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toll-free: (866) 311-3268
fax: (480) 926-3598
http://www.ComplianceTesting.com
info@ComplianceTesting.com

Test Report

Prepared for: Ubiquiti Networks, Inc

Model: B-DB-AC, Bullet

Description: Dual Band Networking Device

Serial Number: N/A

FCC ID: SWX-BDBAC
IC: 6545A-BDBAC

To

FCC Part 15.407 UNII-2

Date of Issue: February 13, 2019

On the behalf of the applicant:	**Ubiquiti Networks, Inc** **2580 Orchard Parkway** **San Jose, CA 95131**
Attention of:	**Mark Feil, Engineer** **Ph: (408)942-3085** **E-mail: mark.feil@ubnt.com**

Prepared By
Compliance Testing, LLC
1724 S. Nevada Way
Mesa, AZ 85204
(480) 926-3100 phone / (480) 926-3598 fax
www.compliancetesting.com
Project No: p1790008

Poona Saber
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	Dec 6, 2017	Poona Saber	Original Document
2.0	September 10, 2018	Poona Saber	-Added the antenna gain units on page 7 -Revised Average table column on page 18 -Revised RF exposure section on page 18 and 19 - based on highest EIRP for all antennas -Added additional information on modes of testing on page 6 and all modes and bandwidths covered added on table on page 7 -Updated Annex A for power tables for UNII-2C 22 dBi antenna and UNII-2A 5205 MHz to 5305 MHz
3.0	October 30, 2018	Poona Saber	Revised channel bandwidths on page 6 and maximum power of the EUT on page 7
4.0	January 7, 2019	Poona Saber	Revised Annex A
5.0	February 12, 2019	Poona Saber	Update page 10 with antenna power limits and updated ANSI C63.4 and C63.10 versions throughout the report

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ILAC / A2LA

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The tests results contained within this test report all fall within our scope of accreditation, unless noted below.

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Testing Certificate Number: **2152.01**

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IC Site Reg. #2044A-2

Non-accredited tests contained in this report:

N/A

The applicant has been cautioned as to the following

15.21 - Information to User

The user's manual or instruction manual for an intentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

15.27(a) - Special Accessories

Equipment marked to a consumer must be capable of complying with the necessary regulations in the configuration in which the equipment is marketed. Where special accessories, such as shielded cables and/or special connectors are required to enable an unintentional or intentional radiator to comply with the emission limits in this part, the equipment must be marketed with, i.e. shipped and sold with, those special accessories. However, in lieu of shipping or packaging the special accessories with the unintentional or intentional radiator, the responsible party may employ other methods of ensuring that the special accessories are provided to the consumer without an additional charge.

Information detailing any alternative method used to supply the special accessories for a grant of equipment authorization or retained in the verification records, as appropriate. The party responsible for the equipment, as detailed in § 2.909 of this chapter, shall ensure that these special accessories are provided with the equipment. The instruction manual for such devices shall include appropriate instructions on the first page of text concerned with the installation of the device that these special accessories must be used with the device. It is the responsibility of the user to use the needed special accessories supplied with the equipment.

Standard Test Conditions Engineering Practices

Except as noted herein, the following conditions and procedures were observed during the testing:

In accordance with ANSI C63.10-2013 and unless otherwise indicated in the specific measurement results, the ambient temperature of the actual EUT was maintained within the range of 10° to 40°C (50° to 104°F) unless the particular equipment requirements specified testing over a different temperature range. Also, unless otherwise indicated, the humidity levels were in the range of 10% to 90% relative humidity.

Measurement results, unless otherwise noted, are worst-case measurements.

Environmental Conditions		
Temperature (ºC)	**Humidity (%)**	**Pressure (mbar)**
25.4 – 26.6	21.4 – 22.5	976.7 – 980.9

EUT Operation during Tests
EUT is powered by POE (Power over Ethernet) Ethernet cable.

EUT Description
Model: B-DB-AC, Bullet
Description: Dual Band Networking Device
Firmware: N/A
Software: N/A
Serial Number: N/A
Additional Information: The Bullet AC (Model: B-DB-AC) is a dual band networking device that is powered over ethernet (passive POE, 24V) and provides an N-type antenna connection. It features dual-band AC mode operation in 5GHz and 2.4GHz bands, and a dedicated 2.4 GHz WiFi management radio for convenient device setup.
For 5 GHz band the radio covers 802.11 a/n/ ac modes with 10,20,30,40,50,60 and 80 MHz bandwidth. It is evaluated that unit would represent worst case operation and highest power number with ac mode and only result of testing is represented for this mode.

