

Test Report No. 7112310971

Applicant: Capacicom LTD.

Equipment Under Test:

IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF

FCC ID: 2AYPY- NBX-R1000-RF

Issued by:

The Standards Institution of Israel

Industry Division

Electrical & Electronics Laboratory

EMC Branch





Test Report No.: 7112310971

Page 2 of 50 Pages

Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF

FCC ID: 2AYPY- NBX-R1000-RF

Applicant:

Capacicom LTD.

Address:

4 Haalon st., 4059300 Kfar Neter Israel

Sample for test selected by:

The customer

The date of test:

7-8/04 & 19/04/2021

Description of Equipment**under Test (EUT):** IoT Repeater - WiFi Transceiver**Model:**

NBX-R1000-RF

Software version :

1.0.0

Hardware version:

5

Manufactured by:

Capacicom LTD.

Reference Documents:

- ❖ CFR 47 FCC (2020). Rules and Regulations: Part 15. Radio frequency devices, Subpart C: Intentional radiators. Section 15.247 Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz, 5725 - 5875 MHz

Test Results

The EUT was found to be in compliance with the following standard:

CFR47 Part 15 Subpart C
sections: 15.203, 15.205, 15.207, 15.209 and 15.247

This Test Report contains 50 pages and may be used only in its entirety.

This Test Report applies only to the specimen tested and may not be applied to other specimens of the same product.

**Table of Contents**

1. <i>Summary of Test Results</i>	4
2. <i>EUT Description</i>	5
2.1. General description:	5
2.2. Transmitter description:	6
2.3. Test setup:	7
2.4. System test configuration:	8
3. <i>Test specification, methods and procedures</i>	9
4. <i>Testing Facility:</i>	9
5. <i>Measurement uncertainty</i>	9
6. <i>Transmitter characteristics - test results</i>	10
6.1. 6dB and Occupied Bandwidth	10
6.2. Maximum Peak Conducted Output Power	14
6.3. Power Spectral Density	18
6.4. Radiated Emissions in Restricted and non-Restricted bands	22
6.5. Band-edge compliance of RF conducted emissions	41
7. <i>AC power line conducted emission measurement</i>	43
8. <i>Antenna requirements</i>	45
9. <i>Appendix 1: Test equipment used</i>	46
10. <i>Appendix 2: Antenna Factor and Cable Loss</i>	47
11. <i>Appendix 3: Test illustrations</i>	49



Test Report No.: 7112310971

Page 4 of 50 Pages

Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF

1. Summary of Test Results

Transmitter characteristic	Ref. Section
6dB and occupied bandwidth	15.247 (a) (2)
Maximum peak conducted output power	15.247 (b) (3)
Power spectral density	15.247 (e)
Radiated emission in restricted and non-restricted bands	15.247 (d), 15.209, 15.205
Band-edge compliance of RF conducted emission	15.247 (d)
AC power line conducted emission measurements	15.207
Antenna requirement	15. 203

Name: Eng. Yuri Rozenberg
Position: Head of Branch

Electrical & Electronics
Laboratory

November 7, 2021

Tested by: Alexander Konkov
Position: Testing Technician

Written by: Galit Gorodetsky
Position: Technical Writer

2. EUT Description

Note: All information in this section was provided by the customer.

2.1. General description:

The Equipment under Test (hereinafter: EUT) is a smart IoT LPWAN repeater system with a transceiver Module which operates in the sub-1GHz ISM frequency spectrum and IP M&C over ETH/WiFi/BT.

The EUT uses WiFi/BT transceiver chip is ESP32 from Espressif Systems. ESP32 is a single 2.4GHz Wi-Fi and Bluetooth combo chip. It uses the same 40MHz TCXO clock source.

The 2.4GHz transceiver uses built-in non detachable antenna printed on the PCB. The EUT has no internal power source. It uses PoE for DC power supply (10-48V).

The test data contained in this report pertains only to the emissions due to the EUT's WiFi transmitter.

