Test Report 2023-018

Version A
Issued 4 Apr 2023

Project GCL-0304
Product Model A04331
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-04431
IC ID: 1792A-04431

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 772 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 19.67 dBm (0.0927 W) or 14.35 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 31.48 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 0.471 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 3.93 dBm in a band of at least 3 kHz.	PASS	63
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	70
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	87
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	12.0 dB of margin to the Class B limit. Tested 30 MHz to 2 GHz applying combined Class B limits.	PASS	94
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	17.93 dB of margin to the appropriate limit. Tested 150 kHz to 30 MHz applying combined Class B limits.	PASS	112

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 2023-023. 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 and 2 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 channels 1-4 and 8-11 in 802.11g mode, channels 1-4 and 9-11 in 802.11n mode, and channel 11 in 802.11b 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 10 in 802.11n 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: Software update. Below are the following changes:
SW Version 12.60
Date applied: 2/17/2023
Reason for this modification: Update to newest software version.
This change improved EUT functionality but did not affect EMC performance. No previous testing was affected.

Modification 4
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	A04331
Serial Numbers Tested	3437296994, 3437296908

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 GCL0304

Test Date(s)	20 Mar 2021
Test Personnel	David Arnett
Product Model	A04331
Serial Number tested	3437296908
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.

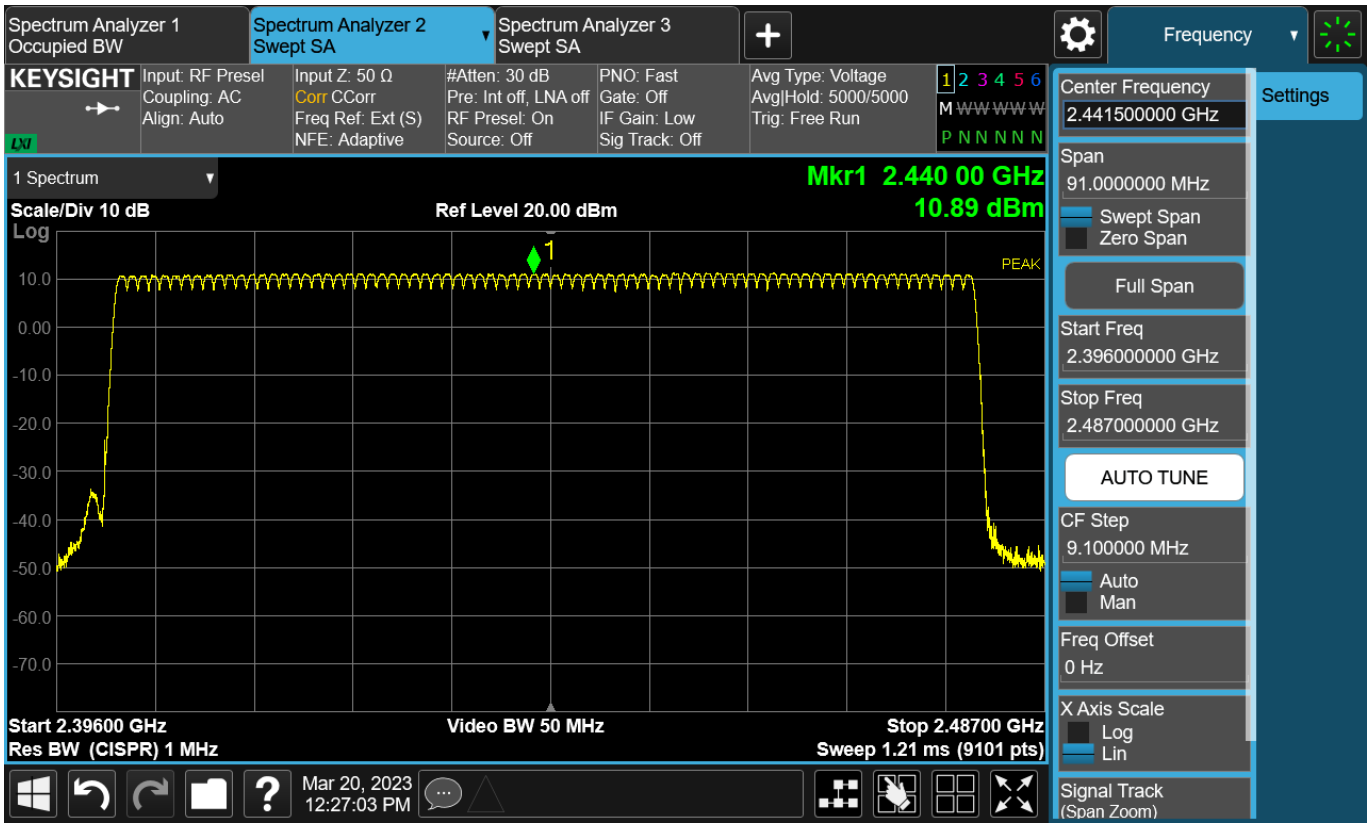


Figure TR42.1: Spectral data, Bluetooth Basic Rate transmissions, showing channels used

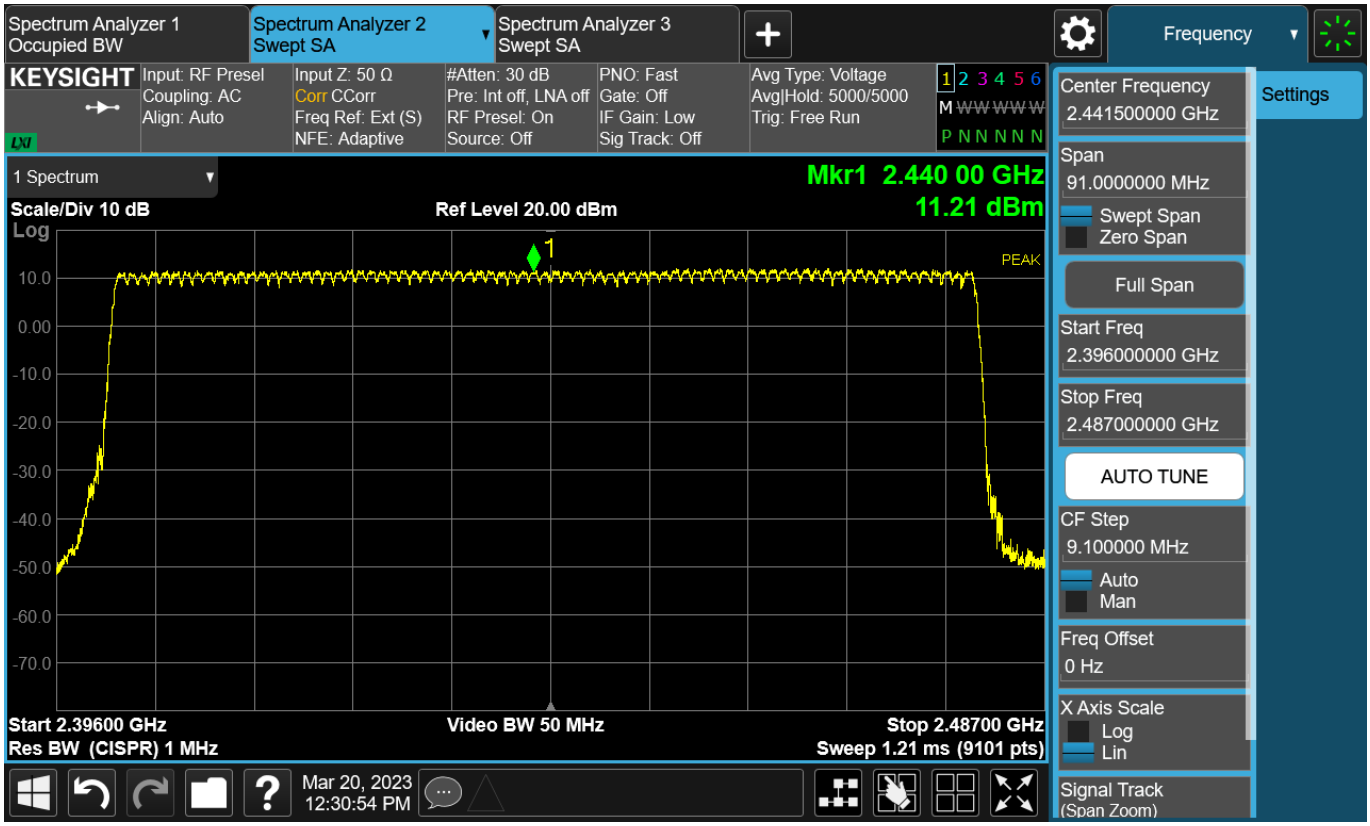


Figure TR42.2: Spectral data, Bluetooth EDR2 transmissions, showing channels used

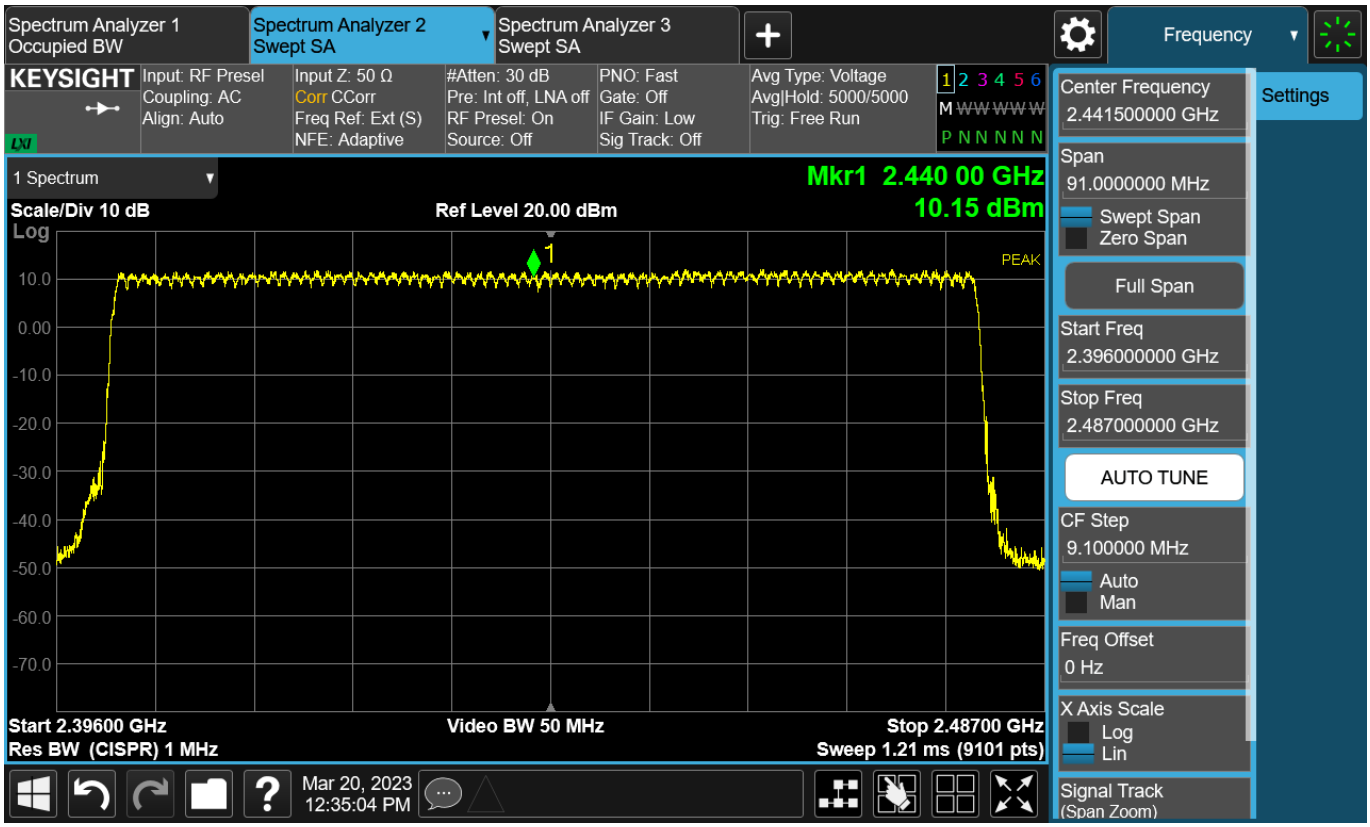


Figure TR42.3: Spectral data, Bluetooth EDR3 transmissions, showing channels used

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	**0.997**	**0.97**	**0.976**
BT EDR2	**1.299**	**1.302**	**1.284**
BT EDR3	**1.306**	**1.309**	**1.302**

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

Figure TR42.1: Spectral data for Bluetooth EDR3 modulation at 2440 MHz

Test Data: Channel Occupancy

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

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

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

Freq (MHz)	2409	2428	2470
BTBR	**0.220**	**0.224**	**0.220**
BT EDR2	**0.223**	**0.220**	**0.220**
BT EDR3	**0.230**	**0.221**	**0.223**

Table TR42.3: Summary of Channel Occupancy results

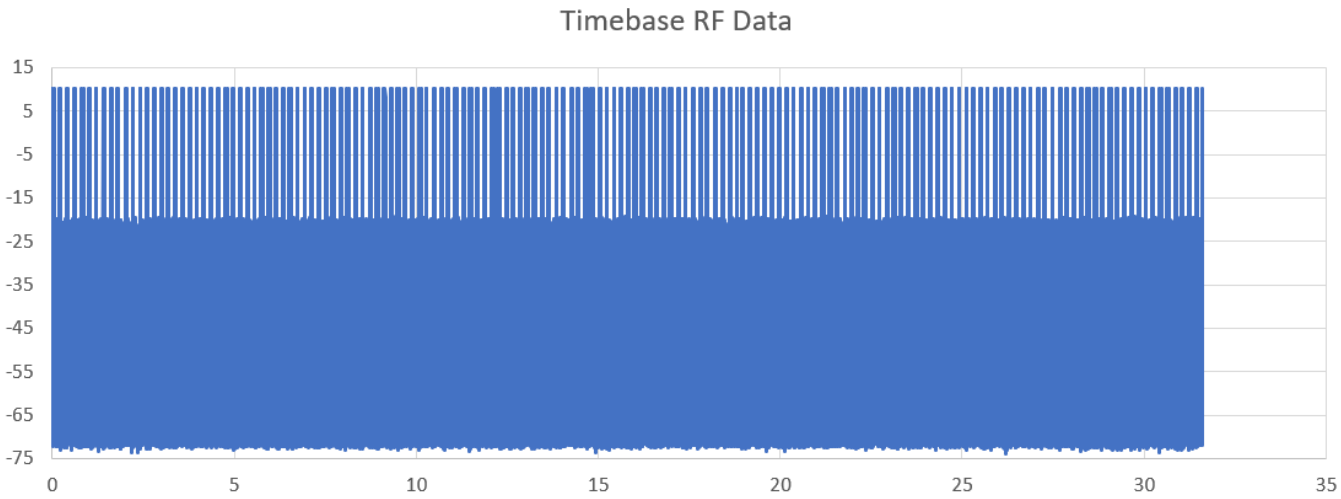


Figure TR42.2: Channel Occupancy time data for Bluetooth EDR3 modulation at 2409 MHz

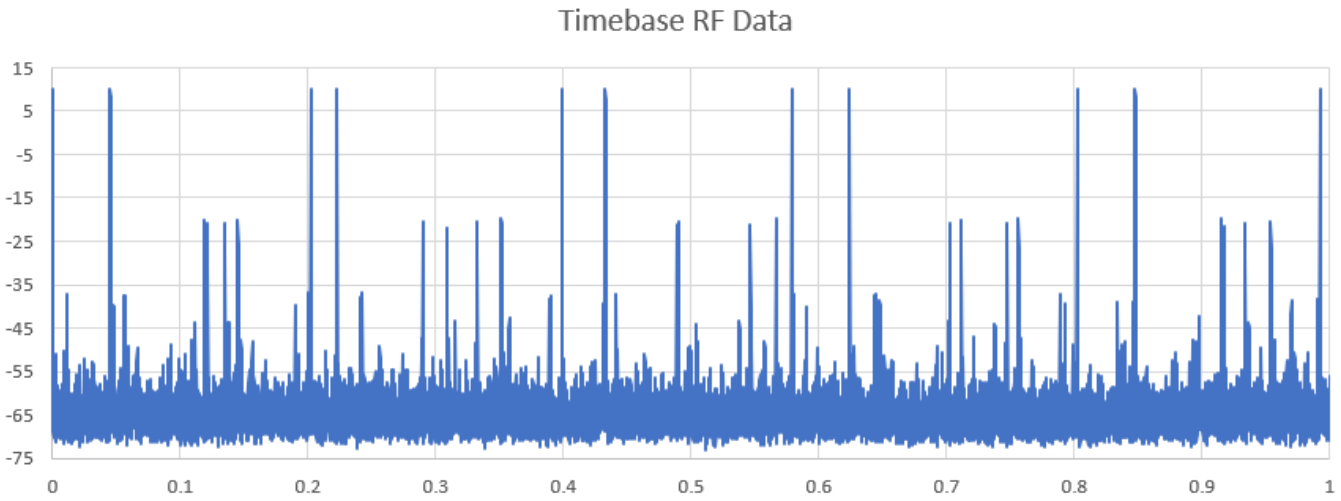


Figure TR42.3: First second of the Channel Occupancy time data for improved clarity

This line is the end of the test record.

Test Record
Transmitter DTS Bandwidth Tests
Test IDs TR14 – TR16
Project GCL-0304

Test Date(s)	21 Feb 2023
Test Personnel	Majid Farah
Product Model	A04331
Serial Number tested	3437296908
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.

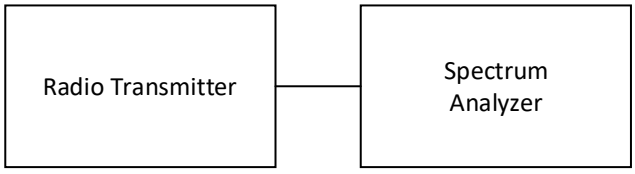


Figure TR14a.1: Test arrangement

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	**772**	**798**	**830**
BLE	2 Mb	**1443**	**1447**	**1783**
ANT	Fixed	**793.2**	**972.8**	**974.3**

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-0304

Test Date(s)	24 Feb and 25 Mar 2023
Test Personnel	Majid Farah, David Arnett
Product Model	A04331
Serial Number tested	3437296908
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: **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 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.

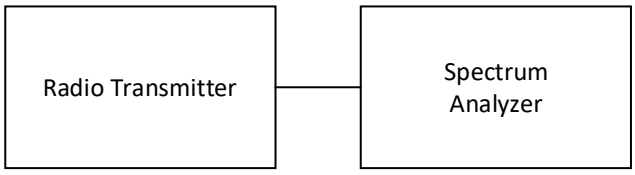


Figure TR17a.1: Test arrangement

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	**10.060**	**10.082**	**10.062**	**10.041**	**10.038**
B	2	**10.072**				**10.046**
B	5.5	**8.259**				**8.775**
B	11	**9.074**	**9.076**	**9.066**	**9.074**	**9.061**
G	6	**16.550**	**16.563**	**16.565**	**16.598**	**16.526**
G	9	**16.578**				**16.542**
G	12	**16.561**				**16.573**
G	18	**16.547**				**16.530**
G	24	**16.546**				**16.499**
G	36	**16.518**				**16.540**
G	48	**16.521**				**16.555**
G	54	**16.536**	**16.562**	**16.565**	**16.558**	**16.554**
N	0	**17.642**	**17.650**	**17.659**	**17.639**	**17.638**
N	1	**17.674**				**17.697**
N	2	**17.664**				**17.683**
N	3	**17.705**				**17.678**
N	4	**17.687**				**17.715**
N	5	**17.658**				**17.698**
N	6	**17.681**				**17.727**
N	7	**17.663**	**17.679**	**17.679**	**17.680**	**17.699**

Table TR17a.2: Summary of measured bandwidths

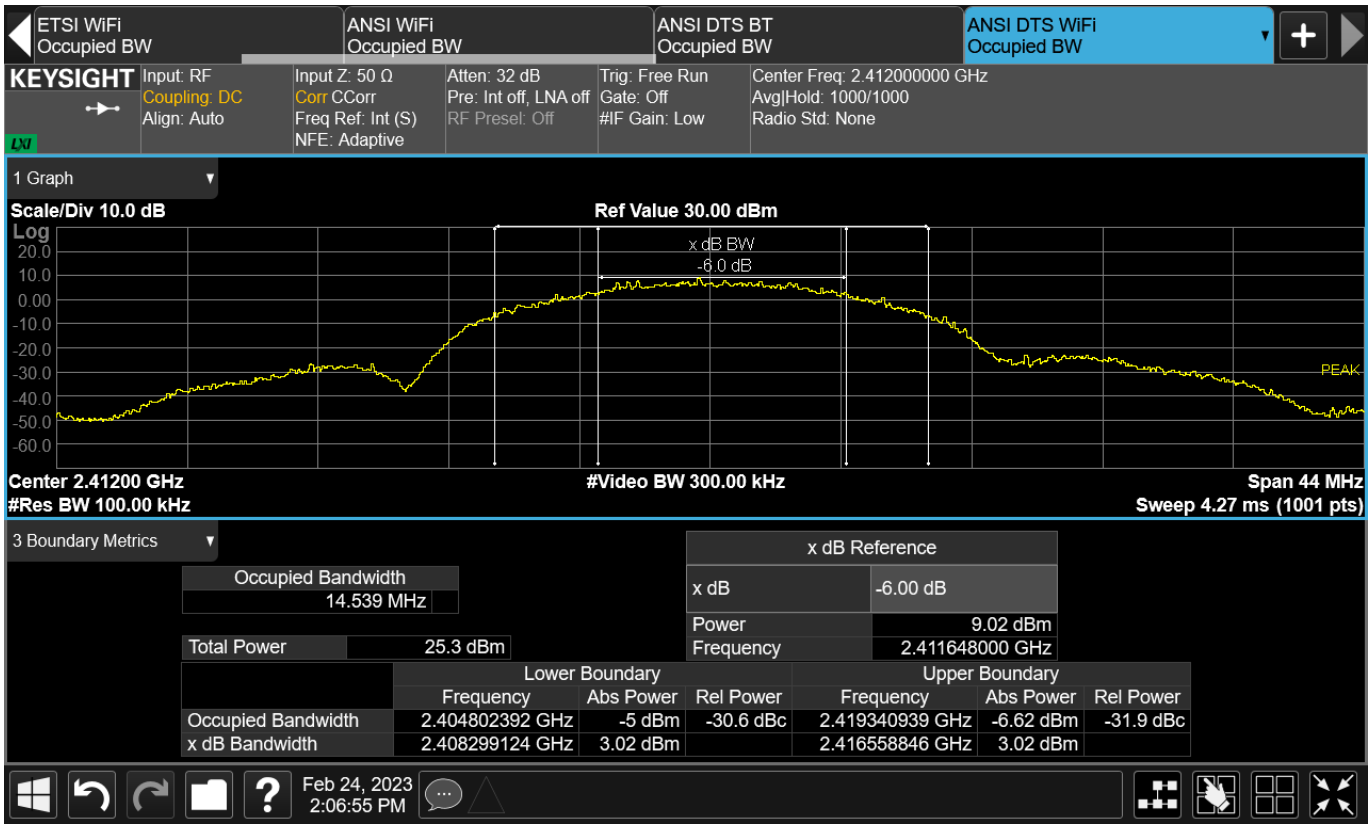


Figure TR17a.2: Channel 1, B mode, 5.5 Mbps modulation

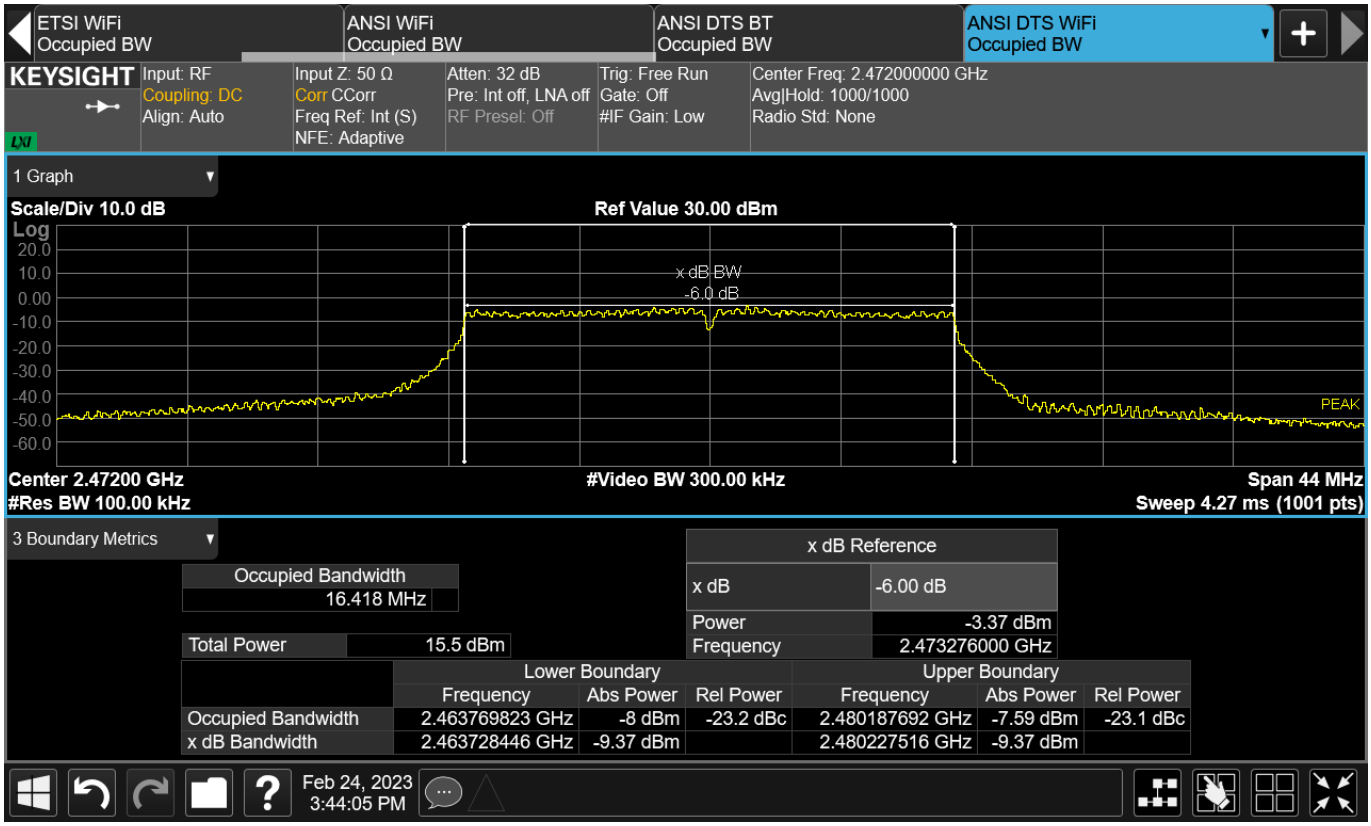


Figure TR17a.3: Channel 13, G mode, 24 Mbps modulation

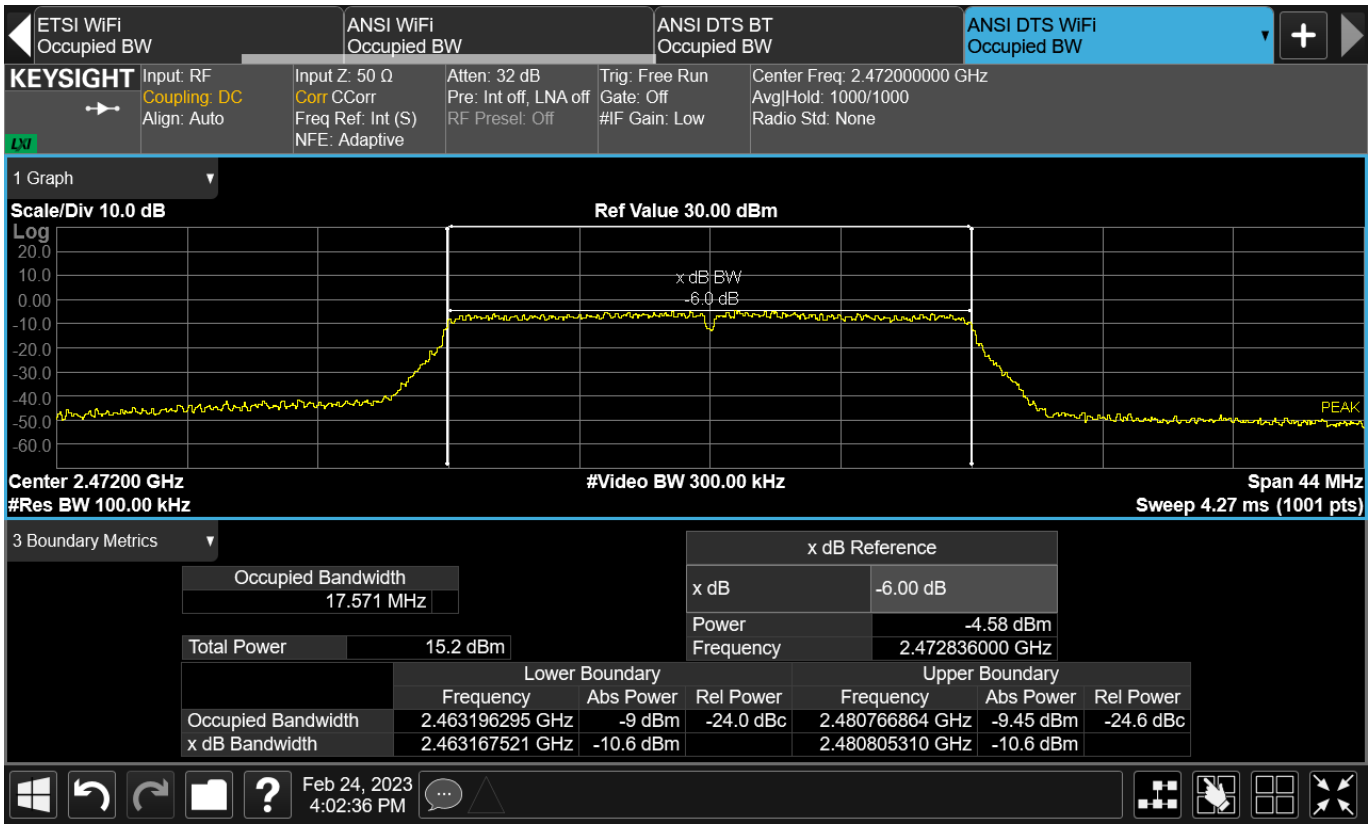


Figure TR17a.4: Channel 13, N mode, MCS0 modulation

This line is the end of the test record.

Test Record
Transmitter Power
Test IDs TR1a
Project GCL-0304

Test Date(s)	14 Feb and 24 Feb 2023
Test Personnel	David Arnett, Majid Farah
Product Model	A04331
Serial Number tested	3437296908
Operating Mode	M9 (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	-3.43 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:	**24 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.

Most of the data presented here was taken on 14 Feb, when almost all of the relevant power settings were finalized. An additional set of data was taken on 24 Feb in response to the changes made for N mode channel 10. In the data tables below, a green highlight indicates data from the 24 Feb test date. All other data was taken on the earlier date. Yellow highlight indicates the value for a particular mode with the highest value, which are all from the early 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	17.83	17.60	17.57	17.52	17.58	17.61	17.67	17.69	17.67	17.67	15.44	9.79	8.89
B	2	17.26	NT	NT	NT	NT	17.54	NT	NT	NT	NT	15.47	9.85	8.95
B	5.5	17.38	NT	NT	NT	NT	17.74	NT	NT	NT	NT	15.63	9.88	8.97
B	11	17.40	17.33	17.38	17.39	17.54	17.77	17.66	17.71	17.75	17.81	15.98	9.82	8.87
G	6	11.43	14.32	14.42	15.64	18.22	18.77	18.78	16.64	16.70	14.76	14.83	10.36	7.01
G	9	10.72	NT	NT	NT	NT	19.17	NT	NT	NT	NT	13.62	9.06	7.27
G	12	10.93	NT	NT	NT	NT	19.67	NT	NT	NT	NT	13.67	9.59	7.99
G	18	10.93	NT	NT	NT	NT	19.31	NT	NT	NT	NT	12.92	9.89	8.20
G	24	11.00	NT	NT	NT	NT	18.10	NT	NT	NT	NT	13.79	9.63	7.99
G	36	10.93	NT	NT	NT	NT	15.23	NT	NT	NT	NT	13.01	9.79	8.12
G	48	11.03	NT	NT	NT	NT	13.65	NT	NT	NT	NT	13.16	9.85	8.17
G	54	11.15	12.66	12.68	13.56	13.56	13.56	13.59	13.57	13.59	13.13	13.10	9.83	8.17
N	MCS0	11.63	13.61	13.57	15.89	19.03	18.95	18.98	18.85	16.80	14.11	12.59	10.88	8.09
N	MCS1	11.45	NT	NT	NT	NT	19.25	NT	NT	NT	NT	13.02	11.23	8.83
N	MCS2	11.61	13.64	13.59	16.34	19.65	19.45	19.40	19.39	17.02	14.45	12.66	10.93	9.54
N	MCS3	11.34	NT	NT	NT	NT	19.27	NT	NT	NT	NT	12.89	11.27	8.83
N	MCS4	12.20	NT	NT	NT	NT	15.71	NT	NT	NT	NT	12.71	10.75	9.32
N	MCS5	12.00	NT	NT	NT	NT	14.16	NT	NT	NT	NT	12.82	10.80	9.36
N	MCS6	12.03	NT	NT	NT	NT	14.13	NT	NT	NT	NT	12.81	10.83	9.34
N	MCS7	11.02	11.17	11.19	12.15	12.16	12.20	12.22	12.25	12.28	12.54	12.26	10.73	9.30

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	14.35	14.13	14.11	14.06	14.12	14.15	14.21	14.22	14.21	14.21	11.96	6.31	5.41
B	2	13.79	NT	NT	NT	NT	14.08	NT	NT	NT	NT	12.00	6.38	5.47
B	5.5	13.92	NT	NT	NT	NT	14.28	NT	NT	NT	NT	12.14	6.39	5.50
B	11	13.92	13.85	13.89	13.90	13.96	14.19	14.18	14.23	14.26	14.22	12.49	6.24	5.35
G	6	7.88	10.79	10.84	12.10	14.70	15.18	15.19	13.11	13.17	11.21	11.32	6.83	3.49
G	9	7.19	NT	NT	NT	NT	15.58	NT	NT	NT	NT	10.08	5.50	3.74
G	12	7.43	NT	NT	NT	NT	16.09	NT	NT	NT	NT	10.18	6.08	4.48
G	18	7.44	NT	NT	NT	NT	15.82	NT	NT	NT	NT	9.42	6.40	4.70
G	24	7.44	NT	NT	NT	NT	14.50	NT	NT	NT	NT	10.25	6.07	4.44
G	36	7.37	NT	NT	NT	NT	11.71	NT	NT	NT	NT	9.49	6.26	4.59
G	48	7.50	NT	NT	NT	NT	10.12	NT	NT	NT	NT	9.64	6.31	4.63
G	54	7.55	9.08	9.10	10.02	10.01	10.01	10.04	10.03	10.03	9.59	9.56	6.29	4.62
N	MCS0	8.08	10.08	10.02	12.32	15.51	15.43	15.36	15.33	13.27	10.57	9.04	7.33	4.56
N	MCS1	7.91	NT	NT	NT	NT	15.75	NT	NT	NT	NT	9.49	7.72	5.32
N	MCS2	8.11	10.11	10.08	12.84	16.15	15.93	15.91	15.88	13.51	10.95	9.14	7.42	6.03
N	MCS3	7.79	NT	NT	NT	NT	15.77	NT	NT	NT	NT	9.35	7.72	5.29
N	MCS4	8.60	NT	NT	NT	NT	12.18	NT	NT	NT	NT	9.19	7.21	5.79
N	MCS5	8.45	NT	NT	NT	NT	10.61	NT	NT	NT	NT	9.25	7.26	5.80
N	MCS6	8.44	NT	NT	NT	NT	10.59	NT	NT	NT	NT	9.27	7.28	5.80
N	MCS7	7.48	7.63	7.64	8.61	8.61	8.65	8.68	8.71	8.72	8.99	8.70	7.20	5.76

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	**60.00**	**57.10**	**56.77**	**56.16**	**56.82**	**57.10**	**58.02**	**58.21**	**57.96**	**58.00**	**34.64**	**9.42**	**7.65**
B	2	**52.66**	**NT**	**NT**	**NT**	**NT**	**56.31**	**NT**	**NT**	**NT**	**NT**	**34.88**	**9.57**	**7.77**
B	5.5	**54.30**	**NT**	**NT**	**NT**	**NT**	**58.93**	**NT**	**NT**	**NT**	**NT**	**36.10**	**9.62**	**7.81**
B	11	**54.28**	**53.42**	**53.94**	**54.09**	**54.78**	**57.59**	**57.62**	**58.34**	**58.71**	**57.99**	**39.11**	**9.25**	**7.57**
G	6	**13.52**	**26.39**	**26.63**	**35.73**	**65.04**	**72.61**	**73.04**	**45.16**	**45.78**	**29.14**	**29.86**	**10.57**	**4.92**
G	9	**11.52**	**NT**	**NT**	**NT**	**NT**	**79.45**	**NT**	**NT**	**NT**	**NT**	**22.51**	**7.84**	**5.22**
G	12	**12.18**	**NT**	**NT**	**NT**	**NT**	**89.34**	**NT**	**NT**	**NT**	**NT**	**23.00**	**8.94**	**6.18**
G	18	**12.20**	**NT**	**NT**	**NT**	**NT**	**84.06**	**NT**	**NT**	**NT**	**NT**	**19.28**	**9.61**	**6.49**
G	24	**12.23**	**NT**	**NT**	**NT**	**NT**	**61.92**	**NT**	**NT**	**NT**	**NT**	**23.36**	**8.94**	**6.12**
G	36	**11.99**	**NT**	**NT**	**NT**	**NT**	**32.70**	**NT**	**NT**	**NT**	**NT**	**19.59**	**9.32**	**6.34**
G	48	**12.40**	**NT**	**NT**	**NT**	**NT**	**22.66**	**NT**	**NT**	**NT**	**NT**	**20.26**	**9.42**	**6.40**
G	54	**12.53**	**17.82**	**17.81**	**22.14**	**22.05**	**22.08**	**22.17**	**22.17**	**22.17**	**20.06**	**19.89**	**9.37**	**6.38**
N	MCS0	**14.17**	**22.42**	**22.14**	**37.46**	**78.29**	**76.89**	**75.66**	**75.13**	**46.78**	**25.07**	**17.62**	**11.92**	**6.29**
N	MCS1	**13.57**	**NT**	**NT**	**NT**	**NT**	**82.69**	**NT**	**NT**	**NT**	**NT**	**19.58**	**13.02**	**7.50**
N	MCS2	**14.23**	**22.52**	**22.42**	**42.34**	**90.83**	**86.36**	**85.85**	**85.43**	**49.52**	**27.37**	**18.07**	**12.16**	**8.84**
N	MCS3	**13.24**	**NT**	**NT**	**NT**	**NT**	**83.16**	**NT**	**NT**	**NT**	**NT**	**18.97**	**12.99**	**7.45**
N	MCS4	**15.89**	**NT**	**NT**	**NT**	**NT**	**36.43**	**NT**	**NT**	**NT**	**NT**	**18.27**	**11.61**	**8.36**
N	MCS5	**15.41**	**NT**	**NT**	**NT**	**NT**	**25.35**	**NT**	**NT**	**NT**	**NT**	**18.54**	**11.72**	**8.38**
N	MCS6	**15.35**	**NT**	**NT**	**NT**	**NT**	**25.25**	**NT**	**NT**	**NT**	**NT**	**18.61**	**11.79**	**8.37**
N	MCS7	**12.32**	**12.74**	**12.80**	**16.00**	**15.99**	**16.17**	**16.26**	**16.36**	**16.42**	**17.47**	**16.31**	**11.55**	**8.30**

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	17.83	30	0.0606	14.35	20
g	19.67	30	0.0927	16.09	20
n	19.65	30	0.0923	16.15	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.

