TEST REPORT

Test Report No. : UL-RPT-RP12185759JD10E

Customer	:	Apple Inc.
Model No.	:	A1990
FCC ID	:	BCGA1990
Technology	:	WLAN
Test Standard(s)	:	FCC Parts 15.209(a) & 15.407
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 1.0

Date of Issue: 27 June 2018

Checked by:

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Company Signatory:

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Customer Information

Company Name:	Apple Inc.
Address:	One Apple Park Way Cupertino, California 95014 U.S.A.
Contact Name:	Stuart Thomas

Report Revision History

Version Number	Issue Date	Revision Details	Revised By
1.0	27/06/2018	Initial Version	Ben Mercer

Table of Contents

1. Attestation of Test Results

1.1. Description of EUT

The equipment under test was a Laptop Computer with WLAN and *Bluetooth*.

1.2. General Information

Specification Reference:	47CFR15.407 and 47CFR15.403
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart E (Unlicensed National Information Infrastructure Devices) – Sections 15.403 and 15.407
Specification Reference:	47CFR15.209
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.209
Site Registration:	209735
Location of Testing:	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
Test Dates:	07 February 2018 to 03 June 2018

1.3. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.35(c)	Transmitter Duty Cycle	Note 1
Part 15.403(i)	Transmitter 26 dB Emission Bandwidth	Complied
Part 15.407(e)	Transmitter Minimum 6 dB Bandwidth (5.725-5.85 GHz band)	Complied
Part 15.407(e)	Transmitter Minimum 6 dB Bandwidth (Channels that straddle the U-NII-2C and U-NII-3 bands at 5725 MHz)	Complied
Part 15.407(a)(1)(iv)	Transmitter Maximum Conducted Output Power (5.15-5.25 GHz band)	Complied
Part 15.407(a)(2)	Transmitter Maximum Conducted Output Power (5.25-5.35 GHz & 5.47-5.725 GHz bands)	Complied
Part 15.407(a)(2)	Transmitter Maximum Conducted Output Power (Channels that straddle the U-NII-2C and U-NII-3 bands at 5725 MHz)	Complied
Part 15.407(a)(3)	Transmitter Maximum Conducted Output Power (5.725-5.85 GHz band)	Complied
Part 15.407(a)(1)(iv)	Transmitter Maximum Power Spectral Density (5.15-5.25 GHz band)	Complied
Part 15.407(a)(2)	Transmitter Maximum Power Spectral Density (5.25-5.35 GHz & 5.47-5.725 GHz bands)	Complied
Part 15.407(a)(2)	Transmitter Maximum Power Spectral Density (Channels that straddle the U-NII-2C and U-NII-3 bands at 5725 MHz)	Complied
Part 15.407(a)(3)	Transmitter Maximum Power Spectral Density (5.725-5.85 GHz band)	Complied
Part 15.407(b)/15.209(a)	Transmitter Out of Band Radiated Emissions	Complied
Part 15.407(b)/15.209(a)	Transmitter Band Edge Radiated Emissions	Complied
Part 15.407(g)	Transmitter Frequency Stability (Temperature & Voltage Variation)	Note 2
Part 15.407(h)(1)	Transmitter Power Control	Note 3

Note(s):

1. The measurement was performed to assist in the calculation of the level of average output power, power spectral density and emissions as the EUT employs pulsed operation.
2. Frequency stability is better than 20 ppm which ensures that the signal remains in the allocated bands under all operational conditions stated in the user manual.
3. Transmit Power Control was not tested as the maximum EIRP is less than 500 mW (27 dBm).

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	
Site 2	X
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

Reference:	ANSI C63.10-2013
Title:	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Reference:	KDB 789033 D02 General U-NII Test Procedures New Rules v02r01 December 14, 2017
Title:	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	5.15 GHz to 5.850 GHz	95%	±1.14 %
26 dB Emission Bandwidth	5.15 GHz to 5.850 GHz	95%	±4.59 %
Minimum 6 dB Emission Bandwidth	5.15 GHz to 5.850 GHz	95%	±4.59 %
Maximum Conducted Output Power	5.15 GHz to 5.850 GHz	95%	±1.13 dB
Maximum Power Spectral Density	5.15 GHz to 5.850 GHz	95%	±1.13 dB
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 Conducted Tests

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2004	Thermohygrometer	Testo	608-H1	45046425	26 Feb 2019	12
A3028	Attenuator	Broadwave Technologies	351-311-006	#2	Calibrated before use	-
A3029	Attenuator	Broadwave Technologies	351-311-006	#3	Calibrated before use	-
A3030	Attenuator	Broadwave Technologies	351-311-006	#4	Calibrated before use	-
A3004	RF Switch	Pickering Interfaces	64-102-002	XZ363230	Calibrated before use	-
M2018	Signal Analyser	Rohde & Schwarz	FSV7	102699	23 Jun 2018	12
G0607	Signal Generator	Rohde & Schwarz	SMU200A	100943	10 May 2019	36
A3005	RePlay Test Rack	N/A	N/A	N/A	Calibration not required	-

Test and Measurement Equipment (continued)

Test Equipment Used for Transmitter Radiated Emissions

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2003	Thermohygrometer	Testo	608-H1	45046641	27 Feb 2019	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	20 Feb 2019	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	18 Apr 2019	12
A2863	Pre Amplifier	Agilent	8449B	3008A02100	19 Feb 2019	12
A2131	Low Pass Filter	AtlanTecRF	AFL-02000	JFB1004-002	22 Feb 2019	12
A490	Antenna	Chase	CBL6111A	1590	03 Apr 2019	12
M2016	Thermohygrometer	Testo	608-H1	45046428	26 Feb 2019	12
K0002	3m RSE Chamber	Rainford EMC	N/A	N/A	07 Feb 2019	12
M1874	Test Receiver	Rohde & Schwarz	ESU26	100553	28 Nov 2018	12
A2973	High Pass Filter	AtlanTecRF	AFH-03000	16080900032	24 Jan 2019	12
A2133	Low Pass Filter	AtlanTecRF	AFL-04000	JFB1006-002	21 Feb 2019	12
A3025	Pre-Amplifier	Com-Power	PAM-118A	551126	12 Oct 2018	12
A1818	Antenna	EMCO	3115	00075692	07 Feb 2019	12
A2891	Pre Amplifier	Schwarzbeck	BBV 9718	9718-306	20 Feb 2019	12
A2893	Pre Amplifier	Schwarzbeck	BBV 9721	9721-021	26 Apr 2019	12
A2889	Antenna	Schwarzbeck	BBHA 9120 B	BBHA 9120 B 653	19 Feb 2019	12
A2890	Antenna	Schwarzbeck	HWRD 750	014	19 Feb 2019	12
A2892	Antenna	Schwarzbeck	BBHA 9170	9170-727	21 Feb 2019	12
A2914	High Pass Filter	AtlanTecRF	AFH-03000	2155	22 Feb 2019	12
A2916	Attenuator	AtlanTecRF	AN18W5-10	832827#1	21 Feb 2019	12
A2947	High Pass Filter	AtlanTecRF	AFH-07000	1601900001	22 Feb 2019	12

Test Equipment Used for Transmitter Band Edge Radiated Emissions

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2003	Thermohygrometer	Testo	608-H1	45046641	27 Feb 2019	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	20 Feb 2019	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	18 Apr 2019	12
A2863	Pre Amplifier	Agilent	8449B	3008A02100	19 Feb 2019	12
A2889	Antenna	Schwarzbeck	BBHA 9120 B	BBHA 9120 B 653	19 Feb 2019	12
A2916	Attenuator	AtlanTecRF	AN18W5-10	832827#1	21 Feb 2019	12

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Apple
Model Name or Number:	A1990
Test Sample Serial Number:	C02VP00AJLDY *(Radiated sample #1)*
Hardware Version:	EVT
Software Version:	17G2057
FCC ID:	BCGA1990

Brand Name:	Apple
Model Name or Number:	A1990
Test Sample Serial Number:	C02WC00DJMFL *(Radiated sample #2)*
Hardware Version:	EVT
Software Version:	17G2057
FCC ID:	BCGA1990

Brand Name:	Apple
Model Name or Number:	A1990
Test Sample Serial Number:	C02WC003JMFN *(Conducted sample #1)*
Hardware Version:	EVT
Software Version:	17G2057
FCC ID:	BCGA1990

3.2. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.3. Additional Information Related to Testing

Technology Tested:	WLAN (IEEE 802.11a,n,ac) / U-NII	
Type of Unit:	Transceiver	
Modulation:	BPSK, QPSK, 16QAM, 64QAM & 256QAM	
Data rates:	802.11a	6, 9, 12, 18, 24, 36 ,48 & 54 Mbps
	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)
Power Supply Requirement(s):	Nominal	3.8 VDC via 120 VAC 60 Hz AC/DC adaptor
Maximum Conducted Output Power:	20 MHz	21.4 dBm
	40 MHz	21.7 dBm
	80 MHz	21.8 dBm

Additional Information Related to Testing (continued)

Channel Spacing:	20 MHz		
Transmit Frequency Band:	5150 MHz to 5250 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	36	5180
	Middle	40	5200
	Top	48	5240
Transmit Frequency Band:	5250 MHz to 5350 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	52	5260
	Middle	56	5280
	Top	64	5320
Transmit Frequency Band:	5470 MHz to 5725 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	100	5500
	Middle	116	5580
	Top	140	5700
Transmit Frequency Band:	Channels that straddle the U-NII-2C and U-NII-3 bands at 5725 MHz		
Transmit Channel Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Single	144	5720
Transmit Frequency Band:	5725 MHz to 5850 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	149	5745
	Middle	157	5785
	Top	165	5825

Additional Information Related to Testing (continued)

Channel Spacing:	40 MHz		
Transmit Frequency Band:	5150 MHz to 5250 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	38	5190
	Top	46	5230
Transmit Frequency Band:	5250 MHz to 5350 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	54	5270
	Top	62	5310
Transmit Frequency Band:	5470 MHz to 5725 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	102	5510
	Middle	118	5590
	Top	134	5670
Transmit Frequency Band:	Channels that straddle the U-NII-2C and U-NII-3 bands at 5725 MHz		
Transmit Channel Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Single	142	5710
Transmit Frequency Band:	5725 MHz to 5850 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	151	5755
	Top	159	5795

Additional Information Related to Testing (continued)

Channel Spacing:	80 MHz		
Transmit Frequency Band:	5150 MHz to 5250 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Single	42	5210
Transmit Frequency Band:	5250 MHz to 5350 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Single	58	5290
Transmit Frequency Band:	5470 MHz to 5725 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Bottom	106	5530
	Top	122	5610
Transmit Frequency Band:	Channels that straddle the U-NII-2C and U-NII-3 bands at 5725 MHz		
Transmit Channel Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Single	138	5690
Transmit Frequency Band:	5725 MHz to 5850 MHz		
Transmit Channels Tested:	**Channel ID**	**Channel Number**	**Channel Frequency (MHz)**
	Single	155	5775

3.4. Description of Available Antennas

The radio utilizes an integrated antenna, with the following maximum gains:

Frequency Range (MHz)	Antenna Gain (dBi)
5150 to 5250	3.8
5250 to 5350	4.9
5470 to 5725	4.9
5725 to 5850	4.0

3.5. Description of Test Setup

Support Equipment

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

Description:	USB-C Adapter
Brand Name:	Belkin
Model Name or Number:	F2CU040
Serial Number:	Not marked or stated

Description:	USB-C Power Adapter
Brand Name:	Apple
Model Name or Number:	A1947
Serial Number:	Not marked or stated

Description:	PHF (Personal Hands Free)
Brand Name:	Apple
Model Name or Number:	Apple EarPods
Serial Number:	Not marked or stated

Description:	Type A USB Cable. Length 3.0 metres.
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	Type C USB Cable. Length 2.0 metres.
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	4 Port USB Hub
Brand Name:	Belkin
Model Name or Number:	F5U404-BLK
Serial Number:	Not marked or stated

