Test Report 2023-009

Version A
Issued 4 Apr 2023

Project GCL-0303
Product Model A04432
Primary Test Standard
FCC part 15
RSS-247 Issue 2
ICES-003 Issue 7

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

Client-supplied Information
FCC ID: IPH-04432
IC ID: 1792A-04432

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. 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]	Hopping channel carrier frequencies are separated by at least 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel. Radio uses at least 15 channels with appropriate channel occupancy times.	PASS	11
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 is 789.3 kHz or greater.	PASS	16
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 is 18.78 dBm (0.0756 W) or 16.91 dBm EIRP.	PASS	23
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	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 33.41 dB.	PASS	29
Restricted Bands	The radio must not emit in certain designated restricted frequency bands above a set of limit values. [15.247(d) and 15.209; RSS-247 at 3.3]	Emissions in the restricted bands were at least 3.52 dB below the applicable limits.	PASS	40
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 was 4.00 dBm in a band of at least 3 kHz.	PASS	67
Hybrid Systems	A radio that is both frequency hopping and digitally modulated should a combination of system rules. [15.247(f); RSS-247 at 5.3]	N/A. The radios described in this report are not subject 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]	NT. The requirements in these sections have no associated test.	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 remained within the allowed radio band under all environmental conditions tested.	PASS with caveat	74
Other Bandwidths	Bandwidth values are presented for 99% Occupied Bandwidth and Necessary Bandwidth	There are requirements to report these numbers, but they do not have performance limits.	Reported	90
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 radio communication	11.9 dB of margin to the Class B limit. Tested 30 MHz to 2 GHz applying combined Class B limits.	PASS	97
Conducted Emissions AC Power Port	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	16.33 dB of margin to the appropriate limit. Tested 150 kHz to 30 MHz applying combined Class B limits.	PASS	115

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

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

Table 1: Summary of results

Report Organization

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

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2023-014. 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: 31 Jan 2023
Test Start Date: 07 Feb 2023
Test End Date: 27 Mar 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 Christian Shepherd and initially issued on 4 Apr 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 found 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) made and are necessary to achieve compliance with one or more of the standards listed in section 6 of this report:

Modifications 1-4 only affected relevant Wi-Fi power levels. Other radio services were not changed, therefore not retested.

Modification 1
Detailed Description: Wi-Fi power table changed. Below are the following changes:
SW Version 12.58
Transmit power was reduced for Wi-Fi channel 1 in 802.11g mode, and channels 1-5 and 7 in 802.11n mode.
Date applied: 2/10/2023
Reason for this modification: Decrease Wi-Fi power levels to meet FCC restricted band limits.
Previous testing on modified channels was repeated. The test(s) that were affected and needed a retest on the modified channels only were: FCC restricted bands and transmit power.

Modification 2
Detailed Description: Wi-Fi power table changed. Below are the following changes:
SW Version 12.59
Transmit power was reduced for Wi-Fi channel 1 in 802.11g mode.
Date applied: 2/15/2023
Reason for this modification: Decrease Wi-Fi power levels to meet FCC restricted band limits.
Previous testing on modified channels was repeated. The test(s) that were affected and needed a retest on the modified channels only were: FCC restricted bands and transmit power.

Modification 3
Detailed Description: Wi-Fi power table changed. Below are the following changes:
SW Version 12.60
Transmit power was reduced for Wi-Fi channel 10 in 802.11g mode and channel 10 in 802.11n mode.
Date applied: 2/17/2023
Reason for this modification: Decrease Wi-Fi power levels to meet FCC restricted band limits.
Previous testing on modified channels was repeated. The test(s) that were affected and needed a retest on the modified channels only were: FCC restricted bands and transmit power.

Modification 4
Detailed Description: Wi-Fi power table changed. Below are the following changes:
Transmit power was reduced for Wi-Fi Channel 1 in 802.11g mode.
Date applied: 2/20/2023
Reason for this modification: Decrease Wi-Fi power levels to meet FCC restricted band limits.
Previous testing on modified channels was repeated. The test(s) that were affected and needed a retest on the modified channels only were: FCC restricted bands and transmit power.

Modification 5
Detailed Description: Functional updates.
SW Version 12.63
Date applied: 2/23/2023
Reason for this modification: Functional updates that were not relevant to radio performance under the US and Canadian rules. Previous US/Canada testing was not repeated.

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model	A04432
Serial Numbers Tested	3437936612, 3437936721

This product tested is portable device with Wi-Fi, BLE, NFC and other connectivity/electronic features used for various activities.

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:	Digital data port with DC power
Radio Transceivers:	IEEE 802.11 b/g/n, Bluetooth, Bluetooth Low Energy, ANT, NFC
Highest internal frequency:	275 MHz
Firmware Revision	See section 4 of this report
Primary Functions:	Creation, collection, and transfer of data.

5.3 Operating modes

During test, the EUT was operated in the following modes.

Mode 1: M1 (NFC Tx). EUT linked to NFC reader pad and transmitting data
Mode 2: M2 (NFC Lnk). EUT linked to NFC reader pad and transmitting data.
Mode 3: M3 (BLE Tx). EUT in test mode-BLE Tx always On.
Mode 4: M4 (BLE Lnk). EUT linked to companion device through BLE.
Mode 7: M7 (ANT Tx). EUT in test mode- ANT Tx always On.
Mode 8: M8 (ANT Lnk). EUT linked to companion device through ANT.
Mode 9: M9 (WiFi Tx). EUT in test mode- Wi-Fi Tx always On.
Mode 10: M10 (NFC Act.). EUT in operating mode linked to NFC reader pad.
Mode 11: M11 (NFC Stnd.). EUT in standby mode awaiting connection to NFC reader pad.
Mode 12: M12 (WiFi Lnk). EUT linked to access point and transmitting data
Mode 13: M13 (All). All relevant radios turned On.
Mode 14: M14 (BLE Rx). EUT in test mode- BLE Rx always On.
Mode 15: M15 (WiFi Rx). EUT in test mode- BLE Rx always On.
Mode 16: M16 (Tx Off). All transmitters turned off on EUT
Mode 17: M17 (BT Class Tx). EUT in test mode- BT Classic Tx always On.
Mode 18: M18 (BT Class Lnk). EUT linked to companion device through Bluetooth Classic.
Mode 19: M19 (BT Class Hop). EUT transmitting Bluetooth Classic while hopping channels.

5.4 EUT Arrangement

During test, the EUT components and associated support equipment were selected including the following arrangement sets.
Arrangement 1: A1 (PwrA) EUT powered up through a DC power supply

Arrangement 2: A2 (NFC) EUT is standalone in NFC mode and near to an NFC reader device

Arrangement 3: A3 (PwrPc) EUT Powered up through DC port of a Laptop

Arrangement 4: A4 (Standalone) EUT Powered up through internal battery

Arrangement 5: A5 (PwrA+NFC) EUT Powered up through arrangement A1 in NFC mode and near to an NFC reader device

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
Smartwatch	Garmin	A04112	3400414926
Laptop	Dell	Latitude 5410	5VSPFB3
Laptop power supply	Dell	65 W	CN-OH374X-CH200-OBD-7TC0-A02
NFC reader	ACS	ACR1252	RR554-086776
AC Power adaptor	Garmin	362-00096-00	N/A
iPad	Apple	iPad Pro (11-inch)	DMPZ7582KD6L
Smartwatch	Garmin	A04600	3423419439
Router	TP-Link	Archer C54	Y21C0A5009834
Headset	Garmin	DEZL 200	N/A
Modified Headset	Garmin	DEZL 200	N/A

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

5.6 Cables used

Description	From	To	Length	EMC Treatment
Data & power	Computer or power source	EUT	50 cm	Shielded

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.

FCC Part 15.247
ANSI C63.4: 2014
ANSI C63.10: 2013
ICES-003 Issue 7: 2020
RSS-GEN Issue 5 Amd 2
RSS-247 Issue 2: 2017

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:	20.3 to 24.3 °C
Relative Humidity:	39.1% to 59.2% (non-condensing)
Barometric Pressure	94.9 to 99.9 kPa

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 TR42
Project GCL0303

Test Date(s)	20 Mar 2021
Test Personnel	David Arnett
Hardware Identifier	A04432
Serial Number tested	3437936721
Operating Mode	M17 (BT Class Tx), M19 (BT Class Hop)
Arrangement	A3 (PwrPc)
Input Power	5 Vdc
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:	**David Arnett**
Date of this test record:	**21 Mar 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023

Table TR42.1: Test equipment used

Test software used: Keysight PXE software A.32.06, FHSS ANSI Occupancy Template v1.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.

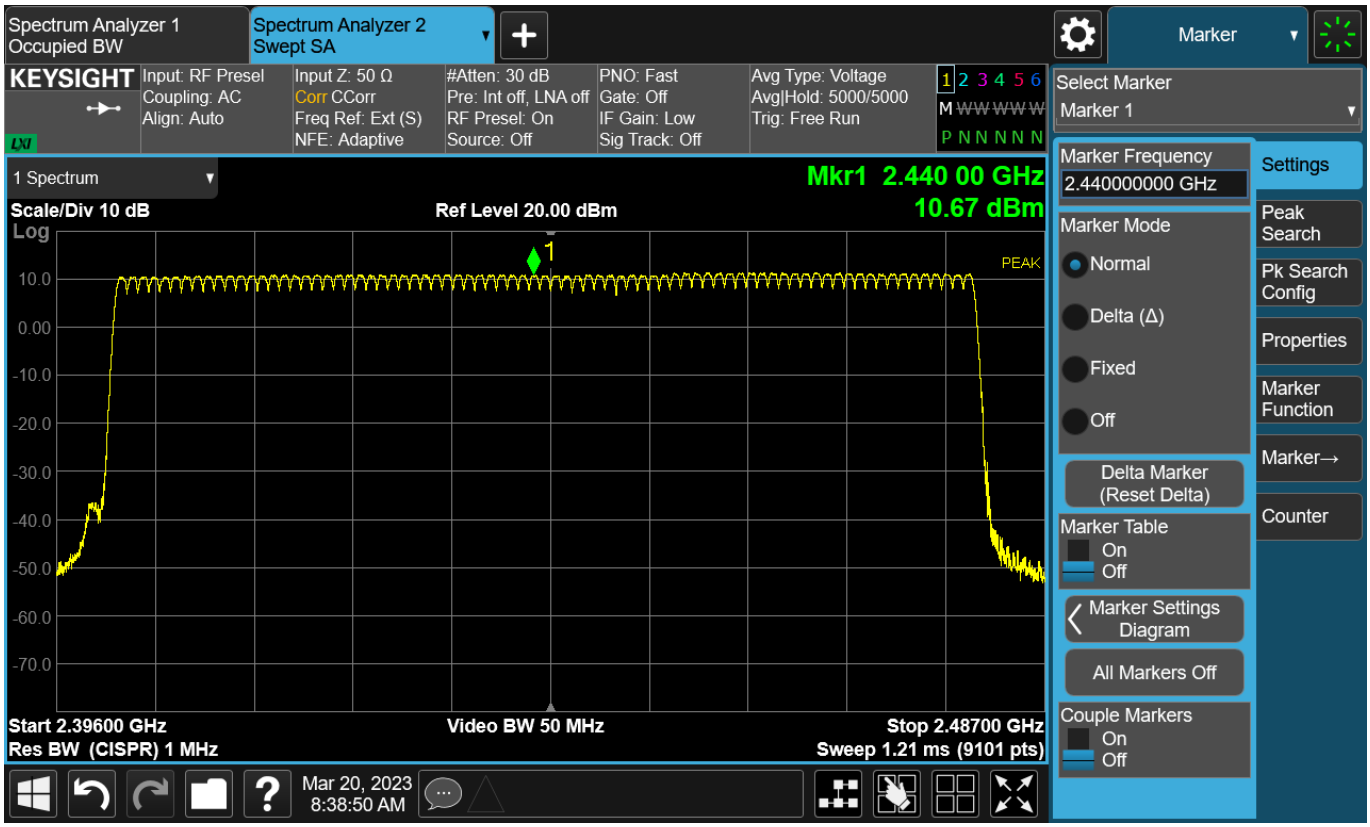

Figure TR42.1: Spectral data, Bluetooth Basic Rate transmissions, showing channels used

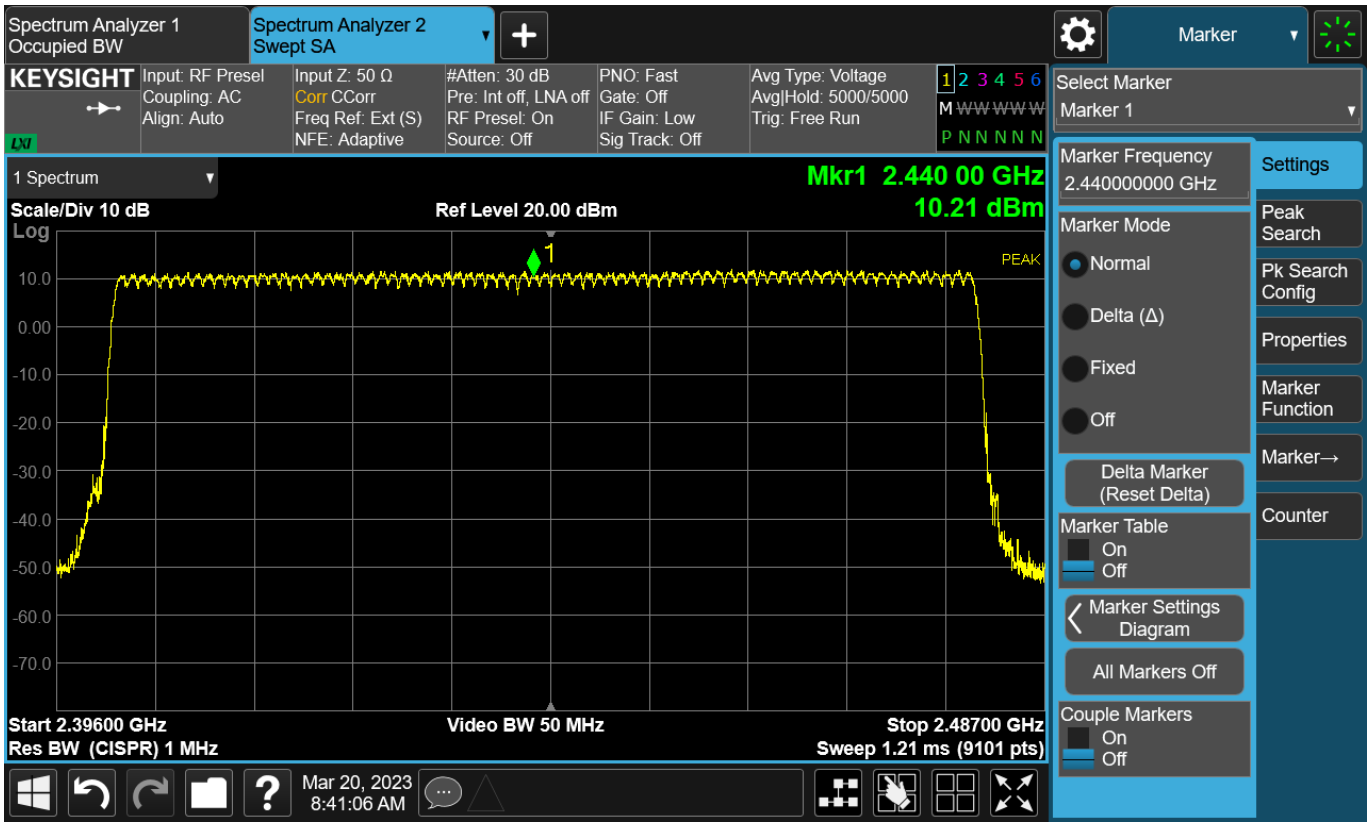

Figure TR42.2: Spectral data, Bluetooth EDR2 transmissions, showing channels used

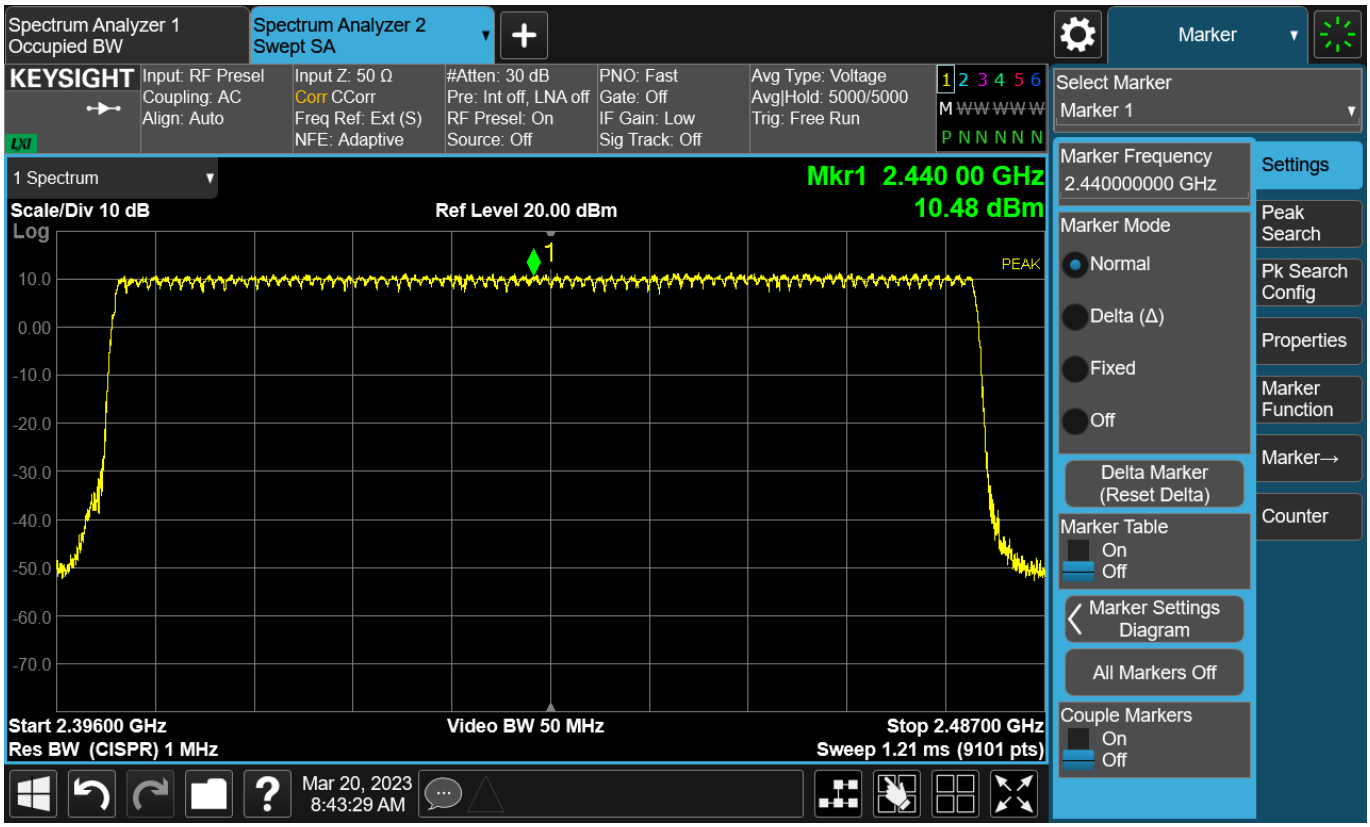

Figure TR42.3: Spectral data, Bluetooth EDR3 transmissions, showing channels used

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
BTBR	**1.015**	**1.003**	**1.022**
EDR2	**1.289**	**1.286**	**1.285**
EDR3	**1.312**	**1.311**	**1.312**

Table TR42.2: Summary of 20 dB Occupied Bandwidth results

Figure TR42.1: Spectral data for Bluetooth EDR3 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.

Frequency	2402	2448	2463
BTBR	**0.221**	**0.213**	**0.218**
EDR2	**0.218**	**0.222**	**0.228**
EDR3	**0.220**	**0.221**	**0.221**

Table TR42.3: Summary of Channel Occupancy results

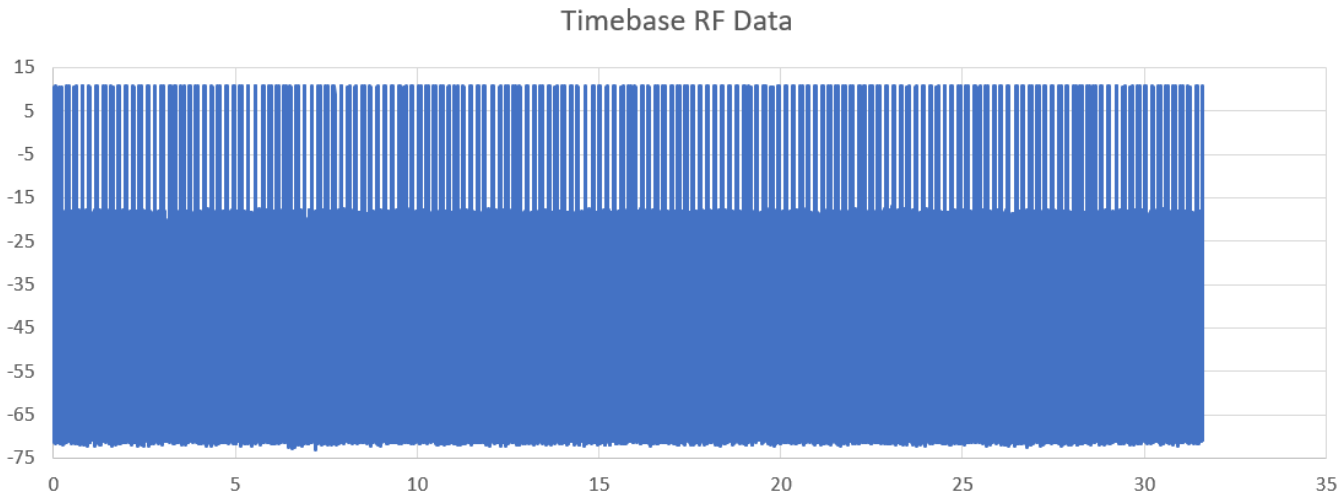

Figure TR42.2: Channel Occupancy time data for Bluetooth EDR2 modulation at 2463 MHz

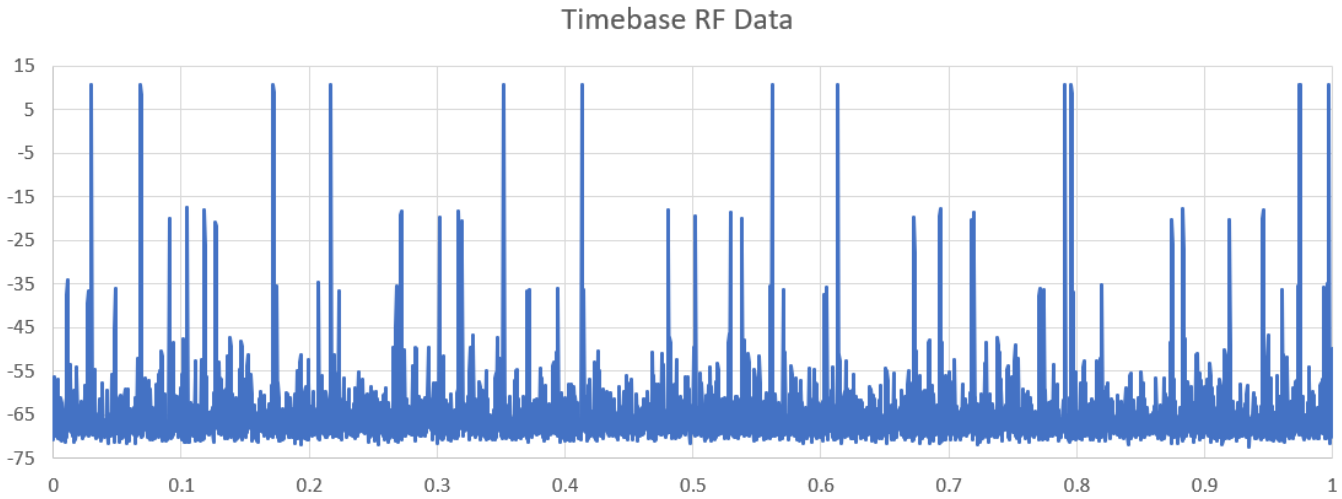

Figure TR42.3: First second of the Channel Occupancy time data for improved clarity

This line is the end of the test record.

Test Record
Transmitter DTS Bandwidth Tests
Test IDs TR14 – TR16
Project GCL-0303

Test Date(s)	27 Feb 2023
Test Personnel	Majid Farah
Product Model	A04432
Serial Number tested	3437936721
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Radio Protocol	Bluetooth Low Energy (1 Mbps, 2 Mbps) and ANT
Radio Band	2400 to 2483.5 MHz
Arrangement	A3 (PwrPc)
Pass/Fail Judgment:	**PASS**
Test record created by:	**David Arnett**
Date of this record:	**25 Mar 2023**

Original record, Version A.

Test Equipment Used

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

Table TR14a.1: List of test equipment used

Test Software Used: Keysight PXE firmware A.33.03

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, and also identify the center frequency error. The spectrum is scanned several hundred 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.

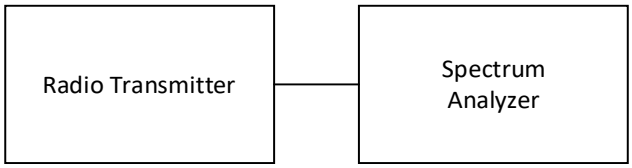

Figure TR14a.1: Test arrangement

Test Data

The data for each test is summarized below, followed by the spectral data for each case analyzed and reported. The test strategy is to measure the bandwidth with the radio tuned to its lowest tunable frequency, its highest tunable frequency, and a mid-band frequency. The midband frequency is 2440 MHz. The low and high frequencies are 2402 MHz and 2480 MHz, except for 2 Mbps BLE where the limits are 2404 MHz and 2478 MHz.

The analysis threshold for the occupied test was the bandwidth containing 99% of the observed power. The standards cited do not limit the Occupied Bandwidth (OBW) for all transmitter types. In such cases an OBW limit stated below may be inapplicable.

Some standards also evaluate a parameter called DTS Bandwidth, which is tested using a spectrum analyzer operating with a specified resolution bandwidth. The analysis finds the smallest continuous range of frequencies containing all emissions within 6 dB of the highest value.

The bold data in the table below is the measured bandwidth, in units of kHz. The values highlighted in yellow are the worst-case results for each signal type, or other data points of interest for which plots of the data are included. Any grey cells indicate operating conditions that were not selected for. The DTS Bandwidth is the x dB Bandwidth shown in the figures.

The data all meet the limit, which is that the DTS Bandwidth be at least 500 kHz.

Mode	Speed	Low	Mid	High
BLE	1 Mb	**789.3**	**850.2**	**891.2**
BLE	2 Mb	**1392**	**1640**	**1649**
ANT	Fixed	**812.9**	**958**	**958.2**

Table TR14a.2: Summary of measured bandwidths

Figure TR14a.2: Bluetooth Low Energy, 1 Mbps, 2402 MHz

Figure TR14a.3: Bluetooth Low Energy, 2 Mbps, 2404 MHz

Figure TR14a.4: ANT, 2402 MHz

This line is the end of the test record.

Test Record
Transmitter DTS Bandwidth Tests
Test IDs TR17a
Project GCL-0303

Test Date(s)	27 – 28 Feb 2023
Test Personnel	Majid Farah
Hardware Number	011-05921-00
Serial Number tested	3437936721
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Radio Protocol	IEEE 802.11b/g/n
Radio Band	2400 to 2483.5 MHz
Arrangement	A3 (PwrPc)

Pass/Fail Judgment: **PASS**

Test record created by: **David Arnett**
Date of this record: **31 Mar 2023**
Original record, Version A was created 25 Mar 2023. Version B on 31 Mar corrects an error in Table TR17a.2.

Test Equipment Used

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

Table TR17a.1: List of test equipment used

Test Software Used: Keysight PXE firmware A.33.03

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, and also identify the center frequency error. The spectrum is scanned several hundred 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.

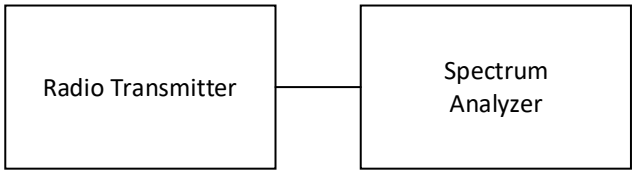

Figure TR17a.1: Test arrangement

Test Data

The data for each test is summarized below, followed by the spectral data for each case analyzed and reported. The test strategy is to measure channel 13 on all modulation types. Channels 1, 6, 11, 12, and 13 are measured for the slowest and fastest data rates in each WiFi mode (b, g, n), in addition to other data rates of interest based on transmit power data.

The analysis threshold for the occupied test was the bandwidth containing 99% of the observed power. The standards cited do not limit the Occupied Bandwidth (OBW) for all transmitter types. In such cases an OBW limit stated below may be inapplicable.

Some standards also evaluate a parameter called DTS Bandwidth, which is tested using a spectrum analyzer operating with a specified resolution bandwidth. The analysis finds the smallest continuous range of frequencies containing all emissions within 6 dB of the highest value.

The bold data in the table below is the measured bandwidth, in units of MHz. The values highlighted in yellow are the worst-case results for each signal type, or other data points of interest for which plots of the data are included. Any grey cells indicate operating conditions that were not selected for. The DTS Bandwidth is the difference between the x dB Bandwidth upper boundary frequency and lower boundary frequency shown in the figures.

The data all meet the limit, which is that the DTS Bandwidth be at least 500 kHz.

Mode	Speed	Ch 1	Ch 6	Ch 11	Ch 12	Ch 13
B	1	**10.057**	**10.065**	**10.039**	**9.557**	**9.558**
B	2					**10.039**
B	5.5					**8.362**
B	11	**9.066**	**9.069**	**9.054**	**9.031**	**9.046**
G	6	**16.562**	**16.541**	**16.519**	**16.528**	**16.518**
G	9					**16.503**
G	12	**16.547**	**16.534**	**16.572**	**16.541**	**16.545**
G	18					**16.525**
G	24					**16.514**
G	36					**16.541**
G	48					**16.524**
G	54	**16.580**	**16.557**	**16.530**	**16.539**	**16.537**
N	0	**17.638**	**17.649**	**17.648**	**17.636**	**17.615**
N	1	**17.671**	**17.665**	**17.697**	**17.666**	**17.679**
N	2					**17.670**
N	3					**17.728**
N	4					**17.654**
N	5					**17.703**
N	6					**17.707**
N	7	**17.676**	**17.671**	**17.647**	**17.591**	**17.650**

Table TR17a.2: Summary of measured bandwidths

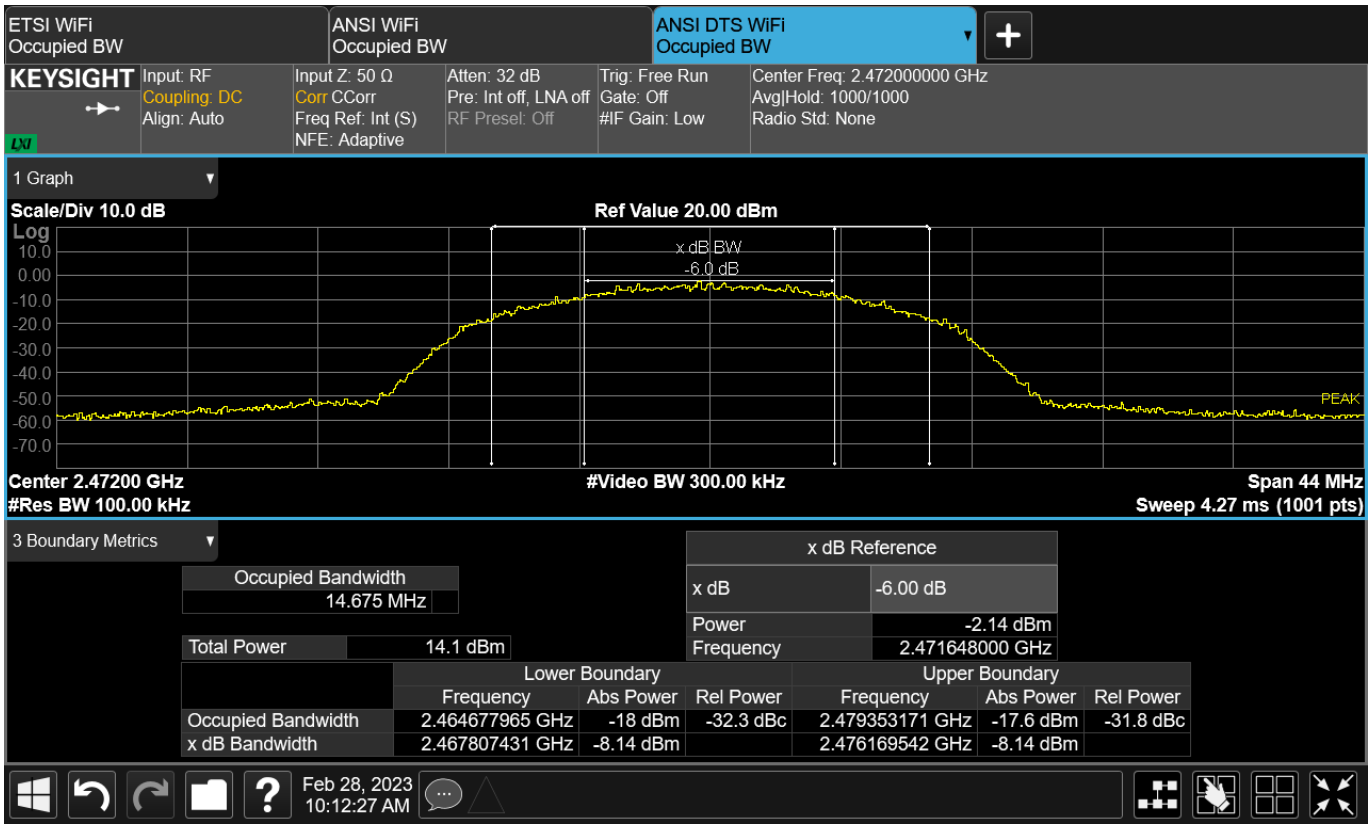

Figure TR17a.2: Channel 13, B mode, 5.5 Mbps modulation

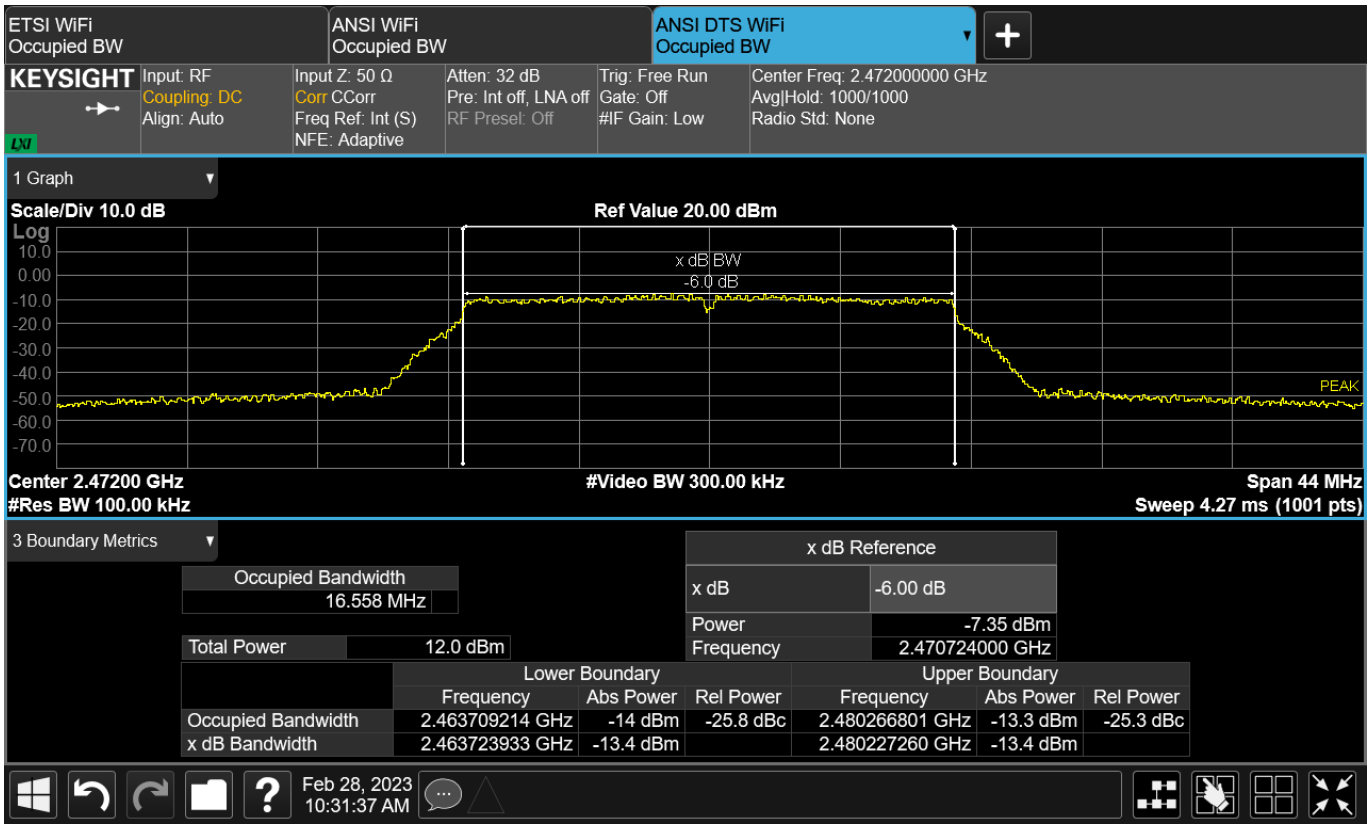

Figure TR17a.3: Channel 13, G mode, 9 Mbps modulation

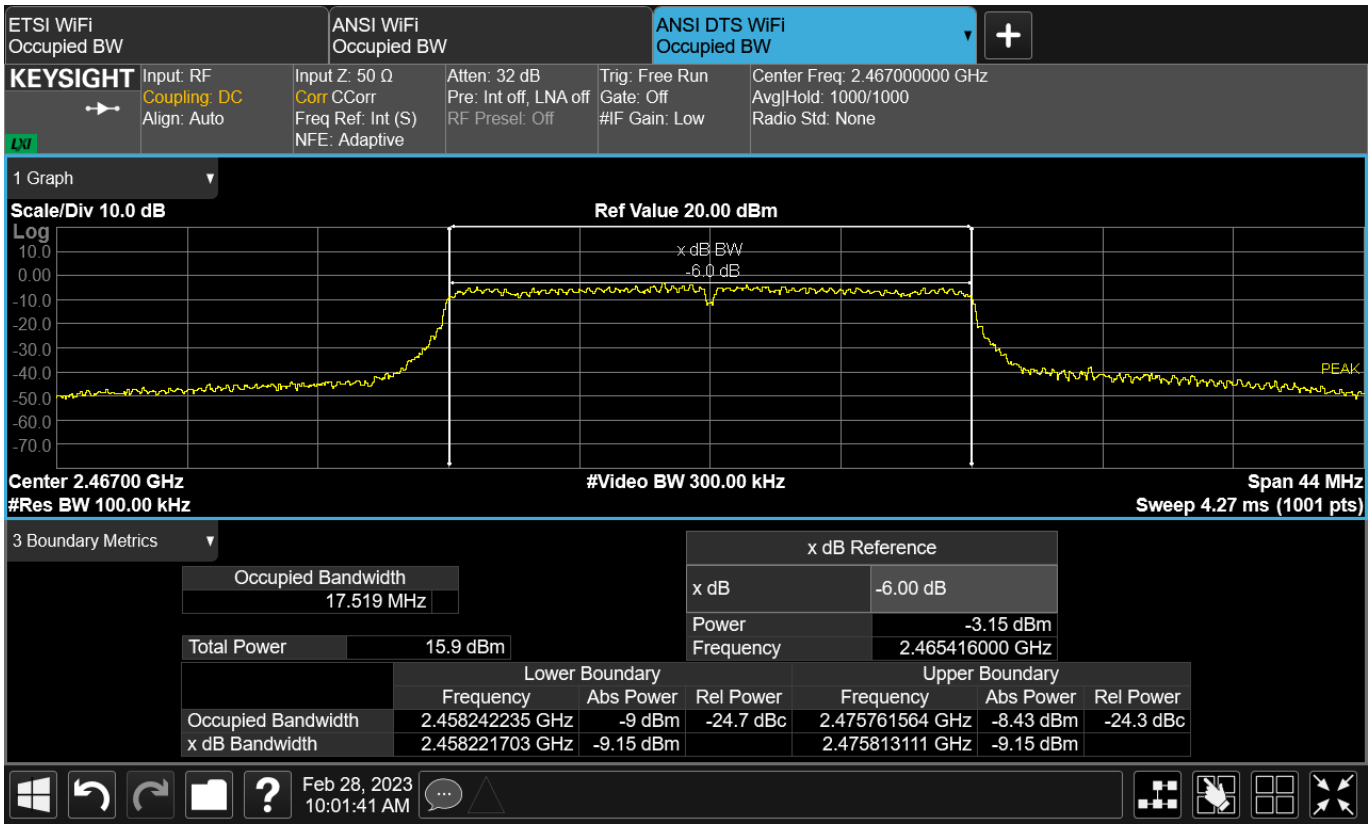

Figure TR17a.4: Channel 12, N mode, MCS7 modulation

This line is the end of the test record.

Test Record
Transmitter Power
Test IDs TR1a
Project GCL-0303

Test Date(s)	2-6 Feb 2023, 2 Mar 2023
Test Personnel	David Arnett, Majid Farah
Product Model	A04432
Serial Number tested	3437936721
Operating Mode	M8 (WiFi Tx)
Arrangement	A1 (PwrA)
Input Power	5Vdc
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	-1.85 dBi, as reported by the client
Radio Protocol	IEEE 802.11b/g/n
Pass/Fail Judgment:	**PASS**
Test record created by:	**David Arnett**
Date of this record:	**23 Mar 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	13-Jul-2022	15-Jul-2023

Table TR1a.1: List of test equipment used

Software used: Rohde & Schwarz Power Viewer V11.3; TimePowerAnalysisSpreadsheetv9.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:	5.4.2.2.1.2
ANSI C63.10:	11.9.1.3

Firmware, Test Dates, and Additional Details
As indicated in earlier parts of the test report, there were several changes to firmware during the course of this project affecting transmit power.

The data taken in early February was taken with the original firmware settings. A set of repeat measurements were made in early March for all channels and modes in which the transmit power settings had been altered. In the data tables below, a green highlight indicates data from the March test date. All other data was taken in February. Yellow highlight indicates the value for a particular mode with the highest value, which are all from the February data. Grey 'NA' entries indicate channels or speeds that were not selected for measurement per the design of the experiment.

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. The data record lengths are 1 second for WiFi and 100 msec for the Bluetooth-like protocols. Where standards cited here apply harmonized test methods and different limits, the more strict limit has applied.

There are three separate analyses performed on the data set from the broadband fast diode power sensor. Under the ANSI method, the analysis reports the peak value of power observed, in dBm units. Under the ETSI method, each transmission burst is analyzed to find the burst with the highest average power, antenna gain is added, and the resulting unit is dBm EIRP. The third analysis looks at average power over the entire data record, in milliwatt units, and is used for RF Exposure evaluations. All three analyses will be reported, even though the report in which this record appears may not need each of these methods.

The results are shown below.

