Test Report 2024-070

Version A
Issued 14 Jun 2024

Project GCL-0407
Model Identifier A04766
Primary Test Standard
CFR 47, FCC Part 15, Subpart C
RSS-247 Issue 3

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

Client-supplied Information

FCC ID:	IPH-04766
IC ID:	1792A-04766

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

1. Summary

The equipment or product described in section 5 of this report was tested at the Garmin Compliance Lab according to standards listed in section 6. This report focuses on the IEEE 802.11 b/g/n (WiFi) and Bluetooth Low Energy (BLE) transceivers. The results are as follows.

Parameter	Description	Key Performance Values	Result	Data starts at page
Radio Modulation	Summary of the kinds of communication this radio can achieve, as stated by the client. [RSS-GEN at Annex A item 10b]	Digitally modulated spread spectrum at rates as high as 72 Mbps.	Reported	N/A
Hopping Channels	The radio manages it use of channels appropriately. [15.247(a)(1); RSS-247 at 5.1]	N/A. The radios described in this report are not subjected to the Frequency Hopping rules.	N/A	N/A
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 0.698 kHz or greater.	PASS	14
Other Bandwidths	Regulatory agencies also require the reporting of signal bandwidths using alternate processes. [2.202; RSS-GEN at 6.7]	These values are reported but have no actual performance requirements.	Reported	18
Transmit Power	The peak transmit power presented to the antenna is no greater than 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 19.96 dBm or 98.4 mW.	PASS	24
Antenna Gain	The radio should not focus too much energy in any direction. Unless additional rules are applied, the antenna gain is no greater than 6 dBi. [15.247(b)(4) and (c)]	NT. The client stated that the antenna gain was 0.8 dBi and will document antenna gain separately.	NT	NT
Unwanted Emissions (Conducted Spurious)	The radio should not provide too much radio energy to the antenna at frequencies beyond its intended frequency band. [15.247(d); RSS-247 at 5.5]	Emissions outside the band must be reduced at least 20 dB from in-band levels. The measured reduction was at least 51 dB.	PASS	30
Restricted Bands	The radio must not emit in certain designated restricted frequency bands above a set of limit values. [15.247(d) and 15.205; RSS-247 at 3.3]	Emissions in the restricted bands were at least 5.9 dB below the applicable limits.	PASS	36

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 measure at -5.11 dBm in a band of at least 3 kHz.	PASS	49
Hybrid Systems	A radio that is both frequency hopping and digitally modulated should satisfy a combination of system rules. [15.247(f); RSS-247 at 5.3]	N/A. The radios described in this report are not subjected to the Hybrid System rules.	N/A	N/A
Frequency Hopping Rules	Frequency hopping systems have additional functional requirements. [15.247(g) and (h); RSS-247 at 5.1]	N/A. The radios described in this report are not subjected to the Frequency Hopping rules.	N/A	N/A
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	53
Unwanted Emissions (Radiated Spurious)	While transmitting, the radiated emissions must not be too strong. [15.209, RSS-Gen at 8.9]	Emissions other than the fundamental and harmonics must meet the 'Class B' limits. The measured emissions had at least 4.1 dB of margin.	PASS	61
Unwanted Emissions (Mains Conducted)	While transmitting, the emissions conducted into the power mains must not be too strong. [15.207, RSS-Gen at 8.8]	N/A	N/A	N/A

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

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

Table 1: Summary of results

Report Organization

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

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2024-076. That report is treated as a part of this document by way of this reference.

2. Test Background

2.1 The Test Lab

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.

2.2 The Client

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: Tim Olson, Sam Bruner, Patrick Flett.

2.3 Other Information

Test Sample received: 04 Mar 2024
Test Start Date: 20 Mar 2024
Test End Date: 28 May 2024

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

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

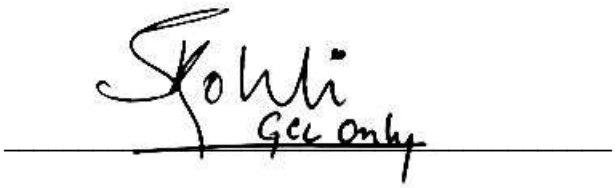
3. Report History and Approval

This report was written by David Arnett and initially issued on 14 Jun 2024 as Version A.

Report Technical Review:

David Arnett
Technical Lead EMC Engineer

Report Approval:



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

4. Test Sample Modifications and Special Conditions

The following special conditions or usage attributes were judged during test to be necessary to achieve compliance with one or more of the standards listed in section 6 of this report:
When using a USB cable for data transactions, a 1 m cable length was found necessary to meet radiated spurious emission requirements.

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

Modification 1
Detailed Description: Update firmware from version 1.1 to 1.2
Date applied: 17 Apr 2024
Reason for this modification: Reduce Tx power slightly on IEEE 802.11 b for PSD conformity to ETSI rules
The following tests were performed without this modification being present, and the presence or absence of the modification is judged by the lab and client to have no significant effect on these specific tests: Tests for BLE and for WiFi in G or N modes; For WiFi in B mode - bandwidth tests, radiated emission tests, and various immunity tests were not repeated as a small Tx power reduction would either have no effect or would only create additional margin to the limit.

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model	A04766
Serial Numbers Tested	8A5000017, 8A5000018, 8A4000458

This product tested is a device for sensing, data storage, and telemetry.

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, often from 12 Vdc sources
I/O Ports:	USB, microSD
Radio Transceivers:	IEEE 802.11 b/g/n, Bluetooth Low Energy
Radio Receivers:	None
Primary Functions:	Sensing, data storage, communication
Typical use:	Vehicle mounted
Highest internal frequency:	2.484 GHz
Firmware Revision	1.20 (See also section 4 of this report)

5.3 Operating modes

During test, the EUT was operated in one or more of the following modes.

M3 (BleTx). Bluetooth Low Energy radio transmits pseudorandom data continuously on a selected frequency and data rate.

M4 (BleLnk). Bluetooth Low Energy radio links to another device according to the standard protocol and exchanges data packets in a very long data exchange session.

M7 (WiFiTx). IEEE 802.11 radio transmits pseudorandom data continuously on a selected channel, modulation scheme, and data rate.

M8 (WiFiLnk). IEEE 802.11 radio links to another device according to the standard protocol and exchanges data packets in a very long data exchange session.

M9 (RxBle). Bluetooth Low Energy radio listens for data but does not transmit.

M10 (RxWiFi). IEEE 802.11 radio listens for data but does not transmit.

M15 (Cam). Video is recorded or streamed for viewing by the test operator.

5.4 EUT Arrangement

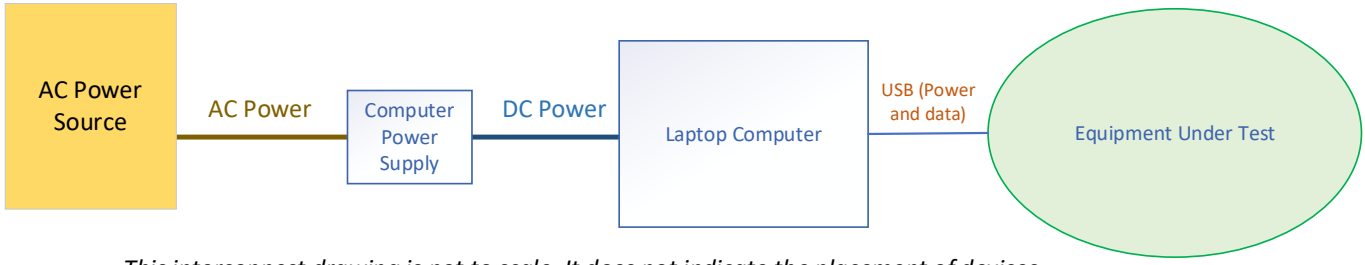
During test, the EUT components and associated support equipment were selected including the following arrangement sets. Not all arrangements were used in the tests contained in this report.

Reference to 12 V power is 12 Vdc vehicular power which is typically set at 13.8 V to match the dynamics of vehicular charging systems. Where 12 V is used, an intermediate power regulator is required because the test sample is only capable of receiving 5 Vdc USB-compatible power. At times, a vehicular On-board Diagnostic (OBD or OBD-II) port connector is the intermediate connector interface. At other times, a vehicular Cigarette Lighter Adapter (CLA) port is the intermediate interface. In all cases, a microSD card is installed in the EUT port.

Arrangement 1: A1 (Pwr) The test sample is provided power over its USB port in a test scenario where the source of that power and its physical layout is not particularly important. No block diagram is needed.

Arrangement 2: A2 (PC) The test sample is connected over a 1 m data cable to a laptop computer.

Arrangement 6: A6 (PC2) The test sample is connected over a 0.5 m data cable to a laptop computer.



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

Figure 1: Block diagram of equipment arrangement A2 or A6

Arrangement 3: A3 (OBD/4m) 12V is supplied to an OBD-style power converter, which then supplies 5 vdc through a 4 m USB-style cable to the test sample.

Arrangement 4: A4 (OBD/8m) 12V is supplied to an OBD-style power converter, which then supplies 5 vdc through an 8 m USB-style cable to the test sample.

Arrangement 5: A5 (Park) 12V is supplied from the vehicle DC power system to directly to a Parking Mode accessory with no intermediate connector. The Parking Mode accessory supplies 5 vdc through a USB-style cable to the test sample.

Arrangement 10: A10 (CLA0/4m) 12V is supplied to a CLA-style power converter type 0, which then supplies 5 vdc through a 4 m USB-style cable to the test sample.

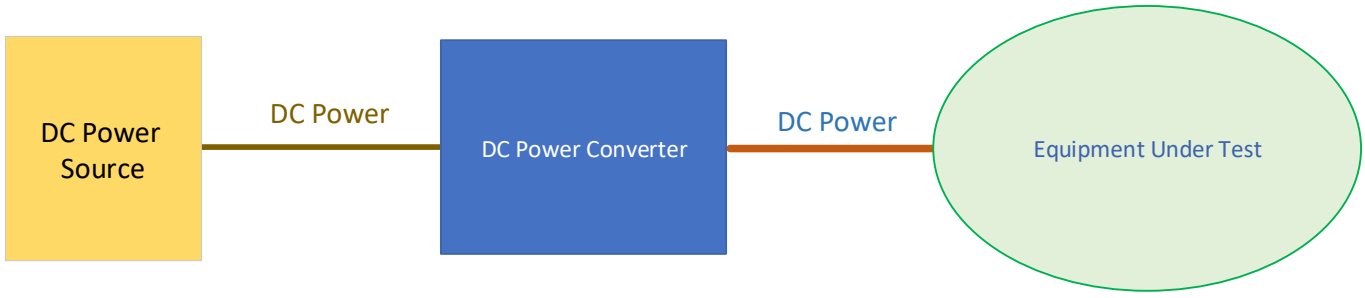
Arrangement 11: A11 (CLA1/4m) 12V is supplied to a CLA-style power converter type 1, which then supplies 5 vdc through a 4 m USB-style cable to the test sample.

Arrangement 12: A12 (CLA3/4m) 12V is supplied to a CLA-style power converter type 3, which then supplies 5 vdc through a 4 m USB-style cable to the test sample.

Arrangement 13: A13 (CLA0/8m) 12V is supplied to a CLA-style power converter type 0, which then supplies 5 vdc through a 8 m USB-style cable to the test sample.

Arrangement 14: A14 (CLA1/8m) 12V is supplied to a CLA-style power converter type 1, which then supplies 5 vdc through a 8 m USB-style cable to the test sample.

Arrangement 15: A15 (CLA3/8m) 12V is supplied to a CLA-style power converter type 3, which then supplies 5 vdc through a 8 m USB-style cable to the test sample.



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

Figure 4: Block diagram of equipment arrangements other than A1, A2, and A6

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
Car DC Adapter CLA	Garmin	013-00797-00	E222100006427
Car DC Adapter CLA	Garmin	013-00797-01	M230900974
Car DC Adapter CLA	Garmin	013-00797-03	M01123090090D
Car DC Adapter OBD	Garmin	320-01425-10	None
Car DC Adapter Parking	Garmin	320-00845-16	None
Laptop PC	Dell	Latitude 7480	13504728854
PC Power Supply	Dell	LA180PM180	None
Laptop	Dell	inspiron	7DCR5R3
Power Supply	Dell	DA65NM191	CN-0KPVMF-DES00-233-EE1V-A00
Laptop	Dell	Latitude 5410	5VSPFB3
Computer	Dell	Latitude 5410	5VSPFB3
Power Supply	Dell	HA65NM191	0BD-7TC0-A02
Power adaptor	Garmin	PSAF10R-050Q	P183100844A1

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

5.6 Cables used

Description	From	To	Length	EMC Treatment
4 m Power	DC power	EUT	405 cm	None
8 m Power	DC power	EUT	812 cm	None
1 m Data	Computer	EUT	106 cm	None

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

6 Test Standards Applied

6.1. Accredited Standards

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

AS/NZS 4268: 2017
CFR 47, FCC Part 15, Subpart C
ANSI C63.10: 2013, ANSI C63.10: 2020, and ANSI C63.10: 2020 +Cor 1: 2023
RSS-GEN Issue 5 Amd 2
RSS-247 Issue 3

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.

FCC Part 2.202
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 23.0 °C
Relative Humidity:	27.7% to 55.8% (non-condensing)
Barometric Pressure	95.7 to 98.9 kPa

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

Table 4: Environmental monitoring device

10 Immunity Performance Criteria

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

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

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

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

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

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

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

ANNEX

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

Test Record
Transmitter Bandwidth Tests - DTS
Test IDs TR06, TR08
Project GCL-0407

Test Date(s)	4 Apr 2024
Test Personnel	David Arnett
Product Model	A04766
Serial Number tested	8A4000458
Operating Mode	M3 (BleTx), M7 (WiFiTx)
Arrangement	A1 (Pwr)
Input Power	5Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-247 (as noted in Section 6 of the report).
Radio Protocol	Bluetooth Low Energy (BLE), WiFi b, g, and n modes
Radio Band	2400 to 2483.5 MHz

Pass/Fail Judgment: **PASS**

Test record created by: **David Arnett**
Date of this record: **12 Apr 2024**
Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
MXE Receiver 8.4 GHz	Keysight	N9038B	MY63460112	28-Feb-2024	1-Mar-2025

Table TR06.1: List of test equipment used

Test Software Used: Keysight PXE firmware rev. 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 portion of the total power observed, and also identify parameters such as the edge frequencies for that bandwidth and the center frequency error. The spectrum is scanned many times so that the varied effects of modulation are appropriately assessed. Since the focus is on the relative distribution of energy across a range of frequencies, the absolute amplitudes recorded during this test are not relevant and may not include cable losses or attenuation factors.

Test Setup

This block diagram shows the test equipment setup.

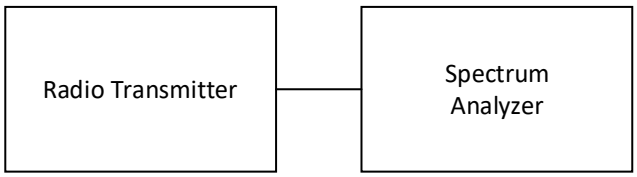


Figure TR06.1: Test setup

Test Data

The Bluetooth transmitter was tested on the low, middle, and high frequencies. All WiFi modulations were tested on Channel 1, and the worst case modulations for B, G, and N modes were also tested on the middle channel (6)and the highest channel (11).The data for each test is summarized below, followed by the spectral data for each case highlighted in yellow.

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

Freq.	2402	2442	2480
DTS BW	0.719	0.711	0.698

Table TR06.2: Summary of bandwidth data in MHz for BLE mode

Mode	Ch 1	Ch 6	Ch 11
B1	9.545	NT	NT
B2	8.712	7.795	8.834
B5.5	9.100	NT	NT
B11	9.461	NT	NT
G6	15.360	NT	NT
G9	15.500	13.890	15.740
G12	15.440	NT	NT
G18	15.410	NT	NT
G24	15.340	14.210	15.770
G36	15.770	NT	NT
G48	15.430	NT	NT
G54	15.460	NT	NT
N0	15.140	13.880	16.100
N1	15.400	NT	NT
N2	15.410	NT	NT
N3	16.090	NT	NT
N4	15.740	NT	NT
N5	15.730	NT	NT
N6	15.780	NT	NT
N7	16.030	NT	NT

Table TR06.3: Summary of bandwidth data in MHz for IEEE 802.11 WiFi modes

Figure TR06.3: Bandwidth data for BLE at high channel (2480 MHz)

Figure TR06.4: Bandwidth data for 802.11b 2 Mbps at channel 6

Figure TR06.5: Bandwidth data for 802.11g 9 Mbps at channel 6

Figure TR06.6: Bandwidth data for 802.11n MCS0 at channel 6

This line is the end of the test record.

Test Record
Transmitter Bandwidth Tests - OBW and NB
Test IDs TR10, TR12
Project GCL-0407

Test Date(s)	4 Apr 2024
Test Personnel	David Arnett
Product Model	A04766
Serial Number tested	8A4000458
Operating Mode	M3 (BleTx), M7 (WiFiTx)
Arrangement	A1 (Pwr)
Input Power	5Vdc
Test Standards:	FCC Part 2.202, ANSI C63.10, TRC-43, RSS-GEN (as noted in Section 6 of the report).
Radio Protocol	Bluetooth Low Energy (BLE), WiFi b, g, and n modes
Radio Band	2400 to 2483.5 MHz
Pass/Fail Judgment:	**Reported**
Test record created by:	**David Arnett**
Date of this record:	**12 Apr 2024**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
MXE Receiver 8.4 GHz	Keysight	N9038B	MY63460112	28-Feb-2024	1-Mar-2025

Table TR10.1: List of test equipment used

Test Software used: Keysight PXE System Code rev. 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.

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

Test Setup

This block diagram shows the test equipment setup.

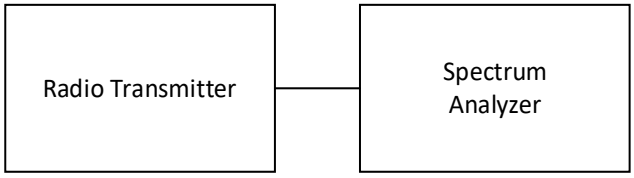


Figure TR10.1: Test setup

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.

The Bluetooth transmitter was tested on the low, middle, and high frequencies. All WiFi modulations were tested on Channel 1, and the worst case modulations for B, G, and N modes were also tested on the middle channel (6)and the highest channel (11).

