



# 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:

**TimeKeeping Systems, Inc.**  
30100 Bainbridge Road, Suite H  
Solon, Ohio 44139

## Test Facility:

**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

|                                                                                                                                                                                                                                                                                   |                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| <i>Equipment Under Test:</i><br>A TimeKeeping Systems, 2.4 GHz Transceiver<br>Model: DD-007 Serial Number: SMP1<br>This will be referred to as the EUT in this Report                                                                                                             |                                                                                                       |
| <i>Date EUT Received at Radiometrics: (Month-Day-Year)</i><br>August 6, 2019                                                                                                                                                                                                      | <i>Test Date(s): (Month-Day-Year)</i><br>August 7 to 21, 2019                                         |
| <i>Test Report Written and Authorized By:</i><br>Joseph Strzelecki<br>Senior EMC Engineer                                                                                                                                                                                         | <i>Test Witnessed By:</i><br>The tests were not witnessed by personnel from TimeKeeping Systems, Inc. |
| <i>Radiometrics' Personnel Responsible for Test:</i><br><br>09/06/2019<br>Date<br>Joseph Strzelecki<br>Senior EMC Engineer<br>NARTE EMC-000877-NE<br><br>Richard L. Tichgelaar<br>EMC Technician | <i>EUT Checked By:</i><br>Joseph Strzelecki<br>Richard Tichgelaar<br>Dave Jarvis<br>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 Emissions | 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<br>CFR Title 47   | 2018 | Code of Federal Regulations Title 47, Chapter 1, Federal Communications Commission, Part 15 - Radio Frequency Devices        |
| IC RSS-247<br>Issue 2 | 2017 | Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices |
| IC RSS-Gen<br>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<br>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<br>C63.10-2013   | 2013 | American National Standard for Testing Unlicensed Wireless Devices                                                                                                                         |
| FCC KDB<br>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](http://www.radiomet.com)). Radiometrics accreditation status can be verified at A2LA's web site ([www.a2la2.org](http://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<br>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<br>kHz | 99% EBW<br>kHz | Minimum<br>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<br>kHz | 99% EBW<br>kHz | Minimum<br>kHz |
|---------|-----------------|----------------|----------------|
| 2402    | 724             | 1048           | 500            |
| 2426    | 718             | 1076           | 500            |

The 6 dB bandwidth is greater than 500 kHz

Judgement: Pass



Agilent 13:13:27 Aug 12, 2019

R T

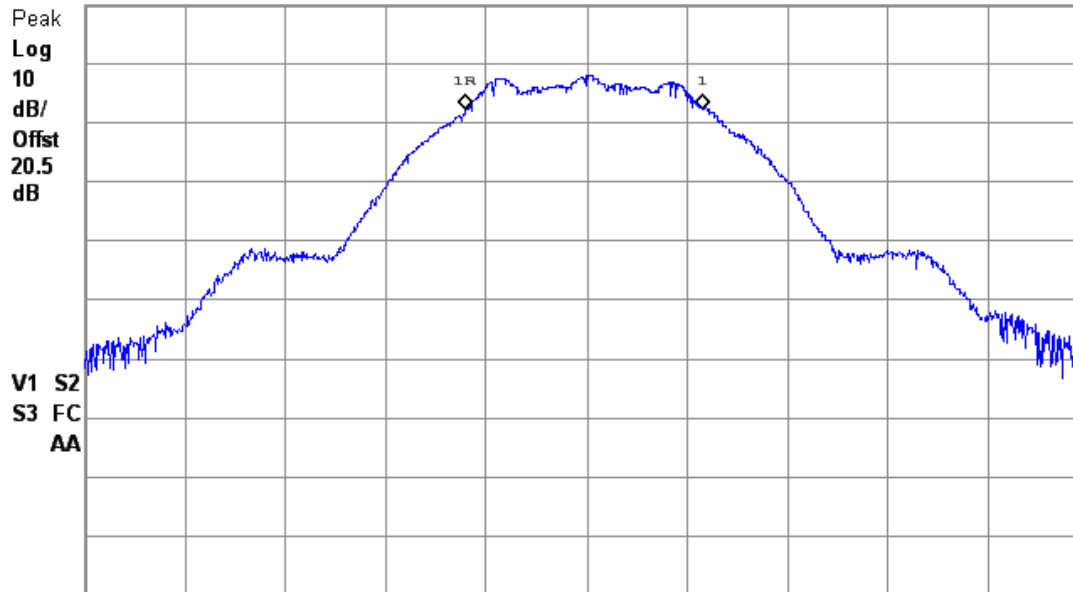
6 dB OBW ; CH37; 2402MHz; PWR 0 dBm

Mkr1  $\Delta$  706 kHz

Ref 10 dBm

Atten 5 dB

0.004 dB



Center 2.402 GHz

Span 3 MHz

#Res BW 100 kHz

#VBW 300 kHz

Sweep 9.99 ms (1000 pts)

Low power Mode; 6 dB Bandwidth

Agilent 13:08:31 Aug 12, 2019

R T

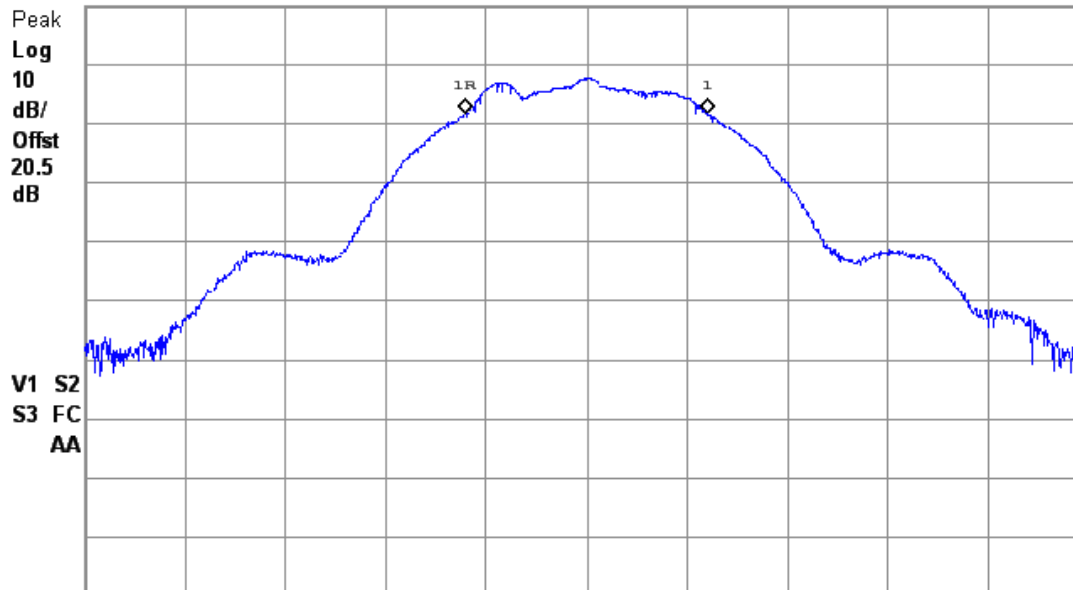
6 dB OBW ; CH38; 2426MHz; PWR 0 dBm

Mkr1  $\Delta$  724 kHz

Ref 10 dBm

Atten 5 dB

0.068 dB



Center 2.426 GHz

Span 3 MHz

#Res BW 100 kHz

#VBW 300 kHz

Sweep 9.99 ms (1000 pts)

Low power Mode; 6 dB Bandwidth





Agilent

13:21:16 Aug 12, 2019

R T

6 dB OBW ; CH37; 2402MHz; PWR 12.5dBm

Mkr1  $\Delta$  724 kHz

Ref 20 dBm

Atten 10 dB

-0.049 dB

Peak

Log

10

dB/

Offst

20.5

dB

V1 S2

S3 FC

AA

Center 2.402 GHz

Span 3 MHz

#Res BW 100 kHz

#VBW 300 kHz

Sweep 9.99 ms (1000 pts)