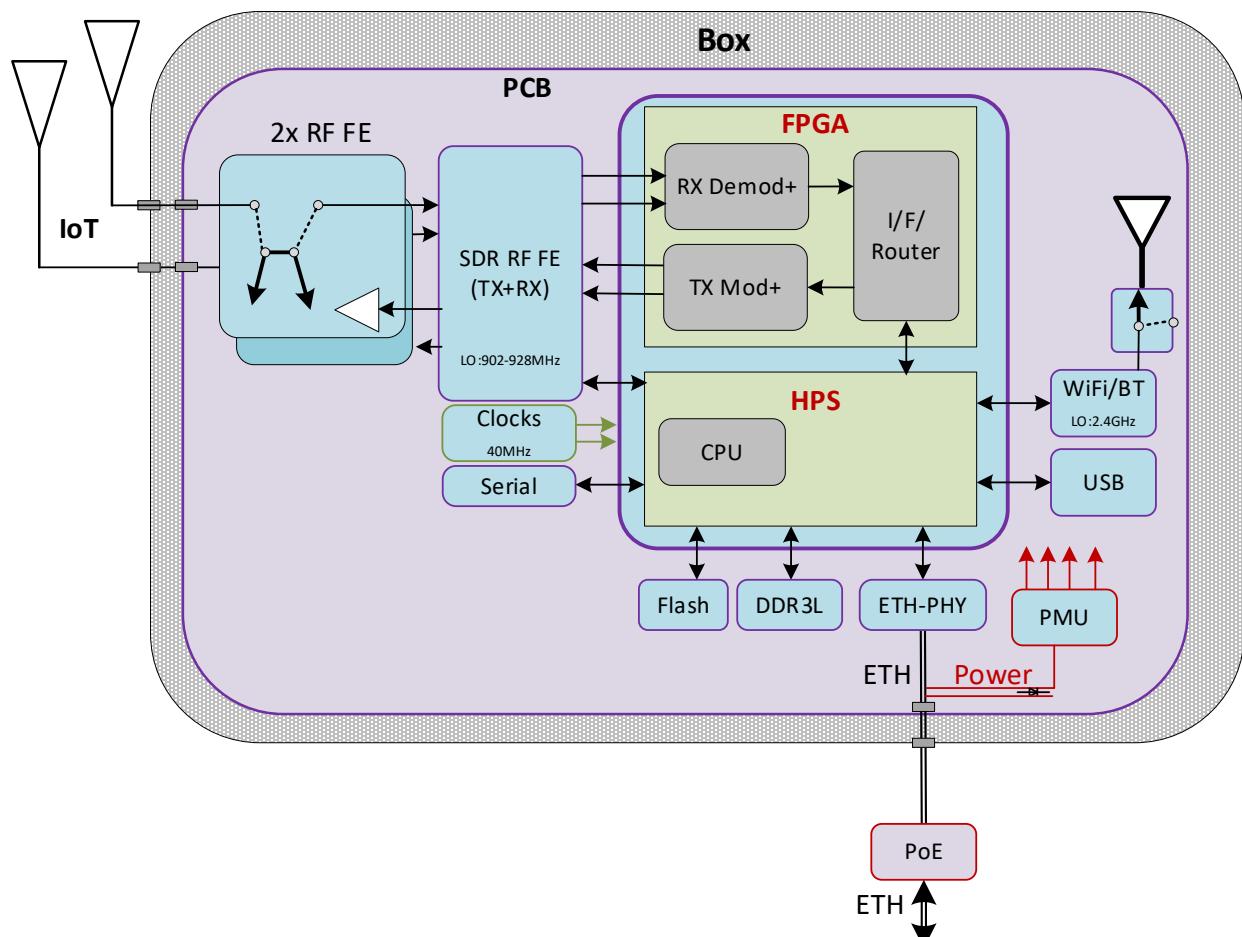


Figure 1. IoT Repeater block diagram



Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF

2.2. Transmitter description:

Type of equipment	Combined equipment (Equipment where the radio part is fully integrated within another type of equipment)
-------------------	--

WLAN standards	IEEE 802.11 b/g/n b – 11Mbit/s g – 54 Mbit/s n – (MCS7) 150 Mbit/s
----------------	---

Intended use	fixed
--------------	-------

Assigned frequency range	from 2400MHz to 2483.5MHz	
Operating frequency range	from 2412MHz to 2462MHz (WLAN transmitter)	
RF channel spacing	20MHz (b,g), 40MHz (n) (WLAN transmitter)	
Maximum rated output power	Effective radiated power (for equipment with no RF connector)	13dBm
transmitter output power is variable	No	-

Antenna information	
Integral with temporary RF connector on board PCB antenna	
Antenna gain = 2dBi	

Transmitter 99% power bandwidth	
Type of modulation	DSSS, OFDM, QPSK
Type of multiplexing	DSSS, OFDM
Modulating test signal (baseband)	PRBS

Transmitter power source	
Nominal rated voltage	24VDC Min. 10V / Max. 48V

2.3. Test setup:

The EUT was tested per the guidance ANSI C63.10: 2013.

The test setup is shown in Figure 2 and 3.

The EUT was connected with auxiliary Laptop via LAN-Power splitter.

Also EUT gets 19VDC power from the AC power adapter via LAN-Power splitter in order to use PoE technology. The EUT configured to transmit continuously, duty cycle $\geq 98\%$.

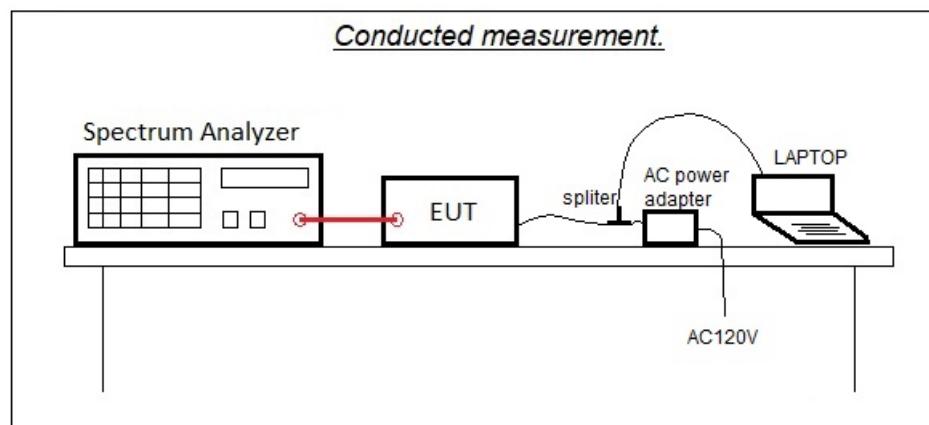


Figure 2. EUT conducted test setup

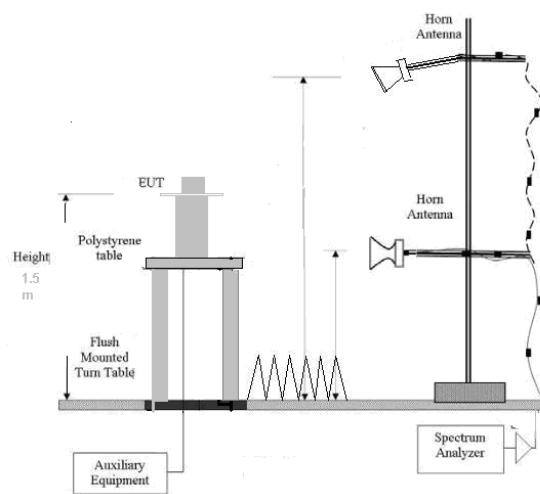


Figure 3. Radiated emission test setup above 1 GHz.



Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF

2.4. System test configuration:802.11b 11M – 20 MHz and 802.11g 54M – 20 MHz

Channel	Frequency MHz	Channel	Frequency MHz
1	2412	7	2442
2	2417	8	2447
3	2422	9	2452
4	2427	10	2457
5	2432	11	2462
6	2437		

802.11n MCS7 – 40 MHz

Channel	Frequency MHz	Channel	Frequency MHz
3	2422	7	2442
4	2427	8	2447
5	2432	9	2452
6	2437		



Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF

3. Test specification, methods and procedures

- ❖ CFR 47 FCC Rules and Regulations: Part 15. Radio frequency devices, Subpart C: Intentional radiators (2020)
- ❖ ANSI C63.4:2014 American National Standard for Method of Measurement of Radio Noise Emissions from Low Voltage Electrical and Electronic Equipment in the Range 9 kHz to 40 GHz.
- ❖ ANSI C63.10: 2013 American National Standard for Testing of Unlicensed Wireless Devices

4. Testing Facility:

Laboratory Name: Standards Institution of Israel (SII)

Test site location: 42 Haim Levanon st., Tel-Aviv Israel

Laboratory Accreditations:

ANAB: AT-1359

5. Measurement uncertainty

The test equipment has been calibrated according to its recommended procedures and is within the manufacturer's published limit of error.

The laboratory calibrates its standards by a third party (traceable to NIST, USA) on a regular basis according to equipment manufacturer requirements.

Test description	Calculated uncertainty U_{LAB}
Conducted measurements	
Frequency error	37.6 Hz
Spurious emission	± 2.98 dB
Radiated measurements	
Electric field strength in a SAR at 3 m distance 30 MHz – 1.0 GHz	± 4.32 dB
Electric field strength in a FAR at 3 m distance 1.0 GHz – 18 GHz	± 4.47
Substitution measurements	
In a FAR at 3 m distance 1.0 GHz – 18 GHz	± 3.41 dB



Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF

6. Transmitter characteristics - test results

6.1. 6dB and Occupied Bandwidth

Limits & methods:

FCC requirements	15.247(a)(2)		
Test procedure	ANSI 63.10 Section 11.8.2 option 2. Conducted measurement		
Operating Frequencies	802.11b 11M – 20 MHz 802.11g 54M – 20 MHz 802.11n MCS7 – 40 MHz		
Ambient Temperature 22°C	Relative Humidity 46%	Air Pressure 1006hPa	

Limit :

The minimum 6dB bandwidth shall be at least 500 kHz.

Results:

WLAN standard	Frequency, MHz	Limit, kHz	6dB bandwidth, MHz	Verdict	Plot #
802.11b 11M – 20 MHz	2412	500	9.67	Pass	1
	2437		9.68	Pass	2
	2462		9.68	Pass	3
802.11g 54M – 20 MHz	2412		16.54	Pass	4
	2437		16.54	Pass	5
	2462		16.53	Pass	6
802.11n MCS7 – 40 MHz	2422		36.48	Pass	7
	2437		36.47	Pass	8
	2452		36.47	Pass	9

Test procedure

The measurements were performed in hopping transmission mode of operation for carrier (channel) frequency at bottom, middle and at the top of 2412MHz to 2462MHz frequency band and maximum transmitting data rate.

