TEST REPORT OF THE
Inventek Systems
2.4 GHz eS-WiFi Module
Models: ISM4343-X
IN CONFORMANCE WITH
ETSI EN 300 328 V2.1.1 (2016-11)
Harmonized EN covering essential requirements under article 3.2 of the Radio Equipment Directive (RED) 2014/53/EU

Remarks:

Equipment complied with the specification	☒
Equipment did not comply with the specification	☐
Results were within measurement uncertainties	☒

This report is issued Under the Authority of: Alan Ghasiani	Signature: *[signature]*
Tested By: Afzal Fazal	Signature *[signature]*
Issue Date: December 20, 2018	**Test Dates:** September 25, 2018 to December 19, 2018

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1 Purpose of the Test Report

This test report is being generated to show that the Inventek eS-WiFi Module, Model ISM4343-X complies with the requirements of ETSI EN 300 328 V2.1.1 (2016-11). The module is designed to transmit from either an etched integrated antenna or through the u.fl port. For u.fl transmission the module is being evaluated with two options of antennas, with the following gain: +1.4 dBi and +3.2 dBi.

2 Identification and Characteristics of Equipment Under Test

This section contains the unmodified Application Form submitted by the Manufacturer. The Application Form contains 13 pages, which are included in the total number of pages of this report.

The Equipment Under Test (EUT) is the Inventek eS-WiFi Module, Model ISM4343-X. The EUT is an embedded Serial WiFi (eS-WiFi), wireless internet connectivity module that operates in the 2.4 GHz spectrum. The eS-WiFi module's hardware consists of an ARM Cortex-based applications processor, a single stream 802.11n MAC/baseband/radio, a power amplifier (PA), and a receive low-noise amplifier (LNA). The eS-WiFi module has two antenna options, an on board PCB etched antenna or an U.FL connector for external 2.4 GHz antenna. The eS-WiFi module provides a UART interface enabling connection to an embedded design. The eS-WiFi module requires no operating system and has a completely integrated TCP/IP Stack. The eS-WiFi module hardware can be used with Inventek's IWIN (Inventek Wireless Interoperability Network). This product is targeted for low cost embedded wireless applications and enables a quick, easy and cost effective method adding WiFi connectivity.

The radio module configuration evaluated in this test report is the Inventek ISM4343-X-R48-L54 2.4 GHz eS-WiFi Module with special designation: ISM4343-X for the CE market.

The different model numbers are applied for marketing reasons and the suffixes depict variations of the module as follows:

-E = integrated trace antenna
-U = external u.fl antenna connecter added
-EVB = evaluation board

3 Standard Specific Transmitter Requirements

E.2 Information as required by EN 300 328 V2.1.1, clause 5.4.1

In accordance with EN 300 328, clause 5.4.1, the following information is provided by the manufacturer.

a) The type of modulation used by the equipment:

☐ FHSS

☒ Other forms of modulation

b) In case of FHSS modulation:

- In case of non-Adaptive Frequency Hopping equipment:

  The number of Hopping Frequencies: N/A

- In case of Adaptive Frequency Hopping Equipment:

  The maximum number of Hopping Frequencies: N/A

  The minimum number of Hopping Frequencies: N/A

- The (average) Dwell Time: N/A

c) Adaptive / non-adaptive equipment:

☐ Non-adaptive Equipment

☒ Adaptive Equipment without the possibility to switch to a non-adaptive mode

☐ Adaptive Equipment which can also operate in a non-adaptive mode

d) In case of adaptive equipment:

The maximum Channel Occupancy Time implemented by the equipment: _<40_ ms

☐ The equipment has implemented an LBT based DAA mechanism

- In case of equipment using modulation different from FHSS:
  - ☐ The equipment is Frame Based equipment
  - ☐ The equipment is Load Based equipment

☐ The equipment can switch dynamically between Frame Based and Load Based equipment

The CCA time implemented by the equipment: _N/A_ µs

☒ The equipment has implemented a non-LBT mechanism

☐ The equipment can operate in more than one adaptive mode

e) In case of non-adaptive Equipment:

The maximum RF Output Power (e.i.r.p.): N/A dBm

The maximum (corresponding) Duty Cycle: N/A %

Equipment with dynamic behavior, that behavior is described here. (e.g. the different combinations of duty cycle and corresponding power levels to be declared): N/A

f) The worst case operational mode for each of the following tests:

RF Output Power

19.2 dBm (EIRP)

Power Spectral Density

9.8 dBm/1MHz

Duty cycle, TX-Sequence, TX-gap

N/A

Accumulated Transmit Time, Frequency Occupation & Hopping Sequence (only for FHSS equipment)

N/A

Hopping Frequency Separation (only for FHSS equipment)

N/A

Medium Utilization

N/A

Adaptivity & Receiver Blocking

Non-LBT & > -30 dBm

Nominal Channel Bandwidth

17.782 MHz

Transmitter unwanted emissions in the OOB domain

The EUT complies with the requirement per clause 4.3.2.8

Transmitter unwanted emissions in the spurious domain

The EUT complies with the requirement per clause 4.3.2.9

Receiver spurious emissions

The EUT complies with the requirement per clause 4.3.2.10

g) The different transmit operating modes (check all that apply):

☒ Operating mode 1: Single Antenna Equipment

☒ Equipment with only one antenna

☐ Equipment with two diversity antennas but only one antenna active at any moment in time

☐ Smart Antenna Systems with two or more antennas, but operating in a (legacy) mode where only one antenna is used. (e.g. IEEE 802.11™ [i.3] legacy mode in smart antenna systems)

☐ Operating mode 2: Smart Antenna Systems - Multiple Antennas without beam forming

☐ Single spatial stream / Standard throughput / (e.g. IEEE 802.11™ [i.3] legacy mode)

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2

NOTE 1: Add more lines if more channel bandwidths are supported.

☐ Operating mode 3: Smart Antenna Systems - Multiple Antennas with beam forming

☐ Single spatial stream / Standard throughput (e.g. IEEE 802.11™ [i.3] legacy mode)

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2

NOTE: Add more lines if more channel bandwidths are supported.

h) In case of Smart Antenna Systems:

- The number of Receive chain: N/A
- The number of Transmit chains: N/A
  - ☐ Symmetrical power distribution
  - ☐ Asymmetrical power distribution

In case of beam forming, the maximum beam forming gain: N/A

NOTE: Beam forming gain does not include the basic gain of a single antenna.

i) Operating Frequency Range(s) of the equipment:

- Operating Frequency Range 1: 2412 MHz to 2472 MHz
- Operating Frequency Range 2:_ MHz to _ MHz

NOTE: Add more lines if more Frequency Ranges are supported.

j) Nominal Channel Bandwidth(s):

- Nominal Channel Bandwidth 1: 17.882 MHz
- Nominal Channel Bandwidth 2:___MHz

NOTE: Add more lines if more channel bandwidths are supported.

k) Type of Equipment (stand-alone, combined, plug-in radio device, etc.):

☐ Stand-alone

☐ Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)

☒ Plug-in radio device (Equipment intended for a variety of host systems)

☐ Other:

l) The normal and the extreme operating conditions that apply to the equipment:

Normal Operating Conditions (if applicable):

Operating temperature range: -40° C to + 85° C

Other (please specify if applicable): N/A

. **Extreme Operating Conditions:**

Operating temperature range: Minimum: -40° C maximum: +85° C

Other (please specify if applicable): Minimum: N/A Maximum: N/A

Details provided are for the:

- ☒ Stand-alone equipment
- ☐ Combined (or host) equipment
- ☒ Test jig

m) The intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p levels:

Antenna Type:

☒ Integral Antenna (information to be provided in case of conducted measurements)

Antenna Gain: 3.2 dBi (max antenna gain)

If applicable, additional beam-forming gain (excluding basic antenna gain): N/A

☐ Temporary RF connector provided

☐ No temporary RF connector provided

☒ Dedicated Antennas (equipment with antenna connector)

☒ Single power level with corresponding antenna(s)

☐ Multiple power settings and corresponding antenna(s)

Number of different Power Levels:

Power Level 1: N/A dBm

Power Level 2: N/A dBm

Power Level 3: N/A dBm

NOTE 1: Add more lines in case the equipment has more power levels.

NOTE 2: These power levels are conducted power levels (at antenna connector).

For each of the Power Levels, provide the intended antenna assemblies, their corresponding gains (G) and the resulting e.i.r.p. levels also taking into account the beam-forming gain (Y) if applicable

Power Level 1: 15.99 dBm + 3.2 dBi = 19.19 dBm (E.I.R.P.)

Number of antenna assemblies provided for this power level:

Assembly #	Gain (dBi)	e.i.r.p. (dBm)	Part number or model name
1	+2.6	17.41	W24P-U 2400-2500 MHz WiFi PCB antenna with U.Fl Connector and 90 mm cable length
2	+3.2	18.01	W24P-U 2400-2500 & 4900-5900 MHz Dual Band WiFi PCB antenna with U.Fl Connector and 90 mm cable length
3	+0.0	14.81	Inventek Etched Antenna
4	N/A	N/A	N/A

NOTE: Add more rows in case more antenna assemblies are supported for this power level.

Power Level 2: N/A dBm

Number of antenna assemblies provided for this power level:

Assembly #	Gain (dBi)	e.i.r.p. (dBm)	Part number or model name
1	N/A	N/A	N/A
2	N/A	N/A	N/A
3	N/A	N/A	N/A
4	N/A	N/A	N/A

NOTE: Add more rows in case more antenna assemblies are supported for this power level.

Power Level 3: N/A dBm

Number of antenna assemblies provided for this power level:

Assembly #	Gain (dBi)	e.i.r.p. (dBm)	Part number or model name
1	N/A	N/A	N/A
2	N/A	N/A	N/A
3	N/A	N/A	N/A
4	N/A	N/A	N/A

NOTE: Add more rows in case more antenna assemblies are supported for this power level.

n) The nominal voltages of the stand-alone radio equipment or the nominal voltages of the combined (host) equipment or test jig in case of plug-in devices:

Details provided are for the:

- ☐ Stand-alone equipment
- ☐ Combined (or host) equipment
- ☐ Test jig

Supply Voltage

- ☐ AC mains State AC voltage: V
- ☒ DC State DC voltage: 3.0 – 5.0 V

In case of DC, indicate the type of power source

- ☐ Internal Power Supply
- ☒ External Power Supply or AC/DC adapter
- ☐ Battery
- ☒ Other: powered via laptop USB port

o) Describe the test modes available which can facilitate testing:

The EUT was able to continuously transmit on individual channels.

p) The equipment type (e.g. Bluetooth®, IEEE 802.11™ [i.3], proprietary, etc.):

IEEE 802.11 b/g/n, WiFi Compliant

q) If applicable, the statistical analysis referred to in clause 5.4.1 q)

(to be provided as separate attachment)

r) If applicable, the statistical analysis referred to in clause 5.4.1 r)

(to be provided as separate attachment)

s) Geo-Location capability supported by the equipment:

☐ Yes

☐ The geographical location determined by the equipment as defined in clause 4.3.1.13.2 or clause 4.3.2.12.2 is not accessible to the user

☒ No

f) Describe the minimum performance criteria that apply to the equipment (see clause 4.3.1.12.3 or clause 4.3.2.11.3):

E.3 Combination for testing (see clause 5.3.2.3 of EN 300 328 V2.1.1)

From all combinations of conducted power settings and intended antenna assembly (ies) specified in clause 3.1 m), specify the combination resulting in the highest e.i.r.p. for the radio equipment.

Unless otherwise specified in EN 300 328, this power setting is to be used for testing against the requirements of EN 300 328. In case there is more than one such conducted power setting resulting in the same (highest) e.i.r.p. level, the highest power setting is to be used for testing. See also EN 300 328, clause 5.3.2.3.

This has been considered. The EUT is programmed to operate at it maximum output setting for this mode of operation.

E.4 Additional information provided by the applicant

E.4.1 Modulation

ITU Class(es) of emission:

Can the transmitter operate unmodulated?

☐ Yes

☒ No

E.4.2 Duty Cycle

The transmitter is intended for:

☐ Continuous duty

☒ Intermittent duty

☐ Continuous operation possible for testing purposes

E.4.3 About the UUT

☒ The equipment submitted is representative production models

☐ If not, the equipment submitted is pre-production models?

☐ If pre-production equipment are submitted, the final production equipment will be identical in all respects with the equipment tested

☐ If not, supply full details

....

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E.4.4 Additional items and/or supporting equipment provided

☐ Spare batteries (e.g. for portable equipment)

☐ Battery charging device

☒ External Power Supply or AC/DC adapter

☐ Test Jig or interface box

☐ RF test fixture (for equipment with integrated antennas)

☒ Host System

- Manufacturer: Inventek Systems
- Model #: ISM4343-X
- Model name: 2.4 GHz eS-WiFi Module

☐ Combined equipment

- Manufacturer:
- Model #:
- Model name:

☒ User Manual

☒ Technical documentation (Handbook and circuit diagrams)

4 Technical Summary

Applicant information

Applicant's representative	:	Martin Tierney
Company	:	Inventek
Address	:	2 Republic Road
City	:	Billerica
State	:	MA
Postal code	:	01862
Country	:	United States
Telephone number	:	+1 978-667-1962
Fax number	:	N/A

Description of test item

Test item	:	ISM43903 2.4GHz WiFi
Manufacturer	:	Inventek
Frequency Characteristics	:	2412 MHz to 2472 MHz
Type	:	802.11 b/g/n
Modulation Type	:	OFDM/64-QAM, 16-QAM,
	:	QPSK, BPSK, CCK,
	:	DQPSK, DBPSK
Temperature Range	:	-40˚C to 85˚C
Specification(s)	:	None
Model Name	:	2.4 GHz eS-WiFi Module
Model Number	:	ISM4343-X
Serial number	:	ENGINEERING SAMPLE
Revision	:	Rev. B
Receipt number	:	18-0270
Receipt date	:	September 17, 2018

Test(s) performed

Location	:	US Tech
Tests started	:	September 25, 2018
Tests completed	:	December 19, 2018
Purpose of tests	:	Compliance with standard
Test specifications	:	ETSI EN 300 328 V2.1.1 (2016-11)
Test engineer(s)	:	Afzal Fazal, Mark Afroozi, George Yang
Project leader	:	George Yang
Report written by	:	Afzal Fazal
Report approved by	:	Alan Ghasiani
Report date	:	December 19, 2018

5 Measurements, Examinations and Derived Results

5.1 Tests Required

The following Tests are required per EN 300 328 V2.1.1:

Table 1. Transmitter Test Suites and Overview of Results

Essential Radio Test suite	Applicable	Reference Clause in Standard	Compliance Results
RF Output Power	Yes	4.3.2.2	Compliant
Power Spectral Density	Yes	4.3.2.3	Compliant
Duty Cycle, TX-Sequence, TX-Gap	No	4.3.2.4	N/A
Accumulated Transmit Time, Frequency Occupation and Hopping Sequence	No	4.3.1.4	N/A
Hopping Frequency Separation	No	4.3.1.5	N/A
Medium Utilization	No	4.3.2.5	N/A
Occupied Channel Bandwidth	Yes	4.3.2.7	Compliant
Transmitter Unwanted Emissions in the OOB Domain	Yes	4.3.2.8	Compliant
Transmitter Unwanted Emissions in the Spurious Domain	Yes	4.3.2.9	Compliant

Table 2. Receiver Test Suites and Overview Results

Essential Radio Test suite	Applicable	Reference clause in this report	Compliance Results
Adaptivity	Yes	4.3.2.6	Compliant
Receiver Spurious Emissions	Yes	4.3.2.10	Compliant
Receiver Blocking	Yes	4.3.2.11	Compliant

5.2 General Comments

This section contains the test results and derived data. Details of the test methods used have been recorded and are kept on file by the laboratory. Wherever possible, the test methods described in ETSI document ETR 027 have been used.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

The testing preformed requires the uncertainty levels to be below the listed values in section 5.2 of ESTI 300 328 v2.1.1. The following table lists the limit of uncertainty per test and the current uncertainty of the testing done

Table 3. Measurement Uncertainty

Parameter	Uncertainty Requirement	Uncertainty of Testing
Occupied Channel Bandwidth	±5.0%	Less Than ±0.1dB
RF Output power, Conducted	±1.5dB	±0.47dB
Power Spectral Density, Conducted	±3.0dB	±0.47dB
Unwanted Emissions, Conducted	±3.0dB	±2.80dB
All Emissions, Radiated	±6.0dB	30MHz - 200MHz, ±5.39dB 200MHz - 1GHz, ±5.18dB 1GHz -18GHz, ±5.21dB
Temperature	±1.0^{o}C	±0.55^{o}C
Humidity	±5.0%	±5.00%
DC and Low Frequency Voltages	±3.0%	±0.05%
Time	±5.0%	±1.00%
Duty Cycle	±5.0%	±1.00%

The purpose of testing was to demonstrate compliance with the latest version of the test specification.

Date of receipt of test sample(s): September 15, 2018

Measurements were performed between the following dates(s):

Start Date: September 25, 2018

Completion Date: December 19, 2018

All of the measurements described in this report were performed at the premises of US Tech, 3505 Francis Circle, Alpharetta, GA 30004 USA.

5.3 Test Results

5.3.1 RF Output Power (Clause 4.3.2.2)

The RF Output Power was measured at the lowest, the middle, and the highest channel and at normal and extreme operating temperatures. The measurements were performed per the procedures of ETSI EN 300 328 section 5.4.2. The test equipment was set to a center frequency at which the EUT will transmit. The span was set to 10 MHz and the RBW and VBW were set to 1 MHz and 3 MHz, respectively.

In accordance with ETSI EN 300 328 section 4.3.2.2, for adaptive equipment using wide band modulations other than FHSS, the maximum RF output power shall be 20 dBm. This limit shall apply for any combination of power level and intended antenna assembly.

Maximum Antenna Assembly Gain: +3.2 dBi

Beam-forming Gain: 0 dBi

Test Date: September 27, 2018

Signature: Afzal Fazal Tested By: Afzal Fazal

Table 4. RF Output Power Measurement

Frequency (MHz)	Mode	Measured Result (dBm) A	Combination of Power Level and Antenna Gain (dBm) A+G+Y	Limit (dBm)	Margin (dB)
Measured at -40˚C					
2412.00	b	12.72	15.92	20	4.08
2437.00	b	13.65	16.85	20	3.15
2462.00	b	13.90	17.10	20	2.90
2472.00	b	14.09	17.29	20	2.71
2412.00	g	11.74	14.94	20	5.06
2437.00	g	13.74	16.94	20	3.06
2462.00	g	12.85	16.05	20	3.95
2472.00	g	14.67	17.87	20	2.13
2412.00	n	11.12	14.32	20	5.68
2437.00	n	12.19	15.39	20	4.61
2462.00	n	11.83	15.03	20	4.97
2472.00	n	12.37	15.57	20	4.43
Measured at 25˚C					
2412.00	b	13.68	16.88	20	3.12
2437.00	b	14.18	17.38	20	2.62
2462.00	b	14.56	17.76	20	2.24
2472.00	b	14.84	18.04	20	1.96
2412.00	g	13.50	16.70	20	3.30
2437.00	g	14.00	17.20	20	2.80
2462.00	g	14.36	17.56	20	2.44
2472.00	g	15.40	18.60	20	1.40
2412.00	n	11.41	14.61	20	5.39
2437.00	n	12.27	15.47	20	4.53
2462.00	n	12.38	15.58	20	4.42
2472.00	n	12.91	16.11	20	3.89
Measured at 85˚C					
2412.00	b	14.36	17.56	20	2.44
2437.00	b	15.20	18.40	20	1.60
2462.00	b	15.26	18.46	20	1.54
2472.00	b	15.99	19.19	20	0.81
2412.00	g	14.18	17.38	20	2.62
2437.00	g	13.93	17.13	20	2.87
2462.00	g	14.37	17.57	20	2.43
2472.00	g	15.20	18.40	20	1.60
2412.00	n	12.08	15.28	20	4.72
2437.00	n	12.76	15.96	20	4.04
2462.00	n	12.87	16.07	20	3.93
2472.00	n	13.46	16.66	20	3.34

Note 1**:** All modes tested at output power set to a value of “20”.

5.3.2 Duty Cycle, TX-Sequence, TX-Gap (Clause 4.3.2.4)

The EUT is considered to be Adaptive equipment and this clause is only applicable for Non-Adaptive Equipment; therefore the Duty Cycle, TX-Sequence, and TX-Gap measurements are not applicable.

5.3.3 Power Spectral Density (Clause 4.3.2.3)

The EUT employs wide band modulation other than frequency hopping spread spectrum (FHSS) modulation; therefore the power spectral density was measured per the procedures of ETSI EN 300 328 section 5.4.3 Option 2. The RBW was set to 1 MHz and the Video Bandwidth was set to 3X RBW. The span was set to 3 MHz the RMS detector was used and the sweep time was set to 60s and the trace was set to Max Hold.

The Power Spectral Density is the mean e.i.r.p spectral density during transmissions burst. In accordance with ETSI EN 300 328 section 4.3.2.3, the power density shall be no greater than 10 dBm per MHz band.

Environmental Conditions:
Ambient Temperature: 20 ˚C
Relative Humidity: 55%

The maximum Power Spectral Density (PSD) e.i.r.p is calculated with the following formula below.

PSD = D+G+Y+10Log (1/DC) (dBm/MHz)

Where:

D is the measured PSD value observed.
DC is the observed Duty Cycle (in this case DC = 1 during testing since the EUT is programmed for >98% duty cycle for testing purpose.)
G is the applicable antenna assembly gain in dBi
Y is the beam-forming gain in dB *if applicable.

Table 5. Power Spectral Density Measurements

Transmitter Frequency (MHz)	Measured PSD (dBm/MHz)	PSD (dBm/MHz) = D + G + Y +10log(1/DC)	Limit (dBm/MHz)	Margin (dB)	Detector
802.11b mode					
2412.55	4.962	8.162	10	1.8	RMS
2436.67	6.163	9.363	10	0.6	RMS
2472.49	6.609	9.809	10	0.2	RMS
802.11g mode					
2413.33	2.724	5.924	10	4.1	RMS
2435.55	3.862	7.062	10	2.9	RMS
2473.27	4.423	7.623	10	2.4	RMS
802.11n mode					
2410.82	2.258	5.458	10	4.5	RMS
2435.69	3.740	6.940	10	3.1	RMS
2470.70	4.201	7.401	10	2.6	RMS

Note 1: 802.11 B mode tested at output power set to “19”
Note 2: All other modes tested at output power set to a value of “20”
Note 2: Antenna gain applied = 3.2 dBm

Test Date: October 3, 2018

Signature: Afzal Fazal Tested By: Afzal Fazal

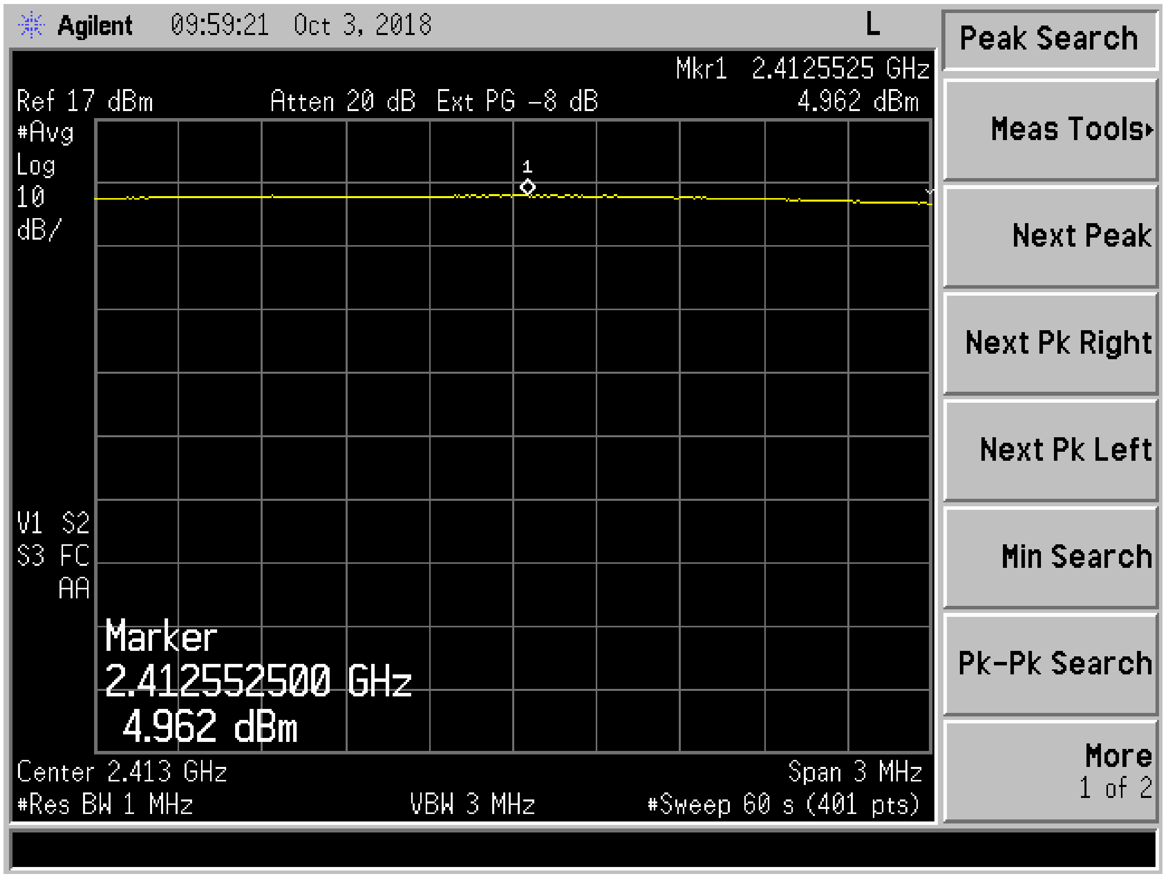


Figure 1. 2412 MHz, b mode Low Channel PSD Plot

Note: Span reduced for AVG detection mode test.

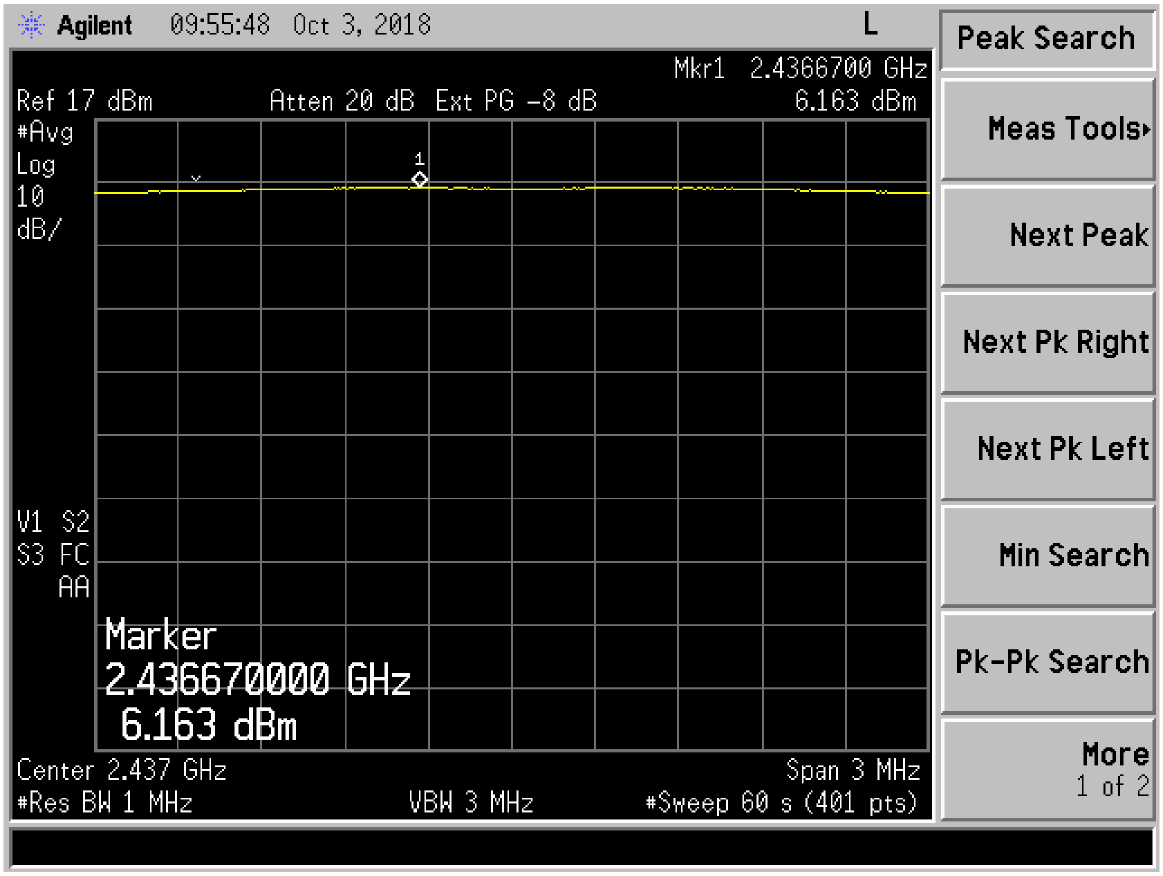


Figure 2. 2437 MHz, b mode Mid Channel PSD Plot

Note: Span reduced for AVG detection mode test.

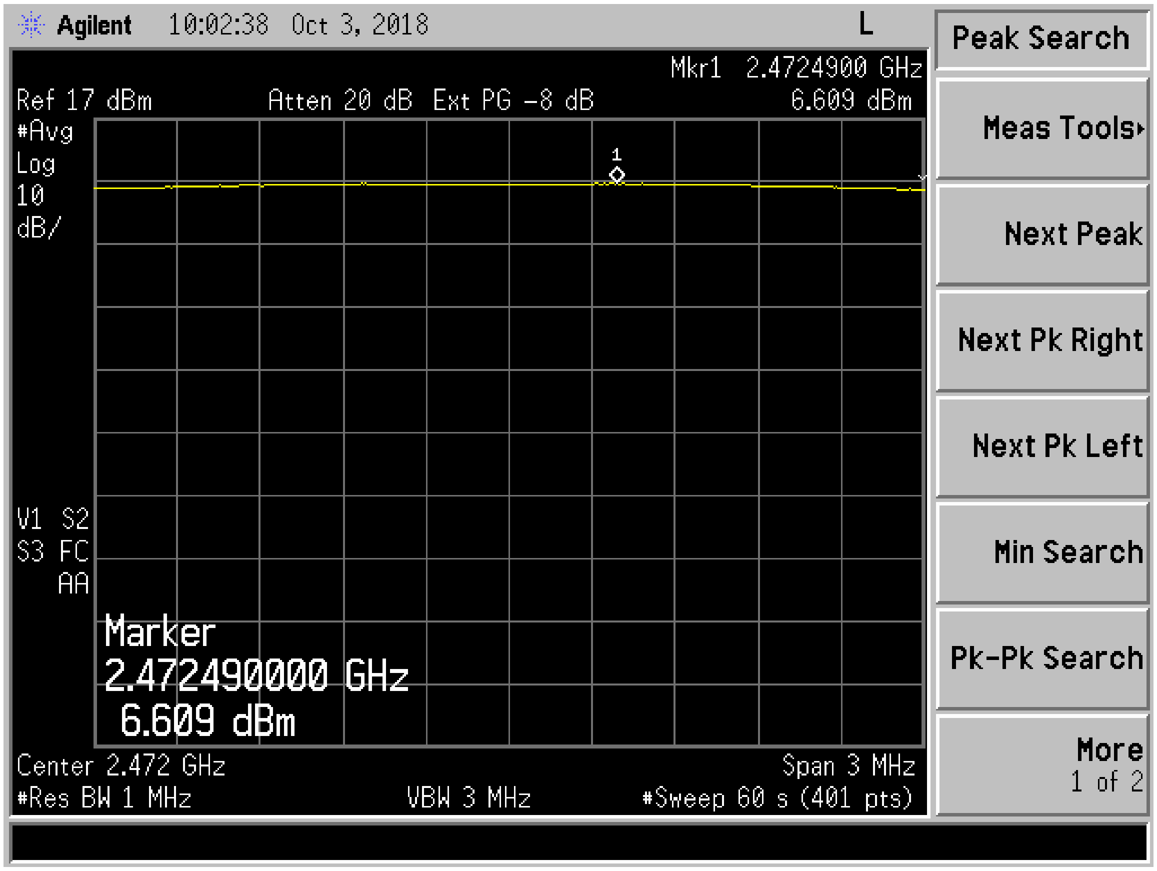


Figure 3. 2472 MHz, b mode High Channel PSD Plot

Note: Span reduced for AVG detection mode test.

