TEST REPORT

Product Name:	ROCK Pi 4
Trademark:	N/A
Model Number:	ROCK Pi 4 MODEL B ROCK Pi 4 MODEL A, ROCK Pi 4 MODEL A+, ROCK Pi 4 MODEL B+
Prepared For:	ROCKPI TRADING LIMITED
Address:	Room 11, 27 / f, Ga wah international centre, 191 Java road, north point, Hong Kong, China
Manufacturer:	ROCKPI TRADING LIMITED
Address:	Room 11, 27 / f, Ga wah international centre, 191 Java road, north point, Hong Kong, China
Prepared By:	Shenzhen BCTC Testing Co., Ltd.
Address:	BCTC Building & 1-2F, East of B Building, Pengzhou Industrial, Fuyuan 1st Road, Qiaotou Community, Fuyong Street, Bao'an District, Shenzhen, China
Sample Received Date:	Feb. 25, 2019
Sample tested Date:	Feb. 25, 2019 to Mar. 11, 2019
Issue Date:	Mar. 11, 2019
Report No.:	BCTC-FY190200673-6E
Test Standards	ETSI EN 301 893 V2.1.1 (2017-05)
Test Results	PASS
Remark:	This is WIFI-5GHz band radio test report.

Compiled by:	Reviewed by:	Approved by:
Bin Mei	Eric Yang	Zero Zhou/Manager

The test report is effective only with both signature and specialized stamp.This result(s) shown in this report refer only to the sample(s) tested. Without written approval of Shenzhen BCTC Testing Co., Ltd, this report can't be reproduced except in full.The tested sample(s) and the sample information are provided by the client.

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(Note: N/A means not applicable)

1. VERSION

Report No.	Issue Date	Description	Approved
BCTC-FY190200673-6E	Mar. 11, 2019	Original	Valid

2. TEST SUMMARY

The Product has been tested according to the following specifications:

No.	Test Parameter	Clause No	Results
1	Nominal Centre frequencies	4.2.1	PASS
2	Nominal Channel Bandwidth and Occupied Channel Bandwidth	4.2.2	PASS
3	RF output power, Transmit Power Control (TPC) and Power Density	4.2.3	PASS
4	Transmitter unwanted emissions	4.2.4	PASS
5	Receiver spurious emissions	4.2.5	PASS
6	Dynamic Frequency Selection (DFS)	4.2.6	N/A
7	Adaptivity (Channel Access Mechanism)	4.2.7	PASS
8	Receiver Blocking	4.2.8	PASS
9	User Access Restrictions	4.2.9	PASS
Note: N/A is an abbreviation for Not Applicable and means this test item is not applicable for this device according to the technology characteristic of device.			

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N/A is an abbreviation for Not Applicable and means this test item is not applicable for this device according to the technology characteristic of device.

3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the Product as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

No.	Item	Uncertainty
1	Occupancy bandwidth	U=±54.3Hz
2	Adjacent channel power	U=±1.3dB
3	Conducted Adjacent channel power	U=±1.38dB
4	Conducted output power Above 1G	U=±1.0dB
5	Conducted output power below 1G	U=±0.9dB
6	Power Spectral Density , Conduction	U=±1.0dB
7	Conduction spurious emissions	U=±2.8dB
8	Out of band emission	U=±54Hz
9	3m camber Radiated spurious emission(30MHz-1GHz)	U=±4.3dB
10	3m chamber Radiated spurious emission(1GHz-18GHz)	U=±4.5dB
11	humidity uncertainty	U=±5.3%
12	Temperature uncertainty	U=±0.59℃
13	Supply volyages	U=±3%
14	Time	U=±5%

4. PRODUCT INFORMATION AND TEST SETUP

4.1 Product Information

Model(s):	ROCK Pi 4 MODEL B ROCK Pi 4 MODEL A, ROCK Pi 4 MODEL A+, ROCK Pi 4 MODEL B+
Model Description:	The product is different for model number and outlook color
Wi-Fi Specification:	IEEE 802.11a/b/g/n/ac
Bluetooth Version:	Bluetooth v4.0 with BLE
Hardware Version:	N/A
Software Version:	N/A

Operation Frequency:	WiFi: IEEE 802.11b/g/n HT20: 2412-2472MHz IEEE 802.11a/n/ac HT20/HT40/HT80 5180-5240MHz Bluetooth: 2402-2480MHz
Max. RF output power:	WiFi (2.4G) : 9.04dBm WiFi (5.2G) : 8.53dBm Bluetooth: 6.97dBm
Type of Modulation:	WiFi: DSSS, OFDM Bluetooth: GFSK, Pi/4 DQPSK, 8DPSK
Antenna installation:	WiFi/Bluetooth: External antenna with RP-SMA connector
Antenna Gain:	WiFi : 1dBi Bluetooth: 1dBi
Ratings:	DC5V From Adaptor

4.2 Test Setup Configuration

See test photographs attached in EUT TEST SETUP PHOTOGRAPHS for the actual connections between Product and support equipment.

4.3 Support Equipment

No.	Device Type	Brand	Model	Series No.	Data Cable	Power Cord
1.	---	---	---	---	---	---

Notes:

1. All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.
2. Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.

4.4 Channel List

CH	Frequency (MHz)	CH	Frequency (MHz)	CH	Frequency (MHz)	CH	Frequency (MHz)
36	5180	38	5190	40	5200	42	5210
44	5220	46	5230	48			

4.5 Test Mode

All test mode(s) and condition(s) mentioned were considered and evaluated respectively by performing full tests, the worst data were recorded and reported.

Test mode	Low channel	Middle channel	High channel
Transmitting(802.11a HT20)	5180MHz	5200	5240
Transmitting(802.11n HT20)	5180MHz	5200	5240
Transmitting(802.11n HT40)	5190Mhz	/	5230
Transmitting(802.11ac HT20)	5180MHz	5200	5240
Transmitting(802.11ac HT40)	5190Mhz	/	5230
Transmitting(802.11ac HT80)	/	5210	/
Receiving(802.11a HT20)	5180MHz	5200	5240
Receiving(802.11n HT20)	5180MHz	5200	5240
Receiving(802.11ac HT80)	/	5210	/

4.6 Test Environment

1. Normal Test Conditions:

Humidity(%):	57
Atmospheric Pressure(hPa):	1010
Temperature(℃):	23
Test Voltage(DC):	230V

2.Extreme Test Conditions:

For tests at extreme temperatures, measurements shall be made over the extremes of the operating temperature range as declared by the manufacturer.

For tests at extreme voltages, measurements shall be made over the extremes of the power source voltage range as declared by the manufacturer.

Test Conditions	**LT**	**HT**
Temperature (℃)	-10	40

5. TEST FACILITY AND TEST INSTRUMENT USED

5.1 Test Facility

All measurement facilities used to collect the measurement data are located at BCTC Building & 1-2F, East of B Building, Pengzhou Industrial, Fuyuan 1st Road, Qiaotou Community, Fuyong Street, Bao'an District, Shenzhen, China. The site and apparatus are constructed in conformance with the requirements of ANSI C63.4 and CISPR 16-1-1 other equivalent standards.

5.2 Test Instrument Used

Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Cal.Date	Cal.Due date
1	966 chamber	ChengYu	966 Room	966	Mar. 03, 2018	Mar. 02, 2023
2	Spectrum Analyzer	Aglient	E4407B	MY45109572	Jun. 20, 2018	Jun. 19, 2019
3	Amplifier	Schwarzbeck	BBV9718	9718-309	Jun. 20, 2018	Jun.19, 2019
4	Amplifier	Schwarzbeck	BBV9744	9744-0037	Jun. 20, 2018	Jun.19, 2019
5	TRILOG Broadband Antenna	schwarzbeck	VULB 9163	VULB9163-942	Jun. 23, 2018	Jun.22, 2019
6	Horn Antenna	SCHWARZBECK	BBHA9120D	1201	Jun. 23, 2018	Jun.22, 2021
7	band rejection filter	ZBSF	ZBSF-C2441.5	1706003605	Aug. 15, 2018	Aug. 14, 2019
8	Signal Generator	Keysight	N5181A	MY50143748	Jun. 20, 2018	Jun.19, 2019
9	Communication test set	R&S	CMU200	119435	Aug. 06, 2018	Aug. 05, 2019
10	Communication test set	Agilent	N4010A	MY49081107	Aug. 06, 2018	Aug. 05, 2019
11	Spectrum Analyzer	Keysight	N9020A	MY49100060	Jul. 11, 2018	Jul. 10, 2019
12	Signal Generator	Keysight	N5182B	MY56200519	Jun. 20, 2018	Jun.19, 2019
13	Power Sensor	Keysight	E9 300A	/	Apr. 15, 2018	Apr. 14, 2019
14	Horn antenna	SCHWARZBECK	BBHA9170	822	Jul. 25, 2018	Jul. 24, 2019
15	Preamplifier	MITEQ	TTA1840-35-HG	2034381	Jul. 25, 2018	Jul. 24, 2019
16	Software	Frad	EZ-EMC	FA-03A2 RE	\	\
17	Software	Keysight	Keysight. ETSLTest system	1.02.05	\	\

6. INFORMATION AS REQUIRED

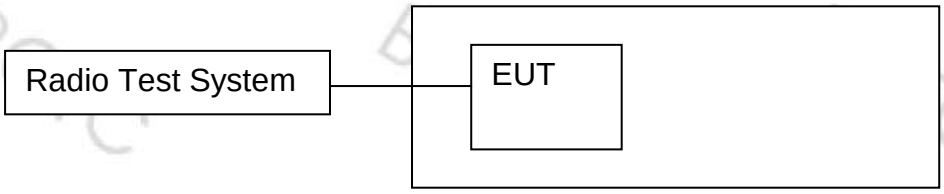
ETSI EN 301 893 V2.1.1 Annex G

a) The Nominal Channel Bandwidth(s):
Refer to section 4.4 channel list.
b) For Load Based Equipment that supports multi-channel operation:
N/A
c) The different transmit operating modes (see clause 5.3.3.2) (tick all that apply):
☒Operating mode 1: Single Antenna Equipment
☒a) Equipment with only 1 antenna
d) In case of Smart Antenna Systems or multiple antenna systems:
• The number of Receive chains: ..... • The number of Transmit chains: ..... • Equal power distribution among the transmit chains: ☐Yes ☐No • In case of beamforming, the maximum (additional) beamforming gain: ..... dB NOTE: Beamforming gain does not include the basic gain of a single antenna (assembly).
e) TPC feature available:
☐Yes ☒No
f) For equipment with TPC range:
The lowest and highest power level (or lowest and highest e.i.r.p. level in case of integrated antenna equipment),intended antenna assemblies and corresponding operating frequency range for the TPC range (or for each of the TPC ranges if more than one is implemented).
g) For equipment without a TPC range:
Power Setting 1: Max.
h) The DFS related operating mode(s) of the equipment:
N/A
i) User access restrictions (please check box below to confirm):
N/A
j) For equipment with Off-Channel CAC functionality:
N/A
k) The equipment can operate in ad-hoc mode:
N/A
l) Operating Frequency Range(s):
Refer to section 4.1.
m) The extreme operating temperature and supply voltage range that apply to the equipment:
Refer to section 4.6
n) The test sequence/test software used (see also ETSI EN 301 893 (V2.1.1), clause 5.3.1.2):
Provide by manufacturer.
o) Type of Equipment:
☒Stand-alone ☐Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)

☐Plug-in radio device (Equipment intended for a variety of host systems) ☐Other .....
p) Adaptivity (Channel Access Mechanism):
☒Frame Based Equipment ☐Load Based Equipment
q) With regards to Adaptivity for Frame Based Equipment
☒The Frame Based Equipment operates as an Initiating Device ☐The Frame Based Equipment operates as an Responding Device ☐The Frame Based Equipment can operate as an Initiating Device and as a Responding Device
r) With regards to Adaptivity for Load Based Equipment
N/A
s) The equipment supports a geo-location capability as defined in clause 4.2.10 of ETSI EN 301 893 V2.1.1:
☐Yes ☒No
t) The minimum performance criteria (see ETSI EN 301 893 V2.1.1, clause 4.2.8.3) that corresponds to the intended use of the equipment:
The minimum performance criterion is a PER of less than or equal to 10 %.
u) The theoretical maximum radio performance of the equipment (e.g. maximum throughput) (see ETSI EN 301 893 V2.1.1, clause 5.4.9.3.1):
N/A

7. NOMINAL CENTRE FREQUENCIES

7.1 Block Diagram Of Test Setup



7.2 Limit

The Nominal Centre Frequencies (fc) for a Nominal Channel Bandwidth of 20 MHz are defined by equation (1). See also figure 3.
fc = 5 160 + (g × 20) MHz, where 0 ⩽ g ⩽ 9 or 16 ⩽ g ⩽ 27 and where g shall be an integer.
A maximum offset of the Nominal Centre Frequency of ±200 kHz is permitted. Where the manufacturer decides to make use of this frequency offset, the manufacturer shall declare the actual centre frequencies used by the equipment.
See clause 5.4.1, item a).
The actual centre frequency for any given channel shall be maintained within the range fc ± 20 ppm.
Equipment may have simultaneous transmissions on more than one Operating Channel with a Nominal Channel Bandwidth of 20 MHz.

7.3 Test procedure

This method is an alternative to the above method in case the UUT cannot be operated in an un-modulated mode.

The UUT shall be connected to spectrum analyser.

Max Hold shall be selected and the centre frequency adjusted to that of the UUT.

The peak value of the power envelope shall be measured and noted. The span shall be reduced and the marker moved in a positive frequency increment until the upper, (relative to the centre frequency), -10 dBc point is reached. This value shall be noted as f1.

The marker shall then be moved in a negative frequency increment until the lower, (relative to the centre frequency), -10 dBc point is reached. This value shall be noted as f2.

The centre frequency is calculated as (f1 + f2) / 2.