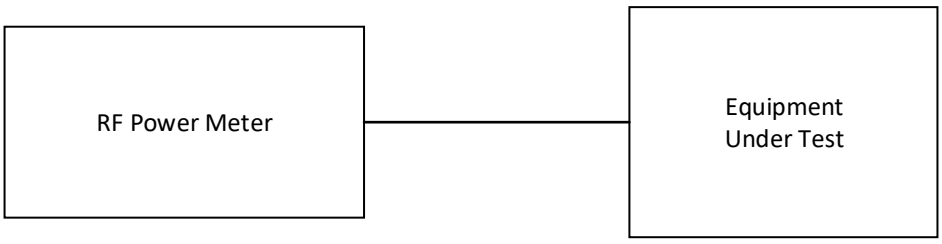


Figure TR1a.1: Test equipment setup

This line is the end of the test record.

Test Record
Transmitter Power
Test IDs TR1b
Project GCL-0304

Test Date(s)	15 Feb 2023
Test Personnel	Majid Farah
Product Model	A04331
Serial Number tested	3437296908
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	-3.43 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
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	**10.98**	**11.01**	**10.98**	**11.13**	**11.21**	**11.29**	**11.00**	**10.96**	**12.01**
Bluetooth	EDR2	**10.69**	**10.73**	**10.70**	**10.89**	**10.98**	**11.23**	**10.93**	**10.92**	**10.92**
Bluetooth	EDR3	**10.29**	**10.29**	**10.29**	**10.40**	**10.41**	**10.78**	**10.48**	**10.45**	**10.42**
BT Low Energy	1 Mbps	**-0.27**	**NT**	**3.38**	**3.38**	**3.55**	**3.81**	**0.60**	**NT**	**0.61**
BT Low Energy	2 Mbps	**NT**	**NT**	**3.20**	**3.39**	**3.72**	**3.66**	**0.62**	**NT**	**NT**
ANT	----	**0.12**	**0.13**	**3.31**	**3.50**	**3.61**	**3.73**	**3.79**	**0.57**	**0.57**

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

Frequency	(MHz)	2402	2403	2404	2420	2440	2460	2478	2479	2480
Bluetooth	Basic	**7.36**	**7.39**	**7.37**	**7.51**	**7.57**	**7.70**	**7.46**	**7.41**	**8.45**
Bluetooth	EDR2	**6.65**	**6.68**	**6.67**	**6.86**	**6.94**	**7.16**	**6.88**	**6.87**	**6.86**
Bluetooth	EDR3	**6.24**	**6.23**	**6.24**	**6.34**	**6.37**	**6.74**	**6.44**	**6.42**	**6.39**
BT Low Energy	1 Mbps	**-3.72**	**NT**	**-0.11**	**-0.10**	**0.06**	**0.32**	**-2.86**	**NT**	**-2.86**
BT Low Energy	2 Mbps	**NT**	**NT**	**-0.28**	**-0.10**	**0.24**	**0.17**	**-2.84**	**NT**	**NT**
ANT	----	**-3.33**	**-3.32**	**-0.17**	**0.02**	**0.13**	**0.25**	**0.29**	**-2.88**	**-2.89**

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

Frequency	(MHz)	2402	2403	2404	2420	2440	2460	2478	2479	2480
Bluetooth	Basic	**9.32**	**9.39**	**9.34**	**9.66**	**9.79**	**10.09**	**9.53**	**9.43**	**12.00**
Bluetooth	EDR2	**7.93**	**7.98**	**7.95**	**8.30**	**8.46**	**8.91**	**8.36**	**8.33**	**8.31**
Bluetooth	EDR3	**7.20**	**7.19**	**7.19**	**7.38**	**7.43**	**8.06**	**7.54**	**7.50**	**7.46**
BT Low Energy	1 Mbps	**0.93**	**NT**	**2.15**	**2.15**	**2.23**	**2.37**	**1.14**	**NT**	**1.14**
BT Low Energy	2 Mbps	**NT**	**NT**	**2.07**	**2.15**	**2.33**	**2.29**	**1.15**	**NT**	**NT**
ANT	----	**1.02**	**1.03**	**2.12**	**2.21**	**2.27**	**2.33**	**2.35**	**1.13**	**1.13**

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	12.01	21	0.0159	8.45	20
BLE	3.81	21	0.0024	0.32	20
ANT	3.79	21	0.0024	0.29	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.

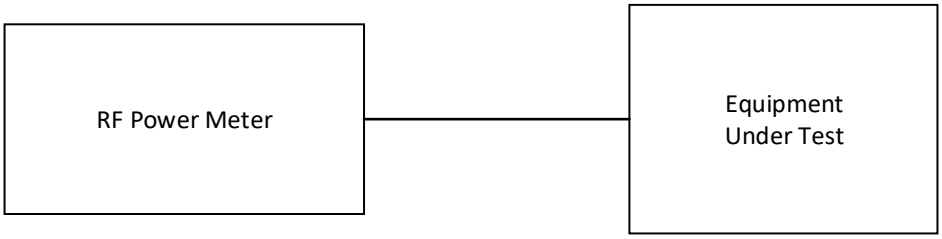


Figure TR1b.1: Test equipment setup

This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test IDs TR22, TR23 and TR24
Project GCL-0304

Test Date(s)	13 Mar 2023
Test Personnel	Majid Farah
Product Model	A04331
Serial Number tested	3437296908
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:	**27 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.

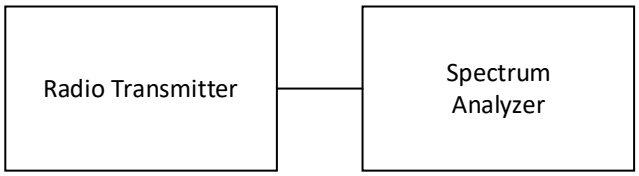


Figure TR22.1: Test setup

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	**46.72**	**NT**	**60.64**	**NT**	**61.49**
BLE 1 Mbps	**31.48**	**NT**	**52.22**	**NT**	**49.87**
BLE 2 Mbps	**NT**	**45.40**	**51.56**	**48.11**	**NT**
ANT	**48.08**	**NT**	**51.81**	**NT**	**49.66**

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.

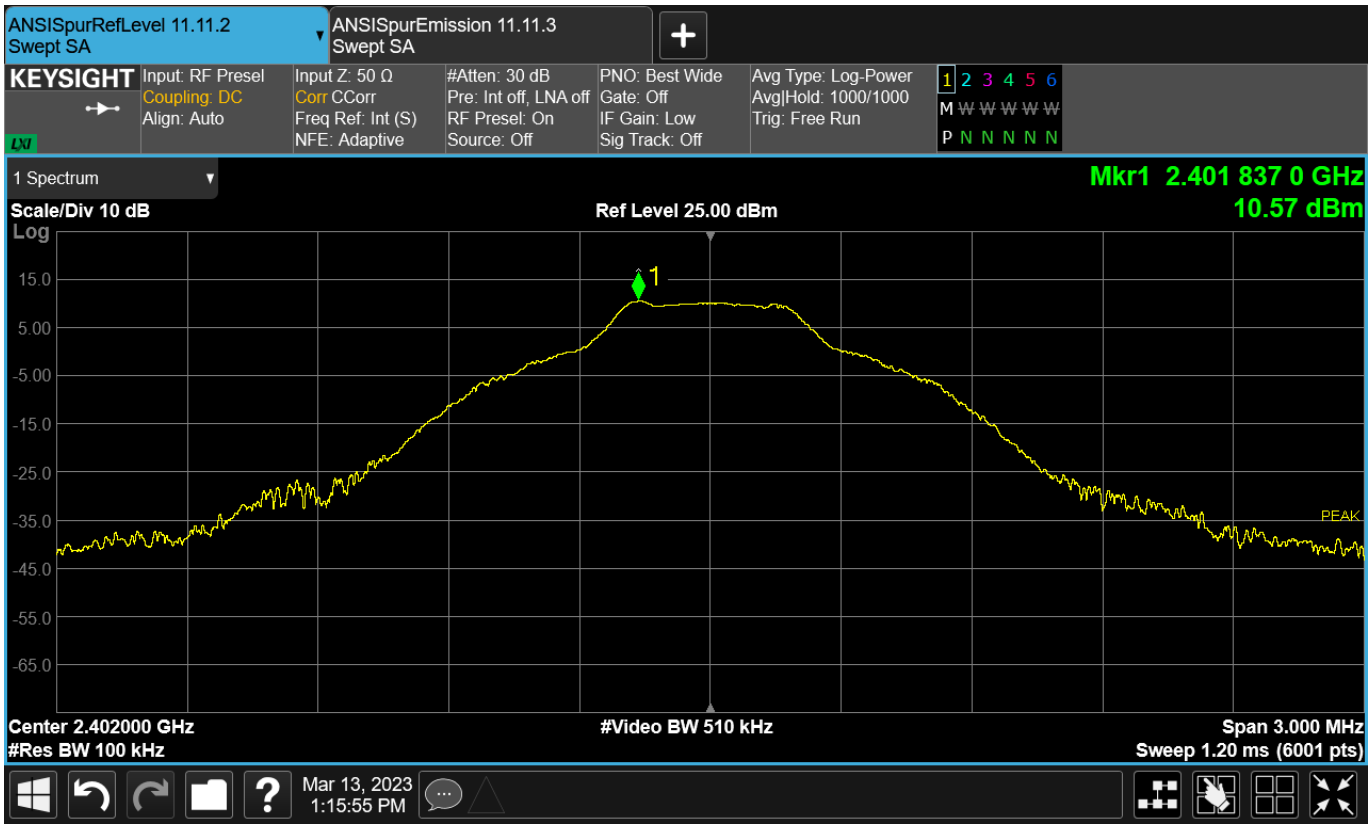


Figure TR22.2: Reference level measurement for Bluetooth BR at 2402 MHz

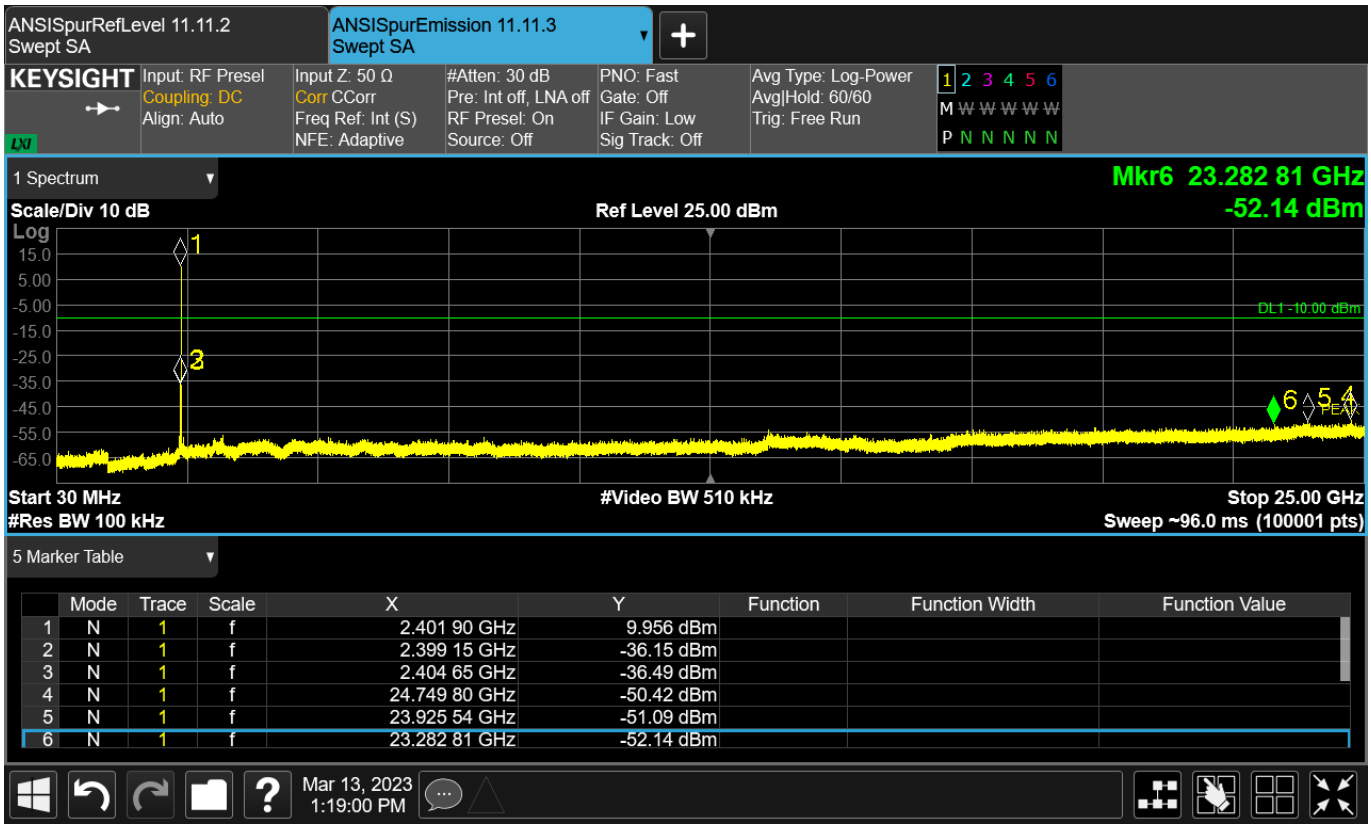


Figure TR22.3: Spectral data for Bluetooth BR at 2402 MHz

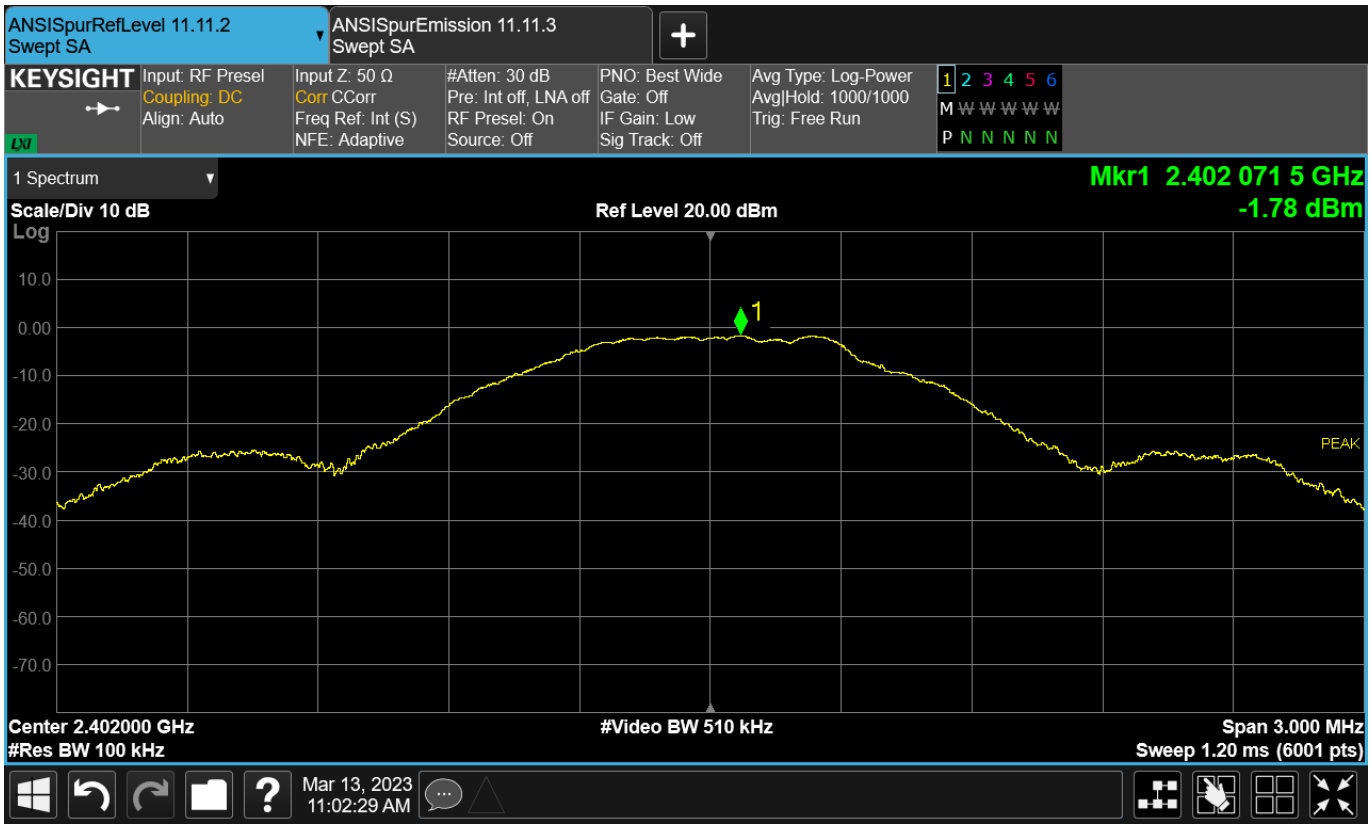


Figure TR22.4: Reference level measurement for Bluetooth BLE 1 Mbps at 2402 MHz

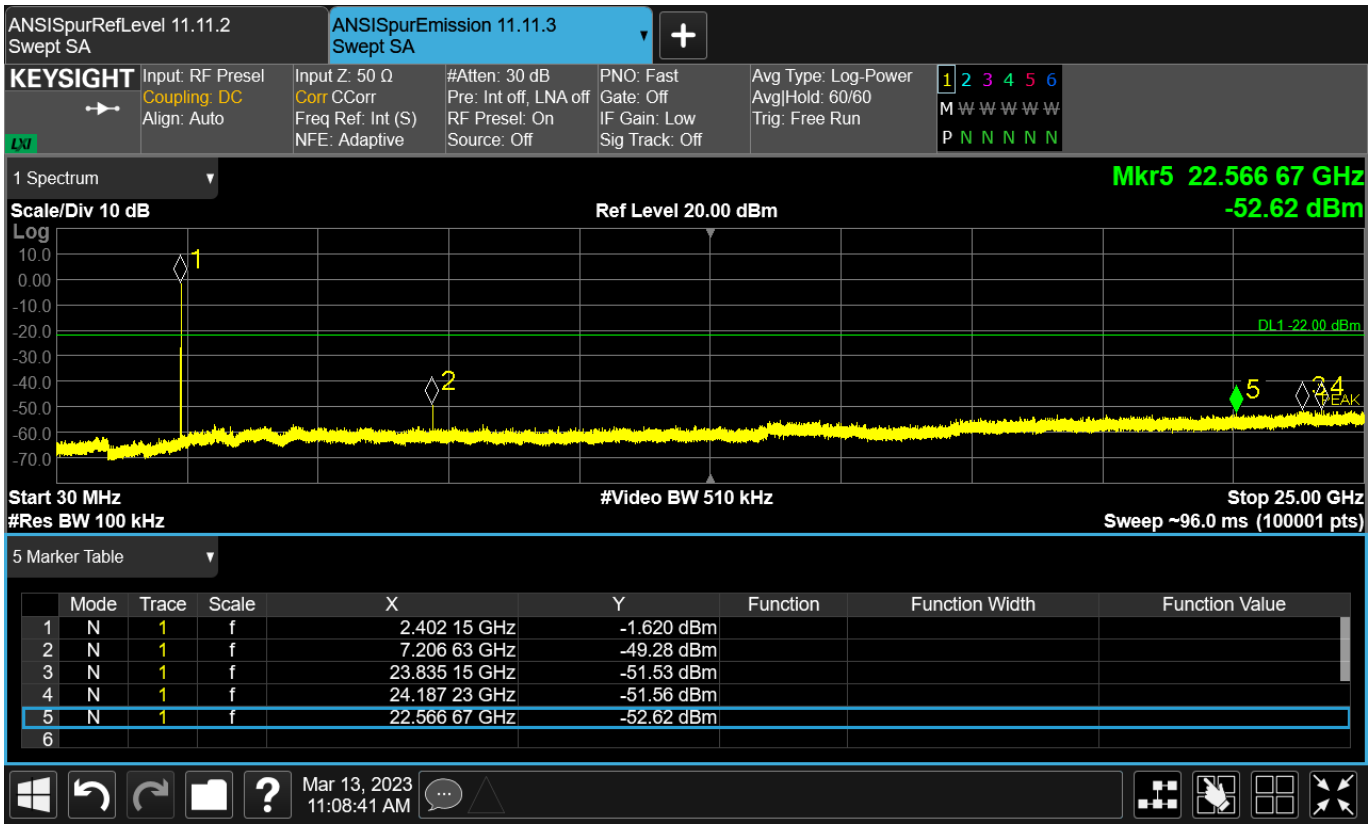


Figure TR22.5 Spectral data for Bluetooth BLE 1 Mbps at 2402 MHz

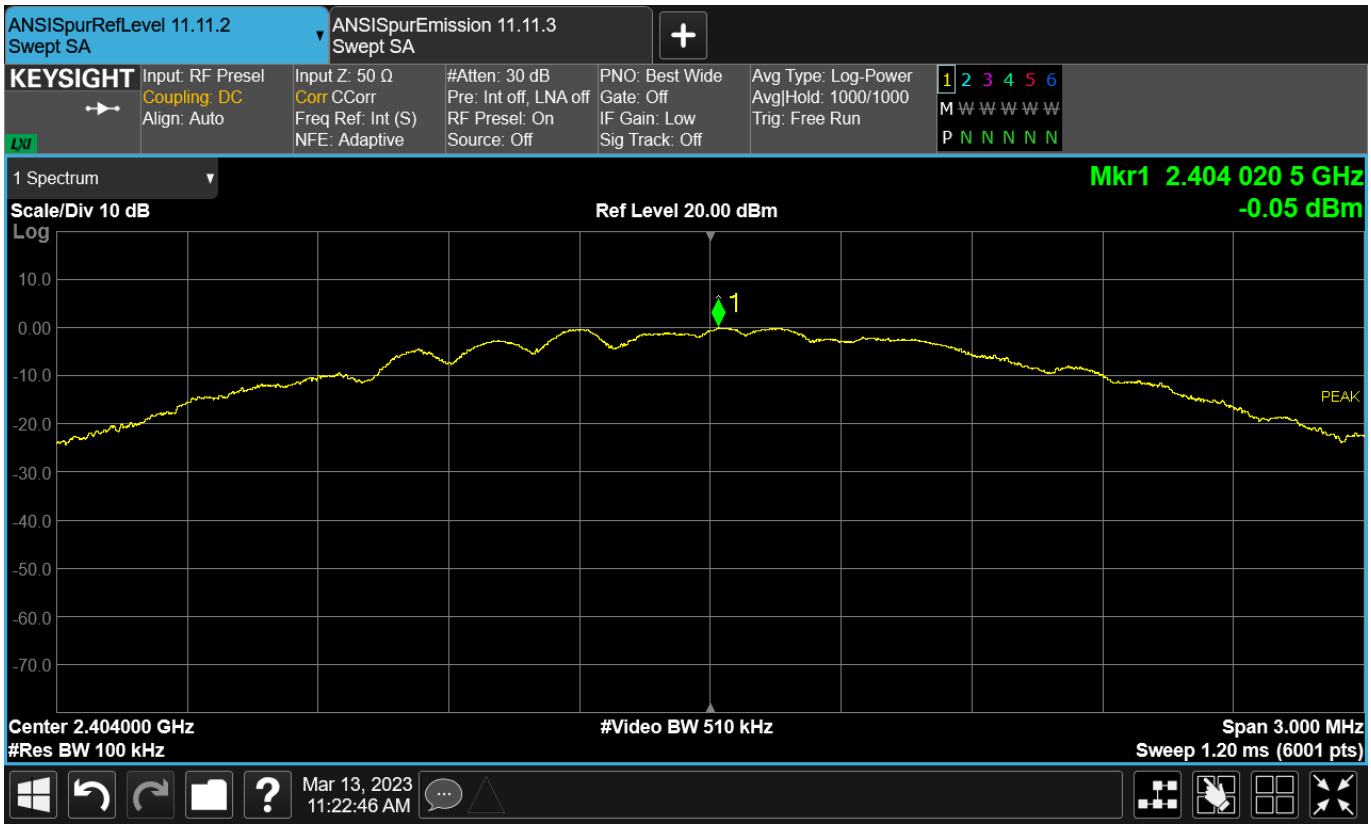
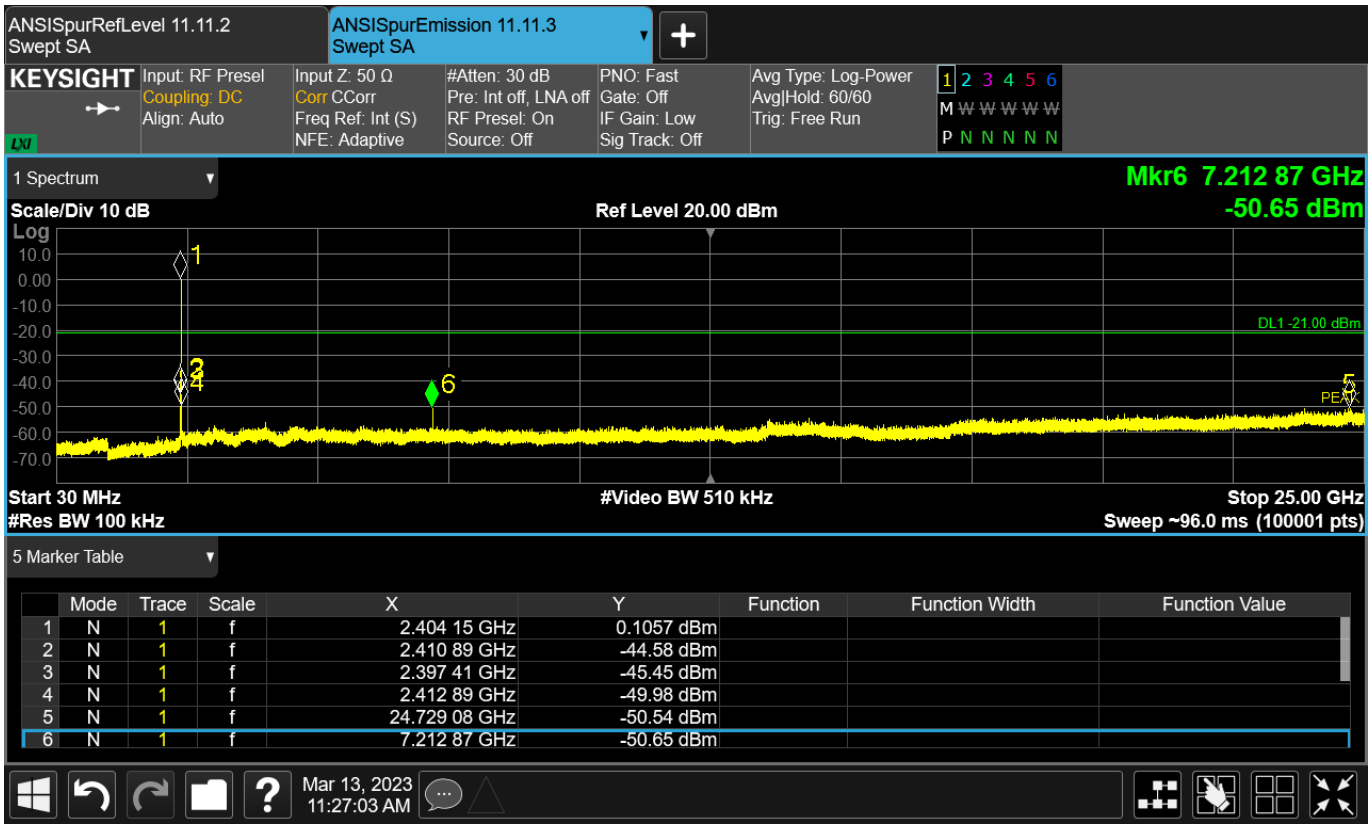


Figure TR22.6: Reference level measurement for Bluetooth BLE 2 Mbps at 2404 MHz



	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.404 15 GHz	0.1057 dBm			
2	N	1	f	2.410 89 GHz	-44.58 dBm			
3	N	1	f	2.397 41 GHz	-45.45 dBm			
4	N	1	f	2.412 89 GHz	-49.98 dBm			
5	N	1	f	24.729 08 GHz	-50.54 dBm			
6	N	1	f	7.212 87 GHz	-50.65 dBm			

Figure TR22.7 Spectral data for Bluetooth BLE 2 Mbps at 2404 MHz

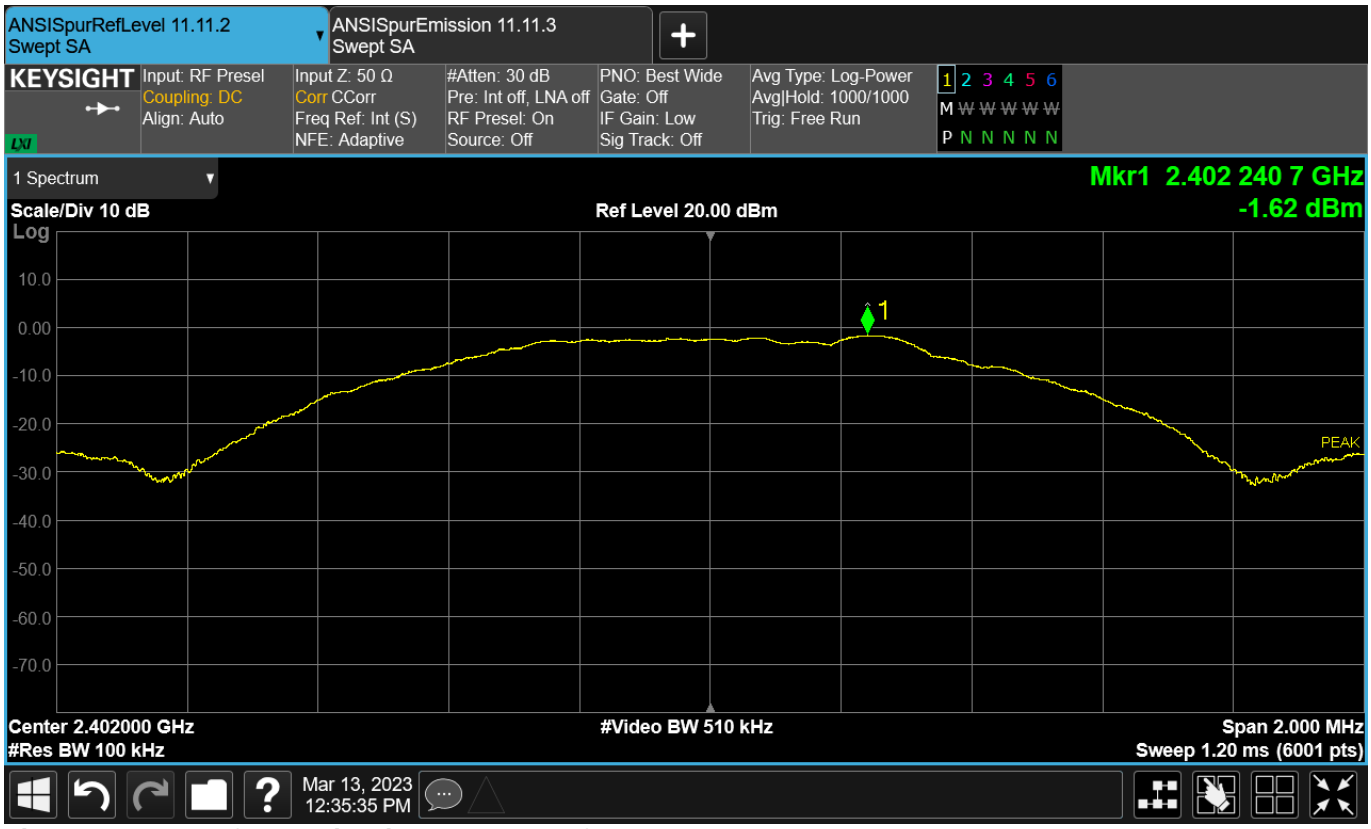
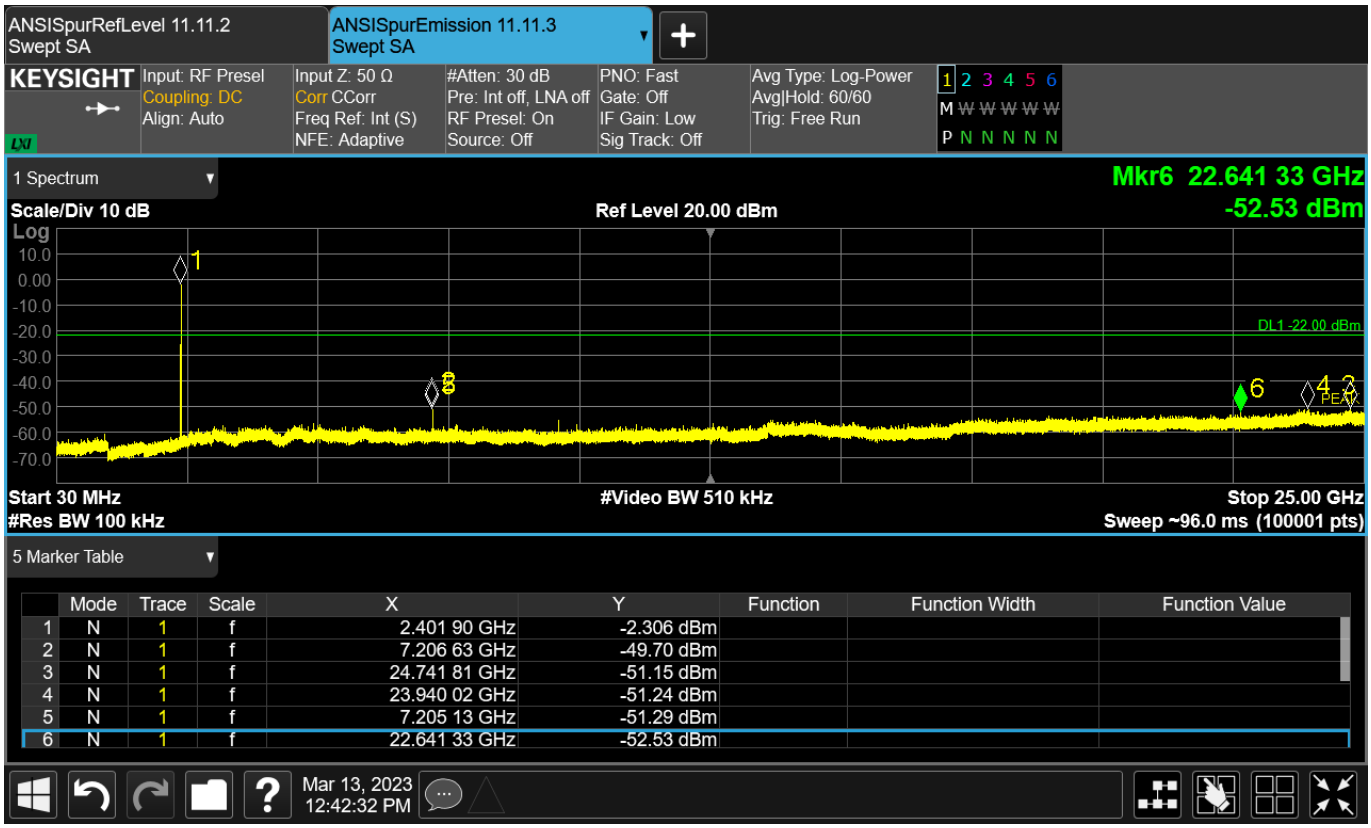


Figure TR22.8: Reference level measurement for ANT at 2402 MHz



	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.401 90 GHz	-2.306 dBm			
2	N	1	f	7.206 63 GHz	-49.70 dBm			
3	N	1	f	24.741 81 GHz	-51.15 dBm			
4	N	1	f	23.940 02 GHz	-51.24 dBm			
5	N	1	f	7.205 13 GHz	-51.29 dBm			
6	N	1	f	22.641 33 GHz	-52.53 dBm			

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-0304

Test Date(s)	13 and 14 Mar 2023
Test Personnel	Majid Farah
Product Model	A04331
Serial Number tested	3437296908
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:	**27 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.

