Test Report 2023-069

Version A
Issued 8 Nov 2023

Project GCL-0457
Model Identifier: AA4714
Primary Test Standard(s)
CFR 47, FCC Part 15.247
RSS-247 Issue 2

Garmin Compliance Lab
Garmin International
1200 E 151st Street
Olathe Kansas 66062 USA

Client-supplied Information

FCC ID: IPH-A4714
IC ID: 1792A-A4714

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 2.4 GHz transceiver(s). The Bluetooth radio is tested under the FHSS provisions. The WiFi, BLE, and ANT radios are treated as DTS devices. The results are as follows.

Parameter	Description	Key Performance Values	Result	Data starts at page
Hopping Channels	The radio manages it use of channels appropriately. [15.247(a)(1); RSS-247 at 5.1]	The Bluetooth radio described in this report met the Frequency Hopping rules of 15.247(a)(1).	PASS	12
DTS Bandwidth	The nature of the radio signal is broadband, being at least 500 kHz wide. [15.247(a)(2); RSS-247 at 5.2(a)]	The 6dB bandwidth of the DTS radios is 703.2 kHz or greater.	PASS	16
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 for all radios but have no actual performance requirements.	Reported	21
Transmit Power	The peak transmit power presented to the antenna is no greater that 1 Watt or 30 dBm. The effective radiated power is limited to 4 Watts or 36 dBm EIRP. [15.247(b); RSS-247 at 5.4(d)]	The maximum transmit power for all radios is 16.3 dBm or 42.7 mW.	PASS	28
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. [15.247(b)(4) and (c)]	NT. The client stated that the antenna gain was -0.3 dBi for all radios and will document antenna gain separately.	NT	NT
Unwanted Emissions (Conducted Spurious)	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 at least 20 dB from in-band levels. The measured reduction was at least 36.8 dB for all radios.	PASS	34
Restricted Bands	The radio must not emit in certain designated restricted frequency bands above a set of limit values. [15.247(d) and 15.205; RSS-247 at 3.3]	Emissions in the restricted bands were at least 7.8 dB below the applicable limits for all radios.	PASS	46
Power Spectral Density	The radio must not focus too much radio energy in a narrow frequency band. [15.247(e); RSS-247 at 5.2(b)]	The limit is 8 dBm in a 3 kHz band. The strongest emission level for any DTS radio was 2.61 dBm in a band of at least 3 kHz.	PASS	70

Hybrid Systems	A radio that is both frequency hopping and digitally modulated should satisfy a combination of system rules. [15.247(f); RSS-247 at 5.3]	N/A. The radios described in this report are not subjected to the Hybrid System rules.	N/A	N/A
Frequency Hopping Rules	Frequency hopping systems have additional functional requirements. [15.247(g) and (h); RSS-247 at 5.1]	The frequency hopping rules of 15.247(g) and (h) are not testable requirements.	NT	NT
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]	Radio emissions for all radios remained within the allowed radio band under all environmental conditions tested.	PASS	76
Unintended Radiated Emissions	Radio emissions that this device may generate via its structures and connected cables that are not necessary for its operation and that may affect other radio communication	8.3 dB of margin for all radios. Appropriate for use in homes, offices, and industrial facilities. [Class B]	PASS	82
AC Mains Conducted Emissions	Radio emissions that this device may generate via its ac power network connections that are not necessary for its operation and that may affect radio communication.	6.5 dB of margin for all radios. Appropriate for use in homes, offices, and industrial facilities. [Class B]	PASS	98

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
10. Immunity Performance Criteria

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 2023-056. 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 Sep 2023
Test Start Date: 07 Sep 2023
Test End Date: 19 Oct 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 Majid Farah and initially issued on 8 Nov 2023 as Version A.

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:
None

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model	AA4714
Serial Numbers Tested	3453413911, 3453413922, 3453413873

This product tested is a mobile device for collecting and sharing data with the user and nearby electronic devices.

The client affirmed that the test samples will be representative of production in all relevant aspects.

5.2 Key Parameters

EUT Input Power:	5 Vdc
I/O Ports:	USB
Radio Transceivers:	IEEE 802.11(b/g/n), Bluetooth, Bluetooth Low Energy, ANT, NFC
Radio Receivers:	GPS L1, Galileo E1, BeiDou, GLONASS
Primary Functions:	Data collection and communication
Typical use:	Portable in multiple orientations
Highest internal frequency:	2.484 GHz
Firmware Revision	3.05

5.3 Operating modes

During test, the EUT was operated in one or more of the following modes. Some modes may not applicable for this product or in this report.

Mode 1: M1 (Bt Tx). Bluetooth, sometimes called Bluetooth Classic, radio is transmitting consistently on a selected channel sending data using the BR (Basic Rate of 1 Mbps), EDR2 (Extended Data Rate of 2 Mbps) or EDR3 (Extended Data Rate of 3 Mbps) modulation types.

Mode 2: M2 (Bt lnk). Bluetooth Classic radio is paired to a companion device, transmitting and receiving data on various channels in accordance with the protocol, and maintaining the paired relationship.

Mode 3: M3 (Ble Tx). Bluetooth Low Energy radio transmitting consistently on a selected channel at 1 Mbps or 2 Mbps

Mode 4: M4 (Ble lnk). Bluetooth Low Energy radio is paired to a companion device, transmitting and receiving data on various channels in accordance with the protocol, and maintaining the paired relationship.

Mode 5: M5 (ANT Tx). ANT radio transmitting consistently on a selected channel.

Mode 6: M6 (ANT lnk). ANT radio is paired to a companion device, transmitting and receiving data in accordance with the protocol, and maintaining the paired relationship.

Mode 7: M7 (WiFi Tx). The IEEE 802.11 b/g/n radio was transmitting consistently on a selected channel, with a specified modulation type, and data rate.

Mode 8: M8 (WiFi Link). The IEEE 802.11 b/g/n radio is paired to a companion device, transmitting and receiving data on a selected channel in accordance with the protocol, and maintaining the paired relationship.

Mode 9: M9 (Rx 2.4). The radio was set to receive 2.4 GHz signals but not transmit. In this situation, it was specifically looking for Bluetooth Low Energy signals which cover the 2.4 GHz band and represent a worst-case scenario.

Mode 10: M10 (All2.4). This means the radio was tested in modes M1, M3, M5, and M7 if applicable.

Mode 11: M11 (GNSS). The Global Navigation Satellite System receiver is monitoring the GNSS bands, attempting to detect a constellation and determine location. Unless otherwise noted, the EUT was provided simulated GNSS signals representing one of more constellation types. In addition, the EUT may have been reporting signal levels and satellite data to an attached computer to monitor link health.

Mode 12: M12 (NFC lnk). The NFC 13.56 MHz transceiver is in Card Emulation mode, and is actively linked to a companion NFC Reader.

5.4 EUT Arrangement

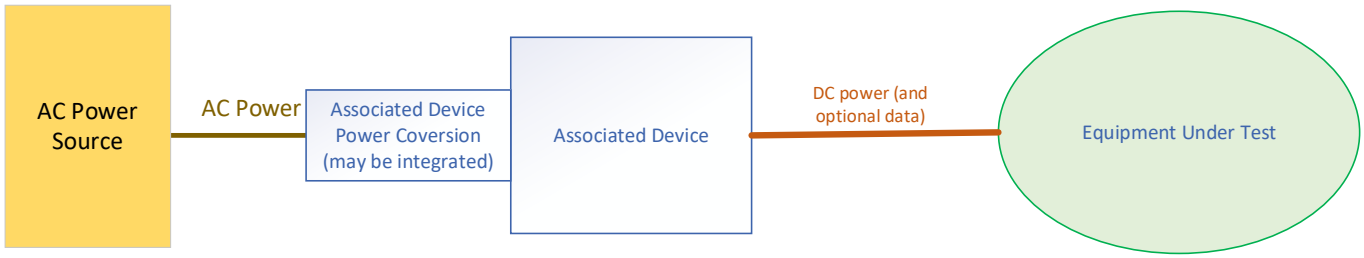
During test, the EUT components and associated support equipment were selected including the following arrangement sets.

Arrangement 1: A1 (Solo). The test sample operates from its battery and no external physical connections. No block diagram is needed for this arrangement.

Arrangement 2: A2 (Upwr). The test sample is attached to a Mains-powered device connected that provides dc power to the sample over a cable but no user data. See the block diagram in Figure 1.

Arrangement 3: A3 (Udata). The test sample is attached to a Mains-powered device connected that provides dc power to the sample and user data over a cable. See the block diagram in Figure 1.

Arrangement 4: A4 (Udc). The test sample is attached to a Mains-powered device connected that provides dc power to the sample and may or may not provide user data. This arrangement is specified in the test plan to provide staff flexibility when the presence or absence of data on the cable is not pertinent. See the block diagram in Figure 1.



This interconnect drawing is not to scale.
It does not indicate the placement of devices.

Figure 1: Block diagram of equipment for arrangements A2, A3, A4

Arrangement 5: A5 (NFCp) The test sample is placed near an NFC Card Reader. The NFC Card Reader is connected to a laptop computer. The test sample is powered by a device that does not include data over the cable, just as with A2. For clarity, test sample is NOT powered by, or connected to, the laptop computer that powers the NFC Card Reader.

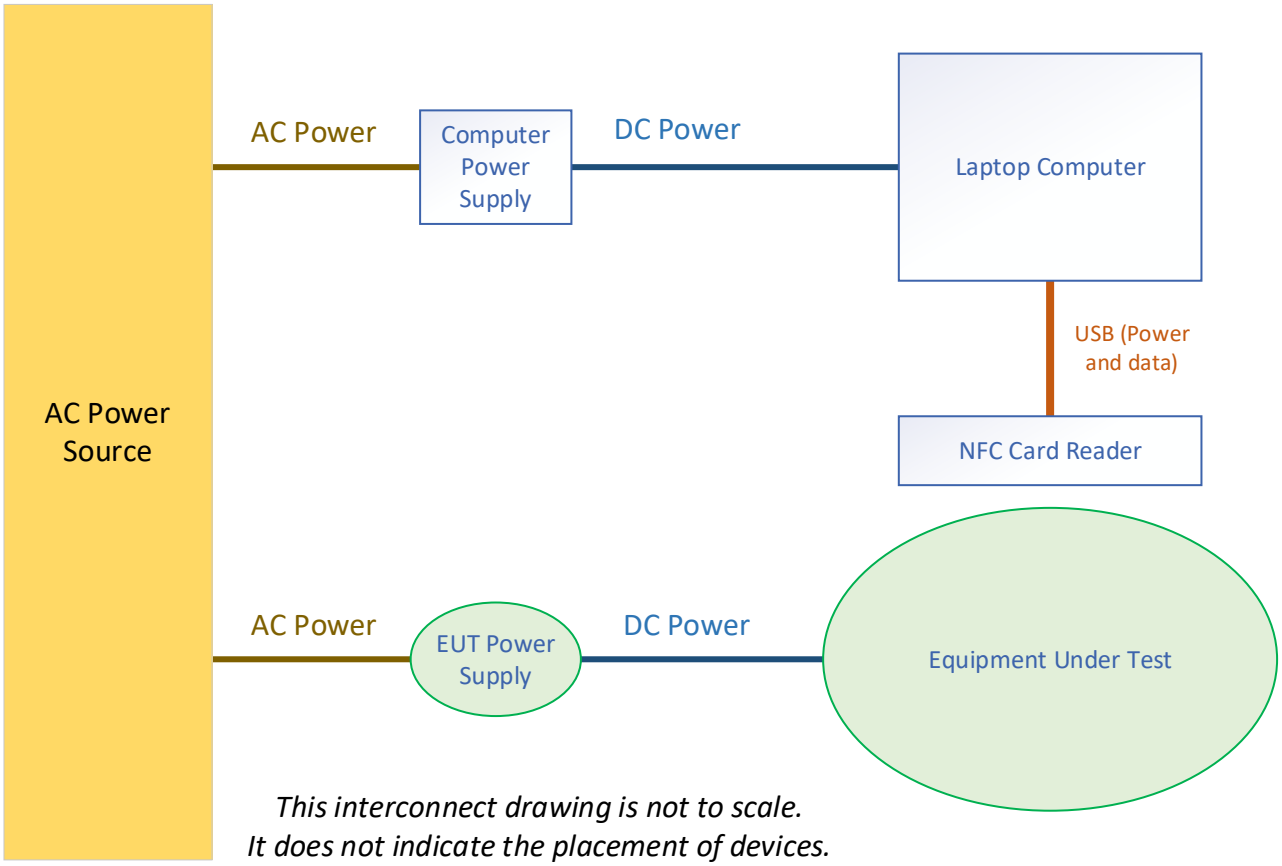


Figure 2: Block diagram of equipment arrangement A5

Arrangement 6: A6 (NFCu) The test sample is placed near an NFC Card Reader. The NFC Card Reader is connected to a laptop computer. The test sample is powered by its own batteries rather than an external power source.

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
AC/DC Power Converter	Phihong technology	PSAF10R-050Q	None
Laptop Computer	Dell	Latitude 5410	5VSPFB3
Laptop Power Supply	Dell	HA65NM191	None

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

5.6 Cables used

Description	From	To	Length	EMC Treatment
USB	Power and/or Data source	EUT	54 cm	None

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

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.

AS/NZS 4268: 2017
CFR 47, FCC Part 15.247
ANSI C63.10: 2013 and ANSI C63.10: 2020
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 0.01% of value 0.5 x LSDPV	None	None

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 23.6 °C
Relative Humidity:	34.3% to 55.7% (non-condensing)
Barometric Pressure	96.3 to 99.2 kPa

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

Table 4: Environmental monitoring device

10 Immunity Performance Criteria

If this report includes immunity tests then results have been categorized as Performance Criteria A, B, C, or D. The standards that the lab applied will define the details for A, B, and C, as well as which criterion is required for each type of test. They will also define the electrical stresses that were applied during each test. In a very general sense the observed criteria noted in this report are as follows:

Criterion A. The stress applied did not alter product operation. This criterion is generally used for 'continuous' stresses that can be present for a long time in the places the product will be used, or that can appear often, even though they may come and go over time.

Criterion B. The stress applied altered product operation, but the product self-recovered so that the user would not have to try to figure out how to restore it to full operation. This criterion is generally used for 'transient' stresses that appear briefly and occasionally, but are usually not present in the places the product will be used.

Criterion C. The stress applied altered product operation, but the user could restore it to full operation, for example by power cycling the product. This criterion is generally used for 'transient' stresses that appear briefly and only rarely in the places the product will be used.

Criterion D. This is not an official criterion in the standards, because it would be a failure of the requirements. This indication in a test record means the product was affected in a way that the user might not be able to correct. The effect could include some degree of hardware damage, or it could include loss of program files or data files necessary for operation.

Repeatability is an issue in all EMC immunity work. When the product operation changes unexpectedly during a test, and the change would fail the requirements of the standard, this is an anomaly. The test operator needs to determine whether the anomaly was a result of the applied electrical stress. The investigation is done by repeating the section of the test where the anomaly occurred three times. If the same or a similar anomaly occurs in any of the three repeat trials, it is confirmed as a response to the stress. If not, the anomaly is judged unreproducible and is not considered when judging the A, B, or C observed performance. Since there is usually no ability to confirm a Criterion D anomaly, these are usually treated as Criterion D upon a single occurrence.

Tests that require Criterion B performance will be judged to Pass if criteria A or B is observed. Similarly, tests that require Criterion C performance will be judged to Pass if criteria A, B, or C is observed.

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
FHSS ANSI Test TR31-33
Project GCL-0457

Test Date(s)	19 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M1(BtTx)
Arrangement	A3 (Udata)
Input Power	5V dc
RF Output	Is not greater than 125 mW (21 dBm) conducted to the antenna
Test Standards:	FCC Part 15.247, ANSI C63.10, AS/NZS 4268, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date of this test record:	**19 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 TR31.1: Test equipment used

Test software used: Keysight PXE software 35.06, FHSS ANSI Occupancy Template v2.xlsx

Test Data

This test looks at details specific to frequency hopping systems in the referenced standards: the number of hopping channels; the relationship between 20 dB Occupied bandwidth and channel separation; and channel occupancy time.

This 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. Since the absolute signal amplitude is not relevant to these tests, the results may not have been adjusted to account for the losses in the laboratory cables.

Test Data: Hopping Channels

The test sample was placed in a test mode where it transmits on its various frequency channels while hopping. The spectrum analyzer scanned a frequency range that included these frequencies in Max Hold condition. The resulting spectra are attached, showing that the sample uses each of the 79 hopping frequencies from 2402 MHz to 2480 MHz, also confirming a channel separation of 1 MHz.

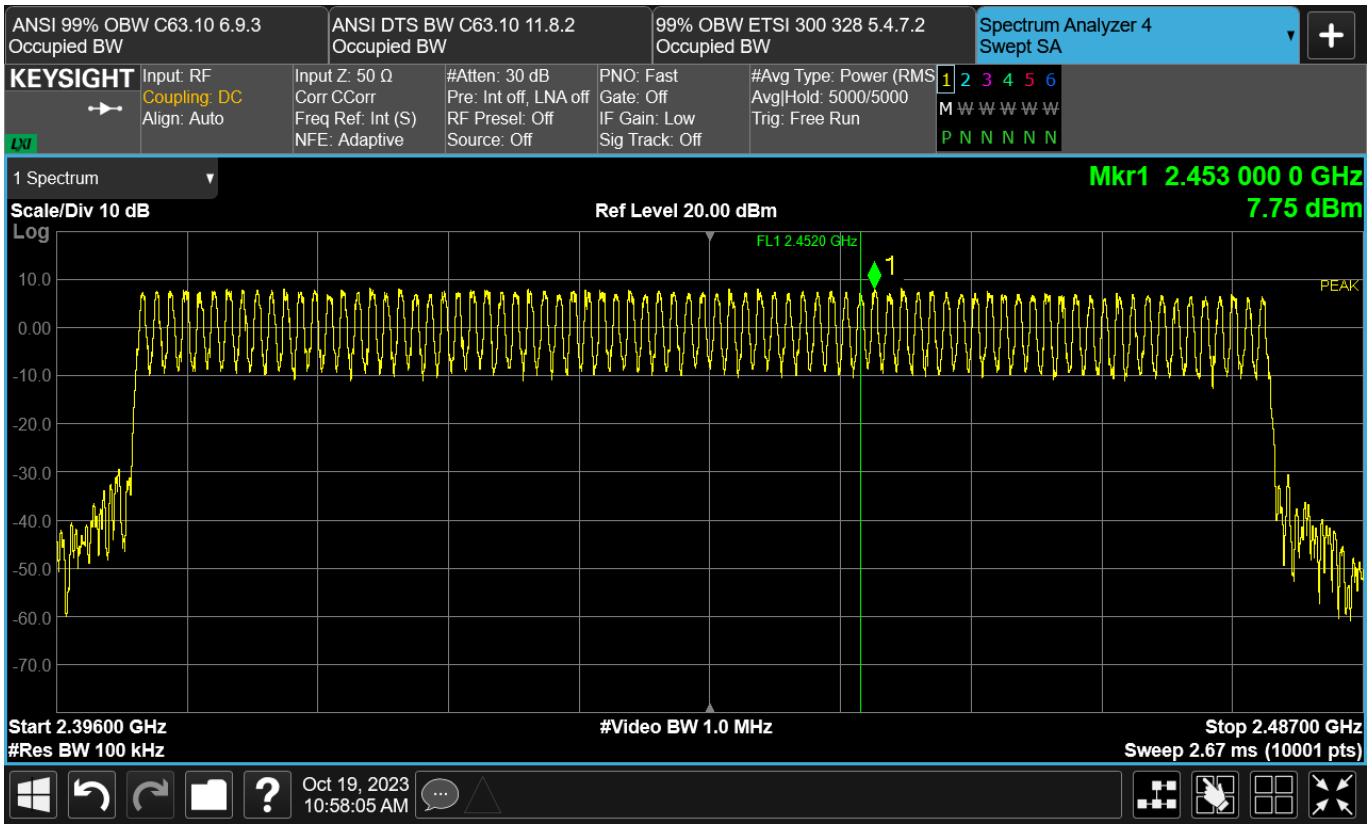


Figure TR31.1: Spectral data, Bluetooth Basic Rate transmission, showing channels used

Test Data: Bandwidth and Channel Separation

The 20 dB Occupied bandwidth (OBW20) was measured for each modulation type, with the transmission fixed on low, middle, and high channels. The maximum bandwidth observed is highlighted in yellow, and the spectrum image for that case is also provided.

The standards require that the hopping channel separation is no less than OBW20 if the transmitted power is above 125 mW. For lower power transmissions, the hopping channel separation must be no less than two-thirds of OBW20. This second case can also be expressed as limiting OBW20 to 1.5 times the channel separation. Based on the 1 MHz separation between hopping channel, and the output power of the transmitter, the 20 dB occupied bandwidth must be no greater than 1.5 MHz. The data below shows compliance with this limit.

	2402	2440	2480
Bluetooth BR	**1.037**	**1.038**	**1.039**

Table TR31.2: Summary of 20 dB Occupied Bandwidth results in MHz

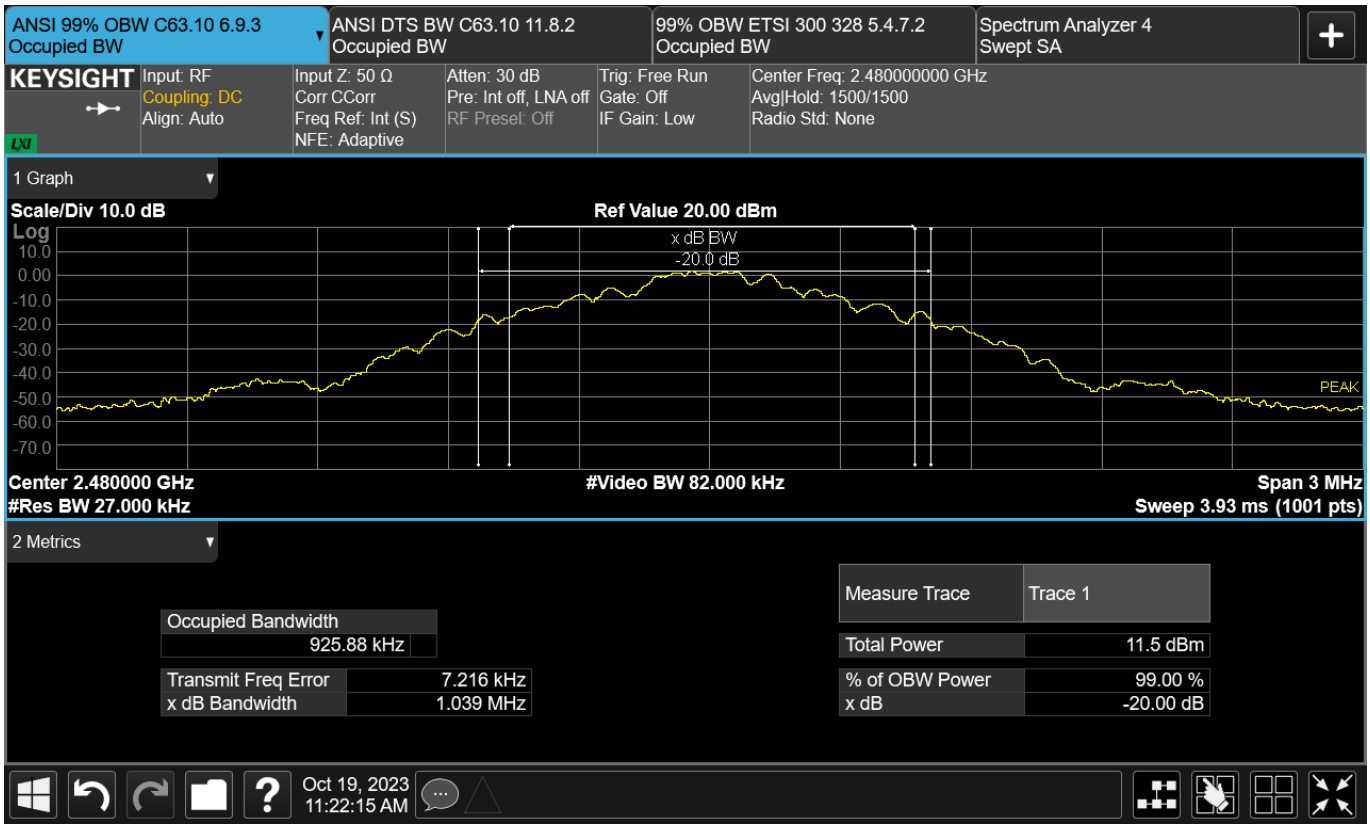


Figure TR31.2: Spectral data for Bluetooth Basic Rate modulation at 2480 MHz

Test Data: Channel Occupancy

The channel occupancy requirement ensures that the transmissions are distributed consistently across the hopping channels. The measurement is made on each of the three randomly selected channels for a period of 0.4 seconds multiplied by the number of hopping channels. For this product, that is a measurement period of 31.6 seconds. During that time, the sum of the transmission times on the selected channel cannot exceed the limit of 0.4 seconds.

This testing is performed at three test channel frequencies, randomly selected within a range. The first range is 2402 to 2427 MHz. The second test frequency range is 2428 to 2454 MHz. The final range is 2455 to 2480 MHz.

The test sample was placed in a test mode where it transmits on its various frequency channels while hopping. The transmissions were measured while the test equipment was tuned to each one of the three test channels using a detector more narrow than the OBW20 value. This provides a record of transmissions only on the selected channel over time. A spreadsheet analyzed the data to determine channel occupancy -- the total sum of time that the transmitter was on the selected channel. The maximum channel occupancy values is highlighted in yellow, and a zero-span time plot image for that case is also provided.

Freq (MHz)	2402	2440	2480
BTBR	0.213	0.215	0.215

Table TR31.3: Summary of Channel Occupancy results in seconds

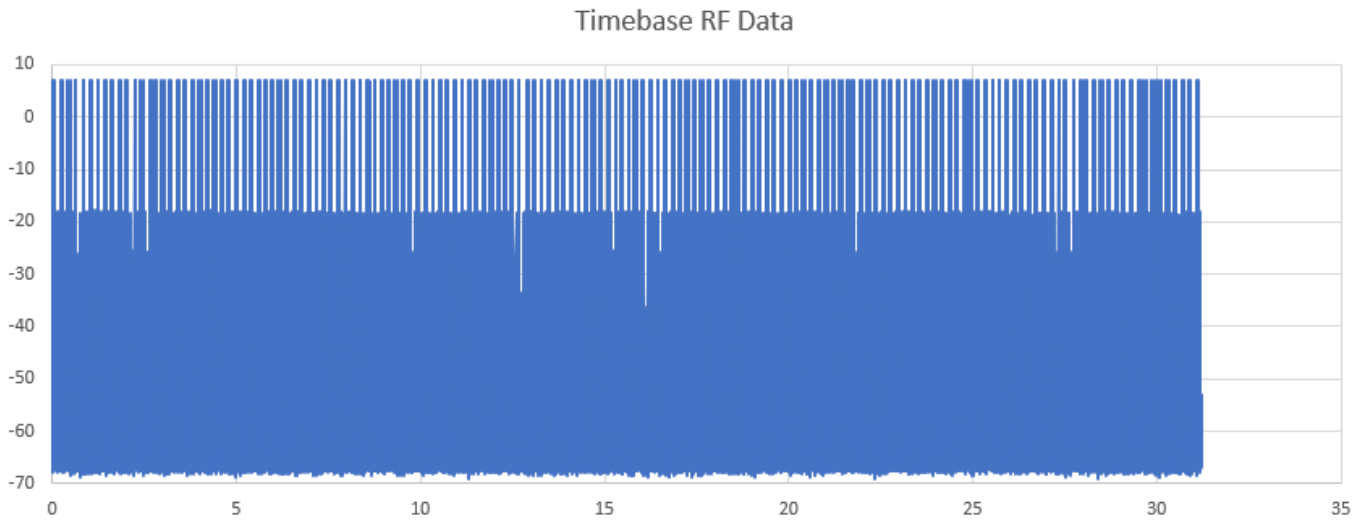


Figure TR31.3: Channel Occupancy time data for Bluetooth Basic Rate modulation at 2480 MHz

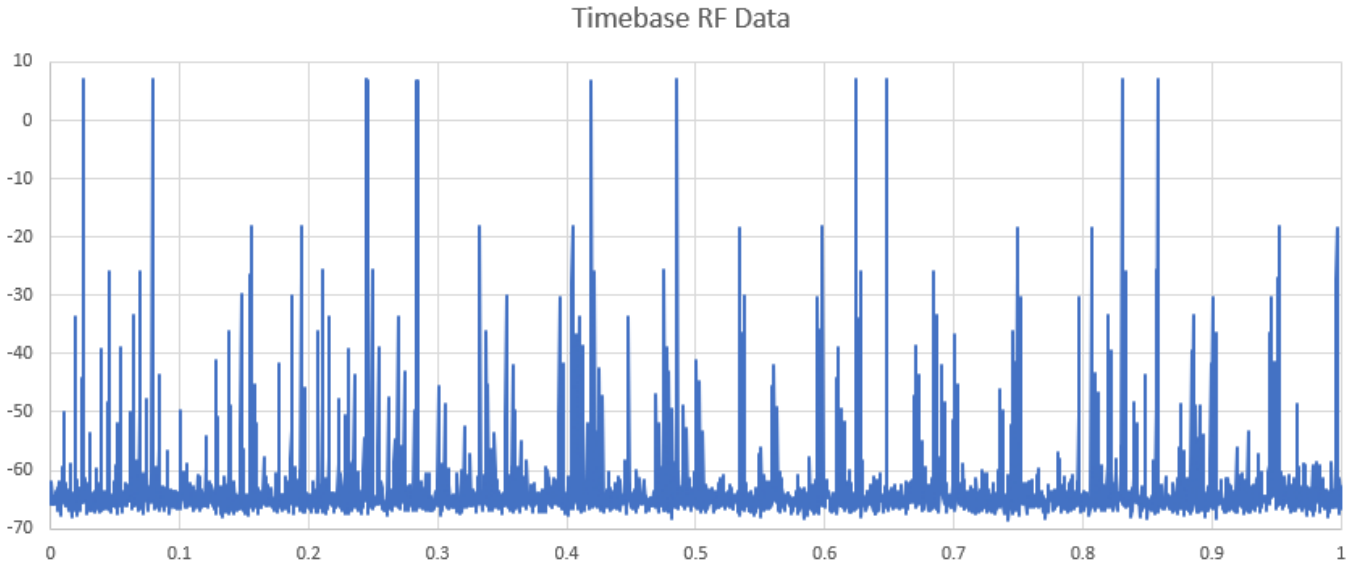


Figure TR31.4: First second of the Channel Occupancy time data for improved clarity

This line is the end of the test record.

Test Record
Transmitter Bandwidth Tests
Test IDs TR02
Project GCL0457

Test Date(s)	28-29 Sep and 04 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M10 (All2.4)
Arrangement	A3 (Udata)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN (as noted in Section 6 of the report).
Radio Protocol	Bluetooth Low Energy (BLE), ANT, IEEE 802.11 b/g/n (WiFi)
Radio Band	2400 to 2483.5 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date of this record:	**06 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 TR02.1: List of test equipment used

Test Software Used: Keysight PXE firmware A.35.06

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 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.

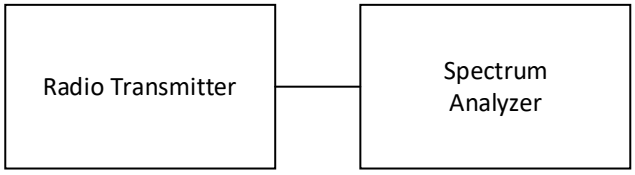


Figure TR02.1: Test setup

Test Data

The data for each test is summarized below, followed by the spectral data for each case highlighted in yellow. For BLE operating at 2 Mbps, the lowest operating frequency was 2404 MHz, and the highest operating frequency was 2478 MHz. For all other radios reported here, the lowest operating frequency was 2402 MHz, and the highest operating frequency was 2480 MHz.

The DTS Bandwidth is measured using a spectrum analyzer operating with a defined resolution bandwidth. The analysis finds the smallest continuous range of frequencies containing all emissions within 6 dB of the highest value. The requirement is that the DTS Bandwidth be greater than 500 kHz. As such the lowest measured bandwidth is worst case. Since the Bluetooth radio had less than a 500 kHz DTS bandwidth, it is being certified under the FHSS rules. All other radios reported here are judged to have met this requirement.

	2402 (04)	2440	2480 (78)
Bluetooth BR	**484.9**	**487.4**	**494.2**
Bluetooth EDR2	**500.4**	**503.2**	**505.3**
Bluetooth EDR3	**500.7**	**502.9**	**505.1**
BLE 1 Mbps	**703.2**	**1273.0**	**704.2**
BLE 2 Mbps	**1444.0**	**1468.0**	**1155.0**
ANT	**932.9**	**905.0**	**941.8**

Table TR02.2: Summary of DTS bandwidth data in kHz for Bluetooth, ANT and BLE modes

	Ch1	Ch6	Ch11	Ch12	Ch13
B1	9.590	9.105	9.587	9.096	9.532
B2	9.089	9.121	9.108	9.106	8.853
B5.5	8.771	8.429	8.355	9.779	8.767
B11	9.092	8.872	9.061	9.159	9.080
G6	16.460	16.540	16.510	16.570	15.890
G9	16.560	16.530	16.560	16.580	16.320
G12	16.530	16.550	16.540	16.550	16.190
G18	16.510	16.530	16.500	16.510	15.780
G24	16.070	16.540	16.490	16.530	16.350
G36	16.050	16.550	16.550	16.550	16.130
G48	16.100	16.540	16.530	16.540	16.360
G54	15.840	16.540	16.530	16.530	16.120
NMCS0	16.290	17.640	17.640	17.640	16.370
NMCS1	16.010	17.690	17.660	17.680	16.350
NMCS2	15.840	17.700	17.670	17.670	16.420
NMCS3	16.090	17.640	17.680	17.690	16.130
NMCS4	15.830	17.710	17.690	17.690	16.330
NMCS5	16.270	17.670	17.680	17.660	16.300
NMCS6	16.130	17.670	17.720	17.720	16.130
NMCS7	16.040	17.480	17.690	17.630	16.320

