Electromagnetic Compatibility Test Report

Tests Performed on a TimeKeeping Systems

2.4 GHz Transceiver, Model DD-007

Radiometrics Document RP-9140

Product Detail:
FCC ID: MTD-0007 IC: 12375A-0007 Equipment type: DTC transmitter
Test Standards:
US CFR Title 47, Chapter I, FCC Part 15 Subpart C FCC Part 15 CFR Title 47: 2017 Canada ISED; RSS-247, Issue 2 IC RSS-GEN Issue 5: 2018 This report concerns: Original Grant for Certification FCC Part 15.247

Tests Performed For:	*Test Facility:*
TimeKeeping Systems, Inc. 30100 Bainbridge Road, Suite H Solon, Ohio 44139	**Radiometrics Midwest Corporation** 12 Devonwood Avenue Romeoville, IL 60446-1349 (815) 293-0772

Test Date(s): (Month-Day-Year)
August 7 to 21, 2019

Document RP-9140 Revisions:

Rev.	Issue Date	Affected Sections	Revised By
0	September 6, 2019		
1	September 17, 2019	2.0, 11.1	Joseph Strzelecki

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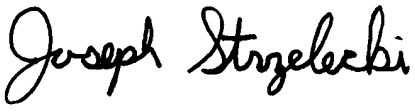
1.0 ADMINISTRATIVE DATA

Equipment Under Test:	
A TimeKeeping Systems, 2.4 GHz Transceiver Model: DD-007 Serial Number: SMP1 This will be referred to as the EUT in this Report	
Date EUT Received at Radiometrics: (Month-Day-Year)	*Test Date(s): (Month-Day-Year)*
August 6, 2019	August 7 to 21, 2019
Test Report Written and Authorized By:	*Test Witnessed By:*
Joseph Strzelecki Senior EMC Engineer	The tests were not witnessed by personnel from TimeKeeping Systems, Inc.
Radiometrics' Personnel Responsible for Test:	*EUT Checked By:*
 09/06/2019 Date Joseph Strzelecki Senior EMC Engineer NARTE EMC-000877-NE Richard L. Tichgelaar EMC Technician	Joseph Strzelecki Richard Tichgelaar Dave Jarvis Radiometrics

2.0 TEST SUMMARY AND RESULTS

The EUT (Equipment Under Test) is a 2.4 GHz Transceiver, Model DD-007, manufactured by TimeKeeping Systems, Inc. The detailed test results are presented in a separate section. The following is a summary of the test results.

Spread Spectrum Transmitter Requirements

Environmental Phenomena	Frequency Range	FCC Section	RSS- Section	Test Result
6 dB Bandwidth Test	2400 to 2483 MHz	15.247 a	RSS-247 (5.2)	Pass
Peak Output Power	2400 to 2483 MHz	15.247 b	RSS-247 (5.4d)	Pass
Spurious Radiated Emissions	30 MHz to 25 GHz	15.247 d	RSS-247 (3.3)	Pass
Antenna Port Conducted Unwanted Emissoins	30 MHz to 25 GHz	15.247 d	RSS-247 (5.5)	Pass
Power Spectral Density	2400 to 2483 MHz	15.247 e	RSS-247 (5.2b)	Pass

RF AC Mains Conducted Emissions is not required since the EUT is battery powered.

2.1 RF Exposure Compliance Requirements

The EUT meets the FCC requirement for RF exposure and it is exempt from RSS-102 SAR and RF exposure evaluations. There are no power level adjustments available to the end user. The antenna is permanently attached. The detailed calculations for RF Exposure are presented in a separate document.

3.0 EQUIPMENT UNDER TEST (EUT) DETAILS

3.1 EUT Description

The EUT is a 2.4 GHz Transceiver, Model DD-007, manufactured by TimeKeeping Systems. The EUT was in good working condition during the tests, with no known defects. The EUT broadcasts a location ping periodically in order to facilitate tracking of staff within a facility equipped with one or more tracking receivers.

3.1.1 FCC Section 15.203 & RSS-GEN Antenna Requirements

The antenna is permanently attached to the printed circuit board. The antenna is internal to the EUT and it is not readily available to be modified by the end user. Therefore, it meets the 15.203 Requirements.

Since the measurements at the antenna port are used to determine the RF output power, RSS-GEN section 6.8 requires that the effective gain of the products antenna be stated. The Antenna max gain is 3.3 dBi, based on the antenna's manufacturer.

4.0 TESTED SYSTEM DETAILS

4.1 Tested System Configuration

The system was configured for testing in a typical fashion. The EUT was placed on an 80-cm or 150 cm high, nonconductive test stand. The testing was performed in conditions as close as possible to installed conditions. The EUT was tested as a stand-alone device. Power was supplied with a new battery.

Tested System Configuration List

Item	Description	Type*	Manufacturer	Model Number	Serial Number
1	2.4 GHz Transceiver	E	TimeKeeping Systems	DD-007	SMP1

* Type: E = EUT, P = Peripheral, S = Support Equipment; H = Host Computer

4.2 EUT Operating Modes

The transmit mode for all tests was continuous. The EUT was in its normal GFSK modulation during the tests. It was tested as a stand-alone, battery powered device, since that is the configuration in the final installation.

4.3 Special Accessories

No special accessories were used during the tests in order to achieve compliance.

4.4 Equipment Modifications

No modifications were made to the EUT at Radiometrics' test facility in order to comply with the standards listed in this report.

5.0 TEST SPECIFICATIONS

Document	Date	Title
FCC CFR Title 47	2018	Code of Federal Regulations Title 47, Chapter 1, Federal Communications Commission, Part 15 - Radio Frequency Devices
IC RSS-247 Issue 2	2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
IC RSS-Gen Issue 5	2019	General Requirements and Information for the Certification of Radiocommunication Equipment (RSS-Gen)

6.0 TEST PROCEDURE DOCUMENTS

The tests were performed using the procedures from the following specifications:

Document	Date	Title
ANSI C63.4-2014	2014	Methods of Measurement of Radio Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	2013	American National Standard for Testing Unlicensed Wireless Devices
FCC KDB 558074 D01	2019	Guidance For Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, And Hybrid System Devices Operating Under § 15.247 Of The FCC Rules; v05r02

7.0 RADIOMETRICS' TEST FACILITIES

The results of these tests were obtained at Radiometrics Midwest Corp. in Romeoville, Illinois, USA. Radiometrics is accredited by A2LA (American Association for Laboratory Accreditation) to conform to ISO/IEC 17025: 2005 "General Requirements for the Competence of Calibration and Testing Laboratories". Radiometrics' Lab Code is 121191 and Certification Number is 1495.01. Radiometrics' scope of accreditation includes all of the test methods listed herein. A copy of the accreditation can be accessed on our web site (www.radiomet.com). Radiometrics accreditation status can be verified at A2LA's web site (www.a2la2.org).

The following is a list of shielded enclosures located in Romeoville, Illinois used during the tests:

Chamber E: Is a custom made anechoic chamber that measures 52' L X 30' W X 18' H. The walls and ceiling are fully lined with RF absorber. Pro-shield of Collinsville, Oklahoma manufactured the chamber. The floor has a 9' x 9' section of microwave absorber for testing above 1 GHz.

Test Station F: Is an area that measures 10' D X 12' W X 10' H. The floor and back wall are metal shielded. This area is used for conducted emissions measurements.

A separate ten-foot long, brass plated, steel ground rod attached via a 6-inch copper braid grounds each of the above chambers. Each enclosure is also equipped with low-pass power line filters.

The FCC has accepted these sites as test site number US1065. The FCC test site Registration Number is 732175. Details of the site characteristics are on file with the Industry Canada as site number IC 3124A-1.

A complete list of the test equipment is provided herein. The calibration due dates are indicated on the equipment list. The equipment is calibrated in accordance to ANSI/NCSL Z540-1 with traceability to the National Institute of Standards and Technology (NIST).

8.0 DEVIATIONS AND EXCLUSIONS FROM THE TEST SPECIFICATIONS

There were no deviations or exclusions from the test specifications.

9.0 CERTIFICATION

Radiometrics Midwest Corporation certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specification and the data contained herein was taken with calibrated test equipment. The results relate only to the EUT listed herein.

10.0 TEST EQUIPMENT TABLE

RMC ID	Manufacturer	Description	Model No.	Serial No.	Frequency Range	Cal Period	Cal Date
AMP-05	RMC/Celeritek	Pre-amplifier	MW110G	1001	1.0-12GHz	12 Mo.	01/10/19
AMP-20	Avantek	Pre-amplifier	SF8-0652	15221	8-18GHz	12 Mo	04/22/19
AMP-59	Amplitech	Pre-amplifier	APTMP44	AMP-59	18-26 GHz	12 Mo.	01/10/19
ANT-66	ETS-Lindgren	Horn Antenna	3115	62580	1.0-18GHz	24 Mo.	03/05/19
ANT-68	EMCO	Log-Periodic Ant.	93146	9604-4456	200-1000MHz	24 Mo.	12/05/17
ANT-80	AH Systems	Bicon Antenna	SAS-540	294	20-330MHz	24 Mo.	12/14/18
CAB-044A	Teledyne	Coaxial Cable	N/A	044A	DC-18 GHz	24 Mo.	05/15/18
CAB-090C	Teledyne	Coaxial Cable	N/A	090C	DC-18 GHz	24 Mo.	05/15/18
CAB-114F	Teledyne	Coaxial Cable	N/A	114F	DC-18 GHz	24 Mo.	05/15/18
CAB-114G	Teledyne	Coaxial Cable	N/A	114G	DC-18 GHz	24 Mo.	05/15/18
CAB-142G	Teledyne	Coaxial Cable	N/A	142G	DC-18 GHz	24 Mo.	05/09/18
CAB-144F	Teledyne	Coaxial Cable	N/A	142G	DC-18 GHz	24 Mo.	05/15/18
CAB-160B	Teledyne	Coaxial Cable	N/A	160B	DC-18 GHz	24 Mo.	05/09/18
CAB-210A	Teledyne	Coaxial Cable	N/A	210A	DC-18 GHz	24 Mo.	05/09/18
CAB-210B	Teledyne	Coaxial Cable	N/A	210B	DC-18 GHz	24 Mo.	05/09/18
CAB-1090	Teledyne	Coaxial Cable	N/A	1090	DC-18 GHz	24 Mo.	05/16/18
HPF-06	Mini-Circuits	High Pass Filter	VHF-3800+	31035	3-11 GHz	24 Mo.	04/04/18
REC-20	HP / Agilent	Spectrum Analyzer	85460A/84562A	33330A00135 3410A00178	30Hz-6GHz	24 Mo.	08/14/19
REC-21	Agilent	Spectrum Analyzer	E7405A	MY45118341	9Hz-26.5 GHz	24 Mo.	01/06/18
REC-22	Rohde Schwarz	Spectrum Analyzer	ESIB 26	100145	26.5 GHz	24 Mo	08/29/17
REC-43	Adventest	Spectrum Analyzer	U3772	150800305	9Hz-43GHz	24 Mo.	06/24/19
THM-03	Fluke	Temp/Humid Meter	971	95850465	N/A	12 Mo.	04/30/18

Note: All calibrated equipment is subject to periodic checks.

Software Company	Test Software Name	Version	Applicable Tests
Radiometrics	REREC11D	04.19.17	RF Radiated Emissions (FCC Part 15 & EN 55032)
Agilent	PSA/ESA-E/L/EMC	2.4.0.42	Bandwidth and screen shots

11.0 TEST SECTIONS

11.1 Occupied Bandwidth

The test procedures were in accordance to FCC DTS Measurement Guideline 558074 D01, Section 8.1.

The spectrum analyzer was set to the MAX HOLD mode to record the worst case of the modulation. The EUT was transmitting at its maximum data rate. The trace was allowed to stabilize.
The marker-to-peak function was set to the peak of the emission. Then the marker-delta function was used to measure 6 or 20 dB down one side of the emission. The marker-delta function was reset and then moved to the other side of the emission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is the bandwidth of the emission.

Tested by: Joseph Strzelecki/ Richard Tichgelaar
Test Date: 08/12/2019

Occupied Bandwidth at EUT Low Power mode

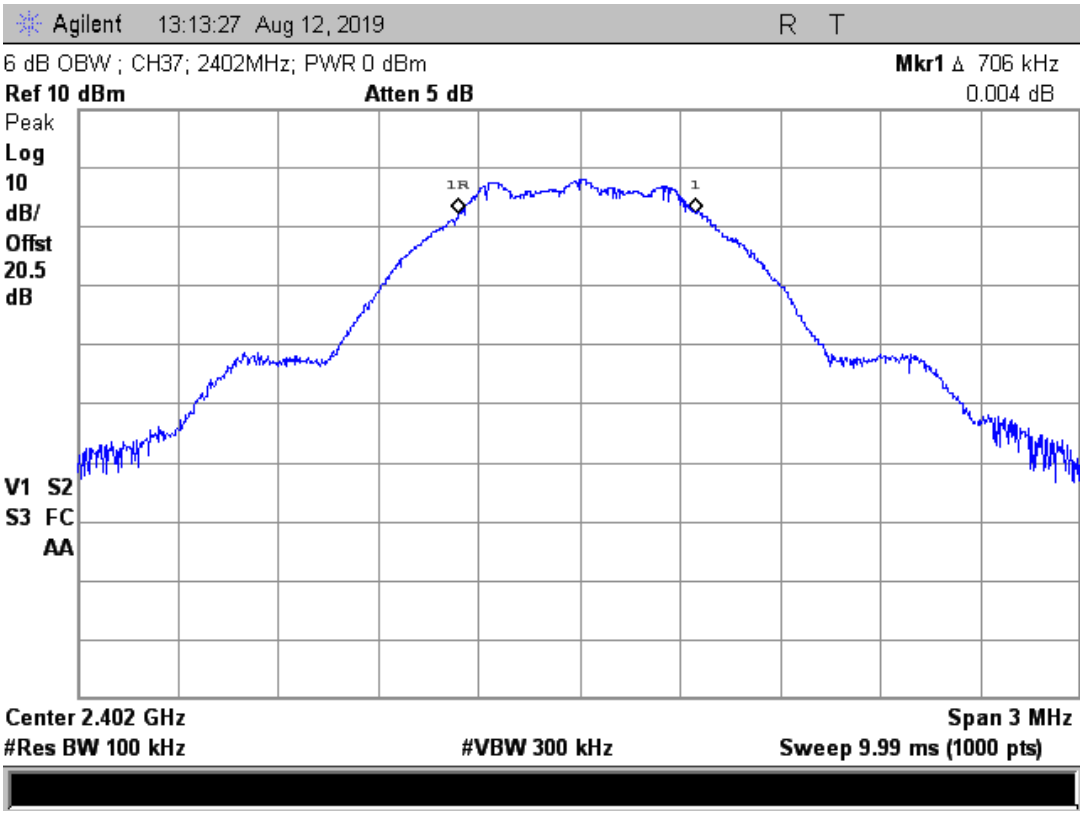
Channel	6 dB EBW kHz	99% EBW kHz	Minimum kHz
2402	706	1040	500
2426	724	1076	500

The 6 dB bandwidth is greater than 500 kHz
Judgement: Pass

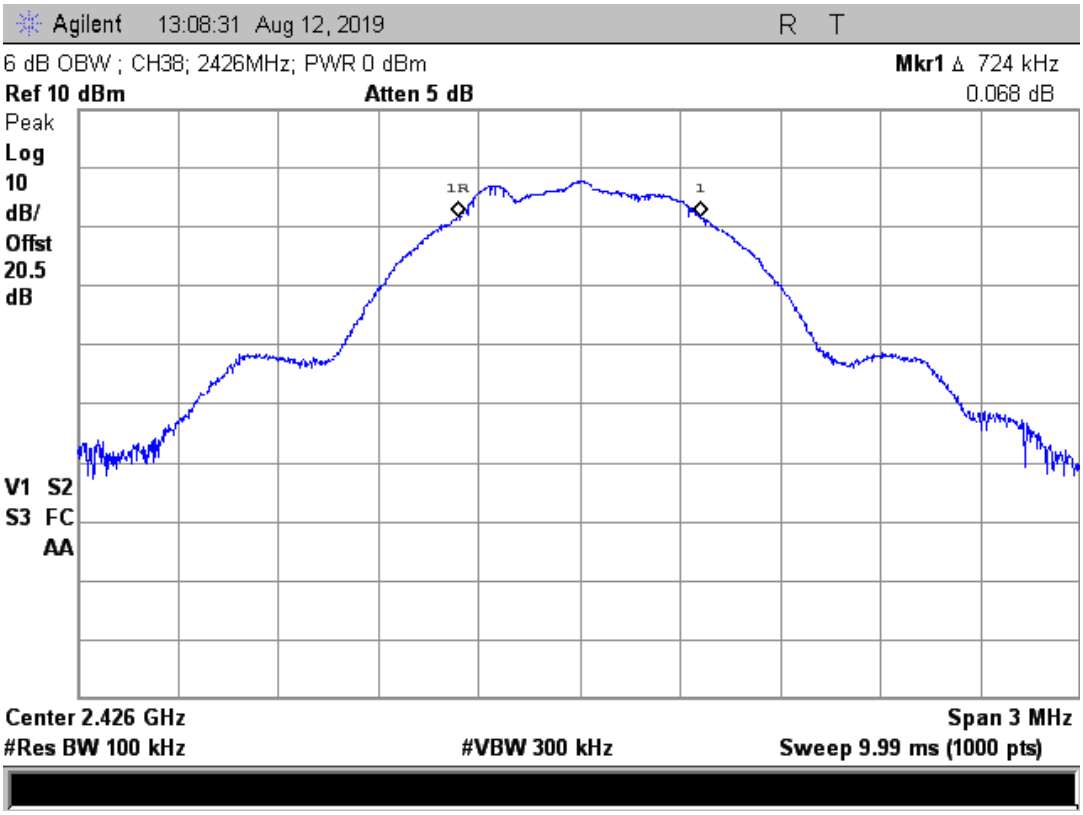
Occupied Bandwidth at EUT High Power mode

