

Test Report 2024-149 s

Version C

Issued 13 Sep 2024

Project GCL-0602

Model Identifier A04392

Primary Test Standard

CFR 47, FCC Part 15.247

RSS-247 Issue 3

Garmin Compliance Lab

Garmin International

1200 E 151st Street

Olathe Kansas 66062 USA

Client-supplied Information

FCC ID: IPH-04392

IC ID: 1792A-04392



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 Bluetooth Low Energy transceiver in accordance with DTS rule. 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 2 Mbps.	Reported	N/A
Hopping Channels	The radio manages its use of channels appropriately. [15.247(a)(1); RSS-247 at 5.1]	N/A.	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 742.20 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	17
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 21.67 dBm or 147 mW.	PASS	21
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 -1.29 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 52.36 dB.	PASS	25
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 1.09 dB below the applicable limits.	PASS	29

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 6.38 dBm in a band of at least 3 kHz.	PASS	35
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	38
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 or satisfy other rules. The measured emissions had at least 0.9 dB of margin.	PASS	42
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
11. 3m RF Chamber Block Diagrams

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 2024-147. 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:

2.3 Other Information

Test Sample received: 09 May 2024
Test Start Date: 05 Jun 2024
Test End Date: 26 Aug 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 Aditya Prakash and initially issued on 19 Aug 2024 as Version A. Version B was created by Aditya Prakash on 3 Sep 2024 to address some editorial changes and include additional test data for the new operating mode introduced in the device. This data is available in TR56 (page 21). Version C was created by Aditya Prakash on 13 Sep 2024 to include RF chamber block diagrams (section 11 of the report).

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:

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: Firmware was upgraded to version 0.97

Date applied: 21-Jun-24

Reason for this modification: To fix the issue where device was not able to operate in low Temperature conditions. BLE 2Mbps disabled.

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: Transmitter Bandwidth testing, Transmitter Power testing, Conducted Spurious Emissions, Radiated emission testing, Transmitter Power Spectral Density testing

Explanatory Note: Under Modification 1, the 2 Mbps BLE functionality was disabled for a time for program development purposes. Under this intentional radiator test program the 2 Mbps functionality was fully exercised and evaluated either prior to this Modification 1 or after Modification 4 where it was re-enabled at the same power levels.

Modification 2

Detailed Description: Firmware was upgraded to version 0.98

Date applied: 24-Jun-24

Reason for this modification: Bug fix for V0.97 to remedy unexpected shutdown behavior of EUT.

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: Transmitter Bandwidth testing, Transmitter Power testing, Conducted Spurious Emissions, Radiated emission testing, Transmitter Power Spectral Density testing

Modification 3

Detailed Description: Firmware was upgraded to version 0.99

Date applied: 27-Jun-24

Reason for this modification: Creates the higher traffic scenario while paired to the companion watch device. The data stream interval has been changed from one Tx packet every 500 ms to the maximum of one Tx packet every 7.5 ms, specifically for the WCT build. This was necessary to achieve the highest data rate with the Radio and test in for compliance.

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: Transmitter Bandwidth testing, Transmitter Power testing, Conducted Spurious Emissions, Radiated emission testing, Transmitter Power Spectral Density testing, Transmitter Stability in Extreme Conditions testing.

Modification 4

Detailed Description: Firmware was upgraded to version 1.02

Date applied: 24-Jul-24

Reason for this modification: BLE 2Mbps enabled.

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 either have no significant effect on these specific tests, or to make results even better than what is reported: Transmitter Bandwidth testing, Transmitter Power testing, Conducted Spurious Emissions, Radiated emission testing, Transmitter Power Spectral Density testing, Transmitter Stability in Extreme Conditions testing.

Modification 5

Detailed Description: Firmware was upgraded to version 1.14

Date applied: 23-Aug-24

Reason for this modification: This SW version added file transfer mode in the device.

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 either have no significant effect on these specific tests, or to make results even better than what is reported: Transmitter Bandwidth testing, Conducted Spurious Emissions, Radiated emission testing, Transmitter Power Spectral Density testing, Transmitter Stability in Extreme Conditions testing.

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model A04392
Serial Numbers Tested 8H1000141 , 8H1000011
This product tested is digital device and data transceiver.

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

5.2 Key Parameters

EUT Input Power: 5 Vdc
I/O Ports: USB
Radio Transceivers: Bluetooth Low Energy
Radio Receivers: None
Primary Functions: Digital device that collects, processes and exchanges data with nearby transceivers.
Typical use: Body worn
Highest internal frequency: 2.480 GHz
Firmware Revision 1.14

5.3 Operating modes

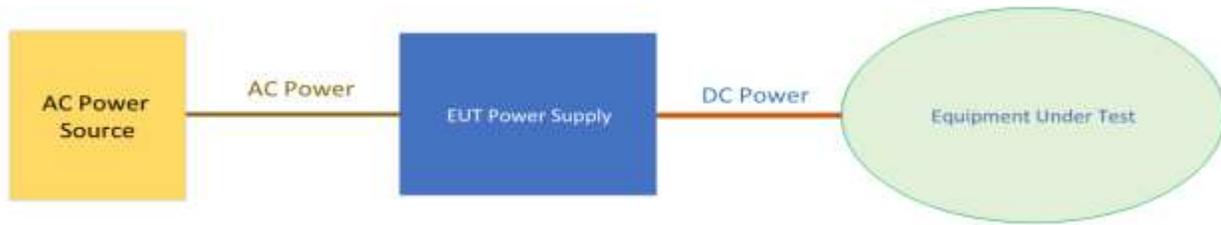
During test, the EUT was operated in one or more of the following modes.

- Mode 1: M3 (BleTx). BLE in transmit mode
- Mode 2: M4 (BleLnk). BLE linked to companion device.
- Mode 3: M15 (Chg). Unit is powered off and charging.
- Mode 4: M17 (BleFtp). Unit is transferring File/Data using BLE.

5.4 EUT Arrangement

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

- Arrangement 1: A1(Solo). The test sample operates from its battery and no external physical connections. No block diagram is needed for this arrangement.
- Arrangement 2: A2(Upwr). The test sample is attached to USB adaptor which is connected to AC mains. The adaptor provides power to the sample over a cable but no user data. See the block diagram in Figure 1.



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

Figure 1: Block diagram of equipment arrangement A2

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
Power adaptor	Garmin	PSAF10R-050Q	P183100844A1
Forerunner 165 watch	Garmin	Forerunner 165 watch	3447638172
Forerunner 165 watch	Garmin	Forerunner 165 watch	3440756173

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

5.6 Cables used

Description	From	To	Length	EMC Treatment
USB type C cable	EUT	Power adaptor	56 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	1.55×10^{-7}	None	1.0×10^{-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 1470 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

$$(7.145 \text{ dBuV}) + (9.812 \text{ dB}) + (0.216 \text{ dB}) = 17.173 \text{ dBuV}$$

8.2 Radiated Emissions at 630 MHz

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

$$(2.25 \text{ dBuV}) + (27.80 \text{ dB/m}) + (2.89 \text{ dB}) = 32.94 \text{ dBuV/m}$$

8.3 Radiated Emissions at 2.7 GHz

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

$$(43.72 \text{ dBuV}) + (32.22 \text{ dB/m}) + (-36.09 \text{ dB}) = 39.85 \text{ dBuV/m}$$

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: 19.8 to 22.5 °C
 Relative Humidity: 42.3% to 60% (non-condensing)
 Barometric Pressure 96.8 to 98.9 kPa

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Barometer	Traceable	6453	240300703	9-Apr-2024	9-Apr-2027

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.

11. 3m RF Chamber Block Diagrams

The 3m chamber has three basic configurations which are shown in the figures below. These figures are not to scale.

Figure 1 shows a semi anechoic setup which is typically used for frequencies below 1 GHz. In this example, the antenna is mounted on a mast capable of 1-4 m elevation changes. If a preamplifier or RF filter is used, they are located at or just below floor level. The receiver is outside the chamber, typically in an adjacent separate shielded room.

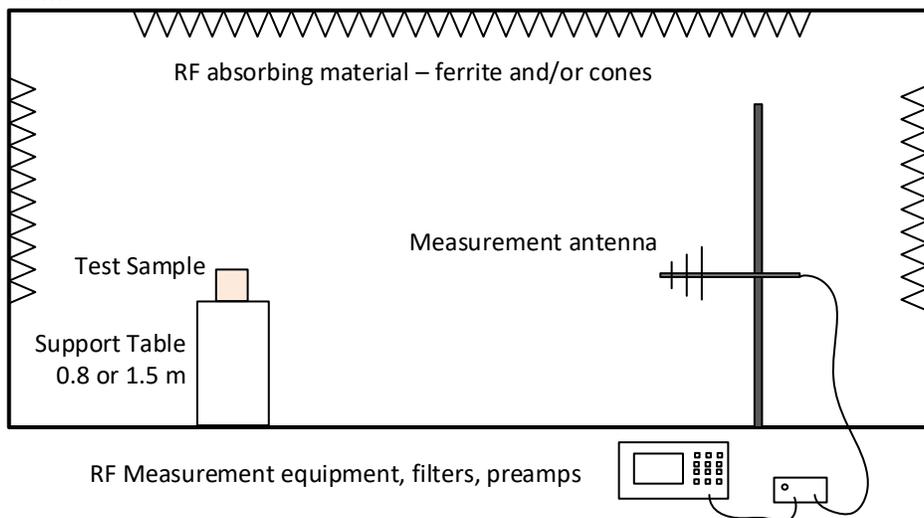


Figure 1: Typical configuration for measurements below 1 GHz

Figure 2 shows an FSOATS setup which is typically used for frequencies above 1 GHz but below an upper limit such as 14 or 18 GHz. In this example, the antenna is mounted on a mast capable of 1-4 m elevation changes and boresighting. If a preamplifier or RF filter is used, they are located at or just below floor level. The receiver is outside the chamber, typically in an adjacent separate shielded room.

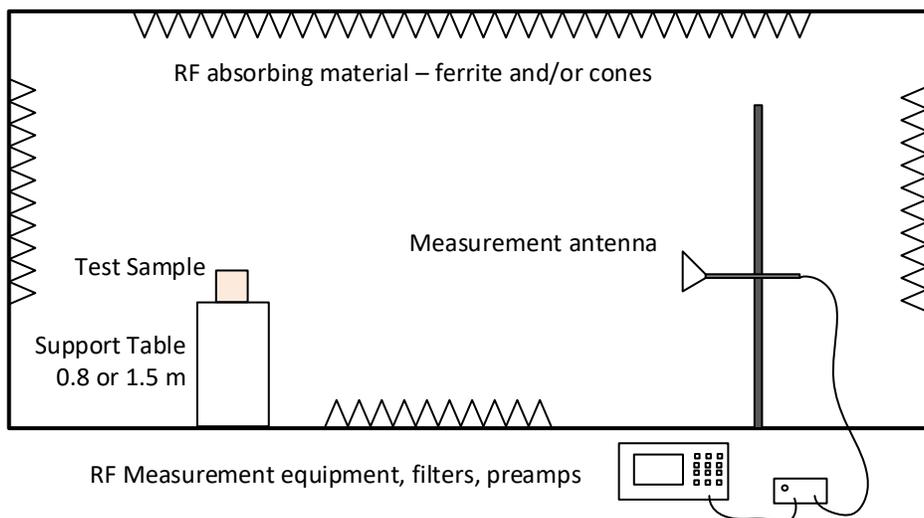


Figure 2: Typical configuration for measurements between 1 GHz and 14 GHz

Figure 3 shows an alternate FSOATS setup which is typically used for frequencies above 14 GHz. In this example, the antenna is mounted on a mast capable of 1-4 m elevation changes and boresighting. A preamplifier is located on the mast just behind the antenna. The receiver is located in the chamber near floor level but outside the antenna beam. The receiver may be operated manually by an operator in the chamber and or remotely via an Ethernet connection.

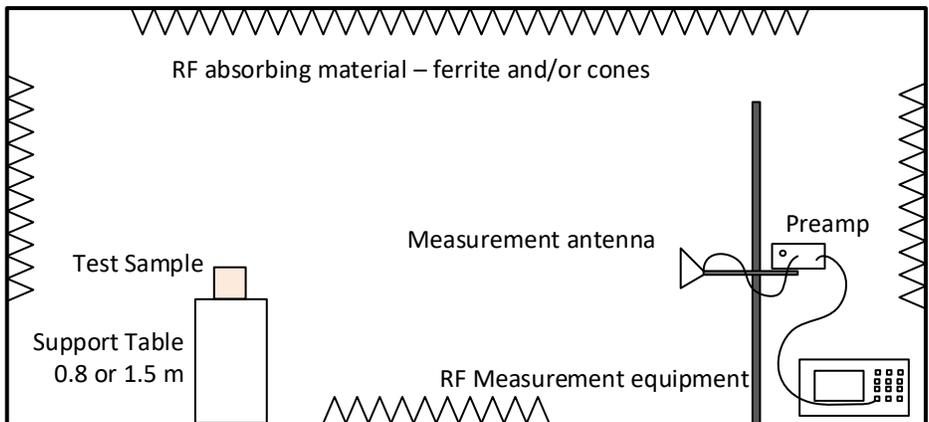


Figure 3: Typical configuration for measurements above 14 GHz

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
Test IDs TR06
Project GCL0602

Test Date(s) 11 Jun 2024
 Test Personnel Aditya Prakash under supervision of Majid Farah

Product Model A04392
 Serial Number tested 8H1000011

Operating Mode M3 (BleTx)
 Arrangement A1(Solo)
 Input Power Battery

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

Radio Protocol Bluetooth Low Energy (BLE)
 Radio Band 2400 to 2483.5 MHz

Pass/Fail Judgment: PASS

Test record created by: Aditya Prakash
Date of this record: 11 Jun 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 MXE firmware A.37.02

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.

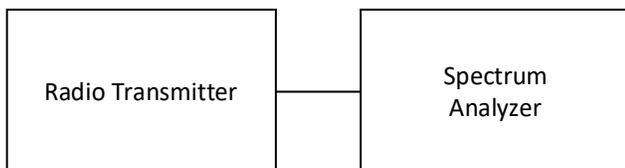


Figure TR06.1: Test setup

Test Data

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

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

		Frequency (MHz)		
		2402 (04)	2440	2480 (78)
BLE	1 Mbps	742.20	744.60	746.70
BLE	2 Mbps	1096.00	1100.00	1097.00