High power Mode; 6 dB Bandwidth

Agilent

13:32:35 Aug 12, 2019

R T

6 dB OBW ; CH38; 2426MHz; PWR 12.5dBm

Mkr1  $\Delta$  718 kHz

Ref 20 dBm

Atten 10 dB

-0.012 dB

Peak

Log

10

dB/

Offst

20.5

dB

V1 S2

S3 FC

AA

Center 2.426 GHz

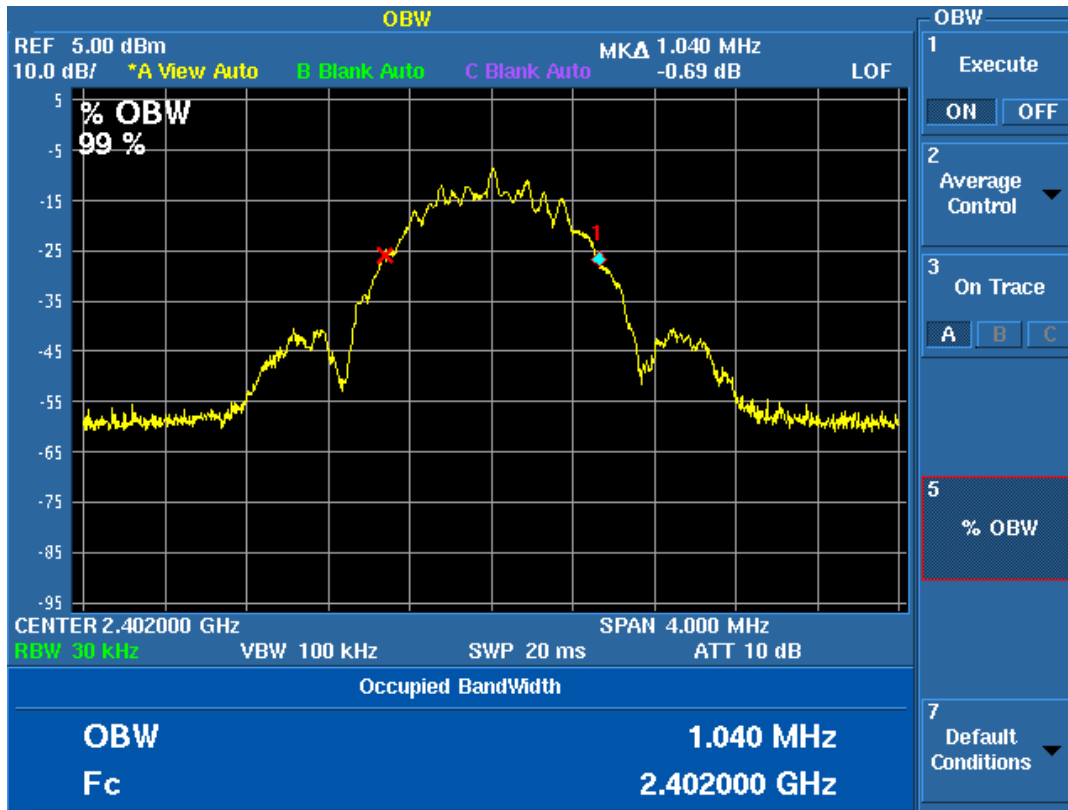
Span 3 MHz

#Res BW 100 kHz

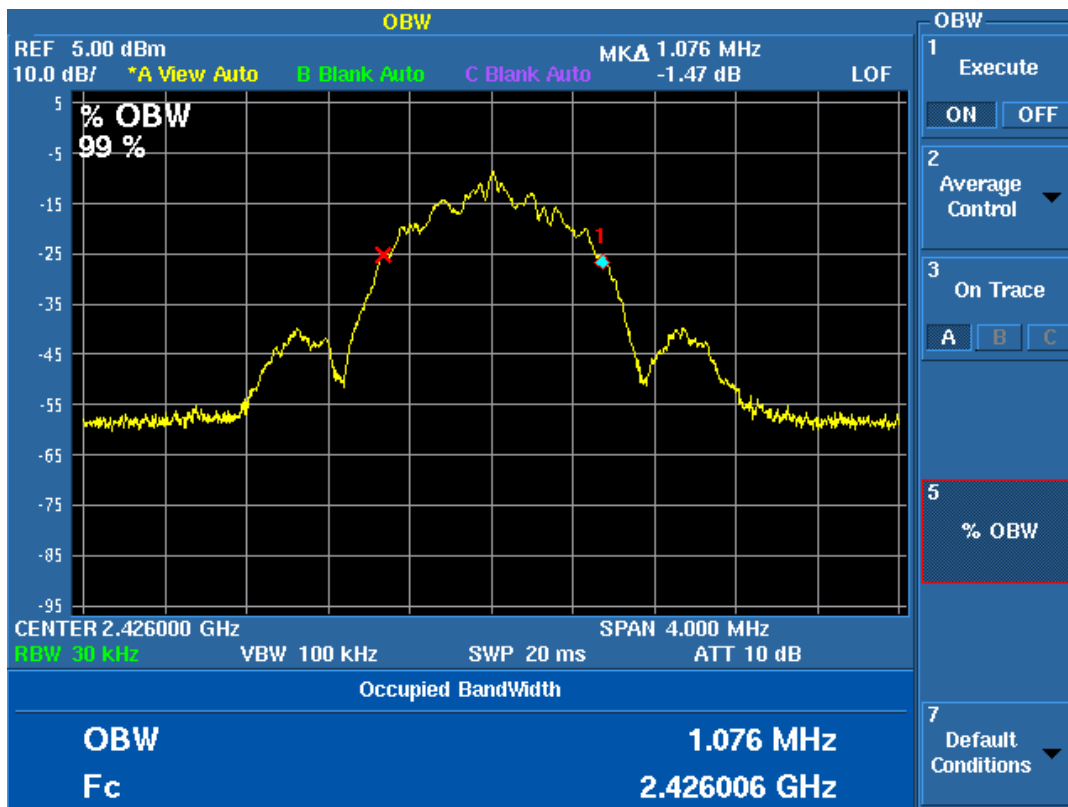
#VBW 300 kHz

Sweep 9.99 ms (1000 pts)

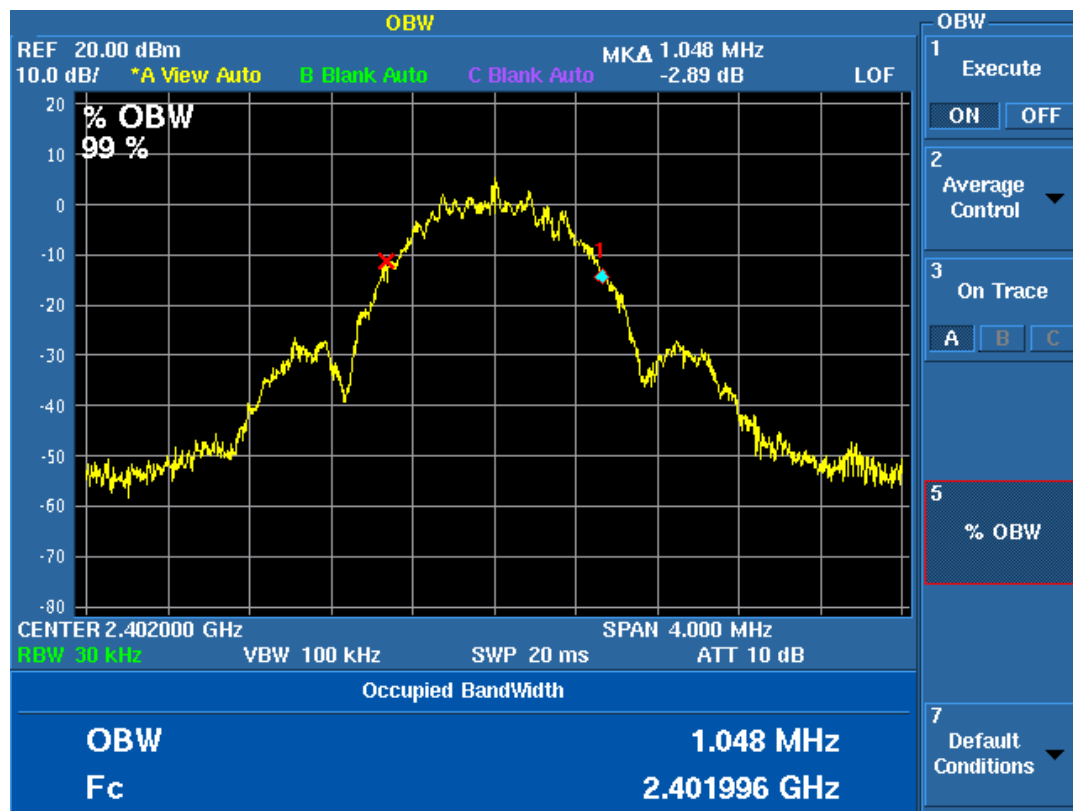
High power Mode; 6 dB Bandwidth



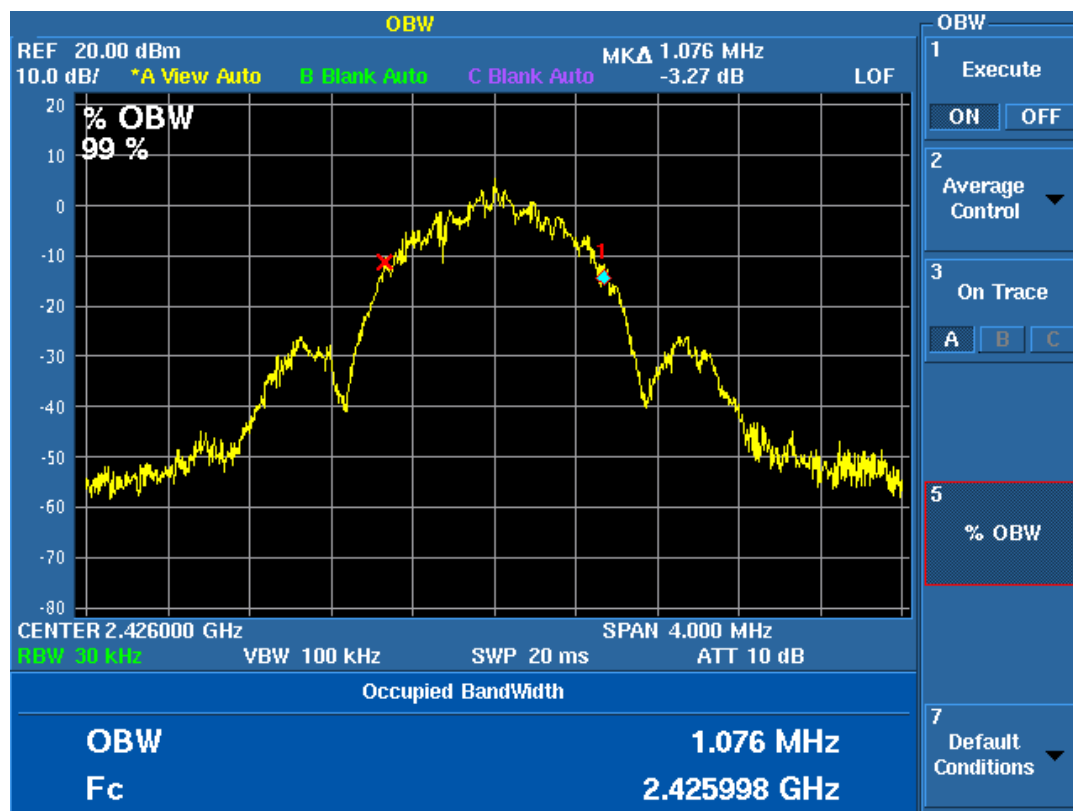
99% OBW; Low Power Mode



99% OBW; Low Power Mode



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.

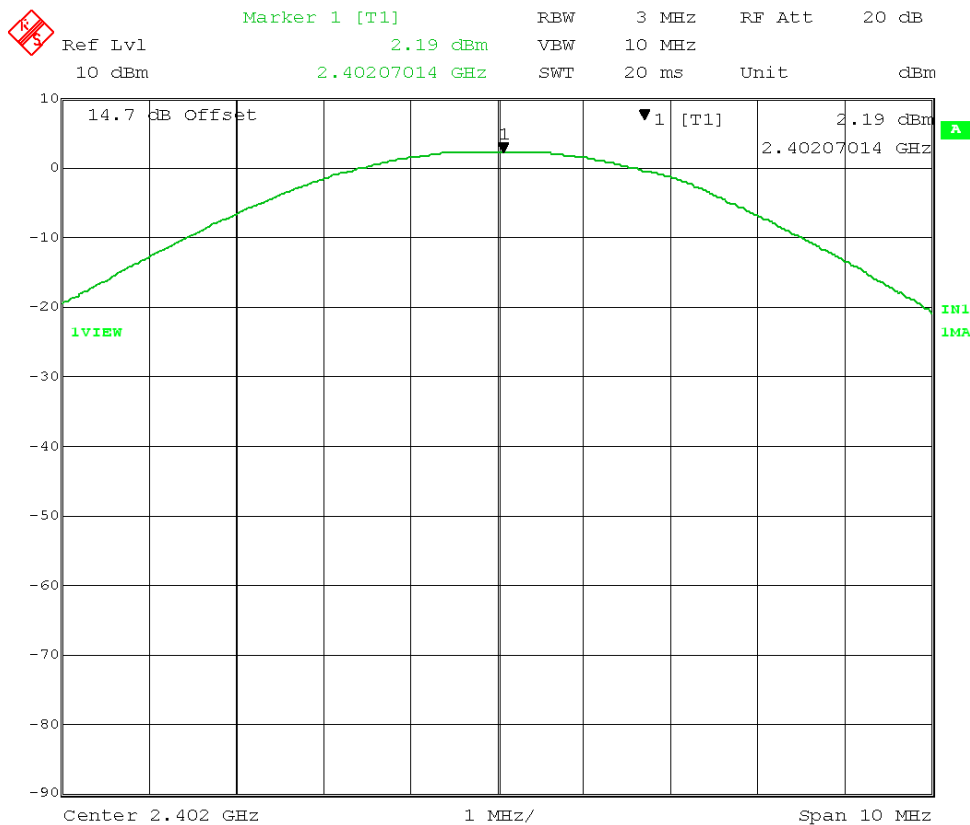
Tested by: Joseph Strzelecki/Richard Tichgelaar

Test Date: 08/13/2019

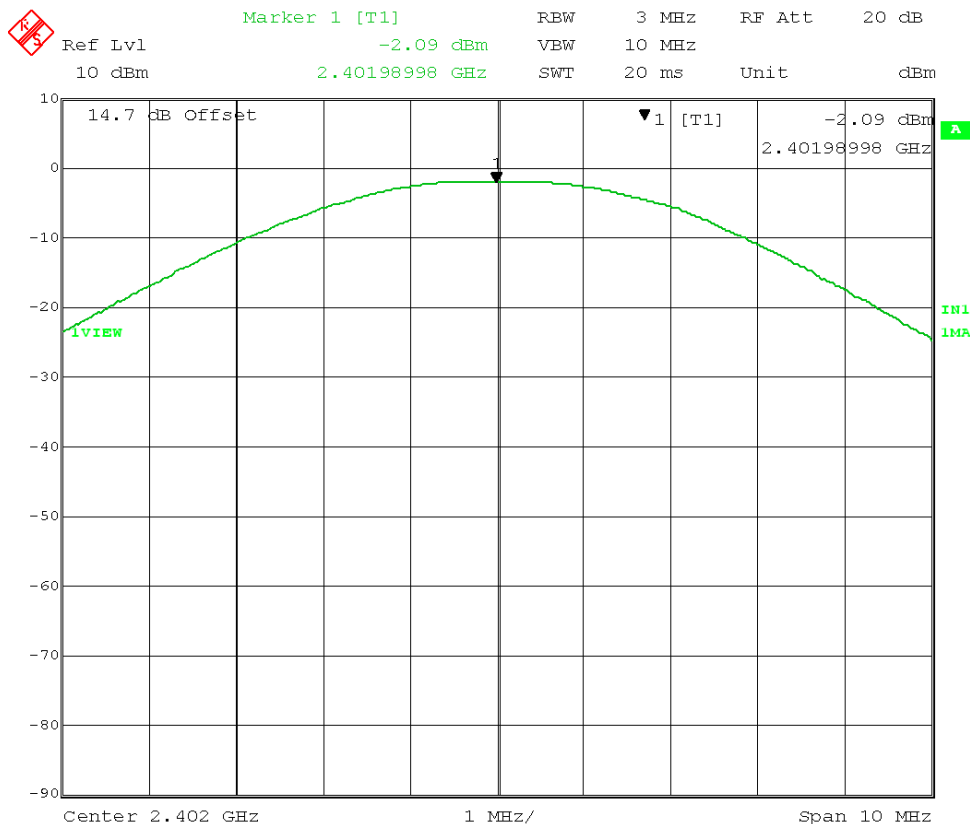
Since the gain of the antenna is always less than 6 dB, the limit is not reduced. The antenna gain is 3.3 dBi.

