EMC & RF Test Report

As per

RSS-247 Issue 2:2017
&
FCC Part 15 Subpart 15.247

Unlicensed Intentional Radiators

on the

Swidget WIFI/BT module (PNS50E0179)

Issued by: **TÜV SÜD Canada Inc.**
1280 Teron Rd
Ottawa, ON K2K 2C1

Prepared by:

Scott Drysdale
Wireless Manager

Reviewed by:

Glen Westwell,
Project Engineer

Testing produced for

SWIDGET
POWER TO LIVE SMART

See Appendix A for full client & EUT details.

ACCREDITED
Testing Laboratory
Certificate #2955.19

Table of Contents

Report Scope 3

Summary 4

Test Results Summary 5
Notes, Justifications, or Deviations 7
Sample Calculation(s) 8

Applicable Standards, Specifications and Methods 9

Document Revision Status 10

Definitions and Acronyms 11

Testing Facility 12

Calibrations and Accreditations 12
Testing Environmental Conditions and Dates 13

Detailed Test Results Section 14

6dB Bandwidth of Digitally Modulated Systems 15
Channel Carrier Bandwidth (Frequency hopping) 21
Carrier Frequency Separation 26
Number of Hopping Frequencies 30
Time of Occupancy 37
Maximum Peak Envelope Conducted Power 43
Antenna Spurious Conducted Emissions (-20 dBc Requirement) 49
Radiated Emissions in Restricted Band 66
Power Spectral Density (Digitally modulated) 83

Appendix A – EUT Summary 94

Appendix B – EUT and Test Setup Photos 97

Report Scope

This report addresses the EMC verification testing and test results of the **Swidget Corp. SWIDGET WIFI/BT MODULE (PNS50E0179)**, and is herein referred to as EUT (Equipment Under Test). The EUT was tested for compliance against the following standards:

RSS-247 Issue 2:2017

FCC Part 15 Subpart C 15.247:2019

Test procedures, results, justifications, and engineering considerations, if any, follow later in this report.

The results contained in this report relate only to the item(s) tested.

This report does not imply product endorsement by any government, accreditation agency, or TÜV SÜD Canada Inc.

Opinions or interpretations expressed in this report, if any, are outside the scope of TÜV SÜD Canada Inc. accreditations. Any opinions expressed do not necessarily reflect the opinions of TÜV SÜD Canada Inc., unless otherwise stated.

Summary

The results contained in this report relate only to the item(s) tested.

EUT:	SWIDGET WIFI/BT MODULE (PNS50E0179)
FCC Certification #, FCC ID:	2AR26-SWIDGETWI100
Industry Canada Certification #, IC:	24603-SWDTWI10100
EUT passed all tests performed	Yes
Tests conducted by	Scott Drysdale

For testing dates, see "Testing Environmental Conditions and Dates".

Test Results Summary

Digitally Modulated Modes (Wi-Fi & BTLE)

Standard/Method	Description	Class/Limit	Result
FCC 15.203	Antenna Requirement	Unique	Pass See Justification
FCC 15.205 RSS-GEN (Table 6)	Restricted Bands for Intentional Operation	QuasiPeak Average	Pass
FCC 15.207 RSS-GEN (Table 3)	Power Line Conducted Emissions	QuasiPeak Average	Pass
FCC 15.209 RSS-GEN (Table 4)	Spurious Radiated Emissions	QuasiPeak Average	Pass
FCC 15.247(a)2 RSS-247 5.2(a)	6 dB Bandwidth	> 500 kHz	Pass
FCC 15.247(b)2 RSS-247 5.4(d)	Max Output Power	< 1 Watt	Pass
FCC 15.247(b)4 RSS-247 5.4(d)	Antenna Gain	< 6 dBi	Pass See Justifications
FCC 15.247(d) RSS-247 5.5	Antenna Conducted Spurious	< 20 dBc	Pass
FCC 15.247(e) RSS-247 5.2(b)	Spectral Density	< 8 dBm (3 kHz BW)	Pass
Overall Result			**Pass**

Frequency Hopping Spread Spectrum (BT)

Standard/Method	Description	Class/Limit	Result
FCC 15.203	Antenna Requirement	Unique	Pass See Justification
FCC 15.205 RSS-GEN (Table 6)	Restricted Bands for Intentional Operation	QuasiPeak Average	Pass
FCC 15.207 RSS-GEN (Table 3)	Power Line Conducted Emissions	QuasiPeak Average	Pass
FCC 15.209 RSS-GEN (Table 4)	Spurious Radiated Emissions	QuasiPeak Average	Pass
FCC 15.247(a)1 RSS-247 5.2(a)	Hopping separation	> 2/3rds of 20 dB BW	Pass
FCC 15.247(a)1 RSS-247 5.4	Max Output Power	< 0.125 Watt	Pass
FCC 15.247(a)1(iii) RSS-247 5.4	Number of channels and Channel time	>15 channels < 0,4 seconds in specific interval	Pass
FCC 15.247(b)4 RSS-247 5.4(d)	Antenna Gain	< 6 dBi	Pass See Justifications
FCC 15.247(d) RSS-247 5.5	Antenna Conducted Spurious	< 20 dBc	Pass
FCC 15.247(e) RSS-247 5.2(b)	Spectral Density	< 8 dBm (3 kHz BW)	Pass
Overall Result			**Pass**

If the product as tested or otherwise complies with the specification, the EUT is deemed to comply with the requirement and is deemed a ‘PASS’ grade. If not ‘FAIL’ grade will be issued. Note that ‘PASS’ / ‘FAIL’ grade is independent of any measurement uncertainties. A ‘PASS’ / ‘FAIL’ grade within measurement uncertainty is marked with a ‘*’.

Notes, Justifications, or Deviations

The following notes, justifications for tests not performed or deviations from the above listed specifications apply:

For the Antenna requirement specified in FCC 15.203 (RSS-247 section 5.5), the unit uses the following antennas:
Johanson Technology Chip Antenna P/N 2450AT43A100E, with a maximum rated gain of -1.7 dBi.
Note: Antenna gains were declared by the manufacturer based on the latest data sheet.

For the Restricted Bands of operation, the EUT is designed to only operate between 2400 – 2483.5 MHz band.

The EUT is not a hybrid system and FCC 15.247 (f) does not apply to it.

In Wi-Fi and BTLE modes, the EUT is a Digitally Modulated transmitter. All modes were evaluated, and the following modes are presented as worst case or representative:
802.11B @ 1Mbps, 1/6/11
802.11G @ 6 Mbps, 1/6/11
802.11N (20 MHz) @ MSC0, 1/6/11
802.11N (40 MHz) @ MCS0, 3/6/9
BTLE, 1 Mbps

In Bluetooth classic mode, the EUT is a FHSS transmitter. All modes were evaluated, and the following modes are presented as worst case or representative.
BT, 1Mbps (Basic Rate - GFSK) / 3 Mbps (EDR - 8DPSK)
Each packet types was considered (e.g. DH1/3/5, 2-DH1/3/5, 3-DH1/3/5), and worst case or representative results are presented.

The EUT was mounted in three orthogonal axis for spurious radiated emissions. Worst case or representative results are presented.

SAR/MPE assessment is applicable to the EUT. See the separate RF Exposure exhibits for details.

Sample Calculation(s)

Radiated Emission Test

Margin = Limit – (Received Signal + Antenna Factor + Cable Loss – Pre-Amp Gain)
Margin = 50.5dBµV/m – (50dBµV + 10dB + 2.5dB – 20dB)
Margin = 8.0 dB (pass)

Applicable Standards, Specifications and Methods

ANSI C63.4:2014	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	American National Standard For Testing Unlicensed Wireless Devices
CFR 47 FCC 15 Subpart C:2017	Code of Federal Regulations – Radio Frequency Devices, Intentional Radiators
FCC KDB 558074: 2017	FCC KDB 558074 Digital Transmission Systems, measurements and procedures
FCC KDB 447498: 2015	RF exposure procedures and equipment authorization policies for mobile and portable devices
ICES-003 Issue 6 2017	Digital Apparatus - Spectrum Management and Telecommunications Policy Interference-Causing Equipment Standard
RSS-GEN Issue 5 2018	General Requirements and Information for the Certification of Radio Apparatus
RSS-247 Issue 2:2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
ISO/IEC 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories

Document Revision Status

Revision	Date	Description
000	Oct 9, 2020	Initial Draft Release
001	Nov 9, 2020	Revisions as per TCB request (on file)
002	Nov 13, 2020	Revisions as per TCB request (page 16 copy paste error corrected)

Definitions and Acronyms

The following definitions and acronyms are applicable in this report.
See also ANSI C63.14.

AE – Auxiliary Equipment. A digital accessory that feeds data into or receives data from another device (host) that in turn, controls its operation.

BT – Bluetooth

BTLE – Bluetooth Light extension

BW – Bandwidth. Unless otherwise stated, this is refers to the 6 dB bandwidth.

EMC – Electro-Magnetic Compatibility. The ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

EMI – Electro-Magnetic Immunity. The ability to maintain a specified performance when the equipment is subjected to disturbance (unwanted) signals of specified levels.

EUT – Equipment Under Test. A device or system being evaluated for compliance that is representative of a product to be marketed.

ITE – Information Technology Equipment with a primary function(s) of entry, storage, display, retrieval, transmission, processing, switching, or control, of data.

LISN – Line Impedance Stabilization Network

NCR – No Calibration Required

RF – Radio Frequency

Testing Facility

Testing for EMC on the EUT was carried out at TÜV SÜD Canada testing lab near Ottawa, Ontario. The testing lab has calibrated 10m semi-anechoic chamber which allow measurements on a EUT that has a maximum width or length of up to 4m and a height of up to 4m. Control of the mast occurs in the control room adjoining the shielded chamber. This facility is capable of testing products that are rated for single phase or 3-phase AC input and DC capability is also available. Radiated emission measurements are performed using a Loop antenna, BiLog antenna and a Horn antenna where applicable. Conducted emissions, unless otherwise stated, are performed using a LISN.

Calibrations and Accreditations

This chamber was calibrated for Normalized Site Attenuation (NSA) using test procedures outlined in ANSI C63.4 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". The chamber is lined with ferrite tiles and absorption cones to minimize any undesired reflections. The NSA data is kept on file at TÜV SÜD Canada. TÜV SÜD Canada Inc. is accredited to ISO/IEC 17025 by A2LA with Testing Certificate #2955.19. The laboratory's current scope of accreditation listing can be found as listed on the A2LA website. All measuring equipment is calibrated on an annual or biennial basis as listed for each respective test.

Testing Environmental Conditions and Dates

Following environmental conditions were recorded in the facility during time of testing

Date	Test	Initials	Temperature (ºC)	Humidity (%)	Pressure (kPa)
Sept 29-Oct 2, 2020	Radiated Emissions	SD	22.2 – 23.5	27.9 – 39.7	101.5- 102.1
Oct 5=8, 2020	Antenna Conducted Emissions	SD	21 = 23	40-65	100.1-102.1

Detailed Test Results Section

6dB Bandwidth of Digitally Modulated Systems

Purpose

The purpose of this test is to ensure that the bandwidth occupied exceeds a stated minimum. This helps ensure the utilization of the frequency allocation is sufficiently wide. This also helps prevent corruption of data by ensuring adequate data separation to distinguish the reception of the intended information.

Limits and Methods

The Limit is as specified in FCC Part 15.247 and RSS 247.

Systems using digital modulation techniques may operate in 2400 - 2483.5 MHz. The minimum 6 dB bandwidth shall be at least 500 kHz. This should be measured with a 100 kHz RBW and equal to or greater than 300 kHz VBW.

The method is given in ANSI C63.10 Clause 11.8 DTS bandwidth.

Results

The EUT passed. The minimum measured 6 dB BW was of all modulations were greater than 500 kHz.

Additional 99% bandwidth were measured for information purpose. There is no requirement on 99% bandwidth, other then it must fall within the 2.4 GHz to 2.4835 GHz band.

Three Channels were measured. The following table show the 6 dB and 99% bandwidth: The external attenuator and cable loss were accounted for as reference offset in the spectrum analyzer. Graphs are presented for worst case OBW (highest bandwidth) and worst case 6 dB Bandwith (narrowest

Bandwidth 802.11B					
Channel	Frequency (MHz)	6 dB BW (MHz)	99% BW (MHz)	6 dB BW Limit (MHz)	Pass/Fail
Low	2412	8.091	13.05	0.5	Pass
Mid	2437	7.59	13.05	0.5	Pass
High	2462	7.67	13.05	0.5	Pass

Bandwidth 802.11G					
Channel	Frequency (MHz)	6 dB BW (MHz)	99% BW (MHz)	6 dB BW Limit (MHz)	Pass/Fail
Low	2412	16.77	16.8	0.5	Pass
Mid	2437	16.68	16.9	0.5	Pass
High	2462	16.68	16.92	0.5	Pass

Bandwidth 802.11N (20 MHz)					
Channel	Frequency (MHz)	6 dB BW (MHz)	99% BW (MHz)	6 dB BW Limit (MHz)	Pass/Fail
Low	2412	17.85	17.64	0.5	Pass
Mid	2437	17.85	17.52	0.5	Pass
High	2462	17.85	17.76	0.5	Pass

Bandwidth 802.11N (40 MHz)					
Channel	Frequency (MHz)	6 dB BW (MHz)	99% BW (MHz)	6 dB BW Limit (MHz)	Pass/Fail
Low	2422	36.45	36.61	0.5	Pass
Mid	2437	36.45	36.5	0.5	Pass
High	2452	36.45	36.61[1]	0.5	Pass

Note 1: See graph for worst case (widest) measurement of Occupied bandwidth.

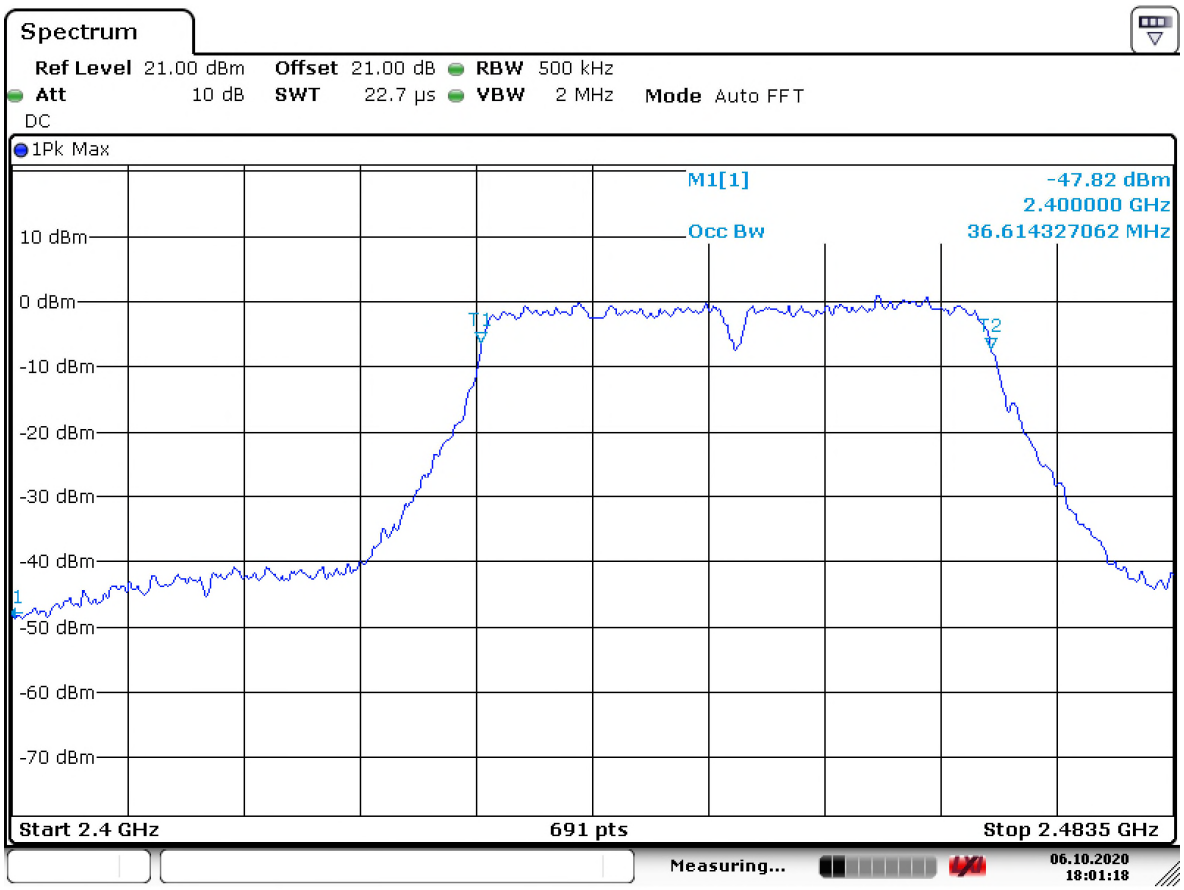
Bandwidth BTLE					
Channel	Frequency (MHz)	6 dB BW (MHz)	99% BW (MHz)	6 dB BW Limit (MHz)	Pass/Fail
Low	2402	0.669	1.02	0.5	Pass
Mid	2440	0.649	1.02	0.5	Pass
High	2480	0.649[1]	1.02	0.5	Pass

Note 1: See graph for worst case (narrowest) 6 dB bandwidth

Graph(s)

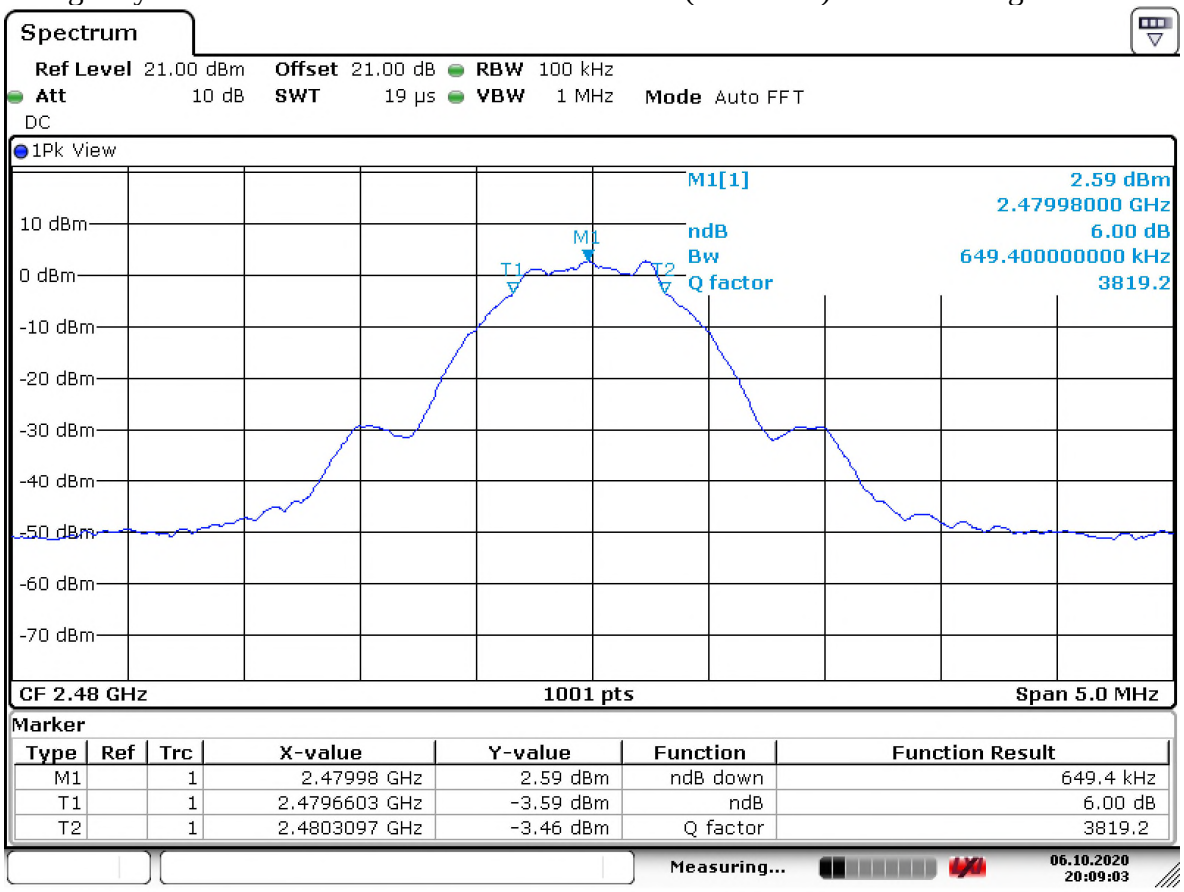
The graphs shown below show the OBW during the operation of the device. This is measured by a max hold on the spectrum analyzer and the RBW set to 1% to 5% of the OBW and a video bandwidth equal to approximately 3 times the resolution bandwidth. The 6 dB bandwidth is obtained with a 100 kHz RBW and a VBW of 300 kHz. Note a greater video bandwidth may be set as a worst case or representative measurement. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

Occupied bandwidth – Digitally modulated worst case (widest) – 802.11N at 40 mpbs.
High Channel



Date: 6.OCT.2020 18:01:18

Digitally modulated 6 dB Bandwidth – worst case (narrowest) – BTLE at high channel



Date: 6.OCT.2020 20:09:03

Measurement uncertainty

The measurement uncertainty for this test is less than ½ of the measurement resolution BW used during the measurement. The reading, or determination of pass or fail is independent of any measurement uncertainties.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
Spectrum Analyzer	FSV40	Rhode & Schwarz	4/1/19	4/1/21	SSG013948
Attenuator 1,3,6,10,20, 30 dB	9414-1	Api / Weinshel	NCR	NCR	GEMC 279

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

Channel Carrier Bandwidth (Frequency hopping)

Purpose

The purpose of this test is to allow for results that is used to help establish other limits. Although there is not specific limit for this requirement, the derived limits dependent on this information helps allow for other spread spectrum devices to co-exist in the same frequency spectrum. This also helps prevent corruption of data by ensuring adequate channel separation to distinguish the reception of the intended information

Limits and Methods

The Limit is as specified in FCC Part 15.247 and RSS 247.

For 2400 to 2483.5 MHz transmitter; there is no specified limit. However, an approximate calculated maximum limit can be obtained by dividing the maximum bandwidth of the frequency allocation by the minimum number of channels. Note that this is a maximum bandwidth, and this measurement is used to calculate other limits.

2400 to 2483.5 MHz 83.5 MHz / 15 channels = maximum bandwidth of 5.57 MHz

The method is given in ANSI C63.10 Section 6.9.2 Occupied bandwidth.

Results

The EUT passed. The minimum 20 dB bandwidth was measured to be 897 kHz and the maximum 20 dB bandwidth was measured to be 1.31 MHz.

Additional 99% bandwidth was additionally measured for information purpose. There is no requirement on 99% bandwidth, other than it must fall within the 2.4 GHz to 2.4835 GHz band.

Three Channels were measured. The external attenuator and cable loss were accounted for as reference offset in the spectrum analyzer. Graphs are presented for worst case (highest bandwidth) 20 dB bandwidth.

Bandwidth BT – BDR 1 Mbps		
Channel	Frequency (MHz)	20 dB BW (MHz)
Low	2402	0.897
Mid	2440	0.899

High	2480	0.899

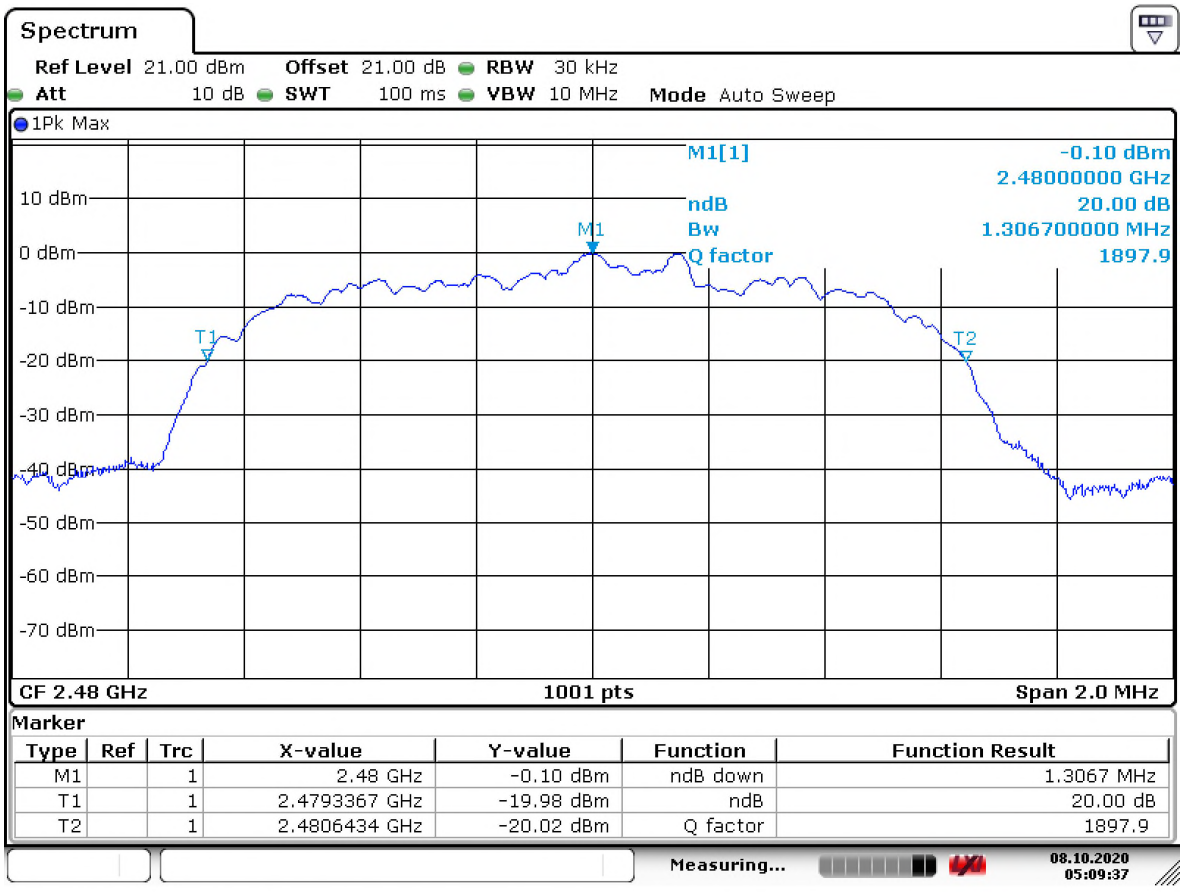
Bandwidth BT – EDR 3 Mbps		
Channel	Frequency (MHz)	20 dB BW (MHz)
Low	2402[1]	1.3087
Mid	2440	1.3067
High	2480	1.3067

Note 1: See graph for worst case (widest) measurement of Occupied bandwidth.