Table TR02.3: Summary of DTS bandwidth data in MHz for WiFi

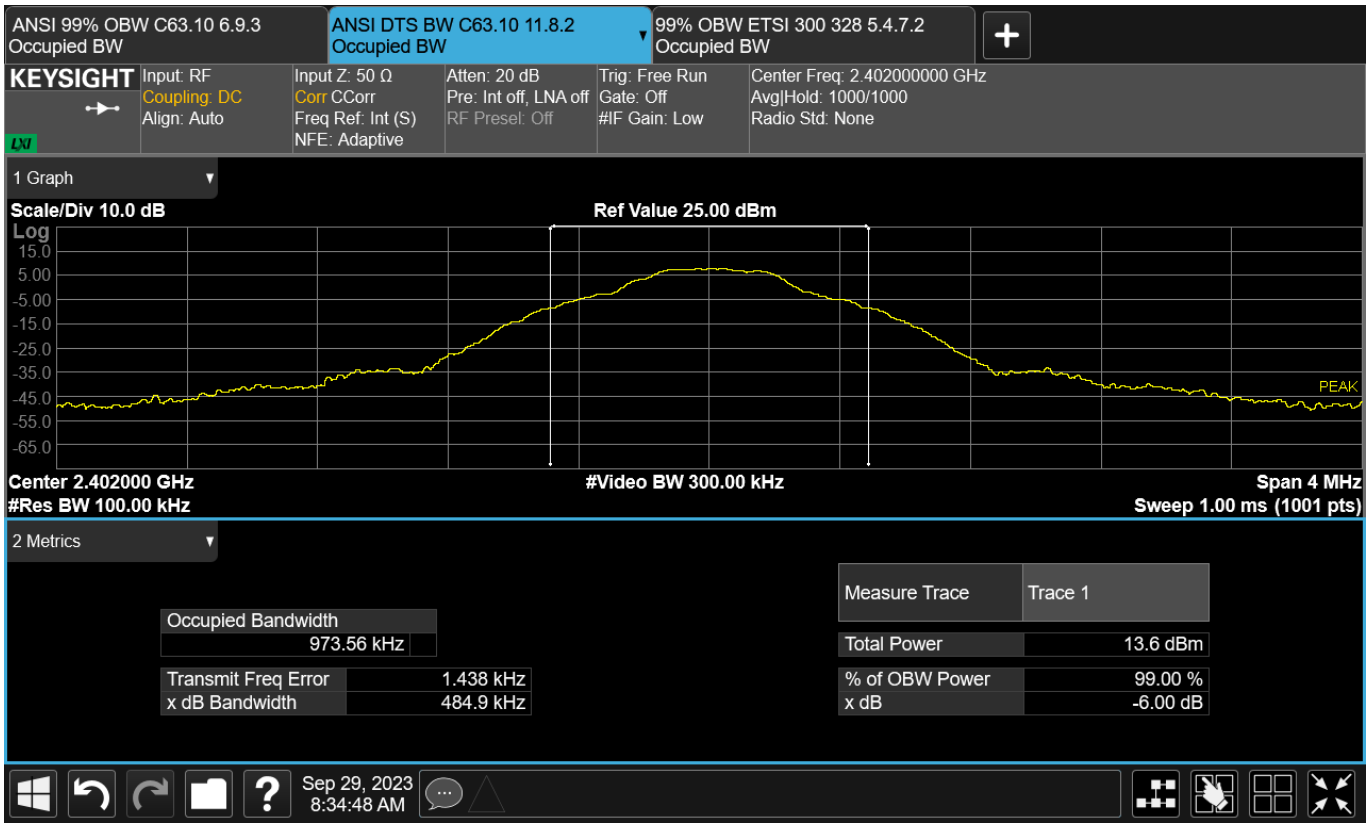


Figure TR02.2: Bandwidth data for Bluetooth BR at 2402 MHz

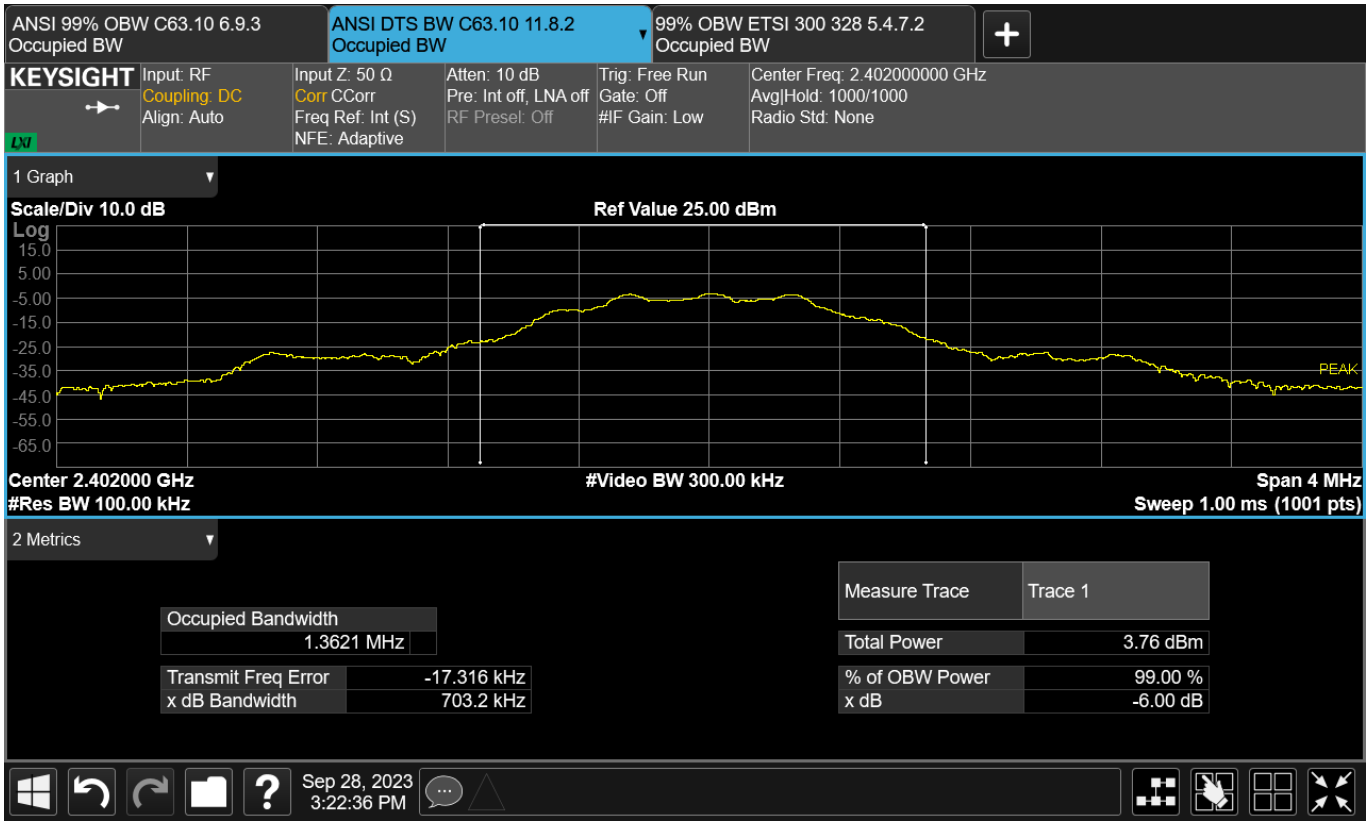


Figure TR02.3: Bandwidth data for BLE 1 Mbps at 2402 MHz

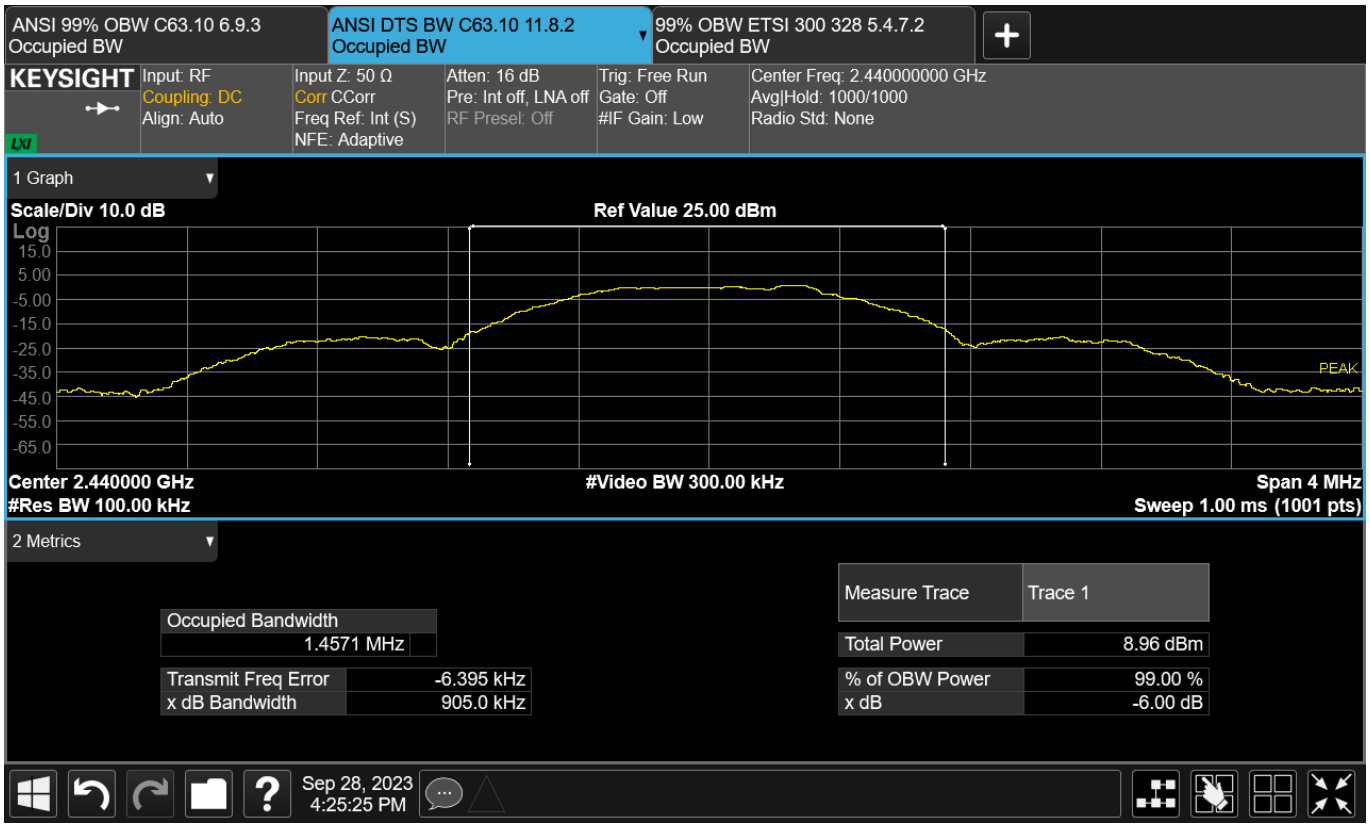


Figure TR02.4: Bandwidth data for ANT at 2440 MHz

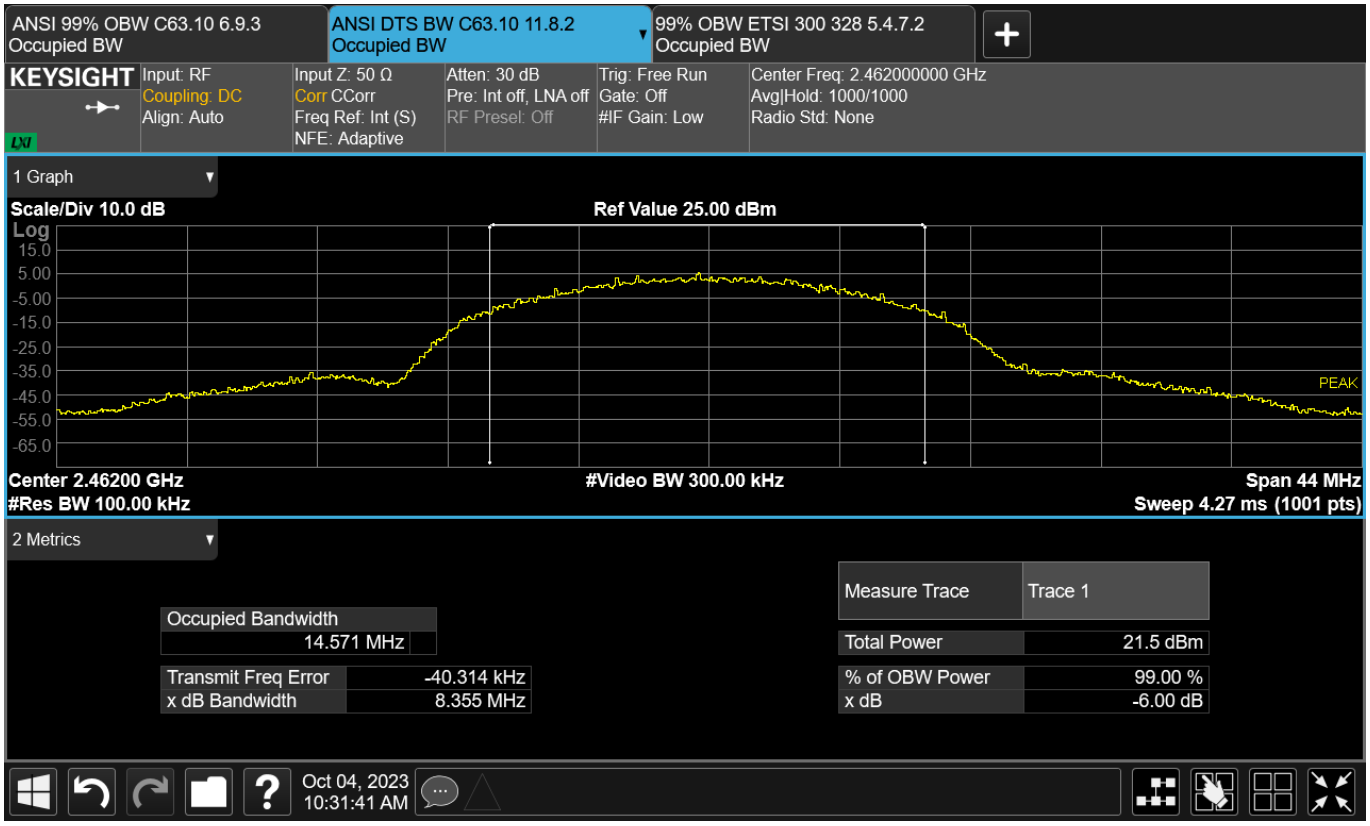


Figure TR02.5: Bandwidth data for B5.5 modulation at channel 11 (2462 MHz)

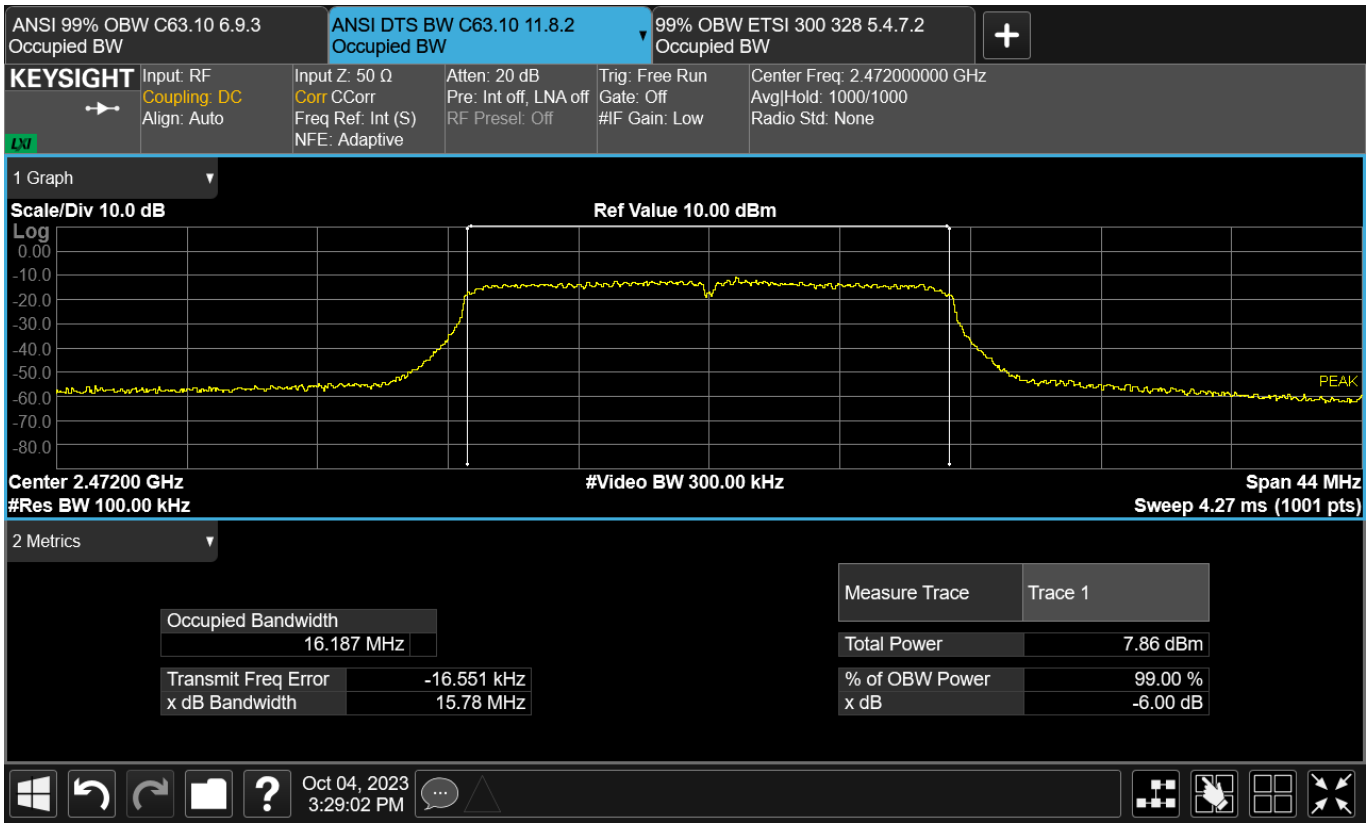


Figure TR02.6: Bandwidth data for G18 modulation at channel 13 (2472 MHz)

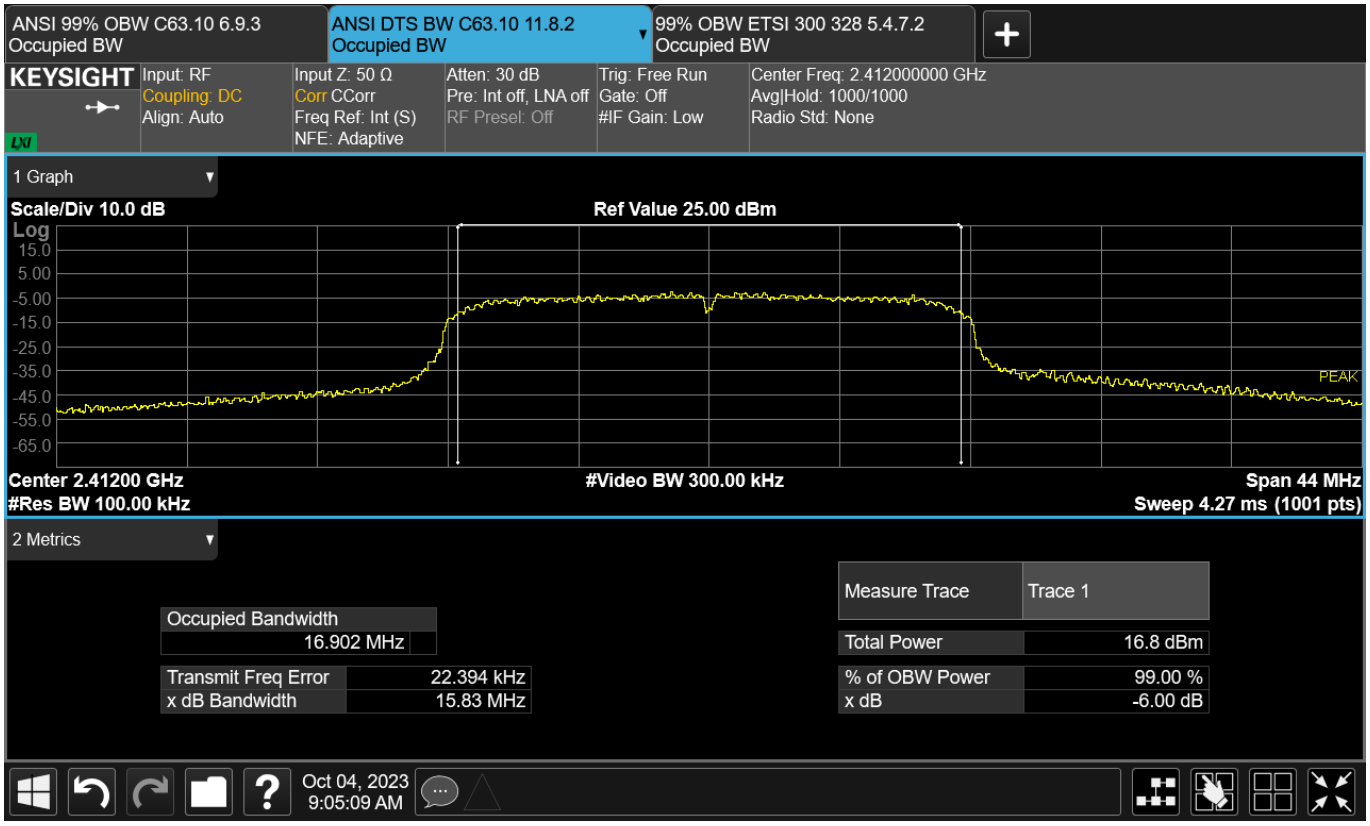


Figure TR02.7: Bandwidth data for NMCS4 modulation at channel 1 (2412 MHz)

This line is the end of the test record.

Test Record
Transmitter Bandwidth Tests
Test IDs TR03
Project GCL0457

Test Date(s)	28-29 Sep and 04 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M10 (All2.4)
Arrangement	A3 (Udata)
Input Power	5 Vdc
Test Standards:	FCC Part 2.202, ANSI C63.10, TRC-43, RSS-GEN (as noted in Section 6 of the report).
Radio Protocol	Bluetooth Classic (Including EDR2 and EDR3), Bluetooth Low Energy (BLE), ANT, IEEE 802.11 b/g/n (WiFi)
Radio Band	2400 to 2483.5 MHz
Pass/Fail Judgment:	**Reported**
Test record created by:	**Majid Farah**
Date of this record:	**06 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 TR03.1: List of test equipment used

Test Software Used: Keysight PXE firmware A.35.06

Background
There are regulatory requirements to present two additional types of bandwidth analyses: 99% Occupied Bandwidth and Necessary Bandwidth. There are no limits or functional requirements around these data, beyond a reporting requirement. The contents of this test record are for information, and do not affect compliance of the devices that are the subject of this report.

For BLE operating at 2 Mbps, the lowest operating frequency was 2404 MHz, and the highest operating frequency was 2478 MHz. For all other Bluetooth, BLE, and ANT radios reported here, the lowest operating frequency was 2402 MHz, and the highest operating frequency was 2480 MHz.

Test Setup
This block diagram shows the test equipment setup.

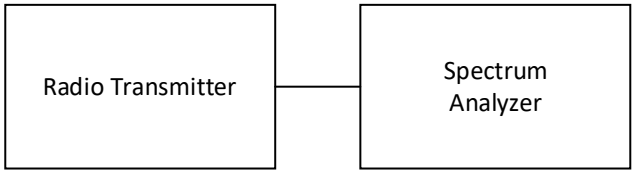


Figure TR03.1: Test setup

Occupied Bandwidth, 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.

Occupied Bandwidth, 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 have MHz as their units of measure.

	2402 (04)	2440	2480 (78)
Bluetooth BR	**0.944**	**0.926**	**0.929**
Bluetooth EDR2	**1.117**	**1.103**	**1.106**
Bluetooth EDR3	**1.122**	**1.103**	**1.104**
BLE 1 Mbps	**1.263**	**1.424**	**1.272**
BLE 2 Mbps	**2.193**	**2.222**	**2.298**
ANT	**1.490**	**1.420**	**1.411**

Table TR03.2: Summary of 99% Occupied Bandwidth Data for Bluetooth, ANT and BLE modes

	Ch1	Ch6	Ch11	Ch12	Ch13
B1	15.046	15.126	15.032	14.941	14.218
B2	14.969	15.177	15.065	14.849	14.289
B5.5	14.622	14.715	14.736	14.762	14.103
B11	14.663	14.759	14.729	14.714	14.178
G6	17.025	17.129	17.059	17.082	16.327
G9	17.008	17.092	17.022	17.034	16.337
G12	16.802	16.904	16.796	16.797	16.233
G18	16.712	16.873	16.739	16.741	16.193
G24	16.269	16.873	16.695	16.700	16.272
G36	16.334	17.051	16.935	16.912	16.360
G48	16.282	16.934	16.769	16.809	16.278
G54	16.254	16.901	16.817	16.818	16.285
NMCS0	16.939	17.767	17.689	17.714	16.963
NMCS1	16.908	17.771	17.647	17.638	16.945
NMCS2	16.889	17.730	17.649	17.630	16.925
NMCS3	16.901	17.753	17.642	17.650	16.927
NMCS4	16.948	17.778	17.659	17.645	16.950
NMCS5	16.924	17.724	17.616	17.620	16.954
NMCS6	16.942	17.796	17.679	17.672	16.967
NMCS7	16.895	17.743	17.610	17.610	16.941

Table TR03.3: Summary of bandwidth data for WiFi modes

Figure TR03.2: Bandwidth data for Bluetooth EDR3 at 2402 MHz

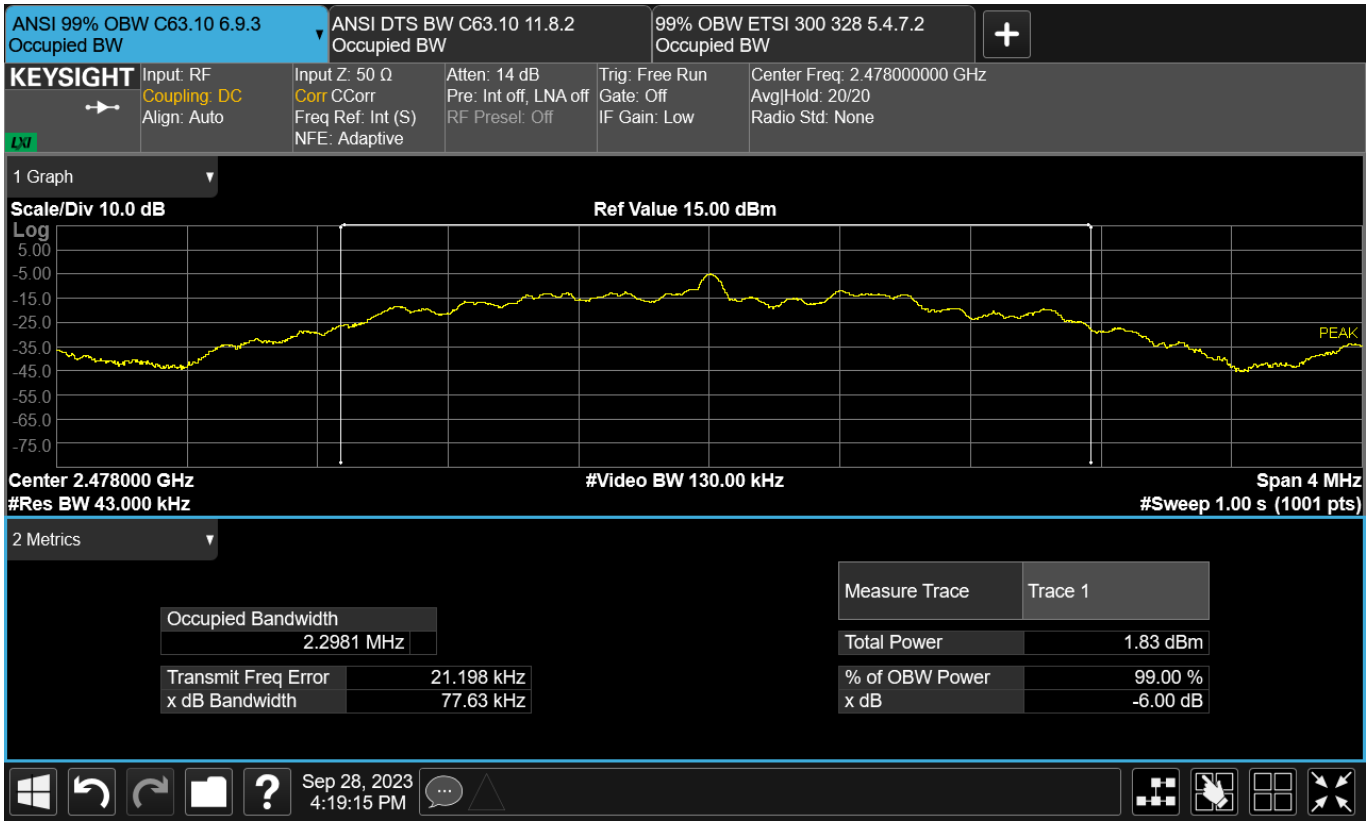


Figure TR03.3: Bandwidth data for BLE 2 Mbps at 2478 MHz

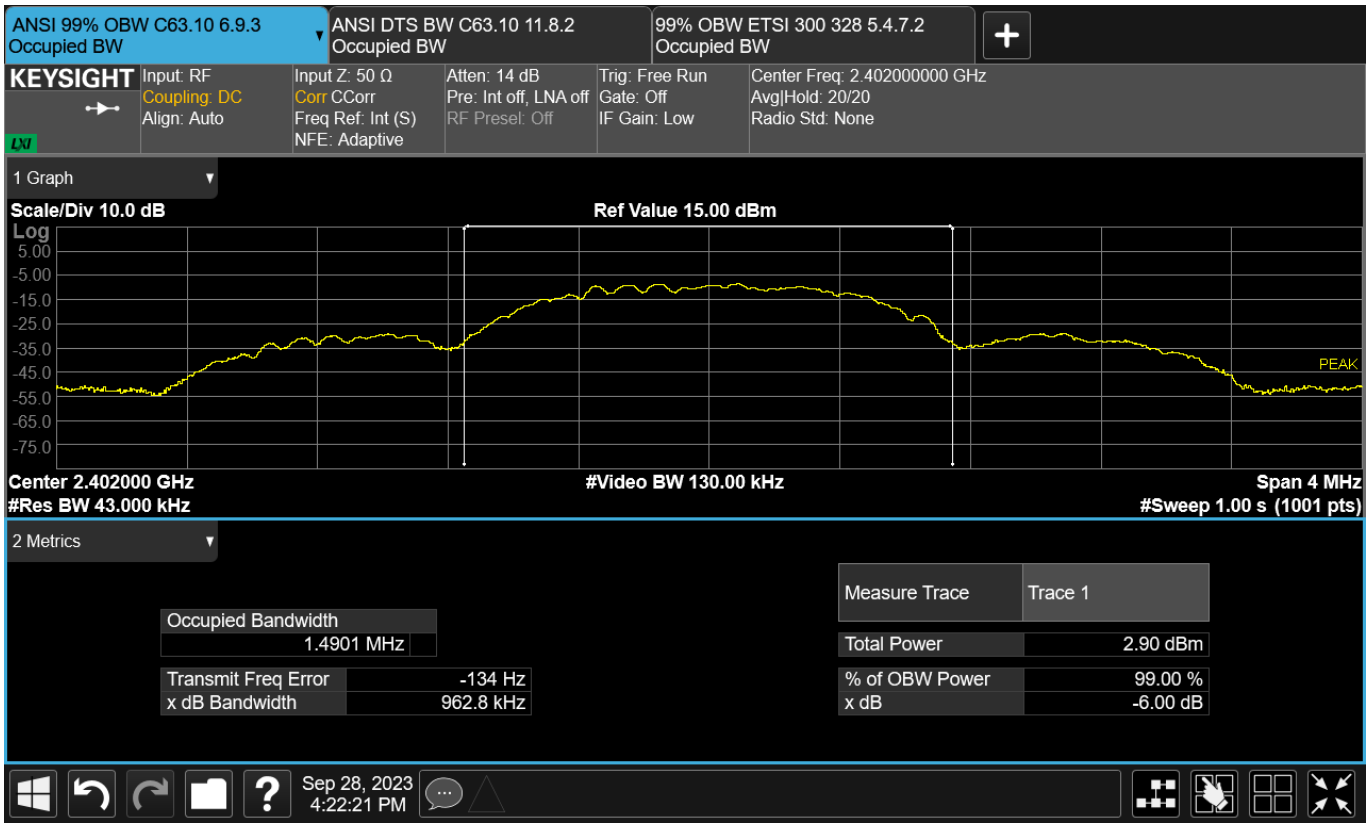


Figure TR03.4: Bandwidth data for ANT at 2402 MHz

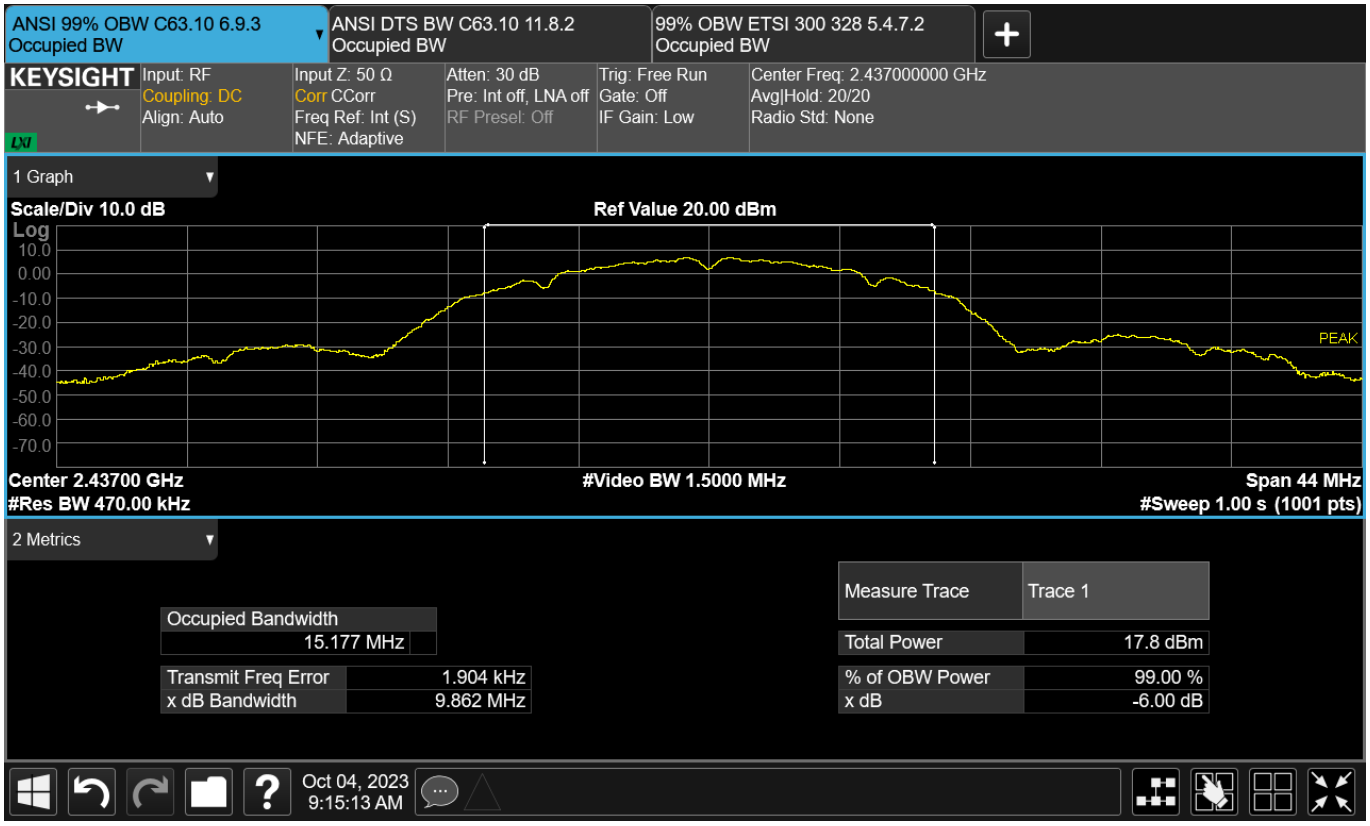


Figure TR03.5: Bandwidth data for B2 Modulation on WiFi Channel 6 (2440 MHz)

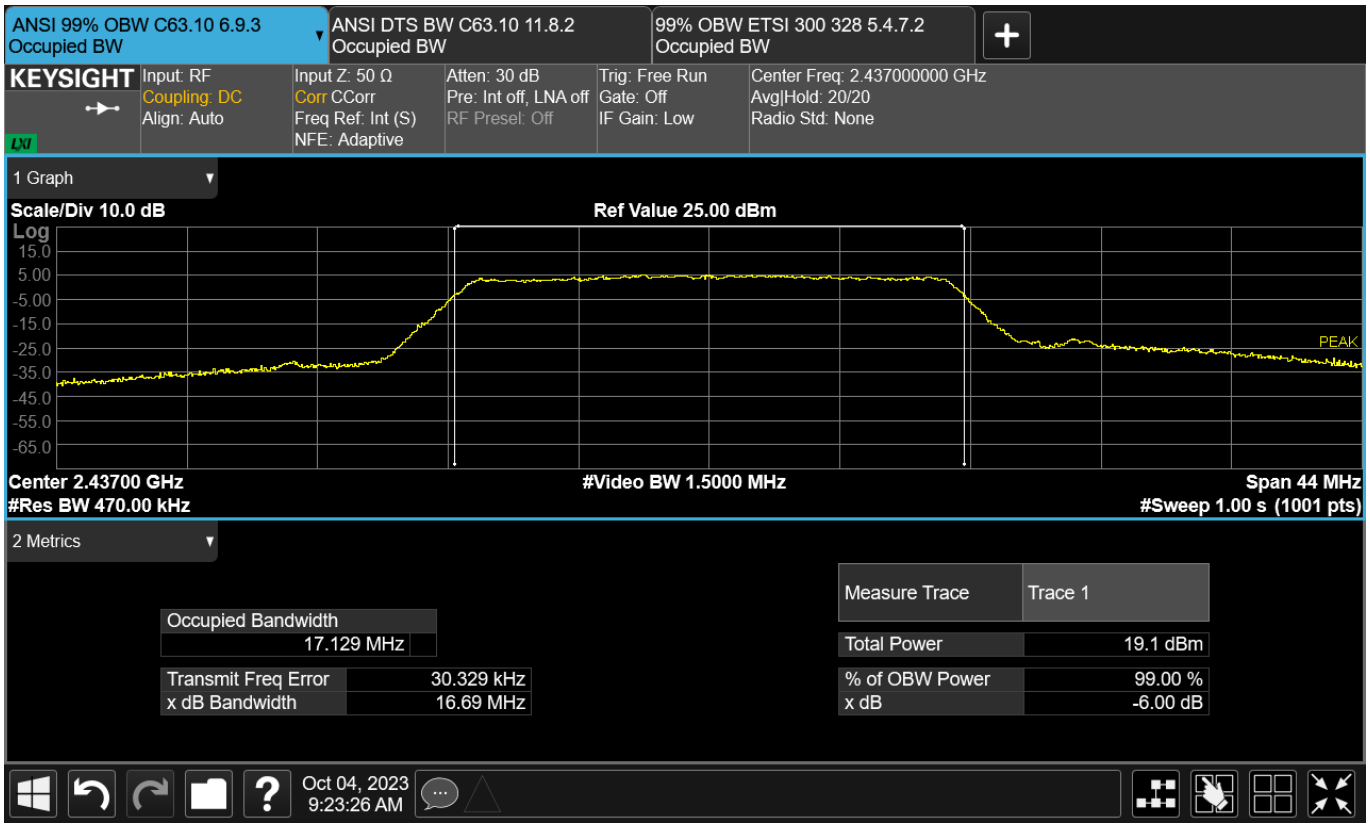


Figure TR03.6: Bandwidth data for G6 Modulation on WiFi Channel 6 (2440 MHz)

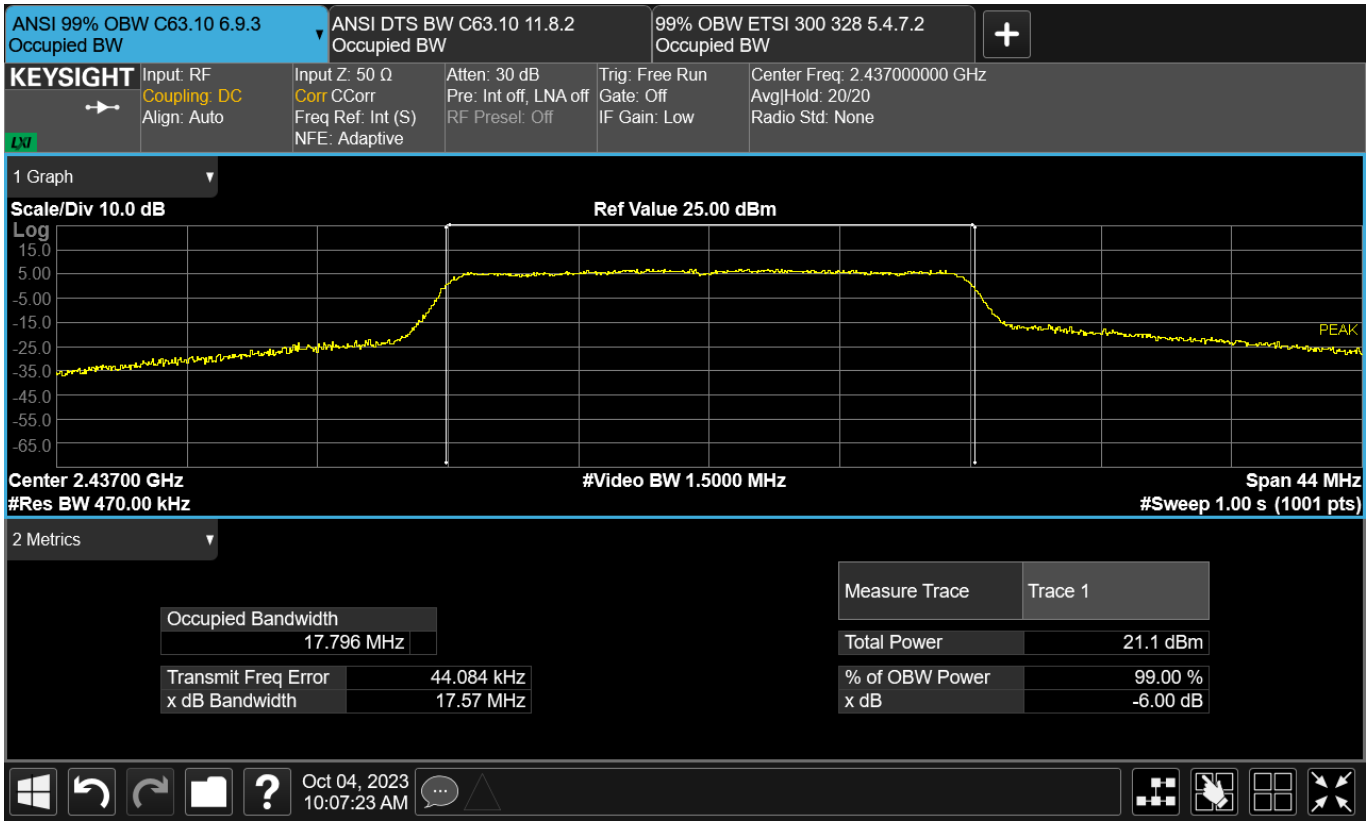


Figure TR03.7: Bandwidth data for NMCS6 Modulation on WiFi Channel 6 (2440 MHz)

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 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.

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)	BN (MHz)
ANT / ANT+	1	1	2	1	2

Table TR03.101: Necessary Bandwidth for ANT and ANT+ Radio Protocols (FCC and TRC-43)

Radio Type	Sub-type	Method	R Mbps	K	S	LogBase2 of (S)	BN (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 TR03.102: Necessary Bandwidth for Bluetooth Radio Protocols (FCC and TRC-43)

Radio Type	Sub-type	R Mbps	K	S	LogBase2 of (S)	BN (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 TR03.103: Necessary Bandwidth for IEEE 802.11 b Radio Protocol (FCC and TRC-43)

Radio Type	Sub-type	R Mbps	K	S	LogBase2 of (S)	BN (MHz)
802.11 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	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

Table TR03.104: Necessary Bandwidth for IEEE 802.11 g and n 20 MHz Radio Protocols (FCC)

As a note, the bit rate for IEEE 802.11 n 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 rate for MCS7would decrease to 65 Mbps for a Necessary Bandwidth of 21.7 MHz.

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	Ns (MHz)	K	BN (MHz)
802.11g	0.3125	53	16.6
802.11n	0.3125	57	17.8

Table TR03.105: Necessary Bandwidth for IEEE 802.11 g and n 20 MHz Radio Protocols (TRC-43)

This line is the end of the test record.

Test Record
Transmitter Power
Test IDs TR01b
Project GCL0457

Test Date(s)	7, 26 Sep 2023
Test Personnel	Majid Farah and Jim Solum
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M10 (All2.4)
Arrangement	A3 (Udata)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247, FCC Part 2.1091, FCC Part 2.1093, RSS-102, ANSI C95.3 (as noted in Section 6 of the report).
Antenna Gain	-0.3 dBi, as reported by the client
Radio Protocol	IEEE 802.11b/g/n
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date of this record:	**27 Sep 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	7-Jul-2023	1-Jul-2024

Table TR01b.1: List of test equipment used

Software used: Rohde & Schwarz Power Viewer V11.3; TimePowerAnalysisSpreadsheetv10.xls

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 30 dBm limit from the US and Canadian standards. All values met the limit with better than 10 dB of margin.

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.