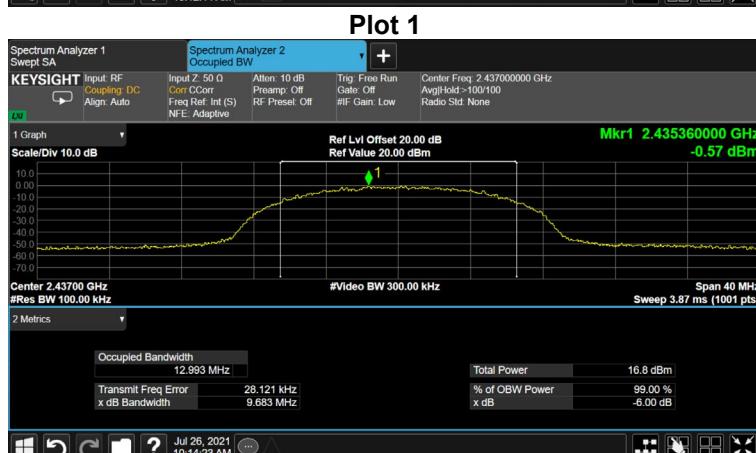


Test Report No.: 7112310971

Page 11 of 50 Pages

Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF

802.11b11M – 20 MHz

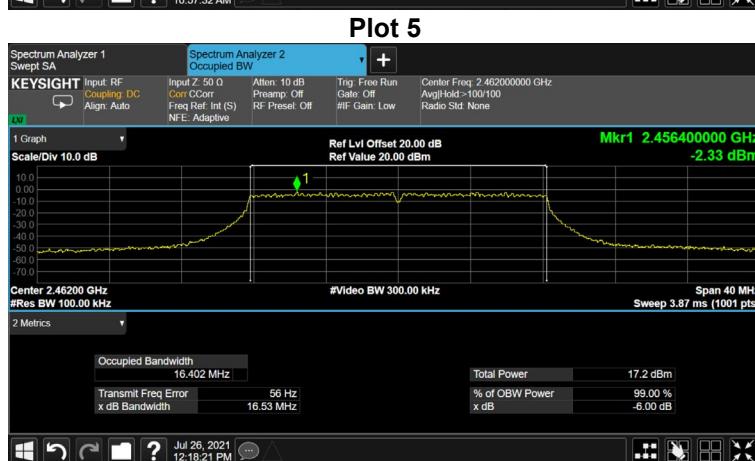
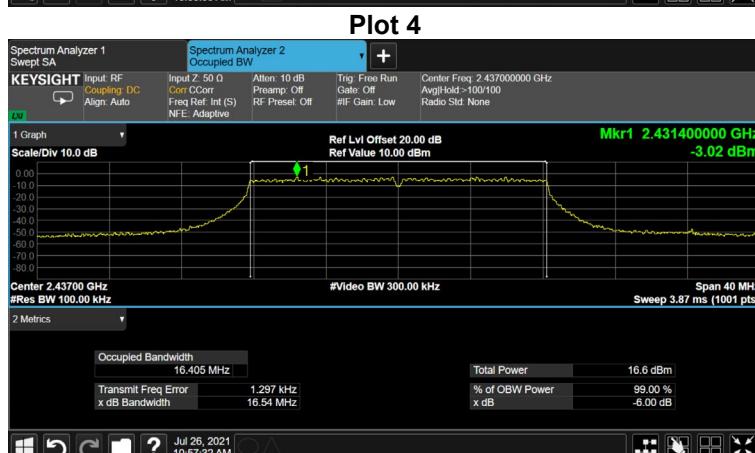
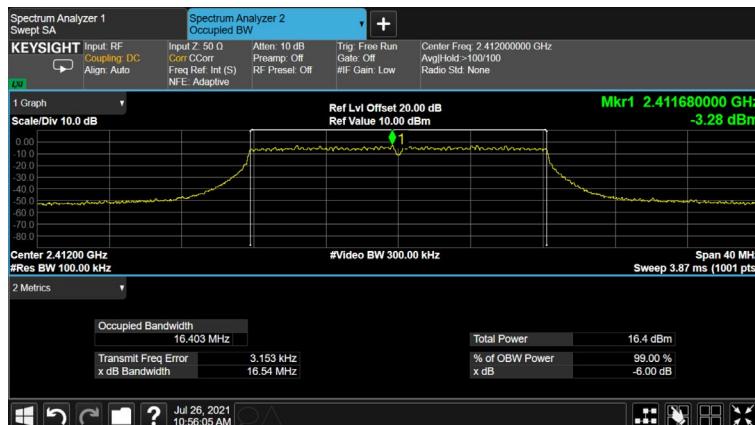


Test Report No.: 7112310971

Page 12 of 50 Pages

Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF

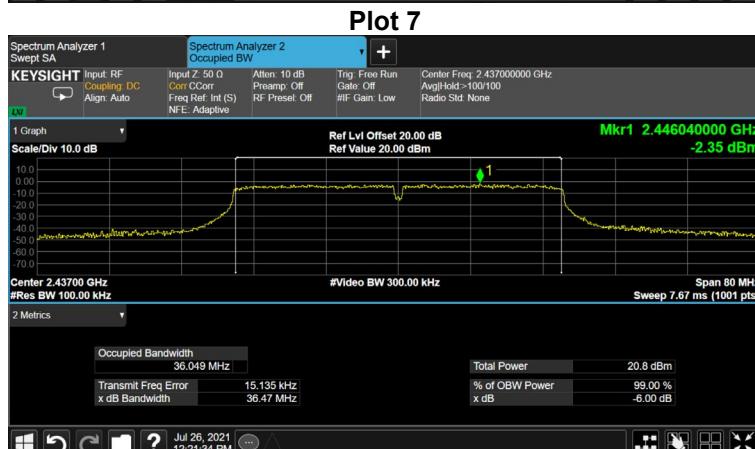
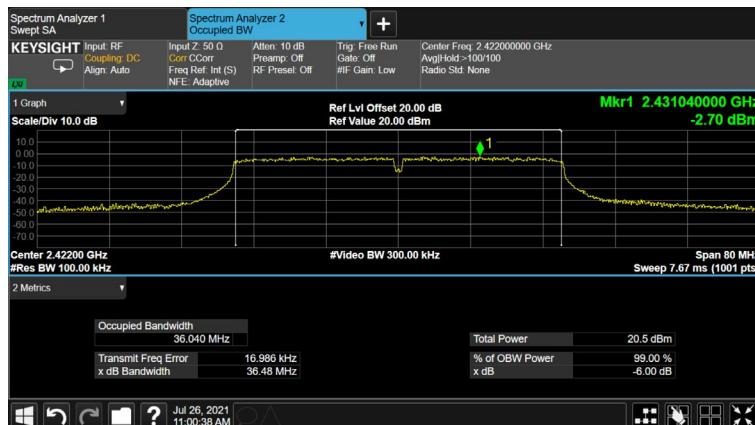
802.11g 54M – 20 MHz**Plot 6**



Test Report No.: 7112310971

Page 13 of 50 Pages

Title: Test on IoT Repeater - WiFi Transceiver
Model: NBX-R1000-RF **FCC ID:** 2AYPY- NBX-R1000-RF

802.11n MCS7 – 40 MHz**Plot 9**



Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF

6.2. Maximum Peak Conducted Output Power

Limits & methods:

FCC requirements	15.247(b)(3)		
Test procedure	ANSI 63.10 Section 11.9.1.2 Conducted Measurement		
Operating Frequencies	802.11b 11M – 20 MHz 802.11g 54M – 20 MHz 802.11n MCS7 – 40 MHz		
Ambient Temperature 22°C	Relative Humidity 46%	Air Pressure 1006hPa	

Limit

The maximum peak conducted output power shall not exceed 1 watt.