Mode	Speed	1	2	3	4	5	6	7	8	9	10	11	12	13
B	1	16.89	15.76	16.82	18.66	18.78	18.78	18.77	18.77	17.25	16.14	14.53	5.84	5.59
B	2	16.23	NT	NT	NT	NT	17.42	NT	NT	NT	NT	12.65	6.79	5.07
B	5.5	16.44	NT	NT	NT	NT	17.68	NT	NT	NT	NT	12.67	6.77	6.34
B	11	16.33	16.46	16.57	17.32	17.44	17.47	17.43	17.45	18.01	16.96	15.20	6.58	6.41
G	6	7.77	16.55	16.63	17.70	17.69	17.67	18.65	18.64	17.64	13.01	9.77	8.45	5.50
G	9	8.67	NT	NT	NT	NT	18.33	NT	NT	NT	NT	9.66	8.30	5.32
G	12	9.11	NT	NT	NT	NT	18.61	NT	NT	NT	NT	10.20	8.79	6.01
G	18	9.12	NT	NT	NT	NT	17.76	NT	NT	NT	NT	10.29	8.85	5.87
G	24	9.05	NT	NT	NT	NT	15.29	NT	NT	NT	NT	10.29	8.86	5.88
G	36	8.91	NT	NT	NT	NT	14.31	NT	NT	NT	NT	10.27	8.82	5.85
G	48	8.92	NT	NT	NT	NT	13.65	NT	NT	NT	NT	10.49	9.04	6.07
G	54	8.90	12.70	12.71	13.64	13.69	13.69	13.69	13.37	12.51	12.15	10.26	8.93	5.93
N	MCS0	9.93	9.98	12.06	12.05	14.70	17.02	16.95	17.46	16.38	10.40	9.45	7.60	5.16
N	MCS1	11.60	NT	NT	NT	NT	16.65	NT	NT	NT	NT	10.13	8.23	5.78
N	MCS2	11.63	10.74	11.86	12.81	14.93	16.59	17.71	17.80	16.84	11.22	11.13	9.26	6.78
N	MCS3	11.54	NT	NT	NT	NT	15.68	NT	NT	NT	NT	10.23	8.34	5.84
N	MCS4	11.52	NT	NT	NT	NT	15.27	NT	NT	NT	NT	10.28	8.37	5.86
N	MCS5	11.54	NT	NT	NT	NT	14.28	NT	NT	NT	NT	10.31	8.40	5.88
N	MCS6	11.52	NT	NT	NT	NT	14.20	NT	NT	NT	NT	10.34	8.42	5.92
N	MCS7	10.98	11.01	11.07	12.08	12.11	12.13	12.13	11.79	10.84	11.23	10.37	8.45	5.97

Table TR1a.2: ANSI Transmit Power Summary, dBm peak

Mode	Speed	1	2	3	4	5	6	7	8	9	10	11	12	13
B	1	15.00	13.87	14.95	16.79	16.91	16.91	16.89	16.90	15.37	14.26	12.64	3.94	3.68
B	2	14.36	NT	NT	NT	NT	15.55	NT	NT	NT	NT	10.76	4.90	3.18
B	5.5	14.52	NT	NT	NT	NT	15.79	NT	NT	NT	NT	10.78	4.87	4.44
B	11	14.43	14.56	14.67	15.43	15.46	15.50	15.54	15.56	16.11	14.99	13.30	4.66	4.48
G	6	5.83	14.61	14.62	15.75	15.75	15.72	16.72	16.70	15.69	11.05	7.81	6.50	3.54
G	9	6.73	NT	NT	NT	NT	16.40	NT	NT	NT	NT	7.72	6.35	3.36
G	12	7.18	NT	NT	NT	NT	16.70	NT	NT	NT	NT	8.28	6.88	4.07
G	18	7.20	NT	NT	NT	NT	15.86	NT	NT	NT	NT	8.37	6.94	3.94
G	24	7.10	NT	NT	NT	NT	13.24	NT	NT	NT	NT	8.34	6.89	3.90
G	36	6.98	NT	NT	NT	NT	12.38	NT	NT	NT	NT	8.34	6.88	3.91
G	48	6.98	NT	NT	NT	NT	11.70	NT	NT	NT	NT	8.56	7.10	4.13
G	54	6.94	10.73	10.75	11.69	11.74	11.75	11.74	11.41	10.54	10.21	8.29	6.95	3.96
N	MCS0	7.98	8.03	10.09	10.10	12.73	15.08	15.01	15.51	14.45	8.43	7.48	5.64	3.20
N	MCS1	9.68	NT	NT	NT	NT	14.71	NT	NT	NT	NT	8.20	6.30	3.85
N	MCS2	9.70	8.82	9.94	10.88	13.00	14.64	15.78	15.88	14.89	9.30	9.21	7.33	4.85
N	MCS3	9.60	NT	NT	NT	NT	13.73	NT	NT	NT	NT	8.26	6.37	3.87
N	MCS4	9.57	NT	NT	NT	NT	13.32	NT	NT	NT	NT	8.34	6.40	3.90
N	MCS5	9.57	NT	NT	NT	NT	12.33	NT	NT	NT	NT	8.35	6.42	3.92
N	MCS6	9.56	NT	NT	NT	NT	12.22	NT	NT	NT	NT	8.36	6.44	3.94
N	MCS7	9.02	9.04	9.10	10.12	10.15	10.16	10.17	9.83	8.87	9.28	8.41	6.49	4.01

Table TR1a.3: ETSI Transmit Power Summary, dBm EIRP

Mode	Speed	1	2	3	4	5	6	7	8	9	10	11	12	13
B	1	48.42	37.30	47.77	73.02	75.09	75.14	74.70	74.91	52.68	40.80	28.14	3.80	3.58
B	2	41.72	NT	NT	NT	NT	54.93	NT	NT	NT	NT	18.25	4.73	3.17
B	5.5	43.32	NT	NT	NT	NT	58.09	NT	NT	NT	NT	18.30	4.71	4.25
B	11	42.42	43.71	44.78	53.38	53.70	54.27	54.74	55.00	62.42	48.22	32.73	4.48	4.29
G	6	5.86	44.28	44.39	57.45	57.55	57.20	71.83	71.52	56.54	19.51	9.24	6.84	3.46
G	9	7.19	NT	NT	NT	NT	66.88	NT	NT	NT	NT	9.05	6.62	3.32
G	12	8.01	NT	NT	NT	NT	71.51	NT	NT	NT	NT	10.31	7.46	3.91
G	18	8.04	NT	NT	NT	NT	58.97	NT	NT	NT	NT	10.51	7.57	3.80
G	24	7.84	NT	NT	NT	NT	32.31	NT	NT	NT	NT	10.41	7.49	3.76
G	36	7.63	NT	NT	NT	NT	26.49	NT	NT	NT	NT	10.44	7.47	3.76
G	48	7.64	NT	NT	NT	NT	22.67	NT	NT	NT	NT	10.99	7.85	3.96
G	54	7.56	18.10	18.17	22.52	22.83	22.83	22.83	21.17	17.29	16.03	10.34	7.60	3.80
N	MCS0	9.60	9.71	15.64	15.65	28.75	49.34	48.51	54.41	42.60	10.65	8.55	5.60	3.19
N	MCS1	14.23	NT	NT	NT	NT	45.22	NT	NT	NT	NT	10.11	6.54	3.71
N	MCS2	14.29	11.67	15.10	18.79	30.59	44.49	57.96	59.33	47.14	13.04	12.76	8.27	4.68
N	MCS3	13.94	NT	NT	NT	NT	36.17	NT	NT	NT	NT	10.28	6.63	3.74
N	MCS4	13.89	NT	NT	NT	NT	32.86	NT	NT	NT	NT	10.45	6.70	3.76
N	MCS5	13.85	NT	NT	NT	NT	26.14	NT	NT	NT	NT	10.45	6.73	3.78
N	MCS6	13.80	NT	NT	NT	NT	25.53	NT	NT	NT	NT	10.49	6.76	3.79
N	MCS7	12.21	12.25	12.43	15.71	15.82	15.92	15.94	14.68	11.82	12.96	10.63	6.83	3.85

Table TR1a.4: RF Exposure Transmit Power Summary, milliwatts

For reference, the test mode for WiFi produced a 100% duty cycle.

This table is a summary of the highest power readings and limits for each type of radio.

WiFi Type	ANSI Power (dBm)	ANSI Limit (dBm)	ANSI Power (Watt)	ESTI Power (dBm EIRP)	ETSI Limit (dBm EIRP)
b	18.78	30	0.0756	16.91	20
g	18.65	30	0.0732	16.72	20
n	17.80	30	0.0602	15.88	20

Table TR1a.5: Transmit Power and Results Summary

Setup Diagram

The following block diagrams show how the EUT and test equipment is arranged for test.

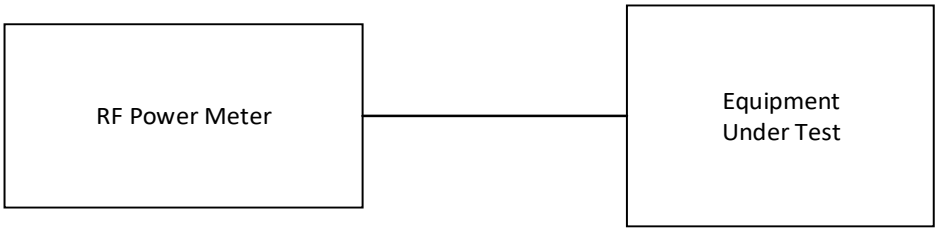

Figure TR1a.1: Test equipment setup

This line is the end of the test record.

Test Record
Transmitter Power
Test IDs TR1b
Project GCL-0303

Test Date(s)	13 Feb 2023
Test Personnel	Majid Farah
Product Model	A04432
Serial Number tested	3437936721
Operating Mode	M3 (BLE Tx), M7 (ANT Tx), M17 (BT Class Tx)
Arrangement	A1 (PwrA)
Input Power	5Vdc
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	-1.85 dBi, as reported by the client
Radio Protocol	Bluetooth, Bluetooth Low Energy, ANT
Pass/Fail Judgment:	**PASS**
Test record created by:	**David Arnett**
Date of this record:	**23 Mar 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	13-Jul-2022	15-Jul-2023

Table TR1b.1: List of test equipment used

Software used: Rohde & Schwarz Power Viewer V11.3; TimePowerAnalysisSpreadsheetv9.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:	5.4.2.2.1.2
ANSI C63.10:	11.9.1.3

Firmware Test Dates, and Additional Details
As indicated in earlier parts of the test report, there were several changes to firmware during the course of this project affecting transmit power.

In the data tables below, a yellow highlight indicates the value for a particular mode with the highest value. Grey 'NA' entries indicate channels or speeds that were not selected for measurement per the design of the experiment, or that are not available under the radio protocol.

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. The data record lengths are 1 second for WiFi and 100 msec for the Bluetooth-like protocols. Where standards cited here apply harmonized test methods and different limits, the more strict limit has applied.

There are three separate analyses performed on the data set from the broadband fast diode power sensor. Under the ANSI method, the analysis reports the peak value of power observed, in dBm units. Under the ETSI method, each transmission burst is analyzed to find the burst with the highest average power, antenna gain is added, and

the resulting unit is dBm EIRP. The third analysis looks at average power over the entire data record, in milliwatt units, and is used for RF Exposure evaluations. All three analyses will be reported, even though the report in which this record appears may not need each of these methods.

The results are shown below.

Frequency	(MHz)	2402	2403	2404	2420	2440	2460	2478	2479	2480
Bluetooth	Basic	**10.21**	**10.22**	**10.25**	**10.40**	**10.47**	**10.76**	**10.50**	**10.44**	**10.44**
Bluetooth	EDR2	**10.21**	**10.23**	**10.25**	**10.42**	**10.44**	**10.80**	**10.60**	**10.55**	**10.44**
Bluetooth	EDR3	**9.94**	**9.90**	**9.91**	**10.02**	**10.00**	**10.16**	**9.89**	**9.86**	**9.84**
BT Low Energy	1 Mbps	**1.52**	**NT**	**4.84**	**4.75**	**4.81**	**4.80**	**1.64**	**NT**	**1.21**
BT Low Energy	2 Mbps	**NT**	**NT**	**4.71**	**4.94**	**4.97**	**4.97**	**1.66**	**NT**	**NT**
ANT	----	**1.62**	**1.64**	**4.96**	**5.03**	**5.08**	**5.07**	**5.02**	**1.75**	**1.76**

Table TR1b.2: ANSI Transmit Power Summary, dBm peak

Frequency	(MHz)	2402	2403	2404	2420	2440	2460	2478	2479	2480
Bluetooth	Basic	**8.05**	**8.07**	**8.08**	**8.25**	**8.30**	**8.61**	**8.35**	**8.31**	**8.30**
Bluetooth	EDR2	**7.55**	**7.57**	**7.59**	**7.76**	**7.79**	**8.15**	**7.95**	**7.91**	**7.80**
Bluetooth	EDR3	**7.47**	**7.44**	**7.42**	**7.55**	**7.54**	**7.70**	**7.41**	**7.38**	**7.38**
BT Low Energy	1 Mbps	**-0.38**	**NT**	**2.93**	**2.85**	**2.90**	**2.88**	**-0.25**	**NT**	**-0.68**
BT Low Energy	2 Mbps	**NT**	**NT**	**2.80**	**3.03**	**3.05**	**3.05**	**-0.23**	**NT**	**NT**
ANT	----	**-0.26**	**-0.26**	**3.04**	**3.12**	**3.16**	**3.15**	**3.10**	**-0.14**	**-0.13**

Table TR1b.3: ETSI Transmit Power Summary, dBm EIRP

Frequency	(MHz)	2402	2403	2404	2420	2440	2460	2478	2479	2480
Bluetooth	Basic	**7.60**	**7.64**	**7.65**	**7.94**	**8.04**	**8.64**	**8.13**	**8.05**	**8.04**
Bluetooth	EDR2	**6.77**	**6.81**	**6.83**	**7.09**	**7.16**	**7.78**	**7.42**	**7.35**	**7.09**
Bluetooth	EDR3	**6.65**	**6.61**	**6.57**	**6.77**	**6.76**	**7.01**	**6.57**	**6.52**	**6.51**
BT Low Energy	1 Mbps	**1.40**	**NT**	**3.01**	**2.95**	**2.98**	**2.97**	**1.45**	**NT**	**1.31**
BT Low Energy	2 Mbps	**NT**	**NT**	**2.92**	**3.07**	**3.09**	**3.09**	**1.45**	**NT**	**NT**
ANT	----	**1.44**	**1.44**	**3.09**	**3.14**	**3.17**	**3.16**	**3.13**	**1.48**	**1.48**

Table TR1b.4: RF Exposure Transmit Power Summary, milliwatts

For reference, the test mode for Bluetooth produced a 77.9% duty cycle, and for all other radios produced a 100% Duty Cycle.

This table is a summary of the highest power readings and limits for each type of radio.

Radio Type	ANSI Power (dBm)	ANSI Limit (dBm)	ANSI Power (Watt)	ESTI Power (dBm EIRP)	ETSI Limit (dBm EIRP)
Bluetooth	10.80	21	0.0120	8.61	20
BLE	4.97	21	0.0031	3.05	20
ANT	5.08	21	0.0032	3.16	20

Table TR1b.5: Transmit Power and Results Summary

Setup Diagram

The following block diagrams show how the EUT and test equipment is arranged for test.

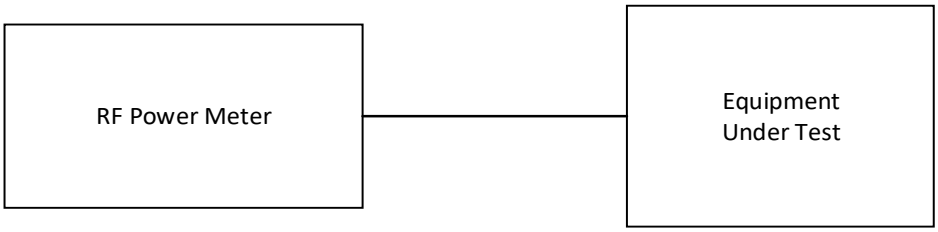

Figure TR1b.1: Test equipment setup

This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test IDs TR22, TR23 and TR24
Project GCL-0303

Test Date(s)	15 Mar 2023
Test Personnel	Majid Farah
Product Model	A04432
Serial Number tested	3437936721
Operating Mode	M3 (BLE Tx), M7 (ANT Tx) and M17 (BT Class Tx)
Arrangement	A1 (PwrA)
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:	**Majid Farah**
Date of this test record:	**25 Mar 2023**

Original record, Version A.

Test Equipment

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

Table TR22.1: Test equipment used

Software used: Keysight PXE software A.33.03.

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.

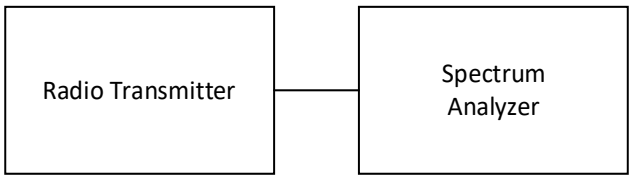

Figure TR22.1: Test setup

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 form 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	2404	2440	2478	2480
Bluetooth BR	**56.66**	**NT**	**57.75**	**NT**	**56.77**
Bluetooth EDR2	**56.83**	**NT**	**57.41**	**NT**	**57.24**
Bluetooth EDR3	**56.33**	**NT**	**56.81**	**NT**	**56.63**
BLE 1 Mbps	**46.91**	**NT**	**50.08**	**NT**	**47.21**
BLE 2 Mbps	**NT**	**48.47**	**48.23**	**44.70**	**NT**
ANT	**46.79**	**NT**	**46.89**	**NT**	**50.22**

Table TR22.2: Results Summary
NT: (Not tested) means the requirement is or may not be applicable by EUT or it is not required by standards.

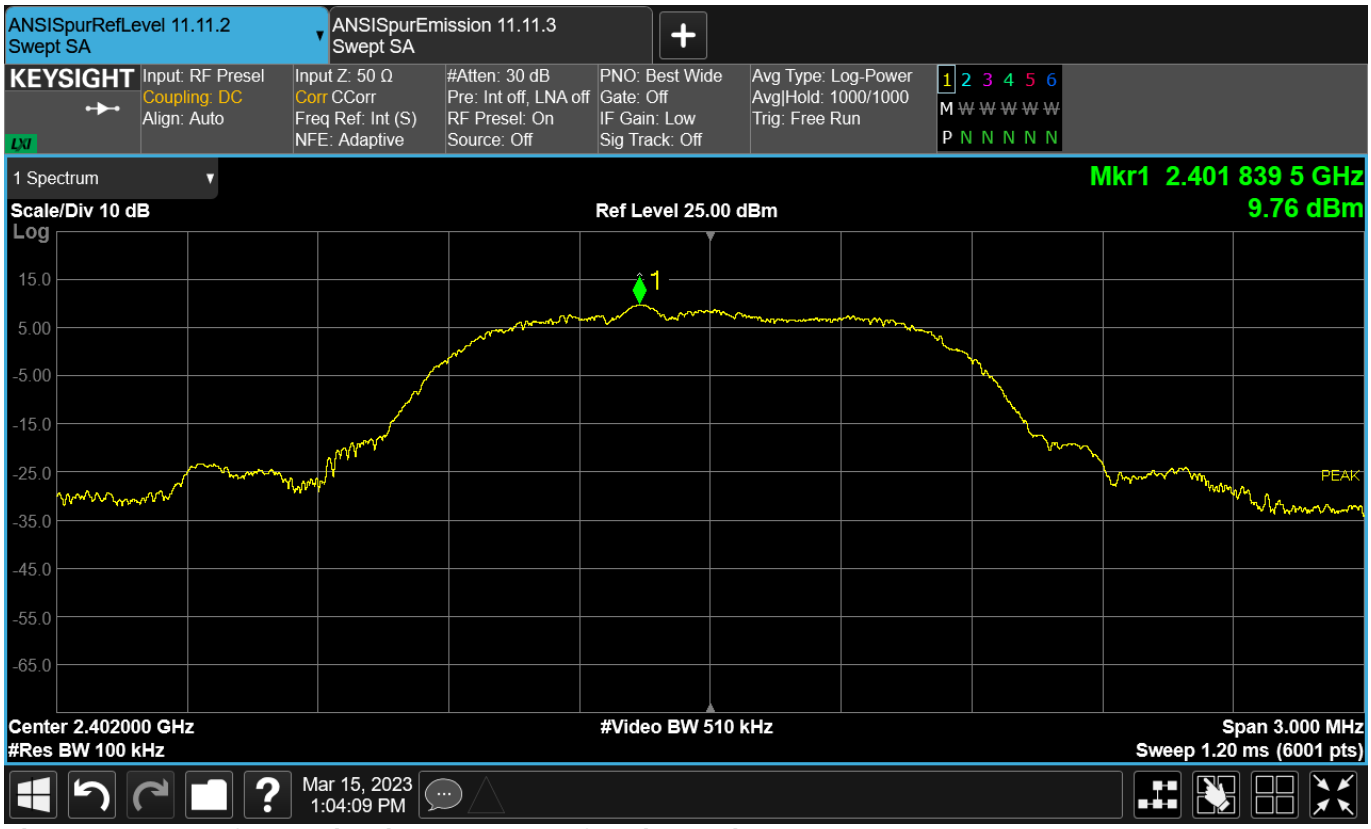

Figure TR22.2: Reference level measurement for Bluetooth EDR3 at 2402 MHz

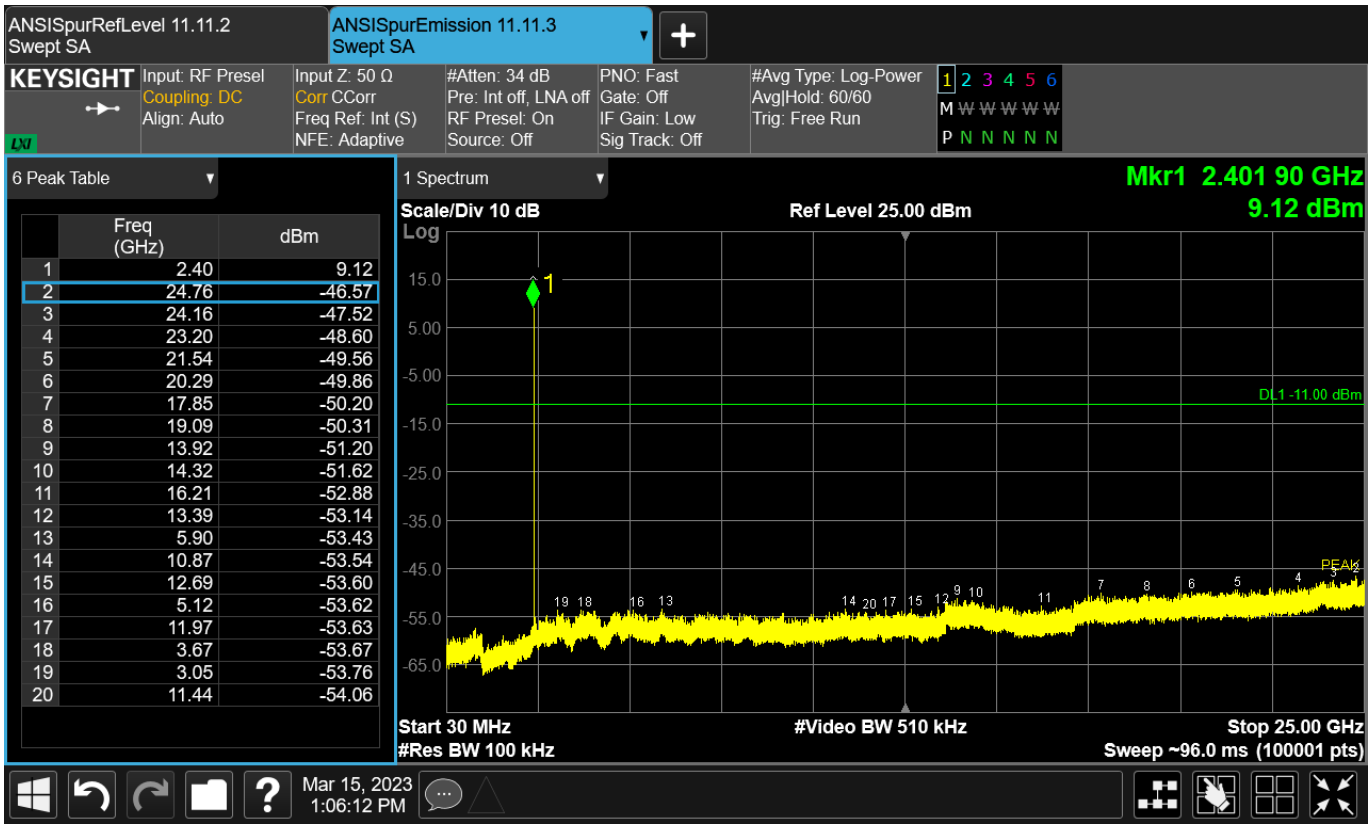

Figure TR22.3: Spectral data for Bluetooth EDR3 at 2402 MHz

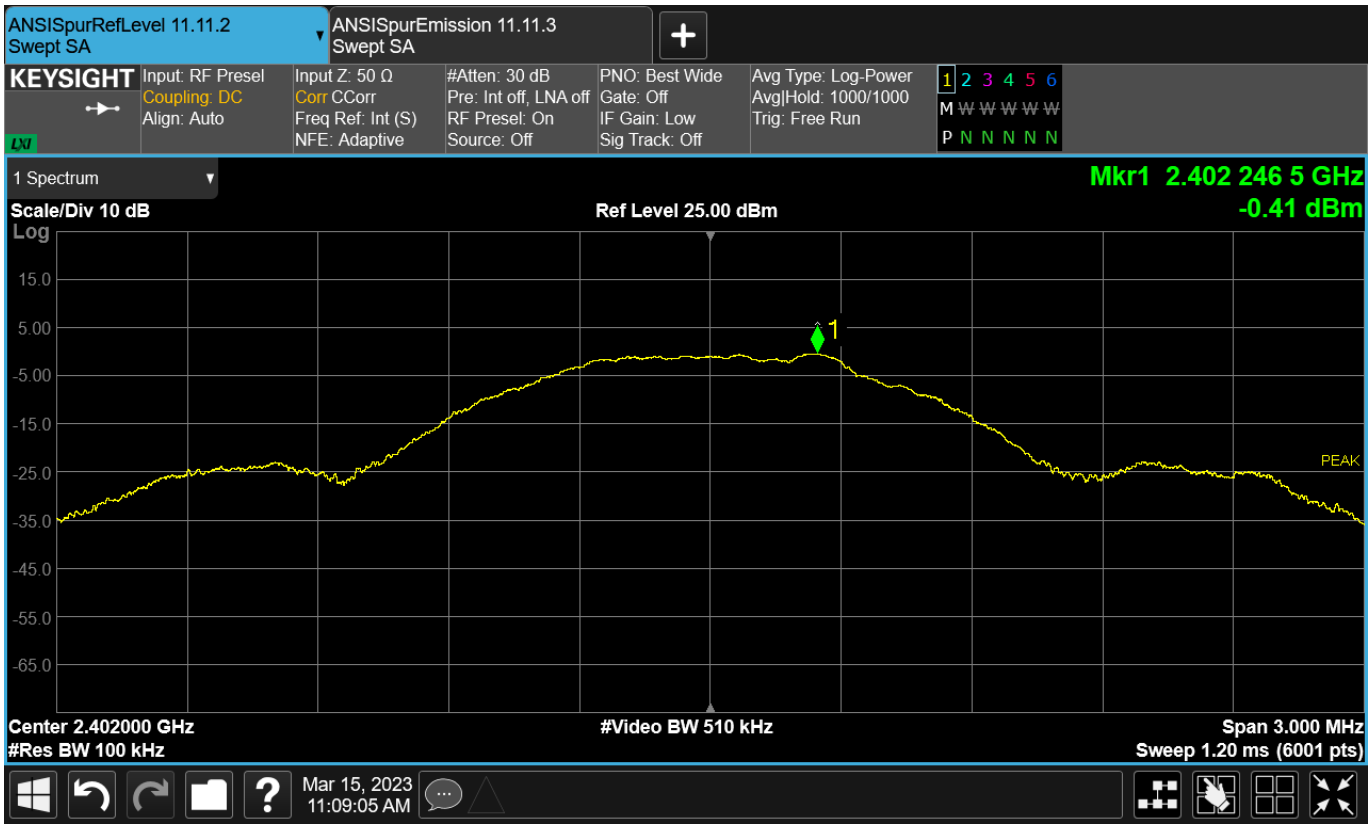

Figure TR22.4: Reference level measurement for Bluetooth BLE 1 Mbps at 2402 MHz

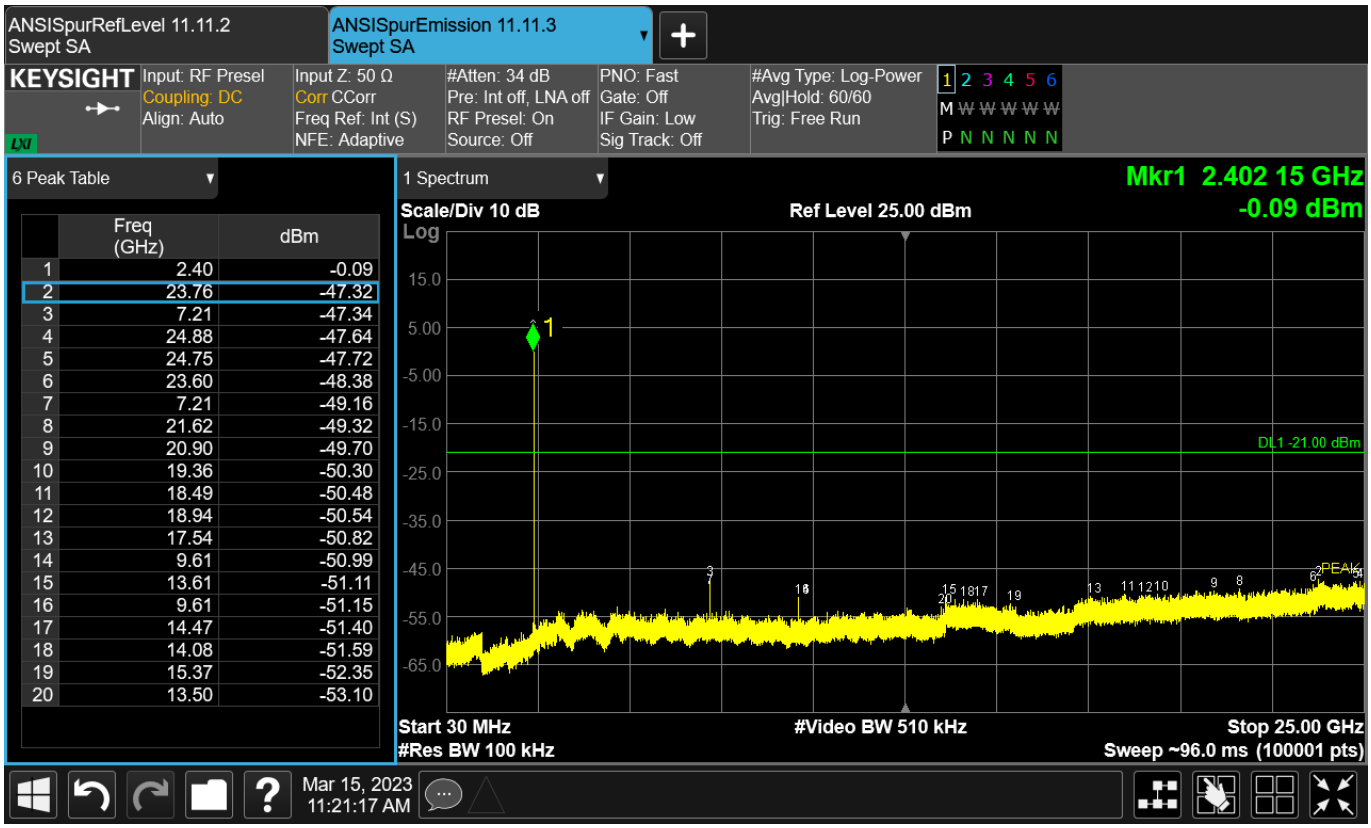

Figure TR22.5 Spectral data for Bluetooth BLE 1 Mbps at 2402 MHz

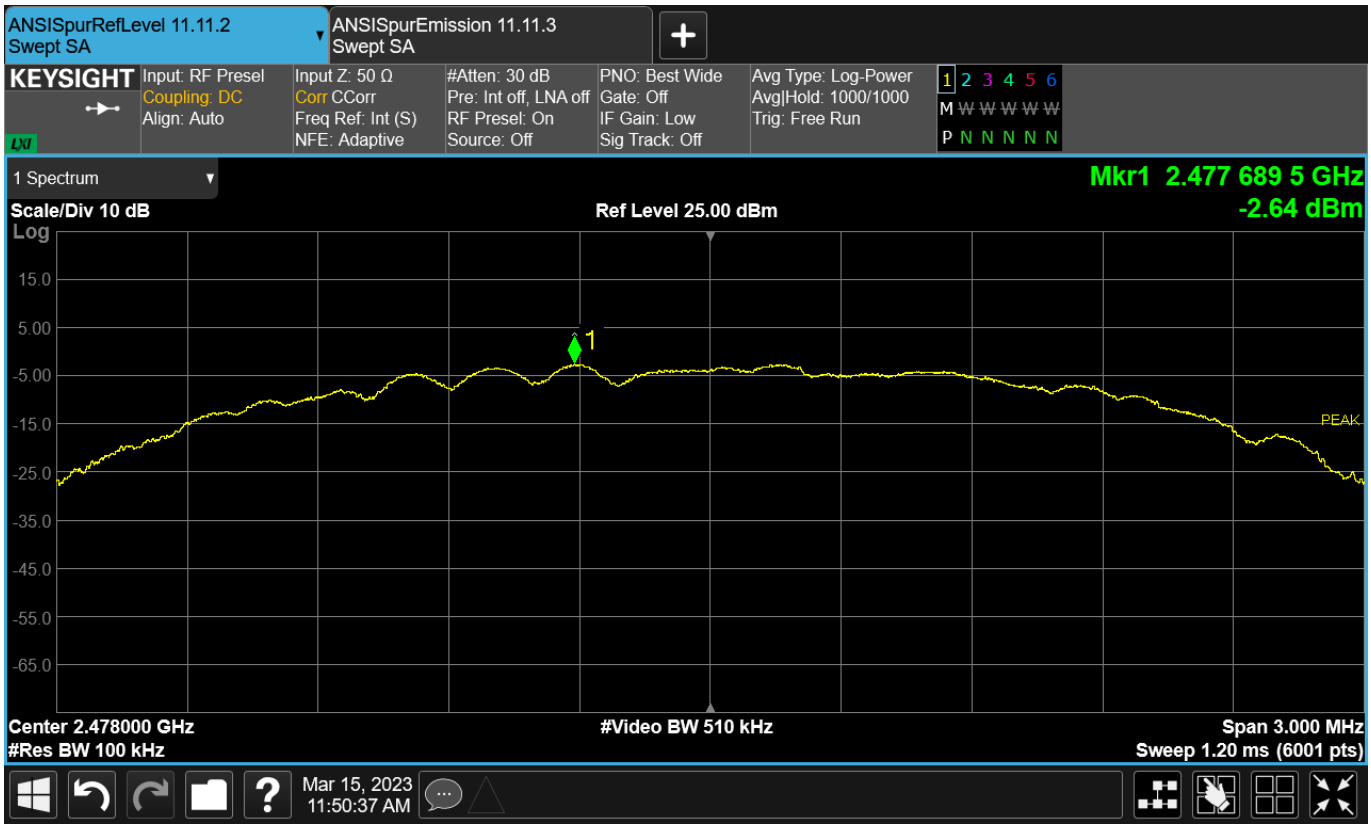

Figure TR22.6: Reference level measurement for Bluetooth BLE 2 Mbps at 2478 MHz

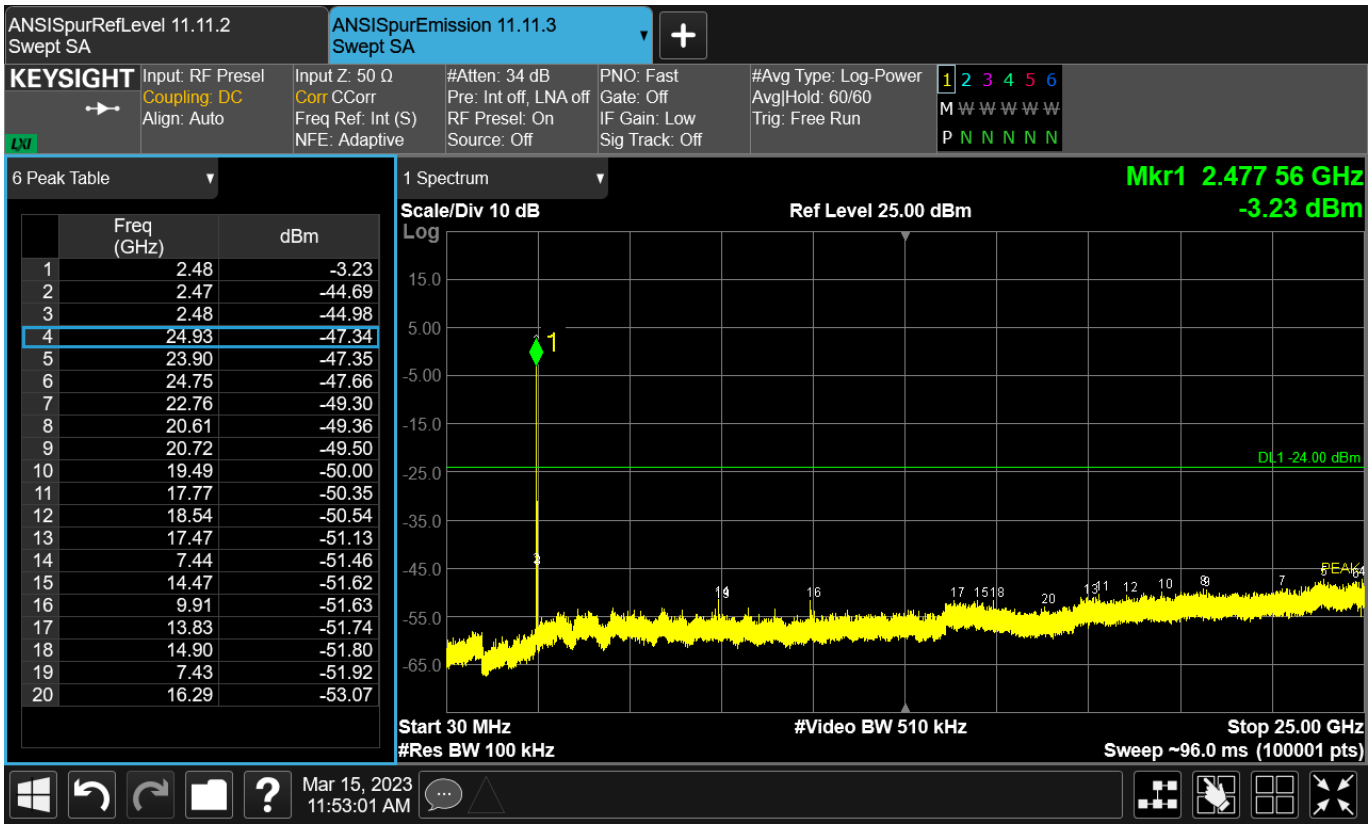

Figure TR22.7 Spectral data for Bluetooth BLE 2 Mbps at 2478 MHz

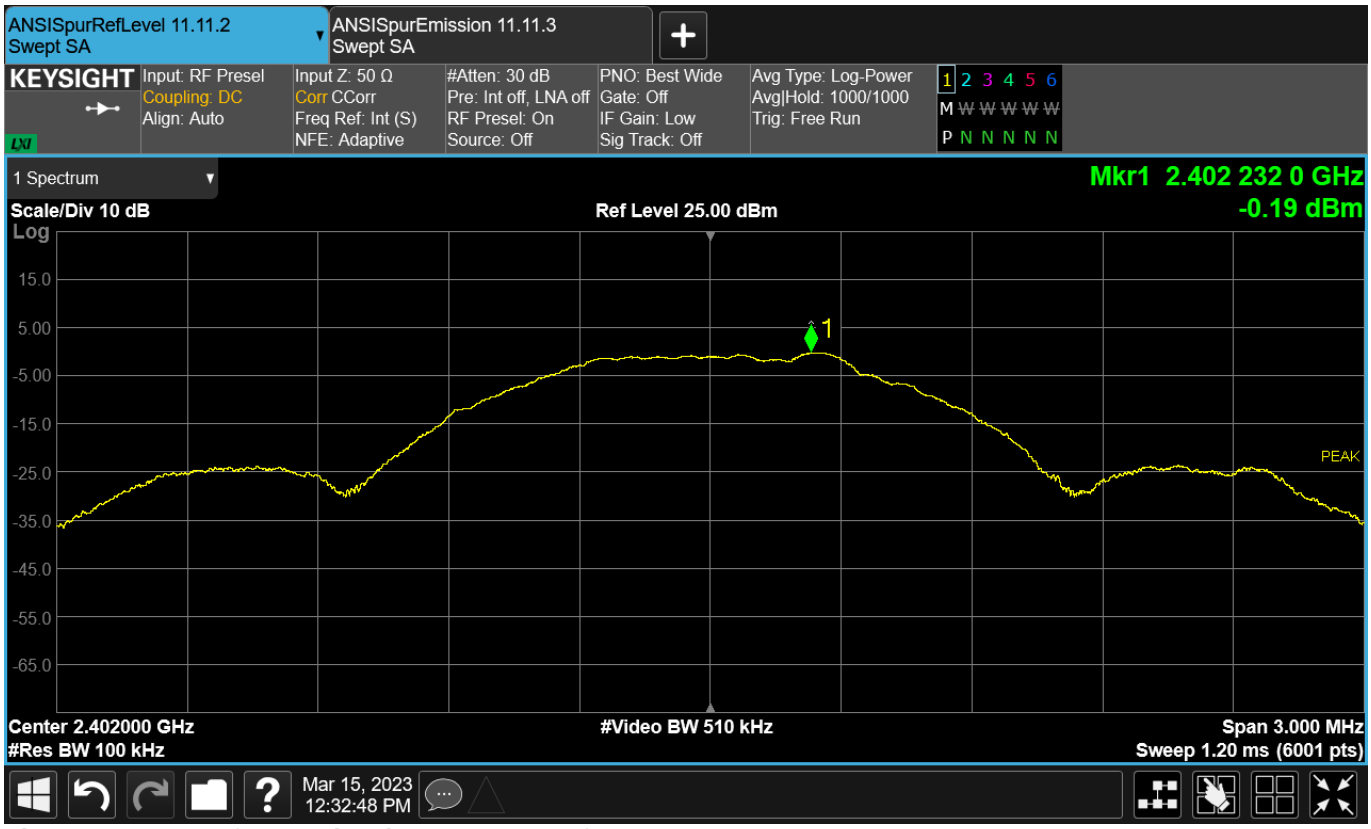

Figure TR22.8: Reference level measurement for ANT at 2402 MHz

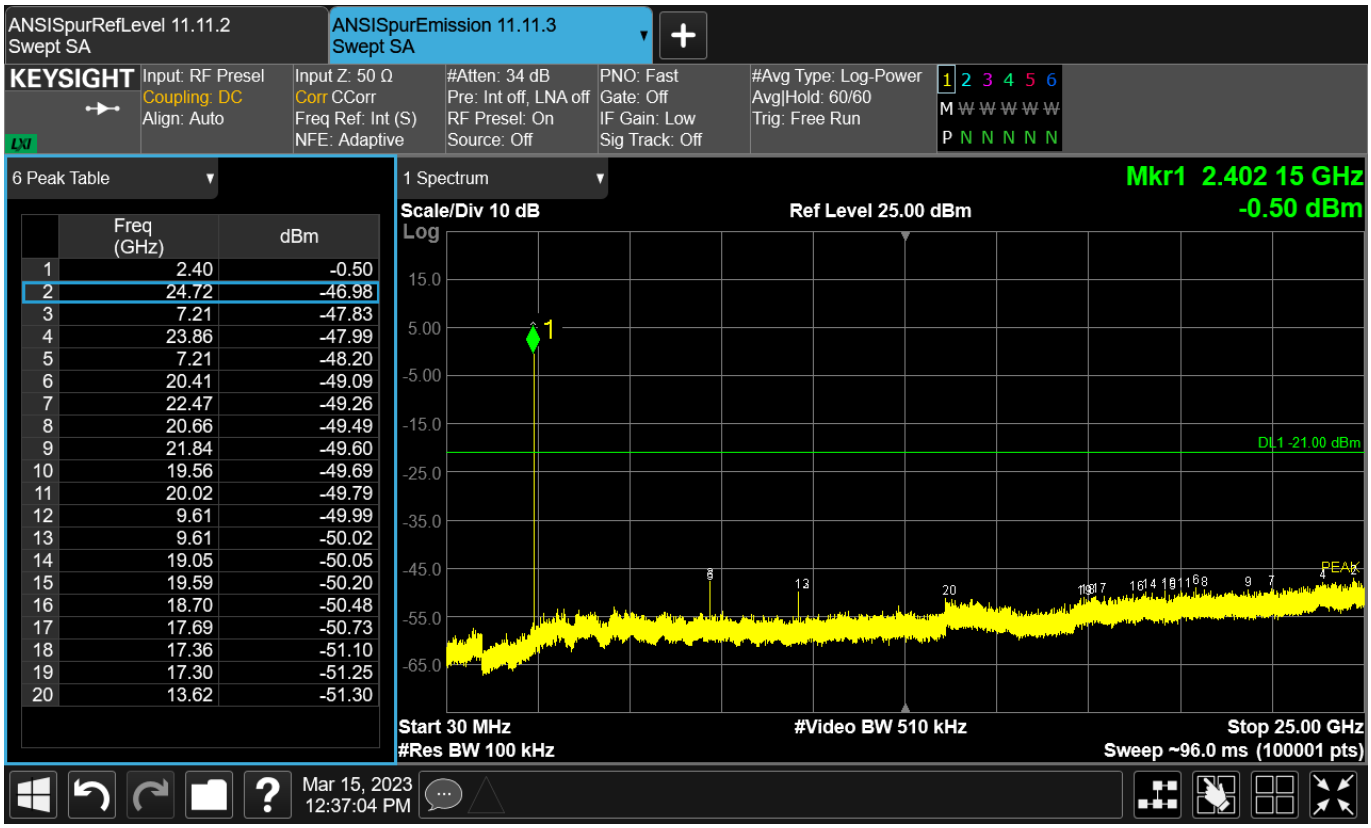

Figure TR22.9 Spectral data for ANT at 2402 MHz
This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test IDs TR25
Project GCL-0303

Test Date(s)	14 and 15 Mar 2023
Test Personnel	Majid Farah
Product Model	A04432
Serial Number tested	3437936721
Operating Mode	M9 (WiFi Tx)
Arrangement	A1 (PwrA)
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:	**Majid Farah**
Date of this test record:	**25 Mar 2023**

Original record, Version A.

Test Equipment

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

Table TR25.1: Test equipment used

Software used: Keysight PXE software A.33.03.

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.

