



# TEST REPORT

**Test Report No. :** UL-RPT-RP12447929-316A V3.0

**Customer** : Grundium Oy

**Model No. / HMN** : OCUS

**FCC ID** : Contains FCC ID: 2AQ5IOCUS1

**ISED Certification No.** : Contains IC: 24290-OCUS1

**Technology** : WLAN

**Test Standard(s)** : FCC Parts 15.205(a), 15.209(a) & 15.407(b)  
ISED Canada RSS-247 6.2.1.2, 6.2.2.2 &  
RSS-Gen 6.13, 8.9 & 8.10

**Test Laboratory** : UL VS LTD, Basingstoke, Hampshire, RG24 8AH, United Kingdom

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2. The results in this report apply only to the sample(s) tested.
3. The sample tested is in compliance with the above standard(s).
4. The test results in this report are traceable to the national or international standards.
5. Version 3.0 supersedes all previous versions.

**Date of Issue:** 27 March 2019

**Checked by:**

Ben Mercer  
Senior Test Engineer, Radio Laboratory

**Company Signatory:**

Sarah Williams  
Senior Test Engineer, Radio Laboratory  
UL VS LTD



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## UL VS LTD

Pavilion A, Ashwood Park, Ashwood Way, Basingstoke, Hampshire, RG23 8BG, UK  
Telephone: +44 (0)1256 312000  
Facsimile: +44 (0)1256 312001

**Customer Information**

<b>Company Name:</b>	Grundium Oy
<b>Address:</b>	Hermiankatu 6-8, Building F, Tampere, 33720 Finland

**Report Revision History**

<b>Version Number</b>	<b>Issue Date</b>	<b>Revision Details</b>	<b>Revised By</b>
1.0	13/03/2019	Initial Version	Ben Mercer
2.0	21/03/2019	Admin update	Ben Mercer
3.0	27/03/2019	Antenna gain corrected	Ben Mercer

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## 1. Attestation of Test Results





### 1.1. Description of EUT

The equipment under test was a digital microscope scanner that contains a FCC / ISED Canada certified 2.4 GHz and 5 GHz WLAN module (FCC ID: 2AQ5IOCUS1 and IC: 24290-OCUS1).

### 1.2. General Information

<b>Specification Reference:</b>	47CFR15.407
<b>Specification Title:</b>	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart E (Unlicensed National Information Infrastructure Devices) – Section 15.407
<b>Specification Reference:</b>	47CFR15.209
<b>Specification Title:</b>	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.209
<b>Specification Reference:</b>	RSS-Gen Issue 5 April 2018
<b>Specification Title:</b>	General Requirements for Compliance of Radio Apparatus
<b>Specification Reference:</b>	RSS-247 Issue 2 February 2017
<b>Specification Title:</b>	Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
<b>FCC Test Firm Registration No.:</b>	621311
<b>ISED Canada Site Registration No.:</b>	3245B-2 & 3245B-3
<b>Test Dates:</b>	28 February 2019 to 06 March 2019

### 1.3. Summary of Test Results

FCC Reference (47CFR)	ISED Canada Reference	Measurement	Result
15.35(c)	RSS-Gen 8.2	Transmitter Duty Cycle	Note 1
15.209(a) / 15.407(b)	RSS-Gen 6.13, 8.9 & 8.10 / RSS-247 6.2.1.2 & 6.2.2.2	Transmitter Out of Band Radiated Emissions	
15.209(a) / 15.407(b)	RSS-Gen 6.13, 8.9 & 8.10 / RSS-247 6.2.1.2 & 6.2.2.2	Transmitter Band Edge Radiated Emissions	
<b>Key to Results</b>  = Complied  = Did not comply			

#### Note(s):

1. The measurement was performed to assist in the calculation of the level of average emissions as the EUT employs pulsed operation.

**1.4. Deviations from the Test Specification**

For the measurements contained within this test report, there were no deviations from, additions to, or exclusions from the test specifications identified above.

## **2. Summary of Testing**

### **2.1. Facilities and Accreditation**

The test site and measurement facilities used to collect data are located at Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom. The following table identifies which facilities were utilised for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

Site 1	X
Site 2	-
Site 17	X

UL VS LTD is accredited by UKAS. The tests reported herein have been performed in accordance with its terms of accreditation.

### **2.2. Methods and Procedures**

<b>Reference:</b>	ANSI C63.10-2013
<b>Title:</b>	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
<b>Reference:</b>	KDB 789033 D02 General U-NII Test Procedures New Rules v02r01 December 14, 2017
<b>Title:</b>	Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices (Part 15, Subpart E)

## **2.3. Calibration and Uncertainty**

### **Measuring Instrument Calibration**

In accordance with UKAS requirements all the measurement equipment is on a calibration schedule. All equipment was within the calibration period on the date of testing.

### **Measurement Uncertainty**

No measurement or test can ever be perfect and the imperfections give rise to error of measurement in the results. Consequently the result of a measurement is only an approximation to the value measured (the specific quantity subject to measurement) and is only complete when accompanied by a statement of the uncertainty of the approximation.

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

The uncertainty of the result may need to be taken into account when interpreting the measurement results.

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor such that a confidence level of approximately 95% is maintained. For the purposes of this document "approximately" is interpreted as meaning "effectively" or "for most practical purposes".

Measurement Type	Range	Confidence Level (%)	Calculated Uncertainty
Duty Cycle	5150 MHz to 5350 MHz	95%	±1.14 %
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±4.65 dB
Radiated Spurious Emissions	1 GHz to 40 GHz	95%	±2.94 dB

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty the published guidance of the appropriate accreditation body is followed.

## 2.4. Test and Measurement Equipment

### Test Equipment Used for Transmitter Duty Cycle

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	JM Handelspunkt	608-H1	45124934	06 Jan 2019	12
K0001	3m RSE Chamber	Rainford EMC	N/A	N/A	04 Oct 2019	12
A3155	Pre Amplifier	Com-Power	PAM-118A	18040037	14 Sep 2019	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	17 Apr 2019	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	03 Oct 2019	12

### Test Equipment Used for Transmitter Radiated Emissions

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2040	Thermohygrometer	Testo	608-H1	45124934	06 Jan 2020	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	04 Oct 2019	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	17 Apr 2019	12
A3155	Amplifier	Com-Power	PAM-118A	18040037	14 Sep 2019	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	03 Oct 2019	12
A2523	Attenuator	AtlanTecRF	AN18W5-10	832827#1	04 Mar 2020	12
A3139	Antenna	Schwarzbeck	HWRD750	00027	04 Oct 2019	12
A3095	High Pass Filter	AtlanTecRF	AFH-07000	18051600012	29 Jun 2019	12
A3141	Pre Amplifier	Schwarzbeck	BBV 9718 B	00021	21 Nov 2019	12
A2896	Antenna	Schwarzbeck	BBV 9721	9721 – 023	08 Feb 2020	12
A2895	Antenna	Schwarzbeck	BBHA 9170	9170-728	08 Feb 2020	12
M1630	Test Receiver	Rohde & Schwarz	ESU40	100233	20 Sep 2019	12
M2003	Thermohygrometer	Testo	608-H1	45046641	06 Jan 2020	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	16 Feb 2020	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	10 Aug 2019	12
A490	Antenna	Chase	CBL6111A	1590	03 Apr 2019	12
A3167	Pre Amplifier	Com-Power	PAM-103	18020010	11 Feb 2020	12
A2131	Low Pass Filter	AtlanTecRF	AFL-02000	JFB1004-002	20 Feb 2020	12



**Test and Measurement Equipment (continued)****Test Equipment Used for Transmitter Band Edge Radiated Emissions**

<b>Asset No.</b>	<b>Instrument</b>	<b>Manufacturer</b>	<b>Type No.</b>	<b>Serial No.</b>	<b>Date Calibration Due</b>	<b>Cal. Interval (Months)</b>
M2040	Thermohygrometer	JM Handelspunkt	608-H1	45124934	06 Jan 2019	12
K0001	3m RSE Chamber	Rainford EMC	N/A	N/A	04 Oct 2019	12
A3155	Pre Amplifier	Com-Power	PAM-118A	18040037	14 Sept 2019	12
M2044	Test Receiver	Rohde & Schwarz	ESU26	100122	17 Apr 2019	12
A3138	Antenna	Schwarzbeck	BBHA 9120 B	00702	03 Oct 2019	12
A2141	Attenuator	AtlanTecRF	AN18-10	090918-04	08 Mar 2019	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	16 Feb 2020	12
M2003	Thermohygrometer	Testo	608-H1	45046641	06 Jan 2020	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	10 Aug 2019	12
A2948	Pre Amplifier	Com-Power	PAM-118A	551087	12 Feb 2020	12
A2889	Antenna	Schwarzbeck	BBHH 9120 B	BBHA 9120 B 653	12 Feb 2020	12
A2916	Attenuator	AtlantecRF	AN18W5-10	832827#1	20 Feb 2020	12

### **3. Equipment Under Test (EUT)**

#### **3.1. Identification of Equipment Under Test (EUT)**

<b>Brand Name:</b>	Grundium Oy
<b>Model No. / HMN:</b>	OCUS
<b>Test Sample Serial Number:</b>	MGU-00001-000035 ( <i>Radiated sample</i> )
<b>Hardware Version:</b>	A.02.02.02
<b>Software Version:</b>	1.0.146
<b>FCC ID:</b>	Contains FCC ID: 2AQ5IOCUS1
<b>ISED Certification Number:</b>	Contains IC: 24290-OCUS1

#### **3.2. Modifications Incorporated in the EUT**

No modifications were applied to the EUT during testing.