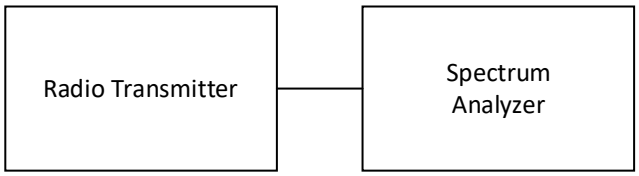


Figure TR25.1: Test setup

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	**35.10**	**56.88**	**52.92**	**53.33**	**45.42**
B	5.5	**34.40**	**60.54**	**52.92**	**52.08**	**51.28**
G	6	**48.52**	**53.75**	**52.92**	**49.22**	**40.57**
G	12	**45.29**	**53.15**	**52.92**	**42.91**	**41.55**
N	MCS0	**44.97**	**53.10**	**52.92**	**45.57**	**41.94**
N	MCS1	**45.34**	**53.29**	**52.92**	**43.79**	**42.28**
N	MCS2	**43.58**	**53.43**	**52.92**	**45.06**	**41.56**

Table TR25.2: Results Summary

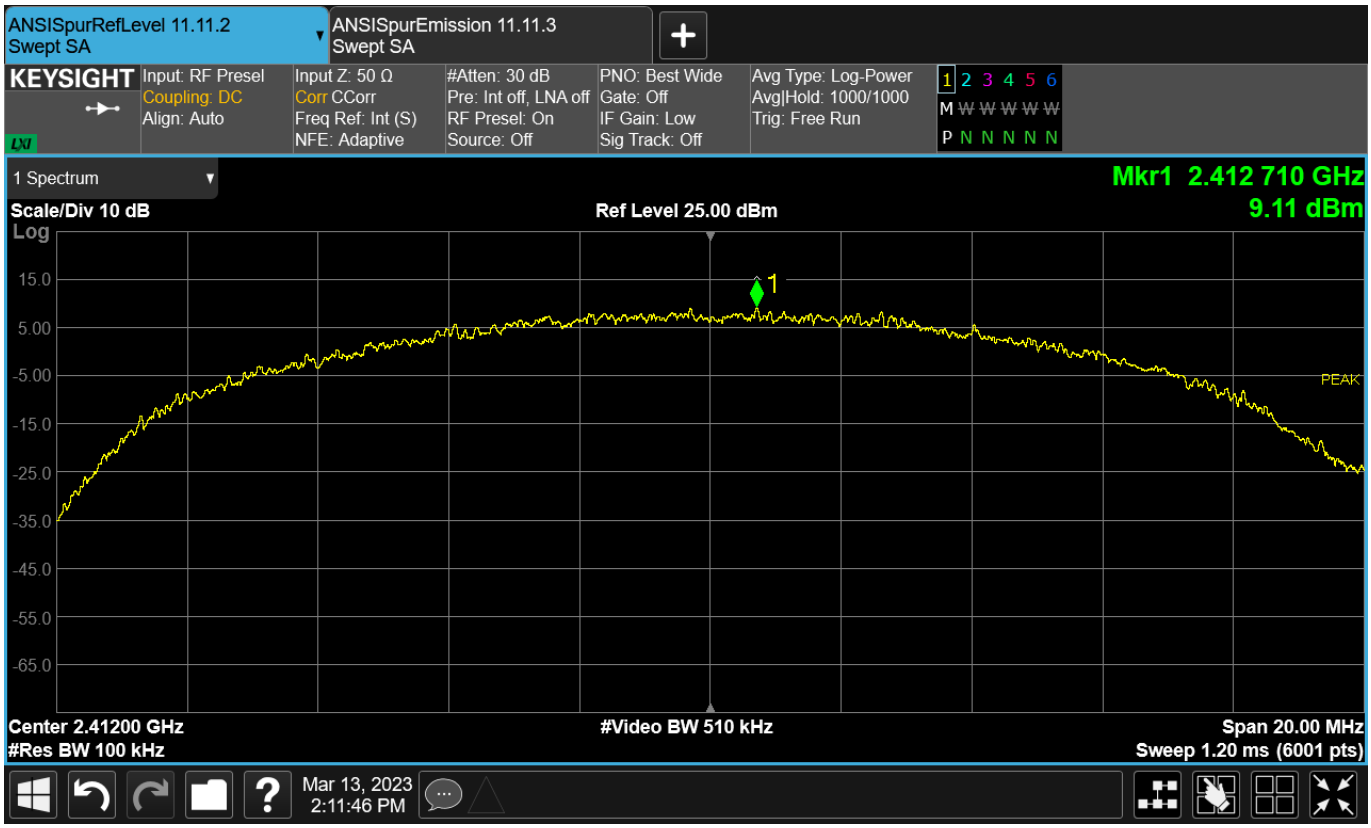


Figure TR25.2: Reference level measurement for IEEE 802.11 b 5.5 Mbps on Ch.1

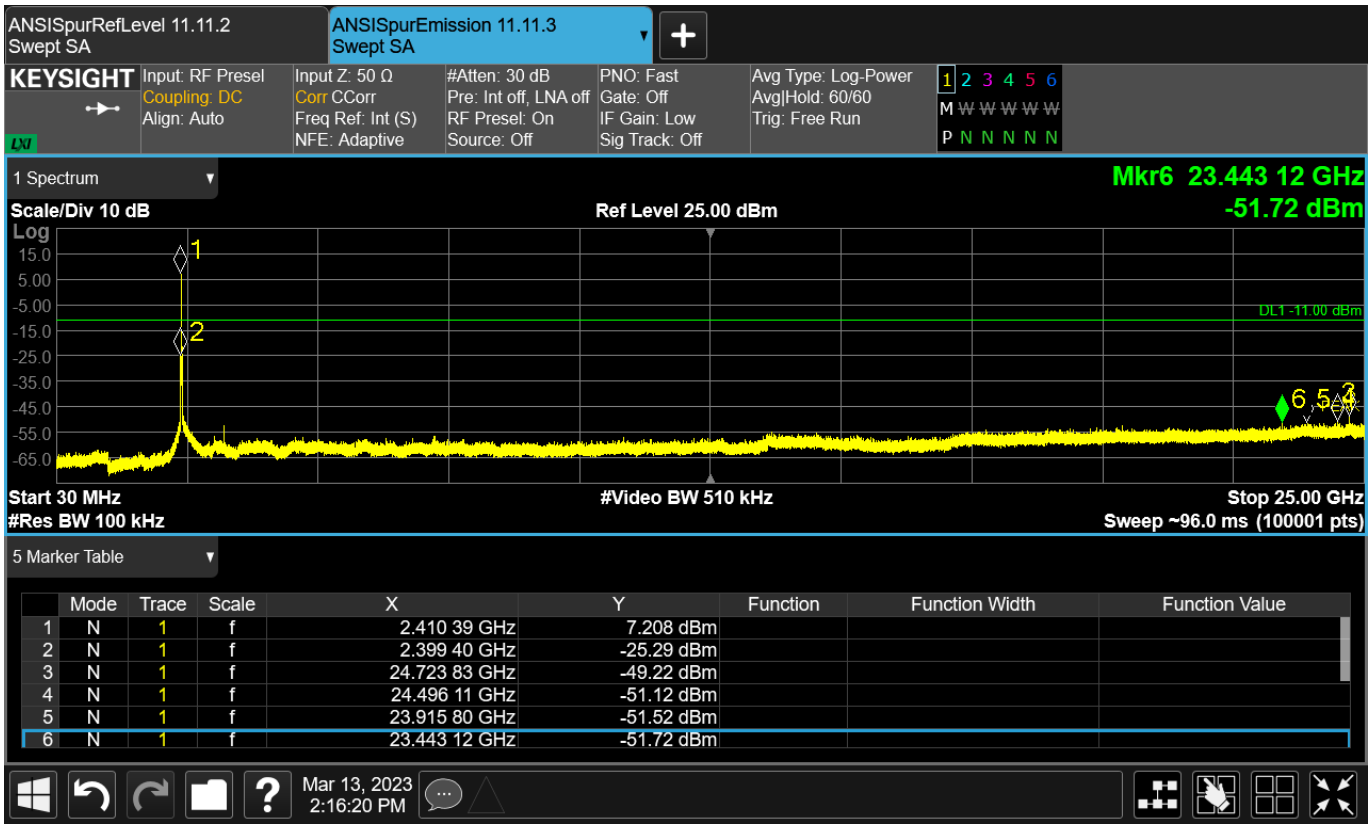


Figure TR25.3: Spectral data for IEEE 802.11 b 5.5 Mbps on Ch.1

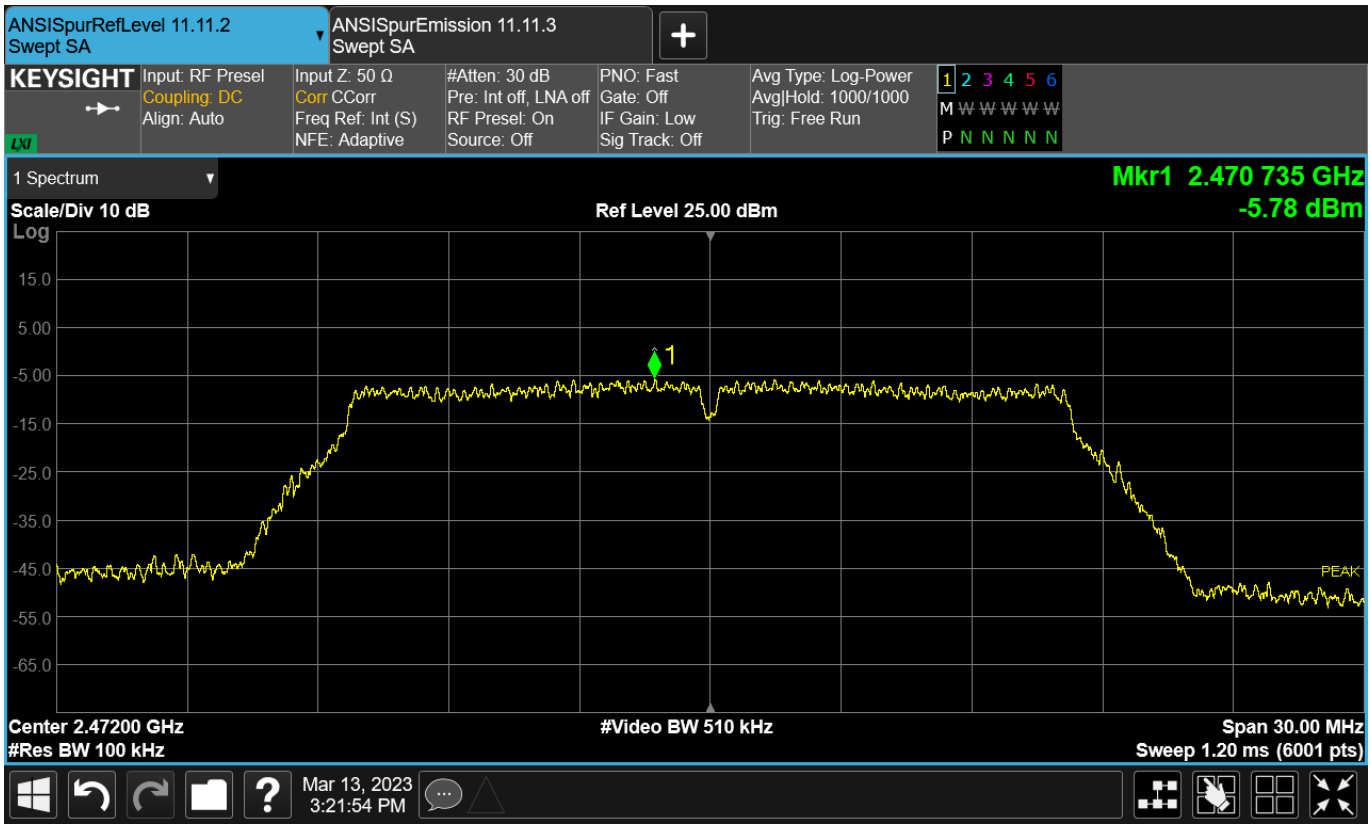
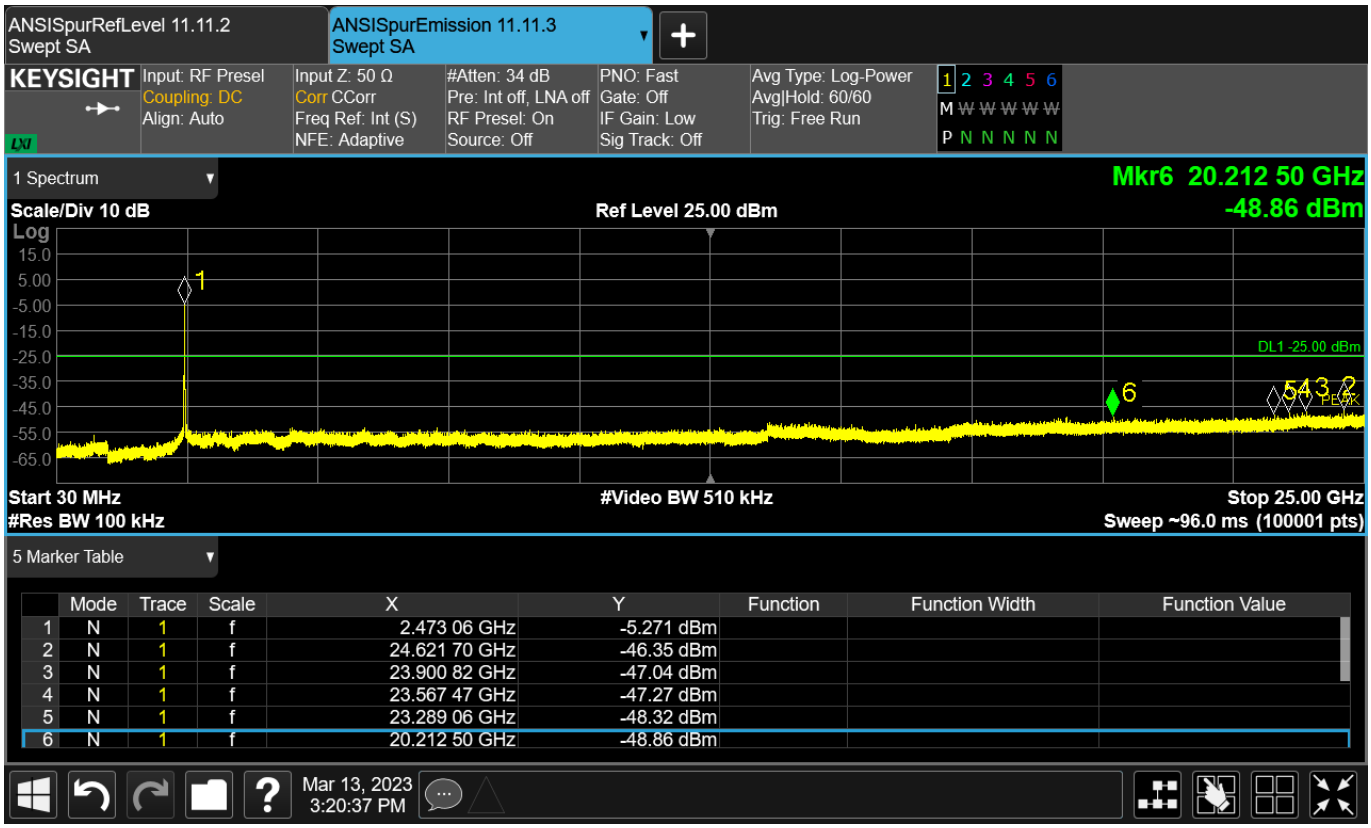


Figure TR25.4: Reference level measurement for IEEE 802.11 g 6 Mbps on Ch.13



	Mode	Trace	Scale	X	Y	Function	Function Width	Function Value
1	N	1	f	2.473 06 GHz	-5.271 dBm			
2	N	1	f	24.621 70 GHz	-46.35 dBm			
3	N	1	f	23.900 82 GHz	-47.04 dBm			
4	N	1	f	23.567 47 GHz	-47.27 dBm			
5	N	1	f	23.289 06 GHz	-48.32 dBm			
6	N	1	f	20.212 50 GHz	-48.86 dBm			

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

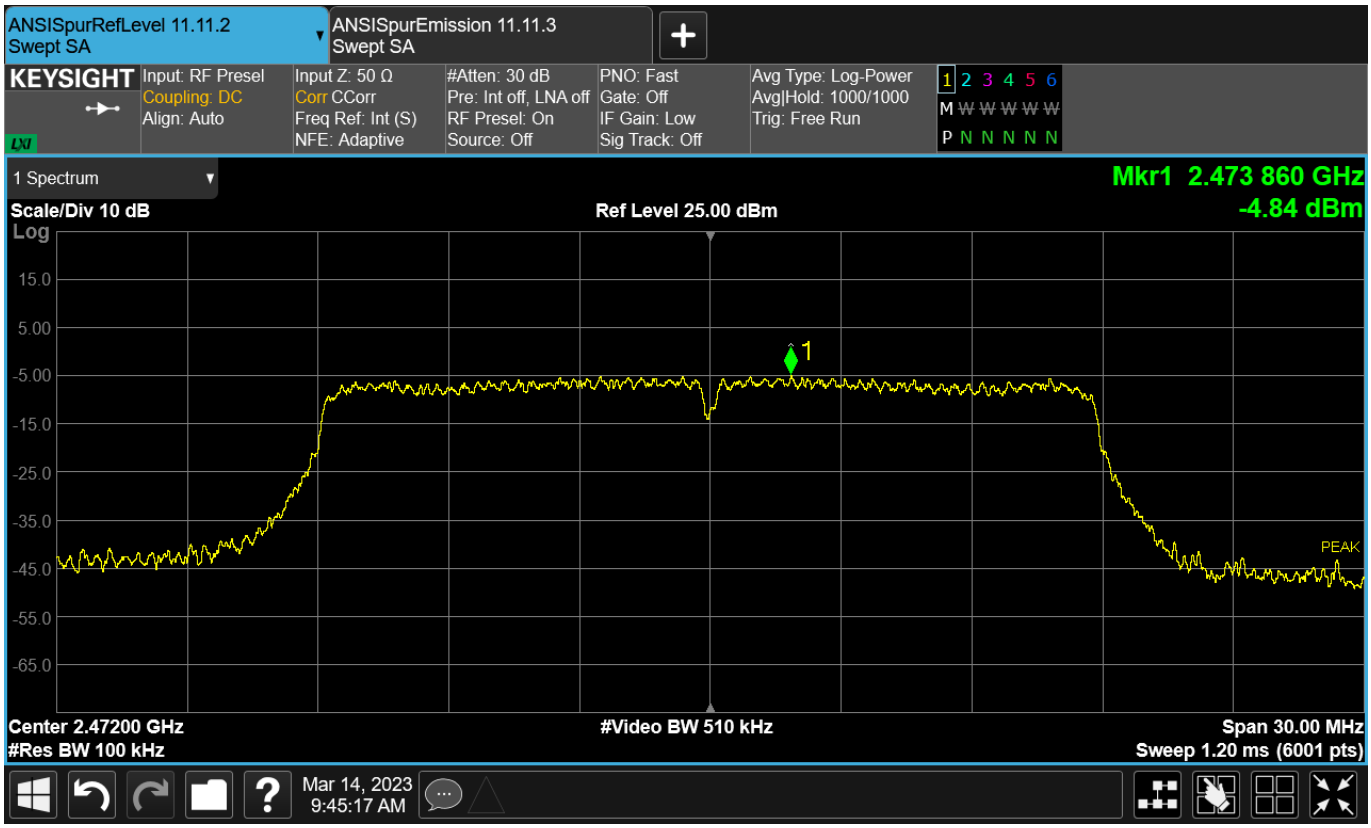


Figure TR25.6: Reference level measurement for IEEE 802.11 n MCS2 on Ch.13

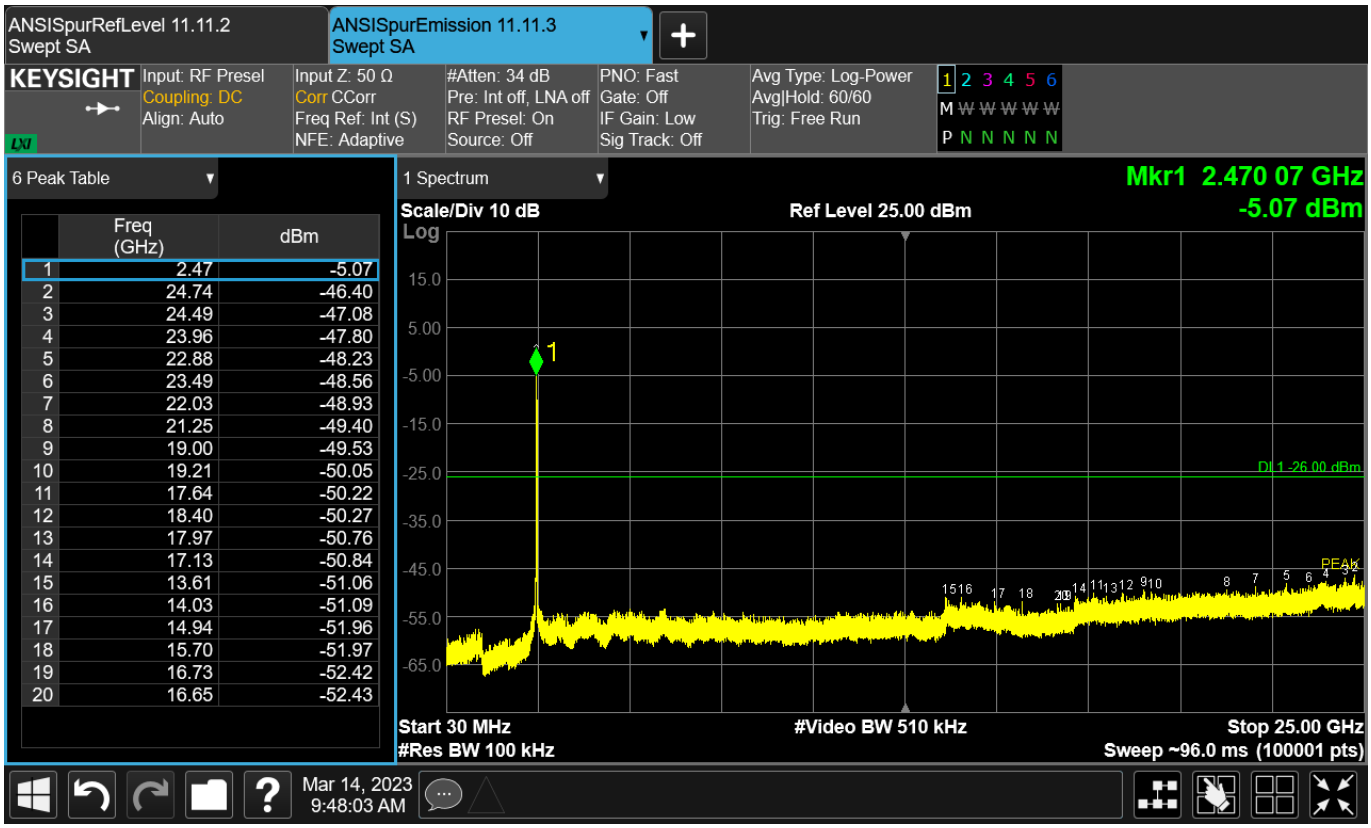


Figure TR25.7 Spectral data for IEEE 802.11 n MCS2 on Ch.13
This line is the end of the test record.

Test Record
Radiated Emission Test RE06
Project GCL0304

Test Date(s)	15 Feb 2023
Test Personnel	David Kerr
Product Model	A04331
Serial Number tested	3437296994
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)	---
2216	54	74	32.01	47.115	21.99	26.885	166	1844	Horz
2389	54	74	32.784	46.653	21.216	27.347	166	1844	Horz

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	38.704	51.938	15.296	22.062	170	1506	Horz
2483.5	54	74	38.723	52.487	15.277	21.513	170	1506	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)	---
2389.3	54	74	34.778	47.609	19.222	26.391	166	1844	Horz
2389.3	54	74	34.773	47.792	19.227	26.208	166	1844	Horz

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	44.853	55.807	9.147	18.193	170	1506	Horz
2484.8	54	74	44.769	54.048	9.231	19.952	170	1506	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.

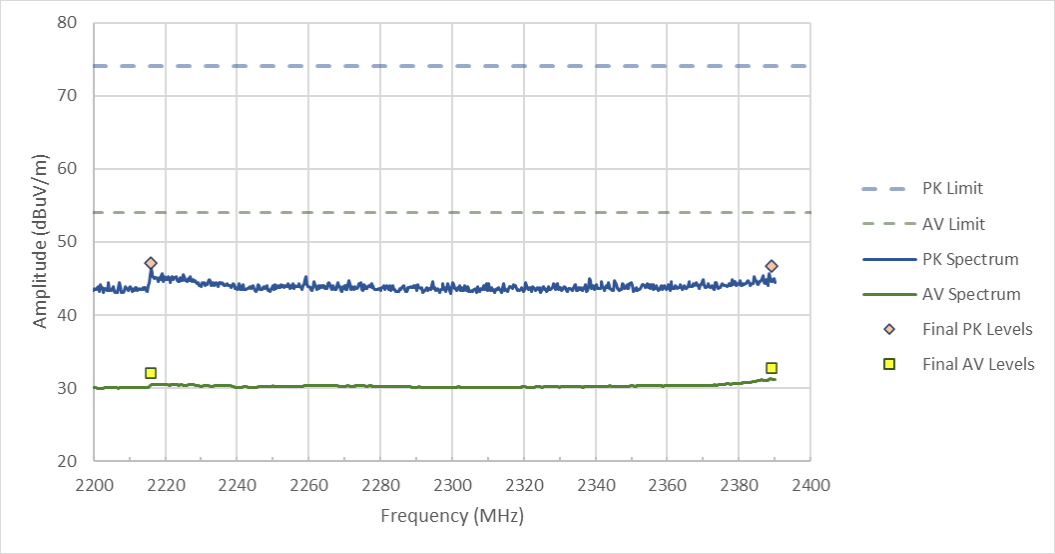


Figure RE06.1: Spectral data FCC restricted band from 2200 to 2390 MHz (1Mbps)

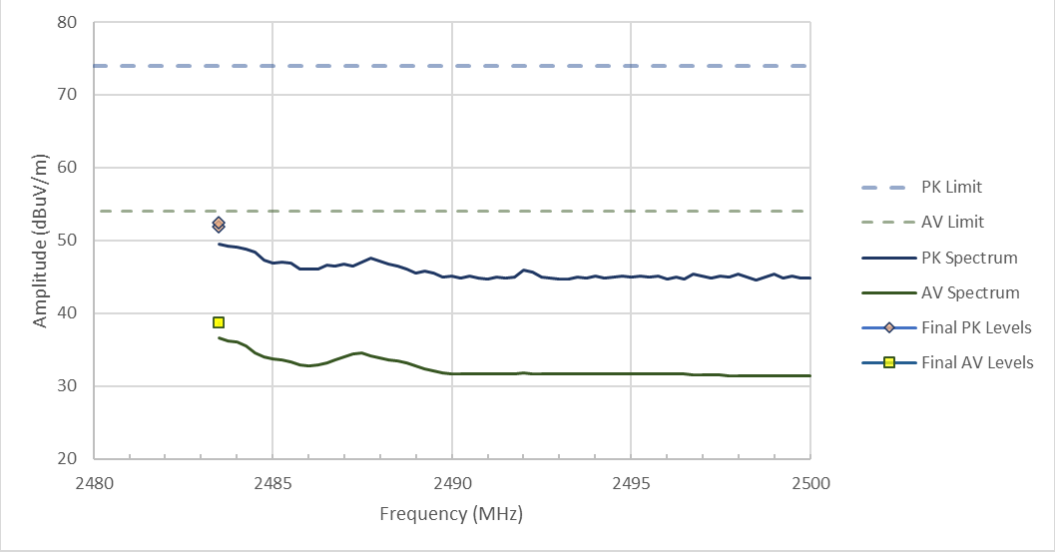


Figure RE06.2: Spectral data FCC restricted band from 2483.5 to 2500 MHz (1 Mbps)

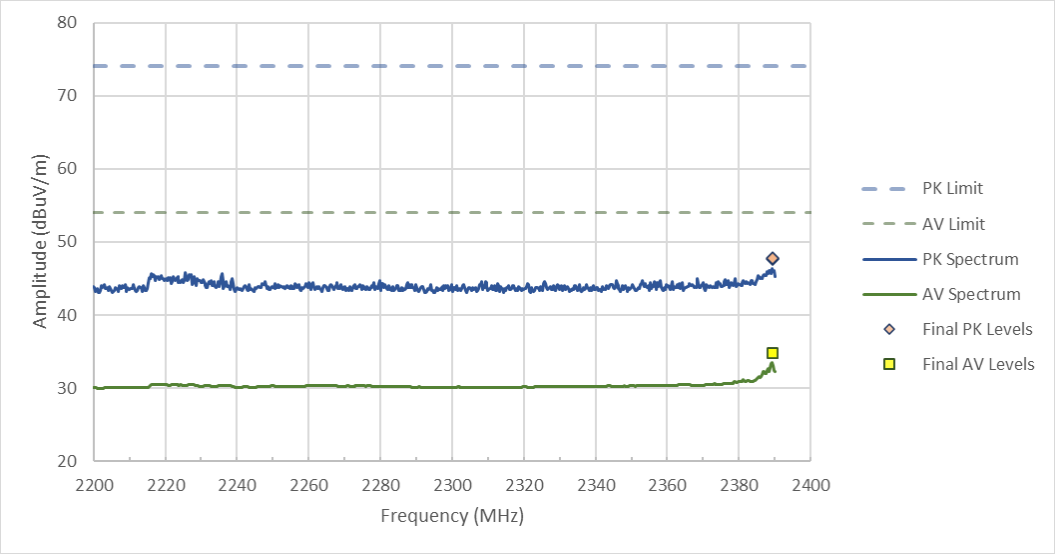


Figure RE06.3: Spectral data FCC restricted band from 2200 to 2390 MHz (2 Mbps)

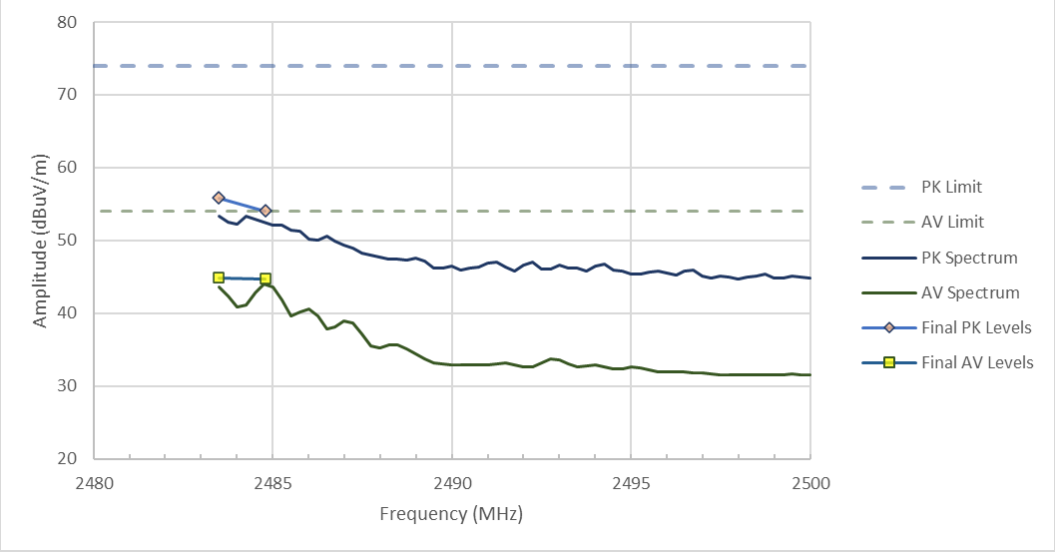


Figure RE06.4: Spectral data FCC restricted band from 2483.5 to 2500 MHz (2 Mbps)

Setup Photographs

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

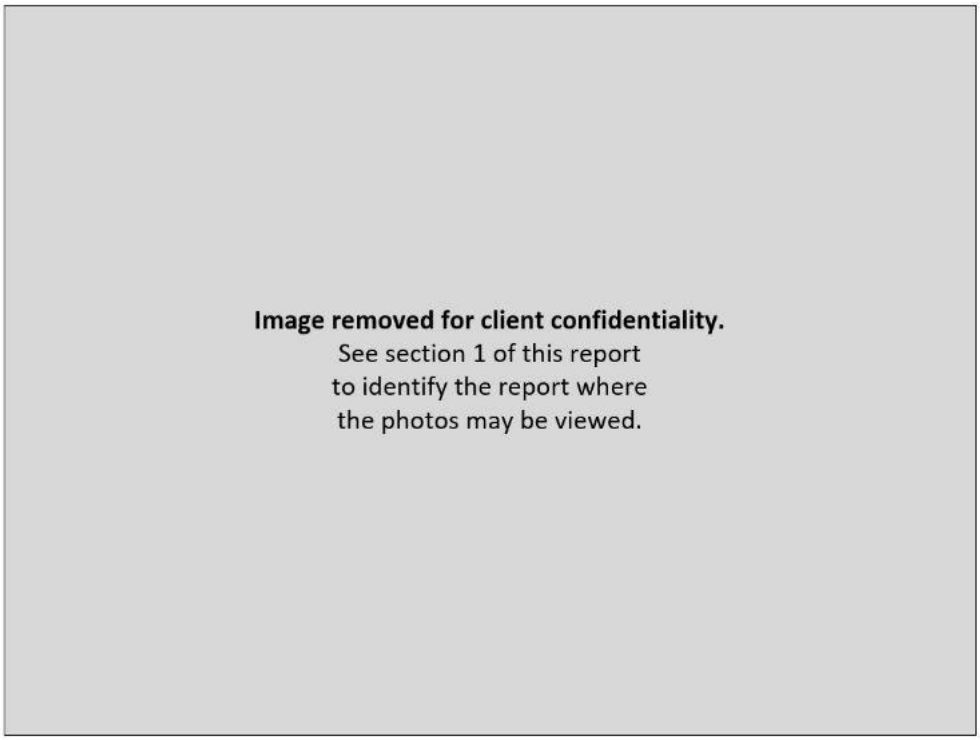


Figure RE06.5: EUT test setup, front view (Z orientation)

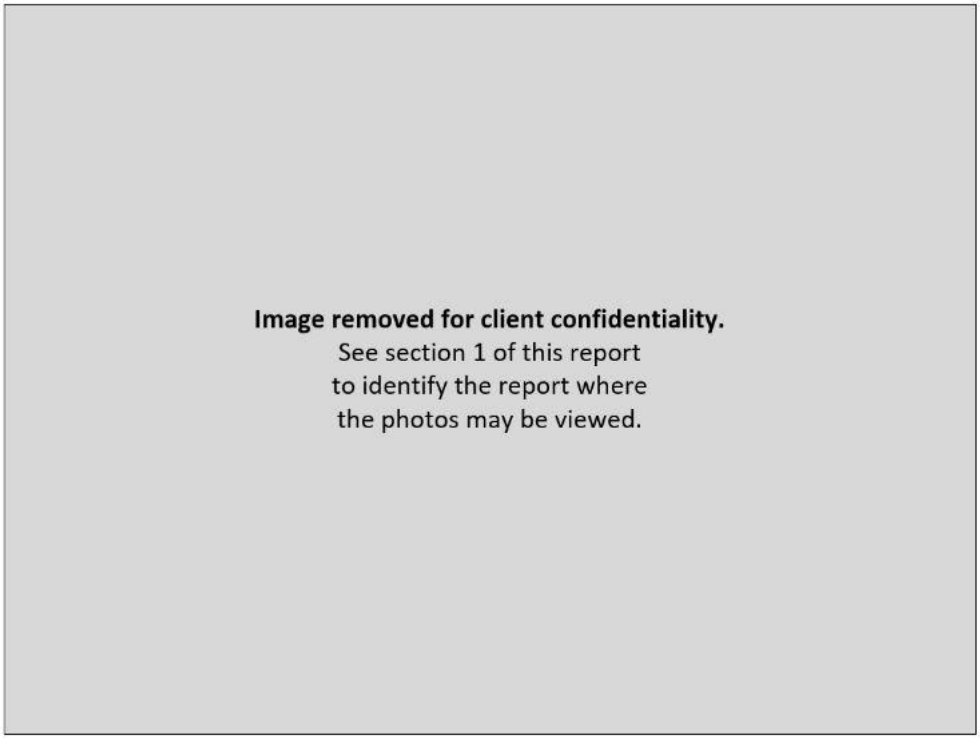


Figure RE06.6: EUT test setup, reverse view (Z orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE07
Project GCL0304

Test Date(s)	15 Feb 2023
Test Personnel	David Kerr
Product Model	A04331
Serial Number tested	3437296994
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:	**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)	---
2216	54	74	31.963	47.162	22.037	26.838	166	1844	Horz
2390	54	74	32.954	46.514	21.046	27.486	166	1844	Horz

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	42.688	51.498	11.312	22.502	170	1506	Horz
2484	54	74	42.777	51.638	11.223	22.362	170	1506	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.

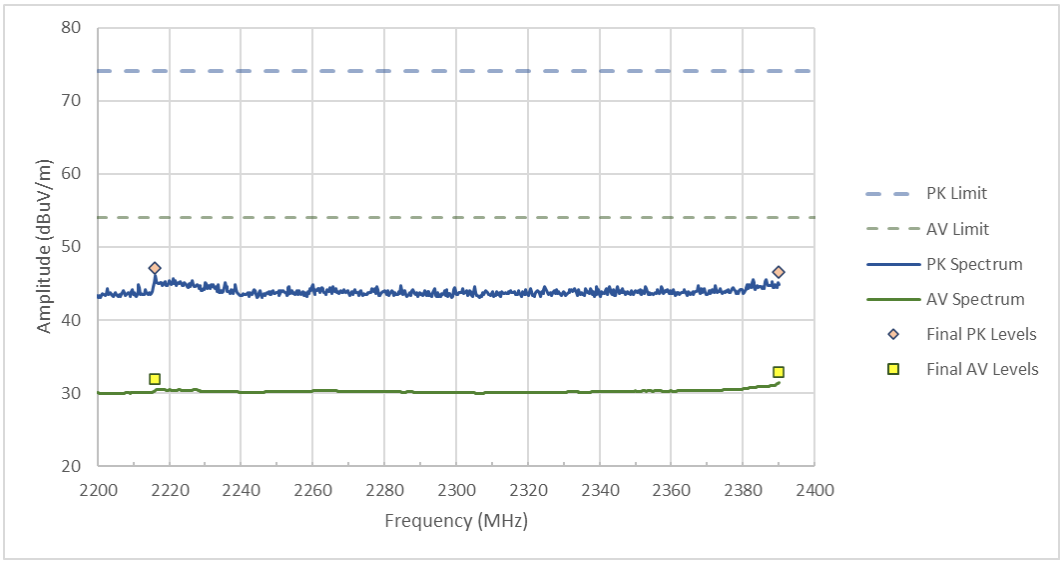


Figure RE07.1: Spectral data FCC restricted band from 2200 to 2390 MHz

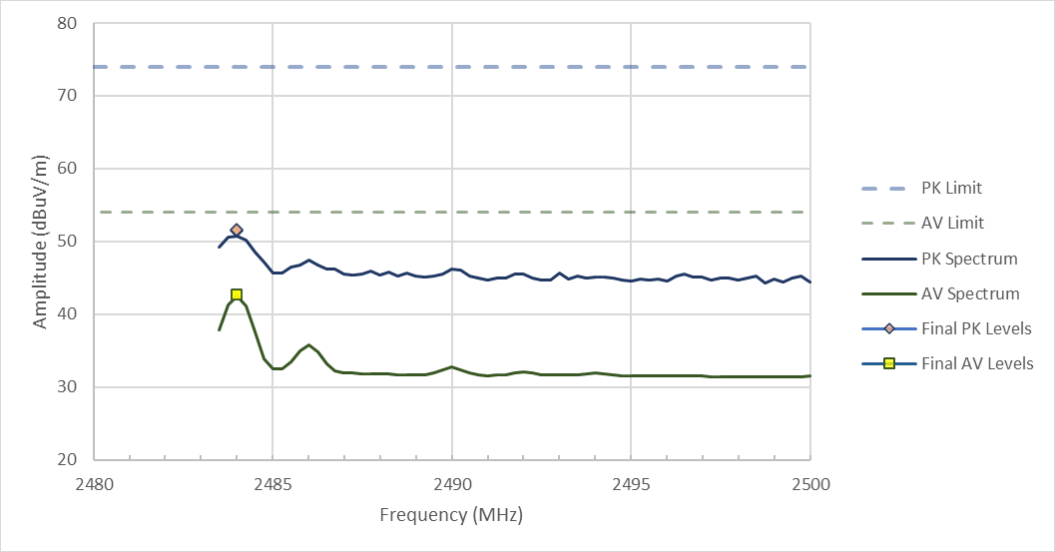


Figure RE07.2: Spectral data FCC restricted band from 2483.5 to 2500 MHz

Setup Photographs

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

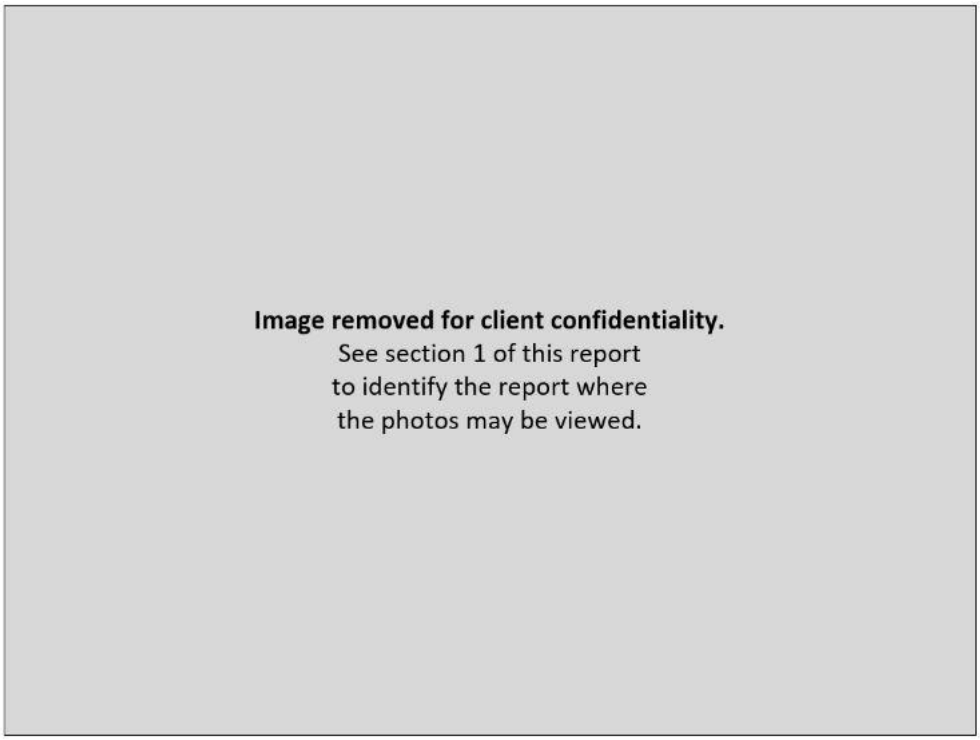


Figure RE07.3: EUT test setup, front view (Z orientation)

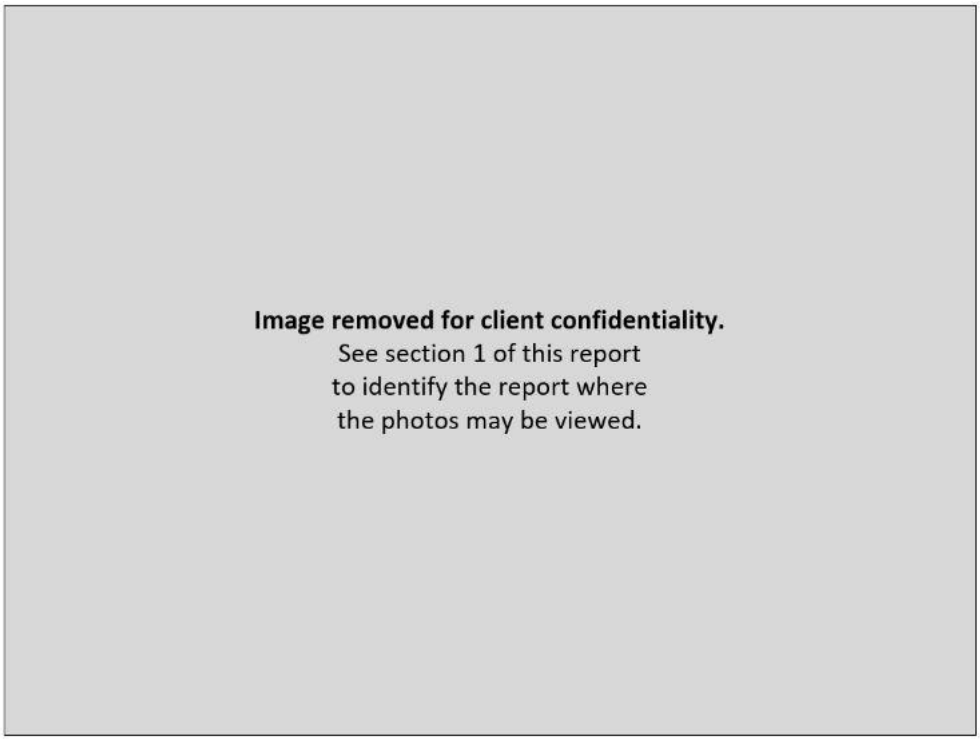


Figure RE07.4: EUT test setup, reverse view (Z orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE08
Project GCL0304