EUT Operation during Tests
Radio testing has been done conducted and radiated with controlling the device for continuous modulation transmission on low, middle and high channels with client's provided commands through telnet.

EUT Specifications

Equipment Code	NII	
FCC ID	SWX-RM5ACL	
Mode(s)Tested	802.11 ac-VHT 20,40,80	
Mode(s) Covered and Channels	Modes	Channel bandwidths (MHz)
	802.11 a	10, 20, 30
	802.11n- HT20	10, 20, 30
	802.11n- HT40	40, 50 ,60
	802.11 ac- VHT20	10, 20 ,30
	802.11 ac- VHT40	40, 50 ,60
	802.11 ac- VHT80	80
Maximum Output Power	22.2 dBm	
Frequency Ranges covered	5250-5350 & 5470-5725 MHz	
Bandwidths	10/20/30/40/50/60/80 MHz	
Data Rates	MCS0	
Modulations	BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM	

Antenna List

No.	Model	Antenna Type	Peak Gain
1	UniFi Omni	Omni	4 dBi
1	AMO-5G13	Omni	13 dBi
1	AM-5AC22-45	Sector	22 dBi
1	RD-5G34	Dish	34 dBi

15.203: Antenna Requirement:

_____	The antenna is permanently attached to the EUT
_____	The antenna uses a unique coupling
X	The EUT must be professionally installed
_____	The antenna requirement does not apply

Accessories:

Qty	Description	Manufacturer	Model	S/N
1	Switching mode power supply/ POE	Ubiquiti	GP-A240-050	N/A

Cables:

Qty	Description	Length (M)	Shielding Y/N	Shielded Hood Y/N	Ferrite Y/N
2	Ethernet cable	<3 meters	N	N	N

Modifications: None

Test Results Summary

Specification	Test Name	Pass, Fail, N/A	Comments
§15.203	Antenna Requirements	Pass	
§15.207 §15.407(b)(6)	Line Conducted Emissions	Pass	
§15.407(a)(2)	Conducted Output Power	Pass	
§15.407(a)(2),(5)	Power Spectral Density	Pass	
§15.403(i) 15.407(a)(5)	26dB Occupied Bandwidth	Pass	
	99% Occupied Bandwidth		
§15.407(b)(2)(3)	Undesirable Emissions	Pass	
§15.205 §15.407(b)(2),(3),(5)(6)(7)	General Field Strength Limits (Restricted Bands and Radiated Emission limits)	Pass	
§15.407(g)	Frequency Stability	Pass	
§15.407(f)	RF Exposure	Pass	

References	Description
CFR47, Part 15, Subpart B	Unintentional Radiators
CFR47, Part 15, Subpart C	Intentional Radiators
CFR47, Part 15, Subpart E	Unlicensed Nation Information Infrastructure Devices (U-NII)
ANSI C63.10-2013	American National standard for testing Unlicensed Wireless Devices
ANSI C63.4-2014	Method and Measurements of Radio-Noise Emissions from low-Voltage Electrical and Electronic Equipment in the range 9kHz to 40GHz.
ISO/IEC 17025:2005	General requirements for the Competence of Testing and Calibrations Laboratories
KDB 644545 D03	Guidance for IEEE 802 11ac New Rules
KDB 789033 D02	General U-NII Test Procedures New Rules V01
KDB 926956 D01	U-NII Transition Plan

Peak Output Power

Engineer: Poona Saber

Test Date: 10/30/17-11/7/17

Test Requirements

(2) For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum conducted output power over the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

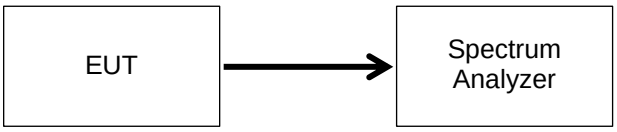
Test Procedure

The RF power was calculated using the spectrum analyzers' band power function per Method SA-1 from KDB 789033 D02 General U-NII Test Procedures New Rules v01. Measurements were made at the low, mid, and high channels of the band.

