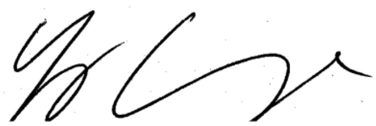
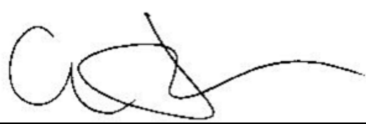
TEST REPORT OF THE Inventek Systems Model: ISM4334X-M4G-L44 IN CONFORMANCE WITH ETSI EN 300 328 V1.8.1 (2012-06) Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive

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: George Yang	Signature: 
Tested By: Carrie Ingram	Signature: 
Issue Date: November 17, 2015	**Test Dates:** June 30, 2015 through November 17, 2015

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1 Identification and Characteristics of Equipment Under Test

This section contains the unmodified Application Form submitted by the Manufacturer. The Application Form contains 9 pages, which are included in the total number of pages of this report.

The Equipment Under Test (EUT) is the Inventek Systems Model ISM4334X-M4G-L44 Module. The ISM4334X-M4G-L44 Module is an embedded wireless internet connectivity module that operates in the 2.4 Ghz, 5.0 Ghz, and 13.56 Mhz (NFC) spectrums. The Module's hardware consists of an ARM Cortex M4 host processor, Broadcom BCM43341/0 Dual-Band 802.11 g/n MAC/Baseband/Radio with integrated Bluetooth 4.0 and NFC support.

The Model Numbers to be included in the approval are:

ISM43340-M4G-L44-C
ISM43340-M4G-L44-U
ISM43341-M4G-L44-C
ISM43341-M4G-L44-U
ISM43340-M4G-L44-10CFH
ISM43340-M4G-L44-10UFH
ISM43341-M4G-L44-10CFH
ISM43341-M4G-L44-10UFH
ISM341-USB

The different model numbers for are marketing purposes: The ISM43340 does not support NFC, the ISM43341 supports NFC. The C or U is for the antenna to be used, either the chip (C) or the external antenna path (U). The F is for an optional external Flash memory, and the H is for Apple HomeKit. The final part number, ISM341-USB, is for a specific customer and includes the NFC filter circuit.

The EUT has two antenna options, a dual band chip antenna or a U.FL connector for use with an approved external antenna.

The 2.4 and 5.0 GHz Wi-Fi and NFC radio features have been tested and the results detailed in a separate report.

Antenna Gain: 1.4 dBi (Chip-AA077); 2.6 dBi (u.fl external antenna-W2.4-5P-U)
Modulation: 20 MHz bandwidth modulation at up to 144 Mbps
Maximum Output Power: 12.44 dBm EIRP (as reported herein)

2 Standard Specific Transmitter Requirements

E.1 Information as required by EN 300 328 V1.8.1, clause 5.3.1

In accordance with EN 300 328, clause 5.3.1, the following information is provided by the supplier.

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: 79

  The minimum number of Hopping Frequencies: 79

- The Dwell Time:2.79 msec
- The Minimum Channel Occupation Time: 6.6 msec

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

☐ Not Assessed. EIRP ≤ 10 dBm

d) In case of adaptive equipment:

The Channel Occupancy Time implemented by the equipment: N/A

☐ 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: µs

The value q as referred to in clause

☒ The equipment has implemented a non-LBT based mechanism

☐ The equipment can operate in more than one adaptive mode

☐ Not Assessed. EIRP ≤ 10 dBm

e) In case of non-adaptive Equipment:

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

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

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

12.44 dBm (EIRP)

Power Spectral Density

N/A

Duty cycle, Tx-Sequence, Tx-gap

N/A

Dwell time, Minimum Frequency Occupation & Hopping Sequence (only for FHSS equipment)

2.79 msec, 6.6 msec, 79 channel sequence

Hopping Frequency Separation (only for FHSS equipment)

1114.45 kHz

Medium Utilization

N/A

Adaptivity & Receiver Blocking

See Section 4.3.7

Occupied Channel Bandwidth

877 kHz

Transmitter unwanted emissions in the OOB domain

See Figures 10 through 31 and Tables 5 through 7

Transmitter unwanted emissions in the spurious domain

See Figures 32 through 40

Receiver spurious emissions

See Figures 41 through 44

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

☒ Operating mode **1**: Single Antenna Equipment

☒ Equipment with only 1 antenna

☐ Equipment with 2 diversity antennas but only 1 antenna active at any moment in time

☐ Smart Antenna Systems with 2 or more antennas, but operating in a (legacy) mode where only 1 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 Occupied Channel Bandwidth 1

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

NOTE: 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 Occupied Channel Bandwidth 1

☐High Throughput (> 1 spatial stream) using Occupied 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:

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: 2402 MHz to 2480 MHz
- Operating Frequency Range 2:_ MHz to _ MHz

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

j) Occupied Channel Bandwidth(s):

- Occupied Channel Bandwidth 1: 877 kHz
- Occupied Channel Bandwidth 2: N/A kHz
- Occupied Channel Bandwidth 3: N/A kHz

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 extreme operating conditions that apply to the equipment:

Operating temperature range: -10 ° C to 65 ° C

Operating voltage range: 3.3 V to 3.3 V ☐AC ☒DC

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

Antenna Gain: 1.4 dBi (Chip) 2.6 dBi (U.FL)

If applicable, additional beamforming gain (excluding basic antenna gain): N/A dB

☐ 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: _dBm

Power Level 2: _dBm

Power Level 3: _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: 9.84 dBm (as measured conducted)

Number of antenna assemblies provided for this power level:

Assembly #	Gain (dBi)	e.i.r.p. (dBm)	Part number or model name
1	1.4	11.24	AA077
2			
3			
4			

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

Power Level 2: 9.84dBm

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	12.44	W2.4-5P-U
2			
3			
4			

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

Power Level 3: _dBm

Number of antenna assemblies provided for this power level:

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

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: 3.3V

In case of DC, indicate the type of power source

- ☐ Internal Power Supply
- ☒ External Power Supply or AC/DC adapter
- ☐ Battery
- ☐ Other:

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

State 1: The EUT was able to continuously transmit on one of the individual channels.
State 2: The EUT was able to continuously hop on one of the individual channels.
State 3: The EUT was able to continuously hop on all of the channels.
State 4: The EUT was able to receive on a channel.

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

Bluetooth 4.0

E.2 Combination for testing (see clause 5.1.3.3 of EN 300 328 V1.8.1)

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 5.1.3.3.

Highest overall e.i.r.p. value: 12.44 dBm	
Corresponding Antenna assembly gain: 2.6 dBi	Antenna Assembly #: 2
Corresponding conducted power setting: 9.84 dBm (also the power level to be used for testing)	Listed as Power Setting #: 2

E.3 Additional information provided by the applicant

E.3.1 Modulation

ITU Class(es) of emission:

Can the transmitter operate unmodulated?

- ☐ yes
- ☒ no

E.3.2 Duty Cycle

The transmitter is intended for:

- ☐ Continuous duty
- ☐ Intermittent duty
- ☒ Continuous operation possible for testing purposes

E.3.3 About the EUT

- ☒ The equipment submitted is representative production models
- ☐ If not, the equipment submitted is pre-production models?
- ☐ If pre-production equipment is submitted, the final production equipment will be identical in all respects with the equipment tested
- ☐ If not, supply full details

  ....

  ....
- ☐ The equipment submitted is CE marked
- ☐ In addition to the CE mark, the Class-II identifier (Alert Sign) is affixed.

E.3.4 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:
  - Model #:
  - Model name:
- ☐ Combined equipment
  - Manufacturer:
  - Model #:
  - Model name:
- ☐ User Manual
- ☐ Technical documentation (Handbook and circuit diagrams)

3 Technical Summary

Applicant information

Applicant's representative	:	Kevin Tierney
Company	:	Inventek Systems
Address	:	2 Republic Rd
City	:	Billerica
State	:	MA
Postal code	:	01862
Country	:	United States
Telephone number	:	978-667-1962
Fax number	:	978-667-1949

Description of test item

Test item	:	ISM4334X-M4G-L44
Manufacturer	:	Inventek Systems Inc.
Power Characteristics	:	12.44 dBm EIRP
Frequency Characteristics	:	2.402 – 2.480 GHz
Type	:	Bluetooth 4.0
Modulation Type	:	FHSS
Temperature Range	:	-10˚C to 65˚C
Receipt number	:	15-0189
Receipt date	:	November 17, 2015
Specification(s)	:	None
Model Name	:	ISM4334X-M4G-L44
Model Number	:	ISM4334X-M4G-L44
Serial number	:	Engineering Sample
Revision	:	Rev. 0
Receipt number	:	15-0189
Receipt date	:	June 18, 2015

Test(s) performed

Location	:	US Tech
Tests started	:	June 30, 2015
Tests completed	:	November 17, 2015
Purpose of tests	:	Compliance with standard
Test specifications	:	ETSI EN 300 328 V1.8.1 (2015-02)
Test engineer(s)	:	Carrie Ingram
Project leader	:	George Yang
Report written by	:	Carrie Ingram
Report approved by	:	George Yang
Report date	:	November 17, 2015

4 Measurements, Examinations and Derived Results

4.1 Tests Required

The following Tests are required per EN 300 328 V1.8.1:

Table 1. Transmitter Test Suites and Overview of Results

Essential Radio Test suite	Applicable	Reference Clause in this Report	Referenced Clause in Standard	Compliance Results
RF Output Power	Yes	4.3.1	5.3.2	Compliant
Duty Cycle	No	4.3.2	5.3.2	N/A
Medium Utilization	No	4.3.3	5.3.2	N/A
Power Spectral Density	No	4.3.4	5.3.3	N/A
Accumulated Transmit Time, Frequency Occupation and Hopping Sequence	Yes	4.3.5	5.3.4	Compliant
Hopping Frequency Separation	Yes	4.3.6	5.3.5	Compliant
Occupied Channel Bandwidth	Yes	4.3.8	5.3.8	Compliant
Transmitter Unwanted Emissions in the OOB Domain	Yes	4.3.10	5.3.9	Compliant
Transmitter Spurious Emissions	Yes	4.3.11	5.3.10	Compliant

Table 2. Receiver Test Suites and Overview Results

Essential Radio Test suite	Applicable	Reference clause in this report	Referenced clause in standard	Compliance Results
Adaptively	No	4.3.9	5.3.7	Compliant
Receiver Spurious Emission	Yes	4.3.12	5.3.11	Compliant

4.2 General Comments

4.2.1 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.

4.2.2 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 performed requires the uncertainty levels to be below the listed values in section 5.2 of ESTI 300 328v1.8. 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°C	±0.55°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%

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

4.2.4 Date of receipt of test sample(s): June 18, 2015

4.2.5 Measurements were performed between the following dates(s):

Start Date: June 30, 2015

Completion Date: November 17, 2015

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

4.3 Test Results

4.3.1 RF Output Power (Clause 5.3.2)

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 5.3.2. The test equipment was set to the center frequency at which the EUT will transmit. The span was set to 0 Hz and the RBW and VBW were set to 1 MHz and 3 MHz, respectively.

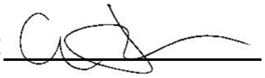
In accordance with ETSI EN 300 328 section 4.3.1.1, the maximum RF output power for non-adaptive equipment shall be no greater than 20 dBm. This limit applied to the combination of power level and intended antenna assembly.

Antenna Assembly Gain: 2.6 dBi
Beam-forming Gain: 0.0 dBi

Table 4. RF Output Power Measurement

Frequency (MHz)	Measured Result (dBm) A	Combination of Power Level and Antenna Gain (dBm) A+G+Y	Limit (dBm)	Margin (dB)
Measured at -10˚C				
2402	8.85	11.45	20.00	8.55
2426	8.68	11.28	20.00	8.72
2480	9.84	12.44	20.00	7.56
Measured at 20˚C				
2402	8.19	10.79	20.00	9.21
2426	8.62	11.22	20.00	8.78
2480	9.29	11.89	20.00	8.11
Measured at 65˚C				
2402	8.53	11.13	20.00	8.87
2426	8.95	11.55	20.00	8.45
2480	9.37	11.97	20.00	8.03