7.4 Test Result

Modulation	Test conditions		Frequency Measured (MHz)		
			Low channel	Middle channel	High channel
			5180.0000	5200.0000	5240.0000
802.11a HT20	Normal		5180.1101	5200.1460	5240.1702
	Extreme	LTLV	5180.1100	5200.1457	5240.1701
		LTHV	5180.1093	5200.1451	5240.1694
		HTLV	5180.1096	5200.1453	5240.1698
		HTHV	5180.1098	5200.1456	5240.1700
Max.Error(ppm)			16.30	16.45	16.24
Limit (ppm)			±20	±20	±20

Modulation	Test conditions		Frequency Measured (MHz)		
			Low channel	Middle channel	High channel
			5180.0000	5200.0000	5240.0000
802.11n HT20	Normal		5180.1619	5200.1321	5240.0801
	Extreme	LTLV	5180.1616	5200.1318	5240.0800
		LTHV	5180.1611	5200.1308	5240.0791
		HTLV	5180.1613	5200.1311	5240.0793
		HTHV	5180.1614	5200.1315	5240.0796
Max.Error(ppm)			15.23	15.43	15.77
Limit (ppm)			±20	±20	±20

Modulation	Test conditions		Frequency Measured (MHz)		
			Low channel	Middle channel	High channel
			5190.0000	/	5230.0000
802.11n HT40	Normal		5190.1760	/	5230.1318
	Extreme	LTLV	5190.1752	/	5230.1311
		LTHV	5190.1753	/	5230.1315
		HTLV	5190.1753	/	5230.1315
		HTHV	5190.1756	/	5230.1316
Max.Error(ppm)			16.57	/	16.77
Limit (ppm)			±20	/	±20

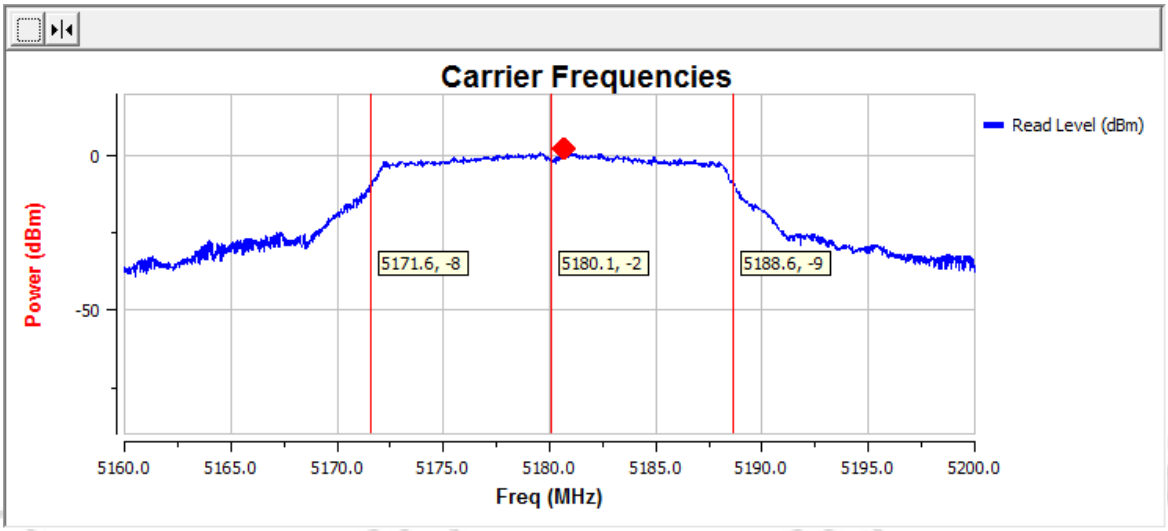
Modulation	Test conditions		Frequency Measured (MHz)		
			Low channel	Middle channel	High channel
			5180.0000	5200.0000	5240.0000
802.11ac HT20	Normal		5180.1118	5200.2480	5240.1860
	Extreme	LTLV	5180.1116	5200.2471	5240.1850
		LTHV	5180.1111	5200.2474	5240.1852
		HTLV	5180.1113	5200.2477	5240.1854
		HTHV	5180.1115	5200.2476	5240.1857
Max.Error(ppm)			18.54	18.56	17.28
Limit (ppm)			±20	±20	±20

Modulation	Test conditions		Frequency Measured (MHz)		
			Low channel	Middle channel	High channel
			5190.0000	/	5230.0000
802.11ac HT40	Normal		5190.2041	/	5230.2200
	Extreme	LTLV	5190.2038	/	5230.2196
		LTHV	5190.2035	/	5230.2193
		HTLV	5190.2033	/	5230.2191
		HTHV	5190.2030	/	5230.2194
Max.Error(ppm)			18.21	/	18.56
Limit (ppm)			±20	/	±20

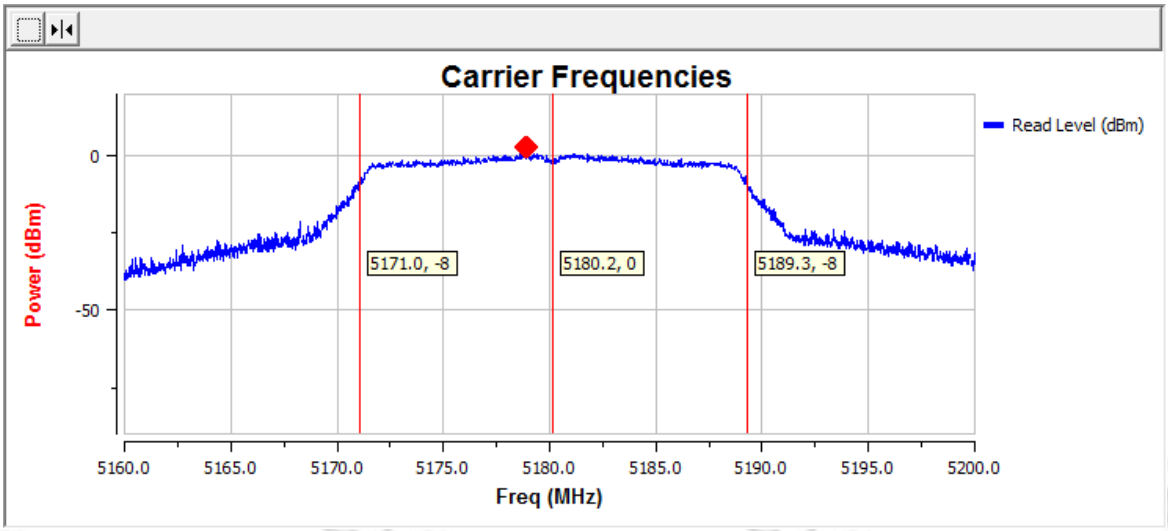
Modulation	Test conditions		Frequency Measured (MHz)		
			Low channel	Middle channel	High channel
			/	5210.0000	/
802.11ac HT80	Normal		/	5210.0640	/
	Extreme	/	/	5210.0635	/
		/	/	5210.0632	/
		/	/	5210.0637	/
		/	/	5210.0633	/
Max.Error(ppm)			/	12.28	/
Limit (ppm)			/	±20	/

Test Plots

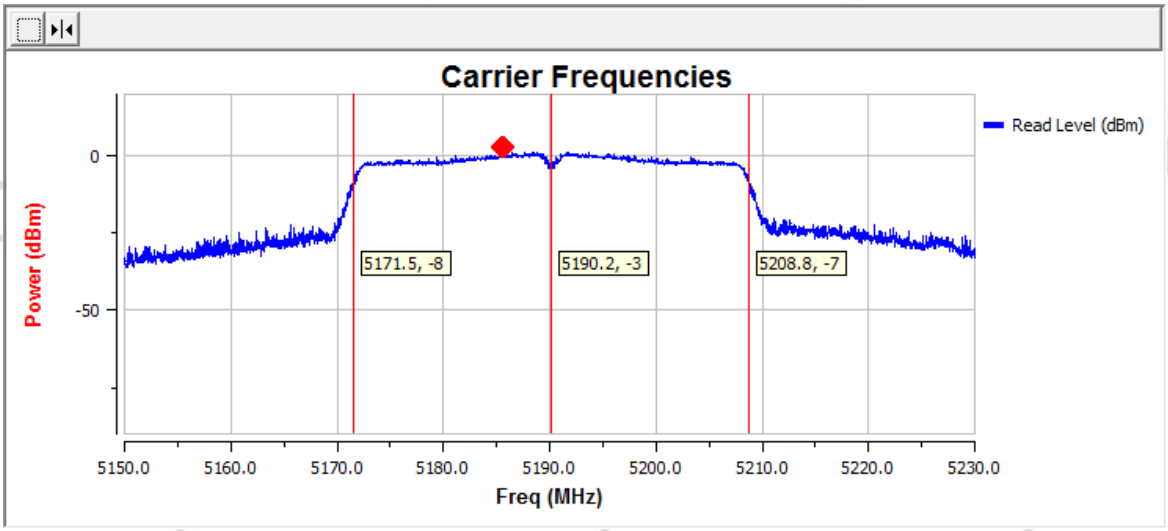
802.11a HT20 Low Channel



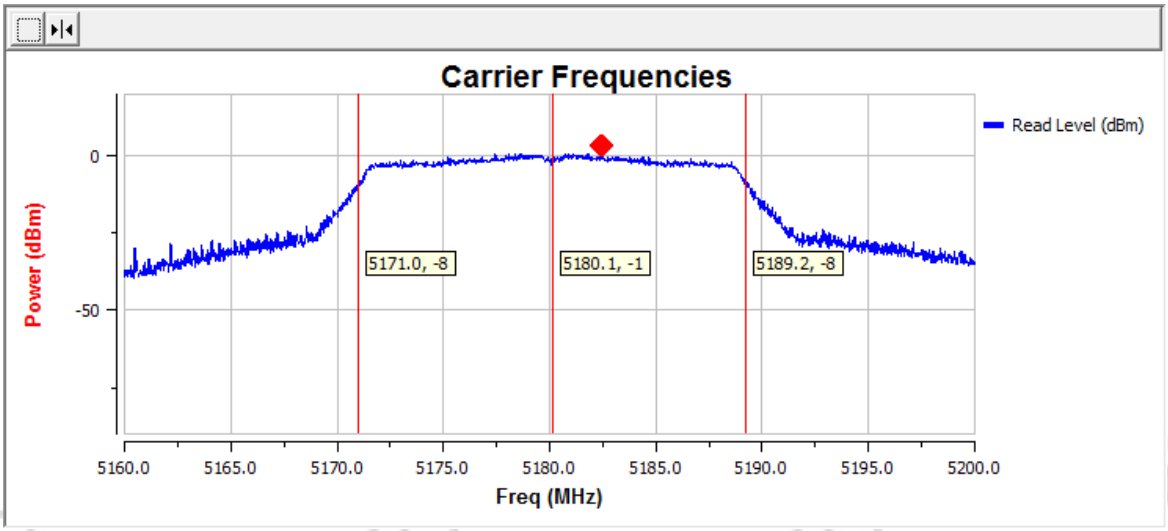
802.11n HT20 Low Channel



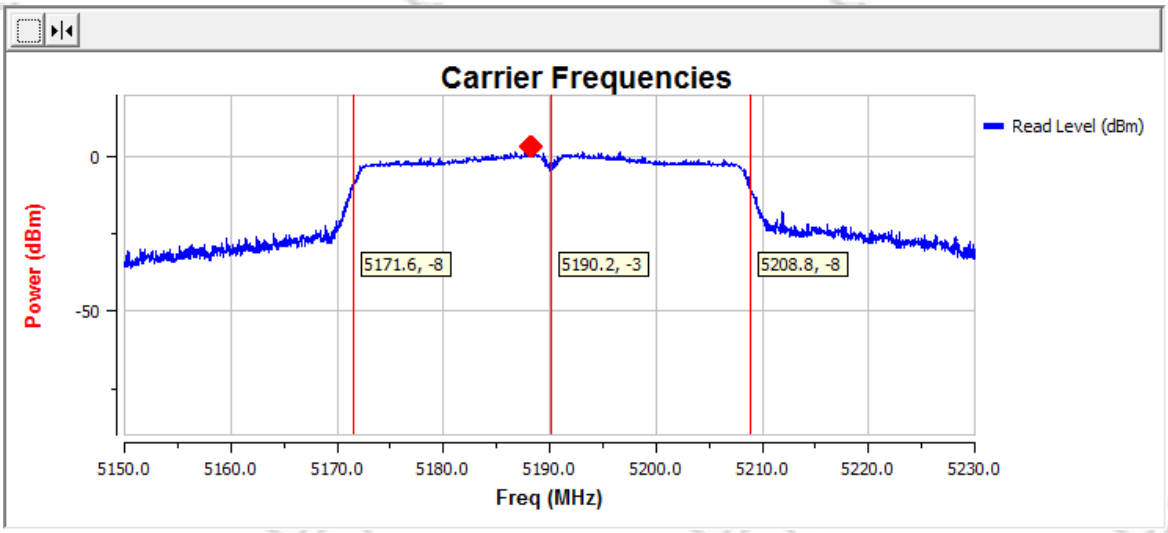
802.11n HT40 Low Channel



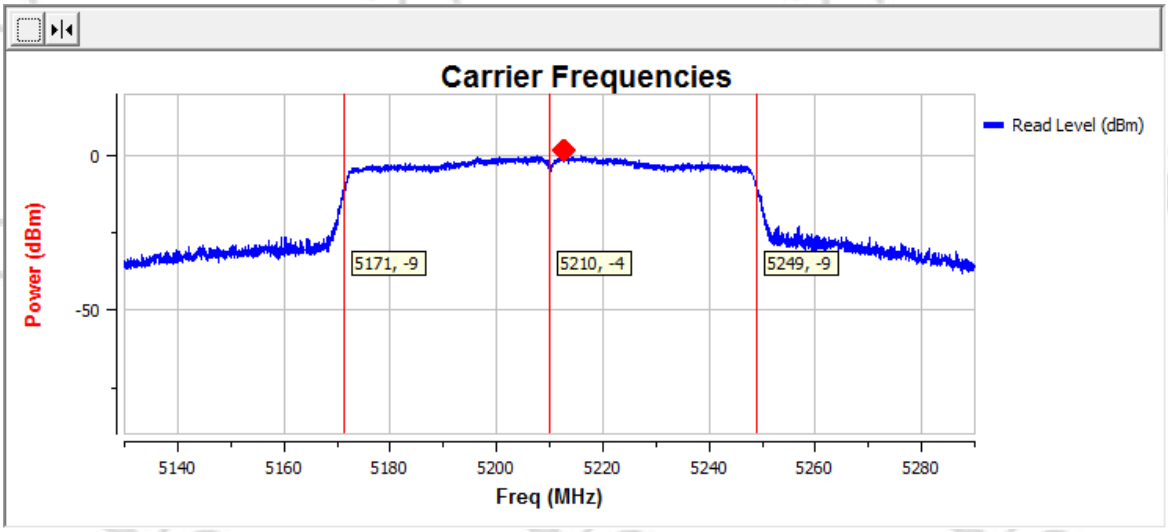
802.11ac HT20 Low Channel



802.11ac HT40 Low Channel

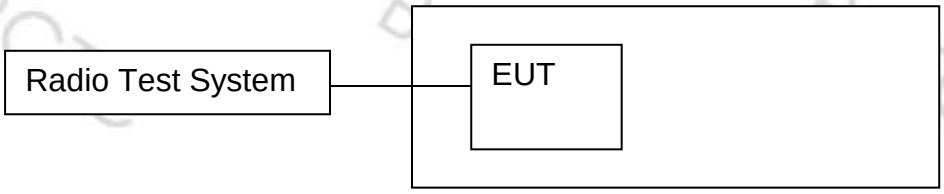


802.11ac HT80 Low Channel



8. NOMINAL CHANNEL BANDWIDTH AND OCCUPIED CHANNEL BANDWIDTH

8.1 Block Diagram Of Test Setup



8.2 Limit

The Nominal Channel Bandwidth for a single Operating Channel shall be 20 MHz. Alternatively, equipment may implement a lower Nominal Channel Bandwidth with a minimum of 5 MHz, providing they still comply with the Nominal Centre Frequencies defined in clause 4.2.1 (20 MHz raster).
The Occupied Channel Bandwidth shall be between 80 % and 100 % of the Nominal Channel Bandwidth. In case of smart antenna systems (devices with multiple transmit chains) each of the transmit chains shall meet this requirement.
The Occupied Channel Bandwidth might change with time/payload.

8.3 Test procedure

Step 1:

- Connect the UUT to the spectrum analyser and use the following settings:

- Centre Frequency: The centre frequency of the channel under test
- Resolution Bandwidth: 100 kHz
- Video Bandwidth: 300 kHz
- Frequency Span: 2 × Nominal Bandwidth (e.g. 40 MHz for a 20 MHz channel)
- Sweep time: > 1 s; for larger Nominal Bandwidths, the sweep time may be increased until a value where the sweep time has no impact on the RMS value of the signal
- Detector Mode: RMS
- Trace Mode: Max Hold

Step 2:

- Wait for the trace to stabilize.

Step 3:

- Make sure that the power envelope is sufficiently above the noise floor of the analyser to avoid the noise signals left and right from the power envelope being taken into account by this measurement.
- Use the 99 % bandwidth function of the spectrum analyser to measure the Occupied Channel Bandwidth of the UUT. This value shall be recorded.