Occupied Bandwith, 99% Test Data

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

Freq.	2402	2442	2480
99% OBW	1.044	1.043	1.044

Table TR10.2: Summary of 99% Occupied Bandwidth Data for Bluetooth, ANT and BLE modes

Mode	Ch 1	Ch 6	Ch 11
B1	14.205	NT	NT
B2	14.237	13.942	14.441
B5.5	13.965	NT	NT
B11	13.964	NT	NT
G6	16.730	NT	NT
G9	16.747	16.580	17.045
G12	16.565	NT	NT
G18	16.581	NT	NT
G24	16.551	16.471	16.711
G36	16.566	NT	NT
G48	16.521	NT	NT
G54	16.523	NT	NT
N0	17.744	17.653	17.971
N1	17.658	NT	NT
N2	17.637	NT	NT
N3	17.605	NT	NT
N4	17.613	NT	NT
N5	17.635	NT	NT
N6	17.636	NT	NT
N7	17.621	NT	NT

Table TR10.3: Summary of 99% Occupied Bandwidth Data for IEEE 802.11 WiFi modes

Figure TR10.2: Occupied bandwidth data for BLE at high channel (2480 MHz)

Figure TR10.4: Occupied bandwidth data for 802.11b 2 Mbps at channel 11

Figure TR10.5: Occupied bandwidth data for 802.11g 9 Mbps at channel 11

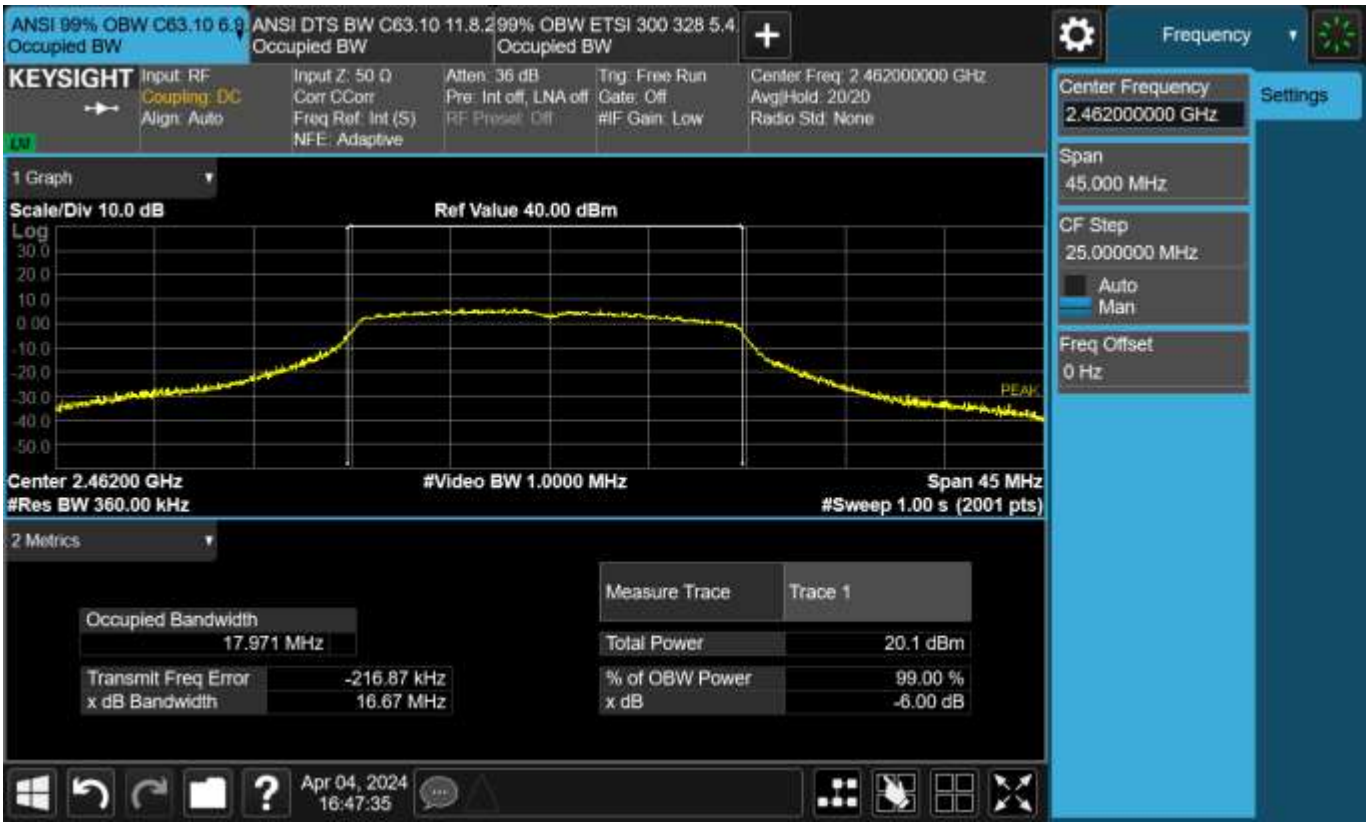


Figure TR10.6: Occupied bandwidth data for 802.11n MCS0 at channel 11

Necessary Bandwidth Calculations

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

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

$B_N = BCK$

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

Table TR10.100: Necessary Bandwidth for NFC

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

$B_N = 2R / Log_2(S)$

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

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

Table TR10.101: Necessary Bandwidth for ANT and ANT+ Radio Protocols (FCC and TRC-43)

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

Table TR10.102: Necessary Bandwidth for Bluetooth Radio Protocols (FCC and TRC-43)

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

Table TR10.103: Necessary Bandwidth for IEEE 802.11 b Radio Protocol (FCC and TRC-43)

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

Table TR10.104: Necessary Bandwidth for IEEE 802.11 a, g, n, and ac 20 MHz Radio Protocols (FCC)

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

Table TR10.105: Necessary Bandwidth for IEEE 802.11 n and ac 40 MHz Radio Protocols (FCC)

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

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

$$B_N = N_S * K$$

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

Table TR10.106: Necessary Bandwidth for IEEE 802.11 a, g, n, and ac Radio Protocols (TRC-43)

This line is the end of the test record.

Test Record
Transmitter Power
Test IDs TR02
Project GCL0407

Test Date(s)	01 Apr, 28 May 2024
Test Personnel	David Arnett, Jim Solum
Product Model	A04813
Serial Number tested	8A5000018 8A5000017 (Power vs Temperature Test)
Operating Mode	M3 (BleTx)
Arrangement	A1 (Pwr)
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	0.8 dBi, as reported by the client
Radio Protocol	Bluetooth Low Energy
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**28 May 2024**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	7-Jul-2023	1-Jul-2024
Thermometer	Thermco	ACCD370P	210607316	21-Sep-2023	15-Sep-2024
Thermal Chamber	Tenney	T2RC	32774-02	Calibration	Not Required

Table TR02.1: List of test equipment used

Software used: Rohde & Schwarz Power Viewer V11.3; TimePowerAnalysisSpreadsheetv11.xls

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

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

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

Transmit Power Data
Each measurement is made conducted from the antenna port with the transmitter on a specified channel and in a selected transmission protocol.

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

The results are shown below. Yellow highlighted cells indicate the highest power value for each radio protocol. Bluetooth Low Energy at the 1 Mbps data has its lowest and highest channel frequencies set at 2402 MHz and 2480 MHz.

Frequency	(MHz)	2402	2440	2480
BT Low Energy	1 Mbps	**8.53**	**8.74**	**7.54**

Table TR02.2: Transmit Power Summary in dBm with ANSI C63.10 analytical methods

Frequency	(MHz)	2402	2440	2480
BT Low Energy	1 Mbps	**9.14**	**9.36**	**8.10**

Table TR02.3: Transmit Power Summary in dBm EIRP with ETSI analytical methods

The table below shows BLE 2440 MHz power vs temperature at nominal and hot and cold temperature extremes.

Temperature	°C	Power, dBm EIRP	Limit, dBm EIRP	Result
Nominal	20	9.51	20	Pass
Hot	60	7.73	20	Pass
Cold	-20	9.82	20	Pass

Table TR02.4: BLE 2440 MHz Transmit Power Summary in dBm EIRP with ETSI analytical methods

Additional Transmit Power Data Analysis

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

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

Frequency	(MHz)	2402	2440	2480
BT Low Energy	1 Mbps	**4.35**	**4.57**	**3.42**

Table TR02.5: Additional RF exposure power summary, with units of milliwatt

Setup Diagram

The following block diagrams show how the EUT and test equipment is arranged for test. The client provided a short length of cable to bring the signals out to a connector. This cable was found to have 0.8 dB of loss in this frequency range. This factor was taken into account during the data analysis.

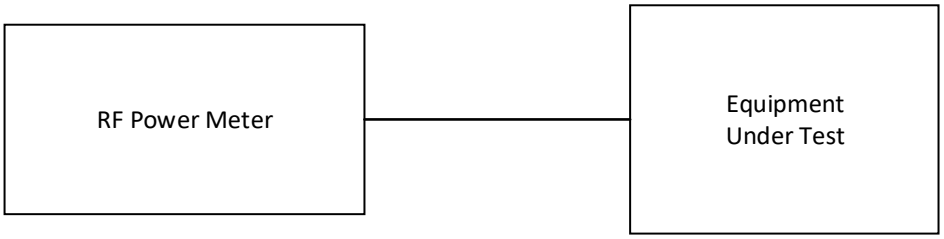


Figure TR02.1: Test equipment setup

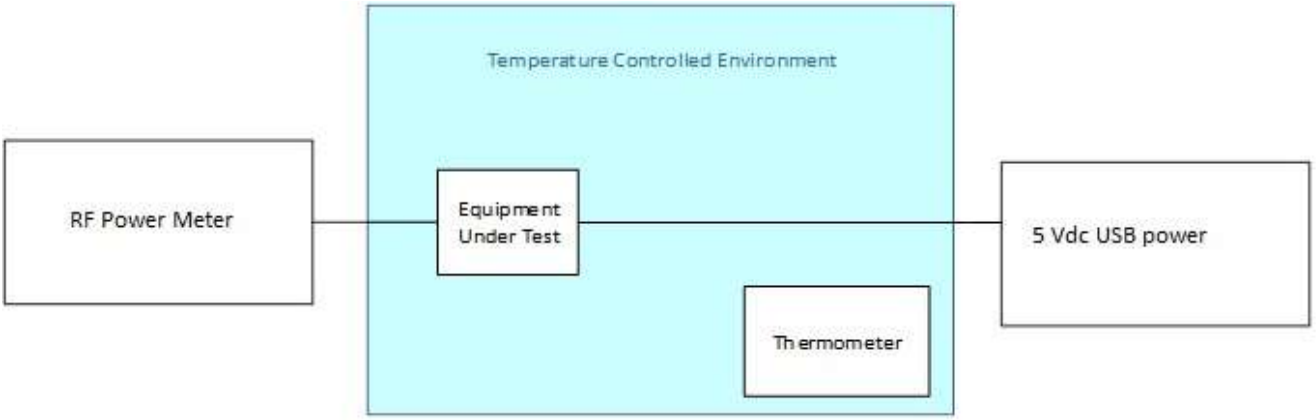


Figure TR02.2: Test equipment setup for transmit power measurements at 60°C and -20°C

This line is the end of the test record.

Test Record
Transmitter Power
Test IDs TR03
Project GCL0407

Test Date(s)	02 Apr 2024
Test Personnel	Jim Solum
Product Model	A04813
Serial Number tested	8A5000018
Operating Mode	M7 (Wifi Tx)
Arrangement	A1 (Pwr)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 FCC Part 2.1091, FCC Part 2.1093, RSS-102, ANSI C95.3 (as noted in Section 6 of the report).
Antenna Gain	0.8 dBi, as reported by the client
Radio Protocol	IEEE 802.11b/g/n
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**04 Apr 2024**

Original record, Version A.

Test Equipment Used

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

Table TR03.1: List of test equipment used

Software used: Rohde & Schwarz Power Viewer V11.3; TimePowerAnalysisSpreadsheetv11.xls

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

ANSI C63.10: 11.9.1.3

Transmit Power Data
Each measurement is made conducted from the antenna port with the transmitter on a specified channel and in a selected transmission protocol. The data record length is 100 msec for the Bluetooth-like protocols and 1 second for WiFi. Where standards cited here apply harmonized test methods and different limits, the more strict limit has applied. Data shown here is for WiFi channels 1 through 11.

The ANSI method finds the highest value (numerical peak) and applies the 30 dBm limit for WiFi from the US and Canadian standards. All values met the respective limits with more than 10 dB of margin.

The results are shown below. Yellow highlighted cells indicate the highest power value for each radio protocol. Grey 'NT' entries indicate channels or speeds that were not selected for measurement per the design of the experiment.

Mode	Speed	1	2	3	4	5	6	7	8	9	10	11
B	1	19.83	19.59	NT	NT	NT	19.37	NT	NT	NT	NT	NT
B	2	NT	NT	NT	NT	NT	19.40	NT	NT	NT	NT	NT
B	5.5	19.87	19.84	19.70	NT	NT	19.56	NT	NT	19.96	19.69	19.44
B	11	NT	NT	NT	NT	NT	19.47	NT	NT	NT	NT	NT
G	6	NT	NT	NT	NT	NT	16.03	NT	NT	NT	NT	NT
G	9	16.38	16.49	16.15	NT	NT	16.14	NT	NT	16.53	16.30	15.70
G	12	NT	NT	NT	NT	NT	15.88	NT	NT	NT	NT	NT
G	18	NT	NT	NT	NT	NT	15.96	NT	NT	NT	NT	NT
G	24	NT	NT	NT	NT	NT	16.00	NT	NT	NT	NT	NT
G	36	NT	NT	NT	NT	NT	16.09	NT	NT	NT	NT	NT
G	48	NT	NT	NT	NT	NT	13.69	NT	NT	NT	NT	NT
G	54	NT	NT	NT	NT	NT	11.57	NT	NT	NT	NT	NT
N	MCS0	15.40	15.00	14.88	NT	NT	15.05	NT	NT	15.40	15.18	14.64
N	MCS1	NT	NT	NT	NT	NT	14.78	NT	NT	NT	NT	NT
N	MCS2	NT	NT	NT	NT	NT	14.89	NT	NT	NT	NT	NT
N	MCS3	NT	NT	NT	NT	NT	14.95	NT	NT	NT	NT	NT
N	MCS4	NT	NT	NT	NT	NT	13.89	NT	NT	NT	NT	NT
N	MCS5	NT	NT	NT	NT	NT	12.82	NT	NT	NT	NT	NT
N	MCS6	NT	NT	NT	NT	NT	12.49	NT	NT	NT	NT	NT
N	MCS7	NT	NT	NT	NT	NT	11.90	NT	NT	NT	NT	NT

Table TR03.2: WiFi transmit power summary in dBm

Additional Transmit Power Data Analysis

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

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

Mode	Speed	1	2	3	4	5	6	7	8	9	10	11
B	1	80.58	78.78	NT	NT	NT	75.33	NT	NT	NT	NT	NT
B	2	NT	NT	NT	NT	NT	68.76	NT	NT	NT	NT	NT
B	5.5	59.03	56.82	55.01	NT	NT	52.90	NT	NT	60.17	56.53	53.42
B	11	NT	NT	NT	NT	NT	39.23	NT	NT	NT	NT	NT
G	6	NT	NT	NT	NT	NT	22.53	NT	NT	NT	NT	NT
G	9	20.37	19.91	18.73	NT	NT	18.99	NT	NT	20.14	19.48	17.30
G	12	NT	NT	NT	NT	NT	16.01	NT	NT	NT	NT	NT
G	18	NT	NT	NT	NT	NT	12.77	NT	NT	NT	NT	NT
G	24	NT	NT	NT	NT	NT	10.56	NT	NT	NT	NT	NT
G	36	NT	NT	NT	NT	NT	10.07	NT	NT	NT	NT	NT
G	48	NT	NT	NT	NT	NT	6.33	NT	NT	NT	NT	NT
G	54	NT	NT	NT	NT	NT	3.72	NT	NT	NT	NT	NT
N	MCS0	18.43	17.73	17.22	NT	NT	17.16	NT	NT	18.04	17.45	15.90
N	MCS1	NT	NT	NT	NT	NT	12.05	NT	NT	NT	NT	NT
N	MCS2	NT	NT	NT	NT	NT	9.67	NT	NT	NT	NT	NT
N	MCS3	NT	NT	NT	NT	NT	7.96	NT	NT	NT	NT	NT
N	MCS4	NT	NT	NT	NT	NT	6.16	NT	NT	NT	NT	NT
N	MCS5	NT	NT	NT	NT	NT	4.99	NT	NT	NT	NT	NT
N	MCS6	NT	NT	NT	NT	NT	4.60	NT	NT	NT	NT	NT
N	MCS7	NT	NT	NT	NT	NT	4.27	NT	NT	NT	NT	NT

Table TR03.3: WiFi additional RF exposure power summary in milliwatts

Setup Diagram

The following block diagrams show how the EUT and test equipment is arranged for test. The client provided a short length of cable to bring the signals out to a connector. This cable was found to have 0.8 dB of loss in this frequency range. This factor was taken into account during the data analysis.

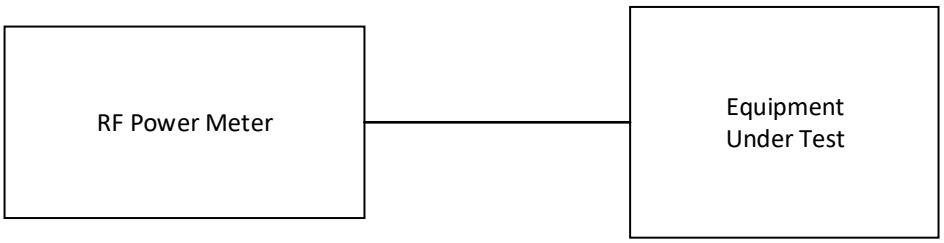


Figure TR03.1: Test equipment setup

This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test IDs TR27, TR29
Project GCL-0407

Test Date(s)	11 Apr 2024
Test Personnel	Jim Solum
Product Model	A04766
Serial Number tested	8A5000018
Operating Mode	M3 (BleTx) and M7(WiFiTx)
Arrangement	A1 (Pwr)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this test record:	**12 Apr 2024**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	13-Mar-2024	15-Mar-2025

Table TR27.1: 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.

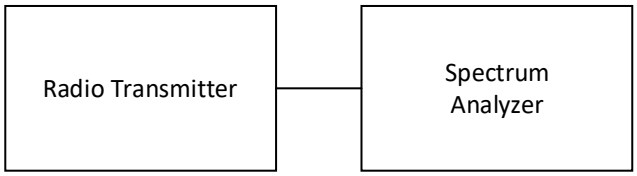


Figure TR27.1: Test setup

Test Data

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

This measurement requires that a coaxial feed line from the transmitter is available as a connector exterior to the test sample. This feed line and connector may be a part of the shipping product, or it may be a special modification to the product for testing purposes. The connector is attached via laboratory cables to the measurement instrument. The results have been adjusted to account for the losses in the laboratory cables. Where feasible, the losses of any added feed lines are also included in that adjustment.

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

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

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

For BLE operating at 1 Mbps, the lowest operating frequency was 2402 MHz, and the highest operating frequency was 2480 MHz.

