

ELECTROMAGNETIC EMISSIONS COMPLIANCE REPORT



EUT Description Sparrow Wi-Fi Module
Applicant: BOTS UNLIMITED LLC
5817 La Colonia, San Antonio, Texas 78218, USA
Manufacturer: BOTS UNLIMITED LLC
5817 La Colonia, San Antonio, Texas 78218, USA
Brand Name: Bots Unlimited
Model No.: SP-01-100
Report Number: TERF2506001929ER
FCC ID 2BPPF-SP01
Date of EUT Received: June 6, 2025
Date of Test: June 9, 2025 ~ September 4, 2025
Issue Date: September 18, 2025

Approved By _____

Jim Chang

We hereby certify that:

The above equipment was tested by SGS Taiwan Ltd. Central RF Lab. The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in ANSI C63.10:2013 and the energy emitted by the sample EUT comply with FCC rule part §15.407.
The results of this report relate only to the sample identified in this report.

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Revision History

Report Number	Revision	Description	Issue Date	Revised By	Remark
TERF2506001929ER	00	Original	Aug. 27, 2025	Candice Li	
TERF2506001929ER	01	Modify the data of ac80 5855MHz on Section 1.4, 1.5, 7.2.2, 7.2.3, 7.3; Section 1.6	Sep. 5, 2025	Candice Li	*
TERF2506001929ER	02	Modify page 79,95,96	Sep. 9, 2025	Candice Li	*
TERF2506001929ER	03	Removed RSS 247 regulations and test results.	Sep. 18, 2025	Candice Li	*

Note:

- 1、The remark "*" indicates modification of the report upon requests from certification body.

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1 GENERAL INFORMATION

1.1 Product Description

EUT Description	Sparrow Wi-Fi Module
Brand Name	Bots Unlimited
Model No.	SP-01-100
Hardware Version	1
Firmware Version	W16.88.10.p173-16.26.10.p173-C4X16698_V4
EUT Series No.	254WSP-01-EVKAAAAA101000001
Power Supply	3.3 Vdc, 1.8 Vdc
Test Software (Name/Version)	Dut labtool

1.2 Modulation & Data Rate

Modulation type:	64QAM, 16QAM, QPSK, BPSK for OFDM in 802.11a, 11n
	256QAM, 64QAM, 16QAM, QPSK, BPSK for OFDM in 802.11ac
Transition Rate:	802.11 n_HT20: up to 144.4 Mbps
	802.11 n_HT40: up to 300 Mbps
	802.11 ac_VHT80: up to 866.6 Mbps

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1.3 Antenna Designation

Antenna Type	Supplier	Antenna Model No.	Ant No.	Freq. (MHz)	Peak Antenna Gain (dBi)
Flexible Printed Circuit	ABRACON	AFG4507W2	Ant0	5150 – 5250	7.68
				5250 – 5350	8.12
				5470 – 5725	8.12
				5725 – 5850	6.91
				5850 – 5895	6.91
Flexible Printed Circuit	ABRACON	AFG4507W2	Ant1	5150 – 5250	7.68
				5250 – 5350	8.12
				5470 – 5725	8.12
				5725 – 5850	6.91
				5850 – 5895	6.91

Note:

1. Pre-scanned was done on the above antennas, measurements were demonstrated by using the antenna with the highest gain as the worst case scenarios.
2. The antenna information is provided by the applicant. The laboratory does not verify the accuracy of this information, and all test results related to antenna characteristics are based solely on the data supplied. Responsibility for the authenticity and accuracy of these specifications rests entirely with the party who provided the information.
3. The antenna complies with part 15.203 requirement and no consideration of replacement. Please see EUT photo for details.
4. The directional gain is calculated according to section F. 2). e). (ii) of FCC KDB 662911 D01.

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1.4 FCC Rated Power

Wi-Fi	Frequency Range	Channels	EIRP/Avg	Rated Power(EIRP/Avg) (dBm) (Worst Case)	Modulation Technology
802.11a	5180~5240	4	Avg	19.90 dBm	OFDM
	5260~5320	4	Avg	19.16 dBm	OFDM
	5500~5700	12	Avg	21.34 dBm	OFDM
	5745~5825	5	Avg	26.26 dBm	OFDM
	5845~5885	3	EIRP	24.36 dBm	OFDM
802.11n_HT20	5180~5240	4	Avg	17.53 dBm	OFDM
	5260~5320	4	Avg	18.41 dBm	OFDM
	5500~5720	12	Avg	21.66 dBm	OFDM
	5745~5825	5	Avg	27.98 dBm	OFDM
	5845~5885	3	EIRP	22.81 dBm	OFDM
802.11n_HT40	5190~5230	2	Avg	20.53 dBm	OFDM
	5270~5310	2	Avg	21.18 dBm	OFDM
	5510~5710	6	Avg	20.81 dBm	OFDM
	5755~5795	2	Avg	26.30 dBm	OFDM
	5835~5875	2	EIRP	24.37 dBm	OFDM
802.11ac_VHT80	5210	1	Avg	10.20 dBm	OFDM
	5290	1	Avg	10.22 dBm	OFDM
	5530~5690	3	Avg	21.83 dBm	OFDM
	5775	1	Avg	22.03 dBm	OFDM
	5855	1	EIRP	26.94 dBm	OFDM

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1.5 Operating Frequencies

UNII-1 5150 MHz ~ 5250MHz

20MHz		40MHz		80MHz	
CH	Freq. (MHz)	CH	Freq. (MHz)	CH	Freq. (MHz)
36	5180	38	5190	42	5210
40	5200	46	5230		
44	5220				
48	5240				

UNII-2A 5250 MHz ~ 5350MHz

20MHz		40MHz		80MHz	
CH	Freq. (MHz)	CH	Freq. (MHz)	CH	Freq. (MHz)
52	5260	54	5270	58	5290
56	5280	62	5310		
60	5300				
64	5320				

UNII-2C 5470 MHz ~ 5725MHz

20MHz		40MHz		80MHz	
CH	Freq. (MHz)	CH	Freq. (MHz)	CH	Freq. (MHz)
100	5500	102	5510	106	5530
104	5520	110	5550	122	5610
108	5540	118	5590	138	5690
112	5560	126	5630		
116	5580	134	5670		
120	5600	142	5710		
124	5620				
128	5640				
132	5660				
136	5680				
140	5700				
144	5720				

UNII-3 5725 MHz ~ 5850MHz

20MHz		40MHz		80MHz	
CH	Freq. (MHz)	CH	Freq. (MHz)	CH	Freq. (MHz)
149	5745	151	5755	155	5775
153	5765	159	5795		
157	5785				
161	5805				
165	5825				

UNII-4 5850 MHz ~ 5925MHz

20MHz		40MHz		80MHz	
CH	Freq. (MHz)	CH	Freq. (MHz)	CH	Freq. (MHz)
169	5845	167	5835	171	5855
173	5865	175	5875		
177	5885				

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1.6 EUT Availability and The Worst Test Modes

1. The EUT has been tested under operating condition.
2. Test program used to control the EUT for staying in continuous transmitting mode is programmed.
3. Investigation has been done on all the possible configurations for searching the worst case. The given UE is pre-scanned among below modes.

Modulation		Transmission Chain							Single Transmission Spatial		Multiple Transmission Spatial		
V	802.11 a	V	Ch0	V	Ch1		Ch2		Ch3	V	1TX		2TX
V	802.11 n	V	Ch0	V	Ch1		Ch2		Ch3		1TX	V	2TX
V	802.11 ac	V	Ch0	V	Ch1		Ch2		Ch3		1TX	V	2TX
	802.11 ax		Ch0		Ch1		Ch2		Ch3		1TX		2TX
	802.11 be		Ch0		Ch1		Ch2		Ch3		1TX		2TX

4. Therefore, below summary is the modes of test configuration that yield the highest reading and generate the highest emission chosen to carry out the relevantly mandatory test items.

CONDUCTED TEST						
MODE	FREQUENCY BAND (MHz)	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION	DATA RATE (Mbps)	ANTENNA PORT
802.11a	5180~5240	36 to 48	36,44,48	OFDM	6	Ch0
	5260~5320	52 to 64	52,60,64			
	5500~5720	100 to 144	100,116,140,144			
	5745~5825	149 to 165	149,157,165			
	5845~5885	169 to 177	169,173,177			
802.11n_HT20	5180~5240	36 to 48	36,44,48	OFDM	MCS0	2TX
	5260~5320	52 to 64	52,60,64			
	5500~5720	100 to 144	100,116,140,144			
	5745~5825	149 to 165	149,157,165			
	5845~5885	169 to 177	169,173,177			
802.11n_HT40	5190~5230	38 to 46	38,46	OFDM	MCS0	2TX
	5270~5310	54 to 62	54,62			
	5510~5710	102 to 142	102,110,134,142			
	5755~5795	151 to 159	151,159			
	5835~5875	167 to 175	167,175			
802.11ac_VHT80	5210	42	42	OFDM	MCS0	2TX
	5290	58	58			
	5530~5690	106 to 138	106,122,138			
	5775	155	155			
	5855	171	171			

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TRANSMIT RADIATED EMISSION TEST (BELOW 1 GHz)						
MODE	FREQUENCY BAND (MHz)	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION	DATA RATE (Mbps)	ANTENNA PORT
802.11a	5180~5240	36 to 48	44	OFDM	6	Ch0
	5260~5320	52 to 64	60	OFDM		
	5500~5720	100 to 144	116	OFDM		
	5745~5825	149 to 165	157	OFDM		
	5845~5885	169 to 177	173	OFDM		
TRANSMIT RADIATED EMISSION TEST (ABOVE 1 GHz)						
MODE	FREQUENCY BAND (MHz)	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION	DATA RATE (Mbps)	ANTENNA PORT
802.11a	5180~5240	36 to 48	36,44,48	OFDM	6	Ch0
	5260~5320	52 to 64	52,60,64	OFDM		
	5500~5720	100 to 144	100,116,140,144	OFDM		
	5745~5825	149 to 165	149,157,165,169	OFDM		
	5855~5895	169 to 177	173,177	OFDM		
802.11n20	5180~5240	36 to 48	36,44,48	OFDM	MCS0	2Tx
	5260~5320	52 to 64	52,60,64	OFDM		
	5500~5720	100 to 144	100,116,140,144	OFDM		
	5745~5825	149 to 165	149,157,165,169	OFDM		
	5855~5895	169 to 177	173,177	OFDM		
802.11n40	5190~5230	38 to 46	38,46	OFDM	MCS0	2Tx
	5270~5310	54 to 62	54,62	OFDM		
	5510~5710	102 to 142	102,110,134,142	OFDM		
	5755~5795	151 to 159	151,159,167	OFDM		
	5835~5875	167 to 175	175	OFDM		
802.11ac80	5210	42	42	OFDM	MCS0	2Tx
	5290	58	58	OFDM		
	5530~5690	106 to 138	106,122,138	OFDM		
	5775	155	155	OFDM		
	5855	171	171	OFDM		

Note:

The field strength of radiated emission was measured as the EUT positioned in different orthogonal planes (E1/E2/H) based on actual usage of the EUT to pre-scan the emissions for determining the worst case scenario.

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2 SUMMARY OF TEST RESULT

FCC Rules	Description Of Test	Result
§15.207	AC Power Line Conducted Emission	Compliant
§15.407(e)	Emission Bandwidth	Compliant
§15.407(a)	Maximum Conducted Output Power	Compliant
§15.407(a)	Power Spectral Density	Compliant
§15.205 §15.209 §15.407(b)	Undesirable Radiated Emissions	Compliant
§15.407(c)	Transmission in case of Absence of Information	Compliant
§15.203	Antenna Requirement	Compliant

2.1 Test Methodology of Applied Standards

1. FCC Part 15, Subpart E §15.407
2. FCC KDB 789033 D02 General UNII Test Procedures New Rules v02r01
3. FCC KDB 662911 D01 Multiple Transmitter Output v02r01
4. FCC KDB 291074 D02 EMC Measurement v01
5. ANSI C63.10:2020

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2.2 Measurement Uncertainty

Test Items	Uncertainty
AC Power Line Conducted Emission	+/- 1.54 dB
Emission Bandwidth	+/- 1.38 Hz
Output Power measurement	+/- 0.97 dB
Peak Power Spectral Density Measurement	+/- 0.61 dB
Frequency Stability	+/- 1.48 Hz
Temperature	+/- 0.60 °C
Humidity	+/- 3.00 %
DC / AC Power Source	+/- 1.00 %

Radiated Spurious Emission Measurement Uncertainty		
Polarization: Vertical	+/- 1.89 dB	9kHz - 30MHz
	+/- 4.10 dB	30MHz - 1000MHz
	+/- 3.37 dB	1GHz - 18GHz
	+/- 3.83 dB	18GHz - 40GHz
Polarization: Horizontal	+/- 1.89 dB	9kHz - 30MHz
	+/- 4.10 dB	30MHz - 1000MHz
	+/- 3.37 dB	1GHz - 18GHz
	+/- 3.83 dB	18GHz - 40GHz
Radiated Spurious Emission	+/- 2.00 dB	33GHz - 50GHz
	+/- 1.59 dB	50GHz - 60GHz
	+/- 1.71 dB	60GHz - 90GHz
	+/- 1.64 dB	90GHz - 140GHz
	+/- 3.84 dB	140GHz - 220GHz

Note:

1. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.
2. The conformity assessment statement in this report is based solely on the test results, measurement uncertainty is excluded.

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2.3 Test Facility

Laboratory	Test Site Address	Test Site Name	FCC Designa- tion number / Registration Number	IC CAB identifier
SGS Taiwan Ltd. Central RF Lab. (TAF code 3702)	No.134, Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan.	SAC 1	TW0027 / 891563	TW3702
		SAC 2		
		SAC 3		
		Conduction 1		
		Conducted 1		
		Conducted 2		
		Conducted 3		
		Conducted 4		
		Conducted 5		
		Conducted 6		
	No.2, Keji 1st Rd., Guishan District, Taoyuan City, Taiwan 333	Conduction C	TW0028 / 200037	
		SAC C		
		SAC D		
		SAC G		
		Conducted A		
		Conducted B		
		Conducted C		
		Conducted D		
		Conducted E		
		Conducted F		
Conducted G				
Note: Test site name is remarked on the equipment list in each section of this report as an indica- tion where measurements occurred in specific test site and address.				

Temperature:	20-23	°C	Relative Humidity:	48-79	%
Test site	Conducted 2		Test Start:	07/11/2025	
Test Engineer:	Dannis Chen		Test Done:	09/04/2025	

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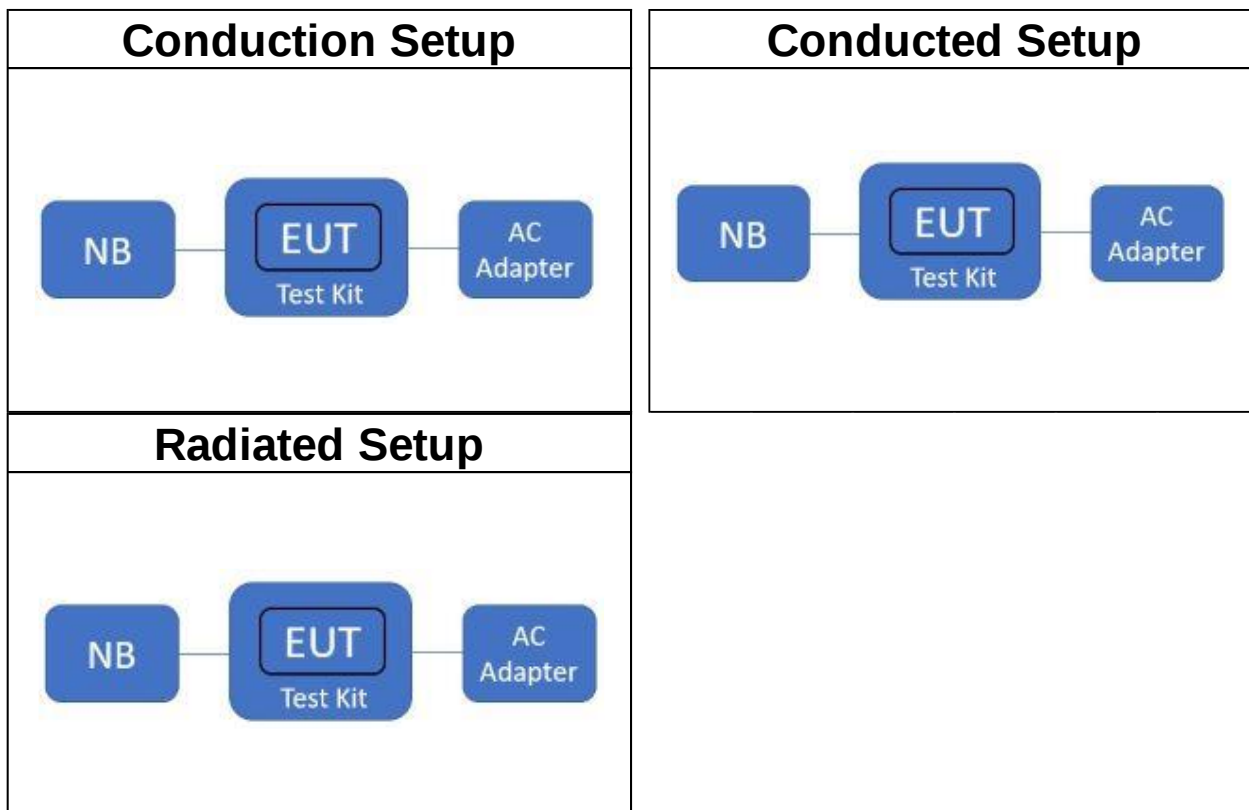
3 CONTROL UNIT(S) AND PERIPHERAL(S)

3.1 EUT Exercise

An engineering test mode (software/firmware) that applicant provided was utilized to manipulate the EUT into transmit, selection of the test channel, and modulation scheme.

The offset level is set in the spectrum analyzer to compensate the RF cable loss and at-ten-uation factor between EUT conducted port and spectrum analyzer. With the offset compen-sation, the spectrum analyzer reading level is exactly EUT RF output level.

3.2 Diagrams



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3.3 List

AC Power-Line Conducted Emission Test Site: Conduction 1					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL. (mm/dd/yyyy)	CAL DUE. (mm/dd/yyyy)
AC Adapter	Tri-Mag, LLC	L6R24-120	N/A	N/A	N/A
Test Kit	Bots Unlimited	SP-01-EVK	N/A	N/A	N/A
Notebook	HP	HSN-Q35C-4	5CD238GDV5	N/A	N/A
Conducted Emission Test Site: Conducted 2					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL. (mm/dd/yyyy)	CAL DUE. (mm/dd/yyyy)
AC Adapter	Tri-Mag, LLC	L6R24-120	N/A	N/A	N/A
Test Kit	Bots Unlimited	SP-01-EVK	N/A	N/A	N/A
Notebook	HP	HSN-Q35C-4	5CD238GDV5	N/A	N/A
Radiated Emission Test Site: SAC 3					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL. (mm/dd/yyyy)	CAL DUE. (mm/dd/yyyy)
AC Adapter	Tri-Mag, LLC	L6R24-120	N/A	N/A	N/A
Test Kit	Bots Unlimited	SP-01-EVK	N/A	N/A	N/A
Notebook	HP	HSN-Q35C-4	5CD238GDV5	N/A	N/A

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4 MEASUREMENT EQUIPMENT USED

4.1 Emission from AC power line

AC Power-Line Conducted Emission Test Site: Conduction 1					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL. (mm/dd/yyyy)	CAL DUE. (mm/dd/yyyy)
Coaxial Cables	EMC Instruments Corp.	EMCCFD300-BM-BM-3000	161207	06/22/2025	06/21/2026
EMI Test Receiver	R&S	ESCI 7	100759	08/28/2024	08/27/2025
LISN	SCHWARZBECK	NSLK 8127	1040	09/07/2024	09/06/2025
Pulse Limiter	SCHWARZBECK	VTSD 9561F-N	793	06/22/2025	06/21/2026
Test Software	Audix	e3	Ver. 9.210616	N.C.R	N.C.R

4.2 Conducted Measurement

Conducted Emission Test Site: Conducted 2					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL. (mm/dd/yyyy)	CAL DUE. (mm/dd/yyyy)
Attenuator	Mini-Circuits	BW-S10W2+	4	12/11/2024	12/10/2025
DC Block	Titan	T0610A00127A	SNK47008	12/11/2024	12/10/2025
MXA Spectrum Analyzer	KEYSIGHT	N9021B	MY62242004	06/11/2025	06/10/2026
Power Meter	Anritsu	ML2496A	2138003	10/09/2024	10/08/2025
Power Sensor	Anritsu	MA2411B	1911393	10/09/2024	10/08/2025
Power Sensor	Anritsu	MA2411B	1911394	10/09/2024	10/08/2025
Test Software	SGS	Radio Test Software	Ver. 21	N.C.R	N.C.R

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4.3 Radiated Measurement

Radiated Emission Test Site: SAC 3					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL. (mm/dd/yyyy)	CAL DUE. (mm/dd/yyyy)
7G High Pass Filter	WI	WHKX7.0	45	12/11/2024	12/10/2025
Attenuator	Mini-Circuits	BW-S10W2+	16	12/11/2024	12/10/2025
Band Reject Filter 5150-5350	Micro-Tronics	BRM50703	1	12/11/2024	12/10/2025
Band Reject Filter 5470-5725	Micro-Tronics	BRM50704	1	12/11/2024	12/10/2025
Band Reject Filter 5725-5895	Titan	T04N5725589550S01	23040703-20	12/11/2024	12/10/2025
Bi-log Antenna	SCHWARZBECK	VULB9168	378	08/09/2024	08/08/2025
Coaxial Cables	EMCI+Huber Suhner	EMC107-SM-SM- 1000 +SUCOFLEX 104PEA +EMC107-SM-SM- 1500 +SUCOFLEX 106	RX Cable 9K-18G (221110+MY4251/4P EA+221106+76096/6)	08/30/2024	08/29/2025
Coaxial Cables	Huber Suhner	SUCOFLEX 102	RX Cable 18G-40G MY2630/2+805062/2	08/30/2024	08/29/2025
EMI Test Receiver	R&S	ESCI 7	100759	08/28/2024	08/27/2025
EXA Spectrum Analyzer	KEYSIGHT	N9010B	MY63440386	02/05/2025	02/04/2026
Horn Antenna	SCHWARZBECK	BBHA9170	184	12/20/2024	12/19/2025
Horn Antenna	SCHWARZBECK	BBHA9120D	1441	09/23/2024	09/22/2025
Loop Antenna	COM-POWER	AL-130R	10160104	12/19/2024	12/18/2025
Pre-Amplifier	EMCI	EMC118A45SEE	980868	08/30/2024	08/29/2025
Pre-Amplifier	EMCI	EMC184045SEE	9080939	08/30/2024	08/29/2025
Pre-Amplifier	HP	8447D	2944A07676	08/30/2024	08/29/2025
Site Cal	SGS	SAC 3	N/A	06/30/2025	06/29/2026
Test Software	Audix	e3	Ver. 9.210616	N.C.R	N.C.R

NOTE: N.C.R refers to Not Calibrated Required.

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5 REGULATORY REQUIREMENTS

5.1 Emission Bandwidth

There is no limit bandwidth for U-NII-1, U-NII-2-A and U-NII-2-C.

The minimum of 6dB Bandwidth measurement is 0.5 MHz for U-NII-3 & UNII-4.

5.2 Maximum Output Power

5.2.1 Duty Cycle

Pre-analysis Check: While conducting average power measurement, duty cycle of each mode shall be checked to ensure its duty cycle in order to compensate for the loss due to insufficient ratio of duty cycle.

All duty cycle is pre-scanned, and result as obtained below shows only the most representative ones where duty cycle is conducted as the given transmission with given virtual operation that expresses the percentage.

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Band	EUT CATEGORY		e-CRF Title 47 §15.407			
			Conducted Output Power	EIRP	TPC	Antenna Directional Gain Requirements
U-NII-1		Fixed point-to-point	1 Watt(30dBm)	Not required	Not required	23dBi
		Outdoor AP	1 Watt(30dBm)	Elevation angle above 30 degrees 125mW (21dBm)	Not required	6dBi
		Indoor AP	1 Watt(30dBm)	Not required	Not required	6dBi
	V	Other	250mW(23.98dBm)	Not required	Not required	6dBi
U-NII-2A	V	Other	250mW(23.98dBm) or 11dBm+10 log B	Not required	When EIRP >500mW At least 6dB below EIRP 1W (30dBm)	6dBi
U-NII-2C	V	Other	250mW(23.98dBm) or 11dBm+10 log B	Not required		6dBi
U-NII-3	V	Other	1 Watt(30dBm)	Not required	Not required	6dBi
		Fixed point-to-point	1 Watt(30dBm)	Not required	Not required	Not required
U-NII-4		Indoor AP (a channel spans 5725~5850 and 5850~5895MHz)	Not required	36dBm	Not required	Not required
	V	Indoor client (a channel spans 5725~5850 and 5850~5895MHz)	Not required	30dBm	Not required	Not required
		Subordinate device	Not required	36dBm	Not required	Not required
1. If transmitting antennas of directional gain greater than the antenna requirements column, the Maximum transmit power shall be reduced by the amount in dB that the direction-al gain of the antenna. 2. For the 10 log B, B is the 26 dB emission bandwidth.						

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5.3 Maximum Power Spectral Density

Operation Bands	EUT CATEGORY		e-CRF Title 47 §15.407 Power Spectral Density	Antenna Directional Gain Requirements
U-NII-1		Outdoor Access Point (Master)	1. 17dBm/ MHz 2. EIRP<=125mW(21dBm) at any elevation angle > 30°	6dBi
		Indoor Access Point (Master)	17dBm / MHz	6dBi
		Fixed point-to-point Access Point	17dBm / MHz	23dBi
	V	Client device	11dBm / MHz	6dBi
U-NII-2A	V	All	11dBm / MHz	6dBi
U-NII-2C	V	All	11dBm / MHz	6dBi
U-NII-3	V	All	30dBm / 500kHz	6dBi
U-NII-4		Indoor AP	20dBm / MHz e.i.r.p.	Not required
	V	Indoor client	14dBm / MHz e.i.r.p.	Not required
		Subordinate device	20dBm / MHz e.i.r.p.	Not required
If transmitting antennas of directional gain greater than the antenna requirements column, the Maximum transmit power shall be reduced by the amount in dB that the direction-al gain of the antenna.				

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5.4 Unwanted Emission

5.4.1 5150~5850 MHz

Standards	Operation Freq. (MHz)	Freq.(MHz)	EIRP Limits (dBm/MHz)	Field Strength @ 3m(dBμV/m)
15.407(b)(1)	5150~5250	f ≤ 5150 f ≥ 5350	PK: -27	PK: 68.2
15.407(b)(2)	5250~5350			
15.407(b)(3)	5475~5725	f ≤ 5470 f ≥ 5725	PK: -27	PK: 68.2
15.407(b)(4)(i)	5725~5850	at 75 MHz or more above or below the band edge	PK:-27	PK: 68.2
		increasing linearly from 75~25MHz above or below the band edge	PK:-27~10	PK: 68.2~105.2
		increasing linearly from 25~5MHz above or below the band edge	PK:10~15.6	PK: 105.2~110.8
		increasing linearly from 5~0 MHz above or below the band edge	PK: 15.6~27	PK:110.8~122.2

EIRP = (E*d)^2 / 30, where E is the field strength in V/m, d is the measurement distance (3m), EIRP is the equivalent isotopically radiated power in Watts.

5.4.2 5850~5925 MHz

Standards	Operation Freq. (MHz)	ETU categories	EIRP Limits (dBm/MHz)	EIRP Limits (dBm/MHz)	Field Strength @3m (dBμV/m)
15.407(b)(5)(i)	5850~5895 or channel span cross 5725~5895	indoor AP or subordinate device	decrease linearly from 5895 ~ 5925MHz and above	PK:35~13 AV:15~-7	PK:130~108 AV:110~88
15.407(b)(5)(ii)		Client device		PK:15~-7 AV:-5~-27	PK:110~88 AV:90~68
15.407(b)(5)(iii)		Client / indoor AP / subordinate device	At or below 5650	PK:-27	PK:68
			increasing linearly from 5650~5700	PK:-27~10	PK:68~105
			increasing linearly from 5700~5720	PK:10~15.6	PK:105~110.6
			increasing linearly from 5720~5725	PK:15.6~27	PK:110.6~122

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5.4.3 Spurious Emission

Unwanted spurious emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table:

Frequency (MHz)	Field strength (microvolts/meter)	Distance (meters)
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

Note: The lower limit shall apply at the transition frequencies.

5.5 AC Power Line Conducted Emission

Frequency range within 150 kHz to 30 MHz shall not exceed the Limit table as below.

Frequency range MHz	Limits (dBuV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50

Note

- 1.The lower limit shall apply at the transition frequencies
- 2.The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz.

5.6 Transmission In The Absence Of Data

According to §15.407(c)

The device shall automatically discontinue transmission in case of either absence of information to transmit or operational failure. These provisions are not intended to preclude the transmission of control or signaling information or the use of repetitive codes used by certain digital technologies to complete frame or burst intervals. Applicants shall include in their application for equipment authorization a description of how this requirement is met.

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5.7 Antenna Requirements

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of § 15.211, 15.213, 15.217, 15.219, 15.221, or § 15.236. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with § 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

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6 TEST CONFIGURATION

6.1 Emission Bandwidth



Place the EUT on the table and set it in transmitting mode.

The testing follows FCC KDB 789033 D02 General UNII Test Procedures New Rules.

Remove the antenna from the EUT and then connect a low loss RF cable from the Antenna port to the spectrum analyzer.

26dB Band width Measurement: Set the spectrum analyzer as 1% of emission BW

Sweep = Auto,

Detector = Peak,

Trace Mode = Max Hold,

Manually readjust RBW until the RBW/EBW ratio is 1% based on EBW as observed on the result of pre-sequence measurement,

Mark the peak frequency and -26dB (upper and lower) frequency.

Minimum Emission Bandwidth for the band 5.725-5.850GHz & 5.850~5.895GHz

Set the spectrum analyzer as

RBW = 100 kHz,

VBW = 3*RBW,

Detector = Peak,

Span = large enough to capture all products of the modulation process,

Sweep = Auto,

Mark the peak frequency and -6dB (upper and lower) frequency.

For 99% Bandwidth: Set the spectrum analyzer as

RBW = 1% to 5% of the OBW,

VBW = 3*RBW,

Span = large enough to capture all products of the modulation process,

Detector = Sample,

Sweep = Auto,

Turn on the 99% bandwidth function, max reading.

Repeat above procedures until all frequency of interest measured was complete.

For 26dB BW and OBW of straddle channels, the results were calculated as below.

straddle channel emission BW in U-NII 2C = (emission BW/2) + (5725-straddle channel)

straddle channel emission bandwidth in U-NII 3 = emission BW- emission BW_U-NII 2C.

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6.2 Maximum Output Power

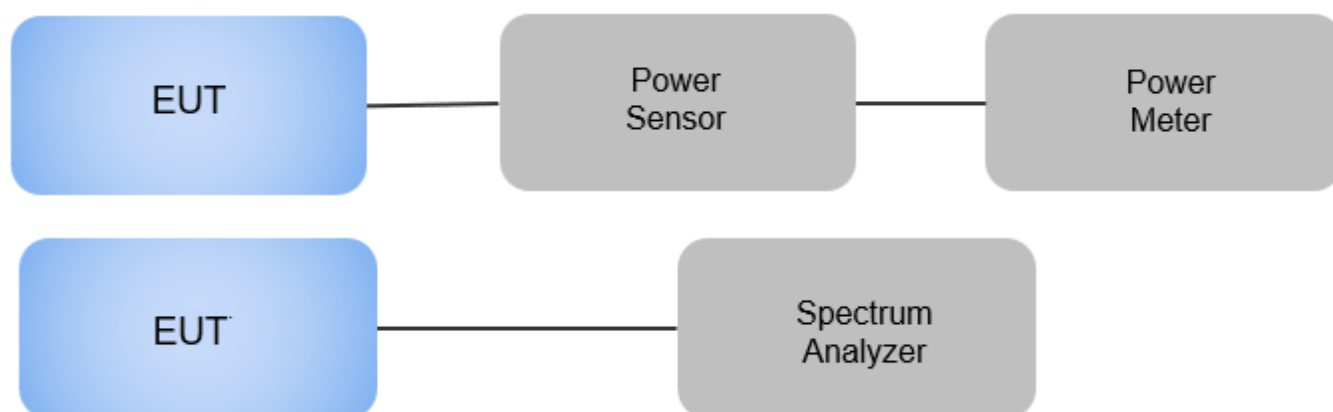
6.2.1 Duty Cycle



Set the spectrum analyzer as

Span = Zero,
RBW = 8 MHz,
VBW = 8 MHz,
Detector = Peak,

6.2.2 Maximum Output Power



Place the EUT on the table and set it in transmitting mode.

The testing follows FCC KDB 789033 D02 General UNII Test Procedures New Rules.

Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the power meter.

Method PM (Measurement using an RF average power meter):

Measurements may be performed using a wideband RF power meter with a thermocouple detector or equivalent if all of the following conditions are satisfied:

The EUT is configured to transmit continuously or to transmit with a constant duty cycle.

At all times when the EUT is transmitting, it must be transmitting at its maximum power control level.

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The integration period of the power meter exceeds the repetition period of the transmitted signal by at least a factor of five.

If the transmitter does not transmit continuously, measure the duty cycle, x , of the transmitter output signal as described in II.B.

Measure the average power of the transmitter. This measurement is an average over both the on and off periods of the transmitter.

Adjust the measurement in dBm by adding $10 \log (1/x)$ where x is the duty cycle (e.g., $10 \log (1/0.25)$ if the duty cycle is 25%).

Method SA-2(trace averaging across on and off times of the EUT transmissions, followed by duty cycle correction).

Measure the duty cycle, x , of the transmitter output signal as described in II.B.

Set span to encompass the EBW (or, alternatively, the entire 99% occupied bandwidth) of the signal.

Set RBW = 1 MHz, VBW $\geq$ 3 MHz.

Number of points in sweep $\geq 2 \times \text{span} / \text{RBW}$. (This ensures that bin-to-bin spacing is $\leq \text{RBW}/2$, so that narrowband signals are not lost between frequency bins.)

Sweep time = Auto.

Detector = power averaging (rms), if available. Otherwise, use sample detector mode.

Do not use sweep triggering. Allow the sweep to "free run."

Trace average at least 100 traces in power averaging (rms) mode; however, the number of traces to be averaged shall be increased above 100 as needed to ensure that the average accurately represents the true average over the on and off periods of the transmitter.

Compute power by integrating the spectrum across the EBW (or, alternatively, the entire 99% occupied bandwidth) of the signal using the instrument's band power measurement function with band limits set equal to the EBW (or occupied bandwidth) band edges. If the instrument does not have a band power function, sum the spectrum levels (in power units) at 1 MHz intervals extending across the EBW (or, alternatively, the entire 99% occupied bandwidth) of the signal.

Add $10 \log (1/x)$, where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times (because the measurement represents an average over both the on and off times of the transmission). For example, add $10 \log (1/0.25) = 6 \text{ dB}$ if the duty cycle is 25%.

Note:

For U-NII1, 2A, 2C and 3 Bands, when the antenna gain is greater than 6 dBi, the power limit attenuated accordingly.

When testing for multiple output ports in simultaneous transmission mode, the measured values of each individual output port are tested separately and then linearly summed.

The directional gain is calculated using the formula

$$\text{Directional Gain} = 10 \times \log_{10} \left[\frac{\left(10^{\frac{G_1}{10}} + 10^{\frac{G_2}{10}} + \dots + 10^{\frac{G_n}{10}} \right)^2}{N_{\{ant\}}} \right]$$

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6.3 Maximum Power Spectral Density



Place the EUT on the table and set it in transmitting mode.

The testing follows FCC KDB 789033 D02 General UNII Test Procedures New Rules.

Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to Spectrum.

For U-NII1, U-NII-2A, U-NII-2C, U-NII-4 Bands:

Set RBW=1MHz, VBW=3MHz, where span is enough to capture the entire bandwidth, Sweep time = Auto (1001 pts), Detector = power averaging (rms), if available. Otherwise, use sample detector mode, traces 100 sweeps of video averaging. (SA-2 with the omission of procedure x, the integration with 26dB EBW bandwidth)

For U-NII-3 Band:

Set RBW=300kHz, VBW=1MHz, where span is enough to capture the entire bandwidth, Sweep time = Auto, detector = RMS or sample, traces 100 sweeps of video averaging.

In addition, measurement bandwidth of Maximum PSD is specified in 500 kHz, add 10 log (500 kHz/RBW) to the measured result.

Use the cursor on spectrum to peak search the highest level of trace

(1) Duty cycle ≥ 98% : Record the max. reading.

(2) Duty cycle < 98% : Record the max. reading and add 10 log(1/duty cycle).

Repeat above procedures until all default test channel (low, middle, and high) was complete.

Note:

For U-NII1, 2A, 2C and 3 Bands, when the antenna gain is greater than 6 dBi, the power spectral density limit attenuated accordingly.

When testing for multiple output ports in simultaneous transmission mode, the measured values of each individual output port are tested separately and then linearly summed.

The directional gain is calculated using the formula

$$Directional\ Gain = 10 \times \log \left\{ 10 \left[\frac{\left(10^{\frac{G_1}{20}} + 10^{\frac{G_2}{20}} + \dots + 10^{\frac{G_n}{20}} \right)^2}{N_{\{ant\}}} \right] \right\}$$

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6.4 Unwanted Emission

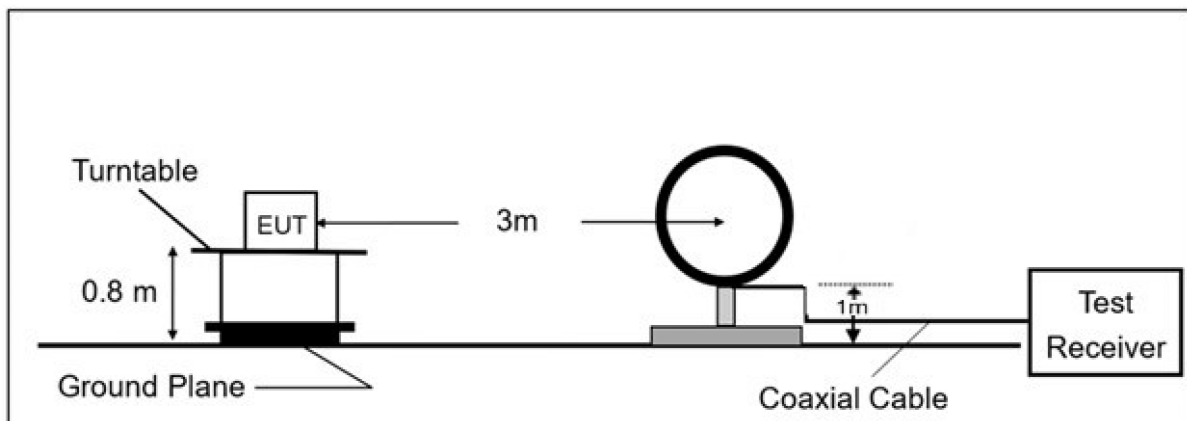
6.4.1 Radiated Emission Test Sites

For Measurements From 9 kHz To 30 MHz

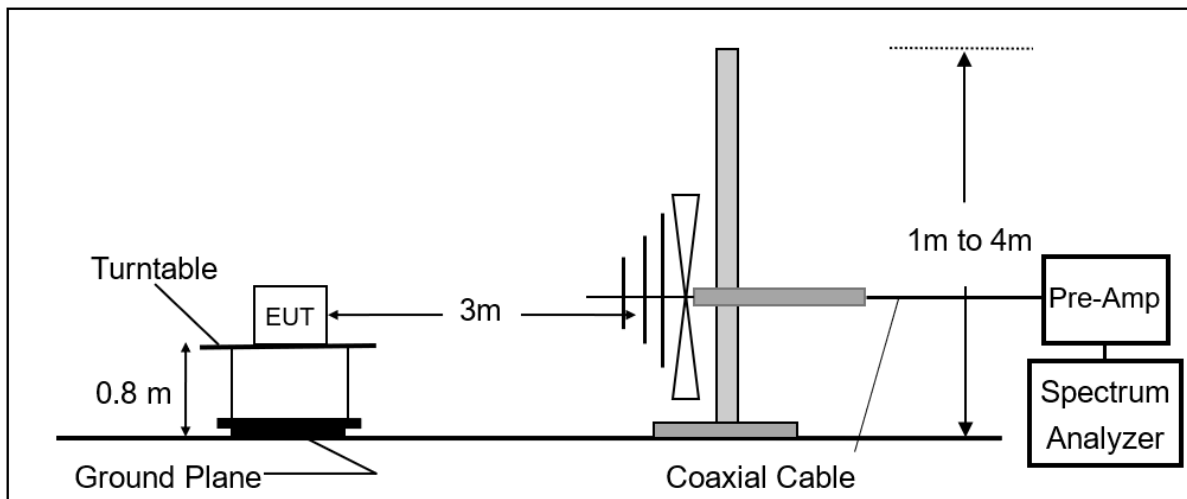
Radiated emission below 30MHz is measured in a 9m*6m*6m semi-anechoic chamber, the measurements correspond to those obtained at an open-field test site.

There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

Radiated Emission Test Set-Up, Frequency Below 30MHz.



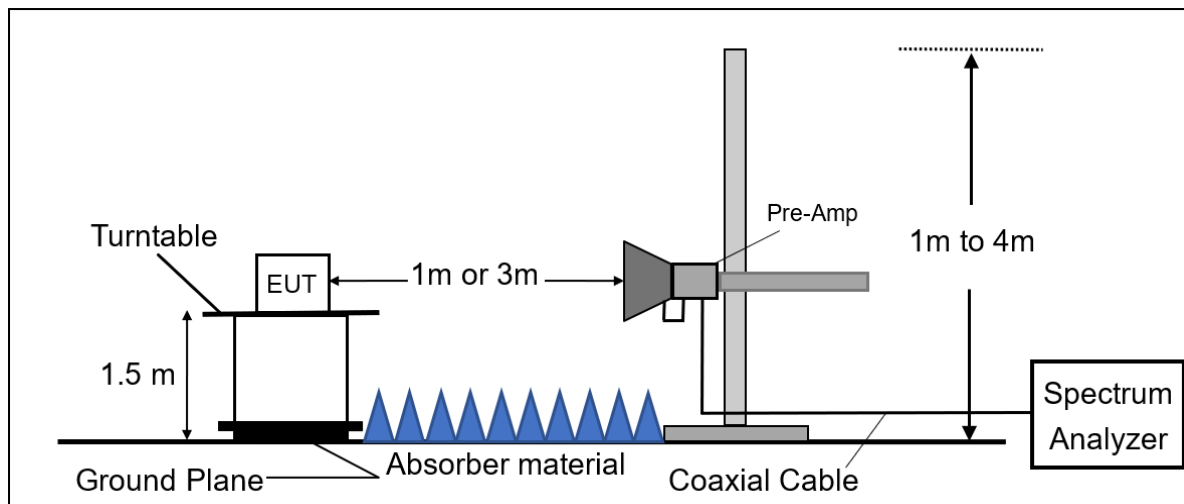
Radiated Emission Test Set-Up, Frequency From 30MHz to 1000MHz



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Radiated Emission Test Set-Up, Frequency Above 1GHz



6.4.2 Measurement Procedure

1. The testing follows FCC KDB 789033 D02.
2. The EUT was placed on a turn table with 0.8m for frequency < 1GHz and 1.5m for frequency > 1GHz above ground plane.
3. The turn table shall rotate 360 degrees to determine the position of maximum emission level.
4. EUT is set 3m away from the receiving antenna which varied from 1m to 4m to find out the highest emissions.
5. Set the spectrum analyzer as RBW=100 kHz and VBW=300 kHz for Peak Detector (PK) at frequency between 30MHz and 1 GHz.
6. Use receiver mode as RBW=120 kHz for Quasi-peak (QP) at frequency between 30MHz and 1 GHz.
7. Set the spectrum analyzer as RBW=1 MHz, VBW=3 MHz for Maximum Emission Measurements at frequency above 1 GHz.
8. Set the spectrum analyzer as RBW=1 MHz, VBW=10 Hz (Duty cycle > 98%) or VBW $\geq 1/T$ (Duty cycle < 98%) for Average Emission Measurements at frequency above 1 GHz.
9. When measurement procedures for electric field radiated emissions above 1 GHz the EUT measurement is to be made "while keeping the antenna in the 'cone of radiation' from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response." is still within the 3dB illumination BW of the measurement antenna.
10. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
11. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
12. Repeat above procedures until all frequency measured were complete.

Note: The emissions from 9 kHz to 30MHz was pre-scanned as 20dB lower than the limits, and hence not reported.

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6.4.3 Field Strength Calculation

The field strength is calculated by adding the antenna factor and cable loss, then subtracting the amplifier gain and any applicable duty cycle correction factor from the measured reading. The basic equation and an example calculation are as follows:

$$FS = RA + AF + CL - AG$$

Where:

FS = Field Strength (dB μ V/m)

RA = Reading Amplitude (dB μ V)

AF = Antenna Factor (dB/m)

CL = Cable Loss (dB)

AG = Amplifier Gain (dB)

The emission limit is expressed in dB μ V/m, which corresponds to the logarithmic conversion of $20 \times \log_{10} (\mu\text{V/m})$.

Actual Field Strength (dB μ V/m) = Spectrum Analyzer Reading (dB μ V) + Total Factor (dB)

Total Factor (dB) = Antenna Factor (dB) + Cable Loss (dB) – Preamplifier Gain (dB)

6.4.4 Test Results of Radiated Spurious Emissions from 9 kHz to 30 MHz

The low frequency range (9 kHz to 30 MHz) was pre-scanned, and the result was 20 dB below the limit; therefore, it was not reported, in accordance with 15.31(o) & RSS-GEN §6.13.2.

Pre-scan was conducted at 5.47 GHz and 5.85 GHz for band-edge measurements of straddle channels 138, 142, and 144. Since the results were 20 dB below the limit, they were not reported, in accordance with 15.31(o) & RSS-GEN §6.13.2.

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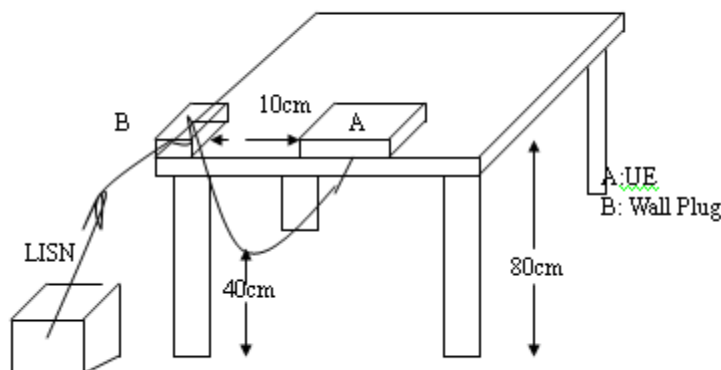
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- ## 6.6 Transmission In the Absence of Data

While the EUT is not transmitting any information, the EUT can automatically discontinue transmission and become standby mode for power saving. The EUT can detect the controlling signal of ASK message transmitting from remote device and verify whether it shall resend or discontinue transmission.

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7 TEST RESULT

7.1 Emission Bandwidth

7.1.1 FCC Occupied Bandwidth

802.11a_Ch0

Freq. (MHz)	26dB BW (MHz)	10 Log (B) (dB)
5180	19.49	12.900
5220	19.61	12.920
5240	19.75	12.960
5260	19.51	12.900
5300	19.54	12.910
5320	19.60	12.920
5500	19.27	12.850
5580	19.45	12.890
5700	19.37	12.870
5720	14.65	11.660

802.11a_Ch0

Freq. (MHz)	6dB BW (MHz)	10 Log (B) (dB)
5720	3.22	5.080
5745	16.47	12.170
5785	16.36	12.140
5825	16.56	12.190
5845(U-NII 3)	13.21	11.210
5845(U-NII 4)	3.21	5.060
5865	16.39	12.150
5885	16.39	12.150

802.11a_Ch0

Freq. (MHz)	Measured Freq. (MHz)	Limit (MHz)
5240	5248.308965	< 5250
5745	5736.321269	> 5725

802.11n_HT20_Ch0

Freq. (MHz)	26dB BW (MHz)	10 Log (B) (dB)
5180	19.81	12.970
5220	19.98	13.010
5240	19.86	12.980
5260	20.03	13.020
5300	19.84	12.980
5320	20.01	13.010
5500	19.91	12.990
5580	20.02	13.010
5700	19.84	12.980
5720	15.01	11.760

802.11n_HT20_Ch0

Freq. (MHz)	6dB BW (MHz)	10 Log (B) (dB)
5720	3.89	5.900
5745	17.57	12.450
5785	17.62	12.460
5825	17.60	12.460
5845(U-NII 3)	13.85	11.410
5845(U-NII 4)	3.85	5.850
5865	17.70	12.480
5885	17.63	12.460

802.11n_HT20_Ch0

Freq. (MHz)	Measured Freq. (MHz)	Limit (MHz)
5240	5248.833605	<5250
5745	5735.991580	>5725

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802.11n_HT20_Ch1

Freq. (MHz)	26dB BW (MHz)	10 Log (B) (dB)
5180	20.14	13.040
5220	20.06	13.020
5240	19.81	12.970
5260	20.19	13.050
5300	20.07	13.030
5320	19.91	12.990
5500	20.30	13.070
5580	19.91	12.990
5700	20.22	13.060
5720	14.99	11.760

802.11n_HT20_Ch1

Freq. (MHz)	6dB BW (MHz)	10 Log (B) (dB)
5720	3.83	5.830
5745	17.64	12.460
5785	17.60	12.460
5825	17.62	12.460
5845(U-NII 3)	13.82	11.400
5845(U-NII 4)	3.82	5.810
5865	17.62	12.460
5885	17.63	12.460

802.11n_HT20_Ch1

Freq. (MHz)	Measured Freq. (MHz)	Limit (MHz)
5240	5248.838181	<5250
5745	5736.135882	>5725

802.11n_HT40_Ch0

Freq. (MHz)	26dB BW (MHz)	10 Log (B) (dB)
5190	40.34	16.060
5230	40.09	16.030
5270	39.77	16.000
5310	39.92	16.010
5510	41.14	16.140
5550	40.09	16.030
5670	40.22	16.040
5710	35.16	15.460

802.11n_HT40_Ch0

Freq. (MHz)	6dB BW (MHz)	10 Log (B) (dB)
5710	3.18	5.020
5755	36.33	15.600
5795	35.98	15.560
5835(U-NII 3)	33.17	15.210
5835(U-NII 4)	3.17	5.000
5875	35.41	15.490

802.11n_HT40_Ch0

Freq. (MHz)	Measured Freq. (MHz)	Limit (MHz)
5230	5248.060436	<5250
5755	5736.905724	>5725

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802.11n_HT40_Ch1

Freq. (MHz)	26dB BW (MHz)	10 Log (B) (dB)
5190	39.64	15.980
5230	39.76	15.990
5270	39.81	16.000
5310	40.21	16.040
5510	39.53	15.970
5550	40.00	16.020
5670	39.80	16.000
5710	34.86	15.420

802.11n_HT40_Ch1

Freq. (MHz)	6dB BW (MHz)	10 Log (B) (dB)
5710	3.19	5.040
5755	35.72	15.530
5795	35.62	15.520
5835(U-NII 3)	32.73	15.150
5835(U-NII 4)	2.73	4.350
5875	36.27	15.600

802.11n_HT40_Ch1

Freq. (MHz)	Measured Freq. (MHz)	Limit (MHz)
5230	5248.097747	<5250
5755	5736.956268	>5725

802.11ac_VHT80_Ch0

Freq. (MHz)	26dB BW (MHz)	10 Log (B) (dB)
5210	85.87	19.340
5290	82.34	19.160
5530	82.10	19.140
5610	81.50	19.110
5690	75.59	18.780

802.11ac_VHT80_Ch0

Freq. (MHz)	6dB BW (MHz)	10 Log (B) (dB)
5690	2.26	3.540
5775	76.38	18.830
5855(U-NII 3)	32.88	15.170
5855(U-NII 4)	42.88	16.320

802.11ac_VHT80_Ch0

Freq. (MHz)	Measured Freq. (MHz)	Limit (MHz)
5210	5247.95611	<5250
5775	5737.13517	>5725

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802.11ac_VHT80_Ch1

Freq. (MHz)	26dB BW (MHz)	10 Log (B) (dB)
5210	81.00	19.080
5290	95.96	19.820
5530	80.98	19.080
5610	81.20	19.100
5690	75.43	18.780

802.11ac_VHT80_Ch1

Freq. (MHz)	6dB BW (MHz)	10 Log (B) (dB)
5690	3.18	5.020
5775	76.38	18.830
5855(U-NII 3)	33.17	15.210
5855(U-NII 4)	43.17	16.350

802.11ac_VHT80_Ch1

Freq. (MHz)	Measured Freq. (MHz)	Limit (MHz)
5210	5247.889153	<5250
5775	5737.137150	>5725

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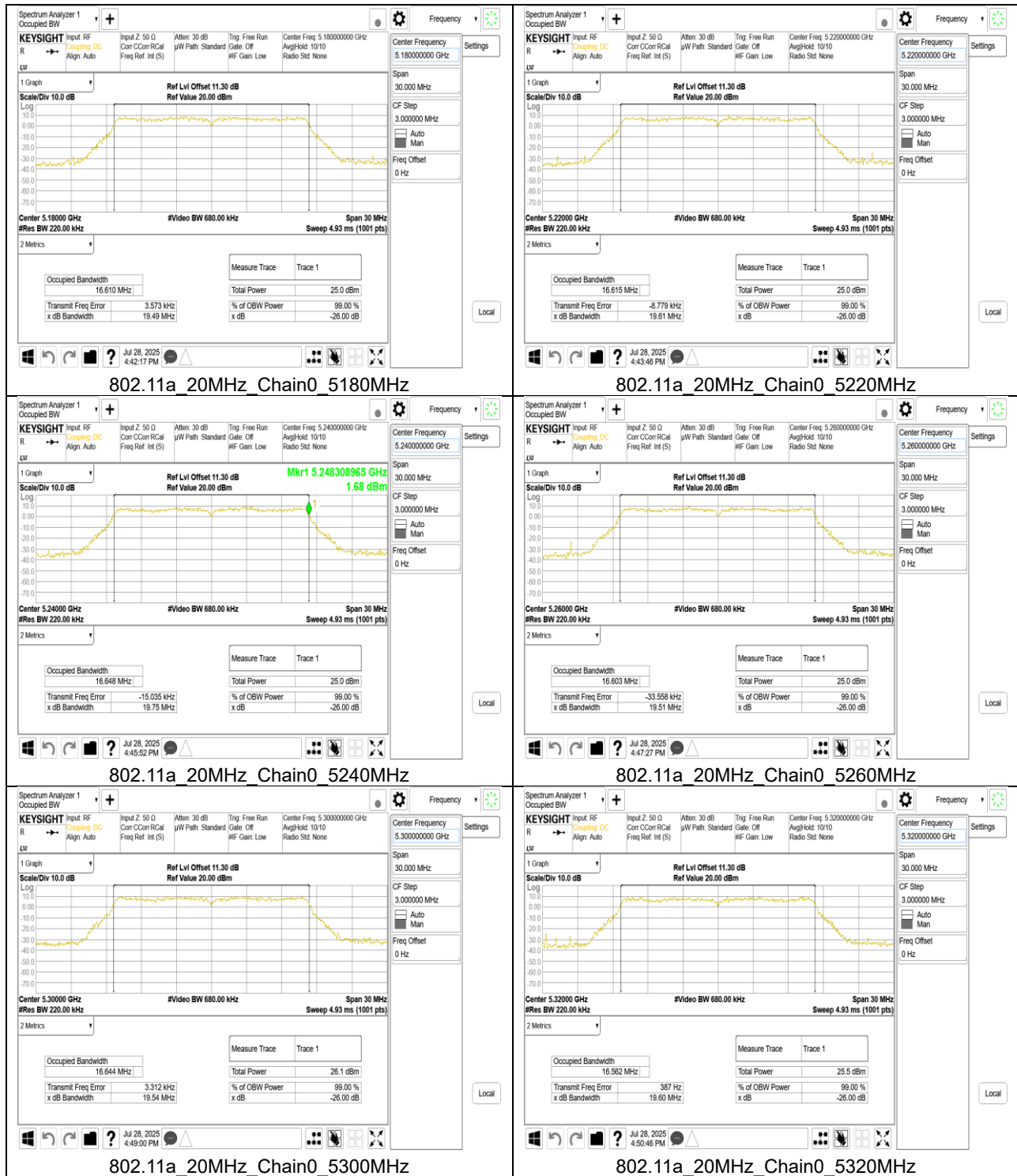
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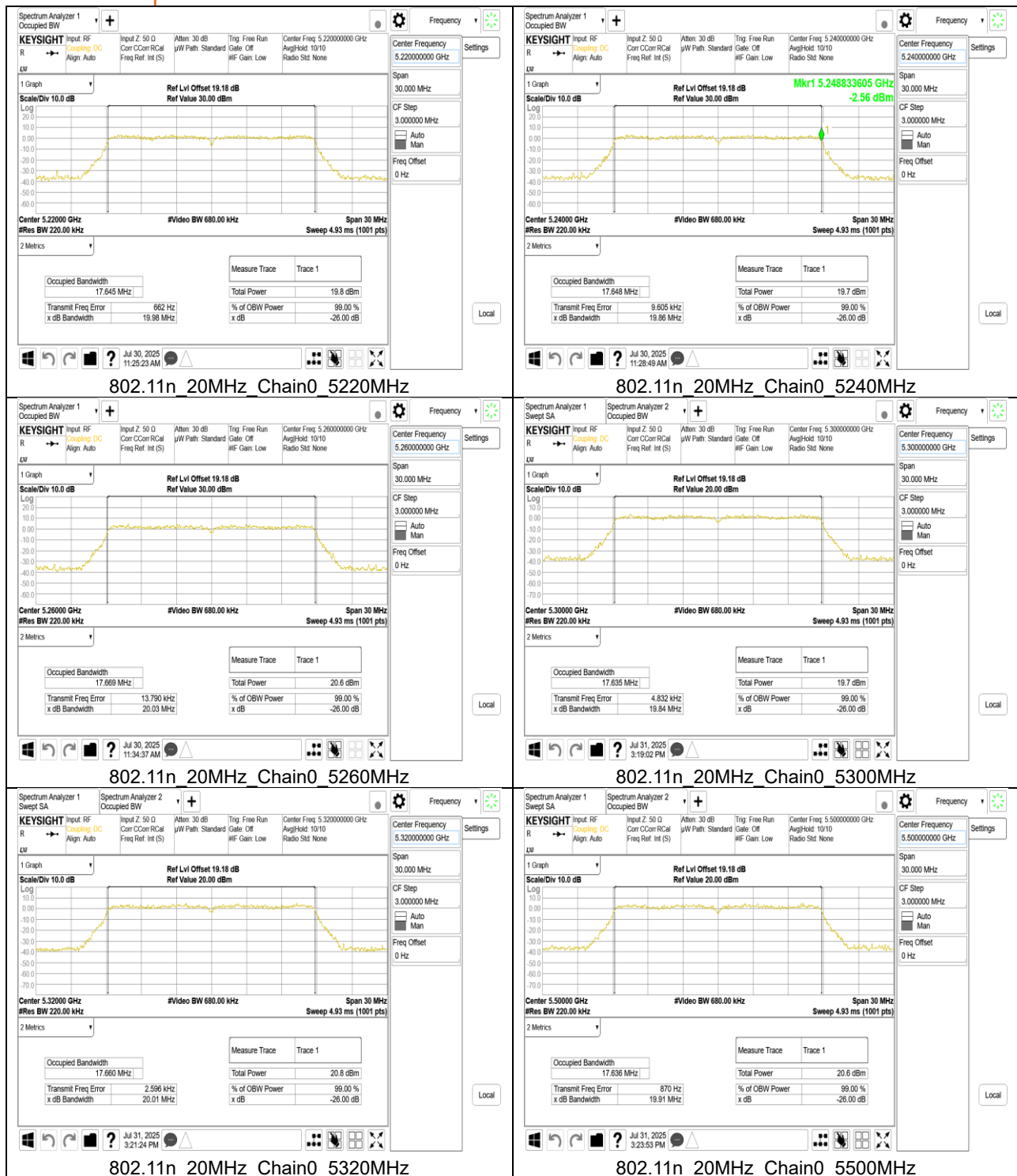
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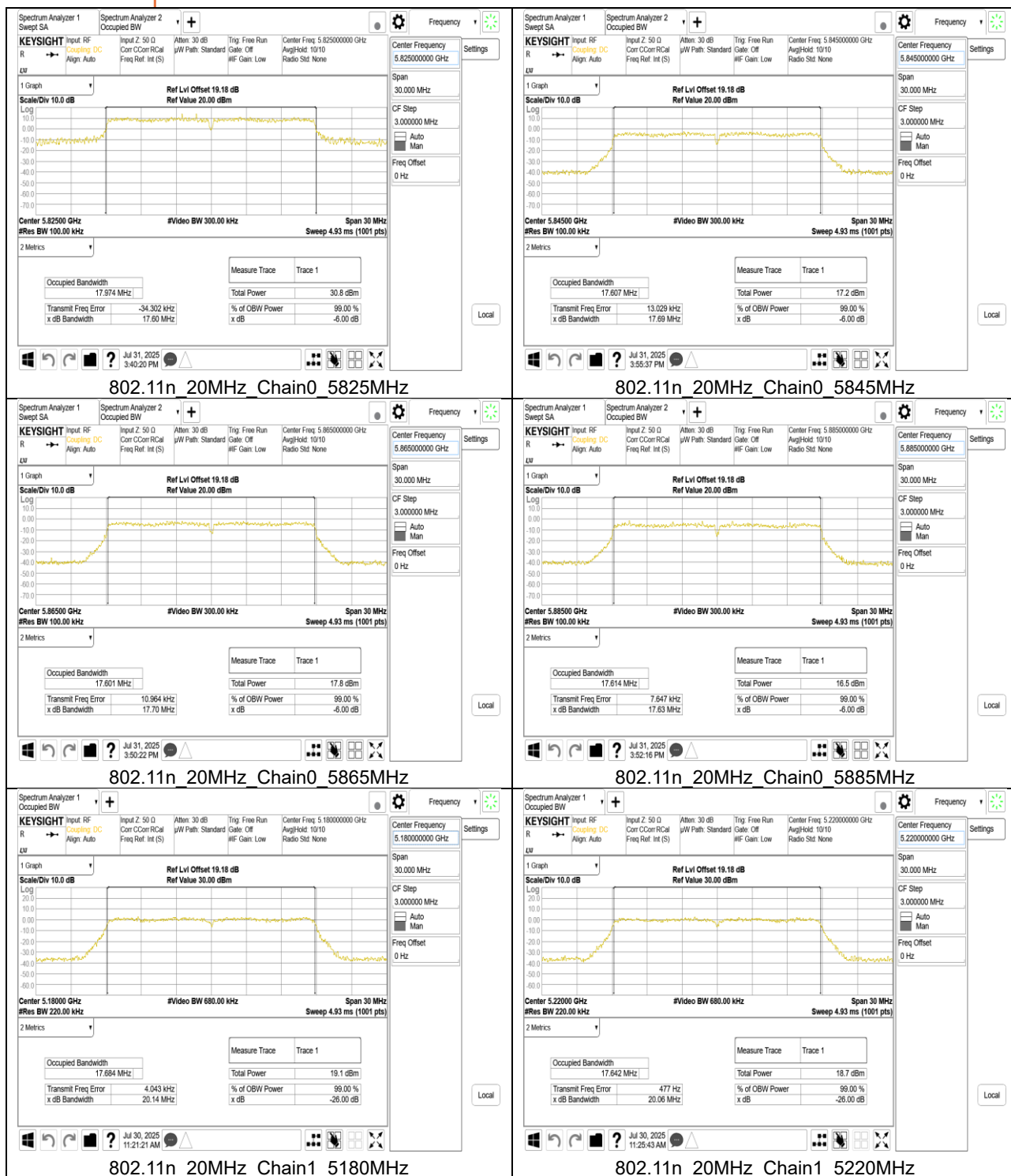
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