Table TR06.2: Summary of DTS bandwidth data in kHz for BLE modes

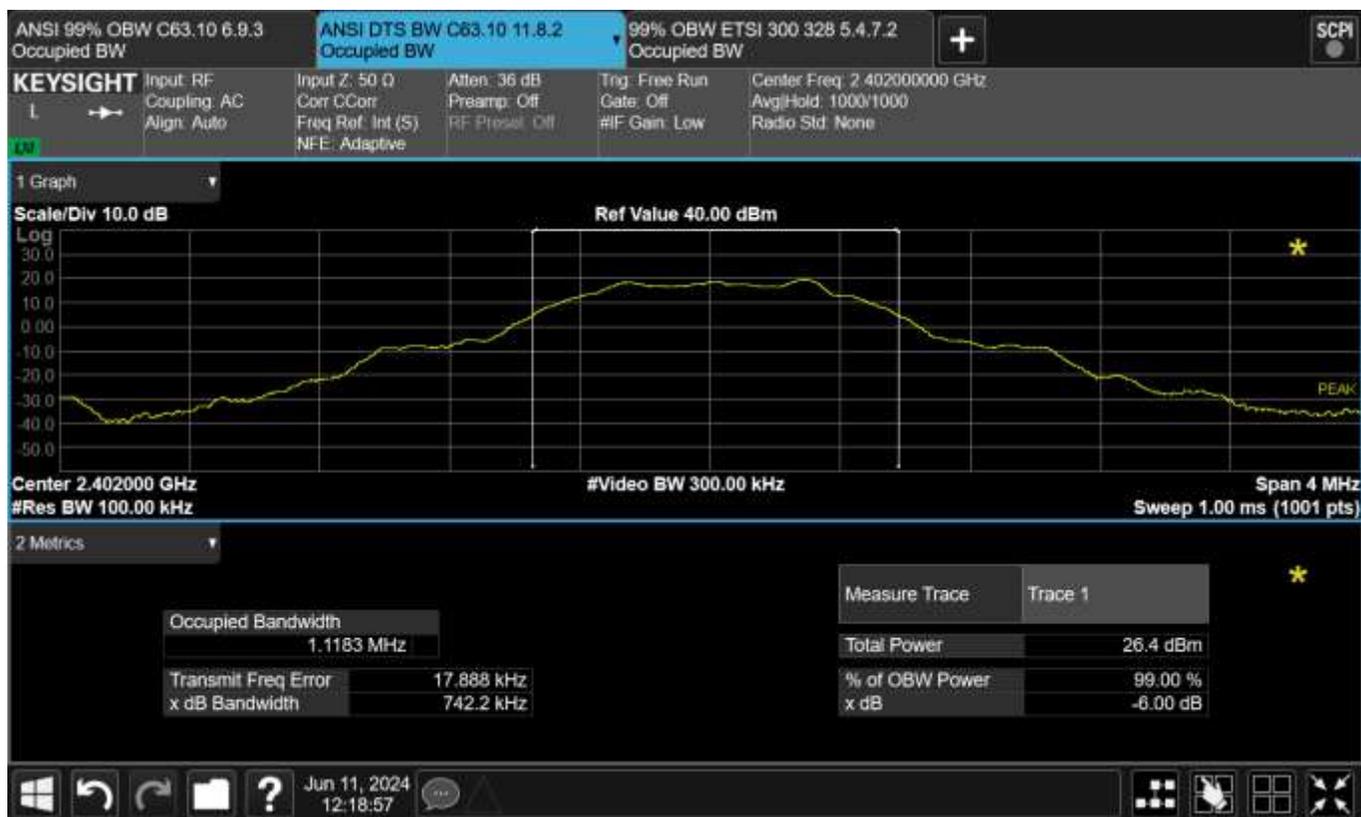


Figure TR06.2: Bandwidth data for BLE 1 Mbps at 2402 MHz

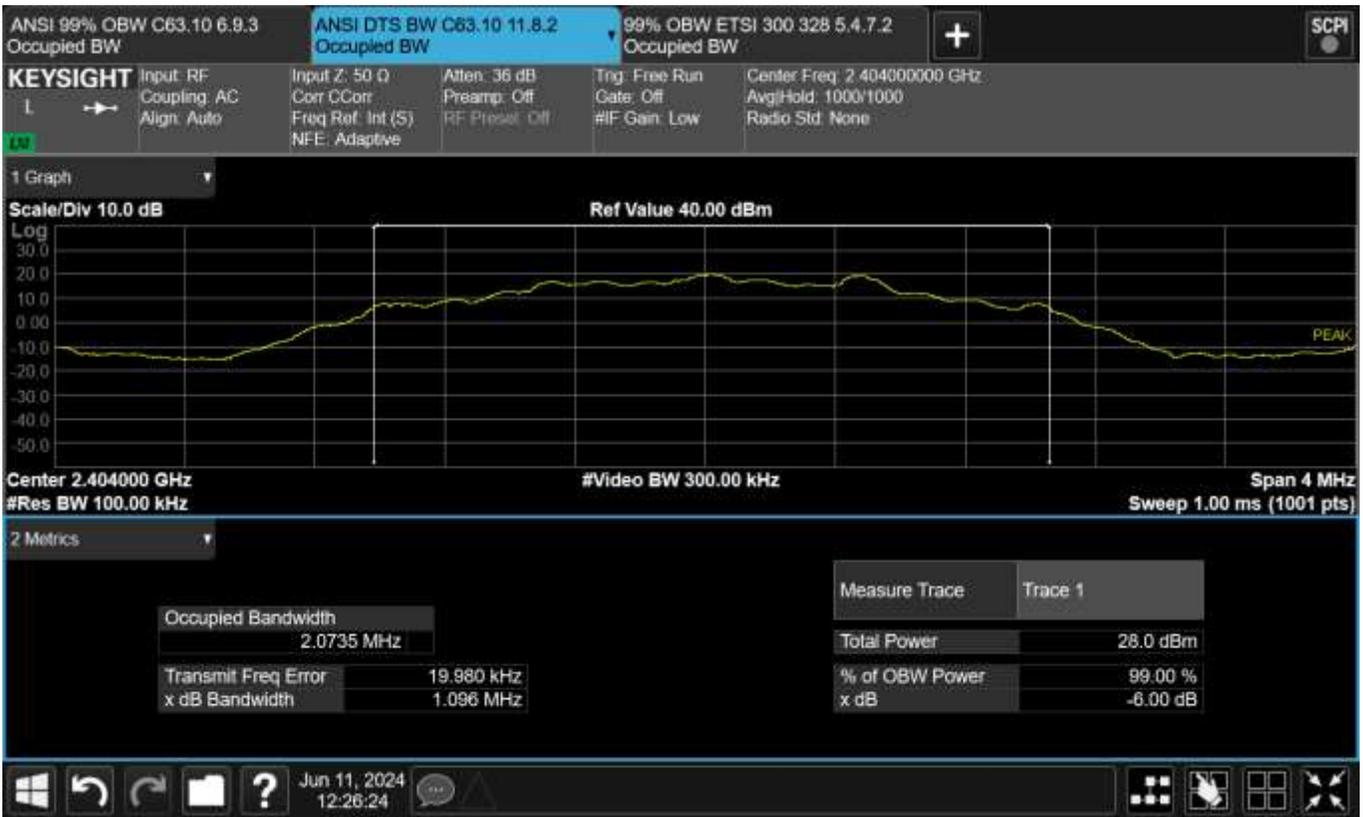


Figure TR06.3: Bandwidth data for BLE 2 Mbps at 2404 MHz

This line is the end of the test record.

Test Record
Transmitter Bandwidth Tests
Test IDs TR10
Project GCL0602

Test Date(s) 11 Jun 2024
 Test Personnel Aditya Prakash under supervision of Majid Farah

Product Model A04392
 Serial Number tested 8H1000011

Operating Mode M3 (BleTx)
 Arrangement A1(Solo)
 Input Power Battery

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)
 Radio Band 2400 to 2483.5 MHz

Pass/Fail Judgment: Reported

Test record created by: Aditya Prakash
Date of this record: 11 Jun 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 MXE firmware A.37.02

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.

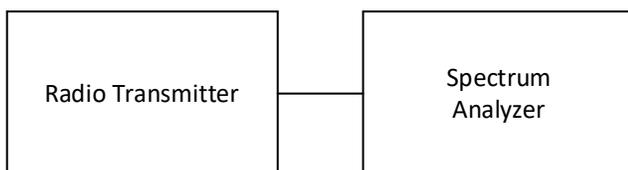


Figure TR10.1: Test setup

Occupied Bandwidth, 99% Test Method

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

Occupied Bandwidth, 99% Test Data

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

		Frequency (MHz)		
Mode	Speed	2402 (04)	2440	2480 (78)
BLE	1 Mbps	1.1029	1.1029	1.1152
BLE	2 Mbps	2.0731	2.0788	2.0778

Table TR10.2: Summary of 99% bandwidth data in MHz for BLE modes



Figure TR10.2: Bandwidth data for BLE 1 Mbps at 2480 MHz



Figure TR10.3: Bandwidth data for BLE 2 Mbps at 2440 MHz

Necessary Bandwidth Calculations

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

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

$$B_N = 2R / \text{Log}_2(S)$$

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

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

Table 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)	BN (MHz)
Bluetooth	BR	GFSK	1	1	2	1	2
	EDR2	Pi/4 DPSK	2	1	4	2	2
	EDR3	8DPSK	3	1	8	3	2
BLE	1Mbps	GFSK	1	1	2	1	2
	2Mbps	DQPSK	2	1	4	2	2

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

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

Table 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)	BN (MHz)
802.11 g	6	6	1	2	1	12
	9	9	1	2	1	18
	12	12	1	4	2	12
	18	18	1	4	2	18
	24	24	1	16	4	12
	36	36	1	16	4	18
	48	48	1	64	6	16
	54	54	1	64	6	18
802.11 n	MCS0	7.2	1	2	1	14.4
	MCS1	14.4	1	4	2	14.4
	MCS2	21.7	1	4	2	21.7
	MCS3	28.9	1	16	4	14.5
	MCS4	43.3	1	16	4	21.7
	MCS5	57.8	1	64	6	19.3
	MCS6	65	1	64	6	21.7
	MCS7	72.2	1	64	6	24.1

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

As a note, the bit rate for IEEE 802.11 n WiFi is calculated based on the IEEE standard's short guard interval of 400 nsec. If only the long guard interval of 800 nsec were implemented, the bit rate for MCS7 would decrease to 65 Mbps for a Necessary Bandwidth of 21.7 MHz.

The TRC-43 method for OFDM signals simply multiplies the number of subcarriers, K, and the subcarrier spacing, N_s . In both cases, N_s 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	N_s (MHz)	K	BN (MHz)
802.11g	0.3125	53	16.6
802.11n	0.3125	57	17.8

Table TR10.105: Necessary Bandwidth for IEEE 802.11 g and n 20 MHz Radio Protocols (TRC-43)

This line is the end of the test record.

Test Record
Transmitter Power
Test IDs TR02
Project GCL0602

Test Date(s) 05 Jun 2024
 Test Personnel Aditya Prakash

Product Model A04392
 Serial Number tested 8H1000011

Operating Mode M3 (BleTx)
 Arrangement A1(Solo)
 Input Power Battery

Test Standards: FCC Part 15, ANSI C63.10, ETSI EN 300 328, RSS-GEN, RSS-210, RSS-247, RSS-310 (as noted in Section 6 of the report).

Antenna Gain -1.29 dBi, as reported by the client. For 2402 MHZ and 2404 MHZ specifically, the antenna gain applied is -3.95 dBi, as reported by the client.

Radio Protocol Bluetooth Low Energy

Pass/Fail Judgment: PASS

Test record created by: Aditya Prakash
Date of this record: 10 Jun 2024

Original record, Version A was created by Aditya Prakash on 10 Jun 2024. Version B was created on 28 Aug 2024 by Aditya Prakash to address some editorial changes.

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 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: 5.4.2.2.1.3
 ANSI C63.10: 11.9.1.3

Transmit Power

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

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

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

2478 MHz. The lowest and highest operating channel frequencies for the other protocols are 2402 MHz and 2480 MHz.

	Frequency (MHz)			ANSI Limit (dBm)
	2402(04)	2440	2480(78)	
BLE 1 Mbps	20.57	20.27	19.70	30
BLE 2 Mbps	21.67	21.17	20.56	30

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

Setup Diagram

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

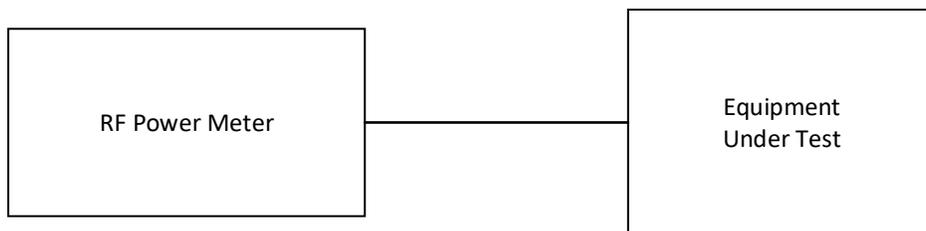


Figure TR02.1: Test equipment setup

This line is the end of the test record.

Test Record
Transmitter Power
Test IDs TR56
Project GCL0602

Test Date(s) 26 Aug 2024
 Test Personnel Jim Solum

Product Model A04392
 Serial Number tested 8H1000011

Operating Mode M17 (BleFtp)
 Arrangement A1(Solo), A2(Upwr)
 Input Power Battery, 5 volts DC

Test Standards: FCC Part 15, ANSI C63.10, EN RSS-GEN, RSS-210 (as noted in Section 6 of the report).

Antenna Gain -1.29 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: 26 Aug 2024
 Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	18-Jul-2024	18-Jul-2026
Thermometer	Thermco	ACCD370P	220608121	18-Jul-2024	18-Jul-2026
Thermal Chamber	Tenney	T2RC	32774-02	Calibration	Not Required

Table TR56.1: 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

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. The lowest and highest operating channel frequencies for BLE 1 Mbps are 2402 MHz and 2480 MHz.

Frequency	(MHz)	2402	2440	2480
BT Low Energy	1 Mbps	1.91	6.82	8.76

Table TR56.2: Transmit Power Summary in dBm with ANSI C63.10 analytical methods

Setup Diagram

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

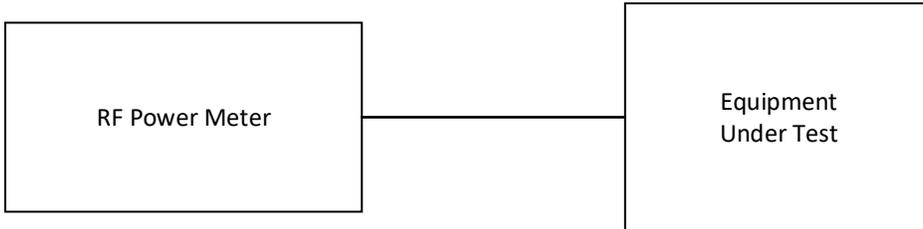


Figure TR56.1: Test equipment setup

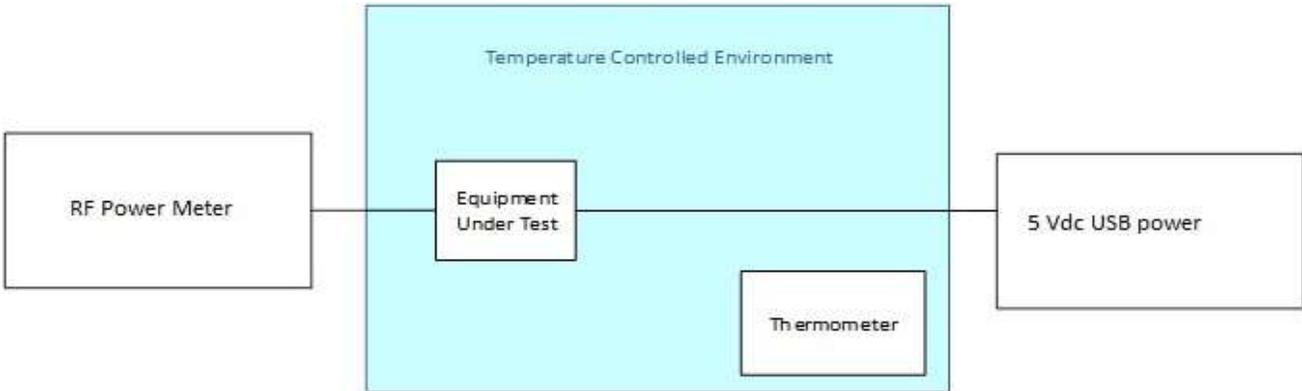


Figure TR56.2: Test equipment setup for power stability vs temperature

This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test IDs TR27
Project GCL-04602

Test Date(s) 13 Jun 2024
 Test Personnel Aditya Prakash under Majid Farah`s supervision.

Product Model A04392
 Serial Number tested 8H1000011

Operating Mode M3 (BleTx)
 Arrangement A1(Solo)
 Input Power Battery

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: Aditya Prakash
Date of this test record: 19 Jun 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.

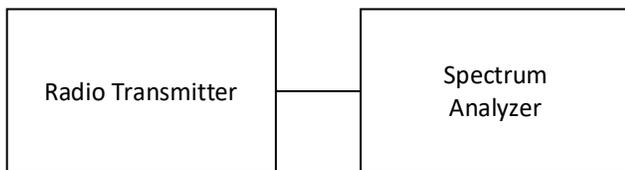


Figure TR27.1: Test setup

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.

For BLE operating at 2 Mbps, the lowest operating frequency was 2404 MHz, and the highest operating frequency was 2478 MHz. For BLE, operating at 1 Mbps, the lowest operating frequency was 2402 MHz, and the highest operating frequency was 2480 MHz.

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 than 20 is a passing result. The minimum margin from the peak level for each mode are highlighted in yellow.