The Spectrum Analyzer was set to the following:

a. RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Sweep time = auto
d. Detector = RMS
e. 100 traces in power averaging mode

Test Setup



The Conducted power limit for each of the antennas used with the device are as following:

4 dBi Antenna allows **24 dBm** power
13 dBi Antenna allows **17dBm** power**:** 13dBi - 6dB= 7dB => 24dBm - 7dB=17dBm
22 dBi Antenna allows **8 dBm** power**:** 22dBi - 6dB= 16dB => 24dBm - 16dB= 8dBm
34 dBi Antenna allow **-6 dBm** power: 34dBi - 6dB= 28dB => 24dBm - 28dB= -4dBm

See Annex A for test results

Transmitter Power Spectral Density

Engineer: Poona Saber

Test Date: 10/30/17-11/7/17

Test Requirements

(2) For the 5.25-5.35 GHz and 5.47-5.725 GHz bands, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

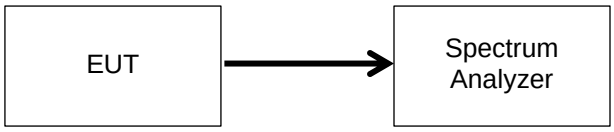
Test Procedure

The Power Spectral Density was measured using the method per SA-1 from KDB 789033 D02 General U-NII Test Procedures New Rules v01. Measurements were made at the low, mid, and high channels of the band. The maximum PSD was determined by finding the peak value across the carrier bandwidth.

The Spectrum Analyzer was set to the following:

a. RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Span 1.5 * BW
d. Sweep time = auto
e. Detector = RMS
f. 100 traces in power averaging mode

Test Setup



See Annex A for test results

Undesirable Emissions Conducted

Engineer: Poona Saber

Test Date: 10/30/17-11/7/17

Test Requirements

Unwanted Emissions that fall Outside Restricted Bands

For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

For transmitters operating in the 5.47-5.725 GHz band: All emissions outside of the 5.47-5.725 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

As specified in § 15.407(b), emissions above 1000 MHz that are outside of the restricted bands are subject to a maximum emission limit of -27 dBm/MHz. However, an out-of-band emission that complies with both the peak and average limits of § 15.209 is not required to satisfy the -27 dBm/MHz maximum emission limit.

The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz

The provisions of §15.205 apply to intentional radiators operating under this section

Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209.

For Conducted Unwanted Emissions in the Restricted Bands

For conducted measurements above 1000 MHz, EIRP was determined and then the field strength computed by the following:
E[dBµV/m] = EIRP[dBm] - 20 log(d[meters]) + 104.77, where E = field strength and d = 3m
E[dBµV/m] = EIRP[dBm] + 95.2, for d = 3 meters.

Test Procedure

Per KDB 789033 D02 General U-NII Test Procedures New Rules v01 conducted RF port measurements were made in lieu of radiated. In addition, Cabinet Emissions measurements were performed in a semi-anechoic chamber with the antenna port terminated by a matching load. See additional section for Radiated Emissions.

The following criteria were addressed:

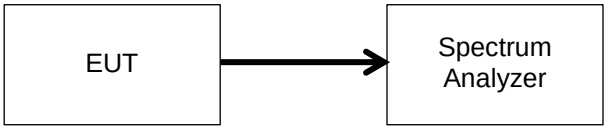
The Spectrum Analyzer was set to the following for emissions > 1000MHz:

a. RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Detector = Peak.
d. Sweep time = auto
e. Trace mode = max hold
    1. Note: For emissions where the peak exceeded that of the average 15.209 emission limit the following was performed.
f. VBW ≤ RBW/100 (i.e., 10 kHz) but not less than 10 Hz

For emissions below 1000MHz the Spectrum Analyzer settings were as follows:

a. RBW = 100 kHz
b. VBW ≥ 300 kHz
c. Detector = Peak
d. Sweep time = auto
e. Trace mode = max hold

Test Setup



Test Results: **See Annex B-1 and B-2: Undesirable Emissions Conducted**

Undesirable Emissions Radiated
Engineer: Poona Saber
Test Date: 10/30/17-11/7/17

Test Requirements

The provision of §15.209 were applied. In addition, the requirements of §15.205 were also applied.