| 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          |

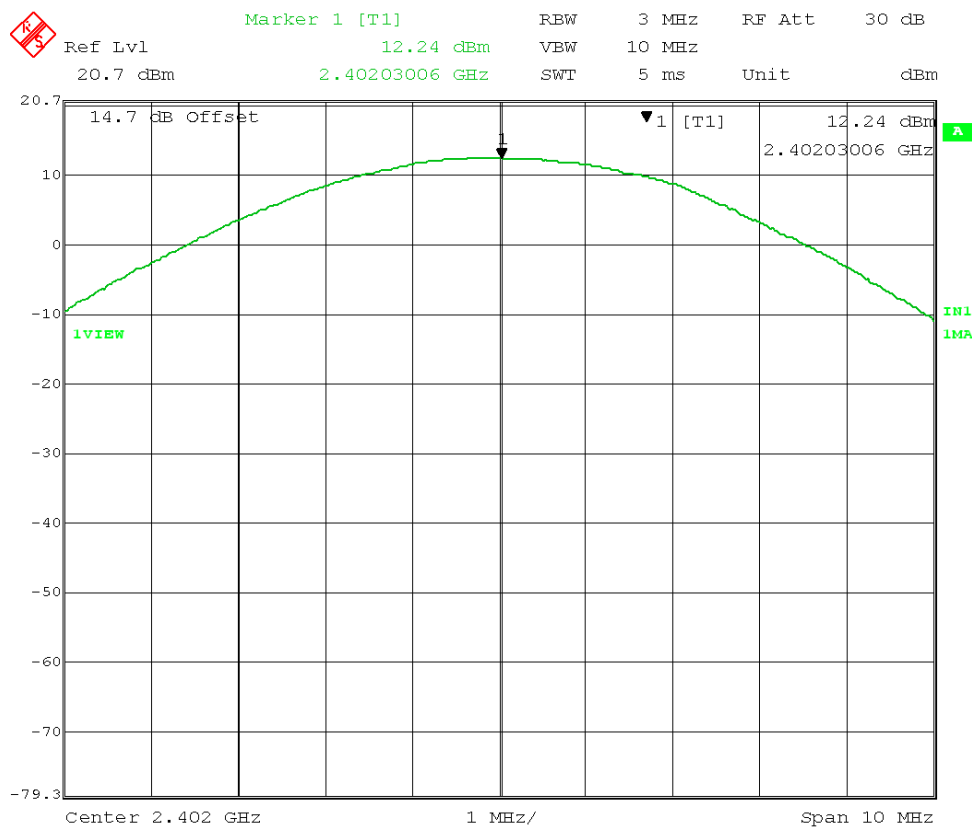
Judgment: Passed by 12.26 dB



Title: Conducted Peak Power: CH 37 : 2402 MHz : Power Level set to 4.0 dBm  
Date: 13.AUG.2019 07:56:09

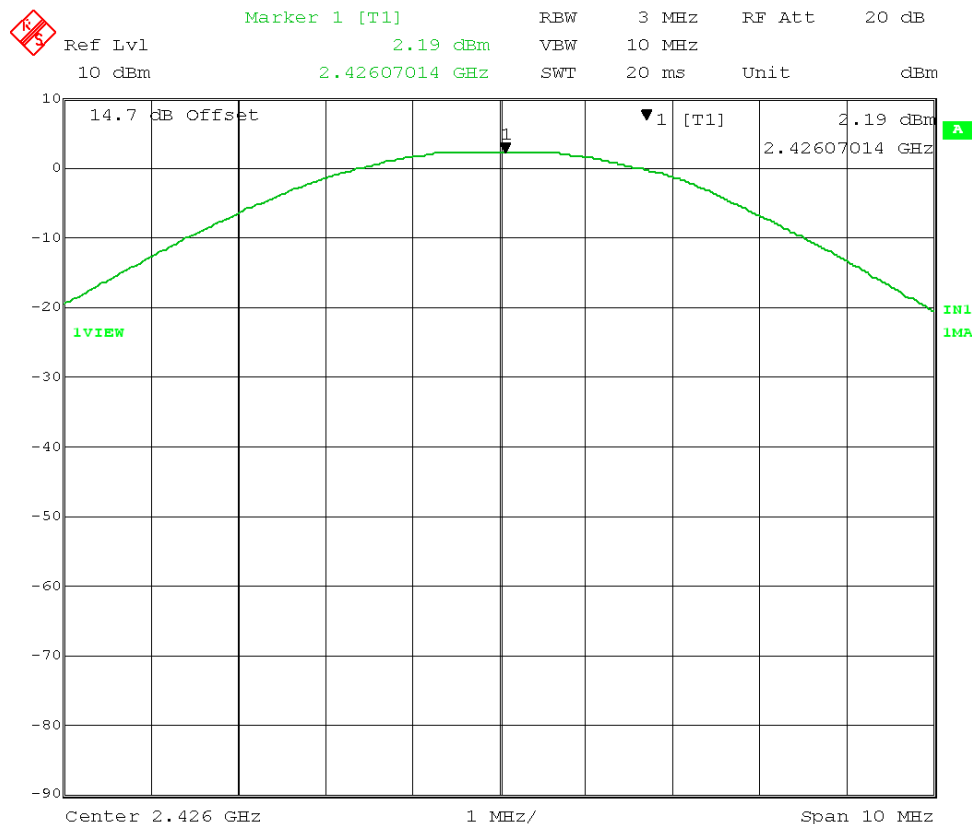


Title: Conducted Peak Power: CH 37 : 2402 MHz : Power Level set to 0 dBm.  
Date: 13.AUG.2019 07:36:28



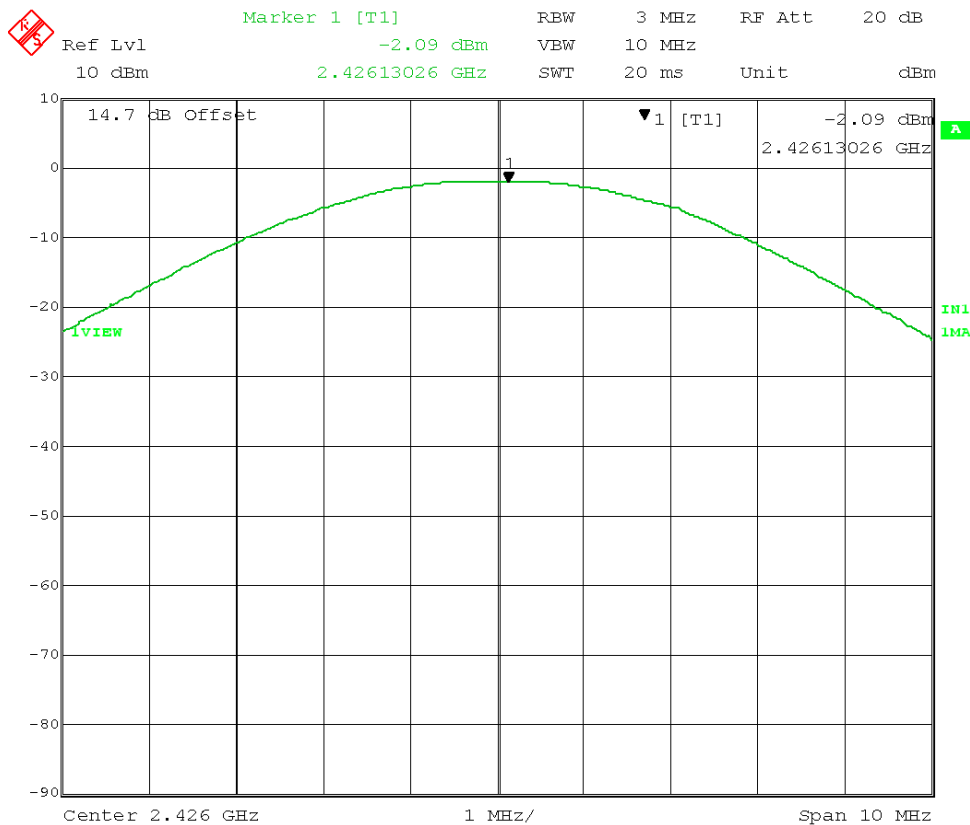
Title: Conducted Peak Power Ch 37: 2402 MHz: Power Level set to 12.5 dBm

Date: 13.AUG.2019 07:02:16

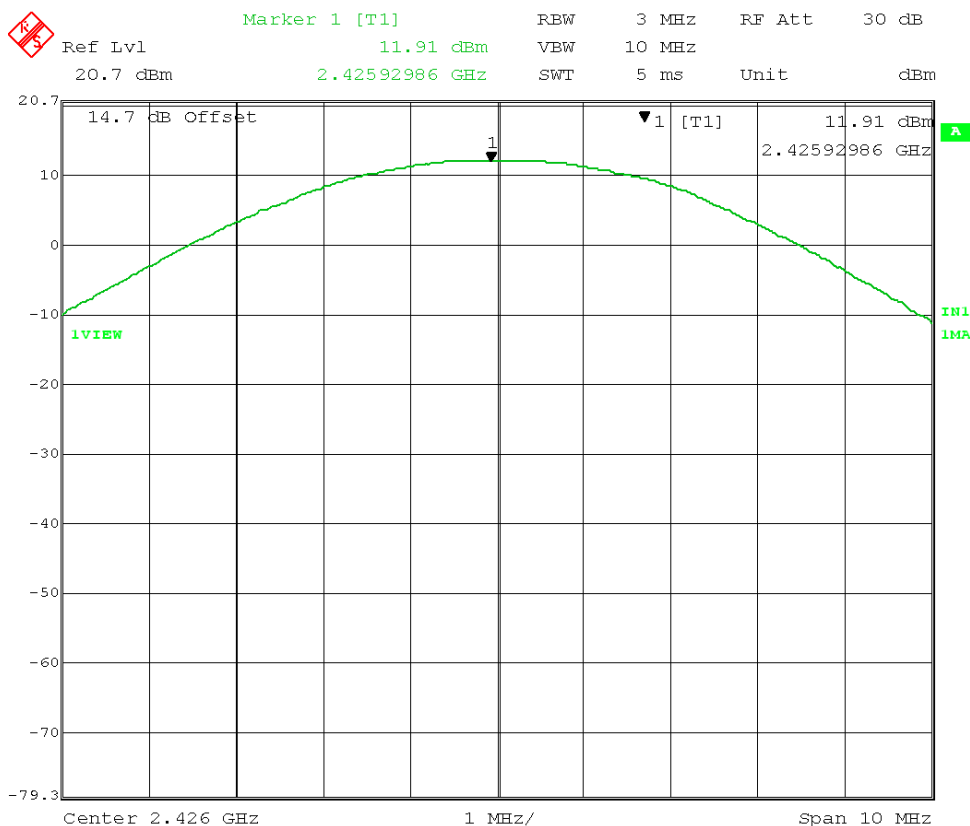


Title: Conducted Peak Power : CH 38 : 2426 MHz : Power Level set to 4.0 dBm

Date: 13.AUG.2019 08:03:07



Title: Conducted Peak Power CH 38: 2426 MHz; Power Level Set to 0 dBm.  
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