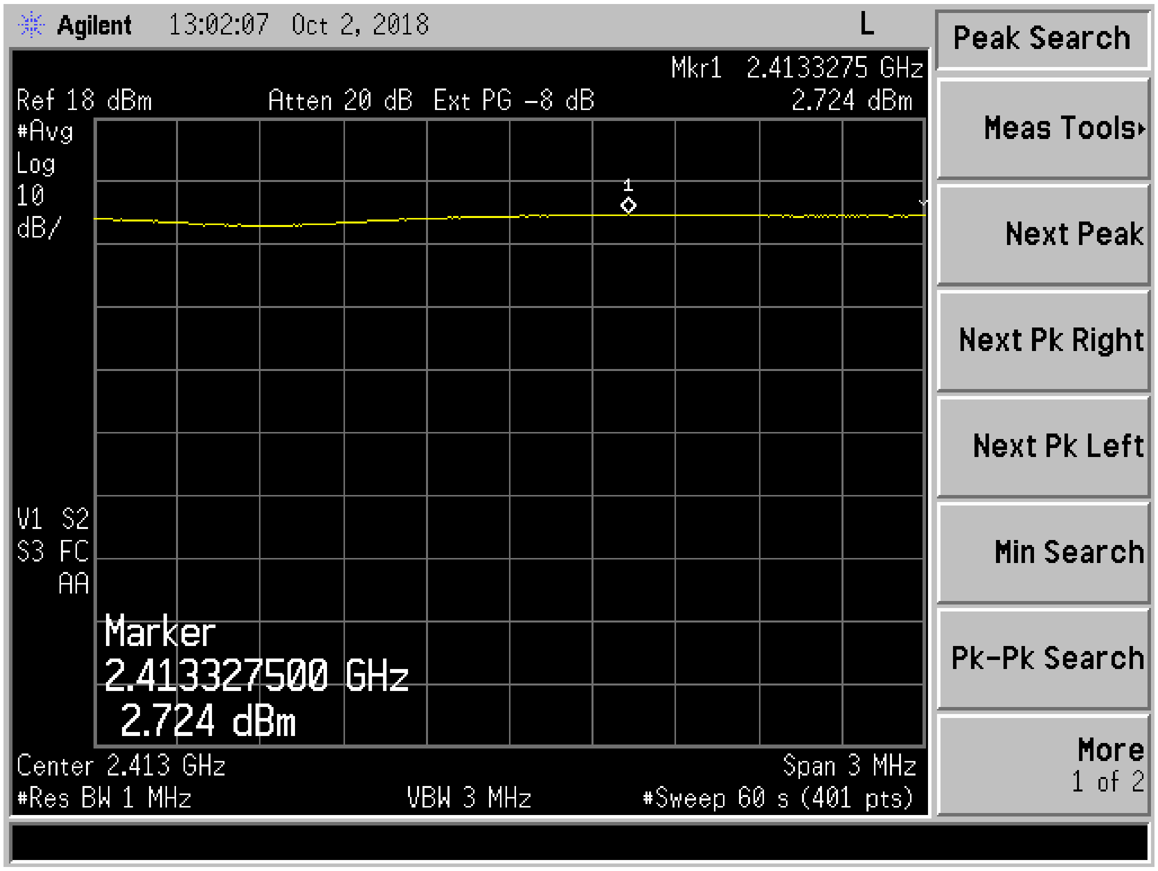


Figure 4. 2412 MHz, g mode Low Channel PSD Plot

Note: Span reduced for AVG detection mode test.

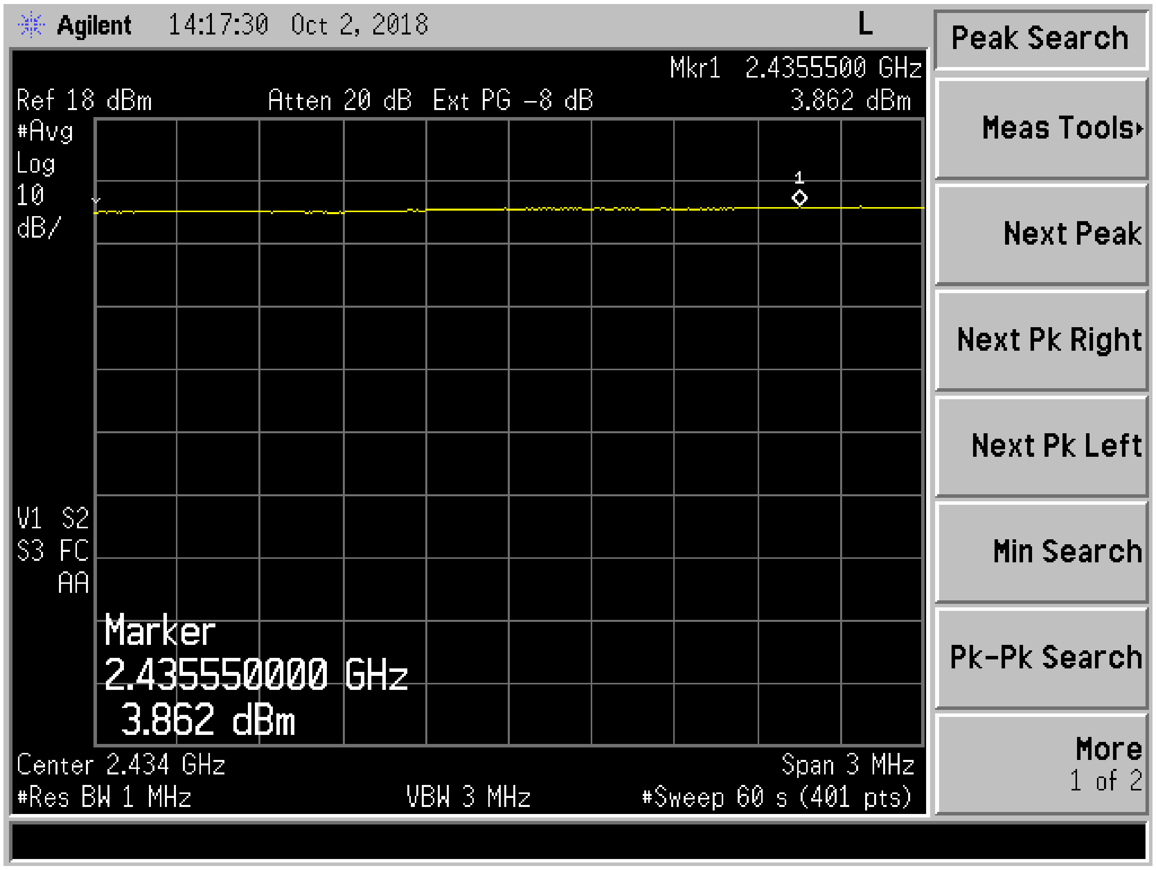


Figure 5. 2437 MHz, g mode Mid Channel PSD Plot

Note: Span reduced for AVG detection mode test.

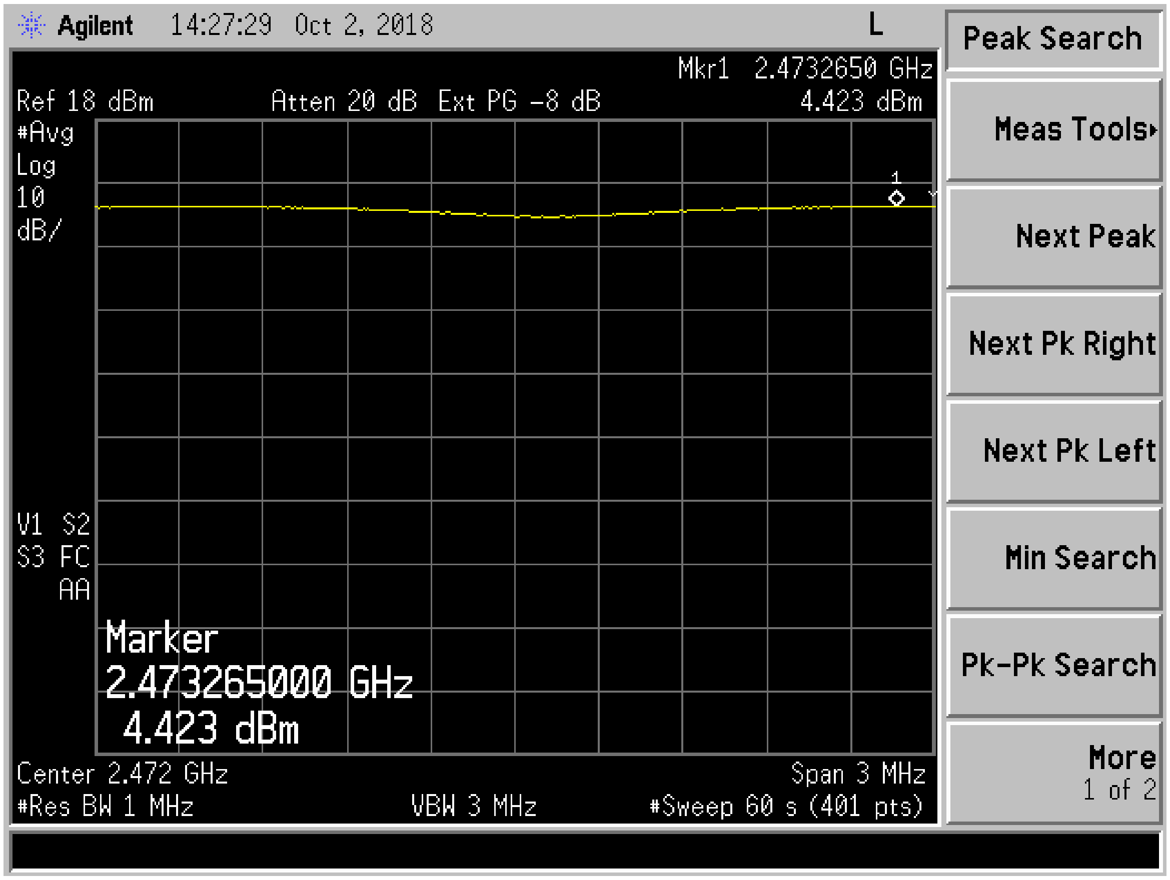


Figure 6. 2472 MHz, g mode High Channel PSD Plot

Note: Span reduced for AVG detection mode test.

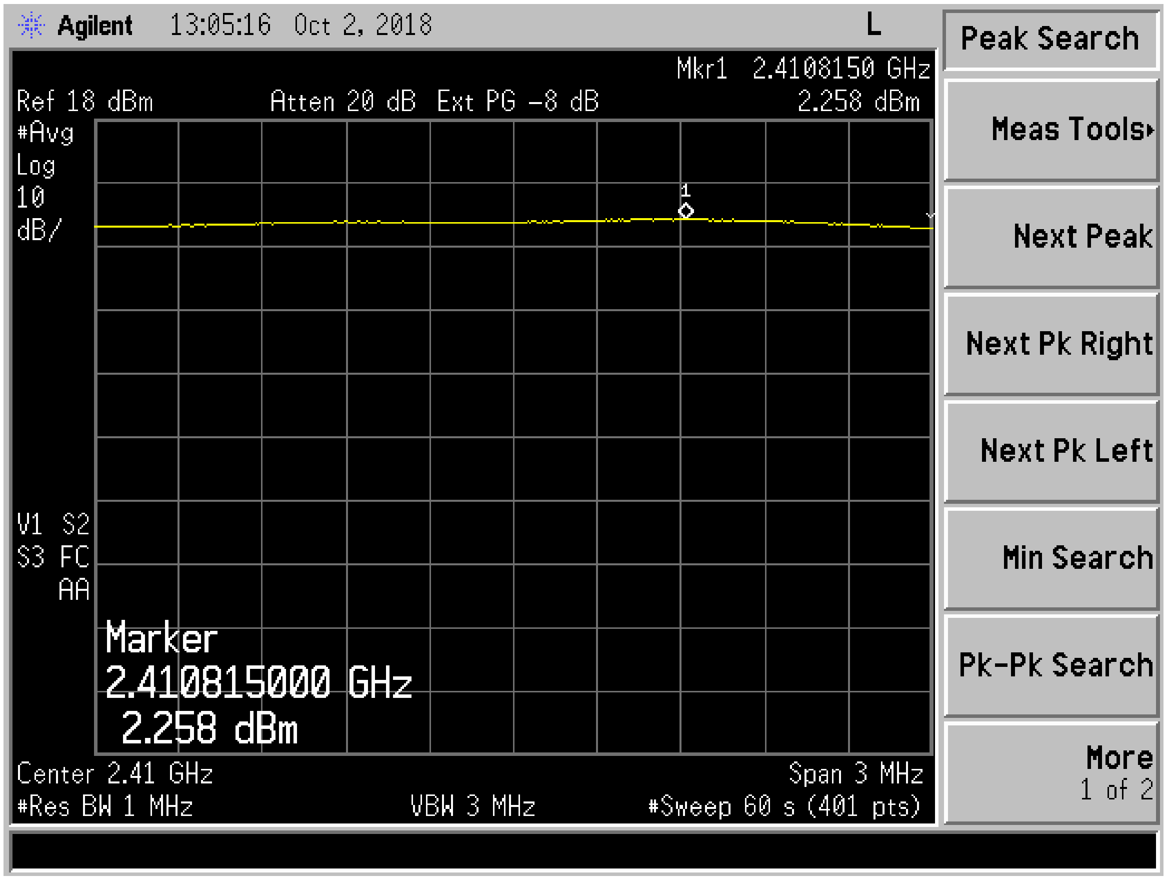


Figure 7. 2412 MHz, n mode Low Channel PSD Plot

Note: Span reduced for AVG detection mode test.

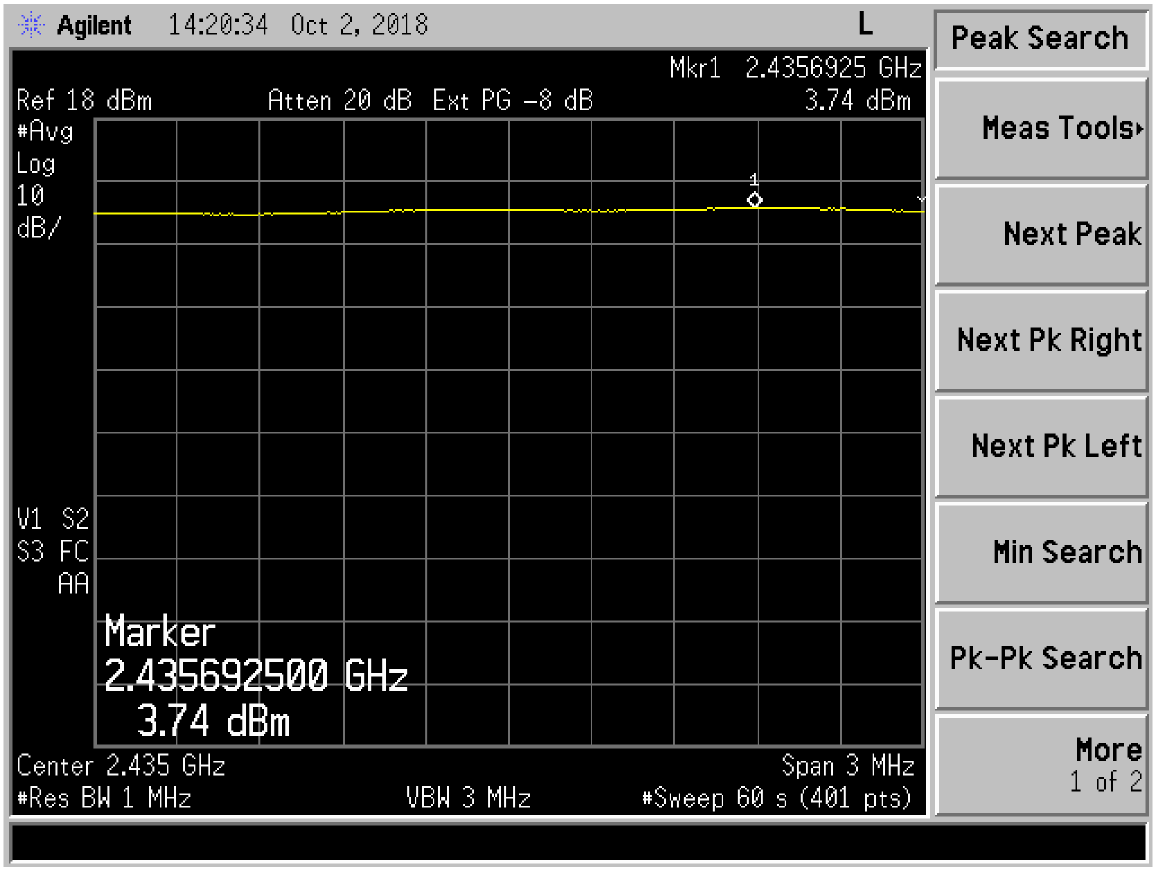


Figure 8. 2437 MHz, n mode Mid Channel PSD Plot

Note: Span reduced for AVG detection mode test.

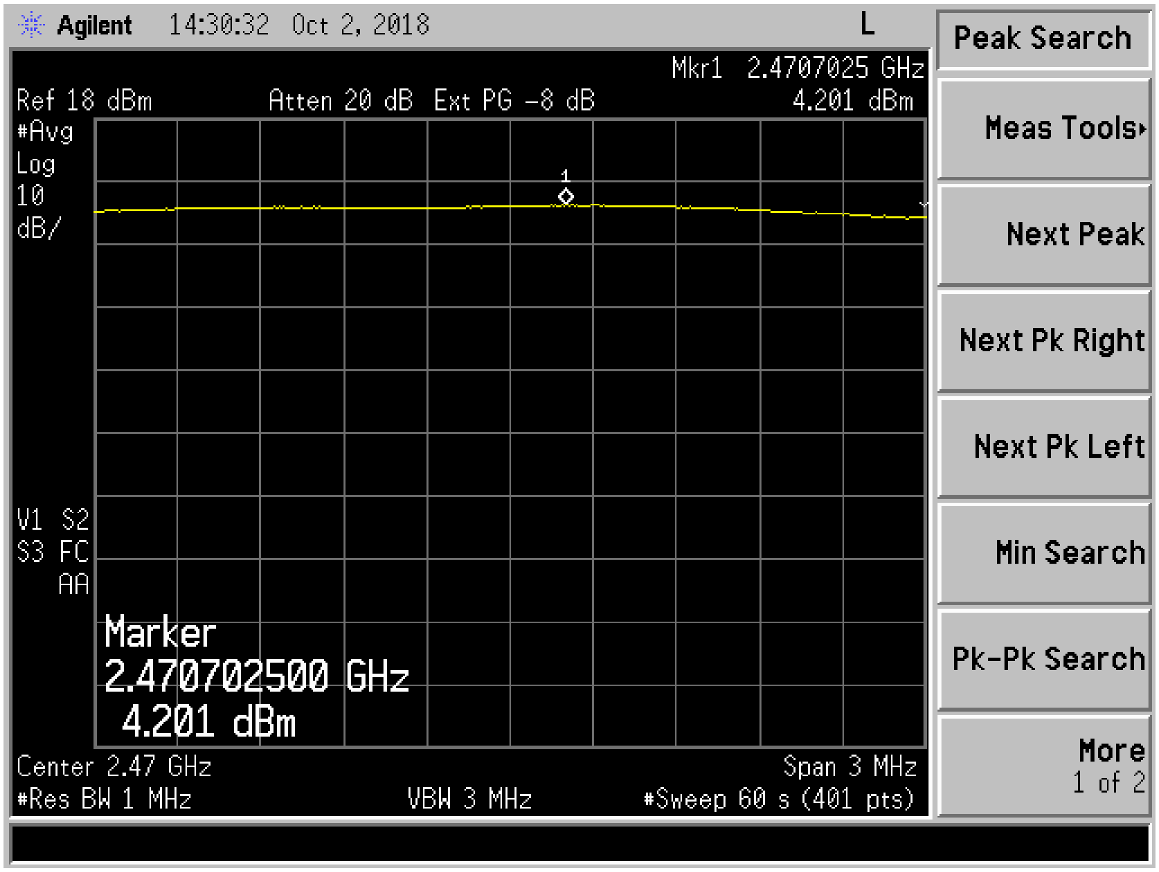


Figure 9. 2472 MHz, n mode High Channel PSD Plot

Note: Span reduced for AVG detection mode test.

5.3.4 Accumulated Transmit Time, Minimum Frequency Occupation and Hopping Sequence (Clause 4.3.1.4)

The EUT uses wide band modulation other than frequency hopping Spread Spectrum (FHSS) modulation and this clause is only applicable for FHSS equipment; therefore the dwell time, minimum frequency occupation and hopping sequence measurements are not applicable.

5.3.5 Hopping Frequency Separation (Clause 4.3.1.5)

The EUT uses wide band modulation other than frequency hopping Spread Spectrum (FHSS) modulation and this clause is only applicable for FHSS Equipment; therefore the Hopping Frequency Separation measurement is not applicable.

5.3.6 Adaptivity (Clause 4.3.2.6)

Adaptive equipment using modulations other than FHSS is equipment that uses a mechanism by which it can adapt to its radio environment by identifying other transmissions present within its Occupied Channel Bandwidth. This equipment shall use a Detect and Avoid mechanism to perform this task.

The EUT was tested and does have a Detect and Avoid feature that meets the requirements of the test standard. A plot of the evaluation is presented below. In this case the EUT uses Non-LBT based Detect and Avoid.

Test Date: December 12, 2018

Signature: ____________ Tested By: George Yang

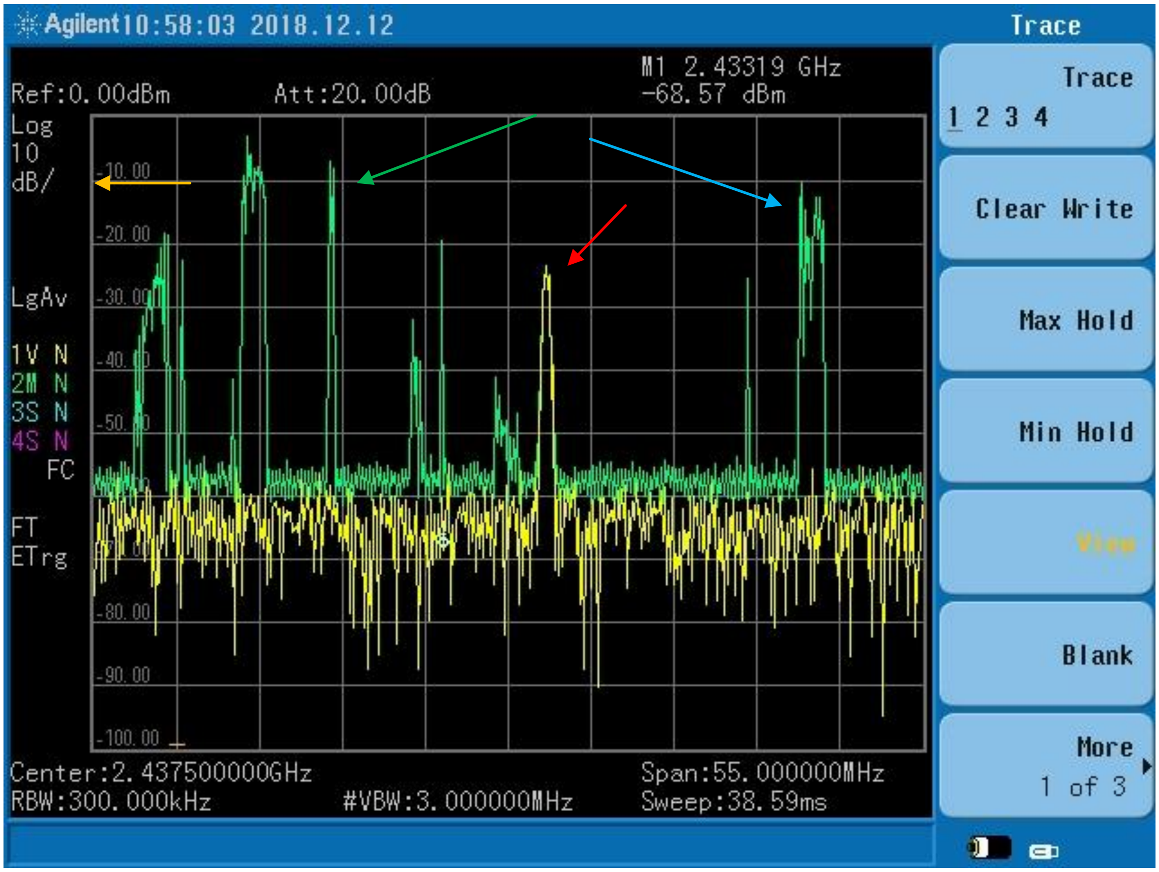


Figure 10. Adaptivity Worst Case

The Orange arrow = 2395 or 2488 MHz Unwanted signal (out of screen).
The Red arrow = 2442 MHz Interference signal.
The Green arrow = Companion device signals.
The Blue arrow = EUT's transmission signal.*

Wanted signal mean power from companion device (dBm)	Unwanted signal frequency (MHz)	Unwanted CW signal power (dBm)
-30	2 395 or 2 488,5 (see note 1)	-35 (see note 2)
NOTE 1: The highest frequency shall be used for testing operating channels within the range 2 400 MHz to 2 442 MHz, while the lowest frequency shall be used for testing operating channels within the range 2 442 MHz to 2 483,5 MHz. See clause 5.4.6.1. NOTE 2: The level specified is the level in front of the UUT antenna. In case of conducted measurements, this level has to be corrected by the actual antenna assembly gain.		

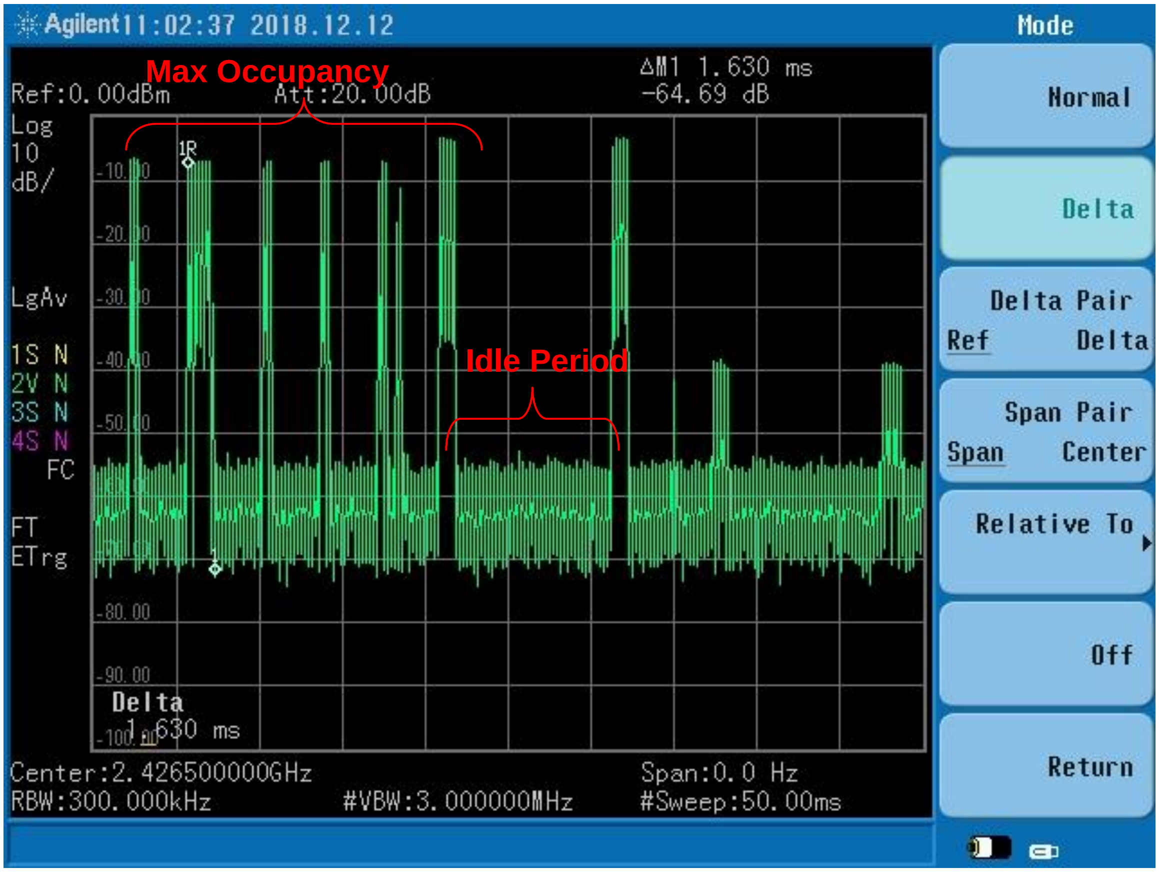


Figure 11. Dwell Time

Max time pulse = 1.630 mSec
Total Dwell time = 9.78 mSec (worst case) << 40 mSec
Idle Period = > 5% or 0.489 mSec

5.3.7 Occupied Channel Bandwidth (Clause 4.3.2.7)

The Occupied Channel Bandwidth is the bandwidth that contains 99% of the signal. In accordance with ETSI EN 300 328 section 4.3.2.7, the Occupied Bandwidth for each hopping frequency shall fall completely within the given frequency band.

The Occupied Channel Bandwidth was measured per the procedures of ETSI EN 300 328 section 5.3.8. The center frequency was set to either the highest or lowest frequency within the allowed frequency band under test and the span was 2x the Occupied Channel bandwidth. The RBW was ~ 1 % of the span and VBW was 3x VBW. The RMS detector mode was used and the trace was set to Max Hold to allow the trace to complete. The 99 % bandwidth function of the spectrum analyser was used to measure the occupied bandwidth.

Environmental Conditions:
Ambient Temperature: 25 ˚C
Relative Humidity: 55 %

Test Date: September 28, 2018

Signature: Afzal Fazal Tested By: Afzal Fazal

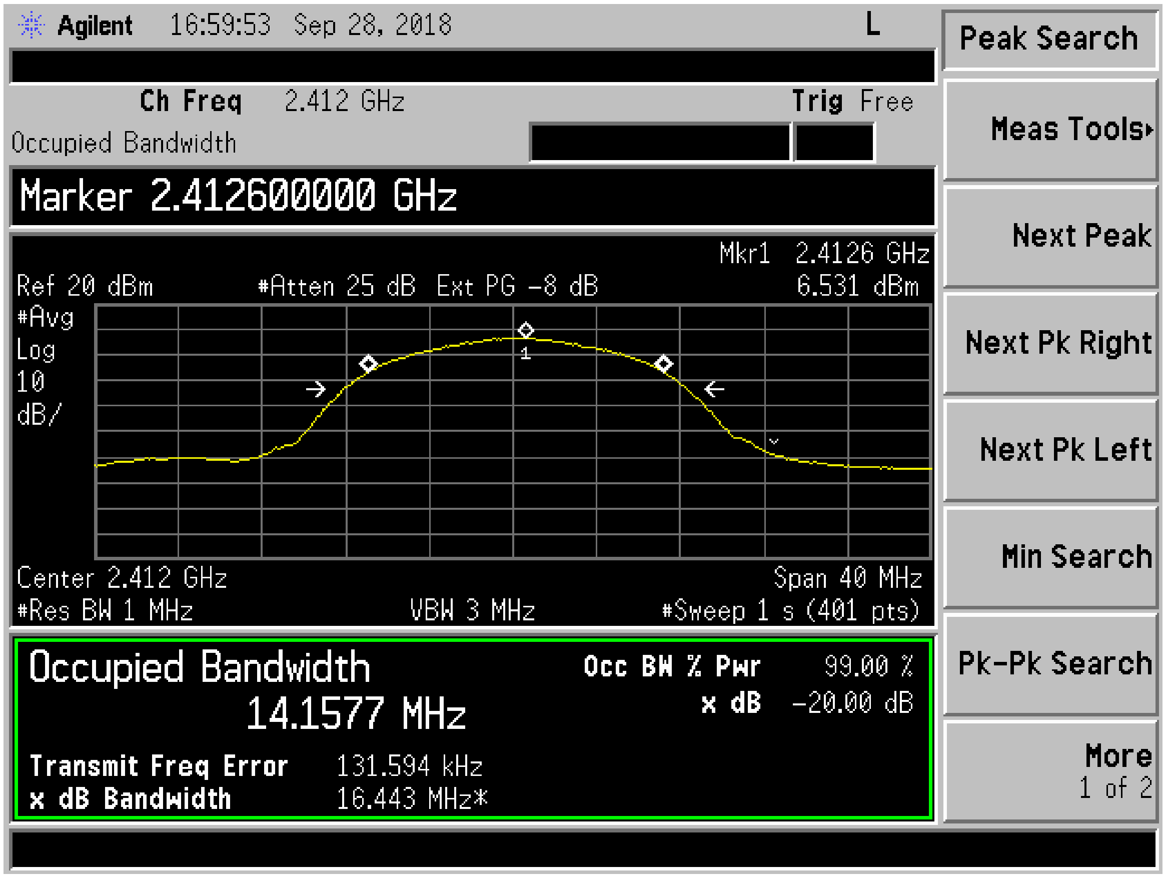


Figure 12. 2412 MHz b mode Channel 1 Occupied Bandwidth

Occupied BW=	14.1577	MHz
Center frequency	2412	MHz
Low Band-edge	2404.921	MHz

Low band-edge contained within 2400 MHz.

