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Amended

FCC/ISED Test Report

Prepared for: **LockState**

Address: **2170 S. Delaware Street**
Denver, CO 80223
USA

Product: **RemoteLock 8i**

Test Report No: **R20180313-21B**

Approved By:

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

DATE: **14 January 2019**

Total Pages: **81**

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	22 October 2018	Original – NJohnson Prepared by KVepuri
A	27 November 2018	Added note to Page 12 to explain how FCC Part 15.247(d) and RSS-247 Section 5.5 are met. -NJ
B	14 January 2019	Corrected calibration dates, removed incorrect reference form Section 1, updated bandedge measurements to use Section 11.12 of C63.10. -NJ

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1.0 SUMMARY OF TEST RESULTS

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 15.35 RSS Gen, Issue 4, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (Nonrestricted) 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 a RemoteLock 8i a LockState Electronic Door Lock from LockState. It features a UGSI WIFi module (MN: WM-N-BM-14A FCC ID: COFWMNBM11) and has transmit and receives capabilities.

EUT	LockState Electronic Door Lock
Model	RemoteLock 8i
EUT Received	2 October 2018
EUT Tested	2 October 2018 - 3 October 2018
Serial No.	NCEETEST1 (assigned)
Operating Band	2400.0 - 2483.5 GHz
Device Type	DTS
Antenna	Trace Antenna (2.8 dBi max gain - Measured)
Power Supply	3 VDC (2 x AA)

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 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 2019
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2019
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2020
EMCO Horn Antenna	3116	2576	31 Jan 2018	31 Jan 2020
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2019*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2019*
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2019*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2019*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2019*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2019*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2019*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2019*

*Internal 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 effect the delta measurement.

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

NOTE:
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (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.

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:

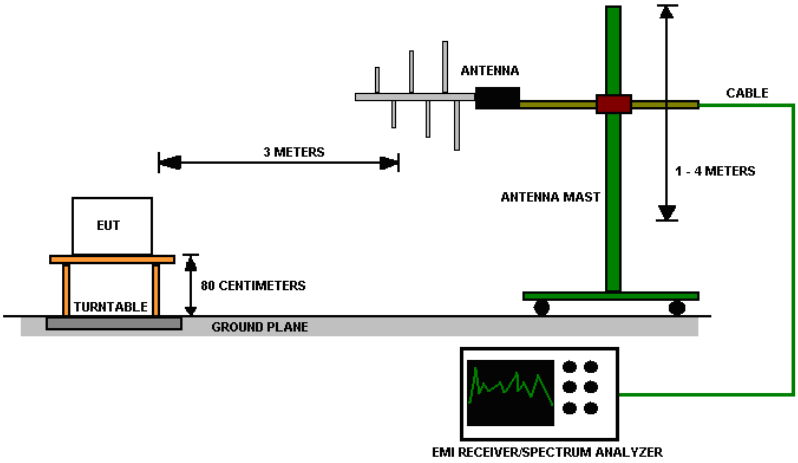

Figure 1 - Radiated Emissions Test Setup

EUT operating conditions
The EUT was powered by 3 VDC 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 80211n which was determined as worst case after investigation.

Test results:

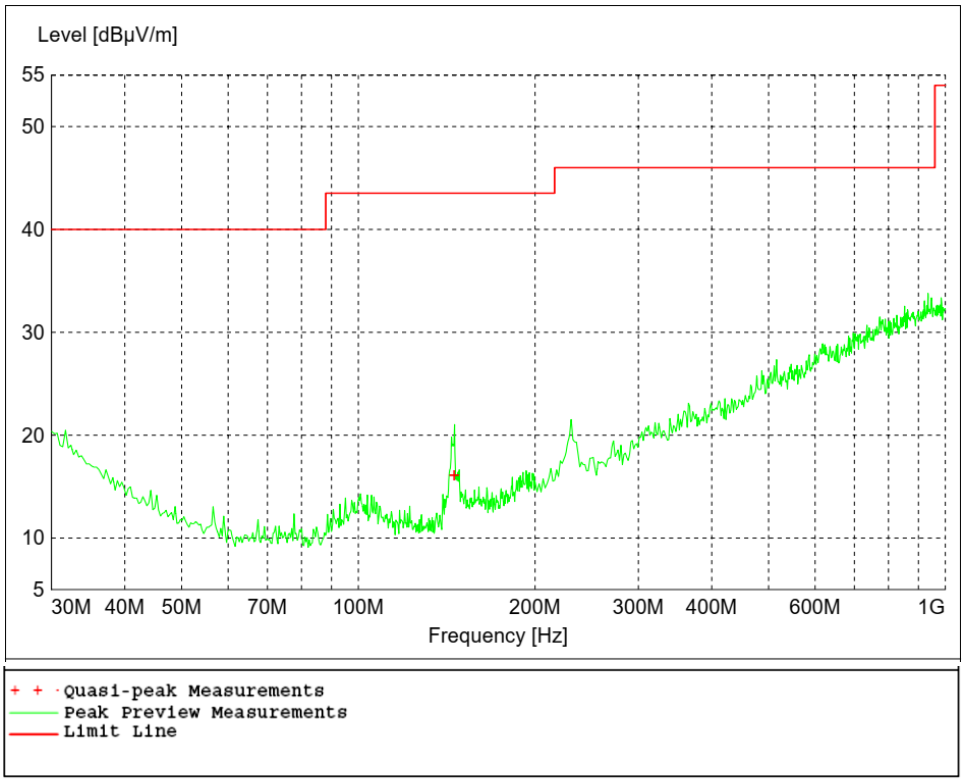

Figure 2 - Radiated Emissions Plot, Receive

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.	
145.680000	16.09	43.50	27.40	98	360	VERT

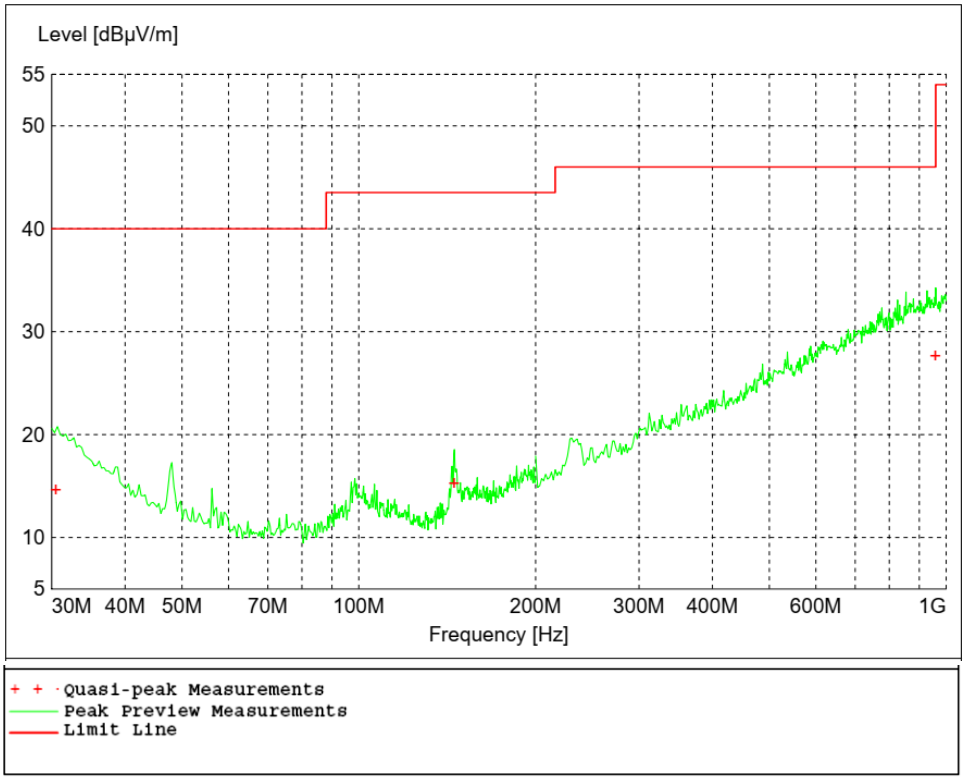

Figure 3 - Radiated Emissions Plot, High Channel

Table 2 - Radiated Emissions Quasi-peak Measurements, High Channel, 802.11n

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.480000	14.71	40.00	25.30	400	74	HORI
145.320000	15.32	43.50	28.20	102	0	VERT
958.440000	27.64	46.00	18.40	264	0	HORI

Table 3 - Radiated Emissions Peak Detector Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
4824.000000	52.92	74.0	21.1	187.0	360	VERT	b
No signals detected above system sensitivity							

Table 4 - Radiated Emissions Average Detector Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
4824.000000	41.33	54.0	12.7	187.0	360	VERT	
No signals detected above system sensitivity							

Table 5 - Radiated Emissions Peak Measurements , Middle Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
4884.000000	53.07	74.0	18.9	100.0	92	VERT	n
7354.000000	43.64	74.0	30.4	289.0	292	VERT	n

Table 6 - Radiated Emissions Average Measurements, Middle Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
4884.000000	42.13	54.0	11.9	100.0	92	VERT	n
7354.000000	30.27	54.0	23.7	289.0	292	VERT	n

Table 7 - Radiated Emissions Peak Measurements , High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
4922.200000	55.87	74.00	18.13	187	0	VERT	n
No signals detected above system sensitivity							

Table 8 - Radiated Emissions Average Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Mode
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		802.11
4922.200000	39.65	54.00	14.35	187	0	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) 11.9.2.3 “Measurement using a power meter (PM)”

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

Test procedures:
The EUT was connected to 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:

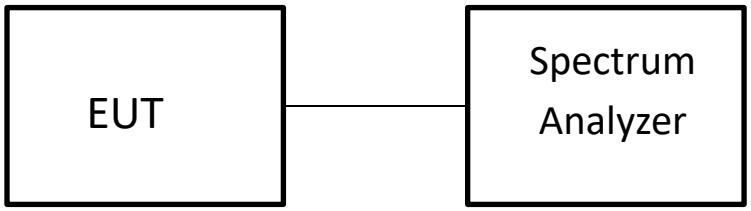

Figure 4 – Peak Output Power Measurements Test Setup
*5.5 dB of cable loss was used for peak and average output power.

EUT operating conditions:
The EUT was powered by 3 VDC 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	EIRP with antenna gain*	Method	RESULT
Low	2412	802.11b	19.47	22.27	Conducted	PASS
Middle	2437	802.11b	19.01	21.81	Conducted	PASS
High	2462	802.11b	18.62	21.42	Conducted	PASS
Low	2412	802.11g	21.63	24.43	Conducted	PASS
Middle	2437	802.11g	21.46	24.26	Conducted	PASS
High	2462	802.11g	21.00	23.80	Conducted	PASS
Low	2412	802.11n	21.63	24.43	Conducted	PASS
Middle	2437	802.11n	21.43	24.23	Conducted	PASS
High	2462	802.11n	20.86	23.66	Conducted	PASS

Average Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	Average OUTPUT POWER (dBm) MU = ±1.37	EIRP with antenna gain*	Method	RESULT
Low	2412	802.11b	13.99	16.79	Conducted	PASS
Middle	2437	802.11b	13.37	16.17	Conducted	PASS
High	2462	802.11b	14.04	16.84	Conducted	PASS
Low	2412	802.11g	13.59	16.39	Conducted	PASS
Middle	2437	802.11g	13.22	16.02	Conducted	PASS
High	2462	802.11g	14.04	16.84	Conducted	PASS
Low	2412	802.11n	13.59	16.39	Conducted	PASS
Middle	2437	802.11n	13.47	16.27	Conducted	PASS
High	2462	802.11n	13.10	15.90	Conducted	PASS

*Antenna gain of 2.8 dBi Maximum was used.

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:

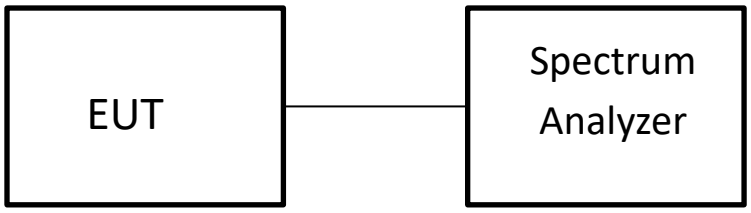

Figure 5 – Peak Output Power Measurements Test Setup

EUT operating conditions:
The EUT was powered by 3 VDC 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	12.37
Middle	2437	802.11b	12.26
High	2462	802.11b	12.22
Low	2412	802.11g	16.33
Middle	2437	802.11g	16.33
High	2462	802.11g	16.33
Low	2412	802.11n	17.53
Middle	2437	802.11n	17.53
High	2462	802.11n	17.53

6dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	6 dB BW (MHz)
Low	2412	802.11b	7.91
Middle	2437	802.11b	7.64
High	2462	802.11b	6.86
Low	2412	802.11g	15.73
Middle	2437	802.11g	15.78
High	2462	802.11g	14.52
Low	2412	802.11n	16.38
Middle	2437	802.11n	16.28
High	2462	802.11n	16.38