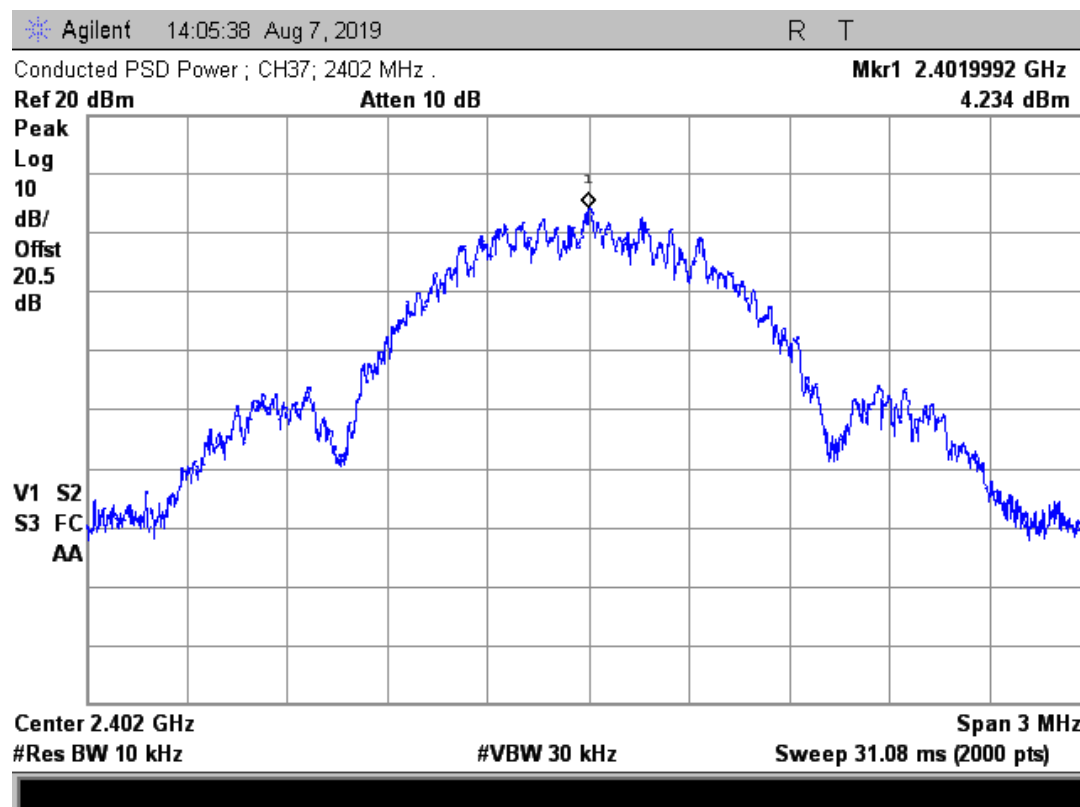
Tested by: Richard Tichgelaar

Test Date: 08/07/2019

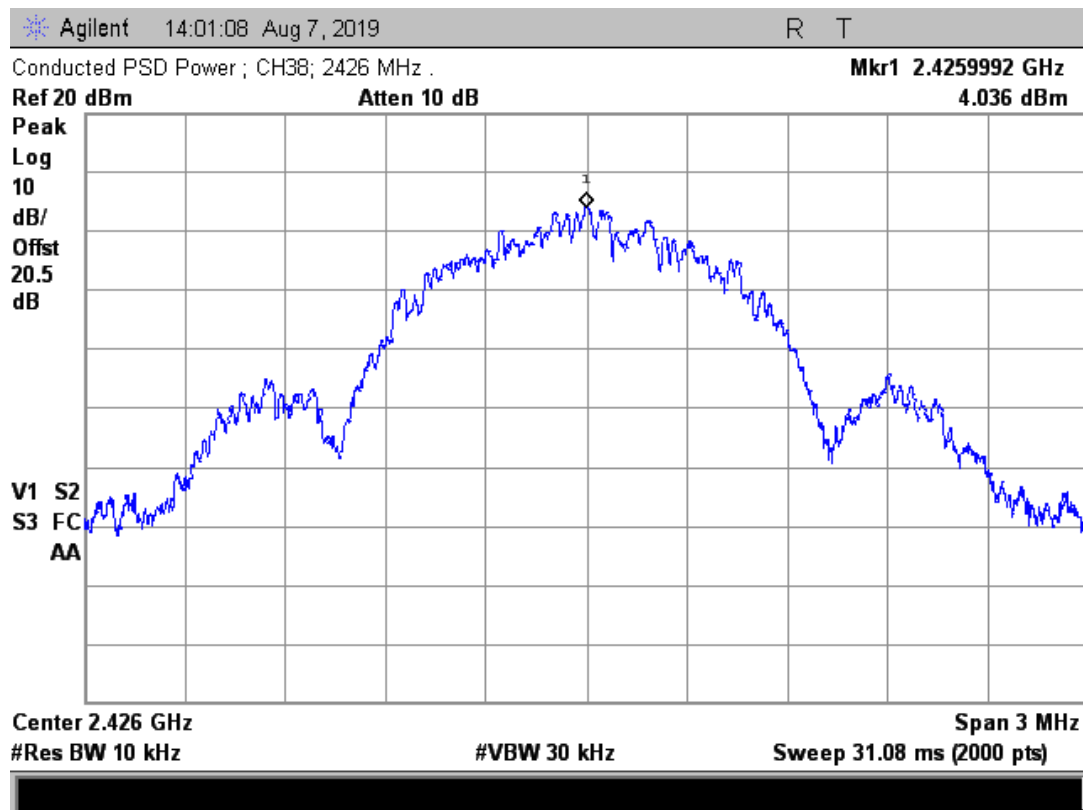
| Power Mode | Frequency (MHz) | Reading dBm | Cable Loss (dB) | 3 kHz Spectral Density (dBm) | Limit (dBm) |
|------------|-----------------|-------------|-----------------|------------------------------|-------------|
| High       | 2402            | 4.23        | 0.25            | 4.48                         | 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  $\Delta$  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)

Agilent 07:23:44 Aug 12, 2019

R T

Lower Band Edge ; TX at 2402 MHz. PWR +12.5 dBm

Mkr1  $\Delta$  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  $\Delta$  18.819 MHz

Ref 5 dBm

Atten 5 dB

57.03 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  $\Delta$  2.422 MHz

Ref 5 dBm

Atten 5 dB

49.14 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

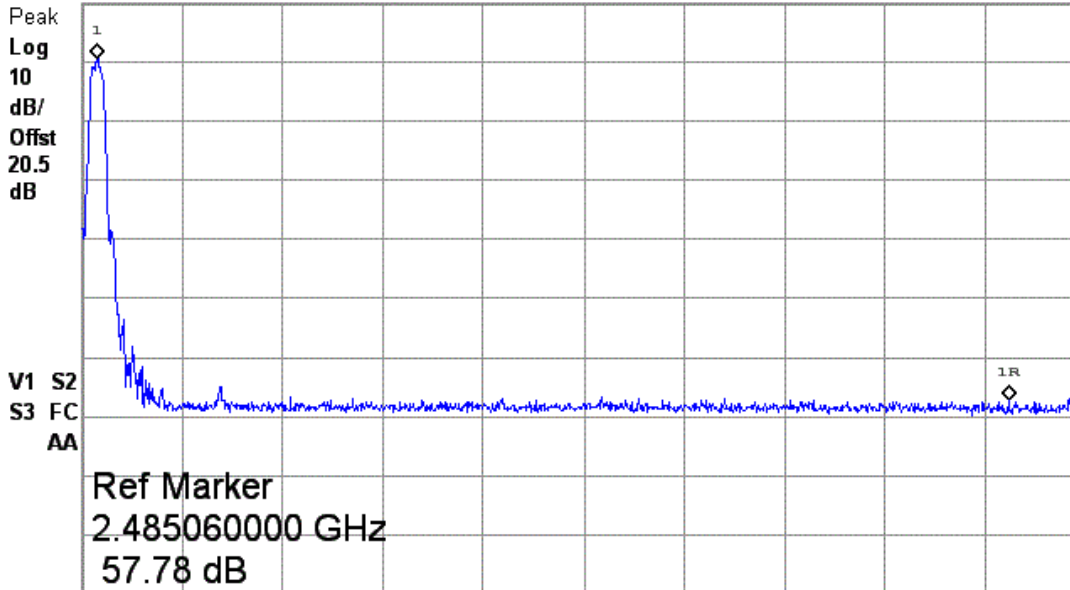
Upper Band Edge ; TX at 2426 MHz ; PWR +12.5 dBm

Mkr1  $\Delta$  -59.02 MHz

Ref 20 dBm

Atten 10 dB

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

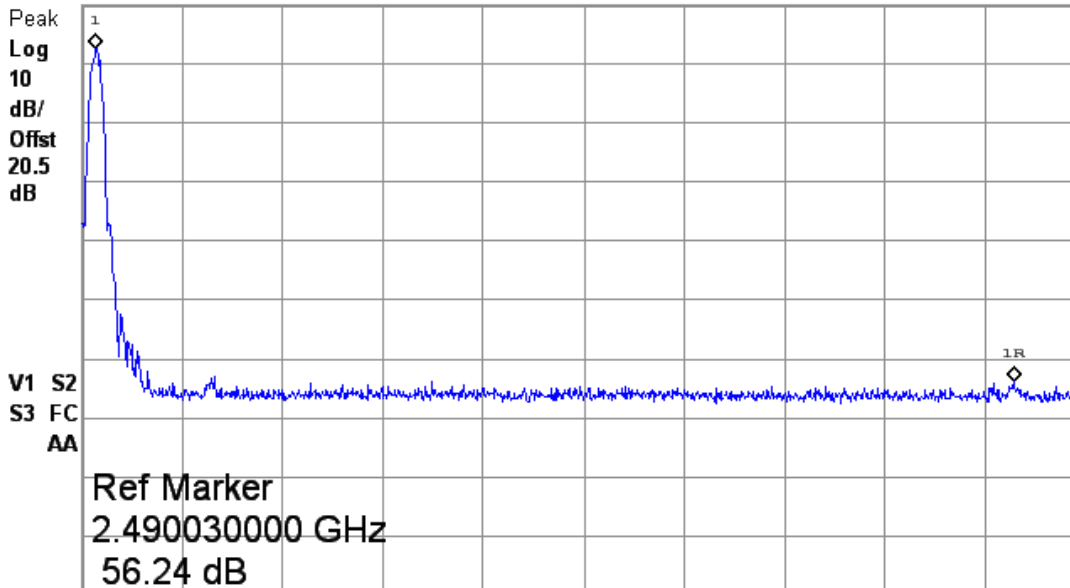
Upper Band Edge ; TX @ 2426 MHz ; PWR 0 dBm

Mkr1  $\Delta$  -63.98 MHz

Ref 5 dBm

Atten 5 dB

56.24 dB



Start 2.425 GHz

Stop 2.495 GHz

#Res BW 100 kHz

#VBW 300 kHz

Sweep 9.99 ms (1000 pts)