Graph(s)

The graphs shown below show the 20 dB bandwidth during the operation of the device. This is measured by a max hold on the spectrum analyzer and the RBW set to 1% to 5% of the 20 dB Bandwidth and a video bandwidth equal to approximately 3 times the resolution bandwidth. Note a greater video bandwidth may be set as a worst case or representative measurement. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

20 dB bandwidth –worst case (widest) – BT 3 mpbs
low Channel



Date: 8.OCT.2020 05:09:37

Measurement uncertainty

The measurement uncertainty for this test is less than ½ of the measurement resolution bandwidth used during the measurement. The reading, or determination of pass or fail is independent of any measurement uncertainties.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
Spectrum Analyzer	FSV40	Rhode & Schwarz	4/1/19	4/1/21	SSG013948
Attenuator 1,3,6,10,20, 30 dB	9414-1	Api / Weinshel	NCR	NCR	GEMC 279

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

Carrier Frequency Separation

Purpose

The purpose of this test is to ensure that the RF energy of frequency hopping systems is sufficiently spread over a spectrum and that the radio energy is not overly dense. This limit helps allow for other spread spectrum devices to co-exist in the same frequency spectrum. This also helps prevent corruption of data by ensuring adequate channel separation to distinguish the reception of the intended information.

Limits and method

The limits are as defined in 47 CFR FCC Part 15 Section 15.247(a)(1). The test method is a defined in ANSI C63.10.

	2400 to 2483.5 MHz
No conditions	25 kHz or 20 dB BW[1]
< 125 mW	25 kHz or 2/3 of 20 dB BW[1]

Note 1: The minimum channel separation is given by the greater of 25 kHz or 20 dB BW for unconditional operation. As the device was less than 125 mW, the 2/3 of the 20 dB BW limit applies. The largest 20 dB BW of the system was measured to be 1.31 MHz, so a minimum channel separation limit of 874 kHz applies.

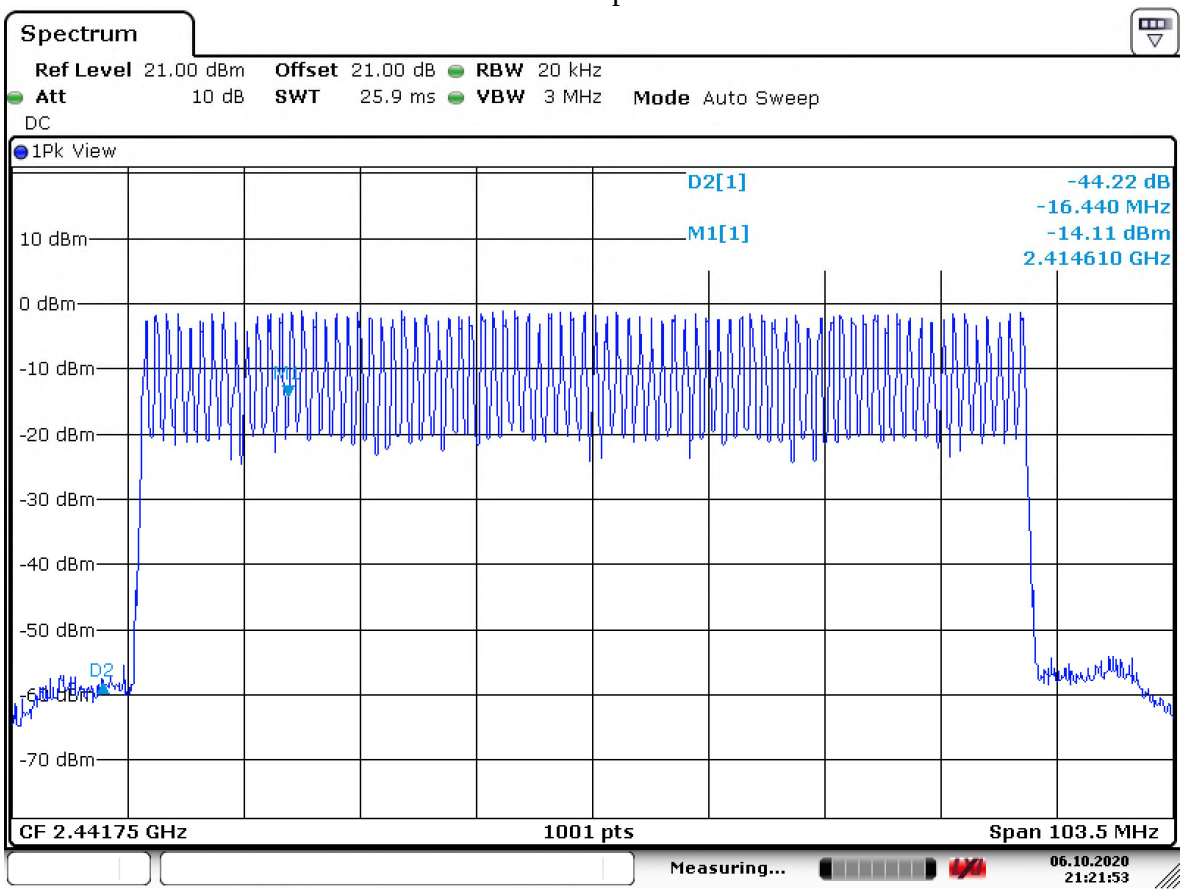
Results

The EUT passed the requirements of channel carrier spacing exceeding 2/3 of the measured 20dB BW of the EUT. The 20 dB BW previously measured was 1.31 MHz and the device had a minimum channel spacing of 1 MHz.

Graph(s)

The graphs shown below shows the channel spacing during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the channel spacing of the signal being measured. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute, as the device is stepping through its hopping table.

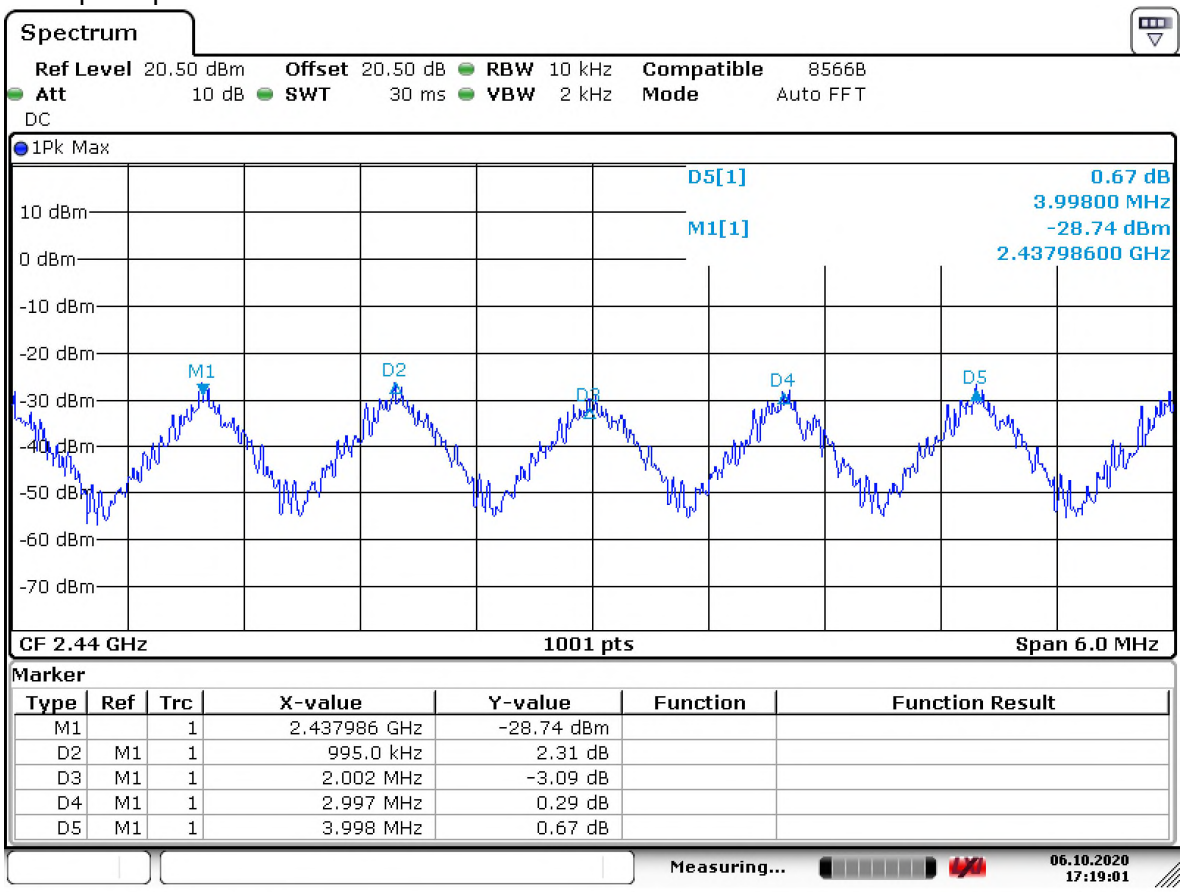
Channel Separation



Date: 6.OCT.2020 21:21:53

Note: 79 channels equally spaced over 79 MHz of spectrum (center to center of lowest to highest channel), for a channel separation of 1 MHz.

Example separation



Date: 6.OCT.2020 17:19:01

Measurement uncertainty

The measurement uncertainty for this test is equal to or less than ½ of the measurement resolution bandwidth used during the measurement. The reading, or determination of pass or fail is independent of any measurement uncertainties.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
Spectrum Analyzer	FSV40	Rhode & Schwarz	4/1/19	4/1/21	SSG013948
Attenuator 1,3,6,10,20, 30 dB	9414-1	Api / Weinshel	NCR	NCR	GEMC 279

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

Number of Hopping Frequencies

Purpose

The purpose of this test is to ensure that the RF energy of frequency hopping systems is sufficiently spread over a spectrum and that the radio energy is not overly dense. This limit helps allow for other spread spectrum devices to co-exist in the same frequency spectrum. This also helps prevent corruption of data by ensuring adequate channel separation to distinguish the reception of the intended information.

Limits and method

The limits are as defined in 47 CFR FCC Part 15 Section 15.247(a)(1). The test method is a defined in ANSI C63.10.

	2400 to 2483.5 MHz
No conditions	≥ 15 channels
20 dB BW exceeds 250 kHz	≥15 channels

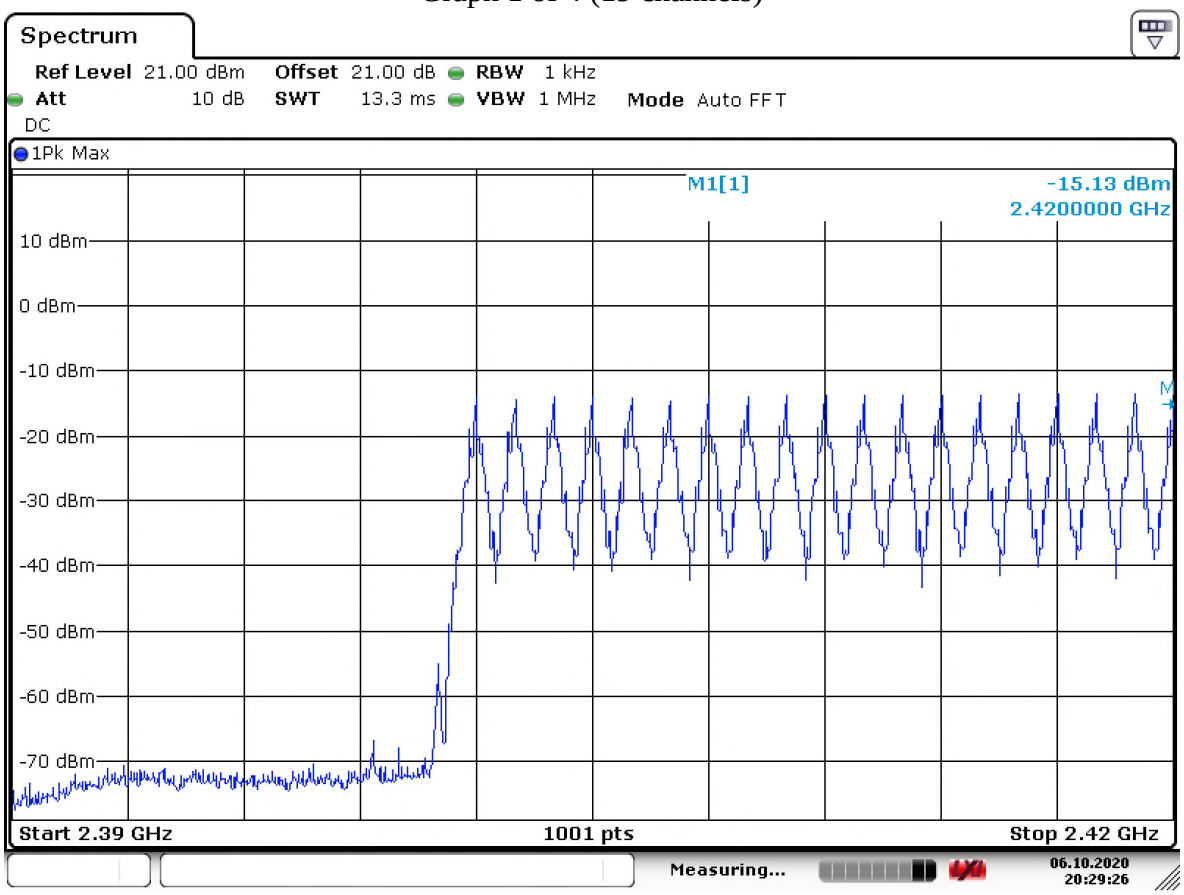
Results

The EUT passed the requirements of the number of channels. The number of channels the device occupies is 79 channels.

Graph(s)

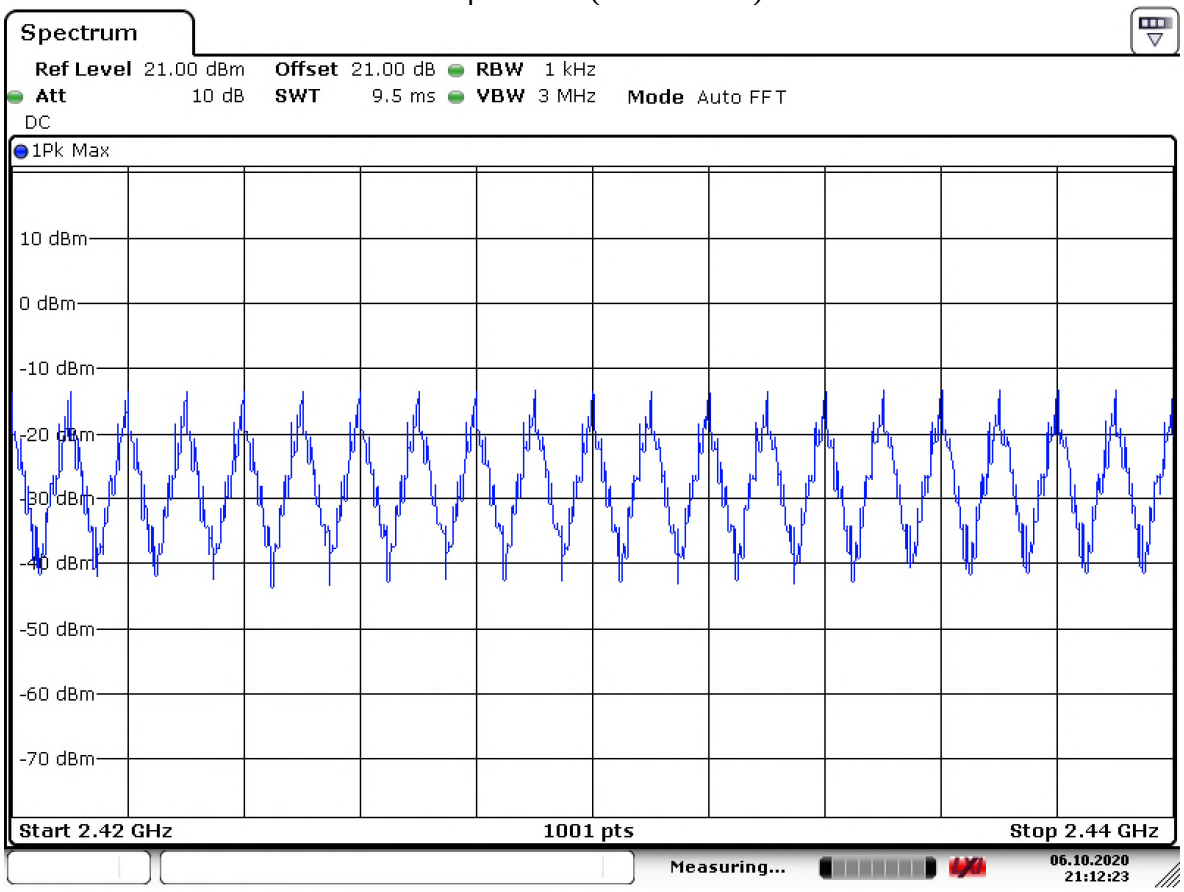
The graphs shown below shows the number of occupied channels during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the channel spacing of the signal being measured. This measurement is a peak measurement. Max hold is performed for a duration of not less than 10 minutes, or as sufficient to capture the channels occupied.

Graph 1 of 4 (19 channels)



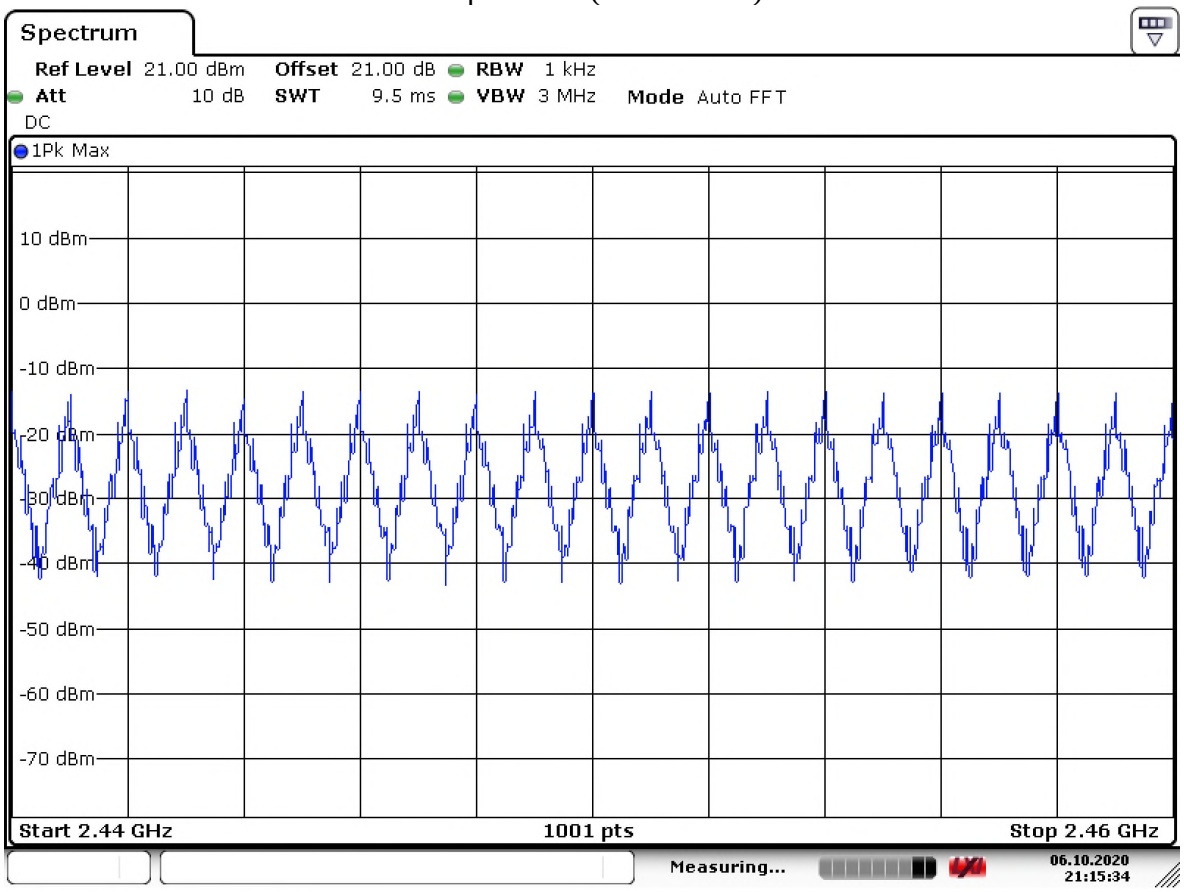
Date: 6.OCT.2020 20:29:26

Graph 2 of 4 (20 channels)



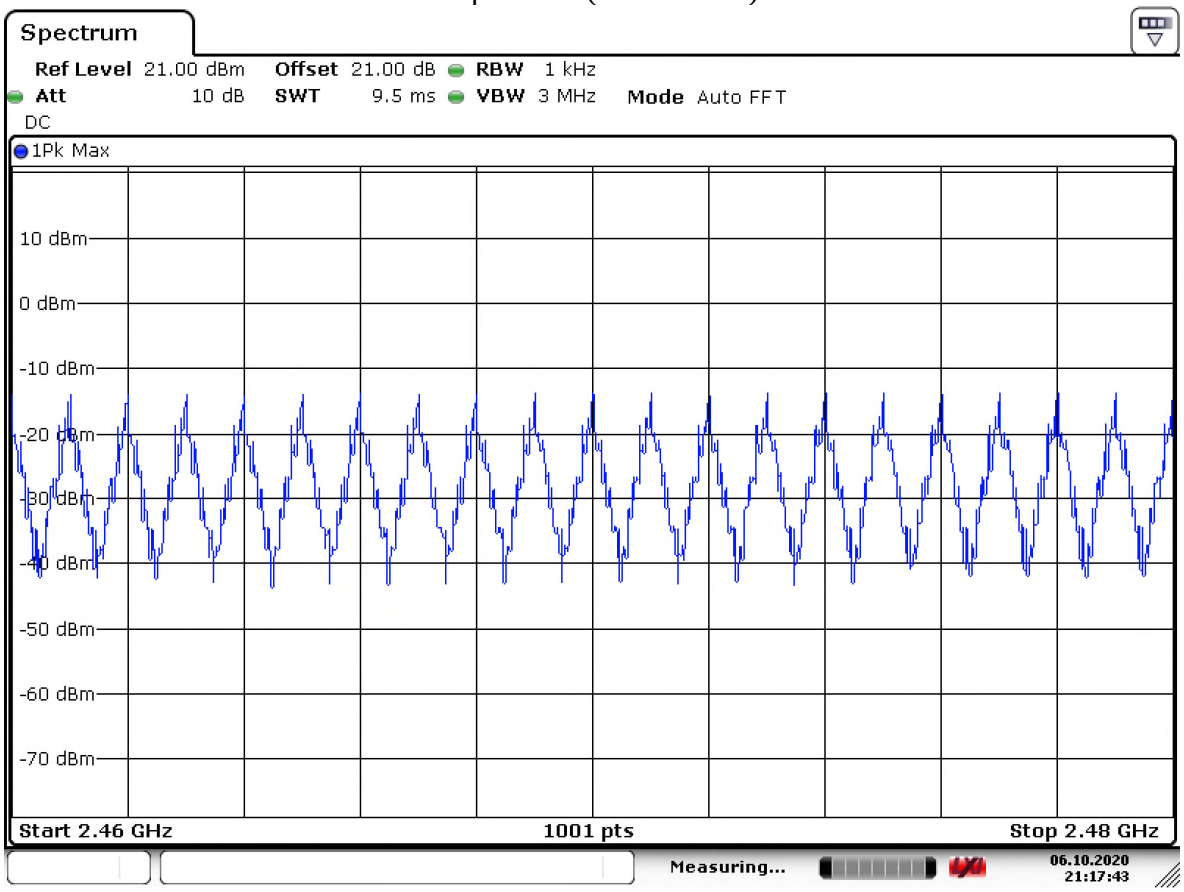
Date: 6.OCT.2020 21:12:23

Graph 3 of 4 (20 channels)