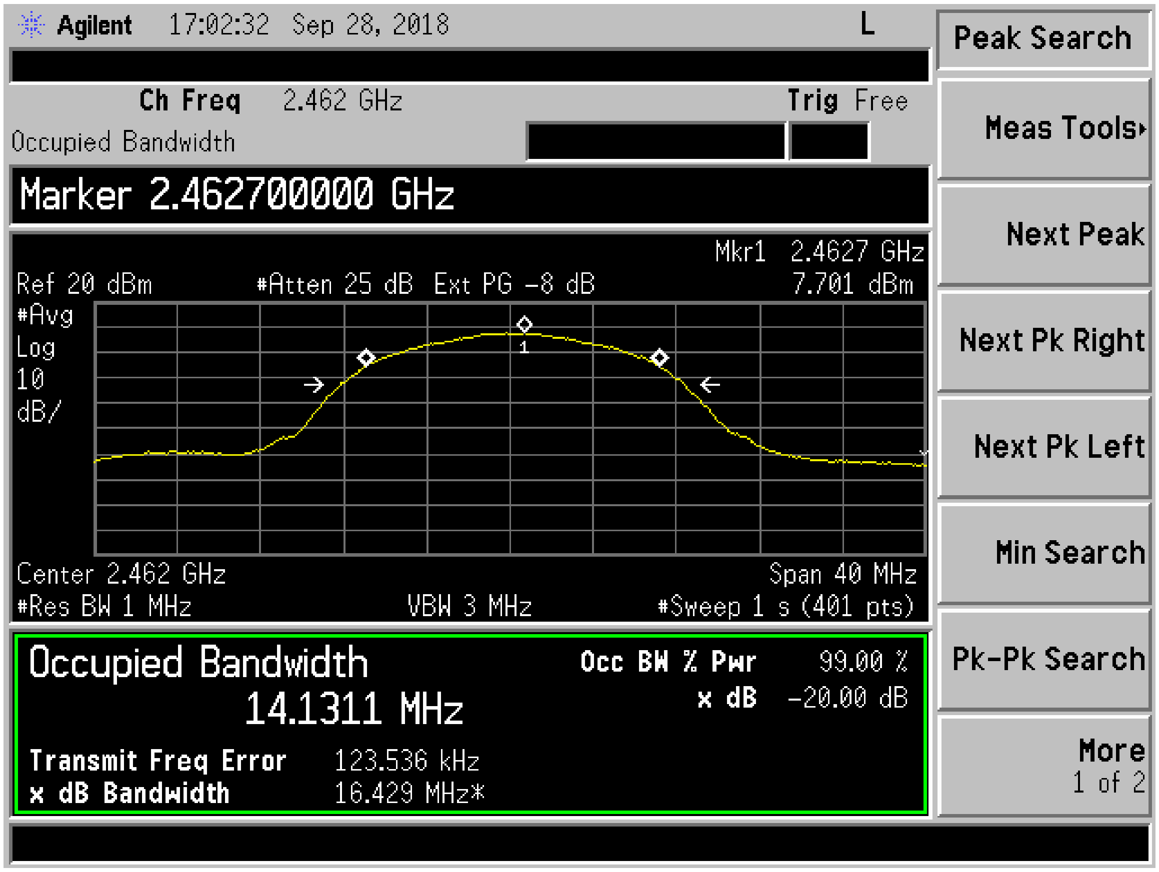


Figure 13. 2462 MHz b mode Channel 11 Occupied Bandwidth

Occupied BW=	14.1311	MHz
Center Frequency	2462	MHz
High Band-edge	2469.066	MHz

High band-edge contained within 2483.5 MHz.

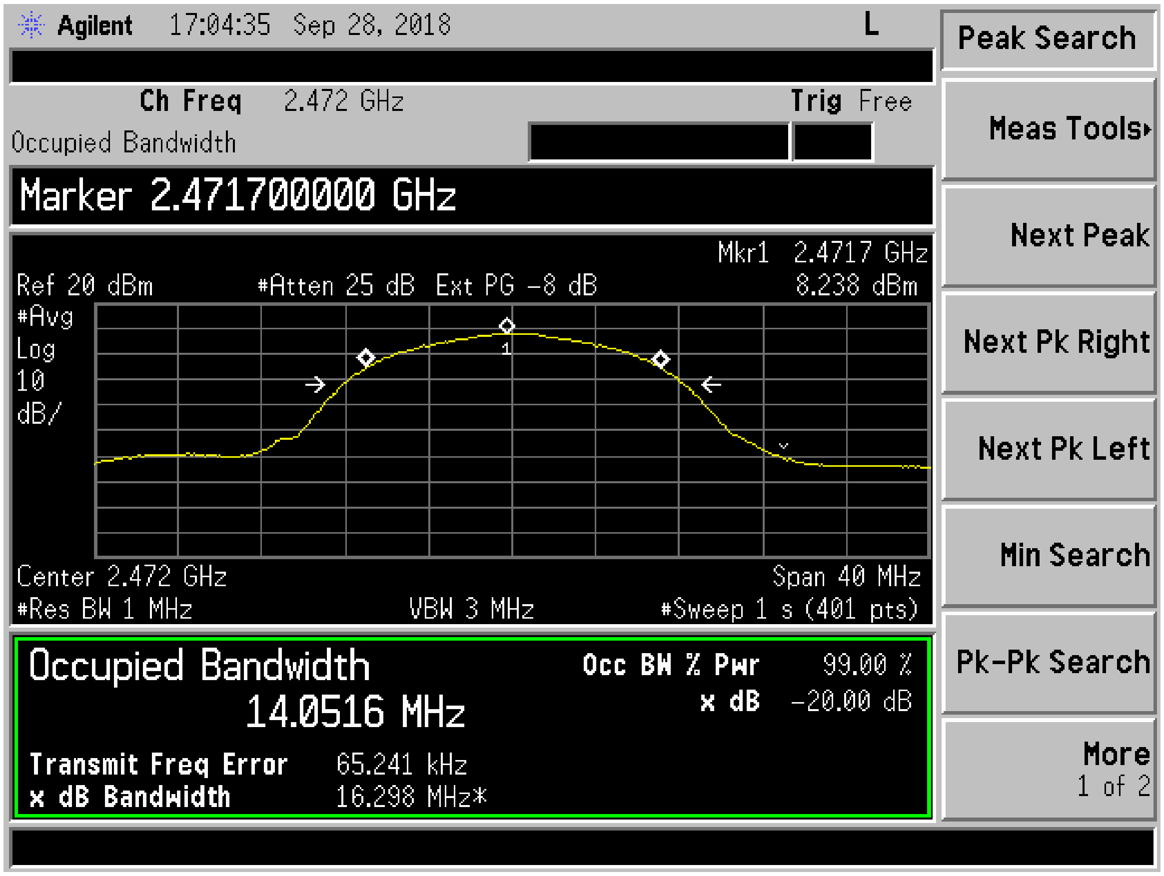


Figure 14. 2472 MHz b mode High Channel 13 Occupied

Occupied BW=	14.0516	MHz
Center frequency	2472	MHz
High Band-edge	2478.646	MHz

High band-edge contained within 2483.5 MHz.

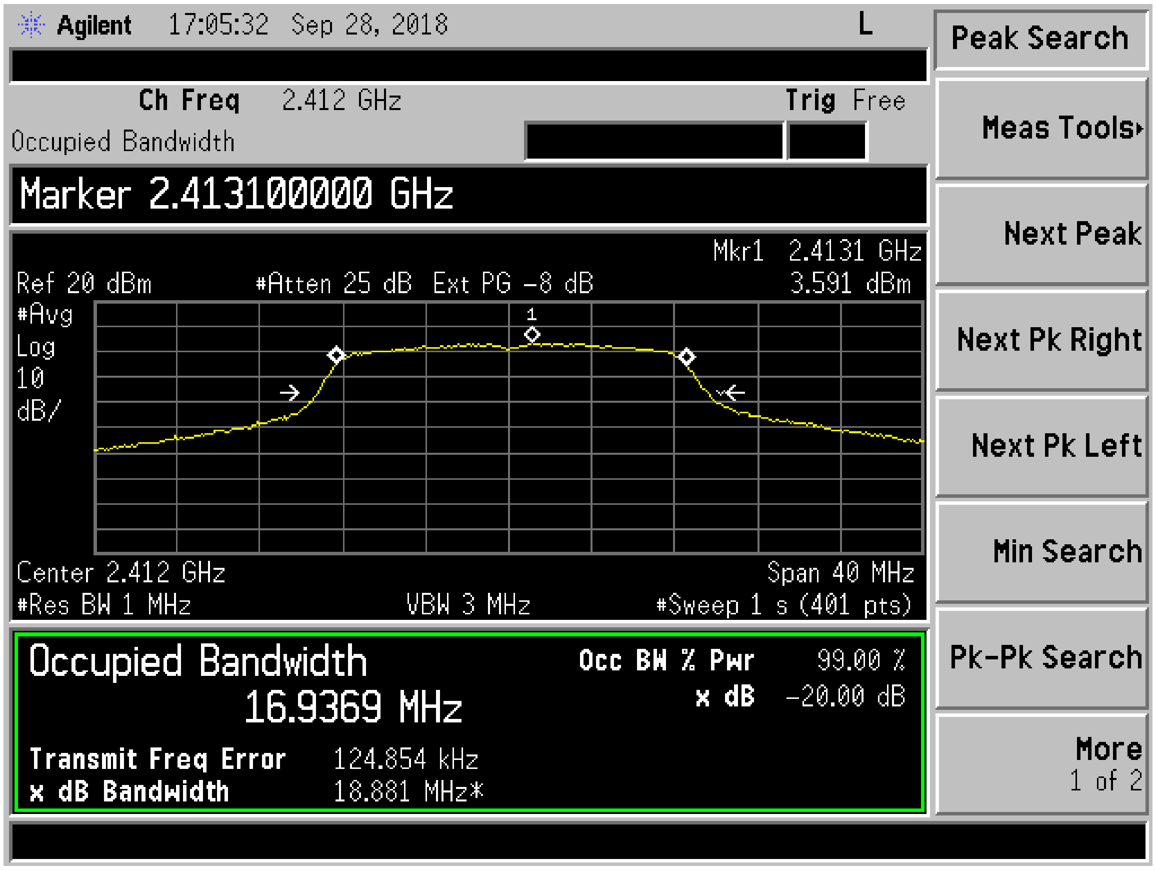


Figure 15. 2412 MHz g mode Channel 1 Occupied Bandwidth

Occupied BW=	16.9369	MHz
Center frequency	2412	MHz
Low Band-edge	2403.532	MHz

Low band-edge contained within 2400 MHz

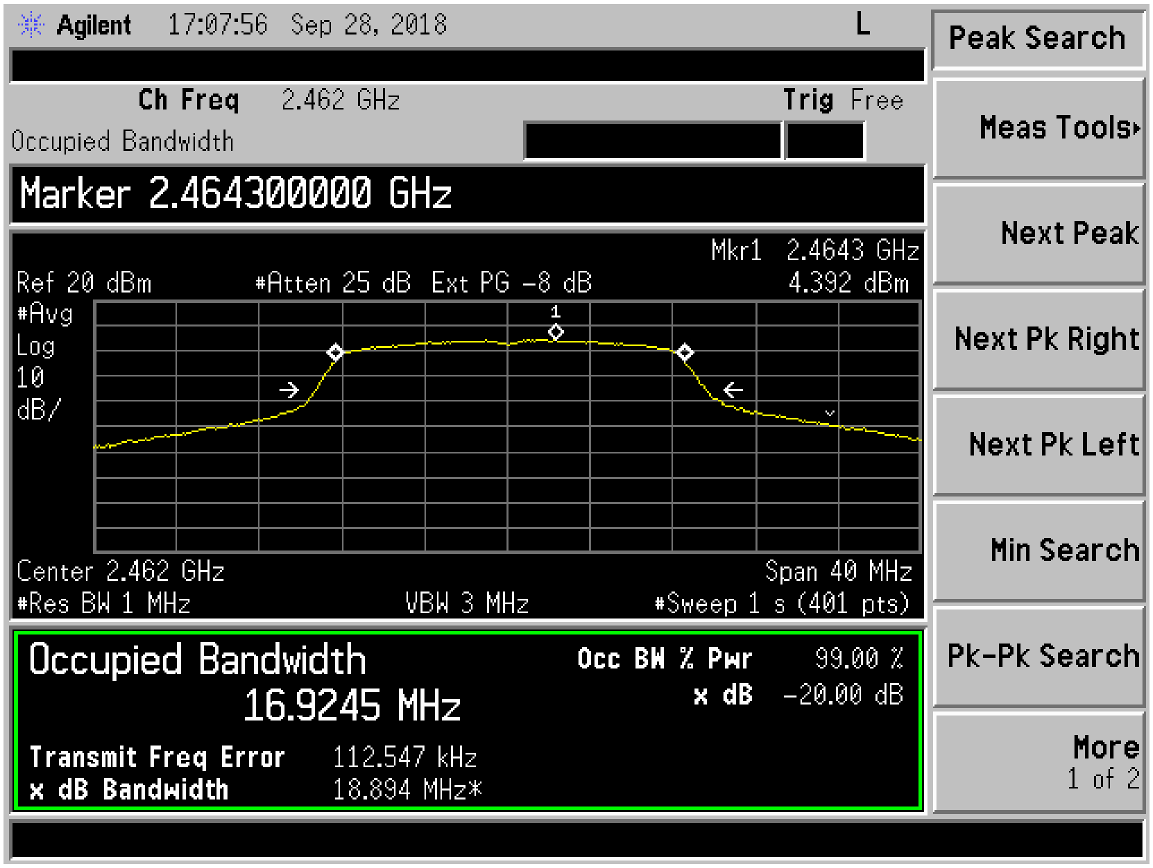


Figure 16. 2462 MHz g mode Channel 11 Occupied Bandwidth

Occupied BW=	16.9245	MHz
Center frequency	2462	MHz
High Band-edge	2470.462	MHz

High band-edge contained within 2483.5 MHz

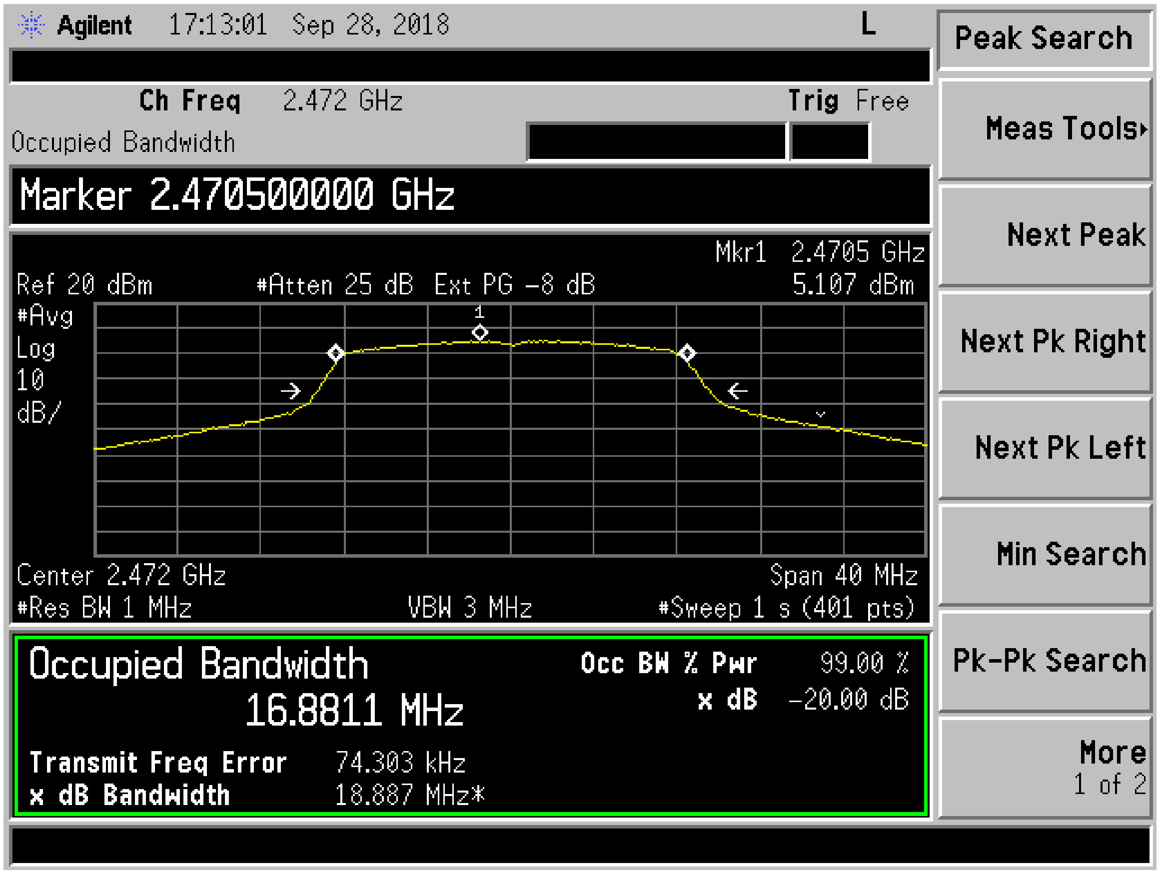


Figure 17. 2472 MHz g mode Channel 13 Occupied Bandwidth

Occupied BW=	16.8811	MHz
Center frequency	2472	MHz
High Band-edge	2480.441	MHz

High band-edge contained within 2483.5 MHz

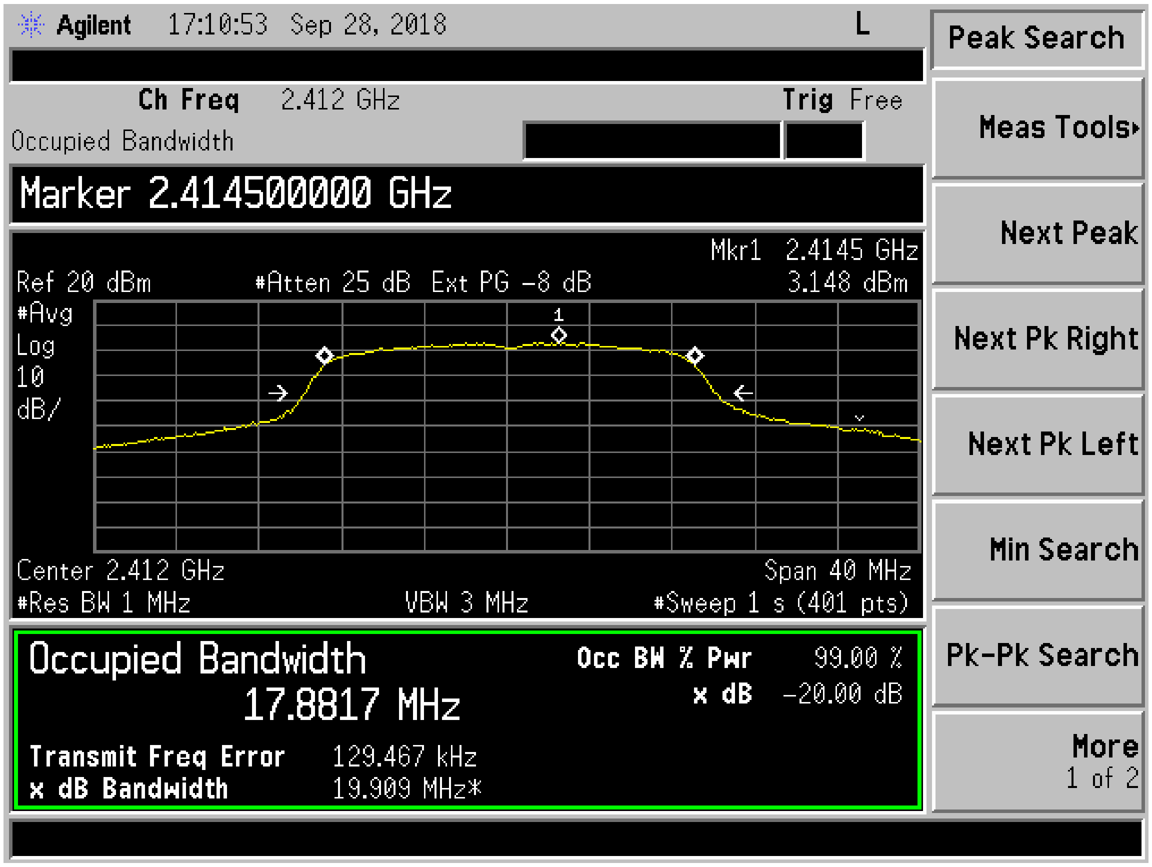


Figure 18. 2412 MHz n mode Channel 1 Occupied Bandwidth

Occupied BW=	17.8817	MHz
Center frequency	2412	MHz
Low Band-edge	2403.059	MHz

Low band-edge contained within 2400 MHz

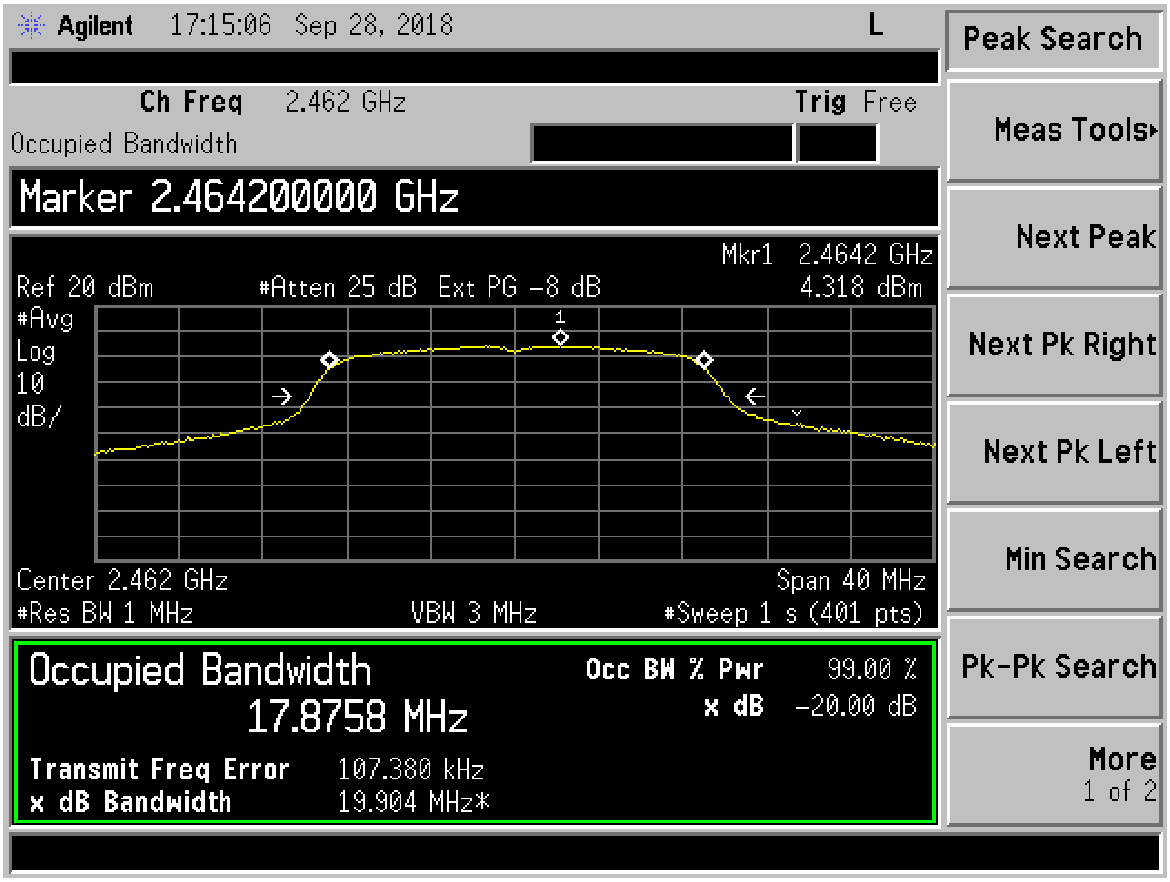


Figure 19. 2462 MHz n mode Channel 11 Occupied Bandwidth

Occupied BW=	17.8758	MHz
Center frequency	2462	MHz
High Band-edge	2470.938	MHz

High band-edge contained within 2483.5 MHz

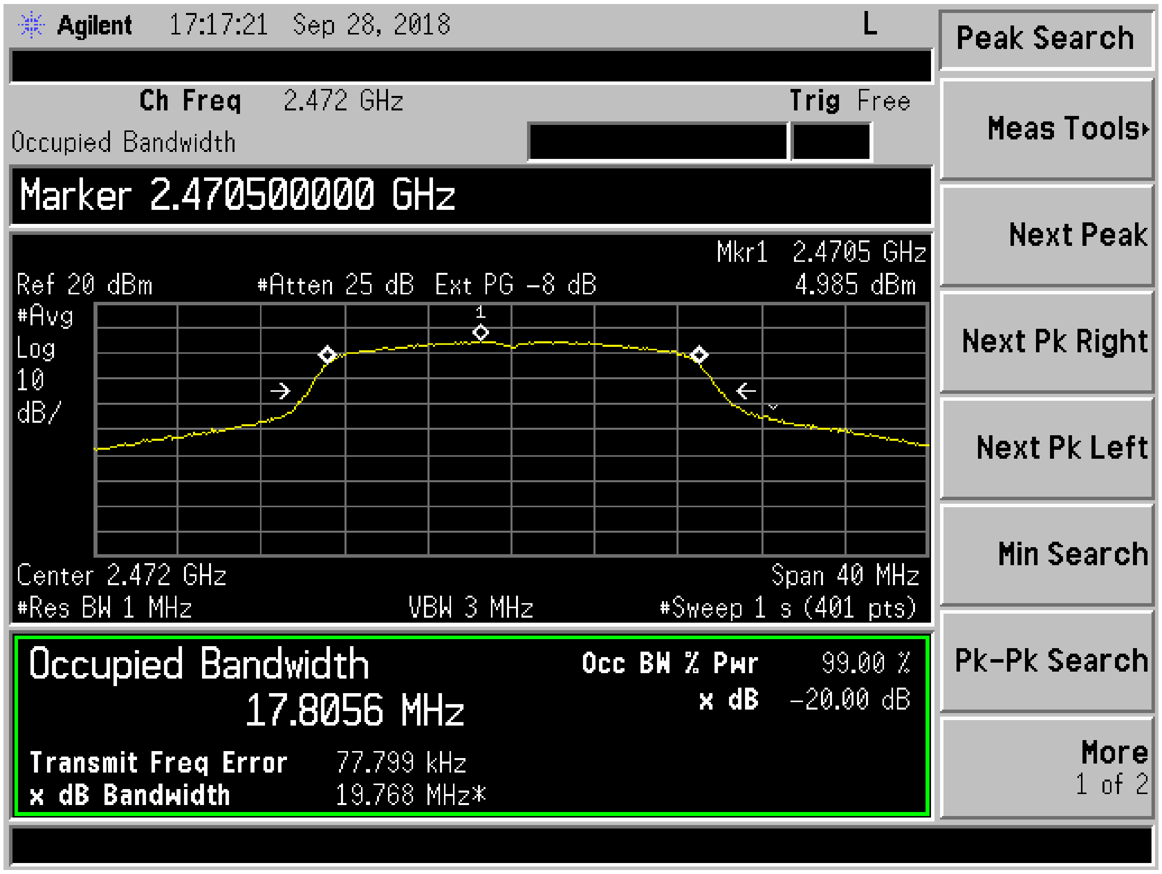


Figure 20. 2472 MHz n mode Channel 13 Occupied Bandwidth

Occupied BW=	17.8056	MHz
Center frequency	2472	MHz
High Band-edge	2480.903	MHz

High band-edge contained within 2483.5 MHz

5.3.8 Transmitter Unwanted Emissions in the Out-Of-Band Domain (Clause 4.3.2.8)

The transmitter unwanted emissions in the out-of-band domain are emissions when the equipment is in Transmit mode, on frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions. In accordance with ETSI EN 300 328 section 4.3.2.8.3, the transmitter unwanted emissions in the out-of-band domain but outside the allocated band, shall not exceed the values provided by the mask in the figure below. Within the band specified, the Out-of-band emissions are fulfilled by compliance with the Occupied Channel Bandwidth requirement in clause 4.3.2.7.

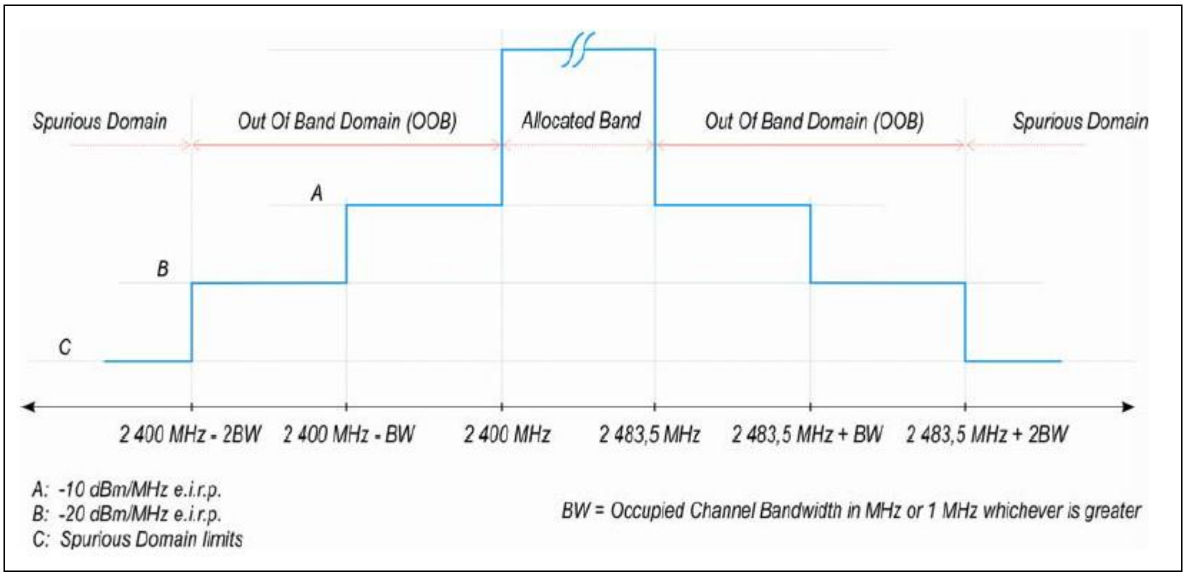


Figure 21. Transmitter Unwanted Emissions in the Out-of-Band Domain Limits

The EUT was tested at normal and extreme temperatures. Only the lowest and highest channels were evaluated for each operational mode. The Occupied Bandwidth used was 20 MHz since this is the maximum allowed bandwidth for this type of transmitter. The RF port of the EUT was directly connected to the Spectrum Analyzer. The resolution bandwidth used was 1 MHz with a video bandwidth of 3 MHz. The Peak detector was used and only the worst case emission was recorded below.