Test Date: September 17, 2015

Signature:  Tested By: Carrie Ingram

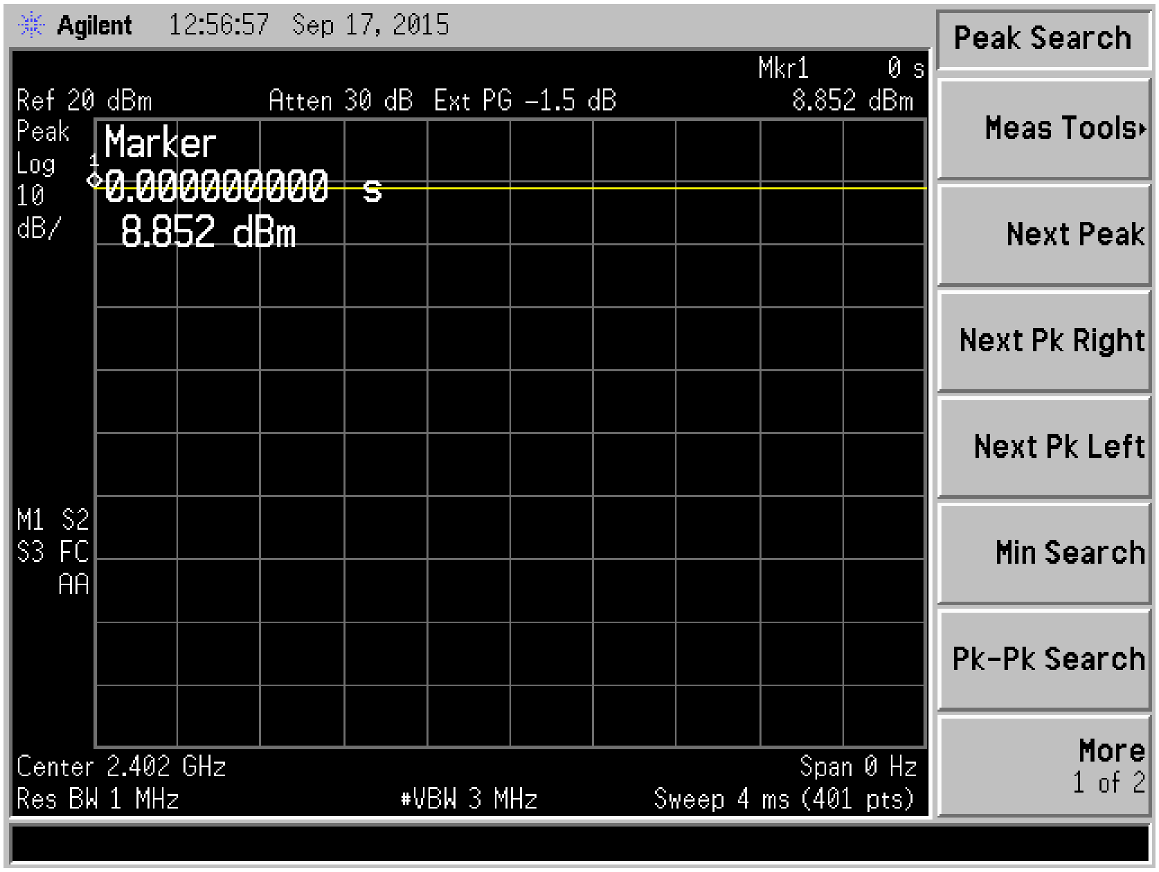


Figure 1. RF Output Power at Low Channel and -10˚C

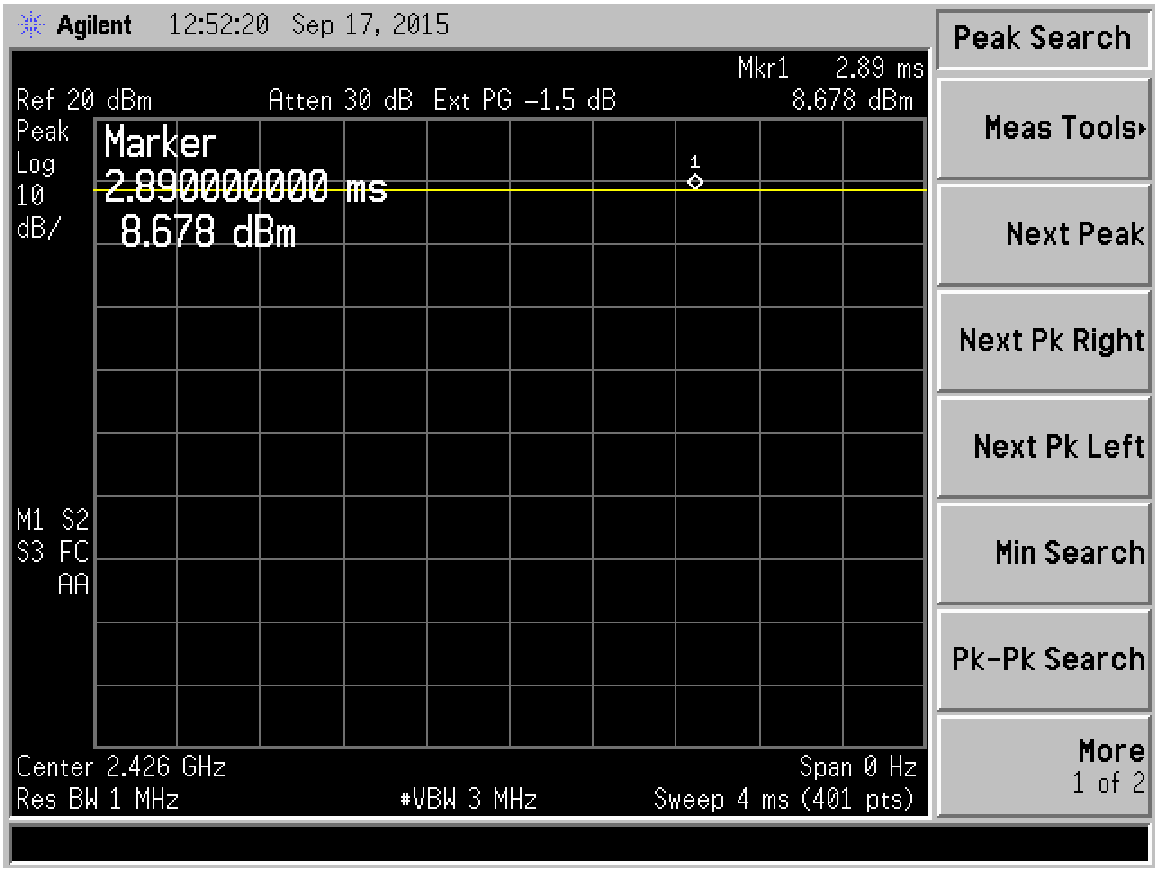


Figure 2. RF Output Power at Mid Channel and -10˚C

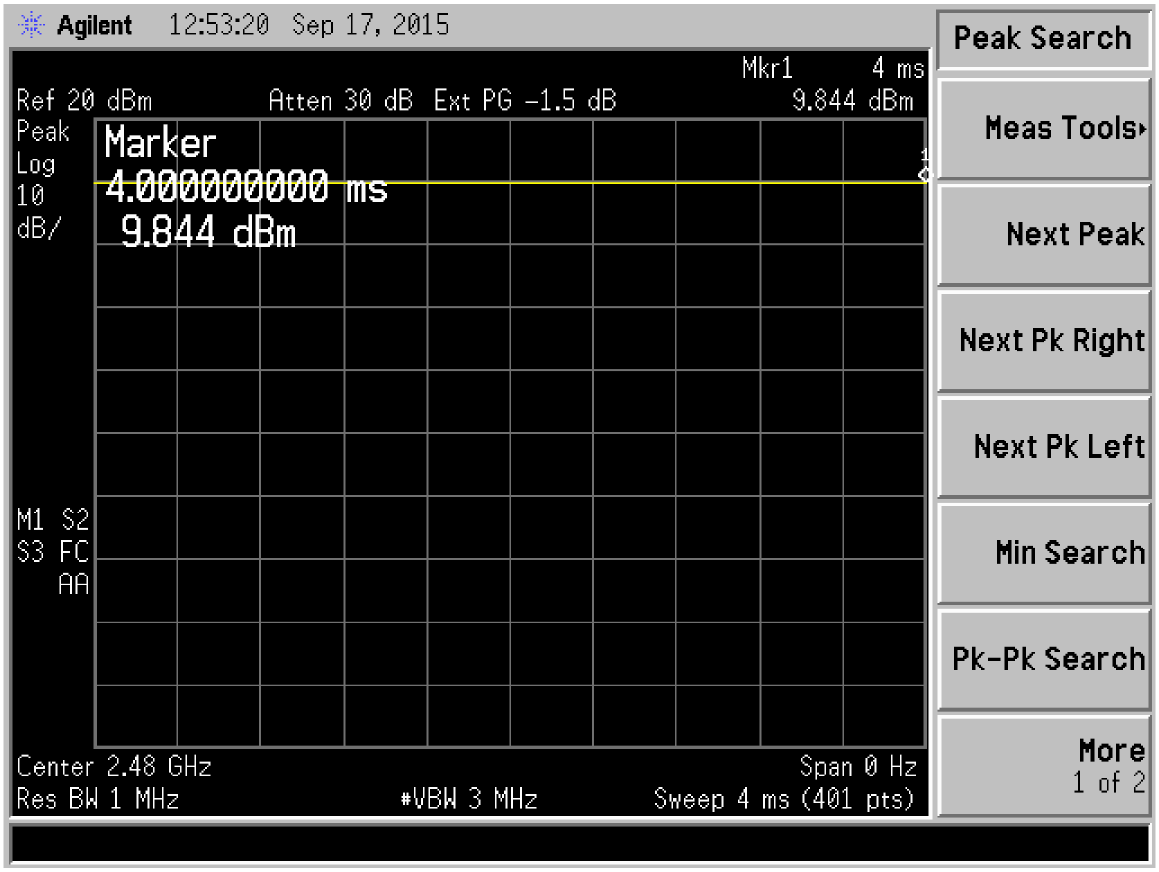


Figure 3. RF Output Power at High Channel and -10˚C

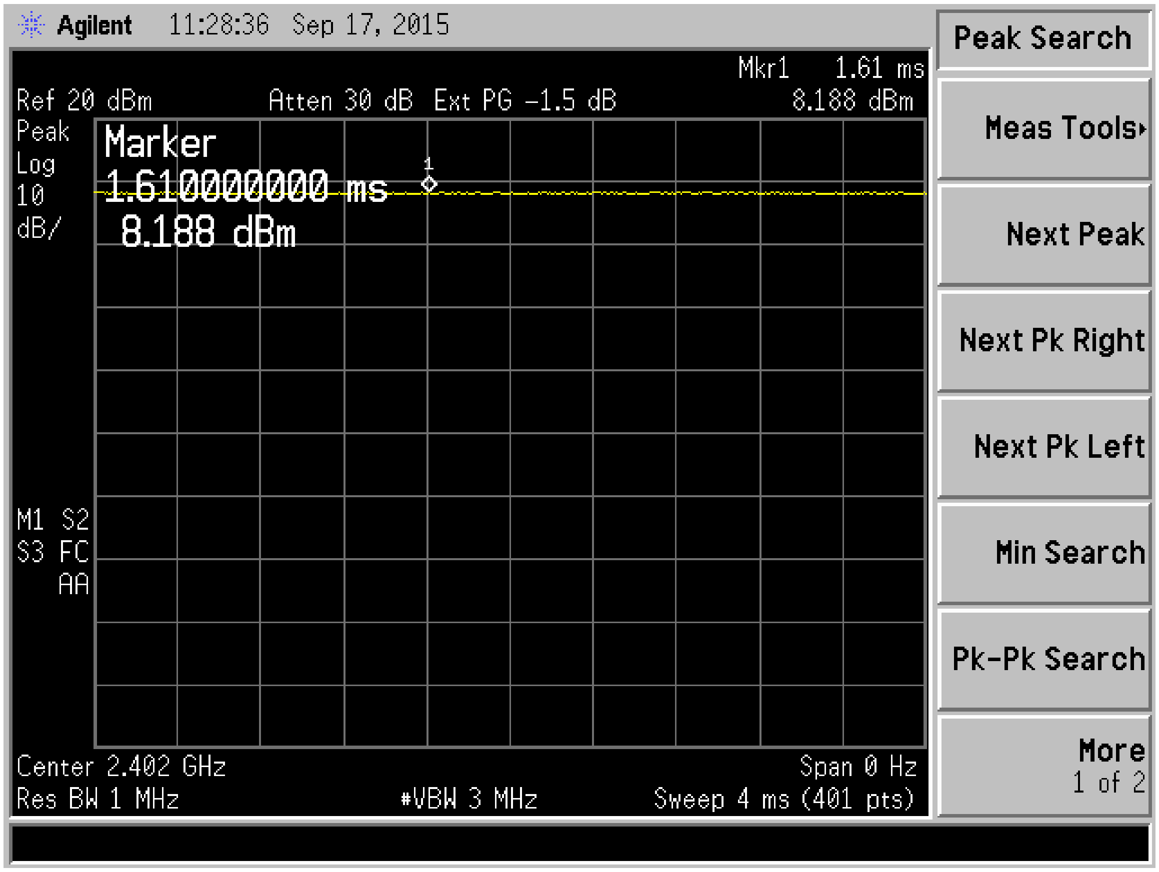


Figure 4. RF Output Power at Low Channel and 20˚C

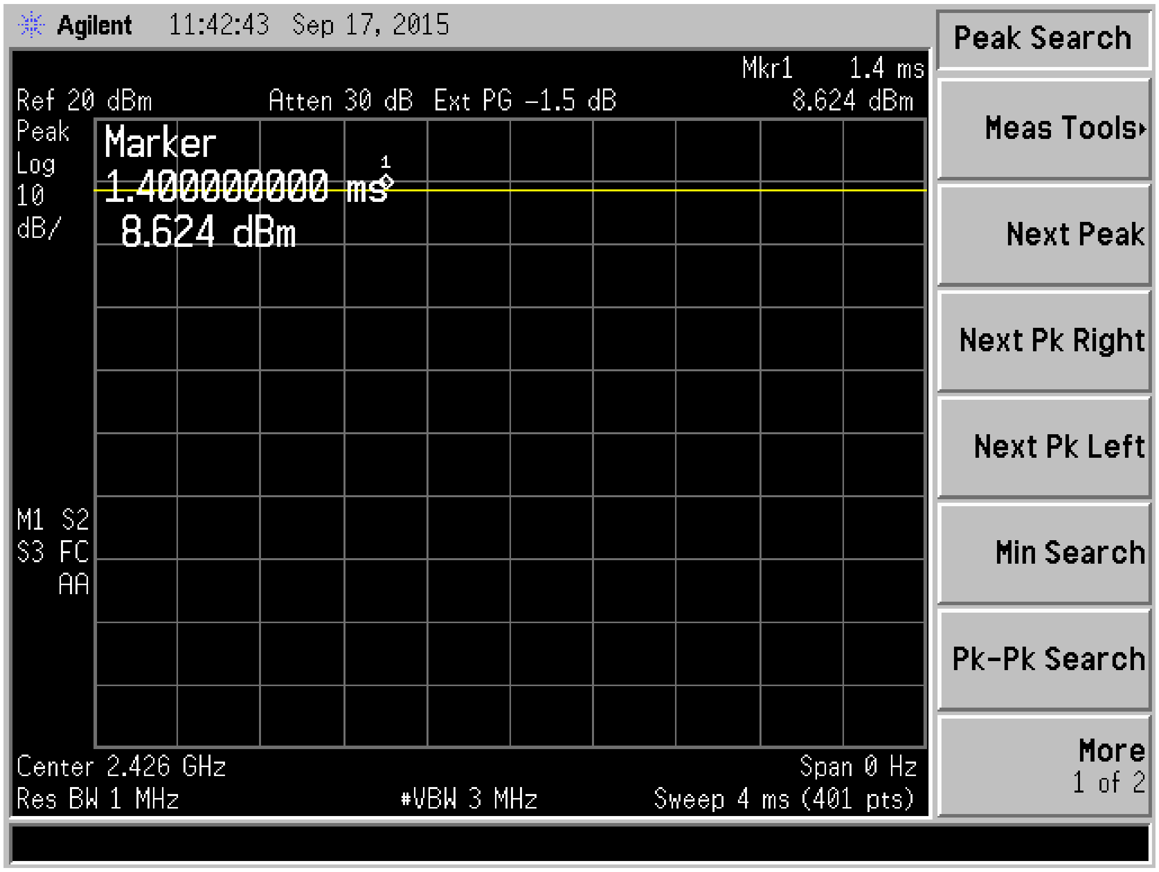


Figure 5. RF Output Power at Mid Channel and 20˚C

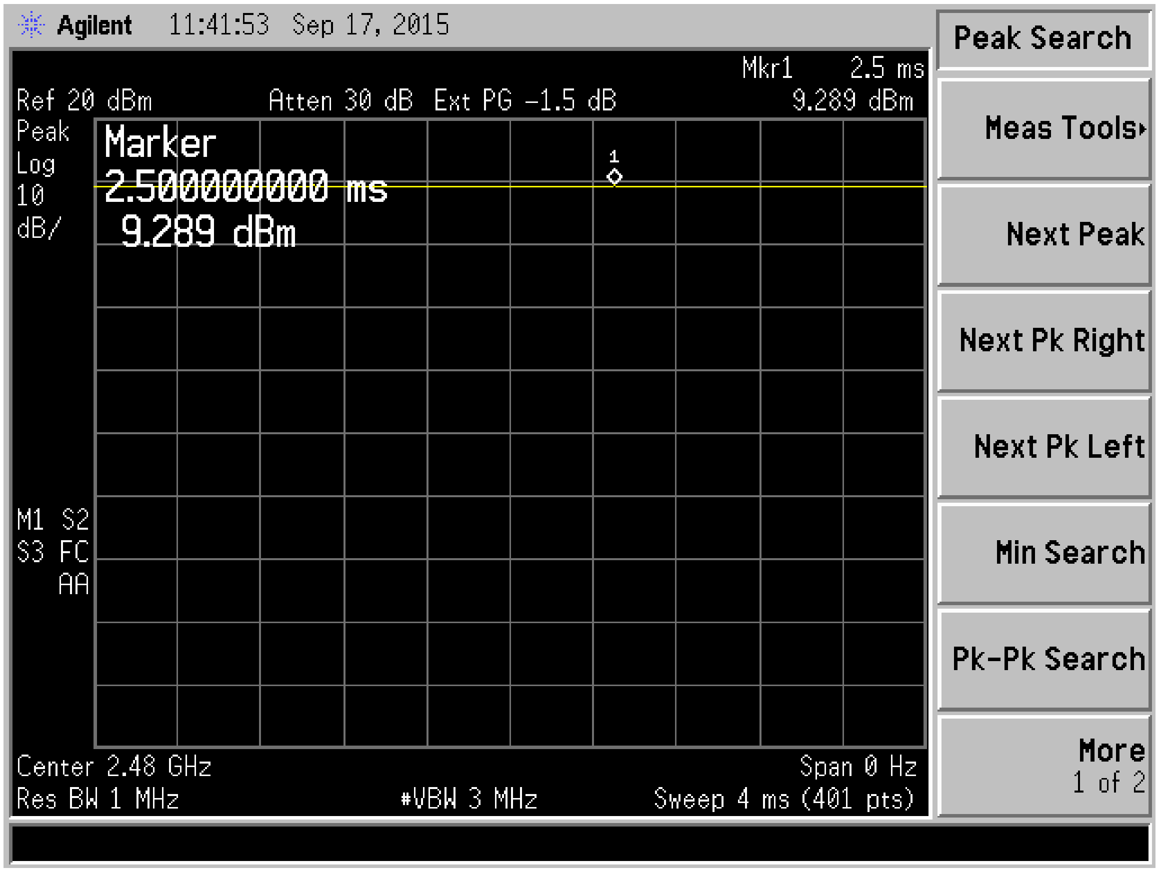


Figure 6. RF Output Power at High Channel and 20˚C

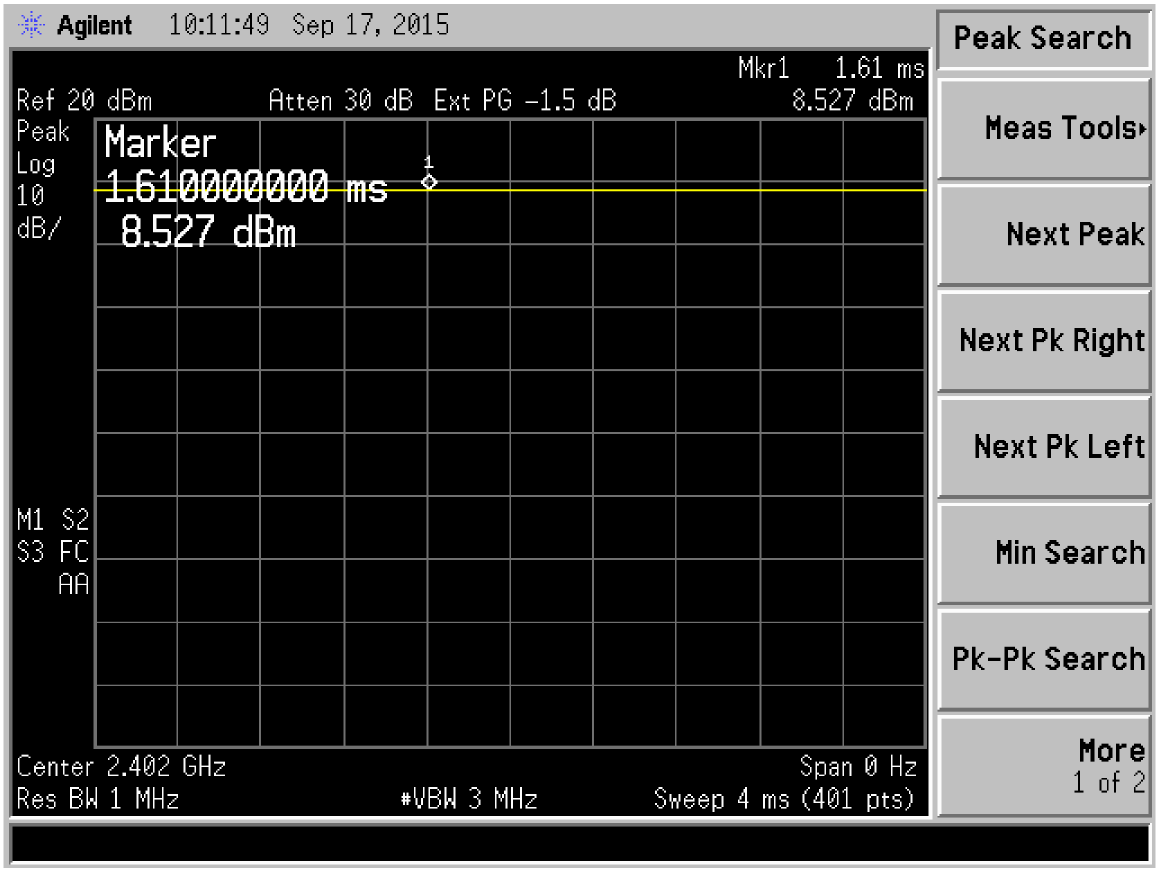


Figure 7. RF Output Power at Low Channel and 65˚C

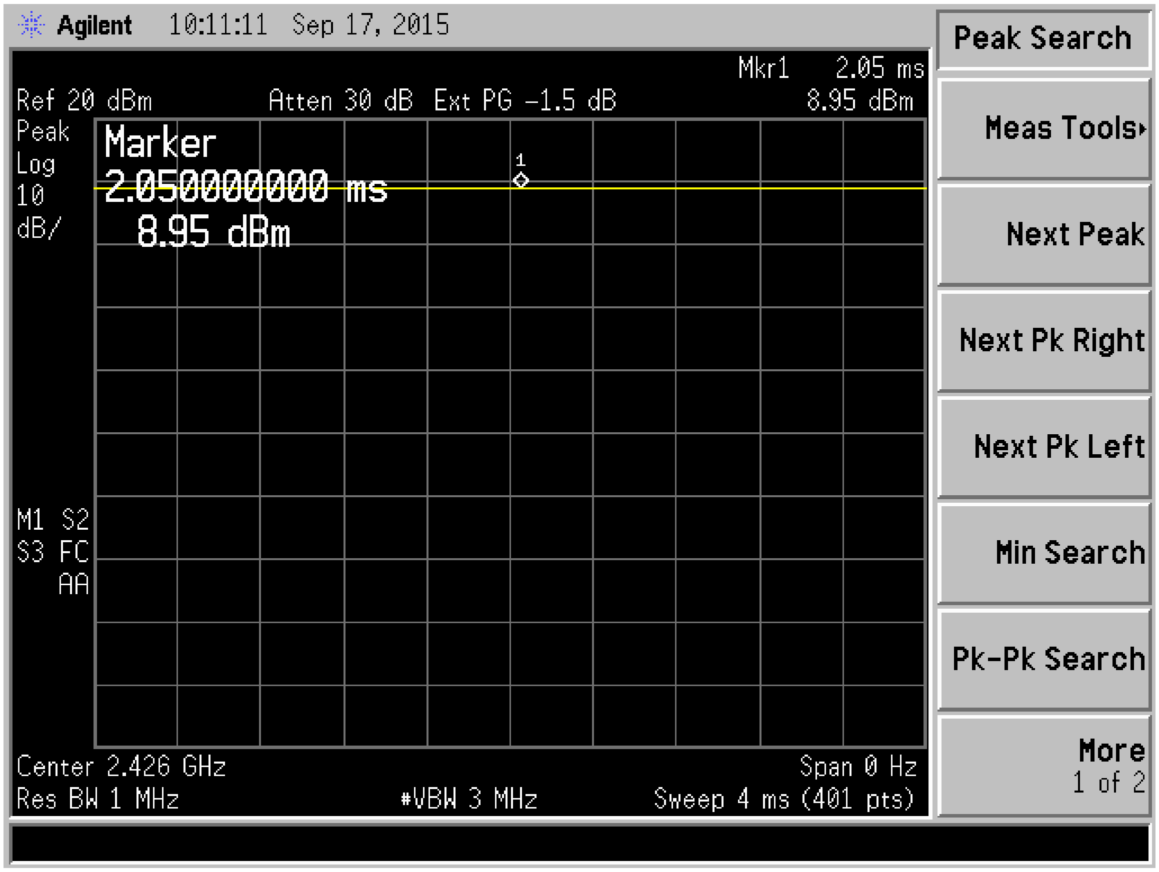


Figure 8. RF Output Power at Mid Channel and 65˚C

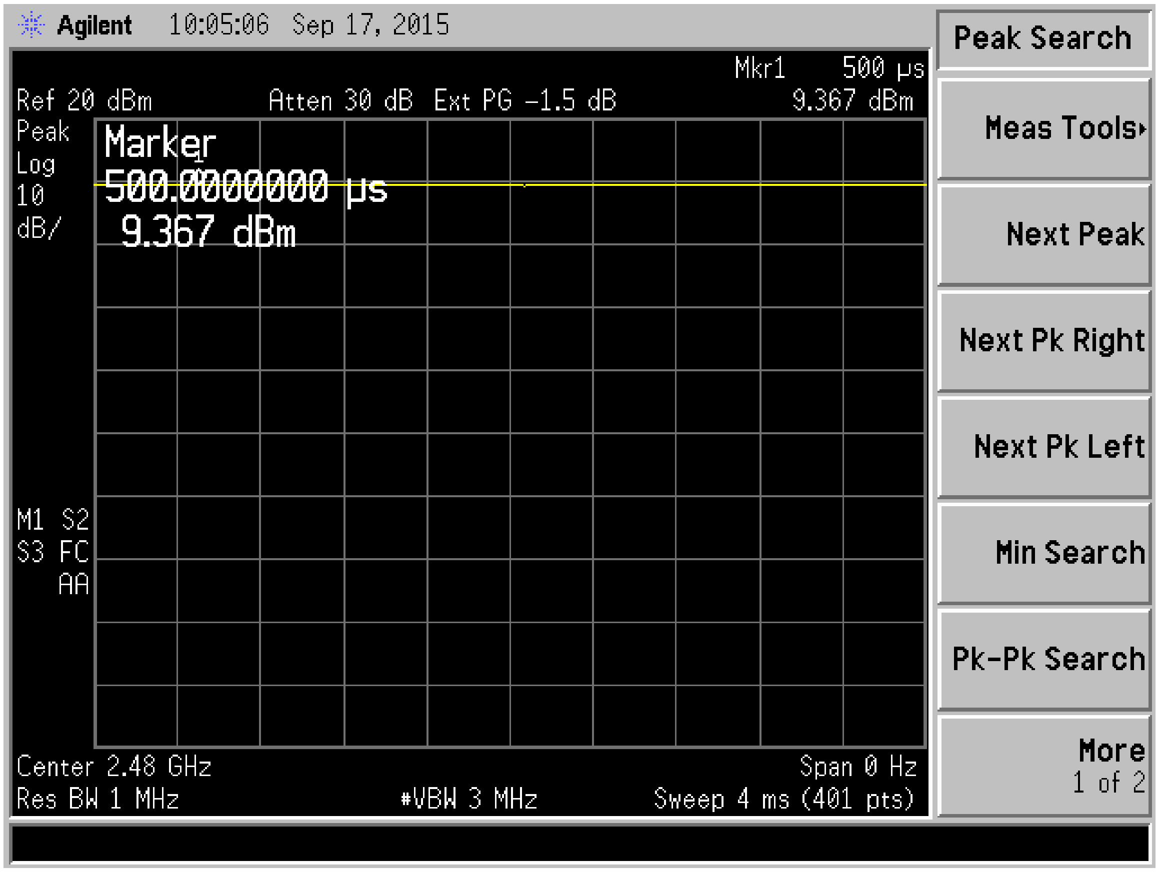


Figure 9. RF Output Power at High Channel and 65˚C

4.3.2 Duty Cycle (Clause 5.3.2)

The EUT is an adaptive system; therefore the Duty Cycle was not tested per ETSI EN 300 328 section 4.3.2.4..

4.3.3 Medium Utilisation (Clause 5.3.2)

The EUT is an adaptive system; therefore the Medium Utilisation was not tested per ETSI EN 300 328 section 4.3.2.4..

4.3.4 Power Spectral Density (Clause 5.3.3)

The EUT employs frequency hopping therefore the power spectral Density measurement is not applicable.

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

The EUT employs frequency hopping therefore the dwell time, minimum frequency occupation and hopping sequence were measured per the procedures of ETSI EN 300 328 section 5.3.4.

4.3.5.1 Dwell time

The dwell time is the time that a hopping frequency would be occupied by the EUT during one hop. In accordance with ETSI EN 300 328 section 4.3.1.4 the dwell time cannot be greater than 15 ms within any period of 15 ms multiplied by the minimum number of hopping frequencies (15), or 15 ms within any period of 225 ms.

To measure the dwell time, the centre frequency of the analyser was set to a hopping channel and the span was set to zero. The RBW was approximately 50% of the Occupied Channel Bandwidth and the VBW ≥ RMS. The sweep time was set to equal the dwell time * the minimum number of hopping frequencies with 30,000 sweep points.

The number of data point identified as resulting from a transmission on the hopping channel being investigated was count and then multiplied by the time difference between two consecutive points. This number is the accumulated Dwell Time. This data is presented below.

Environmental Conditions:
Ambient Temperature: 20 ˚C
Relative Humidity: 40 %

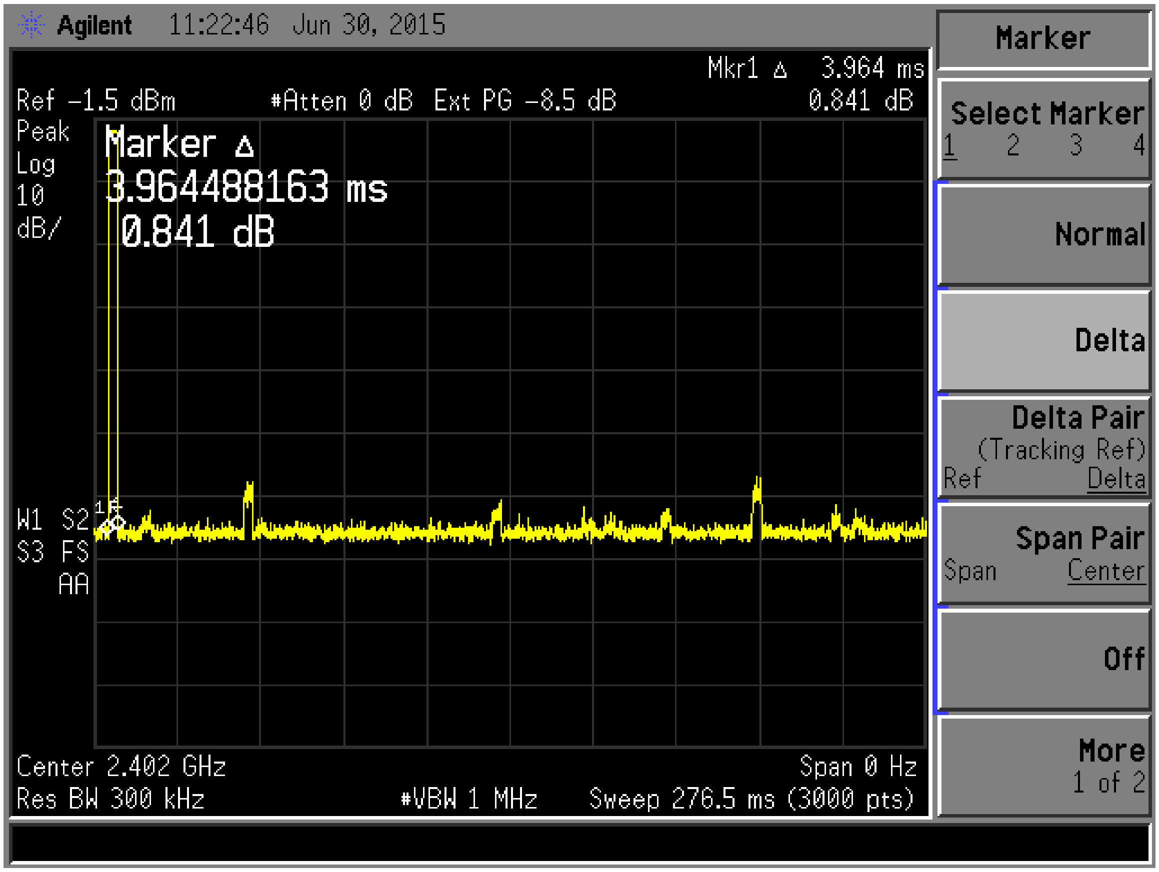


Figure 10. Worst Case Dwell Time Measurements

Total Number of Points Where The Transmission Was On : 31
Time Between Points: .09 ms
Dwell Time: 2.79 ms < 15 ms PASSED

4.3.5.2 Minimum Frequency Occupation

The minimum frequency occupation time is the minimum time each frequency can be occupied within a certain period. In accordance with ETSI EN 300 328 section 4.3.1.3, the minimum frequency occupation time cannot be less than one dwell time within a period less than four times the product of the dwell time per hop and the number of hopping frequencies in use. Since the dwell time was determined to be 2.88 ms, and there are 79 hopping frequencies in use the frequency occupation time cannot be less than one dwell time within a period of 910.0 ms.

To measure the minimum Frequency Occupation, the analyzer was set to the same setting to measure the dwell time, except the sweep time was increased to 4* the Dwell time * the number of hopping frequencies in use. This data is presented following.