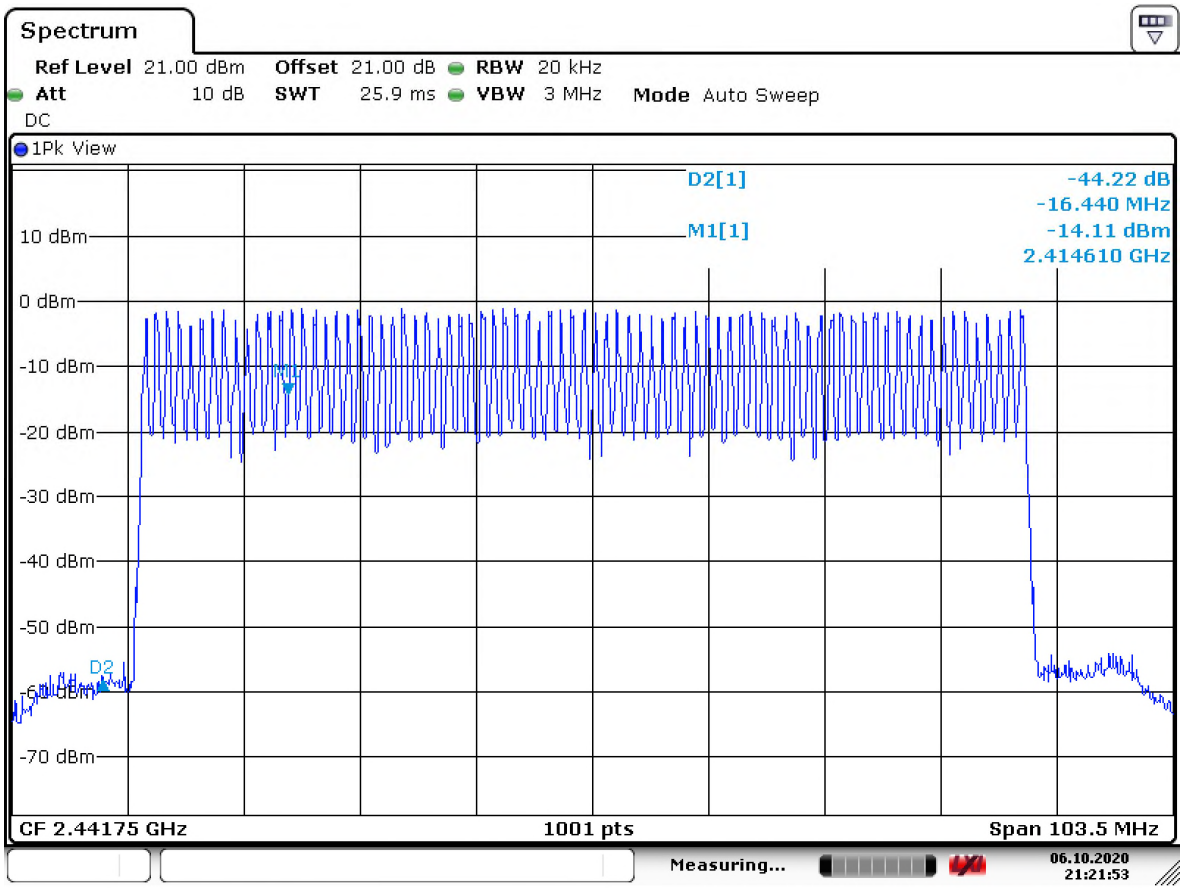
Date: 6.OCT.2020 21:15:34

Graph 4 of 4(20 channels)



Date: 6.OCT.2020 21:17:43

Total Channels



Date: 6.OCT.2020 21:21:53

Note: See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

Measurement uncertainty

The measurement uncertainty for this test is not applicable.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
Spectrum Analyzer	FSV40	Rhode & Schwarz	4/1/19	4/1/21	SSG013948
Attenuator 1,3,6,10,20, 30 dB	9414-1	Api / Weinshel	NCR	NCR	GEMC 279

Time of Occupancy

Purpose

The purpose of this test is to ensure that the RF energy of frequency hopping systems is hopping at a minimum defined rate. This helps ensure sufficient time off to enable other frequency hopping devices to co-operate within this allocated band.

Limits

For 902 to 928 MHz systems, the limits are as defined in 47 CFR FCC Part 15 Section 15.247(a)(1)(iii).

For frequency hopping systems operating in 2.4 GHz band: The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

0.4 seconds * 79 channels = 31.6 Secconds

The average occupancy of any channel shall not exceed 0.4 seconds in 31.6 seconds.

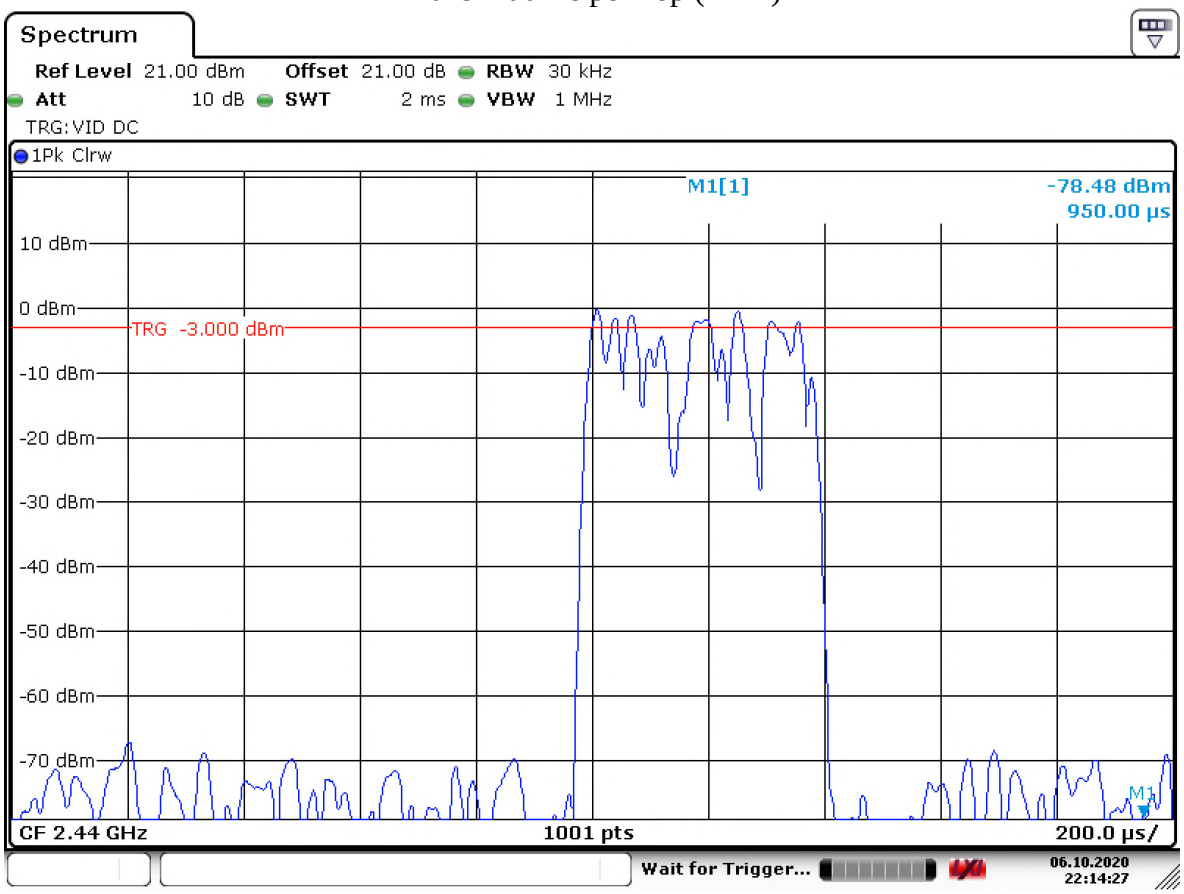
Results

The EUT passed the requirements. The maximum average time of occupancy is worst case under BT EDR 3Mpbs, 0.3 seconds.

The EUT cycles through its pseudo-random generated list of hopping frequencies.

Graph(s)

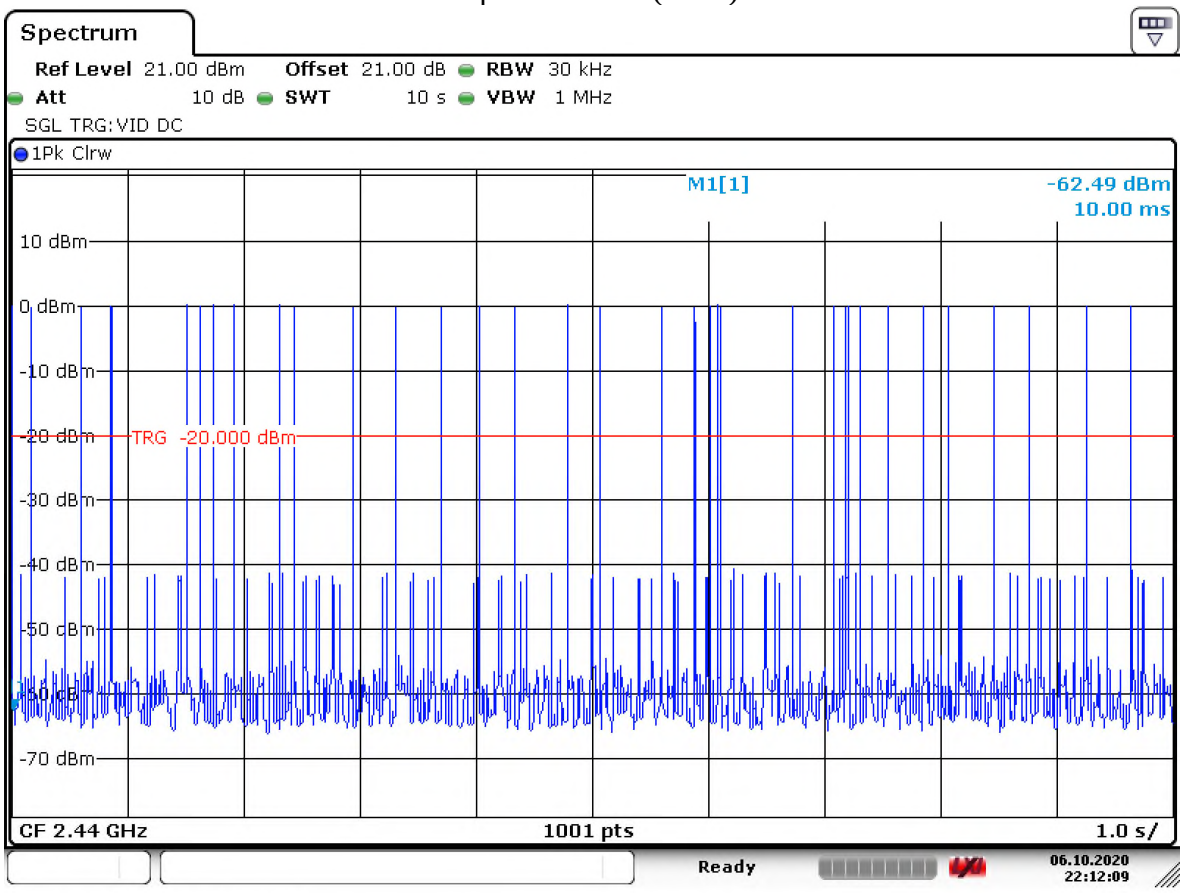
Transmit time per hop (BDR)



Date: 6.OCT.2020 22:14:28

Note: 400 uS per hop.

Repetition Rate (BDR)

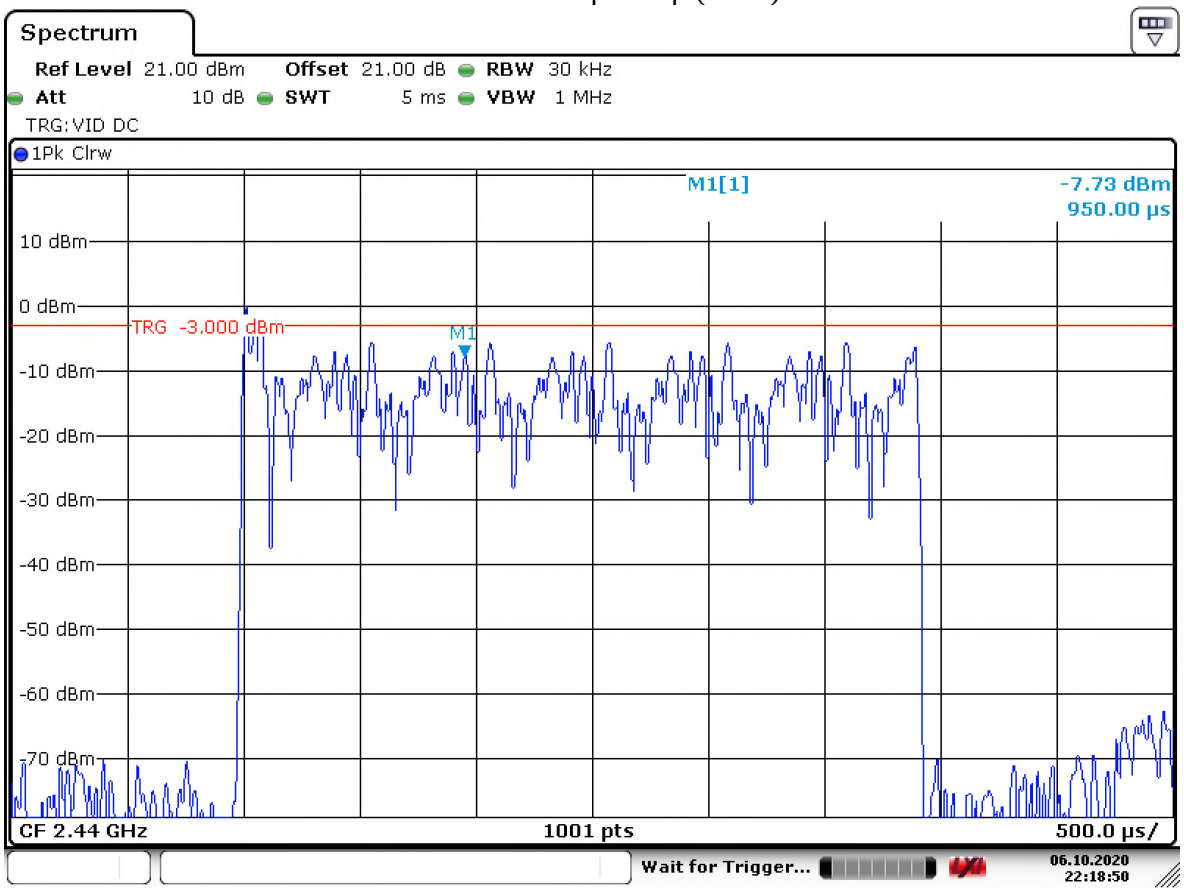


Date: 6.OCT.2020 22:12:09

Note: 33 channel occupancies per 10 seconds.

At 33 channel occupancies per 10 seconds, this equates to 105 occupancies in a 31.6 second period. At 400 uS per occupancy, this is an average occupancy of 42 mS in a 31.6 second period. This is under the 400 mS occupancy limit.

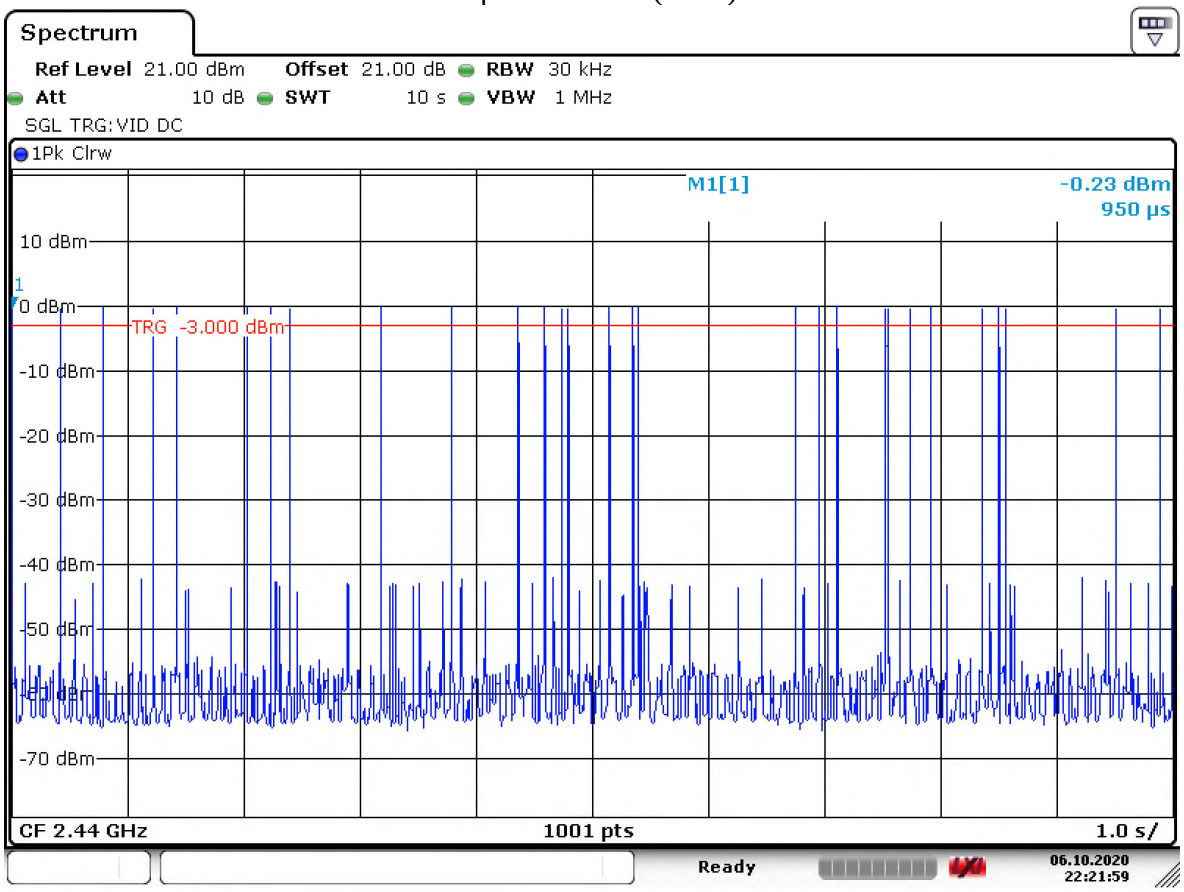
Transmit time per hop (EDR)



Date: 6.OCT.2020 22:18:51

Note: A pulse period time of 3.5 mS was applied.

Repetition Rate (EDR)



Date: 6.OCT.2020 22:22:00

Note: 27 channel occupancies per 10 seconds.

At 27 channel occupancies per 10 seconds, this equates to 86 occupancies in a 31.6 second period. At 3.5 mS per occupancy, this is an average occupancy of 301 mS in a 31.6 second period. This is under the 400 mS occupancy limit.

Measurement uncertainty

The measurement uncertainty for this test is less than ½ of the measurement resolution bandwidth used during the measurement. The timing measurement uncertainty is less than +/- 5% of the time used. The reading, or determination of pass or fail is independent of any measurement uncertainties.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
Spectrum Analyzer	FSV40	Rhode & Schwarz	4/1/19	4/1/21	SSG013948
Attenuator 1,3,6,10,20, 30 dB	9414-1	Api / Weinshel	NCR	NCR	GEMC 279

Maximum Envelope Conducted Power

Purpose

The purpose of this test is to ensure that the maximum power conducted to the radiating element does not exceed the limits specified. This ensures that if the end-user replaces the antenna, that the maximum power does not exceed an amount which may create an excessive power level.

Limits and Methods

The limits are defined in FCC Part 15.247(b) and RSS 247.
For systems using digital modulation in the 2400-2483.5 MHz, the limit is 1 watt.

For Frequency hopping spread spectrum systems, a peak limit of 125 mW was applied as worst case.

Where the Occupied bandwidth exceeds 3 MHz, the method applied is given in ANSI C63.10 Clause 11.9.2.3.1 wideband average power method. Where the Occupied bandwidth is less than 3 MHz, the method applied is given in ANSI C63.10 Clause 11.9.1.1 RBW ≥ DTS bandwidth is applied, and a peak reading is obtained.

Results

The EUT passed. The EUT was set to transmit at maximum power. Three Channels were measured for each data type. The following table shows the peak power: The external attenuator and cable loss were accounted for as reference offset in the spectrum analyzer.