Mode	Speed	1	2	3	4	5	6	7	8	9	10	11	12	13
B	1	15.33	16.28	16.22	15.21	15.34	15.32	15.53	15.56	15.16	15.05	14.29	8.27	5.60
B	2	15.10	NT	NT	NT	NT	15.25	NT	NT	NT	NT	14.26	8.18	5.57
B	5.5	15.14	NT	NT	NT	NT	15.39	NT	NT	NT	NT	14.33	8.16	5.60
B	11	15.12	15.96	15.95	15.09	15.05	15.19	15.32	15.37	15.02	14.90	14.38	8.14	5.60
G	6	11.25	NT	NT	NT	NT	13.00	NT	NT	NT	NT	7.09	3.66	1.73
G	9	11.29	NT	NT	NT	NT	13.02	NT	NT	NT	NT	7.03	3.64	1.70
G	12	11.69	NT	NT	NT	NT	13.45	NT	NT	NT	NT	7.50	4.09	2.24
G	18	11.81	12.81	14.03	13.51	13.41	13.45	13.60	12.43	11.49	10.85	7.57	4.12	2.26
G	24	11.67	NT	NT	NT	NT	13.40	NT	NT	NT	NT	7.49	4.03	2.21
G	36	11.58	NT	NT	NT	NT	13.34	NT	NT	NT	NT	7.43	3.99	2.15
G	48	11.63	NT	NT	NT	NT	13.35	NT	NT	NT	NT	7.48	4.01	2.21
G	54	11.63	12.81	13.96	13.44	13.41	13.34	13.55	12.37	11.91	11.19	7.48	4.03	2.18
N	MCS0	10.16	NT	NT	NT	NT	12.97	NT	NT	NT	NT	5.45	3.14	1.63
N	MCS1	10.68	NT	NT	NT	NT	13.46	NT	NT	NT	NT	5.98	3.73	2.27
N	MCS2	10.73	12.44	13.23	13.91	13.84	13.55	13.47	12.33	11.83	10.82	6.04	3.77	2.29
N	MCS3	10.71	NT	NT	NT	NT	13.45	NT	NT	NT	NT	6.02	3.73	2.28
N	MCS4	10.70	NT	NT	NT	NT	13.67	NT	NT	NT	NT	5.94	3.83	2.24
N	MCS5	10.71	NT	NT	NT	NT	13.71	NT	NT	NT	NT	6.00	3.80	2.29
N	MCS6	10.69	NT	NT	NT	NT	13.62	NT	NT	NT	NT	5.98	3.73	2.32
N	MCS7	10.71	12.19	13.00	13.77	13.66	13.59	13.38	12.20	11.70	10.57	5.97	3.77	2.26

Table TR01b.2: Transmit Power Summary, with units of dBm

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.

Mode	Speed	1	2	3	4	5	6	7	8	9	10	11	12	13
B	1	33.78	42.02	41.61	32.97	33.98	33.83	35.45	35.68	32.54	31.78	26.70	6.64	3.60
B	2	32.14	NT	NT	NT	NT	33.28	NT	NT	NT	NT	26.52	6.52	3.57
B	5.5	32.40	NT	NT	NT	NT	34.30	NT	NT	NT	NT	26.89	6.48	3.59
B	11	32.24	39.08	38.92	31.56	31.68	32.74	33.76	34.12	31.45	30.61	26.72	6.44	3.59
G	6	13.03	NT	NT	NT	NT	19.50	NT	NT	NT	NT	4.98	2.27	1.46
G	9	13.11	NT	NT	NT	NT	19.52	NT	NT	NT	NT	4.92	2.25	1.45
G	12	14.58	NT	NT	NT	NT	21.56	NT	NT	NT	NT	5.55	2.52	1.65
G	18	14.97	18.86	24.92	22.09	21.65	21.87	22.61	17.22	13.89	11.99	5.62	2.53	1.66
G	24	14.31	NT	NT	NT	NT	21.27	NT	NT	NT	NT	5.49	2.47	1.62
G	36	13.97	NT	NT	NT	NT	21.03	NT	NT	NT	NT	5.42	2.44	1.60
G	48	14.20	NT	NT	NT	NT	21.25	NT	NT	NT	NT	5.48	2.45	1.62
G	54	14.11	18.61	24.31	21.48	21.32	21.03	22.05	16.73	15.12	12.81	5.44	2.46	1.60
N	MCS0	10.08	NT	NT	NT	NT	19.38	NT	NT	NT	NT	3.42	2.01	1.42
N	MCS1	11.48	NT	NT	NT	NT	21.88	NT	NT	NT	NT	3.90	2.31	1.66
N	MCS2	11.63	17.20	20.59	24.20	23.82	22.27	21.82	16.79	14.98	11.87	3.95	2.34	1.66
N	MCS3	11.48	NT	NT	NT	NT	21.61	NT	NT	NT	NT	3.89	2.31	1.64
N	MCS4	11.47	NT	NT	NT	NT	22.70	NT	NT	NT	NT	3.85	2.35	1.64
N	MCS5	11.43	NT	NT	NT	NT	22.79	NT	NT	NT	NT	3.87	2.32	1.64
N	MCS6	11.41	NT	NT	NT	NT	22.38	NT	NT	NT	NT	3.87	2.30	1.66
N	MCS7	11.47	16.10	19.46	23.00	22.70	22.38	21.23	16.16	14.38	11.10	3.85	2.31	1.64

Table TR01b.3: Additional RF exposure power summary, with units of milliwatt

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 0.7 dB of loss in this frequency range. This factor was taken into account during the data analysis.

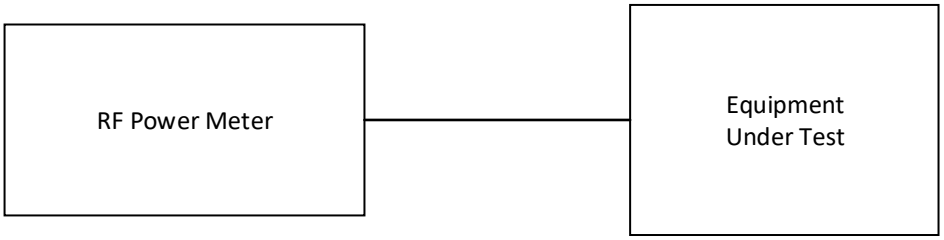


Figure TR01b.1: Test equipment setup

This line is the end of the test record.

Test Record
Transmitter Power
Test IDs TR01c
Project GCL0457

Test Date(s)	7, 26 Sep 2023
Test Personnel	Majid Farah and Jim Solum
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M10 (All2.4)
Arrangement	A3 (Udata)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, ETSI EN 300 328, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Antenna Gain	-0.3 dBi, as reported by the client.
Radio Protocol	Bluetooth, Bluetooth Low Energy, ANT
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date of this record:	**27 Sep 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	7-Jul-2023	1-Jul-2024

Table TR01c.1: List of test equipment used

Software used: Rohde & Schwarz Power Viewer V11.3; TimePowerAnalysisSpreadsheetv10.xls

Test Method
The basic test standards provide options for the time evaluation test method. The following test methods were applied.

ETSI EN 300 328:	5.4.2.2.1
ANSI C63.10:	11.9.1.3

The parameters of duty cycle, transmitter timing, or medium utilization are typically not required for adaptive transceivers or transceivers emitting at 10 dBm EIRP or less, so those results will be omitted from the data set.

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 different analytical test methods for the same fundamental data or different limits, the results for both methods are provided and the more-strict limit may be applied. In this case, the ANSI method finds the highest value (numerical peak) and applies the 30 dBm limit from the US and Canadian standards. By contrast, the ETSI method reports the highest numerical average observed during any transmission burst and applies a 20 dBm EIRP limit. All values met the respective limits with more than 10 dB of margin.

The results are shown below. Yellow highlighted cells indicate the highest power value for each radio protocol. Bluetooth Low Energy at the 2 Mbps data has its lowest and highest channel frequencies set at 2404 MHz and 2478 MHz. The lowest and highest operating channel frequencies for the other protocols are 2402 MHz and 2480 MHz.

	Frequency (MHz)			ANSI Limit
	2402 (04)	2440	2478 (80)	(dBm)
ANT	-1.75	3.78	-3.25	30
BLE 1 Mbps	-2.24	3.47	-3.75	30
BLE 2 Mbps	4.02	3.77	-3.85	30
Bluetooth Basic	9.52	9.67	8.48	30
Bluetooth EDR2	8.91	9.37	8.35	30
Bluetooth EDR3	8.91	9.17	7.92	30

Table TR01c.2: Transmit Power Summary in dBm with ANSI C63.10 analytical methods

	Frequency (MHz)			ETSI Limit
	2402 (04)	2440	2480 (78)	(dBm EIRP)
ANT	-2.08	3.43	-3.58	20
BLE 1 Mbps	-2.57	3.12	-4.08	20
BLE 2 Mbps	3.66	3.41	-4.18	20
Bluetooth Basic	9.03	9.19	7.99	20
Bluetooth EDR2	8.47	8.90	7.88	20
Bluetooth EDR3	8.47	8.73	7.47	20

Table TR01c.3: Transmit Power Summary in dBm EIRP with ETSI analytical methods

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.

Frequency (Mhz)	2402 (04)	2442	2480 (78)
ANT	0.66	2.36	0.47
BLE 1Mbps	0.59	2.20	0.42
BLE 2Mbps	2.49	2.35	0.41
Bluetooth Basic	8.58	8.88	6.75
Bluetooth EDR2	7.54	8.32	6.58
Bluetooth EDR3	7.53	7.99	5.98

Table TR01c.4: Additional RF exposure power summary, with units of milliwatt

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 0.7 dB of loss in this frequency range. This factor was taken into account during the data analysis.

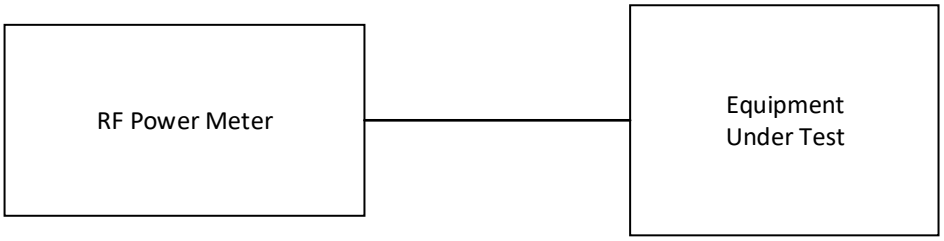


Figure TR01c.1: Test equipment setup

This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test IDs TR12 and TR13
Project GCL-0457

Test Date(s)	11 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M3 (Ble Tx) and M5 (ANT Tx)
Arrangement	A2 (Upwr)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this test record:	**24 Oct 2023**

Original record, Version A.

Test Equipment

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

Table TR13.1: Test equipment used

Software used: Keysight PXE software A.35.06

Test Method

The basic test standards provide options for the test method. The following test methods were applied.

ANSI C63.10: 11.11.2 and 11.11.3

Test Setup

This block diagram shows the test equipment setup.

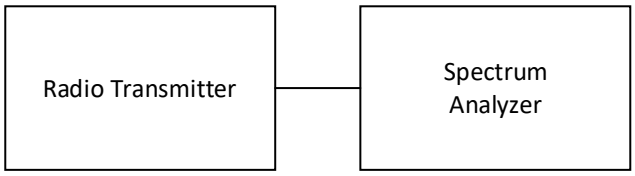


Figure TR13.1: Test setup

Test Data

The conducted spurious emission test measures the strength of intentional and unintentional radio signals conducted from the transmitter to the antenna across a wide range of frequencies. It does not evaluate whether intentional signals meet specific limits. Rather, it ensures that magnitudes unintentional signals are sufficiently reduced relative to the intentional signal to satisfy the requirements of the relevant standards.

This 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 results have been adjusted to account for the losses in the laboratory cables. Where feasible, the losses of any added feed lines are also included in that adjustment.

Data is collected using the required detector function(s) across the frequency range. The instrument uses a 100 kHz bandwidth detector.

The data table below shows the final measurement data which may be at harmonics of the carrier, or at frequencies that represent one of the highest data points measured.

The peak level of the fundamental is also identified. The harmonics or spurious emissions must be reduced from this fundamental level by 20 dBc. This harmonic limit is calculated and used to determine compliance. A reduction from the carrier that is greater that 20 is a passing result. The minimum margin from the peak level for each mode are highlighted in yellow.

For BLE operating at 2 Mbps, the lowest operating frequency was 2404 MHz, and the highest operating frequency was 2478 MHz. For all other Bluetooth, BLE, and ANT radios reported here, the lowest operating frequency was 2402 MHz, and the highest operating frequency was 2480 MHz.

Data plots are provided for the worst-case data sets. One plot shows the spectrum at the carrier, and another shows the spectrum across the band. On this second plot, a green reference line is at approximately the 20 dBc maximum spurious emission level.

		2402 (04)	2440	2480 (78)
BLE	2 Mb	47.73	47.16	40.36
ANT		42.74	44.46	39.18

Table TR13.2: Results Summary

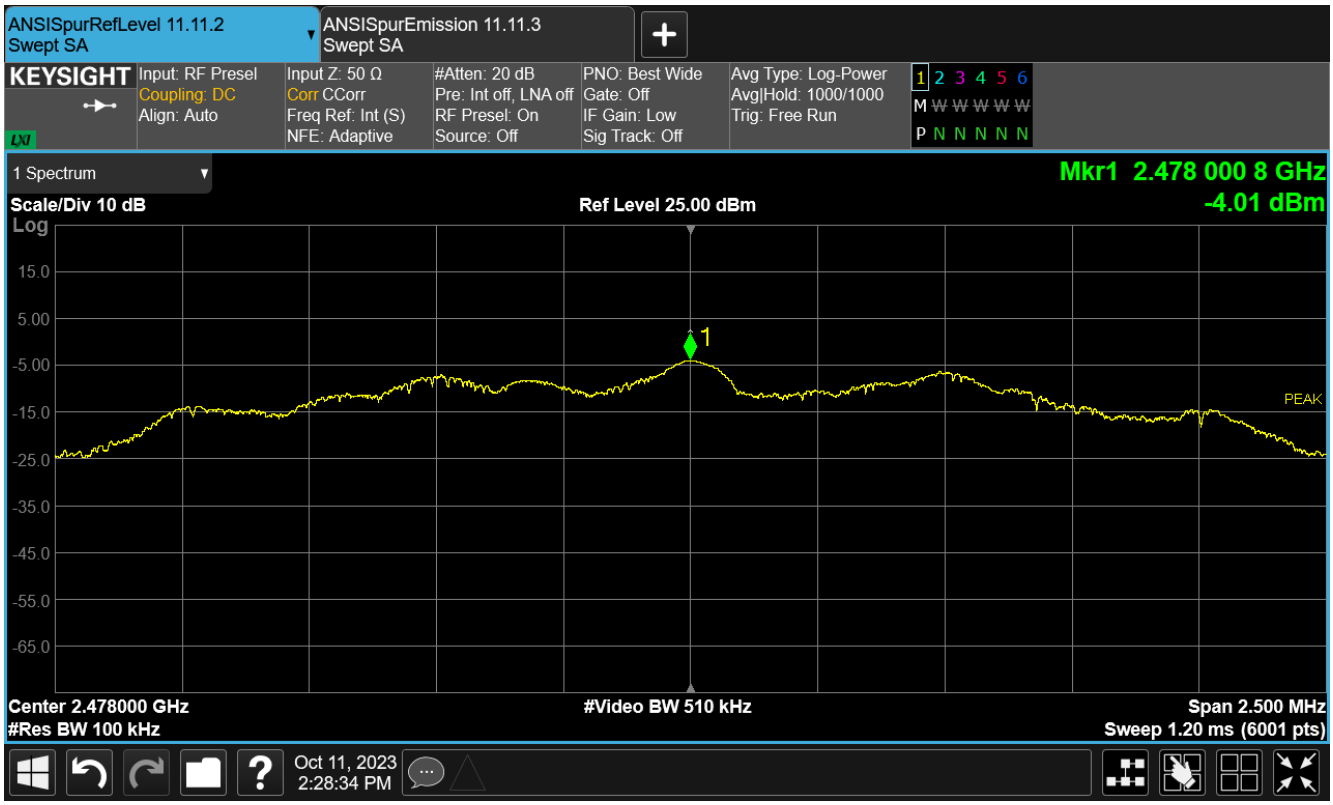


Figure TR13.2: Reference level measurement for Bluetooth BLE 2 Mbps at 2478 MHz

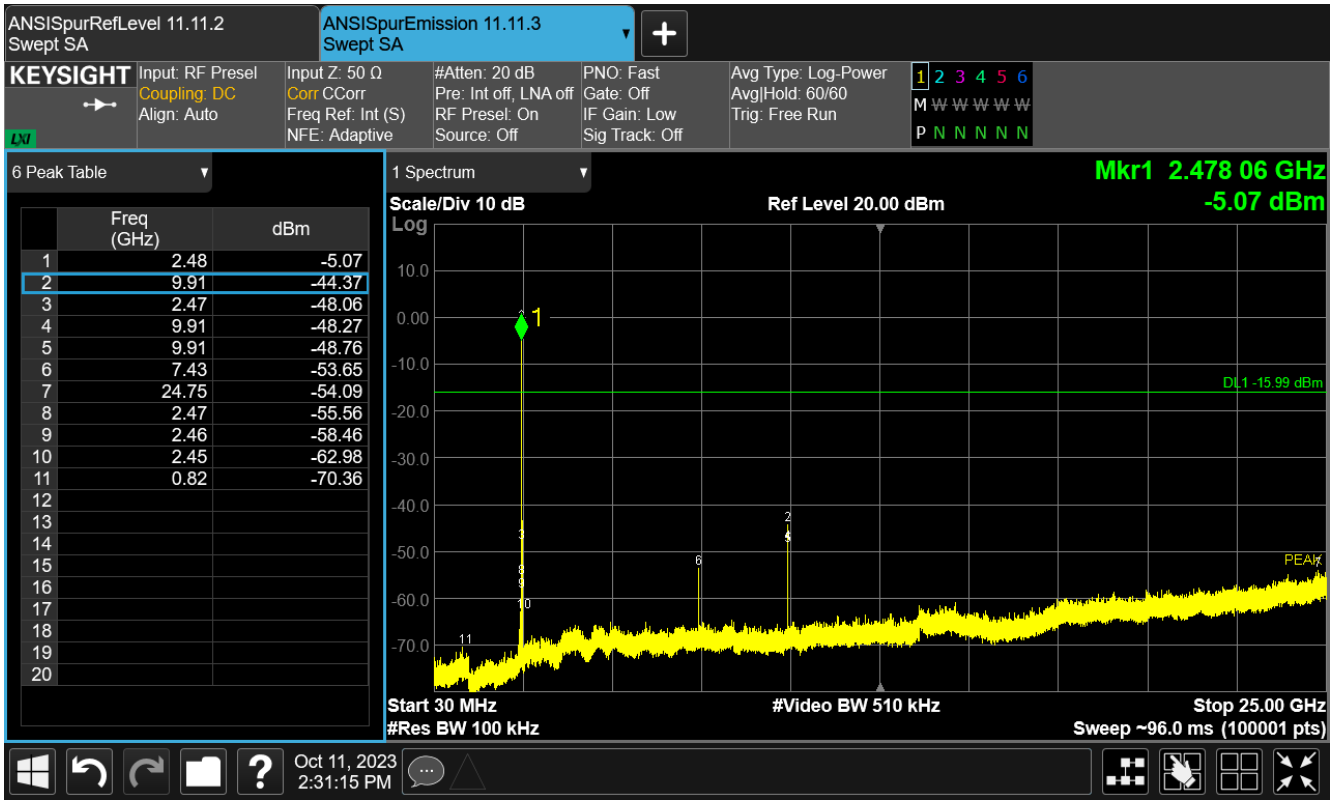


Figure TR13.3 Spectral data for Bluetooth BLE 2 Mbps at 2478 MHz

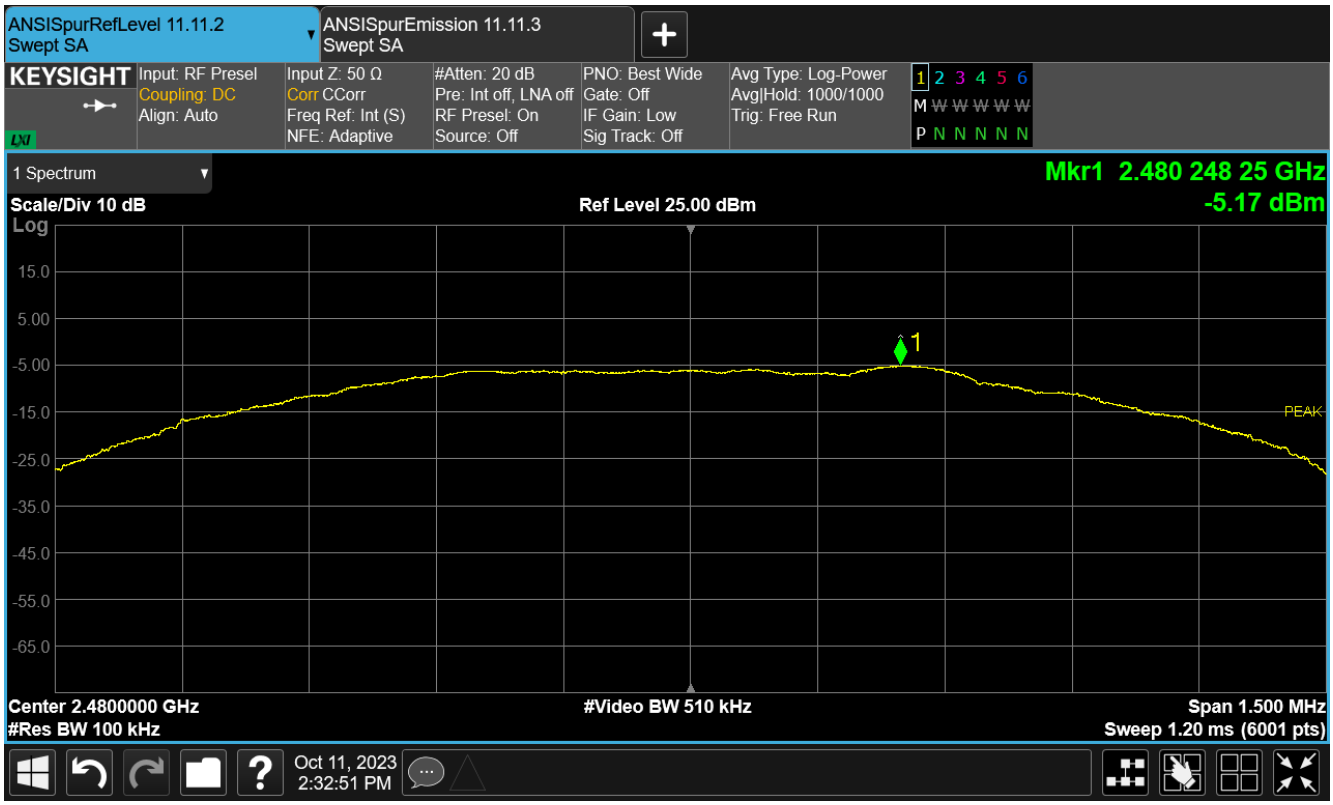


Figure TR13.4: Reference level measurement for ANT at 2480 MHz

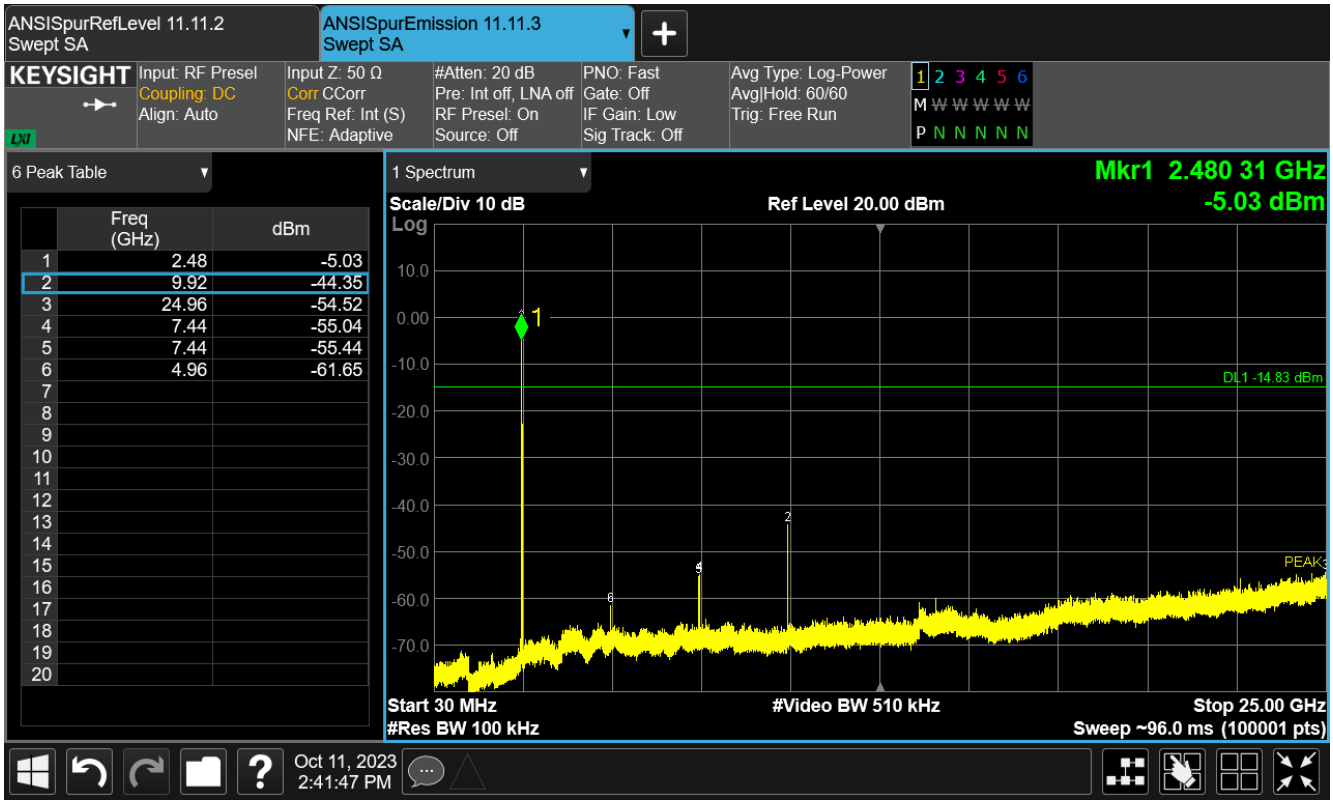


Figure TR13.5 Spectral data for ANT at 2480 MHz

This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test ID TR14
Project GCL-0457

Test Date(s)	11 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M7 (WiFi Tx)
Arrangement	A2 (Upwr)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this test record:	**25 Oct 2023**

Original record, Version A.

Test Equipment

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

Table TR14.1: Test equipment used

Software used: Keysight PXE software A.35.06

Test Method

The basic test standards provide options for the test method. The following test methods were applied.
ANSI C63.10: 11.11.2 and 11.11.3

Test Setup

This block diagram shows the test equipment setup.

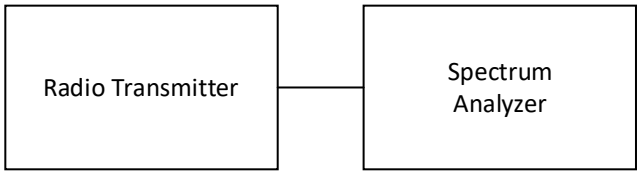


Figure TR14.1: Test setup

Test Data

The conducted spurious emission test measures the strength of intentional and unintentional radio signals conducted from the transmitter to the antenna across a wide range of frequencies. It does not evaluate whether intentional signals meet specific limits. Rather, it ensures that magnitudes unintentional signals are sufficiently reduced relative to the intentional signal to satisfy the requirements of the relevant standards.

This 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 results have been adjusted to account for the losses in the laboratory cables. Where feasible, the losses of any added feed lines are also included in that adjustment.

Data is collected using the required detector function(s) across the frequency range. The instrument uses a 100 kHz bandwidth detector.

The data table below shows the final measurement data which may be at harmonics of the carrier, or at frequencies that represent one of the highest data points measured.

The peak level of the fundamental is also identified. The harmonics or spurious emissions must be reduced from this fundamental level by 20 dBc. This harmonic limit is calculated and used to determine compliance. A reduction from the carrier that is greater that 20 is a passing result. The minimum margin from the peak level for each mode are highlighted in yellow.

Data plots are provided for the worst-case data sets. One plot shows the spectrum at the carrier, and another shows the spectrum across the band. On this second plot, a green reference line is at approximately the 20 dBc maximum spurious emission level.

		Channel No.				
Mode	Data rate (Mbps)	1	6	11	12	13
B	1	47.83	54.76	53.92	46.4	44.19
G	18	46.89	48.10	41.80	38.29	36.95
N	MCS2	46.00	48.36	41.31	38.17	36.78

