Test Report 2022-019

Version B
Issued 04 Nov 2022

Project GCL-0291
Primary Test Standard: FCC Part 15.247; RSS-247 Iss. 2

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

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

1. Summary

The equipment or product described in section 5 of this report was tested at the Garmin Compliance Lab according to standards listed in section 6. The results are as follows.

Table 1.1: Summary of Results

Parameter	**Description**	**Key Performance Values**	**Result**	**Data starts at page**
Hopping Channels	The radio manages it use of channels appropriately. [15.247(a)(1); RSS-247 at 5.1]	N/A. The radios described in this report are not subject to the Frequency Hopping rules.	N/A	N/A
Occupied 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 500 kHz or greater.	PASS	9
Transmit Power	The peak transmit power presented to the antenna is no greater that 1 Watt or 30 dBm. The effective radiated power is limited to 4 Watts or 36 dBm EIRP. [15.247(b); RSS-247 at 5.4(d)]	The maximum transmit power is 6.16 dBm or 0.00413 Watts.	PASS	12
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 2.17 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 33.70 dB.	PASS	13
Restricted Bands	The radio must not emit in certain designated restricted frequency bands above a set of limit values. [15.247(d) and 15.209; RSS-247 at 3.3]	Emissions in the restricted bands were at least 9.638 dB below the applicable limits.	PASS	17
Power Spectral Density	The radio must not focus too much radio energy in a narrow frequency band. [15.247(e); RSS-247 at 5.2(b)]	The limit is 8 dBm in a 3 kHz band. The strongest emission level was 4.21 dBm in a band of at least 3 kHz.	PASS	22
Hybrid Systems	A radio that is both frequency hopping and digitally modulated should a combination of system rules. [15.247(f); RSS-247 at 5.3]	N/A. The radios described in this report are not subject to the Hybrid System rules.	N/A	N/A

Frequency Hopping Rules	Frequency hopping systems have additional functional requirements. [15.247(g) and (h); RSS-247 at 5.1]	N/A. The radios described in this report are not subject 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	25

NT (Not Tested) means the requirement is or may be applicable, but the relevant measurement or test was not performed as part of this test project. The client may address these topics separately.
N/A (Not Applicable) means the lab judged that the test sample is exempt from the requirement.

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

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2022-021. That report is treated as a part of this document by way of this reference.

2. Test Background

The testing reported here was performed at the Garmin Compliance Lab, an organization within Garmin International, located at 1200 E 151st St, Olathe Kansas, USA. The contact telephone number is +1.913.397.8200.

The testing was performed on behalf of Garmin's Consumer Engineering business organization, a separate organization located at 1200 E 151st St, Olathe Kansas, USA. Witnesses from the business group included: None.

Test Sample received: 23 Aug 2022
Test Start Date: 16 Sep 2022
Test End Date: 10 Oct 2022

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

Christian Shepherd wrote this report.
This report is initially issued on 28 Oct 2022 as Version A. Version B is issued on 04 Nov 2022, with editorial corrections to the title page and section 5.2.

Report Technical Review: ______________________

David Arnett
Technical Lead EMC Engineer

Report Approval: ______________________

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

4. Test Sample Modifications and Special Conditions

The following special conditions or usage attributes were found during test to be necessary to achieve compliance with one or more of the standards listed in section 6 of this report:
None

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

Modification 1
Detailed Description: Update firmware from version 0.41 to version 0.48
Date applied: 21 Sep 2022
Reason for this modification: This change updated the transport protocol for certain data transfers to a more-robust method intended for production. The update to eth transport protocol was found to remedy problems observed during Radiated immunity testing.

All tests detailed in this report were performed with this modification present. The Radiated Emission test described in Report 2022-22 was performed before this update was applied and the change is deemed not relevant for that test.

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model	A04408
Serial Numbers Tested	3420635533, 3420635585
Regulatory Identifiers	FCC: IPH-04408; IC: 1792A-04408

The client states that these are pre-production test samples representative of production units.

5.2 Key Parameters

EUT Input Power:	USB 5 Vdc, 2 AA Batteries
I/O Ports:	USB Type C
Primary Functions:	Data exchange and position detection
Typical orientation:	Variable
Highest internal frequency:	96 MHz
Firmware Revisions	0.41 and 0.48

Approximate dimensions	7 cm x 10 cm x 4 cm
Approximate mass category	☐ 100 g or less ☑ 300 g ☐ 1 kg ☐ 3 kg ☐ 10 kg ☐ 30 kg ☐ 100 kg or more

5.3 Operating modes

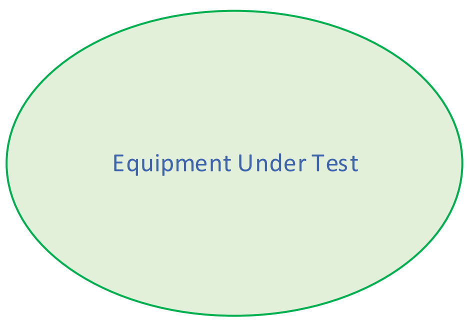
During test, the EUT was operated in the following modes.

Mode 1: Bluetooth Low Energy Tx. The unit produced continuous data transmissions in the 2.4 GHz band on one of the available frequencies

5.4 EUT Arrangement

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

Arrangement 1: Standalone. The EUT has no external cables or accessories.