#### **3.3. Additional Information Related to Testing**

<b>Technology Tested:</b>	WLAN (IEEE 802.11a,n,ac) / U-NII / LE-LAN	
<b>Type of Unit:</b>	Transceiver	
<b>Modulation:</b>	BPSK, QPSK, 16QAM, 64QAM & 256QAM	
<b>Data rates:</b>	802.11a	6, 9, 12, 18, 24, 36, 48 & 54 Mbit/s
	802.11n HT20	MCS0 to MCS7 (SISO)
	802.11n HT40	MCS0 to MCS7 (SISO)
	802.11ac VHT20	MCS0 to MCS8 (SISO)
	802.11ac VHT40	MCS0 to MCS9 (SISO)
	802.11ac VHT80	MCS0 to MCS9 (SISO)
<b>Power Supply Requirement(s):</b>	Nominal	12.0 VDC via 120 VAC 60 Hz adaptor

**Additional Information Related to Testing (continued)**

<b>Channel Spacing:</b>	20 MHz		
<b>Transmit Frequency Band:</b>	5150 MHz to 5250 MHz		
<b>Transmit Channels Tested:</b>	<b>Channel ID</b>	<b>Channel Number</b>	<b>Channel Frequency (MHz)</b>
	Bottom	36	5180
	Top	48	5240
<b>Transmit Frequency Band:</b>	5250 MHz to 5350 MHz		
<b>Transmit Channels Tested:</b>	<b>Channel ID</b>	<b>Channel Number</b>	<b>Channel Frequency (MHz)</b>
	Bottom	52	5260
	Top	64	5320
<b>Channel Spacing:</b>	40 MHz		
<b>Transmit Frequency Band:</b>	5150 MHz to 5250 MHz		
<b>Transmit Channels Tested:</b>	<b>Channel ID</b>	<b>Channel Number</b>	<b>Channel Frequency (MHz)</b>
	Bottom	38	5190
<b>Transmit Frequency Band:</b>	5250 MHz to 5350 MHz		
<b>Transmit Channels Tested:</b>	<b>Channel ID</b>	<b>Channel Number</b>	<b>Channel Frequency (MHz)</b>
	Top	62	5310
<b>Channel Spacing:</b>	80 MHz		
<b>Transmit Frequency Band:</b>	5150 MHz to 5250 MHz		
<b>Transmit Channels Tested:</b>	<b>Channel ID</b>	<b>Channel Number</b>	<b>Channel Frequency (MHz)</b>
	Single	42	5210
<b>Transmit Frequency Band:</b>	5250 MHz to 5350 MHz		
<b>Transmit Channels Tested:</b>	<b>Channel ID</b>	<b>Channel Number</b>	<b>Channel Frequency (MHz)</b>
	Single	58	5290

### **3.4. Description of Available Antennas**

The EUT incorporates 2 integrated antennas.

The antenna assembly consists of a feed board and an antenna board. The EUT chassis runs between the boards and is connected to ground. 2 Pogo pins carry RF from the feed board to the antenna board through holes in the EUT chassis. The antenna board contains 2 PCB stripe antennas. Antenna 1 is used for diversity (Rx only). Antenna 2 is the transmitting antenna, and has the following maximum gain:

<b>Manufacturer</b>	<b>Model</b>	<b>Type</b>	<b>Frequency Range (MHz)</b>	<b>Antenna Gain (dBi)</b>
Radiantum Oy	Not stated	Dipole (Integrated)	5150 to 5350	-4.8

### **3.5. Description of Test Setup**

#### **Support Equipment**

The following support equipment was used to exercise the EUT during testing:

<b>Brand Name:</b>	Lenovo
<b>Description:</b>	Laptop
<b>Model Name or Number:</b>	L480
<b>Serial Number:</b>	PF1EHZQQ

<b>Brand Name:</b>	Asus
<b>Description:</b>	Ethernet Router
<b>Model Name or Number:</b>	RT-AX88U
<b>Serial Number:</b>	JBIUHP000173

<b>Brand Name:</b>	Not Stated
<b>Description:</b>	Ethernet Cable. Length 2 m. Quantity 1.
<b>Model Name or Number:</b>	Not Stated
<b>Serial Number:</b>	Not Stated

<b>Brand Name:</b>	Maplin
<b>Description:</b>	USB Cable. Length 2 m. Quantity 1.
<b>Model Name or Number:</b>	Not Stated
<b>Serial Number:</b>	Not Stated

<b>Brand Name:</b>	Belkin
<b>Description:</b>	USB Hub
<b>Model Name or Number:</b>	F5U 404-BLK
<b>Serial Number:</b>	Not Stated

<b>Brand Name:</b>	XP Power
<b>Description:</b>	AC/DC Power Adapter
<b>Model Name or Number:</b>	AFM45US12
<b>Serial Number:</b>	1727-01442

## **Operating Modes**

The EUT was tested in the following operating mode(s):

- Continuously transmitting with a modulated carrier at maximum power on bottom, middle and top channels as required using the supported data rates/modulation types.

## **Configuration and Peripherals**

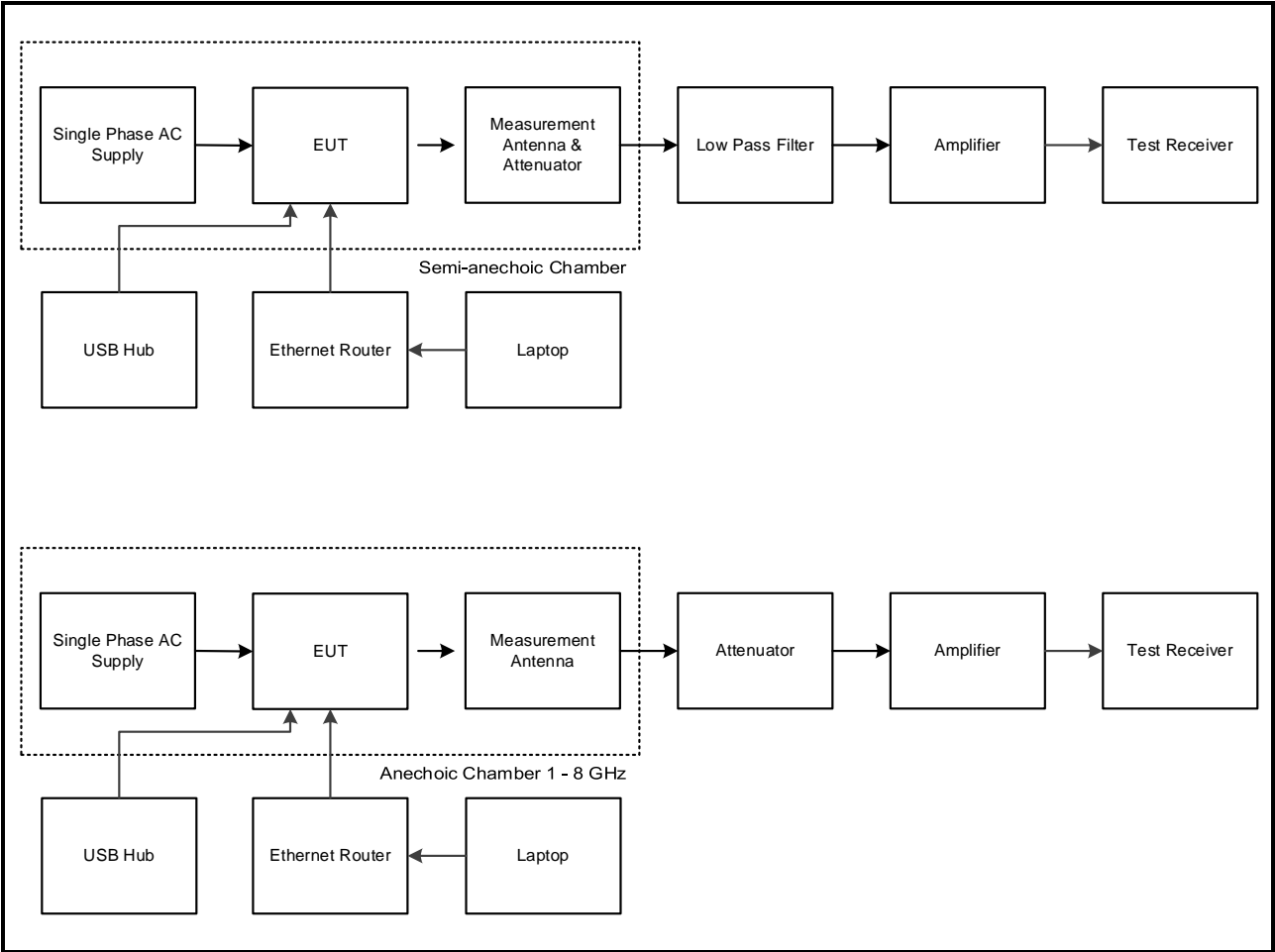
The EUT was tested in the following configuration(s):

- The customer requested the following worst case data rates to be used for all measurements:
  - 802.11a / SISO / BPSK / 6 Mbit/s
  - 802.11n HT20 / SISO / BPSK / MCS0
  - 802.11n HT40 / SISO / BPSK / MCS0
  - 802.11ac VHT80 / SISO / BPSK / MCS0
- The EUT has two separate antennas which correspond to two separate antenna ports. Port 1 and Port 2 correspond to antenna 1 and antenna 2 respectively. Only Port 2 is an active transmitter.
- Transmitter spurious emissions were performed with the EUT transmitting with a data rate of 6 Mbit/s (802.11a). This was found to be the worst case modulation scheme with regards to emissions after preliminary investigations and, as this mode emits the highest transmit output power level, it was deemed to be the worst case.
- The EUT was powered from an AC/DC power adapter connected to a 120 VAC 60 Hz single phase mains supply.
- Transmitter radiated spurious emissions tests were performed with the AC/DC power adapter connected to the EUT, and the USB and Ethernet ports terminated.
- The customer supplied instructions for controlling the device in a document titled "WLAN\_TX\_Commands.docx".
- For 802.11a modes, testing was performed using the power settings defined in the customer supplied document titled "Jetson\_TX2\_WWSafe\_Power\_Q\_Table.pdf".
- For all other modes, testing was performed using the higher power settings provided in "WLAN\_TX\_Commands.docx".