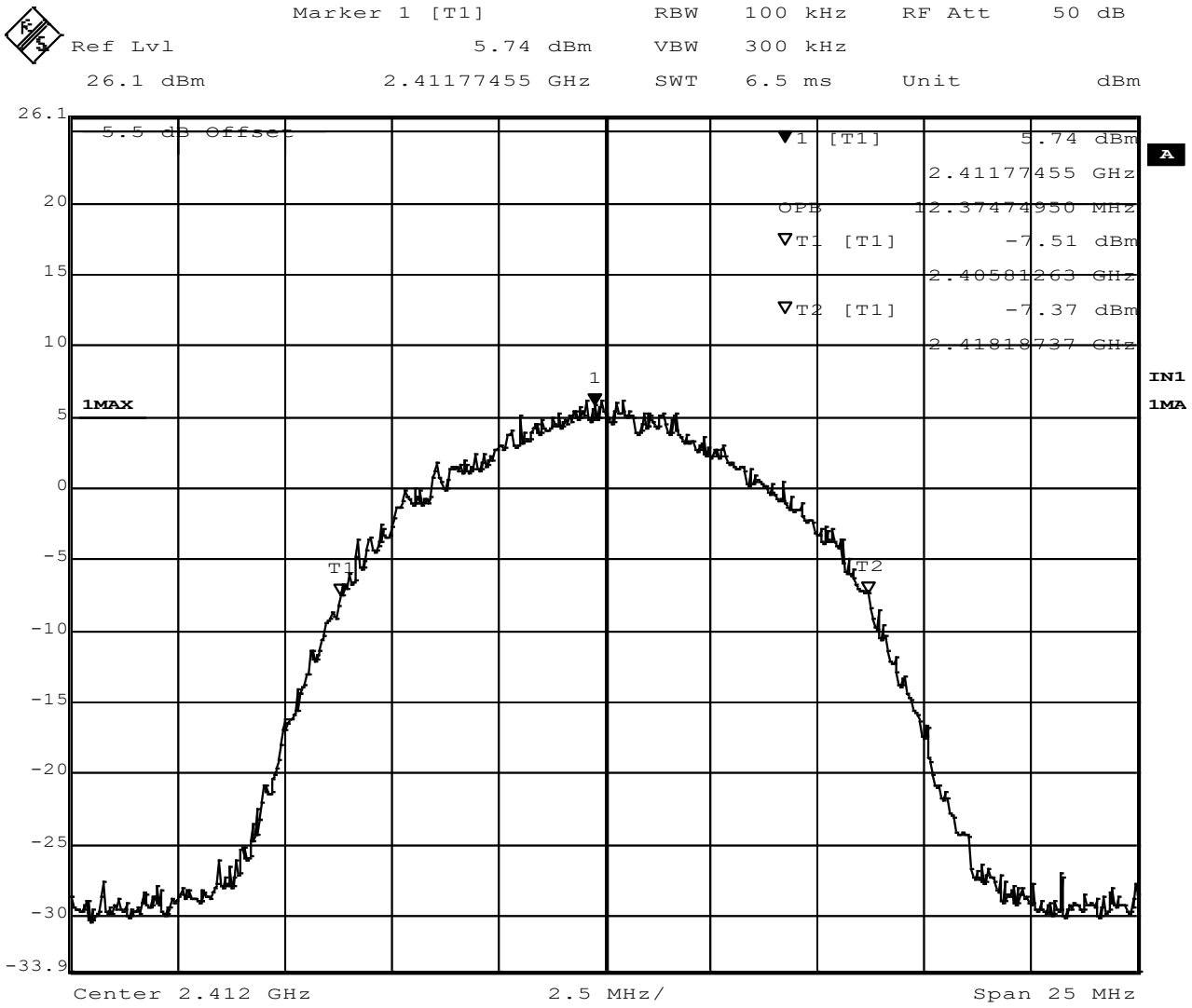

Figure 6 - 99% Occupied Bandwidth, Low Channel, 802.11b

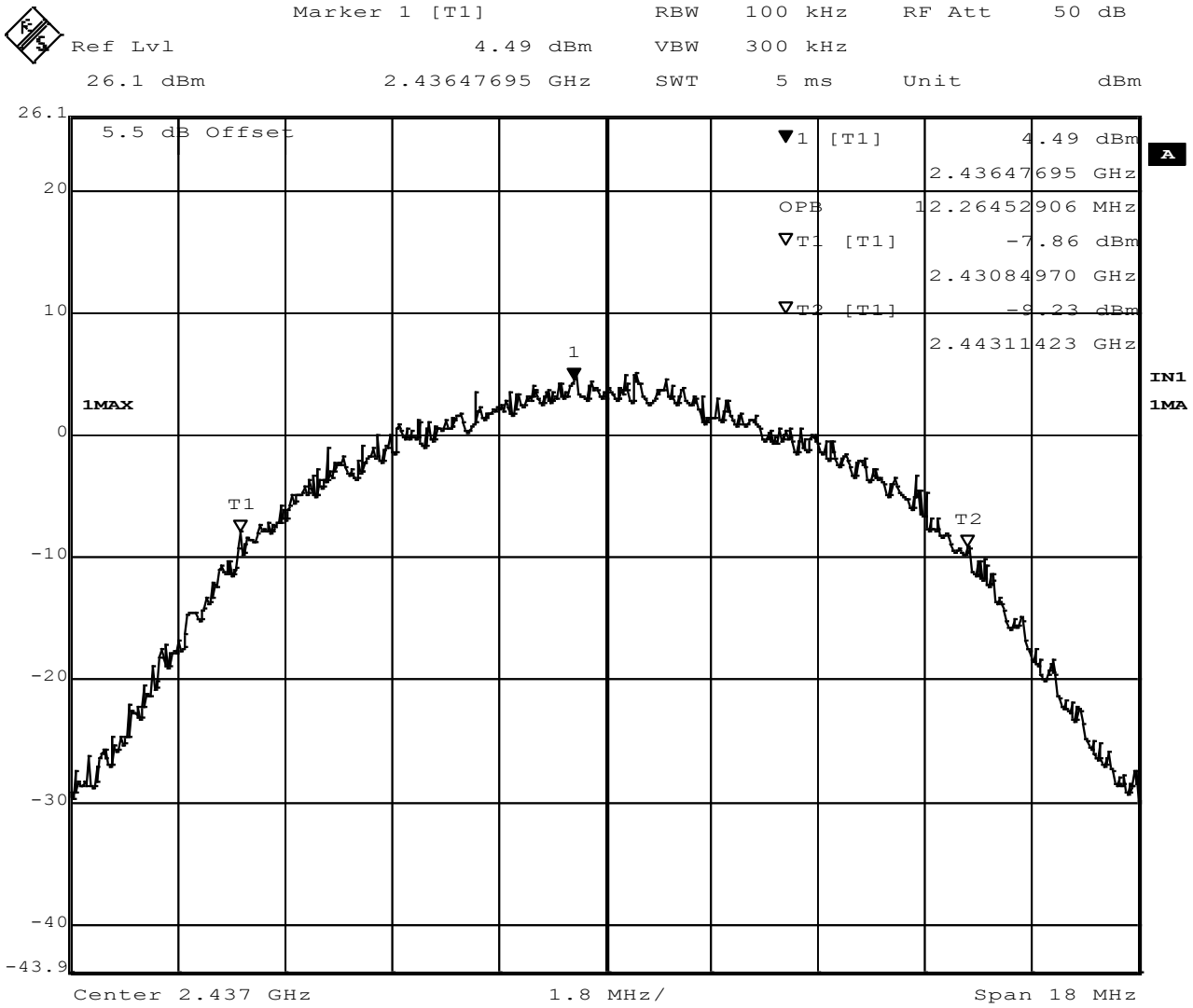

Figure 7 - 99% Occupied Bandwidth, Mid Channel, 802.11b

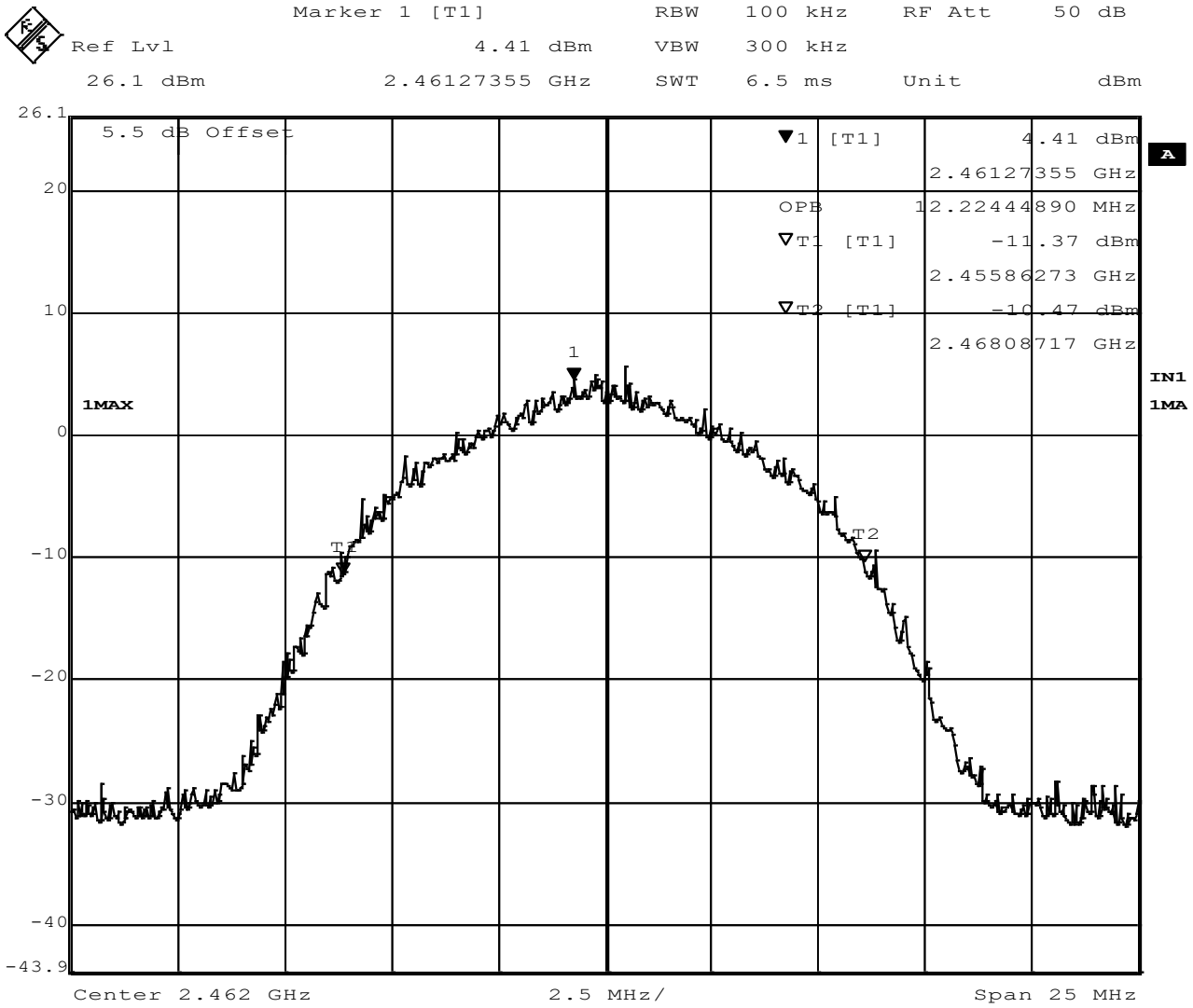

Figure 8 - 99% Occupied Bandwidth, High Channel, 802.11b

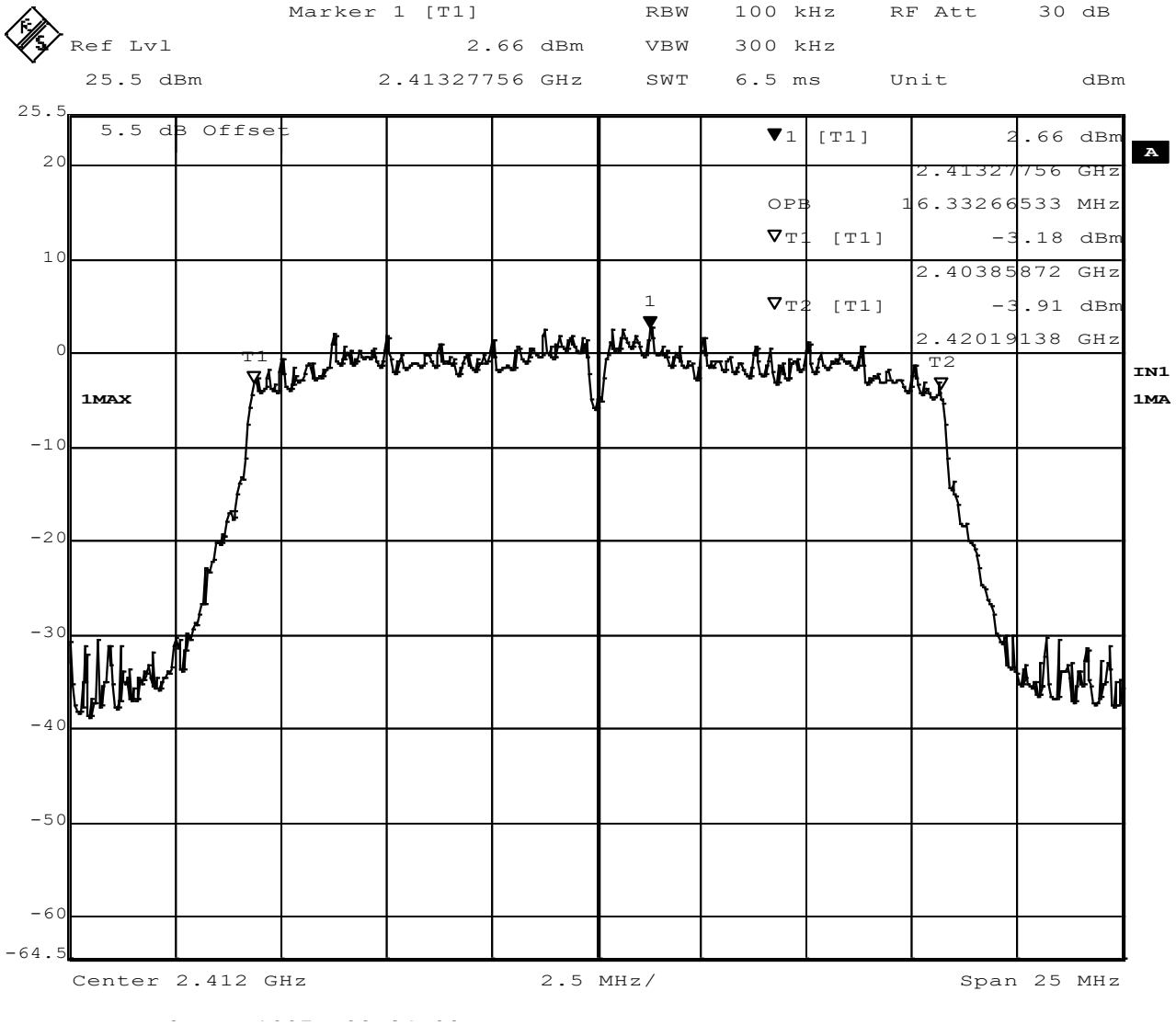

Figure 9 - 99% Occupied Bandwidth, Low Channel, 802.11g

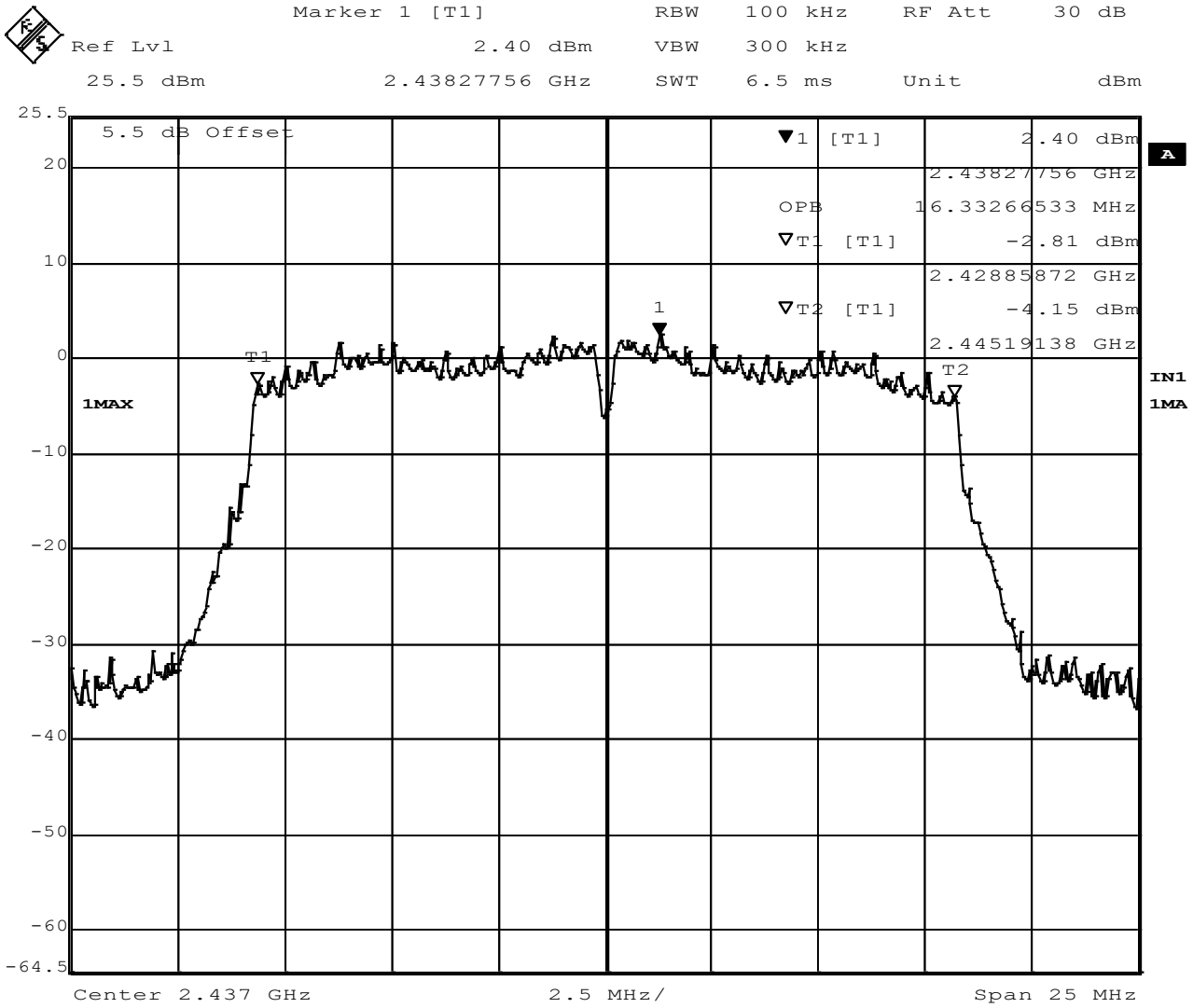

Figure 10 - 99% Occupied Bandwidth, Mid Channel, 802.11g

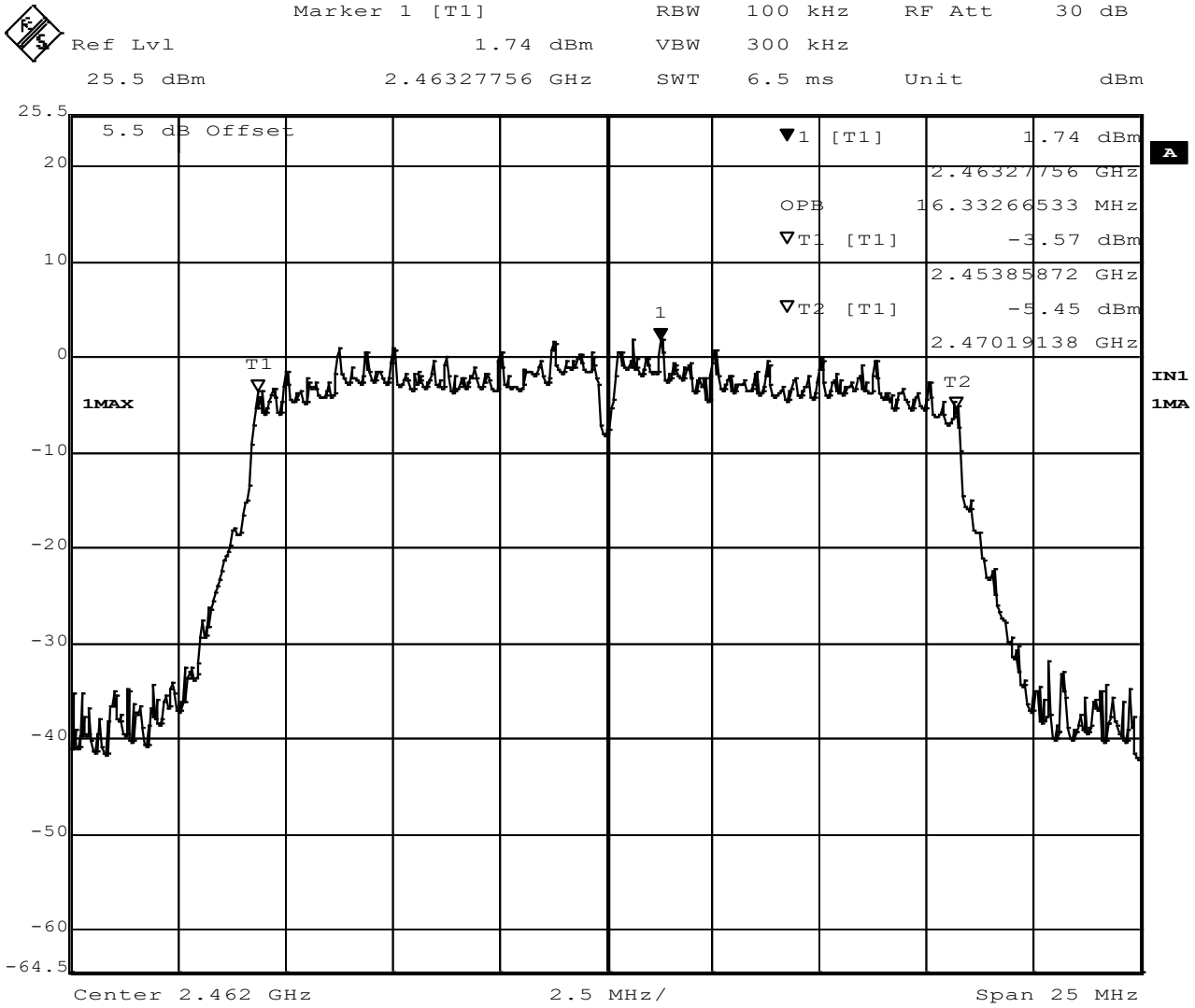

Figure 11 - 99% Occupied Bandwidth, High Channel, 802.11g

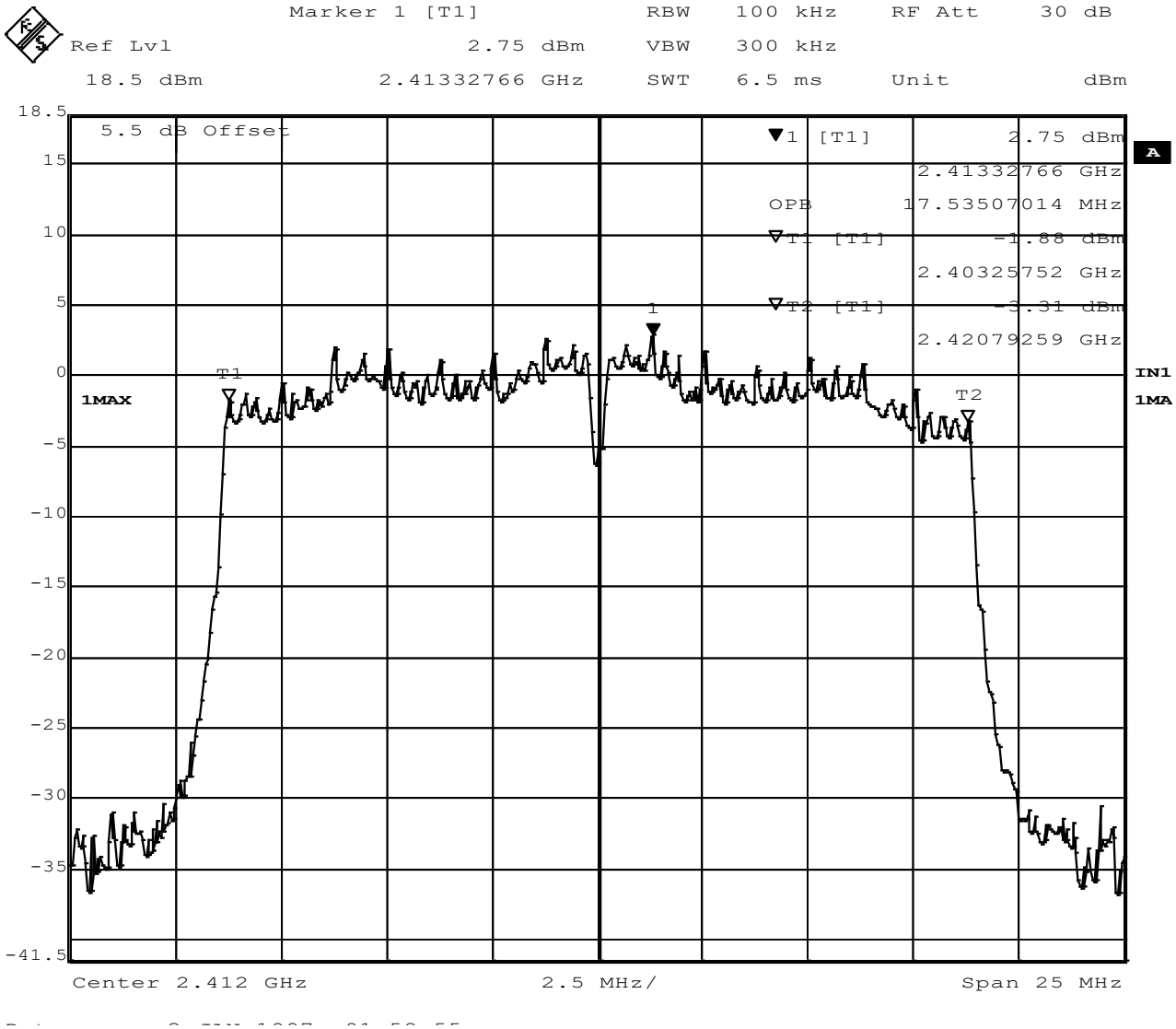

Figure 12 - 99% Occupied Bandwidth, Low Channel, 802.11n

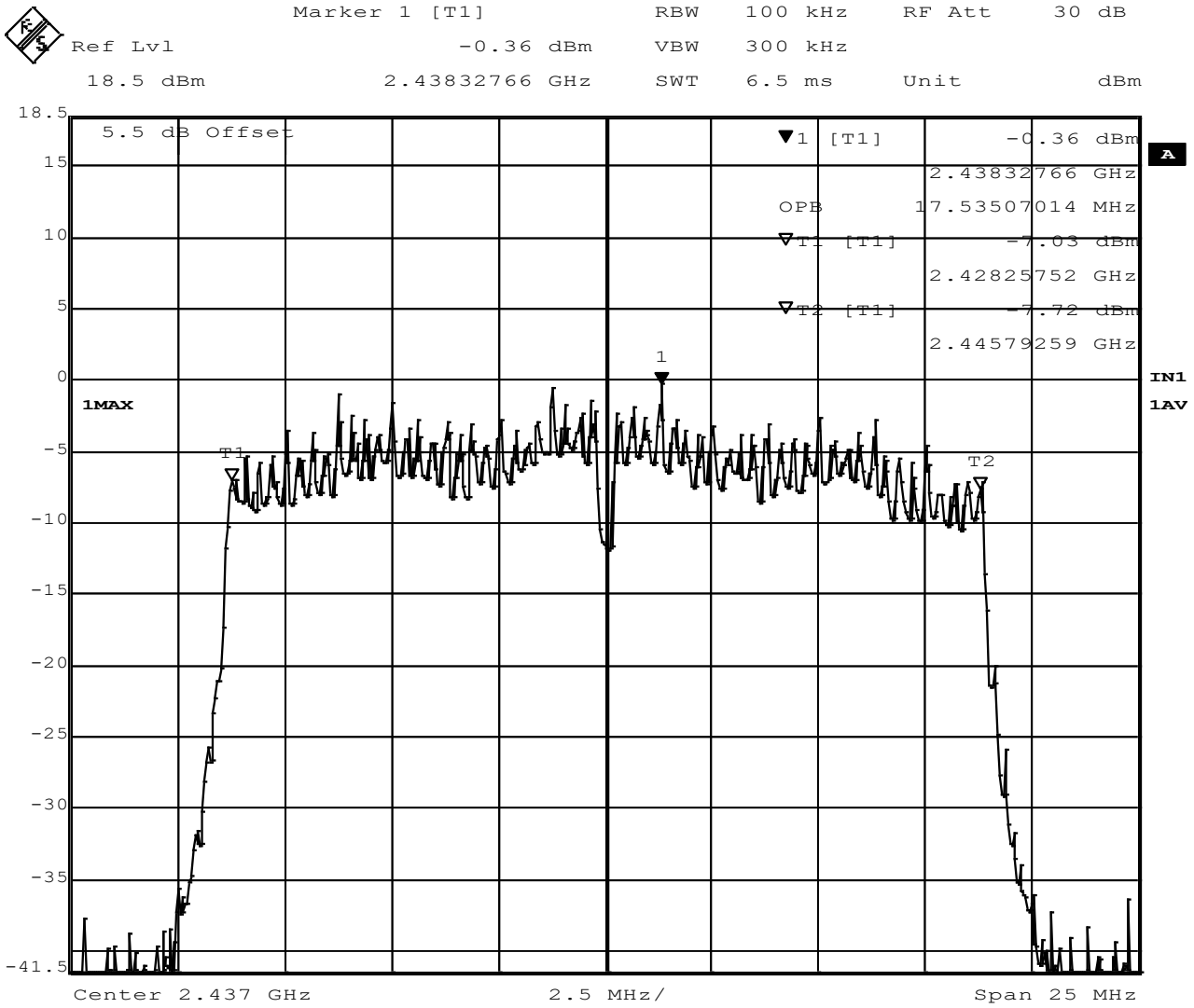

Figure 13 - 99% Occupied Bandwidth, Mid Channel, 802.11n

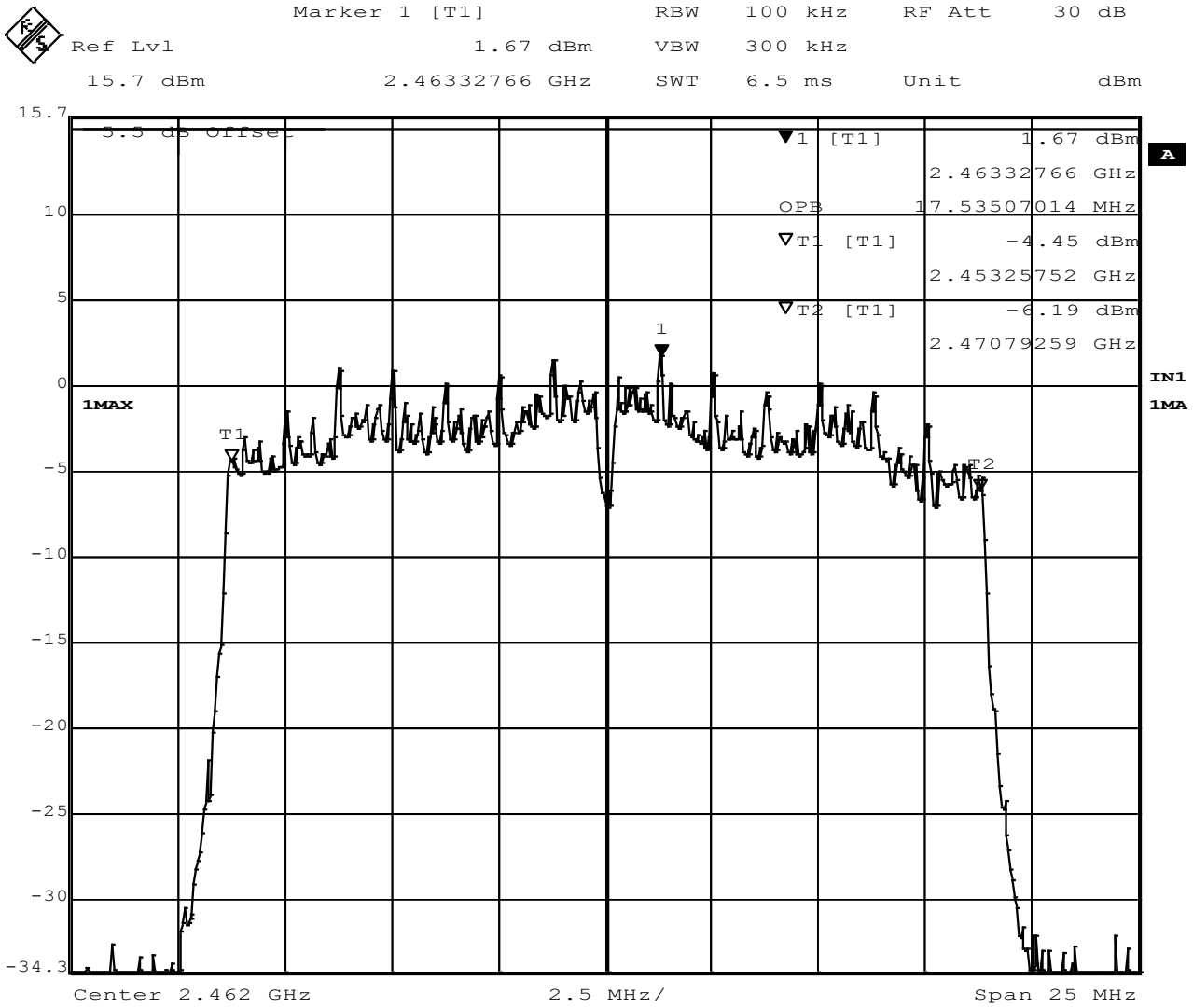

Figure 14 - 99% Occupied Bandwidth, High Channel, 802.11n

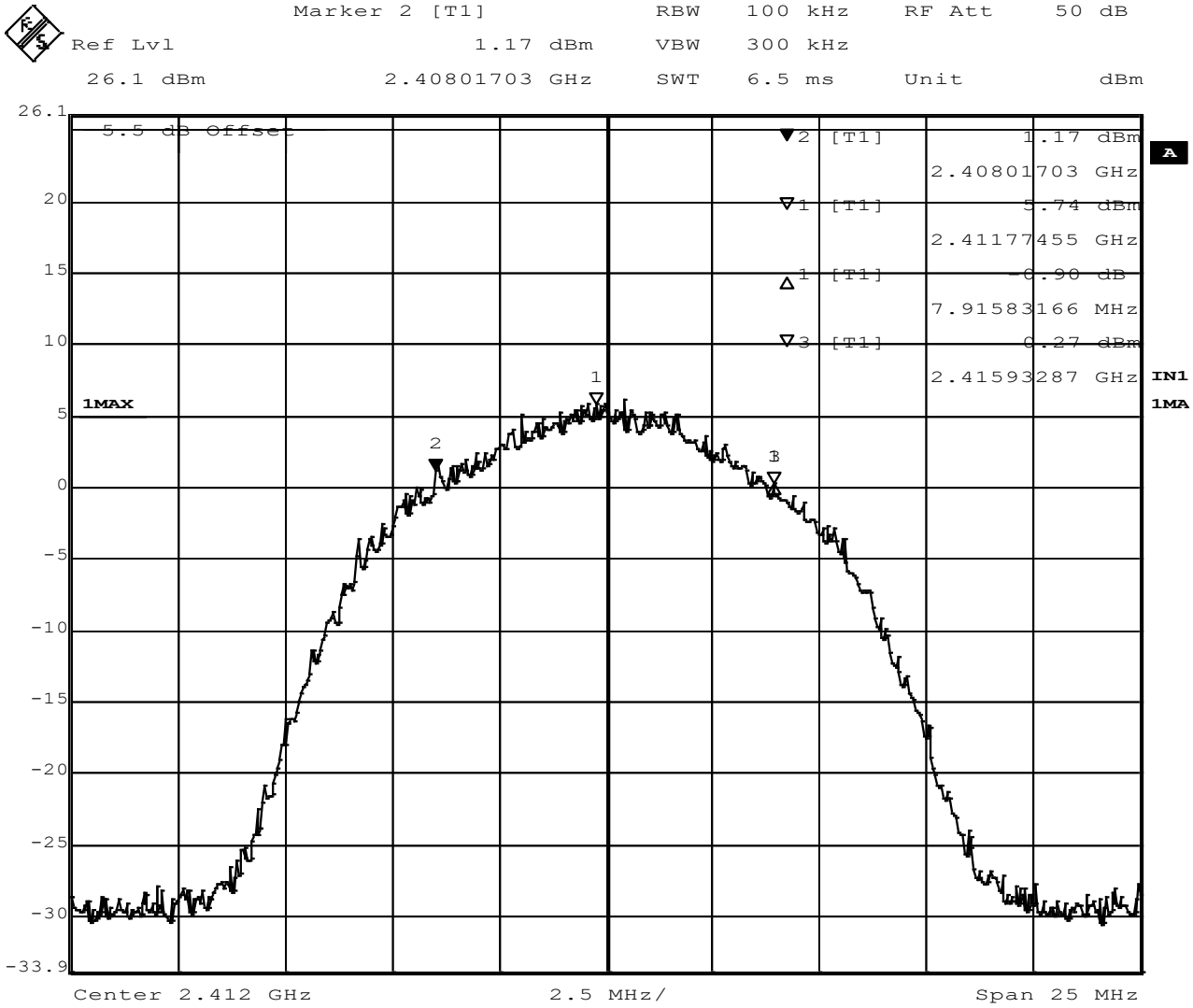

Figure 15 - 6dB Bandwidth, Low Channel, 802.11b

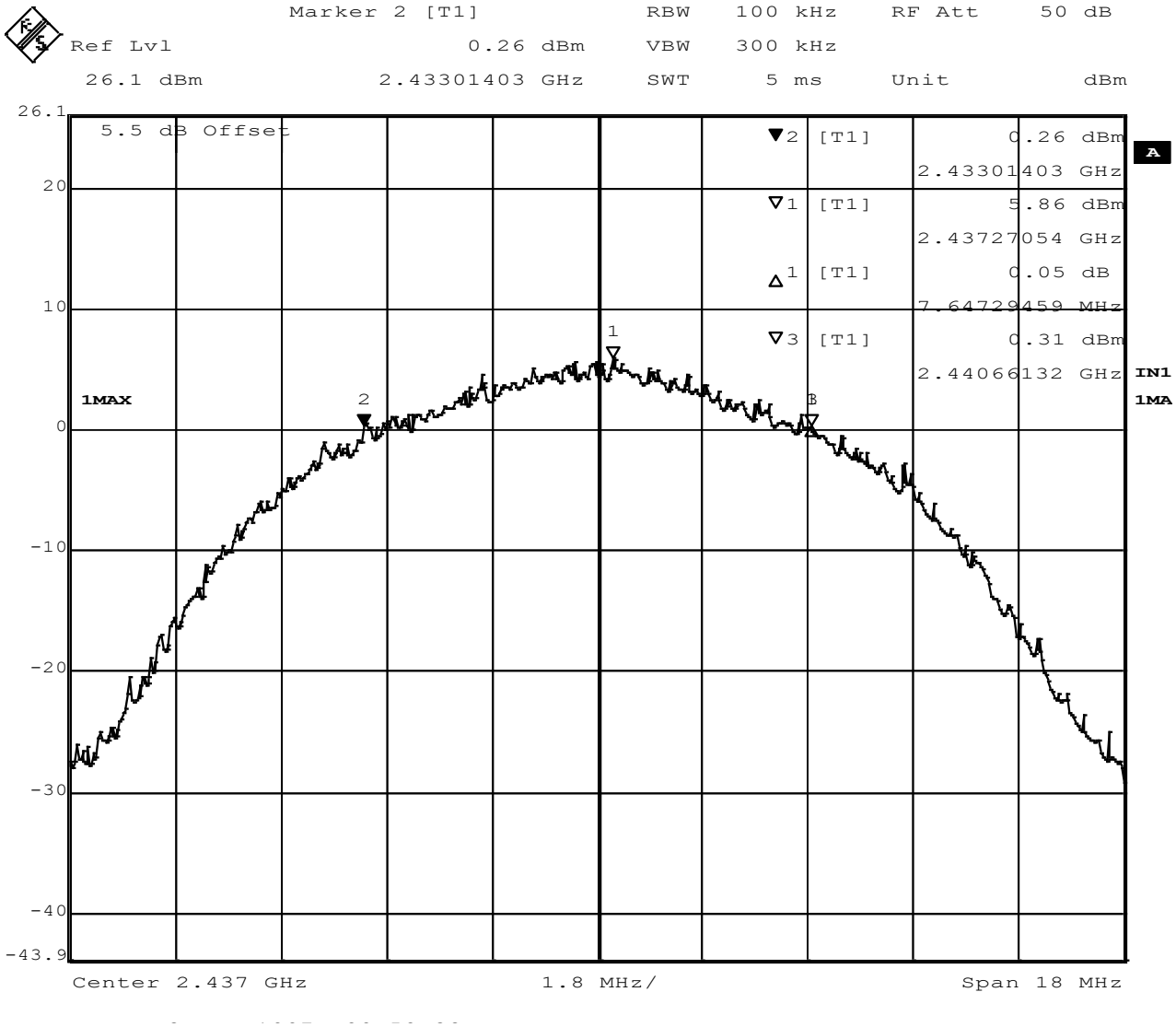

Figure 16 - 6dB Bandwidth, Mid Channel, 802.11b

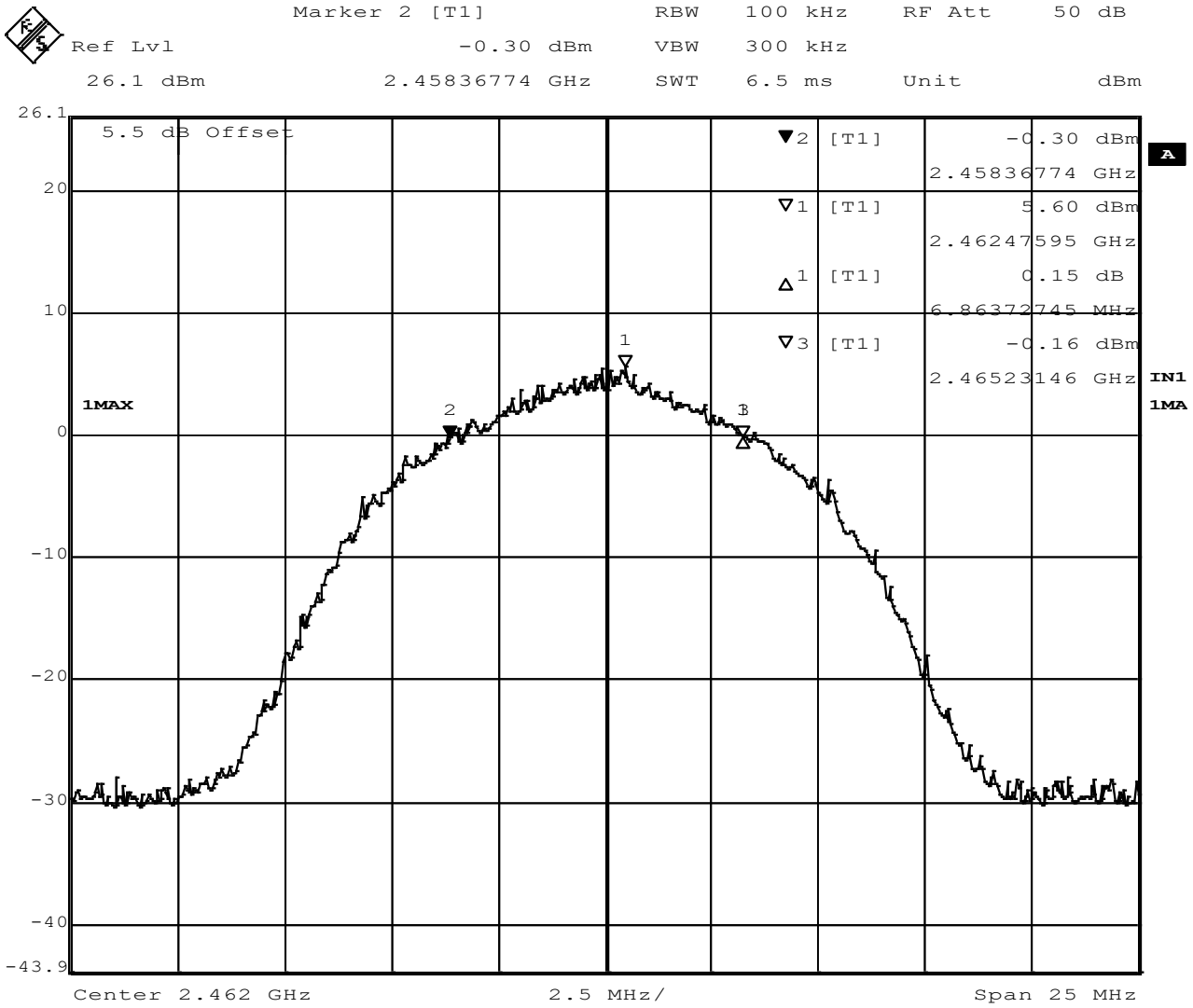

Figure 17 - 6dB Bandwidth, High Channel, 802.11b

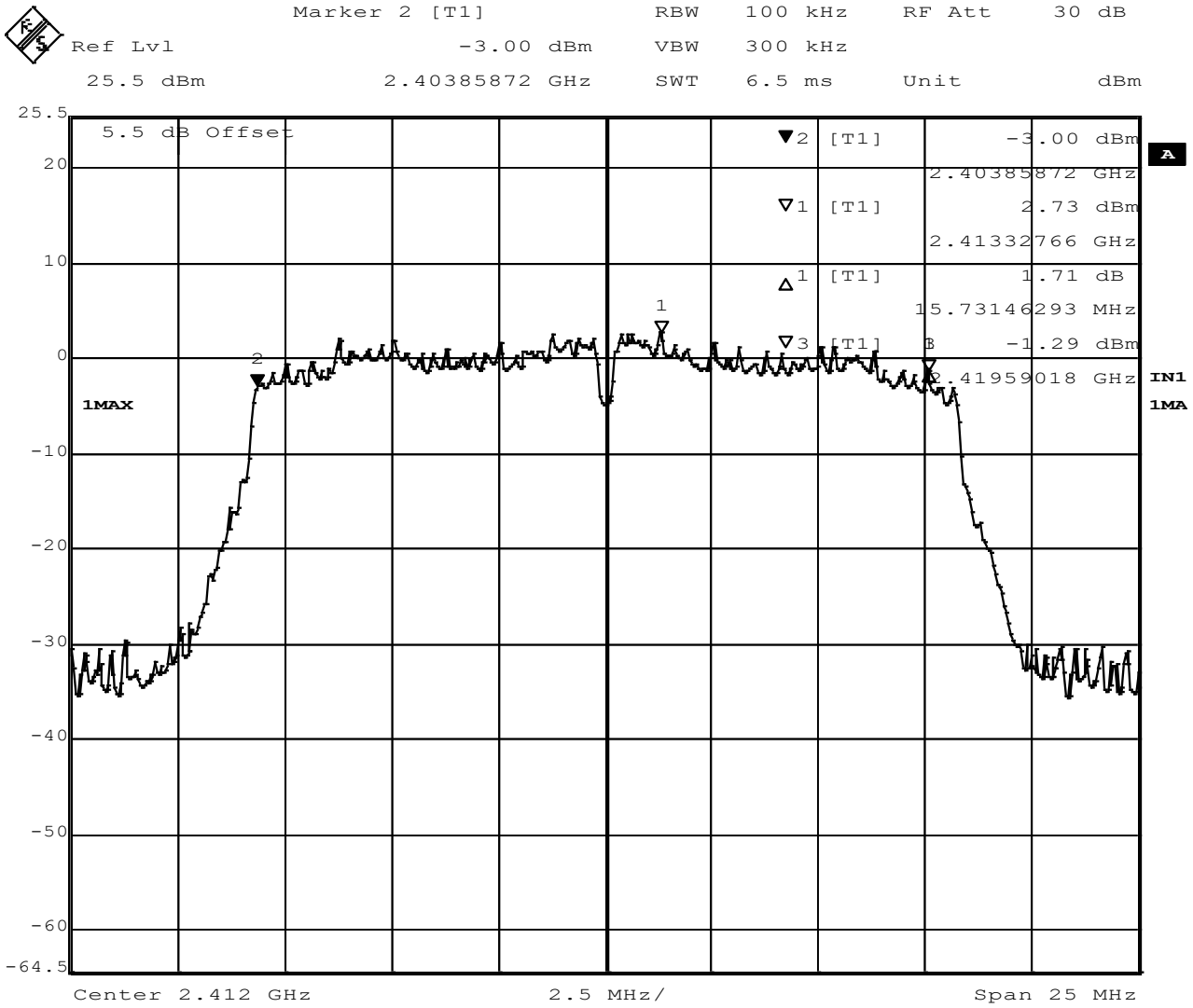

Figure 18 - 6dB Bandwidth, Low Channel, 802.11g

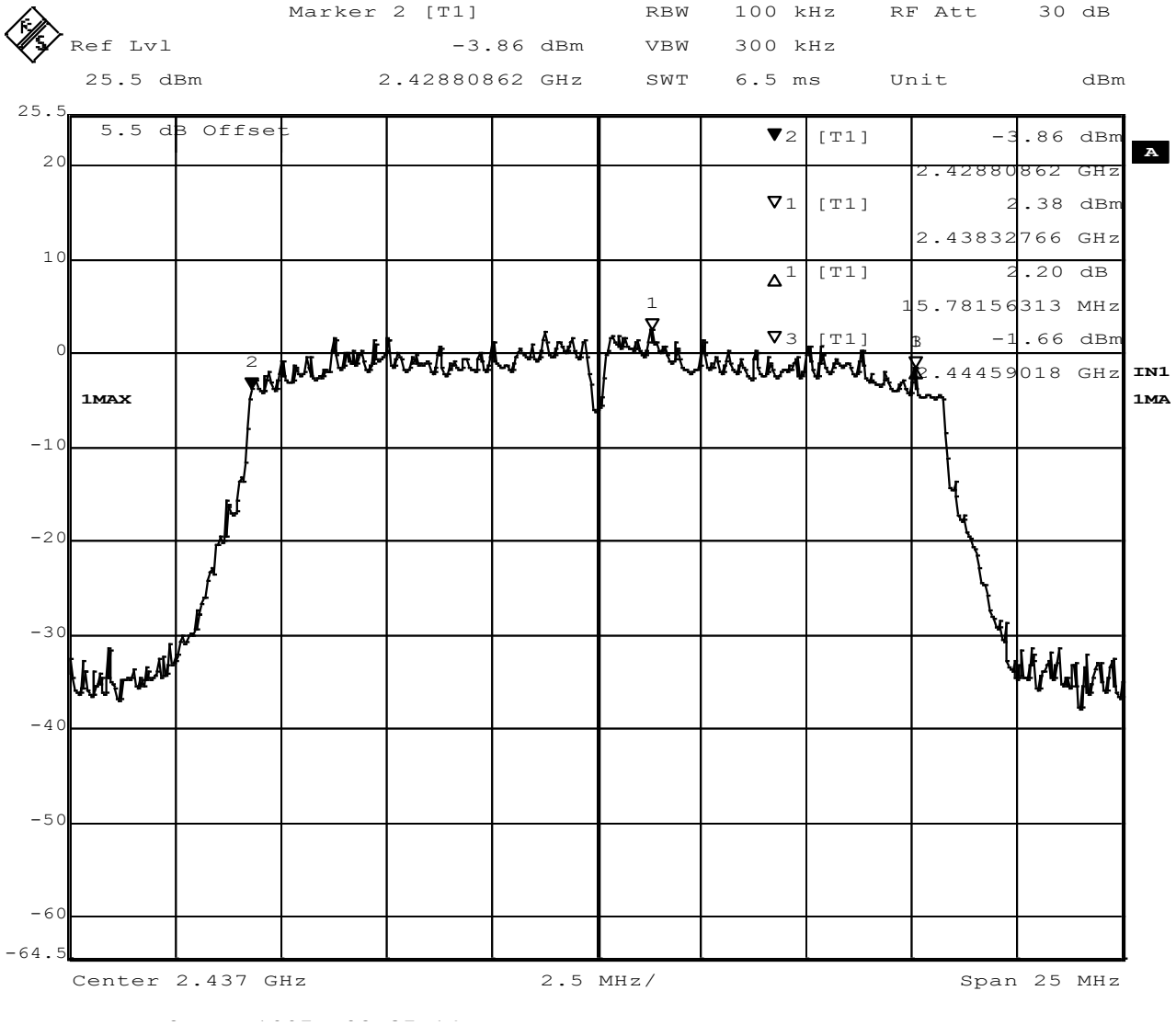

Figure 19 - 6dB Bandwidth, Mid Channel, 802.11g