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

Figure 5.1: EUT Arrangement 1

5.5 Associated Equipment (AE) used

Table 5.1: List of devices used to load or exercise the test sample

Description	Manufacturer	Model	Serial Number
USB Power Adapter	Garmin	PSAF10R-050Q	J201701804 A3
Laptop	Dell	Latitude 5410	5VSPFB3
Laptop Power Supply	Dell	OH374X	0BD-7TC0-A02
Companion Device	Garmin	A04408	3420635582

5.6 Cables used

Table 5.2: List of cables used to interconnect the ports of the EUT and AE

Description	From	To	Length	EMC Treatment
USB	Type A	Type C	50 cm	None

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.

CFR 47, FCC Part 15.247
RSS-GEN Issue 5 Amd 2
RSS-247 Issue 2
ANSI C63.10: 2013

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.

(None)

6.3 Variances

The following variances were applied to standards cited in this section.

Where different test standards cover the same EMC phenomenon, and the standards have compatible differences, the stricter of the requirements is typically applied. A consolidated limit may be applied to emission tests selecting the strictest of the limits at each frequency. 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 including those listed in section 6 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 applied 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 below or in the relevant test records.

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		1.36 dB	3.4 dB	None
Conducted Emissions, Cat 5 LCL, 150 kHz to 30 MHz		3.75 dB	5 dB	None
Conducted Emissions, Cat 3 LCL, 150 kHz to 30 MHz		2.74 dB	5 dB	None
Radiated Emissions, below 30 MHz		0.88 dB	None	6 dB
Radiated Emissions, 30 MHz to 1000 MHz		3.07 dB	6.3 dB	6 dB
Radiated Emissions, 1 GHz to 18 GHz		2.53 dB	5.2 & 5.5 dB	6 dB
Radiated Emissions, 18 GHz to 26.5 GHz		2.67 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		0.95 °C	None	1 °C
Relative Humidity		0.048 x Reading	None	0.05 x Reading
Signal Timing	The greater of these three...	0.63 usec	None	None
		0.01% of value		
		0.5 x LSDPV		

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 as 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:	23.3 to 25.6 °C (73.94 to 78.08 °F)
Relative Humidity:	31.5% to 50.1% (non-condensing)
Barometric Pressure	97.6 to 99.1 kPa

ANNEX

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

Test Record
Transmitter DTS Bandwidth Tests
Test ID TR03
Project GCL0291

Test Date	18 Oct 2022
Test Personnel	Majid Farah supervised by Dave Arnett
Product Model	A04408
Serial Number tested	3420635585
Operating Mode	M1 (BLE Tx)
Arrangement	A1 (Standalone)
Nominal Input Power	3 Vdc replaceable battery
Test Standards:	FCC Part 15.247, ANSI C63.10, RSS-247 (as noted in Section 6 of the report)
Radio Protocol	BLE (Bluetooth Low Energy)
Radio Band	2400 to 2483.5 MHz

Pass/Fail Judgment: **PASS**

Test record created by: **Majid Farah**
Date of this record: **18 Oct 2022**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Thermohygrometer	Mannix	CMM880	10319186	26-May-2021	1-Jun-2024
PXE Receiver 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023

TableTR03.1: Test Equipment Used

Software used: Keysight PXE firmware A.32.06

Test Method

ANSI C63.10 clause 11.8.2

During this test the transmitter output is fed directly to the PXE receiver. The data is corrected for the cable loss between the sample and the receiver. The spectrum is scanned several hundred times so that the varied effects of modulation are appropriately assessed. The test is executed at lower, middle, and higher frequencies within the 2.4 GHz radio band.

Test Data

The data for each frequency tested are summarized below, followed by the spectral images. The DTS bandwidths were found to satisfy the 500 kHz minimum limit, and are judged to pass.

Tx Frequency	DTS BW	Limit	Result
MHz	kHz	kHz	---
2402	517.3	>= 500	Pass
2442	551.0	>= 500	Pass
2480	551.3	>= 500	Pass