Test Date(s)
Test Personnel David Kerr

Product Model A04331
Serial Number tested 3437296994

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: 16 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

Software Used
Keysight PXE N9048B Firmware version A.32.06
RE Signal Maximization Tool v2021Feb25.xlsx
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	2387.8	54	74	42.456	54.355	11.544	19.645	166	1844	HORZ
B11 Average	2390	54	74	42.518	54.875	11.482	19.125	166	1844	HORZ
G18 Peak	2390	54	74	42.959	61.112	11.041	12.888	166	1844	HORZ
G18 Average	2390	54	74	42.865	61.511	11.135	12.489	166	1844	HORZ
N1 Peak	2390	54	74	46.07	63.929	7.93	10.071	166	1844	HORZ
N1 Average	2390	54	74	46.123	63.856	7.877	10.144	166	1844	HORZ

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	2390	54	74	40.187	53.59	13.813	20.41	166	1844	HORZ
B11 Average	2390	54	74	40.166	53.078	13.834	20.922	166	1844	HORZ
G18 Peak	2387.5	54	74	44.221	63.212	9.779	10.788	166	1844	HORZ
G18 Average	2390	54	74	45.948	62.945	8.052	11.055	166	1844	HORZ
N1 Peak	2389	54	74	47.315	65.706	6.685	8.294	166	1844	HORZ
N1 Average	2390	54	74	47.857	65.247	6.143	8.753	166	1844	HORZ

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 ---
G18 Peak	2389.3	54	74	42.847	61.094	11.153	12.906	166	1844	HORZ
G18 Average	2390	54	74	43.302	63.689	10.698	10.311	166	1844	HORZ
N1 Peak	2390	54	74	44.768	63.738	9.232	10.262	166	1844	HORZ
N1 Average	2390	54	74	44.781	63.531	9.219	10.469	166	1844	HORZ

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 ---
G18 Peak	2389.8	54	74	40.848	60.07	13.152	13.93	166	1844	HORZ
G18 Average	2390	54	74	40.984	59.705	13.016	14.295	166	1844	HORZ
N1 Peak	2389.5	54	74	45.256	64.189	8.744	9.811	166	1844	HORZ
N1 Average	2390	54	74	45.523	64.669	8.477	9.331	166	1844	HORZ

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 ---
G6 Peak	2486.8	54	74	43.369	60.28	10.631	13.72	170	1506	HORZ
G6 Average	2483.5	54	74	43.875	60.296	10.125	13.704	170	1506	HORZ

Table RE08.6: Emission summary FCC restricted band from 2483.5 to 2500 MHz (WiFi Ch.8)

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 ---
G6 Peak	2484.8	54	74	45.795	64.603	8.205	9.397	170	1506	HORZ
G6 Average	2483.5	54	74	46.435	64.076	7.565	9.924	170	1506	HORZ
N3 Peak	2486.8	54	74	50.118	71.967	3.882	2.033	170	1506	HORZ
N3 Average	2483.5	54	74	52.019	73.529	1.981	0.471	170	1506	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 ---
B2 Peak	2483.5	54	74	51.233	59.746	2.767	14.254	170	1506	HORZ
B2 Average	2483.5	54	74	51.25	60.005	2.75	13.995	170	1506	HORZ
G6 Peak	2483.5	54	74	42.59	58.737	11.41	15.263	170	1506	HORZ
G6 Average	2483.5	54	74	42.553	58.099	11.447	15.901	170	1506	HORZ
N3 Peak	2483.5	54	74	51.976	71.582	2.024	2.418	170	1506	HORZ
N3 Average	2483.5	54	74	51.897	71.824	2.103	2.176	170	1506	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 ---
B2 Peak	2487.5	54	74	42.708	55.262	11.292	18.738	170	1506	HORZ
B2 Average	2487.8	54	74	42.68	55.09	11.32	18.91	170	1506	HORZ
G6 Peak	2484.3	54	74	47.819	67.601	6.181	6.399	170	1506	HORZ
G6 Average	2483.5	54	74	49.039	67.058	4.961	6.942	170	1506	HORZ
N3 Peak	2483.5	54	74	50.112	69.263	3.888	4.737	170	1506	HORZ
N3 Average	2483.5	54	74	50.159	69.932	3.841	4.068	170	1506	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 ---
B2 Peak	2484	54	74	44.364	54.625	9.636	19.375	170	1506	HORZ
B2 Average	2484.3	54	74	44.579	54.921	9.421	19.079	170	1506	HORZ
G6 Peak	2483.8	54	74	47.852	62.664	6.148	11.336	170	1506	HORZ
G6 Average	2483.5	54	74	47.917	63.013	6.083	10.987	170	1506	HORZ
N3 Peak	2484.3	54	74	51.179	71.225	2.821	2.775	170	1506	HORZ
N3 Average	2483.5	54	74	51.588	70.862	2.412	3.138	170	1506	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 ---
B2 Peak	2485.8	54	74	45.459	54.232	8.541	19.768	170	1506	HORZ
B2 Average	2486	54	74	45.572	54.8	8.428	19.2	170	1506	HORZ
G6 Peak	2484.3	54	74	42.83	56.661	11.17	17.339	170	1506	HORZ
G6 Average	2484	54	74	42.979	56.795	11.021	17.205	170	1506	HORZ
N3 Peak	2485.8	54	74	44.777	66.012	9.223	7.988	170	1506	HORZ
N3 Average	2483.5	54	74	45.989	70.064	8.011	3.936	170	1506	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.

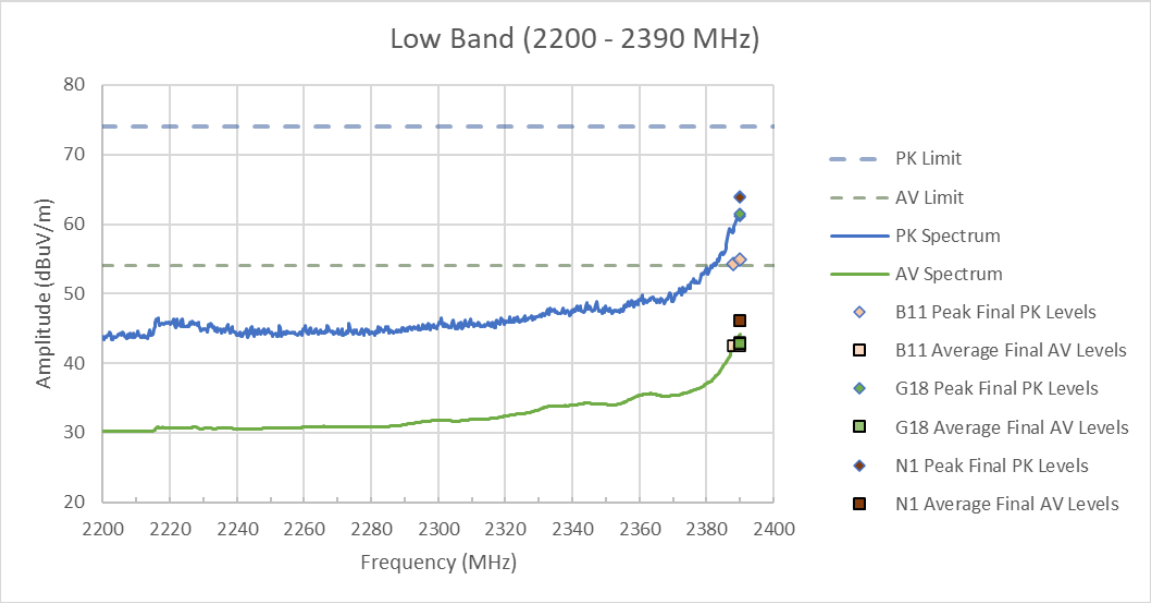


Figure RE08.1: Spectral data FCC restricted band from 2200 to 2390 MHz (WiFi Ch.1)

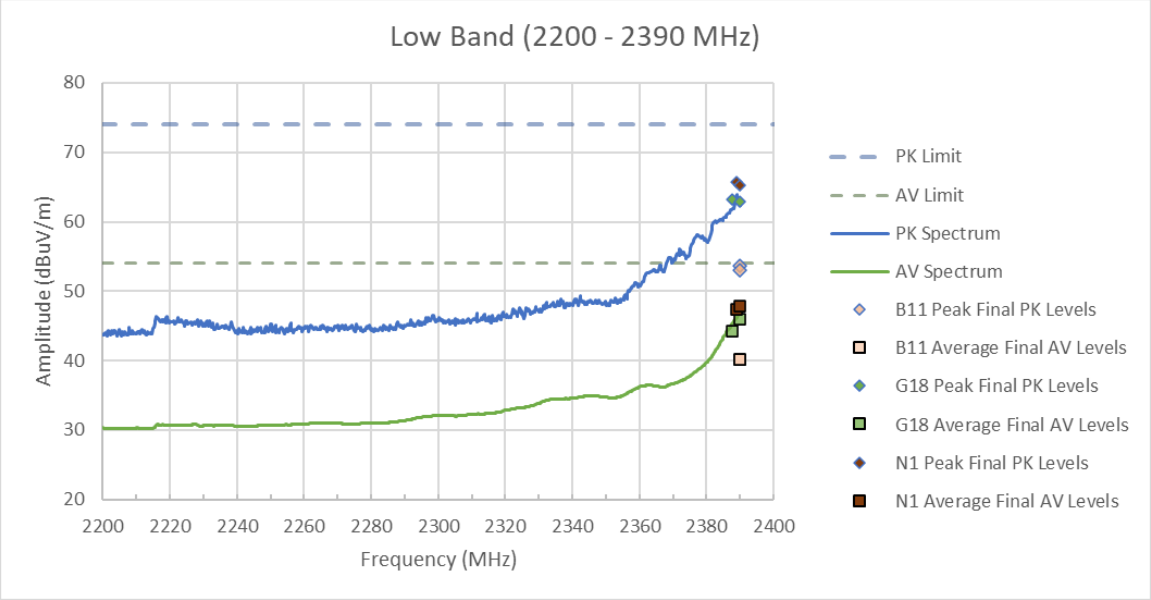


Figure RE08.2: Spectral data FCC restricted band from 2200 to 2390 MHz (WiFi Ch.2)

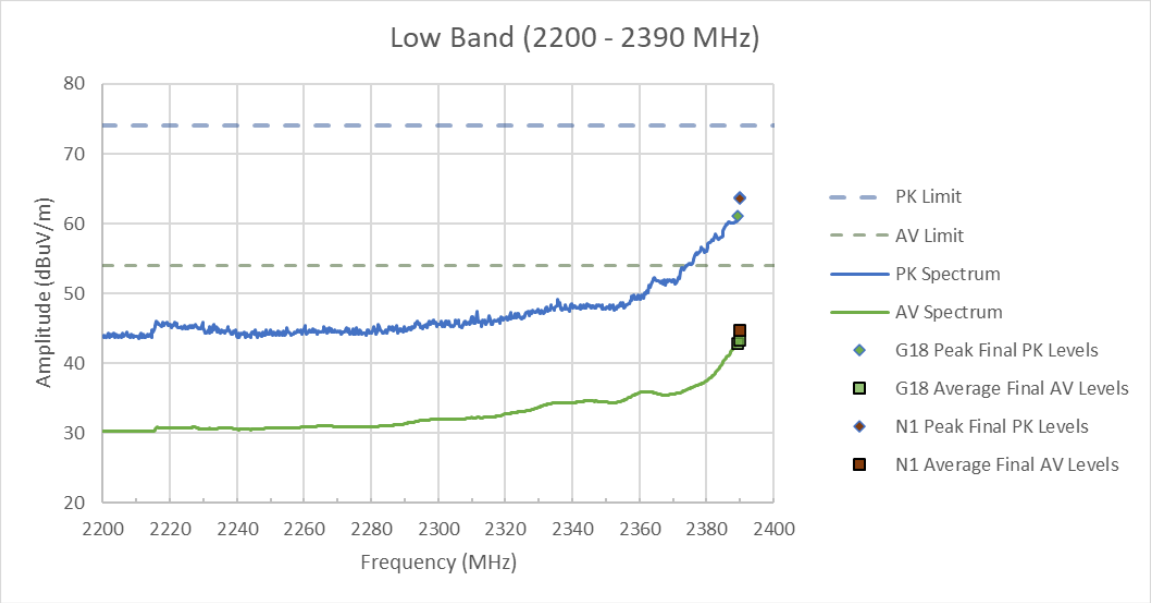


Figure RE08.3: Spectral data FCC restricted band from 2200 to 2390 MHz (Wifi Ch.3)

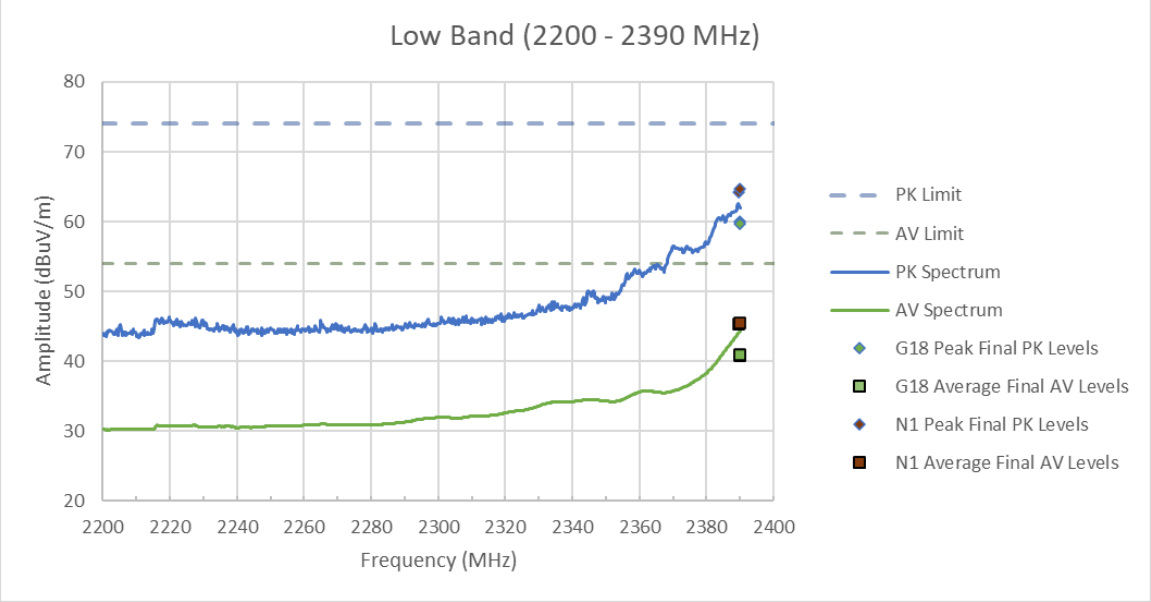


Figure RE08.4: Spectral data FCC restricted band from 2200 to 2390 MHz (Wifi Ch.4)

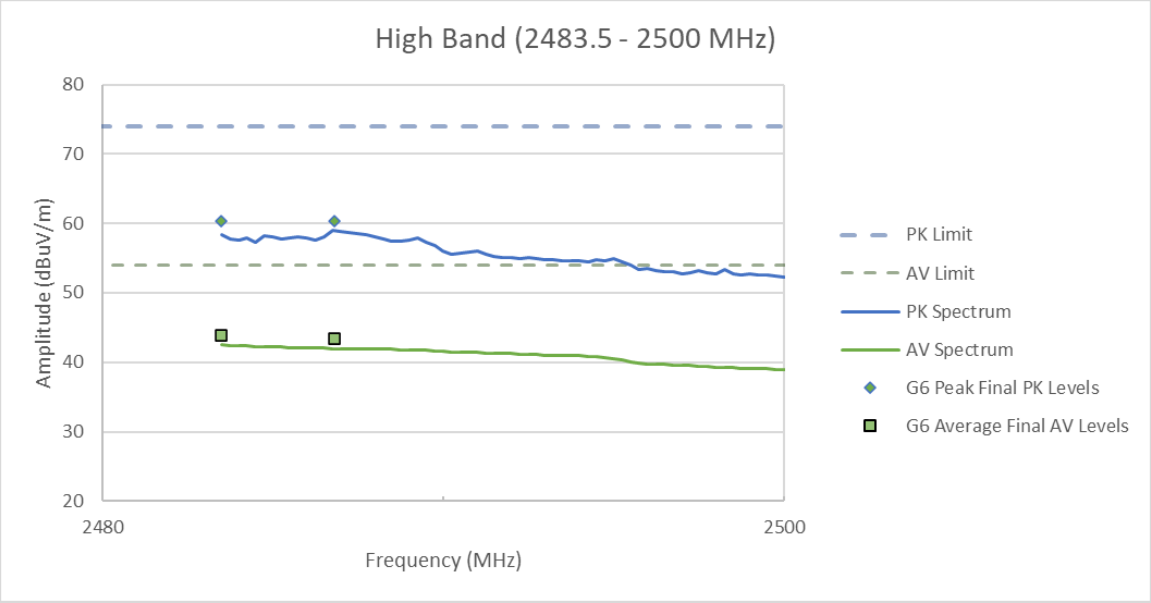


Figure RE08.5: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.8)

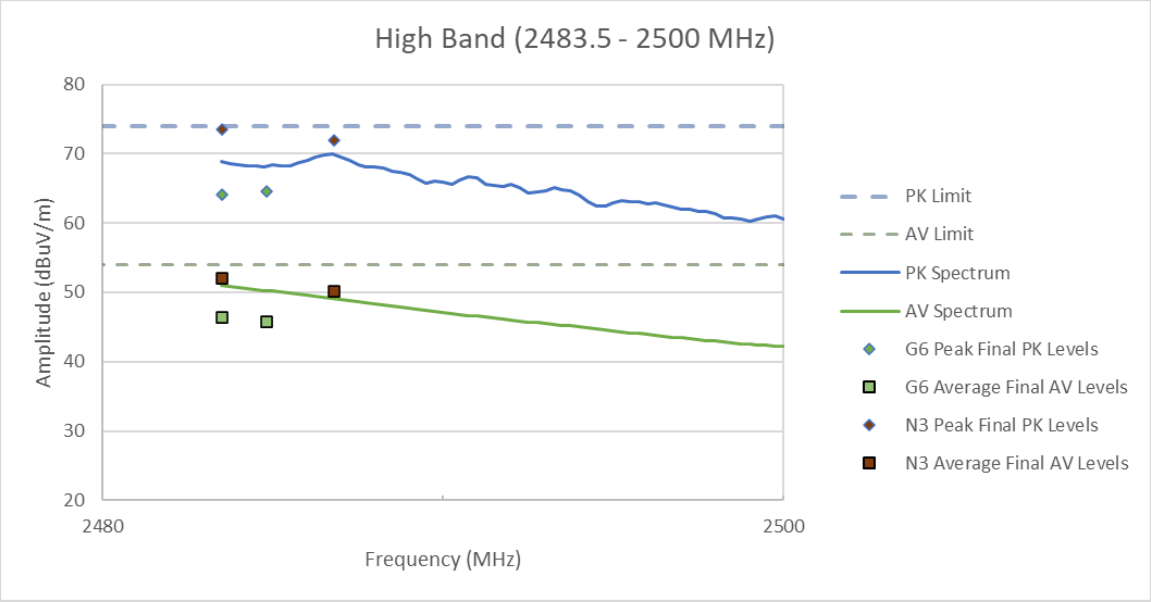


Figure RE08.6: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.9)

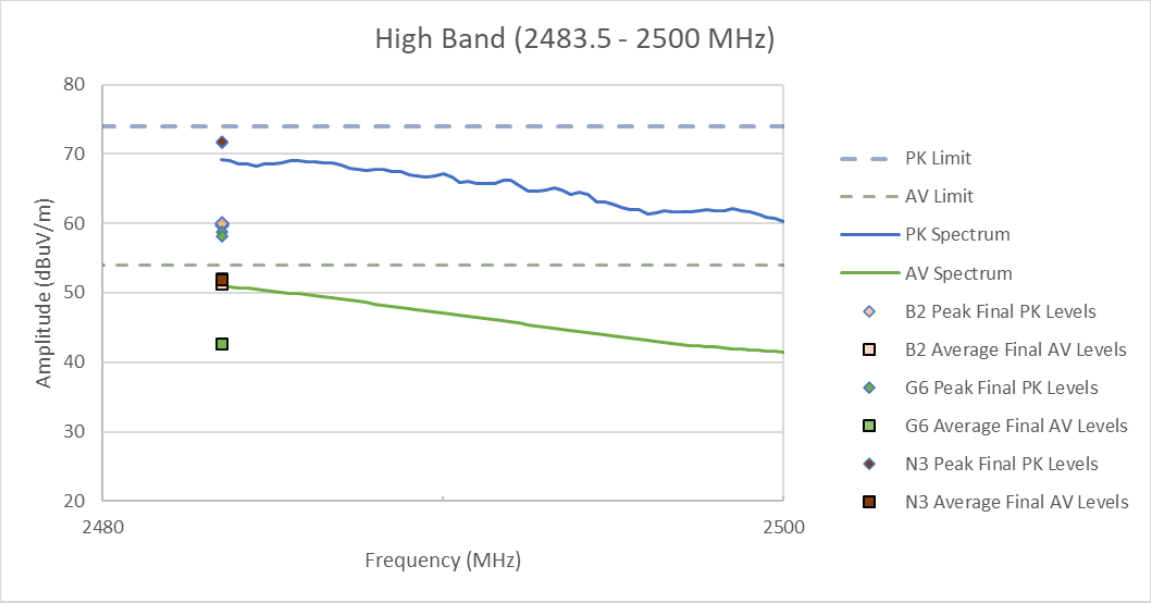


Figure RE08.7: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.10)

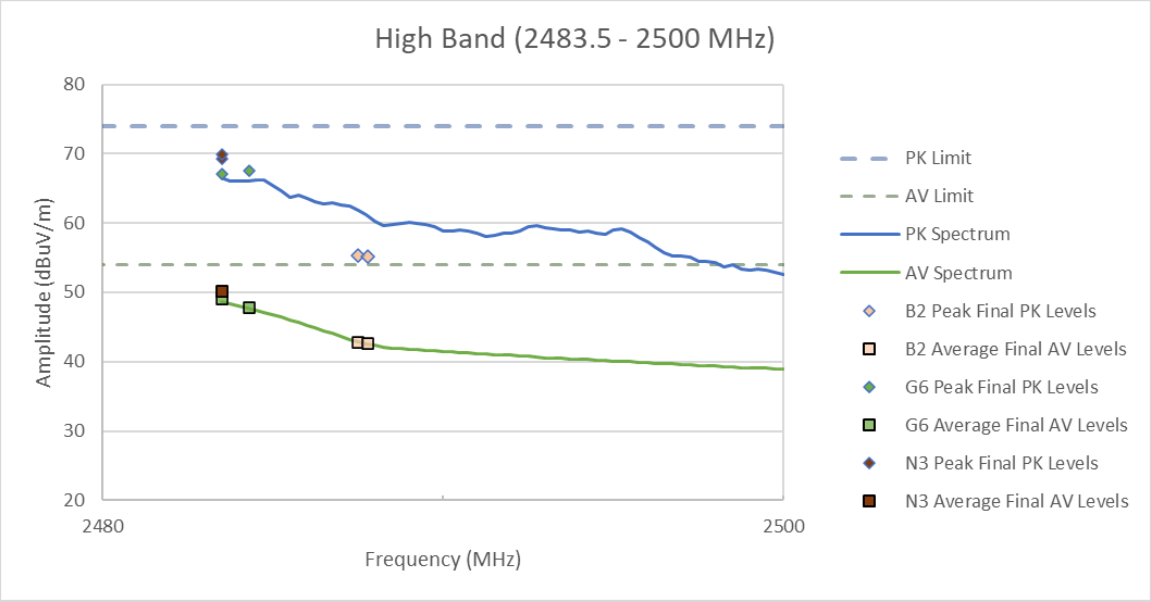


Figure RE08.8: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.11)

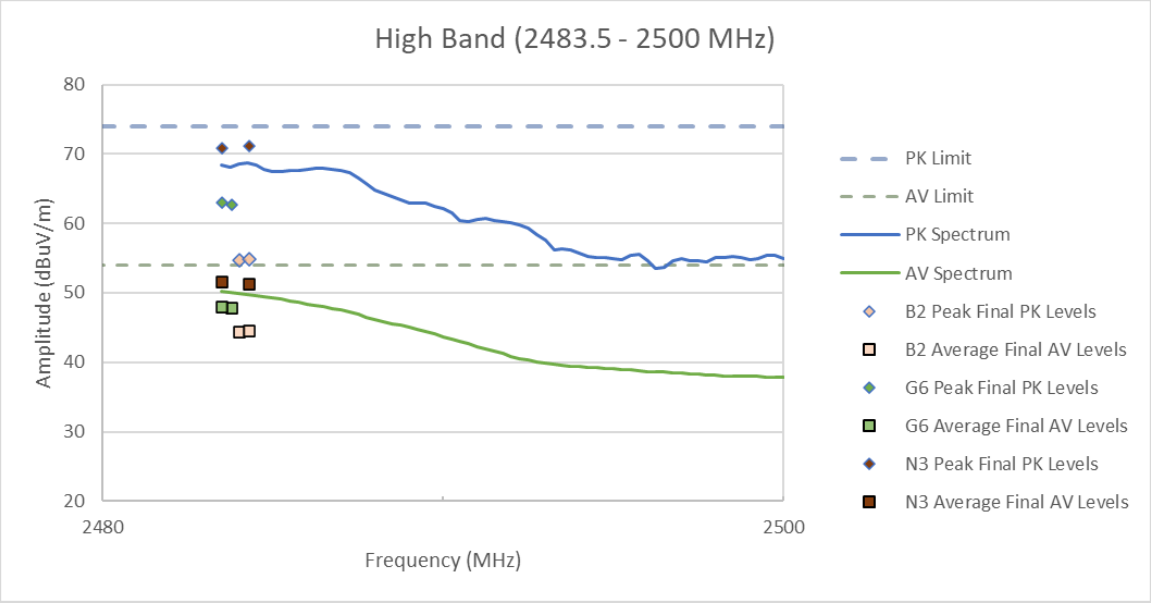


Figure RE08.9: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.12)

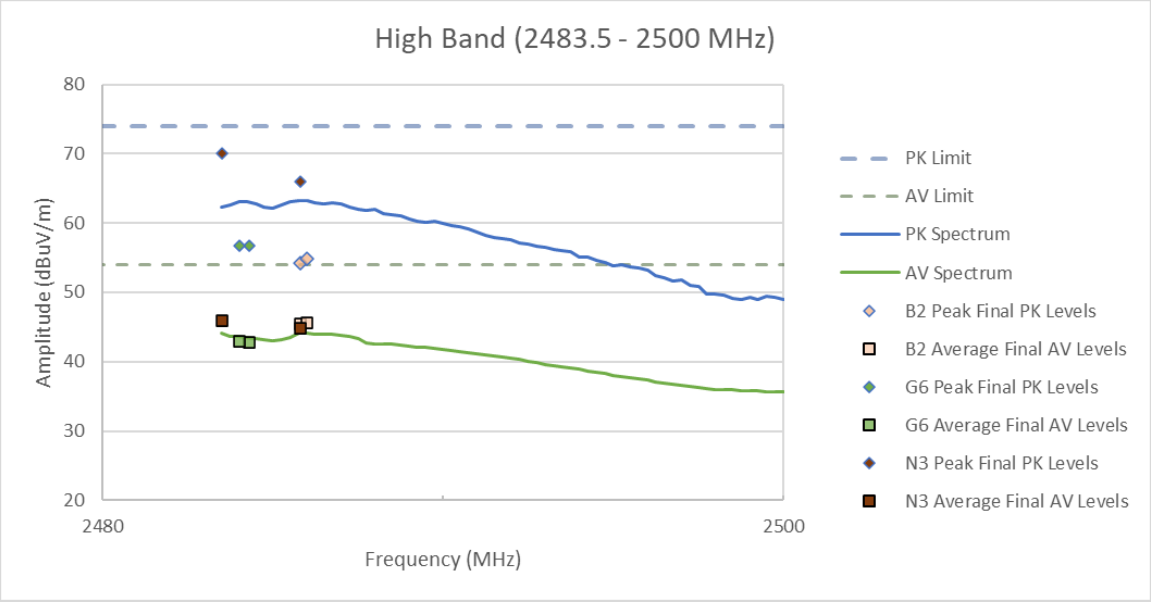


Figure RE08.10: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Wifi Ch.13)

Setup Photographs

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

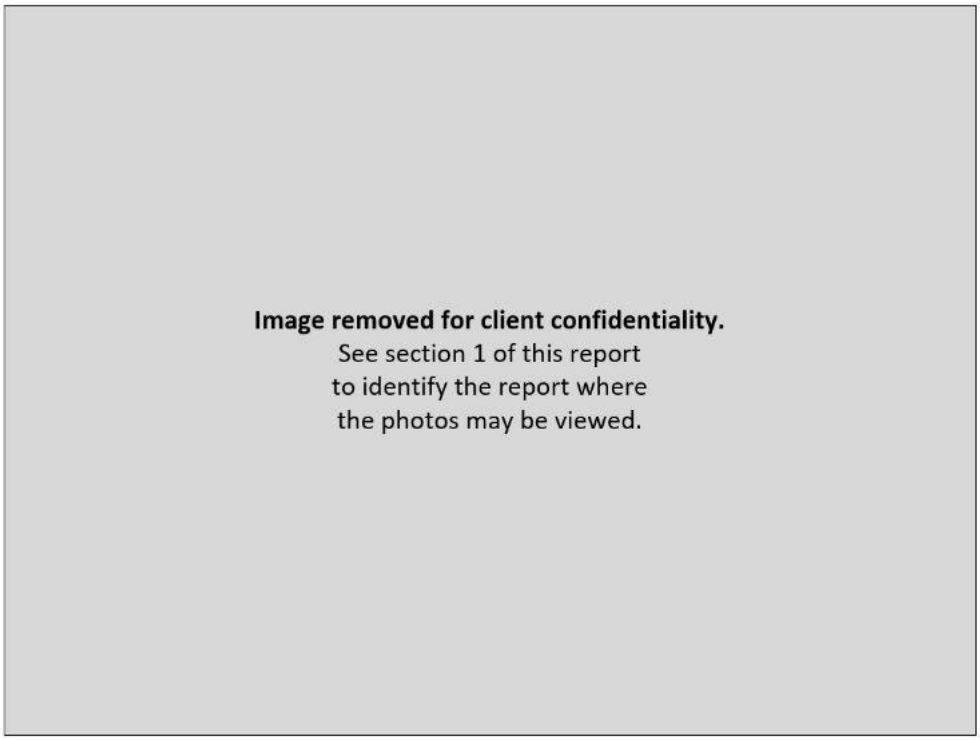


Figure RE08.11: EUT test setup, front view (Z orientation)

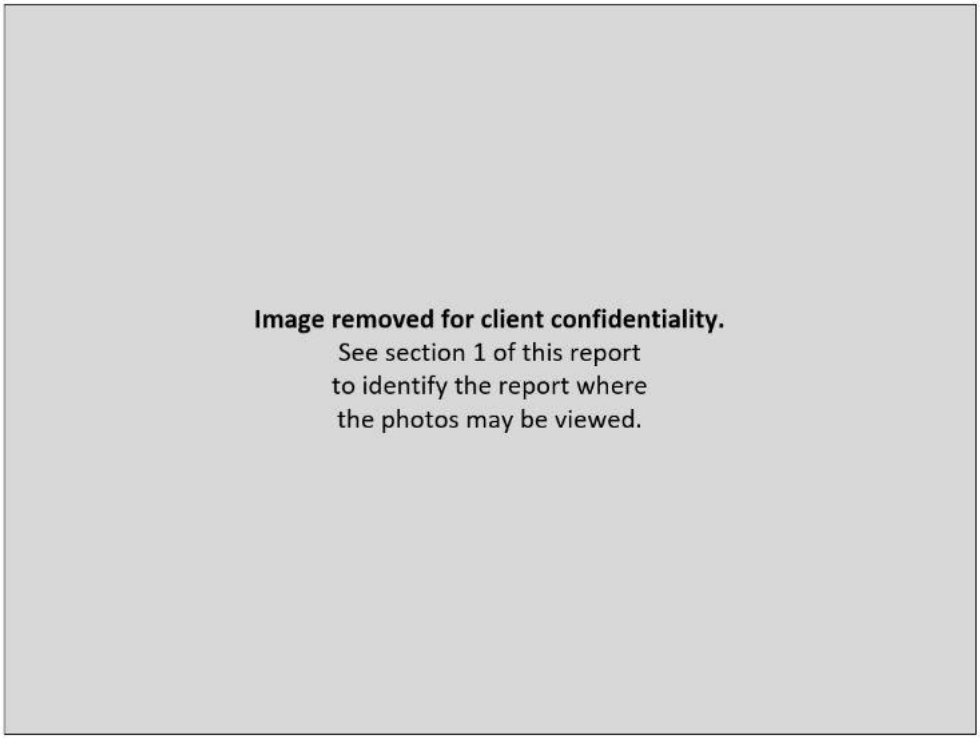


Figure RE08.12: EUT test setup, reverse view (Z orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE09
Project GCL0304

Test Date(s)	15 Feb, Mar 21 2023
Test Personnel	David Kerr / Jim Solum
Product Model	A04331
Serial Number tested	3437296994
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:	**21 Mar 2023**

Original record, Version A dated 13 Mar 2023.
Version B corrected 2483.5 MHz to 2500 MHz EDR 2 data.

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)	---
2385.5	54	74	33.939	48.673	20.061	25.327	166	1844	Horz
2390	54	74	34.311	48.169	19.689	25.831	166	1844	Horz

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	36.362	52.125	17.638	21.875	170	1506	Horz
2483.5	54	74	36.301	52.046	17.699	21.954	170	1506	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)	---
2389.8	54	74	34.039	48.2	19.961	25.8	166	1844	Horz
2390	54	74	34.06	48.211	19.94	25.789	166	1844	Horz

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	43.128	71.922	10.872	2.078	170	1506	Horz
2483.5	54	74	42.975	72.169	11.025	1.831	170	1506	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.