FCC Part 15 Subpart C Paragraph 15.209(a) Limits

Frequency (MHz)	Frequency (microvolts/meter)	Frequency (meter)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Remarks: E field strength (dBµV/m) = 20 log E field strength (uV/m)

Test Procedure

The EUT was setup in accordance with ANSI C63.10. 2013 and tested per KDB 789033. The antenna was replaced with non-radiating matched load. The EUT is placed on non-conductive platform at a height of 0.8 meters above the ground plane of the semi-anechoic chambers. The EUT was rotated 360 degrees and the receive antenna raised and lowered to find the maximum emissions from 30MHz to the 10th harmonic of the fundamental. The EUT was set to the maximum power level allowed and the low, mid, and high channels were investigated for emissions.

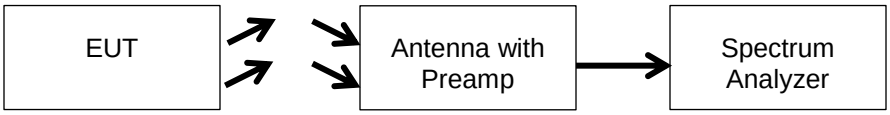
The Spectrum Analyzer was set to the following for emissions > 1000MHz:

a. (RBW = 1 MHz
b. VBW ≥ 3 MHz
c. Detector = Peak
d. Sweep time = auto
e. Trace mode = max hold
    1. Note: For emissions where the peak exceeded that of the average 15.209 emission limit the following was performed.
f. RBW = 1 MHz
g. VBW ≤ RBW/100 (i.e., 10 kHz) but not less than 10Hz

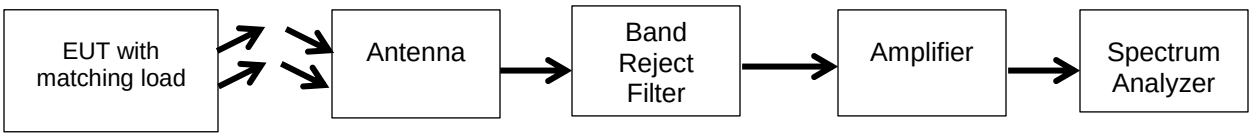
For emissions below 1000MHz the Spectrum Analyzer settings were as follows:

a. RBW = 100 kHz
b. VBW ≥ 300 kHz
c. Detector = Peak
d. Sweep time = auto
e. Trace mode = max hold
    1. Note: A quasi peak detector was used for emissions where the peak exceeded that of the average 15.209 emission limits

Test Setup below 1000MHz



Test Setup above 1000MHz



Test Results: **See Annex C: Undesirable Emission Radiated**

Note: There was no emissions observed beyond noise floor after 18 GHz.

Occupied Bandwidth

Engineer: Poona Saber

Test Date: 10/30/17-11/7/17

Test Requirement

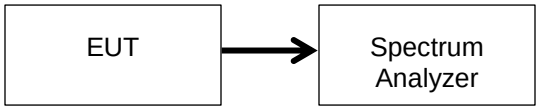
The emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement

Test Procedure

The Spectrum Analyzer was set to the following parameters:

a. RBW = approximately 1 to 5% of the emission bandwidth.
b. VBW > RBW.
c. Detector = Peak.
d. Trace mode = max hold.

Test Setup



Test Results: **See Annex D: Occupied Bandwidth**

Frequency Stability
Engineer: Poona Saber
Test Date: 10/30/17-11/7/17

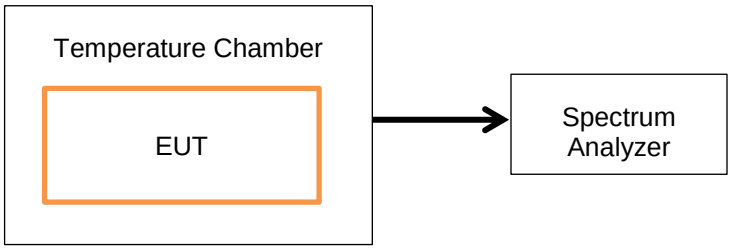
Test Requirement

Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

Test Procedure

a. The EUT was placed into a temperature chamber and the temperature ranges were set to the manufacturer's specifications.
b. The RF output of the EUT was connected to a spectrum analyzer
c. The lowest and highest channels of the band were set to transmit
d. The carrier plots were measured to ensure that the 26dB band width remained within the band over the prescribed temperature extremes.