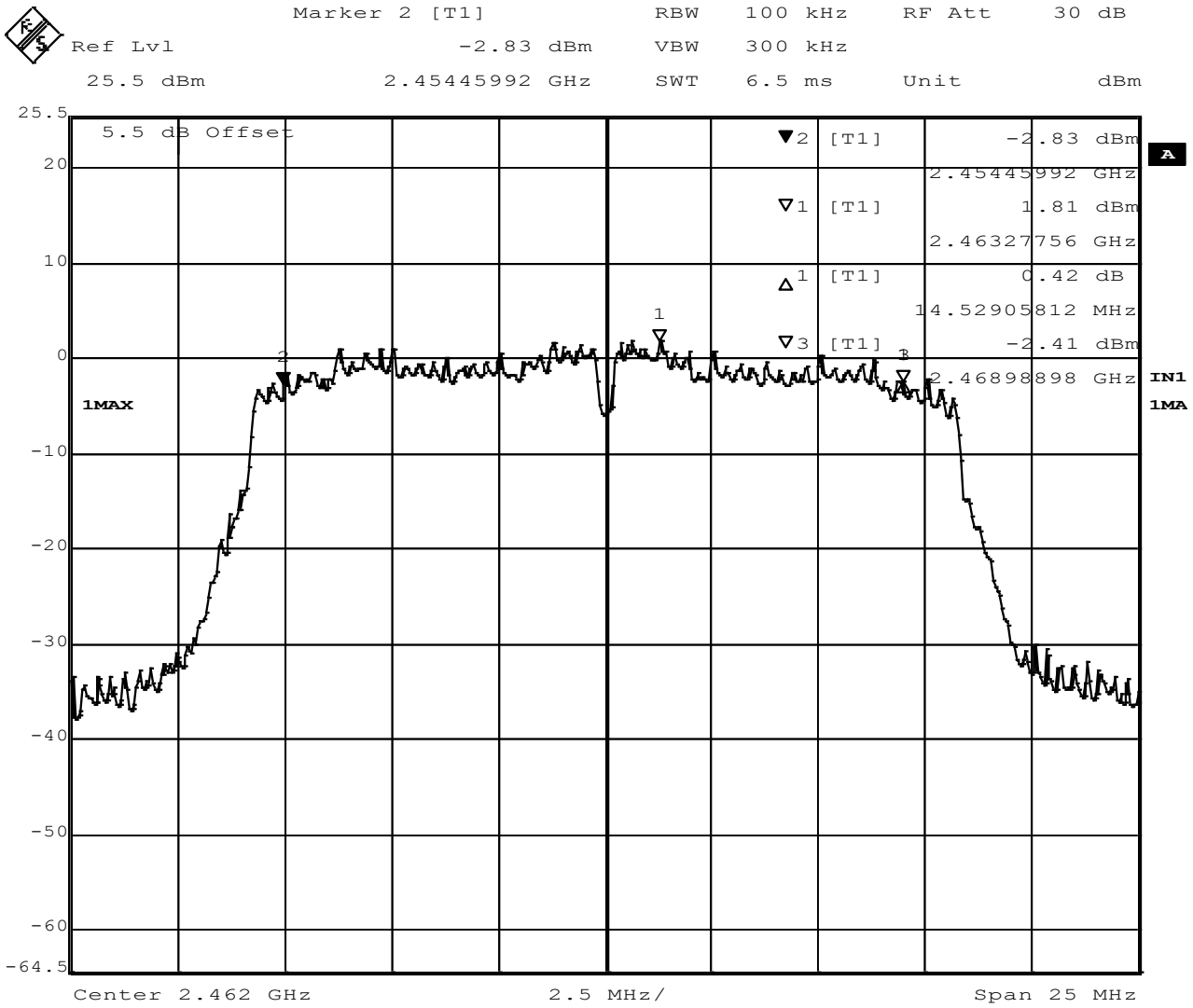

Figure 20 - 6dB Bandwidth, High Channel, 802.11g

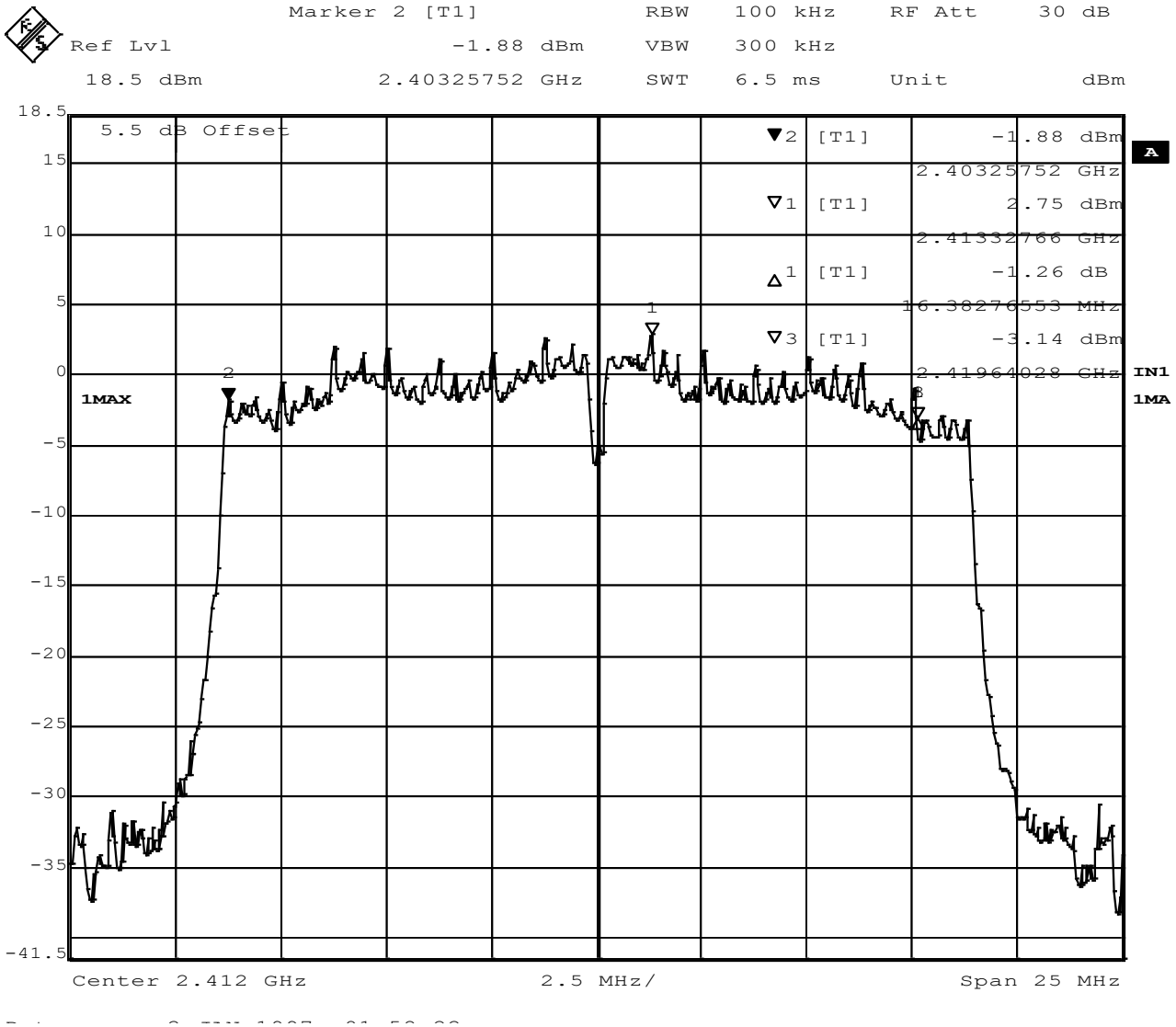

Figure 21 - 6dB Bandwidth, Low Channel, 802.11n

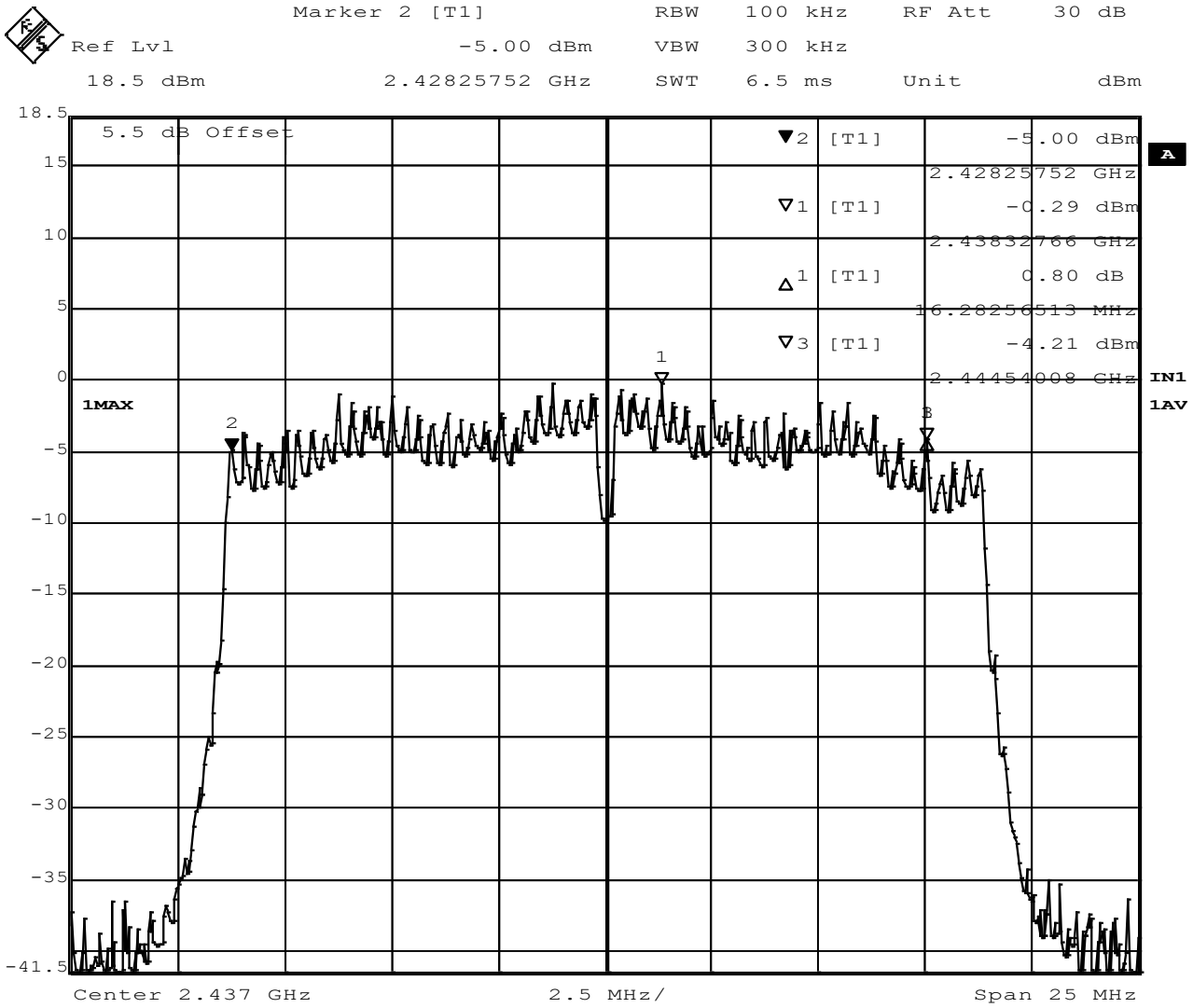

Figure 22 - 6dB Bandwidth, Mid Channel, 802.11n

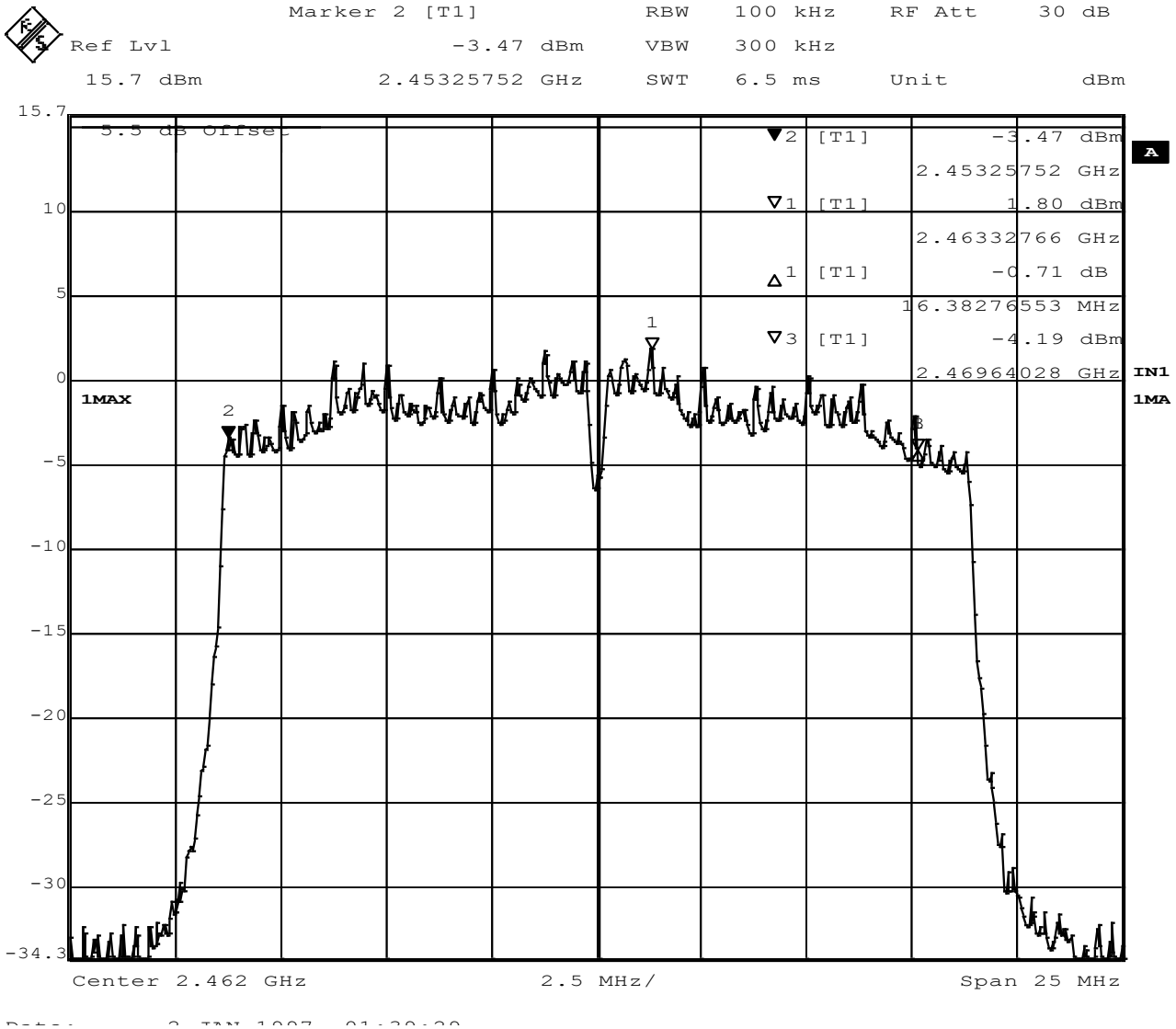

Figure 23 - 6dB Bandwidth, High Channel, 802.11n

4.5 BANDEDGES

Test Method: ANSI C63.10:

1. Section 11.11, Emissions in nonrestricted frequency bands
2. Section 11.12 Emissions in restricted 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 antenna port conducted measurement method was used from ANSI C63.10 Section 11.12.2.4 “Peak power measurement procedure” The resolution bandwidth was set to 100 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 3 VDC 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, Restricted

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result	Mode
1	2390.0 (Nonrestricted, Peak)	-28.81	6.19	35.00	20	PASS	B
3	2483.5 (Nonrestricted, Peak)	-30.58	5.33	35.91	20	PASS	B
1	2390.0 (Nonrestricted, Peak)	-28.73	2.72	31.45	20	PASS	G
3	2483.5 (Nonrestricted, Peak)	-42.39	1.77	44.16	20	PASS	G
1	2390.0 (Nonrestricted, Peak)	-31.54	2.78	34.32	20	PASS	N
3	2483.5 (Nonrestricted, Peak)	-41.66	1.8	43.46	20	PASS	N

*Includes antenna gain of 2.8 dBi. The plots show uncorrected value.