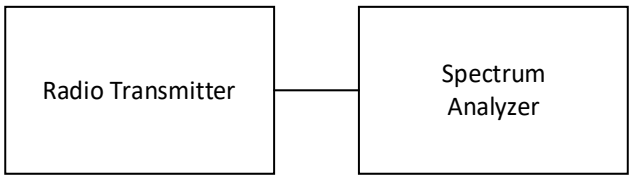

Figure TR25.1: Test setup

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 form 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	**33.41**	**60.43**	**52.86**	**49.92**	**47.39**
B	5.5	**53.41**	**61.34**	**56.12**	**49.02**	**49.10**
G	6	**45.27**	**51.22**	**43.31**	**41.41**	**38.47**
G	12	**42.36**	**51.82**	**43.18**	**42.09**	**39.38**
N	MCS0	**43.75**	**52.26**	**42.49**	**42.04**	**38.99**
N	MCS1	**43.76**	**46.57**	**43.72**	**41.38**	**40.15**
N	MCS2	**43.73**	**51.97**	**42.85**	**41.37**	**38.90**

Table TR25.2: Results Summary

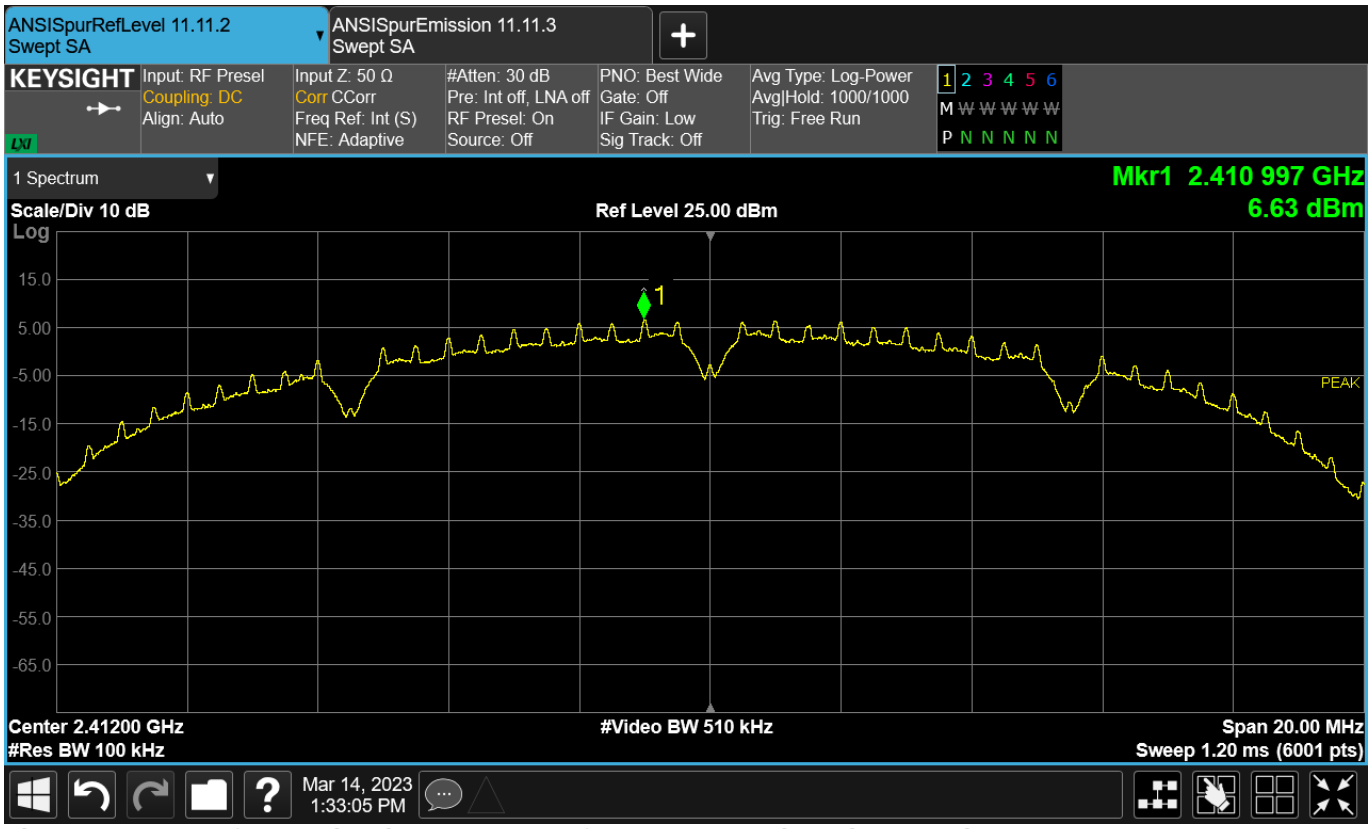

Figure TR25.2: Reference level measurement for IEEE 802.11 b 1 Mbps on Ch.1

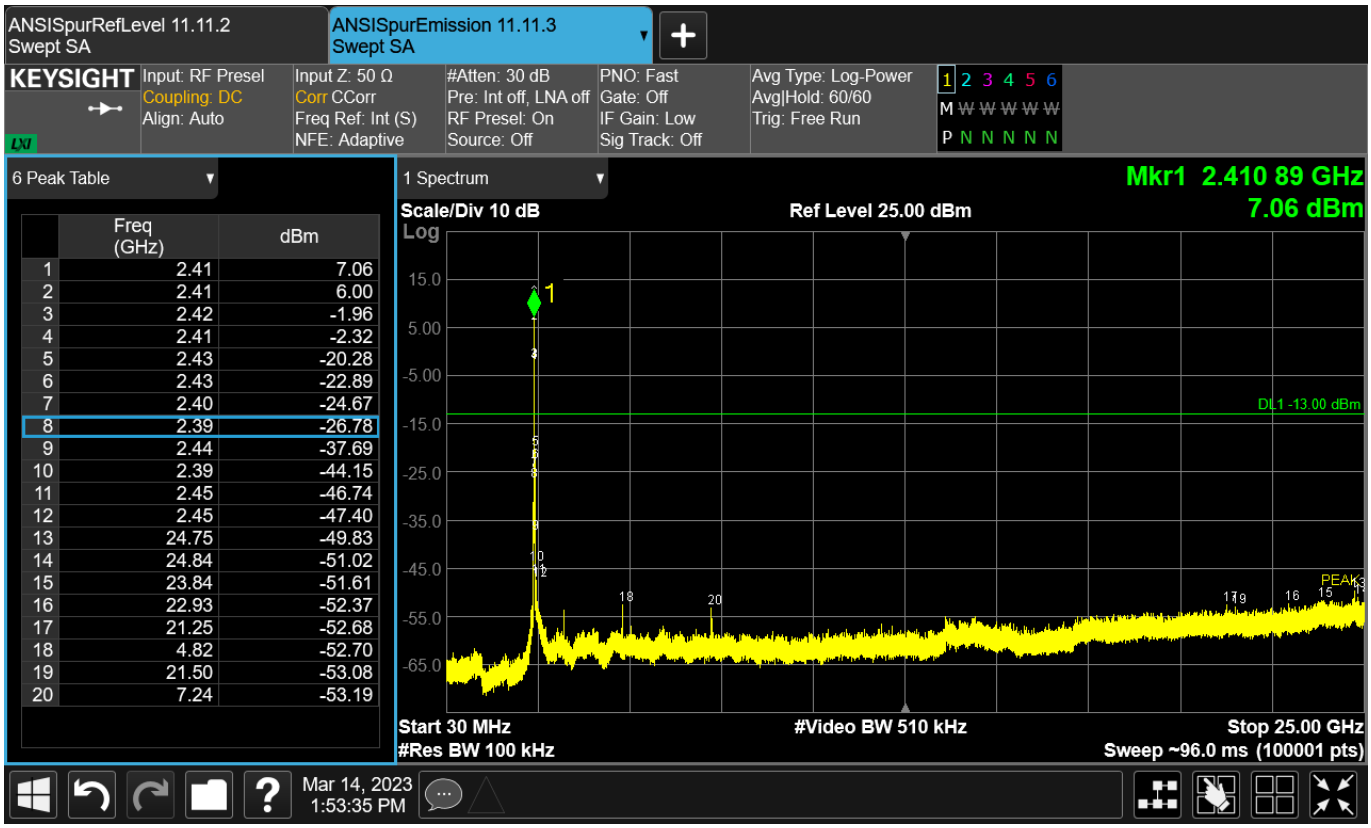

Figure TR25.3: Spectral data for IEEE 802.11 b 1 Mbps on Ch.1

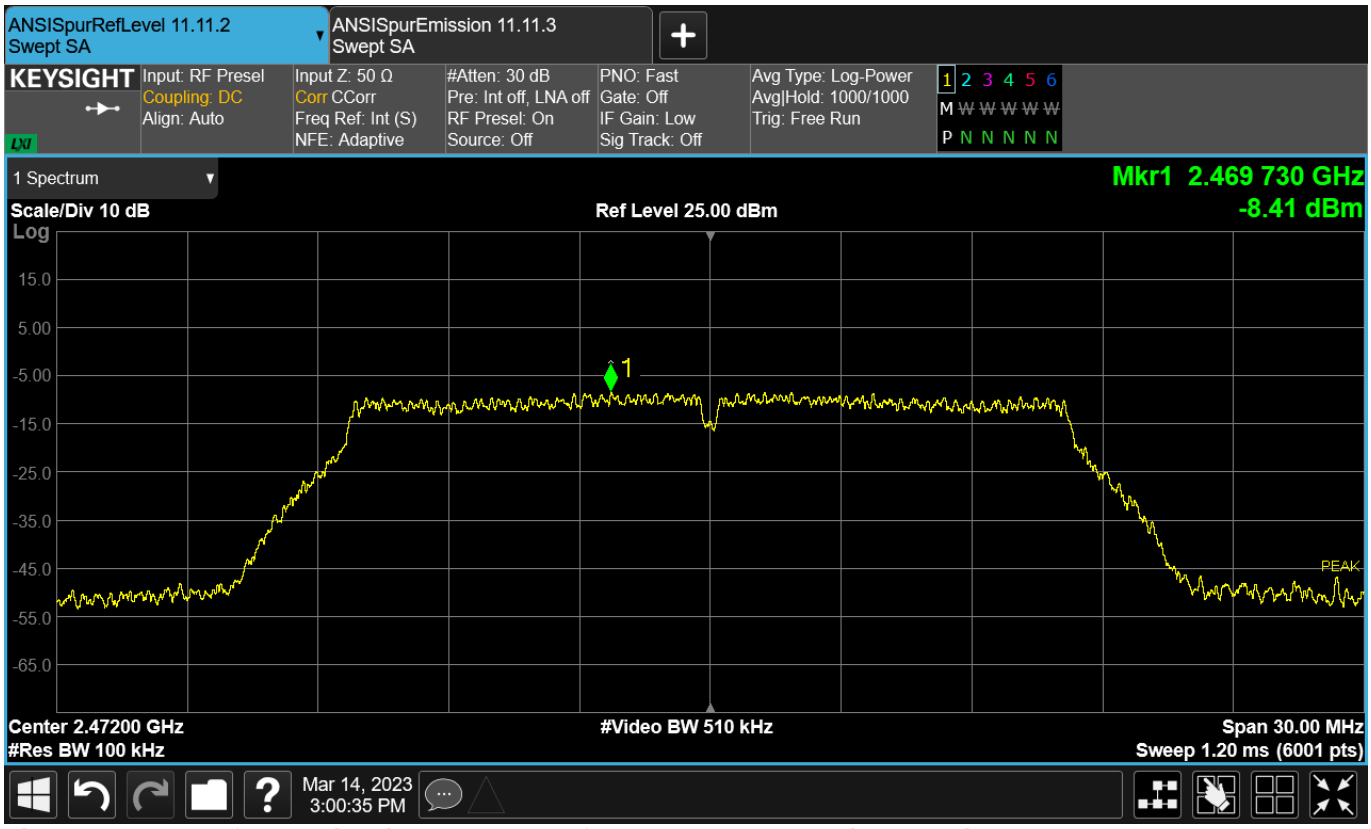

Figure TR25.4: Reference level measurement for IEEE 802.11 g 6 Mbps on Ch.13

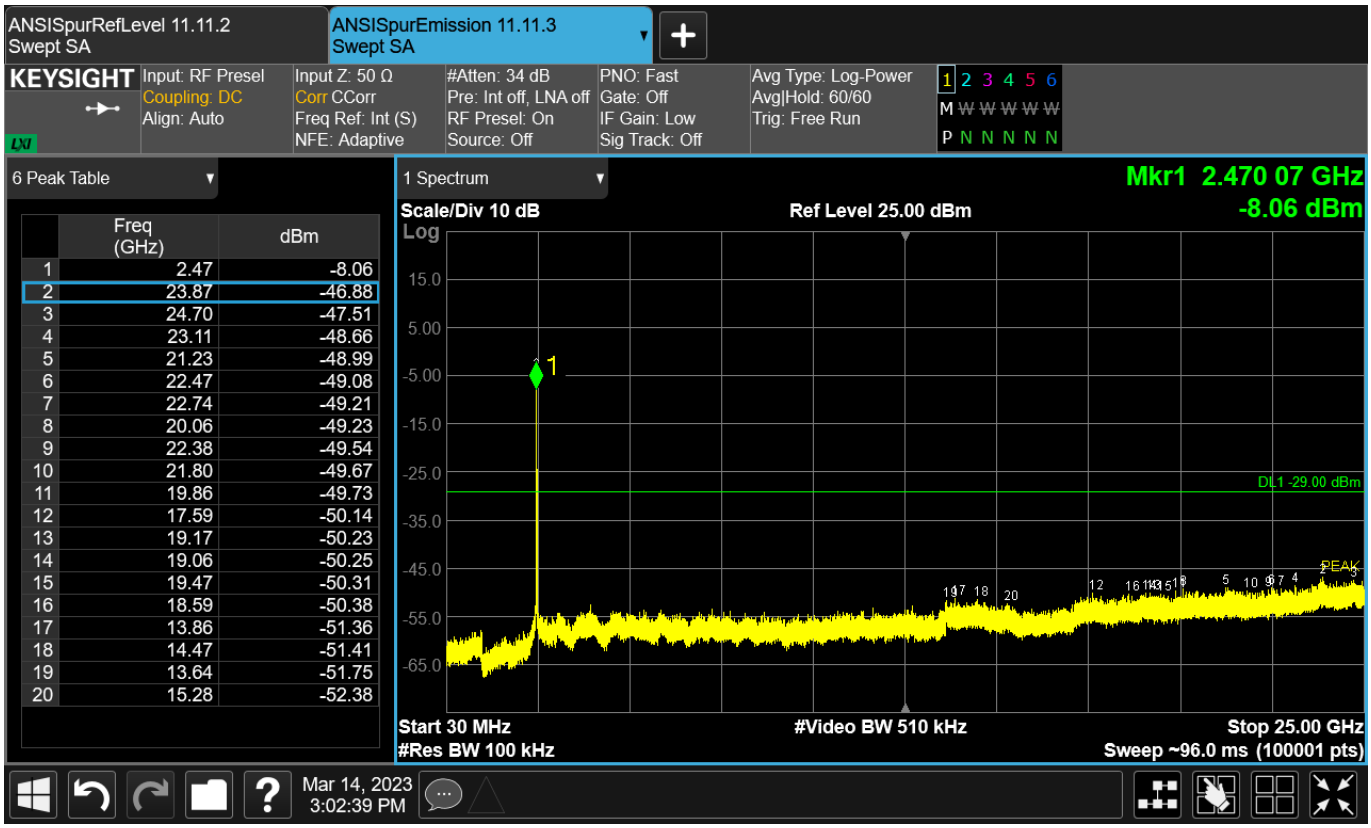

Figure TR25.5 Spectral data for IEEE 802.11 g 6 Mbps on Ch.13

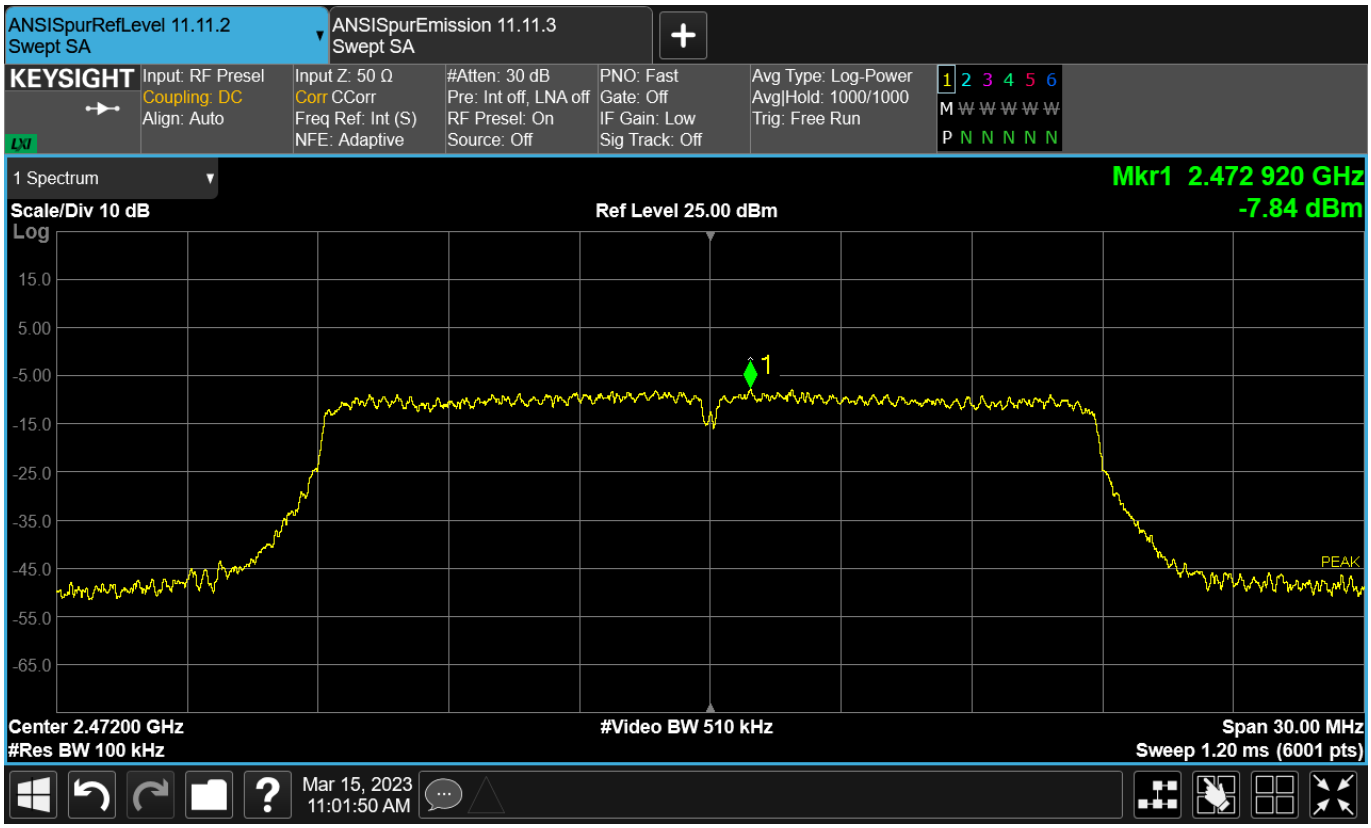

Figure TR25.6: Reference level measurement for IEEE 802.11 n MCS2 on Ch.13

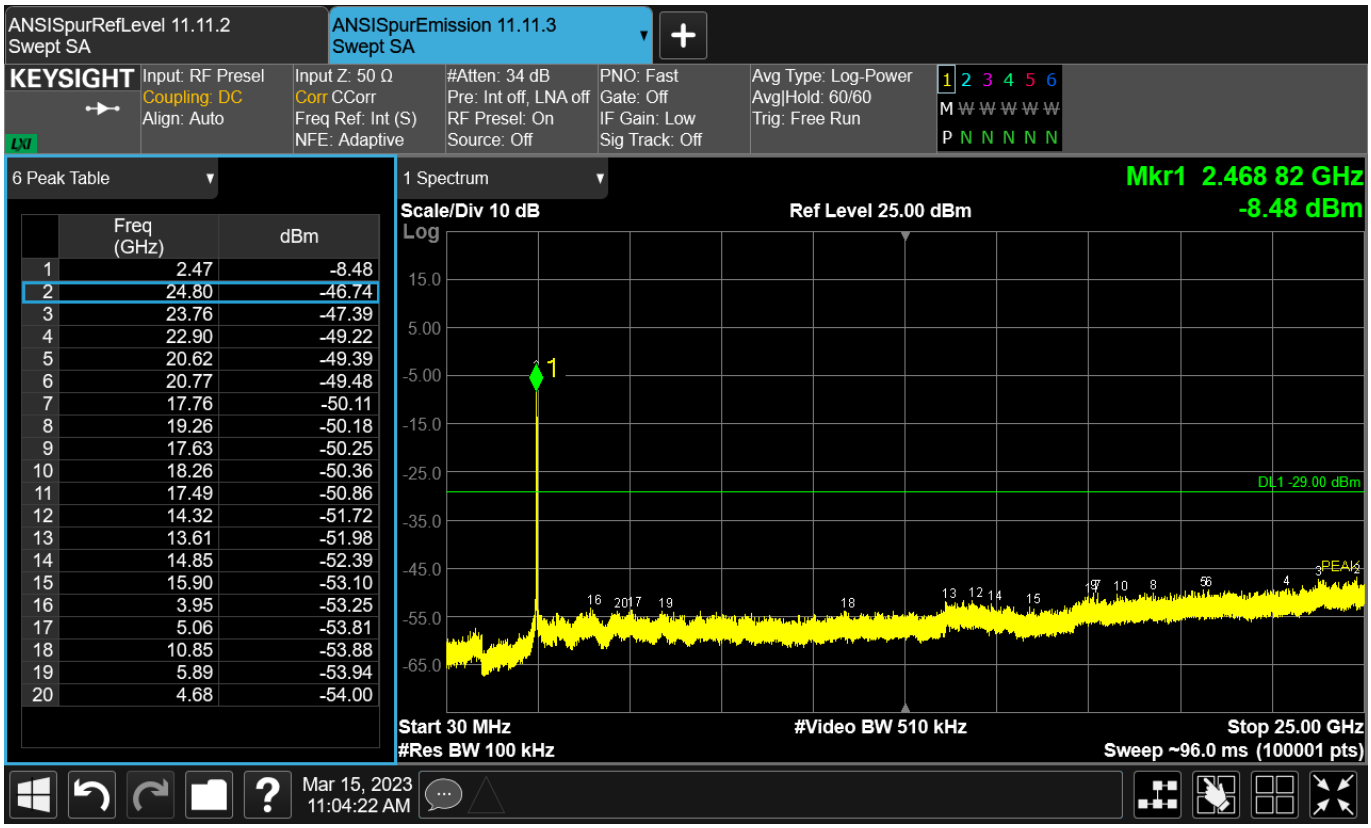

Figure TR25.7 Spectral data for IEEE 802.11 n MCS2 on Ch.13
This line is the end of the test record.

Test Record
Radiated Emission Test RE06
Project GCL0303

Test Date(s)	6 Feb 2023
Test Personnel	David Kerr
Product Model	A04432
Serial Number tested	3437936612
Operating Mode	M3 (BLE tx)
Arrangement	A1 (PwrA)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, (as noted in Section 6 of the report).
Frequency Range:	FCC Restricted Bands (2200 - 2390MHz, 2483.5 - 2500MHz)
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**13 Mar 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
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
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

Table RE06.1: Test Equipment Used

Software Used
Keysight PXE N9048B Firmware version A.32.06
RE Signal Maximization Tool v2021Feb25.xlsx
FCC Restricted Band 2p4GHz Template v1 2022Sep08.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.

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 in 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
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2386	54	74	32.467	46.667	21.533	27.333	-40	2232	VERT
2389	54	74	32.579	46.568	21.421	27.432	149	3918	VERT

Table RE06.2: Emission summary FCC restricted band from 2200 to 2390 MHz (1 Mbps)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2483.5	54	74	41.127	54.499	12.873	19.501	-82	2965	HORZ
2483.5	54	74	42.743	55.811	11.257	18.189	-139	3638	HORZ

Table RE06.3: Emission summary FCC restricted band from 2483.5 to 2500 MHz (1Mbps)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2389.8	54	74	38.18	49.838	15.82	24.162	-173	1590	VERT
2389.3	54	74	39.571	49.731	14.429	24.269	-174	1764	VERT

Table RE06.4: Emission summary FCC restricted band from 2200 to 2390 MHz (2 Mbps)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2483.5	54	74	50.132	60.961	3.868	13.039	-143	3707	HORZ
2484.8	54	74	44.854	54.561	9.146	19.439	-143	3207	HORZ

Table RE06.5: Emission summary FCC restricted band from 2483.5 to 2500 MHz (2 Mbps)

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

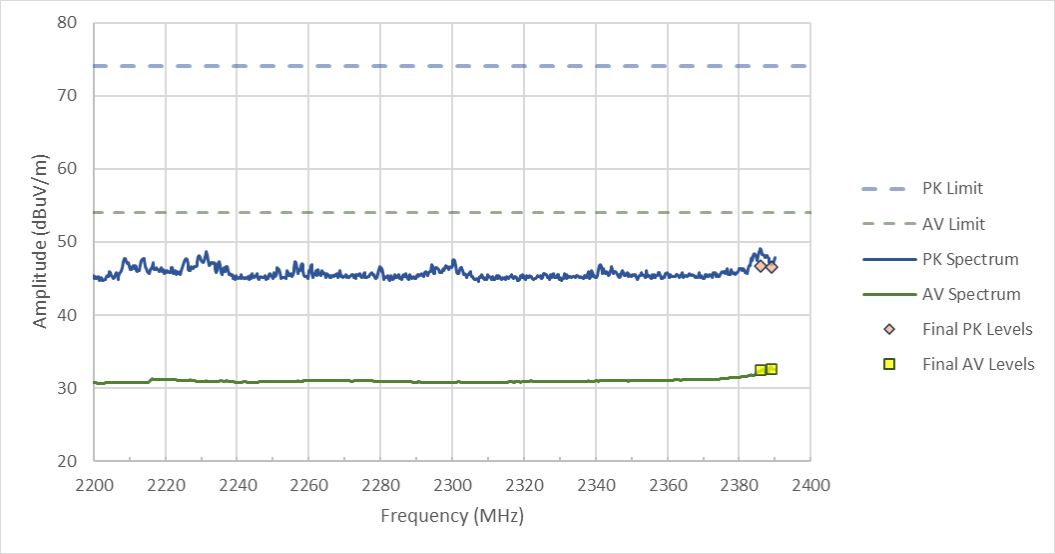

Figure RE06.1: Spectral data FCC restricted band from 2200 to 2390 MHz (1Mbps)

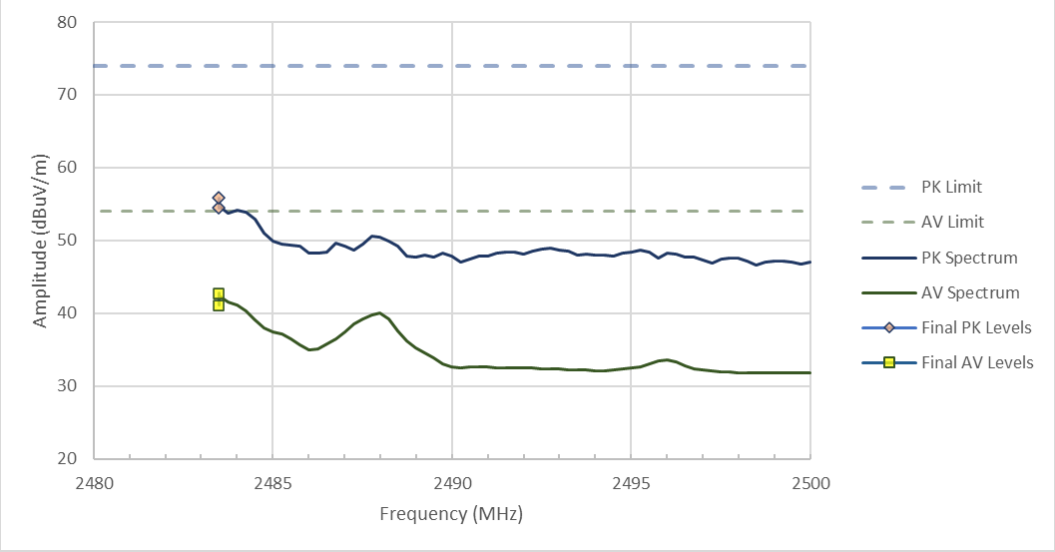

Figure RE06.2: Spectral data FCC restricted band from 2483.5 to 2500 MHz (1 Mbps)

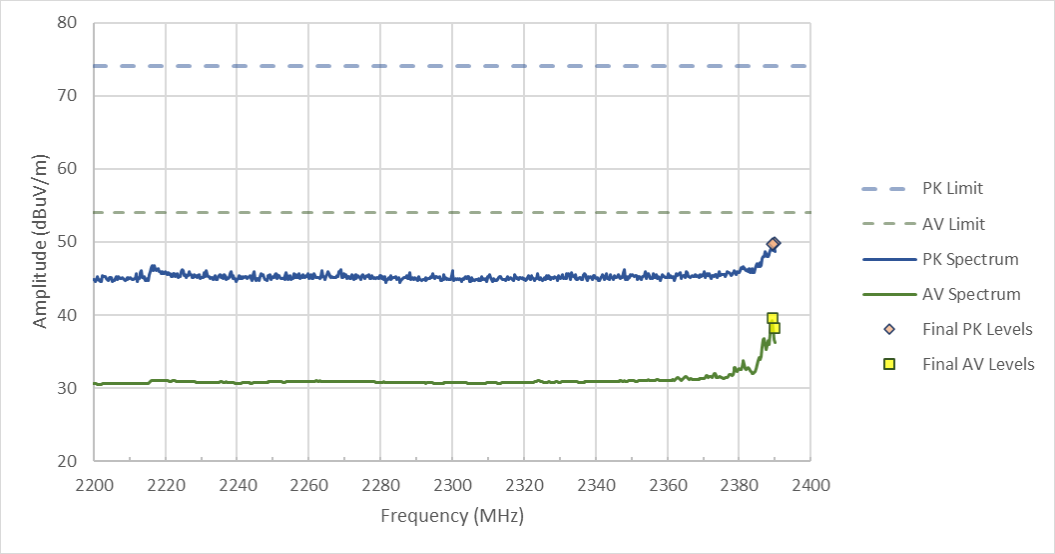

Figure RE06.3: Spectral data FCC restricted band from 2200 to 2390 MHz (2 Mbps)

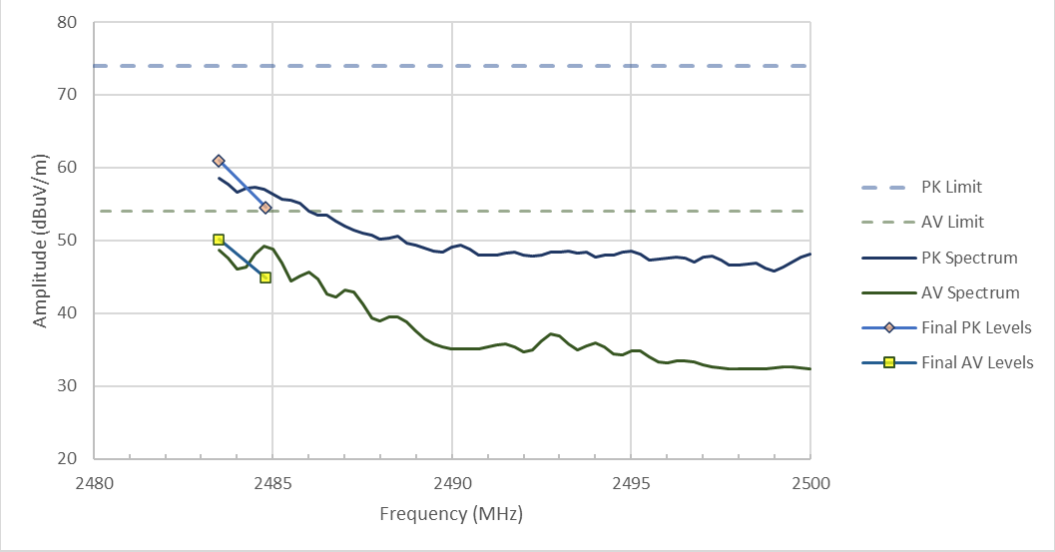

Figure RE06.4: Spectral data FCC restricted band from 2483.5 to 2500 MHz (2 Mbps)

Setup Photographs

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

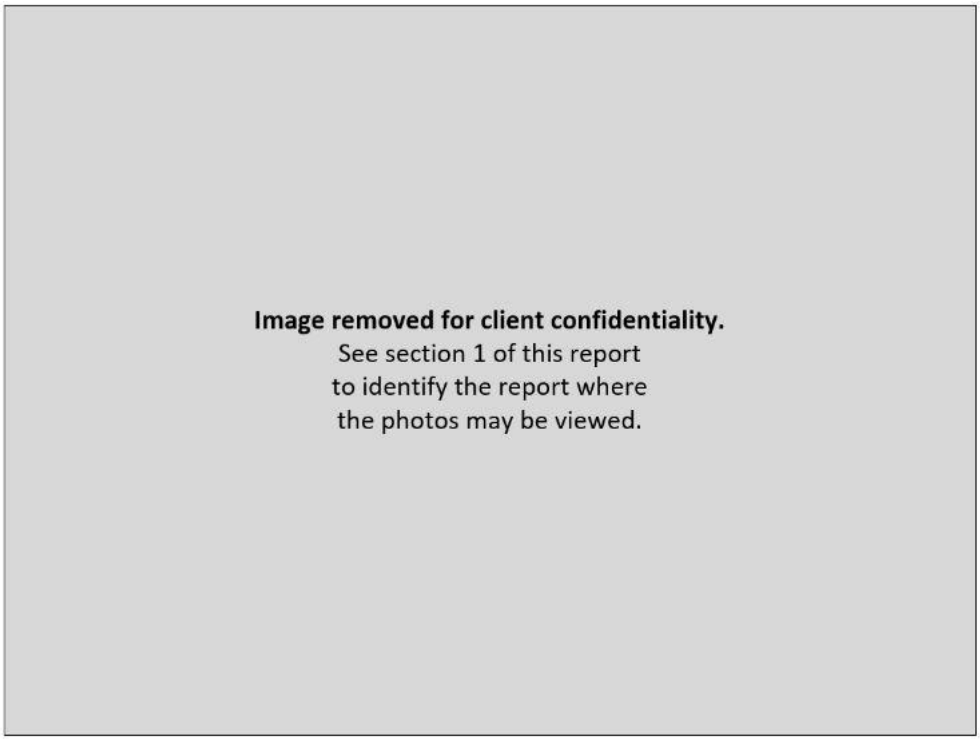

Figure RE06.5: EUT test setup, front view (Z orientation)

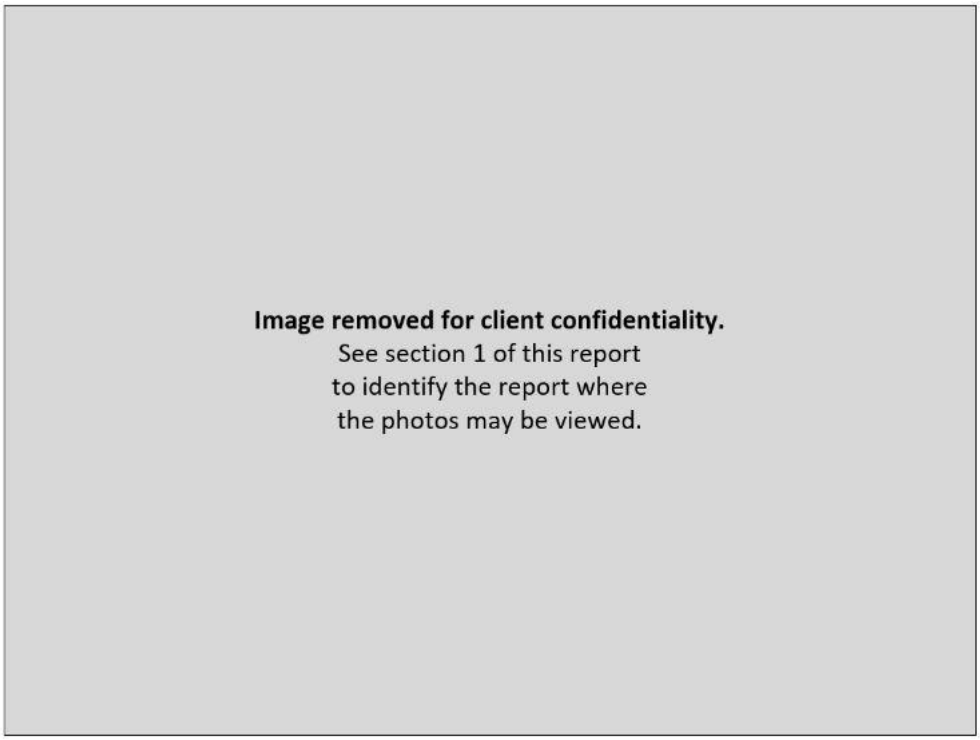

Figure RE06.6: EUT test setup, reverse view (Z orientation)

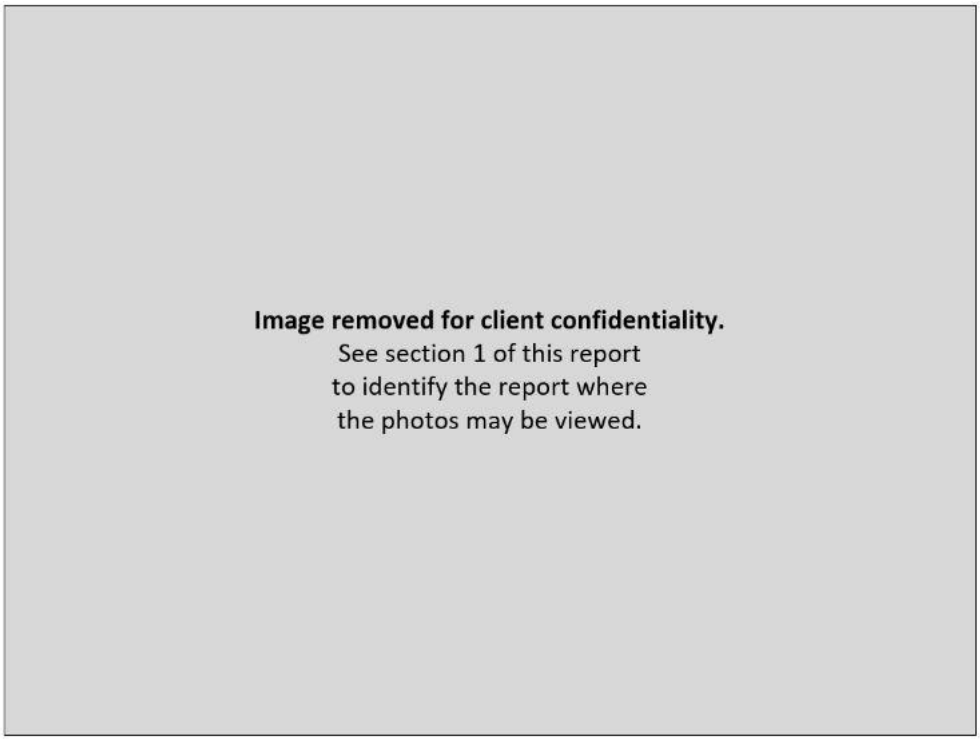

Figure RE06.7: EUT test setup, front view (Y orientation)

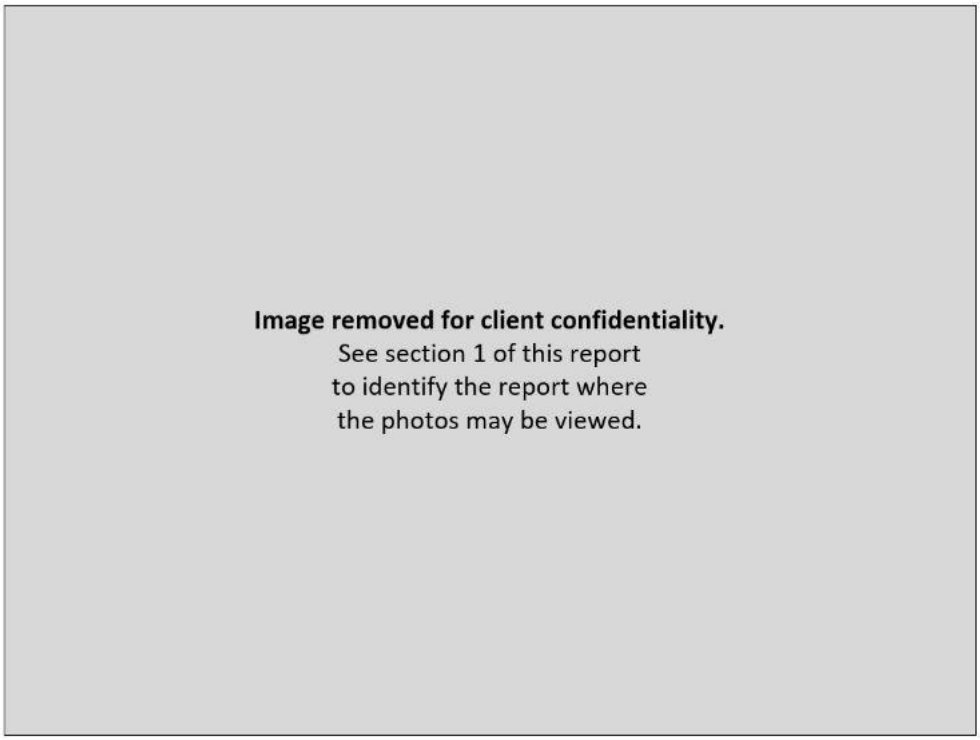

Figure RE06.8: EUT test setup, reverse view (Y orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE07
Project GCL0303

Test Date(s)	07 Feb 2023
Test Personnel	David Kerr
Product Model	A04432
Serial Number tested	3437936612
Operating Mode	M7 (ANT Tx)
Arrangement	A1 (PwrA)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, (as noted in Section 6 of the report).
Frequency Range:	FCC Restricted Bands
Pass/Fail Judgment:	**PASS**
Test record created by:	**David Kerr / Jim Solum**
Date of this record:	**13 Mar 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
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
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

Table RE07.1: Test Equipment Used

Software Used
Keysight PXE N9048B Firmware version A.32.06
RE Signal Maximization Tool v2021Feb25.xlsx
FCC Restricted Band 2p4GHz Template v1 2022Sep08.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.

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 in 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
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2386.5	54	74	32.389	46.171	21.611	27.829	56	2226	HORZ
2390	54	74	32.928	46.518	21.072	27.482	182	2294	VERT

Table RE07.2: Emission summary FCC restricted band from 2200 to 2390 MHz

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2484	54	74	40.474	52.414	13.526	21.586	-127	1773	HORZ
2484	54	74	41.825	52.682	12.175	21.318	-129	3617	HORZ

Table RE07.3: Emission summary FCC restricted band from 2483.5 to 2500 MHz

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

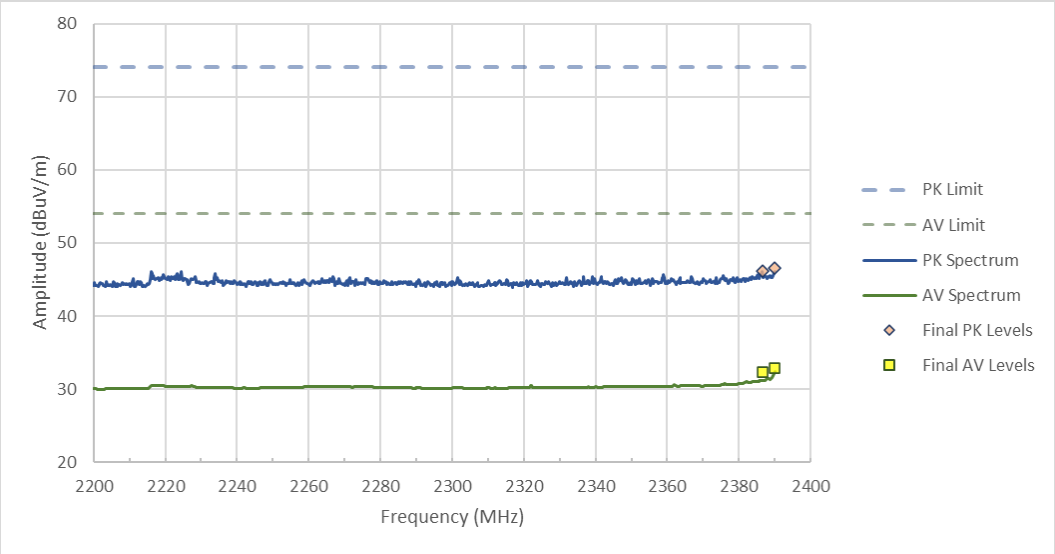

Figure RE07.1: Spectral data FCC restricted band from 2200 to 2390 MHz

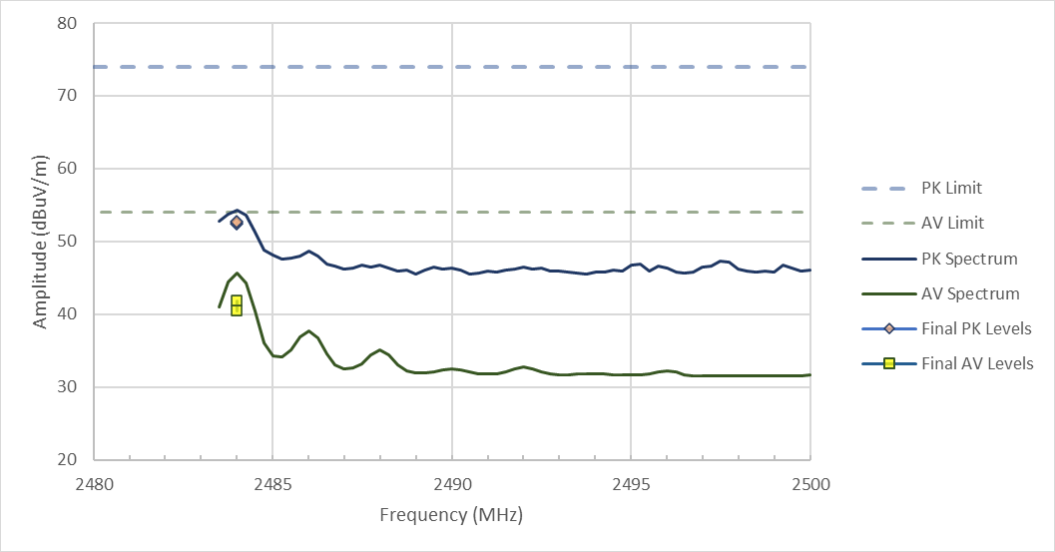

Figure RE07.2: Spectral data FCC restricted band from 2483.5 to 2500 MHz

Setup Photographs

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

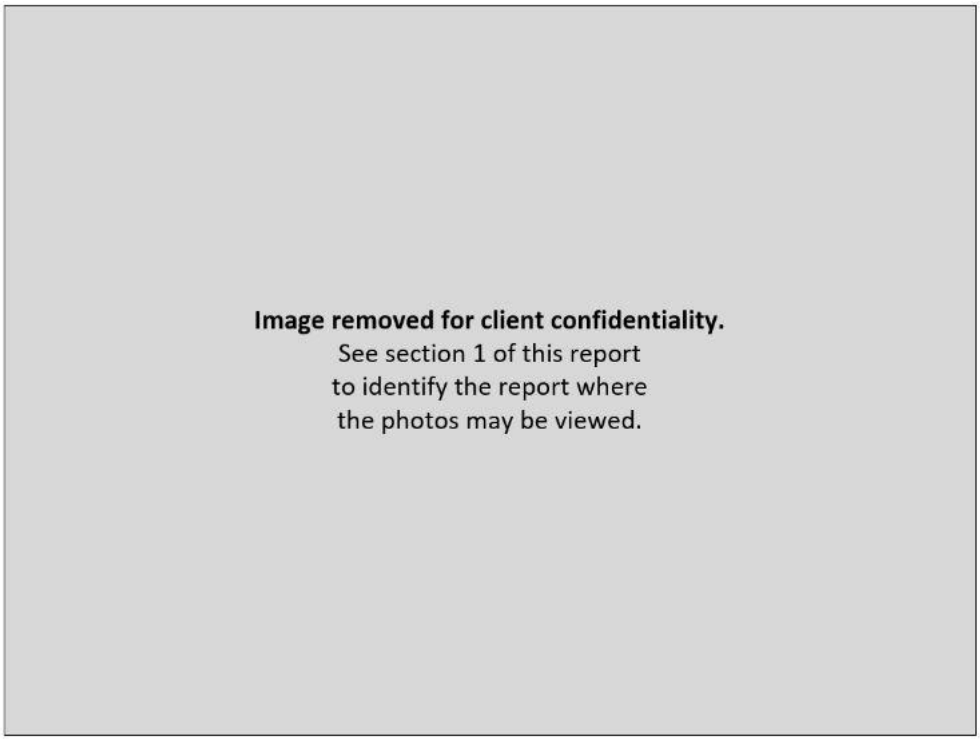

Figure RE07.3: EUT test setup, front view (Z orientation)

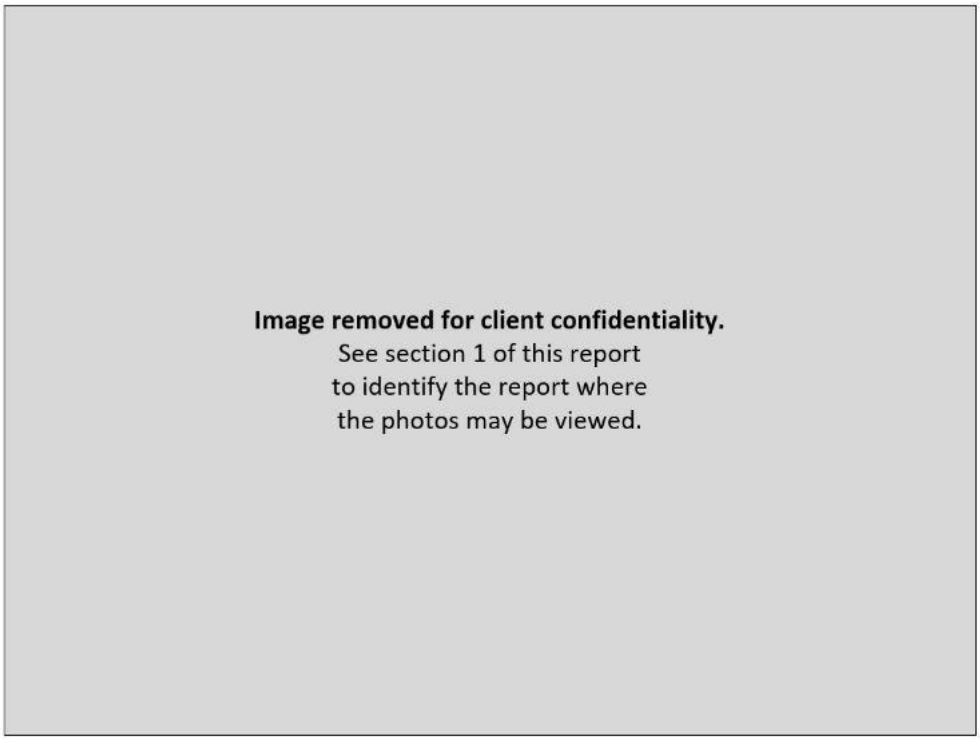

Figure RE07.4: EUT test setup, reverse view (Z orientation)

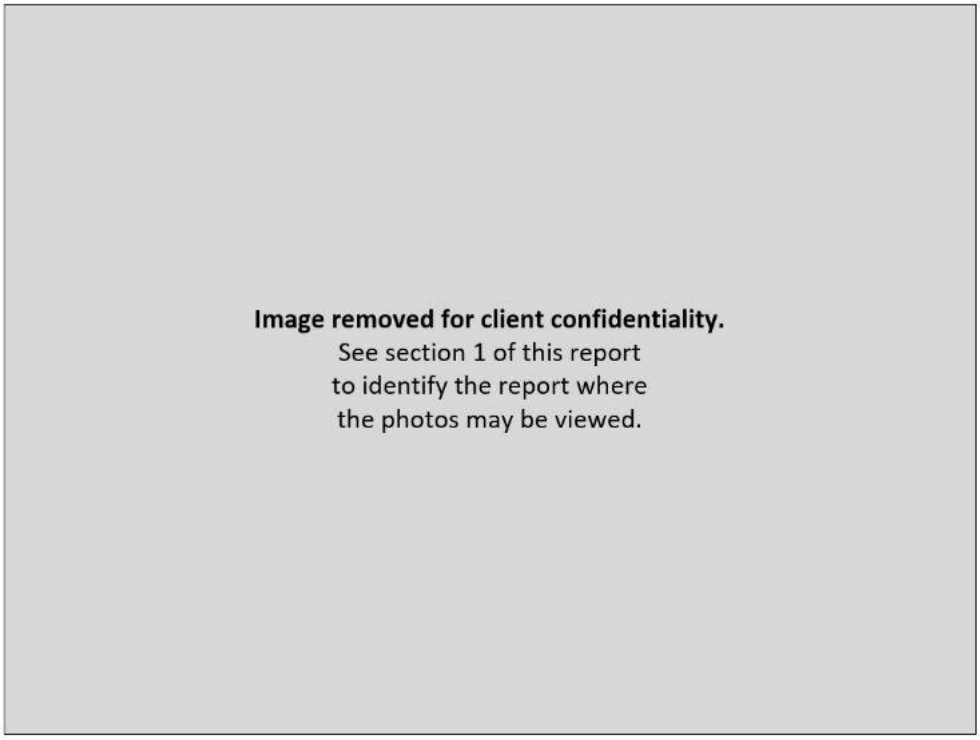

Figure RE07.5: EUT test setup, front view (Y orientation)

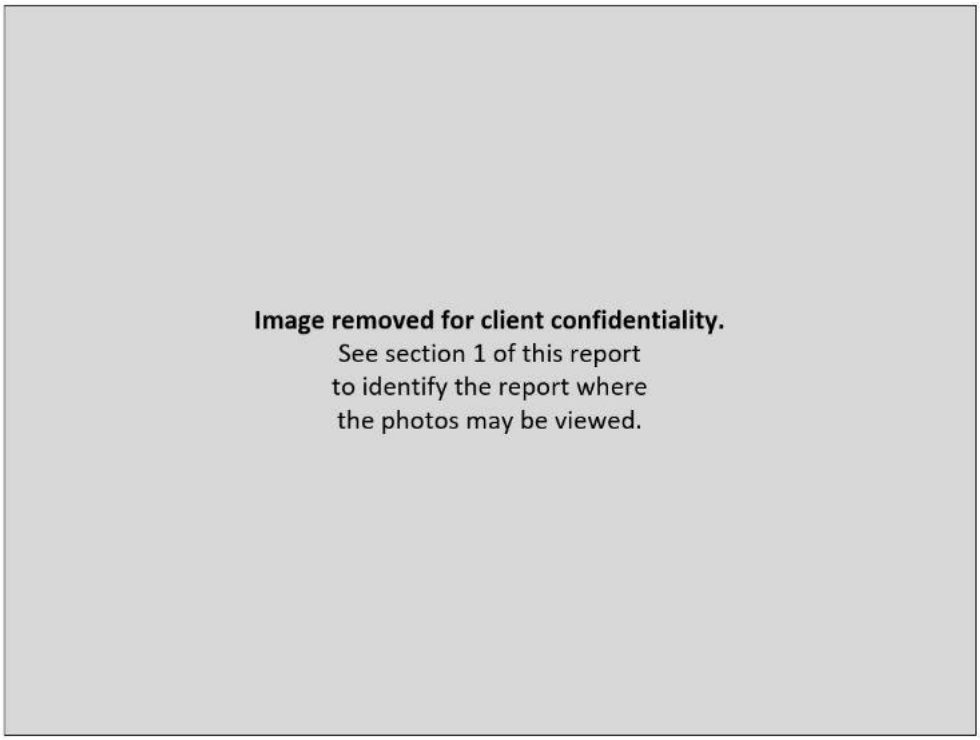

Figure RE07.6: EUT test setup, reverse view (Y orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE08
Project GCL0303

Test Date(s)	07 Feb – 15 Feb 2023
Test Personnel	David Kerr
Product Model	A04432
Serial Number tested	3437936612
Operating Mode	M9 (WiFi Tx)
Arrangement	A1 (PwrA)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10 (as noted in Section 6 of the report).
Frequency Range:	FCC Restricted Bands (2200 - 2390MHz, 2483.5 - 2500MHz)
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**15 Mar 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
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
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

Table RE08.1: Test Equipment Used

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WiFi FCC Restricted Band 2p4GHz Template v1 2022Sep08.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.