TableTR03.2: Summary of Results

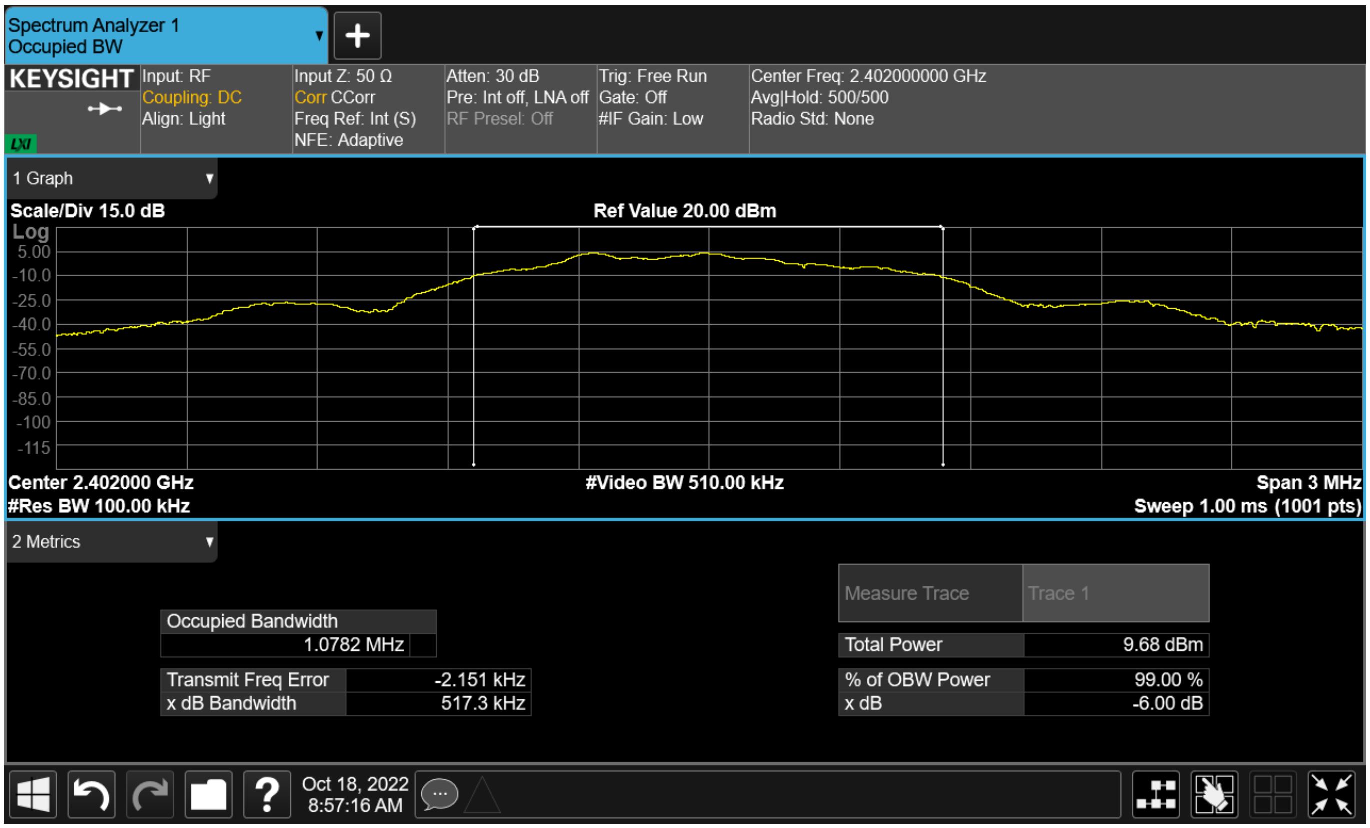


Figure TR03.1: 2402 MHz DTS Bandwidth

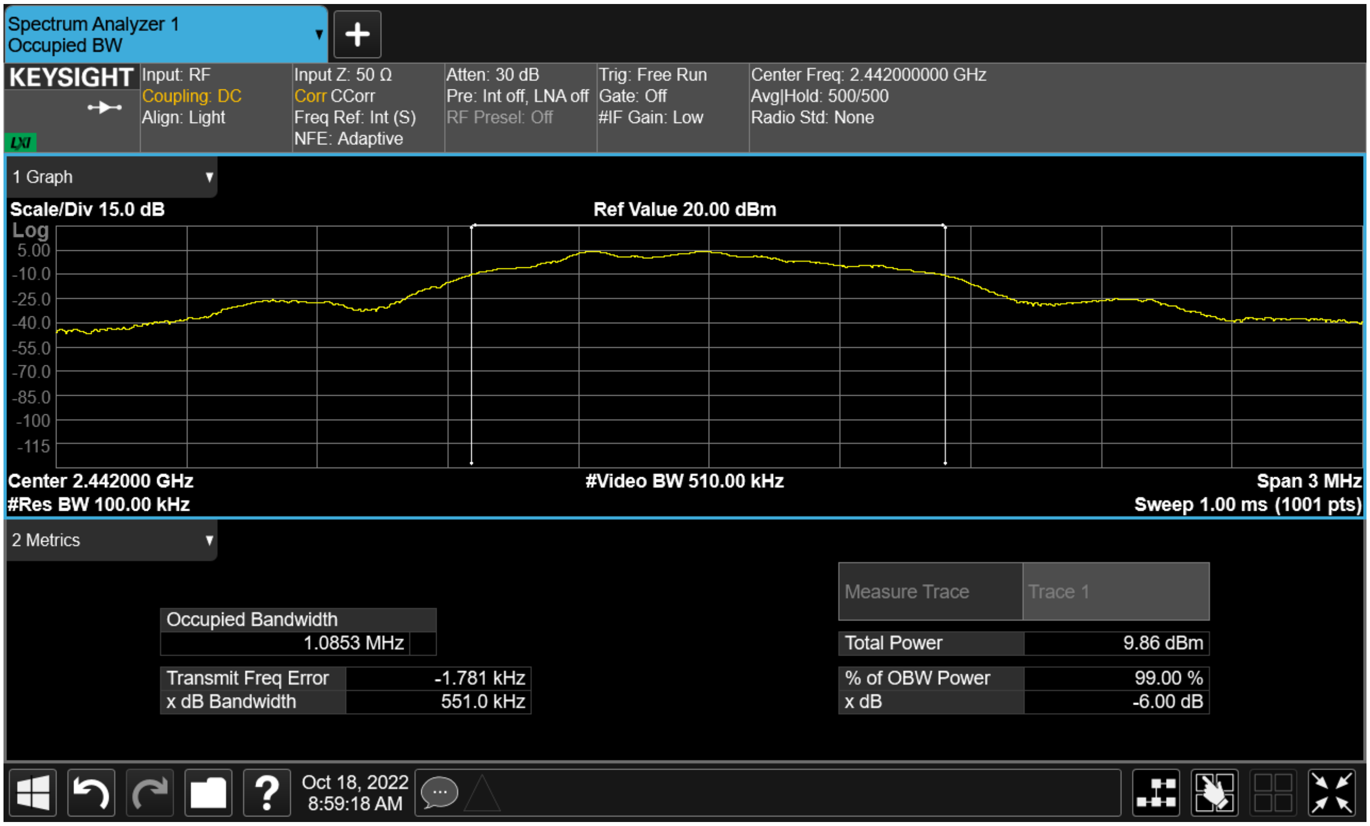


