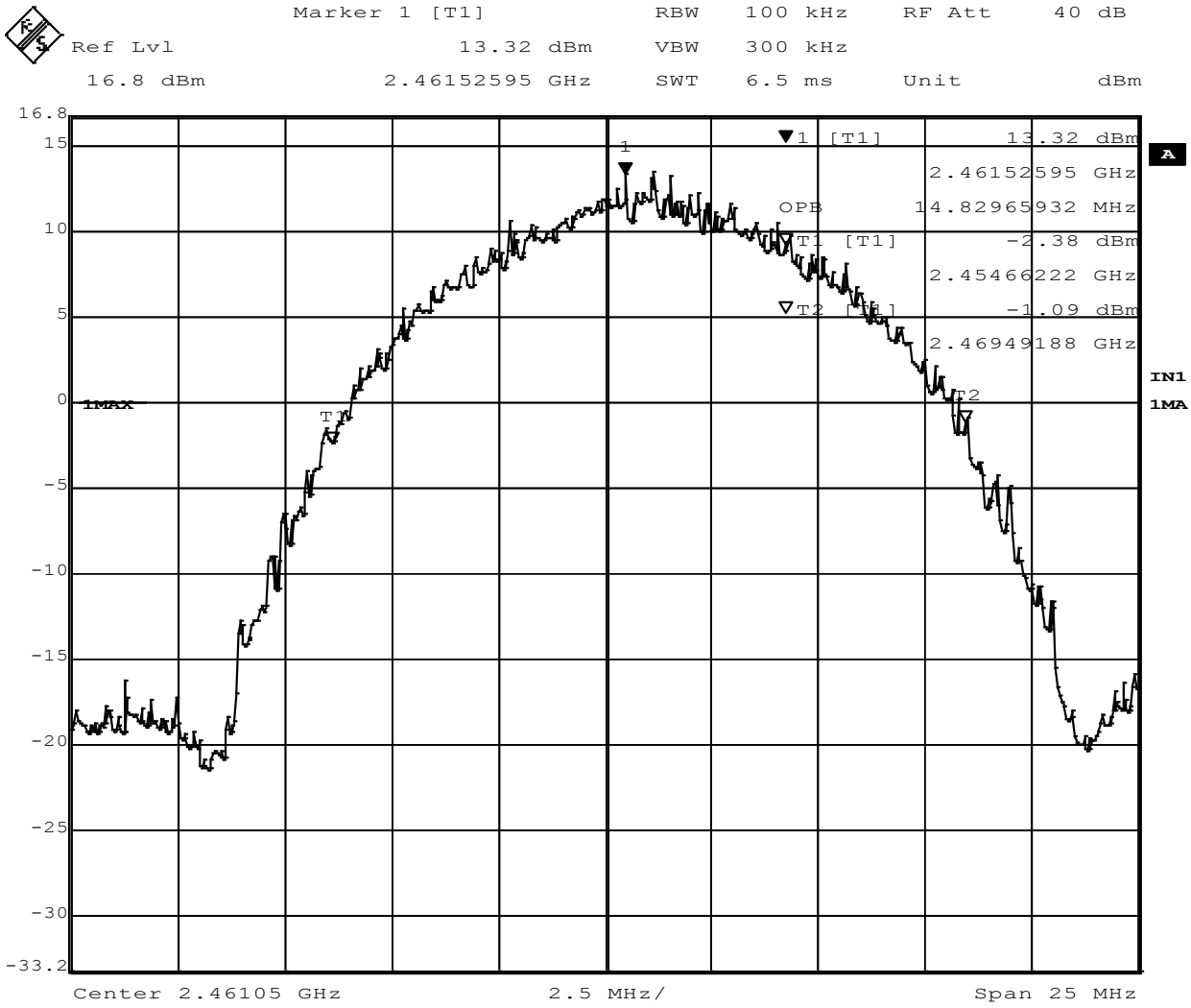

Figure 27 - 99% Occupied Bandwidth, High Channel, 802.11b

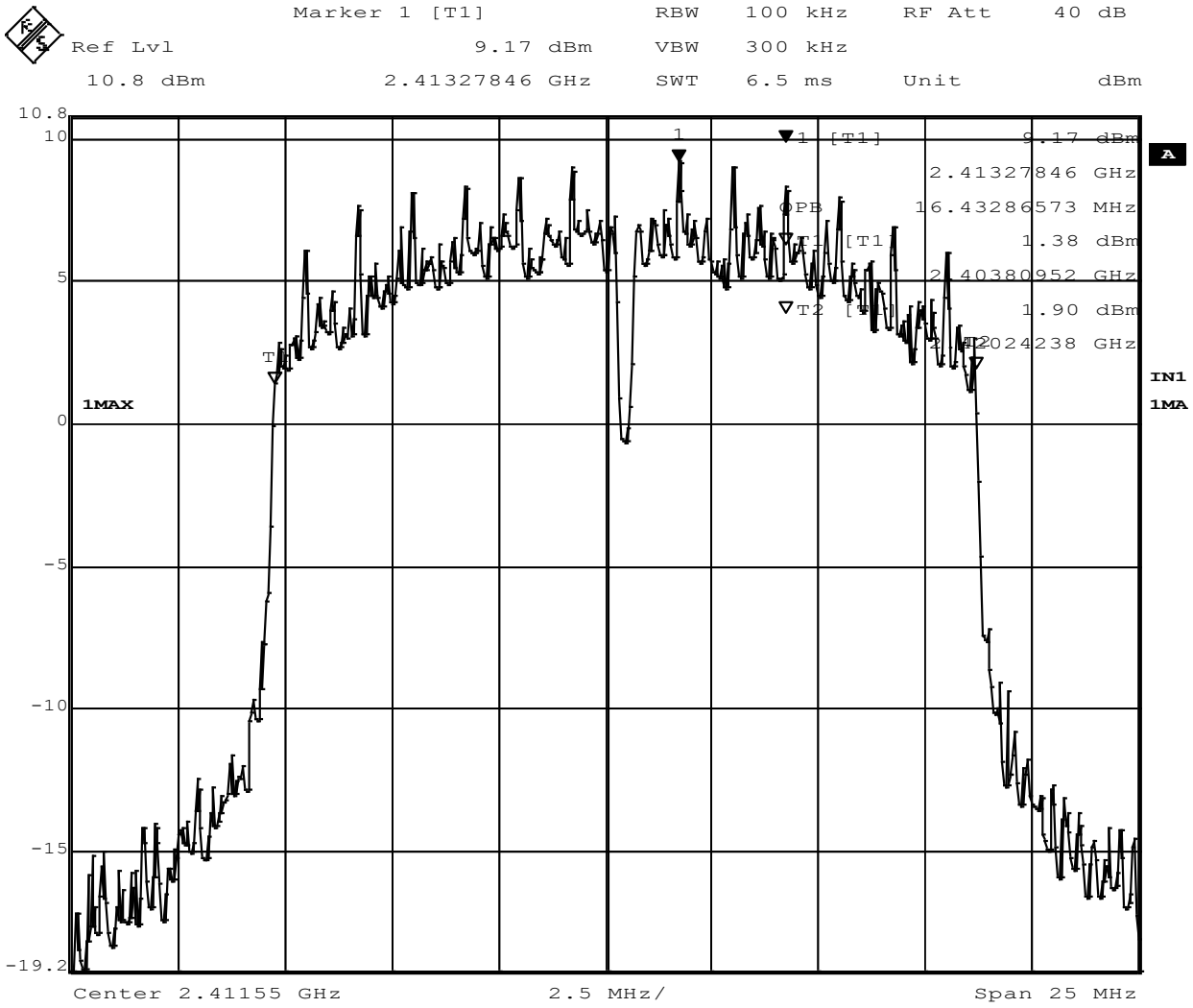

Figure 28 - 99% Occupied Bandwidth, Low Channel, 802.11g

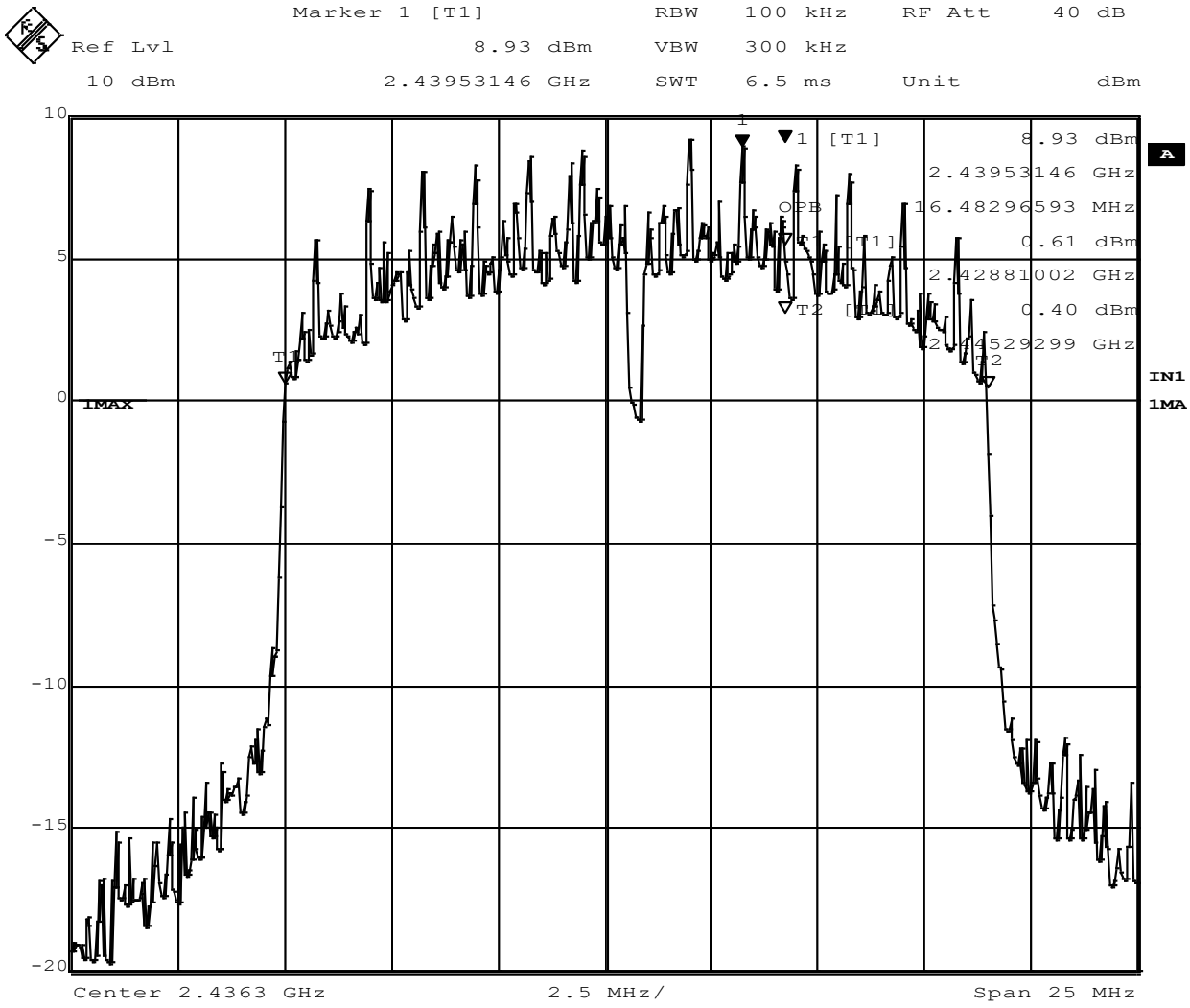

Figure 29 - 99% Occupied Bandwidth, Mid Channel, 802.11g

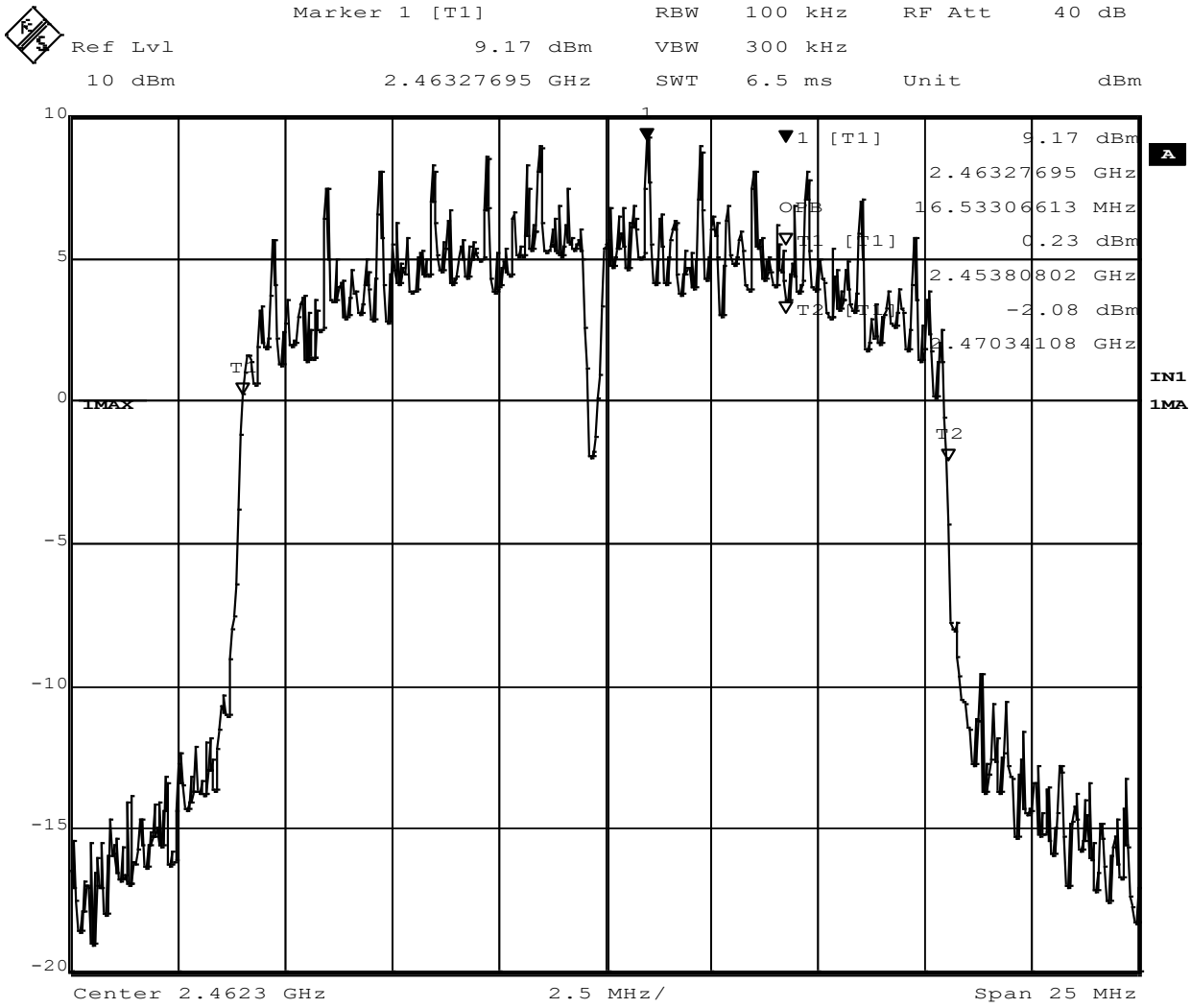

Figure 30 - 99% Occupied Bandwidth, High Channel, 802.11g

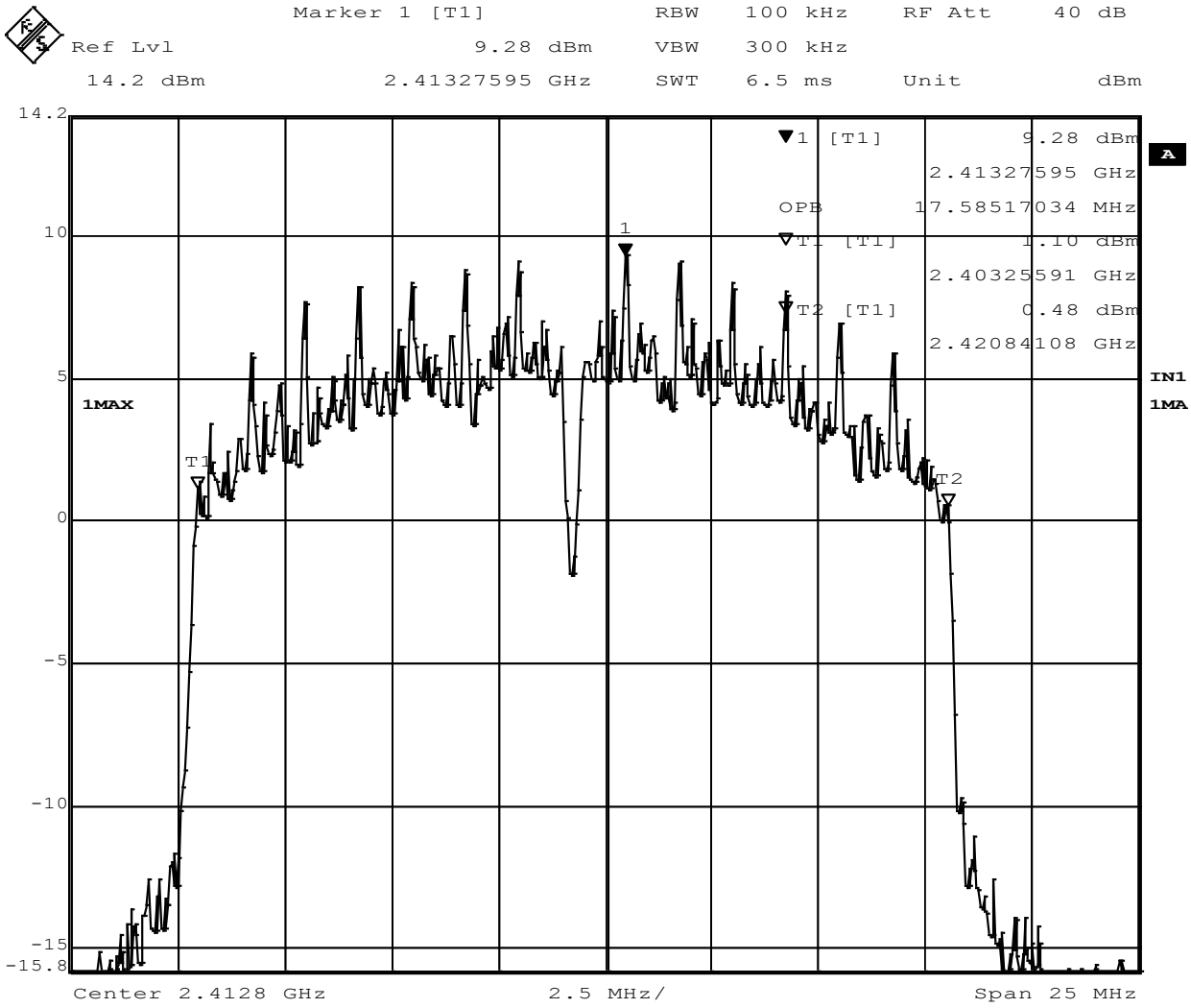

Figure 31 - 99% Occupied Bandwidth, Low Channel, 802.11n

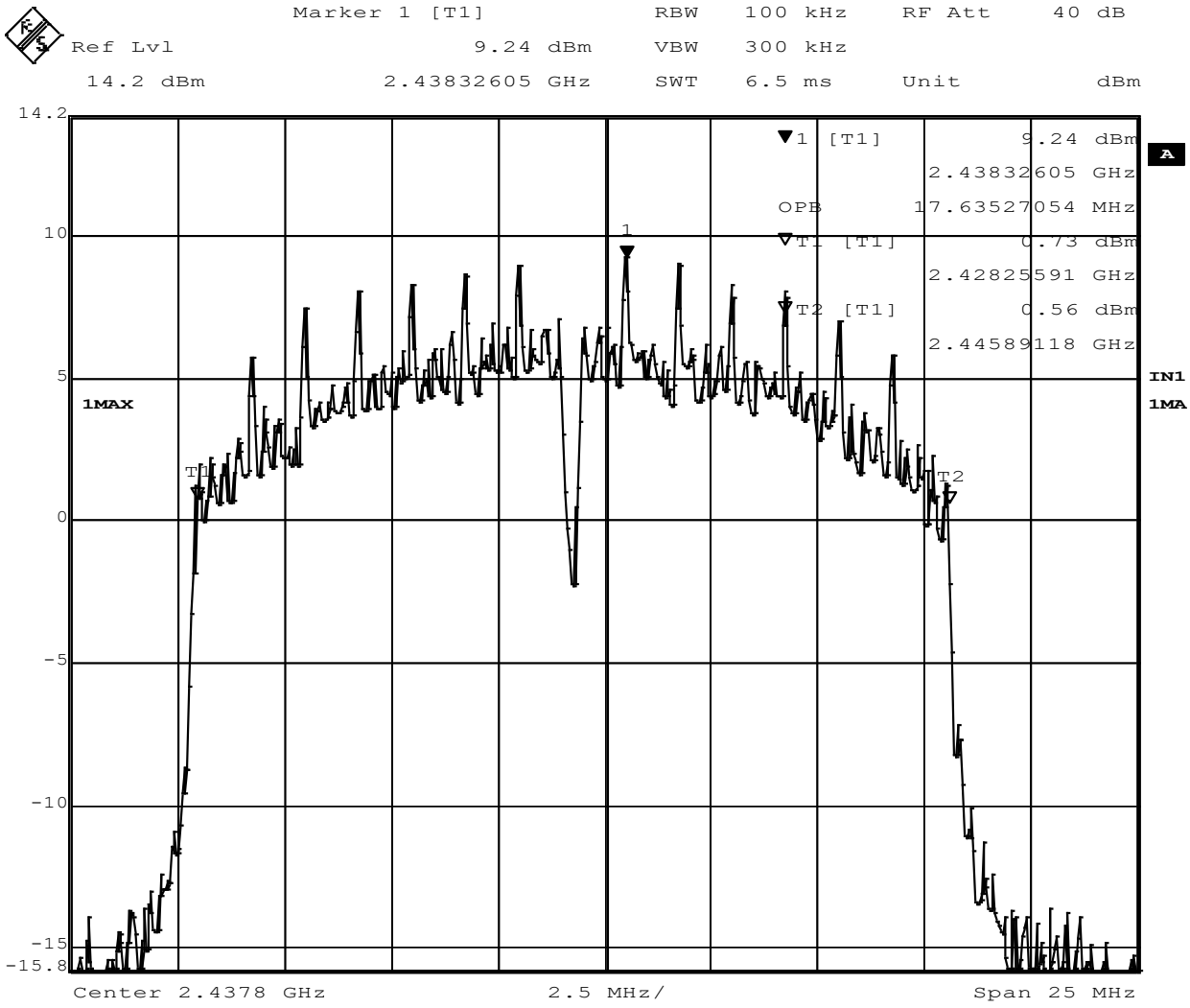

Figure 32 - 99% Occupied Bandwidth, Mid Channel, 802.11n

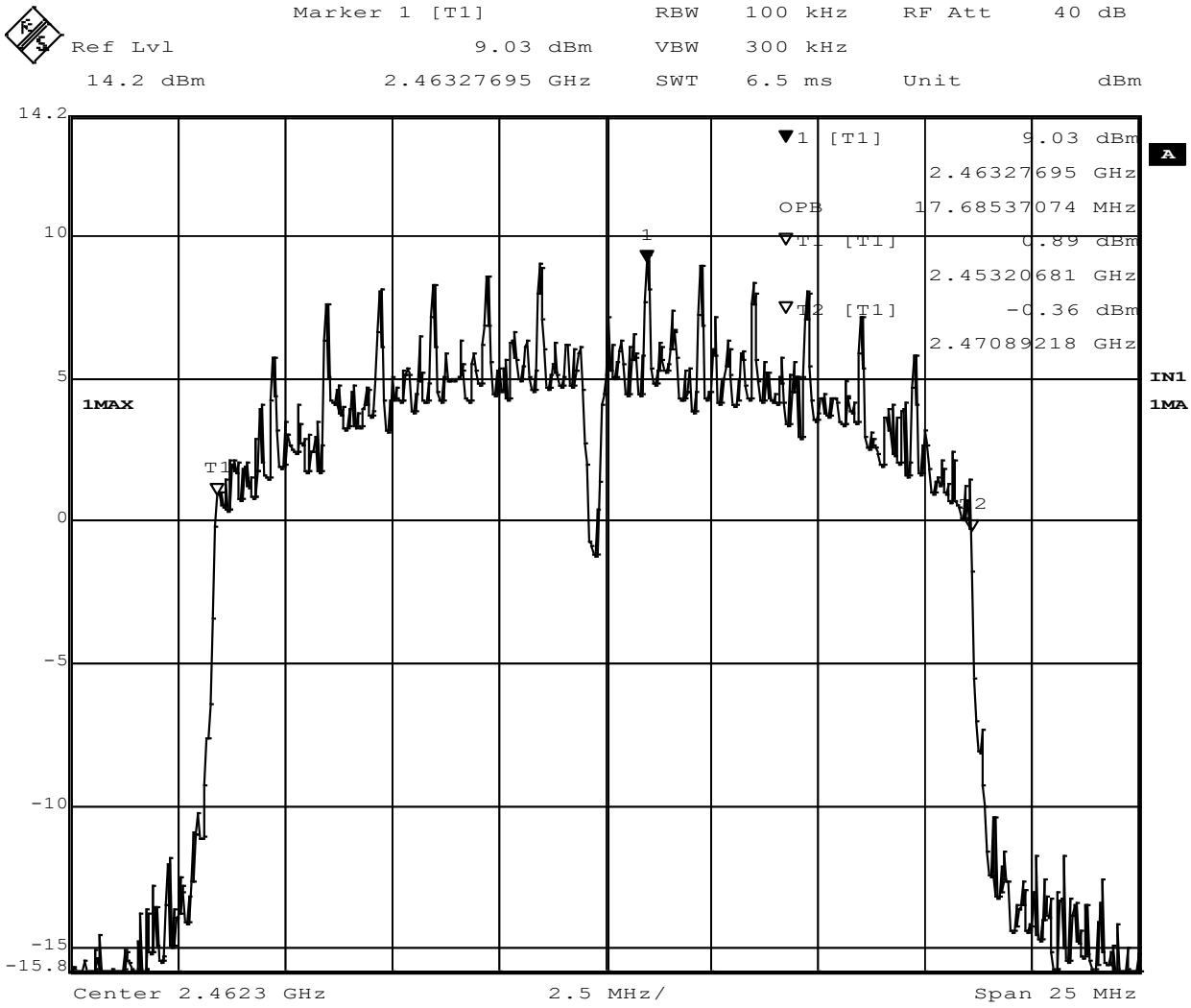

Figure 33 - 99% Occupied Bandwidth, High Channel, 802.11n

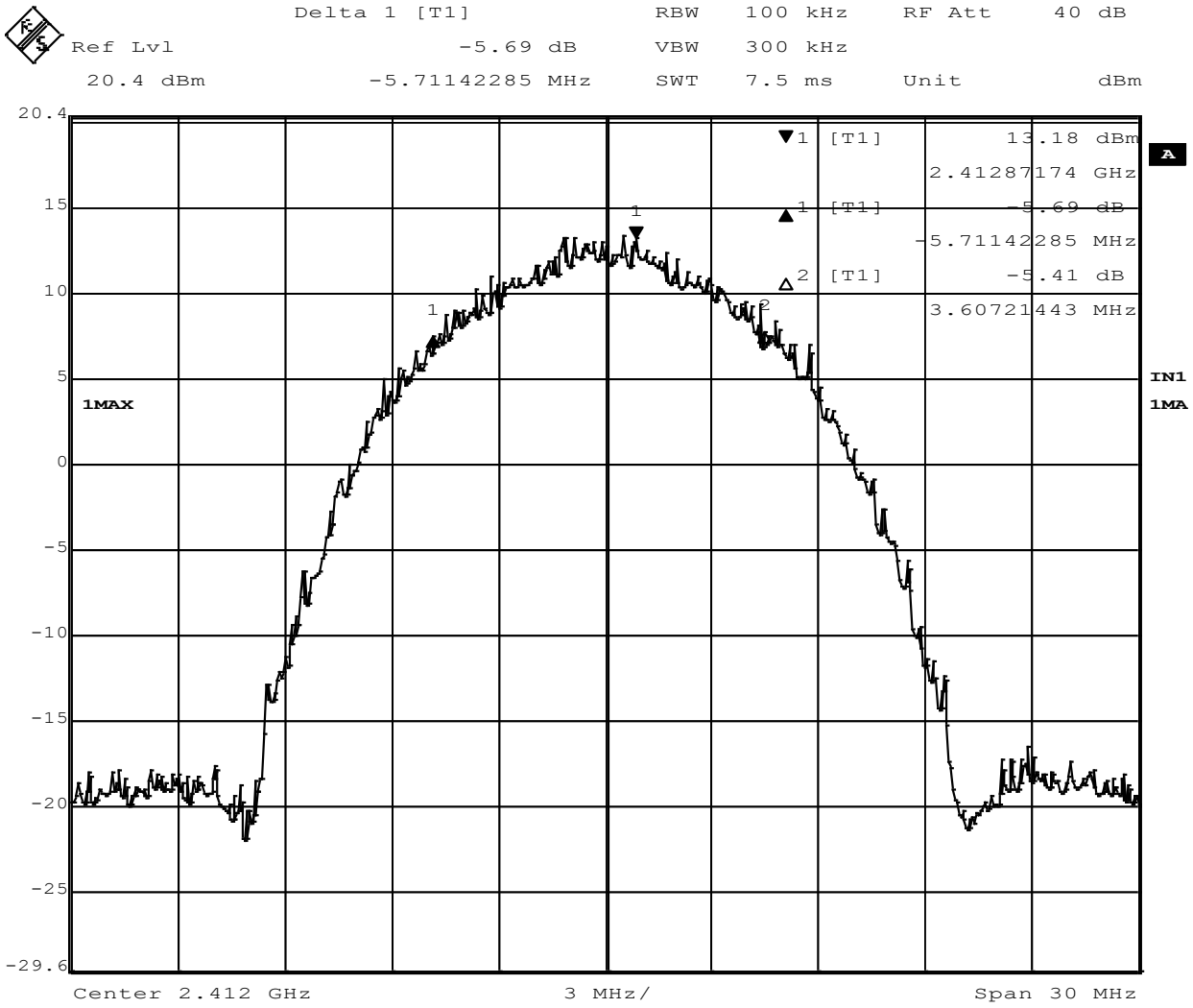

Figure 34 – 6dB Bandwidth, Low Channel, 802.11b

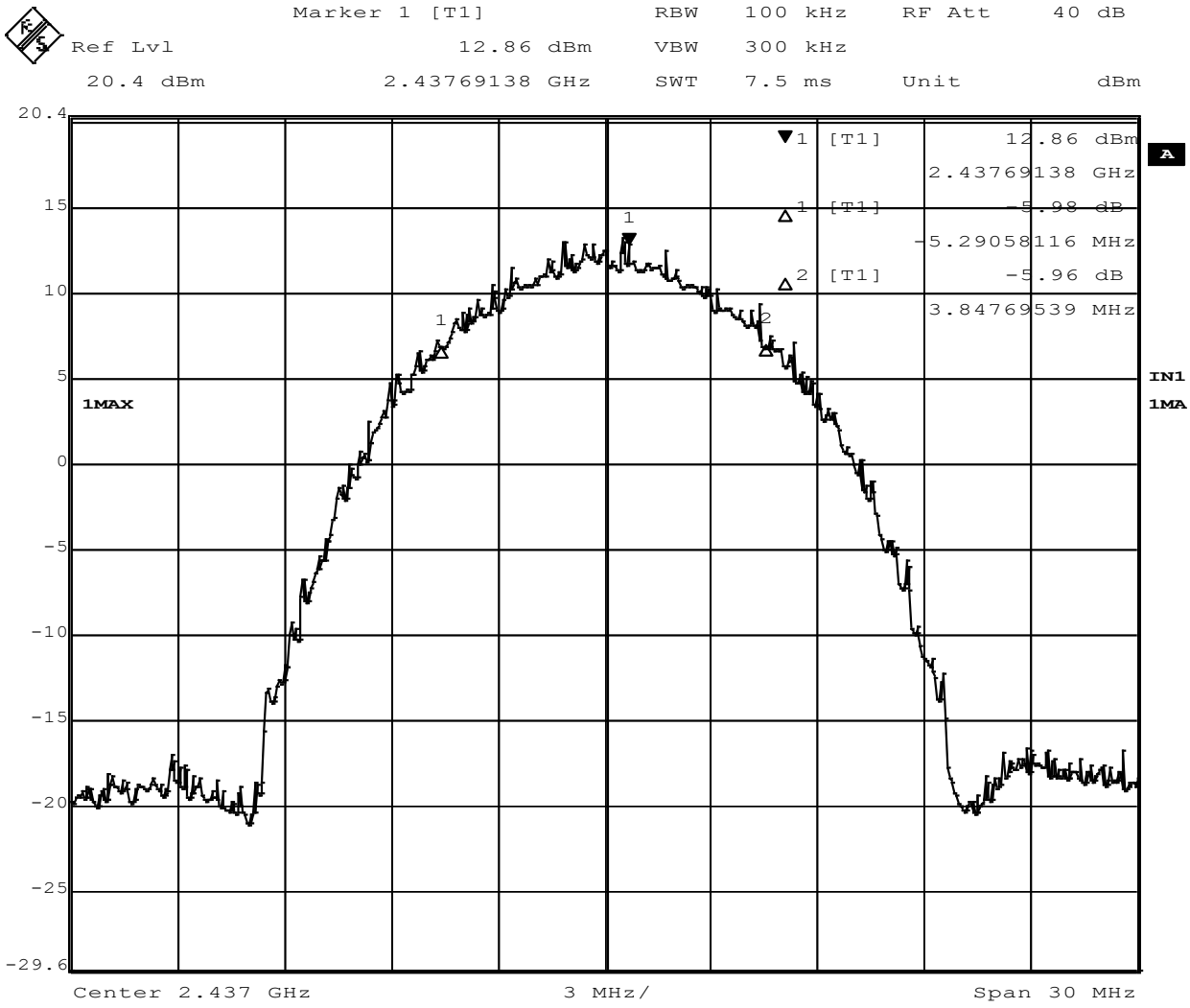

Figure 35 - 6dB Bandwidth, Mid Channel, 802.11b