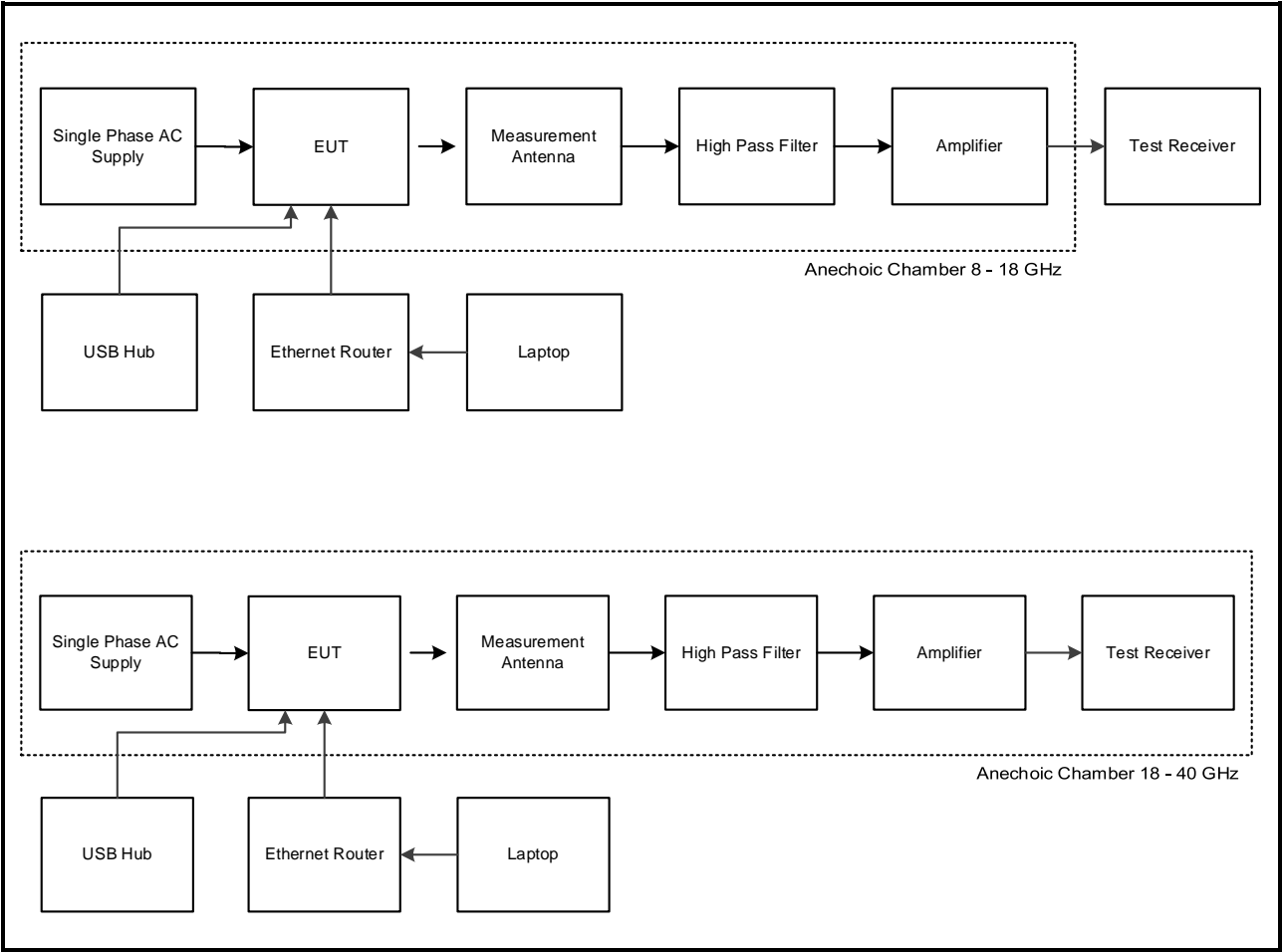
Test Setup Diagrams

Radiated Tests:

Test Setup for Transmitter Radiated Emissions



Test Setup for Transmitter Radiated Emissions (continued)





## **4. Radiated Test Results**

### **4.1. Transmitter Duty Cycle**

#### **Test Summary:**

<b>Test Engineer:</b>	Mark Perry	<b>Test Date:</b>	02 March 2019
<b>Test Sample Serial Number:</b>	MGU-00001-000035		

<b>FCC Reference:</b>	Part 15.35(c)
<b>ISED Canada Reference:</b>	RSS-Gen 8.2
<b>Test Method Used:</b>	KDB 789033 D02 Section II.B.2.b)

#### **Environmental Conditions:**

<b>Temperature (°C):</b>	21
<b>Relative Humidity (%):</b>	40

#### **Note(s):**

1. In order to assist with the determination of the average level of fundamental and spurious emissions field strength, measurements were made of duty cycle to determine the transmission duration and the silent period time of the transmitter. The transmitter duty cycle was measured using a spectrum analyser in the time domain and calculated by using the following calculation:

$$10 \log 1 / (\text{On Time} / [\text{Period or } 100\text{ms whichever is the lesser}]).$$

$$802.11a \text{ 20MHz / SISO / 6 Mbit/s duty cycle: } 10 \log (1 / (1.4293/1.5335)) = 0.3$$

$$802.11n \text{ HT20 / SISO / MCS0 duty cycle: } 10 \log (1 / (1.3381/1.4383)) = 0.3$$

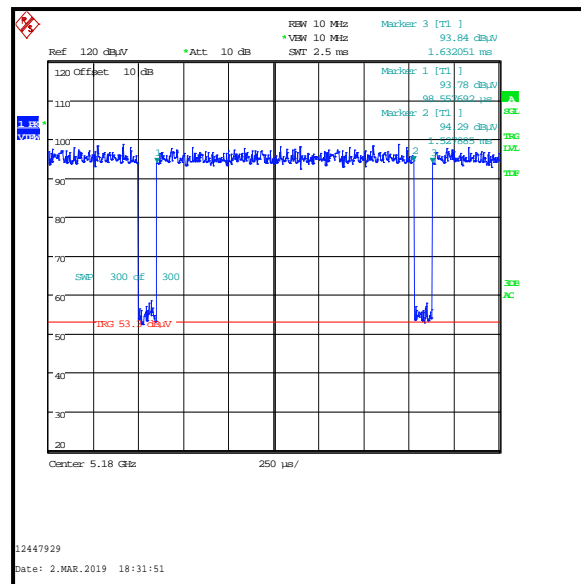
$$802.11n \text{ HT40 / SISO / MCS0 duty cycle: } 10 \log (1 / (0.6611/0.7620)) = 0.6$$

$$802.11ac \text{ VHT80 / SISO / MCS0 duty cycle: } 10 \log (1 / (0.3309/0.4327)) = 1.2$$

### Transmitter Duty Cycle (continued)

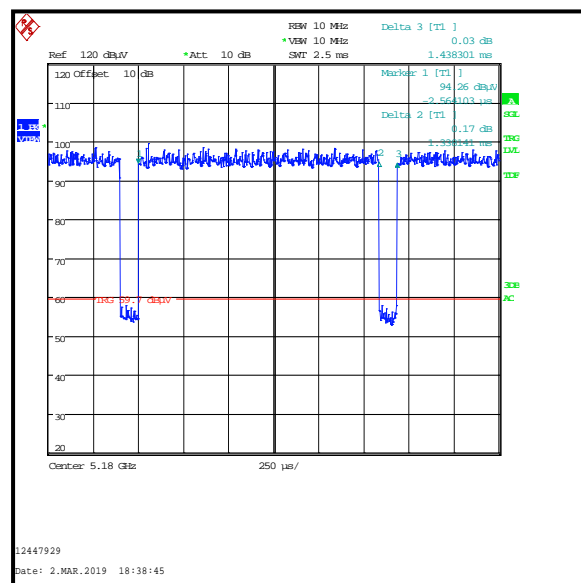
**Results: 802.11a / 20 MHz / SISO / 6 Mbit/s**

Pulse Duration (ms)	Period (ms)	Duty Cycle (dB)
1.4293	1.5335	0.3



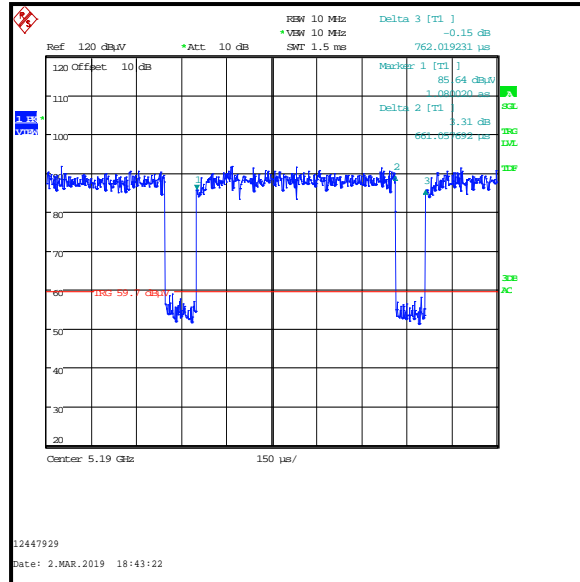
**Results: 802.11n / 20 MHz / SISO / MCS0**