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

		2402	2440	2480
BLE	1 Mb	54.35	52.43	53.09

Table TR27.2: Results summary for BLE1

		Channel No.		
Mode	Data rate (Mbps)	1	6	11
B	5.5	56.50	58.17	57.91
G	9	52.66	53.26	52.02
N	MCS0	55.93	52.25	51.41

Table TR27.3: Results summary for IEEE 802.11 (b,g,n)

Figure TR27.2: Reference level measurement for Bluetooth BLE 1 Mbps at 2440 MHz

Figure TR27.3 Spectral data for Bluetooth BLE 1 Mbps at 2440 MHz

Figure TR27.6: Reference level measurement for IEEE 802.11 B 5.5 Mbps on Ch.1

Figure TR27.7: Spectral data for IEEE 802.11 B 5.5 Mbps on Ch.1

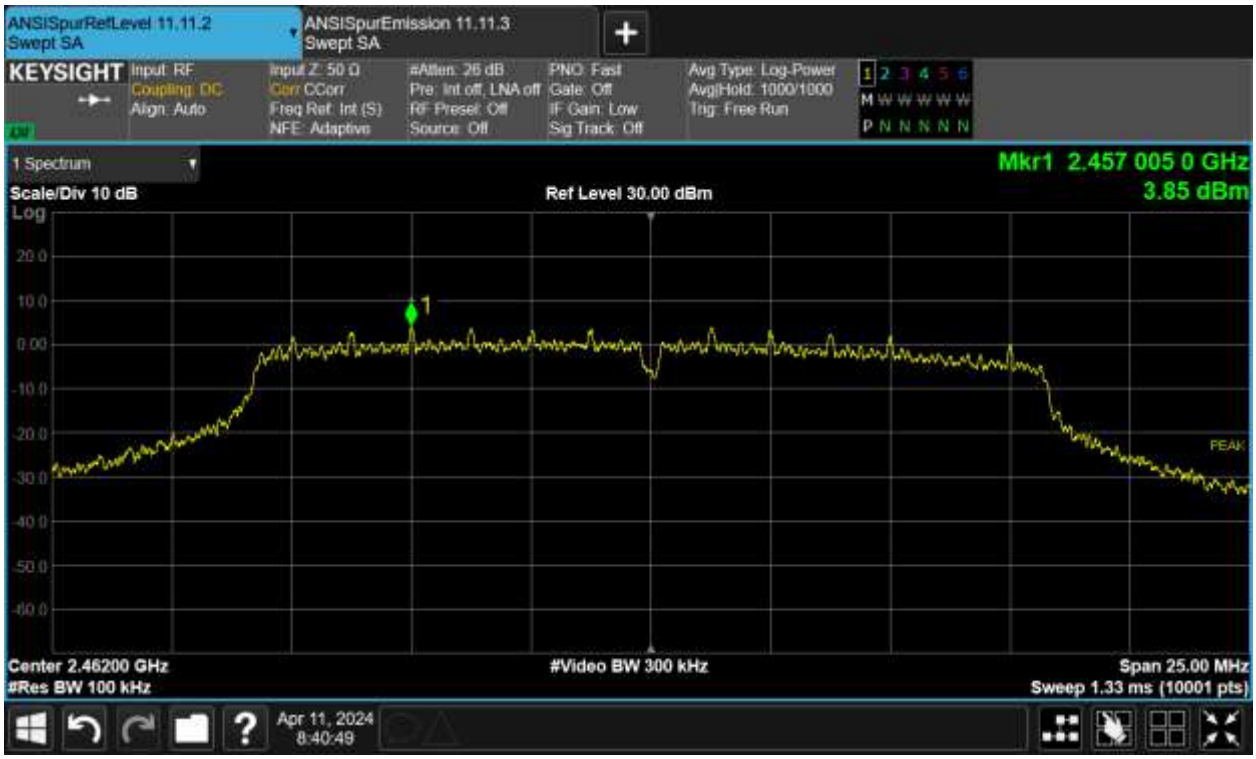


Figure TR27.8: Reference level measurement for IEEE 802.11 G 9 Mbps on Ch.11

Figure TR27.9 Spectral data for IEEE 802.11 G 9 Mbps on Ch.11

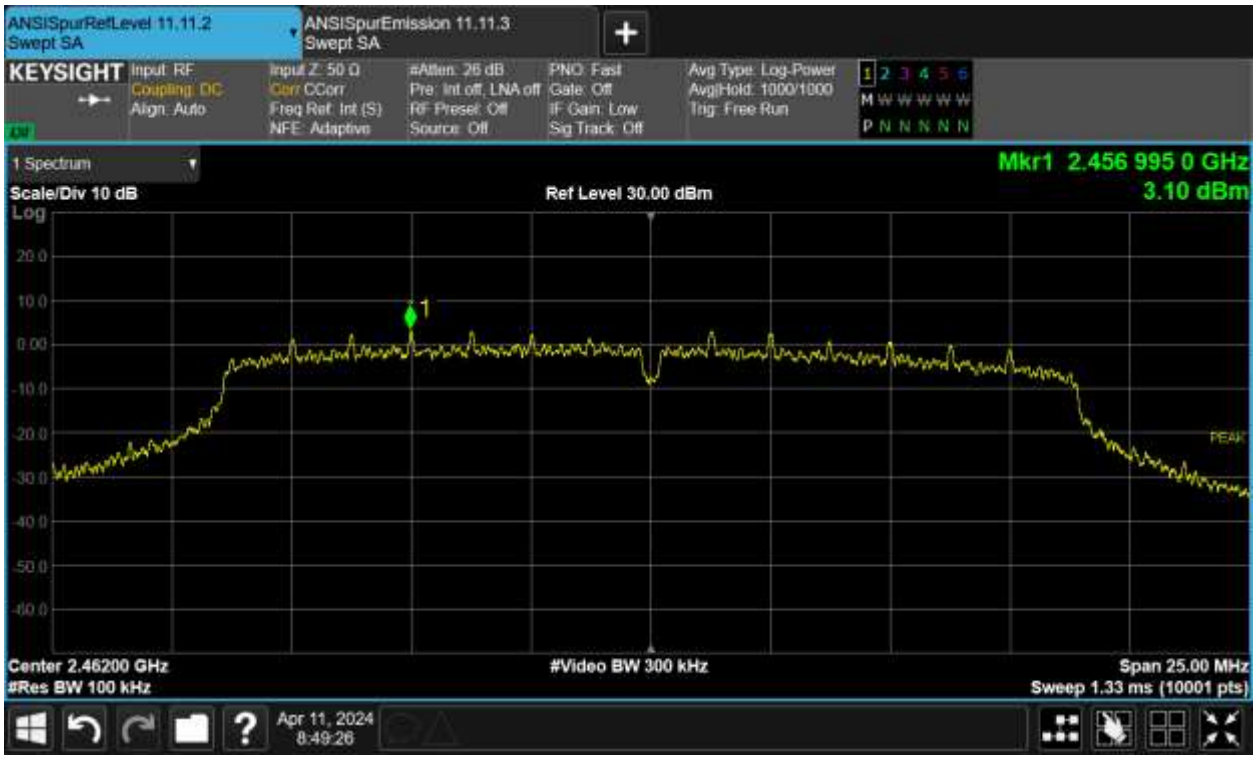


Figure TR27.10: Reference level measurement for IEEE 802.11 N MCS0 on Ch.11

Figure TR27.11 Spectral data for IEEE 802.11 N MCS0 on Ch.11

This line is the end of the test record.

Test Record
Radiated Emission Test RE01
Project GCL0407

Test Date(s)	05 Apr 2024
Test Personnel	David Kerr
Product Model	A04766
Serial Number tested	8A4000458
Operating Mode	M7 (WiFiTx)
Arrangement	A11 (CLA1/4m)
Input Power	12 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN (as noted in Section 6 of the report)
Frequency Range:	Restricted Bands (2200-2300 MHz, 2310-2390 MHz, 2483.5-2500 MHz)
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**08 Apr 2024**

Original record, Version A.

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	21-May-2024

Table RE01.1: Test Equipment Used

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

Test Data

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

The radiated emission test began with a preliminary scan in each restricted band 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. Final field strength measurements were taken in that set of positions.

Restricted band measurements in the lower band were made while the transmitter was tuned to its lowest frequency of Channel 1 (2412 MHz). Measurements in the upper band were made while the transmitter was tuned to its highest frequency of Channel 11 (2462 MHz).

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

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

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2384	54	74	47.861	57.371	6.139	16.629	129	1087	HORZ
2383.8	54	74	47.861	58.035	6.139	15.965	129	1087	HORZ

Table RE01.2: FCC restricted bands from 2200 to 2390 MHz (B 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)	---
2487.5	54	74	43.136	54.015	10.864	19.985	166	2800	HORZ
2487.8	54	74	44.102	54.559	9.898	19.441	166	2800	HORZ

Table RE01.3: FCC restricted band from 2483.5 to 2500 MHz (B 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)	---
2384.8	54	74	40.288	57.925	13.712	16.075	129	1087	HORZ
2385.5	54	74	40.614	57.637	13.386	16.363	129	1087	HORZ

Table RE01.4: FCC restricted bands from 2200 to 2390 MHz (B 11Mbps)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2483.5	54	74	41.537	58.151	12.463	15.849	166	2800	HORZ
2483.5	54	74	41.881	58.313	12.119	15.687	166	2800	HORZ

Table RE01.5: FCC restricted band from 2483.5 to 2500 MHz (B 11Mbps)

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)	---
2390	54	74	42.732	65.892	11.268	8.108	129	1087	HORZ
2390	54	74	42.765	66.111	11.235	7.889	129	1087	HORZ

Table RE01.6: FCC restricted bands from 2200 to 2390 MHz (G 6Mbps)

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	44.09	67.578	9.91	6.422	166	2800	HORZ
2483.5	54	74	44.091	67.363	9.909	6.637	166	2800	HORZ

Table RE01.7: FCC restricted band from 2483.5 to 2500 MHz (G 6Mbps)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2483.5	54	74	41.337	68.096	12.663	5.904	166	2800	HORZ
2483.5	54	74	41.29	68.019	12.71	5.981	166	2800	HORZ

Table RE01.8: FCC restricted band from 2483.5 to 2500 MHz (G 36Mbps)

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)	---
2389.5	54	74	41.21	64.834	12.79	9.166	129	1087	HORZ
2390	54	74	41.602	65.225	12.398	8.775	129	1087	HORZ

Table RE01.9: FCC restricted bands from 2200 to 2390 MHz (N MCS0)

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	42.318	66.604	11.682	7.396	166	2800	HORZ
2483.5	54	74	42.374	66.482	11.626	7.518	166	2800	HORZ

Table RE01.10: FCC restricted band from 2483.5 to 2500 MHz (N MCS0)

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

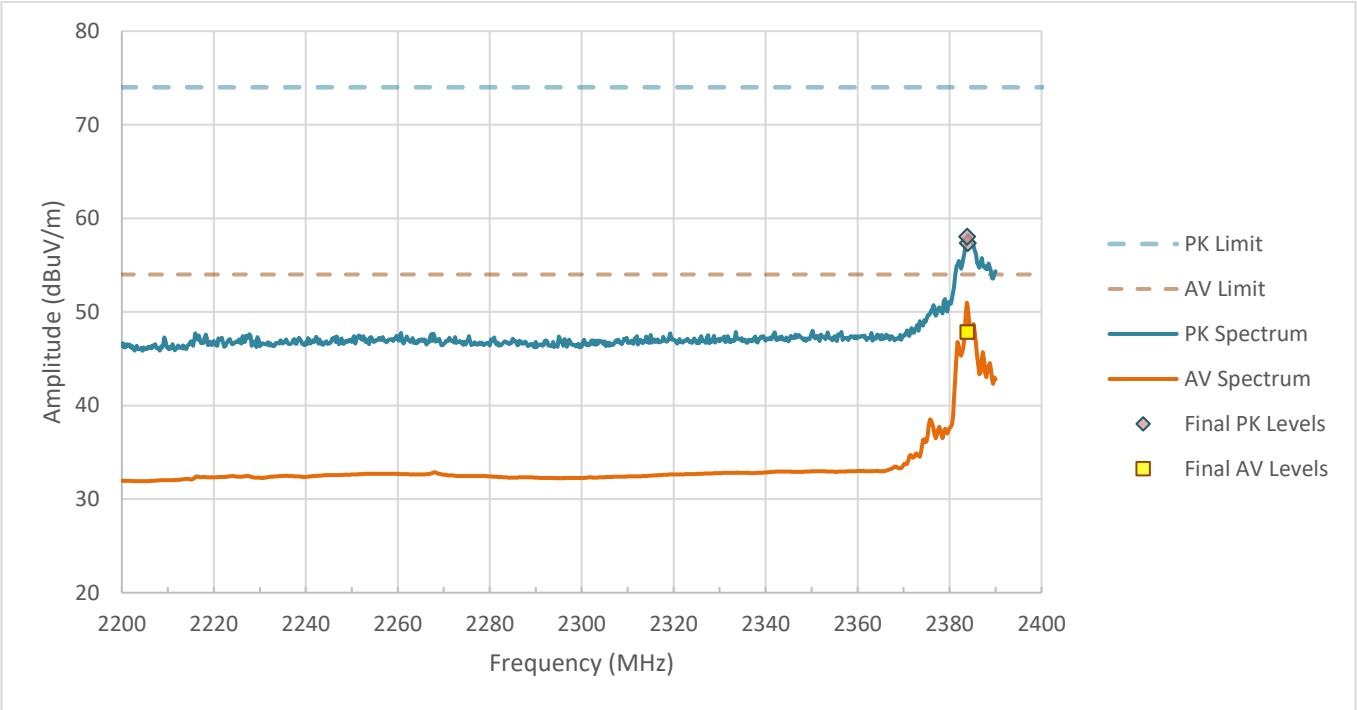


Figure RE01.1: FCC restricted band spectral data from 2200 to 2390 MHz (B 1Mbps)

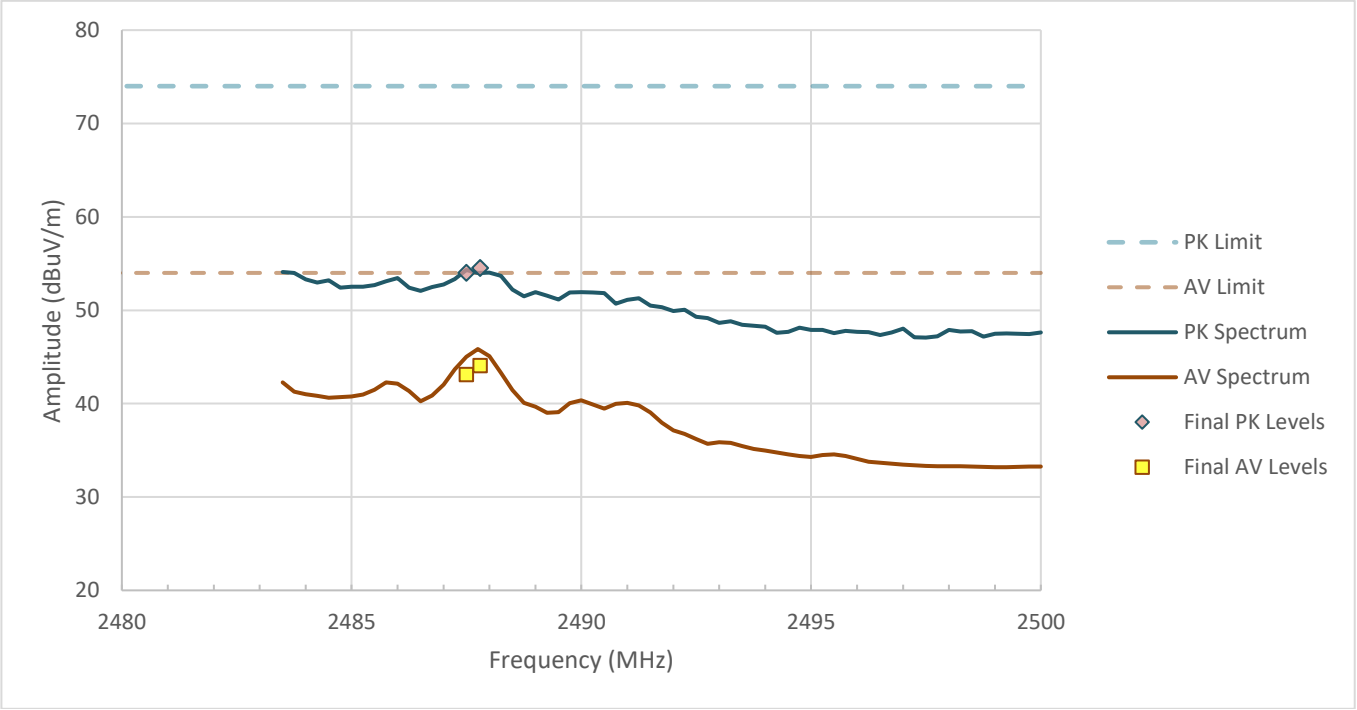


Figure RE01.2: FCC restricted band spectral data from 2483.5 to 2500 MHz (B 1Mbps)

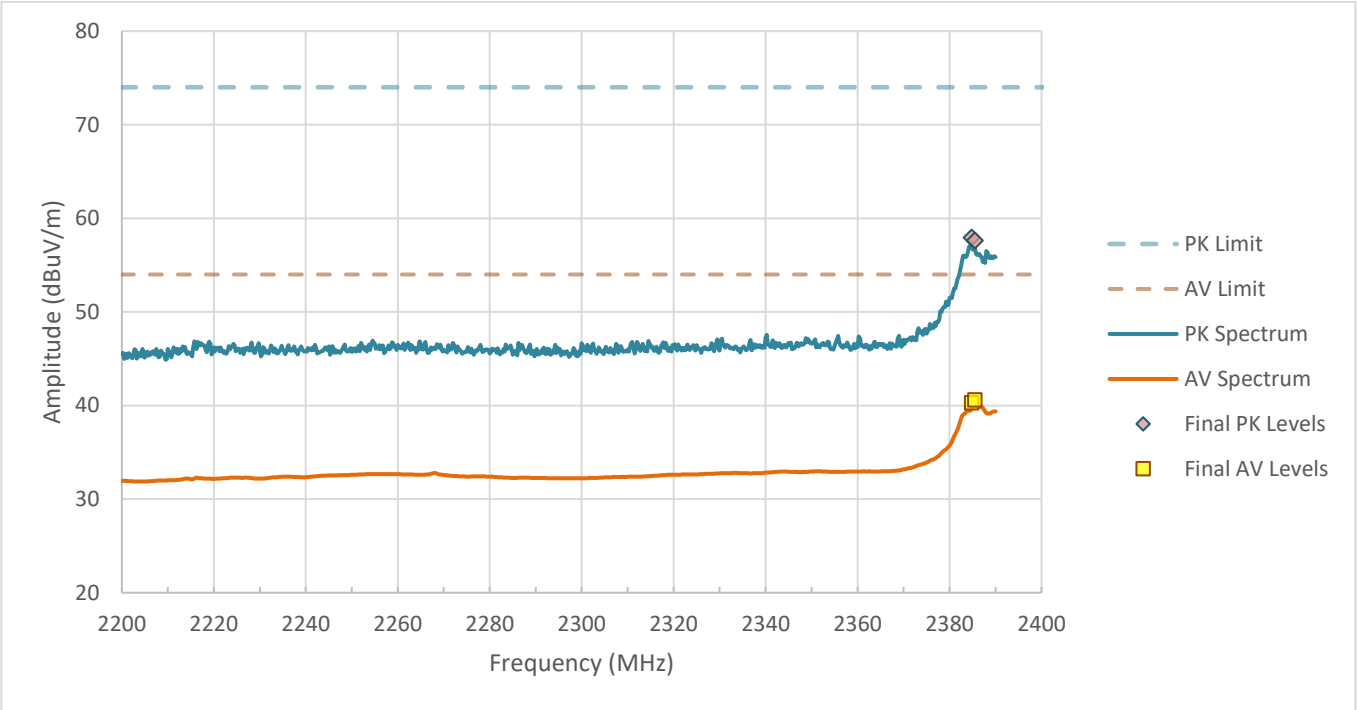


Figure RE01.3: FCC restricted band spectral data from 2200 to 2390 MHz (B 11Mbps)

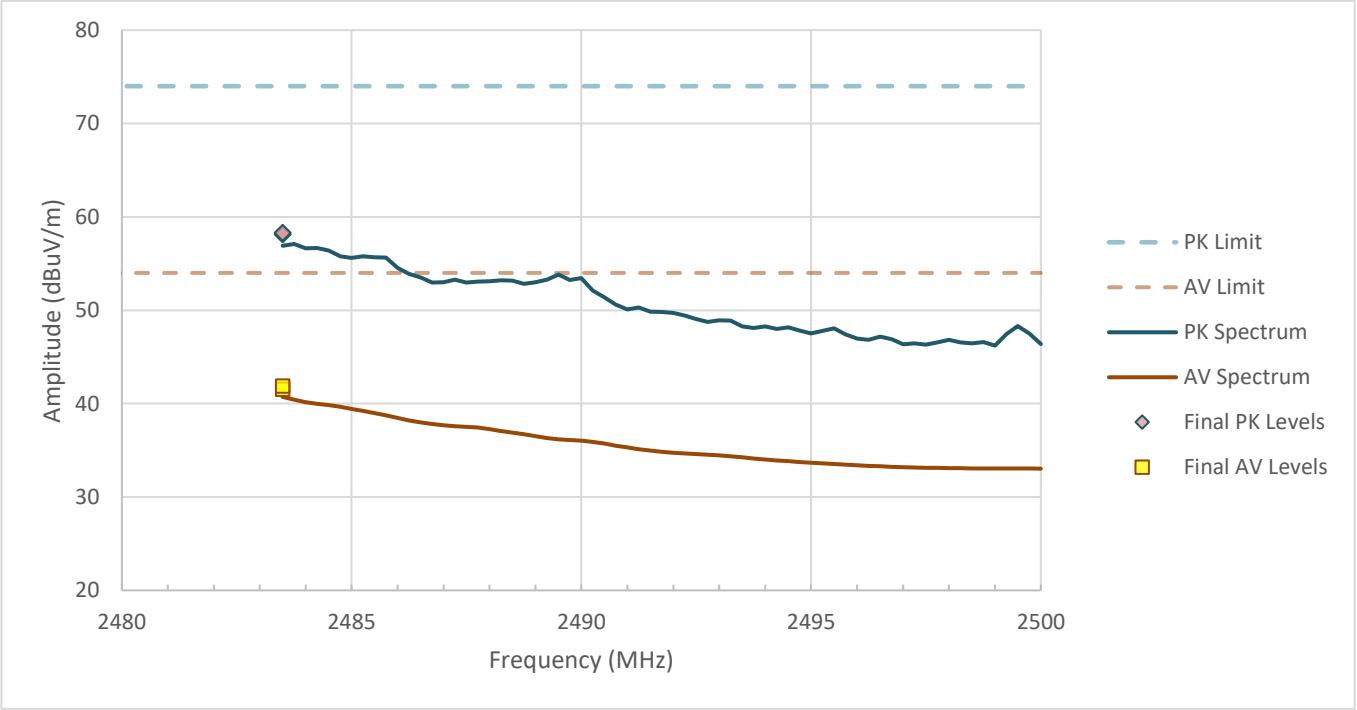


Figure RE01.4: FCC restricted band spectral data from 2483.5 to 2500 MHz (B 11Mbps)