Power – 802.11b					
Channel	Frequency (MHz)	Power (dBm)	Power (mW)	Limit (mW)	Pass/Fail
Low	2412[1]	13.2	20.9	1000	Pass
Mid	2437	13.1	20.5	1000	Pass
High	2462	12.7	18.7	1000	Pass

Note 1: See graph for worst case measurement screen capture of power of digitally modulated

Power – 802.11g					
Channel	Frequency (MHz)	Power (dBm)	Power (mW)	Limit (mW)	Pass/Fail
Low	2412	12.0	15.9	1000	Pass
Mid	2437	11.9	15.5	1000	Pass
High	2462	12.0	15.9	1000	Pass

Power – 802.11n (20 Mbps)					
Channel	Frequency (MHz)	Power (dBm)	Power (mW)	Limit (mW)	Pass/Fail
Low	2412	11.5	14.2	1000	Pass
Mid	2437	11.4	13.9	1000	Pass
High	2462	11.8	15.2	1000	Pass

Power – 802.11n (40 Mbps)					
Channel	Frequency (MHz)	Power (dBm)	Power (mW)	Limit (mW)	Pass/Fail
Low	2422	12.1	16.3	1000	Pass
Mid	2437	11.7	14.8	1000	Pass
High	2452	11.9	15.5	1000	Pass

Power – BTLE					
Channel	Frequency (MHz)	Power (dBm)	Power (mW)	Limit (mW)	Pass/Fail
Low	2402	2.05	1.6	1000	Pass
Mid	2440	2.92	2.0	1000	Pass
High	2480	3.32	2.1	1000	Pass

Power – BT BDR					
Channel	Frequency (MHz)	Power (dBm)	Power (mW)	Limit (mW)	Pass/Fail
Low	2402	2.39	1.7	125	Pass
Mid	2440	2.85	1.9	125	Pass
High	2480	3.28	2.1	125	Pass

Power – BT EDR					
Channel	Frequency (MHz)	Power (dBm)	Power (mW)	Limit (mW)	Pass/Fail
Low	2402	4.87	3.1	125	Pass
Mid	2440	5.85	3.8	125	Pass
High	2480[1]	6.12	4.1	125	Pass

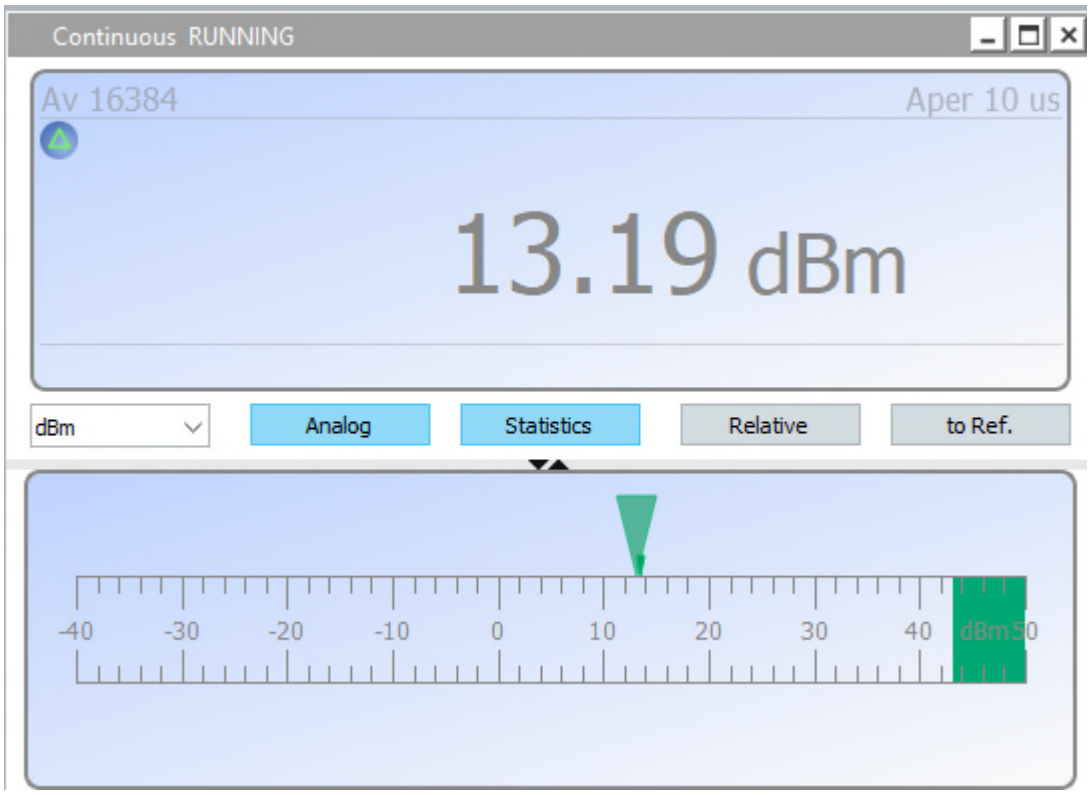
Note 1: See graph for worst case measurement of peak power of digitally modulated

Readings

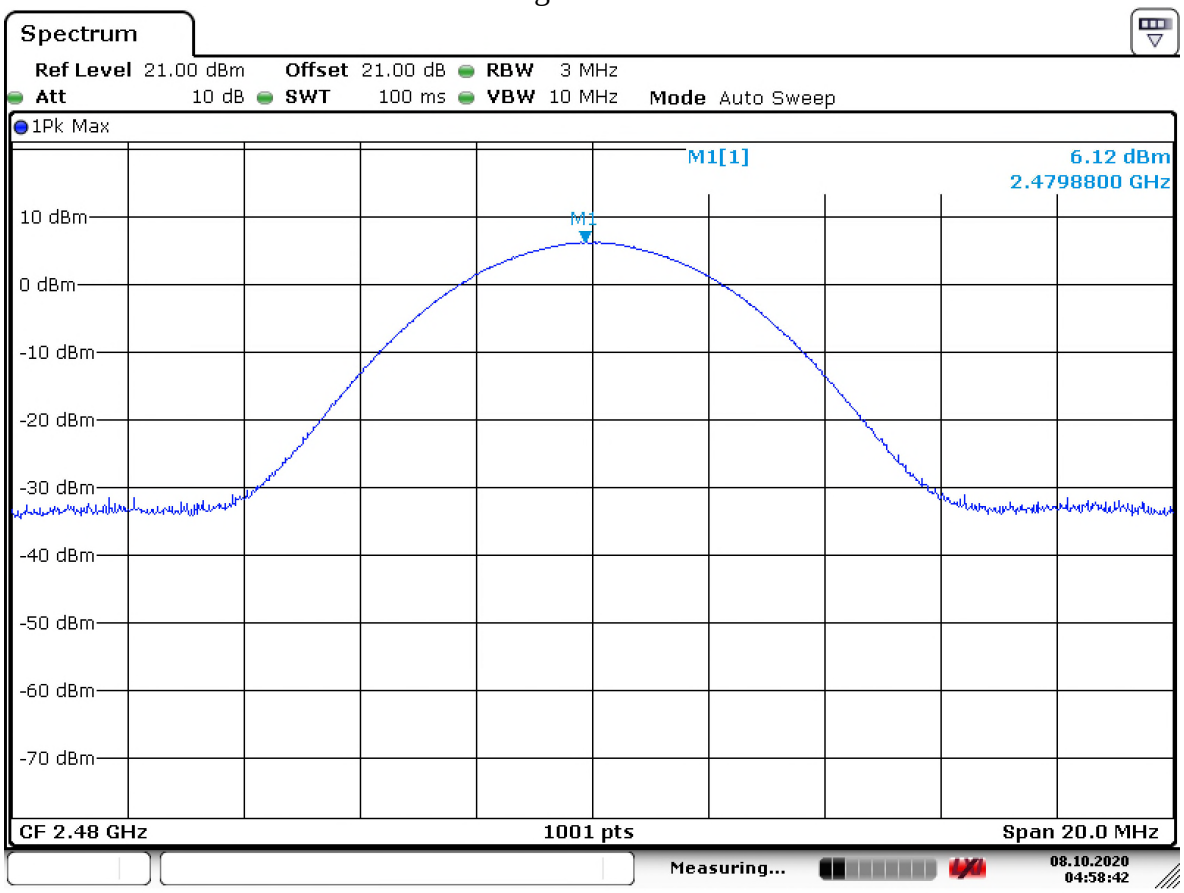
The graphs shown below show the peak power output of the device. This is measured by a max hold on the spectrum analyzer or power meter as appropriate.

Where the Occupied bandwidth is less than 3 MHz, the method applied is given in ANSI C63.10 Clause 11.9.1.1 RBW ≥ DTS bandwidth is applied. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

Maximum Power: Digitally modulated (worst case) – 802.11b 1 mbps
Low Channel



Peak Power: Frequency hopping spread spectrum (worst case) – BT EDR 3 Mpbs
High Channel



Date: 8.OCT.2020 04:58:42

Measurement Uncertainty

The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is ±1.5 dB with a 'k=2' coverage factor and a 95% confidence level.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
Spectrum Analyzer	FSV40	Rhode & Schwarz	4/1/19	4/1/21	SSG013948
Attenuator 1,3,6,10,20, 30 dB	9414-1	Api / Weinshel	NCR	NCR	GEMC 279
Power Meter	NRP-Z81	Rhode & Schwarz	1	4/1/21	SAP169001036

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

Antenna Spurious Conducted Emissions (-30 dBc Requirement)

Purpose

The purpose of this test is to ensure that the maximum power conducted to the radiating element at frequencies outside of the authorized spectrum does not exceed the limits specified. This ensures that the only the intended signal is delivered to the radiating element.

Limits and Methods

The limits are defined in 15.247(d). In any 100 kHz band, the peak spurious harmonics emissions must be at least 20 dB below the fundamental. Spurious Conducted emissions are to be evaluated up to the 10^{th} harmonic. This -30 dBc requirement also applies at the 'band edge' or 2.4 GHz and 2.4835 GHz.

The method is given in ANSI C63.10 Clause 11.11 Emissions in nonrestricted frequency bands

Results

The EUT passed.

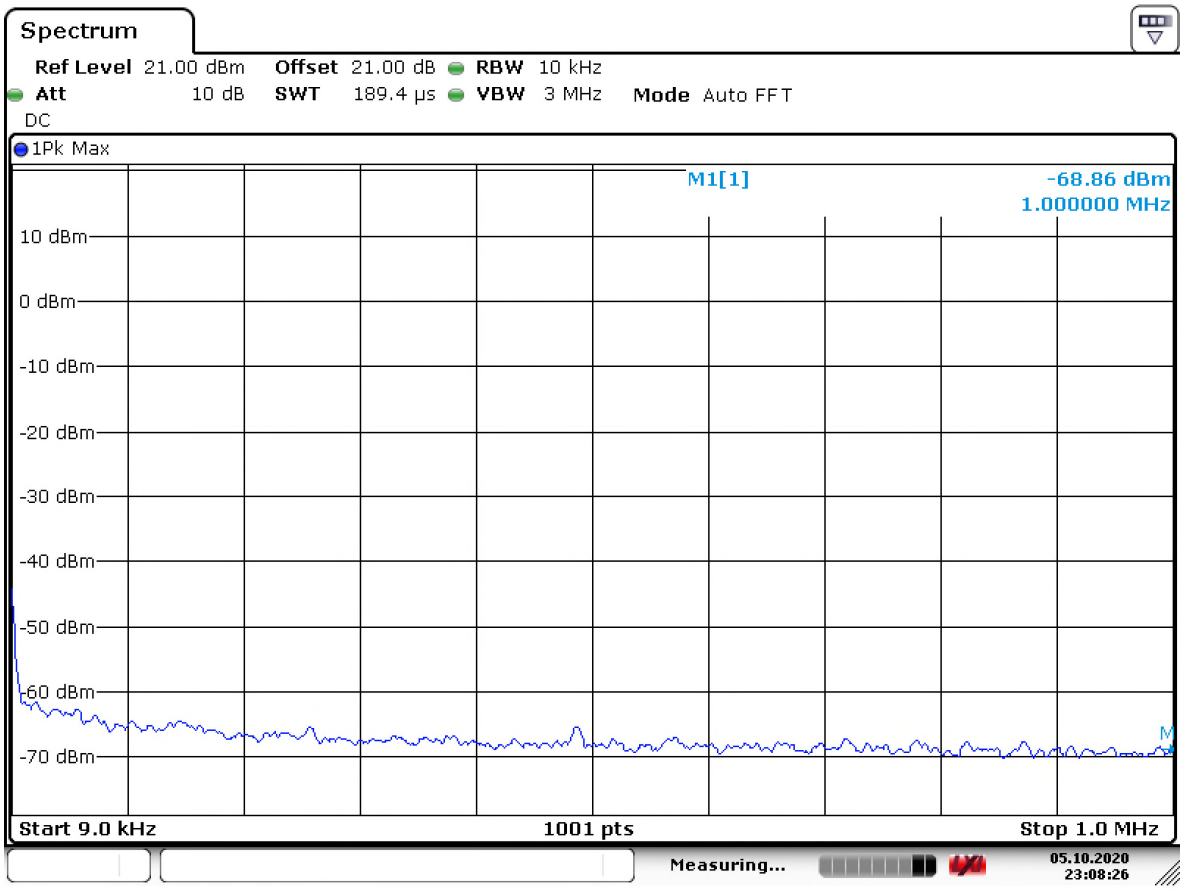
The EUT was set to transmit at maximum power. Three Channels were measured.

Low, middle and high channels were measured for each of the data types. The worst case was presented as a graph for the spectrum. The -30 dBc requirement is shown for the lower band edge at 2.4 GHz in the low band. The -30 dBc requirement is also shown for the higher band edge at 2.4835 GHz in the high band.

Graph(s)

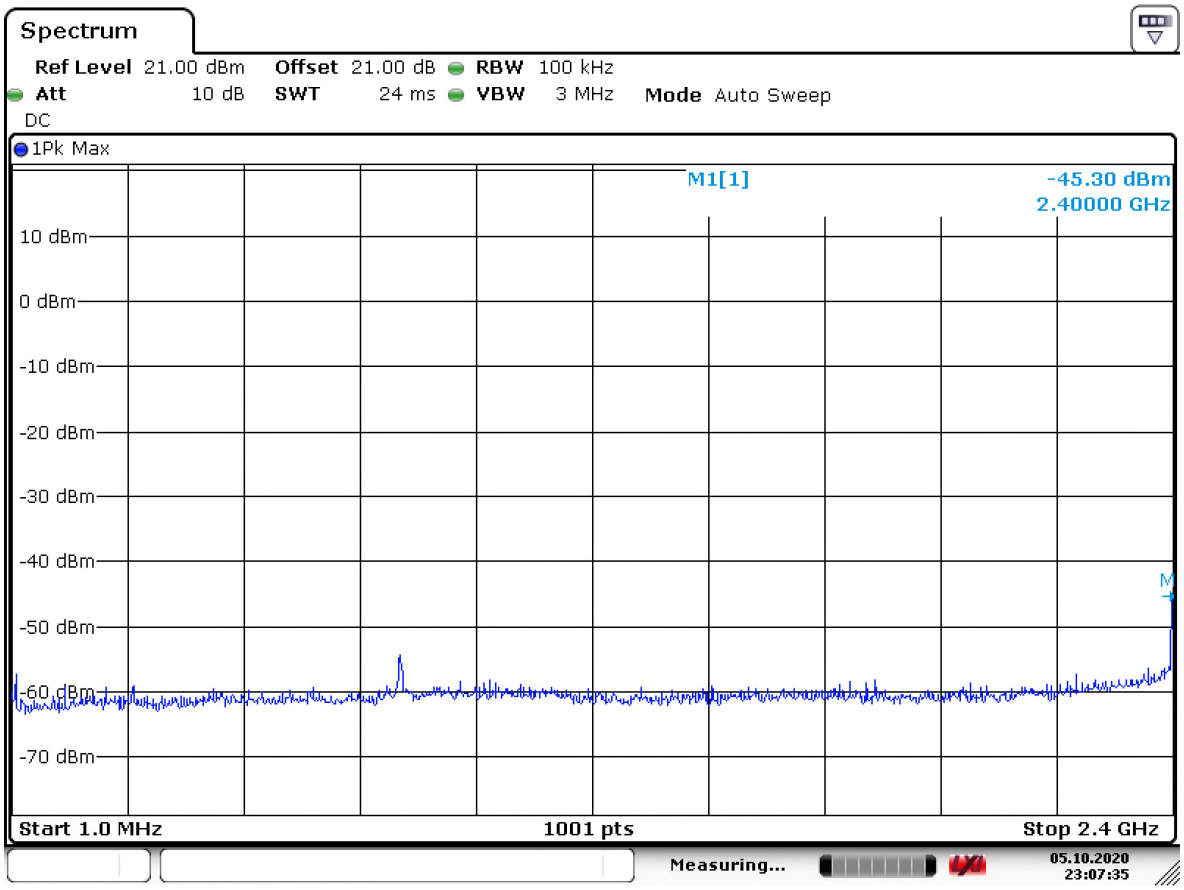
The graphs shown below shows the peak power spectral density of the device. This is measured by a max hold on the spectrum analyzer using a RBW of 100 kHz. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

