Test Report 2023-074

Version B
Issued 8 Dec 2023

Project GCL-0388
Model Identifier A04752
Primary Test Standard

CFR 47, FCC Part 15, Subpart E
RSS-247 Issue 2

Garmin Compliance Lab

Garmin International
1200 E 151st Street
Olathe Kansas 66062 USA

Client-supplied Information

FCC ID:	IPH-04752
IC ID:	1792A-04752

ACCREDITED
CERTIFICATE #6162.01

See section 6 of this report regarding the presence or absence of accreditation logos or marks on this cover page.

1. Summary

The equipment or product described in section 5 of this report was tested at the Garmin Compliance Lab according to standards listed in section 6. This report focuses on the 5 GHz WiFi transceiver(s), operating within the U-NII-1 sub-band (5150-5250 MHz) and the U-NII-3 sub-band (5725-5850 MHz).

Before summarizing the requirements and results, it is important to note that the product being tested operates in the 5150-5250 U-NII-1 sub-band, and is intended to be installed in vehicles as an OEM device. However, the client has stated that operation in this band will only occur indoors. The Canadian requirements applied in this report for U-NII-1 operation reflect indoor use rather than vehicular use, per client request.

The results are as follows.

Parameter	Description	Key Performance Values	Result	Data starts at page
Transmit Power U-NII-1 Sub-band	The peak transmit power presented to the antenna is no greater than 250 mW or 24 dBm. The effective radiated power is limited to 200 mW EIRP or 23 dBm EIRP if the 99% bandwidth is greater than 20 MHz. Narrower signals have a slightly lower EIRP limit. [15.407(a)(1)(iv)); RSS-247 at 6.2.1.1]	The maximum transmit power is 15.76 dBm or 37.7 mW. The maximum effective radiated power is 20.02 dBm EIRP or 100.5 mW EIRP. The results have a minimum margin to the various limits of 2.2 dB.	PASS	13
Transmit Power U-NII-3 Sub-band	The peak transmit power presented to the antenna is no greater than 1 W or 30 dBm. [15.407(a)(3); RSS-247 at 6.2.4.2]	The maximum transmit power is 15.62 dBm or 36.5 mW.	PASS	13
Power Spectral Density U-NII-1 Sub-band	The maximum power spectral density is limited to 11 dBm/MHz, and 10 dBm/MHz EIRP. [15.407(a)(1)(iv)); RSS-247 at 6.2.1.1]	The maximum power spectral density is 5.14 dBm/MHz. The maximum power spectral density is 9.40 dBm/MHz EIRP.	PASS	19
Power Spectral Density U-NII-3 Sub-band	The maximum power spectral density is limited to 30 dBm/500kHz. [15.407(a)(1)(iv)); RSS-247 at 6.2.4.2]	The maximum power spectral density measured was 5.09 dBm/MHz.	PASS	19
DTS Bandwidth U-NII-3 Sub-band	The nature of the radio signal is broadband, being at least 500 kHz wide. [RSS-247 at 6.2.4.2]	The 6dB bandwidth is 15.12 MHz or greater.	PASS	25
Occupied Bandwidth U-NII-1 Sub-band	The bandwidth cannot extend above 5250 MHz.	The emission bandwidths did not extend beyond 5249.917 MHz.	PASS	27
Other Bandwidths	Regulatory agencies also require the reporting of signal bandwidths using alternate processes. [2.202; RSS-GEN at 6.7]	These values are reported but have no actual performance requirements.	Reported	27

Antenna Gain	The radio should not focus too much energy in any direction. Unless additional rules are applied, the antenna gain is no greater than 6 dBi. [15.407(a); RSS-247 at 6.2.4.2]	NT. The client stated that the antenna gain was Y dBi and will document antenna gain separately.	NT	NT
Unwanted Emissions	The radio should not provide too much radio energy to the antenna at frequencies beyond its intended frequency band. [15.247(d); RSS-247 at 5.5]	Emissions outside the band must be reduced below a spectrum mask. The minimum margin to these limits was 0.56 dB.	PASS	35
Restricted Bands	The radio must not emit in certain designated restricted frequency bands above a set of limit values. [15.205; RSS-247 at 6.2]	Emissions in the restricted bands were at least 8.27 dB below the applicable limits.	PASS	45
Radio Safety	The radio emissions must meet public health & safety guidelines related to human exposure. [15.247(i) and 1.1307; RSS-Gen at 3.4]	NT. Client will report radio energy safety results separately.	NT	NT
Frequency Stability	The radio tuning must be robust over a range of temperature and supply voltage conditions. [RSS-Gen at 6.11]	KDB 789033 D02 states that the test report need not document compliance. The manufacturer is separately responsible for compliance.	NT	NT
Unwanted Emissions (Radiated Spurious)	While transmitting, the radiated emissions must not be too strong. [15.209, RSS-Gen at 8.9]	Emissions other than the fundamental and harmonics must meet the ‘Class B’ limits. The measured emissions had at least 0.4 dB of margin.	PASS	48
Unwanted Emissions (Mains Conducted)	While transmitting, the emissions conducted into the power mains must not be too strong. [15.207, RSS-Gen at 8.8]	Emissions other than the fundamental and harmonics must meet the ‘Class B’ limits. The measured emissions had at least 9.84 dB of margin.	PASS	63

NT (Not Tested) means the requirement may or may not be applicable, but the relevant measurement or test was not performed as part of this test project.

N/A (Not Applicable) means the lab judged that the test sample is exempt from the requirement.

Table 1: Summary of results

Report Organization
For convenience of the reader, this report is organized as follows:

1. Summary
2. Test Background
3. Report History and Approval
4. Test Sample Modifications and Special Conditions
5. Description of Equipment Tested
6. Test Standards Applied
7. Measurement Instrumentation Uncertainty
8. Selected Examples of Calculations
9. Environmental Conditions During Test

Annex: Test records are provided for each type of test, following the order and page numbering stated in the summary table. Concluding notes appear on the final page of this report.

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2023-076. That report is treated as a part of this document by way of this reference.

2. Test Background

The testing reported here was performed at the Garmin Compliance Lab, an organization within Garmin International, located at 1200 E 151st St, Olathe Kansas, USA. The contact telephone number is +1.913.397.8200.

The testing was performed on behalf of the Garmin design group, a separate organization located at 1200 E 151st St, Olathe Kansas, USA. Witnesses from the business group included: None.

Test Sample received: 01 Aug 2023
Test Start Date: 19 Sep 2023
Test End Date: 03 Nov 2023

The data in this test report apply only to the specific samples tested.

Upon receipt all test samples were believed to be properly assembled and ready for testing.

3. Report History and Approval

This report was written by David Arnett and initially issued on 29 Nov 2023 as Version A. Version B on 8 Dec 2023 corrects the lists of referenced standards in several test records, and adds equivalent PSD data to table TR23.4.

Report Technical Review: ______________________

David Arnett
Technical Lead EMC Engineer

Report Approval: ______________________

Shruti Kohli
Manager Test and Measurement (EMC, Reliability and Calibration)

4. Test Sample Modifications and Special Conditions

The following special conditions or usage attributes were judged during test to be necessary to achieve compliance with one or more of the standards listed in section 6 of this report:
None

The following modifications to the test sample(s) were made, and are judged necessary to achieve compliance with one or more of the standards listed in section 6 of this report:

Modification 1
Detailed Description: The audio cable from the docking unit was terminated and the audio common wire in that cable was connected to the ground of the dc cable. Specifically, the black wire in the audio cable was connected the blue wire with a 200 Ohm resistor, to the White wire with a 10 kOhm resistor, to the Grey wire with a 10 kOhm resistor, and to the black wire of the Power/CAN bus cable with piece of wire 18 cm long.

Date applied: 25 Oct 2023
Reason for this modification: Without this modification, an emission at 247.62 MHz was above the limit and appeared to be radiating from the previously-unterminated audio cable.

The emission was determined to be unrelated to radio transmitter frequencies and uncorrelated to radio transmission activity. The emission was observed to be present whether the various radios were active or idle. The following tests were performed without this modification being present, and the presence or absence of the modification is judged by the lab and client to have no significant effect on these specific tests: All transmitter characterization tests (transmit power, bandwidths, spectral densities, and other emission tests above 1 GHz); Radiated emission tests above 1 GHz; AC Powerline emission tests. This modification was present during the spurious emission tests below and above 1 GHz for the 5 GHz radio services and no negative effect above 1 GHz was observed due to its presence.

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model	A04752
Serial Numbers Tested	3449554812 (unmodified, with memory card), 3449554852 (modified), 3449554828 (modified)

This product tested is an information collection and distribution system for vehicular use.

The client affirmed that the test samples will be representative of production in all relevant aspects. The product design includes one antenna for the 2.5 GHz and a separate antenna for the 5 GHz radio band. Two test samples were modified to replace the antennas with RF cables. Each modified sample had two RF cables representing the different transmission paths.

5.2 Key Parameters

EUT Input Power:	12 Vdc Nominal (13.8 Vdc expected and generally used in test)
I/O Ports:	USB; micro-SD memory card; docking unit interface to power, audio, and CAN bus
Radio Transceivers:	IEEE 802.11 a/b/g/n/ac, Bluetooth, Bluetooth Low Energy, ANT/ANT+
Radio Receivers:	GNSS
Primary Functions:	Collecting and distributing information
Typical use:	Vehicle mounted in a set orientation
Highest internal frequency:	5.85 GHz
Firmware Revision	1.16

5.3 Operating modes

During test, the EUT was operated in one or more of the following modes. Note that 802.11 n and ac both use MCS-based modulation indices. They are treated as interchangeable in this report, meaning that where one of the two WiFi modes was selected it represents both.

Mode 1: M1 (BtcTx). The unit continuously transmits Bluetooth data packets on a selected channel. Note that for this test series, M1 only relates to EDR2 (2 Mbps using π/4 DPSK) and EDR3 (3 Mbps using 8DPSK modulation). The Bluetooth Basic Rate is handled under mode M6.

Mode 2: M2 (BleTx). The unit continuously transmits Bluetooth Low Energy (BLE) data packets on a selected channel at a 1 Mbps rate using frequency shift keying.

Mode 3: M3 (WiFi2Tx). The unit continuously transmits WiFi data packets on a selected channel in the 2.4 GHz band under the IEEE 802.11 b/g/n/ac protocols using 20 MHz or 40 MHz nominal channel bandwidths.

Mode 4: M4 (WiFi5Tx). The unit continuously transmits WiFi data packets on a selected channel in the 5 GHz band (U-NII-1 and U-NII-3 sub-bands) under the IEEE 802.11 a/n/ac protocols using 20 MHz or 40 MHz nominal channel bandwidths.

Mode 5: M5 (GNSS). The unit attempts to receive and decode GNSS signals from a variety of constellations. Where relevant, GPS signals were provided to the test sample.

Mode 6: M6 (AntTx). The unit continuously transmits Bluetooth Basic Rate data packets on a selected channel. The modulation scheme is GFSK. The client stated that this operating mode represents both Bluetooth Basic rate and ANT/ANT+ transmissions. See mode M1 for EDR2 and EDR3 transmissions.

5.4 EUT Arrangement

During test, the EUT components and associated support equipment were selected including the following arrangement sets. Test sample 3449554812 had a microSD data card installed in all configurations tested. The other test samples did not.

Arrangement 1: A1 (Mounted.) The test sample is connected to a docking interface unit. The docking interface unit connects for multiple functions. It connect the test sample to dc power. It connects the test sample to a typical accessory containing a VHF radio that is already certified and not exercised in this test series. The docking unit is capable of connecting the test sample to a vehicle CAN bus interface and to an audio system. The CAN bus and audio interfaces were left unterminated per client instruction. See section 4 of this report related audio interface termination.

Arrangement 2: A2 (USB.) The test sample is connected to an AC/DC power converter via its USB port. The docking interface is not connected, and the USB port does not carry data.

Arrangement 3: A3 (PC.) The test sample is connected to a computer via its USB port and the USB interface carries data. The docking interface is not connected.

Arrangement 4: A4 (Dual.) The test sample is connected to computer via its USB port as in A3 (PC) and to the docking interface as in A1 (Mounted).

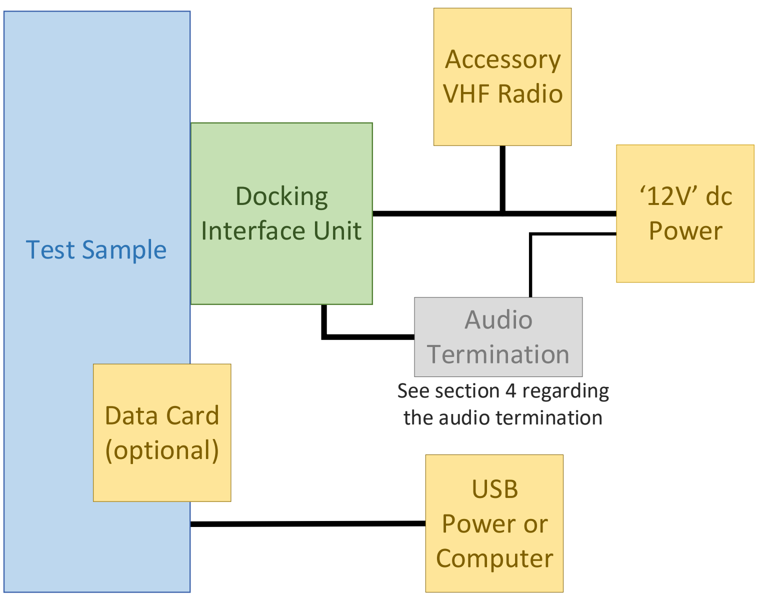

Figure 1: Block diagram of equipment present in arrangements A1 through A4

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
USB Power Adaptor	Phihong	PSAF10R-050Q	P183100844A1
Laptop	Dell	Inspiron	7DCR5R3
Power Supply	Dell	DA65NM191	CN-0KPVMF-DES00-233-EE1V-A00
Computer	Dell	Latitude 5410	5VSPFB3
Power Supply	Dell	HA65NM191	0BD-7TC0-A02
UHF Radio	Garmin	011-05234-84	75B005065
UHF Radio	Garmin	011-05234-84	75B004799
4G microSD memory card	Transcend	9193AB 4G 07SM1	None

Table 2: List of associated equipment that may have been used during test

5.6 Cables used

Note that the docking interface unit is treated as a cable because its function is interconnection.

Description	From	To	Length	EMC Treatment
Docking Interface 1	EUT port	Audio, CAN, Power, VHF radio	57 cm	None
Docking Interface 2	EUT port	Audio, CAN, Power, VHF radio	57 cm	None
Docking Interface 3	EUT port	Audio, CAN, Power, VHF radio	57 cm	Termination resistors placed on audio port, and ground wire included between audio common line and dc power ground
USB cable	EUT USB port	PC or USB power adapter	50 cm	None

Table 3: List of cables that may have been used during test

5.7 Channel identification

With regard to test modes, the channel numbering for 40 MHz WiFi signals seems to have some inconsistency across the industry. For the purpose of this report, here are the channels numbers used by this lab and their corresponding center frequencies. It may arise that one of these 40 MHz channels was mentioned in a test record using a channel number two lower than what is cited. For example, if a 40 MHz test cites operation on channel 36, it correlates to channel 38 in this table.

Channel #	38	46	151	159
Freq (MHz)	5190	5230	5755	5795

Table 4: Identification of 40 MHz channels

6 Test Standards Applied

6.1. Accredited Standards

The following test or measurement standards were applied and are within the scope of the lab's accreditation. All results in this report that cite these standards are presented as Accredited results consistent with ISO/IEC 17025.

CFR 47, FCC Part 15, Subpart E
ANSI C63.10: 2013
RSS-GEN Issue 5 Amd 2
RSS-247 Issue 2

6.2. Non-accredited Standards

The following test or measurement standards were applied and are either outside the scope of the lab's accreditation, or were performed in such a way that results are not presented as being fully accredited.

TRC-43 Issue 3

6.3 Variances

The following variances were applied to standards cited in this section.

Where different test standards cover the same test parameter or phenomenon, and the standards have compatible differences, the stricter of the requirements is typically applied. For example, a consolidated limit may be applied to emission tests selecting the strictest of the limits at each frequency. Likewise, if one standard requires a vertical antenna sweep with boresighting and another does not, swept motion with boresighting will typically be used as it is the more stringent requirement.

6.4 Laboratory Accreditation

The Garmin Compliance Lab, an organization within Garmin International, is registered with the US Federal Communication Commission as US1311. The lab is recognized by the Canada Department of Innovation, Science, and Economic Development (ISED) under CAB identifier US0233.

The Garmin Compliance Lab, an organization within Garmin International, is accredited by A2LA, Certificate No. 6162.01. The presence of the A2LA logo on the cover of this report indicates this is an accredited ISO/IEC 17025 test report. If the logo is absent, this report is not issued as an accredited report. Other marks and symbols adjacent to the A2LA logo are accreditation co-operations of which A2LA is a member under a mutual recognition agreement, and to which the Garmin Compliance Lab has been sublicensed.

7 Measurement Instrumentation Uncertainty

The lab has analyzed the sources of measurement instrumentation uncertainty. The analysis concludes that the actual measurement values cited in this report are accurate within the U_{LAB} intervals shown below with approximately 95% statistical confidence. Where the report shows a judgment that a test sample passes a test against a published limit based on these measured values, that judgment has a statistical confidence of 97.5% or greater. Measurement Instrumentation Uncertainty is one component of over-all measurement uncertainty, and other uncertainty components are not considered as part of this analysis.

The primary benchmark for measurement instrumentation uncertainty (MIU) in an electromagnetic compatibility (EMC) test lab is the set of U_{CISPR} values published in CISPR 16-4-2. In all cases where a U_{CISPR} value is published by CISPR, the analysis shows that U_{LAB} – this lab's estimated MIU – is better than the U_{CISPR} benchmark.

The secondary benchmark for MIU in an EMC lab performing radio transceiver tests is a set of uncertainty limit values published in various ETSI standards. In this report, U_{ETSI} is the most restrictive of the values found in the ETSI EN standards listed in section 5 of this report. The analysis principles are described in the ETSI TR documents listed there. In most cases U_{LAB} is better than the U_{ETSI} benchmark. Where U_{LAB} exceeds the U_{ETSI} benchmark cited here, that entry is preceded by an asterisk. When required by the ETSI EN standards, excess uncertainty will be added to the measurand before comparison to a limit. In an individual test report, staff may re-evaluate that excess uncertainty based on the uncertainty of the method used and the uncertainty limits of the actual ETSI EN standard being applied, and the revised uncertainty values will be shown in the test report.

Some measurement uncertainties analyzed and reported here are not addressed in CISPR 16-4-2 or the ETSI standards, as indicated by the entry 'None.'

Test Type		**U_{LAB}**	**U_{CISPR}**	**U_{ETSI}**
Conducted DC voltage		0.09% + 2 x LSDPV	None	1%
Conducted AC voltage below 500 Hz		1.0% + 3 x LSDPV	None	2%
Conducted Emissions, Mains Voltage		0.10% + 10 mV	None	None
Conducted Emissions, Mains Current		0.10% + 3 mA	None	None
Conducted Emissions, Mains Power		0.15% + 100 mW	None	None
Conducted Emissions, Power Mains, 9 kHz to 150 kHz		1.49 dB	3.8 dB	None
Conducted Emissions, Power Mains, 150 kHz to 30 MHz		1.40 dB	3.4 dB	None
Conducted Emissions, Cat 6 LCL, 150 kHz to 30 MHz		2.80dB	5 dB	None
Conducted Emissions, Cat 5 LCL, 150 kHz to 30 MHz		3.21 dB	5 dB	None
Conducted Emissions, Cat 3 LCL, 150 kHz to 30 MHz		4.24 dB	5 dB	None
Radiated Emissions, below 30 MHz		0.88 dB	None	6 dB
Radiated Emissions, 30 MHz to 1000 MHz		2.77 dB	6.3 dB	6 dB
Radiated Emissions, 1 GHz to 18 GHz		2.60 dB	5.2 & 5.5 dB	6 dB
Radiated Emissions, 18 GHz to 26.5 GHz		2.73 dB	None	6 dB
*Radio Signal Frequency Accuracy		*1.55 x 10^-7	None	1.0 x 10^-7
Radio Signal Occupied Bandwidth		0.95%	None	5%
Radio Power or Power Spectral Density		0.98 dB	None	1 dB
Temperature		0.38 °C	None	1 °C
Barometric Pressure		0.38 kPA	None	None
Relative Humidity		2.85% RH	None	±5% RH
Signal Timing	The greater of these three...	0.63 usec	None	None
		0.01% of value		
		0.5 x LSDPV		

Note: *LSDPV stands for the Least Significant Digit Place Value reported. In the value 1470 msec, the least significant digit is the 7. It has a 10 msec place value. The LSDPV is thus 10 msec and the maximum error due to roundoff would be 5 msec. If the time value were reported as 147<u>0</u> msec, the underscore indicates that the 0 is a significant figure and the error due to roundoff would be 0.5 msec. All digits provided to the right of a decimal point radix are significant.*

8 Selected Example Calculations

Certain regulators require samples of the calculations that lead from the raw measurement to the final result for AC Mains conducted and unintended radiated emissions. The assumption is that the lab performs raw measurements, then adds, subtracts, multiplies, or divides based on transducer factors, amplifier gains, and losses in the signal transmission path. In this lab, our CISPR 16 Receiver does not work that way. The calibration factors and losses and gains are provided to the receiver as detailed data files. These factors are applied in the RF measurement path prior to the detector. But as a step in the lab measurement process, staff frequently verify that these factors are applied correctly. They make a measurement with the factors applied inside the receiver, then they disable the factors and remeasure the result manually adding in the various relevant factors.

The transmission loss is measured including the combined losses and gains of preamplifiers, cables, and any band-selective filters. In many cases above 1 GHz it is a negative value, indicating that the preamplifier gain is greater than these other losses.

Here are examples of these calculations. The data in these examples was not taken as part of this project:

8.1 AC Mains conducted emissions at 22 MHz

(Raw measurement) + (AMN factor) + (transmission loss) = Result

(7.145 dBuV) + (9.812 dB) + (0.216 dB) = 17.173 dBuV

8.2 Radiated Emissions at 630 MHz

(Raw measurement) + (Antenna factor) + (transmission loss) = Result

(2.25 dBuV) + (27.80 dB/m) + (2.89 dB) = 32.94 dBuV/m

8.3 Radiated Emissions at 2.7 GHz

(Raw measurement) + (Antenna factor) + (transmission loss) = Result

(43.72 dBuV) + (32.22 dB/m) + (-36.09 dB) = 39.85 dBuV/m

9 Environmental Conditions During Test

Environmental conditions in the test lab were monitored during the test period. Temperature and humidity are controlled by an air handling system. As information to the reader, the conditions were observed at the values or within the ranges noted below. For any tests where environmental conditions are critical to test results and require further constraints or details, the test records in the annex may provide more specific information.

Temperature: 20.5 to 24.0 °C
Relative Humidity: 19.9% to 55.7% (non-condensing)
Barometric Pressure 96.3 to 99.5 kPa

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table 5: Environmental monitoring device

ANNEX

The remainder of this report is an Annex containing individual test data records. These records are the basis for the judgments summarized in section 1 of this report. The Annex ends with a set of concluding notes regarding use of the report.

Test Record
Transmitter Power
Test IDs TR04, TR05
Project GCL0388

Test Date(s) 26, 27 Sep 2023
Test Personnel Jim Solum

Product Model A04752
Serial Number tested 3449554852

Operating Mode M4(WiFi5Tx)
Arrangement A4 (Dual)
Input Power 13.8 Vdc

Test Standards: FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 referencing SP 5150 MHz, FCC Part 2.1091, FCC Part 2.1093, RSS-102, ANSI C95.3 (as noted in Section 6 of the report).

Antenna Gain 4.26 dBi, as reported by the client

Radio Protocol IEEE 802.11 a/ac

Pass/Fail Judgment: PASS

Test record created by: Jim Solum, David Arnett
Date of this record: 24 Oct 2023

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109124	18-Jul-2023	15-Jul-2025

Table TR04.1: List of test equipment used

Software used: Rohde & Schwarz Power Viewer V11.3; TimePowerAnalysisSpreadsheetV10.xlsx

Test Method
The basic test standards provide options for the time evaluation test method. The following test methods were applied.
ANSI C63.10: 11.9.1.3

Transmit Power Data
Each measurement is made conducted from the antenna port with the transmitter on a specified channel and in a selected transmission protocol. Where standards cited here apply harmonized test methods and different limits, the more strict limit has applied.