Channel	6 dB EBW kHz	99% EBW kHz	Minimum kHz
2402	724	1048	500
2426	718	1076	500

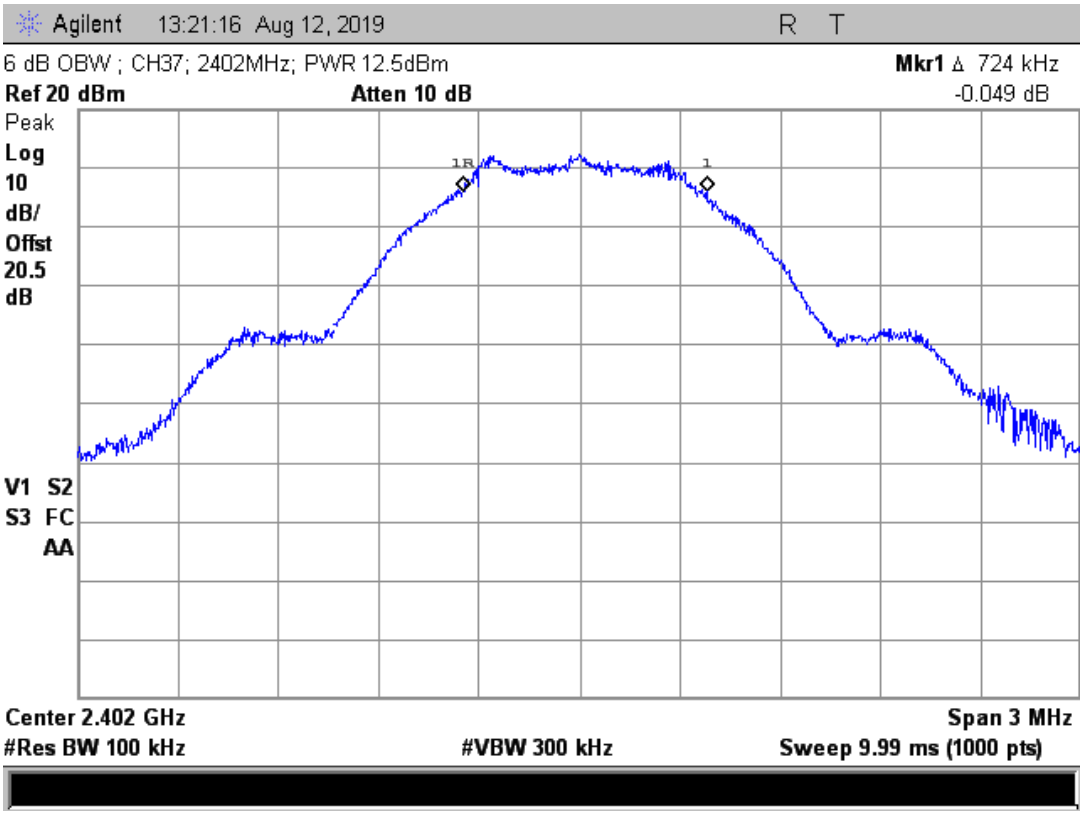
The 6 dB bandwidth is greater than 500 kHz
Judgement: Pass



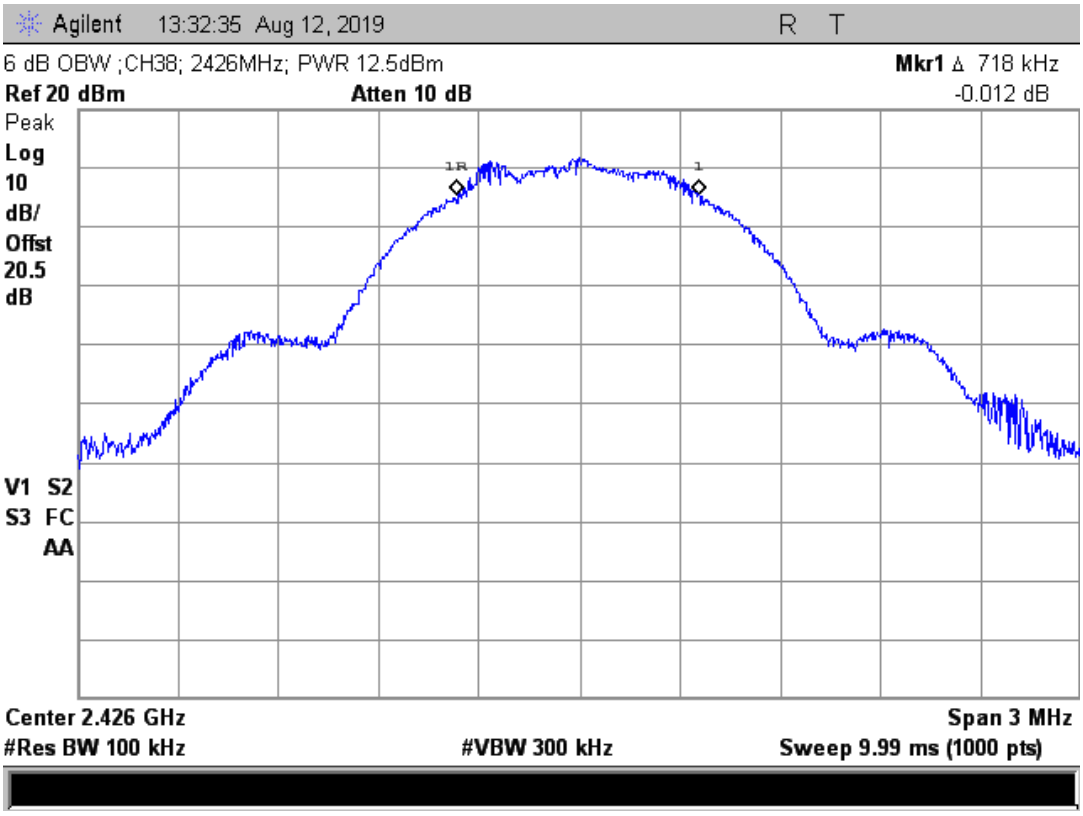
Low power Mode; 6 dB Bandwidth



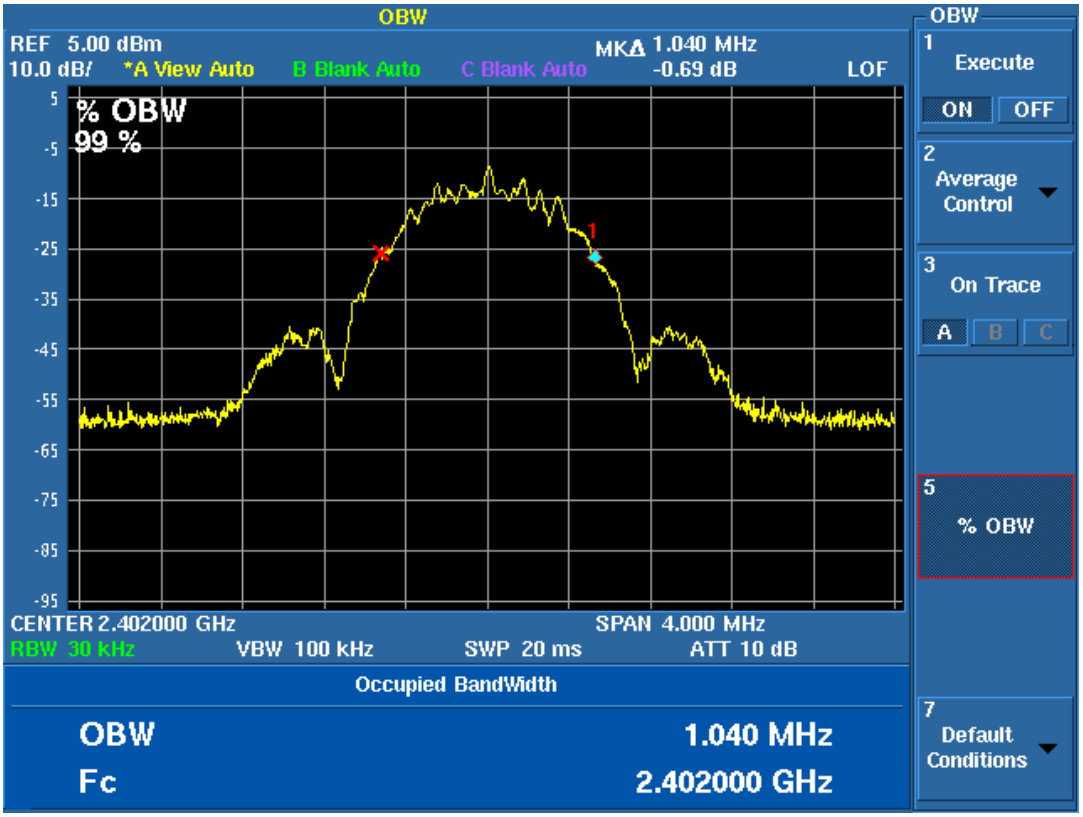
Low power Mode; 6 dB Bandwidth



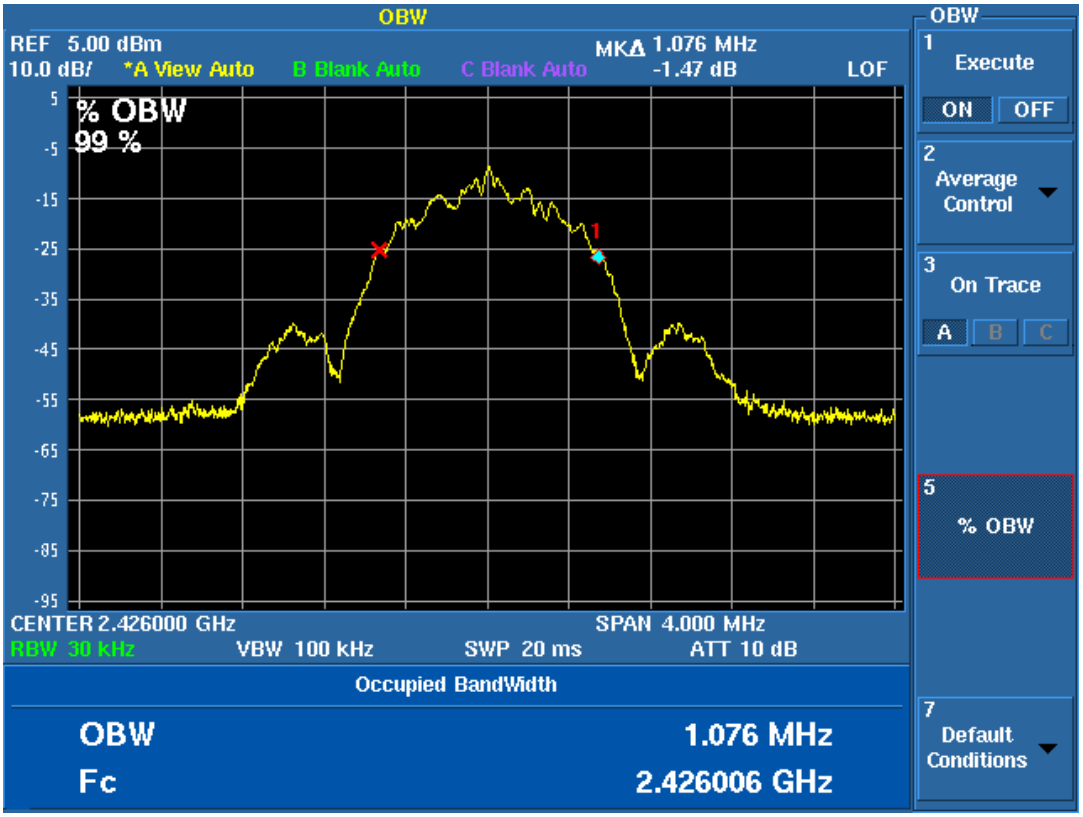
High power Mode; 6 dB Bandwidth



High power Mode; 6 dB Bandwidth



99% OBW; Low Power Mode



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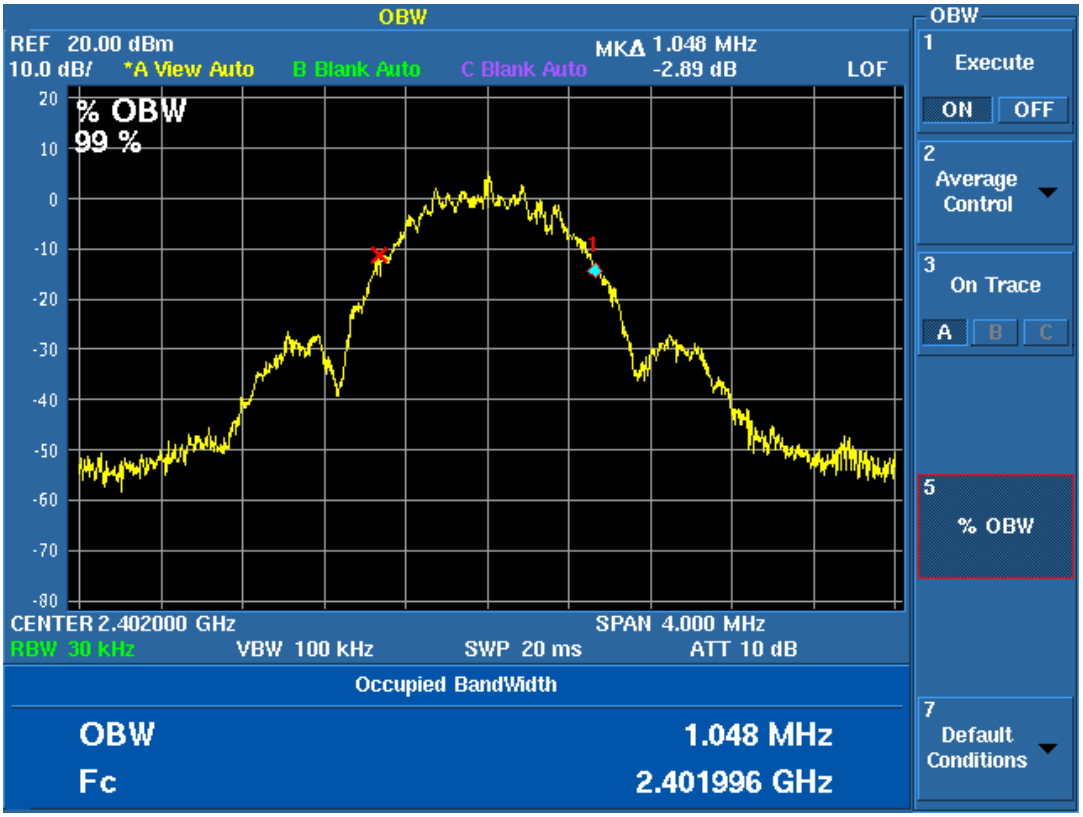
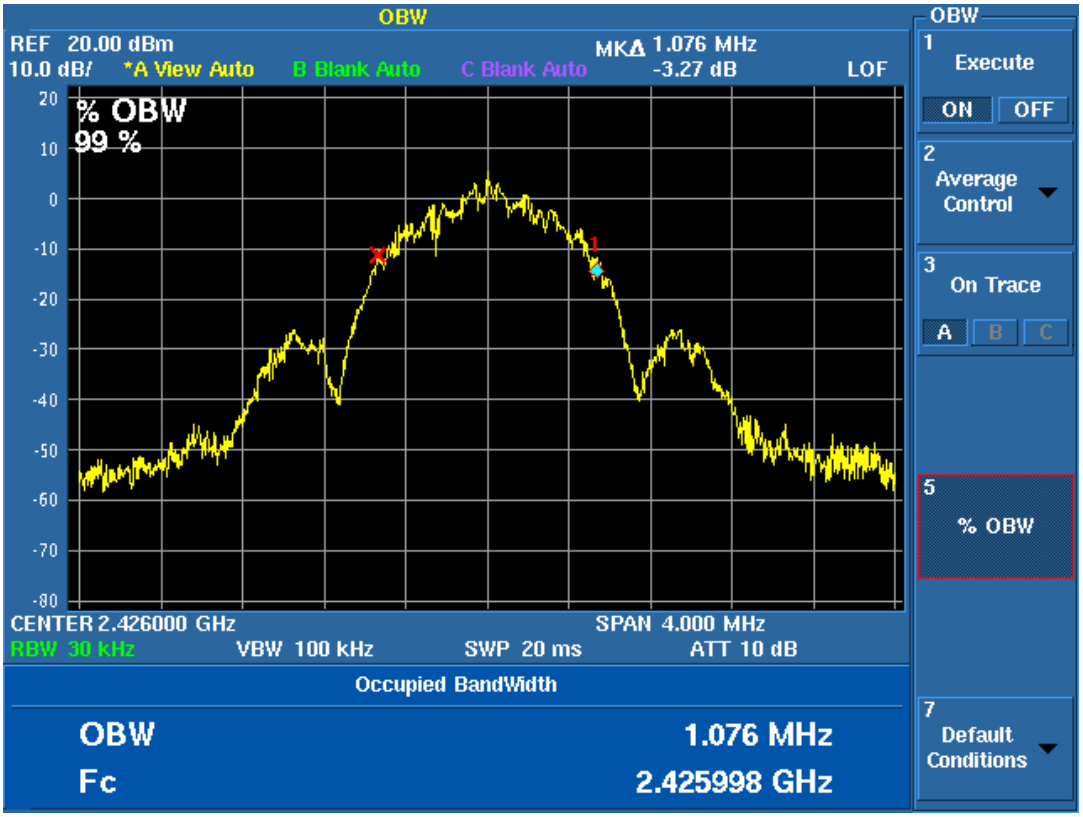


99% OBW; High Power Mode



99% OBW; High Power Mode

11.2 Peak Output Power

The power output test method from ANSI C63.10 section 11.9.1.1 was used for this test. The spectrum analyzer was set to the following settings:

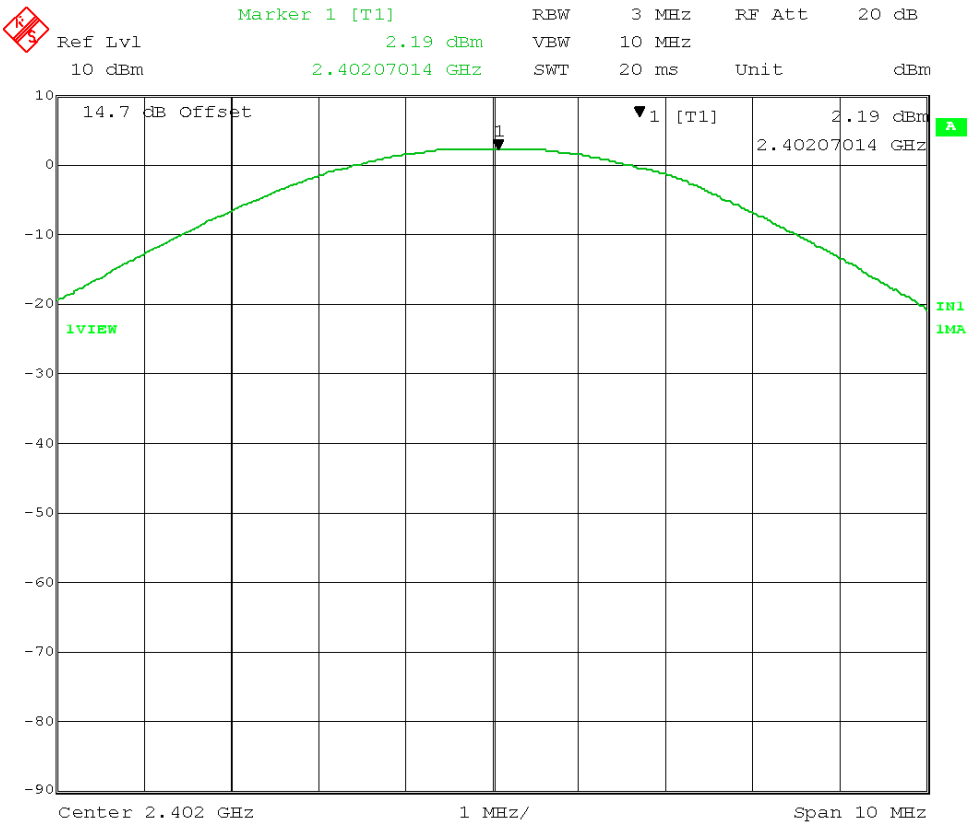
Span = 10 MHz
RBW = 3 MHz
VBW = 10 MHz
Sweep = auto
Detector function = peak
Trace = max hold

The trace was allowed to stabilize. The indicated level is the peak output power. Since the gain of the antenna is always less than 6 dB, the limit is not reduced. The EUT antenna port was connected to the Spectrum analyzer Via a low loss coaxial cable.