Figure TR03.2 2442 MHz DTS Bandwidth

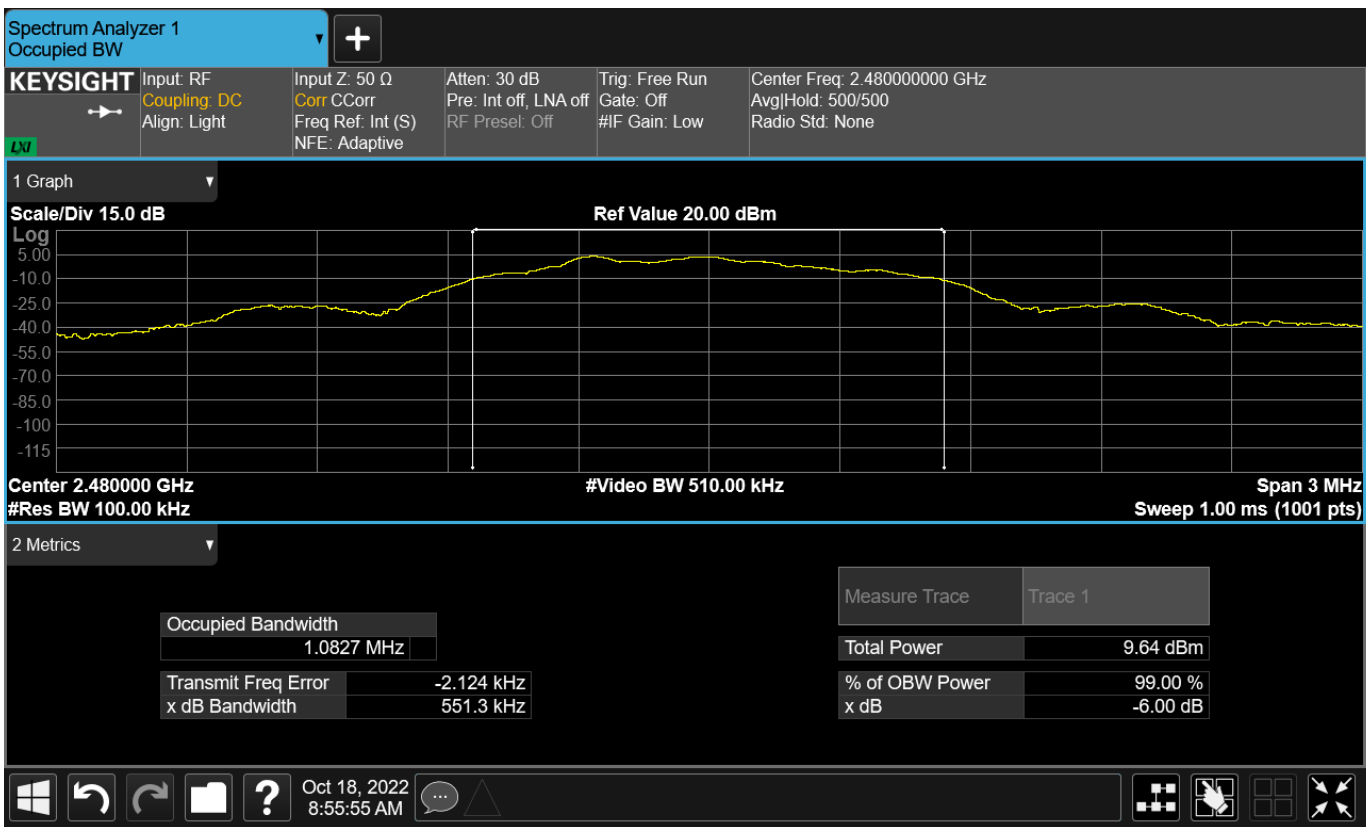


Figure TR03.3: 2480 MHz DTS Bandwidth

This line is the end of the test record.