The ANSI method finds the highest value (numerical peak) and applies the limits from the US and Canadian standards. For the U-NII-1 band, the US limit is 30 dBm. For the U-NII-3 band, the US and Canadian limits are aligned at 30 dBm. All values met the Tx Power limit with better than 14.2 dB of margin. In addition, Canada imposes an EIRP limit for the U-NII-1 band segment that is based on the 99% Occupied Bandwidth. For 40 MHz WiFi signals, the limit is 23 dBm EIRP. For 20 MHz WiFi signals, test record TR13 shows that narrowest signal is 16.71 MHz wide, which gives a limit of 22.23 dBm EIRP. Based on the 4.26 dBi antenna gain shown above, this limits the power to the antenna at 17.97 dBm. This Canadian EIRP limit is also met with 2.2 dB of margin or better.

Data shown here for channels in the 5 GHz UNII-1 and UNII-3 bands. Data for both 20MHz and 40 MHz bandwidths are displayed. The results are shown below. Yellow highlighted cells indicate the highest power value for each radio protocol. An NT entry in a grey cell indicates a combination of data rate and transmit channel that were not tested.

		U-NII-1				U-NII-3				
Mode	Speed	36	40	44	48	149	153	157	161	165
A	6	**13.68**	**15.52**	**15.88**	**15.49**	**15.30**	**NT**	**15.26**	**NT**	**15.42**
A	9	**13.48**	**15.44**	**15.45**	**15.43**	**15.30**	**NT**	**15.25**	**NT**	**15.35**
A	12	**13.61**	**15.54**	**15.54**	**15.76**	**15.36**	**NT**	**15.27**	**NT**	**15.39**
A	18	**13.76**	**15.63**	**15.62**	**15.74**	**15.39**	**NT**	**15.34**	**NT**	**15.45**
A	24	**13.78**	**15.71**	**15.67**	**15.76**	**15.39**	**15.52**	**15.35**	**15.62**	**15.46**
A	36	**12.72**	**14.60**	**14.56**	**14.65**	**15.01**	**NT**	**14.29**	**NT**	**14.33**
A	48	**10.90**	**13.01**	**13.02**	**13.12**	**14.61**	**NT**	**12.69**	**NT**	**12.52**
A	54	**10.56**	**12.64**	**12.65**	**12.74**	**14.21**	**NT**	**12.31**	**NT**	**12.13**
AC	MCS0	**13.62**	**15.56**	**15.43**	**15.46**	**15.57**	**15.44**	**15.29**	**15.43**	**15.20**
AC	MCS1	**13.57**	**15.55**	**15.42**	**15.67**	**15.45**	**NT**	**15.36**	NT	**15.27**
AC	MCS2	**13.64**	**15.61**	**15.46**	**15.62**	**15.44**	**NT**	**15.37**	NT	**15.26**
AC	MCS3	**13.62**	**15.63**	**15.49**	**15.59**	**15.43**	**NT**	**15.33**	NT	**15.24**
AC	MCS4	**12.29**	**14.22**	**14.11**	**14.25**	**15.13**	**NT**	**15.04**	NT	**13.82**
AC	MCS5	**10.61**	**12.72**	**12.68**	**12.80**	**14.44**	**NT**	**14.49**	NT	**12.36**
AC	MCS6	**10.28**	**12.43**	**12.39**	**12.49**	**12.19**	**NT**	**14.48**	NT	**12.03**
AC	MCS7	**9.95**	**12.07**	**12.06**	**12.15**	**14.43**	**NT**	**13.78**	NT	**11.75**
AC	MCS8	**8.94**	**11.03**	**11.00**	**11.08**	**10.76**	**NT**	**13.63**	NT	**10.64**

Table TR04.2: Peak Transmit Power Summary, with units of dBm (20 MHz bandwidth)

		U-NII-1		U-NII-3	
Mode	Speed	38	46	151	159
AC40	MCS0	**10.65**	**11.53**	**11.50**	**11.31**
AC40	MCS1	**10.50**	**11.42**	**11.32**	**11.21**
AC40	MCS2	**9.15**	**10.03**	**11.02**	**10.91**
AC40	MCS3	**8.19**	**9.12**	**8.95**	**10.86**
AC40	MCS4	**6.97**	**7.85**	**7.68**	**10.41**
AC40	MCS5	**5.68**	**6.42**	**9.96**	**9.88**
AC40	MCS6	**5.46**	**6.20**	**5.96**	**9.93**
AC40	MCS7	**5.15**	**5.90**	**5.67**	**8.60**
AC40	MCS8	**4.25**	**8.81**	**8.31**	**7.65**
AC40	MCS9	**3.95**	**4.66**	**4.43**	**8.79**

Table TR04.3: Peak Transmit Power Summary, with units of dBm (40 MHz bandwidth)

The strongest emission in the U-NII-1 sub-band is 15.76 dBm (37.7 mW) or 20.02 dBm EIRP (100.5 mW EIRP).
The strongest emission in the U-NII-3 sub-band is 15.62 dBm (36.5 mW)

Additional Transmit Power Data Analysis

The technical requirements for safety to RF exposure also look at transmitter power. Since data from this report may be compared with data from RF exposure reports, this lab has performed a further analysis of the same raw data for power over time used above. This analysis applies standards such as FCC Part 2.1091, FCC Part 2.1093, RSS-102, ANSI C95.3, EN/IEC 62311, or EN 62479.

These data analyses look at average power over time in linear milliwatt units. These data are averaged over a time period no longer than 1 second.

		U-NII-1				U-NII-3				
Mode	Speed	36	40	44	48	149	153	157	161	165
A	6	**13.39**	**20.48**	**21.00**	**20.37**	**19.61**	**NT**	**19.45**	**NT**	**20.20**
A	9	**10.76**	**16.90**	**16.95**	**16.90**	**16.34**	**NT**	**16.17**	**NT**	**16.56**
A	12	**9.45**	**14.74**	**14.72**	**15.50**	**14.20**	**NT**	**13.91**	**NT**	**14.31**
A	18	**7.75**	**11.91**	**11.88**	**12.21**	**11.27**	**NT**	**11.14**	**NT**	**11.43**
A	24	**6.37**	**9.92**	**9.86**	**10.05**	**9.24**	**9.51**	**9.15**	**9.76**	**9.39**
A	36	**4.92**	**7.55**	**7.50**	**7.67**	**6.93**	**NT**	**7.06**	**NT**	**7.13**
A	48	**3.38**	**5.49**	**5.50**	**5.64**	**5.06**	**NT**	**5.10**	**NT**	**4.91**
A	54	**3.17**	**5.12**	**5.14**	**5.25**	**4.72**	**NT**	**4.74**	**NT**	**4.56**
AC	MCS0	**12.38**	**19.33**	**18.79**	**18.95**	**19.50**	**18.92**	**18.27**	**18.73**	**17.90**
AC	MCS1	**8.63**	**13.64**	**13.24**	**14.02**	**13.34**	**NT**	**13.07**	**NT**	**12.79**
AC	MCS2	**6.88**	**10.83**	**10.48**	**10.88**	**10.45**	**NT**	**10.26**	**NT**	**10.01**
AC	MCS3	**5.74**	**9.08**	**8.81**	**9.03**	**8.70**	**NT**	**8.50**	**NT**	**8.33**
AC	MCS4	**4.51**	**7.04**	**6.86**	**7.08**	**6.73**	**NT**	**6.55**	**NT**	**6.42**
AC	MCS5	**3.19**	**5.20**	**5.15**	**5.29**	**4.95**	**NT**	**4.75**	**NT**	**4.79**
AC	MCS6	**3.00**	**4.89**	**4.87**	**4.98**	**4.64**	**NT**	**4.45**	**NT**	**4.48**
AC	MCS7	**2.81**	**4.57**	**4.56**	**4.67**	**4.34**	**NT**	**4.16**	**NT**	**4.25**
AC	MCS8	**2.26**	**3.66**	**3.64**	**3.70**	**3.44**	**NT**	**3.30**	**NT**	**3.35**

Table TR04.4: Additional RF Exposure Power Summary in milliwatts. (20 MHz bandwidth)

		U-NII-1		U-NII-3	
Mode	Speed	38	46	151	159
AC40	MCS0	**4.33**	**5.29**	**5.28**	**5.05**
AC40	MCS1	**2.80**	**3.46**	**3.38**	**3.30**
AC40	MCS2	**2.20**	**2.70**	**2.62**	**2.55**
AC40	MCS3	**1.84**	**2.27**	**2.19**	**2.13**
AC40	MCS4	**1.44**	**1.76**	**1.70**	**1.65**
AC40	MCS5	**1.09**	**1.30**	**1.23**	**1.22**
AC40	MCS6	**1.05**	**1.24**	**1.17**	**1.15**
AC40	MCS7	**0.98**	**1.17**	**1.11**	**1.09**
AC40	MCS8	**0.80**	**0.95**	**0.90**	**0.88**
AC40	MCS9	**0.75**	**0.89**	**0.84**	**0.83**

Table TR04.5: Additional RF Exposure Power Summary in milliwatts. (40 MHz bandwidth)

While performing this data averaging, the analysis tool also determines for each period within the data record whether the transmitter was on, as opposed to periods of time when the transmitter was off. This transmitter does not have reduced power control levels, which simplifies the analysis. With this information it calculates the embedded duty cycle within the data set, which is the total amount of the time when the transmitter was on divided by the total length of the data record. These results are presented in Tables TR04.6 and TR04.7.

		UNII - 1 Band					UNII - 3 Band				
Mode	Speed	32	36	40	44	48	149	153	157	161	165
A	6	**NT**	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**NT**	**0.72**	**NT**	**0.72**
A	9	**NT**	**0.66**	**0.66**	**0.66**	**0.65**	**0.65**	**NT**	**0.66**	**NT**	**0.66**
A	12	**NT**	**0.61**	**0.61**	**0.61**	**0.61**	**0.61**	**NT**	**0.61**	**NT**	**0.61**
A	18	**NT**	**0.55**	**0.55**	**0.55**	**0.55**	**0.55**	**NT**	**0.55**	**NT**	**0.55**
A	24	**NT**	**0.51**	**0.51**	**0.51**	**0.51**	**0.51**	**0.51**	**0.51**	**0.51**	**0.51**
A	36	**NT**	**0.47**	**0.46**	**0.47**	**0.47**	**0.46**	**NT**	**0.47**	**NT**	**0.47**
A	48	**NT**	**0.44**	**0.44**	**0.44**	**0.44**	**0.43**	**NT**	**0.44**	**NT**	**0.44**
A	54	**NT**	**0.43**	**0.43**	**0.43**	**0.43**	**0.43**	**NT**	**0.43**	**NT**	**0.43**
AC	MCS0	**NT**	**0.69**	**0.70**	**0.69**	**0.70**	**0.70**	**0.69**	**0.70**	**0.70**	**0.69**
AC	MCS1	**NT**	**0.59**	**0.59**	**0.59**	**0.59**	**0.59**	**NT**	**0.59**	**NT**	**0.59**
AC	MCS2	**NT**	**0.53**	**0.53**	**0.53**	**0.53**	**0.53**	**NT**	**0.53**	**NT**	**0.53**
AC	MCS3	**NT**	**0.50**	**0.50**	**0.50**	**0.50**	**0.50**	**NT**	**0.49**	**NT**	**0.50**
AC	MCS4	**NT**	**0.46**	**0.46**	**0.46**	**0.46**	**0.46**	**NT**	**0.46**	**NT**	**0.45**
AC	MCS5	**NT**	**0.43**	**0.44**	**0.44**	**0.43**	**0.43**	**NT**	**0.43**	**NT**	**0.43**
AC	MCS6	**NT**	**0.43**	**0.43**	**0.43**	**0.43**	**0.43**	**NT**	**0.43**	**NT**	**0.43**
AC	MCS7	**NT**	**0.42**	**0.42**	**0.42**	**0.42**	**0.42**	**NT**	**0.42**	**NT**	**0.42**
AC	MCS8	**NT**	**0.41**	**0.41**	**0.41**	**0.41**	**0.41**	**NT**	**0.41**	**NT**	**0.41**
AC	MCS9	**NT**	**NT**	**NT**	**NT**	**NT**	**NT**	**NT**	**NT**	**NT**	**NT**
AC	MCS32	**NT**	**NT**	**NT**	**NT**	**NT**	**NT**	**NT**	**NT**	**NT**	**NT**

Table TR04.6: WiFi Embedded Duty Cycle, linear ratio (20 MHz bandwidth)

		UNII - 1 Band		UNII - 3 Band	
Mode	Speed	38	46	151	159
AC40	MCS0	**0.58**	**0.58**	**0.58**	**0.58**
AC40	MCS1	**0.49**	**0.49**	**0.49**	**0.49**
AC40	MCS2	**0.46**	**0.46**	**0.45**	**0.45**
AC40	MCS3	**0.43**	**0.43**	**0.43**	**0.43**
AC40	MCS4	**0.41**	**0.41**	**0.41**	**0.41**
AC40	MCS5	**0.40**	**0.40**	**0.39**	**0.39**
AC40	MCS6	**0.39**	**0.39**	**0.39**	**0.39**
AC40	MCS7	**0.39**	**0.39**	**0.39**	**0.39**
AC40	MCS8	**0.39**	**0.39**	**0.38**	**0.38**
AC40	MCS9	**0.38**	**0.38**	**0.38**	**0.38**
AC40	MCS32	**NT**	**NT**	**NT**	**NT**

Table TR04.7: WiFi Embedded Duty Cycle, linear ratio (40 MHz bandwidth)

The guidance in KDB entry 789033 D02 v02r01 is to evaluate Transmit Power not using peak power as described in the normative reference ANSI C63.10, but based on the time-averaged power adjusted for duty cycle. That analysis is provided here for information. The data in Tables TR04.8 and TR04.9 are calculated as 10*log10(Pa) + 10*log(1/D). Pa is the average linear power data in tables TR04.4 and TR04.5 which must be converted from milliwatts to dBm. Since linear power is averaged over the entire 1-second data record, the integration period requirements of the KDB entry are satisfied. D is the duty cycle data from Tables TR04.6 and TR04.7 which are similarly converted to decibel units.

As one would expect, the time-averaged transmit power levels adjusted for duty cycle as shown below are lower than the peak transmit power values already presented in Tables TR04.2 and TR04.3. Compliance with the transmit power limits is demonstrated by either method.

		U-NII-1				U-NII-3				
Mode	Speed	36	40	44	48	149	153	157	161	165
A	6	**12.68**	**14.53**	**14.64**	**14.51**	**14.35**	**NT**	**14.32**	**NT**	**14.47**
A	9	**12.15**	**14.11**	**14.13**	**14.13**	**13.98**	**NT**	**13.92**	**NT**	**14.02**
A	12	**11.92**	**13.84**	**13.85**	**14.07**	**13.69**	**NT**	**13.60**	**NT**	**13.71**
A	18	**11.48**	**13.35**	**13.33**	**13.46**	**13.12**	**NT**	**13.09**	**NT**	**13.18**
A	24	**10.97**	**12.89**	**12.88**	**12.94**	**12.59**	**12.71**	**12.54**	**12.81**	**12.65**
A	36	**10.24**	**12.12**	**12.06**	**12.15**	**11.74**	**NT**	**11.81**	**NT**	**11.85**
A	48	**8.86**	**10.98**	**10.99**	**11.09**	**10.67**	**NT**	**10.66**	**NT**	**10.48**
A	54	**8.67**	**10.74**	**10.77**	**10.84**	**10.38**	**NT**	**10.42**	**NT**	**10.24**
AC	MCS0	**12.51**	**14.44**	**14.32**	**14.36**	**14.48**	**14.36**	**14.19**	**14.30**	**14.11**
AC	MCS1	**11.67**	**13.66**	**13.52**	**13.80**	**13.56**	**NT**	**13.47**	**NT**	**13.39**
AC	MCS2	**11.13**	**13.11**	**12.96**	**13.12**	**12.93**	**NT**	**12.91**	**NT**	**12.76**
AC	MCS3	**10.63**	**12.62**	**12.49**	**12.60**	**12.44**	**NT**	**12.35**	**NT**	**12.25**
AC	MCS4	**9.93**	**11.88**	**11.75**	**11.90**	**11.69**	**NT**	**11.53**	**NT**	**11.50**
AC	MCS5	**8.66**	**10.77**	**10.73**	**10.87**	**10.59**	**NT**	**10.40**	**NT**	**10.42**
AC	MCS6	**8.44**	**10.58**	**10.55**	**10.66**	**10.36**	**NT**	**10.17**	**NT**	**10.18**
AC	MCS7	**8.25**	**10.35**	**10.33**	**10.43**	**10.15**	**NT**	**9.93**	**NT**	**10.05**
AC	MCS8	**7.41**	**9.47**	**9.46**	**9.54**	**9.22**	**NT**	**9.09**	**NT**	**9.09**

Table TR04.8: Time-averaged Transmit Power Summary, with units of dBm (20 MHz bandwidth)

		U-NII-1		U-NII-3	
Mode	Speed	38	46	151	159
AC40	MCS0	**8.72**	**9.60**	**9.59**	**9.42**
AC40	MCS1	**7.53**	**8.48**	**8.37**	**8.25**
AC40	MCS2	**6.84**	**7.72**	**7.65**	**7.52**
AC40	MCS3	**6.27**	**7.19**	**7.03**	**6.94**
AC40	MCS4	**5.47**	**6.30**	**6.18**	**6.07**
AC40	MCS5	**4.40**	**5.13**	**5.00**	**4.91**
AC40	MCS6	**4.25**	**4.99**	**4.74**	**4.74**
AC40	MCS7	**4.00**	**4.79**	**4.55**	**4.48**
AC40	MCS8	**3.15**	**3.90**	**3.74**	**3.61**
AC40	MCS9	**2.95**	**3.66**	**3.44**	**3.36**

Table TR04.9: Time-averaged Transmit Power Summary, with units of dBm (40 MHz bandwidth)

Setup Diagram

The following block diagrams show how the EUT and test equipment is arranged for test. The client provided a short length of cable to bring the signals out to a connector. This cable was found to have 0.23 dB of loss in this frequency range. This factor was taken into account during the data analysis.

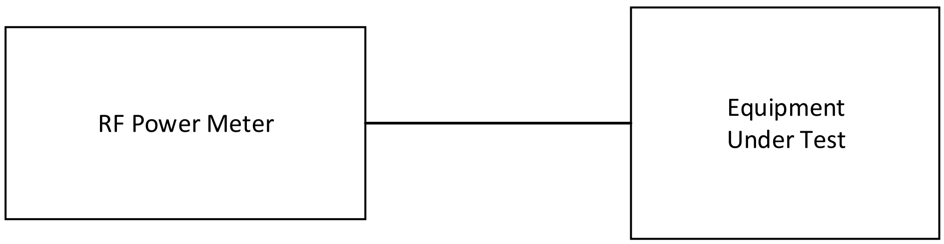

Figure TR04.1: Test equipment setup

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test IDs TR17
Project GCL-0388

Test Date(s)	10 Oct 2023
Test Personnel	David Arnett
Product Model	A04752
Serial Number tested	3449554852
Operating Mode	M5 (WiFi5Tx)
Arrangement	A4 (Dual)
Input Power	13.8 Vdc
Test Standards:	FCC Part 15, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Antenna Gain	4.26 dBi, as reported by the client
Radio Protocol	IEEE 802.11 a/n/ac with 20 MHz and 40 MHz nominal bandwidths in the U-NII-1 and U-NII-3 sub-bands
Pass/Fail Judgment:	**PASS**
Test record created by:	**David Arnett**
Date of this record:	**6 Nov 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024

Table TR17.1: Test equipment used

Software Used: Keysight PXE software A.32.06

Test Method

The basic test standard ANSI C63.10 does not options for this test. The best we have is the set of definitions and requirements in the standards, and the informative guidance in KDB 789033 D02 v02r01. The test tool provided by the RF chip manufacturer does not easily create a consistent duty cycle over a long timeframe. But it does create a consistent duty cycle greater than 85% for a timeframe that is long compared to the response time of an rms power detector.

Given that condition, the approach used for this test is a variant on the method II E 2 b within the KDB entry. The KDB method uses an rms power detector (average detector) and trace averaging over at least 100 traces. It requires that the transmitter be at a maximum power level for each sweep so that the trace averaging provides averaging of valid data.

The variant used here is to use Max Hold on thousands of traces rather than trace averaging on hundreds. Since the data train is long compared to the detector response, and so many traces are included, no duty cycle correction applies. The resulting Max Hold spectrum cannot be lower than what one would get with trace averaging, so this method is a worse case approach. When compliance is shown using this worse-case approach, compliance is assured relative to the method described in the KDB entry and the requirements stated in 15.407 and RSS-247.

Test Setup

This block diagram shows the test equipment setup.

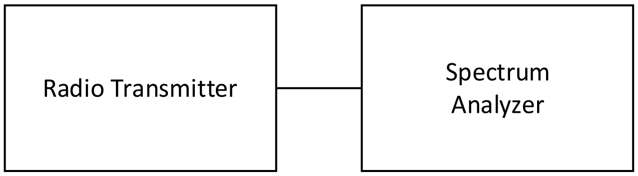

Figure TR17.1: Test setup

Test Data

Each measurement is made conducted from the antenna port with the transmitter on a specified channel and in a selected transmission protocol. The results include the effects of any measurement cable losses. Results reported are in units of dBm/Bandwidth and do not include the effect of antenna gain. The standard limit is 11 dBm/MHz in the U-III-1 sub-band, and 30 dBm/500 kHz in the U-III-3 sub-band. Meeting the limit with higher resolution bandwidths is permitted. All data met the consolidated worst-case limit of 11 dBm / MHz using a 1 MHz resolution bandwidth. RSS-247 also imposes a 10 dBm/MHz EIRP limit, and the data satisfy this limit as well.

Data were measured for all data rates on the lowest channel of the U-NII-3 sub-band. At the data rate with the highest PSD in the first part of the test, as well as the lowest and highest data rates, further measurements were made on the remaining low and high channels in each sub-band.

The highest PSD levels for each mode are highlighted in yellow, and graphical results are provided for those cases.

Frq (MHz)	5180	5240	5745	5825
Channel	36	48	149	165
Nom BW	20	20	20	20
Modulation				
A6	2.69	4.23	4.04	4.17
A9	NT	NT	4.40	NT
A12	NT	NT	4.16	NT
A18	NT	NT	4.10	NT
A24	3.50	5.07	4.83	5.09
A36	NT	NT	4.44	NT
A48	NT	NT	4.19	NT
A54	2.29	5.14	4.47	4.77
MCS0	3.22	4.96	4.34	4.89
MCS1	NT	NT	4.09	NT
MCS2	NT	NT	4.24	NT
MCS3	NT	NT	4.34	NT
MCS4	3.20	4.87	4.41	4.54
MCS5	NT	NT	3.82	NT
MCS6	NT	NT	3.77	NT
MCS7	NT	NT	3.97	NT
MCS8	2.29	3.72	2.94	3.38

Table TR17.2: Summary of results for 20 MHz channels

Frq (MHz)	5190	5230	5755	5795
Channel	38	46	151	159
Nom BW	40	40	40	40
Modulation				
MCS0	-4.63	-5.89	-4.16	-3.90
MCS1	NT	NT	-3.82	NT
MCS2	NT	NT	-3.81	NT
MCS3	-4.23	-5.42	-3.68	-3.50
MCS4	NT	NT	-3.83	NT
MCS5	NT	NT	-4.35	NT
MCS6	NT	NT	-4.45	NT
MCS7	NT	NT	-4.38	NT
MCS8	NT	NT	-4.97	NT
MCS9	-5.27	-6.45	-5.04	-4.96

Table TR17.3: Summary of results for 40 MHz channels

The maximum PSD in the U-NII-1 sub-band is 5.14 dBm/MHz. Given the 4.26 dBi antenna gain cited above, this correlates to 9.40 dBm/MHz EIRP.

