TEST REPORT

Test Report No. : UL-RPT-RP11456397JD18A

Manufacturer	:	Neeo AG
Model No.	:	6336-BRAIN
FCC ID	:	2AKK7-BR633601
Technology	:	WLAN
Test Standard(s)	:	FCC Parts 15.209(a) & 15.247

1. This test report shall not be reproduced in full or partial, without the written approval of UL VS LTD.
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: 26 April 2017

Checked by:

Ian Watch
Senior Engineer, Radio Laboratory

Company Signatory:

Sarah Williams
Senior Engineer, Radio Laboratory
UL VS LTD

0644

This laboratory is accredited by UKAS. The tests reported herein have been performed in accordance with its terms of accreditation.

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1. Customer Information

Company Name:	Neeo AG
Address:	Ritterquai 8 4500 Solothurn Switzerland

2. Summary of Testing

2.1. General Information

Specification Reference:	47CFR15.247
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.247
Specification Reference:	47CFR15.209
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Sections 15.207 and 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:	13 December 2016 to 21 April 2017

2.2. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.247(a)(2)	Transmitter Minimum 6 dB Bandwidth	✓
Part 15.247(e)	Transmitter Power Spectral Density	✓
Part 15.247(b)(3)	Transmitter Maximum (Average) Output Power	✓
Part 15.247(d) & 15.209(a)	Transmitter Radiated Emissions	✓
Part 15.247(d) & 15.209(a)	Transmitter Band Edge Radiated Emissions	✓

Key to Results

✓ = Complied ✗ = Did not comply

2.3. Methods and Procedures

Reference:	ANSI C63.10-2013
Title:	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Reference:	KDB 558074 D01 DTS Meas Guidance v03r05 April 8, 2016
Title:	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

2.4. 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 specification identified above.

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Neeo
Model Name or Number:	6336-BRAIN
Test Sample Serial Number:	Not marked or stated *(Radiated sample)*
Hardware Version:	Hardware Rev. 5
Software Version:	0.23.0
FCC ID:	2AKK7-BR633601

Brand Name:	Neeo
Model Name or Number:	6336-BRAIN
Test Sample Serial Number:	Not marked or stated *(Conducted sample with RF port)*
Hardware Version:	Hardware Rev. 5
Software Version:	0.23.0
FCC ID:	2AKK7-BR633601

3.2. Description of EUT

The Equipment Under Test was a base station for home automation. It contains Z-Wave, *Bluetooth* BR/EDR/ LE, IEEE 802.15.4 and WLAN transceivers. It is powered from an AC/DC adaptor.

3.3. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.4. Additional Information Related to Testing

Technology Tested:	WLAN (IEEE 802.11b,g,n) / Digital Transmission System		
Type of Unit:	Transceiver		
Modulation Type:	DBPSK, DQPSK, BPSK, QPSK, 16QAM & 64QAM		
Data Rates:	802.11b	1, 2, 5.5 & 11 Mbps	
	802.11g	6, 9, 12, 18, 24, 36, 48 & 54 Mbps	
	802.11n HT20	MCS0 to MCS7	
Power Supply Requirement(s):	Nominal	5.2 VDC via 120 VAC 60 Hz adaptor	
Declared Antenna Gain:	0.5 dBi		
Channel Spacing:	20 MHz		
Transmit Frequency Range:	2412 MHz to 2462 MHz		
Transmit Channels Tested:	**Channel Number**	**Channel Frequency (MHz)**	
	1	2412	
	6	2437	
	11	2462	

3.5. Support Equipment

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

Description:	Laptop PC
Brand Name:	Dell
Model Name or Number:	E5400
Serial Number:	01160

Description:	USB to TTL Serial Cable. Length 1.8 metres
Brand Name:	FTDI Chip
Model Name or Number:	TTL-232R-3V3-AJ
Serial Number:	Not marked or stated

Description:	AC/DC Adaptor
Brand Name:	Liteon
Model Name or Number:	PA-1100-25
Serial Number:	KPO1003005 6088111EPE03

Description:	HDMI Cable. Length 3 metres
Brand Name:	Not marked or stated
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

Description:	Now TV Box for HDMI Termination
Brand Name:	Sky
Model Name or Number:	2400SK
Serial Number:	1MM4DE006281

Description:	Infra-Red Sensor
Brand Name:	Neeo
Model Name or Number:	Not marked or stated
Serial Number:	Not marked or stated

4. Operation and Monitoring of the EUT during Testing

4.1. Operating Modes

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

- Continuously transmitting with a modulated carrier at maximum power with a 100% duty cycle on the bottom, middle and top channels as required using the supported data rates/modulation types.

4.2. Configuration and Peripherals

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

- A laptop PC with an open source terminal application Tera Term V4.83 was used to place the EUT into test mode. The application was used to enable a continuous transmission mode, at required power and to select the test channels, data rates and modulation schemes as required. The procedure to set up and control the EUT was supplied by the customer in a documents titled 'new wifi commands.txt' dated 12/12/2016.
- All supported modes and channel widths were initially investigated on one channel. The modes that produced the highest power and widest bandwidth were:
    - Highest power
        - 802.11b – DBPSK / 1 Mbps
        - 802.11g – QPSK / 18 Mbps
        - 802.11n HT20 – 64-QAM / 52 Mbps / MCS5
        - 802.11n HT40 – 64-QAM / 121.5 Mbps / MCS6
    - Highest power spectral density
        - 802.11b – DBPSK / 1 Mbps
        - 802.11g – 64-QAM / 54 Mbps
        - 802.11n HT20 – 64-QAM / 52 Mbps / MCS5
        - 802.11n HT40 – 64-QAM / 121.5 Mbps / MCS6
    - Widest bandwidth
        - 802.11b – DBPSK / 1 Mbps
        - 802.11g – QPSK / 18 Mbps
        - 802.11n HT20 – QPSK / 13 Mbps / MCS1
        - 802.11n HT40 – BPSK / 13.5 Mbps / MCS0
- Transmitter spurious emissions were performed with the EUT transmitting with a data rate of 1 Mbps. This was found to be the worst case data rate with regards to emissions after preliminary investigations and, as this mode emits the highest output power level, it was deemed to be the worst case.
- Radiated spurious emissions were performed with the EUT in the worst case orientation/position. The support equipment was used to terminate all active ports. The HDMI port was connected via the HDMI cable to the Now TV Box. The Infra-Red Sensor was connected to the Infra-Red Sensor port.
- The EUT radiated sample was used for radiated spurious emissions tests.
- The EUT conducted sample was used for all other tests.

4.3. Power Settings

The table below shows the EUT power settings used for each Mode and Data Rate tested.

Mode	Data Rate	Power setting
802.11b	1 Mbps	57
802.11g	9 Mbps	55
	18 Mbps	57
	54 Mbps	57
802.11n HT20	MCS1	48
	MCS5	55
802.11n HT40	MCS0	51
	MCS6	45

5. Measurements, Examinations and Derived Results

5.1. General Comments

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to *Section 6. Measurement Uncertainty* for details.

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.

5.2. Test Results

5.2.1. Transmitter Minimum 6 dB Bandwidth

Test Summary:

Test Engineer:	David Doyle	**Test Date:**	13 December 2016
Test Sample Serial Number:	Not marked or stated *(Conducted sample with RF port)*		

FCC Reference:	Part 15.247(a)(2)
Test Method Used:	FCC KDB 558074 Section 8.1

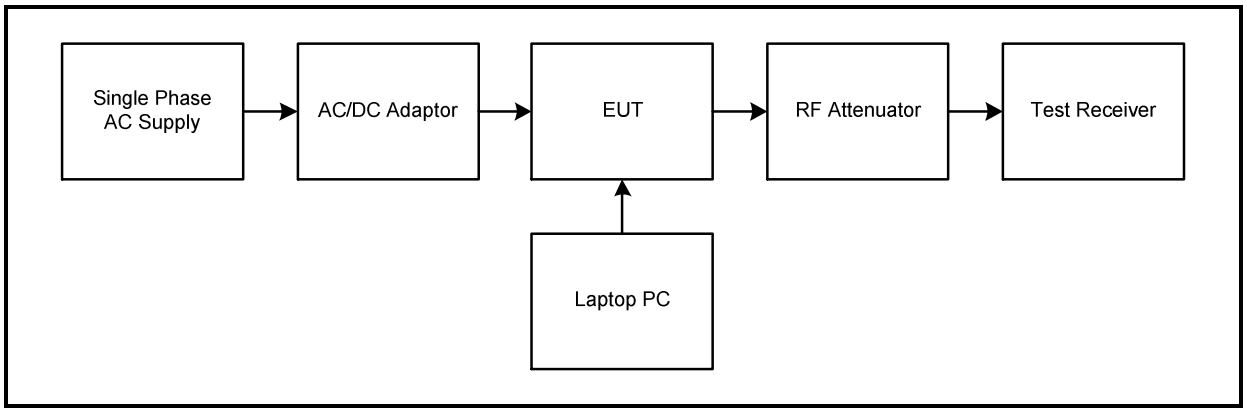
Environmental Conditions:

Temperature (℃):	24
Relative Humidity (%):	43

Note(s):

1. All configurations supported by the EUT were investigated on one channel in accordance with KDB 558074 Section 8.1 Option 1 measurement procedure. The test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The span was set to 30 MHz for 20 MHz channel bandwidth and 60 MHz for 40 MHz channel bandwidth. The DTS bandwidth was measured at 6 dB down from the peak of the signal. The data rates that produced the narrowest bandwidth and therefore deemed worst case were:
    - 802.11b – DBPSK / 1 Mbps
    - 802.11g – BPSK / 9 Mbps
    - 802.11n HT20 – 64-QAM / 52 Mbps / MCS5
    - 802.11n HT40 – 64-QAM / 58.5 Mbps / MCS6
2. Final measurements were performed using the above configurations on the bottom, middle and top channels in accordance with KDB 558074 Section 8.1 Option 1 measurement procedure.
3. Plots for all data rates are archived on the UL VS LTD IT server and available for inspection upon request.
4. The test receiver was connected to the RF port on the EUT using suitable attenuation and RF cable.

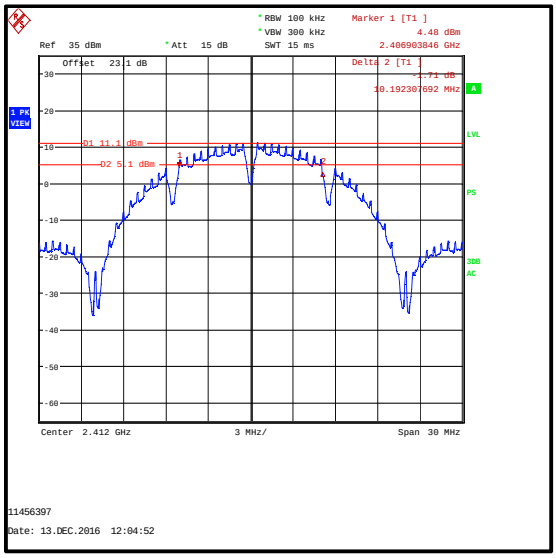
Test setup:



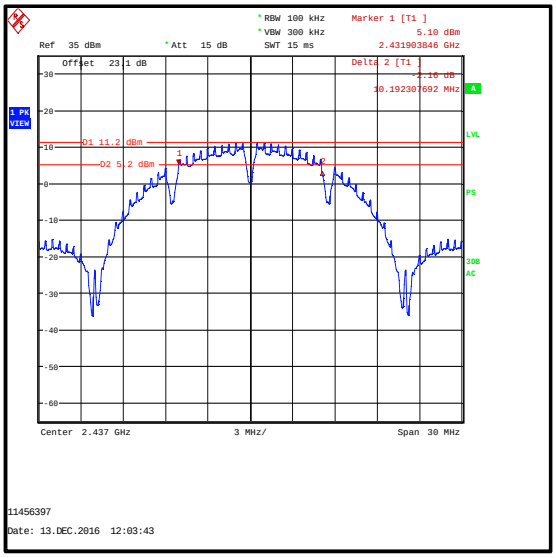
Transmitter Minimum 6 dB Bandwidth (continued)

Results: 802.11b / 20 MHz / DBPSK / 1 Mbps

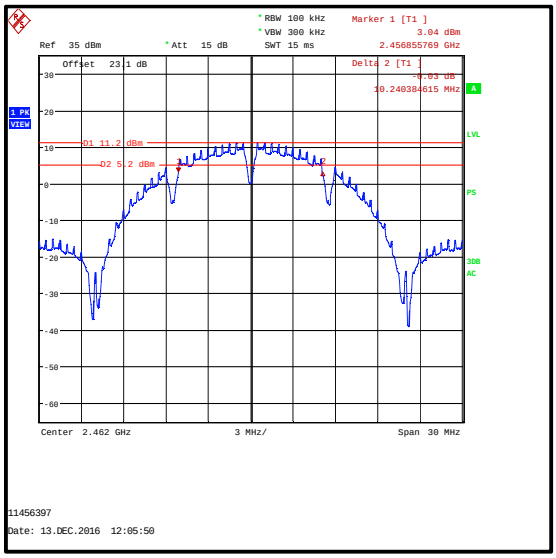
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	10192.308	≥500	9692.308	Complied
Middle	10192.308	≥500	9692.308	Complied
Top	10240.385	≥500	9740.385	Complied