Results:

WLAN standard	Frequency, MHz	Peak power Limit, Watt	Peak power, dBm	Calculated power, mWatt	Verdict	Plot #
802.11b 11M – 20 MHz	2412	1	12.61	18.239	Pass	10
	2437		12.80	19.055	Pass	11
	2462		12.88	19.409	Pass	12
802.11g 54M – 20 MHz	2412		12.27	16.87	Pass	13
	2437		12.51	17.82	Pass	14
	2462		12.80	19.05	Pass	15
802.11n MCS7 – 40 MHz	2422		12.93	19.63	Pass	16
	2437		12.95	19.72	Pass	17
	2452		12.43	17.50	Pass	18

Test procedure

The measurements were performed in hopping transmission mode of operation for carrier (channel) frequency at bottom, middle and at the top of 2412MHz to 2462MHz frequency band and maximum transmitting data rate.



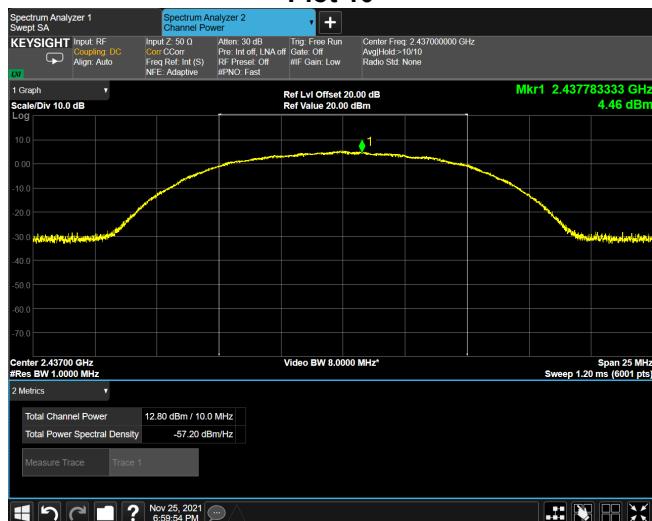
Test Report No.: 7112310971

Page 15 of 50 Pages

Title: Test on IoT Repeater - WiFi Transceiver
Model: NBX-R1000-RF **FCC ID:** 2AYPY- NBX-R1000-RF

802.11b 11M

Plot 10



Plot 11



Plot 12



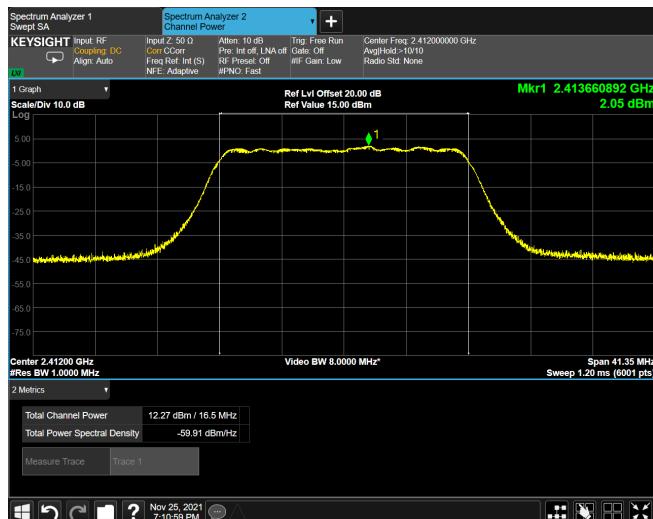
Test Report No.: 7112310971

Page 16 of 50 Pages

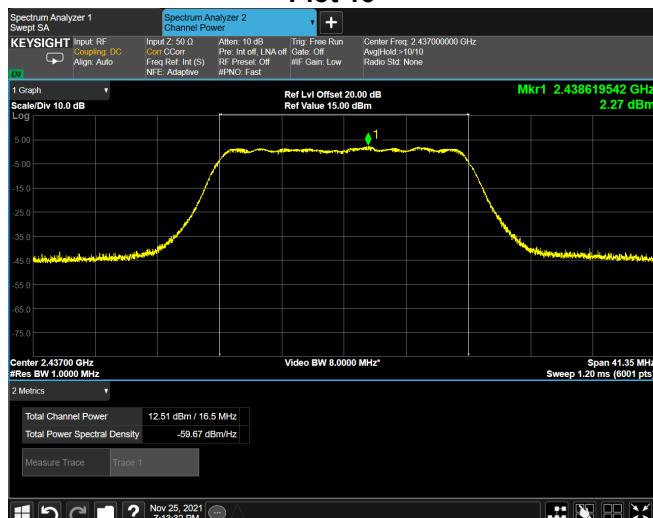
Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF

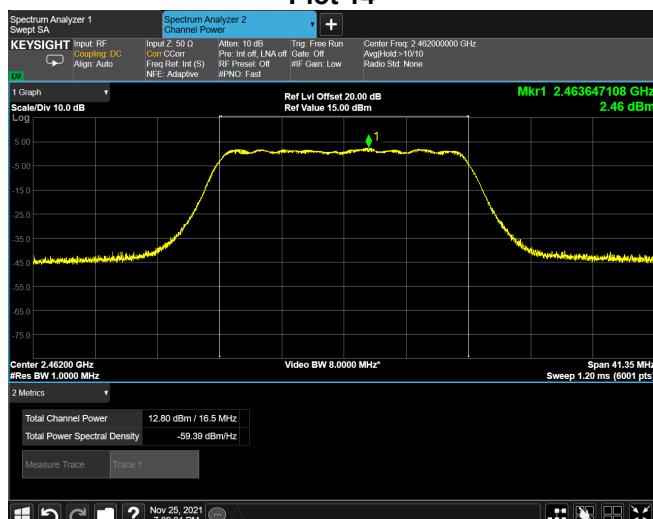
FCC ID: 2AYPY- NBX-R1000-RF

802.11g 54M

Plot 13



Plot 14



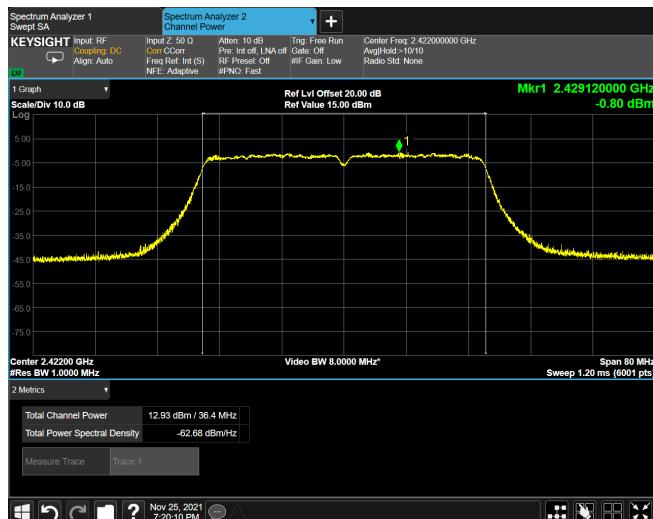
Plot 15



Test Report No.: 7112310971

Page 17 of 50 Pages

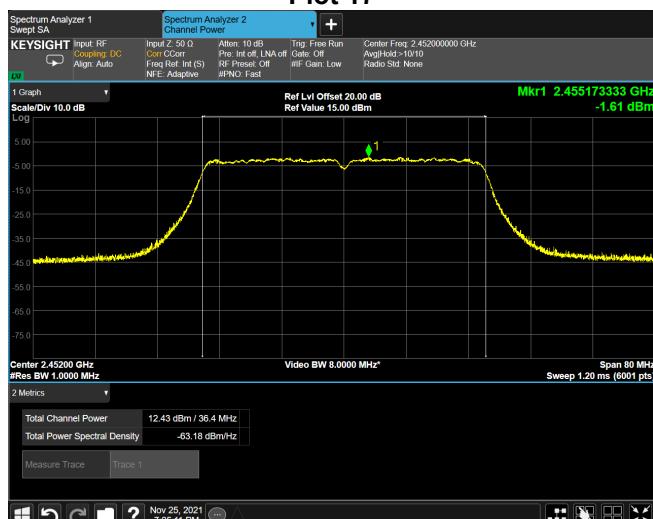
Title: Test on IoT Repeater - WiFi Transceiver
Model: NBX-R1000-RF **FCC ID:** 2AYPY- NBX-R1000-RF

802.11n MCS7

Plot 16



Plot 17



Plot 18



6.3. Power Spectral Density

Limits & methods:

FCC requirements	15.247(e)		
Test procedure	ANSI 63.10 Section 11.10.2 method PKPSD (peak PSD) Conducted measurement		
Operating Frequencies	802.11b 11M – 20 MHz 802.11g 54M – 20 MHz 802.11n MCS7 – 40 MHz		
Ambient Temperature 22°C	Relative Humidity 46%	Air Pressure 1006hPa	