9k to 1 MHz



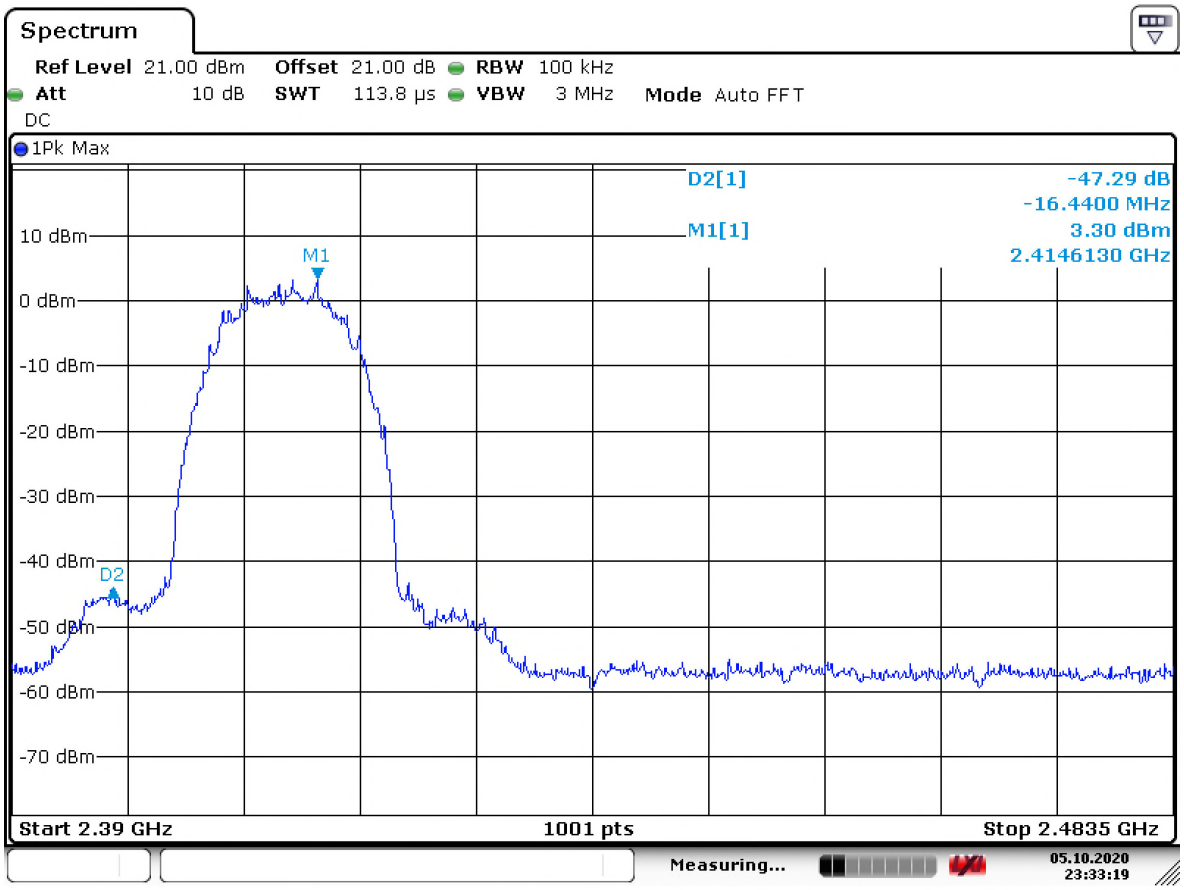
Date: 5.OCT.2020 23:08:26

1 MHz to 2.4 GHz



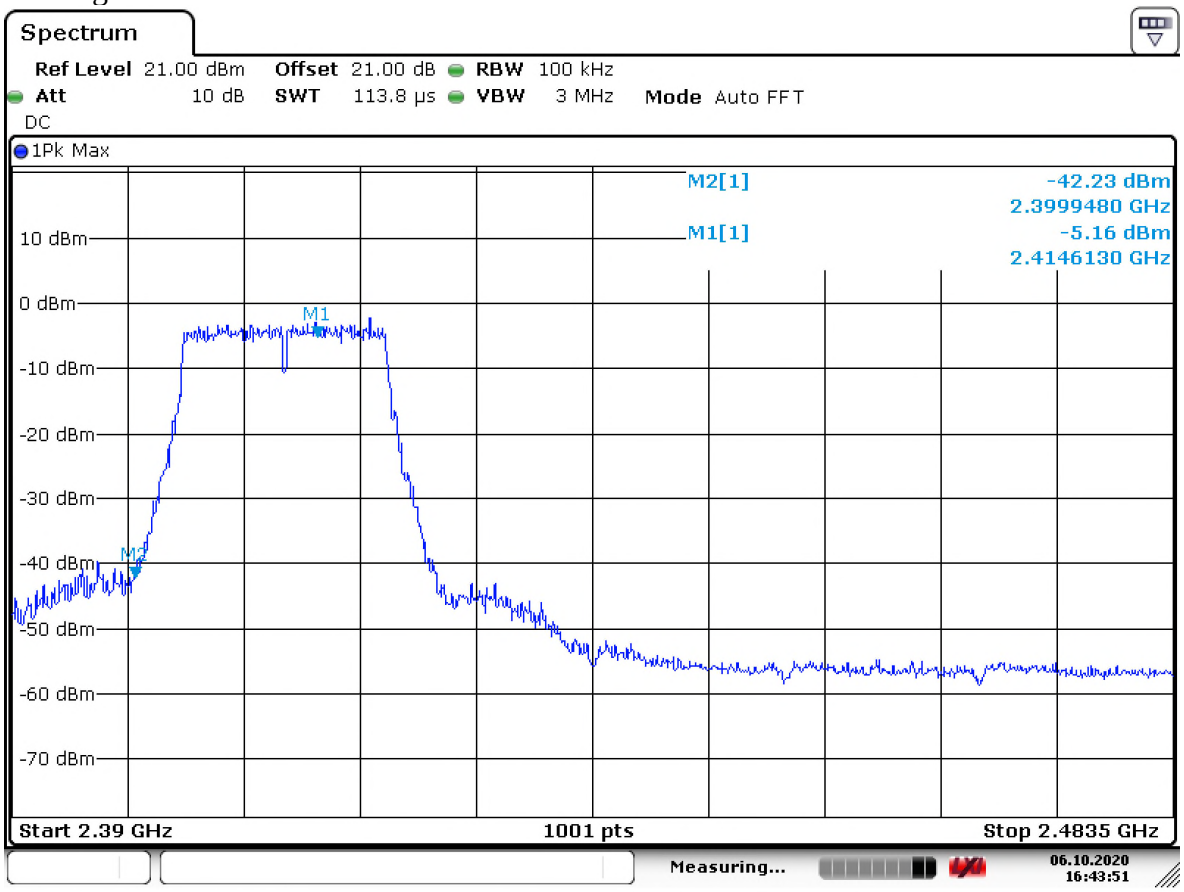
Date: 5.OCT.2020 23:07:36

802.11b – low



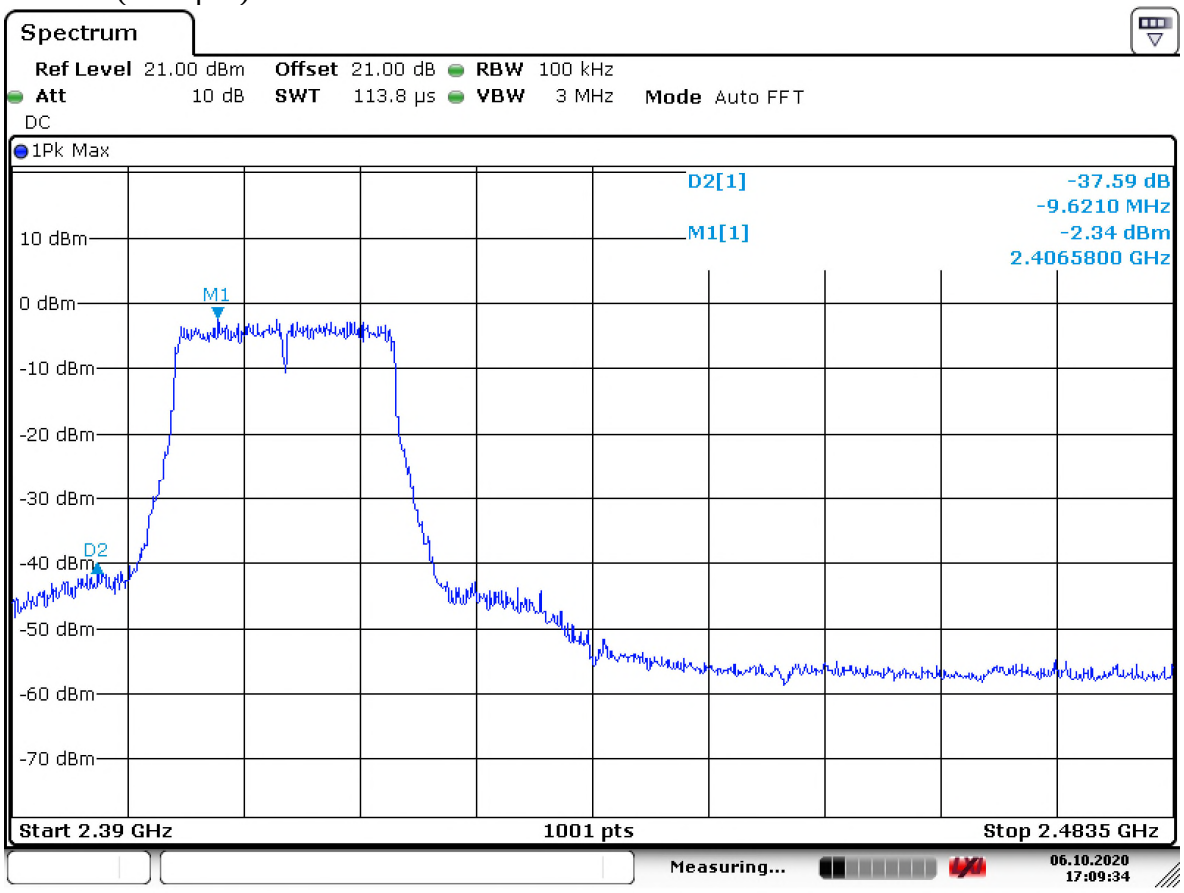
Date: 5.OCT.2020 23:33:19

802.11g – low



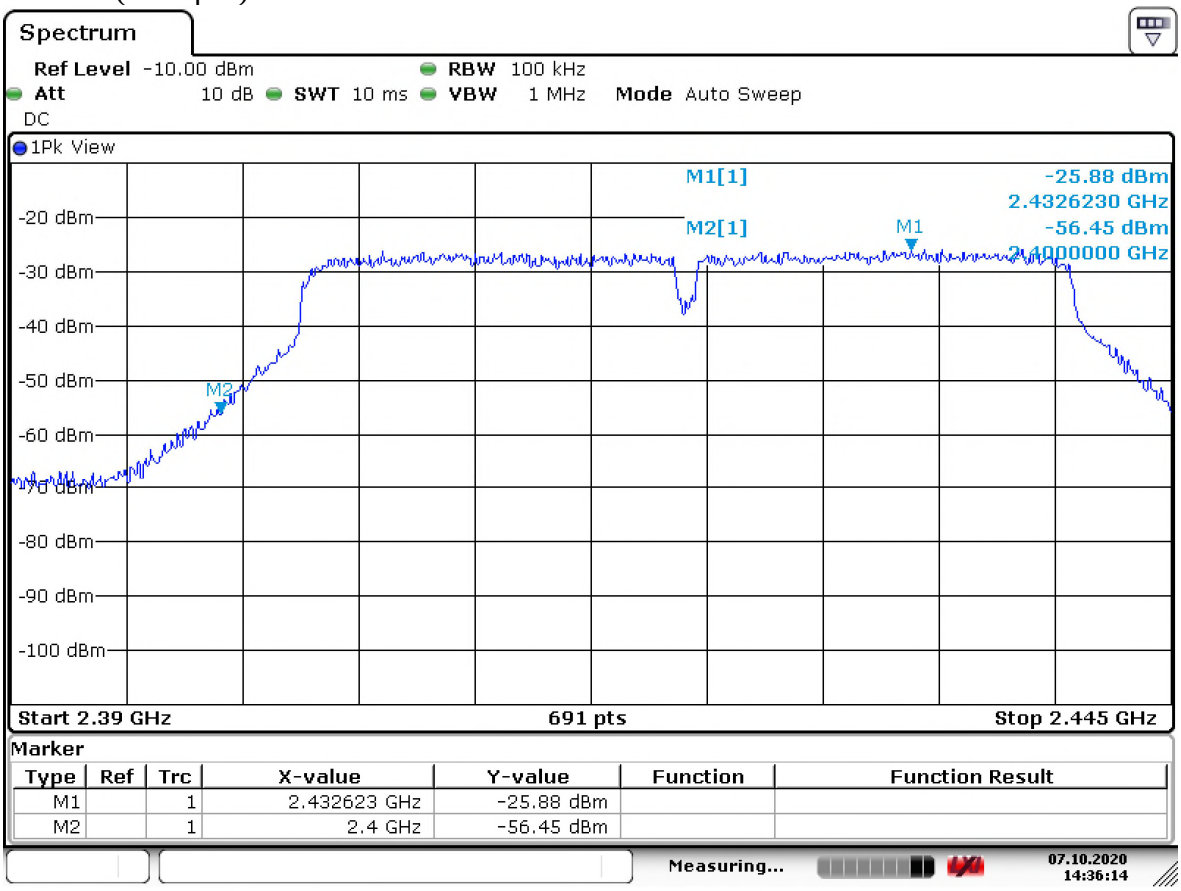
Date: 6.OCT.2020 16:43:51

802.11n (20 Mpbs) – low



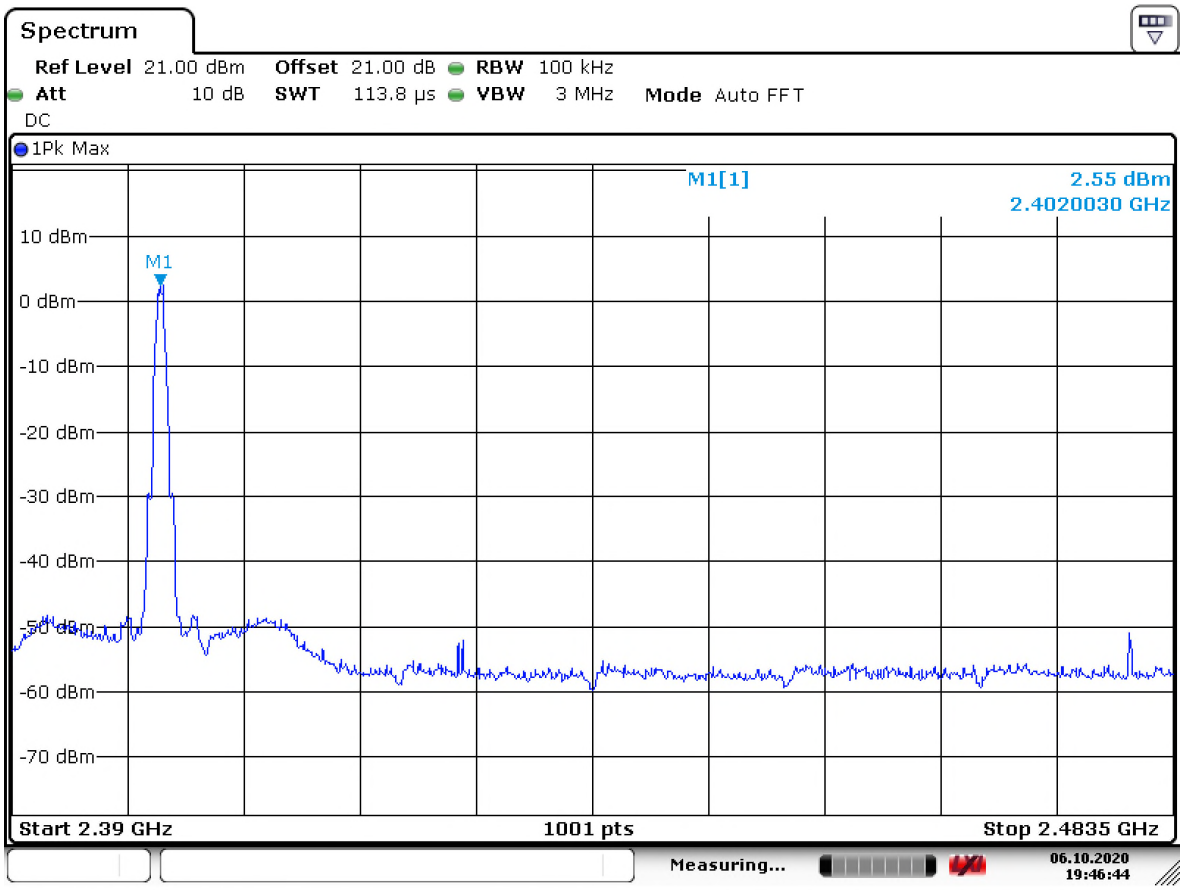
Date: 6.OCT.2020 17:09:34

802.11n (40 Mpbs) – low



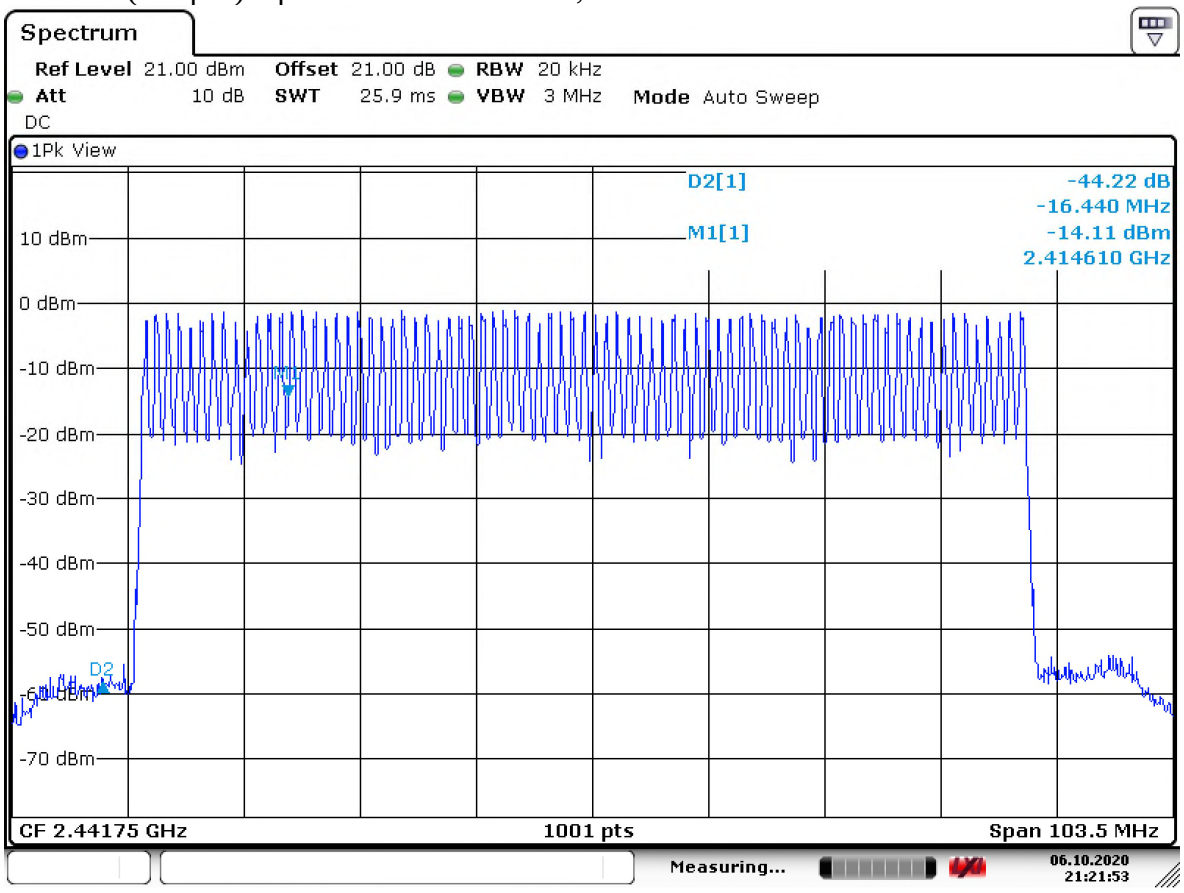
Date: 7.OCT.2020 14:36:14

BTLE – Low



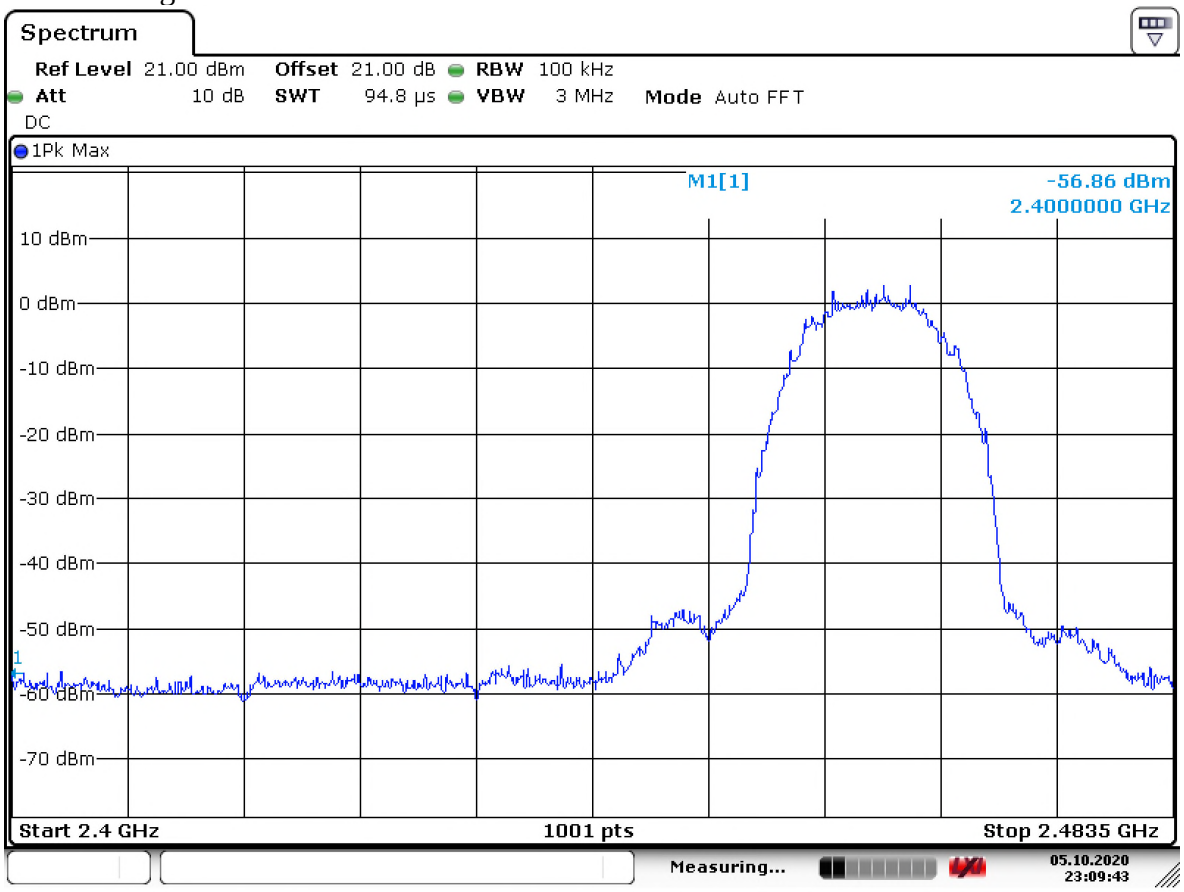
Date: 6.OCT.2020 19:46:45

BT BDR (1 Mpbs) representative –max hold, all channels shown



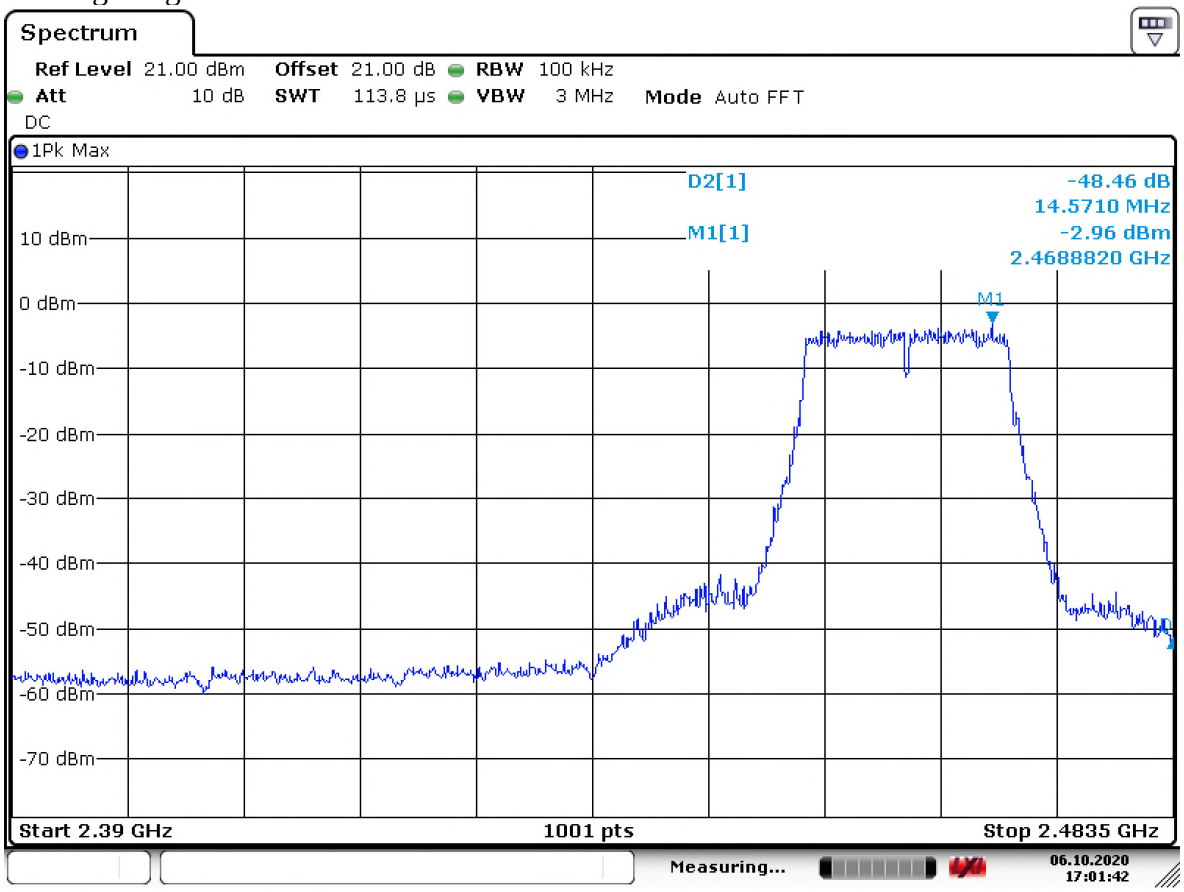
Date: 6.OCT.2020 21:21:53

802.11b - high



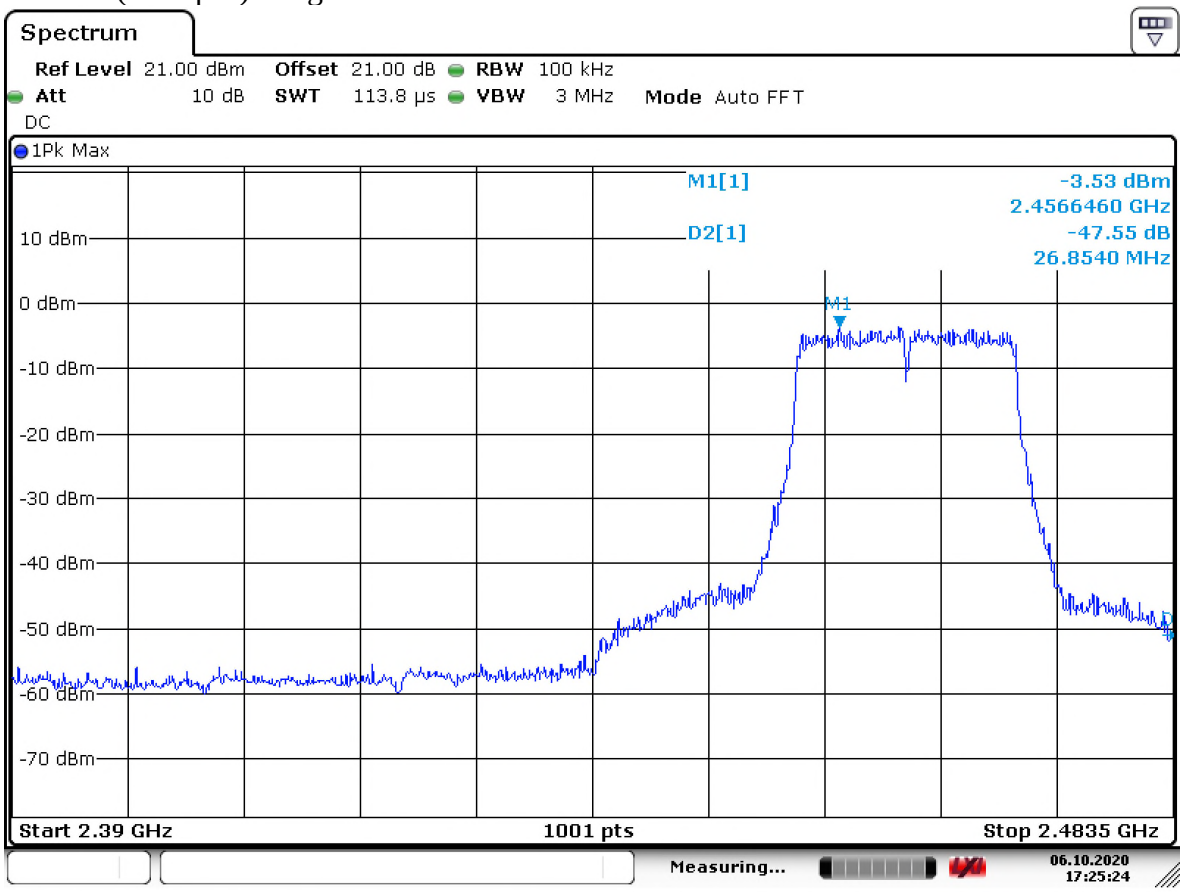
Date: 5.OCT.2020 23:09:44

802.11g – high



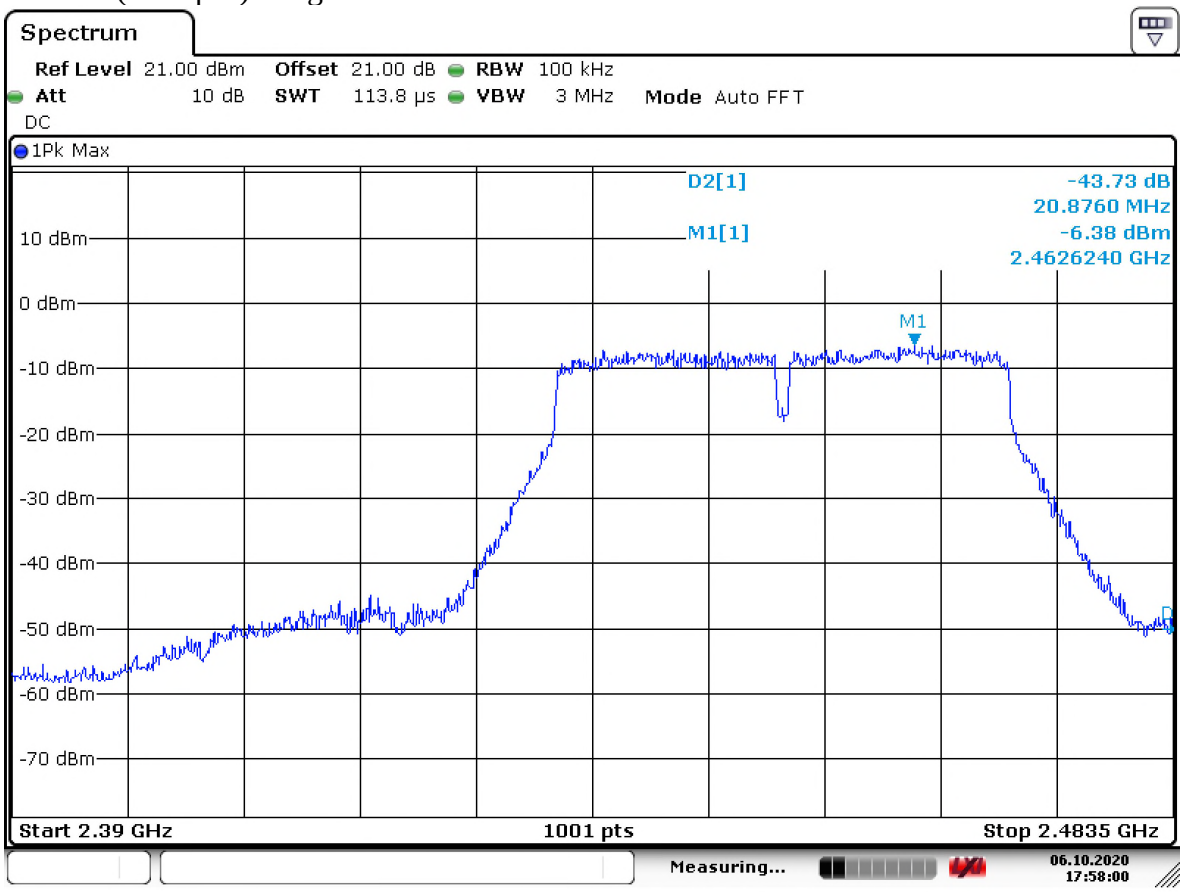
Date: 6.OCT.2020 17:01:42

802.11n (20 Mpbs) – high



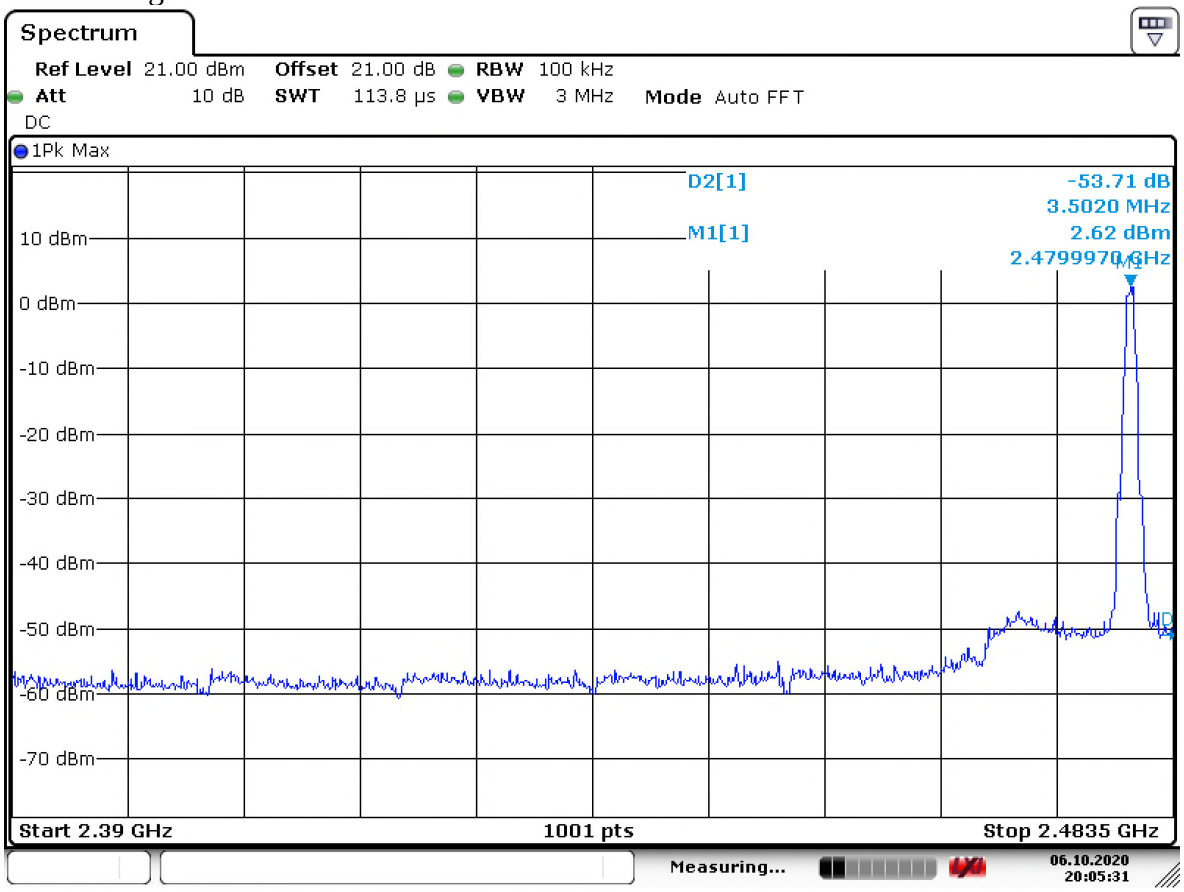
Date: 6.OCT.2020 17:25:24

802.11n (40 Mpbs) – high



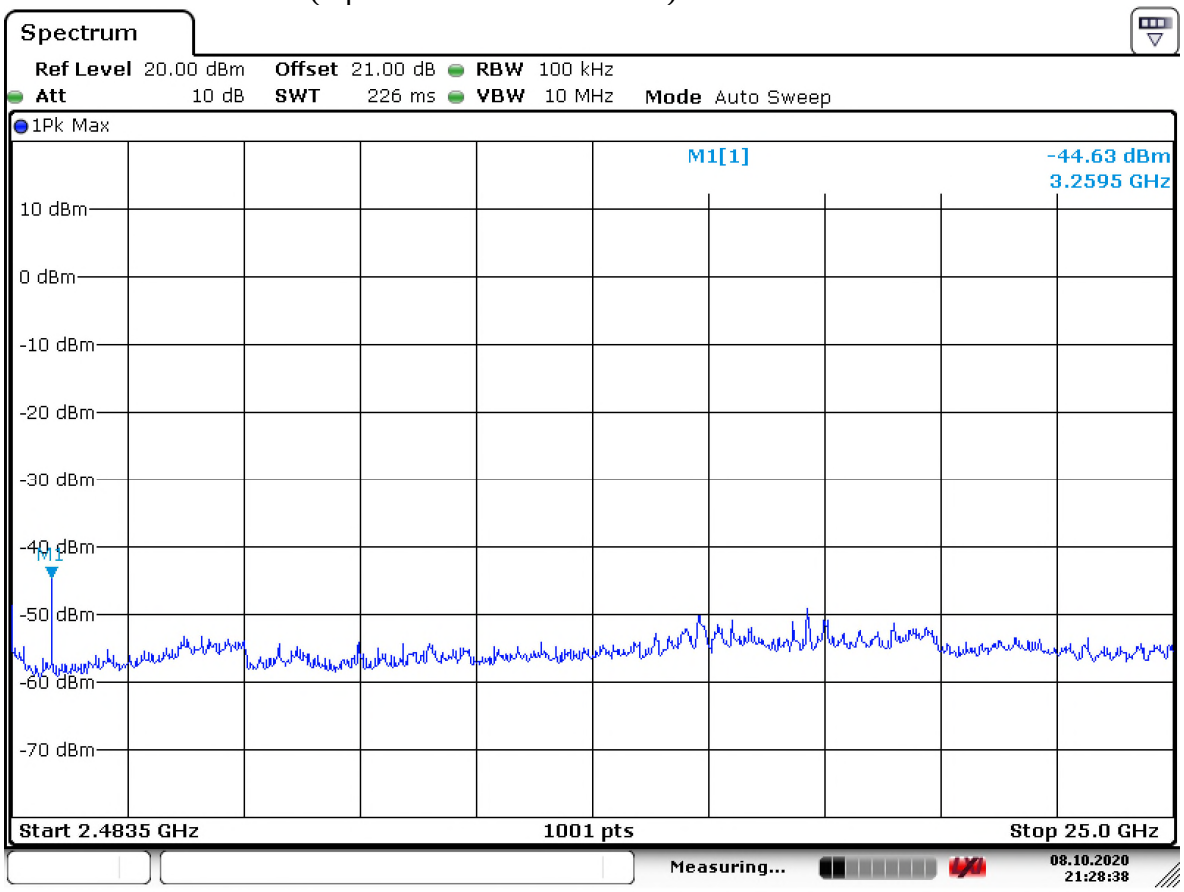
Date: 6.OCT.2020 17:58:00

BTLE – High



Date: 6.OCT.2020 20:05:31

2.4835 GHz to 25 GHz (representative / worst case)



Date: 8.OCT.2020 21:28:38

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
Spectrum Analyzer	FSV40	Rhode & Schwarz	4/1/19	4/1/21	SSG013948
Attenuator 1,3,6,10,20, 30 dB	9414-1	Api / Weinshel	NCR	NCR	GEMC 279

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

Radiated Emissions in Restricted Band

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT does not exceed the limits listed below as defined in the applicable test standard, as measured from a receiving antenna. This helps protect broadcast radio services such as television, FM radio, pagers, cellular telephones, emergency services, and so on, from unwanted interference.

Limit and Method

The method is given in ANSI C 63.10
The limits are as defined in FCC Part 15, Section 15.209 and RSS GEN:

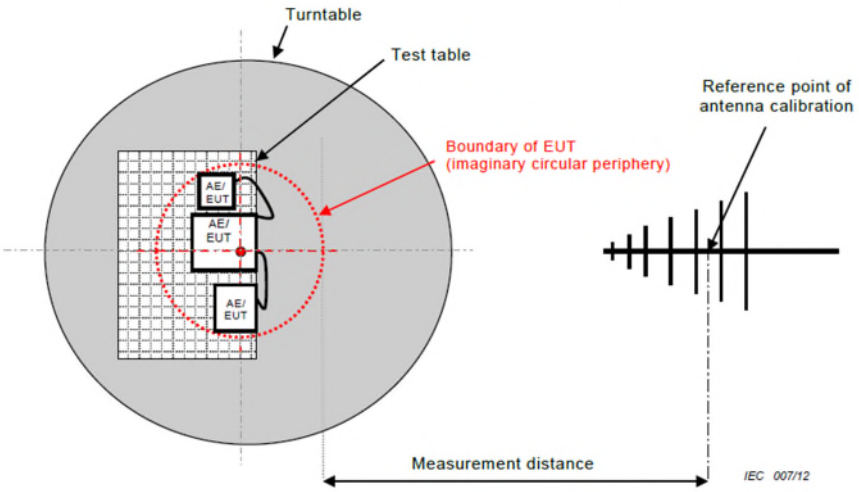
The limits, as defined in 15.247(d) for unintentional radiated emissions apply for those emissions that fall in the restricted bands, as defined in Section 15.205(a). These emissions must comply with the radiated emission limits specified in Section 15.209(a).

All unintentional emissions must also meet the 'Spurious Conducted Emissions' requirements of -20 dBc or greater. See also 'Spurious Conducted Emissions' for further details.

0.009 MHz – 0.490 MHz, 2400/F (kHz) uV/m at 300 m[1]
0.490 MHz – 1.705 MHz, 24000/F (kHz) uV/m at 30 m[1]