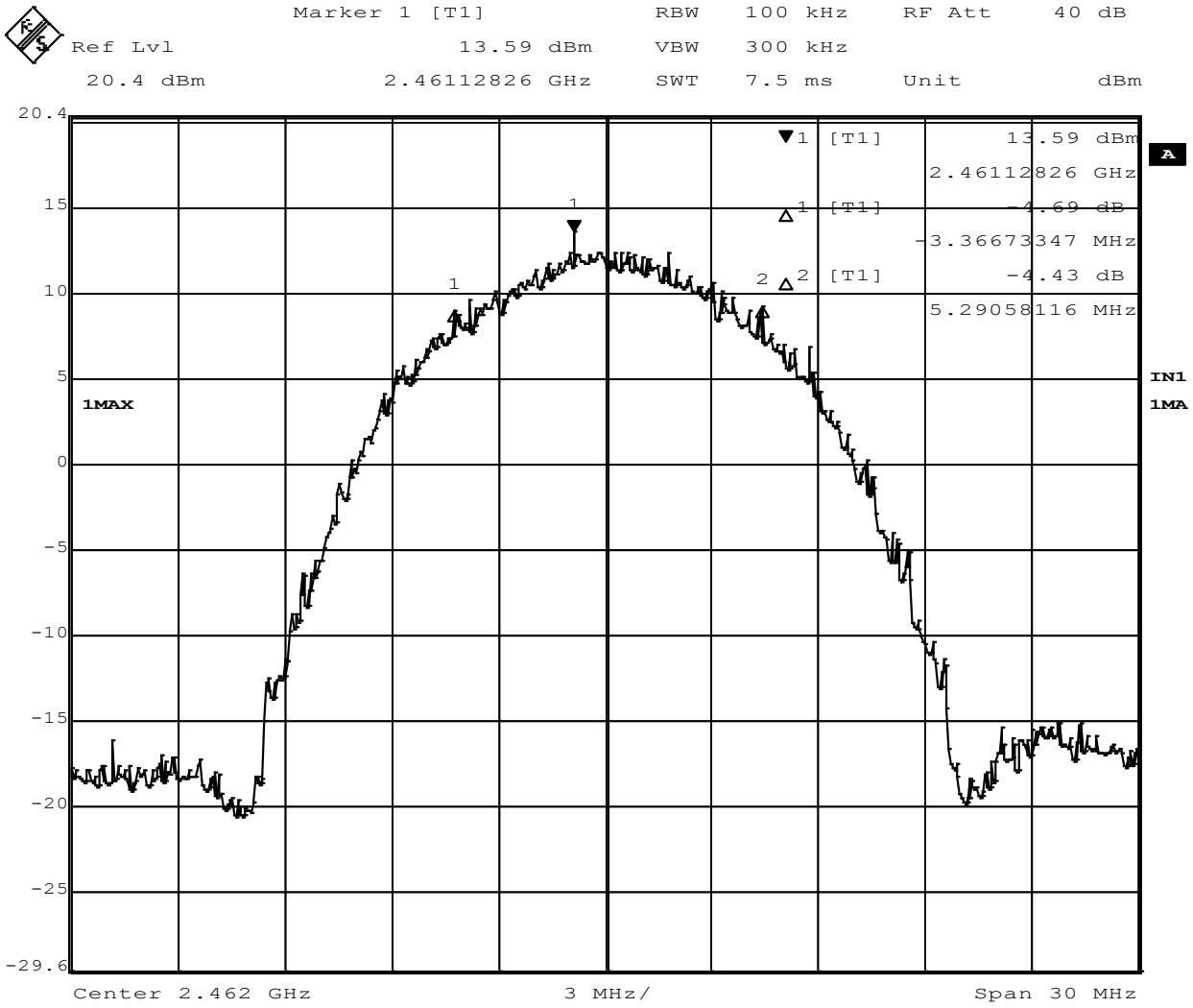

Figure 36 - 6dB Bandwidth, High Channel, 802.11b

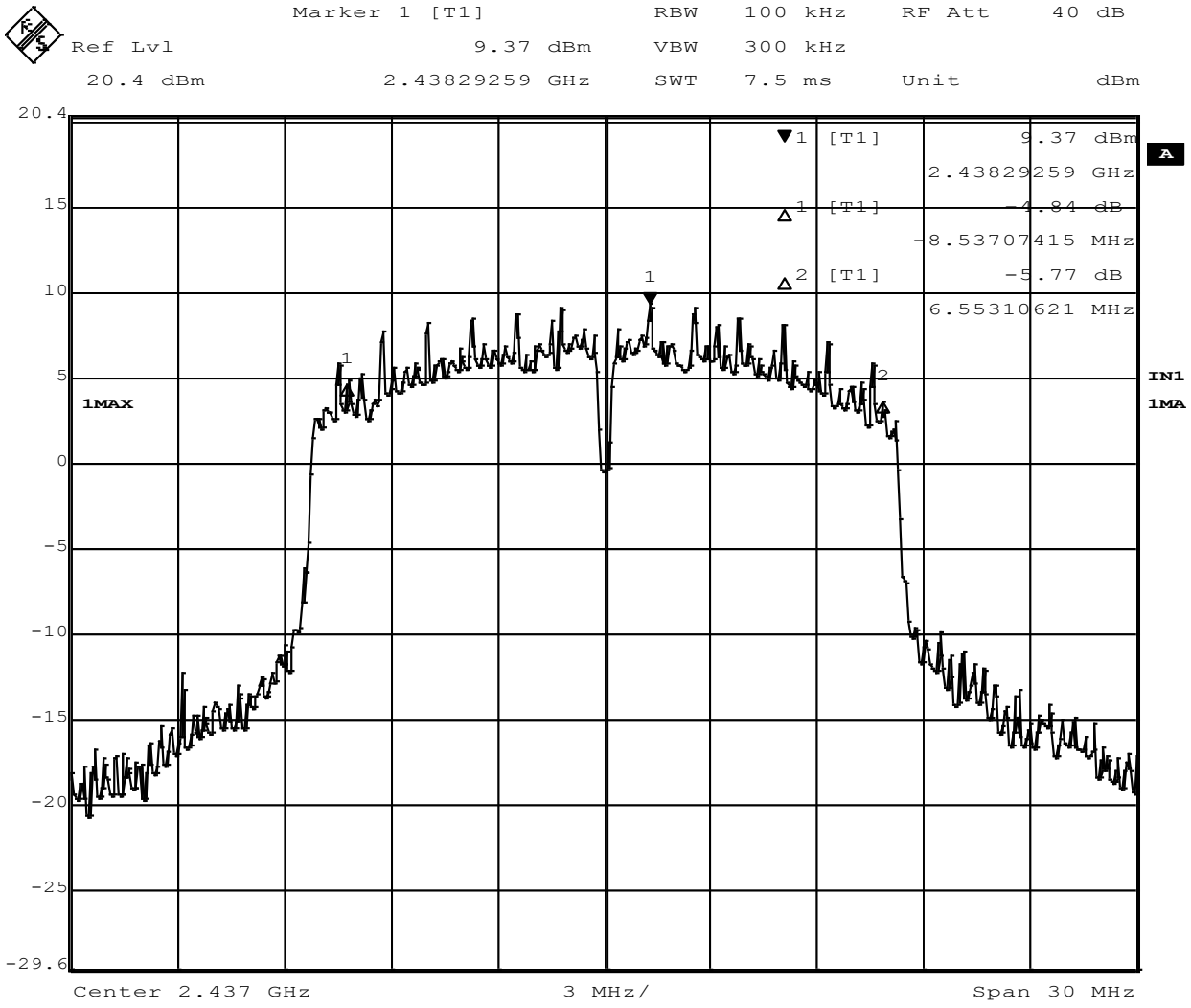

Figure 37 - 6dB Bandwidth, Low Channel, 802.11g

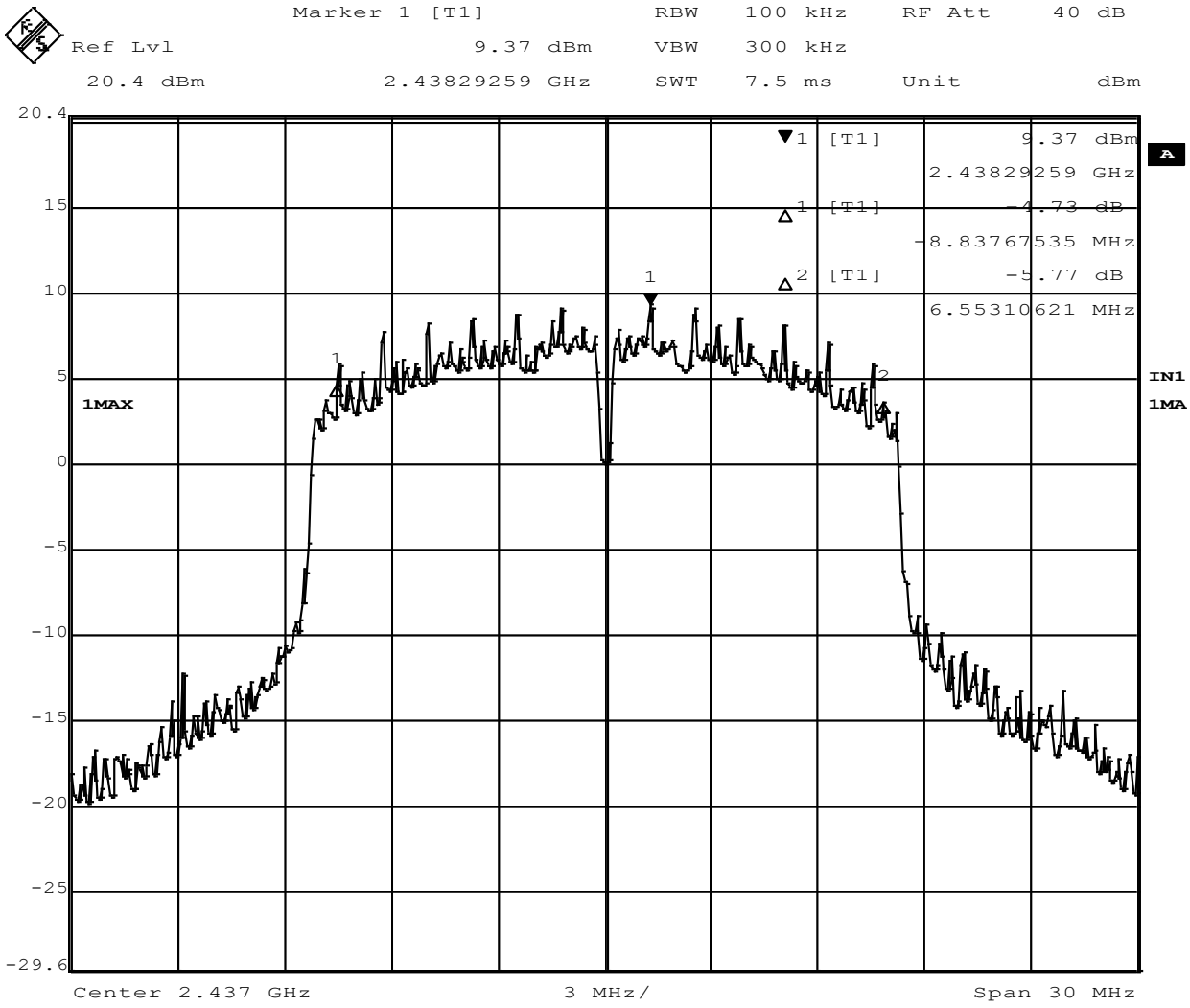

Figure 38 - 6dB Bandwidth, Mid Channel, 802.11g

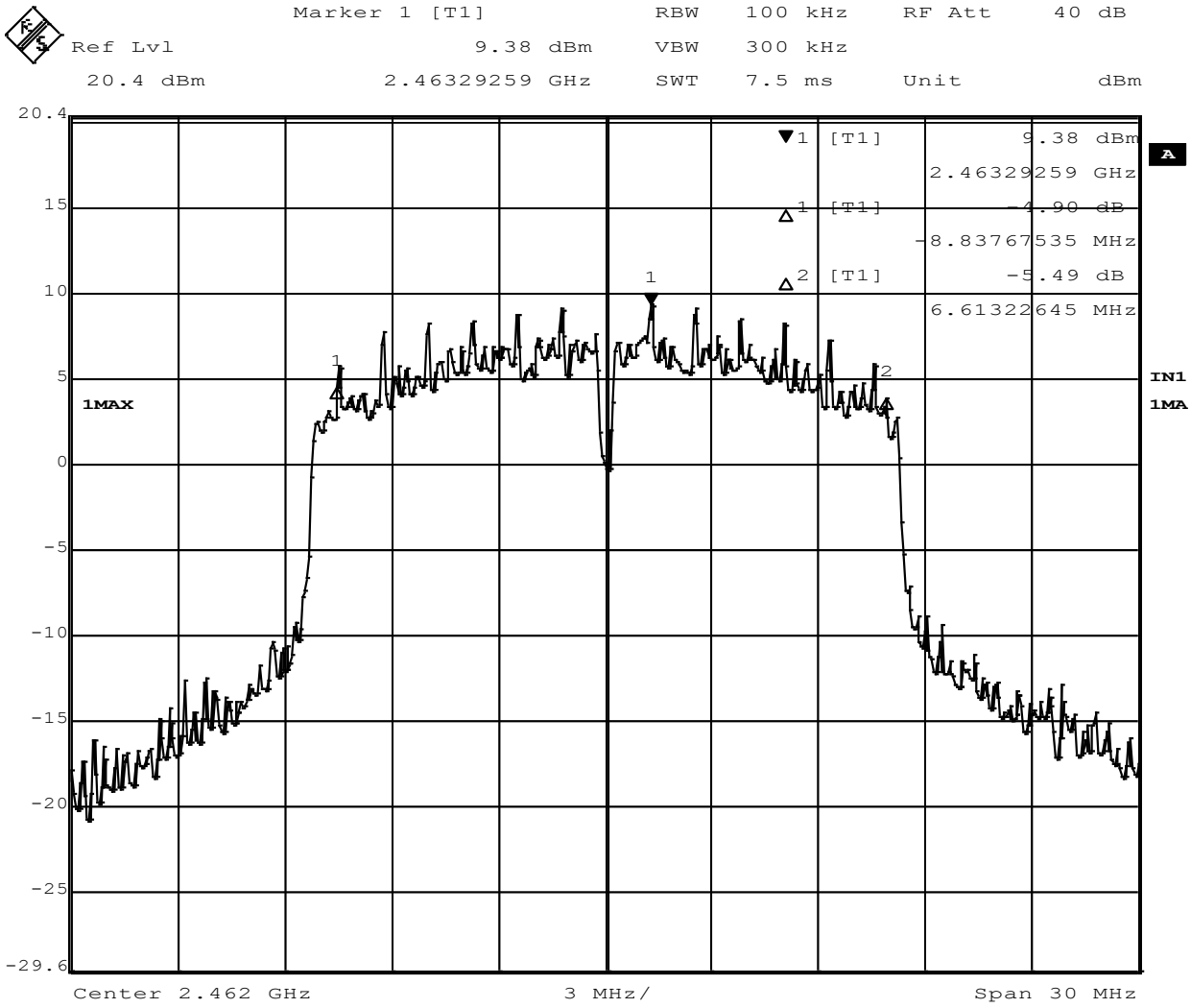

Figure 39 - 6dB Bandwidth, High Channel, 802.11g

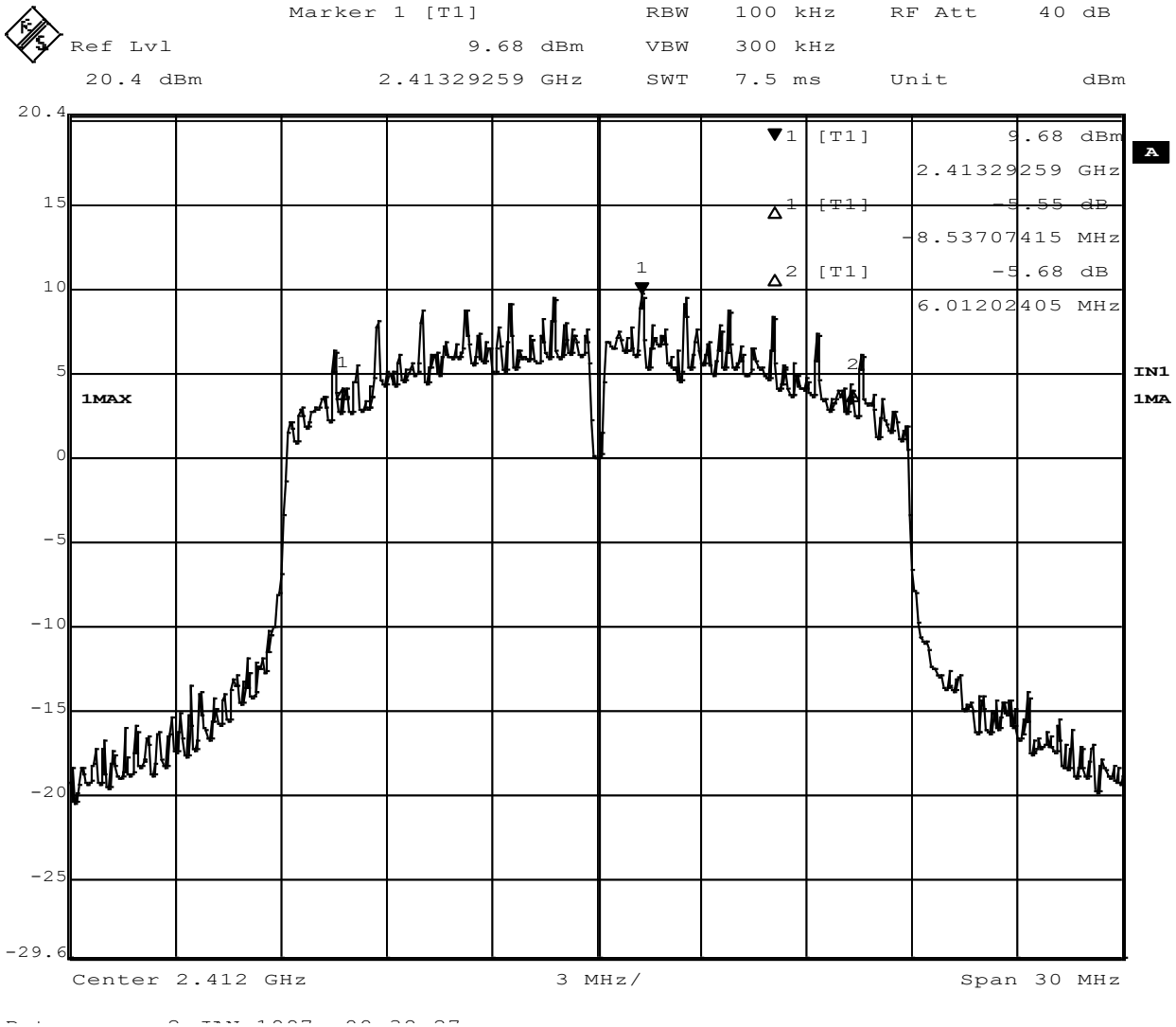

Figure 40 - 6dB Bandwidth, Low Channel, 802.11n

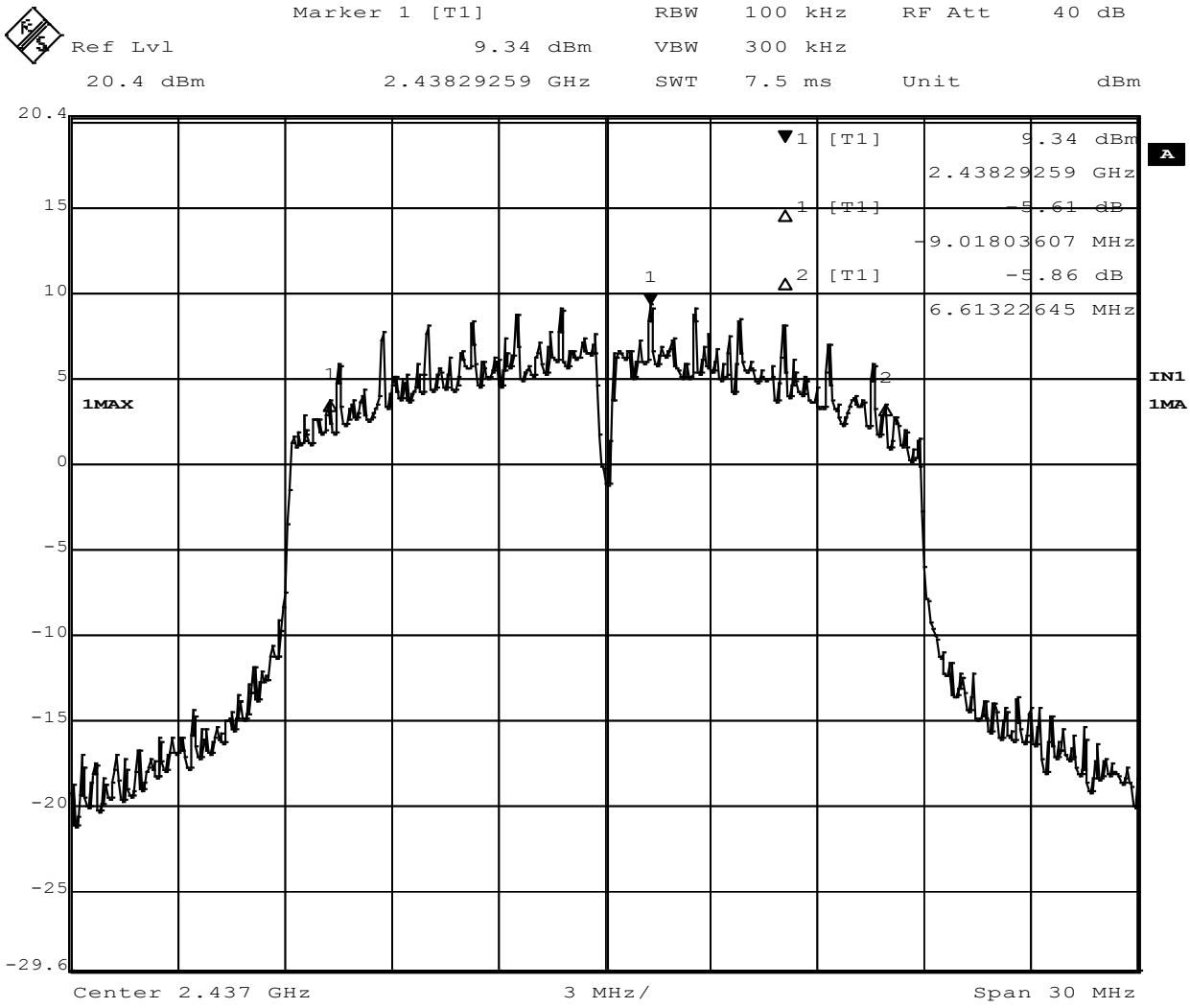

Figure 41 - 6dB Bandwidth, Mid Channel, 802.11n

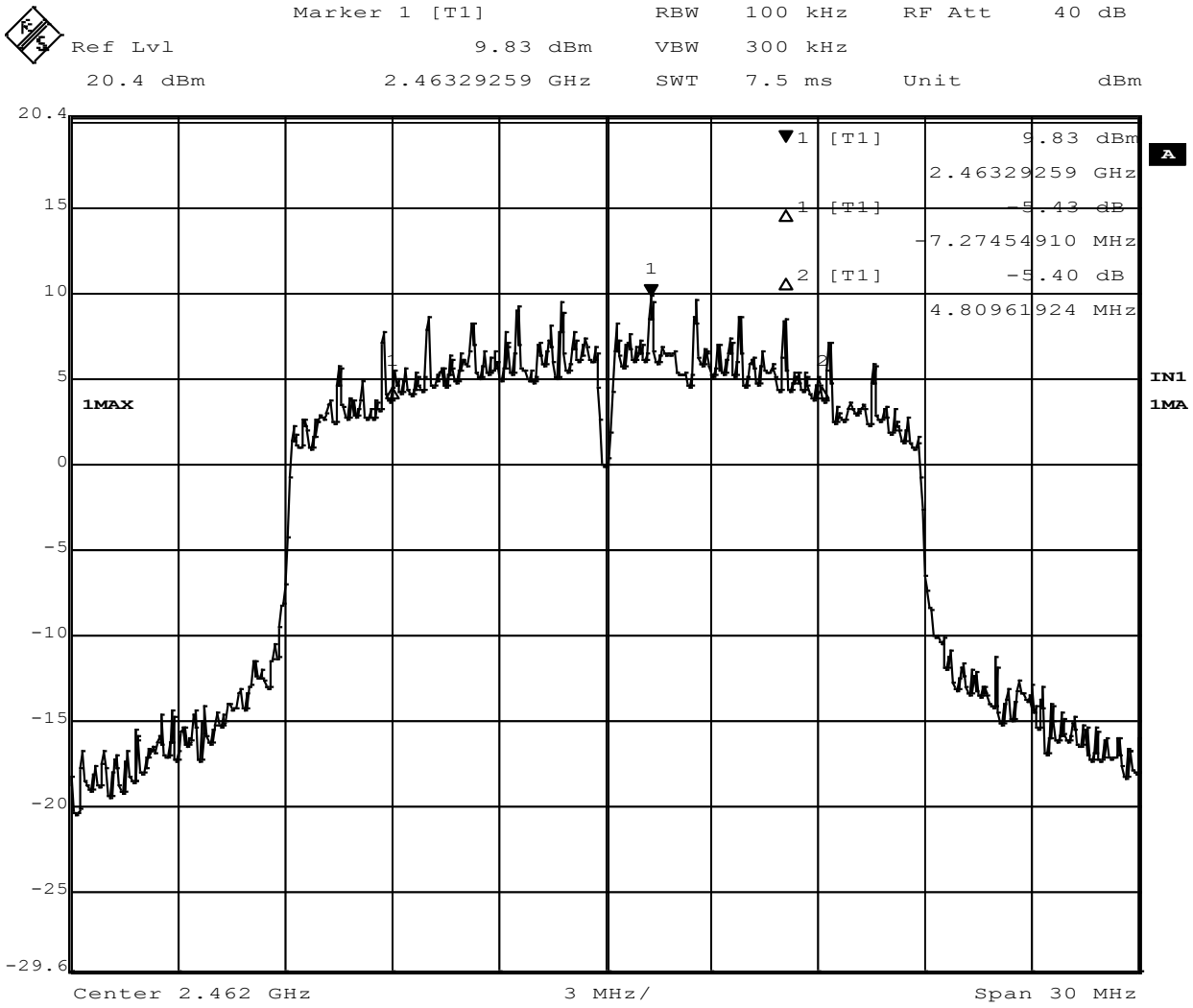

Figure 42 - 6dB Bandwidth, High Channel, 802.11n

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 *4.2 – Radiated Emissions*. 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 4.2

EUT operating conditions:
The EUT was powered by 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	2400.0 (Unrestricted, Peak)	-76.42	-45.75	30.67	20	PASS
1	2400.0 (Unrestricted, Average)	-89.10	-56.64	32.46	20	PASS
11	2483.5 (Unrestricted, Peak)	-92.21	-46.72	45.49	20	PASS
11	2483.5 (Unrestricted, Average)	-104.39	-58.36	46.03	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Limit* (dBm)	Margin	Result
1	2340.0 (Restricted, Peak)	-86.49	-38.82	-21.23	17.59	PASS
1	2340.0 (Restricted, Average)	-100.64	-52.97	-41.23	11.74	PASS
11	2483.5 (Restricted, Peak)	-90.19	-42.52	-21.23	21.29	PASS
11	2483.5 (Restricted, Average)	-104.40	-56.73	-41.23	15.50	PASS

Corrected Emission level= Highest out of band conducted measurement + 107+CL+AF-95.23
CL=7.6 (LBE), 7.7 (HBE); AF=28.3(LBE), 28.2 (HBE)
Margin= Limit-Corrected Emission Level
*Limits from Part 15.209 in dBm, converted from 3m limit to EIRP. 3m Limit – 95.23 = EIRP.