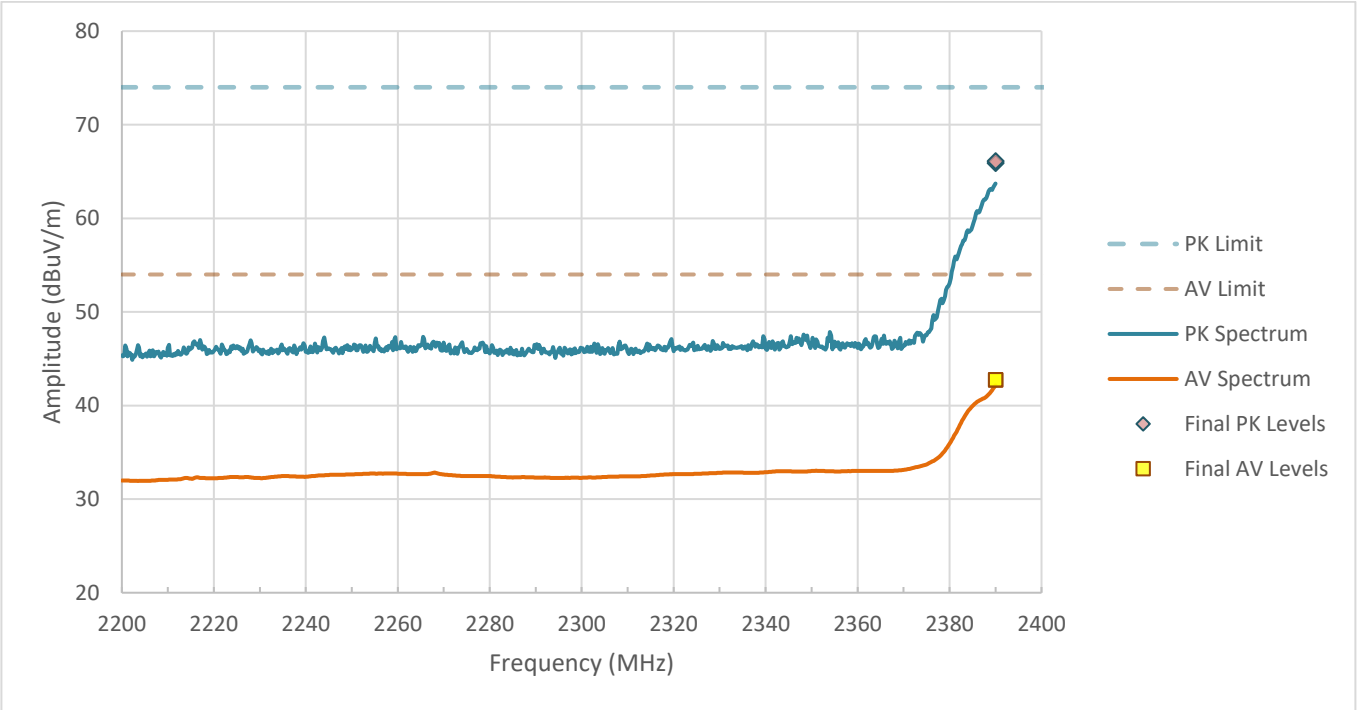


Figure RE01.5: FCC restricted band spectral data from 2200 to 2390 MHz (G 6Mbps)

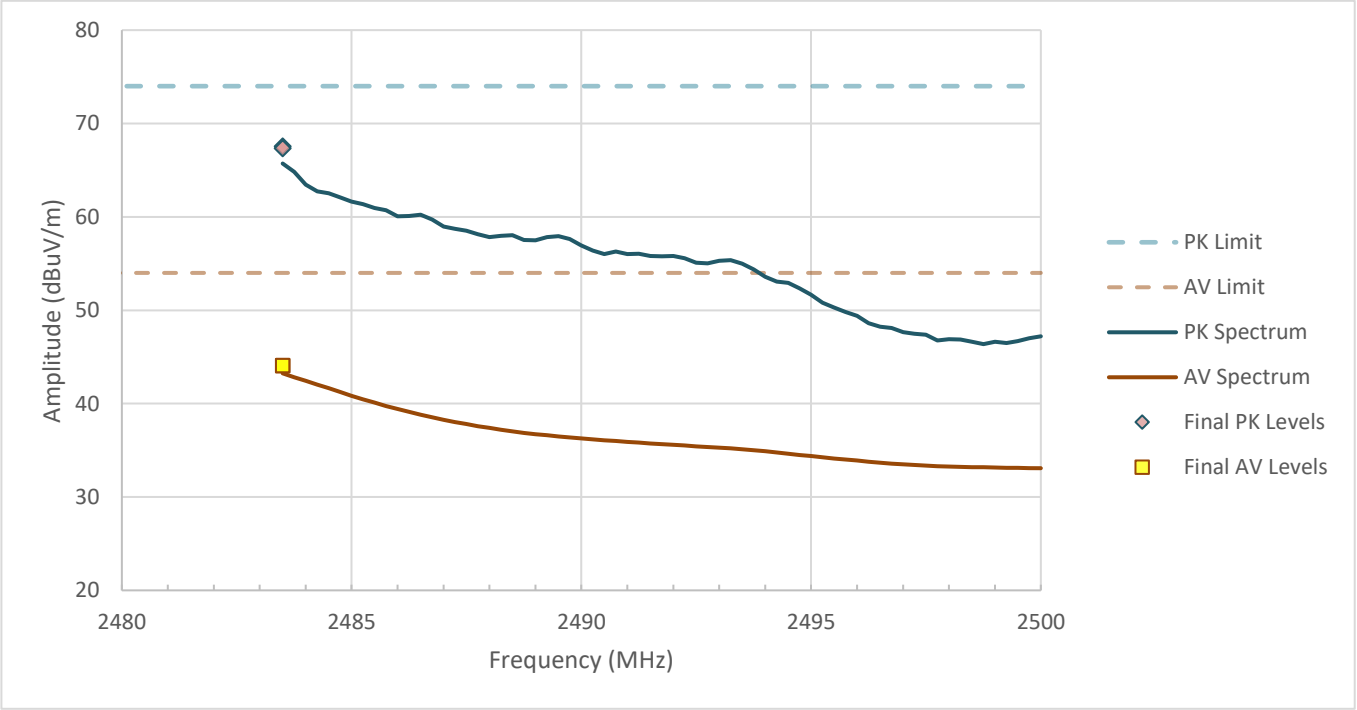


Figure RE01.6: FCC restricted band spectral data from 2483.5 to 2500 MHz (G 6Mbps)

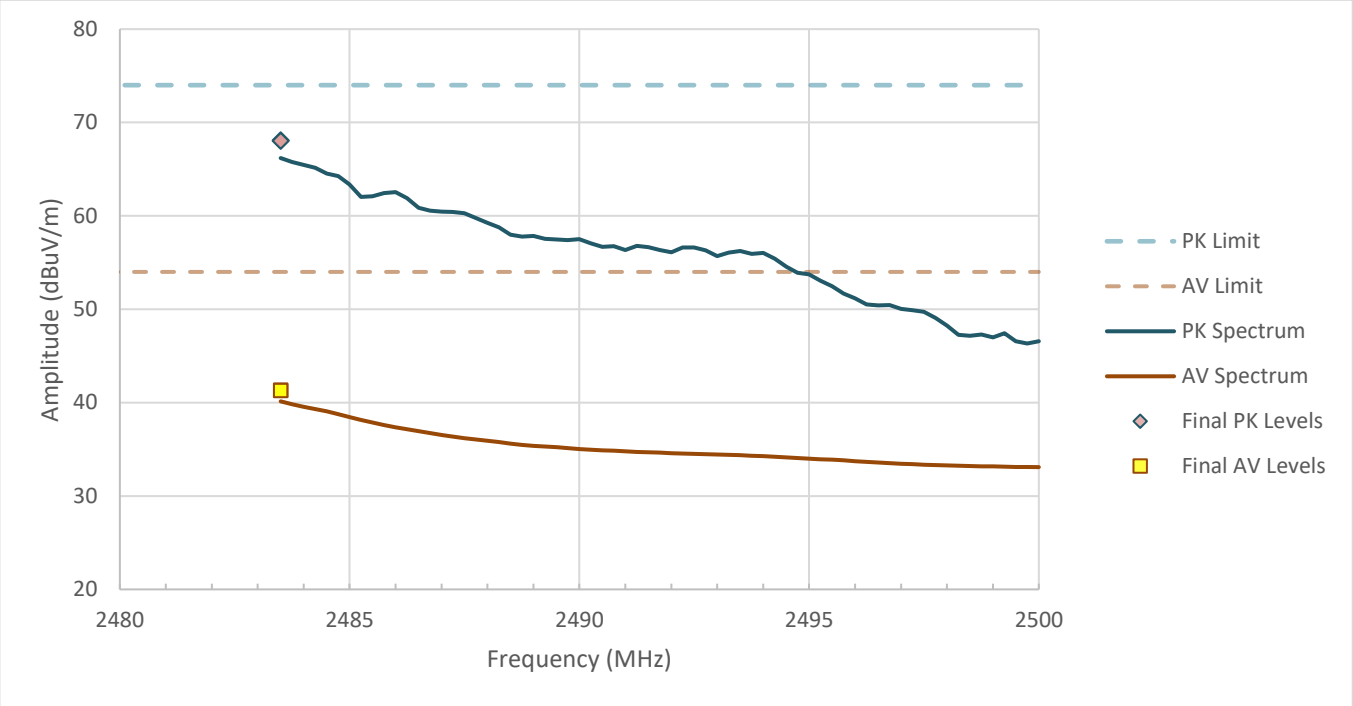


Figure RE01.7: FCC restricted band spectral data from 2483.5 to 2500 MHz (G 36Mbps)

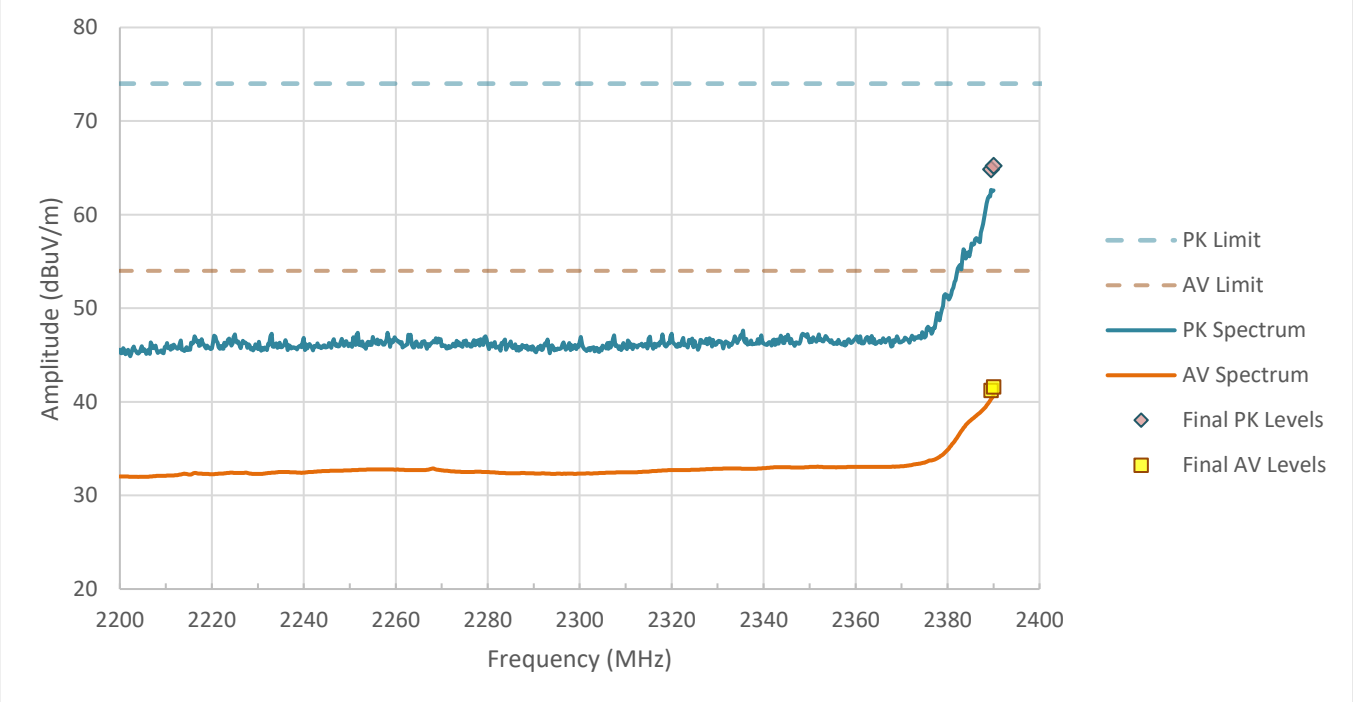


Figure RE01.8: FCC restricted band spectral data from 2200 to 2390 MHz (N MCS0)

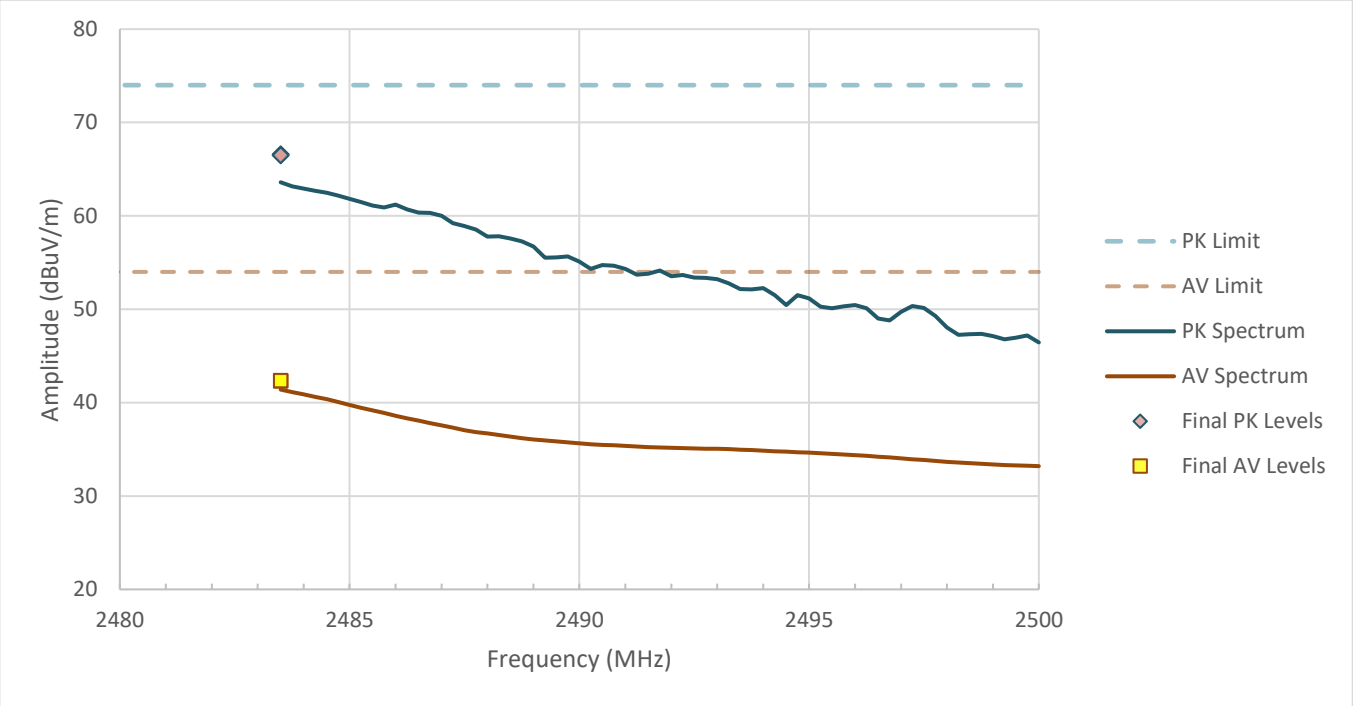


Figure RE01.9: FCC restricted band spectral data from 2483.5 to 2500 MHz (N MCS0)

Setup Photographs

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

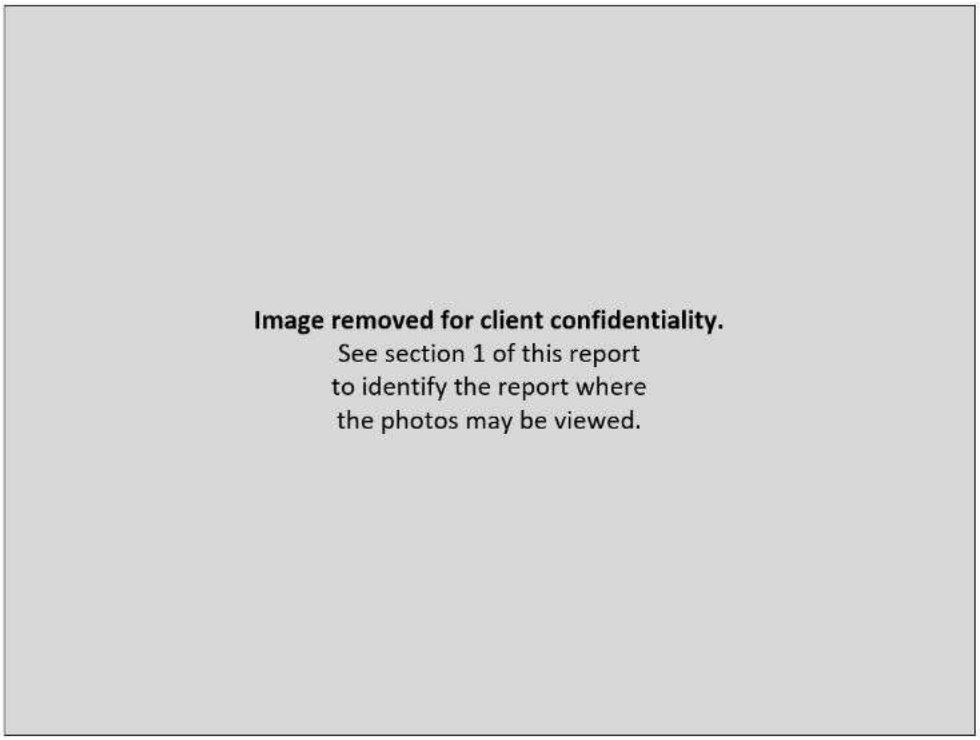


Figure RE01.10: EUT test setup, primary view

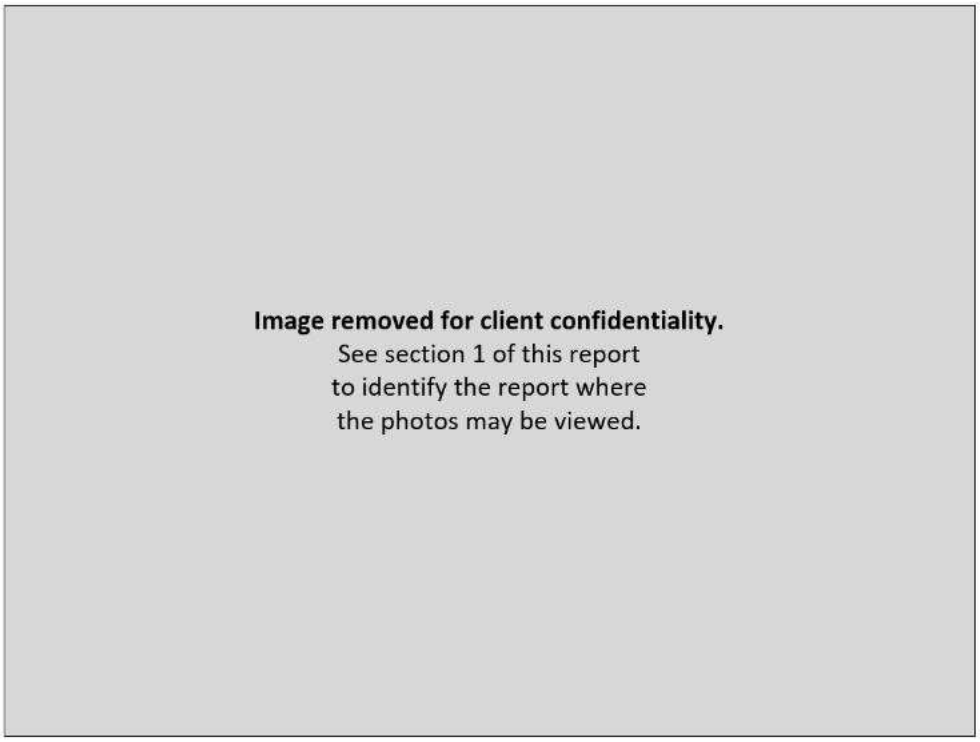


Figure RE01.11: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Radiated Emission Test RE03
Project GCL0407

Test Date(s)	09 Apr 2024
Test Personnel	David Kerr
Product Model	A04766
Serial Number tested	8A4000458
Operating Mode	M3 (BleTx)
Arrangement	A11 (CLA1/4m)
Input Power	12 Vdc
Test Standards:	FCC Part 15 (as noted in Section 6 of the report)
Frequency Range:	Restricted Bands (2200-2300 MHz, 2310-2390 MHz, 2483.5-2500 MHz)
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**09 Apr 2024**

Original record, Version A.