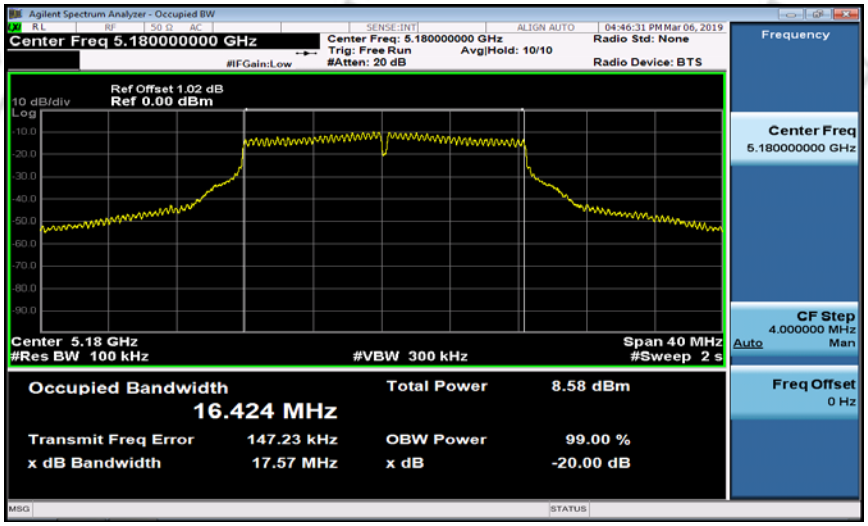
The measurement described in step 1 to step 3 above shall be repeated in case of simultaneous transmissions in non-adjacent channels.

8.4 Test Result

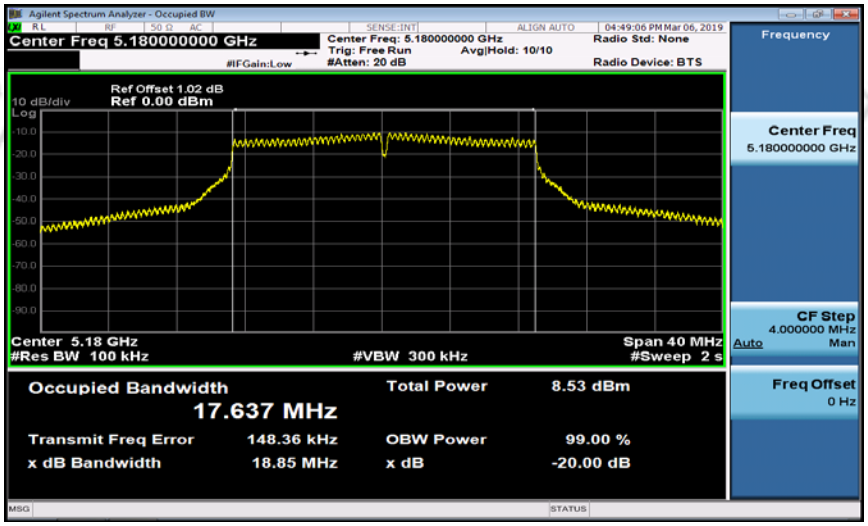
Modulation	Test conditions	OCCUPIED CHANNEL BANDWIDTH (MHz)		
		Low Channel	Middle Channel	High Channel
802.11a HT20	Normal	16.424	16.435	16.425
802.11n HT20	Normal	17.637	17.641	17.634
802.11n HT40	Normal	36.182	/	36.215
802.11ac HT20	Normal	17.642	17.640	17.636
802.11ac HT40	Normal	36.187	/	36.207
802.11ac HT80	Normal	/	75.532	/

Test Plots

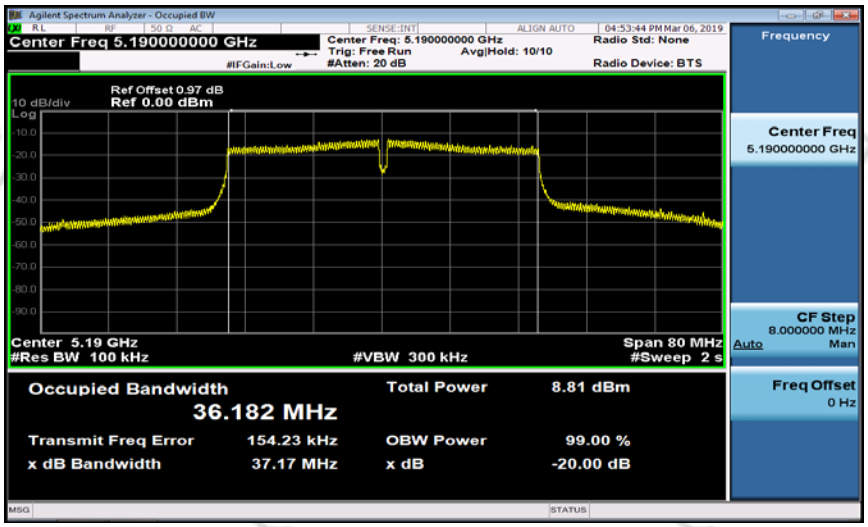
802.11a HT20 Low Channel



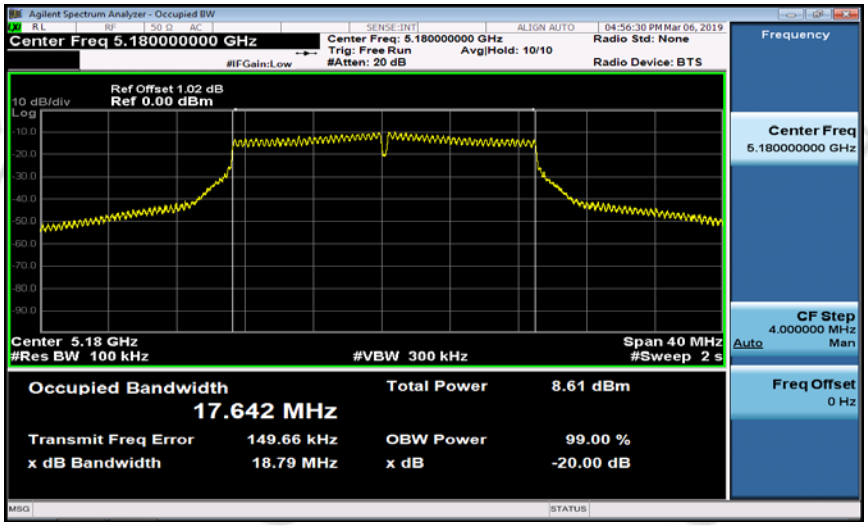
802.11n HT20 Low Channel



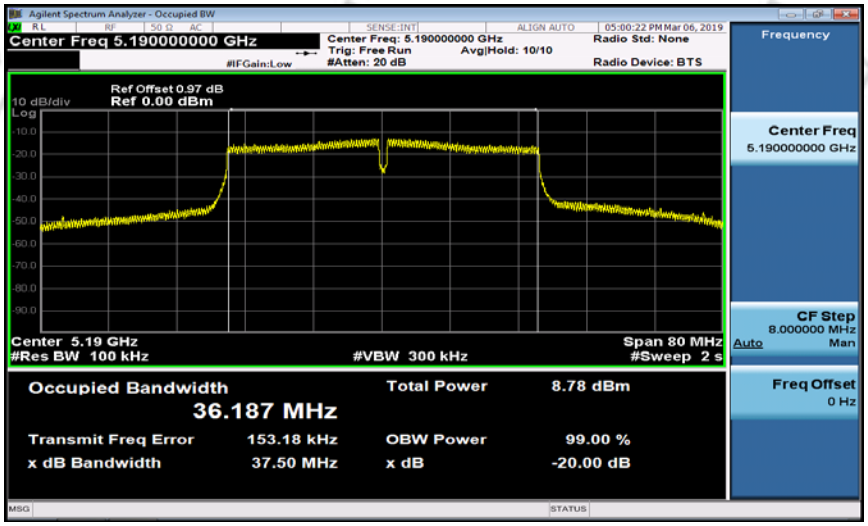
802.11n HT40 Low Channel



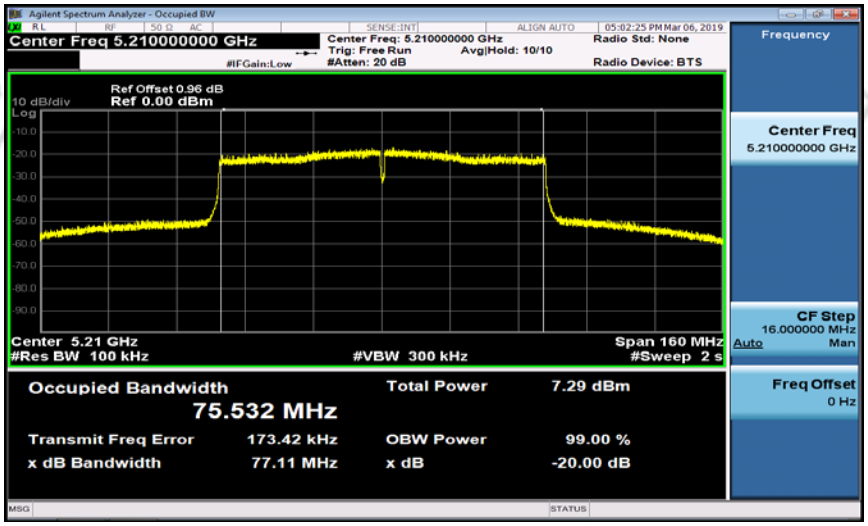
802.11ac HT20 Low Channel



802.11ac HT40 Low Channel

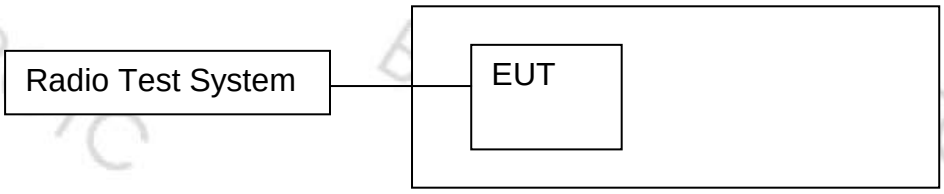


802.11ac HT80 Middle Channel



9. RF OUTPUT POWER, TRANSMIT POWER CONTROL (TPC)

9.1 Block Diagram Of Test Setup



9.2 Limit

Frequency range (MHz)	Mean e.i.r.p. limit for P_H (dBm)		Mean e.i.r.p. density limit (dBm/MHz)	
	with TPC	without TPC	with TPC	without TPC
5 150 to 5 350	23	20/23 (see note 1)	10	7/10 (see note 2)
5 470 to 5 725	30 (see note 3)	27 (see note 3)	17 (see note 3)	14 (see note 3)

NOTE 1: The applicable limit is 20 dBm, except for transmissions whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz, in which case the applicable limit is 23 dBm.
NOTE 2: The applicable limit is 7 dBm/MHz, except for transmissions whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz, in which case the applicable limit is 10 dBm/MHz.
NOTE 3: Slave devices without a *Radar Interference Detection* function shall comply with the limits for the frequency range 5 250 MHz to 5 350 MHz.

9.3 Test procedure

This option is for equipment that operates only in one sub-band or that is capable for operation in two sub-bands simultaneously but, for the purpose of the testing, the equipment can be configured to:

- operate in a continuous transmit mode or with a constant duty cycle (x), and
- operate only in one sub-band.

Step 1:

For equipment configured into a continuous transmit mode (x = 1), proceed immediately with step 2.

- The output power of the transmitter shall be coupled to a matched diode detector or equivalent thereof. The output of the diode detector shall be connected to the vertical channel of an oscilloscope.
- The combination of the diode detector and the oscilloscope shall be capable of faithfully reproducing the duty cycle of the transmitter output signal.
- The observed duty cycle of the transmitter (Tx on / (Tx on + Tx off)) shall be noted as x ($0 < x \leqslant 1$), and recorded in the test report.

Step 2:

- The RF output power shall be determined using a wideband RF power meter with a thermocouple detector or an equivalent thereof and with an integration period that exceeds the repetition period of the transmitter by a factor 5 or more. The observed value shall be noted as A (in dBm).
- In case of conducted measurements on smart antenna systems operating in a mode with multiple transmit chains active simultaneously, the output power of each transmit chain shall be measured separately to calculate the total power (value A in dBm) for the UUT.

Step 3:

- The RF output power at the highest power level PH (e.i.r.p.) shall be calculated from the above measured power output A (in dBm), the observed duty cycle x, the stated antenna gain G in dBi and if applicable the beamforming gain Y in dB, according to the formula below. This value shall be recorded in the test report.

If more than one antenna assembly is intended for this power setting or TPC range, the gain of the antenna assembly with the highest gain shall be used.

$PH = A + G + Y + 10 \times \log (1 / x)$ (dBm). (5)

- This value PH shall be compared to the applicable limit contained in table 2 of clause 4.2.3.2.2.

9.4 Test Result

Remark: PH = A + G + Y + 10 × log (1 / x) (dBm)

Antenna Gain G=1 dBi, beamforming gain Y= 0 dB, duty cycle X=100%

Modulation	Test conditions		e.i.r.p. (dBm)		
			Low channel	Middle channel	High channel
802.11a HT20	Normal		8.31	8.22	7.99
	Extreme	LTLV	8.26	8.17	7.96
		LTHV	8.13	8.07	7.84
		HTLV	8.18	8.10	7.88
		HTHV	8.23	8.12	7.92
Limit			≤100mW (20dBm)		

Modulation	Test conditions		e.i.r.p. (dBm)		
			Low channel	Middle channel	High channel
802.11n HT20	Normal		8.53	8.27	8.08
	Extreme	LTLV	8.50	8.24	8.02
		LTHV	8.47	8.21	7.98
		HTLV	8.40	8.11	7.86
		HTHV	8.43	8.15	7.92
Limit			≤100mW (20dBm)		

Modulation	Test conditions		e.i.r.p. (dBm)		
			Low channel	Middle channel	High channel
802.11n HT40	Normal		6.89	/	7.37
	Extreme	LTLV	6.83	/	7.35
		LTHV	6.75	/	7.27
		HTLV	6.72	/	7.23
		HTHV	6.80	/	7.31
Limit			≤100mW (20dBm)		

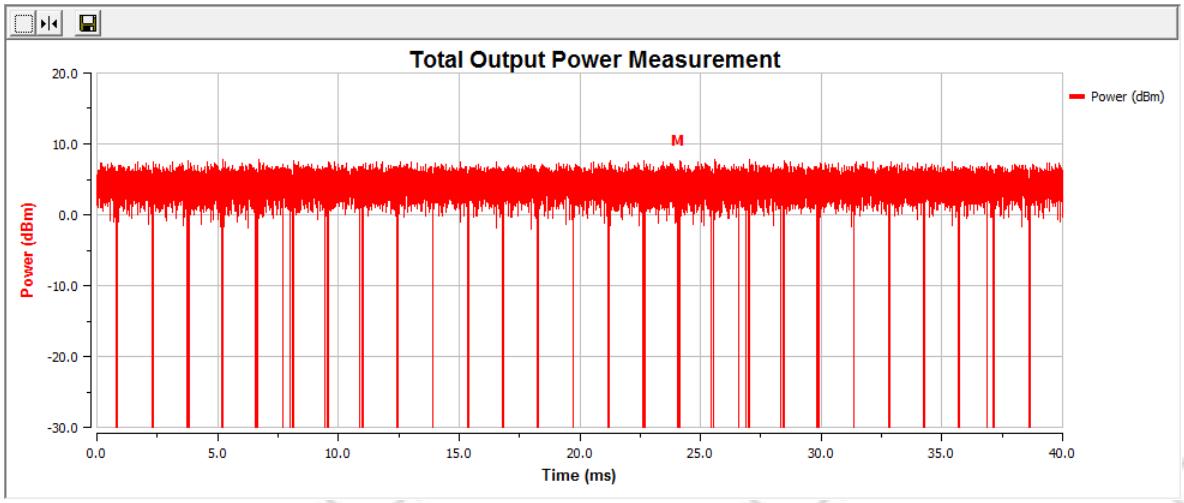
Modulation	Test conditions		e.i.r.p. (dBm)		
			Low channel	Middle channel	High channel
802.11ac HT20	Normal		8.03	7.90	7.90
	Extreme	LTLV	7.87	7.77	7.79
		LTHV	7.97	7.81	7.88
		HTLV	7.91	7.84	7.86
		HTHV	7.96	7.86	7.83
Limit			≤100mW (20dBm)		