Operating Modes

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

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

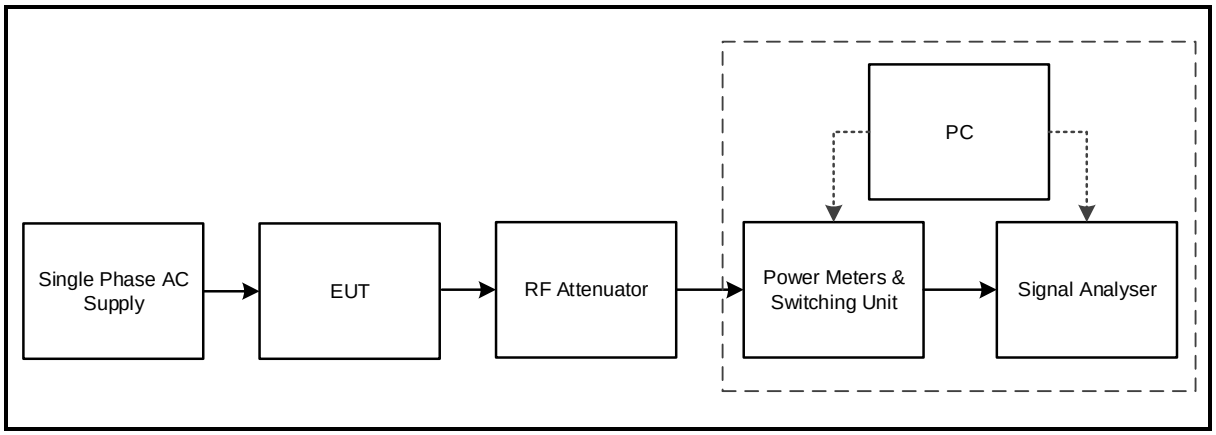
Configuration and Peripherals

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

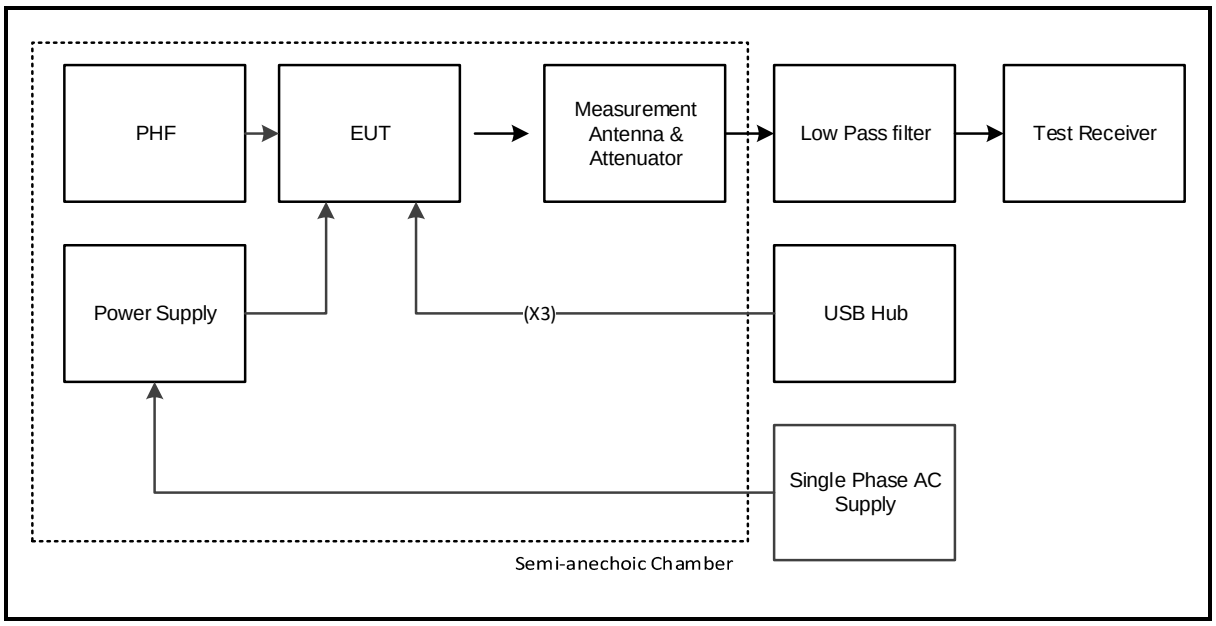
- Controlled in test mode using a software application on the EUT supplied by the customer. The application was used to enable a continuous transmission and to select the test channels as required. The customer supplied scripts 'EUT_EVT_wlan_setup_v1.sh' to control the EUT.
- The customer requested the following data rates to be used for all measurements:
    - 802.11a SISO – BPSK / 6 Mbps / Core 2
    - 802.11n HT20 / SISO – BPSK / MCS0 / Core 2
    - 802.11n HT40 / SISO – BPSK / MCS0 / Core 2
    - 802.11ac VHT80 / SISO – BPSK / MCS0x1 / Core 2
- Transmitter spurious emissions were performed with the EUT transmitting in an 802.11a / 6 Mbps / SISO configuration. This was found to be the worst case with regards to emissions after preliminary investigations and, as this mode emits the highest transmit power spectral density, it was deemed to be the worst case.
- Transmitter radiated spurious emissions tests were performed with the AC Charger and PHF connected to the EUT. The USB ports were terminated to a USB hub which was placed outside the chamber.
- The EUT was powered from a 120 VAC 60 Hz single phase mains supply.

Test Setup Diagrams

Test Setup for Transmitter Conducted Tests

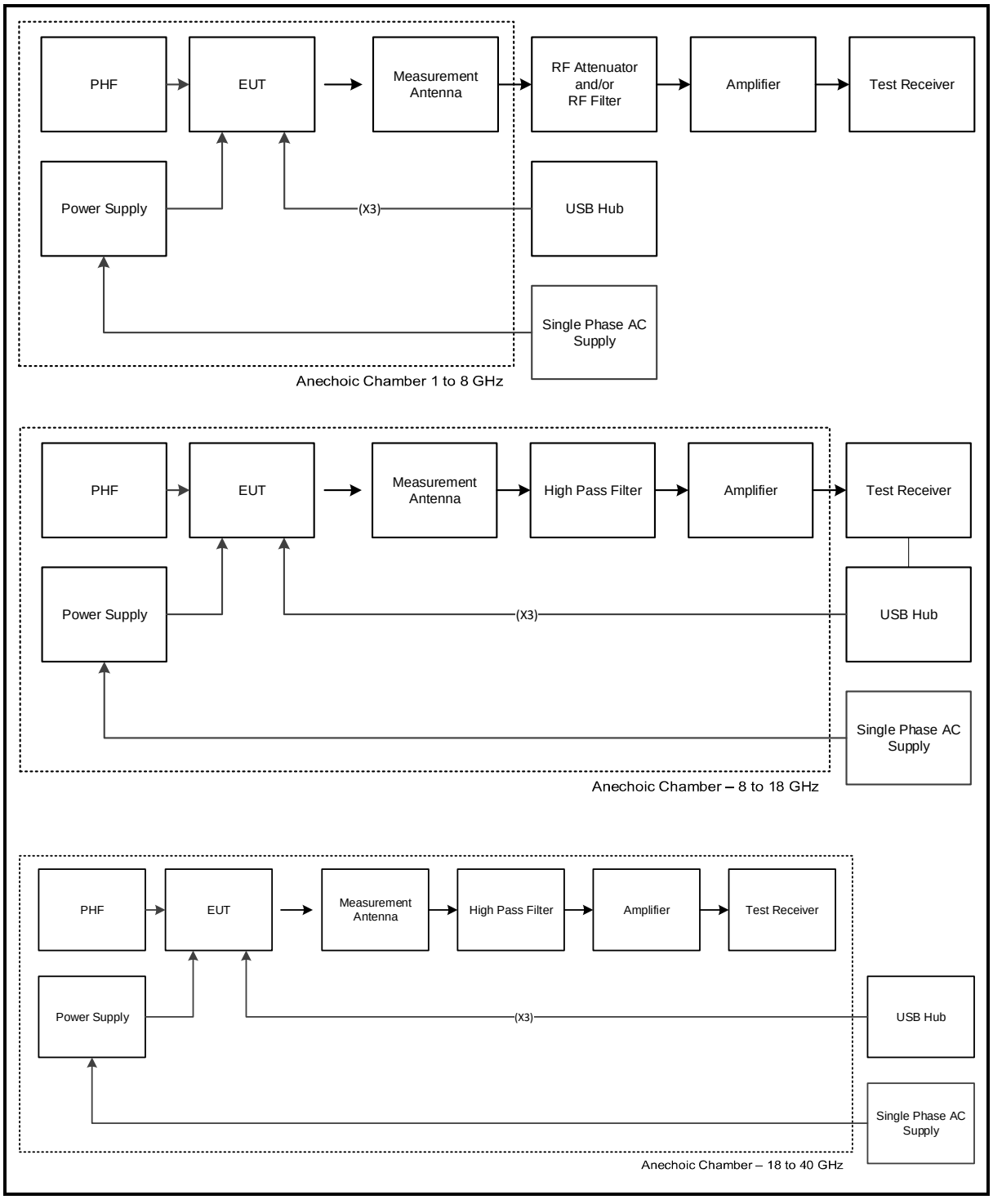


Test Setup for Transmitter Radiated Emissions



Test Setup Diagrams (continued)

Test Setup for Transmitter Radiated Emissions (continued)



4. Antenna Port Test Results

4.1. Transmitter Duty Cycle

Test Summary:

Test Engineer:	Max Passell	**Test Date:**	23 May 2018
Test Sample Serial Number:	C02WC003JMFN		

FCC Reference:	Part 15.35(c)
Test Method Used:	KDB 789033 D02 Section II.B.2.b)

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	51

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 signal analyser in the time domain and calculated by using the following calculation:

   10 log 1 / (On Time / [Period or 100ms whichever is the lesser]).

   802.11n H40 / SISO / MCS0 duty cycle: 10 log (1 / (0.942 / 0.968)) = 0.1
   802.11ac VHT80 / SISO / MCS0x1 duty cycle: 10 log (1 / (1 / (0.459 / 0.483)) = 0.2

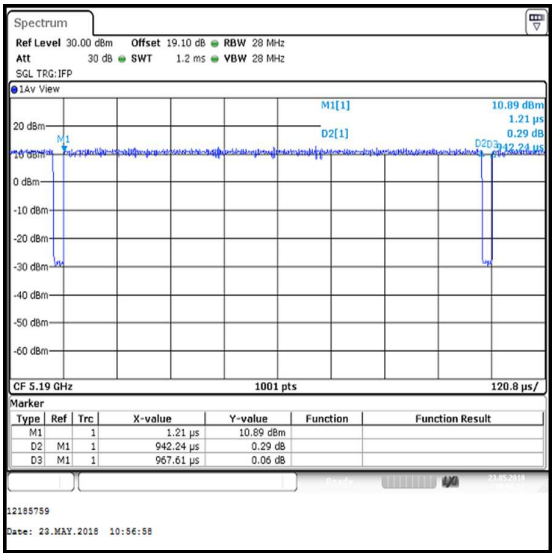
2. Plots below are for data rates with a duty cycle less than 98%. Results for all other modes having a duty cycle >98% are archived on the UL VS LTD IT server and available for inspection if required.

3. The signal analyser was connected to the RF port on the EUT using an RF switch, suitable attenuation and RF cables. An RF level offset was entered on the signal analyser to compensate for the loss of the switch, attenuators and RF cables.

Transmitter Duty Cycle (continued)

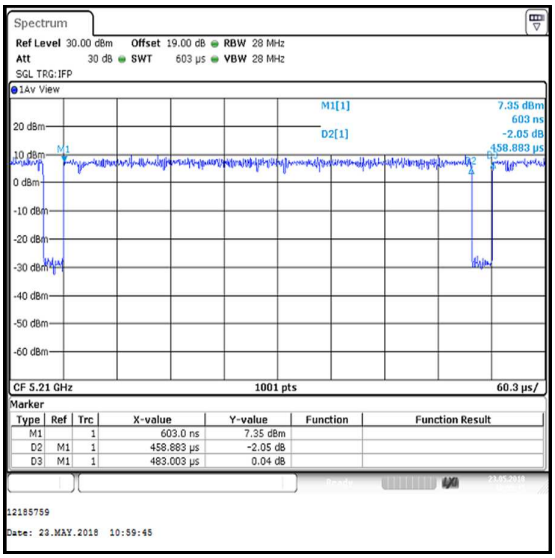
Results: 802.11n / 40 MHz / SISO / MCS0

Pulse Duration (ms)	Period (ms)	Duty Cycle (dB)
0.942	0.968	0.1



Results: 802.11ac / 80 MHz / SISO / MCS0x1

Pulse Duration (ms)	Period (ms)	Duty Cycle (dB)
0.459	0.483	0.2



4.2. Transmitter 26 dB Emission Bandwidth

Test Summary:

Test Engineer:	Max Passell	**Test Date:**	23 May 2018
Test Sample Serial Number:	C02WC003JMFN		

FCC Reference:	Part 15.403(i)
Test Method Used:	KDB 789033 D02 Section II.C.1.

Environmental Conditions:

Temperatures (°C):	23
Relative Humidity (%):	48

Note(s):

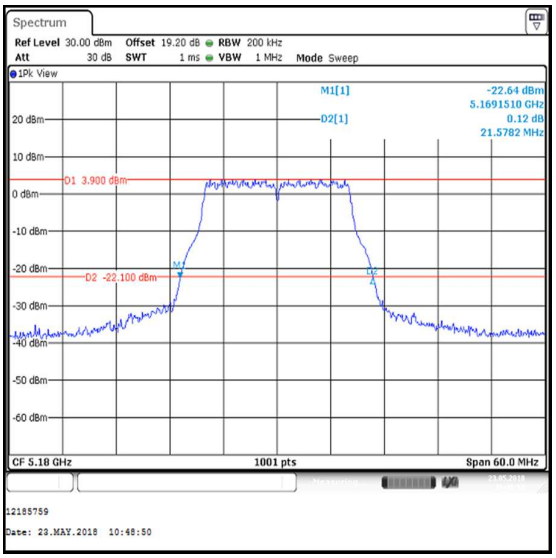
1. Measurements were performed on data rates detailed in Section 3.5 on the relevant channels.
2. The signal analyser's resolution bandwidth was set to approximately 1% of the measured 26 dB emission bandwidth.
3. The signal analyser was connected to the RF port on the EUT using an RF switch, suitable attenuation and RF cables. An RF level offset was entered on the signal analyser to compensate for the loss of the switch, attenuators and RF cables.
4. For channels that straddle the U-NII-2C and U-NII-3 bands at 5725 MHz, emission bandwidth measurements were performed twice. Measurements of the entire 26 dB emission bandwidth that is contained on both U-NII-2C and U-NII-3 bands, were used for power measurements. Measurements on the emission's portion that is contained only within the U-NII-2C band, were used to calculate the conducted power limit on U-NII-2C tests. These are labelled as 'Reference plots'.