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	21-May-2024

Table RE03.1: Test Equipment Used

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

Test Data

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

The radiated emission test began with a preliminary scan in each restricted band 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. Final field strength measurements were taken in that set of positions.

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

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

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

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2348.8	54	74	33.769	49.005	20.231	24.995	129	1087	Horz
2390	54	74	34.729	48.966	19.271	25.034	129	1087	Horz

Table RE03.2: FCC restricted bands from 2200 to 2390 MHz (BIe 2402MHz)

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	36.645	51.23	17.355	22.77	166	2800	Horz
2484	54	74	36.759	51.045	17.241	22.955	166	2800	Horz

Table RE03.3: FCC restricted band from 2483.5 to 2500 MHz (BIe 2480MHz)

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

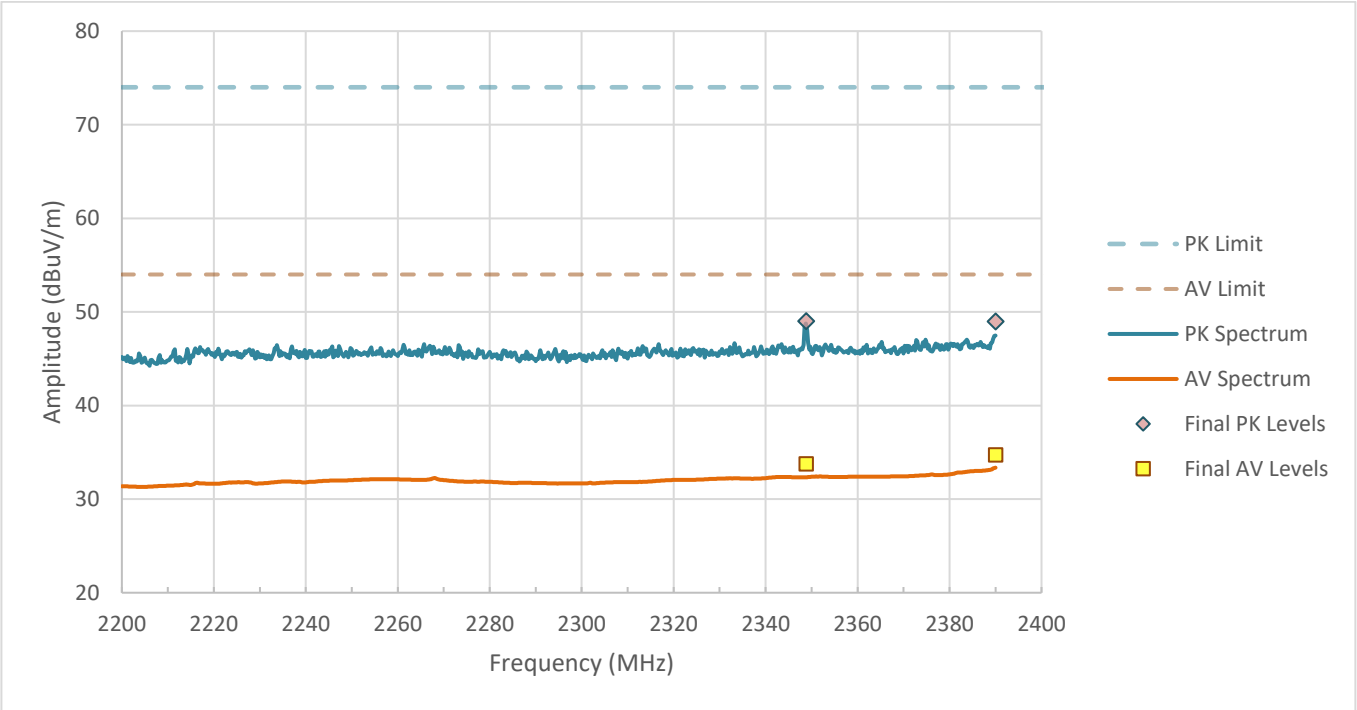


Figure RE03.1: FCC restricted band spectral data from 2200 to 2390 MHz (Ble 2402MHz)

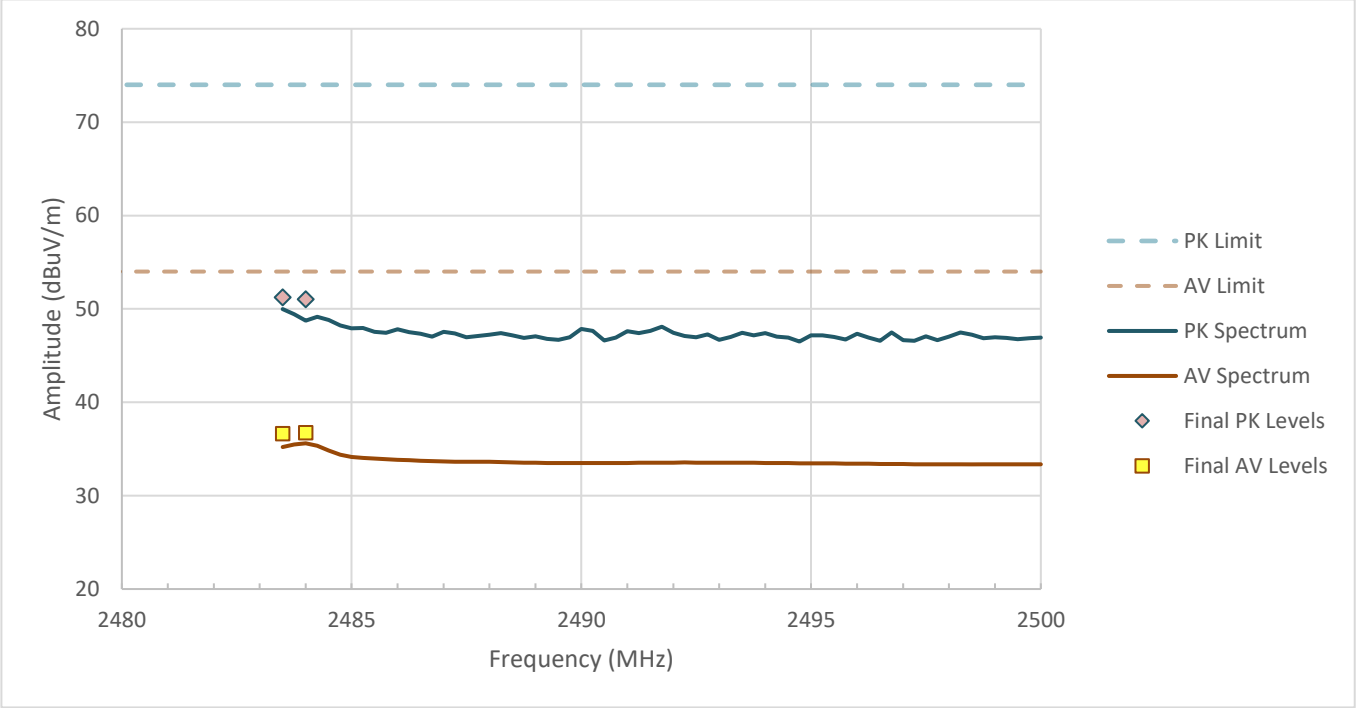


Figure RE03.2: FCC restricted band spectral data from 2483.5 to 2500 MHz (B1)

Setup Photographs

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

Figure RE03.3: EUT test setup, primary view

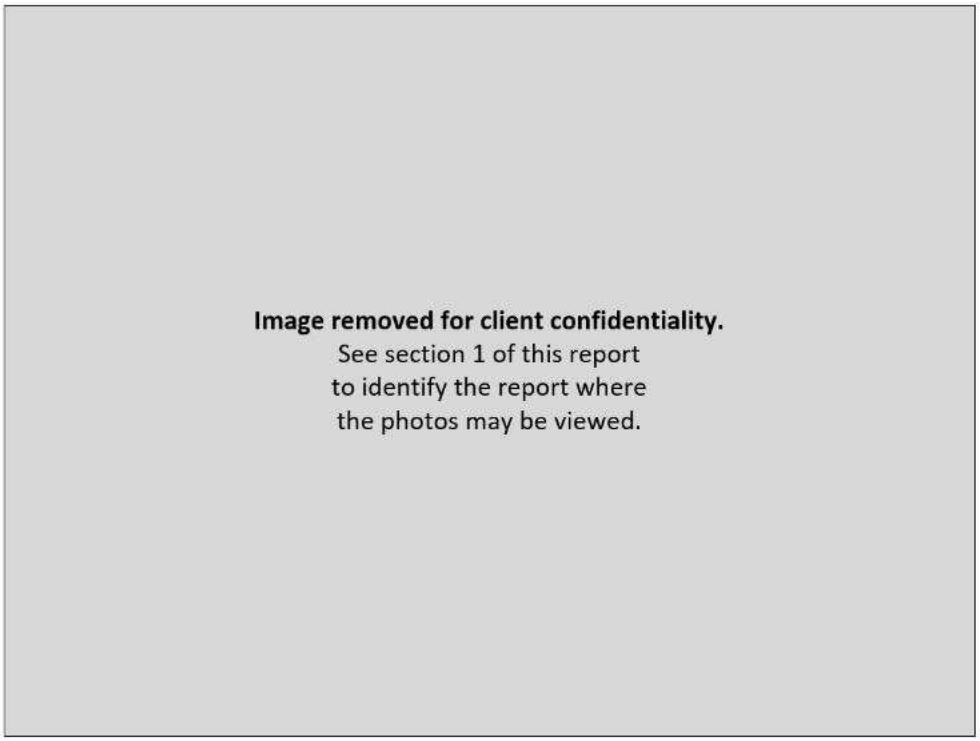


Figure RE03.4: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test IDs TR19
Project GCL-0407

Test Date(s)	5 Apr 2024
Test Personnel	David Arnett
Product Model	A04766
Serial Number tested	8A4000458
Operating Mode	M3 (BleTx) M7 (WiFiTx)
Arrangement	A1 (Pwr)
Input Power	5Vdc
Test Standards:	FCC Part 15, ANSI C63.10, AS/NZS 4268, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Antenna Gain	0.8 dBi, as reported by the client
Radio Protocol	Bluetooth Low Energy (BLE), IEEE 802.11 b/g/n (WiFi)
Pass/Fail Judgment:	**PASS**
Test record created by:	**David Arnett**
Date of this record:	**30 May 2024**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	13-Mar-2024	15-Mar-2025

Table TR19.1: 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.

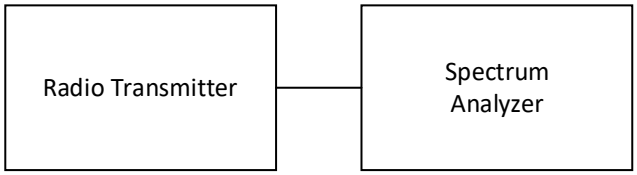


Figure TR19.1: Test setup

Test Data

Each measurement is made conducted from the antenna port with the transmitter on a specified channel and in a selected transmission protocol. The results include the effects of any measurement cable losses. Results reported are in units of dBm/Bandwidth and do not include the effect of antenna gain. The standard limit is 8 dBm / 3 kHz, and meeting the limit with wider resolution bandwidths is permitted. All data met the limit using a 3 kHz resolution bandwidth.

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

	Lo	Mid	Hi
BLE	-16.71	-14.37	-15.50
B 5.5	-12.58	-10.03	-5.11
G 9	-8.97	-9.50	-10.72
N 0	-11.08	-11.15	-11.75

Table TR19.2: Summary of results, in dBm/3 kHz

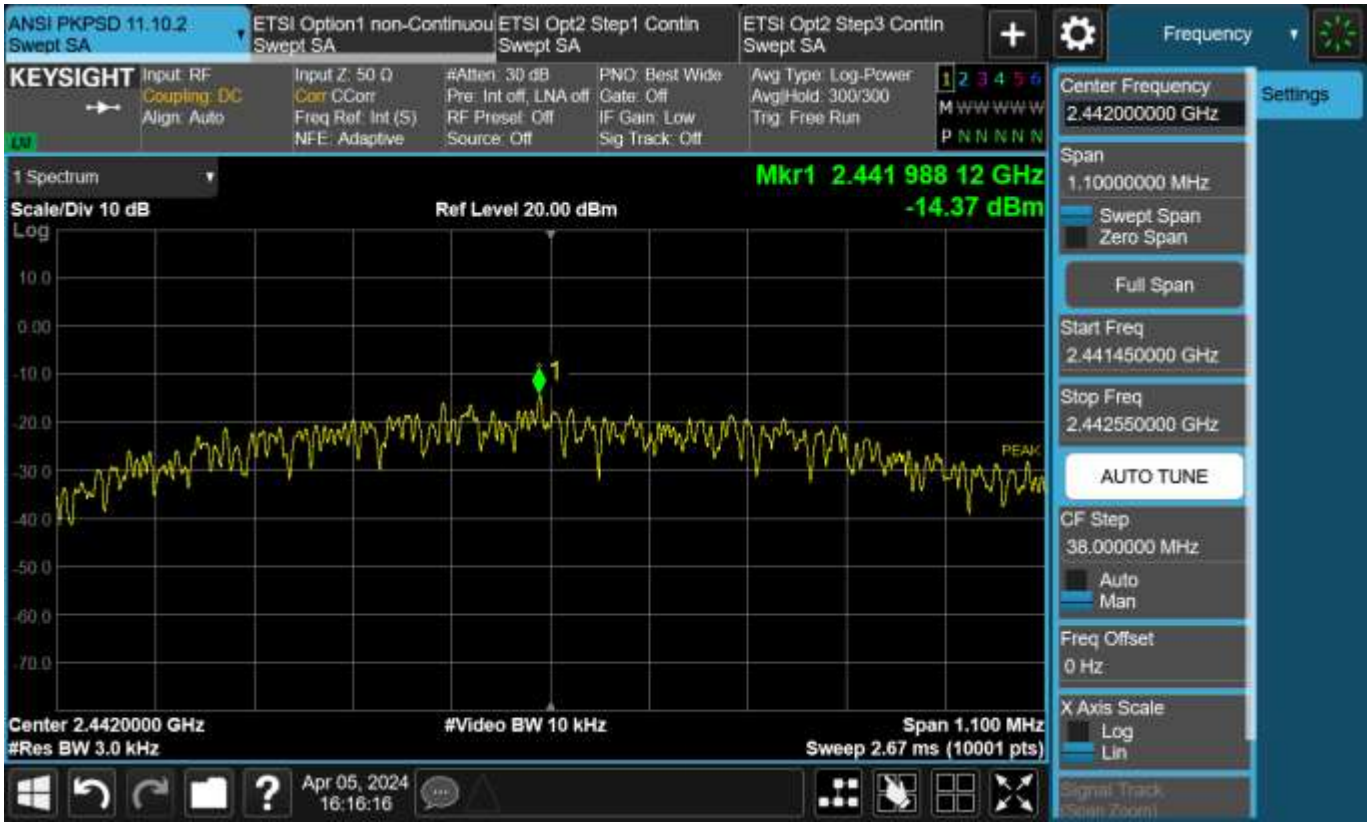


Figure TR19.3: Test data for BLE Mid frequency

Figure TR19.4: Test data for 802.11 b 5.5 Mbps channel 11

Figure TR19.5: Test data for 802.11 g 9 Mbps channel 1

Figure TR19.6: Test data for 802.11 n MCS 0 channel 1

This line is the end of the test record.

Test Record
Transmitter Stability in Extreme Conditions
Test IDs TR43
Project GCL0407

Test Date(s)	3-9 May 2024
Test Personnel	David Arnett
Product Model	A04766
Serial Number tested	8A5000018
Operating Mode	M3 (BleTx)
Arrangement	A1 (Pwr)
Nominal Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN (as noted in Section 6 of the report)
Radio Protocol	BLE
Pass/Fail Judgment:	**PASS**
Test record created by:	**David Arnett**
Date this record:	**31 May 2024**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
MXE Receiver 8.4 GHz	Keysight	N9038B	MY63460112	28-Feb-2024	1-Mar-2025
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	21-May-2024
Thermometer	Thermco	ACCD370P	220608121	26-Aug-2022	1-Sep-2024
Thermal Chamber	Tenney	T2RC	32774-02	Calibration	Not Required

Table TR43.1: List of test equipment used

Test Method

The standards cited require observation of the stability for transmission frequency and/or power at certain environmental extremes. The reference is performance on nominal input voltage and a temperature of 20 °C. Where the standards cited here impose different limits or conditions, the most stringent limits and conditions have been applied. The standard requires that performance be checked at temperature intervals from -20 °C to 60 °C at intervals not greater than 10 °C. Performance was verified at target intervals of 8 °C with the test chamber temperature maintained within a tolerance of +/- 1 °C to ensure that actual intervals were within the allowance provided.

The acceptance criterion is that the transmitted signals remain within the permitted radio band of 2400 – 2483.5 MHz. The modes utilized include those that showed emissions closest to the band edge during prior bandwidth testing. Acceptance is shown by demonstrating that the spectral energy at the band edge frequency is well below the intentional signal level.

Test Data

The test sample(s) were subjected to extreme conditions and performed as shown below. The table shows, at each temperature and voltage point, the decibel ratio of in-band energy to band edge energy. The data points highlighted

in yellow are selected as points of interest and the corresponding full data plots, including the marker and delta-marker data, are provided afterward.