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 in 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.

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
B11 Peak	2386.5	54	74	50.48	62.479	3.52	11.521	173	1591	VERT
B11 Average	2387.5	54	74	50.027	60.854	3.973	13.146	146	1506	VERT
G54 Peak	2390	54	74	46.555	64.351	7.445	9.649	160	1509	VERT
G54 Average	2390	54	74	46.643	64.96	7.357	9.04	160	1509	VERT
N2 Peak	2390	54	74	47.461	66.182	6.539	7.818	-186	1782	VERT
N2 Average	2390	54	74	47.426	66.116	6.574	7.884	-186	1782	VERT

Table RE08.2: Emission summary FCC restricted band from 2200 to 2390 MHz (WiFi Ch.1)

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
B11 Peak	2389.5	54	74	47.826	61.074	6.174	12.926	144	1500	VERT
B11 Average	2390	54	74	45.435	58.412	8.565	15.588	-62	3219	VERT
G54 Peak	2389.5	54	74	44.342	61.781	9.658	12.219	140	1516	VERT
G54 Average	2390	54	74	44.678	61.777	9.322	12.223	140	1516	VERT
N2 Peak	2389.5	54	74	44.479	61.936	9.521	12.064	-186	1782	VERT
N2 Average	2390	54	74	44.642	61.826	9.358	12.174	-186	1782	VERT

Table RE08.3: Emission summary FCC restricted band from 2200 to 2390 MHz (WiFi Ch.2)

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
N2 Peak	2388.8	54	74	44.641	61.772	9.359	12.228	-186	1782	VERT
N2 Average	2390	54	74	44.869	61.441	9.131	12.559	-186	1782	VERT

Table RE08.4: Emission summary FCC restricted band from 2200 to 2390 MHz (WiFi Ch.3)

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
N2 Peak	2388.8	54	74	41.746	56.892	12.254	17.108	-186	1782	VERT
N2 Average	2390	54	74	41.836	58.238	12.164	15.762	-186	1782	VERT

Table RE08.5: Emission summary FCC restricted band from 2200 to 2390 MHz (WiFi Ch.4)

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
N2 Peak	2389.5	54	74	45.152	63.866	8.848	10.134	-186	1782	VERT
N2 Average	2390	54	74	45.206	64.379	8.794	9.621	-186	1782	VERT

Table RE08.6: Emission summary FCC restricted band from 2200 to 2390 MHz (WiFi Ch.5)

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
B11 Peak	2488.5	54	74	48.585	63.395	5.415	10.605	-142	3241	HORZ
B11 Average	2483.5	54	74	48.803	60.826	5.197	13.174	-142	3241	HORZ
G54 Peak	2483.8	54	74	43.008	62.995	10.992	11.005	-142	3241	HORZ
G54 Average	2484.5	54	74	43.006	62.539	10.994	11.461	-142	3241	HORZ
N7 Peak	2484.3	54	74	40.887	60.606	13.113	13.394	-142	3241	HORZ
N7 Average	2498	54	74	41.149	55.876	12.851	18.124	-142	3241	HORZ

Table RE08.7: Emission summary FCC restricted band from 2483.5 to 2500 MHz (WiFi Ch.9)

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
B11 Peak	2484.5	54	74	48.619	61.835	5.381	12.165	-142	3241	HORZ
B11 Average	2483.5	54	74	49.651	61.116	4.349	12.884	-142	3241	HORZ
G6 Peak	24840	54	74	46.361	64.635	7.639	9.365	-142	3241	HORZ
G6 Average	2483.5	54	74	46.428	64.132	7.572	9.868	-142	3241	HORZ
N3 Peak	2485.5	54	74	46.925	68.219	7.075	5.781	-142	3241	HORZ
N3 Average	2485.5	54	74	47.511	66.828	6.489	7.172	-142	3241	HORZ

Table RE08.8: Emission summary FCC restricted band from 2483.5 to 2500 MHz (WiFi Ch.10)

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
B11 Peak	2487.8	54	74	44.87	57.014	9.13	16.986	-142	3241	HORZ
B11 Average	24863	54	74	45.371	56.759	8.629	17.241	-142	3241	HORZ
G54 Peak	2483.5	54	74	46.455	66.129	7.545	7.871	-142	3241	HORZ
G54 Average	2483.5	54	74	46.467	65.899	7.533	8.101	-142	3241	HORZ
N2 Peak	2483.5	54	74	49.859	69.188	4.141	4.812	-142	3241	HORZ
N2 Average	2483.5	54	74	49.944	69.385	4.056	4.615	-142	3241	HORZ

Table RE08.9: Emission summary FCC restricted band from 2483.5 to 2500 MHz (WiFi Ch.11)

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
B11 Peak	2483.5	54	74	42.117	54.551	11.883	19.449	-142	3241	HORZ
B11 Average	2483.5	54	74	42.099	54.051	11.901	19.949	-142	3241	HORZ
G54 Peak	2485	54	74	45.699	66.311	8.301	7.689	-142	3241	HORZ
G54 Average	2483.5	54	74	46.532	65.833	7.468	8.167	-142	3241	HORZ
N2 Peak	2483.5	54	74	50.001	67.36	3.999	6.64	-142	3241	HORZ
N2 Average	2483.5	54	74	50.043	69.569	3.957	4.431	-142	3241	HORZ

Table RE08.10: Emission summary FCC restricted band from 2483.5 to 2500 MHz (WiFi Ch.12)

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
B11 Peak	2487	54	74	43.777	55.193	10.223	18.807	-142	3241	HORZ
B11 Average	2485.5	54	74	44.502	55.335	9.498	18.665	-142	3241	HORZ
G54 Peak	2485.8	54	74	43.87	63.331	10.13	10.669	-142	3241	HORZ
G54 Average	2484	54	74	44.15	62.143	9.85	11.857	-142	3241	HORZ
N2 Peak	2483.5	54	74	48.671	67.982	5.329	6.018	-142	3241	HORZ
N2 Average	2484	54	74	48.389	68.022	5.611	5.978	-142	3241	HORZ

Table RE08.11: Emission summary FCC restricted band from 2483.5 to 2500 MHz (WiFi Ch.13)

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

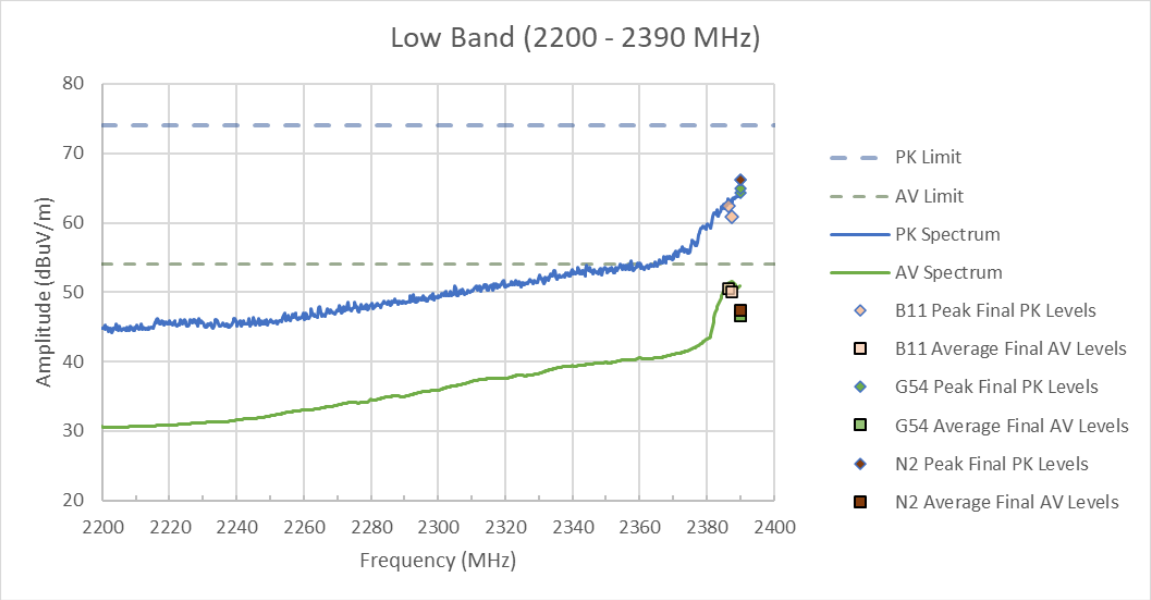

Figure RE08.1: Spectral data FCC restricted band from 2200 to 2390 MHz (WiFi Ch.1)

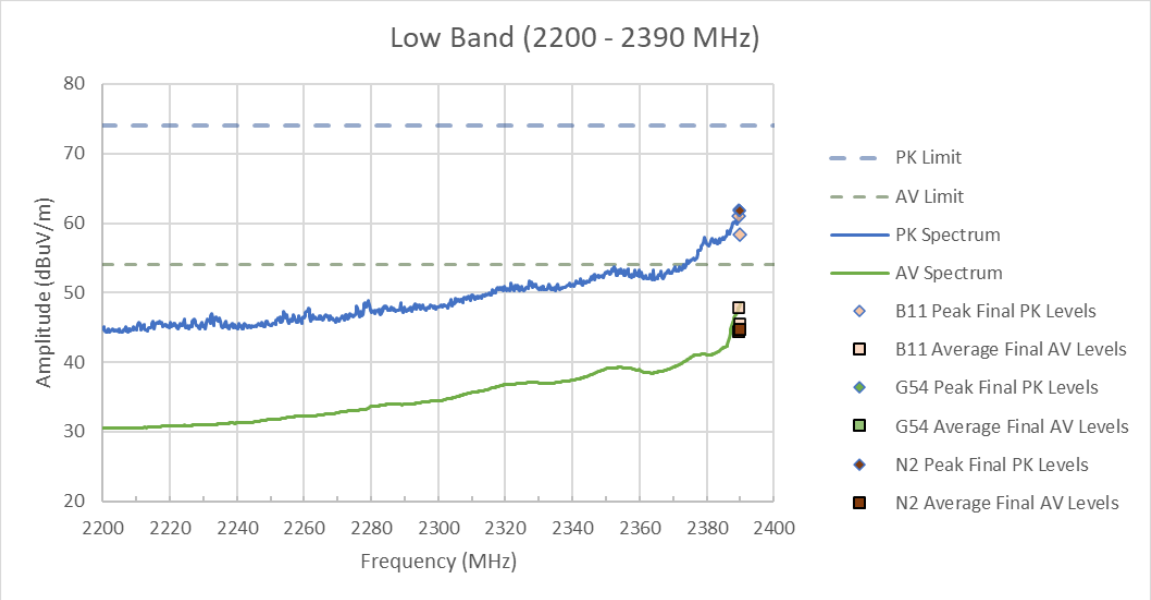

Figure RE08.2: Spectral data FCC restricted band from 2200 to 2390 MHz (WiFi Ch.2)

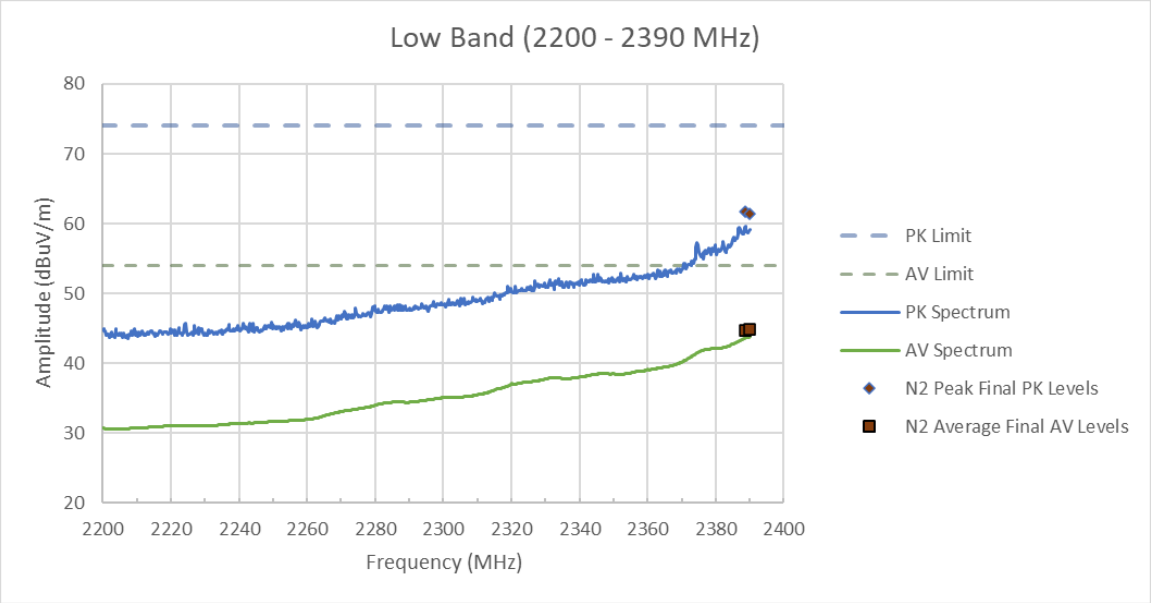

Figure RE08.3: Spectral data FCC restricted band from 2200 to 2390 MHz (Wifi Ch.3)

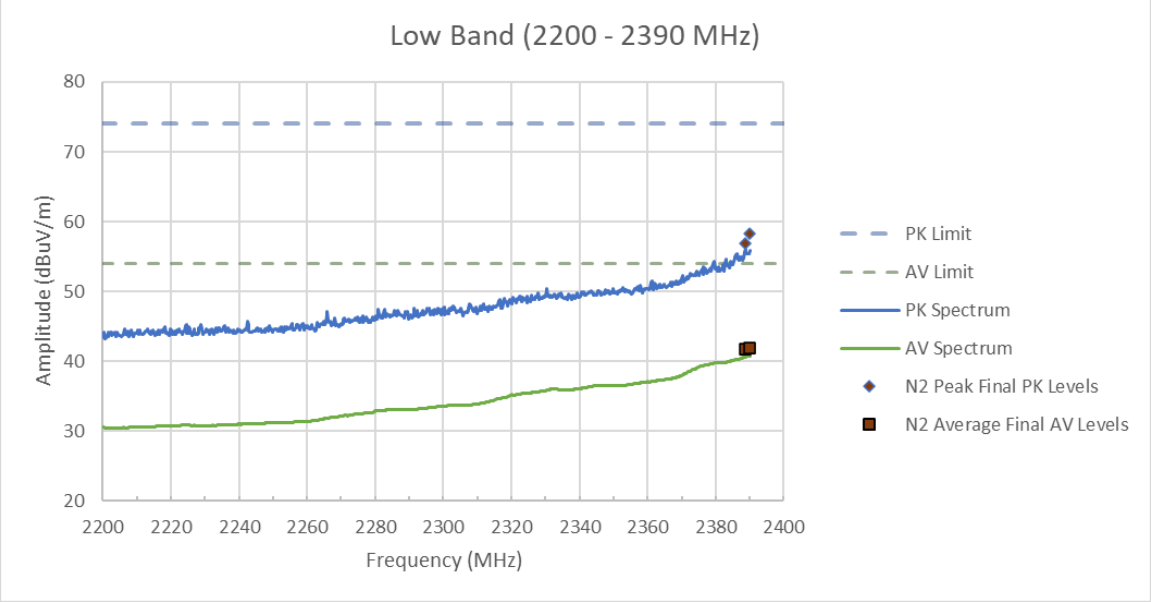

Figure RE08.4: Spectral data FCC restricted band from 2200 to 2390 MHz (Wifi Ch.4)

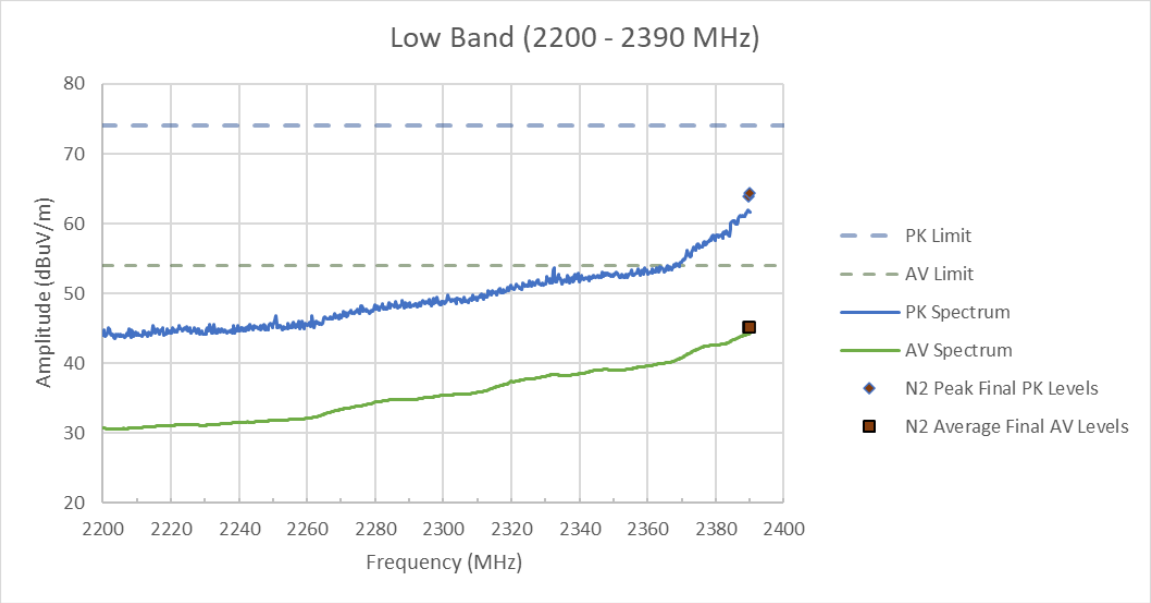

Figure RE08.5: Spectral data FCC restricted band from 2200 to 2390 MHz (Wifi Ch.5)

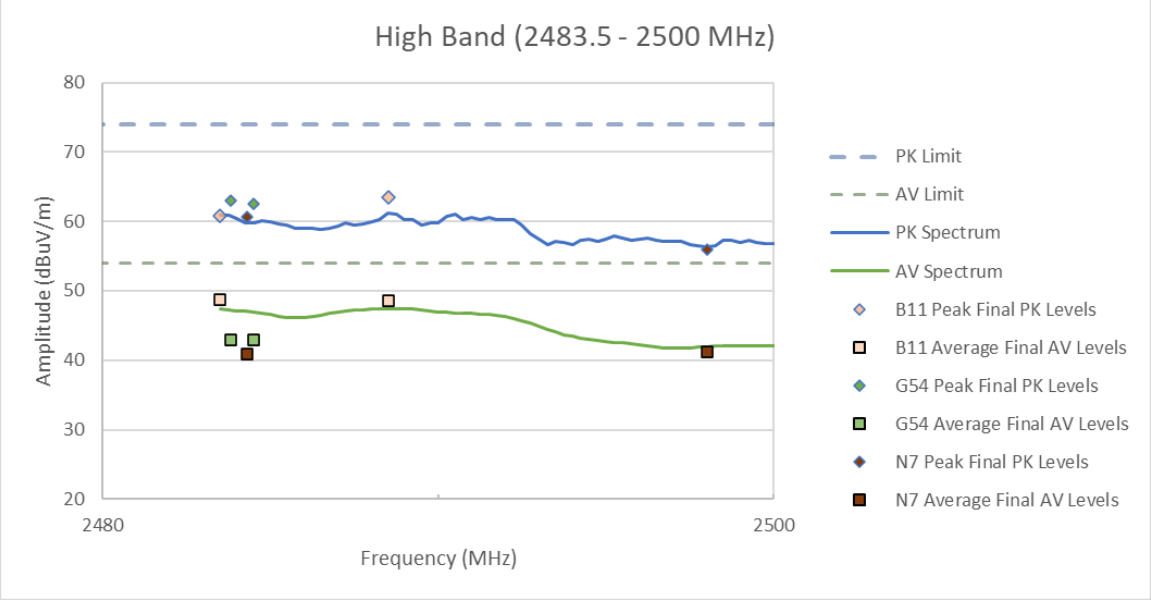

Figure RE08.6: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.9)

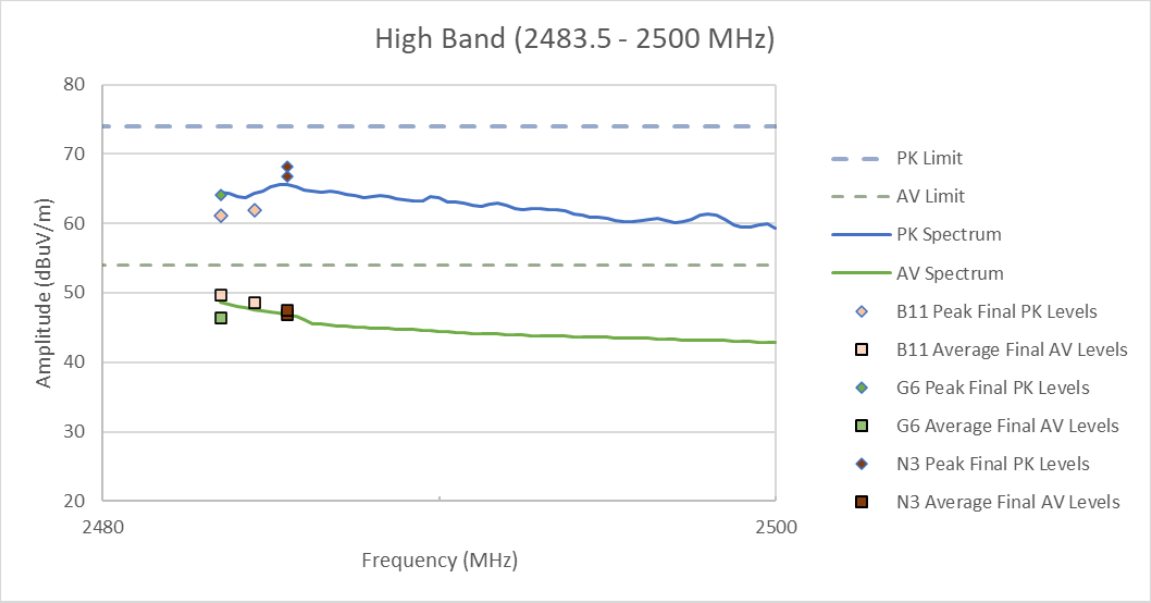

Figure RE08.7: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.10)

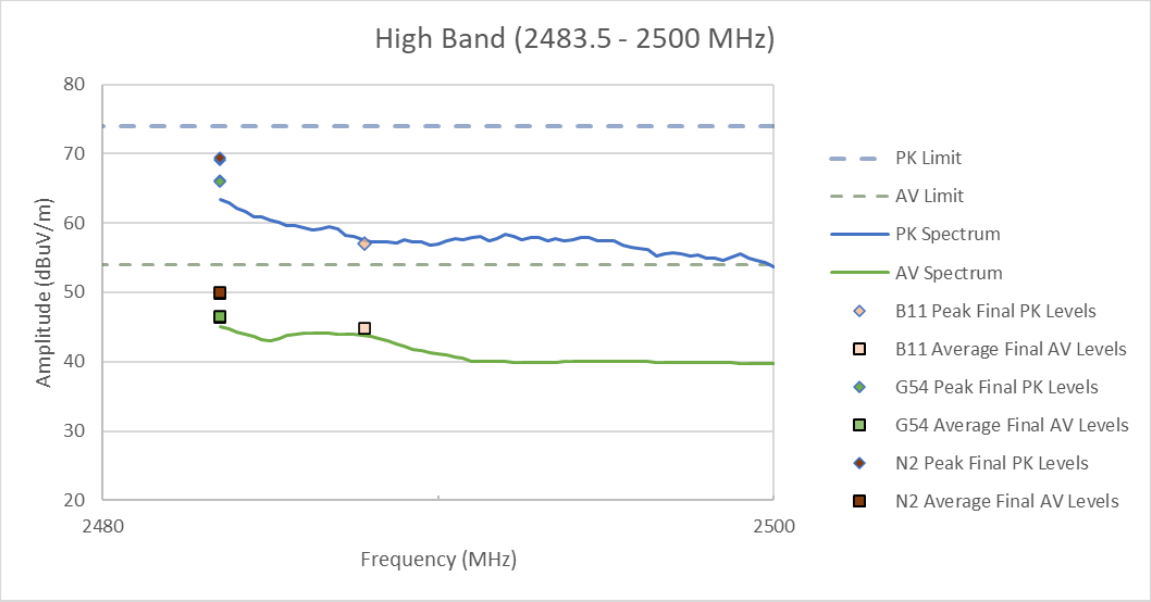

Figure RE08.8: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.11)

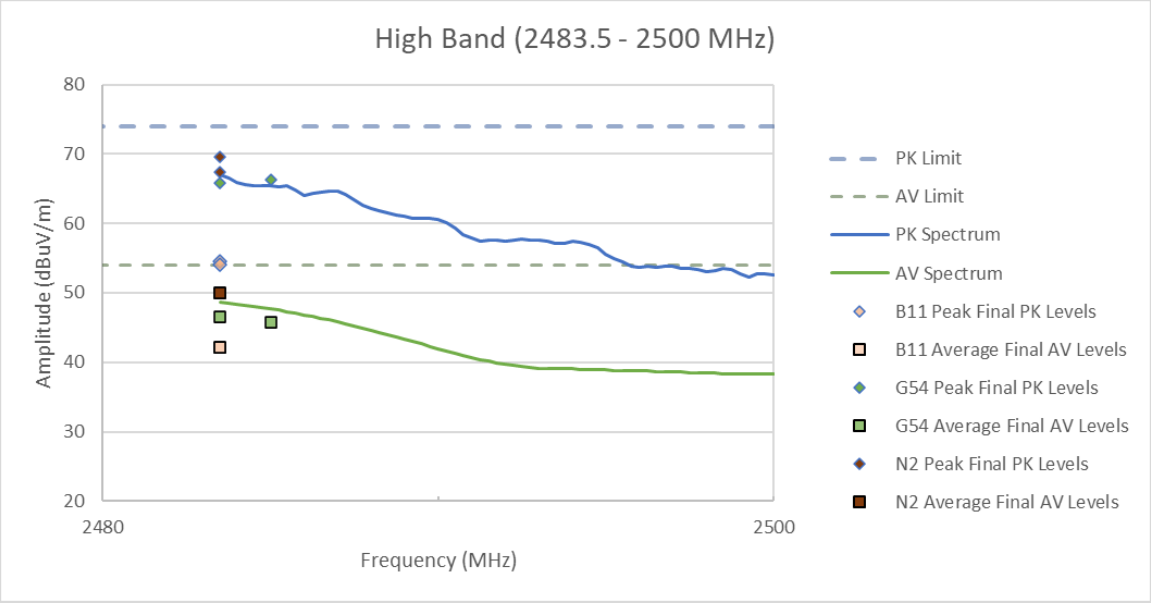

Figure RE08.9: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.12)

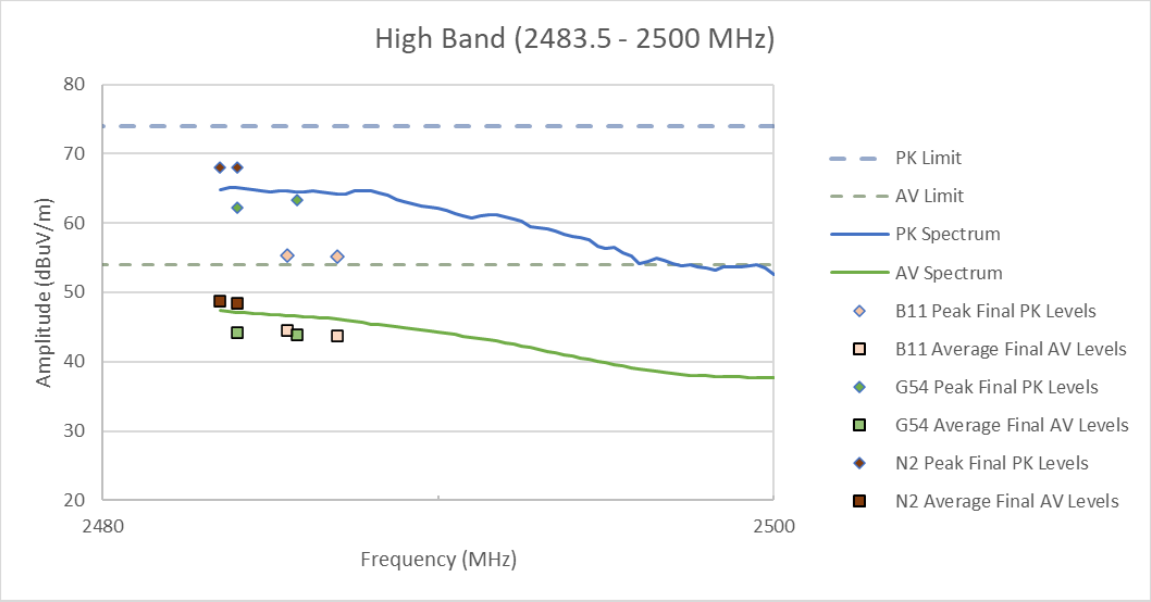

Figure RE08.10: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.13)

Setup Photographs

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

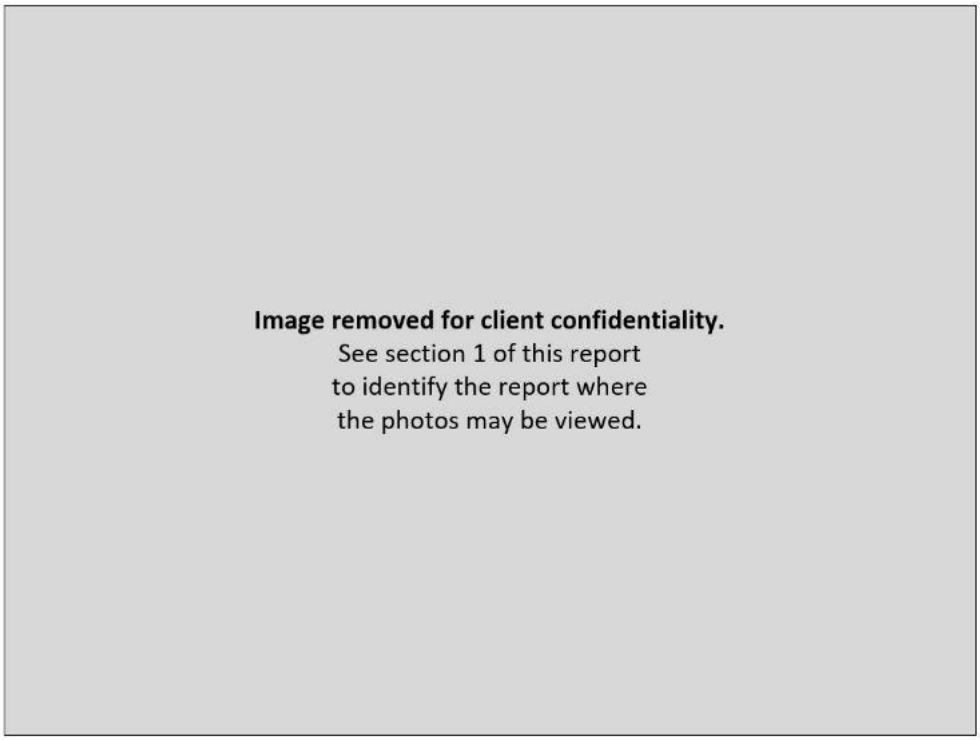

Figure RE08.11: EUT test setup, front view (Z orientation)

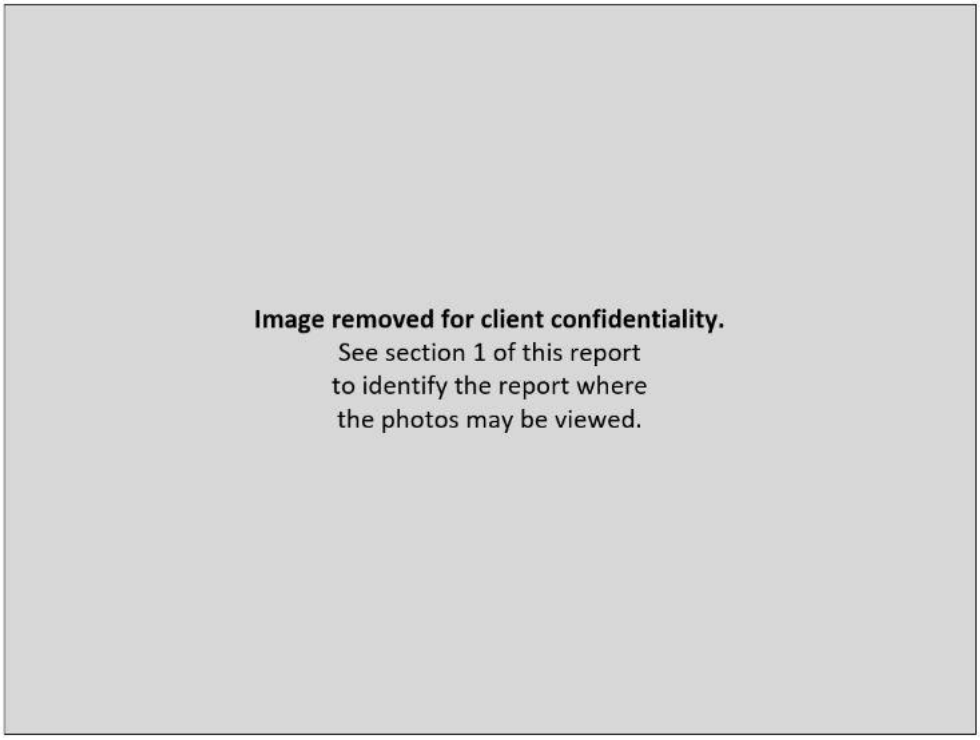

Figure RE08.12: EUT test setup, reverse view (Z orientation)

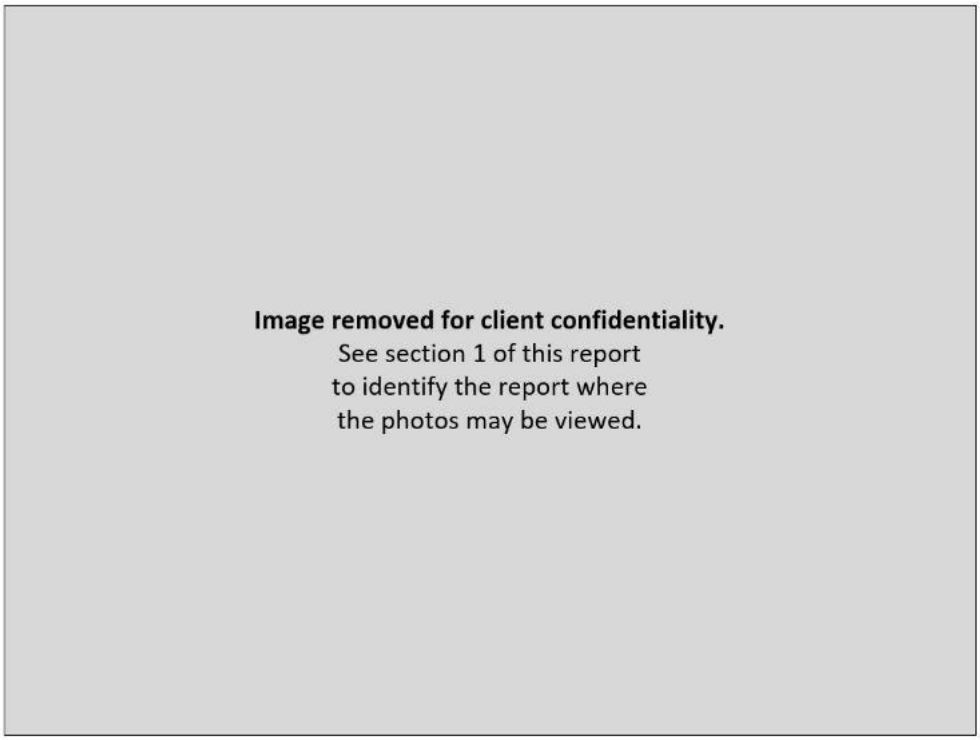

Figure RE08.13: EUT test setup, front view (Y orientation)

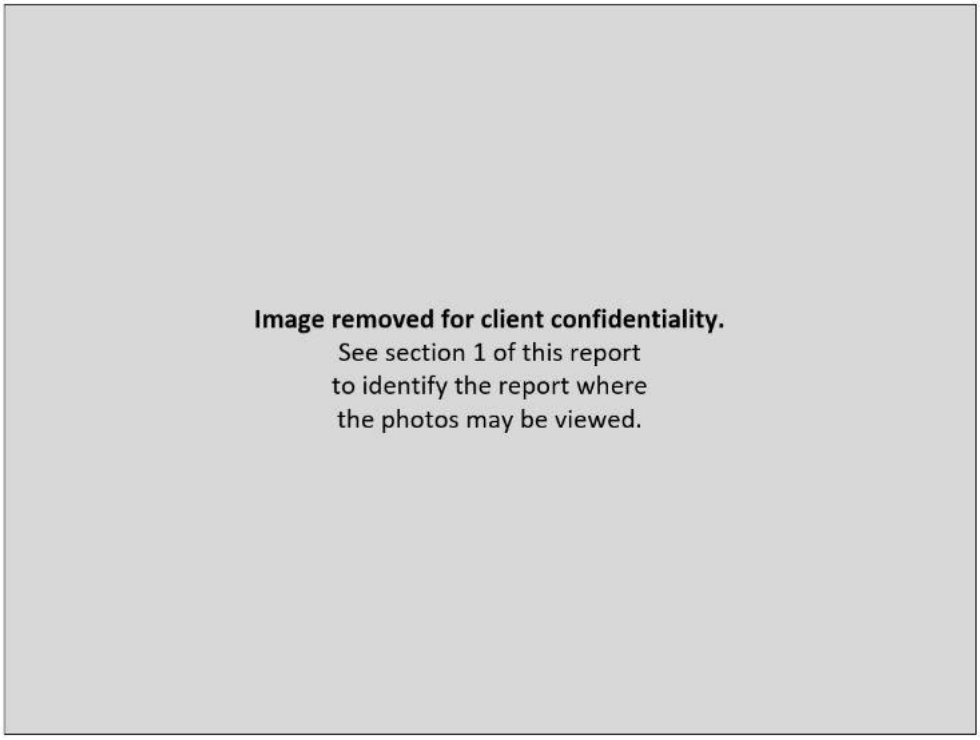

Figure RE08.14: EUT test setup, reverse view (Y orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE09
Project GCL0303

Test Date(s)	20 Feb 2023
Test Personnel	David Kerr
Product Model	A04432
Serial Number tested	3437936612
Operating Mode	M3 (BT Class)
Arrangement	A1 (PwrA)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, (as noted in Section 6 of the report).
Frequency Range:	FCC Restricted Bands (2200 - 2390MHz, 2483.5 - 2500MHz)
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**13 Mar 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
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
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

Table RE09.1: Test Equipment Used

Software Used
Keysight PXE N9048B Firmware version A.32.06
RE Signal Maximization Tool v2021Feb25.xlsx
FCC Restricted Band 2p4GHz Template v1 2022Sep08.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.