Environmental Conditions:
Ambient Temperature: 20 ˚C
Relative Humidity: 40 %

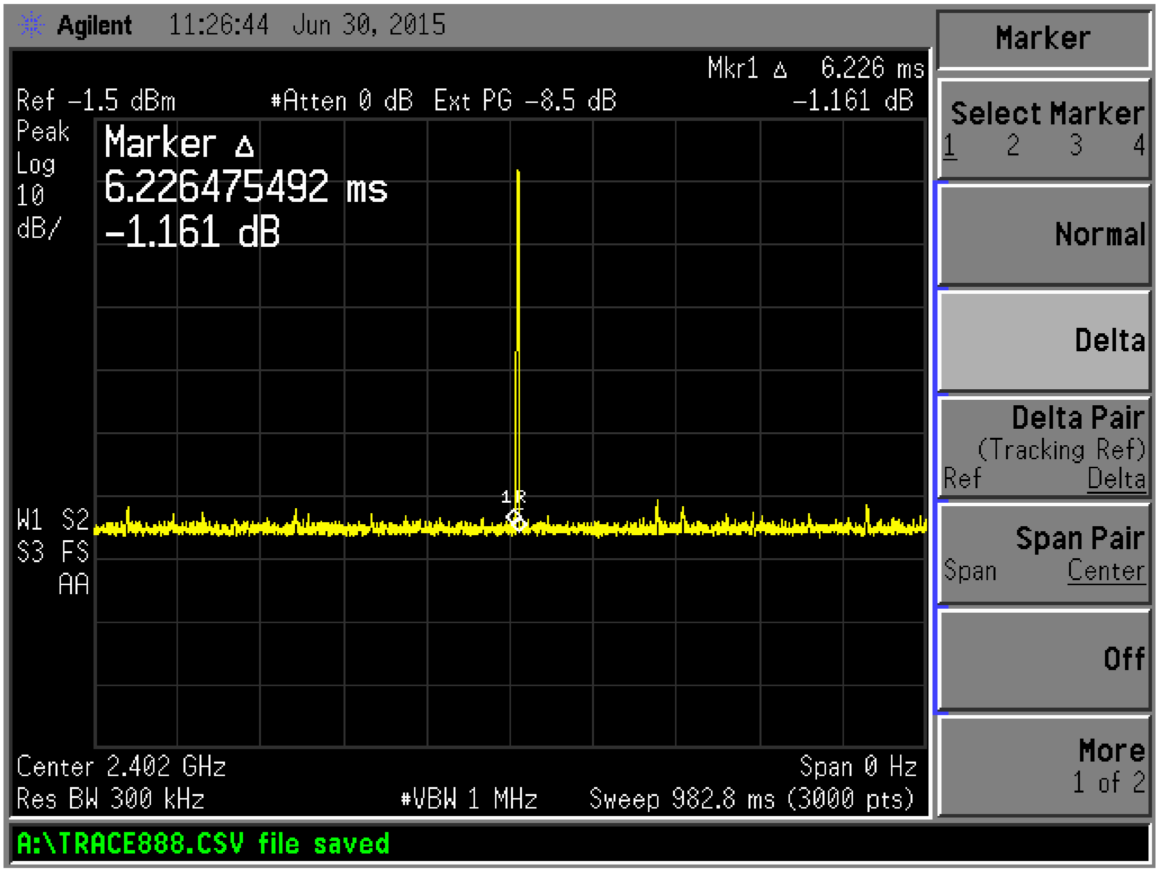


Figure 11. Worst Case Minimum Frequency Occupation Measurement

Total Number of Points Where The Transmission Was On: 20
Time Between Points: .33 ms
Frequency Occupation: 6.6 ms > 2.79 ms PASSED

4.3.5.3 Hopping Sequence

The hopping sequence of a frequency hopping system is the unrepeated pattern of the hopping frequency used by the EUT. In accordance with ETSI EN 300 328 section 4.3.1.3, the hopping sequence shall have at least 15 frequencies.

To measure the number of frequencies used by the hopping sequence the analyser was set to a start frequency of 2400 MHz and a stop frequency of 2483.5 MHz. The sweep time was set to auto and the trace was set to Max Hold. The RBW and VBW were kept the same at were used to measure the Dwell Time and Frequency Occupation.

The EUT used 79 Channels as shown below therefore the EUT complies with the requirement.

Environmental Conditions:
Ambient Temperature: 20 ˚C
Relative Humidity: 40%

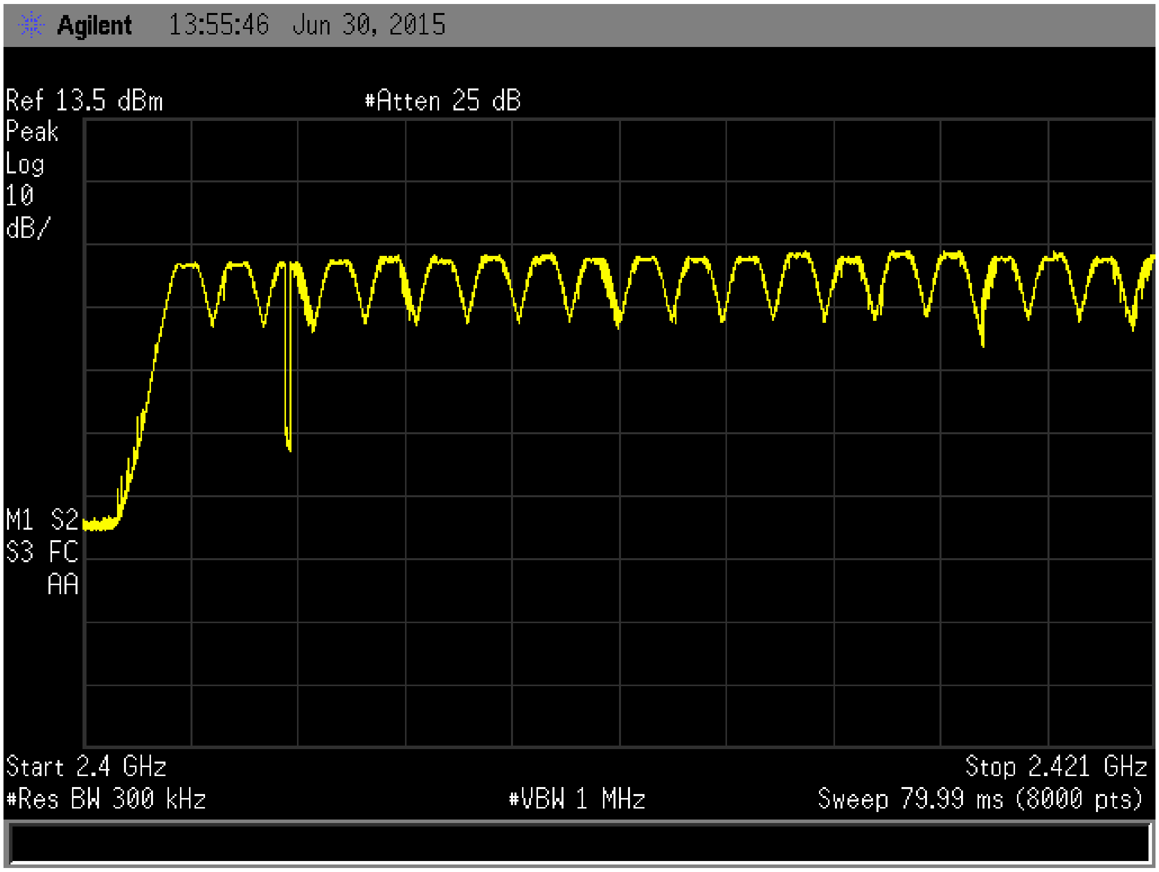


Figure 12. Channel 0 to Channel 18

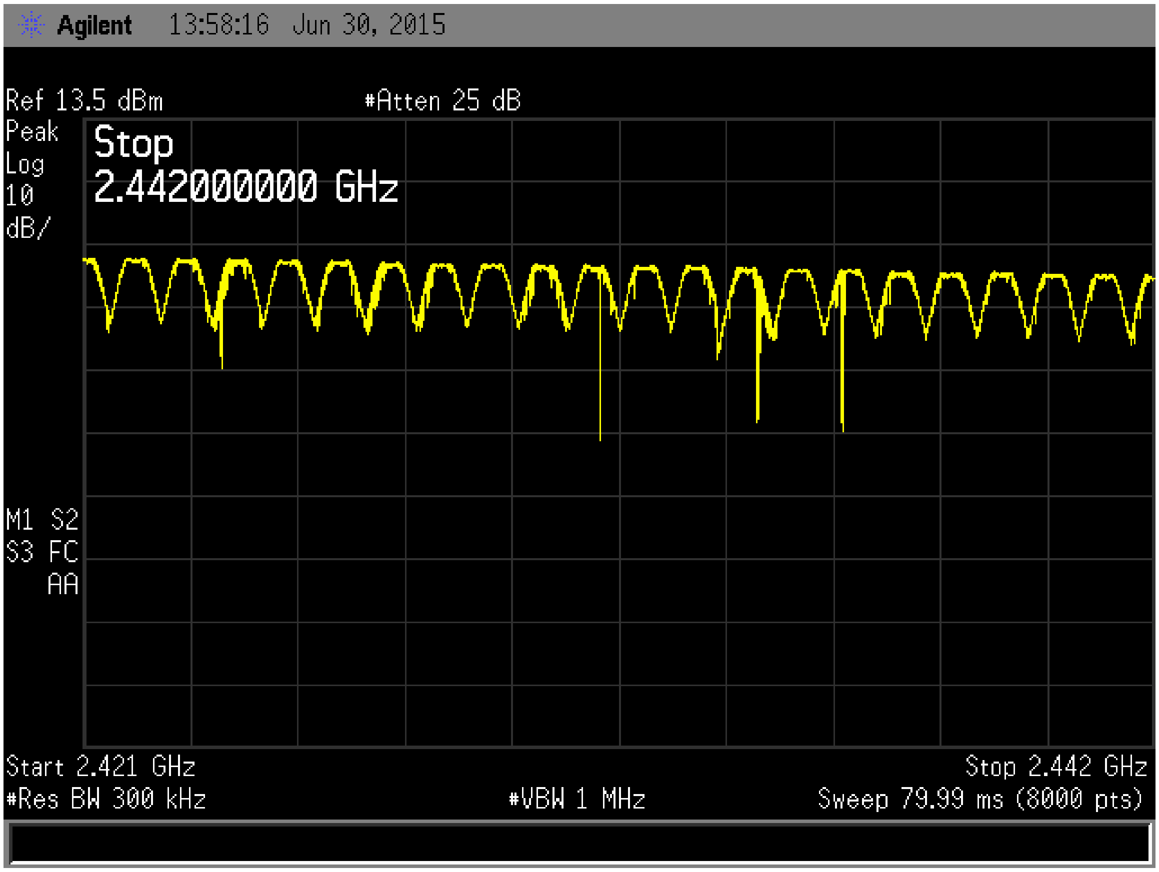


Figure 13. Channel 19 to 40

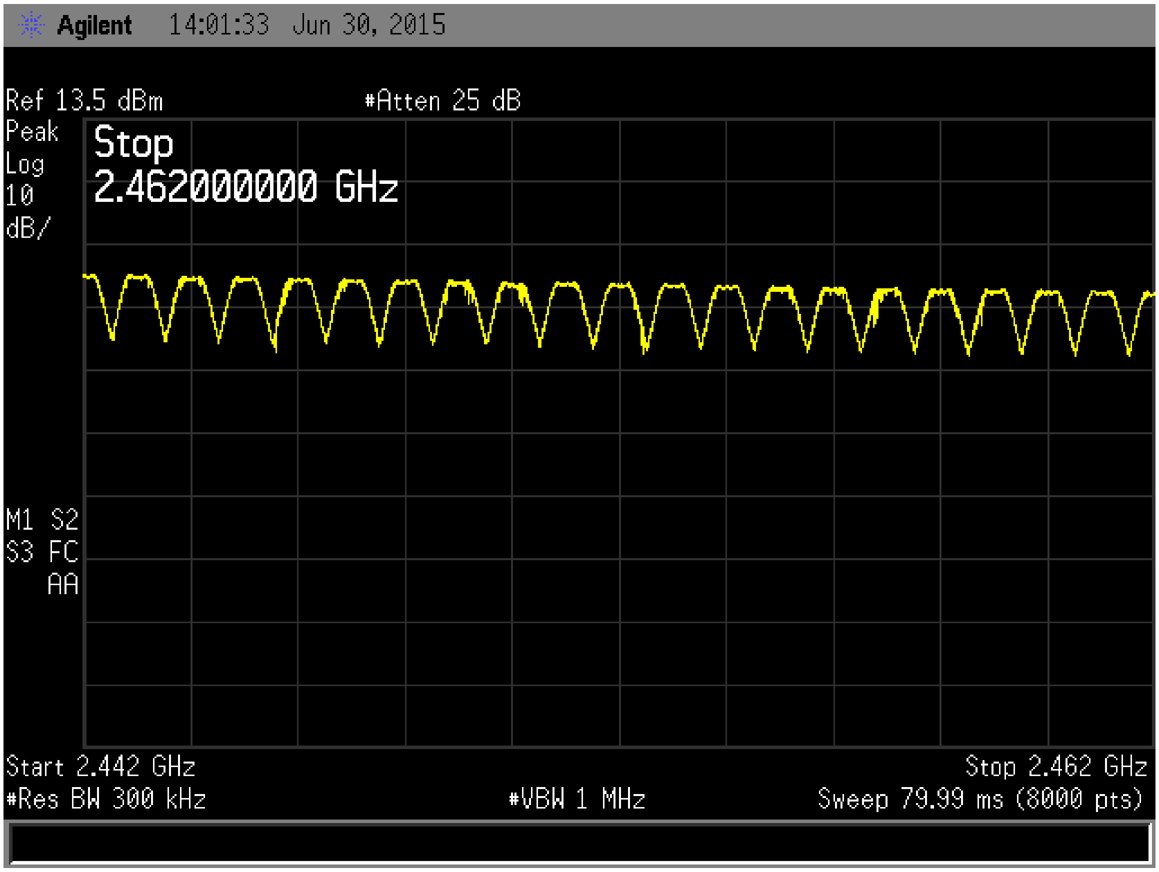


Figure 14. Channel 41 to 60

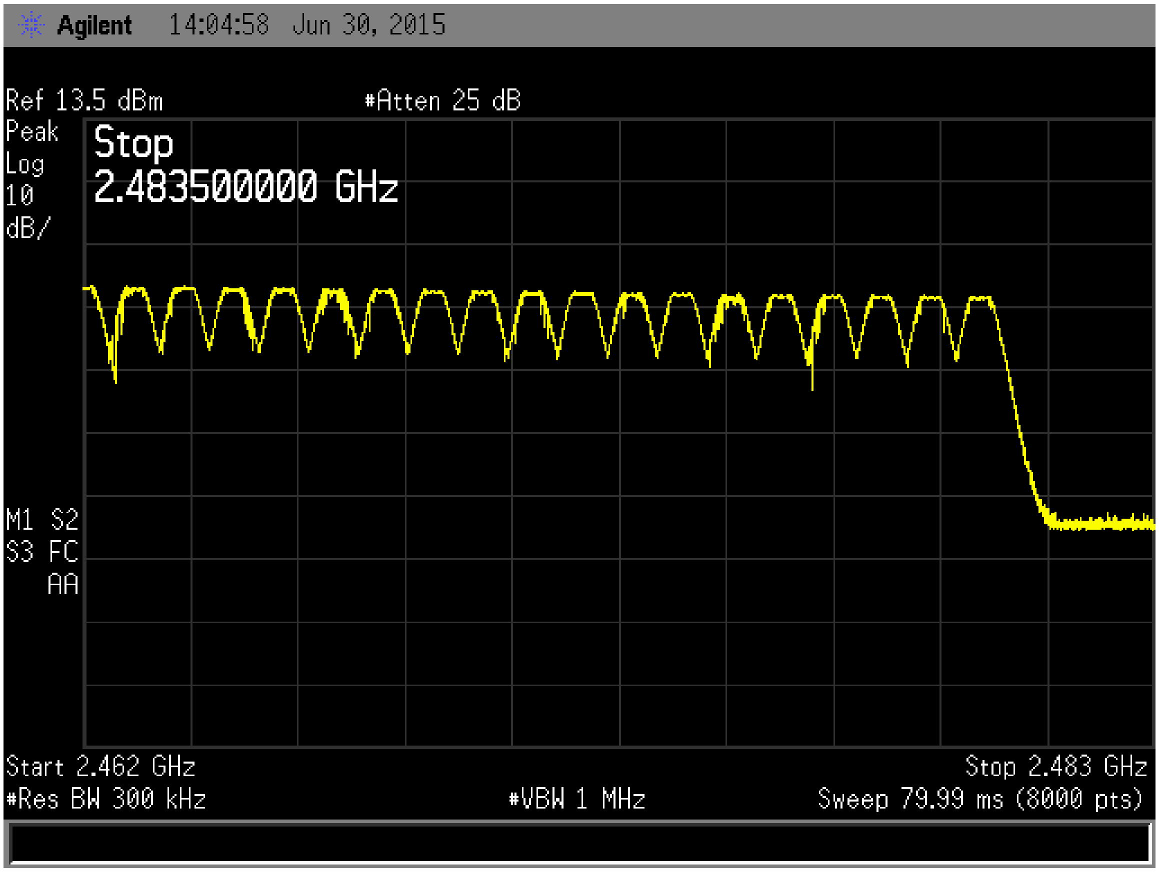


Figure 15. Channel 61 to 78

4.3.6 Hopping Frequency Separation (Clause 5.3.5)

The EUT employs frequency hopping; therefore the Hopping Frequency Separation was measured per the procedures of ETSI EN 300 328 section 5.3.4. The analyser was centred in two adjacent hopping frequencies, and the span was set wide enough to captures the power envelope of those two hopping channels. The RBW was ~ 1% of the Span and the VBW was 3*RBW. The trace was set to max hold with the sweep time on Auto.

The Hopping Frequency Separation is the separation of two adjacent hopping frequencies. The minimum Separation is required to be equal to the Occupied Channel Bandwidth of a single hop, with a minimum of 100 kHz. A marker-delta measurement was taken, see figure below.

Environmental Conditions:
Ambient Temperature: 20 ˚C
Relative Humidity: 40 %

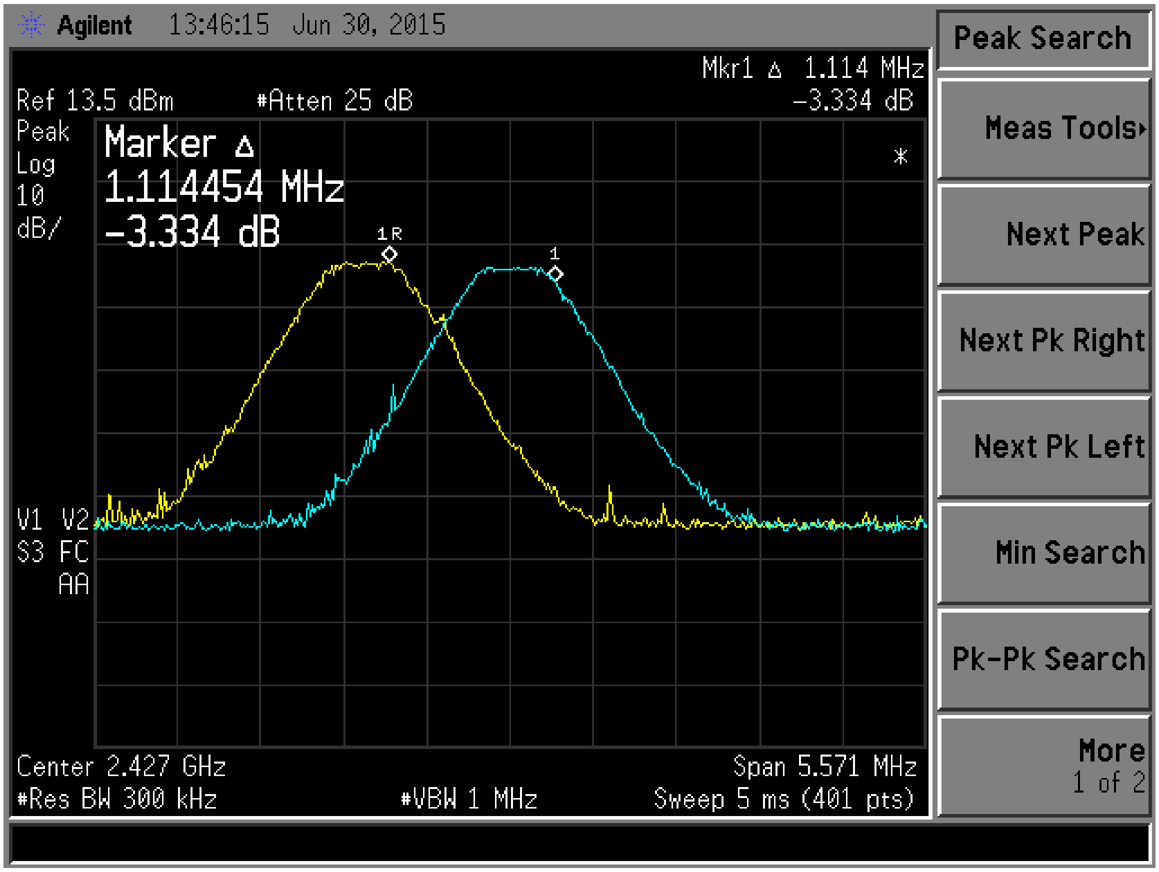


Figure 16. Hopping Frequency Separation

Frequency separation	1114.45	kHz
Limit	100.00	kHz
Margin	914.45	kHz

4.3.7 Adaptivity (Clause 5.3.7)

The EUT uses Non-LBT based Detect and Avoid mechanism. The requirements of ESTI EN 300 328 section 4.3.2.5.1.2 was applied and the test procedures of section 5.3.7.2.1.2 were used to access the EUT adaptivity mechanism.

The EUT was connected to a companion device during the test, and the interference signal generator, blocking signal generator, spectrum analyser, EUT, and companion device were all connected using the setup in Figure 5 of the test standard. The RBW, VBW were maximized, the span was set to zero and the sweep time was adjusted to ensure sufficient coverage.

The EUT was configured for normal transmission and connected to the companion device. Using the procedure defined in section 5.3.7.2.1.4 of the standard the Channel Occupant Time and Idle Period were measured. The data is presented below.

Sweep Time in Spectrum analyser:	50.00	ms
/ Total number of Points:	640	points
Time Between each set of points	0.078	ms
Total number of Points with Transmission ON	3	points
Time Between each set of points	0.078	ms
Channel Occupancy	0.23	ms
Channel Occupancy Limit	40.00	ms
Measured Channel Occupancy	0.23	ms
Margin	39.77	ms
Sweep Time	50.00	ms
-Measured Channel Occupancy Time	00.23	ms
Idle Time in 50.00 ms sweep	49.77	ms
Measured Idle Time	49.77	ms
Minimum Idle Time	0.01	ms
Margin	49.76	ms

The interference signal was injected and centred on the hopping frequency; the PSD was adjusted per the section 4.3.1.6.2.2 of the standard. The spectrum analyser was used to monitor the transmission of the EUT on the operating channel. The data is presented following.