Modulation	Test conditions		e.i.r.p. (dBm)		
			Low channel	Middle channel	High channel
802.11ac HT40	Normal		6.06	/	6.06
	Extreme	LTLV	6.02	/	6.03
		LTHV	5.88	/	5.86
		HTLV	5.91	/	5.90
		HTHV	5.96	/	5.93
Limit			≤100mW (20dBm)		

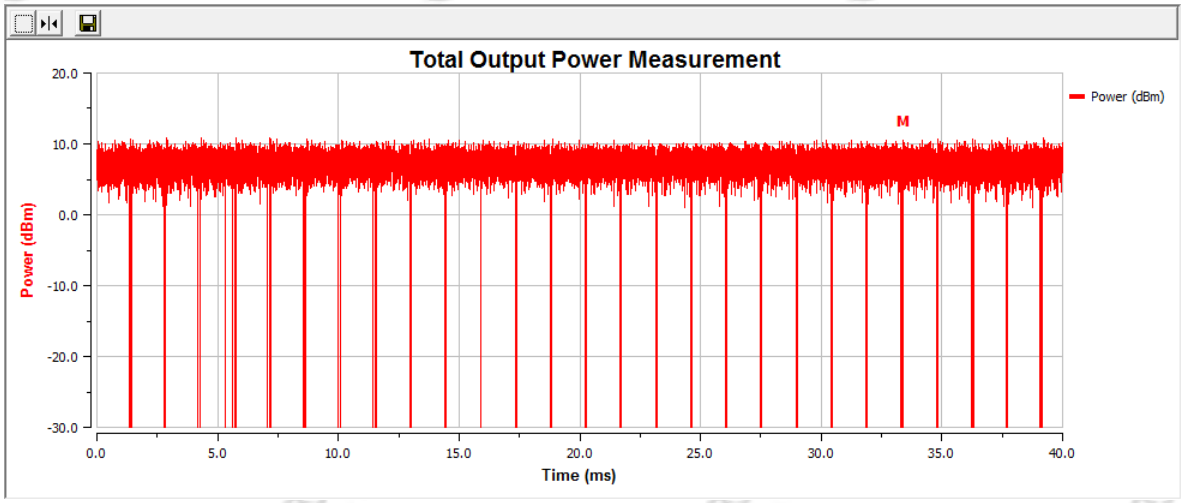
Modulation	Test conditions		e.i.r.p. (dBm)		
			Low channel	Middle channel	High channel
802.11ac HT80	Normal		/	5.03	/
	Extreme	LTLV	/	5.01	/
		LTHV	/	4.96	/
		HTLV	/	4.98	/
		HTHV	/	4.91	/
Limit			≤100mW (20dBm)		

Test Plots

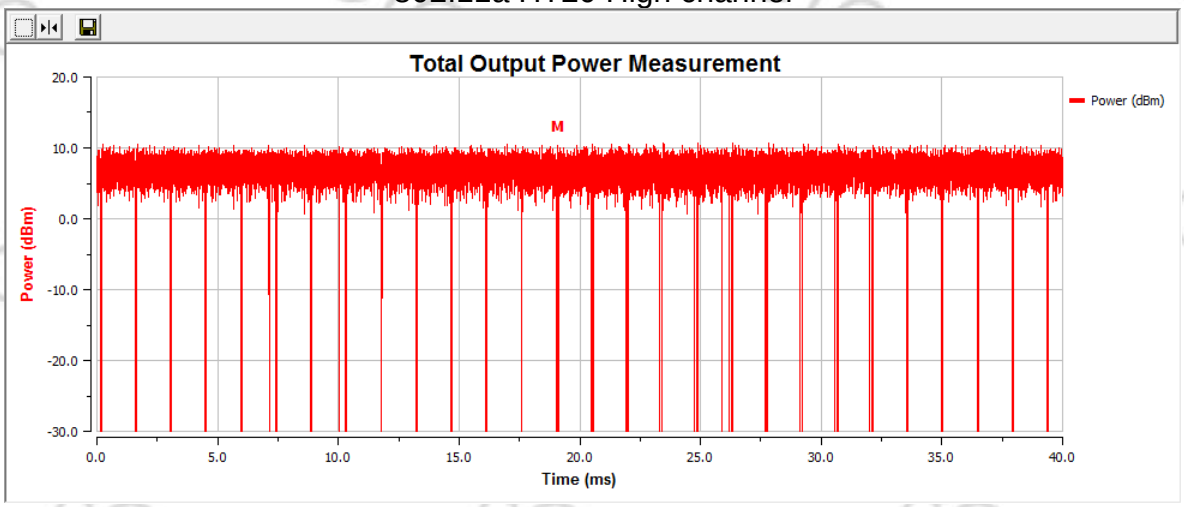
802.11a HT20 Low channel



802.11a HT20 Mid channel

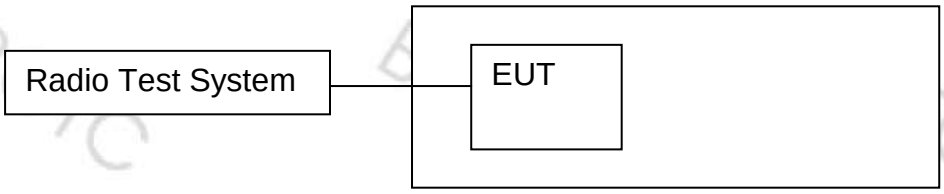


802.11a HT20 High channel



10. POWER DENSITY

10.1 Block Diagram Of Test Setup



10.2 Limit

Frequency range (MHz)	Mean e.i.r.p. limit for P_H (dBm)		Mean e.i.r.p. density limit (dBm/MHz)	
	with TPC	without TPC	with TPC	without TPC
5 150 to 5 350	23	20/23 (see note 1)	10	7/10 (see note 2)
5 470 to 5 725	30 (see note 3)	27 (see note 3)	17 (see note 3)	14 (see note 3)

NOTE 1: The applicable limit is 20 dBm, except for transmissions whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz, in which case the applicable limit is 23 dBm.
NOTE 2: The applicable limit is 7 dBm/MHz, except for transmissions whose nominal bandwidth falls completely within the band 5 150 MHz to 5 250 MHz, in which case the applicable limit is 10 dBm/MHz.
NOTE 3: Slave devices without a *Radar Interference Detection* function shall comply with the limits for the frequency range 5 250 MHz to 5 350 MHz.

10.3 Test procedure

This option is for equipment that can be configured to operate in a continuous transmit mode or with a constant duty cycle (x).

Step 1:

• Connect the UUT to the spectrum analyser and use the following settings:

- Centre Frequency: The centre frequency of the channel under test
- RBW: 1 MHz
- VBW: 3 MHz
- Frequency Span: 2 × Nominal Bandwidth (e.g. 40 MHz for a 20 MHz channel)
- Detector Mode: Peak
- Trace Mode: Max Hold

Step 2:

• When the trace is complete, find the peak value of the power envelope and record the frequency.

Step 3:

- Make the following changes to the settings of the spectrum analyser:

- Centre Frequency: Equal to the frequency recorded in step 2

- Frequency Span: 3 MHz

- RBW: 1 MHz

- VBW: 3 MHz

- Sweep Time: 1 minute

- Detector Mode: RMS

- Trace Mode: Max Hold

Step 4:

- When the trace is complete, the trace shall be captured using the "Hold" or "View" option on the spectrum analyser.

- Find the peak value of the trace and place the analyser marker on this peak. This level is recorded as the highest mean power (Power Density) D in a 1 MHz band.

- Alternatively, where a spectrum analyser is equipped with a function to measure spectral Power Density, this function may be used to display the Power Density D in dBm / MHz.

- In case of conducted measurements on smart antenna systems operating in a mode with multiple transmit chains active simultaneously, the Power Density of each transmit chain shall be measured separately to calculate the total Power Density (value D in dBm / MHz) for the UUT.

Step 5:

- The maximum spectral Power Density e.i.r.p. is calculated from the above measured Power Density D, the observed duty cycle x (see clause 5.4.4.2.1.1.2, step 1), the applicable antenna assembly gain G in dBi and if applicable the beamforming gain Y in dB, according to the formula below. This value shall be recorded in the test report. If more than one antenna assembly is intended for this power setting, the gain of the antenna assembly with the highest gain shall be used:

$PD = D + G + Y + 10 \times \log (1 / x)$ (dBm / MHz) (14)

10.4 Test Result

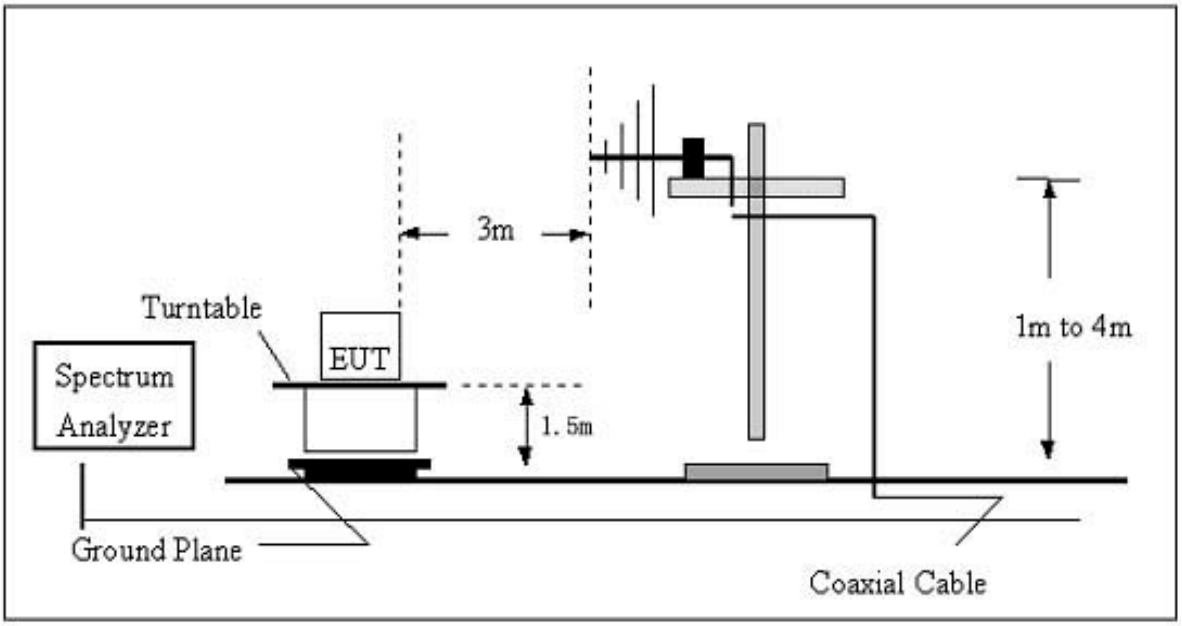
Remark: PH = A + G + Y + 10 × log (1 / x) (dBm)
Antenna Gain G=1 dBi, beamforming gain Y= 0 dB, duty cycle X=100%

Modulation	Test conditions	Power Density (dBm/MHz)		
		Low channel	Middle channel	High channel
802.11a HT20	Normal	-1.96	-2.15	-1.64
802.11n HT20	Normal	-2.65	-2.81	-2.17
802.11n HT40	Normal	-5.36	/	-5.17
802.11ac HT20	Normal	-2.77	-3.40	-2.34
802.11ac HT40	Normal	-5.73	/	-5.37
802.11ac HT80	Normal	/	-9.06	/
Limit		≤10dBm/MHz		

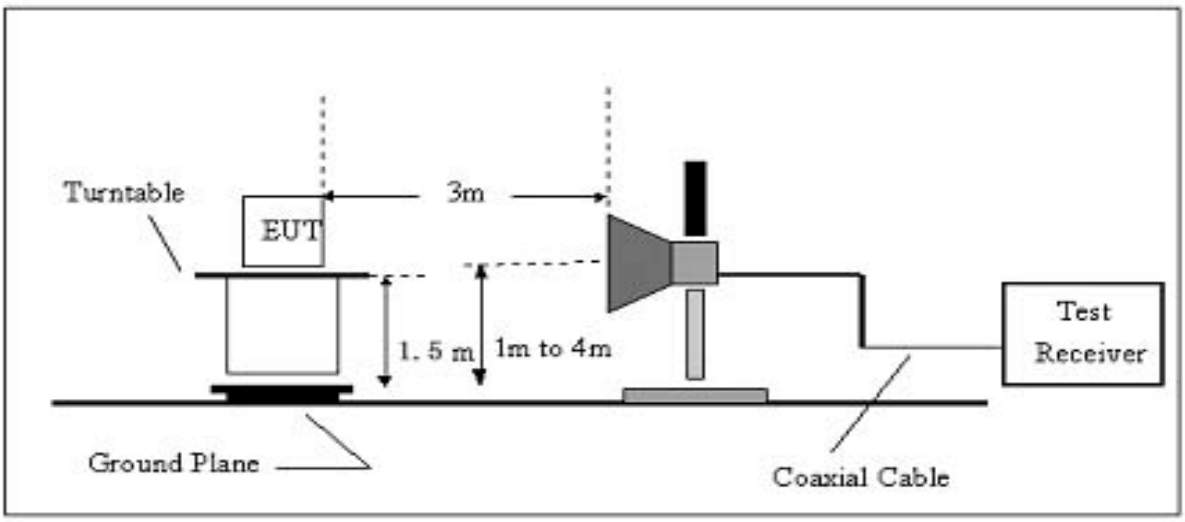
11. TRANSMITTER UNWANTED EMISSIONS IN THE SPURIOUS DOMAIN

11.1 Block Diagram Of Test Setup

(A) Radiated Emission Test Set-Up, Frequency Below 1000MHz



(B) Radiated Emission Test Set-Up Frequency Above 1 GHz



11.1 Limits

Frequency range	Maximum power, e.r.p. (≤ 1 GHz) e.i.r.p. (> 1 GHz)	Bandwidth
30 MHz to 47 MHz	-36 dBm	100 kHz/300KHz
47 MHz to 74 MHz	-54 dBm	100 kHz/300KHz
74 MHz to 87,5 MHz	-36 dBm	100 kHz/300KHz
87,5 MHz to 118 MHz	-54 dBm	100 kHz/300KHz
118 MHz to 174 MHz	-36 dBm	100 kHz/300KHz
174 MHz to 230 MHz	-54 dBm	100 kHz/300KHz
230 MHz to 470 MHz	-36 dBm	100 kHz/300KHz
470 MHz to 862 MHz	-54 dBm	100 kHz/300KHz
862 MHz to 1 GHz	-36 dBm	100 kHz/300KHz
1 GHz to 5.15 GHz	-30 dBm	1 MHz/3MHz
5.35 GHz to 5.47 GHz	-30 dBm	1 MHz/3MHz
5.725 GHz to 26 GHz	-30 dBm	1 MHz/3MHz

11.3 Test Procedure

30MHz ~ 1GHz:

a. The Product was placed on the nonconductive turntable 1.5m above the ground in a full anechoic chamber.

b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 120 kHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied between 1~4 m in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.

c. For each frequency whose maximum record was higher or close to limit, measure its QP value: vary the antenna's height and rotate the turntable from 0 to 360 degrees to find the height and degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to QP Detector and specified bandwidth with Maximum Hold Mode, and record the maximum value.