Table TR14.2: Results Summary

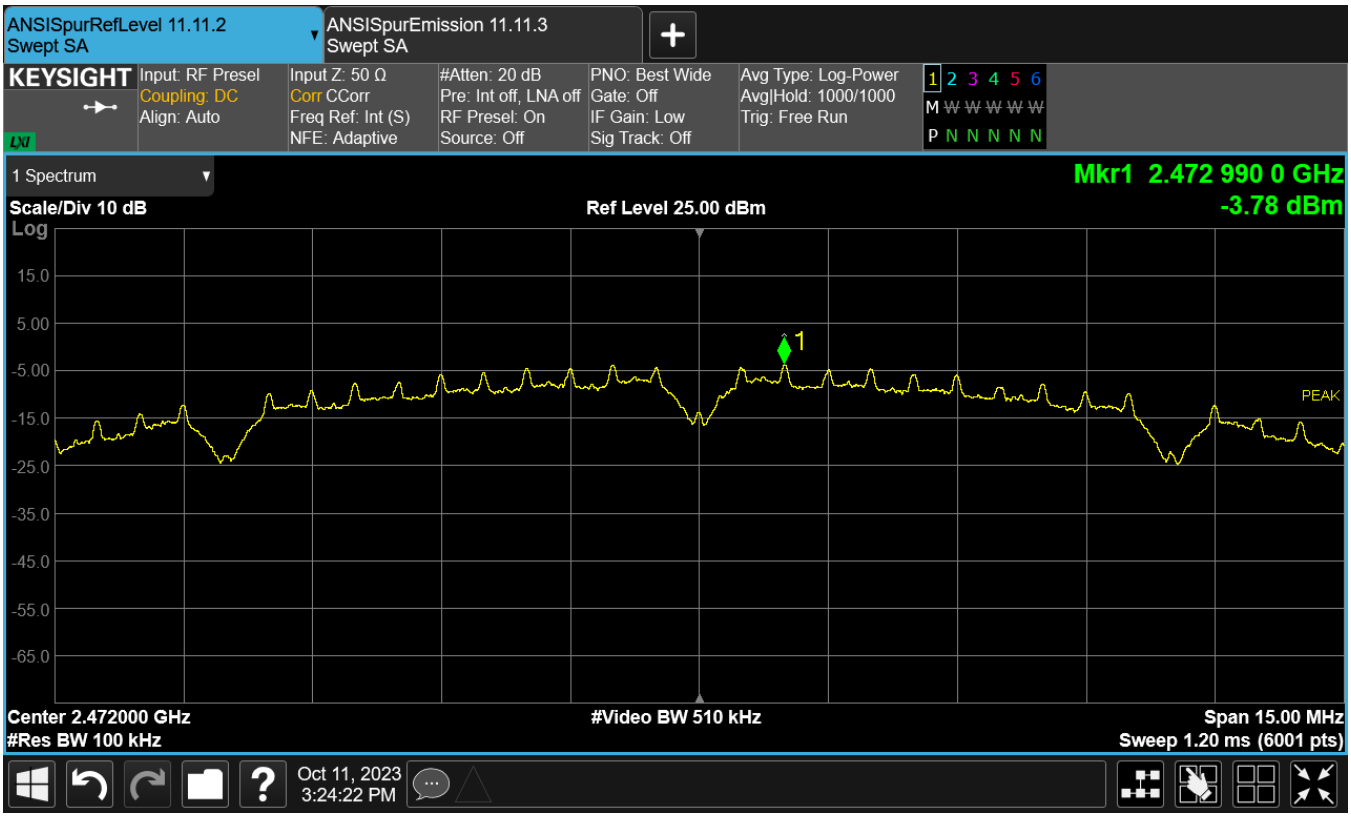


Figure TR14.2: Reference level measurement for IEEE 802.11 B 1 Mbps on Ch.13

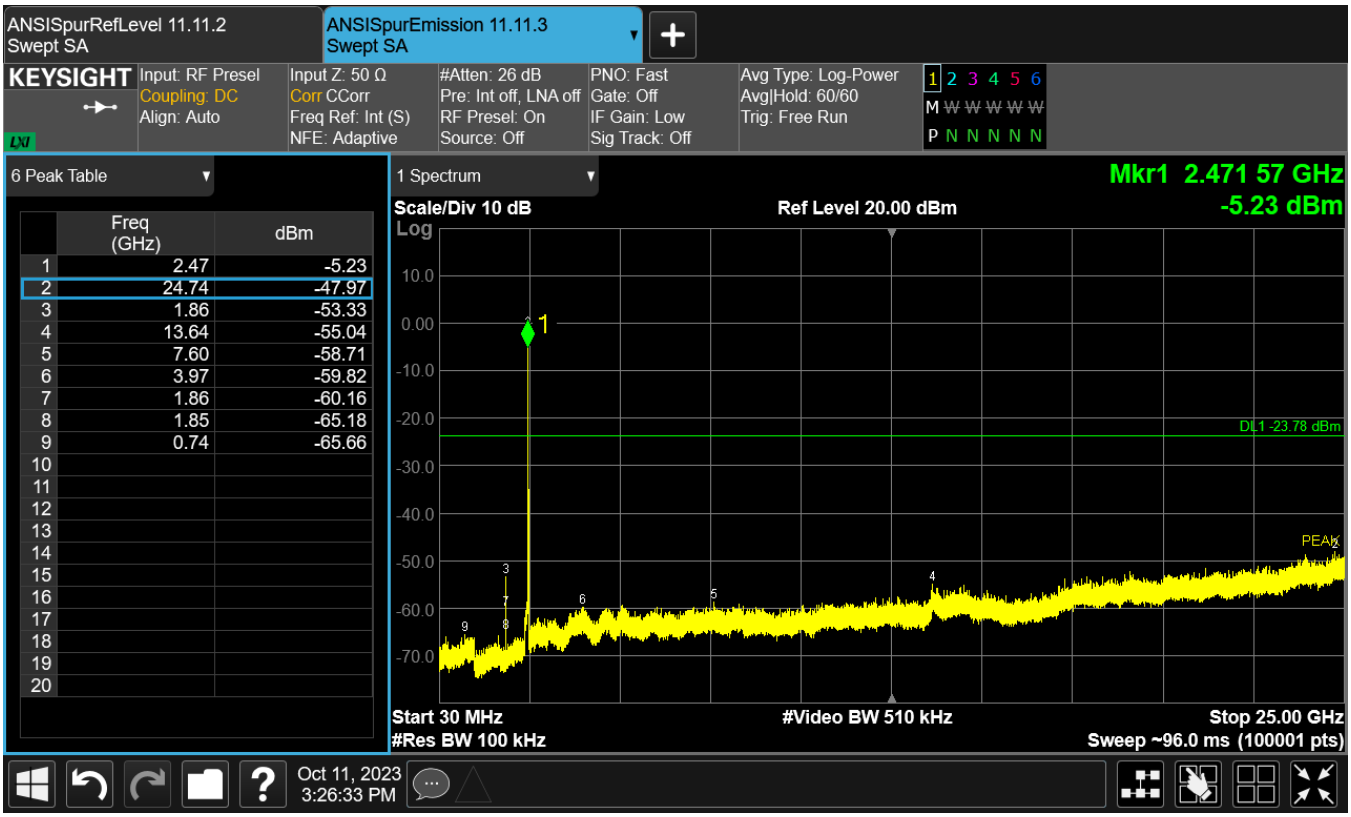


Figure TR14.3: Spectral data for IEEE 802.11 B 1 Mbps on Ch.13

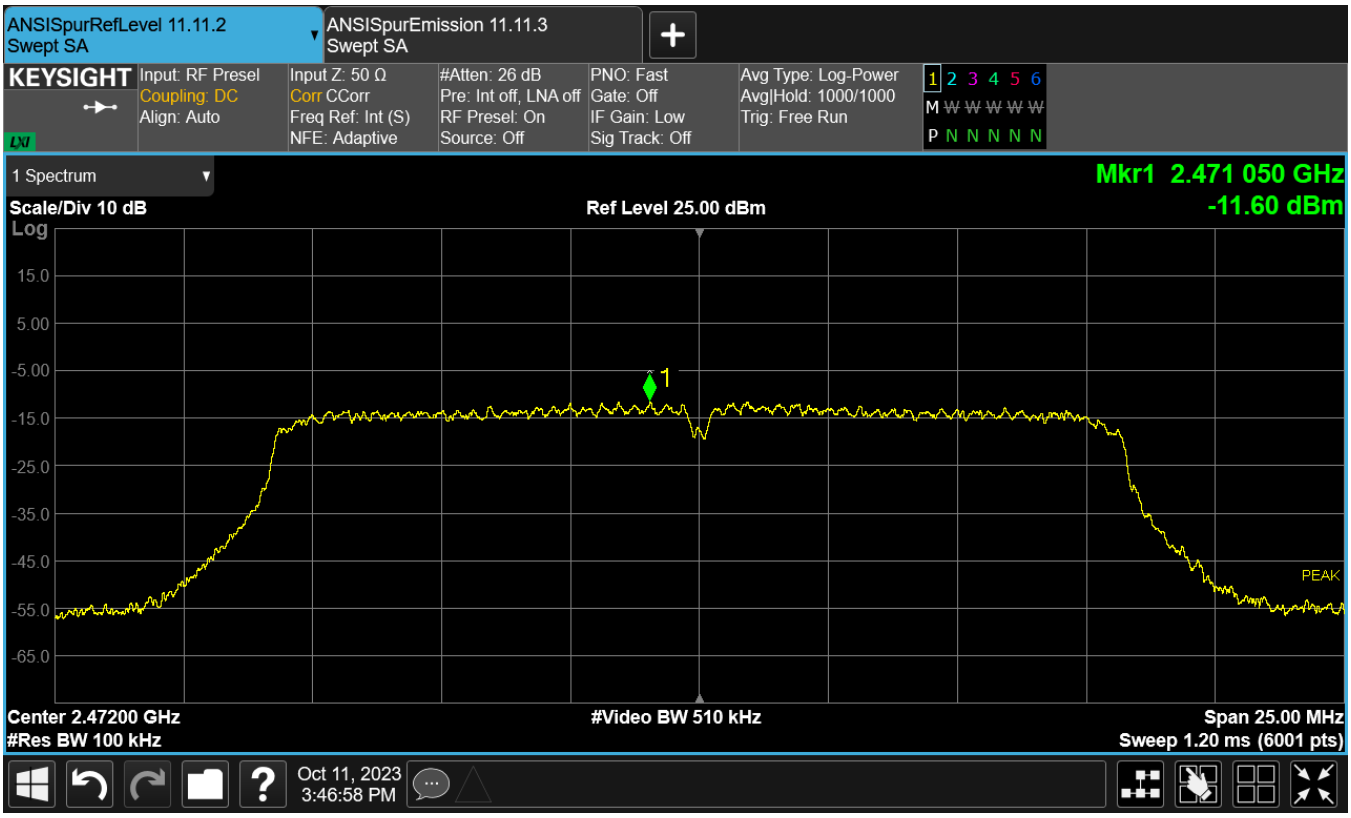


Figure TR14.4: Reference level measurement for IEEE 802.11 G 18 Mbps on Ch.13

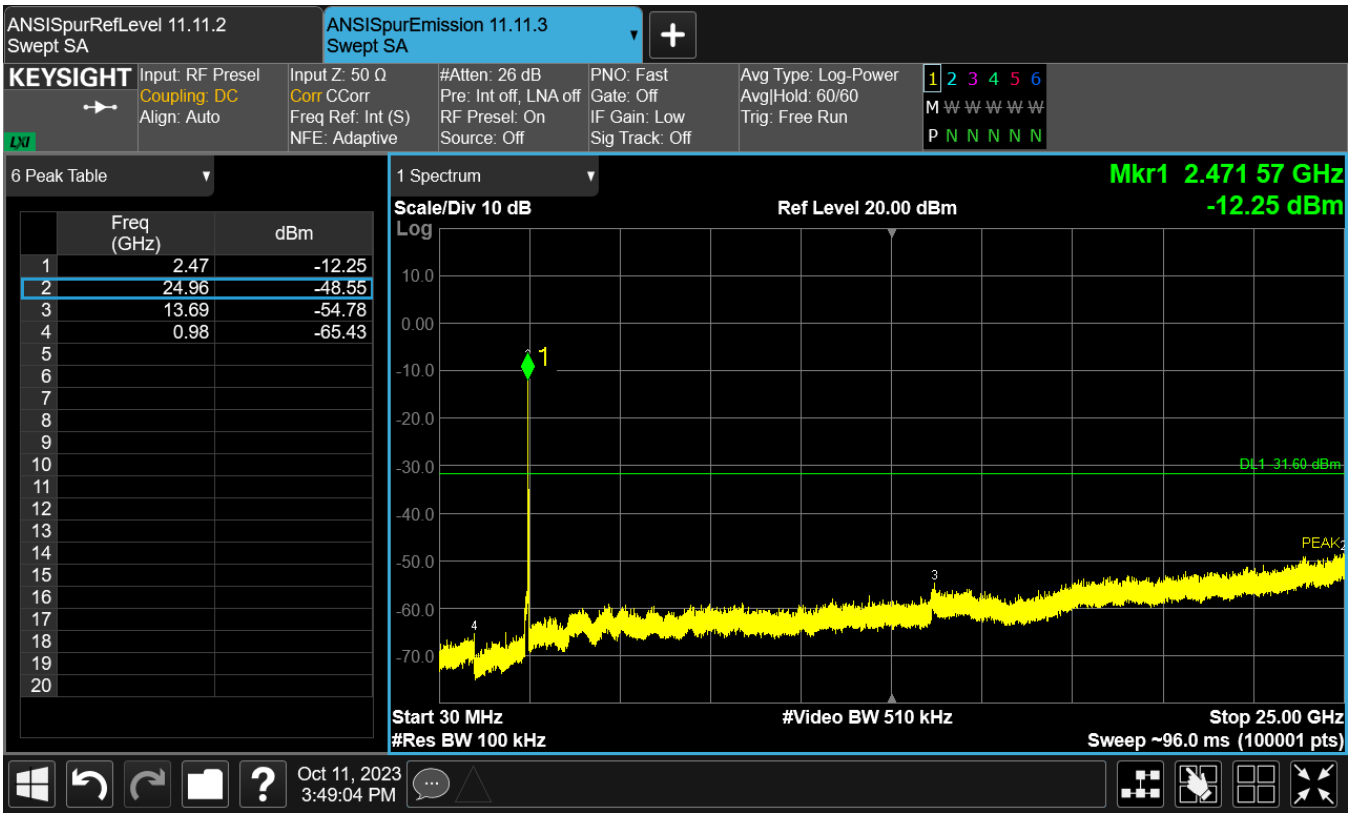


Figure TR14.5 Spectral data for IEEE 802.11 G 18 Mbps on Ch.13

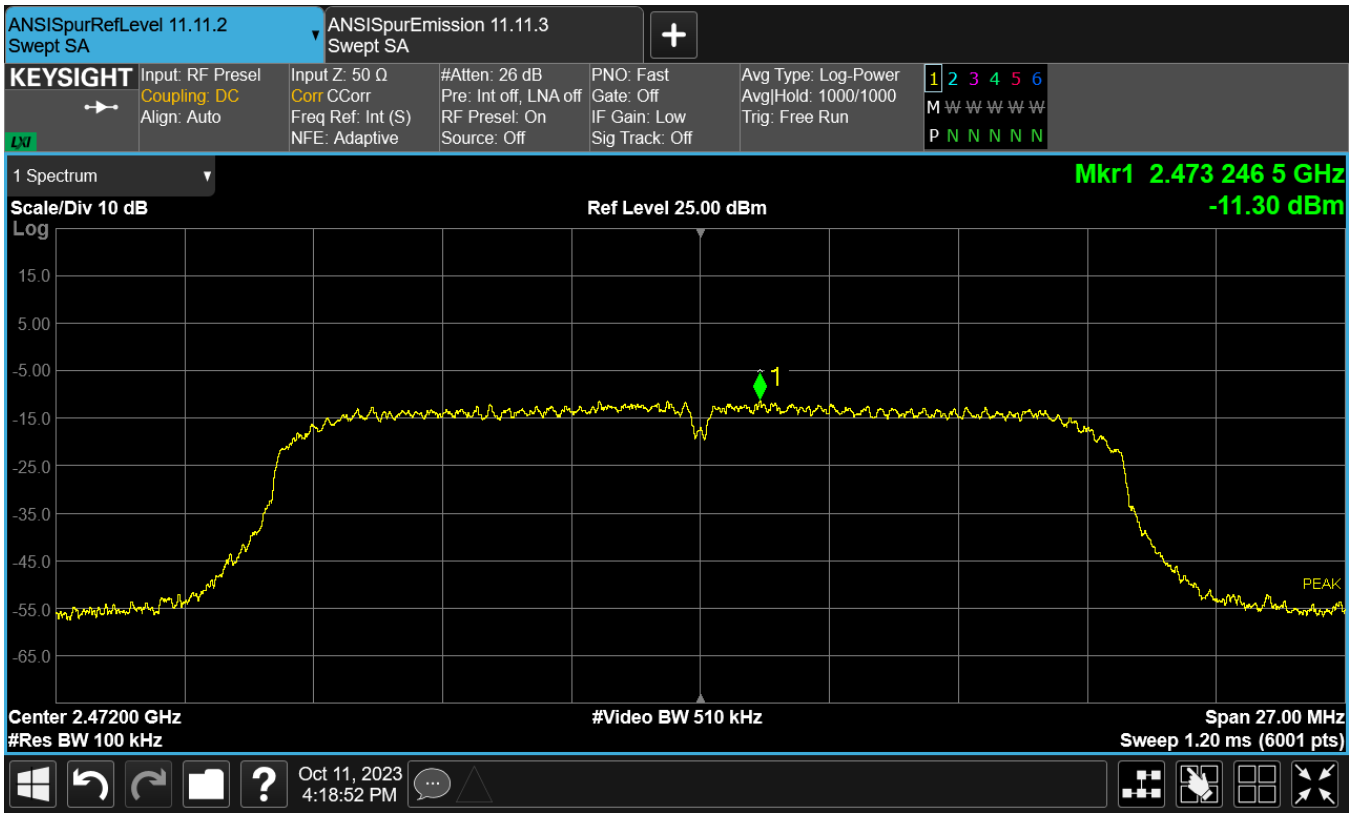


Figure TR14.6: Reference level measurement for IEEE 802.11 N MCS2 on Ch.13

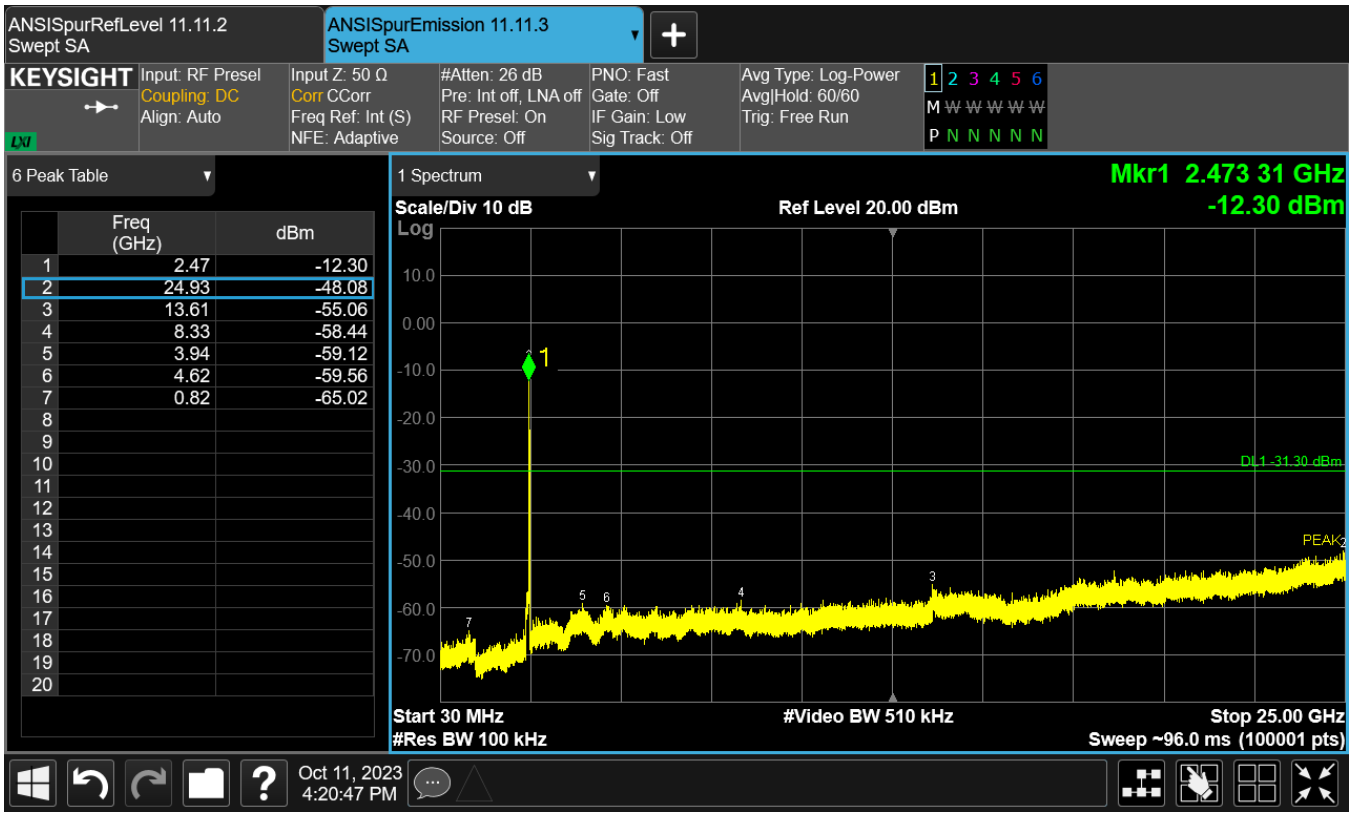


Figure TR14.7 Spectral data for IEEE 802.11 N MCS2 on Ch.13

This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test ID TR34
Project GCL-0457

Test Date(s)	11 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M1 (Bt Tx)
Arrangement	A2 (Upwr)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this test record:	**24 Oct 2023**

Original record, Version A.

Test Equipment

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

Table TR34.1: Test equipment used

Software used: Keysight PXE software A.35.06

Test Method

The basic test standards provide options for the test method. The following test methods were applied.

ANSI C63.10: 11.11.2 and 11.11.3

Test Setup

This block diagram shows the test equipment setup.

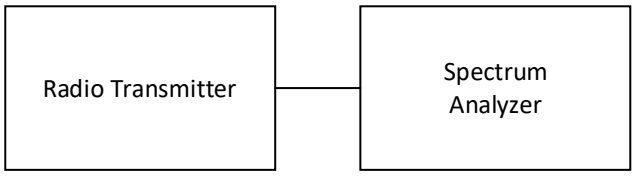


Figure TR34.1: Test setup

Test Data

The conducted spurious emission test measures the strength of intentional and unintentional radio signals conducted from the transmitter to the antenna across a wide range of frequencies. It does not evaluate whether

intentional signals meet specific limits. Rather, it ensures that magnitudes unintentional signals are sufficiently reduced relative to the intentional signal to satisfy the requirements of the relevant standards.

This 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 results have been adjusted to account for the losses in the laboratory cables. Where feasible, the losses of any added feed lines are also included in that adjustment.

Data is collected using the required detector function(s) across the frequency range. The instrument uses a 100 kHz bandwidth detector.

The data table below shows the final measurement data which may be at harmonics of the carrier, or at frequencies that represent one of the highest data points measured.

The peak level of the fundamental is also identified. The harmonics or spurious emissions must be reduced from this fundamental level by 20 dBc. This harmonic limit is calculated and used to determine compliance. A reduction from the carrier that is greater that 20 is a passing result. The minimum margin from the peak level for each mode are highlighted in yellow.

Data plots are provided for the worst-case data sets. One plot shows the spectrum at the carrier, and another shows the spectrum across the band. On this second plot, a green reference line is at approximately the 20 dBc maximum spurious emission level.

	Frequency (MHz)		
	2402	2440	2480
Bluetooth BR	62.79	62.34	59.36

Table TR34.2: Results Summary

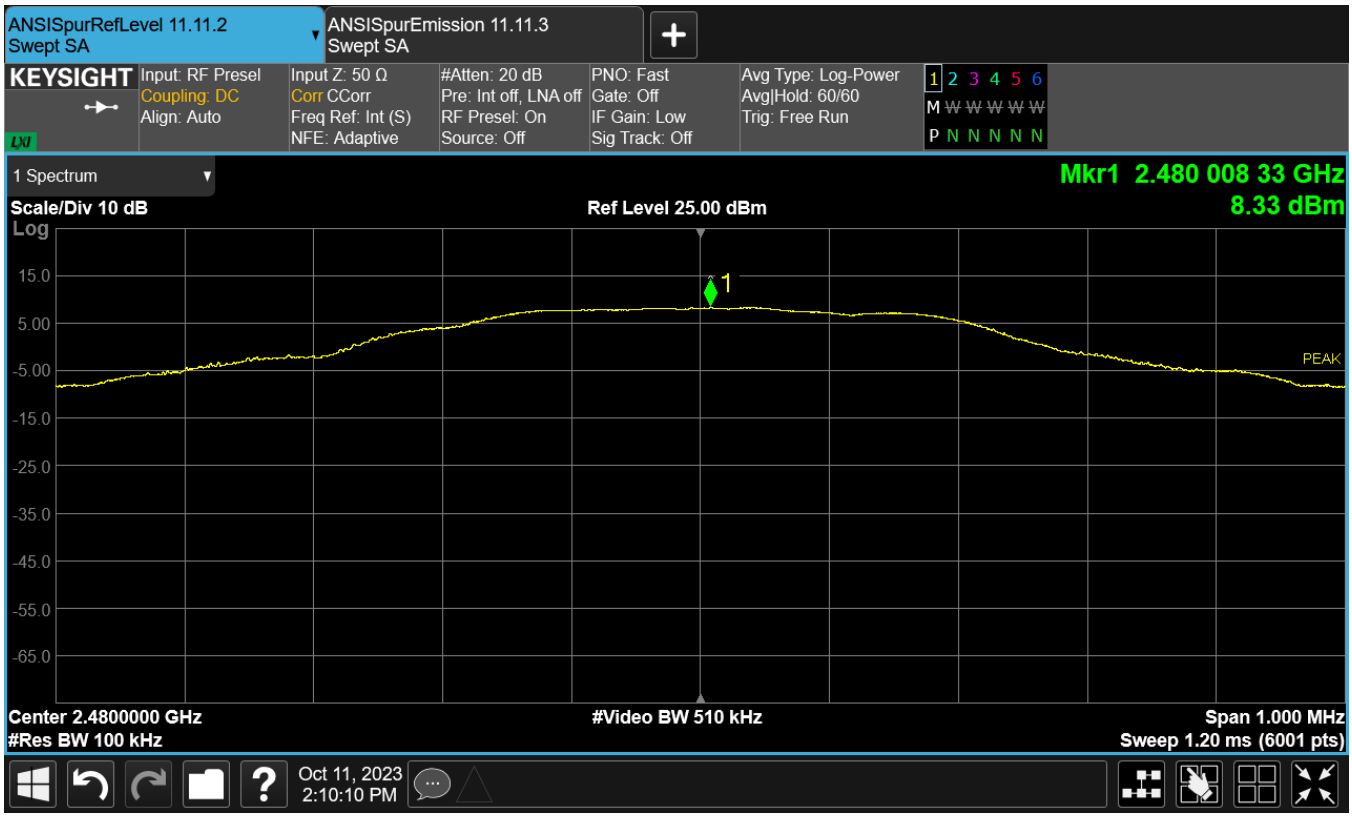


Figure TR13.2: Reference level measurement for Bluetooth Basic Rate at 2480 MHz

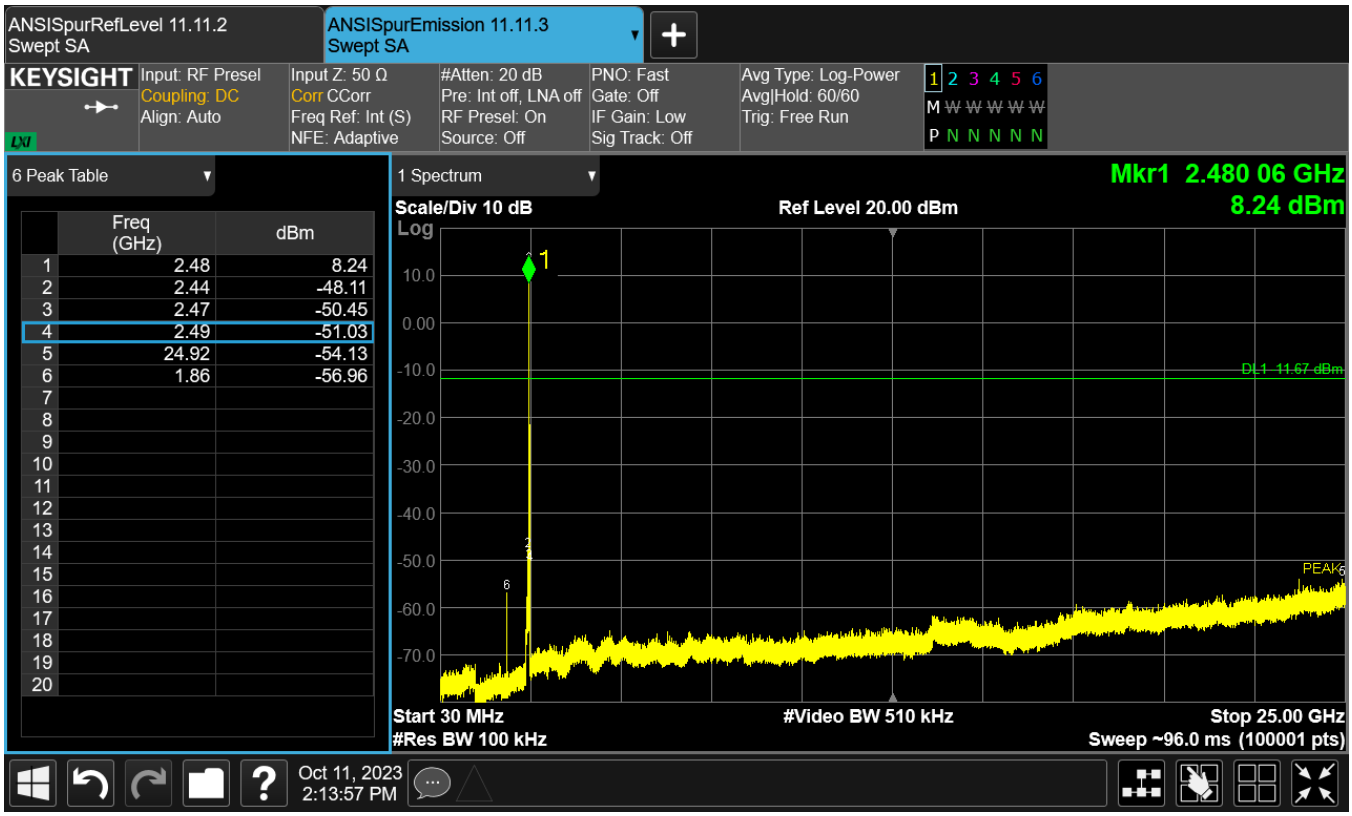


Figure TR13.3 Spectral data for Bluetooth Basic Rate at 2480 MHz

This line is the end of the test record.

Test Record
Radiated Emission Test RE01
Project GCL0457

Test Date(s)	15 Sep 2023, 18 Sep 2023
Test Personnel	David Kerr, Jim Solum
Product Model	AA4714
Serial Number tested	3453413922
Operating Mode	M1 (Bt Tx)
Arrangement	A2 (Upwr)
Input Power	USB 5 Vdc
Test Standards:	FCC Part 15, RSS-Gen (as noted in Section 6 of the report).
Frequency Range:	2200-2390 MHz and 2483.5 to 2500 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**22-Sep-2023**

Original record, Version A.

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
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required

Table RE01.1: Test Equipment Used

Software Used
N9048B Keysight PXE firmware version A.33.03
RE Signal Maximization Tool v2023Jul14.xlsx
FCC Restricted Band 2p4GHz Template v1b 2023Jun20.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.

Restricted band measurements in the lower band were made while the transmitter was tuned to its lowest frequency of 2402 MHz. Measurements in the upper band were made while the transmitter was tuned to its highest frequency of 2480 MHz.

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 tables show the selected final measurement data between the FCC restricted bands. It includes the 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 restricted band Class B Limit at 3m.

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2387.8	54	74	34.852	48.205	19.148	25.795	170	1785	VERT	Z
2390	54	74	35.222	48.658	18.778	25.342	170	1785	VERT	Z

Table RE01.2: FCC restricted band from 2200 to 2390 MHz (Z orientation) Basic Rate

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2483.5	54	74	40.779	54.606	13.221	19.394	0	1050	HORZ	X
2483.5	54	74	40.751	54.826	13.249	19.174	0	1050	HORZ	X

Table RE01.3: FCC restricted band from 2483.5 to 2500 MHz (X orientation) Basic Rate

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2389.5	54	74	35.248	49.093	18.752	24.907	170	1785	VERT	Z
2390	54	74	35.311	48.995	18.689	25.005	170	1785	VERT	Z

Table RE01.4: BT EDR2 FCC restricted band from 2200 to 2390 MHz (Z orientation)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2483.5	54	74	41.108	55.573	12.892	18.427	0	1050	HORZ	X
2483.5	54	74	41.116	56.29	12.884	17.71	0	1050	HORZ	X

Table RE01.5: BT EDR2 FCC restricted band from 2483.5 to 2500 MHz (X orientation)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2388.5	54	74	35.909	49.952	18.091	24.048	170	1785	VERT	Z
2390	54	74	36.183	50.403	17.817	23.597	170	1785	VERT	Z

Table RE01.6: BT EDR3 FCC restricted band from 2200 to 2390 MHz (Z orientation)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2483.5	54	74	41.339	55.763	12.661	18.237	0	1050	HORZ	X
2483.5	54	74	41.318	55.513	12.682	18.487	0	1050	HORZ	X

Table RE01.7: BT EDR3 FCC restricted band from 2483.5 to 2500 MHz (X orientation)

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

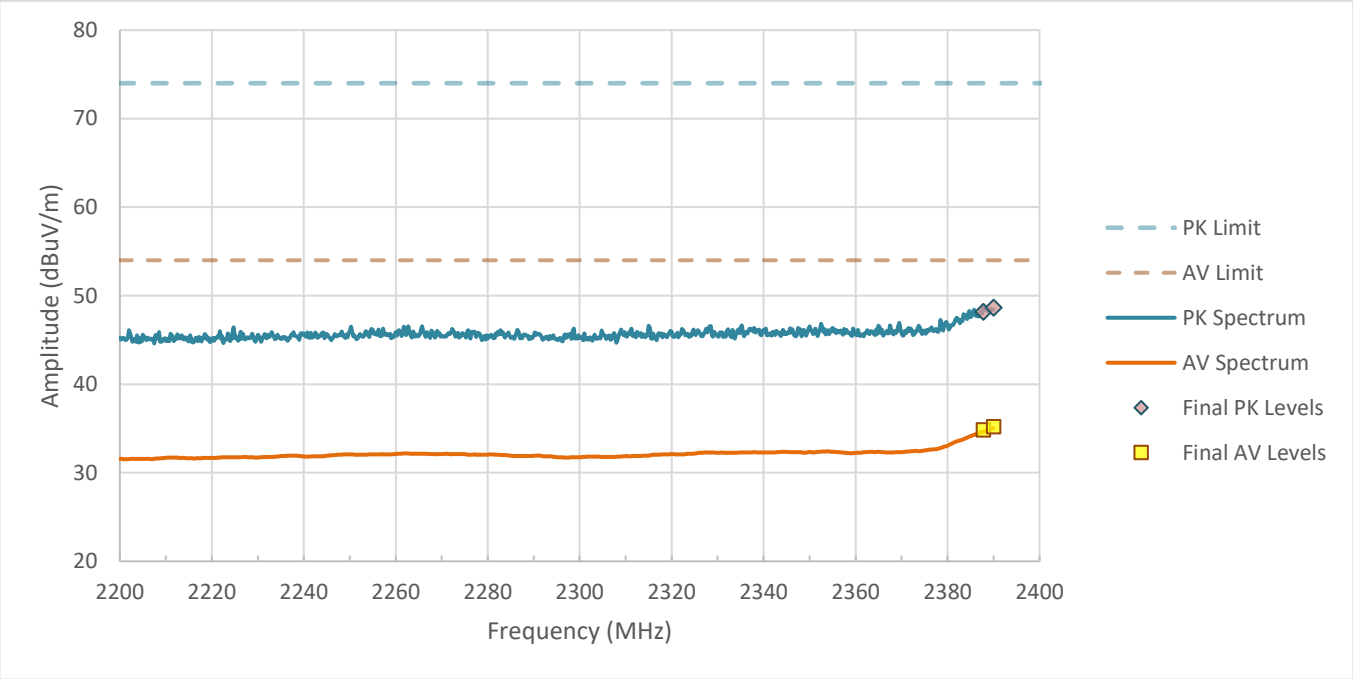


Figure RE01.1: FCC restricted band spectral data from 2200 to 2390 MHz (Basic Rate)

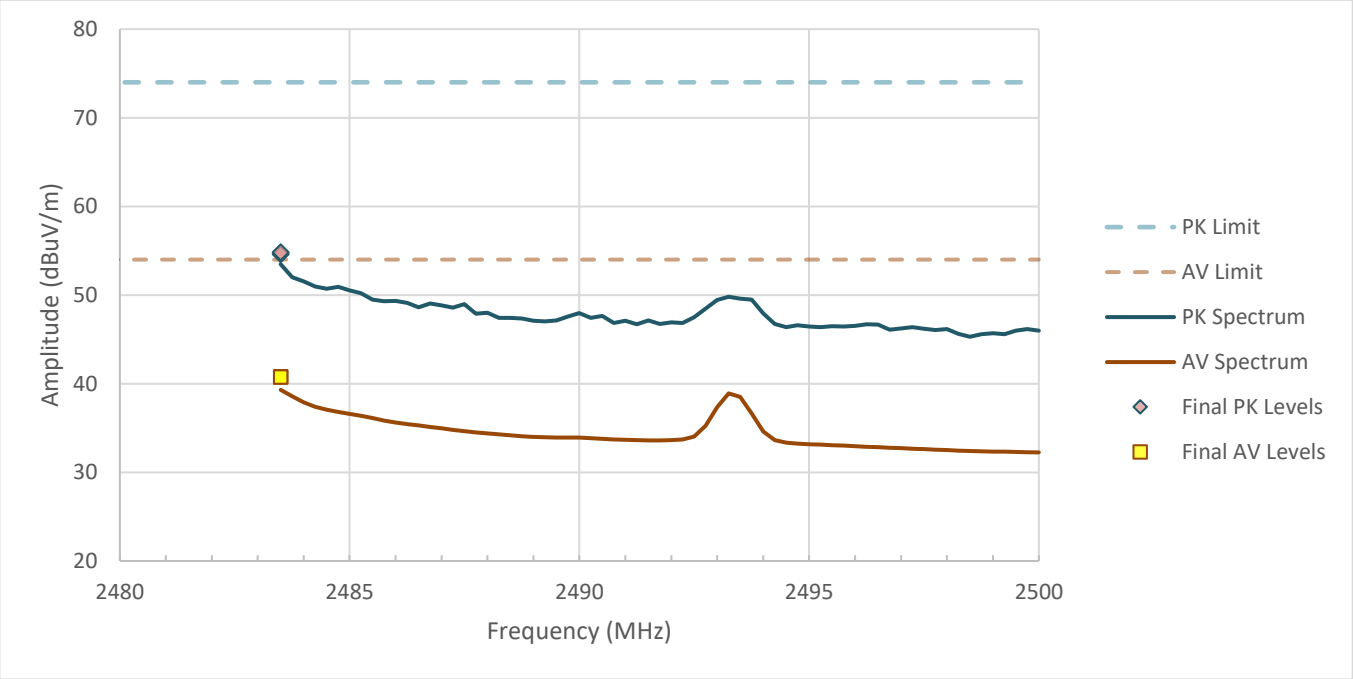


Figure RE01.2: FCC restricted band spectral data from 2483.5 to 2500 MHz (Basic Rate)

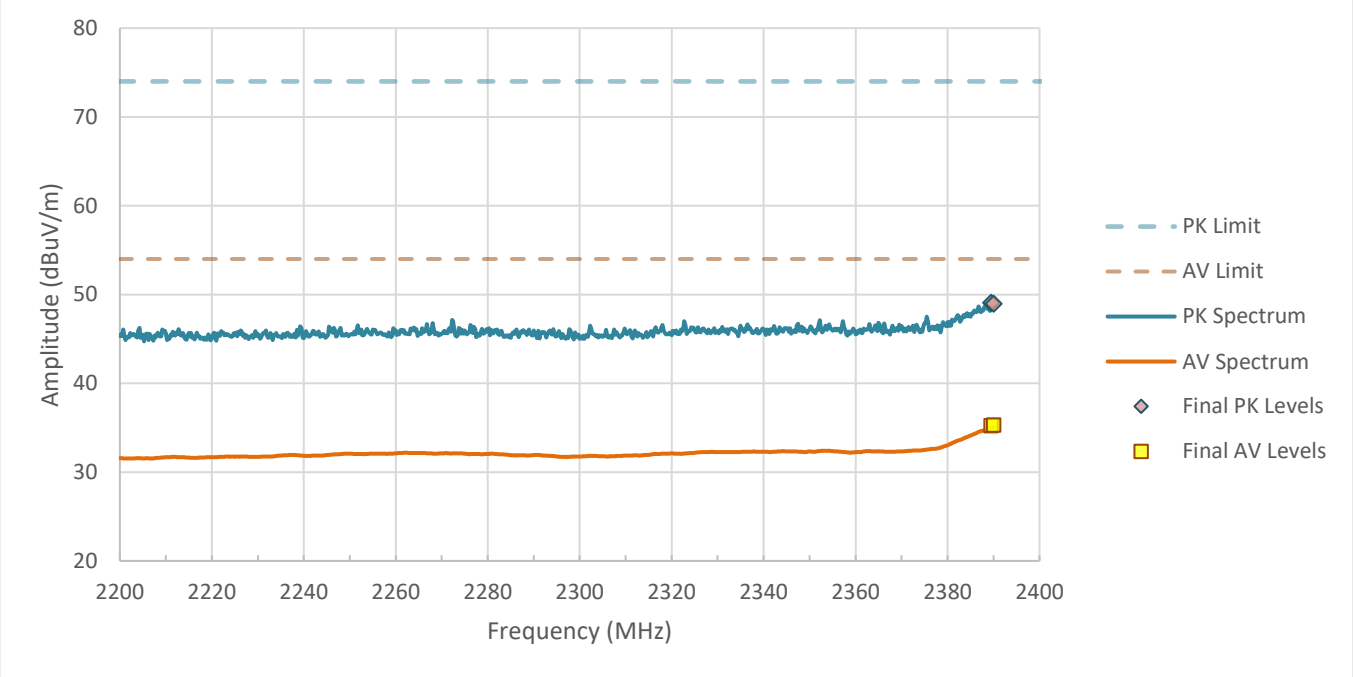


Figure RE01.3: BT EDR2 FCC restricted band spectral data from 2200 to 2390 MHz

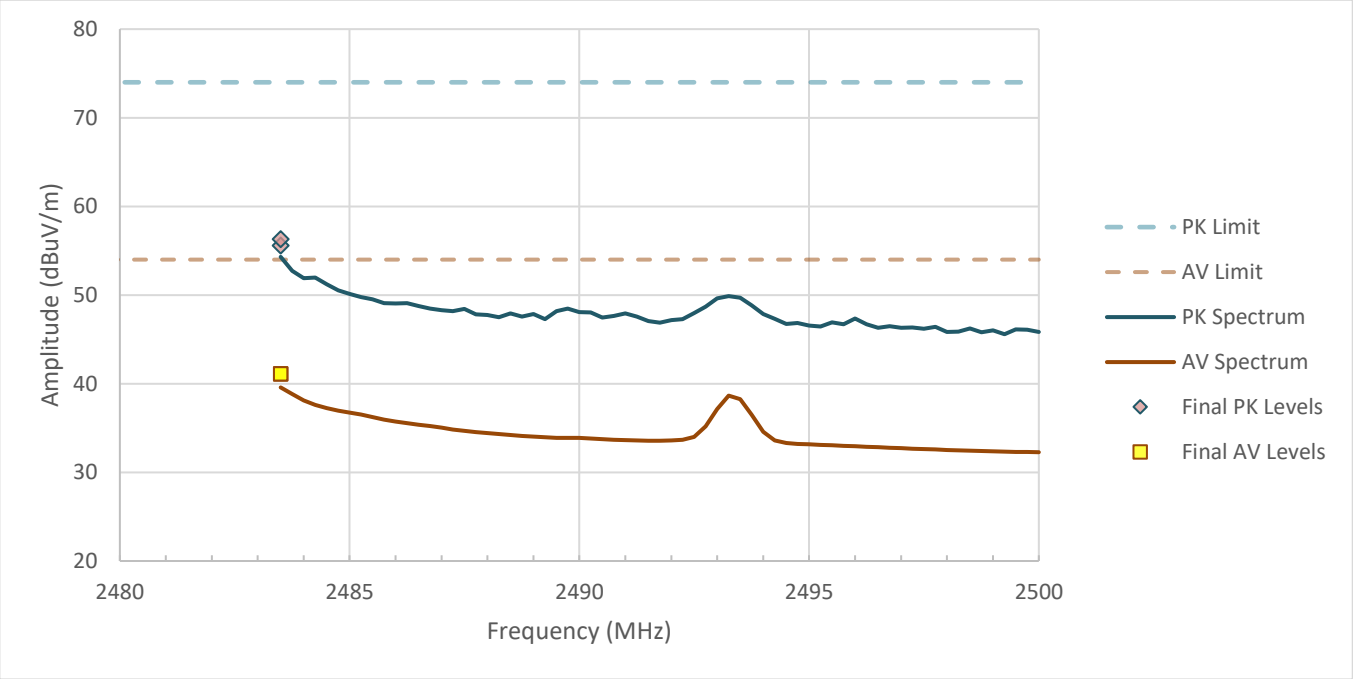


Figure RE01.4: BT EDR2 FCC restricted band spectral data from 2483.5 to 2500 MHz

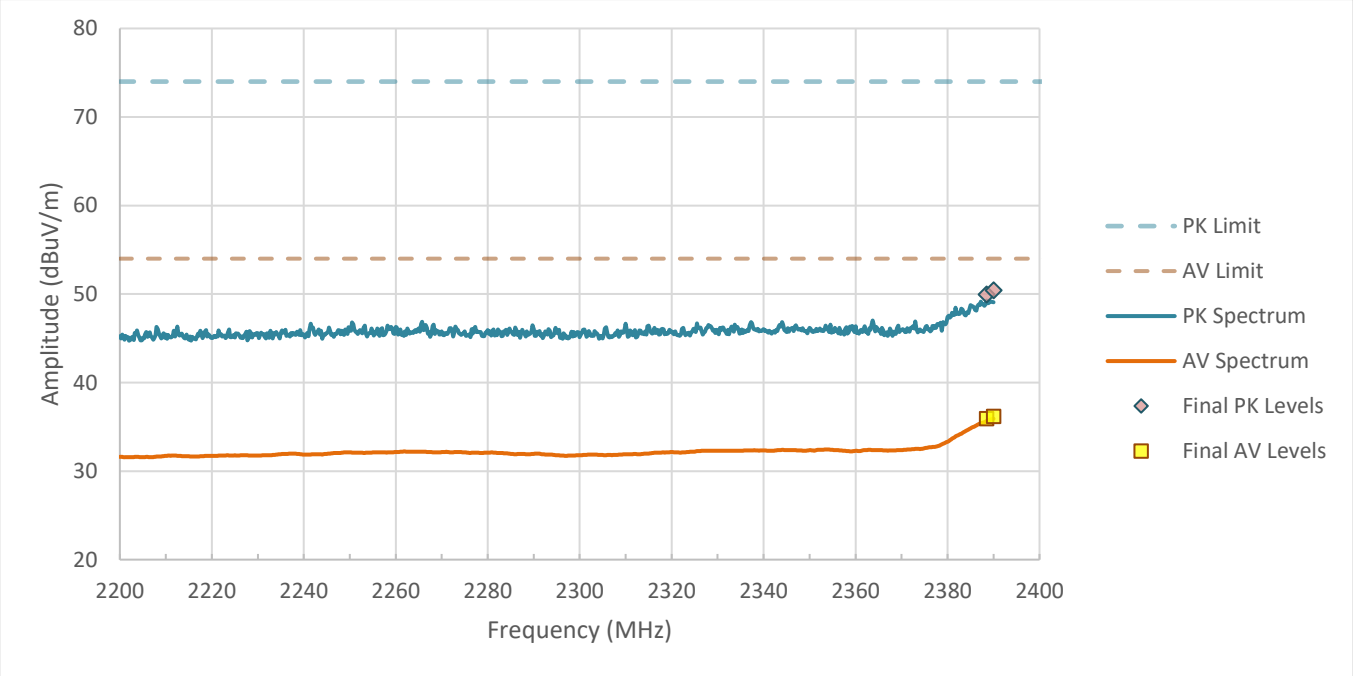


Figure RE01.5: BT EDR3 FCC restricted band spectral data from 2200 to 2390 MHz

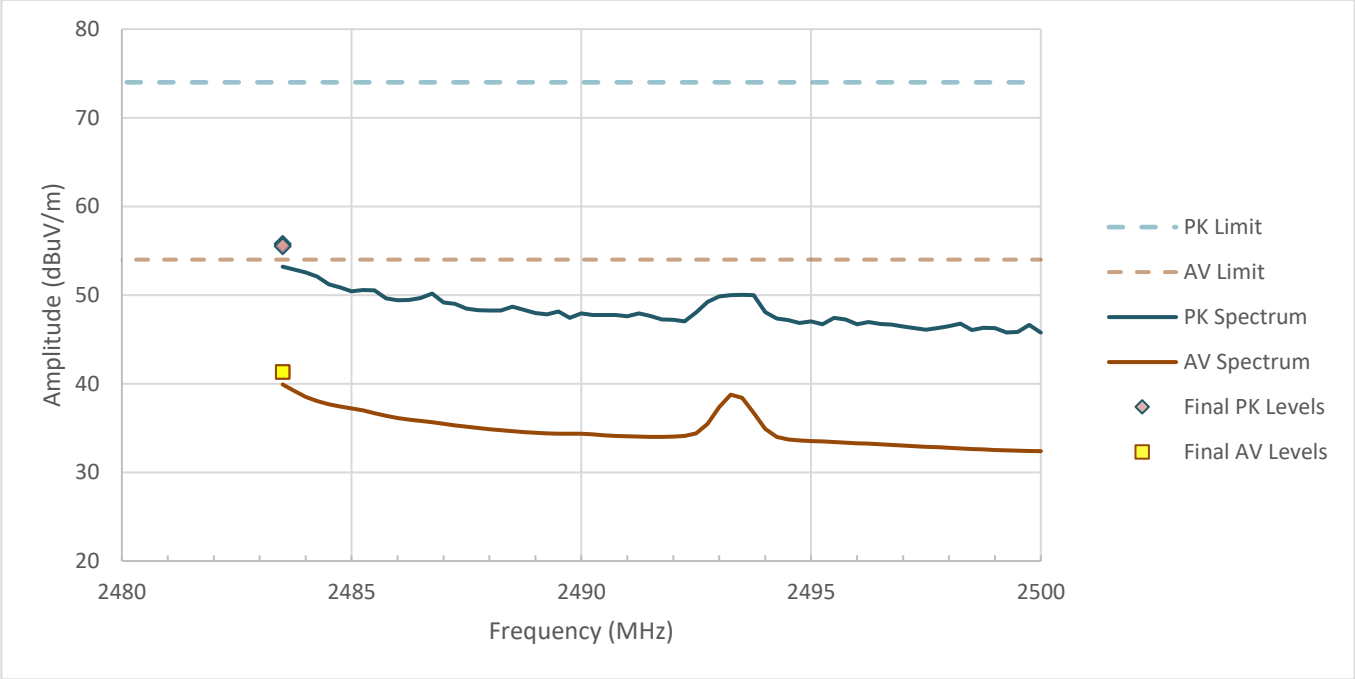


Figure RE01.6: BT EDR3 FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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