Limit

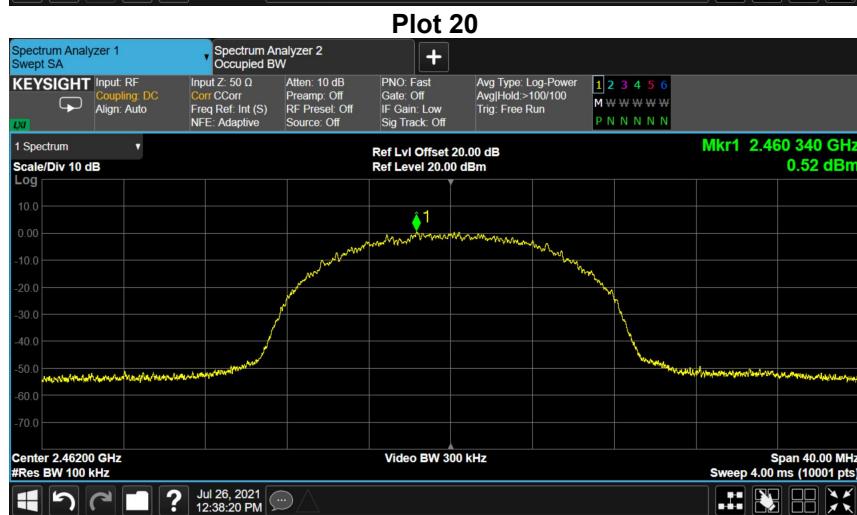
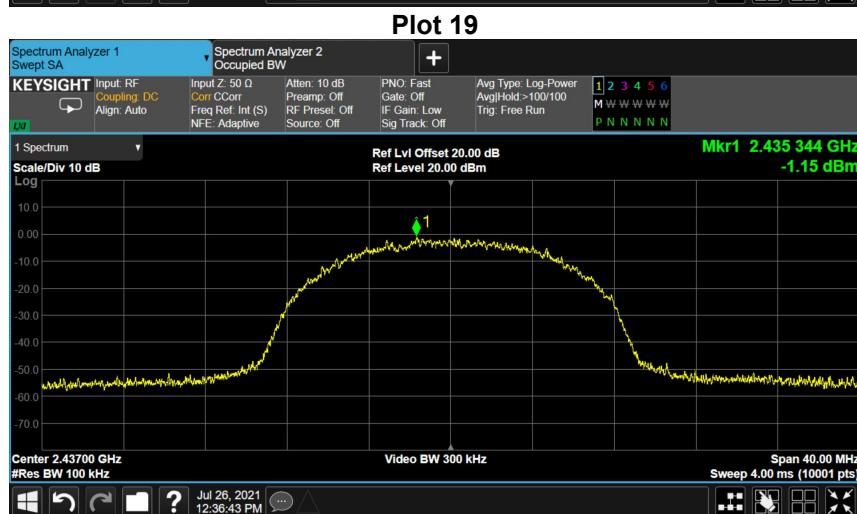
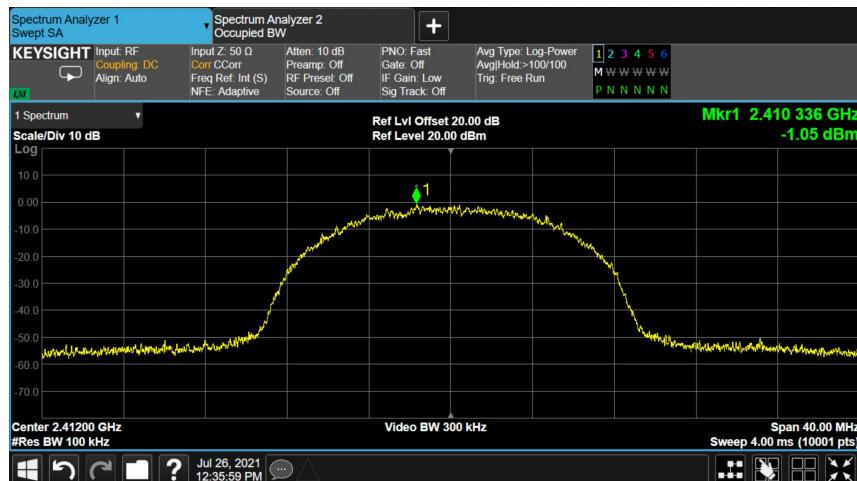
The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission

Results:

WLAN standard	Frequency, MHz	Limit, dBm/ 3kHz	Measured result, dBm/ 3kHz	Verdict	Plot #
802.11b 11M – 20 MHz	2412	8	-1.05	Pass	19
	2437		-1.15	Pass	20
	2462		0.52	Pass	21
802.11g 54M – 20 MHz	2412		-3.43	Pass	22
	2437		-3.16	Pass	23
	2462		-2.41	Pass	24
802.11n MCS7 – 40 MHz	2422		-2.88	Pass	25
	2437		-2.39	Pass	26
	2452		-2.07	Pass	27

Test procedure

The measurements were performed in hopping transmission mode of operation for carrier (channel) frequency at bottom, middle and at the top of 2412MHz to 2462MHz frequency band and maximum transmitting data rate.

Test Report No.: 7112310971
Page 19 of 50 Pages
Title: Test on IoT Repeater - WiFi Transceiver
Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF
802.11b 11M