Transmitter 26 dB Emission Bandwidth (5.15-5.25 GHz band) (continued)

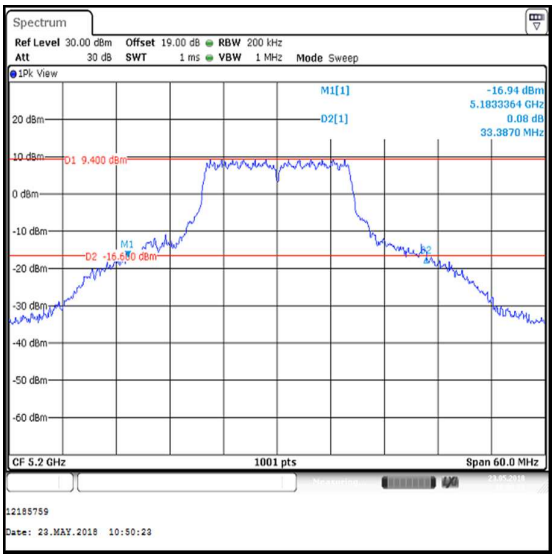
4.2.1. 5.15-5.25 GHz band

Results: 802.11a / 20 MHz / SISO / BPSK / 6 Mbps / Core 2

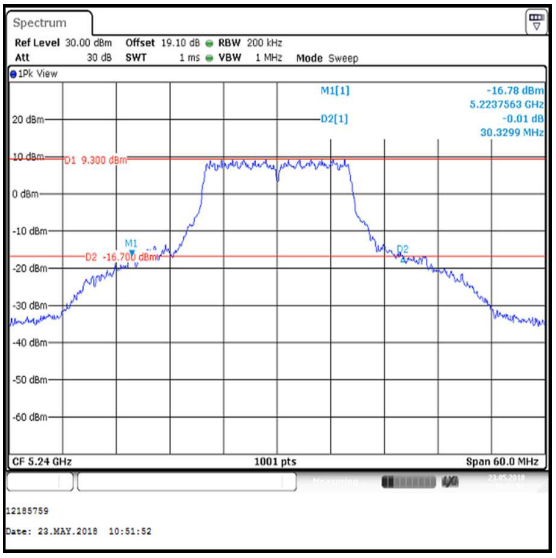
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5180	21.578
Middle	5200	33.387
Top	5240	30.330



Bottom Channel



Middle Channel

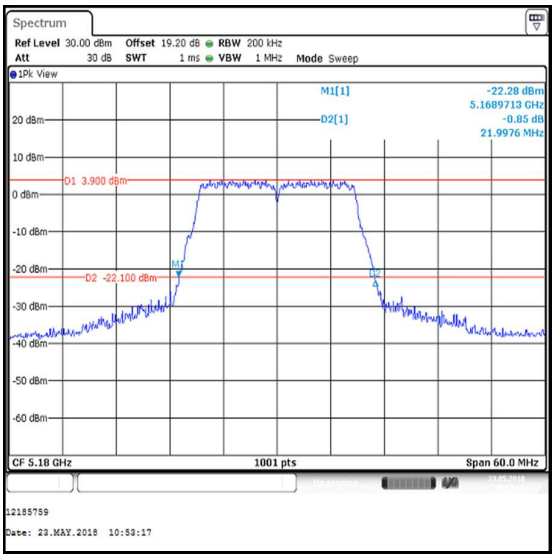


Top Channel

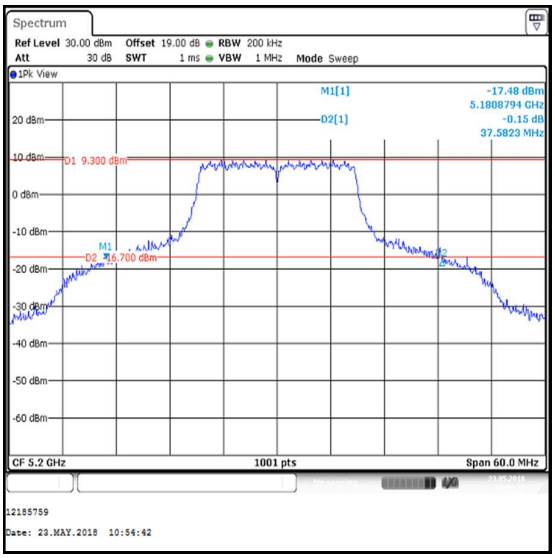
Transmitter 26 dB Emission Bandwidth (5.15-5.25 GHz band) (continued)

Results: 802.11n / 20 MHz / SISO / BPSK / MCS0 / Core 2

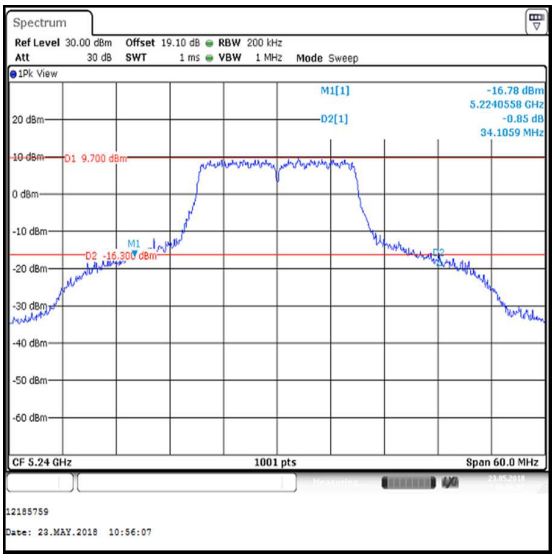
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5180	21.998
Middle	5200	37.582
Top	5240	34.106



Bottom Channel



Middle Channel

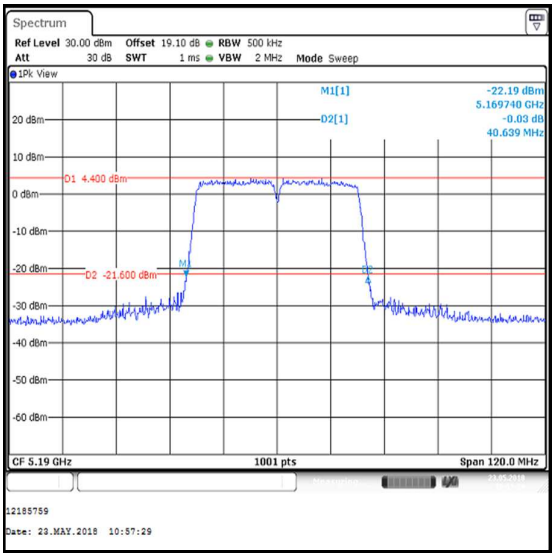


Top Channel

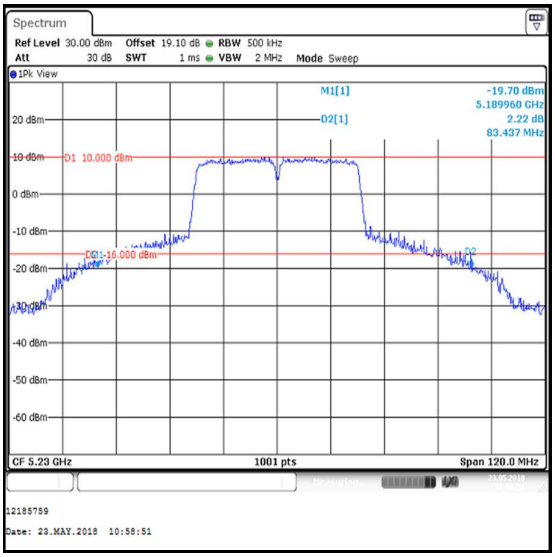
Transmitter 26 dB Emission Bandwidth (5.15-5.25 GHz band) (continued)

Results: 802.11n / 40 MHz / SISO / BPSK / MCS0 / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5190	40.639
Top	5230	83.437



Bottom Channel

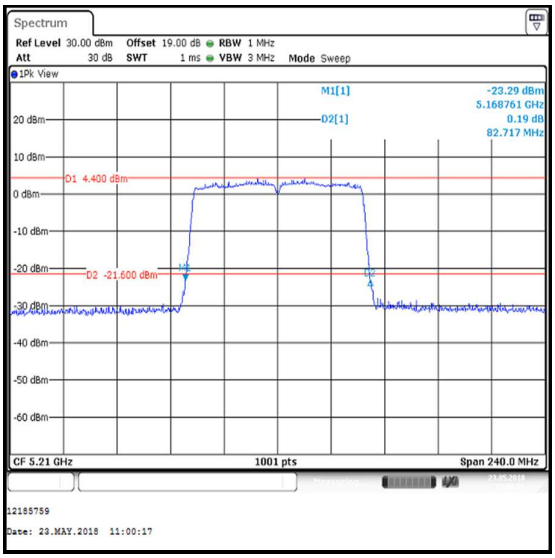


Top Channel

Transmitter 26 dB Emission Bandwidth (5.15-5.25 GHz band) (continued)

Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0x1 / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5210	82.717



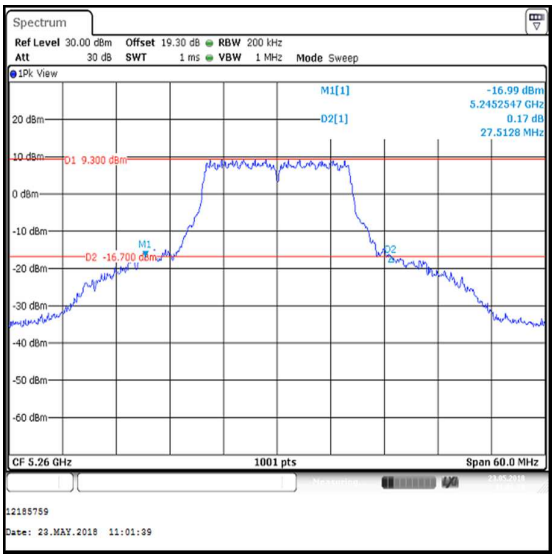
Single Channel

Transmitter 26 dB Emission Bandwidth (5.25-5.35 GHz band) (continued)

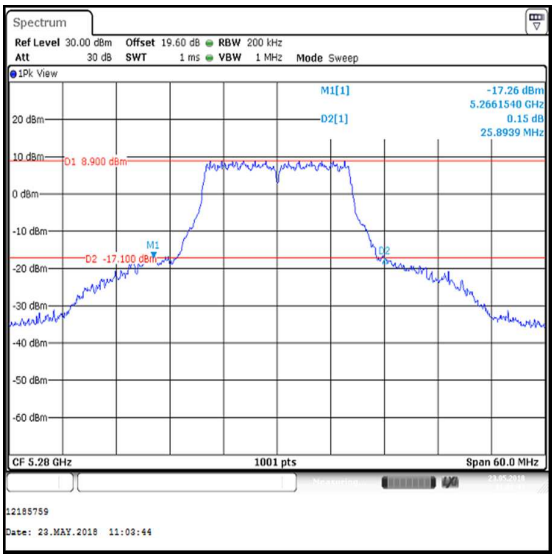
4.2.2. 5.25-5.35 GHz band

Results: 802.11a / 20 MHz / SISO / BPSK / 6 Mbps / Core 2

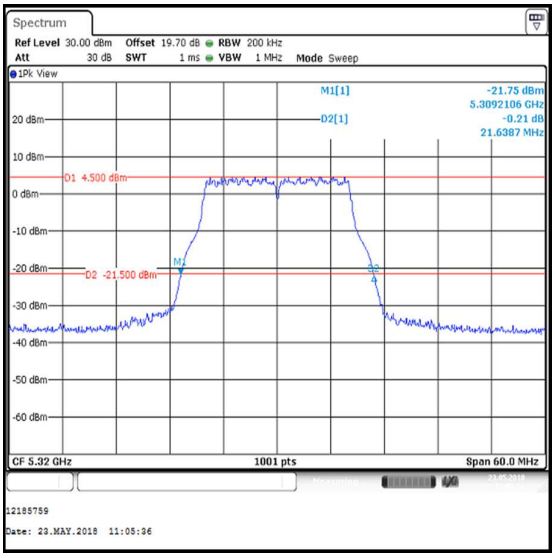
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5260	27.513
Middle	5280	25.894
Top	5320	21.639



Bottom Channel



Middle Channel

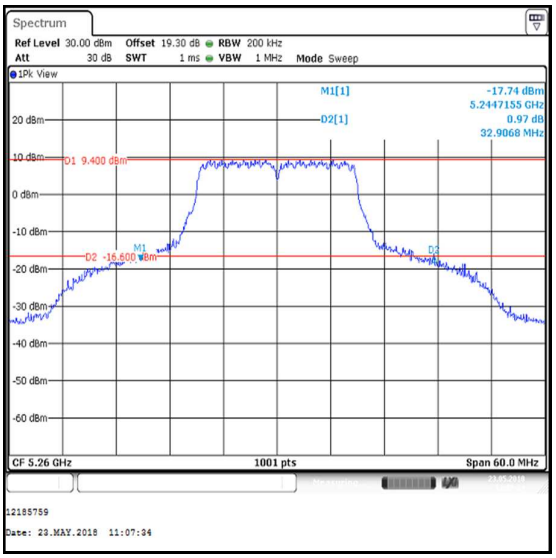


Top Channel

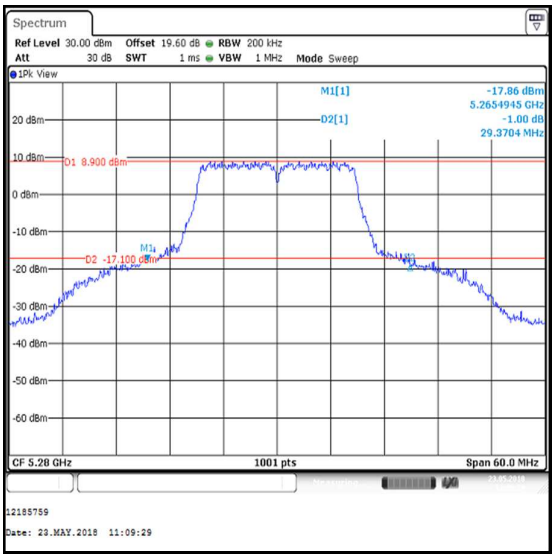
Transmitter 26 dB Emission Bandwidth (5.25-5.35 GHz band) (continued)

Results: 802.11n / 20 MHz / SISO / BPSK / MCS0 / Core 2

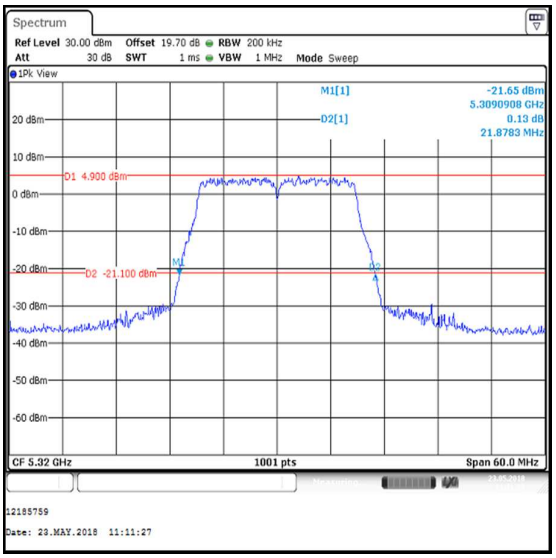
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5260	32.907
Middle	5280	29.370
Top	5320	21.878