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

		2402 (04)	2440	2480 (78)
BLE	1 Mbps	60.07	57.62	57.20
	2 Mbps	55.74	55.87	52.36

Table TR27.2: Results Summary

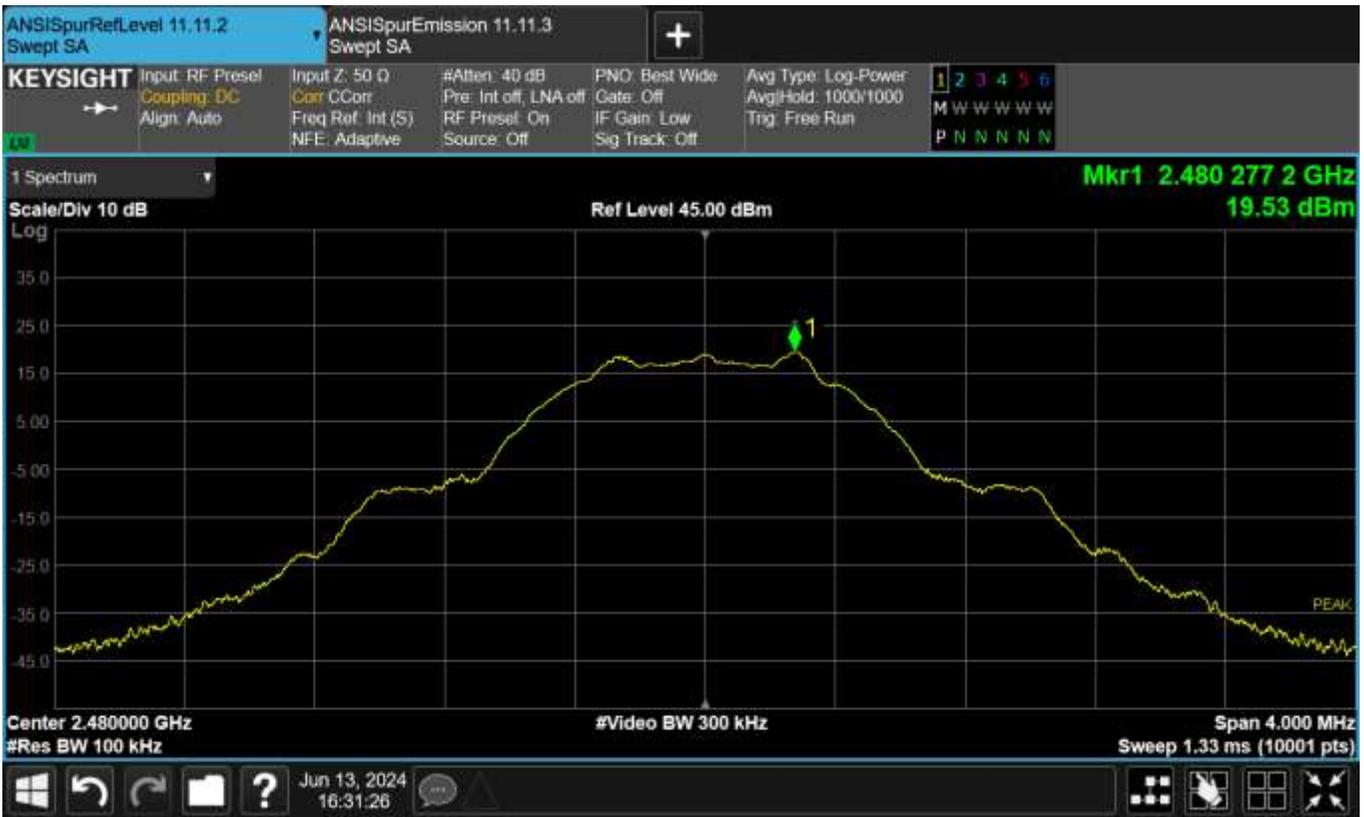


Figure TR27.2: Reference level measurement for Bluetooth BLE 1 Mbps at 2480 MHz



Figure TR27.3: Spectral data for Bluetooth BLE 1 Mbps at 2480 MHz



Figure TR27.4: Reference level measurement for Bluetooth BLE 2 Mbps at 2478 MHz



Figure TR27.5 Spectral data for Bluetooth BLE 2 Mbps at 2478 MHz

This line is the end of the test record.

Test Record
Radiated Emission Test RE03
Project GCL0602

Test Date(s) 06 Jun 2024
 Test Personnel David Kerr

Product Model A04392
 Serial Number tested 8H1000141

Operating Mode M3 (BleTx)
 Arrangement A1(Solo)
 Input Power Battery

Test Standards: FCC Part 15, ANSI C63.10, RSS-210 (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: Dave Kerr, Vladimir Tolstik
Date of this record: June 11, 2024

Original record, Version A was created on 11 Jun 2024 by Dave Kerr and Valdimir Tolstik. Version B of this record was created by Aditya Prakash on 23 Aug 2024 to make some editorial changes.

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	227596	14-Sep-2023	14-Sep-2025
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required

Table RE03.1: Test Equipment Used

Software Used

Keysight PXE receiver software A.32.06, RE Substitution Signal Maximization Tool V1.xlsx, FCC Restricted Band 2p4GHz Data Analysis 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 for the 1 Mbps data rate, and 2404 MHz for the 2 Mbps data rate. Measurements in the upper band were made while the transmitter was tuned to its highest frequency of 2480 MHz for the 1 Mbps data rate, and 2478 MHz for the 2 Mbps data rate.

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

The tables show the selected final measurement data between the FCC restricted bands. It includes 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.

BLE 1Mb prescan 2200- 2390 was performed at 1 meter and extrapolated to 3 meter, Final measurements were made at 3 meters with the amplifier. 2483.5 – 2500 MHz were performed at 3 meters without using an amplifier in the measurement chain.. Final measurements were performed at 3 meters. BLE 2Mb was performed at 3 meters without using an amplifier in the measurement chain to address overload issues in the spectrum analyzer.

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarization
2389.5	54	74	38.34	54.084	15.66	19.916	113	3536	HORZ
2378	54	74	37.555	49.321	16.44	24.679	113	3536	HORZ

Table RE03.2: FCC restricted bands from 2200 to 2390 MHz (BLE 1Mb)

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarization
2492.8	54	74	51.524	66.615	2.476	7.385	118	3722	HORZ
2483.5	54	74	52.90889	66.317	1.09	7.683	118	3722	HORZ

Table RE03.3: FCC restricted band from 2483.5 to 2500 MHz (BLE 1Mb)

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
2245.5	54	74	44.098	57.876	9.902	16.124	-20	1623	HORZ
2380	54	74	44.979	59.868	9.021	14.132	-20	1623	HORZ

Table RE03.4: FCC restricted bands from 2200 to 2390 MHz (BLE 2Mb)

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
2484	54	74	47.3	61.593	6.7	12.407	46	3363	HORZ
2483.5	54	74	47.423	60.692	6.577	13.308	46	3363	HORZ

Table RE03.5: FCC restricted band from 2483.5 to 2500 MHz (BLE 2Mb)

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

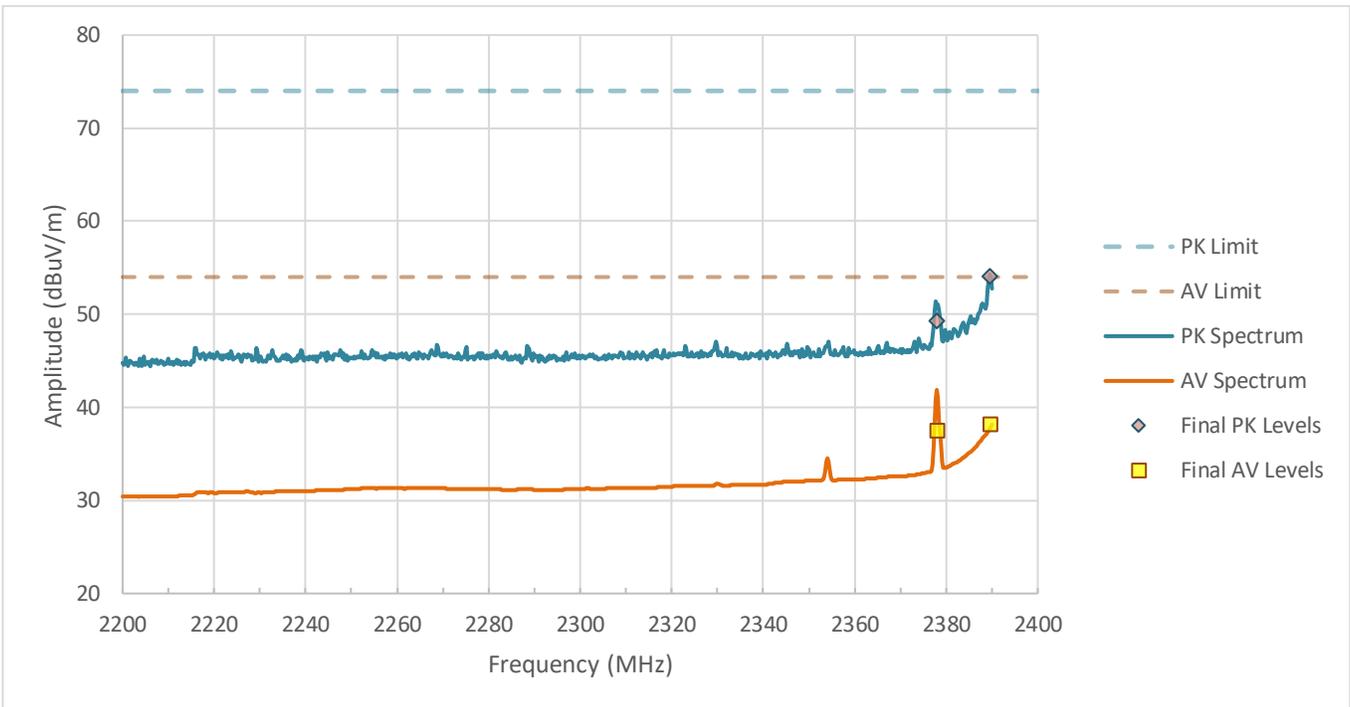


Figure RE03.1: FCC restricted band spectral data from 2200 to 2390 MHz (BLE 1Mb) at 1 meter

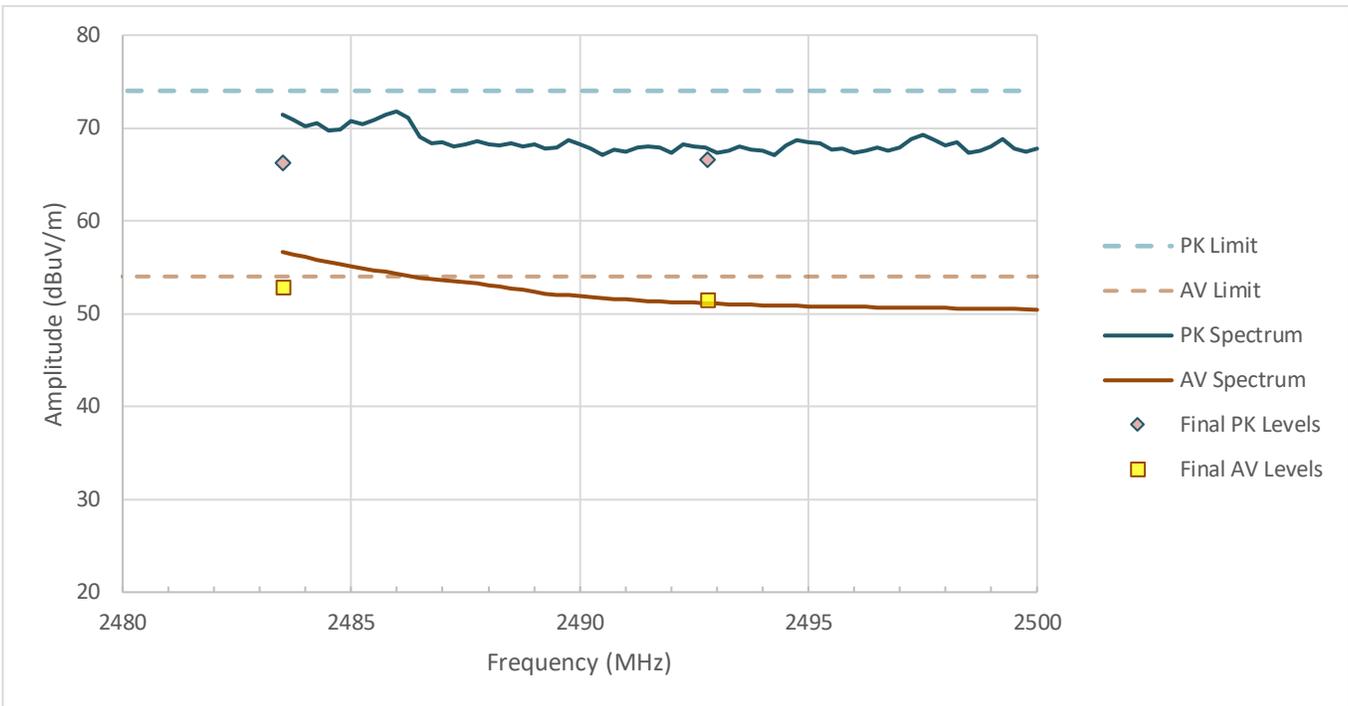


Figure RE03.2: FCC restricted band spectral data from 2483.5 to 2500 MHz (BLE 1Mb) at 3 meter

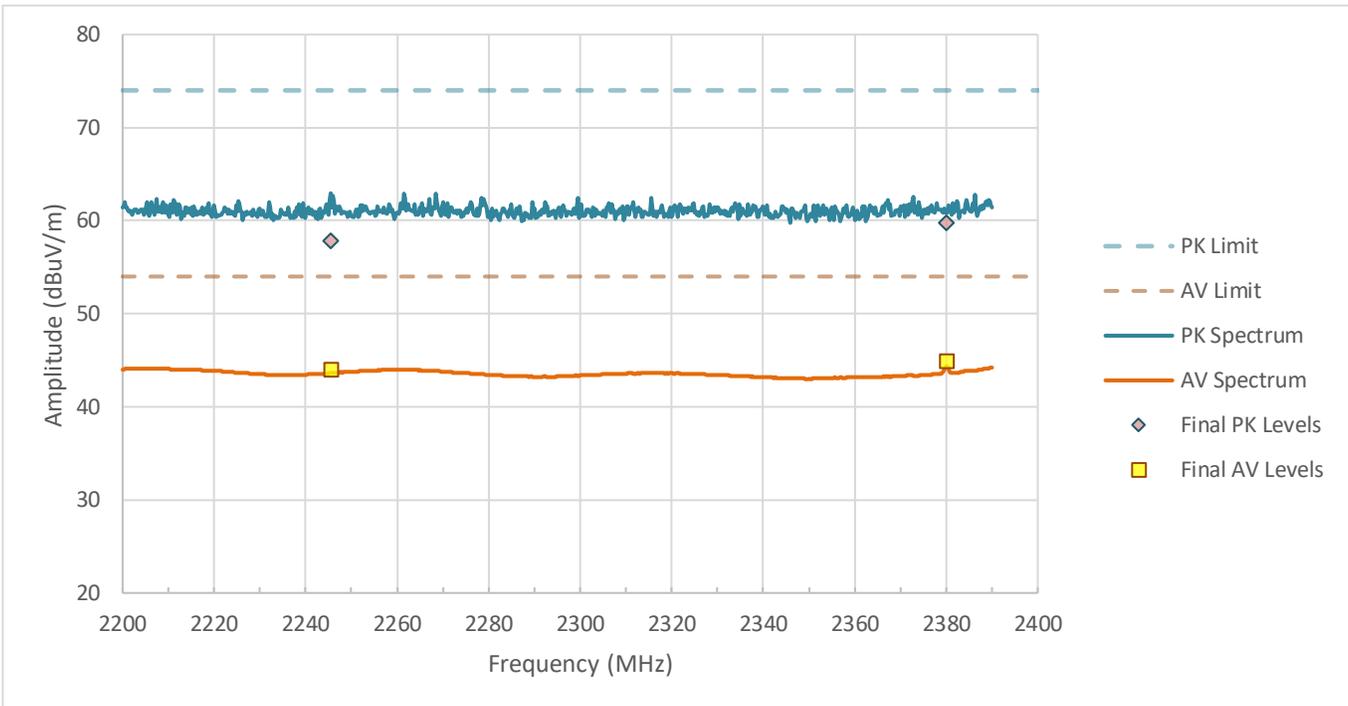


Figure RE03.3: FCC restricted band spectral data from 2200 to 2390 MHz (BLE 2Mb) at 3meter