1.705 MHz – 30 MHz, 30 uV/m at 30 m[1]
30 MHz – 88 MHz, 100 uV/m (40.0 dBuV/m[1]) at 3 m
88 MHz – 216 MHz, 150 uV/m (43.5 dBuV/m[1]) at 3 m
216 MHz – 960 MHz, 200 uV/m (46.0 dBuV/m[1]) at 3 m
Above 960 MHz, 500 uV/m (54.0 dBuV/m[1]) at 3 m
Above 1000 MHz, 500 uV/m (54 dBuV/m[2]) at 3m
Above 1000 MHz, 500 uV/m (74 dBuV/m[3]) at 3m

[1]Limit is with Quasi Peak detector with bandwidths as defined in CISPR-16-1-1
[2]Limit is with 1 MHz measurement bandwidth and using an Average detector
[3]Limit is with 1 MHz measurement bandwidth and using a Peak detector

Typical Radiated Emissions Setup



Measurement Uncertainty

The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is ±5.67dB for 30MHz – 1GHz and ±4.58dB for 1GHz – 18GHz with a 'k=2' coverage factor and a 95% confidence level.

Preliminary Graphs

Note the graphs shown below are for graphical illustration only. For final measurements with the appropriate detector, please refer to the final measurement table where applicable. The graph shown below is a maximized peak measurement graph, measured with a resolution bandwidth greater than the final required detector and over a full 0-360 rotation. This peaking process is done as a worst case measurement. This process enables the detection of frequencies of concern for final measurement, and provides considerable time savings.

In accordance with FCC Part 15, Subpart A, Section 15.33, the device was scanned to the 10^{th} harmonic (a minimum of a 24.835 GHz).

Devices scanned may be scanned at alternate test distances, and in accordance with FCC Part 15, Subpart A, Section 15.31, an extrapolation factor of 20 dB/decade was used above 30 MHz and 40 dB/decade below 30 MHz. For example for 1 meter measurements, an extrapolation factor 9.5 dB from 20 Log (1m / 3m) is applied.

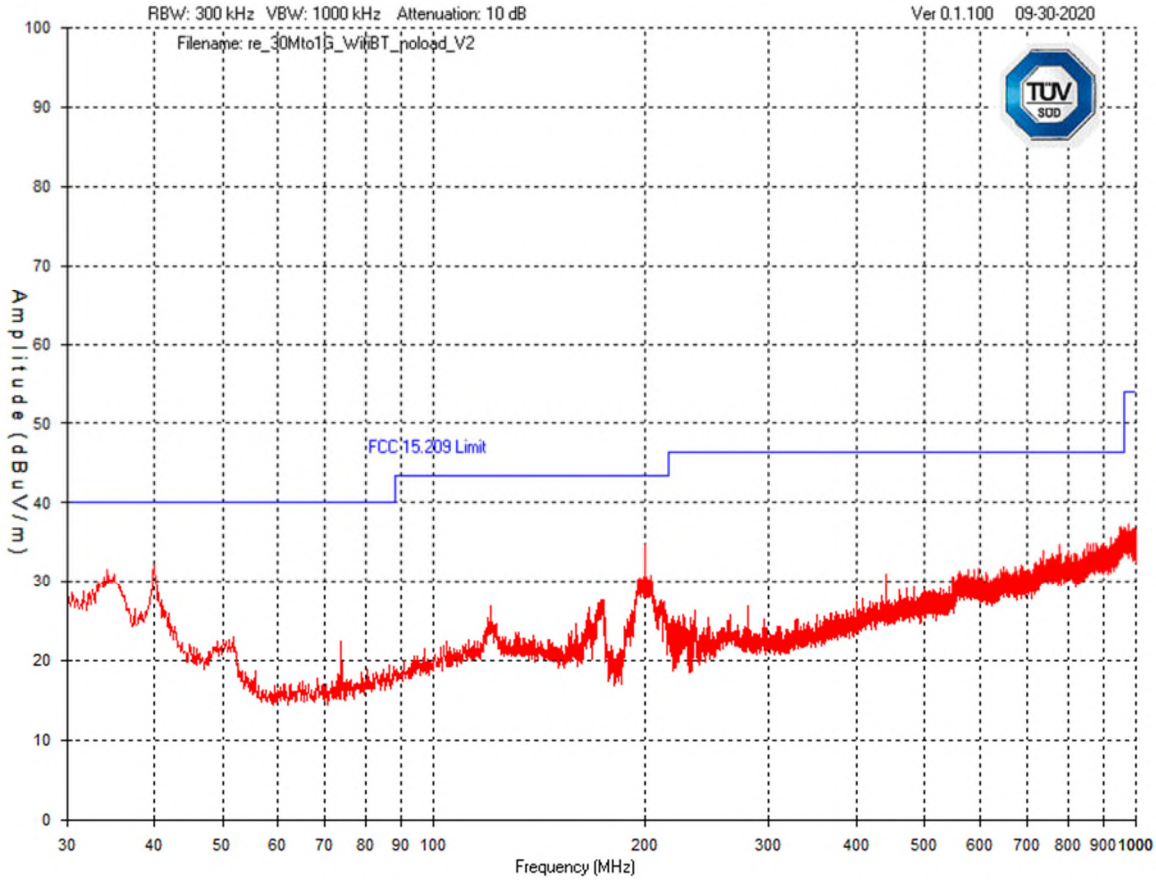
The EUT was set to transmit at maximum power. Low, middle and high channels in each mode were measured; however the worst case or representative graphs are presented.

Band edge measure graphs are shown for illustrations purpose. No emissions were detected between 9kHz and 30 MHz and the noise floor of the instrumentation was below the applicable limit.

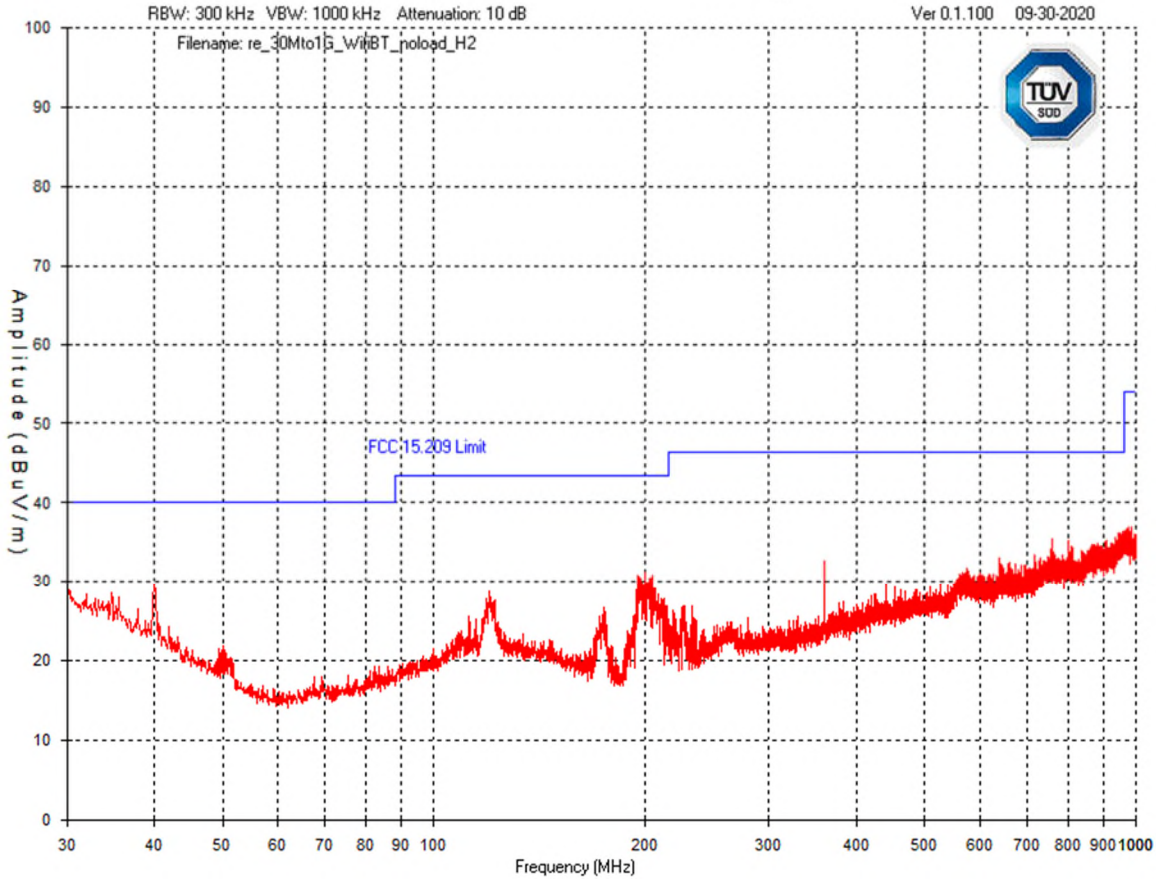
See final measurement section for all measurements.

Below 3 GHz – Peak Radiated Emissions Graphs

Worst case - 802.11b low channel 1 Mpbs - 30 MHz – 1 GHz
Vertical – Peak Emission Graph

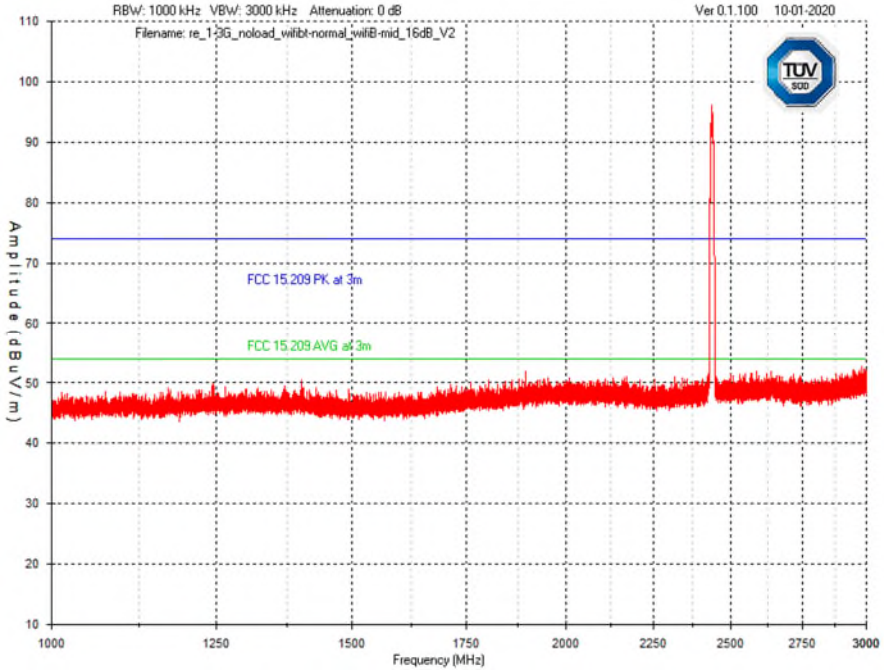


Worst case - 802.11b low channel 1 Mpbs - 30 MHz – 1 GHz
Horizontal - Peak Emission Graph