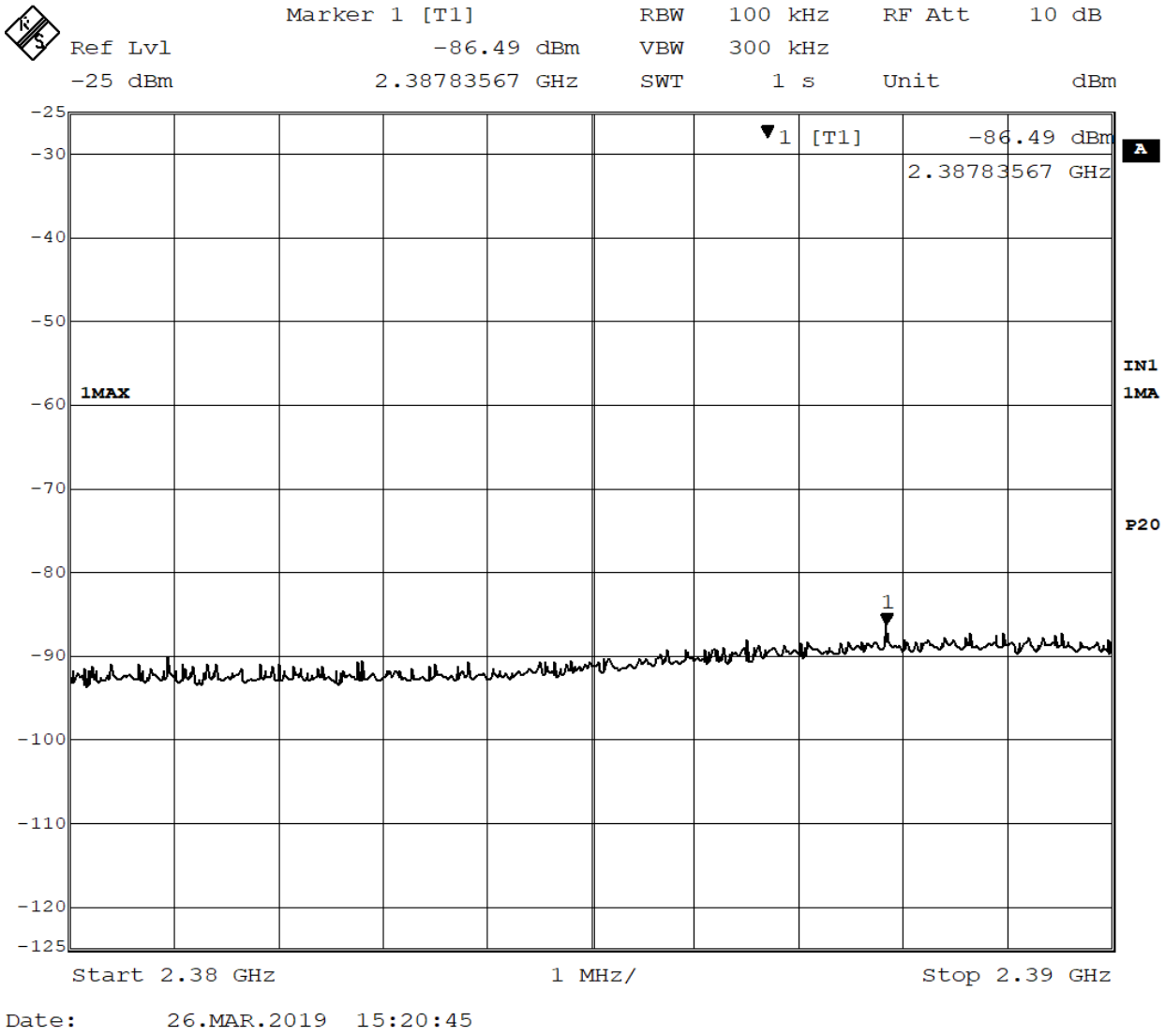

Figure 43 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

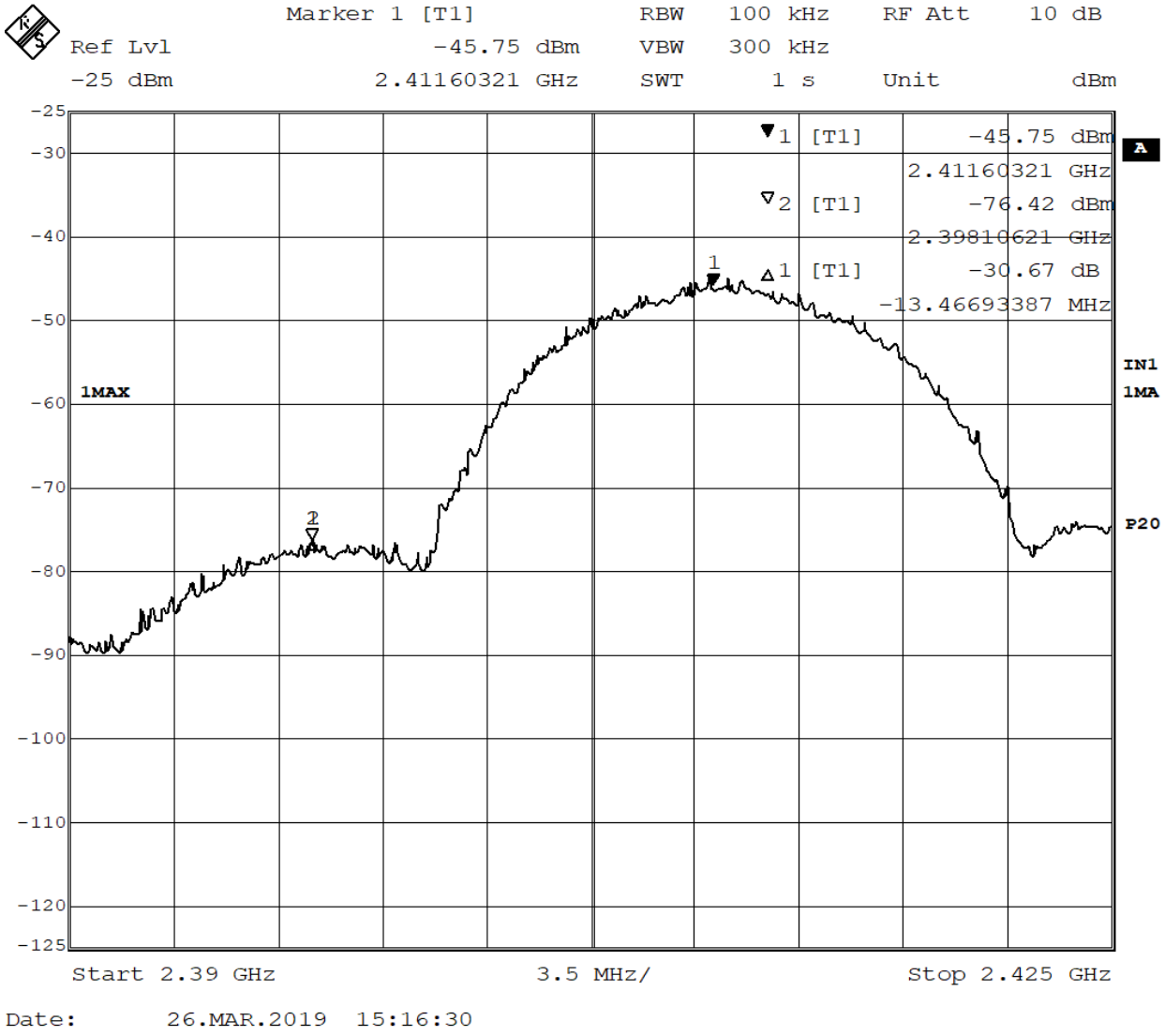

Figure 44 - Band-edge Measurement, Low Channel, Fundamental, Peak

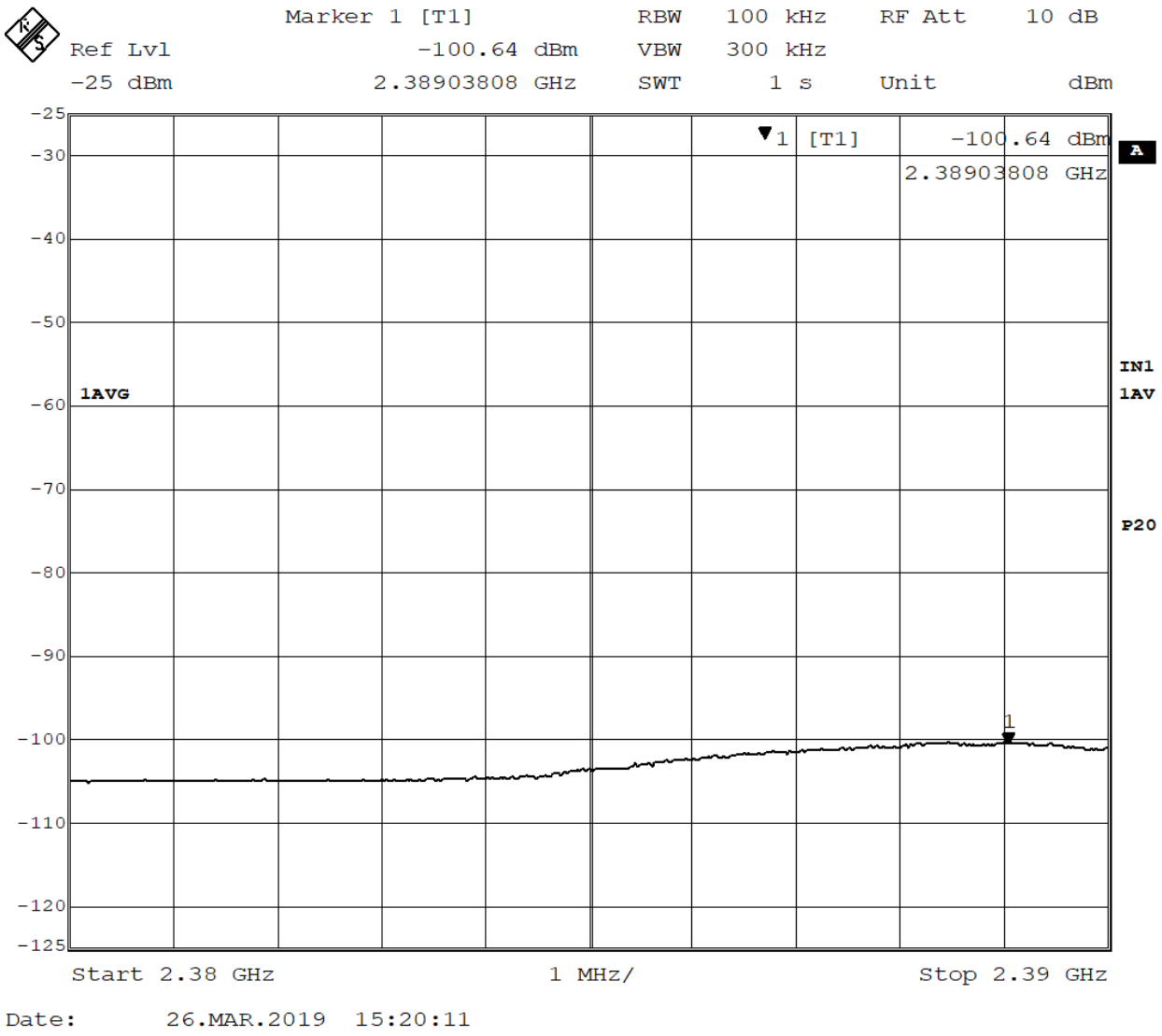

Figure 45 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

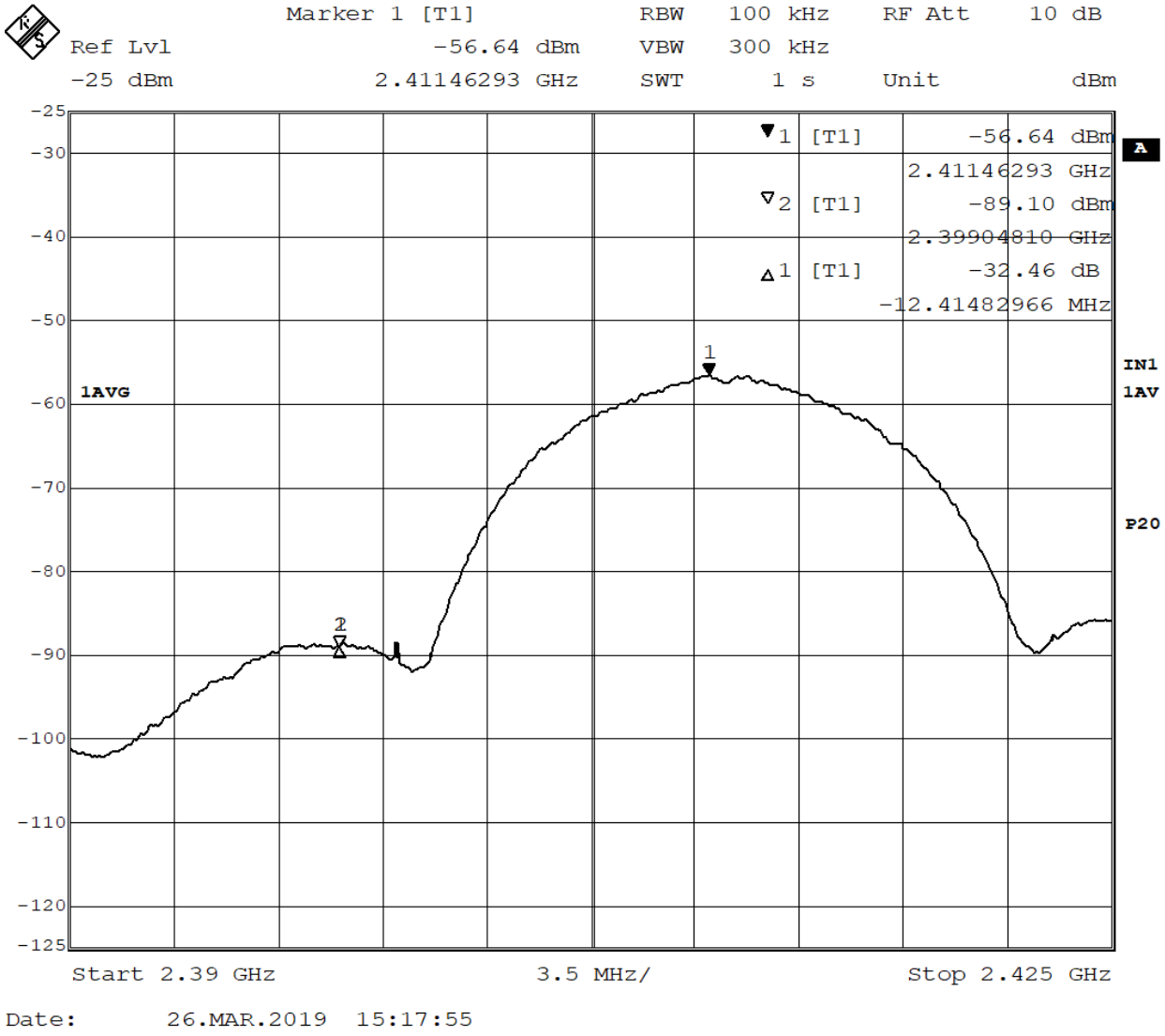

Figure 46 - Band-edge Measurement, Low Channel, Fundamental, Average

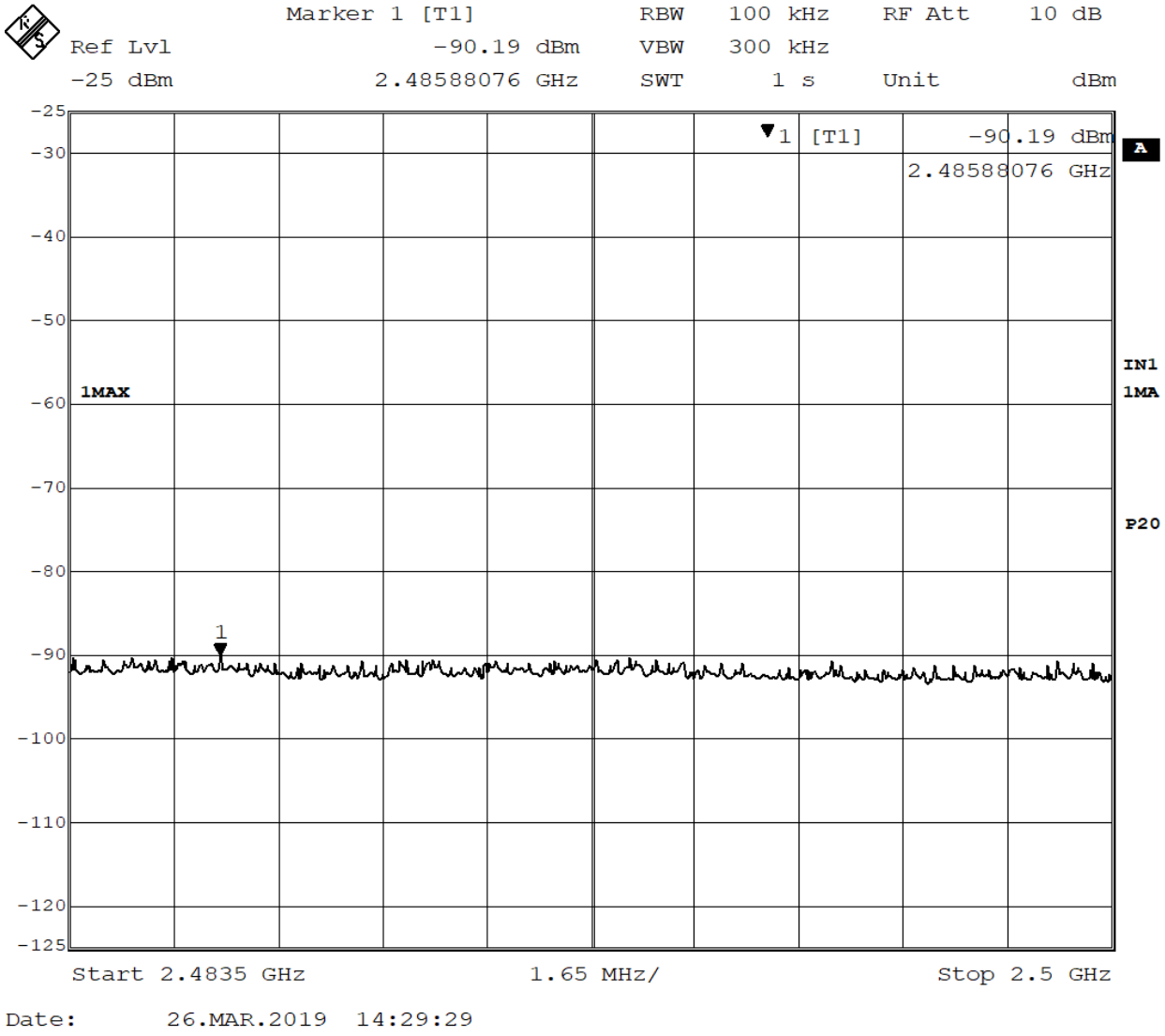

Figure 47 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

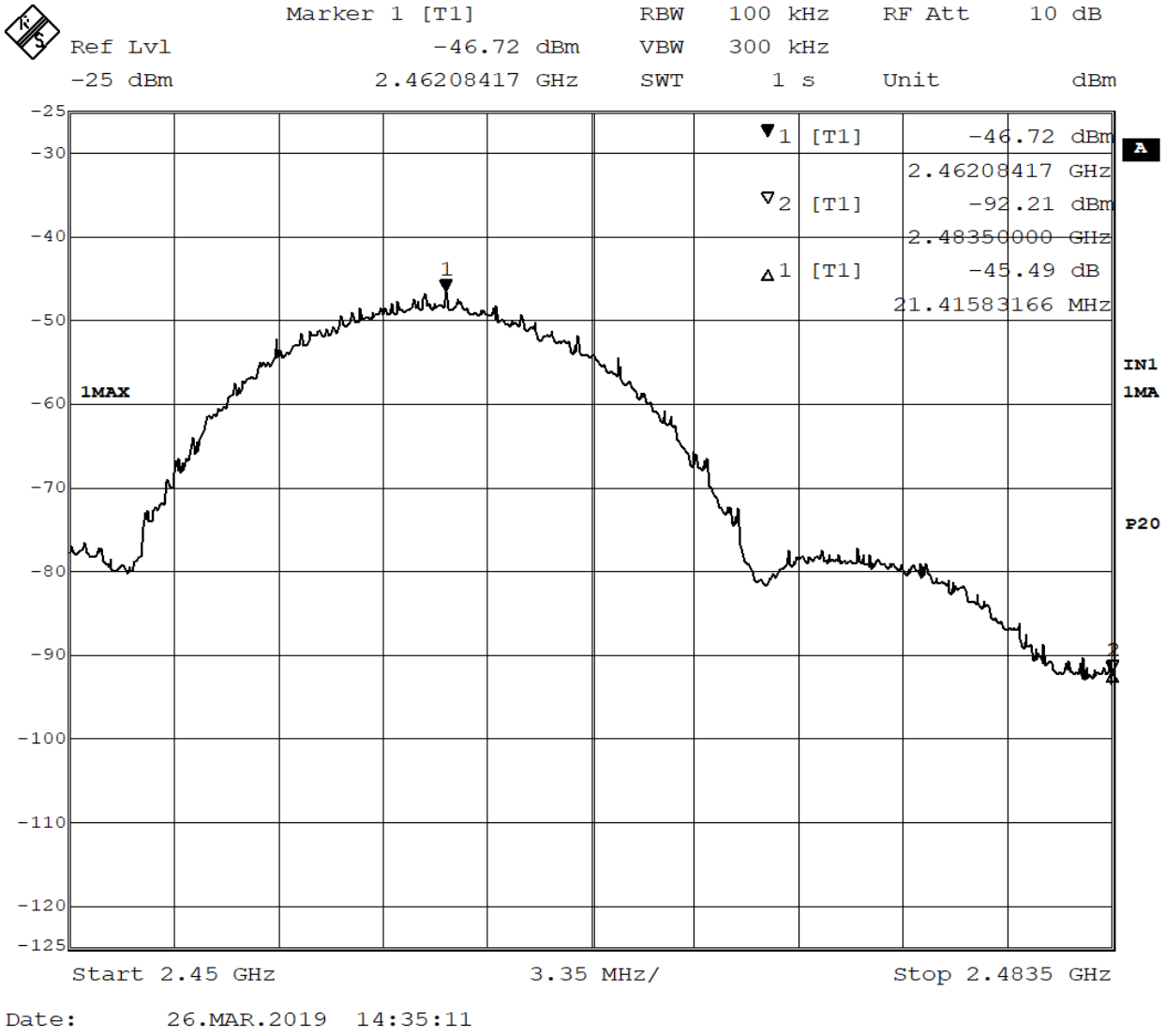

Figure 48 - Band-edge Measurement, High Channel, Fundamental, Peak

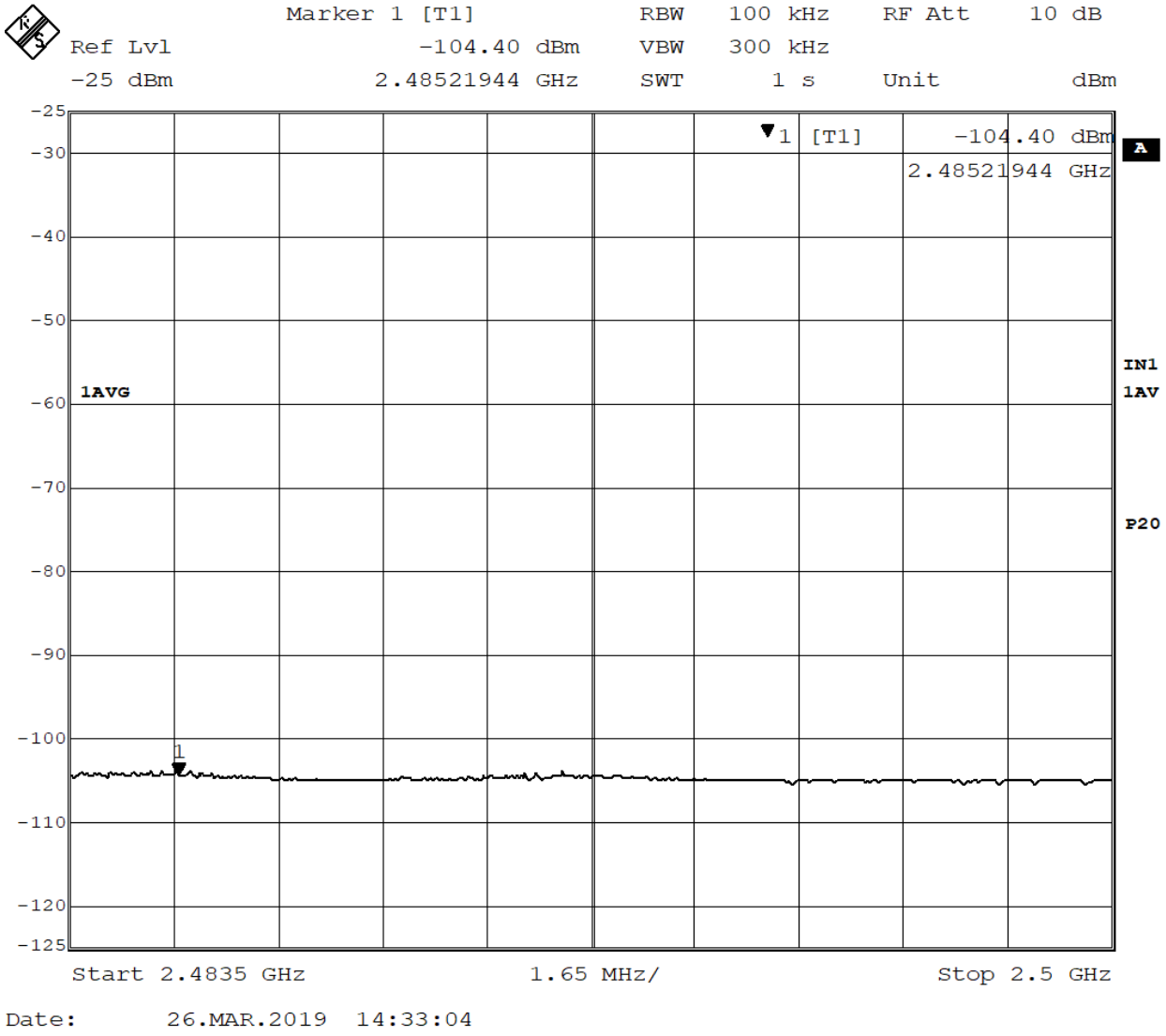

Figure 49 - Band-edge Measurement, High Channel, Restricted Frequency, Average

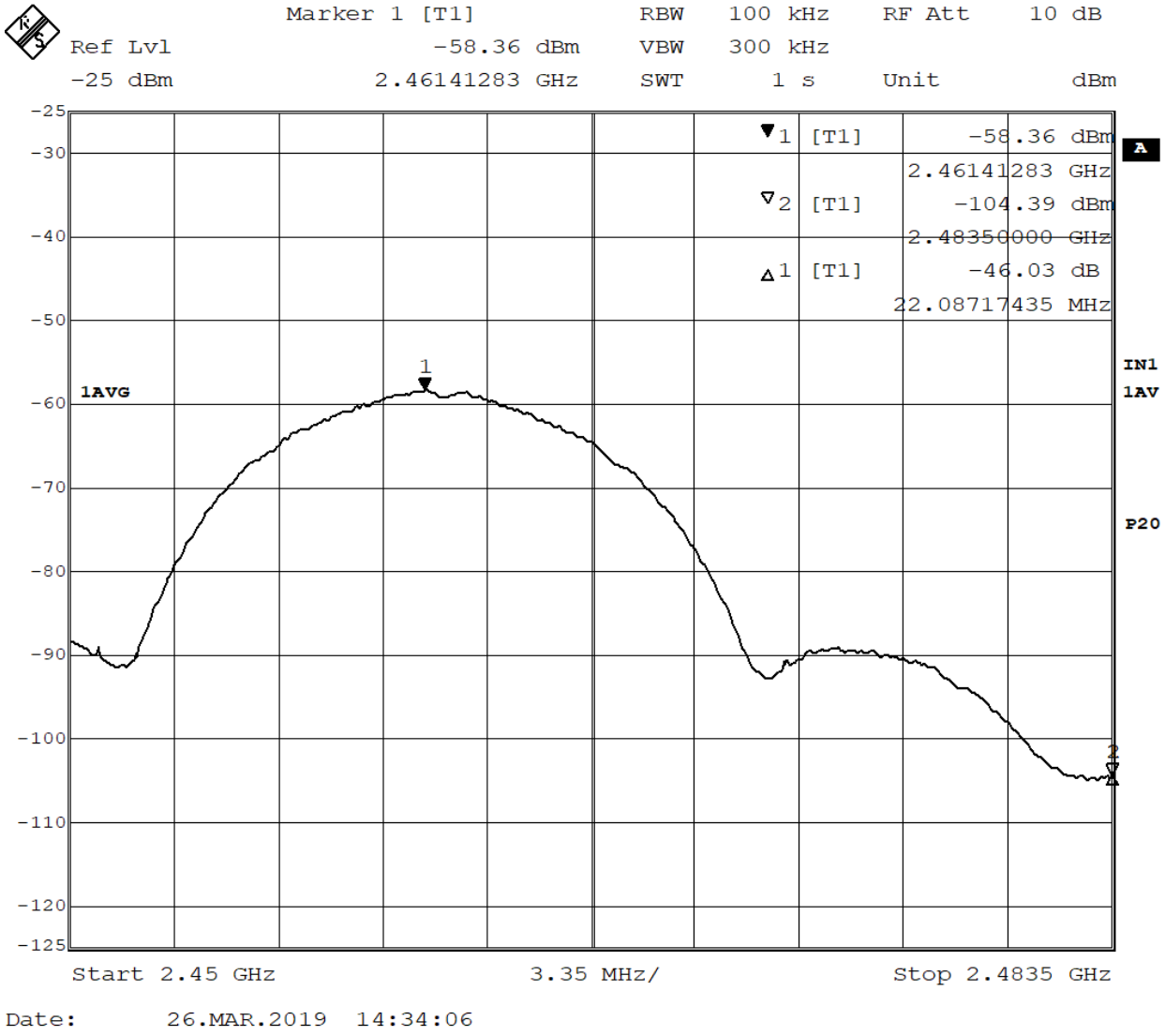

Figure 50 - Band-edge Measurement, High Channel, Fundamental, Average

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	2400.0 (Unrestricted, Peak)	-73.32	-49.68	23.64	20	PASS
1	2400.0 (Unrestricted, Average)	-88.59	-61.10	27.49	20	PASS
11	2483.5 (Unrestricted, Peak)	-89.35	-50.93	38.42	20	PASS
11	2483.5 (Unrestricted, Average)	-101.98	-62.09	39.89	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Limit* (dBm)	Margin	Result
1	2340.0 (Restricted, Peak)	-87.41	-39.74	-21.23	18.51	PASS
1	2340.0 (Restricted, Average)	-101.44	-53.77	-41.23	12.54	PASS
11	2483.5 (Restricted, Peak)	-87.96	-40.29	-21.23	19.06	PASS
11	2483.5 (Restricted, Average)	-101.41	-53.74	-41.23	12.51	PASS

Corrected Emission level= Highest out of band conducted measurement + 107+CL+AF-95.23
CL=7.6 (LBE), 7.7 (HBE); AF=28.3(LBE), 28.2 (HBE)
Margin= Limit-Corrected Emission Level
*Limits from Part 15.209 in dBm, converted from 3m limit to EIRP. 3m Limit – 95.23 = EIRP.