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 in 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
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2386.5	54	74	36.283	49.789	17.717	24.211	-186	1782	Vert
2362	54	74	35.705	49.789	18.295	24.211	-186	1782	Vert

Table RE09.2: Emission summary FCC restricted band from 2200 to 2390 MHz (EDR 2)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2483.5	54	74	40.295	57.995	13.705	16.005	-142	3241	HORZ
2483.5	54	74	40.316	57.472	13.684	16.528	-142	3241	HORZ

Table RE09.3: Emission summary FCC restricted band from 2483.5 to 2500 MHz (EDR 2)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2387.3	54	74	35.416	49.815	18.584	24.185	-186	1782	Vert
2362	54	74	36.345	50.33	17.655	23.67	-186	1782	Vert

Table RE09.4: Emission summary FCC restricted band from 2200 to 2390 MHz (EDR 3)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2483.5	54	74	39.25	56.811	14.75	17.189	-142	3241	HORZ
2483.5	54	74	39.213	56.362	14.787	17.638	-142	3241	HORZ

Table RE09.5: Emission summary FCC restricted band from 2483.5 to 2500 MHz (EDR 3)

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

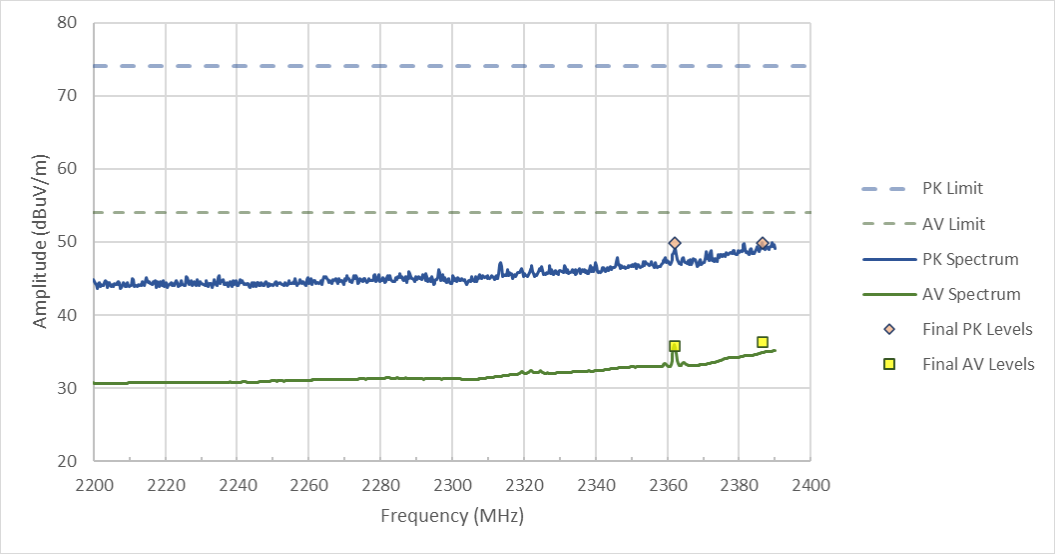

Figure RE09.1: Spectral data FCC restricted band from 2200 to 2390 MHz (EDR 2)

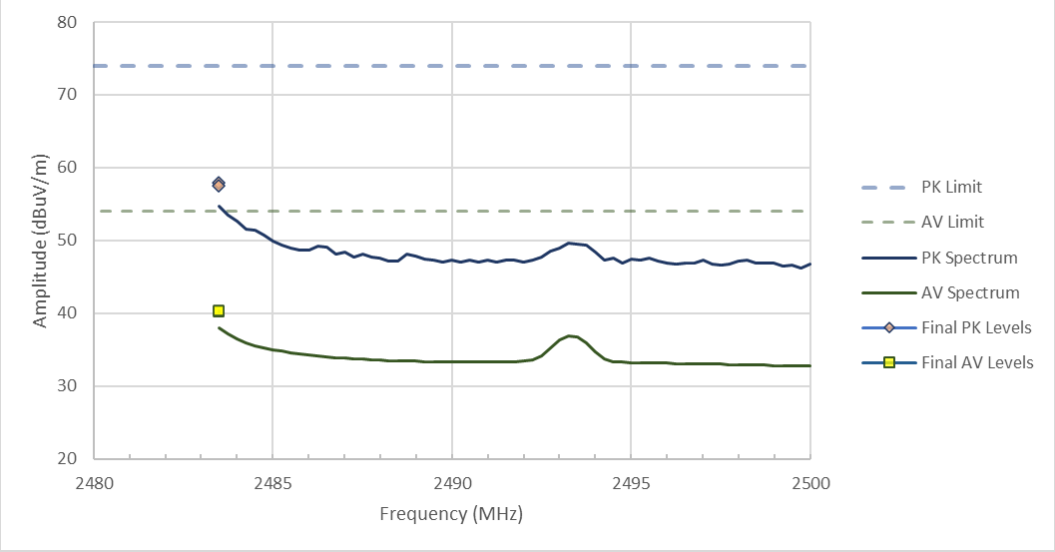

Figure RE09.2: Spectral data FCC restricted band from 2483.5 to 2500 MHz (EDR 2)

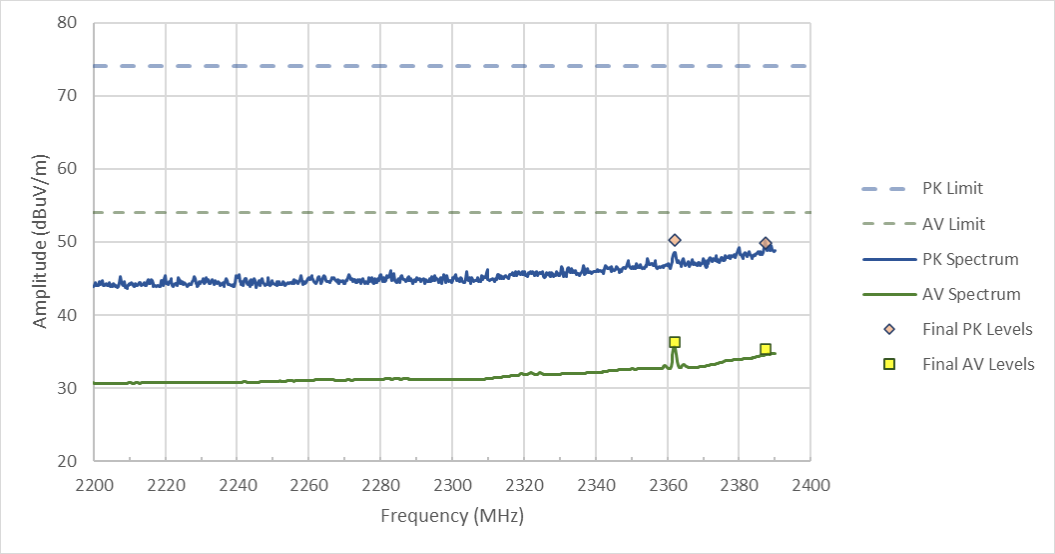

Figure RE09.3: Spectral data FCC restricted band from 2200 to 2390 MHz (EDR 3)

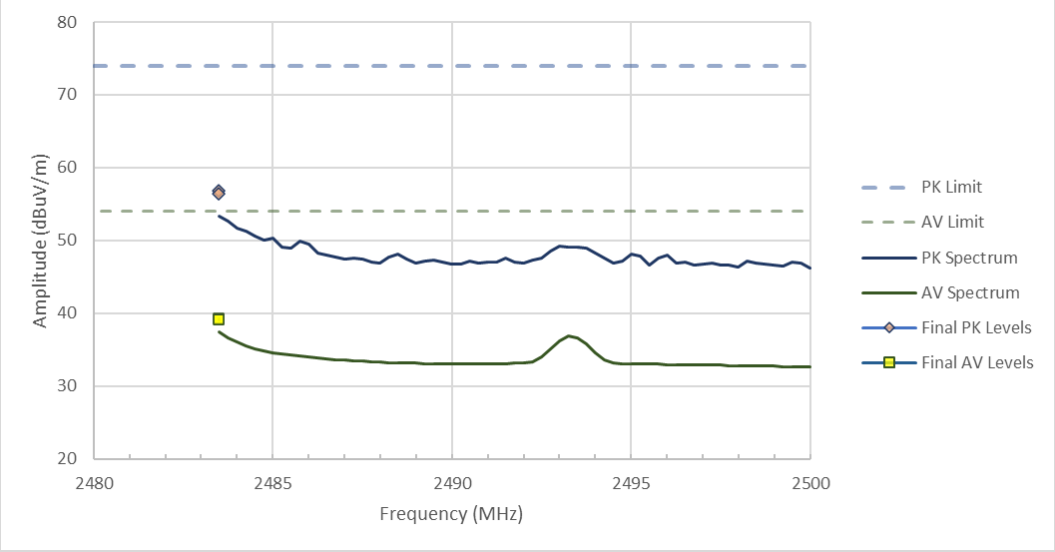

Figure RE09.4: Spectral data FCC restricted band from 2483.5 to 2500 MHz (EDR 3)

Setup Photographs

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

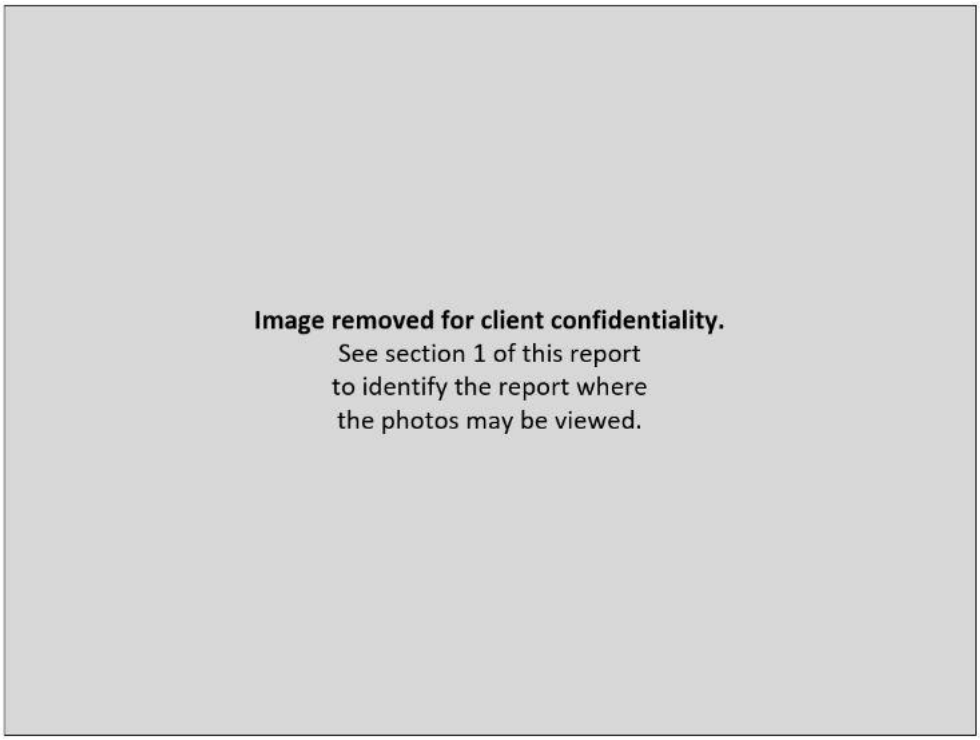

Figure RE09.5: EUT test setup, front view (Z orientation)

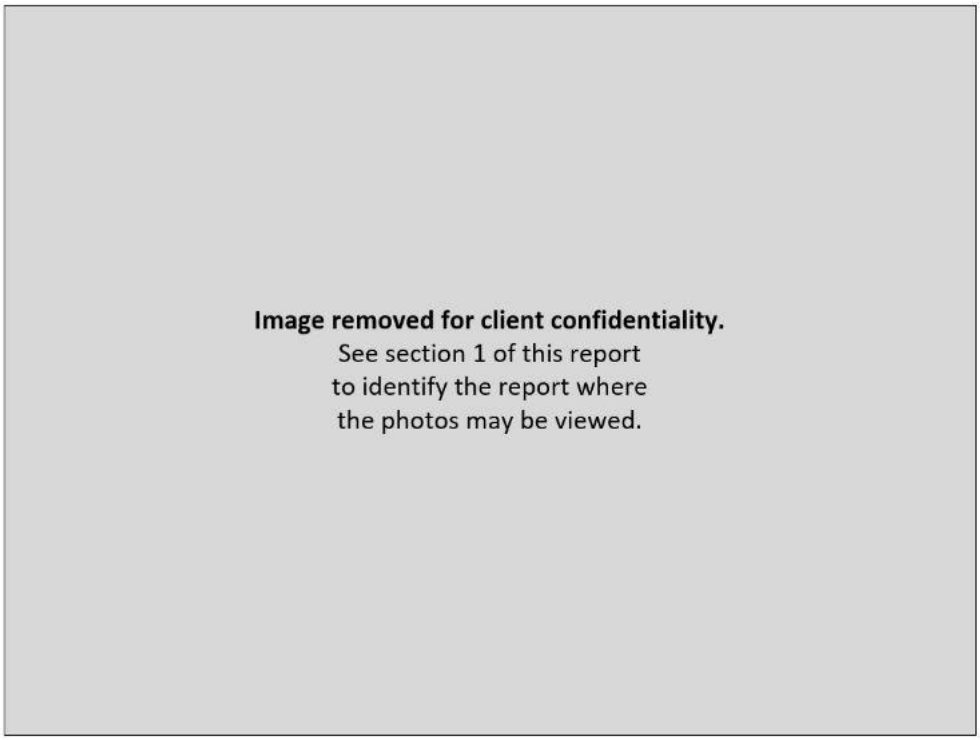

Figure RE09.6: EUT test setup, reverse view (Z orientation)

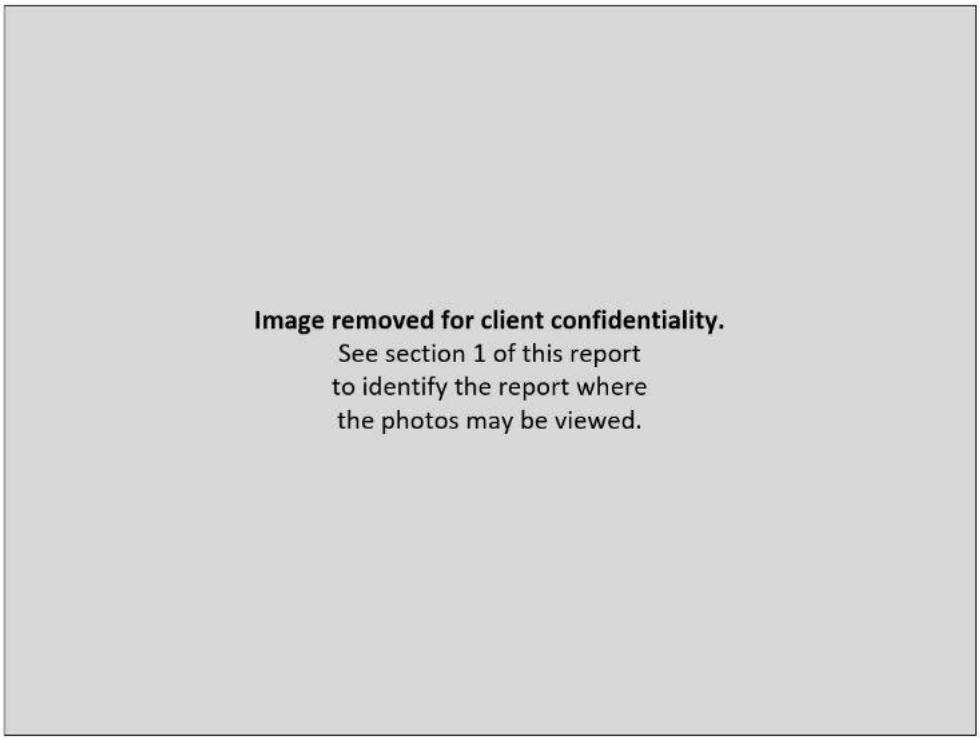

Figure RE09.7: EUT test setup, front view (Y orientation)

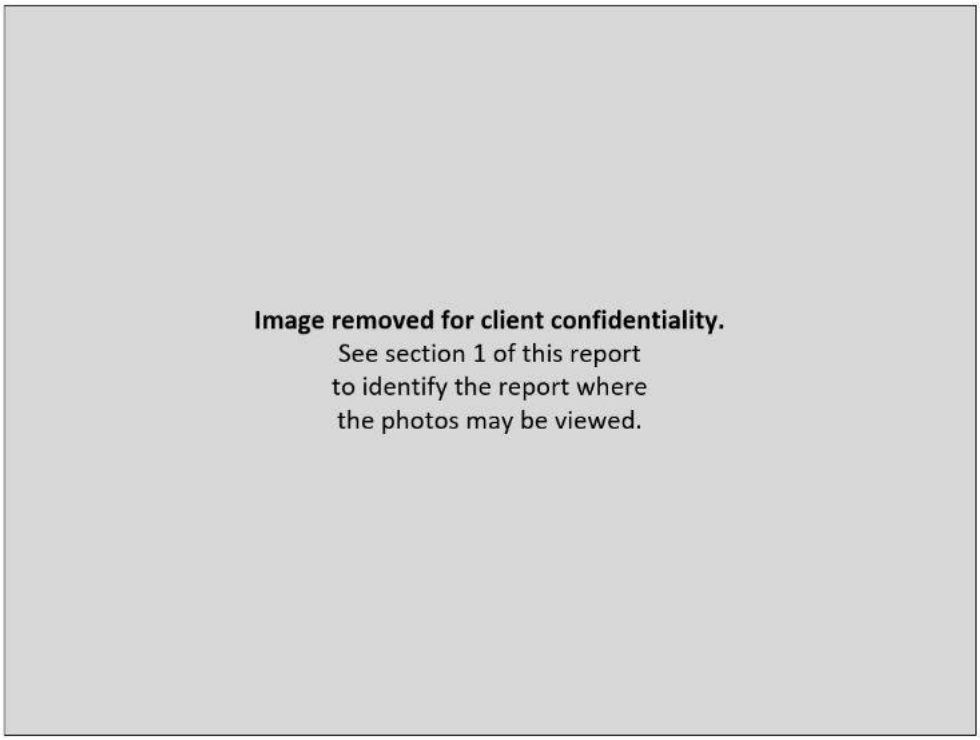

Figure RE09.8: EUT test setup, reverse view (Y orientation)

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test IDs TR6, TR7 and TR8
Project GCL-0303

Test Date(s)	1 Mar 2023
Test Personnel	Majid Farah
Product Model	A04432
Serial Number tested	3437936721
Operating Mode	M3 (BLE Tx), M7 (ANT Tx) and M17 (BT Class Tx)
Arrangement	A1 (PwrA)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Antenna Gain	-3.43 dBi, as reported by the client
Radio Protocol	Bluetooth (BR, EDR2 and EDR3), BLE (Bluetooth Low Energy), ANT
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date of this record:	**25 Mar 2023**

Original record, Version A.

Test Equipment

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

Table TR6.1: Test equipment used

Software Used: Keysight PXE software A.33.03

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.

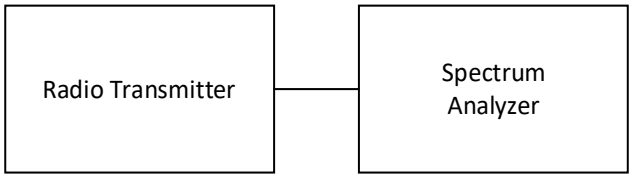

Figure TR6.1: Test setup

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 as EIRP include the effect of antenna gain.

The highest PSD for each mode are highlighted in yellow, and graphical results are provided for those cases. The PSD limit is 8 dbm per 3 KHz.

	Frequency (MHz)				
	2402	2404	2440	2478	2480
Bluetooth BR	**-0.03**	**NT**	**0.30**	**NT**	**0.37**
Bluetooth EDR2	**-5.34**	**NT**	**-4.81**	**NT**	**-4.61**
Bluetooth EDR3	**-5.45**	**NT**	**-4.98**	**NT**	**-5.31**
BLE 1 Mbps	**-15.95**	**NT**	**-12.12**	**NT**	**-15.62**
BLE 2 Mbps	**NT**	**-12.30**	**-12.62**	**-16.53**	**NT**
ANT	**-15.06**	**NT**	**-9.66**	**NT**	**-14.35**

Table TR6.2: Summary of results

NT: (Not tested) means the requirement is or may not be applicable by EUT or it is not required by standards.

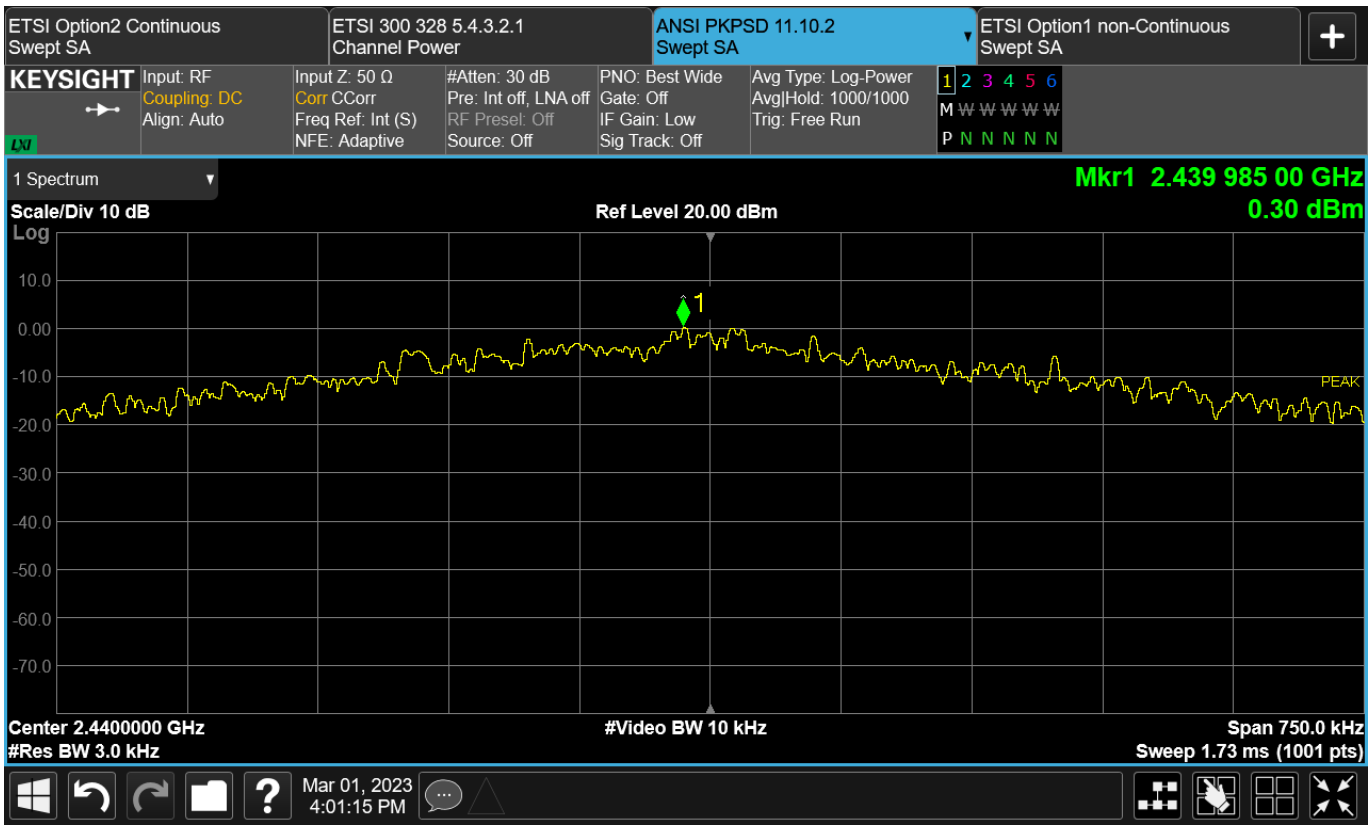

Figure TR6.2: Test data for Bluetooth BR on 2440 MHz

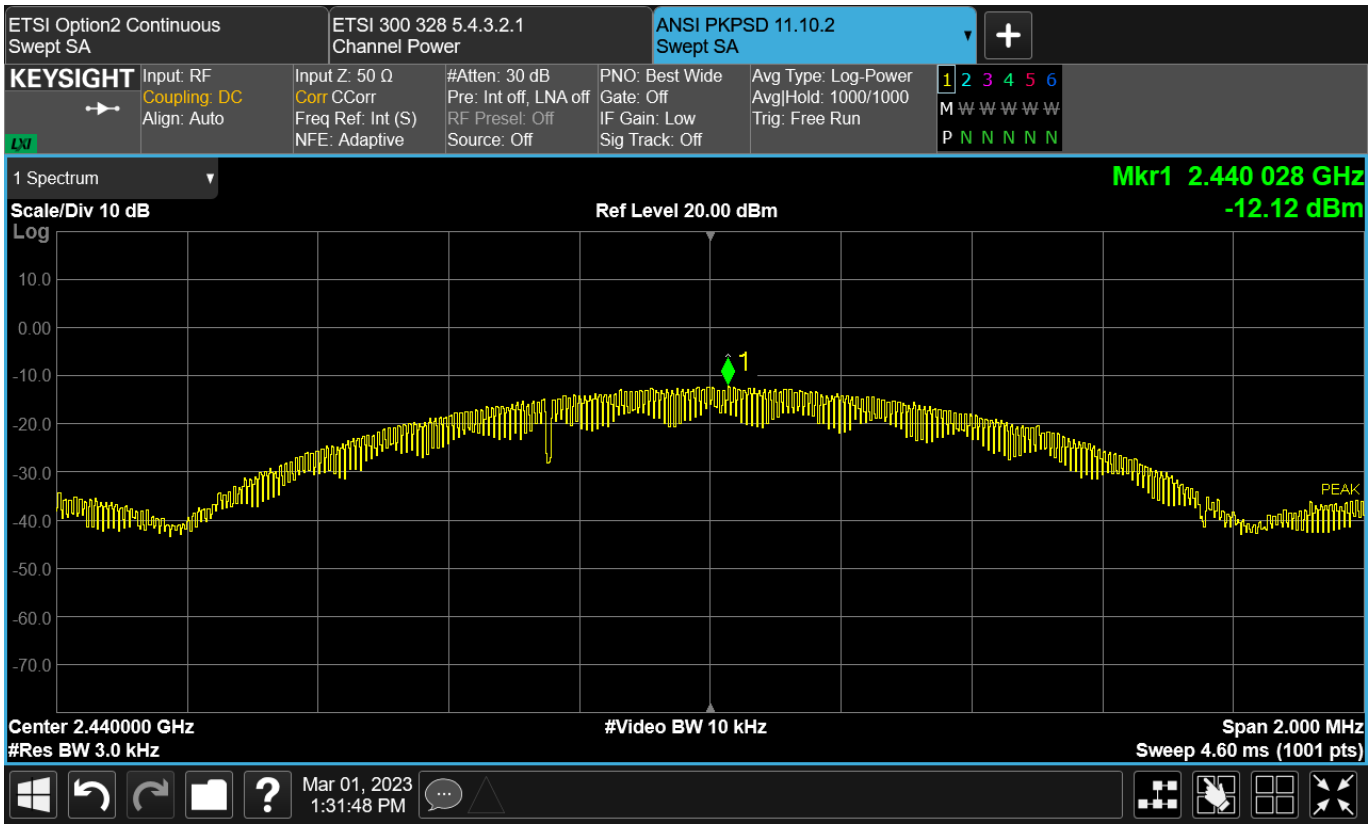

Figure TR6.3: Test data for BLE 1 Mbps on 2440 MHz

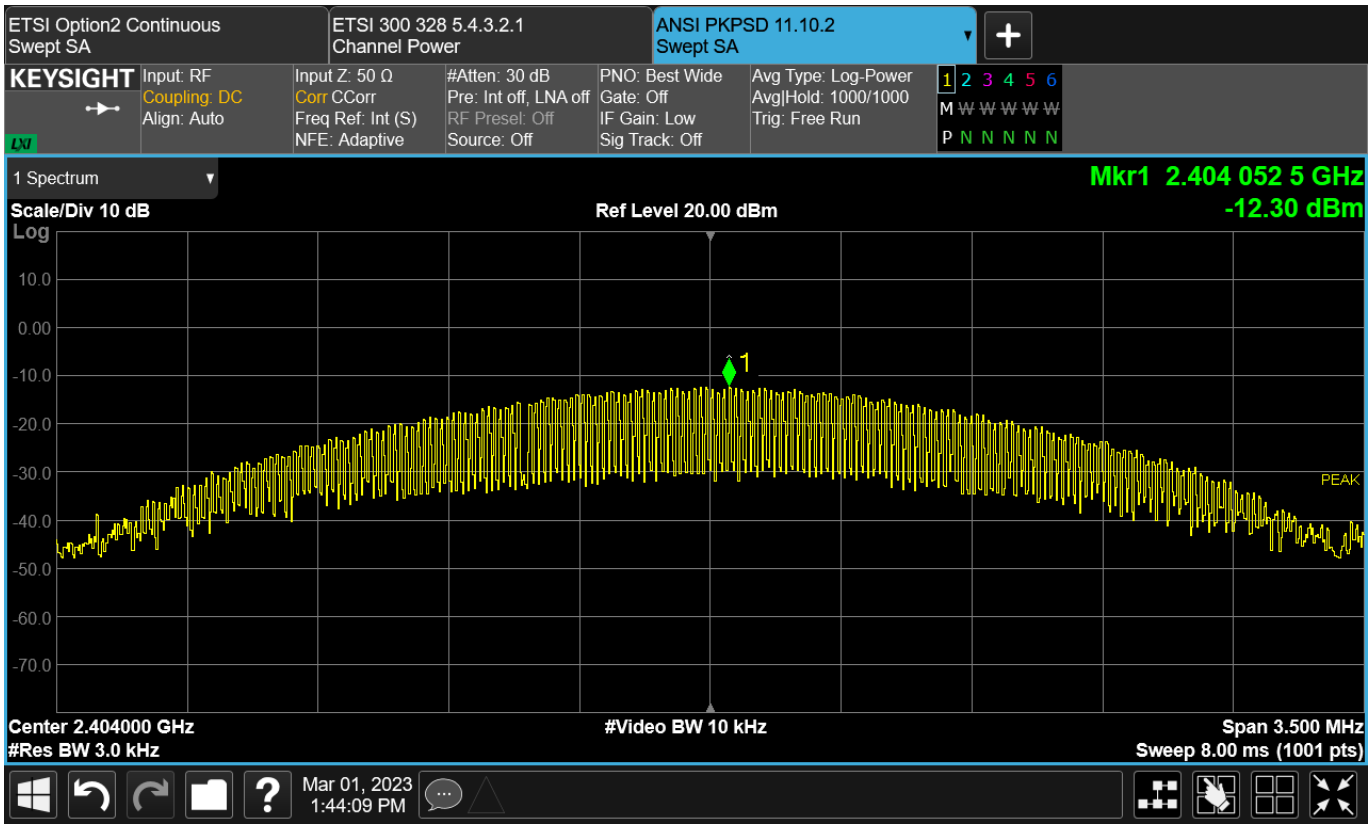

Figure TR6.4: Test data for BLE 2 Mbps on 2404 MHz

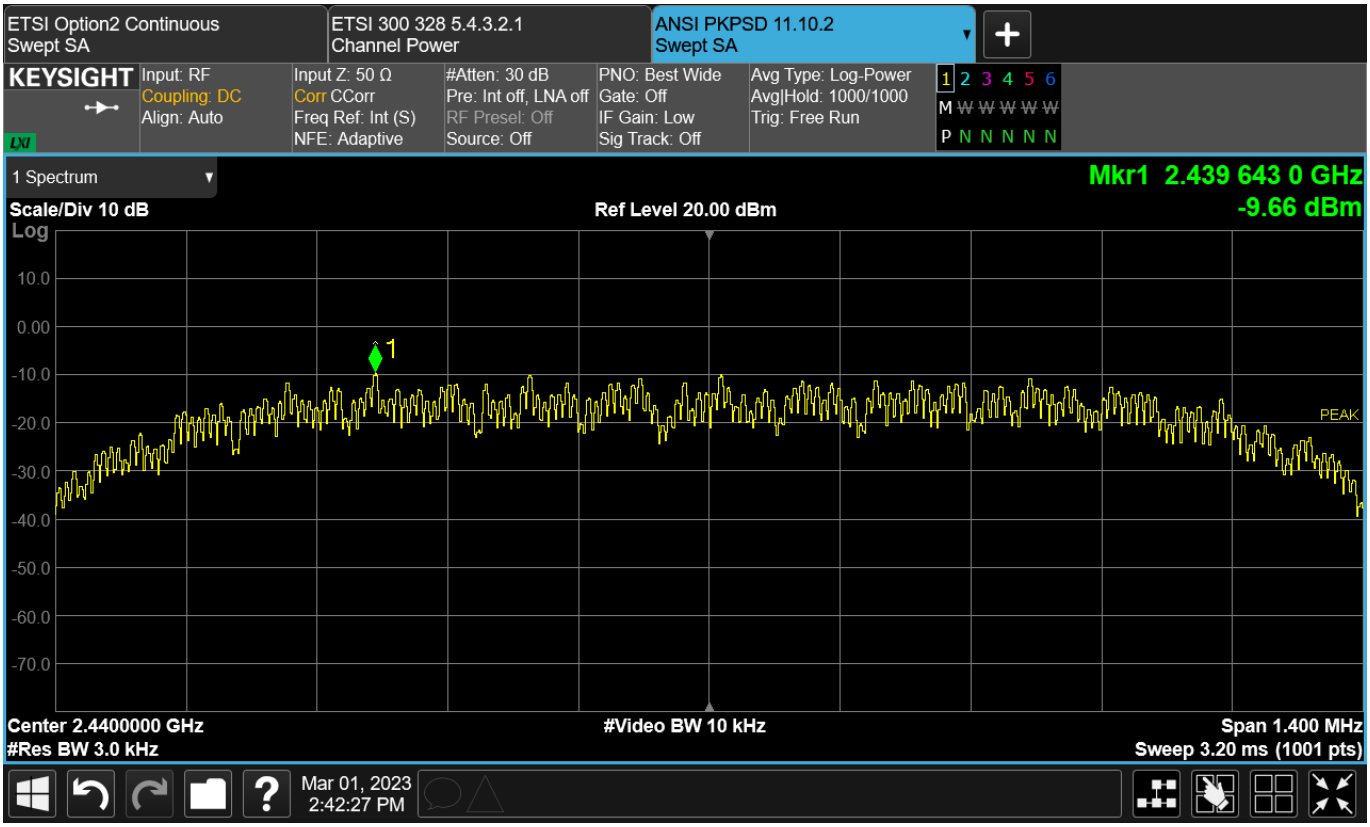

Figure TR6.5: Test data for ANT on 2440 MHz

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test IDs TR9
Project GCL-0303

Test Date(s)	1 Mar 2023
Test Personnel	Majid Farah
Product Model	A04432
Serial Number tested	3437936721
Operating Mode	M9 (WiFi Tx)
Arrangement	A1 (PwrA)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Antenna Gain	-3.43 dBi, as reported by the client
Radio Protocol	WiFi (IEEE 802.11 b/g/n)
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date of this record:	**25 Mar 2023**

Original record, Version A.

Test Equipment

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

Table TR9.1: Test equipment used

Software Used: Keysight PXE software A.33.03

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.

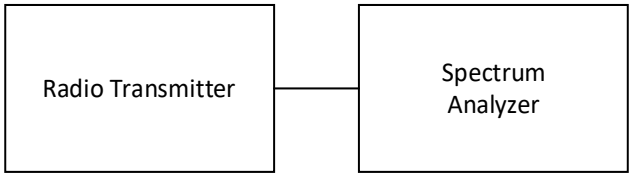

Figure TR9.1: Test setup

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 as EIRP include the effect of antenna gain.

The highest PSD for each mode are highlighted in yellow, and graphical results are provided for those cases. The PSD limit is 8 dbm per 3 KHz.

		Channel No.				
Mode	Data rate (Mbps)	1	6	11	12	13
B	1	**1.48**	**4.00**	**-0.13**	**-7.99**	**-8.34**
B	2	**-6.92**	**-4.40**	**-8.57**	**-16.43**	**-15.04**
G	6	**-14.77**	**-5.65**	**-13.80**	**-15.24**	**-18.05**
G	12	**-15.43**	**-6.80**	**-13.61**	**-15.60**	**-18.72**
G	54	**-15.72**	**-10.14**	**-14.23**	**-15.29**	**-18.25**
N	MCS0	**-14.18**	**-7.22**	**-15.09**	**-16.68**	**-18.29**
N	MCS1	**-13.95**	**-7.48**	**-14.48**	**-16.28**	**-18.80**
N	MCS7	**-13.08**	**-12.43**	**-14.01**	**-16.07**	**-18.38**

Table TR9.2: Summary of results

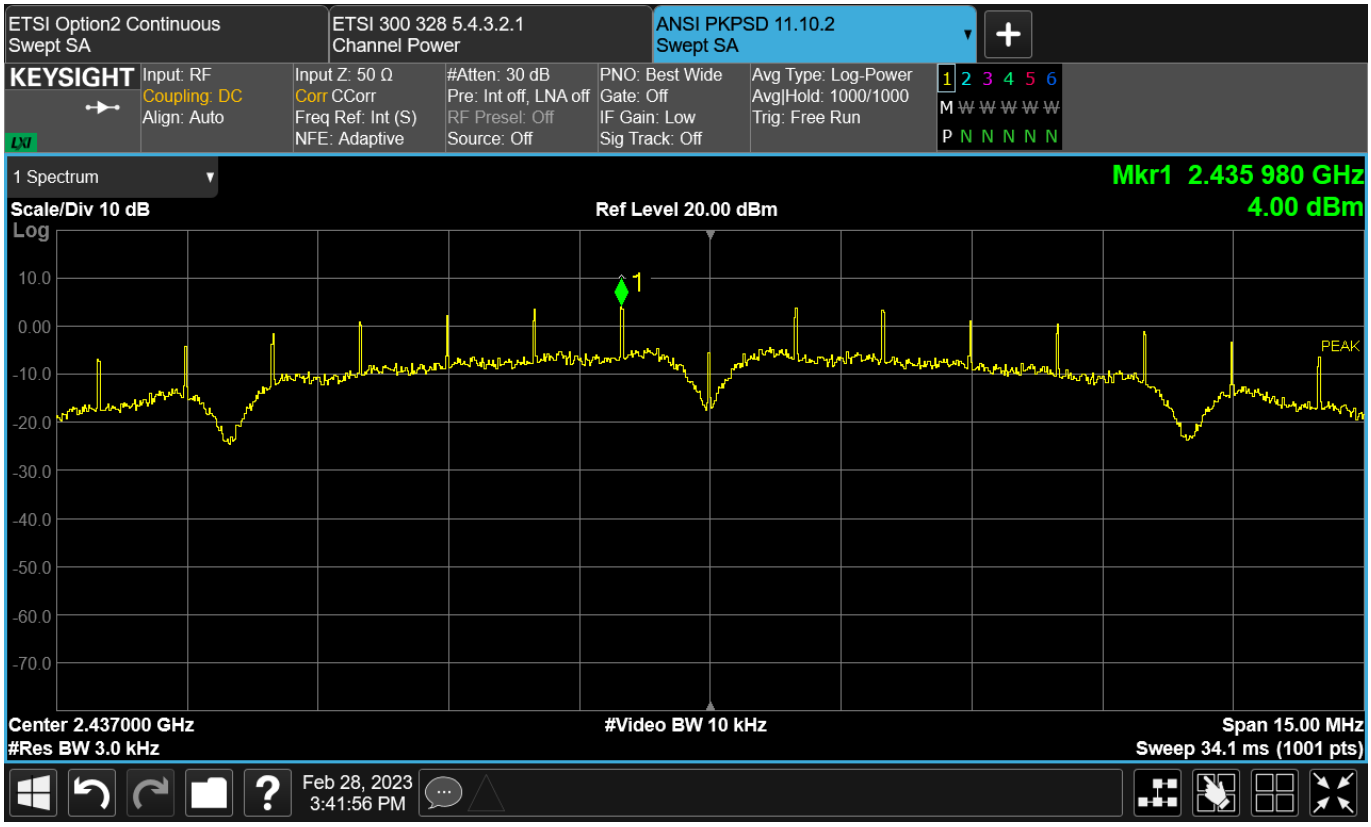

Figure TR9.2: Test data for IEEE 802.11 b 1 Mbps on Ch. 6

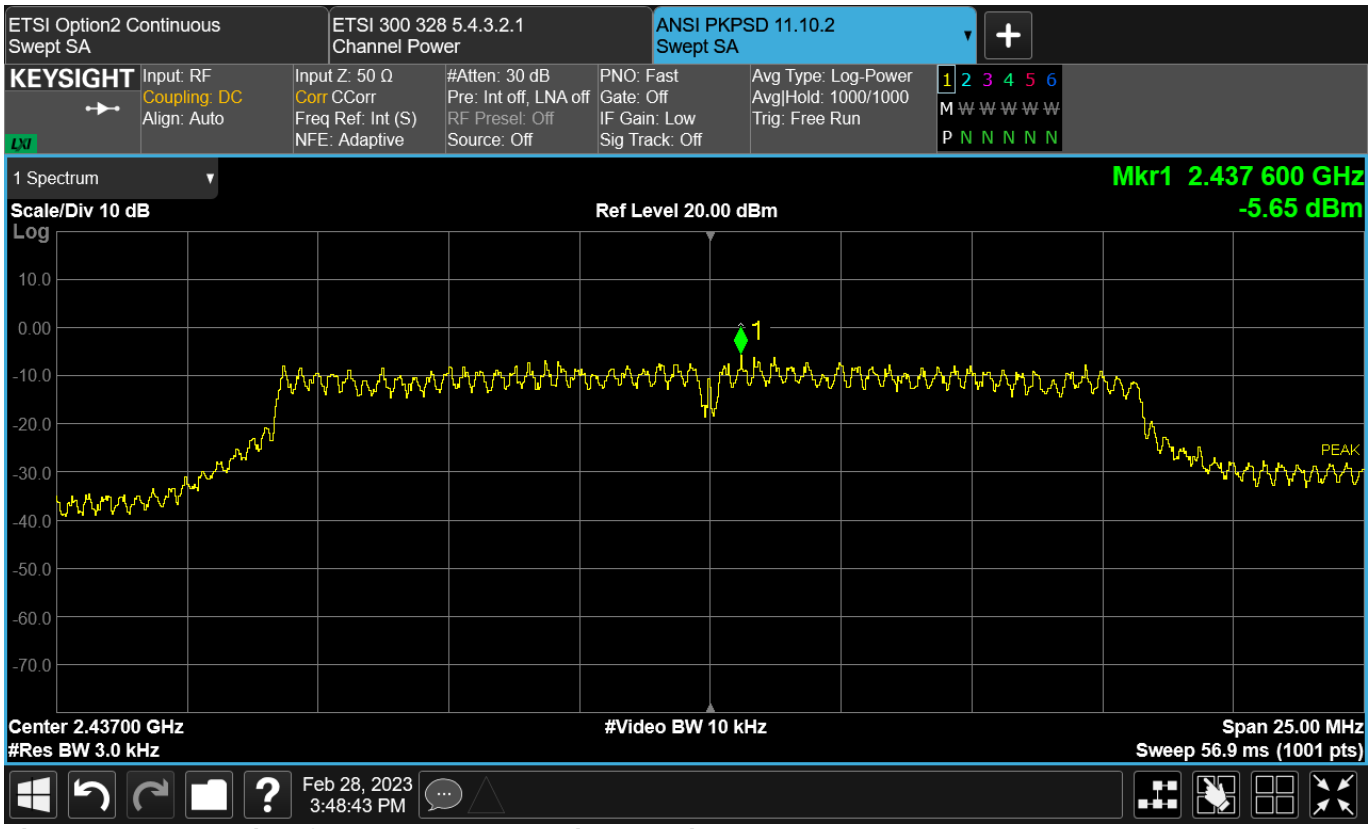

Figure TR9.3: Test data for IEEE 802.11 g 6 Mbps on Ch. 6

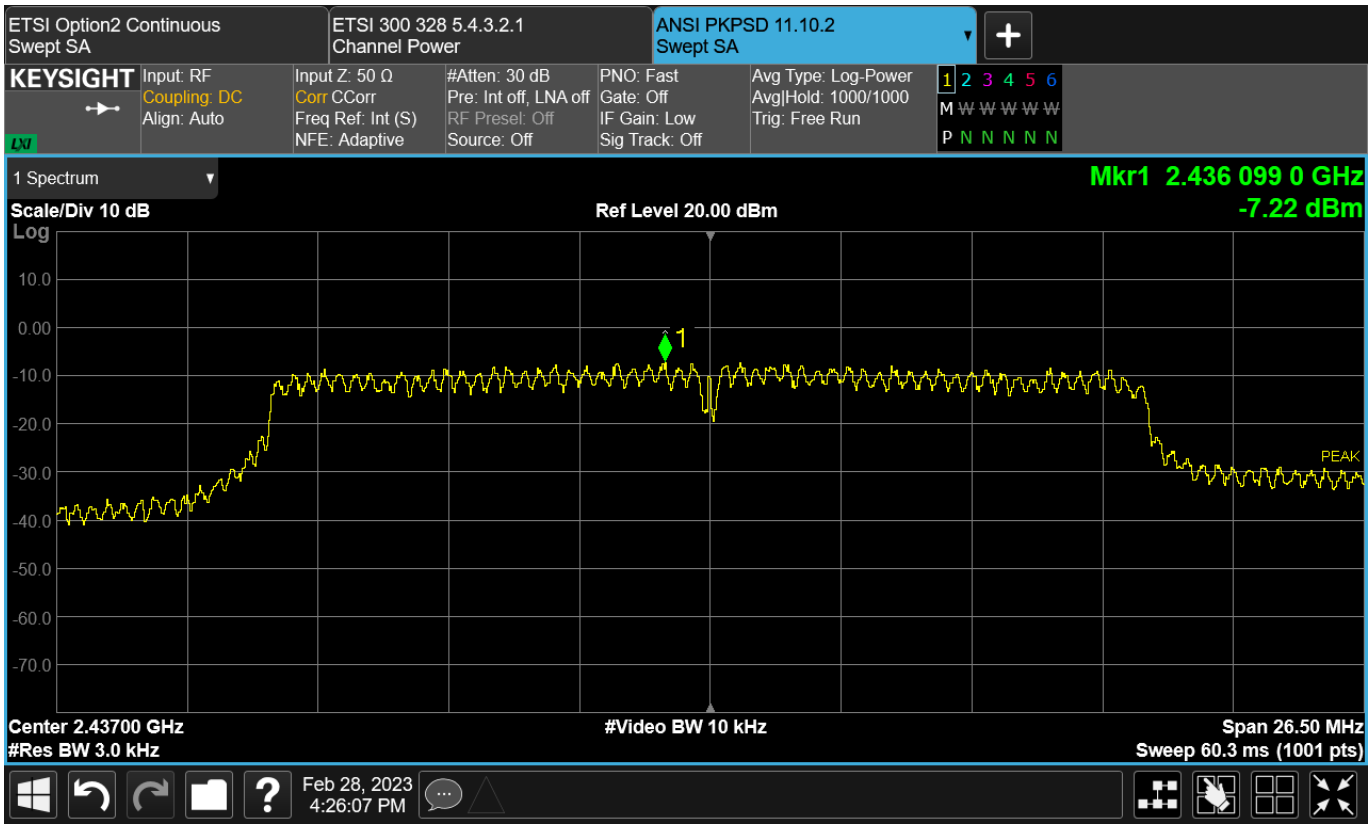

Figure TR9.4: Test data for IEEE 802.11 n MCS0 on Ch. 6
This line is the end of the test record.

Test Record
Transmitter Frequency Stability
Test IDs TR33, TR34 and TR35
Project GCL-0303

Test Date(s)	17 and 20 Mar 2023
Test Personnel	Majid Farah
Product Model	A04432
Serial Number tested	3437936721
Operating Mode	M3 (BLE Tx), M7 (ANT Tx) and M17 (BT Class Tx)
Arrangement	A1 (PwrA)
Nominal Input Power	5 Vdc
Test Standards:	FCC part 15, RSS-GEN, RSS-210, ANSI C63.10 (as noted in Section 6 of the report)
Radio Protocol	Bluetooth (BR, EDR2 and EDR3), BLE (Bluetooth Low Energy), ANT
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah / Jim Solum**
Date this record:	**24 Mar 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
DMM Multimeter	FLUKE	79 III	71740743	18-Apr-2022	15-Apr-2023
Signal analyzer PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Thermometer	Thermco	ACCD370P	210607316	11-Aug-2021	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Thermal Chamber	TPS	T2RC	32774-02	19-Oct-22	15-Oct-23
Power source	TENMA	72-2080	2440	Calibration	Not Required

Table TR33.1: Equipment used

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

Test Method

The RSS-GEN standard requires a frequency stability test with variations in temperature and supply voltage, but RSS-247 does not provide further guidance on this test. RSS-GEN suggests one possible criterion for unlicensed transmitters could be that the carrier remains in the central 80% of the frequency band. However, the Bluetooth and ANT protocols have carriers that are intentionally closer to the band edge. The basic concept applied here is that the 6 dBc Occupied Bandwidth of the modulated signal should remain within the 2400-2483.5 MHz radio band. To evaluate this, the peak carrier level and the level at the band edge are compared to ensure that signal at the band edge is reduced at least 6 dB across the specified range of voltages and temperatures. The data is reported in terms of dBc as a positive value, meaning we report the ratio between the peak carrier signal level and the level at the band edge to demonstrate that the resulting intentional signals remained within the allowed band.