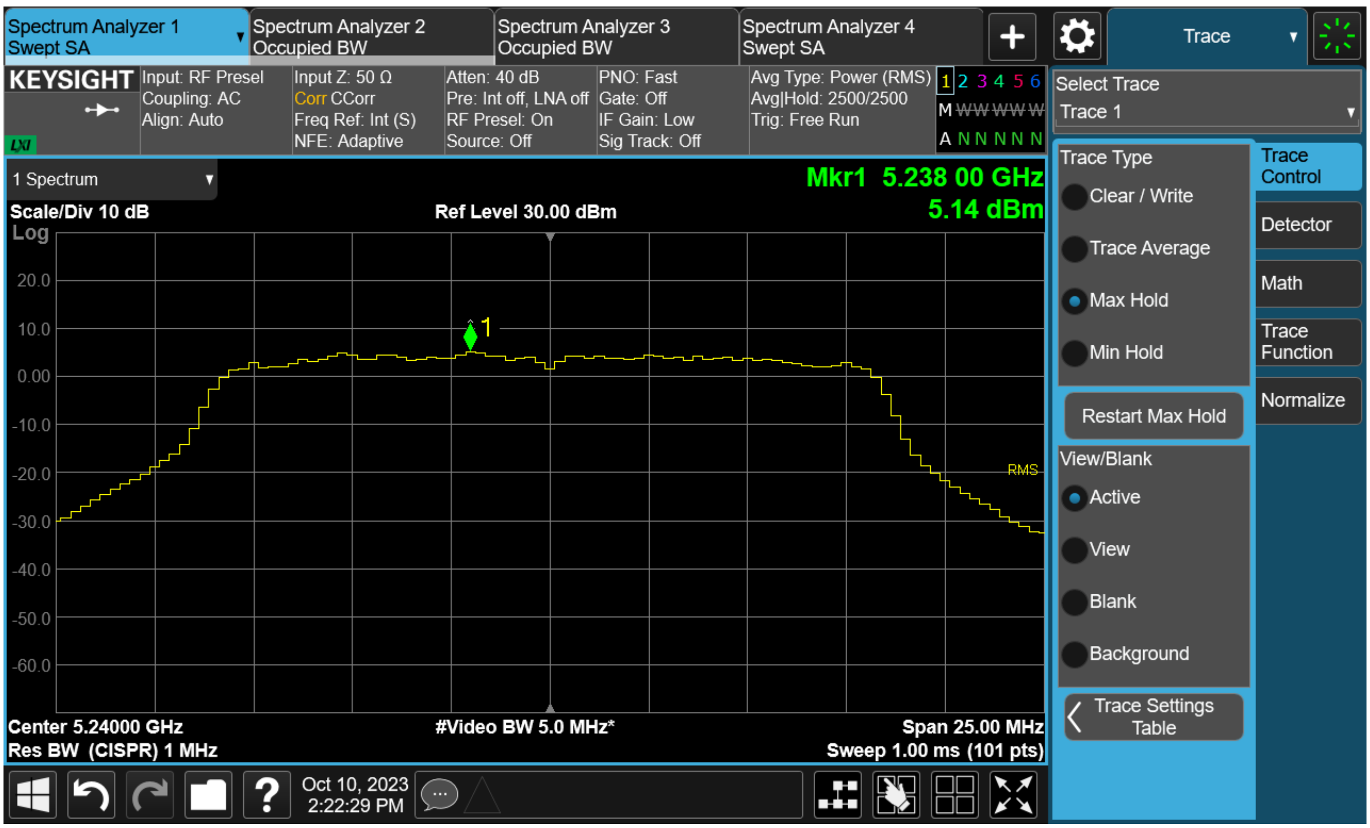

Figure TR17.3: Test data for A54 transmissions at 5240 MHz

Figure TR17.4: Test data for A24 transmissions at 5825 MHz

Figure TR17.5: Test data for 20 MHz MCS0 transmissions at 5240 MHz

Figure TR17.6: Test data for 20 MHz MCS0 transmissions at 5825 MHz

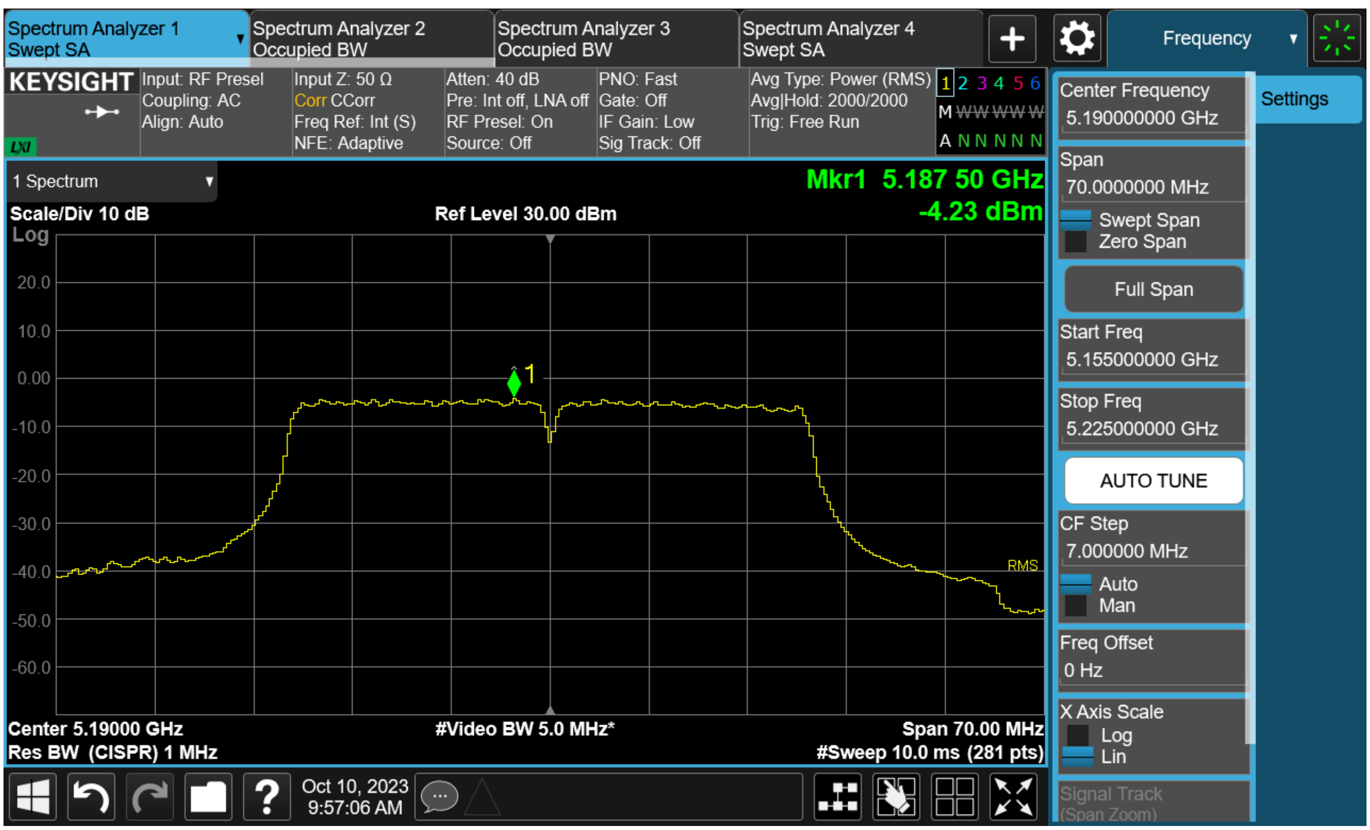

Figure TR17.7: Test data for 40 MHz MCS3 transmissions at 5190 MHz

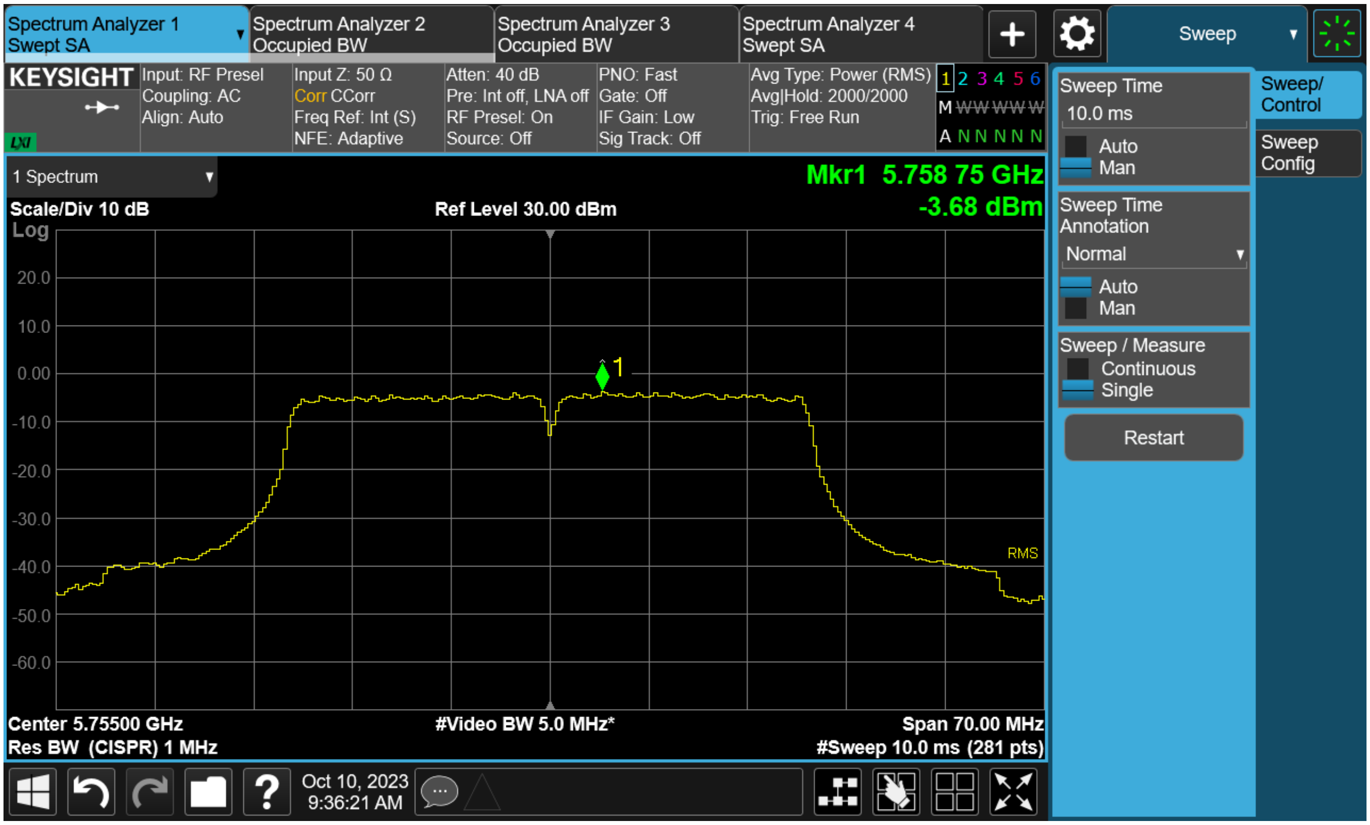

Figure TR17.8: Test data for 40 MHz MCS3 transmissions at 5755 MHz

This line is the end of the test record.

Test Record

Transmitter DTS Bandwidth Tests
Test IDs TR28
Project GCL0388

Test Date(s) 20 Oct 2023
Test Personnel David Arnett

Product Model A04752
Serial Number tested 3449554828

Operating Mode M4 (WiFi5Tx)
Arrangement A4 (Dual)
Input Power 13.8 Vdc

Test Standards: ANSI C63.10, RSS-247 (as noted in Section 6 of the report).

Radio Protocol IEEE 802.11 a/n/ac (WiFi)
Radio Band U-NII-3 sub-band (5725-5850 MHz)

Pass/Fail Judgment: Pass

Test record created by: David Arnett
Date of this record: 20 Nov 2023
Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024

Table TR28.1 Equipment Used

Test Software used: Keysight PXE System Code rev A.33.03

Test Method

RSS-247 at 6.2.4.2 requires that the 6 dB DTS Bandwidth be greater than 500 kHz. This requirement applies only to transmissions in the U-NII-3 sub-band. During this test the transmitter output is fed directly, or through RF attenuators, to the spectrum analyzer. The analyzer has a built-in capability to identify the minimum bandwidth that contains a specified portion of the total power observed, and also identify parameters such as the edge frequencies for that bandwidth and the center frequency error. The spectrum is scanned many times so that the varied effects of modulation are appropriately assessed. Since the focus is on the relative distribution of energy across a range of frequencies, the absolute amplitudes recorded during this test are not relevant and may not include cable losses or attenuation factors.

Test Setup

This block diagram shows the test equipment setup.

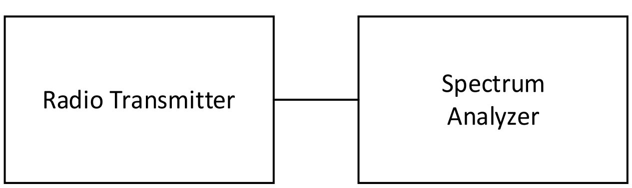

Figure TR28.1: Test setup

Test Data

The data for each type of bandwidth is summarized below, followed by the spectral data for the case highlighted in yellow. The analysis threshold for this test was the bandwidth containing all emissions within 6 dB of the spectral peak. The standards require testing a frequency near the bottom, middle, and top of the band. The measured bandwidth data are in bold font and have MHz as their units of measure.

Frq (MHz)	5745	5785	5825
Channel	149	157	165
Modulation			
A6	**16.020**	**16.050**	**16.040**
A54	**16.340**	**16.340**	**16.330**
MCS0	**16.680**	**17.000**	**15.120**
MCS8	**16.180**	**16.190**	**16.840**

Table TR28.2: Summary of DTS Bandwidth Data for IEEE 802.11a/n/ac Modes with 20 MHz channels

Frq (MHz)	5755	5795
Channel	151	159
Modulation		
MCS0	**35.880**	**36.440**
MCS9	**36.020**	**36.020**

Table TR28.3: Summary of DTS Bandwidth Data for IEEE 802.11n/ac Modes with 40 MHz channels

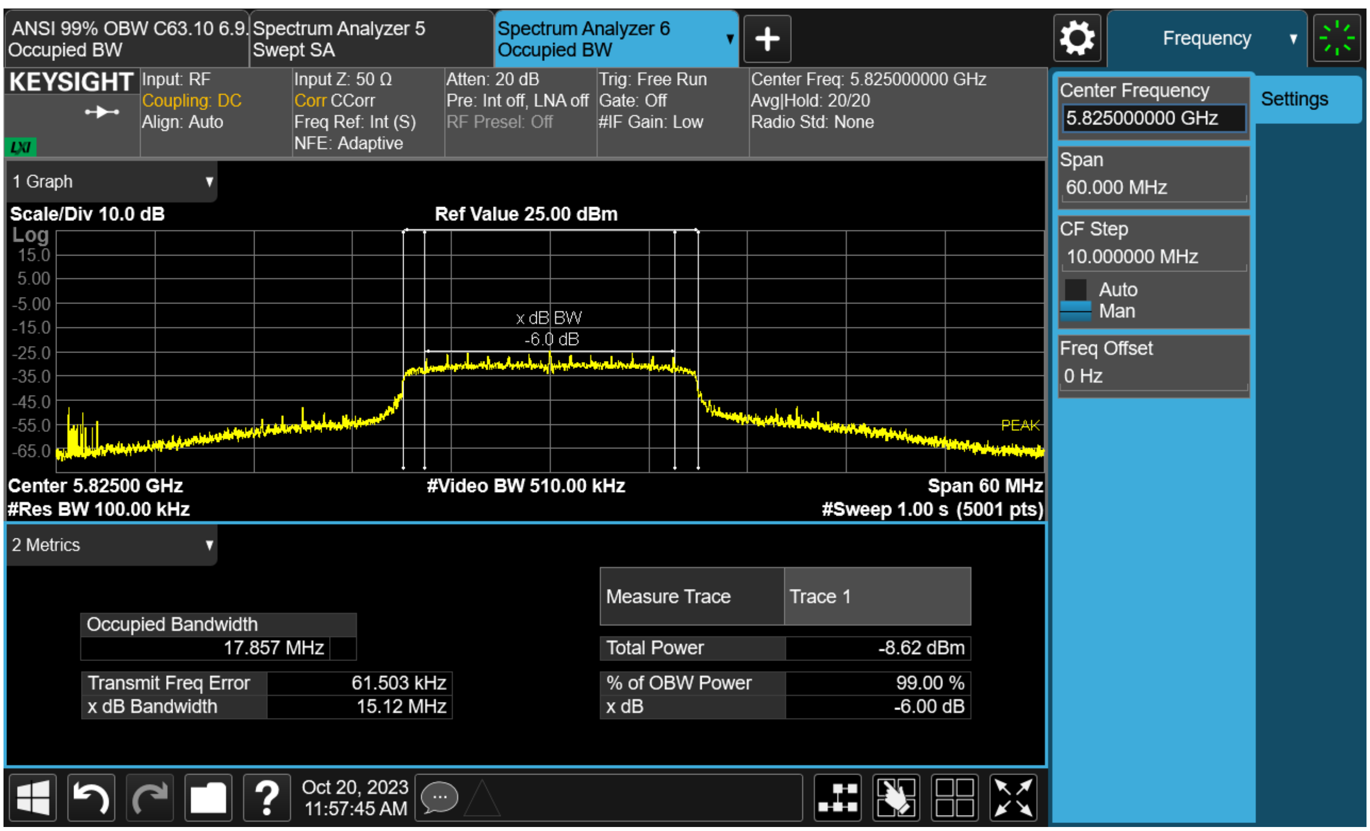

Figure TR28.1: Occupied bandwidth data for 802.11ac with MCS0 modulation at channel 165

This line is the end of the test record.

Test Record
Transmitter Bandwidth Tests
Test IDs TR13
Project GCL0388

Test Date(s) 03 Oct 2023
Test Personnel David Arnett

Product Model A04752
Serial Number tested 3449554852

Operating Mode M4 (WiFi5Tx)
Arrangement A4 (Dual)
Input Power 13.8 Vdc

Test Standards: FCC Part 2.202, ANSI C63.10, TRC-43, RSS-GEN, RSS-247 (as noted in Section 6 of the report).

Radio Protocol IEEE 802.11 a/n/ac (WiFi)
Radio Band U-NII-1 and U-NII-3 bands (5150-5250 MHz and 5725-5850 MHz)

Pass/Fail Judgment: **Pass/Reported**

Test record created by: **David Arnett**
Date of this record: **5 Oct 2023**
Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220146	3-Jun-2023	3-Jun-2024

Table TR13.1 Equipment Used

Test Software used: Keysight PXE System Code rev A.35.06

There are regulatory requirements to present two additional types of bandwidth analyses: 99% Occupied Bandwidth and Necessary Bandwidth. RSS-247 at 6.2.1.2 requires that the 99% Occupied Bandwidth not extend beyond 5250 MHz. Other tests may be affected by the results of the 99% OBW results. But there are no other limits or functional requirements around these data, beyond a reporting requirement.

Test Setup

This block diagram shows the test equipment setup.

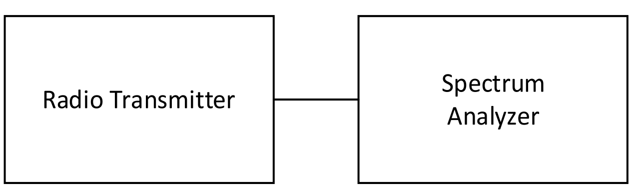

Figure TR13.1: Test setup

Occupied Bandwith, 99% Test Method
During this test the transmitter output is fed directly, or through RF attenuators, to the spectrum analyzer. The analyzer has a built-in capability to identify the minimum bandwidth that contains a specified percentage of the total power observed. The spectrum is scanned hundreds of times so that the varied effects of modulation are appropriately assessed. Since the focus is on the relative distribution of energy across a range of frequencies, the absolute amplitudes recorded during this test are not relevant and may not include cable losses or attenuation factors.

In general, the various modulations are evaluated while the radio is tuned to a middle channel to find the worst case modulation. For that modulation, the lowest and highest channels are also evaluated. Lowest and highest channels are Not tested (NT) for other modulations. The n and ac modes result in the same modulation so only a and ac were actually exercised in this portion of the test program.

Occupied Bandwith, 99% Test Data

The data for each type of bandwidth is summarized below, followed by the spectral data for the cases highlighted in yellow. The analysis threshold for this test was the bandwidth containing 99% of the observed power using the ANSI C63.10 method. The standards require testing a frequency near the bottom, middle, and top of the band. The measured bandwidth data are in bold font and have MHz as their units of measure.

Frq (MHz)	5180	5200	5220	5240	5745	5765	5785	5805	5825
Channel	36	40	44	48	149	153	157	161	165
Modulation									
A6	NT	NT	**16.968**	NT	NT	NT	NT	NT	NT
A9	NT	NT	**16.889**	NT	NT	NT	NT	NT	NT
A12	NT	NT	**16.853**	NT	NT	NT	NT	NT	NT
A18	NT	NT	**16.87**	NT	NT	NT	NT	NT	NT
A24	**17.409**	**17.566**	**17.567**	**17.544**	**17.472**	**17.47**	**17.497**	**17.416**	**17.51**
A36	NT	NT	**16.724**	NT	NT	NT	NT	NT	NT
A48	NT	NT	**16.707**	NT	NT	NT	NT	NT	NT
A54	NT	NT	**16.778**	NT	NT	NT	NT	NT	NT

Table TR13.2: Summary of 99% Occupied Bandwidth Data for IEEE 802.11a

Frq (MHz)	5180	5200	5220	5240	5745	5765	5785	5805	5825
Channel	36	40	44	48	149	153	157	161	165
Modulation									
MCS0	NT	NT	**17.945**	NT	NT	NT	NT	NT	NT
MCS1	NT	NT	**17.933**	NT	NT	NT	NT	NT	NT
MCS2	NT	NT	**17.873**	NT	NT	NT	NT	NT	NT
MCS3	NT	NT	**17.912**	NT	NT	NT	NT	NT	NT
MCS4	NT	NT	**17.785**	NT	NT	NT	NT	NT	NT
MCS5	NT	NT	**17.857**	NT	NT	NT	NT	NT	NT
MCS6	**18.015**	**18.026**	**18.031**	**18.029**	**18.015**	**18.012**	**18.023**	**18.008**	**18.027**
MCS7	NT	NT	**17.856**	NT	NT	NT	NT	NT	NT
MCS8	NT	NT	**17.829**	NT	NT	NT	NT	NT	NT

Table TR13.3: Summary of 99% Occupied Bandwidth Data for IEEE 802.11 ac 20 MHz WiFi modes

Frq (MHz)	5190	5230	5755	5795
Channel	38	46	151	159
Modulation				
MCS0	NT	**37.636**	**37.582**	NT
MCS1	NT	**37.442**	**37.585**	NT
MCS2	NT	**37.018**	**36.970**	NT
MCS3	NT	**37.444**	**37.321**	NT
MCS4	NT	**37.045**	**36.920**	NT
MCS5	NT	**37.025**	**36.962**	NT
MCS6	NT	**37.129**	**37.026**	NT
MCS7	NT	**37.131**	**37.002**	NT
MCS8	NT	**36.868**	**36.791**	NT
MCS9	**39.603**	**39.751**	**39.555**	**39.655**

Table TR13.4: Summary of 99% Occupied Bandwidth Data for IEEE 802.11 ac 40 MHz WiFi modes

The table below analyzes the 99% Occupied Bandwidth data in the figures below relative to the highest channel in the U-NII-1 band, to ensure that the top edge of the band is below the 5250 MHz U-NII-1 band edge. The analysis adds together the center frequency, the frequency error, and half of the measured bandwidth to find the top edge of the occupied frequency range. In all cases, the result is below 5250 MHz.