Test Record
Transmitter Effective Radiated Power
Test IDs TR01a
Project GCL-0291

Test Date(s)	22 Sep 2022
Test Personnel	David Arnett assisted by Majid Farah
Product Model	A04408
Serial Number tested	3420635585
Operating Mode	M1 (Bluetooth Low Energy Tx)
Arrangement	A1 (Standalone)
Input Power	2 AA battery 1.5V dc
Test Standards:	FCC Part 15.247, RSS-247, ANSI C63.10 (as noted in Section 6 of the report).
Radio Protocol	Bluetooth Low Energy (BLE) 1Mbps
Pass/Fail Judgment:	**PASS**
Test record created by:	**David Arnett**
Date of this record:	**21 Oct 2022**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Thermohygrometer	Mannix	CMM880	10319186	26-May-2021	1-Jun-2024
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	13-Jul-2022	15-Jul-2023

Table TR01a.1: Equipment used

Software used: R&S Power Viewer firmware V 11.3, TimePowerAnalysisSpreadsheetV4a.xlsx

Test Method

The basic test standards provide options for the test method. The following test methods were applied.
ANSI C63.10 11.9.2.3.2 AVGPM-G

With the Bluetooth protocols, power is measured across a range of frequencies including the lowest and highest operating frequencies. Note that the Bluetooth Low Energy protocols only operate on even-valued frequencies.

Test Data

Each measurement is made conducted from the antenna port with the transmitter on a specified channel and in Bluetooth Low Energy 1 Mbps protocol. The results include the effects of any measurement cable losses.

Yellow highlight indicates the frequency with the strongest transmit power.

Tx Freq., MHz	2402	2404	2422	2442	2462	2478	2480
Peak Power, dBm	**6.13**	**6.13**	**6.16**	**6.15**	**6.15**	**6.13**	**6.12**
Peak Power, W	**0.00410**	**0.00411**	**0.00413**	**0.00413**	**0.00412**	**0.00410**	**0.00409**

Table TR01a.2: Transmit power in dBm EIRP for Bluetooth operations.

All readings were well below the 1 Watt or 0.125 Watt limit.
This line is the end of the test record.

Test Record

Conducted Spurious Emissions
Test ID Test TR09
Project GCL0291

Test Date	18 Oct 2022
Test Personnel	Majid Farah supervised by David Arnett
Product Model	A04408
Serial Number tested	3420635585
Operating Mode	M1 (BLE Tx)
Arrangement	A1 (Standalone)
Input Power	3 Vdc replaceable battery
Test Standards:	FCC Part 15, ANSI C63.10, RSS-247 (as noted in Section 6 of the report).
Radio Protocol	BLE (Bluetooth Low Energy)
Radio Band	2400 to 2483.5 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date of this test record:	**18 Oct 2022**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Thermohygrometer	Mannix	CMM880	10319186	26-May-2021	1-Jun-2024
PXE Receiver 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023

Table TR09.1: Test equipment used

Software used: Keysight PXE firmware A.32.06, FccIsedConductedSpurAnalysis V2.xlsx

Test Method

ANSI C63.10 section 11.11.

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. The maximum output power spectral density conducted from the transmitter to the antenna has been measured from 30 MHz to 25000 MHz. The spectrum is scanned dozens of time until the trace has stabilized so that the varied effects of modulation are appropriately assessed.

The test is executed for lower, middle and higher transmit frequencies.

Test Data

The data tables that follow show the final measurement data at harmonics of the carrier. This is identified for each harmonic number n by identifying the nth multiple of the lower, middle and higher frequencies within the 2.4 GHz radio band. The data record is searched to identify the frequency in this harmonic range with the largest amplitude. That frequency is selected and reported. Particularly for higher order harmonics, this frequency will often be the measurement of instrumentation noise floor.

The peak level of the fundamental is also identified. For many standards, the harmonics must be reduced from this fundamental level by a certain decibel ratio. This harmonic limit is calculated and used to determine compliance. Positive margin indicates that the result is compliant.

Also, the graphs that follow show the spectral data as continuous curves. Superimposed are the harmonic data points reported in the accompanying tables. The harmonic limit line is included as a reference.

Harmonic	Frequency	Level	Limit	Margin
#	MHz	dBm	dBm	dB
Fund.	2401.70	3.91	None	None
2	4966.80	-58.77	-16.09	42.67
3	7378.25	-58.83	-16.09	42.74
4	9606.90	-55.72	-16.09	39.63
5	12210.50	-58.11	-16.09	42.01
6	14537.30	-54.94	-16.09	38.85
7	17191.55	-53.75	-16.09	37.66
8	19335.00	-53.62	-16.09	37.53
9	21673.05	-51.73	-16.09	35.64
10	24050.90	-51.60	-16.09	35.51