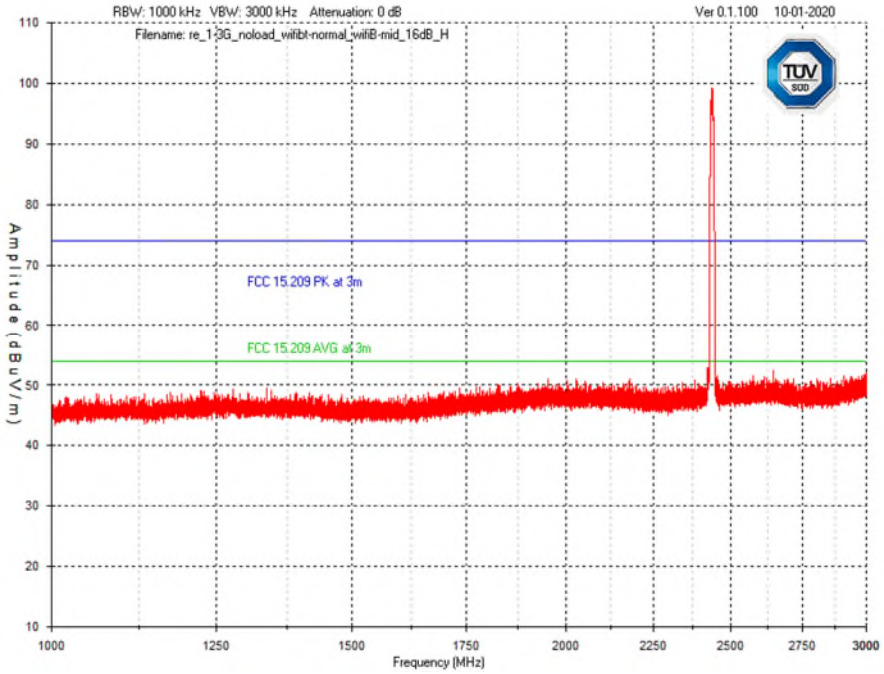


1-3 GHz (covering in band) Peak Radiated Graphs

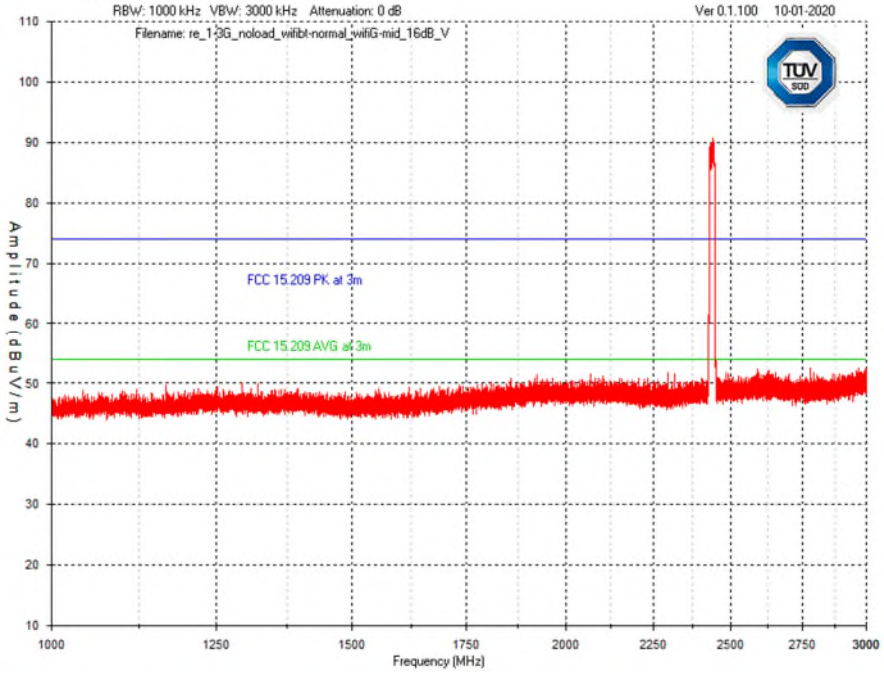
802.11b Vertical – Mid



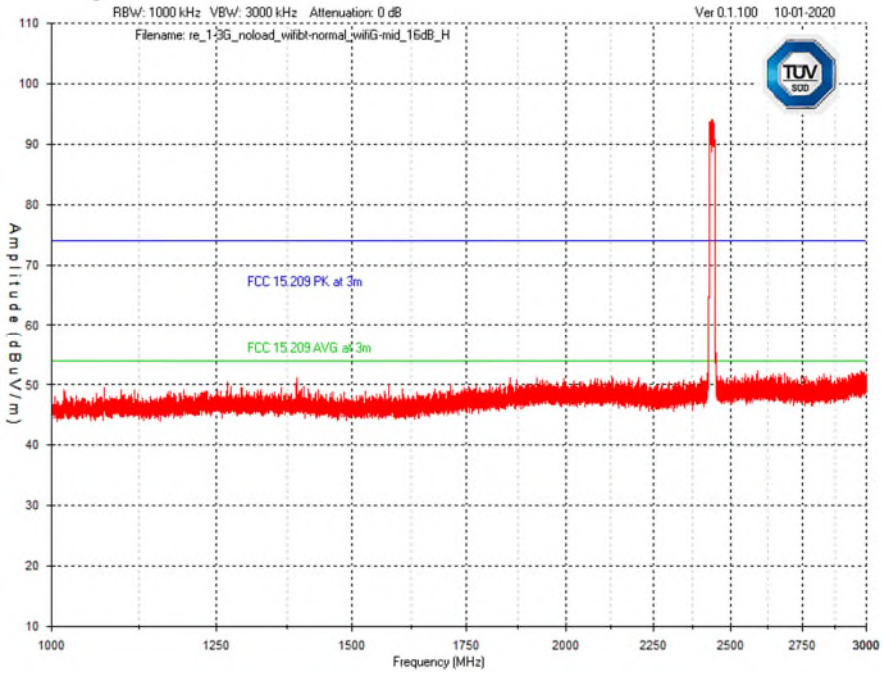
802.11b Horizontal – Mid



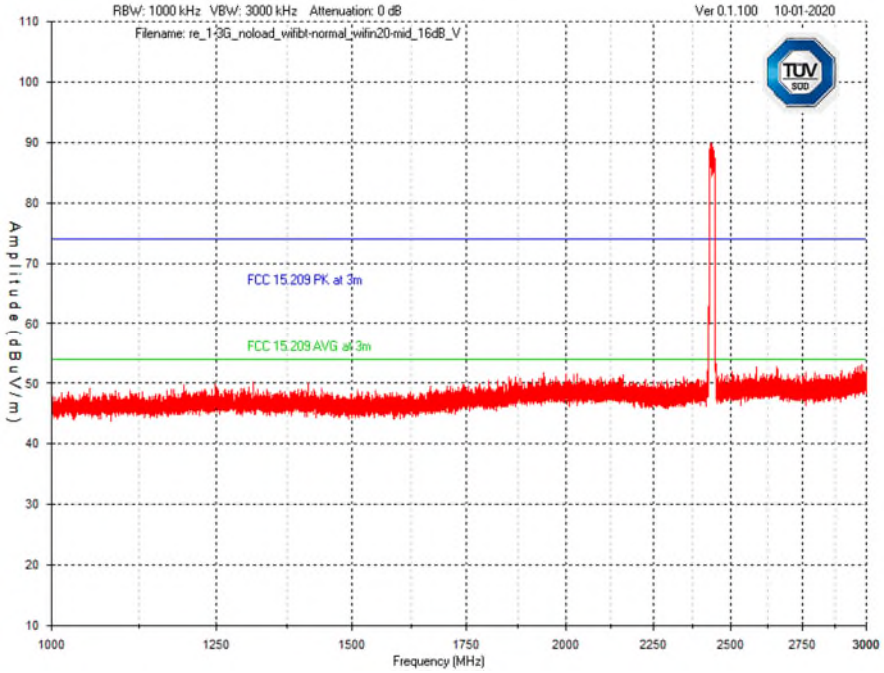
802.11g Vertical – Mid



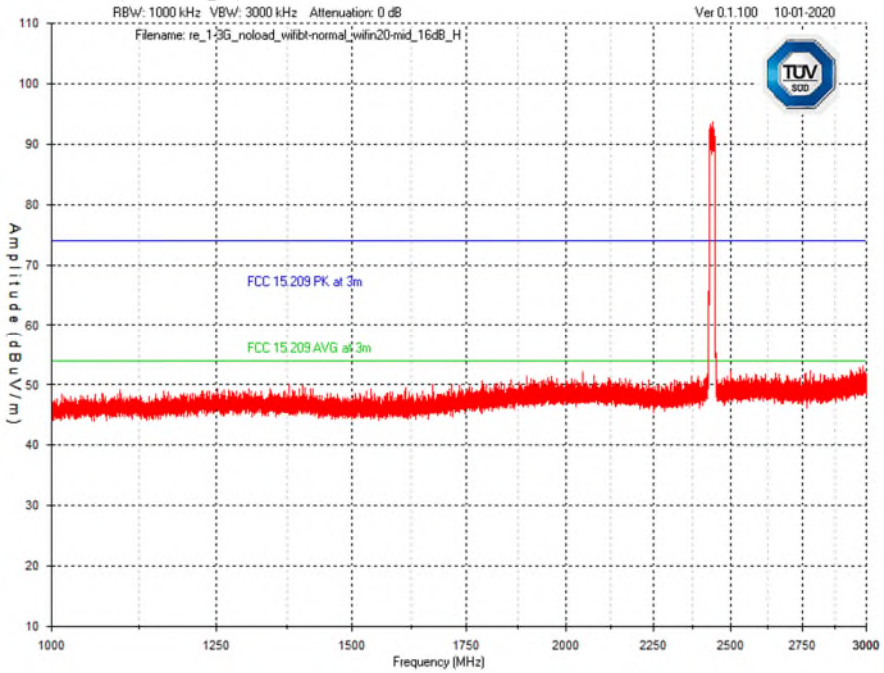
802.11g Horizontal – Mid



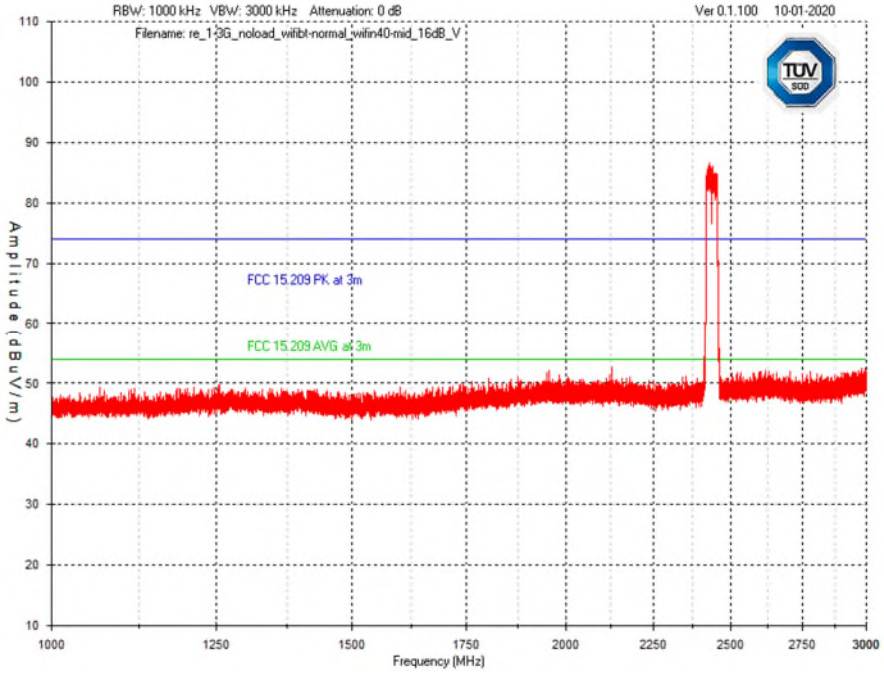
802.11n (20 Mbps) Vertical – Mid



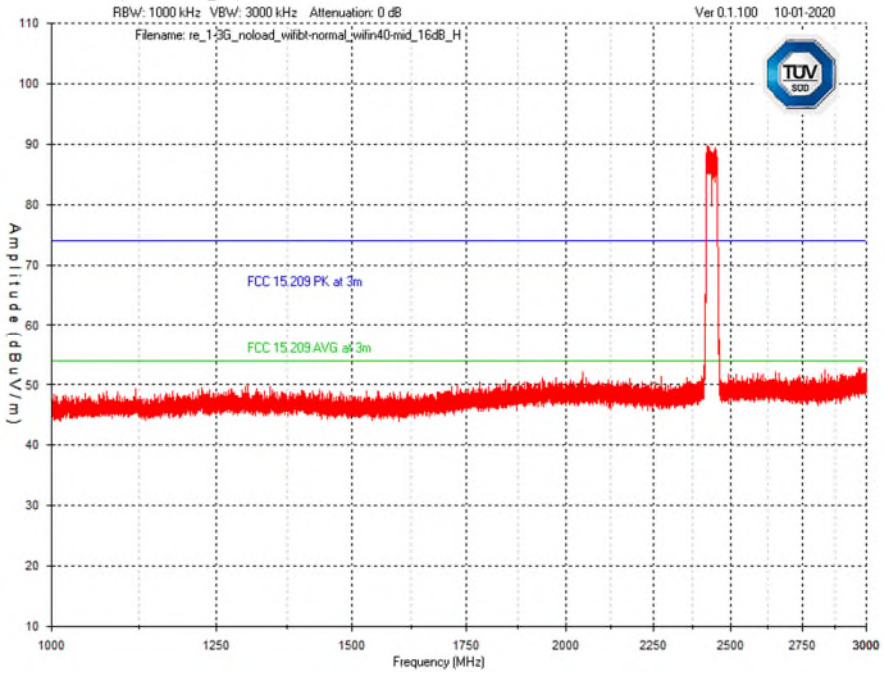
802.11n (20 Mbps) Horizontal – Mid



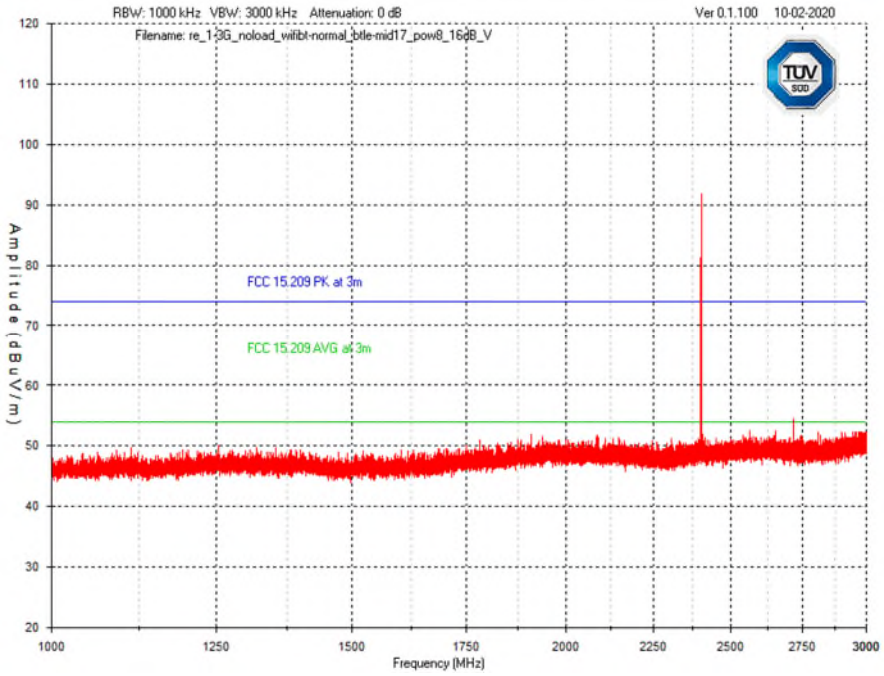
802.11n (40 Mbps) Vertical – Mid



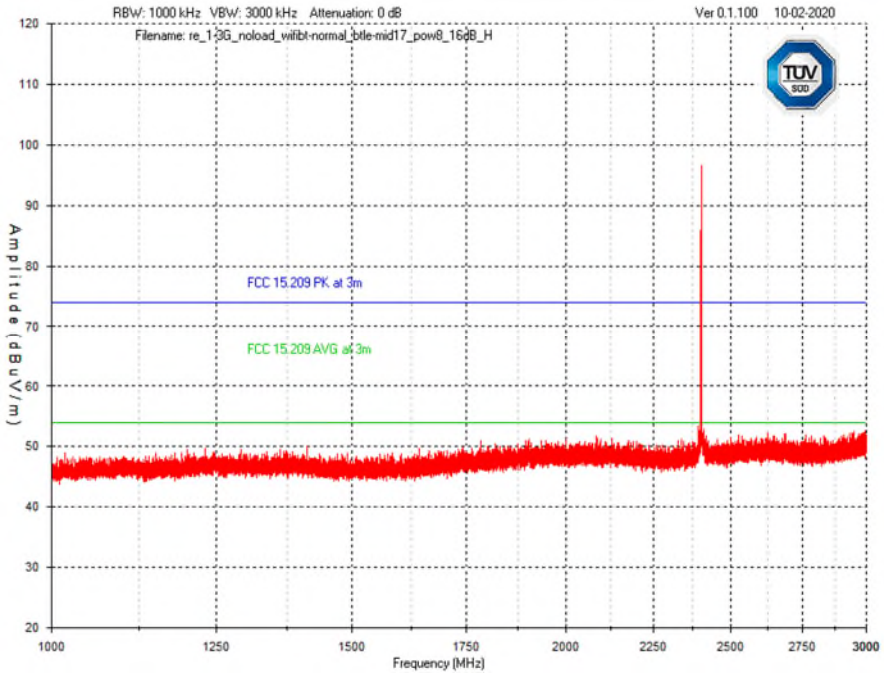
802.11n (40 Mbps) Horizontal – Mid



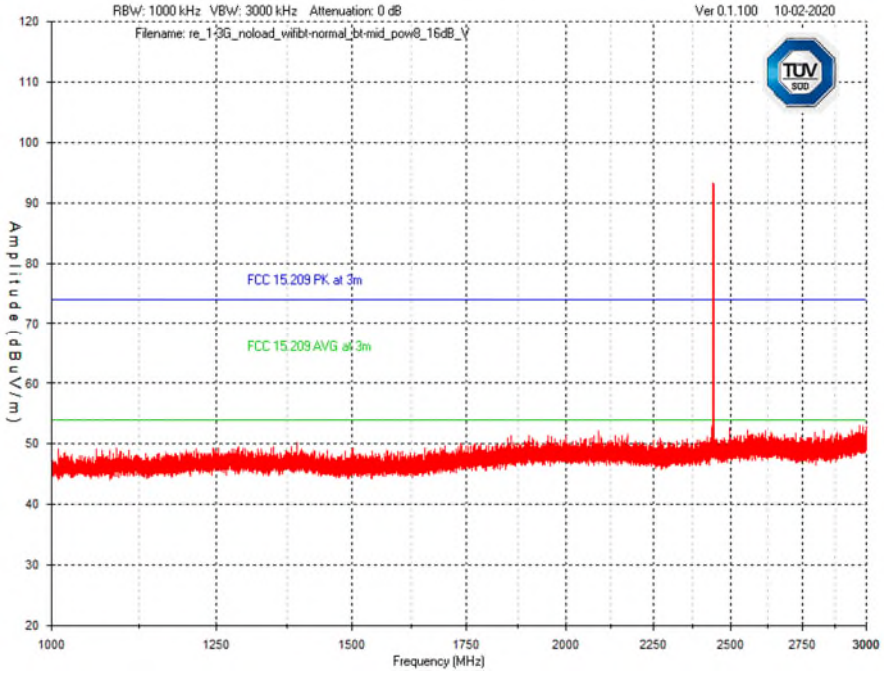
BTLE – Vertical Mid



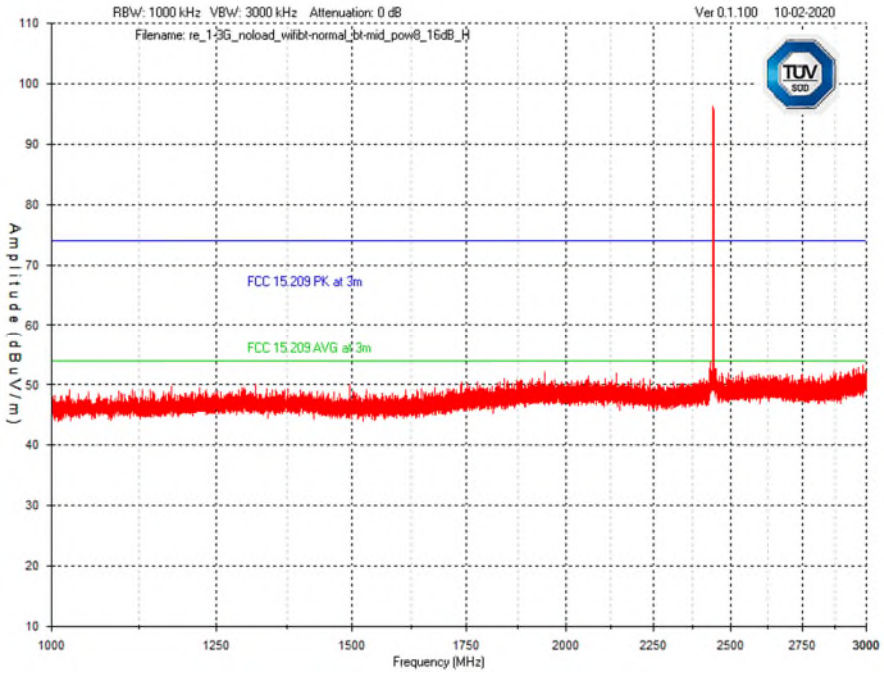
BTLE – Horizontal Mid



BT – Vertical - Mid



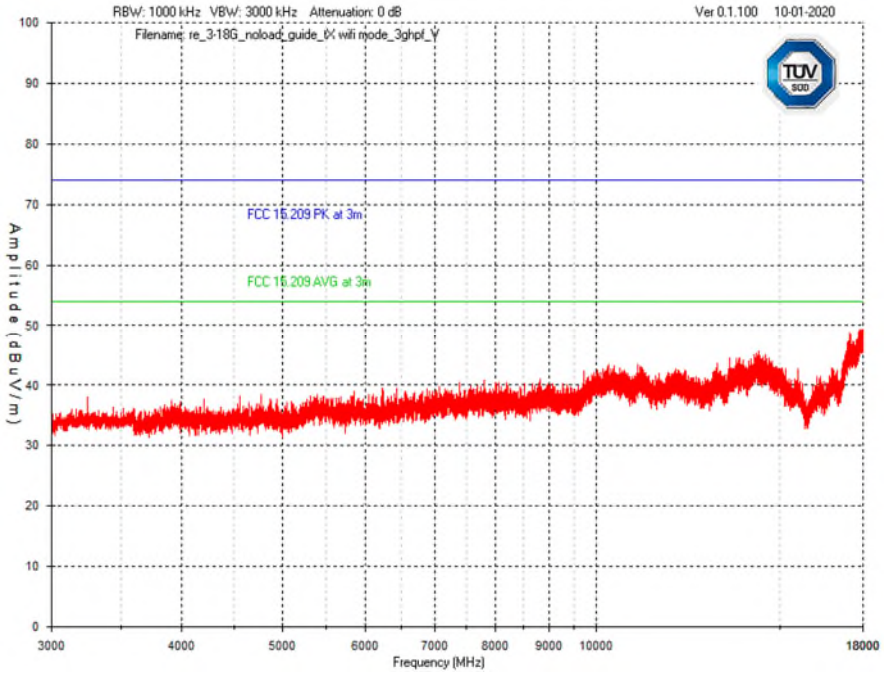
BT – Horizontal – Mid



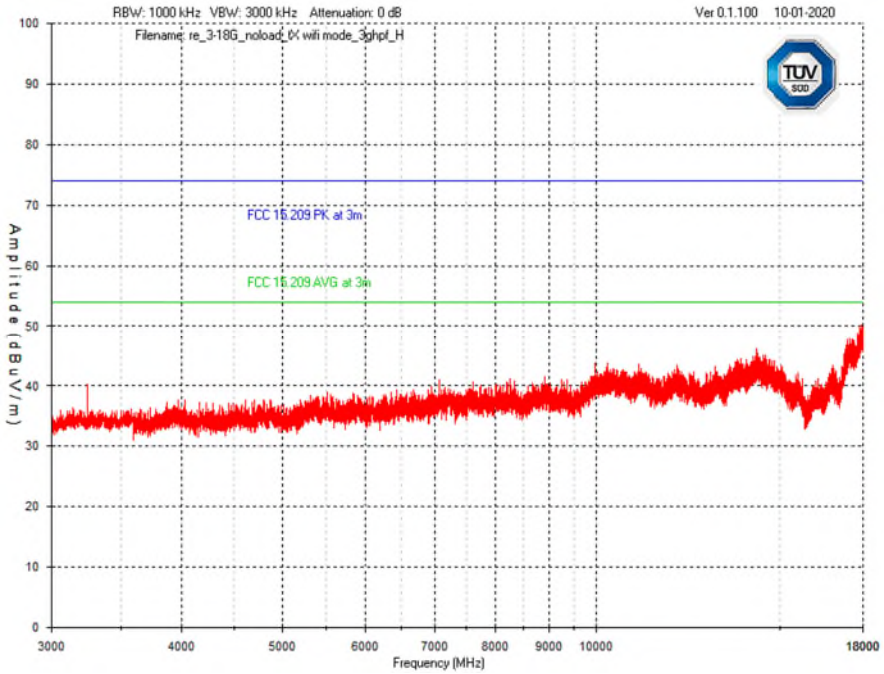
3 GHz to 25 GHz

Worst case / Representative

Vertical



Horizontal



Final Measurements and Results

The EUT passed the limits. Low, middle and high bands for each applicable modulation scheme were measured.

In accordance with 15.247(d), only frequencies exceeding the 15.209 limit that occur within the bands listed in 15.205, need to be verified with a final detector. Emission outside the restricted bands were measured for information purpose.

The measurements were maximized by rotating the turn table over a full 0-360 rotation and the antenna height was varied from 1 m to 4 m.

Where the device complied with the Quasi-Peak or Average limit, and was measured with a Peak detector, it was deemed to have met the requirement and peak data is compared to the applicable limit.

All emissions from 9 kHz to 30 MHz were instrument noise floor of the measurement instrument and below the applicable limit. No emissions were found from the EUT in this frequency range.

All emissions above 18 GHz were instrument noise floor of measurement instrument and below the applicable limit. No emissions were found from the EUT in this frequency range.

Mode	Frequency (MHz)	Detector	Received Signal (dBµV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-Amp (dB)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Test Result
	Horizontal Antenna Polarization – Low channel									
802.11b Low	2390	PEAK	42.3	28.3	16.0	-40.5	46.1	74.0	27.9	Pass
	2390	AV	N/A	28.3	16.0	-40.5		54.0	7.9	Pass
	2400	PEAK	43.3	28.4	16.0	-40.6	47.1	74.0	26.9	Pass
	2400	AV	N/A	28.4	16.0	-40.6		54.0	6.9	Pass
	2412	PEAK	96.0	28.4	16.1	-40.6	99.9			Pass
	2412	AV	89.6	28.4	16.1	-40.6	93.5			Pass
802.11g Low	2390	PEAK	43.2	28.3	16.0	-40.5	47.0	74.0	27.0	Pass
	2390	AV	N/A	28.3	16.0	-40.5		54.0	7.0	Pass
	2400	PEAK	56.9	28.4	16.0	-40.6	60.7	74.0	13.3	Pass
	2400	AV	47.9	28.4	16.0	-40.6	51.7	54.0	2.3	Pass
	2412	PEAK	93.7	28.4	16.1	-40.6	97.6			Pass
	2412	AV	84.6	28.4	16.1	-40.6	88.5			Pass
802.11n20 Low	2390	PEAK	44.9	28.3	16.0	-40.5	48.7	74.0	25.3	Pass
	2390	AV	N/A	28.3	16.0	-40.5		54.0	5.3	Pass
	2400	PEAK	55.3	28.4	16.0	-40.6	59.1	74.0	14.9	Pass
	2400	AV	45.2	28.4	16.0	-40.6	49.0	54.0	5.0	Pass
	2412	PEAK	93.3	28.4	16.1	-40.6	97.2			Pass
	2412	AV	83.6	28.4	16.1	-40.6	87.5			Pass
802.11n40 Low	2390	PEAK	44.0	28.3	16.0	-40.5	47.8	74.0	26.2	Pass
	2390	AV	N/A	28.3	16.0	-40.5		54.0	6.2	Pass
	2400	PEAK	59.5	28.4	16.0	-40.6	63.3	74.0	10.7	Pass
	2400	AV	48.9	28.4	16.0	-40.6	52.7	54.0	1.3	Pass
	2421	PEAK	93.1	28.4	16.1	-40.6	97.0			Pass
	2421	AV	82.1	28.4	16.1	-40.6	86.0			Pass
BTLE Low	2390	PEAK	46.9	28.3	16.0	-40.5	50.7	74.0	23.3	Pass
	2390	AV	N/A	28.3	16.0	-40.5		54.0	3.3	Pass
	2400	PEAK	67.6	28.4	16.0	-40.6	71.4	74.0	2.6	Pass
	2400	AV	66.8	28.4	16.0	-40.6	70.6	See note 1		Pass
	2402	PEAK	87.7	28.4	16.0	-40.6	91.5			Pass
	2402	AV	86.5	28.4	16.0	-40.6	90.3			Pass
BT 1 mbps Low	2390	PEAK	45.7	28.3	16.0	-40.5	49.5	74.0	24.5	Pass
	2390	AV	N/A	28.3	16.0	-40.5		54.0	4.5	Pass

	2400	PEAK	54.5	28.4	16.0	-40.6	58.3	74.0	15.7	Pass
	2400	AV	53.9	28.4	16.0	-40.6	57.7	See note 1		Pass
	2402	PEAK	93.9	28.4	16.0	-40.6	97.7			Pass
	2402	AV	93.4	28.4	16.0	-40.6	97.2			Pass
BT 3 mbps Low	2390	PEAK	44.9	28.3	16.0	-40.5	48.7	74.0	25.3	Pass
	2390	AV	N/A	28.3	16.0	-40.5		54.0	5.3	Pass
	2400	PEAK	57.8	28.4	16.0	-40.6	61.6	74.0	12.4	Pass
	2400	AV	56.5	28.4	16.0	-40.6	60.3	See note 1		Pass
	2402	PEAK	94.8	28.4	16.0	-40.6	98.6			Pass
	2402	AV	94.1	28.4	16.0	-40.6	97.9			Pass

Note 1: This frequency did not meet the limit defined in 15.209, however as it was not in a restricted band as listed in 15.205, and the 30 dBc requirement as applicable in 15.247 was applied.