Pulse Duration (ms)	Period (ms)	Duty Cycle (dB)
1.3381	1.4383	0.3

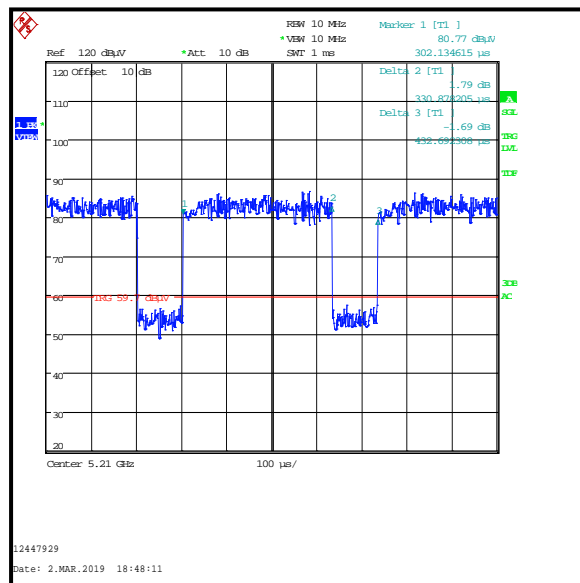


**Transmitter Duty Cycle (continued)****Results: 802.11n / 40 MHz / SISO / MCS0**

Pulse Duration (ms)	Period (ms)	Duty Cycle (dB)
0.6611	0.7620	0.6

**Results: 802.11ac / 80 MHz / SISO / MCS0**

Pulse Duration (ms)	Period (ms)	Duty Cycle (dB)
0.3309	0.4327	1.2



## 4.2. Transmitter Out of Band Radiated Emissions <1 GHz

### Test Summary:

Test Engineer:	Marco Zunarelli	Test Date:	28 February 2019
Test Sample Serial Number:	MGU-00001-000035		

FCC Reference:	Parts 15.407(b)(2),(6),(7) & 15.209(a)
ISED Canada Reference:	RSS-Gen 6.13, 8.9 & RSS-247 6.2.2.2
Test Method Used:	KDB 789033 II.G. & ANSI C63.10 Sections 6.3 and 6.5
Frequency Range:	30 MHz to 1000 MHz

### Environmental Conditions:

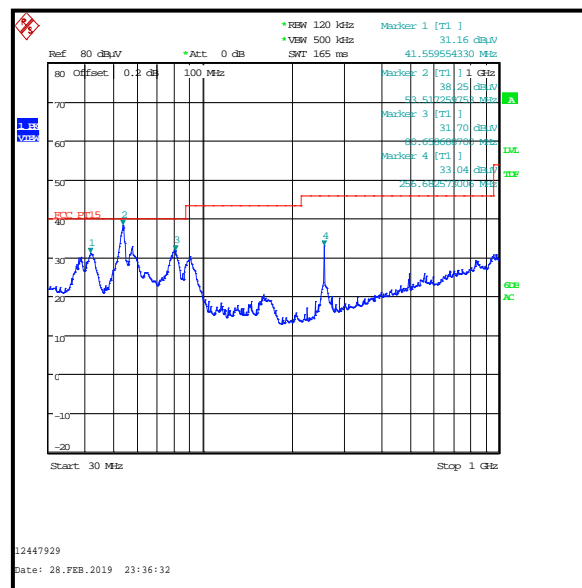
Temperature (°C):	24
Relative Humidity (%):	38

### Note(s):

1. The final measured value, for the given emission in the field strength result tables, incorporates the calibrated antenna factor and cable loss.
2. Pre-scans were performed with the EUT transmitting in the band 5.25 to 5.35 GHz band with a data rate of 802.11a / SISO / 6 Mbit/s on top channel in this band as it produced the highest power spectral density and was therefore deemed worst case. An enquiry was made to the FCC and the response was pre-scans could be performed in the band with the highest power spectral density and all final measurements should be performed on any emission seen in each band.
3. The preliminary scans showed similar emission levels below 1 GHz, for each channel of operation. Therefore final radiated emissions measurements were performed with the EUT set to the top channel only.
4. All other emissions shown on the pre-scan were investigated and found to be ambient, or >20 dB below the applicable limit or below the measurement system noise floor.
5. Measurements below 1 GHz were performed in a semi-anechoic chamber (Asset Number K0017) at a distance of 3 metres. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
6. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 120 kHz and video bandwidth 500 kHz. The sweep time was set to auto. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.
7. Final measurements were performed on the marker frequencies and the results entered into the table below. The test receiver resolution bandwidth was set to 120 kHz, using a CISPR quasi-peak detector and span wide enough to see the whole emission.

**Transmitter Out of Band Radiated Emissions (5.25-5.35 GHz band operation) (continued)****Results: Quasi-Peak / Top Channel / 802.11a / SISO / BPSK / 6 Mbit/s**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
38.415	Vertical	24.7	40.0	15.3	Complied
53.676	Vertical	31.3	40.0	8.7	Complied
78.866	Vertical	26.2	40.0	13.8	Complied
59.214	Vertical	27.4	40.0	12.6	Complied
90.762	Vertical	25.6	43.5	17.9	Complied
256.001	Vertical	31.2	46.0	14.8	Complied



Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

**4.3. Transmitter Out of Band Radiated Emissions >1 GHz****4.3.1. 5.15-5.25 GHz band****Transmitter Out of Band Radiated Emissions (5.15-5.25 GHz band operation)****Test Summary:**

<b>Test Engineer:</b>	Marco Zunarelli	<b>Test Dates:</b>	28 February 2019 & 06 March 2019
<b>Test Sample Serial Number:</b>	MGU-00001-000035		

<b>FCC Reference:</b>	Parts 15.407(b)(1),(7) & 15.209(a)
<b>ISED Canada Reference:</b>	RSS-Gen 6.13, 8.9, 8.10 & RSS-247 6.2.1.2
<b>Test Method Used:</b>	KDB 789033 II.G. & ANSI C63.10 Sections 6.3 and 6.6
<b>Frequency Range:</b>	1 GHz to 40 GHz

**Environmental Conditions:**

<b>Temperature (°C):</b>	23 to 24
<b>Relative Humidity (%):</b>	35 to 36

**Note(s):**

1. FCC Part 15.407(b)(1) states for transmitters operating in the band 5.15 to 5.25 GHz: all emissions outside of the 5.15 to 5.35 GHz band will not exceed -27 dBm/MHz. Part(b)(7) states the provisions of 15.205 apply e.g. restricted bands of operation.
2. In accordance with ANSI C63.10-2013 Section 6.5.4, emissions more than 20 dB below the limit do not need to be reported.
3. Pre-scans were performed with the EUT transmitting in the band 5.25 to 5.35 GHz band with a data rate of 802.11a / SISO / 6 Mbit/s on top channel in this band as it produced the highest power spectral density and was therefore deemed worst case. An enquiry was made to the FCC and the response was pre-scans could be performed in the band with the highest power spectral density and all final measurements should be performed on any emission seen in each band.
4. All emissions shown on the pre-scan plots were investigated and found to be ambient, or >20 dB below the applicable limit or below the measurement system noise floor. Therefore the highest peak and average noise floor readings of the measuring receiver were recorded in the 5.25-5.35 GHz results section of this report.
5. Appropriate RF filters and attenuators were used during pre-scans and final measurements. Insertion losses were entered on the spectrum analyser as RF levels offsets.
6. In accordance with KDB 789033 Section II.G.1.c) if the peak measurement is below the average limit, it is not necessary to perform a separate average measurement.
7. Measurements above 1 GHz were performed in a fully anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was placed at a height of 1.5 metres above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.

**Results: Top Channel / EIRP**

Frequency (MHz)	Antenna Polarity	Level (dBm)	Limit (dBm)	Margin (dB)	Result
See note 4					

**4.3.2. 5.25-5.35 GHz band****Transmitter Out of Band Radiated Emissions (5.25-5.35 GHz band operation)****Test Summary:**

<b>Test Engineer:</b>	Marco Zunarelli	<b>Test Dates:</b>	28 February 2019 & 06 March 2019
<b>Test Sample Serial Number:</b>	MGU-00001-000035		

<b>FCC Reference:</b>	Part 15.407(b)(2),(7) & 15.209(a)
<b>ISED Canada Reference:</b>	RSS-Gen 6.13, 8.9 & 8.10 / RSS-247 5.5 & 6.2.2.2
<b>Test Method Used:</b>	KDB 789033 II.G. & ANSI C63.10 Sections 6.3 and 6.6
<b>Frequency Range:</b>	1 GHz to 40 GHz

**Environmental Conditions:**

<b>Temperature (°C):</b>	23 to 24
<b>Relative Humidity (%):</b>	35 to 36

**Note(s):**

1. FCC Part 15.407(b)(2) states for transmitters operating in the band 5.15 to 5.25 GHz: all emissions outside of the 5.15 to 5.35 GHz band will not exceed -27 dBm/MHz. Part(b)(7) states the provisions of 15.205 apply e.g. restricted bands of operation.
2. In accordance with ANSI C63.10-2013 Section 6.5.4, emissions more than 20 dB below the limit do not need to be reported.
3. Pre-scans were performed with the EUT transmitting in the band 5.25 to 5.35 GHz band with a data rate of 802.11a / SISO / 6 Mbit/s on top channel in this band as it produced the highest power spectral density and was therefore deemed worst case. An enquiry was made to the FCC and the response was pre-scans could be performed in the band with the highest power spectral density and all final measurements should be performed on any emission seen in each band.
4. All emissions shown on the pre-scan plots were investigated and found to be ambient, or >20 dB below the applicable limit or below the measurement system noise floor. Therefore the highest peak and average noise floor readings of the measuring receiver were recorded in the table below.
5. The final measured value, for the given emission in the field strength result tables, incorporates the calibrated antenna factor and cable loss.
6. Appropriate RF filters and attenuators were used during pre-scans and final measurements. Insertion losses were entered on the spectrum analyser as RF levels offsets.
7. The emission shown on the 4 GHz to 6 GHz plot is the EUT fundamental.
8. Measurements were performed across the two restricted bands closest to the bands of operation with the EUT transmitting on the bottom channel in the 5.15 to 5.25 GHz band and top channel in the 5.25 to 5.35 GHz band. Plots are included in this section of the test report. Peak and average measurements were made.
9. Measurements above 1 GHz were performed in a fully anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was placed at a height of 1.5 metres above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.