Table TR09.2: BLE Carrier Frequency 2402 MHz

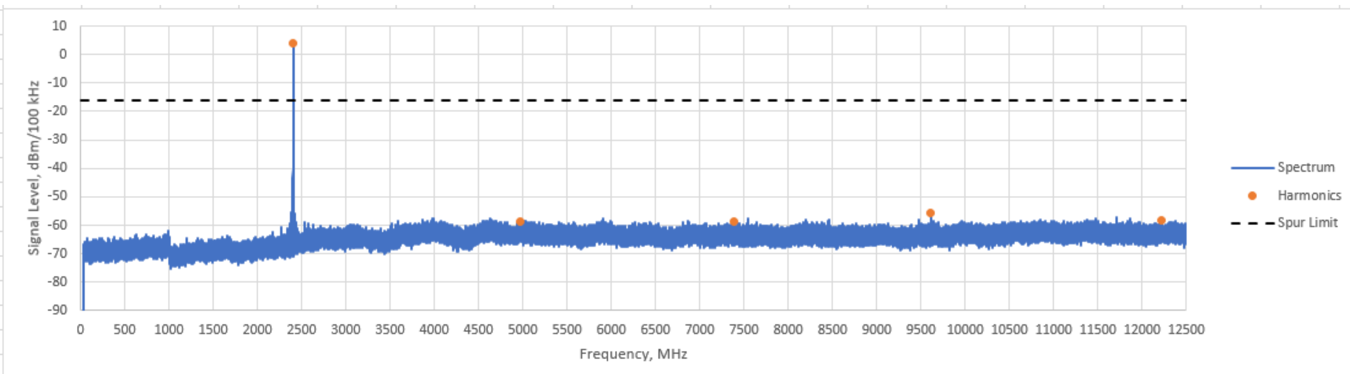


Figure TR09.1: BLE Carrier Frequency 2402 MHz Spectral data up to 12500 MHz

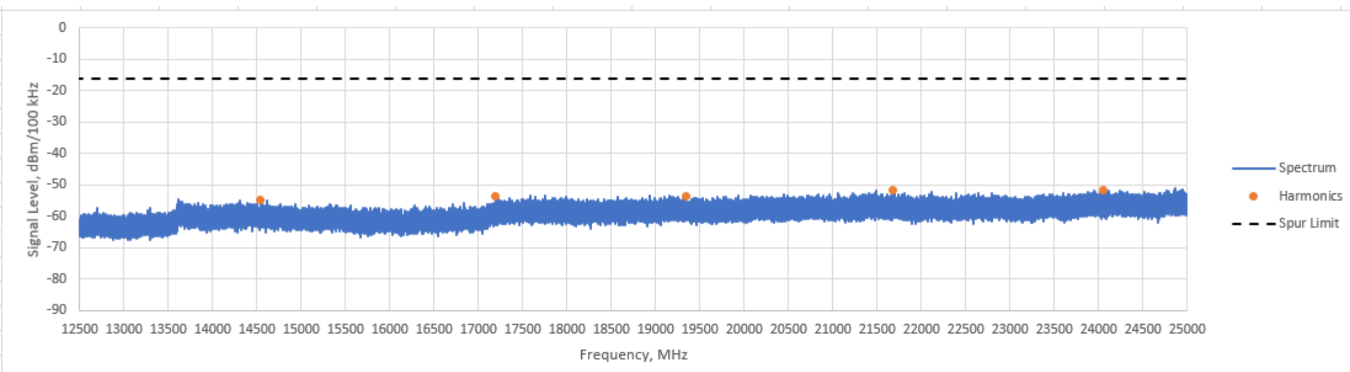


Figure TR09.2: BLE Carrier Frequency 2402 MHz Spectral data 12500 GHz to 25000 MHz

Harmonic	Frequency	Level	Limit	Margin
#	MHz	dBm	dBm	dB
Fund.	2441.90	2.18	None	None
2	4965.70	-58.14	-17.82	40.32
3	7444.55	-58.94	-17.82	41.12
4	9648.65	-58.82	-17.82	41.00
5	12297.00	-57.98	-17.82	40.16
6	14450.50	-55.10	-17.82	37.28
7	17376.50	-53.95	-17.82	36.13
8	19208.55	-52.78	-17.82	34.96
9	21870.80	-52.21	-17.82	34.38
10	24817.10	-51.52	-17.82	33.70