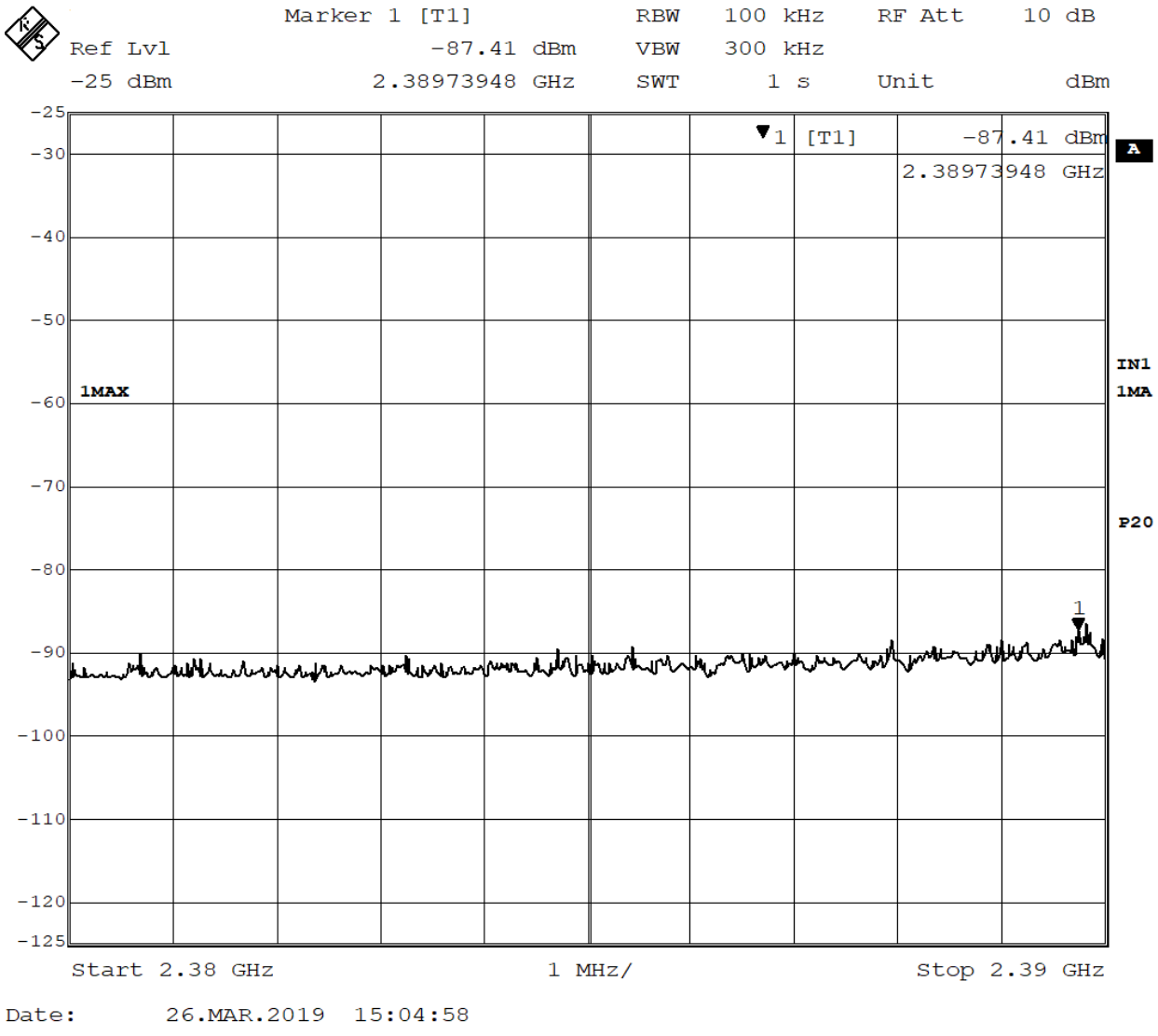

Figure 51 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

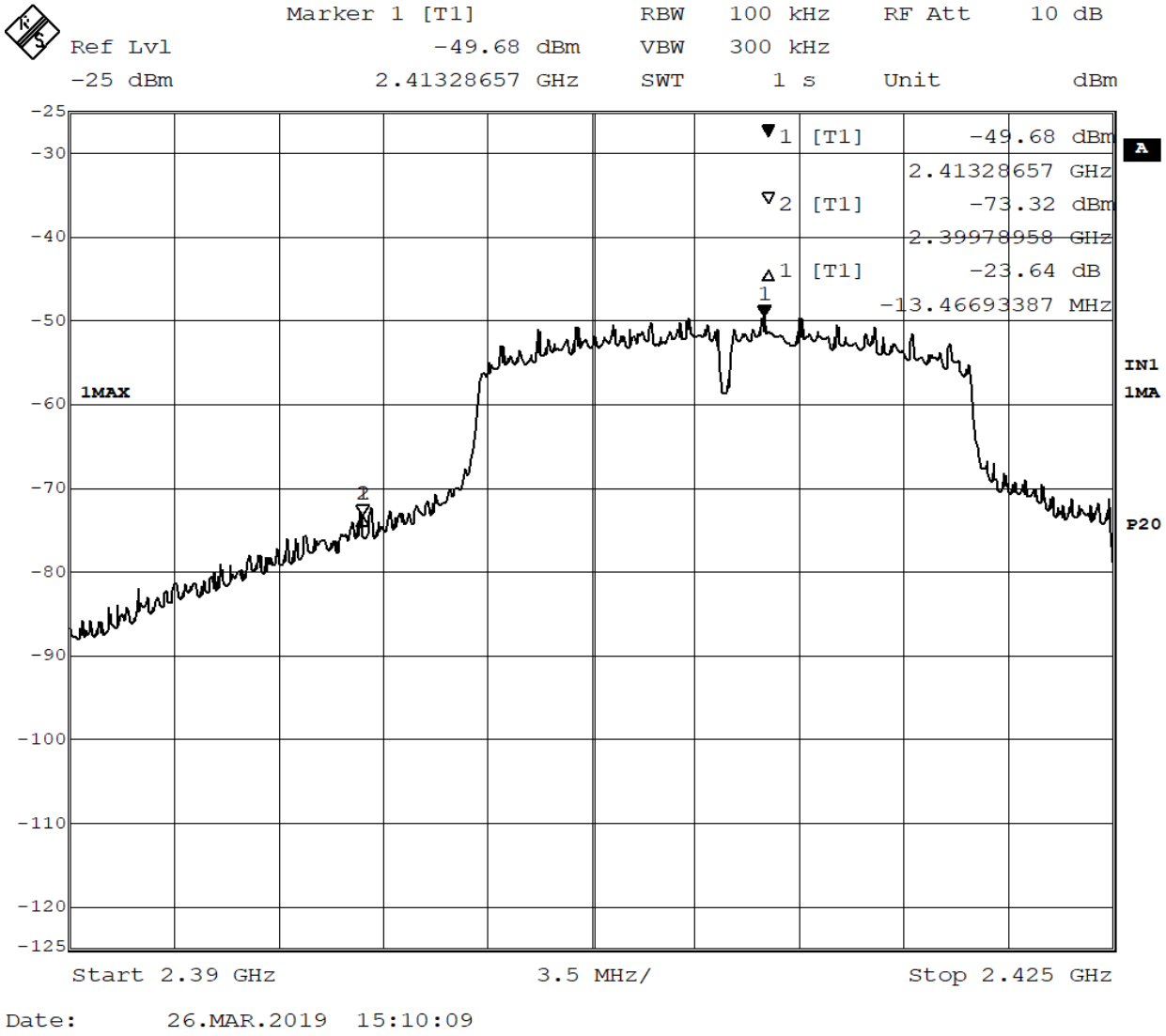

Figure 52 - Band-edge Measurement, Low Channel, Fundamental, Peak

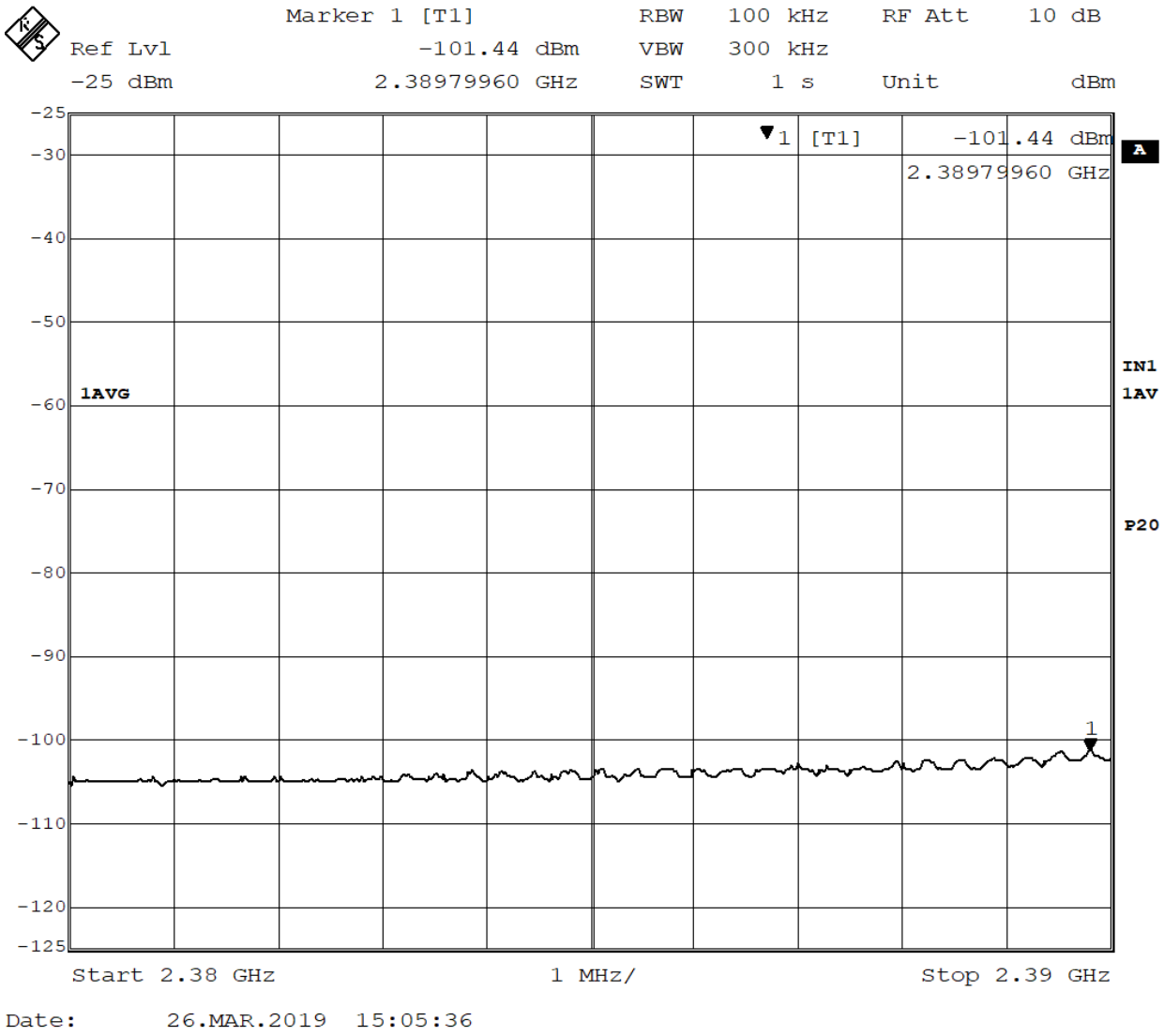

Figure 53 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

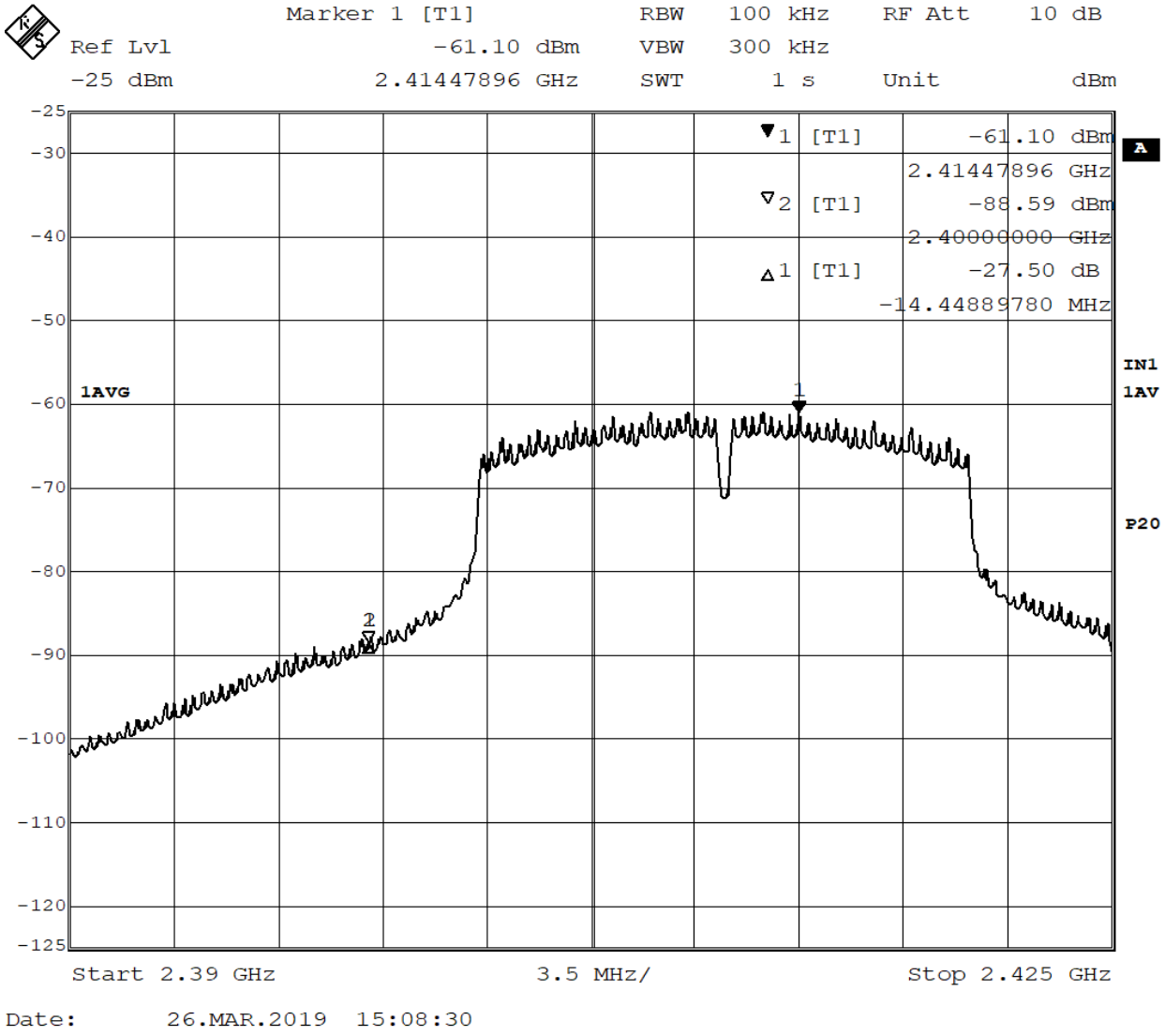

Figure 54 - Band-edge Measurement, Low Channel, Fundamental, Average

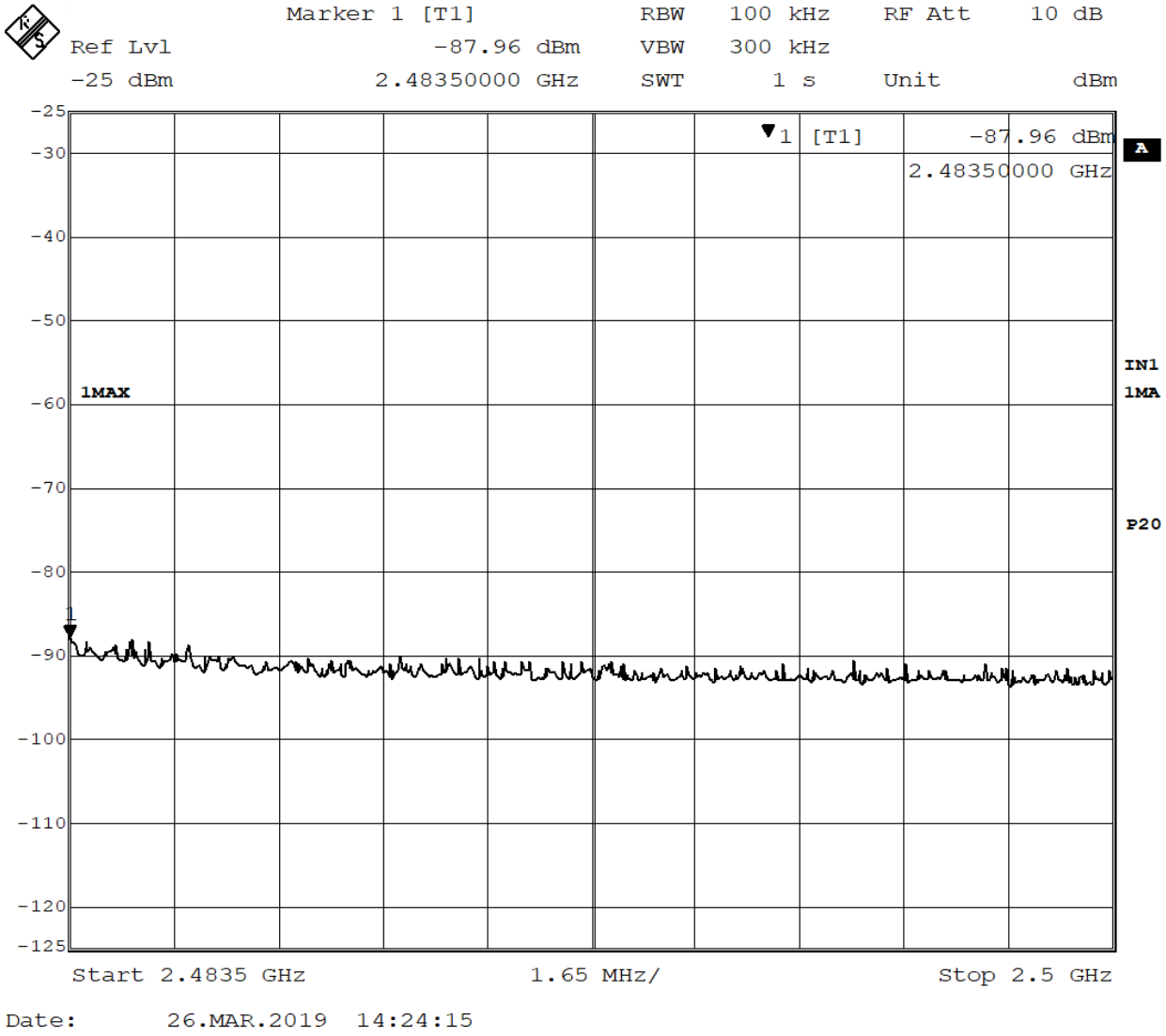

Figure 55 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

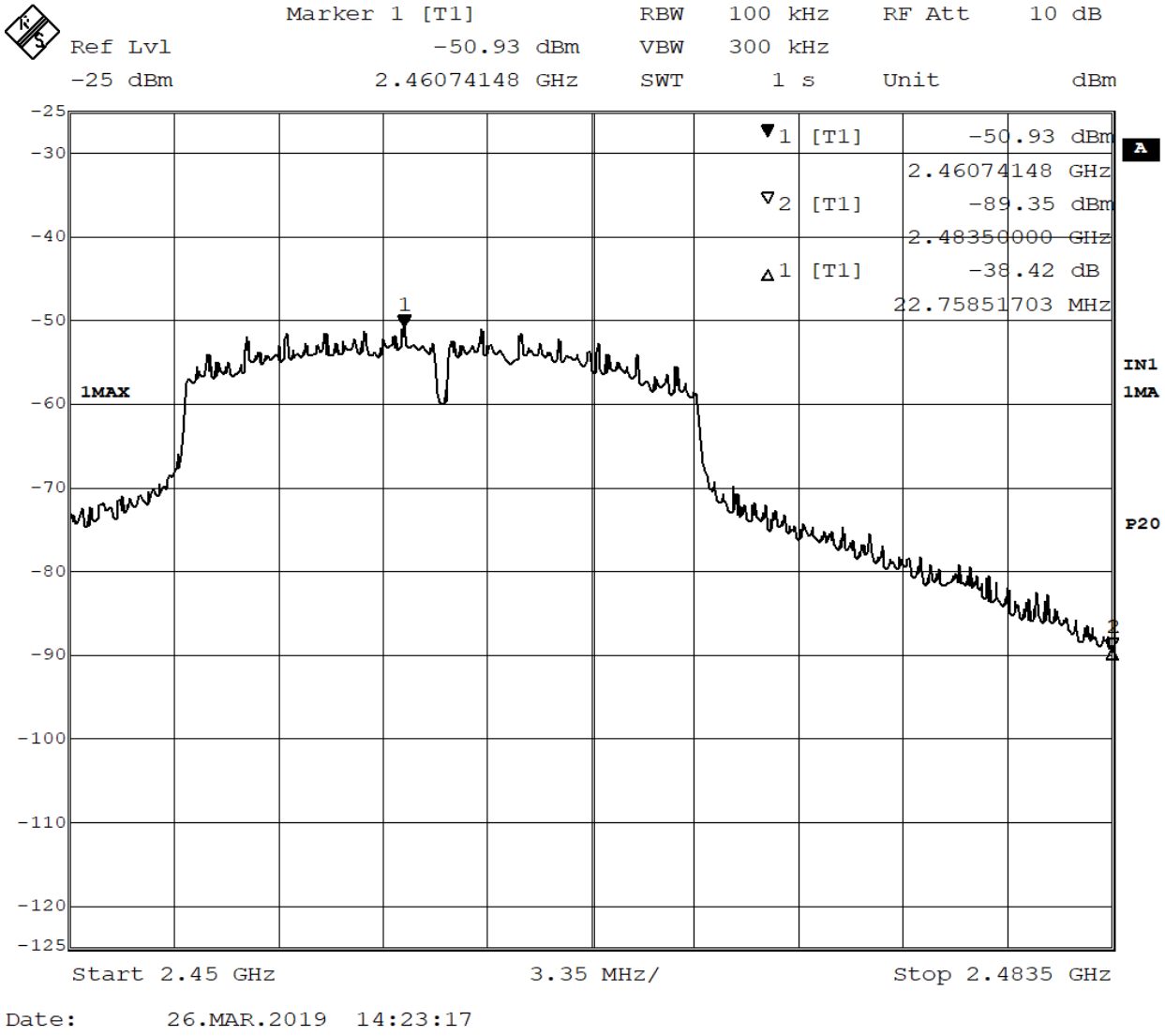

Figure 56 - Band-edge Measurement, High Channel, Fundamental, Peak

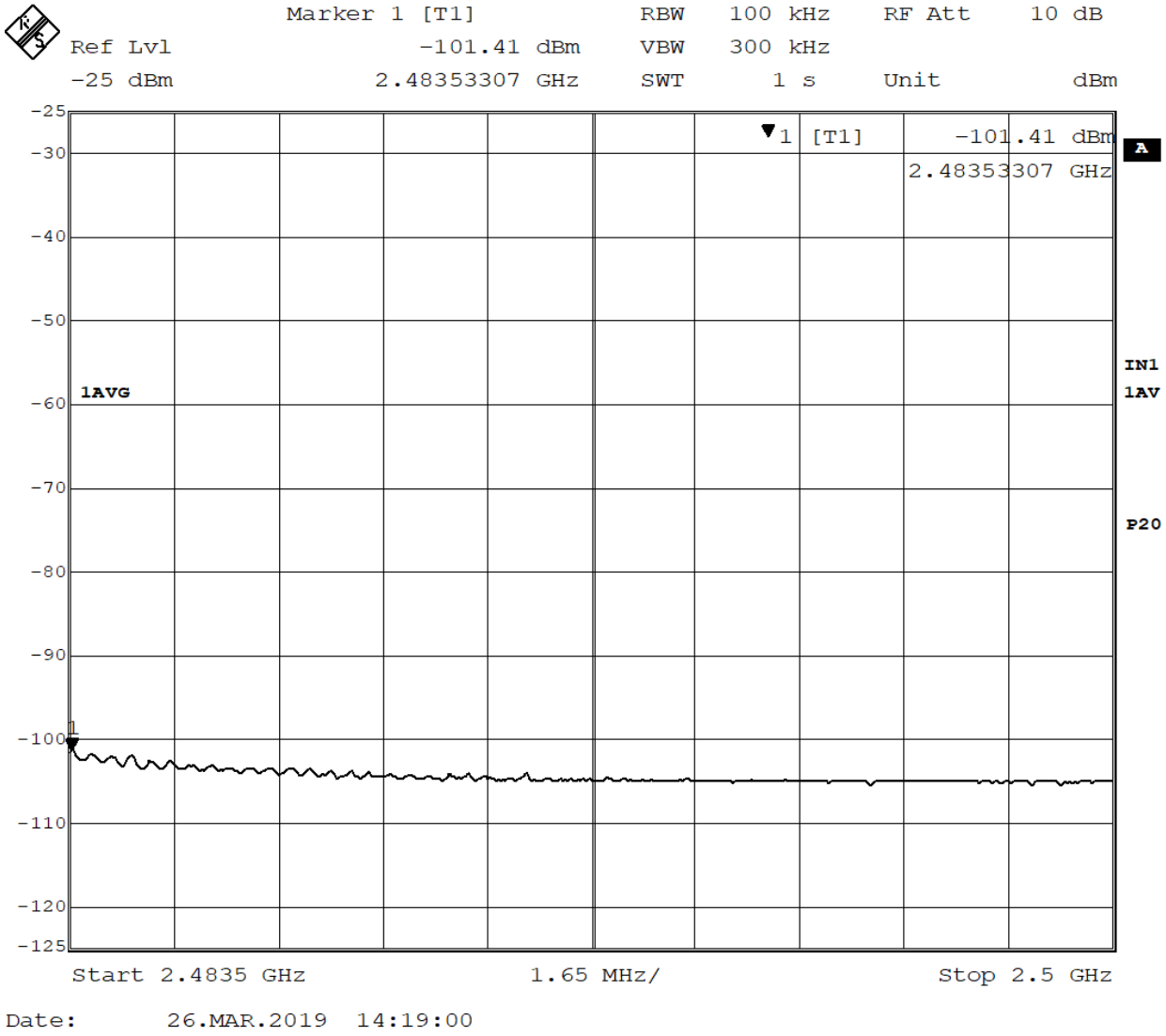

Figure 57 - Band-edge Measurement, High Channel, Restricted Frequency, Average

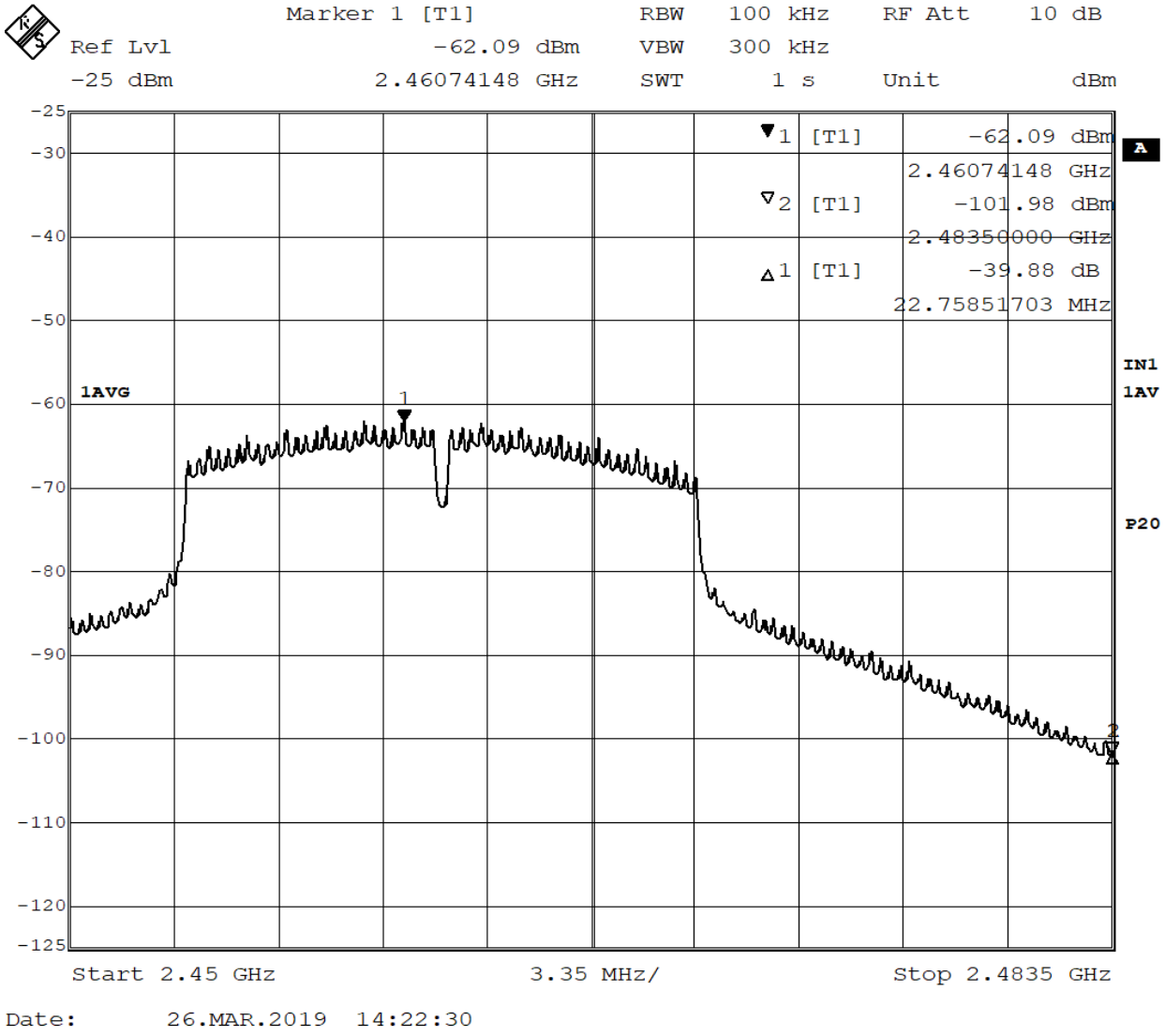

Figure 58 - Band-edge Measurement, High Channel, Fundamental, Average

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	2400.0 (Unrestricted, Peak)	-75.41	-49.60	25.81	20	PASS
1	2400.0 (Unrestricted, Average)	-88.79	-60.40	28.39	20	PASS
11	2483.5 (Unrestricted, Peak)	-87.09	-51.59	35.50	20	PASS
11	2483.5 (Unrestricted, Average)	-102.50	-62.19	40.31	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Limit* (dBm)	Margin	Result
1	2340.0 (Restricted, Peak)	-85.60	-37.93	-21.23	16.70	PASS
1	2340.0 (Restricted, Average)	-100.49	-52.82	-41.23	11.59	PASS
11	2483.5 (Restricted, Peak)	-87.86	-40.19	-21.23	18.96	PASS
11	2483.5 (Restricted, Average)	-101.36	-53.69	-41.23	12.46	PASS

Corrected Emission level= Highest out of band conducted measurement + 107+CL+AF-95.23
CL=7.6 (LBE), 7.7 (HBE); AF=28.3(LBE), 28.2 (HBE)
Margin= Limit-Corrected Emission Level
*Limits from Part 15.209 in dBm, converted from 3m limit to EIRP. 3m Limit – 95.23 = EIRP.