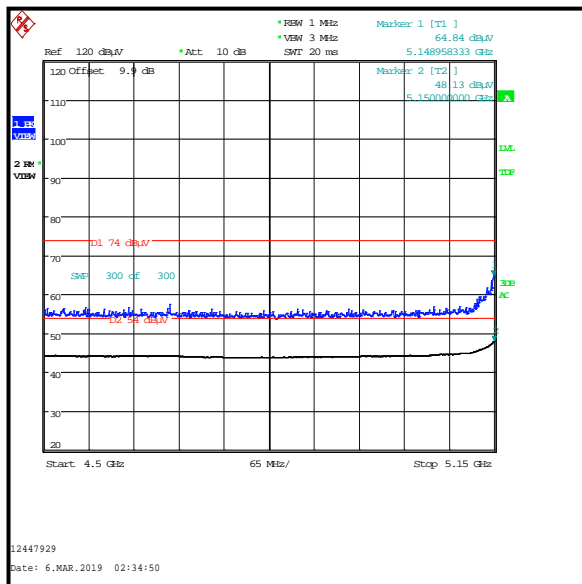
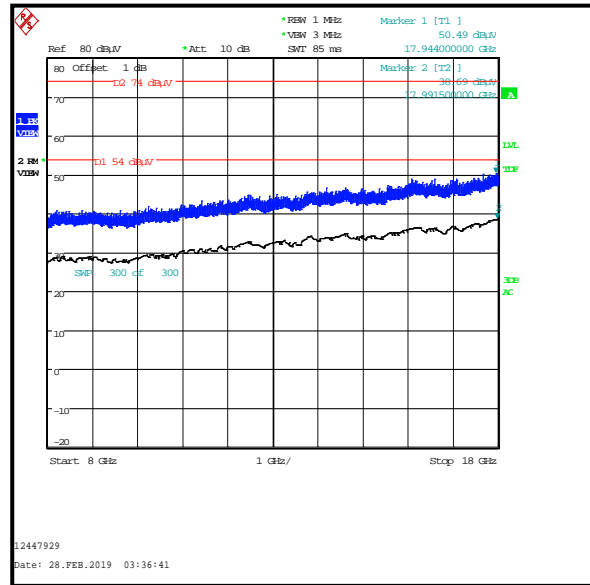
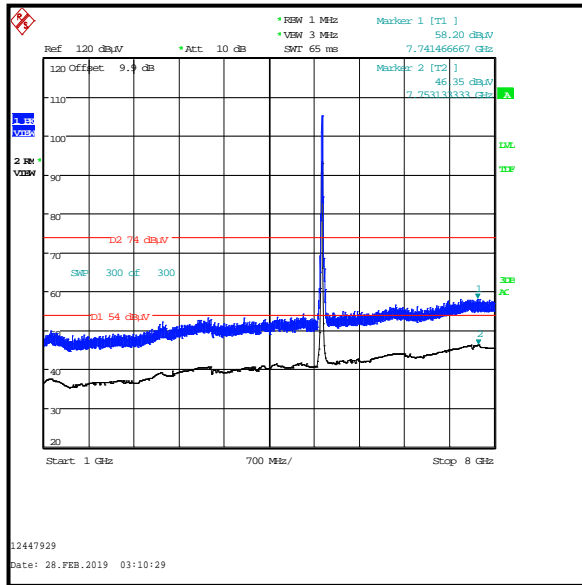
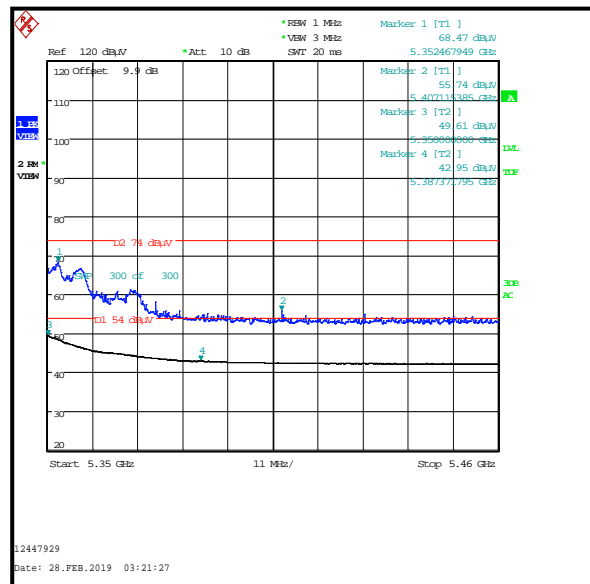
**Transmitter Out of Band Radiated Emissions (5.25-5.35 GHz band operation) (continued)****Results: Top Channel / Field Strength / Peak**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
40000.000	Vertical	59.2	74.0	14.8	Complied

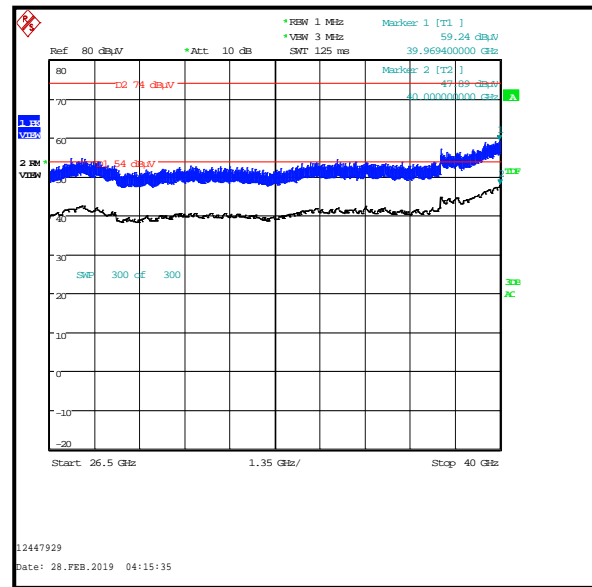
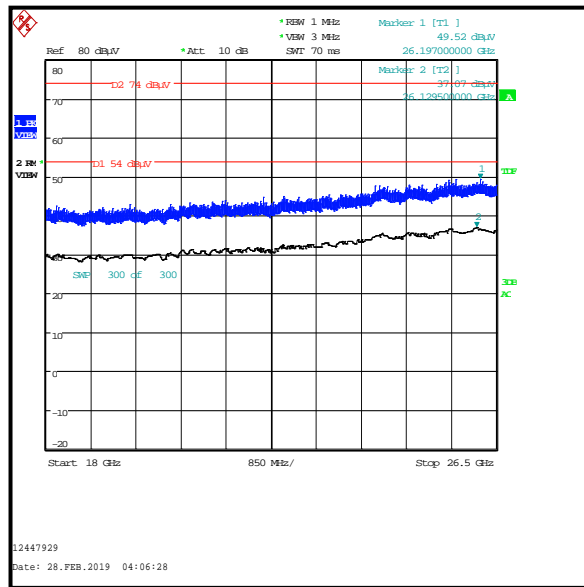
**Results: Top Channel / Field Strength / Average**

Frequency (MHz)	Antenna Polarity	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
40000.000	Vertical	47.9	54.0	6.1	Complied



**Transmitter Out of Band Radiated Emissions (5.25-5.35 GHz band operation) (continued)****Restricted Band 4.5 GHz to 5.15 GHz****Restricted Band 5.35 GHz to 5.46 GHz**

**Transmitter Out of Band Radiated Emissions (5.25-5.35 GHz band operation) (continued)**



*Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.*

#### **4.4. Transmitter Band Edge Radiated Emissions**

##### **4.4.1. 5.15-5.25 GHz band**

###### **Test Summary:**

<b>Test Engineer:</b>	Mark Perry	<b>Test Dates:</b>	02 March 2019 & 03 March 2019
<b>Test Sample Serial Number:</b>	MGU-00001-000035		

<b>FCC Reference:</b>	Parts 15.407(b)(1),(7), 15.205 & 15.209(a)
<b>ISED Canada Reference:</b>	RSS-Gen 6.13, 8.9, 8.10 & RSS-247 6.2.1.2
<b>Test Method Used:</b>	ANSI C63.10 Section 6.10 & KDB 789033 II.G.

###### **Environmental Conditions:**

<b>Temperature (°C):</b>	21 to 23
<b>Relative Humidity (%):</b>	38 to 40

###### **Note(s):**

1. An Inquiry was made to the FCC and the response confirmed band edge measurements need only be performed in the EUT modes that produce the highest power and the widest bandwidths. The modes that produced the highest power and widest bandwidth were:
  - o 802.11a / SISO / BPSK / 6 Mbps
  - o 802.11n HT20 / SISO / BPSK / MCS0
  - o 802.11n HT40 / SISO / BPSK / MCS0
  - o 802.11ac VHT80 / SISO / BPSK / MCS0
2. Lower band edge measurements were performed with the EUT transmitting on the bottom channel. Upper band edge measurements were performed with the EUT transmitting on the top channel.
3. For transmitters operating in the 5.15-5.25 GHz band: all emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27 dBm/MHz. However, there are restricted bands of operation below the lower band edge at 4.5-5.15 GHz and also above the upper band edge at 5.35-5.46 GHz therefore the provisions of FCC Part 15.205 apply. Tests were performed in these restricted bands of operation, the results are included in the transmitter 5.25-5.35 GHz band radiated spurious emission section of this test report.
4. Field strength measurements using peak and average detectors were performed in the restricted bands below 5.15 GHz and above 5.35 GHz. Field strength and EIRP results were found to be compliant with the restricted band limits and Part 15.407 out-of-band limits.
5. For all average measurements in this section, 300 sweeps were used. This satisfies the requirement for the minimum number of sweep points, as stated in KDB 789033 Section II.G.6.c) Method AD (vi).
6. In accordance with KDB 789033 Section II.G.6.c) Method AD (vii), for average measurements, data rates where the EUT was transmitting <98% duty cycle, the duty cycle correction factor calculated in section 4.1 was added to the measured result.