Table TR09.3: BLE Carrier Frequency 2442 MHz

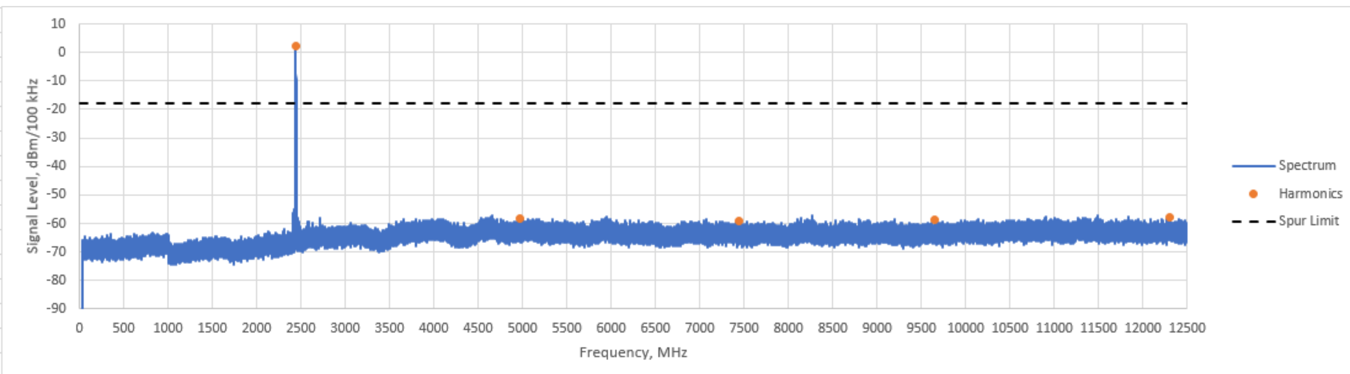


Figure TR09.3: BLE Carrier Frequency 2442 MHz Spectral data up to 12500 MHz

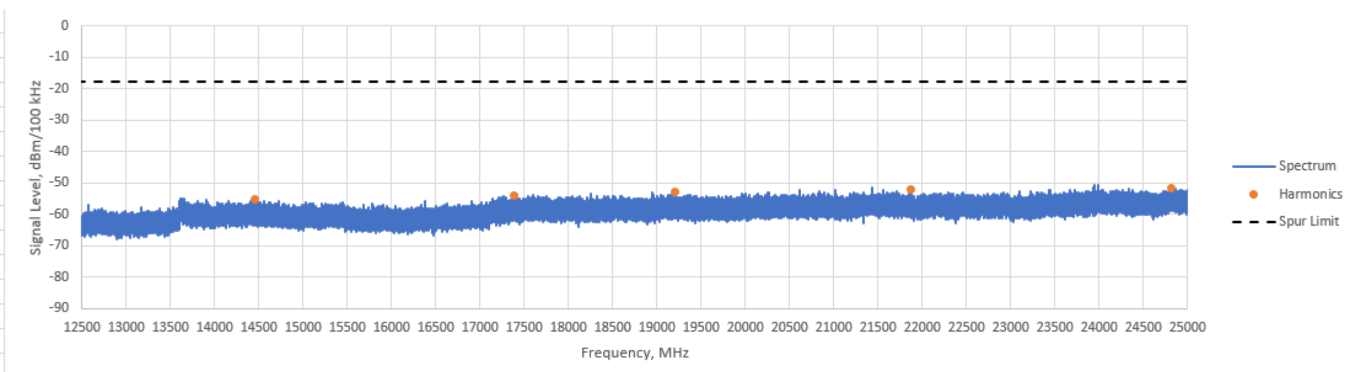


Figure TR09.4: BLE Carrier Frequency 2442 MHz Spectral data 12500 GHz to 25000 MHz

Harmonic	Frequency	Level	Limit	Margin
#	MHz	dBm	dBm	dB
Fund.	2479.95	3.84	None	None
2	4963.40	-58.33	-16.16	42.17
3	7389.50	-58.56	-16.16	42.40
4	9907.90	-58.98	-16.16	42.82
5	12386.25	-58.10	-16.16	41.94
6	14490.75	-54.40	-16.16	38.24
7	17319.40	-53.26	-16.16	37.10
8	19636.70	-53.25	-16.16	37.08
9	21669.45	-52.40	-16.16	36.24
10	24301.65	-51.42	-16.16	35.26

Table TR09.4: BLE Carrier Frequency 2480 MHz

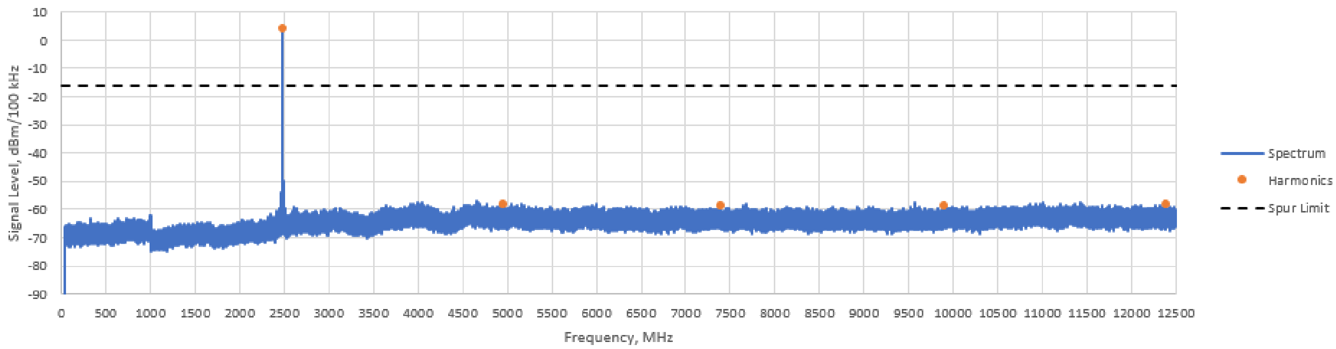


Figure TR09.5: BLE Carrier Frequency 2442 MHz Spectral data up to 12500 MHz

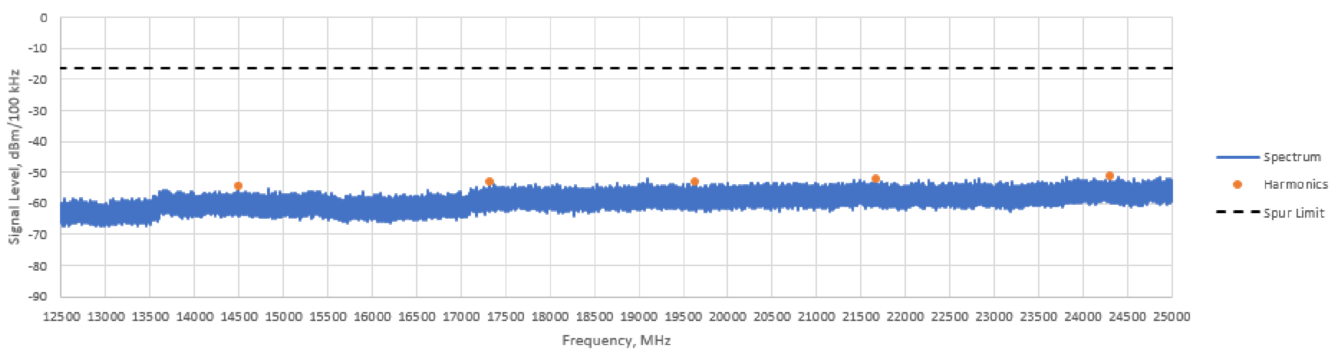


Figure TR09.6: BLE Carrier Frequency 2480 MHz Spectral data 12500 MHz to 25000 MHz

This line is the end of the test record.