Tested by: Joseph Strzelecki/Richard Tichgelaar
Test Date: 08/13/2019
Since the gain of the antenna is always less than 6 dB, the limit is not reduced. The antenna gain is 3.3 dBi.

Frequency (MHz)	EUT Power Mode	Reading (dBm)	Cable Loss (dB)	Total Power (dBm)		Limit (dBm)
				dBm	milliwatts	
2402	High	12.24	0.25	12.49	17.74	30
2426	High	11.91	0.25	12.16	16.44	30
2402	Mid	2.19	0.25	2.44	1.75	30
2426	Mid	2.19	0.25	2.44	1.75	30
2402	Low	-2.09	0.25	-1.84	0.65	30
2426	Low	-2.09	0.25	-1.84	0.65	30

Judgment: Passed by 12.26 dB



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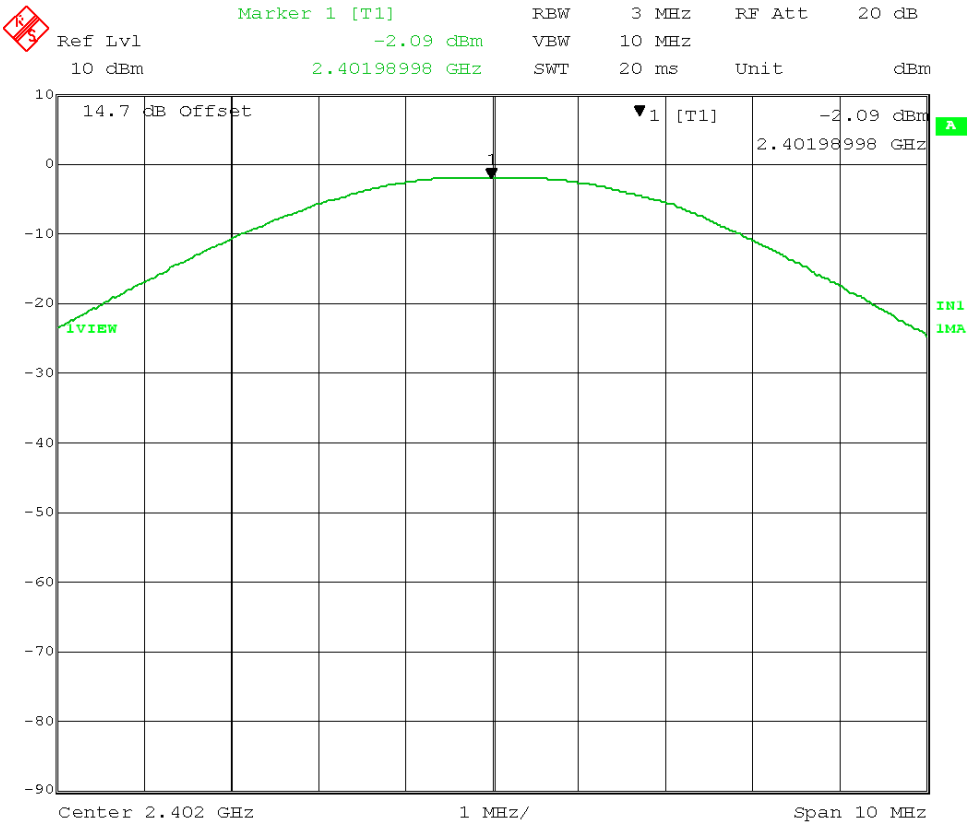
Date: 13.AUG.2019 07:56:09



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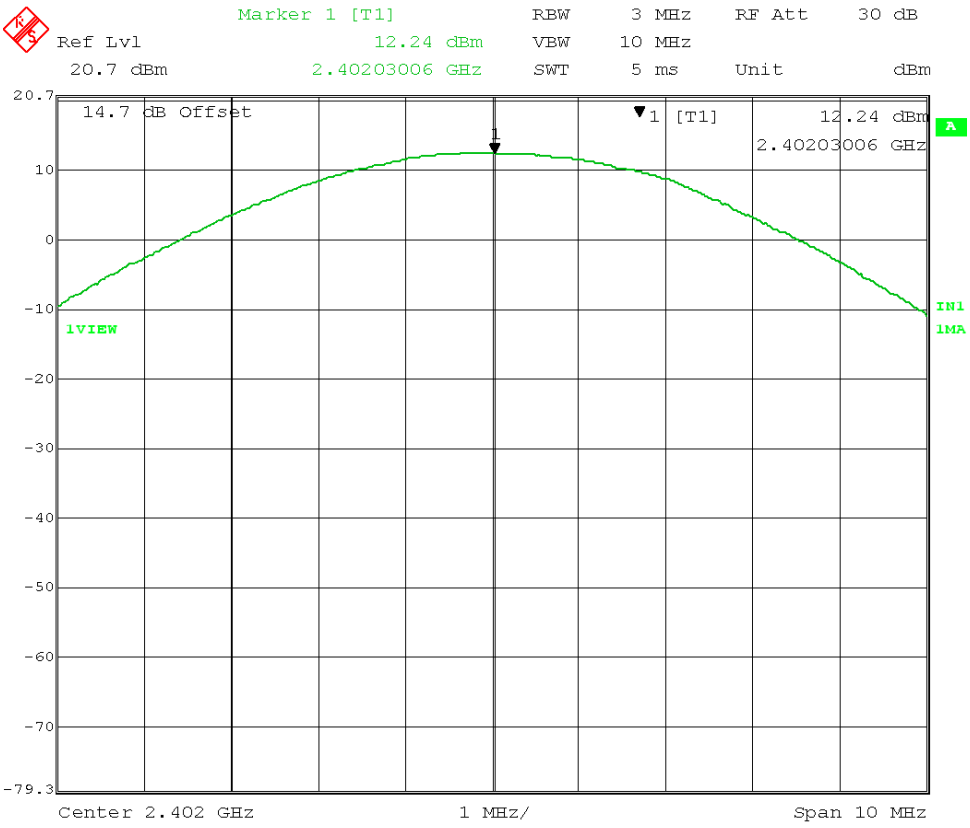

Title: Conducted Peak Power Ch 37: 2402 MHz: Power Level set to 12.5 dBm
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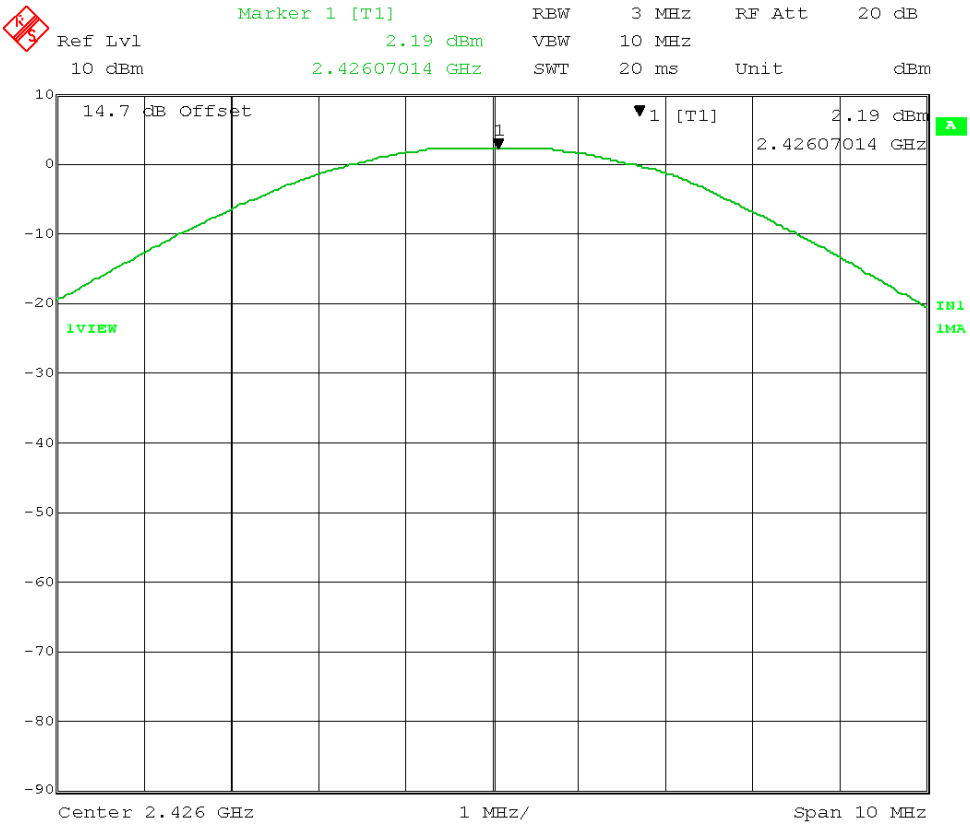
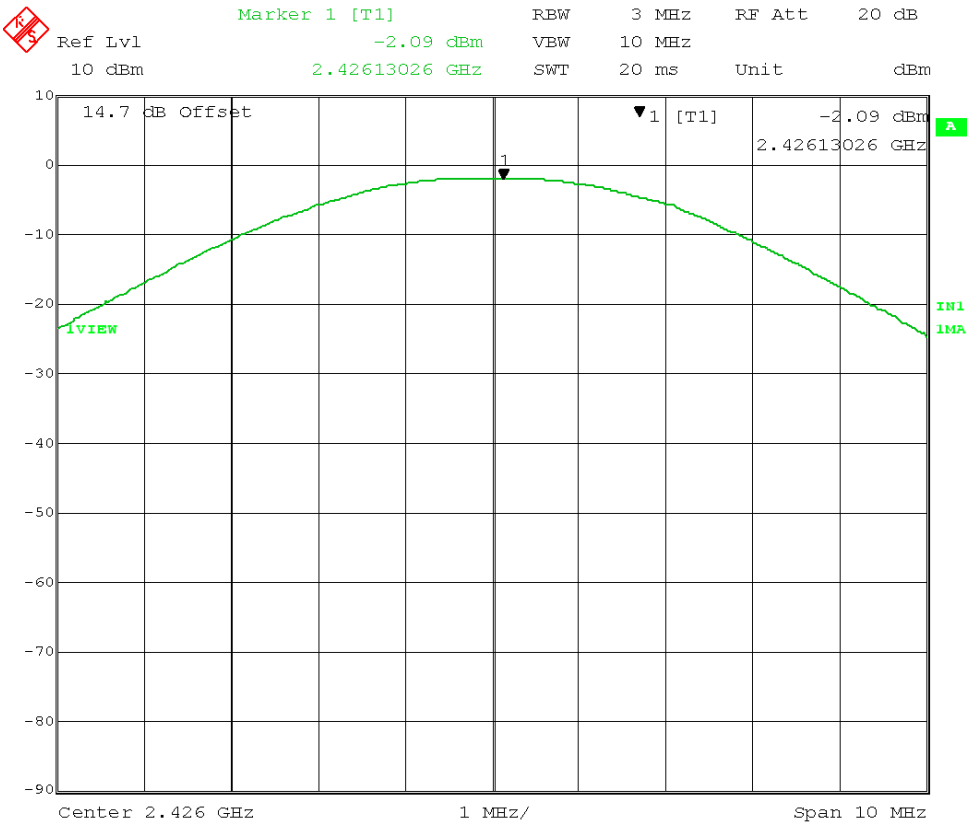


Title: Conducted Peak Power : CH 38 : 2426 MHz : Power Level set to 4.0 dBm
Date: 13.AUG.2019 08:03:07



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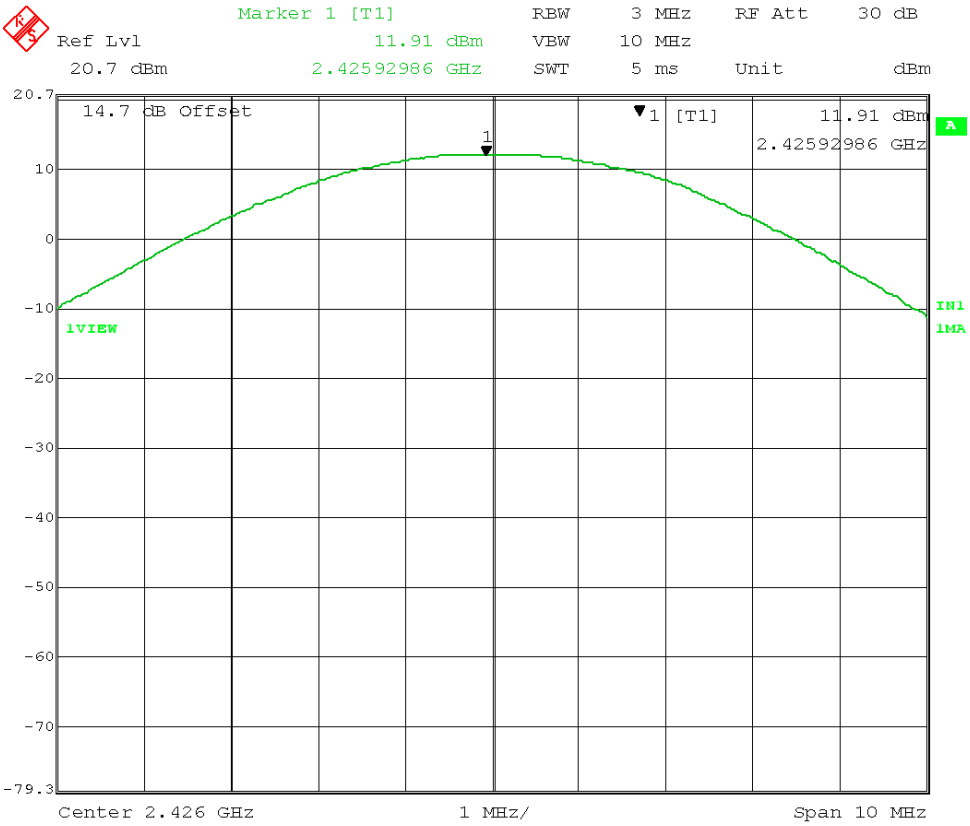
Date: 13.AUG.2019 07:26:15



Title: Conducted Peak Power Ch 38: 2426 MHz: Power Level set to 12.5 dBm
Date: 13.AUG.2019 07:13:25

11.3 Power Spectral Density

The PSD test method from ANSI C63.10 section 11.10.2 and FCC DTS Measurement Guideline 558074 D01, Section 10.2. The spectrum analyzer was set to the following settings:

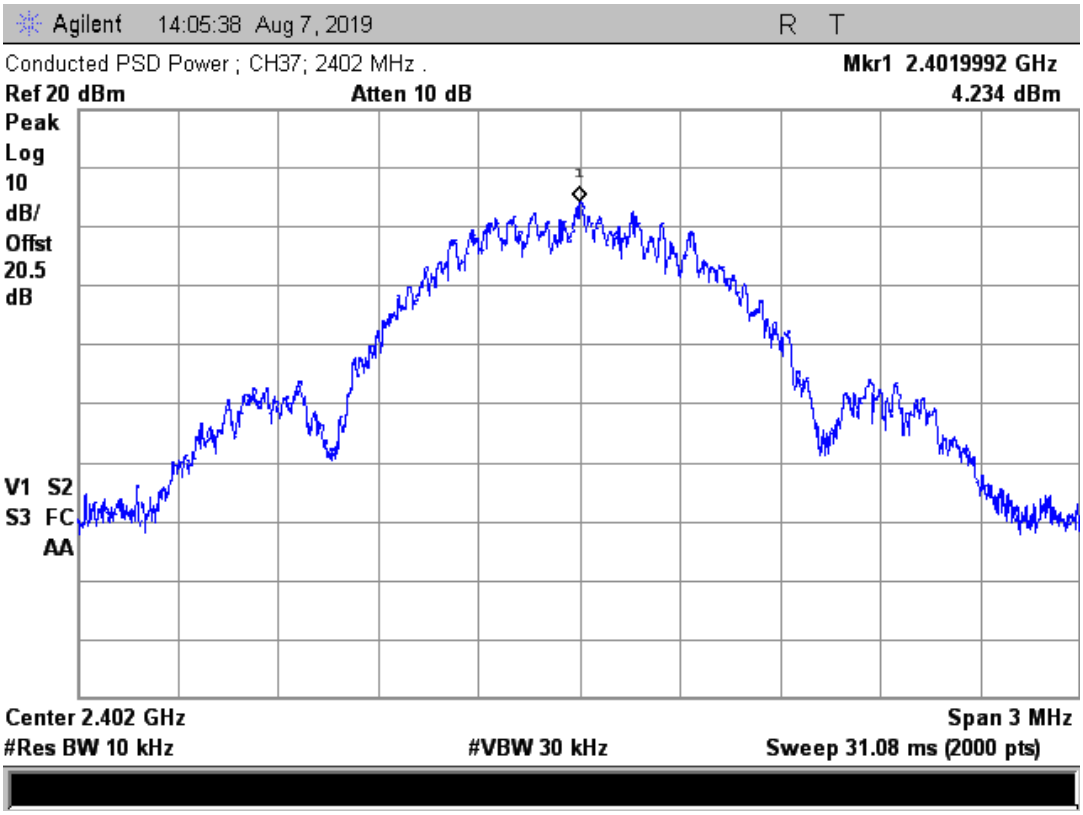
Span = 3 MHz; RBW = 10 kHz; VBW = 30 kHz