**Transmitter Band Edge Radiated Emissions (5.15-5.25 GHz band operation) (continued)****Results: 802.11a / 20 MHz / BPSK / 6 Mbps****Results: Lower Band Edge / Peak**

Frequency (MHz)	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5149.872	63.5	74.0	10.5	Complied
5150.000	62.6	74.0	11.4	Complied

**Results: Upper Band Edge / Peak**

Frequency (MHz)	Peak Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	54.1	74.0	15.9	Complied
5413.846	55.3	74.0	18.7	Complied

**Results: Lower Band Edge / Average**

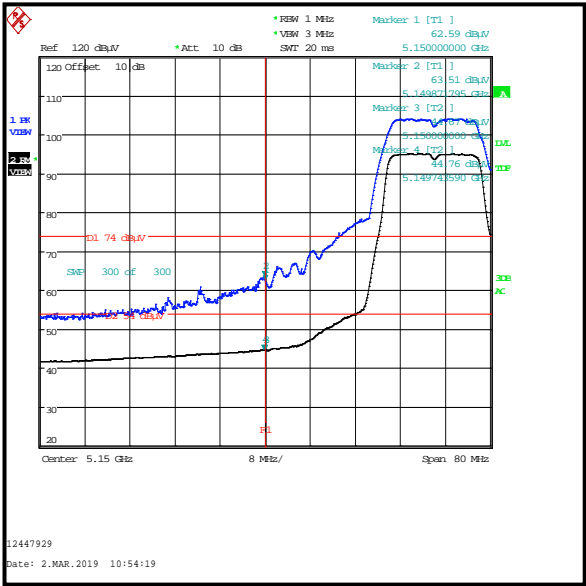
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5149.743	44.8	0.3	45.1	54.0	8.9	Complied
5150.000	44.7	0.3	45.0	54.0	9.0	Complied

**Results: Upper Band Edge / Average**

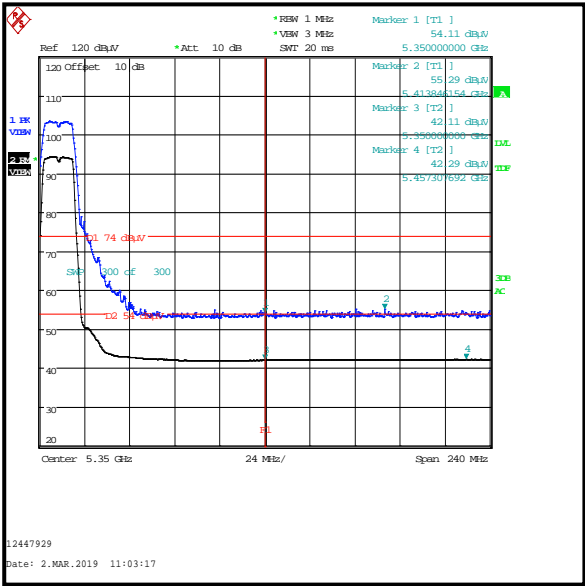
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	42.1	0.3	42.4	54.0	11.6	Complied
5457.308	42.3	0.3	42.6	54.0	11.4	Complied

Transmitter Band Edge Radiated Emissions (5.15-5.25 GHz band operation) (continued)

Results: 802.11a / 20 MHz / BPSK / 6 Mbps



Lower Band Edge



Upper Band Edge

**Transmitter Band Edge Radiated Emissions (5.15-5.25 GHz band operation) (continued)****Results: 802.11n / 20 MHz / SISO / BPSK / MCS0****Results: Lower Band Edge / Peak**

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
5148.077	64.6	74.0	9.4	Complied
5150.000	64.3	74.0	9.7	Complied

**Results: Upper Band Edge / Peak**

Frequency (MHz)	Peak Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
5350.000	54.0	74.0	20.0	Complied
5403.462	54.7	74.0	19.3	Complied

**Results: Lower Band Edge / Average**

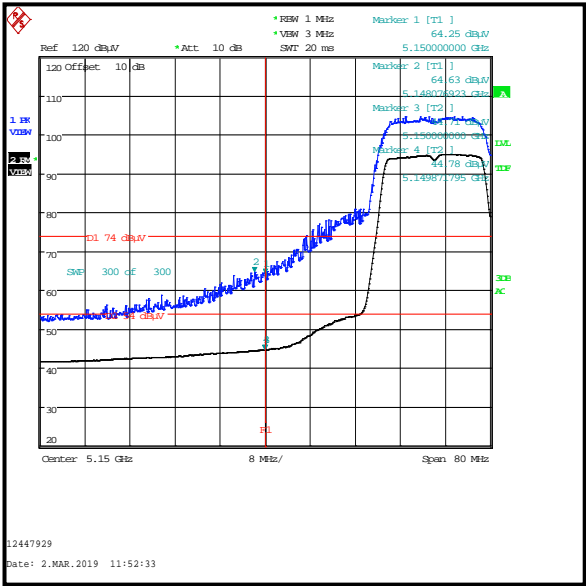
Frequency (MHz)	Level (dBμV/m)	Duty Cycle correction (dB)	Corrected Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
5149.872	44.8	0.3	45.1	54.0	8.9	Complied
5150.000	44.7	0.3	45.0	54.0	9.0	Complied

**Results: Upper Band Edge / Average**

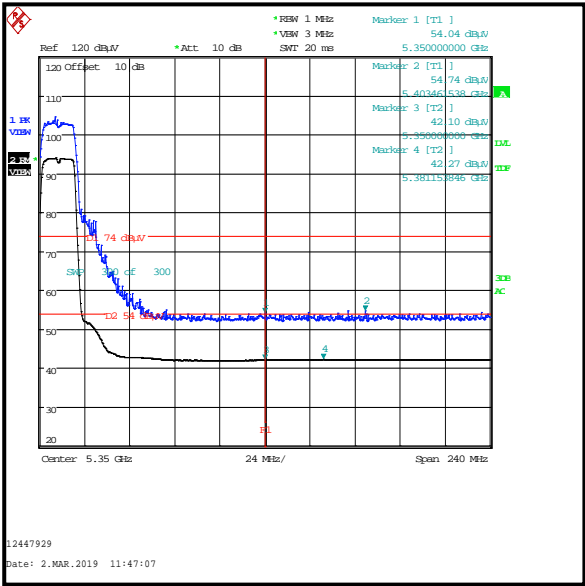
Frequency (MHz)	Level (dBμV/m)	Duty Cycle correction (dB)	Corrected Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Result
5350.000	42.1	0.3	42.4	54.0	11.6	Complied
5381.154	42.3	0.3	42.6	54.0	11.4	Complied

**Transmitter Band Edge Radiated Emissions (5.15-5.25 GHz band operation) (continued)**

**Results: 802.11n / 20 MHz / SISO / BPSK / MCS0**



Lower Band Edge



Upper Band Edge

**Transmitter Band Edge Radiated Emissions (5.15-5.25 GHz band operation) (continued)****Results: 802.11n / 40 MHz / SISO / BPSK / MCS0****Results: Lower Band Edge / Peak**

Frequency (MHz)	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5150.000	67.8	74.0	6.2	Complied

**Results: Upper Band Edge / Peak**

Frequency (MHz)	Peak Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	57.0	74.0	17.0	Complied
5468.910	58.4	74.0	15.6	Complied

**Results: Lower Band Edge / Average**

Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5149.808	47.7	0.6	48.3	54.0	5.7	Complied
5150.000	47.7	0.6	48.3	54.0	5.7	Complied

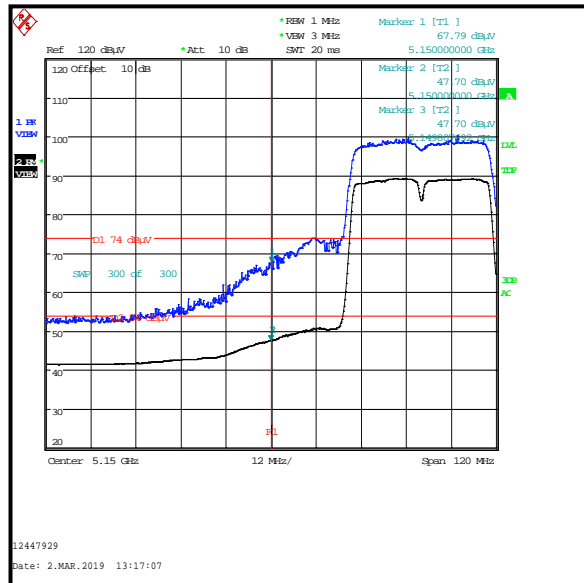
**Results: Upper Band Edge / Average**

Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	45.5	0.6	46.1	54.0	7.9	Complied
5484.615	46.0	0.6	46.6	54.0	7.7	Complied