Bottom Channel



Middle Channel

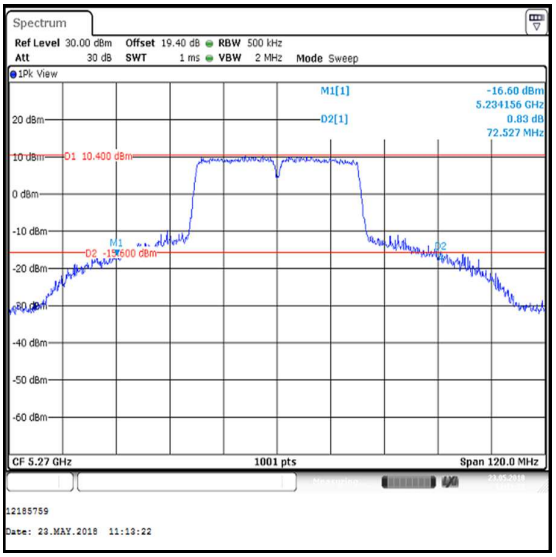


Top Channel

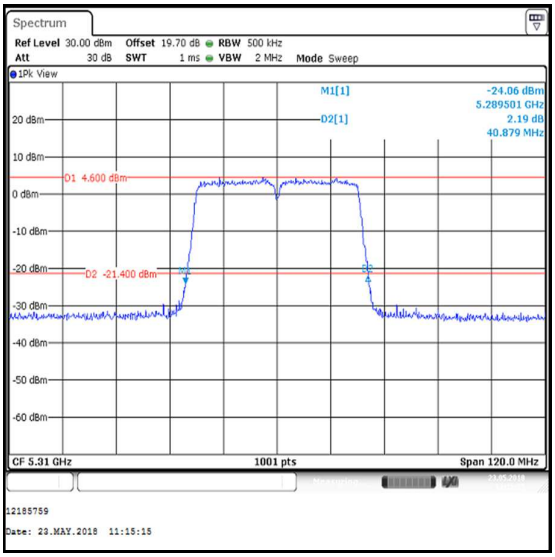
Transmitter 26 dB Emission Bandwidth (5.25-5.35 GHz band) (continued)

Results: 802.11n / 40 MHz / SISO / BPSK / MCS0 / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5270	72.527
Top	5310	40.879



Bottom Channel

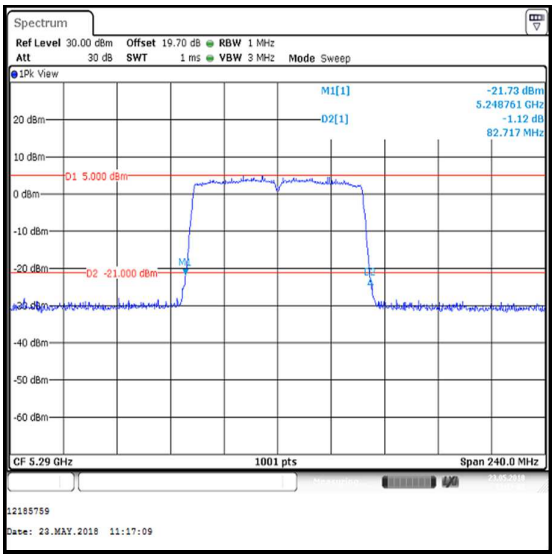


Top Channel

Transmitter 26 dB Emission Bandwidth (5.25-5.35 GHz band) (continued)

Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0x1 / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5290	82.717



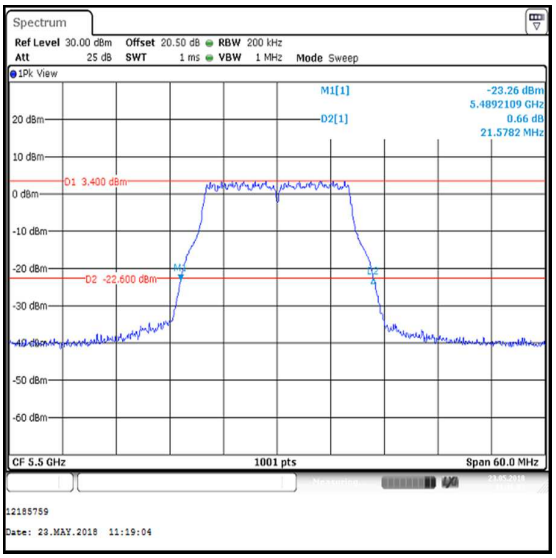
Single Channel

Transmitter 26 dB Emission Bandwidth (5.47-5.725 GHz band) (continued)

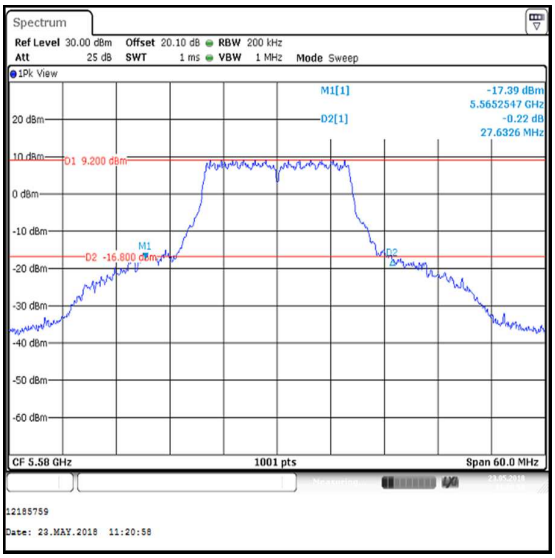
4.2.3. 5.47-5.725 GHz band

Results: 802.11a / 20 MHz / SISO / BPSK / 6 Mbps / Core 2

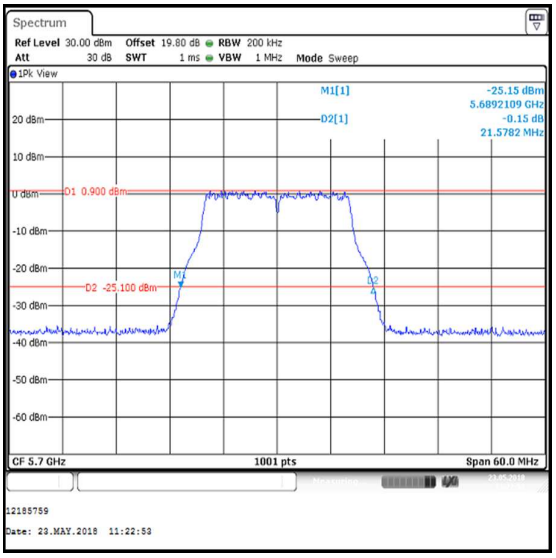
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5500	21.578
Middle	5580	27.633
Top	5700	21.578



Bottom Channel



Middle Channel

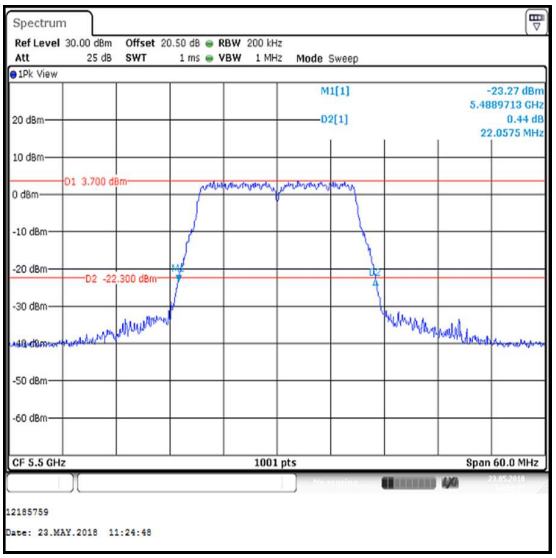


Top Channel

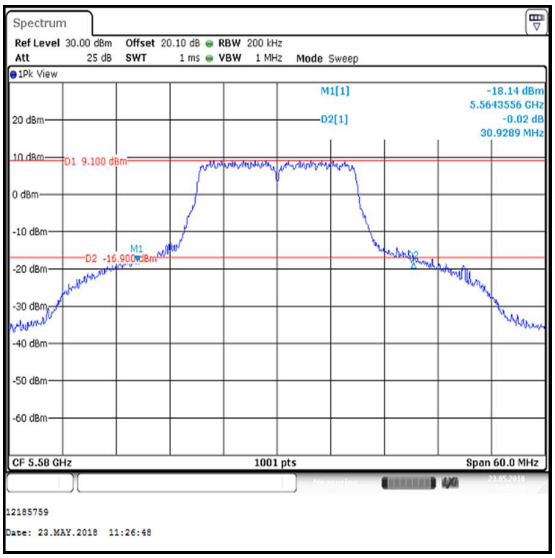
Transmitter 26 dB Emission Bandwidth (5.47-5.725 GHz band) (continued)

Results: 802.11n / 20 MHz / SISO / BPSK / MCS0 / Core 2

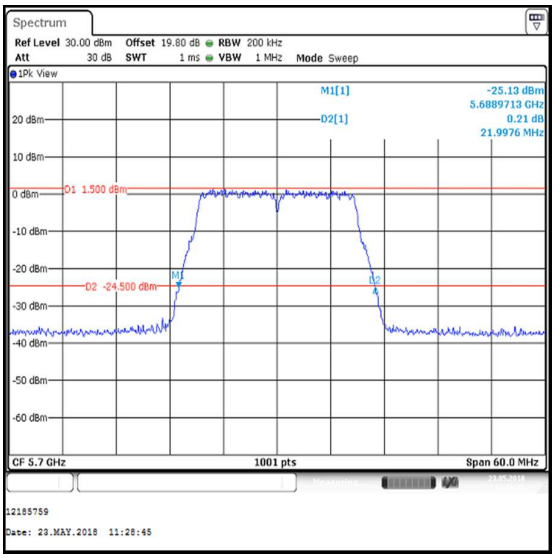
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5500	22.058
Middle	5580	30.929
Top	5700	21.998



Bottom Channel



Middle Channel

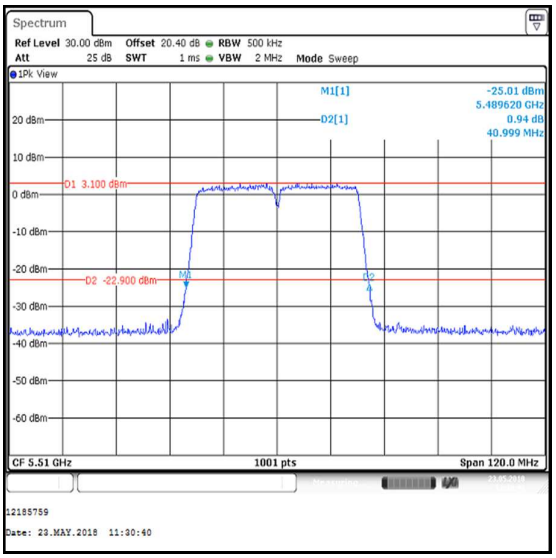


Top Channel

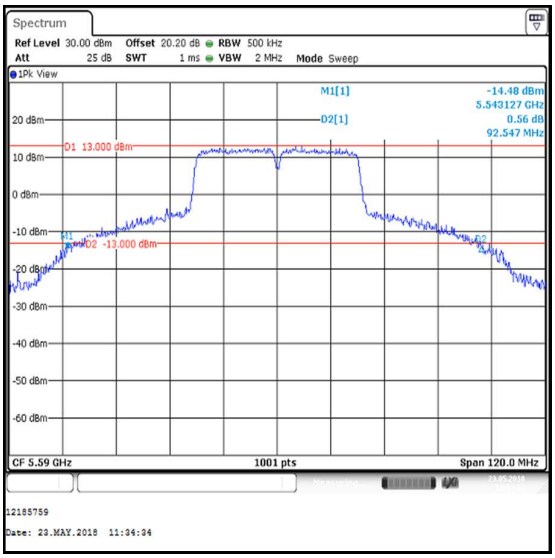
Transmitter 26 dB Emission Bandwidth (5.47-5.725 GHz band) (continued)

Results: 802.11n / 40 MHz / SISO / BPSK / MCS0 / Core 2

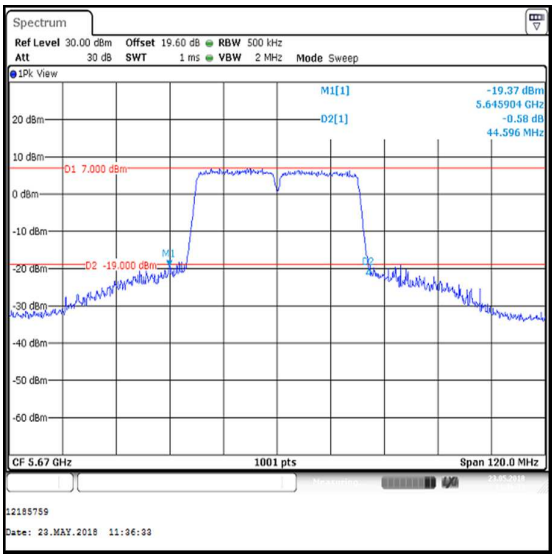
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5510	40.999
Middle	5590	92.547
Top	5670	44.596



Bottom Channel



Middle Channel

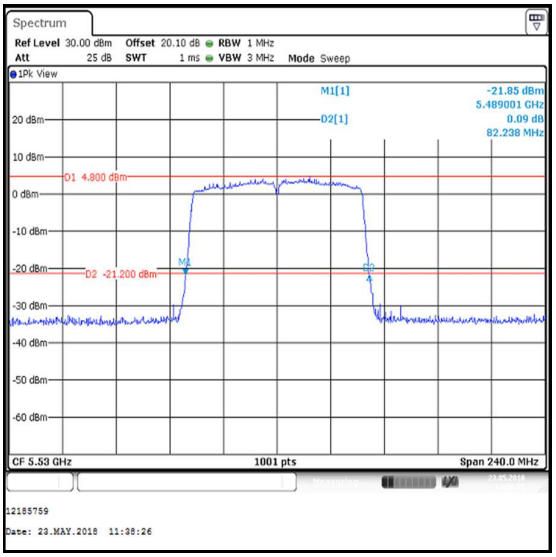


Top Channel

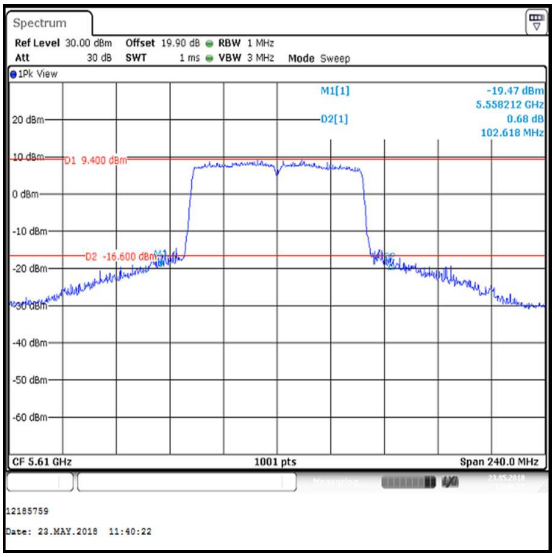
Transmitter 26 dB Emission Bandwidth (5.47-5.725 GHz band) (continued)

Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0x1 / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5530	82.238
Top	5610	102.618



Bottom Channel



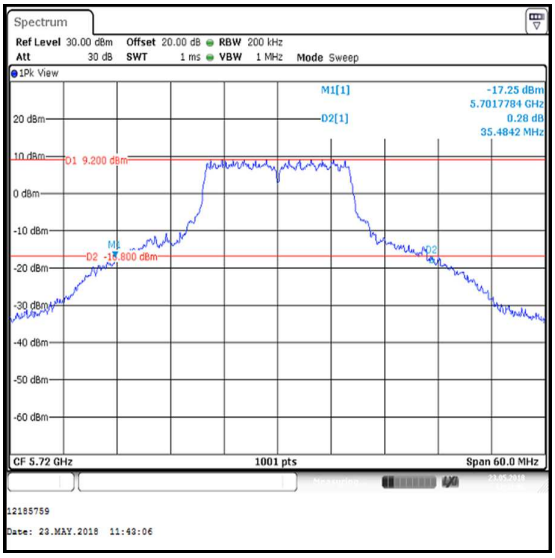
Top Channel

Transmitter 26 dB Emission Bandwidth (Straddle Channels) (continued)

4.2.4. Channels that straddle the U-NII-2C and U-NII-3 bands

Results: 802.11a / 20 MHz / SISO / BPSK / 6 Mbps / Core 2

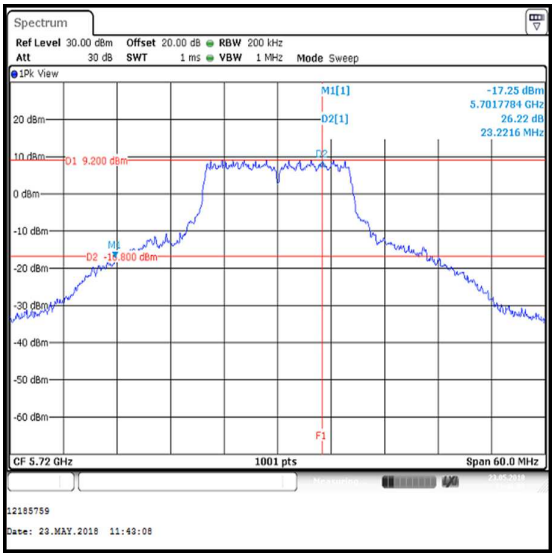
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5720	35.484



Single Channel

Results: Reference Plots / 802.11a / 20 MHz / SISO / BPSK / 6 Mbps / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5720	23.222

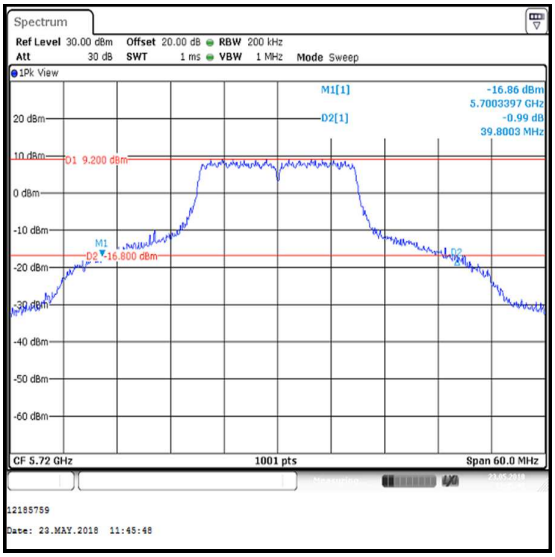


Single Channel

Transmitter 26 dB Emission Bandwidth (Straddle Channels) (continued)

Results: 802.11n / 20 MHz / SISO / BPSK / MCS0 / Core 2

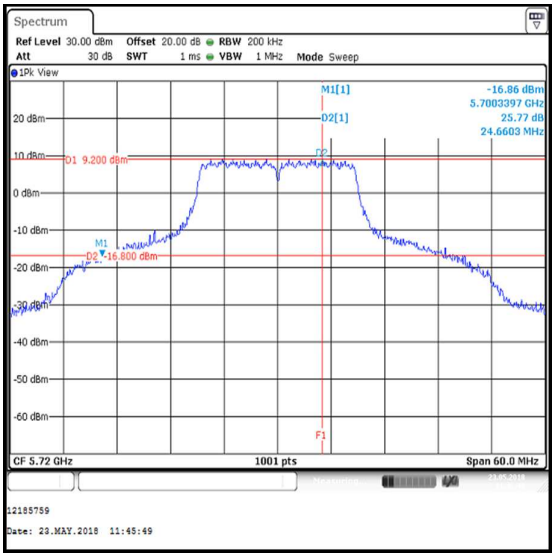
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5720	39.800



Single Channel

Results: Reference Plots / 802.11n / 20 MHz / SISO / BPSK / MCS0 / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5720	24.660

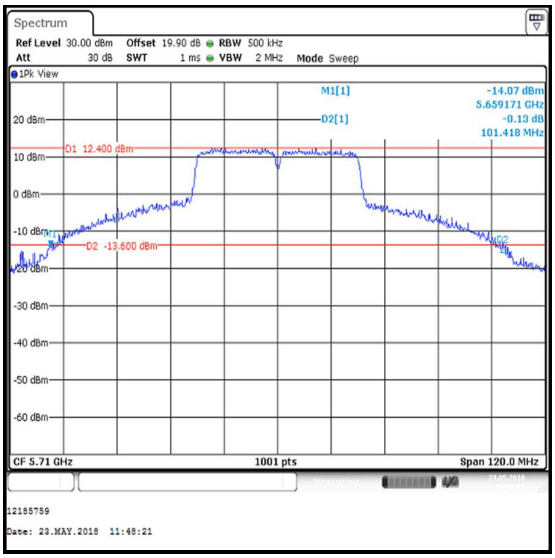


Single Channel

Transmitter 26 dB Emission Bandwidth (Straddle Channels) (continued)

Results: 802.11n / 40 MHz / SISO / BPSK / MCS0 / Core 2

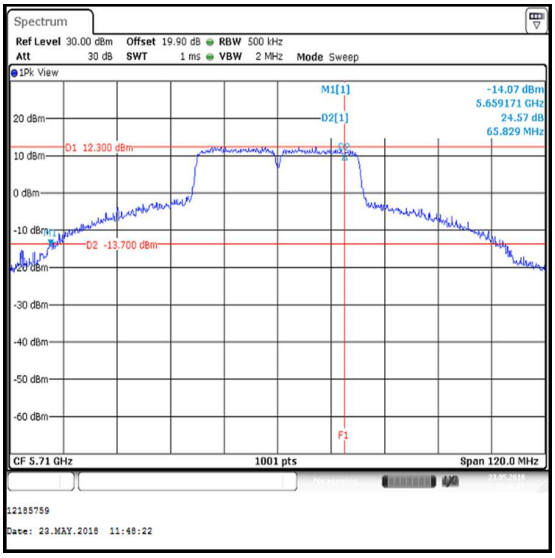
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5710	101.418



Single Channel

Results: Reference Plots / 802.11n / 40 MHz / SISO / BPSK / MCS0 / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5710	65.829

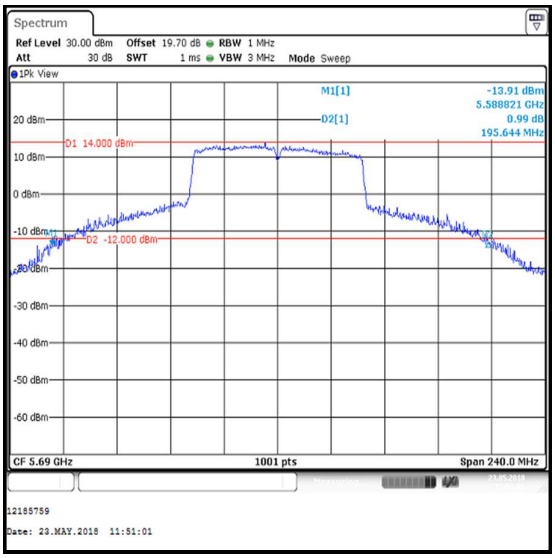


Single Channel

Transmitter 26 dB Emission Bandwidth (Straddle Channels) (continued)

Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0x1 / Core 2

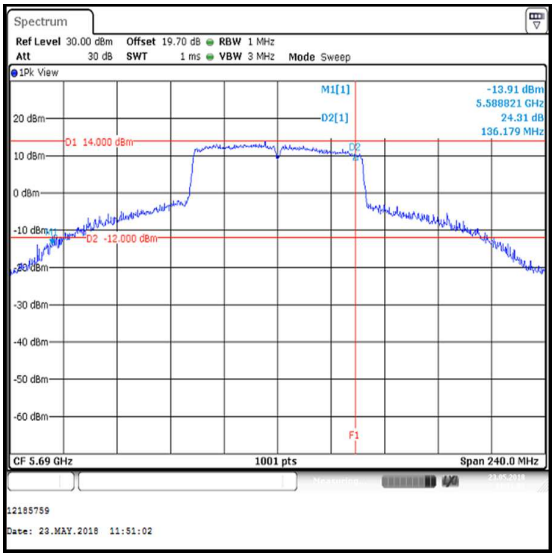
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5690	195.644



Single Channel

Results: Reference Plots / 802.11ac / 80 MHz / SISO / BPSK / MCS0x1 / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5690	136.179



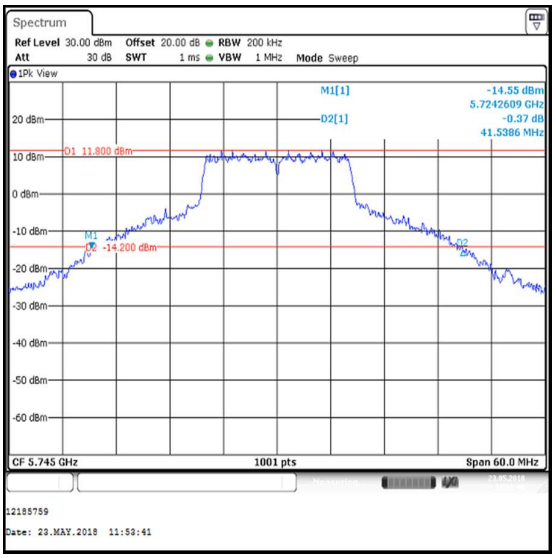
Single Channel

Transmitter 26 dB Emission Bandwidth (5.725-5.85 GHz band) (continued)

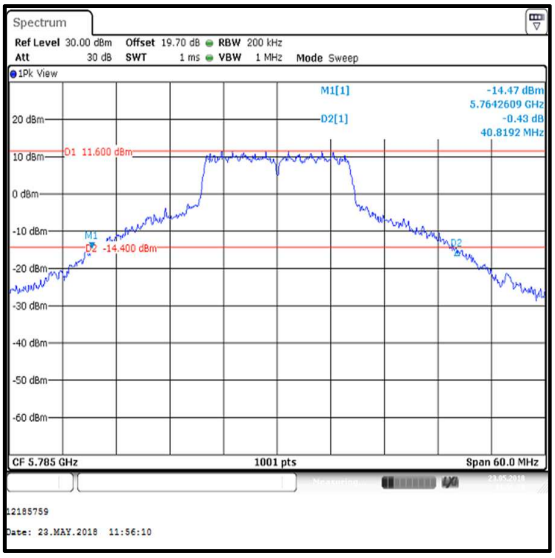
4.2.5. 5.725-5.85 GHz band

Results: 802.11a / 20 MHz / SISO / BPSK / 6 Mbps / Core 2

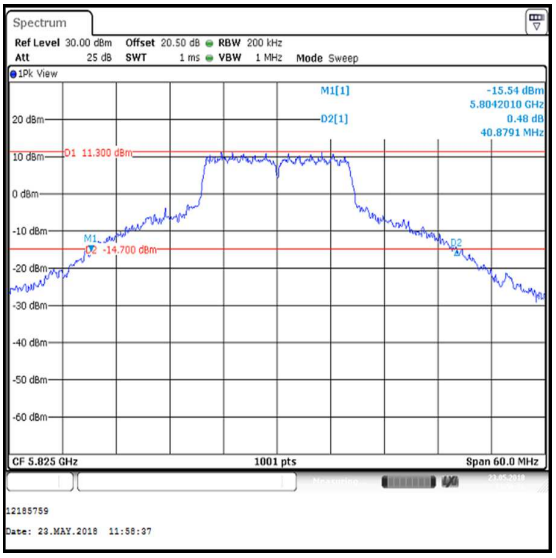
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5745	41.539
Middle	5785	40.819
Top	5825	40.879



Bottom Channel



Middle Channel

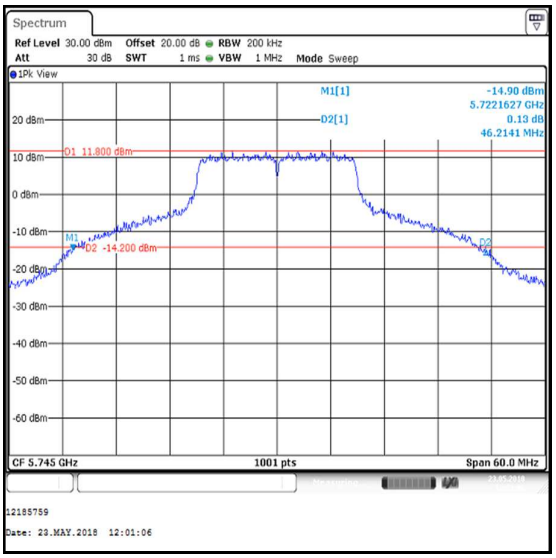


Top Channel

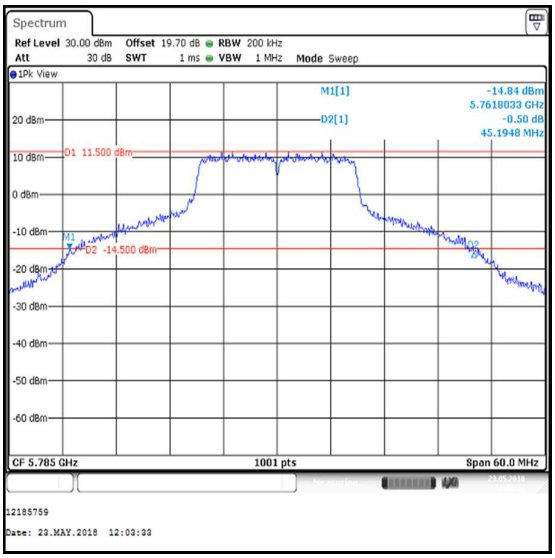
Transmitter 26 dB Emission Bandwidth (5.725-5.85 GHz band) (continued)