Mode	Frequency (MHz)	Detector	Received Signal (dBµV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-Amp (dB)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Test Result
	Horizontal Antenna Polarization – mid channel									
802.11b	2437.0	PEAK	96.0	28.5	16.1	-40.5	100.1	N/A	N/A	Pass
mid	2437.0	AV	87.1	28.5	16.1	-40.5	91.2	N/A	N/A	Pass
802.11g	2437.0	PEAK	93.3	28.5	16.1	-40.5	97.4	N/A	N/A	Pass
mid	2437.0	AV	84.0	28.5	16.1	-40.5	88.1	N/A	N/A	Pass
802.11n20	2437.0	PEAK	93.1	28.5	16.1	-40.5	97.2	N/A	N/A	Pass
mid	2437.0	AV	83.7	28.5	16.1	-40.5	87.8	N/A	N/A	Pass
802.11n40	2437.0	PEAK	90.8	28.5	16.1	-40.5	94.9	N/A	N/A	Pass
mid	2437.0	AV	81.0	28.5	16.1	-40.5	85.1	N/A	N/A	Pass
BTLE	2440.0	PEAK	89.2	28.6	16.2	-40.5	93.5	N/A	N/A	Pass
mid	2440.0	AV	88.7	28.6	16.2	-40.5	93.0	N/A	N/A	Pass
BT 1 mbps	2440.0	PEAK	92.2	28.6	16.2	-40.5	96.5	N/A	N/A	Pass
mid	2440.0	AV	90.7	28.6	16.2	-40.5	95.0	N/A	N/A	Pass
BT 3 mbps	2440.0	PEAK	91.7	28.6	16.2	-40.5	96.0	N/A	N/A	Pass
mid	2440.0	AV	90.1	28.6	16.2	-40.6	94.3	N/A	N/A	Pass

Mode	Frequency (MHz)	Detector	Received Signal (dBµV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-Amp (dB)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Test Result
	Horizontal Antenna Polarization									
802.11b high	2462.0	PEAK	95.8	28.5	16.1	-40.5	99.9			Pass
	2462.0	AV	86.6	28.5	16.1	-40.5	90.7			Pass
	2483.5	PEAK	44.1	28.6	16.2	-40.6	48.3	74.0	25.7	Pass
	2483.5	AV	N/A	28.6	16.2	-40.6		54.0	5.7	Pass
802.11g high	2462.0	PEAK	93.1	28.5	16.1	-40.5	97.2			Pass
	2462.0	AV	84.2	28.5	16.1	-40.5	88.3			Pass
	2483.5	PEAK	44.4	28.6	16.2	-40.6	48.6	74.0	25.4	Pass
	2483.5	AV	N/A	28.6	16.2	-40.6		54.0	5.4	Pass
802.11n20 high	2462.0	PEAK	92.5	28.5	16.1	-40.5	96.6			Pass
	2462.0	AV	85.9	28.5	16.1	-40.5	90.0			Pass
	2483.5	PEAK	45.2	28.6	16.2	-40.6	49.4	74.0	24.6	Pass
	2483.5	AV	N/A	28.6	16.2	-40.6		54.0	4.6	Pass
802.11n40 high	2452.0	PEAK	90.3	28.5	16.1	-40.5	94.4			Pass
	2452.0	AV	81.5	28.5	16.1	-40.5	85.6			Pass
	2483.5	PEAK	45.5	28.6	16.2	-40.6	49.7	74.0	24.3	Pass
	2483.5	AV	N/A	28.6	16.2	-40.6		54.0	4.3	Pass
BTLE high	2480.0	PEAK	88.9	28.6	16.2	-40.5	93.2			Pass
	2480.0	AV	86.6	28.6	16.2	-40.5	90.9			Pass
	2483.5	PEAK	45.8	28.6	16.2	-40.6	50.0	74.0	24.0	Pass
	2483.5	AV	N/A	28.6	16.2	-40.6		54.0	4.0	Pass
BT 1 mbps high	2480.0	PEAK	89.0	28.6	16.2	-40.5	93.3			Pass
	2480.0	AV	86.6	28.6	16.2	-40.5	90.9			Pass
	2483.5	PEAK	44.1	28.6	16.2	-40.6	48.3	74.0	25.7	Pass
	2483.5	AV	N/A	28.6	16.2	-40.6		54.0	5.7	Pass
	2485.5	PEAK	43.9	28.6	16.2	-40.6	48.1	74.0	25.9	Pass
	2485.5	AV	N/A	28.6	16.2	-40.6		54.0	5.9	Pass
BT 3 mbps high	2480.0	PEAK	92.3	28.6	16.2	-40.5	96.6			Pass
	2480.0	AV	91.1	28.6	16.2	-40.5	95.4			Pass
	2483.5	PEAK	45.6	28.6	16.2	-40.6	49.8	74.0	24.2	Pass
	2483.5	AV	N/A	28.6	16.2	-40.6		54.0	4.2	Pass

Test Equipment List

Description	Make	Model number	Asset ID	Calibr. date	Calibr. due
Bilog Antenna	Teseq	6111D	SSG013955	2019-12-03	2020-12-03
Double Ridged Horn Antenna	Emco	3115	SSG012508	2020-05-11	2021-05-11
Horn Antenna (18 - 26.5 GHz)	Emco	3160-09	SSG012292	2019-08-26	2021-08-26
Horn Antenna (26.5 - 40 GHz)	Emco	3160-10	SSG012294	2019-08-26	2021-08-26
EMI Receiver	Rohde & Schwarz	ESU26	SSG013729	2020-03-19	2021-03-19
EMI Receiver	Rohde & Schwarz	ESU40	SSG013672	2019-10-08	2021-01-08
Coaxial Cable	Huber & Suhner	106A	SSG013841	2020-01-06	2021-01-06
Coaxial Cable	Huber & Suhner	106A	SSG012711	2020-01-06	2021-01-06
Coaxial Cable	Huber & Suhner	104PEA	SSG012041	2020-01-06	2021-01-06
Coaxial Cable	Huber & Suhner	ST18/Nm/ Nm/36	SSG012785	2020-01-06	2021-01-06
Coaxial Cable	Micro-Coax	UFA 210B-1-1500-504504	SSG012376	2020-01-02	2021-01-02
Coaxial Cable	Huber & Suhner	101 PEA, Sucoflex	SSG012290	2018-11-13	2020-11-13
RF Amplifier	Hewlett Packard	8447D	SSG013045	2020-01-08	2021-01-08
Pre-Amplifier	BNR	LNA	SSG012360	2019-09-26	2020-12-26
Power Supply	Hewlett Packard	6216A	SSG013063	not required	not required
Power Supply	Lambda	LPD-421A-FM	SSG013085	not required	not required
Loop Antenna	EM 6871	Electro-Metrics	GEMC 70	2019-02-15	2021-02-15
Loop Antenna	EM 6872	Electro-Metrics	GEMC 71	2019-02-15	2021-02-15

Power Spectral Density (Digitally modulated)

Purpose

The purpose of this test is to ensure that the maximum power spectral density to the radiating element does not exceed the limits specified. This ensures that the modulation is significantly wide enough, or low enough in power that it will allow for co-operation of other wireless devices operating within this frequency allocation.

Limits and Methods

The limits are defined in 15.247(e).

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

The method is given in ANSI 63.10 11.10.2 Method PKPSD as worst case.

Results

The EUT passed. The EUT was set to transmit at maximum power. Three Channels were measured. The following tables show the peak power spectral density: External attenuator and cable loss were accounted for as reference offset in the spectrum analyzer.

PSD 802.11b				
Channel	Frequency (MHz)	PSD/3kHz (dBm)	Limit (dBm/3kHz)	Pass/Fail
1	2412	-12.31	8	Pass
6	2437	-12.36	8	Pass
11	2462	-12.86	8	Pass

PSD 802.11g				
Channel	Frequency (MHz)	PSD/3kHz (dBm)	Limit (dBm/3kHz)	Pass/Fail
1	2412	-18.6	8	Pass
6	2437	-18.24	8	Pass
11	2462	-18.58	8	Pass

PSD 802.11n (20 Mbps)				
Channel	Frequency (MHz)	PSD/3kHz (dBm)	Limit (dBm/3kHz)	Pass/Fail
1	2412	-17.75	8	Pass
6	2437	-17.84	8	Pass
11	2462	-18.2	8	Pass

PSD 802.11 (40 Mbps)				
Channel	Frequency (MHz)	PSD/3kHz (dBm)	Limit (dBm/3kHz)	Pass/Fail
1	2412	-19.1	8	Pass
6	2437	-19.42	8	Pass
11	2462	-19.34	8	Pass

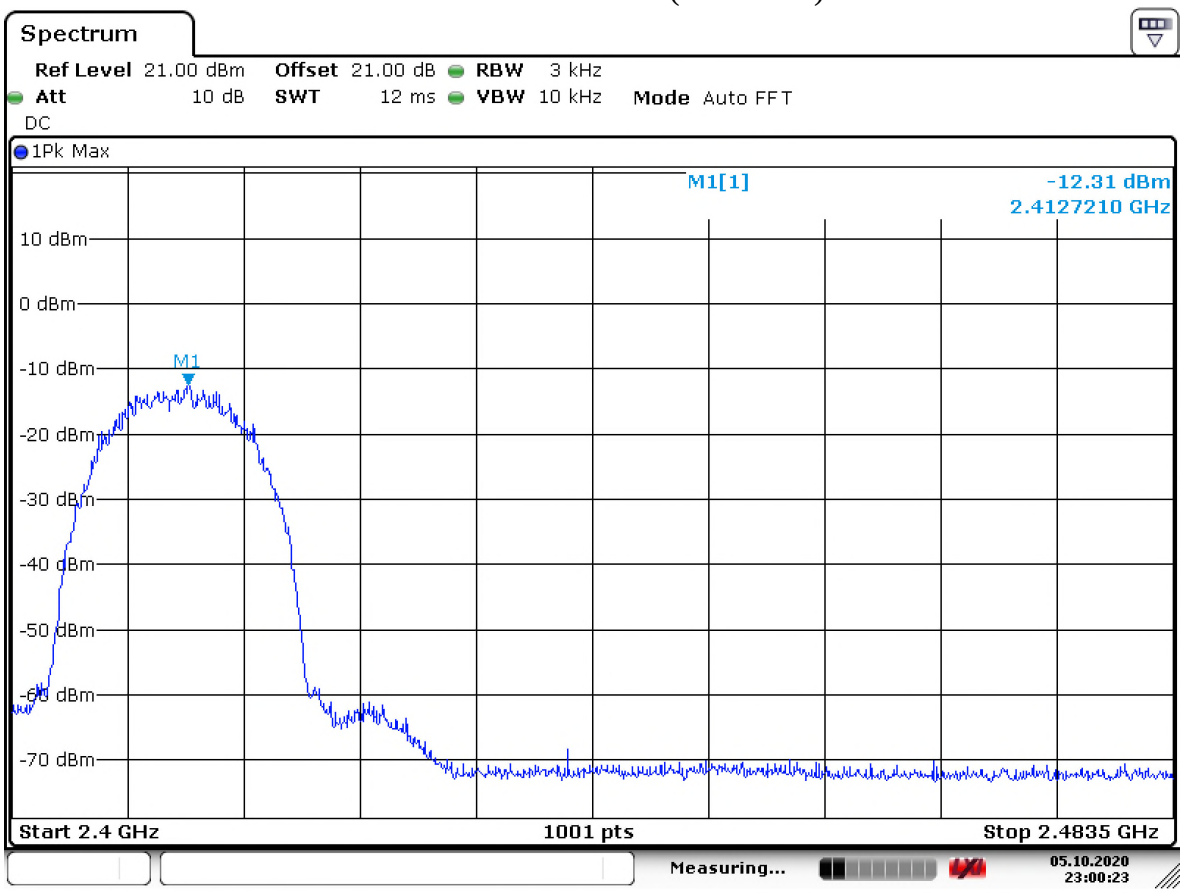
BTLE				
Channel	Frequency (MHz)	PSD/3kHz (dBm)	Limit (dBm/3kHz)	Pass/Fail
37	2402	-13.36	8	Pass
17	2440	-13.34	8	Pass
39	2480	-13.57	8	Pass

Graph(s)

The graphs shown below show the power spectral density of the device. This is measured by a max hold on the spectrum analyzer using a RBW of 3 kHz. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

Low, middle, and high channel for each mode was investigated in each mode, with the worst case being presented.

Peak Power Spectral Density
802.11b - Low Channel (worst case)



Date: 5.OCT.2020 23:00:23

Measurement Uncertainty

The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is ±2.67dB for with a 'k=2' coverage factor and a 95% confidence level.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration / Verification date	Next calibration/ Verification due date	Asset #
Spectrum Analyzer	FSV40	Rhode & Schwarz	4/1/19	4/1/21	SSG013948
Attenuator 1,3,6,10,20, 30 dB	9414-1	Api / Weinshel	NCR	NCR	GEMC 279

This report module is based

Power Line Conducted Emissions

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT's power line does not exceed the limits listed below as defined in the applicable test standard and measured from a LISN. This helps protect lower frequency radio services such as AM radio, shortwave radio, amateur radio, maritime radio, CB radio, and so on, from unwanted interference.

Limits & Method

The method is as defined in ANSI C63.10. The limits are as defined in FCC Part 15 Section 15.207 and RSS-GEN:

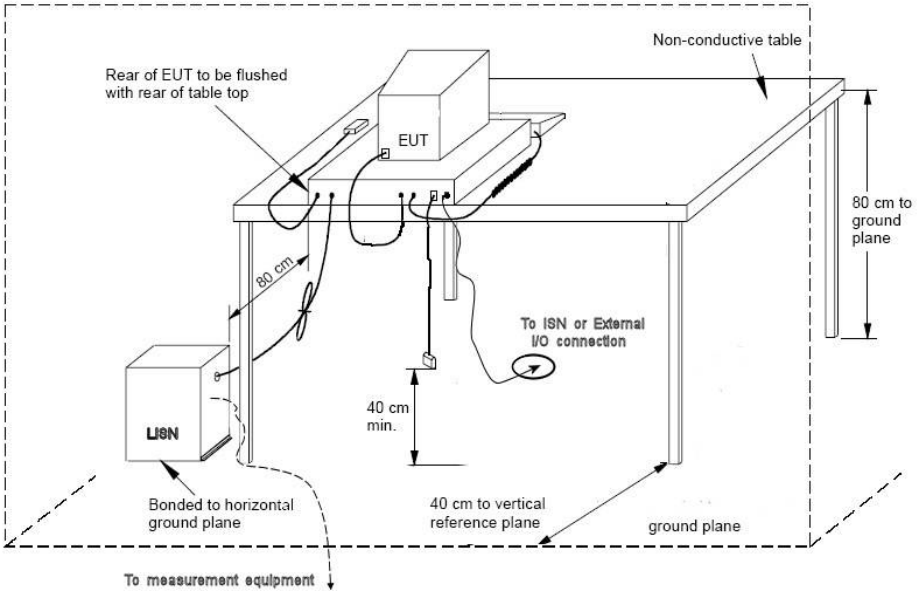
Average Limits		Quasi-Peak Limits	
150 kHz – 500 kHz	56 to 46* dBµV	150 kHz – 500 kHz	66 to 56* dBµV
500 kHz – 5 MHz	46 dBµV	500 kHz – 5 MHz	56 dBµV
5 MHz – 30 MHz	50 dBµV	5 MHz – 30 MHz	60 dBµV

* Decreases linearly with the logarithm of the frequency

Both Quasi-Peak and Average limits are applicable, and each is specified as being measured with a resolution bandwidth of 9 kHz. For Quasi-Peak, a video bandwidth at least three times greater than the resolution bandwidth is used.

If the Peak or Quasi-Peak detector measurements do not exceed the Average limits, then the EUT is deemed to have passed the requirements.

Typical Setup Diagram



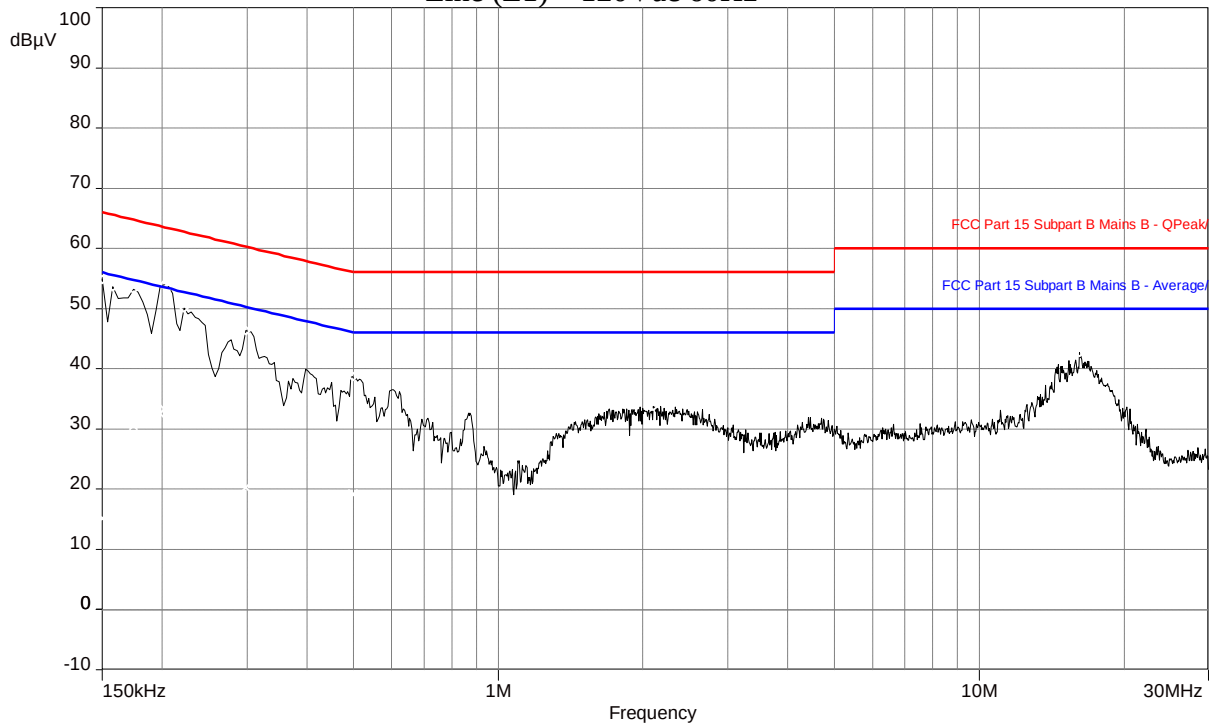
Measurement Uncertainty

The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is ±2.27dB with a 'k=2' coverage factor and a 95% confidence level.

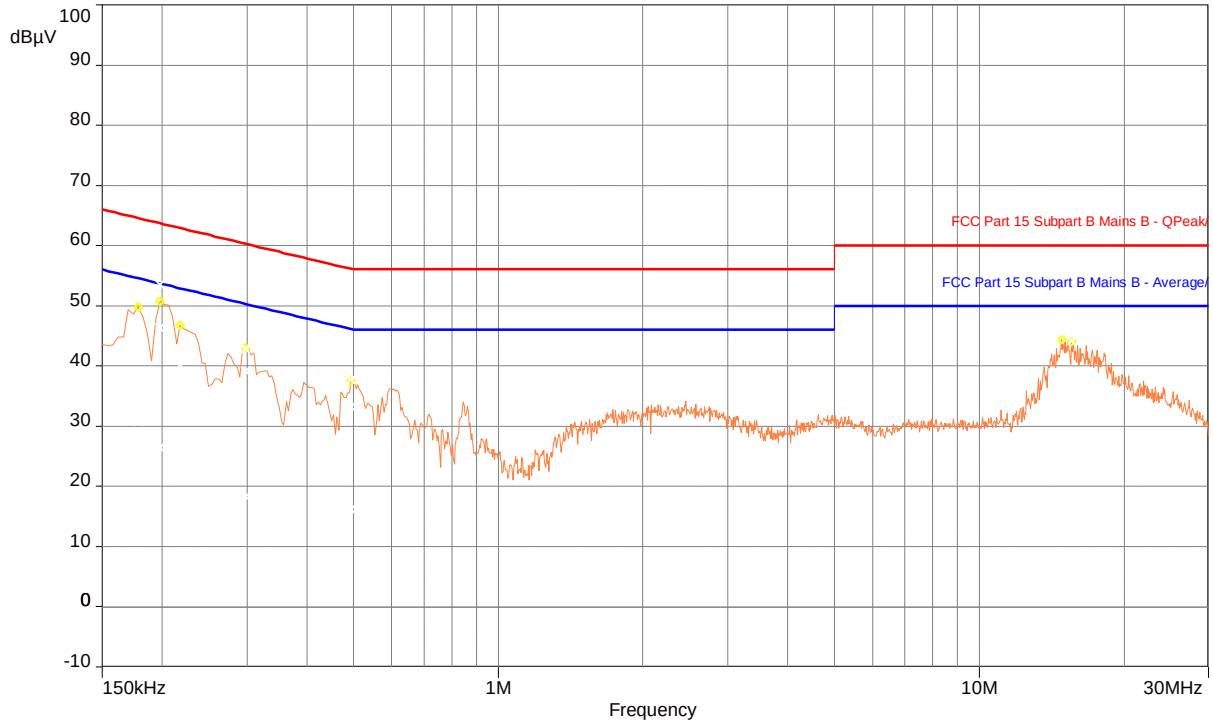
Preliminary Graphs

The graphs shown below are maximized peak measurement graphs measured with a resolution bandwidth greater than or equal to the final required detector. This peaking process is done as a worst case measurement and enables the detection of frequencies of concern for final measurement. For final measurements with the appropriate detector, where applicable, please refer to the tables under Final Measurements.

Line (L1) – 120Vac 60Hz



Neutral (L2) – 120Vac 60Hz



Final Measurements

Line 1

Freq (MHz)	Level Avg (dBµV)	Level QP (dBµV)	Level Peak (dBµV)	Margin AVG (dB)	Margin QP (dB)	Limit AVG (dBuV)	Limit QP (dBuV)	Corrections (dB)
0.145518	15.21	19.66	29.91	-40.79	-46.34	56.00	66.00	9.91
0.158414	25.53	42.71	57.34	-30.04	-22.86	55.57	65.57	9.91
0.173064	30.55	47.62	59.52	-24.22	-17.14	54.77	64.77	9.92
0.199318	32.56	49.72	52.56	-21.13	-13.98	53.69	63.69	9.94
0.201752	33.34	49.47	56.90	-20.19	-14.06	53.53	63.53	9.94
0.222648	26.88	44.16	52.40	-25.87	-18.58	52.74	62.74	9.95
0.296272	20.23	40.31	46.97	-30.07	-19.99	50.30	60.30	9.97
0.496362	19.21	33.45	37.87	-26.82	-22.58	46.03	56.03	10.00
2.104682	18.52	28.02	34.00	-27.48	-27.98	46.00	56.00	10.04
16.19261	25.49	34.38	43.27	-24.51	-25.62	50.00	60.00	10.37

Line 2

Freq (MHz)	Level Avg (dBµV)	Level QP (dBµV)	Level Peak (dBµV)	Margin AVG (dB)	Margin QP (dB)	Limit AVG (dBuV)	Limit QP (dBuV)	Corrections (dB)
0.177676	29.08	46.20	55.59	-25.50	-18.38	54.58	64.58	9.99
0.196218	26.44	46.31	53.47	-27.25	-17.38	53.69	63.69	9.99
0.217424	21.39	39.89	47.87	-31.51	-23.00	52.89	62.89	9.99
0.296308	18.30	39.10	42.82	-32.00	-21.19	50.30	60.30	9.99
0.49391	16.20	33.21	37.72	-29.90	-22.89	46.10	56.10	10.00
14.83043	22.26	34.89	45.43	-27.74	-25.11	50.00	60.00	10.34
15.57019	23.03	34.26	44.08	-26.97	-25.74	50.00	60.00	10.36

See 'Appendix B – EUT, Peripherals and Test Setup Photos' for photos showing the test set-up for the highest line conducted emission

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Spectrum Analyzer	ESU26	Rohde & Schwarz	Mar 19, 2020	Mar 19, 2021	SSG013729
LISN	FCC-LISN-50/250-16-2-01	FCC	Feb. 27, 2019	Feb. 27, 2021	GEMC 303
RF Cable 3m	LMR-400-3M-50Ω-MN-MN	LexTec	NCR	NCR	GEMC 276
Attenuator 10 dB	10-A-MFN-10	Bird/Hutton	NCR	NCR	GEMC 323
Emissions Software	0.1.99	TUV SUD Canada, Inc.	NCR	NCR	GEMC 58

This report module is based on report template 'FCC_ICES003_CE_Rev1'

Appendix A – EUT Summary

For further details for filing purposes, refer to filing package.

General EUT Description

Client	
Organization / Address	Swidget Corp..
Contact	
Phone	
Email	
EUT Details	
EUT Name	
FCC ID	
Industry Canada #	
Equipment Category	Low power wireless transceiver
Basic EUT Functionality	EUT is a 2.4 GHz wireless module
Peripherals Required for Test	None
Release type	Final
Intentional Radiator Frequency	2400 – 2483.5 MHz DM and FHSS
EUT Configuration	Wireless configured to transmit continuously at 100% duty cycle

Note the EUT is considered to have been received the date of the commencement of the first test, unless otherwise stated. For a close-up picture of the EUT, see 'Appendix B – EUT and Test Setup Photos'.

EUT Configuration

Please see Appendix B for a picture of the unit running in normal conditions.

- Wireless were configured to transmit at maximum possible duty cycle

Operational Setup

These devices are required to be attached to the EUT for its normal operation.

- A debug host was connected to the EUT via a 10 cm cable to issue test commands and to power it.
- Radiated emissions were tested with 10 cm cable from to provide separation from a representative host.

Appendix B – EUT and Test Setup Photos

Refer to the photo exhibit provided separate from this test report