Highest Out of Band Emissions, 802.11b

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level condcuted dBm	Calculated Field Strength Level (dBµV/m)	Limit	Margin	Mode
1	2340.0 (Restricted, Peak)	-94.81	-6.75	76.00	82.75	B
1	2340.0 (Restricted, Average)	-101.94	-13.88	56.00	69.88	B
3	2483.5 (Restricted, Peak)	-104.12	-16.06	76.00	92.06	B
3	2483.5 (Restricted, Average)	-101.32	-13.26	56.00	69.26	B
1	2340.0 (Restricted, Peak)	-40.14	47.92	76.00	28.08	G
1	2340.0 (Restricted, Average)	-47.53	40.53	56.00	15.47	G
3	2483.5 (Restricted, Peak)	-40.25	47.81	76.00	28.19	G
3	2483.5 (Restricted, Average)	-44.49	43.57	56.00	12.43	G
1	2340.0 (Restricted, Peak)	-39.13	48.93	76.00	27.07	N
1	2340.0 (Restricted, Average)	-46.15	41.91	56.00	14.09	N
3	2483.5 (Restricted, Peak)	-38.75	49.31	76.00	26.69	N
3	2483.5 (Restricted, Average)	-46.00	42.06	56.00	13.94	N

Includes antenna gain of 2.8 dBi.
Bandwidth conversion converts measurements with 100 kHz RBW to 1 MHz RBW (10log[1000/1000]) = 10
EIRP (dBm) converted to 3m field strength
Antenna gain = 9.44 dBi 3m conversion = 10log(3/1) = -9.44 dB dBm to dBµV/m = +104.8
Preamplifier = 20dB EIRP = Level (dBm) + antenna gain (dBi) + PA gain (dB) + BW conversion (dB)
E = EIRP – 20logd + 104.8

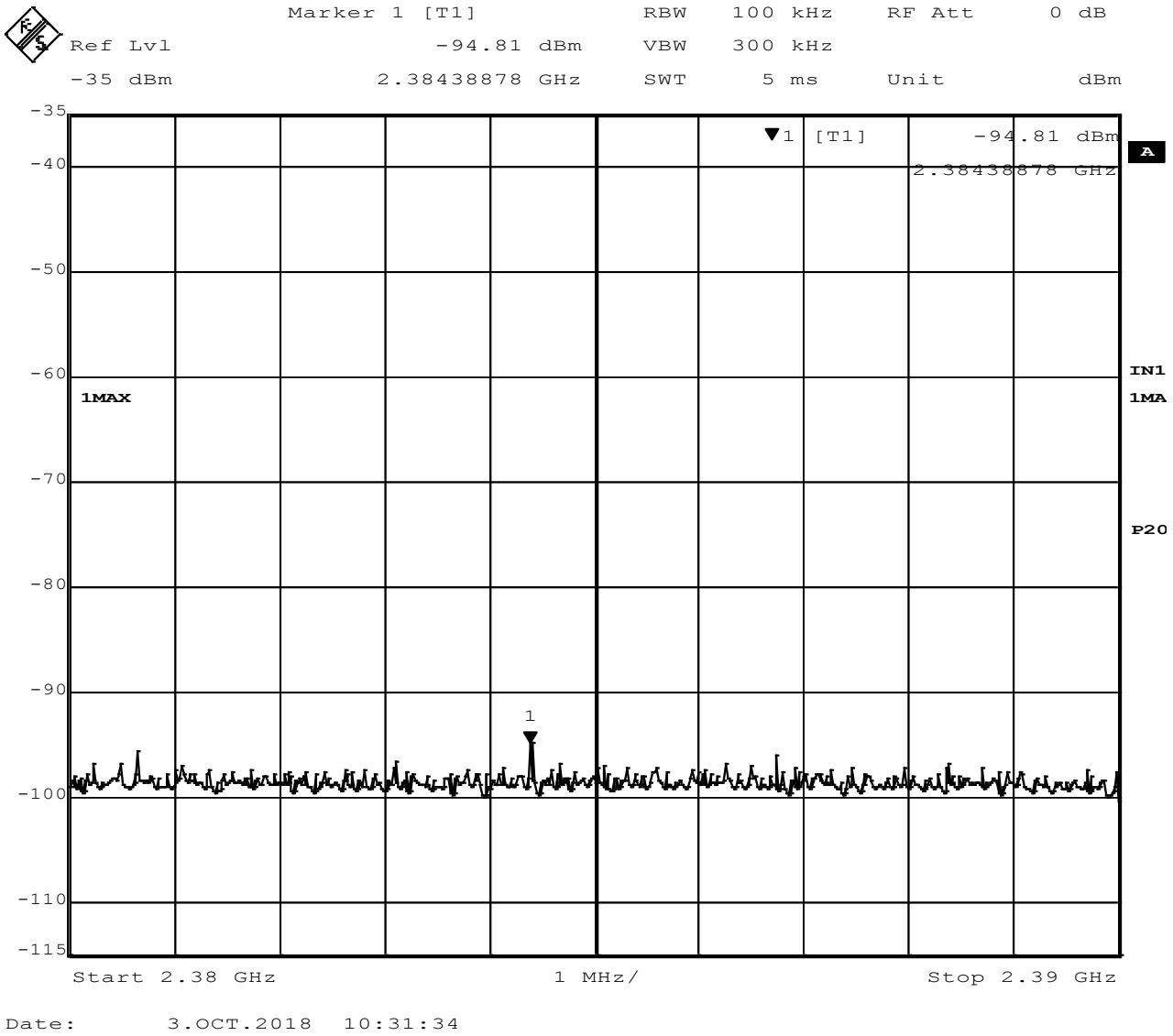

Figure 24 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak, 802.11b

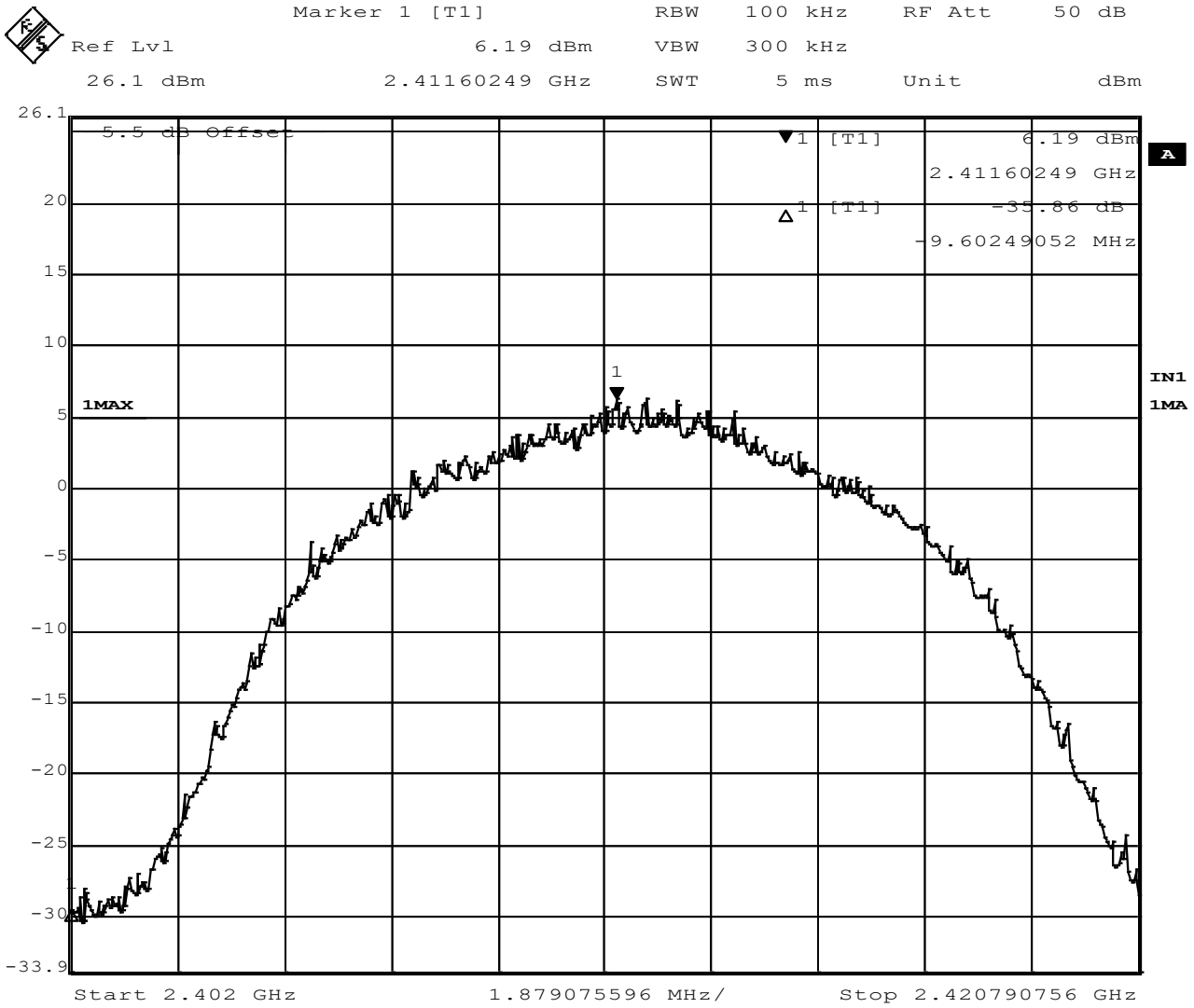

Figure 25 - Band-edge Measurement, Low Channel, Fundamental, Peak, 802.11b

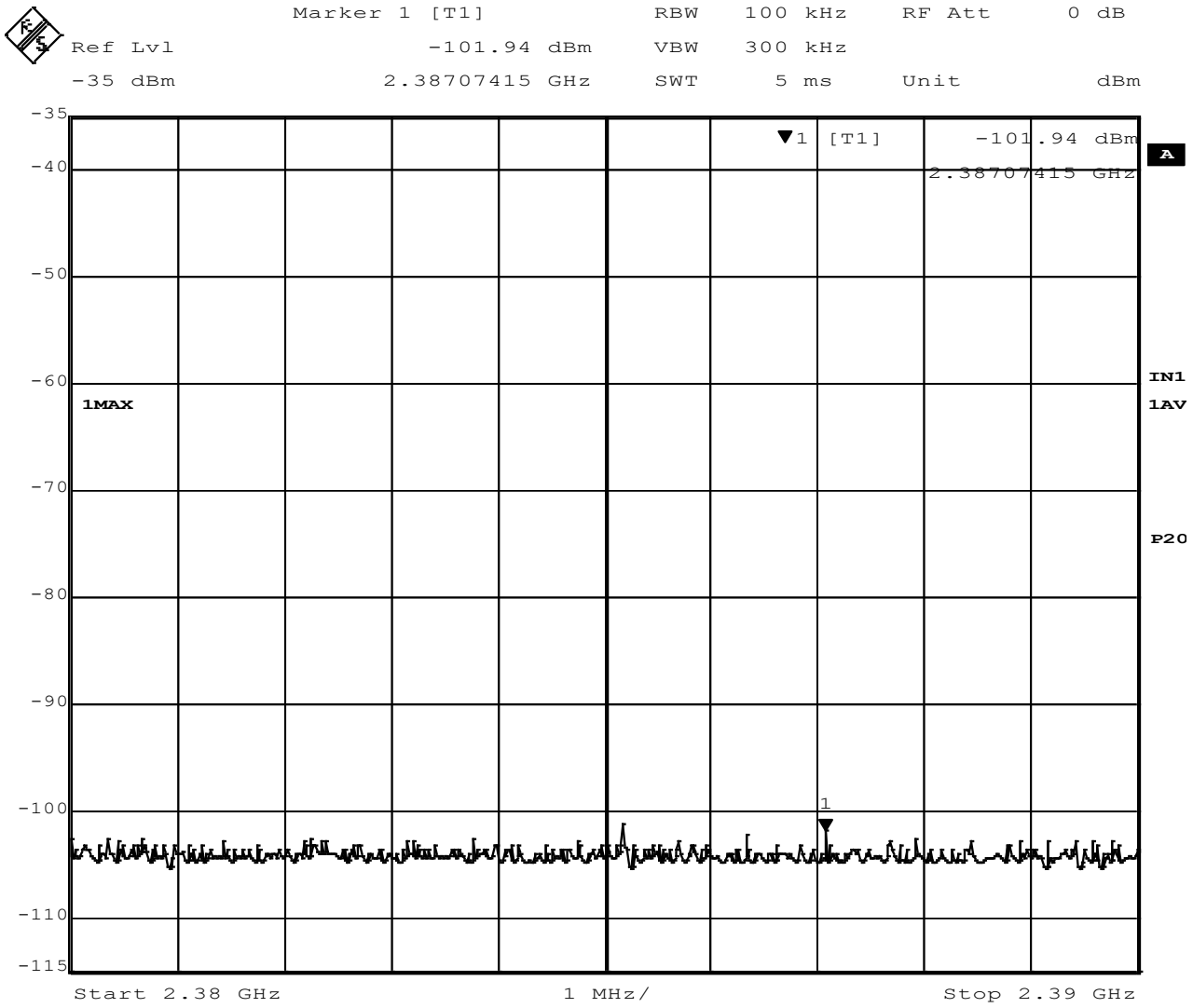

Figure 26 - Band-edge Measurement, Low Channel, Restricted Frequency, Average, 802.11b

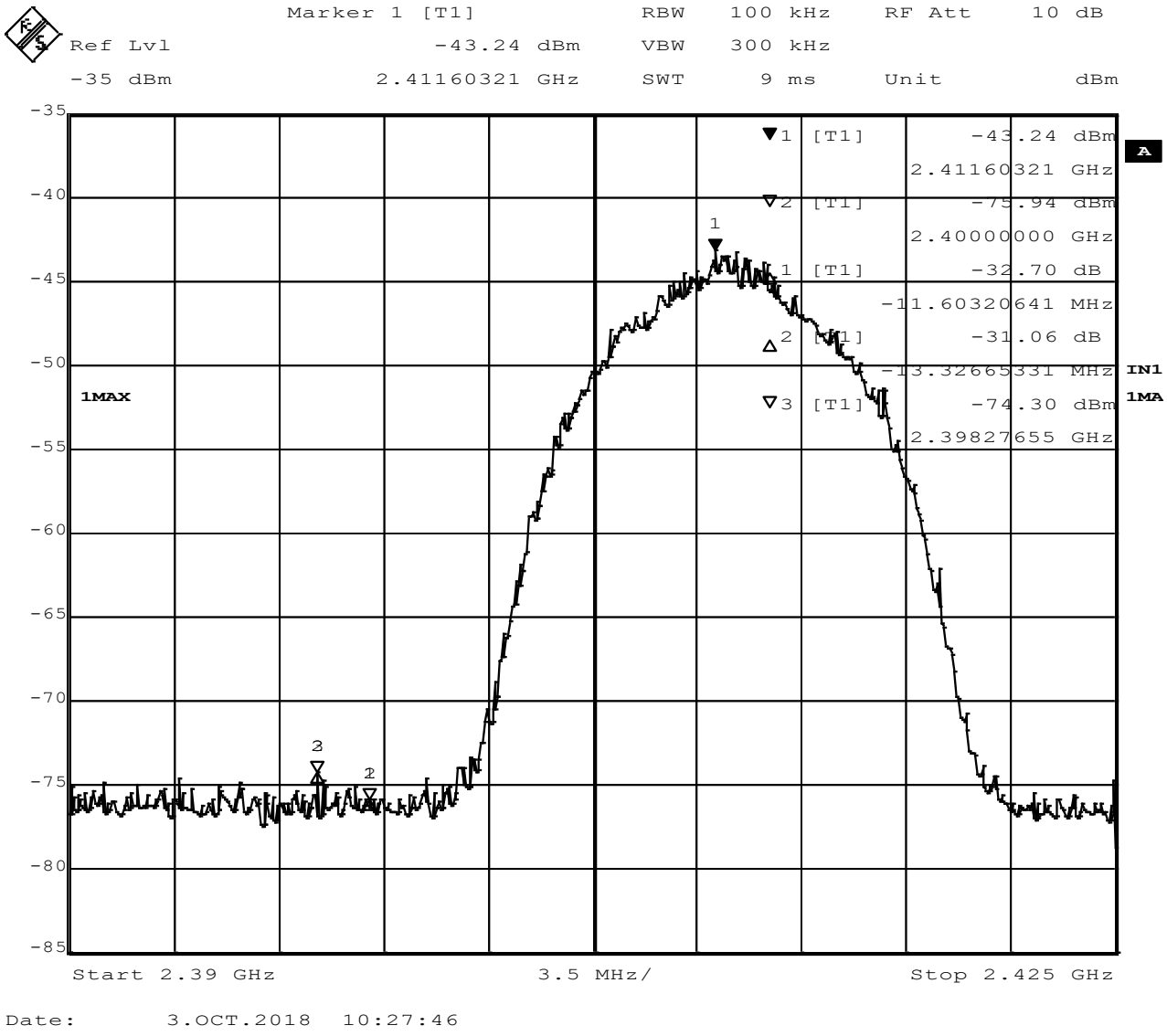

Figure 27 - Band-edge Measurement, Low Channel, Fundamental, Average, 802.11b

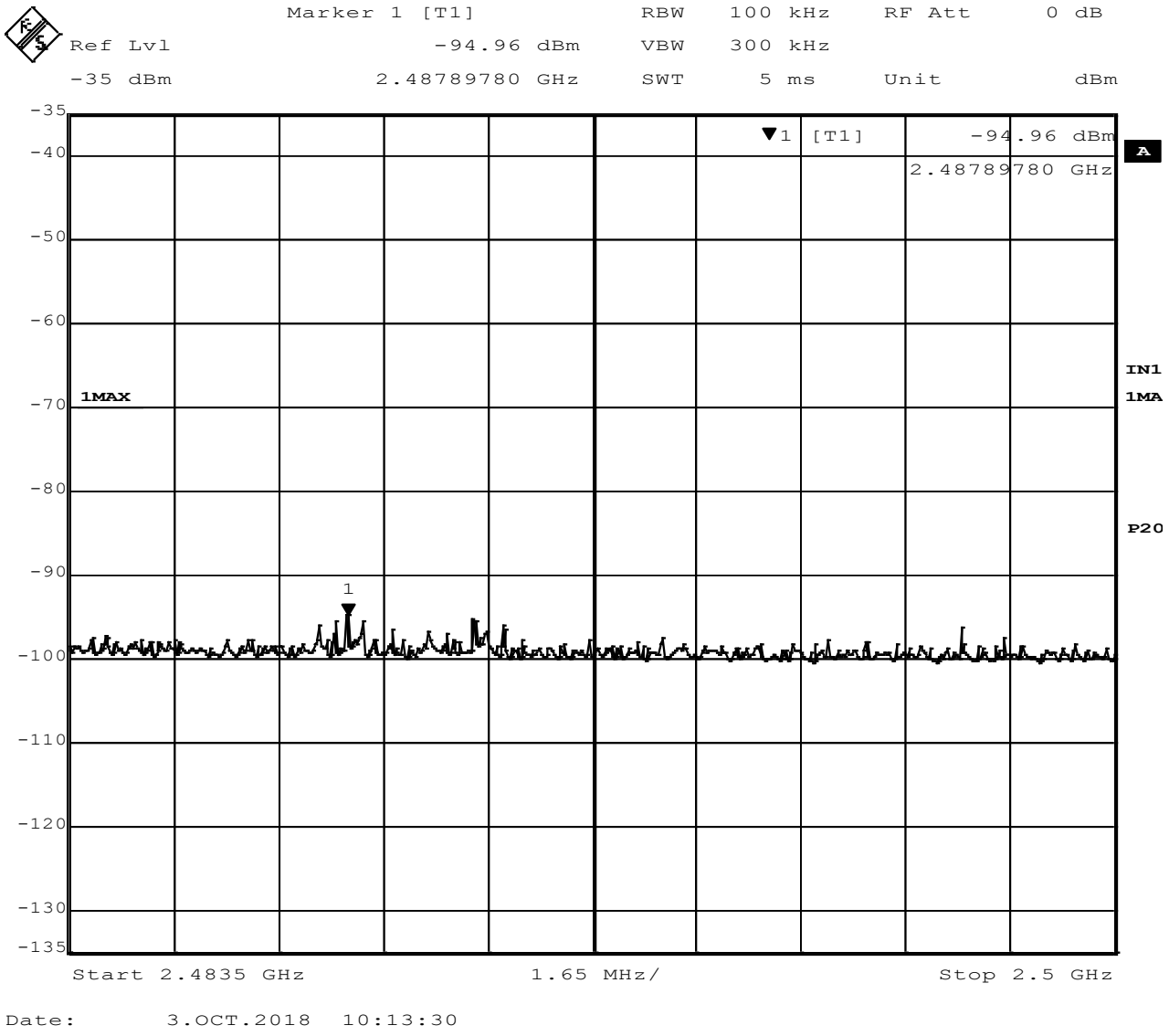

Figure 28 - Band-edge Measurement, High Channel, Restricted Frequency, Peak, 802.11b