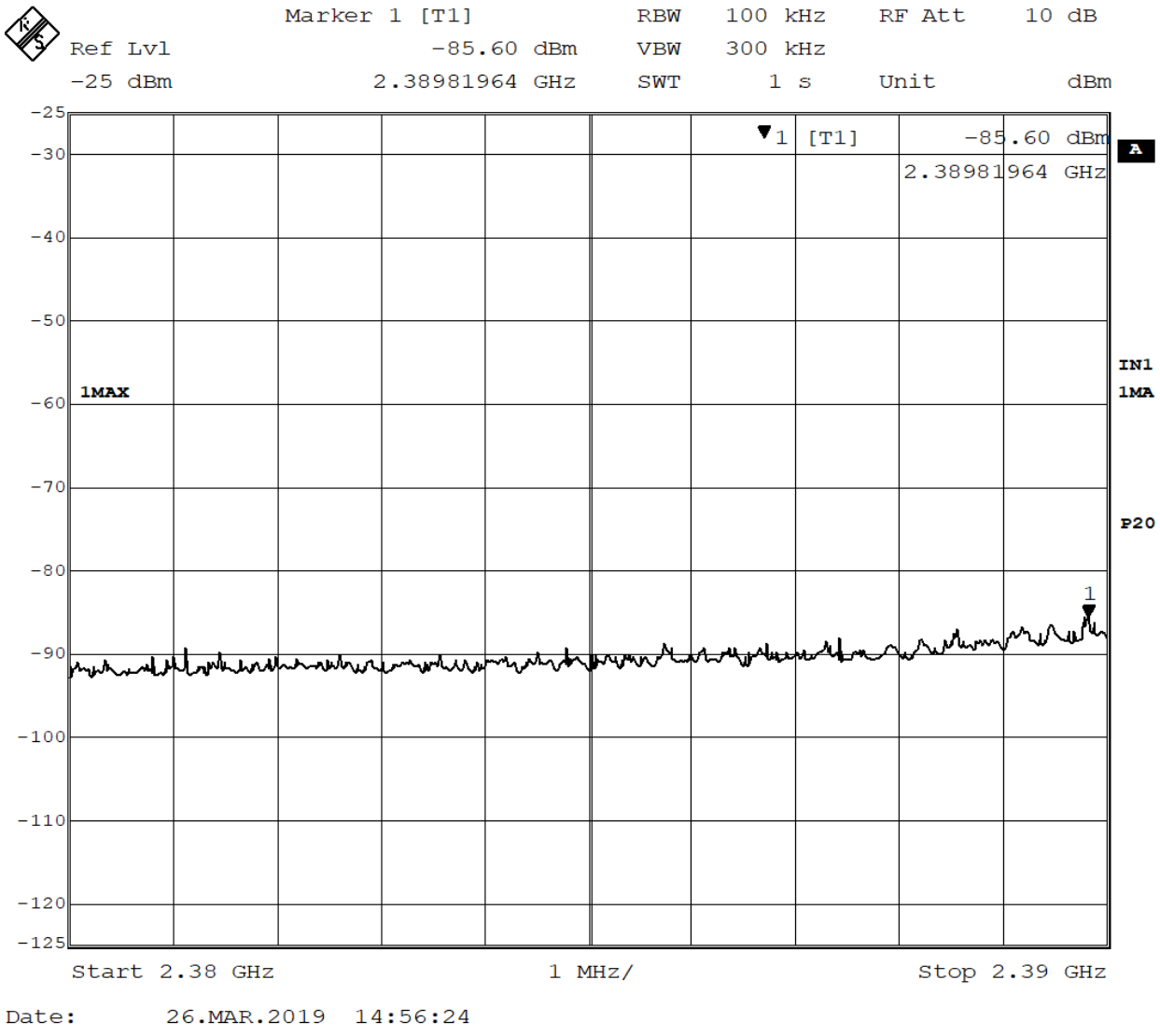

Figure 59 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

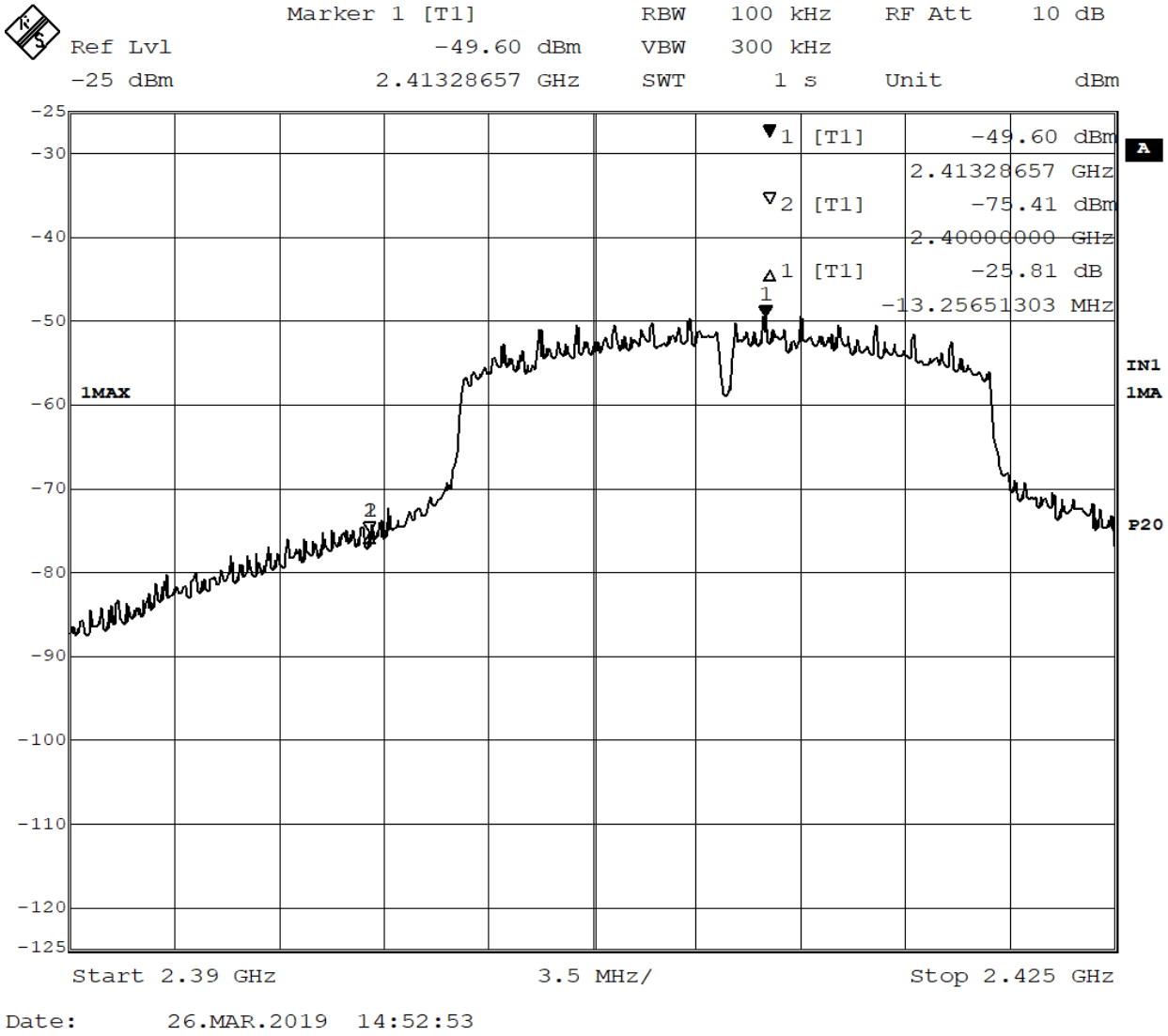

Figure 60 - Band-edge Measurement, Low Channel, Fundamental, Peak

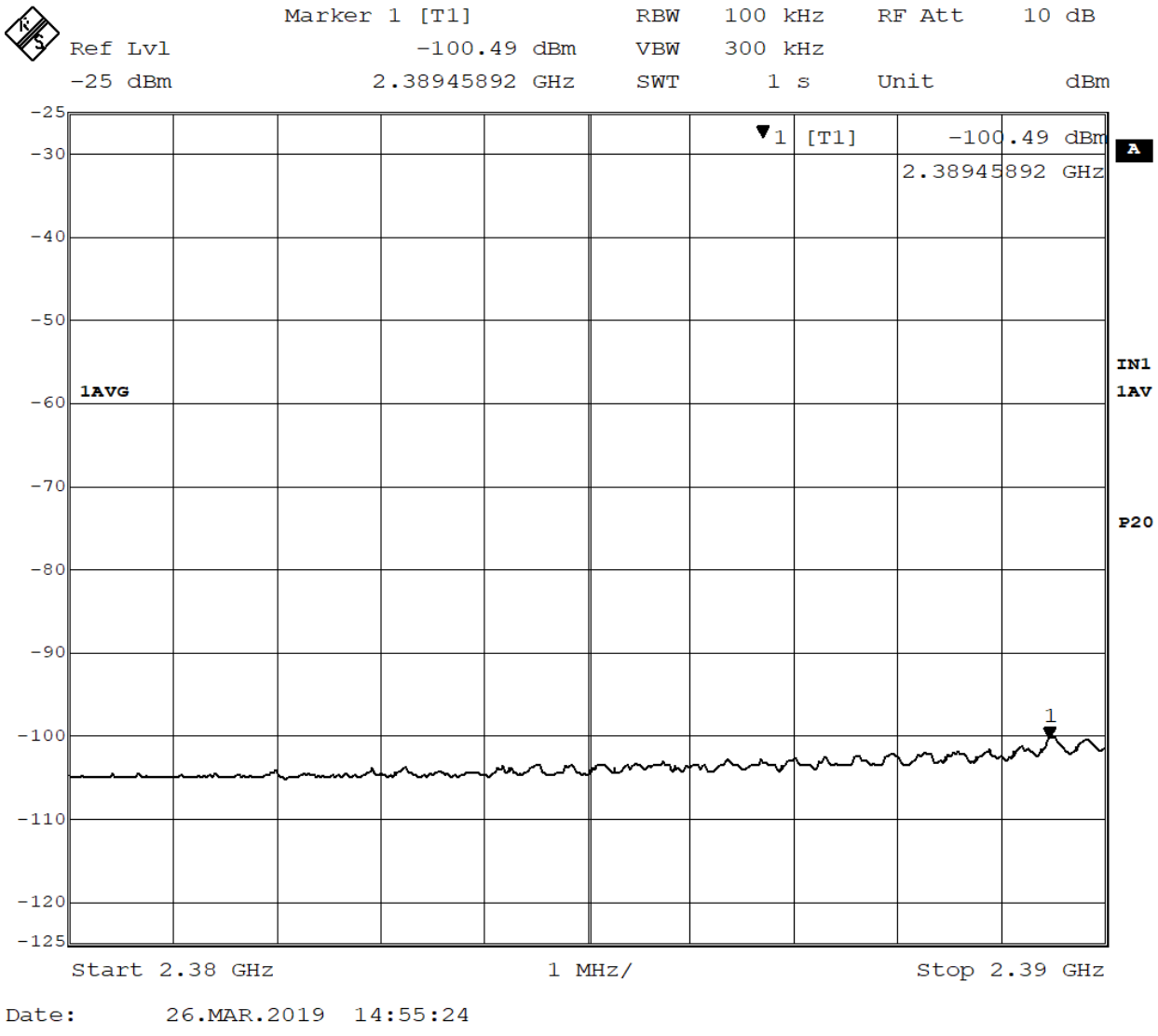

Figure 61 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

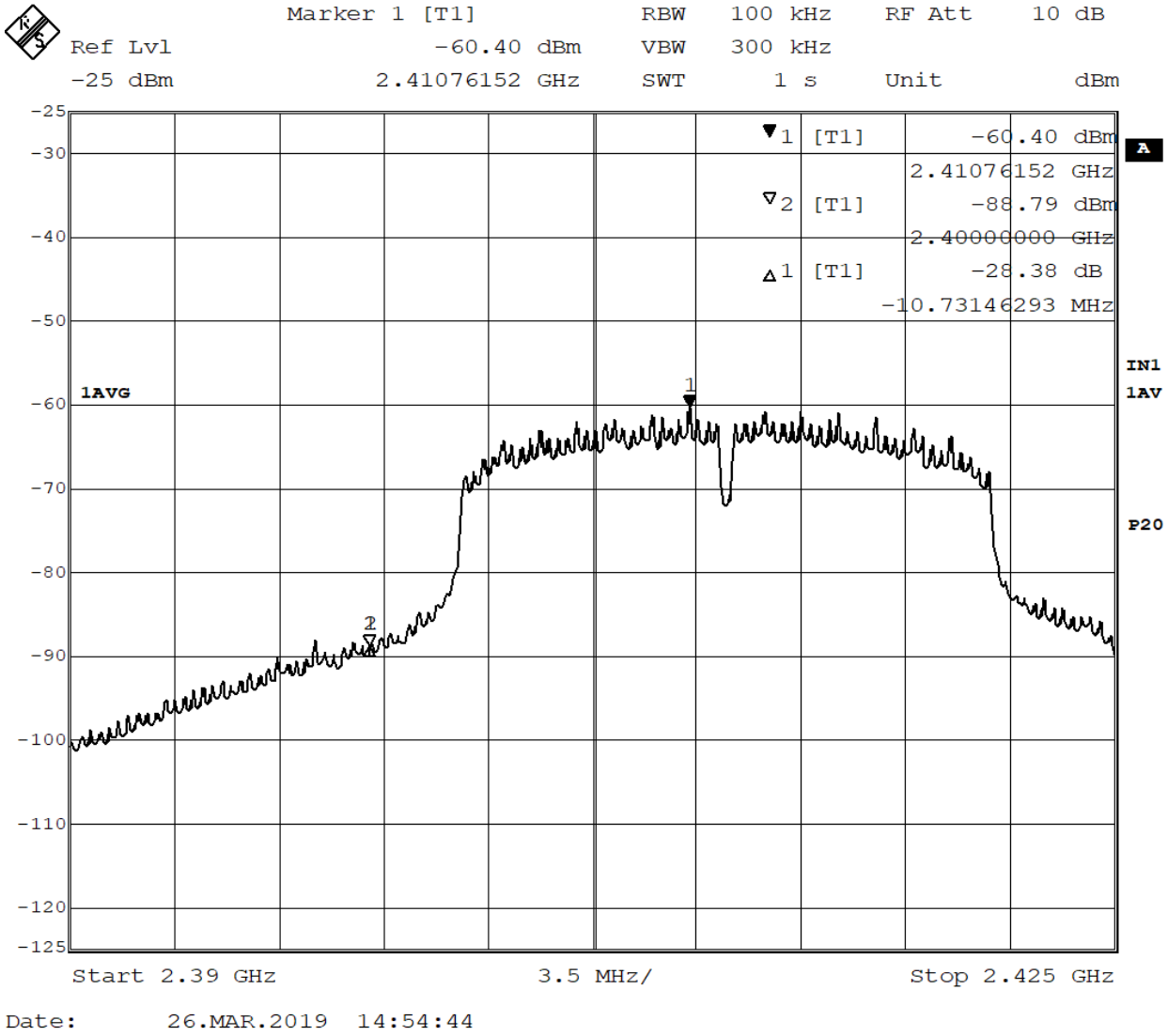

Figure 62 - Band-edge Measurement, Low Channel, Fundamental, Average

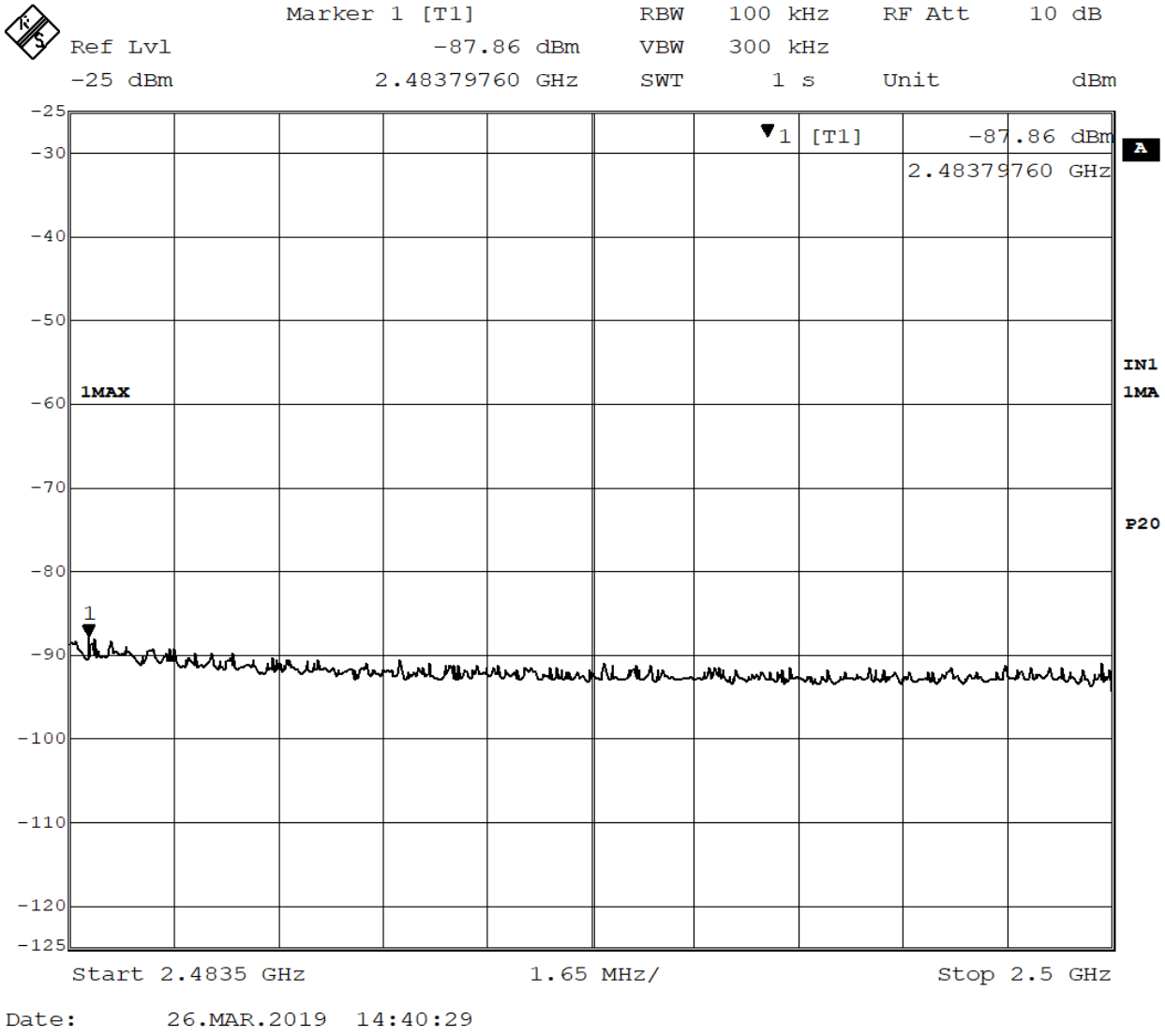

Figure 63 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

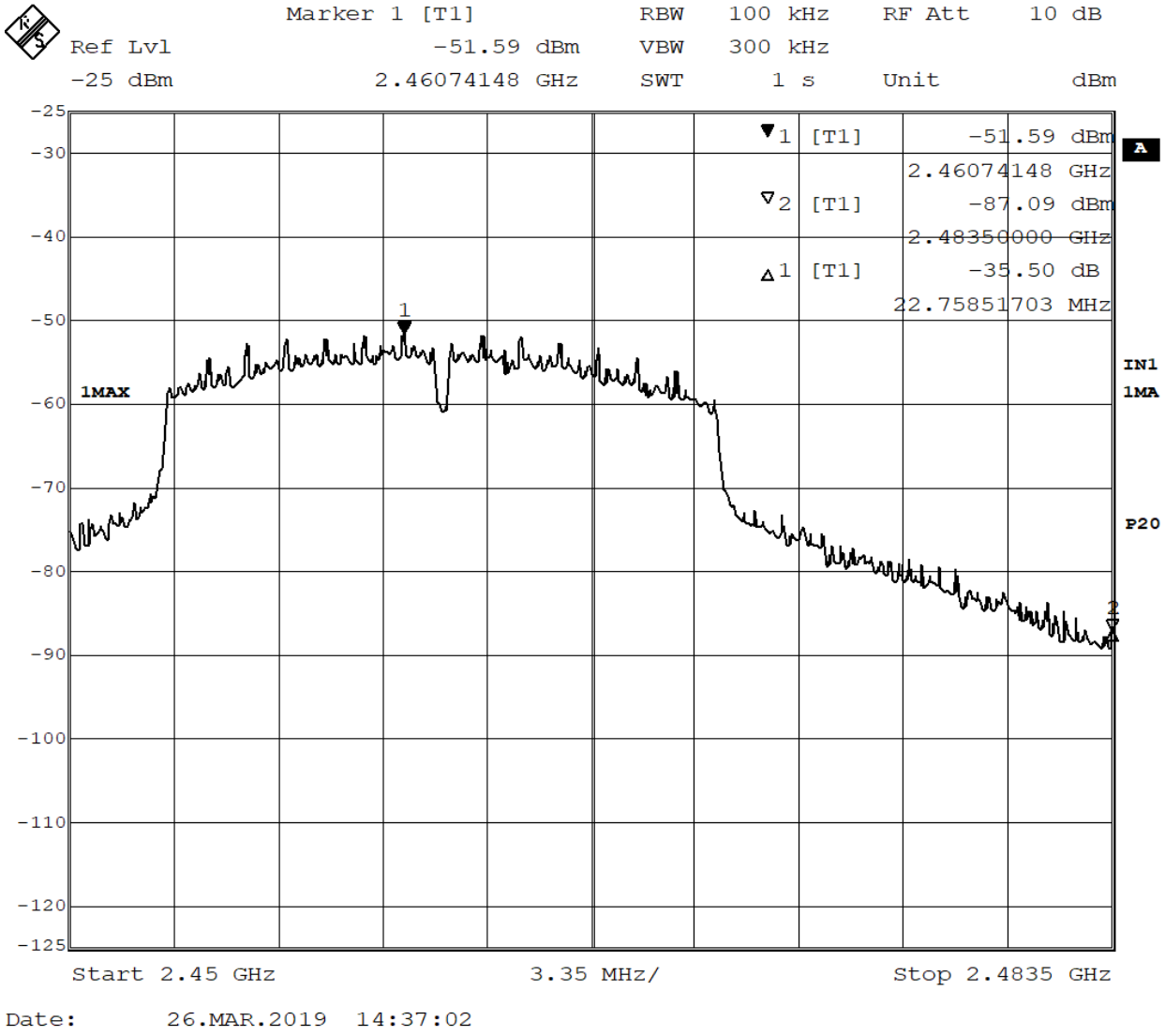

Figure 64 - Band-edge Measurement, High Channel, Fundamental, Peak

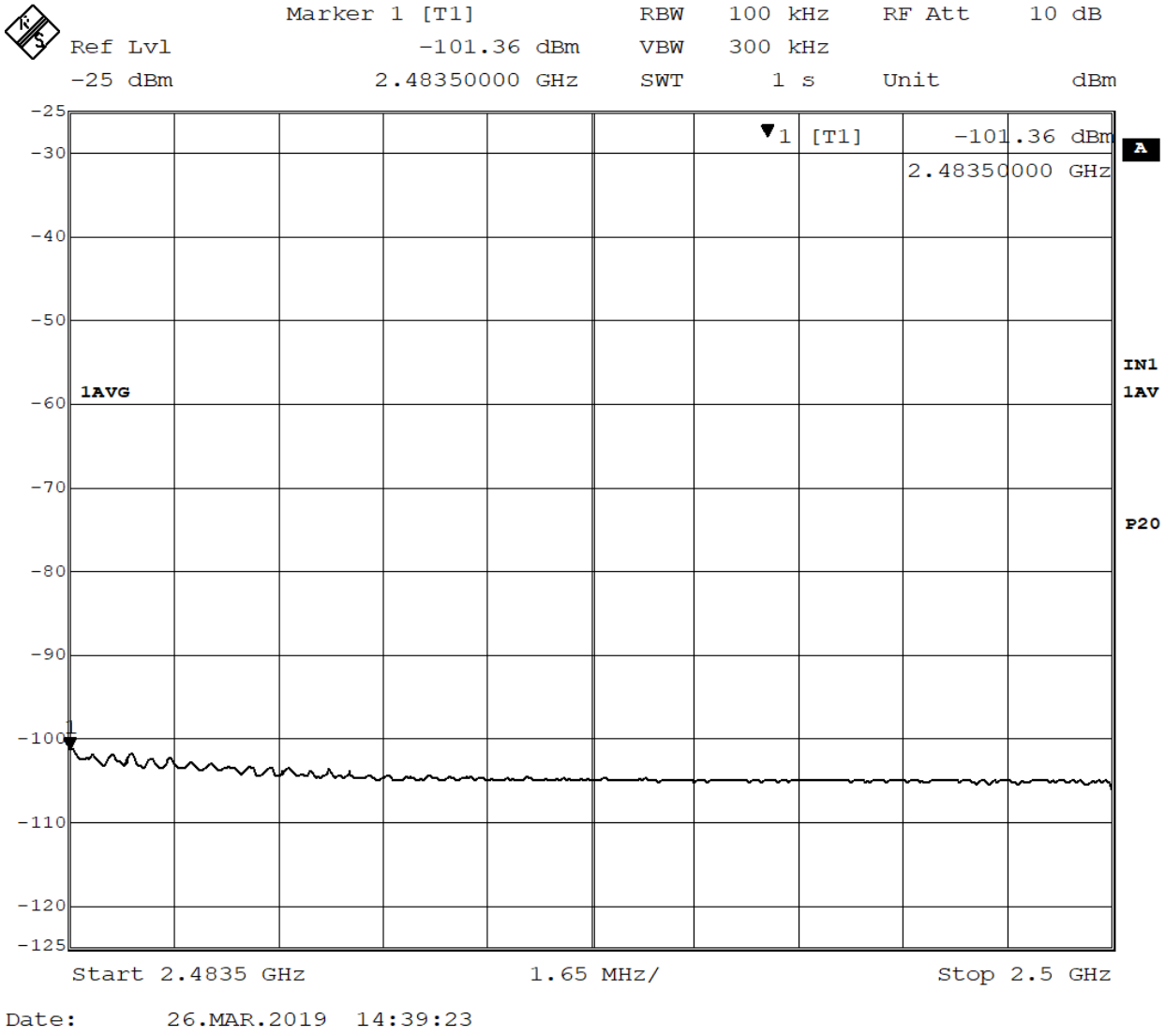

Figure 65 - Band-edge Measurement, High Channel, Restricted Frequency, Average

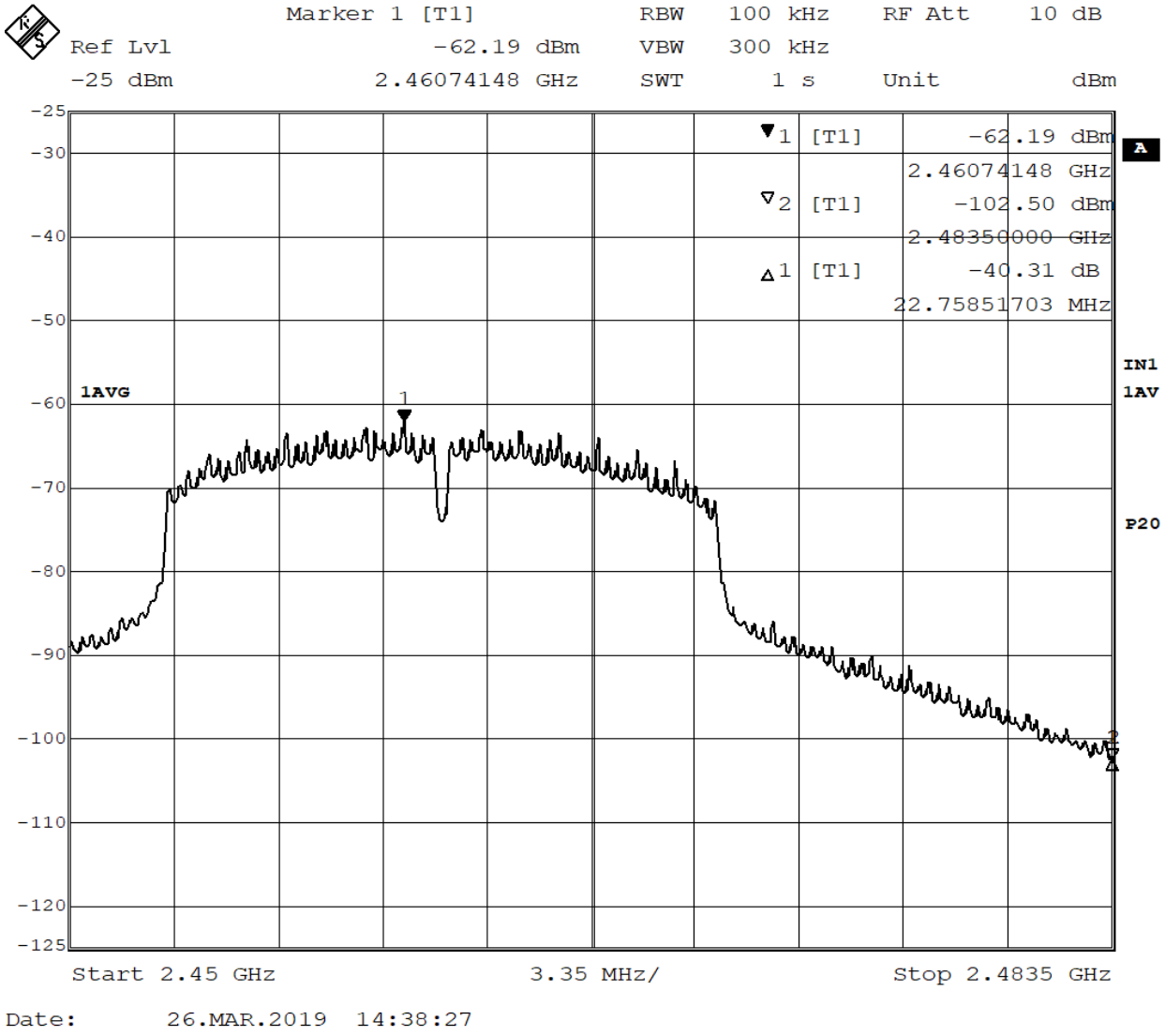

Figure 66 - Band-edge Measurement, High Channel, Fundamental, Average

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. 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 12 VDC Marine 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

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	PEAK PSD(dBm)	Method	Limit (dBm)	RESULT
Low	2412	802.11b	-0.71	Conducted	8.00	PASS
Middle	2437	802.11b	-1.31	Conducted	8.00	PASS
High	2462	802.11b	-1.15	Conducted	8.00	PASS
Low	2412	802.11g	-5.26	Conducted	8.00	PASS
Middle	2437	802.11g	-3.44	Conducted	8.00	PASS
High	2462	802.11g	-5.58	Conducted	8.00	PASS
Low	2412	802.11n	-4.66	Conducted	8.00	PASS
Middle	2437	802.11n	-5.64	Conducted	8.00	PASS
High	2462	802.11n	-5.30	Conducted	8.00	PASS

*0.5 dB of cable loss was added as the plots don't reflect the corrected value.