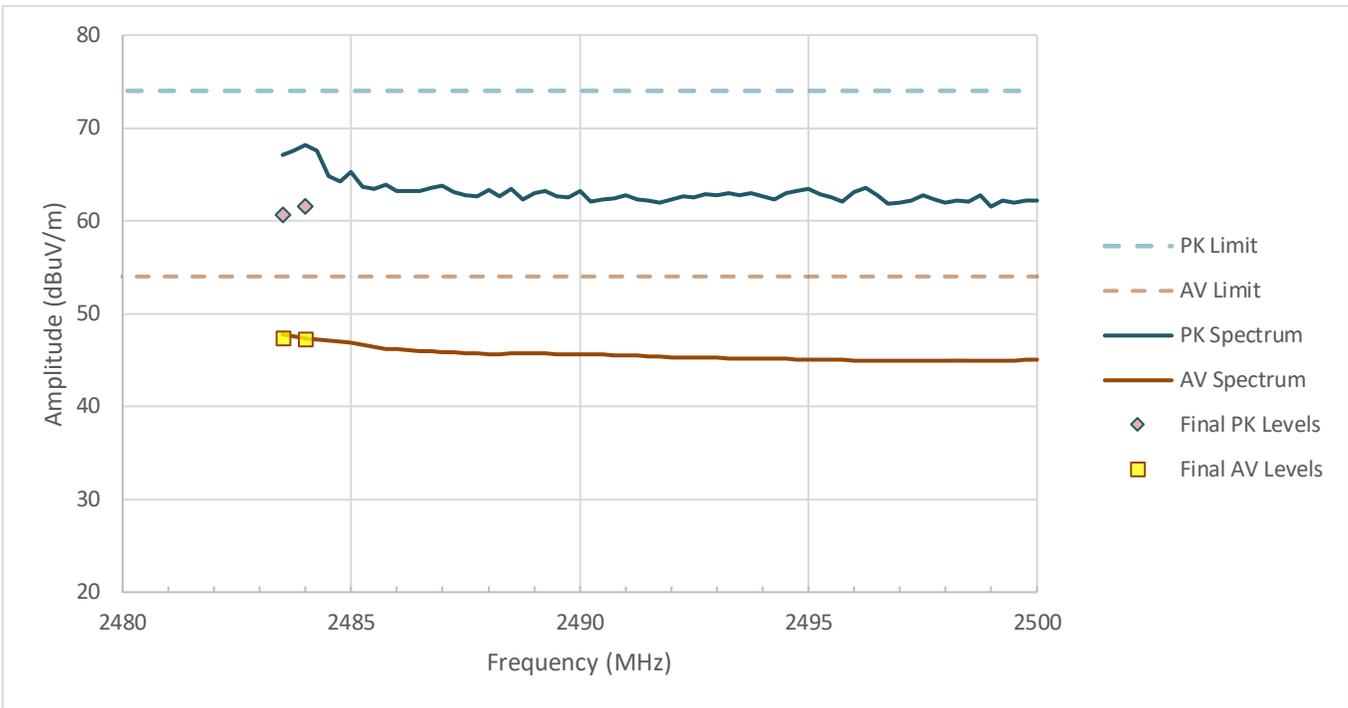


Figure RE03.4: FCC restricted band spectral data from 2483.5 to 2500 MHz (BLE 2Mb) at 3 meters

Setup Photographs

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

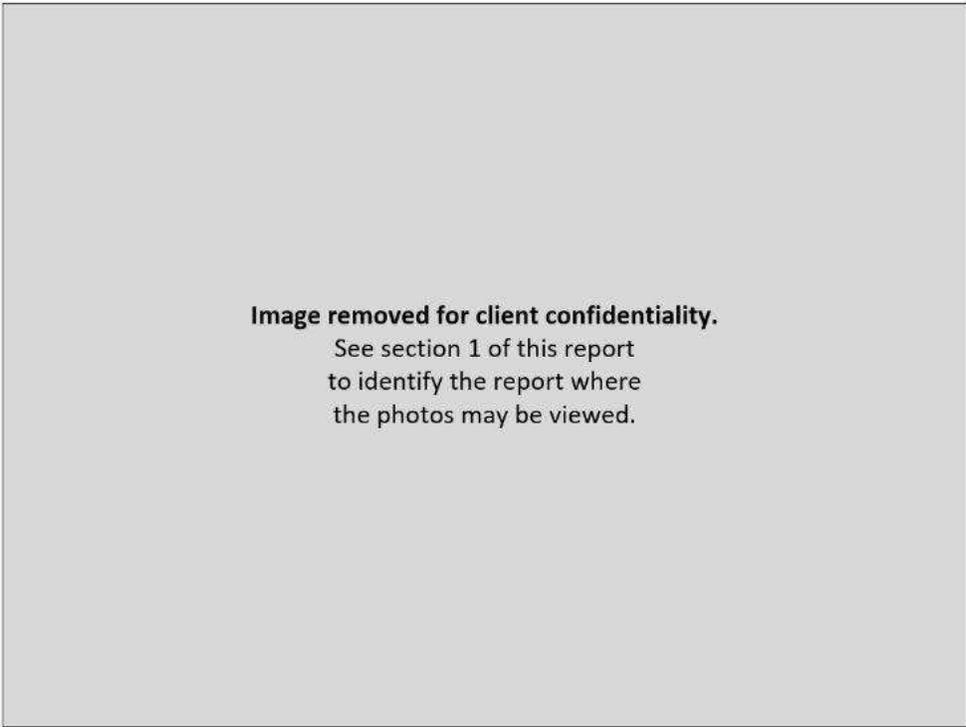


Figure RE03.5: EUT test setup, primary view



Figure RE03.6: 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-0602

Test Date(s) 13 Jun 2024
 Test Personnel Aditya Prakash under the supervision of Majid Farah

Product Model A04392
 Serial Number tested 8H1000011

Operating Mode M3 (BleTx)
 Arrangement A1(Solo)
 Input Power Battery

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 -1.29 dBi, as reported by the client
 Radio Protocol Bluetooth Low Energy (BLE)

Pass/Fail Judgment: PASS

Test record created by: Aditya Prakash
Date of this record: 13 Jun 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

Test Software Used: Keysight PXE firmware 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.

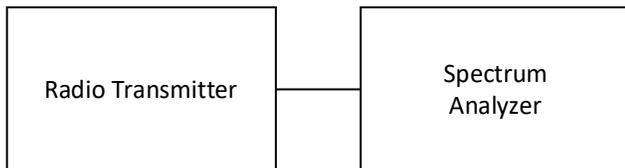


Figure TR19.1: Test setup

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

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

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

	Frequency (MHz)		
(Units in dBm)	2402(04)	2440	2480(78)
BLE 1Mbps	6.38	6.14	5.73
BLE 2Mbps	3.20	2.69	2.40

Table TR19.2: Summary of results

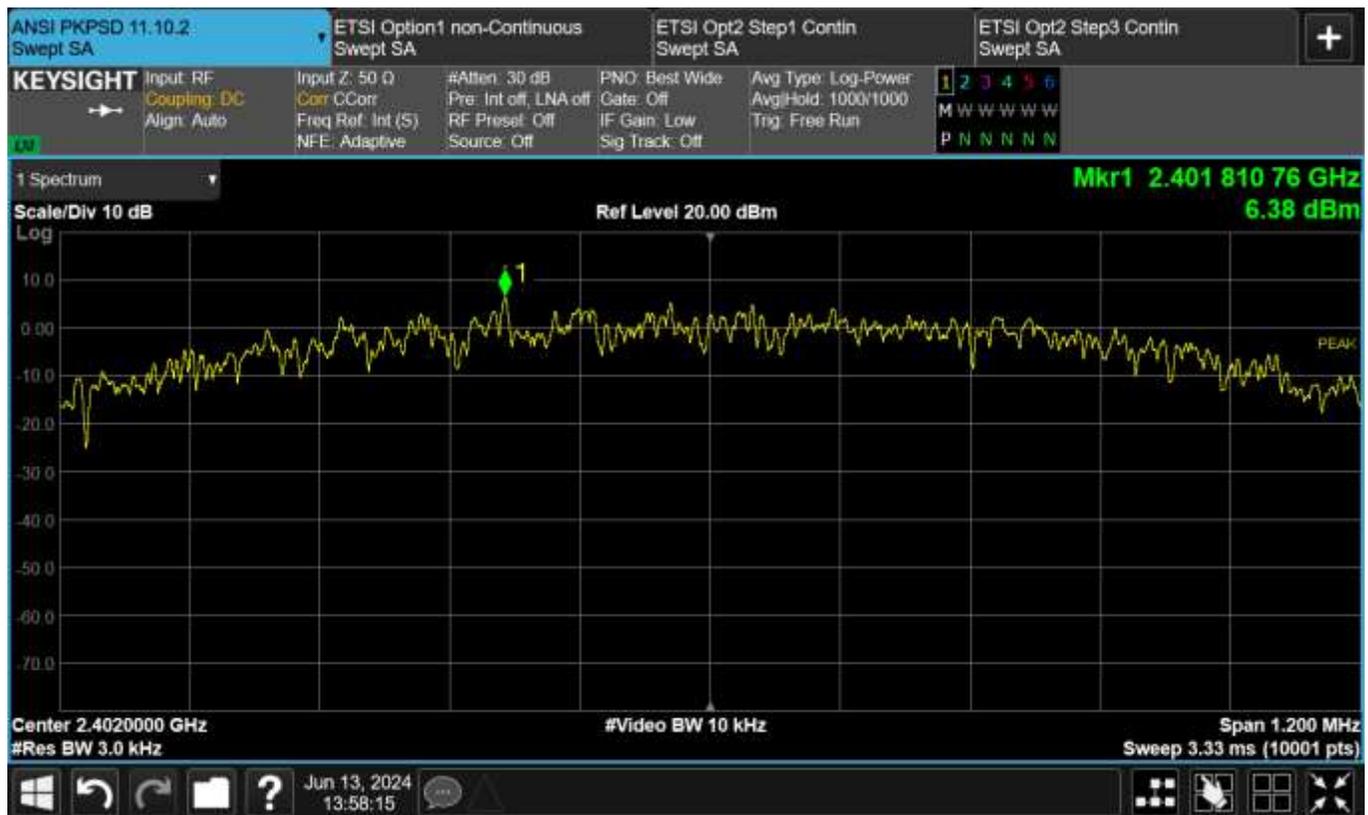


Figure TR19.2: Test data for BLE 1 Mbps 2402 MHz

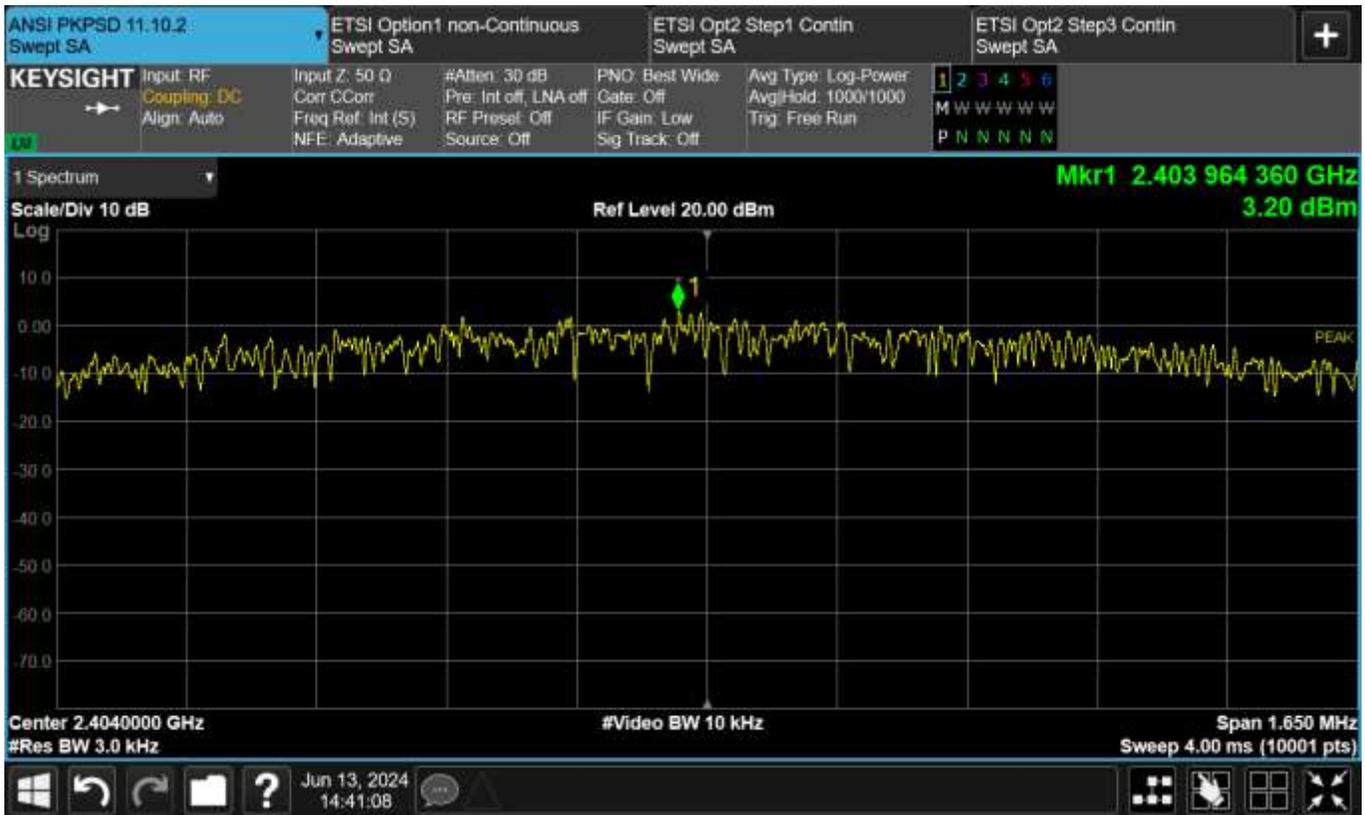


Figure TR19.3: Test data for BLE 2 Mbps 2404 MHz

This line is the end of the test record.

Test Record
Transmitter Stability in Extreme Conditions
Test IDs TR43
Project GCL-0602

Test Date(s) 26 Jun 2024
 Test Personnel Vladimir Tolstik assisted by Majid Farah

Product Model A04392
 Serial Number tested 8H1000011

Operating Mode M3 (BleTx)
 Arrangement A1(Solo)
 Nominal Input Power Battery

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

Radio Protocol BLE (Bluetooth Low Energy)

Pass/Fail Judgment: PASS

Test record created by: Vladimir Tolstik, Aditya Prakash
Date this record: 28 Jun 2024

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
MXE Receiver 8.4 GHz	Keysight	N9038B	MY63460112	28-Feb-2024	1-Mar-2025
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	7-Jul-2023	1-Jul-2024
DMM Multimeter	FLUKE	79 III	71740743	11-Apr-2024	11-Apr-2027
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Thermometer	Thermco	ACCD370P	210607316	21-Sep-2023	15-Sep-2024
Thermal Chamber	Tenney	T2RC	32774-02	Calibration	Not Required

Table TR043.1: List of test equipment used

Software Used: MXE Software Revision A.37.02

Test Method

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

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

Test Data

The test sample(s) were subjected to extreme conditions and performed as shown below. Yellow highlights indicate the highest level for a protocol, for which an image of the spectrum is also provided. In the spectral plots, the data sets have been combined to present the low and high channel results side by side. Markers 1 and 3 indicate the spectral peak while markers 2 and 4 are at the 2400 MHz or 2483.5 MHz band edge. Markers 2 and 4 in the table below spectral data show differences to Markers 1 and 3.

The test sample(s) were subjected to extreme conditions and performed as shown below.