Above 1GHz:

a. The Product was placed on the non-conductive turntable 1.5 m above the ground in a full anechoic chamber..

b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 1MHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.

c. For each frequency whose maximum record was higher or close to limit, measure its AV value: rotate the turntable from 0 to 360 degrees to find the degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to AV value and specified bandwidth with Maximum Hold Mode, and record the maximum value.

11.4 Test Results

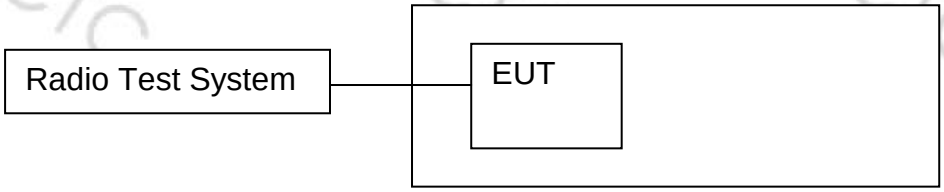
Test Mode: Transmitting 802.11a (worst case)

Frequency	Receiver Reading	Turn table Angle	RX Antenna		Correct	Absolute Level	Result	
			Height	Polar	Factor		Limit	Margin
(MHz)	(dBm)	Degree	(m)	(H/V)	(dBm)	(dBm)	(dBm)	(dB)
low channel								
502.71	-56.86	229	1.8	H	-8.87	-65.73	-54	-11.73
502.71	-55.37	261	1.0	V	-8.87	-64.24	-54	-10.24
10360.00	-47.96	302	1.8	H	10.36	-37.60	-30	-7.60
10360.00	-46.36	163	1.0	V	10.36	-36.00	-30	-6.00
15540.00	-50.13	92	1.4	H	15.62	-34.51	-30	-4.51
15540.00	-49.97	65	1.2	V	15.62	-34.35	-30	-4.35
High channel								
502.71	-57.65	71	1.3	H	-8.87	-66.52	-54	-12.52
502.71	-54.58	247	1.8	V	-8.87	-63.45	-54	-9.45
10480.00	-48.18	284	1.2	H	10.47	-37.71	-30	-7.71
10480.00	-46.05	97	1.1	V	10.47	-35.58	-30	-5.58
15720.00	-49.95	304	1.9	H	15.93	-34.02	-30	-4.02
15720.00	-49.59	253	1.8	V	15.93	-33.66	-30	-3.66

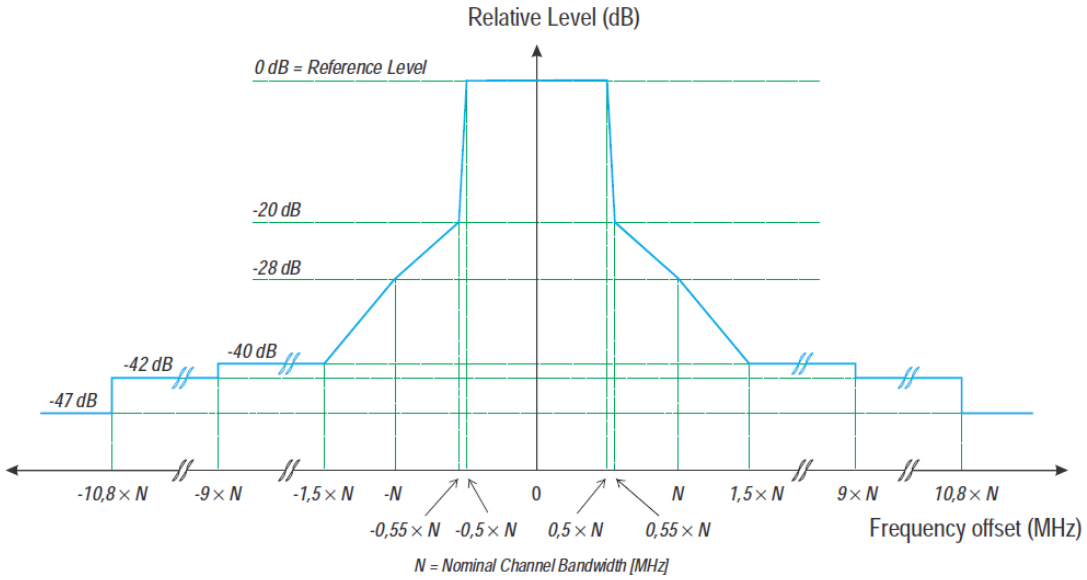
Remark:
Absolute Level = Receiver Reading + Factor

12. TRANSMITTER UNWANTED EMISSIONS IN THE OUT-OF-BAND DOMAIN

12.1 Block Diagram Of Test Setup



12.2 Limit



12.3 Test procedure

The UUT shall be configured for continuous transmit mode (duty cycle equal to 100 %). If this is not possible, then option 2 shall be used.

Step 1: Determination of the reference average power level.

- Spectrum analyser settings:

- Resolution bandwidth: 1 MHz

- Video bandwidth: 30 kHz

- Detector mode: Peak

- Trace mode: Video Average

- Sweep Time: Coupled

- Centre Frequency: Centre frequency of the channel being tested

- Span: 2 × Nominal Channel Bandwidth

- Use the marker to find the highest average power level of the power envelope of the UUT. This level shall be used as the reference level for the relative measurements.

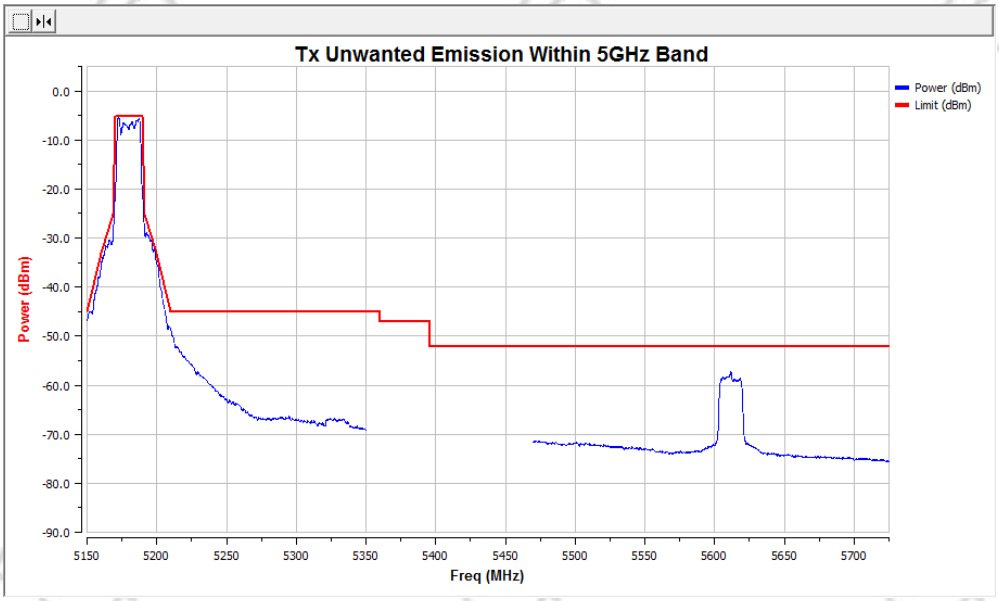
Step 2: Determination of the relative average power levels.

- Adjust the frequency range of the spectrum analyser to allow the measurement to be performed within the sub-bands 5 150 MHz to 5 350 MHz and 5 470 MHz to 5 725 MHz. No other parameter of the spectrum analyser should be changed.

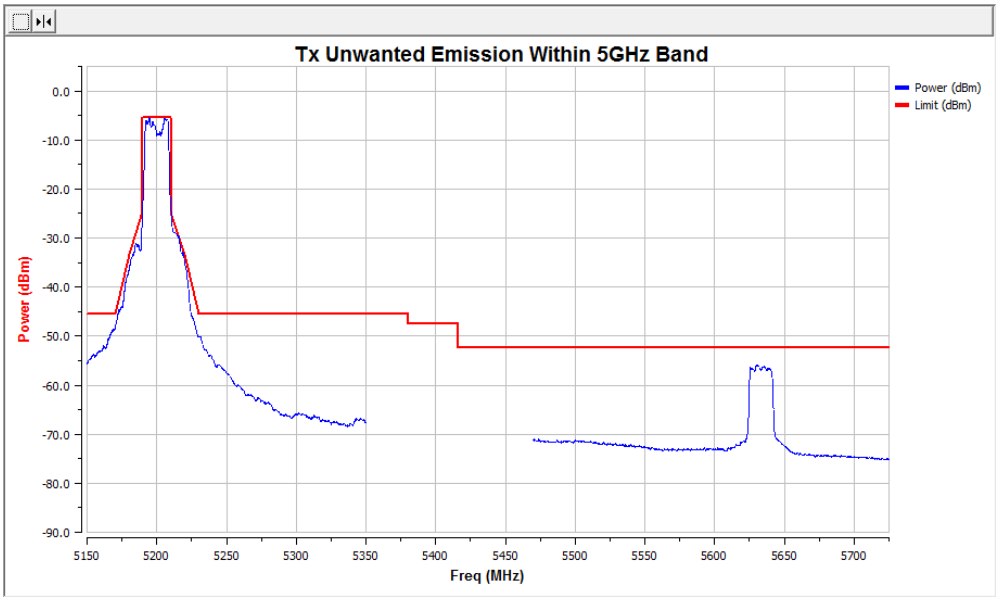
- Compare the relative power envelope of the UUT with the limits defined in clause 4.2.4.2.2.

12.4 Test Result

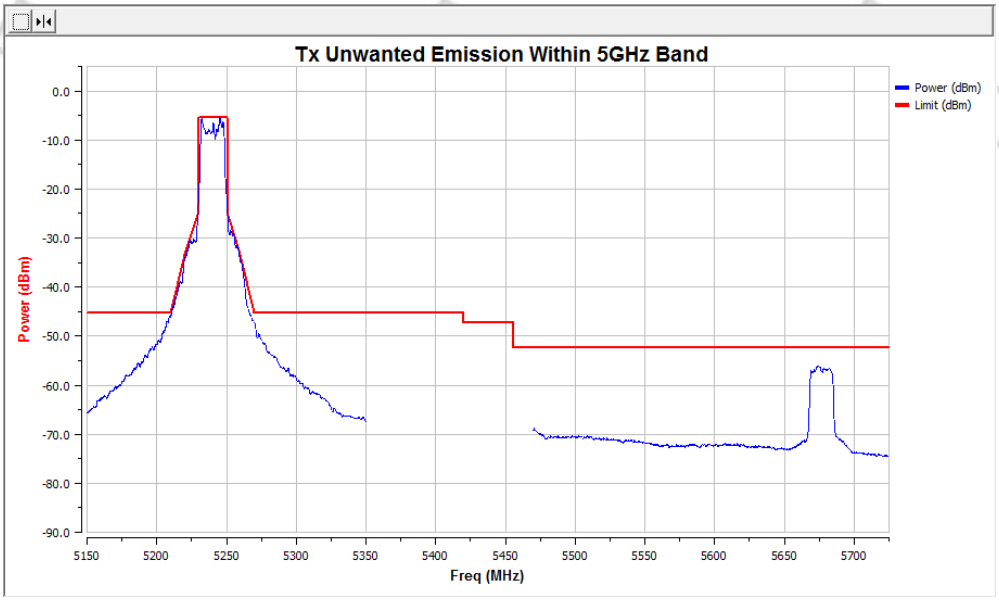
Modulation	Test Freq (MHz)	Status
802.11 a20 (Band 1)	5180	Pass



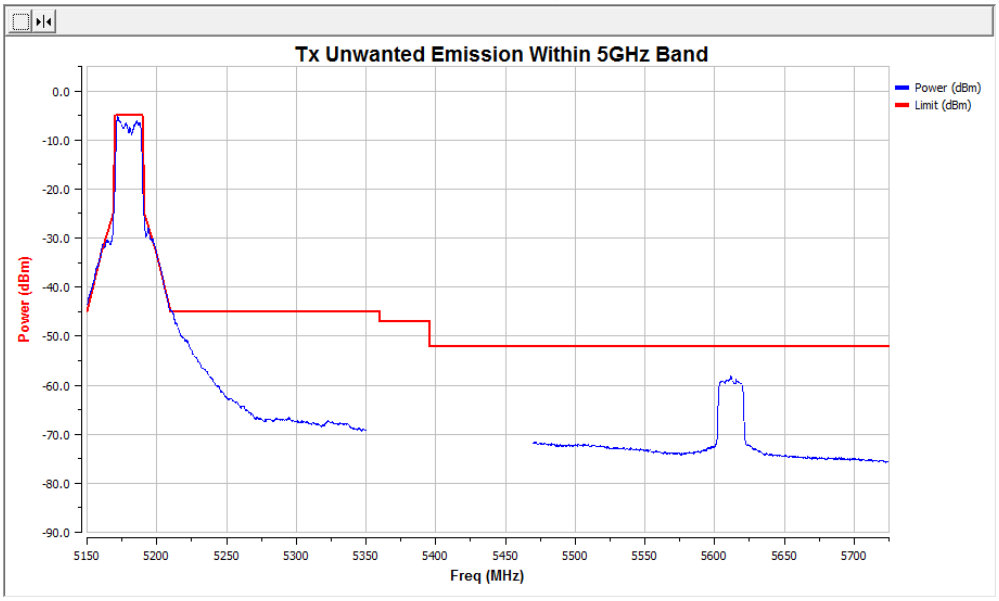
Modulation	Test Freq (MHz)	Status
802.11 a20 (Band 1)	5200	Pass



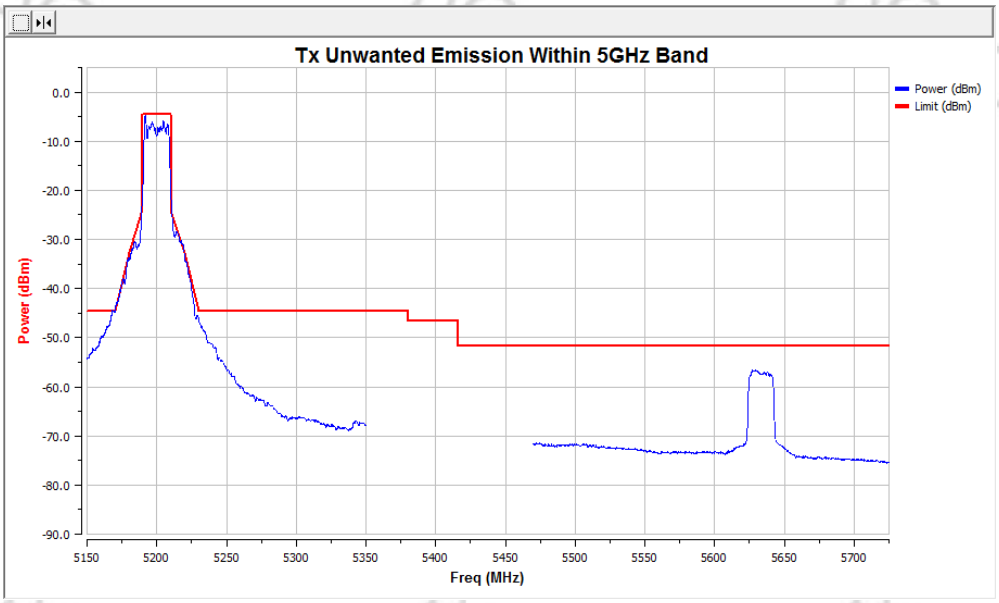
Modulation	Test Freq (MHz)	Status
802.11 a20 (Band 1)	5240	Pass



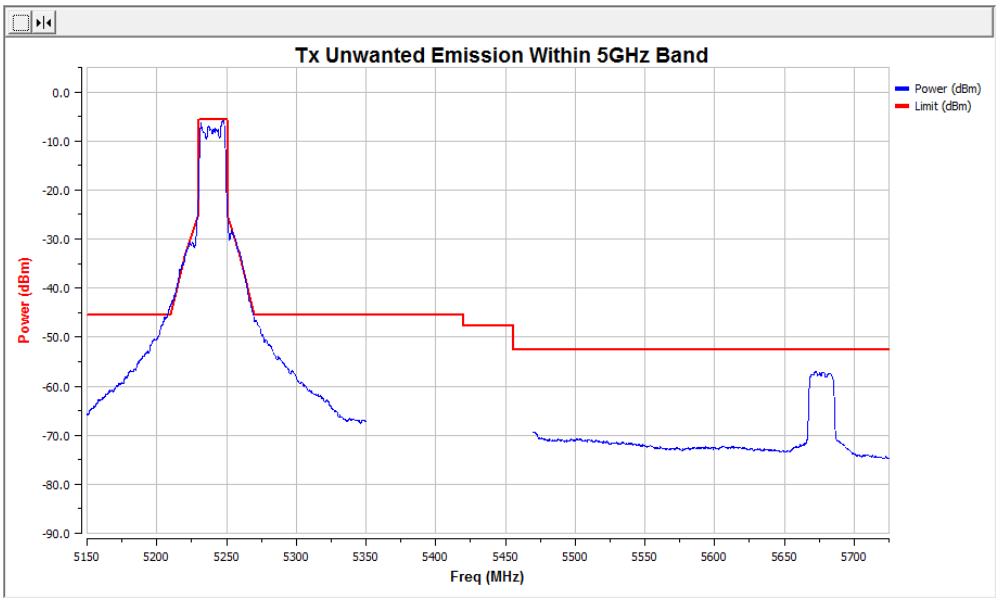
Modulation	Test Freq (MHz)	Status
802.11 n20 (Band 1)	5180	Pass



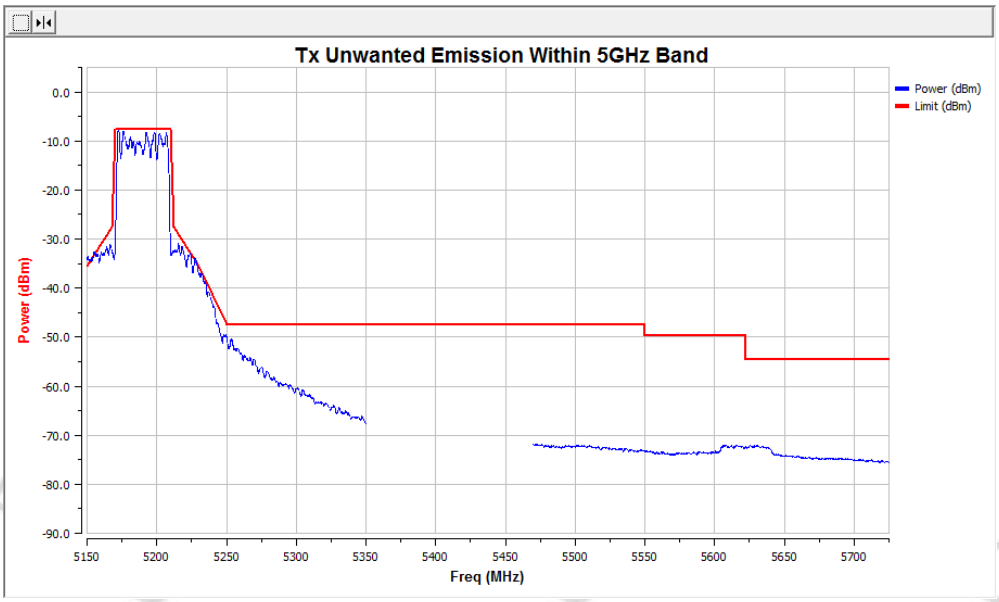
Modulation	Test Freq (MHz)	Status
802.11 n20 (Band 1)	5200	Pass



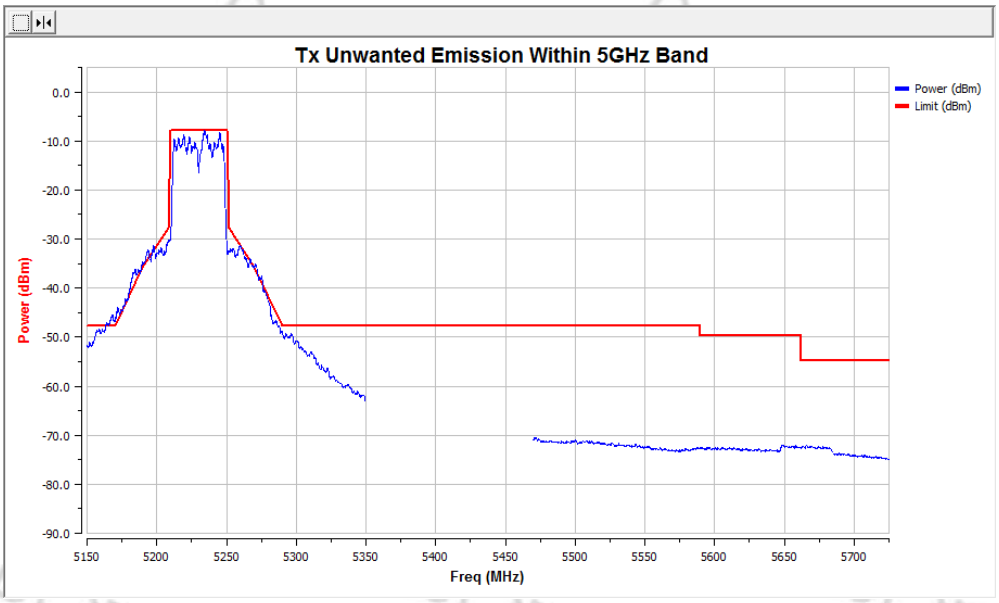
Modulation	Test Freq (MHz)	Status
802.11 n20 (Band 1)	5240	Pass



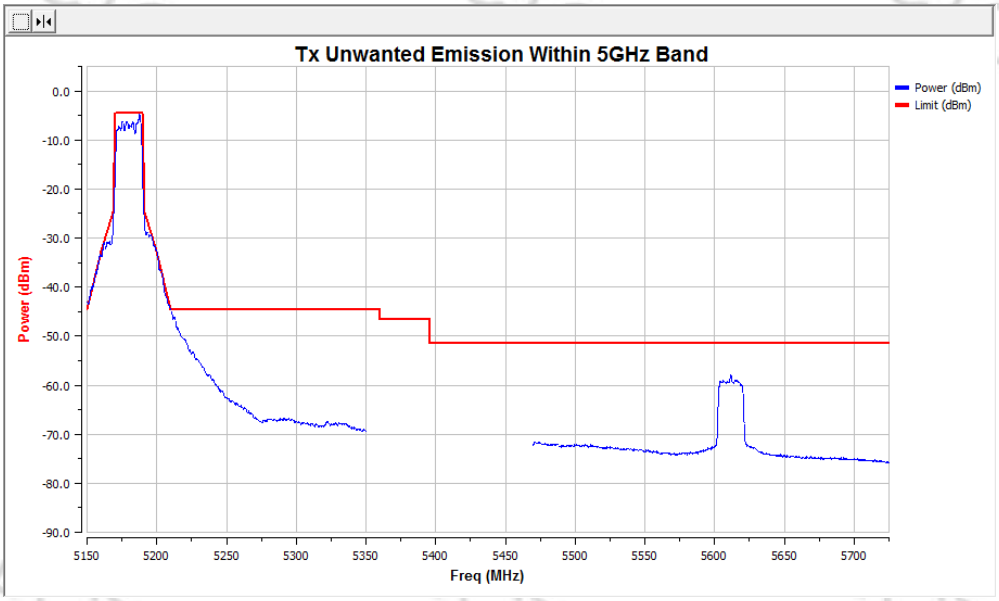
Modulation	Test Freq (MHz)	Status
802.11 n40 (Band 1)	5190	Pass



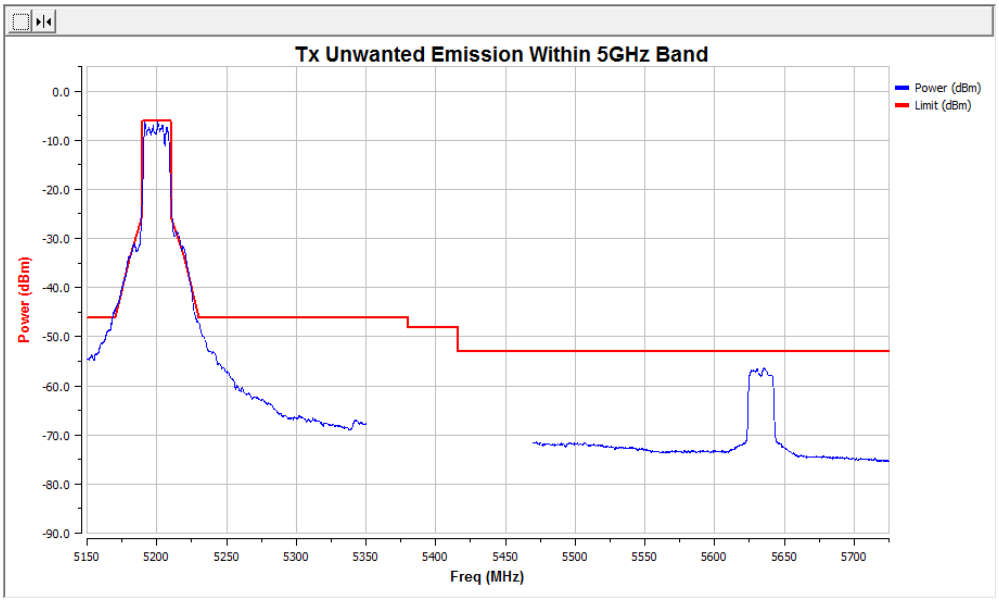
Modulation	Test Freq (MHz)	Status
802.11 n40 (Band 1)	5230	Pass



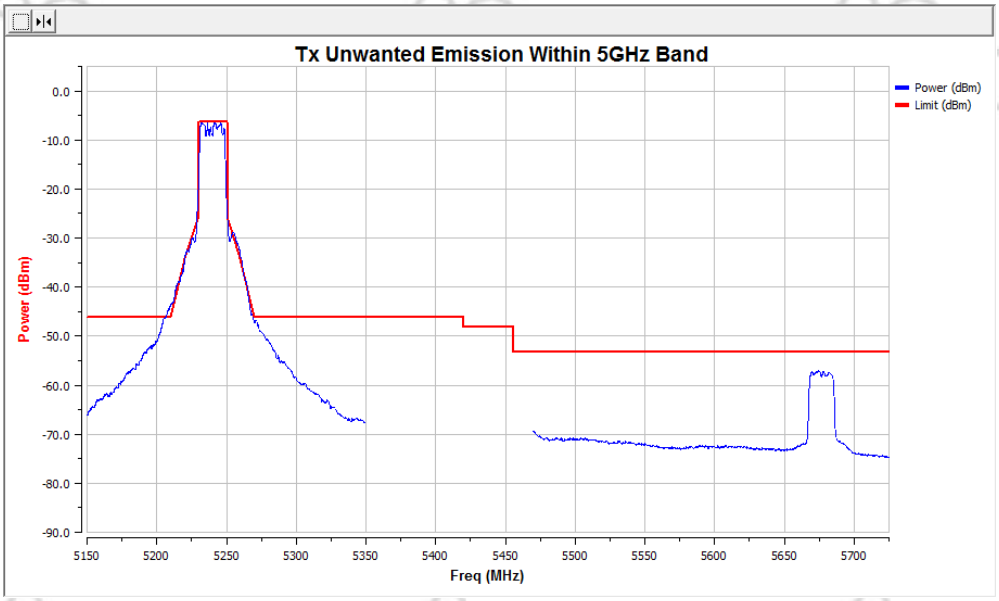
Modulation	Test Freq (MHz)	Status
802.11 ac20 (Band 1)	5180	Pass



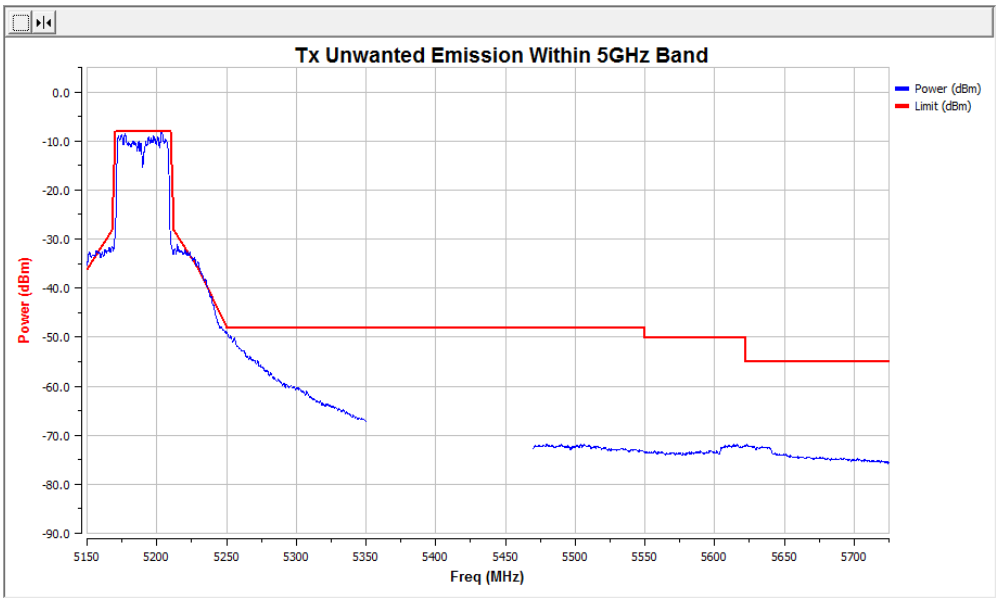
Modulation	Test Freq (MHz)	Status
802.11 ac20 (Band 1)	5200	Pass