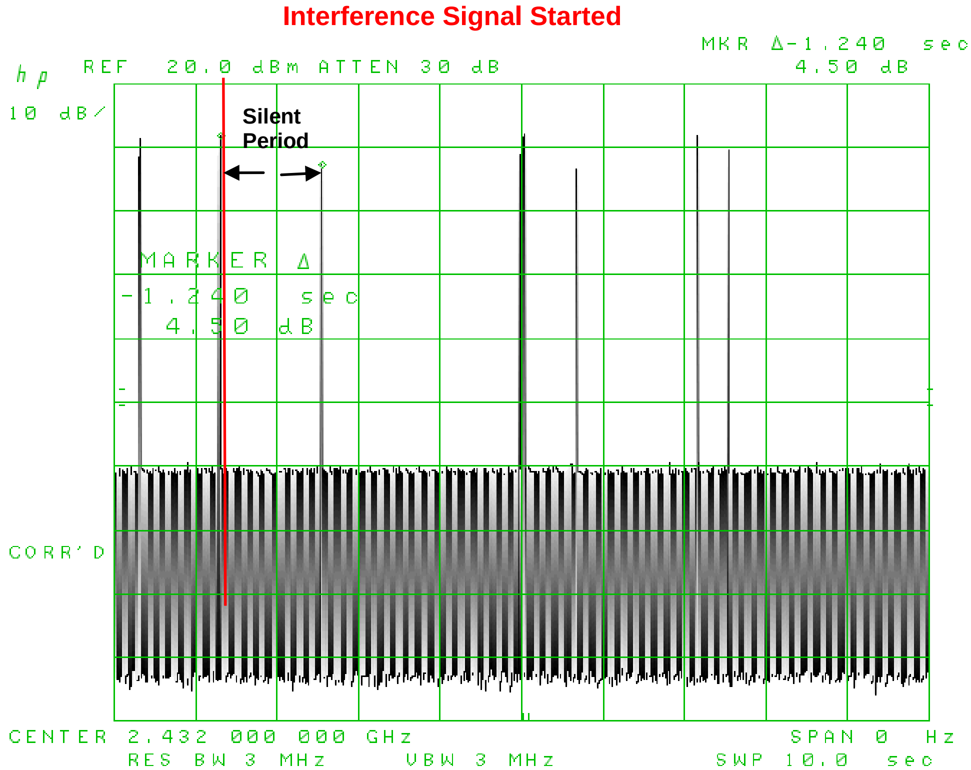


Figure 17. Reaction to Interference Signal

Note: The red line on the figure above shows when the interference signal was injected into the test system.

Silent period limit	1.00	s
Measured Silent period (from figure 37)	1.24	s
Margin	0.24	s

The Short Controlling Signal Transmissions (SCST) can have a maximum duty cycle of 10 %

Sweep Time in Spectrum analyser:	30.00	ms
/ Total number of Points:	640	points
Time Between each set of points	0.078	ms

Total number of Points with Transmission on	28	points
Time Between each set of points	0.078	ms
SCST Time On	2.19	ms

SCST Time On	2.19	ms
/ Total Sweep Time	30.00	ms
*	100	%
Duty Cycle	7.29	%

Limit	10	%
Duty Cycle	7.29	%
Margin	2.71	%

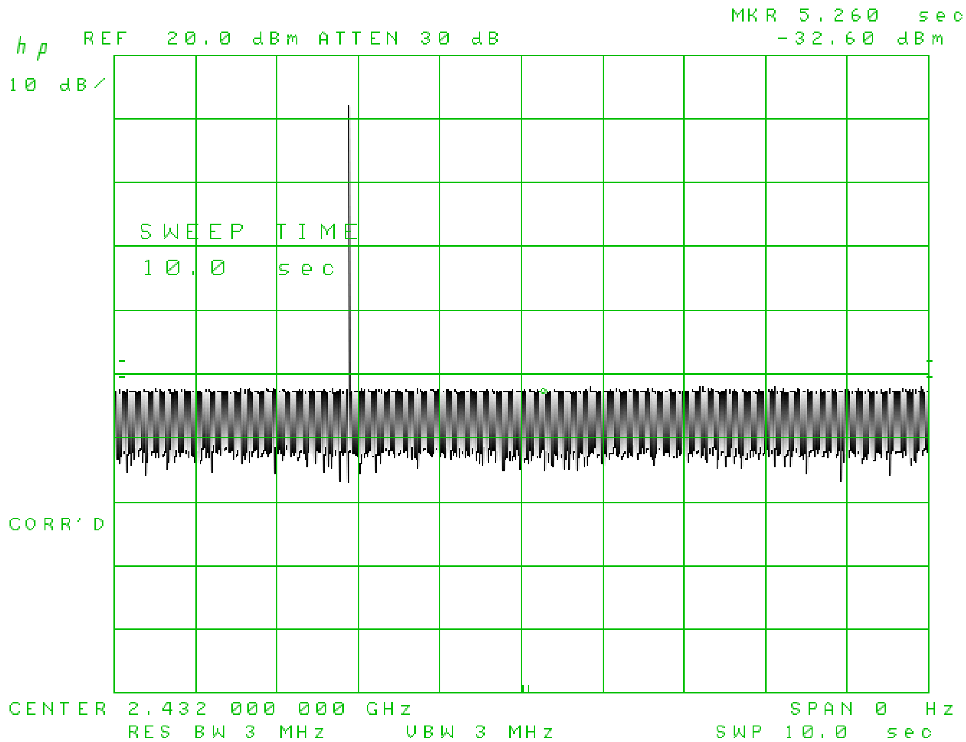


Figure 18. Reaction to Interference Signal and Blocking Signal

With the interfering signal present, a 100% duty cycle CW signal was inserted as the blocking signal per clause 4.3.5.1.2 of the standard. The EUT did not resume normal transmissions. The transmission continued as seen above in Figure 38. There is noticeably less transmissions occurring. When the Interference and Blocking Signal are removed, the normal transmission will start back up as can be seen in Figure 39 below.

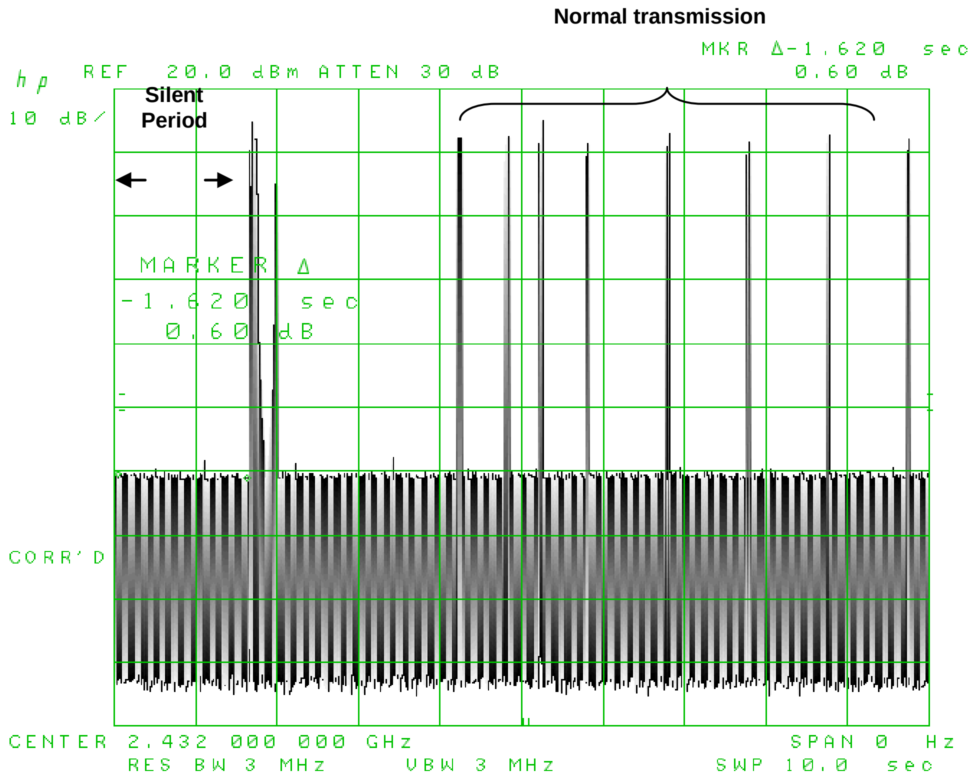


Figure 19. Reaction to Removal of Inference Signal and Blocking Signal

Note: The inference and blocking signal were removed and the sweep was started. There were no transmissions from the EUT until 1.62 s after the sweep began. A start up signal is seen, followed by the normal transmissions of the EUT.

Measured Silent Period	1.62	s
-Silent Period Limit	1.00	s
Margin	0.62	s

4.3.8 Occupied Channel Bandwidth (Clause 5.3.8)

The Occupied Channel Bandwidth is the bandwidth that contains 99% of the signal. In accordance with ETSI EN 300 328 section 4.3.1.7, the Occupied Bandwidth for each hopping frequency shall fall completely within the given frequency band and be less than or equal to the value the supplier declares.

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 2* the Occupied Channel bandwidth. The RBW was ~ 1 % of the span and VBW was 3* VBW. 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: 20 ˚C
Relative Humidity: 40 %

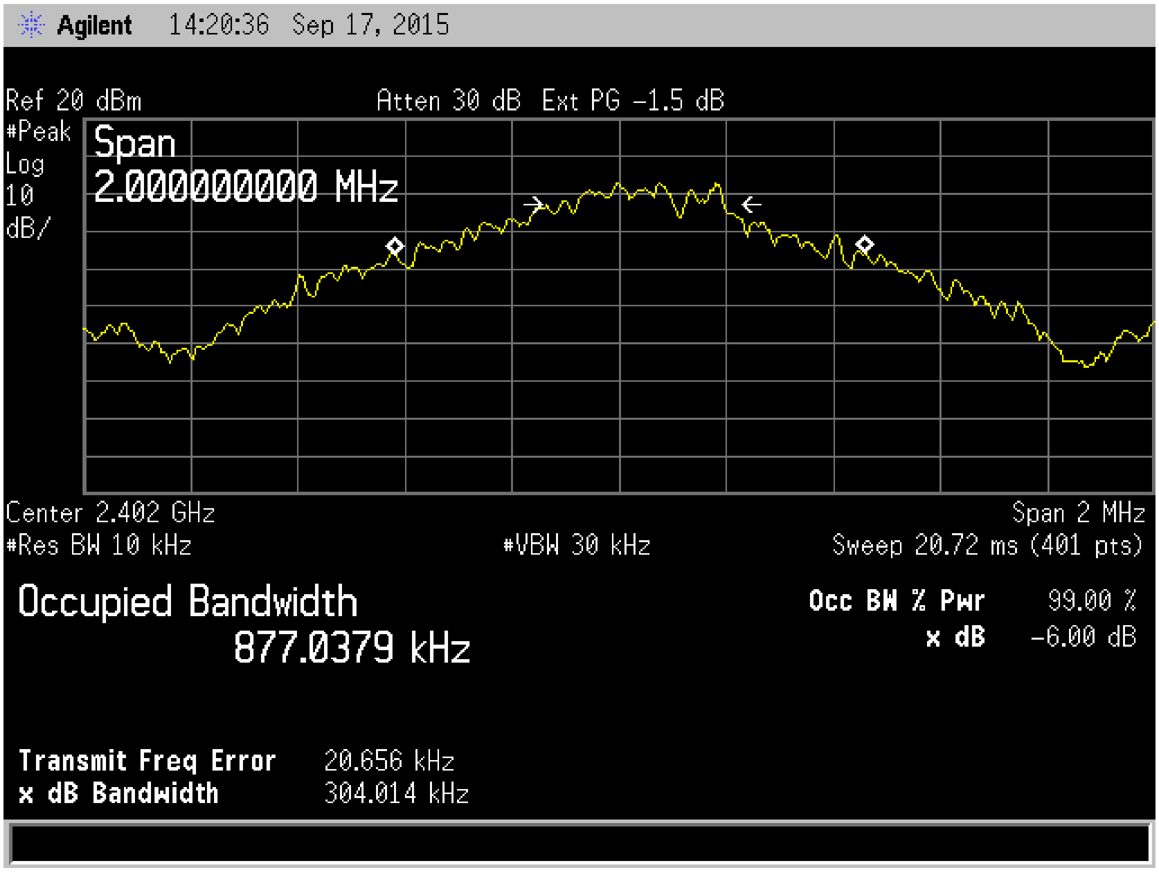


Figure 20. Low Channel Occupied Bandwidth

Carrier Frequency	2402.00	MHz
-0.5* Occupied Bandwidth (from Figure 17)	.44	MHz
Lower Carrier Edge	2401.56	MHz
Lower Carrier Edge	2401.56	MHz
-Limit (Lower Band Edge)	2400.00	MHz
Margin	1.56	MHz

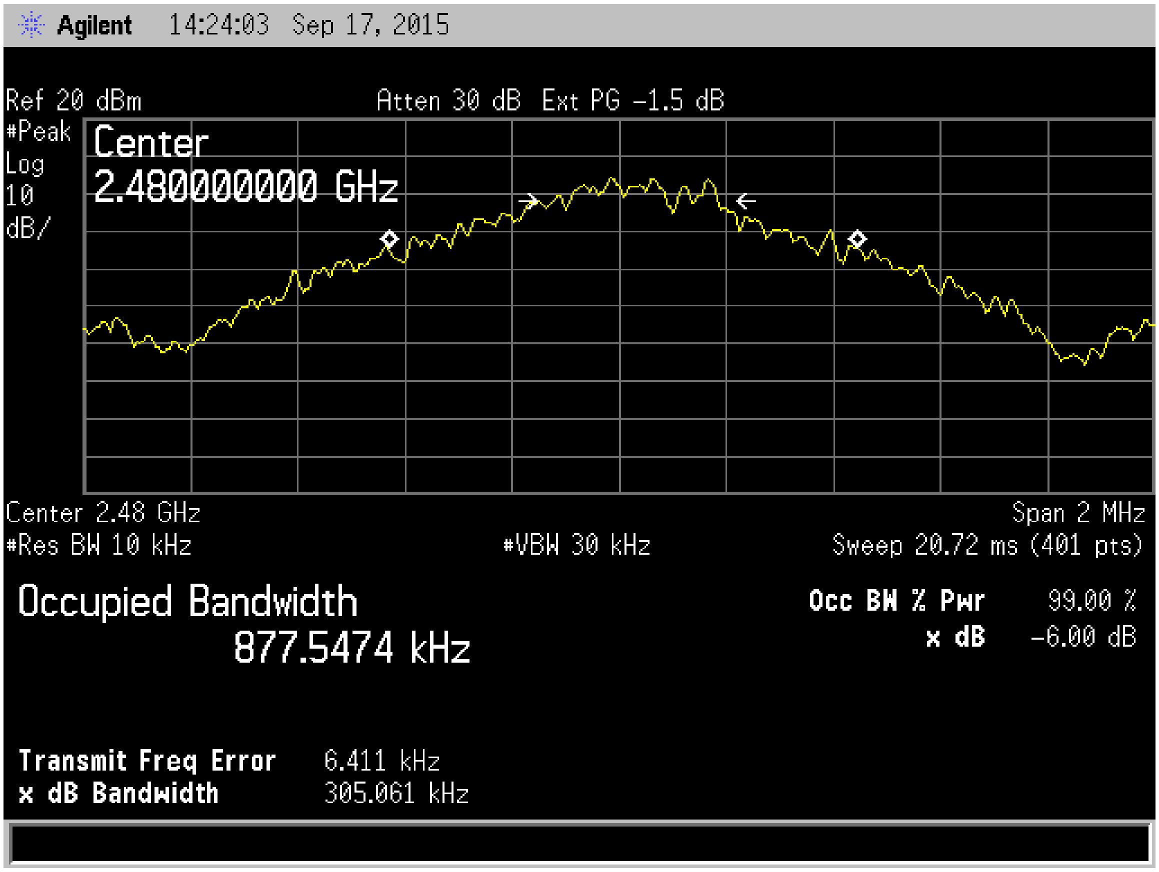


Figure 21. High Channel Occupied Bandwidth

Carrier Frequency	2480.00	MHz
+0.5*Occupied Bandwidth (from Figure 18)	0.44	MHz
Upper Carrier Edge	2480.44	MHz
Limit (Upper Band Edge)	2483.50	MHz
-Upper Carrier Edge	2480.44	MHz
Margin	3.06	MHz

4.3.9 Transmitter Unwanted Emissions in the Out-Of-Band Domain (Clause 5.3.9)

The unwanted emissions in the out-of-band domain are emissions when the EUT transmits in frequencies immediately outside the necessary bandwidth. This is a result from the modulation process. In accordance with ETSI EN 300 328 4.3.1.8 the unwanted emissions in the out-of-band domain, but inside the allocated band are not greater than the given limit seen in Figure 19 below. The limit applies to the combination of the measured emissions and the intended antenna assembly gain.

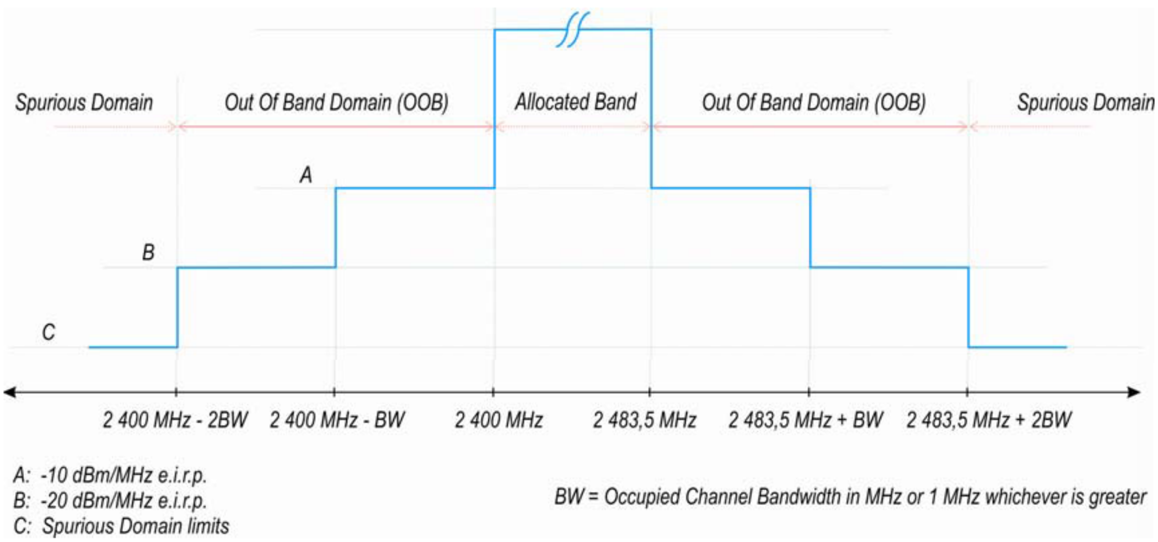


Figure 22. Transmissions Mask

The Transmitter unwanted emissions in the Out-Of-Band Domain were measured per the procedures of ETSI EN 300 328 section 5.3.9. The measurements were repeated at normal and extreme temperatures. For systems employing FHSS modulation, the EUT was in normal operation mode during measurements, and for systems using wide band modulation other than FHSS, the measurement was performed at the lowest and the highest channel the EUT can operate. In either case the EUT was operating under its highest output power. The analyser was set to a zero span at each of the frequencies specified in ETSI EN 300 328 section 5.3.9.2.1 with a RBW of 1 MHz and a VBW of 3 MHz with 5000 sweep points.

Antenna Gain: 2.6 dBi

Bandwidth: 1 MHz

Table 5. Transmitter Out-Of-Band Measurements at -10˚C

Frequency (MHz)	Measured Emission (dBm)	Combination of Antenna Assembly (dBm)	Limit (dBm)	Margin (dB)
2400 MHz – BW to 2400 MHz				
2399.50	-23.51	-20.91	-10.0	10.9
2400 MHz – 2 BW to 2400 MHz - BW				
2398.50	-36.24	-33.64	-20.0	13.6
2483.5 MHz to 2483.5 MHz + BW				
2484.00	-29.73	-27.13	-10.0	17.1
2483.5 MHz + BW to 2483.5 + 2 BW				
2485.00	-36.85	-34.25	-20.0	14.3