2364.40 MHz to 2382.20 MHz limit = -20 dBm/MHz
2382.20 MHz to 2400 MHz limit = -10 dBm/MHz
2483.5 MHz to 2501.39 MHz limit = -10 dBm/MHz
2501.39 MHz to 2519.28 MHz limit = -20 dBm/MHz

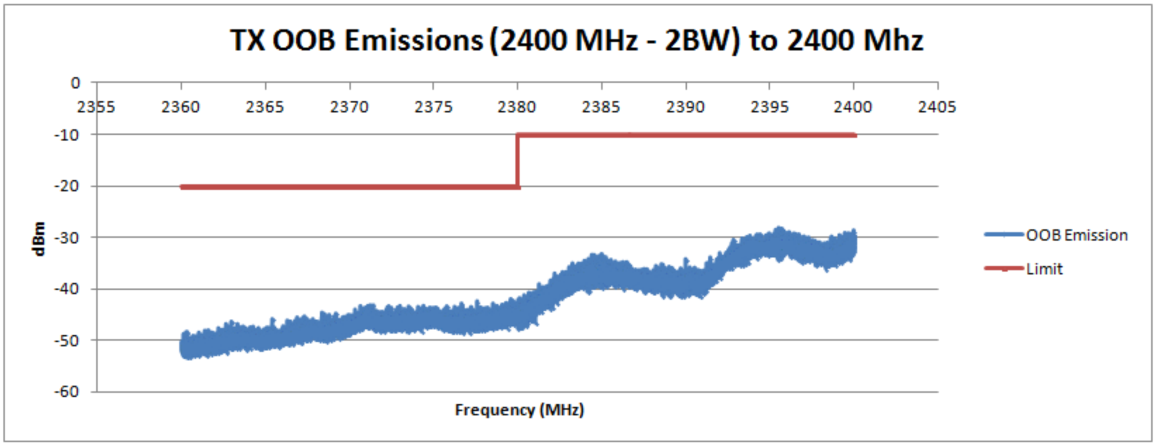


Figure 22. b mode, Low Channel TX OOB Plot 1

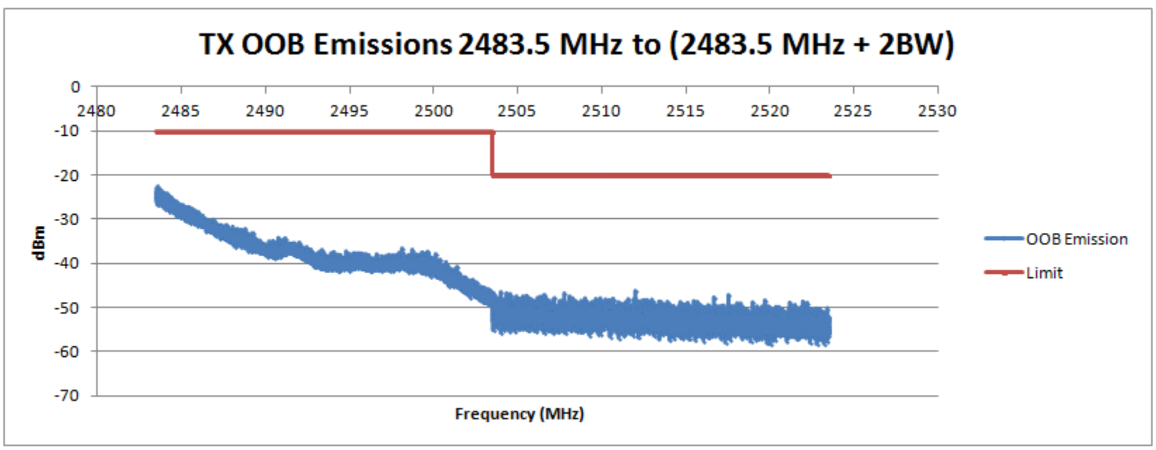


Figure 23. b mode, Low Channel TX OOB Plot 2

Test Date: September 26, 2018

Signature:________________ Tested By: Afzal Fazal

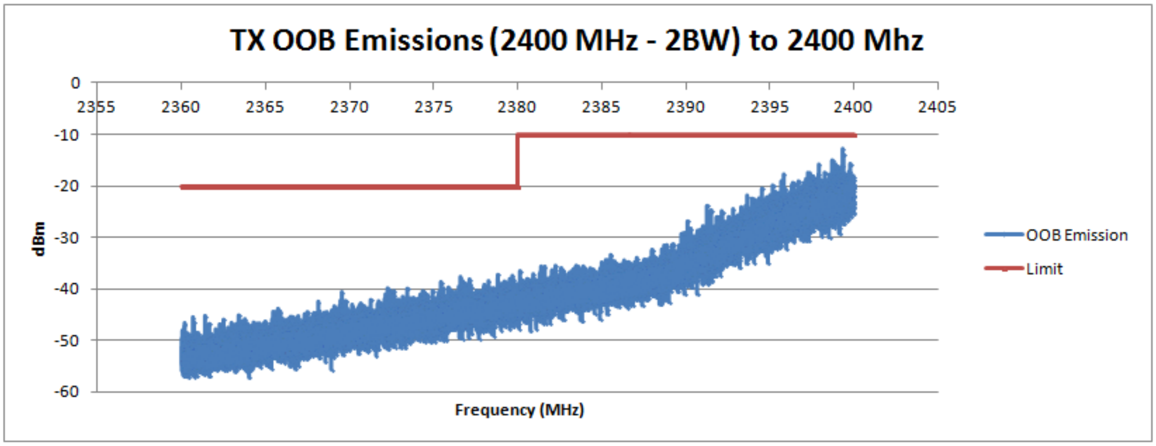


Figure 24. g mode, Low Channel TX OOB Plot 1

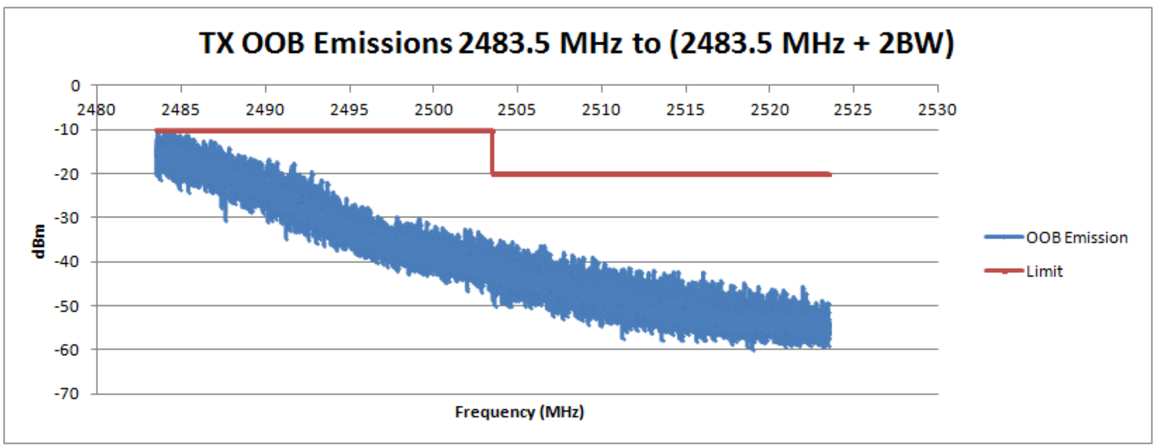


Figure 25. g mode, Low Channel TX OOB Plot 2

Test Date: September 26, 2018

Signature: Afzal Fazal Tested By: Afzal Fazal

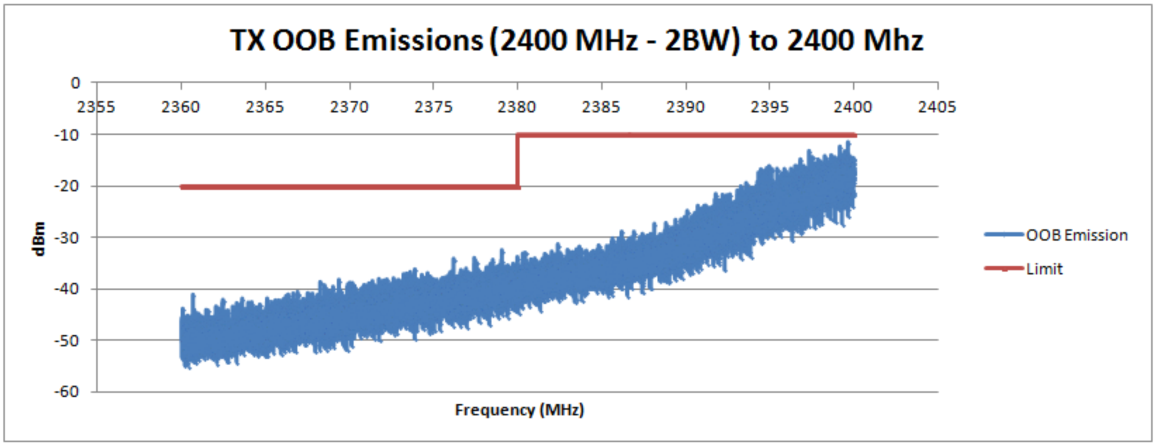


Figure 26. n mode, High Channel TX OOB Plot 1

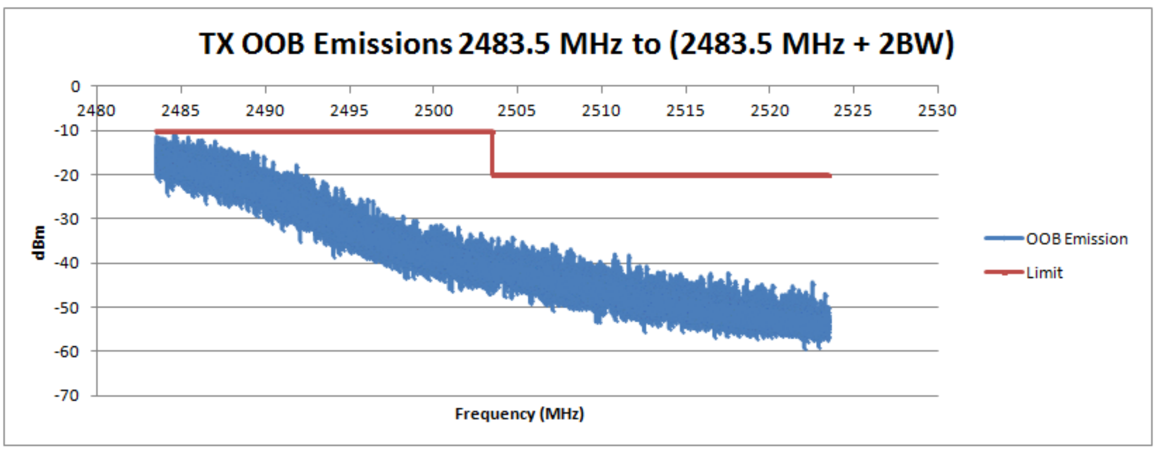


Figure 27. n mode, High Channel TX OOB Plot 2

Test Date: September 26, 2018

Signature: ______________ Tested By: Afzal Fazal

5.3.9 Transmitter Unwanted Emissions in the Spurious Domain (Clause 4.3.2.9)

Transmitter unwanted emissions in the spurious domain are emissions outside the allocated band and the Out-Of-Band domain when the equipment is in transmit mode, in accordance ETSI EN 300 328 section 4.3.2.9, the spurious emissions cannot be greater than the limits in the Tables following.

Table 6. Transmitter Unwanted Emission Limits

Frequency Range	Maximum power, e.r.p. (≤ 1 GHz) e.i.r.p (> 1 GHz)	Bandwidth
30 MHz to 47 MHz	-36 dBm	100 kHz
47 MHz to 74 MHz	-54 dBm	100 kHz
74 MHz to 87.5 MHz	-36 dBm	100 kHz
87.5 MHz to 118 MHz	-54 dBm	100 kHz
118 MHz to 174 MHz	-36 dBm	100 kHz
174 MHz to 230 MHz	-54 dBm	100 kHz
230 MHz to 470 MHz	-36 dBm	100 kHz
470 MHz to 862 MHz	-54 dBm	100 kHz
862 MHz to 1 GHz	-36 dBm	100 kHz
1 GHz to 12.75 GHz	-30 dBm	1 MHz

The following radiated measurements were performed while the EUT was operating in transmit mode:

- Fundamental and Harmonics in the Spurious Domain (refer to the tables below).
- Unwanted Emissions in the Spurious Domain. The middle channel 2437 MHz was used for these measurements (refer to the tables below).

The 3.2 dB gain dual band antenna generated the worst case emissions. The external antenna test data presented below are the test results collected using that antenna.

A conducted measurement was also performed for the unwanted emissions in the spurious domain refer to the plots below.

Note: The radio module was programmed to output at +20 dBm.

Spurious Emissions Testing performed by:

Test Date: September 26, 2018

Signature: [signature] Tested By: Afzal Fazal

Table 7. Transmitter Spurious Emissions Fundamental Signal (chip antenna – b mode)

Freq. (MHz)	Maximum RX Reading (dBuV)	Recreated Reading (dBuV)	Difference Column A – B (dB)	TX Gain (dBi)	TX Gain Relative to Dipole (dB)	RF Power into TX Antenna	RF Power into Substitution TX Antenna Corrected By TX Gain Relative to Dipole and TX Cable (dBm)	Limit (dBm)	Margin (dB)
Channel 1 – 2412 MHz									
2412.00	71.13	70.29	0.84	8.8	6.7	0.0	6.34	20	13.66
Channel 6 – 2437 MHz									
2437.00	76.69	75.64	1.05	8.8	6.7	4.0	10.53	20	9.47
Channel 11 – 2462 MHz									
2462.00	78.85	79.61	-0.76	8.8	6.7	6.0	10.72	20	9.28
Channel 12 – 2467 MHz									
2467.00	78.18	79.33	-1.15	8.8	6.7	6.0	10.33	20	9.67
Channel 13 – 2472 MHz									
2472.00	78.50	78.88	-0.38	8.8	6.7	6.0	11.10	20	8.90

Note 1) RF Power (dBm) into substitution antenna from signal generator corrected with cable loss and other attenuators factors.
Note 2) Radiated RF power (dBm) was calculated by summing the antenna factor/cable loss, Input RF Power, and the difference in column D.

Sample calculation for 2412.00 MHz:

Maximum RX Reading (column 2)	71.13	(dBuV/m)
Less Recreated Reading (column 3)	70.29	(dBuV/m)
TX Gain Relative to Dipole (column 6)	6.70	(dB)
RF Power into TX Antenna (column 7)	0.00	(dBm)
Antenna factor/Cable loss from spreadsheet factors	-1.2	(dBm)
Corrected RF Power (column 8)	6.34	(dBm)

Table 8. Transmitter Spurious Emissions Fundamental Signal (chip antenna – g mode)

Freq. (MHz)	Maximum RX Reading (dBuV)	Recreated Reading (dBuV)	Difference Column A – B (dB)	TX Gain (dBi)	TX Gain Relative to Dipole (dB)	RF Power into TX Antenna	RF Power into Substitution TX Antenna Corrected By TX Gain Relative to Dipole and TX Cable (dBm)	Limit (dBm)	Margin (dB)
Channel 1 – 2412 MHz									
2412.00	70.80	70.29	0.51	8.8	6.7	0.0	6.01	20	13.99
Channel 6 – 2437 MHz									
2437.00	75.85	75.64	0.21	8.8	6.7	4.0	9.69	20	10.31
Channel 11 – 2462 MHz									
2462.00	78.94	79.61	-0.67	8.8	6.7	6.0	10.81	20	9.19
Channel 12 – 2467 MHz									
2467.00	78.90	79.33	-0.43	8.8	6.7	6.0	11.05	20	8.95
Channel 13 – 2472 MHz									
2472.00	78.02	78.88	-0.86	8.8	6.7	6.0	10.62	20	9.38

Note 1) RF Power (dBm) into substitution antenna from signal generator corrected with cable loss and other attenuators factors.
Note 2) Radiated RF power (dBm) was calculated by summing the antenna factor/cable loss, Input RF Power, and the difference in column D.

Sample calculation for 2412.00 MHz:

Maximum RX Reading (column 2)	70.80	(dBuV/m)
Less Recreated Reading (column 3)	70.29	(dBuV/m)
TX Gain Relative to Dipole (column 6)	6.70	(dB)
RF Power into TX Antenna (column 7)	0.00	(dBm)
Antenna factor/Cable loss from spreadsheet factors	-1.2	(dBm)
Corrected RF Power (column 8)	6.01	(dBm)

Table 9. Transmitter Spurious Emissions Fundamental Signal (chip antenna – n mode)

Freq. (MHz)	Maximum RX Reading (dBuV)	Recreated Reading (dBuV)	Difference Column A – B (dB)	TX Gain (dBi)	TX Gain Relative to Dipole (dB)	RF Power into TX Antenna	RF Power into Substitution TX Antenna Corrected By TX Gain Relative to Dipole and TX Cable (dBm)	Limit (dBm)	Margin (dB)
Channel 1 – 2412 MHz									
2412.00	71.12	70.29	0.83	8.8	6.7	0.0	6.33	20	13.67
Channel 6 – 2437 MHz									
2437.00	75.38	75.64	-0.26	8.8	6.7	4.0	9.22	20	10.78
Channel 11 – 2462 MHz									
2462.00	78.81	79.61	-0.80	8.8	6.7	6.0	10.68	20	9.32
Channel 12 – 2467 MHz									
2467.00	77.79	79.33	-1.54	8.8	6.7	6.0	9.94	20	10.06
Channel 13 – 2472 MHz									
2472.00	77.39	78.88	-1.49	8.8	6.7	6.0	9.99	20	10.01

Note 1) RF Power (dBm) into substitution antenna from signal generator corrected with cable loss and other attenuators factors.
Note 2) Radiated RF power (dBm) was calculated by summing the antenna factor/cable loss, Input RF Power, and the difference in column D.

Sample calculation for 2412.00 MHz:

Maximum RX Reading (column 2)	71.12	(dBuV/m)
Less Recreated Reading (column 3)	70.29	(dBuV/m)
TX Gain Relative to Dipole (column 6)	6.70	(dB)
RF Power into TX Antenna (column 7)	0.00	(dBm)
Antenna factor/Cable loss from spreadsheet factors	-1.2	(dBm)
Corrected RF Power (column 8)	6.33	(dBm)

Table 10. Transmitter Spurious Emissions Fundamental Signal (external antenna – b mode)

Freq. (MHz)	Maximum RX Reading (dBuV)	Recreated Reading (dBuV)	Difference Column A – B (dB)	TX Gain (dBi)	TX Gain Relative to Dipole (dB)	RF Power into TX Antenna	RF Power into Substitution TX Antenna Corrected By TX Gain Relative to Dipole and TX Cable (dBm)	Limit (dBm)	Margin (dB)
Channel 1 – 2412 MHz									
2412.00	78.05	77.92	0.13	8.8	6.7	5.0	10.59	20	9.41
Channel 6 – 2437 MHz									
2437.00	79.61	81.96	-2.35	8.8	6.7	7.0	10.10	20	9.90
Channel 11 – 2462 MHz									
2462.00	81.69	81.96	-0.27	8.8	6.7	5.0	10.18	20	9.82
Channel 12 – 2467 MHz									
2467.00	81.87	81.96	-0.09	8.8	6.7	5.0	10.36	20	9.64
Channel 13 – 2472 MHz									
2472.00	82.13	81.76	0.37	8.8	6.7	5.0	10.82	20	9.18

Note 1) RF Power (dBm) into substitution antenna from signal generator corrected with cable loss and other attenuators factors.
Note 2) Radiated RF power (dBm) was calculated by summing the antenna factor/cable loss, Input RF Power, and the difference in column D.

Sample calculation for 2412.00 MHz:

Maximum RX Reading (column 2)	78.05	(dBuV/m)
Less Recreated Reading (column 3)	77.92	(dBuV/m)
TX Gain Relative to Dipole (column 6)	6.70	(dB)
RF Power into TX Antenna (column 7)	5.0	(dBm)
Antenna factor/Cable loss from spreadsheet factors	-1.24	(dBm)
Corrected RF Power (column 8)	10.59	(dBm)

Table 11. Transmitter Spurious Emissions Fundamental Signal (external antenna – g mode)

Freq. (MHz)	Maximum RX Reading (dBuV)	Recreated Reading (dBuV)	Difference Column A – B (dB)	TX Gain (dBi)	TX Gain Relative to Dipole (dB)	RF Power into TX Antenna	RF Power into Substitution TX Antenna Corrected By TX Gain Relative to Dipole and TX Cable (dBm)	Limit (dBm)	Margin (dB)
Channel 1 – 2412 MHz									
2412.00	77.89	77.92	-0.03	8.8	6.7	5.0	10.43	20	9.57
Channel 6 – 2437 MHz									
2437.00	79.80	81.96	-2.16	8.8	6.7	7.0	10.29	20	9.71
Channel 11 – 2462 MHz									
2462.00	81.72	81.96	-0.24	8.8	6.7	5.0	10.21	20	9.79
Channel 12 – 2467 MHz									
2467.00	81.39	81.96	-0.57	8.8	6.7	5.0	9.88	20	10.12
Channel 13 – 2472 MHz									
2472.00	82.03	81.76	0.27	8.8	6.7	5.0	10.72	20	9.28

Note 1) RF Power (dBm) into substitution antenna from signal generator corrected with cable loss and other attenuators factors.
Note 2) Radiated RF power (dBm) was calculated by summing the antenna factor/cable loss, Input RF Power, and the difference in column D.

Sample calculation for 2412.00 MHz:

Maximum RX Reading (column 2)	77.89	(dBuV/m)
Less Recreated Reading (column 3)	77.92	(dBuV/m)
TX Gain Relative to Dipole (column 6)	6.70	(dB)
RF Power into TX Antenna (column 7)	5.0	(dBm)
Antenna factor/Cable loss from spreadsheet factors	-1.24	(dBm)
Corrected RF Power (column 8)	10.43	(dBm)

Table 12. Transmitter Spurious Emissions Fundamental Signal (external antenna – n mode)

Freq. (MHz)	Maximum RX Reading (dBuV)	Recreated Reading (dBuV)	Difference Column A – B (dB)	TX Gain (dBi)	TX Gain Relative to Dipole (dB)	RF Power into TX Antenna	RF Power into Substitution TX Antenna Corrected By TX Gain Relative to Dipole and TX Cable (dBm)	Limit (dBm)	Margin (dB)
Channel 1 – 2412 MHz									
2412.00	76.77	77.92	-1.15	8.8	6.7	5.0	9.31	20	10.69
Channel 6 – 2437 MHz									
2437.00	78.01	81.96	-3.95	8.8	6.7	7.0	8.50	20	11.50
Channel 11 – 2462 MHz									
2462.00	79.46	81.96	-2.50	8.8	6.7	5.0	7.95	20	12.05
Channel 12 – 2467 MHz									
2467.00	79.89	81.96	-2.07	8.8	6.7	5.0	8.38	20	11.62
Channel 13 – 2472 MHz									
2472.00	79.74	81.76	-2.02	8.8	6.7	5.0	8.43	20	11.57

Note 1) RF Power (dBm) into substitution antenna from signal generator corrected with cable loss and other attenuators factors.
Note 2) Radiated RF power (dBm) was calculated by summing the antenna factor/cable loss, Input RF Power, and the difference in column D.

Sample calculation for 2412.5 MHz:

Maximum RX Reading (column 2)	76.77	(dBuV/m)
Less Recreated Reading (column 3)	77.92	(dBuV/m)
TX Gain Relative to Dipole (column 6)	6.70	(dB)
RF Power into TX Antenna (column 7)	5.0	(dBm)
Antenna factor/Cable loss from spreadsheet factors	-1.24	(dBm)
Corrected RF Power (column 8)	9.31	(dBm)

Table 13. Transmitter Unwanted Emissions in Spurious Domain - Vertical

Freq. (MHz)	Maximum RX Reading (dBuV)	Recreated Reading (dBuV)	Difference Column A – B (dB)	TX Gain (dBi)	TX Gain Relative to Dipole (dB)	RF Power into TX Antenna	RF Power into Substitution TX Antenna Corrected By TX Gain Relative to Dipole and TX Cable (dBm)	Limit (dBm)	Margin (dB)
31.31	61.51	59.12	2.39	-13.8	-13.8	-42.0	-53.55	-36	17.55
58.28	60.88	61.97	-1.09	-3.8	-3.8	-55.0	-60.03	-54	6.03
118.24	63.43	63.73	-0.30	0.3	0.3	-42.0	-42.22	-36	6.22
134.76	60.82	60.80	0.02	0.6	0.6	-50.0	-49.65	-36	13.65
188.52	54.99	56.37	-1.38	0.6	0.6	-59.0	-60.09	-54	6.09
213.33	65.55	67.46	-1.91	5.1	5.1	-63.0	-60.12	-54	6.12
219.00	66.69	67.26	-0.57	5.5	5.5	-65.0	-60.38	-54	6.38
263.00	60.06	58.11	1.95	5.7	5.7	-52.0	-44.71	-36	8.71
1566.00	59.77	61.78	-2.01	8.9	8.9	-42.0	-36.07	-30	6.07
2975.00	53.47	51.88	1.59	10.0	10.0	-48.0	-37.83	-30	7.83
3030.00	51.96	53.41	-1.45	9.4	9.4	-43.0	-36.43	-30	6.43

Note 1) RF Power (dBm) into substitution antenna from signal generator corrected with cable loss and other attenuators factors.
Note 2) Radiated RF power (dBm) was calculated by summing the antenna factor/cable loss, Input RF Power, and the difference in column D.

Sample calculation for 31.31 MHz:

Maximum RX Reading (column 2)	61.51	(dBuV/m)
Less Recreated Reading (column 3)	59.12	(dBuV/m)
TX Gain Relative to Dipole (column 6)	-13.80	(dB)
RF Power into TX Antenna (column 7)	-42.00	(dBm)
Antenna factor/Cable loss from spreadsheet factors	-0.14	(dBm)
Corrected RF Power (column 8)	-53.55	(dBm)

Table 14. Transmitter Unwanted Emissions in Spurious Domain - Horizontal

Freq. (MHz)	Maximum RX Reading (dBuV)	Recreated Reading (dBuV)	Difference Column A – B (dB)	TX Gain (dBi)	TX Gain Relative to Dipole (dB)	RF Power into TX Antenna	RF Power into Substitution TX Antenna Corrected By TX Gain Relative to Dipole and TX Cable (dBm)	Limit (dBm)	Margin (dB)
58.57	57.22	55.78	1.44	-4.8	-4.8	-57.0	-60.50	-54	6.50
120.20	59.94	61.64	-1.70	1.0	1.0	-55.0	-55.92	-36	19.92
128.00	62.05	59.84	2.21	0.9	0.9	-57.0	-54.11	-36	18.11
192.20	45.62	43.81	1.81	1.6	1.6	-70.0	-66.90	-54	12.90
213.330	64.01	66.74	-2.73	5.0	5.0	-62.0	-60.04	-54	6.04
216.630	66.71	68.37	-1.66	5.3	5.3	-64.0	-60.67	-54	6.67
251.900	64.76	66.69	-1.93	5.8	5.8	-50.0	-46.49	-36	10.49
1975.00	50.77	51.47	-0.70	9.1	9.1	-46.0	-38.70	-30	8.70
2975.00	54.30	56.43	-2.13	10.0	10.0	-43.0	-36.51	-30	6.51
3053.00	51.91	50.86	1.05	9.5	9.5	-46.0	-36.89	-30	6.89

Note 1) RF Power (dBm) into substitution antenna from signal generator corrected with cable loss and other attenuators factors.
Note 2) Radiated RF power (dBm) was calculated by summing the antenna factor/cable loss, Input RF Power, and the difference in column D.

Sample calculation for 58.57 MHz:

Maximum RX Reading (column 2)	57.22	(dBuV/m)
Less Recreated Reading (column 3)	55.78	(dBuV/m)
TX Gain Relative to Dipole (column 6)	-4.80	(dB)
RF Power into TX Antenna (column 7)	-57.00	(dBm)
Antenna factor/Cable loss from spreadsheet factors	-0.14	(dBm)
Corrected RF Power (column 8)	-60.50	(dBm)

Conducted Spurious Emissions Testing performed by:

Test Date: October 1, 2018

Signature: Afzal Fazal Tested By: Afzal Fazal

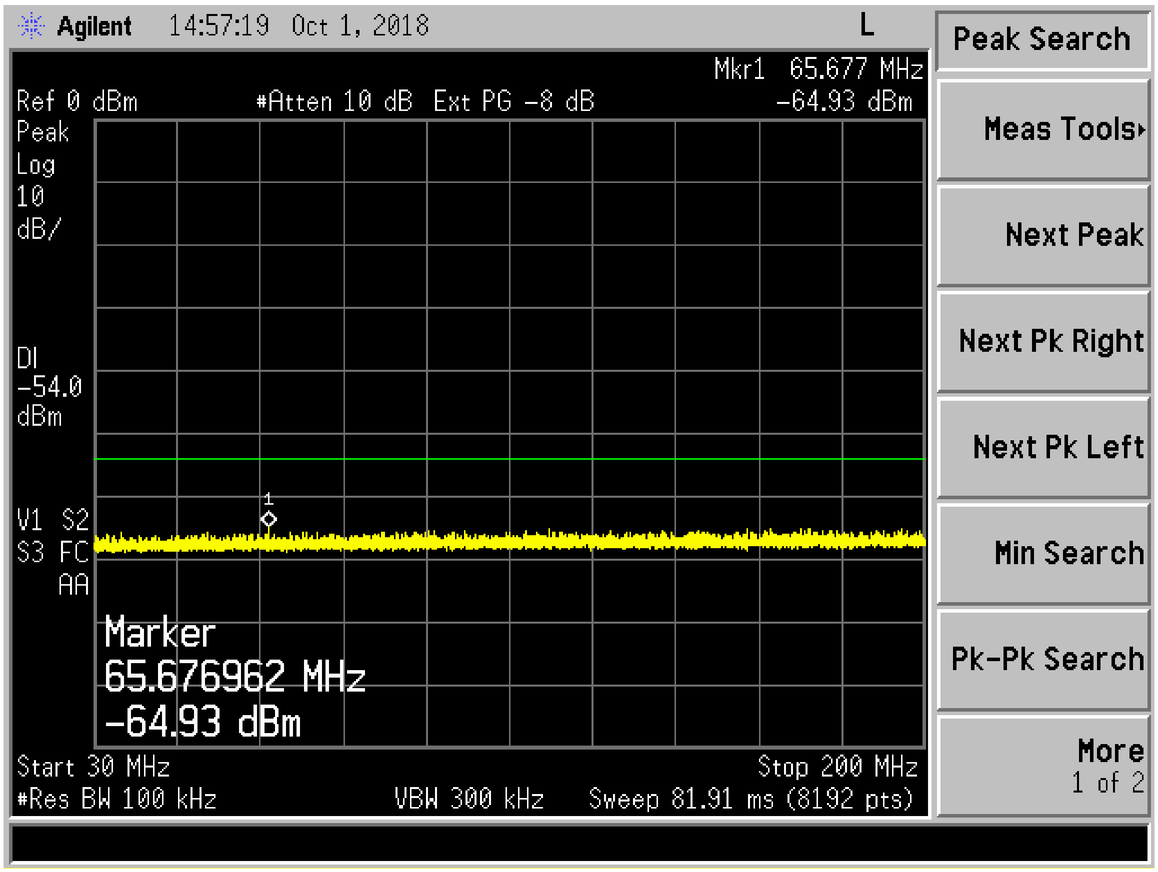


Figure 28. 802.11b, Low Channel, Plot 1

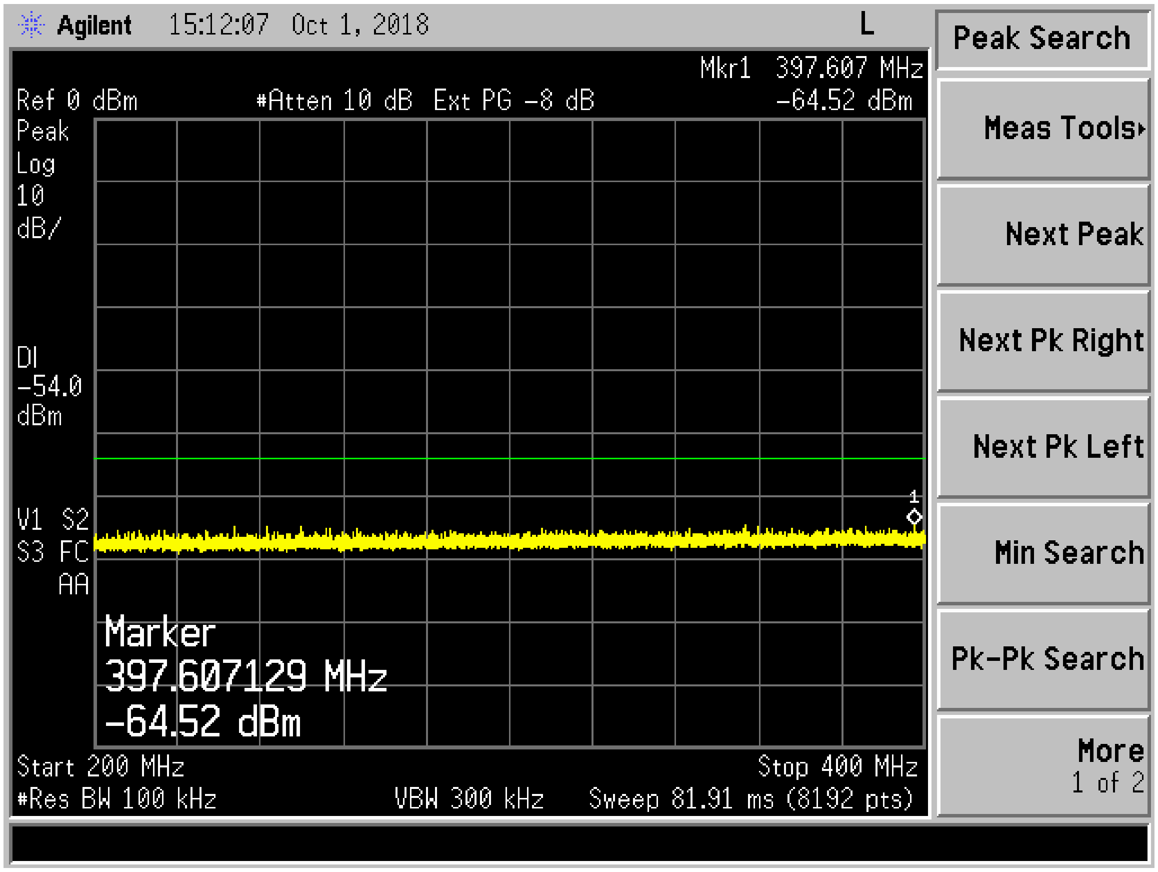


Figure 29. 802.11b, Low Channel, Plot 2

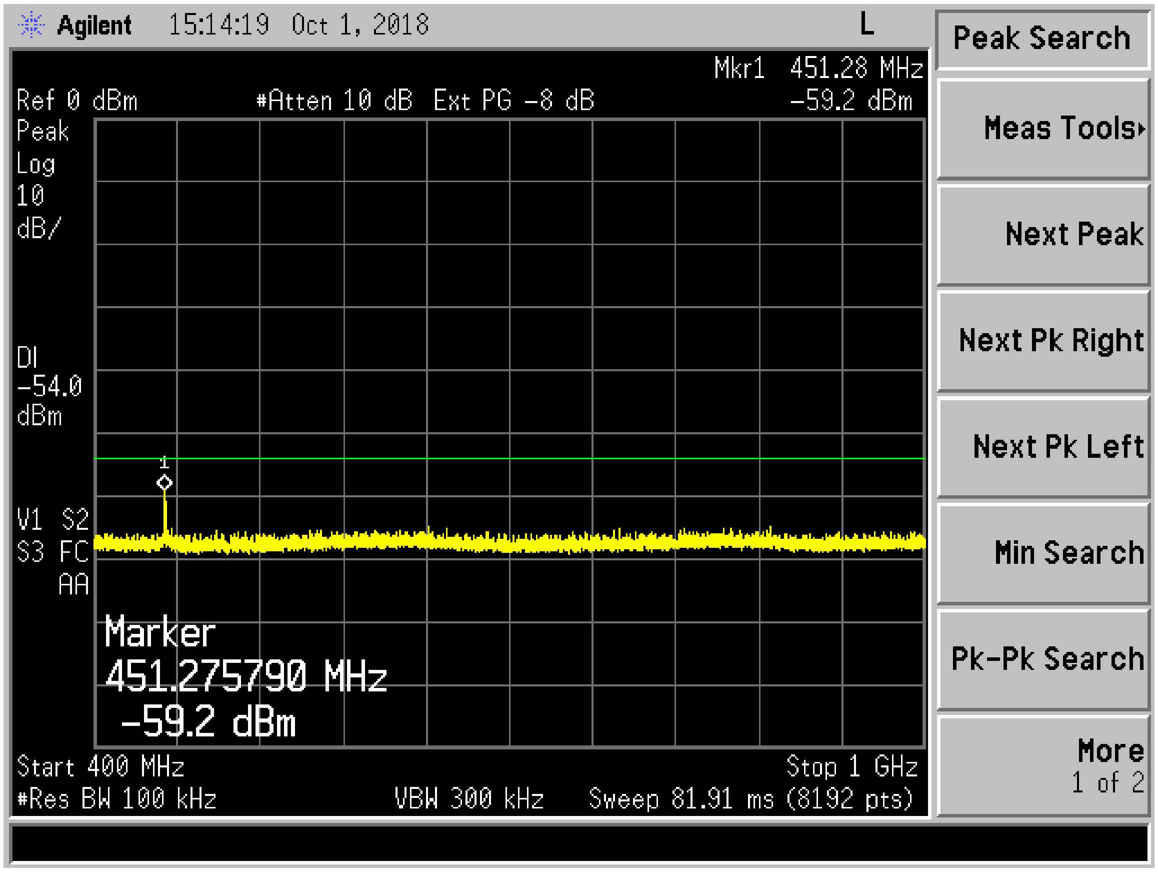


Figure 30. 802.11b, Low Channel, Plot 3

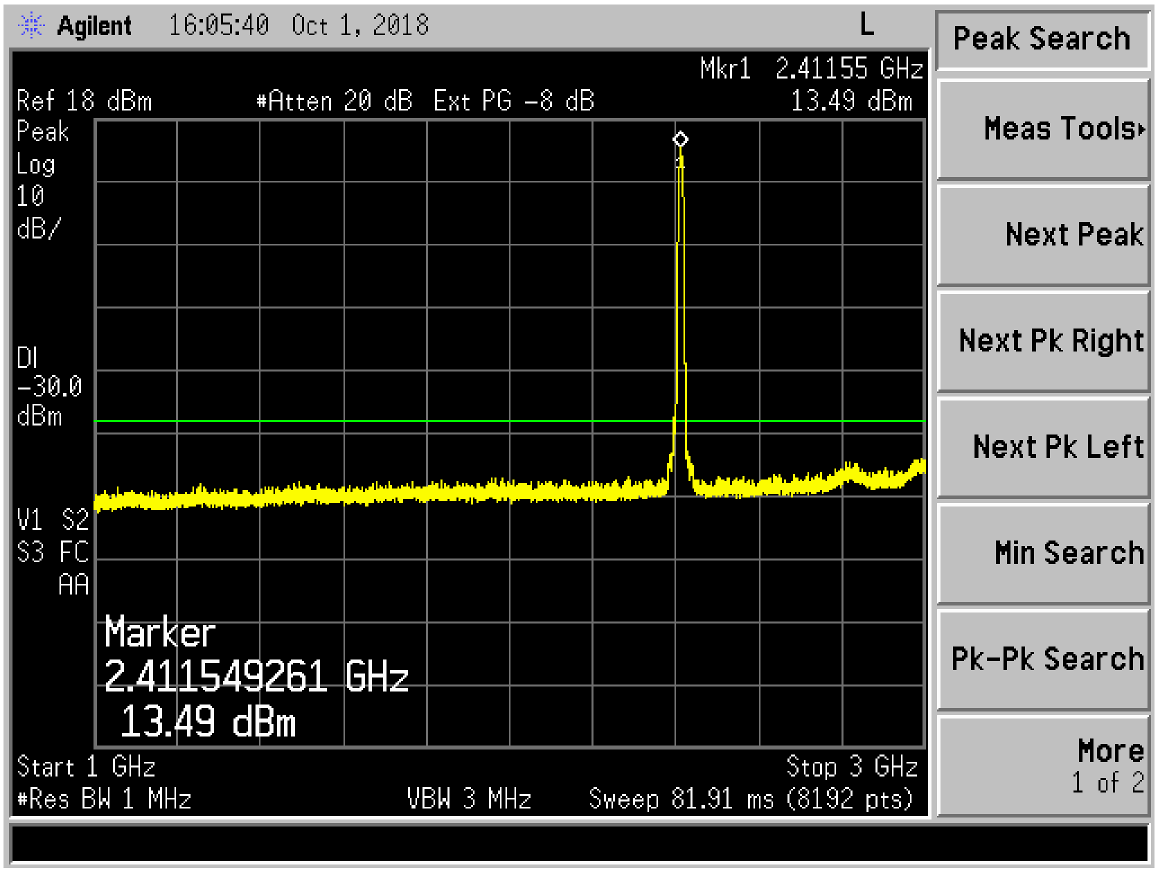


Figure 31. 802.11b, Low Channel, Plot 4

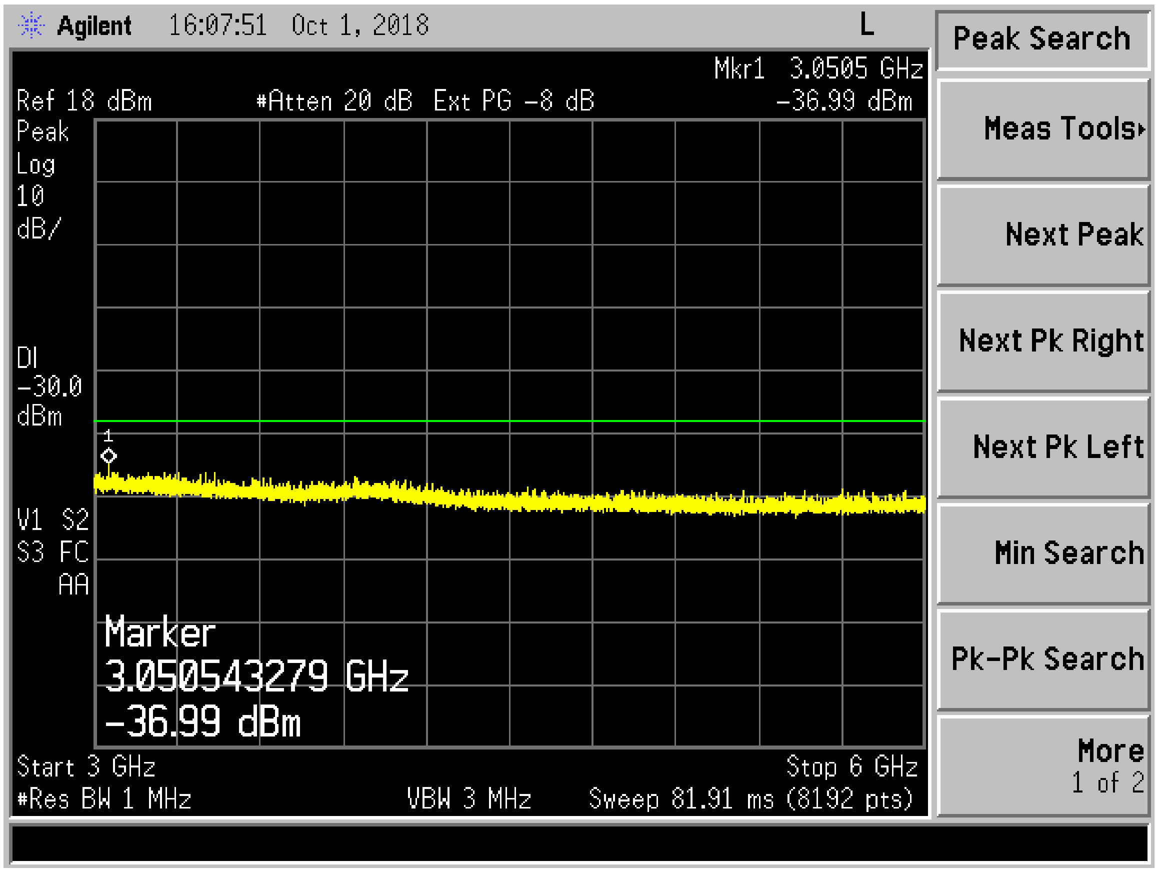


Figure 32. 802.11b, Low Channel, Plot 5

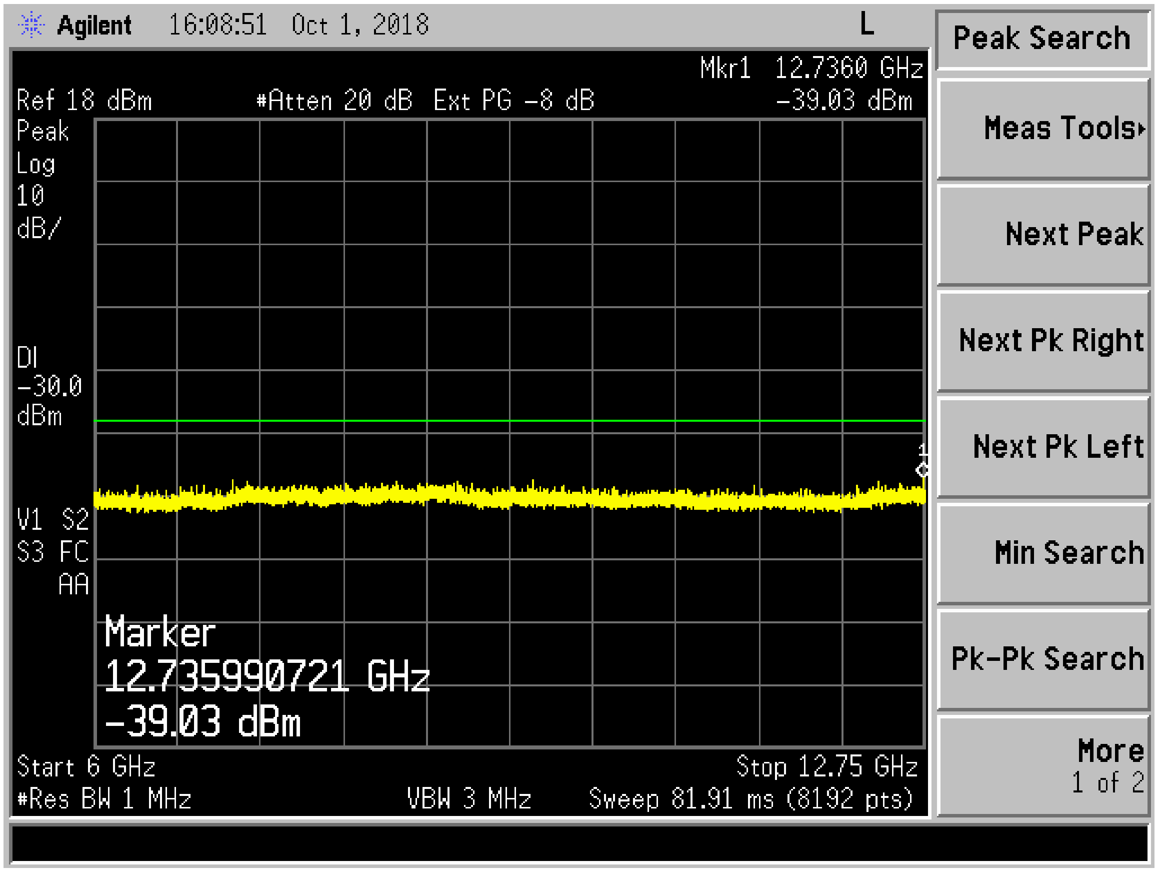


Figure 33. 802.11b, Low Channel, Plot 6

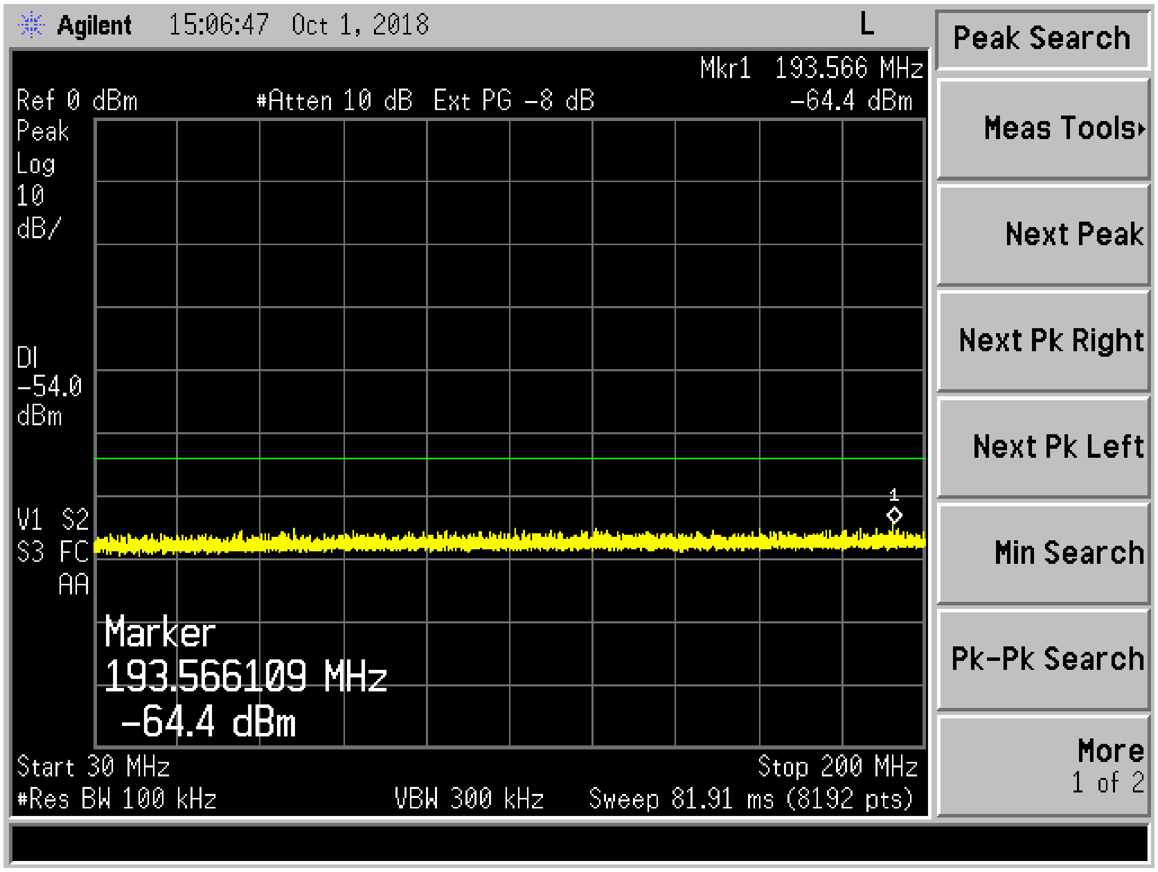


Figure 34. 802.11b, High Channel, Plot 1

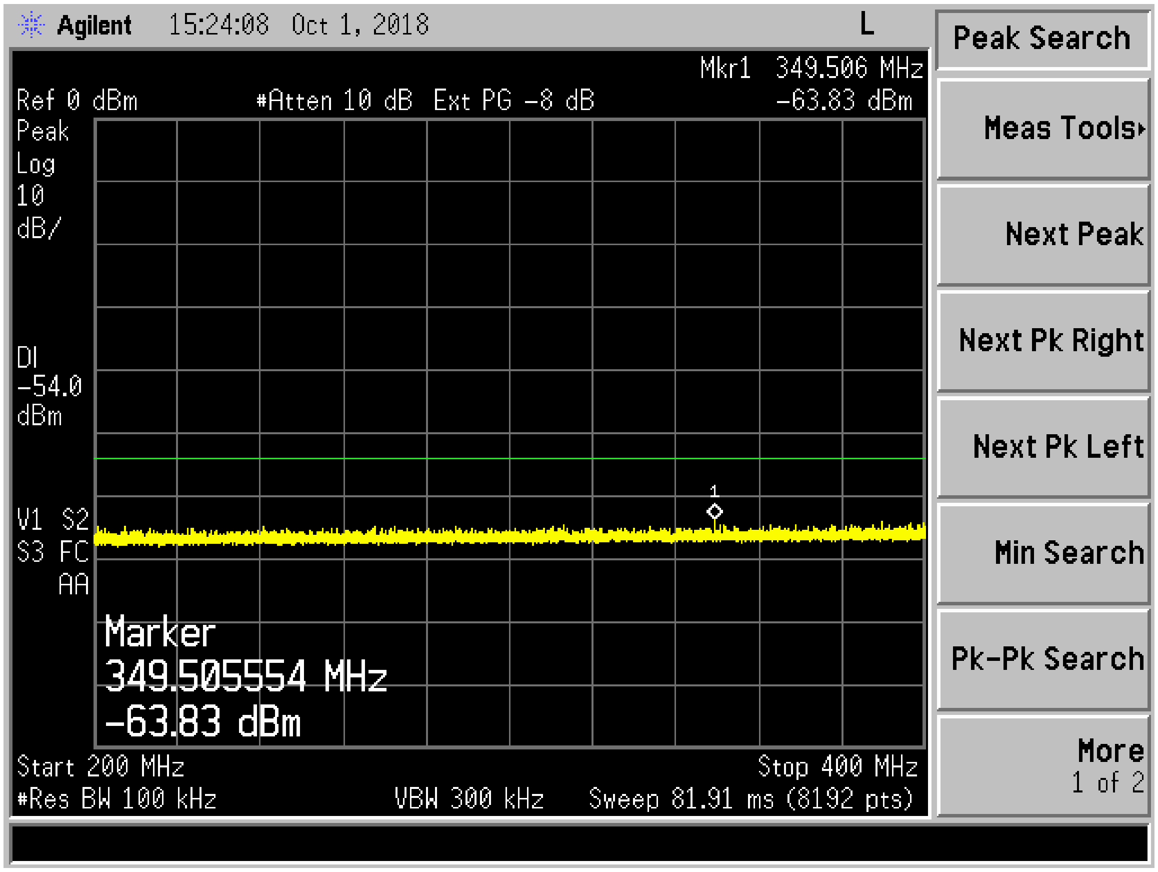


Figure 35. 802.11b, High Channel, Plot 2

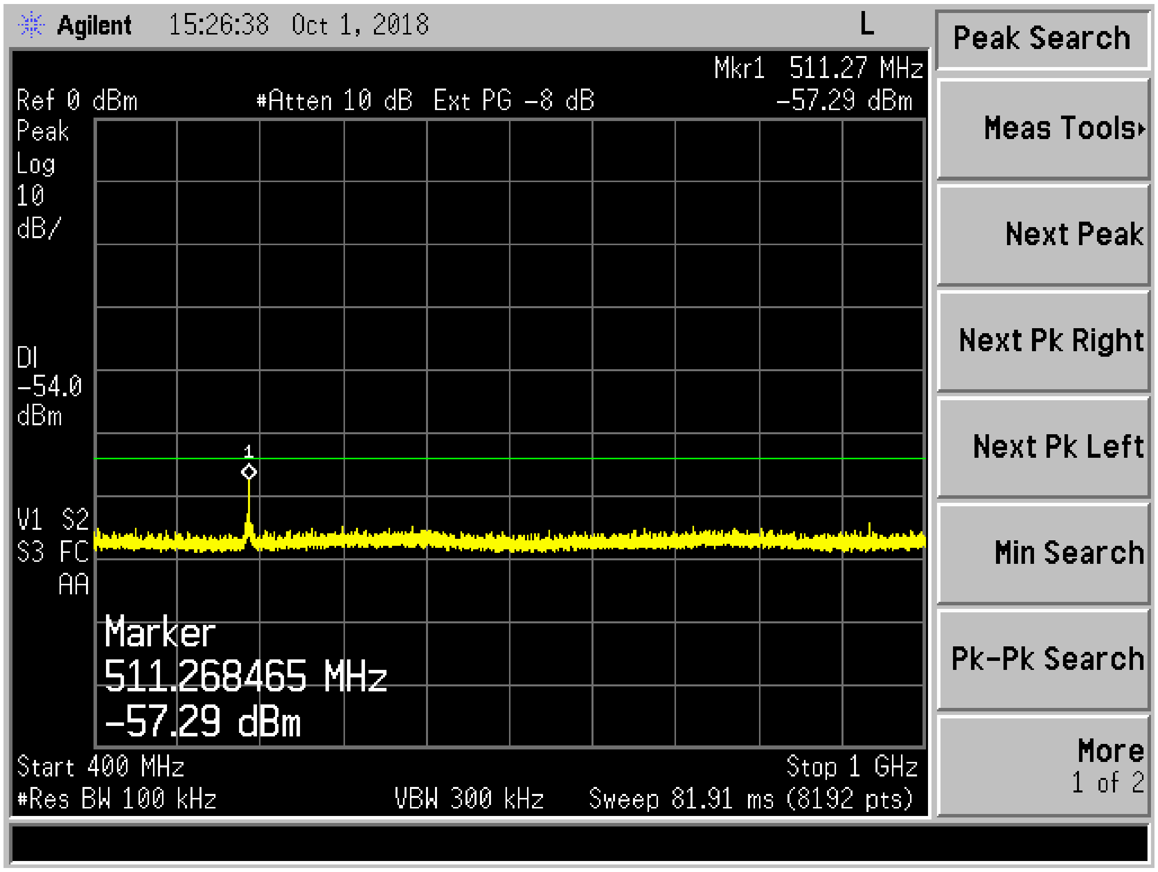


Figure 36. 802.11b, High Channel, Plot 3

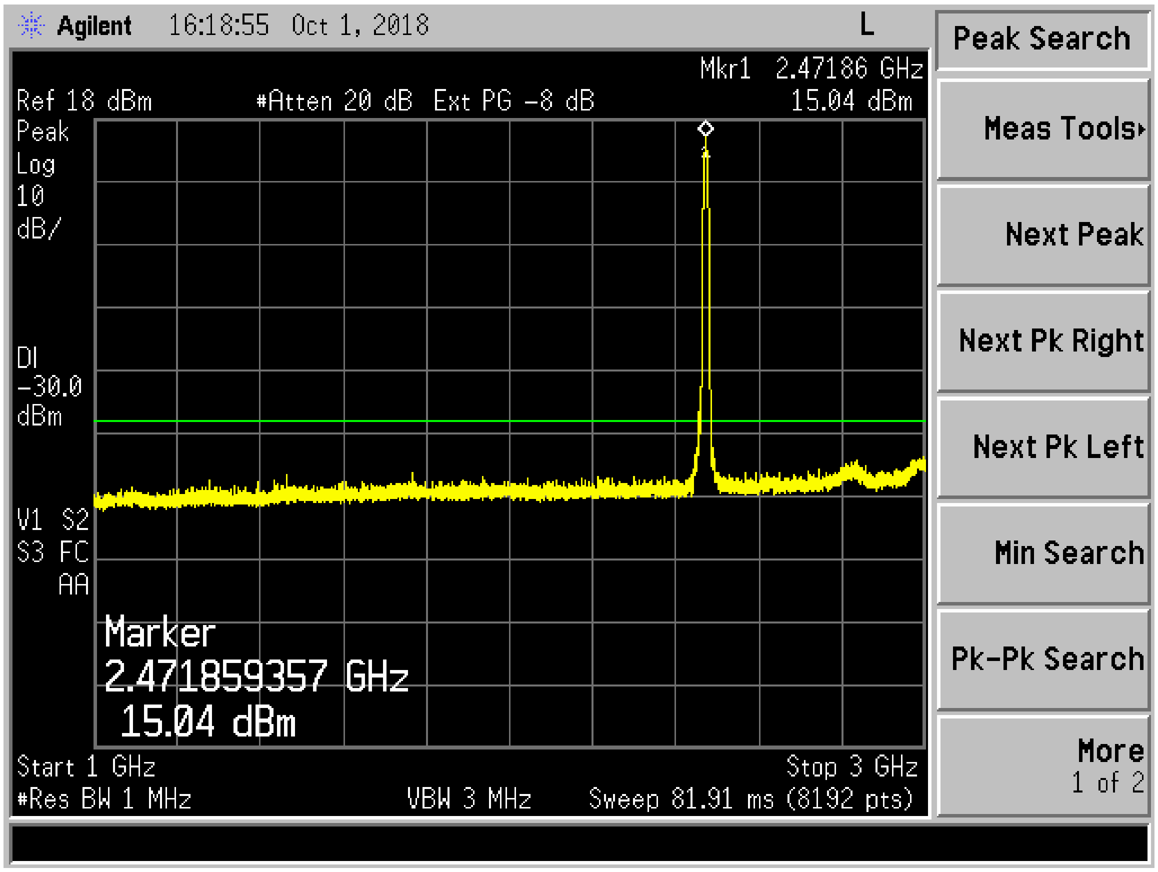


Figure 37. 802.11b, High Channel, Plot 4

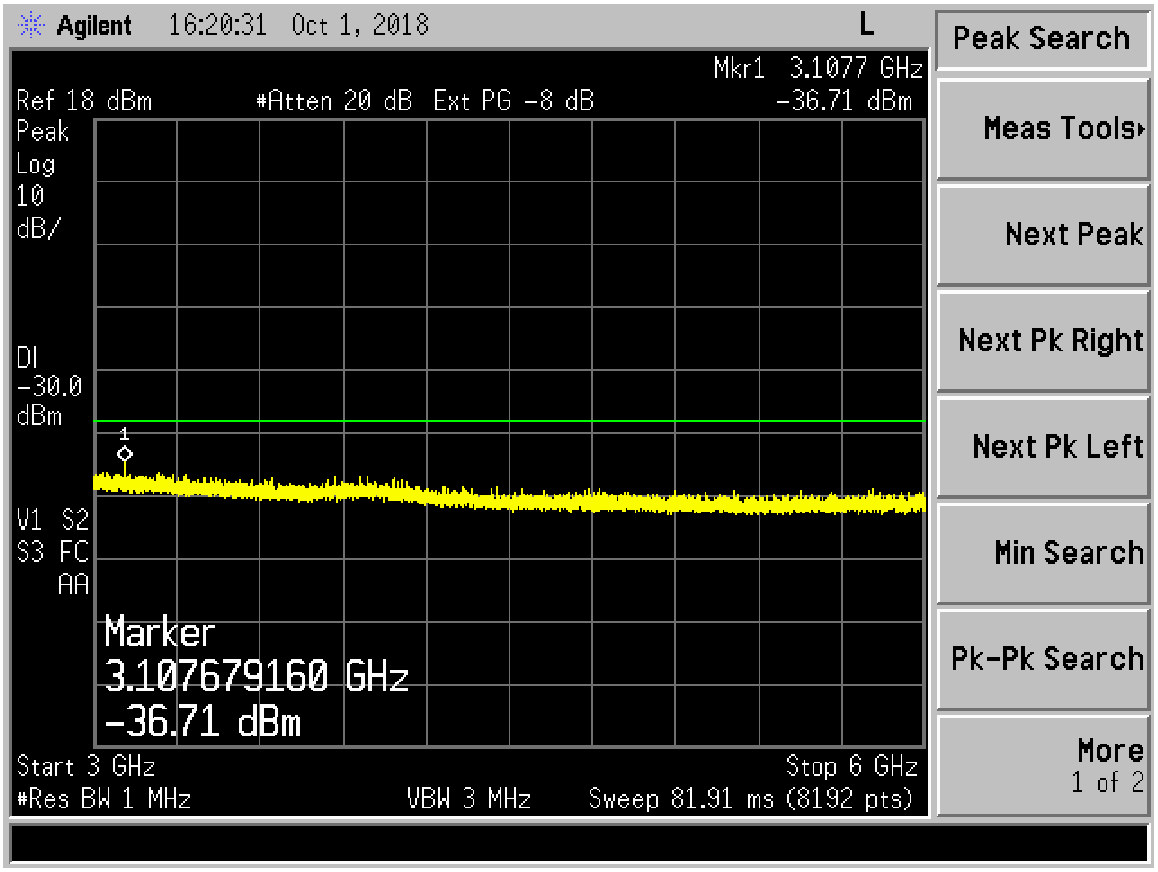


Figure 38. 802.11b, High Channel, Plot 5

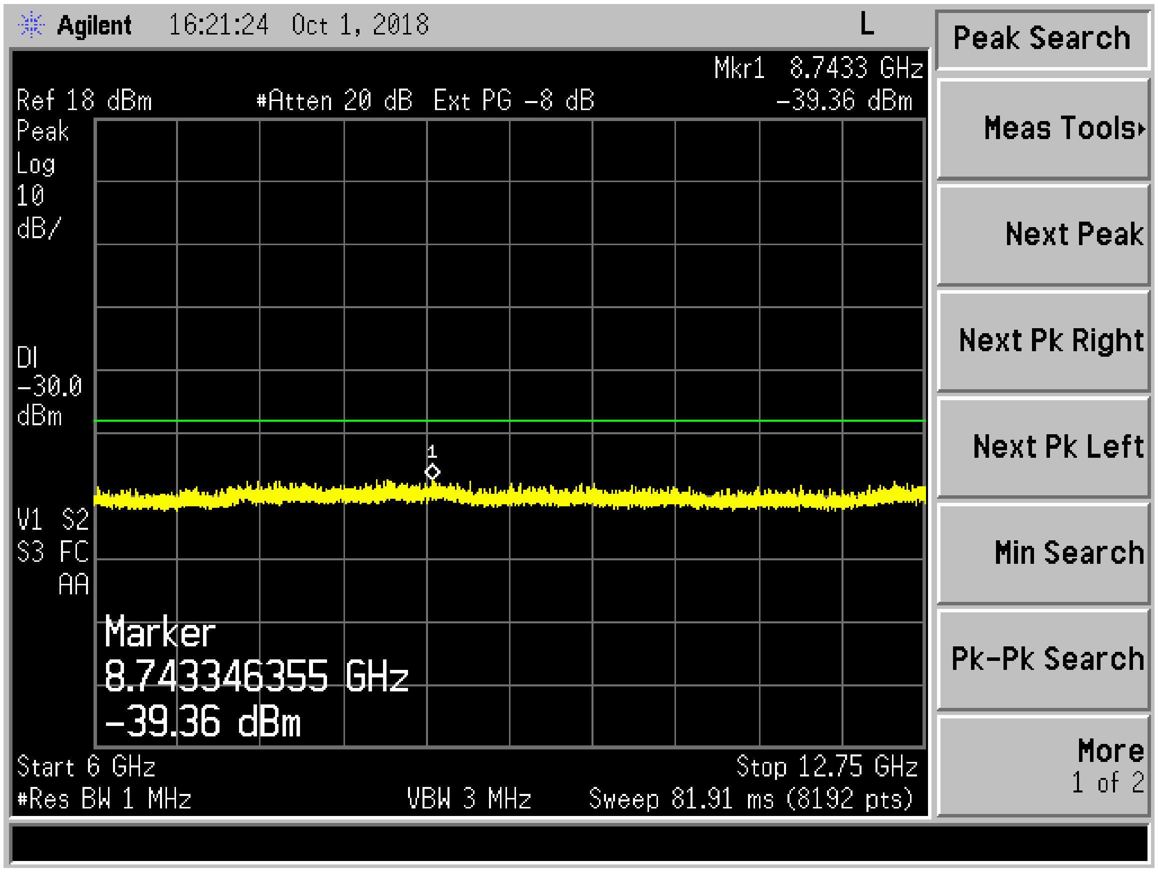


Figure 39. 802.11b, High Channel, Plot 6

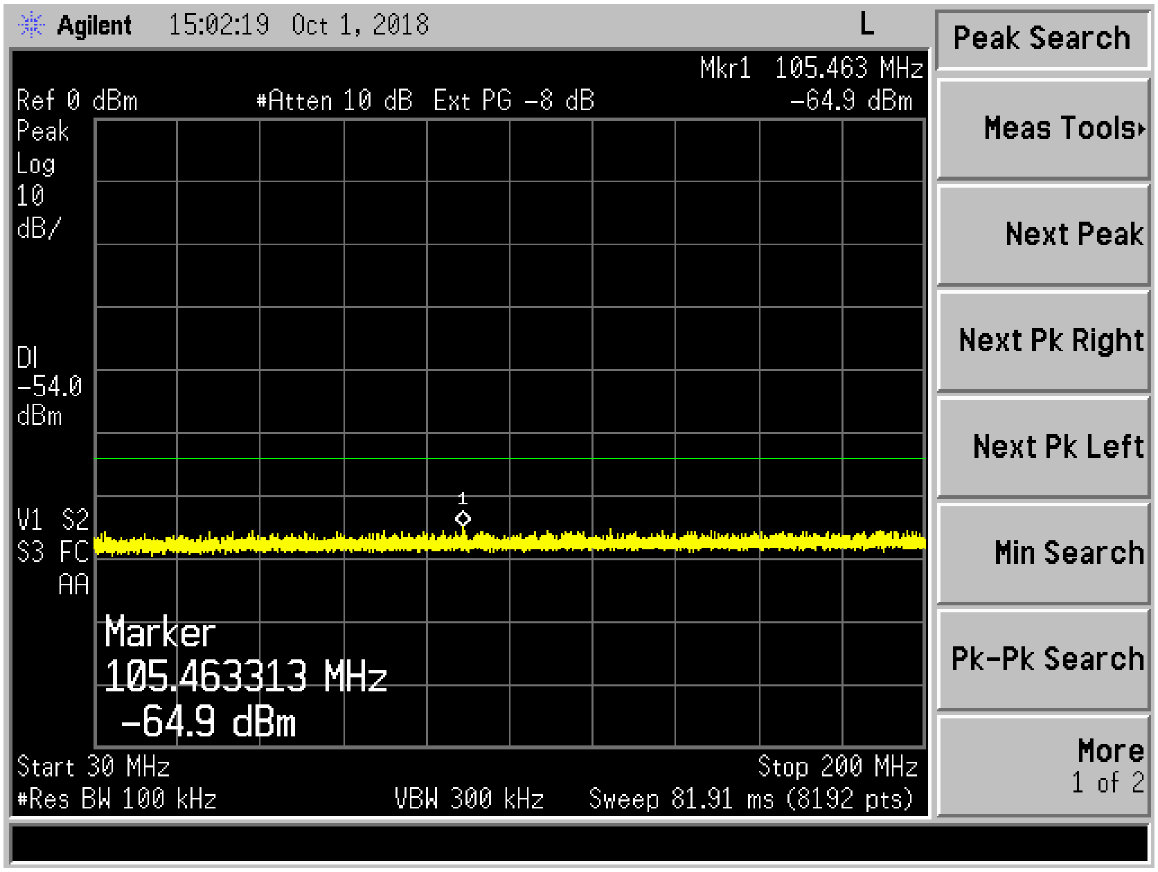


Figure 40. 802.11g, Low Channel, Plot 1

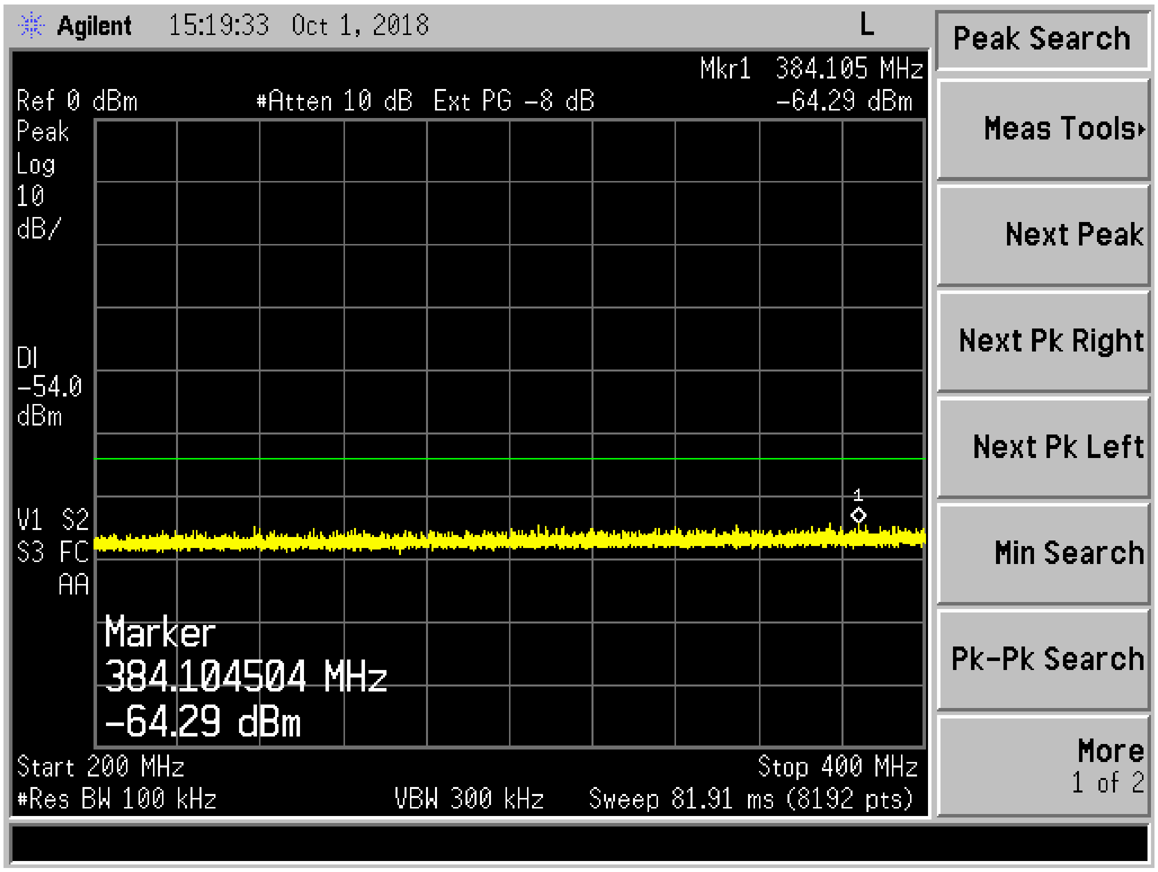


Figure 41. 802.11g, Low Channel, Plot 2

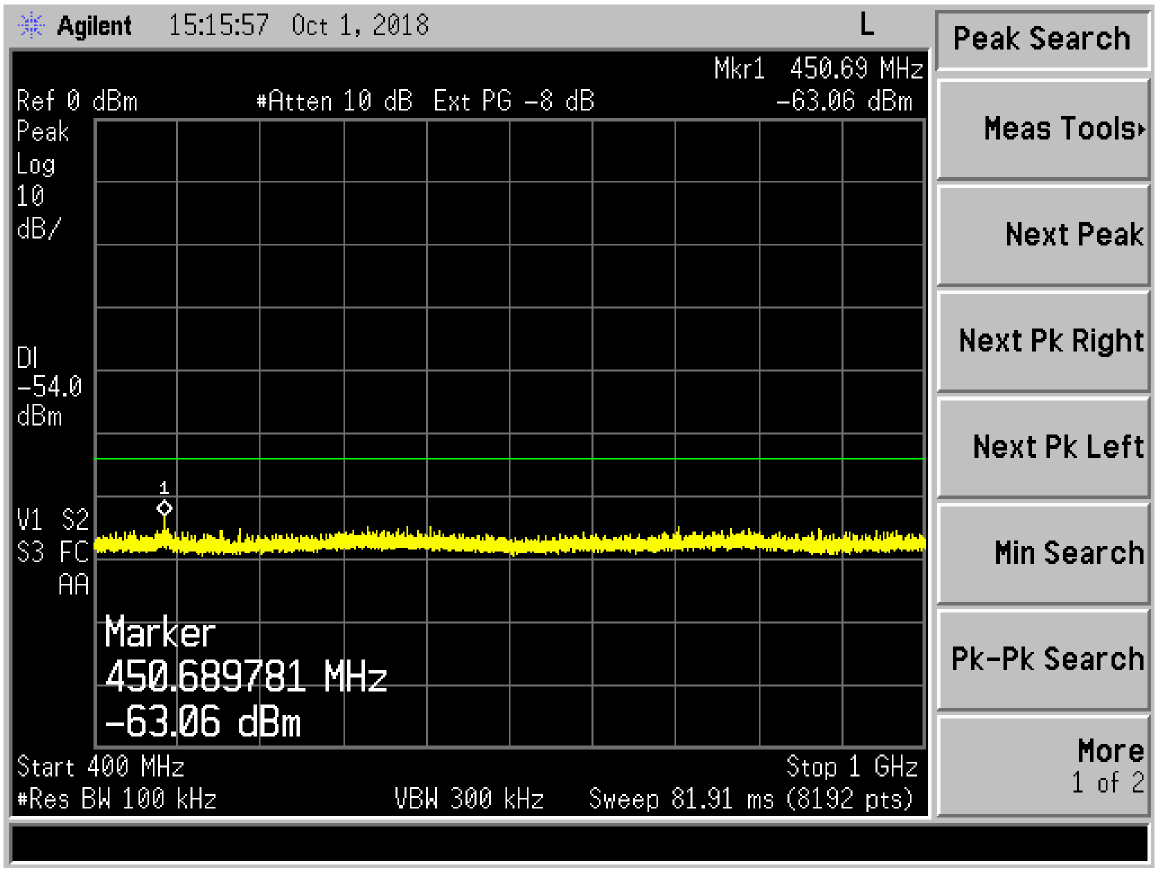


Figure 42. 802.11g, Low Channel, Plot 3

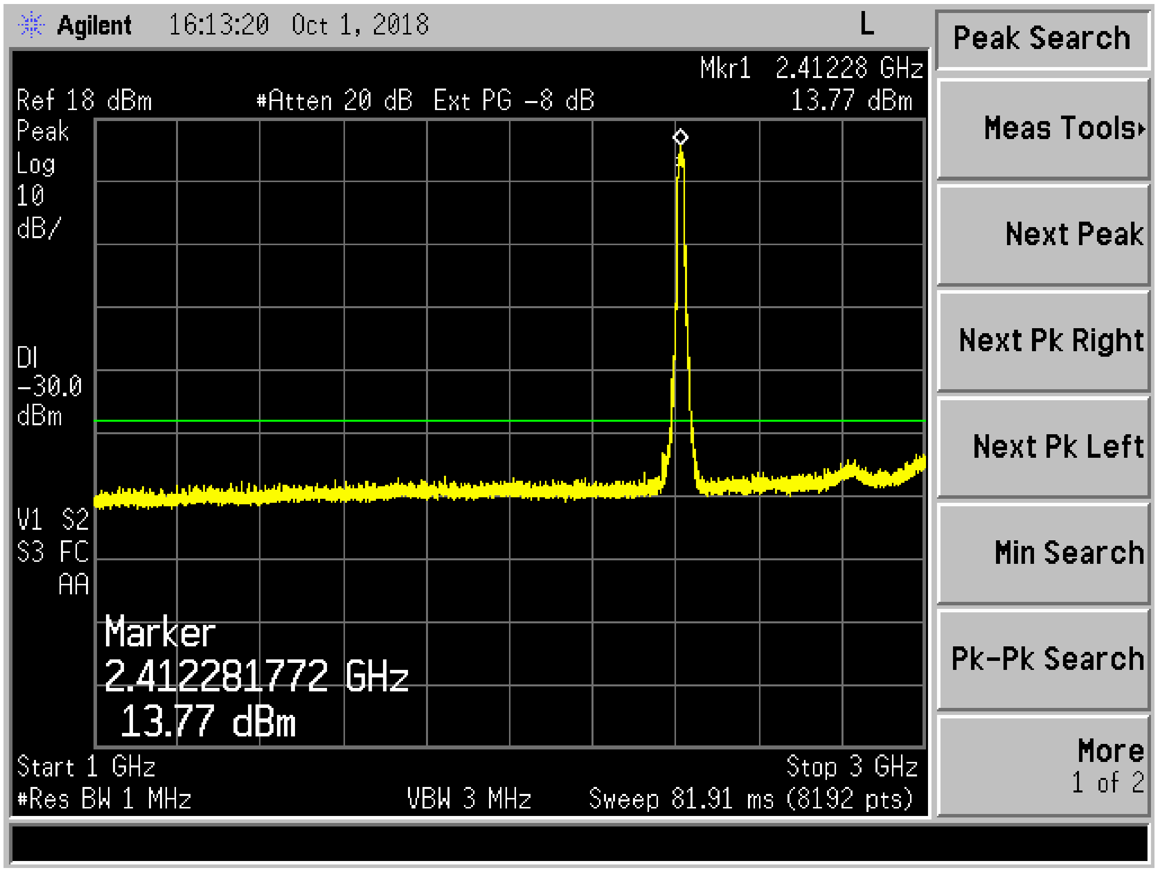


Figure 43. 802.11g, Low Channel, Plot 4

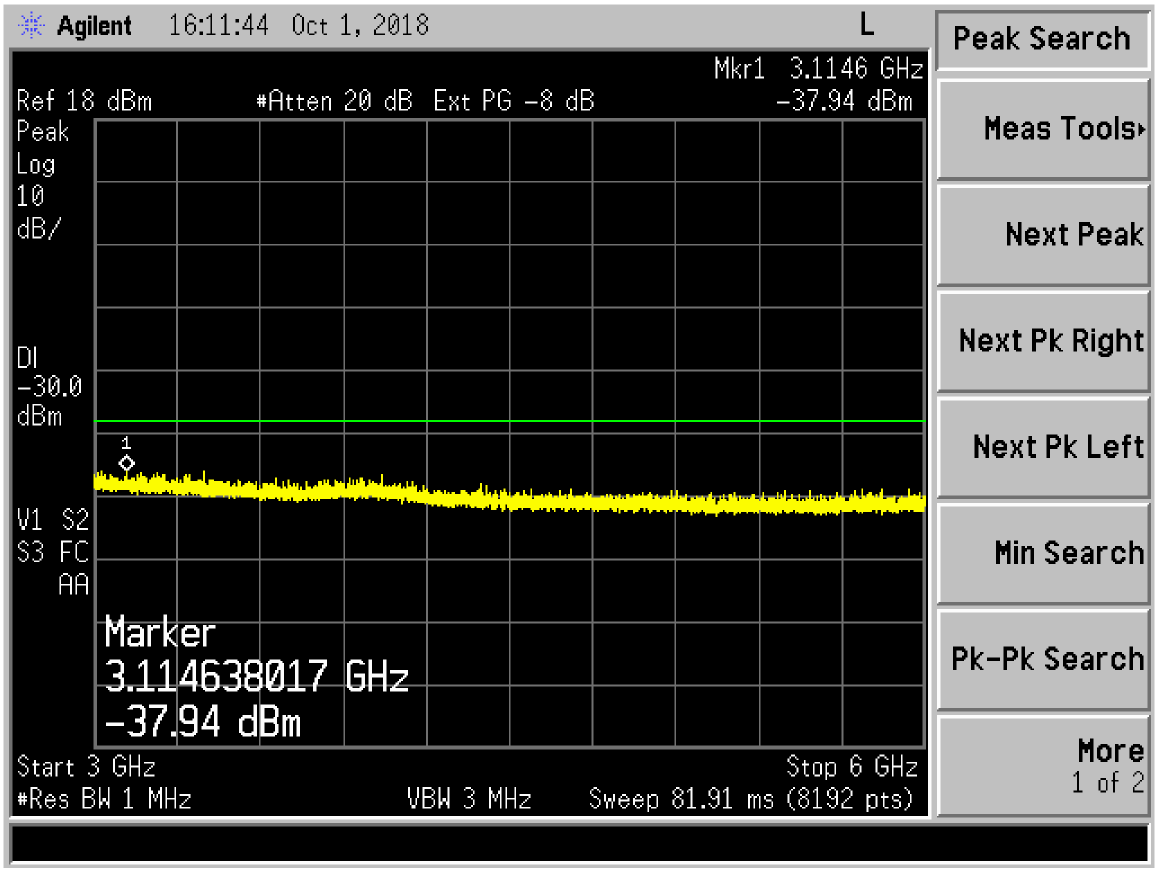


Figure 44. 802.11g, Low Channel, Plot 5

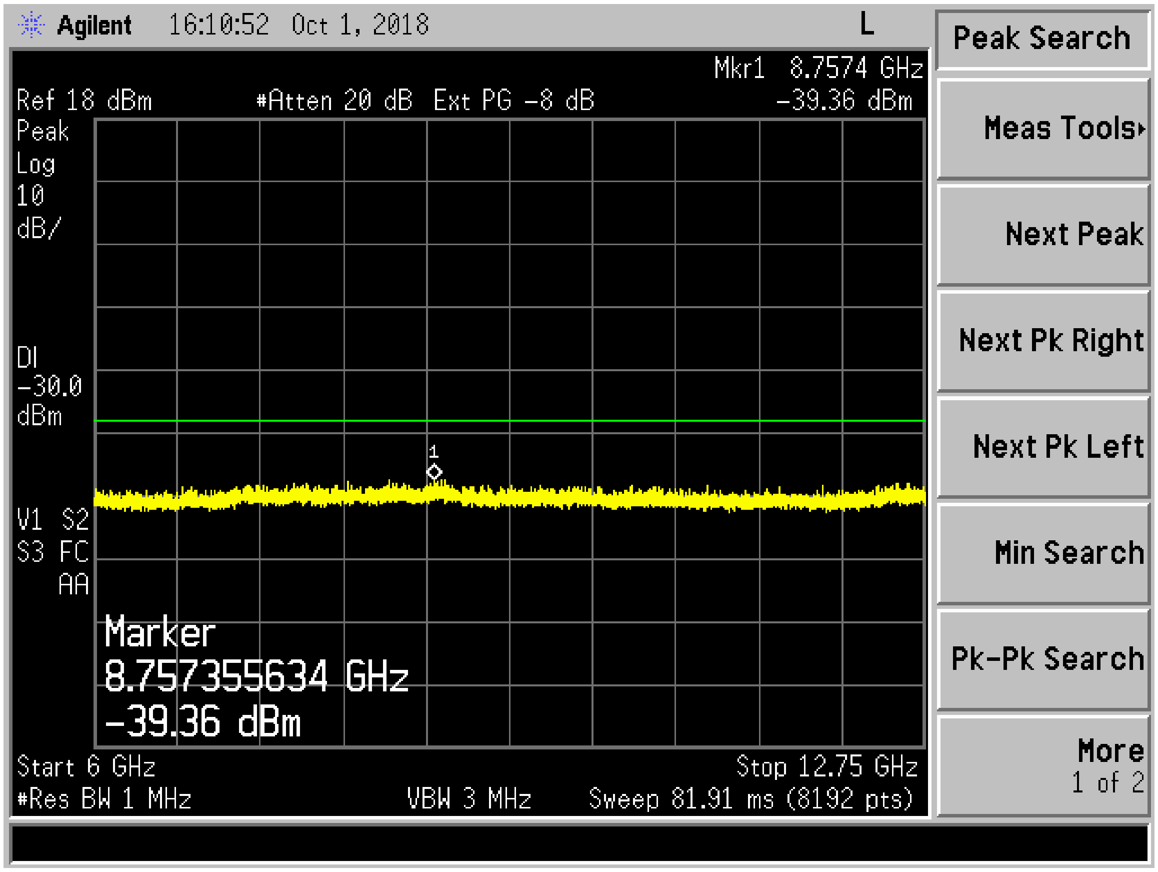


Figure 45. 802.11g, Low Channel, Plot 6

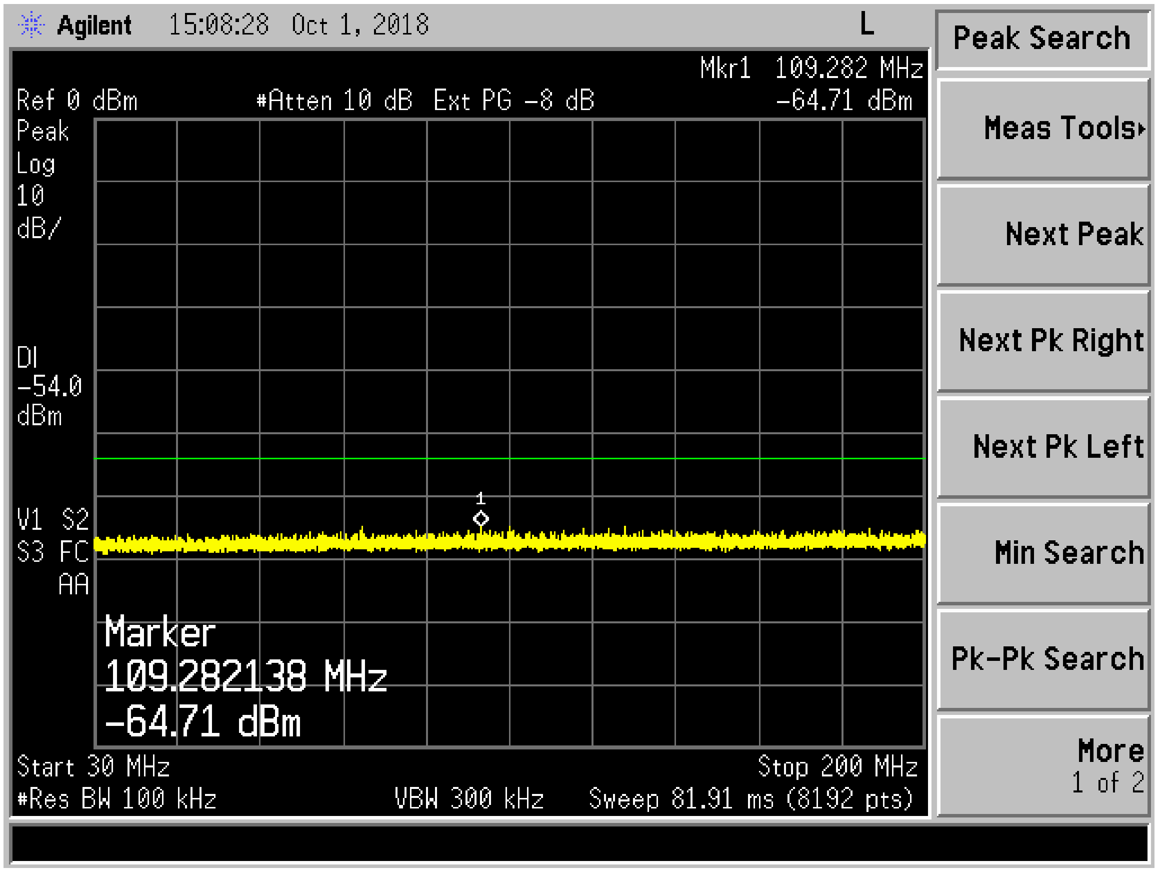


Figure 46. 802.11g, High Channel, Plot 1

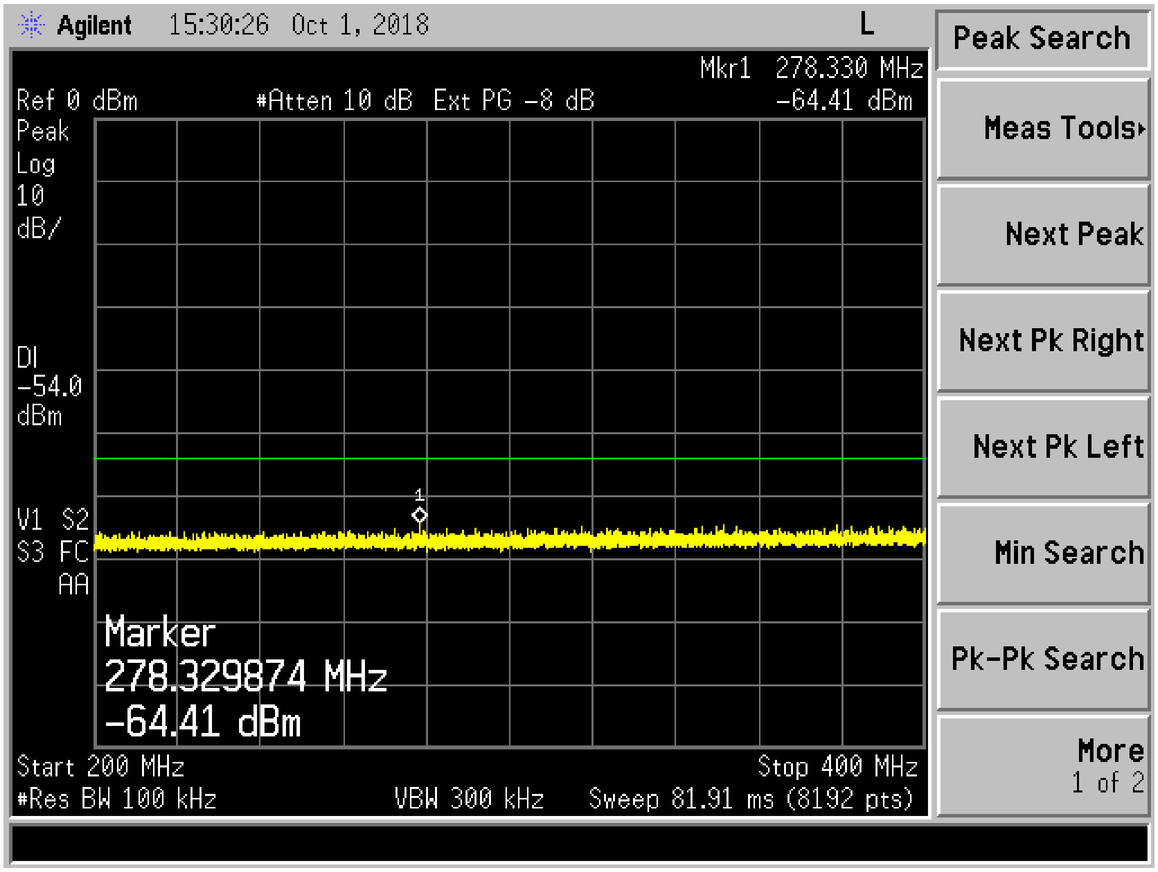


Figure 47. 802.11g, High Channel, Plot 2

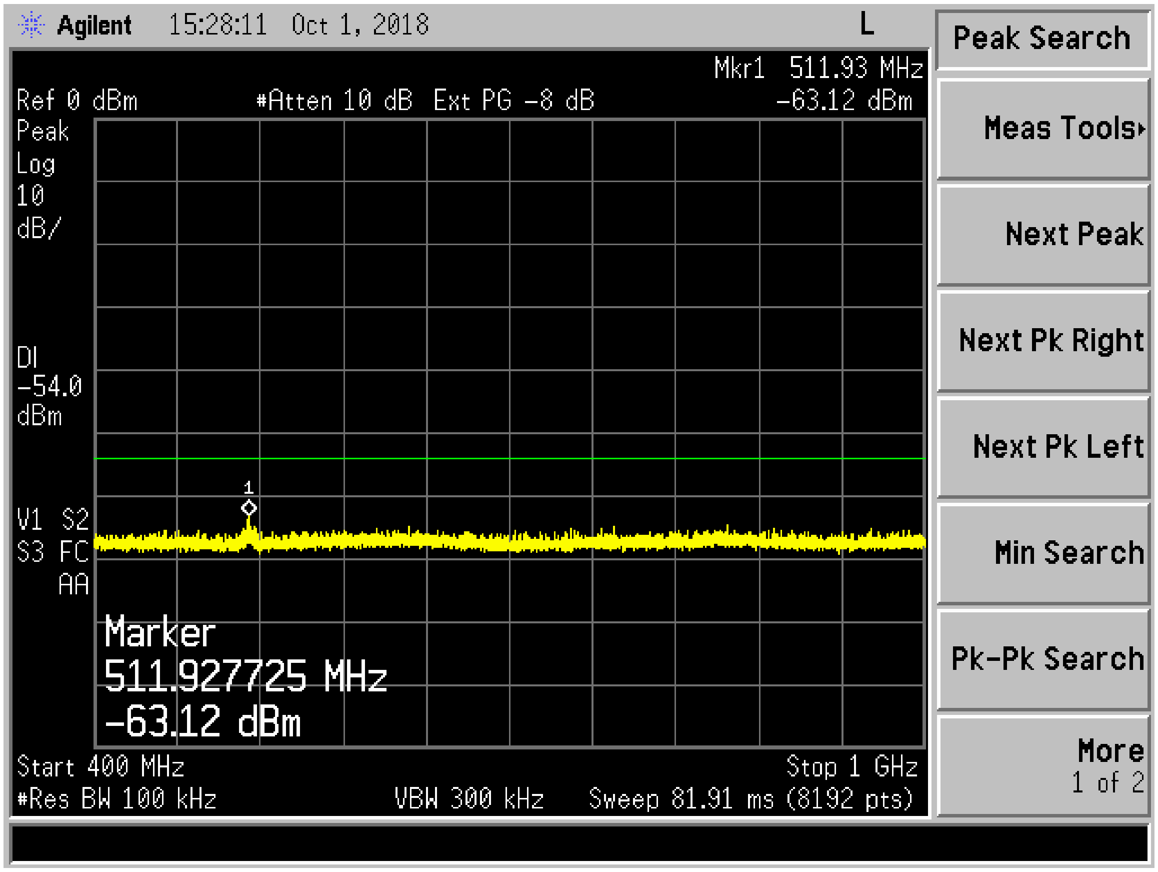


Figure 48. 802.11g, High Channel, Plot 3

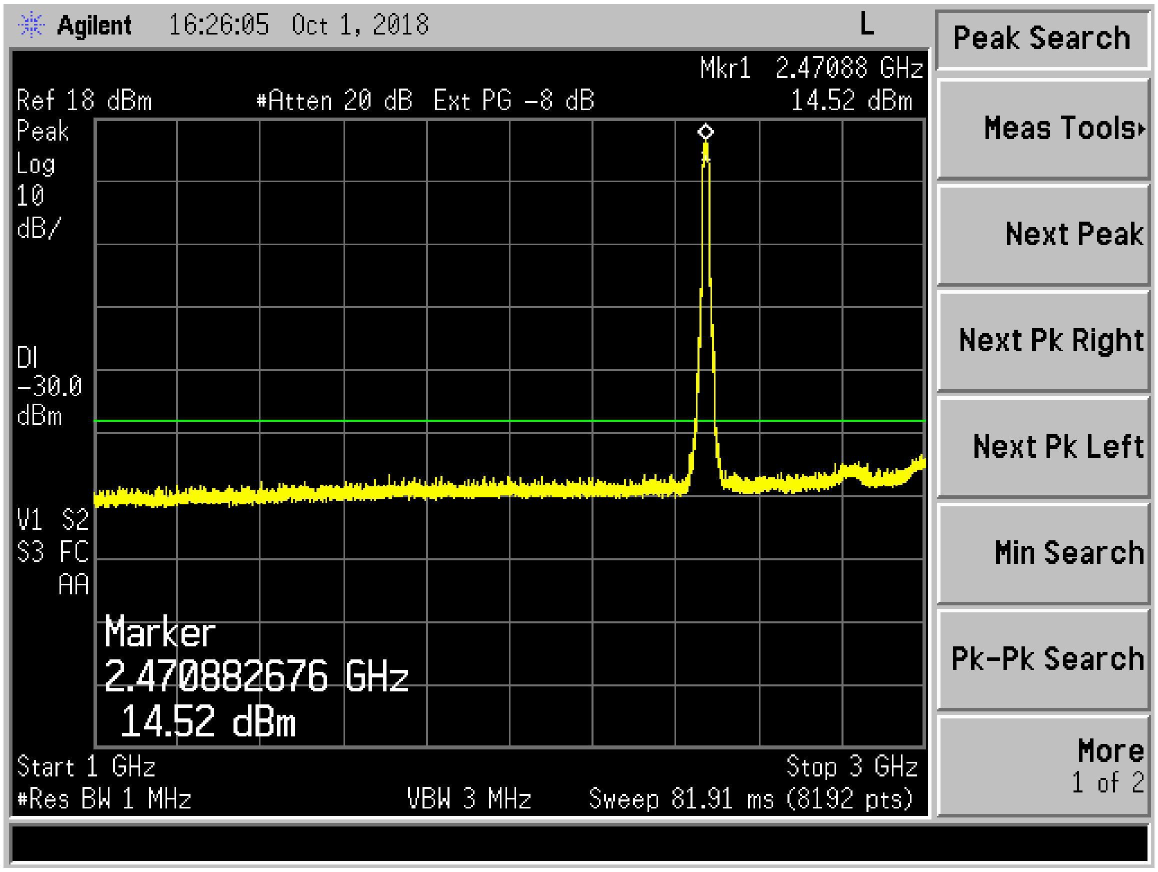


Figure 49. 802.11g, High Channel, Plot 4

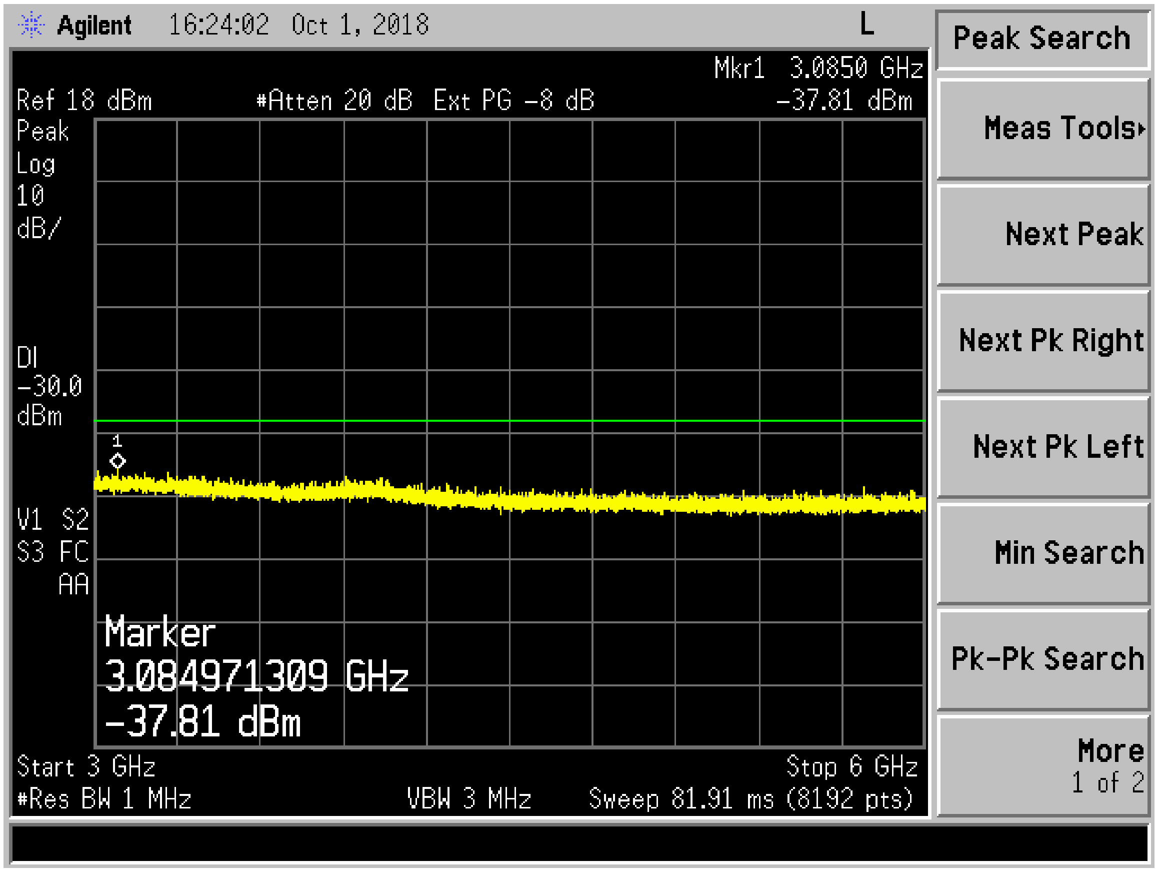


Figure 50. 802.11g, High Channel, Plot 5

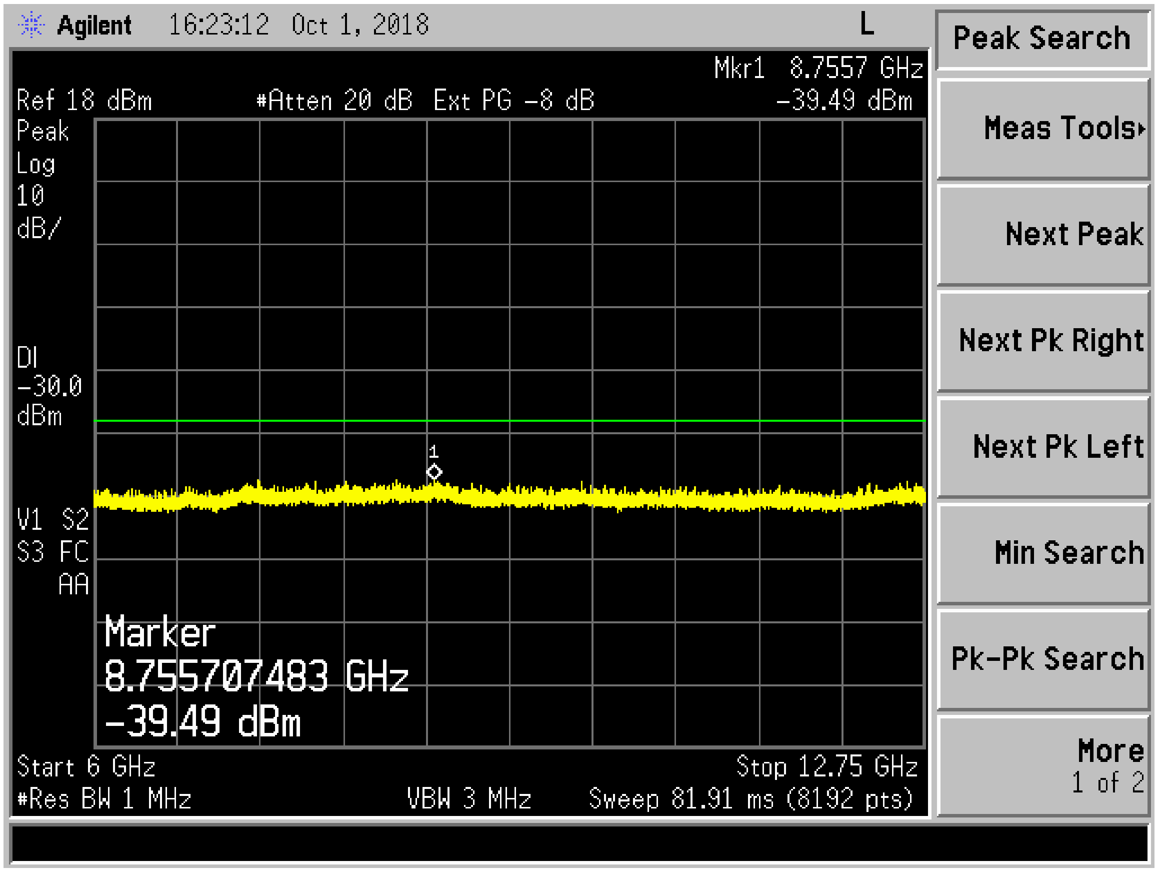


Figure 51. 802.11g, High Channel, Plot 6

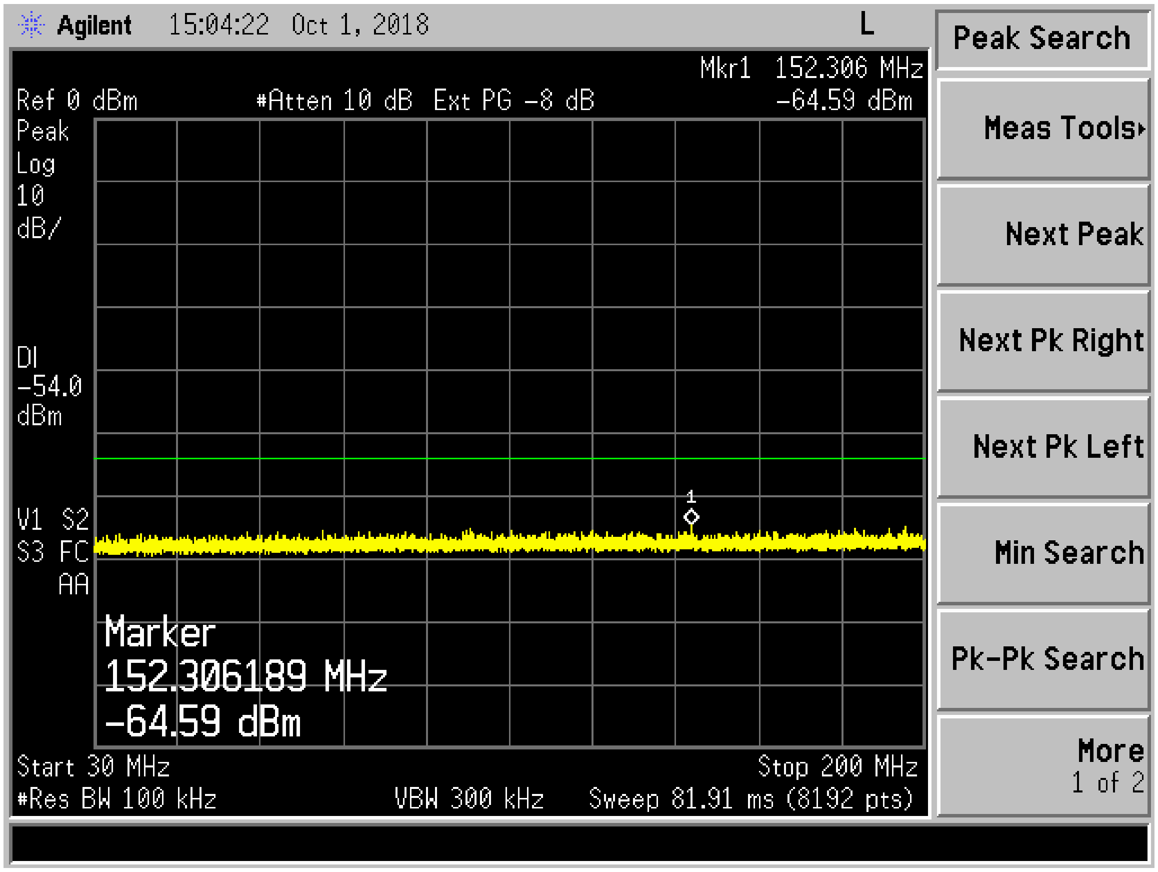


Figure 52. 802.11n, Low Channel, Plot 1

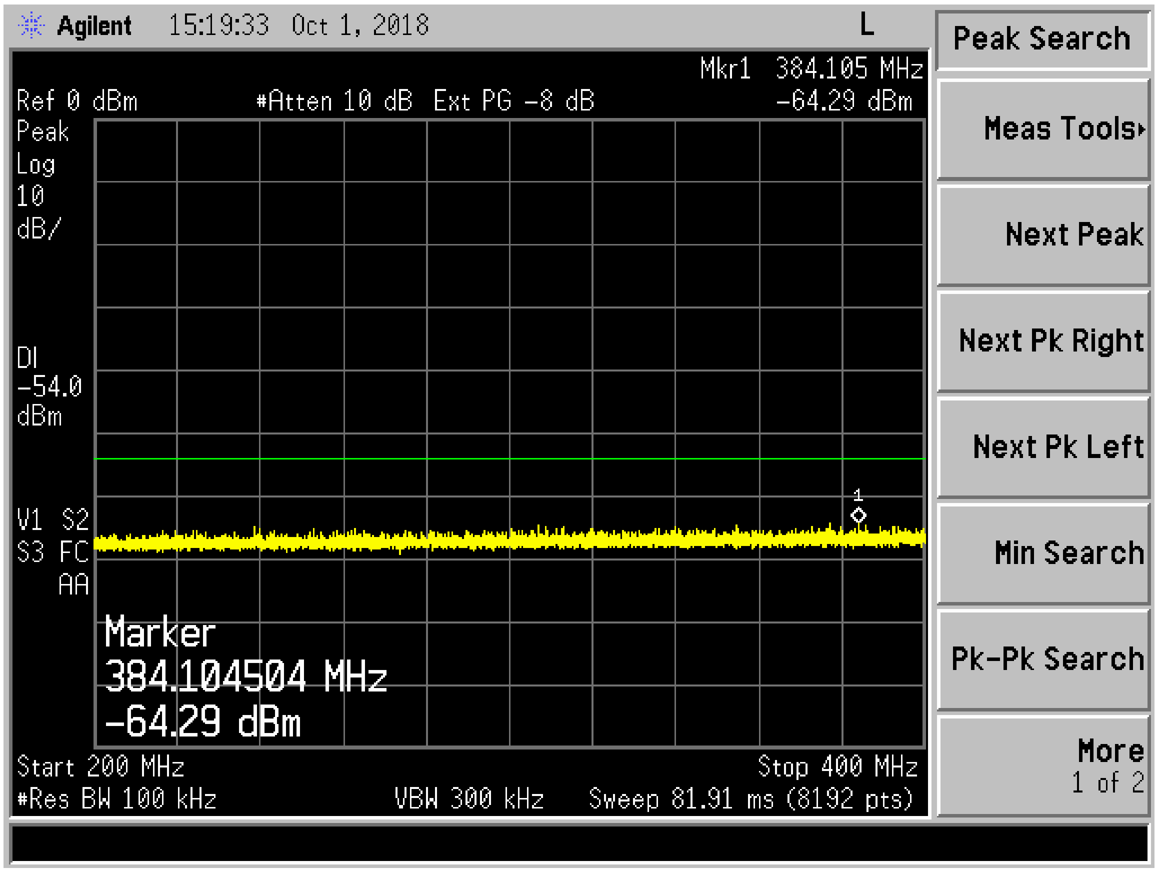


Figure 53. 802.11n, Low Channel, Plot 2

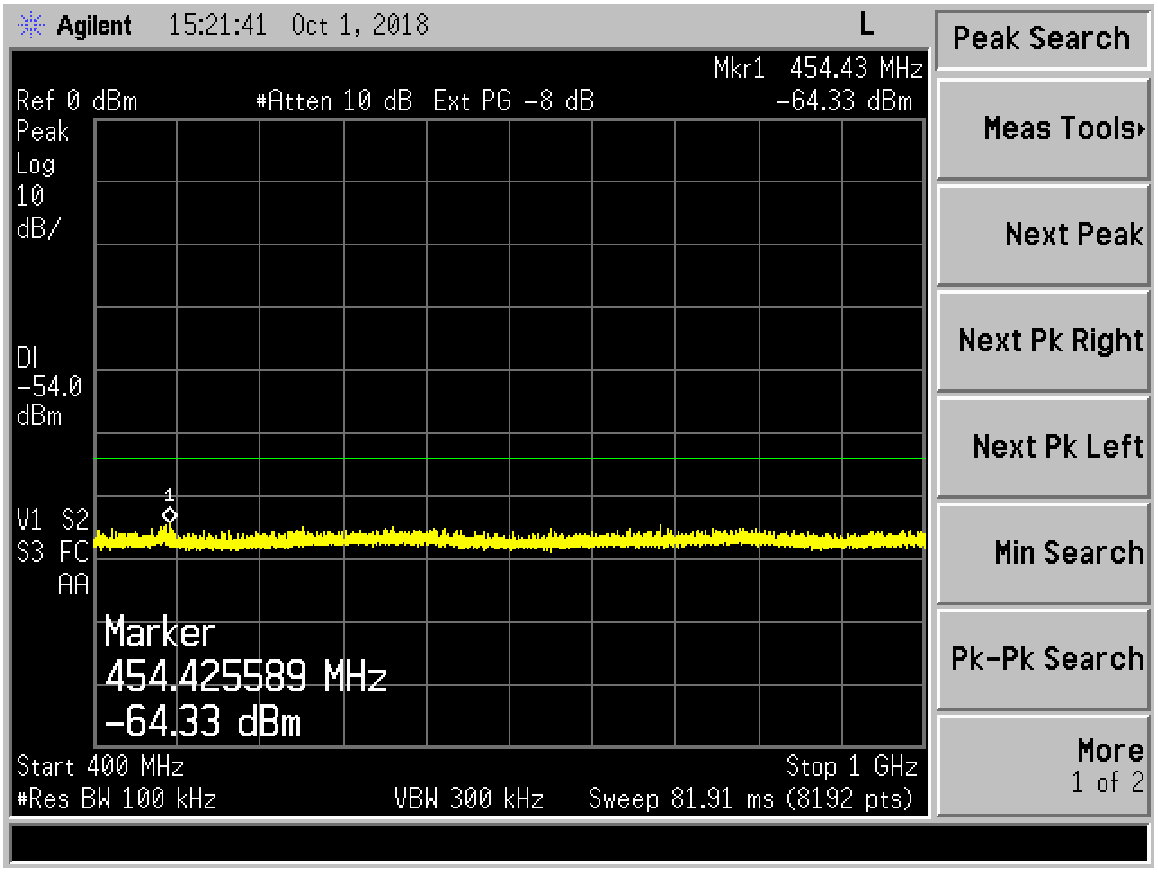


Figure 54. 802.11n, Low Channel, Plot 3