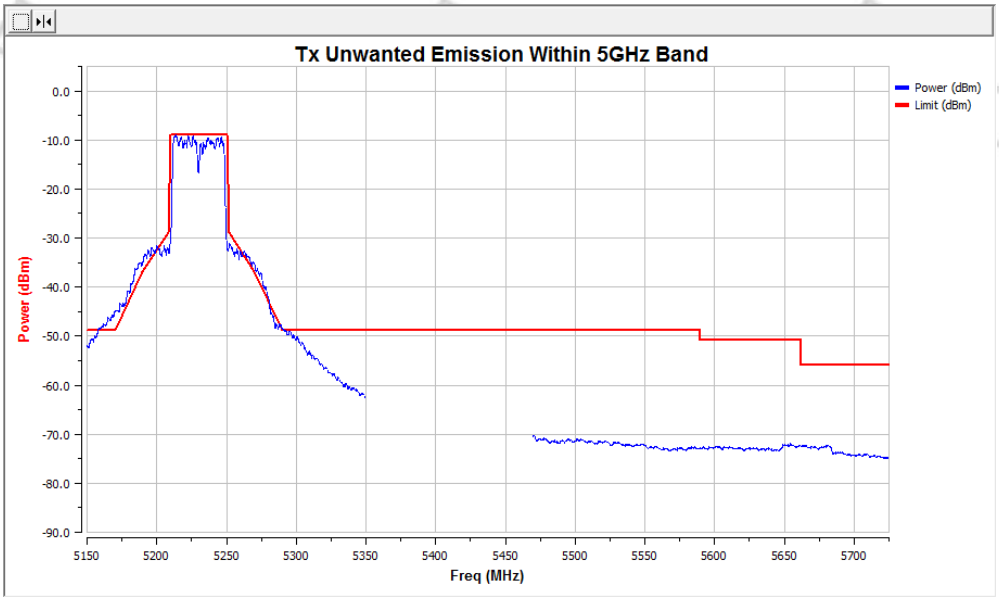
Modulation	Test Freq (MHz)	Status
802.11 ac20 (Band 1)	5240	Pass



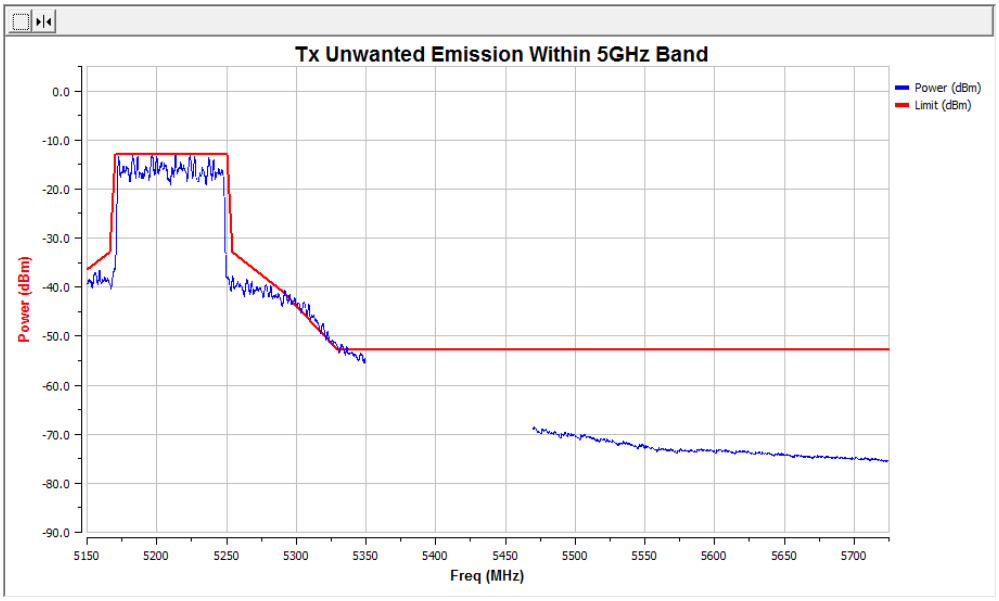
Modulation	Test Freq (MHz)	Status
802.11 ac40 (Band 1)	5190	Pass



Modulation	Test Freq (MHz)	Status
802.11 ac40 (Band 1)	5230	Pass



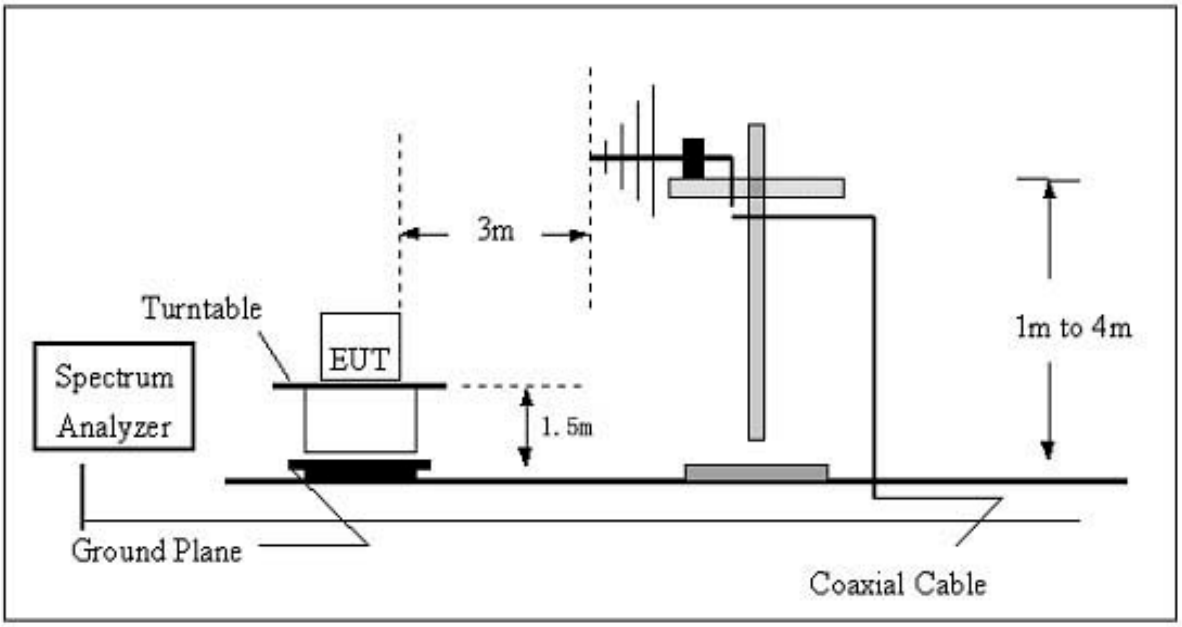
Modulation	Test Freq (MHz)	Status
802.11 ac80 (Band 1)	5210	Pass



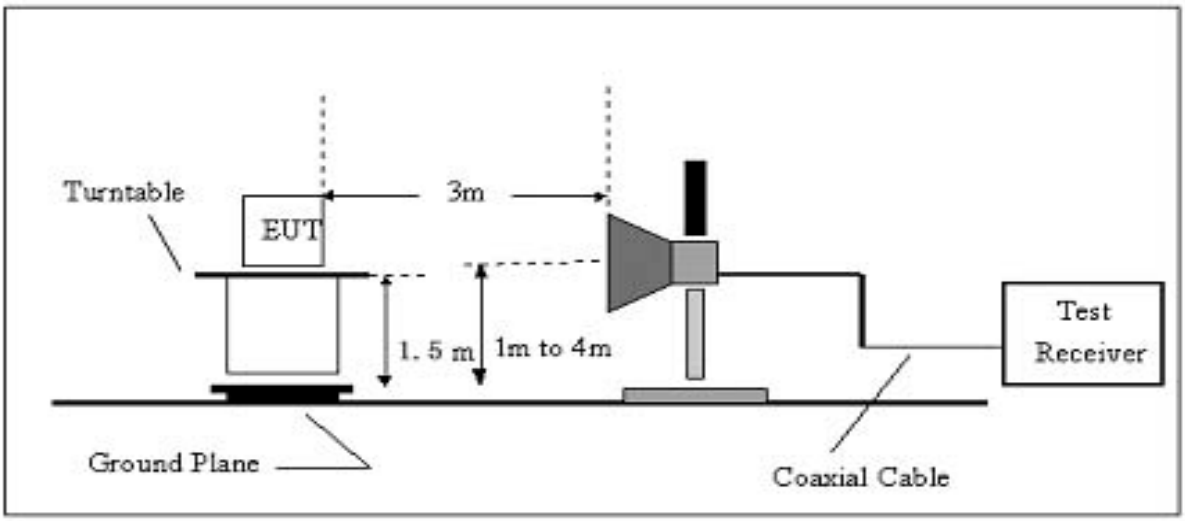
13. RECEIVER SPURIOUS EMISSIONS

13.1 Block Diagram Of Test Setup

(A) Radiated Emission Test Set-Up, Frequency Below 1000MHz



(B) Radiated Emission Test Set-Up Frequency Above 1 GHz



13.2 Limits

Frequency(MHz)	Limit
30-1000	-57dBm
1000-12750	-47dBm

13.3 Test Procedure

30MHz ~ 1GHz:

a. The Product was placed on the nonconductive turntable 1.5m above the ground in a full anechoic chamber.

b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 120 kHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied between 1~4 m in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.

c. For each frequency whose maximum record was higher or close to limit, measure its QP value: vary the antenna's height and rotate the turntable from 0 to 360 degrees to find the height and degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to QP Detector and specified bandwidth with Maximum Hold Mode, and record the maximum value.

Above 1GHz:

a. The Product was placed on the non-conductive turntable 1.5 m above the ground in a full anechoic chamber..

b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 1MHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.

c. For each frequency whose maximum record was higher or close to limit, measure its AV value: rotate the turntable from 0 to 360 degrees to find the degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to AV value and specified bandwidth with Maximum Hold Mode, and record the maximum value.

13.4 Test Results

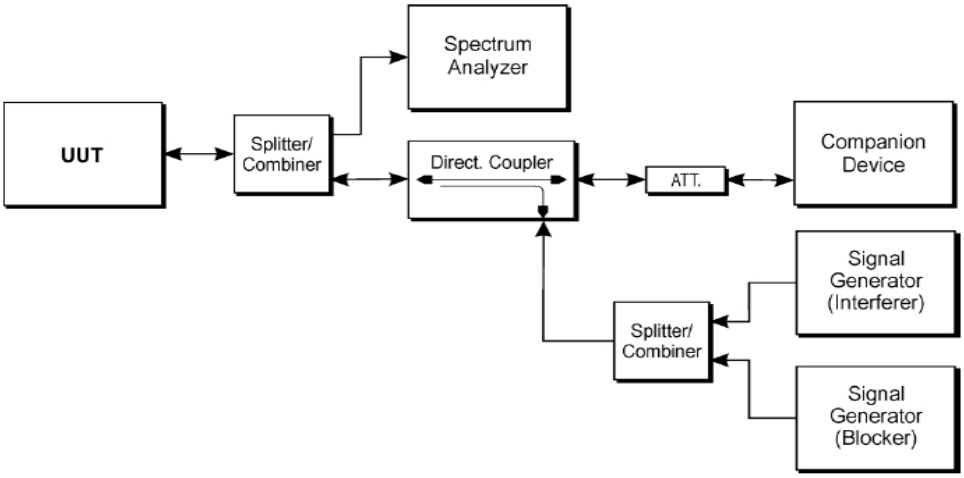
Modulation : 802.11a20 (the worst data)

Frequency	Receiver Reading	Turn table Angle	RX Antenna		Correct	Absolute Level	Result	
			Height	Polar	Factor		Limit	Margin
(MHz)	(dBm)	Degree	(m)	(H/V)	(dBm)	(dBm)	(dBm)	(dB)
802.11a20 low channel								
366.59	-54.52	276	1.3	H	-11.84	-66.36	-57.00	-9.36
366.59	-55.61	142	1.4	V	-11.84	-67.45	-57.00	-10.45
2489.63	-51.25	63	1.7	H	-6.80	-58.05	-47.00	-11.05
2489.63	-53.12	241	1.7	V	-6.80	-59.92	-47.00	-12.92
802.11a20 Mid channel								
366.59	-54.18	306	1.4	H	-11.84	-66.02	-57.00	-9.02
366.59	-55.02	1	1.9	V	-11.84	-66.86	-57.00	-9.86
2489.63	-50.97	259	1.0	H	-6.80	-57.77	-47.00	-10.77
2489.63	-53.02	180	2.0	V	-6.80	-59.82	-47.00	-12.82
802.11a20 high channel								
366.59	-54.20	149	1.4	H	-11.84	-66.03	-57.00	-9.03
366.59	-54.68	31	1.9	V	-11.84	-66.52	-57.00	-9.52
2489.63	-52.12	159	1.2	H	-6.80	-58.92	-47.00	-11.92
2489.63	-52.13	123	1.5	V	-6.80	-58.93	-47.00	-11.93

Remark:
Absolute Level = Receiver Reading + Factor
Factor = Antenna Factor + Cable Loss – Pre-amplifier.

14. ADAPTIVITY

14.1 Block Diagram Of Test Setup



14.2 Limit

Requirement	Operational Mode		
	Frame Based Equipment	Load Based Equipment (CCA using 'energy detect')	Load Based Equipment (CCA not using any of the mechanisms referenced)
Minimum Clear Channel Assessment (CCA) Time	20 us (see note 1)	(see note 2)	20 us (see note 1)
Maximum Channel Occupancy (COT) Time	1ms to 10 ms	(see note 2)	(13/32)*q ms (see note 3)
Minimum Idle Period	5% of COT	(see note 2)	NA
Extended CCA check	NA	(see note 2)	N*CCA (see note 4)
Short Control Signalling Transmissions	Maximum duty cycle of 5% within an observation period of 50 ms (see note 5)		

Note 1: The CCA time used by the equipment shall be declared by the manufacturer.
Note 2: LBT based spectrum sharing mechanism based on the Clear Channel Assessment (CCA) mode using 'energy detect', as described in IEEE 802.11™-2007[9], clauses 15 and 17, in IEEE 802.11n ™ -2009[10], clauses 20.
Note 3: q is selected by the manufacturer in the range [4…32]
Note 4: The value of N shall be randomly selected in the range [1…q]
Note 5: Adaptive equipment may or may not have Short Control Signaling Transmissions.

14.3 Test procedure

Step 1:

• The UUT shall connect to a companion device during the test. The signal generator, the spectrum analyser, the UUT, the traffic source and the companion device are connected using a set-up equivalent to the example given by figure 14 although the interference source is switched off at this point in time. The spectrum analyser is used to monitor the transmissions of the UUT in response to the interference signal. The traffic source might be part of the UUT itself.

• The received signal level (wanted signal from the companion device) at the UUT shall be sufficient to maintain a reliable link for the duration of the test. A typical value for the received signal level which can be used in most cases is -50 dBm/MHz.

• The analyser shall be set as follows:

- RBW: ≥ Occupied Channel Bandwidth (if the analyser does not support this setting, the highest available setting shall be used)
- VBW: ≥ RBW (if the analyser does not support this setting, the highest available setting shall be used)
- Detector Mode: RMS
- Centre Frequency: Equal to the centre frequency of the operating channel
- Span: 0 Hz
- Sweep time: > 2 × Channel Occupancy Time
- Trace Mode: Clear/Write
- Trigger Mode: Video or RF/IF Power

Step 2:

• Configure the traffic source so that it fills the UUT's buffers to a level causing the UUT to always have transmissions queued (buffer-ready-for-transmission condition) towards the companion device. Where this is not possible, the UUT shall be configured to occupy the Channel Occupancy Time of the Fixed Frame Period to the highest extent possible.

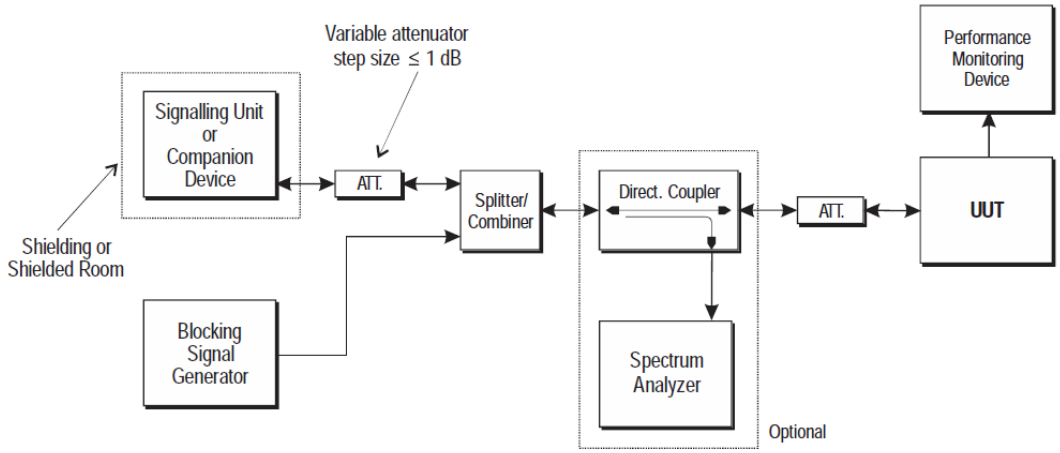
• To avoid adverse effects on the measurement results, a unidirectional traffic source should be used. An example of such a unidirectional traffic source not triggering reverse traffic on higher layer protocols is UDP.

14.4 Test Result

Pass

15. RECEIVER BLOCKING

11.1 Block Diagram Of Test Setup



11.2 Limit

Wanted signal mean power from companion device (dBm)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 2)		Type of blocking signal
		Master or Slave with radar detection (see table D.2, note 2)	Slave without radar detection (see table D.2, note 2)	
Pmin + 6 dB	5 100	-53	-59	Continuous Wave
Pmin + 6 dB	4 900 5 000 5 975	-47	-53	Continuous Wave

NOTE 1: P_{min} is the minimum level of the wanted signal (in dBm) required to meet the minimum performance criteria as defined clause 4.2.8.3 in the absence of any blocking signal.

NOTE 2: The levels specified are levels in front of the UUT antenna. In case of conducted measurements, the same levels should be used at the antenna connector irrespective of antenna gain.

11.3 Test procedure

Step 1:

- The UUT shall be set to the first operating frequency to be tested (see clause 5.3.2).

Step 2:

- The blocking signal generator is set to the first frequency as defined in table 9.

Step 3:

- With the blocking signal generator switched off a communication link is set up between the UUT and the associated companion device using the test setup shown in figure 18. The attenuation of the variable attenuator shall be increased in 1 dB steps to

a value at which the minimum performance criteria as specified in clause 4.2.8.3 is still met. The resulting level for the wanted signal at the input of the UUT is Pmin.

- This signal level (Pmin) is increased by 6 dB resulting in a new level (Pmin + 6 dB) of the wanted signal at the UUT receiver input.

Step 4:

- The level of the blocking signal at the UUT input is set to the level provided in table 9. It shall be verified and recorded in the test report that the performance criteria as specified in clause 4.2.8.3 are met.
- If the performance criteria as specified in clause 4.2.8.3 are met, the level of the blocking signal at the UUT may be further increased (e.g. in steps of 1 dB) until the level whereby the performance criteria as specified in clause 4.2.8.3 are no longer met. The highest level at which the performance criteria are met is recorded in the test report.

Step 5:

- Repeat step 4 for each remaining combination of frequency and level as specified in table 9.

Step 6:

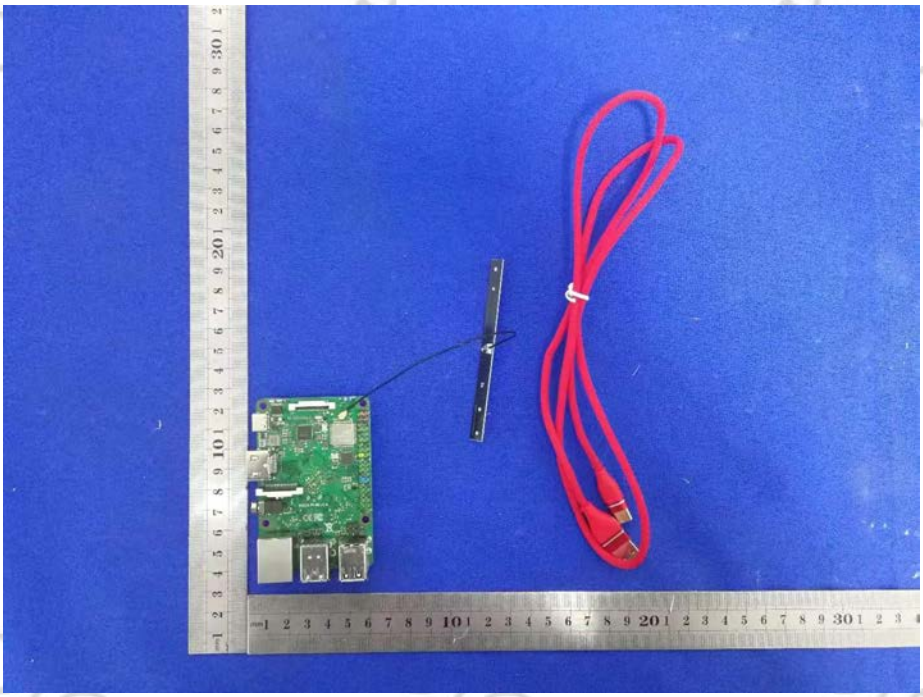
- Repeat step 2 to step 5 with the UUT operating at the other operating frequencies at which the blocking test has to be performed. See clause 5.3.2.

11.4 Test Result

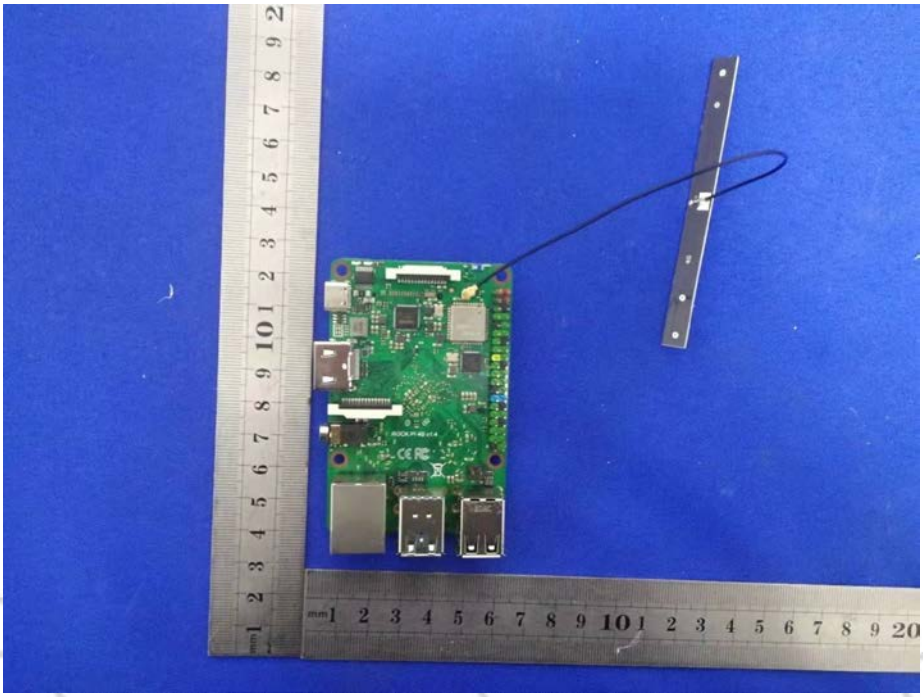
Pass

16. EUT PHOTOGRAPHS

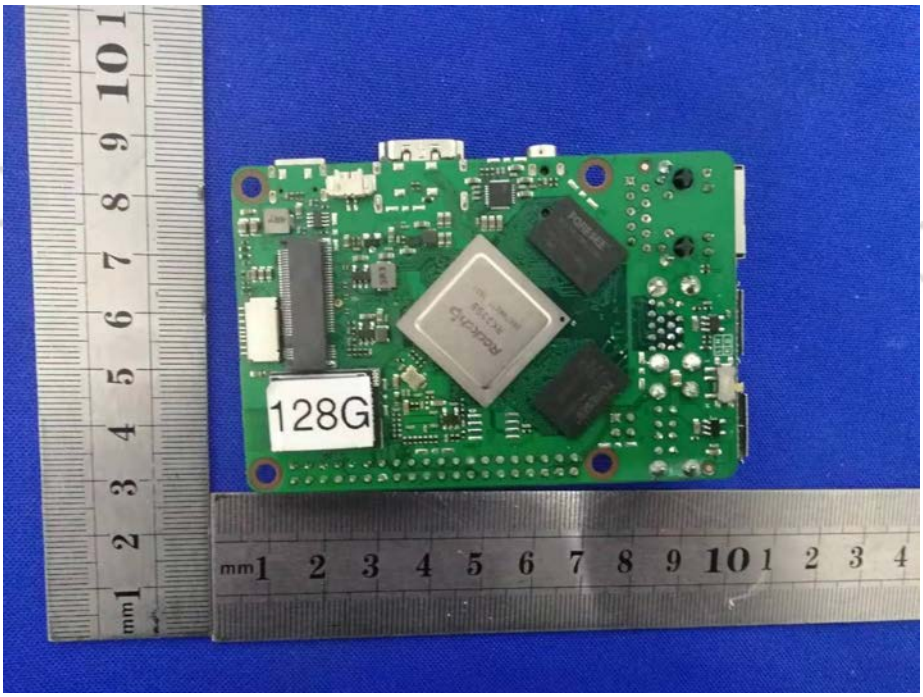
EUT Photo 1



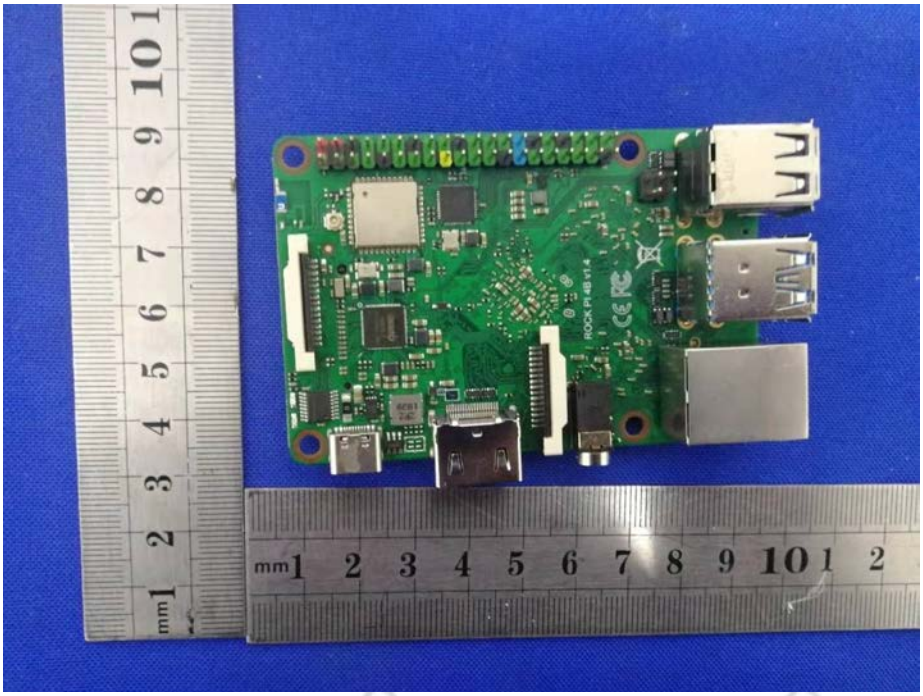
EUT Photo 2



EUT Photo 3

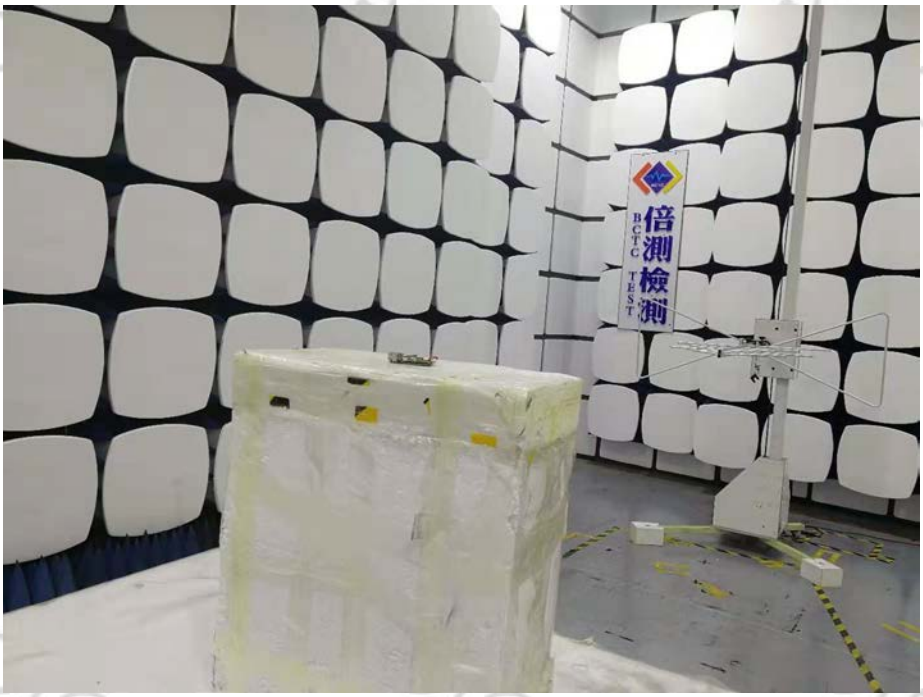


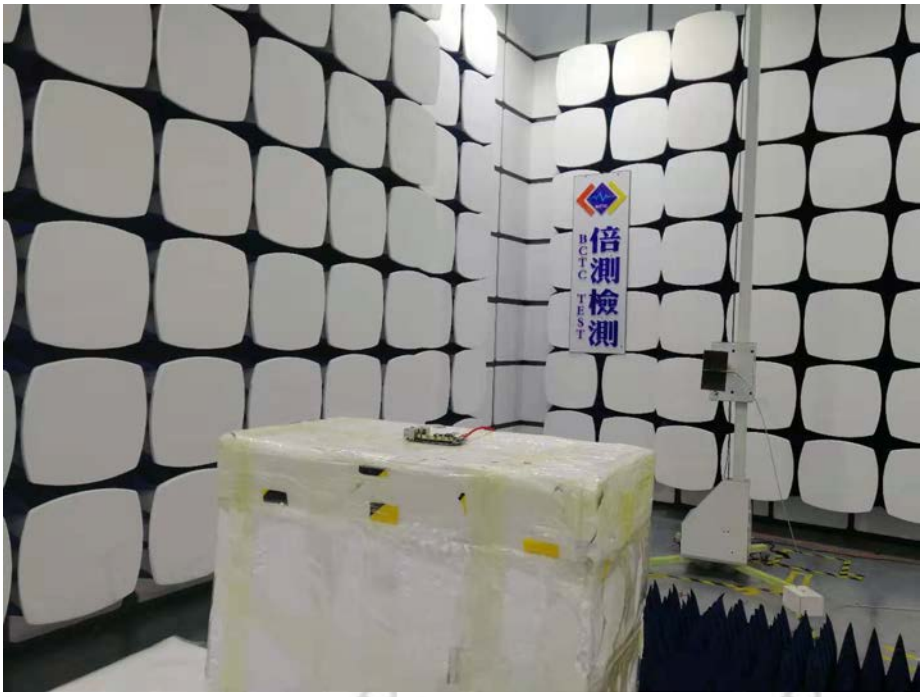
EUT Photo 4



17. EUT TEST SETUP PHOTOGRAPHS

Spurious emissions





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