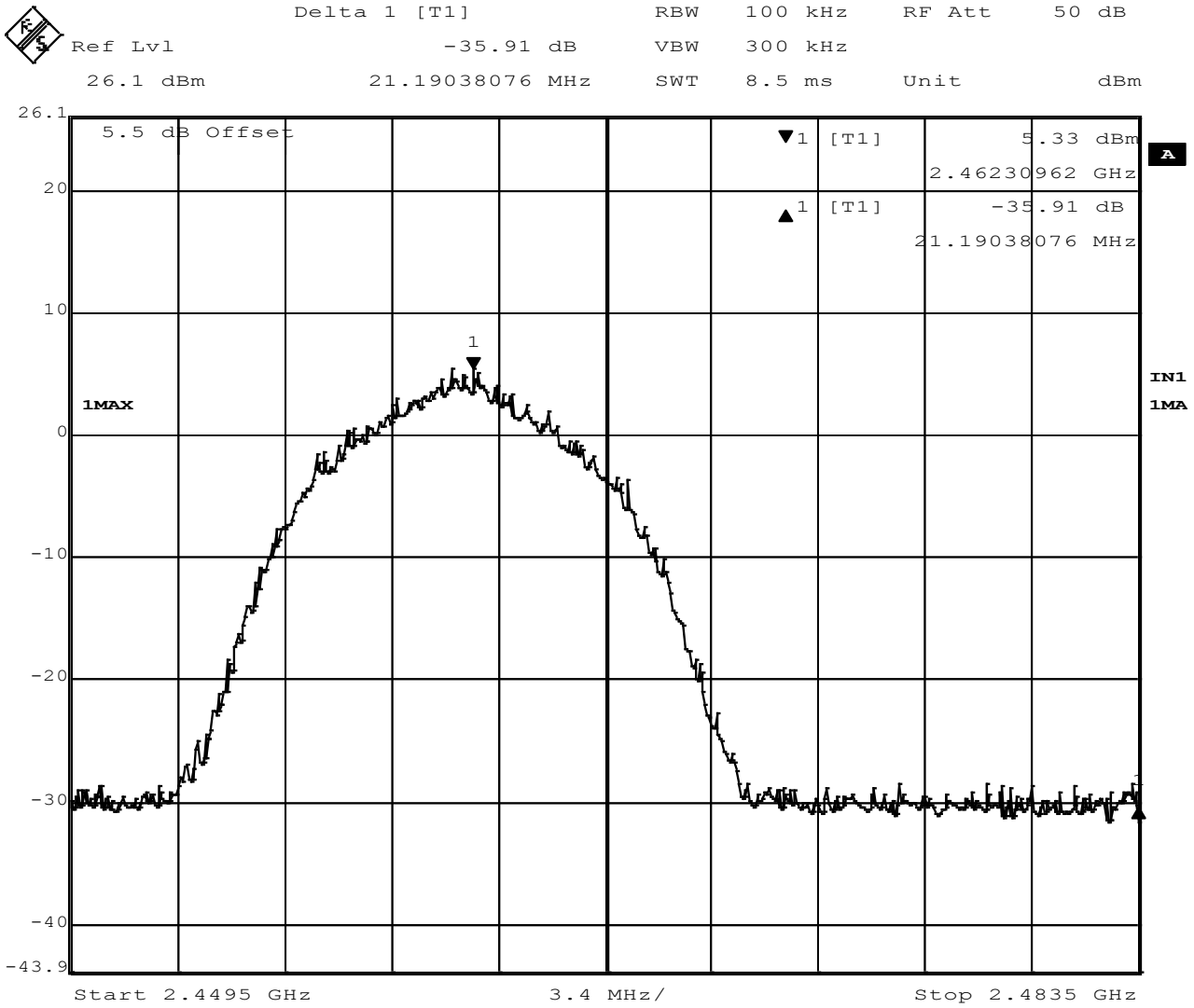

Figure 29 - Band-edge Measurement, High Channel, Fundamental, Peak, 802.11b

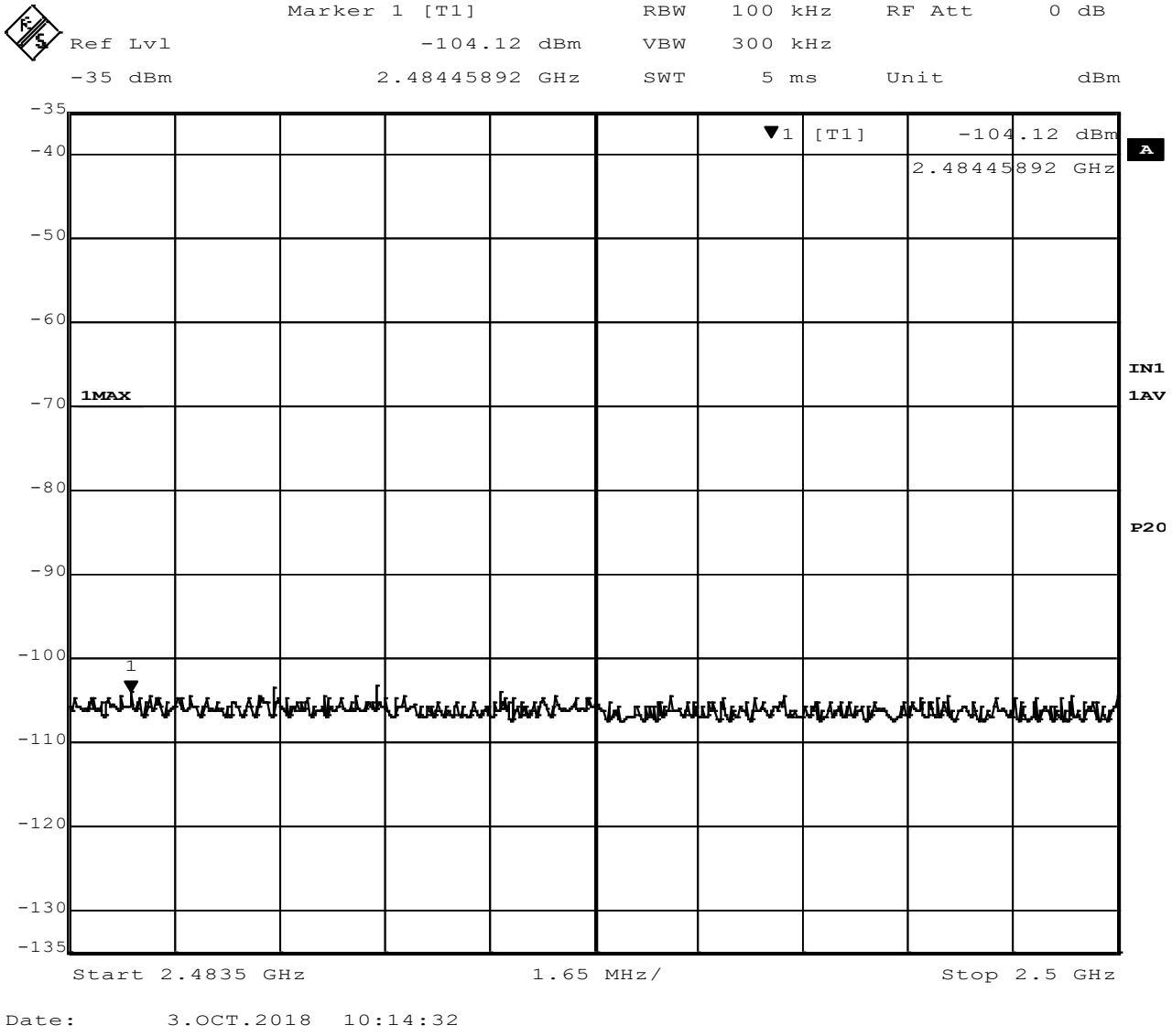

Figure 30 - Band-edge Measurement, High Channel, Restricted Frequency, Average, 802.11b

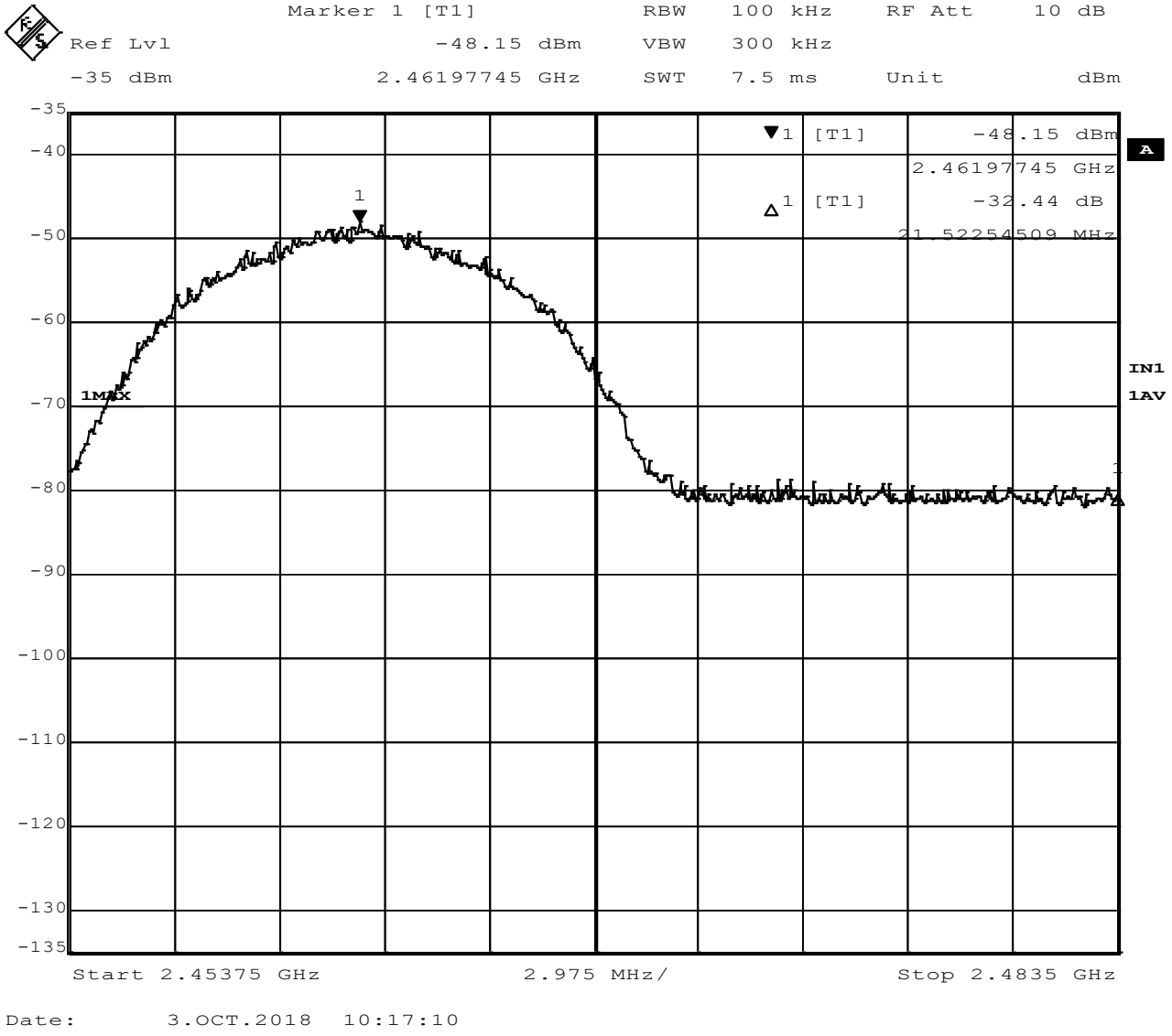

Figure 31 - Band-edge Measurement, High Channel, Fundamental, Average, 802.11b

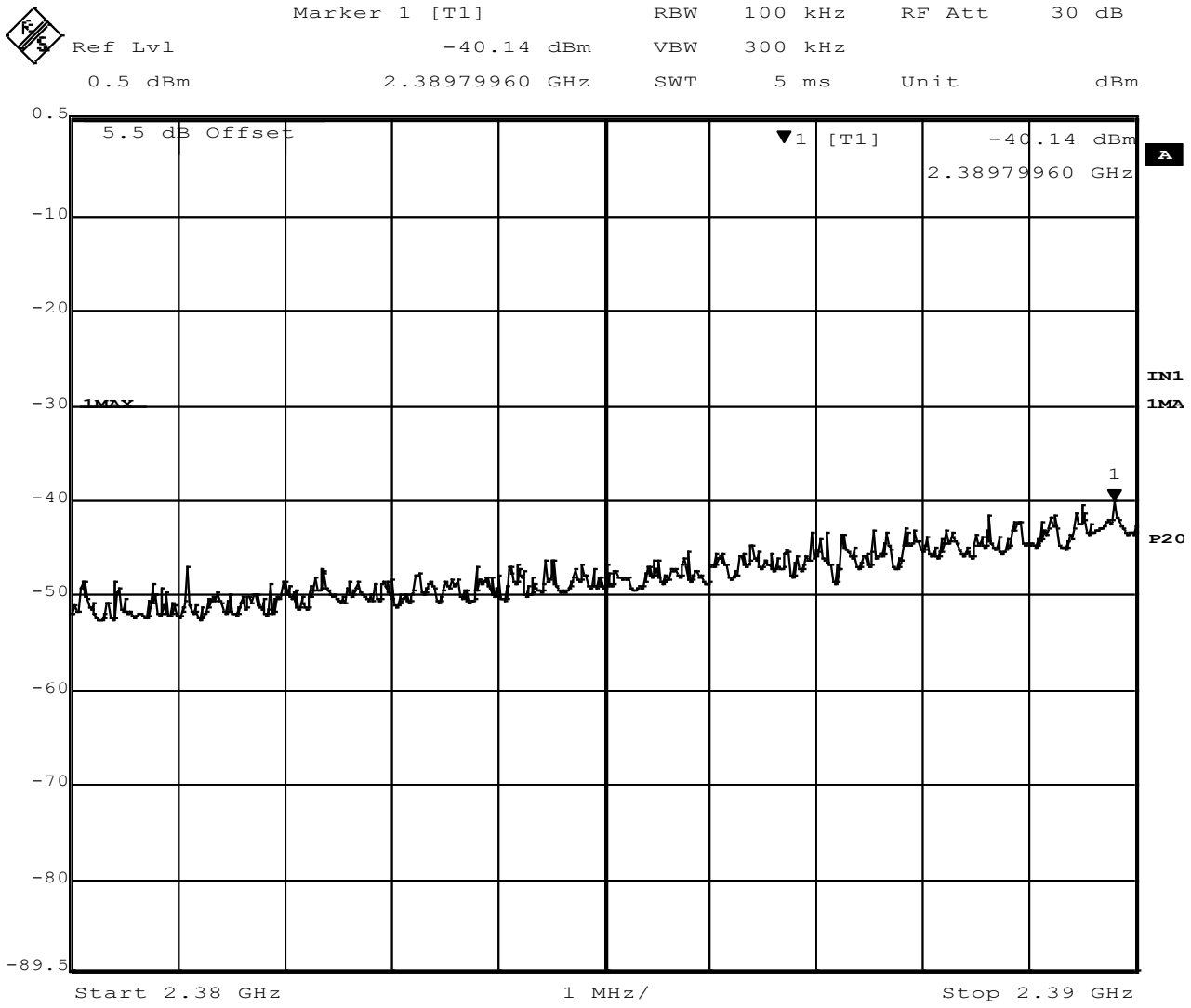

Figure 32 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak, 802.11b

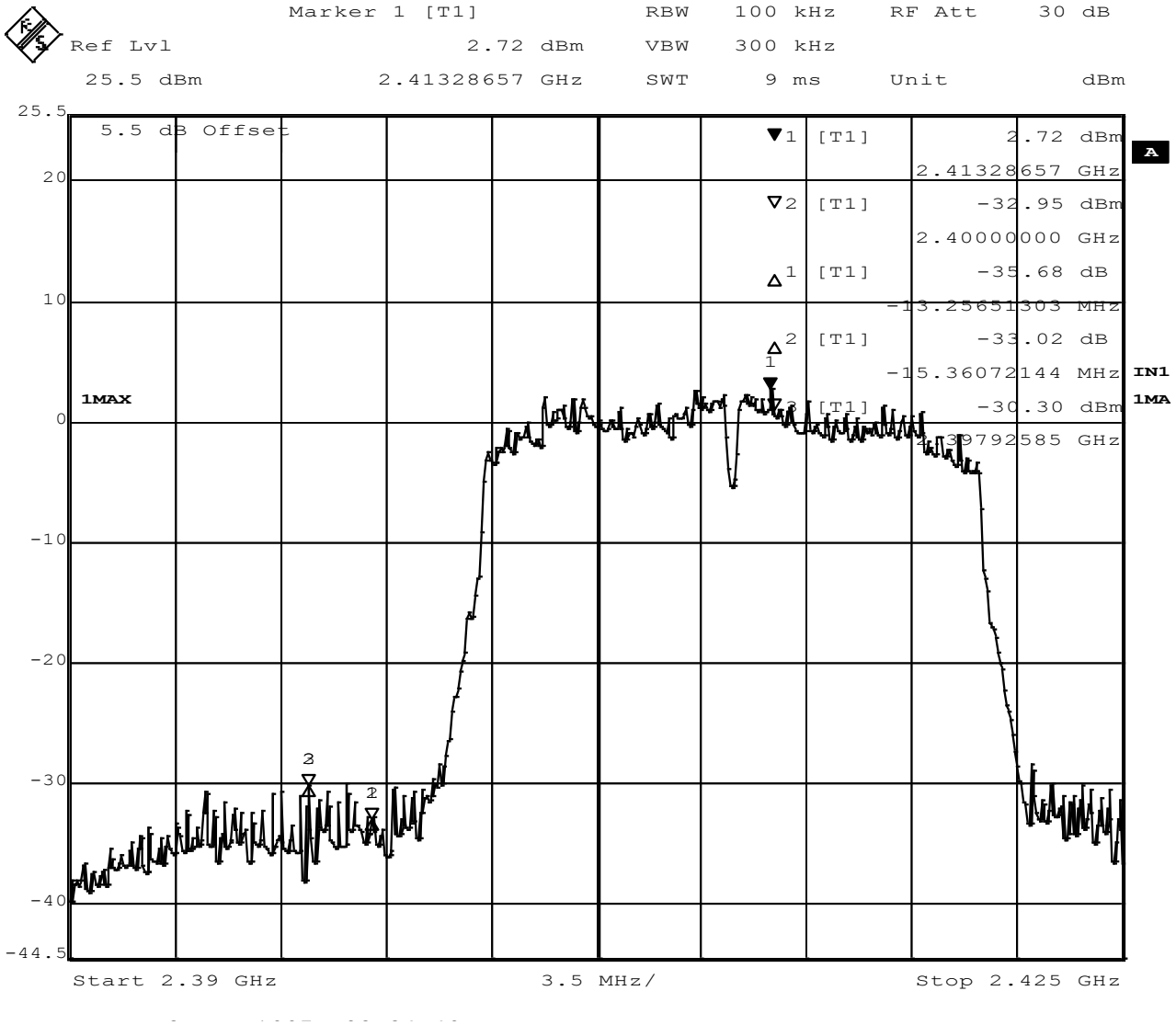

Figure 33 - Band-edge Measurement, Low Channel, Fundamental, Peak, 802.11b

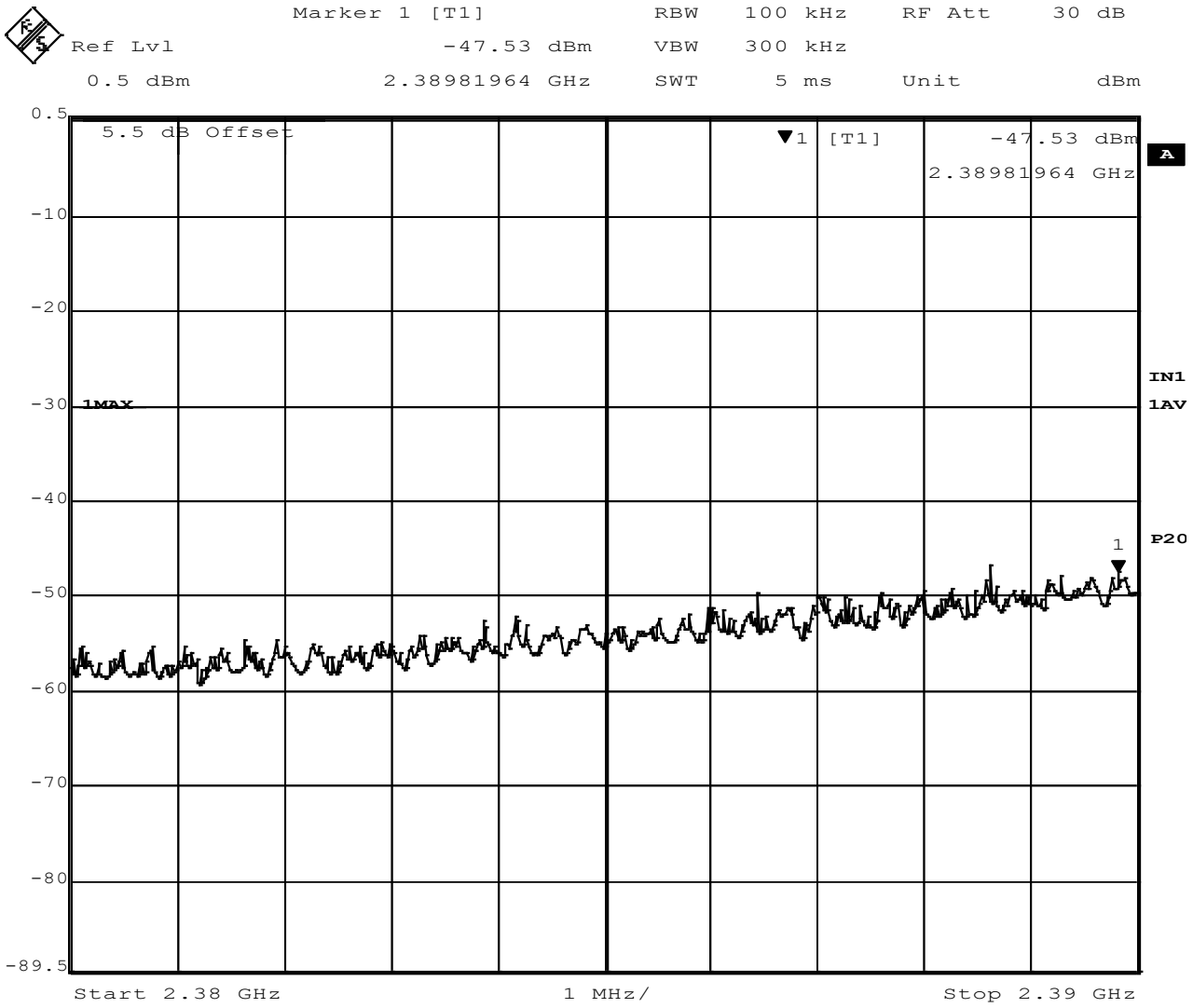

Figure 34 - Band-edge Measurement, Low Channel, Restricted Frequency, Average, 802.11g

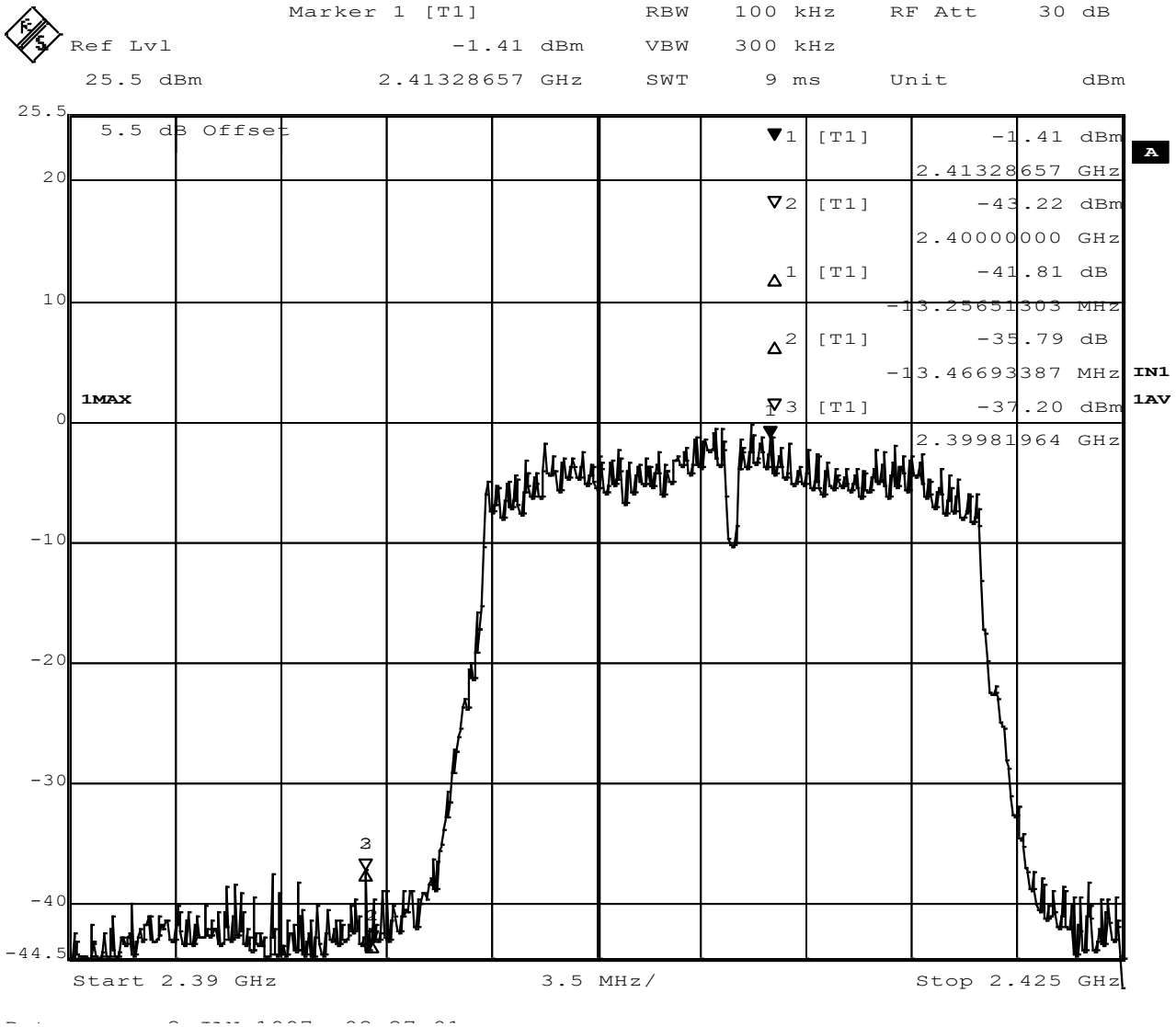

Figure 35 - Band-edge Measurement, Low Channel, Fundamental, Average, 802.11g

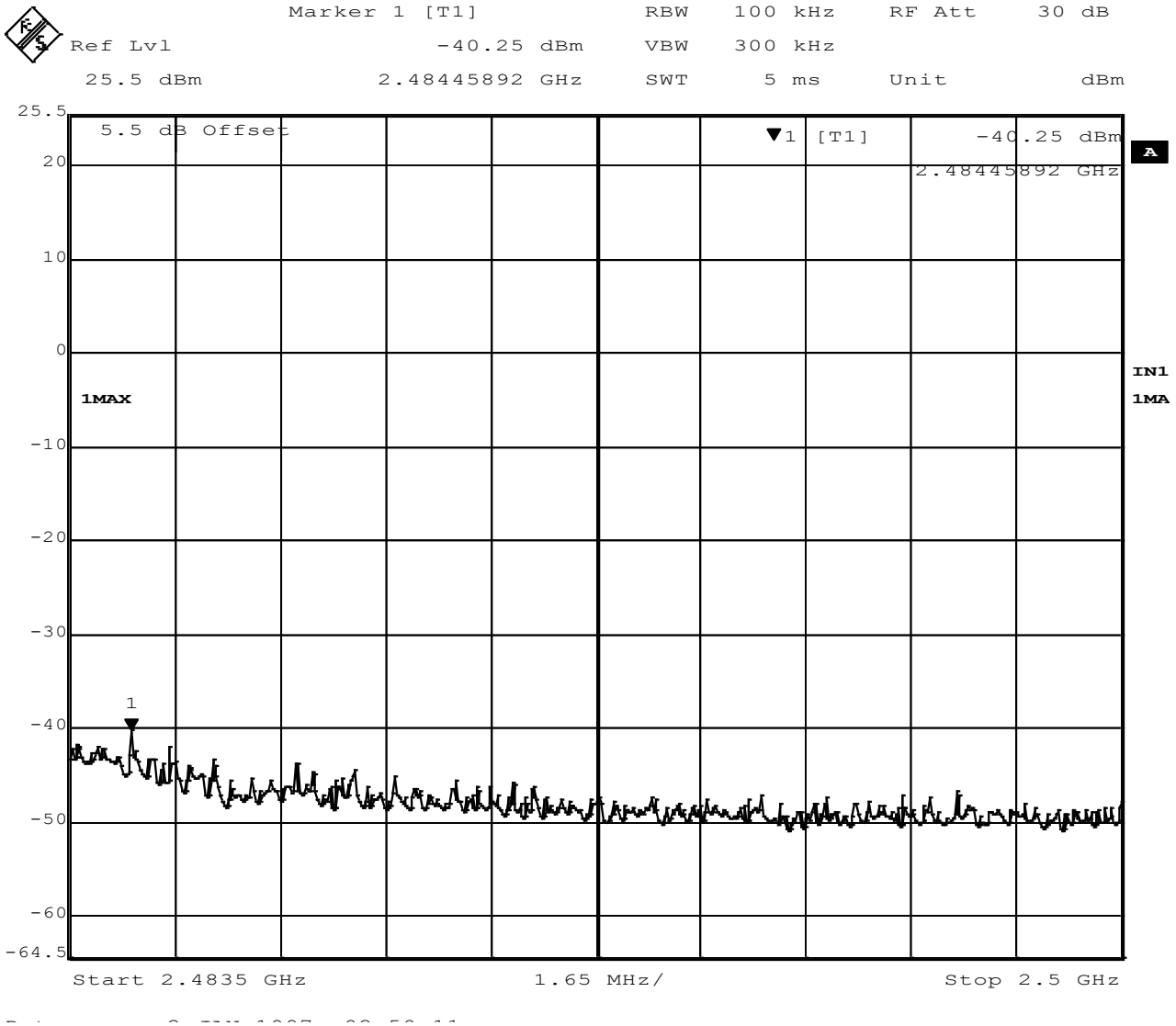

Figure 36 - Band-edge Measurement, High Channel, Restricted Frequency, Peak, 802.11g