Bottom Channel



Middle Channel

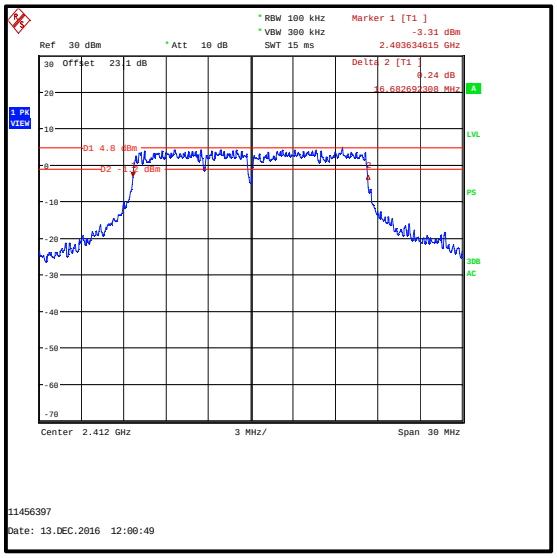


Top Channel

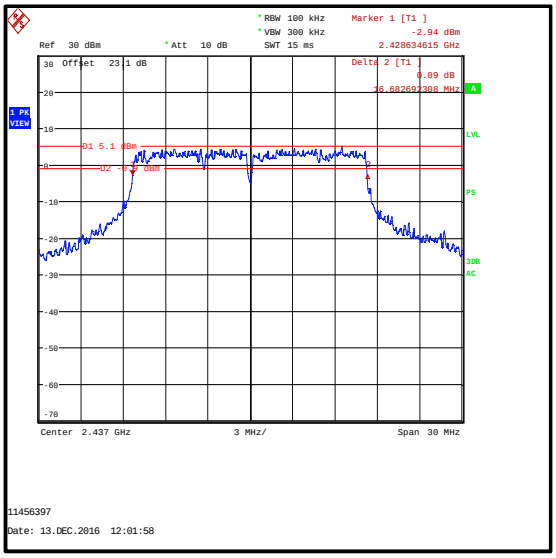
Transmitter Minimum 6 dB Bandwidth (continued)

Results: 802.11g / 20 MHz / BPSK / 9 Mbps

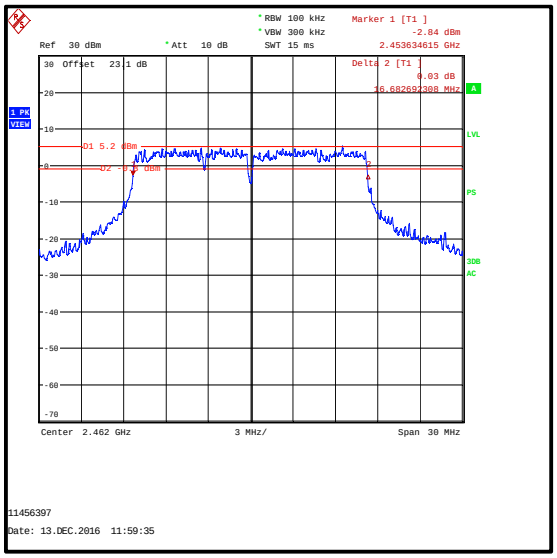
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	16682.692	≥500	16182.692	Complied
Middle	16682.692	≥500	16182.692	Complied
Top	16682.692	≥500	16182.692	Complied



Bottom Channel



Middle Channel

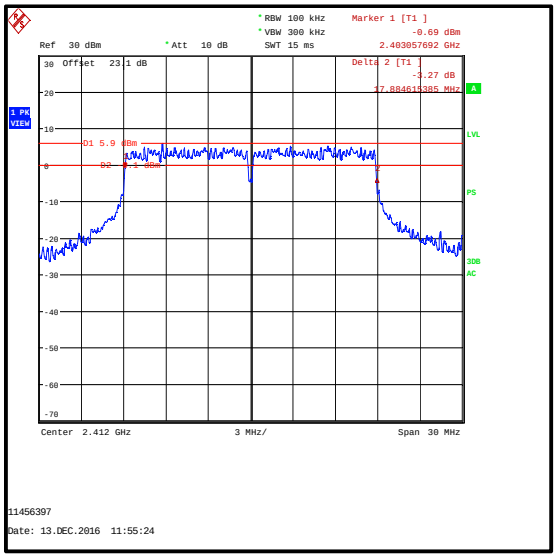


Top Channel

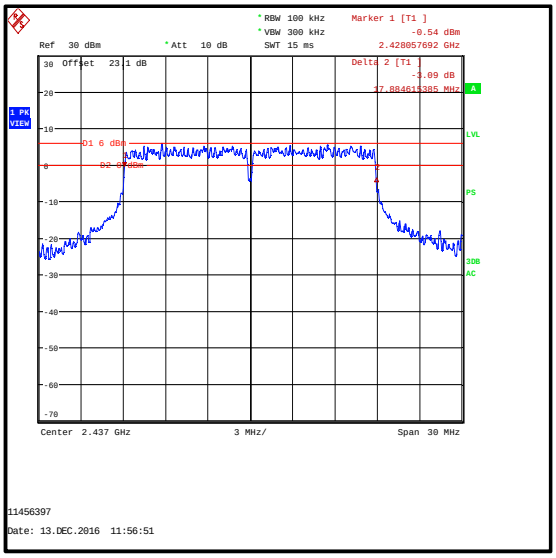
Transmitter Minimum 6 dB Bandwidth (continued)

Results: 802.11n / HT20 / 64-QAM / 52 Mbps / MCS5

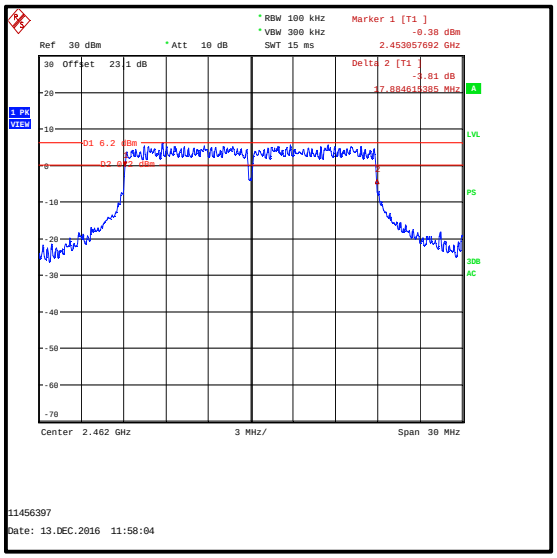
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	17884.615	≥500	17384.615	Complied
Middle	17884.615	≥500	17384.615	Complied
Top	17884.615	≥500	17384.615	Complied



Bottom Channel



Middle Channel

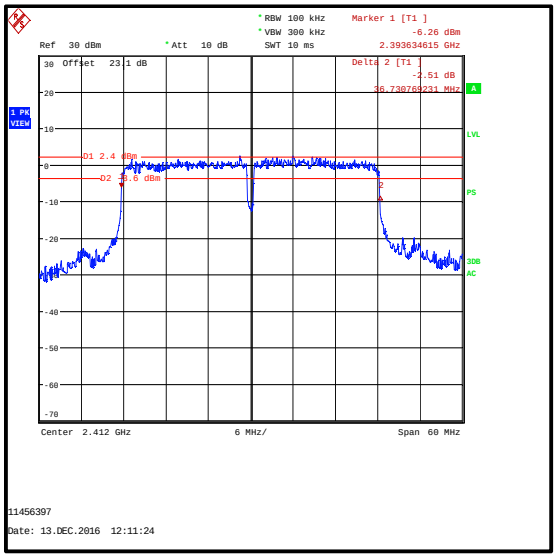


Top Channel

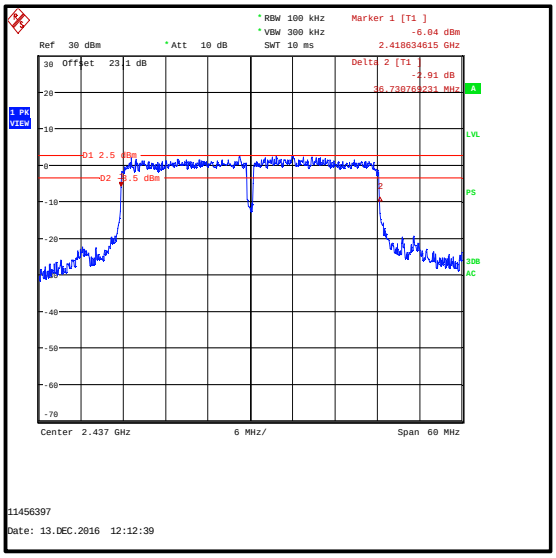
Transmitter Minimum 6 dB Bandwidth (continued)

Results: 802.11n / HT40 / 64-QAM / 58.5 Mbps / MCS6

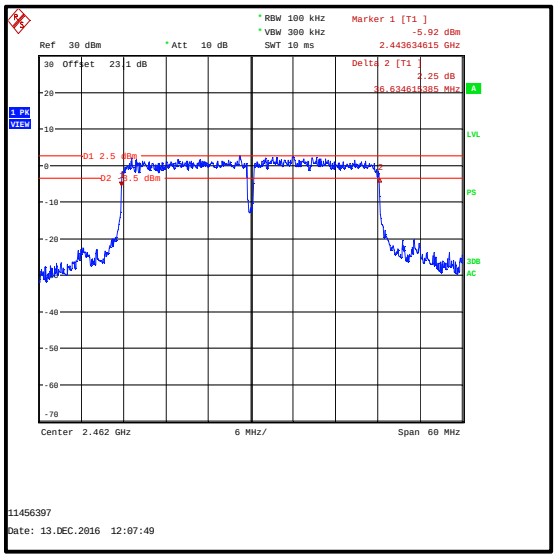
Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	36730.769	≥500	36230.769	Complied
Middle	36730.769	≥500	36230.769	Complied
Top	36634.615	≥500	36134.615	Complied



Bottom Channel



Middle Channel



Top Channel

Transmitter Minimum 6 dB Bandwidth (continued)

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1659	Thermohygrometer	JM Handelspunkt	30.5015.13	Not stated	02 Apr 2017	12
M1874	Test Receiver	Rohde & Schwarz	ESU26	100553	28 Oct 2017	12
A2526	Attenuator	AtlanTecRF	AN18W5-20	832828#1	Calibrated before use	-
M260	Signal Generator	Rohde & Schwarz	SMP02	829076/008	09 May 2017	12
M199	Power Meter	Rohde & Schwarz	NRVS	827023/075	11 Apr 2018	24
M1267	Power Sensor	Rohde & Schwarz	NRV-Z52	100155	15 Apr 2018	24

5.2.2. Transmitter Power Spectral Density

Test Summary:

Test Engineer:	David Doyle	**Test Dates:**	16 December 2016 & 19 December 2016
Test Sample Serial Number:	Not marked or stated *(Conducted sample with RF port)*		

FCC Reference:	Part 15.247(e)
Test Method Used:	FCC KDB 558074 Sections 10.3

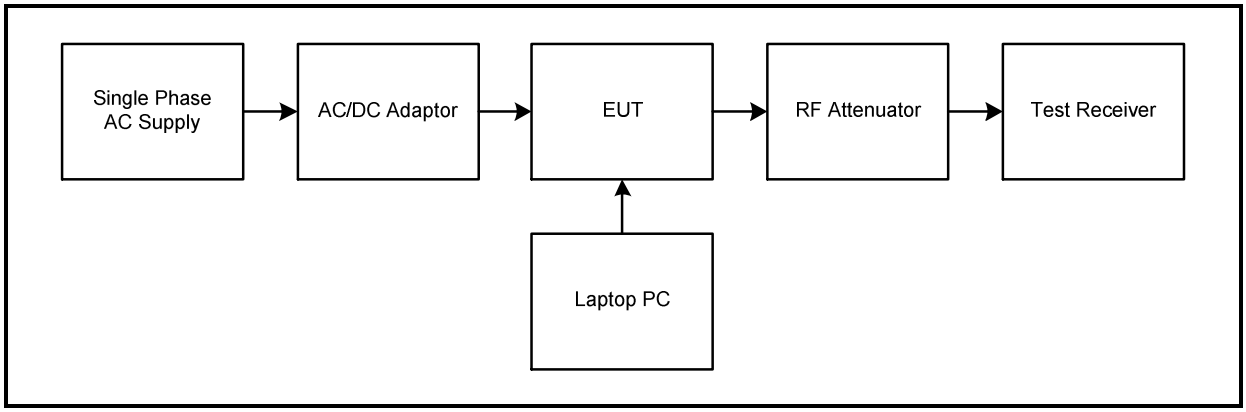
Environmental Conditions:

Temperature (°C):	21 to 23
Relative Humidity (%):	42 to 44

Note(s):

1. All supported modes and channel widths were initially investigated on one channel. The modes that produced the highest power were:
    - 802.11b – DBPSK / 1 Mbps
    - 802.11g – 64-QAM / 54 Mbps
    - 802.11n HT20 – 64-QAM / 52 Mbps / MCS5
    - 802.11n HT40 – 64-QAM / 121.5 Mbps / MCS6
2. Final measurements were performed using the above configurations on the bottom, middle and top channels.
3. For all data rates, the EUT was transmitting at 100% duty cycle and testing was performed in accordance with KDB 558074 Section 10.3 Method AVGPSD-1. Test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. An RMS detector was used and sweep time set manually to perform trace averaging over 100 traces. The span was set to at least 1.5 times the 99% occupied emission bandwidth. The highest peak of the measured signal was recorded.
4. The test receiver was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF level offset was entered on the test receiver to compensate for the loss of the attenuator and RF cable.