Channel	48	48	46
Modulation	A24	MCS6	MCS9
99% OBW	17.544	18.029	39.751
Center Frq (MHz)	5240	5240	5230
Error (kHz)	87.825	48.351	41.869
Max Freq (MHz)	**5248.86**	**5249.063**	**5249.917**

Table TR13.5: Analysis of U-NII-1 99% Occupied Bandwidth Data for upper band edge compliance

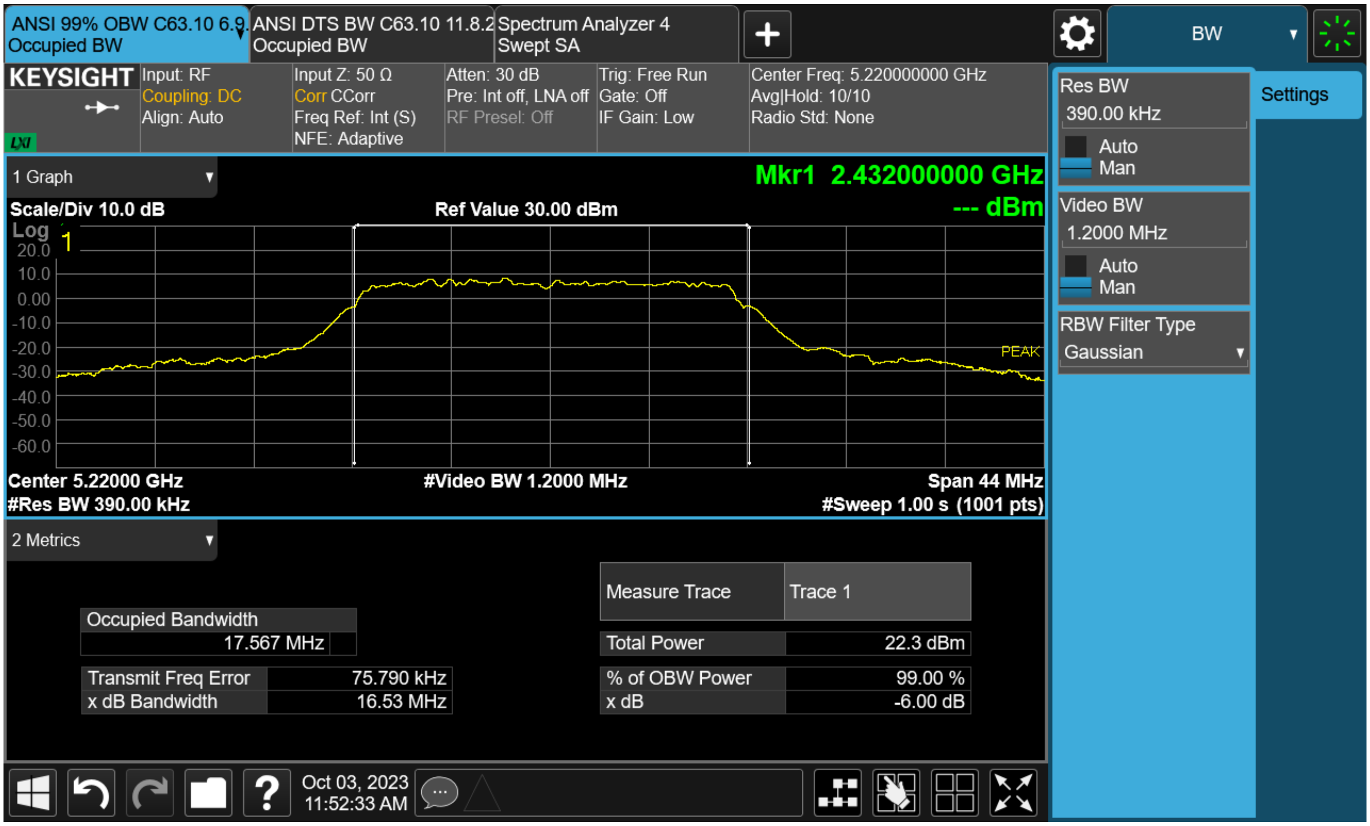

Figure TR13.1: Occupied bandwidth data for 802.11a 24 Mbps at channel 44

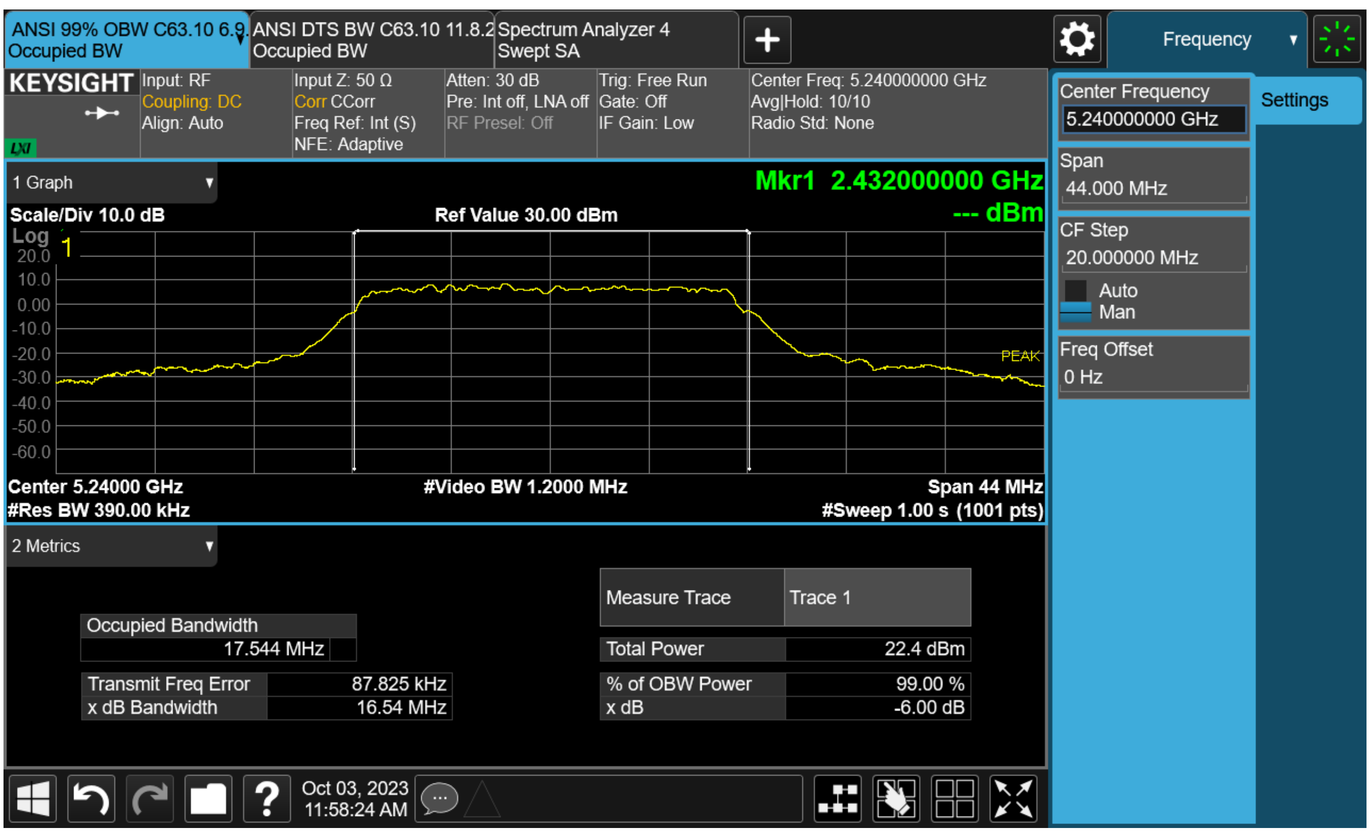

Figure TR13.2: Occupied bandwidth data for 802.11a 24 Mbps at channel 48

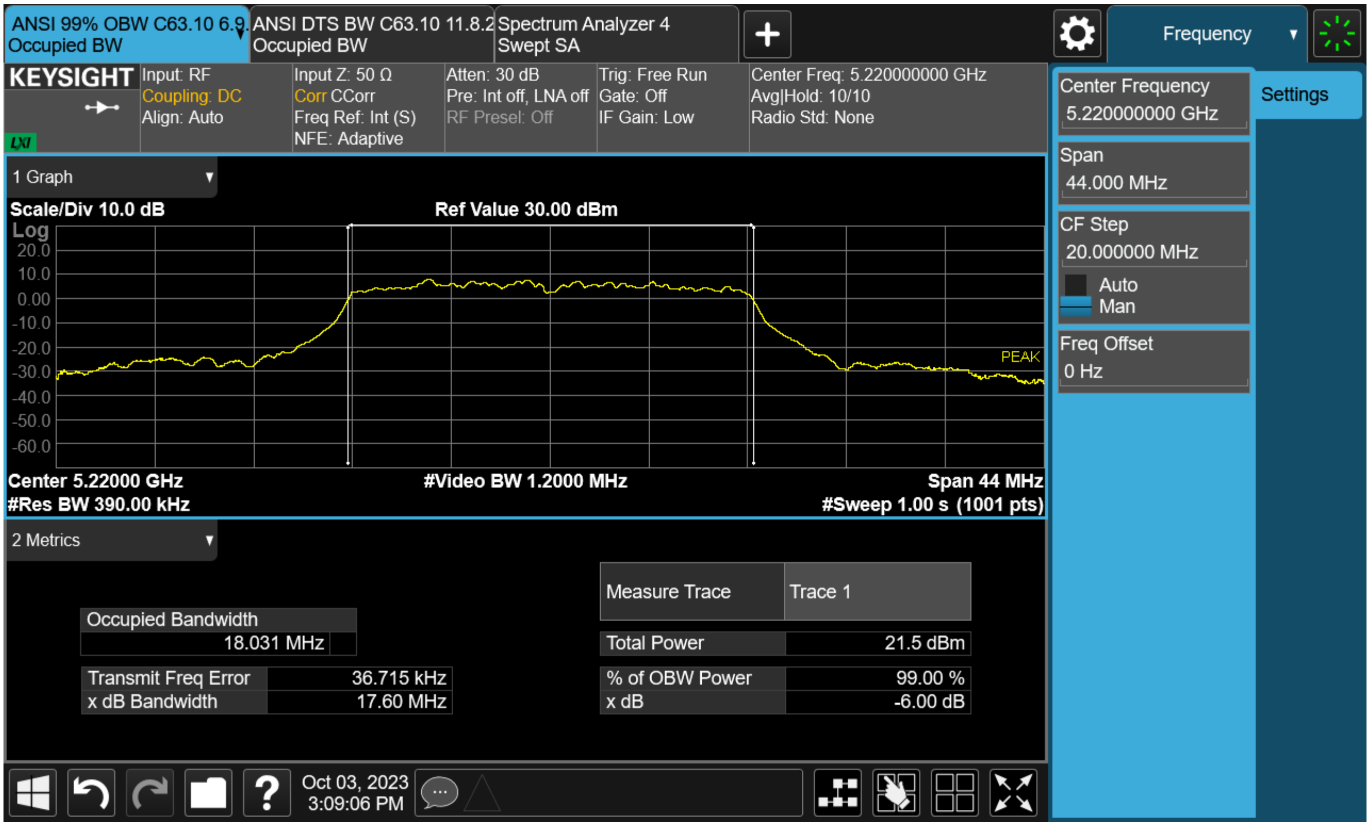

Figure TR13.3: Occupied bandwidth data for 802.11ac MCS6 20 MHz at channel 44

Figure TR13.4: Occupied bandwidth data for 802.11ac MCS6 20 MHz at channel 48

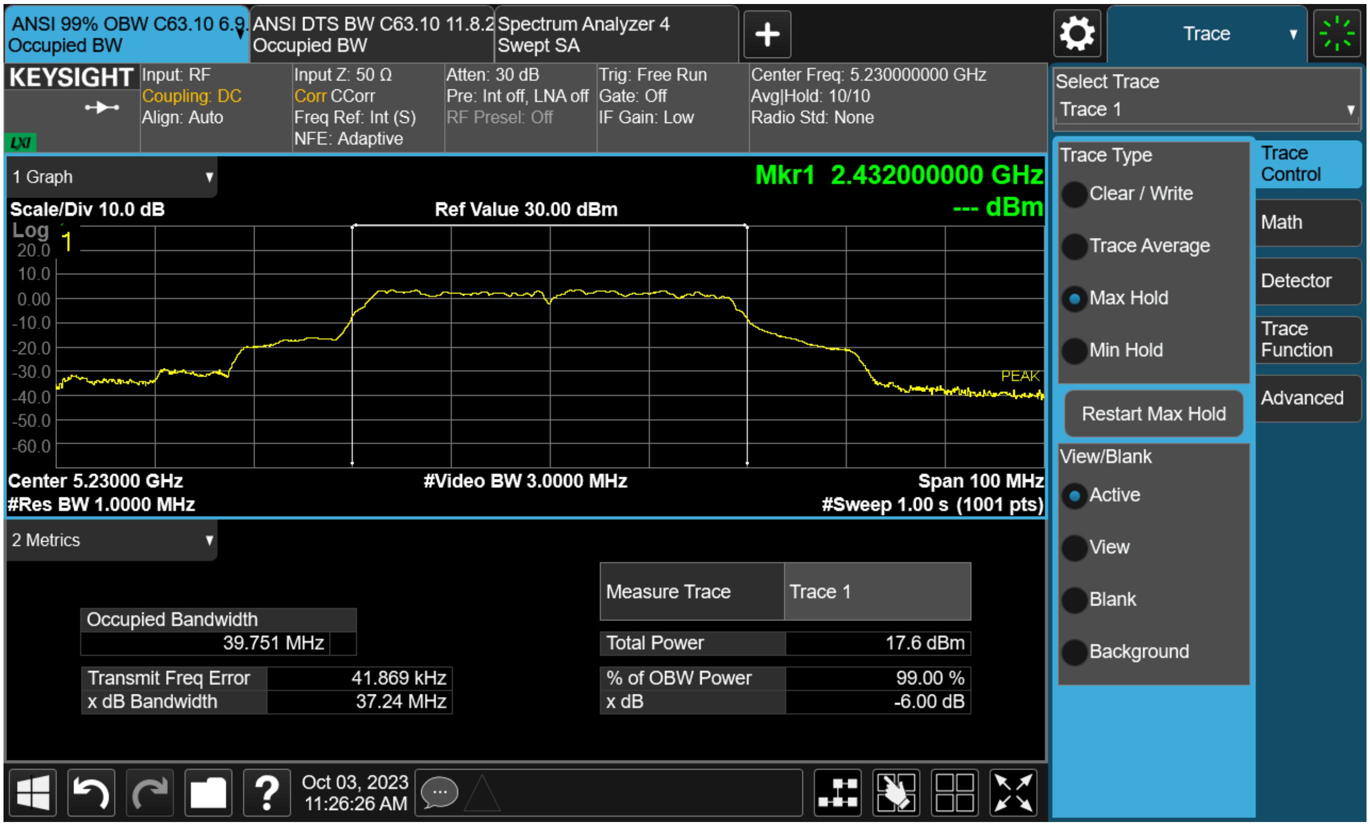

Figure TR13.5: Occupied bandwidth data for 802.11a MCS9 40 MHz at channel 46

Necessary Bandwidth Calculations

The Necessary Bandwidth is a theoretical value based on the specifications for a communication protocol, rather than the hardware implementation and a subsequent lab measurement. The analysis methods in FCC Part 2.202 and TRC-43 are the same for NFC, Bluetooth, ANT, and IEEE 802.11b WiFi. However, they differ for IEEE 802.11g and 11n systems because the Canadian TRC-43 standard provides different analysis methods for Orthogonal Frequency Division Multiplexing systems (OFDM). The tables below will show the analysis for most of the radios signals as a combined approach, then separately analyze the results for IEEE 802.11g and n systems. The tables below may include radio protocols that are not part of the product being evaluated.

NFC (Near Field Communication) at 13.56 MHz uses continuous wave telegraphy without tone modulation. The bit rate 'B' in the FCC and TRC equations is split into two parts here. B is the baud rate. C is a coding factor. C=1 for Miller encoding where the transition speed is as high as the bit rate, or C=2 for Manchester encoding where the transition speed is as high as twice the bit rate). K is a factor set to 3 for non-fading circuits under the standards. The Necessary Bandwidth, B_N is then:

$$B_N = BCK$$

Radio Type	B (kbaud)	C	K	B_N (kHz)
NFC A	106	1	3	318.0
NFC B	212	2	3	1272.0
NFC B	424	2	3	2544.0

Table TR13.100: Necessary Bandwidth for NFC

The radio modulation schemes for Ant, for the various Bluetooth protocols, and for IEEE 802.11 b WiFi are a mix of Phase Shift Key (PSK) and Quadrature Amplitude Modulation (QAM) techniques. The Necessary Bandwidth calculations use the equations from 47CFR Part 2.202(g) table section 6. We have set the variable K=1, which leaves the equation for both PSK and QAM as:

$$B_N = 2R / \log_2(S)$$

where B_N is the Necessary Bandwidth, R is the bit rate, and S is the number of signaling states.

Radio Type	R Mbps	K	S	LogBase2 of (S)	B_N (MHz)
ANT / ANT+	1	1	2	1	2

Table TR13.101: Necessary Bandwidth for ANT and ANT+ Radio Protocols (FCC and TRC-43)

Radio Type	Sub-type	Method	R Mbps	K	S	LogBase2 of (S)	B_N (MHz)
Bluetooth	BR	GFSK	1	1	2	1	2
	EDR2	Pi/4 DPSK	2	1	4	2	2
	EDR3	8DPSK	3	1	8	3	2
BLE	1Mbps	GFSK	1	1	2	1	2
	2Mbps	DQPSK	2	1	4	2	2

Table TR13.102: Necessary Bandwidth for Bluetooth Radio Protocols (FCC and TRC-43)

Radio Type	Sub-type	R Mbps	K	S	LogBase2 of (S)	B_N (MHz)
802.11 b	1	1	1	2	1	2
	2	2	1	4	2	2
	5.5	5.5	1	4	2	5.5
	11	11	1	4	2	11

Table TR13.103: Necessary Bandwidth for IEEE 802.11 b Radio Protocol (FCC and TRC-43)

Radio Type	Sub-type	R Mbps	K	S	LogBase2 of (S)	B_N (MHz)
802.11 a/g	6	6	1	2	1	12
	9	9	1	2	1	18
	12	12	1	4	2	12
	18	18	1	4	2	18
	24	24	1	16	4	12
	36	36	1	16	4	18
	48	48	1	64	6	16
	54	54	1	64	6	18
802.11 n/ac	MCS0	7.2	1	2	1	14.4
	MCS1	14.4	1	4	2	14.4
	MCS2	21.7	1	4	2	21.7
	MCS3	28.9	1	16	4	14.5
	MCS4	43.3	1	16	4	21.7
	MCS5	57.8	1	64	6	19.3
	MCS6	65	1	64	6	21.7
	MCS7	72.2	1	64	6	24.1
	MCS8	86.7	1	256	8	21.7

Table TR13.104: Necessary Bandwidth for IEEE 802.11 a, g, n, and ac 20 MHz Radio Protocols (FCC)

Radio Type	Sub-type	R Mbps	K	S	LogBase2 of (S)	B_N (MHz)
802.11 n/ac	MCS0	15	1	2	1	30.0
	MCS1	30	1	4	2	30.0
	MCS2	45	1	4	2	45.0
	MCS3	60	1	16	4	30.0
	MCS4	90	1	16	4	45.0
	MCS5	120	1	64	6	40.0
	MCS6	135	1	64	6	45.0
	MCS7	150	1	64	6	50.0
	MCS8	180	1	256	8	45.0
	MCS9	200	1	256	8	50.0

Table TR13.105: Necessary Bandwidth for IEEE 802.11 n and ac 40 MHz Radio Protocols (FCC)

As a note, the bit rate for IEEE 802.11 n or ac WiFi is calculated based on the IEEE standard's short guard interval of 400 nsec. If only the long guard interval of 800 nsec were implemented, the bit rates would decrease by a small amount.

The TRC-43 method for OFDM signals simply multiplies the number of subcarriers, K, and the subcarrier spacing, N_S. In both cases, Ns is 312.5 kHz. The count of subcarriers includes nulls. So for example, 802.11 n uses 4 pilot subcarriers, 52 data subcarriers, and one null suppressed subcarrier in the middle for 57 total subcarrier channels.

$B_N = N_S * K$

Radio Type	Mode	Ns (MHz)	K	B_N (MHz)
802.11a/g	20 MHz	0.3125	53	16.6
802.11n/ac	20 MHz	0.3125	57	17.8
802.11n/ac	40 MHz	0.3125	117	36.6

Table TR13.106: Necessary Bandwidth for IEEE 802.11 a, g, n, and ac Radio Protocols (TRC-43)

This line is the end of the test record.

Test Record
Spurious Emissions Test TR23, TR24
Project GCL-0388

Test Date(s) 12 Oct, 27 Oct, 3 Nov 2023
Test Personnel David Arnett

Product Model A04752
Serial Number tested 3449554828 (conducted), 3449554812 (radiated)

Operating Mode M5 (WiFi5Tx)
Arrangement A4 (Dual)
Input Power 13.8 Vdc

Test Standards: FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report)

Antenna Gain 4.26 dBi, as reported by the client
Radio Protocol IEEE 802.11 a/n/ac with 20 MHz and 40 MHz nominal bandwidths in the U-NII-1 and U-NII-3 sub-bands

Pass/Fail Judgment: PASS

Test record created by: David Arnett
Date of this test record: 8 Dec 2023

Original record, Version A, issued 8 Nov 2023. Version B on 8 Dec 2023 corrects the list of standards and revises table TR23.4 to include equivalent PSD levels.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44 GHz A	Keysight	N9048B	MY62220146	3-Jun-2023	3-Jun-2024
PXE Receiver 44 GHz B	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Antenna, Horn, 10-40 GHz	ETS Lindgren	3116C	00227673	14-Aug-2023	15-Aug-2025
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1” x 33’	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Tape measure, 1” x 33’	Lufkin	PHV1410CMEN	10721	30-Aug-2023	1-Sep-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	15-Apr-2024
8 GHz High Pass Filter	Mini-Circuits	ZHSS-8G-S+	3 2240	Calibration	Not Required

Table TR23.1: Test equipment used

Test software used: Keysight PXE software A.35.06 (44 GHz unit A, duty cycle), A.33.03 (44 GHz unit B, conducted spurs), and A.32.06 (26 GHz unit, radiated spurs)

Test Method
The spurious emission test measures the strength of unintentional radio signals emitted from the transmitter across a wide range of frequencies. Under the US and Canadian standards, the limit across most of the band is -27 dBm/MHz EIRP. This limit does not apply within the U-NII-1 sub-band where the device under test is transmitting on U-NII-1 frequencies. When it is transmitting on frequencies within the U-NII-3 sub-band, there is a spectral mask that reaches just beyond the band edges. The spectral mask drops to -27 dBm/MHz EIRP for all frequencies more than 75 MHz beyond the U-NII-3 band edges.

There is no test method provided directly in the normative test standard ANSI C63.10. However, the principles of clauses 6.7 and 11.1 were used as guides, along with the informative guidance in KDB entry 789033 D02 v02r01.

This measurement can be done as a conducted test from the test sample RF port, as a radiated field test at 3 m, or as a radiated field substitution test at 3 m. The first two methods were used together and are reported here.

Prior to looking at the radiated and conducted test methods, it is important to consider the effect of transmitter duty cycle. The test tool provided by the RF chip manufacturer does not easily create a consistent duty cycle over a long timeframe. But it does create a consistent duty cycle greater than 80% for a timeframe that is long compared to the response time of a peak detector. The measured signal level is to be adjusted upward to account for the effect of duty cycle when averaging occurs as part of a measurement. This is a peak detector Max-Hold measurement with long dwell times, so no averaging occurs. However, the KDB entry instructs lab to apply a duty cycle correction nd that was done here. In this case, the adjustment is specific to the duty cycle of a particular radio operating mode and is less than 1 dB. For each test, this record will be explicit about what duty cycle adjustment was made and where in the process that adjustment happened.

The conducted measurement requires that a coaxial feed line from the transmitter is available as a connector exterior to the test sample. This feed line and connector may be a part of the shipping product, or it may be a special modification to the product for testing purposes. The connector is attached via laboratory cables to the measurement instrument. The measurement uses a peak detector and a 1 MHz resolution bandwidth. The measured results have been adjusted to account for the losses in the laboratory cables and also for the losses in the test sample's feed line. In the conducted test, a conservative approach is recommended in the KDB entry, which is to convert from dBm/MHz to dBm/MHZ EIRP by adding the in-band antenna gain, or 2 dBi, which ever is greater. The duty cycle factor is also added.

The radiated measurement is made with an unmodified test sample placed in a test chamber on a 1.5 m support table. The measurement antenna is placed at a 3 m distance. The measurement uses a peak detector and a 1 MHz resolution bandwidth. The test sample is rotated through 360 degrees of azimuth and the antenna is moved between 1 m and 4 m elevations to find the strongest emission direction. The reported field measurement can be adjusted downward by a factor of 95.2 dB to determine the EIRP values. Alternately, the -27 dBm/MHz EIRP limit can be restated as a 68.2 dBuV/m limit. The radiated measurement is of higher validity than the conducted result because the test sample's real radiative gain at this frequency is used, rather than applying the conservative value of in-band antenna gain.

Data is first collected using as a conducted measurement across the frequency range from 1 to 40 GHz. This may be done by subranges such as 1- 20 GHz and 20-40 GHz. In addition, due to the spectral mask, U-NII-3 signals spectra are measured on a narrower frequency span.

Emissions which meet the conservative limit using the conducted method are judged compliant. Emissions that do not meet this conservative limit are then subjected to final measurement using the radiated field approach to reach a final determination of pass/fail.