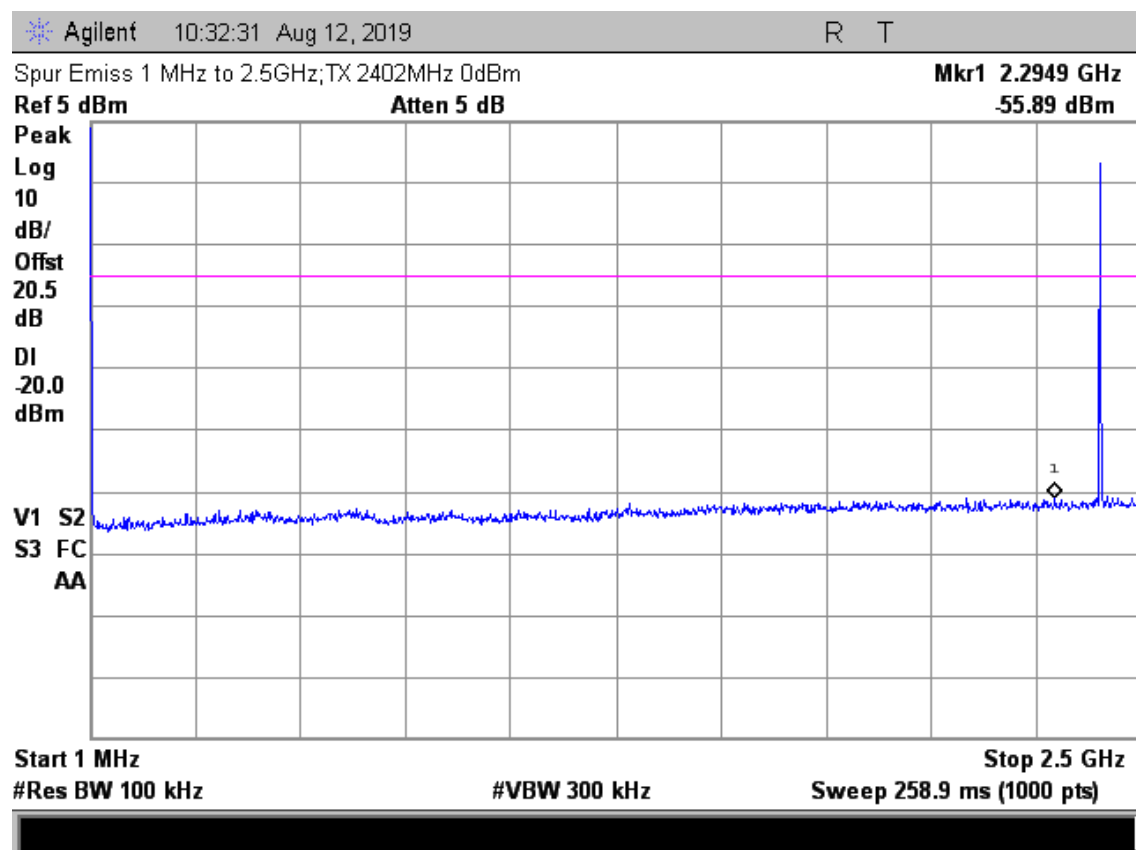
## 11.5 Spurious RF Conducted Emissions at Antenna Port

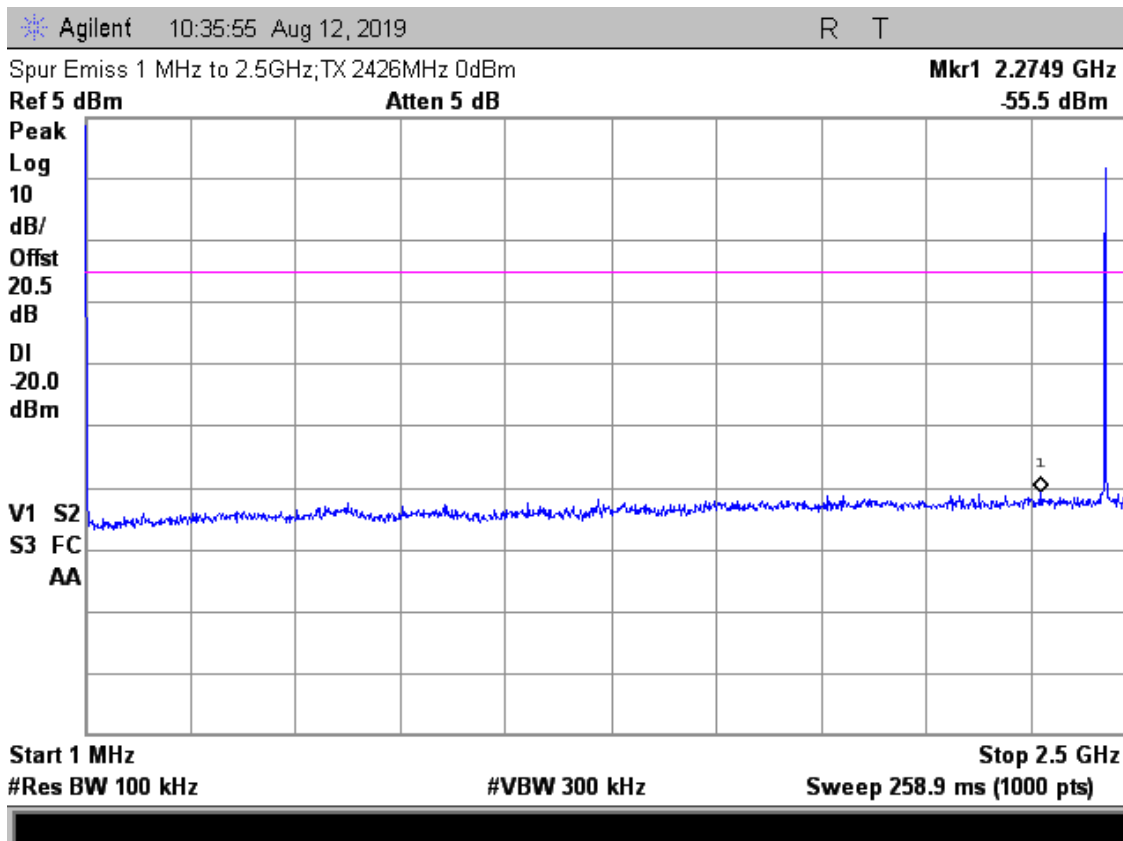
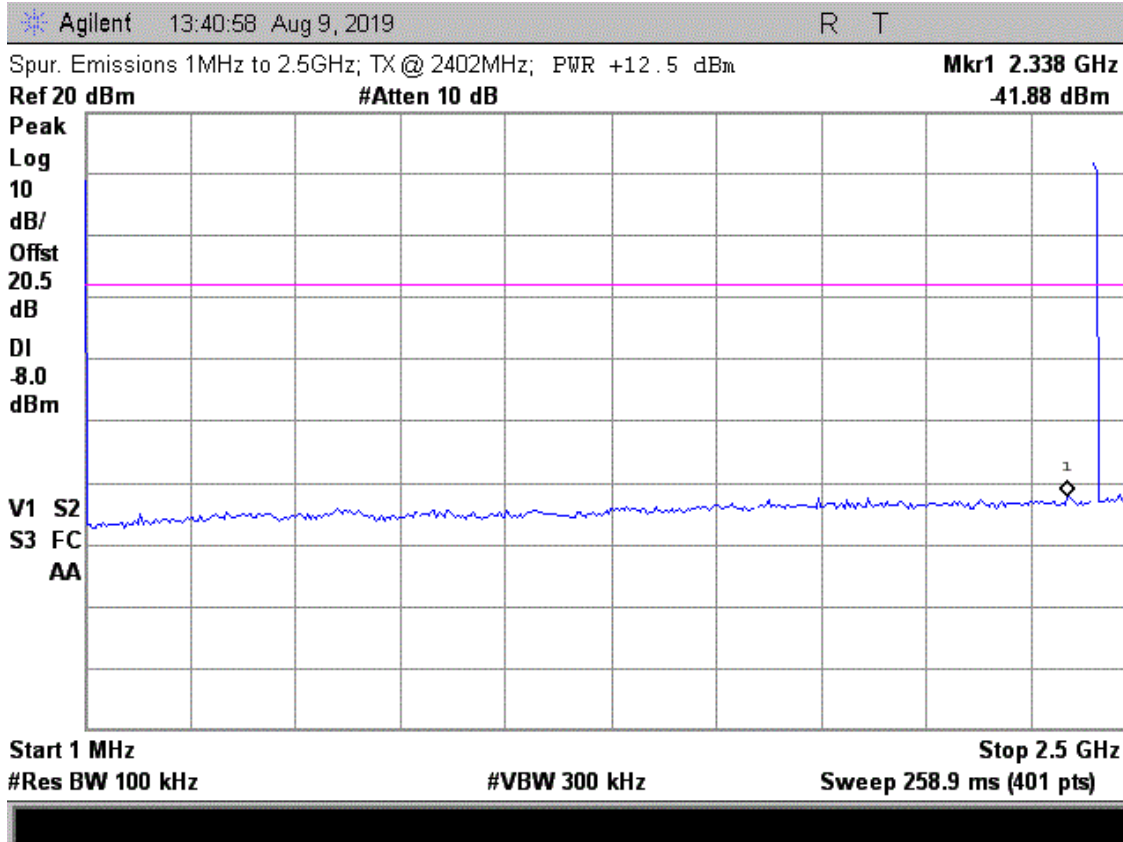
The spectrum analyzer was set to the MAX HOLD mode to record all spurious emissions from the lowest frequency generated in the EUT up through the 10<sup>th</sup> harmonic. The trace was allowed to stabilize. The first two plots were made while stepping through three frequencies (Low middle and high).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

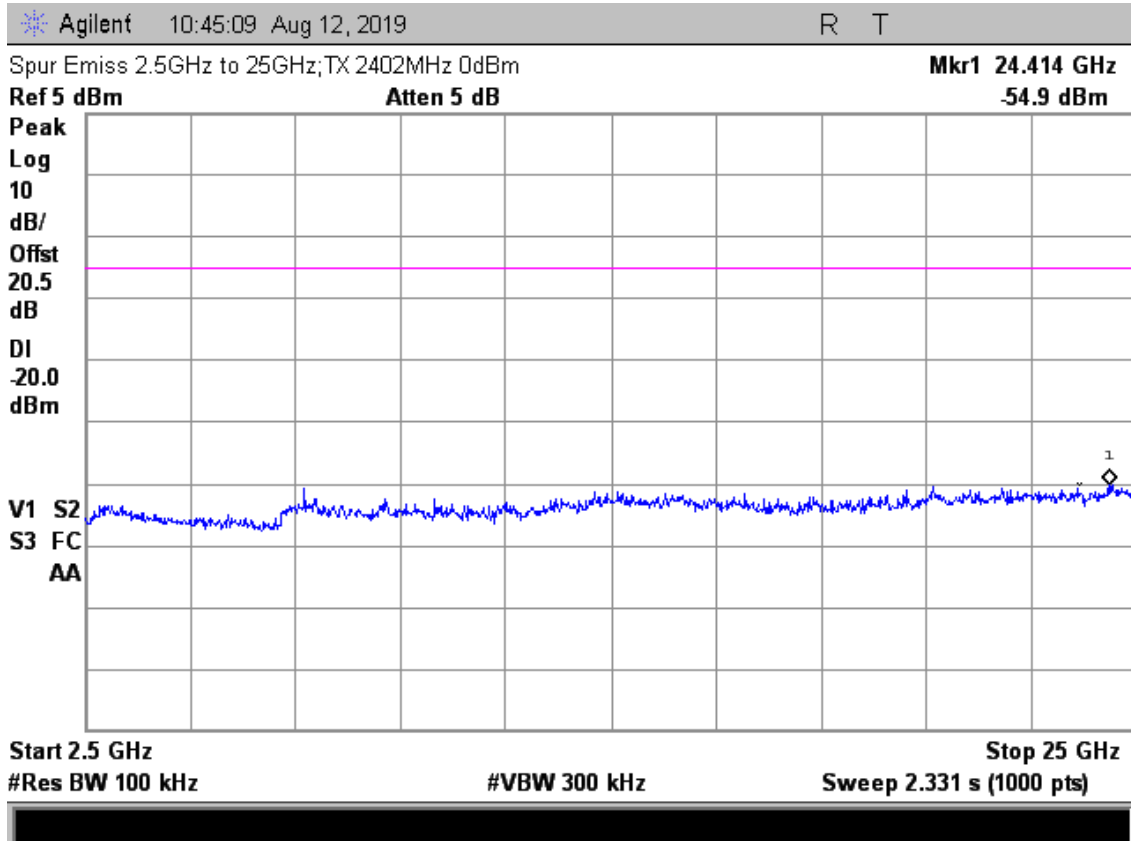
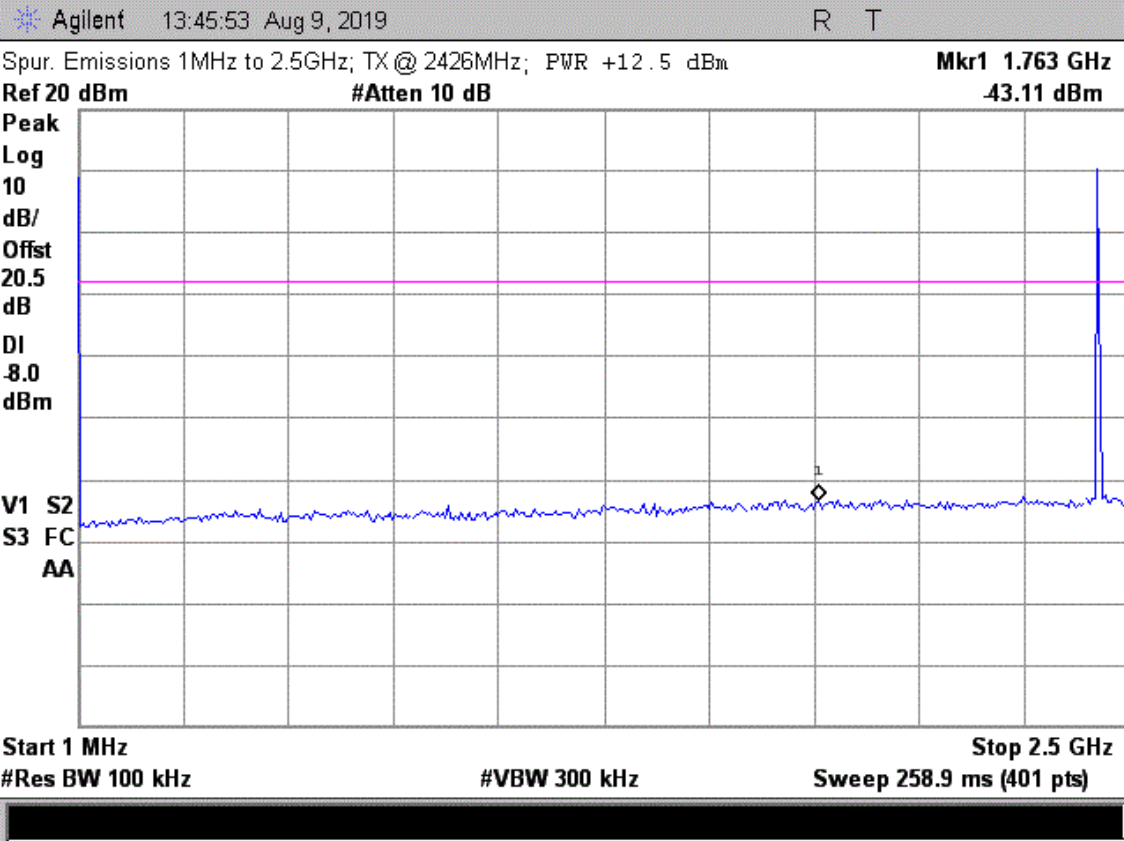
Tested by: Joseph Strzelecki/ Richard Tichgelaar