Results: 802.11n / 20 MHz / SISO / BPSK / MCS0 / Core 2

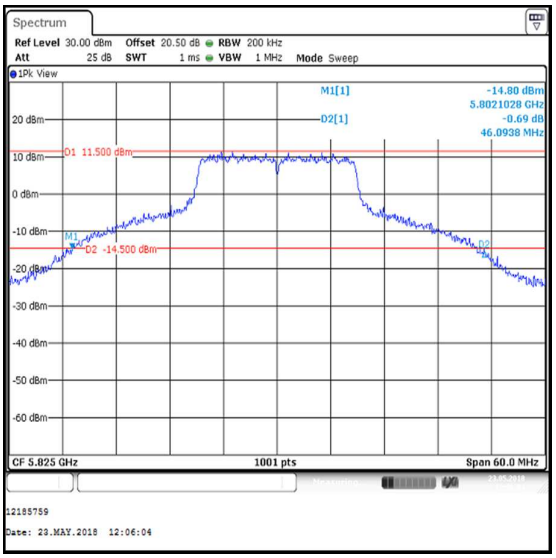
Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5745	46.214
Middle	5785	45.195
Top	5825	46.094



Bottom Channel



Middle Channel

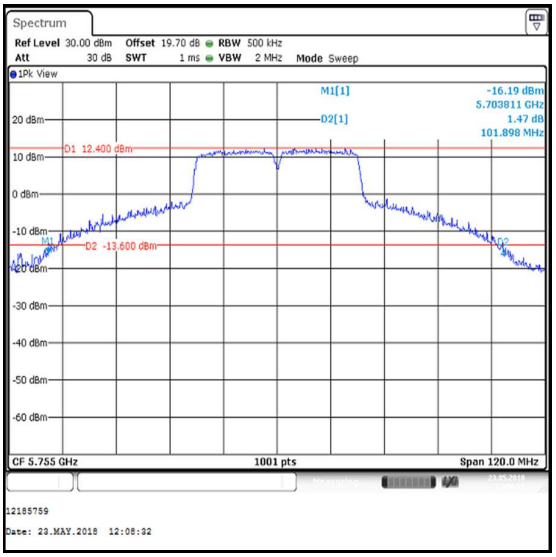


Top Channel

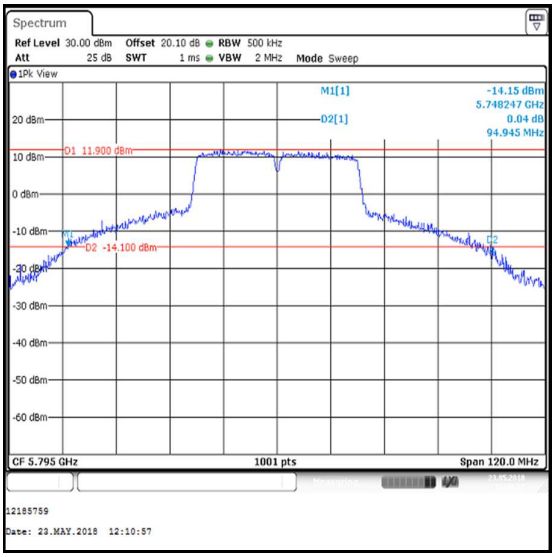
Transmitter 26 dB Emission Bandwidth (5.725-5.85 GHz band) (continued)

Results: 802.11n / 40 MHz / SISO / BPSK / MCS0 / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Bottom	5755	101.898
Top	5795	94.945



Bottom Channel

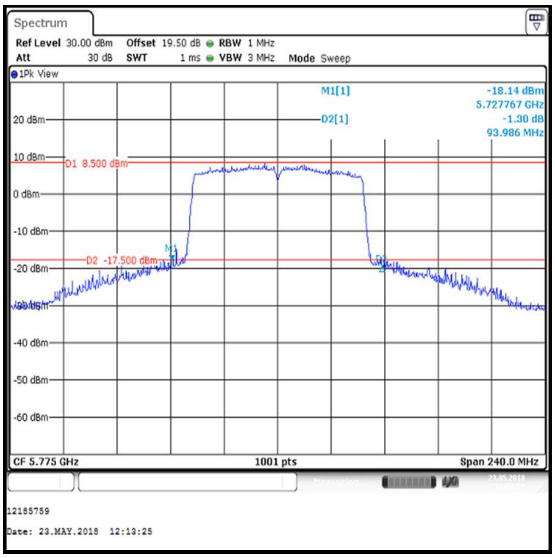


Top Channel

Transmitter 26 dB Emission Bandwidth (5.725-5.85 GHz band) (continued)

Results: 802. 11ac / 80 MHz / SISO / BPSK / MCS0x1 / Core 2

Channel	Frequency (MHz)	26 dB Emission Bandwidth (MHz)
Single	5775	93.986



Single Channel

4.3. Transmitter Minimum 6 dB Bandwidth (5.725-5.85 GHz band)

Test Summary:

Test Engineer:	Max Passell	**Test Date:**	23 May 2018
Test Sample Serial Number:	C02WC003JMFN		

FCC Reference:	Part 15.407(e)
Test Method Used:	KDB 789033 D02 Section II.C.2.

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	51

Note(s):

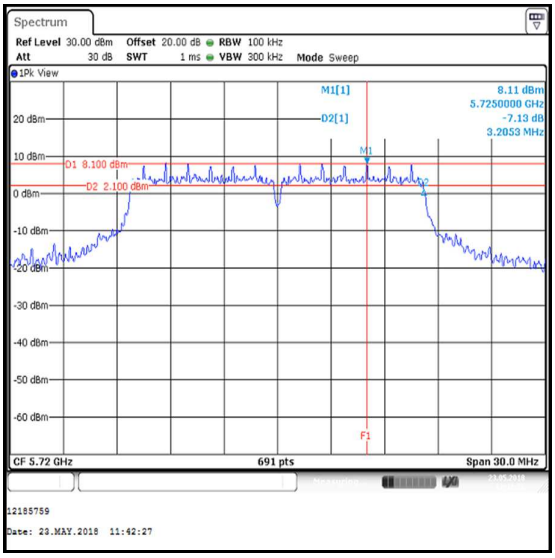
1. Measurements were performed on data rates detailed in Section 3.5 on the relevant channels.
2. For channels that straddle the U-NII-2C and U-NII-3 bands at 5725 MHz, measurements were performed on the portion of the emission that is contained within the U-NII-3 band.
3. The signal analyser was connected to the RF port on the EUT using an RF switch, suitable attenuation and RF cables. An RF level offset was entered on the signal analyser to compensate for the loss of the switch, attenuators and RF cables.

Transmitter Minimum 6 dB Bandwidth (Straddle Channels) (continued)

4.3.1. Channels that straddle the U-NII-2C and the U-NII-3 bands at 5.725 GHz

Results: 802.11a / 20 MHz / SISO / BPSK / 6 Mbps / Core 2

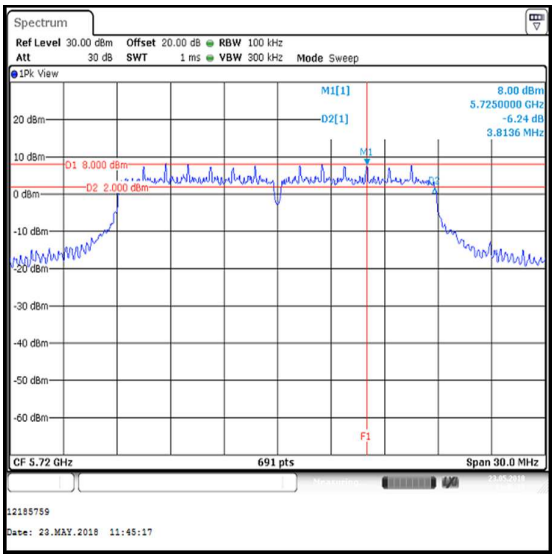
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Single	3205	≥500	2705	Complied



Single Channel

Results: 802.11n / 20 MHz / SISO / BPSK / MCS0 / Core 2

Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Single	3814	≥500	3314	Complied

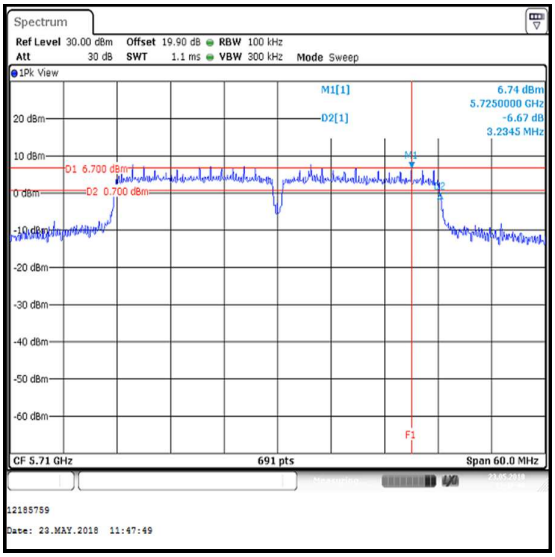


Single Channel

Transmitter Minimum 6 dB Bandwidth (Straddle Channels) (continued)

Results: 802.11n / 40 MHz / SISO / BPSK / MCS0 / Core 2

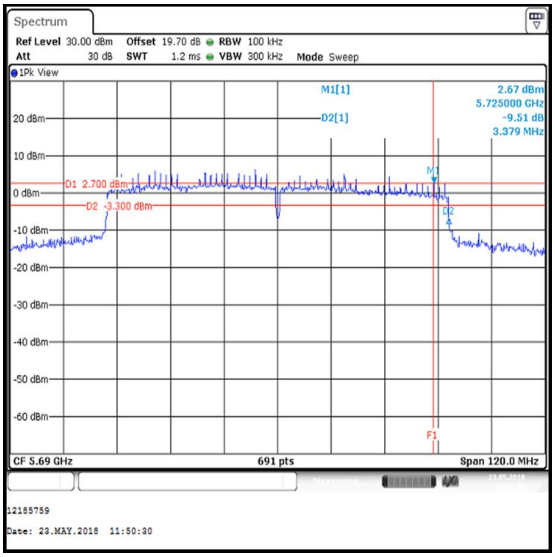
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Single	3235	≥500	2735	Complied



Single Channel

Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0x1 / Core 2

Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Single	3379	≥500	2879	Complied



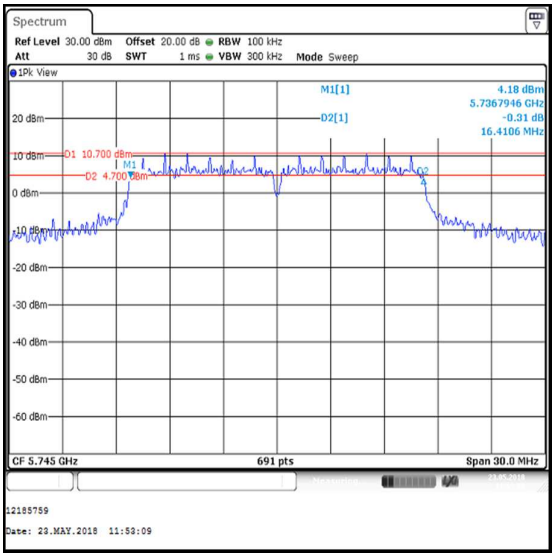
Single Channel

Transmitter Minimum 6 dB Bandwidth (5.725-5.85 GHz band) (continued)

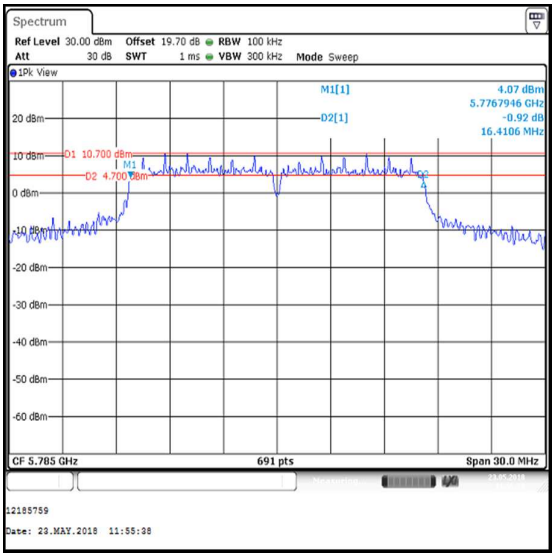
4.3.2. 5.725-5.85 GHz band

Results: 802.11a / 20 MHz / SISO / BPSK / 6 Mbps / Core 2

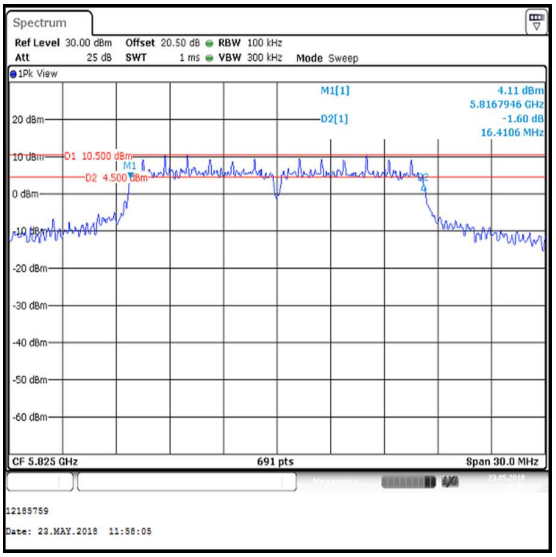
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	16411	≥500	15911	Complied
Middle	16411	≥500	15911	Complied
Top	16411	≥500	15911	Complied