Bluetooth, BLE and ANT use channel plans with a minimum transmission center frequency at 2402 MHz and a maximum at 2480 MHz. EDR2 was selected as the worst case in Bluetooth to investigate, due to its higher

occupied bandwidth. Additional information regarding Bluetooth, BLE and ANT technologies is provided in the following table.

	First Channel	Last Channel	Channel spacing	Data rate
	MHz	MHz	MHz	Mb/s
Bluetooth BR	2402	2480	1	1
Bluetooth EDR2	2402	2480	1	2
Bluetooth EDR3	2402	2480	1	3
BLE1	2402	2480	2	1
BLE2	2404	2478	2	2
ANT	2402	2402	1	60 Kb/s

Table TR33.2 Bluetooth, BLE and ANT overview

The test sample was placed in a thermal chamber and connected to an appropriate dc power source. The sample has an appropriate output to be used for conducted measurement. The analyzer was set up to detect radio signals from the test sample.

The test temperatures range is from +50 °C to -20 °C by 10 °C decrement at each test step for nominal input voltage (5 V). For the voltage variation test at +20 °C, the voltage is to be varied 15% above and below nominal input voltage. Data was taken at 5 Vdc and 15% lower at 4.25 Vdc plus 15% higher at 5.75 Vdc.

Test Data

The various standards 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 apply to different limits or conditions, the most stringent limits and conditions have been applied.

During Bluetooth, BLE and ANT test mode, each measurement is made conducted from the antenna port of the sample with the transmitter continuous “ON” at a specified channel and in a selected transmission protocol. The amplitude results are unscaled and may not include the effects such as cable losses. Such effects are minimal when comparing two nearby data points in a single spectral scan.

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.
	˚C	Vdc	dBc	dBc
BT EDR2	50	5	28.9	48.8
BT EDR2	40	5	28.9	51.4
BT EDR2	30	5	28.8	50.4
BT EDR2	20	5	29.0	51.3
BT EDR2	10	5	29.9	50.8
BT EDR2	0	5	30.1	49.2
BT EDR2	-10	5	29.6	49.5
BT EDR2	-20	5	30.2	47.6

Table TR33.3 Difference between peak and band edge levels for Bluetooth EDR2 transmissions during temperature variations

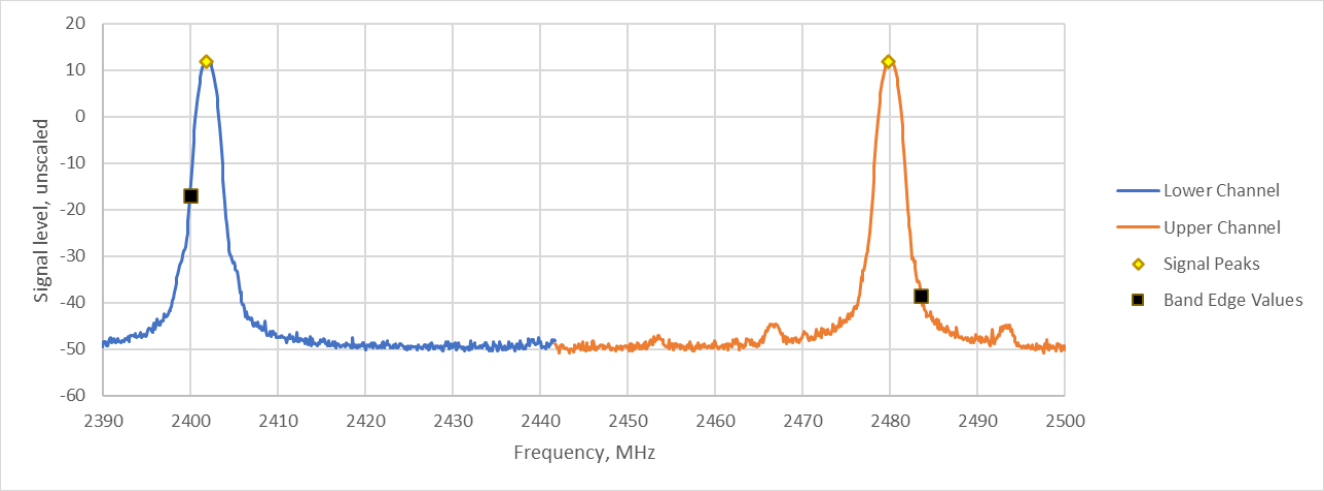

Figure TR33.1: Spectral data for Bluetooth EDR2 at 30 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
BT EDR2	20	4.25	29.1	51.1
BT EDR2	20	5	29.0	51.3
BT EDR2	20	5.75	29.2	50.3

Table TR33.4 Difference between peak and band edge levels for Bluetooth EDR2 transmissions at 20 °C during voltage variations

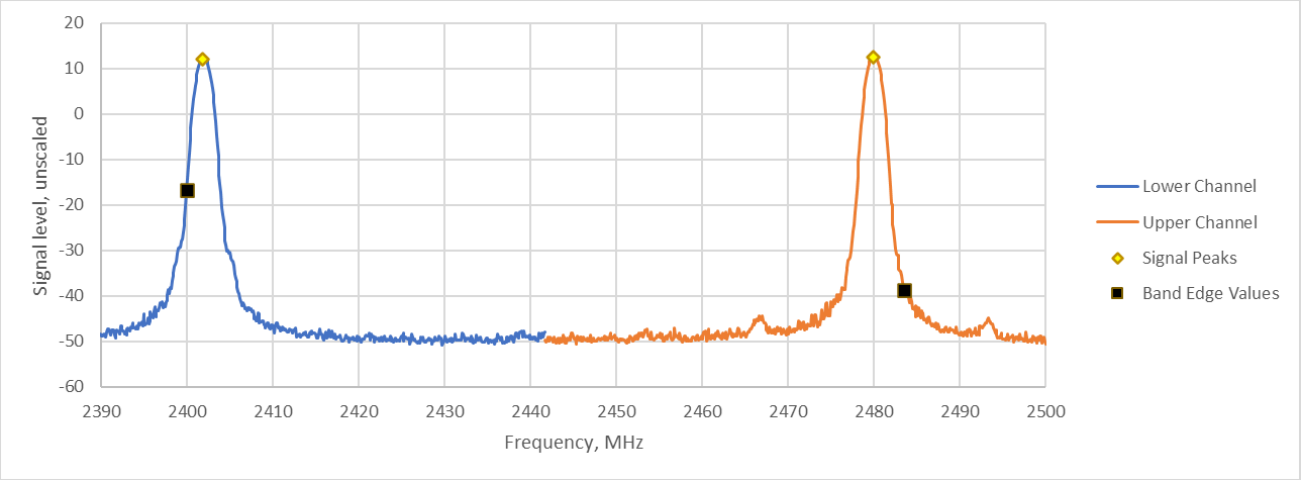

Figure TR33.2: Spectral data for Bluetooth EDR2 at 20 °C and 5 Vdc

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
BLE 1 Mbps	50	5	23.2	42.8
BLE 1 Mbps	40	5	23.7	41.1
BLE 1 Mbps	30	5	23.0	42.4
BLE 1 Mbps	20	5	23.7	42.5
BLE 1 Mbps	10	5	24.7	42.2
BLE 1 Mbps	0	5	24.0	41.1
BLE 1 Mbps	-10	5	25.2	43.4
BLE 1 Mbps	-20	5	23.9	41.3

Table TR33.5 Difference between peak and band edge levels for BLE 1 Mbps transmissions during temperature variations

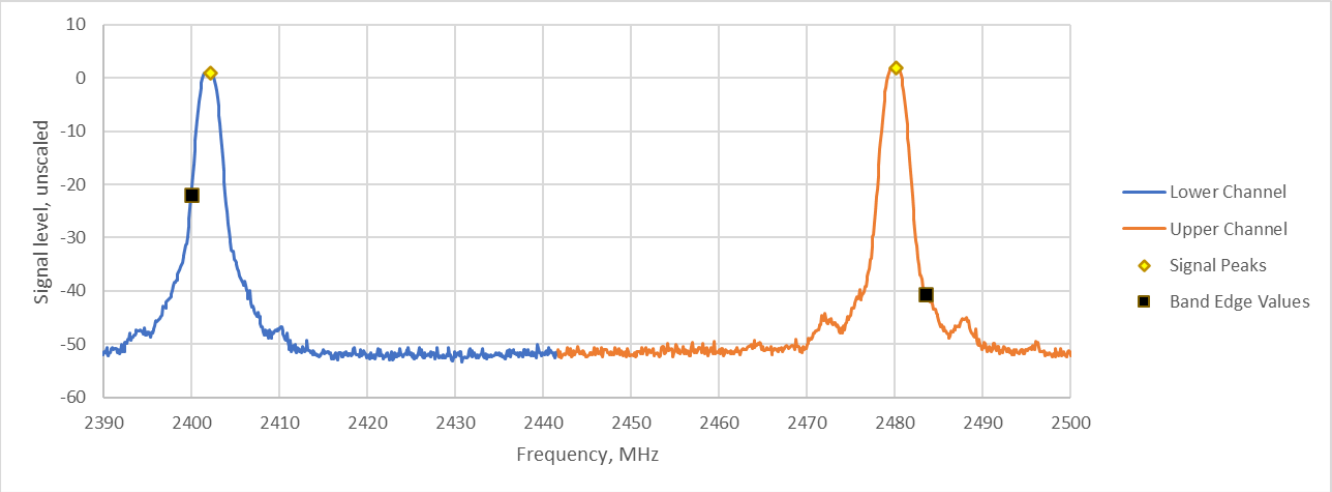

Figure TR33.3: Spectral data for BLE 1 Mbps at 30 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
BLE 1 Mbps	20	4.25	23.3	41.2
BLE 1 Mbps	20	5	23.7	42.5
BLE 1 Mbps	20	5.75	22.9	41.5

Table TR33.6 Difference between peak and band edge levels for BLE 1 Mbps transmissions at 20 °C during voltage variations

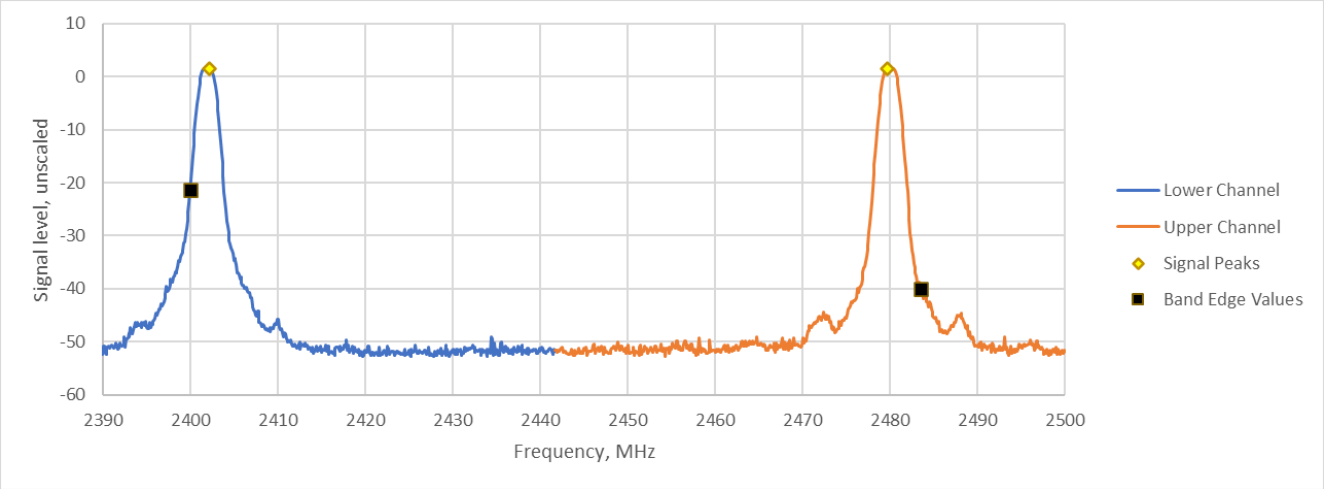

Figure TR33.4: Spectral data for BLE 1 Mbps at 20 °C and 5.75 Vdc

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
BLE 2 Mbps	50	5	33.6	36.5
BLE 2 Mbps	40	5	33.2	37.0
BLE 2 Mbps	30	5	33.4	36.1
BLE 2 Mbps	20	5	33.6	36.2
BLE 2 Mbps	10	5	33.3	36.3
BLE 2 Mbps	0	5	33.9	38.4
BLE 2 Mbps	-10	5	34.0	36.6
BLE 2 Mbps	-20	5	32.6	40.1

Table TR33.7 Difference between peak and band edge levels for BLE 2 Mbps transmissions during temperature variations

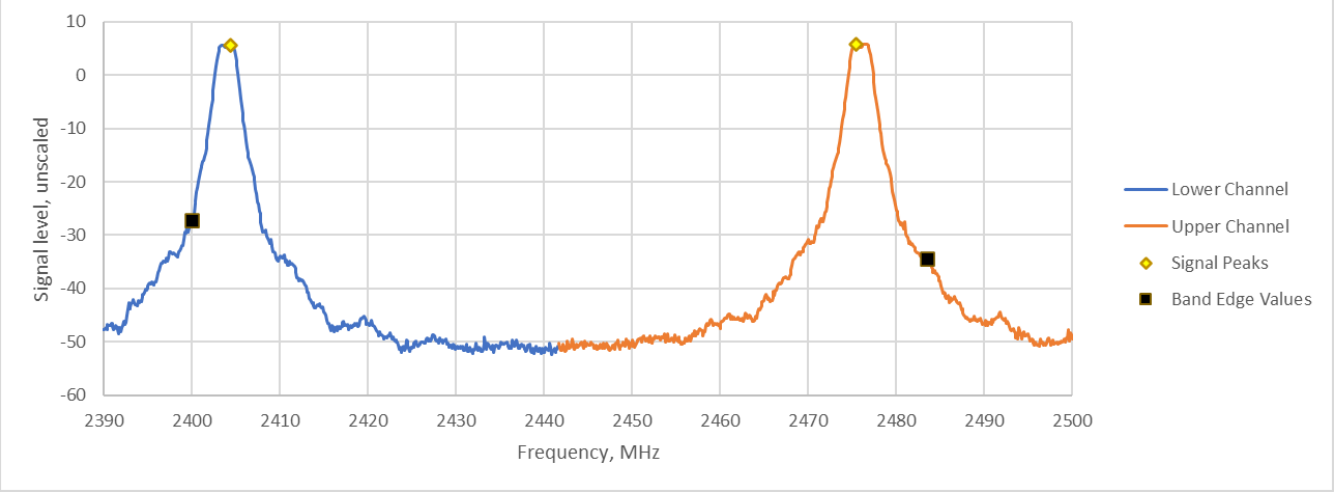

Figure TR33.5: Spectral data for BLE 2 Mbps at -20 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
BLE 2 Mbps	20	4.25	33.6	36.0
BLE 2 Mbps	20	5	33.6	36.2
BLE 2 Mbps	20	5.75	33.3	36.3

Table TR33.8 Difference between peak and band edge levels for BLE 2 Mbps transmissions at 20 °C during voltage variations

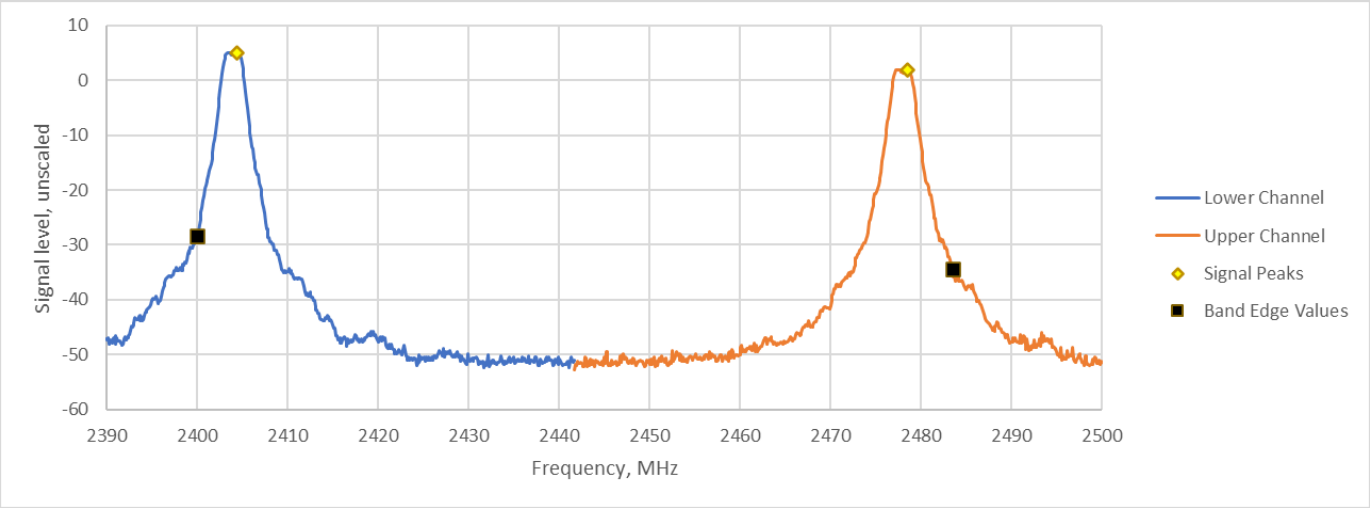

Figure TR33.6: Spectral data for BLE 2 Mbps at 20 °C and 5.75 Vdc

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
ANT	50	5	23.4	41.4
ANT	40	5	24.3	40.9
ANT	30	5	25.1	43.7
ANT	20	5	26.5	43.6
ANT	10	5	24.0	41.7
ANT	0	5	24.3	41.9
ANT	-10	5	25.0	42.7
ANT	-20	5	25.2	42.9

Table TR33.9 Difference between peak and band edge levels for ANT transmissions during temperature variations

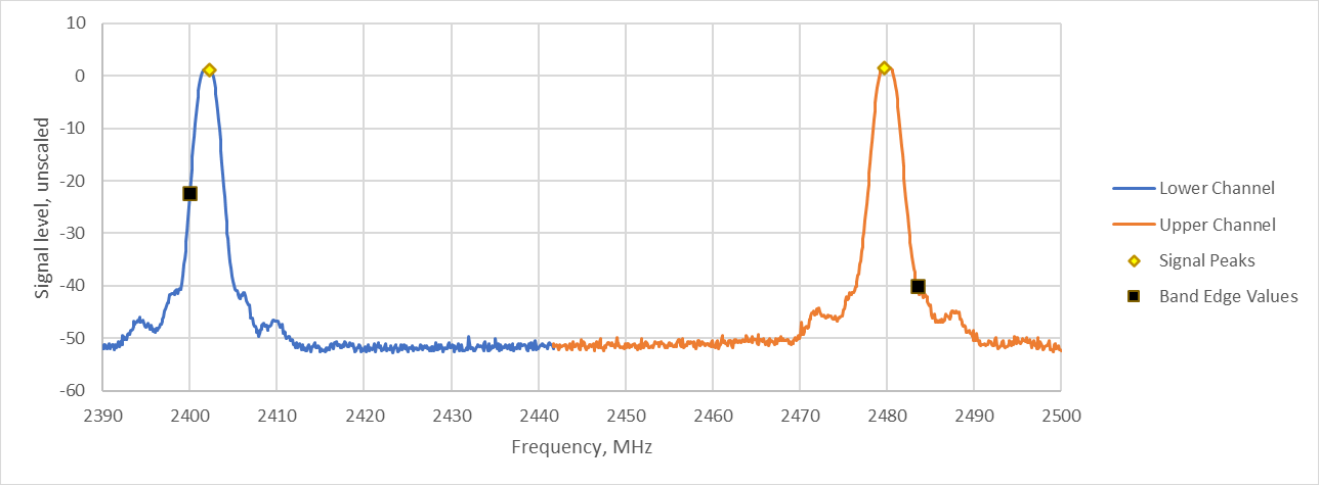

Figure TR33.7: Spectral data for ANT at 50 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
ANT	20	4.25	26.1	43.3
ANT	20	5	26.5	43.6
ANT	20	5.75	25.2	44.1

Table TR33.10 Difference between peak and band edge levels for ANT transmission at 20 °C during voltage variations

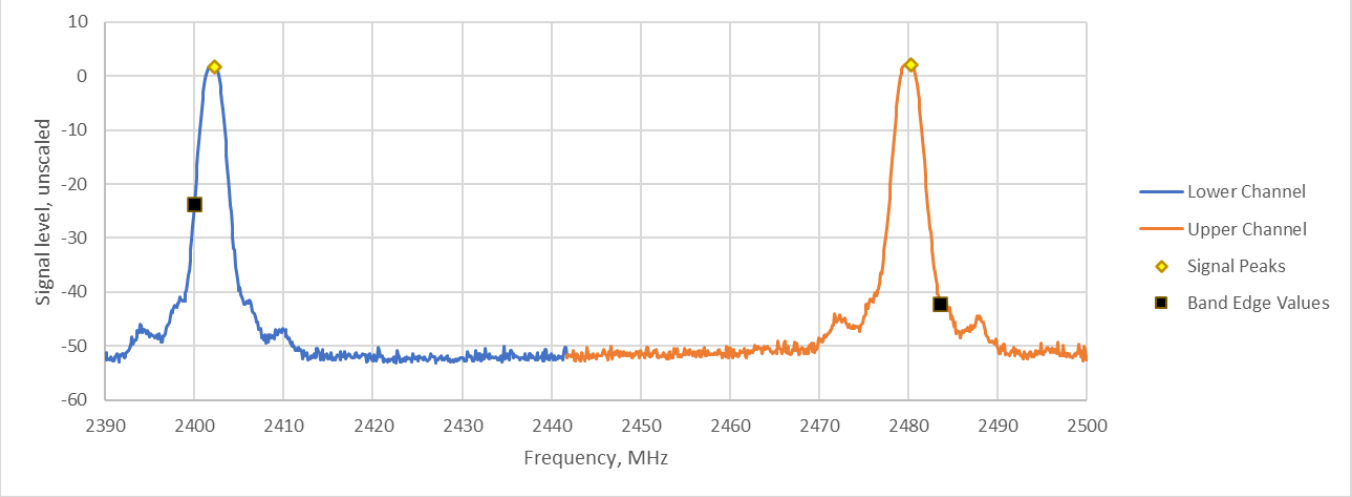

Figure TR33.8: Spectral data for ANT at 20 °C and 5.75 Vdc

Setup Block Diagram

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

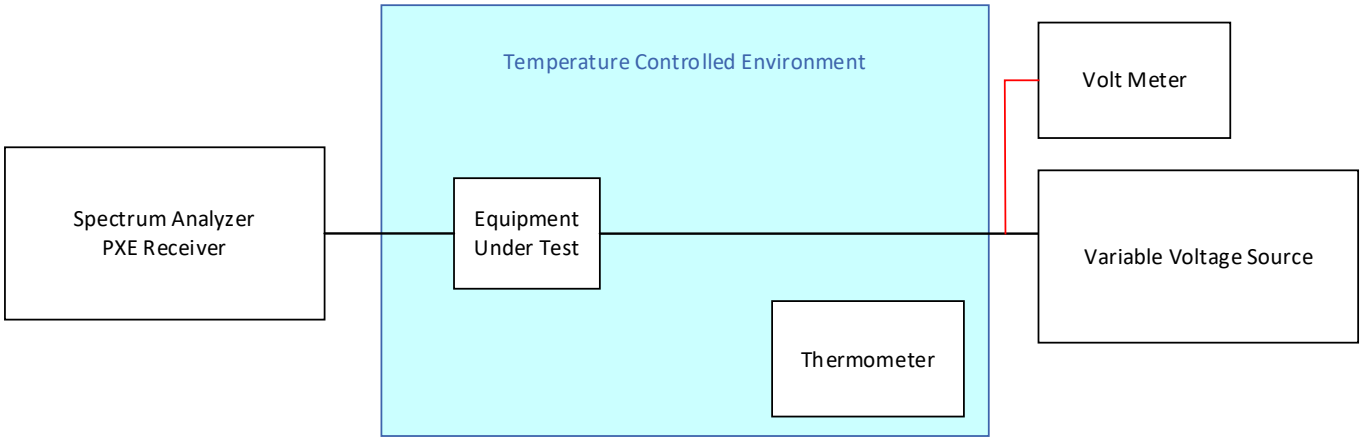

Figure TR33.9: Schematic drawing of the test equipment setup for Bluetooth, BLE and ANT

This line is the end of the test record.

Test Record
Transmitter Frequency Stability
Test IDs TR36
Project GCL-0303

Test Date(s)	17 and 20 Mar 2023
Test Personnel	Majid Farah
Product Model	A04432
Serial Number tested	3437936721
Operating Mode	M9 (WiFi Tx)
Arrangement	A1 (PwrA)
Nominal Input Power	5 Vdc
Test Standards:	FCC part 15, RSS-GEN, RSS-210, 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 / Jim Solum**
Date this record:	**24 Mar 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
DMM Multimeter	FLUKE	79 III	71740743	18-Apr-2022	15-Apr-2023
Signal analyzer PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Thermometer	Thermco	ACCD370P	210607316	11-Aug-2021	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Thermal Chamber	TPS	T2RC	32774-02	19-Oct-22	15-Oct-23
Power source	TENMA	72-2080	2440	Calibration	Not Required

Table TR36.1: Equipment used

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

Test Method

The RSS-GEN standard requires a frequency stability test with variations in temperature and supply voltage, but RSS-247 does not provide further guidance on this test. RSS-GEN suggests one possible criterion for unlicensed transmitters could be that the carrier remains in the central 80% of the frequency band. However, the Bluetooth and ANT protocols have carriers that are intentionally closer to the band edge. The basic concept applied here is that the 6 dBc Occupied Bandwidth of the modulated signal should remain within the 2400-2483.5 MHz radio band. To evaluate this, the peak carrier level and the level at the band edge are compared to ensure that signal at the band edge is reduced at least 6 dB across the specified range of voltages and temperatures. The data is reported in terms of dBc as a positive value, meaning we report the ratio between the peak carrier signal level and the level at the band edge to demonstrate that the resulting intentional signals remained within the allowed band.

The EUT has a minimum transmission center frequency at 2412 MHz (channel 1) and a maximum at 2472 MHz (channel 13). The temperature stability of these transmissions was observed for channel 1, 11 and 13 and for different link rates of IEEE 802.11 b/g/n. b1, g12 and n MCS1 modulations were selected as the worst case to investigate due to their high occupied bandwidth.

The test sample was placed in a thermal chamber and connected to an appropriate dc power source. The sample has an appropriate output to be used for conducted measurement. The analyzer was set up to detect radio signals from the test sample.

The test temperatures range is from +50 °C to -20 °C by 10 °C decrement at each test step for nominal input voltage (5 V). For the voltage variation test at +20 °C, the voltage is to be varied 15% above and below nominal input voltage. Data was taken at 5 Vdc and 15% lower at 4.25 Vdc plus 15% higher at 5.75 Vdc.

Test Data

The various standards 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 apply to different limits or conditions, the most stringent limits and conditions have been applied.

During WiFi test mode, each measurement is made conducted from the antenna port of the sample with the transmitter continuous “ON” at a specified channel and in a selected transmission protocol. The amplitude results are unscaled and may not include the effects such as cable losses. Such effects are minimal when comparing two nearby data points in a single spectral scan.

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
B 1 Mbps	50	5	37.2	47.9	42.9
B 1 Mbps	40	5	37.2	47.6	43.7
B 1 Mbps	30	5	35.7	47.9	45.2
B 1 Mbps	20	5	36.5	48.9	45.3
B 1 Mbps	10	5	36.3	48.1	45.4
B 1 Mbps	0	5	36.6	49.5	44.1
B 1 Mbps	-10	5	37.5	49.4	44.7
B 1 Mbps	-20	5	36.8	49.3	43.5

Table TR36.2 Difference between peak and band edge levels for IEEE 802.11 b 1 Mbps transmissions during temperature variations

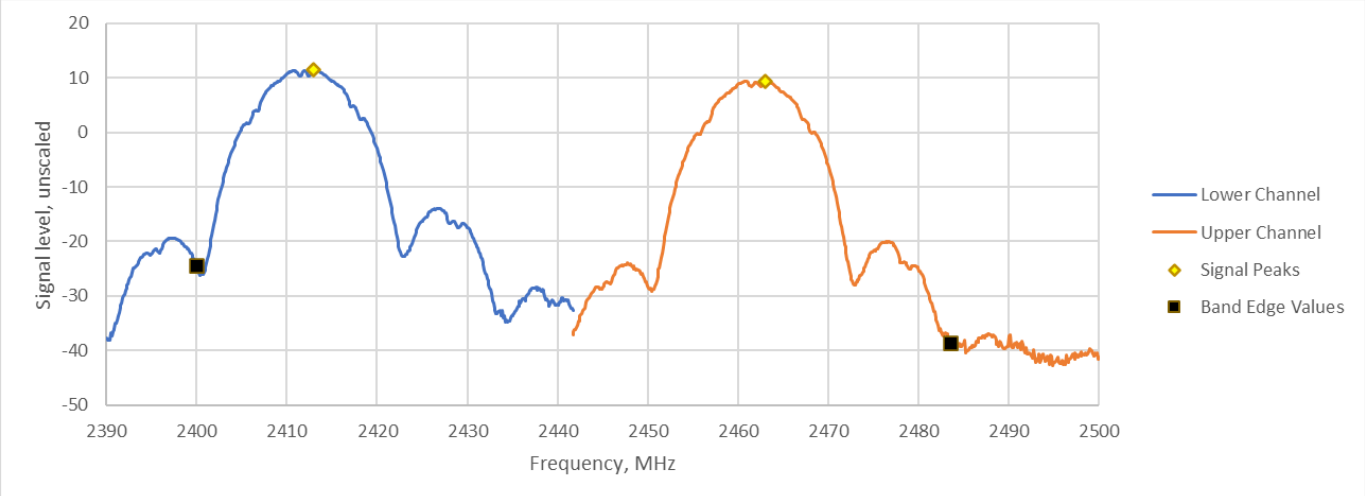

Figure TR36.1: Spectral data for IEEE 802.11 b 1 Mbps at 30 °C which represent Ch1 and Ch11

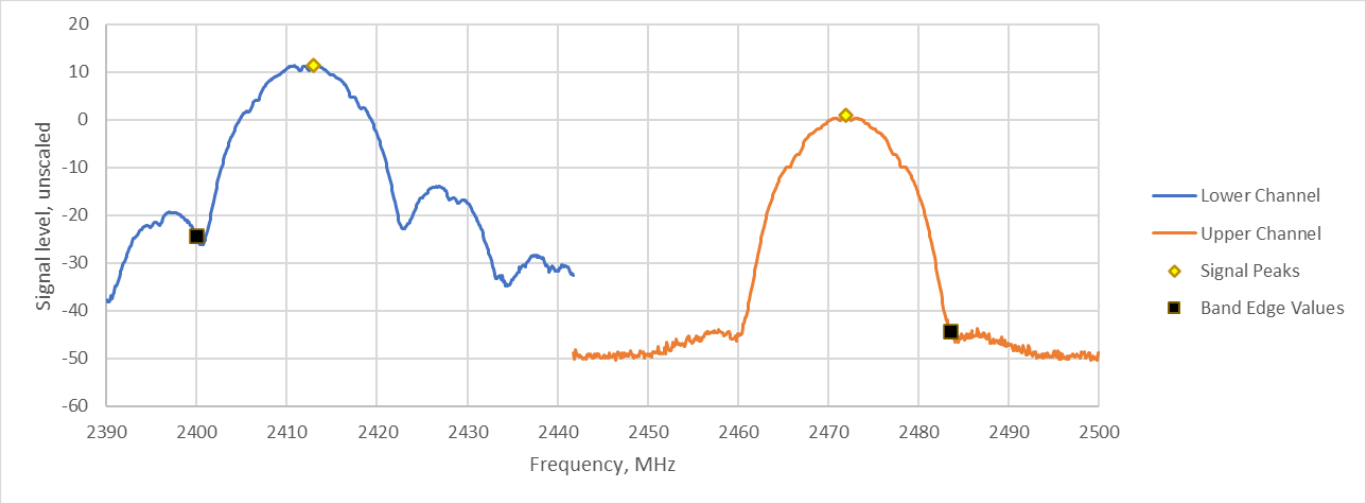

Figure TR36.2: Spectral data for IEEE 802.11 b 1 Mbps at 30 °C which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
B 1 Mbps	20	4.25	36.5	48.9	45.4
B 1 Mbps	20	5	36.5	48.9	45.3
B 1 Mbps	20	5.75	36.6	49.1	44.9

Table TR36.3 Difference between peak and band edge levels for IEEE 802.11 b 1 Mbps transmissions at 20 °C during voltage variations

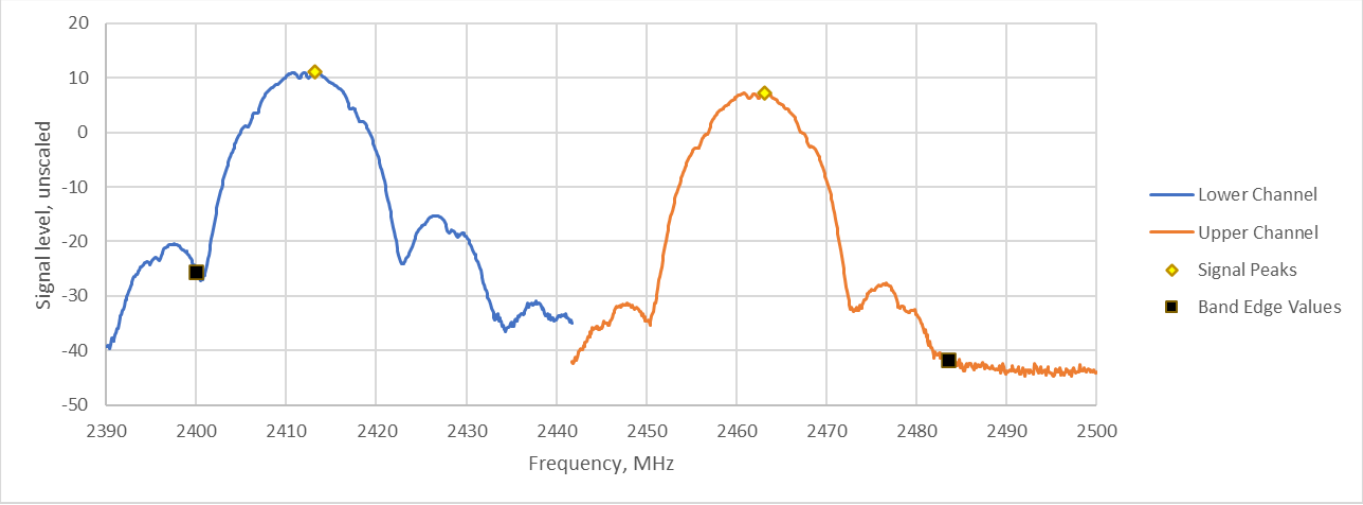

Figure TR36.3: Spectral data for IEEE 802.11 b 1 Mbps at 20 °C and 5 Vdc which represent Ch1 and Ch11

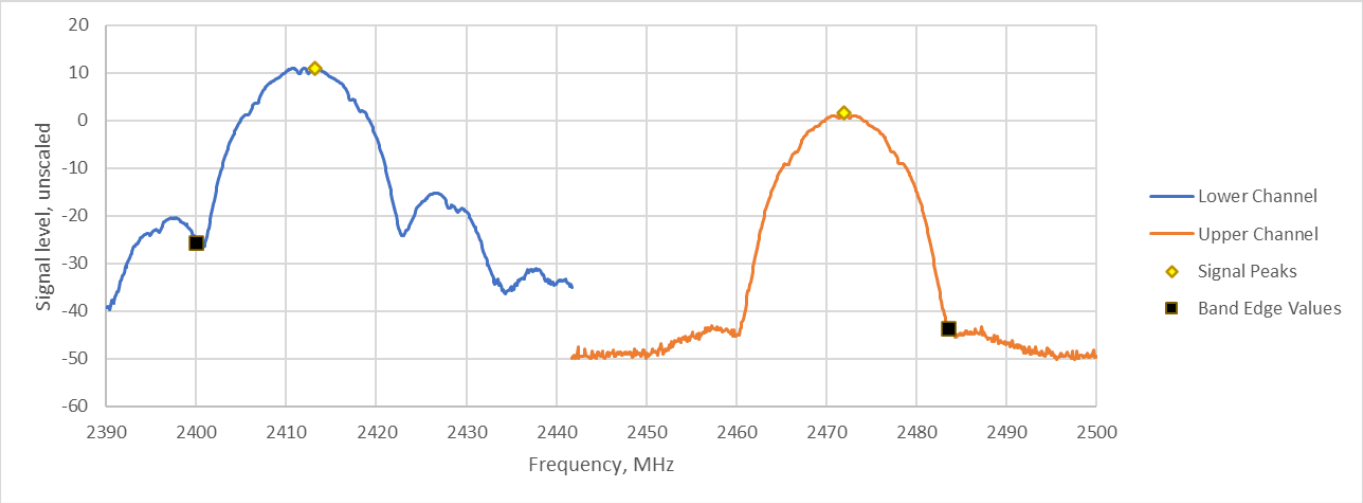

Figure TR36.4: Spectral data for IEEE 802.11 b 1 Mbps at 20 °C and 5 Vdc which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
G 12 Mbps	50	5	38.6	37.4	37.5
G 12 Mbps	40	5	39.5	37.2	37.7
G 12 Mbps	30	5	40.7	38.4	36.4
G 12 Mbps	20	5	39.6	38.3	35.6
G 12 Mbps	10	5	41.2	37.4	35.6
G 12 Mbps	0	5	39.5	35.9	36.3
G 12 Mbps	-10	5	39.9	35.4	34.3
G 12 Mbps	-20	5	37.3	39.4	34.6

Table TR36.4 Difference between peak and band edge levels for IEEE 802.11 g 12 Mbps transmissions during temperature variations

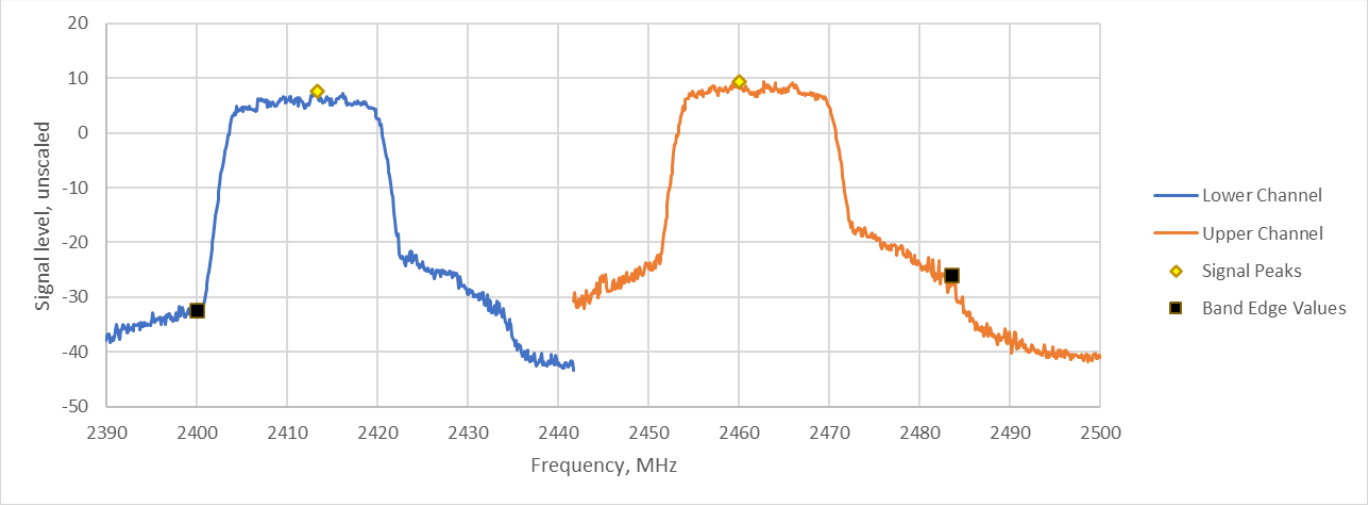

Figure TR36.5: Spectral data for IEEE 802.11 g 12 Mbps at -10 °C which represent Ch1 and Ch11

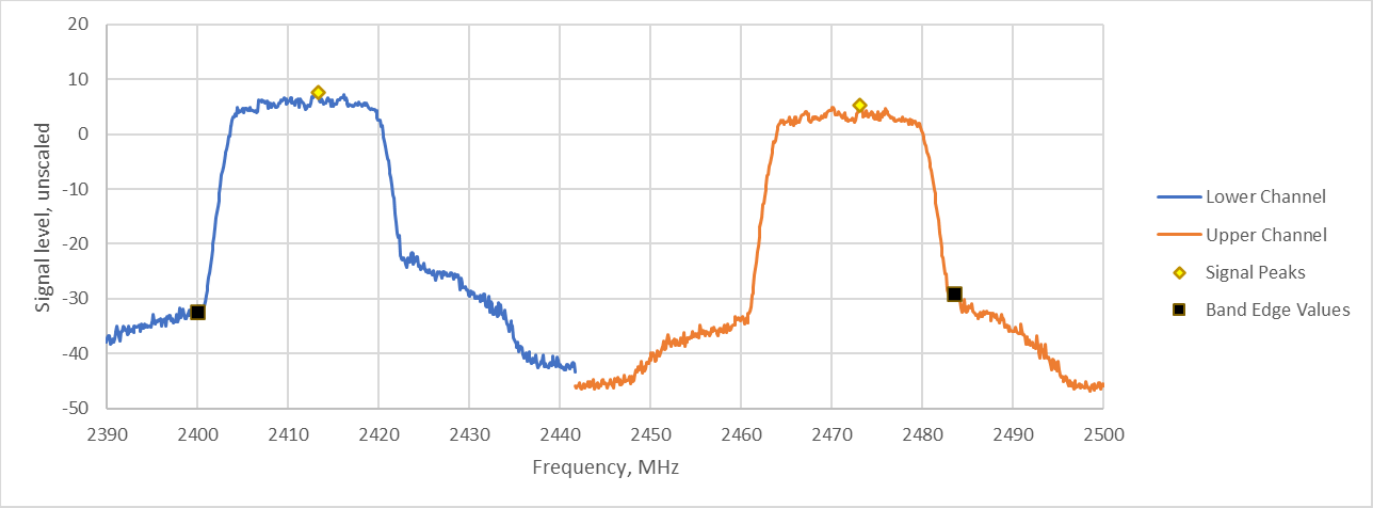

Figure TR36.6: Spectral data for IEEE 802.11 g 12 Mbps at -10 °C which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
G 12 Mbps	20	4.25	39.0	36.8	34.6
G 12 Mbps	20	5	39.6	38.3	35.6
G 12 Mbps	20	5.75	39.8	38.0	35.7

Table TR36.5 Difference between peak and band edge levels for IEEE 802.11 g 12 Mbps transmissions at 20 °C during voltage variations

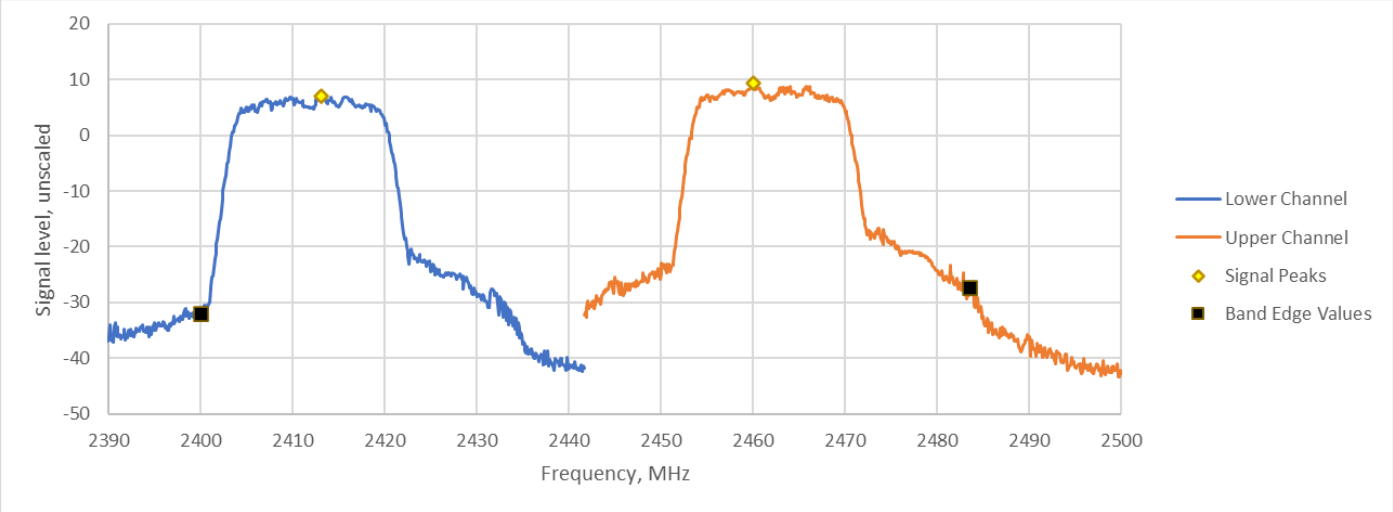

Figure TR36.7: Spectral data for IEEE 802.11 g 12 Mbps at 20 °C and 4.25 Vdc which represent Ch1 and Ch11

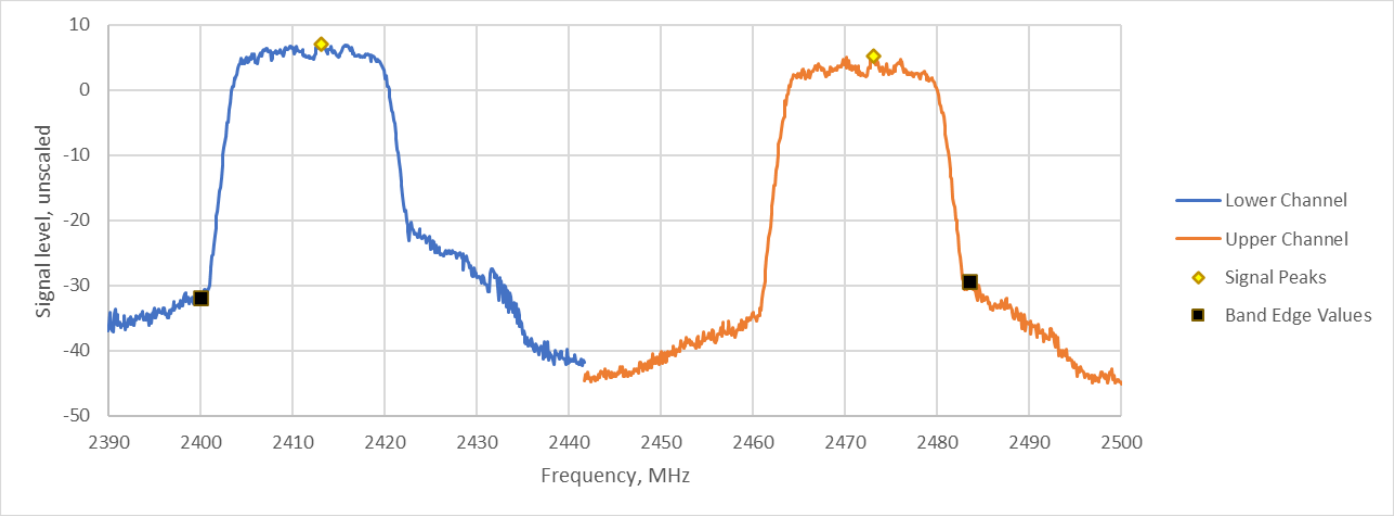

Figure TR36.8: Spectral data for IEEE 802.11 g 12 Mbps at 20 °C and 4.25 Vdc which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
N MCS1	50	5	33.2	35.3	37.2
N MCS1	40	5	32.5	35.0	38.6
N MCS1	30	5	30.7	33.5	37.7
N MCS1	20	5	32.3	32.8	36.3
N MCS1	10	5	31.9	34.9	35.7
N MCS1	0	5	31.3	33.9	37.9
N MCS1	-10	5	29.8	34.4	36.7
N MCS1	-20	5	33.2	33.6	35.5