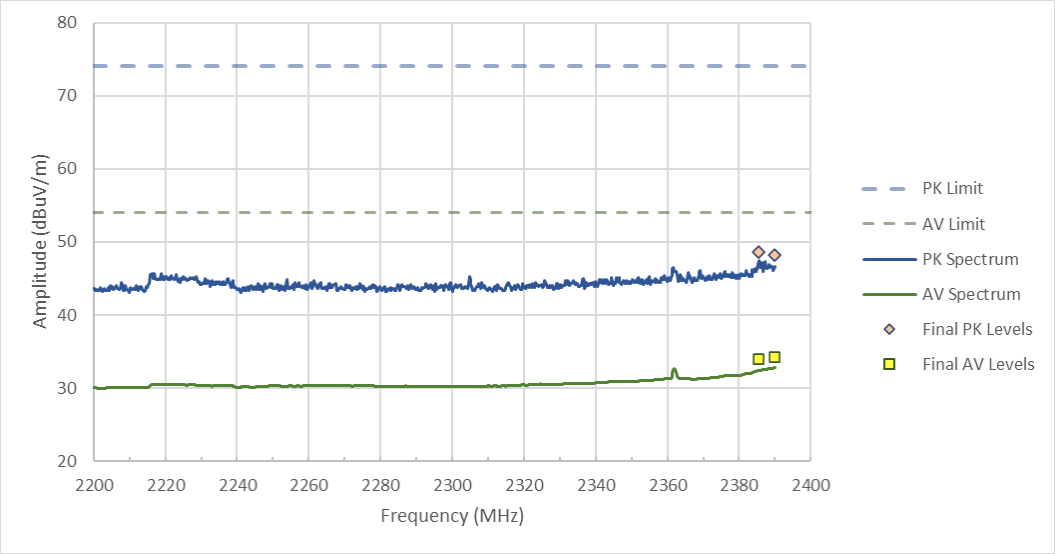


Figure RE09.1: Spectral data FCC restricted band from 2200 to 2390 MHz (EDR 2)

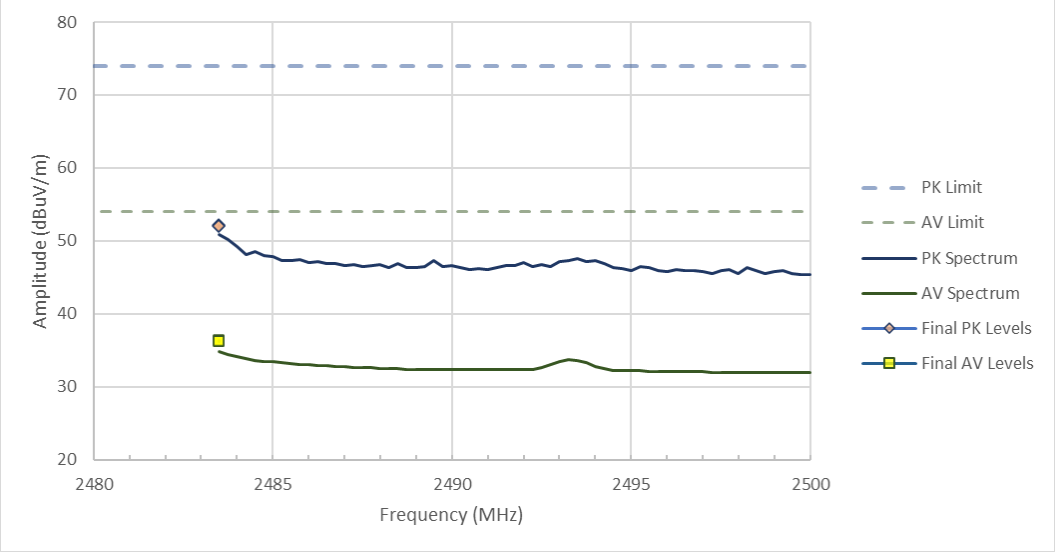


Figure RE09.2: Spectral data FCC restricted band from 2483.5 to 2500 MHz (EDR 2)

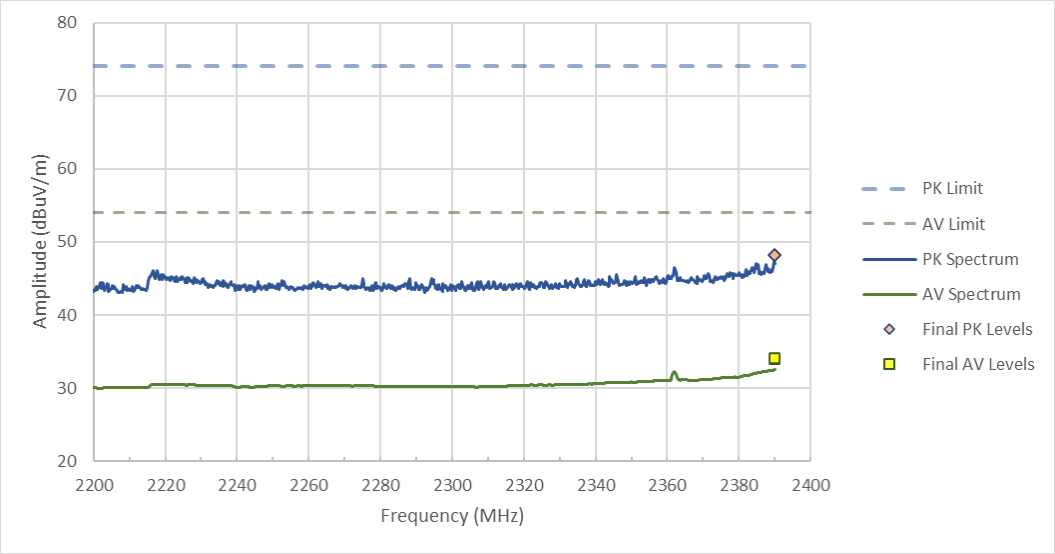


Figure RE09.3: Spectral data FCC restricted band from 2200 to 2390 MHz (EDR 3)

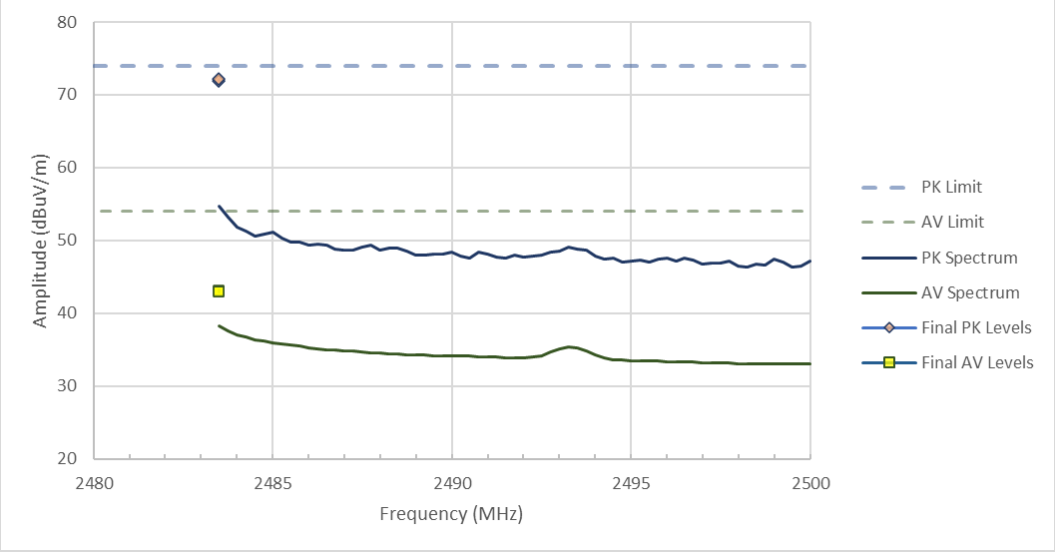


Figure RE09.4: Spectral data FCC restricted band from 2483.5 to 2500 MHz (EDR 3)

Setup Photographs

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

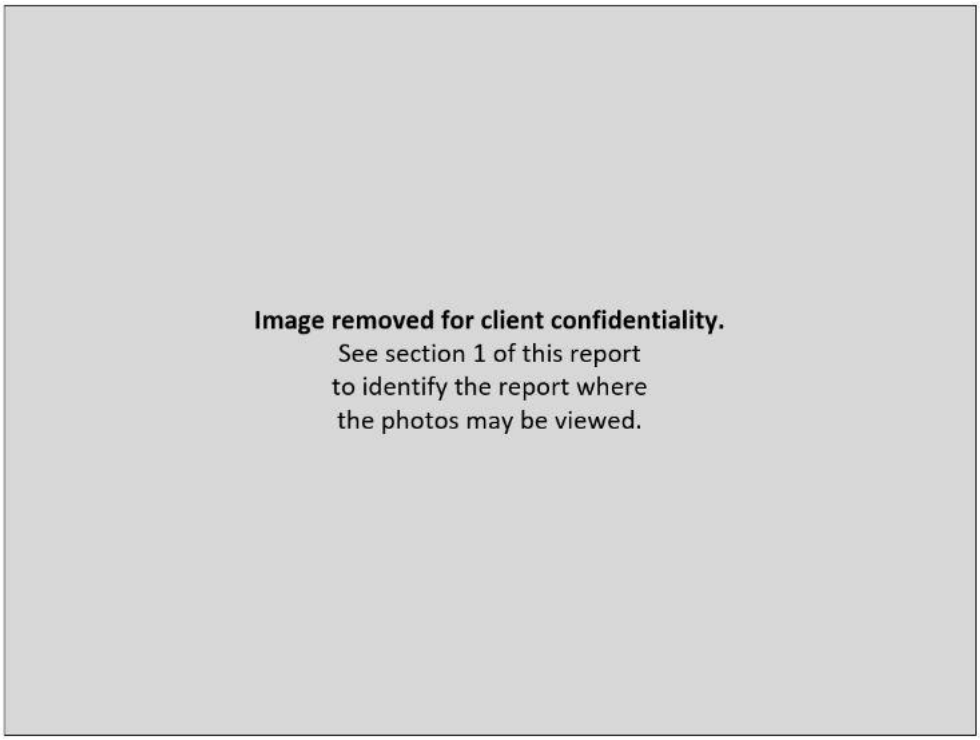


Figure RE09.5: EUT test setup, front view (Z orientation)

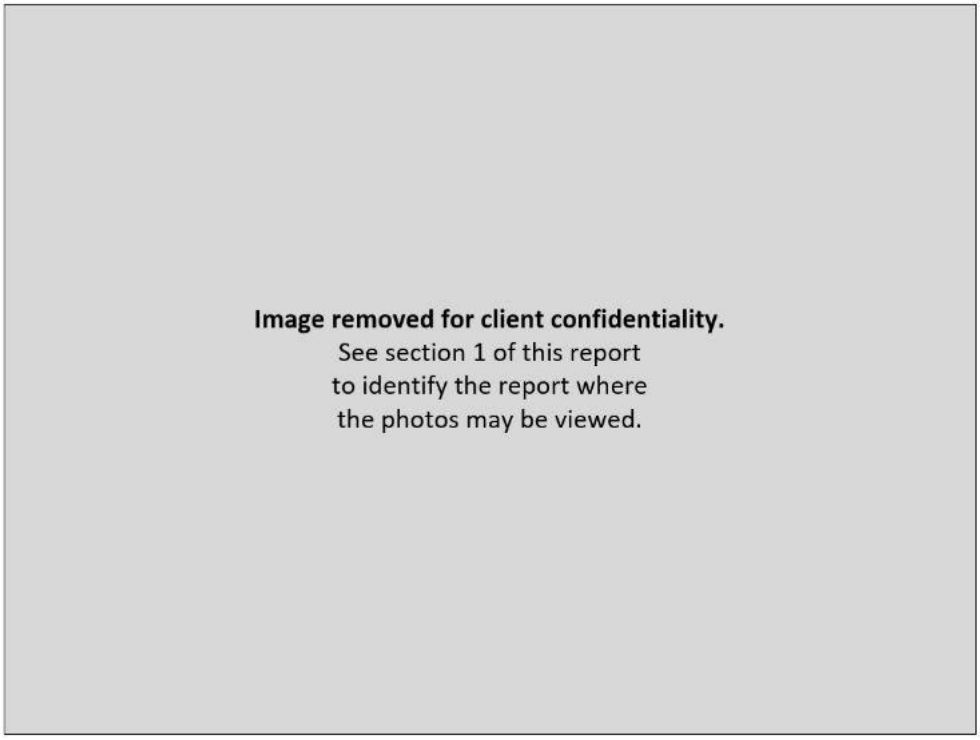


Figure RE09.6: EUT test setup, reverse view (Z orientation)

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test IDs TR6, TR7 and TR8
Project GCL-0304

Test Date(s)	10 Mar 2023
Test Personnel	Majid Farah
Product Model	A04331
Serial Number tested	3437296908
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:	**24 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.

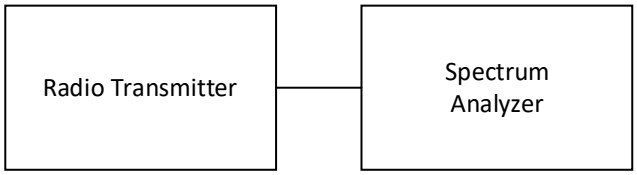


Figure TR6.1: Test setup

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	**0.96**	**NT**	**1.38**	**NT**	**1.16**
Bluetooth EDR2	**-4.56**	**NT**	**-4.13**	**NT**	**-4.40**
Bluetooth EDR3	**-4.86**	**NT**	**-4.49**	**NT**	**-4.36**
BLE 1 Mbps	**-17.71**	**NT**	**-13.86**	**NT**	**-16.06**
BLE 2 Mbps	**NT**	**-13.55**	**-14.41**	**-18.05**	**NT**
ANT	**-17.80**	**NT**	**-11.20**	**NT**	**-16.10**

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.

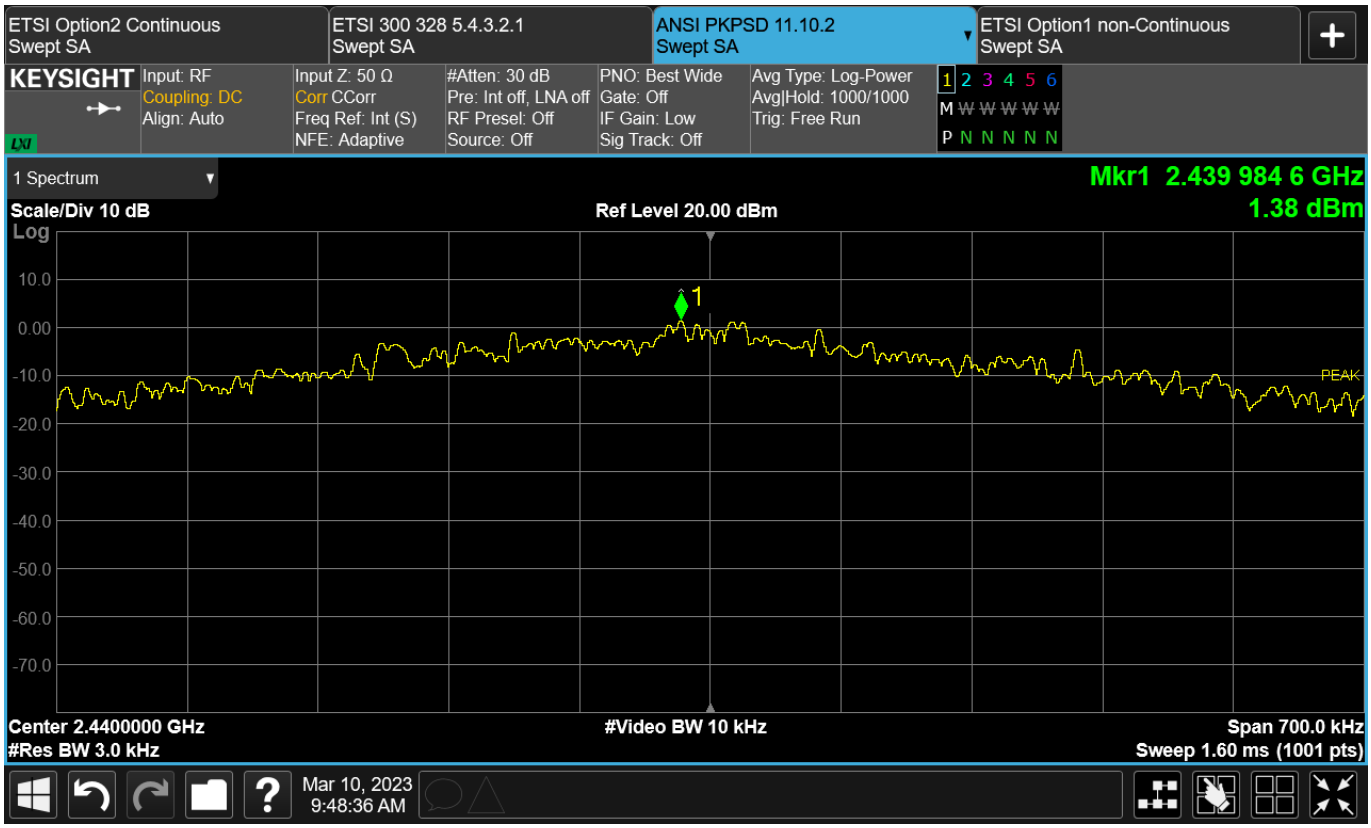


Figure TR6.2: Test data for Bluetooth BR on 2440 MHz

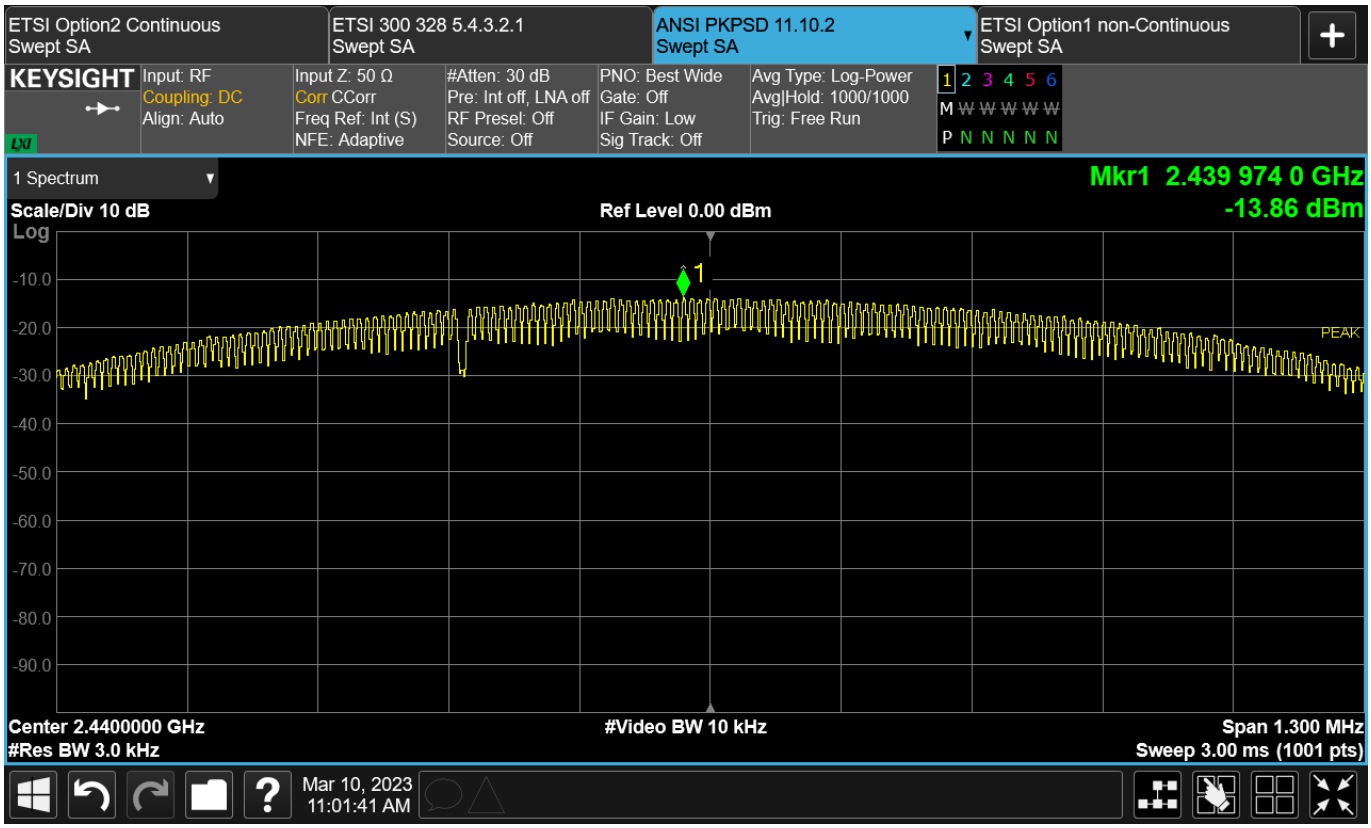


Figure TR6.3: Test data for BLE 1 Mbps on 2440 MHz

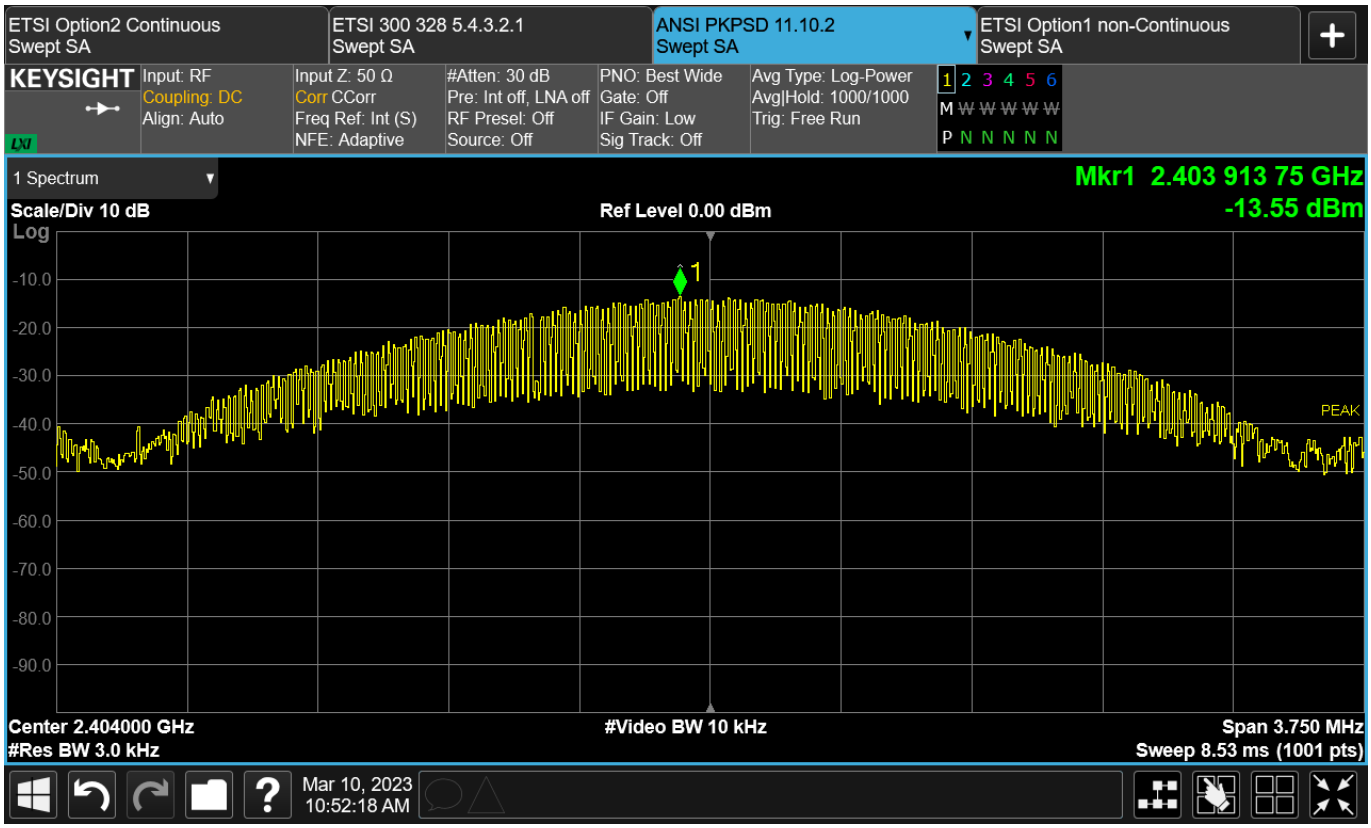


Figure TR6.4: Test data for BLE 2 Mbps on 2404 MHz

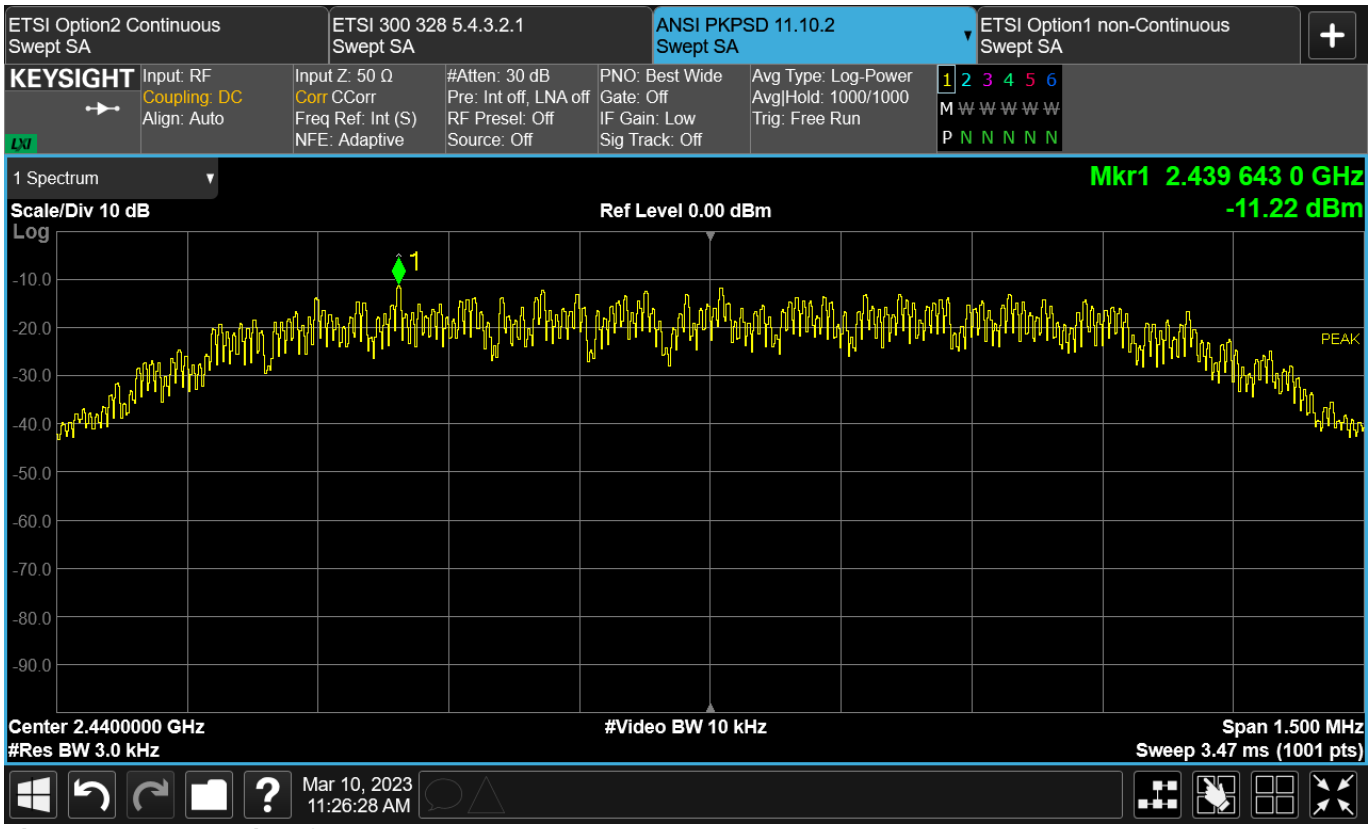


Figure TR6.5: Test data for ANT on 2440 MHz

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test IDs TR9
Project GCL-0304

Test Date(s)	3,6,9 and 24 Mar 2023
Test Personnel	Majid Farah
Product Model	A04331
Serial Number tested	3437296908
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:	**24 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.

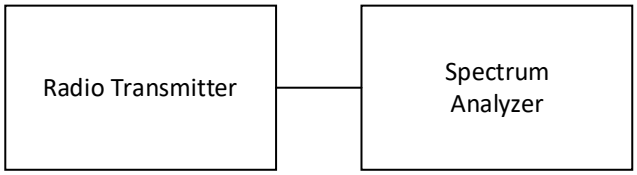


Figure TR9.1: Test setup

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	**-6.06**	**3.93**	**1.35**	**-3.47**	**-5.00**
B	2	**-2.53**	**-0.95**	**-2.82**	**-8.55**	**-9.92**
B	11	**-6.34**	**-5.31**	**-7.06**	**-12.28**	**-13.98**
G	6	**-11.67**	**-4.06**	**-8.76**	**-14.73**	**-16.11**
G	54	**-13.57**	**-9.30**	**-10.57**	**-14.36**	**-15.69**
N	MCS0	**-13.44**	**-5.26**	**-11.80**	**-14.69**	**-15.96**
N	MCS2	**-12.58**	**-4.05**	**-11.00**	**-13.10**	**-14.64**
N	MCS7	**-14.09**	**-12.02**	**-12.14**	**-14.22**	**-15.01**

Table TR9.2: Summary of results

.

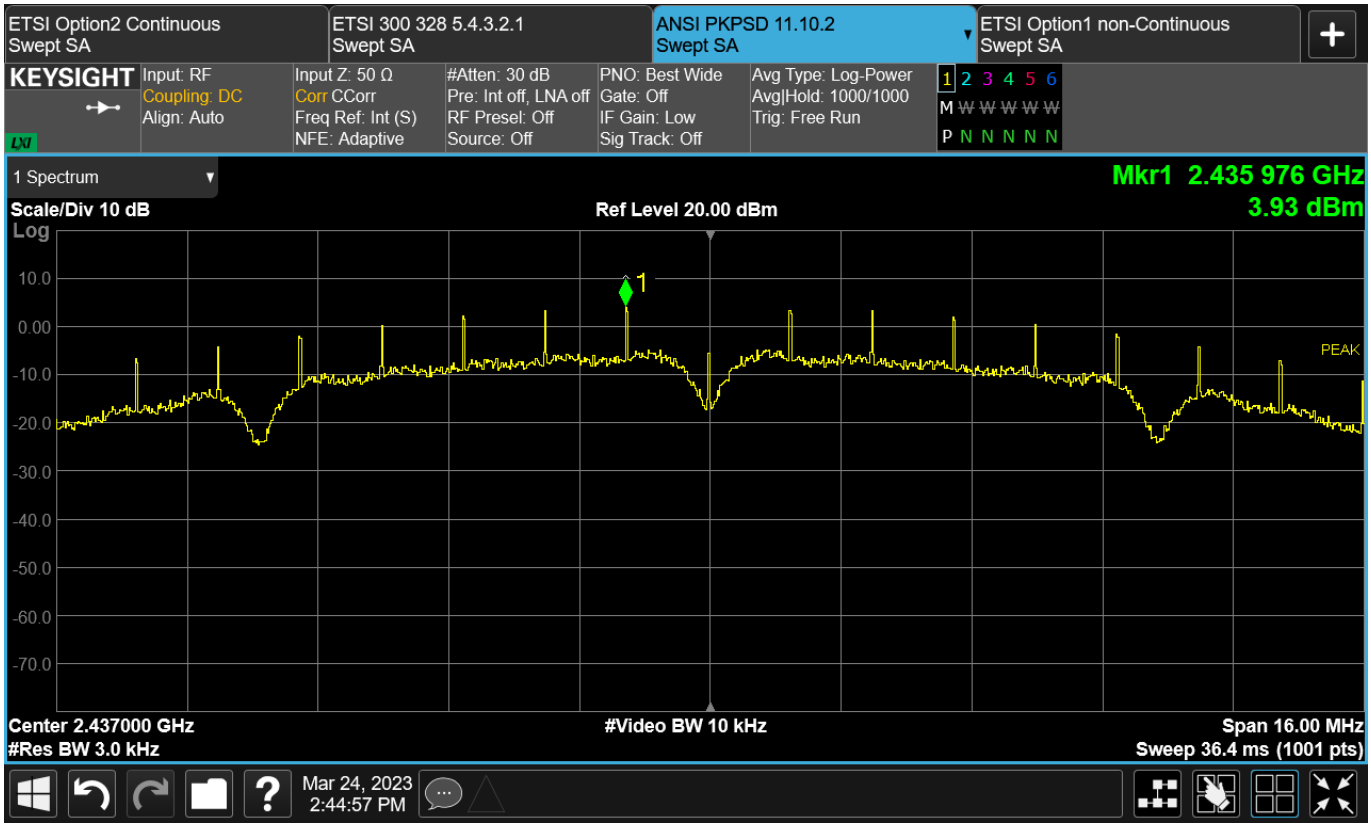


Figure TR9.2: Test data for IEEE 802.11 b 1 Mbps on Ch. 6

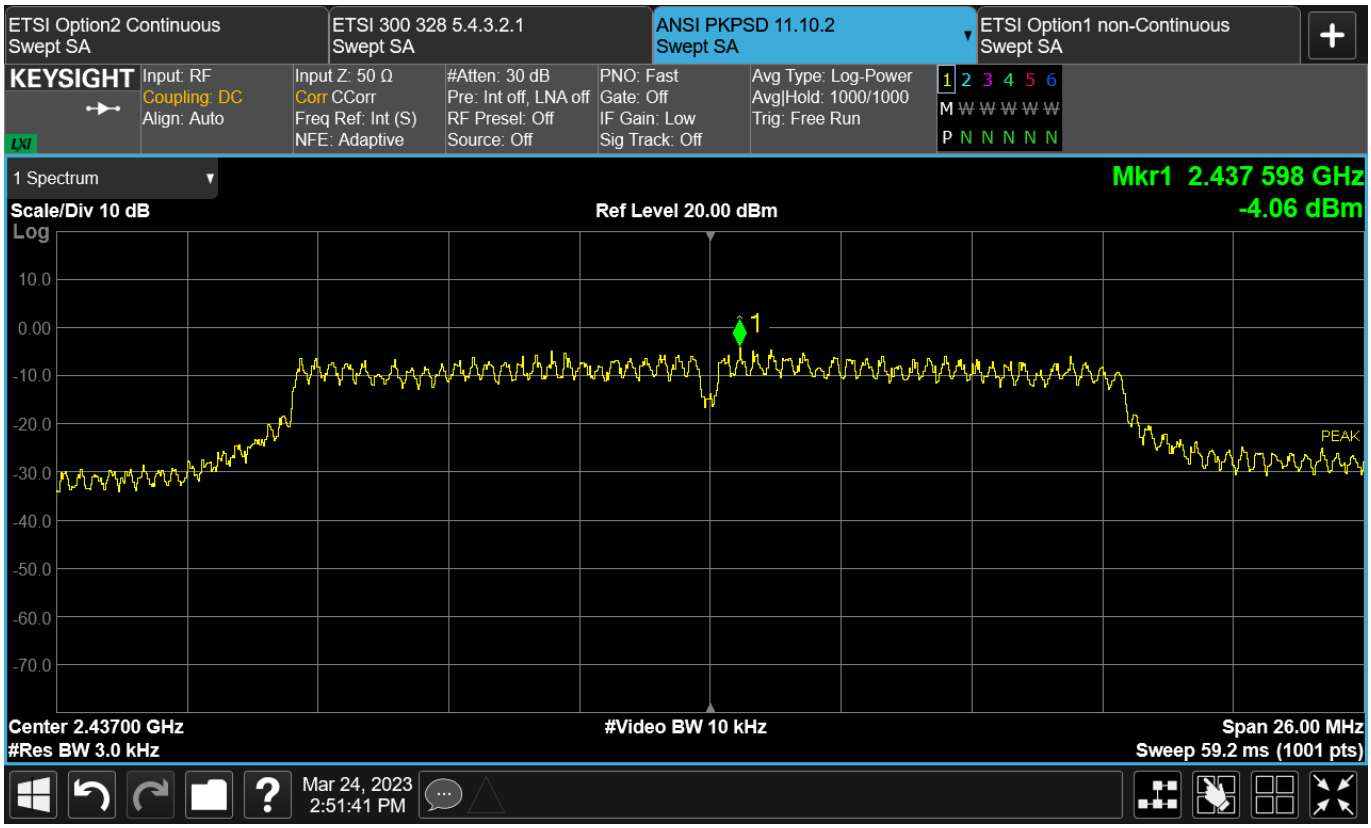


Figure TR9.3: Test data for IEEE 802.11 g 6 Mbps on Ch. 6

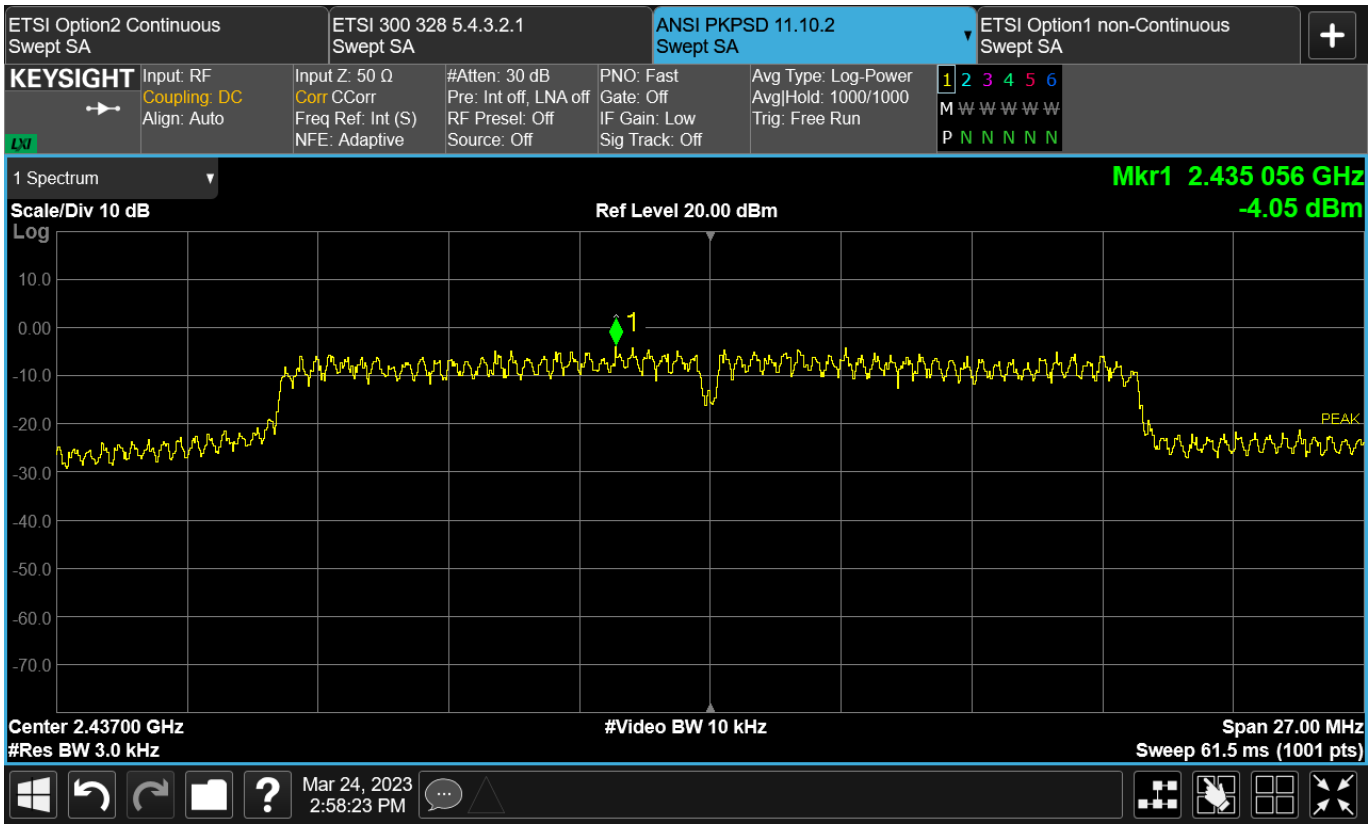


Figure TR9.4: Test data for IEEE 802.11 n MCS2 on Ch. 6
This line is the end of the test record.