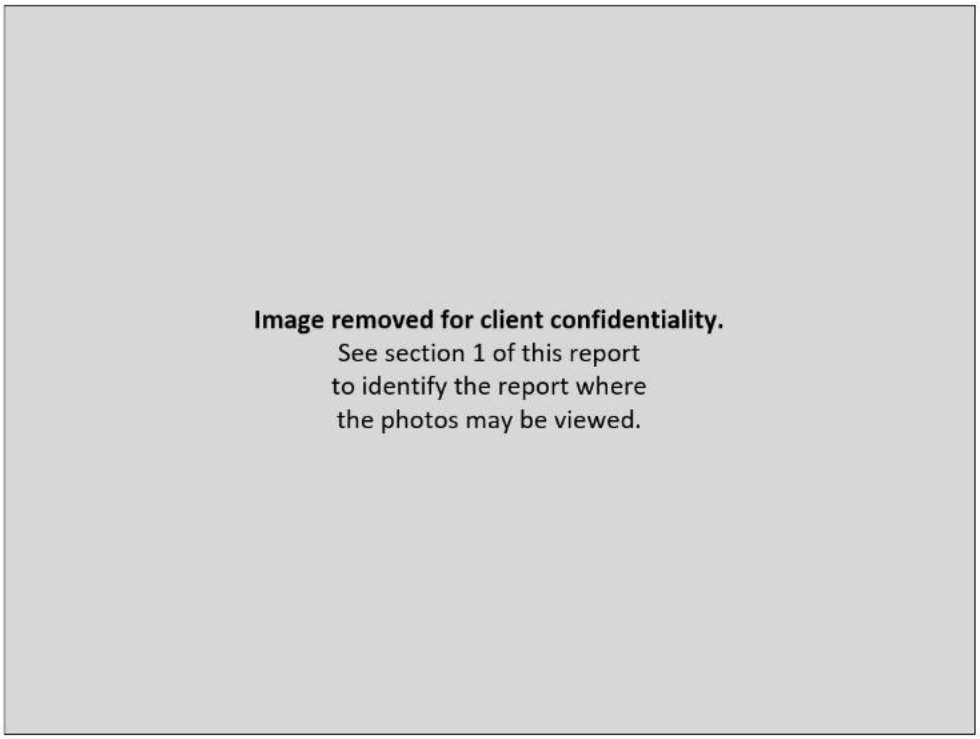


Figure RE01.7: EUT test setup X orientation (front view)

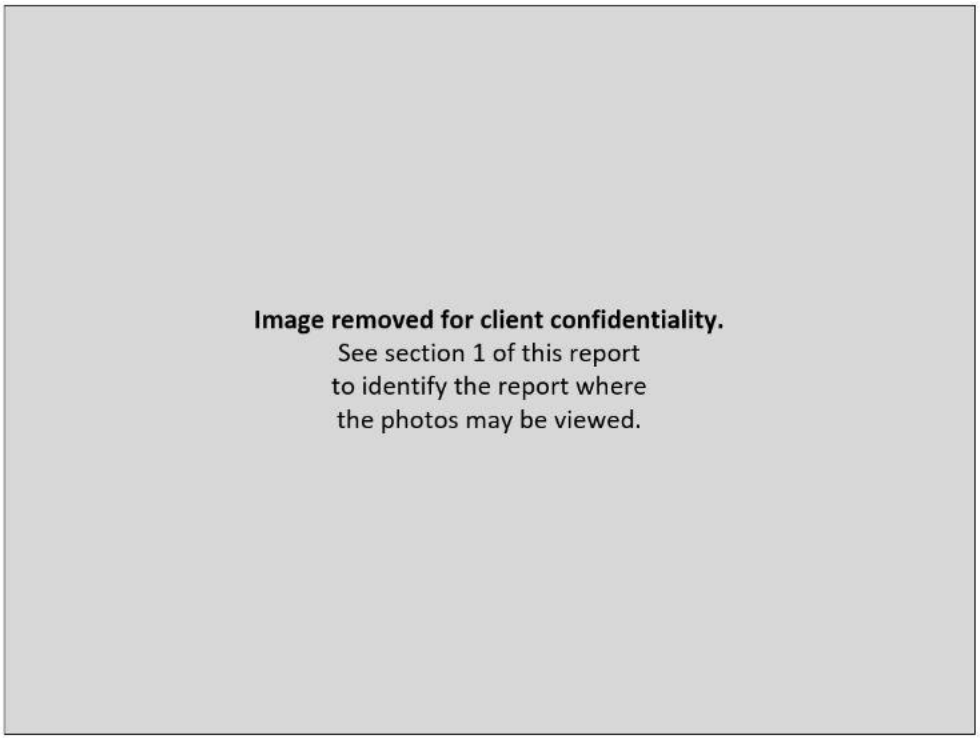


Figure RE01.8: EUT test setup X orientation (rear view)

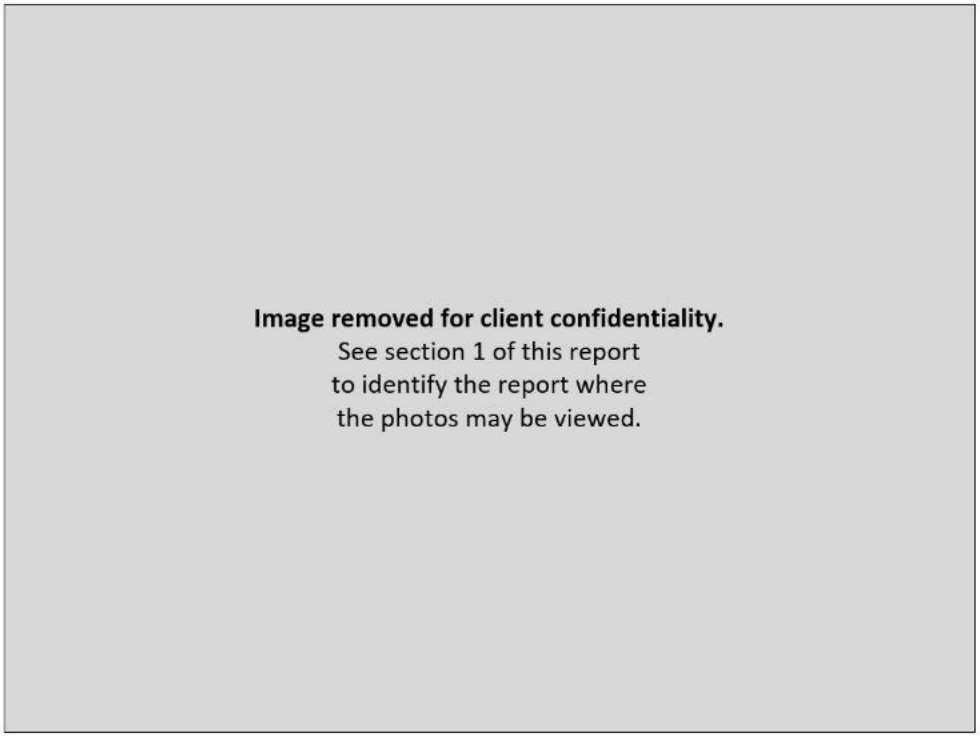


Figure RE01.9: EUT test setup Z orientation (front view)

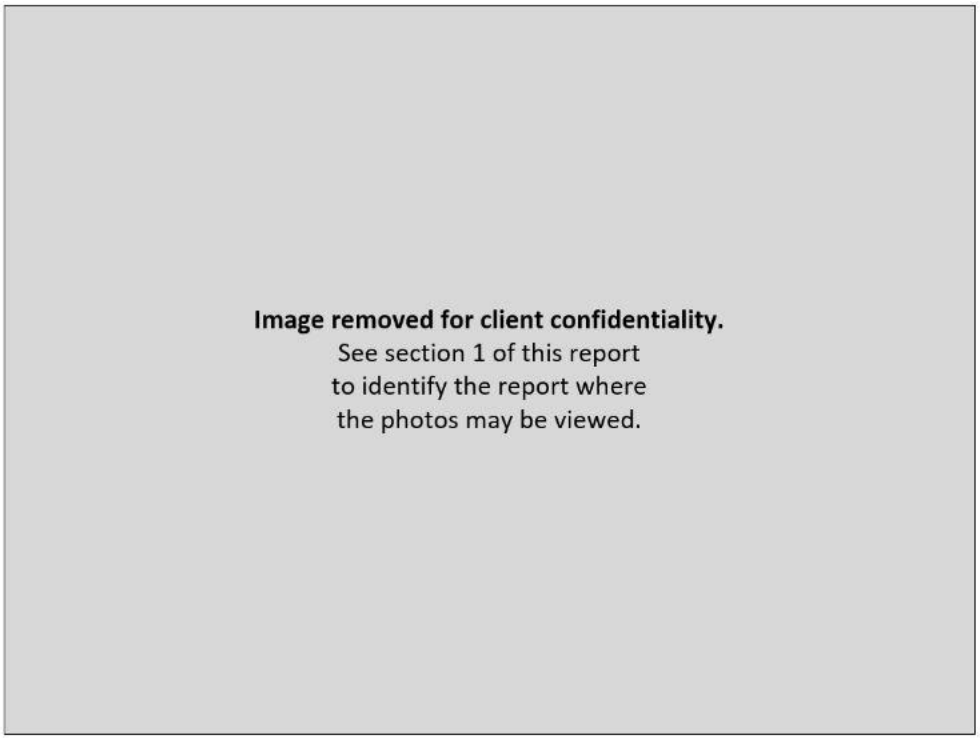


Figure RE01.10: EUT test setup Z orientation (rear view)

This line is the end of the test record.

Test Record
Radiated Emission Test RE02
Project GCL0457

Test Date(s)	15 Sep 2023, 18 Sep 2023
Test Personnel	David Kerr, Jim Solum
Product Model	AA4714
Serial Number tested	3453413922
Operating Mode	M3 (BLE Tx)
Arrangement	A2 (Upwr)
Input Power	USB 5 Vdc
Test Standards:	FCC Part 15, RSS-Gen (as noted in Section 6 of the report).
Frequency Range:	2200-2390 MHz and 2483.5 to 2500 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**22-Sep-2023**

Original record, Version A.

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
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required

Table RE02.1: Test Equipment Used

Software Used
N9048B Keysight PXE firmware version A.33.03
RE Signal Maximization Tool v2023Jul14.xlsx
FCC Restricted Band 2p4GHz Template v1b 2023Jun20.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.

Restricted band measurements in the lower band were made while the transmitter was tuned to its lowest frequency of 2402 MHz for the 1 Mbps data rate, and 2404 MHz for the 2 Mbps data rate. Measurements in the upper band were made while the transmitter was tuned to its highest frequency of 2480 MHz for the 1 Mbps data rate, and 2478 MHz for the 2 Mbps data rate.

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 tables show the selected final measurement data between the FCC restricted bands. It includes the 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 restricted band Class B Limit at 3m.

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2389.3	54	74	38.424	49.964	15.576	24.036	170	1785	VERT	Z
2389	54	74	38.518	49.849	15.482	24.151	170	1785	VERT	Z

Table RE02.2: FCC restricted band from 2200 to 2390 MHz (Z orientation)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2483.5	54	74	46.212	56.989	7.788	17.011	0	1050	HORZ	X
2483.5	54	74	46.2	56.783	7.8	17.217	0	1050	HORZ	X

Table RE02.3: FCC restricted band from 2483.5 to 2500 MHz (X orientation)

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

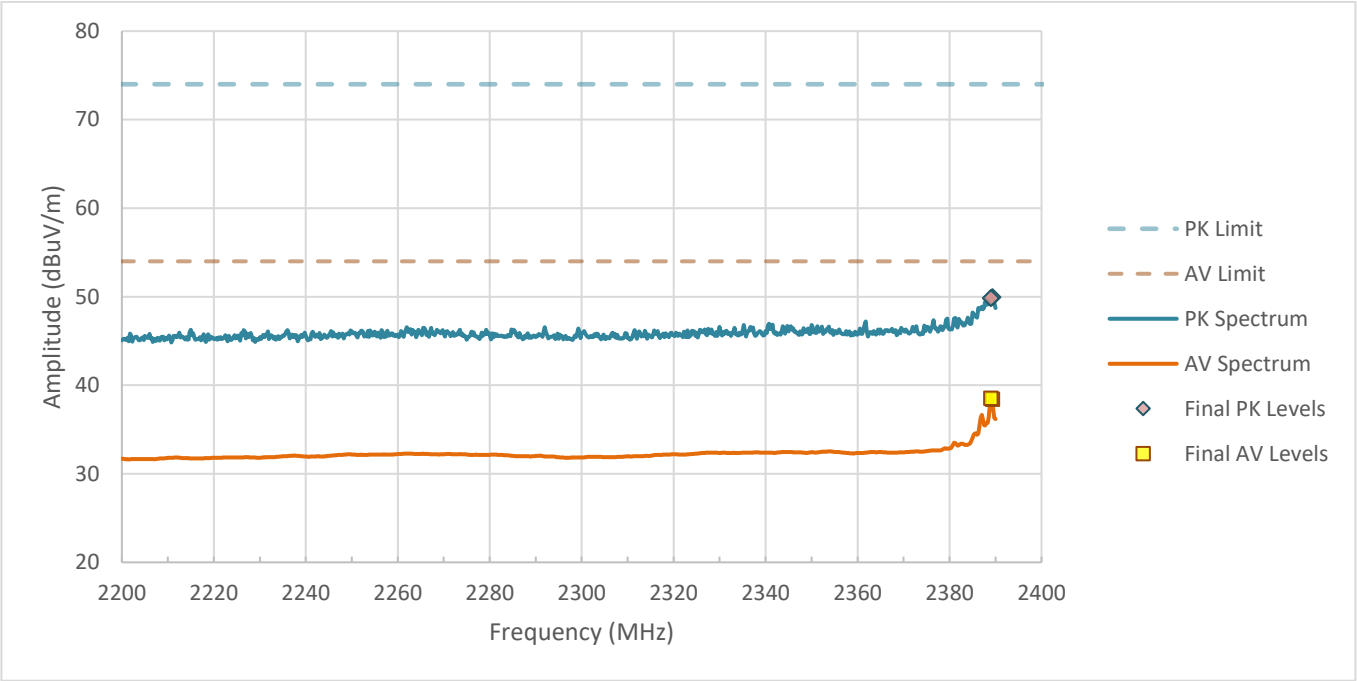


Figure RE02.1: FCC restricted band spectral data from 2200 to 2390 MHz

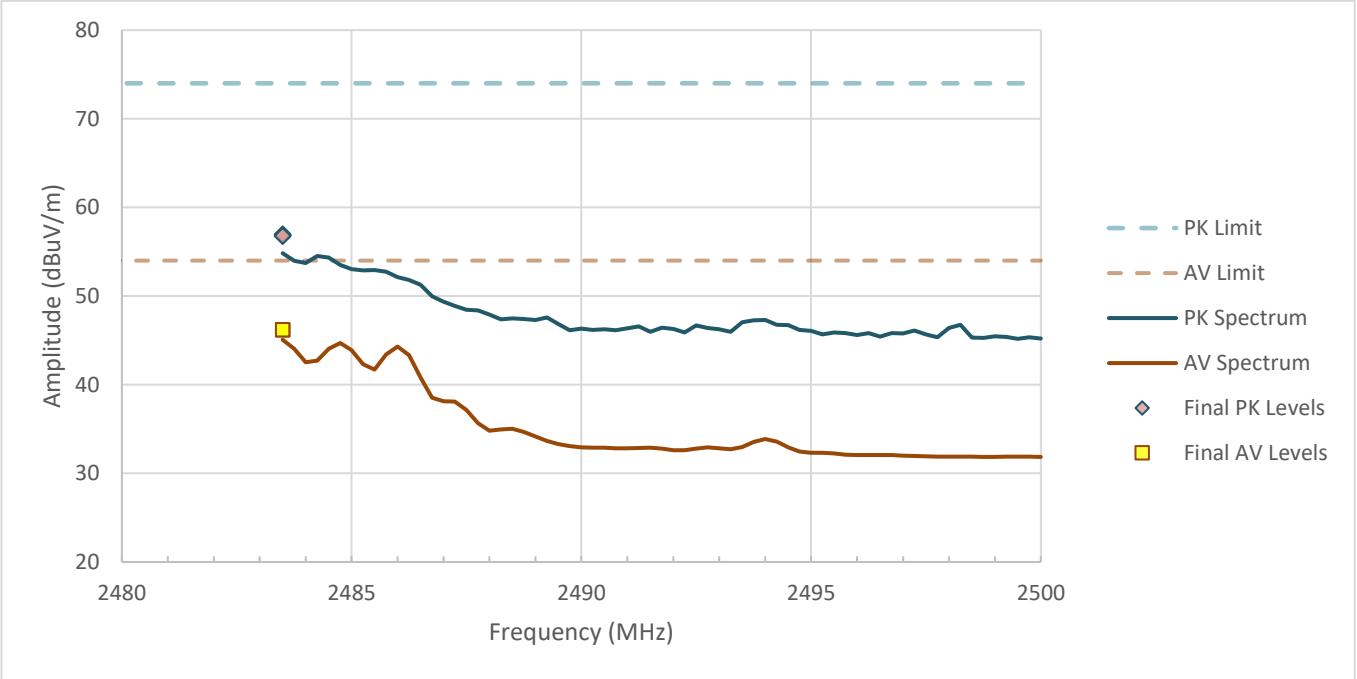


Figure RE02.2: FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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

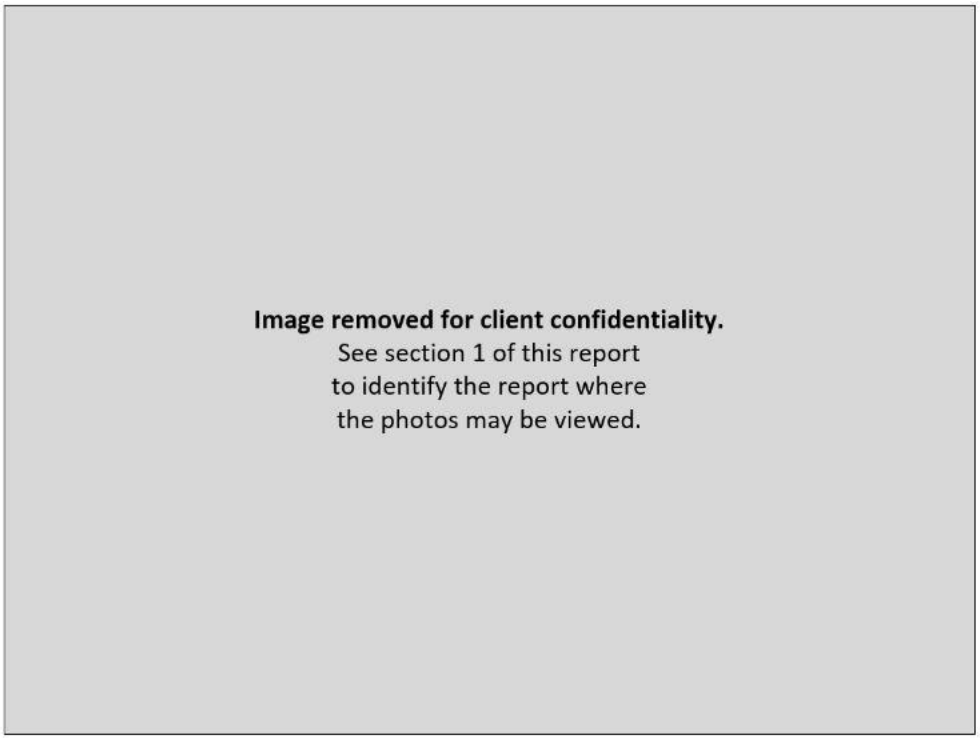


Figure RE02.3: EUT test setup X orientation (front view)

Figure RE02.4: EUT test setup X orientation (rear view)

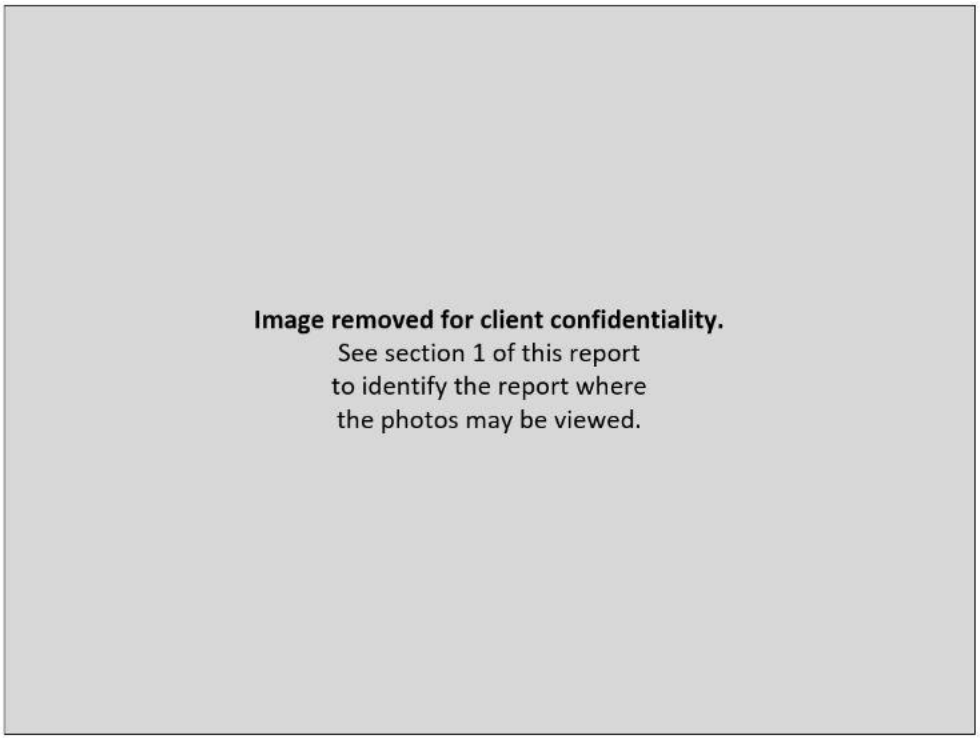


Figure RE02.5: EUT test setup Z orientation (front view)

Figure RE02.6: EUT test setup Z orientation (rear view)

This line is the end of the test record.

Test Record
Radiated Emission Test RE03
Project GCL0457

Test Date(s)	15 Sep 2023, 18 Sep 2023
Test Personnel	David Kerr, Jim Solum
Product Model	AA4714
Serial Number tested	3453413922
Operating Mode	M5 (ANT Tx)
Arrangement	A2 (Upwr)
Input Power	USB 5 Vdc
Test Standards:	FCC Part 15, RSS-Gen (as noted in Section 6 of the report).
Frequency Range:	2200-2390 MHz and 2483.5 to 2500 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**27-Sep-2023**

Original record, Version A.

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
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required

Table RE03.1: Test Equipment Used

Software Used
N9048B Keysight PXE firmware version A.33.03
RE Signal Maximization Tool v2023Jul14.xlsx
FCC Restricted Band 2p4GHz Template v1b 2023Jun20.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.

Restricted band measurements in the lower band were made while the transmitter was tuned to its lowest frequency of 2402 MHz. Measurements in the upper band were made while the transmitter was tuned to its highest frequency of 2480 MHz.

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 tables show the selected final measurement data between the FCC restricted bands. It includes the 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 restricted band Class B Limit at 3m.

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2389.8	54	74	33.715	47.8	20.285	26.2	170	1785	VERT	Z
2390	54	74	33.74	47.48	20.26	26.52	170	1785	VERT	Z

Table RE03.2: FCC restricted band from 2200 to 2390 MHz (Z orientation)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2484.3	54	74	40.518	52.185	13.482	21.815	0	1050	HORZ	X
2484	54	74	41.048	52.007	12.952	21.993	0	1050	HORZ	X

Table RE03.3: FCC restricted band from 2483.5 to 2500 MHz (X orientation)

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

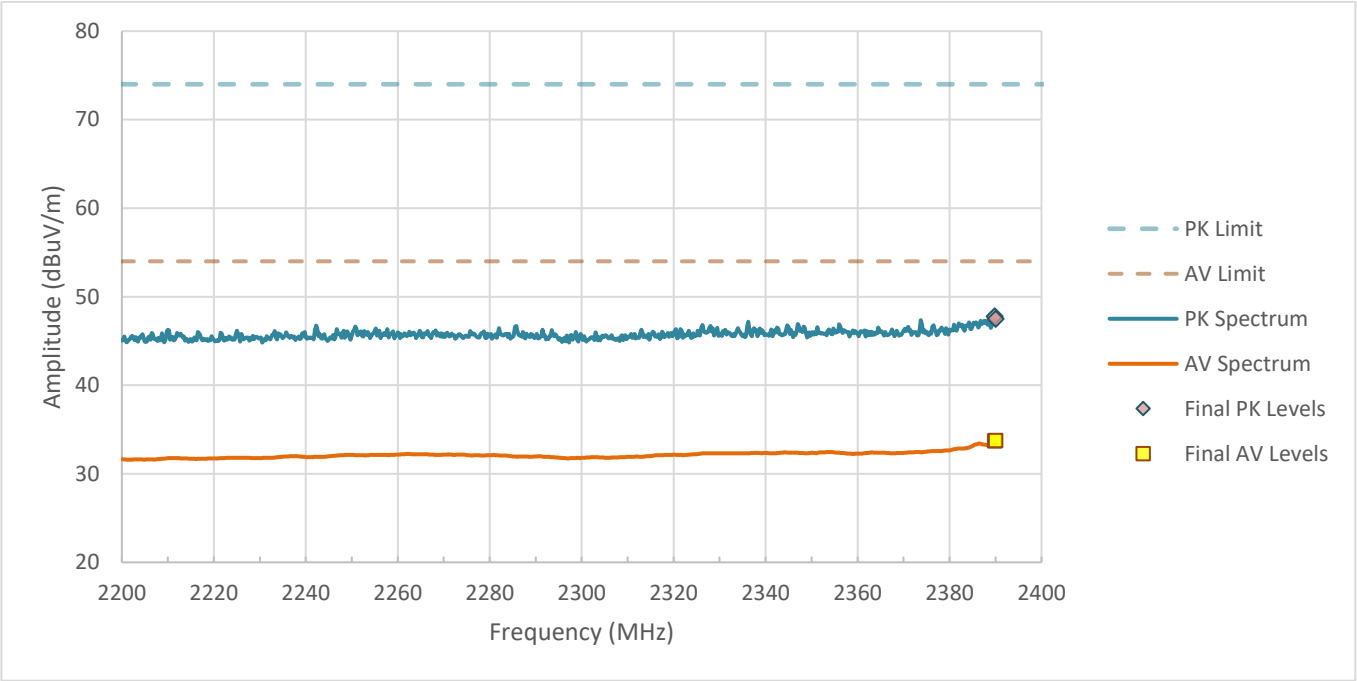


Figure RE03.1: FCC restricted band spectral data from 2200 to 2390 MHz

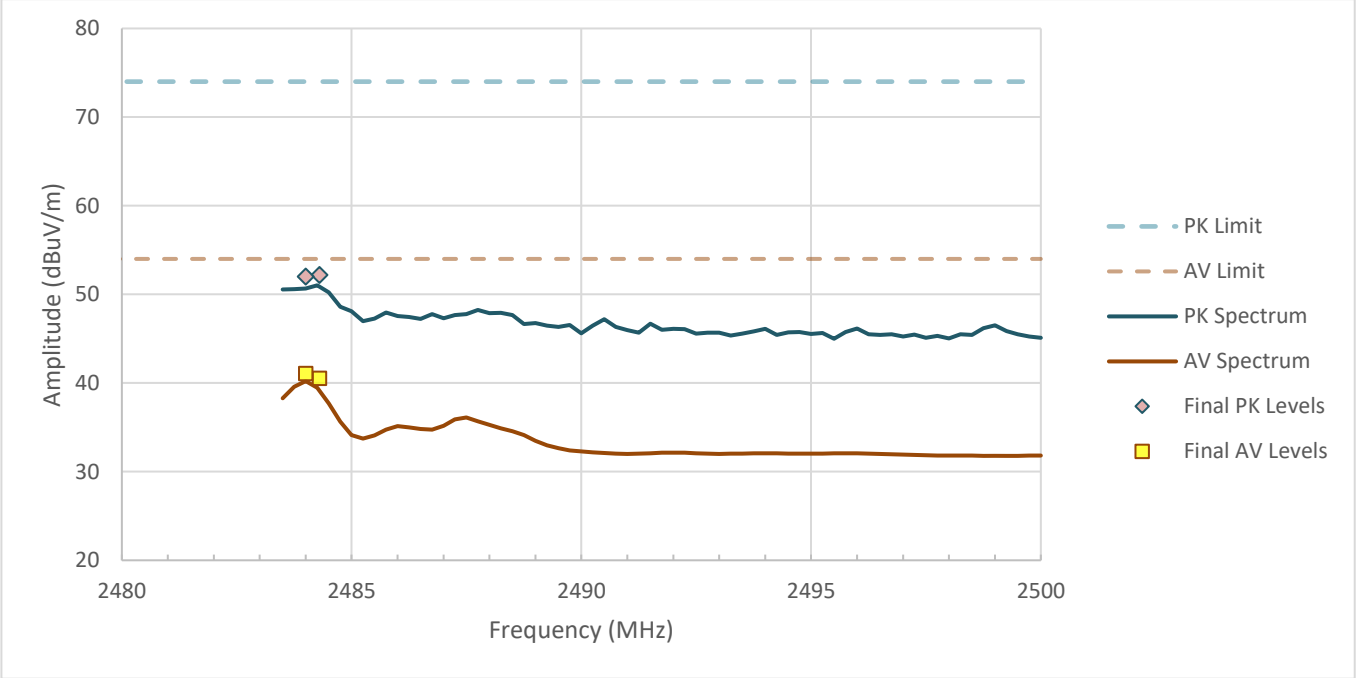


Figure RE03.2: FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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

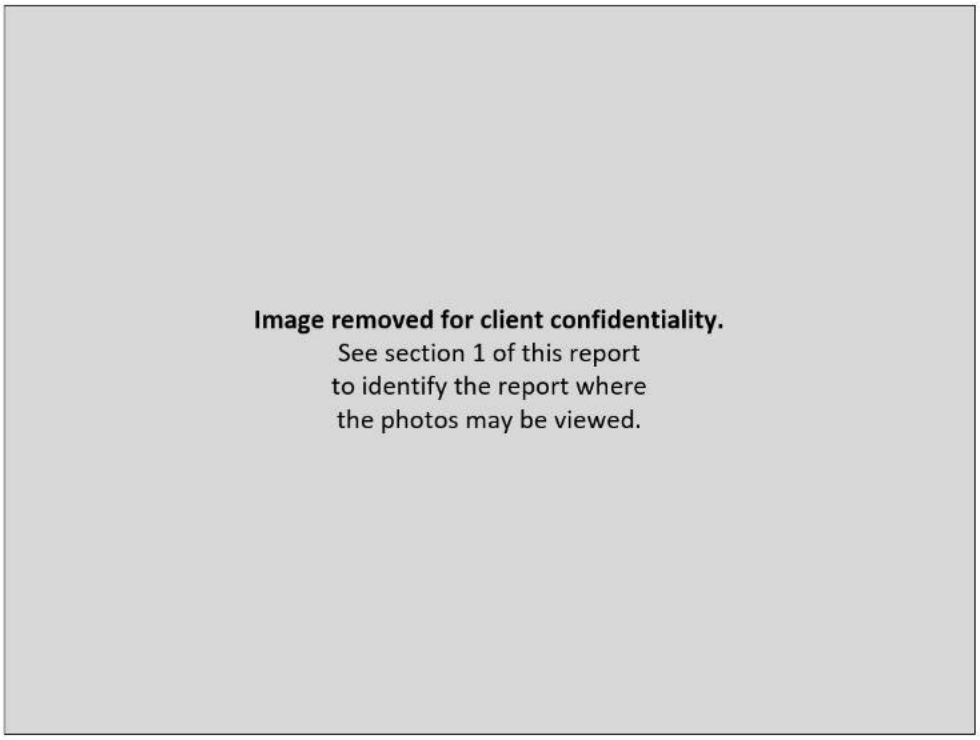


Figure RE03.3: EUT test setup X orientation (front view)

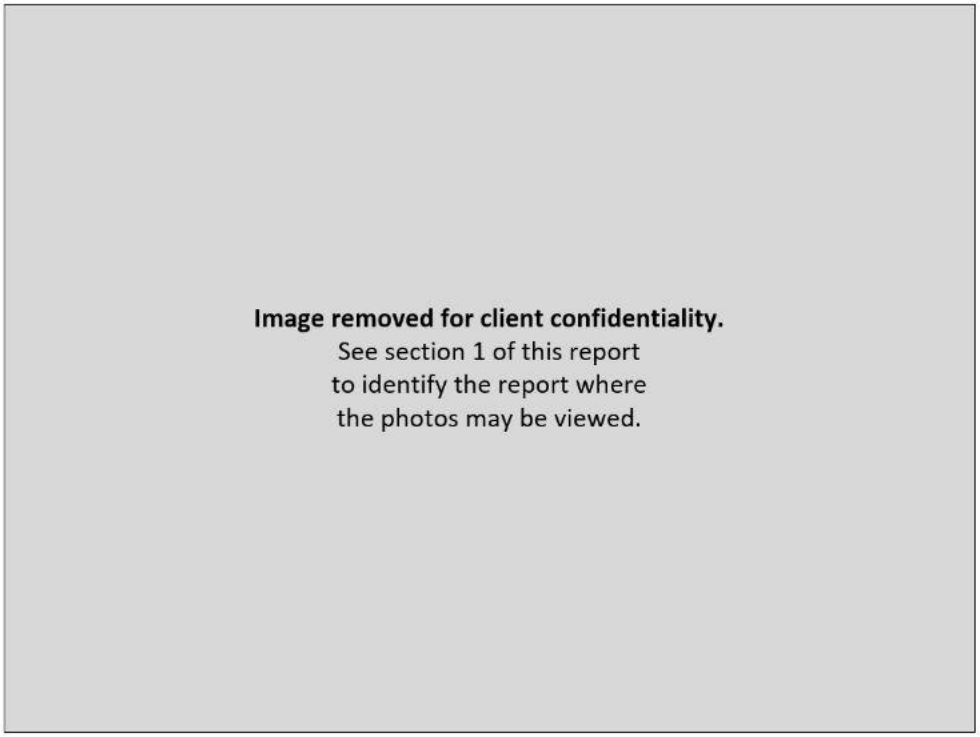


Figure RE03.4: EUT test setup X orientation (rear view)

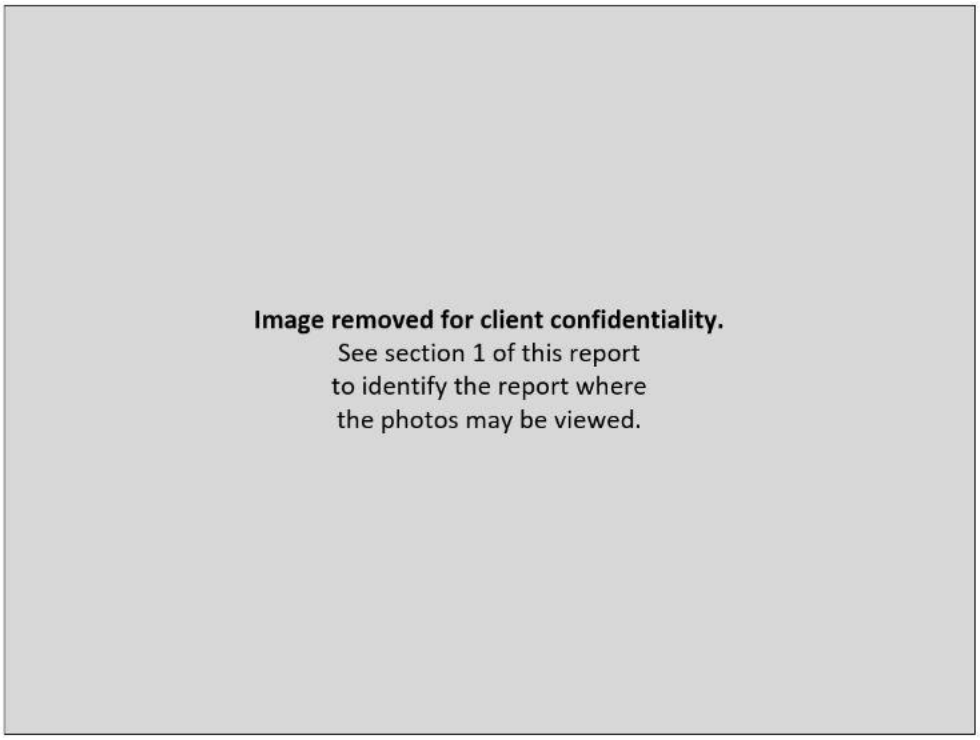


Figure RE03.5: EUT test setup Z orientation (front view)

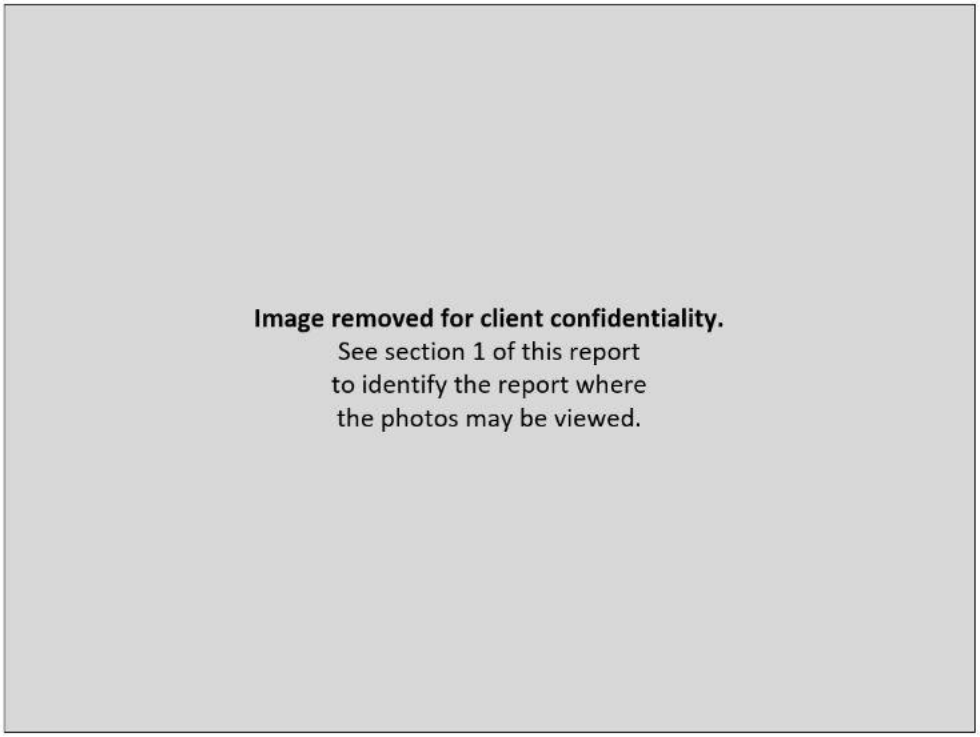


Figure RE03.6: EUT test setup Z orientation (rear view)

This line is the end of the test record.

Test Record
Radiated Emission Test RE04
Project GCL0457

Test Date(s)	15 Sep 2023, 18 Sep 2023
Test Personnel	David Kerr, Jim Solum
Product Model	AA4714
Serial Number tested	3453413922
Operating Mode	M7 (WiFi Tx)
Arrangement	A2 (Upwr)
Input Power	USB 5 Vdc
Test Standards:	FCC Part 15, RSS-Gen (as noted in Section 6 of the report).
Frequency Range:	2200-2390 MHz and 2483.5 to 2500 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**27-Sep-2023**

Original record, Version A.

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
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required

Table RE04.1: Test Equipment Used

Software Used
N9048B Keysight PXE firmware version A.33.03
RE Signal Maximization Tool v2023Jul14.xlsx
FCC Restricted Band 2p4GHz Template v1b 2023Jun20.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.

Restricted band measurements in the lower band were made while the transmitter was tuned to channel 1. Measurements in the upper band were made while the transmitter was tuned to channels 11,12 and 13.

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 tables show the selected final measurement data between the FCC restricted bands. It includes the 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 restricted band Class B Limit at 3m.