Duty Cycle Test Data

This test placed the 6 GHz transmitters in modes that were designed to assure a consistent duty cycle that was as high as feasible while also consistent over many multiples of the detector response time. Once we were assured that the transmitter was constant for a large number of data frames, and the most accurate measure of duty cycle became the on period in a data frame divided by the overall period of the data frame. Based on previous power and spectral density data, it was decided to perform the spurious emission test using A24, MCS4 with a 20 MHz nominal channel bandwidth, MCS3 with a 40 MHz nominal channel bandwidth.

Table TR23.2 summarizes the duty cycles used for these three modulations. It also includes the results for MCS9 with a 40 MHz nominal channel bandwidth to show the greatest potential effect observed from duty cycle among the array of modulations checked. Figure TR23.1 is the time based (zero span) data trace for a 40 MHz channel with MCS3 modulation. Marker 1 is set at the rising edge of the data frame, marker 2 is at the falling edge, and marker 3 is at the rising edge of the next frame. The delta markers in the table show that the transmitter was on for 582.7 usec in a 624.5 usec frame. This gives the 93.3% duty cycle and a 0.3 dB duty cycle adjustment shown in Table TR23.2.

Modulation	Channel Nom BW	Duty Cycle	Adjustment dB
A24	20 MHz	96.7%	**0.15**
MCS4	20 MHz	96.1%	**0.17**
MCS3	40 MHz	93.3%	**0.30**
MCS9	40 MHz	82.7%	0.83

Table TR23.2: Duty cycles and corresponding correction values for selected transmission modes

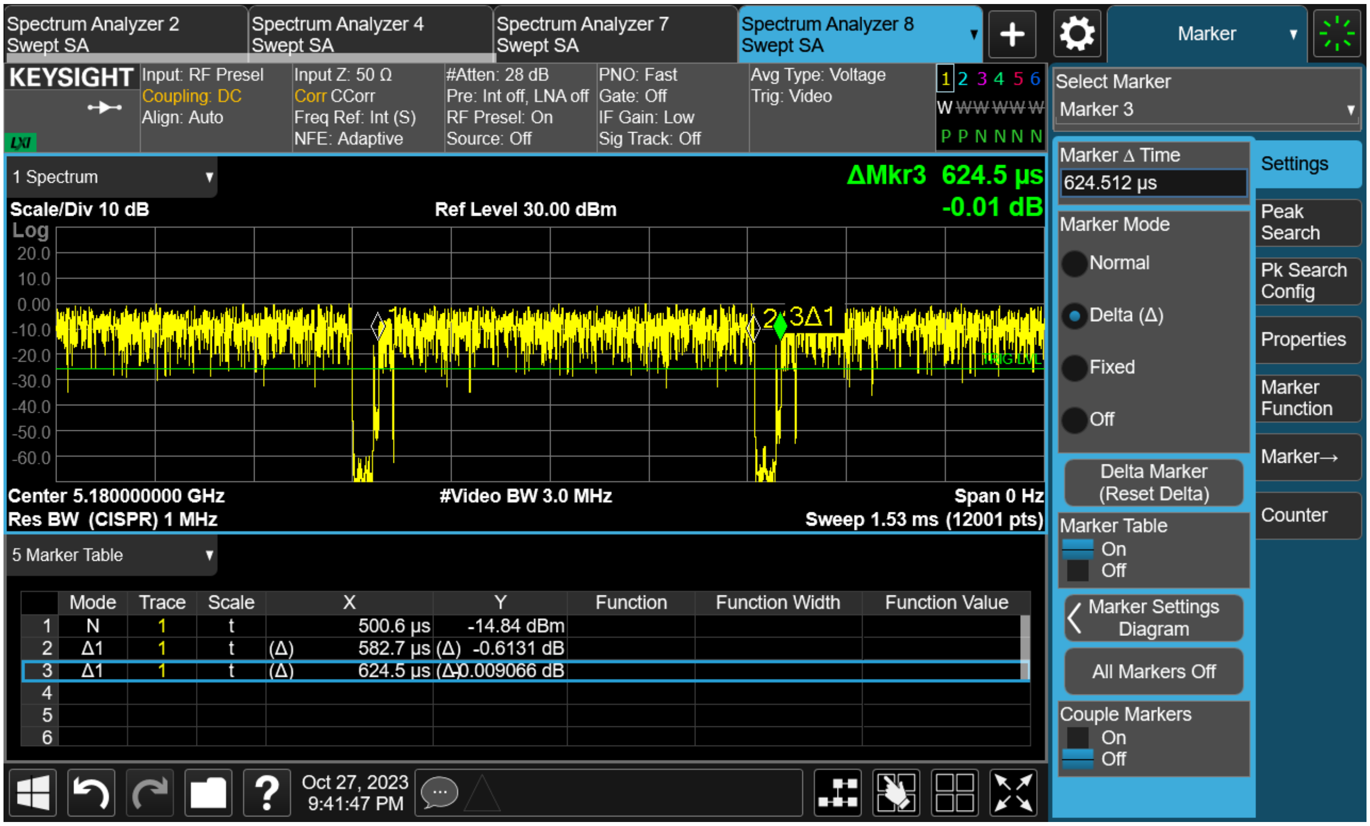

Figure TR23.1: Time trace of an MCS30 40 MHz data frame

Conducted Spurious Emission Test Data

For U-NII-1 signals, the measured values were adjusted within the PXE receiver for cable losses. A reference line on the display shows an emission limit visual guideline at -32.5 dBm. It was selected as follows: -27 dBm/MHz limit, -4.26 dBi antenna gain, no more than -1 dB adjustment for duty cycle is -32.26. This was rounded down to -32.5 dBm. The numerical data measured has to be manually adjusted in a post processing step to get the correct values.

For U-NII-3 signals, the limit is not a flat line. The measured values were adjusted within the PXE receiver for cable losses, for antenna gain, and for duty cycle. The yellow limit line shown on the receiver display is the unadjusted limit line, including the mask in the vicinity of the transmit band.

Based on previous power and spectral density data, it was decided to perform the spurious emission test using A24, MCS4 with a 20 MHz nominal channel bandwidth, MCS3 with a 40 MHz nominal channel bandwidth. These were tested on the low and high channel for each U-NII sub-band. For both sub bands, markers were placed using the analyzer peak search function at multiple emission frequencies to record the signals of greatest interest. The carrier level was also noted.

The data table below summarizes the conducted test results. It shows the level of the strongest emission - other than the intentional modulated carrier – observed for each test case. The emission levels shown in table are fully corrected and adjusted. In most test cases, one emission was at or above the limit. In no case were two emissions at or above the limit.

Three test cases had a single signal above the limit and needed to have radiated emission measurements to resolve the compliance status of those signals. They are highlighted in yellow, and the conducted data for these cases is also provided.

Channel	Moduation	Frequency	PXE Level	Adjustment	Final Level	Margin	Judgment
(#)	type	GHz	dBm	dB	dBm/MHz	dB	---
36	A24	10.359	-36.49	4.41	-32.08	5.08	PASS
48	A24	10.482	-31.27	4.41	-26.86	-0.14	Field Test
36	MCS4	10.359	-36.84	4.43	-32.41	5.41	PASS
48	MCS4	10.480	-33.19	4.43	-28.76	1.76	PASS
38	MCS3	10.379	-39.00	4.56	-34.44	7.44	PASS
46	MCS3	10.460	-38.82	4.56	-34.26	7.26	PASS
149	A24	11.493	-27.84	0	-27.84	0.84	PASS
165	A24	11.646	-26.04	0	-26.04	-0.96	Field Test
149	MCS4	11.489	-28.19	0	-28.19	1.19	PASS
165	MCS4	11.649	-26.52	0	-26.52	-0.48	Field Test
151	MCS3	11.510	-33.67	0	-33.67	6.67	PASS
159	MCS3	11.590	-33.71	0	-33.71	6.71	PASS

Table TR23.3: Summary of strongest spurious emissions observed - conducted

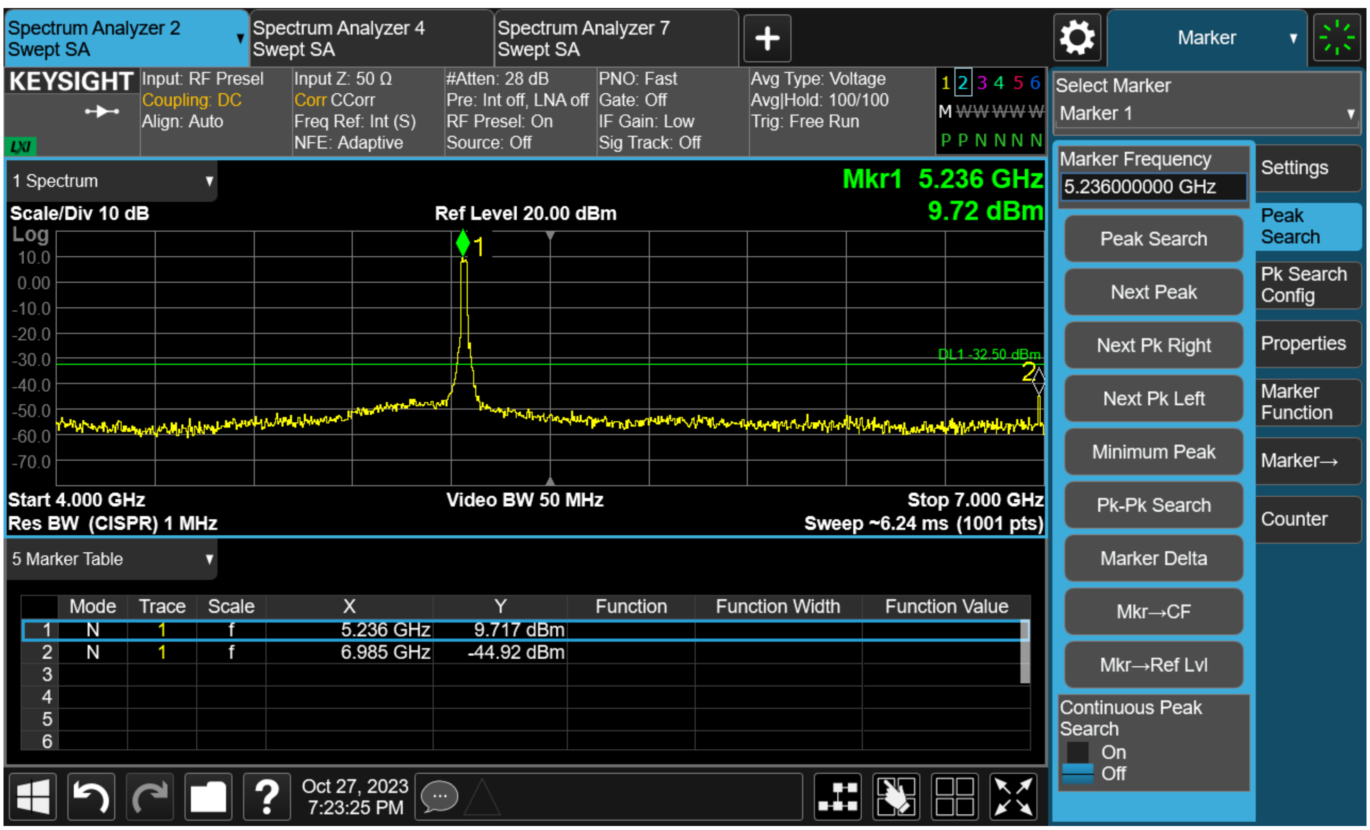

Figure TR23.2a: Conducted emission spectrum for Channel 48 on 802.11a24 modulation, band A

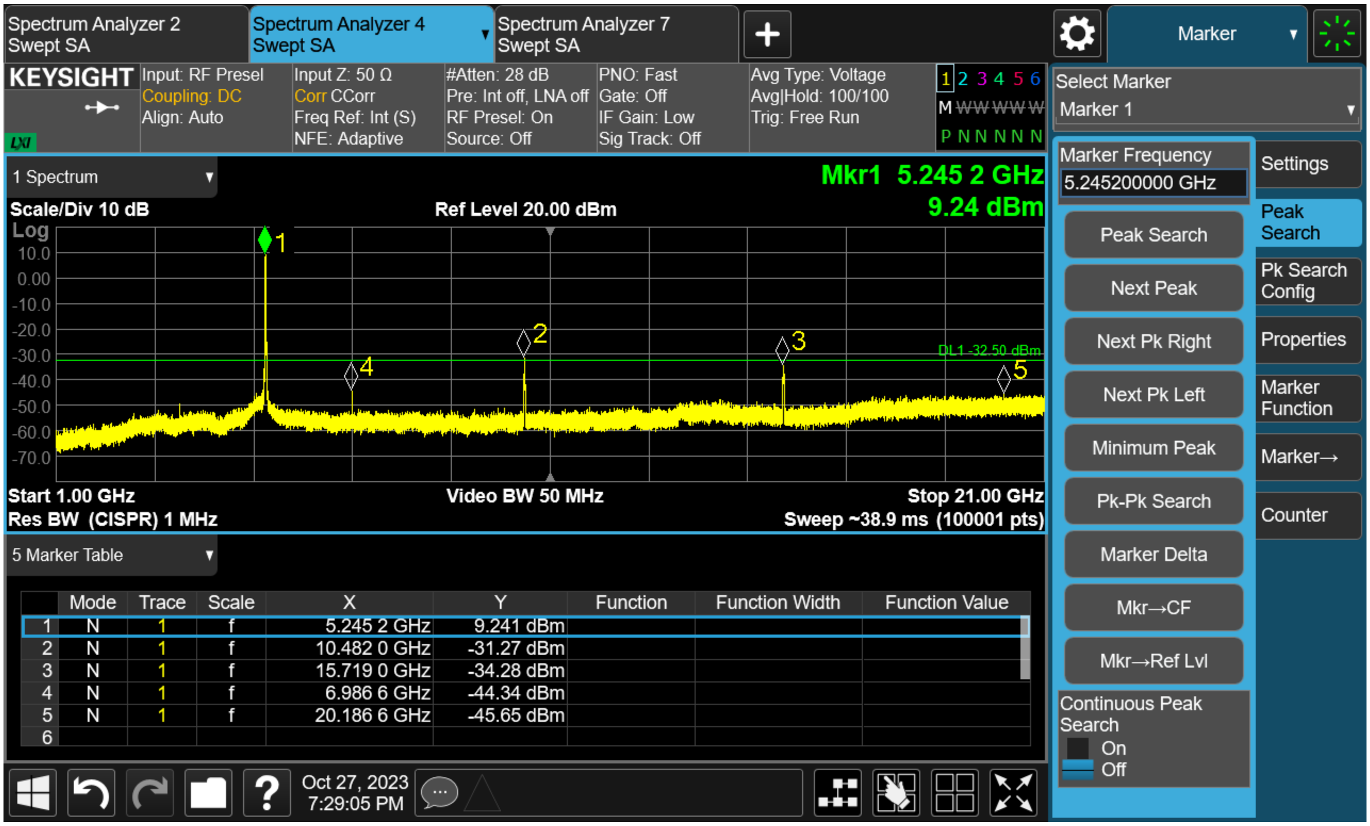

Figure TR23.2b: Conducted emission spectrum for Channel 48 on 802.11a24 modulation, band B

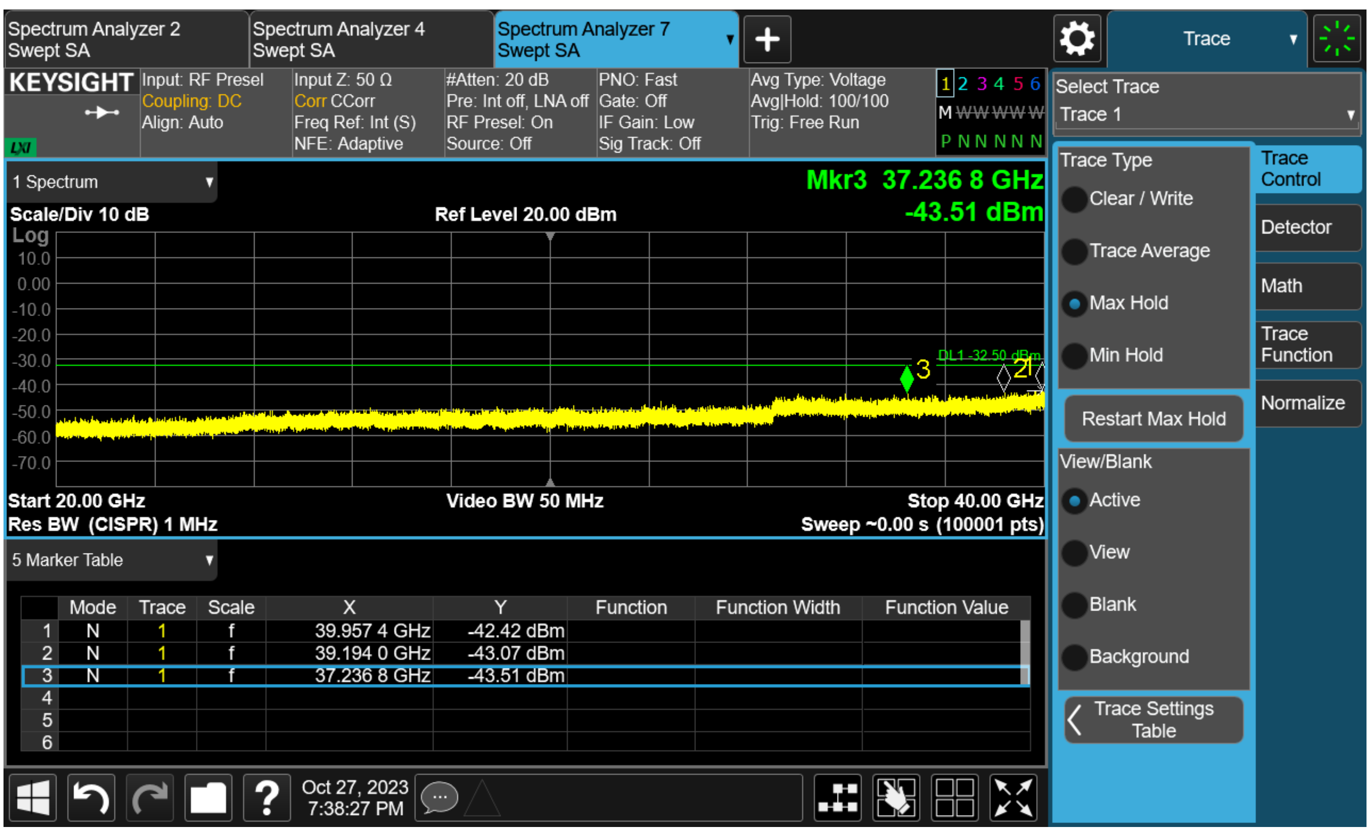

Figure TR23.2c: Conducted emission spectrum for Channel 48 on 802.11a24 modulation, band C

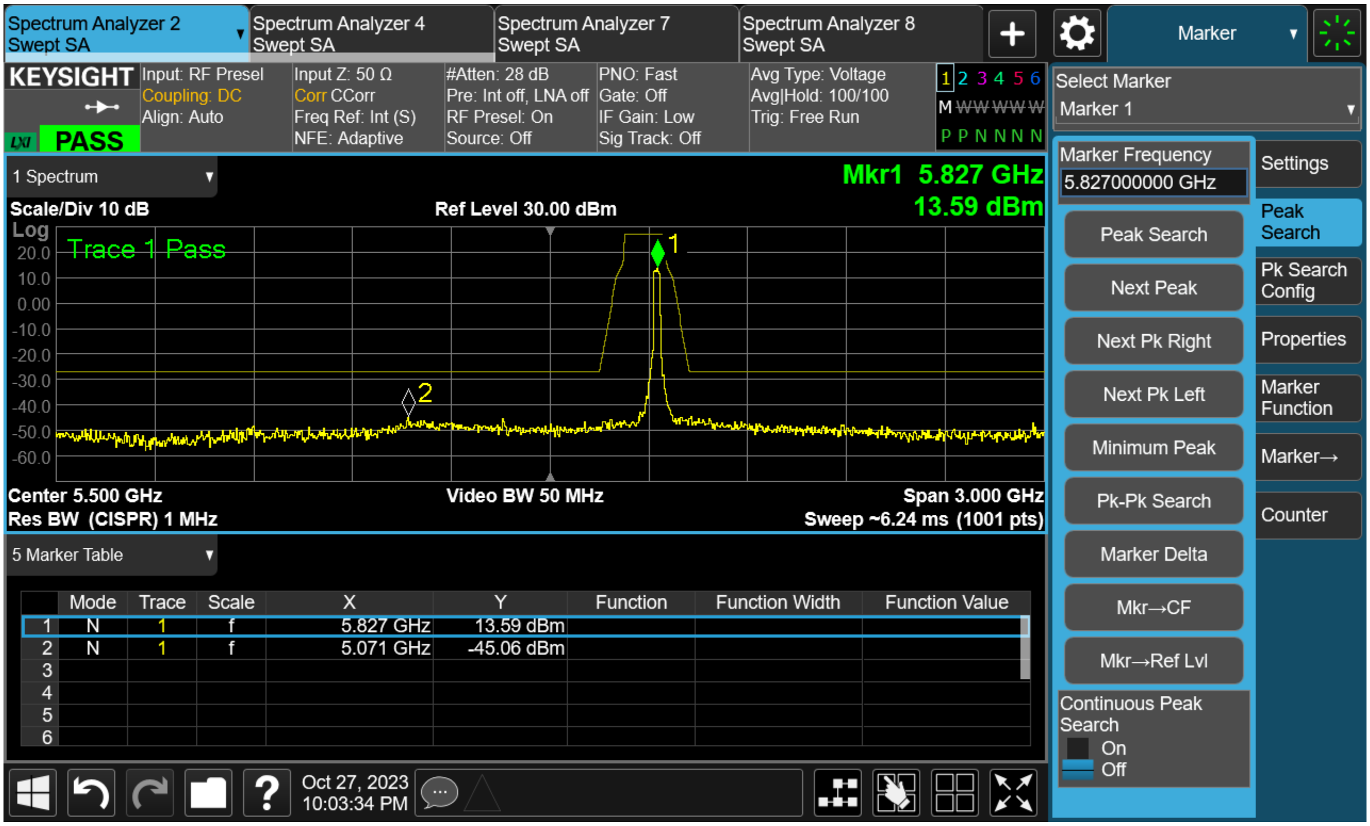

Figure TR23.3a: Conducted emission spectrum for Channel 165 on 802.11a24 modulation, band A

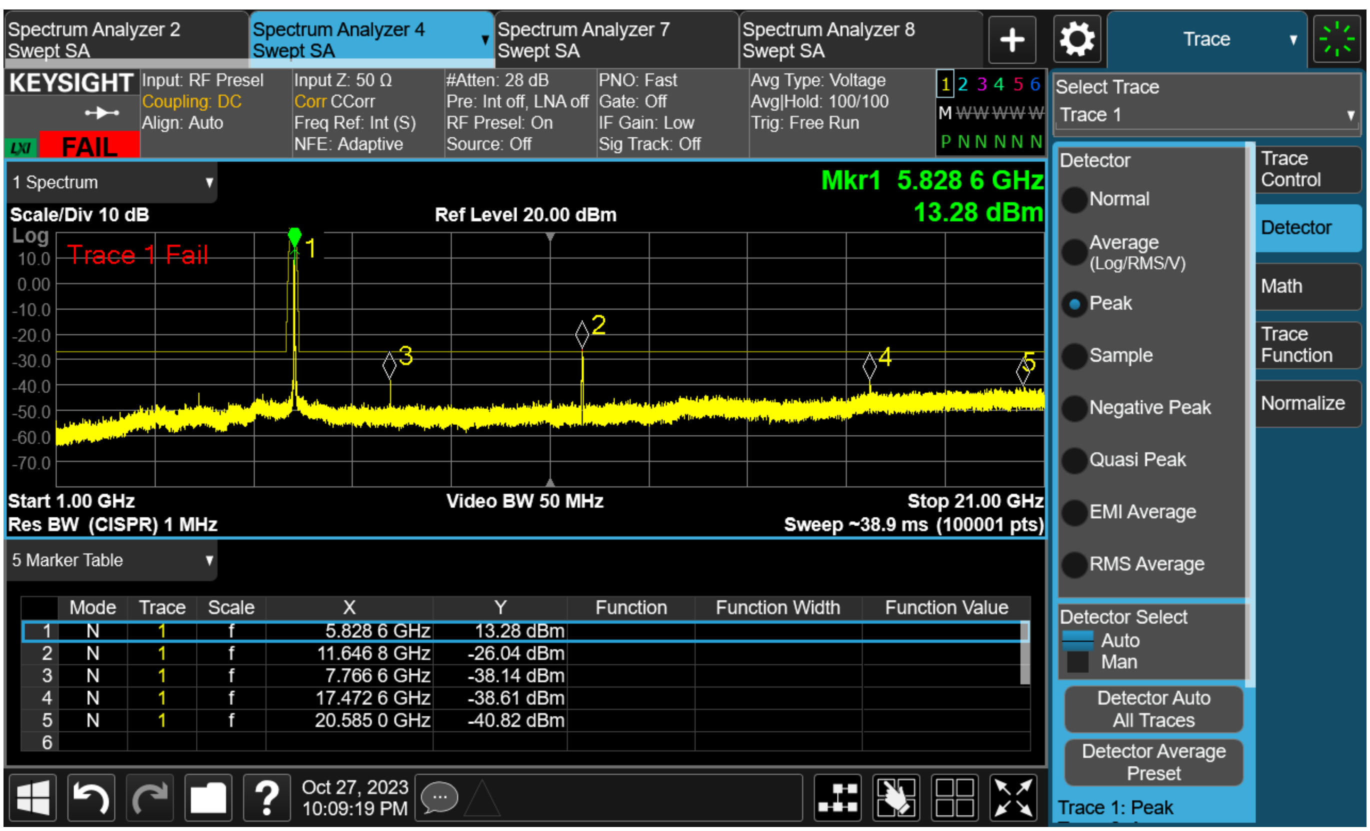

Figure TR23.3b: Conducted emission spectrum for Channel 165 on 802.11a24 modulation, band B