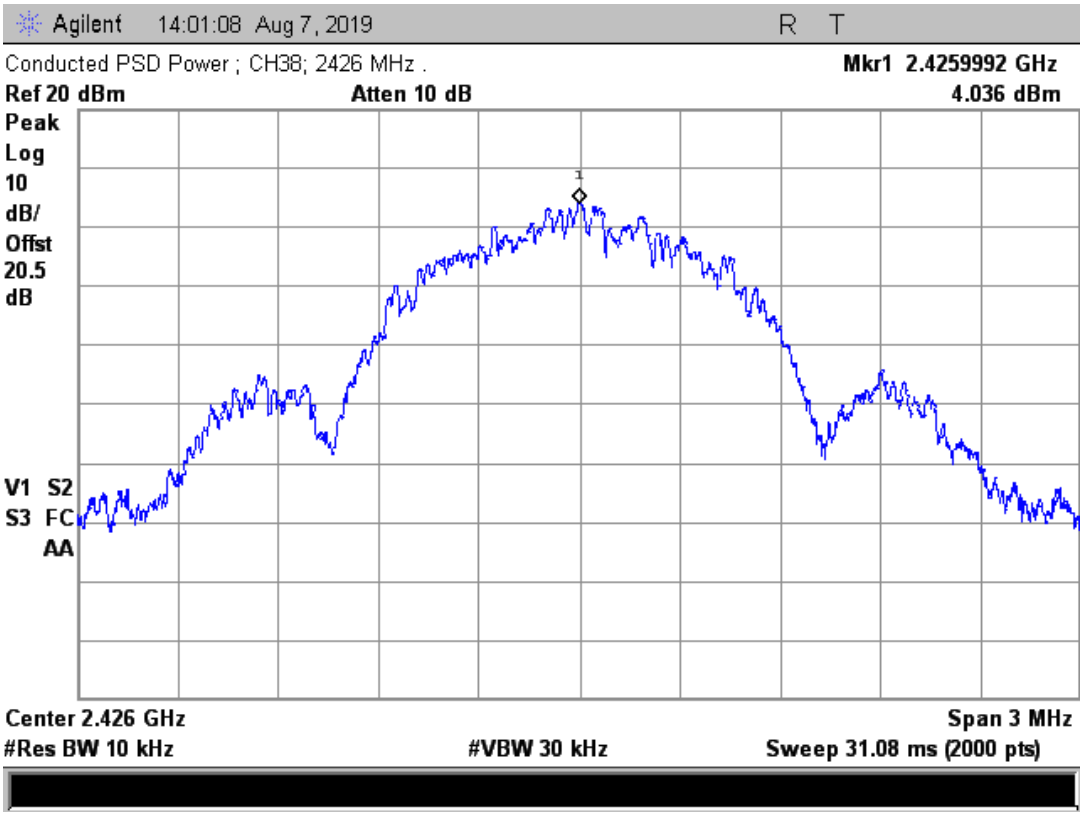
Tested by: Richard Tichgelaar
Test Date: 08/07/2019

Power Mode	Frequency (MHz)	Reading dBm	Cable Loss (dB)	3 kHz Spectral Density (dBm)	Limit (dBm)
High	2402	4.23	0.25	4.48	8.0
High	2426	4.04	0.25	4.29	8.0

Judgment: Passed by 3.52 dB

The lower power modes were not tested since the peak levels of the lower power modes are lower than the PSD of the high-power mode. See section 11.3 herein for the peak power data.





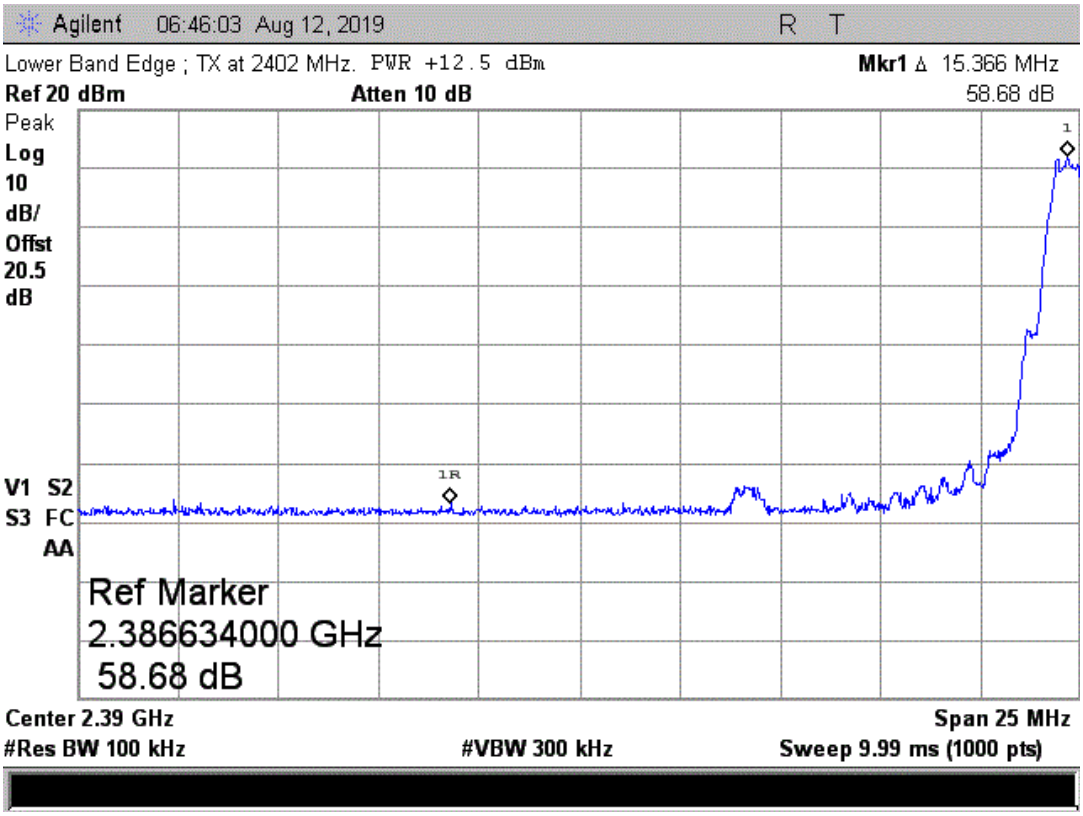
11.4 Band-edge Compliance of RF Conducted Emissions

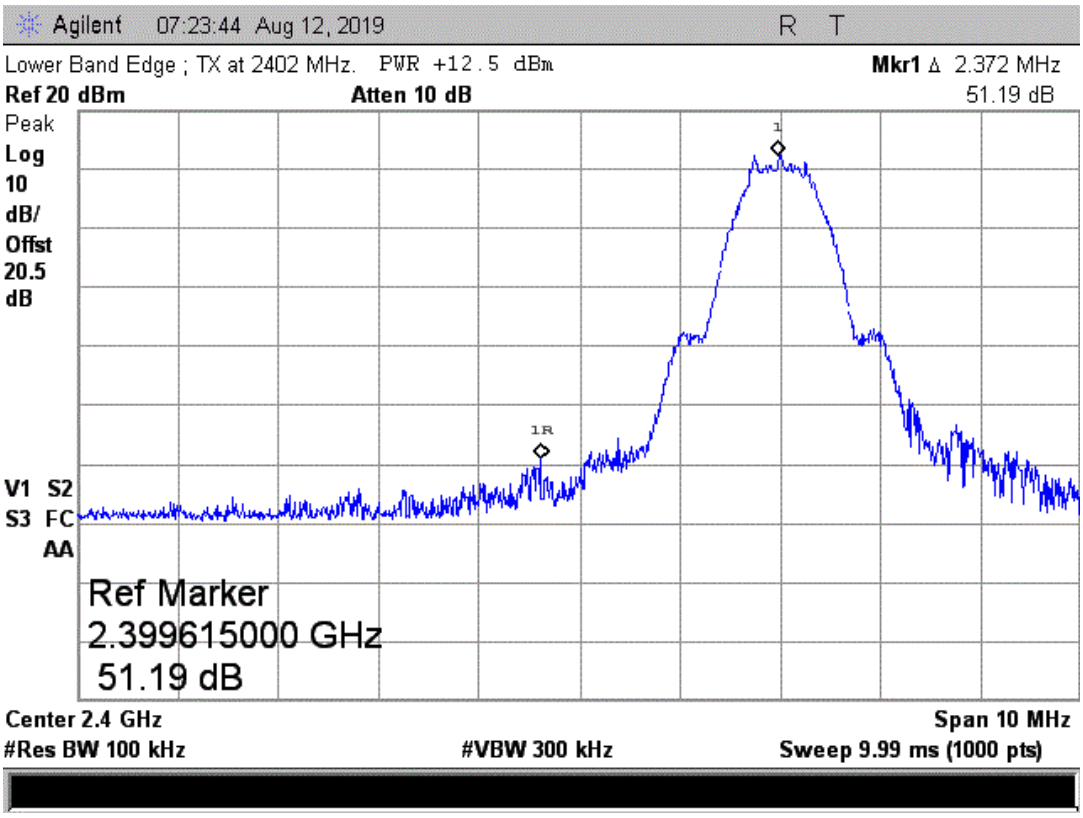
The spectrum analyzer was set to the MAX HOLD mode to record the worst case of the modulation at the band-edge, with the EUT set to the lowest or highest frequency. The trace was allowed to stabilize.

Tested by: Richard Tichgelaar
Test Date: 08/12/2019

Channel	EUT Power Mode	Reading at Band Edge		Minimum Allowed
		Freq. (MHz)	Delta (dB)	dB
2402 Lower Band edge	High Power	2390	58.7	20
2402 Lower Band edge	High Power	2400	51.2	20
2402 Lower Band edge	Low Power	2390	57.0	20
2402 Lower Band edge	Low Power	2400	49.1	20
2426 Upper Band edge	High Power	2483.5	57.8	20
2426 Upper Band edge	Low Power	2483.5	56.2	20

Judgment: Passed by at least 20 dB


Agilent 06:46:03 Aug 12, 2019
R T
Lower Band Edge ; TX at 2402 MHz. PWR +12.5 dBm
Mkr1 Δ 15.366 MHz
Ref 20 dBm
Atten 10 dB
58.68 dB
Peak
Log
10
dB/
Offst
20.5
dB
V1 S2
S3 FC
AA
Ref Marker
2.386634000 GHz
58.68 dB
Center 2.39 GHz
Span 25 MHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 9.99 ms (1000 pts)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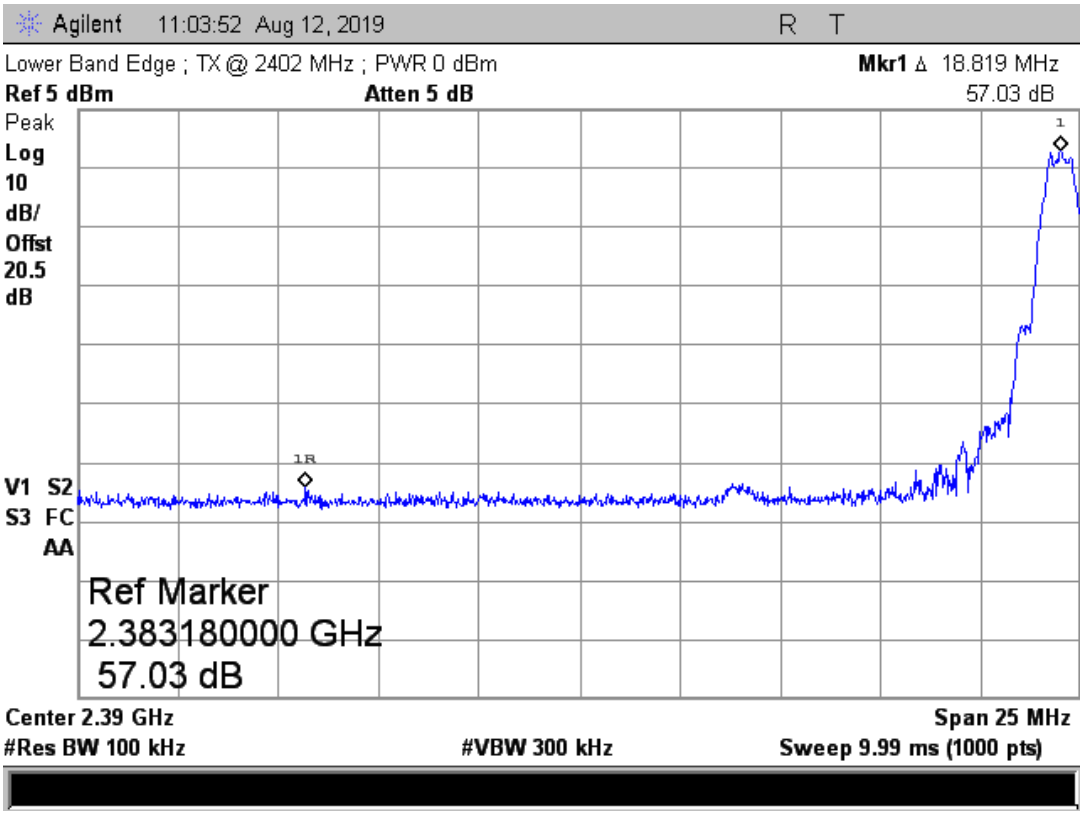
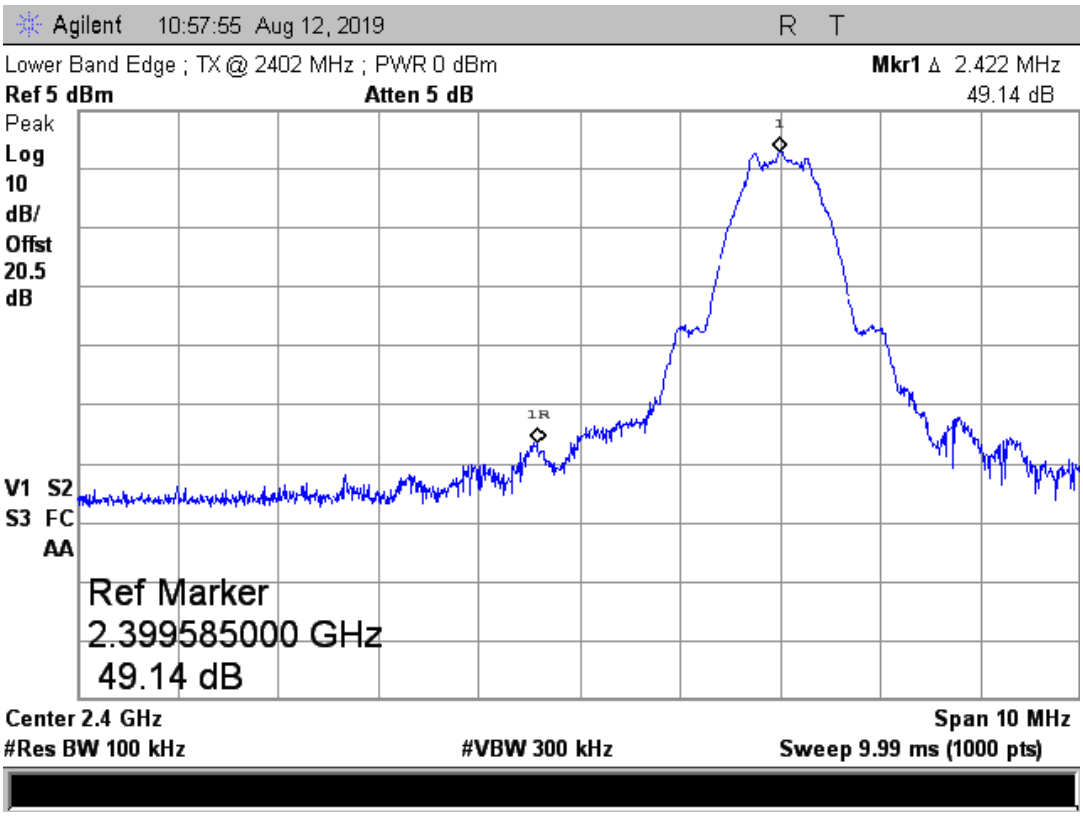
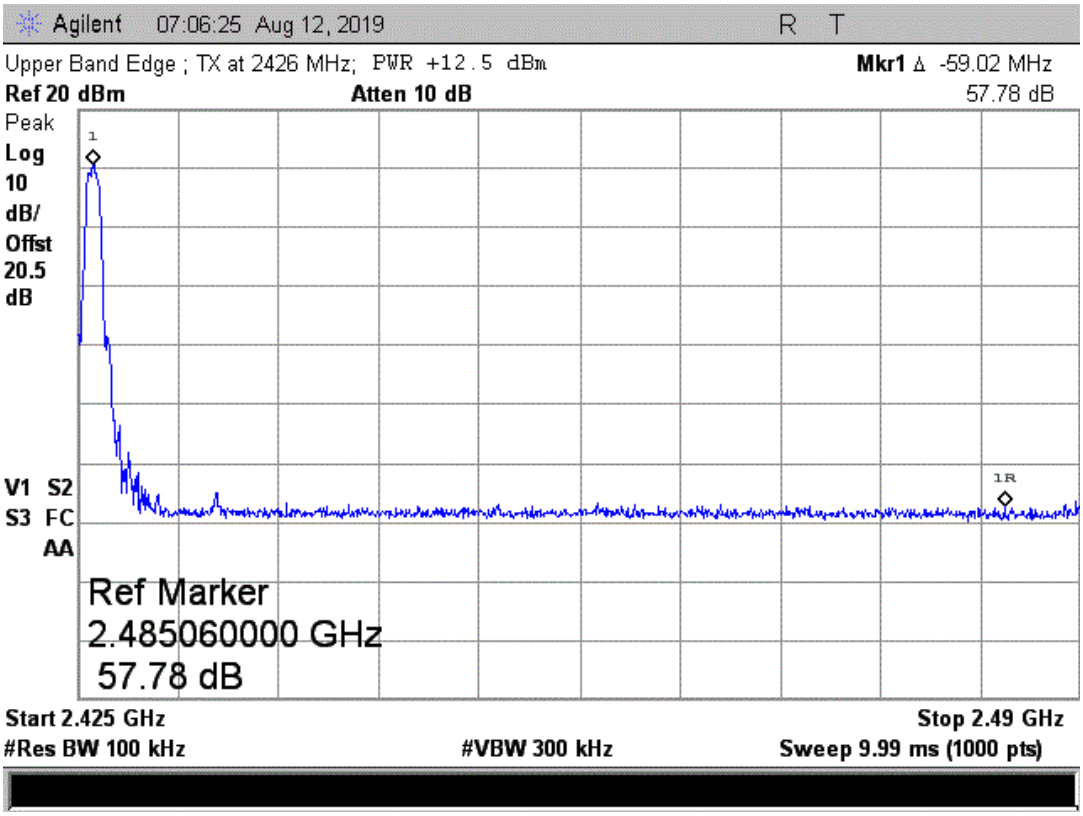
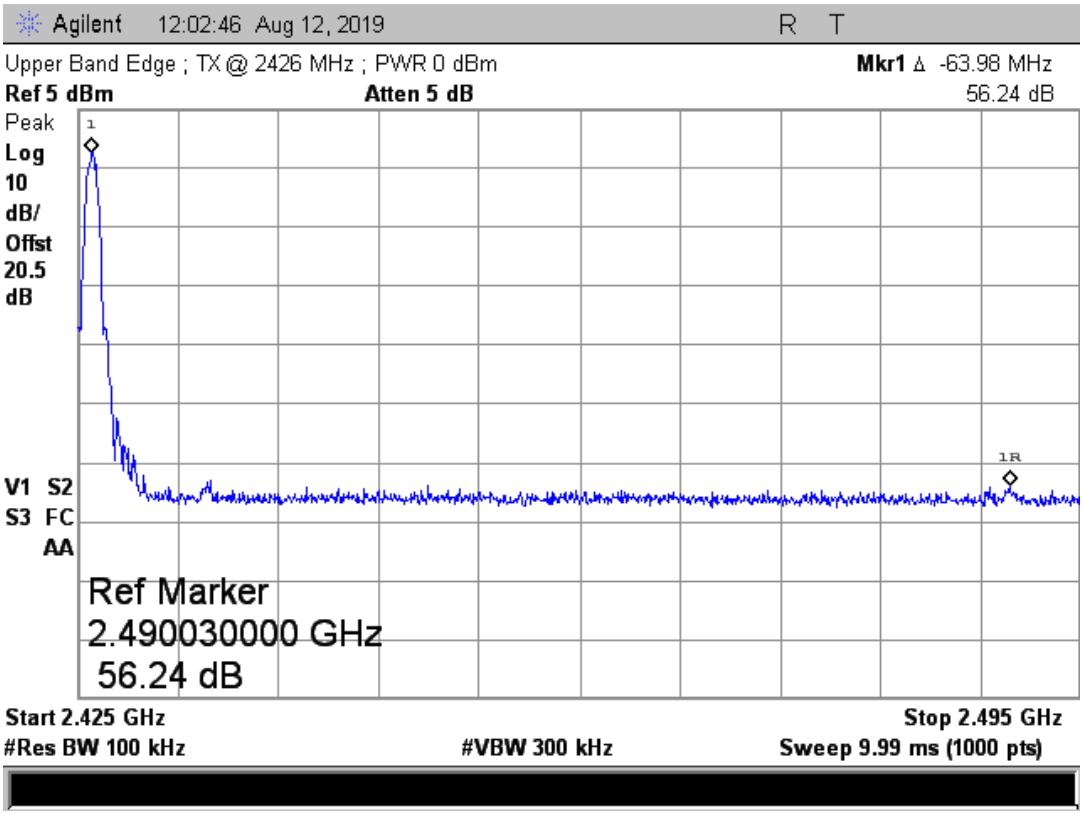
R T
Lower Band Edge ; TX at 2402 MHz. PWR +12.5 dBm
Mkr1 Δ 2.372 MHz
Ref 20 dBm
Atten 10 dB
51.19 dB
Peak
Log
10
dB/
Offst
20.5
dB
V1 S2
S3 FC
AA
Ref Marker
2.399615000 GHz
51.19 dB
Center 2.4 GHz
Span 10 MHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 9.99 ms (1000 pts)