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2389	54	74	39.796	53.656	14.204	20.344	170	1785	VERT	Z
2390	54	74	39.979	53.966	14.021	20.034	170	1785	VERT	Z

Table RE04.2: FCC restricted band from 2200 to 2390 MHz (Z orientation) B11, Ch1

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2484.5	54	74	41.718	55.2	12.282	18.8	0	1050	HORZ	X
2483.5	54	74	42.265	55.862	11.735	18.138	0	1050	HORZ	X

Table RE04.3: FCC restricted band from 2483.5 to 2500 MHz (X orientation) B11, Ch 11

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2483.8	54	74	43.642	56.354	10.358	17.646	0	1050	HORZ	X
2483.5	54	74	44.047	56.305	9.953	17.695	0	1050	HORZ	X

Table RE04.4: FCC restricted band from 2483.5 to 2500 MHz (X orientation) B11, Ch 12

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2484	54	74	41.695	55.19	12.305	18.81	0	1050	HORZ	X
2485.3	54	74	42.085	54.481	11.915	19.519	0	1050	HORZ	X

Table RE04.5: FCC restricted band from 2483.5 to 2500 MHz (X orientation) B11, Ch 13

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

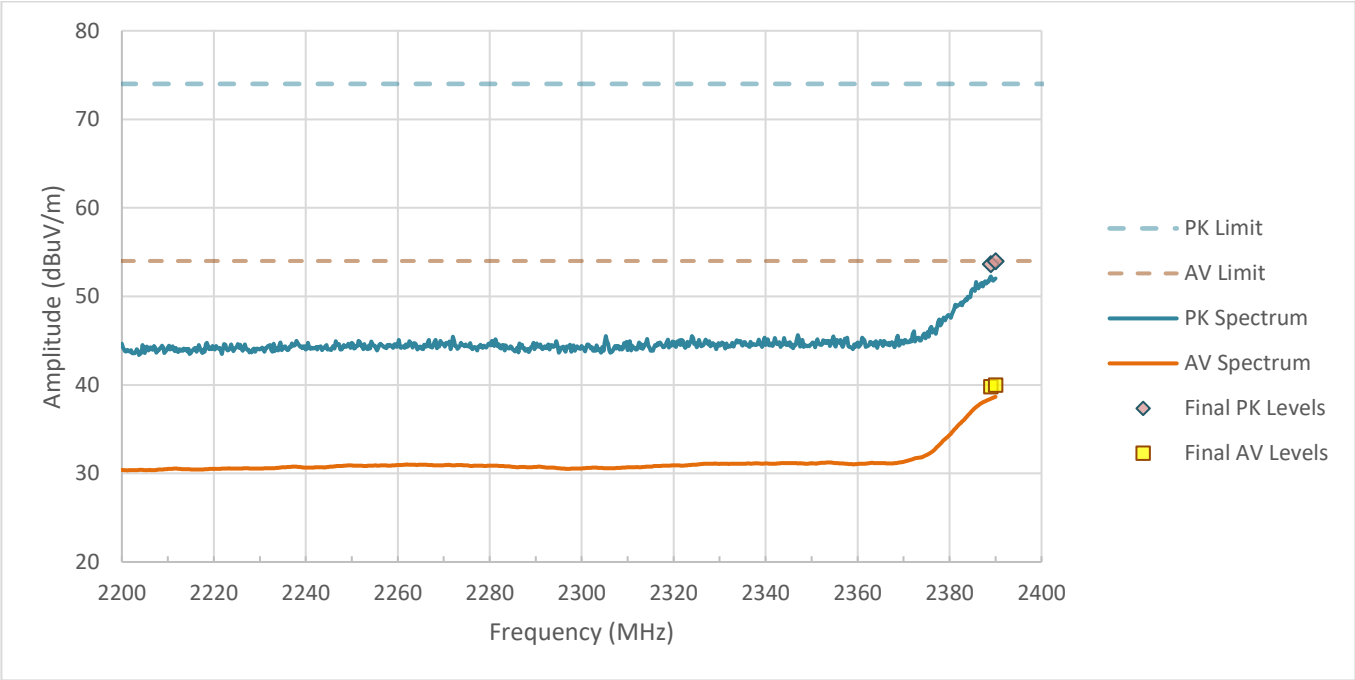


Figure RE04.1: FCC restricted band spectral data from 2200 to 2390 MHz Ch 1

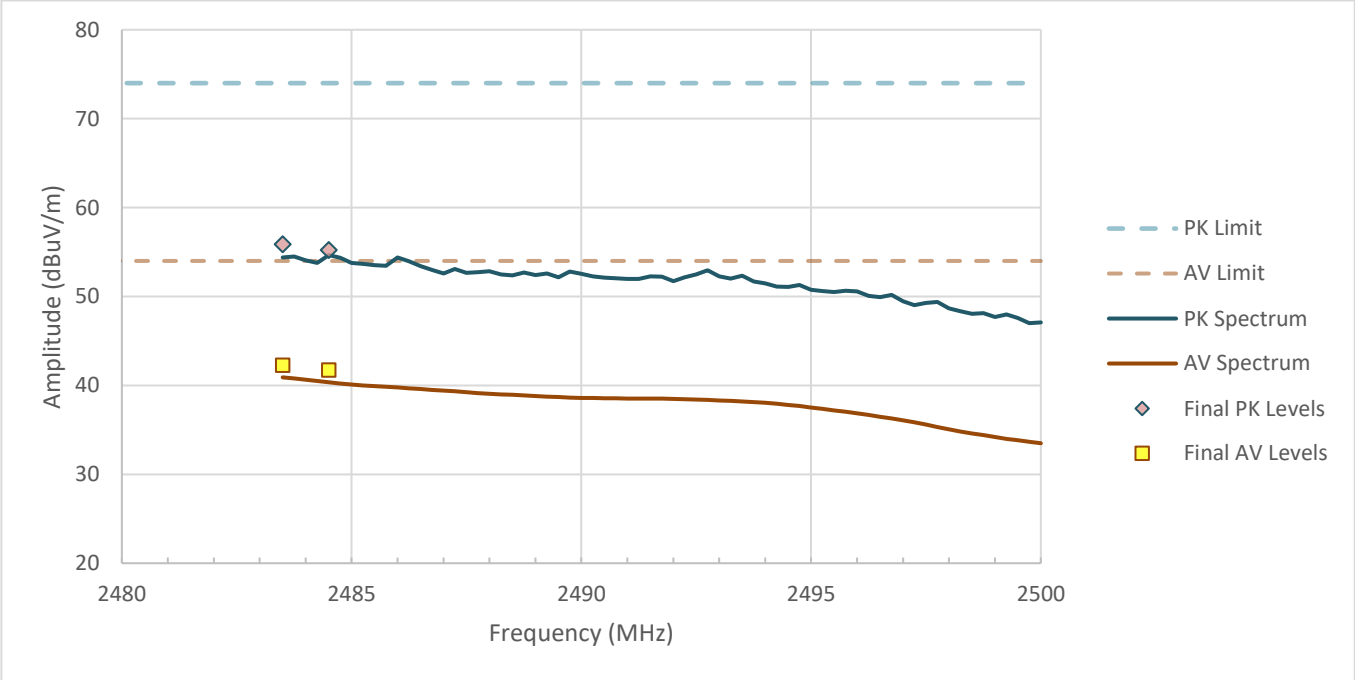


Figure RE04.2: FCC restricted band spectral data from 2483.5 to 2500 MHz Ch 11

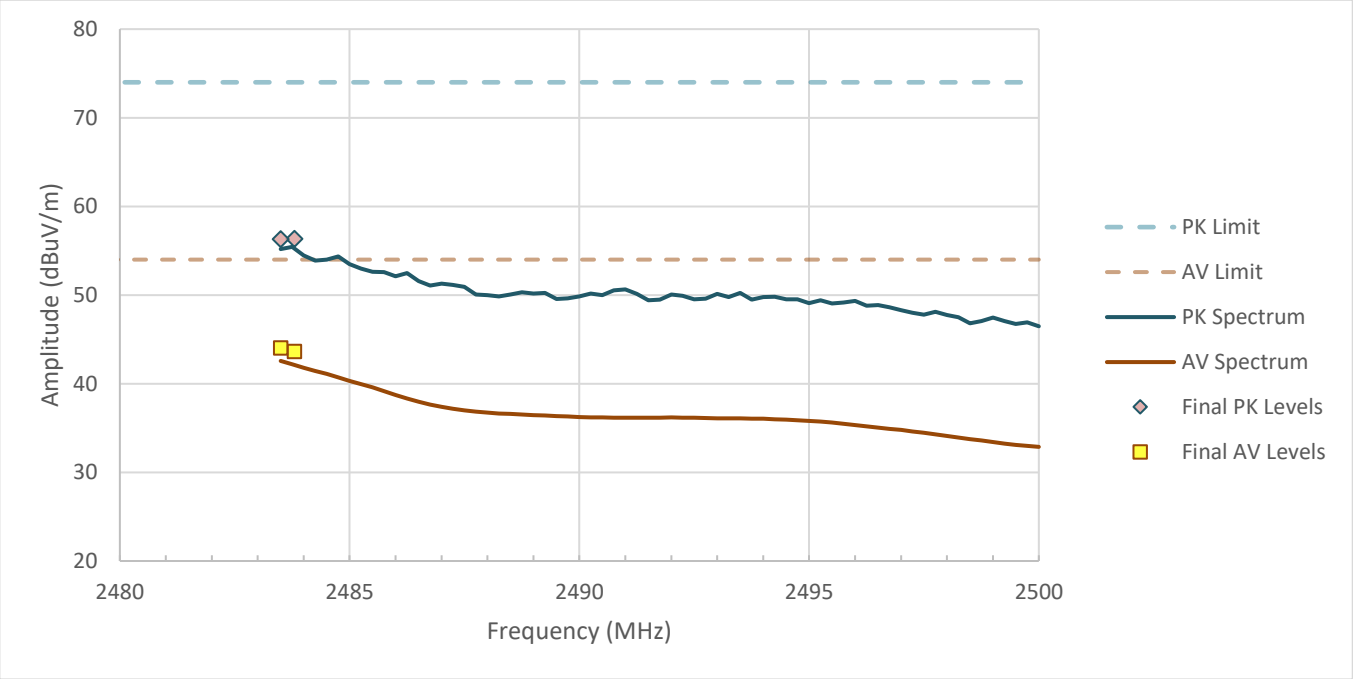


Figure RE04.3: FCC restricted band spectral data from 2483.5 to 2500 MHz Ch 12

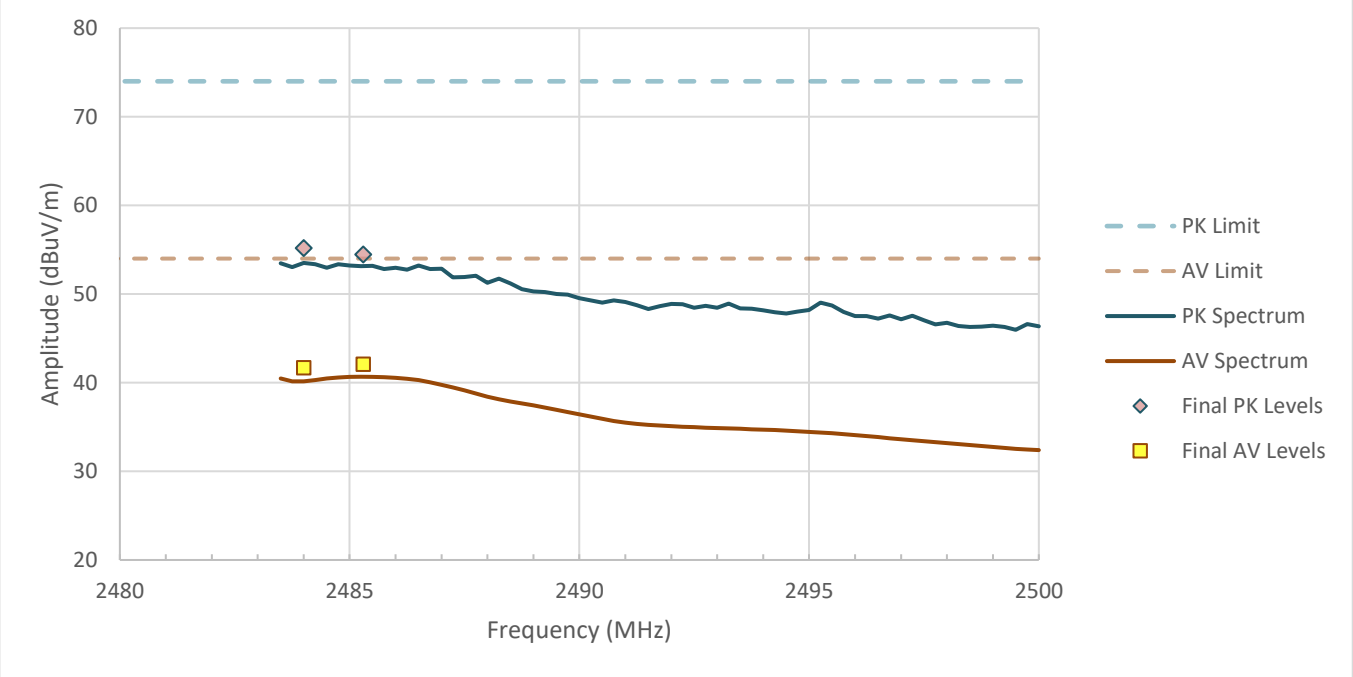


Figure RE04.4: FCC restricted band spectral data from 2483.5 to 2500 MHz Ch 13

Setup Photographs

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

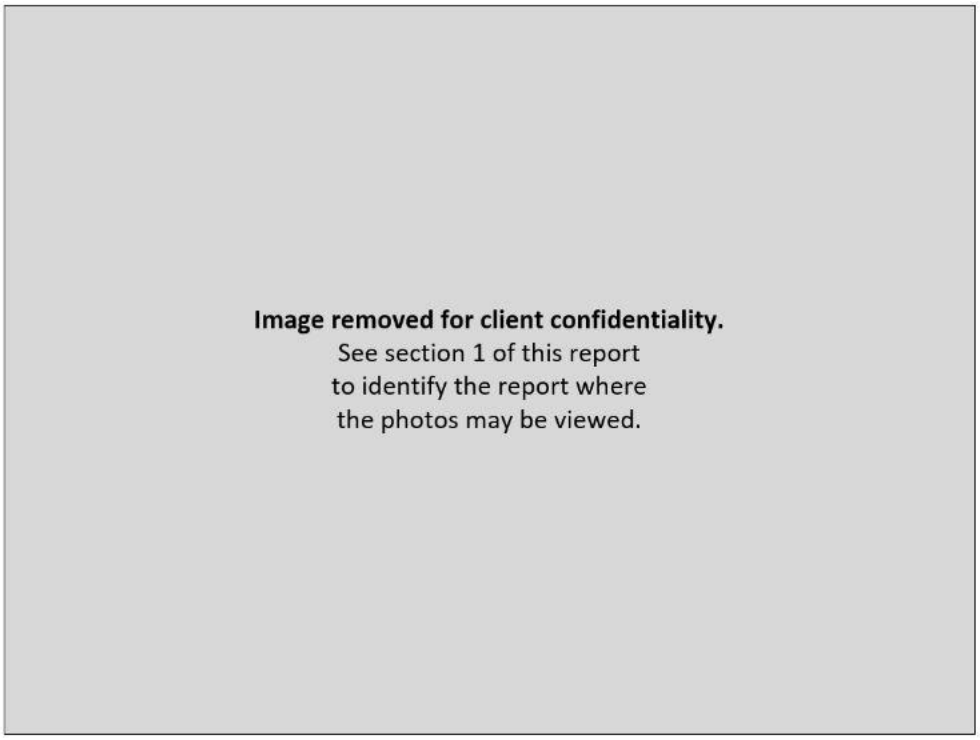


Figure RE04.5: EUT test setup X orientation (front view)

Figure RE04.6: EUT test setup X orientation (rear view)

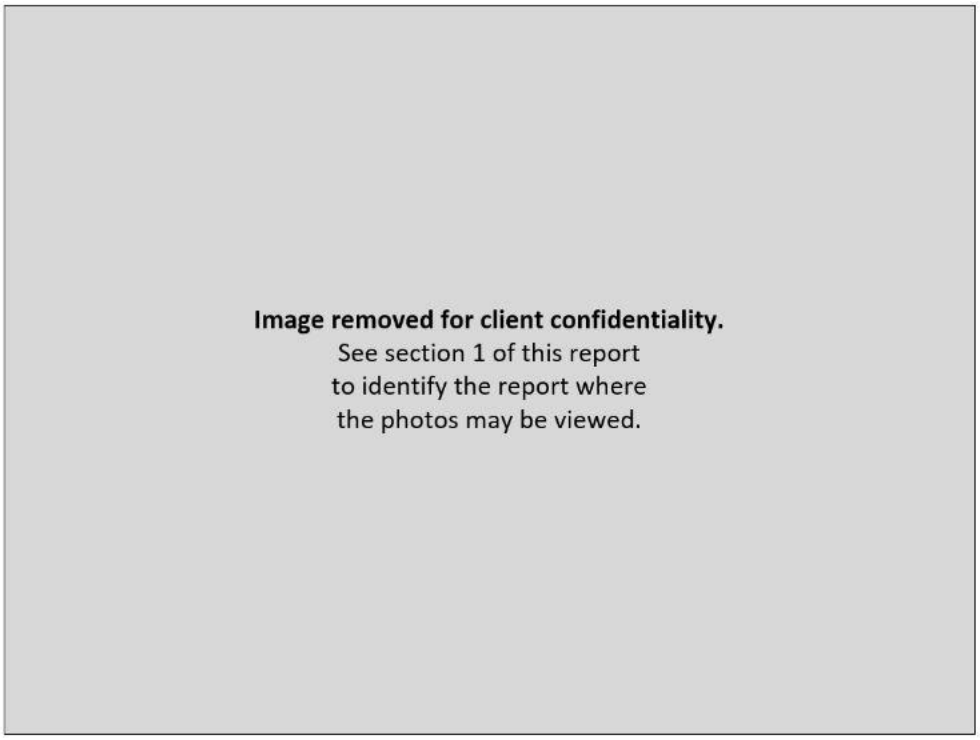


Figure RE04.7: EUT test setup Z orientation (front view)

Figure RE04.8: EUT test setup Z orientation (rear view)

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test IDs TR05, TR06
Project GCL-0457

Test Date(s)	10 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M3 (Ble Tx), M5 (ANT Tx)
Arrangement	A2 (Upwr)
Input Power	5Vdc
Test Standards:	FCC Part 15, ANSI C63.10, AS/NZS 4268, RSS-GEN, RSS-210, (as noted in Section 6 of the report).
Antenna Gain	-0.3 dBi, as reported by the client
Radio Protocol	Bluetooth Low Energy (BLE), ANT
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**25 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 TR05.1: Test equipment used

Software Used: Keysight PXE software A.35.06

Test Method

The basic test standards provide options for the test method. The following test methods were applied.

ANSI C63.10: PKPSD (11.10.2)

Test Setup

This block diagram shows the test equipment setup.

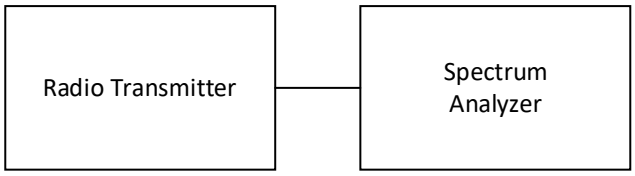


Figure TR05.1: Test setup

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 8 dBm / 3 kHz,

and meeting the limit with higher resolution bandwidths is permitted. All data met the limit using a 3 kHz resolution bandwidth.

For BLE operating at 2 Mbps, the lowest operating frequency was 2404 MHz, and the highest operating frequency was 2478 MHz. For all other Bluetooth, BLE, and ANT radios reported here, the lowest operating frequency was 2402 MHz, and the highest operating frequency was 2480 MHz.

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

	2402 (04)	2440	2480 (78)
BLE 1 Mbps	**-16.31**	**-11.01**	**-18.54**
BLE 2 Mbps	**-13.17**	**-12.94**	**-18.89**
ANT	**-18.79**	**-12.57**	**-20.24**

Table TR05.2: Summary of results

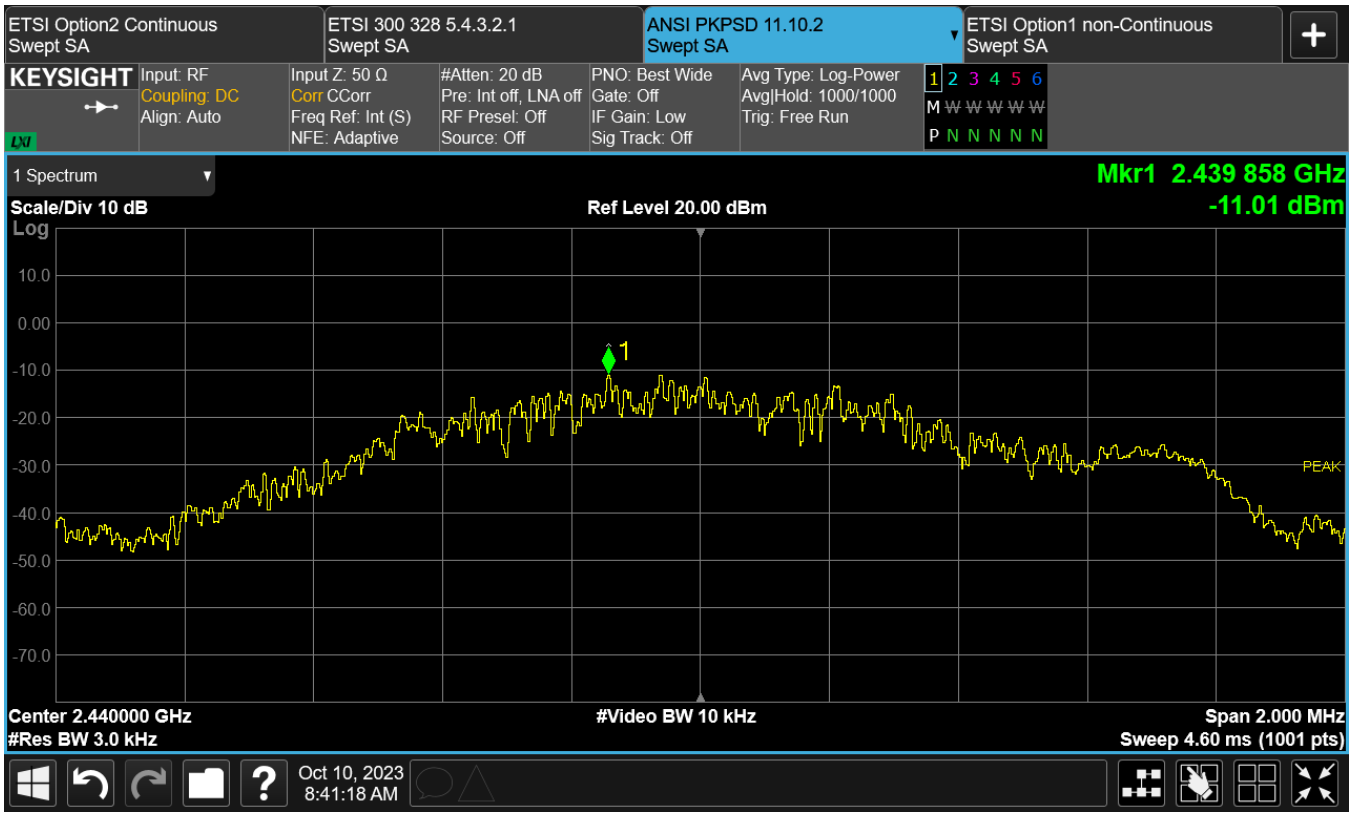


Figure TR05.2: Test data for BLE 1 Mbps, 2440 MHz

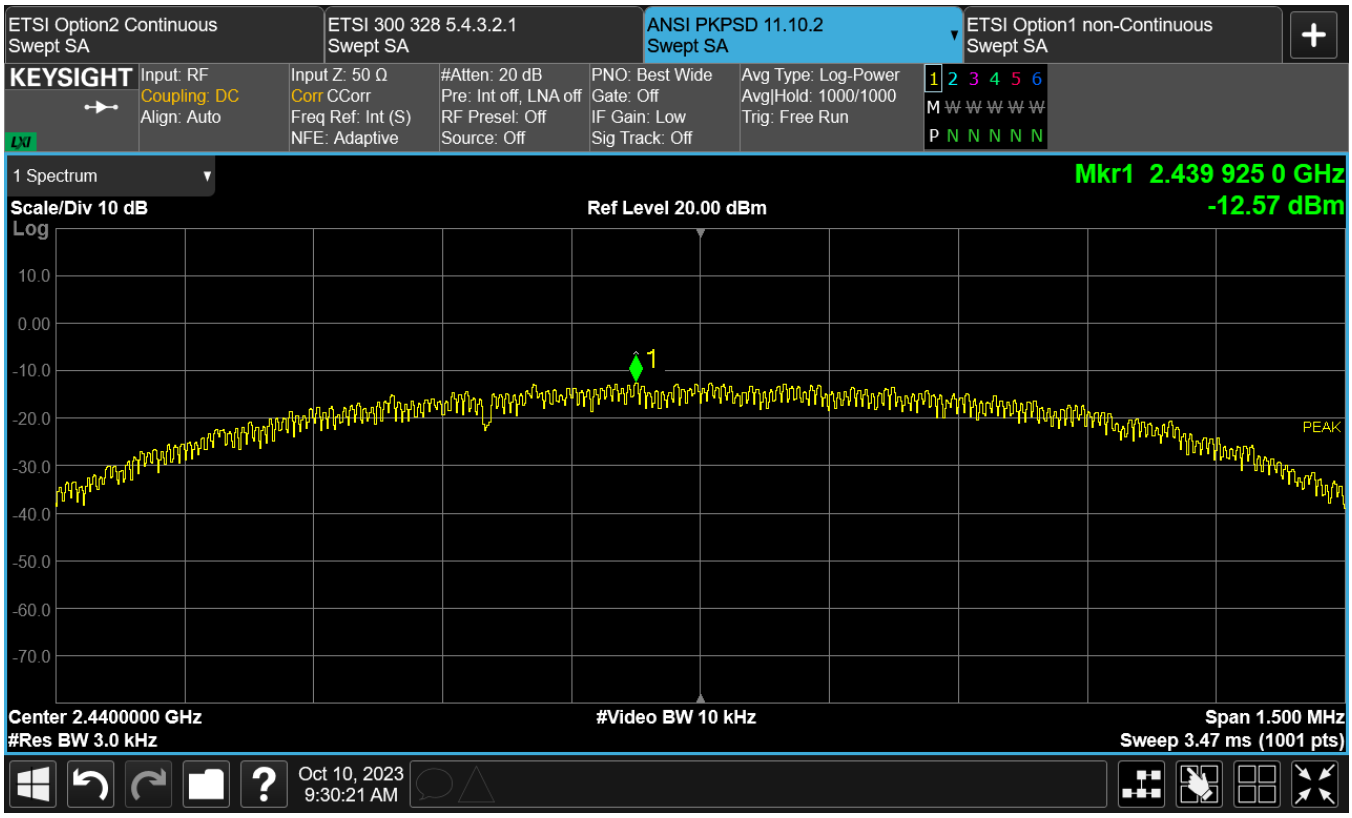


Figure TR05.3: Test data for ANT, 2440 MHz

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test ID TR07
Project GCL-0457

Test Date(s)	10 Oct 2023
Test Personnel	Majid Farah assisted by David Kerr
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M7 (WiFi TX)
Arrangement	A2 (Upwr)
Input Power	5Vdc
Test Standards:	FCC Part 15, ANSI C63.10, AS/NZS 4268, RSS-GEN, RSS-210, RSS-247 (as noted in Section 6 of the report).
Antenna Gain	-0.3 dBi, as reported by the client
Radio Protocol	IEEE 802.11 b/g/n (WiFi)
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**25 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 TR07.1: Test equipment used

Software Used: Keysight PXE software A.35.06

Test Method

The basic test standards provide options for the test method. The following test methods were applied.

ANSI C63.10: PKPSD (11.10.2)

Test Setup

This block diagram shows the test equipment setup.

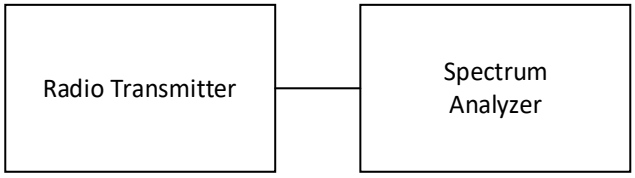


Figure TR07.1: Test setup

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 8 dBm / 3 kHz,

and meeting the limit with higher resolution bandwidths is permitted. All data met the limit using a 3 kHz resolution bandwidth.

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

	Ch1	Ch6	Ch11	Ch12	Ch13
B1	2.61	1.88	1.79	-4.50	-7.16
G18	-13.00	-11.18	-17.36	-21.00	-22.31
NMCS2	-13.21	-10.76	-17.52	-20.52	-22.20

Table TR07.2: Summary of results

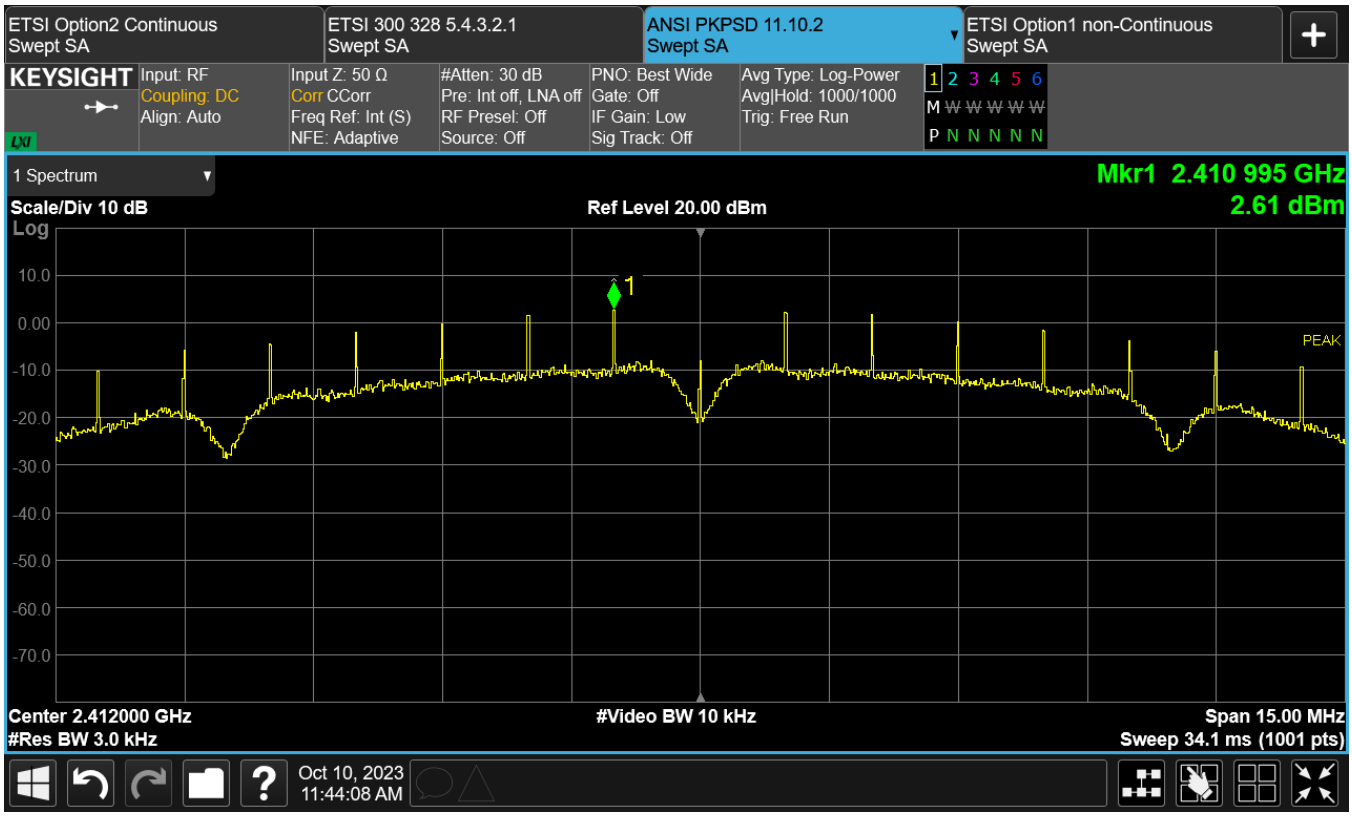


Figure TR07.2: Test data for IEEE 802.11 B1 modulation, channel 1

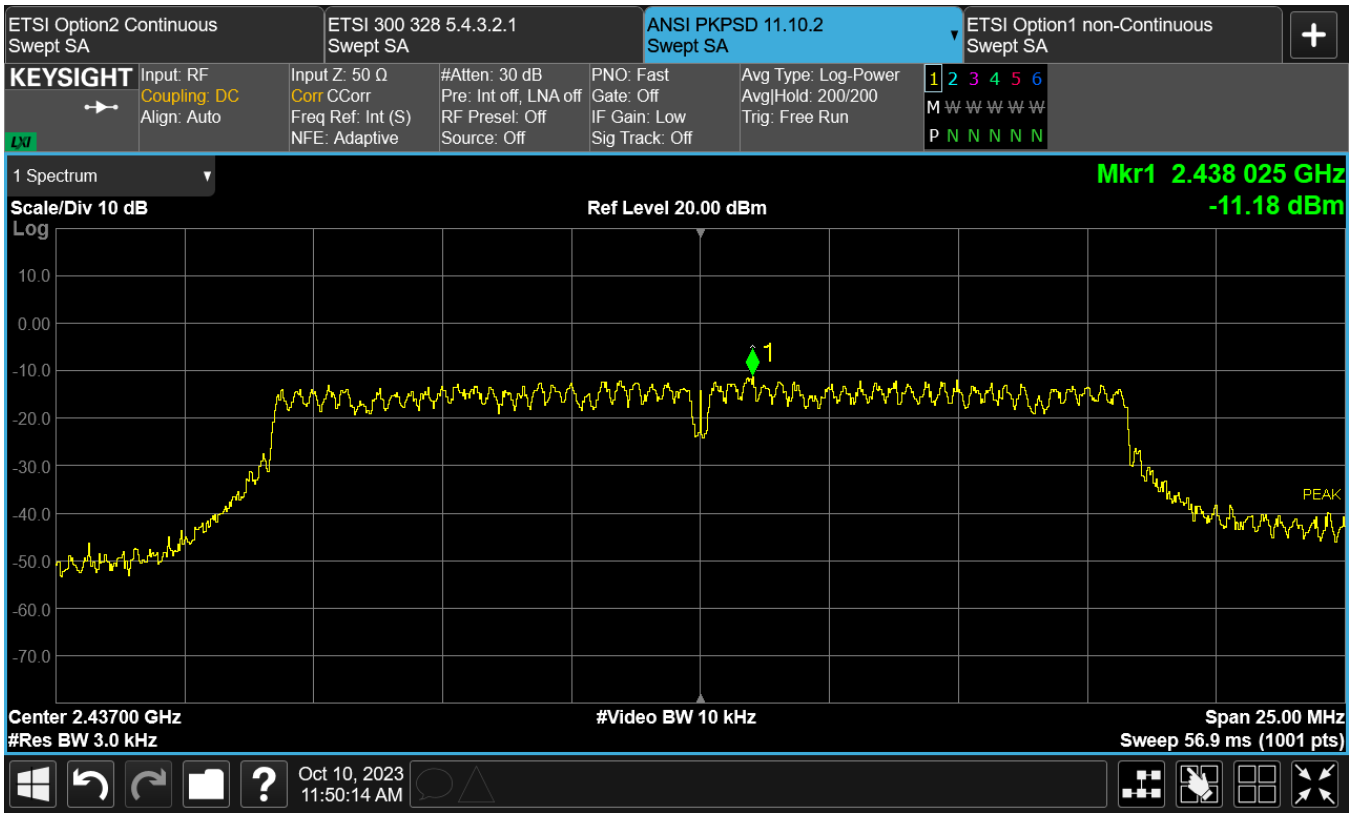


Figure TR07.3: Test data for IEEE 802.11 G18 modulation, Channel 6

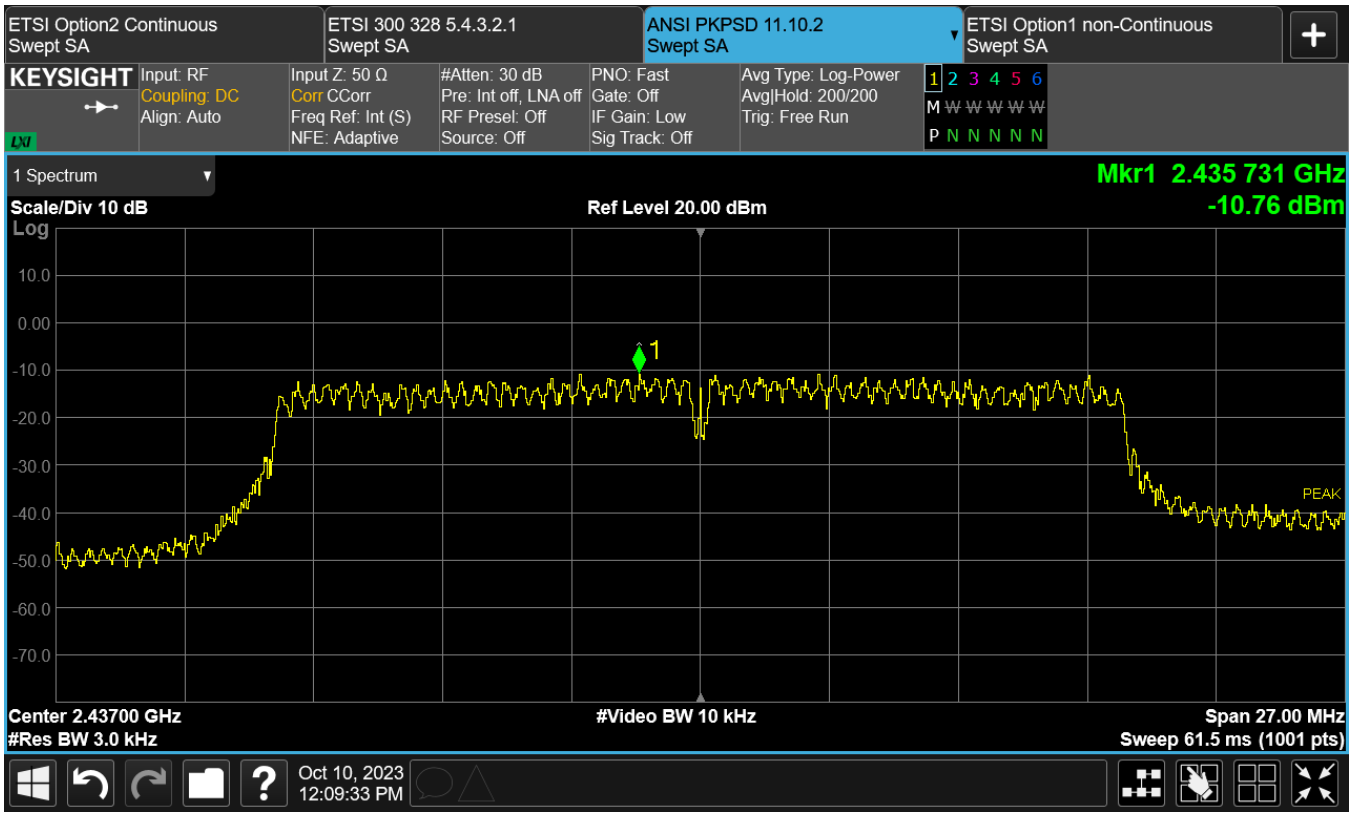


Figure TR07.5: Test data for IEEE 802.11 N MSC2 modulation, channel 6

This line is the end of the test record.

Test Record
Transmitter Stability in Extreme Conditions
Test IDs TR27
Project GCL-0457

Test Date(s)	15 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M5 (ANTTx)
Arrangement	A3 (Udata)
Nominal Input Power	5 Vdc
Test Standards:	FCC part 15, RSS-GEN, ANSI C63.10 (as noted in Section 6 of the report)
Radio Protocol	Bluetooth (BR, EDR2, EDR3), BLE (Bluetooth Low Energy), ANT
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date this record:	**20 Oct 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Thermometer	Thermco	ACCD370P	220608121	26-Aug-2022	1-Sep-2024
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
DMM Multimeter	FLUKE	79 III	71740743	5-Apr-2023	1-Apr-2024
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	15-Apr-2024
Thermal Chamber	Tenney	T2RC	32774-02	Calibration	Not Required

Table TR27.1: Equipment used

Software Used: PXE Software Revision A.33.03, FrequencyStabilityAnalysistemplateV1.xlsx

Test Method

The standards cited require observation of the stability for transmission frequency and/or power at certain environmental extremes. The reference is performance on nominal input voltage and a temperature of 20 °C. Where the standards cited here impose different limits or conditions, the most stringent limits and conditions have been applied.