Test Record
Transmitter Frequency Stability
Test IDs TR33, TR34 and TR35
Project GCL-0304

Test Date(s)	17 and 20 Mar 2023
Test Personnel	Majid Farah
Product Model	A04331
Serial Number tested	3437296908
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**
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	28.6	47.8
BT EDR2	40	5	27.4	48.3
BT EDR2	30	5	28.0	50.3
BT EDR2	20	5	27.5	49.8
BT EDR2	10	5	28.4	48.8
BT EDR2	0	5	28.6	50.4
BT EDR2	-10	5	29.2	51.7
BT EDR2	-20	5	29.4	51.9

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

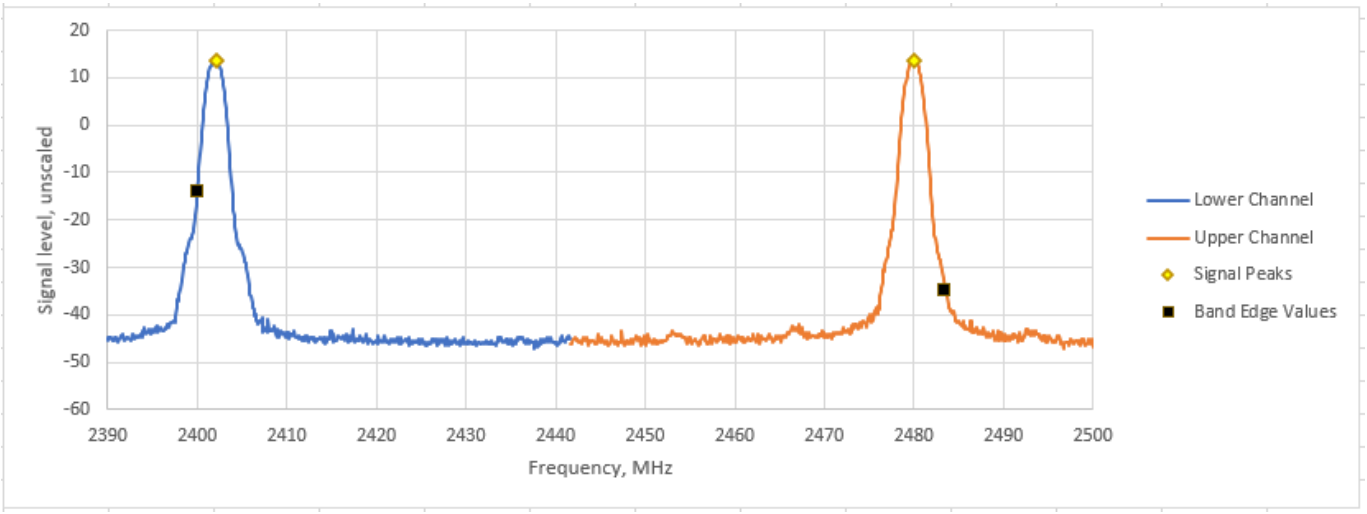


Figure TR33.1: Spectral data for Bluetooth EDR2 at 40 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
BT EDR2	20	4.25	27.2	49.4
BT EDR2	20	5	27.5	49.8
BT EDR2	20	5.75	27.5	49.1

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

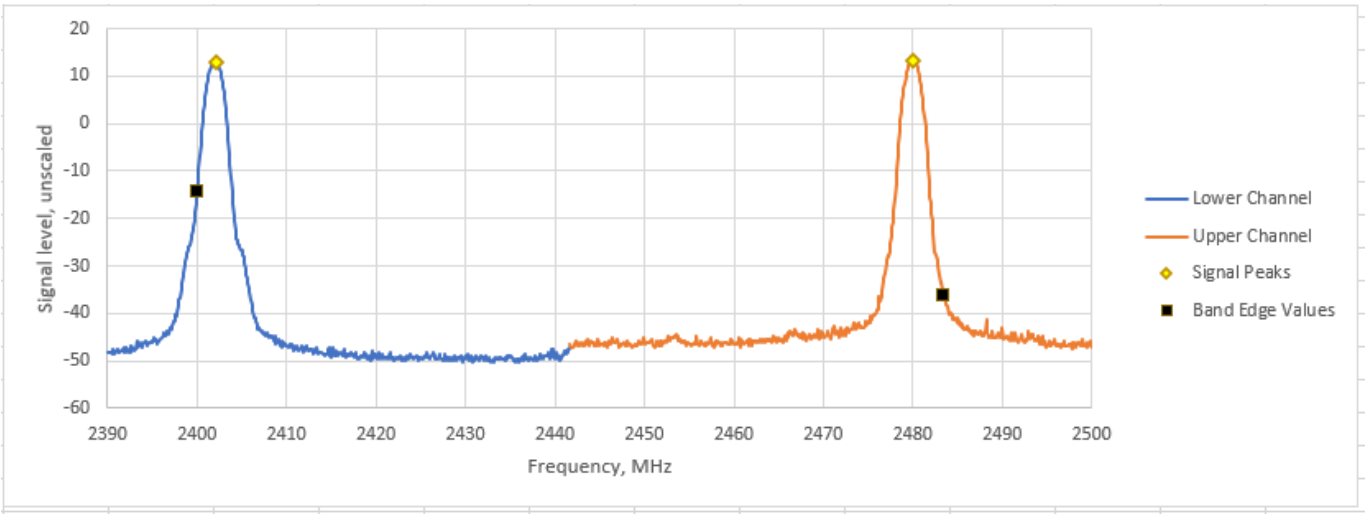


Figure TR33.2: Spectral data for Bluetooth EDR2 at 20 °C and 4.25 Vdc

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
BLE 1 Mbps	50	5	22.9	40.8
BLE 1 Mbps	40	5	23.4	41.5
BLE 1 Mbps	30	5	24.1	41.3
BLE 1 Mbps	20	5	22.6	42.9
BLE 1 Mbps	10	5	23.0	40.2
BLE 1 Mbps	0	5	23.7	41.4
BLE 1 Mbps	-10	5	39.6	41.3
BLE 1 Mbps	-20	5	23.9	42.1

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

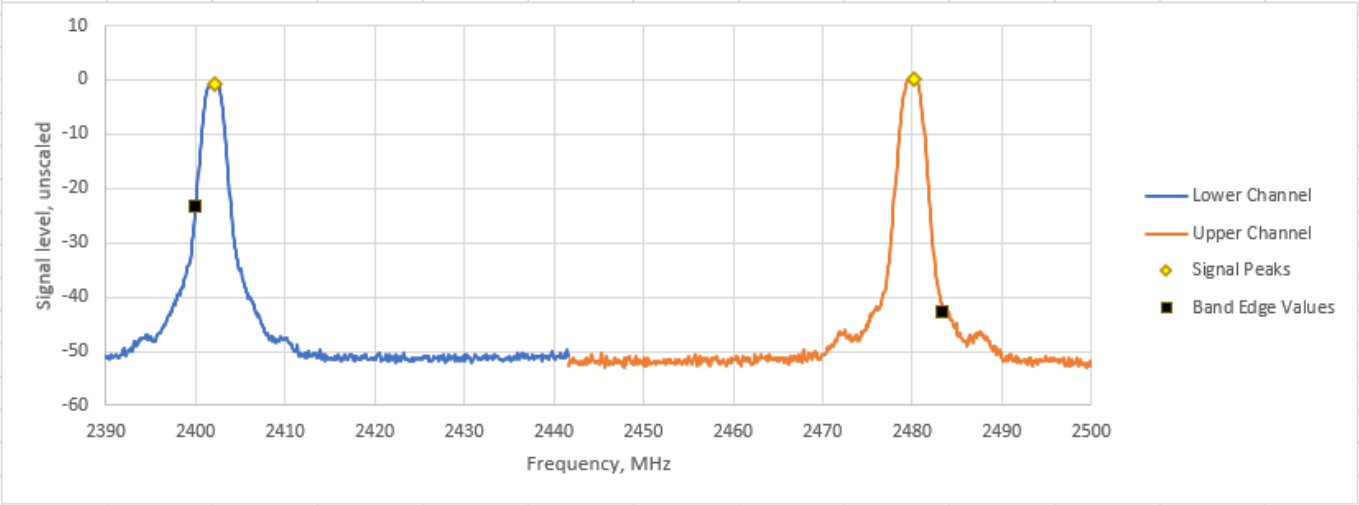


Figure TR33.3: Spectral data for BLE 1 Mbps at 20 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
BLE 1 Mbps	20	4.25	23.7	41.7
BLE 1 Mbps	20	5	22.6	42.9
BLE 1 Mbps	20	5.75	23.1	42.8

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

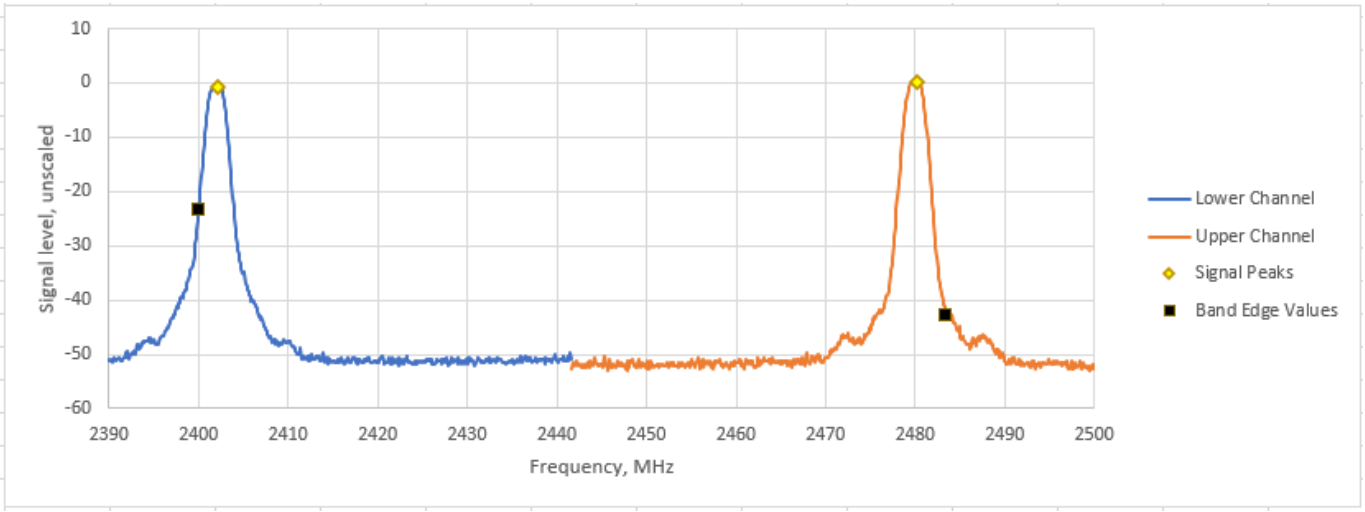


Figure TR33.4: Spectral data for BLE 1 Mbps at 20 °C and 5 Vdc

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
BLE 2 Mbps	50	5	33.3	38.9
BLE 2 Mbps	40	5	33.1	37.5
BLE 2 Mbps	30	5	34.0	38.2
BLE 2 Mbps	20	5	33.5	37.8
BLE 2 Mbps	10	5	34.0	37.6
BLE 2 Mbps	0	5	35.8	36.6
BLE 2 Mbps	-10	5	33.6	38.2
BLE 2 Mbps	-20	5	33.8	38.1

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

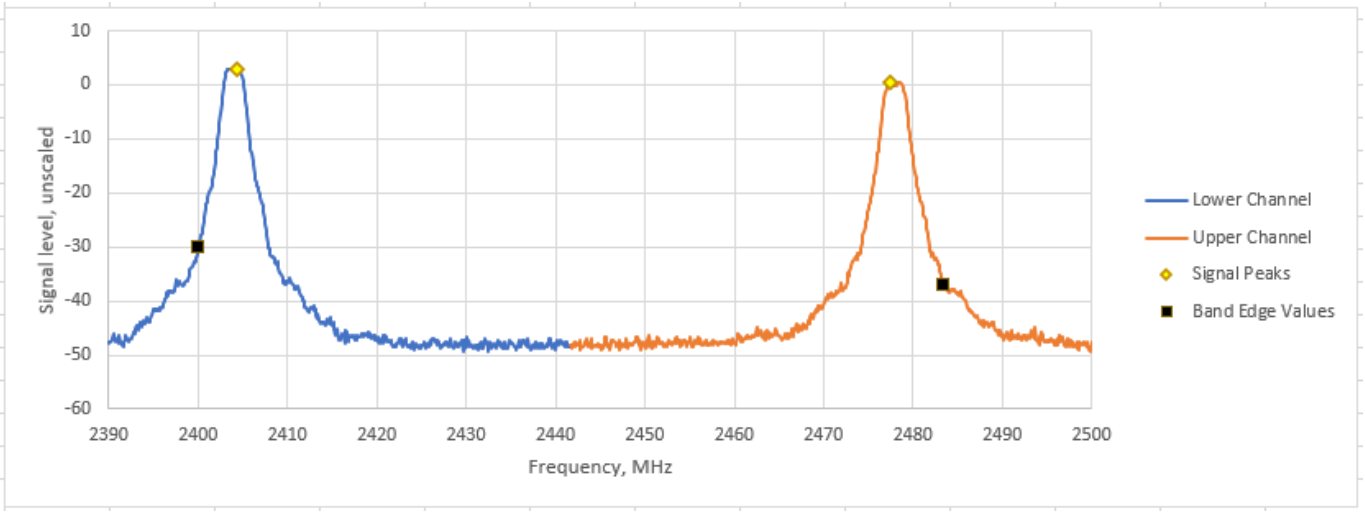


Figure TR33.5: Spectral data for BLE 2 Mbps at 40 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
BLE 2 Mbps	20	4.25	33.3	37.3
BLE 2 Mbps	20	5	33.5	37.8
BLE 2 Mbps	20	5.75	32.6	37.8

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

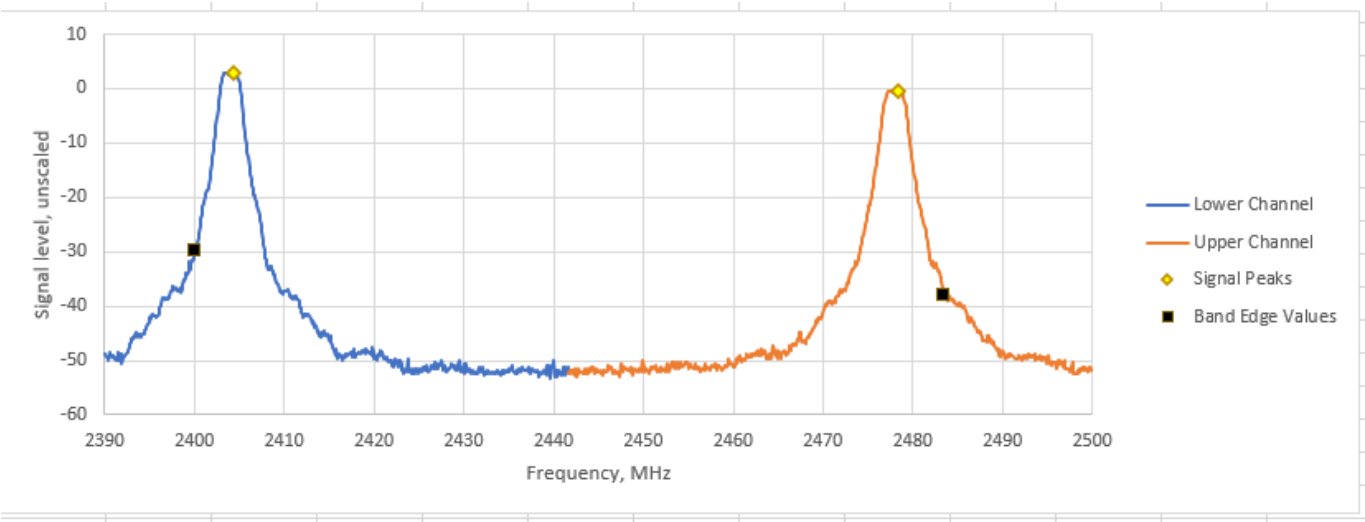


Figure TR33.6: Spectral data for BLE 2 Mbps at -20 °C and 5.75 Vdc

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
ANT	50	5	23.7	41.2
ANT	40	5	25.2	43.0
ANT	30	5	25.1	43.8
ANT	20	5	24.0	41.5
ANT	10	5	24.0	42.6
ANT	0	5	25.9	41.6
ANT	-10	5	25.3	43.5
ANT	-20	5	24.3	41.7

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

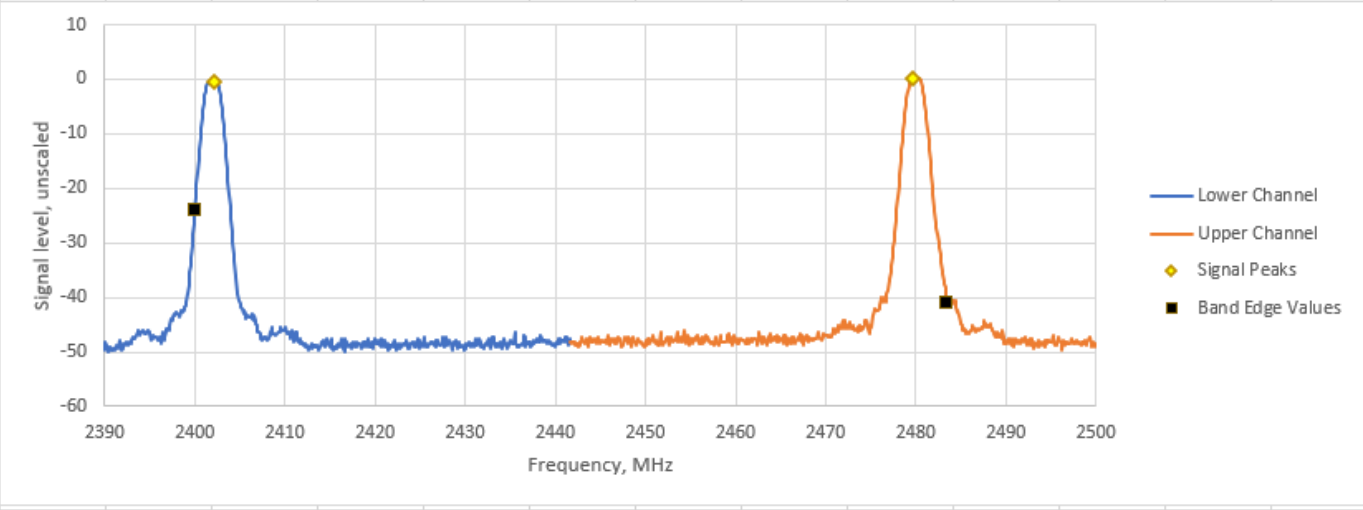


Figure TR33.7: Spectral data for ANT at 50 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	˚C	Vdc	dBc	dBc
ANT	20	4.25	24.2	40.5
ANT	20	5	24.0	41.5
ANT	20	5.75	24.2	41.6

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

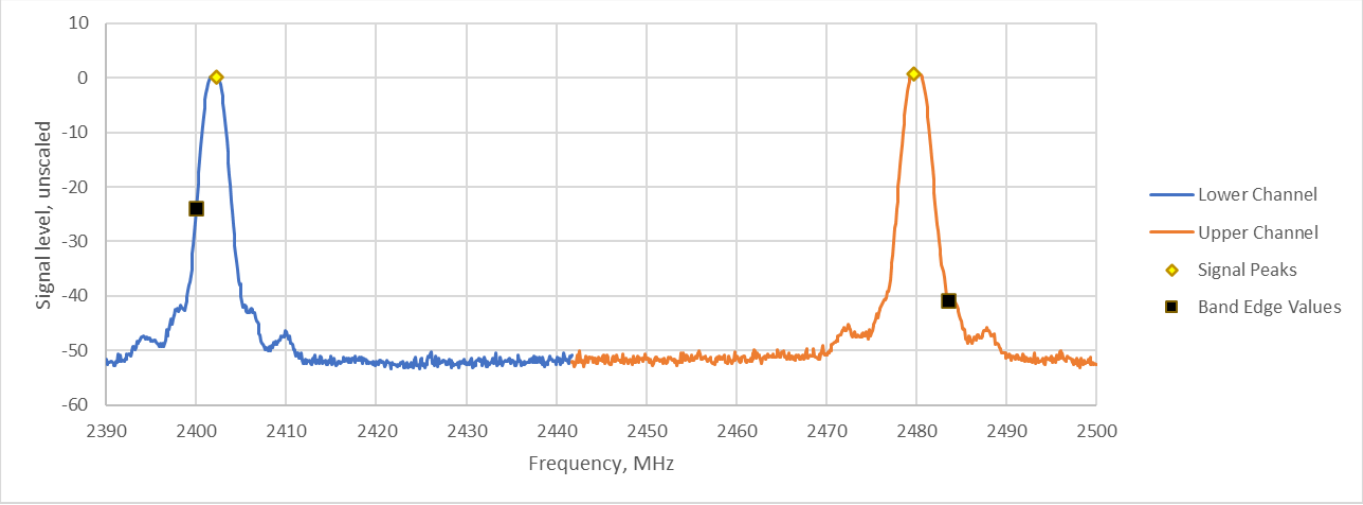


Figure TR33.8: Spectral data for ANT at 20 °C and 5 Vdc

Setup Block Diagram

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

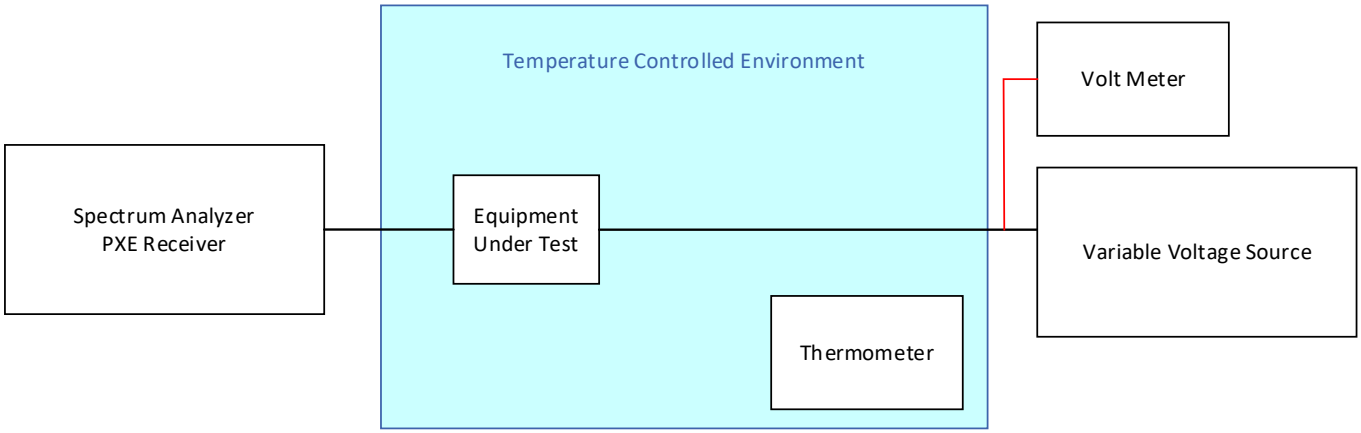


Figure TR33.9: Schematic drawing of the test equipment setup for Bluetooth, BLE and ANT

This line is the end of the test record.

Test Record
Transmitter Frequency Stability
Test IDs TR36
Project GCL-0304

Test Date(s)	17 and 20 Mar 2023
Test Personnel	Majid Farah
Product Model	A04331
Serial Number tested	3437296908
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**
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, g9 and n MCS5 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	38.6	48.0	43.8
B 1 Mbps	40	5	37.2	43.7	43.4
B 1 Mbps	30	5	37.6	48.7	43.7
B 1 Mbps	20	5	36.2	47.8	43.3
B 1 Mbps	10	5	35.7	47.4	44.0
B 1 Mbps	0	5	38.2	48.8	43.8
B 1 Mbps	-10	5	37.8	48.2	43.2
B 1 Mbps	-20	5	37.3	48.4	43.9

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

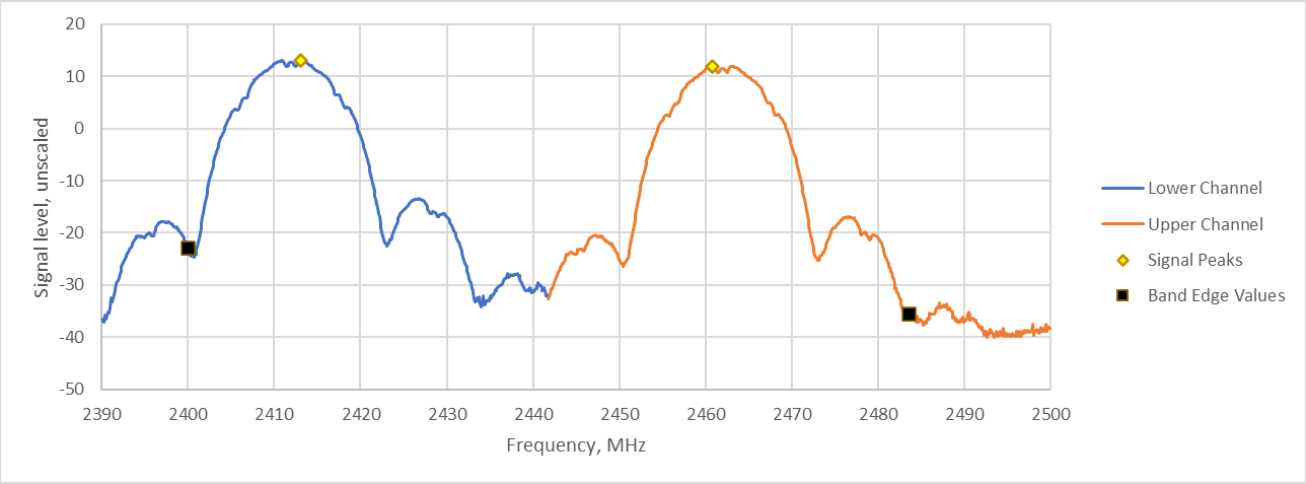


Figure TR36.1: Spectral data for IEEE 802.11 b 1 Mbps at 10 °C which represent Ch1 and Ch11

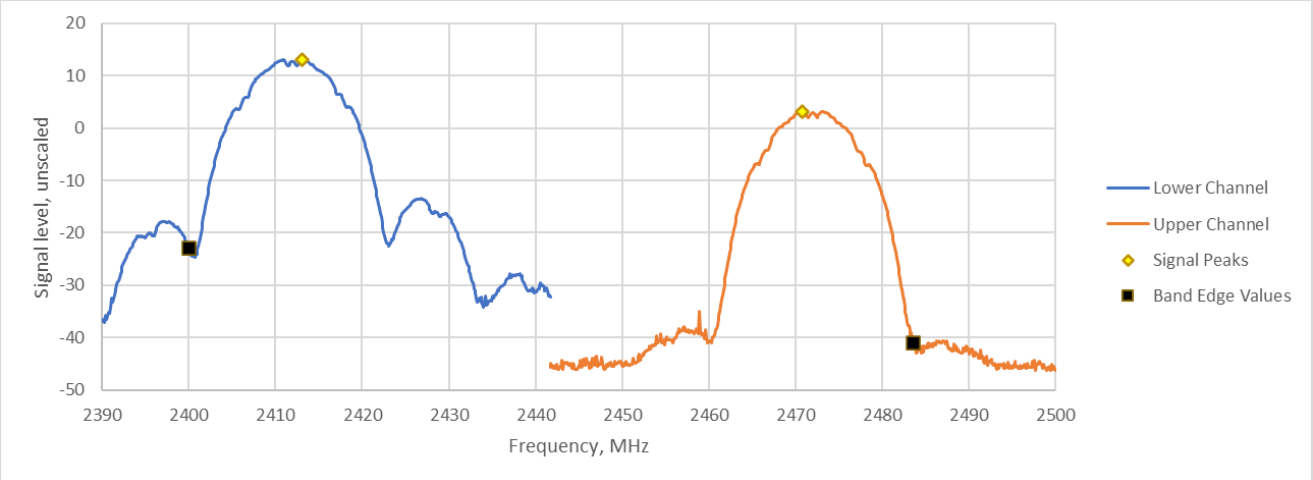


Figure TR36.2: Spectral data for IEEE 802.11 b 1 Mbps at 10 °C which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
B 1 Mbps	20	4.25	36.8	44.8	44.2
B 1 Mbps	20	5	36.2	47.8	43.3
B 1 Mbps	20	5.75	36.7	48.4	44.5

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

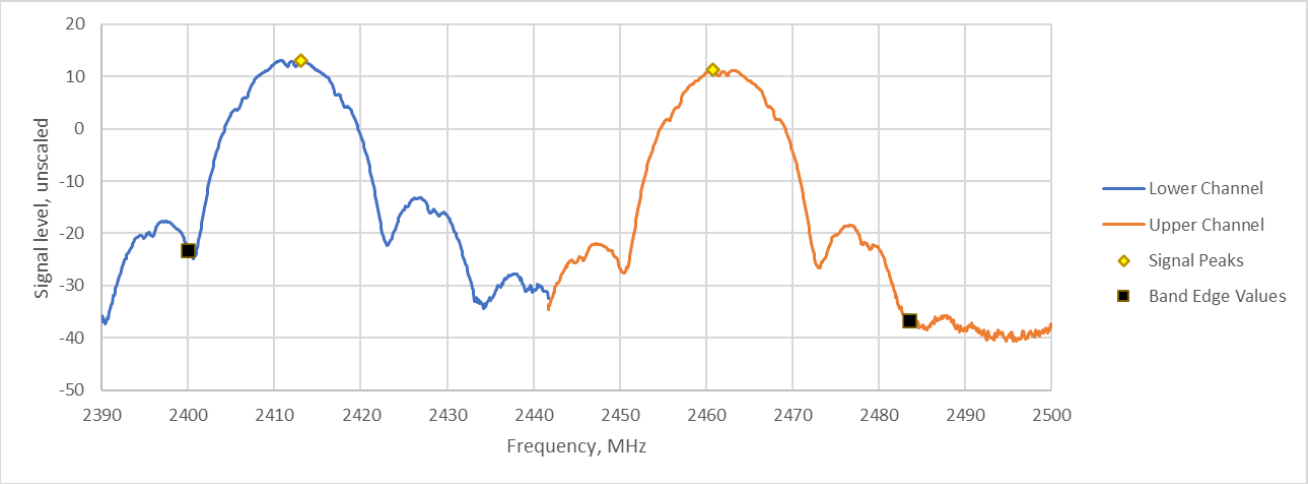


Figure TR36.3: Spectral data for IEEE 802.11 b 1 Mbps at 20 °C and 5 Vdc which represent Ch1 and Ch11

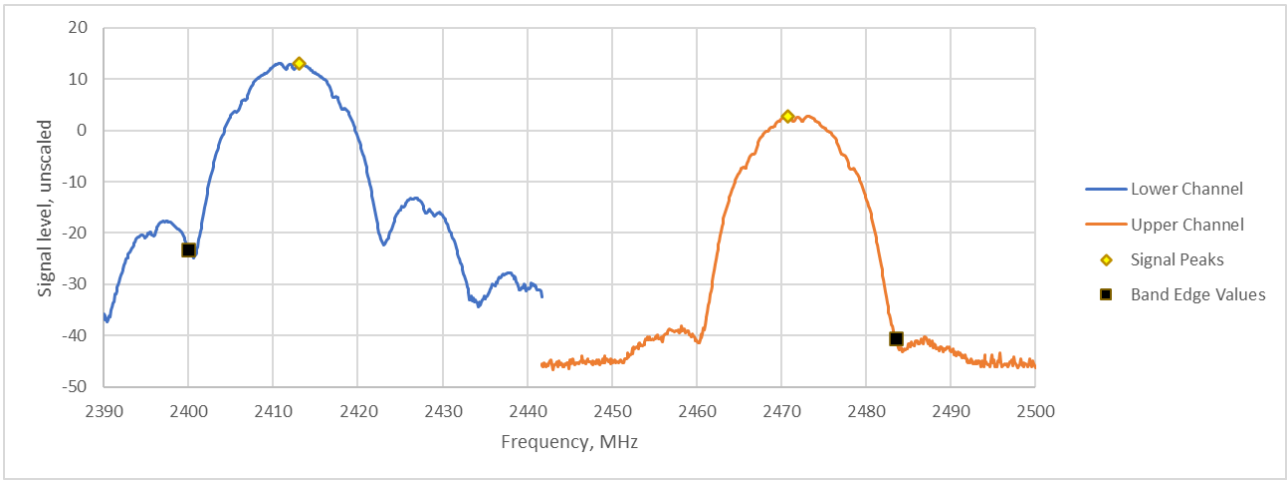


Figure TR36.4: Spectral data for IEEE 802.11 b 1 Mbps at 20 °C and 5 Vdc which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
G 9 Mbps	50	5	37.4	33.1	42.0
G 9 Mbps	40	5	37.5	36.5	42.3
G 9 Mbps	30	5	38.1	36.8	49.4
G 9 Mbps	20	5	38.9	33.0	42.5
G 9 Mbps	10	5	38.1	33.9	42.2
G 9 Mbps	0	5	38.2	32.9	40.7
G 9 Mbps	-10	5	36.9	33.8	40.6
G 9 Mbps	-20	5	36.7	37.0	39.4

Table TR36.4 Difference between peak and band edge levels for IEEE 802.11 g 9 Mbps transmissions during temperature variations

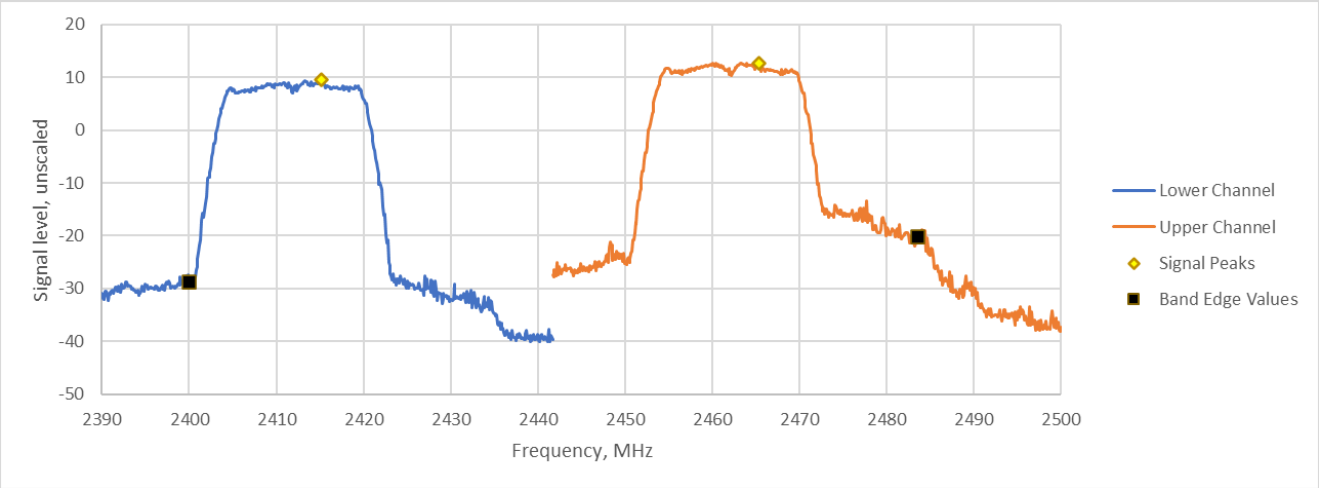


Figure TR36.5: Spectral data for IEEE 802.11 g 9 Mbps at 0 °C which represent Ch1 and Ch11

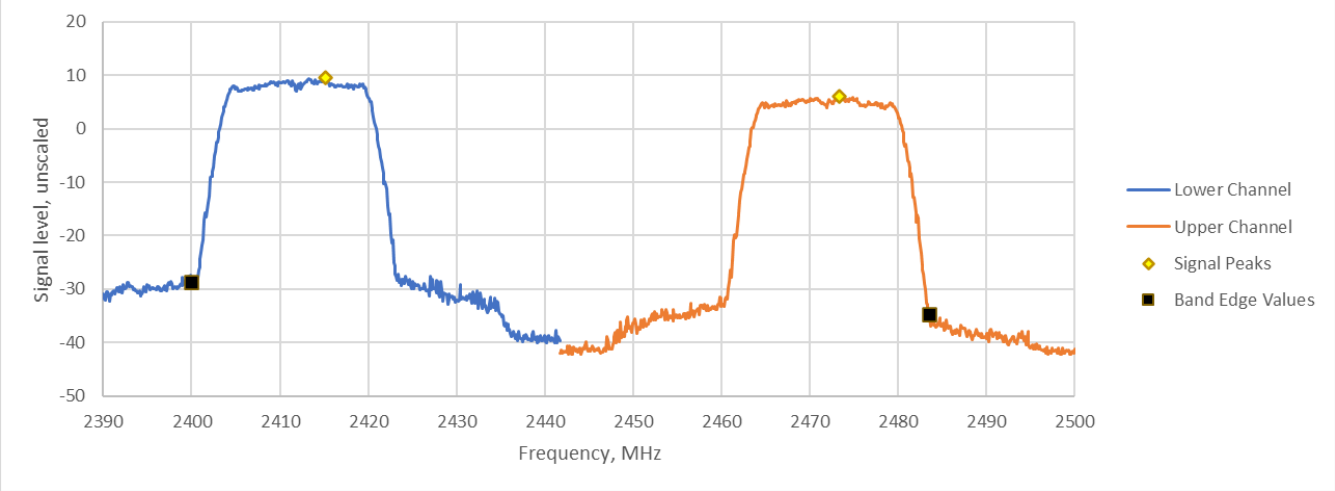


Figure TR36.6: Spectral data for IEEE 802.11 g 9 Mbps at 0 °C which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
G 9 Mbps	20	4.25	38.7	36.8	42.0
G 9 Mbps	20	5	38.9	33.0	42.5
G 9 Mbps	20	5.75	38.5	34.8	42.5

Table TR36.5 Difference between peak and band edge levels for IEEE 802.11 g 9 Mbps transmissions at 20 °C during voltage variations

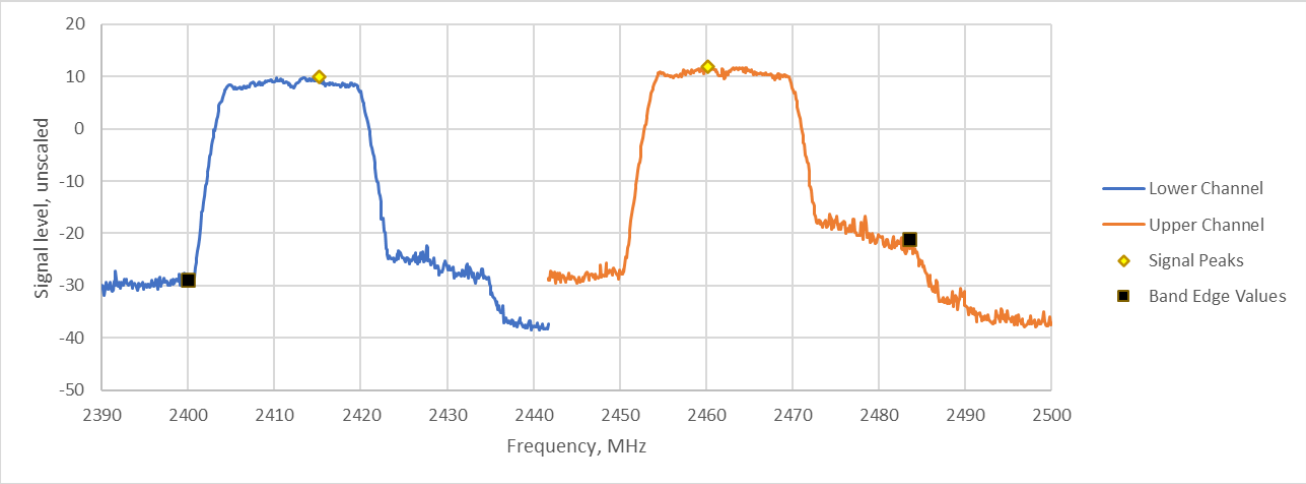


Figure TR36.7: Spectral data for IEEE 802.11 g 9 Mbps at 20 °C and 5 Vdc which represent Ch1 and Ch11

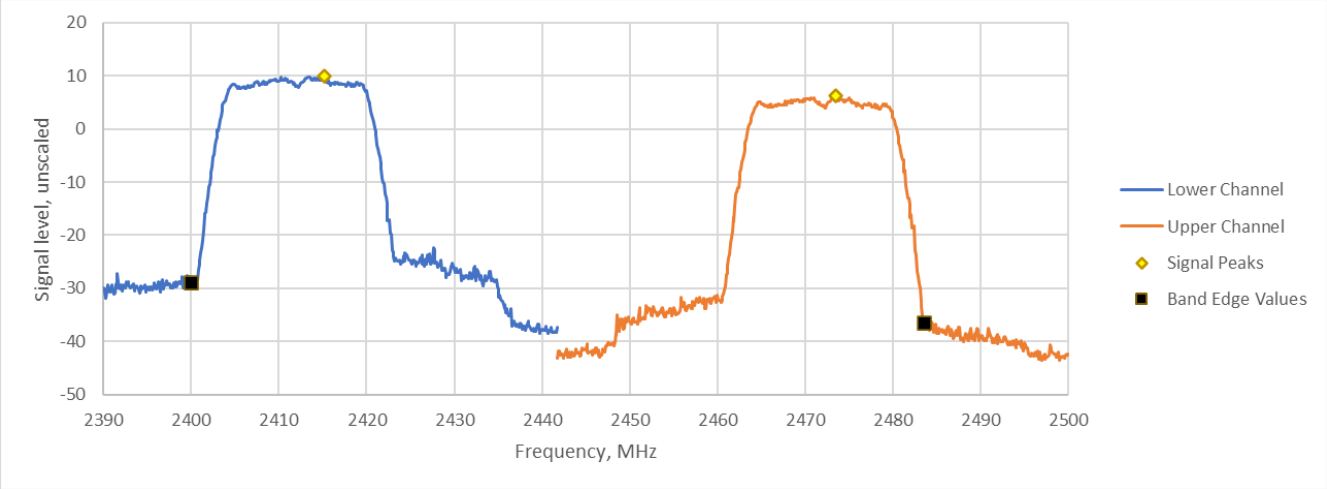


Figure TR36.8: Spectral data for IEEE 802.11 g 9 Mbps at 20 °C and 5 Vdc which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
N MCS5	50	5	33.7	33.9	35.7
N MCS5	40	5	35.6	35.6	37.7
N MCS5	30	5	33.2	33.5	34.9
N MCS5	20	5	31.0	32.9	31.7
N MCS5	10	5	31.9	33.9	30.2
N MCS5	0	5	29.9	35.2	31.6
N MCS5	-10	5	27.1	33.8	31.1
N MCS5	-20	5	28.5	33.3	31.5

Table TR36.6 Difference between peak and band edge levels for IEEE 802.11 n MCS5 transmissions during temperature variations

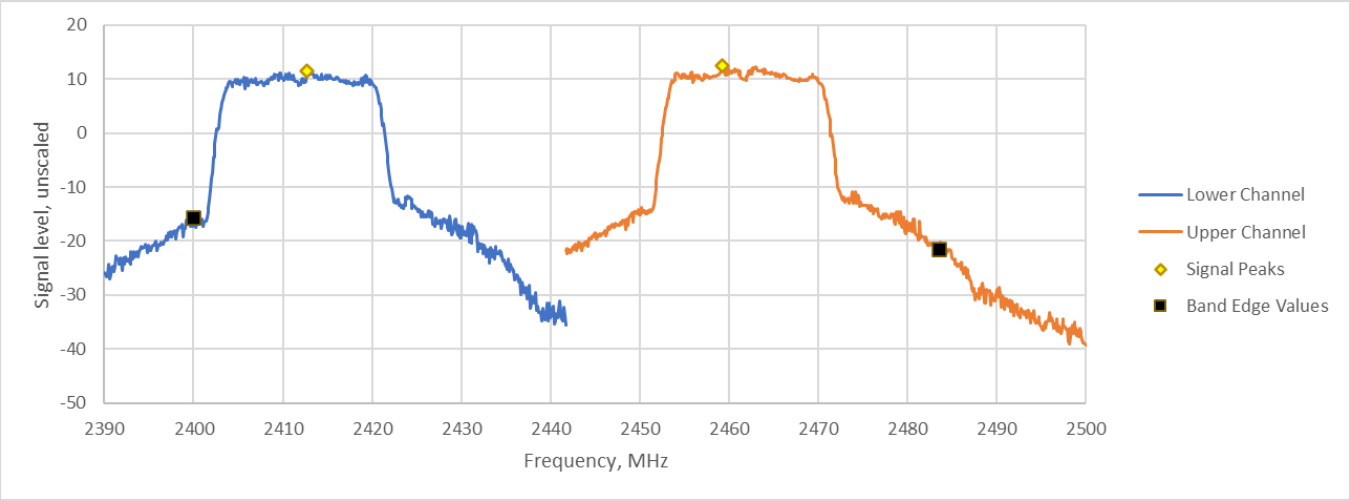


Figure TR36.9: Spectral data for IEEE 802.11 n MCS5 at -10 °C which represent Ch1 and Ch11