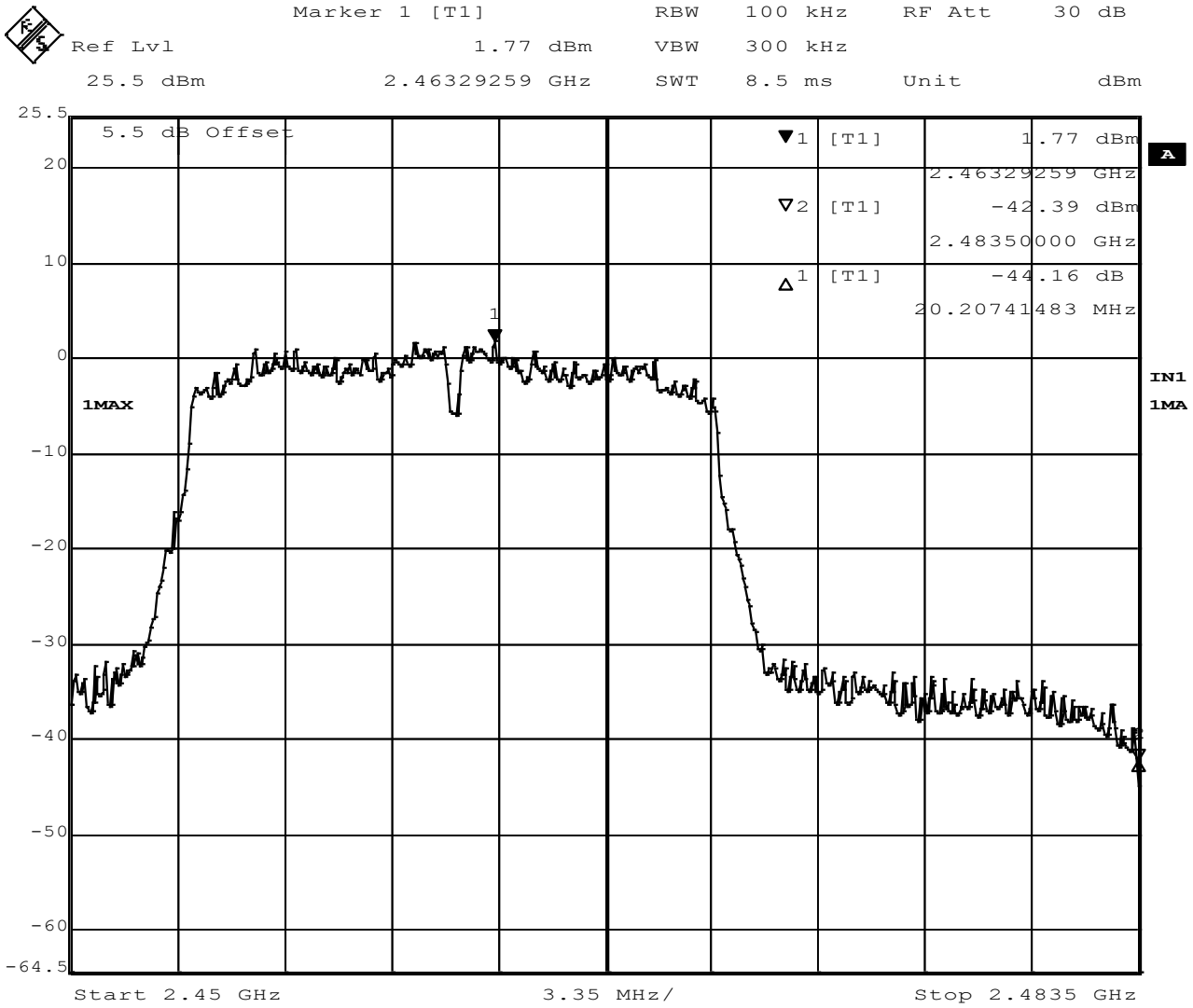

Figure 37 - Band-edge Measurement, High Channel, Fundamental, Peak, 802.11g

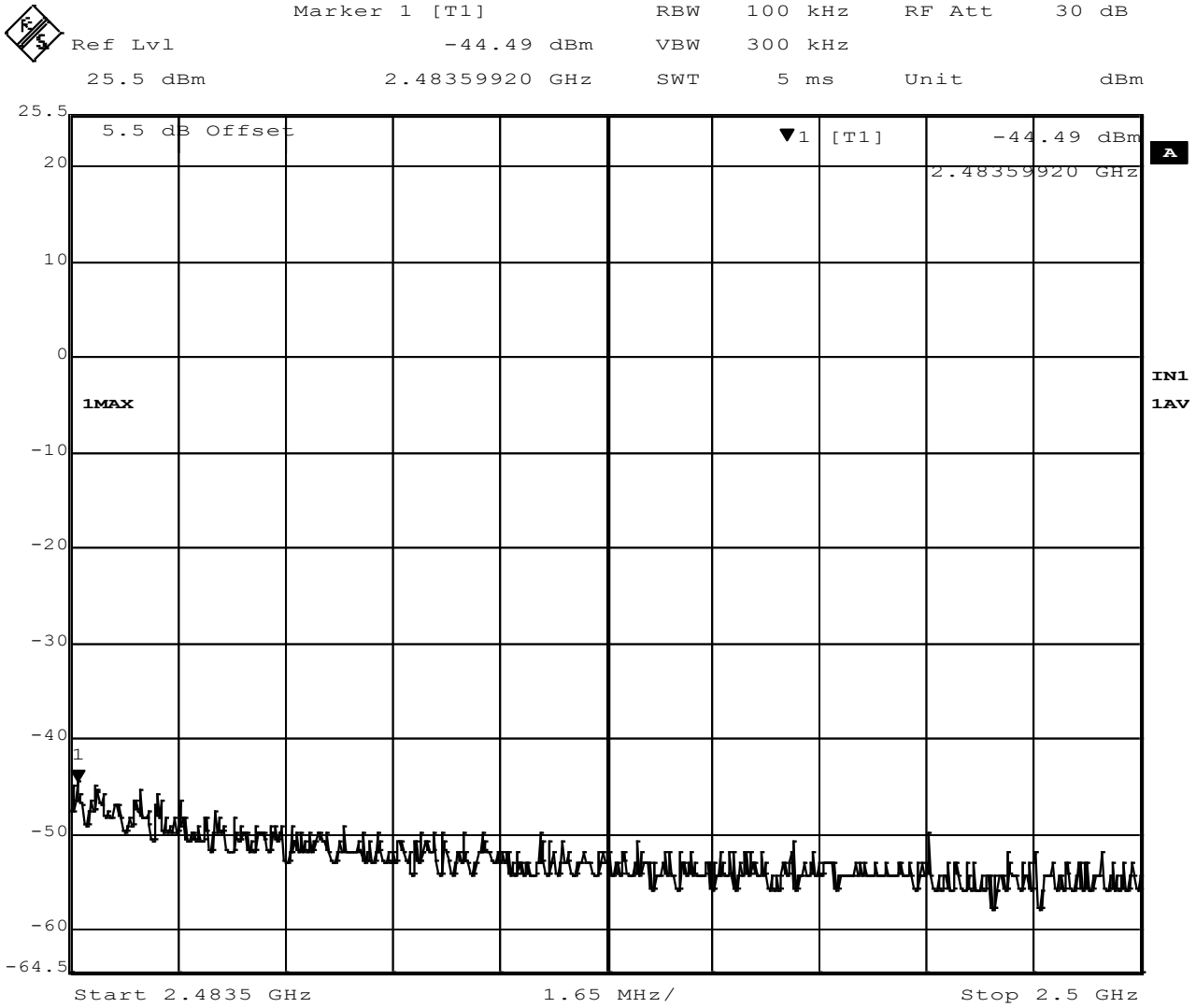

Figure 38 - Band-edge Measurement, High Channel, Restricted Frequency, Average, 802.11g

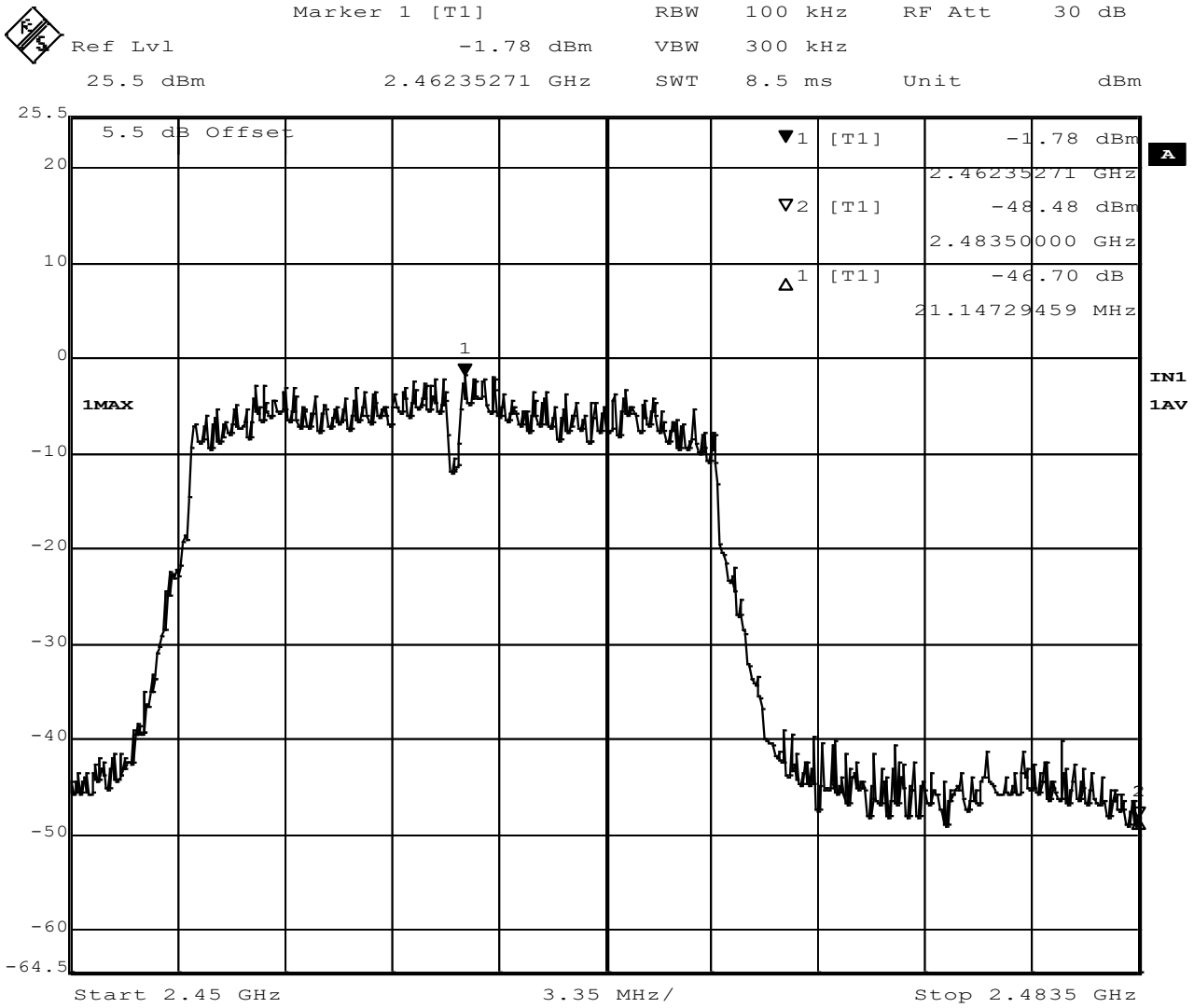

Figure 39 - Band-edge Measurement, High Channel, Fundamental, Average, 802.11g

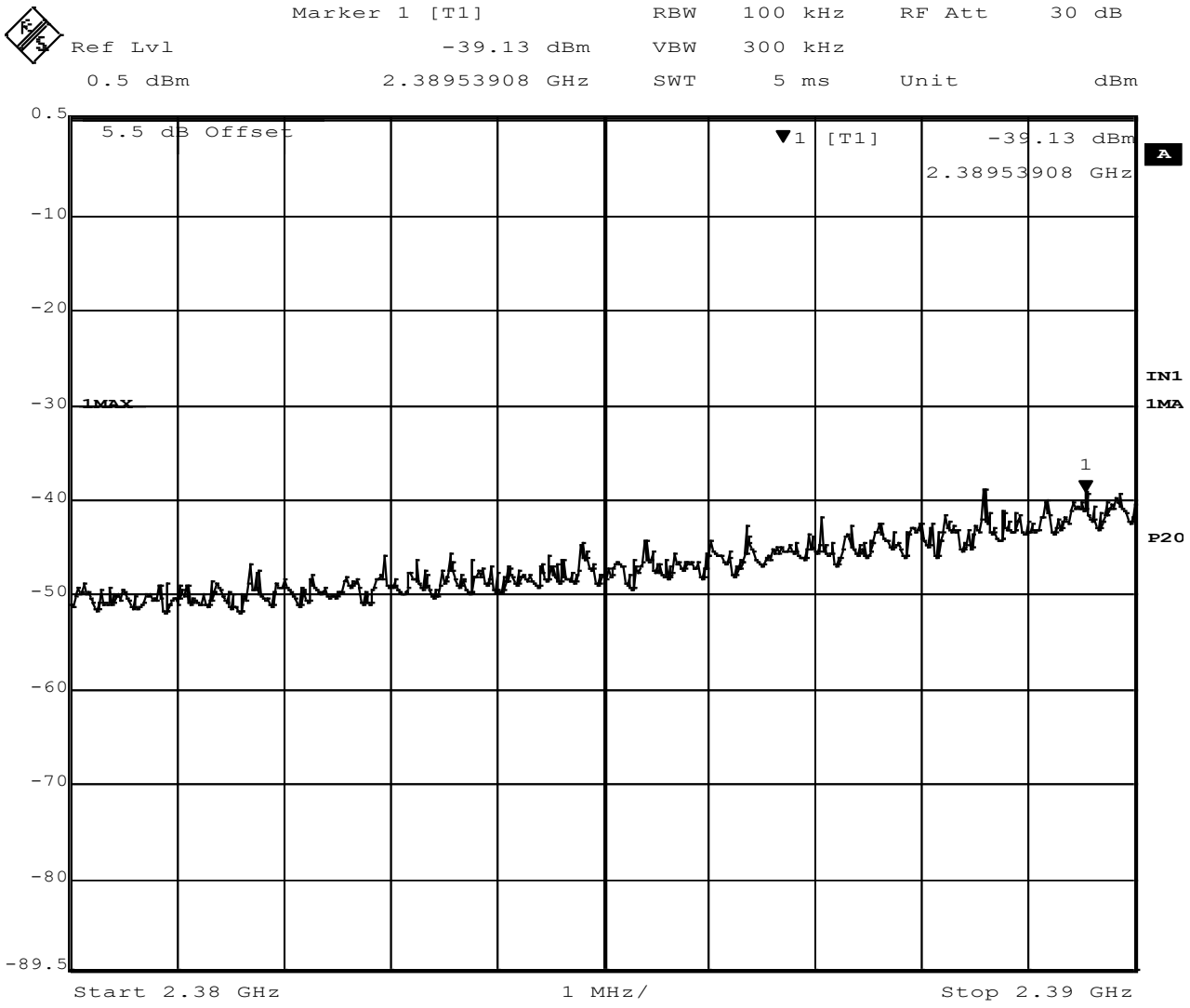

Figure 40 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak, 802.11n

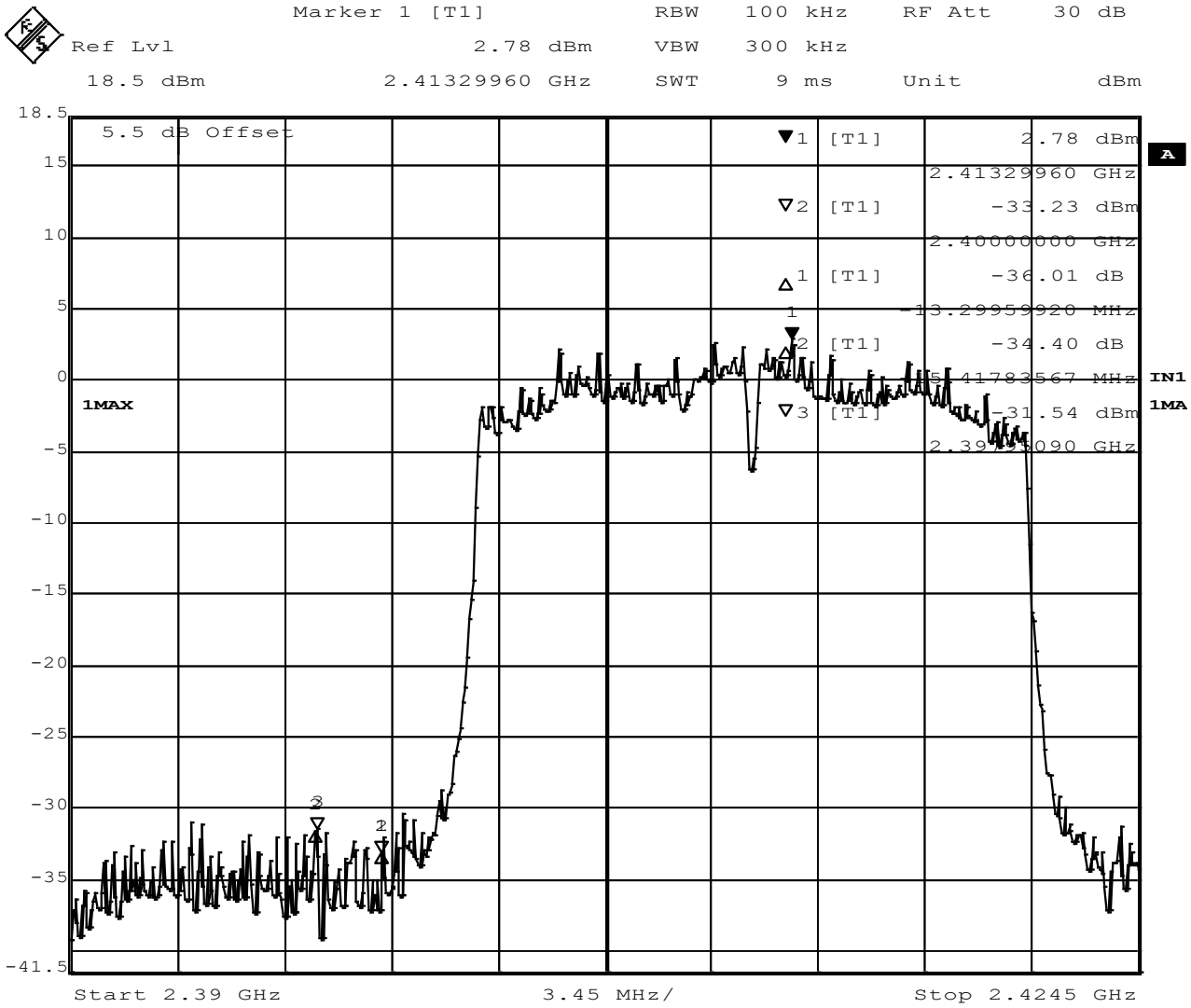

Figure 41 - Band-edge Measurement, Low Channel, Fundamental, Peak, 802.11n

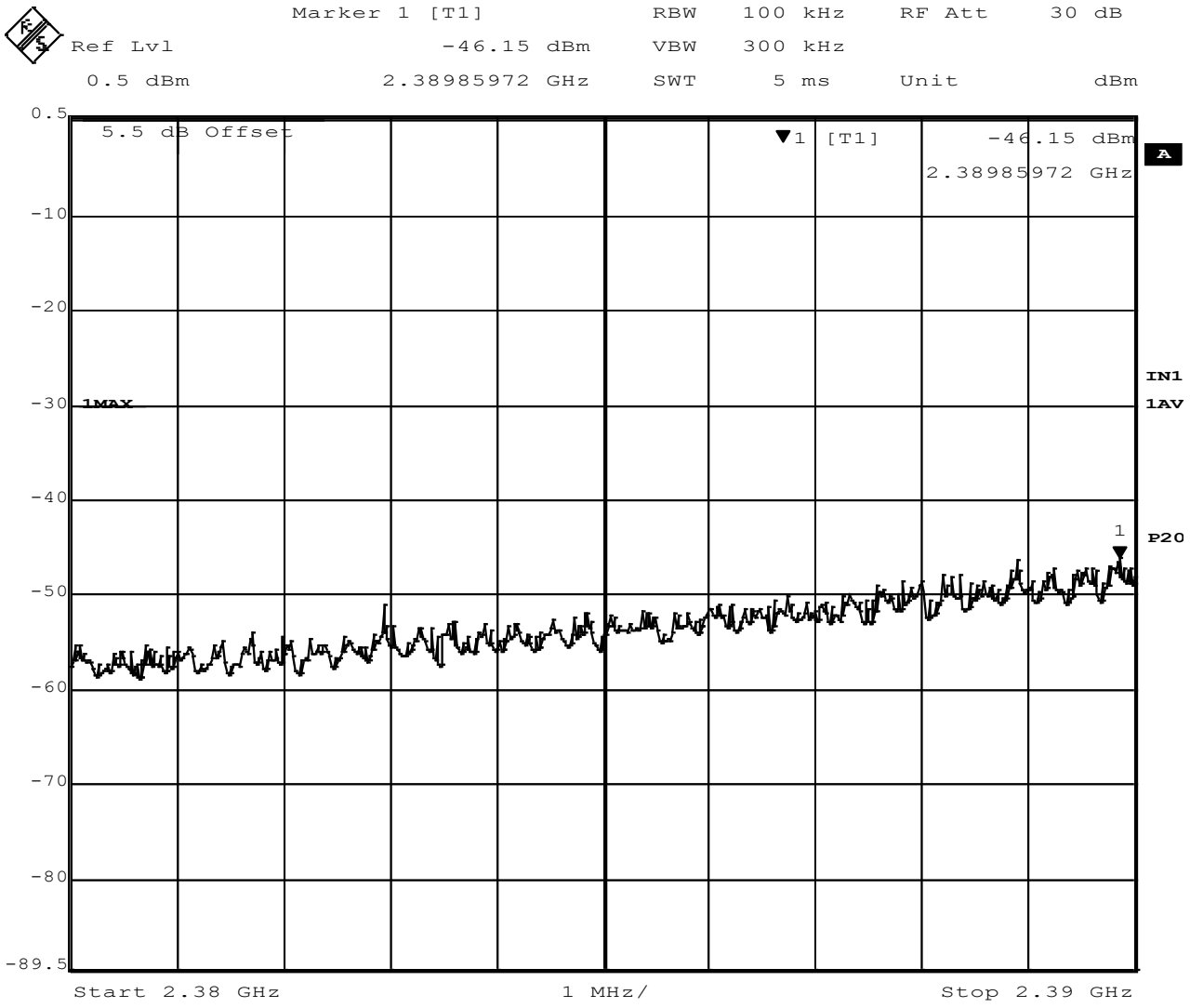

Figure 42 - Band-edge Measurement, Low Channel, Restricted Frequency, Average, 802.11n