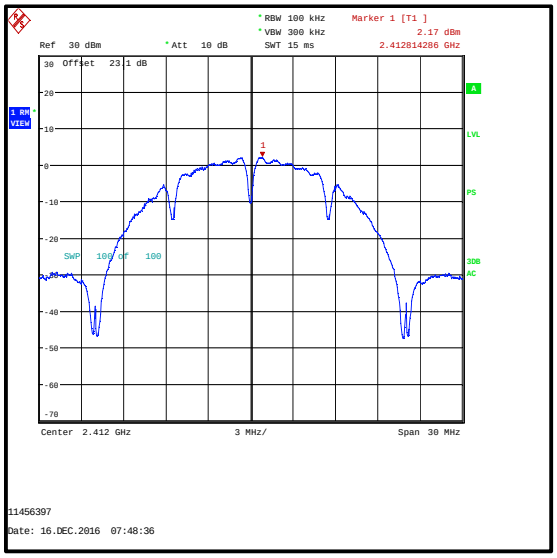
Test setup:



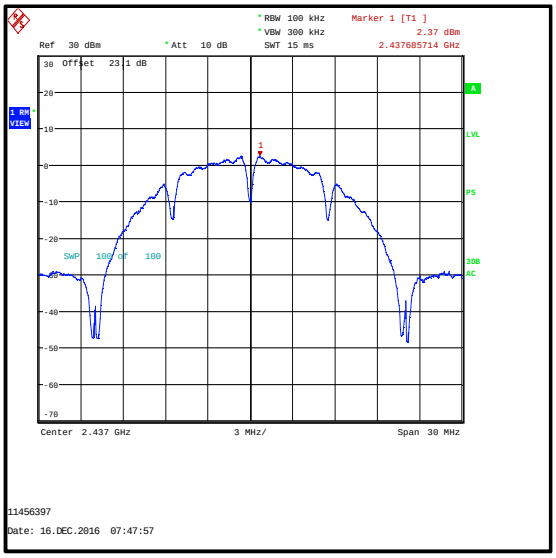
Transmitter Power Spectral Density (continued)

Results: 802.11b / 20 MHz / DBPSK / 1 Mbps

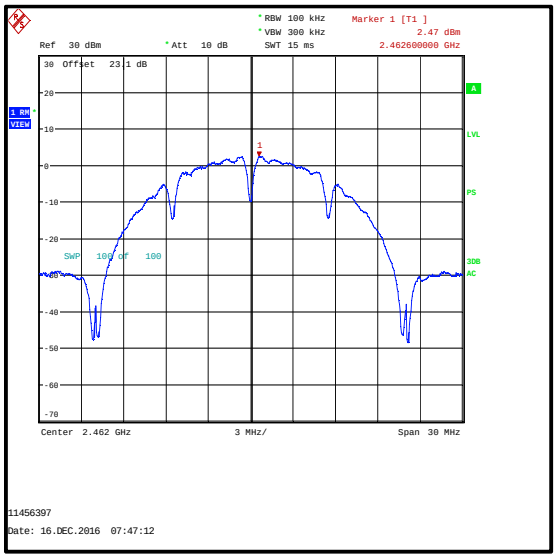
Channel	Output Power (dBm/100 kHz)	Limit (dBm/3kHz)	Margin (dB)	Result
Bottom	2.2	8.0	5.8	Complied
Middle	2.4	8.0	5.6	Complied
Top	2.5	8.0	5.5	Complied



Bottom Channel



Middle Channel

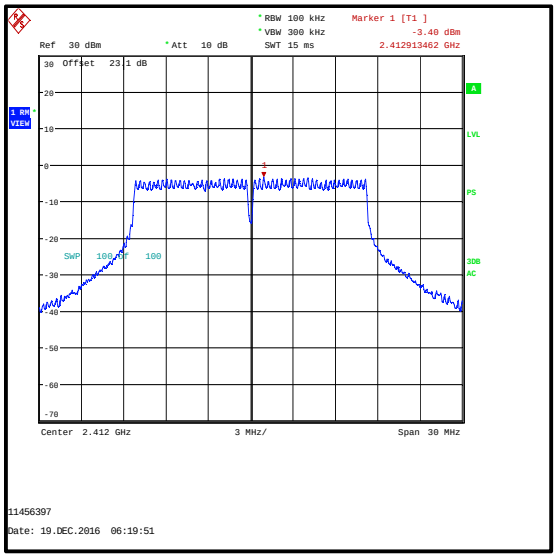


Top Channel

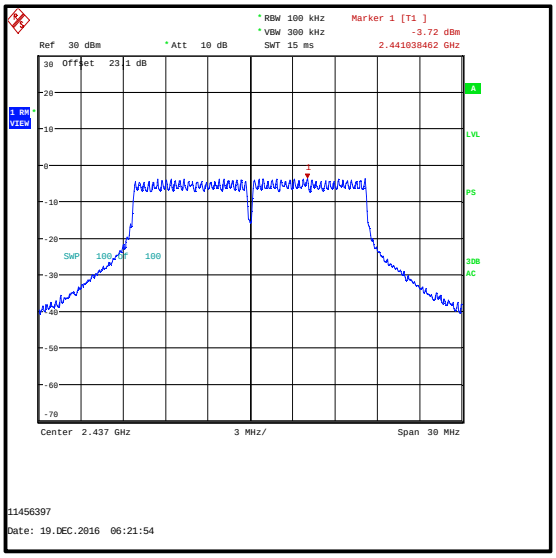
Transmitter Power Spectral Density (continued)

Results: 802.11g / 20 MHz / 64-QAM / 54 Mbps

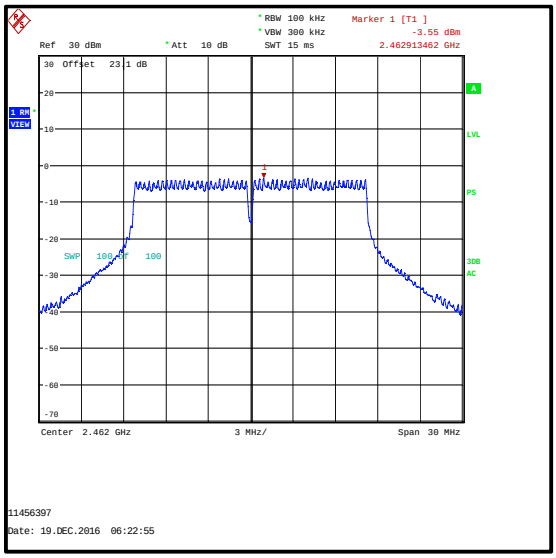
Channel	Output Power (dBm/100 kHz)	Limit (dBm/3kHz)	Margin (dB)	Result
Bottom	-3.4	8.0	11.4	Complied
Middle	-3.7	8.0	11.7	Complied
Top	-3.5	8.0	11.5	Complied



Bottom Channel



Middle Channel

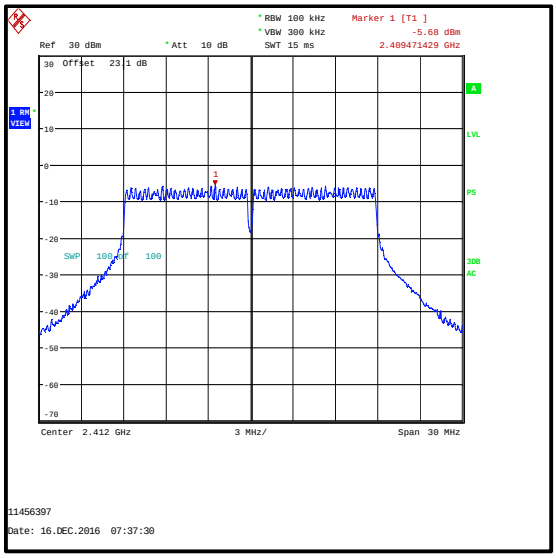


Top Channel

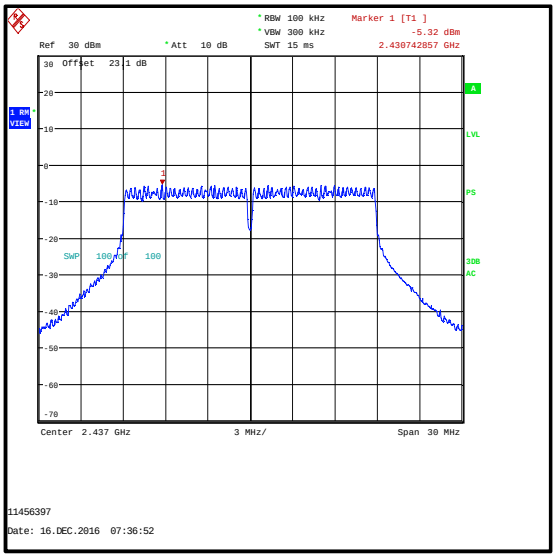
Transmitter Power Spectral Density (continued)

Results: 802.11n / HT20 / 64-QAM / 52 Mbps / MCS5

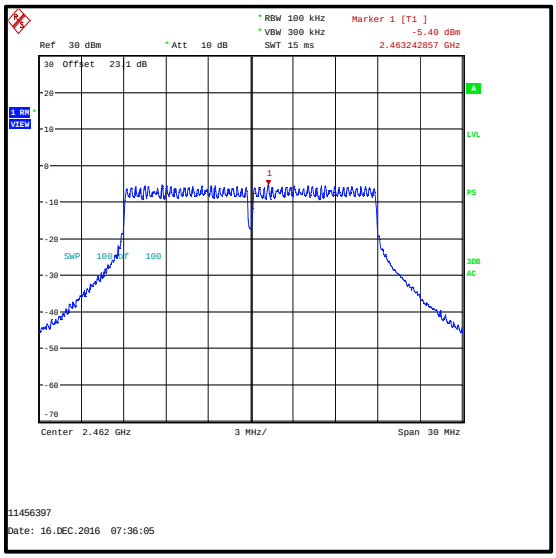
Channel	Output Power (dBm/100 kHz)	Limit (dBm/3kHz)	Margin (dB)	Result
Bottom	-5.7	8.0	13.7	Complied
Middle	-5.3	8.0	13.3	Complied
Top	-5.4	8.0	13.4	Complied



Bottom Channel



Middle Channel

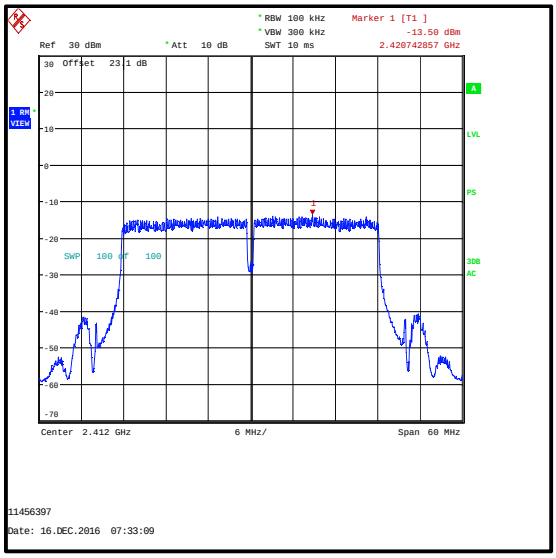


Top Channel

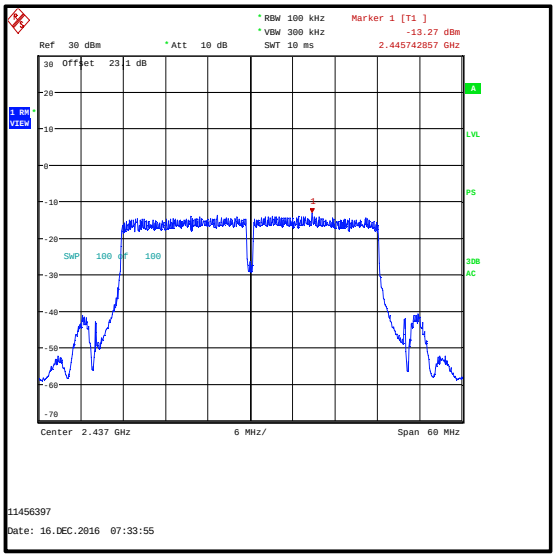
Transmitter Power Spectral Density (continued)

Results: 802.11n / HT40 / 64-QAM / 121.5 Mbps / MCS6

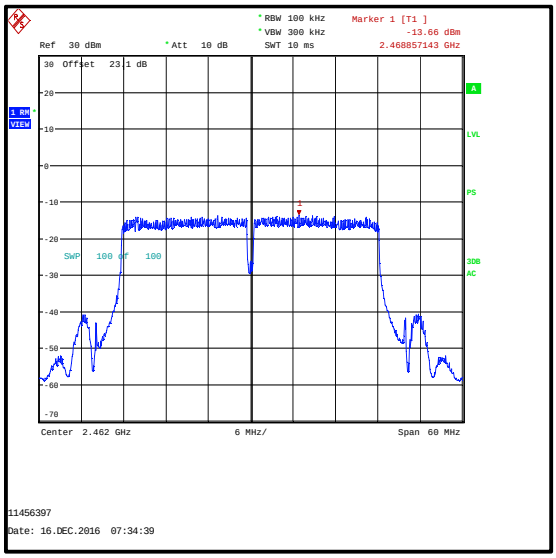
Channel	Output Power (dBm/100 kHz)	Limit (dBm/3kHz)	Margin (dB)	Result
Bottom	-13.5	8.0	21.5	Complied
Middle	-13.3	8.0	21.3	Complied
Top	-13.7	8.0	21.7	Complied