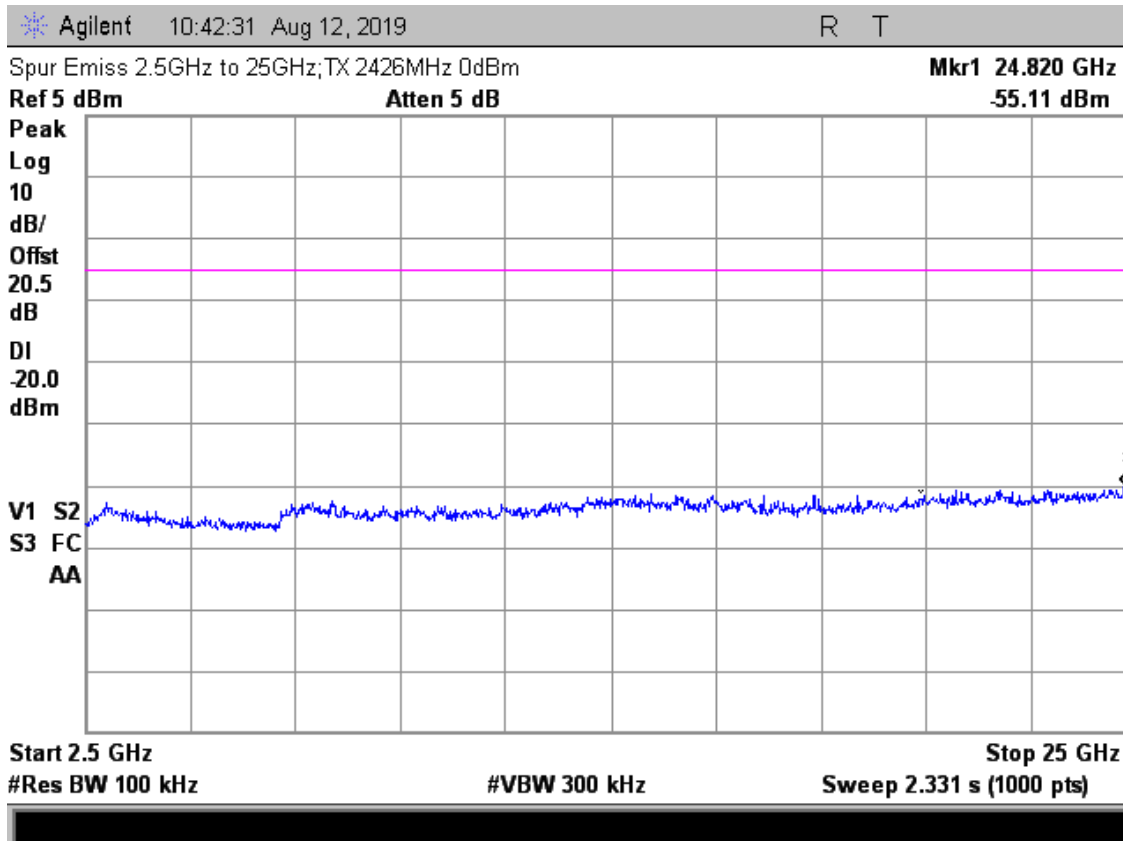
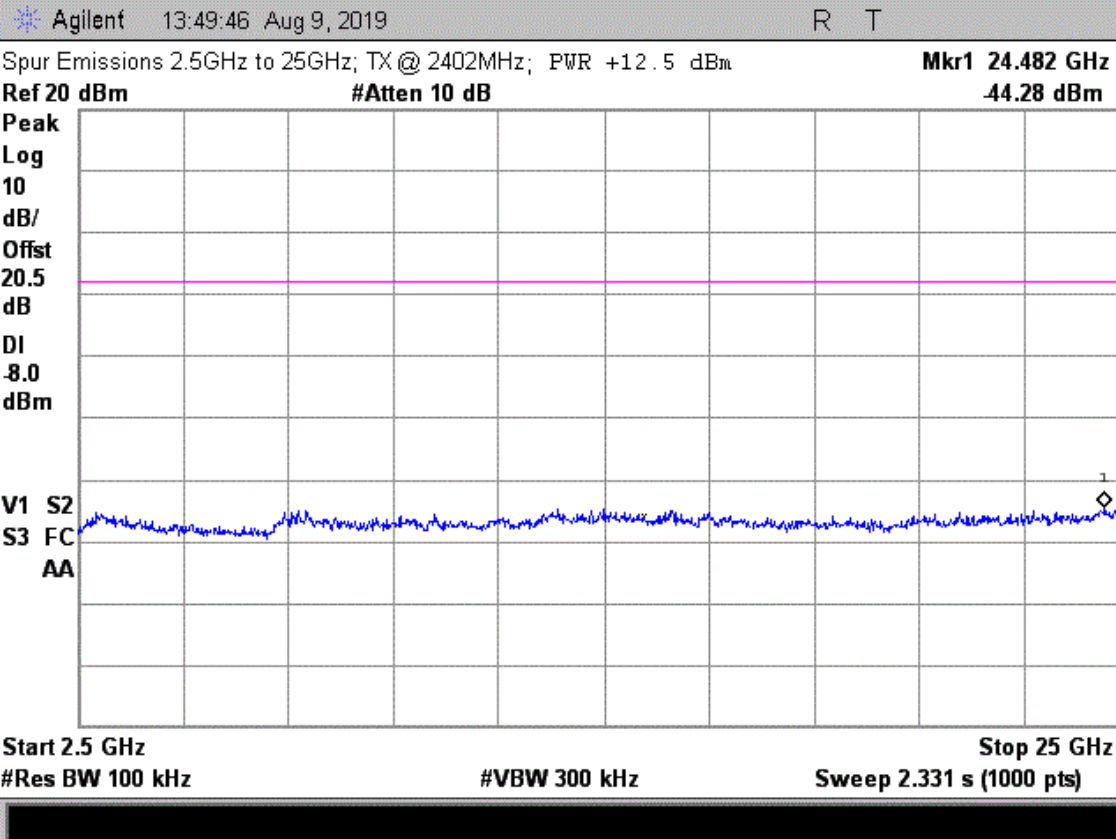
Test Date: 08/12/2019

Judgement: Pass by at least 10 dB

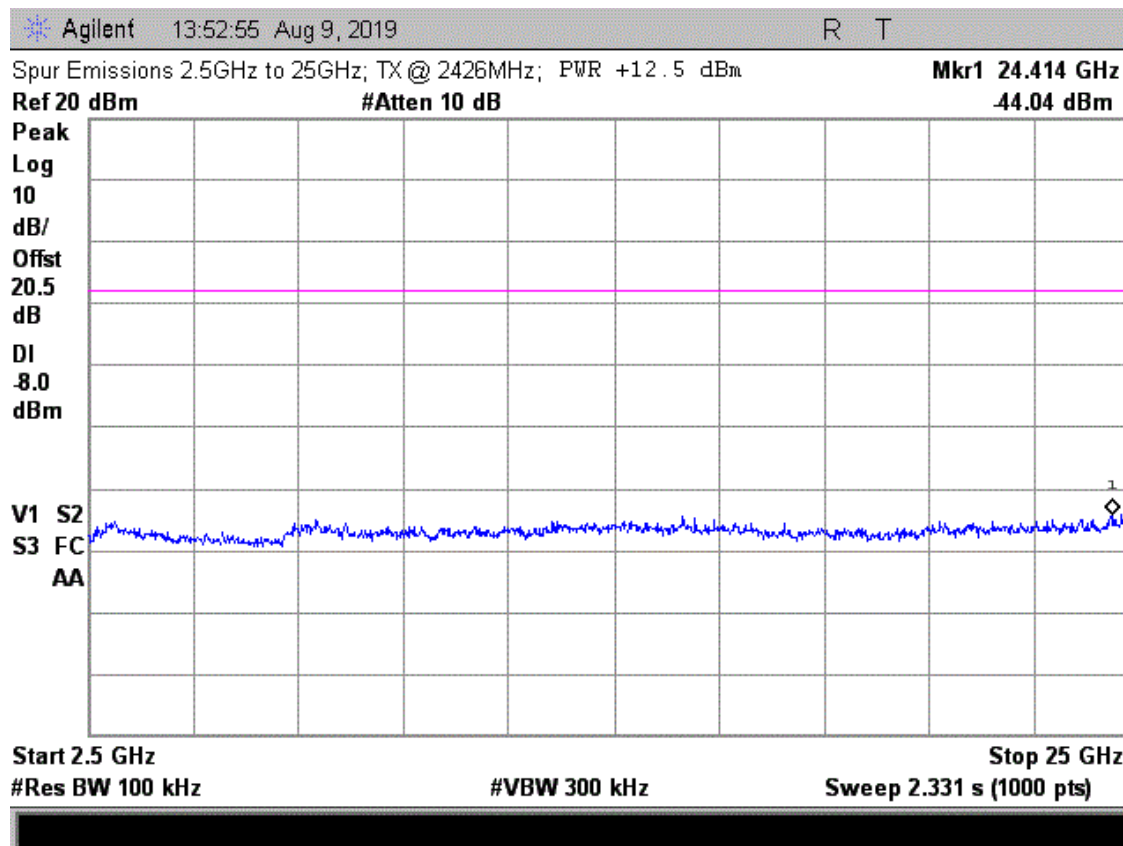












## 11.6 Spurious Radiated Emissions (Restricted Band)

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

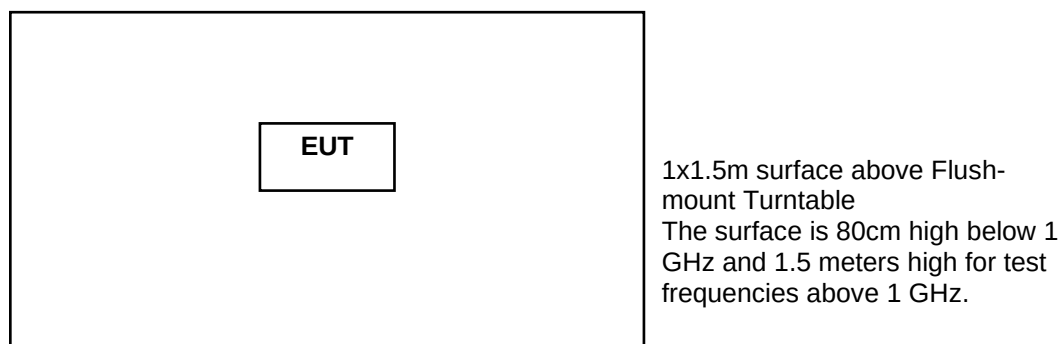
HPF = High pass Filter Loss

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  $20 * \text{Log}(\text{Duty cycle}/100)$ .