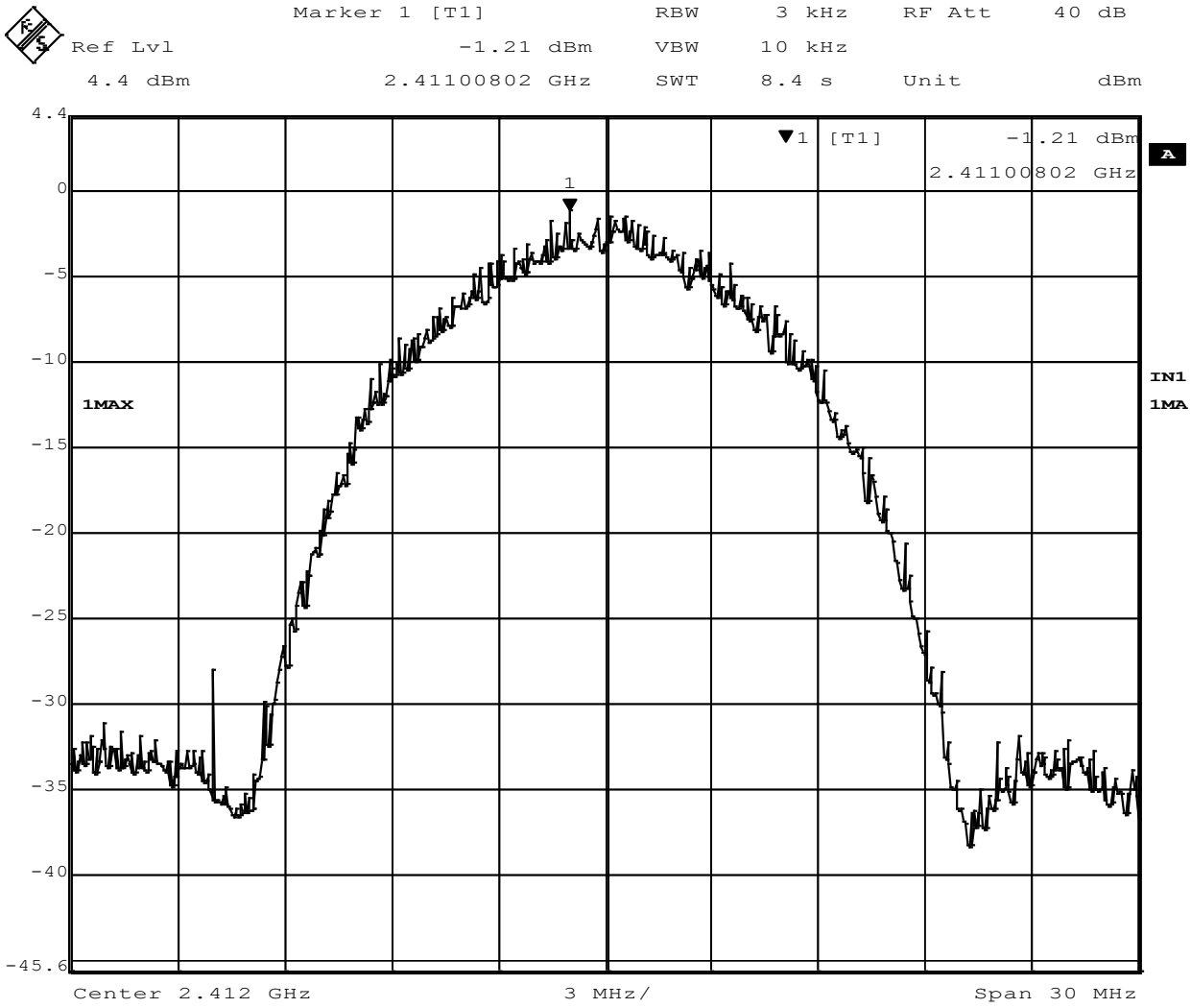

Figure 67 - Power Spectral Density, Low Channel, 802.11b

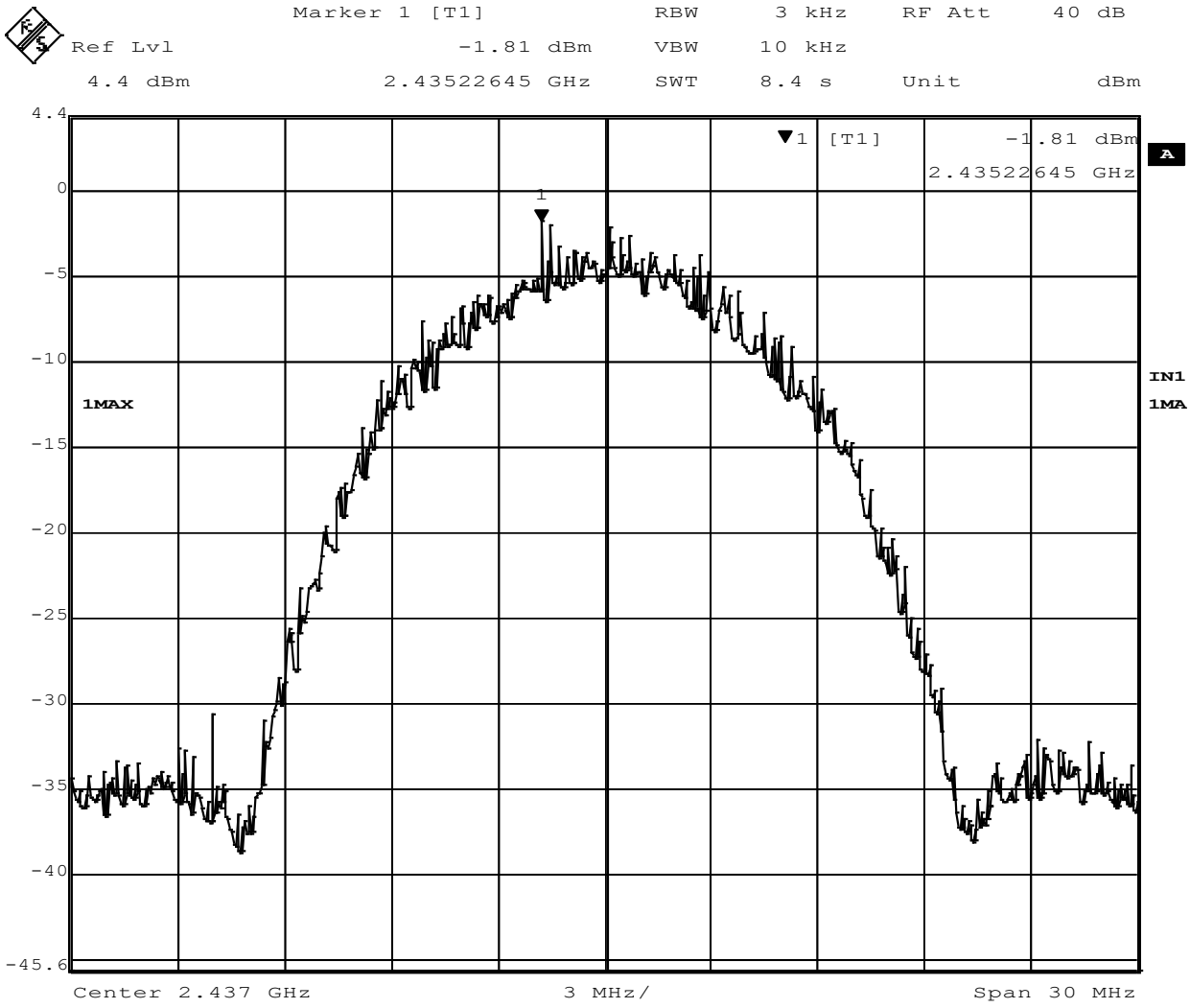

Figure 68 - Power Spectral Density, Mid Channel, 802.11b

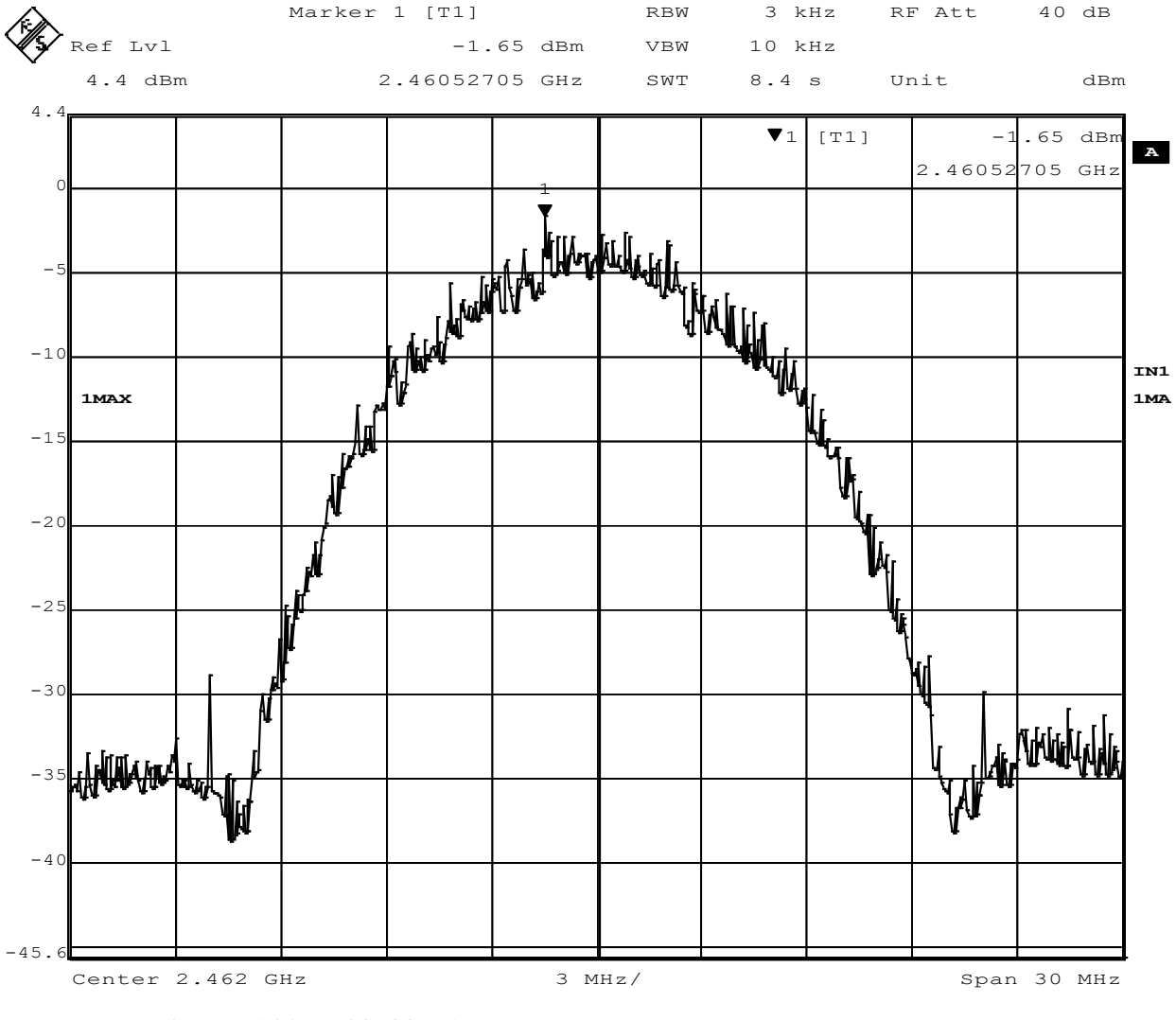

Figure 69 - Power Spectral Density, High Channel, 802.11b

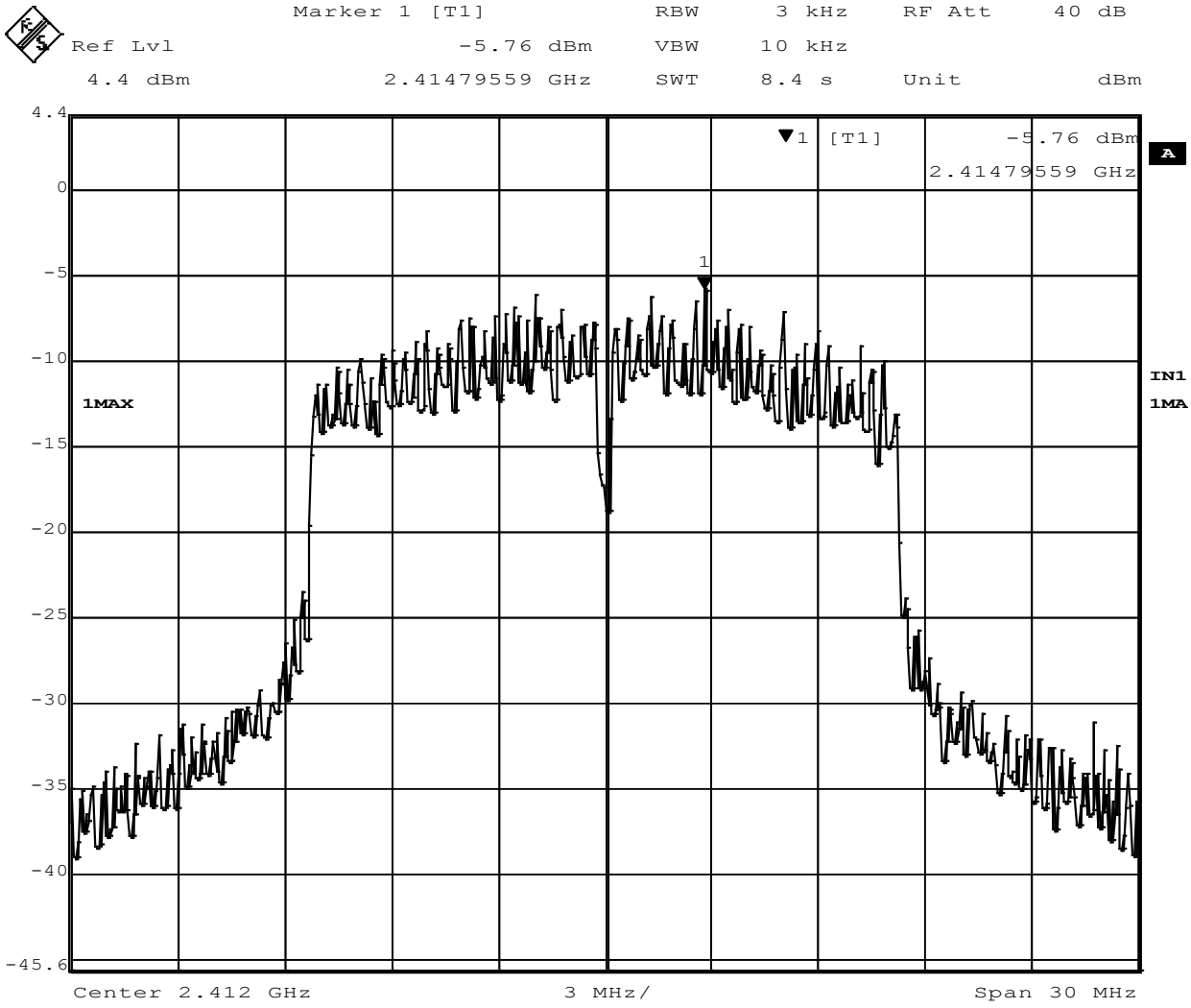

Figure 70 - Power Spectral Density, Low Channel, 802.11g

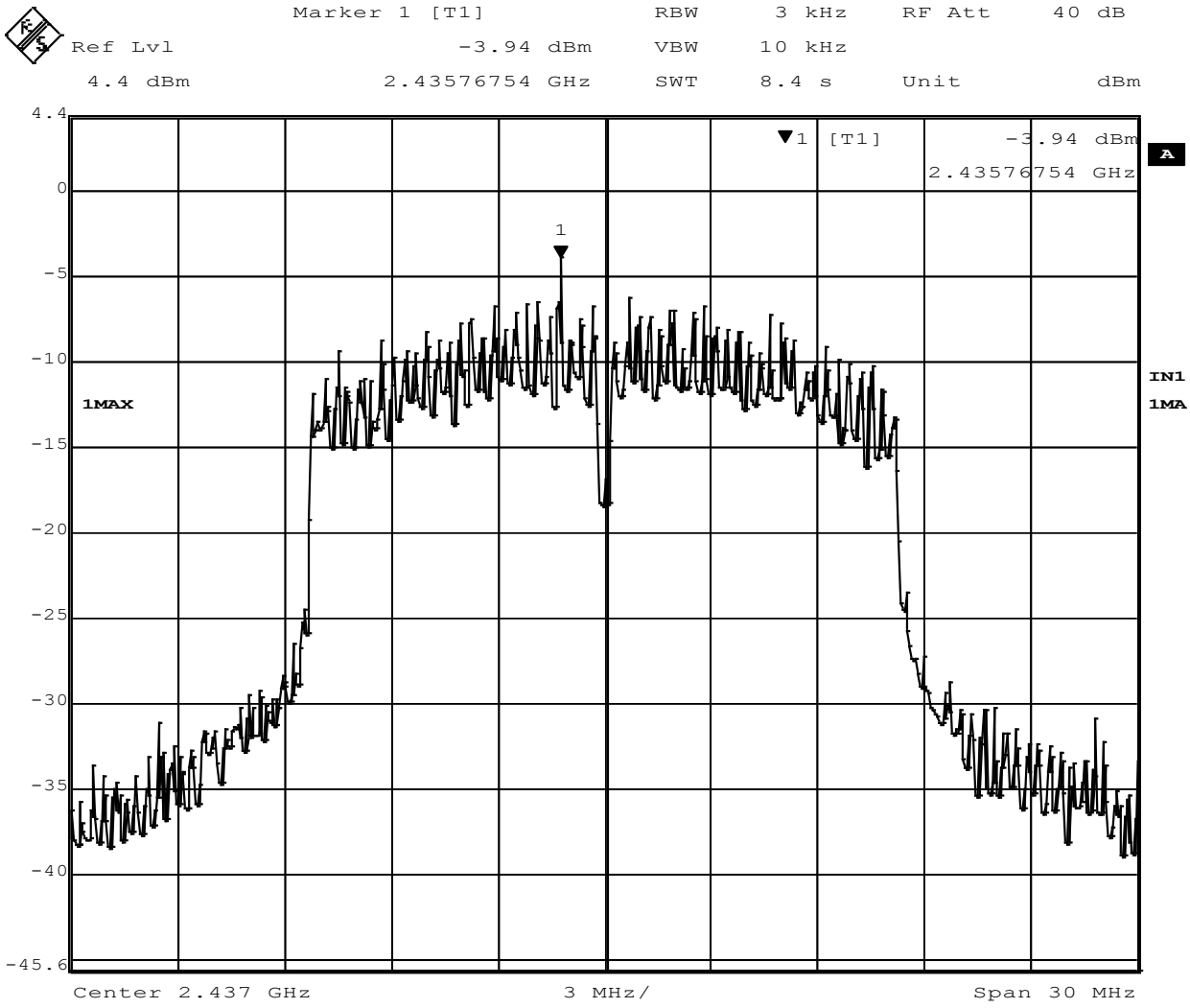

Figure 71 - Power Spectral Density, Mid Channel, 802.11g