Tx mode	Temp	Source Voltage	Low Ch.	High Ch.
	°C		dBc	dBc
BLE 1 Mbps	60	Internal Battery	35.53	53.31
BLE 1 Mbps	50	Internal Battery	34.42	53.19
BLE 1 Mbps	40	Internal Battery	34.94	52.92
BLE 1 Mbps	30	Internal Battery	34.86	52.66
BLE 1 Mbps	20	Internal Battery	34.41	53.72
BLE 1 Mbps	10	Internal Battery	33.82	53.58
BLE 1 Mbps	0	Internal Battery	33.31	53.48
BLE 1 Mbps	-10	Internal Battery	33.85	49.37
BLE 1 Mbps	-20	Internal Battery	32.86	49.77

Table TR43.2 Difference between peak and band edge levels for BLE 1 Mbps transmissions during temperature variations

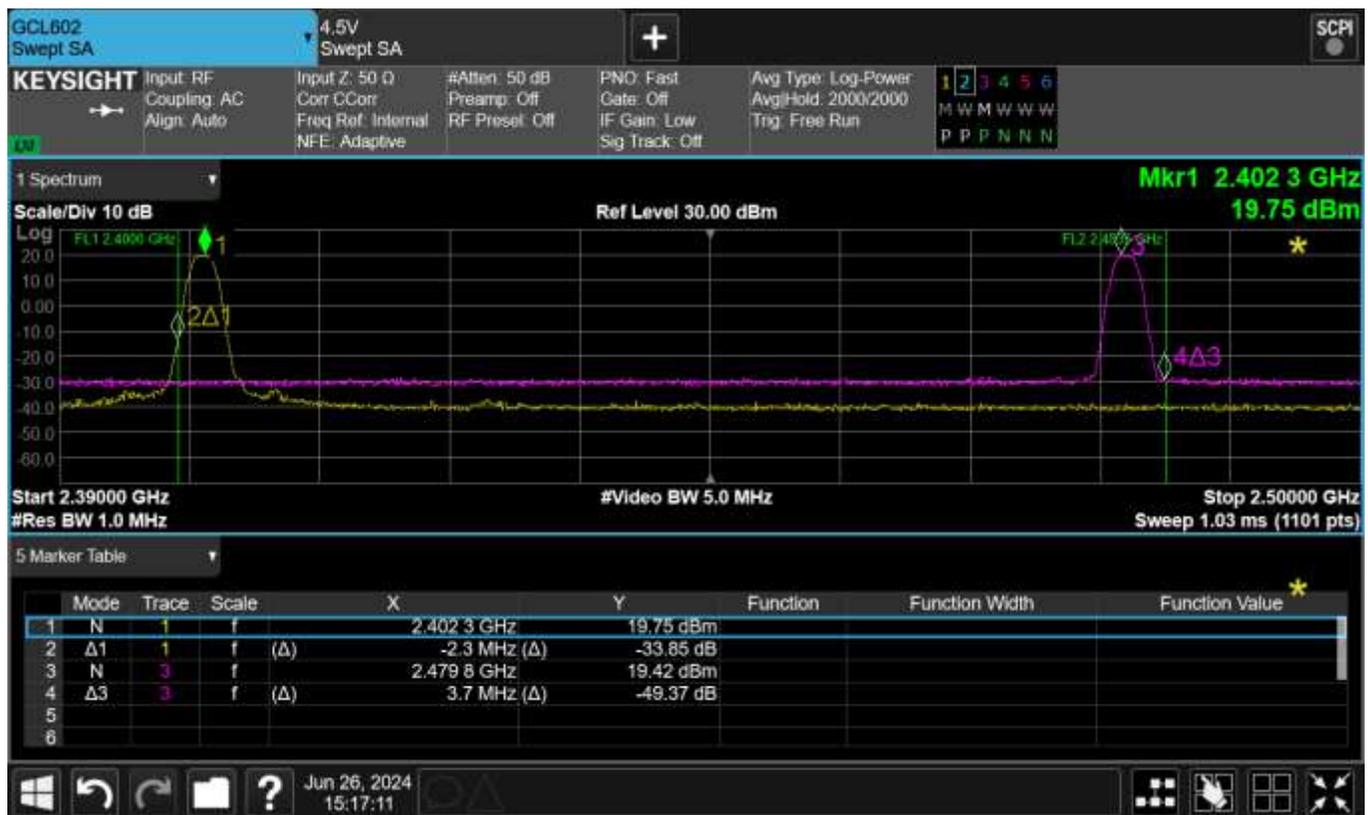
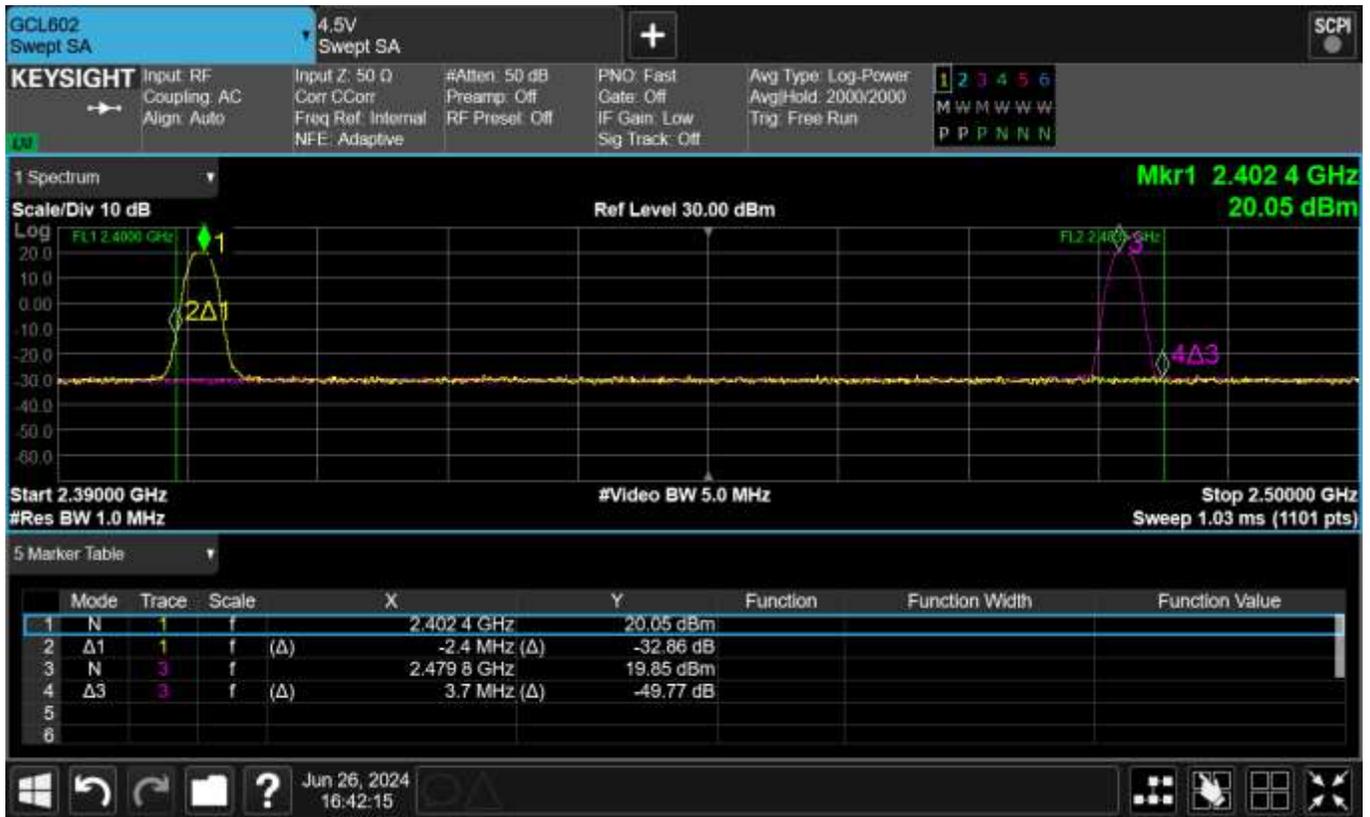


Figure TR43.1: Spectral data for BLE 1 Mbps at -10 °C which represent low and high channel



Tx mode	Temp	Battery Voltage state	Low Ch.	High Ch.
	°C		dBc	dBc
BLE 1 Mbps	20	5% charge	34.44	52.75
BLE 1 Mbps	20	50% charge	34.41	53.72
BLE 1 Mbps	20	100% charge	34.48	53.68

Table TR43.3 Difference between peak and band edge levels for BLE 1 Mbps transmissions at 20 °C during voltage variations



Figure TR43.3: Spectral data for BLE 1 Mbps at 20 °C which represent low and high channel at 5% charge state.

Setup Block Diagram

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

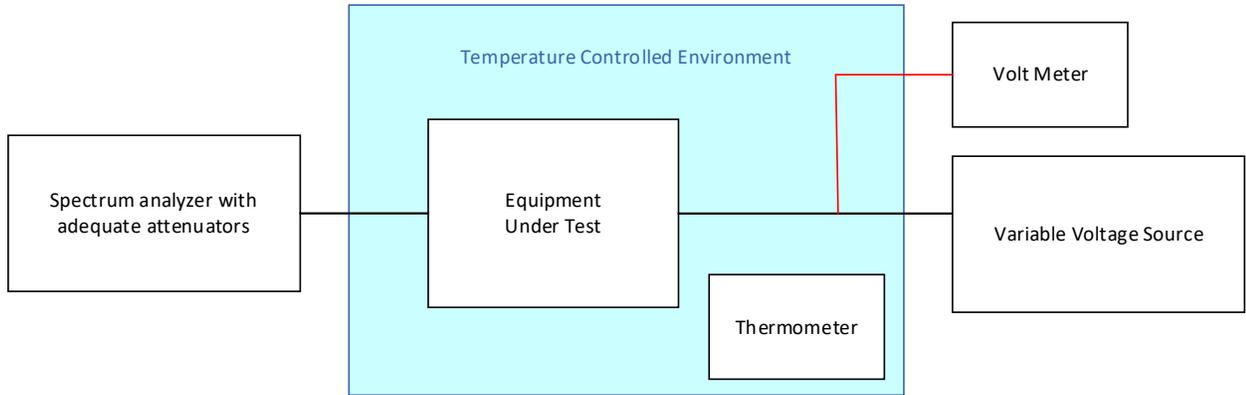


Figure TR43.4: Schematic drawing of the test equipment setup

This line is the end of the test record.

Test Record
Radiated Emission Test RE30
Project GCL0602

Test Date(s) 14 Aug 2024
 Test Personnel David Kerr

Product Model A04392
 Serial Number tested 8H1000141

Operating Mode M3 (BleTx)
 Arrangement A2(Upwr)
 Input Power USB 5 Vdc

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

Frequency Range: 9 kHz to 30 MHz
Pass/Fail Judgment: PASS

Test record created by: David A Kerr
Date of this record: 14 Aug 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
Loop antenna, amplified	Schwarzbeck	FMZB 1519B	174	18-Jul-2024	18-Jul-2026
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	7-Nov-2022	7-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

Table RE30.1: Test Equipment Used

Software Used: Keysight PXE software A.32.06, RE 150k to 30M XYZ_orientations_TemplateV6.xlsm, RE 9k to 30M XYZ_orientations_TemplateV7.xlsm

Test Data

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

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

The table shows the selected final measurement data between 9 kHz and 30 MHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m. Any unintentional radio emission limits are not applied to intentional radio signals.

In this test, fewer than six emissions were observed within 20 dB of the limit. The relevant emissions were measured, including one or more noise floor signals as judged appropriate to the spectrum.

Freq.	Level	Detector	Limit	Margin	Peak Level	Pk Limit	Pk Margin	Antenna	Table
MHz	dBuV/m	Type	dBuV/m	dB	dBuV/m	dBuV/m	dB	Orientation	Azimuth, deg
0.0091	46.50	Avg	128.42	81.93	57.48	148.42	90.95	X	180
28.858	21.52	QP	69.54	48.02	29.92	None	None	Y	169

Table RE30.2: Emission summary

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

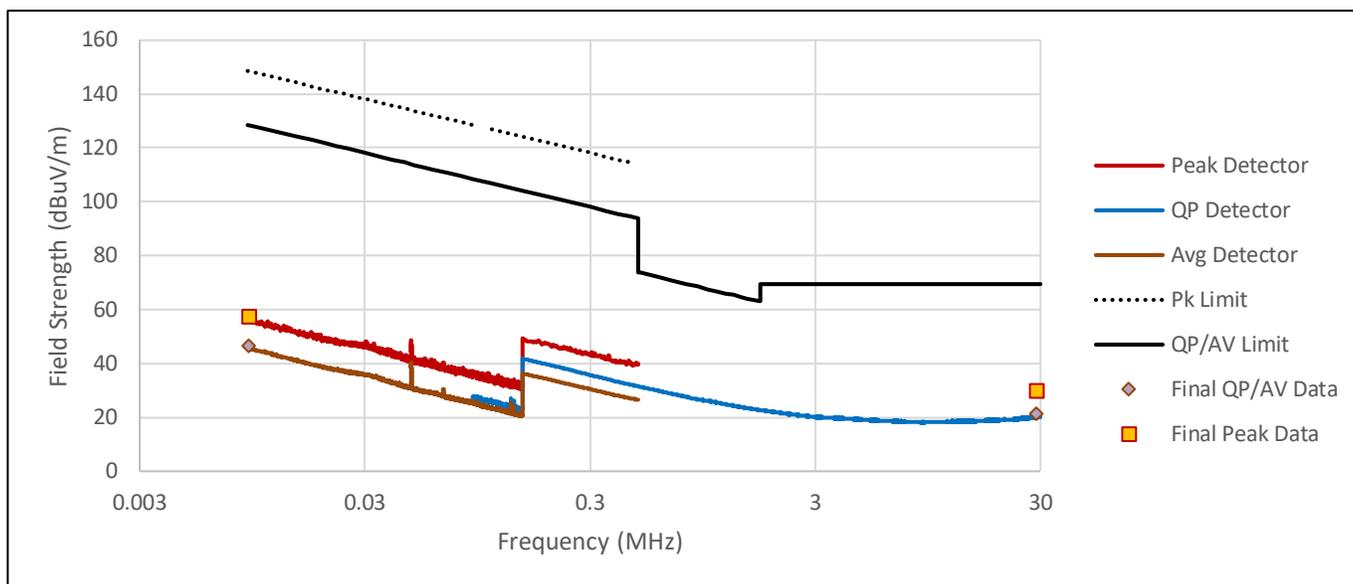


Figure RE30.1: Spectral data

Setup Photographs

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



Figure RE30.2: EUT test setup, first view (EUT Z orientation, Antenna Y orientation)

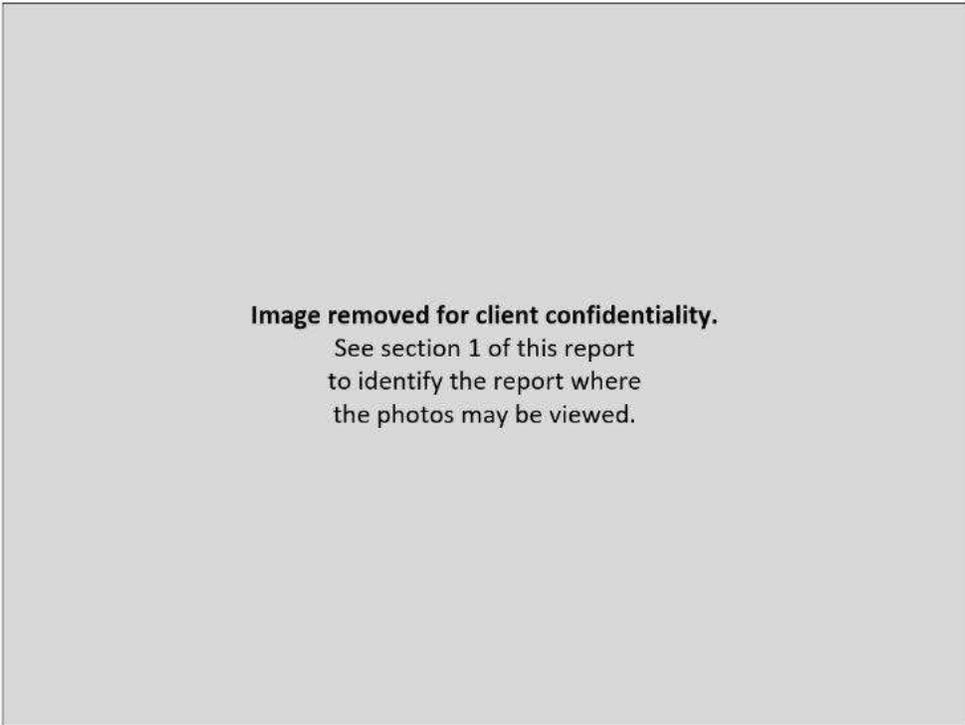


Figure RE30.3: EUT test setup, second view (EUT Z orientation, Antenna Y orientation)



Figure RE30.4: EUT test setup, first view (EUT Z orientation, Antenna X orientation)

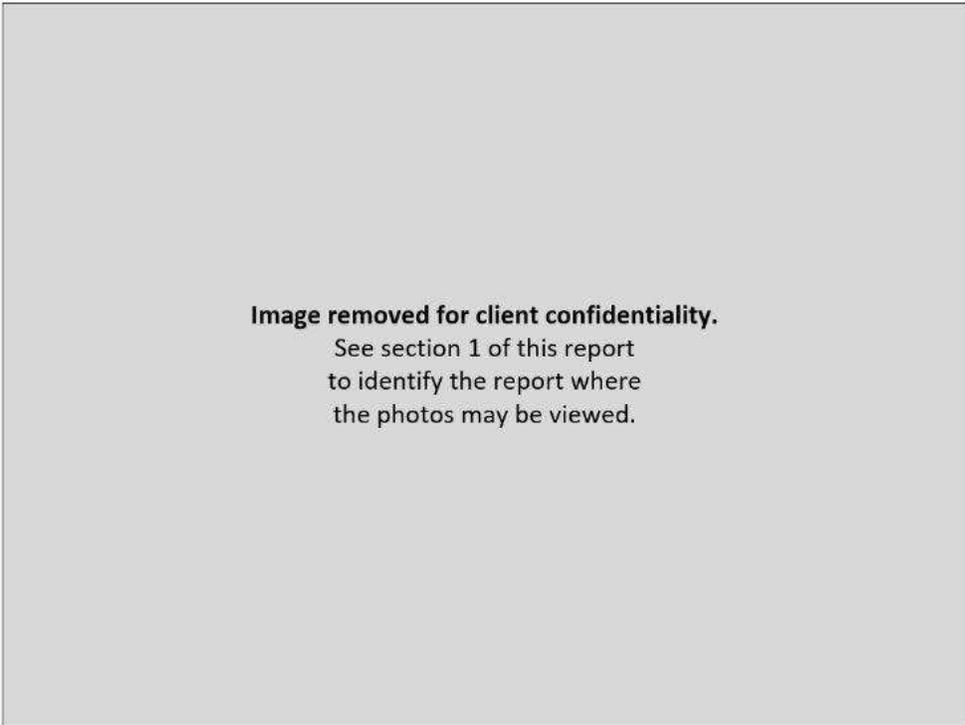


Figure RE30.5: EUT test setup, second view (EUT Z orientation, Antenna X orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE07
Project GCL0602

Test Date(s) 17 June 2024
 Test Personnel David Kerr

Product Model A04392
 Serial Number tested 8H1000141

Operating Mode M3 (BleTx)
 Arrangement A1 (Solo)
 Input Power Battery

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: David A Kerr
Date of this record: 17 June 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	233204	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	10720	16-Jan-2023	15-Jan-2026

Table RE07.1: Test Equipment Used

Software Used: Keysight PXE 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 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 in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC 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
		QP		QP	QP	QP		
30.720	H	3.6	22.3	25.9	40.0	14.1	177.4	346.0
215.550	H	0.4	19.4	19.8	43.5	23.7	392.7	137.0
400.890	H	0.0	27.3	27.3	46.0	18.7	318.8	346.0
539.460	V	-0.4	31.0	30.6	46.0	15.4	274.7	303.0
779.430	H	-0.2	34.1	33.9	46.0	12.1	100.0	248.0
960.030	H	-0.4	36.3	35.9	54.0	18.1	400.0	7.0

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.