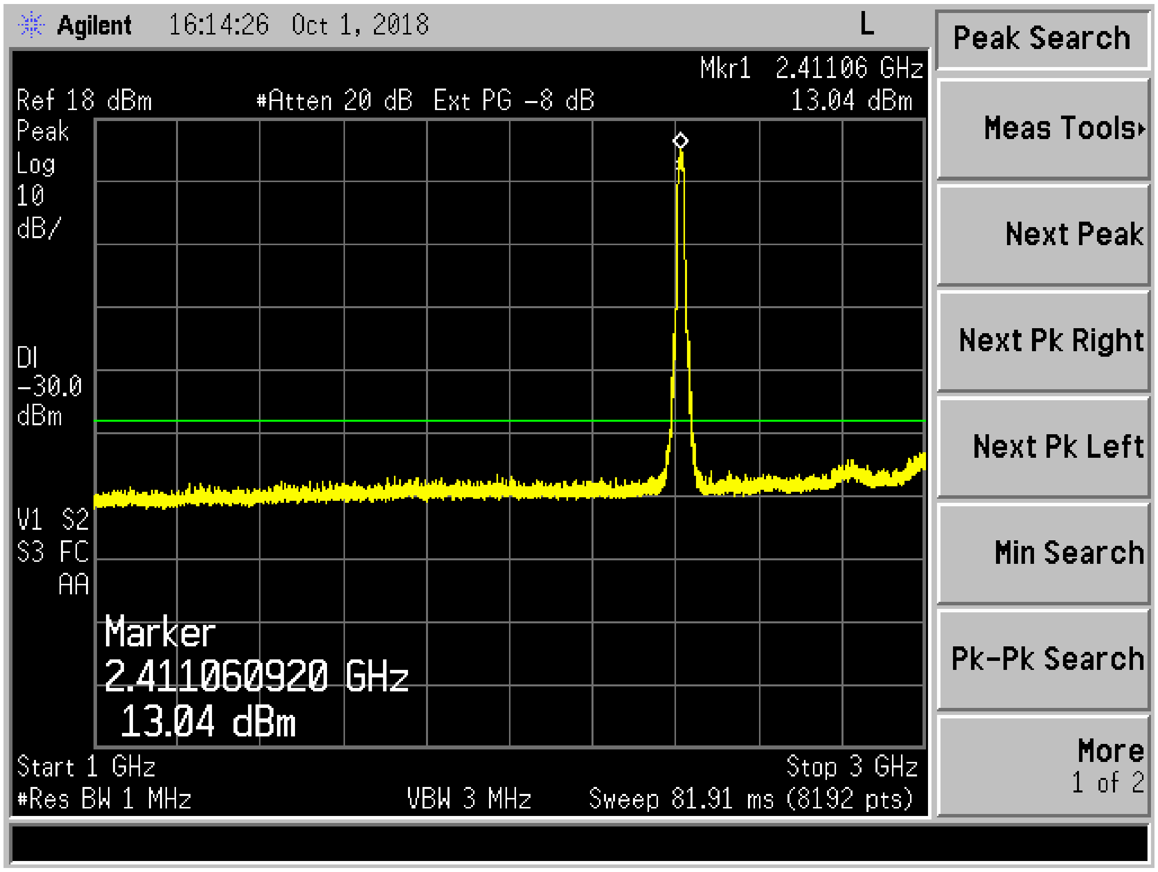


Figure 55. 802.11n, Low Channel, Plot 4

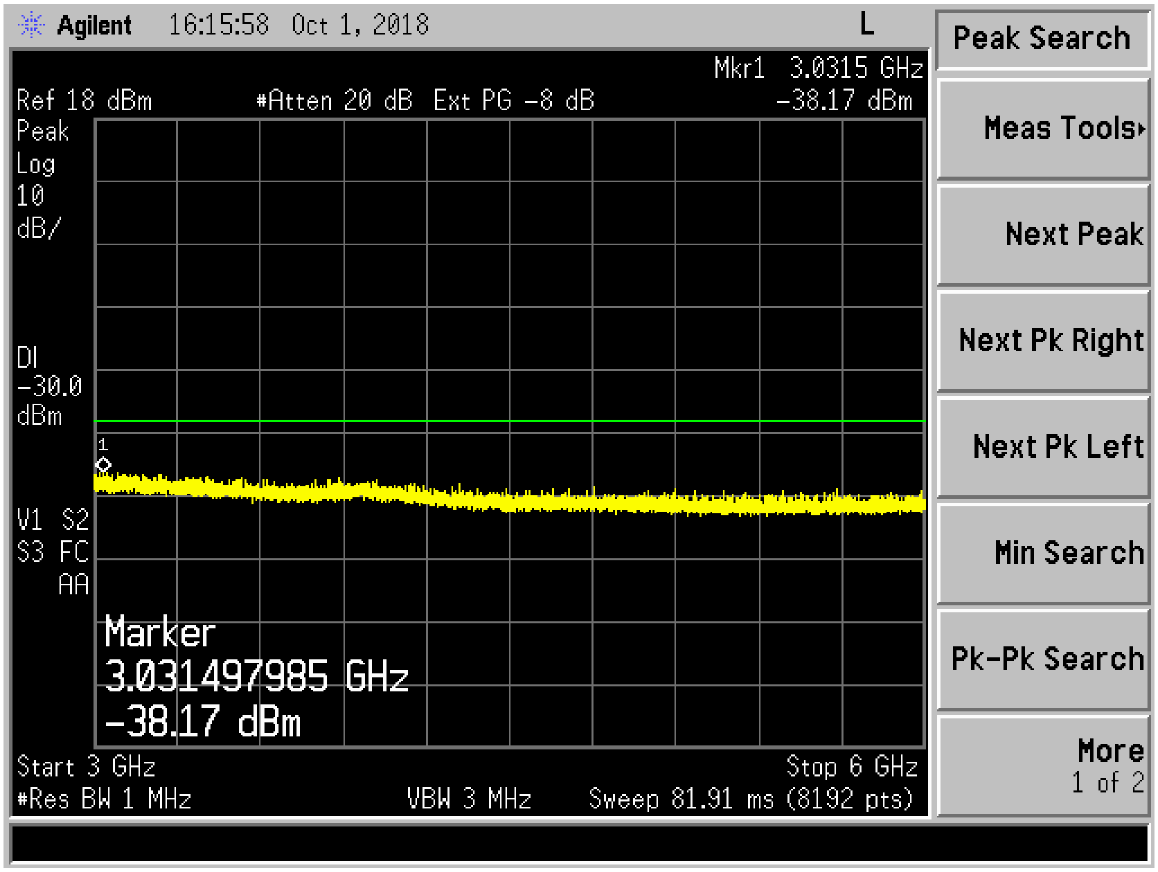


Figure 56. 802.11n, Low Channel, Plot 5

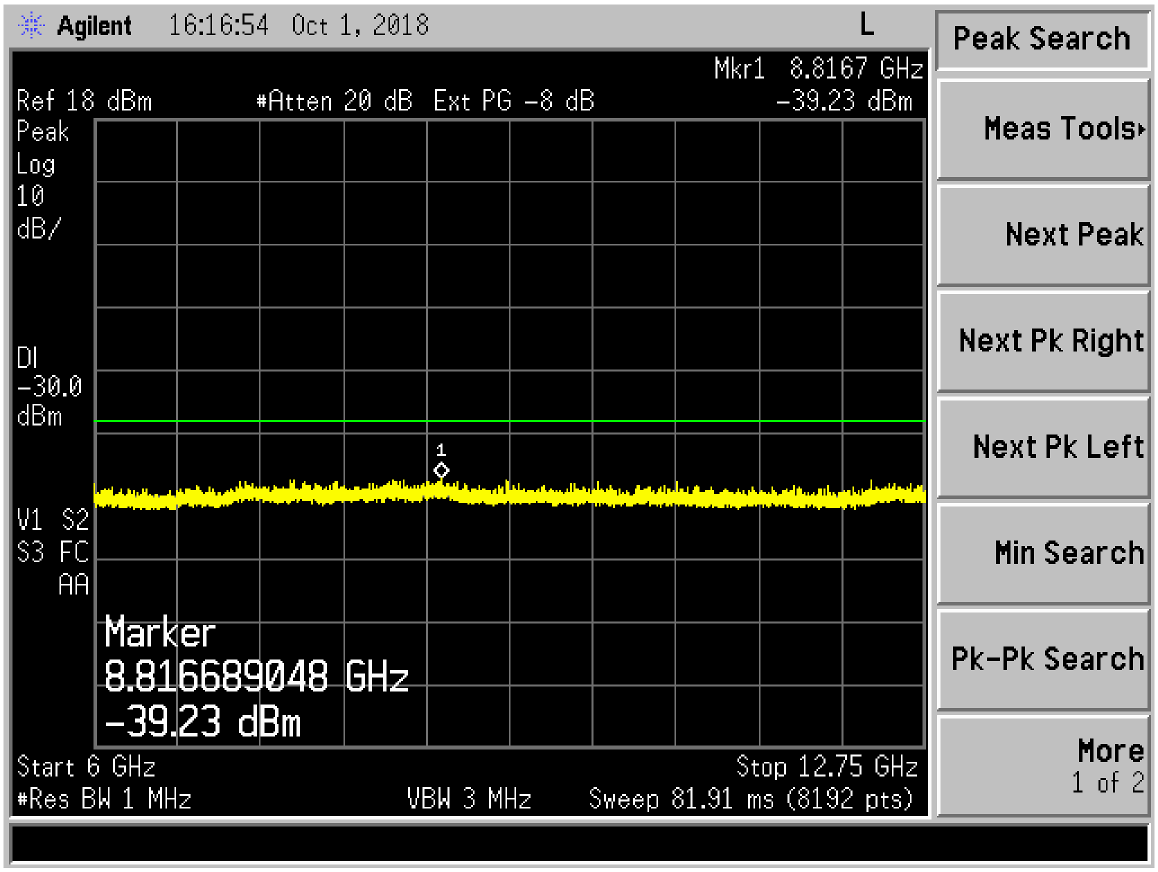


Figure 57. 802.11n, Low Channel, Plot 6

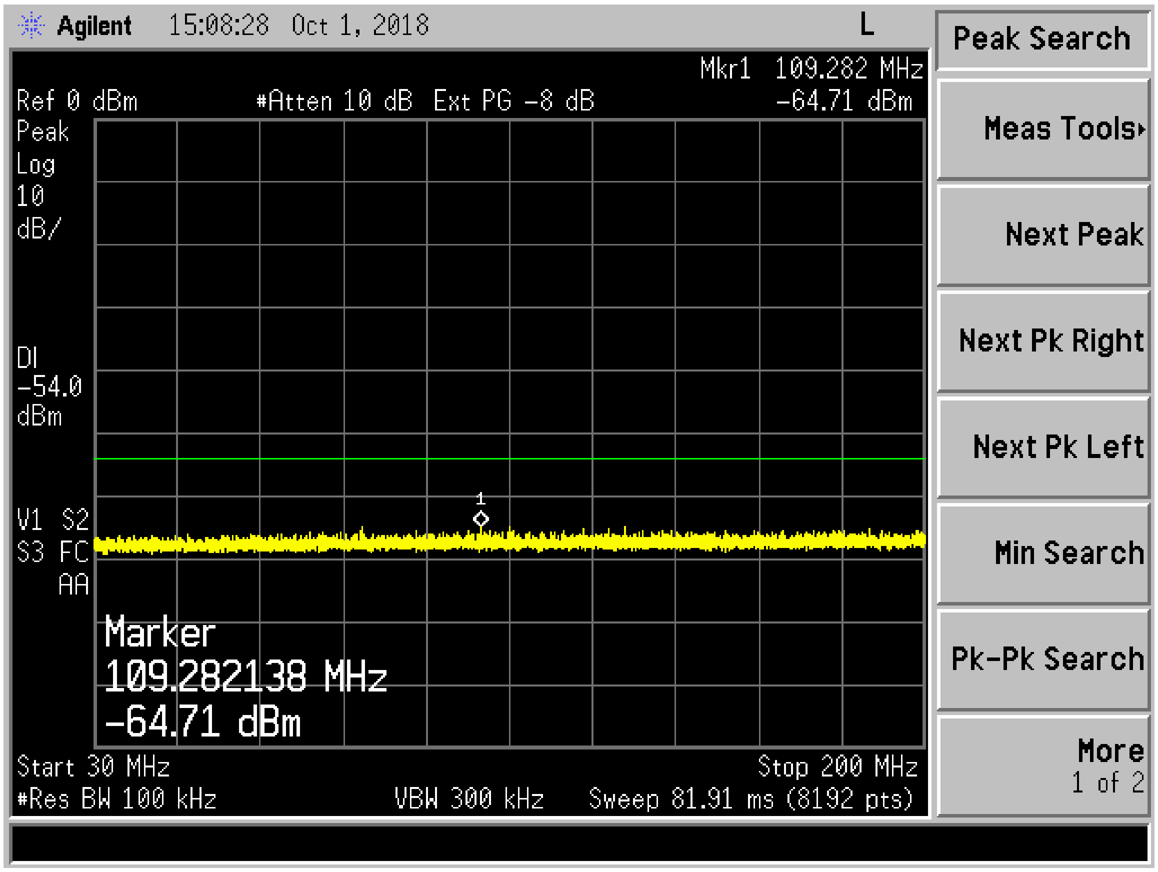


Figure 58. 802.11n, High Channel, Plot 1

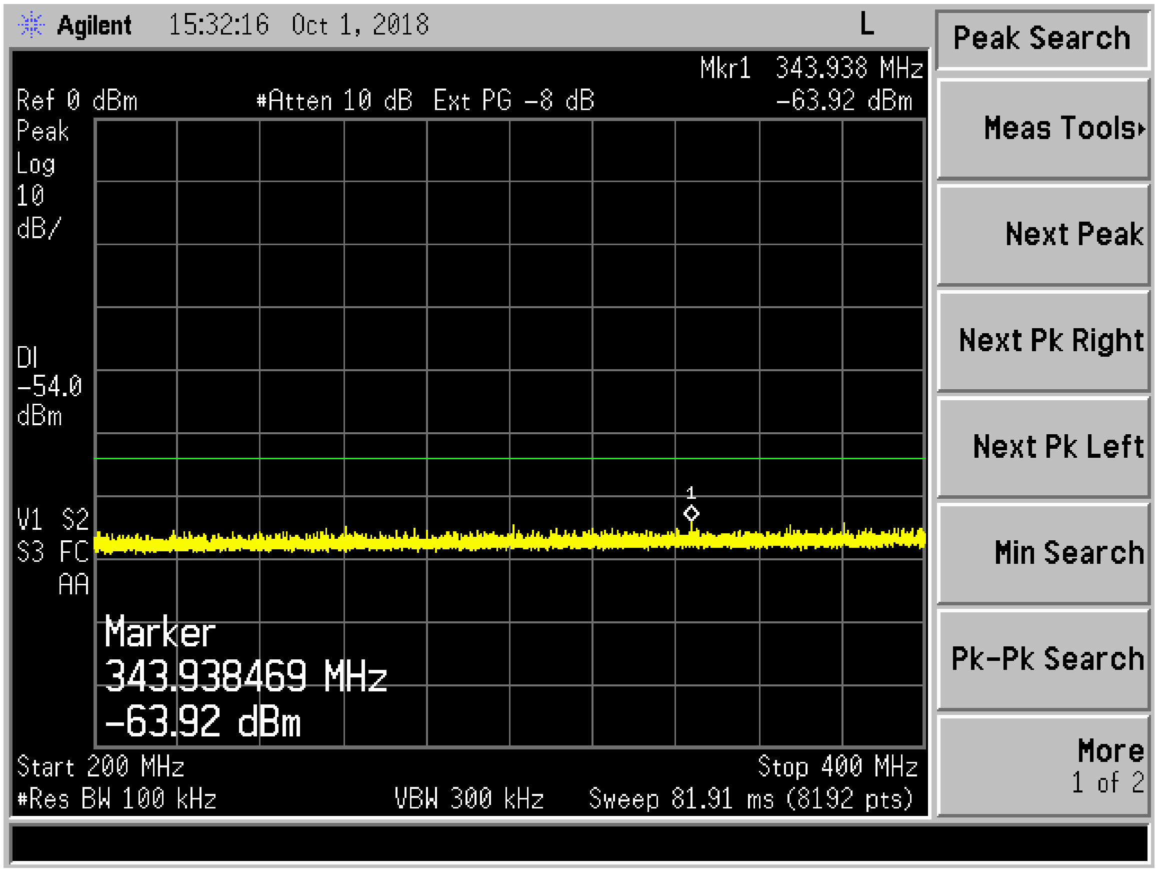


Figure 59. 802.11n, High Channel, Plot 2

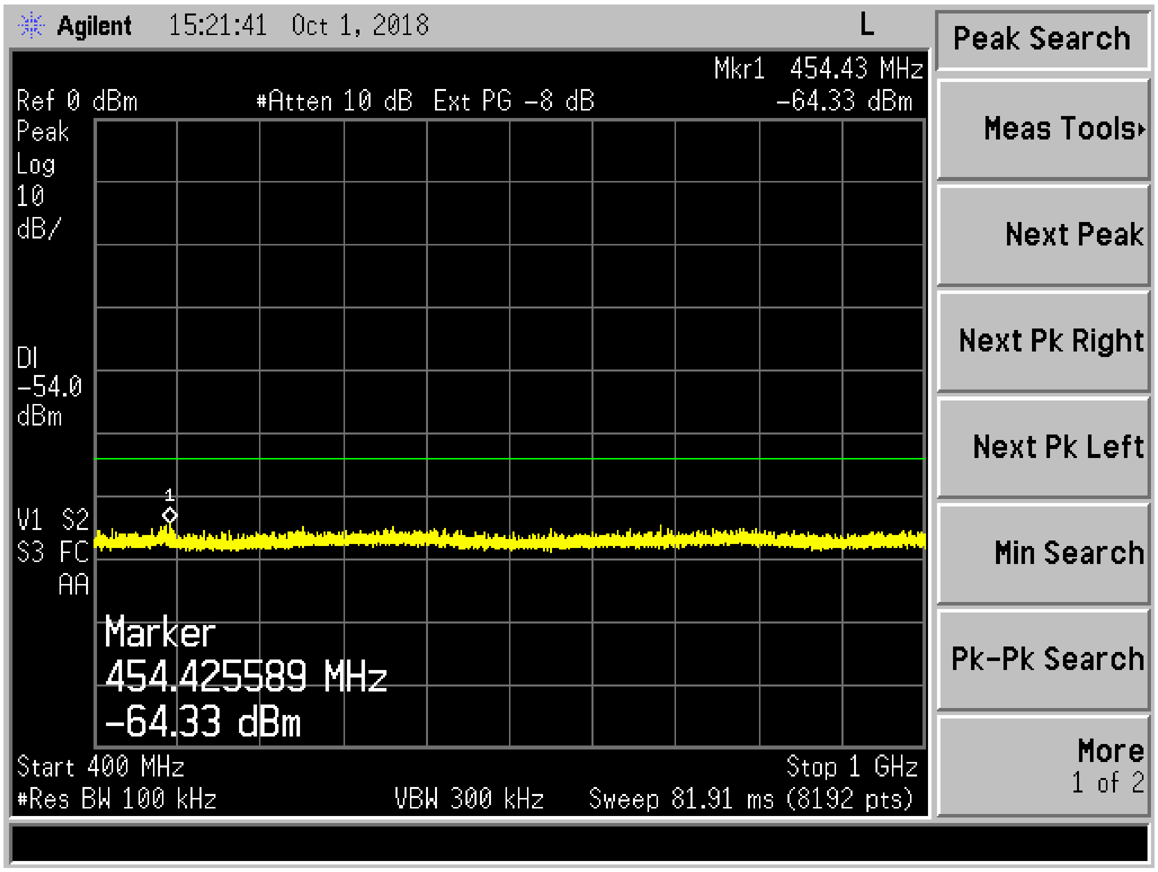


Figure 60. 802.11n, High Channel, Plot 3

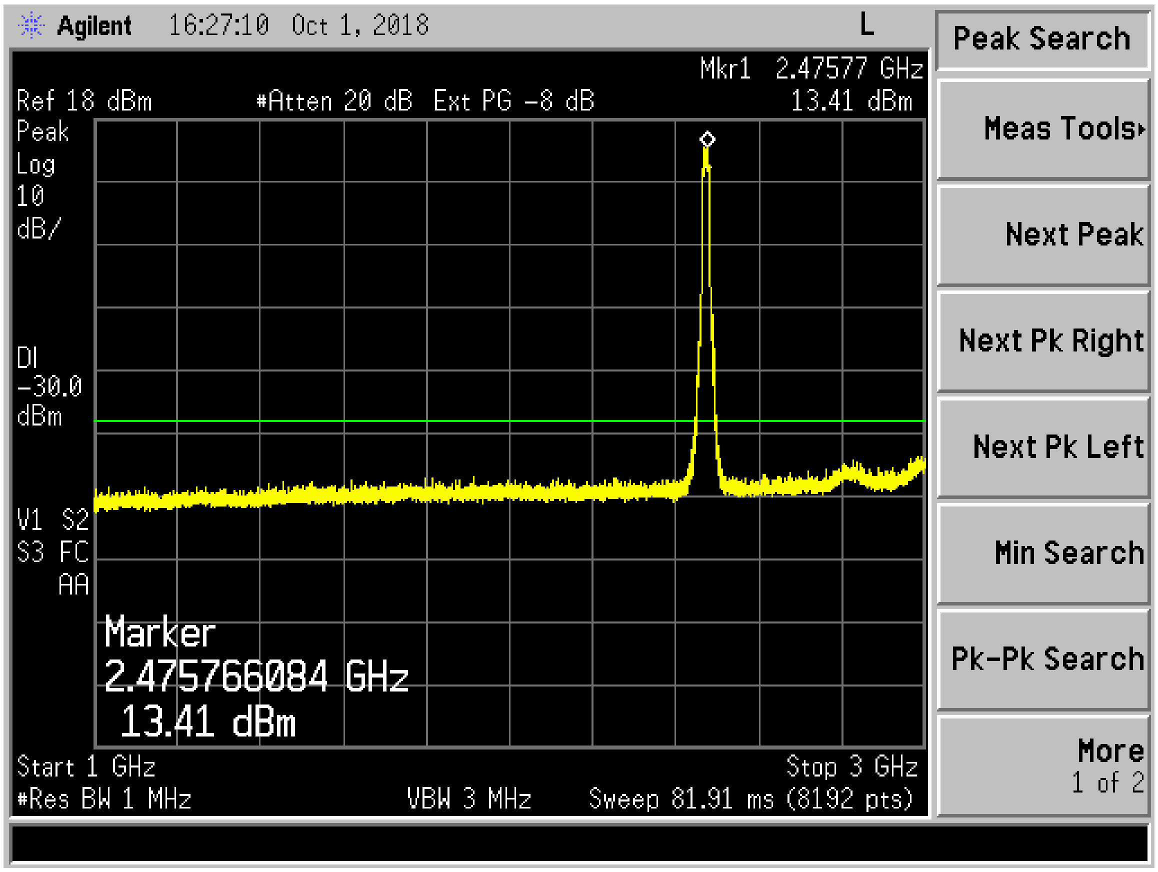


Figure 61. 802.11n, High Channel, Plot 4

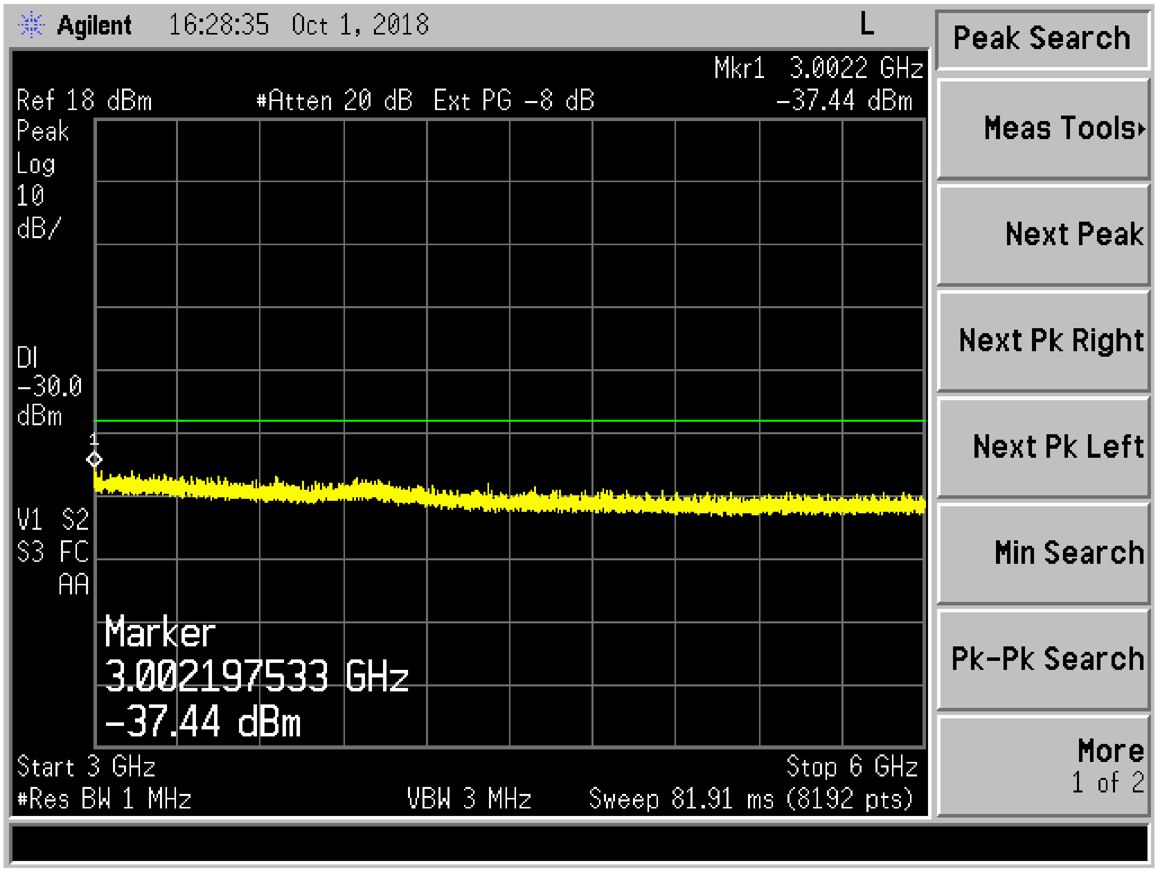


Figure 62. 802.11n, High Channel, Plot 5

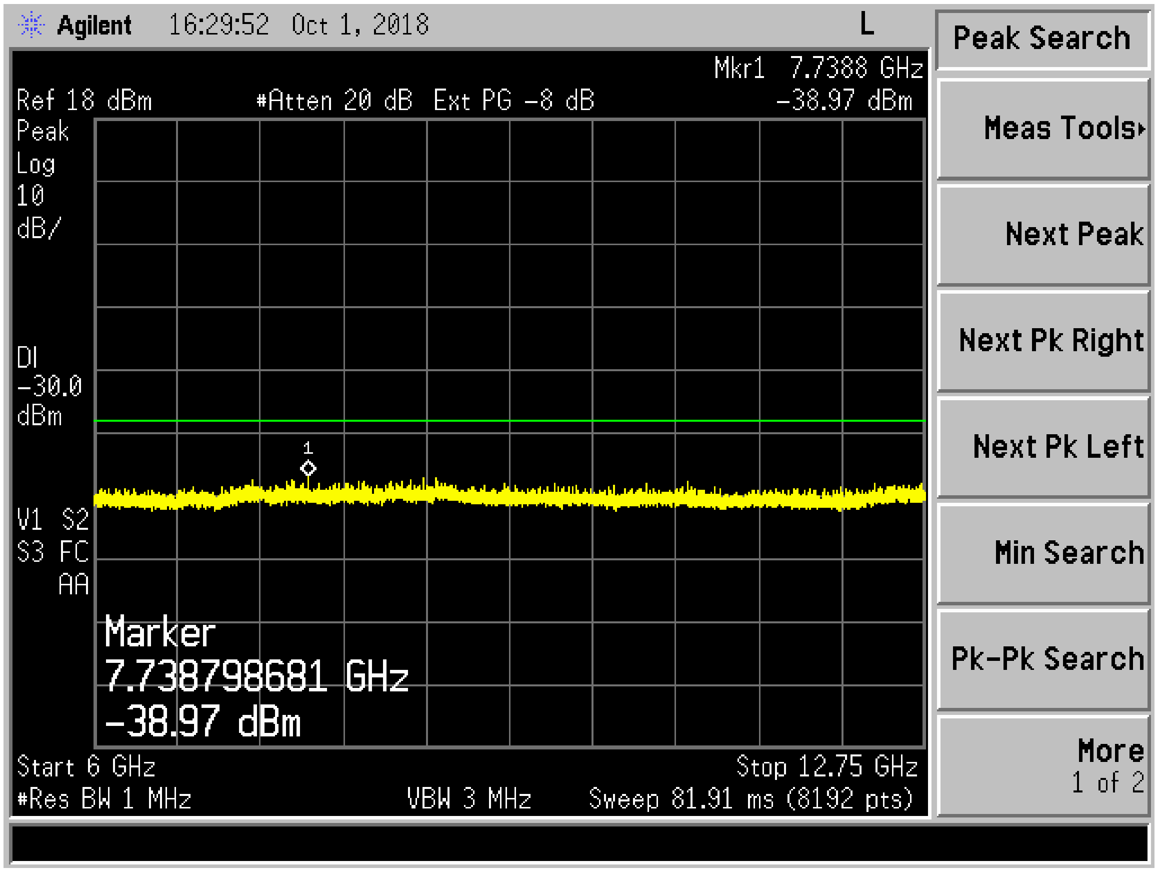


Figure 63. 802.11n, High Channel, Plot 6

5.3.10 Receiver Unwanted Emissions in the Spurious (Clause 5.4.10)

Receiver spurious emissions are the emissions at any frequency when the equipment is in receive mode. In accordance ETSI EN 300 328 section 4.3.2.11, the spurious emissions cannot be greater than the limits in the Tables following

Table 15. Spurious Emissions Limits for Receivers

Frequency Range	Maximum Power	Bandwidth
30 MHz to 1 GHz	-57 dBm	100 kHz
1 GHz to 12.75 GHz	-47 dBm	1 MHz

Table 16. Transmitter Unwanted Emissions in Spurious Domain - Horizontal

Freq. (MHz)	Maximum RX Reading (dBuV)	Recreated Reading (dBuV)	Difference Column A – B (dB)	TX Gain (dBi)	TX Gain Relative to Dipole (dB)	RF Power into TX Antenna	RF Power into Substitution TX Antenna Corrected By TX Gain Relative to Dipole and TX Cable (dBm)	Limit (dBm)	Margin (dB)
No emissions seen 6 dB above the noise floor.									

Sample calculation: N/A

5.3.11 Receiver Blocking (Clause 5.4.11)

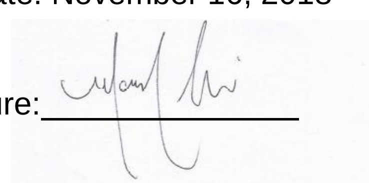
Receiver blocking is a measure of the ability of the equipment to receive a wanted signal on its operating channel without exceeding a given degradation in the presence of an unwanted signal (blocking signal) at frequencies other than those of the operating band. In accordance with ETSI EN 300 328 section 4.3.2.11.

The EUT is categorized as Receiver Category 1 equipment.

Table 17. Receiver Blocking Parameters for Receiver Category 1 Equipment

Wanted signal mean power from companion device (dBm)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 2)	Type of blocking signal