Temperature	Voltage	Low	High
°C	V	Channel	Channel
60	5	**28.09**	**26.97**
52	5	**35.89**	**33.27**
44	5	**35.13**	**33.52**
36	5	**35.24**	**36.71**
28	5	**36.2**	**38.83**
20	5	**34.25**	**37.63**
20	5.75	**35.76**	**37.55**
20	4.25	**35.34**	**35.21**
12	5	**36.96**	**36.99**
4	5	**37.27**	**39.05**
-4	5	**36.11**	**38.93**
-12	5	**35.57**	**39.54**
-20	5	**36.67**	**38.63**

Table TR43.2: Frequency stability data with voltage and temperature variation

Figure TR43.1: Spectral plot for 60 °C and 5 V test condition

Figure TR43.2: Spectral plot for 20 °C and 5 V test condition

Figure TR43.3: Spectral plot for 20 °C and 5.75 V test condition

Figure TR43.4: Spectral plot for -20 °C and 5 V test condition

Setup Block Diagram

The following block diagram shows the EUT configured and arranged in the manner in which it was measured.

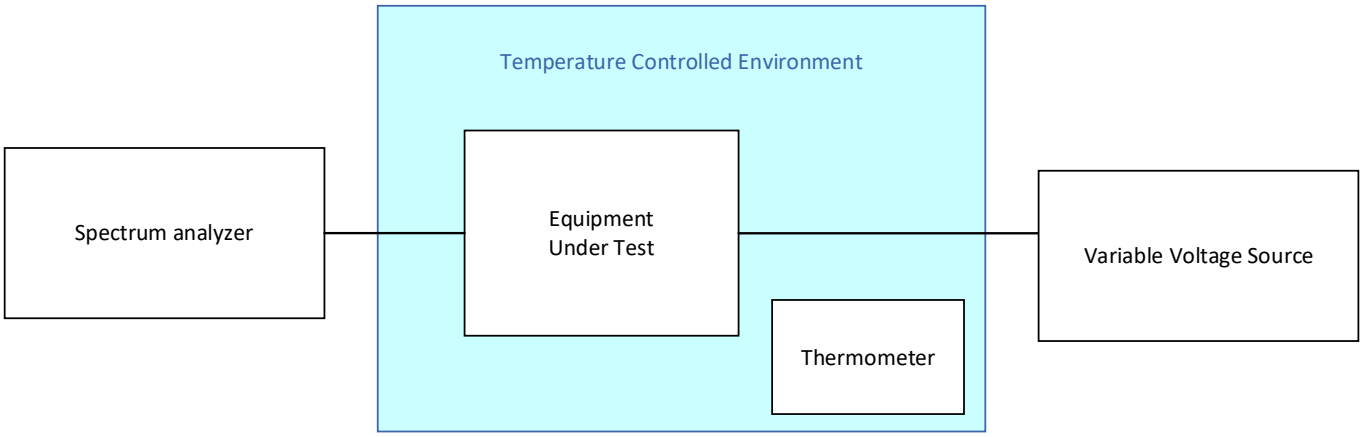


Figure TR43.101: Test setup (not to scale)

This line is the end of the test record.

Test Record
Transmitter Stability in Extreme Conditions
Test IDs TR44
Project GCL0407

Test Date(s)	3-9 May 2024
Test Personnel	David Arnett
Product Model	A04766
Serial Number tested	8A5000018
Operating Mode	M7 (WiFiTx)
Arrangement	A1 (Pwr)
Nominal Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN (as noted in Section 6 of the report)
Radio Protocol	IEEE 802.11 n MCS0

Pass/Fail Judgment: **PASS**

Test record created by: **David Arnett**
Date this record: **31 May 2024**
Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
MXE Receiver 8.4 GHz	Keysight	N9038B	MY63460112	28-Feb-2024	1-Mar-2025
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	21-May-2024
Thermometer	Thermco	ACCD370P	220608121	26-Aug-2022	1-Sep-2024
Thermal Chamber	Tenney	T2RC	32774-02	Calibration	Not Required

Table TR44.1: List of test equipment used

Test Method

The standards cited require observation of the stability for transmission frequency and/or power at certain environmental extremes. The reference is performance on nominal input voltage and a temperature of 20 °C. Where the standards cited here impose different limits or conditions, the most stringent limits and conditions have been applied. The standard requires that performance be checked at temperature intervals from -20 °C to 60 °C at intervals not greater than 10 °C. Performance was verified at target intervals of 8 °C with the test chamber temperature maintained within a tolerance of +/- 1 °C to ensure that actual intervals were within the allowance provided.

The acceptance criterion is that the transmitted signals remain within the permitted radio band of 2400 – 2483.5 MHz. The modes utilized include those that showed emissions closest to the band edge during prior bandwidth testing. Acceptance is shown by demonstrating that the spectral energy at the band edge frequency is well below the intentional signal level.

Test Data

The test sample(s) were subjected to extreme conditions and performed as shown below. The table shows, at each temperature and voltage point, the decibel ratio of in-band energy to band edge energy. The data points highlighted in yellow are selected as points of interest and the corresponding full data plots, including the marker and delta-marker data, are provided afterward.

Temperature	Voltage	Low	High
°C	V	Channel	Channel
60	5	**22.53**	**33.80**
52	5	**20.71**	**44.55**
44	5	**21.96**	**42.96**
36	5	**21.71**	**45.31**
28	5	**20.35**	**40.61**
20	5	**20.96**	**43.62**
20	5.75	**19.49**	**44.17**
20	4.25	**21.02**	**43.90**
12	5	**21.60**	**42.39**
4	5	**21.98**	**43.28**
-4	5	**21.80**	**42.05**
-12	5	**22.92**	**40.09**
-20	5	**22.71**	**42.04**

Table TR44.2: Frequency stability data with voltage and temperature variation

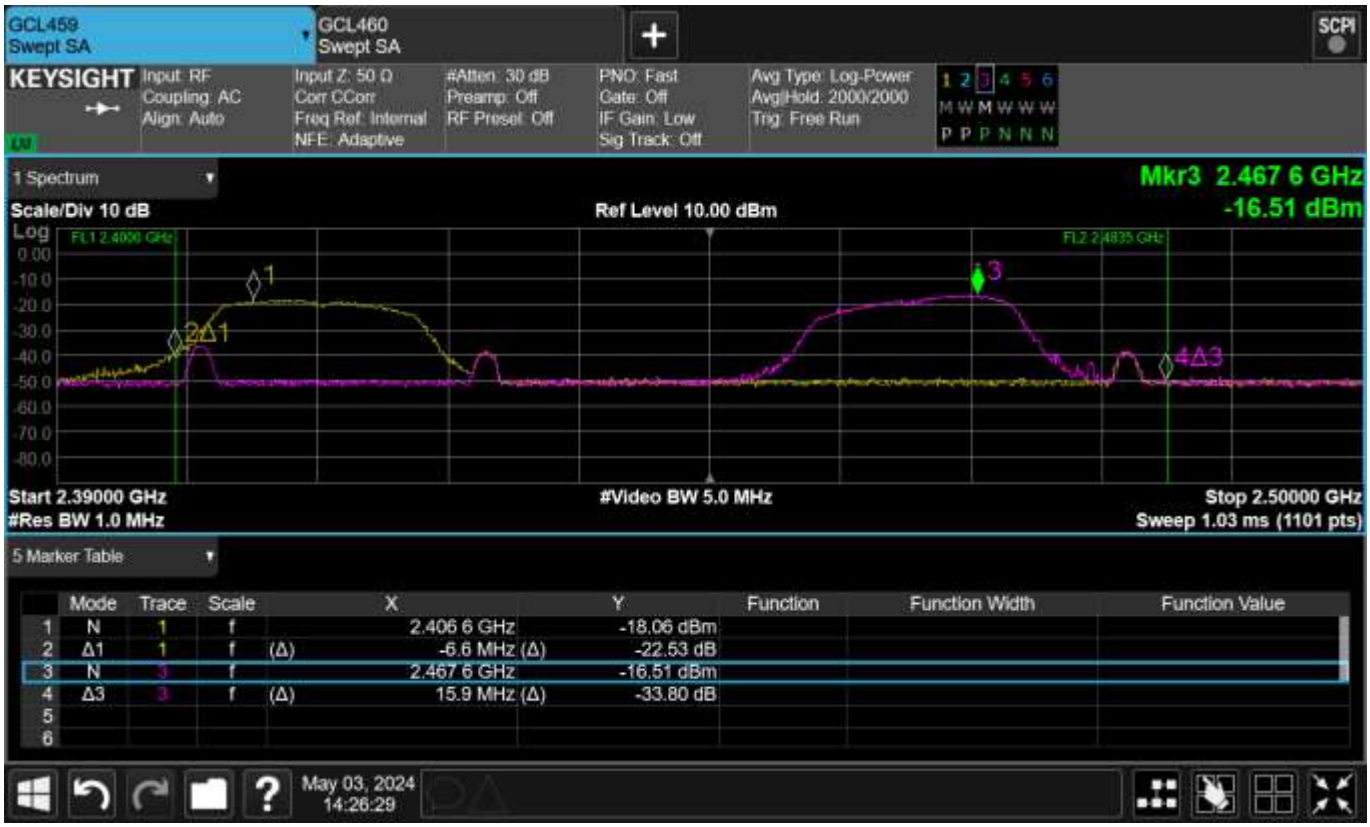


Figure TR44.1: Spectral plot for 60 °C and 5 V test condition

Figure TR44.2: Spectral plot for 20 °C and 5 V test condition

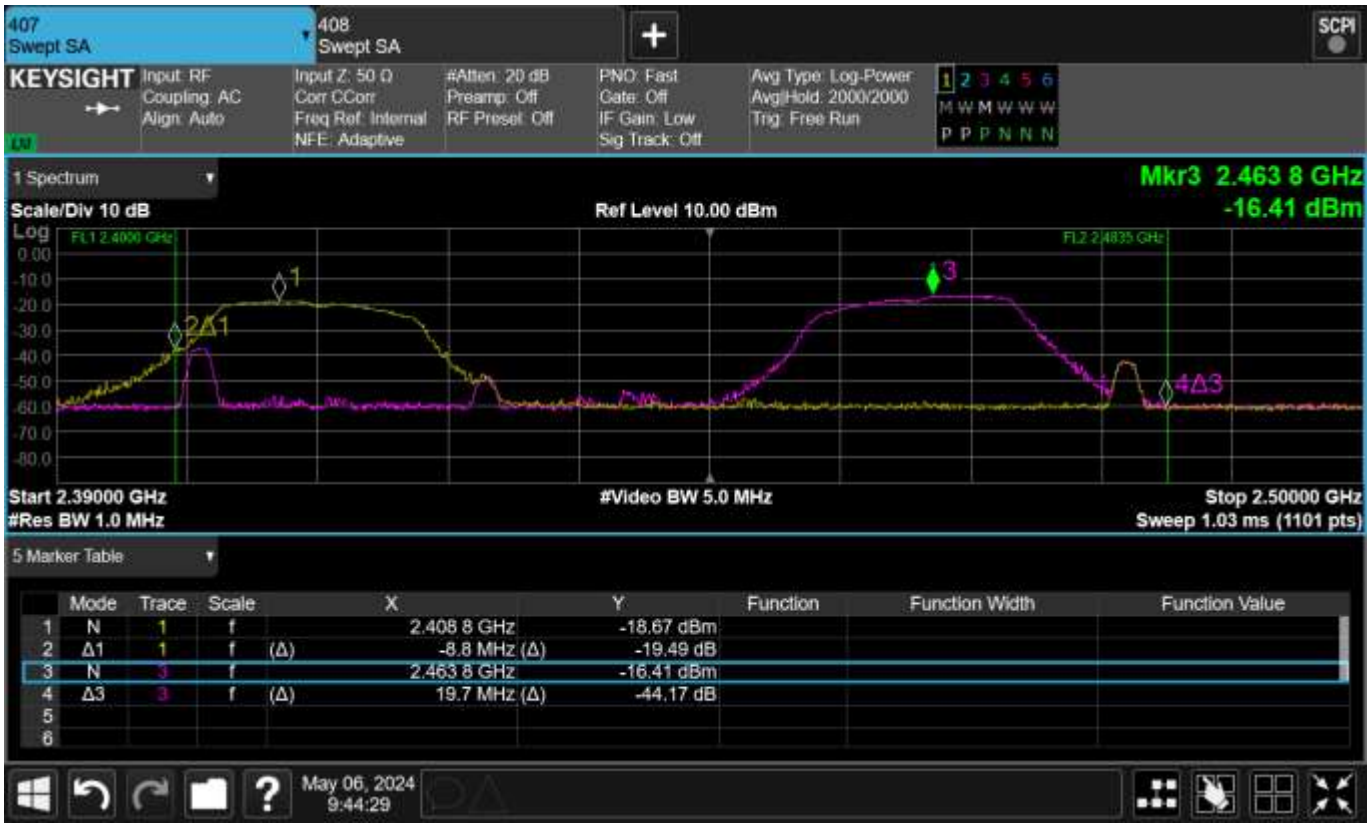


Figure TR44.3: Spectral plot for 20 °C and 5.75 V test condition

Figure TR44.4: Spectral plot for -20 °C and 5 V test condition

Setup Block Diagram

The following block diagram shows the EUT configured and arranged in the manner in which it was measured.

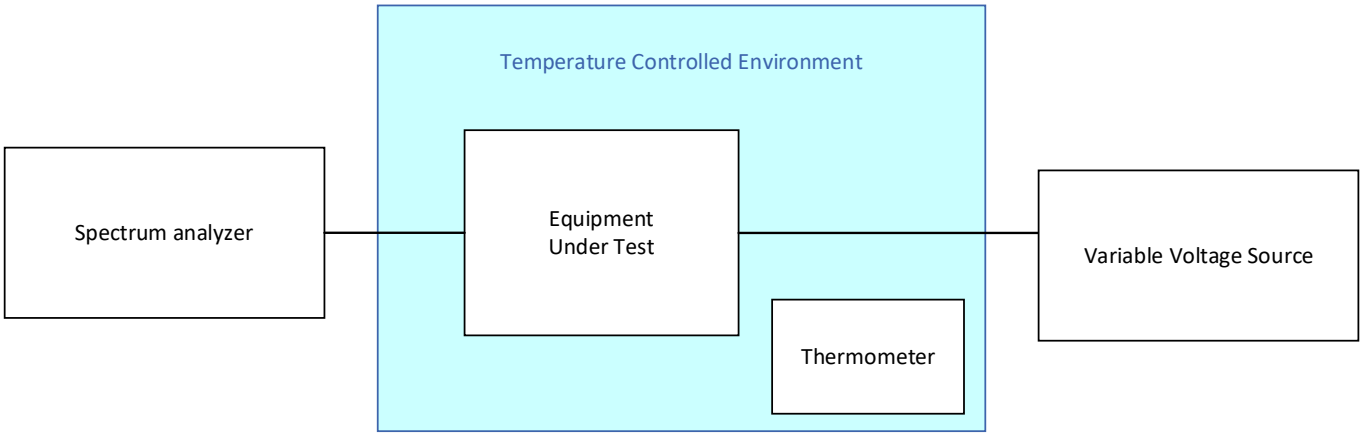


Figure TR44.101: Test setup (not to scale)

This line is the end of the test record.

Test Record
Radiated Emission Test RE07
Project GCL0407

Test Date(s)	15 Apr 2024
Test Personnel	Jim Solum
Product Model	A04766
Serial Number tested	8A4000458
Operating Mode	M3 (BleTx)
Arrangement	A11 (CLA1/4m)
Input Power	12 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (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:	**16 Apr 2024**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Antenna, Biconilog, 30M-6 GHz	ETS Lindgren	3142E	00233204	2-Nov-2023	1-Nov-2025
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	7-Nov-2022	7-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	30-Aug-2023	1-Sep-2026
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	21-May-2024

Table RE07.1: Test Equipment Used

Software Used: Keysight PXE receiver software A.32.06, EPX test software Version 2023.01.001

Test Data

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

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

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

margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m. Any unintentional radio emission limits are not applied to intentional radio signals.

Frequency MHz	Pol	Reading dB(µV)	Factor dB(1/m)	Level(QP) dB(µV/m)	Limit dB(µV/m)	Margin dB	Height cm	Angle deg
37.8	V	7.2	18.6	25.8	40	14.2	100	309
118.59	V	2.7	15.7	18.4	43.5	25.1	100	0
192	H	5.5	18.2	23.7	43.5	19.8	183.7	211
240	H	6.9	21	27.9	46	18.1	121.9	247
432	H	15.1	26.8	41.9	46	4.1	203.5	356
528	H	5	30.4	35.4	46	10.6	143.2	358
943.14	V	-0.1	36.6	36.5	46	9.5	310.3	284