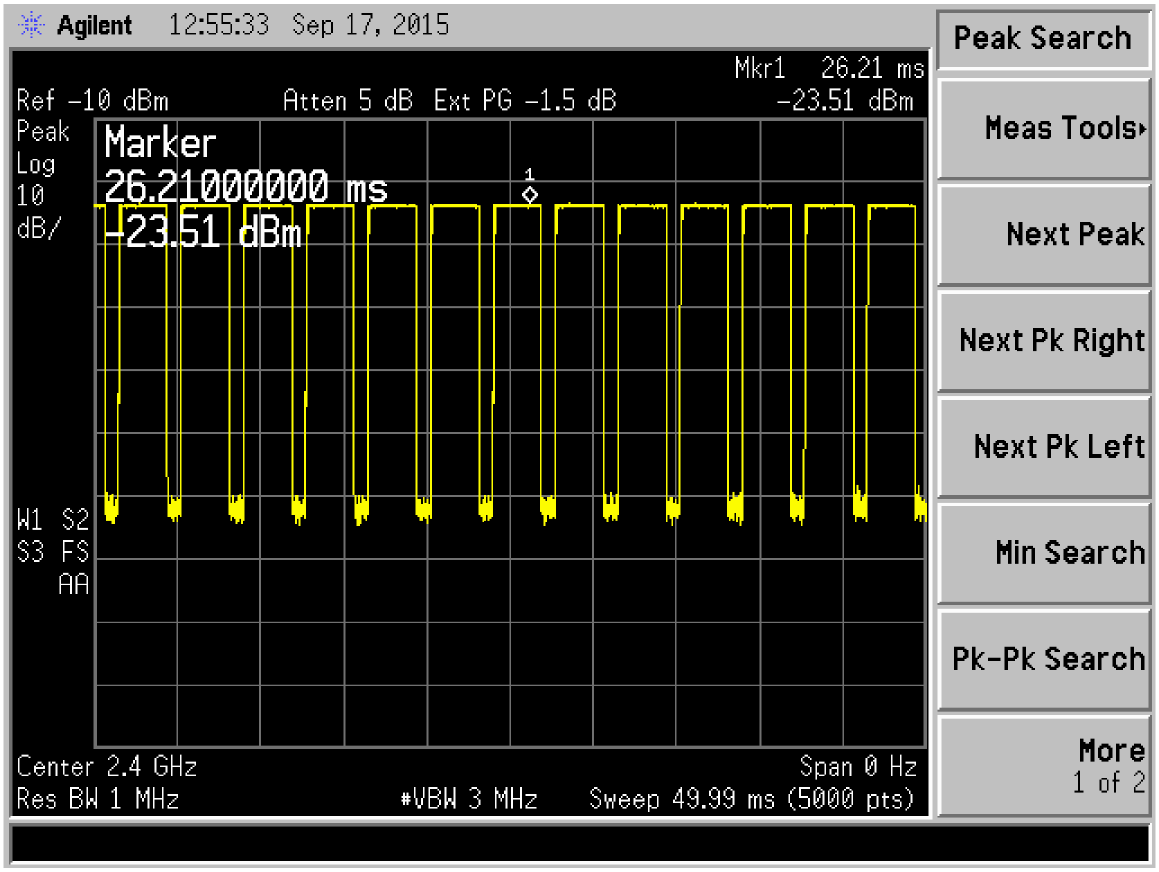


Figure 23. OOB Emission at 2399.5 MHz and -10˚C

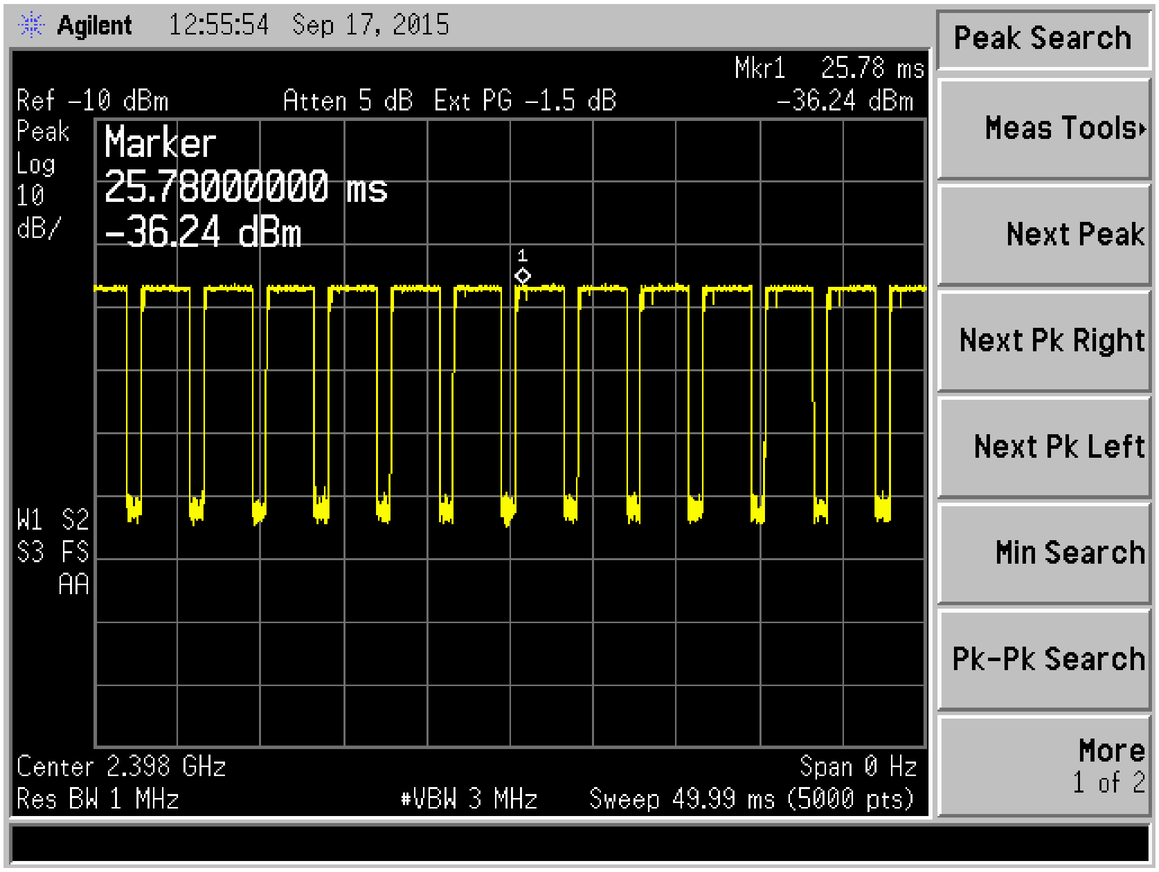


Figure 24. OOB Emission at 2398.5 MHz and -10˚C

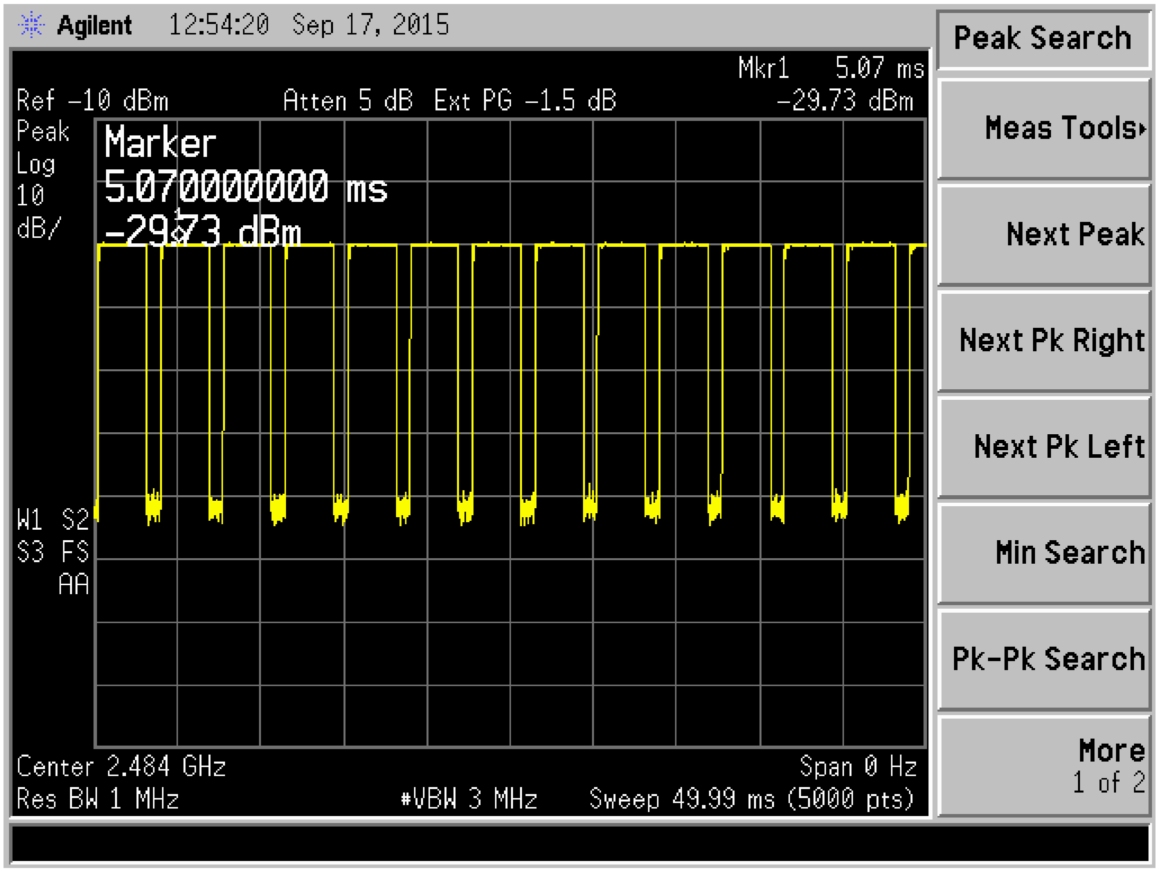


Figure 25. OOB Emission at 2484.0 MHz and -10˚C

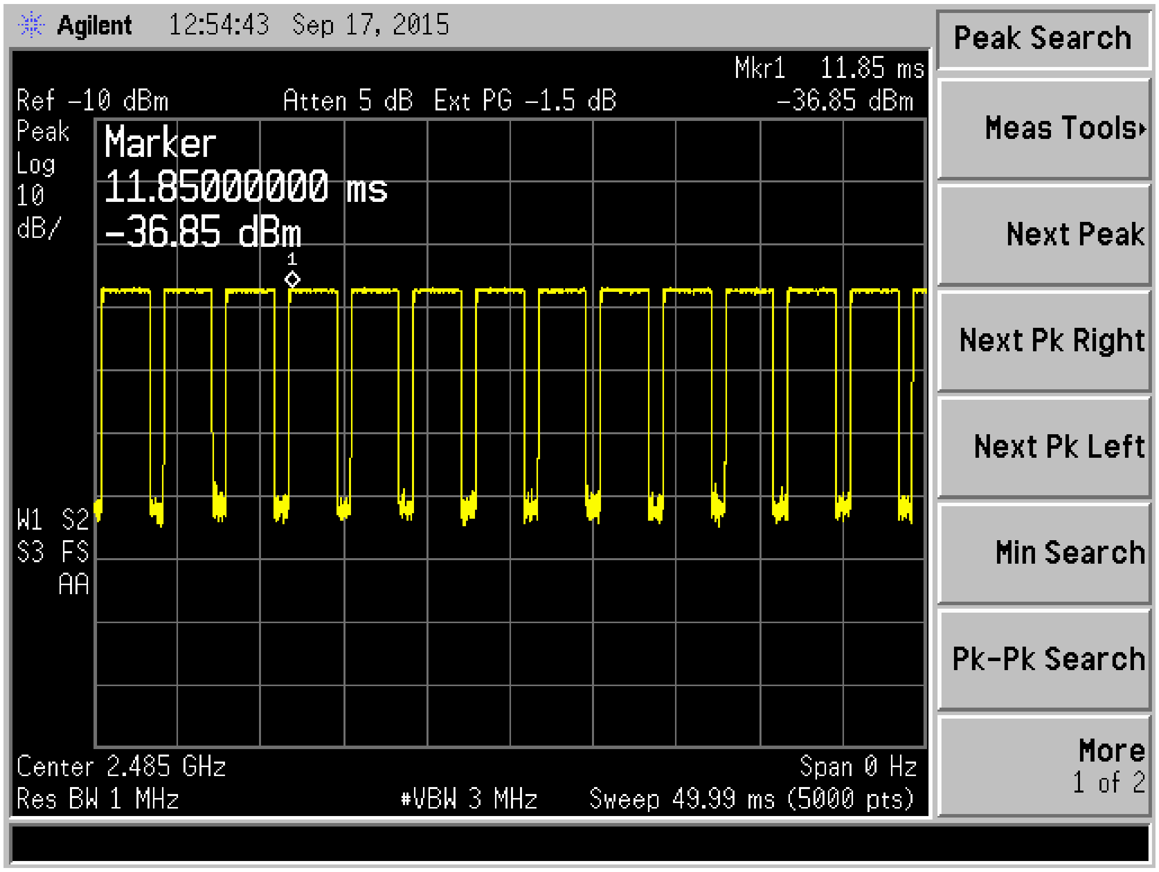


Figure 26. OOB Emission at 2485.0 MHZ and -10˚C

Antenna Gain: 2.6 dBi

Bandwidth : 1 MHz

Table 6. Transmitter Out-Of-Band Measurements at 20˚C

Frequency (MHz)	Measured Emission (dBm)	Combination of Antenna Assembly (dBm)	Limit (dBm)	Margin (dB)
2400 MHz – BW to 2400 MHz				
2399.50	-24.43	-21.83	-10.0	11.8
2400 MHz – 2 BW to 2400 MHz – BW				
2398.50	-37.17	-34.57	-20.0	14.6
2483.5 MHz to 2483.5 +BW				
2484.00	-30.23	-27.63	-10.0	17.6
2483.5 MHz + BW to 2483.5 + 2 BW				
2485.00	-37.43	-34.83	-20.0	14.8

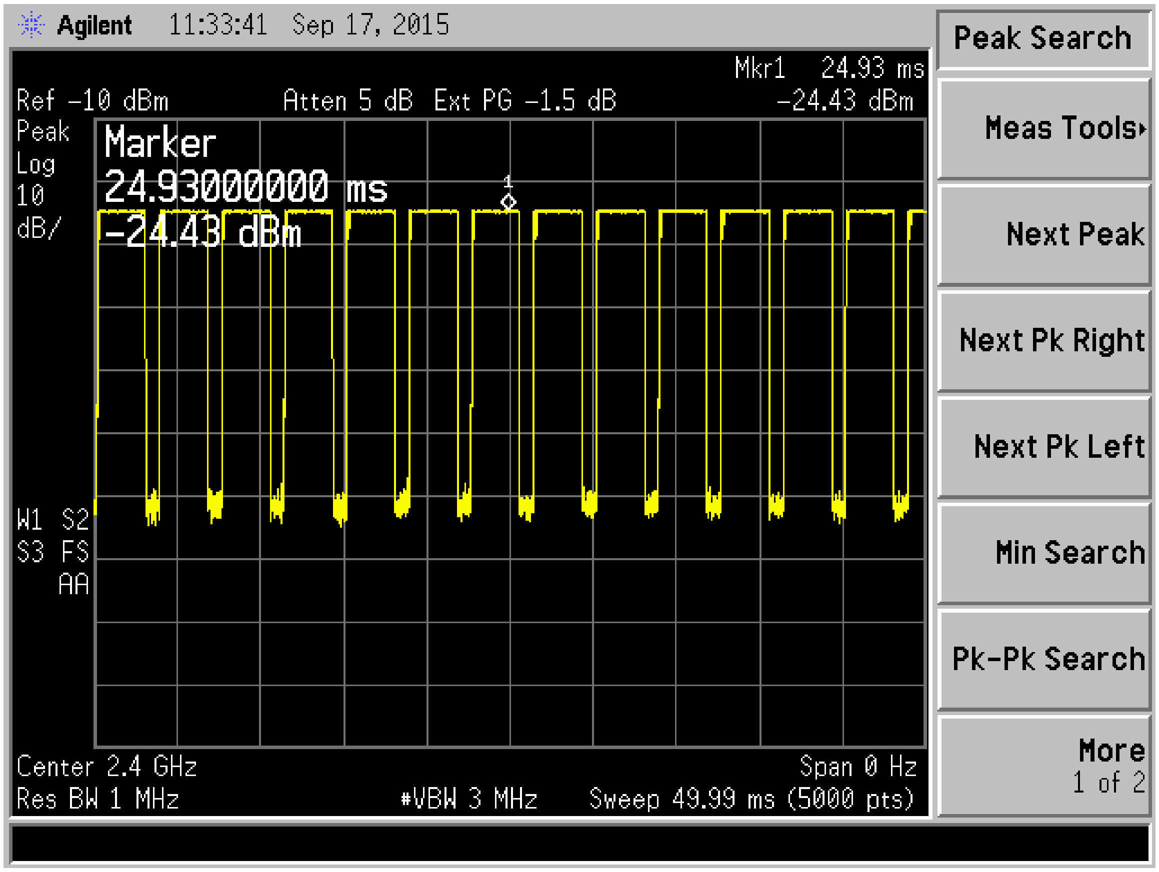


Figure 27. OOB Emission at 2399.5 MHz and 20˚C

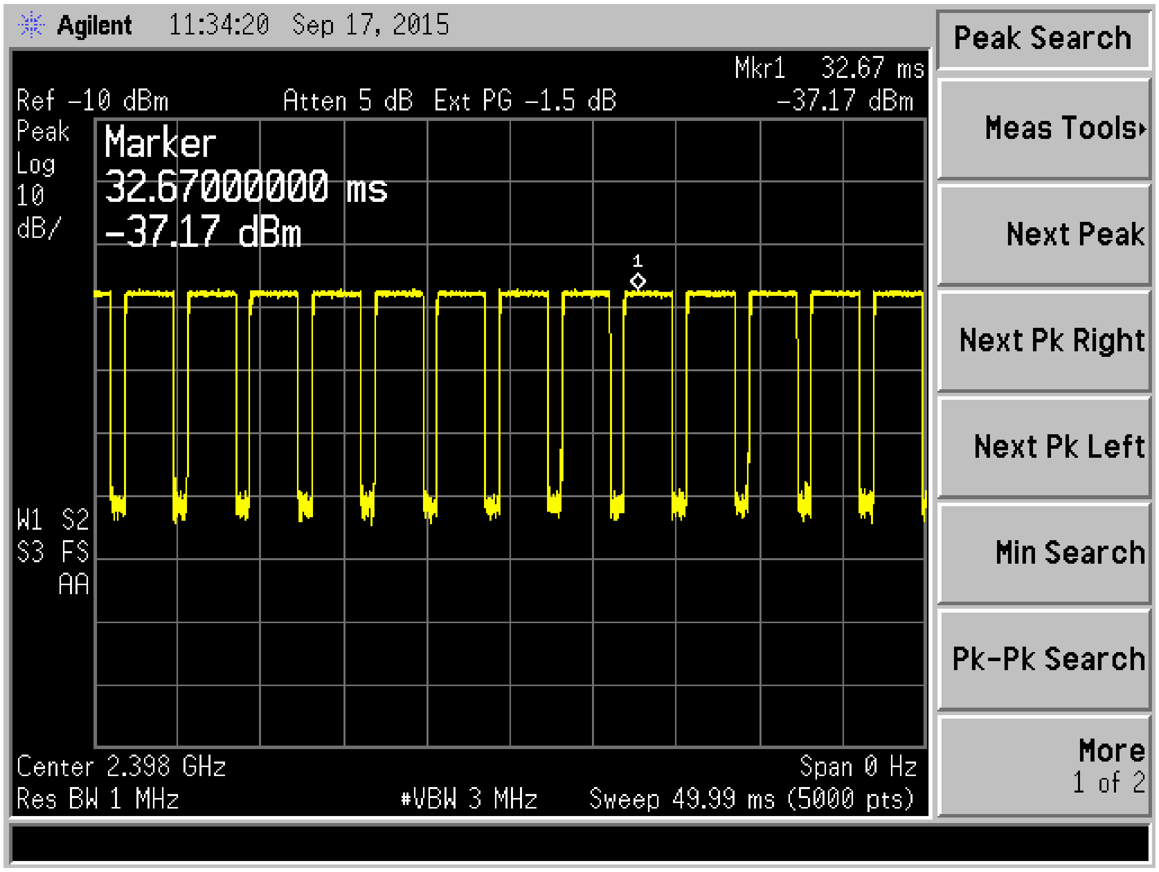


Figure 28. OOB Emission at 2398.5 MHz and 20˚C

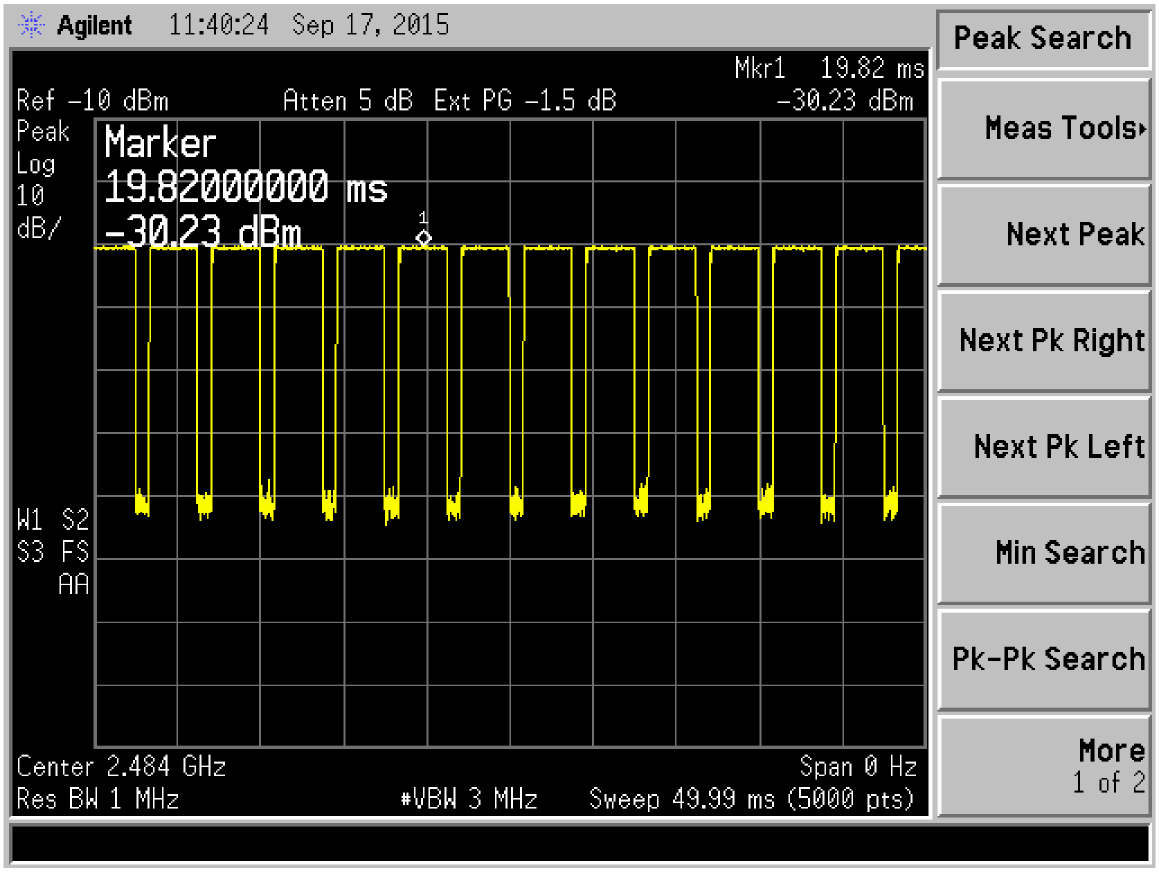


Figure 29. OOB Emission at 2484.0 MHz and 20˚C

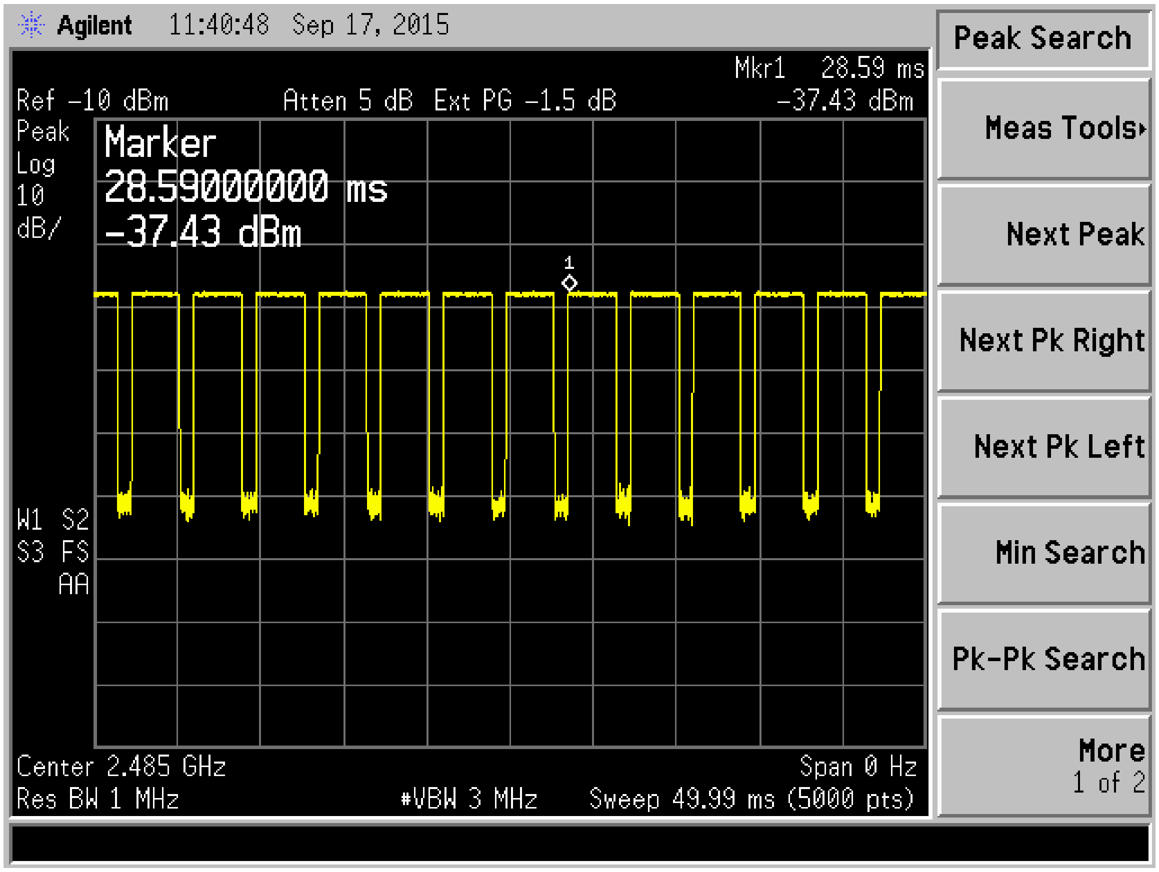


Figure 30. OOB Emission at 2485.0 MHz and 20˚C

Antenna Gain: 2.6 dBi
Bandwidth : 1 MHz

Table 7. Transmitter Out-Of-Band Emissions Measurements at 65˚C

Frequency (MHz)	Emissions Measurement (dBm)	Combination of Antenna Assembly (dBm)	Limit (dBm)	Margin (dB)
2400 MHz – BW to 2400 MHz				
2399.50	-23.84	-21.24	-10.0	11.2
2400 MHz – 2 BW to 2400 MHz – BW				
2398.50	-36.61	-34.01	-20.0	14.0
2483.5 MHz to 2483.5 + BW				
2484.00	-30.48	-27.88	-10.0	17.9
2483.5 + BW to 2483.5 + 2 BW				
2485.00	-37.66	-35.06	-20.0	15.1