P_{min} + 6 dB	2 380 2 503,5	-53	CW
P_{min} + 6 dB	2 300 2 330 2 360	-47	CW
P_{min} + 6 dB	2 523,5 2 553,5 2 583,5 2 613,5 2 643,5 2 673,5	-47	CW
NOTE 1: P_{min} is the minimum level of the wanted signal (in dBm) required to meet the minimum performance criteria as defined in clause 4.3.2.11.3 in the absence of any blocking signal. NOTE 2: The levels specified are levels in front of the UUT antenna. In case of conducted measurements, the levels have to be corrected by the actual antenna assembly gain.			

Test Date: November 16, 2018



Signature:_______________ Tested By: Mark Afroozi

The measurements were performed at normal test conditions. The EUT uses wide band modulation other than frequency hopping Spread Spectrum (FHSS) modulation. The EUT was tested first while receiving on the lowest channel and then again while receiving on the highest channel. The system has only one receiver chain. The procedures in clause 5.4.11.2.1 were followed for this test. The test results are provided below.

Antenna Gain: +3.2 dBi
P_{min} = Threshold level of RX and TX communication link.
FHSS: No, the EUT was programmed to receive first on the lowest channel then on the highest channel.

Table 18. Blocking Signal Test Results

Wanted Signal Mean Power	Blocking Signal Frequency (MHz)	Blocking Signal Power Limit (dBm)	Actual Blocking Signal Power (dBm)
Pmin + 6 dBm	2380	-53 + max antenna gain	**> -30 dBm**
Pmin + 6 dBm	2503.5		**> -30 dBm**
Pmin + 6 dBm	2300	-47 + max antenna gain	**> -30 dBm**
Pmin + 6 dBm	2330		**> -30 dBm**
Pmin + 6 dBm	2360		**> -30 dBm**
Pmin + 6 dBm	2523.5	-47 + max antenna gain	**> -30 dBm**
Pmin + 6 dBm	2553.5		**> -30 dBm**
Pmin + 6 dBm	2583.5		**> -30 dBm**
Pmin + 6 dBm	2613.5		**> -30 dBm**
Pmin + 6 dBm	2643.5		**> -30 dBm**
Pmin + 6 dBm	2673.5		**> -30 dBm**

Test Results: The actual blocking signal power is greater than the required minimum level per the standard. The EUT meets these requirements.

5.4 RF Exposure

EN 50385:2002 MPE compliance:

The maximum output power measured is 18.01 dBm with the EUT in 802.11 b mode. This level is used to show compliance for all modes of operation.

Test Results:

Frequency range	Maximum Output Power	Power density at 0.2m distance	Limit	Result
2412 MHz to 2462 MHz	20.0 dBm	0.4158 W/m^2	10 W/m^2	PASS

Maximum Antenna Gain: 3.2 dBi = 2.09 Numeric