Table RE07.2: Emission summary

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

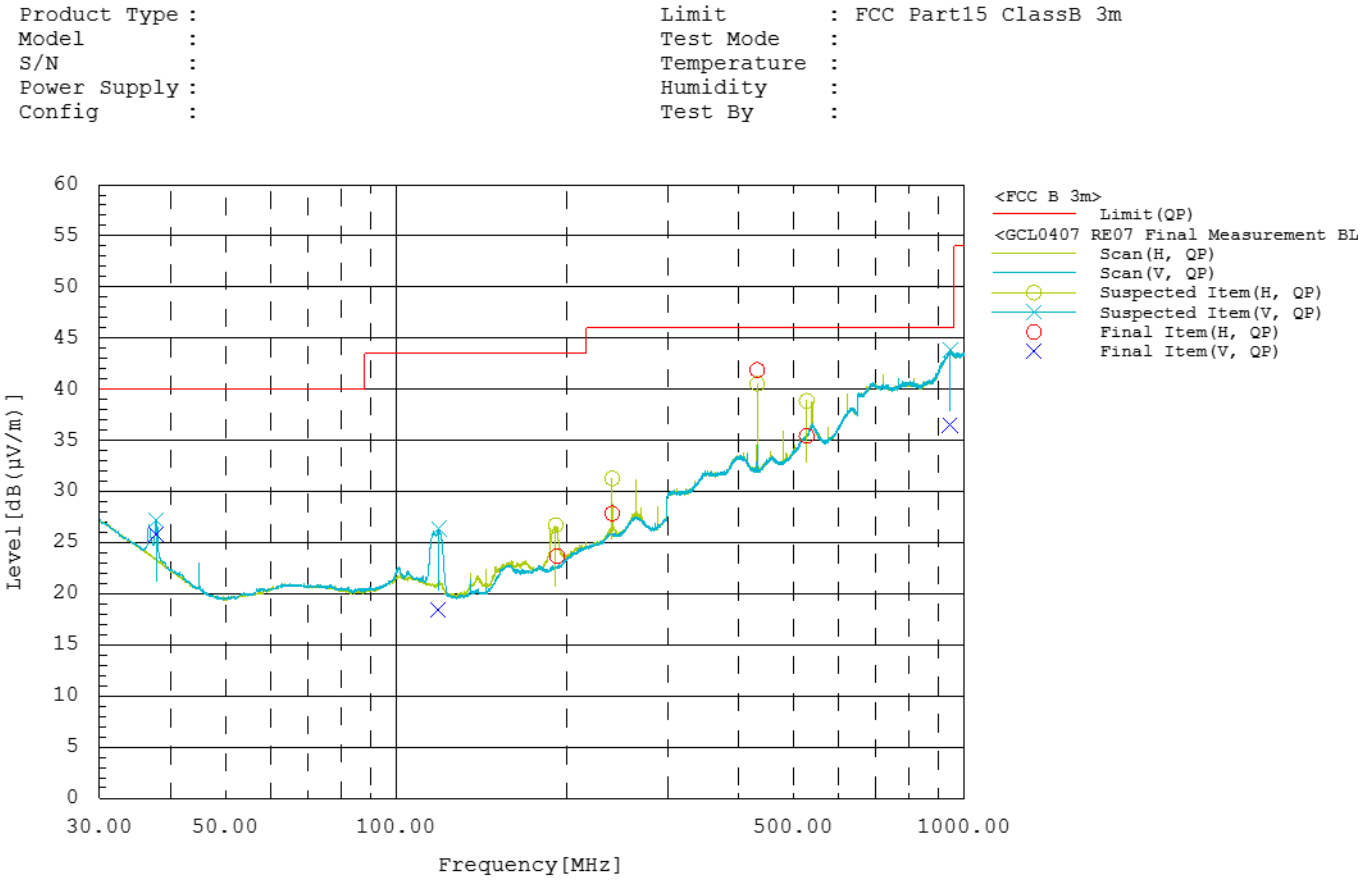


Figure RE07.1: Spectral data

Setup Photographs

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

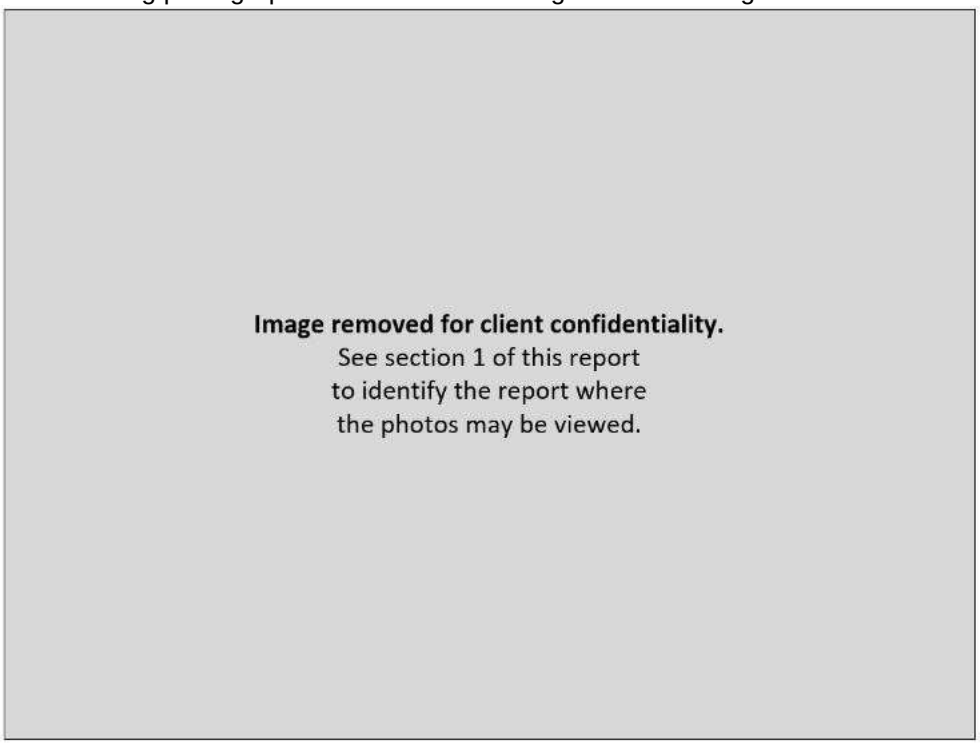


Figure RE07.2: EUT test setup, front view

Figure RE07.3: EUT test setup, reverse view
This line is the end of the test record.

Test Record
Radiated Emission Test RE08
Project GCL0407

Test Date(s)	15 Apr 2024
Test Personnel	Jim Solum
Product Model	A04766
Serial Number tested	8A4000458
Operating Mode	M7 (WiFiTx)
Arrangement	A11 (CLA1/4m)
Input Power	12 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (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:	**16 Apr 2024**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Antenna, Biconilog, 30M-6 GHz	ETS Lindgren	3142E	00233204	2-Nov-2023	1-Nov-2025
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	7-Nov-2022	7-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	30-Aug-2023	1-Sep-2026
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	21-May-2024

Table RE08.1: Test Equipment Used

Software Used: Keysight PXE receiver software A.32.06, EPX test software Version 2023.01.001

Test Data

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

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

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

margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m. Any unintentional radio emission limits are not applied to intentional radio signals.

Frequency MHz	Pol	Reading dB(µV)	Factor dB(1/m)	Level(QP) dB(µV/m)	Limit dB(µV/m)	Margin dB	Height cm	Angle deg
37.11	V	7.7	19	26.7	40	13.3	100	248
117.45	V	8.2	15.7	23.9	43.5	19.6	100	358
264	H	5.5	22.4	27.9	46	18.1	114.1	269
432	H	15.1	26.8	41.9	46	4.1	182.4	0
539.94	H	4.3	31	35.3	46	10.7	141.2	1
914.43	V	-0.2	35.8	35.6	46	10.4	120	19

Table RE08.2: Emission summary

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

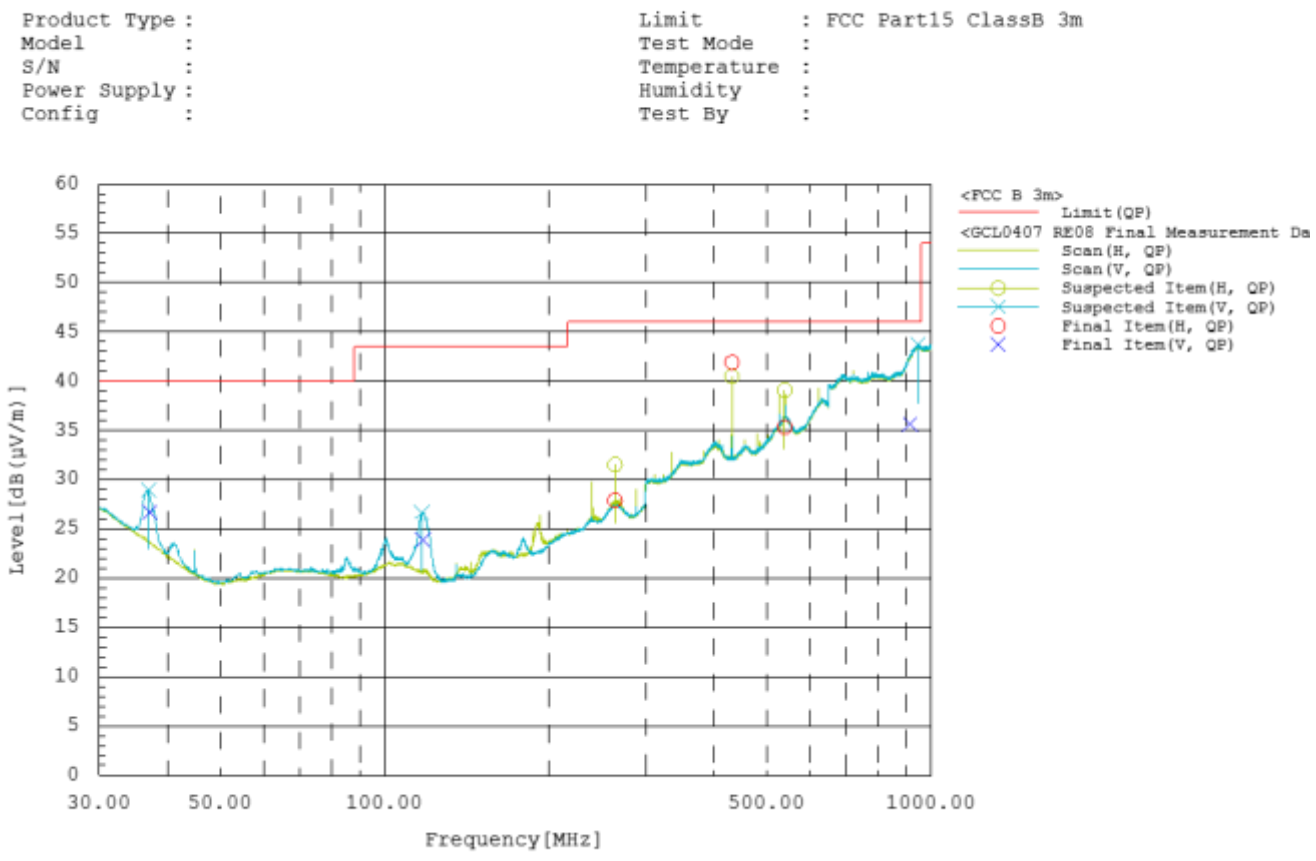


Figure RE08.1: Spectral data

Setup Photographs

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

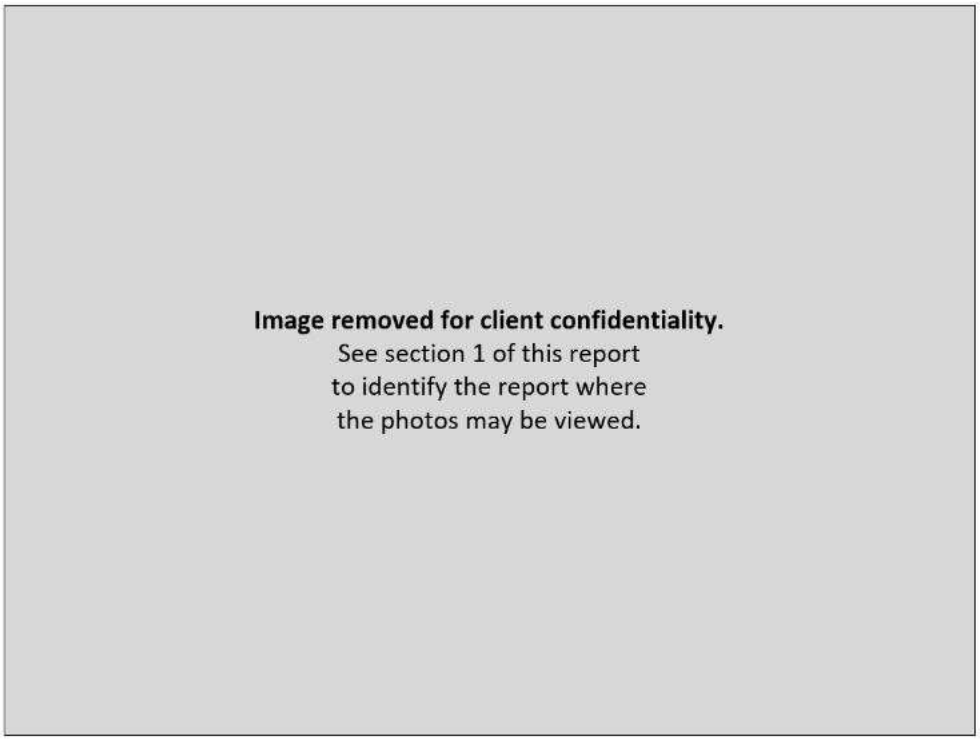


Figure RE08.2: EUT test setup, front view

Figure RE08.3: EUT test setup, reverse view
This line is the end of the test record.

Test Record
Radiated Emission Test RE05
Project GCL0407

Test Date(s)	11 Apr 2024
Test Personnel	David Kerr
Product Model	A04766
Serial Number tested	8A4000458
Operating Mode	M3 (BleTx)
Arrangement	A11 (CLA1/4m)
Input Power	12 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Frequency Range:	1000-2200 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**11 Apr 2024**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	21-May-2024

Table RE05.1: Test Equipment Used

Software Used: Keysight PXE receiver software A.32.06, EPX test software Version 2023.01.001

Test Data

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

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

The table shows the selected final measurement data between 1000 MHz and 2.2 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m. Any unintentional radio emission limits are not applied to intentional radio signals.

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
1296.000	H	39.2	57.3	-4.4	34.8	52.9	54.0	74.0	19.2	21.1	272.1	49.0
2160.000	H	36.3	53.8	-1.2	35.1	52.6	54.0	74.0	18.9	21.4	207.8	317.0
1728.000	H	34.9	47.4	-3.3	31.6	44.1	54.0	74.0	22.4	29.9	142.1	299.0

Table RE05.2: Emission summary (BIe 2402MHz)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
1404.000	V	35.3	53.2	-4.0	31.3	49.2	54.0	74.0	22.7	24.8	108.6	172.0
1485.000	V	32.7	56.2	-3.6	29.1	52.6	54.0	74.0	24.9	21.4	100.0	183.0
1296.000	H	42.8	62.6	-4.4	38.4	58.2	54.0	74.0	15.6	15.8	100.0	0.0
2160.000	H	36.9	54.3	-1.2	35.7	53.1	54.0	74.0	18.3	20.9	126.5	316.0
1080.000	H	34.1	51.5	-6.1	28.0	45.4	54.0	74.0	26.0	28.6	136.0	45.0
1458.000	H	33.7	53.7	-3.8	29.9	49.9	54.0	74.0	24.1	24.1	114.4	24.0

Table RE05.3: Emission summary (BIe 2440MHz)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
1484.500	V	32.2	50.8	-3.6	28.6	47.2	54.0	74.0	25.4	26.8	313.3	343.0
2169.500	V	32.4	45.9	-1.2	31.2	44.7	54.0	74.0	22.8	29.3	317.2	303.0
1296.000	H	41.1	59.9	-4.4	36.7	55.5	54.0	74.0	17.3	18.5	106.5	0.0
1080.000	H	33.7	51.8	-6.1	27.6	45.7	54.0	74.0	26.4	28.3	136.5	43.0

Table RE05.4: Emission summary (BIe 2480MHz)

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

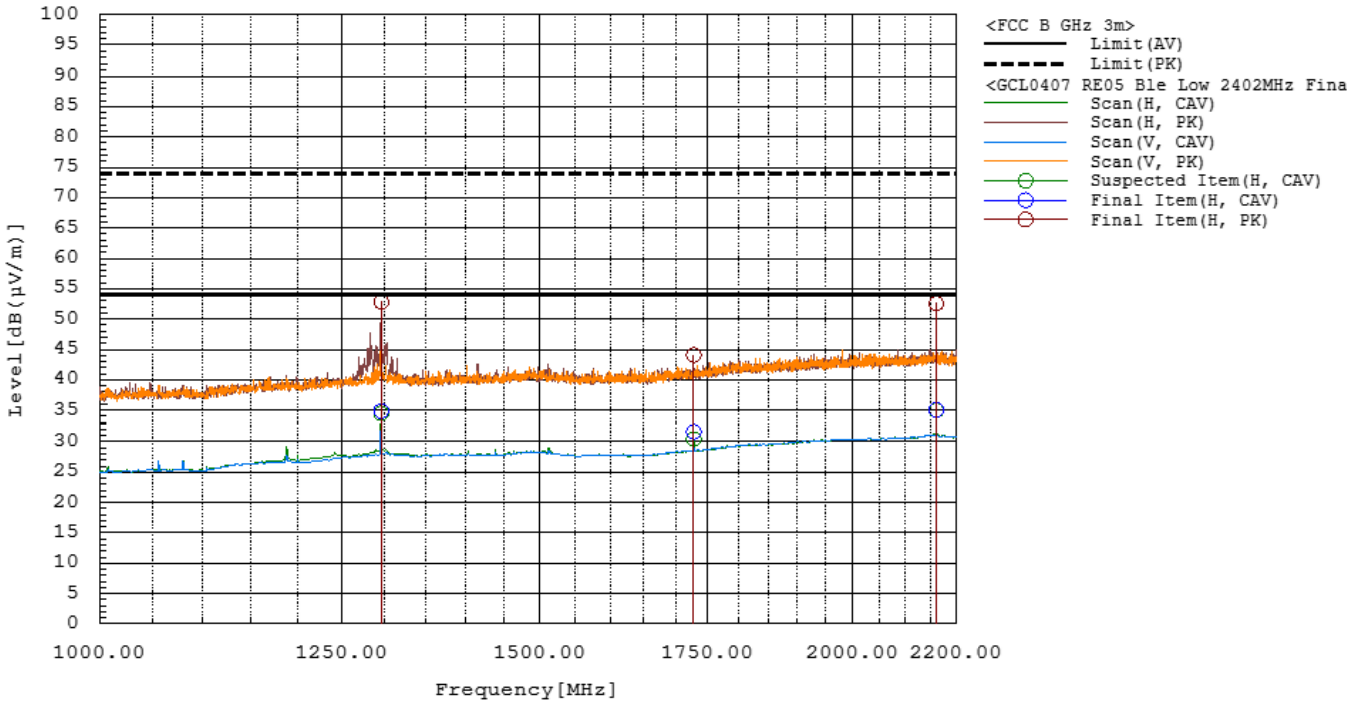


Figure RE05.1: Spectral data (Ble 2402MHz)

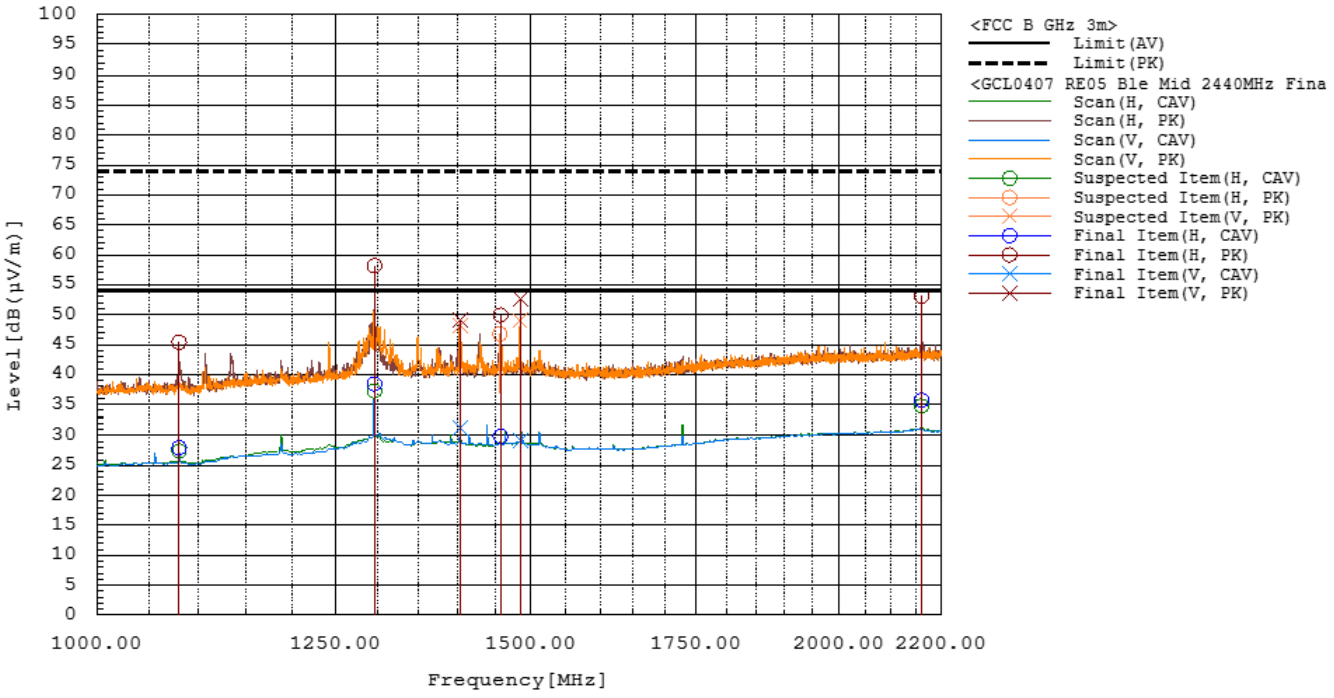


Figure RE05.2: Spectral data (Ble 2440MHz)