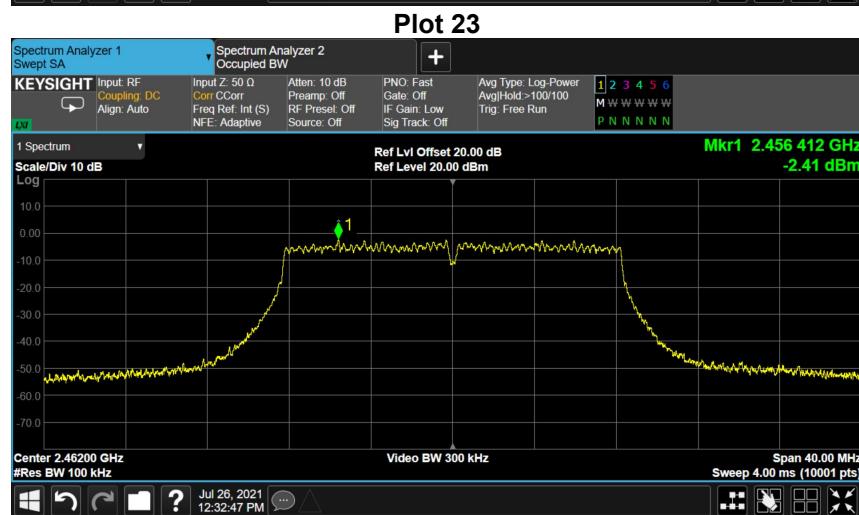
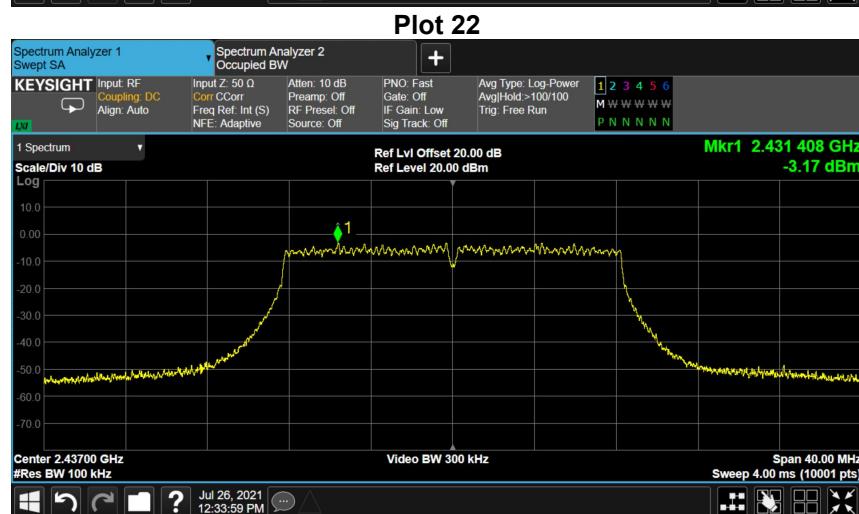
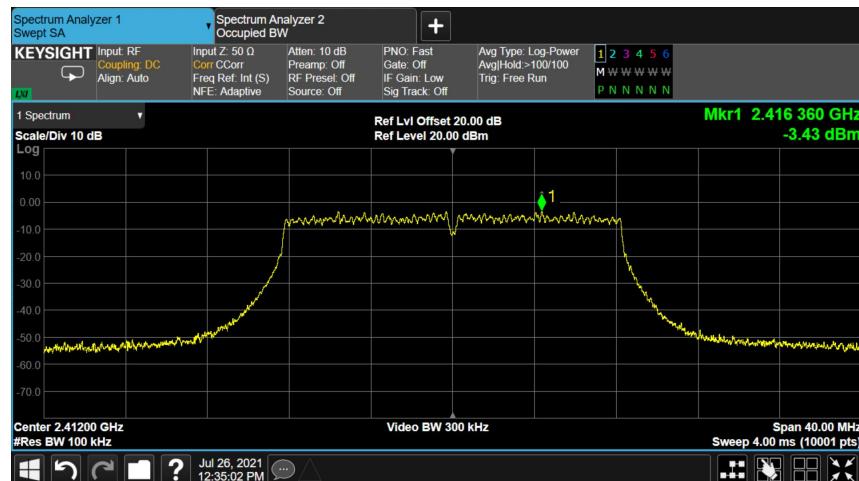


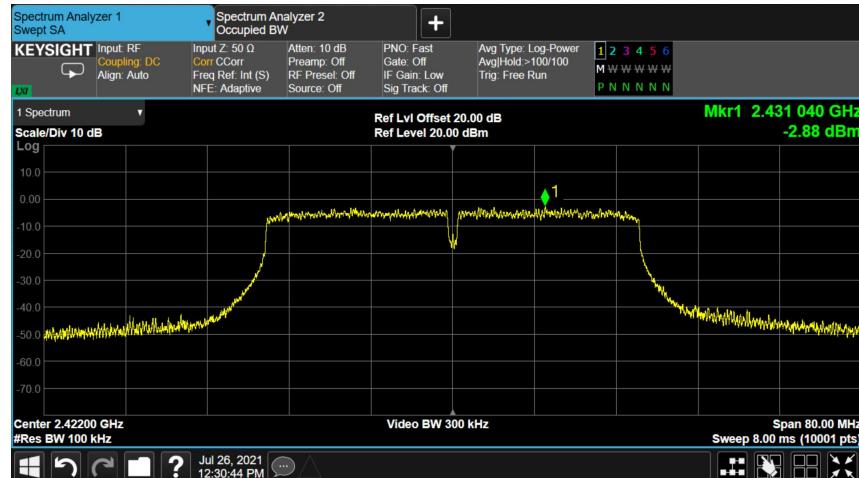
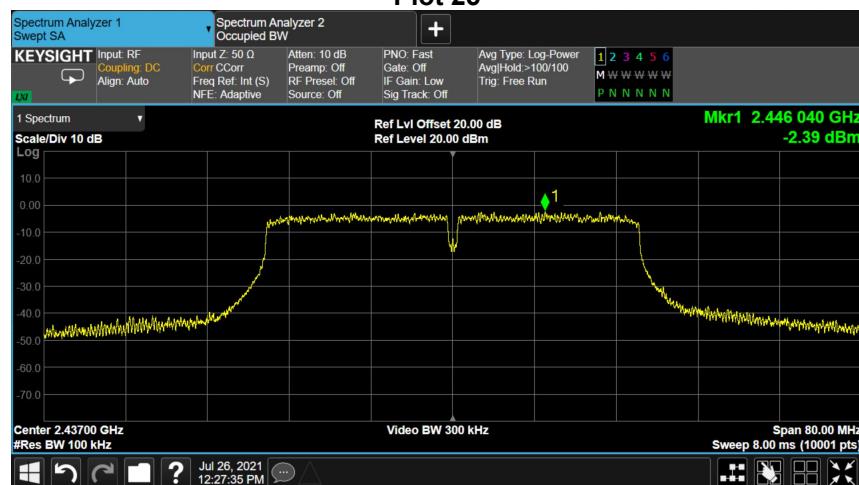
Test Report No.: 7112310971

Page 20 of 50 Pages

Title: Test on IoT Repeater - WiFi Transceiver

Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF

802.11g 54M**Plot 24**

Test Report No.: 7112310971
Page 21 of 50 Pages
Title: Test on IoT Repeater - WiFi Transceiver
Model: NBX-R1000-RF FCC ID: 2AYPY- NBX-R1000-RF
802.11n MCS7

Plot 25

Plot 26

Plot 27