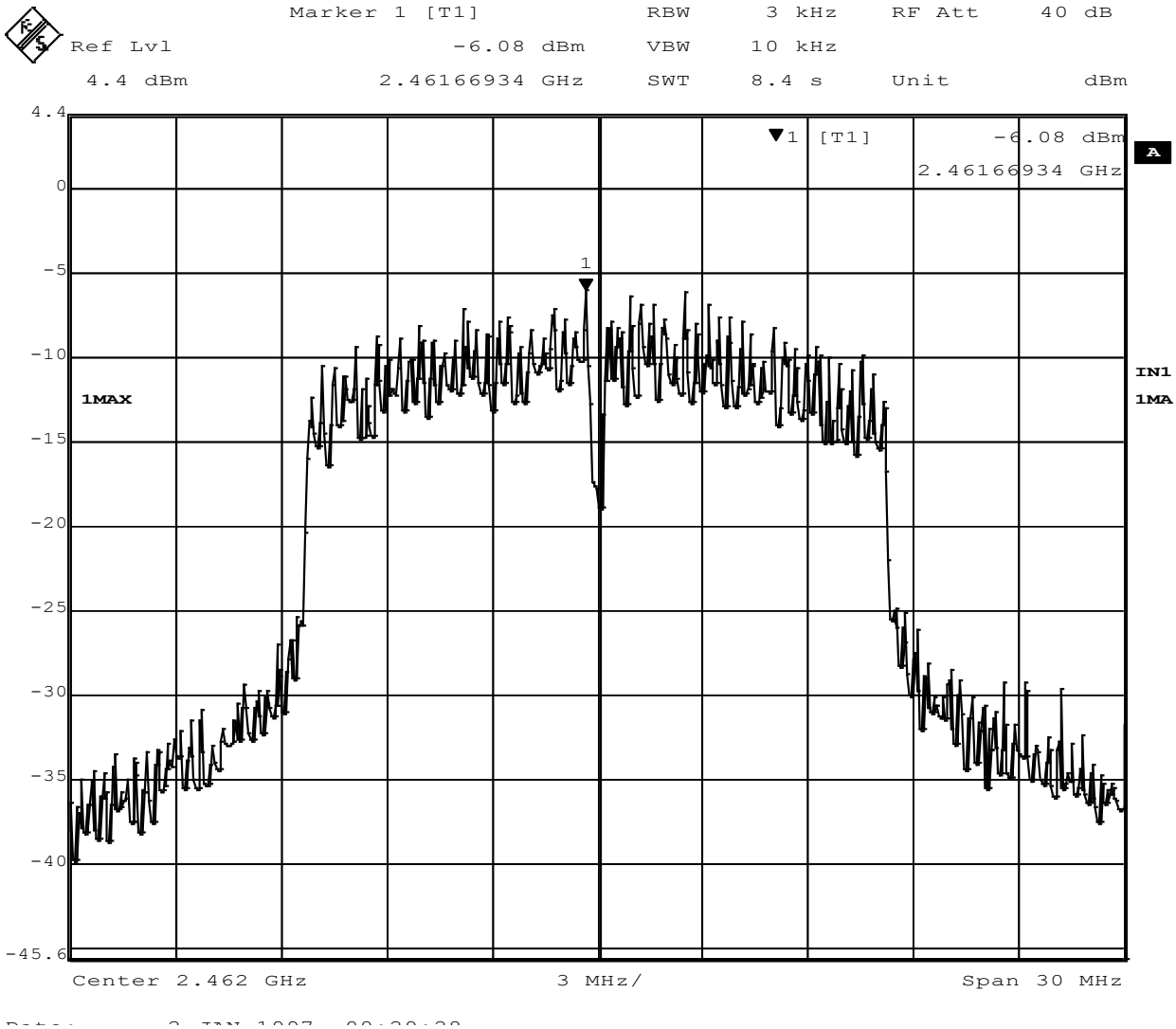

Figure 72 - Power Spectral Density, High Channel, 802.11g

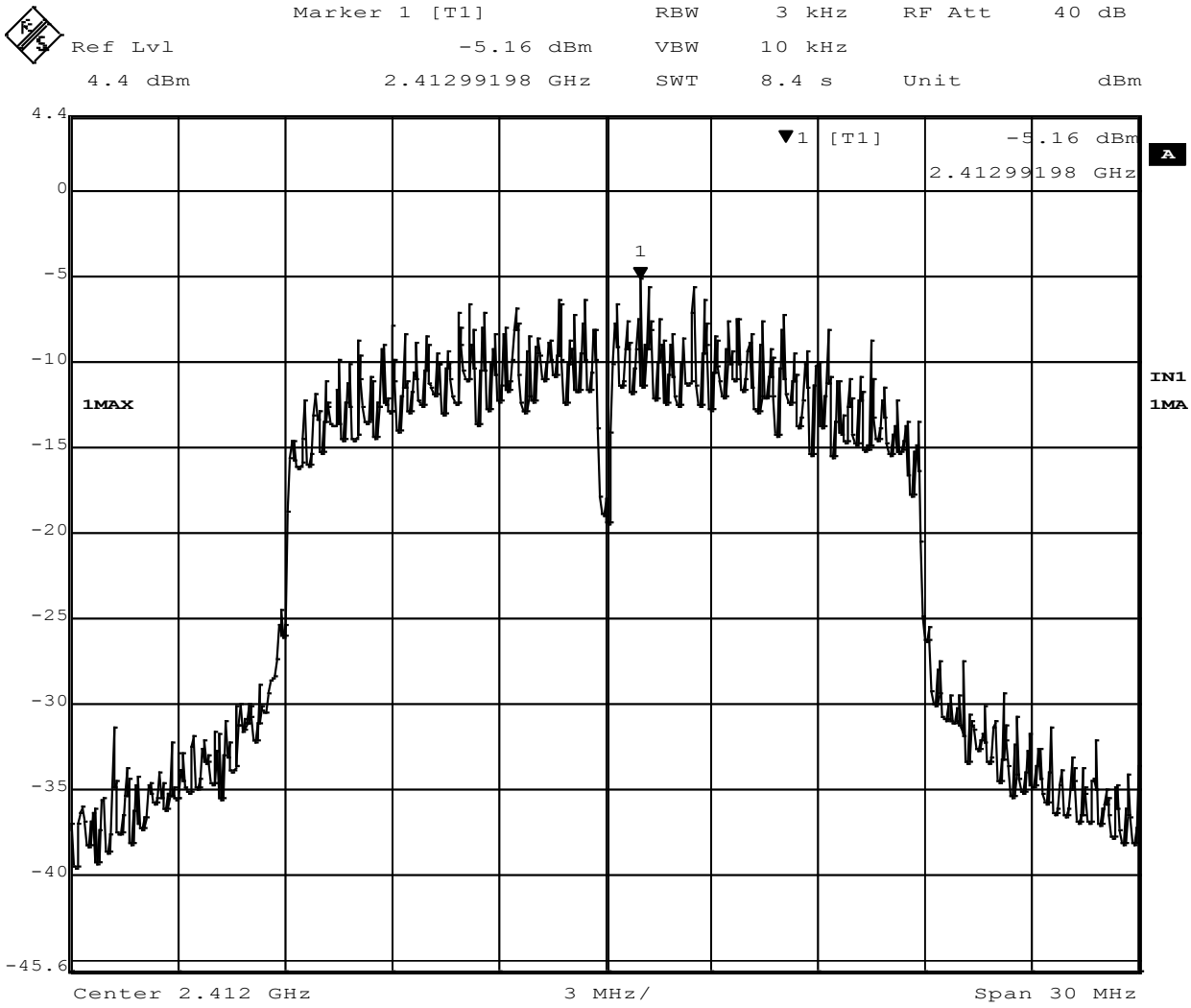

Figure 73 - Power Spectral Density, Low Channel, 802.11n

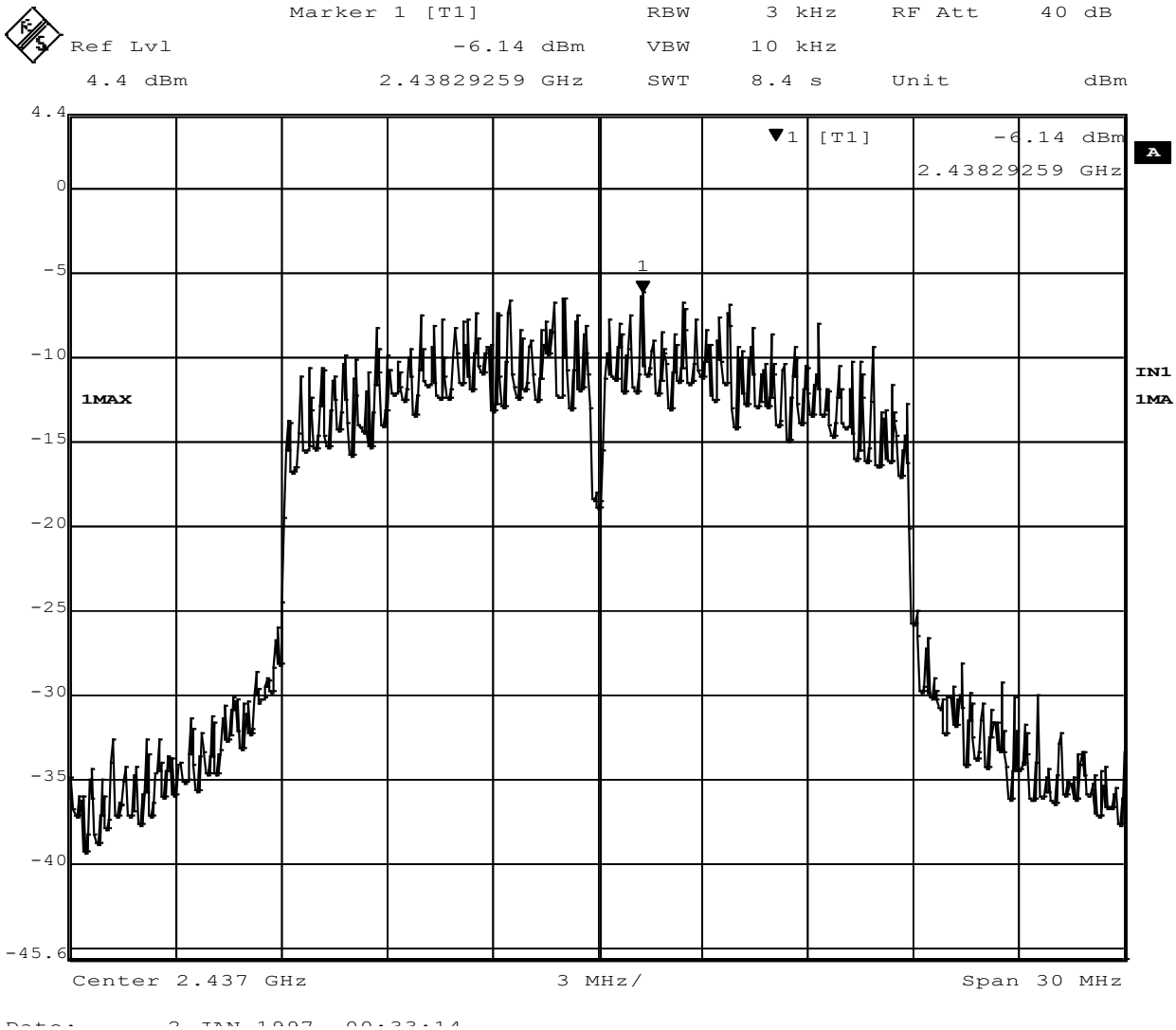

Figure 74 - Power Spectral Density, Mid Channel, 802.11n

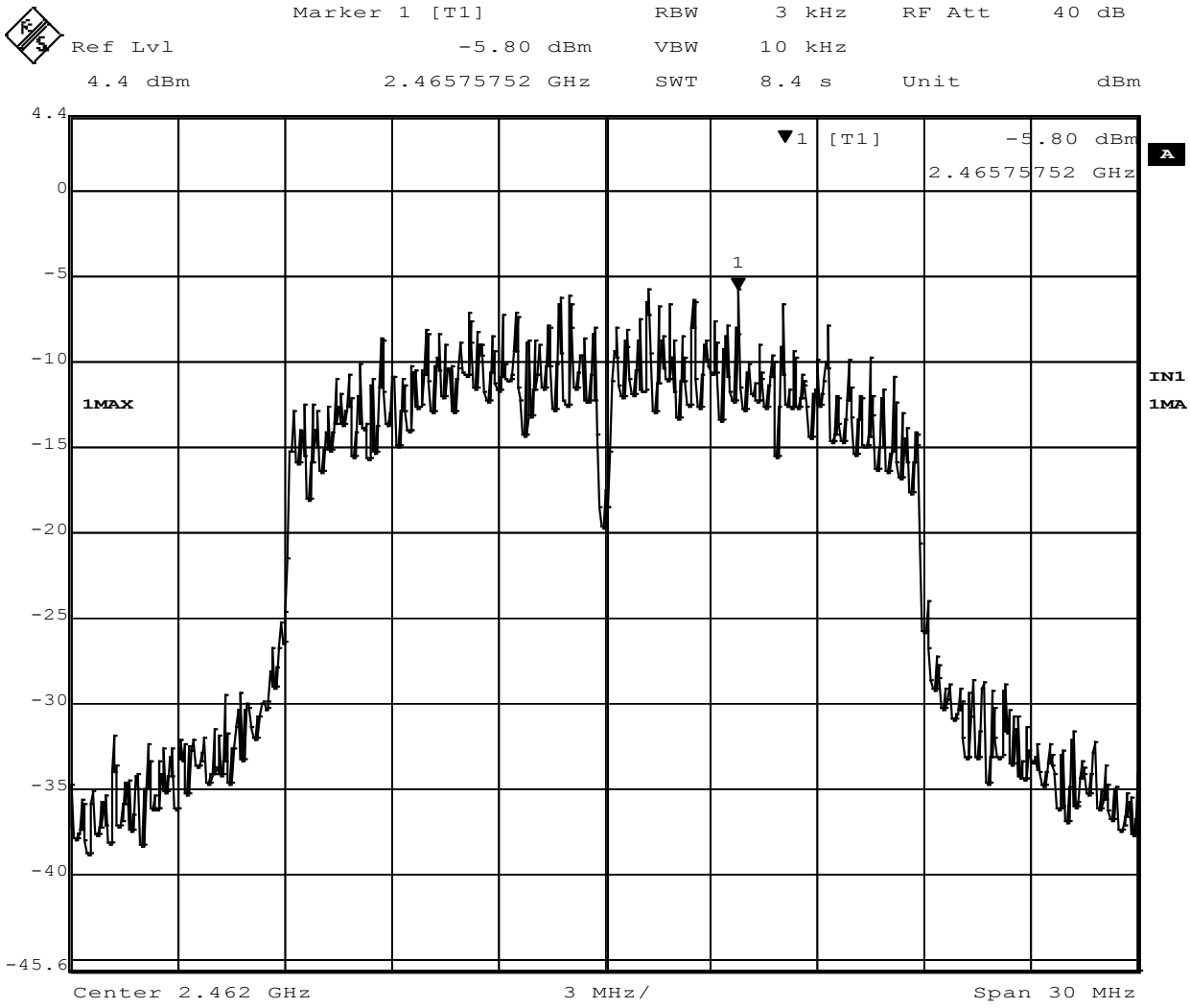

Figure 75 - Power Spectral Density, High Channel, 802.11n

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