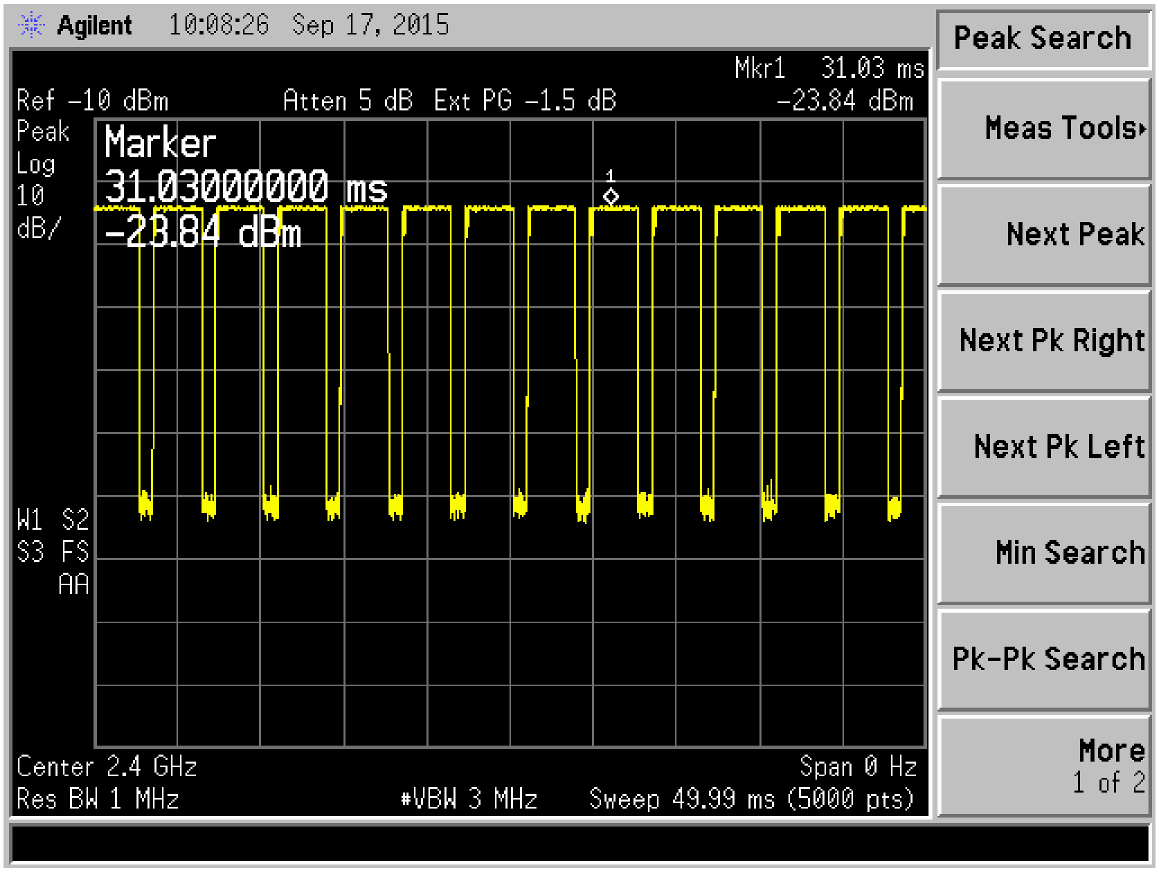


Figure 31. OOB Emission at 2399.5 MHz and 65˚C

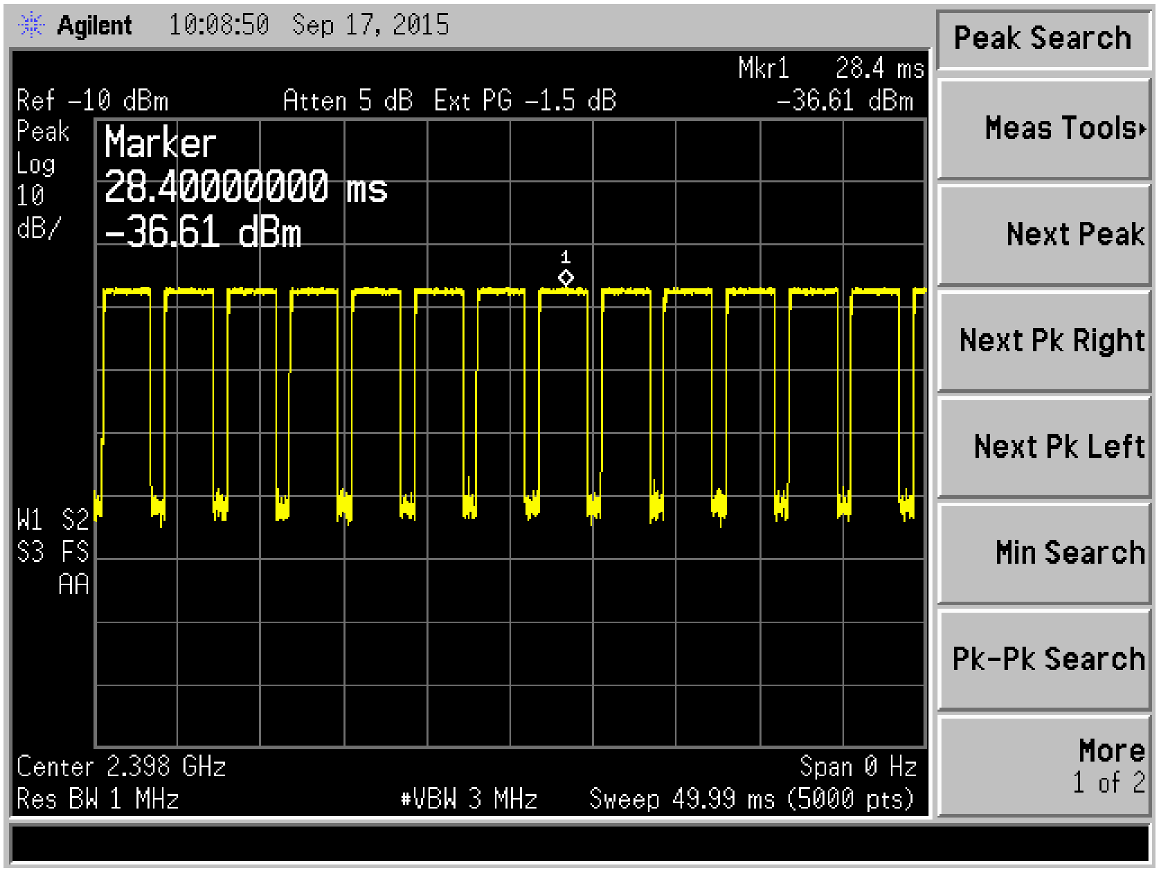


Figure 32. OOB Emission at 2398.5 MHz and 65˚C

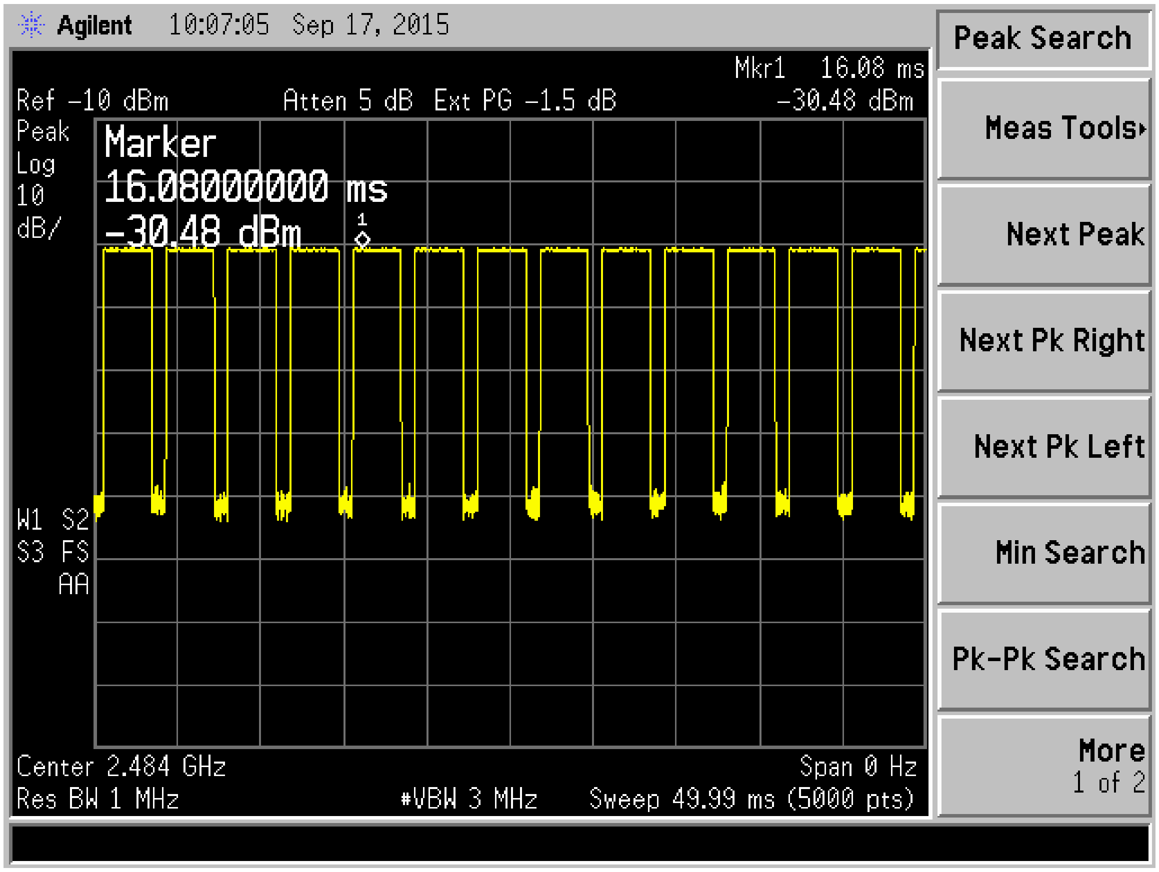


Figure 33. OOB Emission at 2484.0 MHz and 65˚C

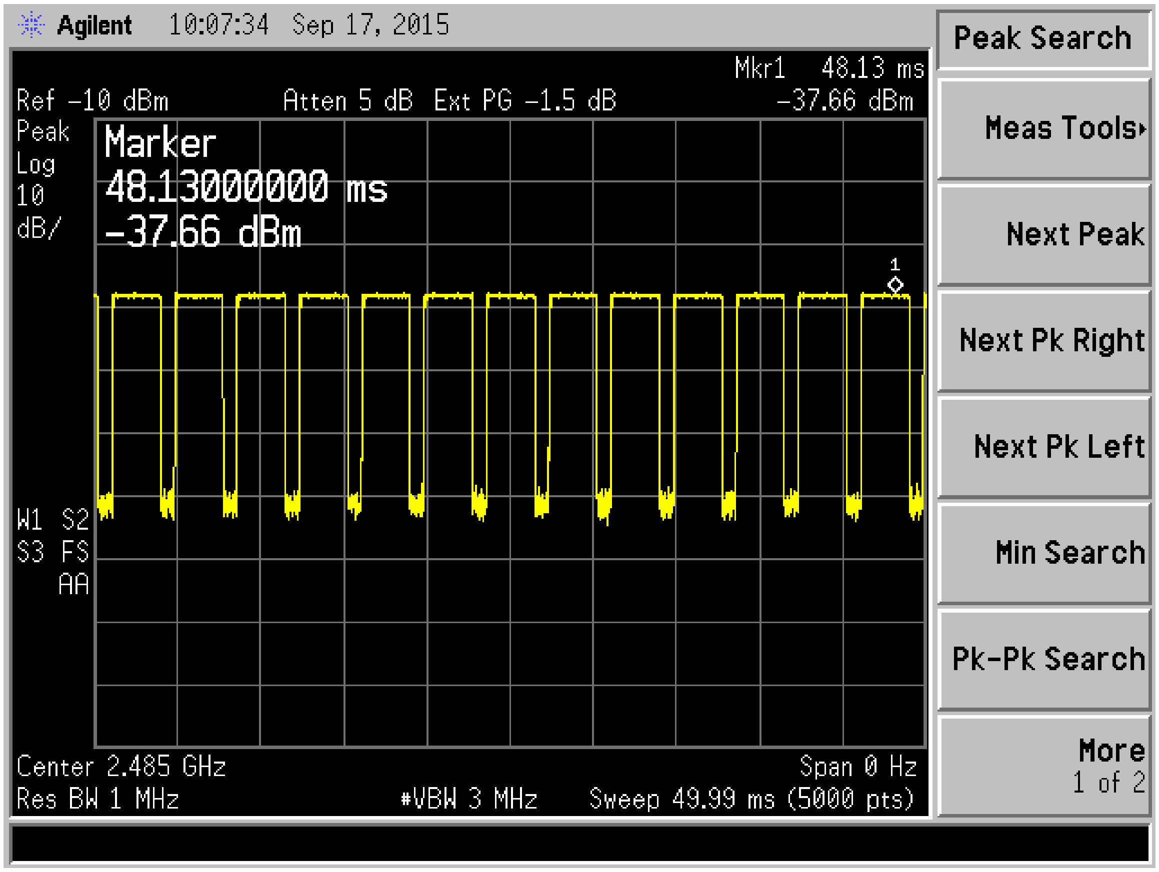


Figure 34. OOB Emission at 2485.0 MHz and 65˚C

4.3.10 Transmitter Unwanted Emissions in the Spurious (Clause 5.3.10)

Transmitter unwanted emissions in the spurious domain are emissions outside the allocated band and the Out-Of-Band domain In accordance ETSI EN 300 328 section 4.3.1.9, the spurious emissions cannot be greater than the limits in Table 8.

Table 8. 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 transmitter unwanted emissions in the spurious domain were measured at normal test conditions and with the equipment operating at its worst case scenario with respect to spurious emissions. Measurements were performed at the lowest and highest channels the EUT can operate on.

4.3.10.1 Conducted Transmitter Unwanted Emissions

A pre-scan was performed per ETSI EN 300 328 section 5.3.10.2.1.1. The individual unwanted emissions were then measured per ETSI EN 300 328 section 5.3.10.2.1.2 and compared to the spurious limits above. The results are presented below.

Environmental Conditions:
Ambient Temperature: 20 ˚C
Relative Humidity: 40 %

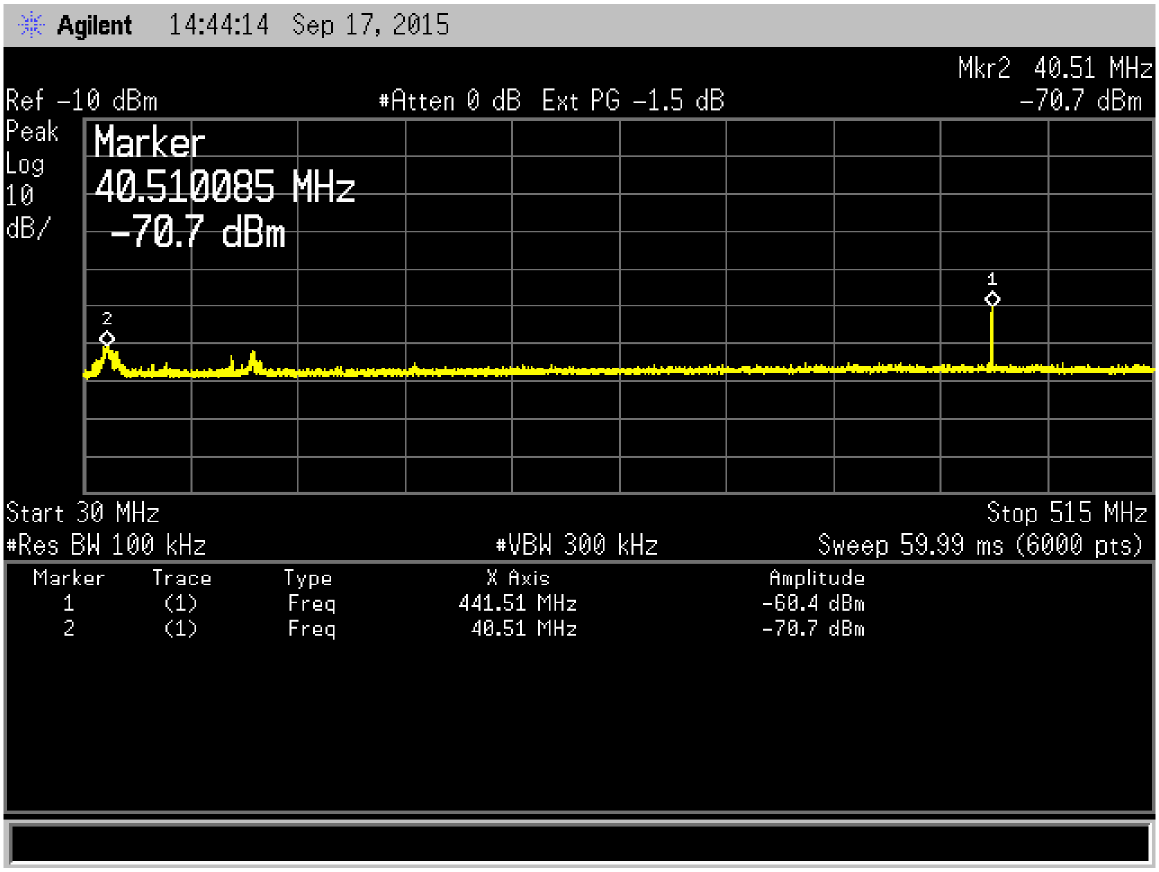


Figure 35. Conducted Spurious emissions Low Channel 30 MHz to 515 MHz

Limit (per Table 8)	-36.00 dBm
Measured Emissions (40.51 MHz)	-70.70 dBm
Margin	34.70 dB

Limit (per Table 8)	-36.00 dBm
Measured Emissions (441.51 MHz)	-60.40 dBm
Margin	24.40 dB

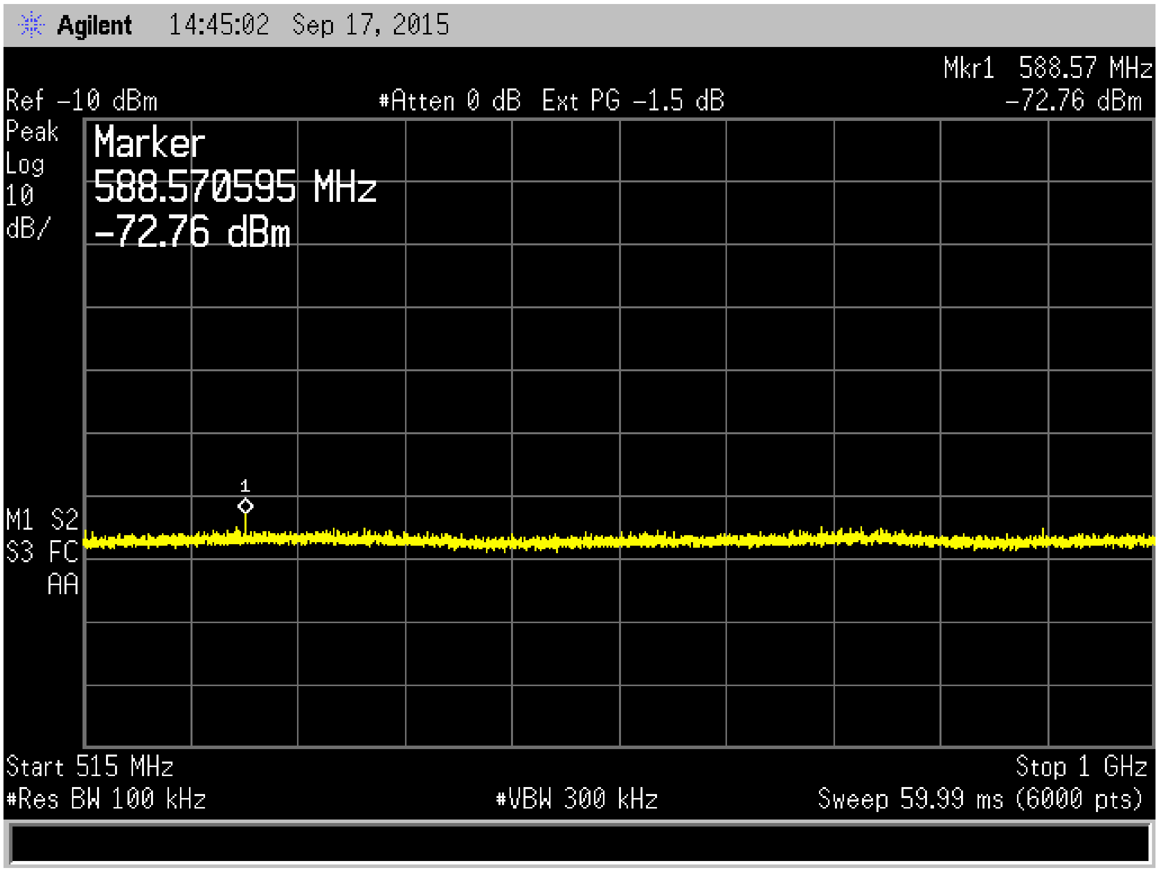


Figure 36. Conducted Spurious emissions Low Channel 515 MHz to 1 GHz

Limit (per Table 8)	-54.00 dBm
Measured Emissions (per Figure 33)	-75.76 dBm
Margin	21.76 dB

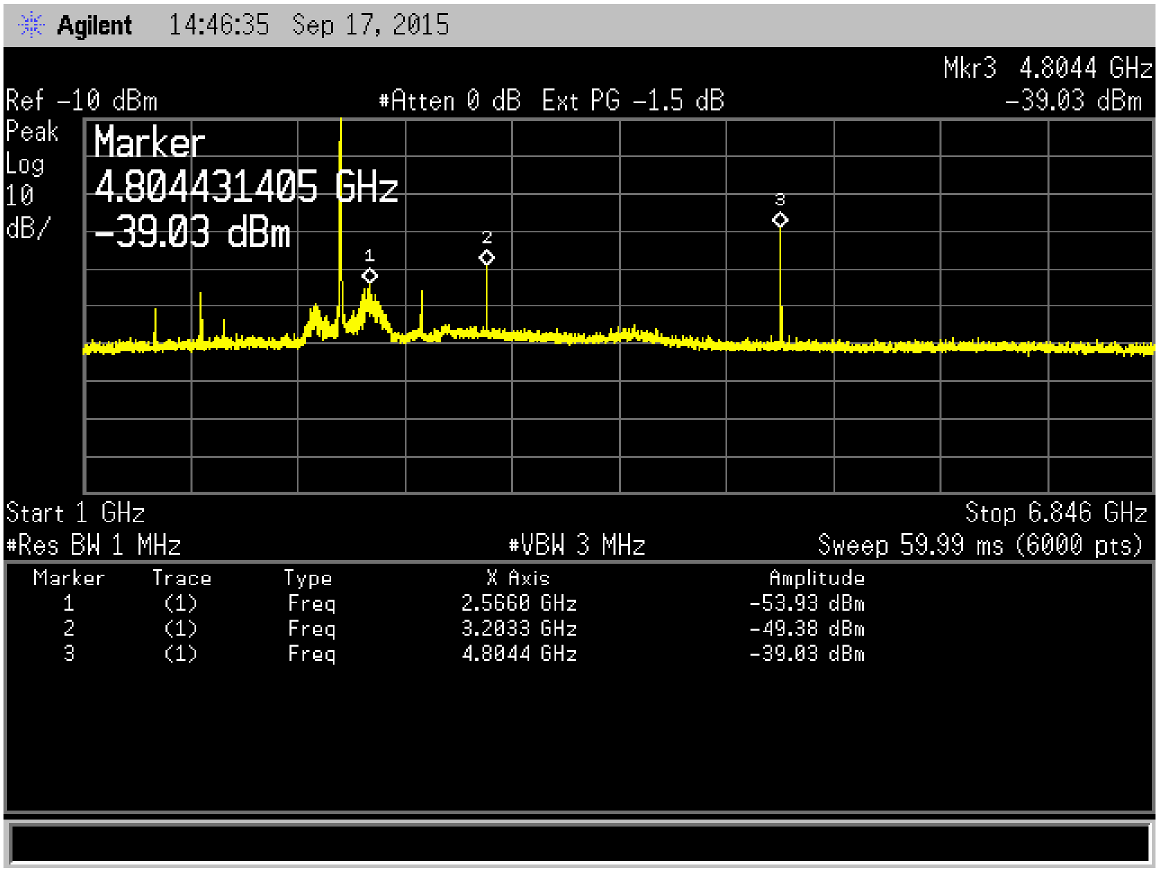


Figure 37. Conducted Spurious emissions Low Channel 1 GHz to 6.875 GHz

Limit (per Table 8)	-30.00 dBm
Measured Emissions (2566 MHz)	-53.93 dBm
Margin	23.93 dB
Limit (per Table 8)	-30.00 dBm
Measured Emissions (3203.3 MHz)	-49.38 dBm
Margin	19.38 dB
Limit (per Table 8)	-30.00 dBm
Measured Emissions (4804.4 MHz)	-39.03 dBm
Margin	9.03 dB