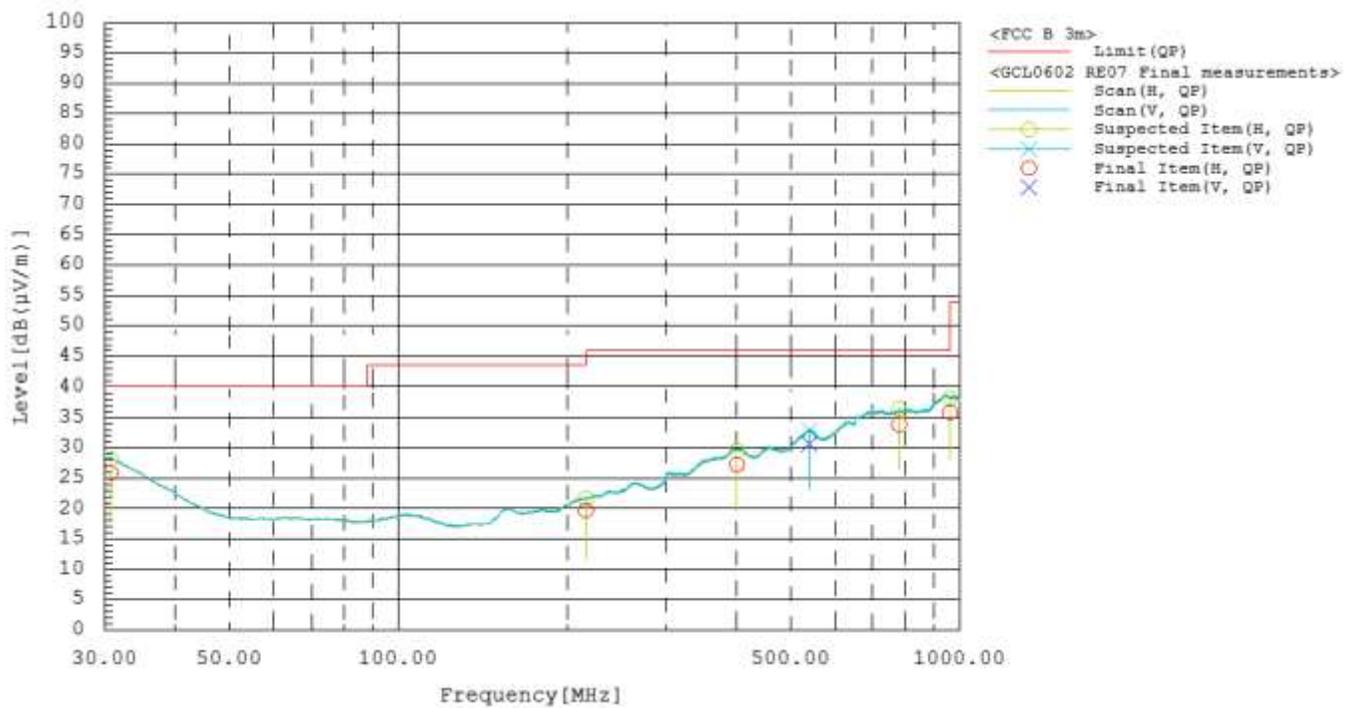


Figure RE07.1: Spectral data

Setup Photographs

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

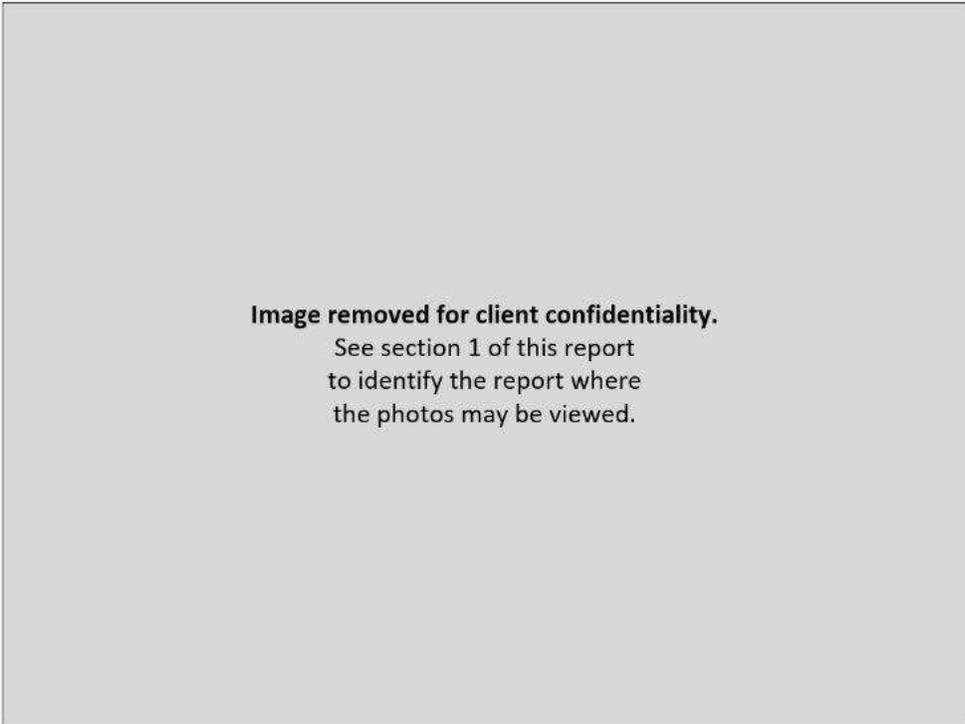


Figure RE07.2: EUT test setup, first view (Button and light towards antenna, Z orientation)

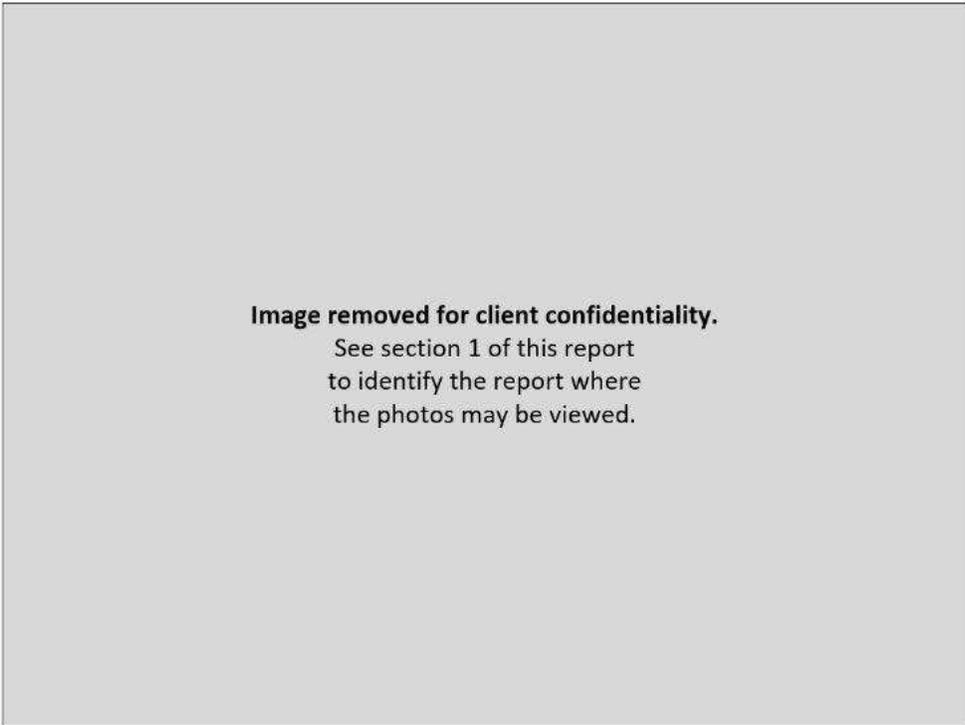


Figure RE07.3: EUT test setup, second view (Button and light towards antenna, Z orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE31
Project GCL0602

Test Date(s) 05, 06, 07 Aug 2024
 Test Personnel David Kerr, Valdimir Tolstik supervised by Jim Solum

Product Model A04392
 Serial Number tested 8H1000141

Operating Mode M3 (BleTx)
 Arrangement A1(Solo), A2(Upwr)
 Input Power Battery, USB 5 Vdc

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

Frequency Range: 1 GHz to 18 GHz
Pass/Fail Judgment: PASS

Test record created by: David A Kerr, Vladimir Tolstik
Date of this record: 14 Aug 2024

Original record, Version A was created on 14 Aug 2024 by Dave Kerr and Valdimir Tolstik. Version B of this record was created by Aditya Prakash on 23 Aug 2024 to make some editorial changes.

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	30-May-2024	30-May-2026
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
3 GHz High Pass filter	Anatech Electronics	0K0R2	1	Calibration	Not Required

Table RE31.1: Test Equipment Used

Software Used: Keysight PXE software A.32.06, EPX test software Version 2024.01.001

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.

In the 1 GHz to 3.2 GHz frequency range, pre-scan spectral data and final measurements were taken at 3 meters. A Chebyshev 'Wifi' notch filter covering the 2.4 GHz ISM band was placed in series just before the preamplifier to ensure it operated in its linear range. This filter is accounted for in the system loss, so it appears in the prescan plots a high noise floor levels from 2400 – 2483 MHz. These are not failing emissions.

In the 3.2 GHz to 18 GHz frequency range, pre-scan spectral data was taken at 1 meter and extrapolated to a 3 meter distance. Final measurements were made at 3 meters.

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 1 GHz and 18 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 in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m, except Tables 31.2 and 31.3 with test limit is the Combo B GHz Limit (Worst case of FCC class B and CISPR Limits. Please refer to section 6.3 of the report.) 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			
		CAV	PK			CAV	PK	AV	PK	CAV			PK
2216.250	H	33.2	48.8	-1.2	32.0	47.6	50.0	70.0	18.0	22.4	323.5	291.0	
3000.000	H	32.8	46.2	0.6	33.4	46.8	50.0	70.0	16.6	23.2	112.0	252.0	

Table RE31.2: Emission summary (BLE 1Mb 2402MHz, 1-3.2GHz)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle	
MHz		dB(μV)			dB(1/m)	dB(μV/m)		dB(μV/m)		dB			
		CAV	PK			CAV	PK	AV	PK	CAV			PK
2344.000	V	33.6	47.0	-0.6	33.0	46.4	50.0	70.0	17.0	23.6	359.2	29.0	
2368.000	H	34.6	48.1	-0.5	34.1	47.6	50.0	70.0	15.9	22.4	124.9	345.0	
2488.000	H	35.5	48.4	0.6	36.1	49.0	50.0	70.0	13.9	21.0	353.4	293.0	
2512.000	H	34.4	48.0	0.4	34.8	48.4	50.0	70.0	15.2	21.6	114.4	301.0	
3141.750	V	33.1	46.7	1.5	34.6	48.2	54.0	74.0	19.4	25.8	255.2	0.0	

Table RE31.3: Emission summary (BLE 1Mb 2440MHz, 1-3.2GHz)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle	
MHz		dB(μV)			dB(1/m)	dB(μV/m)		dB(μV/m)		dB			
		CAV	PK			CAV	PK	AV	PK	CAV			PK
2359.750	H	33.2	46.7	-0.4	32.8	46.3	54.0	74.0	21.2	27.7	204.2	319.0	
2485.750	H	42.6	60.8	0.6	43.2	61.4	54.0	74.0	10.8	12.6	120.4	293.0	
2504.000	H	43.4	55.8	0.4	43.8	56.2	54.0	74.0	10.2	17.8	112.6	301.0	
3070.750	V	32.9	46.3	1.1	34.0	47.4	54.0	74.0	20.0	26.6	400.0	270.0	

Table RE31.4: Emission summary (BLE 1Mb 2480MHz, 1-3.2GHz)

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		
9608.000	V	28.2	42.1	15.1	43.3	57.2	54.0	74.0	10.7	16.8	381.8	18.0
12010.000	V	27.3	41.0	18.5	45.8	59.5	54.0	74.0	8.2	14.5	245.6	350.0
14412.000	V	25.9	39.6	20.7	46.6	60.3	54.0	74.0	7.4	13.7	400.0	40.0
4804.500	H	38.1	49.1	7.3	45.4	56.4	54.0	74.0	8.6	17.6	100.0	183.0
7206.750	H	39.5	50.2	11.5	51.0	61.7	54.0	74.0	3.0	12.3	100.0	146.0
16812.250	H	32.8	44.9	24.1	56.9	69.0	54.0	74.0	-2.9	5.0	195.8	292.0

Table RE31.5: Emission summary (BLE 1Mb 2402MHz, 3.2 - 18GHz)

16812.250 GHz is not in a restricted band, so the limits of Part 15.209 or RSS-Gen table 5 do not strictly apply. The requirements of 15.247(d) and RSS-247 section 5.5 were applied to this radiated emission as follows using a 100 kHz resolution bandwidth. The carrier to emission ratio was measured and found compliant with the minimum 20 dBc rule as follows:

Emission	Frq (MHz)	Azimuth (deg)	Height (cm)	Peak (dBuV/m)	Avg (dBuV/m)
Carrier	2402.000	315	1270	114.9	105.3
Spur	16812.250	34	3076	61.5	48.2
Reduction (dBc)				53.4	57.1

Table RE31.5b: Emission detail for selected emission

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		
7320.750	V	40.8	51.1	11.6	52.4	62.7	54.0	74.0	1.6	11.3	241.0	320.0
9758.750	V	28.6	41.7	14.9	43.5	56.6	54.0	74.0	10.5	17.4	177.4	322.0
12200.000	V	26.5	40.3	19.4	45.9	59.7	54.0	74.0	8.1	14.3	155.8	163.0
14640.000	V	26.2	39.9	21.0	47.2	60.9	54.0	74.0	6.8	13.1	359.0	130.0
4880.500	H	35.3	47.2	6.7	42.0	53.9	54.0	74.0	12.0	20.1	100.0	183.0
17081.750	V	27.5	41.2	24.1	51.6	65.3	54.0	74.0	2.4	8.7	385.4	213.0

Table RE31.6: Emission summary (BLE 1Mb 2440MHz, 3.2 - 18GHz)

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		
7439.250	V	41.4	51.5	11.7	53.1	63.2	54.0	74.0	0.9	10.8	254.9	336.0
9921.250	V	29.0	42.5	16.2	45.2	58.7	54.0	74.0	8.8	15.3	379.8	203.0
12400.000	V	27.4	40.8	18.9	46.3	59.7	54.0	74.0	7.7	14.3	110.4	298.0
14880.000	V	26.0	40.2	21.4	47.4	61.6	54.0	74.0	6.6	12.4	329.6	303.0
4959.500	H	34.4	46.6	6.8	41.2	53.4	54.0	74.0	12.8	20.6	100.0	0.0
17361.750	V	28.1	41.5	23.6	51.7	65.1	54.0	74.0	2.3	8.9	223.5	9.0

Table RE31.7: Emission summary (BLE 1Mb 2480MHz, 3.2 - 18GHz)

The graph below shows the background spectrum observed during pre-scan, as well as the final data points from the table above. Except Figure RE31.1, RE31.2 which have the Combo B GHz 3m and more strict than FCC B GHz 3m.