$S = PG/4\pi r^2$

P = 20.0 dBm = 0.100 W
G= 3.2 dBi = 2.09 numeric
r= 0.2m

$S = (0.100 * 2.09) / (4\pi*0.2*0.2) = 0.209/ 0.5027= 0.4158\ W/m^2$

The radio meets the requirements.

Test Date: December 19, 2018

Signature:____________ Tested By: George Yang

6 Test Instruments

Table 19. Test Equipment

INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	CALIBRATION DUE DATE
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	8/17/2020 2 yr.
SPECTRUM ANALYZER	N9342CN	AGILENT	SG05310114	7/21/2019 2 yr.
SIGNAL GENERATOR	70004A	HEWLETT PACKARD	70340A	Verified before use
SIGNAL GENERATOR	8648B	HEWLETT PACKARD	3642U01679	Verified before use
SIGNAL GENERATOR	MG3671B	ANRITSU	M520731M5357 3/M17473	Verified before use
BICONICAL ANTENNA	3110B	EMCO	9307-1431	10/23/2019 2 yr.
BICONICAL ANTENNA	3110B	EMCO	9306-1708	5/02/2019 2 yr.
LOG PERIODIC ANTENNA	3146	EMCO	9110-3236	5/01/2019 2 yr.
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	12/21/2018 Extended
HORN ANTENNA	SAS-571	A.H. Systems	605	10/18/2019 2 yr.
HORN ANTENNA	3115	EMCO	9107-3723	12/22/2018 Extended
PRE-AMPLIFIER	8449B	HEWLETT PACKARD	3008A00480	6/04/2019
PRE-AMPLIFIER	8447D	HEWLETT PACKARD	1937A02980	3/07/2019
RF SPLITTER/COMBINER	ZAPD-21	MINI-CIRCUITS	N/A	Verified Before Use
RF SPLITTER/COMBINER	ZFRSC-42	MINI-CIRCUITS	N/A	Verified Before Use
HIGH PASS FILTER	VHP-16	MINI-CIRCUITS	N/A	3/7/2019
COPPER SHIELD BOX	N/A	US TECH	N/A	Not Required

Note 1: The calibration interval of the above test instruments is 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.
Note 2: verified with calibrated equipment during test.

7 Photographs

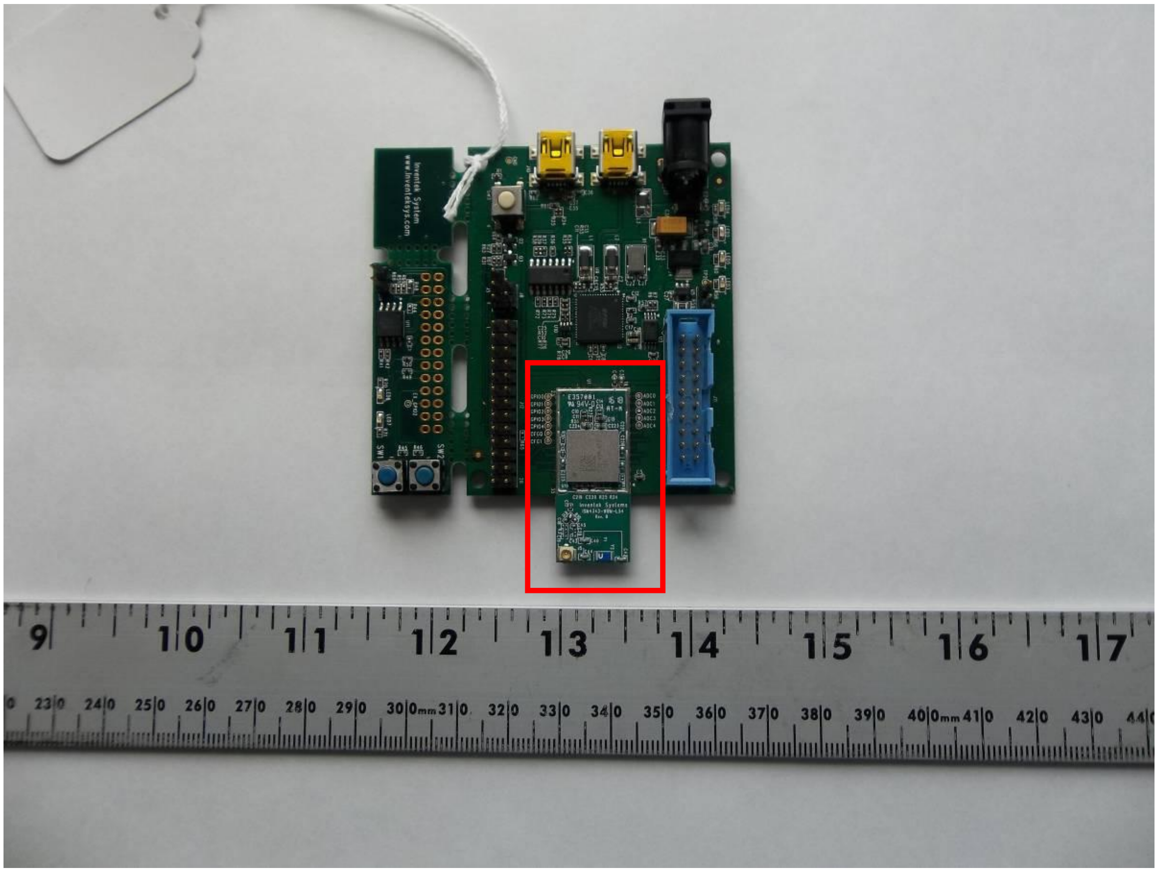


Figure 64. EUT (circled) on Evaluation Board

Figure 65. Radiated Spurious Emissions Below 200 MHz

Figure 66. Radiated Spurious Emissions Below 1000 MHz

Figure 67. Radiated Spurious Emissions Above 1000 MHz

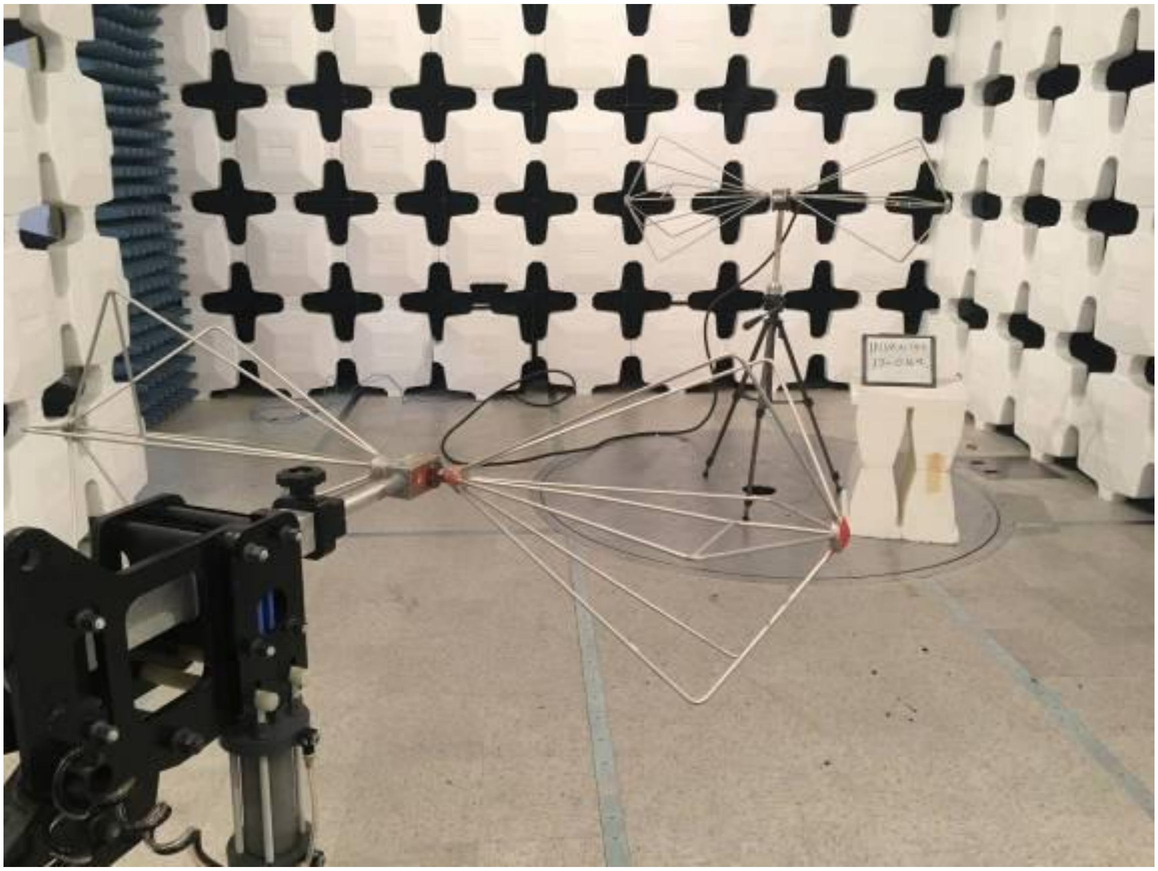


Figure 68. 30-200 MHz Substitution Test Setup

Figure 69. 200-1000 MHz Substitution Testing

Figure 70. Above 1 GHz Substitution Testing

Figure 71. Extreme Temperature Test Setup

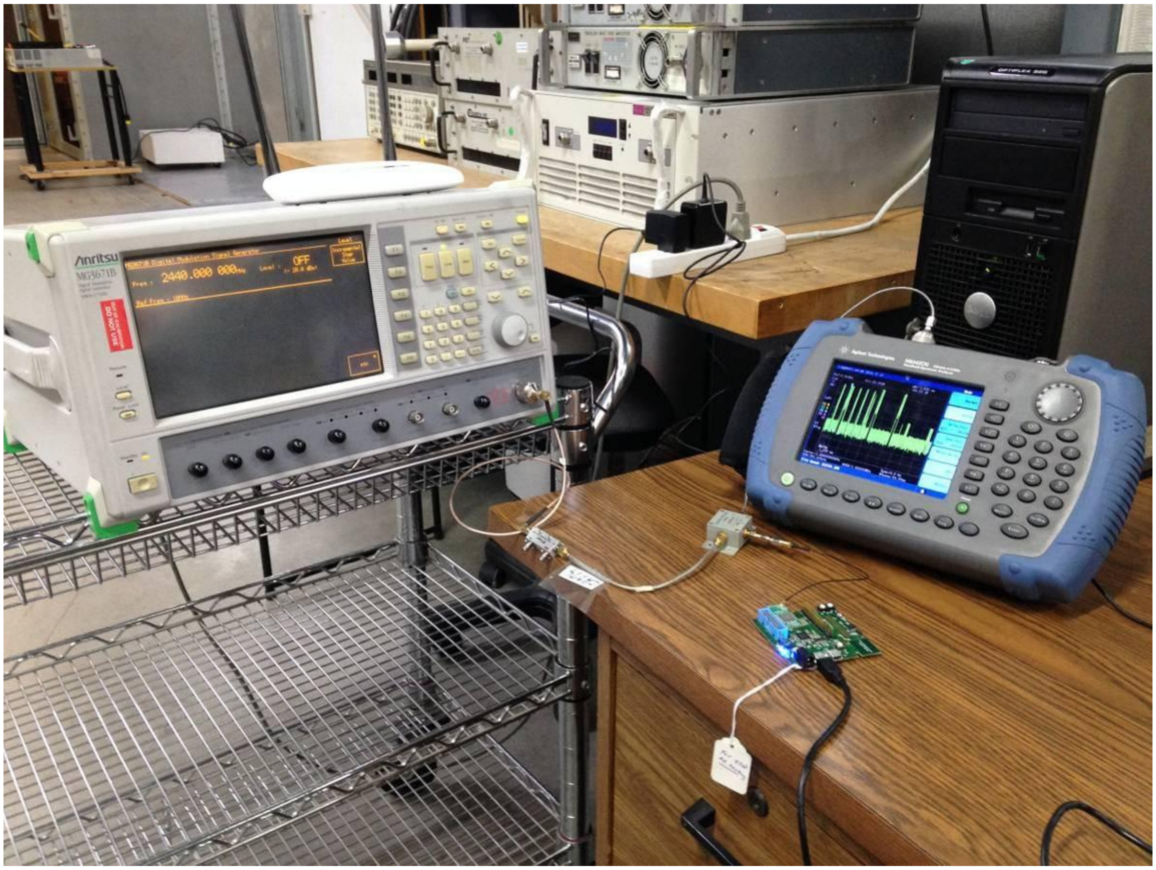


Figure 72. Adaptivity Test Setup

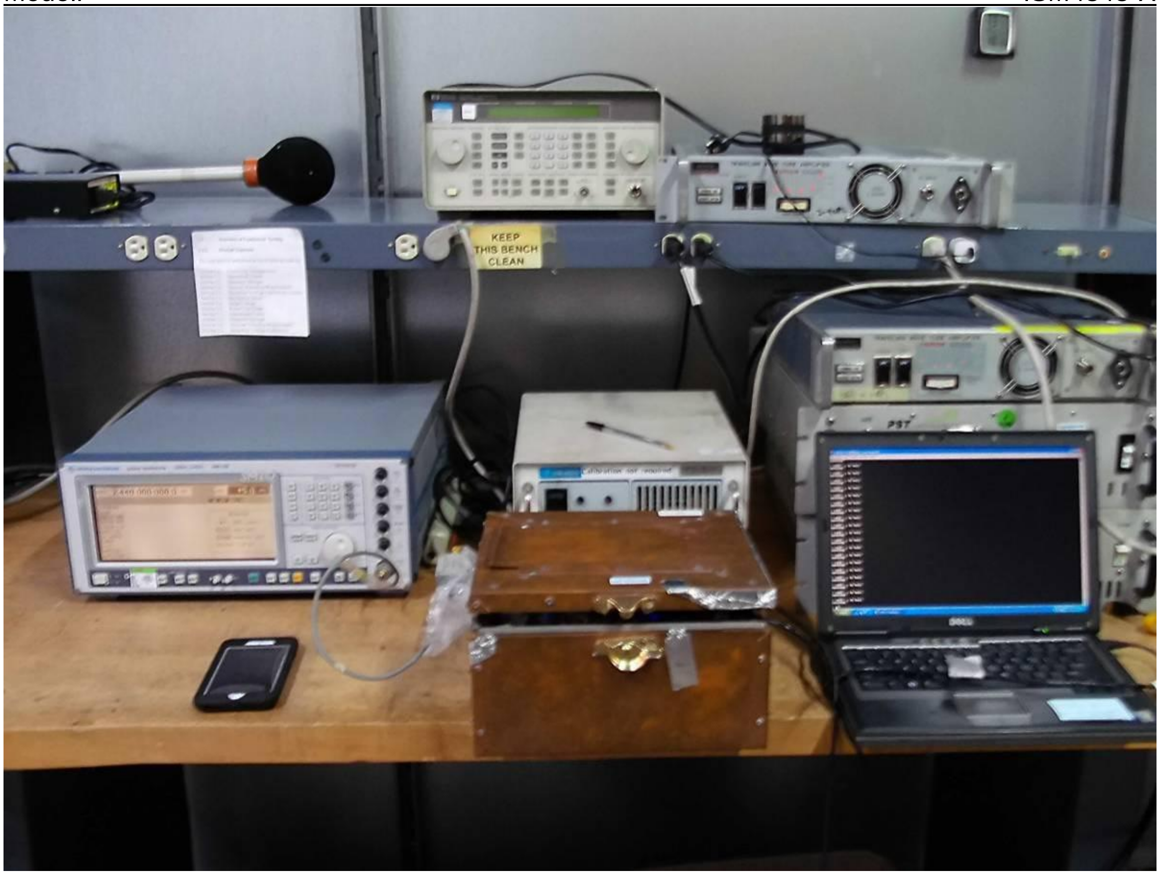


Figure 73. Receiver Blocking Test Setup

Note: EUT in receive mode placed inside the Copper Shield box during testing.