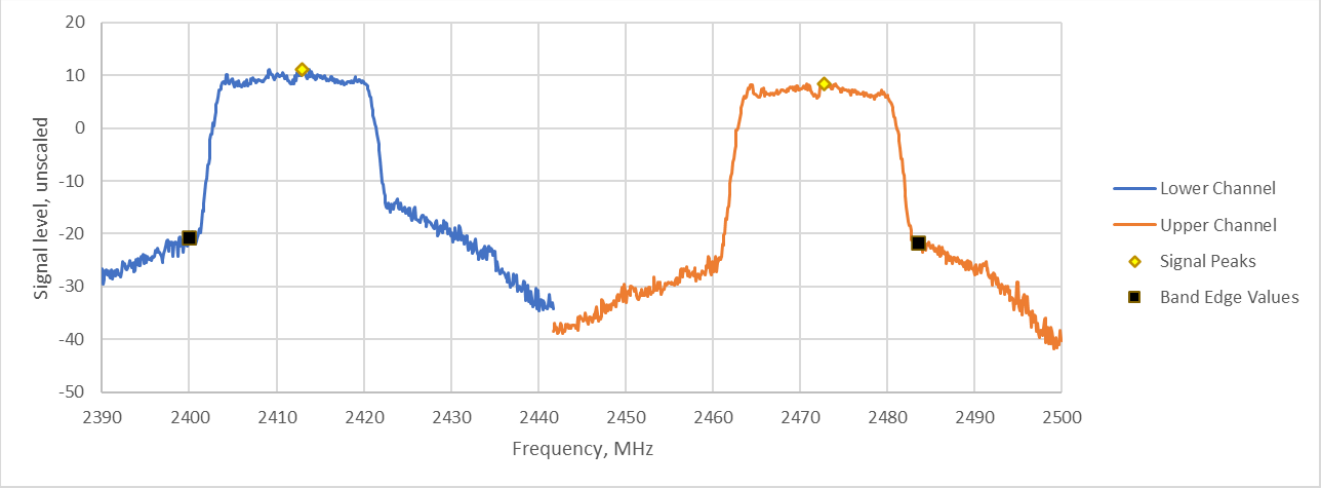


Figure TR36.10: Spectral data for IEEE 802.11 n MCS5 at -10 °C which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
N MCS5	20	4.25	31.8	32.8	33.0
N MCS5	20	5	31.0	32.9	31.7
N MCS5	20	5.75	30.3	34.6	33.3

Table TR36.7 Difference between peak and band edge levels for IEEE 802.11 n MCS5 transmissions at 20 °C during voltage variations

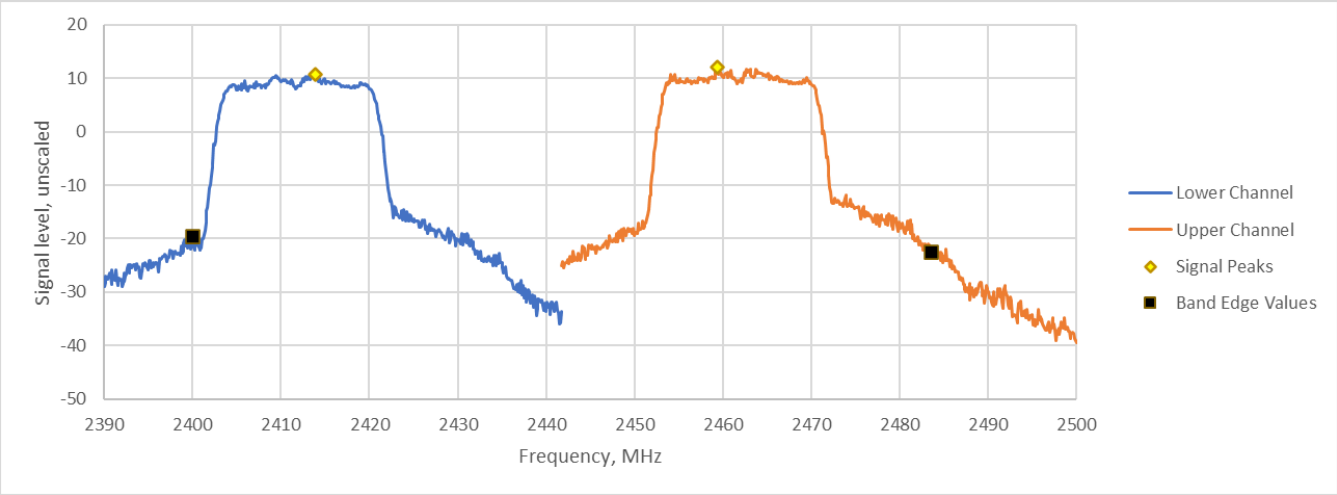


Figure TR36.11: Spectral data for IEEE 802.11 n MCS5 at 20 °C and 5.75 Vdc which represent Ch1 and Ch11

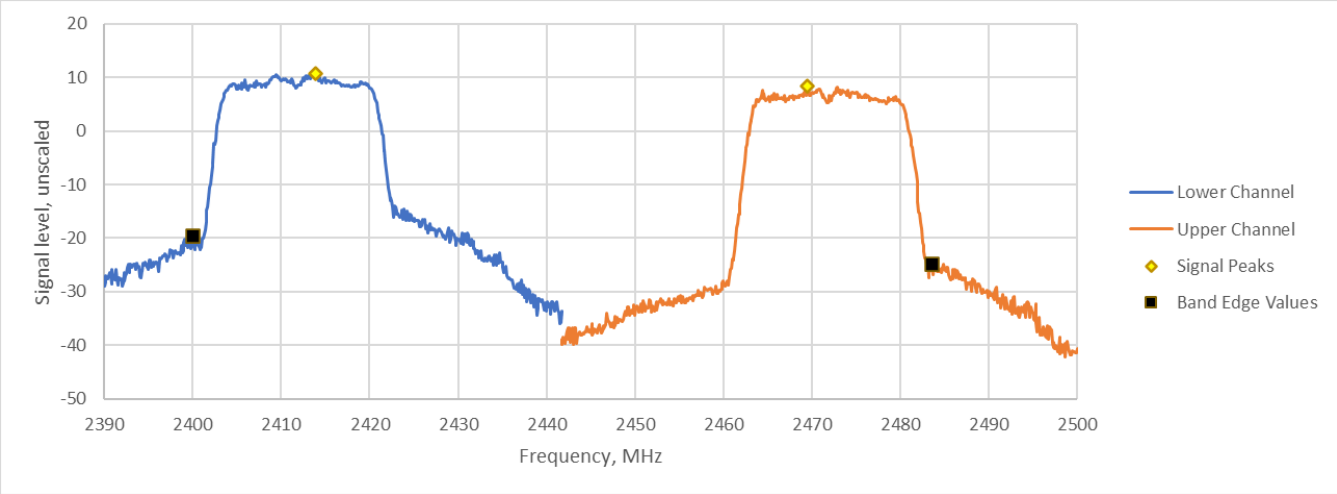


Figure TR36.12: Spectral data for IEEE 802.11 n MCS5 at 20 °C and 5.75 Vdc which represent Ch1 and Ch13

Setup Block Diagram

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

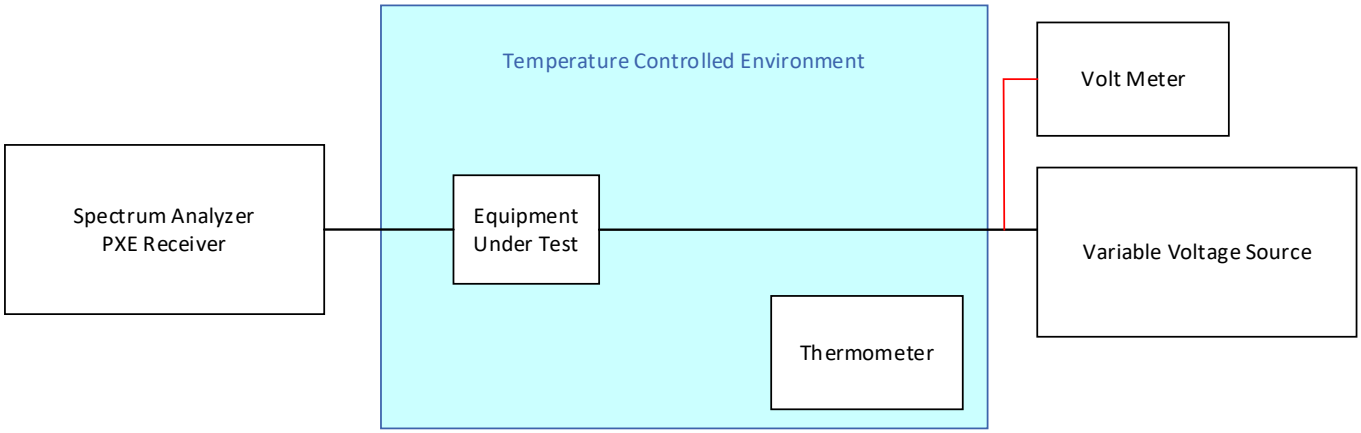


Figure TR36.13: Schematic drawing of the test equipment setup for WiFi (IEEE 802.11 b/g/n)

This line is the end of the test record.

Test Record
Other Bandwidth Tests
Test IDs TR15 (TR14 – TR17)
Project GCL0304

Test Date(s)	21 Feb, 24 Feb, 25 Mar2023
Test Personnel	Majid Farah, David Arnett
Product Model	A04331
Serial Number tested	3437296908
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.

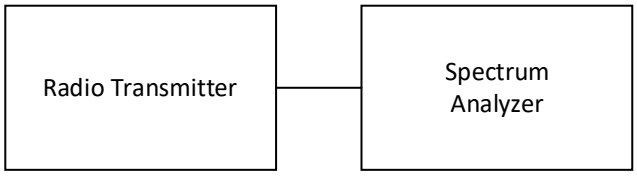


Figure TR15.1: Test setup

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	**911**	**911**	**903**
BTC	EDR2	**1205**	**1203**	**1203**
BTC	EDR3	**1192**	**1191**	**1191**
BLE	1 Mb	**1301**	**1375**	**1333**
BLE	2 Mb	**2462**	**2487**	**2535**
ANT	Fixed	**1293**	**1762**	**1811**

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	**15.640**	**15.494**	**15.224**	**14.972**	**14.979**
B	2	**15.658**				**14.944**
B	5.5	**14.661**				**14.774**
B	11	**14.969**	**15.060**	**14.874**	**14.781**	**14.773**
G	6	**17.061**	**20.583**	**17.104**	**17.050**	**17.060**
G	9	**17.082**				**17.056**
G	12	**16.829**				**16.825**
G	18	**16.768**				**16.775**
G	24	**16.826**				**16.809**
G	36	**16.940**				**16.909**
G	48	**16.804**				**16.843**
G	54	**16.861**	**17.237**	**16.928**	**16.857**	**16.839**
N	0	**17.742**	**23.718**	**17.727**	**17.704**	**17.702**
N	1	**17.687**				**17.652**
N	2	**17.694**				**17.651**
N	3	**17.692**				**17.651**
N	4	**17.715**				**17.676**
N	5	**17.766**				**17.751**
N	6	**17.734**				**17.683**
N	7	**17.663**	**17.699**	**17.706**	**17.654**	**17.645**

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 high channel (2478 MHz)

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

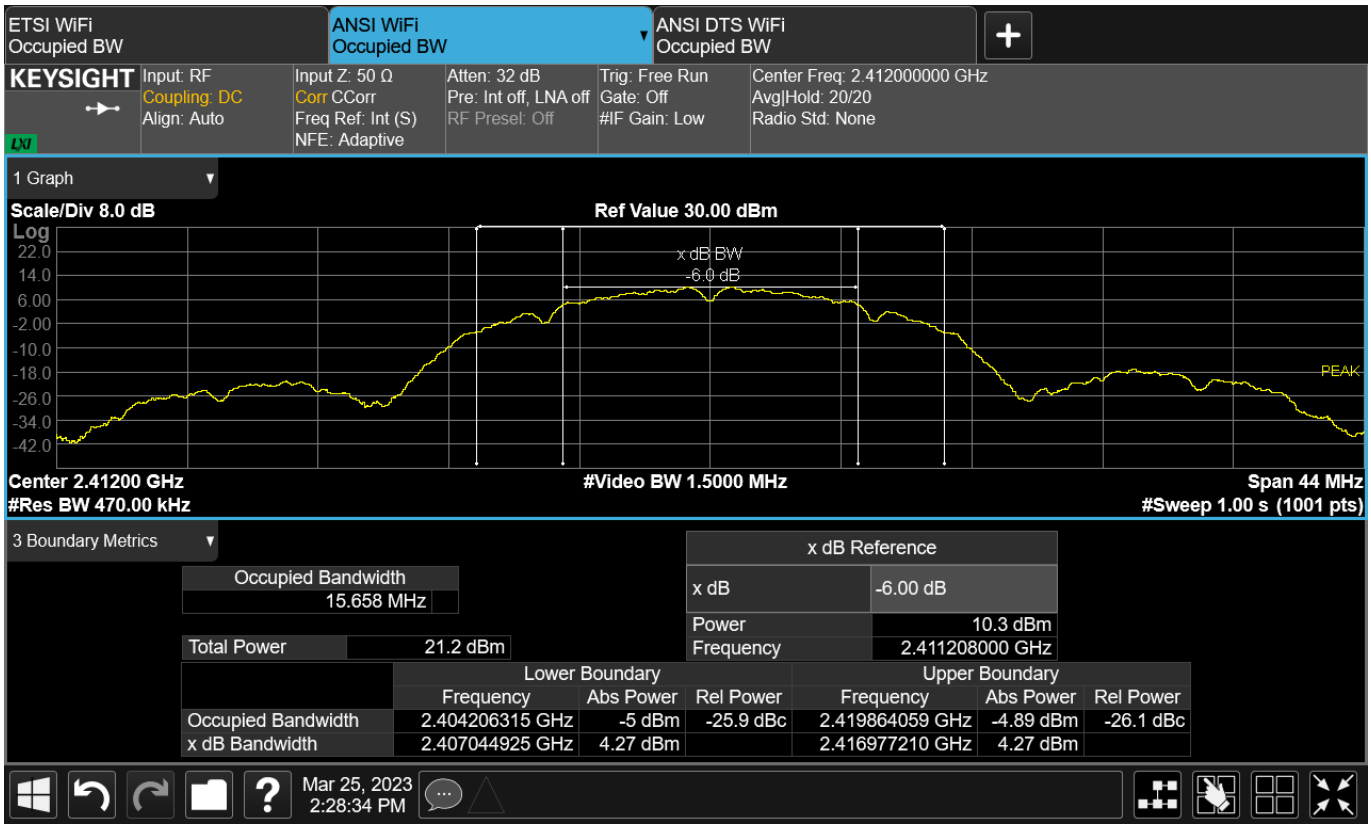


Figure TR15.4: Occupied bandwidth data for 802.11b 2 Mbps at channel 1

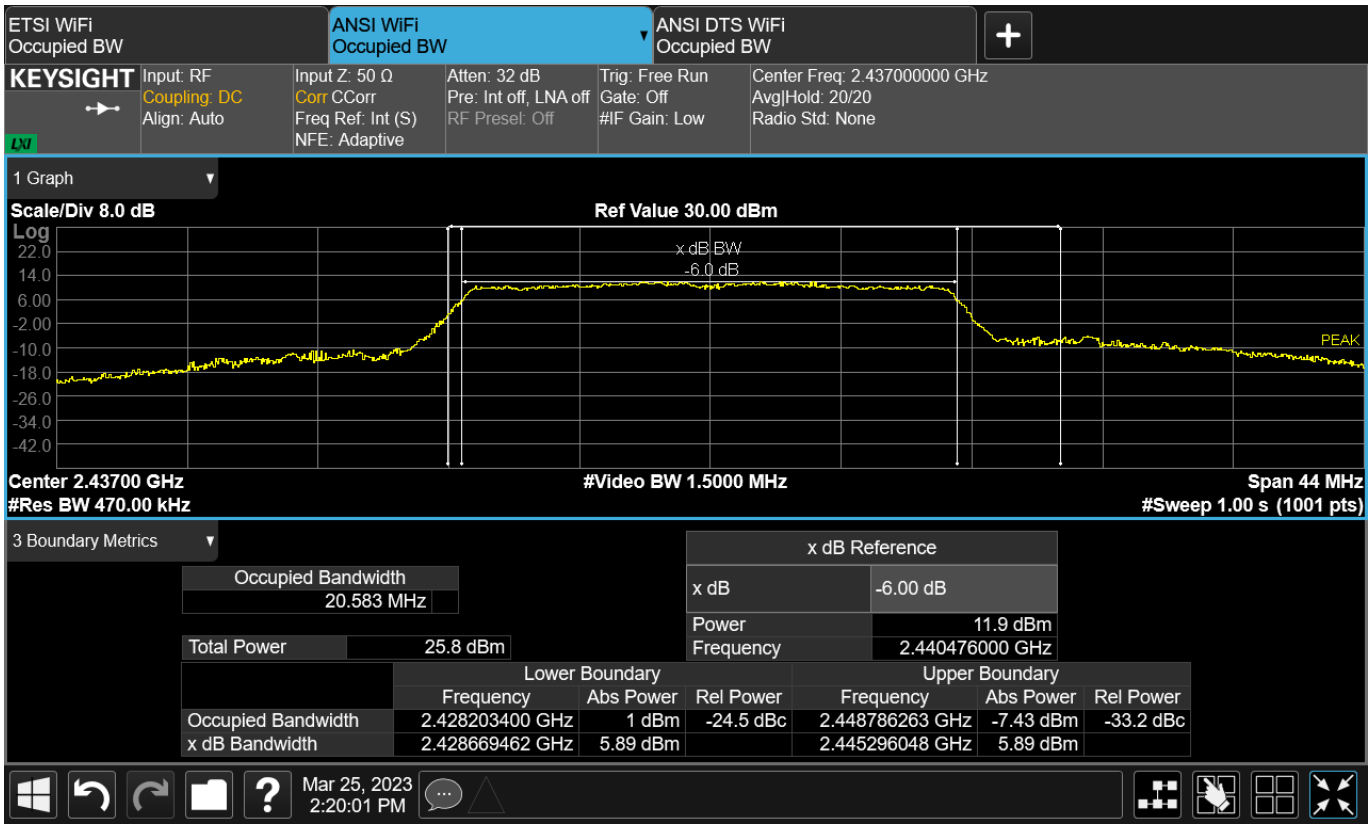


Figure TR15.5: Occupied bandwidth data for 802.11g 6 Mbps at channel 6

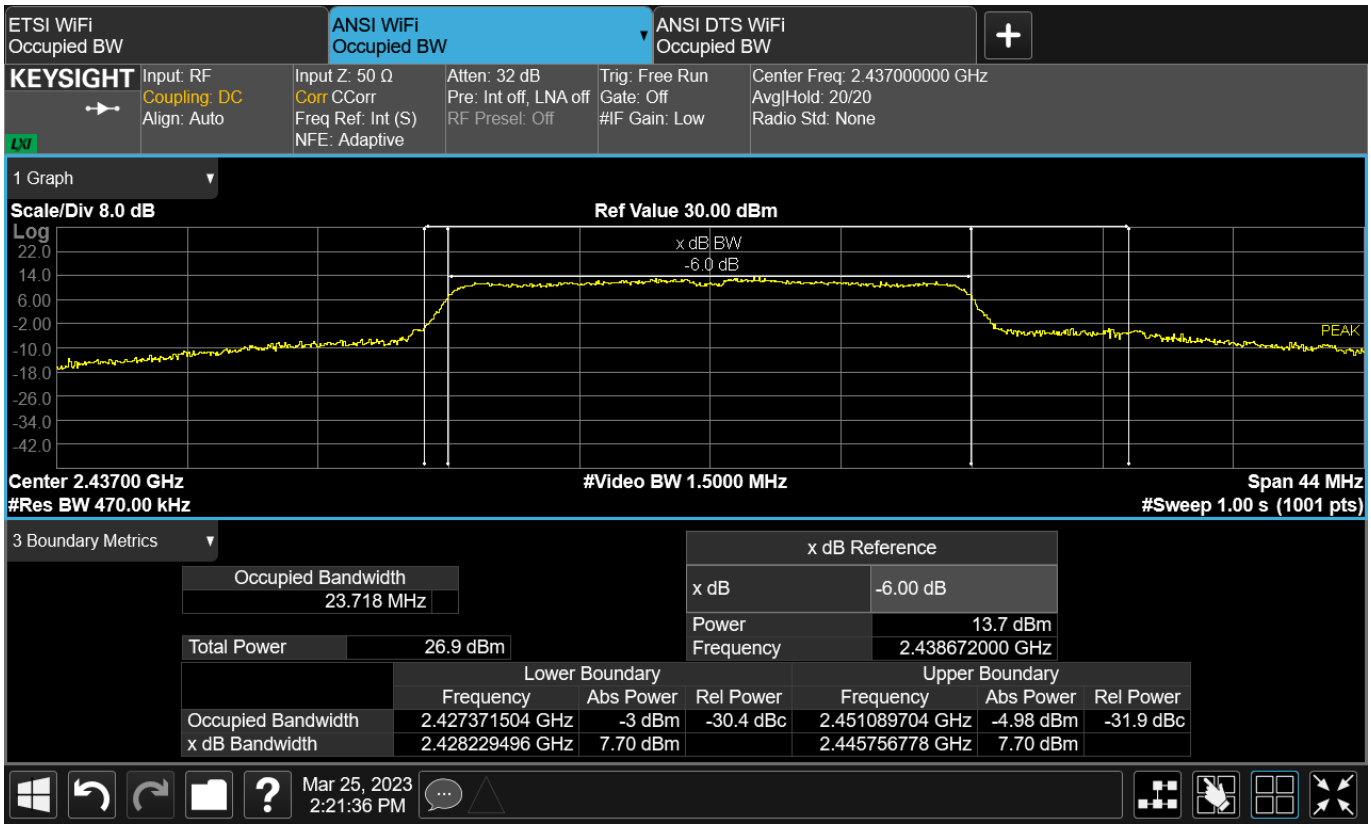


Figure TR15.6: Occupied bandwidth data for 802.11n MCS0 at channel 6

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 GCL0304

Test Date(s)	22 Feb 2023
Test Personnel	David Kerr
Product Model	A04331
Serial Number tested	3437296994
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:	**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 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	27.7	12.3	48	1692	HORZ
72.570	40.0	17.1	22.9	48	1692	HORZ
200.550	40.0	20.1	19.9	48	1692	HORZ
541.980	46.0	27.5	18.5	48	1692	HORZ
694.950	46.0	30.0	16.0	48	1692	HORZ
945.390	46.0	33.7	12.3	48	1692	HORZ

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	27.6	12.4	105	3740	HORZ
156.780	40.0	19.9	20.1	105	3740	Horz
263.970	46.0	23.1	22.9	105	3740	HORZ
540.630	46.0	28.1	17.9	105	3740	HORZ
802.560	46.0	31.2	14.8	105	3740	HORZ
942.570	46.0	33.3	12.7	105	3740	HORZ

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.

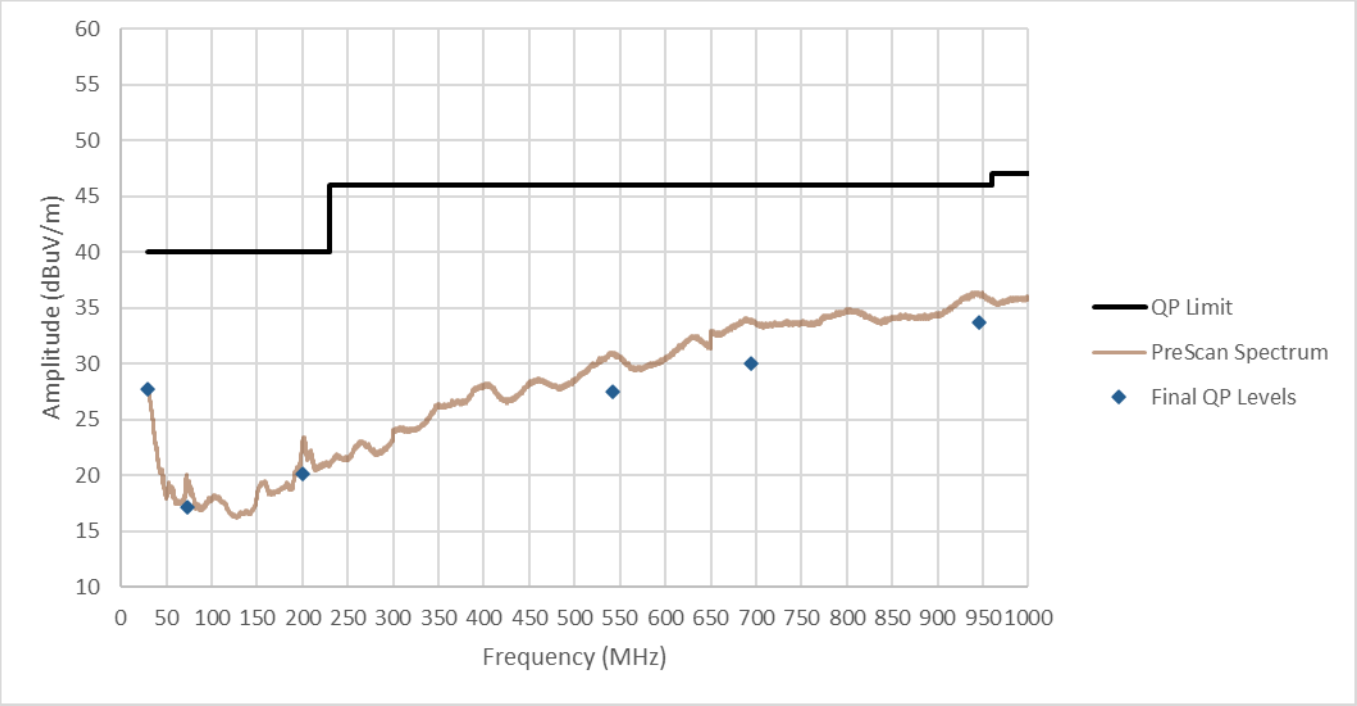


Figure RE01.1: Spectral data (1 Mbps)

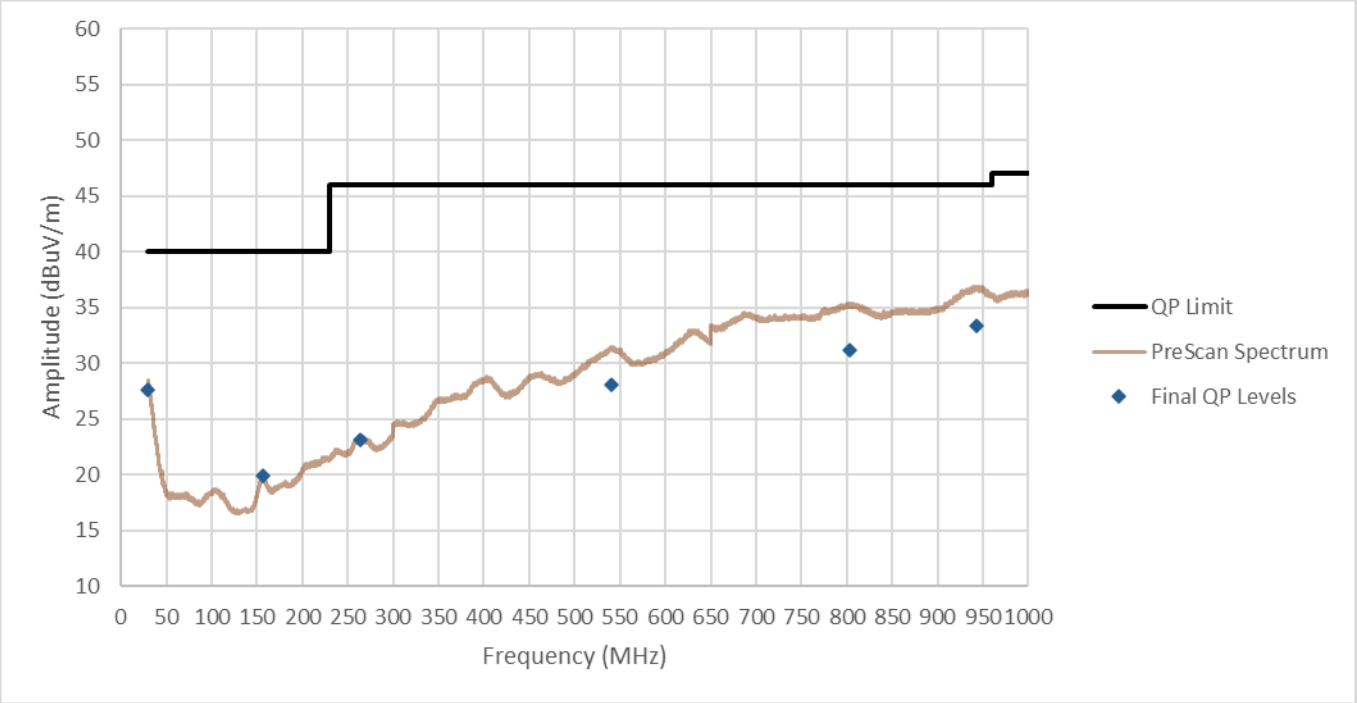


Figure RE01.2: Spectral data (2 Mbps)

Setup Photographs

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

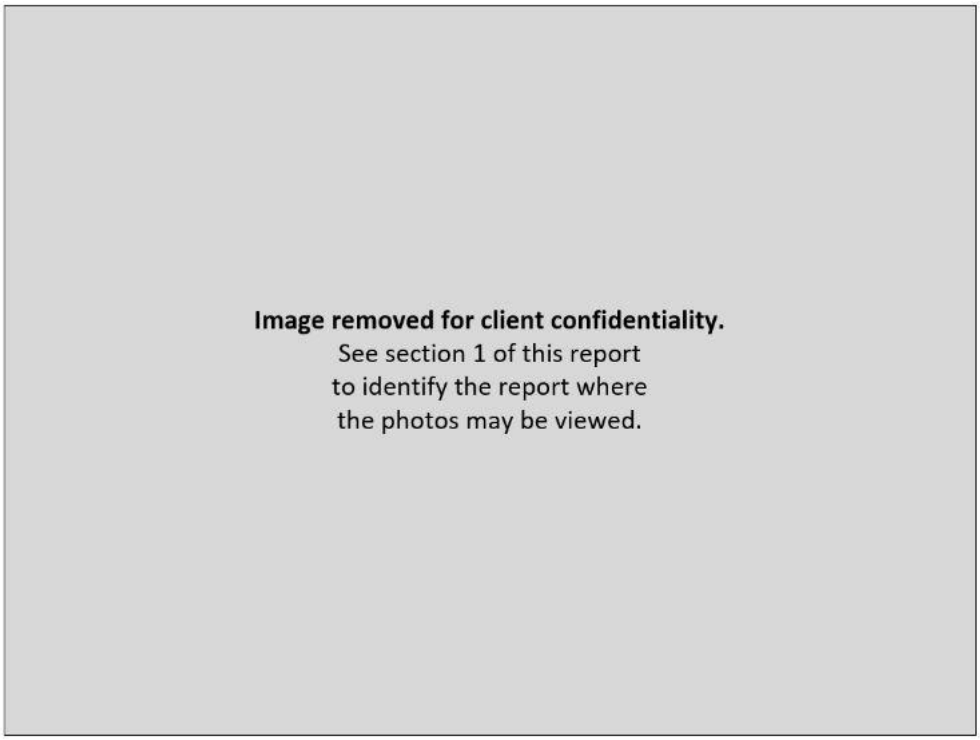


Figure RE01.3: EUT test setup, front view

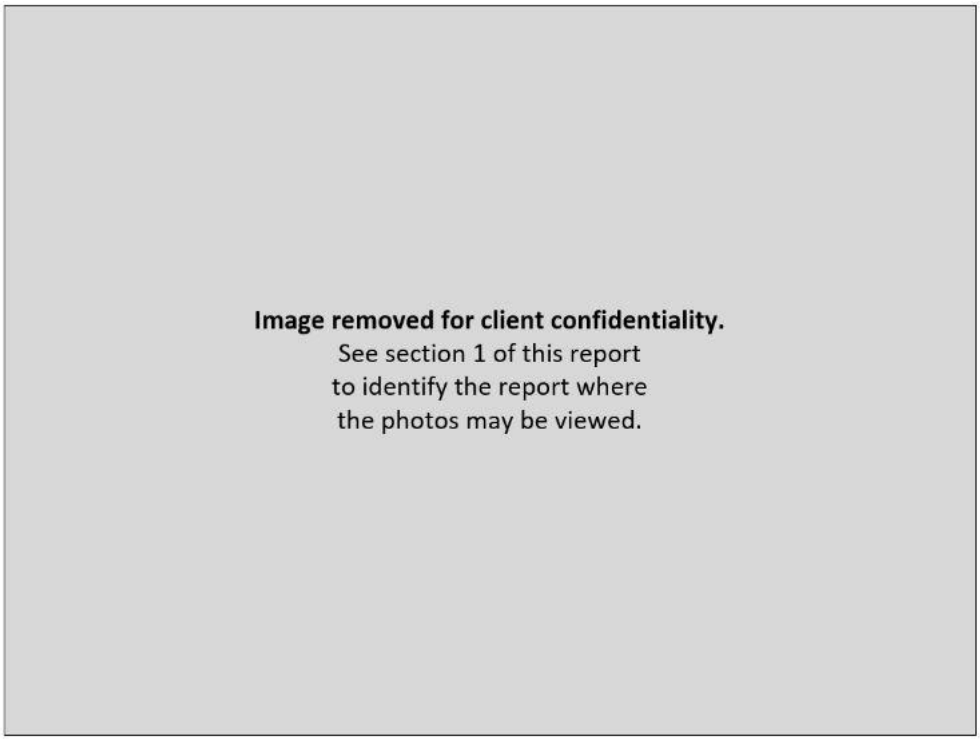


Figure RE01.4: EUT test setup, reverse view

This line is the end of the test record.

Test Record

Radiated Emission Test RE04
Project GCL0304

Test Date(s)	22 Feb 2023
Test Personnel	David Kerr
Product Model	A04331
Serial Number tested	3437296994
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	27.9	12.1	-198	2272	VERT
103.770	40.0	18.5	21.5	-198	2272	VERT
267.720	46.0	23.2	22.8	-198	2272	VERT
538.830	46.0	27.7	18.3	-198	2272	VERT
798.870	46.0	31.5	14.5	-198	2272	VERT
941.520	46.0	34.0	12.0	-198	2272	VERT

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.

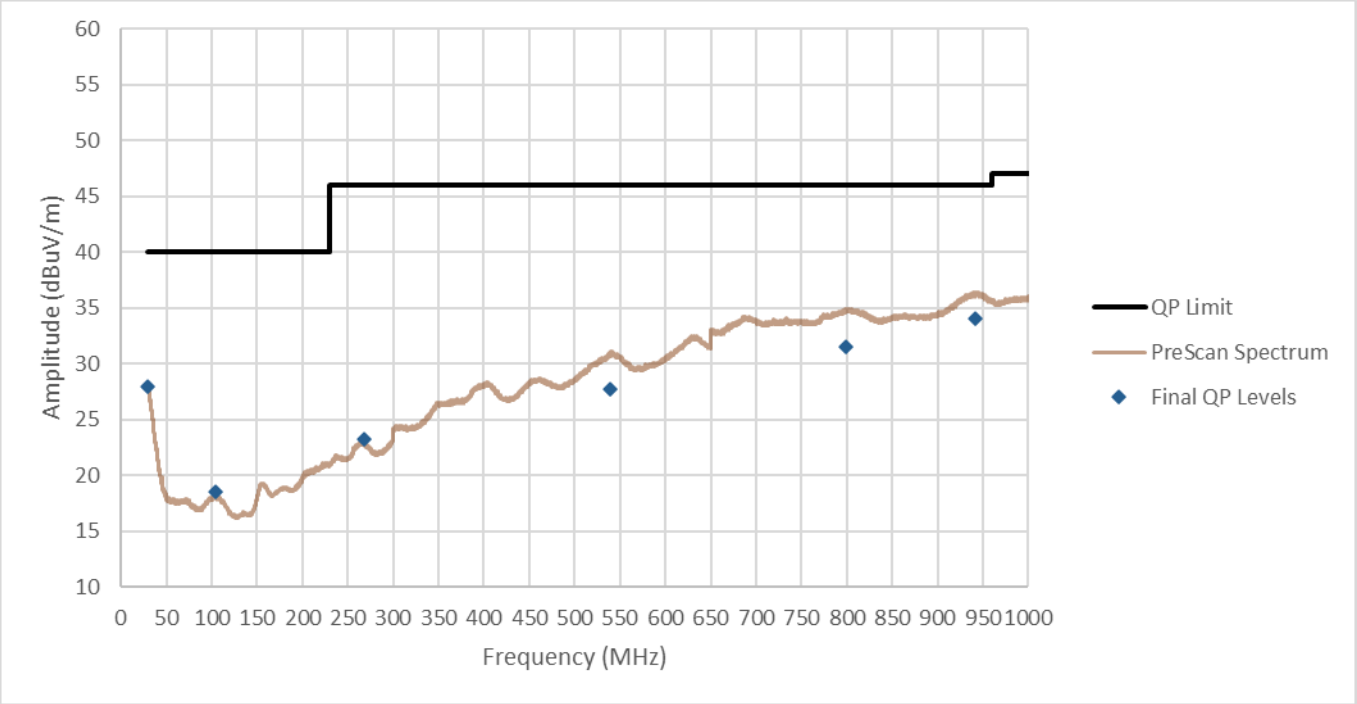


Figure RE04.1: Spectral data

Setup Photographs

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

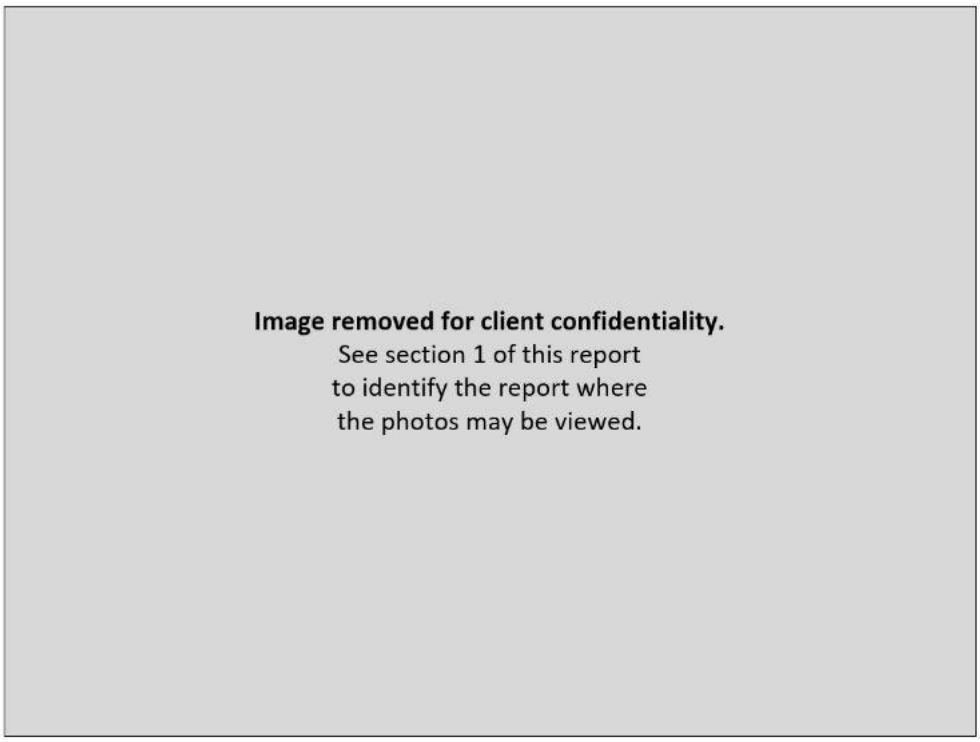


Figure RE04.2: EUT test setup, front view

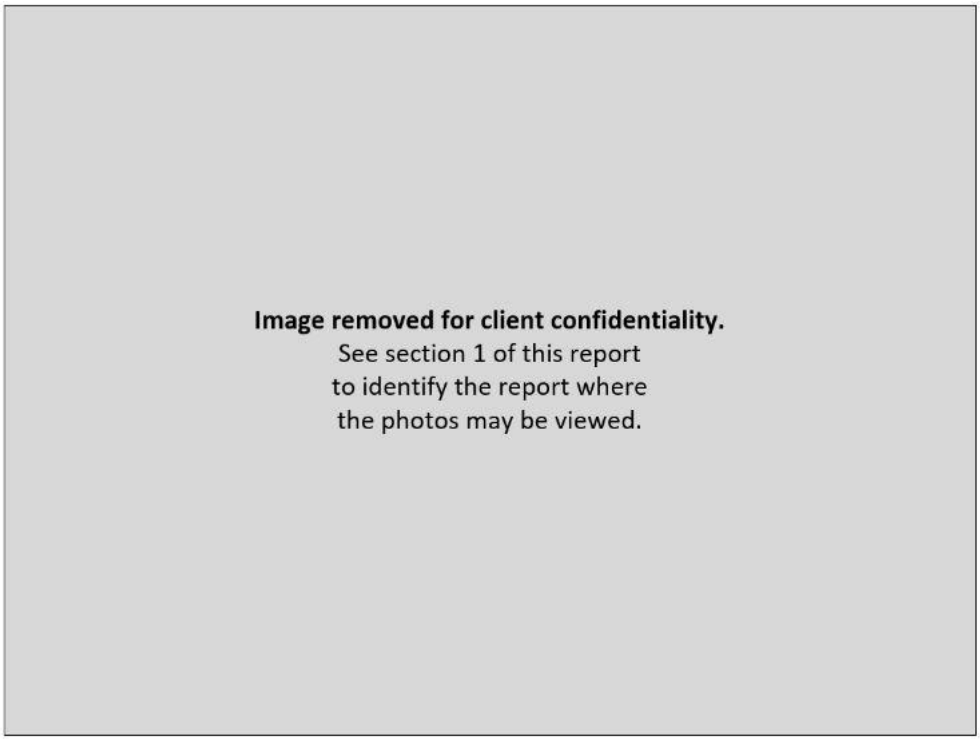


Figure RE04.3: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Radiated Emission Test RE05
Project GCL0304

Test Date(s)	28 Feb 23
Test Personnel	David Kerr
Product Model	A04331
Serial Number tested	3437296994
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:	**03 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	-52	1611	HORZ
154.980	40.0	19.9	20.1	80	3784	VERT
202.710	40.0	19.7	20.3	71	3551	VERT
688.260	46.0	30.3	15.7	51	3154	VERT
809.190	46.0	31.2	14.8	-106	1860	HORZ
944.100	46.0	32.9	13.1	163	1953	VERT

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.