Bottom Channel



Middle Channel



Top Channel

Transmitter Power Spectral Density (continued)

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1659	Thermohygrometer	JM Handelspunkt	30.5015.13	Not stated	02 Apr 2017	12
M1874	Test Receiver	Rohde & Schwarz	ESU26	100553	28 Oct 2017	12
A2526	Attenuator	AtlanTecRF	AN18W5-20	832828#1	Calibrated before use	-
M260	Signal Generator	Rohde & Schwarz	SMP02	829076/008	09 May 2017	12
M199	Power Meter	Rohde & Schwarz	NRVS	827023/075	11 Apr 2018	24
M1267	Power Sensor	Rohde & Schwarz	NRV-Z52	100155	15 Apr 2018	24

5.2.3. Transmitter Maximum (Average) Output Power

Test Summary:

Test Engineer:	David Doyle	**Test Date:**	16 December 2016
Test Sample Serial Number:	Not marked or stated *(Conducted sample with RF port)*		

FCC Reference:	Part 15.247(b)(3)
Test Method Used:	FCC KDB 558074 Section 9.2.2.2 and Notes below

Environmental Conditions:

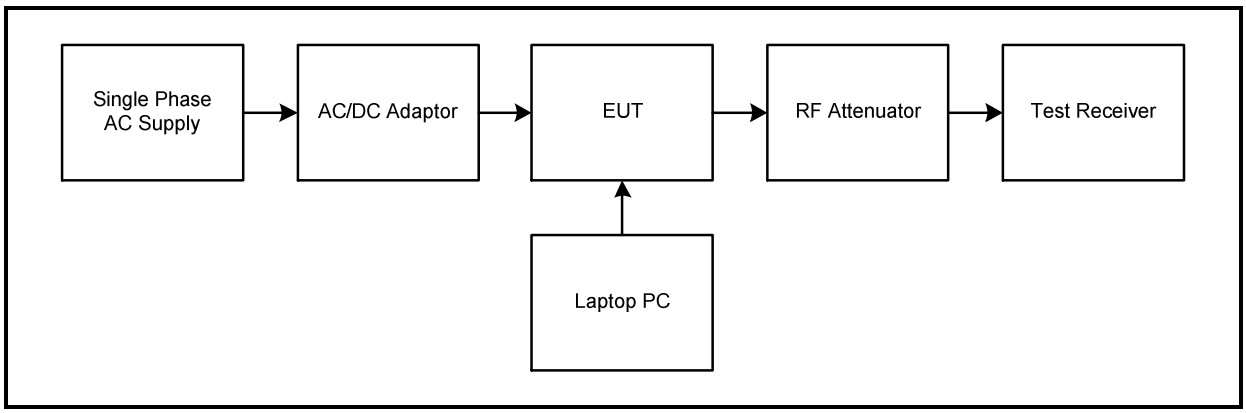
Temperature (°C):	23
Relative Humidity (%):	42

Note(s):

1. All supported modes and channel widths were initially investigated on one channel. The modes that produced the highest power were:
    - 802.11b – DBPSK / 1 Mbps
    - 802.11g – QPSK / 18 Mbps
    - 802.11n HT20 – 64-QAM / 52 Mbps / MCS5
    - 802.11n HT40 – 64-QAM / 121.5 Mbps / MCS6
2. Final measurements were performed using the above configurations on the bottom, middle and top channels. The power has been integrated over the 99% emission bandwidth. Plots for the occupied bandwidth are archived on the UL VS LTD IT server and available for inspection upon request.
3. For all data rates, the EUT was transmitting at 100% duty cycle and testing was performed in accordance with KDB 558074 Section 9.2.2.2 Method AVGSA-1. The signal analyser's integration function was used to integrate across the 99% occupied bandwidth.
4. For 20 MHz channel bandwidth, the test receiver's resolution bandwidth was set to 200 kHz and video bandwidth 1 MHz. An RMS detector was used with sweep time set to auto couple. Trace averaging was employed over 100 traces. The span was set to at least 1.5 times the 99% occupied emission bandwidth.
5. For 40 MHz channel bandwidth, the test receiver's resolution bandwidth was set to 500 kHz and video bandwidth 2 MHz An RMS detector was used with sweep time set to auto couple. Trace averaging was employed over 100 traces. The span was set to at least 1.5 times the 99% occupied emission bandwidth.
6. The signal analyser was connected to the RF port on the EUT using 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.

Transmitter Maximum (Average) Output Power (continued)

Test setup:



Transmitter Maximum (Average) Output Power (continued)

Results: 802.11b / 20 MHz / DBPSK / 1 Mbps

Conducted Peak Limit Comparison

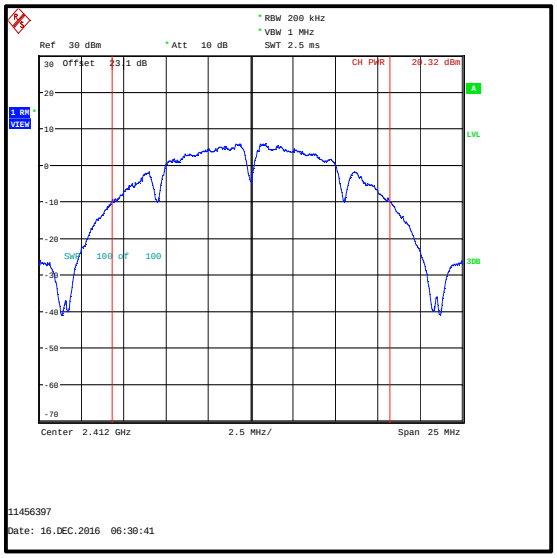
Channel	Conducted Power (dBm)	Conducted Power Limit (dBm)	Margin (dB)	Result
Bottom	20.3	30.0	9.7	Complied
Middle	20.2	30.0	9.8	Complied
Top	20.3	30.0	9.7	Complied

De Facto EIRP Limit Comparison

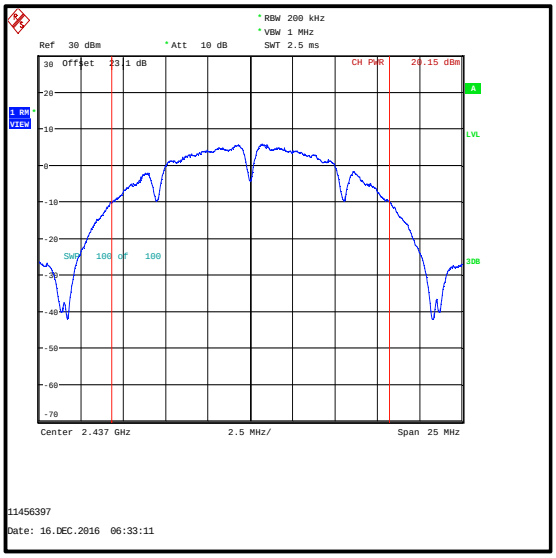
Channel	Conducted Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	20.3	0.5	20.8	36.0	15.2	Complied
Middle	20.2	0.5	20.7	36.0	15.3	Complied
Top	20.3	0.5	20.8	36.0	15.2	Complied

Transmitter Maximum Output Power (continued)

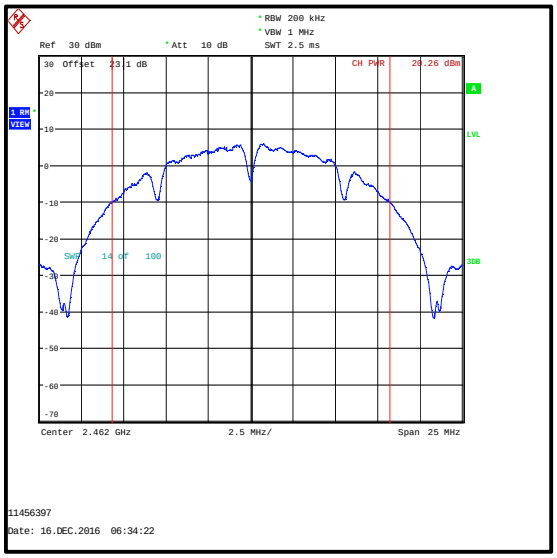
Results: 802.11b / 20 MHz / DBPSK / 1 Mbps



Bottom Channel



Middle Channel



Top Channel

Transmitter Maximum (Average) Output Power (continued)

Results: 802.11g / 20 MHz / QPSK / 18 Mbps

Conducted Peak Limit Comparison

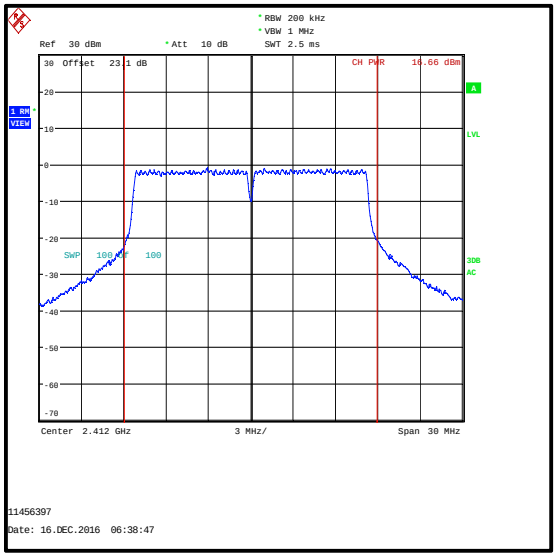
Channel	Conducted Power (dBm)	Conducted Power Limit (dBm)	Margin (dB)	Result
Bottom	16.7	30.0	13.3	Complied
Middle	16.5	30.0	13.5	Complied
Top	16.6	30.0	13.4	Complied

De Facto EIRP Limit Comparison

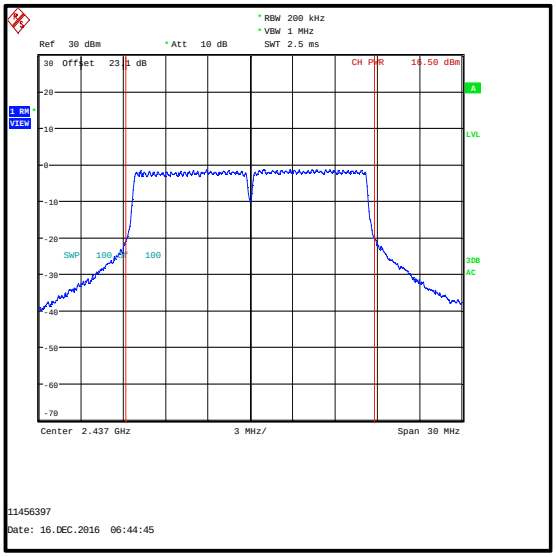
Channel	Conducted Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	16.7	0.5	17.2	36.0	18.8	Complied
Middle	16.5	0.5	17.0	36.0	19.0	Complied
Top	16.6	0.5	17.1	36.0	18.9	Complied

Transmitter Maximum (Average) Output Power (continued)

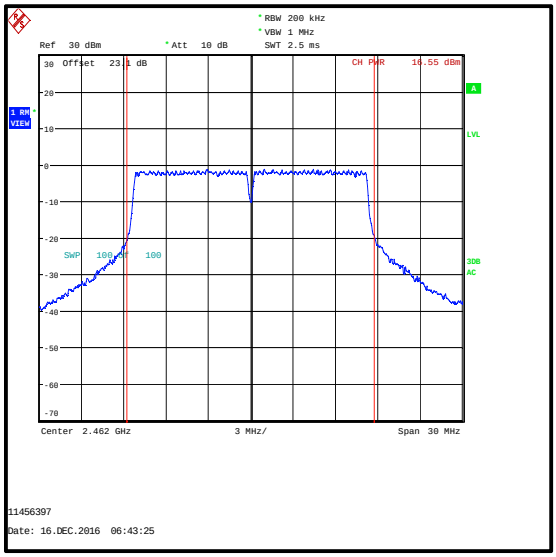
Results: 802.11g / 20 MHz / QPSK / 18 Mbps



Bottom Channel



Middle Channel



Top Channel

Transmitter Maximum (Average) Output Power (continued)

Results: 802.11n / HT20 / 64-QAM / 52 Mbps / MCS5

Conducted Peak Limit Comparison

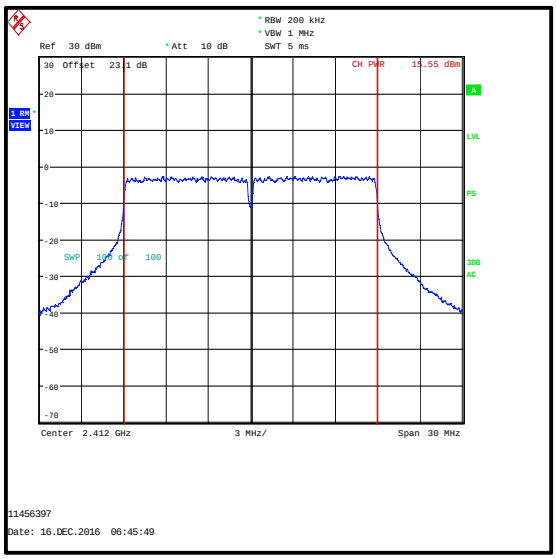
Channel	Conducted Power (dBm)	Conducted Power Limit (dBm)	Margin (dB)	Result
Bottom	15.6	30.0	14.4	Complied
Middle	15.8	30.0	14.2	Complied
Top	16.0	30.0	14.0	Complied