Agilent 11:03:52 Aug 12, 2019
R T
Lower Band Edge ; TX @ 2402 MHz ; PWR 0 dBm
Mkr1 Δ 18.819 MHz
57.03 dB
Ref 5 dBm
Atten 5 dB
Peak
Log
10
dB/
Offst
20.5
dB
V1 S2
S3 FC
AA
Ref Marker
2.383180000 GHz
57.03 dB
Center 2.39 GHz
Span 25 MHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 9.99 ms (1000 pts)


Agilent 10:57:55 Aug 12, 2019
R T
Lower Band Edge ; TX @ 2402 MHz ; PWR 0 dBm
Mkr1 Δ 2.422 MHz
49.14 dB
Ref 5 dBm
Atten 5 dB
Peak
Log
10
dB/
Offst
20.5
dB
V1 S2
S3 FC
AA
Ref Marker
2.399585000 GHz
49.14 dB
Center 2.4 GHz
Span 10 MHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 9.99 ms (1000 pts)


Agilent 07:06:25 Aug 12, 2019
R T
Upper Band Edge ; TX at 2426 MHz; PWR +12.5 dBm
Mkr1 Δ -59.02 MHz
57.78 dB
Ref 20 dBm
Atten 10 dB
Peak
Log
10
dB/
Offst
20.5
dB
1
1R
V1 S2
S3 FC
AA
Ref Marker
2.485060000 GHz
57.78 dB
Start 2.425 GHz
Stop 2.49 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 9.99 ms (1000 pts)

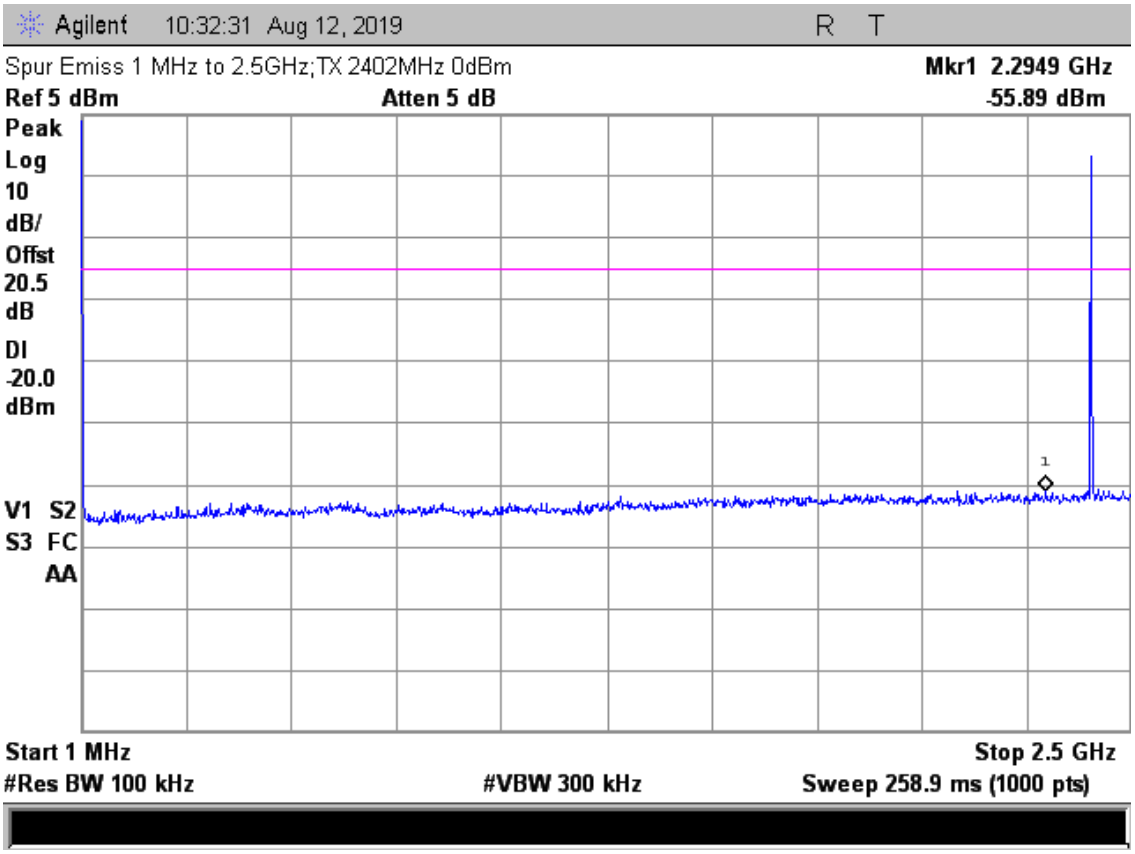

Agilent 12:02:46 Aug 12, 2019
R T
Upper Band Edge ; TX @ 2426 MHz ; PWR 0 dBm
Mkr1 Δ -63.98 MHz
56.24 dB
Ref 5 dBm
Atten 5 dB
Peak
Log
10
dB/
Offst
20.5
dB
1
1R
V1 S2
S3 FC
AA
Ref Marker
2.490030000 GHz
56.24 dB
Start 2.425 GHz
Stop 2.495 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 9.99 ms (1000 pts)

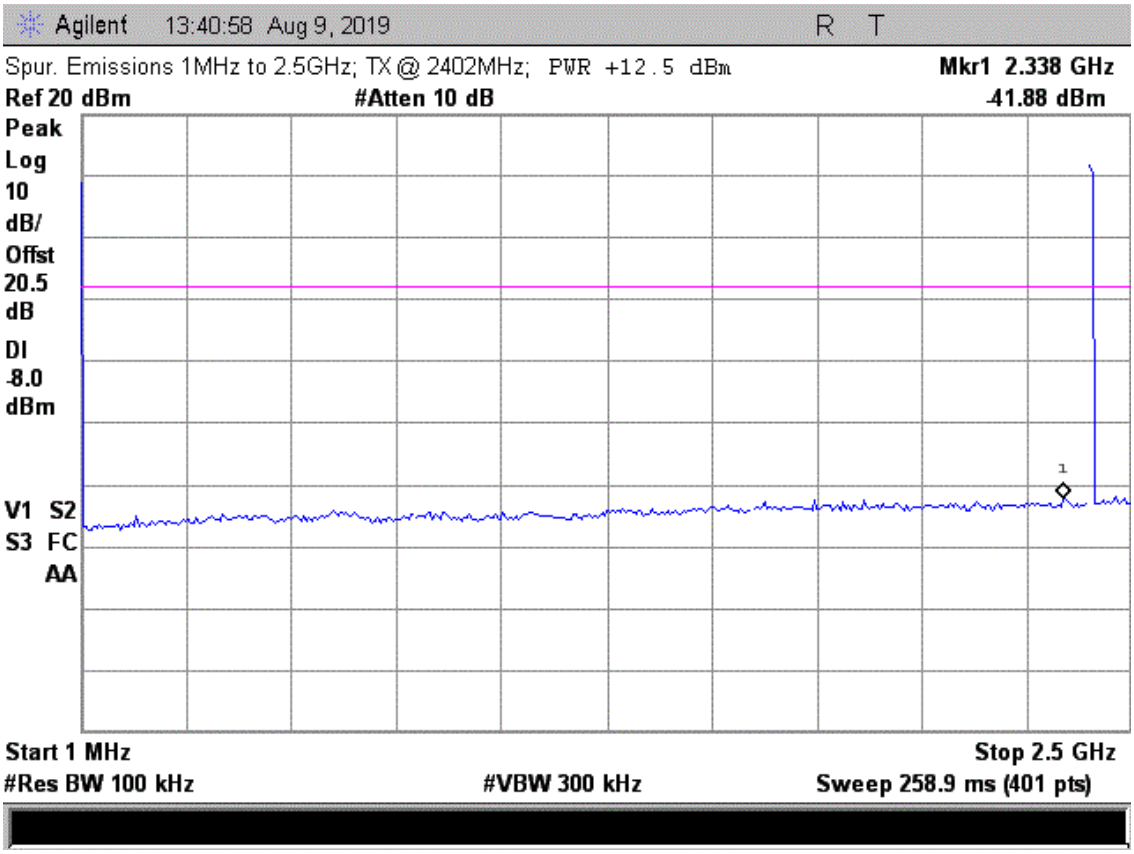
11.5 Spurious RF Conducted Emissions at Antenna Port

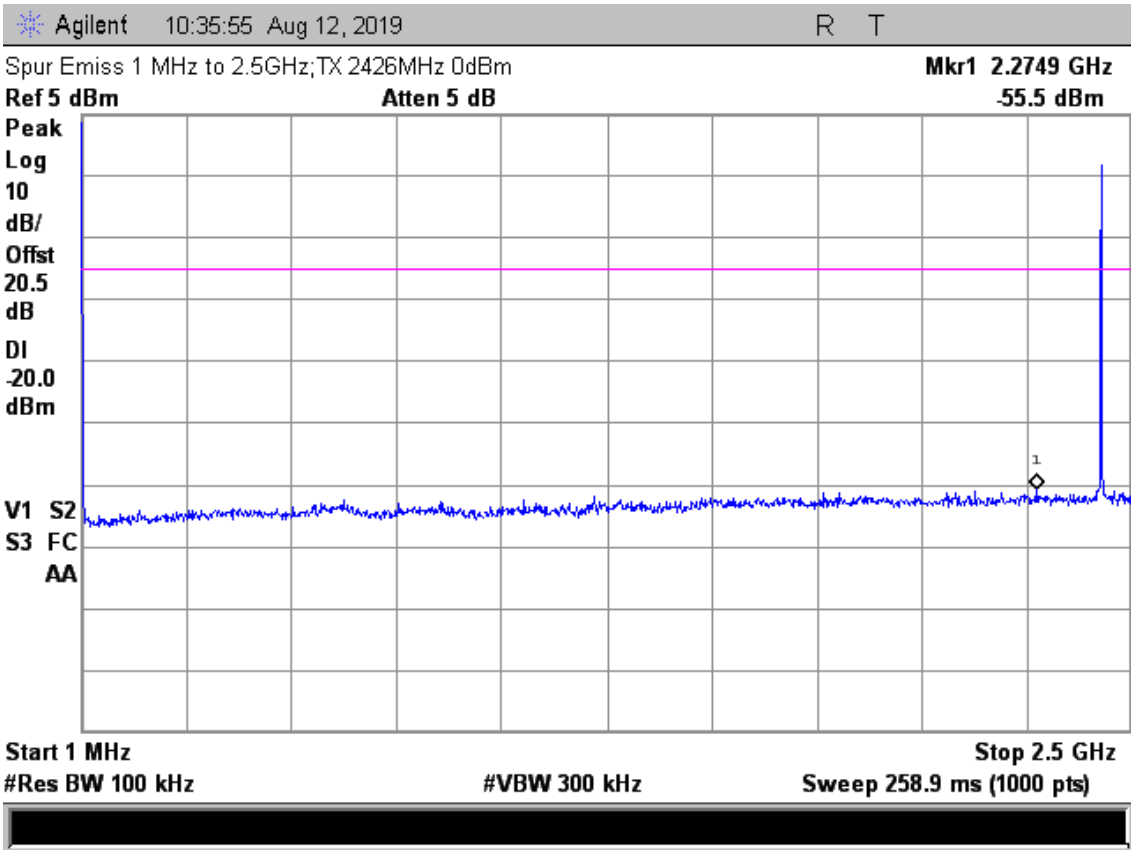
The spectrum analyzer was set to the MAX HOLD mode to record all spurious emissions from the lowest frequency generated in the EUT up through the 10th harmonic. The trace was allowed to stabilize. The first two plots were made while stepping through three frequencies (Low middle and high). Each frequency was on for at least 30 seconds.

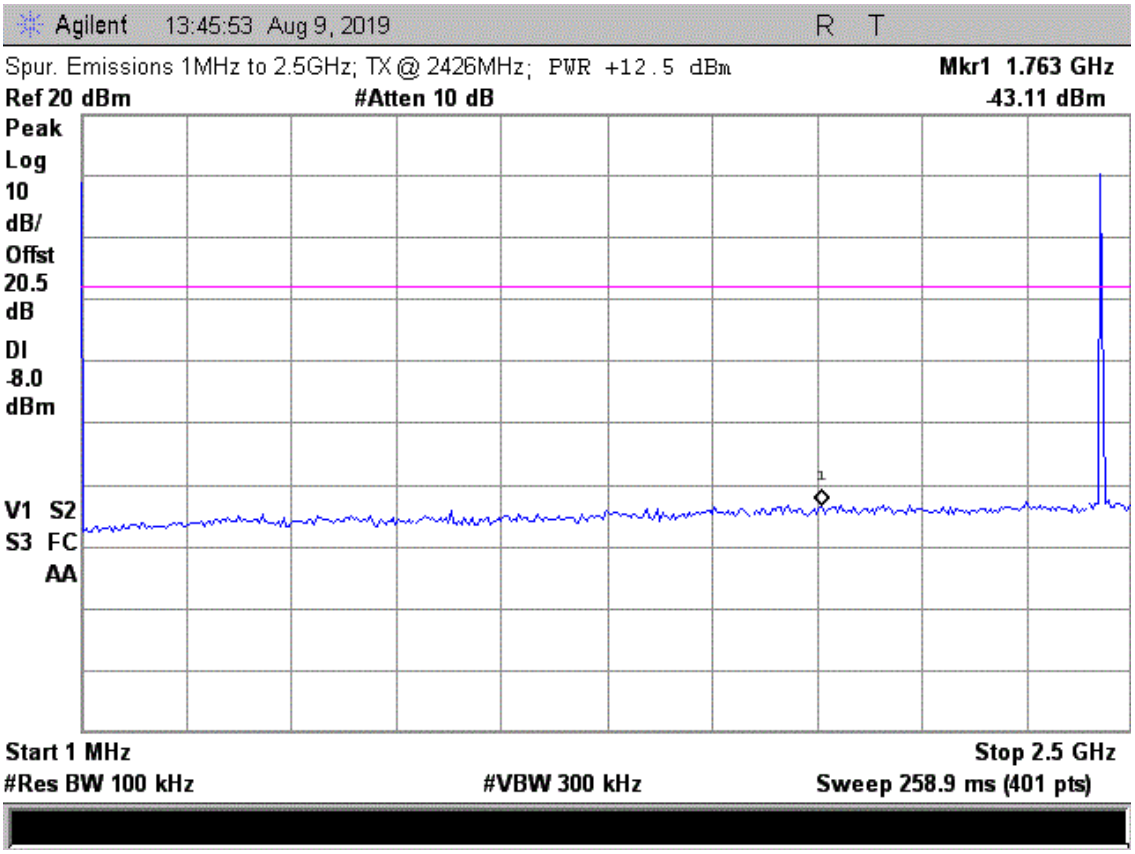
Tested by: Joseph Strzelecki/ Richard Tichgelaar
Test Date: 08/12/2019