The acceptance criterion is that the 6 dBc Occupied Bandwidth of the modulated signal should remain within the 2400-2483.5 MHz radio band. The ANT transmit mode was selected to also represent Bluetooth and BLE because they use the same transmitting hardware and ANT showed emissions closest to the band edge during prior bandwidth testing.

Test Data

The test sample(s) were subjected to extreme conditions and performed as shown below. Yellow highlights indicate the highest level for a protocol, for which an image of the spectrum is also provided. In the spectral plots, the data

sets have been combined to present the low and high channel results side by side. Orange diamond markers indicate the spectral peak, which the black square markers are at the 2400 MHz or 2483.5 MHz band edge.

Tx Mode	Temp	Volts	Low Ch.	High Ch.
Bluetooth	˚C	Vdc	dBc	dBc
ANT	50	5	25.6	41.6
ANT	40	5	24.3	41.6
ANT	30	5	25.2	41.0
ANT	20	5	25.4	40.8
ANT	10	5	25.6	43.1
ANT	0	5	23.9	42.1
ANT	-10	5	24.0	42.7
ANT	-20	5	24.3	42.0

Table TR27.2 Difference between peak and band edge levels for ANT transmissions during temperature variations

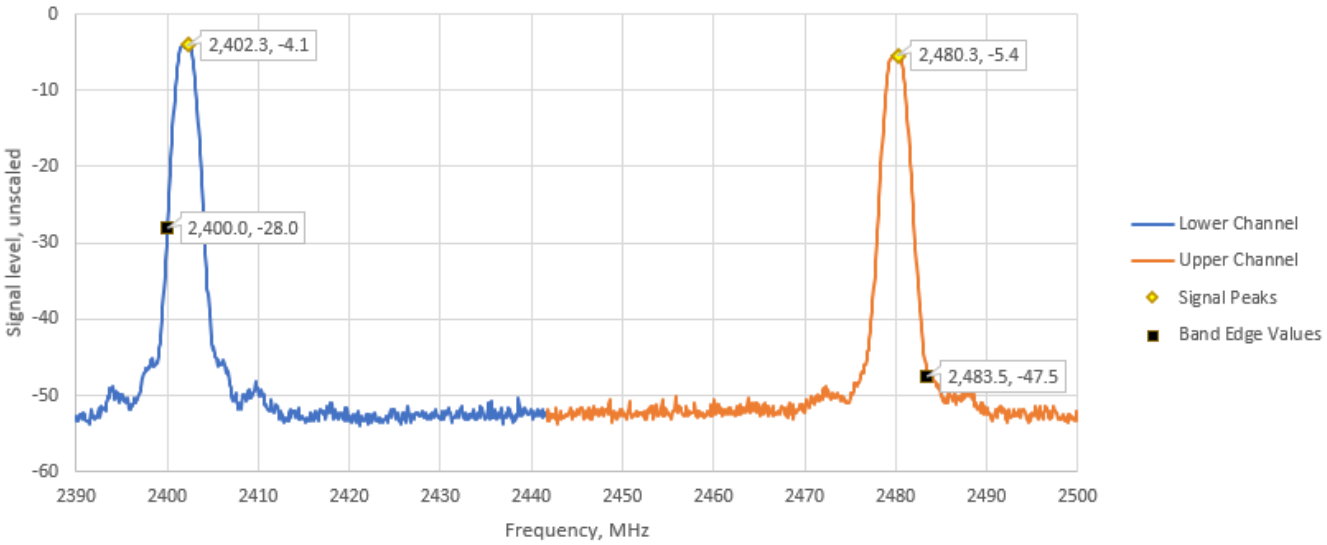


Figure TR27.1: Spectral data for ANT at 0°C which represent low and high channel

Tx Mode	Temp	Volts	Low Ch.	High Ch.
Bluetooth	˚C	Vdc	dBc	dBc
ANT	20	4.25	25.5	42.4
ANT	20	5	25.4	40.8
ANT	20	5.75	25.5	42.5

Table TR27.3 Difference between peak and band edge levels for ANT transmissions at 20 °C during voltage variations

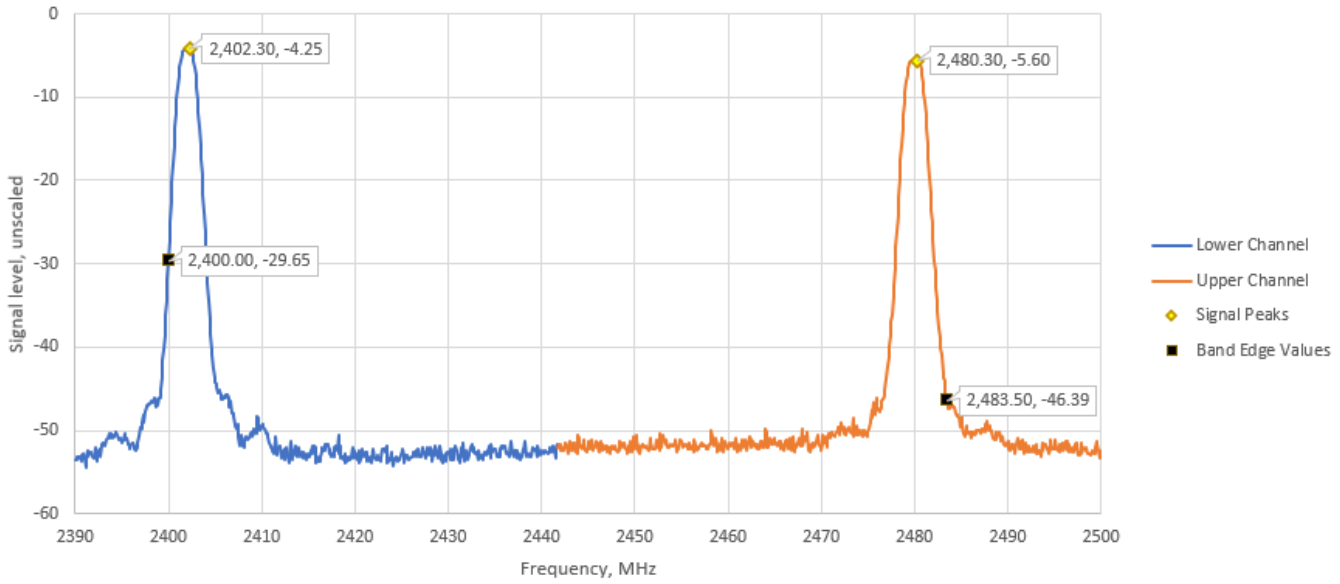


Figure TR27.2: Spectral data for ANT at 20 °C which represent low and high channel

Setup Block Diagram

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

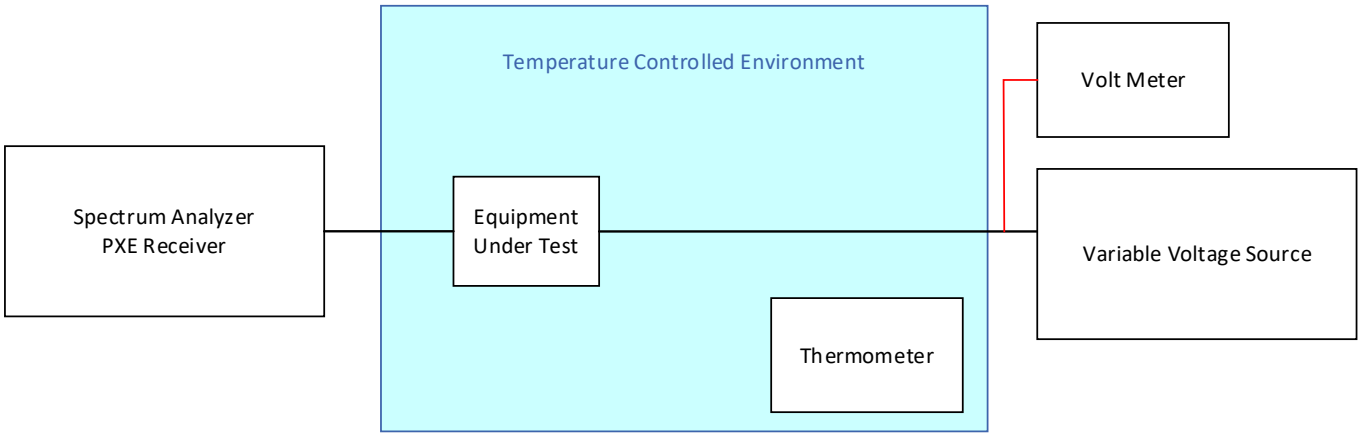


Figure TR27.3: Schematic drawing of the test equipment setup

This line is the end of the test record.

Test Record
Transmitter Stability in Extreme Conditions
Test IDs TR28
Project GCL-0457

Test Date(s)	15 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M5 (WifiTx)
Arrangement	A3 (Udata)
Nominal Input Power	5 Vdc
Test Standards:	FCC part 15, RSS-GEN, ANSI C63.10 (as noted in Section 6 of the report)
Radio Protocol	WiFi (IEEE 802.11 b/g/n)
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date this record:	**20 Oct 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Thermometer	Thermco	ACCD370P	220608121	26-Aug-2022	1-Sep-2024
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
DMM Multimeter	FLUKE	79 III	71740743	5-Apr-2023	1-Apr-2024
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	15-Apr-2024
Thermal Chamber	Tenney	T2RC	32774-02	Calibration	Not Required

Table TR28.1: Equipment used

Software Used: PXE Software Revision A.33.03, FrequencyStabilityAnalysistemplateV1.xlsx

Test Method

The standards cited require observation of the stability for transmission frequency and/or power at certain environmental extremes. The reference is performance on nominal input voltage and a temperature of 20 °C. Where the standards cited here impose different limits or conditions, the most stringent limits and conditions have been applied.

The acceptance criterion is that the 6 dBc Occupied Bandwidth of the modulated signal should remain within the 2400-2483.5 MHz radio band. The modes utilized include those that showed emissions closest to the band edge during prior bandwidth testing.

Test Data

The test sample(s) were subjected to extreme conditions and performed as shown below. Yellow highlights indicate the highest level for a protocol, for which an image of the spectrum is also provided. In the spectral plots, the data

sets have been combined to present the low and high channel results side by side. Orange diamond markers indicate the spectral peak, which the black square markers are at the 2400 MHz or 2483.5 MHz band edge.

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
N MCS0	50	5	41.5	47.6	41.8
N MCS0	40	5	41.1	44.8	41.4
N MCS0	30	5	41.1	45.2	42.5
N MCS0	20	5	39.7	45.4	41.9
N MCS0	10	5	40.5	45.5	41.2
N MCS0	0	5	40.4	46.2	42.2
N MCS0	-10	5	41.3	46.3	41.9
N MCS0	-20	5	40.6	43.9	42.9

Table TR28.2 Difference between peak and band edge levels for IEEE 802.11 n MCS0 at 20 °C transmissions during temperature variations

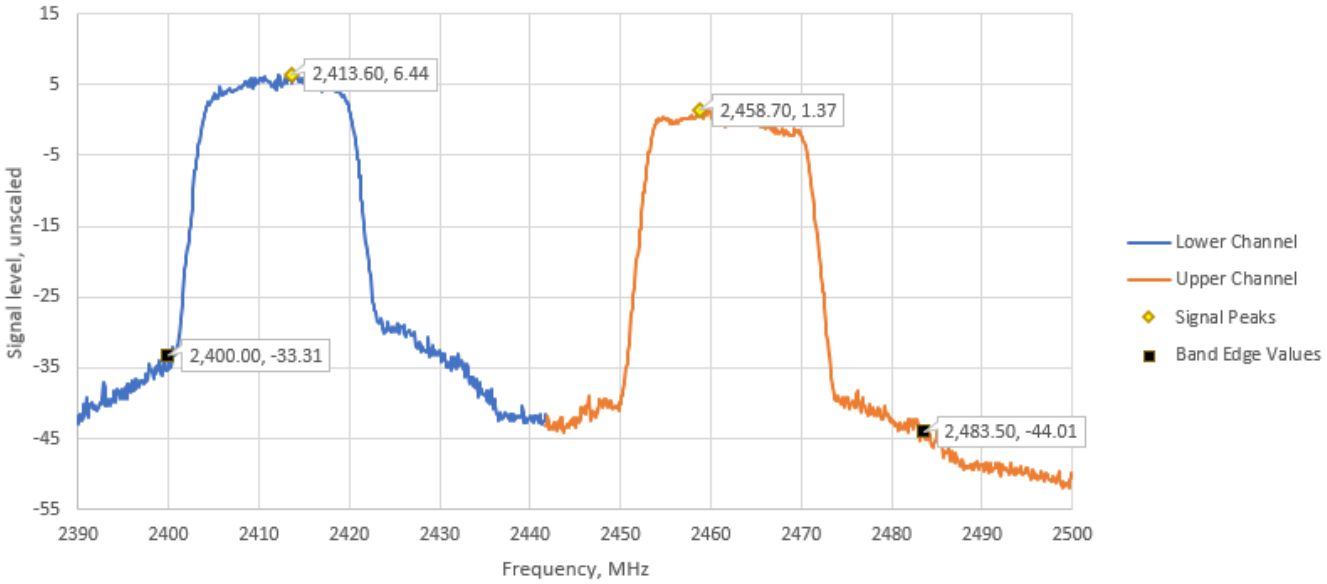


Figure TR28.1: Spectral data for IEEE 802.11 n MCS0 at 20 °C at 0°C which represent Ch1 and Ch11

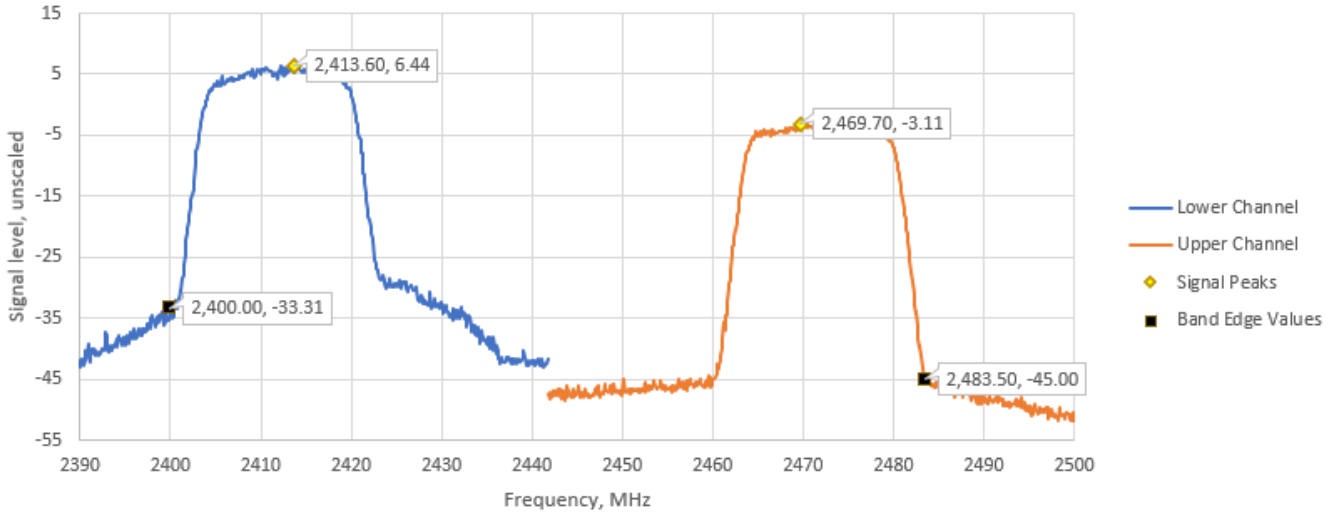


Figure TR28.2: Spectral data for IEEE 802.11 n MCS0 at 20 °C at 0°C which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
N MCS6	20	4.25	41.1	46.6	41.9
N MCS6	20	5	39.7	45.4	41.9
N MCS6	20	5.75	40.1	46.8	41.8

Table TR28.3 Difference between peak and band edge levels for IEEE 802.11 n MCS0 transmissions at 20 °C during voltage variations

Spectral data for IEEE 802.11 n MCS0 at 20 °C which represent Ch1, Ch11 and Ch13 are same as shown in figure TR28.1 and figure TR28.2.

Setup Block Diagram

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

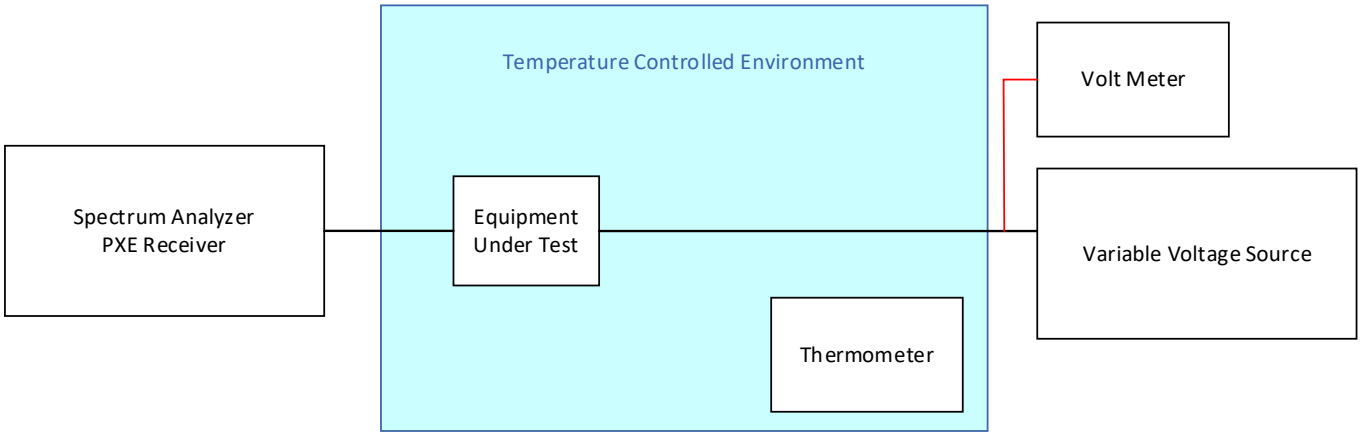


Figure TR28.3: Schematic drawing of the test equipment setup

This line is the end of the test record.

Test Record
Radiated Emission Test RE05
Project GCL0457

Test Date(s)	14 Oct 2023
Test Personnel	David Kerr
Product Model	AA4714
Serial Number tested	3453413922
Operating Mode	M7 (Wifi Tx)
Arrangement	A2 (Upwr)
Input Power	5 Vdc (USB)
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:	**David A Kerr**
Date of this record:	**14 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	00233201	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

RE05.1: Test Equipment Used

Software Used:
N9048B Keysight PXE firmware version 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	Pol.	Reading	Factor	Level	Limit	Margin	Height	Angle
MHz		dB(µV)	dB(1/m)	dB(µV/m)	dB(µV/m)	dB	cm	deg
		QP		QP	QP	QP		
942.870	H	0.9	36.8	37.7	46.0	8.3	379.4	67.0
52.050	V	7.7	13.9	21.6	40.0	18.4	100.0	208.0
76.860	V	4.8	14.5	19.3	40.0	20.7	104.4	333.0
52.020	V	7.5	13.9	21.4	40.0	18.6	104.4	129.0
107.610	V	6.5	16.6	23.1	43.5	20.4	104.4	353.0
266.010	V	1.5	22.5	24.0	46.0	22.0	151.4	319.0
51.420	V	8.1	14.0	22.1	40.0	17.9	100.0	204.0

Table RE05.2: Emission summary (Ch1 B11)

Frequency	Pol.	Reading	Factor	Level	Limit	Margin	Height	Angle
MHz		dB(µV)	dB(1/m)	dB(µV/m)	dB(µV/m)	dB	cm	deg
		QP		QP	QP	QP		
194.340	H	7.8	18.3	26.1	43.5	17.4	166.3	269.0
47.370	V	8.7	14.6	23.3	40.0	16.7	100.0	126.0
53.640	V	9.5	14.0	23.5	40.0	16.5	100.0	169.0
81.180	V	5.9	14.3	20.2	40.0	19.8	135.2	56.0
107.640	V	6.5	16.6	23.1	43.5	20.4	100.0	354.0
942.480	V	0.9	36.8	37.7	46.0	8.3	383.4	179.0

Table RE05.3: Emission summary (Ch6 B11)

Frequency	Pol.	Reading	Factor	Level	Limit	Margin	Height	Angle
MHz		dB(µV)	dB(1/m)	dB(µV/m)	dB(µV/m)	dB	cm	deg
		QP		QP	QP	QP		
194.340	H	8.3	18.3	26.6	43.5	16.9	174.9	106.0
47.340	V	8.3	14.6	22.9	40.0	17.1	100.0	130.0
53.700	V	9.0	14.0	23.0	40.0	17.0	100.0	136.0
944.430	V	0.7	36.8	37.5	46.0	8.5	363.9	20.0
107.730	V	6.5	16.6	23.1	43.5	20.4	100.0	354.0
81.300	V	5.8	14.3	20.1	40.0	19.9	119.9	353.0

Table RE05.4: Emission summary (Ch11 B11)

Frequency	Pol.	Reading	Factor	Level	Limit	Margin	Height	Angle
MHz		dB(µV)	dB(1/m)	dB(µV/m)	dB(µV/m)	dB	cm	deg
		QP		QP	QP	QP		
204.000	H	10.3	19.1	29.4	43.5	14.1	153.0	101.0
938.700	H	0.7	36.7	37.4	46.0	8.6	114.1	0.0
47.280	V	8.6	14.6	23.2	40.0	16.8	100.0	176.0
53.640	V	9.9	14.0	23.9	40.0	16.1	100.0	169.0
95.400	V	6.6	15.6	22.2	43.5	21.3	100.0	235.0
107.520	V	6.4	16.6	23.0	43.5	20.5	104.4	55.0

Table RE05.5: Emission summary (Ch13 B11)

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

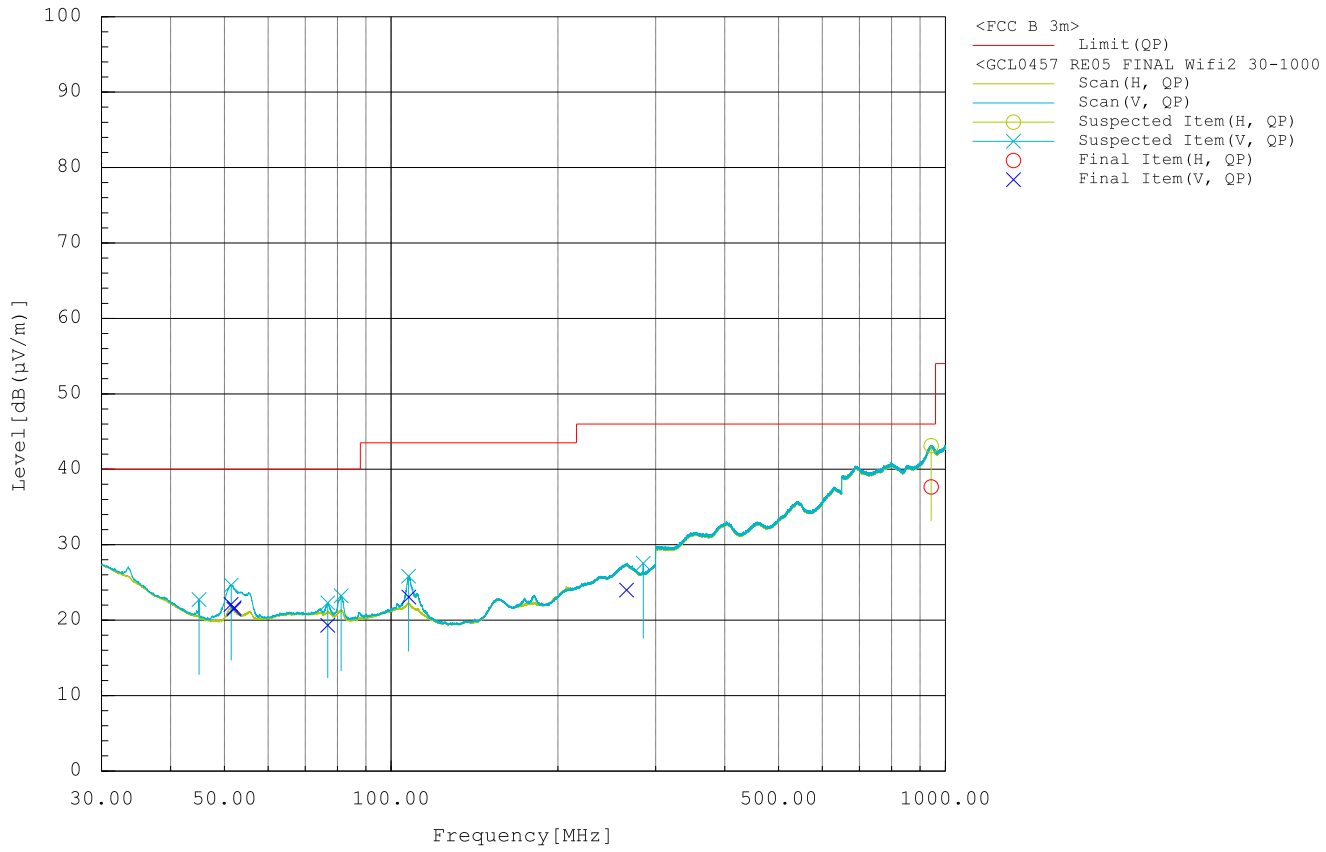


Figure RE05.1: Spectral data (Ch1 B11)

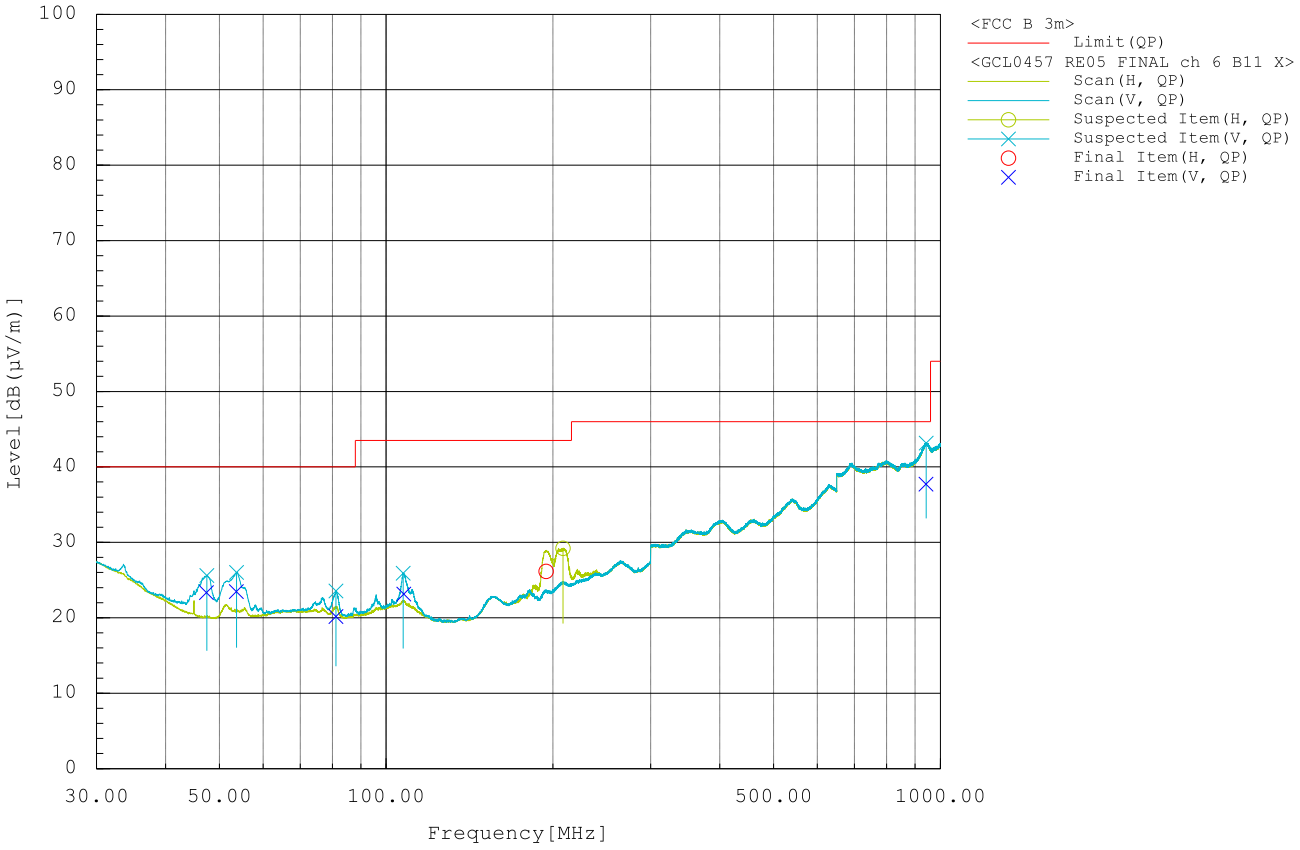


Figure RE05.2: Spectral data (Ch6 B11)

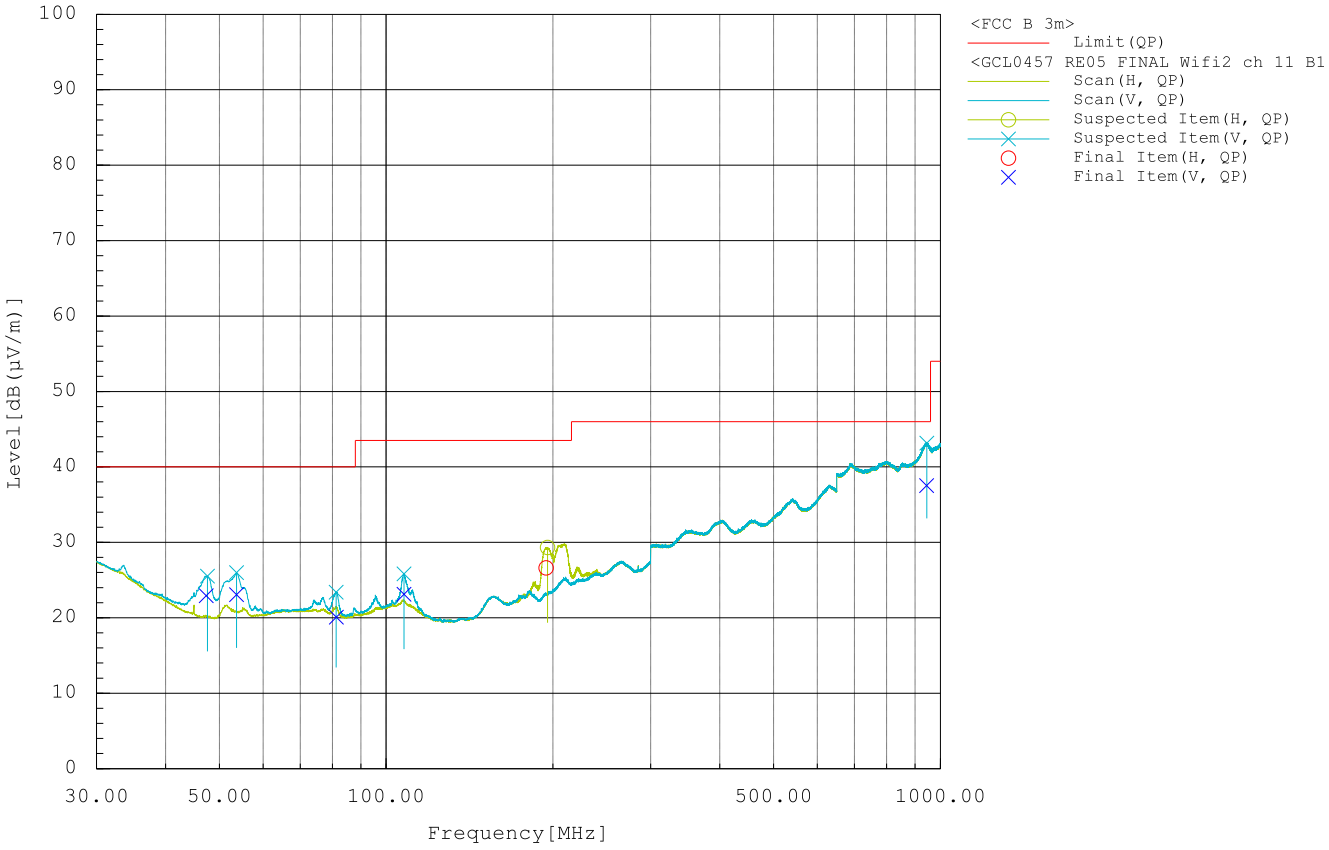


Figure RE05.3: Spectral data (Ch11 B11)

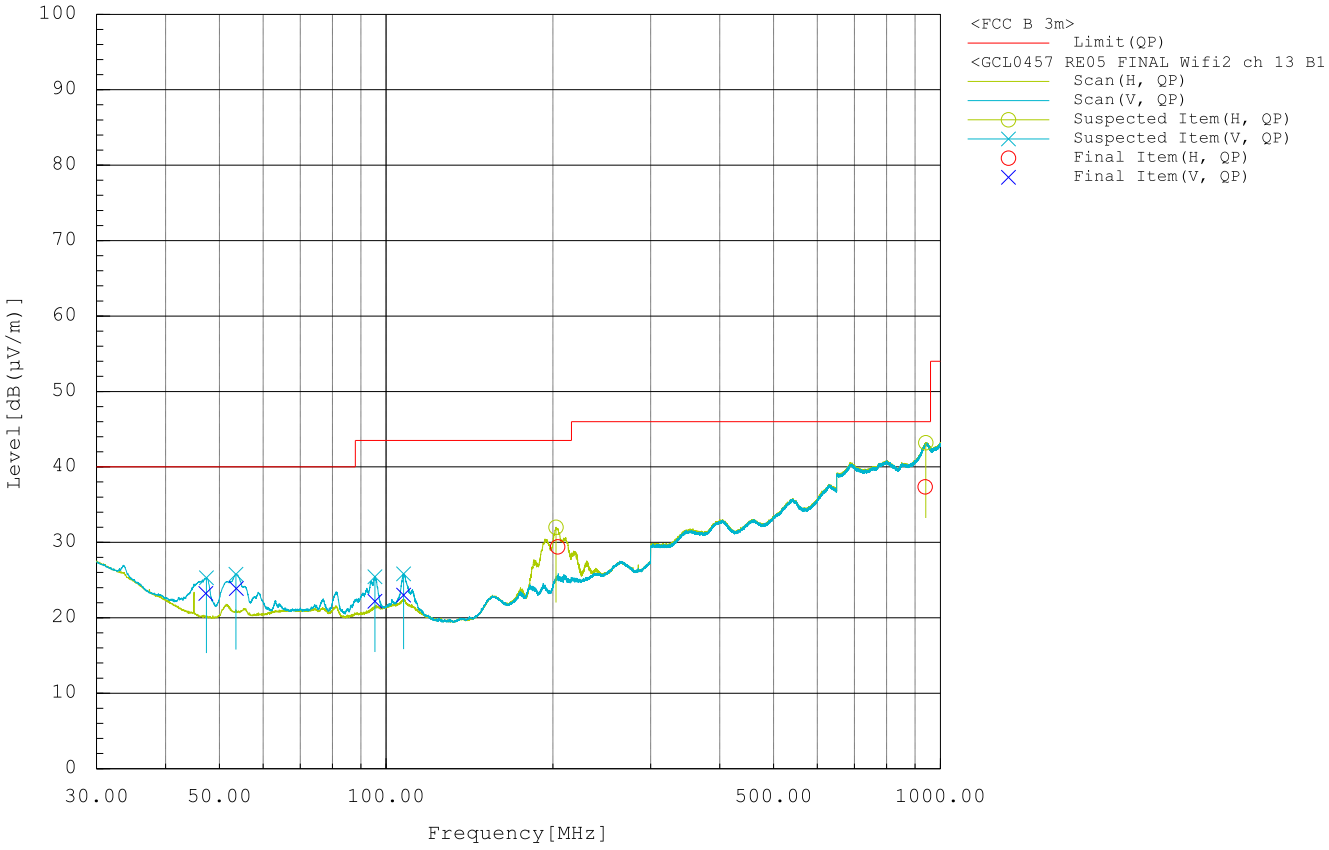
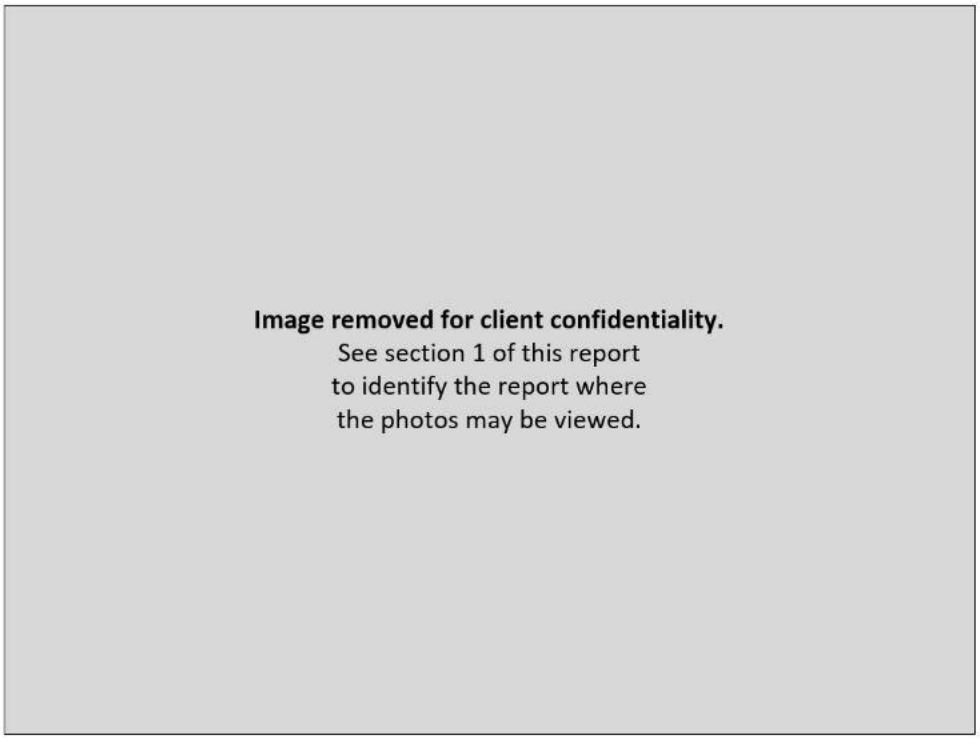


Figure RE05.4: Spectral data (Ch13 B11)

Setup Photographs

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



]

Figure RE05.5: EUT test setup, front view (Z orientation)

Figure RE05.6: EUT test setup, reverse view (Z orientation)

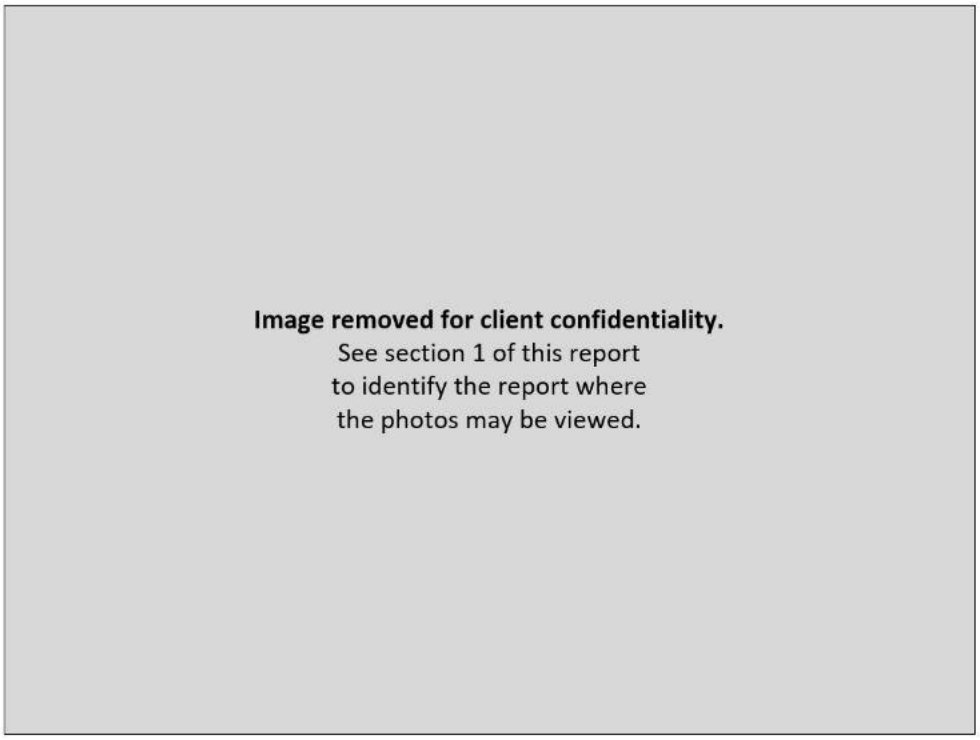


Figure RE05.7: EUT test setup, front view (X orientation)

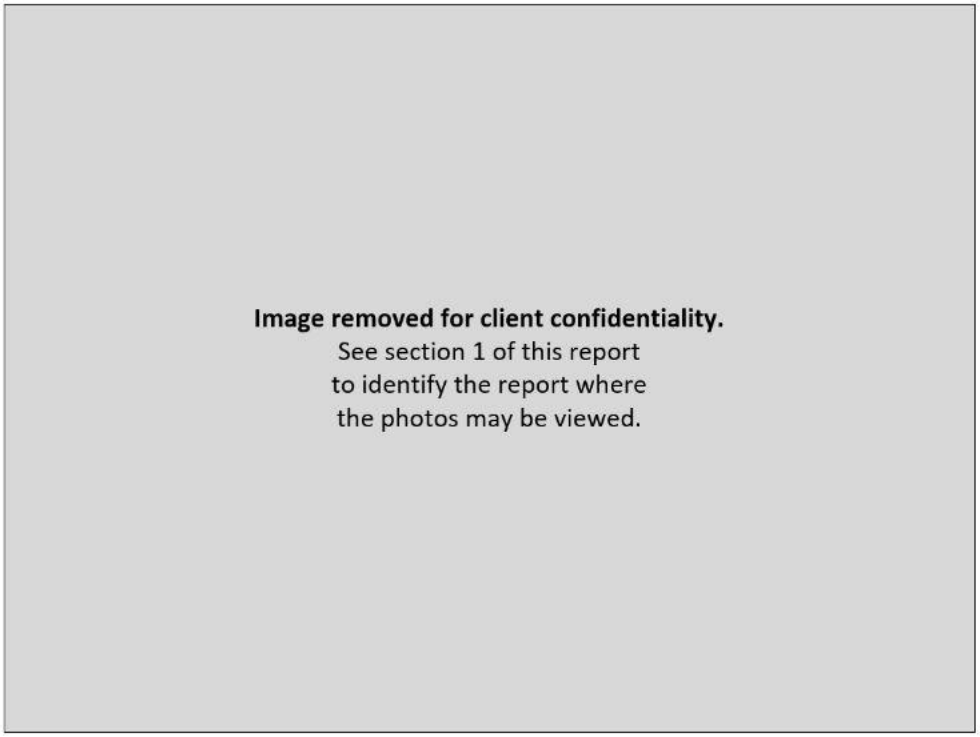


Figure RE05.8: EUT test setup, reverse view (X orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE06
Project GCL0457

Test Date(s)	09 Oct 2023
Test Personnel	Dave Kerr, Jim Solum
Product Model	AA4714
Serial Number tested	3453413922
Operating Mode	M7 (WiFi Tx)
Arrangement	A2 (Upwr)
Input Power	5 Vdc (USB)
Test Standards:	FCC Part 15, ANSI C63.10 (as noted in Section 6 of the report).
Frequency Range:	1 GHz to 2.2 GHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Dave Kerr, Jim Solum**
Date of this record:	**10 Oct 2023**

Original record, Version A.