De Facto EIRP Limit Comparison

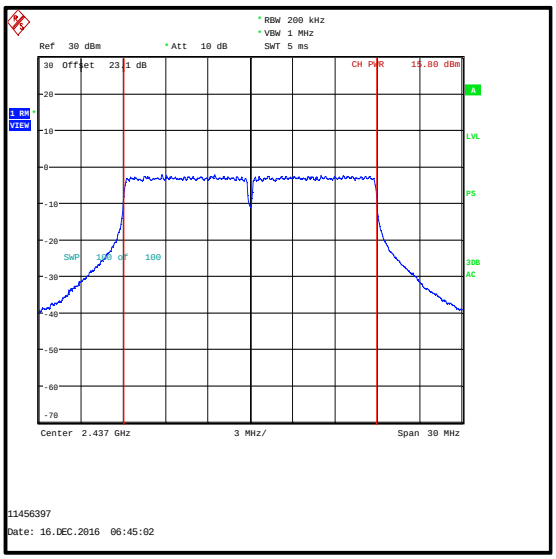
Channel	Conducted Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	15.6	0.5	16.1	36.0	19.9	Complied
Middle	15.8	0.5	16.3	36.0	19.7	Complied
Top	16.0	0.5	16.5	36.0	19.5	Complied

Transmitter Maximum (Average) Output Power (continued)

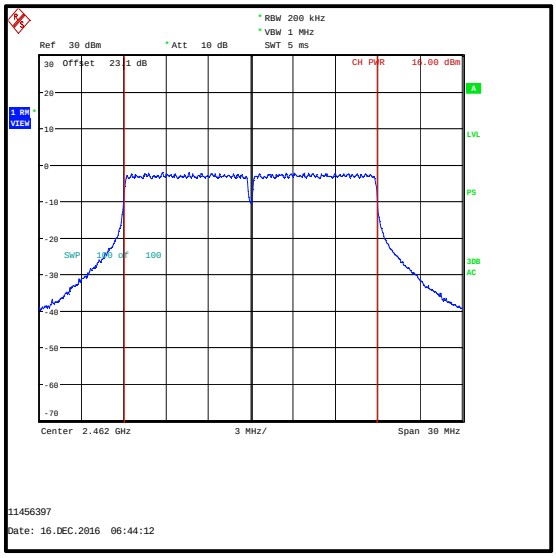
Results: 802.11n / HT20 / 64-QAM / 52 Mbps / MCS5



Bottom Channel



Middle Channel



Top Channel

Transmitter Maximum (Average) Output Power (continued)

Results: 802.11n / HT40 / 64-QAM / 121.5 Mbps / MCS6

Conducted Peak Limit Comparison

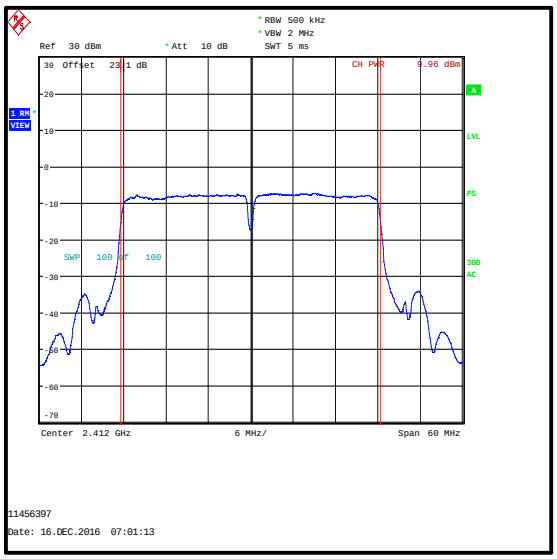
Channel	Conducted Power (dBm)	Conducted Power Limit (dBm)	Margin (dB)	Result
Bottom	10.0	30.0	20.0	Complied
Middle	10.3	30.0	19.7	Complied
Top	10.3	30.0	19.7	Complied

De Facto EIRP Limit Comparison

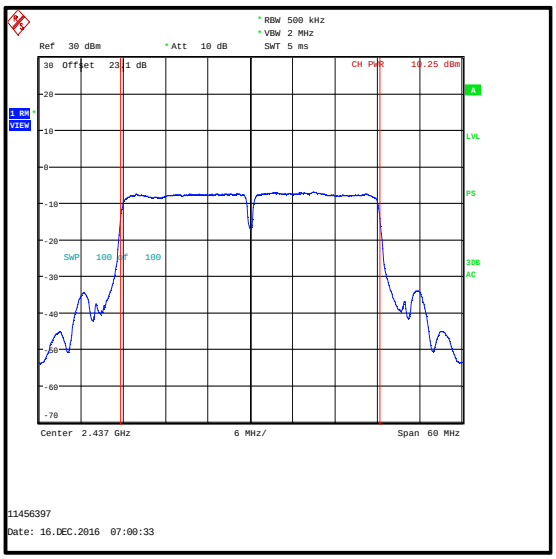
Channel	Conducted Power (dBm)	Declared Antenna Gain (dBi)	EIRP (dBm)	De Facto EIRP Limit (dBm)	Margin (dB)	Result
Bottom	10.0	0.5	10.5	36.0	25.5	Complied
Middle	10.3	0.5	10.8	36.0	25.2	Complied
Top	10.3	0.5	10.8	36.0	25.2	Complied

Transmitter Maximum (Average) Output Power (continued)

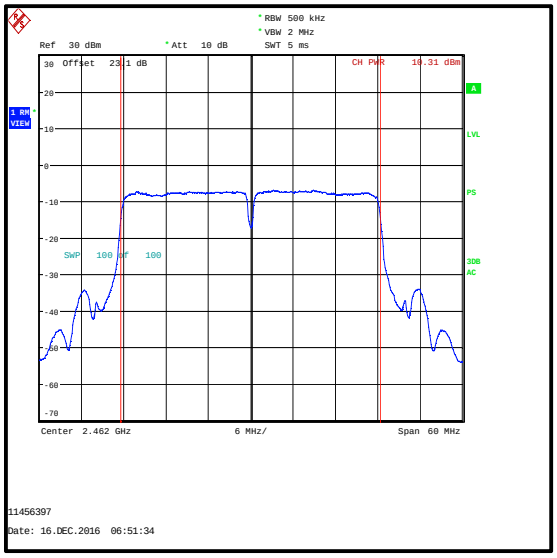
Results: 802.11n / HT40 / 64-QAM / 121.5 Mbps / MCS6



Bottom Channel



Middle Channel



Top Channel

Transmitter Maximum (Average) Output Power (continued)

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1659	Thermohygrometer	JM Handelspunkt	30.5015.13	Not stated	02 Apr 2017	12
M1874	Test Receiver	Rohde & Schwarz	ESU26	100553	28 Oct 2017	12
A2526	Attenuator	AtlanTecRF	AN18W5-20	832828#1	Calibrated before use	-
M260	Signal Generator	Rohde & Schwarz	SMP02	829076/008	09 May 2017	12
M199	Power Meter	Rohde & Schwarz	NRVS	827023/075	11 Apr 2018	24
M1267	Power Sensor	Rohde & Schwarz	NRV-Z52	100155	15 Apr 2018	24

5.2.4. Transmitter Radiated Emissions

Test Summary:

Test Engineer:	David Doyle	**Test Date:**	13 January 2017
Test Sample Serial Number:	Not marked or stated *(Radiated sample)*		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	ANSI C63.10 Sections 6.3 and 6.5
Frequency Range	30 MHz to 1000 MHz

Environmental Conditions:

Temperature (°C):	22
Relative Humidity (%):	30

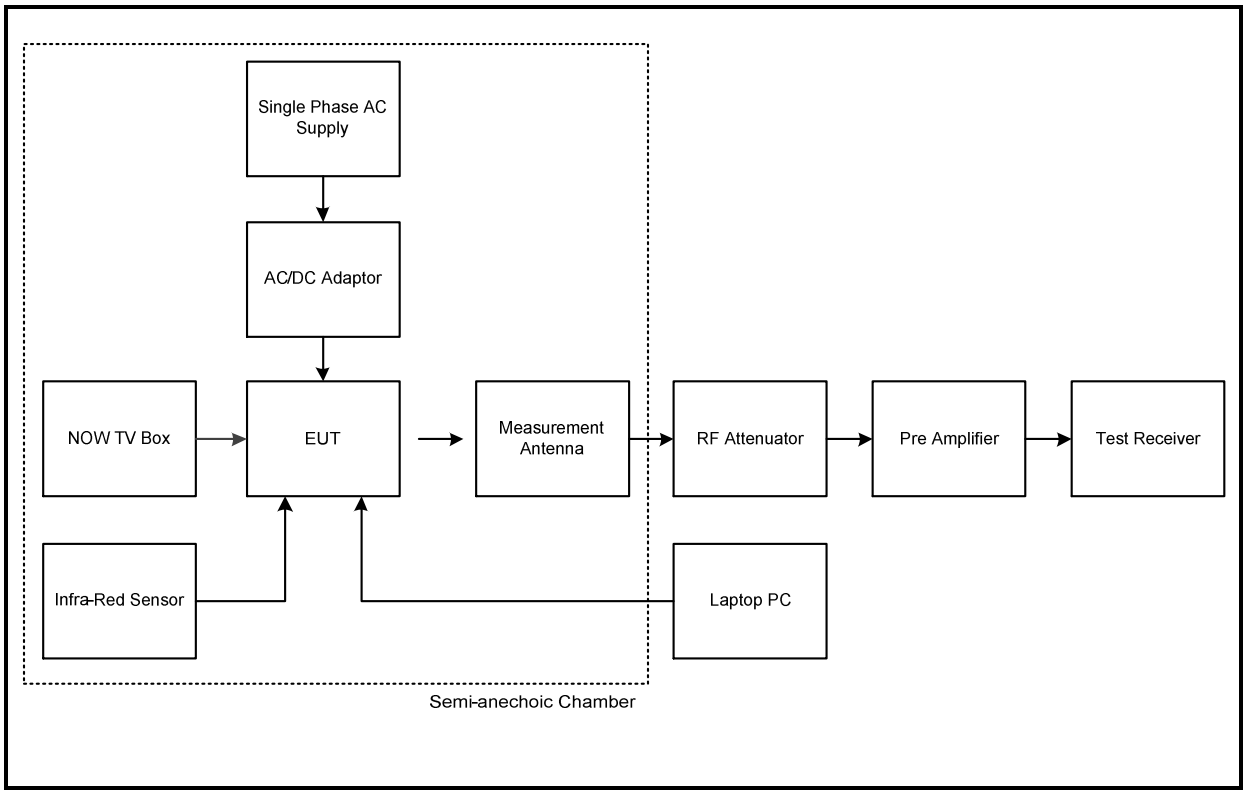
Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. 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 middle channel only.
3. All other 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 and therefore not recorded.
4. Measurements below 1 GHz were performed in a semi-anechoic chamber (Asset Number K0001) 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.
5. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.
6. 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.

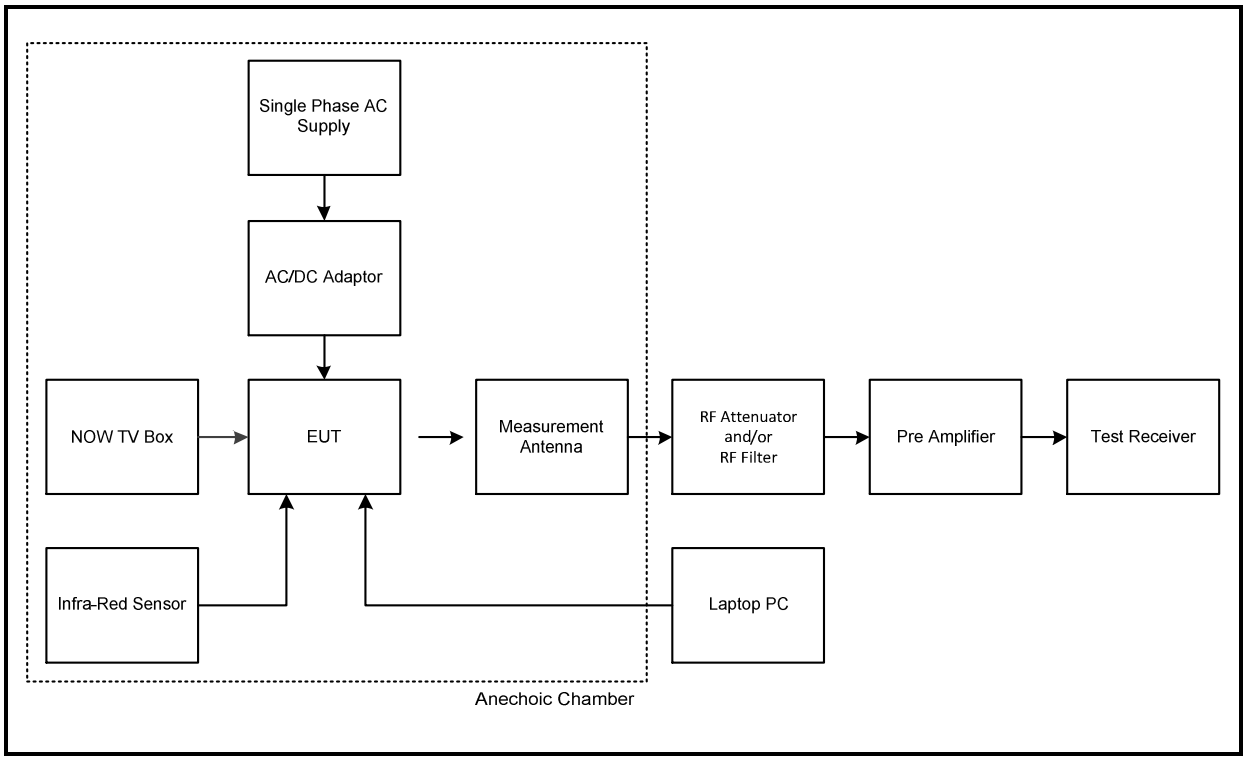
Transmitter Radiated Emissions (continued)