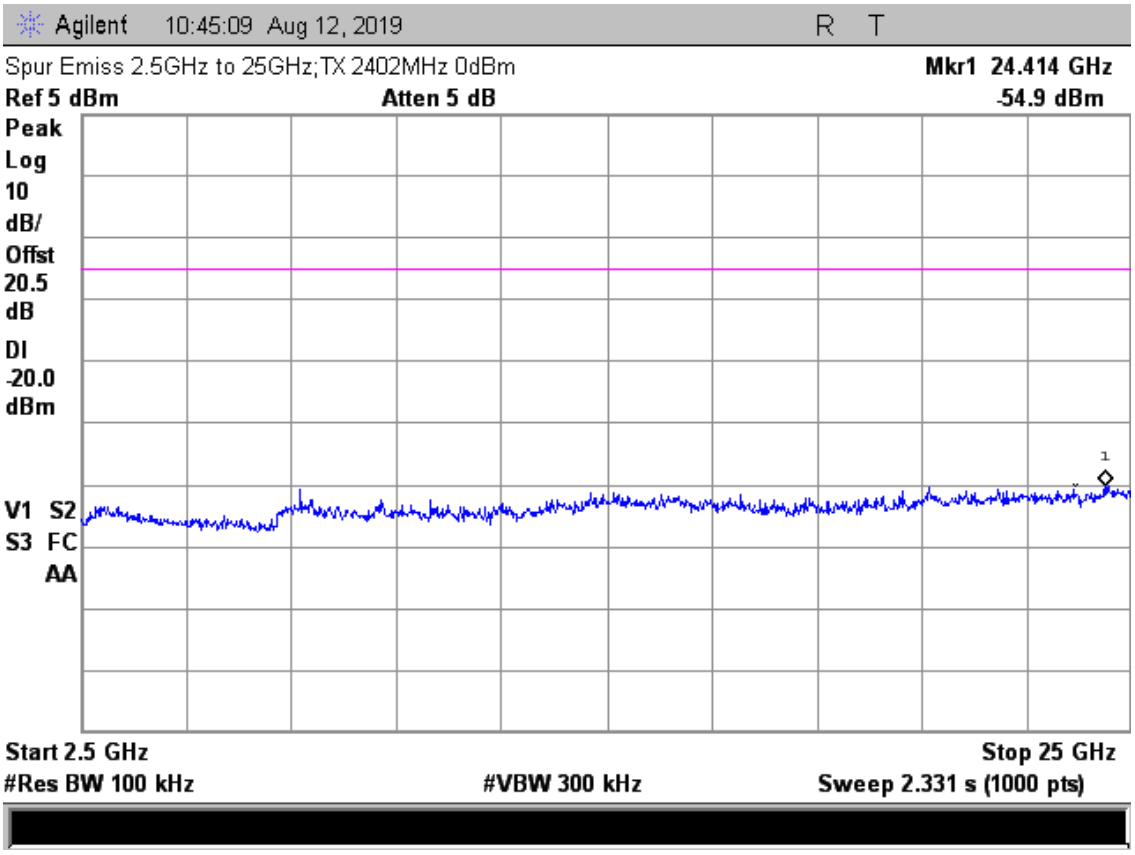
Judgement: Pass by at least 10 dB

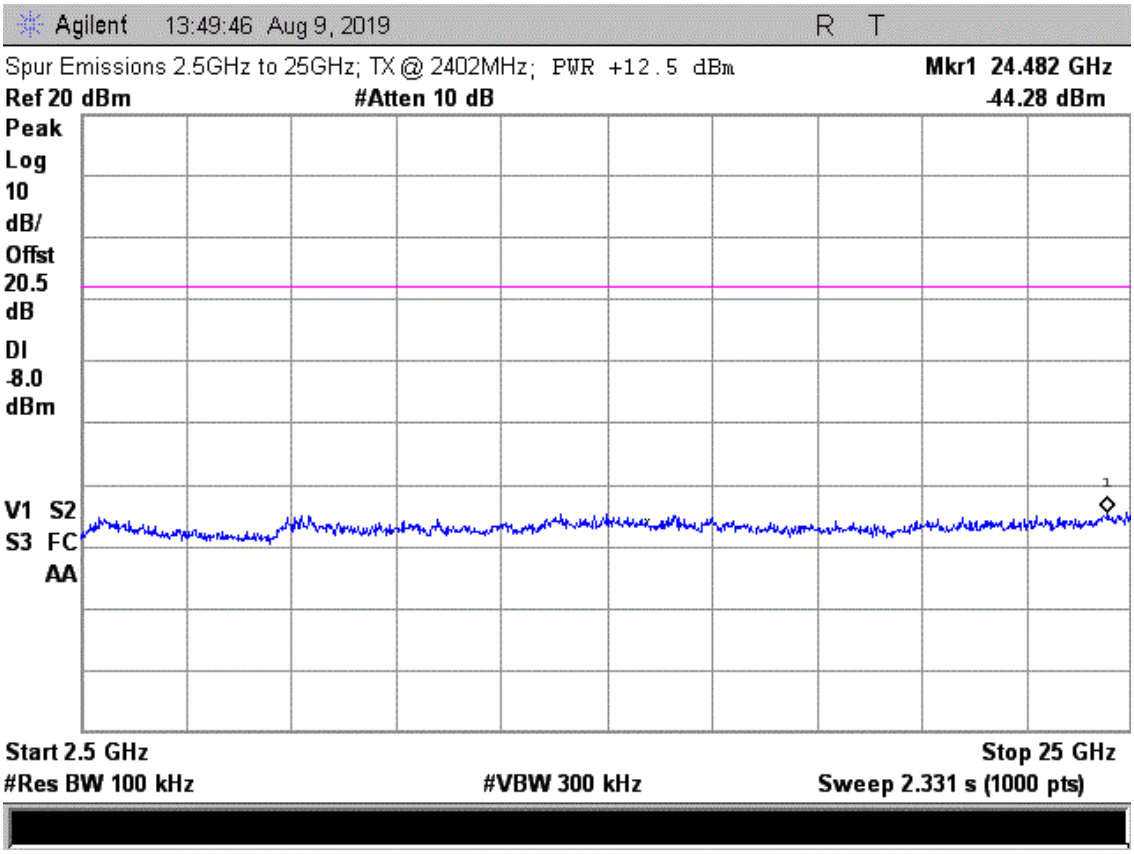


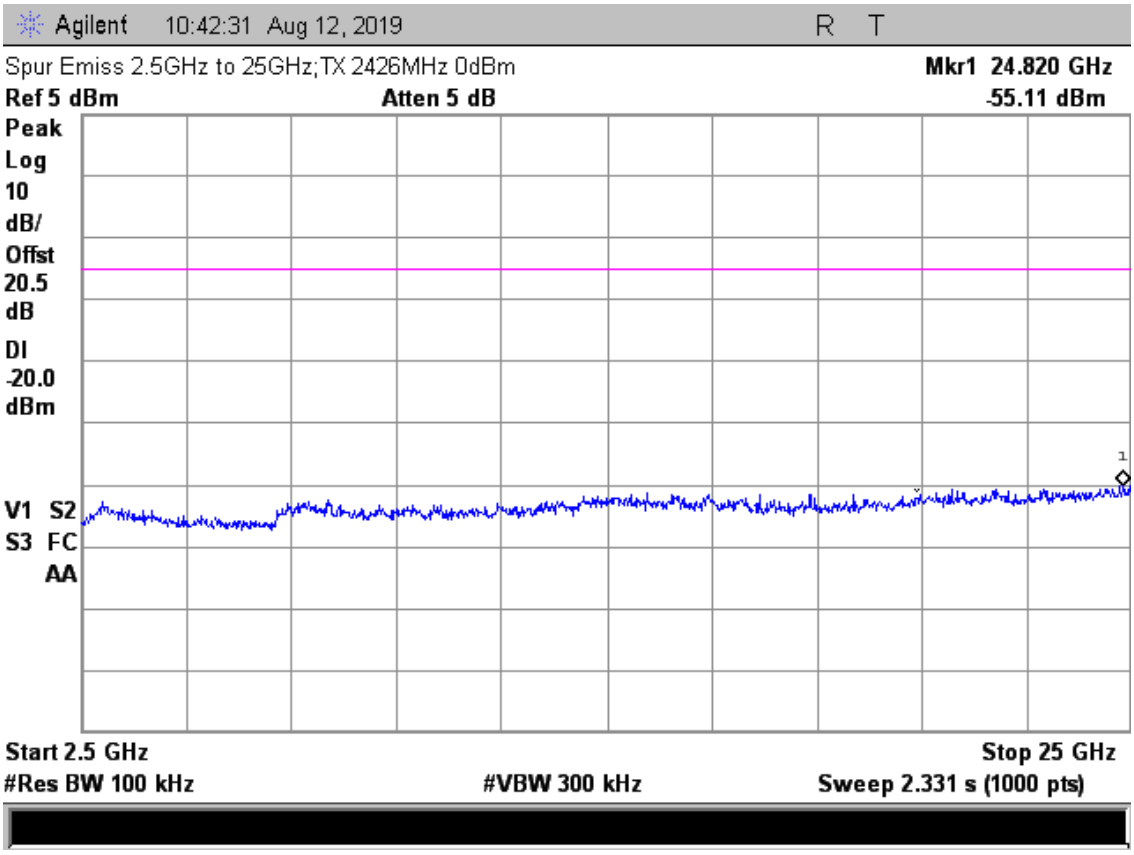

Agilent 13:40:58 Aug 9, 2019
R T
Spur. Emissions 1MHz to 2.5GHz; TX @ 2402MHz; PWR +12.5 dBm
Mkr1 2.338 GHz
Ref 20 dBm
#Atten 10 dB
-41.88 dBm
Peak
Log
10
dB/
Offst
20.5
dB
Dl
-8.0
dBm
V1 S2
S3 FC
AA
Start 1 MHz
Stop 2.5 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 258.9 ms (401 pts)

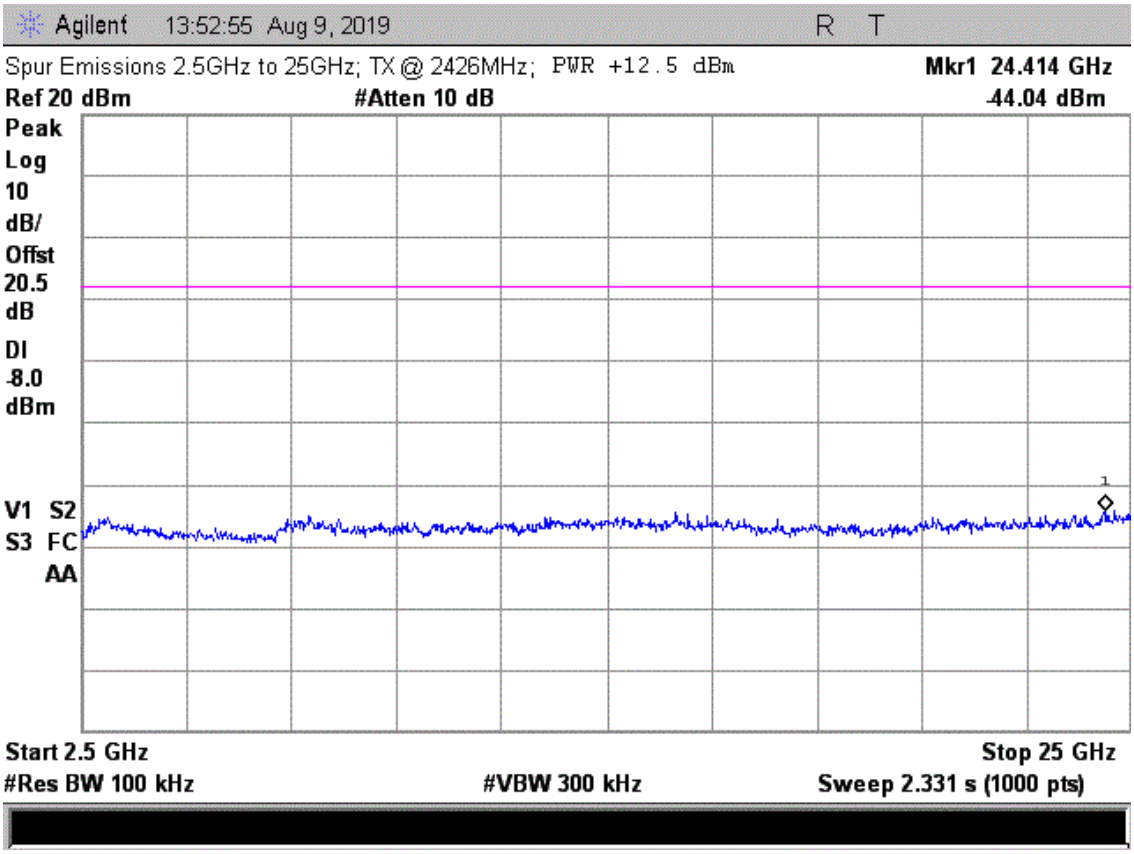

Agilent 10:35:55 Aug 12, 2019
R T
Spur Emiss 1 MHz to 2.5GHz;TX 2426MHz 0dBm
Mkr1 2.2749 GHz
Ref 5 dBm
Atten 5 dB
-55.5 dBm
Peak
Log
10
dB/
Offst
20.5
dB
Dl
-20.0
dBm
V1 S2
S3 FC
AA
Start 1 MHz
Stop 2.5 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 258.9 ms (1000 pts)


Agilent 13:45:53 Aug 9, 2019
R T
Spur. Emissions 1MHz to 2.5GHz; TX @ 2426MHz; PWR +12.5 dBm
Mkr1 1.763 GHz
Ref 20 dBm
#Atten 10 dB
-43.11 dBm
Peak
Log
10
dB/
Offst
20.5
dB
Dl
-8.0
dBm
V1 S2
S3 FC
AA
Start 1 MHz
Stop 2.5 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 258.9 ms (401 pts)


Agilent 10:45:09 Aug 12, 2019
R T
Spur Emiss 2.5GHz to 25GHz;TX 2402MHz 0dBm
Mkr1 24.414 GHz
Ref 5 dBm
Atten 5 dB
-54.9 dBm
Peak
Log
10
dB/
Offst
20.5
dB
Dl
-20.0
dBm
V1 S2
S3 FC
AA
Start 2.5 GHz
Stop 25 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 2.331 s (1000 pts)


Agilent 13:49:46 Aug 9, 2019
R T
Spur Emissions 2.5GHz to 25GHz; TX @ 2402MHz; PWR +12.5 dBm
Mkr1 24.482 GHz
Ref 20 dBm
#Atten 10 dB
-44.28 dBm
Peak
Log
10
dB/
Offst
20.5
dB
Dl
-8.0
dBm
V1 S2
S3 FC
AA
Start 2.5 GHz
Stop 25 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 2.331 s (1000 pts)


Agilent 10:42:31 Aug 12, 2019
R T
Spur Emiss 2.5GHz to 25GHz;TX 2426MHz 0dBm
Mkr1 24.820 GHz
Ref 5 dBm
Atten 5 dB
-55.11 dBm
Peak
Log
10
dB/
Offst
20.5
dB
Dl
-20.0
dBm
V1 S2
S3 FC
AA
Start 2.5 GHz
Stop 25 GHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 2.331 s (1000 pts)



11.6 Spurious Radiated Emissions (Restricted Band)

The procedures were in accordance to FCC DTS Measurement Guideline 558074 D01, Section 12.1 and ANSI C63.10.

Radiated emission measurements were performed with linearly polarized broadband antennas. The results obtained with these antennas can be correlated with results obtained with a tuned dipole antenna. The radiated emission measurements were performed with a spectrum analyzer. The bandwidth used from 150 kHz to 30 MHz is 9 or 10 kHz and the bandwidth from 30 MHz to 1000 MHz is 100 or 120 kHz. Above 1 GHz, a 1 MHz bandwidth is used. A 10 dB linearity check is performed prior to start of testing in order to determine if an overload condition exists. Figure 4 herein lists the details of the test equipment used during radiated emissions tests.

For tests from 1 to 10 GHz, a high pass filter was used to reduce the fundamental emission. High pass filters were not needed above 10 GHz, since the preamplifiers attenuated the fundamental emission. Figure 4 herein lists the details of the test equipment used during radiated emissions tests. The was device was rotated through three orthogonal axes as per ANSI C63.10 during the radiated tests.

Final radiated emissions measurements were performed inside of an anechoic chamber at a test distance of 3 meters. The anechoic chamber is designated as Chamber E. This Chamber meets the Site Attenuation requirements of ANSI C63.4. Chamber E is located at 12 East Devonwood Ave. Romeoville, Illinois EMI test lab.

The entire frequency range from 30 to 25,000 MHz was slowly scanned with particular attention paid to those frequency ranges which appeared high. Measurements were performed using two antenna polarizations, (vertical and horizontal). The worst case emissions were recorded. All measurements may be performed using either the peak, average or quasi-peak detector functions. If the peak detector data exceeds or is marginally close to the limits, the measurements are repeated using a quasi-peak detector or average function as required by the specification for final determination of compliance.

The detected emission levels were maximized by rotating the EUT, adjusting the positions of all cables, and by scanning the measurement antenna from 1 to 4 meters above the ground.

Radiated Emissions Field Strength Limits

Frequency Range (MHz)	Test Distance (meters)	Class B Limits	
		uV/m	dB(uV/m)
30 - 88	3	100	40.0
88 - 216	3	150	43.5
216 - 960	3	200	46.0
Above 960	3	500	54.0

11.6.1 Radiated Emissions Field Strength Sample Calculation

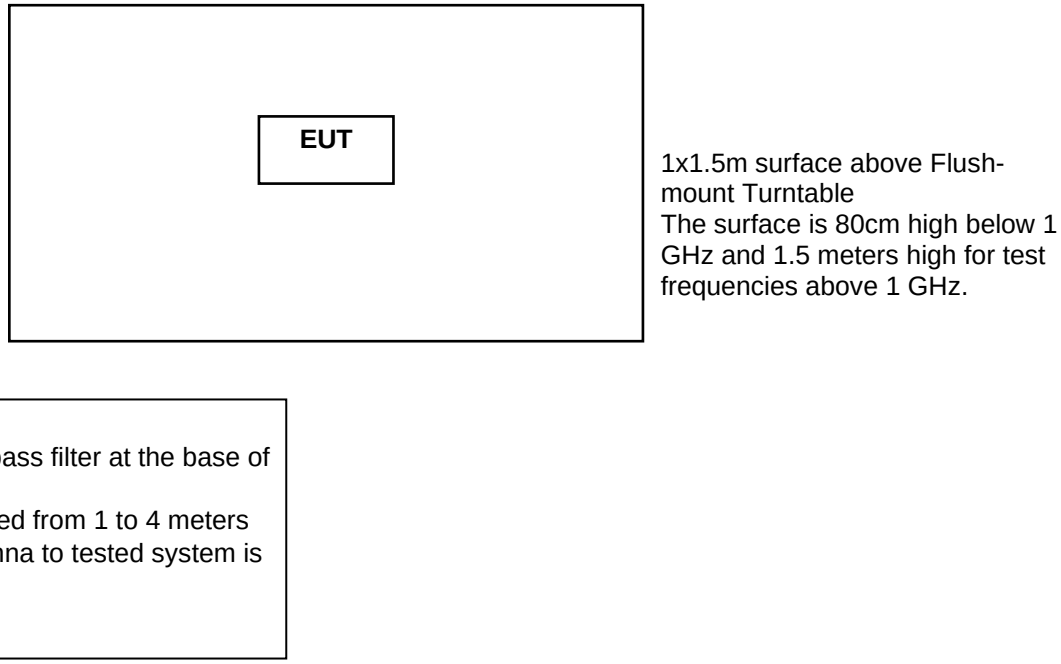
The field strength is calculated by adding the Antenna Factor and Cable Loss, and by subtracting the Amplifier Gain from the measured reading. The basic equation is as follows:

FS = RA + AF + CF - AG

Where: FS = Field Strength
RA = Receiver Amplitude
AF = Antenna Factor
CF = Cable Attenuation Factor
AG = Amplifier Gain
HPF = High pass Filter Loss
PKA = Peak to Average Factor (This is zero for non-average measurements)

The Peak to average factor is used when average measurements are required. It is calculated by the highest duty cycle in percent over any 100mS transmission. The factor in dB is 20 * Log(Duty cycle/100).