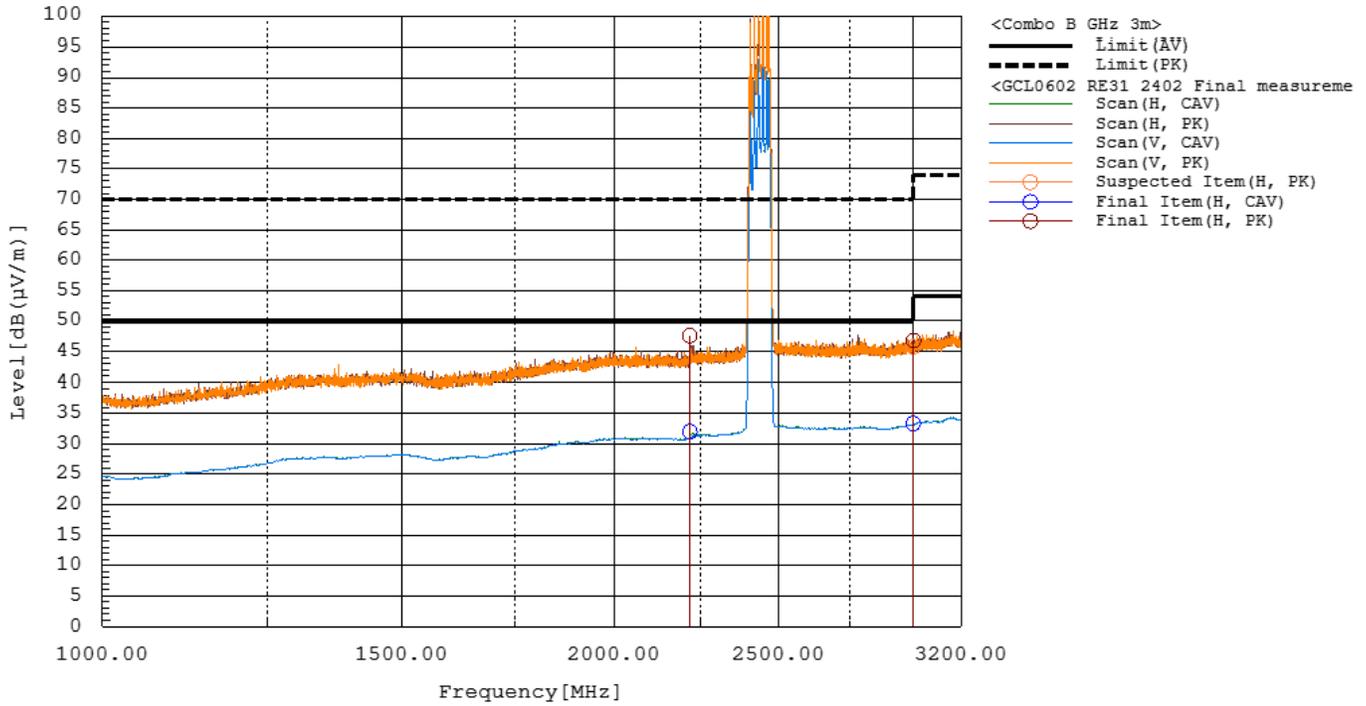


Figure RE31.1: Spectral data (BLE 1Mb 2402MHz, 1-3.2GHz)

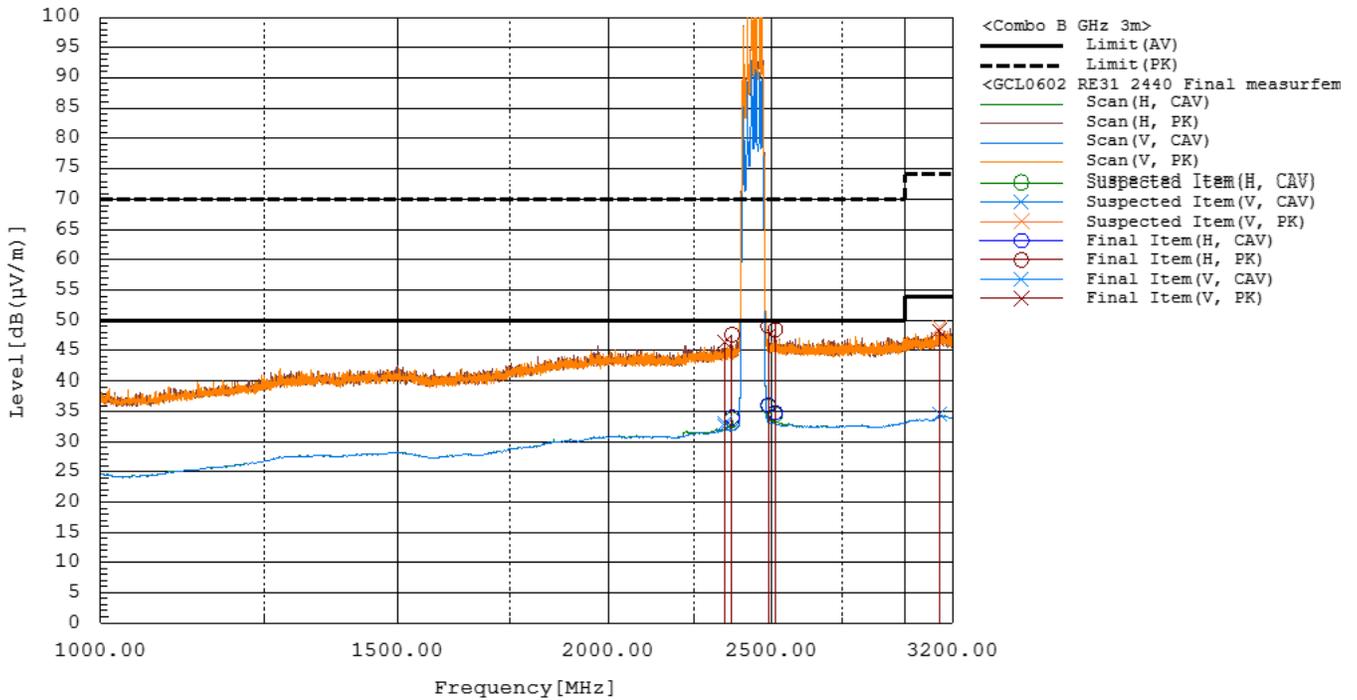


Figure RE31.2: Spectral data (BLE 1Mb 2440MHz, 1-3.2GHz)

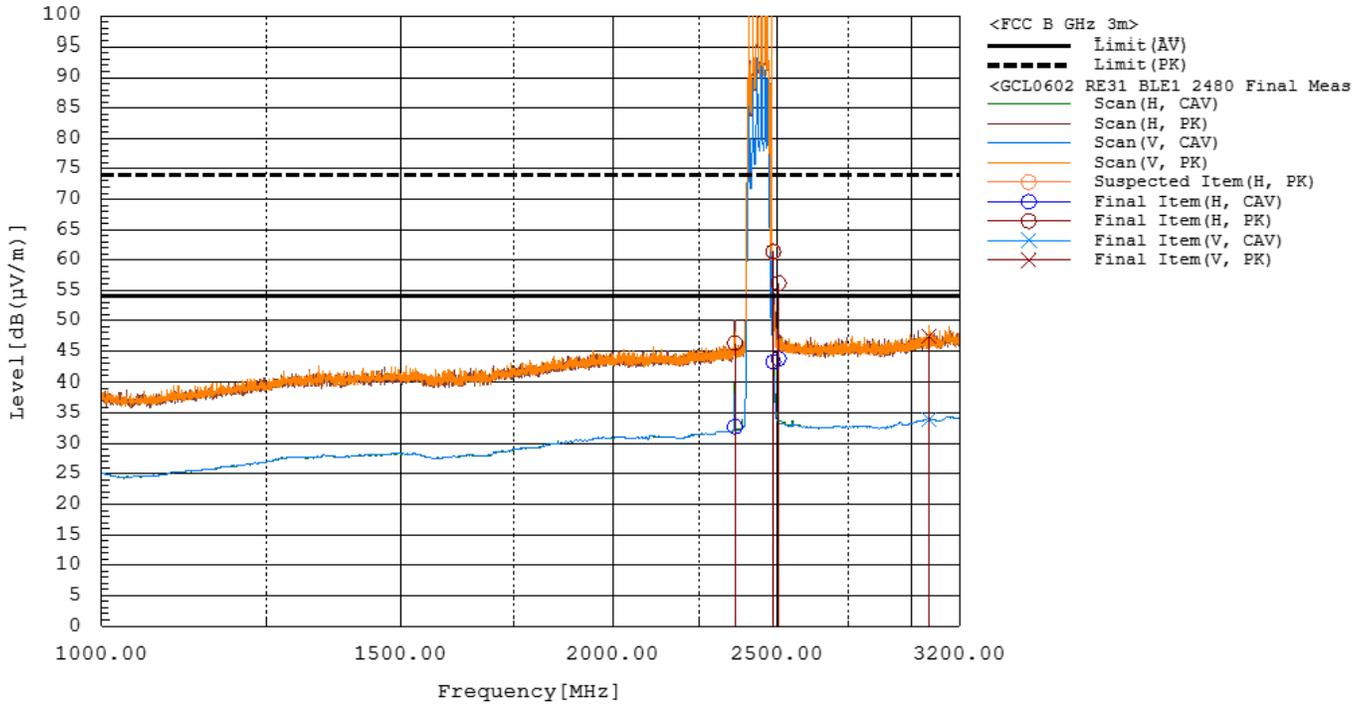


Figure RE31.3: Spectral data (BLE 1Mb 2480MHz, 1-3.2GHz)

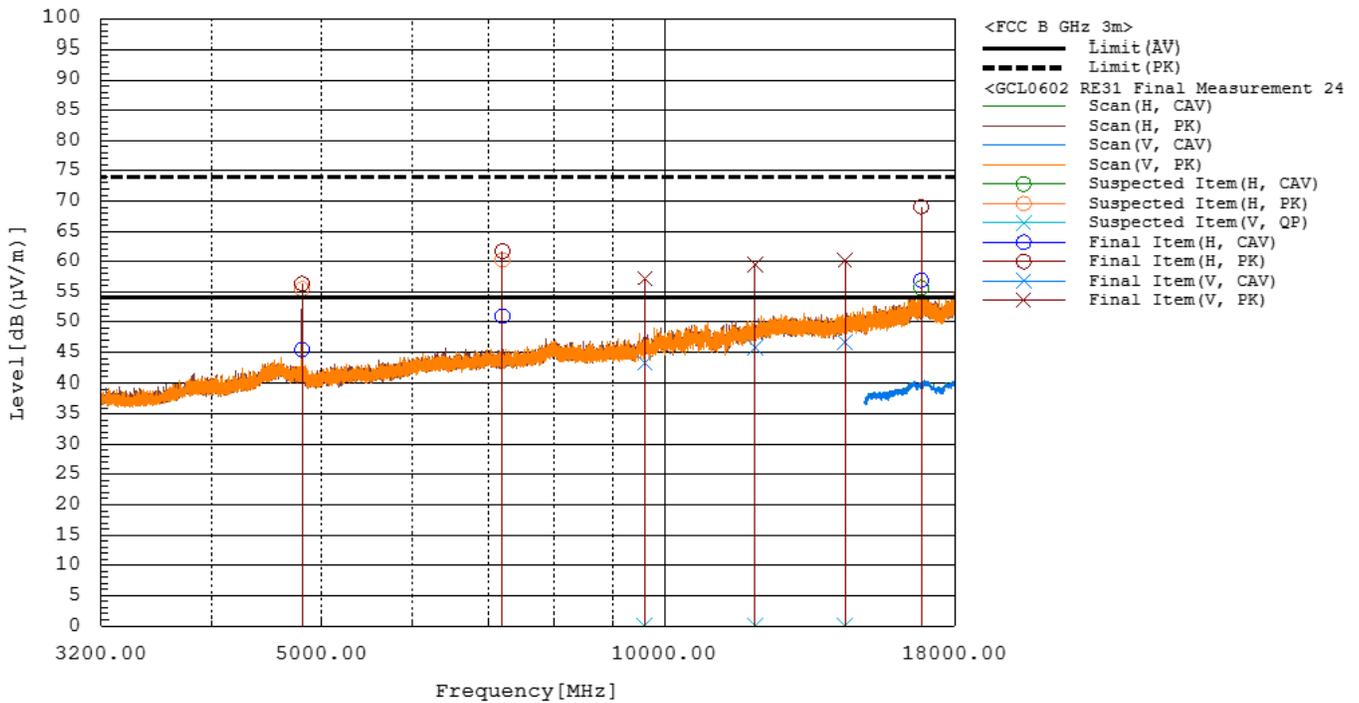


Figure RE31.4: Spectral data (BLE 1Mb 2402MHz, 3.2 - 18GHz)

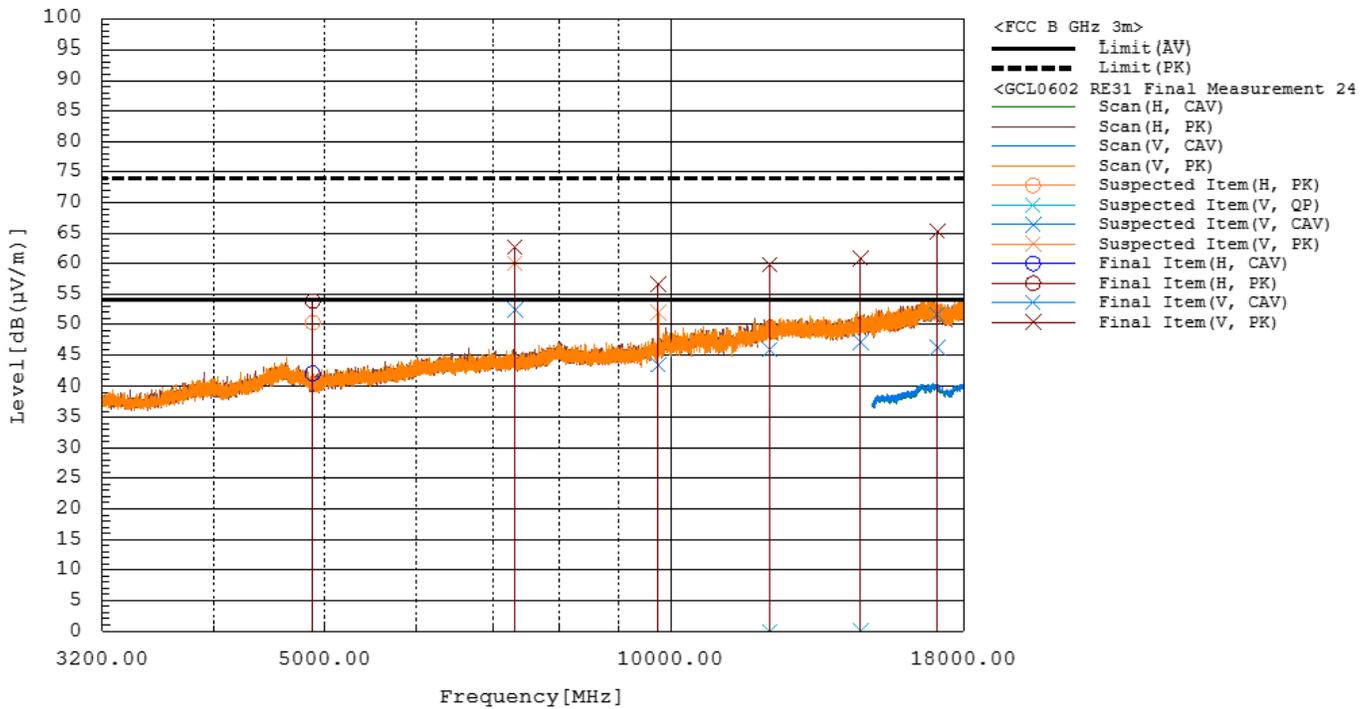


Figure RE31.5: Spectral data (BLE 1Mb 2440MHz, 3.2 - 18GHz)