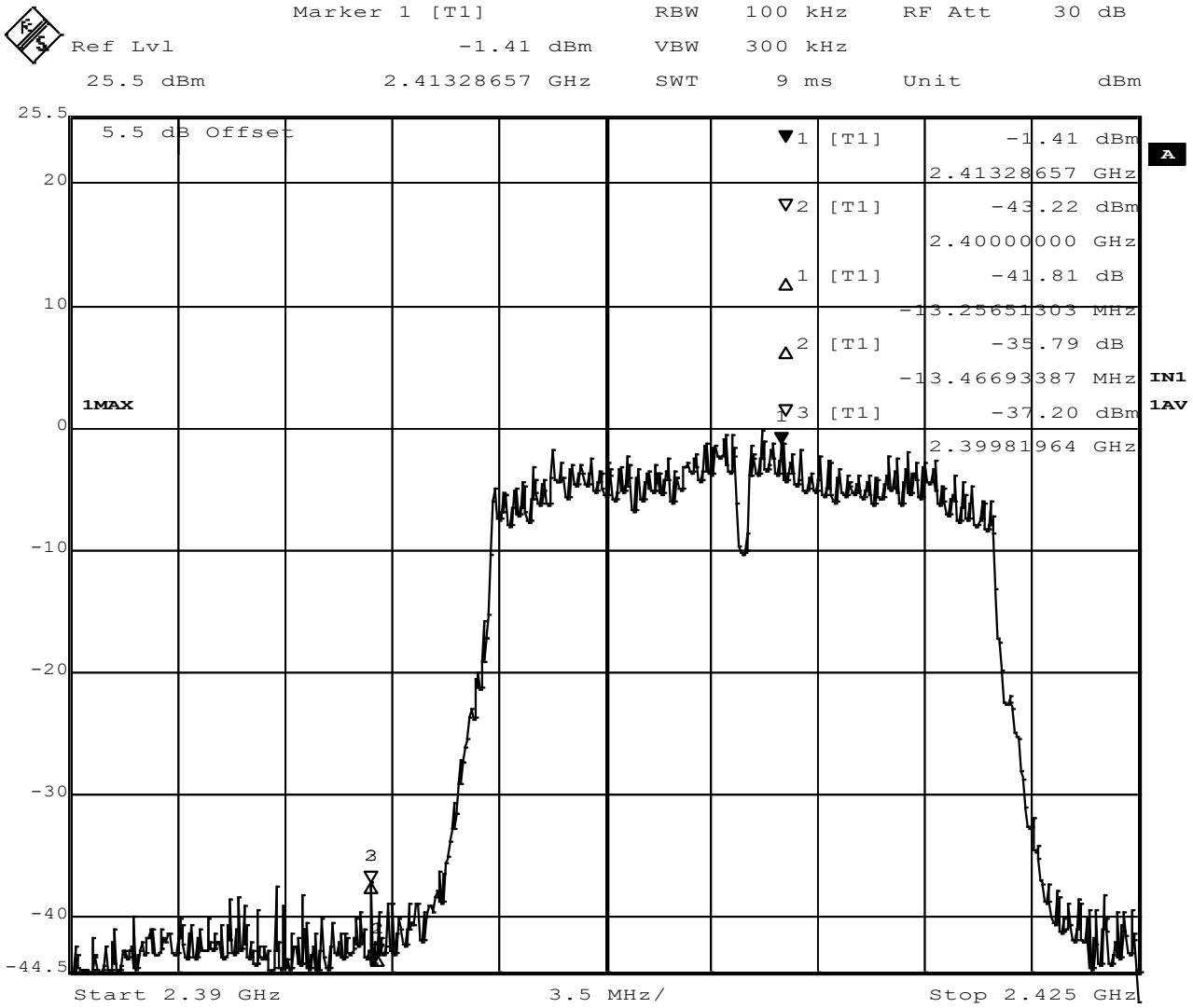

Figure 43 - Band-edge Measurement, Low Channel, Fundamental, Average, 802.11n

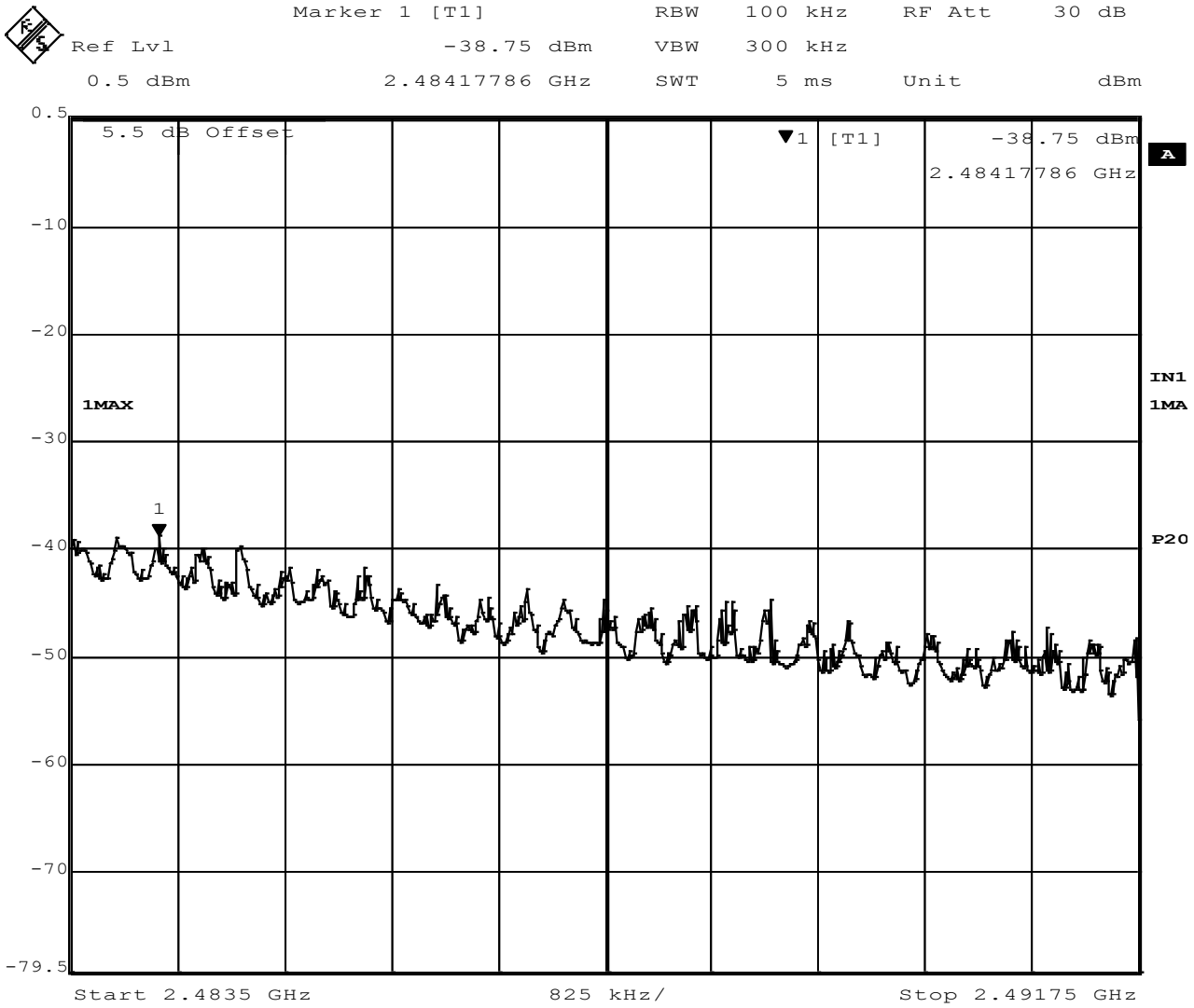

Figure 44 - Band-edge Measurement, High Channel, Restricted Frequency, Peak, 802.11n

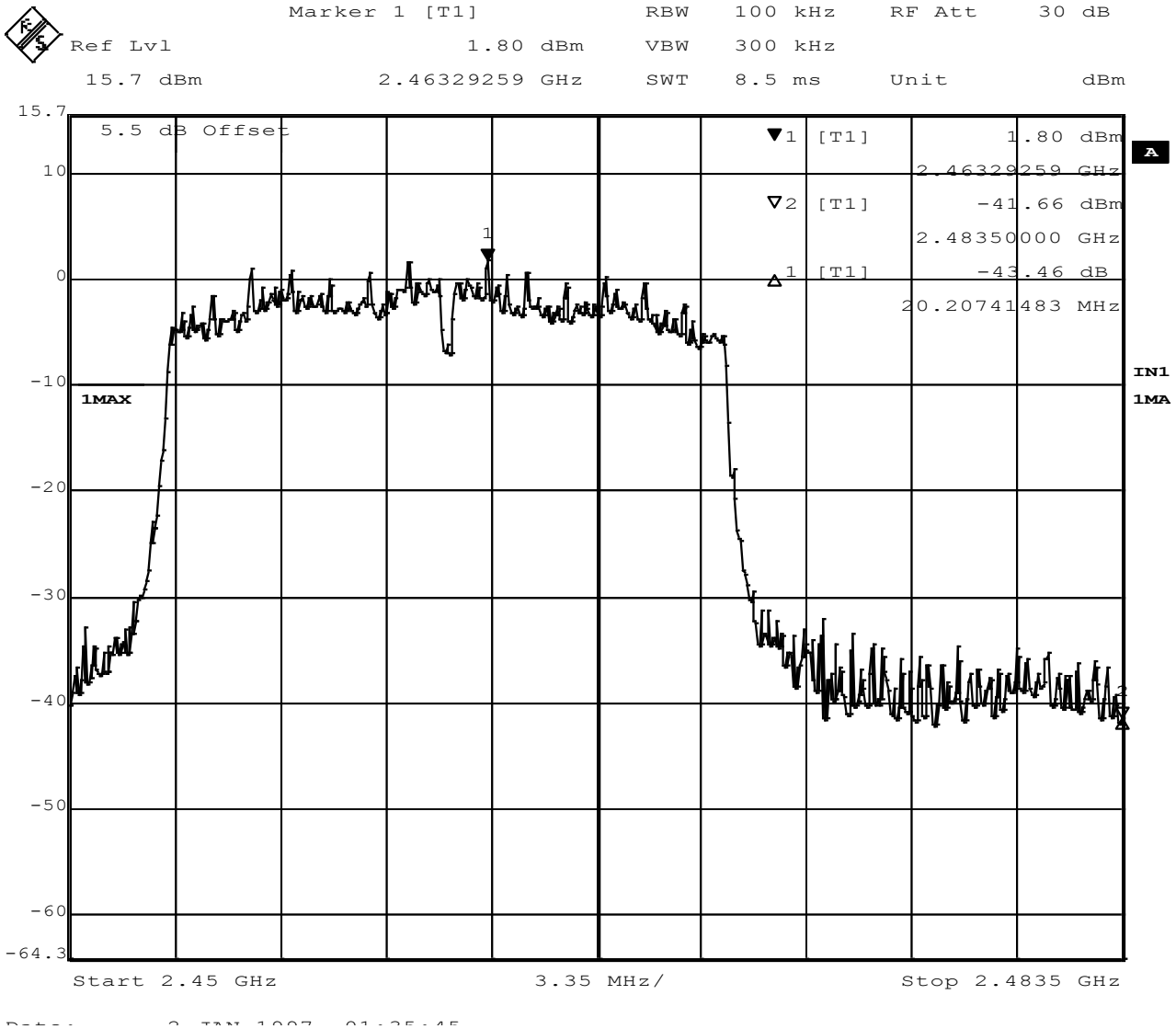

Figure 45 - Band-edge Measurement, High Channel, Fundamental, Peak, 802.11n

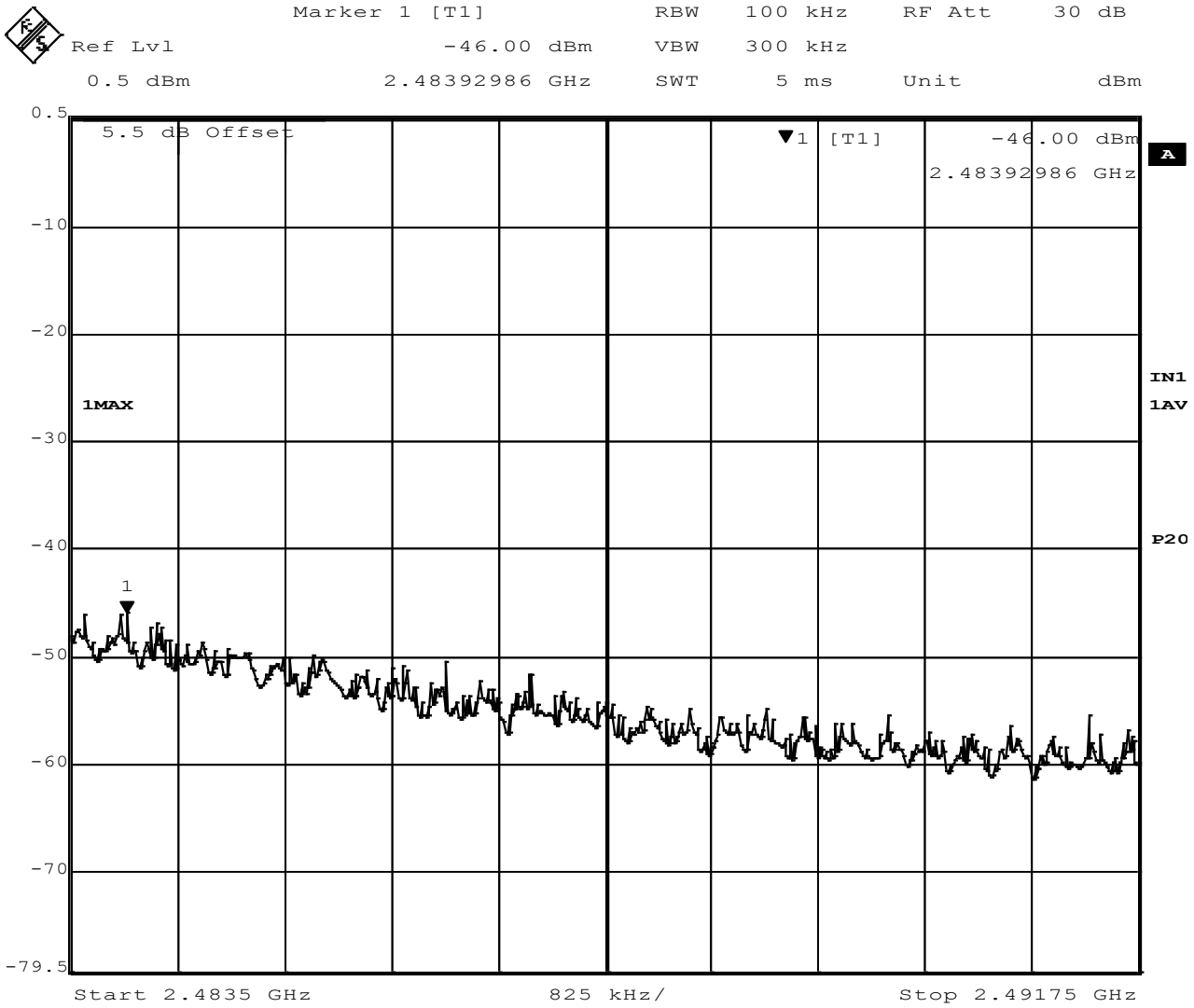

Figure 46 - Band-edge Measurement, High Channel, Restricted Frequency, Average, 802.11n

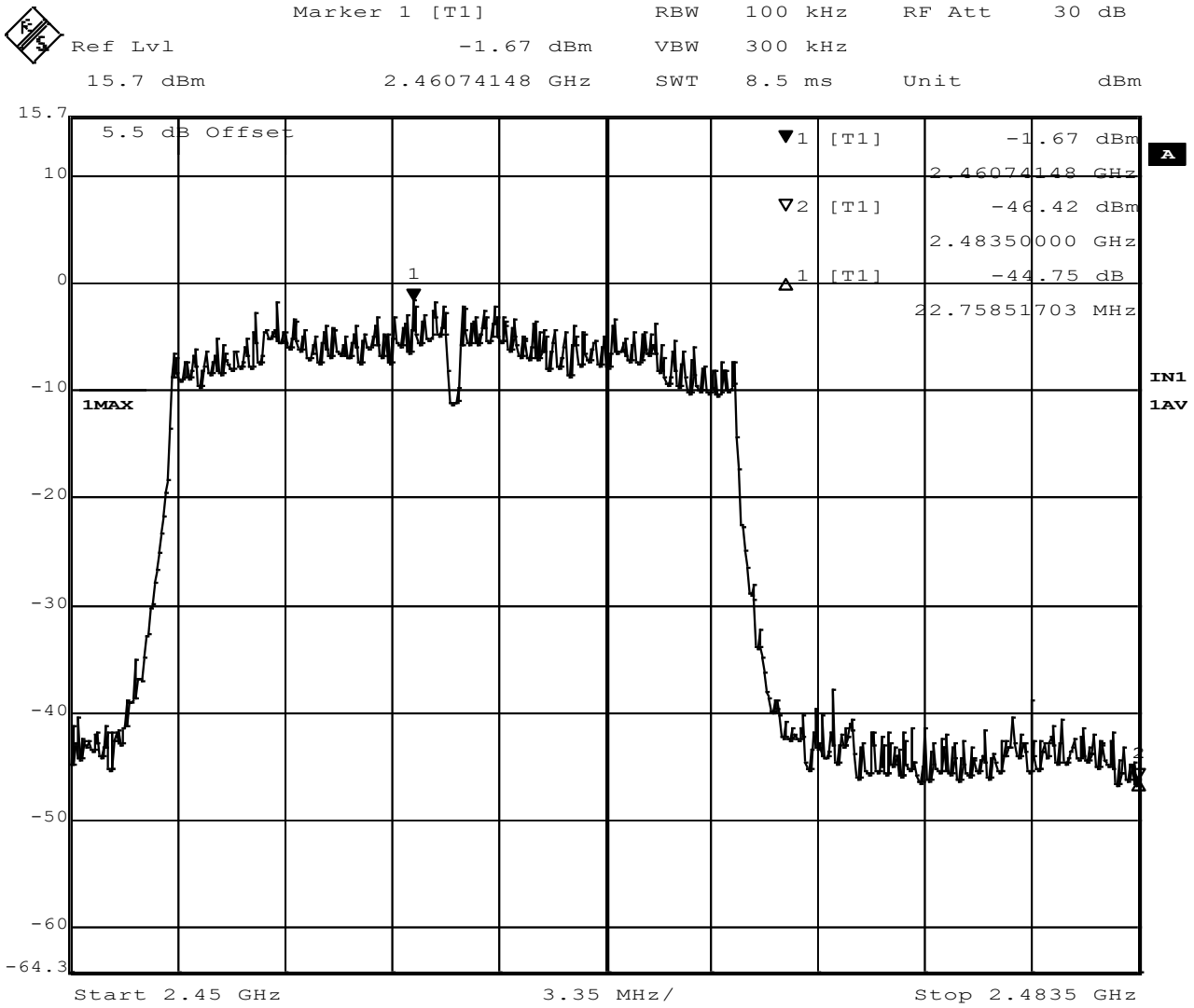

Figure 47 - Band-edge Measurement, High Channel, Fundamental, Average, 802.11n

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 3 VDC 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)	EIRP with antenna gain* (dBm)	Method	Limit (dBm)	RESULT
Low	2412	802.11b	-8.64	-5.84	Conducted	8.00	PASS
Middle	2437	802.11b	-9.67	-6.87	Conducted	8.00	PASS
High	2462	802.11b	-10.95	-8.15	Conducted	8.00	PASS
Low	2412	802.11g	-11.69	-8.89	Conducted	8.00	PASS
Middle	2437	802.11g	-11.28	-8.48	Conducted	8.00	PASS
High	2462	802.11g	-12.77	-9.97	Conducted	8.00	PASS
Low	2412	802.11n	-12.59	-9.79	Conducted	8.00	PASS
Middle	2437	802.11n	-12.31	-9.51	Conducted	8.00	PASS
High	2462	802.11n	-13.02	-10.22	Conducted	8.00	PASS

*Measured Antenna gain of 2.8 dBi Maximum was used.