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	10721	30-Aug-2023	1-Sep-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required

Table RE06.1: Test Equipment Used

Software Used: N9048B Keysight PXE firmware version A.33.03
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 tables show the selected final measurement data between 1000 MHz and 2200 MHz. 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	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(μV)		dB(1/m)	dB(μV/m)		dB(μV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
2056.500	V	32.5	45.7	-1.5	31.0	44.2	54.0	74.0	23.0	29.8	338.0	95.0
1964.750	V	32.5	46.0	-1.7	30.8	44.3	54.0	74.0	23.2	29.7	221.9	25.0
1781.000	H	32.2	45.5	-2.7	29.5	42.8	54.0	74.0	24.5	31.2	305.9	126.0
2149.000	H	32.5	46.3	-1.2	31.3	45.1	54.0	74.0	22.7	28.9	332.7	0.0
1306.000	H	31.7	45.5	-4.3	27.4	41.2	54.0	74.0	26.6	32.8	117.7	180.0
1194.000	H	31.9	45.4	-5.3	26.6	40.1	54.0	74.0	27.4	33.9	100.0	1.0

Table RE06.2: Emission summary (WiFi B11 Ch1)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(μV)		dB(1/m)	dB(μV/m)		dB(μV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
1274.250	V	31.8	45.1	-4.3	27.5	40.8	54.0	74.0	26.5	33.2	132.4	285.0
2034.000	V	32.3	45.6	-1.5	30.8	44.1	54.0	74.0	23.2	29.9	169.7	352.0
1568.500	H	31.9	45.4	-4.0	27.9	41.4	54.0	74.0	26.1	32.6	400.0	245.0
1766.750	H	32.1	45.5	-2.9	29.2	42.6	54.0	74.0	24.8	31.4	365.0	63.0
2126.000	H	32.5	46.0	-1.3	31.2	44.7	54.0	74.0	22.8	29.3	293.2	240.0
2157.250	H	32.4	45.8	-1.2	31.2	44.6	54.0	74.0	22.8	29.4	336.7	242.0

Table RE06.3: Emission summary (WiFi B11 Ch6)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(μV)		dB(1/m)	dB(μV/m)		dB(μV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
1409.250	V	31.8	45.3	-3.9	27.9	41.4	54.0	74.0	26.1	32.6	207.1	293.0
1047.250	H	31.4	44.8	-6.0	25.4	38.8	54.0	74.0	28.6	35.2	132.3	0.0
1132.750	H	31.8	45.5	-5.8	26.0	39.7	54.0	74.0	28.0	34.3	126.5	234.0
1597.000	H	32.0	45.4	-3.9	28.1	41.5	54.0	74.0	25.9	32.5	231.1	242.0
1996.500	H	32.3	46.0	-1.6	30.7	44.4	54.0	74.0	23.3	29.6	226.7	356.0
2067.750	H	32.4	46.0	-1.5	30.9	44.5	54.0	74.0	23.1	29.5	298.1	285.0

Table RE06.4: Emission summary (WiFi B11 Ch11)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(μV)		dB(1/m)	dB(μV/m)		dB(μV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
1052.500	V	31.2	44.5	-6.0	25.2	38.5	54.0	74.0	28.8	35.5	332.7	60.0
1493.500	V	31.9	45.2	-3.5	28.4	41.7	54.0	74.0	25.6	32.3	346.1	97.0
1857.750	V	32.1	45.3	-2.2	29.9	43.1	54.0	74.0	24.1	30.9	332.9	210.0
1222.000	H	31.6	45.3	-4.8	26.8	40.5	54.0	74.0	27.2	33.5	137.0	0.0
1493.000	H	31.9	45.7	-3.5	28.4	42.2	54.0	74.0	25.6	31.8	272.5	329.0
2132.500	H	32.4	46.1	-1.3	31.1	44.8	54.0	74.0	22.9	29.2	297.0	70.0

Table RE06.5: Emission summary (WiFi B11 Ch13)

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

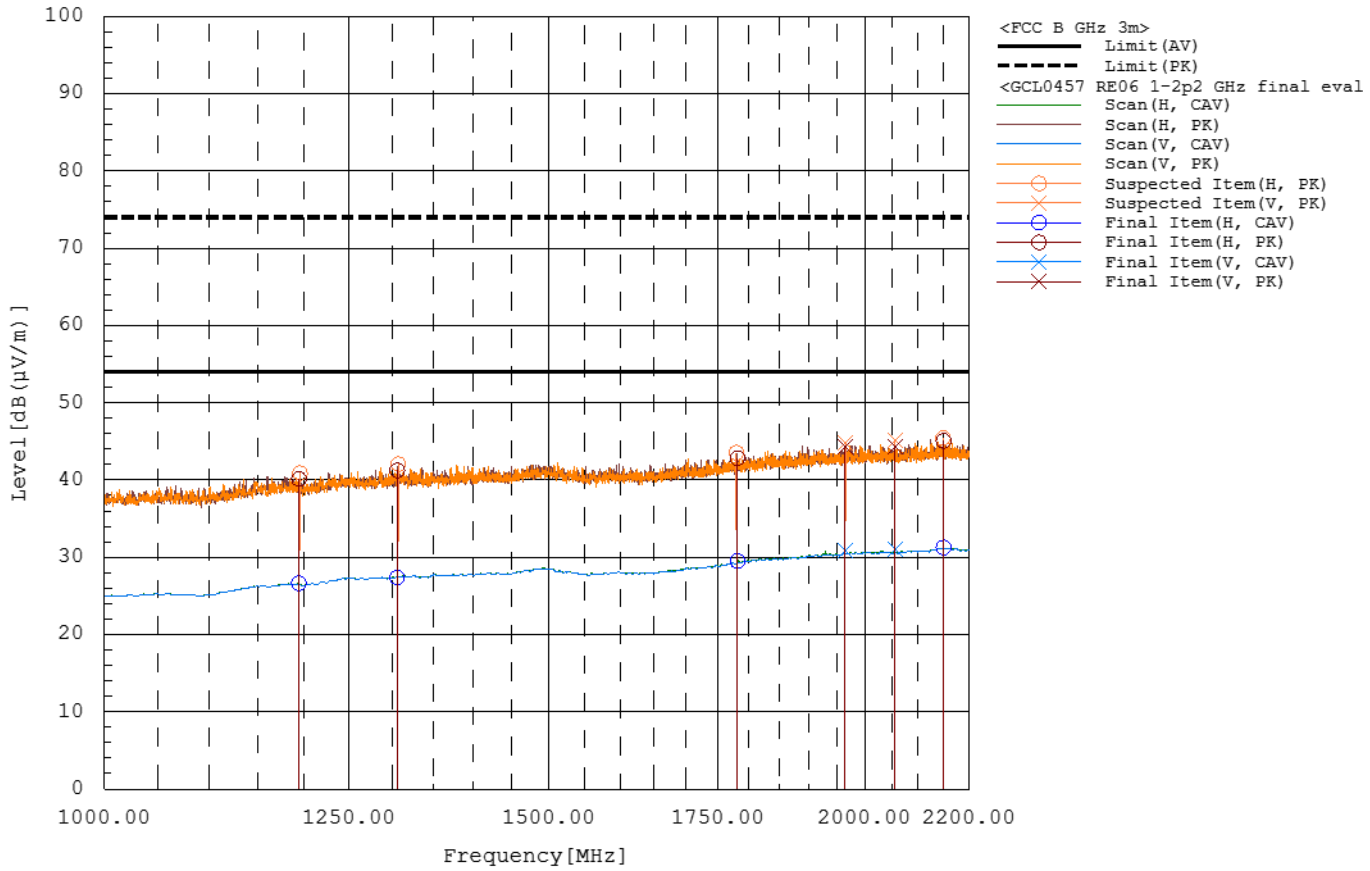


Figure RE06.1: Spectral data (WiFi B11 Ch1)

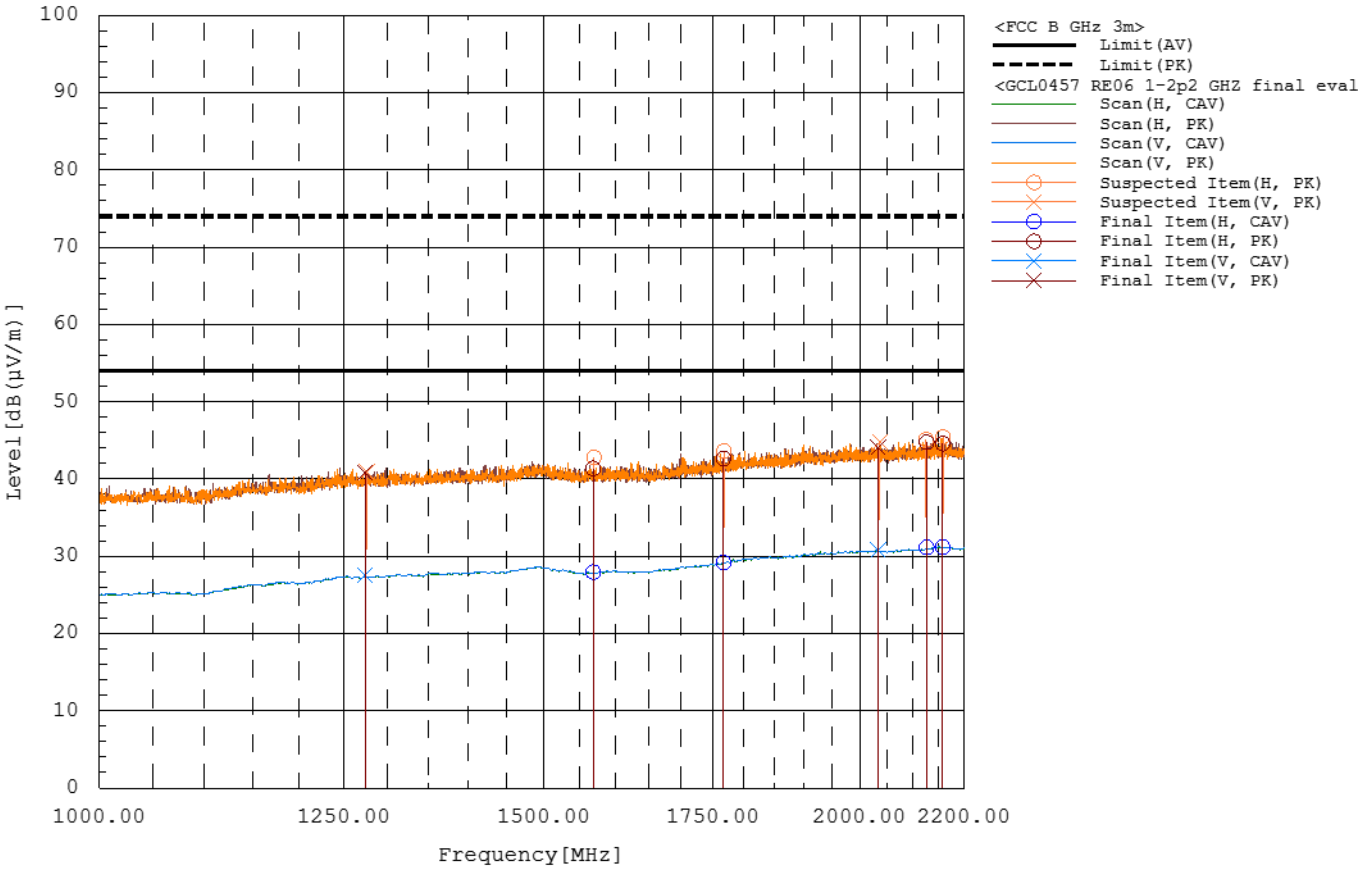


Figure RE06.2: Spectral data (WiFi B11 Ch6)

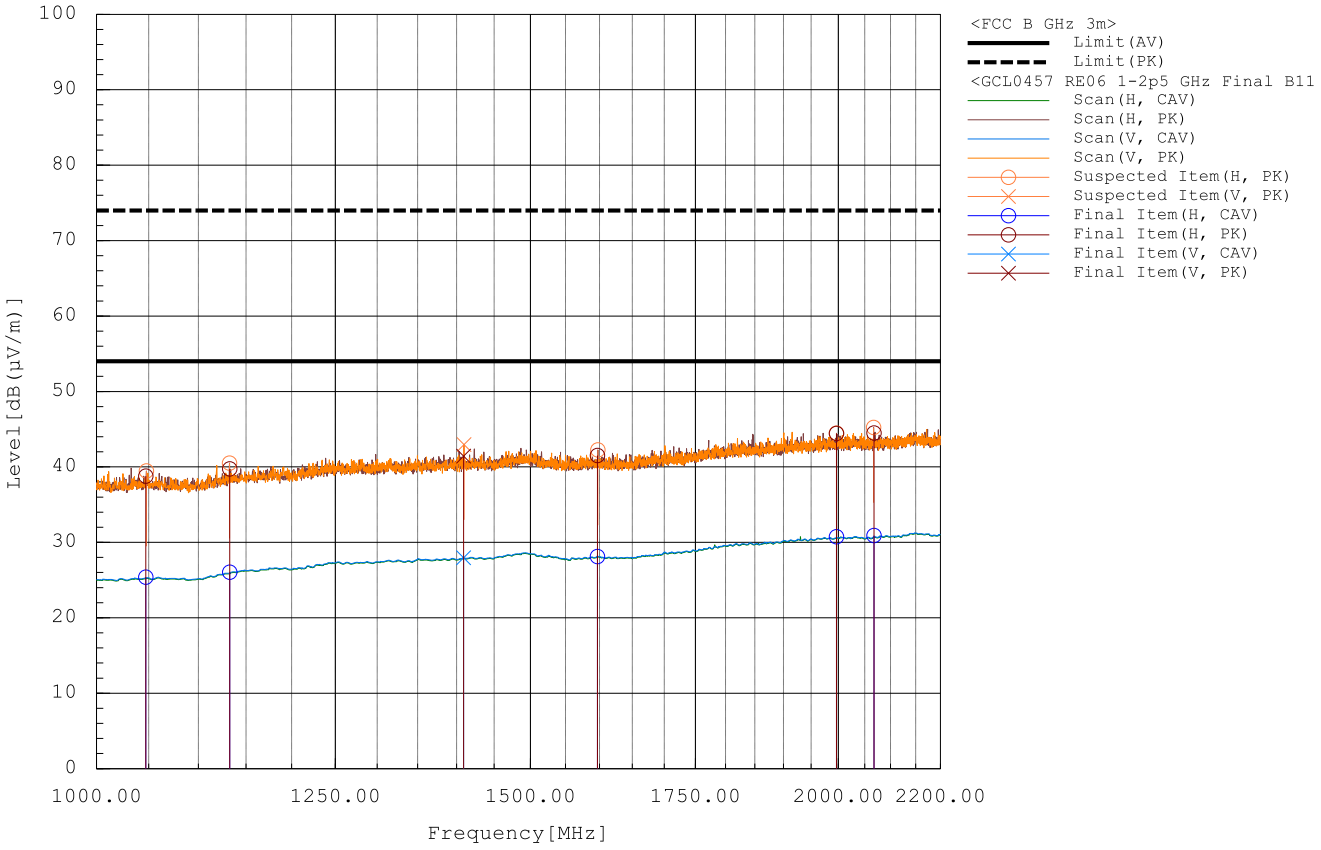


Figure RE06.3: Spectral data (WiFi B11 Ch11)

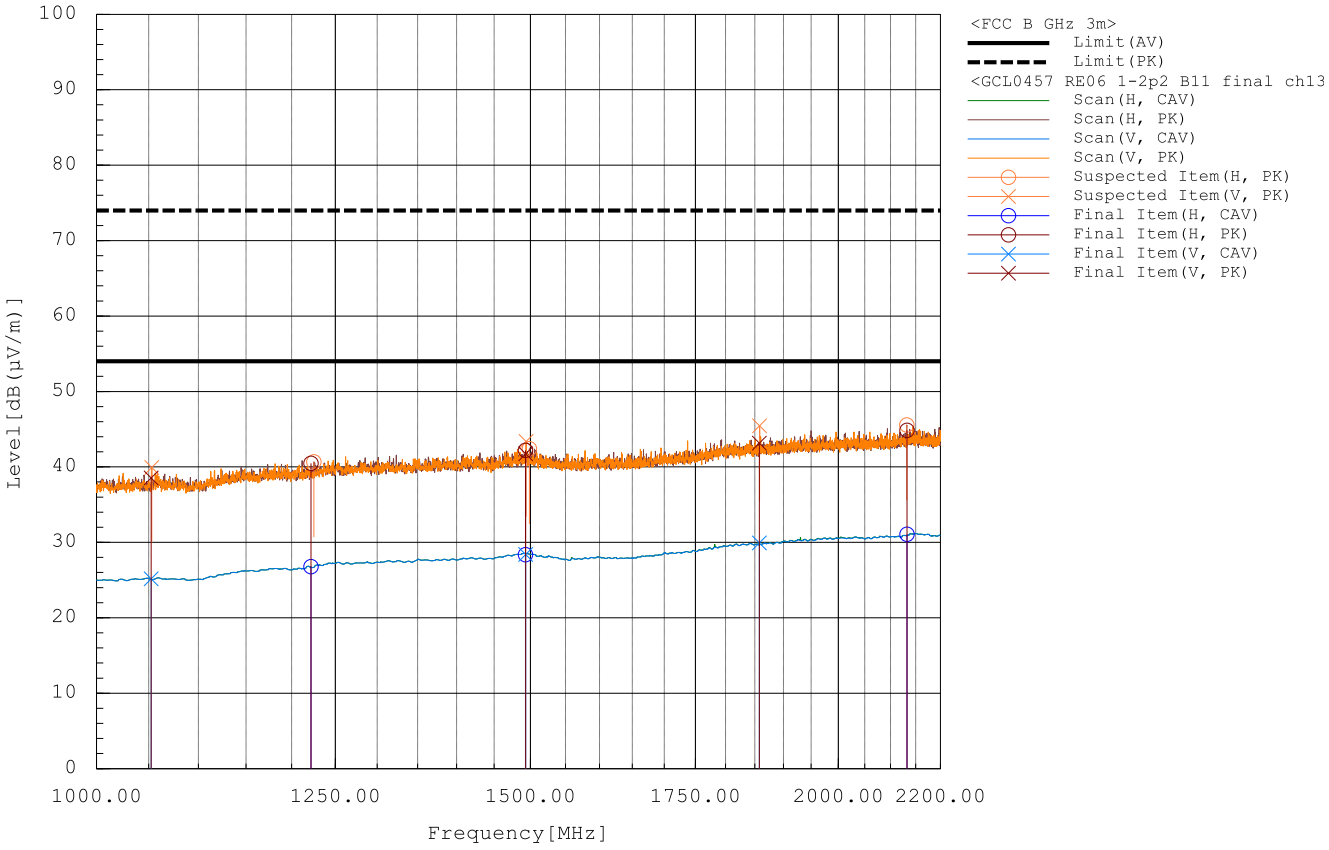


Figure RE06.4: Spectral data (WiFi B11 Ch13)

Setup Photographs

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

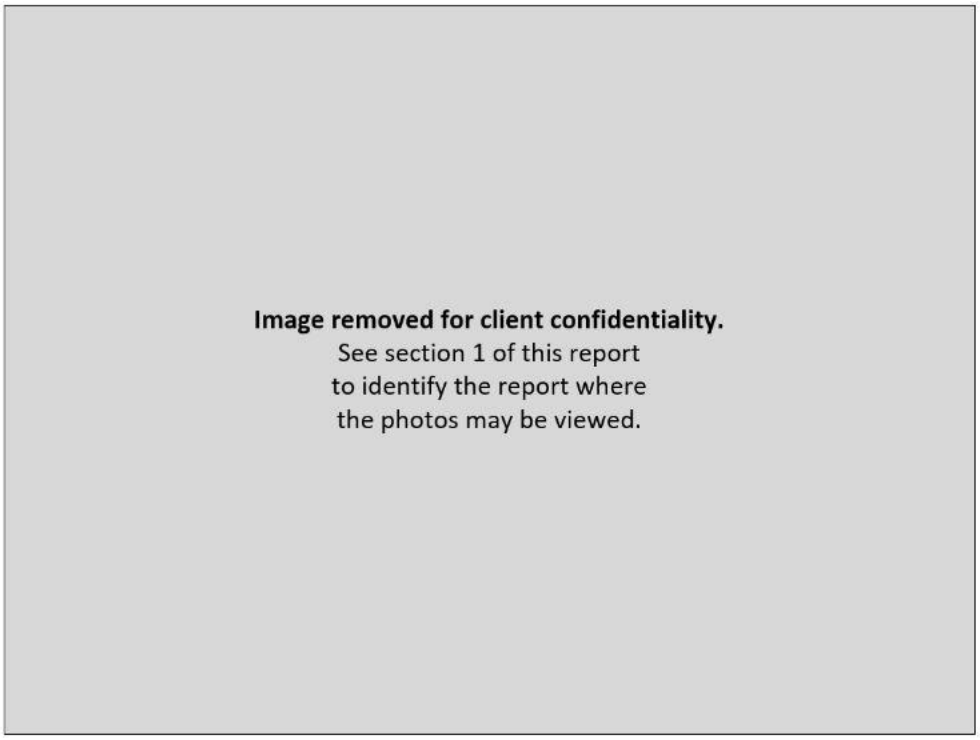


Figure RE06.5: EUT test setup, (WiFi B11 Ch1) Z orientation front view

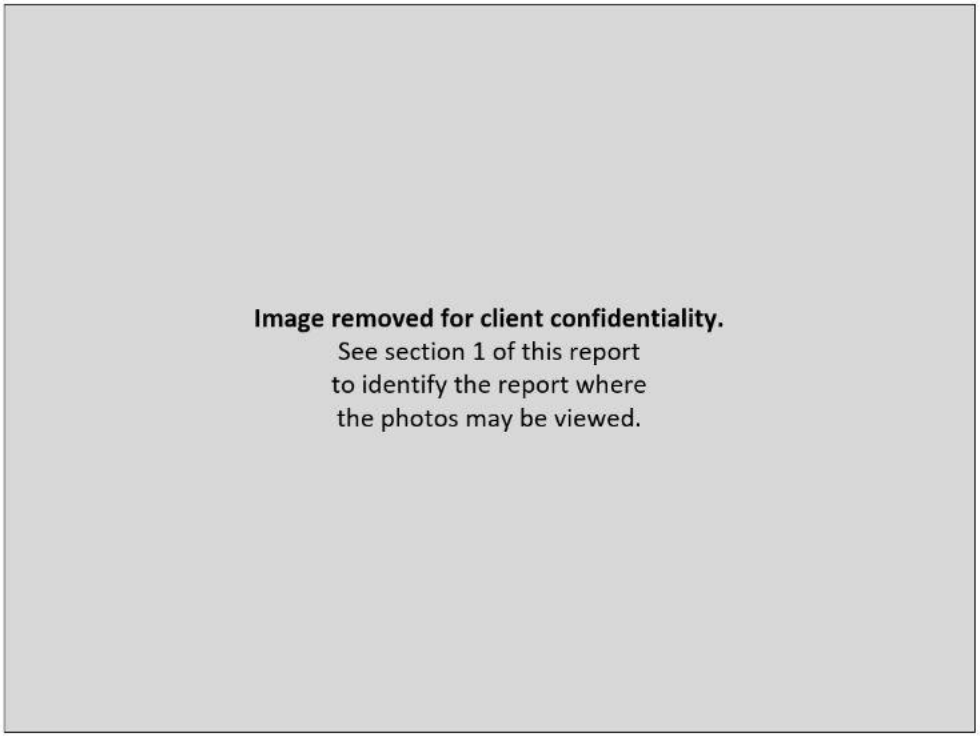


Figure RE06.6: EUT test setup, (WiFi B11 Ch1) Z orientation reverse view

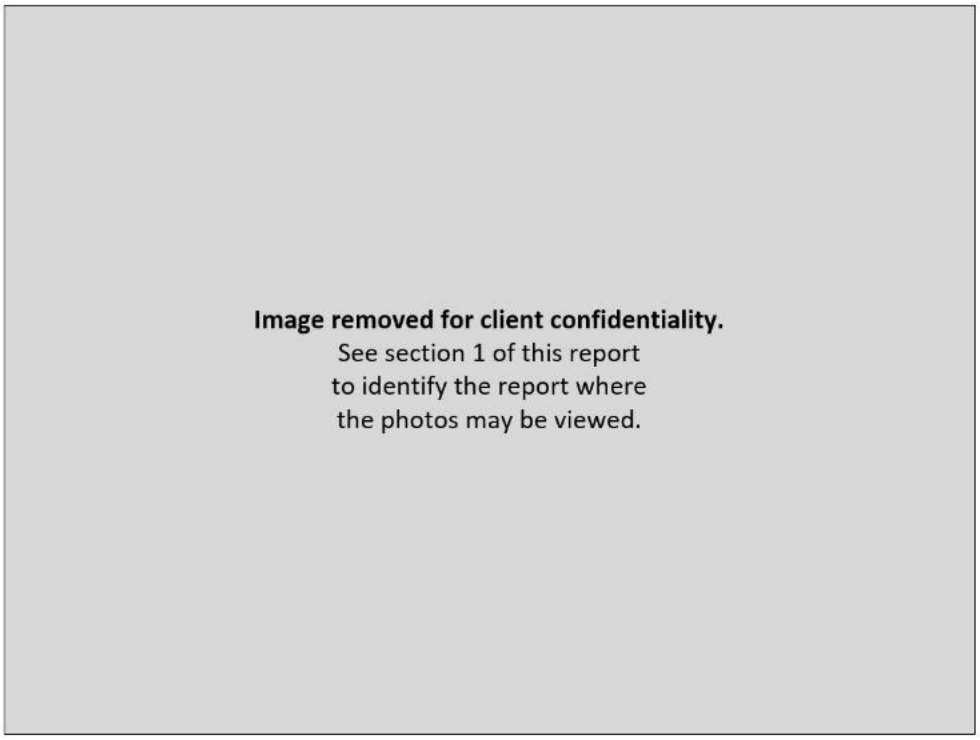


Figure RE06.7: EUT test setup, (WiFi B11 Ch6, Ch11, Ch13) X orientation front view

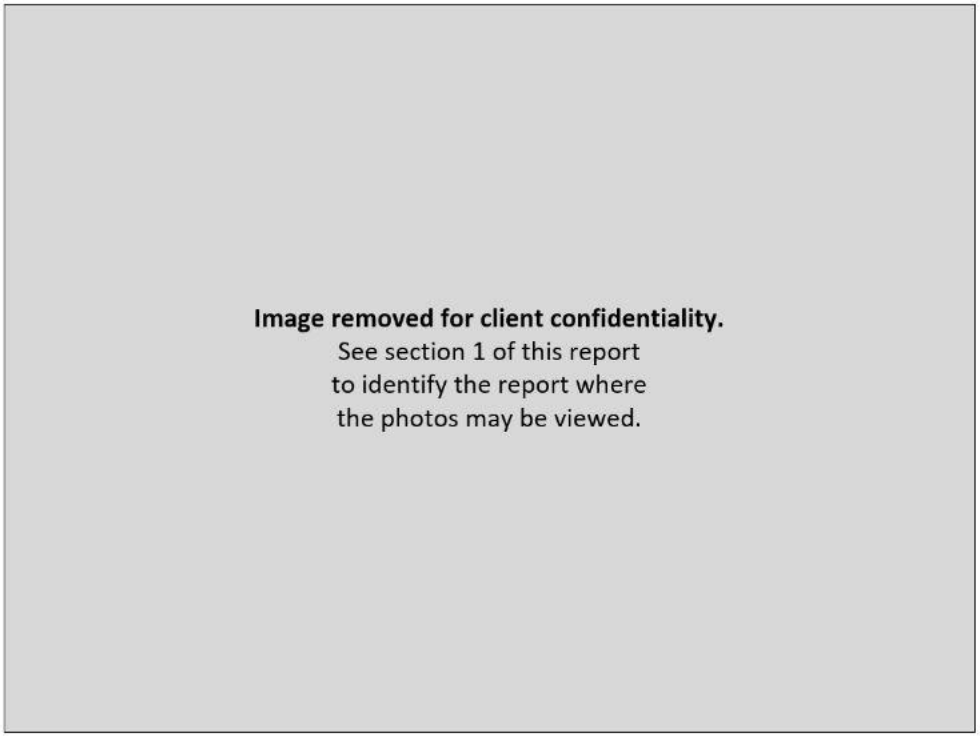


Figure RE06.8: EUT test setup, (WiFi B11 Ch6, Ch11, Ch13) X orientation reverse view

This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE01
Project GCL0457

Test Date(s)	06 Oct 2023
Test Personnel	David Kerr
Product Model	AA4714
Serial Number tested	3453413873
Operating Mode	M7 (Wifi Tx)
Arrangement	A2 (Upwr)
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 CE01.1: 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)
645	56.00	46.00	28.12	26.59	22.96	21.15	27.88	23.04
683	56.00	46.00	43.80	39.03	39.53	32.40	12.20	6.47
717	56.00	46.00	28.80	27.33	24.27	22.06	27.20	21.73
1327	56.00	46.00	29.50	26.63	23.88	21.34	26.50	22.12
1363	56.00	46.00	31.22	27.09	26.27	21.95	24.78	19.73
1399	56.00	46.00	29.90	27.38	25.23	21.98	26.10	20.77

Table CE01.2: Emission summary

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

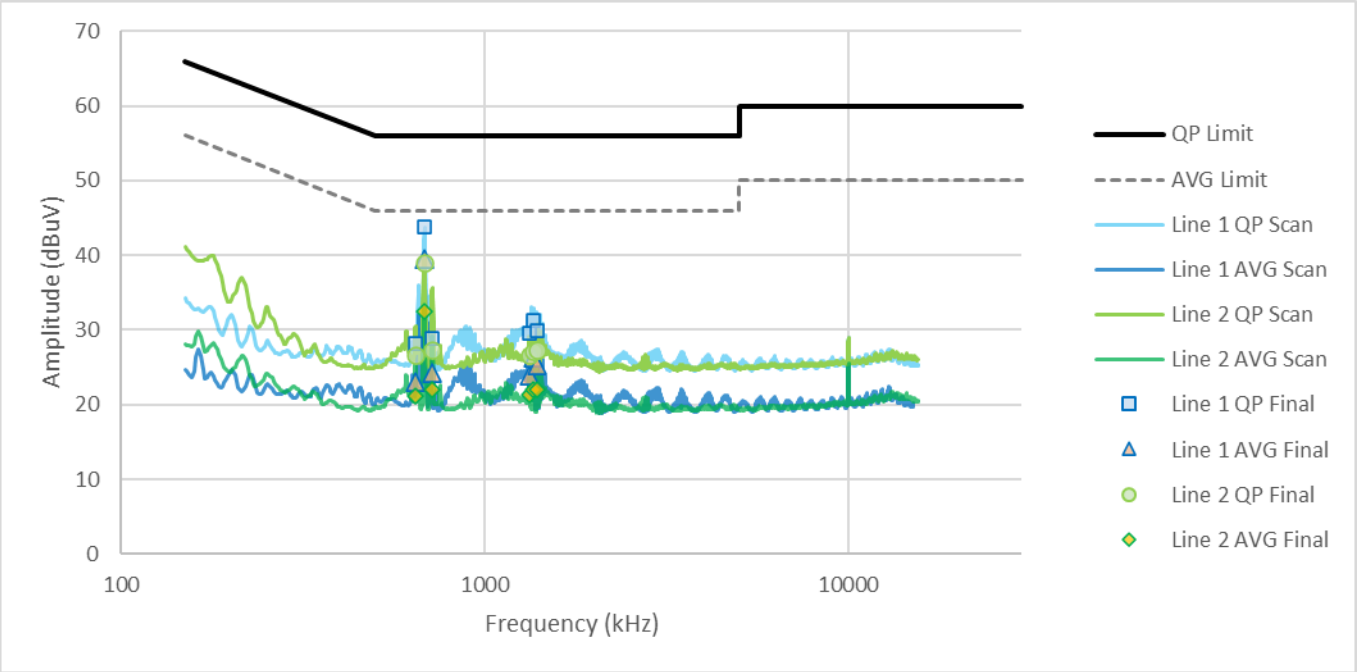


Figure CE01.1: Spectral data

Setup Photographs

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

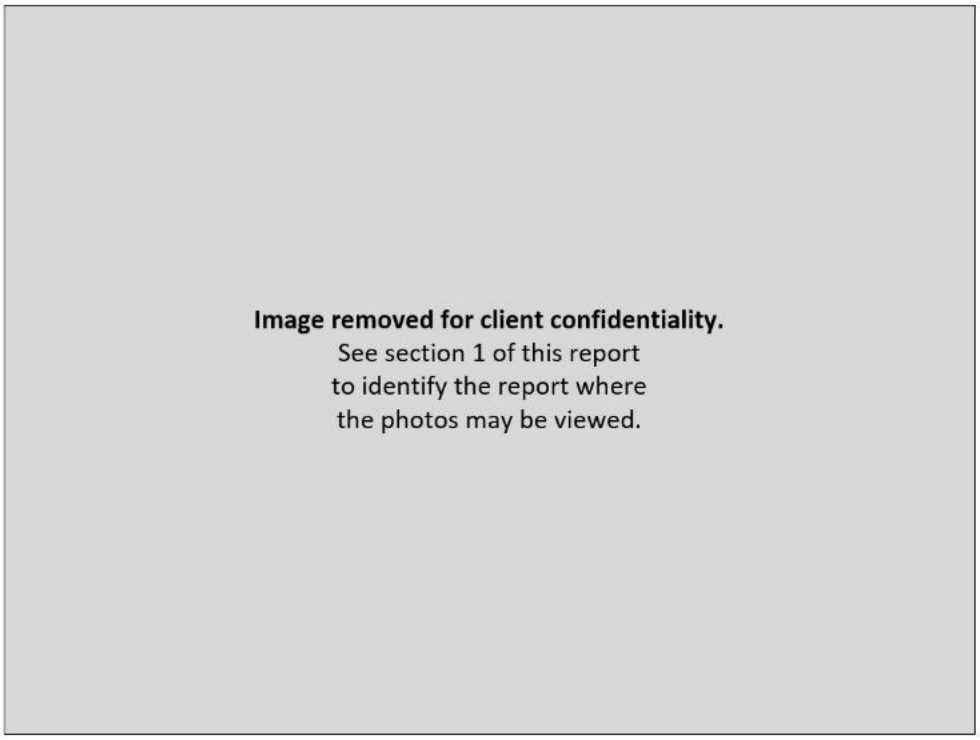


Figure CE01.2: Test setup, front view

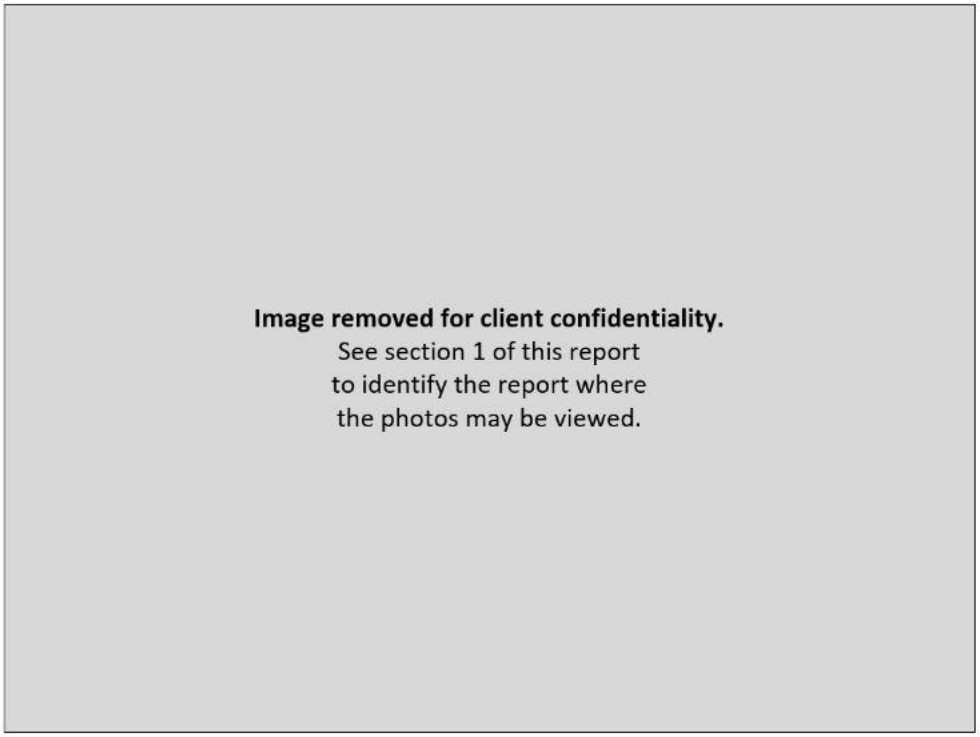


Figure CE01.3: Test setup, side view

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.