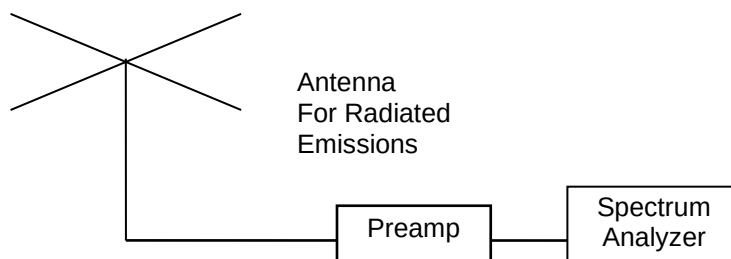


Figure 1. Drawing of Radiated Emissions Setup



**Notes:**

- AC outlet with low-pass filter at the base of the turntable
- Antenna height varied from 1 to 4 meters
- Distance from antenna to tested system is 3 meters
- Not to Scale



### 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  $f \geq 1$  GHz, 100 kHz for  $f < 1$  GHz

VBW  $\geq$  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                     |       |       |      | 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.

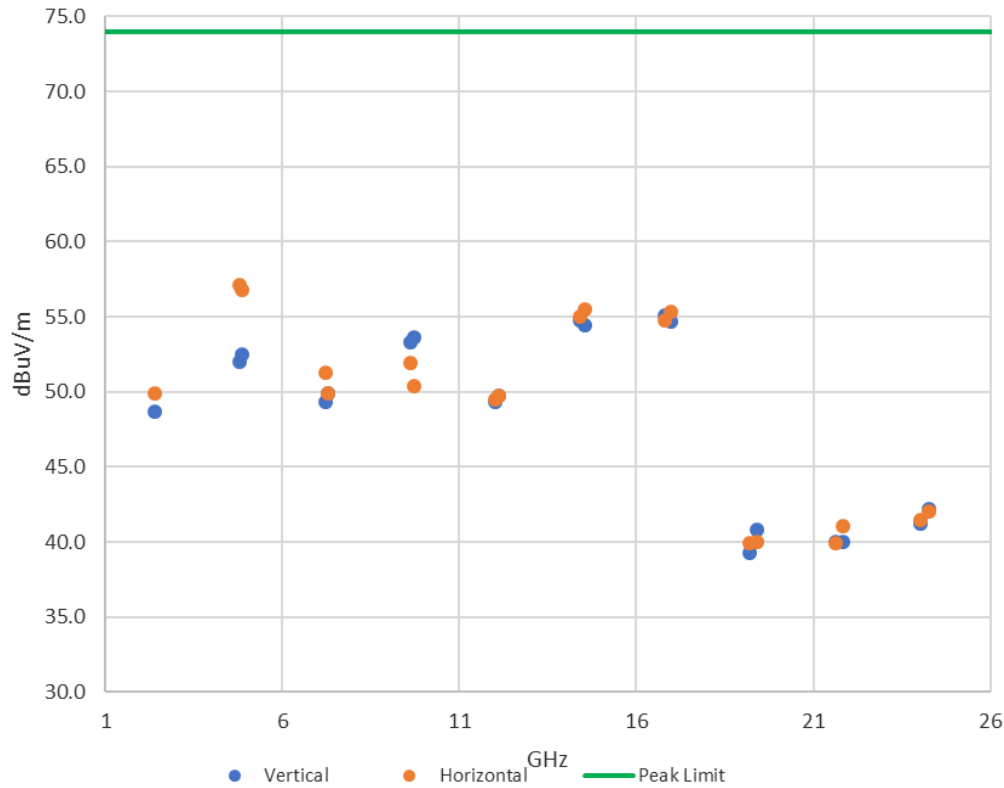
Column #17. The margin (last column) is the worst-case margin under the peak or average limits for that row.

Overall Judgment: Passed by at least 10 dB

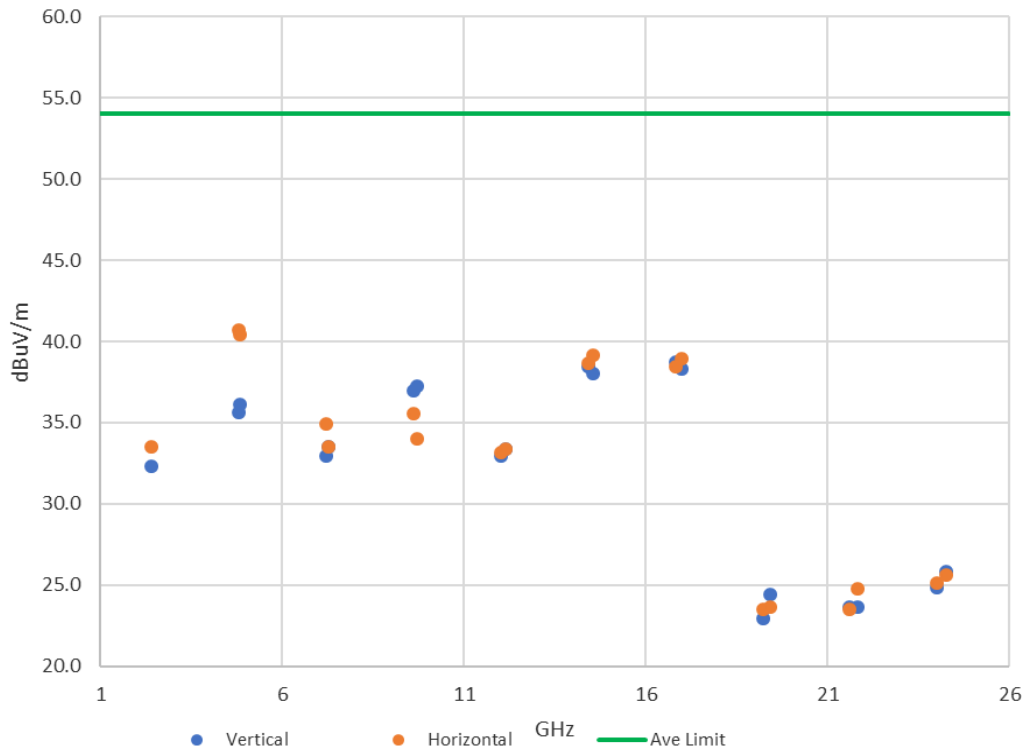
No other Emissions were detected from 30 to 25,000 MHz within 10 dB of the limits.