Table TR36.6 Difference between peak and band edge levels for IEEE 802.11 n MCS1 transmissions during temperature variations

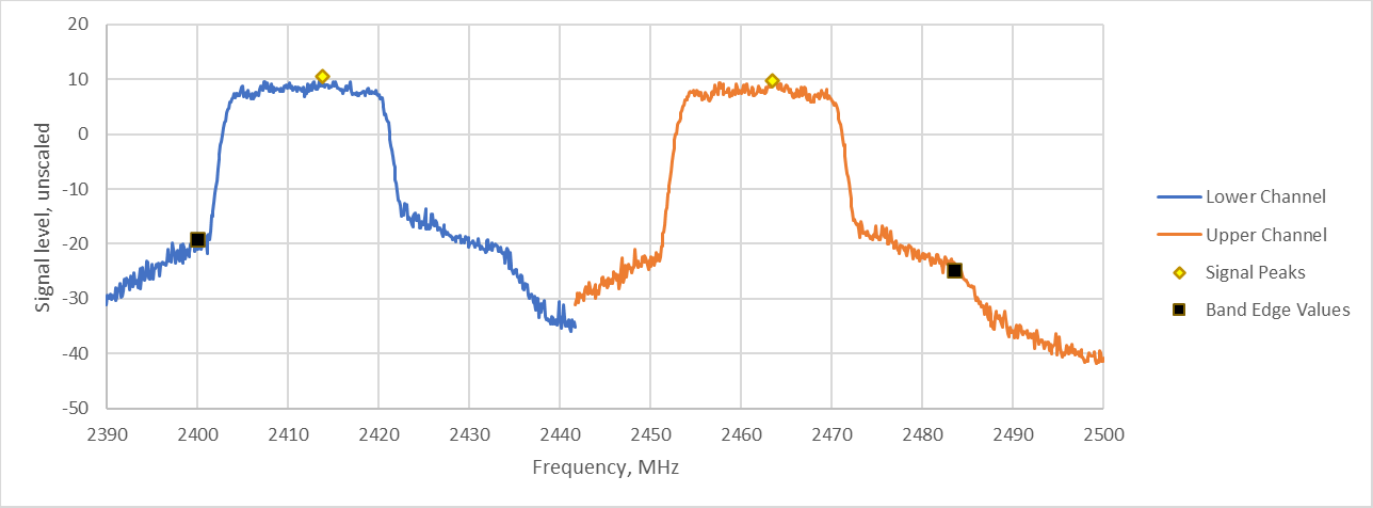

Figure TR36.9: Spectral data for IEEE 802.11 n MCS1 at -10 °C which represent Ch1 and Ch11

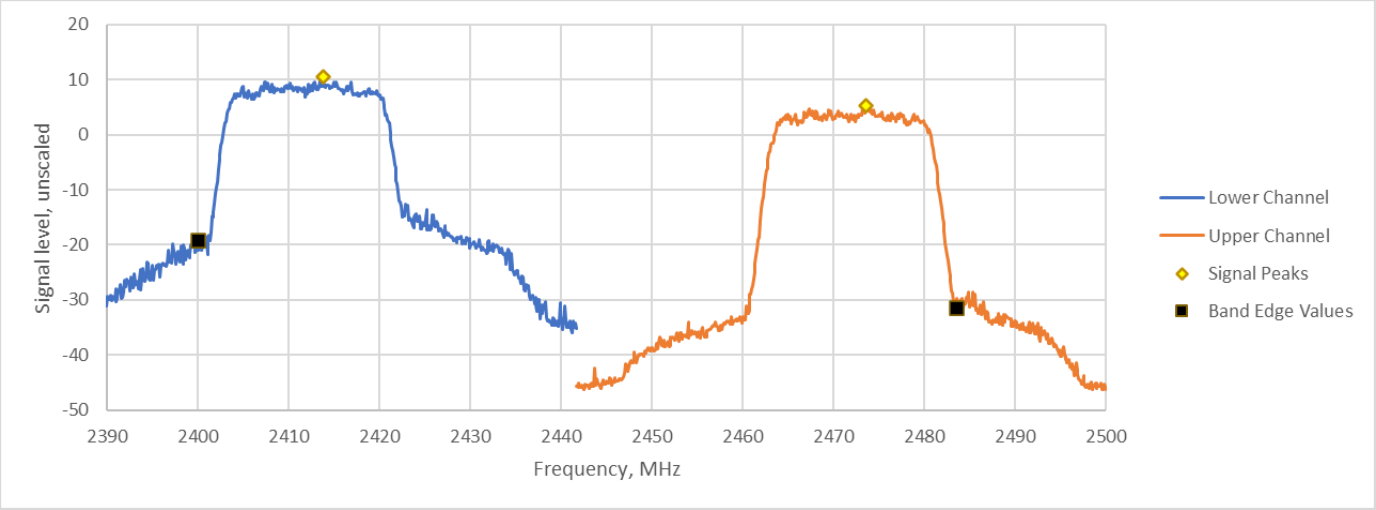

Figure TR36.10: Spectral data for IEEE 802.11 n MCS1 at -10 °C which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
N MCS1	20	4.25	30.6	33.1	37.0
N MCS1	20	5	32.3	32.8	36.3
N MCS1	20	5.75	30.0	33.6	36.2

Table TR36.7 Difference between peak and band edge levels for IEEE 802.11 n MCS1 transmissions at 20 °C during voltage variations

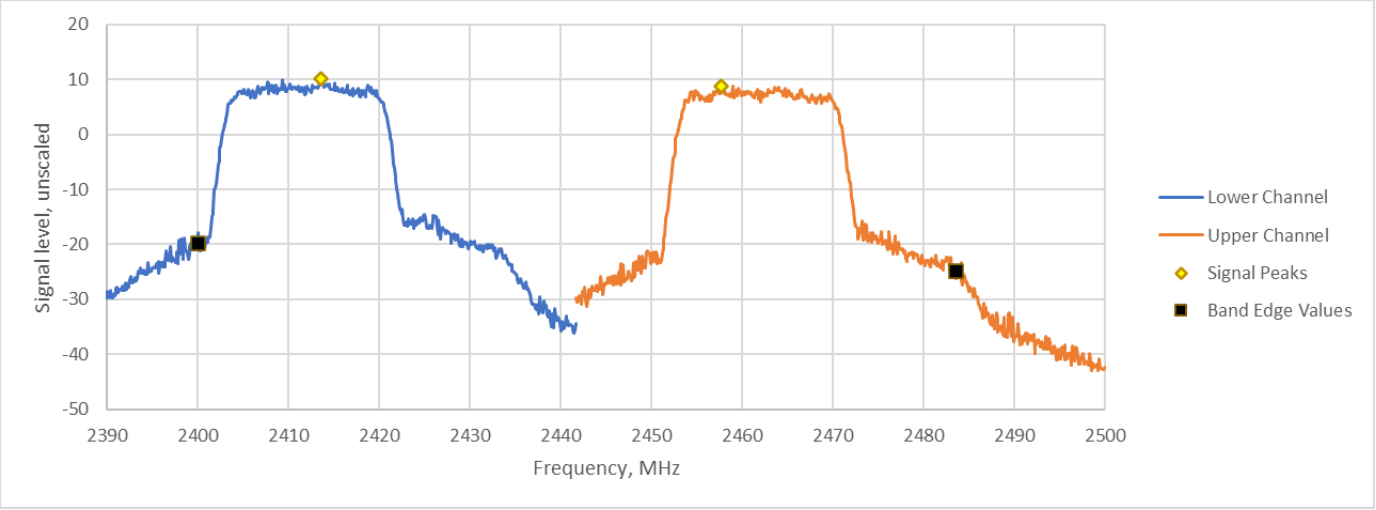

Figure TR36.11: Spectral data for IEEE 802.11 n MCS1 Mbps at 20 °C and 5.75 Vdc which represent Ch1 and Ch11

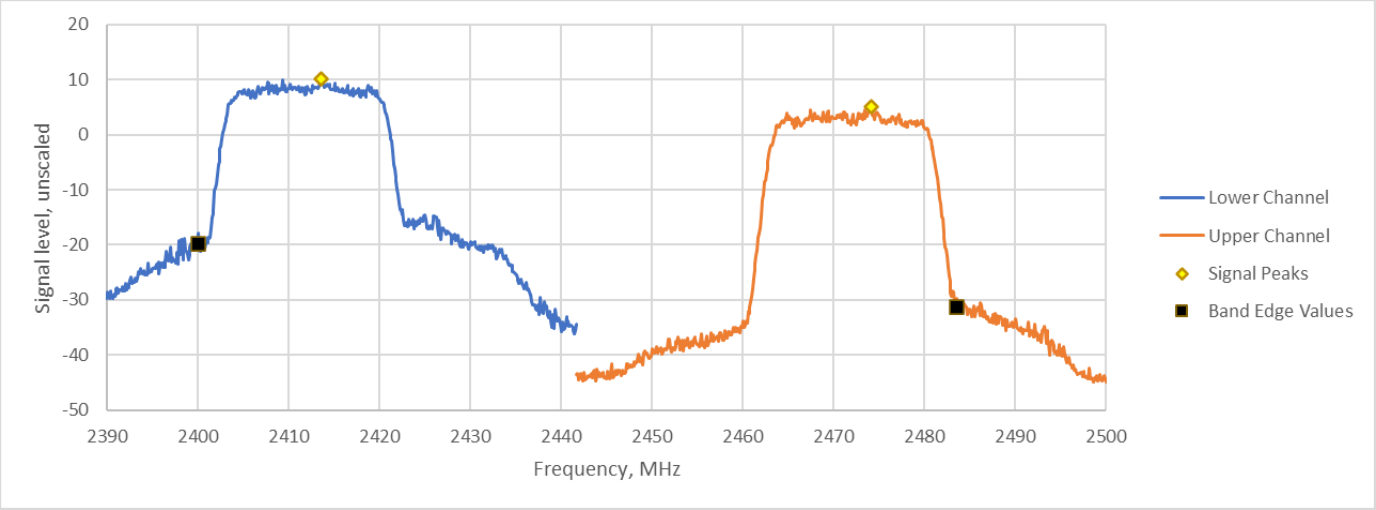

Figure TR36.12: Spectral data for IEEE 802.11 n MCS1 Mbps at 20 °C and 5.75 Vdc which represent Ch1 and Ch13

Setup Block Diagram

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

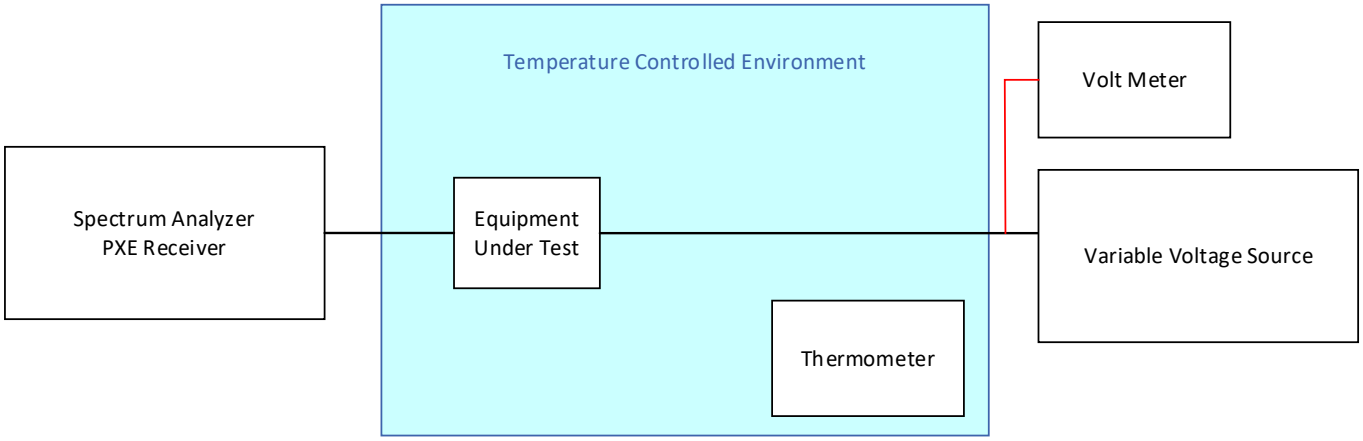

Figure TR33.13: Schematic drawing of the test equipment setup for WiFi (IEEE 802.11 b/g/n)

This line is the end of the test record.

Test Record
Other Bandwidth Tests
Test IDs TR15 (TR14 – TR17)
Project GCL0303

Test Date(s)	27 – 28 Feb 2023
Test Personnel	Majid Farah
Product Model	A04432
Serial Number tested	3437936721
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	2480 to 2483.5 MHz
Arrangement	A3 (PwrPc)
Pass/Fail Judgment:	**Reported**
Test record created by:	**David Arnett**
Date of this record:	**25 Mar 2023**

Original record, Version A.

Test Equipment Used

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

Table TR15.1: List of test equipment used

Test Software Used: Keysight PXE firmware A.33.03

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.

Test Setup

This block diagram shows the test equipment setup.

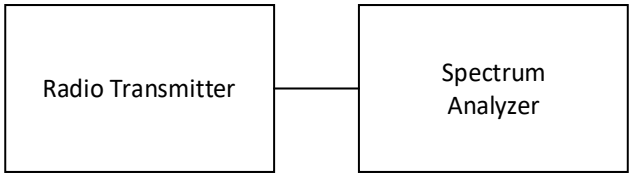

Figure TR15.1: Test setup

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

Occupied Bandwith, 99% Test Data

The data for each type of bandwidth is summarized below, followed by the spectral data for the cases highlighted in yellow. Grey cells are cases where no measurement was made. The analysis threshold for this test was the bandwidth containing 99% of the observed power using the ANSI C63.10 method. The standards require testing a frequency near the bottom, middle, and top of the band. The measured bandwidth data are in bold font and have MHz as their units of measure for WiFi, and kHz for other radio types. Channel numbers are provided for WiFi. The Low-Mid-High frequency designators for Bluetooth Classic, Bluetooth Low Energy, and ANT radios are 2402, 2440, and 2480 MHz – except for BLE 2MB where the lowest and highest frequencies are limited to 2404 and 2478 MHz.

Mode	Speed	Low	Mid	High
BTC	BR	**908**	**908**	**910**
BTC	EDR2	**1203**	**1202**	**1203**
BTC	EDR3	**1194**	**1193**	**1194**
BLE	1 Mb	**1354**	**1380**	**1393**
BLE	2 Mb	**2452**	**2524**	**2517**
ANT	Fixed	**1314**	**1429**	**1733**

Table TR15.2: Units in kHz. Summary of 99% Occupied Bandwidth Data, ANT, BTC and BLE modes

Mode	Speed	Ch 1	Ch 6	Ch 11	Ch 12	Ch 13
B	1	**15.557**	**16.232**	**15.154**	**14.928**	**14.884**
B	2					**14.837**
B	5.5					**14.767**
B	11	**15.034**	**15.356**	**14.884**	**14.742**	**14.733**
G	6	**17.04**	**21.784**	**17.032**	**17.063**	**17.037**
G	9					**17.066**
G	12	**16.834**	**22.878**	**16.802**	**16.809**	**16.815**
G	18					**16.742**
G	24					**16.79**
G	36					**16.886**
G	48					**16.816**
G	54	**16.818**	**17.033**	**16.861**	**16.854**	**16.833**
N	0	**17.733**	**22.174**	**17.721**	**17.731**	**17.708**
N	1	**17.718**	**22.976**	**17.68**	**17.662**	**17.651**
N	2					**17.653**
N	3					**17.66**
N	4					**17.684**
N	5					**17.734**
N	6					**17.682**
N	7	**17.673**	**17.733**	**17.681**	**17.646**	**17.637**

Table TR15.3: Units in MHz. Summary of 99% Occupied Bandwidth Data, IEEE 802.11 WiFi modes

Figure TR15.1: Occupied bandwidth data for Bluetooth Classic EDR2 at low channel (2402 MHz)

Figure TR15.2: Occupied bandwidth data for BLE 2Mbps at mid channel (2440 MHz)

Figure TR15.3: Occupied bandwidth data for ANT at high channel (2480 MHz)

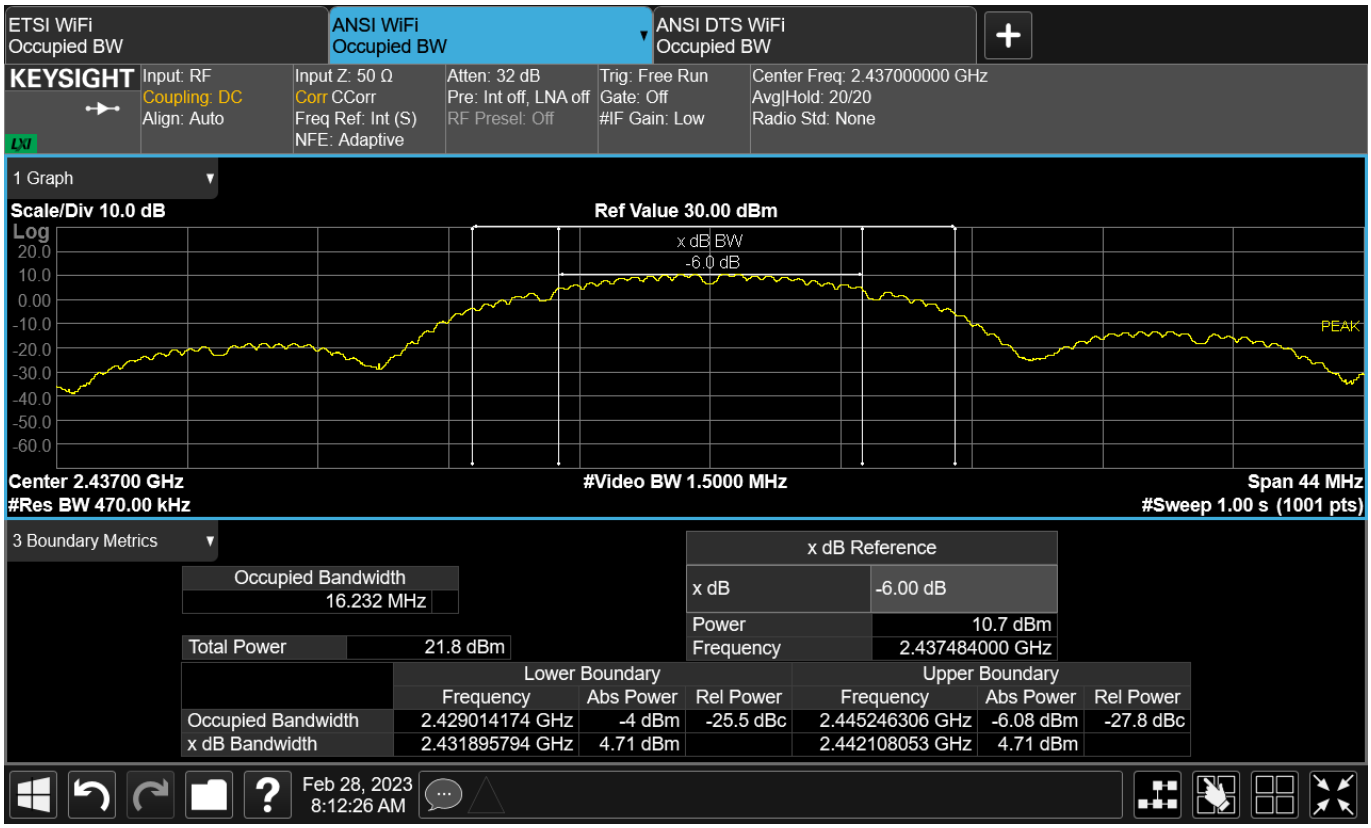

Figure TR15.4: Occupied bandwidth data for 802.11b 1 Mbps at channel 6

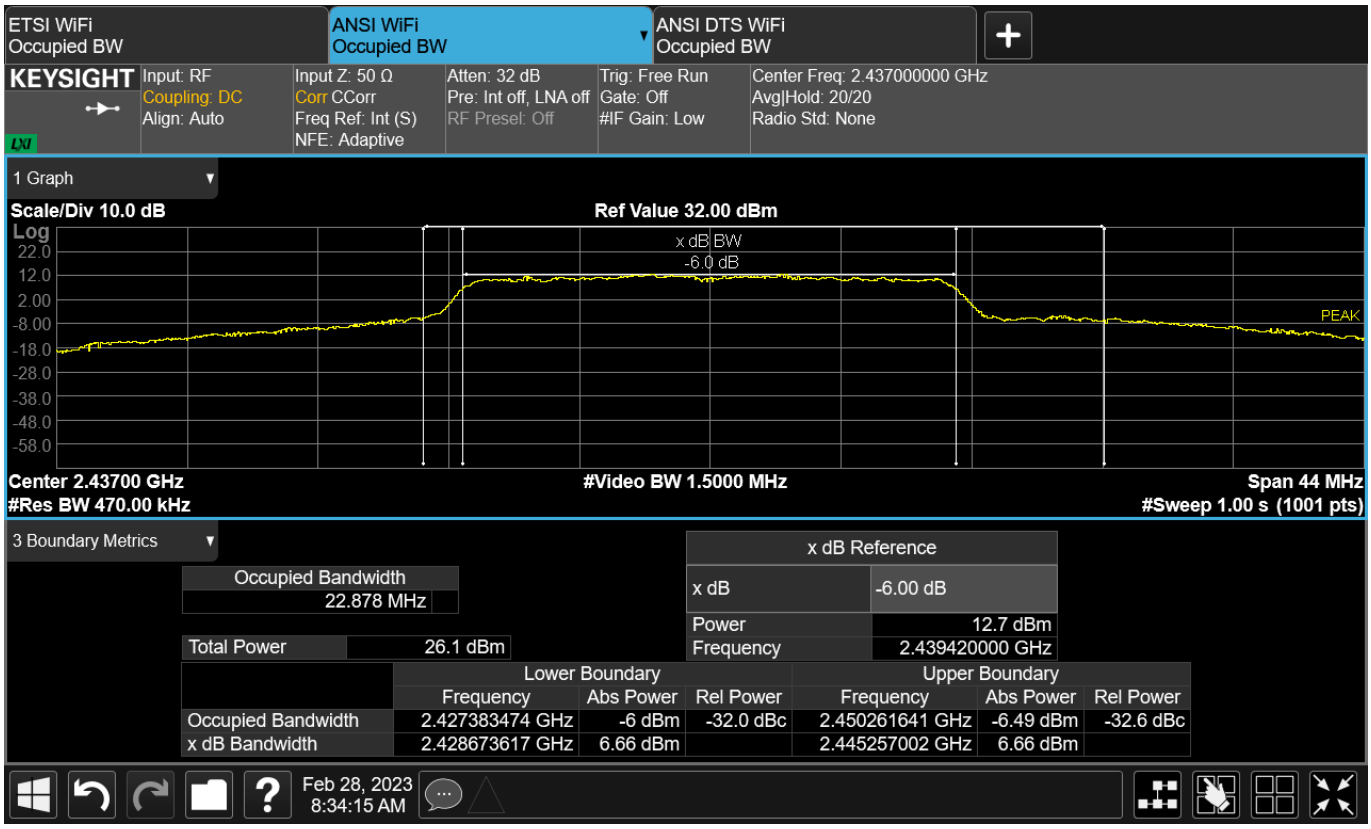

Figure TR15.5: Occupied bandwidth data for 802.11g 12 Mbps at channel 6

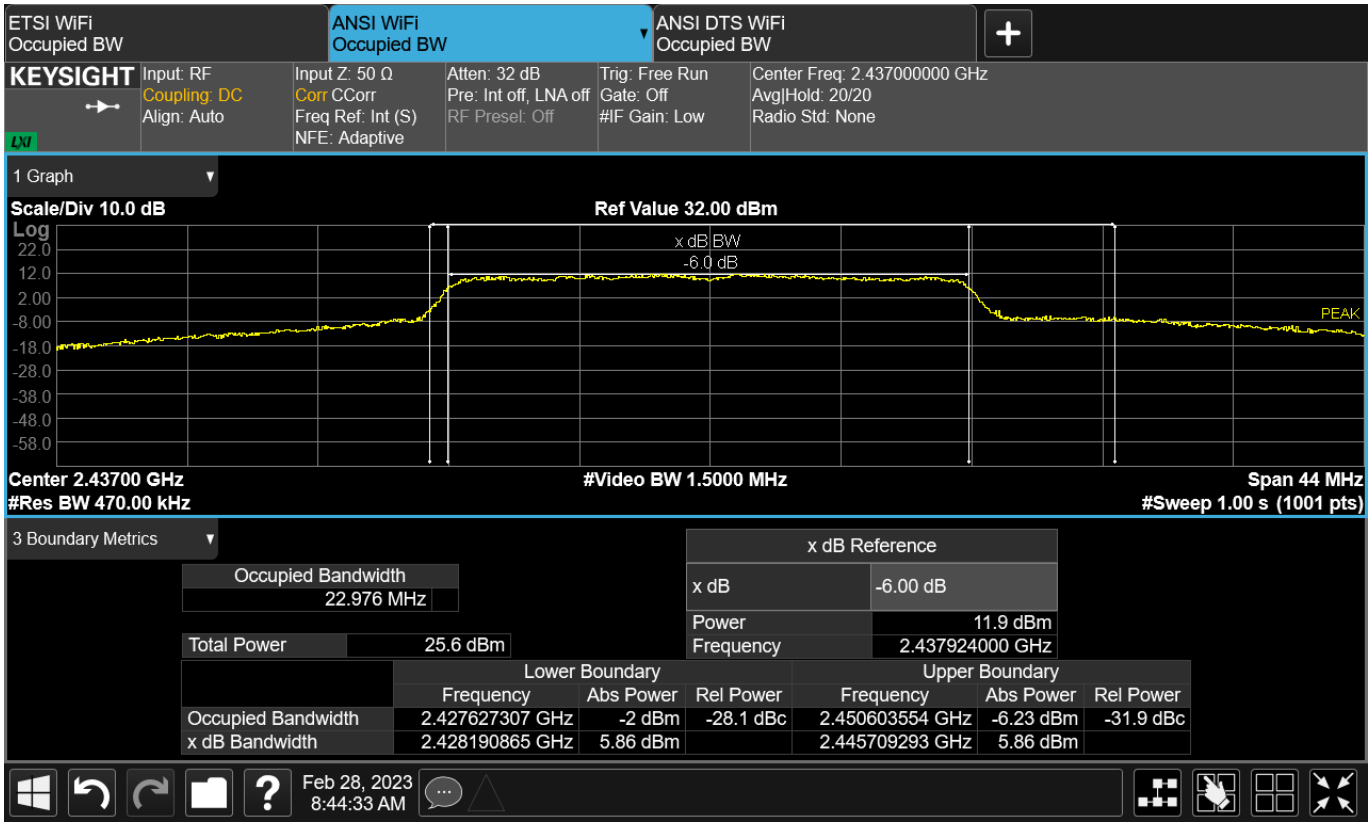

Figure TR15.6: Occupied bandwidth data for 802.11n MCS1 at channel 6

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 TR15.101: 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 TR15.102: 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 TR15.103: 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 TR15.104: 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 TR15.105: 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
Radiated Emission Test RE01
Project GCL0303

Test Date(s)	21 Feb 2023
Test Personnel	Christian Shepherd / Jim Solum
Product Model	A04432
Serial Number tested	3437936612
Operating Mode	M3 (BLE Tx)
Arrangement	A1 (PwrA)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.4, ICES-003, CISPR 32, EN 55032, (as noted in Section 6 of the report).
Frequency Range:	30 MHz to 1000 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**01 Mar 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
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
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE01.1: Test Equipment Used

Software Used

Keysight PXE software A.32.06
RE Signal Maximization Tool v2021Feb25.xlsx
RE 30M to 1G Data Analysis Template V3 2022May10.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.

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 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 Composite FCC/CISPR Class B Limit at 3m.

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.000	40.0	27.4	12.6	21	2378	VERT
401.070	46.0	24.6	21.4	21	2378	VERT
541.980	46.0	27.3	18.7	21	2378	VERT
688.290	46.0	30.0	16.0	21	2378	VERT
802.950	46.0	31.0	15.0	21	2378	VERT
943.290	46.0	33.6	12.4	21	2378	VERT

Table RE01.2: Emission summary (1 Mbps)

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.000	40.0	27.1	12.9	-151	1413	VERT
45.000	40.0	18.2	21.8	-151	1413	VERT
399.030	46.0	24.0	22.0	-151	1413	VERT
536.490	46.0	27.0	19.0	-151	1413	VERT
802.950	46.0	30.8	15.2	-151	1413	VERT
941.370	46.0	32.6	13.4	-151	1413	VERT

Table RE01.3: Emission summary (2 Mbps)

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

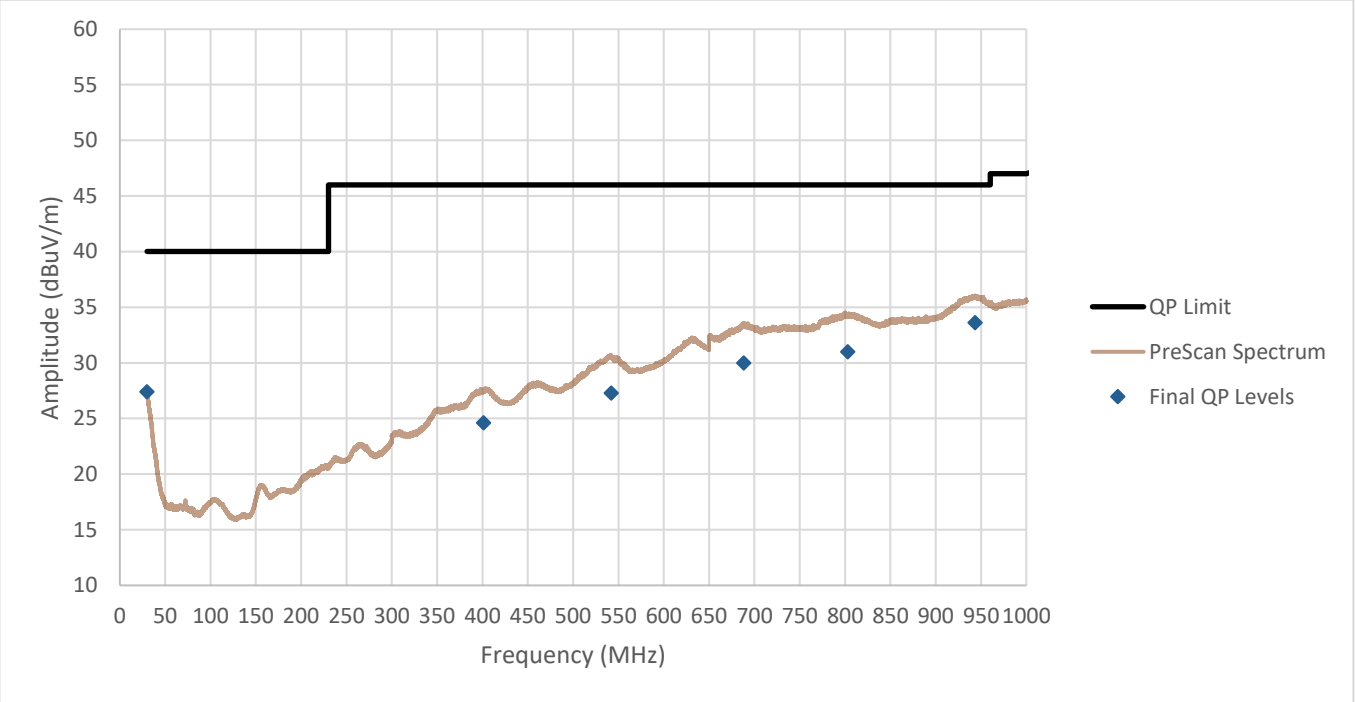

Figure RE01.1: Spectral data (1 Mbps)

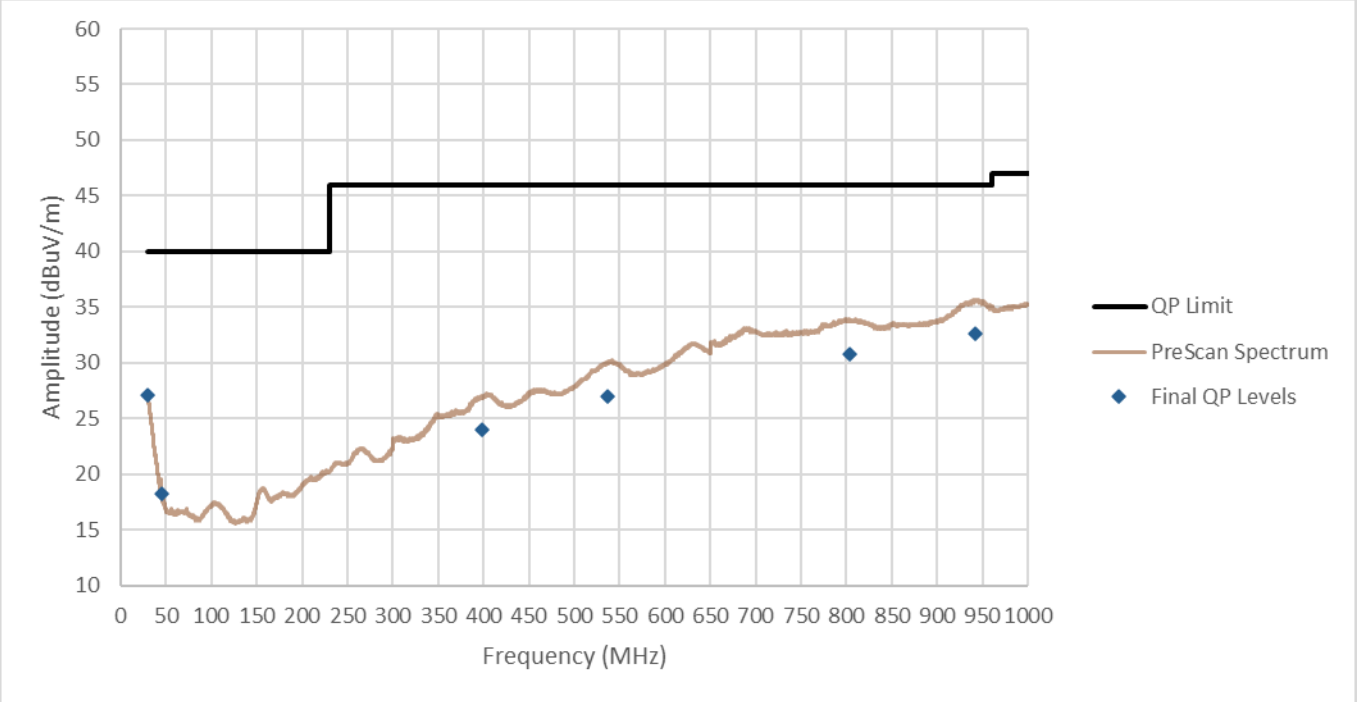

Figure RE01.2: Spectral data (2 Mbps)

Setup Photographs

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

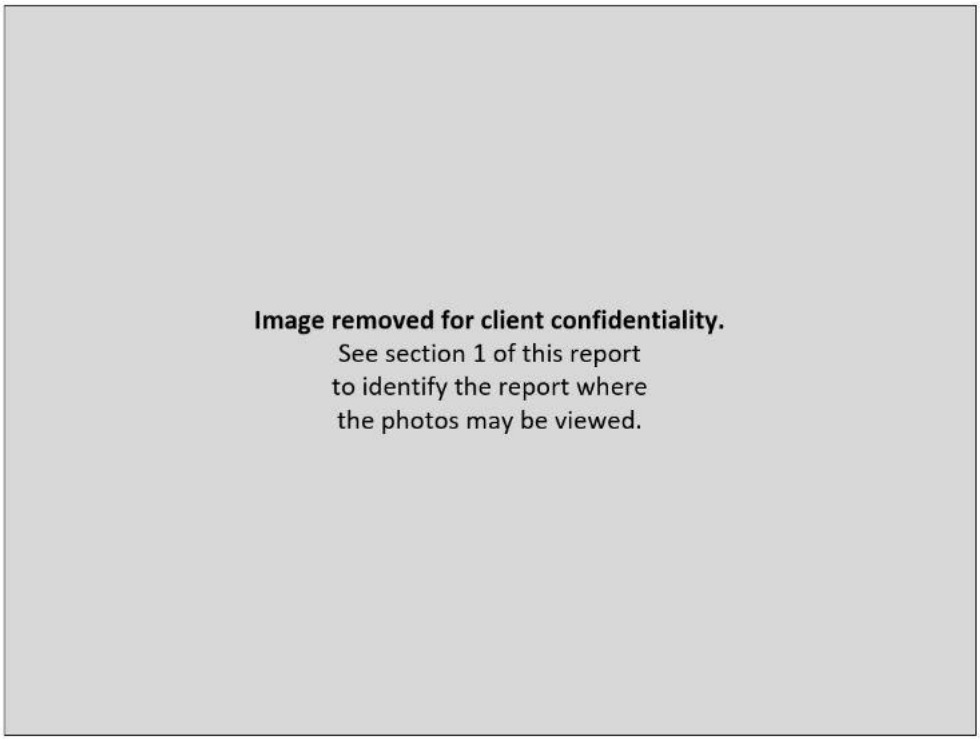

Figure RE01.3: EUT test setup, front view (1 Mbps, Z orientation)

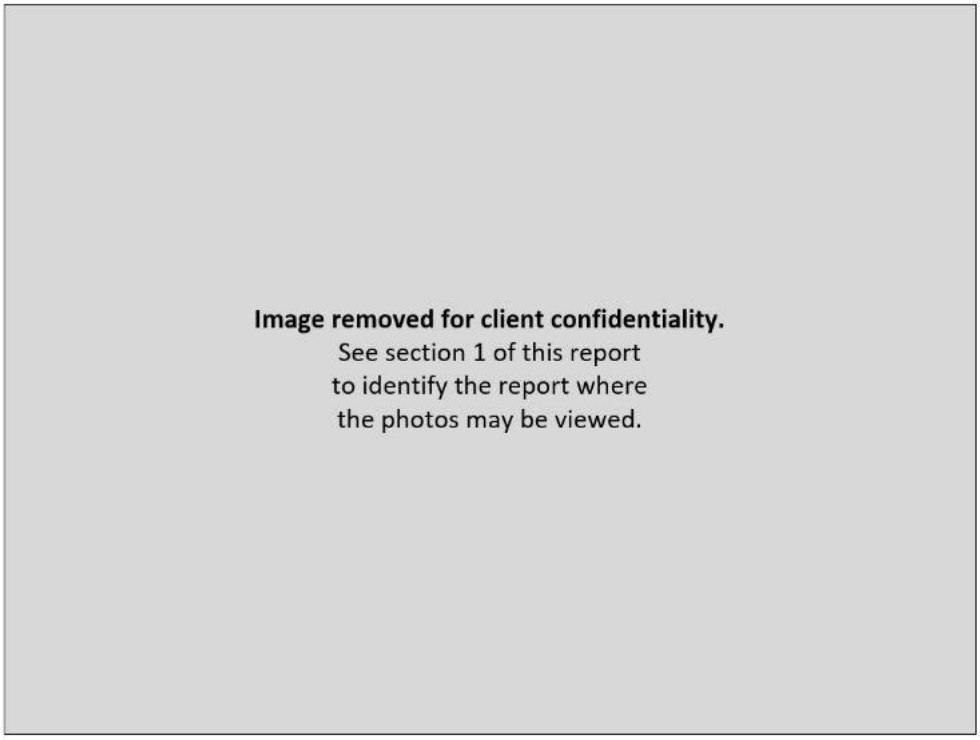

Figure RE01.4: EUT test setup, reverse view (1 Mbps, Z orientation)

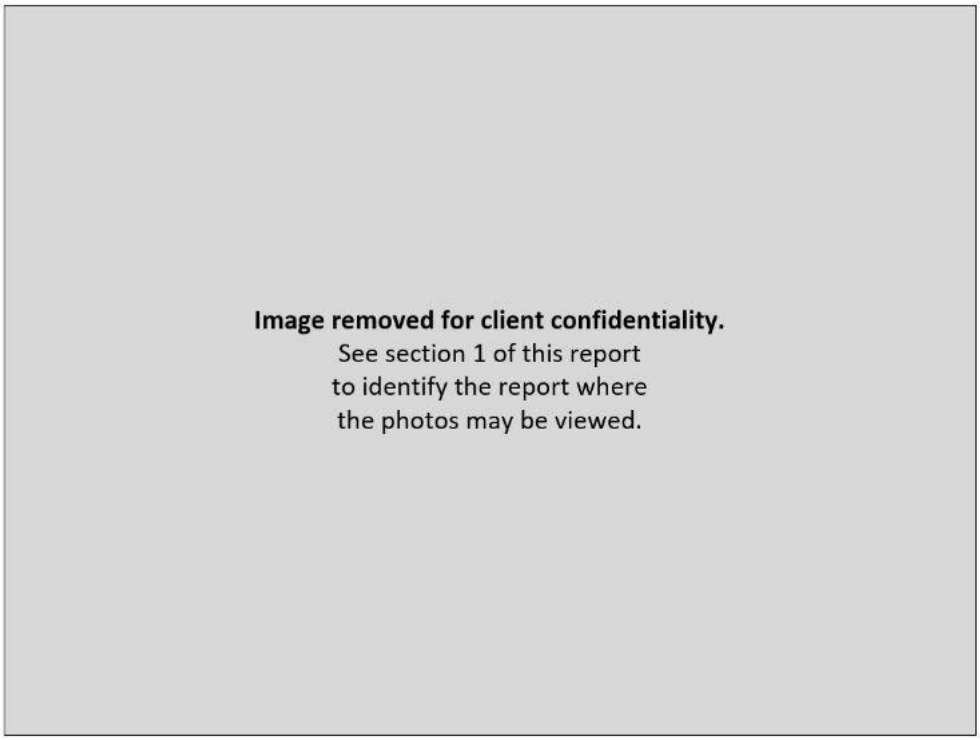

Figure RE01.5: EUT test setup, front view (2 Mbps, X orientation)

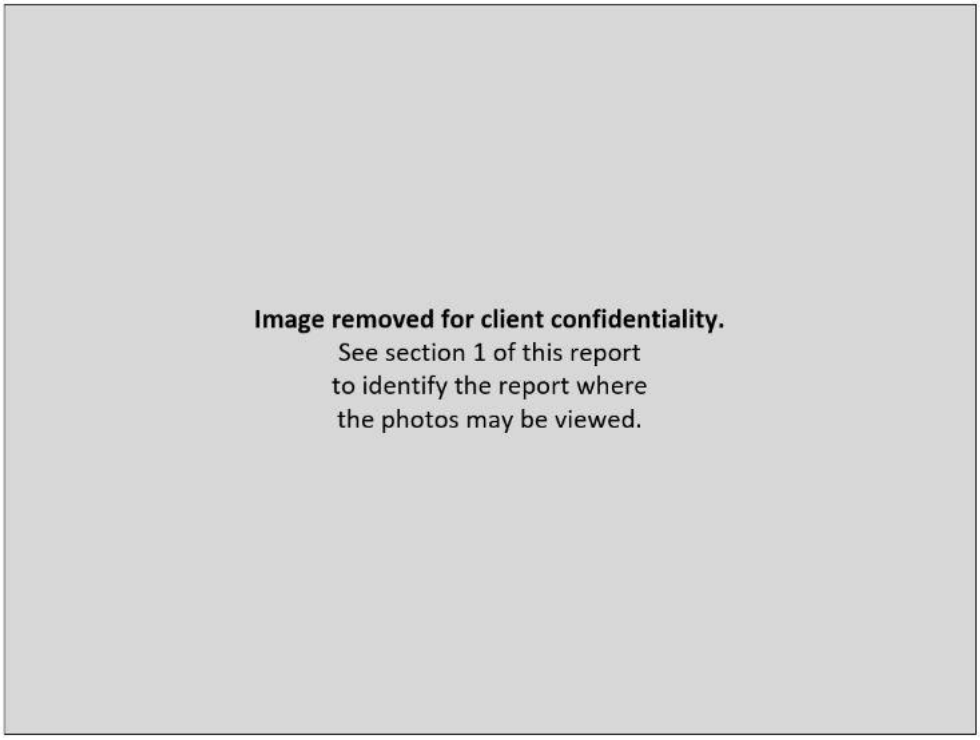

Figure RE01.6: EUT test setup, reverse view (2 Mbps, X orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE04
Project GCL0303

Test Date(s)	21 Feb 2023
Test Personnel	Jim Solum
Product Model	A04432
Serial Number tested	3437936612
Operating Mode	M7 (ANT Tx)
Arrangement	A1 (PwrA)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.4, ICES-003, CISPR 32, EN 55032, (as noted in Section 6 of the report).
Frequency Range:	30 MHz to 1000 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**02 Mar 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
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
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE04.1: Test Equipment Used

Software Used:
Keysight PXE software A.32.06
RE Signal Maximization Tool v2021Feb25.xlsx
RE 30M to 1G Data Analysis Template V3 2022May10.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.

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

The table shows the 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 Composite FCC/CISPR Class B Limit at 3m.