Test Setup



Test Results: **See Annex E: Frequency Stability**

RF Exposure
Engineer: Poona Saber
Test Date: 10/30/17-11/7/17

Requirements

U-NII devices are subject to the radio frequency radiation exposure requirements specified in §1.1307(b), §2.1091 and §2.1093 of this chapter, as appropriate. All equipment shall be considered to operate in a "general population/uncontrolled" environment. Applications for equipment authorization of devices operating under this section must contain a statement confirming compliance with these requirements for both fundamental emissions and unwanted emissions. In addition, systems operating under the provisions of this section shall be operated in a manner that insures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

Exposure Limits

At operating frequencies less than or equal to 6 GHz, the limits for maximum permissible exposure (MPE) shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Section 1.1307(b), except for portable devices as defined in §2.1093 as these evaluations shall be performed according to the SAR provisions in §2.1093 of this chapter.

MPE Limit Calculations

Exposure Limit 1mW/cm^2

Source Based Time Averaged Power Calculation

Average Power Calculations

Average Power = Peak Power * duty-cycle%

Tuned Frequency (MHz)	Conducted Peak Output Power (mW)	Duty Cycle (%)	Average Power (mW)
5600	33.11	100	33.11

MPE Evaluation

This is a **fixed/mobile** device used in uncontrolled /general population exposure environment.

Limits Uncontrolled Exposure	0.3-1.234 MHz	Limit [mW/cm²] = 100
47 CFR 1.1310	1.34-30 MHz	Limit [mW/cm²] = (180/f²)
Table 1, (B)	30-300 MHz	Limit [mW/cm²] = 0.2
	300-1500 MHz	Limit [mW/cm²] = f/1500
	1500-100,000 MHz	Limit [mW/cm²] = 1.0

Test Data

Test Frequency, MHz	5600
Power, Conducted, mW (P)	33.11
Antenna Gain Isotropic	13 dBi
Antenna Gain Numeric (G)	19.95
Antenna Type	omni
Distance (R)	20

$$S = \frac{P * G}{4\pi r^2}$$

Power Density (S) mw/cm²	Power mW (P)	Numeric Gain (G)	Distance (r^2) cm
	33.11	19.95	20

Power Density (S) = 0.131
Limit =(from above table) = 1

A/C Powerline Conducted Emission

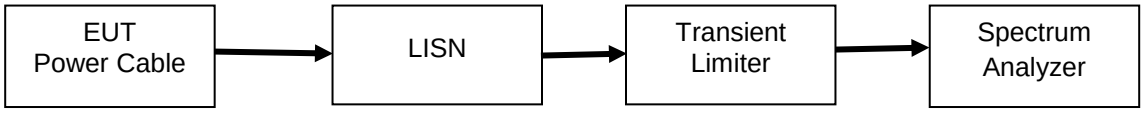
Engineer: Poona Saber

Test Date: 12/12/2017

Test Procedure

The EUT power cable was connected to a LISN and the monitored output of the LISN was connected to a transient limiter, which then connected directly to a spectrum analyzer. The conducted emissions from 150 kHz to 30 MHz were measured and compared to the specification limits.

Test Setup



Test Results: **See Annex F: A/C Powerline Conducted Emission**

Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
Temperature Chamber	Tenney	Tenney II Benchmaster	i00287	NCR	NCR
Preamplifier	HP	8447D	i00055	NCR	NCR
Harmonic Mixer 26.5-40GHz	HP	11970A	i00193	6/4/15	6/4/18
Horn Antenna, Amplified	ARA	DRG-118/A	i00271	6/16/16	6/16/18
Spectrum Analyzer	Agilent	E4407B	i00331	11/21/2017	11/21/2018
Bi-Log Antenna	Teseq	CBL 6111D	i00349	8/3/16	8/3/18
EMI Analyzer	Agilent	E7405A	i00379	2/22/2017	2/22/2018

In addition to the above listed equipment standard RF connectors and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT