

Test Report

Product	Telematics unit for mounting on forklifts
Name and address of the applicant	Toyota Material Handling, Inc. 5559 Inwood Drive, Columbus IN 47201, USA
Name and address of the manufacturer	Toyota Material Handling, Inc. 5559 Inwood Drive, Columbus IN 47201, USA
Model	DHUnx
Rating	External DC supply (12-48 V _{DC})
Trademark	TOYOTA
Additional information	WiFi, BT Classic, BLE, WCDMA, LTE
Tested according to	Parts of FCC Part 15.407 Unlicensed National Information Infrastructure Devices (U-NII) Parts of ISED Canada RSS-247, Issue 3 Licence-Exempt Local Area Network (LE-LAN) Devices
Order number	PRJ0033045
Tested in period	2023-08-23 to 2023-08-29
Issue date	2023-11-20
Name and address of the testing laboratory	 Nemko Scandinavia AS Instituttveien 6 2007 Kjeller, Norway www.nemko.com CAB Number: FCC: NO0001 ISED: NO0470 ISED No: 2040D-1   An accredited technical test executed under the Norwegian accreditation scheme
 Prepared by [Frode Sveinsen]  Approved by [Jan G Eriksen]	
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Revision history

Revision	Date	Comment	Sign
A	2023-11-20	First edition	FS

GENERAL REMARKS

This report applies only to the sample(s) tested. It is the manufacturer's responsibility to ensure the additional production units of this product are manufactured with identical electrical and mechanical components. The manufacturer is solely responsible for any modifications to the product that could result in non-compliance with the relevant regulations.

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Opinions expressed within this report regarding general assessments and qualifications for PASS or FAIL to the standards limits and requirements, are not part of the current accreditation. Neither are opinions expressed regarding model variants covered by the testing of this report.

CALIBRATION

All instruments used in the tests given in this test report are calibrated and traceable to national or international standards. Between calibrations all test set-ups are controlled and verified on a regular basis by periodic checks to ensure, with 95% confidence, that the instruments remain within the calibrated levels.

MEASUREMENT UNCERTAINTY

Measurement uncertainties are calculated or considered for all instruments and instrument set-ups used during these tests. Uncertainty figures are found in a separate clause in this report.

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1 INFORMATION

1.1 Test Item

Name	Toyota
Model	DHUnx
FCC ID	2A226-TELETMH02
ISED ID	27732-TELETMH02
Serial number	202308REVC161150
Hardware identity and/or version	Rev. C
Software identity and/or version	1.3.0-Engdrop3-Gerrit7902_3-b253bde
Frequency Ranges	U-NII 1 : 5180 – 5240 MHz: 4 channels U-NII 2A : 5260 – 5320 MHz: 4 channels U-NII 2C : 5500 – 5720 MHz: 12 channels U-NII 3 : 5745 – 5825 MHz: 5 channels
Operating Modes	802.11a 802.11n (20/40 MHz BW) 802.11ac (40/80 MHz BW)
Type of Modulation	Digital (OFDM - Orthogonal frequency-division multiplexing)
Conducted Output Power	5180 – 5240 MHz: 15.1 mW 5260 – 5320 MHz: 14.5 mW 5500 – 5720 MHz: 14.8 mW 5745 – 5825 MHz: 14.5 mW
Antenna Connector	Quad MiniFakra
Antenna Type	Molex Antenna, P/N: 2144500750 (P/N is for version with 750mm cable length, longer cables may also be used) Antenna element LTE1: Rx/Tx Antenna element LTE2: Rx Only Antenna element WiFi/BT: Rx/Tx 2.4GHz WiFi/BT/BLE and 5GHz WiFi Antenna element GNSS: Rx Only GNSS/GPS
Antenna Diversity Supported	Not for WiFi
Smart Antennas Supported	No
TPC Supported	Not implemented. Not required when EIRP is below 500 mW
DFS Supported	Client Device without Radar Detection
Ad-hoc Mode	EUT does not support Ad-hoc Mode in DFS bands
Hotspot Mode	EUT does not support Hotspot Mode in DFS bands
Power Source	External DC Supply (12-48V _{DC} , supplied through MX23 connector)
Interfaces	MX23 Connector HSD Connector (100TX Ethernet)

Description of Test Item

The EUT is a telematics unit with radio modules for BT/BLE/WiFi and Mobile (WCDMA and LTE). Both radio modules are certified radio modules. The EUT also contains a GPS receiver.

This test report covers only additional radiated tests for the new antennas.

1.2 Normal test conditions

Temperature:	20 - 24 °C
Relative humidity:	20 - 50 %
Normal test voltage:	24V DC (2x 12V lead acid batteries, Fiamm FG20451)

The EUT was powered from two fully charged batteries during all tests.

The values are the limit registered during the test period.

1.3 Test Engineer

Frode Sveinsen

1.4 Antenna Requirement

Does the EUT have detachable antenna(s)?	☒ YES	☐ NO
If detachable, is the antenna connector(s) non-standard?	☒ YES	☐ NO
Antenna Connector: Quad MiniFakra		

Requirement: FCC 15.203, 15.204

1.5 Worst-Case Configuration

Radiated Emissions and Power Line Conducted Emissions were performed with the EUT set to transmit at the channel with the highest output power as worst-case scenario.

1.6 EUT Operating Modes

Description of operating modes	Continuous TX, 5 GHz 20/40/80 MHz Mode
Additional information	EUT was controlled from a computer and programmed with the Qualcomm Test App.

1.7 Radio Modules

Data for radio modules				
Manufacturer	Model No	Identification	Original Test Report	Technology
Quectel	AF20	FCC ID: XMR202303AF20 IC: 10224A-202306AF20	TA R2212A1318-R2V1	BT Classic
			TA R2212A1318-R1V1	BT Low Energy
			TA R2212A1318-R1V1	WLAN
			TA R2212A1318-R3V1	UNII 2TX
			TA R2212A1318-R4V1	DFS
Quectel	AG35-NA	FCC ID: XMR201905AG35NA IC: 10224A-2019AG35NA	Sporton FG912203A Sporton FG180602A	WCDMA
			Sporton FG912203B Sporton FG180602B	LTE

GSM850/GSM1900 (2G) is disabled in this product.

1.8 EUT Power Levels

Power Index								
Channel	802.11a	802.11n HT20	802.11ac VHT20	Channel	802.11n HT40	802.11ac HT40	Channel	802.11ac HT80
036	12	12	12	038	10	12.5	042	9
040	12	12	12	046	12.5	12.5	058	10
048	12	12	12	054	12.5	12.5	106	11
052	12	12	12	062	10.5	12.5	122	11
060	12	12	12	102	9	12.5	155	11
064	12	12	12	110	12.5			
100	11	10	12	118	12.5	12.5		
104	12	12		134	12.5	12.5		
120	12	12	12	151	12.5	12.5		
136	12	12		159	12.5	12.5		
140	10	10	12					
151	12	12	12					
157	12	12	12					
165	12	12	12					

1.9 Comments

The measurements were done with the EUT powered from fully charged batteries.

All ports were populated during spurious emission measurements.

This test report covers only selected tests for new antennas, all other tests are covered by the original Test Reports.

2 TEST REPORT SUMMARY

2.1 General

All measurements are traceable to national standards.

The tests were conducted for demonstrating compliance with FCC CFR 47 Part 15, paragraph 15.407 and ISED Canada RSS-247 Issue 3.

Tests were performed in accordance with ANSI C63.4-2014 and ANSI C63.10-2013.

Radiated tests were performed in a semi-anechoic chamber at measuring distances of 1m and 3m.

☒ New Submission	☒ Production Unit
☐ Class II Permissive Change	☐ Pre-production Unit
NII Equipment Code	☐ Family Listing

2.2 Test Summary

Name of test	FCC Part 15 reference	RSS-247 Issue 3 RSS-GEN Issue 5 reference	Result
Supply Voltage Variations	15.31(e)	6.11 (RSS-GEN)	Complies
Antenna Requirement	15.203	6.8 (RSS-GEN)	Complies
Power Line Conducted Emission	15.107(a) 15.207(a)	7.2 / 8.8 (RSS-GEN)	N/A
Maximum Output Power	15.407(a)	6.2	Complies
Power Spectral Density	15.407(a)	6.2	N/T
Emission Bandwidth	15.407(a)(2)	6.2	N/T
Unwanted Emissions	15.407(b)	6.2	Complies
Discontinuation of Transmission	15.407(c)	6.3	N/T ¹
6 dB Bandwidth	15.407(e)	6.2.4	N/T
Transmit Power Control	15.407(h)	6.2.3	N/A ²
Dynamic Frequency Selection	15.407(h)	6.3	N/T ³
Radiated Emissions	15.205 15.209	3.3 7.3 (RSS-GEN) 8.9 (RSS-GEN)	Complies

¹ See manufacturers declaration

² Transmit Power Control is not required when Max EIRP is below 500 mW

³ The EUT is a Client Device without Radar Detection.

3 TEST RESULTS

3.1 Maximum Output Power, EIRP

FCC 15.407 (a)

ISED Canada RSS-247, Issue 3, Clause 6.2

Measurement procedure: ANSI C63.10-2013 Clause 12.3, method SA-1

Test Results: Complies

Measurement Data:

Ch. No.	Nominal Frequency (MHz)	Maximum Field Strength (dBµV/m)		Maximum e.i.r.p. (dBm)	
		802.11a	802.11n HT20	802.11a	802.11n HT20
36	5180	100.9	100.7	5.7	5.5
64	5320	104.9	101.7	9.7	6.5
100	5500	98.5	96.3	3.3	1.1
136	5680	100.6	100.4	5.4	5.2
140	5700	97.3	97.1	2.1	1.9
149	5745	99.1	98.9	3.9	3.7
157	5785	100.5	100.4	5.3	5.2
165	5825	98.5	98.3	3.3	3.1
Ch. No.	Nominal Frequency (MHz)	Maximum Field Strength (dBµV/m)		Maximum e.i.r.p. (dBm)	
		802.11n HT40	802.11ac VHT80	802.11n HT40	802.11ac VHT80
38	5190	99.6		4.4	
46	5230	101.2		6.0	
54	5270	101.9		6.7	
62	5310	99.5		4.3	
102	5510	97.4		2.2	
110	5550	100.3		5.1	
118	5590	100.0		4.8	
134	5670	100.4		5.2	
151	5755	99.1		3.9	
159	5795	98.9		3.7	
42	5210		97.8		2.6
58	5290		99.0		3.8
106	5530		98.2		3.0
122	5610		98.4		3.2
155	5775		97.9		2.7

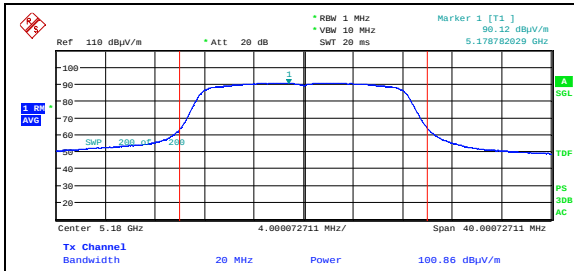
The EUT operates continuously; therefore, method SA-1 of ANSI C63.10-2013 clause 12.3 was used.

EIRP values were calculated from Field Strength values using the method described in KDB 412172 D01.

This is an indoor device with directional Antenna Gain less than 6 dBi.

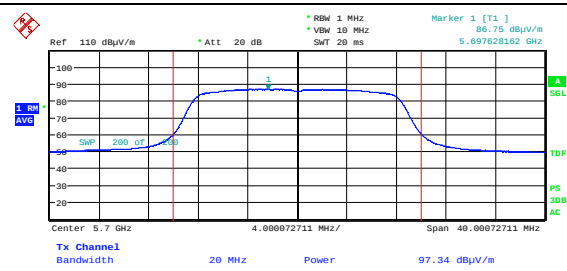
Limits for Indoor Device:

Frequency Band	FCC 15.407(a)	ISED RSS-247 Issue 2
5150 – 5250 MHz	Less than 250 mW (24 dBm) for client device Less than 1 W (30 dBm) for master device	Less than the lesser of 200 mW e.i.r.p. or $10 + 10 \log_{10} B$ dBm e.i.r.p.
5250 – 5350 MHz	Less than the lesser of 250 mW (24 dBm) or $11 + 10 \log_{10} B$ dBm	Less than the lesser of 250 mW or $11 + 10 \log_{10} B$ dBm, and Less than the lesser of 1 W e.i.r.p. or $17 + 10 \log_{10} B$ dBm e.i.r.p. Devices with e.i.r.p. greater than 500 mW shall implement TPC in order to have the capability to operate at least 6 dB below the maximum permitted e.i.r.p. of 1 W
5470 – 5725 MHz		
5725 – 5825 MHz	Less than 1 Watt	Less than 1 Watt If Antenna Gain is more than 6 dBi the Power Limit is reduced by the amount exceeding 6 dBi
	If Antenna Gain is more than 6 dBi the Power Limit is reduced by the amount exceeding 6 dBi	
	B is the 26dB emission bandwidth in MHz	B is the 99% emission bandwidth in MHz



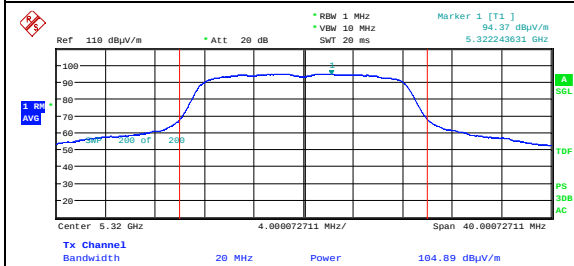
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Maximum EIRP, Ch036, 802.11a, 6M



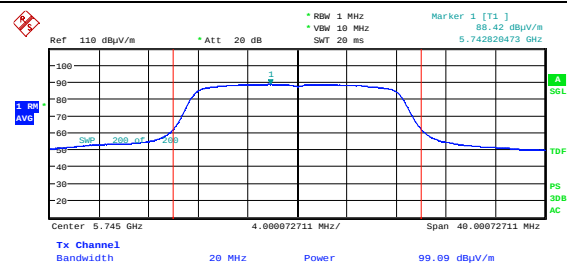
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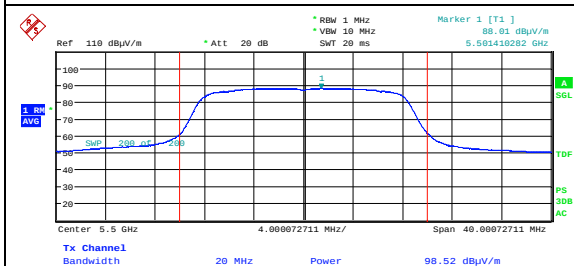
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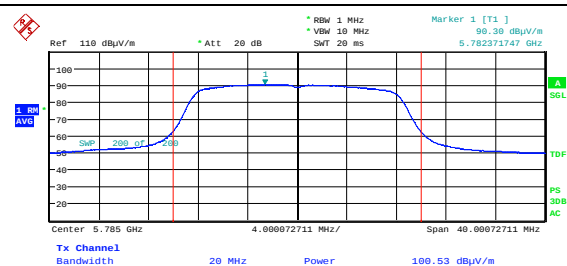
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Maximum EIRP, Ch149, 802.11a, 6M



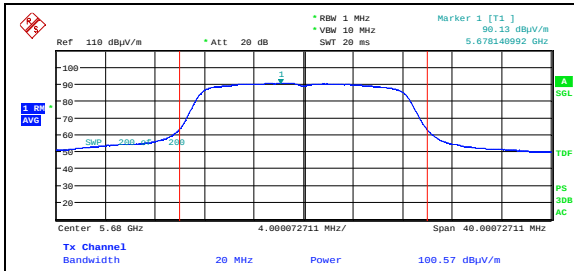
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Maximum EIRP, Ch100, 802.11a, 6M



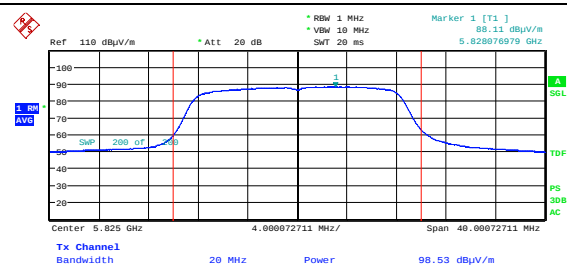
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Maximum EIRP, Ch157, 802.11a, 6M



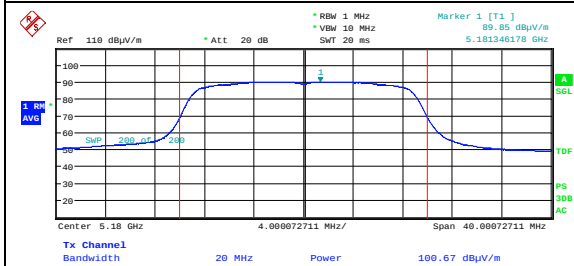
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Maximum EIRP, Ch136, 802.11a, 6M



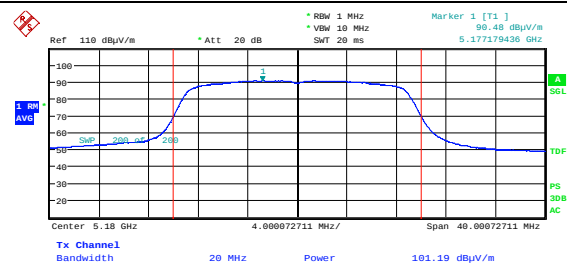
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Maximum EIRP, Ch165, 802.11a, 6M



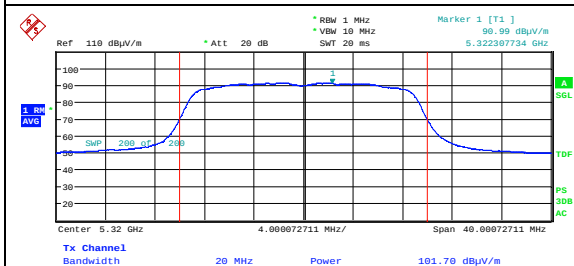
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Maximum EIRP, Ch036, 802.11n, HT20, MCS0



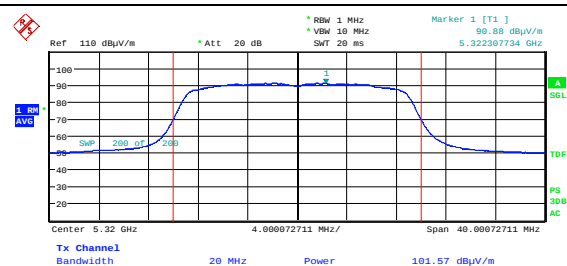
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Maximum EIRP, Ch036, 802.11ac, VHT20, MCS0



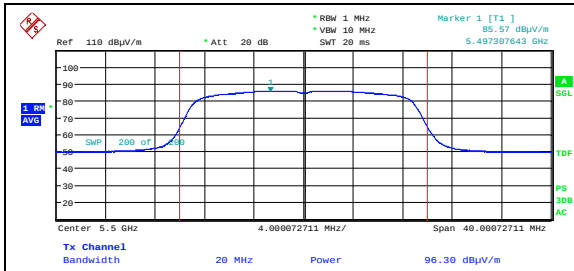
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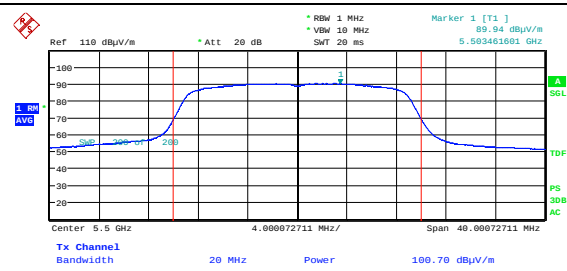
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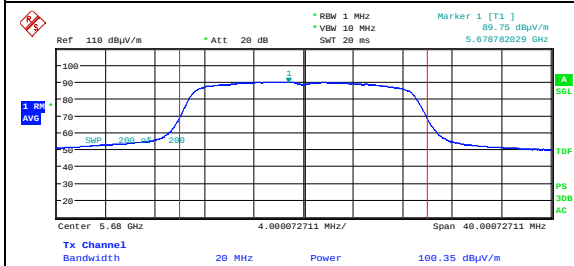
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Maximum EIRP, Ch100, 802.11n, HT20, MCS0 PL10



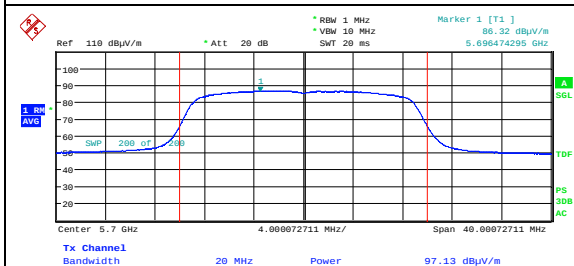
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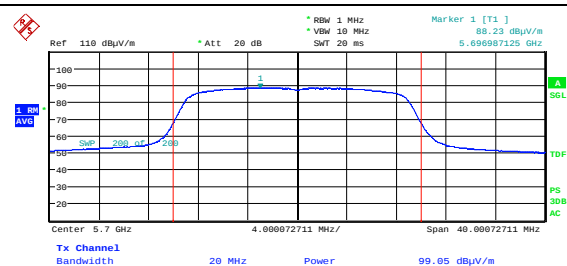
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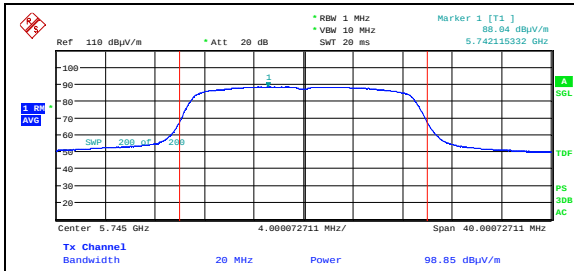
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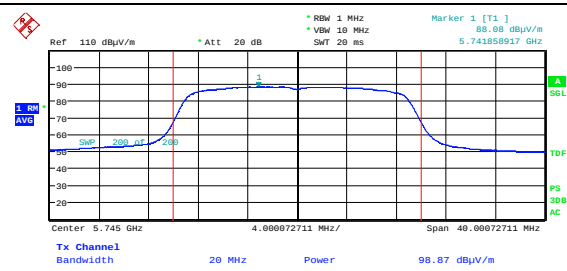
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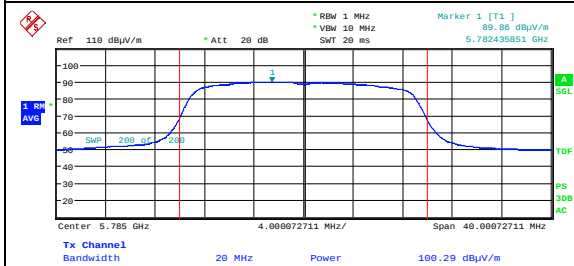
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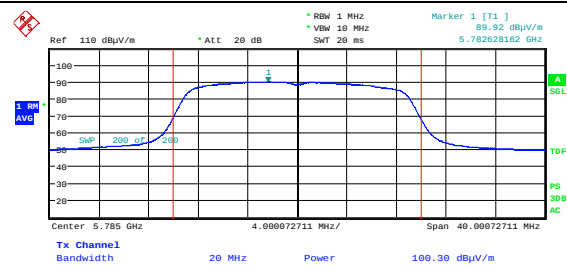
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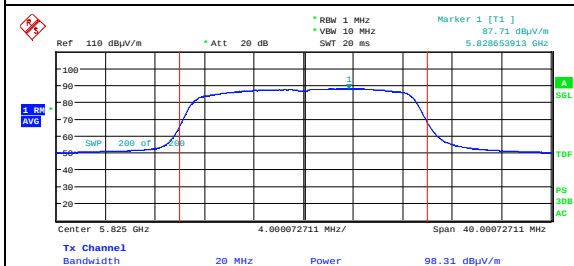
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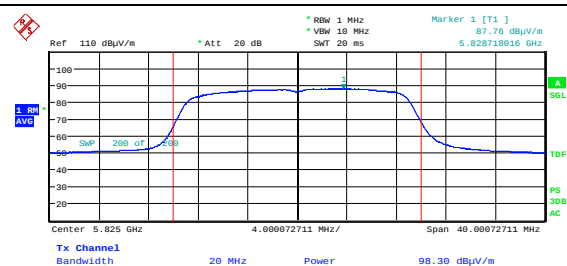
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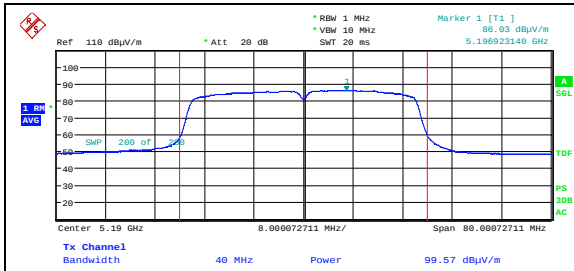
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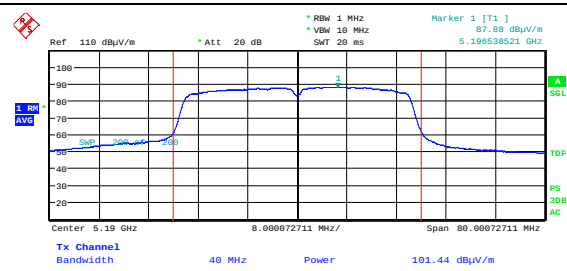
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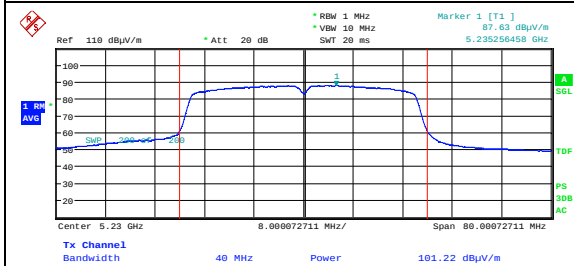
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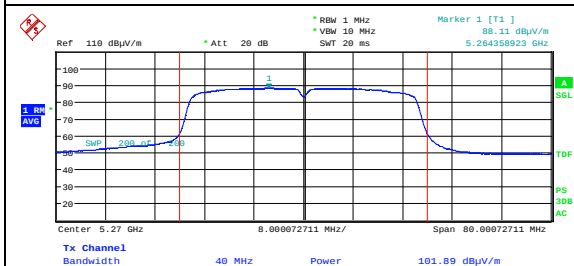
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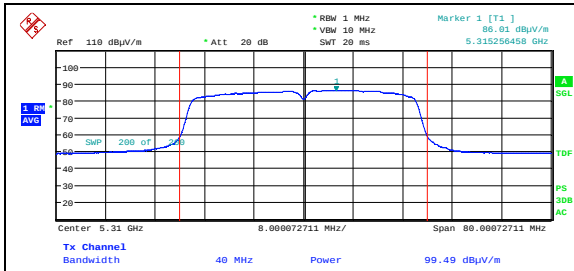
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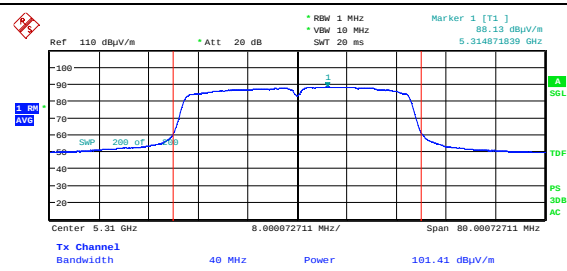
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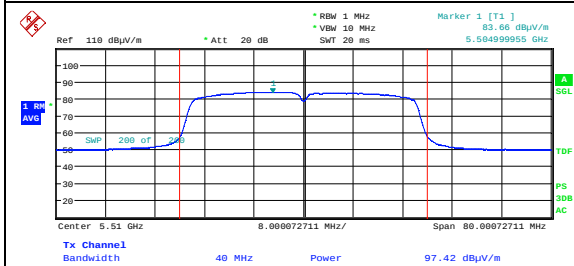
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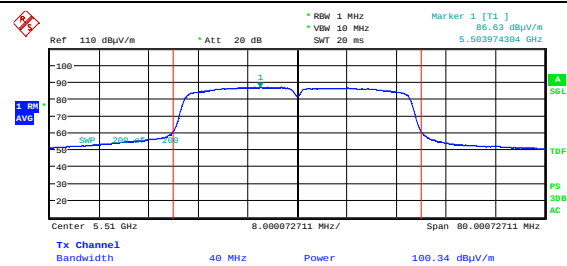
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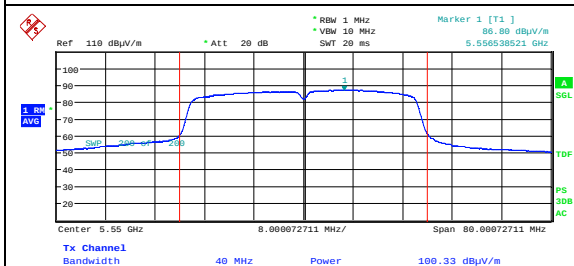
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Maximum EIRP, Ch102, 802.11n, HT40, MCS0 PL9



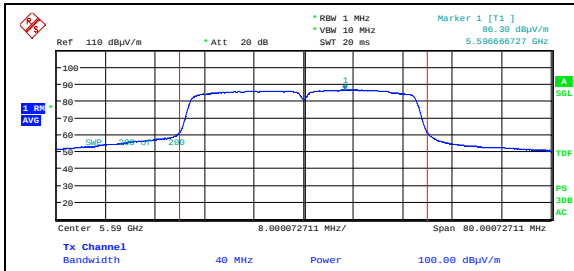
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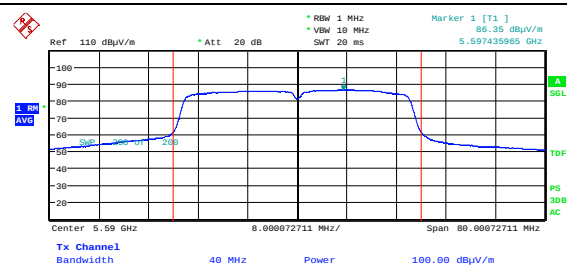
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Maximum EIRP, Ch110, 802.11n, HT40, MCS0



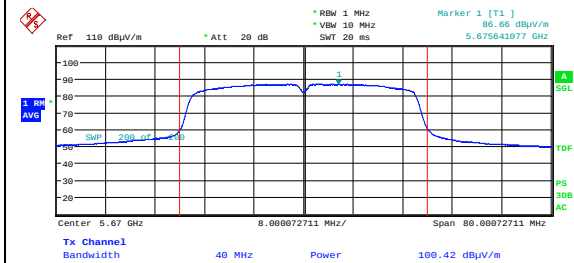
Date: 24.AUG.2023 11:06:06

Maximum EIRP, Ch118, 802.11n, HT40, MCS0



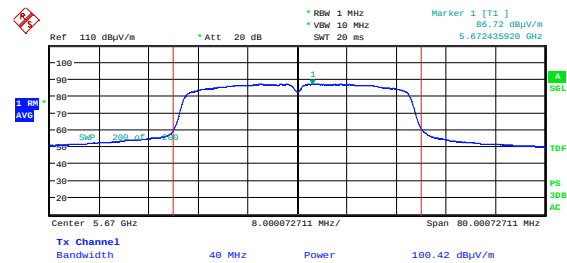
Date: 24.AUG.2023 11:07:14

Maximum EIRP, Ch118, 802.11ac, VHT40, MCS0



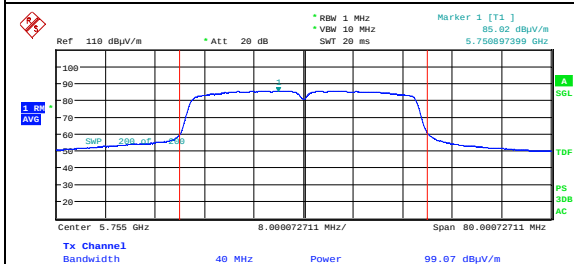
Date: 24.AUG.2023 11:03:23

Maximum EIRP, Ch134, 802.11n, HT40, MCS0



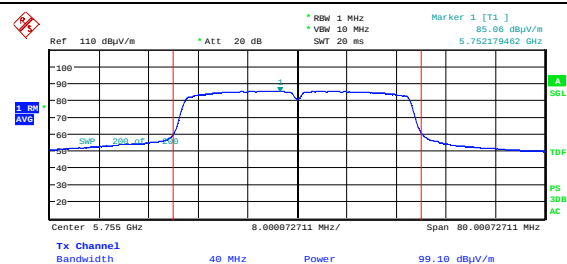
Date: 24.AUG.2023 11:01:44

Maximum EIRP, Ch134, 802.11ac, VHT40, MCS0



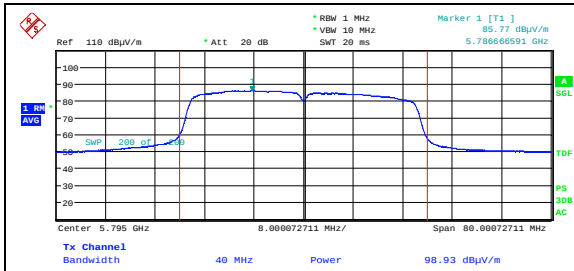
Date: 24.AUG.2023 10:55:45

Maximum EIRP, Ch151, 802.11n, HT40, MCS0



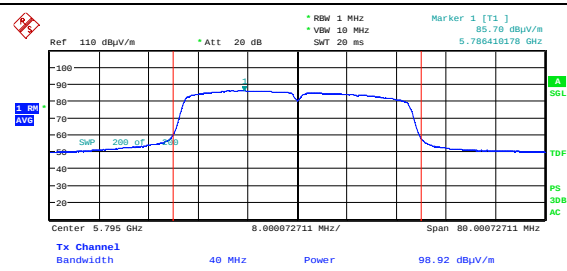
Date: 24.AUG.2023 10:53:10

Maximum EIRP, Ch151, 802.11ac, VHT40, MCS0



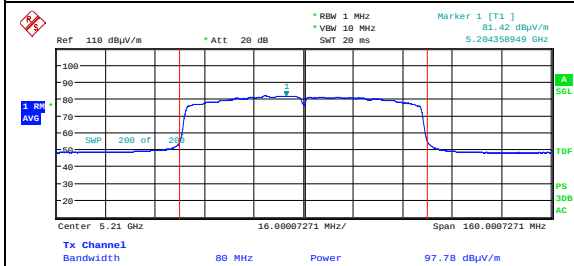
Date: 24.AUG.2023 10:47:47

Maximum EIRP, Ch159, 802.11n, HT40, MCS0



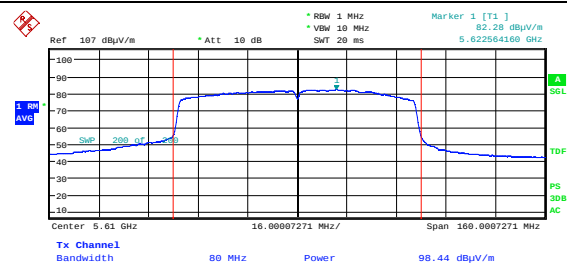
Date: 24.AUG.2023 10:49:38

Maximum EIRP, Ch159, 802.11ac, VHT40, MCS0



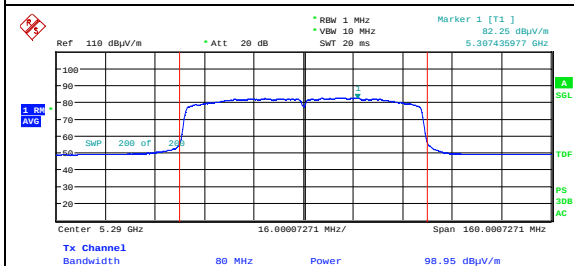
Date: 24.AUG.2023 12:20:48

Maximum EIRP, Ch042, 802.11ac, VHT80, MCS0 PL9



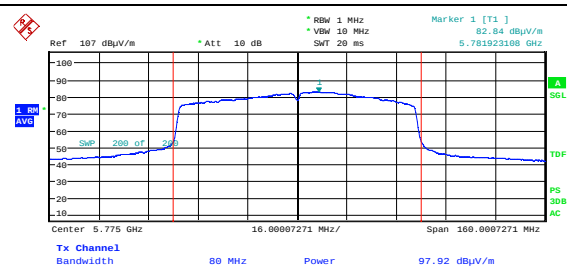
Date: 24.AUG.2023 12:38:11

Maximum EIRP, Ch122, 802.11ac, VHT80, MCS0



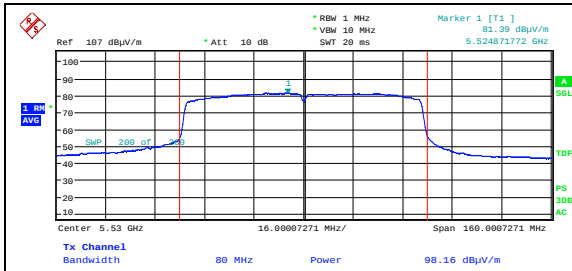
Date: 24.AUG.2023 12:26:28

Maximum EIRP, Ch058, 802.11ac, VHT80, MCS0 PL10



Date: 24.AUG.2023 12:44:26

Maximum EIRP, Ch155, 802.11ac, VHT80, MCS0



Date: 24.AUG.2023 12:33:49

Maximum EIRP, Ch106, 802.11ac, VHT80, MCS0

3.2 Unwanted Emissions

FCC 15.407 (b)

ISED Canada RSS-247, Issue 3, clause 6.2

Measurement procedure: ANSI C63.10-2013 Clause 12.7

Test Results: Complies

Measurement Data:

Band Edge Emissions:

Ch. No.	Carrier Freq (MHz)	Band Edge Freq (MHz)	Measured Values (dBm/MHz e.i.r.p.)			
			11a 6M	11n HT20 MCS0	11n HT40 MCS0	11ac VHT80 MCS0
36	5180	5150	-32.6	-32.9		
64	5320	5350	-33.2	-33.2		
100	5500	5470	-35.3	-36.2		
140	5700	5725	-32.6	-34.4		
149	5745	5650	<-37	<-37		
149	5745	5700	<-35	<-35		
165	5825	5875	<-35	<-35		
165	5825	5925	<-37	<-37		
38	5190	5150			-32.6	
62	5310	5350			-32.9	
102	5510	5470			-34.9	
134	5670	5725			-35.6	
151	5755	5650			<-37	
151	5755	5700			<-35	
159	5795	5875			<-35	
159	5795	5925			<-37	
42	5210	5150				-37.6
58	5290	5350				-35.5
106	5530	5470				-37.0
122	5610	5725				-40.6
155	5775	5650				<-37
155	5775	5700				<-35
155	5775	5875				<-35
155	5775	5925				<-37

The measurement was performed radiated.

EIRP values were calculated from field strength using the method in KDB 412172 D01.

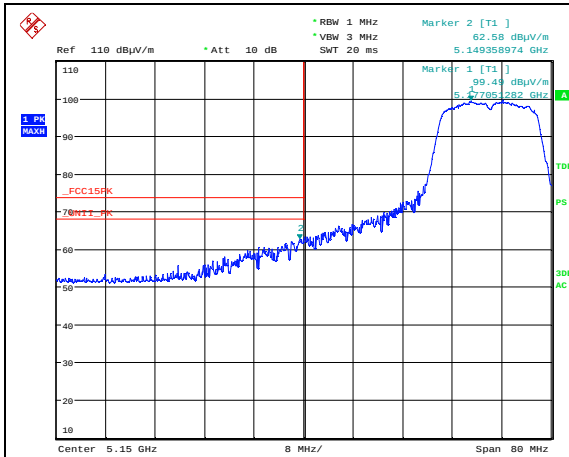
The tested equipment is for indoor use only, no band-edge requirements apply at 5250 MHz.

A 10 dB attenuator was used before the preamp for all Band Edge measurements.

Limits:

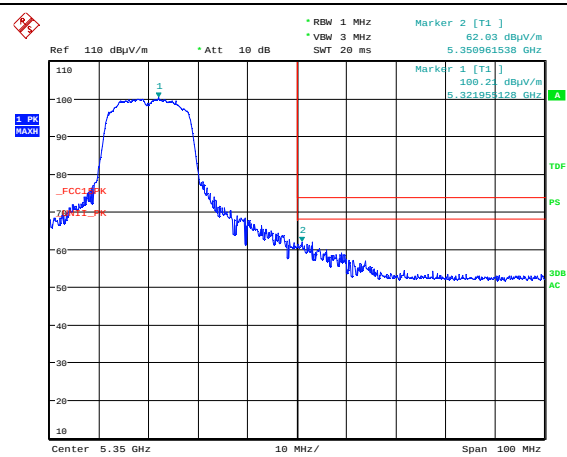
Operating Frequency band	Limit for Emissions Outside Operating Frequency Band
5150 – 5250 MHz	-27 dBm/MHz e.i.r.p.
5250 – 5350 MHz	-27 dBm/MHz e.i.r.p.
5470 – 5725 MHz	-27 dBm/MHz e.i.r.p.
5725 – 5825 MHz	See FCC 15.407(b)(4)(i) or 15.407(b)(4)(ii)

Devices operating in the 5.25-5.35 GHz band that generate emissions in the 5.15-5.25 GHz band must meet all applicable technical requirements for operation in the 5.15-5.25 GHz band (including indoor use) or alternatively meet an out-of-band emission EIRP limit of -27 dBm/MHz in the 5.15-5.25 GHz band.



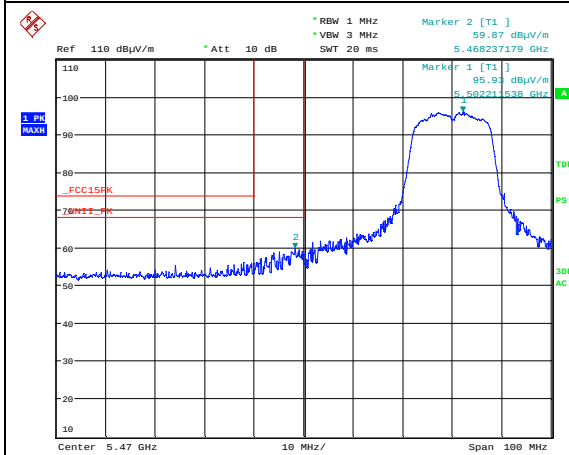
Date: 23.AUG.2023 16:32:19

Band Edge 5150 MHz, ch036, 802.11a 6M, Max



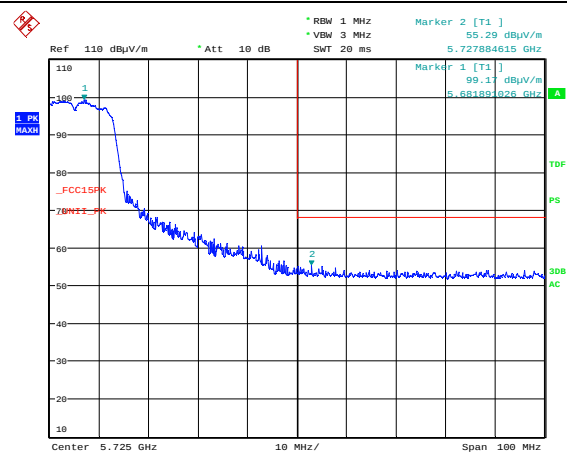
Date: 24.AUG.2023 09:21:45

Band Edge 5350 MHz, ch064, 802.11a 6M, Max



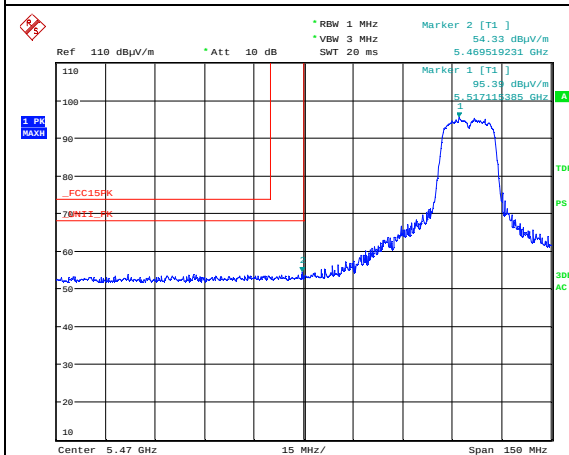
Date: 24.AUG.2023 09:40:47

Band Edge 5470 MHz, ch100, 802.11a 6M, Max



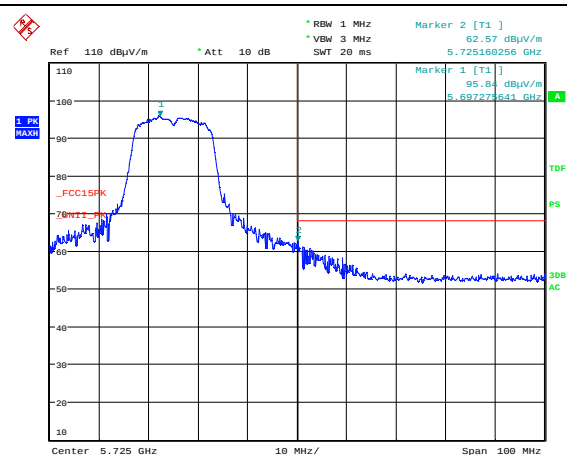
Date: 24.AUG.2023 09:58:02

Band Edge 5725 MHz, ch136, 802.11a 6M, Max



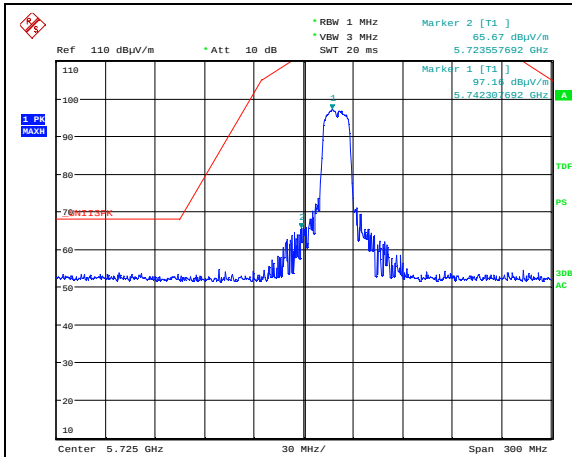
Date: 24.AUG.2023 09:51:20

Band Edge 5470 MHz, ch104, 802.11a 6M, Max PL10



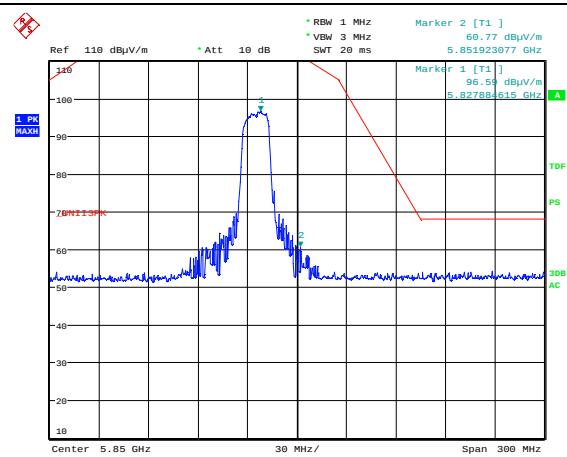
Date: 24.AUG.2023 10:03:17

Band Edge 5725 MHz, ch140, 802.11a 6M, Max PL10



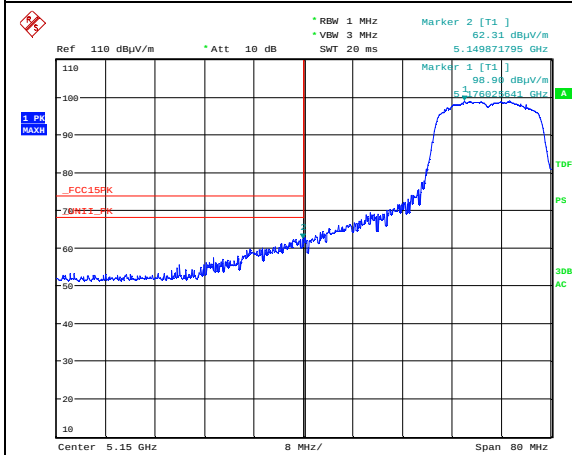
Date: 24.AUG.2023 10:25:52

Band Edge 5725MHz, ch149, 802.11a 6M, Max



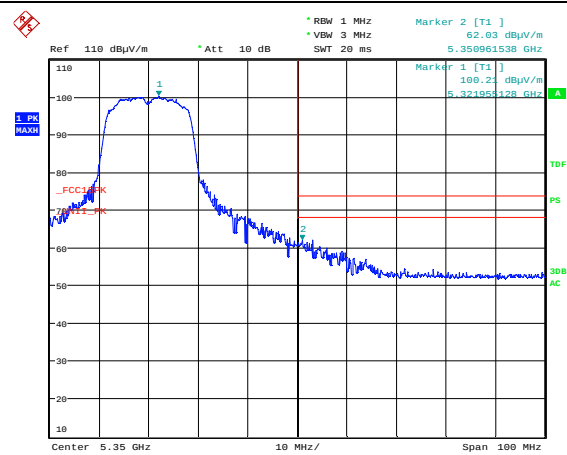
Date: 24.AUG.2023 10:42:26

Band Edge 5850MHz, ch165, 802.11a 6M, Max



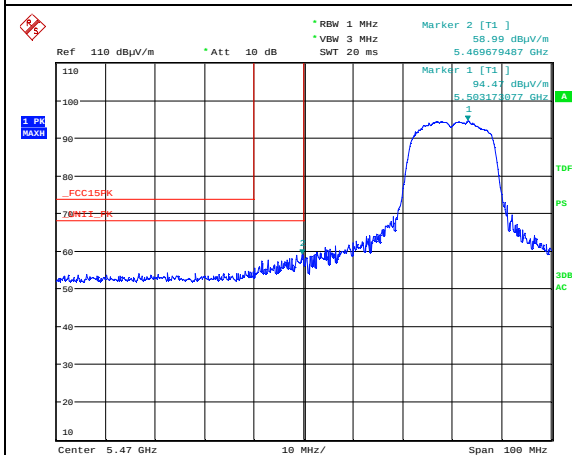
Date: 23.AUG.2023 16:41:25

Band Edge 5150 MHz, ch036, 802.11n MCS0, Max



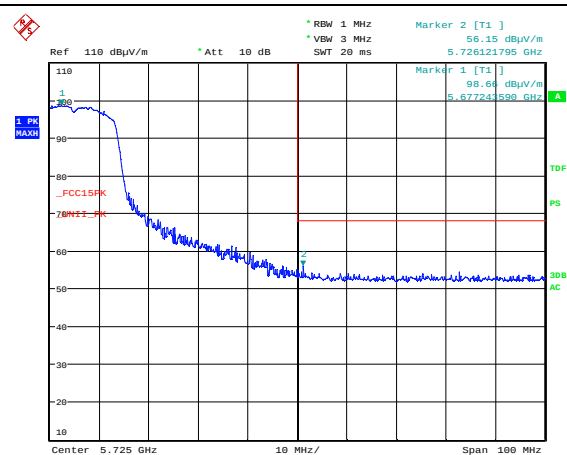
Date: 24.AUG.2023 09:21:45

Band Edge 5350MHz, ch064, 802.11n MCS0, Max



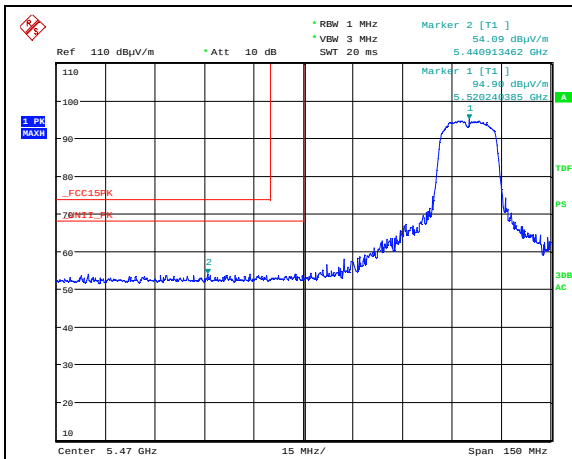
Date: 24.AUG.2023 09:43:56

Band Edge 5470MHz, ch100, 802.11n MCS0, Max PL10



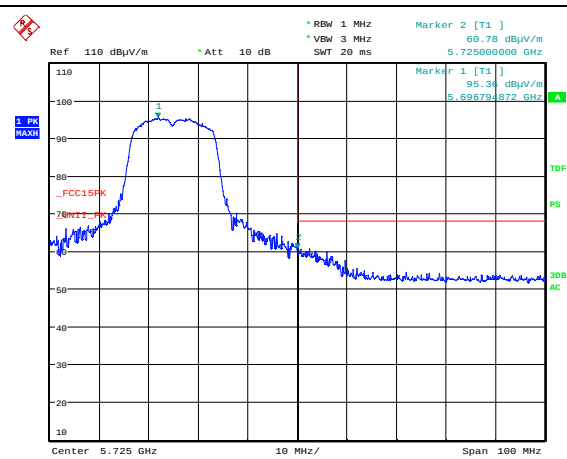
Date: 24.AUG.2023 09:59:41

Band Edge 5725MHz, ch136, 802.11n MCS0, Max



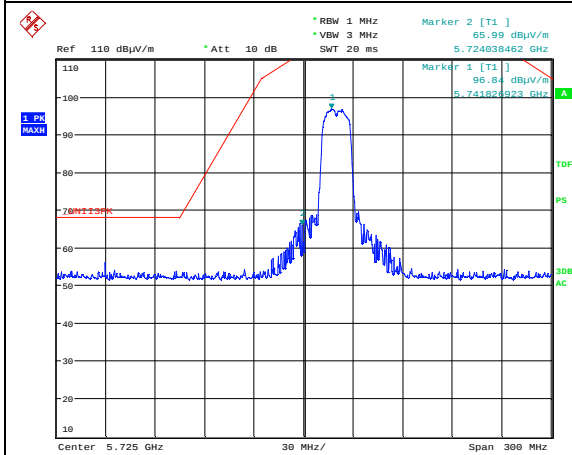
Date: 24.AUG.2023 09:49:12

Band Edge 5470 MHz, ch104, 802.11n MCS0, Max



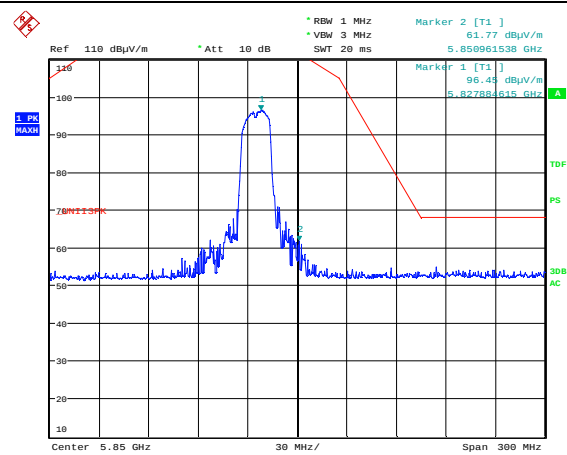
Date: 24.AUG.2023 10:01:20

Band Edge 5725 MHz, ch140, 802.11n MCS0, Max PL10



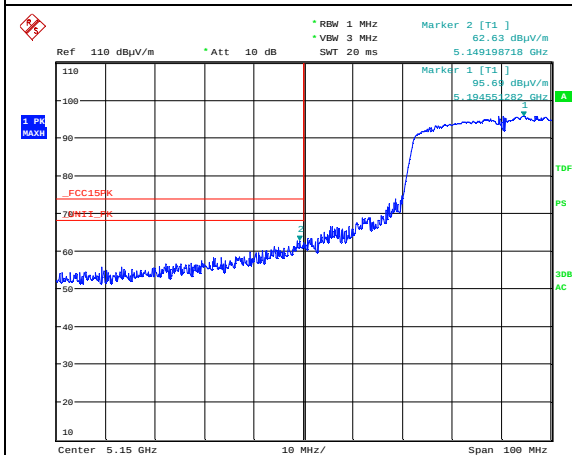
Date: 24.AUG.2023 10:27:43

Band Edge 5725 MHz, ch149, 802.11n MCS0, Max



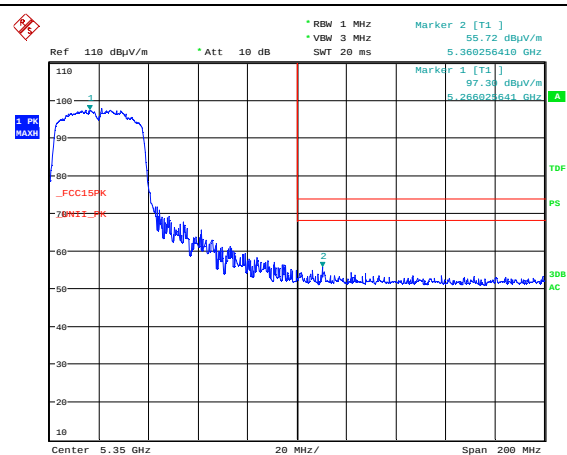
Date: 24.AUG.2023 10:40:40

Band Edge 5850 MHz, ch165, 802.11n MCS0, Max



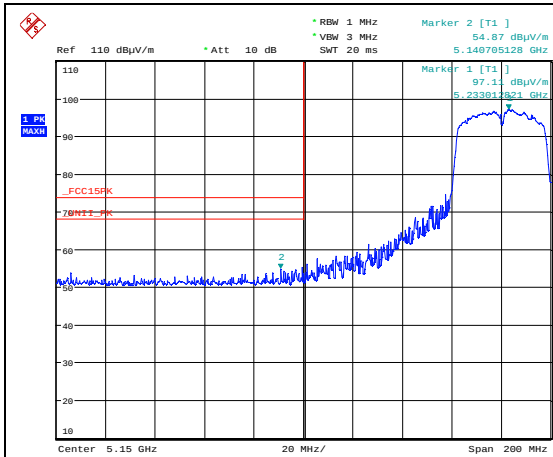
Date: 24.AUG.2023 12:14:12

Band Edge 5150 MHz, ch038, 802.11n HT40 MCS0, Max



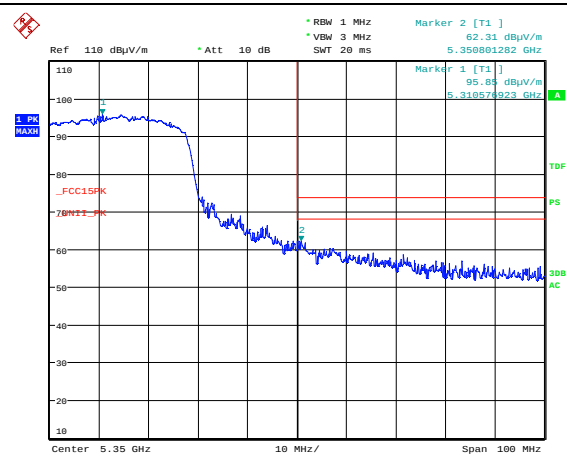
Date: 24.AUG.2023 12:04:21

Band Edge 5350 MHz, ch054, 802.11n HT40 MCS0, Max



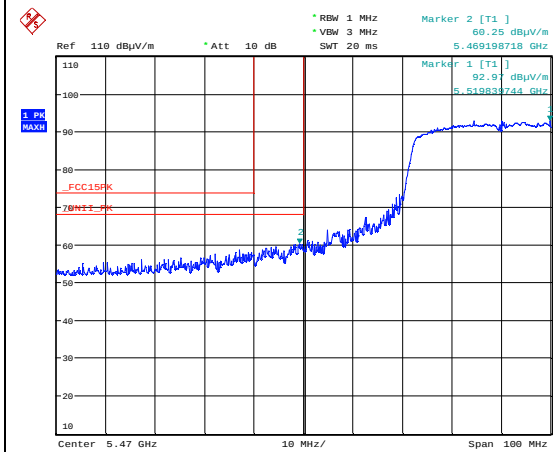
Date: 24.AUG.2023 12:08:52

Band Edge 5150 MHz, ch046, 802.11n HT40 MCS0, Max



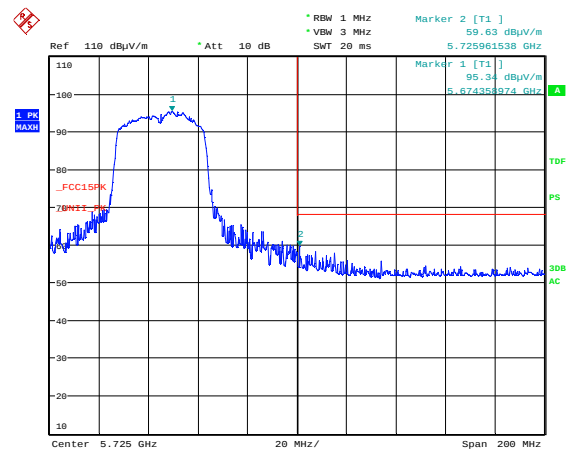
Date: 24.AUG.2023 12:00:03

Band Edge 5350 MHz, ch062, 802.11n HT40 MCS0, Max



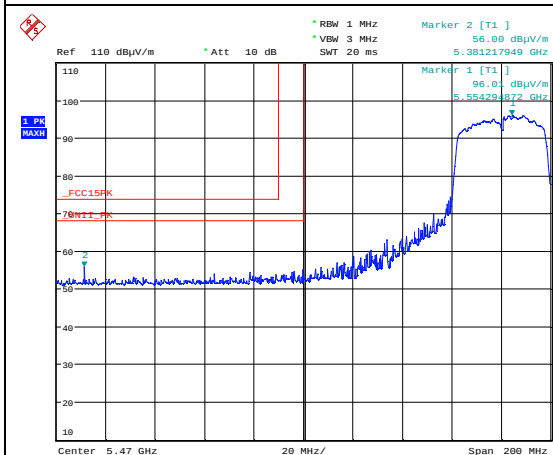
Date: 24.AUG.2023 11:14:30

Band Edge 5470 MHz, ch102, 802.11n HT40 MCS0, Max PL9



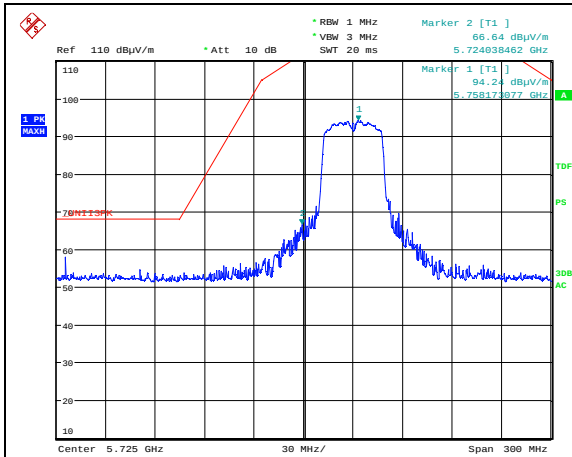
Date: 24.AUG.2023 10:58:22

Band Edge 5725 MHz, ch134, 802.11n HT40 MCS0, Max



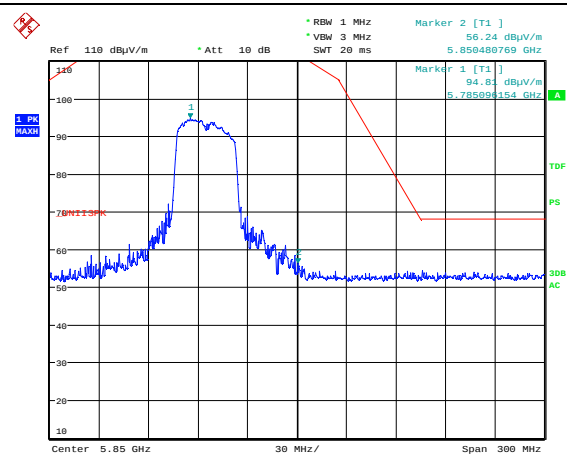
Date: 24.AUG.2023 11:10:56

Band Edge 5470 MHz, ch110, 802.11n HT40 MCS0, Max



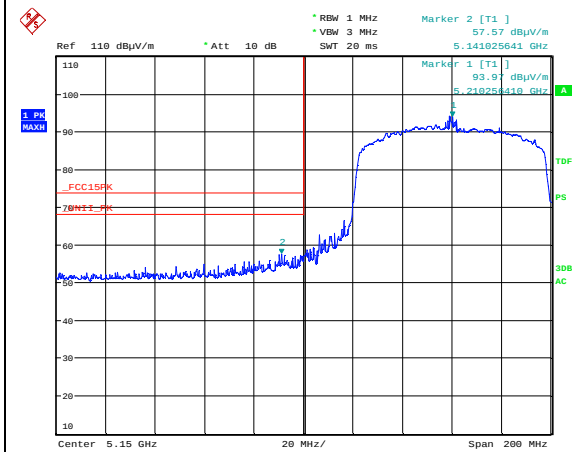
Date: 24.AUG.2023 10:56:31

Band Edge 5725 MHz, ch151, 802.11n HT40 MCS0, Max



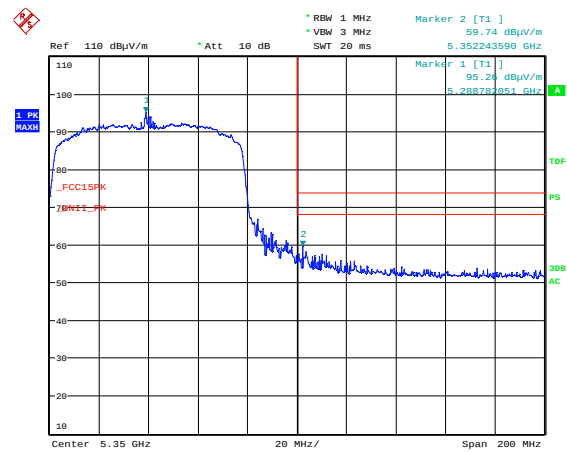
Date: 24.AUG.2023 10:48:33

Band Edge 5850 MHz, ch159, 802.11n HT40 MCS0, Max



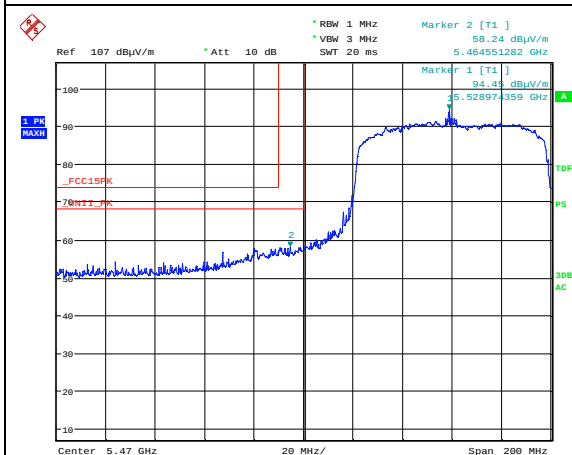
Date: 24.AUG.2023 12:21:34

Band Edge 5150 MHz, ch042, 802.11ac VHT80 MCS0, Max



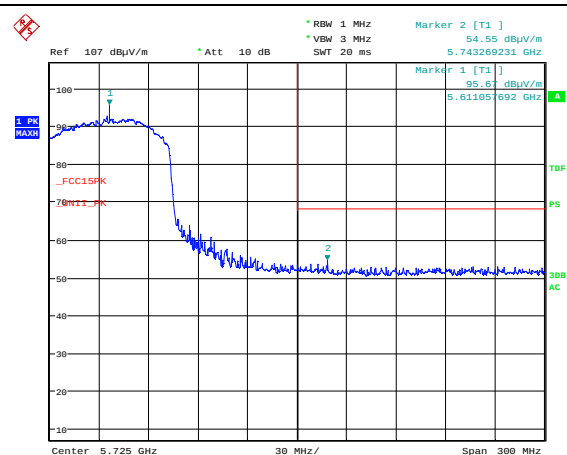
Date: 24.AUG.2023 12:27:14

Band Edge 5350 MHz, ch058, 802.11ac VHT80 MCS0, Max



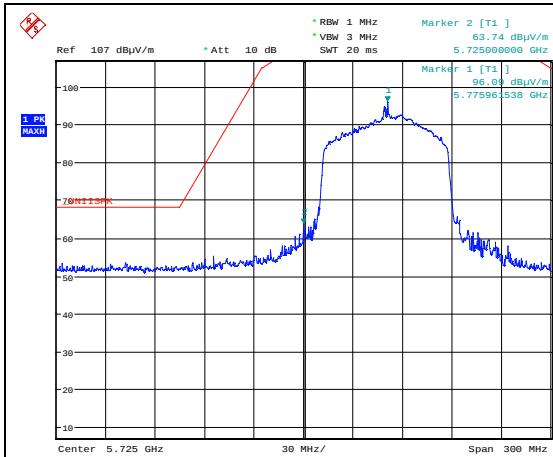
Date: 24.AUG.2023 12:34:35

Band Edge 5470 MHz, ch106, 802.11ac VHT80 MCS0, Max



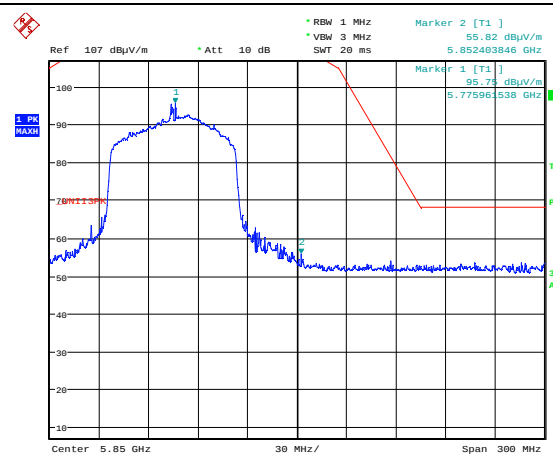
Date: 24.AUG.2023 12:38:57

Band Edge 5725 MHz, ch122, 802.11ac VHT80 MCS0, Max



Date: 24.AUG.2023 12:45:12

Band Edge 5725 MHz, ch155, 802.11ac VHT80 MCS0, Max



Date: 24.AUG.2023 12:47:48

Band Edge 5850 MHz, ch155, 802.11ac VHT80 MCS0, Max

3.3 Restricted Bands of operation

Restricted Bands of operation for FCC and ISSED are defined in FCC Part 15.205 and ISSED Canada RSS-GEN, Issue 5 clause 8.10.

Generally, no fundamentals are allowed in the restricted bands and all emissions must comply with the limits in FCC 15.209 or RSS-GEN, Issue 5, clause 8.9.

FCC (MHz)	ISED (MHz)	FCC (GHz)	ISED (GHz)
0.090-0.110		0.96-1.24 1.3-1.427	0.96-1.427
0.495-0.505		1.435-1.6265	
2.1735-2.1905		1.6455-1.6465	
	3.020-3.026	1.660-1.710	
4.125-4.128		1.7188-1.7222	
4.17725-4.17775		2.2-2.3	
4.20725-4.20775		2.31-2.39	
	5.677-5.683	2.4835-2.5	
6.215-6.218		2.69-2.9	2.655-2.9
6.26775-6.26825		3.26-3.267	
6.31175-6.31225		3.332-3.339	
8.291-8.294		3.3458-3.358	
8.362-8.366		3.6-4.4	3.5-4.4
8.37625-8.38675		4.5-5.15	
8.41425-8.41475		5.35-5.46	
12.29-12.293		7.25-7.75	
12.51975-12.52025		8.025-8.5	
12.57675-12.57725		9.0-9.2	
13.36-13.41		9.3-9.5	
16.42-16.423		10.6-12.7	
16.69475-16.69525		13.25-13.4	
16.80425-16.80475		14.47-14.5	
25.5-25.67		15.35-16.2	
37.5-38.25		17.7-21.4	
73-74.6		22.01-23.12	
74.8-75.2		23.6-24.0	
108-121.94 123-138	108-138	31.2-31.8	
149.9-150.05		36.43-36.5	
156.52475-156.52525		Above 38.6	
156.7-156.9			
162.0125-167.17			
167.72-173.2			
240-285			
322-335.4			
399.9-410			
608-614			

Frequencies in **Bold** text are specific for FCC or ISSED, all other frequencies are common.

3.4 Radiated Emissions, 30 – 1000 MHz

FCC 15.205, 15.209, 15.407

ISED Canada RSS-GEN, Issue 5, Clause 8.9

Measurement procedure: ANSI C63.10-2013 Clause 12.7

Test Results: Complies

Measurement Data:

Detector: QuasiPeak (Peak for Pre-Scan)

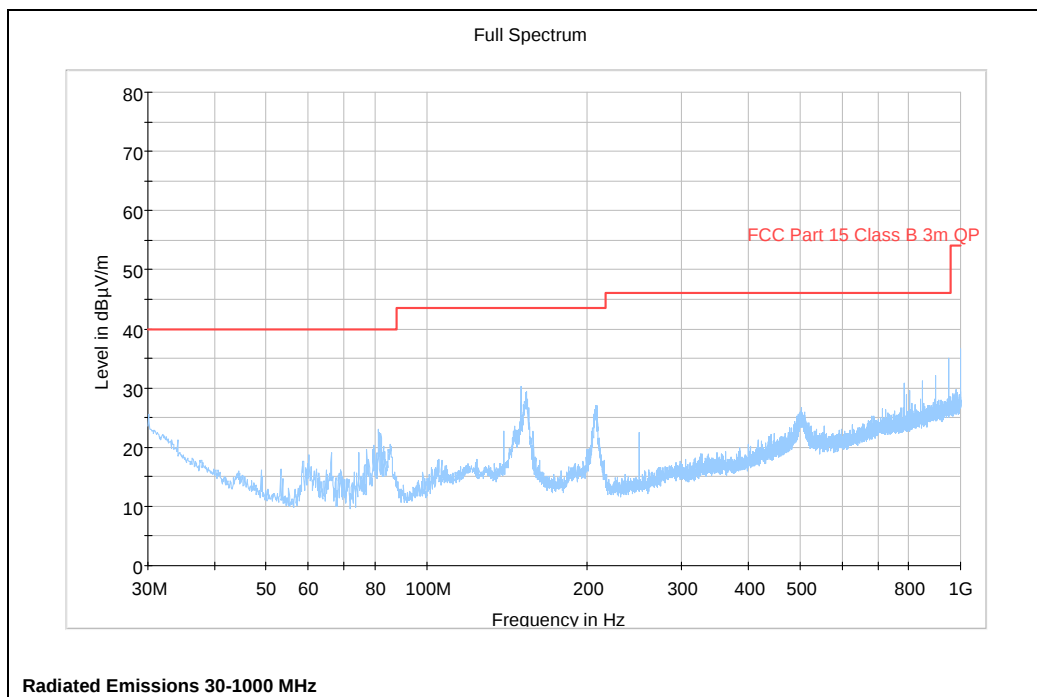
Measuring distance 3m

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
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See attached plots.

Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, Clause 8.9 @ frequencies defined in clause 8.10	
Frequency	Radiated emission limit @3 meters	
30 – 88 MHz	100 µV/m	40.0 dBµV/m
88 – 216 MHz	150 µV/m	43.5 dBµV/m
216 – 960 MHz	200 µV/m	46.0 dBµV/m
960 – 1000 MHz	500 µV/m	54.0 dBµV/m
	Limits above are with Quasi Peak Detector	



3.5 Radiated Emissions, 1 – 40 GHz

FCC 15.205, 15.209, 15.407

ISED Canada RSS-GEN, Issue 5, Clause 8.9

Measurement procedure: ANSI C63.10-2013 Clause 12.7

Test Results: Complies

Measurement Data:

Measuring distance 3m up to 18 GHz, 1m above 18 GHz.

RBW/VBW = 1MHz/3MHz

Worst Carrier Frequency (MHz)	Spurious Frequency (GHz)	Modulation	Measured Emissions (dBμV/m)		Limit (dBμV/m)		Margin (dB)	
			Peak	Average	Peak	Average	Peak	Average
Any	5150	Any	62.6	43.0	74	54	11.4	11.0
Any	5350	Any	62.3	43.4	74	54	11.7	10.6
Any	5460	Any	58.2	45.1	74	54	15.8	8.9
Any	Any	Any	< 56	< 46	74	54	>18	>8

Band Edge values with Peak Detector are reported in clause 3.2.

Band Stop Filters were used for measurements from 1 to 18 GHz that were not at the Band Edge.

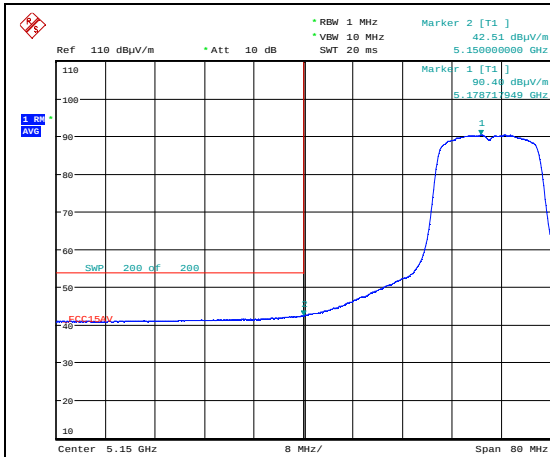
A 10 dB attenuator was used before the preamp for all Band Edge measurements.

Antenna factor, amplifier gain and cable loss are included in Spectrum Analyzer "Transducer factor".

See attached plots.

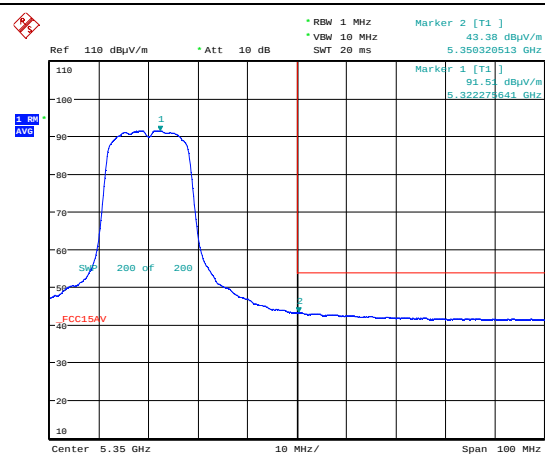
Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, Clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency	Average Detector (dBμV/m)	Peak Detector (dBμV/m)
1 – 40 GHz	54.0	74.0



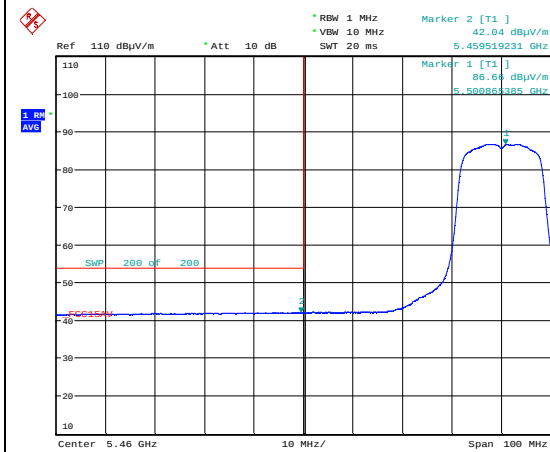
Date: 23.AUG.2023 16:32:47

Band Edge 5150MHz, ch036, 802.11a 6M, Max, AV



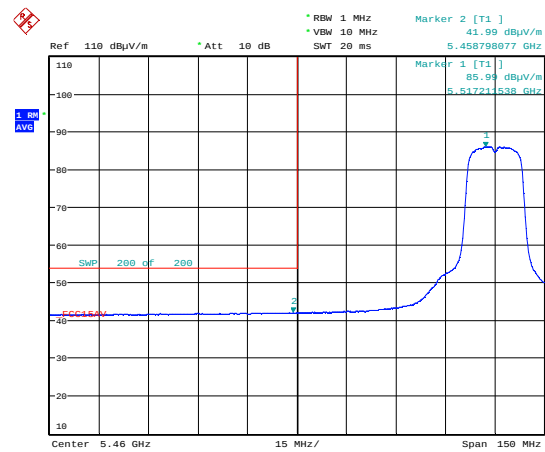
Date: 24.AUG.2023 09:15:18

Band Edge 5350MHz, ch064, 802.11a 6M, Max, AV



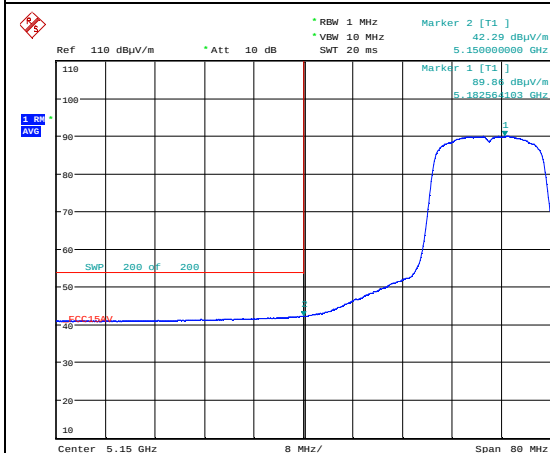
Date: 24.AUG.2023 09:41:10

Band Edge 5460 MHz, ch100, 802.11a 6M, Max, AV PL11



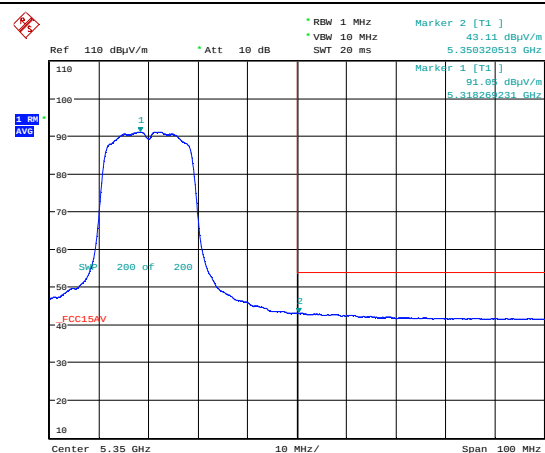
Date: 24.AUG.2023 09:51:43

Band Edge 5460 MHz, ch104, 802.11a 6M, Max, AV



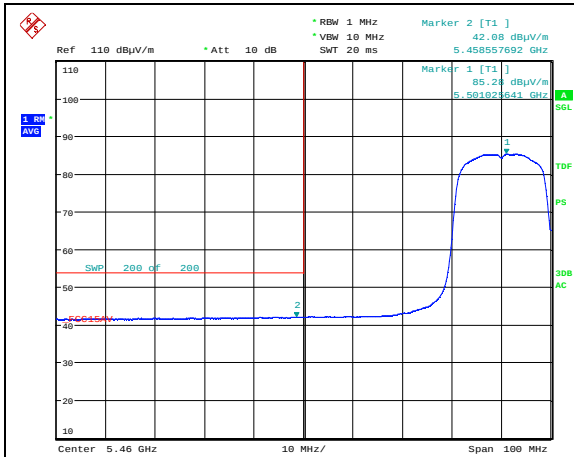
Date: 23.AUG.2023 16:41:48

Band Edge 5150MHz, ch036, 802.11n MCS0, Max, AV



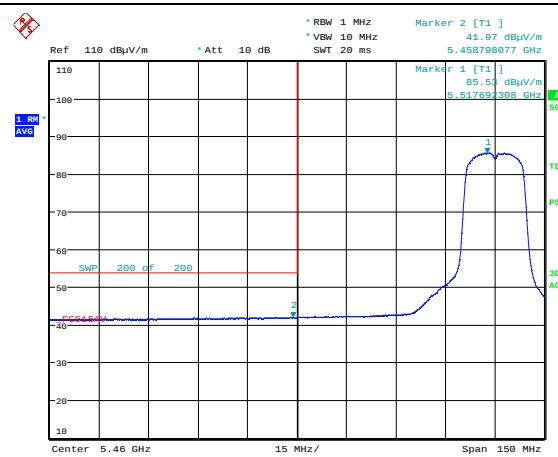
Date: 24.AUG.2023 09:22:08

Band Edge 5350MHz, ch064, 802.11n MCS0, Max, AV



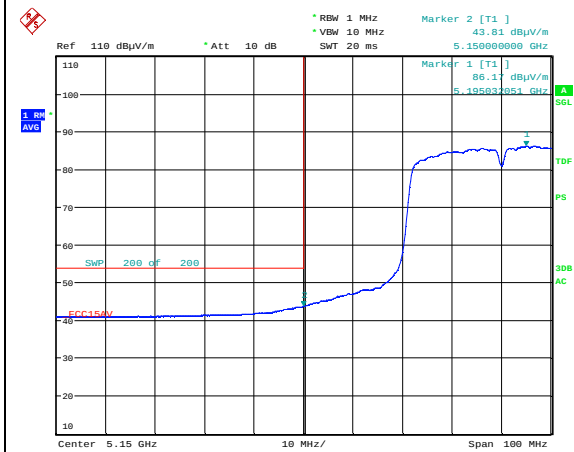
Date: 24.AUG.2023 09:44:19

Band Edge 5460 MHz, ch100, 802.11n MCS0, Max, AV PL10



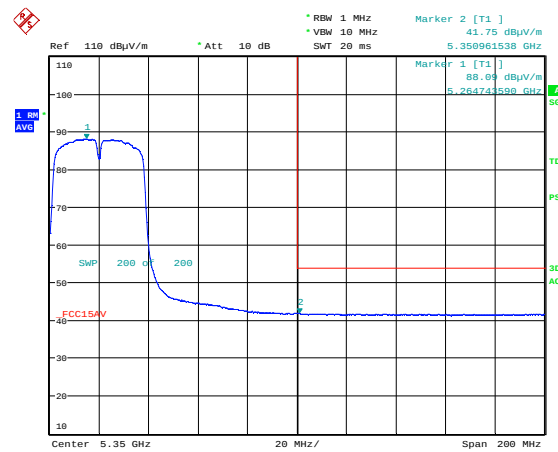
Date: 24.AUG.2023 09:49:35

Band Edge 5460 MHz, ch104, 802.11n MCS0, Max, AV



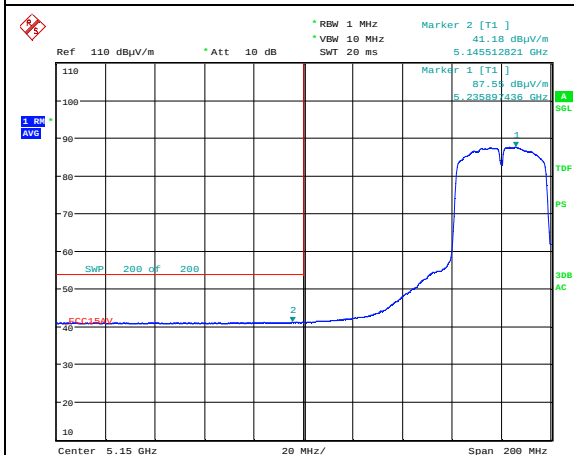
Date: 24.AUG.2023 12:14:34

Band Edge 5150 MHz, ch038, 802.11n HT40 MCS0, Max, AV PL10



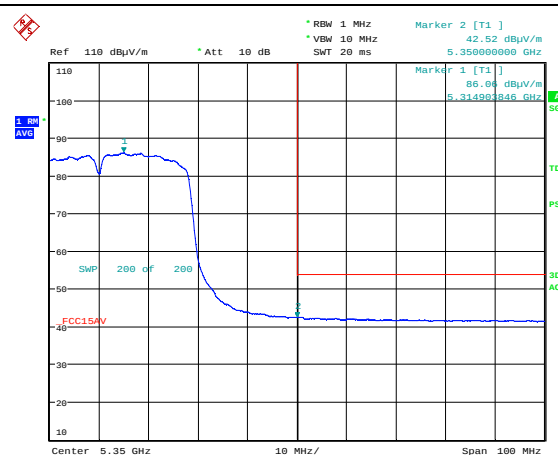
Date: 24.AUG.2023 12:05:02

Band Edge 5350 MHz, ch054, 802.11n HT40 MCS0, Max, AV



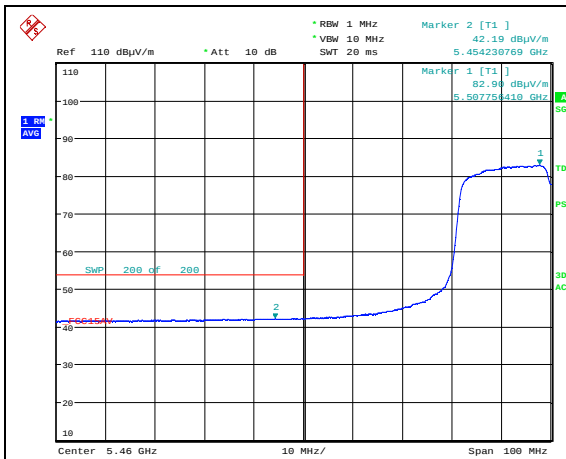
Date: 24.AUG.2023 12:09:35

Band Edge 5150 MHz, ch046, 802.11n HT40 MCS0, Max, AV



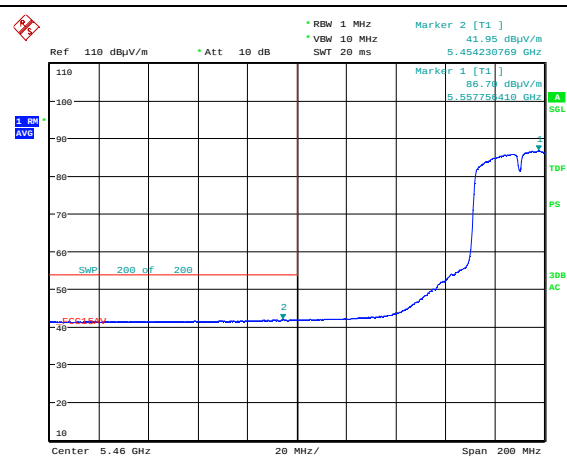
Date: 24.AUG.2023 12:00:26

Band Edge 5350 MHz, ch062, 802.11n HT40 MCS0, Max, AV



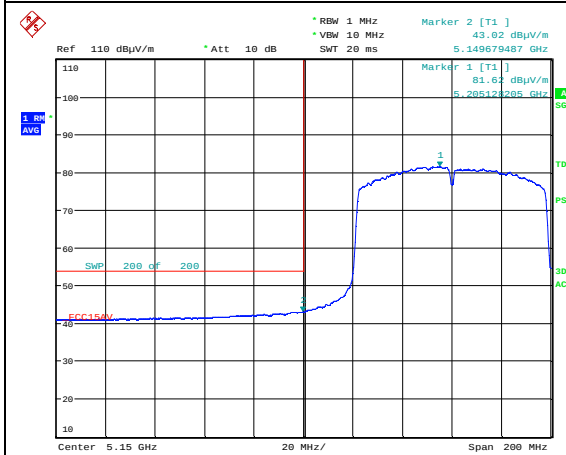
Date: 24.AUG.2023 11:14:53

Band Edge 5460 MHz, ch102, 802.11n HT40 MCS0, Max, AV PL9



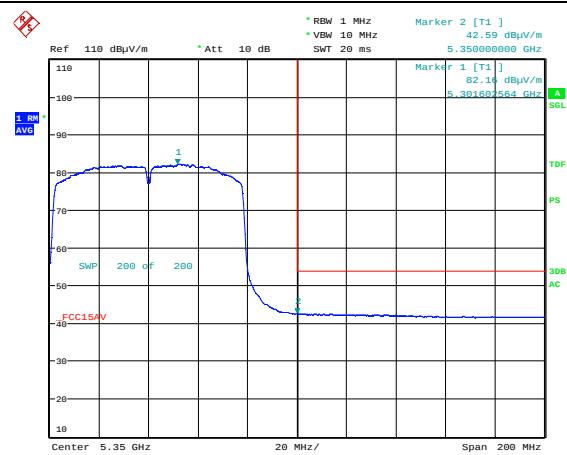
Date: 24.AUG.2023 11:11:38

Band Edge 5460 MHz, ch110, 802.11n HT40 MCS0, Max, AV



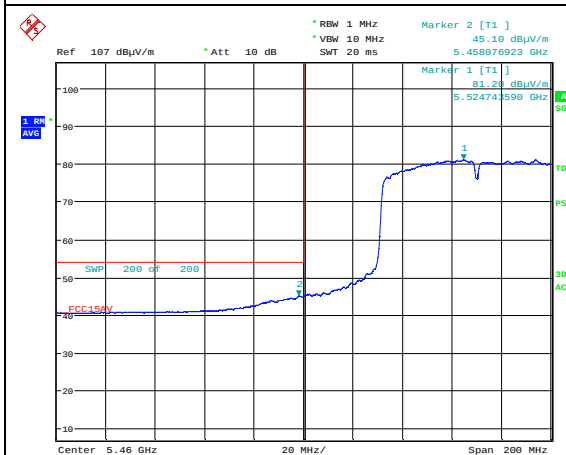
Date: 24.AUG.2023 12:22:17

Band Edge 5150 MHz, ch042, 802.11ac VHT80 MCS0, Max, AV PL9



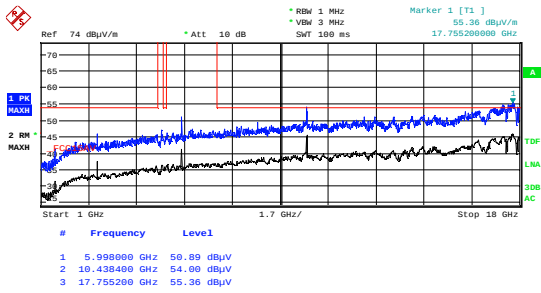
Date: 24.AUG.2023 12:27:56

Band Edge 5350 MHz, ch058, 802.11ac VHT80 MCS0, Max, AV



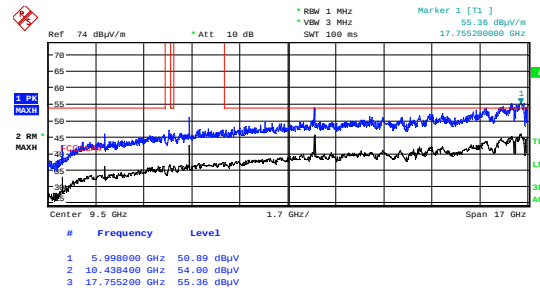
Date: 24.AUG.2023 12:35:17

Band Edge 5470 MHz, ch106, 802.11ac VHT80 MCS0, Max, AV PL11



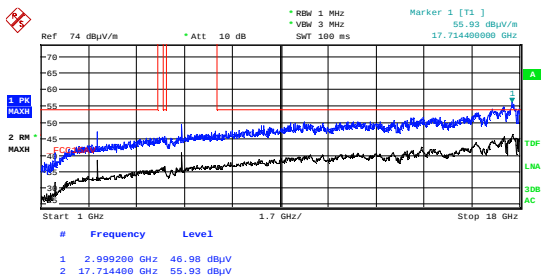
Date: 28.AUG.2023 09:36:04

Radiated Emissions 1 -18 GHz, Ch044, 802.11a 6M, VP



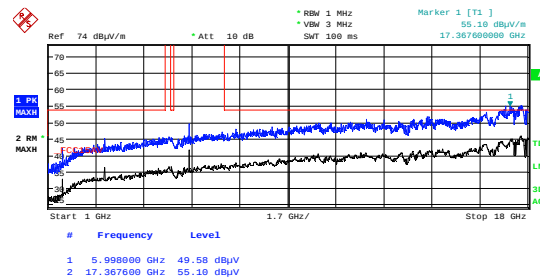
Date: 28.AUG.2023 09:38:00

HP



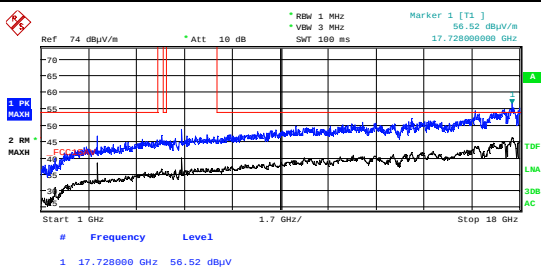
Date: 28.AUG.2023 11:22:47

Radiated Emissions 1 -18 GHz, Ch116, 802.11a 6M, VP



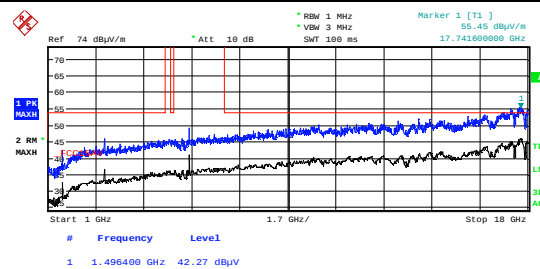
Date: 28.AUG.2023 11:24:43

HP



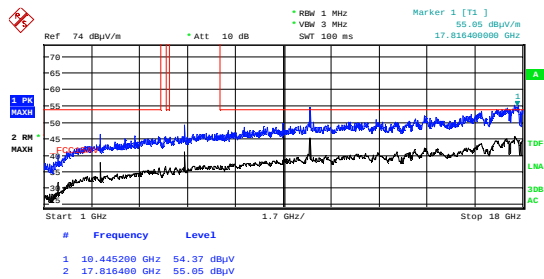
Date: 28.AUG.2023 11:36:34

Radiated Emissions 1 -18 GHz, Ch157, 802.11a 6M, VP



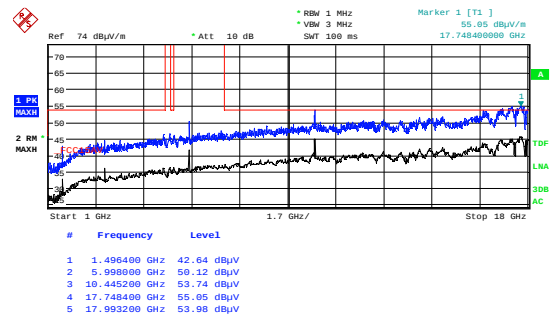
Date: 28.AUG.2023 11:38:30

HP



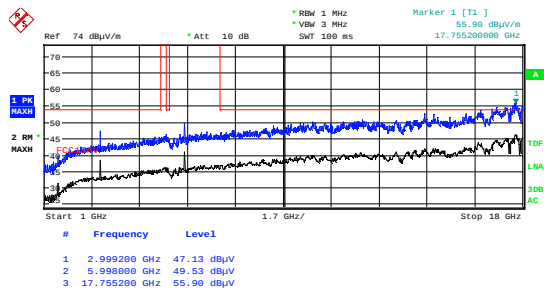
Date: 28.AUG.2023 09:48:48

Radiated Emissions 1 -18 GHz, Ch044, 802.11n MCS0, VP



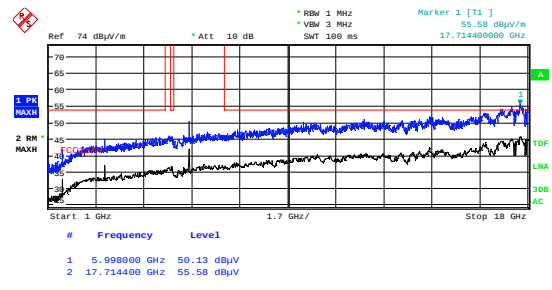
Date: 28.AUG.2023 09:50:45

HP



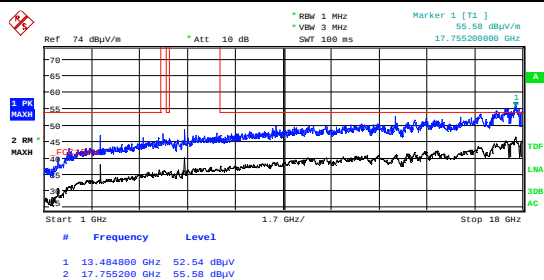
Date: 28.AUG.2023 11:12:47

Radiated Emissions 1 -18 GHz, Ch116, 802.11n MCS0, VP



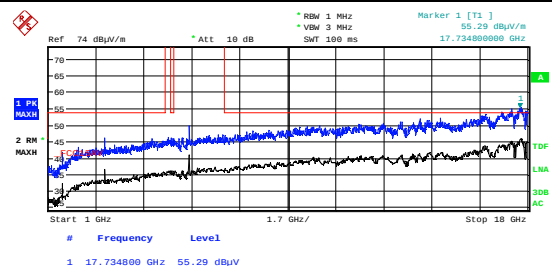
Date: 28.AUG.2023 11:14:44

HP



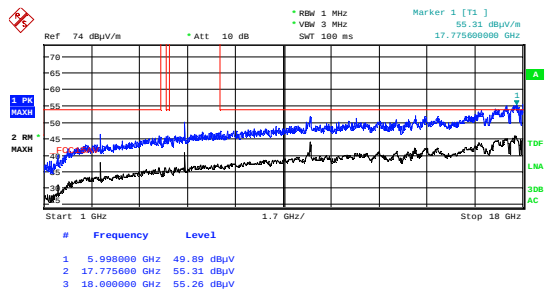
Date: 28.AUG.2023 11:43:13

Radiated Emissions 1 -18 GHz, Ch157, 802.11n MCS0, VP



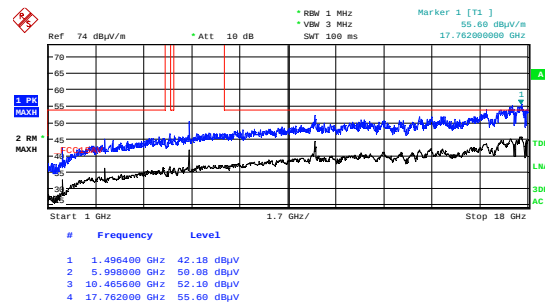
Date: 28.AUG.2023 11:45:18

HP



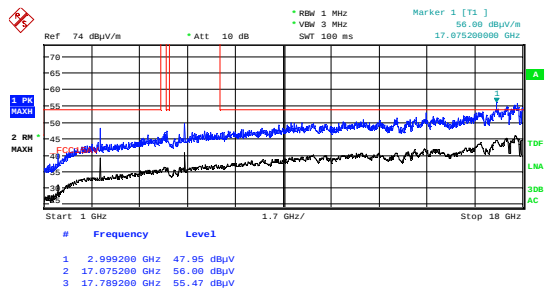
Date: 28.AUG.2023 10:06:32

Radiated Emissions 1 -18 GHz, Ch046, 802.11n HT40 MCS0, VP



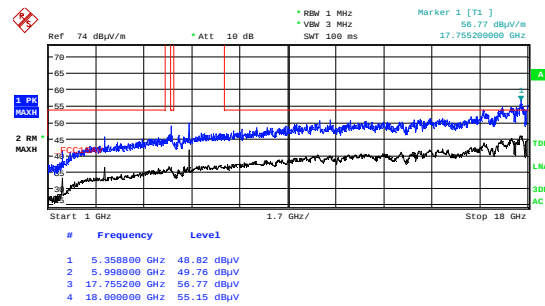
Date: 28.AUG.2023 10:08:28

HP



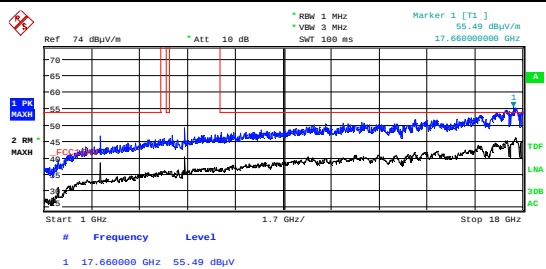
Date: 28.AUG.2023 11:05:28

Radiated Emissions 1 -18 GHz, Ch110, 802.11n HT40 MCS0, VP



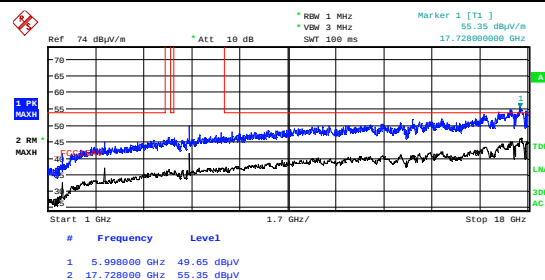
Date: 28.AUG.2023 11:07:24

HP



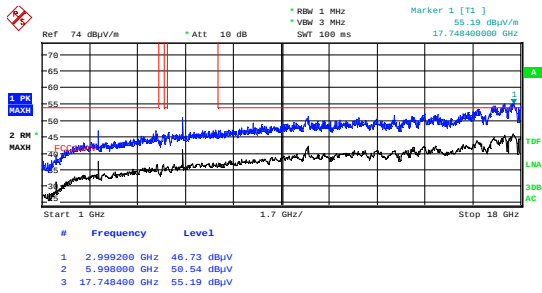
Date: 28.AUG.2023 11:55:52

Radiated Emissions 1 -18 GHz, Ch151, 802.11n HT40 MCS0, VP



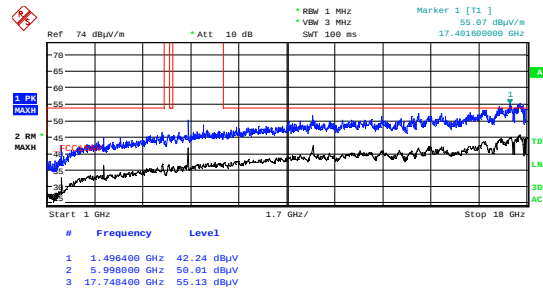
Date: 28.AUG.2023 11:57:48

HP



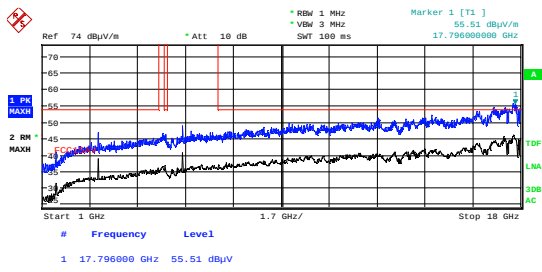
Date: 28.AUG.2023 10:26:29

Radiated Emissions 1 -18 GHz, Ch042, 802.11ac HT80 MCS0, VP



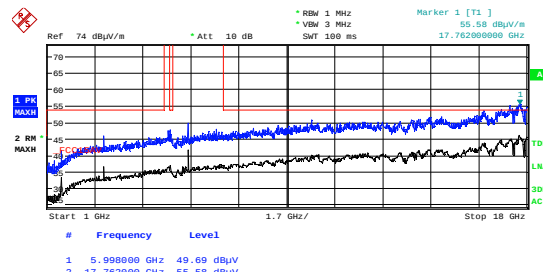
Date: 28.AUG.2023 10:28:26

HP



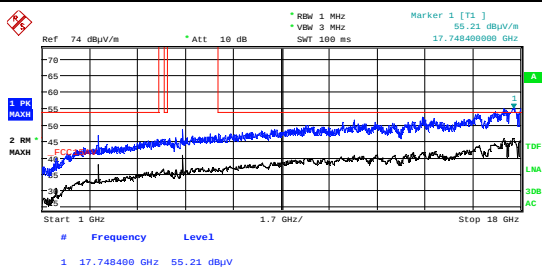
Date: 28.AUG.2023 10:53:24

Radiated Emissions 1 -18 GHz, Ch106, 802.11ac HT80 MCS0, VP



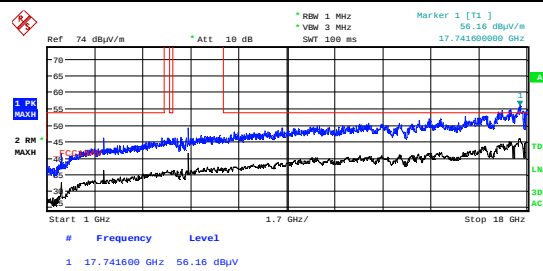
Date: 28.AUG.2023 10:55:21

HP



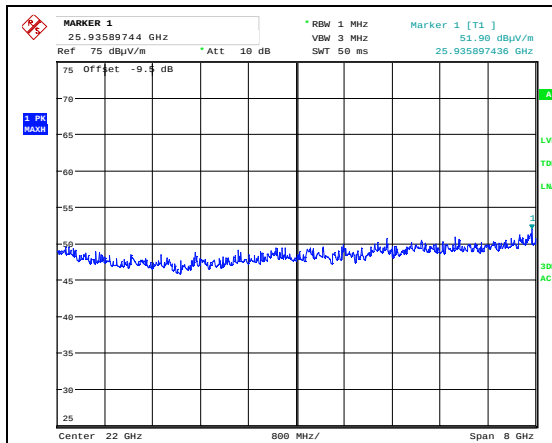
Date: 28.AUG.2023 12:26:09

Radiated Emissions 1 -18 GHz, Ch155, 802.11ac HT80 MCS0, VP



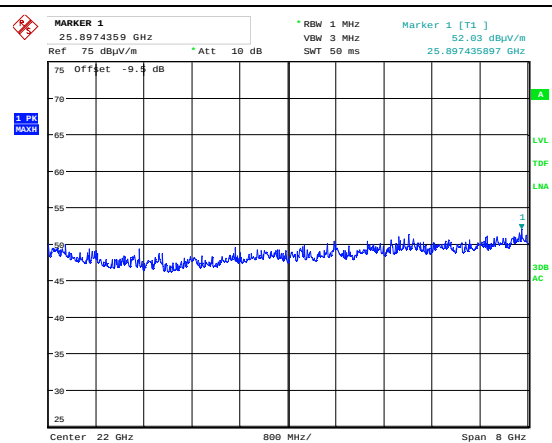
Date: 28.AUG.2023 12:28:05

HP



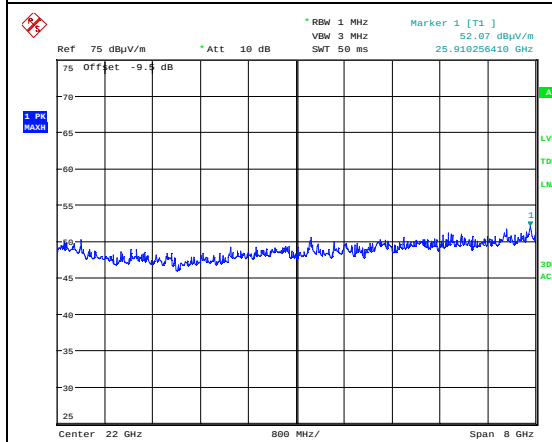
Date: 28.AUG.2023 14:25:55

Emissions 18-26 GHz, Ch116, 802.11a 6M, VP @1m



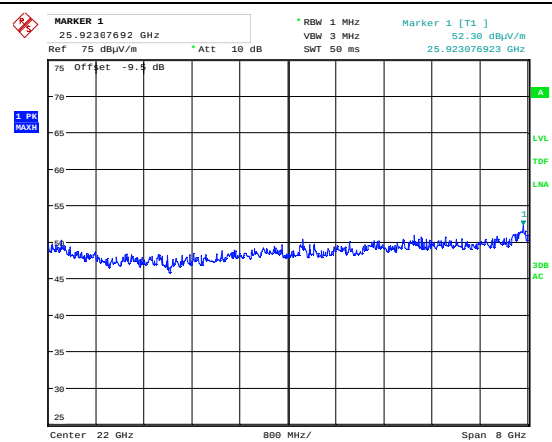
Date: 28.AUG.2023 14:23:34

HP



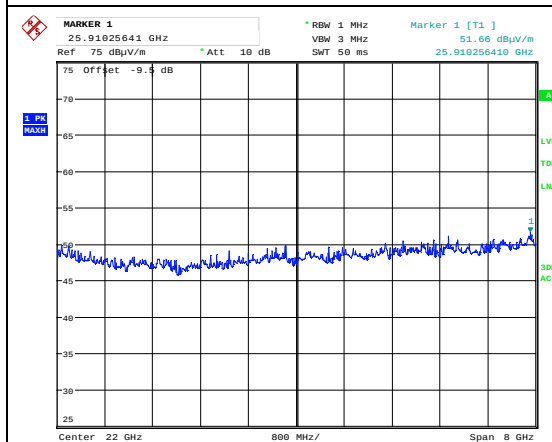
Date: 28.AUG.2023 13:57:34

Emissions 18-26 GHz, Ch044, 802.11n MCS0, VP @1m



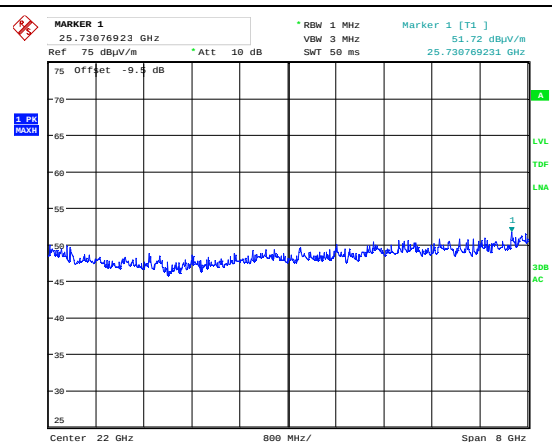
Date: 28.AUG.2023 14:00:57

HP



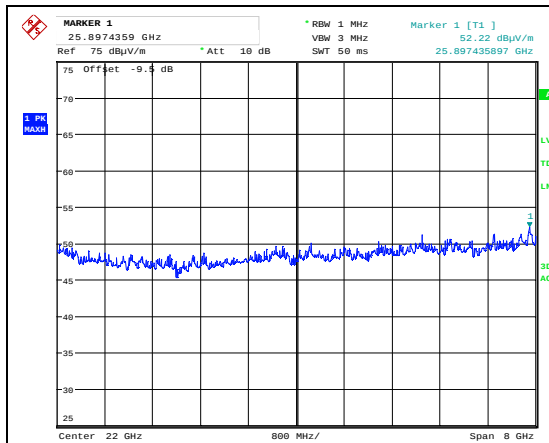
Date: 28.AUG.2023 14:28:41

Emissions 18-26 GHz, Ch116, 802.11n MCS0, VP @1m



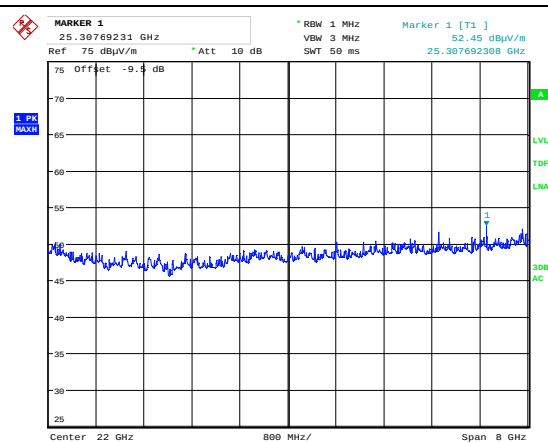
Date: 28.AUG.2023 14:31:19

HP



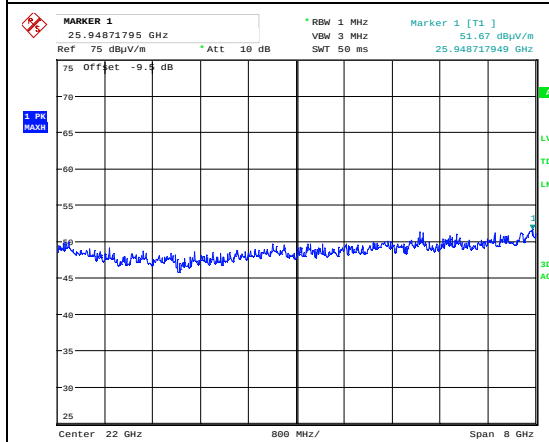
Date: 28.AUG.2023 14:37:08

Emissions 18-26 GHz, Ch157, 802.11n MCS0, VP @1m



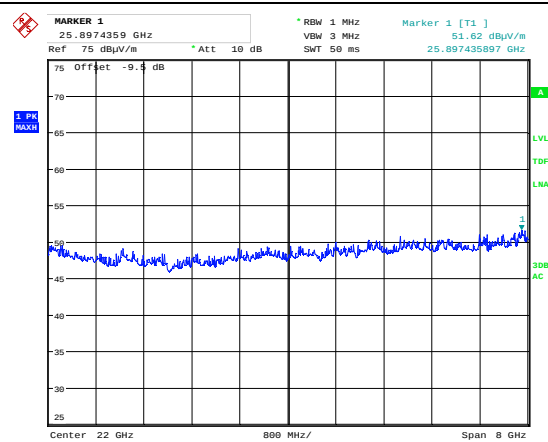
Date: 28.AUG.2023 14:35:02

HP



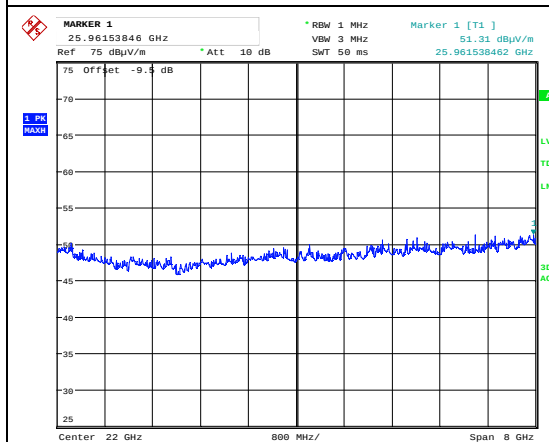
Date: 28.AUG.2023 14:10:03

Emissions 18-26 GHz, Ch046, 802.11n HT40 MCS0, VP @1m



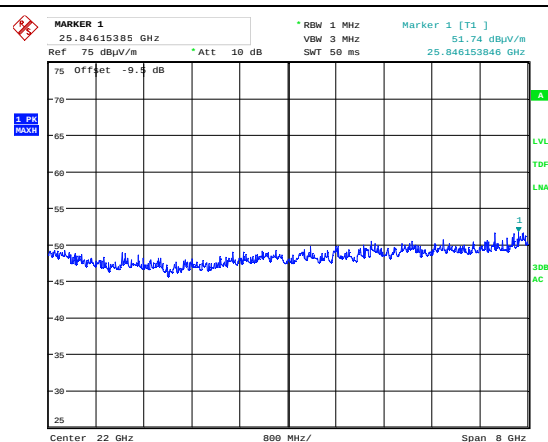
Date: 28.AUG.2023 14:06:50

HP



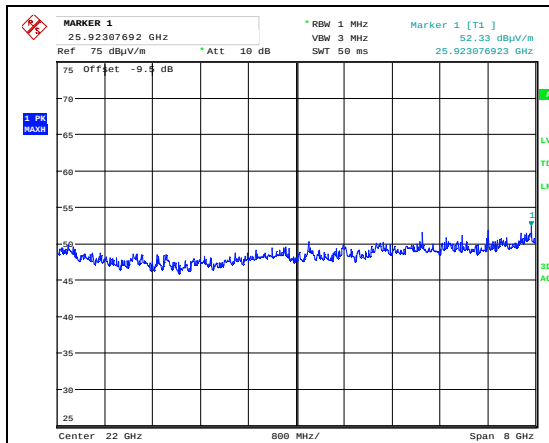
Date: 28.AUG.2023 14:48:59

Emissions 18-26 GHz, Ch110, 802.11n HT40 MCS0, VP @1m



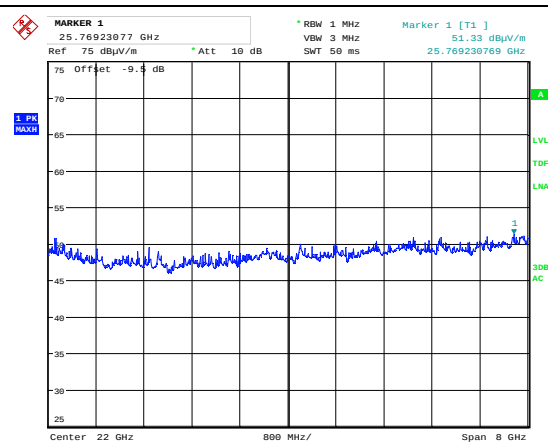
Date: 28.AUG.2023 14:45:22

HP



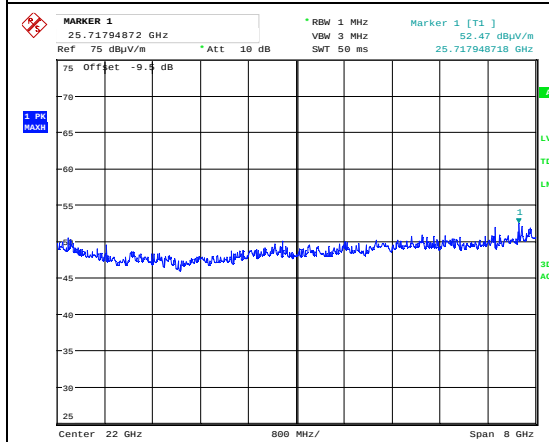
Date: 28.AUG.2023 14:52:30

Emissions 18-26 GHz, Ch151, 802.11n HT40 MCS0, VP @1m



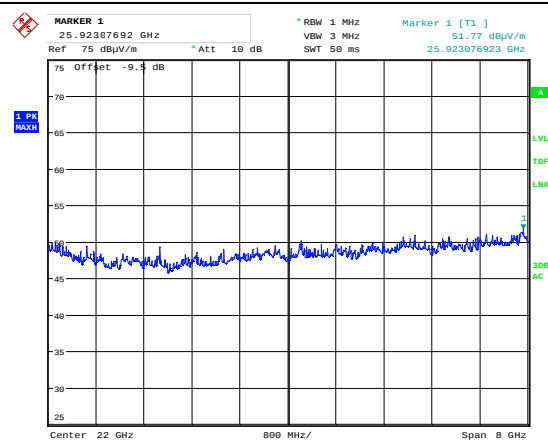
Date: 28.AUG.2023 14:55:28

HP



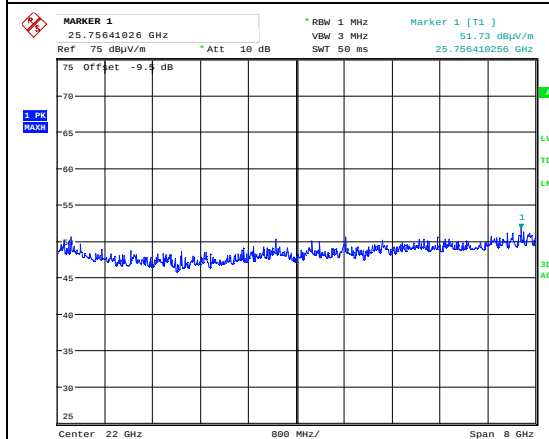
Date: 28.AUG.2023 14:15:24

Emissions 18-26 GHz, Ch042, 802.11ac HT80 MCS0, VP @1m



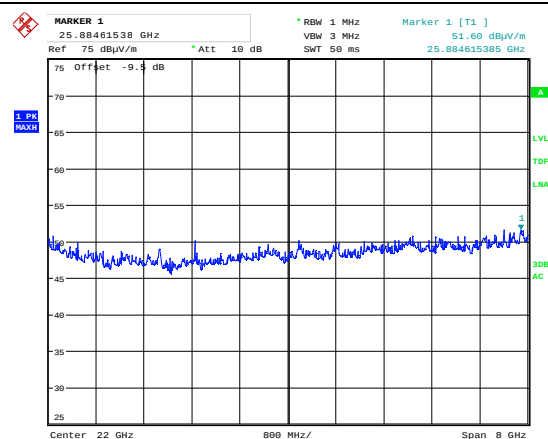
Date: 28.AUG.2023 14:18:25

HP



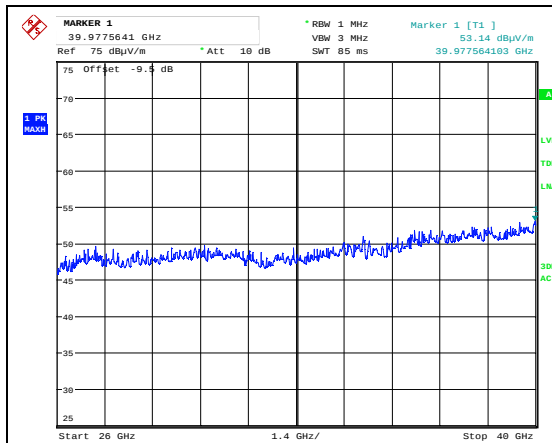
Date: 28.AUG.2023 15:02:18

Emissions 18-26 GHz, Ch106, 802.11ac HT80 MCS0, VP @1m



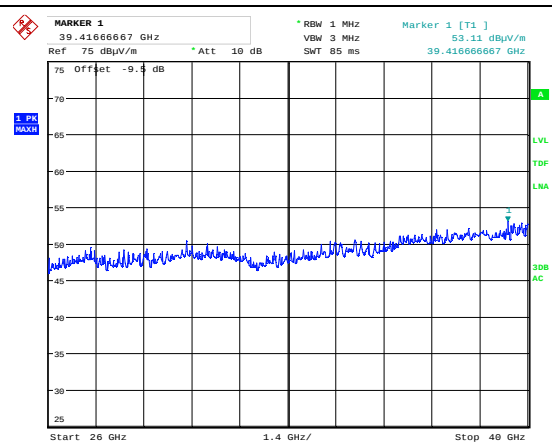
Date: 28.AUG.2023 15:00:05

HP



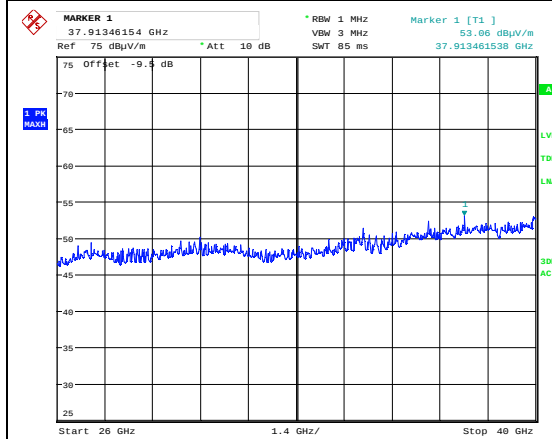
Date: 28.AUG.2023 16:56:45

Emissions 26-40 GHz, Ch044, 802.11n MCS0, VP @1m



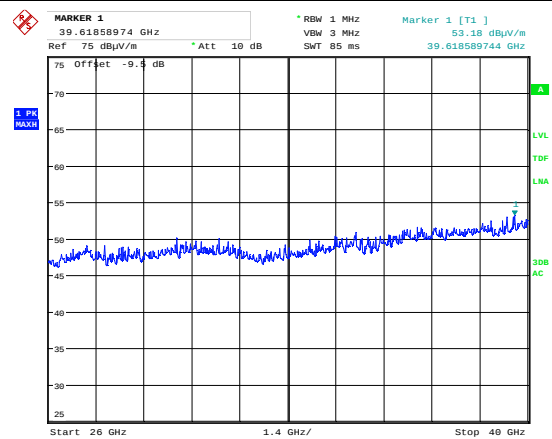
Date: 28.AUG.2023 16:59:03

HP



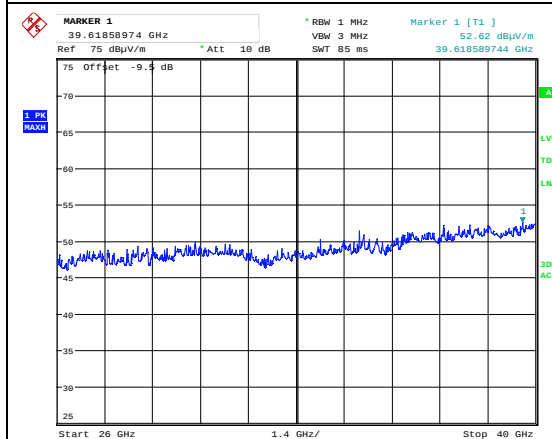
Date: 28.AUG.2023 17:03:44

Emissions 26-40 GHz, Ch116, 802.11n MCS0, VP @1m



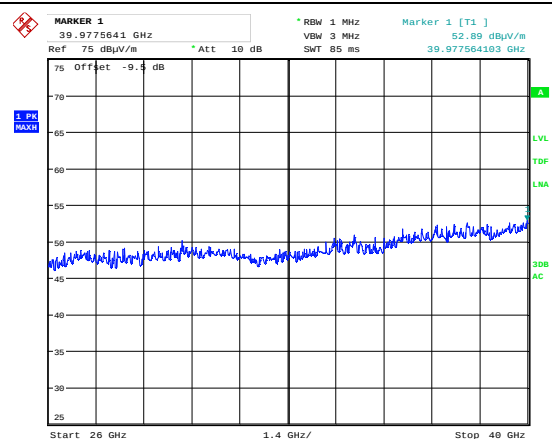
Date: 28.AUG.2023 17:01:37

HP



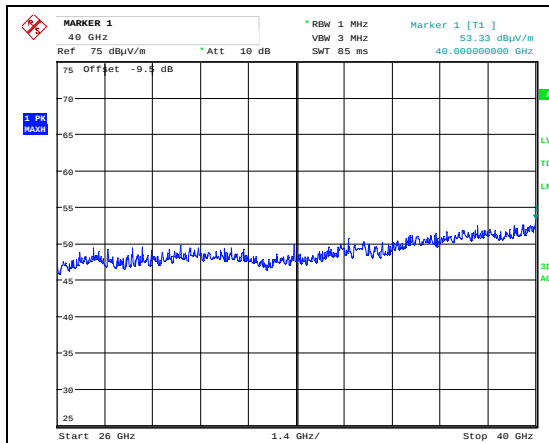
Date: 28.AUG.2023 17:06:52

Emissions 26-40 GHz, Ch157, 802.11n MCS0, VP @1m



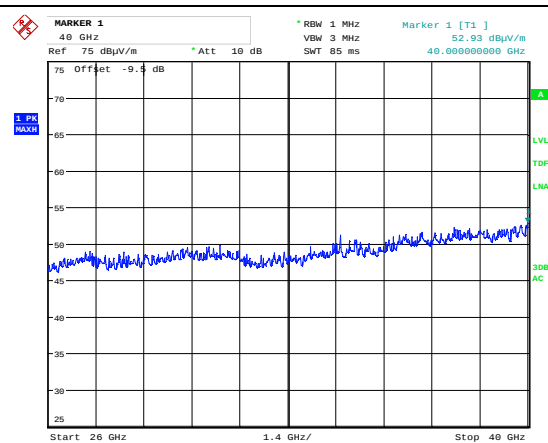
Date: 28.AUG.2023 17:09:51

HP



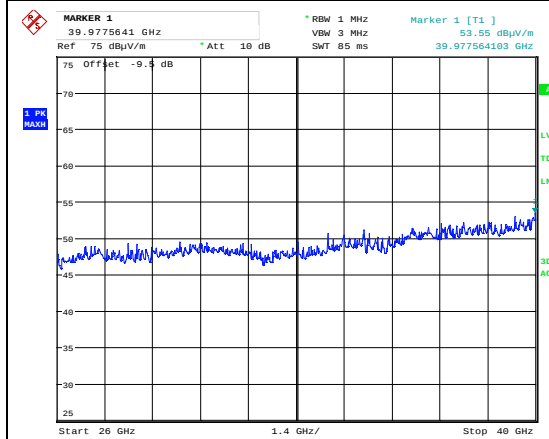
Date: 28.AUG.2023 17:16:17

Emissions 26-40 GHz, Ch110, 802.11n HT40 MCS0, VP @1m



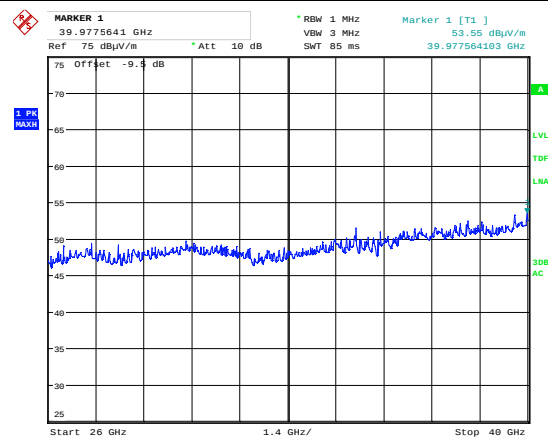
Date: 28.AUG.2023 17:14:18

HP



Date: 28.AUG.2023 17:19:45

Emissions 26-40 GHz, Ch106, 802.11n HT80 MCS0, VP @1m



Date: 28.AUG.2023 17:21:51

HP

4 Measurement Uncertainty

Measurement Uncertainty Values		
Test Item		Uncertainty
Output Power		±0.5 dB
Power Spectral Density		±0.5 dB
Out of Band Emissions, Conducted	< 3.6 GHz	±0.6 dB
	> 3.6 GHz	±0.9 dB
Spurious Emissions, Radiated	< 1 GHz	±2.5 dB
	> 1 GHz	±2.2 dB
Emission Bandwidth		±4 %
Power Line Conducted Emissions		+2.9 / -4.1 dB
Spectrum Mask Measurements	Frequency	±5 %
	Amplitude	±1.0 dB
Frequency Error		±0.6 ppm
Temperature Uncertainty		±1 °C

All uncertainty values are expanded standard uncertainty to give a confidence level of 95%, based on coverage factor k=2

5 LIST OF TEST EQUIPMENT

To facilitate inclusion on each page of the test equipment used for related tests, each item of test equipment and ancillaries are identified (numbered) by the Test Laboratory.

No.	Model number	Description	Manufacturer	Ref. no.	Cal. date	Cal. Due
1	ESU40	Measuring Receiver	Rohde & Schwarz	LR 1639	2023-01	2024-01
2	WLK5-1100-1485-7000-40SS	Low Pass Filter (1.0 GHz)	Wainwright Inst.	LR 1761	COU	
3	N0452501 (5150-5350 MHz)	BandStop Filter	Microwave Circuits	LR 1775	COU	
4	N0555983 (5470-5725 MHz)	BandStop Filter	Microwave Circuits	LR 1774	COU	
5	N0257881 (5725-5850 MHz)	BandStop Filter	Microwave Circuits	LR 1764	COU	
6	310	Preamplifier	Sonoma Inst.	LR 1686	2023-08	2024-08
7	8449A	Pre-amplifier	Hewlett Packard	LR 1322	2023-08	2024-08
8	3115	Horn Antenna	EMCO	LR 1226	2022-12	2027-12
9	3117-PA	Horn Antenna +PreAmp	EMCO	LR 1717	2023-08	2024-08
10	JS4-20004000	Preamplifier	Miteq	LR 1591	2022-08 2023-08	2023-08 2024-08
11	Model 638	Antenna Horn	Narda	LR 1480	N/A	
12	Model V637	Antenna Horn	Narda	LR 099	N/A	
13	JB3	BiLog Antenna	Sunol	N-4525	2023-04	2026-04

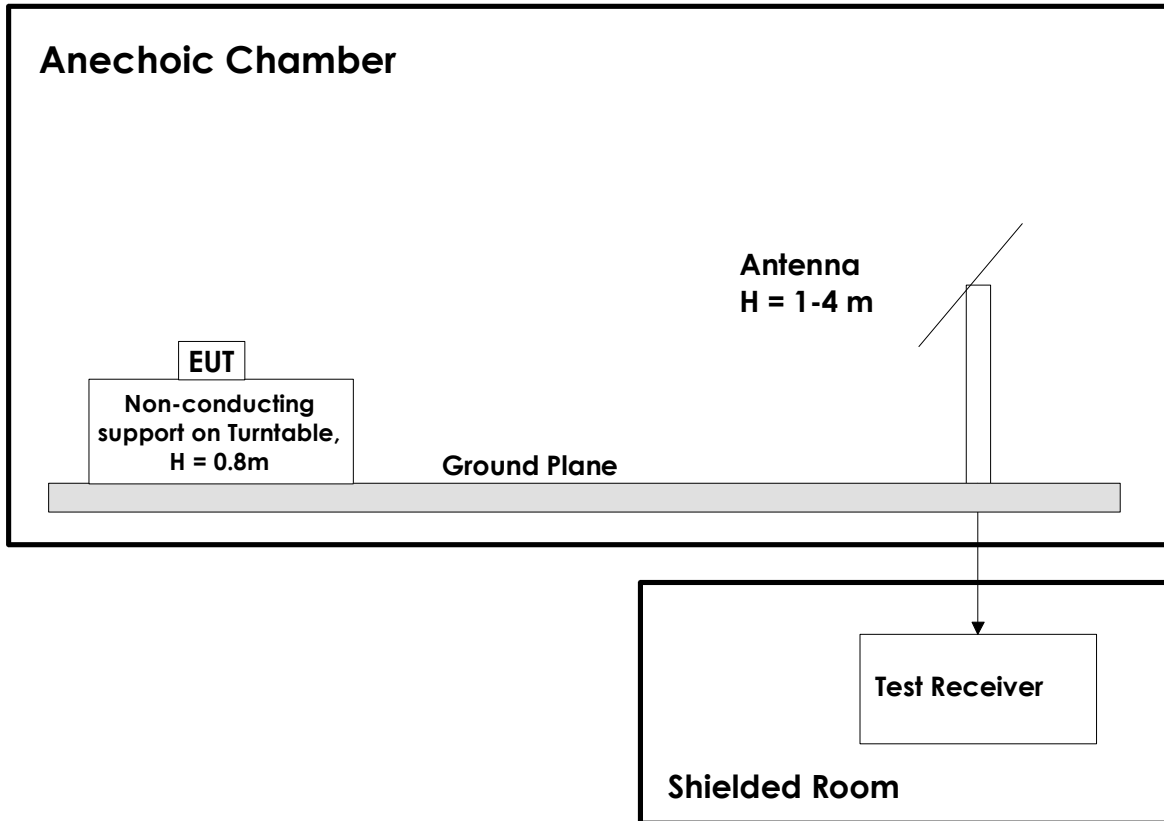
Note: COU – calibrate on use; N/A – Not Applicable

The software listed below has been used for one or more tests.

No.	Manufacturer	Name	Version	Comment
1	Rohde & Schwarz	EMC32	10.50.10	EMC test software
2	Nemko AS	RSPlot	1.0.8.0	Screenshots from R&S Spectrum Analyzers

6 BLOCK DIAGRAM

6.1 Test Site Radiated Emission



This test setup is used for all radiated emissions tests. Measuring distance is 3m for all frequencies.

Emissions above 1 GHz are measured with a Spectrum Analyzer and Horn Antenna.

All measurements at 1GHz and above were performed with turntable height 1.5m and with the ground plane covered by absorbers.

A pre-amplifier is used for all measurements, and High-Pass filter is used for all harmonics.