Test setup for radiated measurements:

Semi-anechoic chamber



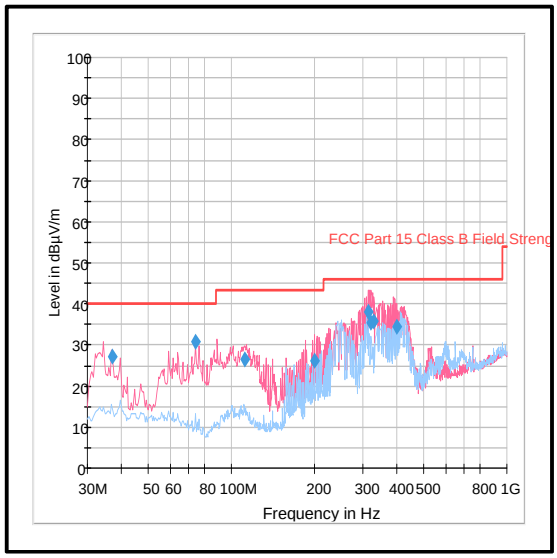
Anechoic chamber



Transmitter Radiated Emissions (continued)

Results: Middle Channel / 802.11n / HT20 / DQPSK / 1 Mbps

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
74.142	Vertical	30.8	40.0	9.2	Complied
112.032	Vertical	26.5	43.5	17.0	Complied
328.732	Vertical	35.7	46.0	10.3	Complied



Note: This plot is a pre-scan and for indication purposes only. For final measurements, see accompanying table.

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2014	Thermohygrometer	Testo	608-H1	45046246	10 Jun 2017	12
K0001	5m RSE Chamber	Rainford EMC	N/A	N/A	07 Dec 2017	12
G0543	Amplifier	Sonoma	310N	230801	09 Jun 2017	6
M1273	Test Receiver	Rohde & Schwarz	ESIB26	100275	11 Apr 2017	12
A2959	Antenna	Schwarzbeck	VULB 9163	9163-967	08 Sep 2017	12
A1834	Attenuator	Hewlett Packard	8491B	10444	30 Mar 2017	12

Transmitter Radiated Emissions (continued)

Test Summary:

Test Engineer:	David Doyle	**Test Date:**	21 April 2017
Test Sample Serial Number:	Not marked or stated *(Radiated sample)*		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	ANSI C63.10 Sections 6.3 and 6.6 & FCC KDB 558074 Sections 11, 12.2.4 & 12.2.5.1
Frequency Range	1 GHz to 25 GHz

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	38

Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. All other emissions shown on the pre-scan plot were investigated and found to be ambient or >20 dB below the appropriate limit or below the measurement system noise floor.
3. The emission shown approximately at 2437 MHz on the 1 GHz to 3 GHz plot is the EUT fundamental.
4. All measurement above 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 1.5 m 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.
5. Pre-scans were performed and a marker placed on the highest measured level of the appropriate plot. The signal analyser resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz. The sweep time was set to auto.
6. *In accordance with ANSI C63.10 Section 6.6.4.3, Note 1, if the peak measured value complies with the average limit, it is unnecessary to perform an average measurement.

Transmitter Radiated Emissions (continued)

Results: Peak / Bottom Channel

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
4823.907	Vertical	53.2	54.0*	0.8	Complied
19295.743	Vertical	46.7	54.0*	7.3	Complied

Results: Peak / Middle Channel

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
4873.886	Vertical	53.0	54.0*	1.0	Complied
7312.171	Vertical	54.5	74.0	19.5	Complied
19495.793	Vertical	48.6	54.0*	5.4	Complied

Results: Average / Middle Channel

Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
7309.686	Vertical	47.0	54.0	7.0	Complied

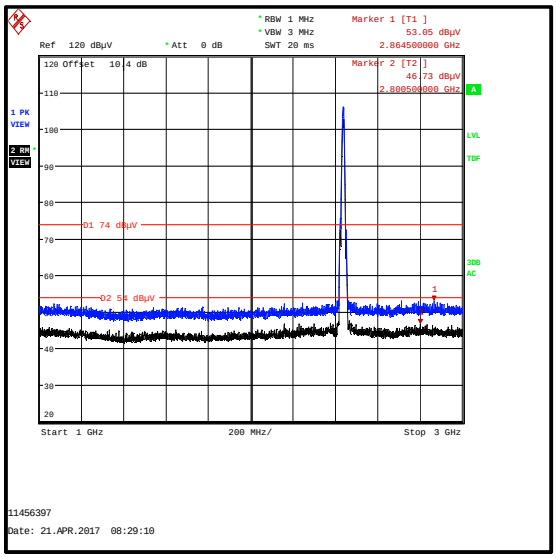
Results: Peak / Top Channel

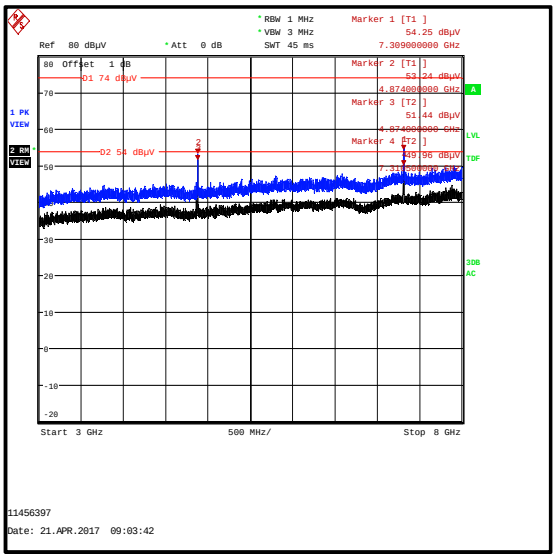
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
4923.872	Vertical	56.1	74.0	17.9	Complied
7386.900	Vertical	57.2	74.0	16.8	Complied
19695.993	Vertical	47.4	54.0*	6.6	Complied

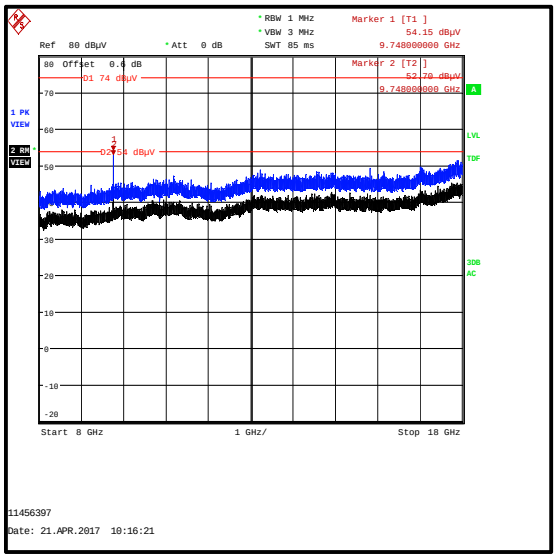
Results: Average / Top Channel

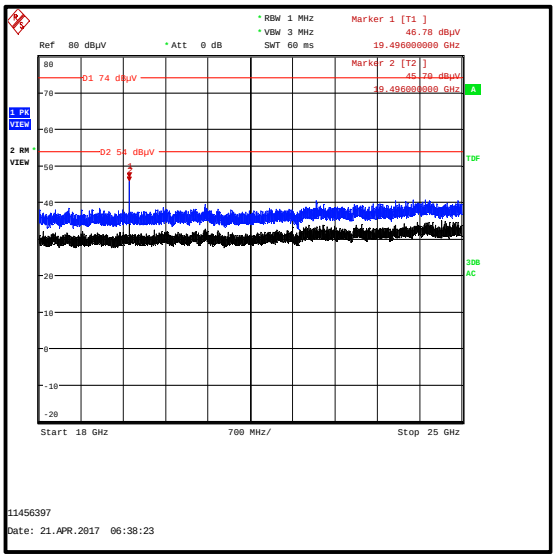
Frequency (MHz)	Antenna Polarity	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
4923.952	Vertical	52.5	54.0	1.5	Complied
7386.986	Vertical	50.5	54.0	3.5	Complied

Transmitter Radiated Emissions (continued)









Transmitter Radiated Emissions (continued)

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2003	Thermohygrometer	Testo	608-H1	45046641	22 Feb 2018	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	14 Apr 2018	12
M1630	Test Receiver	Rohde & Schwarz	ESU40	100223	23 Feb 2018	12
A2889	Antenna	Schwarzbeck	BBHA 9120 B	BBHA 9120 B 653	11 Apr 2018	12
A2890	Antenna	Schwarzbeck	HWRD 750	014	11 Apr 2018	12
A2892	Antenna	Schwarzbeck	BBHA 9170	9170-727	11 Apr 2018	12
A2863	Pre-Amplifier	Agilent	8449B	3008A02100	11 Apr 2018	12
A2891	Pre-Amplifier	Schwarzbeck	BBV 9718	9718-306	11 Apr 2018	12
A2893	Pre-Amplifier	Schwarzbeck	BBV 9721	9721-021	11 Apr 2018	12
A2914	High Pass Filter	AtlanTecRF	AFH-03000	2155	06 Mar 2018	12
A2947	High Pass Filter	AtlanTecRF	AFH-07000	1601900001	01 Jun 2017	12
A2916	Attenuator	AtlanTecRF	AN185W-10	832827#1	03 Mar 2018	12

5.2.5. Transmitter Band Edge Radiated Emissions

Test Summary:

Test Engineer:	Andrew Edwards	**Test Date:**	14 December 2016
Test Sample Serial Number:	Not marked or stated *(Radiated sample)*		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	ANSI C63.10 Section 6.6 & FCC KDB 558074 Sections 11 & 12

Environmental Conditions:

Temperature (°C):	23 to 24
Relative Humidity (%):	40 to 41

Note(s):

1. All supported modes and channel widths were initially investigated on one channel. The modes that produced the highest power and widest bandwidth were:
    - 802.11b – DBPSK / 1 Mbps
    - 802.11g – BPSK / 9 Mbps
    - 802.11g – QPSK / 18 Mbps
    - 802.11n HT20 – QPSK / 13 Mbps / MCS1
    - 802.11n HT20 – 64-QAM / 52 Mbps / MCS5
    - 802.11n HT40 – BPSK / 13.5 Mbps / MCS0
    - 802.11n HT40 – 64-QAM / 121.5 Mbps / MCS6

    Final measurements were performed with the above configurations.
2. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
3. The maximum conducted (average) output power was previously measured. In accordance with FCC KDB 558074 Section 11.1(b), the lower band edge measurement should be performed with a peak detector and the -30 dBc limit applied.
4. As the lower band edge falls within a non-restricted band, only peak measurements are required. In accordance with FCC KDB 558074 Section 11.1, the test method in Section 11.3 was followed: the test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The test receiver was left to sweep for a sufficient length of time in order to maximise the carrier level and out-of-band emissions. A marker and corresponding reference level line were placed on the peak of the carrier. As the maximum conducted (average) output power was measured using an RMS detector in accordance with FCC KDB 558074 Section 9.2.2.2 Method AVGSA-1 an out-of-band limit line was placed 30 dB (FCC KDB 558074 Section 11.1(b)) below the peak level. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent non-restricted band of operation (where a higher level emission was present). Marker frequencies and levels were recorded.

Transmitter Band Edge Radiated Emissions (continued)

5. As the upper band edge falls within a restricted band both peak and average measurements were recorded by placing a marker at the edge of the band. For peak measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. For average measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. An RMS detector was used, sweep time was set to auto and trace average over 300 sweeps. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent restricted band of operation (where a higher level emission was present). Marker frequencies and levels were recorded.
6. There is a restricted band 10 MHz below the lower band edge. The test receiver was set up as follows: the RBW set to 1 MHz, the VBW set to 3 MHz, with the sweep time set to auto couple. Peak and average measurements were performed with their respective detectors. Markers were placed on the highest point on each trace.