Figure 1. Drawing of Radiated Emissions Setup



11.6.2 Spurious Radiated Emissions Test Results (Restricted Band)

The following spectrum analyzer settings were used.

Span = wide enough to fully capture the emission being measured
RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
A Video Bandwidth of 10 Hz was used for Average measurements above 1 GHz.

The EUT was in the highest power mode and the highest duty cycle for this test.

Manufacturer	TimeKeeping Systems	Specification	FCC Part 15 Subpart C & RSS-210
Model	DD-007	Test Date	08/13/2019
Serial Number	SMP1	Test Distance	3 Meters
Abbreviations	Pol = Antenna Polarization; V = Vertical; H = Horizontal; BC = Biconical (ANT-3); LP = Log-Periodic (ANT-6); HN = Horn (ANT-13) P = peak; Q = QP		
Notes	Corr. Factors = Cable Loss – Preamp Gain + HP Filter Loss		

This table includes all emissions except Fundamental, Band edge, and harmonics emissions.
This table includes Non-Restricted band emissions.

Freq. MHz	Meter Reading dBuV	Dect.	Ant. Pol.	Ant Factor	Cable & amp Factors	Dist Fact dB	EUT dBuV/m	Limit dBuV/m	Margin Under Limit dB	Note
30.0	8.9	P	H	13.8	0.4	0.0	23.0	40.0	17.0	
32.2	13.9	P	H	13.1	0.4	0.0	27.4	40.0	12.6	
51.0	7.2	P	H	9.4	0.5	0.0	17.1	40.0	22.9	
210.1	10.9	P	H	14.7	1.1	0.0	26.7	43.5	16.8	
249.5	8.1	P	H	11.9	1.2	0.0	21.2	46.0	24.8	
251.0	9.8	P	H	15.5	1.2	0.0	26.5	46.0	19.5	
289.2	9.9	P	H	13.4	1.3	0.0	24.6	46.0	21.4	
338.3	10.2	P	H	13.9	1.4	0.0	25.6	46.0	20.4	
417.7	11.4	P	H	15.8	1.6	0.0	28.8	46.0	17.2	
434.7	11.5	P	H	16.1	1.7	0.0	29.2	46.0	16.8	
473.1	10.1	P	H	16.8	1.7	0.0	28.7	46.0	17.3	
555.0	9.6	P	H	18.3	1.9	0.0	29.8	46.0	16.2	
670.0	9.5	P	H	20.2	2.1	0.0	31.9	46.0	14.1	
781.3	9.9	P	H	21.6	2.3	0.0	33.8	46.0	12.2	
981.3	8.6	P	H	22.5	2.6	0.0	33.8	54.0	20.2	
1000.0	42.1	P	H	23.9	-33.9	0.0	32.1	54.0	21.9	
1055.0	43.6	P	H	24.4	-34.2	0.0	33.8	74.0	40.2	
1422.5	42.6	P	H	25.1	-34.3	0.0	33.5	74.0	40.5	
2362.5	47.8	P	H	28.2	-33.7	0.0	42.3	74.0	31.7	1
3322.5	41.5	P	H	31.1	-32.5	0.0	40.0	74.0	34.0	1
3675.0	42.2	P	H	31.8	-32.3	0.0	41.7	74.0	32.3	1
4077.5	42.5	P	H	32.5	-31.7	0.0	43.3	74.0	30.7	1
4322.5	42.6	P	H	32.2	-31.6	0.0	43.2	74.0	30.8	1
4687.5	40.9	P	H	32.8	-31.0	0.0	42.7	74.0	31.3	1
4982.5	38.8	P	H	33.2	-30.6	0.0	41.4	74.0	32.6	1
30.0	7.9	P	V	13.8	0.4	0.0	22.1	40.0	17.9	
36.6	15.2	P	V	11.9	0.4	0.0	27.5	40.0	12.5	
64.3	9.9	P	V	9.3	0.6	0.0	19.7	40.0	20.3	
152.7	9.9	P	V	12.8	0.9	0.0	23.6	43.5	19.9	
251.0	9.6	P	V	15.5	1.2	0.0	26.3	46.0	19.7	
276.6	10.3	P	V	13.1	1.3	0.0	24.7	46.0	21.3	
342.1	10.0	P	V	13.9	1.5	0.0	25.4	46.0	20.6	
393.8	11.0	P	V	15.0	1.6	0.0	27.5	46.0	18.5	
462.4	10.1	P	V	16.6	1.7	0.0	28.4	46.0	17.6	
501.5	9.6	P	V	17.6	1.8	0.0	29.0	46.0	17.0	
508.8	8.0	P	V	17.9	1.8	0.0	27.8	46.0	18.2	
635.0	9.2	P	V	19.6	2.0	0.0	30.9	46.0	15.1	
727.5	10.4	P	V	20.2	2.2	0.0	32.8	46.0	13.2	
855.0	10.2	P	V	22.5	2.4	0.0	35.2	46.0	10.8	
1000.0	38.9	P	V	23.9	-33.9	0.0	28.8	54.0	25.2	1
1150.0	42.6	P	V	24.5	-34.3	0.0	32.8	74.0	41.2	1
1542.5	41.5	P	V	25.2	-34.2	0.0	32.5	74.0	41.5	1
2362.5	50.0	P	V	28.2	-33.7	0.0	44.5	74.0	29.5	1
2490.0	46.1	P	V	28.4	-33.6	0.0	40.8	74.0	33.2	1

Freq. MHz	Meter Reading dBuV	Dect.	Ant. Pol.	Ant Factor	Cable & amp Factors	Dist Fact dB	EUT dBuV/m	Limit dBuV/m	Margin Under Limit dB	Note
3605.0	39.1	P	V	31.5	-32.4	0.0	38.1	74.0	35.9	1
3815.0	39.3	P	V	32.8	-32.0	0.0	40.1	74.0	33.9	1
3945.0	38.8	P	V	32.8	-32.1	0.0	39.5	74.0	34.5	1
4000.0	38.5	P	V	32.7	-32.0	0.0	39.2	74.0	34.8	1
4020.0	37.9	P	V	32.7	-31.9	0.0	38.7	74.0	35.3	1
4477.5	39.0	P	V	32.5	-31.4	0.0	40.1	74.0	33.9	1
4727.5	38.2	P	V	32.9	-30.9	0.0	40.2	74.0	33.8	1
4930.0	37.8	P	V	33.2	-30.6	0.0	40.3	74.0	33.7	1

Note 1: The Peak data is under the Average limit, therefore Average measurement not performed.

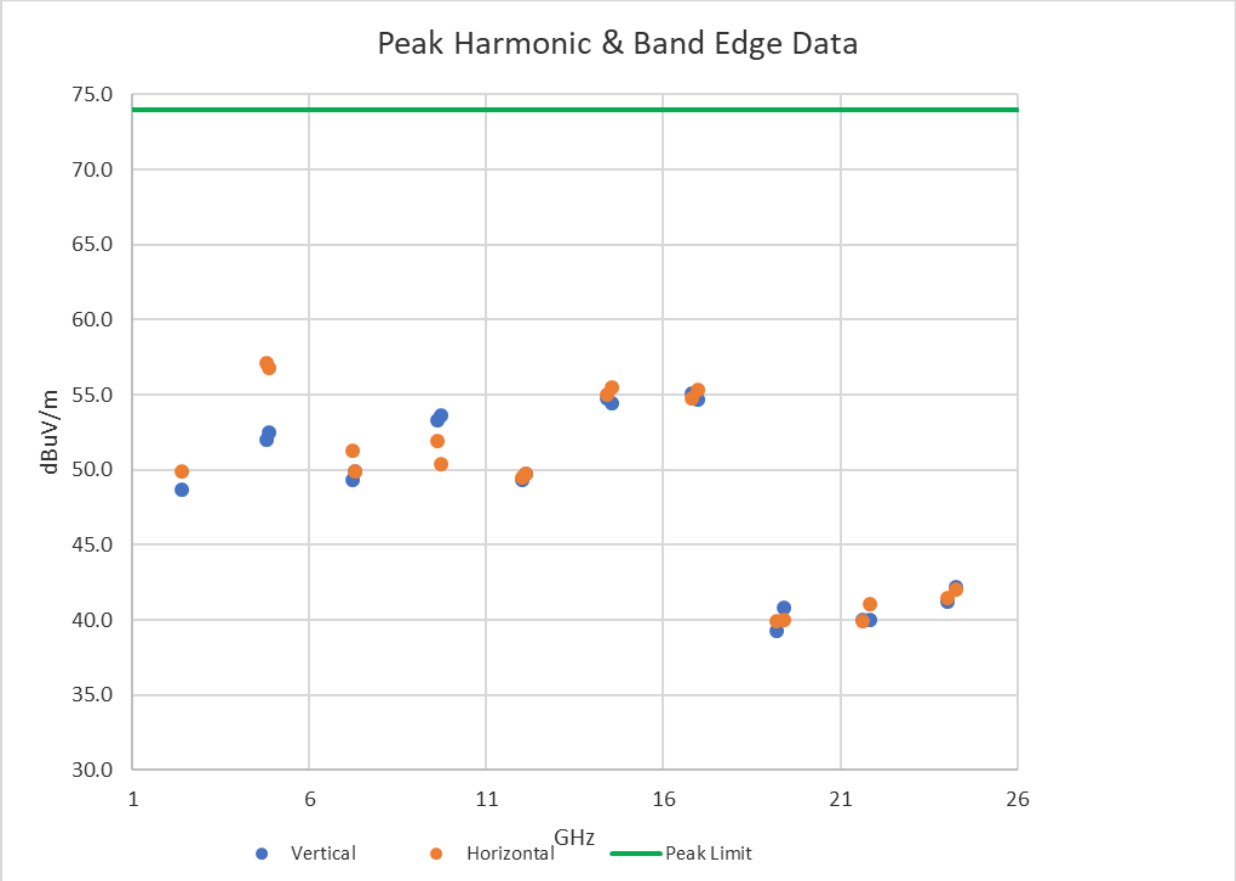
Intentional Radiator emissions (Fundamental, Band edge and Harmonics)

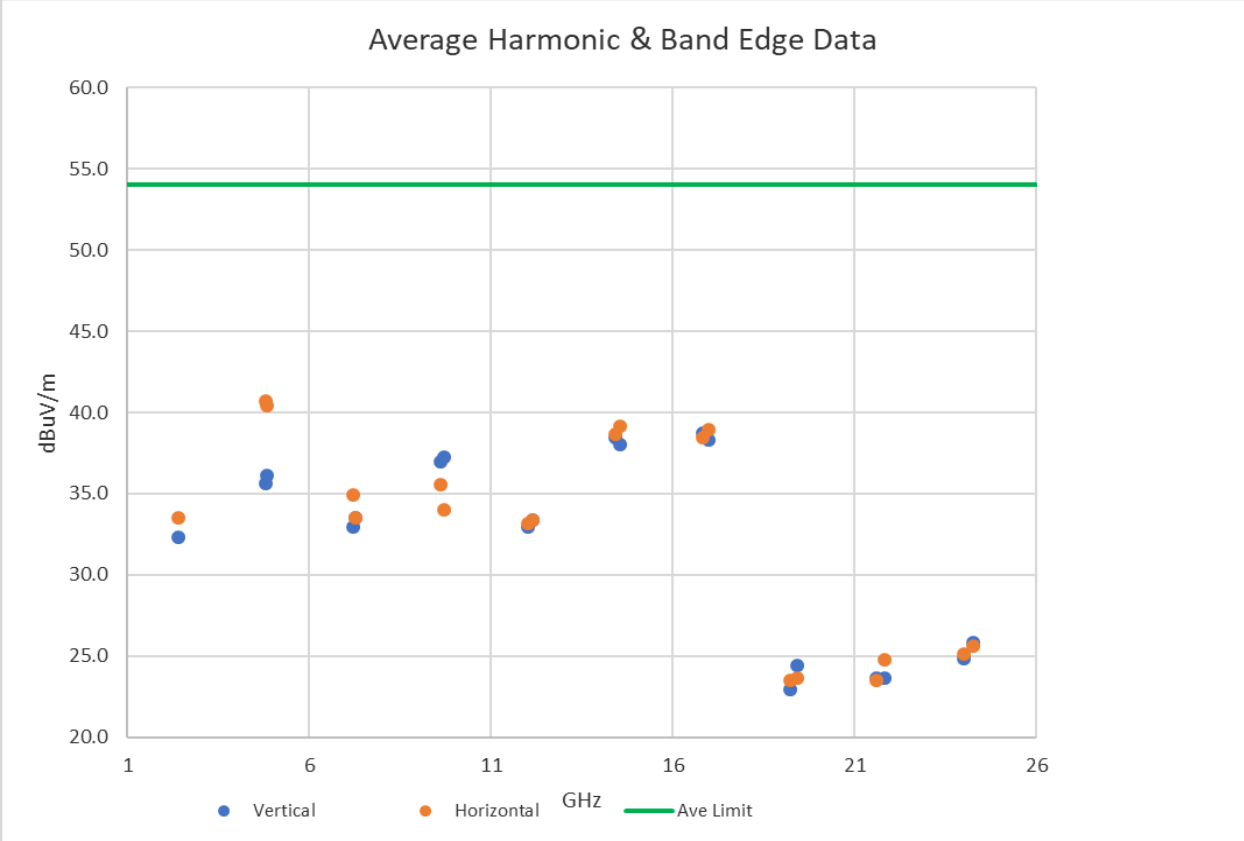
Fundamental, Harmonic and Band edge emissions

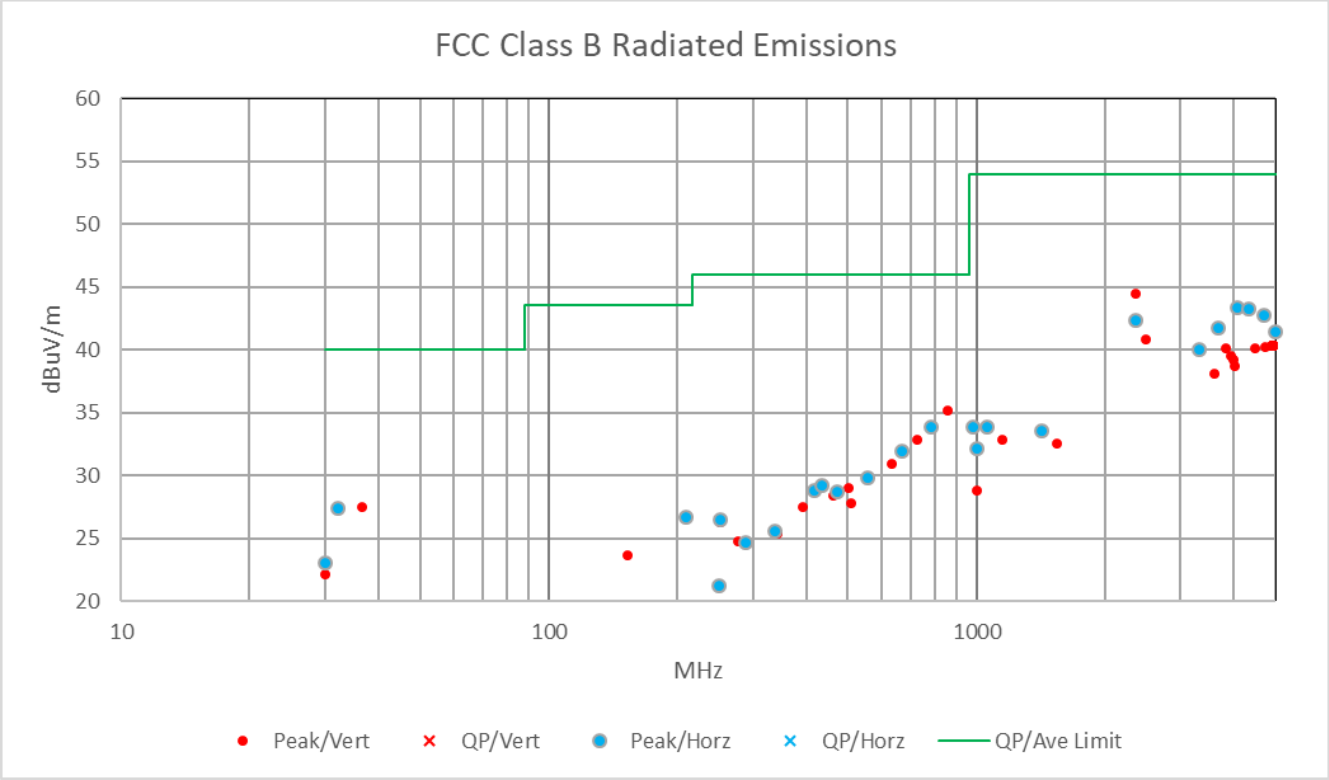
	Tx	Spectrum Analyzer Readings dBuV									EUT	Peak	Ave	Peak	Ave	Margin
harm	Freq	Peak			Ave	Peak			Ave	Corr.	Emission	Tot. FS		Limit		Under
#	MHz	Vertical Polarization				Horizontal Polarization				Fact dB	Freq MHz	dBuV/m		dBuV/m		Limit dB
		X	Y	Z	Max	X	Y	Z	Max							
1	2402	104.4	112.7	105.8	96.3	107.9	113.9	105.5	97.5	-5.3	2402.0	108.6	92.2	125	125	16.4
BE	2402	45.7	54.0	47.1	37.6	49.2	55.2	46.8	38.8	-5.3	2400.0	49.9	33.5	74	54	20.5
2	2402	46.2	49.0	47.8	32.6	54.1	48.0	48.4	37.7	3.0	4804.0	57.1	40.7	74	54	13.3
3	2402	40.7	41.9	40.7	25.5	41.1	41.8	43.9	27.5	7.4	7206.0	51.3	34.9	74	54	19.1
4	2402	40.9	38.9	38.9	24.5	39.2	38.6	39.5	23.1	12.4	9608.0	53.3	36.9	74	54	17.1
1	2426	103.9	112.0	106.2	95.6	113.7	107.3	104.9	97.3	-5.2	2426.0	108.5	92.1	125	125	16.5
2	2426	46.9	49.4	48.0	33.0	49.4	48.2	53.7	37.3	3.1	4852.0	56.8	40.4	74	54	13.6
3	2426	39.0	42.1	40.1	25.7	39.0	39.9	42.1	25.7	7.8	7278.0	49.9	33.5	74	54	20.5
4	2426	38.3	41.5	38.1	25.1	38.3	38.0	38.0	21.9	12.1	9704.0	53.6	37.2	74	54	16.8
Column numbers (see below for explanations)																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Column #1. harm = Harmonic; BE = Band Edge emissions
Column #2. Frequency of Transmitter.
Column #3. Uncorrected readings from the spectrum analyzer with First Axis Rotation.
Column #4. Uncorrected readings from the spectrum analyzer with Second Axis Rotation.
Column #5. Uncorrected readings from the spectrum analyzer with Third Axis Rotation.
Column #6. Average Reading based on peak reading reduced by the Duty cycle correction
Column #7. Uncorrected readings from the spectrum analyzer with First Axis Rotation.
Column #8. Uncorrected readings from the spectrum analyzer with Second Axis Rotation.
Column #9. Uncorrected readings from the spectrum analyzer with Third Axis Rotation.
Column #10. Average Reading based on peak reading reduced by the Duty cycle correction
Column #11. Corr. Factors = Cable Loss – Preamp Gain + Antenna Factor
Column #12. Frequency of Tested Emission
Column #13. Highest peak field strength at listed frequency.
Column #14. Highest Average field strength at listed frequency.
Column #15. Peak Limit.
Column #16. Average Limit.
Column #17. The margin (last column) is the worst-case margin under the peak or average limits for that row.