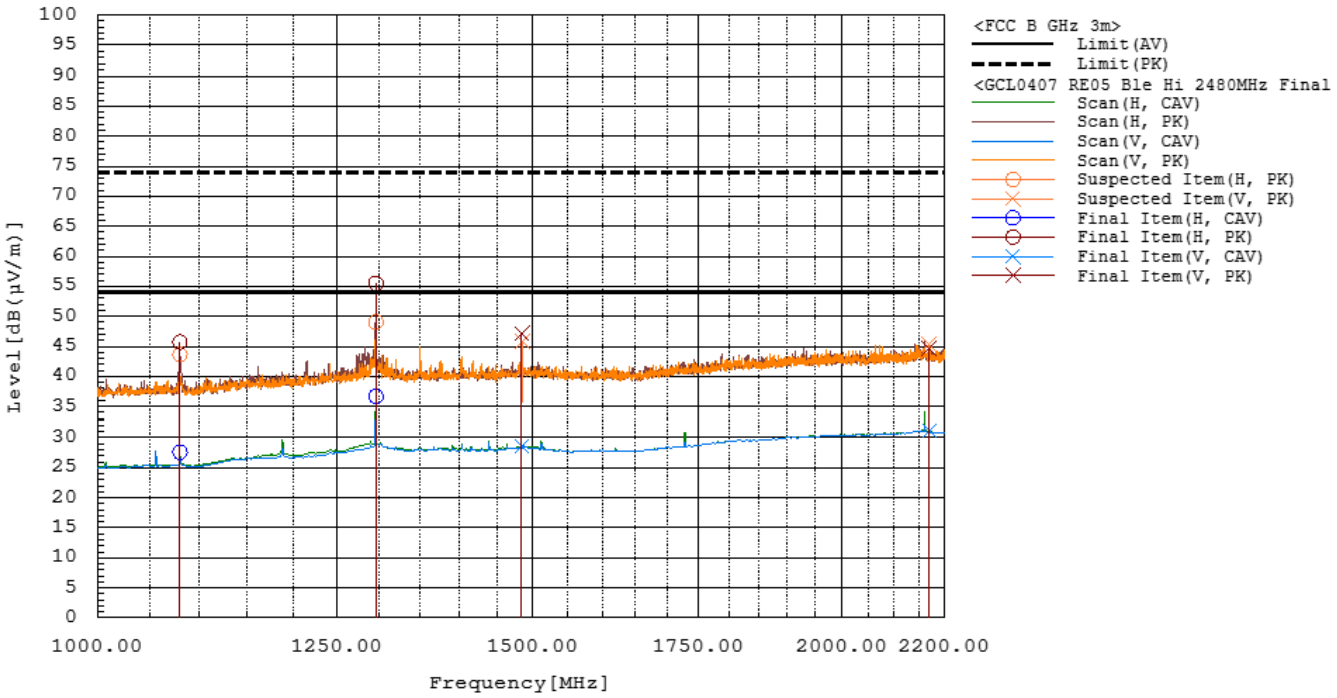


Figure RE05.3: Spectral data (Ble 2480MHz)

Setup Photographs

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

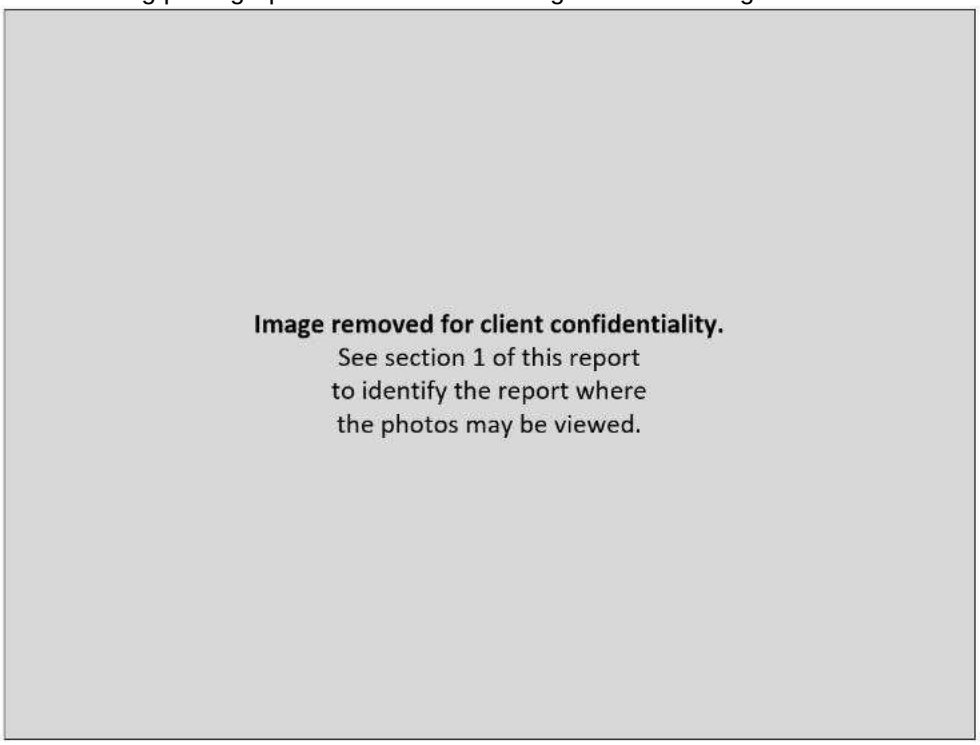


Figure RE05.4: EUT test setup, front view

Figure RE05.5: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Radiated Emission Test RE06
Project GCL0407

Test Date(s)	11 Apr 2024
Test Personnel	David Kerr
Product Model	A04766
Serial Number tested	8A4000458
Operating Mode	M7 (WiFiTx)
Arrangement	A11 (CLA1/4m)
Input Power	12 Vdc
Test Standards:	FCC Part 15 (as noted in Section 6 of the report).
Frequency Range:	1000-2200 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**11 Apr 2024**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	21-May-2024

Table RE06.1: Test Equipment Used

Software Used: Keysight PXE receiver software A.32.06, EPX test software Version 2023.01.001

Test Data

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

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

The table shows the selected final measurement data between 1000 MHz and 2.2 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m. Any unintentional radio emission limits are not applied to intentional radio signals.

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
1296.000	H	40.6	58.3	-4.4	36.2	53.9	54.0	74.0	17.8	20.1	221.4	29.0
1241.750	H	32.5	50.9	-4.4	28.1	46.5	54.0	74.0	25.9	27.5	195.2	23.0
1188.000	H	34.8	50.7	-5.3	29.5	45.4	54.0	74.0	24.5	28.6	114.4	345.0
2160.000	H	37.2	54.3	-1.2	36.0	53.1	54.0	74.0	18.0	20.9	126.3	40.0
1728.000	H	33.7	46.9	-3.3	30.4	43.6	54.0	74.0	23.6	30.4	173.9	21.0
1376.500	H	32.3	47.0	-4.0	28.3	43.0	54.0	74.0	25.7	31.0	100.0	19.0

Table RE06.2: Emission summary (ch 1, B, 5.5 Mbps)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
1296.000	H	42.4	62.7	-4.4	38.0	58.3	54.0	74.0	16.0	15.7	142.4	29.0
1484.250	H	32.7	53.7	-3.6	29.1	50.1	54.0	74.0	24.9	23.9	148.2	60.0
1512.000	H	33.6	50.1	-3.6	30.0	46.5	54.0	74.0	24.0	27.5	189.3	259.0
2160.000	H	35.6	51.0	-1.2	34.4	49.8	54.0	74.0	19.6	24.2	150.2	41.0
1404.000	H	35.7	53.5	-4.0	31.7	49.5	54.0	74.0	22.3	24.5	242.6	36.0
1188.000	H	35.8	52.1	-5.3	30.5	46.8	54.0	74.0	23.5	27.2	112.6	347.0

Table RE06.3: Emission summary (ch 6, B, 5.5 Mbps)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
1484.750	V	32.5	54.7	-3.6	28.9	51.1	54.0	74.0	25.1	22.9	357.0	275.0

1458.000	V	32.9	51.6	-3.8	29.1	47.8	54.0	74.0	24.9	26.2	372.2	273.0
1296.000	H	41.3	61.8	-4.4	36.9	57.4	54.0	74.0	17.1	16.6	274.6	24.0
1440.000	H	36.3	50.6	-3.9	32.4	46.7	54.0	74.0	21.6	27.3	241.1	28.0
1728.000	H	35.7	47.9	-3.3	32.4	44.6	54.0	74.0	21.6	29.4	142.3	17.0
2160.000	H	35.5	53.6	-1.2	34.3	52.4	54.0	74.0	19.7	21.6	124.5	39.0

Table RE06.4: Emission summary (ch 11, B, 5.5 Mbps)

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

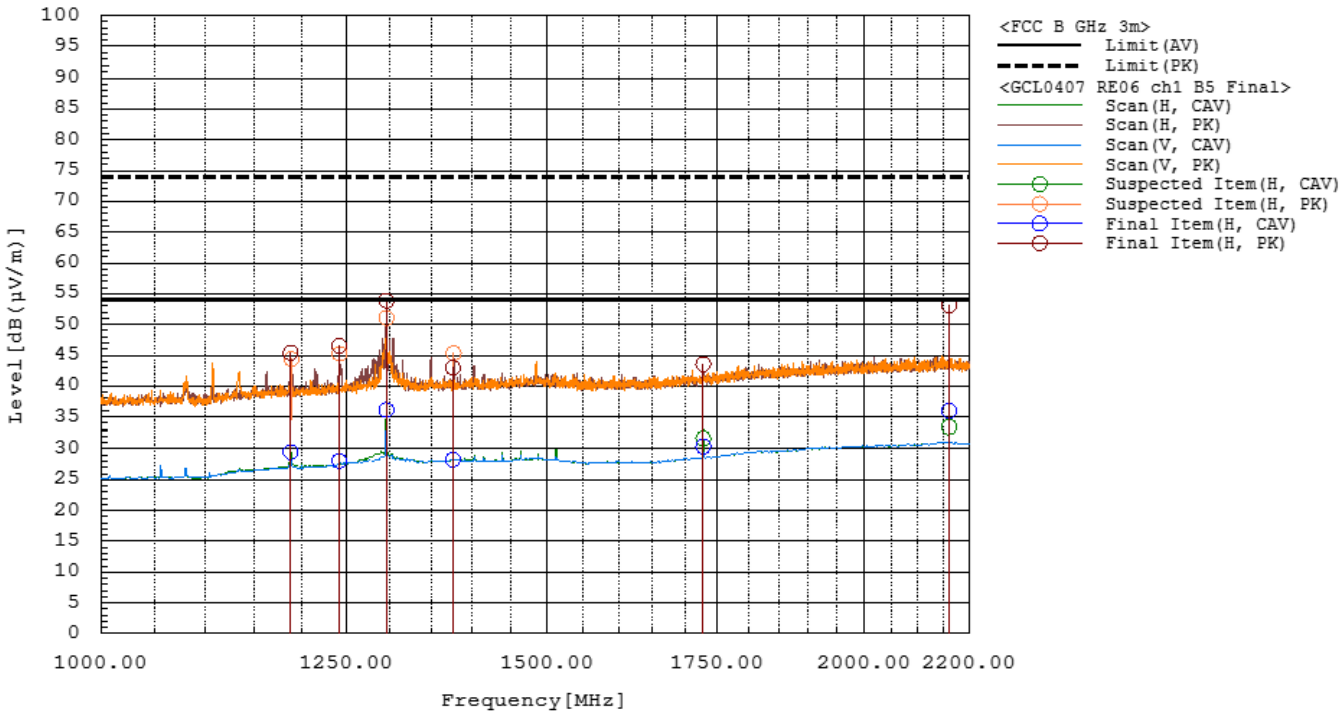


Figure RE06.1: Spectral data (ch 1, B, 5.5 Mbps)

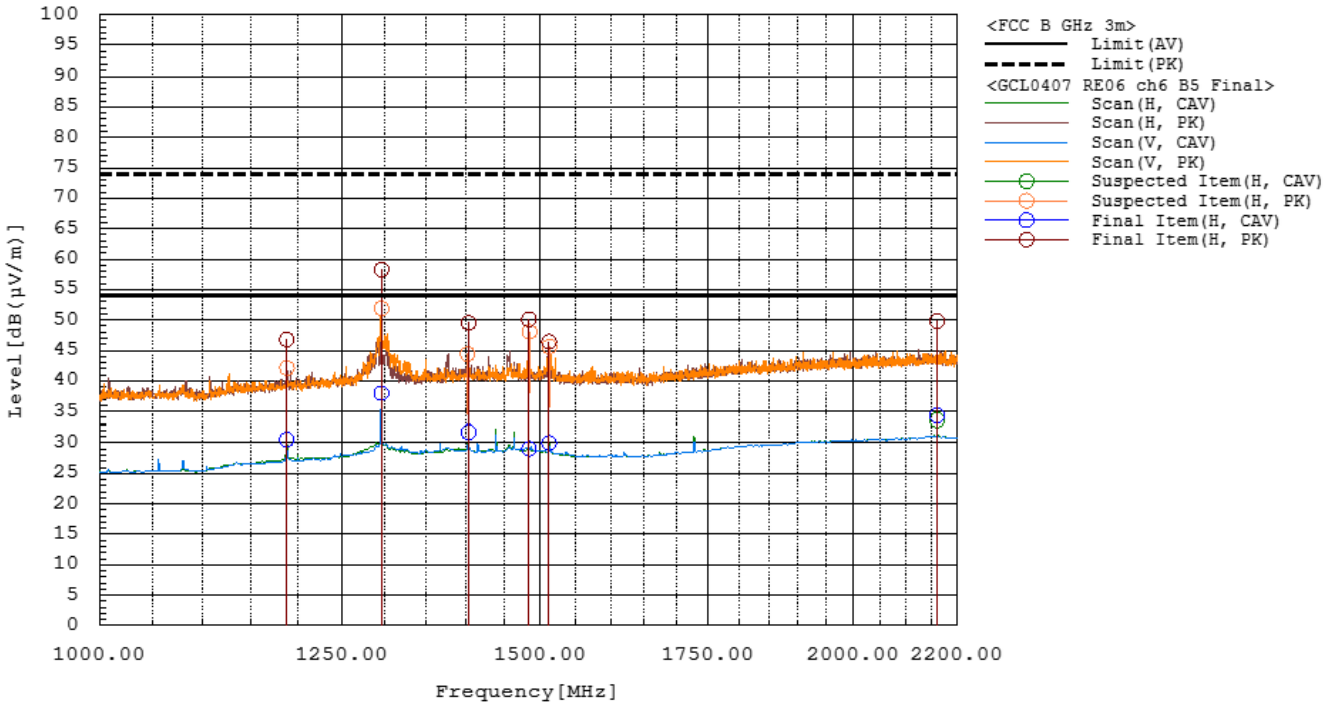


Figure RE06.2: Spectral data (ch 6, B, 5.5 Mbps)

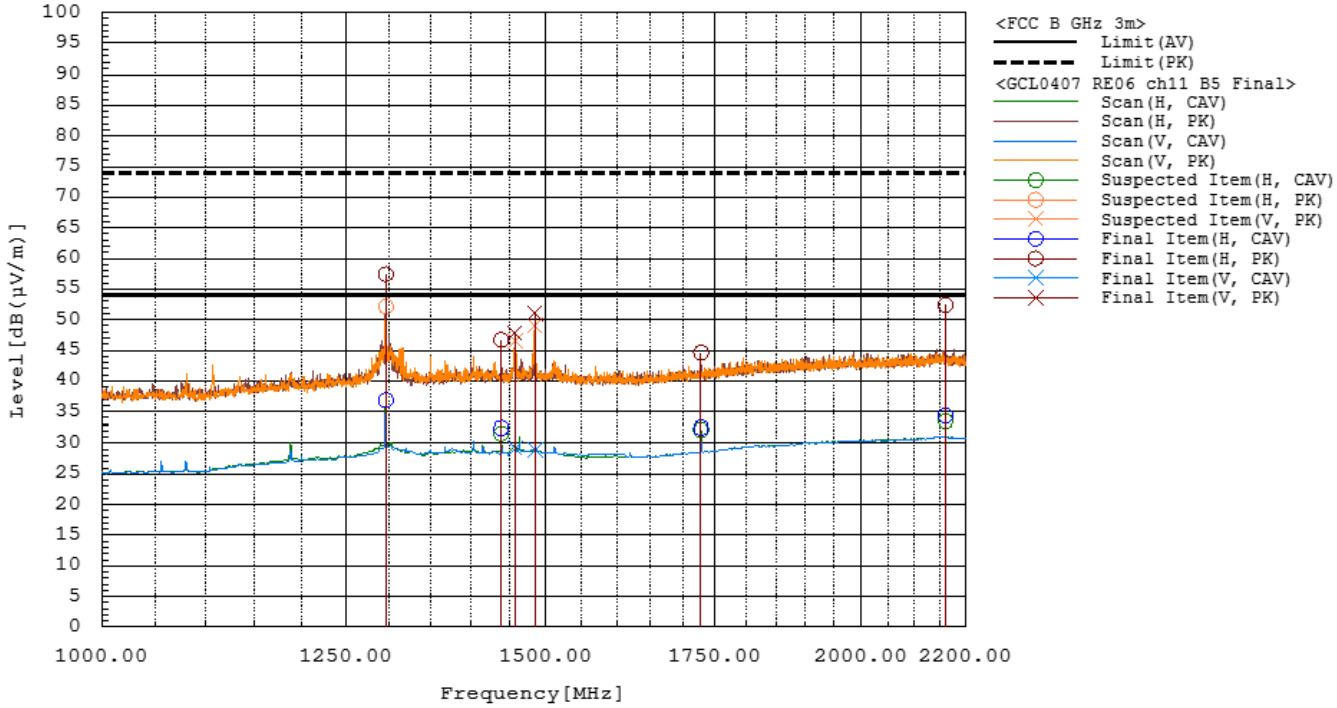


Figure RE06.3: Spectral data (ch 11, B, 5.5 Mbps)

Setup Photographs

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

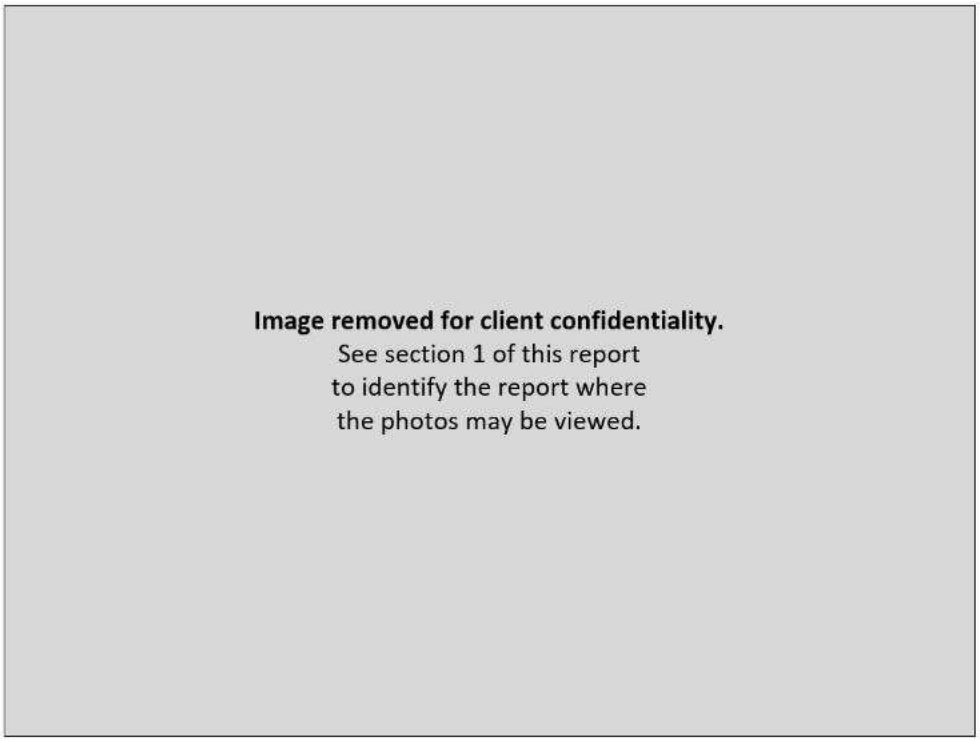


Figure RE06.4: EUT test setup, front view

Figure RE06.5: EUT test setup, reverse view

This line is the end of the test record.

Concluding Notes

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

This is the final page of the report.