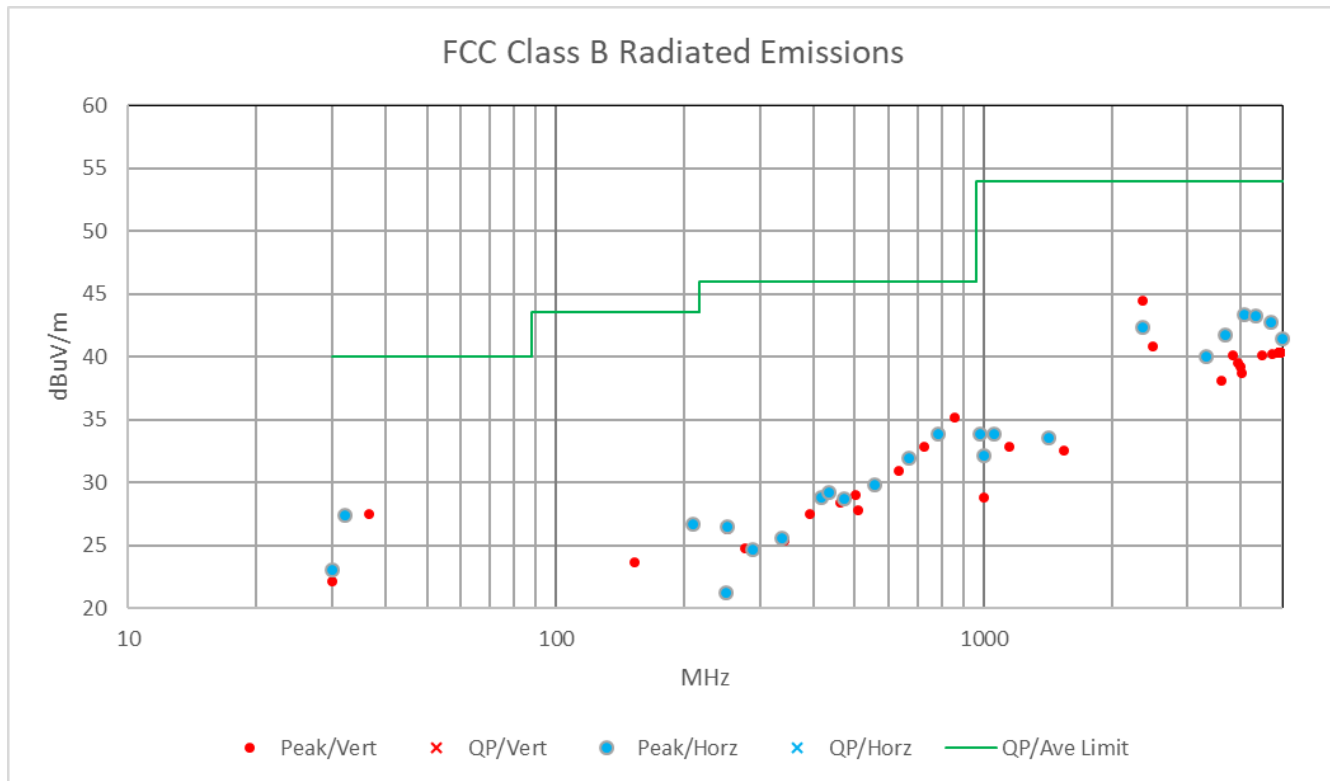


Peak Harmonic & Band Edge Data



Average Harmonic & Band Edge Data





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

### 11.7 Duty Cycle

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

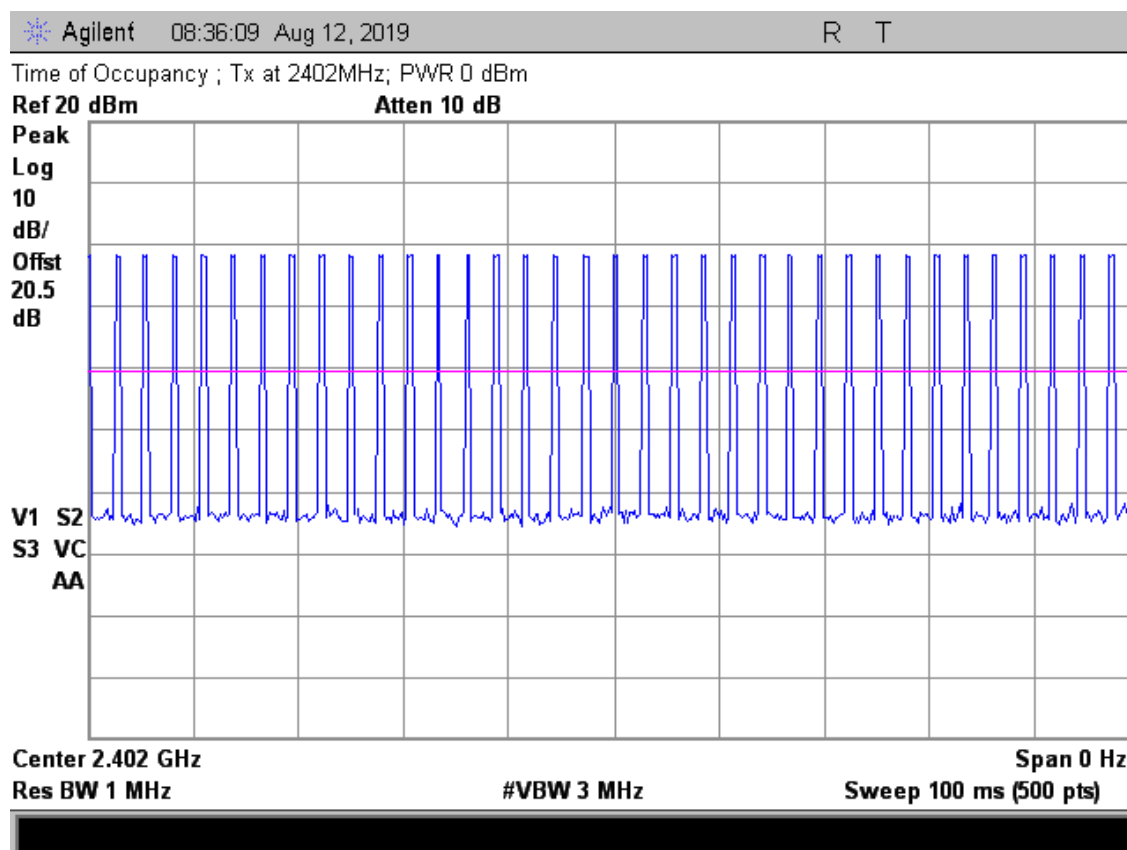
- a) The EUT was set to the “worst-case” pulse ON time.
- b) The RF output was Coupled to the input of a spectrum analyzer by a “near-field” coupling method. The signal received shall be of sufficient level to trigger adequately the spectrum analyzer sweep display.
- c) The center frequency of the spectrum analyzer was set to the center of the RF signal.
- d) The spectrum analyzer was set for ZERO SPAN.
- e) The sweep time 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  $20 * \text{Log}(\text{Duty cycle}/100)$ .

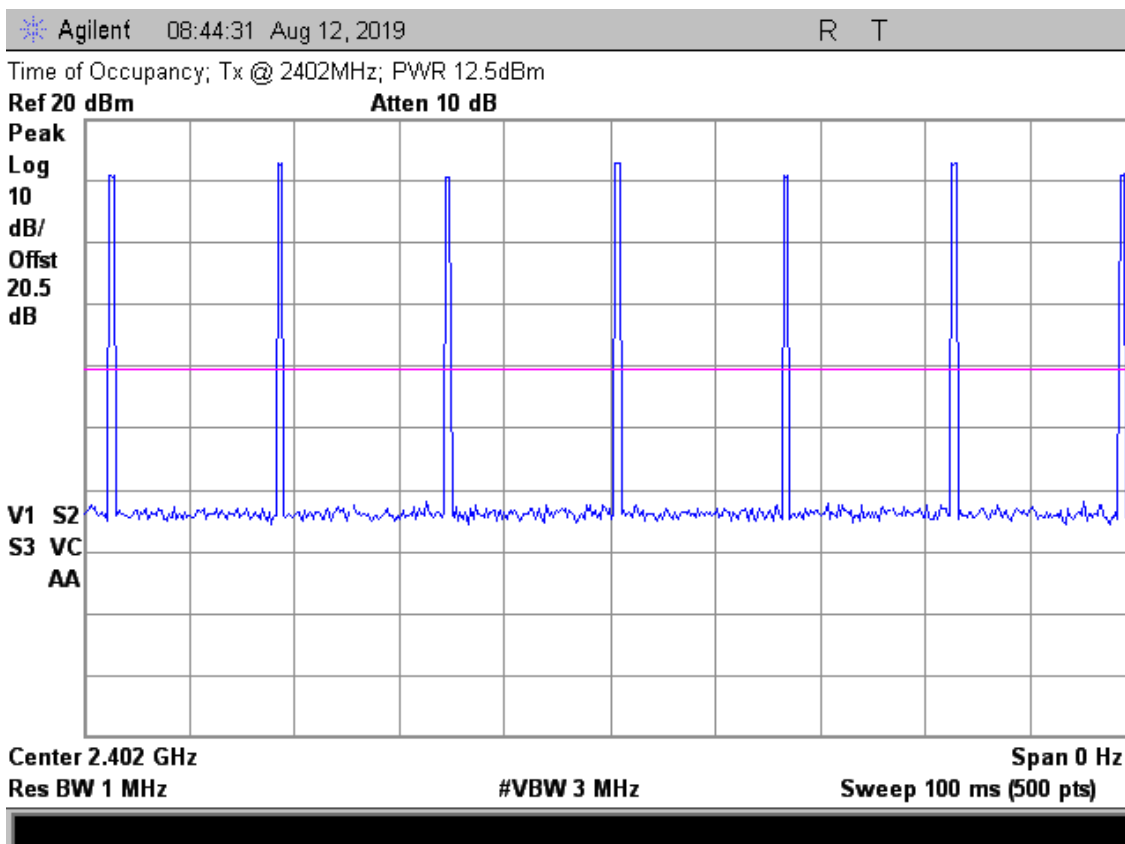
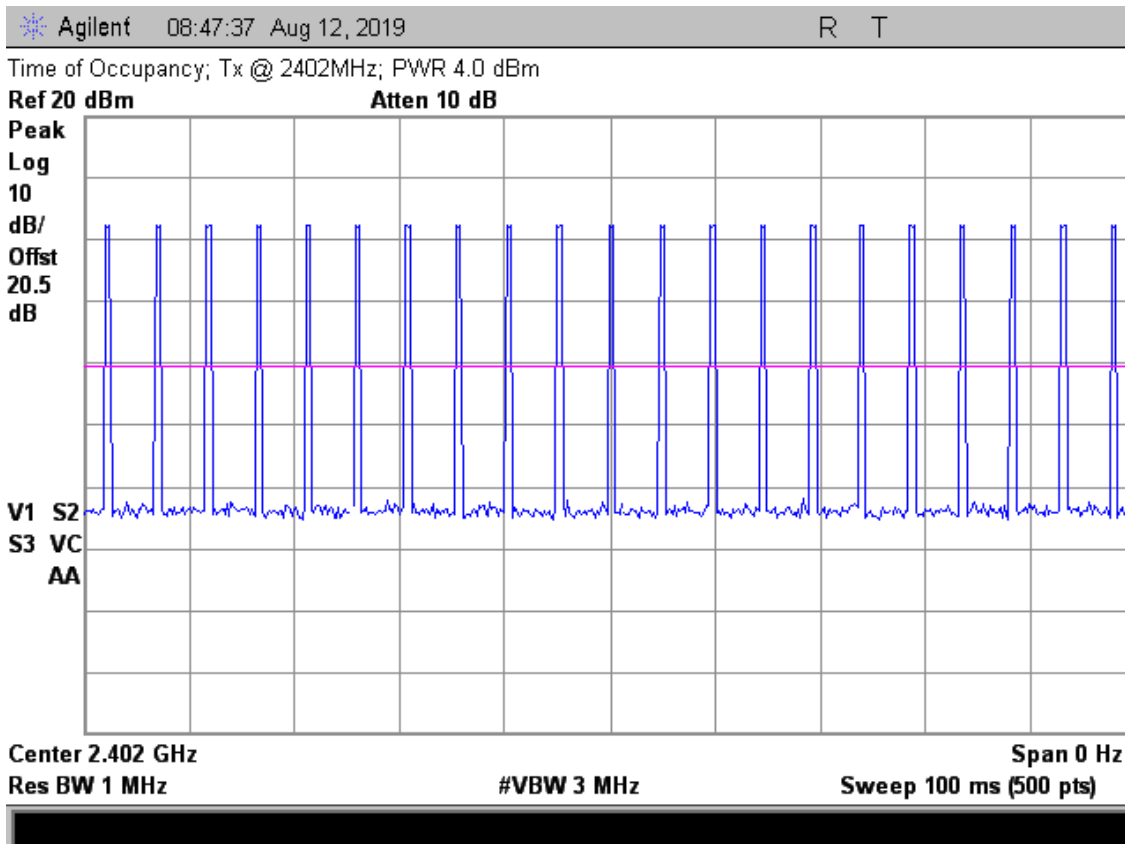
Tested by: Joseph Strzelecki/Richard Tichgelaar  
Test Date: 08/12/2019

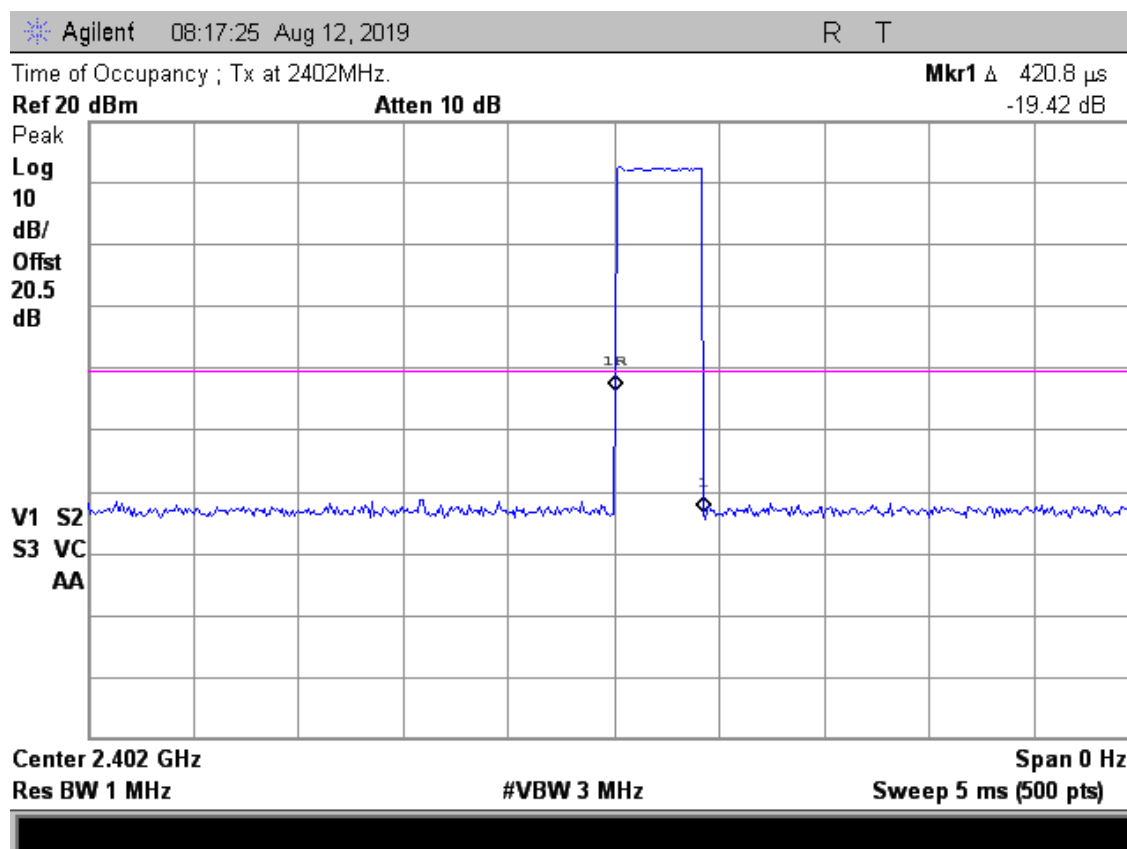


| EUT Power Mode | Pulse Width (mS) | Number of pulses in 100 mS | Max on Time per 100 mS | Duty Cycle % |
|----------------|------------------|----------------------------|------------------------|--------------|
| Low            | 0.421            | 36                         | 15.16              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

**Figure 2. Duty Cycle Plots**







### 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.