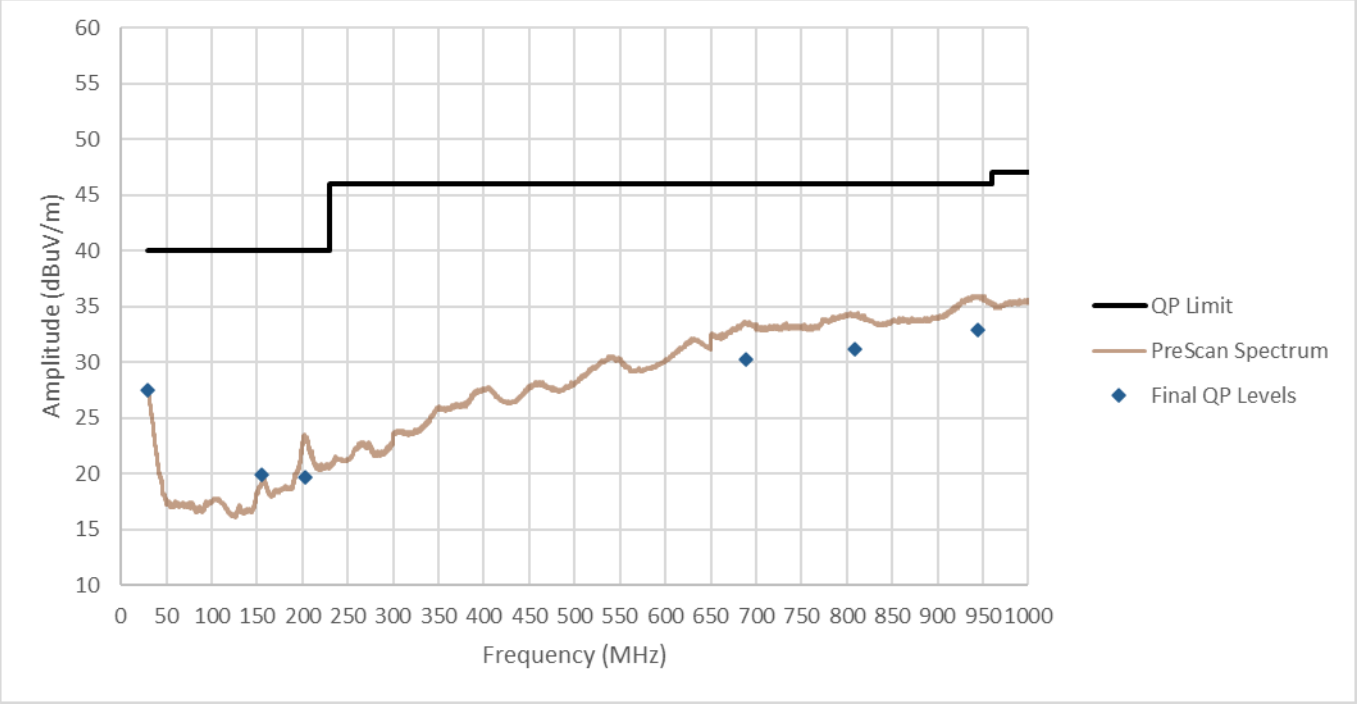


Figure RE05.1: Spectral data

Setup Photographs

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

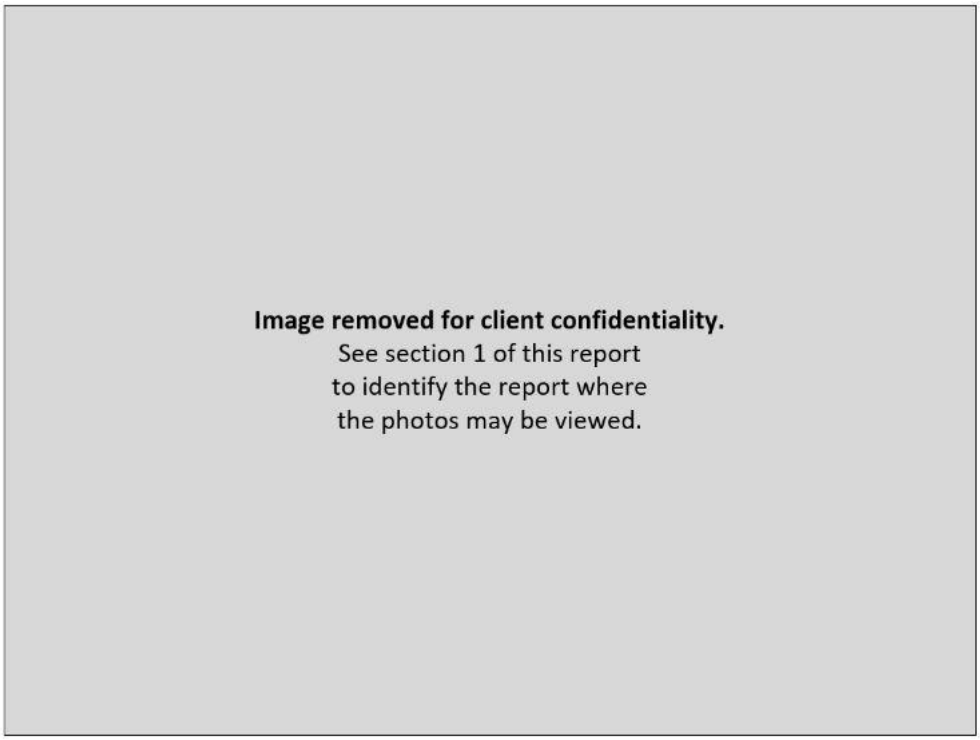


Figure RE05.2: EUT test setup, front view (Y orientation)

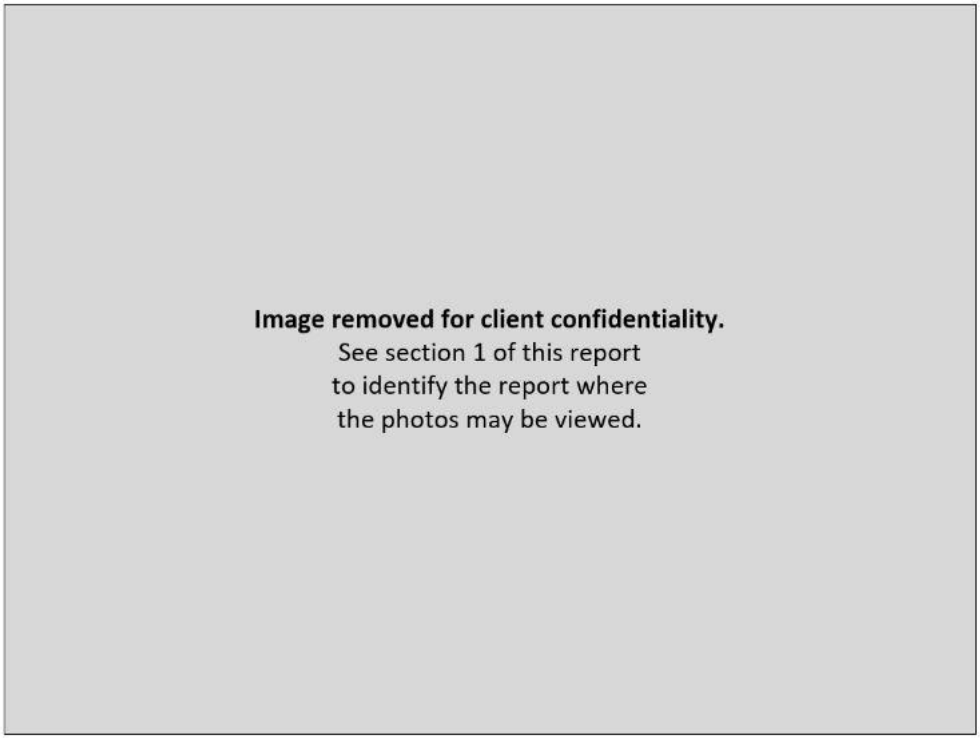


Figure RE05.3: EUT test setup, reverse view (Y orientation)

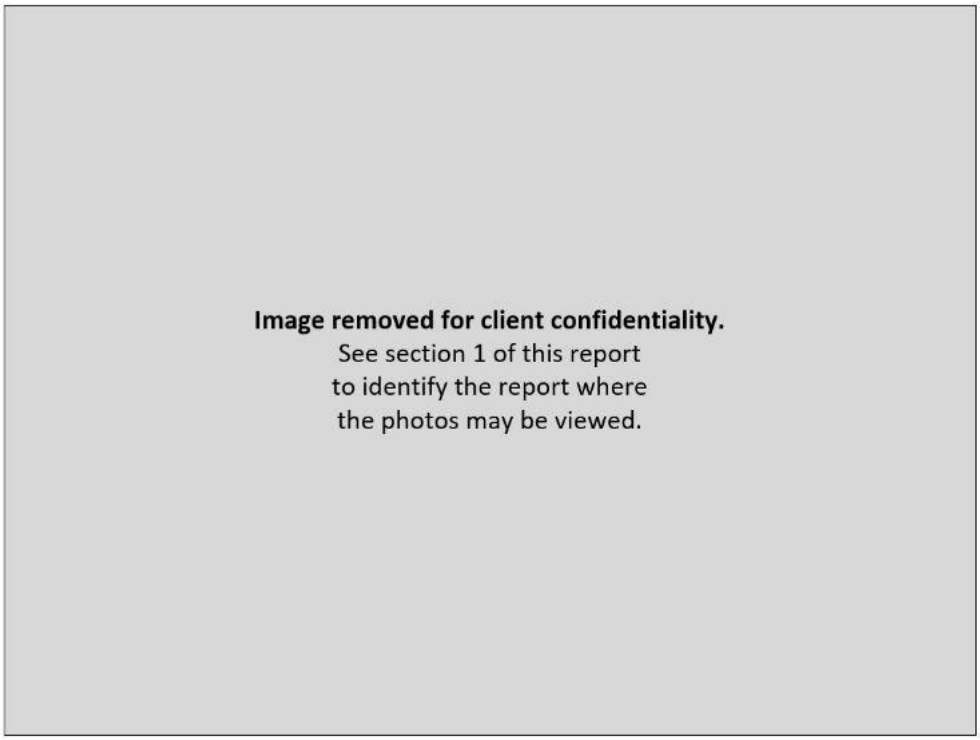


Figure RE05.2: EUT test setup, front view (Z orientation)

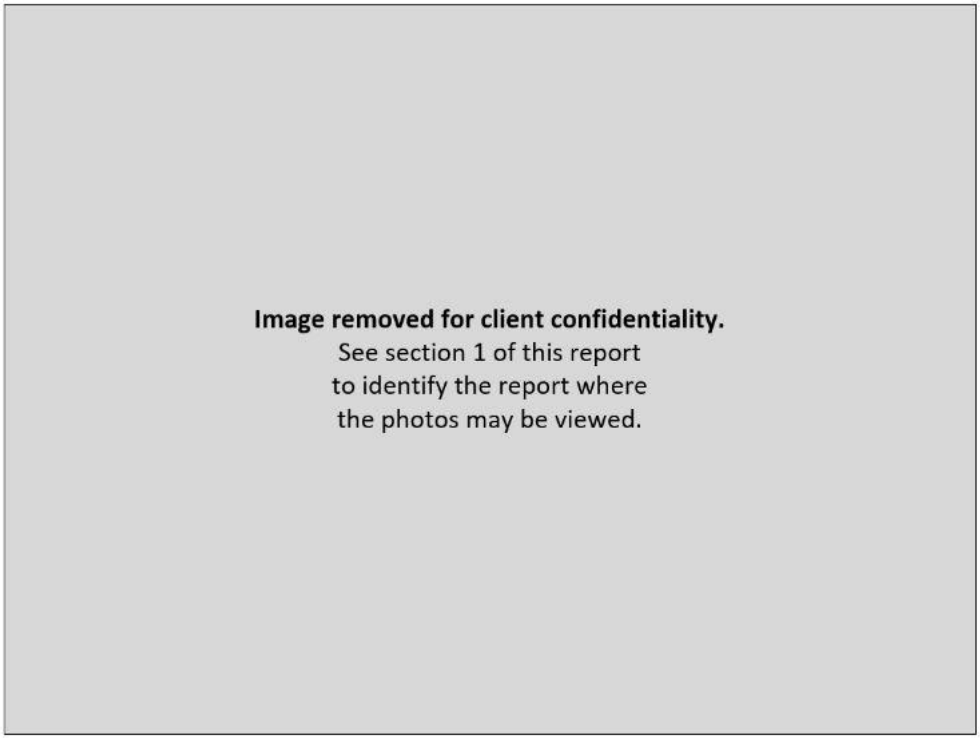


Figure RE05.3: EUT test setup, reverse view (Z orientation)

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	A04331
Serial Number tested	3437296994
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)	---
1973.500	50.0	70.0	31.7	44.9	18.3	25.1	22	3902	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.

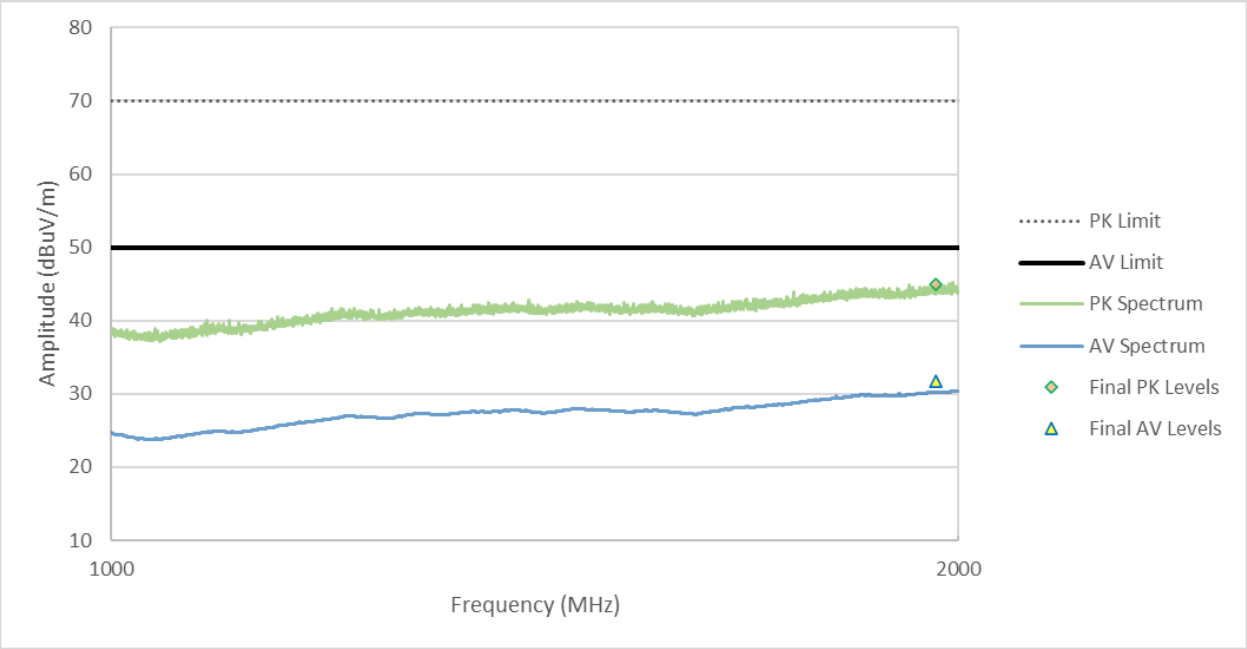


Figure RE16.3: Spectral data

Setup Photographs

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

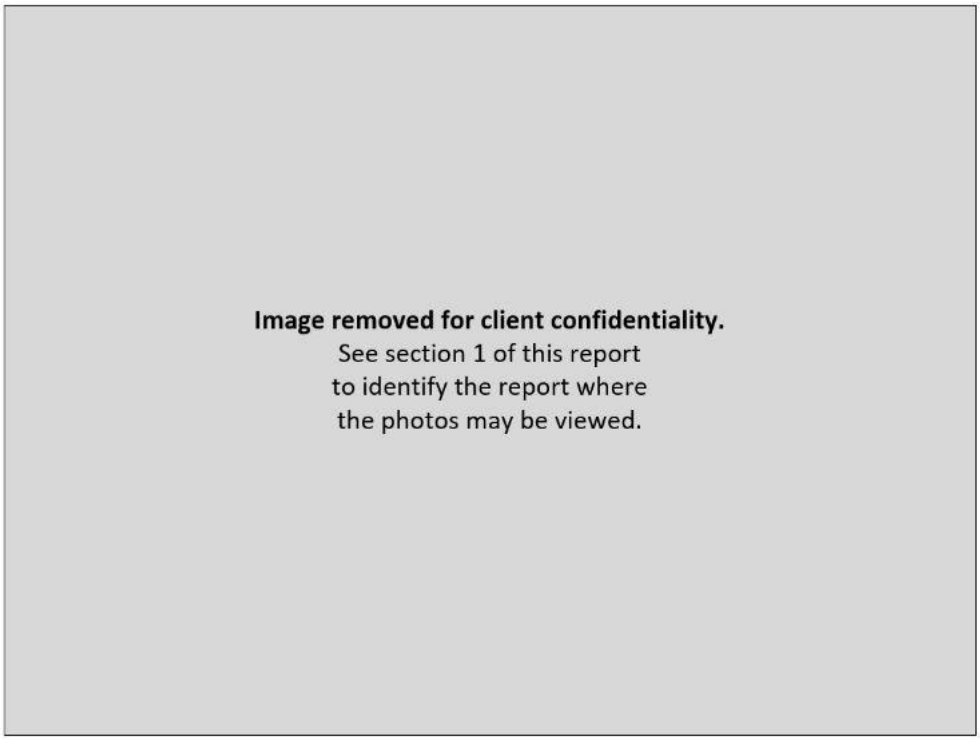


Figure RE16.4: EUT test setup, front view

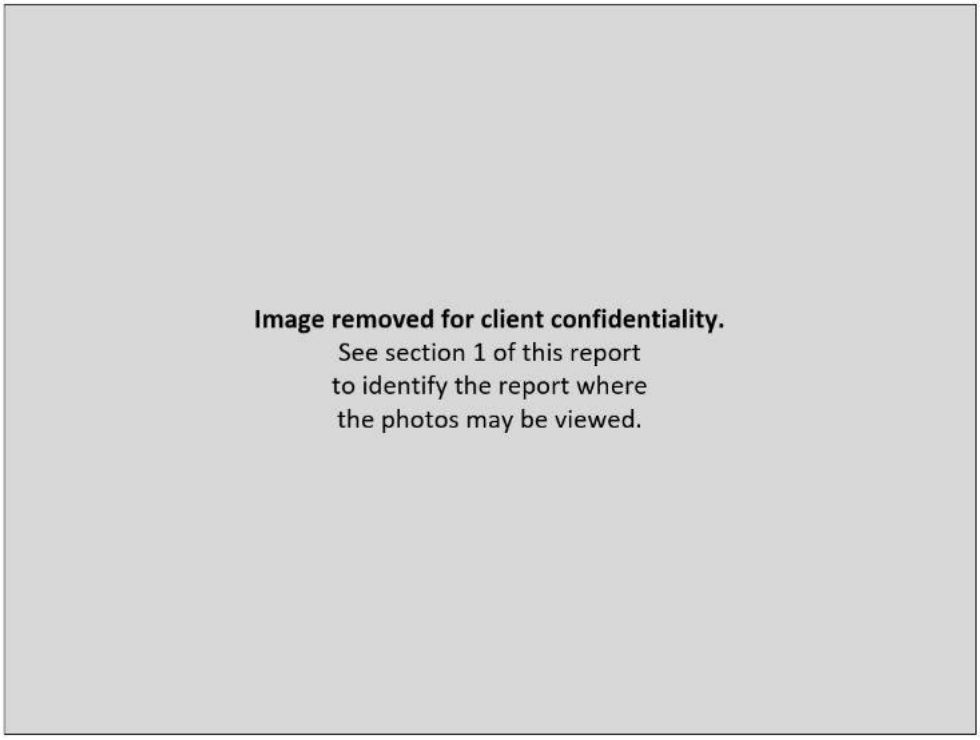


Figure RE16.5: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Radiated Emission Test RE17
Project GCL0304

Test Date(s)	22 Feb 23
Test Personnel	David Kerr
Product Model	A04331
Serial Number tested	3437296994
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	27.7	12.3	155	2868	HORZ
103.770	40.0	18.5	21.5	155	2868	HORZ
267.720	46.0	23.2	22.8	155	2868	HORZ
538.830	46.0	27.5	18.5	155	2868	HORZ
798.870	46.0	31.6	14.4	155	2868	HORZ
941.520	46.0	33.9	12.1	155	2868	HORZ

Table RE17.2: Emission summary (EDR 2)

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.000	40.0	27.7	12.3	-115	3933	VERT
156.030	40.0	20.2	19.8	-115	3933	VERT
267.690	46.0	23.2	22.8	-115	3933	VERT
548.040	46.0	28.3	17.7	-115	3933	VERT
806.340	46.0	31.0	15.0	-115	3933	VERT
990.990	47.0	33.1	13.9	-115	3933	VERT

Table RE17.3: Emission summary (EDR 3)

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

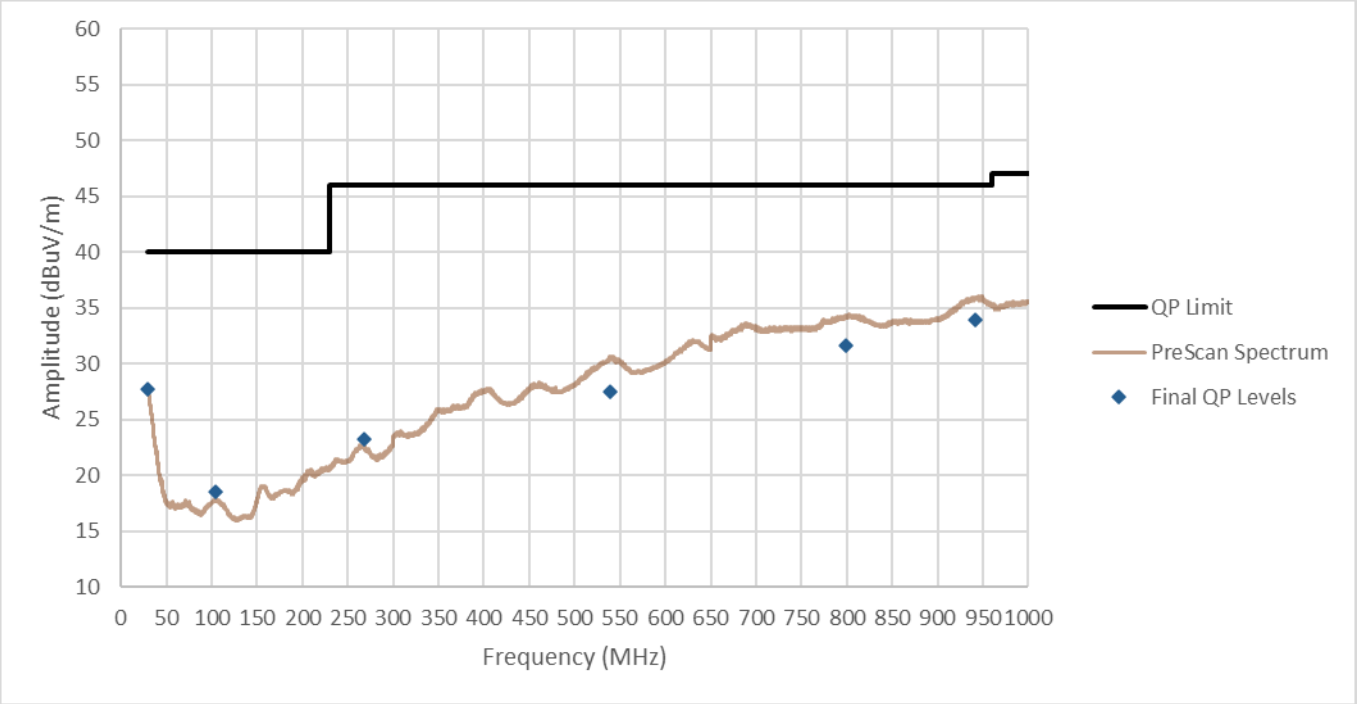


Figure RE17.1: Spectral data (EDR 2)

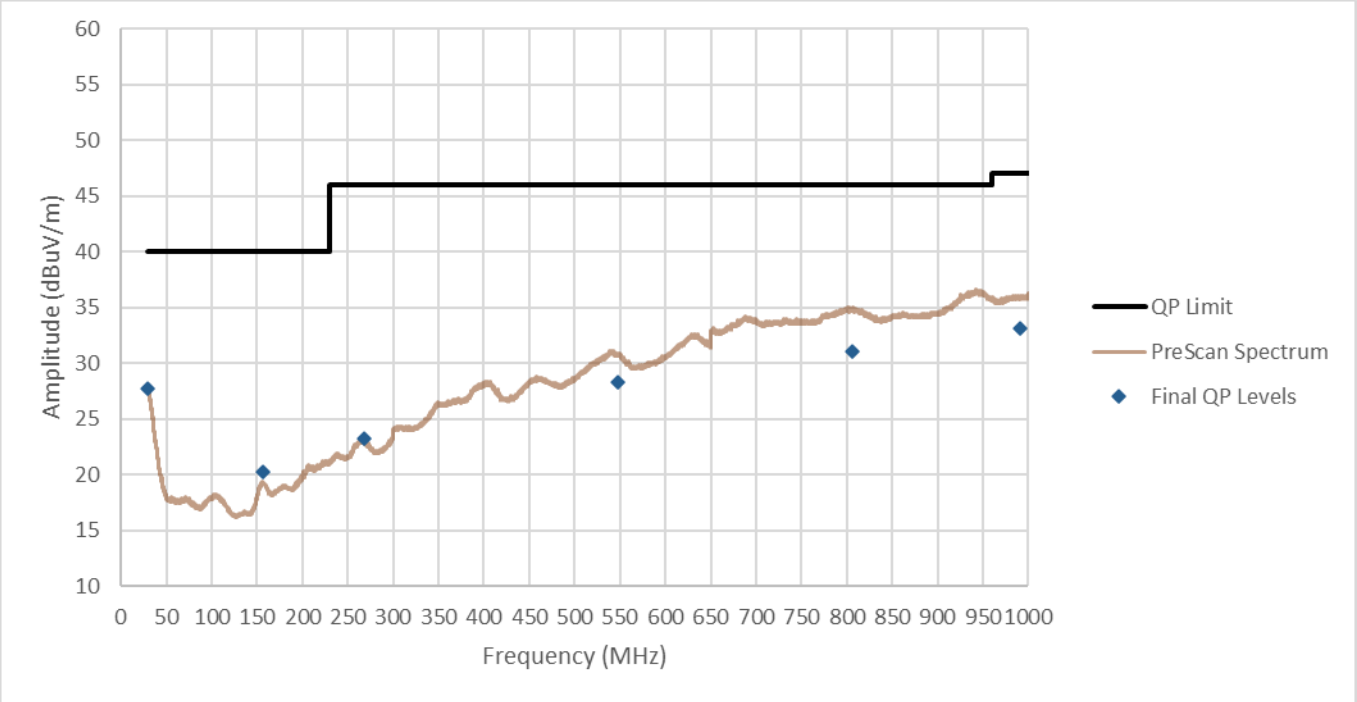


Figure RE17.2: Spectral data (EDR 3)

Setup Photographs

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

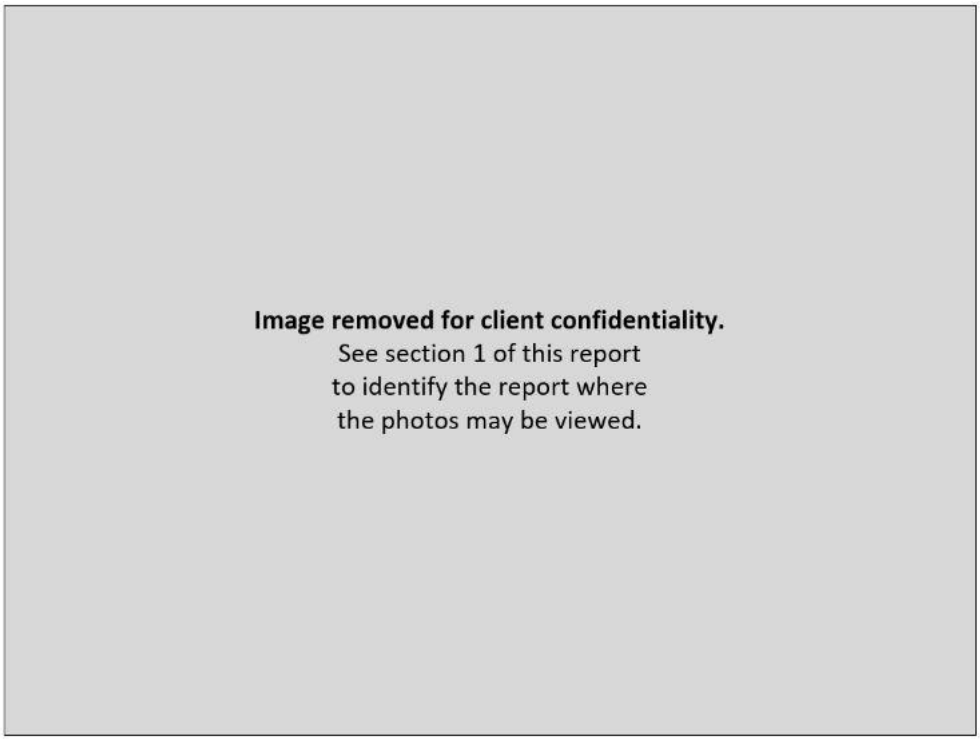


Figure RE17.3: EUT test setup, front view

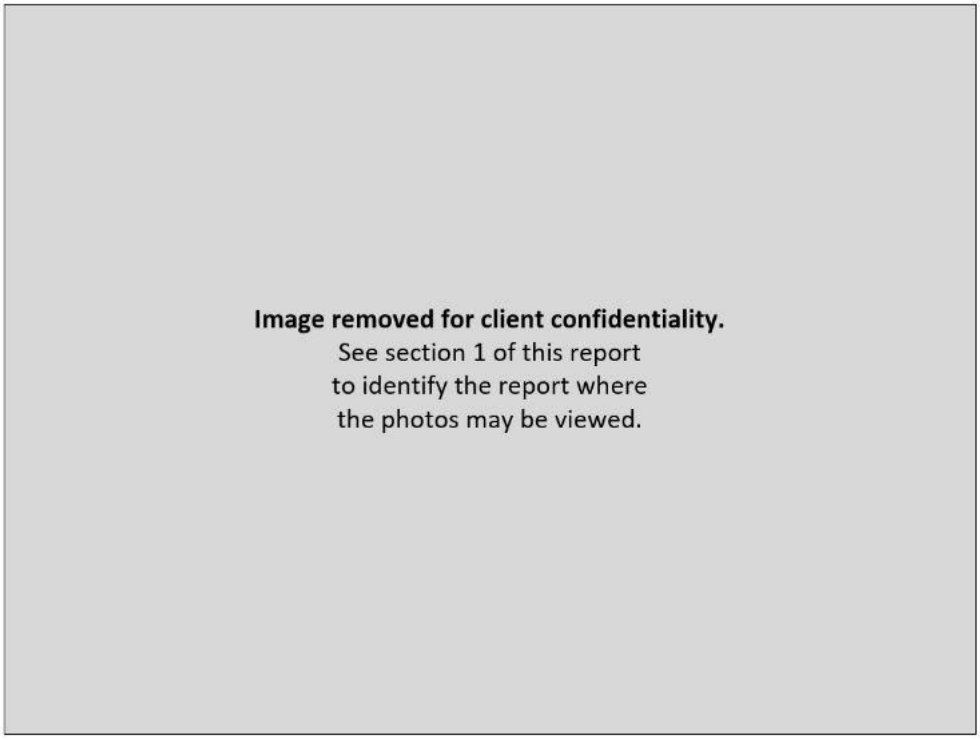


Figure RE17.4: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE02
Project GCL0304

Test Date(s)	16 Feb 2023
Test Personnel	Christian Shepherd assisted by David Kerr
Product Model	A04331
Serial Number tested	3437296994
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	26.21	25.94	14.80	14.02	39.79	41.20
321	59.68	49.68	23.64	21.6	19.23	18.27	36.04	30.45
344	59.12	49.12	21.62	19.28	15.95	15.02	37.50	33.17
688	56	46	38.07	32.57	27.84	27.35	17.93	18.16
1363	56	46	24.83	19.91	14.56	13.79	31.17	31.44
1775	56	46	21.03	17.44	13.86	13.17	34.97	32.14
2551	56	46	20.3	16.35	13.45	12.08	35.70	32.55
4117	56	46	19.25	15.59	12.79	11.31	36.75	33.21
14557	60	50	14.25	13.04	9.28	8.17	45.75	40.72

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.

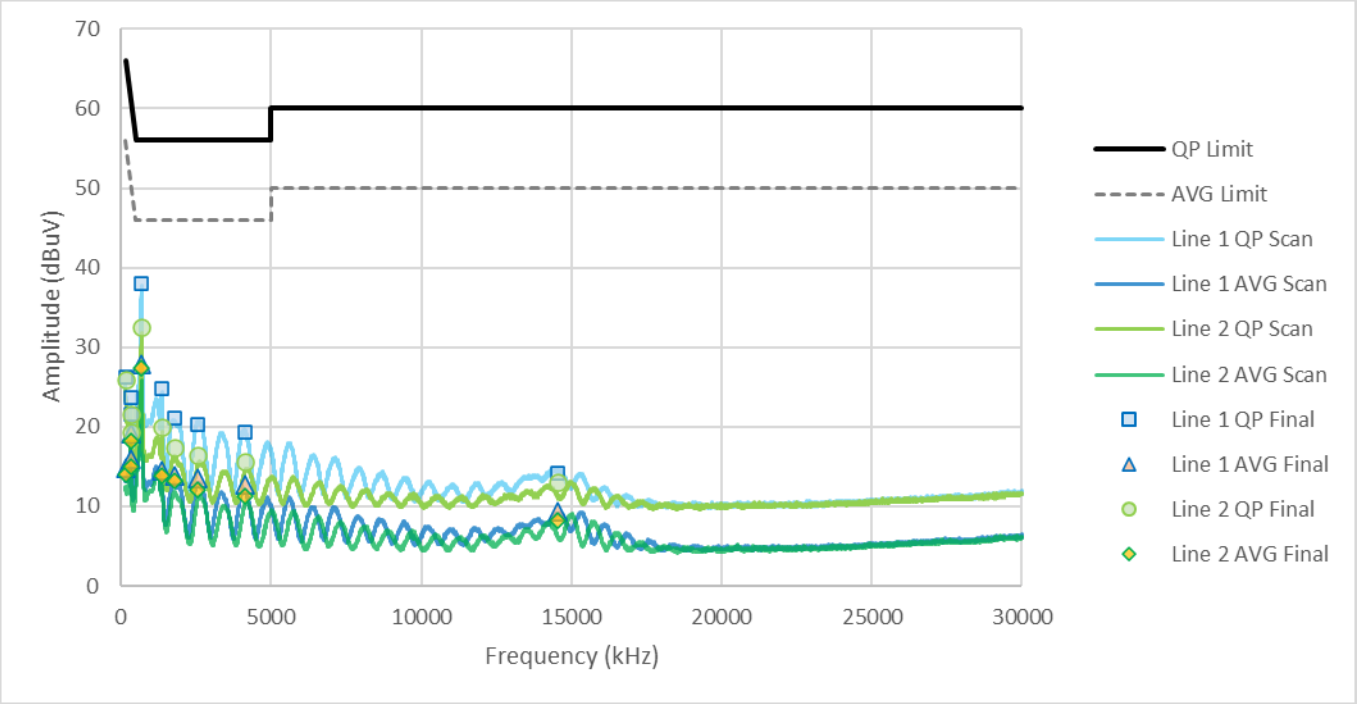


Figure CE02.1: Spectral data

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

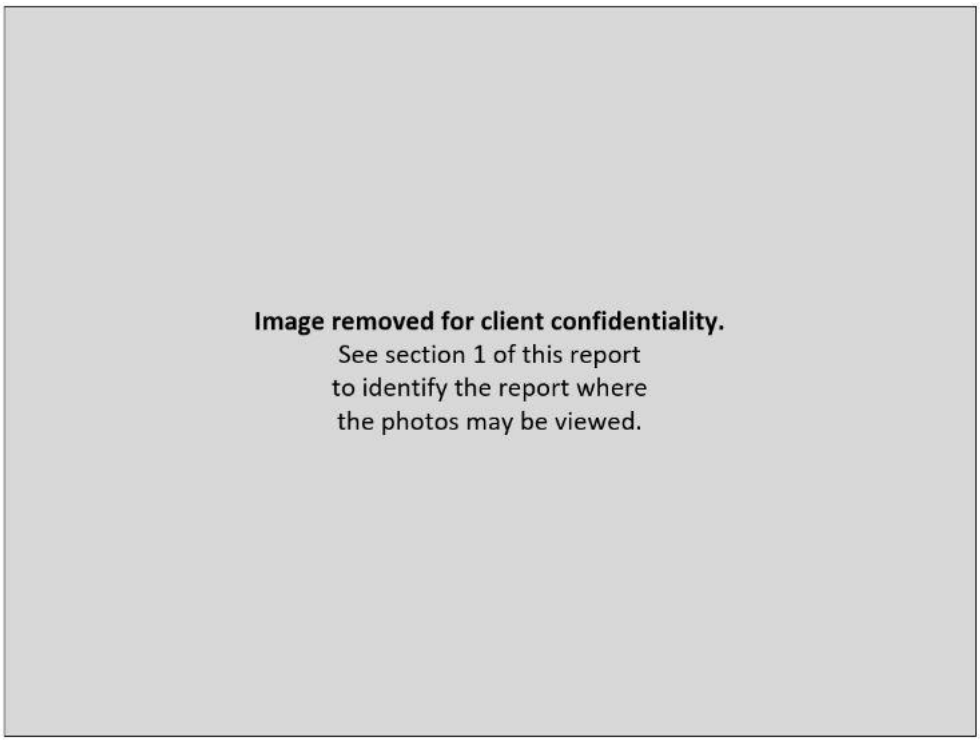


Figure CE02.3: EUT test setup

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.