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.000	40.0	26.9	13.1	-44	1357	HORZ
45.000	40.0	18.0	22.0	-44	1357	HORZ
539.250	46.0	27.9	18.1	-44	1357	HORZ
692.700	46.0	30.0	16.0	-44	1357	HORZ
811.170	46.0	31.2	14.8	-44	1357	HORZ
943.170	46.0	32.6	13.4	-44	1357	HORZ

Table RE04.2: Emission summary

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

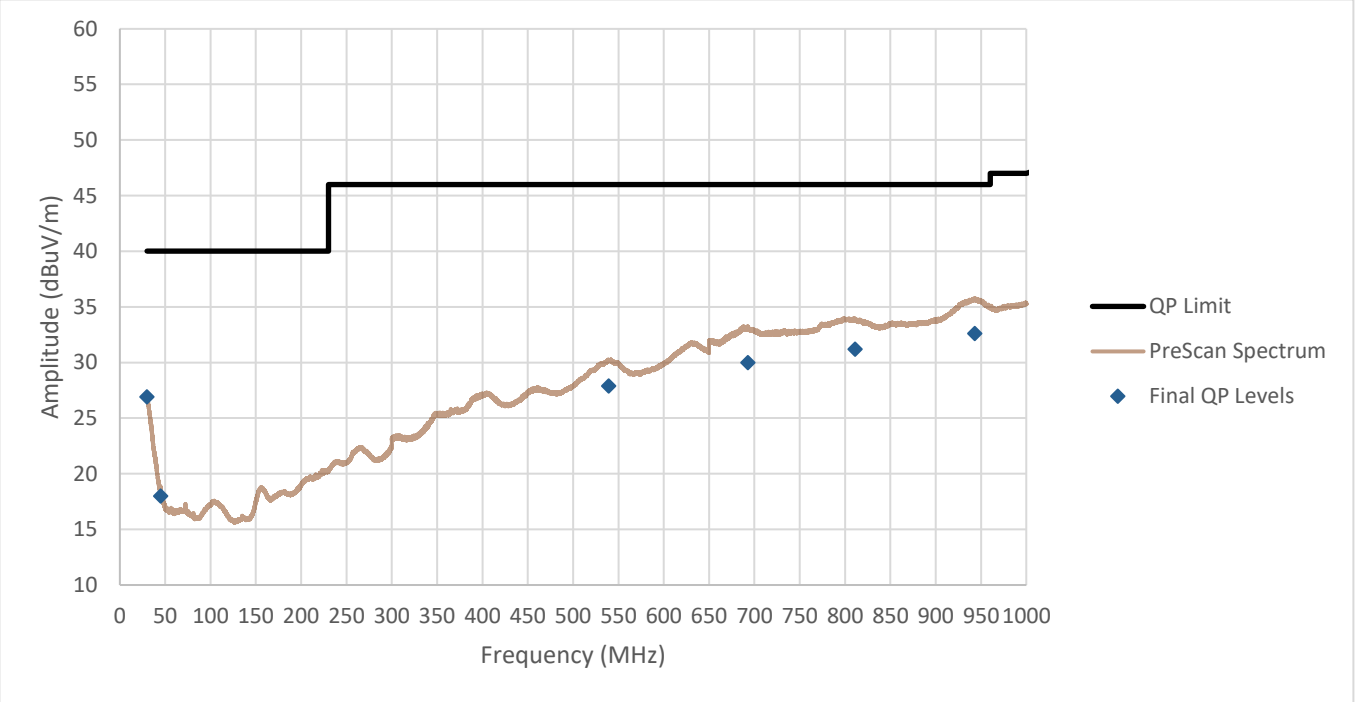

Figure RE04.1: Spectral data

Setup Photographs

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

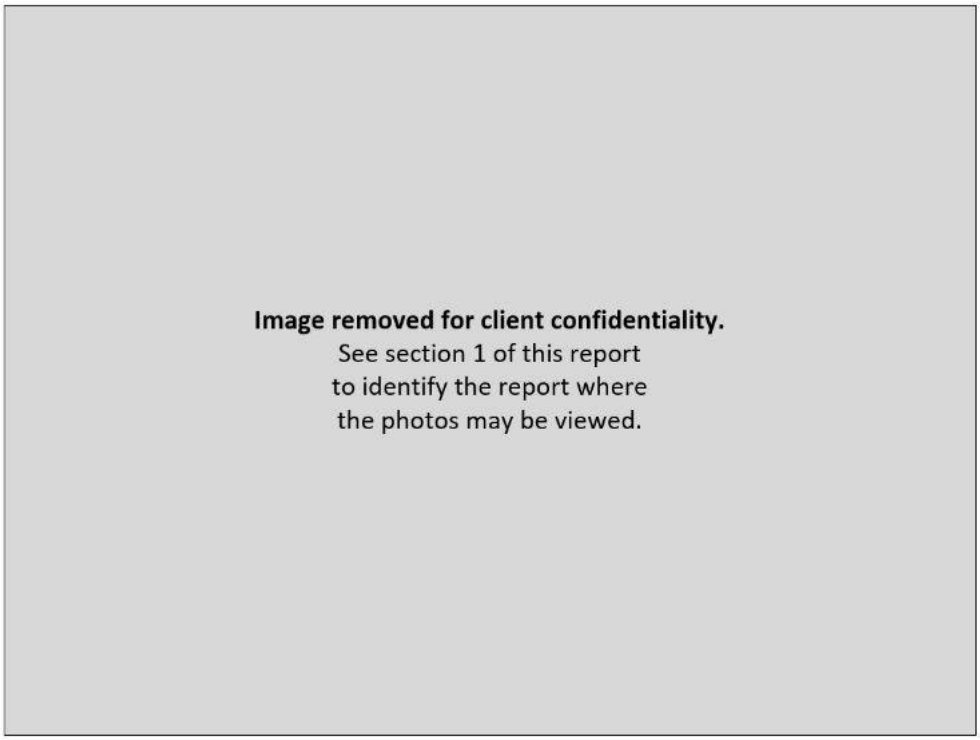

Figure RE04.2: EUT test setup, front view

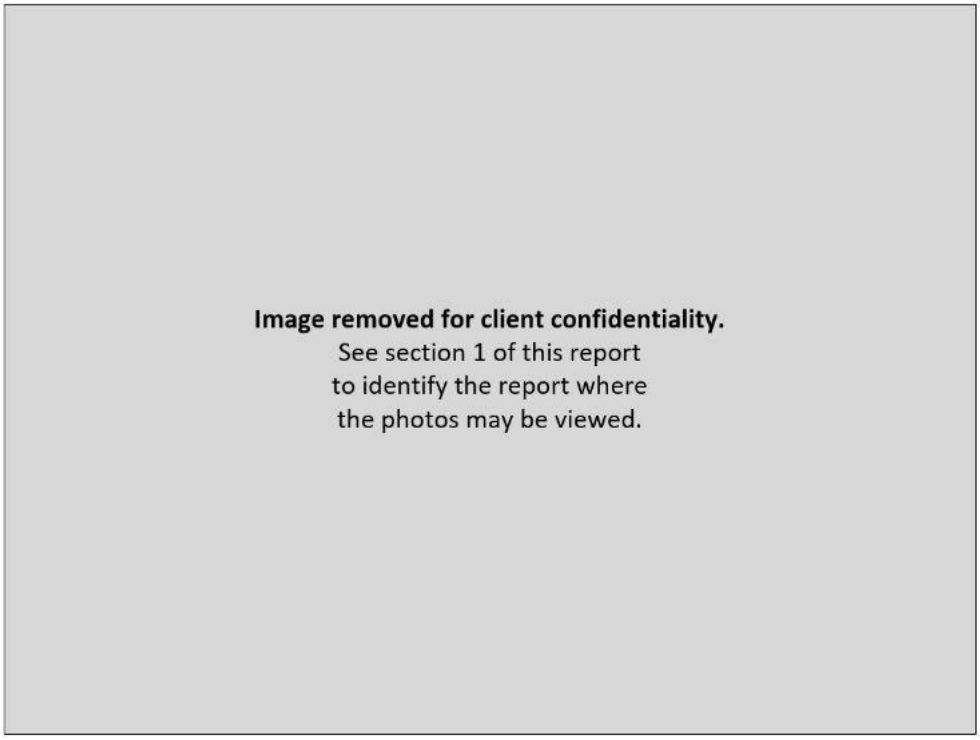

Figure RE04.3: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Radiated Emission Test RE05
Project GCL0303

Test Date(s)	28 Feb 2023
Test Personnel	David Kerr
Product Model	A04432
Serial Number tested	3437936612
Operating Mode	M9 WiFi Tx
Arrangement	A1 PwrA
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.4, ICES-003, CISPR 32, EN 55032, (as noted in Section 6 of the report).
Frequency Range:	30 MHz to 1000 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**02 Mar 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
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
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE05.1: Test Equipment Used

Software Used

Keysight PXE software A.32.06
RE Signal Maximization Tool v2021Feb25.xlsx
RE 30M to 1G Data Analysis Template V3 2022May10.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.

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

designation of the X, Y, and Z orientations of the test sample are sample dependent, so these are reported by use of photographs.

The table shows the 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 Composite FCC/CISPR Class B Limit at 3m.

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.000	40.0	27.5	12.5	4	1456	HORZ
53.010	40.0	16.9	23.1	-119	2794	VERT
205.380	40.0	20.1	19.9	-189	3886	VERT
540.720	46.0	27.6	18.4	-151	1205	VERT
801.570	46.0	30.4	15.6	-62	2958	VERT
948.960	46.0	32.7	13.3	48	3340	HORZ

Table RE05.2: Emission summary

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

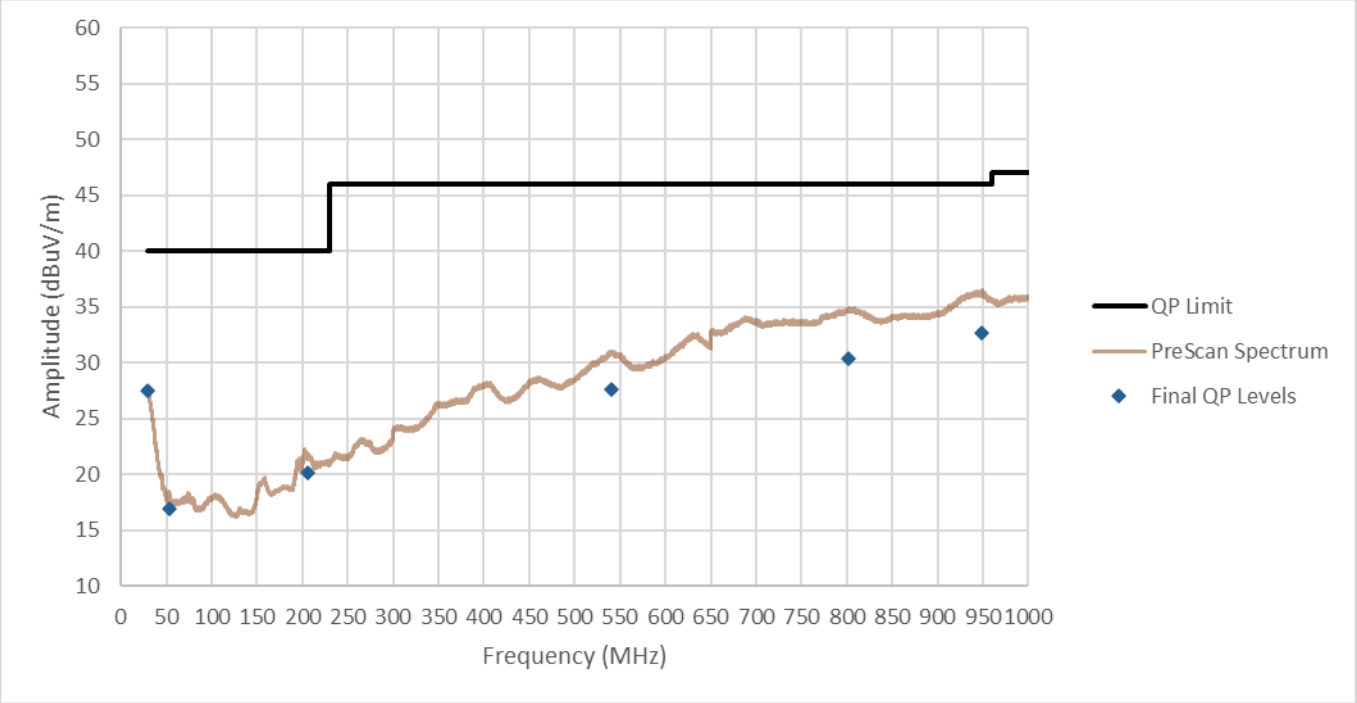

Figure RE05.1: Spectral data

Setup Photographs

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

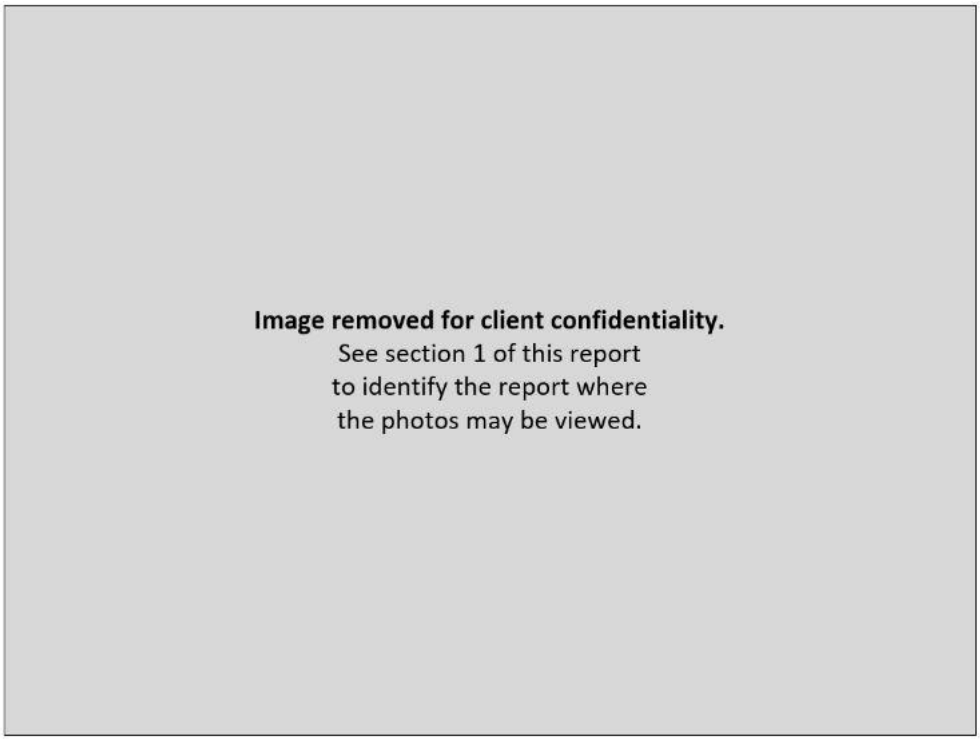

Figure RE05.2: EUT test setup, front view

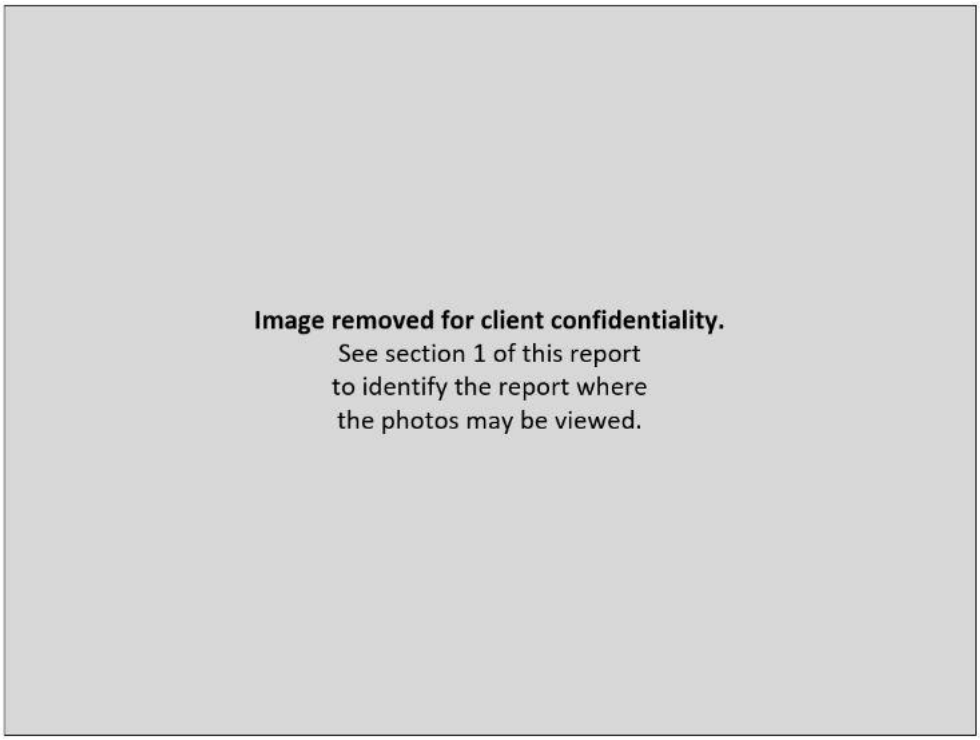

Figure RE05.3: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Radiated Emission Test RE16
Project GCL0303

Test Date(s)	22 Mar 2023
Test Personnel	Jim Solum
Product Model	A04432
Serial Number tested	3437936612
Operating Mode	M16 (Tx off)
Arrangement	A1 (PwrA)
Input Power	5 Vdc
Test Standards:	FCC Part 15.109, EN 55032 (as noted in Section 6 of the report).
Frequency Range:	1000 MHz to 2000 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**23 Mar 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
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
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required

Table RE16.1: Test Equipment Used

Software Used:
Keysight PXE software A.32.06,
RE Signal Maximization Tool v2021Feb25.xlsx,
RE 1G to 2G Data AnalysisV1 2022May10.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.

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

designation of the X, Y, and Z orientations of the test sample are sample dependent, so these are reported by use of photographs.

The table shows the selected final measurement data between 1GHz and 2 GHz. 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 Composite FCC/CISPR Class B Limit at 3m. No emissions were found and a noise floor measurement was made.

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
1970.000	50.0	70.0	31.6	45.1	18.4	24.9	139	1683	VERT

Table RE16.2: Emission summary

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

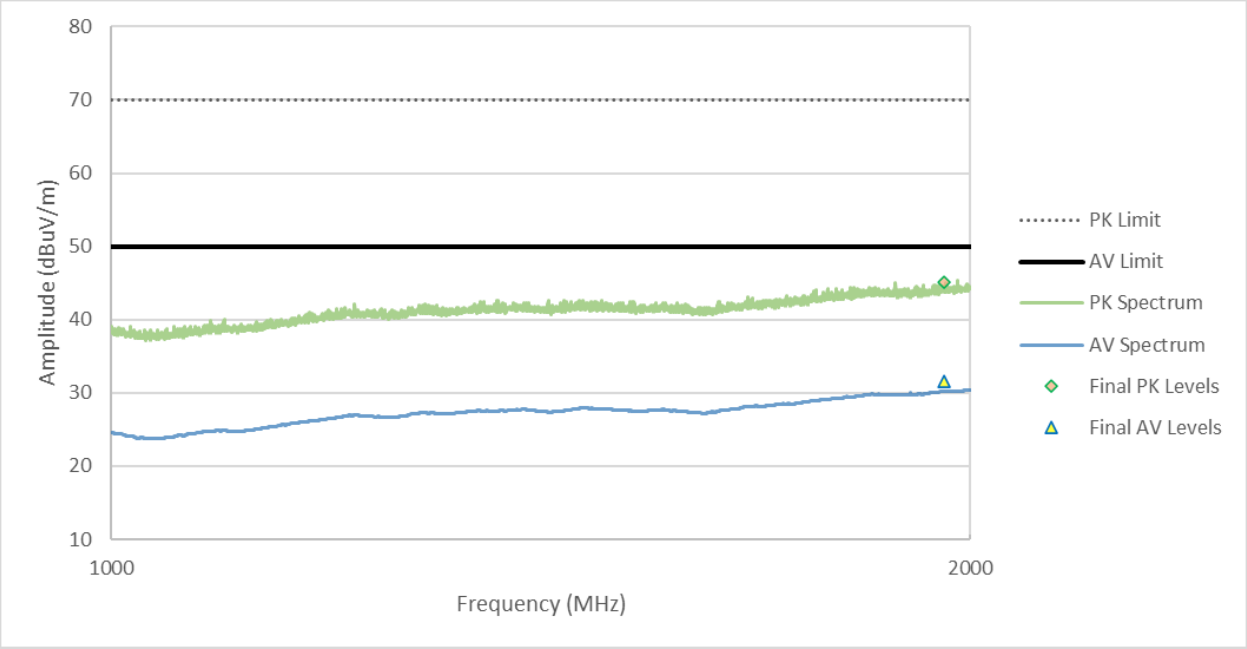

Figure RE16.3: Spectral data

Setup Photographs

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

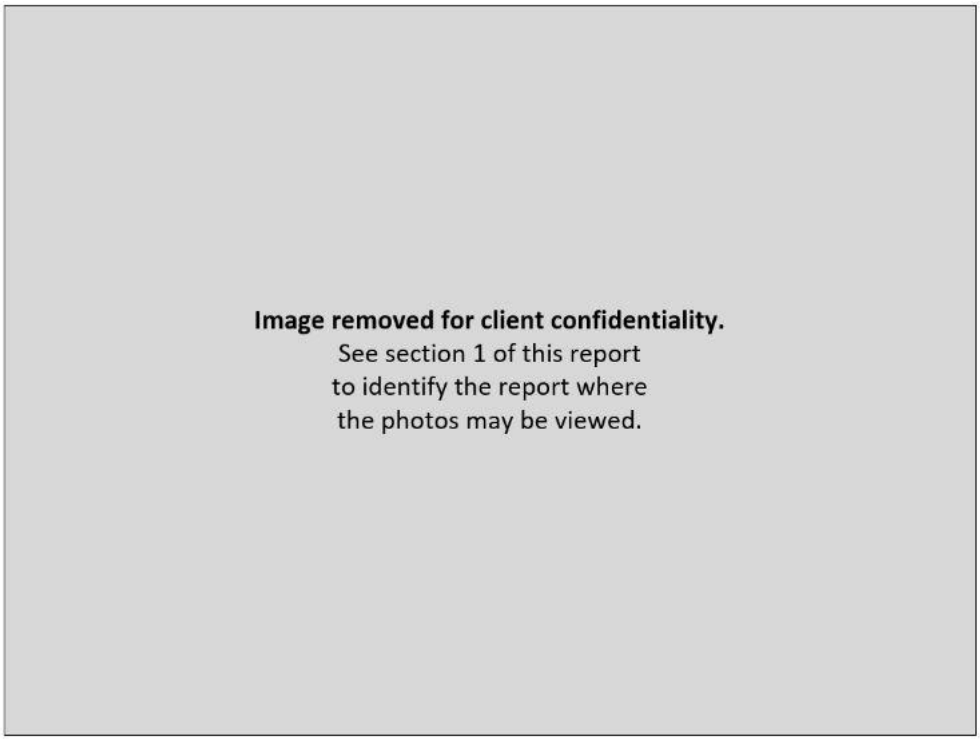

Figure RE16.4: EUT test setup, front view

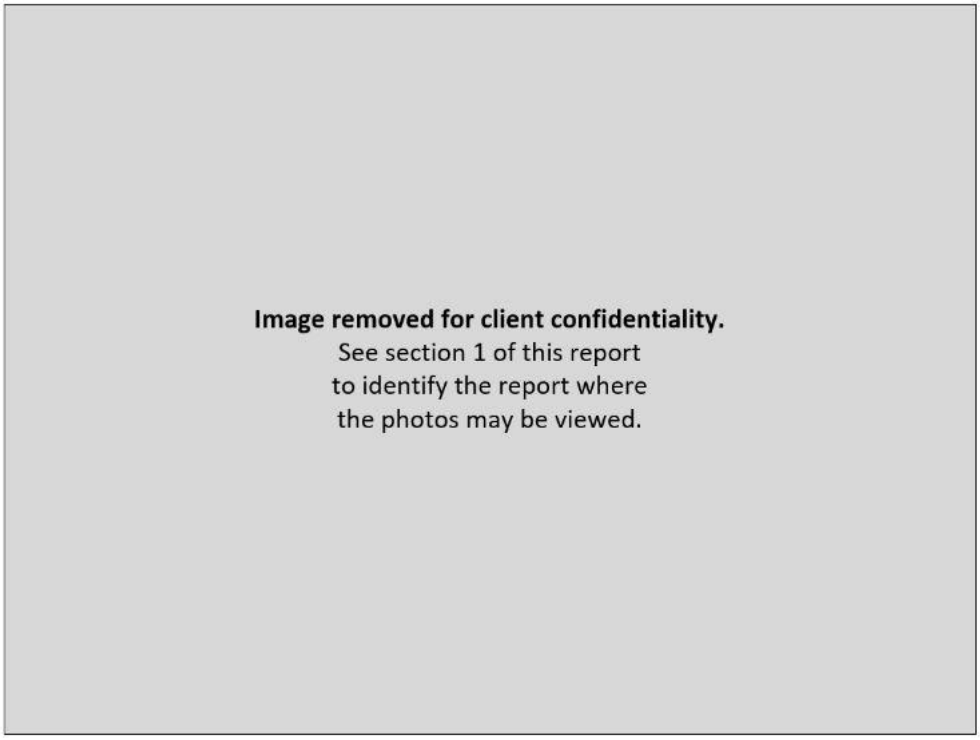

Figure RE16.5: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Radiated Emission Test RE17
Project GCL0303

Test Date(s)	21 Feb 2023
Test Personnel	David Kerr
Product Model	A04432
Serial Number tested	3437936612
Operating Mode	M17 (BT Class Tx)
Arrangement	A1 (PwrA)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.4, ICES-003, CISPR 32, EN 55032, (as noted in Section 6 of the report).
Frequency Range:	30 MHz to 1000 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**02 Mar 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
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
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE17.1: Test Equipment Used

Software Used:]

Keysight PXE software A.32.06
RE Signal Maximization Tool v2021Feb25.xlsx
RE 30M to 1G Data Analysis Template V3 2022May10.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.

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 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 Composite FCC/CISPR Class B Limit at 3m.

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.000	40.0	27.0	13.0	75	1909	VERT
45.000	40.0	18.1	21.9	75	1909	VERT
155.190	40.0	19.5	20.5	75	1909	VERT
405.240	46.0	23.7	22.3	75	1909	VERT
688.380	46.0	29.4	16.6	75	1909	VERT
943.860	46.0	32.2	13.8	75	1909	VERT

Table RE17.2: Emission summary (EDR2)

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.000	40.0	27.9	12.1	75	1909	VERT
155.280	40.0	20.3	19.7	75	1909	VERT
403.350	46.0	25.5	20.5	75	1909	VERT
544.050	46.0	28.1	17.9	75	1909	VERT
796.260	46.0	31.8	14.2	75	1909	VERT
941.460	46.0	34.1	11.9	75	1909	VERT

Table RE17.3: Emission summary (EDR3)

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

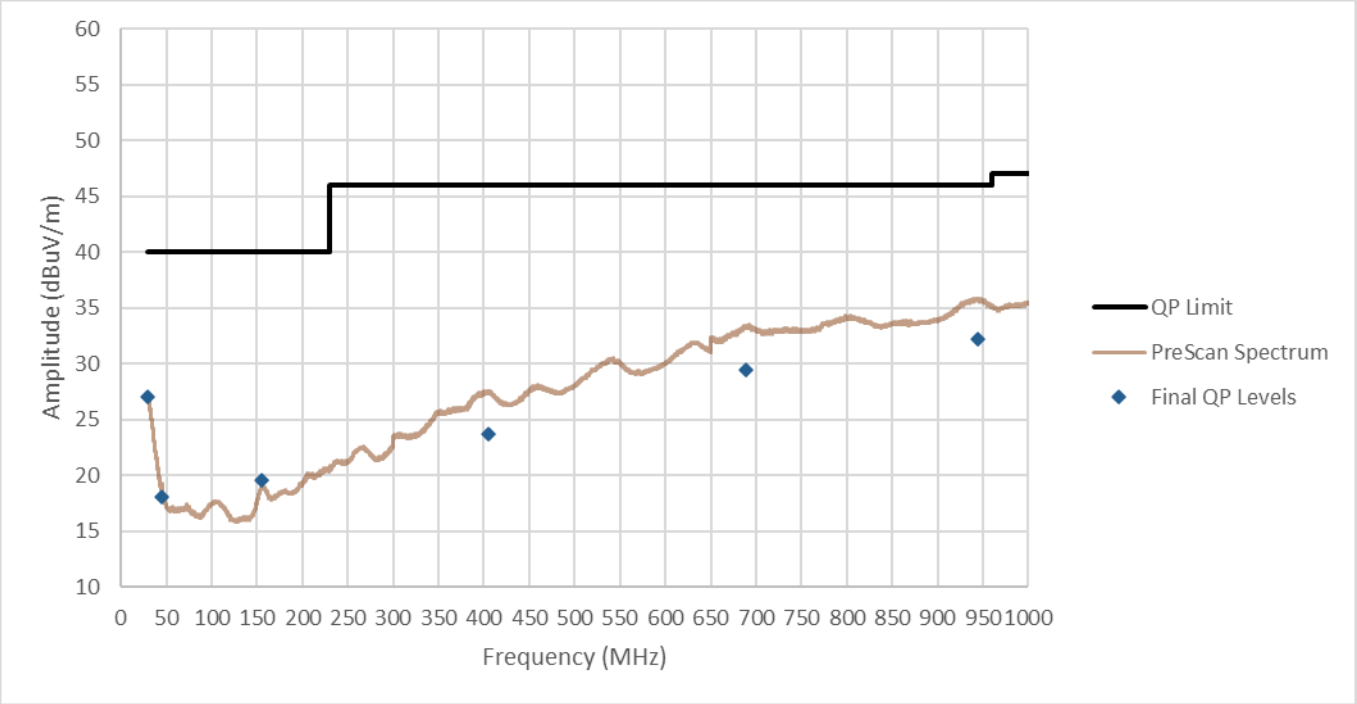

Figure RE17.4: Spectral data (EDR2)

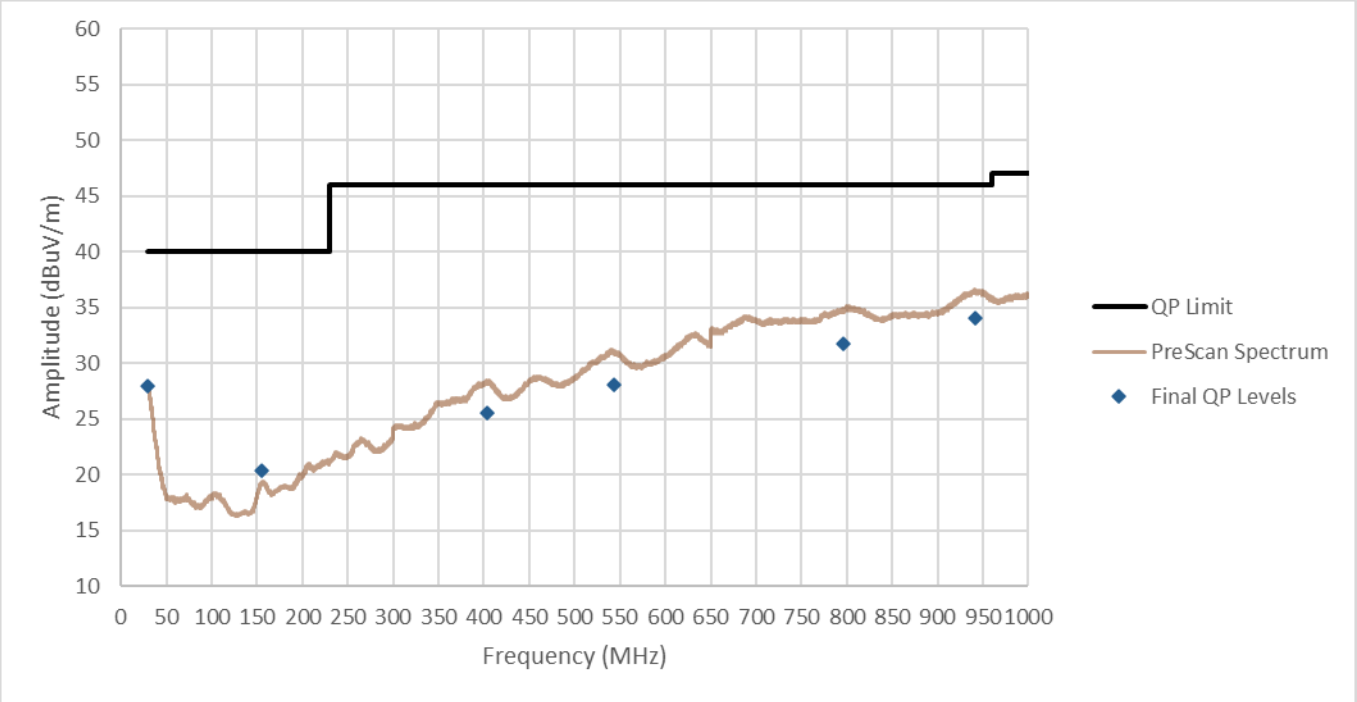

Figure RE17.5: Spectral data (EDR3)

Setup Photographs

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

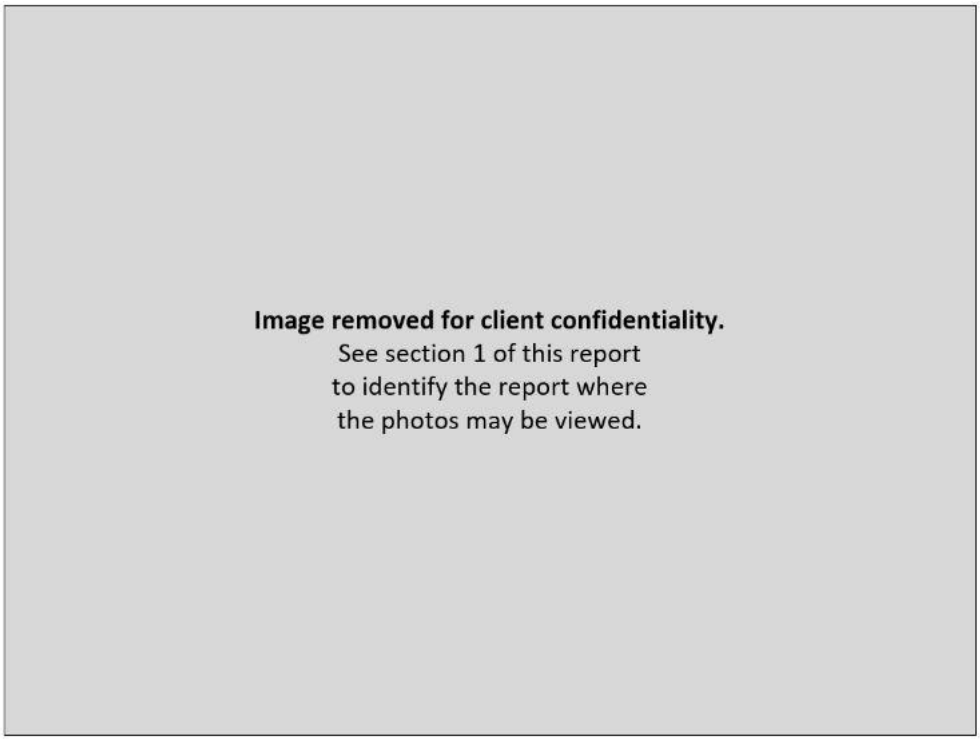

Figure RE17.6: EUT test setup, front view

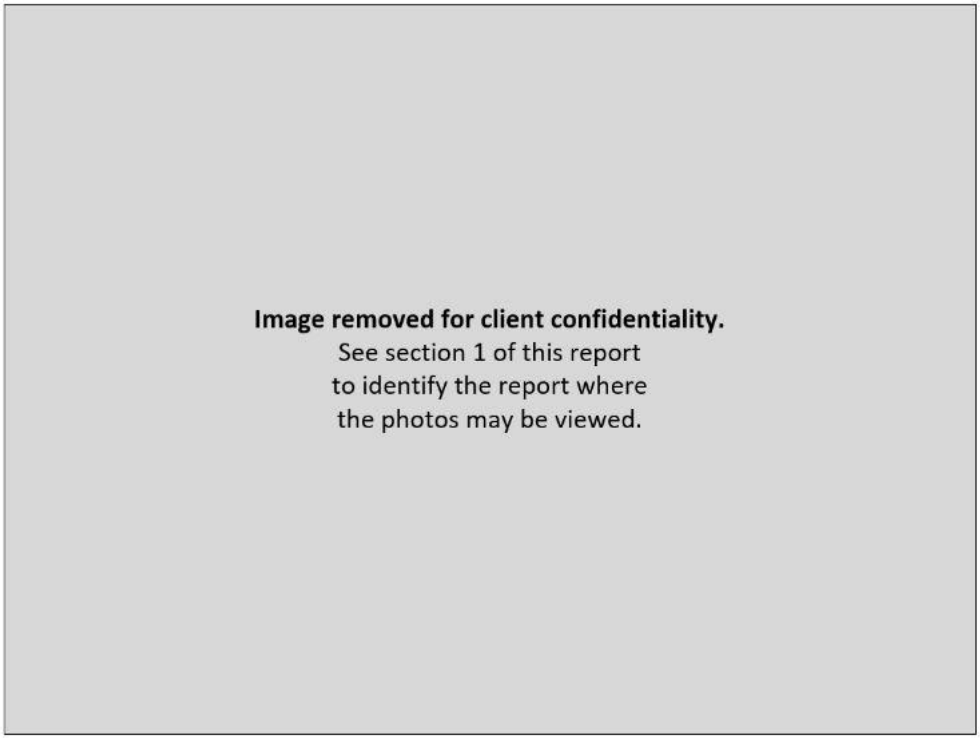

Figure RE17.7: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE02
Project GCL0303

Test Date(s)	20 Feb 2023
Test Personnel	Christian Shepherd assisted by David Kerr
Product Model	A04432
Serial Number tested	3437936612
Operating Mode	M3 (BLE Tx)
Arrangement	A2 (PwrA)
Input Power	120 Vac 60 Hz
Test Standards:	FCC Part 15, ANSI C63.4 (as noted in Section 6 of the report).
Frequency Range:	150 kHz to 30 MHz
Pass/Fail Judgment:	**PASS**

Test record created by: Christian Shepherd
Date of this record: 02 Mar 2023

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
DMM Multimeter	FLUKE	79 III	71740743	18-Apr-2022	15-Apr-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
LISN multiline; 15A to 9kHz	Com-Power	LI-215A	192027	22-Aug-2022	15-Aug-2023

Table CE02.1: Test Equipment Used

Software Used
PXE Receiver firmware version A.32.06

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/CISPR Class B Limit.

Frequency (kHz)	QP Limit (dBuV)	AV Limit (dBuV)	L1 QP (dBuV)	L2 QP (dBuV)	L1 AV (dBuV)	L2 AV (dBuV)	QP Margin (dB)	AV Margin (dB)
150	66.00	56.00	37.01	25.28	15.06	12.91	28.99	40.94
152	65.88	55.88	31.43	25.91	14.96	13.16	34.44	40.92
679	56	46	38.93	33.16	28.5	27.26	17.07	17.50
681	56	46	39.67	34	29.19	28.01	16.33	16.81
1028	56	46	24.07	19.44	15.73	14.93	31.93	30.27
1097	56	46	24.41	19.85	15.64	15.42	31.59	30.36
1163	56	46	24.47	20.97	16.09	16.2	31.53	29.80
1435	56	46	17.72	14.6	11.13	9.46	38.28	34.87
1565	56	46	23.01	17.05	13.8	12.05	32.99	32.20
2438	56	46	21.6	17.07	13.71	12.5	34.40	32.29
2850	56	46	17.59	14.61	10.86	9.63	38.41	35.14
3116	56	46	20.51	15.38	12.25	10.21	35.49	33.75
4247	56	46	18.93	15.86	11.76	11.33	37.07	34.24
4585	56	46	18.74	13.92	11.02	8.72	37.26	34.98
5530	60	50	17.77	15.71	10.84	11.39	42.23	38.61
14789	60	50	15.79	13.77	10.43	9.31	44.21	39.57

Table CE02.2: Emission summary

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

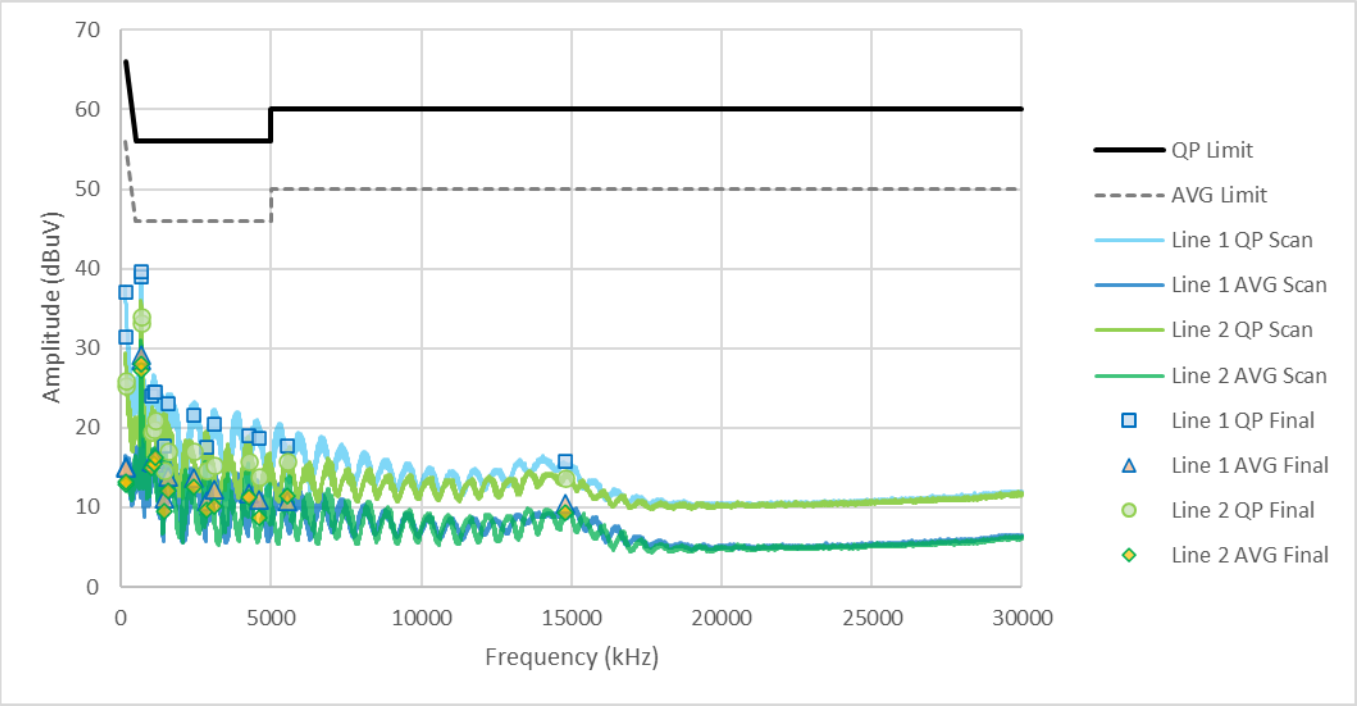

Figure CE02.1: Spectral data

Setup Photographs

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

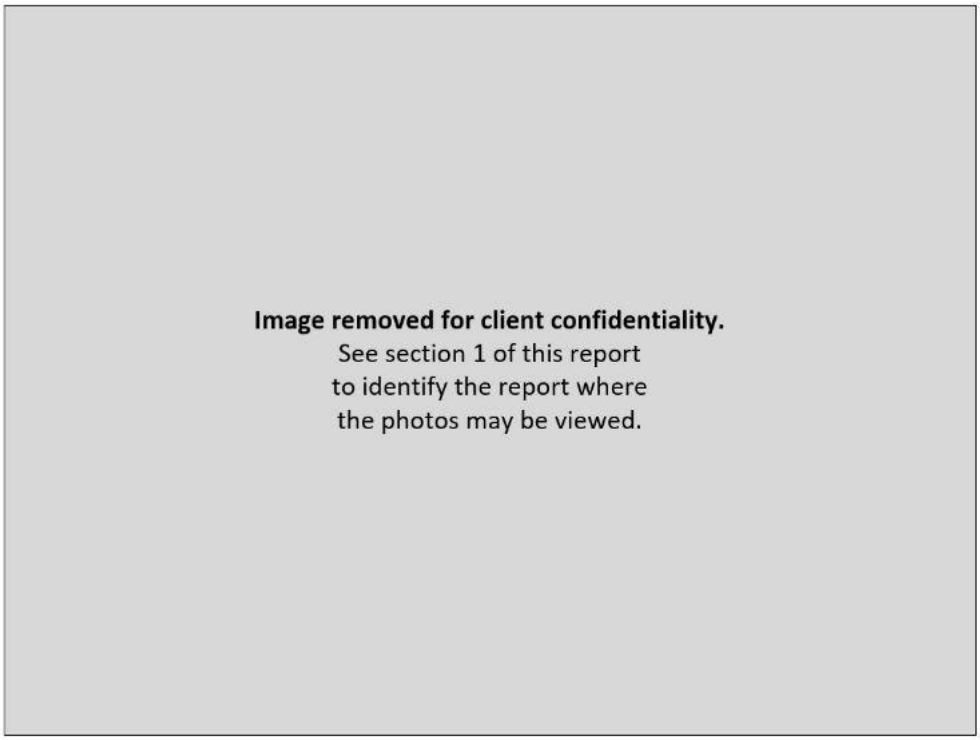

Figure CE02.2: EUT test setup

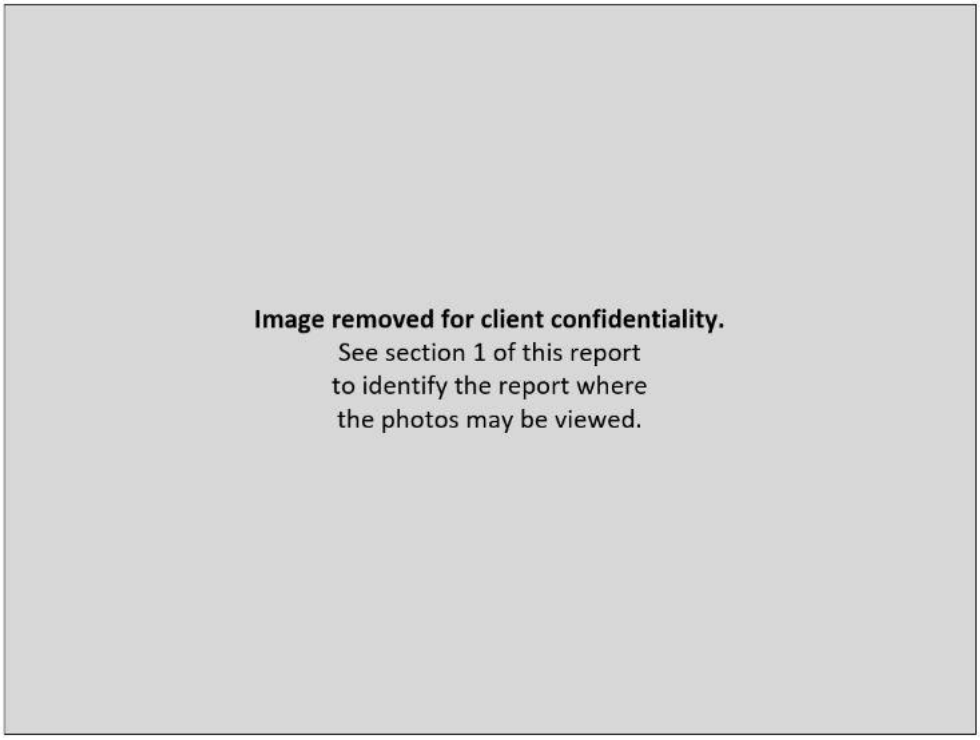

Figure CE02.3: EUT test setup

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.