Bottom Channel



Middle Channel

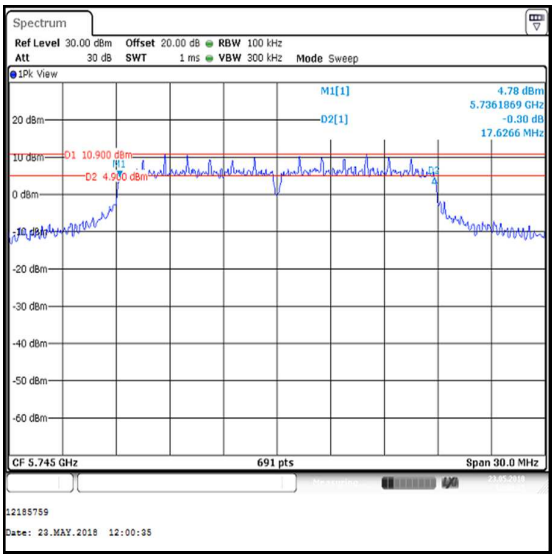


Top Channel

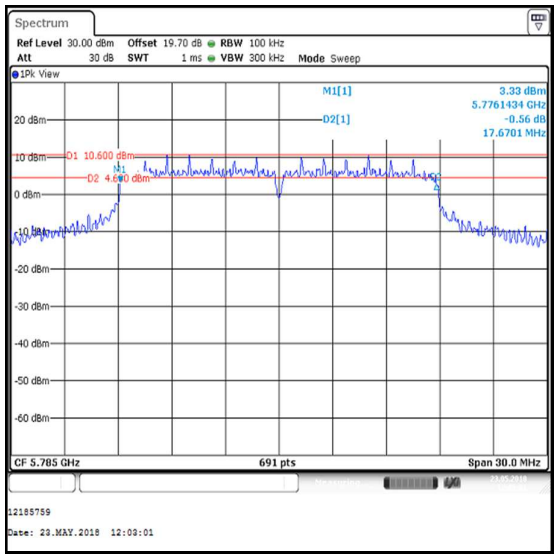
Transmitter Minimum 6 dB Bandwidth (5.725-5.85 GHz band) (continued)

Results: 802.11n / 20 MHz / SISO / BPSK / MCS0 / Core 2

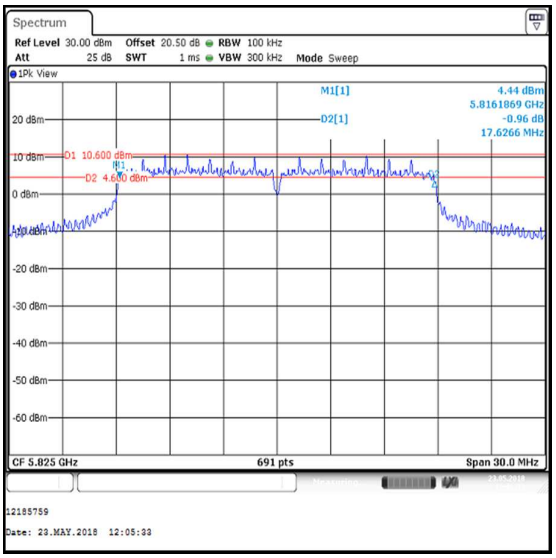
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	17627	≥500	17127	Complied
Middle	17670	≥500	17170	Complied
Top	17627	≥500	17127	Complied



Bottom Channel



Middle Channel

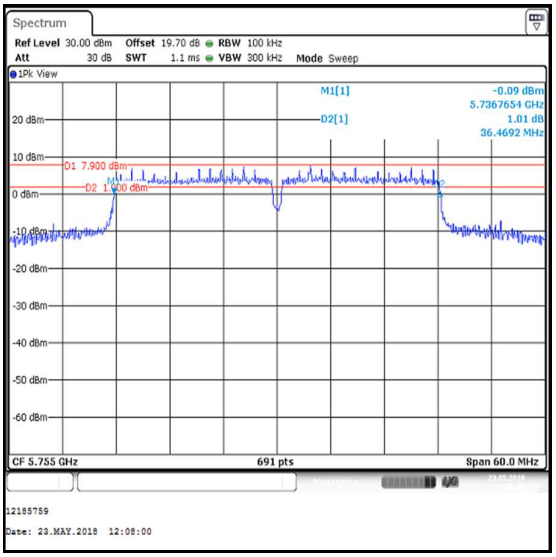


Top Channel

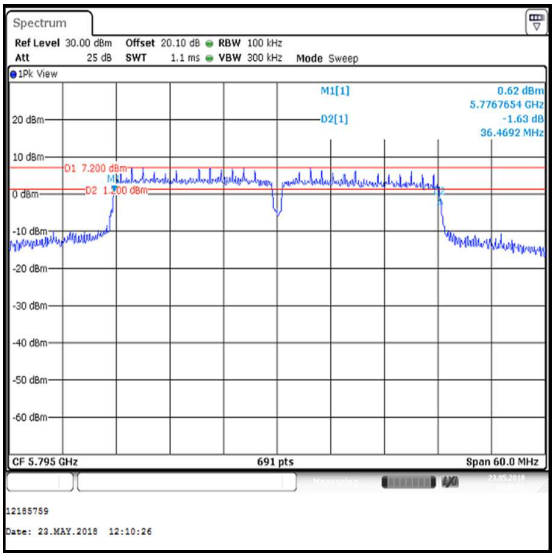
Transmitter Minimum 6 dB Bandwidth (5.725-5.85 GHz band) (continued)

Results: 802.11n / 40 MHz / SISO / BPSK / MCS0 / Core 2

Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	36469	≥500	35969	Complied
Top	36469	≥500	35969	Complied



Bottom Channel

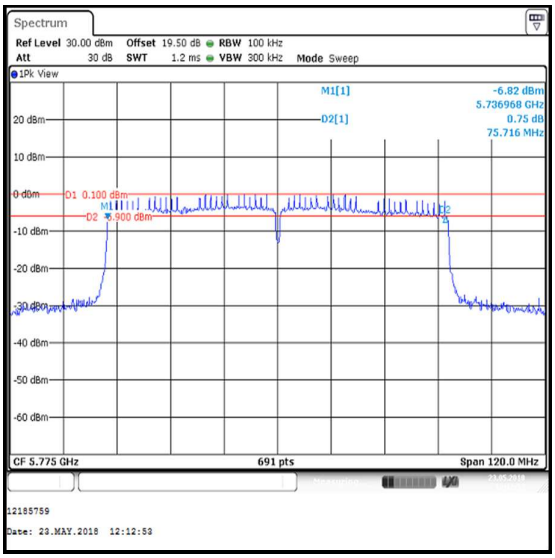


Top Channel

Transmitter Minimum 6 dB Bandwidth (5.725-5.85 GHz band) (continued)

Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0x1 / Core 2

Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Single	75716	≥500	75216	Complied



Single Channel

4.4. Transmitter Maximum Conducted Output Power

4.4.1. 5.15-5.25 GHz band

Test Summary:

Test Engineer:	Max Passell	**Test Date:**	23 May 2018
Test Sample Serial Number:	C02WC003JMFN		

FCC Reference:	Part 15.407(a)(1)(iv)
Test Method Used:	KDB 789033 D02 Section II.E.2.b) and II.E.2.d)

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	54

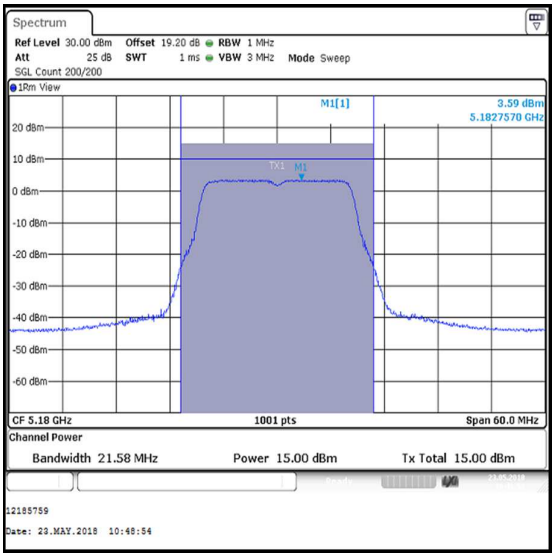
Note(s):

1. For conducted power tests where the duty cycle is >98%, the measurements were performed using a signal analyser in accordance with FCC KDB 789033 II.E.2.b) Method SA-1. Where the duty cycle is <98%, the measurements were performed in accordance with FCC KDB 789033 II.E.2.d) Method SA-2. The signal analyser's integration function was used to integrate across the 26 dB emission bandwidth. The resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz. An RMS detector was used and sweep time was set to auto and 200 traces performed. The span was set to encompass the entire 26 dB emission bandwidth. The channel power results are recorded in the tables below.
2. Measurements were performed using configurations detailed in Section 3.5 of this test report on the relevant channels.
3. For data rates where the EUT was transmitting at <98% duty cycle, the calculated duty cycle in Section 4.1 was added to the measured power in order to compute the average power during the actual transmission time.
4. For all modes of operation, the antenna gain is < 6 dBi.
5. For details on antenna gains refer to Section 3.4 of this test report.
6. The signal analyser was connected to the RF port on the EUT using an RF switch, suitable attenuation and RF cable. An RF level offset was entered on the signal analyser to compensate for the loss of the attenuator and RF cable.
7. The Part 15.407(a)(1)(iv) limit shall not exceed 250 mW (24.0 dBm).

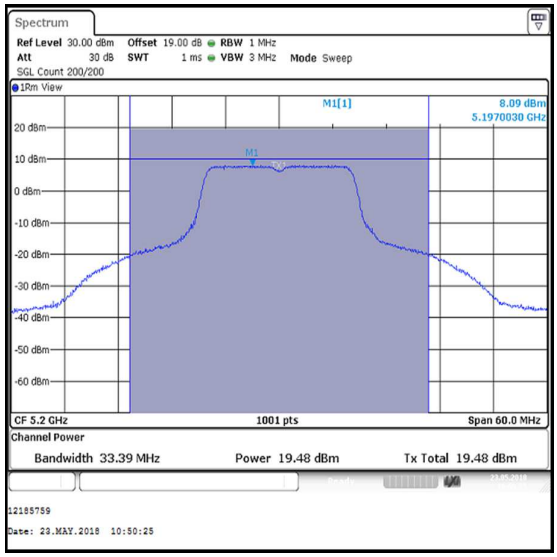
Transmitter Maximum Conducted Output Power (5.15-5.25 GHz band) (continued)

Results: 802.11a / 20 MHz / SISO / BPSK / 6 Mbps / Core 2

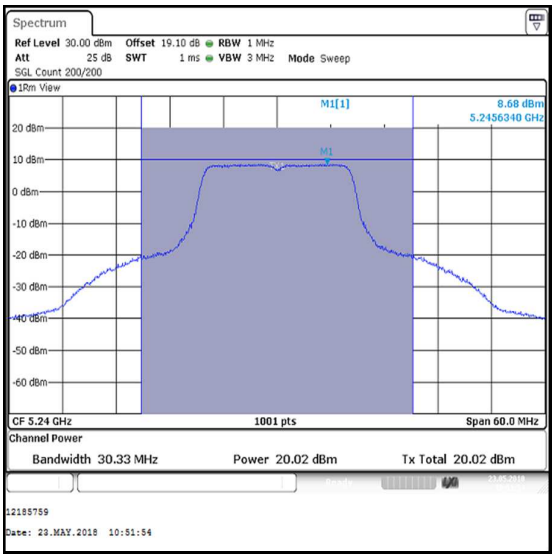
Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Margin (dB)	Result
Bottom	5180	15.0	24.0	9.0	Complied
Middle	5200	19.5	24.0	4.5	Complied
Top	5240	20.0	24.0	4.0	Complied



Bottom Channel



Middle Channel

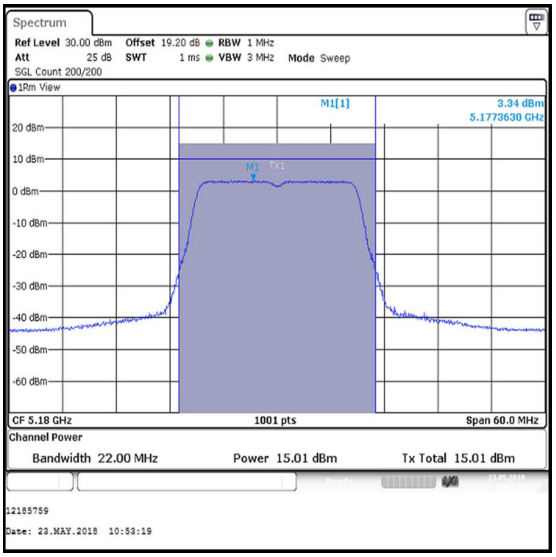


Top Channel

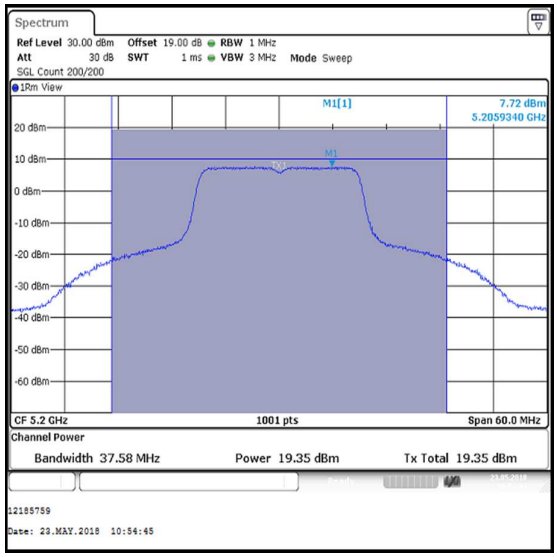
Transmitter Maximum Conducted Output Power (5.15-5.25 GHz band) (continued)