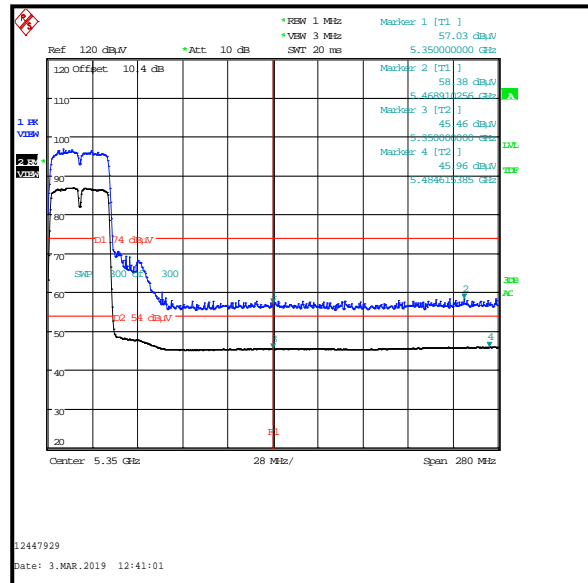


**Transmitter Band Edge Radiated Emissions (5.15-5.25 GHz band operation) (continued)**

**Results: 802.11n / 40 MHz / SISO / BPSK / MCS0**



### Lower Band Edge



Upper Band Edge

**Transmitter Band Edge Radiated Emissions (5.15-5.25 GHz band operation) (continued)****Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0****Results: Lower Band Edge / Peak**

Frequency (MHz)	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5149.359	64.0	74.0	10.0	Complied
5150.000	61.6	74.0	12.4	Complied

**Results: Upper Band Edge / Peak**

Frequency (MHz)	Peak Level (dB $\mu$ V/m)	Average Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	52.6	74.0	11.4	Complied

**Results: Lower Band Edge / Average**

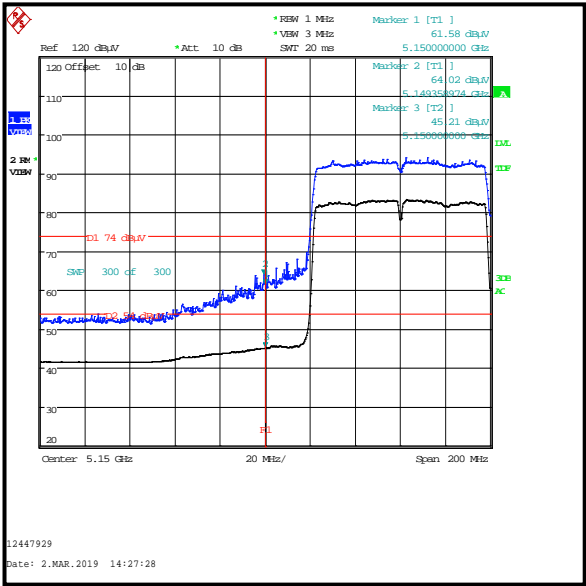
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5150.000	45.2	1.2	46.4	54.0	7.6	Complied

**Results: Upper Band Edge / Average**

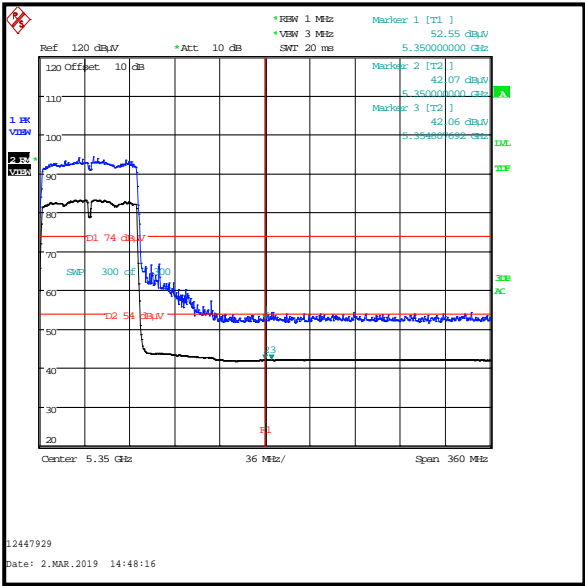
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	42.1	1.2	43.3	54.0	10.7	Complied
5354.808	42.1	1.2	43.3	54.0	10.7	Complied

**Transmitter Band Edge Radiated Emissions (5.15-5.25 GHz band operation) (continued)**

**Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0**



Lower Band Edge



Upper Band Edge

**Transmitter Band Edge Radiated Emissions (5.25-5.35 GHz band)****4.4.2. 5.25-5.35 GHz band****Test Summary:**

<b>Test Engineer:</b>	Mark Perry	<b>Test Dates:</b>	02 March 2019 & 03 March 2019
<b>Test Sample Serial Number:</b>	MGU-00001-000035		

<b>FCC Reference:</b>	Parts 15.407(b)(2),(7), 15.205 & 15.209(a)
<b>ISED Canada Reference:</b>	RSS-Gen 6.13, 8.9 & 8.10 / RSS-247 6.2.2.2
<b>Test Method Used:</b>	ANSI C63.10 Section 6.10 & KDB 789033 II.G.

**Environmental Conditions:**

<b>Temperature (°C):</b>	21 to 23
<b>Relative Humidity (%):</b>	38 to 40

**Note(s):**

1. An Inquiry was made to the FCC and the response confirmed band edge measurements need only be performed in the EUT modes that produce the highest power and the widest bandwidths. The modes that produced the highest power and widest bandwidth were:
  - 802.11a SISO / BPSK / 6 Mbps
  - 802.11n HT20 / SISO / BPSK / MCS0
  - 802.11n HT40 / SISO / BPSK / MCS0
  - 802.11ac VHT80 / SISO / BPSK / MCS0
2. Lower band edge measurements were performed with the EUT transmitting on the bottom channel. Upper band edge measurements were performed with the EUT transmitting on the top channel.
3. For transmitters operating in the 5.25-5.35 GHz band: all emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27 dBm/MHz. However, there are restricted bands of operation below the lower band edge at 4.5-5.15 GHz and also above the upper band edge at 5.35-5.46 GHz therefore the provisions of FCC Part 15.205 apply. Tests were performed in these restricted bands of operation with the EUT transmitting on the bottom and top channels within 5.25-5.35 GHz band, the results are included in the transmitter 5.25-5.35 GHz band radiated spurious emissions section of this test report.
4. Field strength measurements using peak and average detectors were performed in the restricted bands below 5.15 GHz and above 5.35 GHz. Field strength and EIRP results were found to be compliant with the restricted band limits and Part 15.407 out-of-band limits.
5. For all average measurements in this section, 300 sweeps were used. This satisfies the requirement for the minimum number of sweep points, as stated in KDB 789033 Section II.G.6.c) Method AD (vi).
6. In accordance with KDB 789033 Section II.G.6.c) Method AD (vii), for average measurements, data rates where the EUT was transmitting <98% duty cycle, the duty cycle correction factor calculated in section 4.1 was added to the measured result.

**Transmitter Band Edge Radiated Emissions (5.25-5.35 GHz band operation) (continued)****Results: 802.11a / 20 MHz / BPSK / 6 Mbps****Results: Lower Band Edge / Peak**

Frequency (MHz)	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5113.846	53.9	74.0	20.1	Complied
5150.000	51.8	74.0	22.2	Complied

**Results: Upper Band Edge / Peak**

Frequency (MHz)	Peak Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	57.9	74.0	16.1	Complied
5350.128	60.6	74.0	13.4	Complied

**Results: Lower Band Edge / Average**

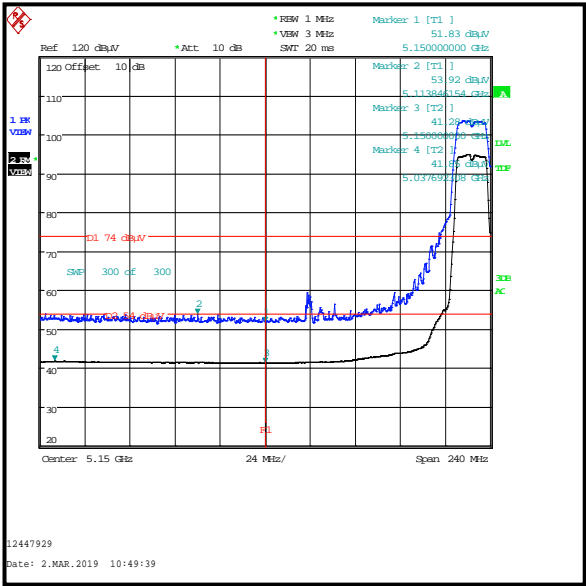
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5037.692	41.9	0.3	42.2	54.0	11.8	Complied
5150.000	41.3	0.3	41.6	54.0	12.4	Complied

**Results: Upper Band Edge / Average**

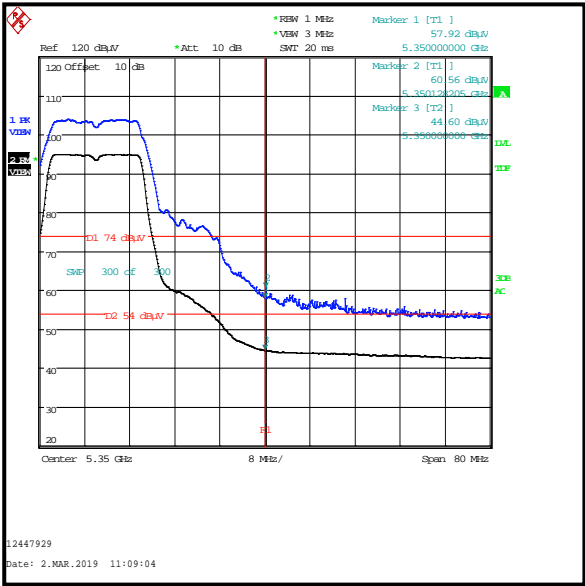
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	44.6	0.3	44.9	54.0	9.3	Complied

Transmitter Band Edge Radiated Emissions (5.25-5.35 GHz band operation) (continued)

Results: 802.11a / 20 MHz / BPSK / 6 Mbps



Lower Band Edge



Upper Band Edge

**Transmitter Band Edge Radiated Emissions (5.25-5.35 GHz band operation) (continued)****Results: 802.11n / 20 MHz / SISO / BPSK / MCS0****Results: Lower Band Edge / Peak**