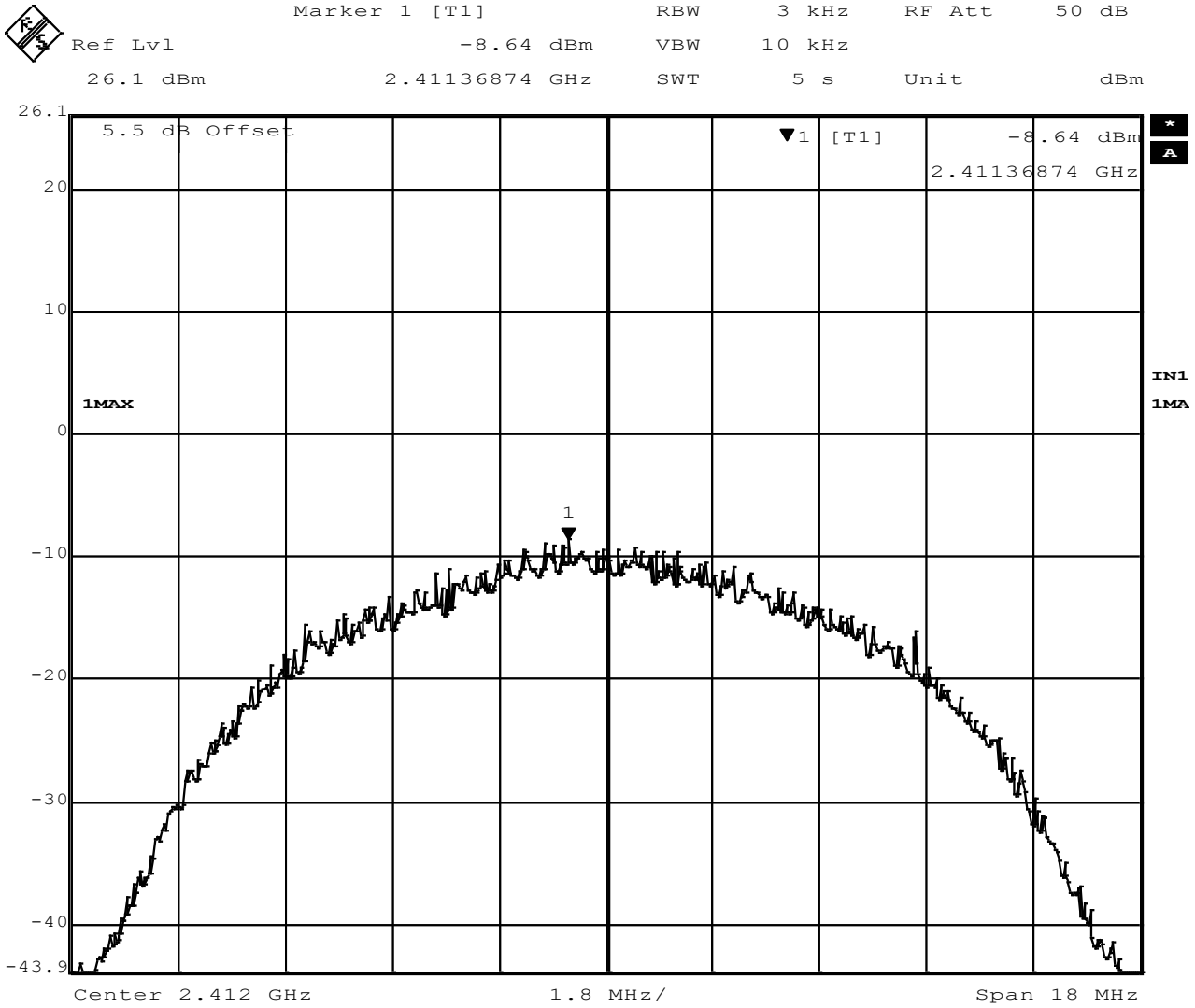

Figure 48 - Power Spectral Density, Low Channel, 802.11b

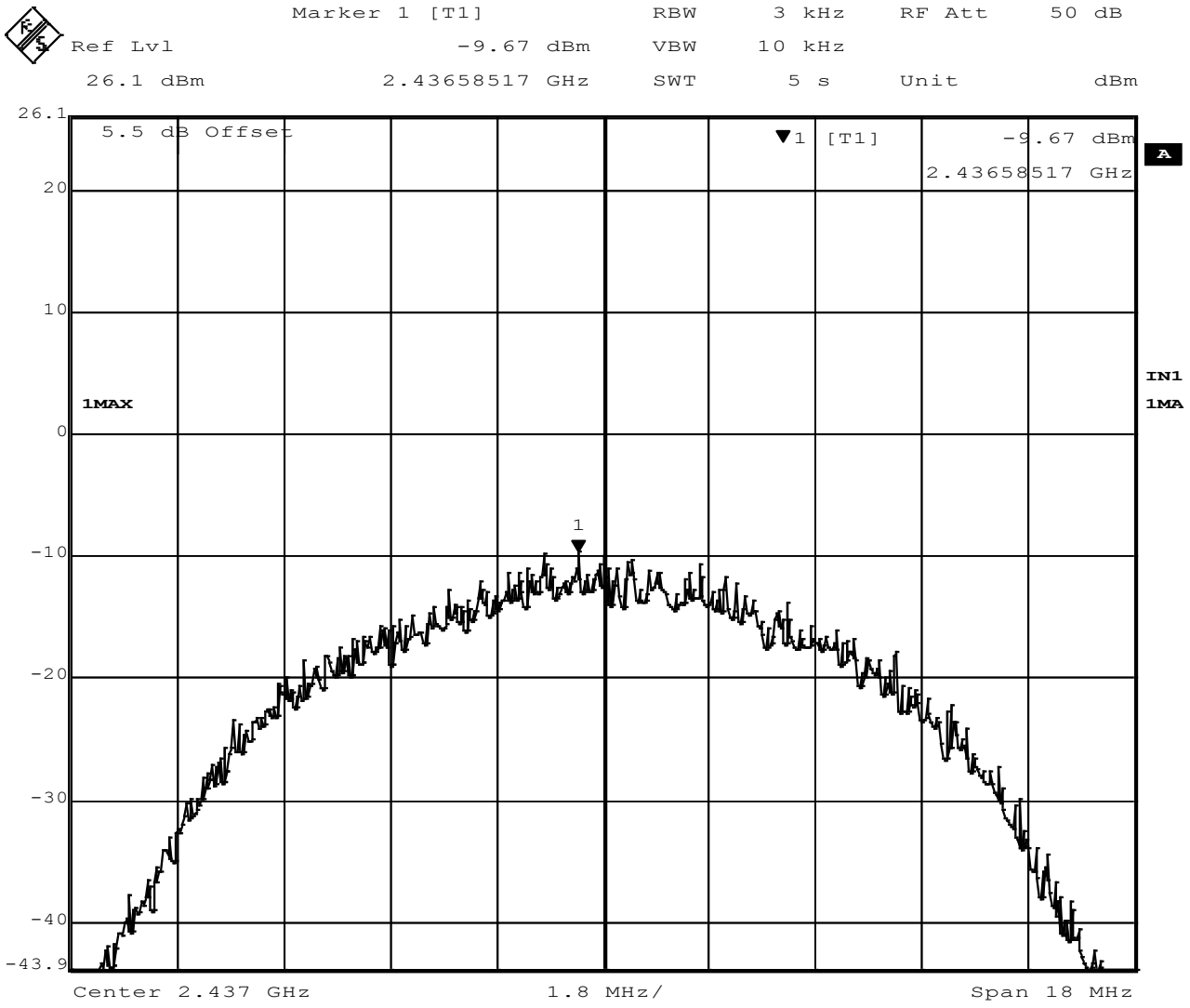

Figure 49 - Power Spectral Density, Mid Channel, 802.11b

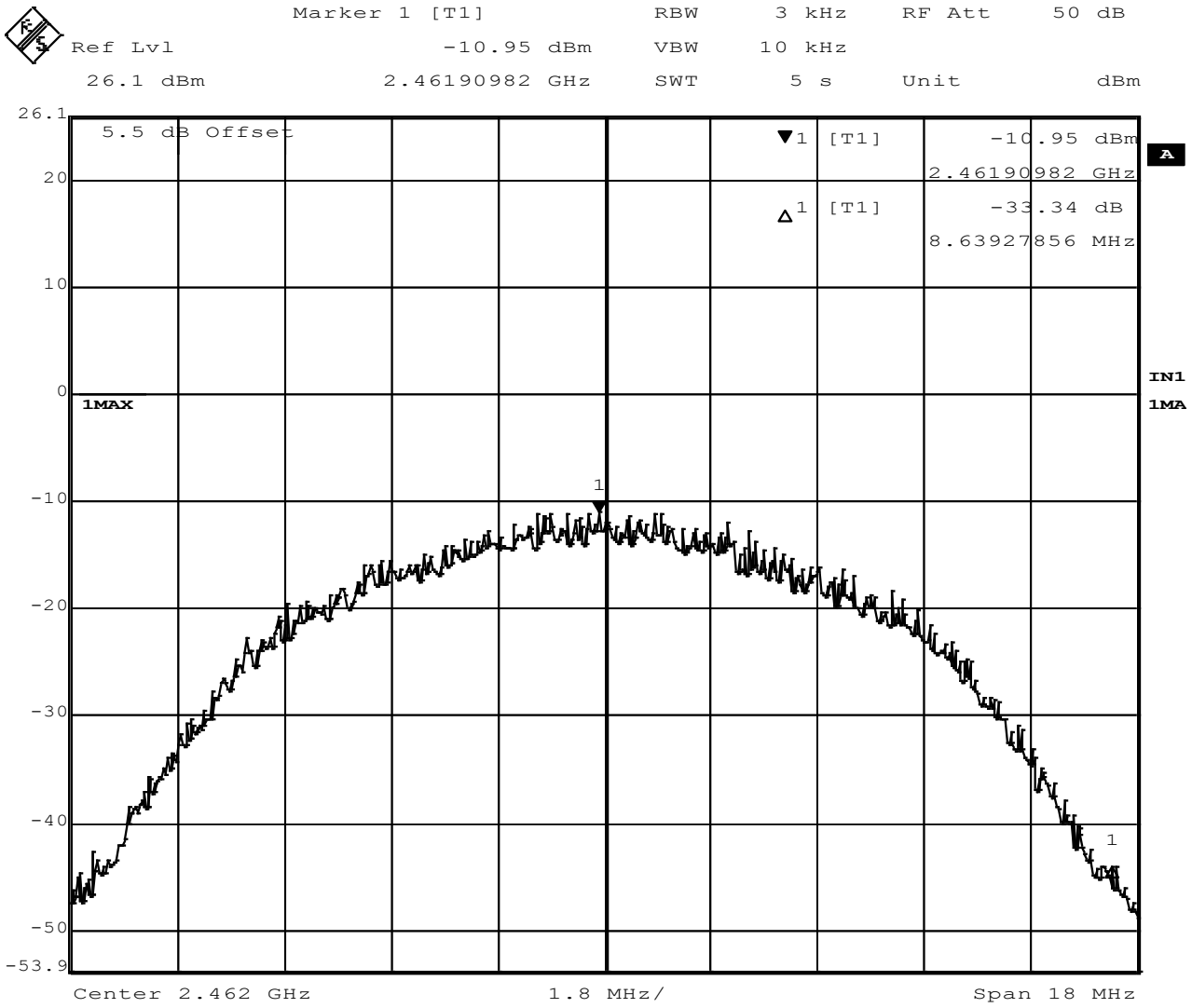

Figure 50 - Power Spectral Density, High Channel, 802.11b

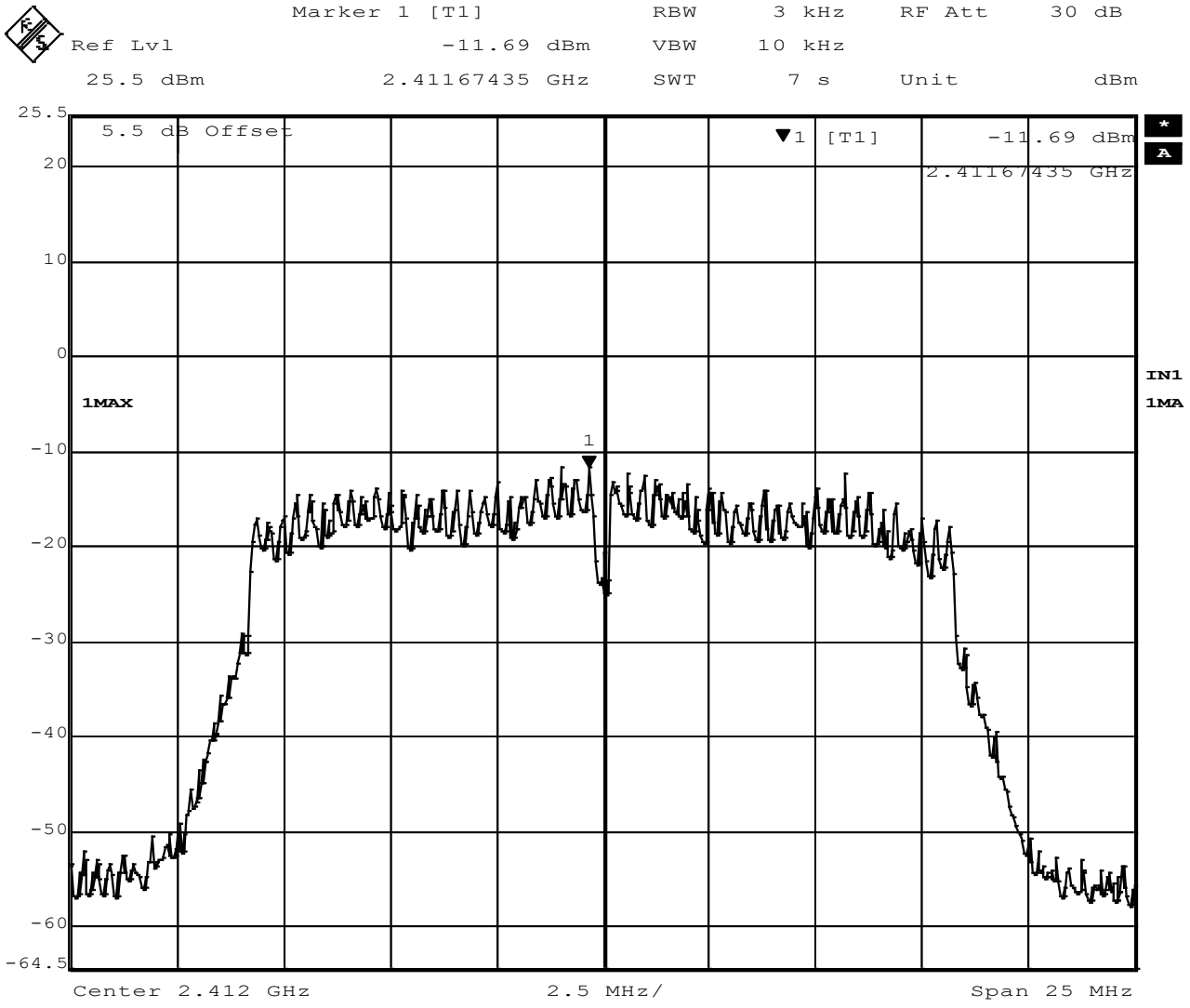

Figure 51 - Power Spectral Density, Low Channel, 802.11g

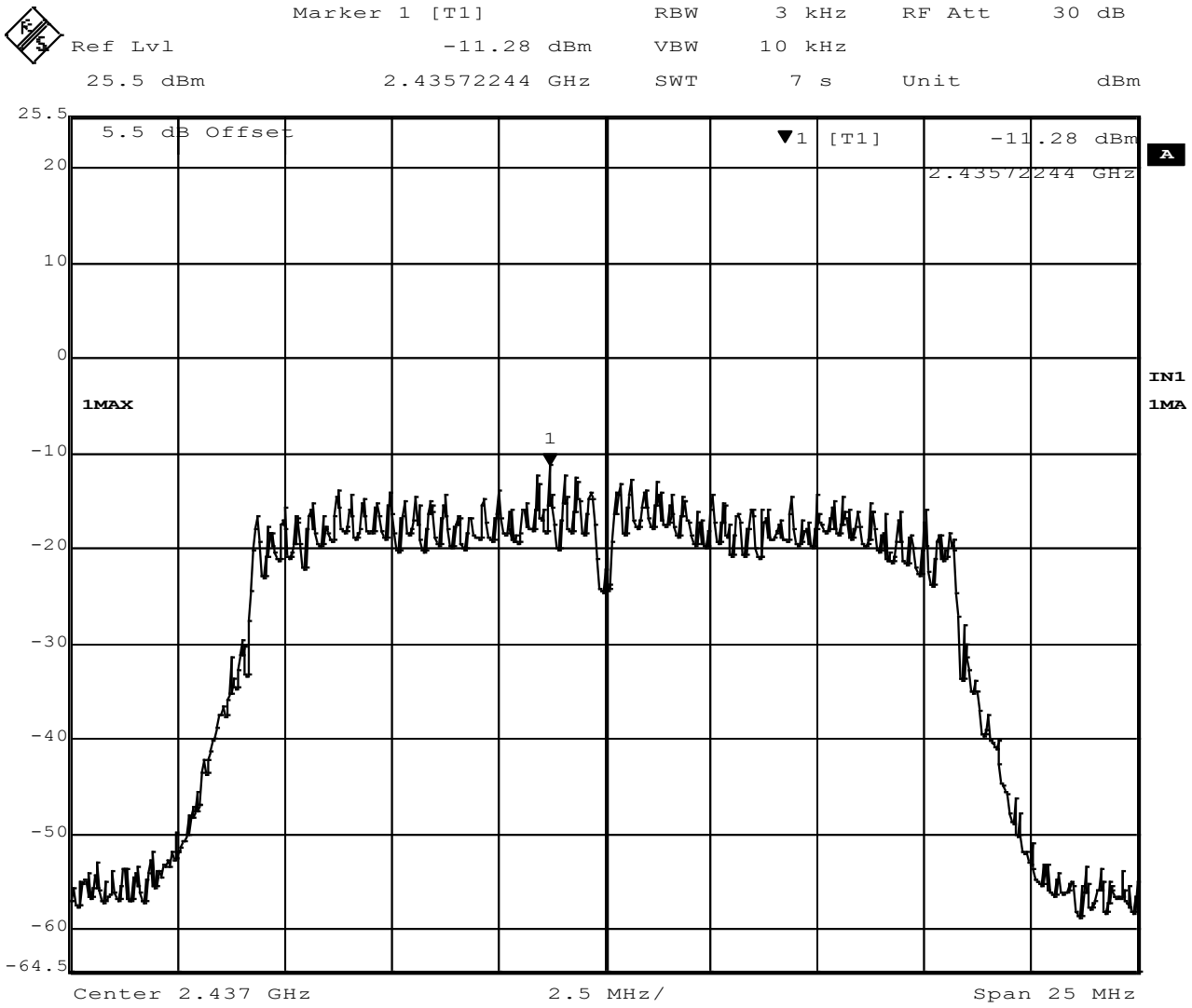

Figure 52 - Power Spectral Density, Mid Channel, 802.11g

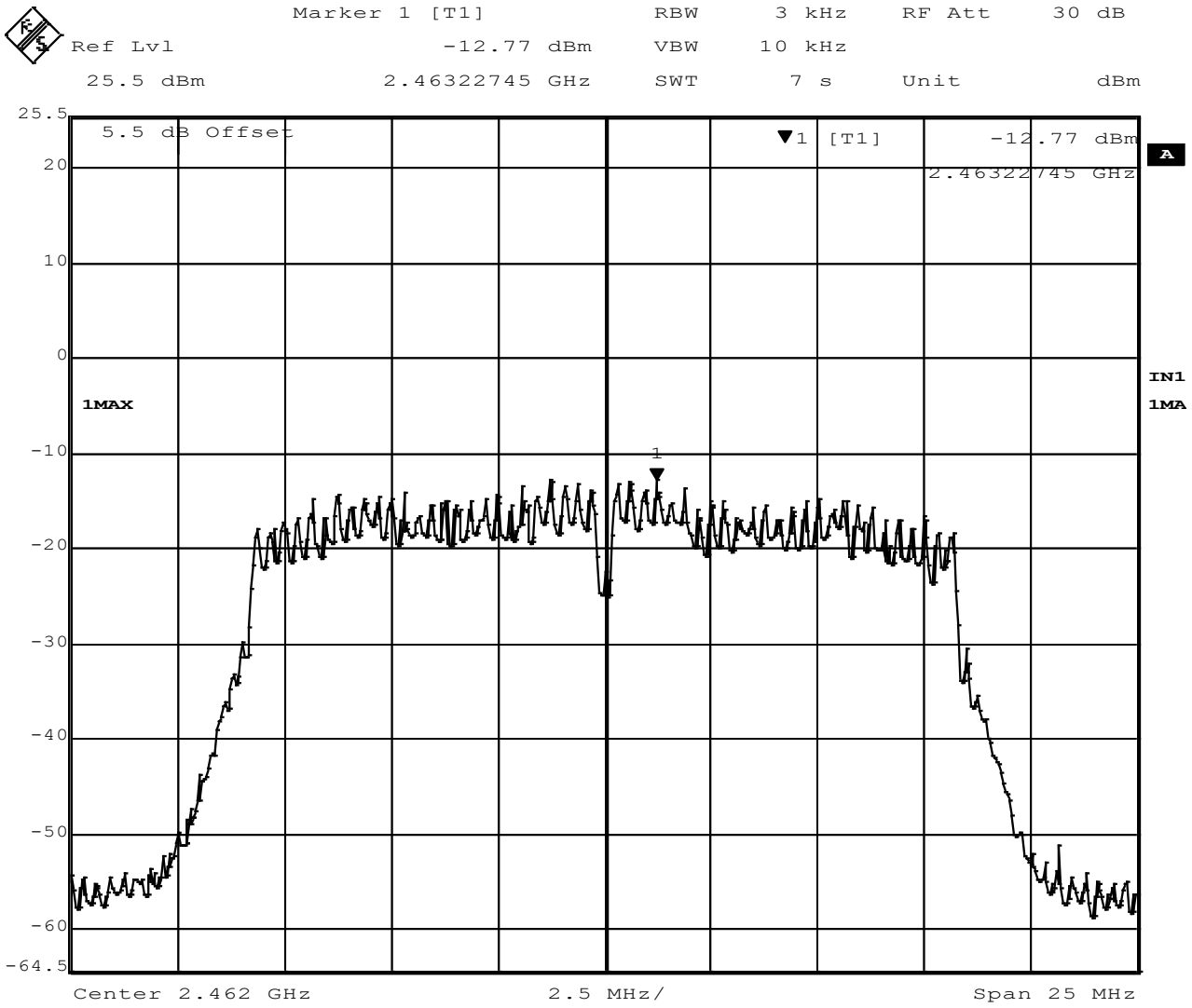

Figure 53 - Power Spectral Density, High Channel, 802.11g

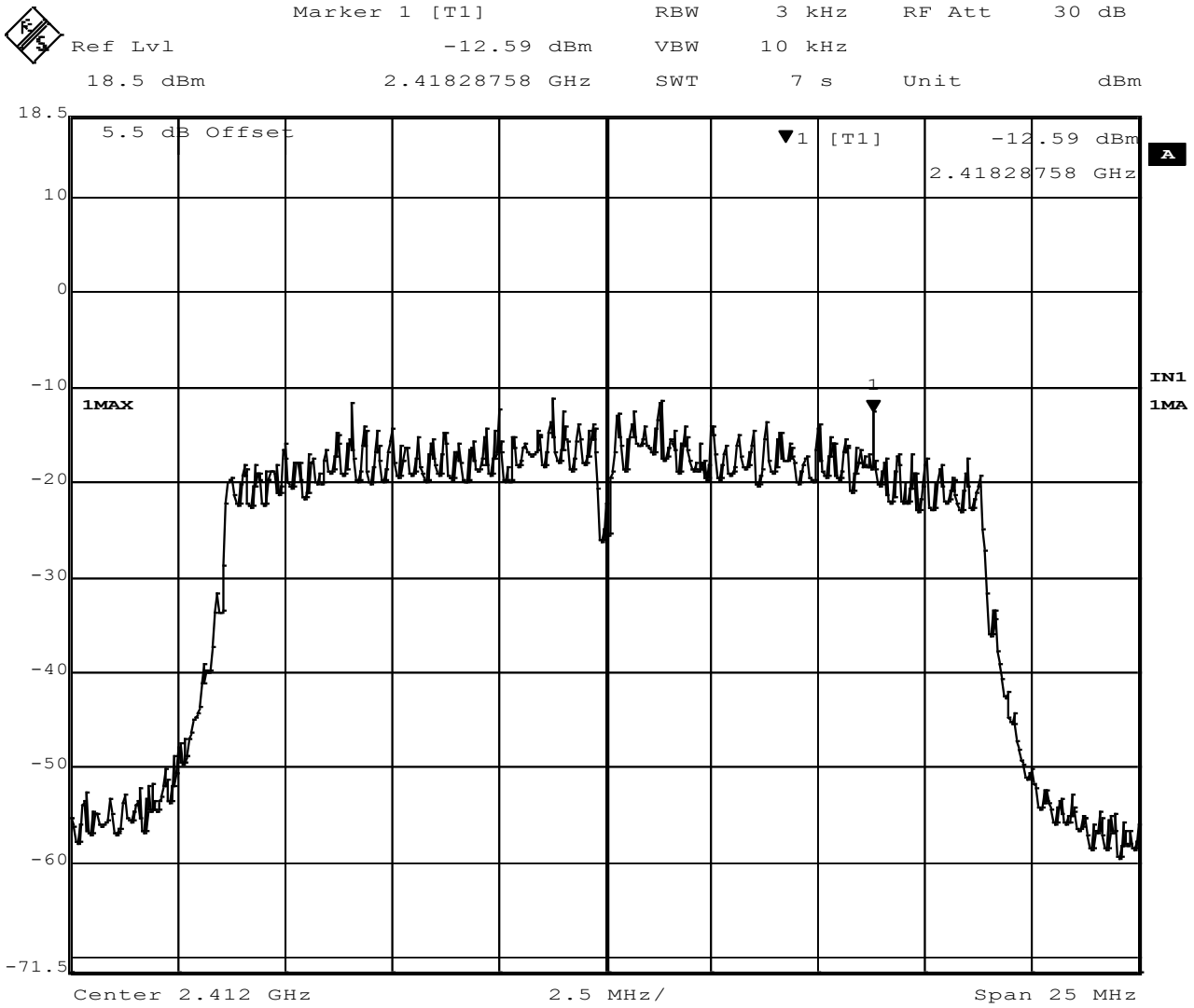

Figure 54 - Power Spectral Density, Low Channel, 802.11n

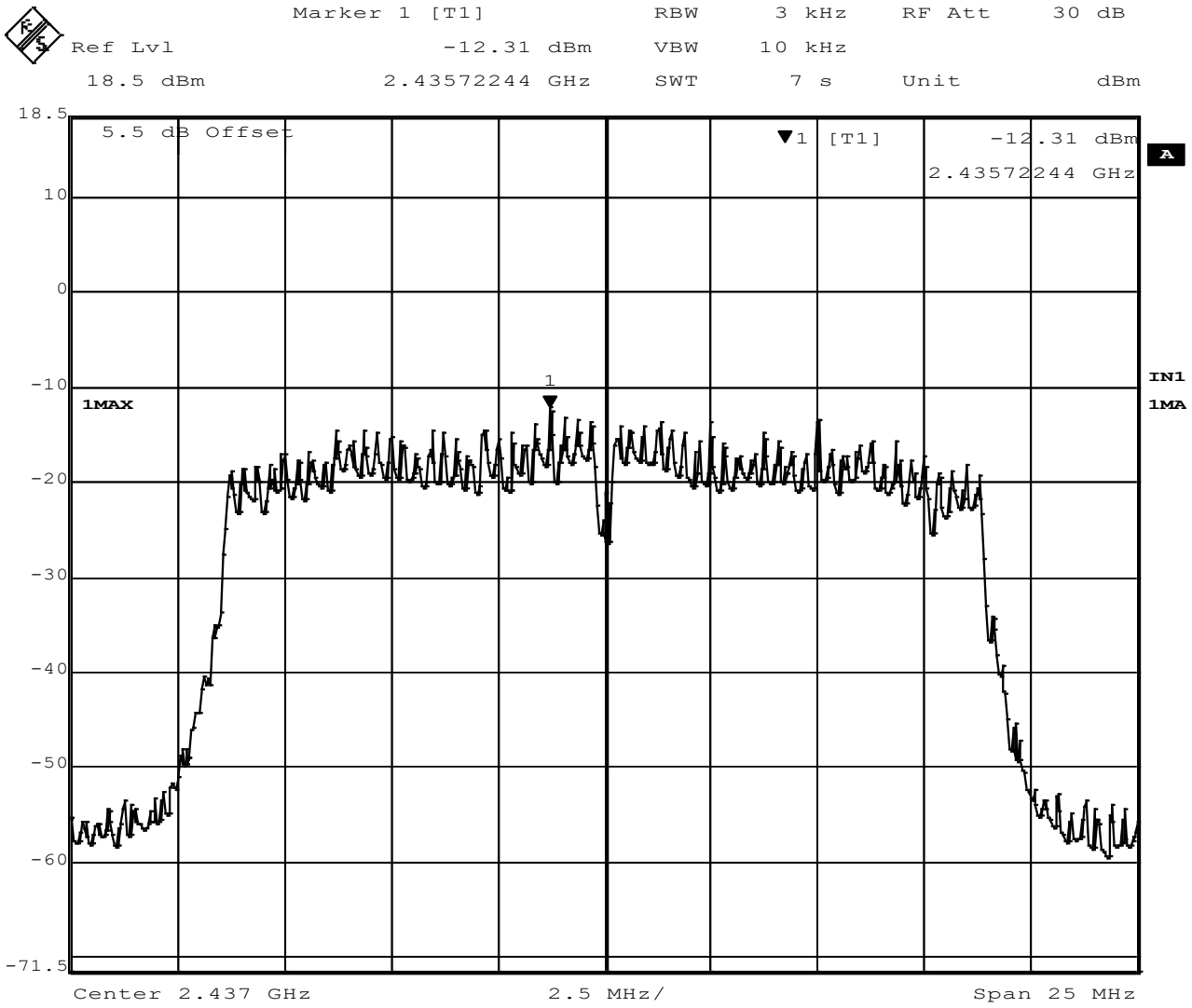

Figure 55 - Power Spectral Density, Mid Channel, 802.11n

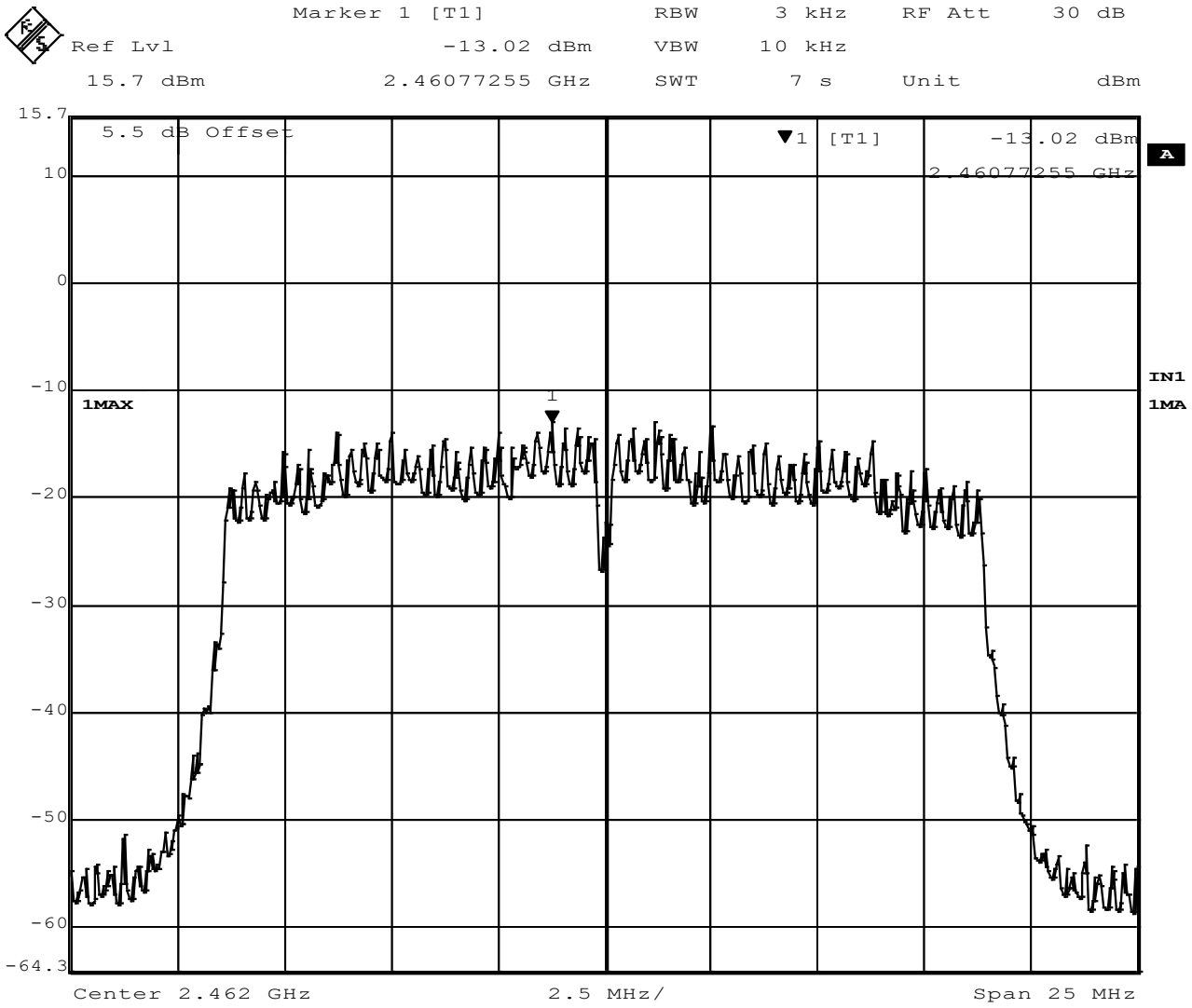

Figure 56 - Power Spectral Density, High Channel, 802.11n

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