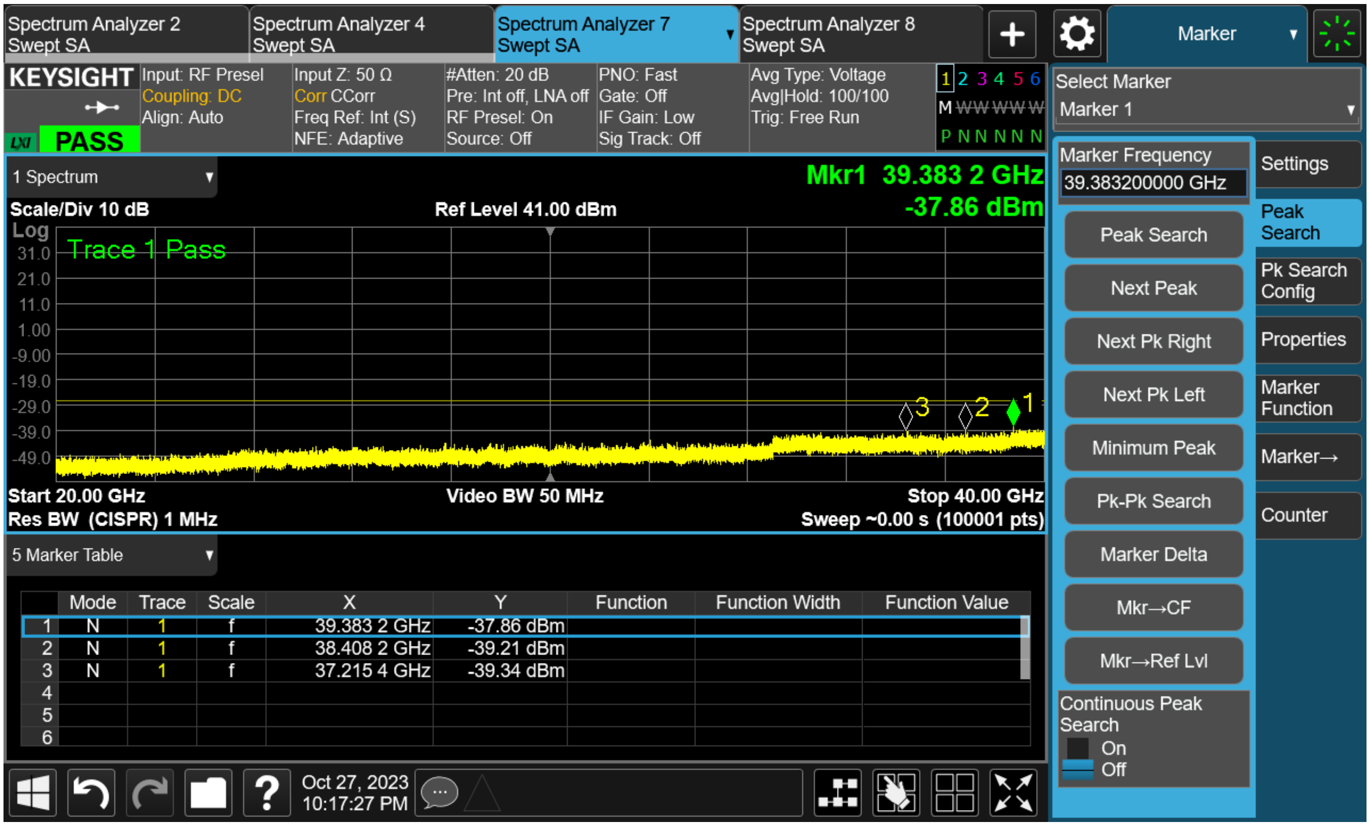

Figure TR23.3c: Conducted emission spectrum for Channel 165 on 802.11a24 modulation, band C

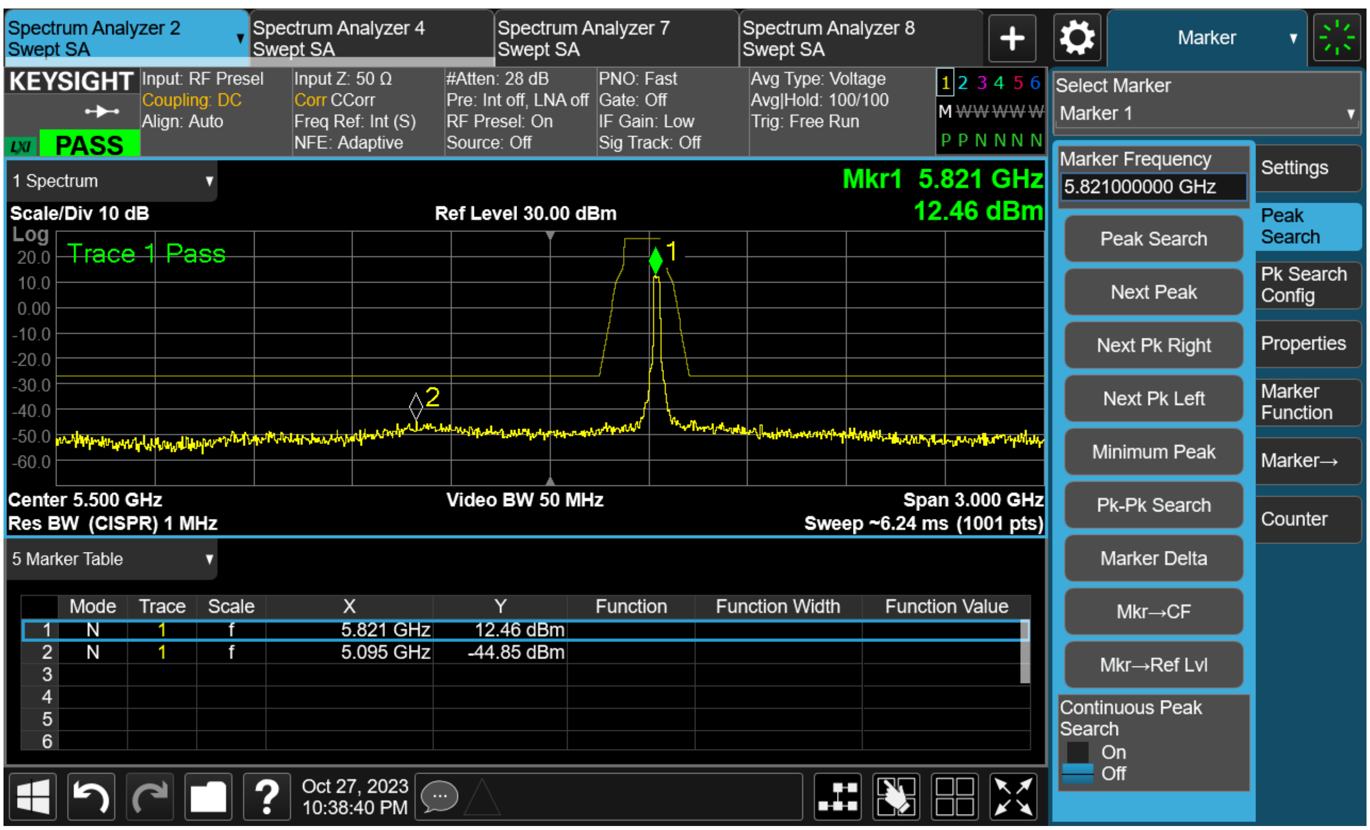

Figure TR23.4a: Conducted emission spectrum for Channel 165 on 802.11ac MCS4 modulation, band A

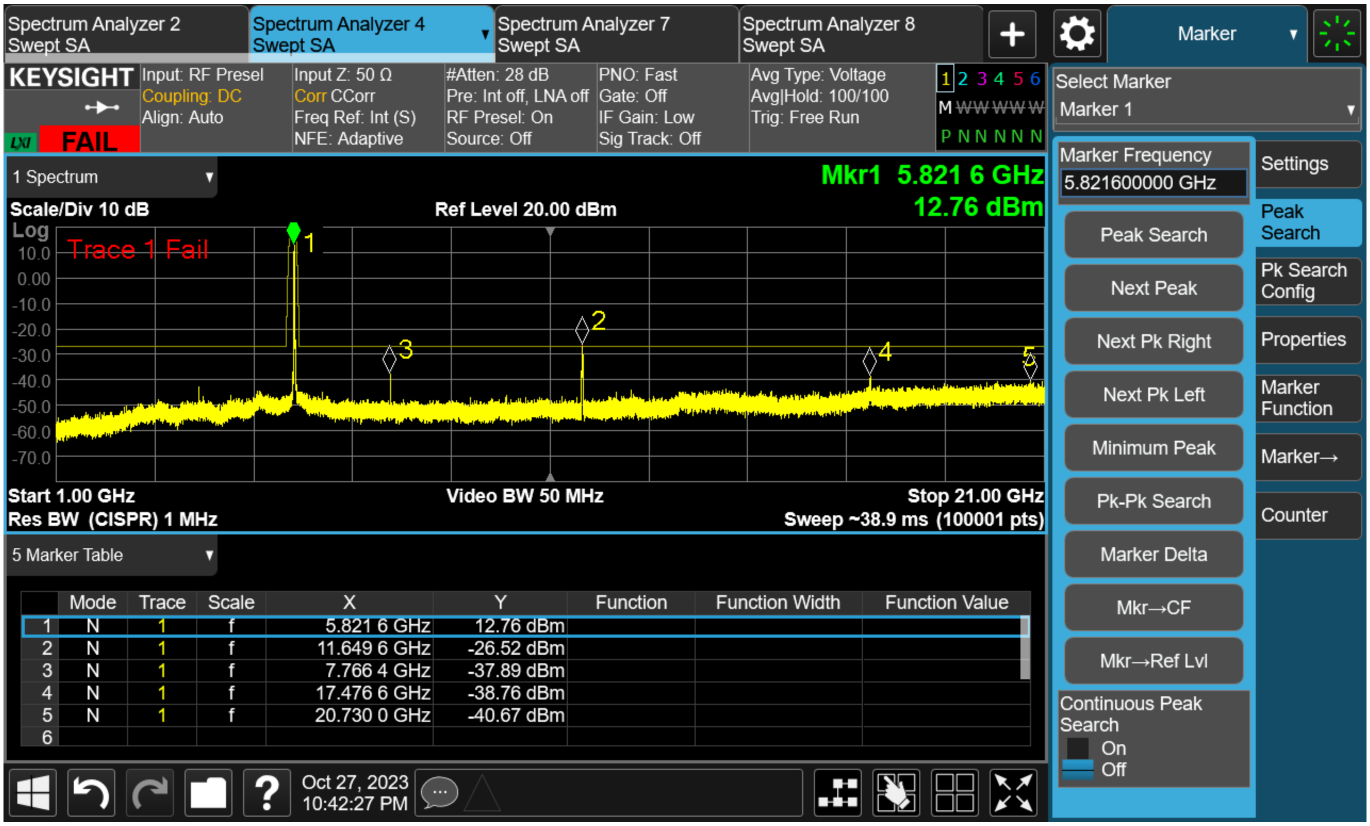

Figure TR23.4b: Conducted emission spectrum for Channel 165 on 802.11ac MCS4 modulation, band B

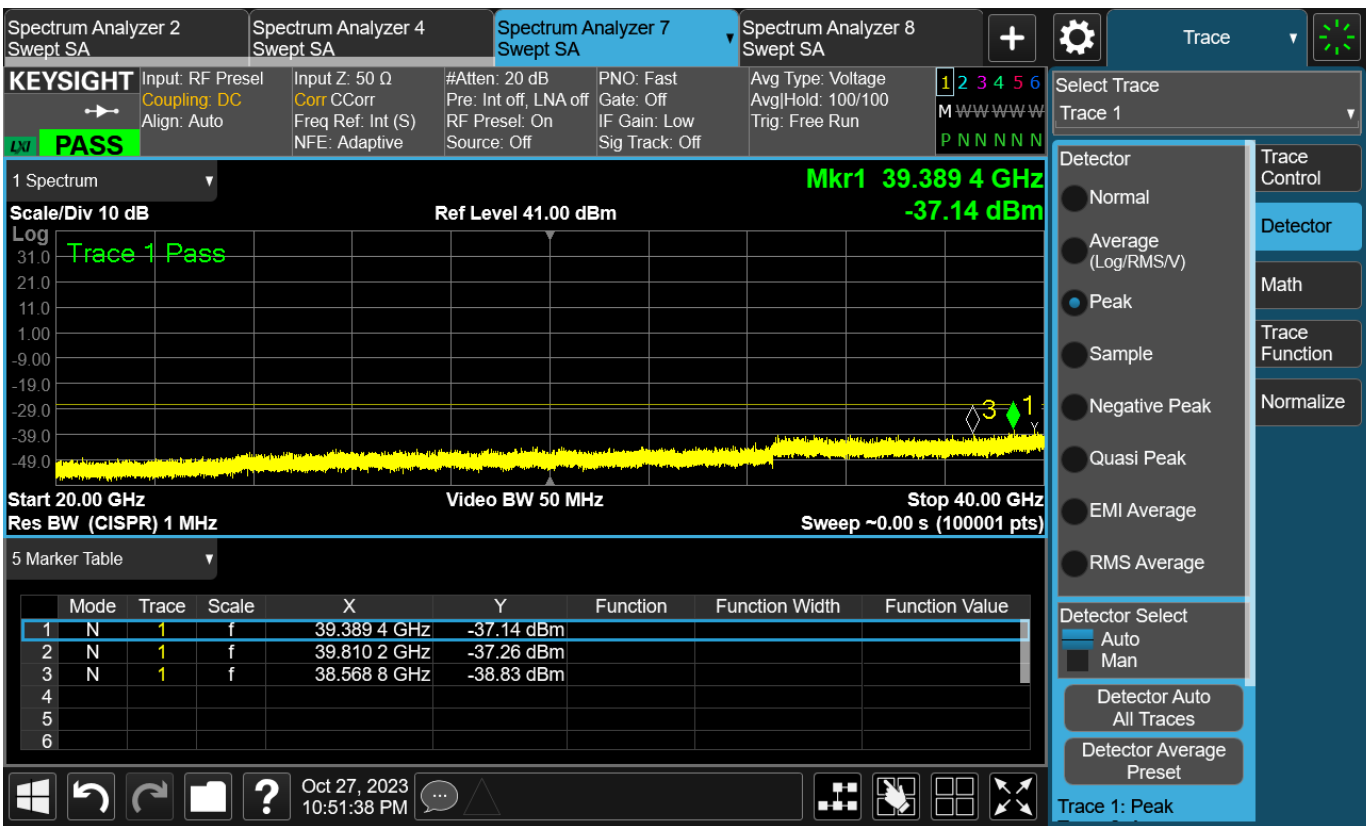

Figure TR23.4c: Conducted emission spectrum for Channel 165 on 802.11ac MCS4 modulation, band C

Radiated Spurious Emission Test Data

The three emissions identified above were then subjected to radiated field testing to determine their true levels, not assuming in-band gain levels. The measurements were made in a semianechoic chamber as shown in these photographs. DC power was fed from outside the chamber through filters and to an outlet at the turntable floor level. The power was routed up to the table surface into the back of the test sample. The test sample was held vertically and positioned at the rotational center of the table stack.

Image removed for client confidentiality.
See section 1 of this report
to identify the report where
the photos may be viewed.

Figure TR23.5a: Radiated emission setup, rear table view

Image removed for client confidentiality.
See section 1 of this report
to identify the report where
the photos may be viewed.

Figure TR23.5b: Radiated emission setup, perspective view

For reference, at azimuth angle 0° the ‘front’ reference mark of the turntable is pointed Southward. At 90° the reference mark points West. At -90° it points East. At -7° the turntable reference mark is pointed directly at the antenna.

Radiated field testing has better accuracy for measuring true effective isotropic radiated signal levels, but tends to have poorer system noise floor margins. It was genuinely difficult to find these emissions in azimuth and antenna height using the peak detector so the maximization exercise used the average detector. The emissions search included placing the receive antenna in the vertical and horizontal orientations. In all three cases the strongest emissions were horizontal as shown in the table below. These values include an adjustment for duty cycle. They also include the highest frequency observed in the conducted test and the highest frequency observed in this radiated field setting.

Channel	Moduation	Frequency	Rx Level	Adjustment	Final Level	Limit	Margin	Equivalent PSD	Polarization	Azimuth	Height	Judgment
(#)	type	GHz	dBuV/m	dB	dBuV/m	dBuV/m	dB	dBm/MHz EIRP	H/V	degrees	cm	---
48	A24	10.480	67.49	0.15	67.64	68.2	**0.56**	-27.56	Horiz	-167	214	PASS
48	A24	10.482	67.42	0.15	67.57	68.2	**0.63**	-27.63	Horiz	-167	214	PASS
165	A24	11.640	66.29	0.15	66.44	68.2	**1.76**	-28.76	Horiz	120	268	PASS
165	A24	11.652	65.31	0.15	65.46	68.2	**2.74**	-29.74	Horiz	120	268	PASS
165	MCS4	11.650	67.14	0.17	67.31	68.2	**0.89**	-27.89	Horiz	120	268	PASS
165	MCS4	11.652	66.15	0.17	66.32	68.2	**1.88**	-28.88	Horiz	120	268	PASS

Table TR23.4: Summary of final spurious emission levels - radiated

This line is the end of the test record.

Test Record
Radiated Emission Test RE05
Project GCL0388

Test Date(s) 27 Sep 2023
Test Personnel David Arnett

Product Model A04752
Serial Number tested 3449554812

Operating Mode M4 (WiFi5Tx)
Arrangement A1 (Mounted)
Input Power 13.8 Vdc

Test Standards: FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report)

Frequency Range: 5 GHz Restricted Band (5350-5460 MHz)
Pass/Fail Judgment: PASS

Test record created by: David Arnett
Date of this record: 8 Dec 2023
Original record, Version A, issued 28 Sep 2023. Version B on 8 Dec 2023 corrects the list of standards.

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1” x 33’	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Tape measure, 1” x 33’	Lufkin	PHV1410CMEN	10721	30-Aug-2023	1-Sep-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	15-Apr-2024
PSG Analog Signal Generator	Keysight	E8257D	SG59140055	7-Jul-2023	1-Jul-2024

Table RE05.1: Test Equipment Used

Software Used
Keysight PXE receiver software A.33.03, RE Signal Maximization Tool v2021Feb25.xlsx

Test Data

This restricted band investigation began with a benchtop setup wherein the emissions in the restricted bands were observed from a modified test sample with an RF output cable replacing the onboard antenna. The actual emission levels within restricted bands in many of the test sample’s available transmission modes are too low to be reliably measured in the radiated environment. By applying the required peak and average detectors and bandwidths to the signals direct from the transmitter, lab staff identified the worst-case operational modes. These were then measured using an unmodified unit in the required radiated environment.

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using on the orientation(s) producing the highest result relative to the test limit. Where the test standard requires cable manipulation, this was done at one of more likely worst case frequencies selected by the test personnel while observing the receiver display. At each of the frequencies selected for final measurements, the turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings. Final field strength measurements were taken in that set of positions.

At azimuth angle 0° the 'front' reference mark of the turntable is pointed Southward. At 90° the reference mark points West. At -90° it points East. At -7° the turntable reference mark is pointed directly at the antenna. The designation of the X, Y, and Z orientations of the test sample are sample dependent, so these are reported by use of photographs.

The table shows the worst case final measurement data within the FCC restricted band for each IEEE 802.11 WiFi mode. It includes a the strongest emissions observed relative to the test limit. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC restricted band ("Class B") limit at 3m.

Mode	Nominal BW	Data	Channel	Frequency	Pk Level	Avg Level	Pk Limit	Av Limit	Pk Margin	Av Margin
---	MHz	Rate	---	MHZ	dBuV/m	dBuV/m	dBuV/m	dBuV/m	dB	dB
802.11a	20	36 Mbps	48	5447.50	58.20	44.98	74	54	15.80	9.02
802.11a	20	12 Mbps	149	5447.50	58.37	44.98	74	54	15.63	9.02
802.11ac	20	MCS0	48	5367.25	58.33	44.83	74	54	15.67	9.17
802.11ac	20	MCS2	149	5447.50	58.64	44.88	74	54	15.36	9.12
802.11ac	40	MCS0	46	5352.75	60.16	45.73	74	54	13.84	8.27
802.11ac	40	MCS2	151	5447.50	58.46	45.02	74	54	15.54	8.98

Table RE05.2: FCC restricted band data summary

The graph below shows the spectrum observed in the restricted band for the case highlighted above, as well as the final data points from the table above.

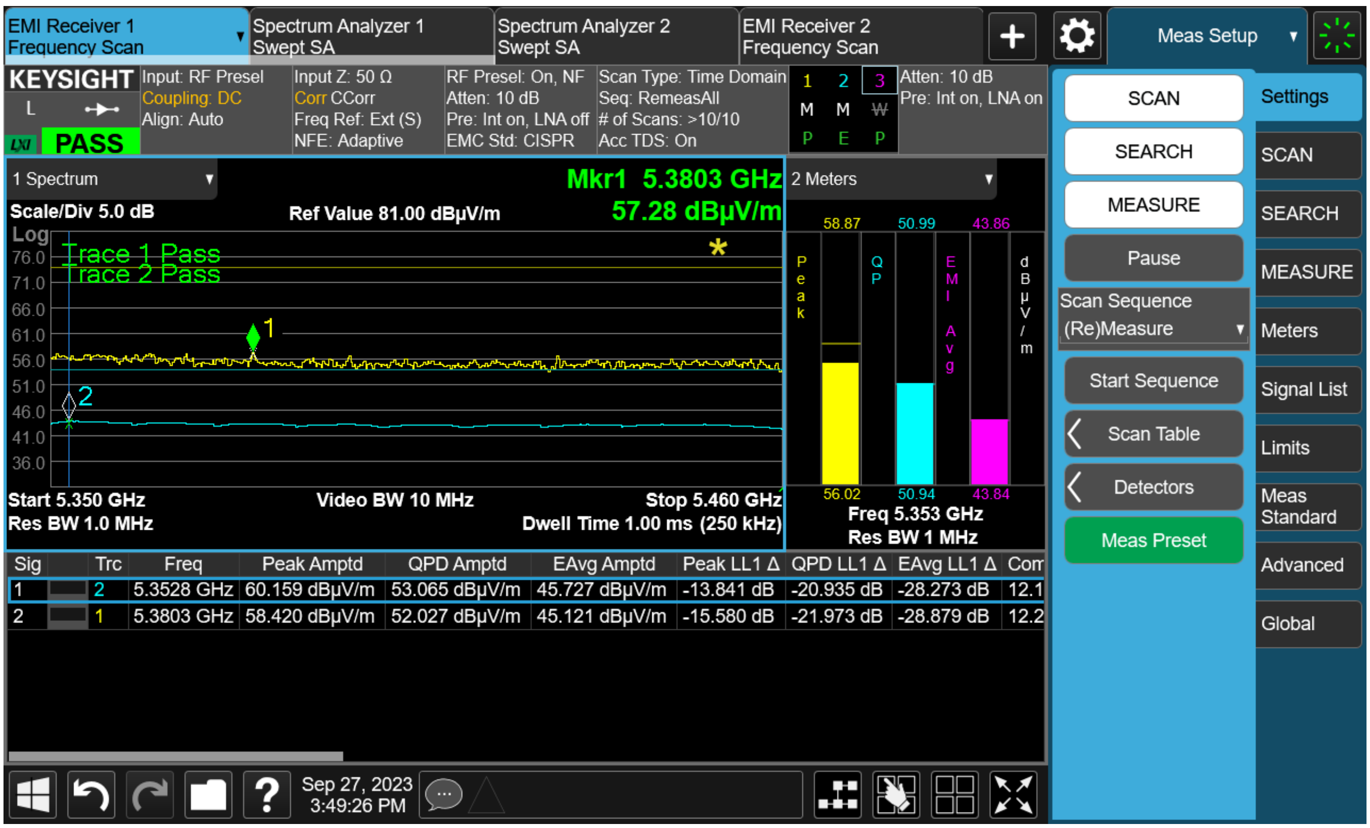

Figure RE05.1: FCC restricted band spectral data for 11ac, 40 MHz channel, MCS0 on channel 46

Setup Photographs

The following photographs show the EUT configured and arranged in the manner in which it was measured.