Transmitter Band Edge Radiated Emissions (continued)

Results: 802.11b / 20 MHz / 1 Mbps

Results: Lower Band Edge

Frequency (MHz)	Level (dBµV/m)	-30 dBc Limit (dBµV/m)	Margin (dB)	Result
2398.478	68.4	71.0	2.6	Complied
2400.000	67.4	71.0	3.6	Complied

Results: Upper Band Edge / Peak

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	53.6	74.0	20.4	Complied
2490.311	54.7	74.0	19.3	Complied

Results: Upper Band Edge / Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	43.3	54.0	10.7	Complied
2484.622	43.6	54.0	10.4	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

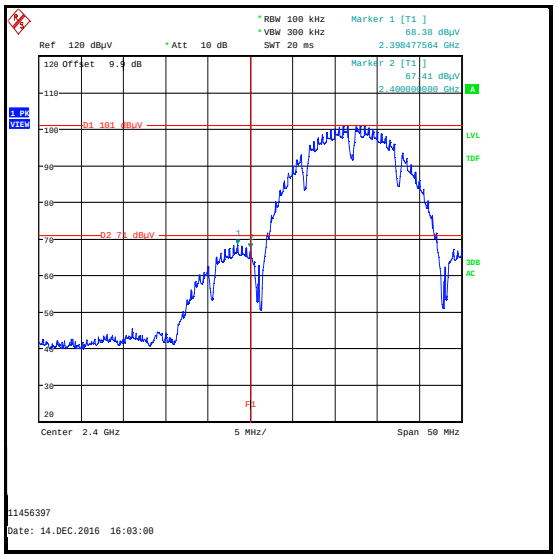
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2389.718	55.0	74.0	19.0	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

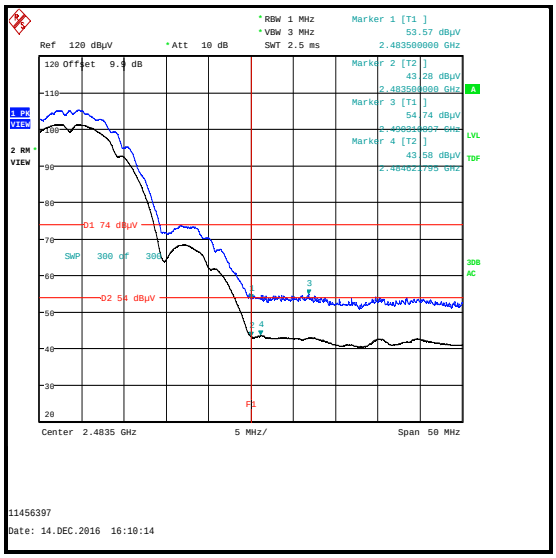
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2389.359	44.0	54.0	10.0	Complied

Transmitter Band Edge Radiated Emissions (continued)

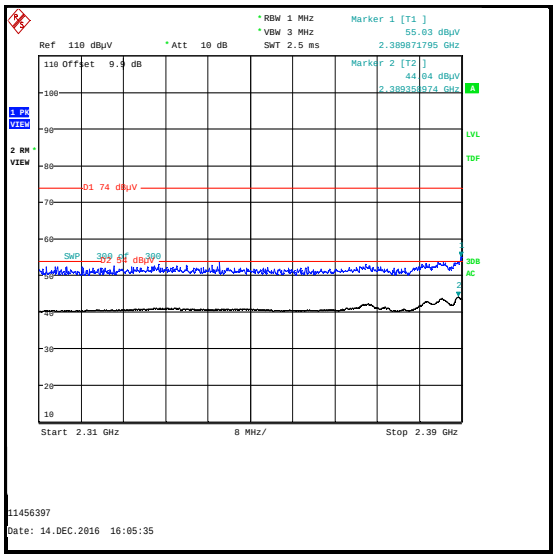
Results: 802.11b / 20 MHz / 1 Mbps



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

Transmitter Band Edge Radiated Emissions (continued)

Results: 802.11g / 20 MHz / 9 Mbps

Results: Lower Band Edge

Frequency (MHz)	Level (dBµV/m)	-30 dBc Limit (dBµV/m)	Margin (dB)	Result
2399.920	60.7	60.9	0.2	Complied
2400.000	60.3	60.9	0.6	Complied

Results: Upper Band Edge / Peak

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	65.4	74.0	8.6	Complied

Results: Upper Band Edge / Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	46.5	54.0	7.5	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

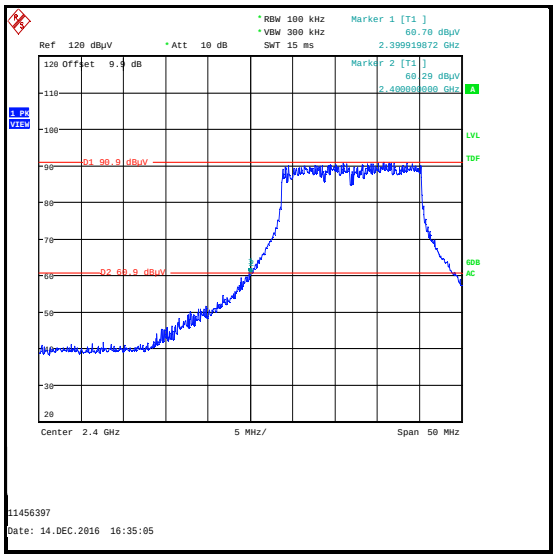
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2390.000	60.3	74.0	13.7	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

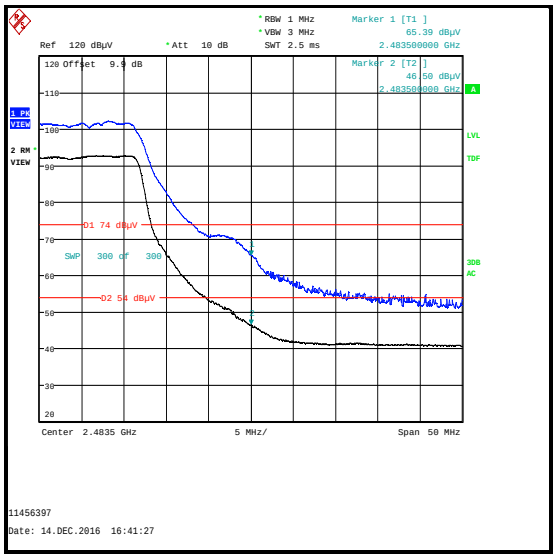
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2390.000	44.6	54.0	9.4	Complied

Transmitter Band Edge Radiated Emissions (continued)

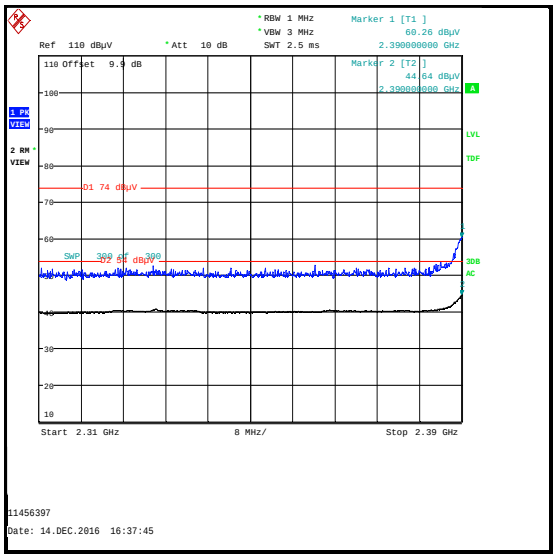
Results: 802.11g / 20 MHz / 9 Mbps



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

Transmitter Band Edge Radiated Emissions (continued)

Results: 802.11g / 20 MHz / 18 Mbps

Results: Lower Band Edge

Frequency (MHz)	Level (dBµV/m)	-30 dBc Limit (dBµV/m)	Margin (dB)	Result
2399.359	60.5	62.4	1.9	Complied
2400.000	60.0	62.4	2.4	Complied

Results: Upper Band Edge / Peak

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	63.9	74.0	10.1	Complied

Results: Upper Band Edge / Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	47.7	54.0	6.3	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

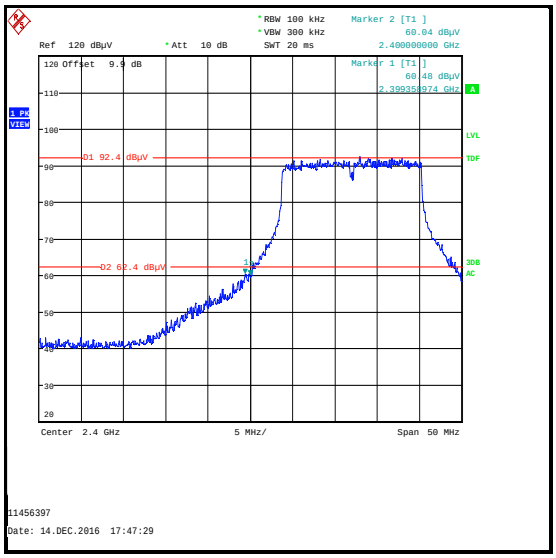
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2390.000	58.2	74.0	15.8	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

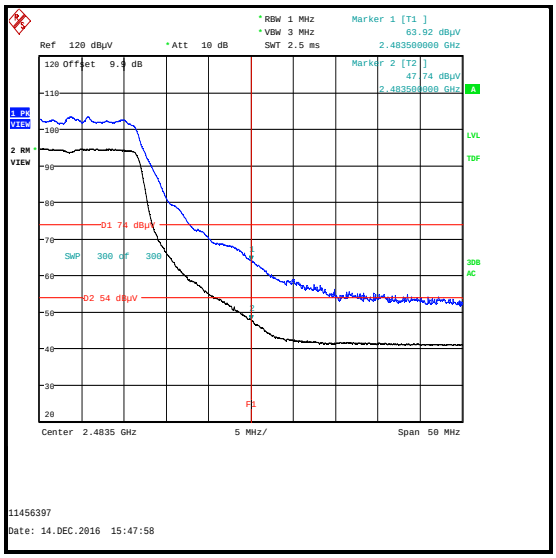
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2390.000	47.7	54.0	6.3	Complied

Transmitter Band Edge Radiated Emissions (continued)

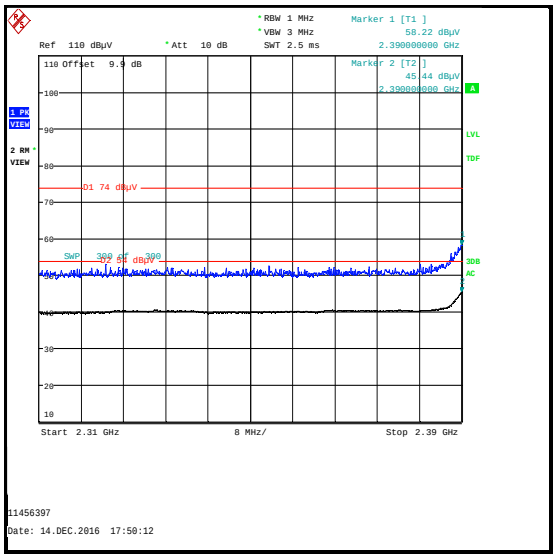
Results: 802.11g / 20 MHz / 18 Mbps



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

Transmitter Band Edge Radiated Emissions (continued)

Results: 802.11n HT20 / MCS1

Results: Lower Band Edge

Frequency (MHz)	Level (dBµV/m)	-30 dBc Limit (dBµV/m)	Margin (dB)	Result
2400.000	57.6	57.9	0.3	Complied

Results: Upper Band Edge / Peak

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	54.2	74.0	19.8	Complied
2484.542	54.4	74.0	19.6	Complied

Results: Upper Band Edge / Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	41.8	54.0	12.2	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

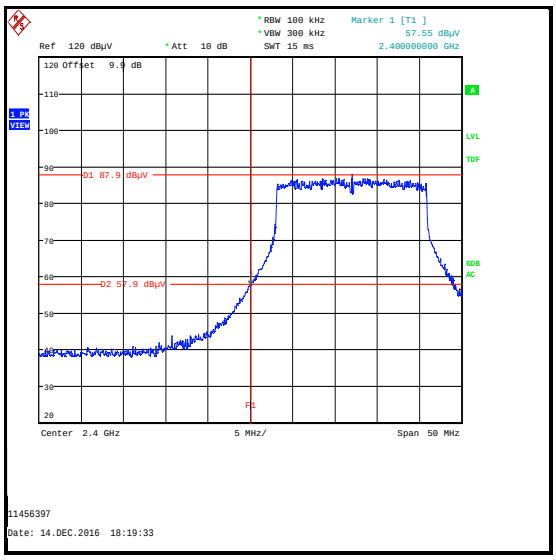
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2389.872	54.2	74.0	19.8	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

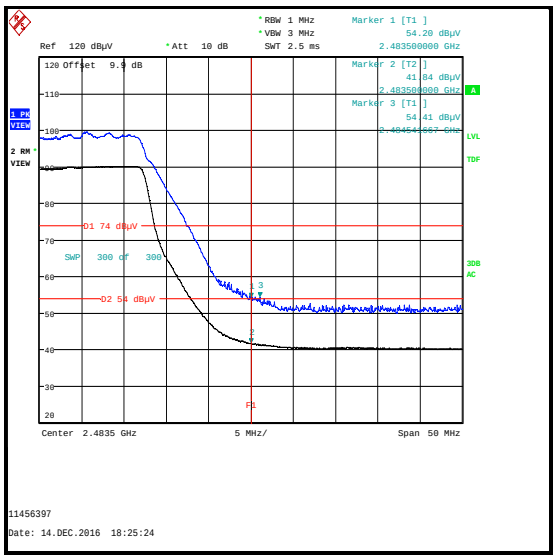
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2389.744	41.4	54.0	12.6	Complied

Transmitter Band Edge Radiated Emissions (continued)