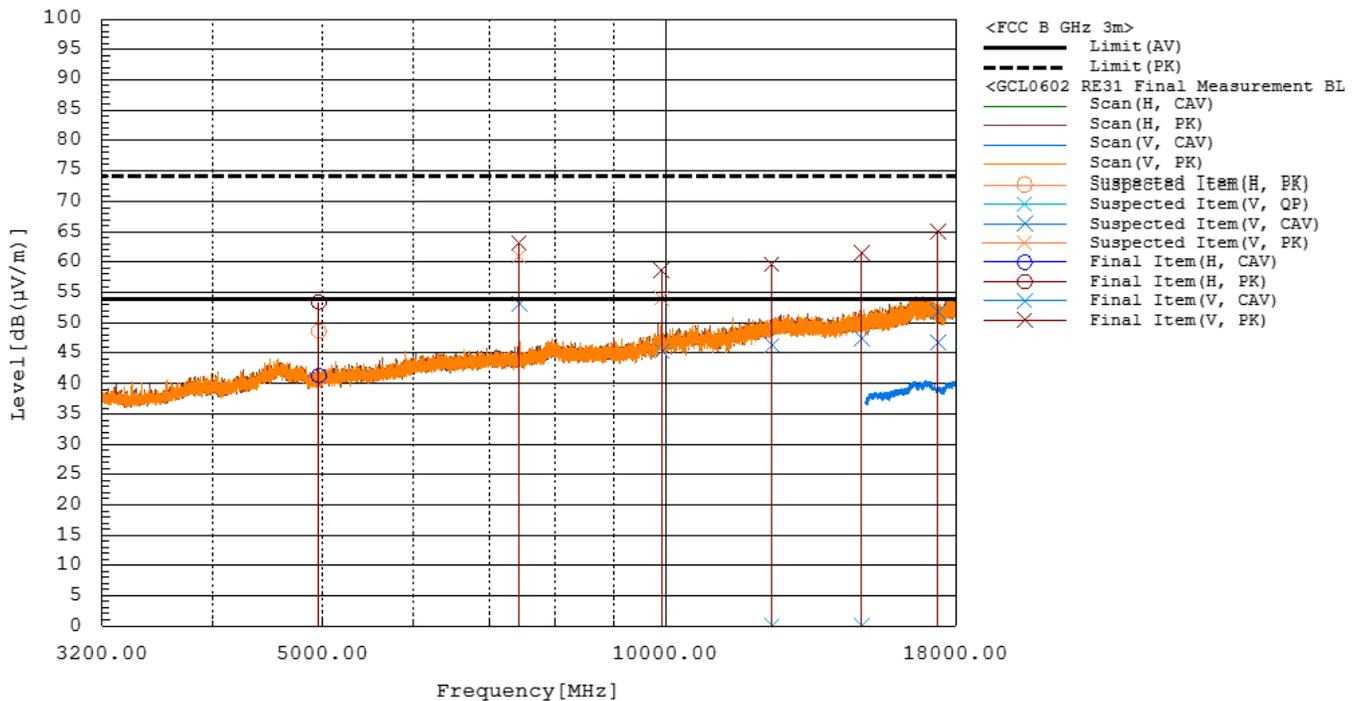


Figure RE31.6: Spectral data (BLE 1Mb 2480MHz, 3.2 - 18GHz)

Setup Photographs

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

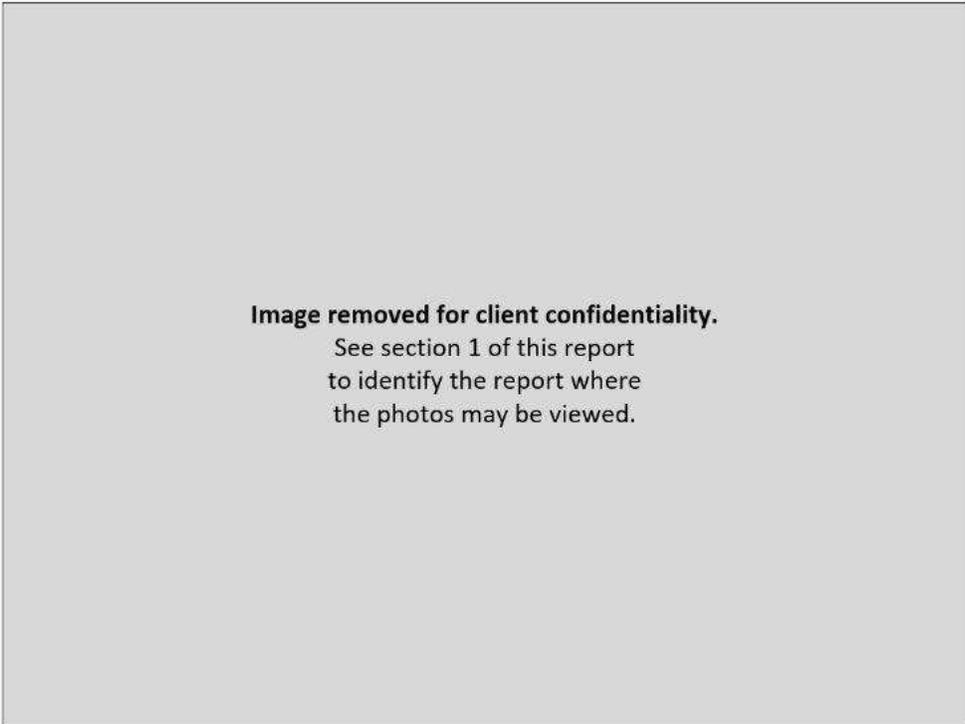


Figure RE31.7: EUT test setup, first view (Z Orientation), arrangement A1(Solo)

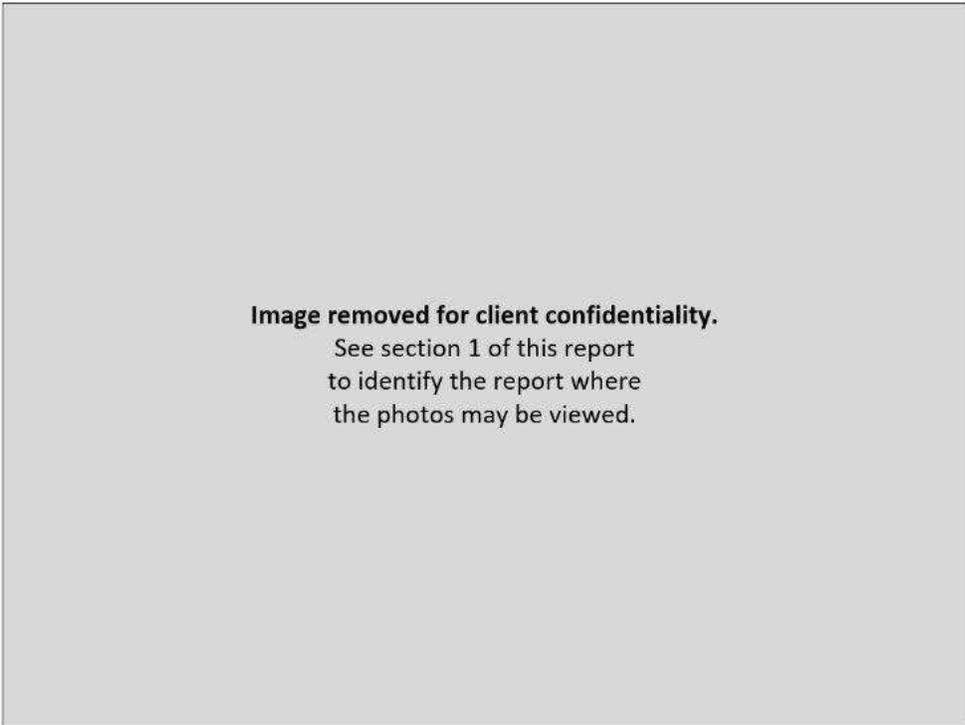


Figure RE31.8: EUT test setup, second view (Z orientation), arrangement A1(Solo)



Figure RE31.9: EUT test setup, first view (Z Orientation), arrangement A2(Upwr)

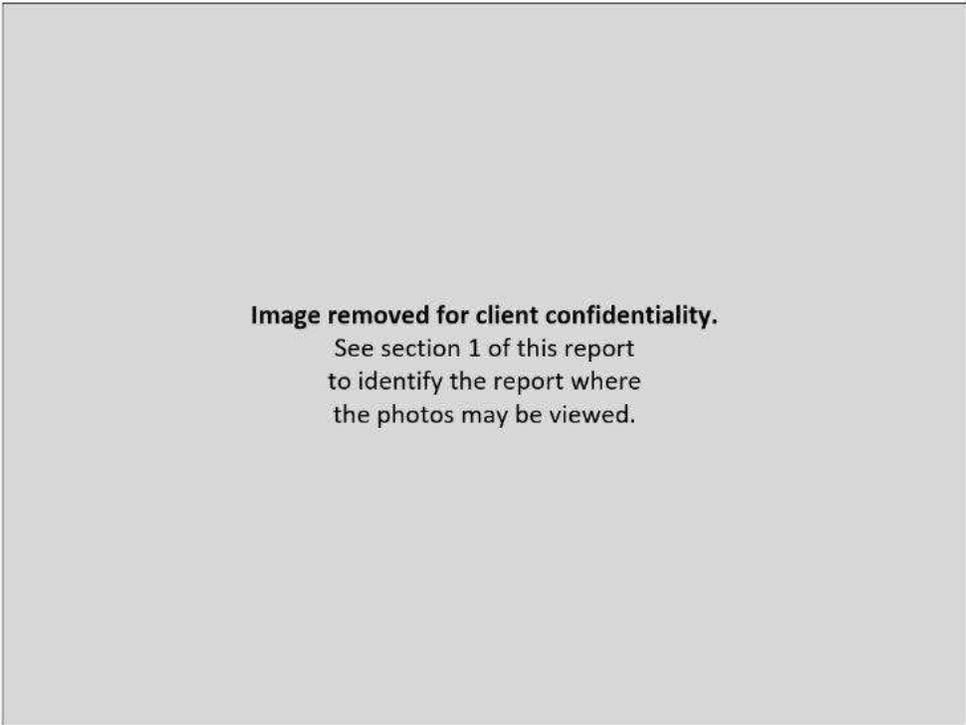


Figure RE31.10: EUT test setup, second view (Z orientation), arrangement A2(Upwr)

This line is the end of the test record.

Test Record
Radiated Emission Test RE32
Project GCL0602

Test Date(s) 13 Aug 2024
 Test Personnel Dave Kerr, Vladimir Tolstik supervised by Jim Solum

Product Model A04392
 Serial Number tested 8H1000141

Operating Mode M3 (BleTx)
 Arrangement A2(Upwr)
 Input Power USB 5 Vdc

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

Frequency Range: 18 GHz to 25 GHz
Pass/Fail Judgment: PASS

Test record created by: Vladimir Tolstik
Date of this record: 16 Aug 2024

Original record, Version A was created on 16 Aug 2024 by Valdimir Tolstik. Version B of this record was created by Aditya Prakash on 23 Aug 2024 to make some editorial changes.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	13-Mar-2024	15-Mar-2025
Antenna, Horn, 10-40 GHz	ETS Lindgren	3116C	00227673	14-Sep-2023	15-Sep-2025
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Shockforce G1 Tape Measure	Crecent Lufkin	L1135CME-02	GMN0013784	26-Jun-2024	26-Jun-2027
Preamplifier, 18 Ghz to 40 Ghz	Com-Power	PAM-840A	461364	Calibration	Not Required

Table RE32.1: Test Equipment Used

Software Used: Keysight PXE software A.33.03, 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.

In the 18 GHz to 26.5 GHz frequency range, pre-scan spectral data was taken at 1 meter and extrapolated to a 3 meter distance. Final measurements were made at 3 meters.

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 18 GHz and 25 GHz. Where a data point is highlighted in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m. Any unintentional radio emission limits are not applied to intentional radio signals.

The relevant emissions were measured, including one or more noise floor signals as judged appropriate to the spectrum.

Frequency MHz	Pol.	Reading		Factor dB(1/m)	Level		Limit		Margin		Height cm	Angle deg
		dB(μ V)			dB(μ V/m)		dB(μ V/m)		dB			
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
19213.750	H	26.4	39.5	18.9	45.3	58.4	54.0	74.0	8.7	15.6	187.5	296.0
21618.000	V	23.2	36.7	19.9	43.1	56.6	54.0	74.0	10.9	17.4	233.0	308.0

Table RE32.2: Emission summary

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

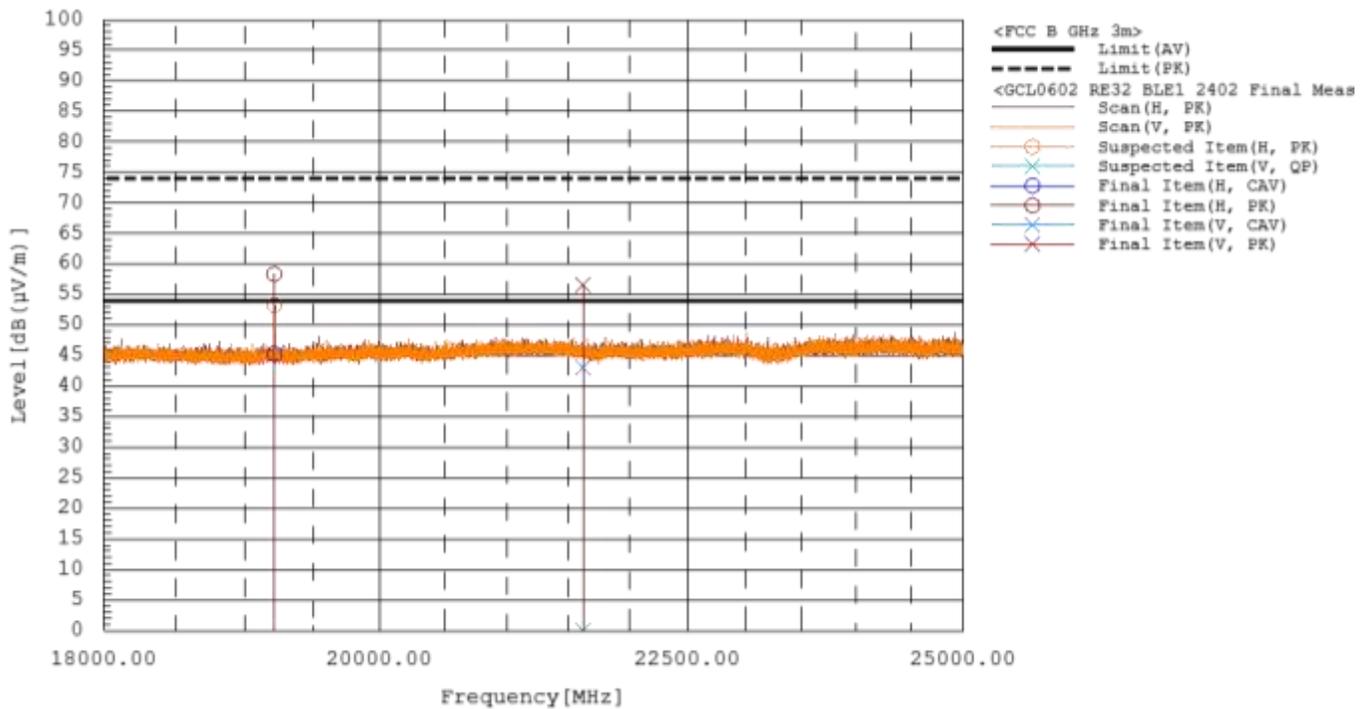


Figure RE32.1: Spectral data graph

Setup Photographs

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



Figure RE32.2: EUT test setup, first view

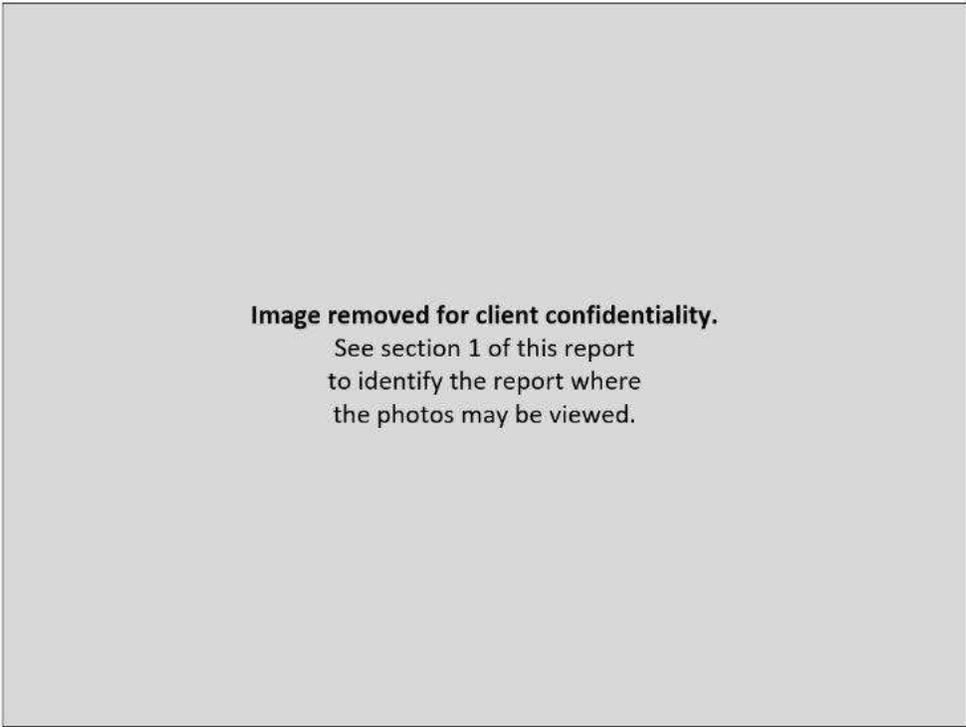


Figure RE32.3: EUT test setup, second view

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.

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