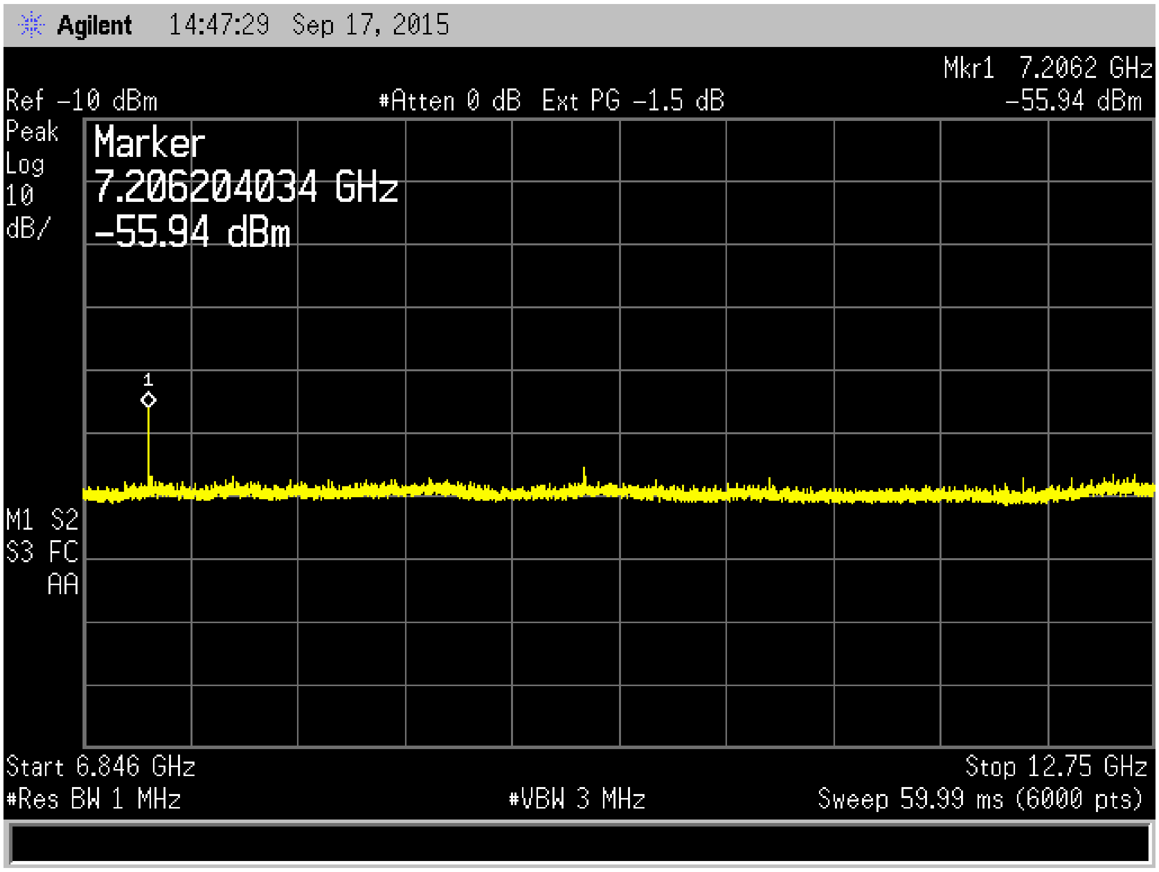


Figure 38. Conducted Spurious emissions Low Channel 6.846 GHz to 12.75 GHz

Limit (per Table 8)	-30.00 dBm
Measured Emissions (per Figure 36)	-55.94 dBm
Margin	25.94 dB

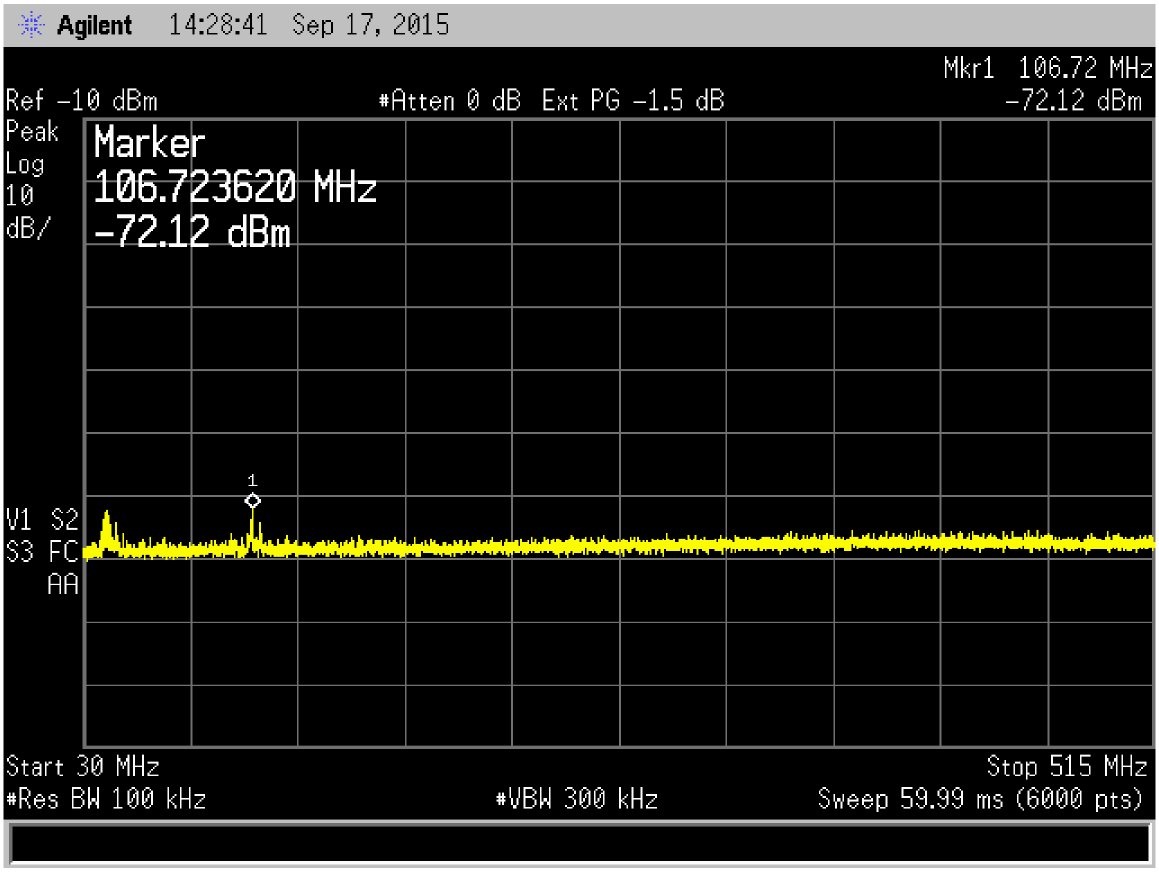


Figure 39. Conducted Spurious emissions High Channel 30 MHz to 515 MHz

Limit (per Table 8)	-54.00 dBm
Measured Emissions (Figure 36)	-72.12 dBm
Margin	18.12 dB

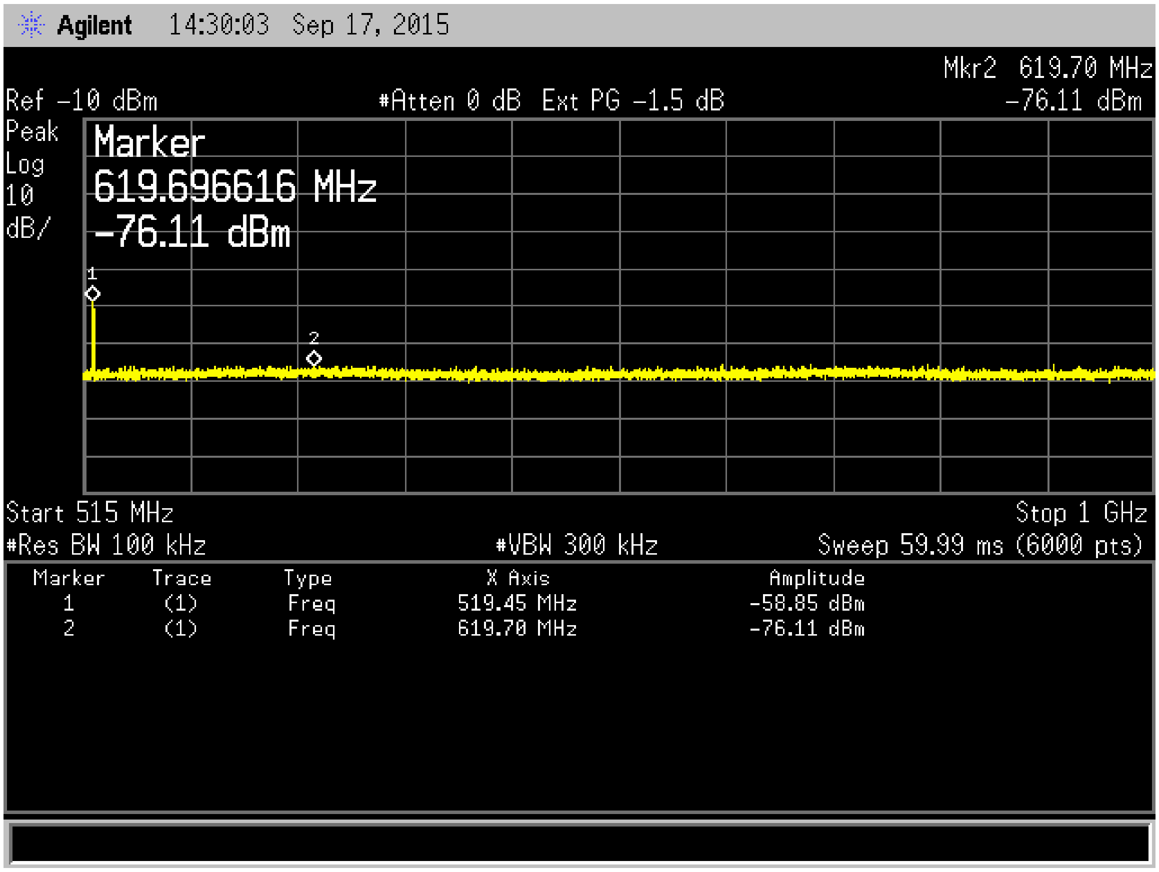


Figure 40. Conducted spurious emissions High Channel 515 MHz to 1 GHz

Limit (per Table 8)	-54.00 dBm
Measured Emissions (519.45 MHz)	-58.85 dBm
Margin	4.85 dB

Limit (per Table 8)	-54.00 dBm
Measured Emissions (519.70 MHz)	-76.11 dBm
Margin	22.11 dB

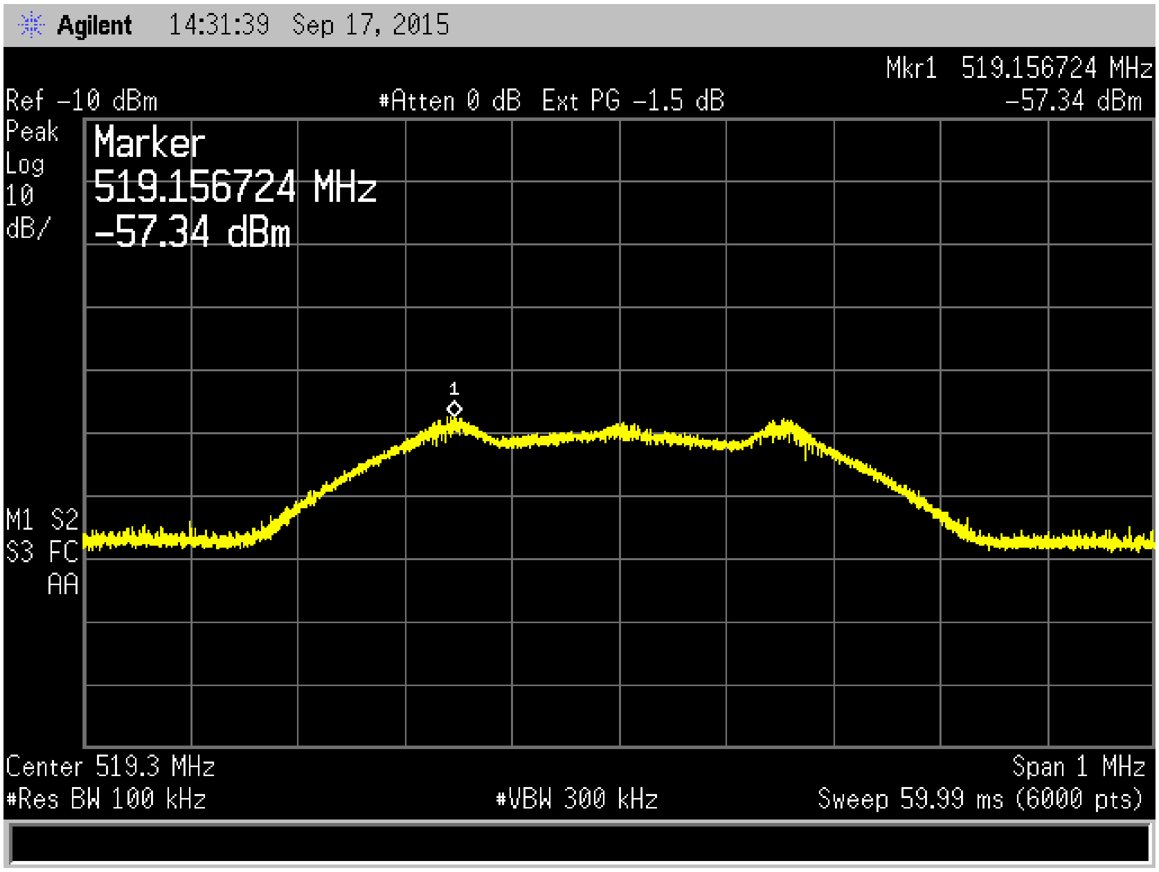


Figure 41. Conducted Emission at 519.4 MHz

Limit (per Table 8)	-54.00 dBm
Measured Emissions (519.16 MHz)	-57.34 dBm
Margin	3.34 dB

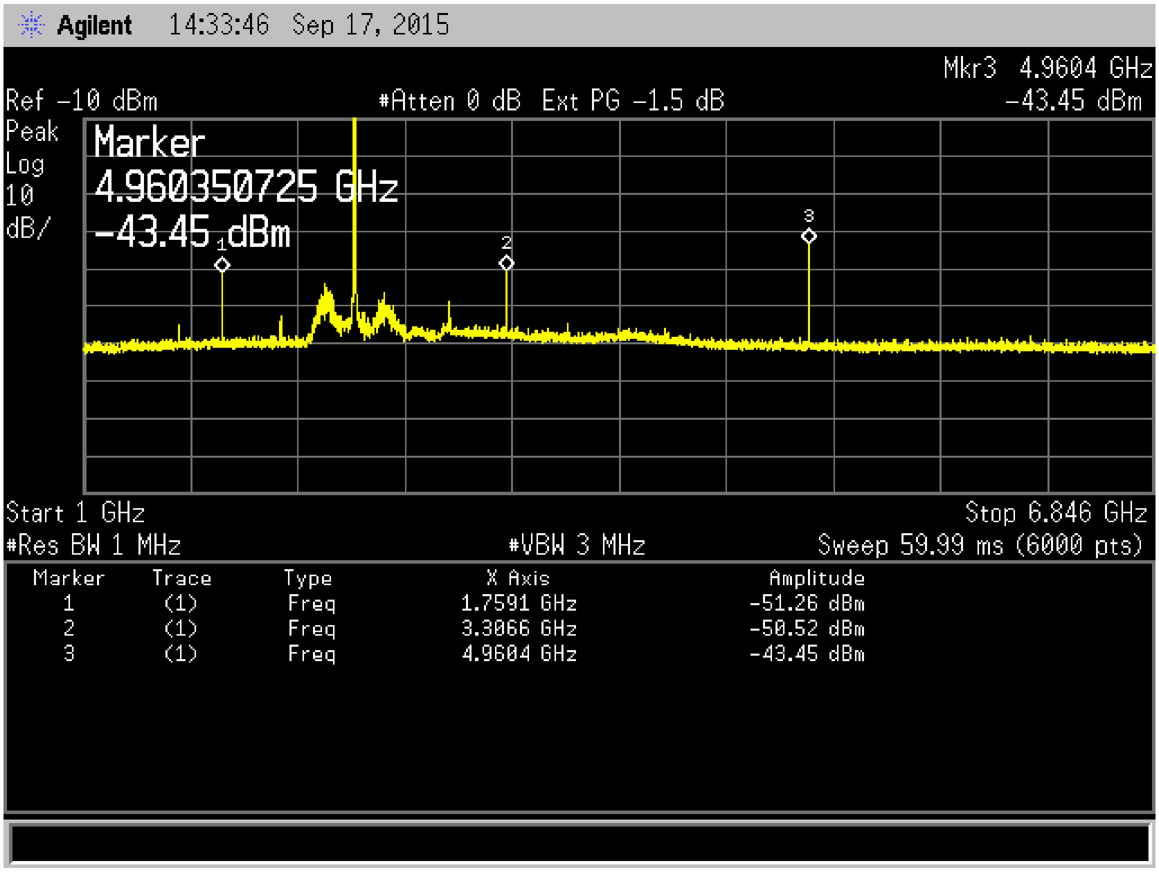


Figure 42. Conducted Spurious emissions High Channel 1 GHz to 6.875 GHz

Limit (per Table 8)	-30.00 dBm
Measured Emissions (1759.1 MHz)	-51.26 dBm
Margin	21.26 dB

Limit (per Table 8)	-30.00 dBm
Measured Emissions (3306.6 MHz)	-50.52 dBm
Margin	20.52 dB

Limit (per Table 8)	-30.00 dBm
Measured Emissions (4960.4 MHz)	-43.45 dBm
Margin	13.45 dB

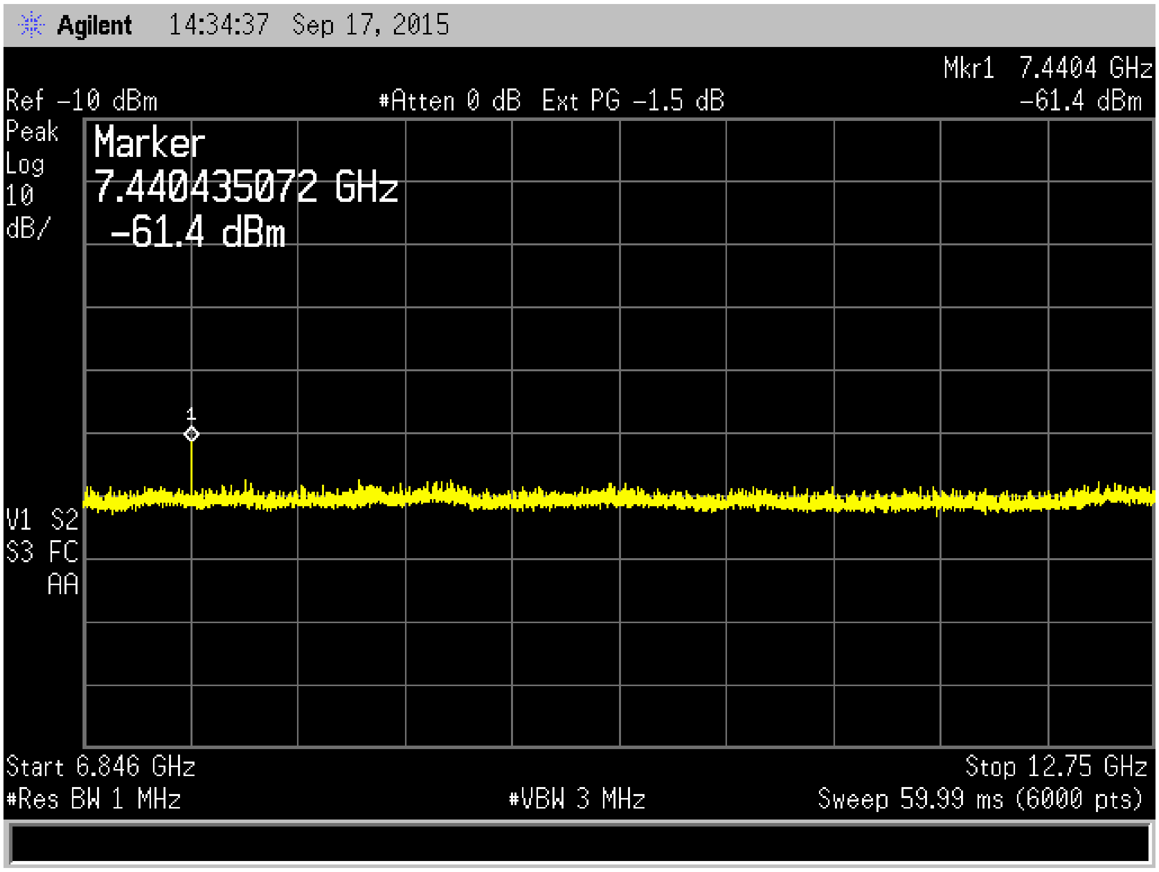


Figure 43. Conducted Spurious emissions High Channel 6.875 GHz to 12.75 GHz

Limit (per Table 8)	-30.00 dBm
Measured Emissions (per Figure 40)	-61.40 dBm
Margin	31.40 dB

4.3.11 Receiver Unwanted Emissions in the Spurious (Clause 5.3.11)

The EUT was in receiving mode only. Receiver unwanted emissions in the spurious domain are emissions outside the allocated band and the Out-Of-Band domain In accordance with ETSI EN 300 328 section 4.3.1.10. The spurious emissions cannot be greater than the limits in Table 9.

Table 9. Receiver Unwanted Emissions Limits

Frequency Range	Maximum power, e.r.p. (≤ 1 GHz) e.i.r.p (> 1 GHz)	Bandwidth
30 MHz to 1 GHz	-57 dBm	100 kHz
1 GHz to 12.75 GHA	-47 dBm	1 MHz

The receiver unwanted emissions in the spurious domain were measured at normal test conditions and with the equipment operating at its worst case scenario with respect to spurious emissions.

4.3.11.1 Conducted Receiver Unwanted Emissions

A pre-scan was performed per ETSI EN 300 328 section 5.3.11.2.1.1. The individual unwanted emissions were then measured per section 5.3.11.2.1.2 and compared to the spurious limits above. The results are presented following.