Image removed for client confidentiality.
See section 1 of this report
to identify the report where
the photos may be viewed.

Figure RE05.2: EUT test setup, primary view

Image removed for client confidentiality.
See section 1 of this report
to identify the report where
the photos may be viewed.

Figure RE05.3: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Radiated Emission Test RE15
Project GCL0388

Test Date(s)	28 Sep 2023
Test Personnel	David Arnett assisted by Majid Farah
Product Model	A04752
Serial Number tested	3449554812
Operating Mode	M4 (WiFi5Tx) operating in 802.11ac 20 MHz, MCS0 modulation, channel 36
Arrangement	A1 (Mounted)
Input Power	13.8 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Frequency Range:	1000 MHz to 8500 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David Arnett**
Date of this record:	**8 Dec 2023**

Original record, Version A, issued 28 Sep 2023. Version B on 8 Dec 2023 corrects the list of standards.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1” x 33’	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Tape measure, 1” x 33’	Lufkin	PHV1410CMEN	10721	30-Aug-2023	1-Sep-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
PSG Analog Signal Generator	Keysight	E8257D	SG59140055	7-Jul-2023	1-Jul-2024

Table RE15.1: Test Equipment Used

Software Used: Keysight PXE software A.33.03, RE Signal Maximization Tool v2023Jul14.xlsx

Test Data

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using on the orientation(s) producing the highest result relative to the test limit. Where the test standard requires cable manipulation, this was done at one of more likely worst case frequencies selected by the test personnel while observing the receiver display. At each of the frequencies selected for final measurements, the turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings. Final field strength measurements were taken in that set of positions. Full maximization was not performed at frequencies that are noise floor measurements included per the test standard requirements. These noise floor measurements are indicated in the data table by a blue highlight in the frequency column.

A 6 dB attenuator was characterized and added between the antenna and antenna cable. This level of attenuation was found to keep gain compression of the preamplifier below 1 dB in the presence of the transmitted signal. In the immediate vicinity of the transmitted signal, the front end attenuation of the PXE receiver was elevated to ensure overload did not occur. This will appear as a rise in the noise floor in the plotted and tabular data, surrounding the

transmitted signal. This range is within the allowed radio band, and for ease of analysis the out-of-band limit is shown even though it does not strictly apply within the allowed band.

At azimuth angle 0° the ‘front’ reference mark of the turntable is pointed Southward. At 90° the reference mark points West. At -90° it points East. At -7° the turntable reference mark is pointed directly at the antenna.

The table shows the selected final measurement data between 1 GHz and 8.5 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
1373.250	54.0	74.0	35.9	48.5	18.1	25.5	-133	1303	HORZ
3453.250	54.0	74.0	41.3	54.4	12.7	19.6	143	1021	VERT
5106.250	54.0	74.0	51.1	64.0	2.9	10.0	-180	1100	HORZ
5278.000	54.0	74.0	51.0	65.0	3.0	9.0	-180	1100	VERT
7680.250	54.0	74.0	45.0	58.8	9.0	15.2	-180	1100	HORZ
8273.500	54.0	74.0	45.3	58.6	8.7	15.4	-180	1100	VERT

Table RE15.2: Emission summary

The graph below shows the background spectrum observed during pre-scan, as well as the final data points from the table above.

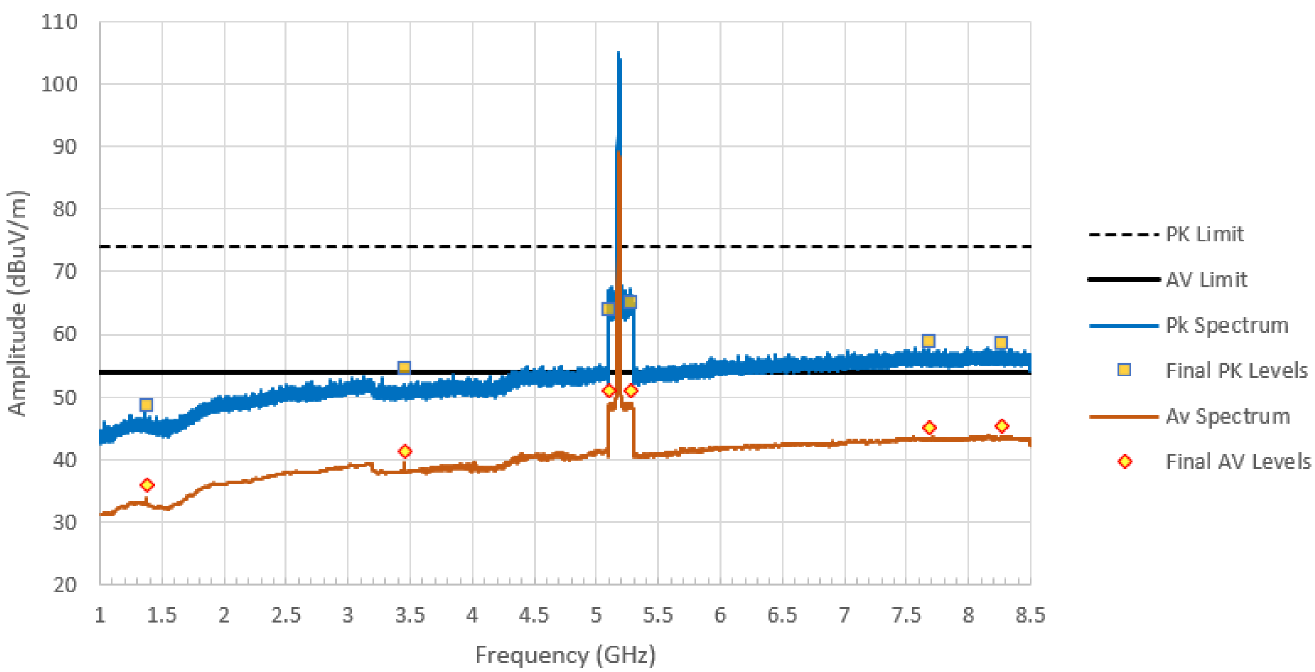

Figure RE15.1: Spectral data

Setup Photographs

The following photographs show the EUT configured and arranged in the manner in which it was measured.

Image removed for client confidentiality.
See section 1 of this report
to identify the report where
the photos may be viewed.

Figure RE15.2: EUT test setup, front view

Image removed for client confidentiality.
See section 1 of this report
to identify the report where
the photos may be viewed.

Figure RE15.3: EUT test setup, reverse view

This line is the end of the test record.

Test Record

Radiated Emission Test RE16A
Project GCL0388

Test Date(s) 28 – 29 Sep 2023
Test Personnel David Arnett

Product Model A04752
Serial Number tested 3449554812

Operating Mode M4 (WiFi5Tx) operating in 802.11ac 40 MHz, MCS0 modulation, channel 38
Arrangement A1 (Mounted)
Input Power 13.8 Vdc

Test Standards: FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).

Frequency Range: 1000 MHz to 8500 MHz
Pass/Fail Judgment: PASS

Test record created by: David Arnett
Date of this record: 8 Dec 2023
Original record, Version A, issued 29 Sep 2023. Version B on 8 Dec 2023 corrects the list of standards.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1” x 33’	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Tape measure, 1” x 33’	Lufkin	PHV1410CMEN	10721	30-Aug-2023	1-Sep-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
PSG Analog Signal Generator	Keysight	E8257D	SG59140055	7-Jul-2023	1-Jul-2024

Table RE16A.1: Test Equipment Used

Software Used: Keysight PXE software A.33.03, RE Signal Maximization Tool v2023Jul14.xlsx

Test Data

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using on the orientation(s) producing the highest result relative to the test limit. Where the test standard requires cable manipulation, this was done at one of more likely worst case frequencies selected by the test personnel while observing the receiver display. At each of the frequencies selected for final measurements, the turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings. Final field strength measurements were taken in that set of positions. Full maximization was not performed at frequencies that are noise floor measurements included per the test standard requirements. These noise floor measurements are indicated in the data table by a blue highlight in the frequency column.

A 6 dB attenuator was characterized and added between the antenna and antenna cable. This level of attenuation was found to keep gain compression of the preamplifier below 1 dB in the presence of the transmitted signal. In the immediate vicinity of the transmitted signal, the front end attenuation of the PXE receiver was elevated to ensure overload did not occur. This will appear as a rise in the noise floor in the plotted and tabular data, surrounding the

transmitted signal. This range is within the allowed radio band, and for ease of analysis the out-of-band limit is shown even though it does not strictly apply within the allowed band.

At azimuth angle 0° the ‘front’ reference mark of the turntable is pointed Southward. At 90° the reference mark points West. At -90° it points East. At -7° the turntable reference mark is pointed directly at the antenna.

The table shows the selected final measurement data between 1 GHz and 8.5 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
1373.250	54.0	74.0	36.2	48.1	17.8	25.9	-133	1000	HORZ
3460.000	54.0	74.0	41.4	54.3	12.6	19.7	145	1025	VERT
4407.250	54.0	74.0	41.9	55.4	12.1	18.6	-180	1100	HORZ
4554.000	54.0	74.0	42.4	55.7	11.6	18.3	-180	1100	HORZ
5117.500	54.0	74.0	51.6	64.1	2.4	9.9	34	4000	HORZ
8076.500	54.0	74.0	45.3	58.6	8.7	15.4	-180	1100	VERT

Table RE16A.2: Emission summary

The graph below shows the background spectrum observed during pre-scan, as well as the final data points from the table above.

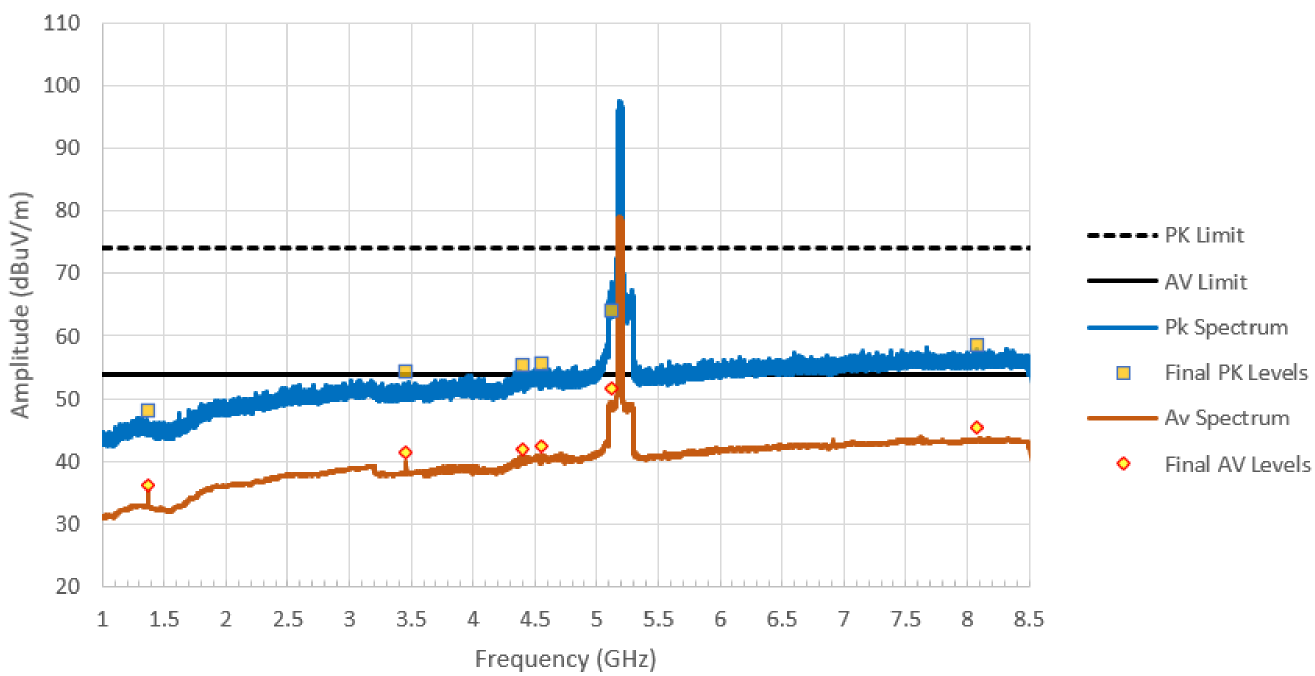

Figure RE16A.1: Spectral data

Setup Photographs

The physical setup in the test chamber was unchanged among the set of 1 – 8.5 GHz spurious emission tests. The channel and modulation were varied, but not the setup. See test record RE15 for the setup photographs.

This line is the end of the test record.

Test Record
Radiated Emission Test RE16B
Project GCL0388

Test Date(s) 29 Sep 2023
Test Personnel David Arnett assisted by Majid Farah

Product Model A04752
Serial Number tested 3449554812

Operating Mode M4 (WiFi5Tx) operating in 802.11ac 20 MHz, MCS2 modulation, channel 149
Arrangement A1 (Mounted)
Input Power 13.8 Vdc

Test Standards: FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).

Frequency Range: 1000 MHz to 8500 MHz
Pass/Fail Judgment: PASS

Test record created by: David Arnett
Date of this record: 8 Dec 2023
Original record, Version A, issued 29 Sep 2023. Version B on 8 Dec 2023 corrects the list of standards.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	30-Aug-2023	1-Sep-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
PSG Analog Signal Generator	Keysight	E8257D	SG59140055	7-Jul-2023	1-Jul-2024

Table RE16B.1: Test Equipment Used

Software Used: Keysight PXE software A.33.03, RE Signal Maximization Tool v2023Jul14.xlsx

Test Data

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using on the orientation(s) producing the highest result relative to the test limit. Where the test standard requires cable manipulation, this was done at one of more likely worst case frequencies selected by the test personnel while observing the receiver display. At each of the frequencies selected for final measurements, the turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings. Final field strength measurements were taken in that set of positions. Full maximization was not performed at frequencies that are noise floor measurements included per the test standard requirements. These noise floor measurements are indicated in the data table by a blue highlight in the frequency column.

A 6 dB attenuator was characterized and added between the antenna and antenna cable. This level of attenuation was found to keep gain compression of the preamplifier below 1 dB in the presence of the transmitted signal. In the immediate vicinity of the transmitted signal, the front end attenuation of the PXE receiver was elevated to ensure overload did not occur. This will appear as a rise in the noise floor in the plotted and tabular data, surrounding the

transmitted signal. This range is within the allowed radio band, and for ease of analysis the out-of-band limit is shown even though it does not strictly apply within the allowed band.

At azimuth angle 0° the 'front' reference mark of the turntable is pointed Southward. At 90° the reference mark points West. At -90° it points East. At -7° the turntable reference mark is pointed directly at the antenna.

The table shows the selected final measurement data between 1 GHz and 8.5 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
1373.250	54.0	74.0	36.0	48.7	18.0	25.3	-133	1013	HORZ
3830.000	54.0	74.0	42.9	55.3	11.1	18.7	108	2600	VERT
5729.250	54.0	74.0	53.6	70.6	0.4	3.4	157	3689	HORZ
5853.250	54.0	74.0	52.1	64.7	1.9	9.3	-180	1100	VERT
7660.000	54.0	74.0	45.7	58.5	8.3	15.5	-139	1019	HORZ
8098.500	54.0	74.0	45.3	58.7	8.7	15.3	-180	1100	HORZ

Table RE16B.2: Emission summary

The graph below shows the background spectrum observed during pre-scan, as well as the final data points from the table above.

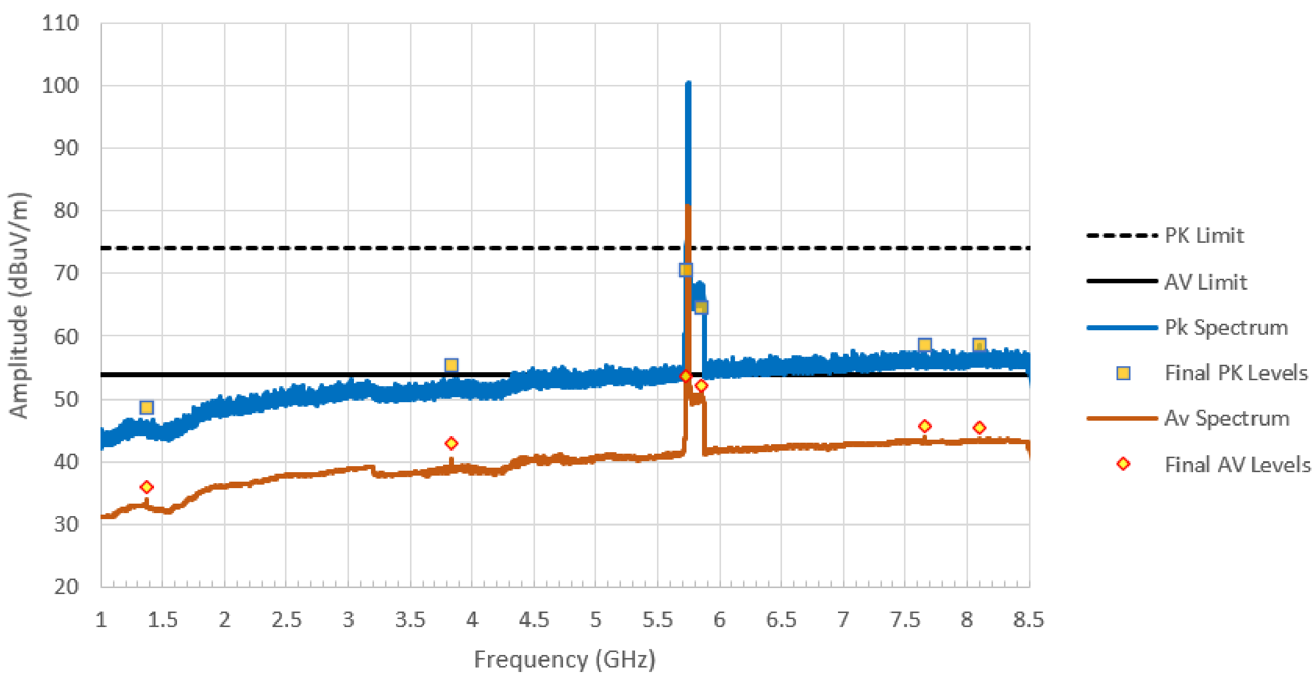

Figure RE16B.1: Spectral data

Setup Photographs

The physical setup in the test chamber was unchanged among the set of 1 – 8.5 GHz spurious emission tests. The channel and modulation were varied, but not the setup. See test record RE15 for the setup photographs.

This line is the end of the test record.

Test Record
Radiated Emission Test RE17
Project GCL0388

Test Date(s) 29 Sep 2023
Test Personnel David Arnett assisted by Majid Farah

Product Model A04752
Serial Number tested 3449554812

Operating Mode M4 (WiFi5Tx) operating in 802.11ac 40 MHz, MCS2 modulation, channel 159
Arrangement A1 (Mounted)
Input Power 13.8 Vdc

Test Standards: FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).

Frequency Range: 1000 MHz to 8500 MHz
Pass/Fail Judgment: PASS

Test record created by: David Arnett
Date of this record: 8 Dec 2023
Original record, Version A, issued 29 Sep 2023. Version B on 8 Dec 2023 corrects the list of standards.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	30-Aug-2023	1-Sep-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
PSG Analog Signal Generator	Keysight	E8257D	SG59140055	7-Jul-2023	1-Jul-2024

Table RE17.1: Test Equipment Used

Software Used: Keysight PXE software A.33.03, RE Signal Maximization Tool v2023Jul14.xlsx

Test Data

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using on the orientation(s) producing the highest result relative to the test limit. Where the test standard requires cable manipulation, this was done at one of more likely worst case frequencies selected by the test personnel while observing the receiver display. At each of the frequencies selected for final measurements, the turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings. Final field strength measurements were taken in that set of positions. Full maximization was not performed at frequencies that are noise floor measurements included per the test standard requirements. These noise floor measurements are indicated in the data table by a blue highlight in the frequency column.

A 6 dB attenuator was characterized and added between the antenna and antenna cable. This level of attenuation was found to keep gain compression of the preamplifier below 1 dB in the presence of the transmitted signal. In the immediate vicinity of the transmitted signal, the front end attenuation of the PXE receiver was elevated to ensure overload did not occur. This will appear as a rise in the noise floor in the plotted and tabular data, surrounding the

transmitted signal. This range is within the allowed radio band, and for ease of analysis the out-of-band limit is shown even though it does not strictly apply within the allowed band.

At azimuth angle 0° the 'front' reference mark of the turntable is pointed Southward. At 90° the reference mark points West. At -90° it points East. At -7° the turntable reference mark is pointed directly at the antenna.

The table shows the selected final measurement data between 1 GHz and 8.5 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
1373.250	54.0	74.0	36.4	48.4	17.6	25.6	-135	1252	HORZ
3188.750	54.0	74.0	39.9	53.4	14.1	20.6	-180	1100	VERT
3863.250	54.0	74.0	43.0	55.6	11.0	18.4	119	3000	VERT
4580.000	54.0	74.0	42.5	56.1	11.5	17.9	-180	1100	HORZ
5731.250	54.0	74.0	52.4	68.1	1.6	5.9	159	3050	HORZ
8174.750	54.0	74.0	45.5	58.8	8.5	15.2	-180	1100	HORZ

Table RE17.2: Emission summary

The graph below shows the background spectrum observed during pre-scan, as well as the final data points from the table above.

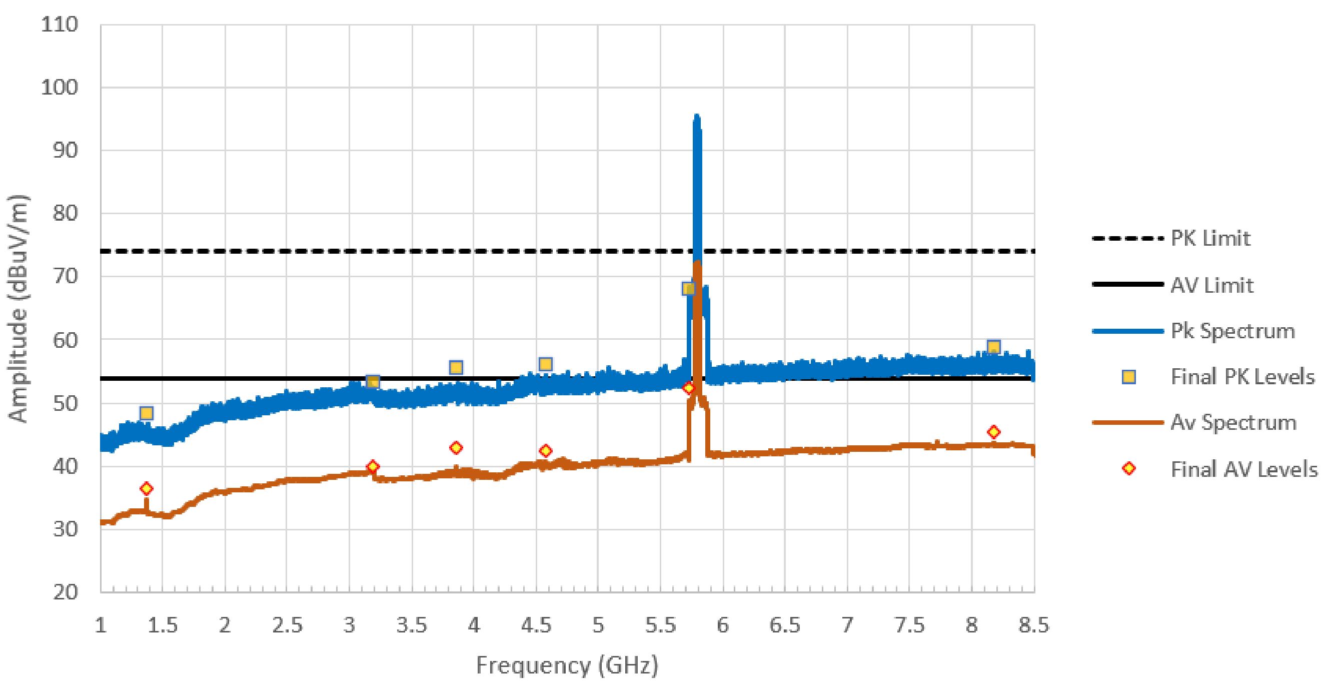

Figure RE17.1: Spectral data

Setup Photographs

The physical setup in the test chamber was unchanged among the set of 1 – 8.5 GHz spurious emission tests. The channel and modulation were varied, but not the setup. See test record RE15 for the setup photographs.