Overall Judgment: Passed by at least 10 dB
No other Emissions were detected from 30 to 25,000 MHz within 10 dB of the limits.


Peak Harmonic & Band Edge Data
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
dBuV/m
1
6
11
16
21
26
GHz
Vertical
Horizontal
Peak Limit


Average Harmonic & Band Edge Data
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
dBuV/m
1
6
11
16
21
26
GHz
Vertical
Horizontal
Ave Limit



Radiated emissions in a graphical format. The above charts are the same data as the previous table.

11.7 Duty Cycle

The averave value of the pulsed emissions were measured as per section 7.5, formula (10) of of ANSI C63.10-2013.

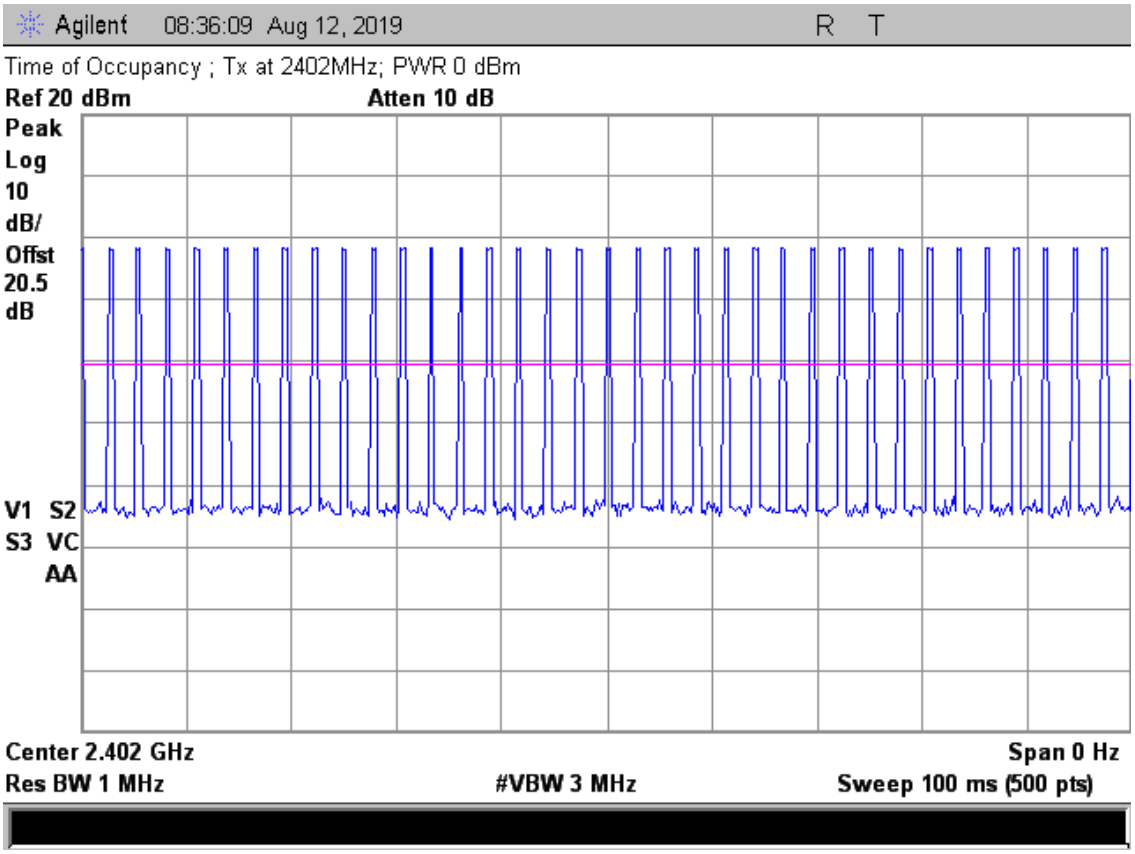
a) The EUT was set to the “worst-case” pulse ON time.
b) The RF output was Coupled to the input of a spectrum analyzer by a “near-field” coupling method. The signal received shall be of sufficient level to trigger adequately the spectrum analyzer sweep display.
c) The center frequency of the spectrum analyzer was set to the center of the RF signal.
d) The spectrum analyzer was set for ZERO SPAN.
e) The sweep time was of the analyzer was set to 100 ms and other times to show the duty cycle.
f) Since the pulse train has a period that exceeds 100 ms, or as an alternative to step f), then:
    1) The trigger on the spectrum analyzer was set to capture the greatest amount of pulse “ON time” over 100 ms.
    2) The 100 ms period that contains the maximum “on time” was found.
    3) The duty cycle was determined by dividing the total maximum “ON time” by 100 ms (tON/100 ms).
h) The duty cycle correction factor was used applying Equation (10) of ANSI C63.10 to the duty cycle determined in the preceding steps.

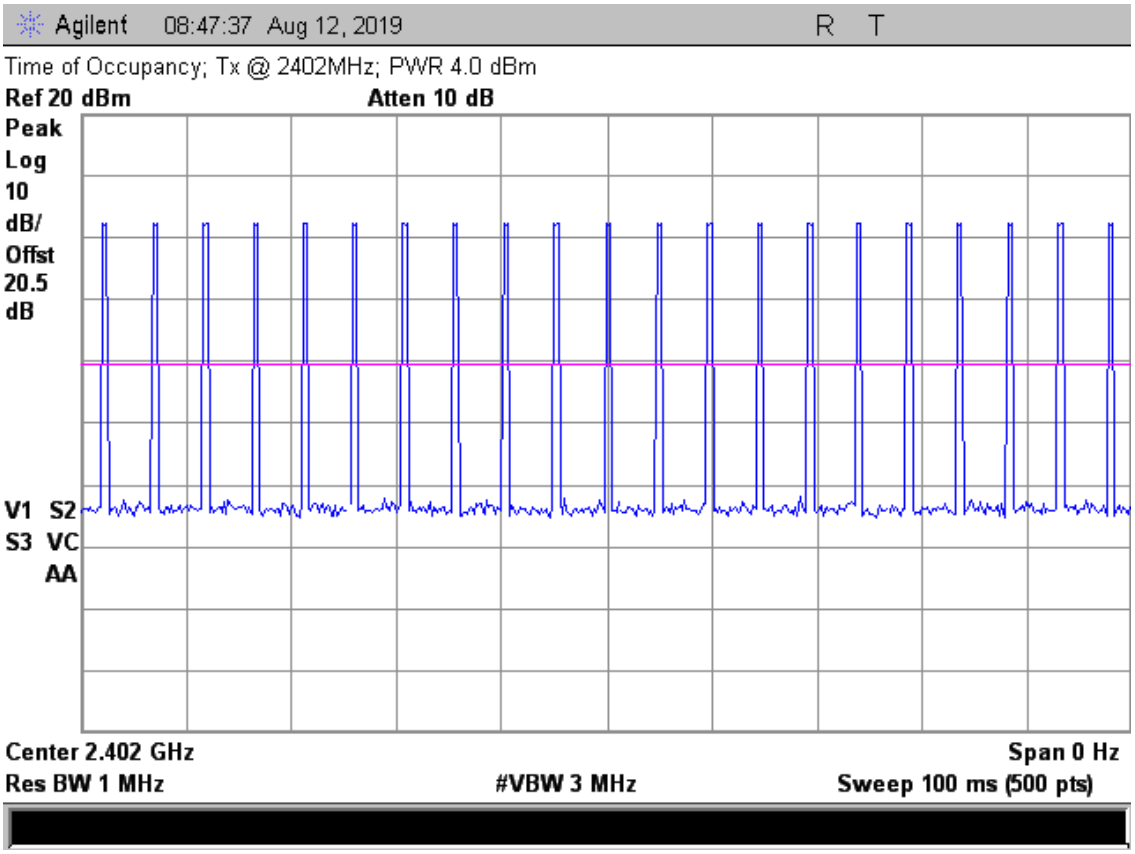
The Peak to average factor is calculated by the highest duty cycle in percent over any 100mS transmission. The factor in dB is 20 * Log(Duty cycle/100).

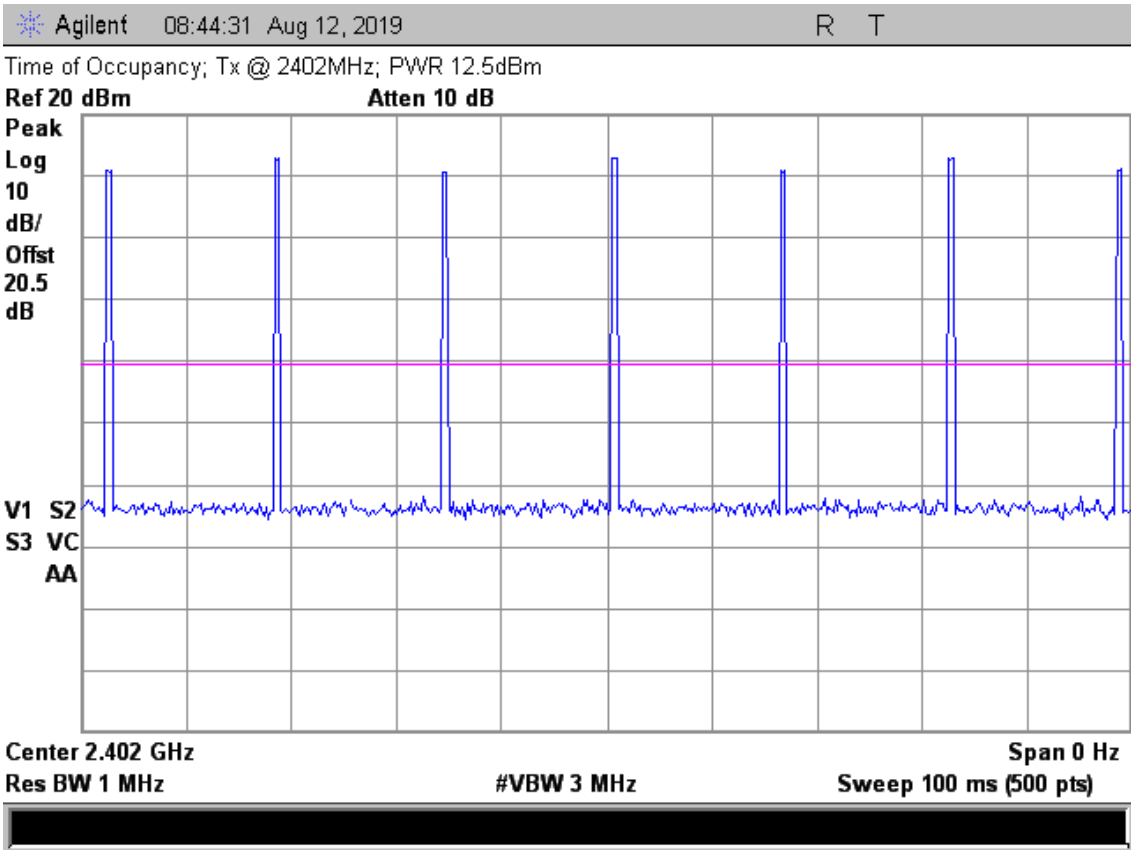
Tested by: Joseph Strzelecki/Richard Tichgelaar
Test Date: 08/12/2019

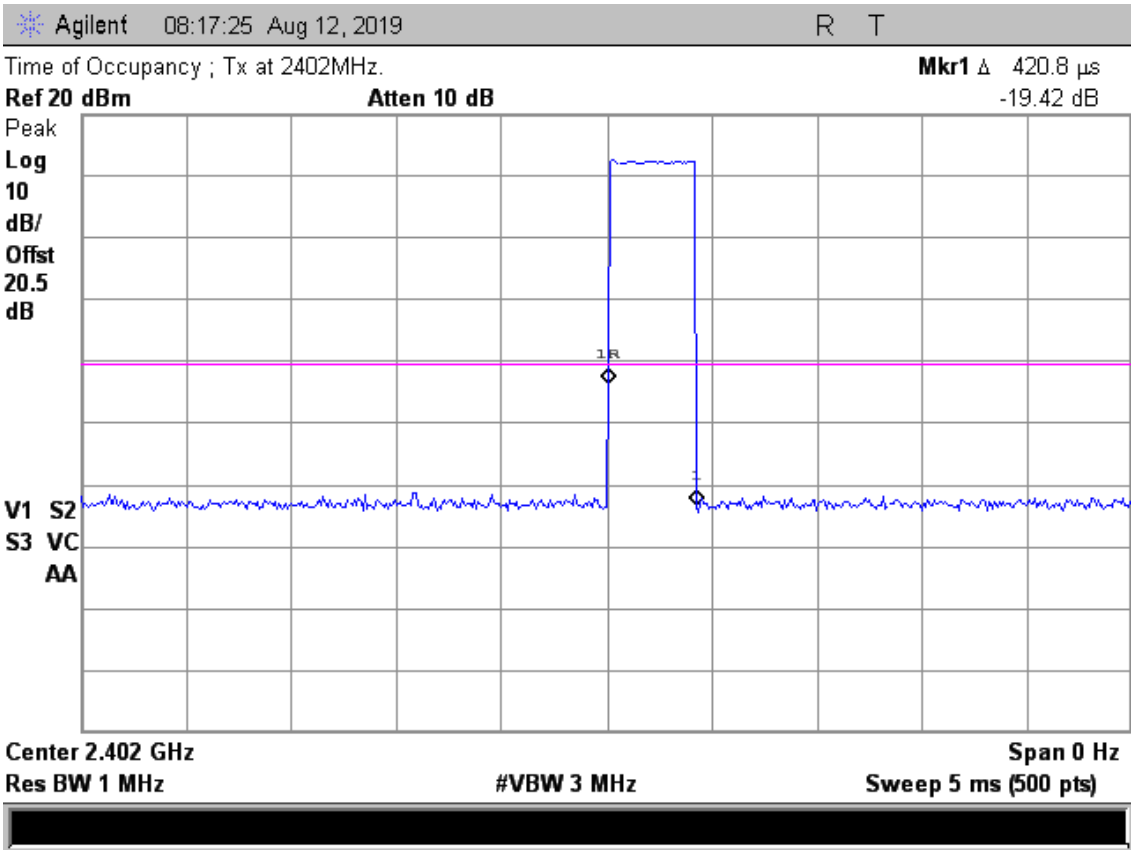
EUT Power Mode	Pulse Width (mS)	Number of pulses in 100 mS	Max on Time per 100 mS	Duty Cycle %
Low	0.421	36	15.16	15.16
Mid	0.421	21	8.84	8.84
High	0.421	7	2.95	2.95

Figure 2. Duty Cycle Plots




Agilent 08:47:37 Aug 12, 2019
R T
Time of Occupancy; Tx @ 2402MHz; PWR 4.0 dBm
Ref 20 dBm
Atten 10 dB
Peak
Log
10
dB/
Offst
20.5
dB
V1 S2
S3 VC
AA
Center 2.402 GHz
Span 0 Hz
Res BW 1 MHz
#VBW 3 MHz
Sweep 100 ms (500 pts)


Agilent 08:44:31 Aug 12, 2019
R T
Time of Occupancy; Tx @ 2402MHz; PWR 12.5dBm
Ref 20 dBm
Atten 10 dB
Peak
Log
10
dB/
Offst
20.5
dB
V1 S2
S3 VC
AA
Center 2.402 GHz
Span 0 Hz
Res BW 1 MHz
#VBW 3 MHz
Sweep 100 ms (500 pts)



11.7.1 Measurement Instrumentation Uncertainty

Measurement	Uncertainty
Radiated Emissions, E-field, 3 meters, 30 to 200 MHz	3.3 dB
Radiated Emissions, E-field, 3 meters, 200 to 1000 MHz	4.9 dB
Radiated Emissions, E-field, 3 meters, 1 to 18 GHz	4.8 dB
Radiated Emissions, E-field, 3 meters, 18 to 26 GHz	5.3 dB
Bandwidth using marker delta method at a span of 10 MHz	4 kHz
Bandwidth using marker delta method at a span of 50 kHz	470 Hz
99% Occupied Bandwidth using REC-43	1% of frequency span
Amplitude measurement 1-25000 MHz	2.5 dB
Temperature THM-02	0.6 Deg C

The uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k=2 in accordance with CISPR 16-4-2.