Results: 802.11n / 20 MHz / SISO / BPSK / MCS0 / Core 2

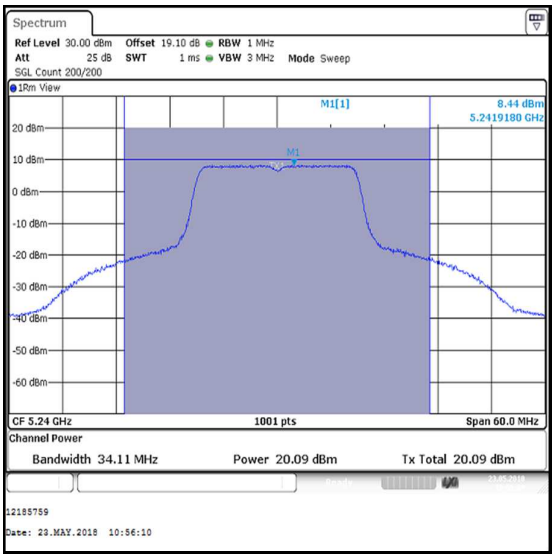
Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Margin (dB)	Result
Bottom	5180	15.0	24.0	9.0	Complied
Middle	5200	19.4	24.0	4.6	Complied
Top	5240	20.1	24.0	3.9	Complied



Bottom Channel



Middle Channel

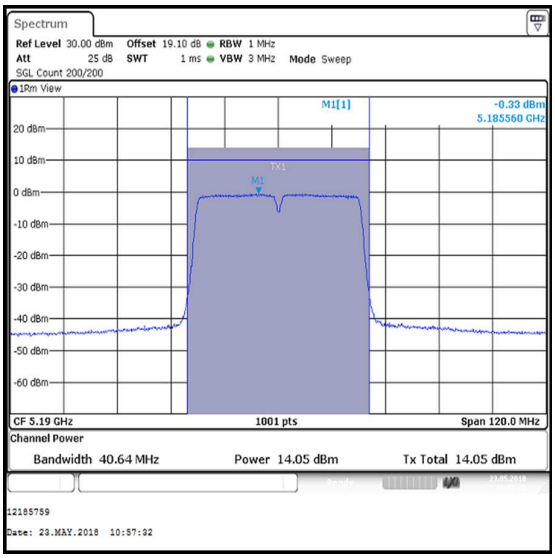


Top Channel

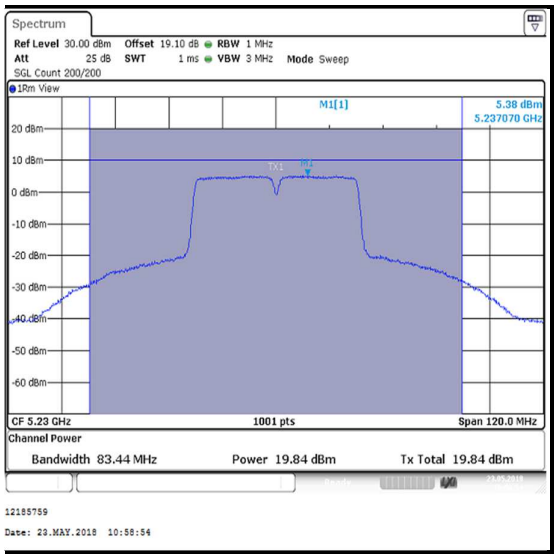
Transmitter Maximum Conducted Output Power (5.15-5.25 GHz band) (continued)

Results: 802.11n / 40 MHz / SISO / BPSK / MCS0 / Core 2

Channel	Frequency (MHz)	Conducted Power (dBm)	Duty cycle correction factor (dB)	Corrected Conducted Power (dBm)	Limit (dBm)	Margin (dB)	Result
Bottom	5190	14.1	0.1	14.2	24.0	9.8	Complied
Top	5230	19.8	0.1	19.9	24.0	4.1	Complied



Bottom Channel

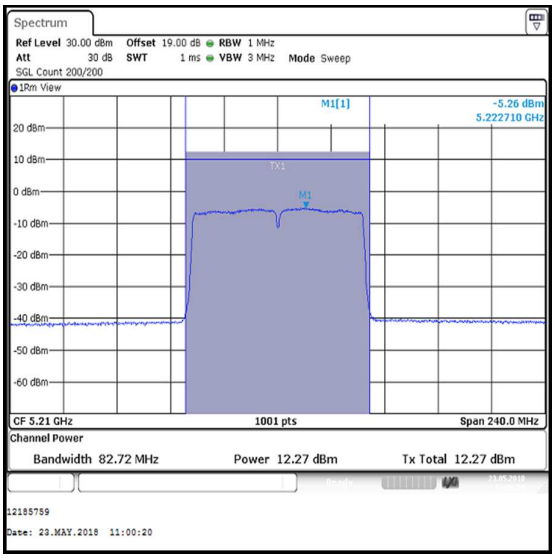


Top Channel

Transmitter Maximum Conducted Output Power (5.15-5.25 GHz band) (continued)

Results: 802.11ac / 80 MHz / SISO / BPSK / MCS0x1 / Core 2

Channel	Frequency (MHz)	Conducted Power (dBm)	Duty cycle correction factor (dB)	Corrected Conducted Power (dBm)	Limit (dBm)	Margin (dB)	Result
Single	5210	12.3	0.2	12.5	24.0	11.5	Complied



Single Channel

Transmitter Maximum Conducted Output Power (5.25-5.35 GHz band)

4.4.2. 5.25-5.35 GHz band

Test Summary:

Test Engineer:	Max Passell	**Test Date:**	23 May 2018
Test Sample Serial Number:	C02WC003JMFN		

FCC Reference:	Part 15.407(a)(2)
Test Method Used:	KDB 789033 D02 Section II.E.2.b) and II.E.2.d)

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	54

Note(s):

1. For conducted power tests where the duty cycle is >98%, the measurements were performed using a signal analyser in accordance with FCC KDB 789033 II.E.2.b) Method SA-1. Where the duty cycle is <98%, the measurements were performed in accordance with FCC KDB 789033 II.E.2.d) Method SA-2. The signal analyser's integration function was used to integrate across the 26 dB emission bandwidth. The resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz. An RMS detector was used and sweep time was set to auto and 200 traces performed. The span was set to encompass the entire 26 dB emission bandwidth. The channel power results are recorded in the tables below.
2. Measurements were performed using configurations detailed in Section 3.5 of this test report on the relevant channels.
3. For data rates where the EUT was transmitting at <98% duty cycle, the calculated duty cycle in Section 4.1 was added to the measured power in order to compute the average power during the actual transmission time.
4. For all modes of operation, the antenna gain is < 6 dBi.
5. For details on antenna gains refer to Section 3.4 of this test report.
6. The signal analyser was connected to the RF port on the EUT using an RF switch, suitable attenuation and RF cable. An RF level offset was entered on the signal analyser to compensate for the loss of the attenuator and RF cable.
7. The FCC Part 15.407(a)(2) limit is the lesser of 250 mW (24.0 dBm) or 11 dBm + 10 $\log_{10}$ B, where B is the previously measured 26 dB emission bandwidth in MHz. For U-NII-2A band, the 26 dB EBW is greater than 20 MHz.

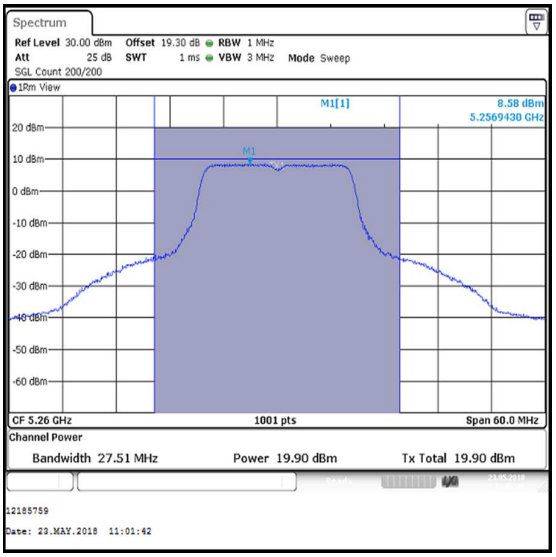
$$\begin{gathered}\text{For B} > 20\ \text{MHz} \rightarrow \\ \rightarrow \log_{10}\text{B} > \log_{10} 20 \rightarrow \\ \rightarrow 10\log_{10}\text{B} > 10\log_{10} 20 \rightarrow \\ \rightarrow 11 + 10\log_{10}\text{B} > 11 + 10\log_{10} 20 \rightarrow \\ \rightarrow 11 + 10\log_{10}\text{B} > 24.0\ \text{dBm}\end{gathered}$$

Therefore for measured emission bandwidths greater than 20 MHz, the lesser of the two limits is the fixed limit of 250 mW (24.0 dBm). This was applied to the results.

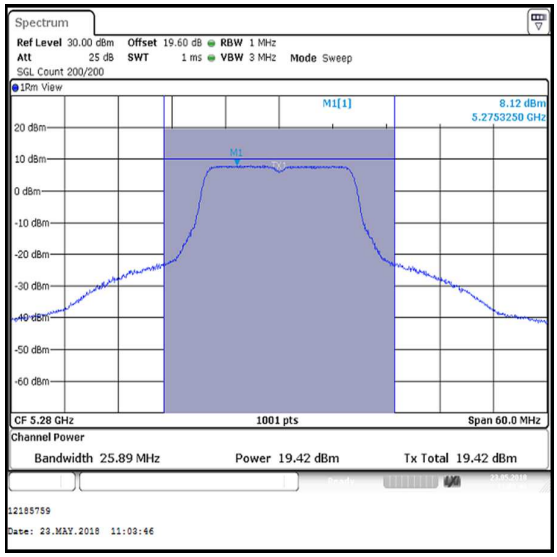
Transmitter Maximum Conducted Output Power (5.25-5.35 GHz band) (continued)

Results: 802.11a / 20 MHz / SISO / BPSK / 6 Mbps / Core 2

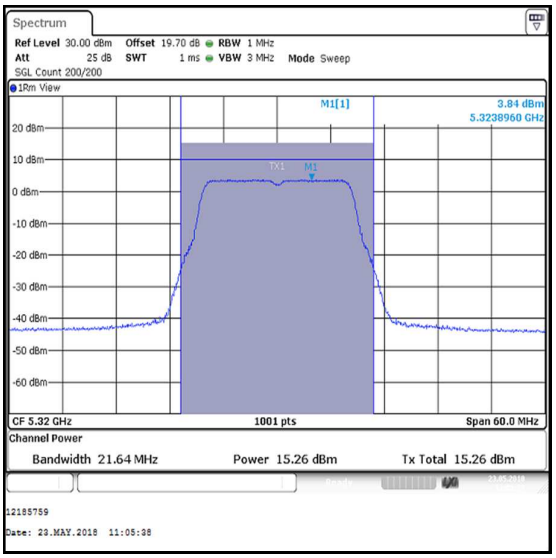
Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Margin (dB)	Result
Bottom	5260	19.9	24.0	4.1	Complied
Middle	5280	19.4	24.0	4.6	Complied
Top	5320	15.3	24.0	8.7	Complied



Bottom Channel



Middle Channel

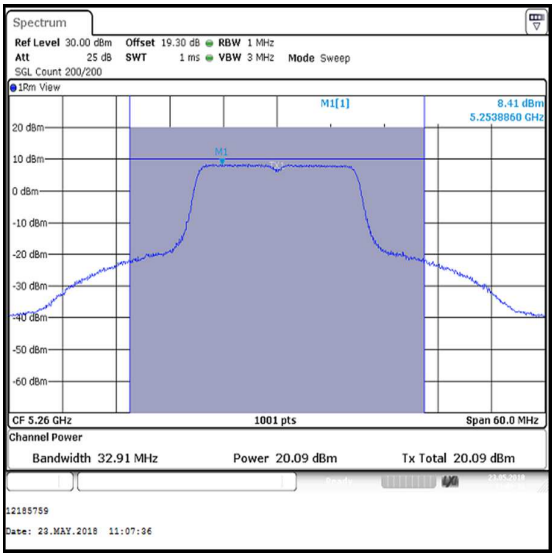


Top Channel

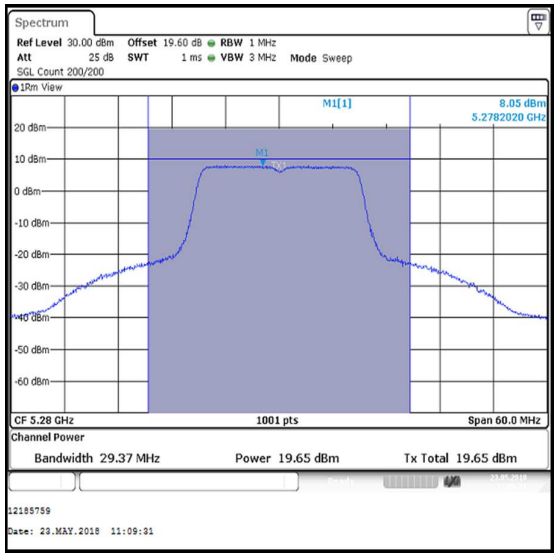
Transmitter Maximum Conducted Output Power (5.25-5.35 GHz band) (continued)

Results: 802.11n / 20 MHz / SISO / BPSK / MCS0 / Core 2

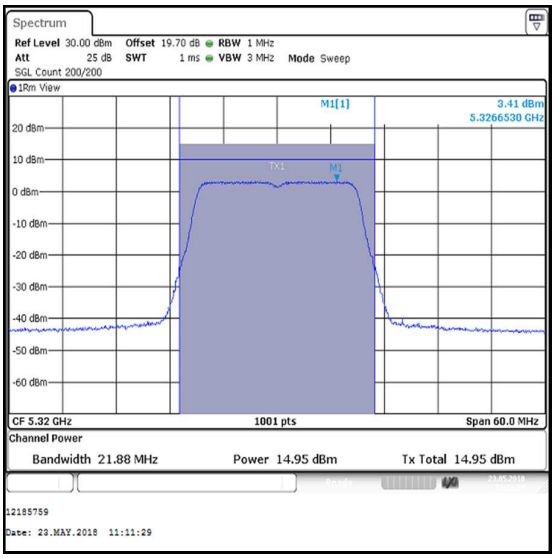
Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Margin (dB)	Result
Bottom	5260	20.1	24.0	3.9	Complied
Middle	5280	19.7	24.0	4.3	Complied
Top	5320	15.0	24.0	9.0	Complied



Bottom Channel



Middle Channel



Top Channel