This line is the end of the test record.

Test Record

Radiated Emission Test RE18
Project GCL0388

Test Date(s) 29-30 Sep 2023
Test Personnel David Arnett

Product Model A04752
Serial Number tested 3449554812

Operating Mode M4 (WiFi5Tx) operating in 802.11ac 20 MHz, MCS2 modulation, channel 165
Arrangement A1 (Mounted)
Input Power 13.8 Vdc

Test Standards: FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).

Frequency Range: 1000 MHz to 8500 MHz
Pass/Fail Judgment: PASS

Test record created by: David Arnett
Date of this record: 8 Dec 2023
Original record, Version A, issued 30 Sep 2023. Version B on 8 Dec 2023 corrects the list of standards.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	30-Aug-2023	1-Sep-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
PSG Analog Signal Generator	Keysight	E8257D	SG59140055	7-Jul-2023	1-Jul-2024

Table RE18.1: Test Equipment Used

Software Used: Keysight PXE software A.33.03, RE Signal Maximization Tool v2023Jul14.xlsx

Test Data

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using on the orientation(s) producing the highest result relative to the test limit. Where the test standard requires cable manipulation, this was done at one of more likely worst case frequencies selected by the test personnel while observing the receiver display. At each of the frequencies selected for final measurements, the turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings. Final field strength measurements were taken in that set of positions. Full maximization was not performed at frequencies that are noise floor measurements included per the test standard requirements. These noise floor measurements are indicated in the data table by a blue highlight in the frequency column.

A 6 dB attenuator was characterized and added between the antenna and antenna cable. This level of attenuation was found to keep gain compression of the preamplifier below 1 dB in the presence of the transmitted signal. In the immediate vicinity of the transmitted signal, the front end attenuation of the PXE receiver was elevated to ensure overload did not occur. This will appear as a rise in the noise floor in the plotted and tabular data, surrounding the

transmitted signal. This range is within the allowed radio band, and for ease of analysis the out-of-band limit is shown even though it does not strictly apply within the allowed band.

At azimuth angle 0° the 'front' reference mark of the turntable is pointed Southward. At 90° the reference mark points West. At -90° it points East. At -7° the turntable reference mark is pointed directly at the antenna.

The table shows the selected final measurement data between 1 GHz and 8.5 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
1373.250	54.0	74.0	36.2	48.3	17.8	25.7	-132	1000	HORZ
3883.250	54.0	74.0	43.7	56.5	10.3	17.5	125	2600	VERT
4578.000	54.0	74.0	42.8	56.4	11.2	17.6	-180	1100	HORZ
4713.000	54.0	74.0	42.6	56.2	11.4	17.8	-180	1100	VERT
5731.250	54.0	74.0	52.6	65.5	1.4	8.5	-180	1100	HORZ
8409.250	54.0	74.0	45.2	58.7	8.8	15.3	-180	1100	VERT

Table RE18.2: Emission summary

The graph below shows the background spectrum observed during pre-scan, as well as the final data points from the table above.

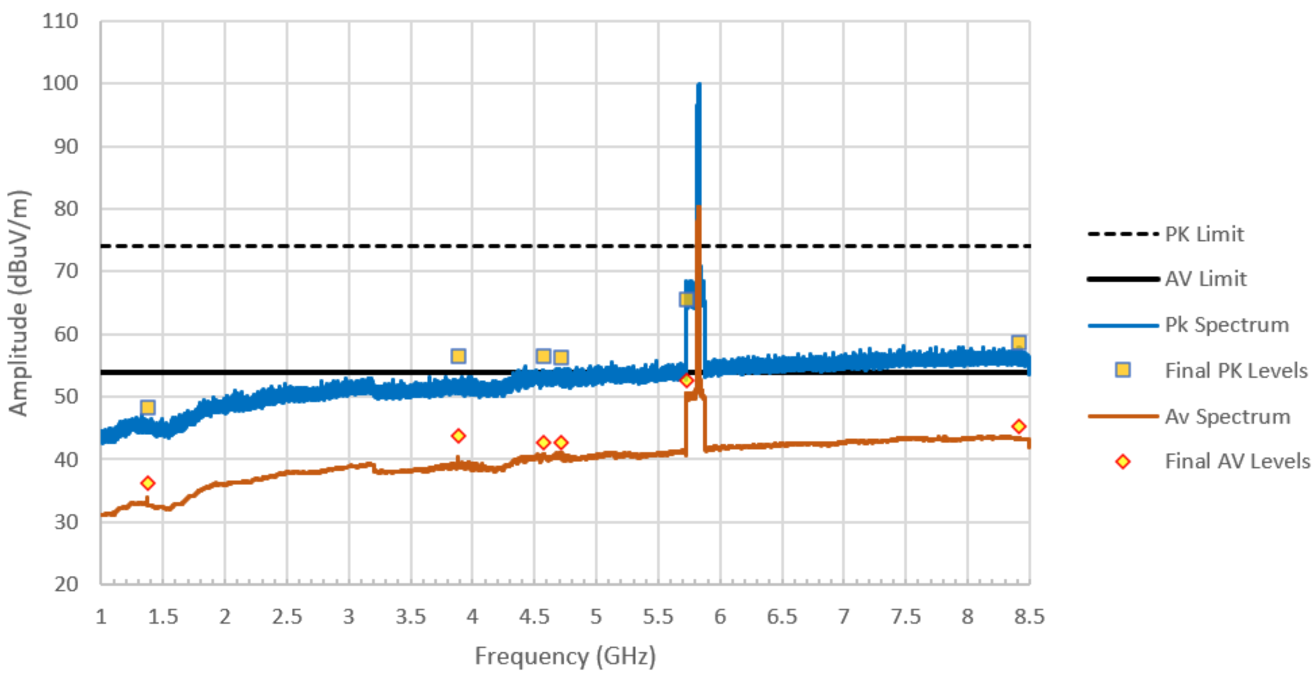

Figure RE18.1: Spectral data

Setup Photographs

The physical setup in the test chamber was unchanged among the set of 1 – 8.5 GHz spurious emission tests. The channel and modulation were varied, but not the setup. See test record RE15 for the setup photographs.

This line is the end of the test record.

Test Record
Radiated Emission Test RE26
Project GCL0388

Test Date(s)	26 Oct 2023
Test Personnel	David Kerr
Product Model	A04752
Serial Number tested	3449554812
Operating Mode	M4 (WiFi5Tx)
Arrangement	A1 (Mounted)
Input Power	13.8 Vdc
Test Standards:	FCC Part 15, ANSI C63.10 (as noted in Section 6 of the report).
Frequency Range:	30 MHz to 1000 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Aditya Prakash**
Date of this record:	**30 Oct 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Antenna, Biconilog, 30M-6 GHz	ETS Lindgren	3142E	233201	19-Jul-2022	15-Jul-2024
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	7-Nov-2022	7-Nov-2025
Tape measure, 1” x 33’	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
DMM Multimeter	FLUKE	79 III	71740743	5-Apr-2023	1-Apr-2024
Power supply	Samlex America	SEC1212	03051-7F03-00426	Calibration	Not Required

Table RE26.1: Test Equipment Used

Software Used:
Keysight PXE software A.32.06
EPX/RE automation software ver. 2023.01.001

Test Data

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using on the orientation(s) producing the highest result relative to the test limit. Where the test standard requires cable manipulation, this was done at one of more likely worst case frequencies selected by the test personnel while observing the receiver display. At each of the frequencies selected for final measurements, the turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings. Final field strength measurements were taken in that set of positions. Full maximization was not performed at frequencies that are noise floor measurements included per the test standard requirements.

At azimuth angle 180° the 'front' reference mark of the turntable is pointed Southward. At 270° the reference mark points West. At 90° it points East. At 173° the turntable reference mark is pointed directly at the antenna. The designation of the X, Y, and Z orientations of the test sample are sample dependent, so these are reported by use of photographs.

The table shows the selected final measurement data between 30 MHz and 1 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency MHz	Pol.	Reading dB(µV) QP	Factor dB(1/m)	Level dB(µV/m) QP	Limit dB(µV/m) QP	Margin dB QP	Height cm	Angle deg
31.320	V	8.5	22.1	30.6	40.0	9.4	100.0	39.0
274.620	H	22.0	21.9	43.9	46.0	2.1	100.0	212.0
343.290	H	6.3	24.2	30.5	46.0	15.5	100.0	218.0
237.360	H	14.8	21.0	35.8	46.0	10.2	119.9	290.0
114.030	H	11.2	16.2	27.4	43.5	16.1	270.3	116.0
823.860	H	8.3	34.6	42.9	46.0	3.1	100.0	354.0

Table RE26.2: Emission summary

The graph below shows the background spectrum observed during pre-scan, as well as the final data points from the table above.

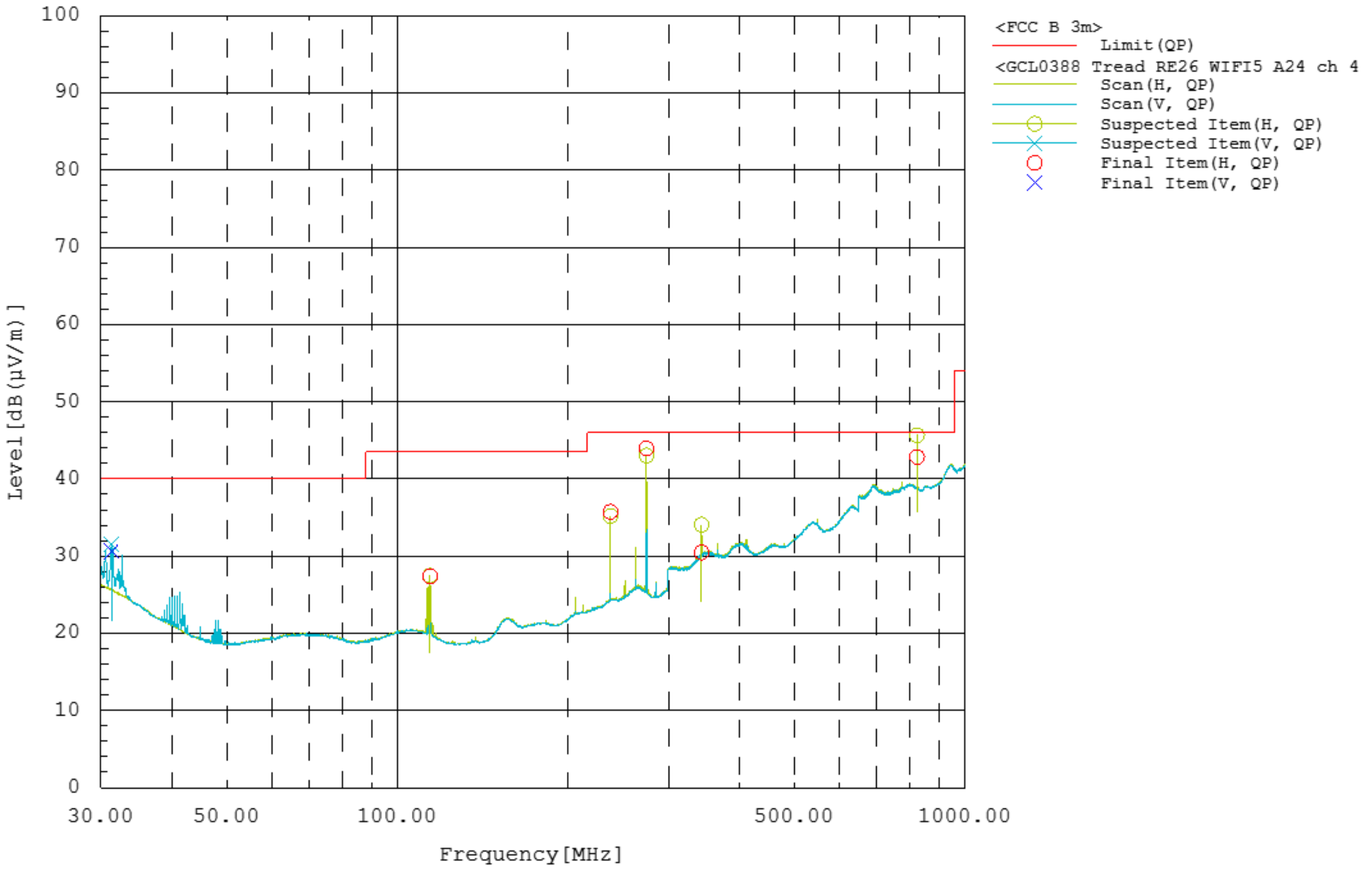

Figure RE26.1: Spectral data

Setup Photographs

The following photographs show the EUT configured and arranged in the manner in which it was measured.

Image removed for client confidentiality.
See section 1 of this report
to identify the report where
the photos may be viewed.

Figure RE26.2: EUT test setup, front view

Image removed for client confidentiality.
See section 1 of this report
to identify the report where
the photos may be viewed.

Figure RE26.3: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE04
Project GCL0388

Test Date(s)	06 Oct 2023
Test Personnel	David Kerr
Product Model	A04752
Serial Number tested	3449554812
Operating Mode	M4 (WiFi5Tx)
Arrangement	A2 (USB)
Input Power	115 V/ 60 Hz
Test Standards:	FCC Part 15 (as noted in Section 6 of the report).
Frequency Range:	150 kHz to 30 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Aditya Prakash**
Date of this record:	**10 Oct 2023**

Original record, Version A.

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-23	1-Feb-24
Tape measure, 1” x 33’	Lufkin	PHV1410CMEN	10721	30-Aug-23	1-Sep-26
DMM Multimeter	FLUKE	79 III	71740743	5-Apr-23	1-Apr-24
LISN multiline; 20A 50uH	Com-Power	LIN-120C	20160005	10-Feb-23	15-Feb-24

Table CE04.1: Test Equipment Used

Software Used
Keysight PXE software A.33.03; CE Mains 150k to 30M Data Analysis V2 2021Jun10.xlsx

Test Data

The conducted emission test process began with a set of preliminary scans on both power conductors using both Quasi-Peak and Average detectors across the frequency range. Where the test standard requires cable manipulation, one or more likely worst case frequencies selected by the test personnel. Cables were manipulated to find the maximal signal strength while observing the receiver levels at those selected frequencies. At each of the frequencies selected for final measurements, Quasi-peak and Average detector readings were taken on each conductor.

The table shows the selected final measurement data. It includes at least the six strongest emissions observed relative to the limit lines, along with other data points of interest. The yellow highlight indicate the data points with the least margin to the quasi-peak detector limit and the average detector limit. A positive margin value indicates that the emission was below the test limit. The test limit is the Composite FCC Class B Limit.

Frequency (kHz)	QP Limit (dBuV)	AV Limit (dBuV)	L1 QP (dBuV)	L2 QP (dBuV)	L1 AV (dBuV)	L2 AV (dBuV)	QP Margin (dB)	AV Margin (dB)
150	66	56	49.93	49.34	30.92	30.16	16.07	25.08
164	65.28	55.28	49.05	48.39	31.41	30.9	16.23	23.87
584	56	46	40.59	37.78	32.6	28.21	15.41	13.4
645	56	46	43.77	41.19	36.16	29.99	12.23	9.84
1291	56	46	41.74	36.05	30.47	27.28	14.26	15.53
1345	56	46	42.31	35.98	31.1	27.67	13.69	14.9

Table CE04.2: Emission summary

The graph below shows preliminary scan data as continuous curves. Superimposed are the final measurement data points reported in the table above.

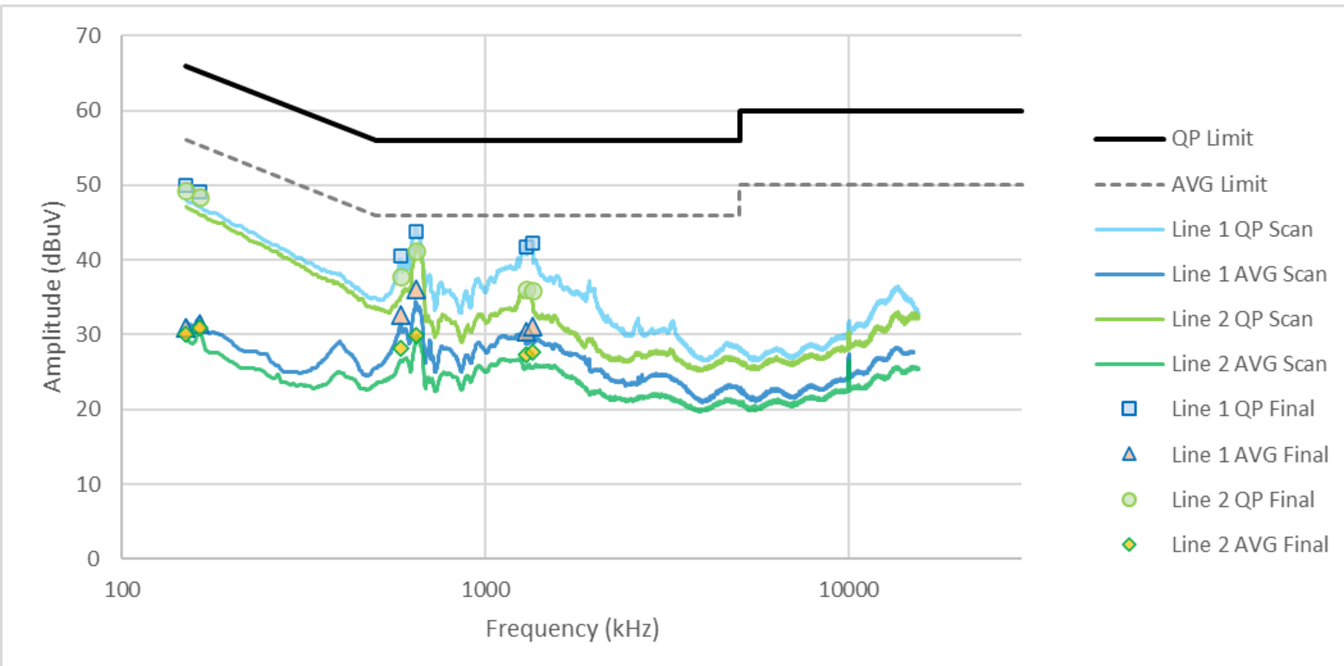

Figure CE04.1: Spectral data

Setup Photographs

The following photographs show the EUT configured and arranged in the manner in which it was measured.

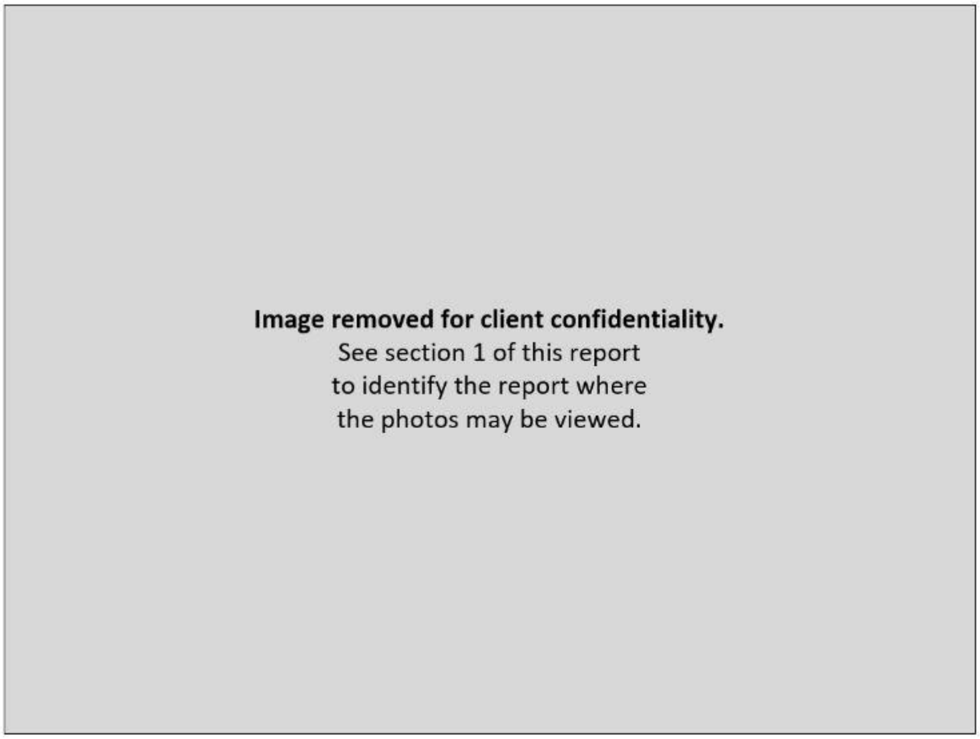

Figure CE04.2: Test setup, front view

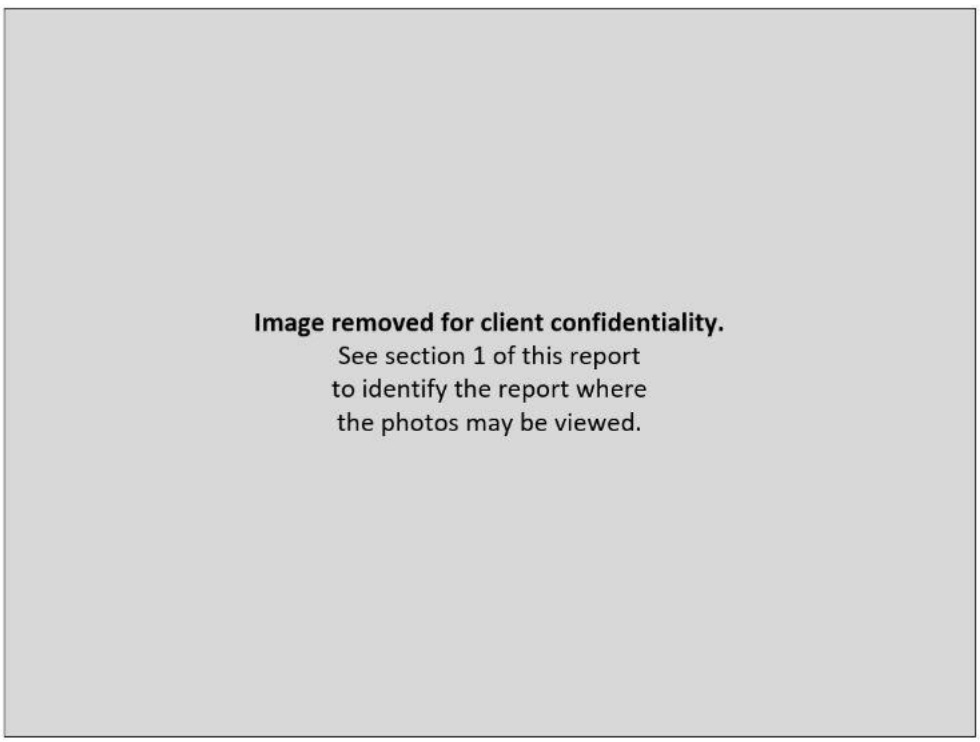

Figure CE04.3: Test setup, side view

This line is the end of the test record.
Concluding Notes

This report stands as an integrated record of the tests performed and must be copied or distributed in its complete form. The reproduction of selected pages or sections separate from the complete report would require specific approval from the manager of the Garmin Compliance Lab.

This is the final page of the report.