Frequency (MHz)	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5088.846	53.9	74.0	20.1	Complied
5150.000	51.9	74.0	22.1	Complied

**Results: Upper Band Edge / Peak**

Frequency (MHz)	Peak Level (dB $\mu$ V/m)	Average Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	63.2	74.0	10.8	Complied
5350.128	64.7	74.0	9.3	Complied

**Results: Lower Band Edge / Average**

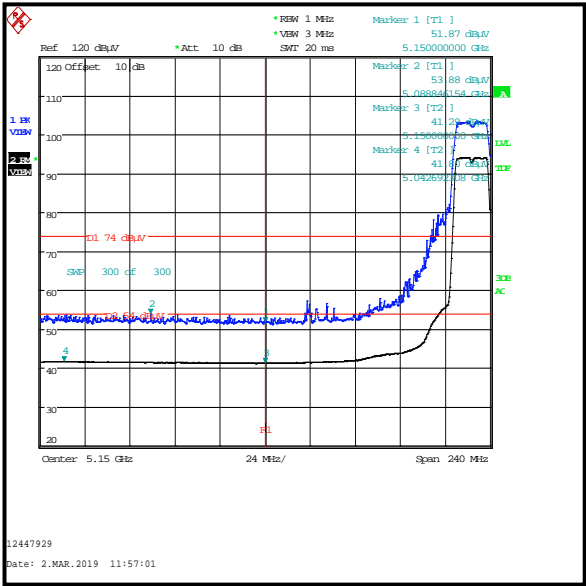
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5042.692	41.8	0.3	42.1	54.0	11.9	Complied
5150.000	41.3	0.3	41.6	54.0	12.4	Complied

**Results: Upper Band Edge / Average**

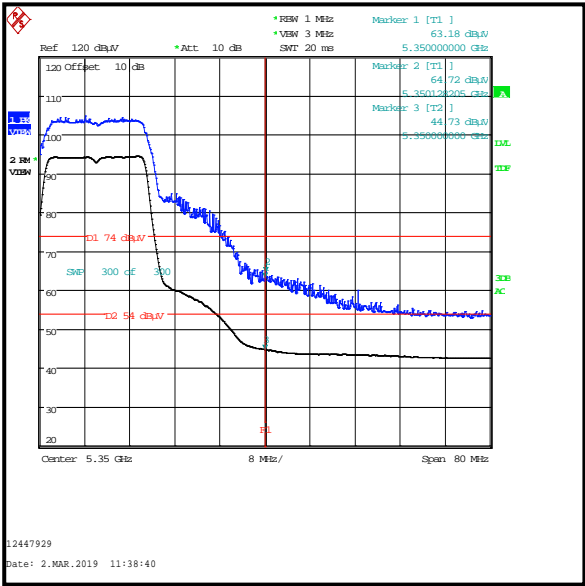
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	44.7	0.3	45.0	54.0	9.0	Complied

Transmitter Band Edge Radiated Emissions (5.25-5.35 GHz band operation) (continued)

Results: 802.11n / 20 MHz / SISO / BPSK / MCS0



Lower Band Edge



Upper Band Edge



**Transmitter Band Edge Radiated Emissions (5.25-5.35 GHz band operation) (continued)****Results: 802.11n / 40 MHz / SISO / BPSK/ MCS0****Results: Lower Band Edge / Peak**

Frequency (MHz)	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5048.590	57.4	74.0	16.6	Complied
5150.000	54.6	74.0	19.4	Complied

**Results: Upper Band Edge / Peak**

Frequency (MHz)	Peak Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	65.1	74.0	8.9	Complied
5350.577	66.2	74.0	7.8	Complied

**Results: Lower Band Edge / Average**

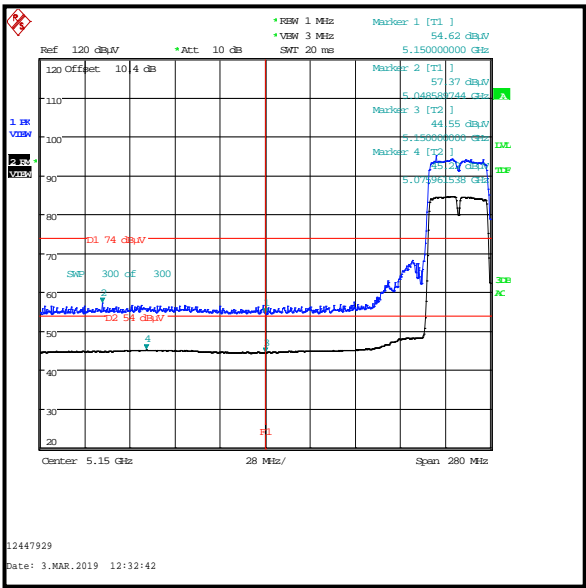
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5075.962	45.2	0.6	45.8	54.0	8.2	Complied
5150.000	44.6	0.6	45.2	54.0	8.8	Complied

**Results: Upper Band Edge / Average**

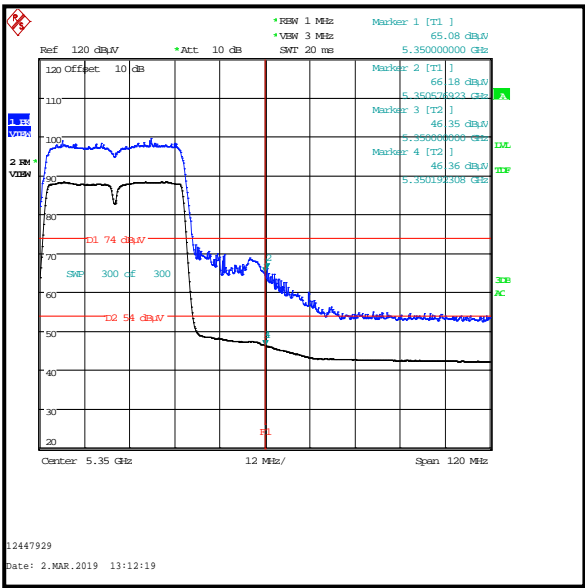
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	46.4	0.6	47.0	54.0	7.0	Complied
5350.192	46.4	0.6	47.0	54.0	7.0	Complied

Transmitter Band Edge Radiated Emissions (5.25-5.35 GHz band operation) (continued)

Results: 802.11n / 40 MHz / SISO / BPSK / MCS0



Lower Band Edge



Upper Band Edge

**Transmitter Band Edge Radiated Emissions (5.25-5.35 GHz band operation) (continued)****Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0****Results: Lower Band Edge / Peak**

Frequency (MHz)	Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5145.500	54.3	74.0	9.7	Complied
5150.000	52.4	74.0	11.6	Complied

**Results: Upper Band Edge / Peak**

Frequency (MHz)	Peak Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	63.3	74.0	10.7	Complied

**Results: Lower Band Edge / Average**

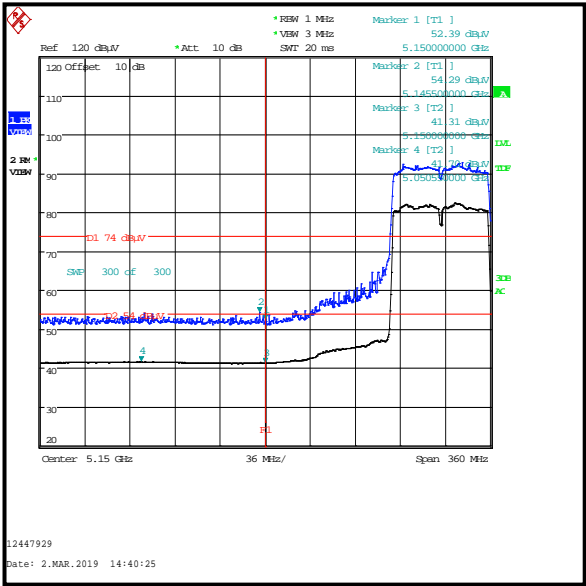
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5050.550	41.7	1.2	42.9	54.0	11.1	Complied
5150.000	41.3	1.2	42.5	54.0	11.5	Complied

**Results: Upper Band Edge / Average**

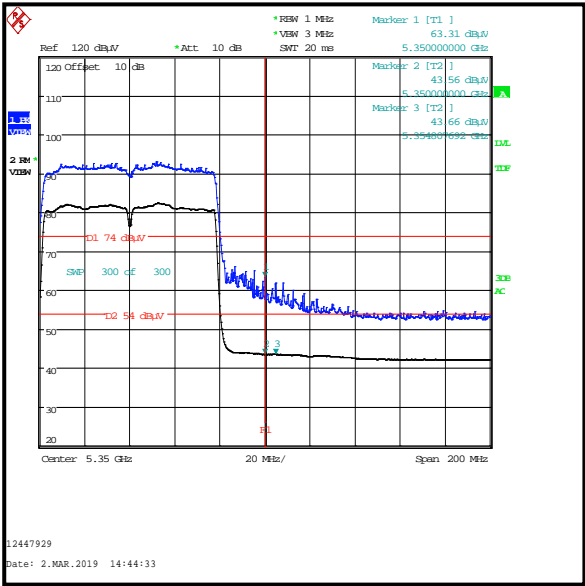
Frequency (MHz)	Level (dB $\mu$ V/m)	Duty Cycle correction (dB)	Corrected Level (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Result
5350.000	43.6	1.2	44.8	54.0	9.2	Complied
5354.808	43.7	1.2	44.9	54.0	9.1	Complied

**Transmitter Band Edge Radiated Emissions (5.25-5.35 GHz band operation) (continued)**

**Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0**



Lower Band Edge



Upper Band Edge

--- END OF REPORT ---