Environmental Conditions:
Ambient Temperature: 20˚C
Relative Humidity: 40 %

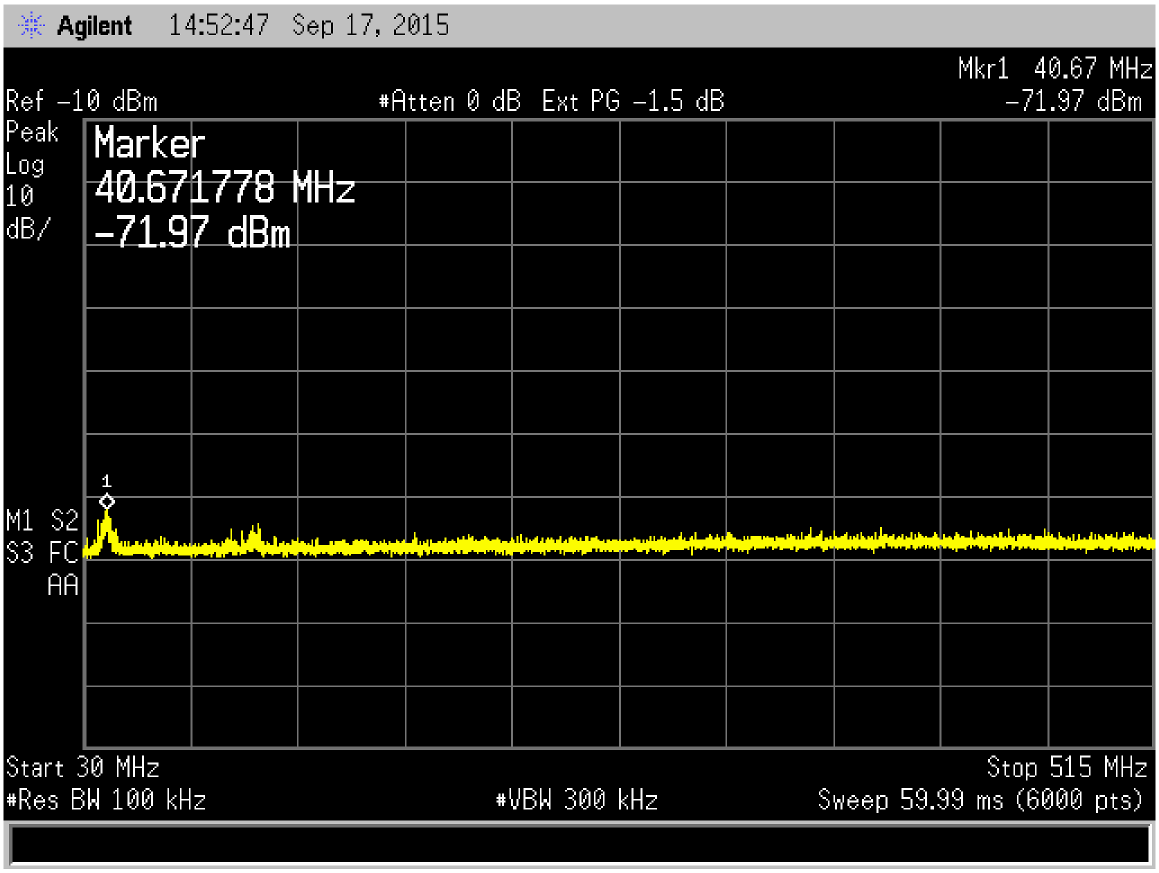


Figure 44. Receiver Conducted Spurious Emissions 30 MHz to 515 MHz

Limit (per Table 9)	-57.00 dBm
Measured Emissions (Figure 41)	-71.97 dBm
Margin	14.97 dB

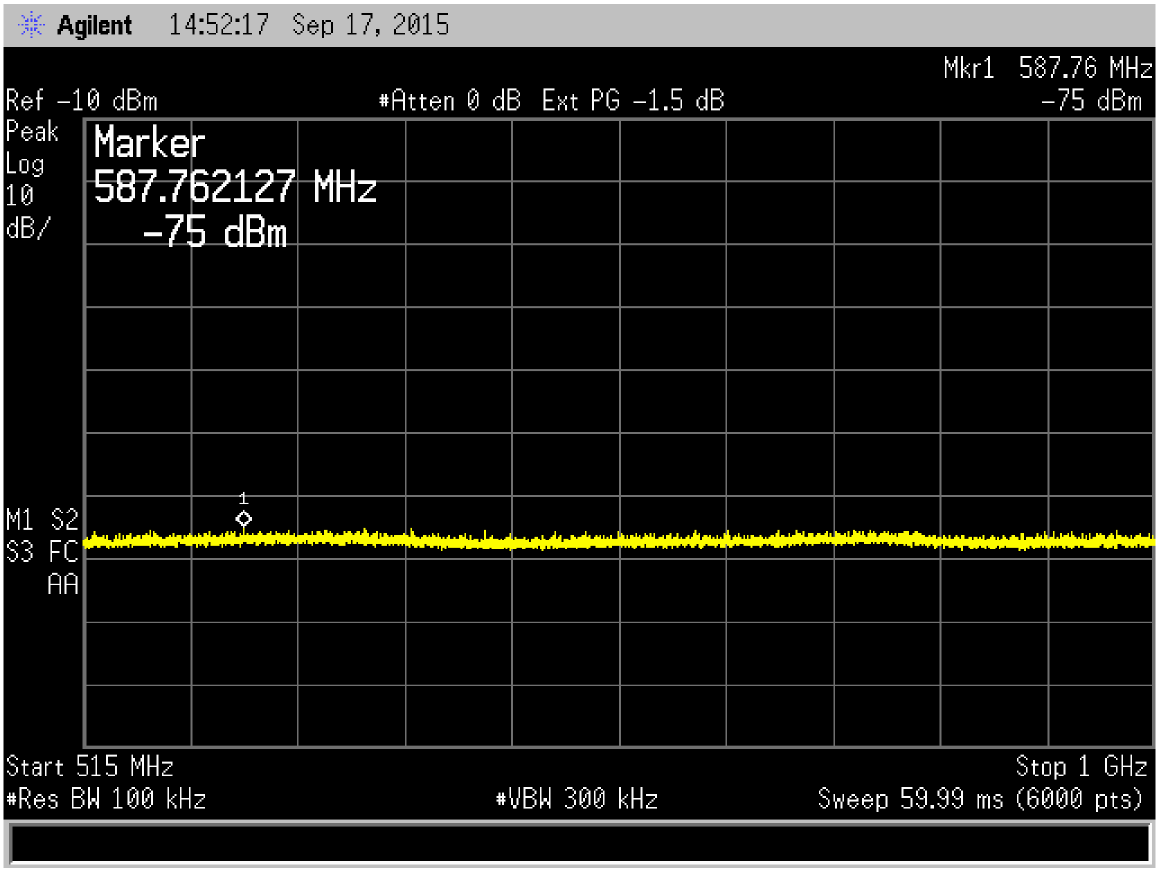


Figure 45. Receiver Conducted Spurious Emissions 515 MHz to 1 GHz

Limit (per Table 9)	-57.00 dBm
Measured Emissions (per Figure 42)	-75.00 dBm
Margin	18.00 dB

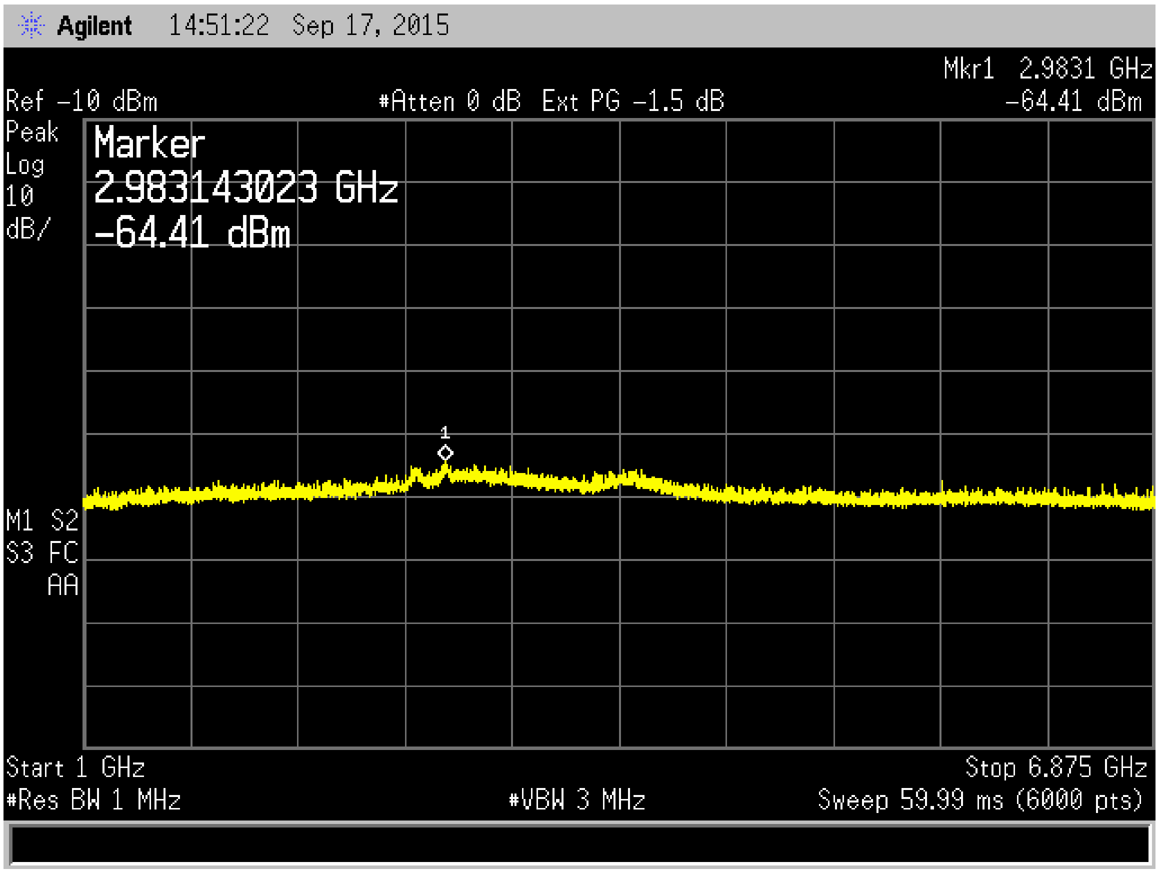


Figure 46. Conducted Spurious Emissions 1 GHz to 6.875 GHz

Limit (per Table 9)	-47.00 dBm
Measured Emissions (per Figure 43)	-64.41 dBm
Margin	17.41 dB

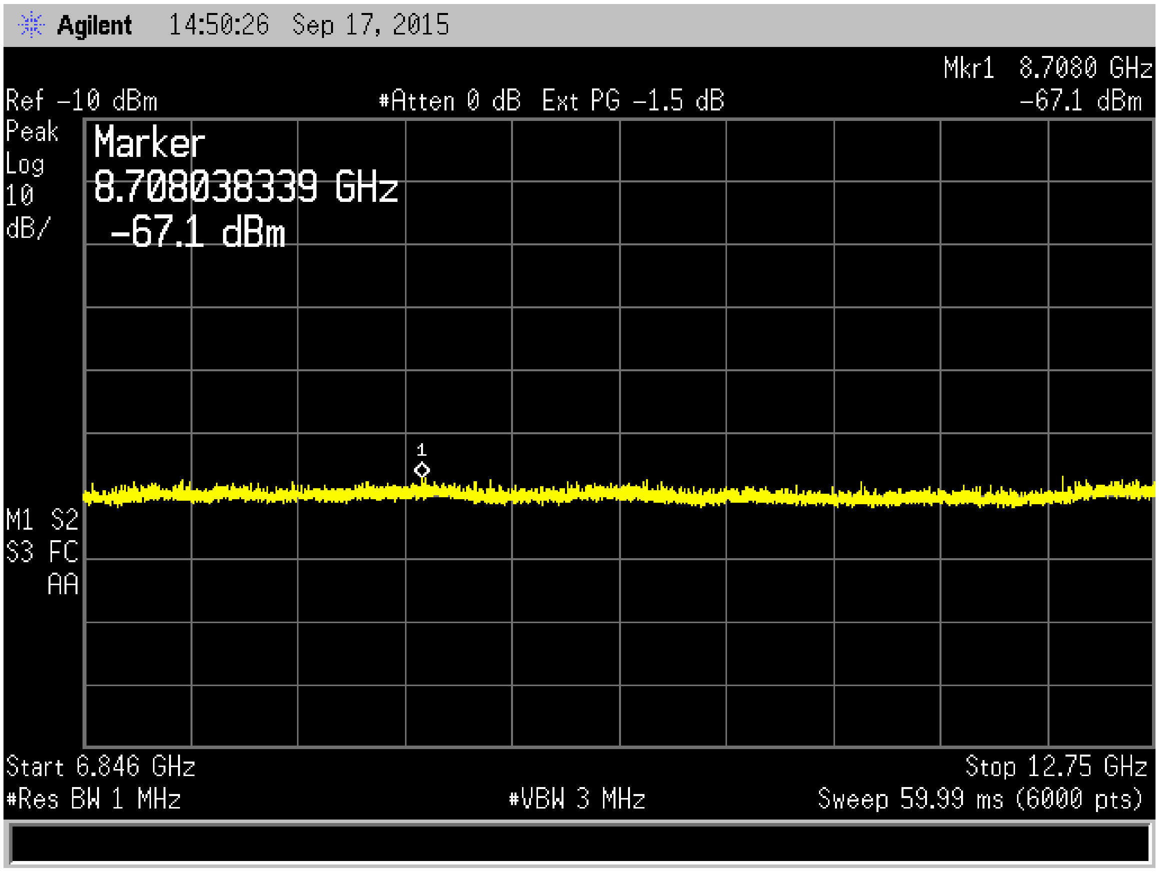


Figure 47. Conducted Spurious Emissions 6.875 GHz to 12.75 GHz

Limit (per Table 9)	-47.00 dBm
Measured Emissions (per Figure 44)	-67.10 dBm
Margin	20.10 dB

4.4 RF Exposure

The EUT meets the requirement of EN 62311:2008.

The maximum exposure level to the public from the RF power of the EUT shall not exceed a power density, S, of 1 mW/cm^2 at a distance, d, of 20 cm from the EUT.

Therefore for:

Measured maximum output power: 12.44 dBm (EIRP)
Highest Gain Antenna (Type of Antenna): 2.6 dBm

Peak Power (Watts) = 0.018 (Manufacture's claimed highest output power)
Gain of Transmit Antenna = 2.6 dBi = 2.14 numeric
D = distance = 2- cm = 0.2 m

$S = (PG/4\pi d^2) = EIRP/4A = (0.018*2.14)/4\pi*0.2*0.2$
$= .039/.5027 = 0.077\ W/m^2$
$= (W/m^2)\ (1\ m^2/W)(0.1 mW/cm^2)$
$=.0077$

Which is << less than 1.0 mW/cm^2

5 Co-Location Testing

A test site similar to that as described in Annex B of EN 300 328 v1.8.2 (2012) was used to measure the radiated spurious emission per Annex C of EN 300 328 v 1.8.2 (2012).

This data taken and reported in the WiFi report associated with this project; under report number: 15-0112 for ETSI EN 300 328 v1.8.1.

6 Test Instruments

Table 10. Test Equipment

INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	DATE OF LAST CALIBRATION
SPECTRUM ANALYZER	8566B	HEWLETT-PACKARD	2747A05665	5/7/2015
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	1/28/2015
SIGNAL GENERATOR	70004A	HEWLETT-PACKARD	70340A	Not Required*
BICONICAL ANTENNA	3110B	EMCO	9306-1708	11/24/2014 2 yr.
BICONICAL ANTENNA	3110B	EMCO	9307-1431	8/25/2015 2 yr.
LOG PERIODIC ANTENNA	3146	EMCO	9110-3236	11/19/2014 2 yr.
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	7/1/2014 2 yr.
HORN ANTENNA	SAS-571	A.H. Systems	605	8/25/2015 2 yr.
HORN ANTENNA	3115	EMCO	9107-3723	7/8/2014 2 yr.
HORN ANTENNA	3116	EMO	9505-2255	1/27/2015 2 yr.
PRE-AMPLIFIER	8449B	HEWLETT-PACKARD	3008A00480	12/5/2014
PRE-AMPLIFIER	8477E	HEWLETT-PACKARD	1145A00307	11/21/2014
PRE-AMPLIFIER	8447D	HEWLETT-PACKARD	1937A02980	12/4/2014
LISN x 2	9247-50-TS-50-N	SOLAR ELECTRONICS	955824 and 955825	12/30/2014

*Calibration not required; verified with calibrated equipment during test.
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7 Photographs

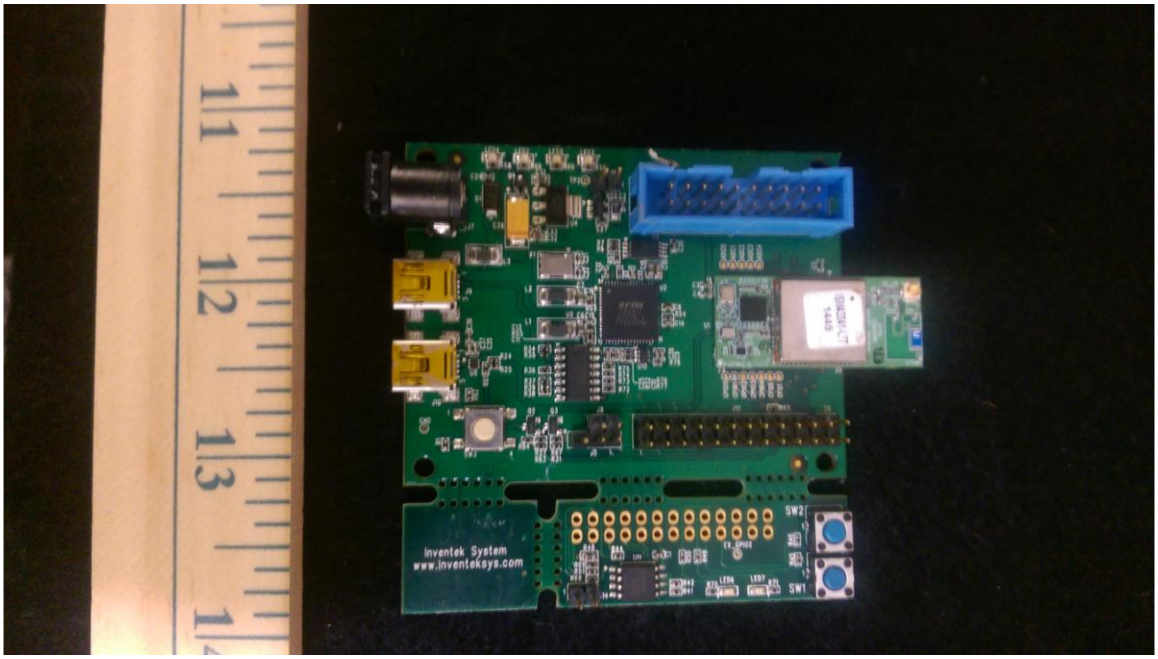

Figure 48. Outside of EUT

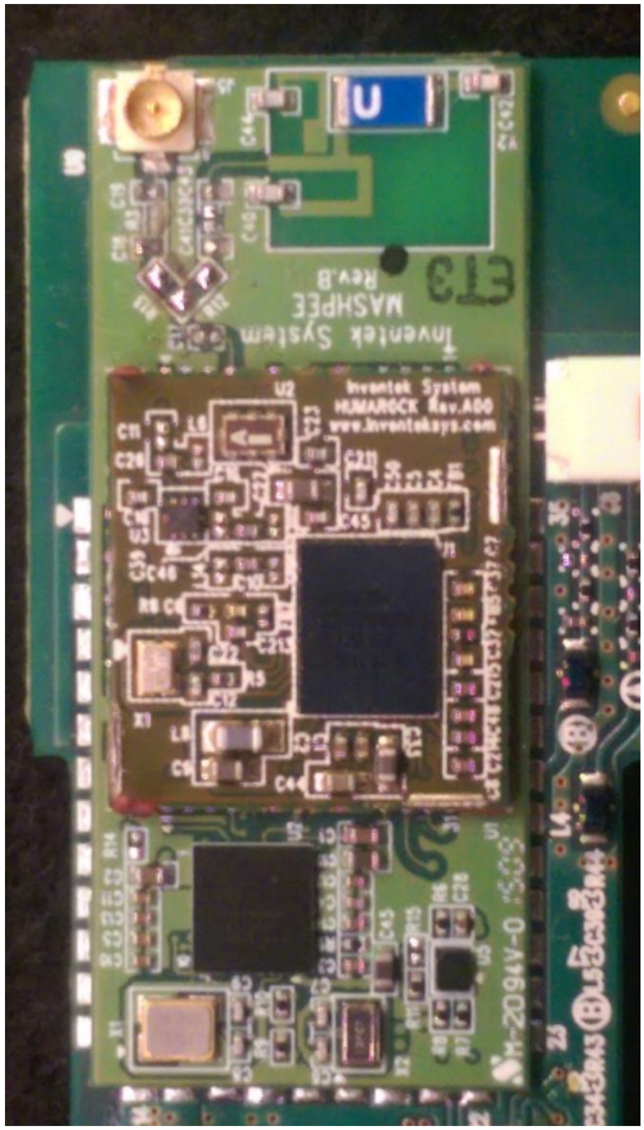

Figure 49. Top of EUT Circuit Board (Radio Close Up)

Figure 50. Bottom of EUT Circuit Board

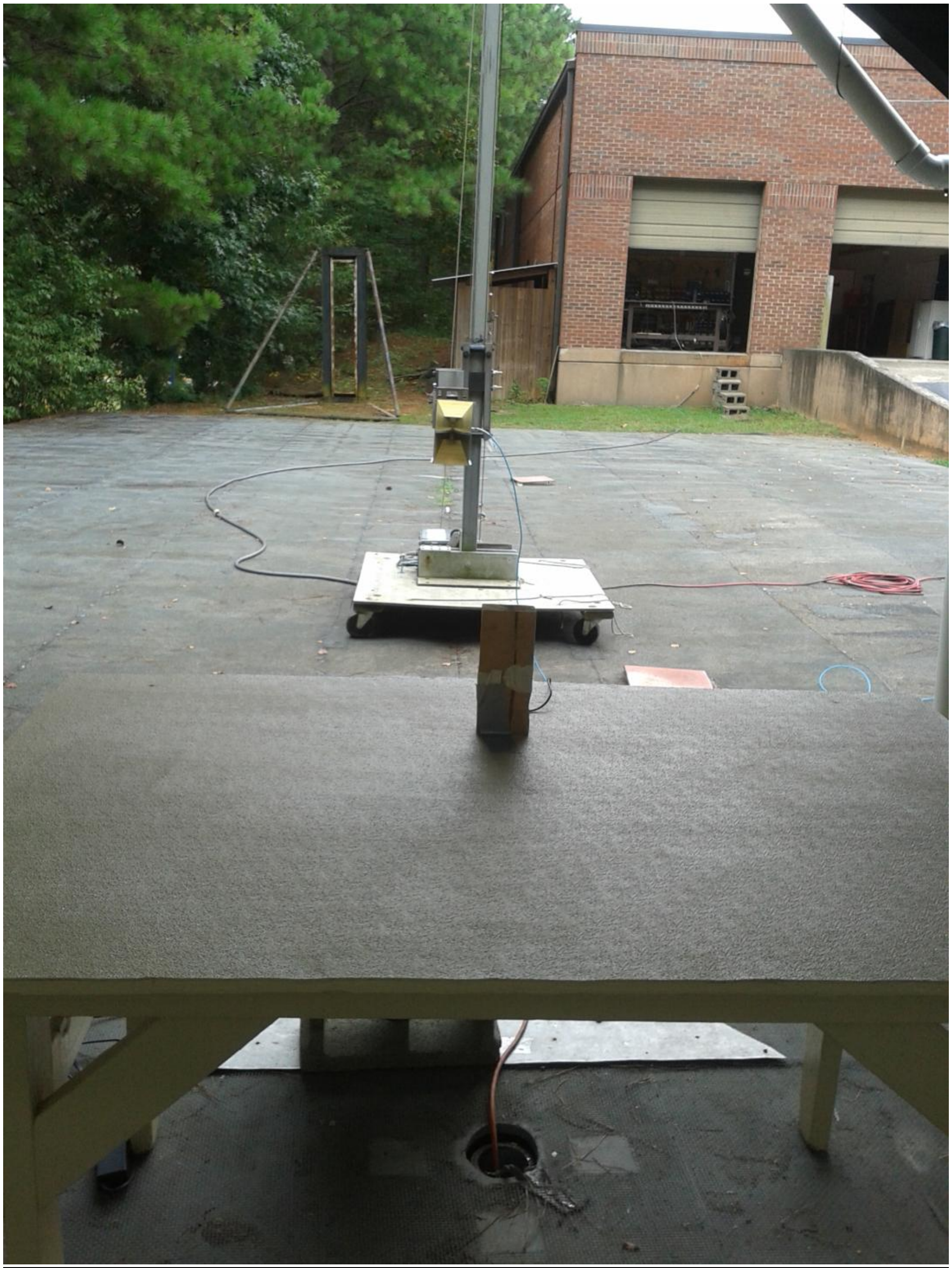

Figure 51. Radiated Emissions Test Setup Rear

Figure 52. Radiated Emissions Test Setup Front

Figure 53. Extreme Temperature Testing

Figure 54. Conducted Powerline Emissions Test Setup