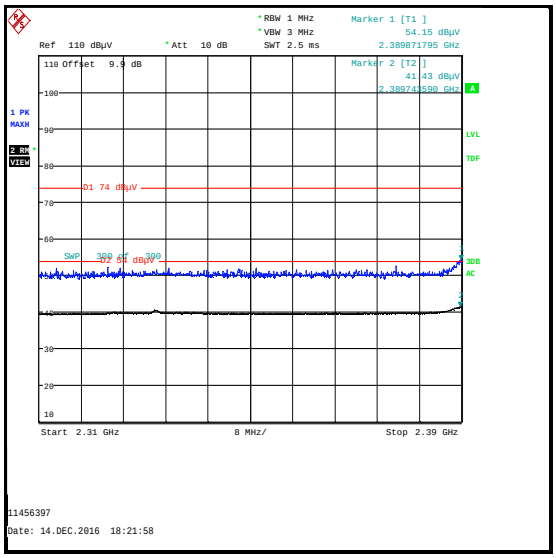
Results: 802.11n HT20 / MCS1



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

Transmitter Band Edge Radiated Emissions (continued)

Results: 802.11n HT20 / MCS5

Results: Lower Band Edge

Frequency (MHz)	Level (dBµV/m)	-30 dBc Limit (dBµV/m)	Margin (dB)	Result
2399.920	60.9	61.4	0.5	Complied
2400.000	60.7	61.4	0.7	Complied

Results: Upper Band Edge / Peak

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	66.6	74.0	7.2	Complied

Results: Upper Band Edge / Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	47.9	54.0	6.1	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

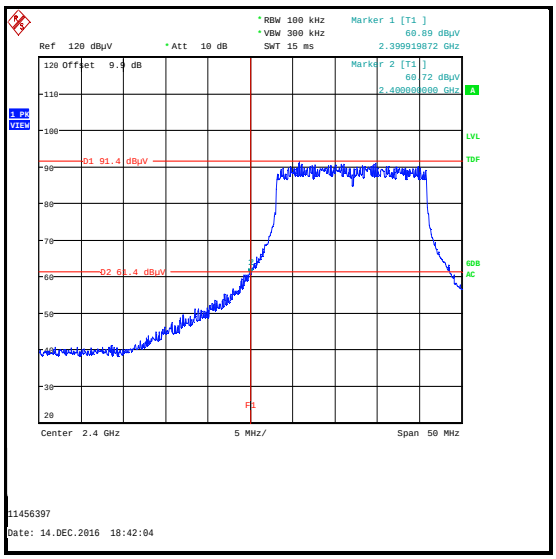
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2389.872	61.5	74.0	12.5	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

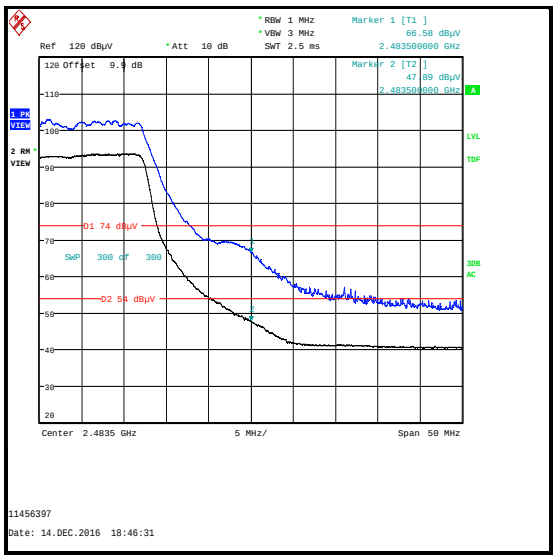
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2390.000	46.3	54.0	7.7	Complied

Transmitter Band Edge Radiated Emissions (continued)

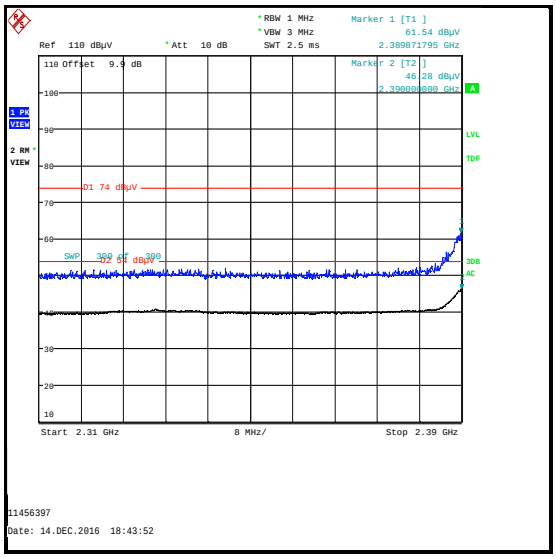
Results: 802.11n HT20 / MCS5



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

Transmitter Band Edge Radiated Emissions (continued)

Results: 802.11n HT40 / MCS0

Results: Lower Band Edge

Frequency (MHz)	Level (dBµV/m)	-30 dBc Limit (dBµV/m)	Margin (dB)	Result
2398.229	56.0	56.6	0.6	Complied
2400.000	52.5	56.6	4.1	Complied

Results: Upper Band Edge / Peak

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	57.4	74.0	16.6	Complied
2485.263	59.1	74.0	14.9	Complied

Results: Upper Band Edge / Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	44.0	54.0	10.0	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

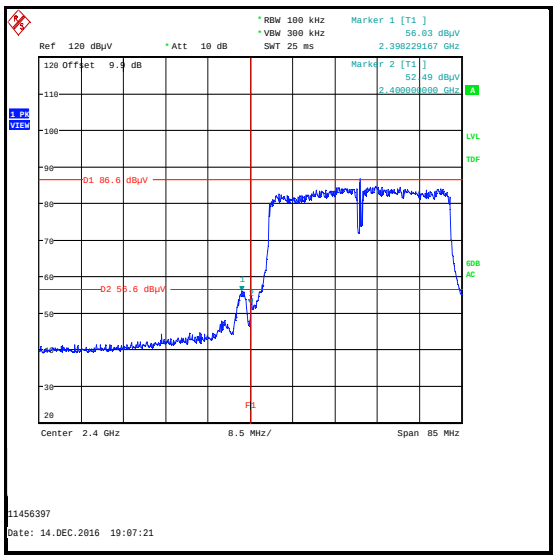
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2388.462	57.6	74.0	16.4	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

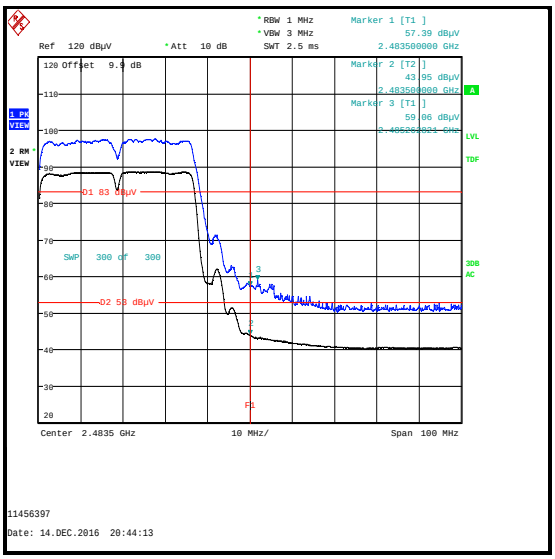
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2388.846	43.5	54.0	10.5	Complied

Transmitter Band Edge Radiated Emissions (continued)

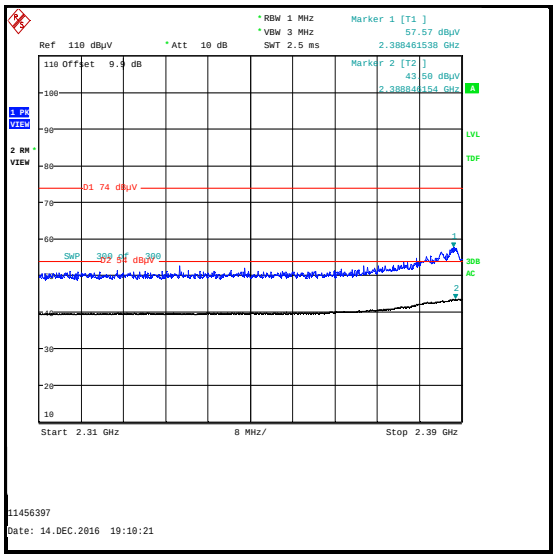
Results: 802.11n HT40 / MCS0



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

Transmitter Band Edge Radiated Emissions (continued)

Results: 802.11n HT40 / MCS6

Results: Lower Band Edge

Frequency (MHz)	Level (dBµV/m)	-30 dBc Limit (dBµV/m)	Margin (dB)	Result
2398.229	56.1	56.3	0.2	Complied
2400.000	52.1	56.3	4.2	Complied

Results: Upper Band Edge / Peak

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	51.5	74.0	22.5	Complied
2487.186	53.5	74.0	20.5	Complied

Results: Upper Band Edge / Average

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2483.500	40.8	54.0	13.2	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

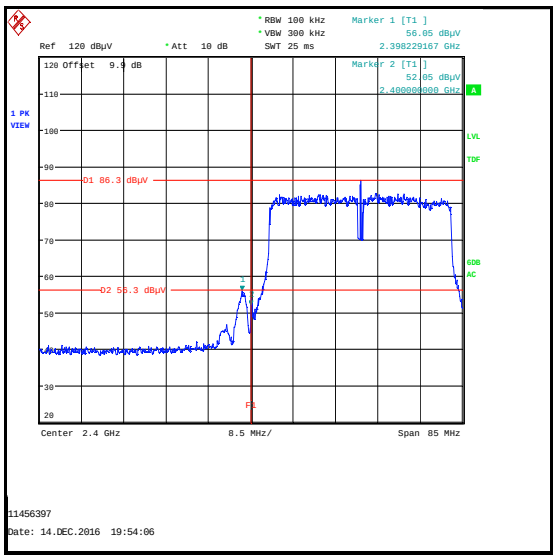
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2389.359	52.3	74.0	21.7	Complied

Results: 2310 MHz to 2390 MHz Restricted Band / Average

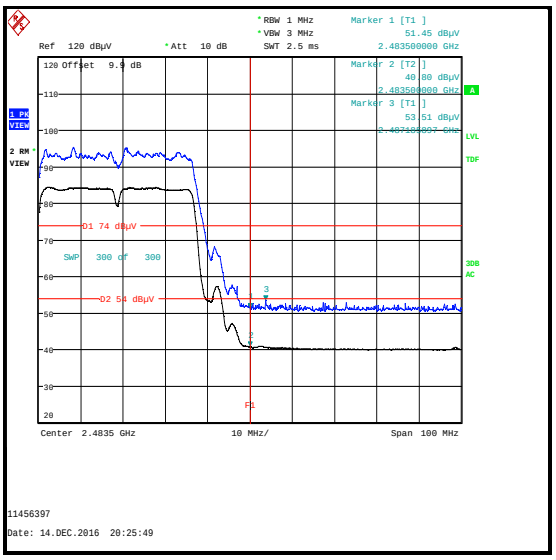
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2390.000	40.8	54.0	13.2	Complied

Transmitter Band Edge Radiated Emissions (continued)

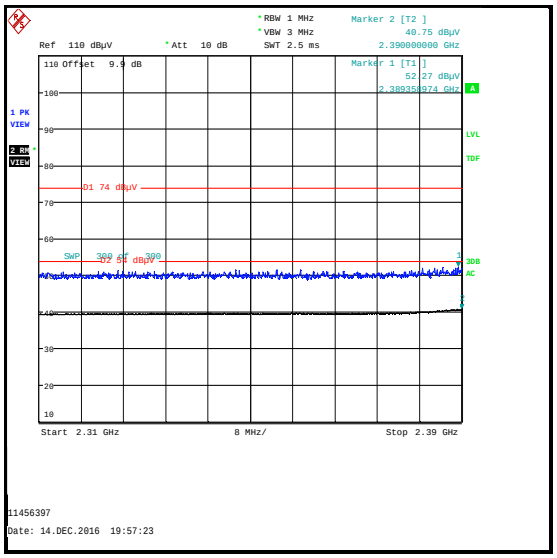
Results: 802.11n HT40 / MCS6



Lower Band Edge



Upper Band Edge



2310 MHz to 2390 MHz Restricted Band

Transmitter Band Edge Radiated Emissions (continued)

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2003	Thermohygrometer	Testo	608-H1	45046641	22 Apr 2017	12
K0017	3m RSE Chamber	Rainford EMC	N/A	N/A	17 May 2017	12
M1995	Test Receiver	Rohde & Schwarz	ESU40	100428	21 Mar 2017	12
A2863	Pre Amplifier	Agilent	8449B	3008A02100	07 Jan 2017	12
A2889	Antenna	Schwarzbeck	BBHA 9120 B	BBHA 9120 B 653	07 Apr 2017	12
A2916	Attenuator	AtlanTecRF	AN18W5-10	832827#1	19 May 2017	12

6. 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 of the measurand (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
Minimum 6 dB Bandwidth	2.4 GHz to 2.4835 GHz	95%	±4.59 %
Spectral Power Density	2.4 GHz to 2.4835 GHz	95%	±1.13 dB
Conducted Maximum Output Power	2.4 GHz to 2.4835 GHz	95%	±1.13 dB
Radiated Spurious Emissions	30 MHz to 1 GHz	95%	±5.65 dB
Radiated Spurious Emissions	1 GHz to 25 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.

7. Report Revision History

Version Number	Revision Details		
	Page No(s)	Clause	Details
1.0	-	-	Initial Version

--- END OF REPORT ---