Test Record
Radiated Emission Test RE03
Project GCL0291

Test Date(s) 30 Sep 2022
Test Personnel Christian Shepherd

Product Model A04408
Serial Number tested 3420635533

Operating Mode M1 BLE Tx
Arrangement A1 (Standalone)
Input Power Battery

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

Frequency Range: FCC Restricted Bands
Pass/Fail Judgment: PASS

Test record created by: Christian Shepherd
Date of this record: 09 Sep 2022

Original record, Version A.

Table RE03.1: Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	3-Jan-2020	7-Jan-2023
Thermohygrometer	Mannix	CMM880	10319186	26-May-2021	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	4-Nov-2021	4-Nov-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required
PXE 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023

Software used: Keysight PXE firmware A.32.06, RE Signal Maximization Tool v2021Feb25.xlsx, FCC Restricted Band 2p4GHz Template v1 2022Sep08.xlsx

Test Data

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

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

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

Table RE03.2: FCC restricted band from 2200 to 2390 MHz

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 ---	EUT Orientation
2390	54	74	32.85	57.193	21.15	16.807	31	3651	VERT	Z
2370	54	74	32.121	47.005	21.879	26.995	30	3610	VERT	Z

Table RE03.3: FCC restricted band from 2483.5 to 2500 MHz

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 ---	EUT Orientation
2483.5	54	74	34.633	64.362	19.367	9.638	21	3542	HORZ	Y

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

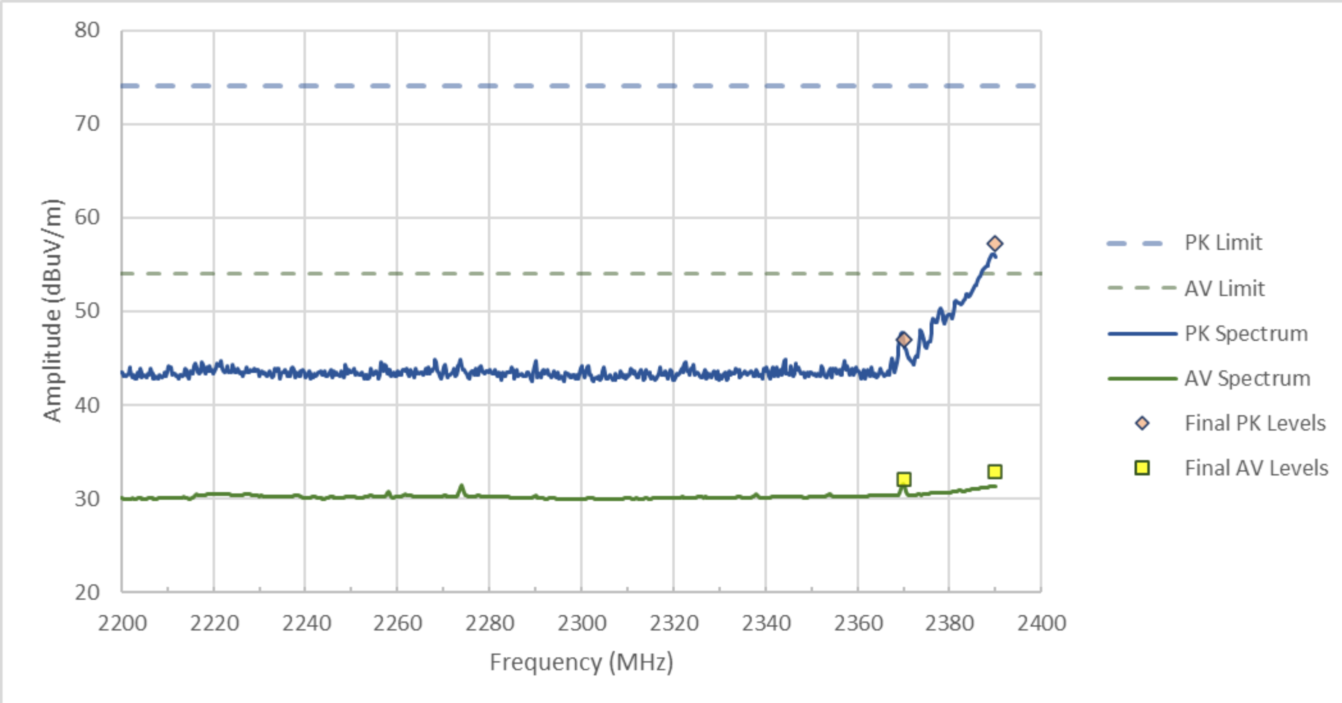


Figure RE03.1: FCC restricted band spectral data from 2200 to 2390 MHz

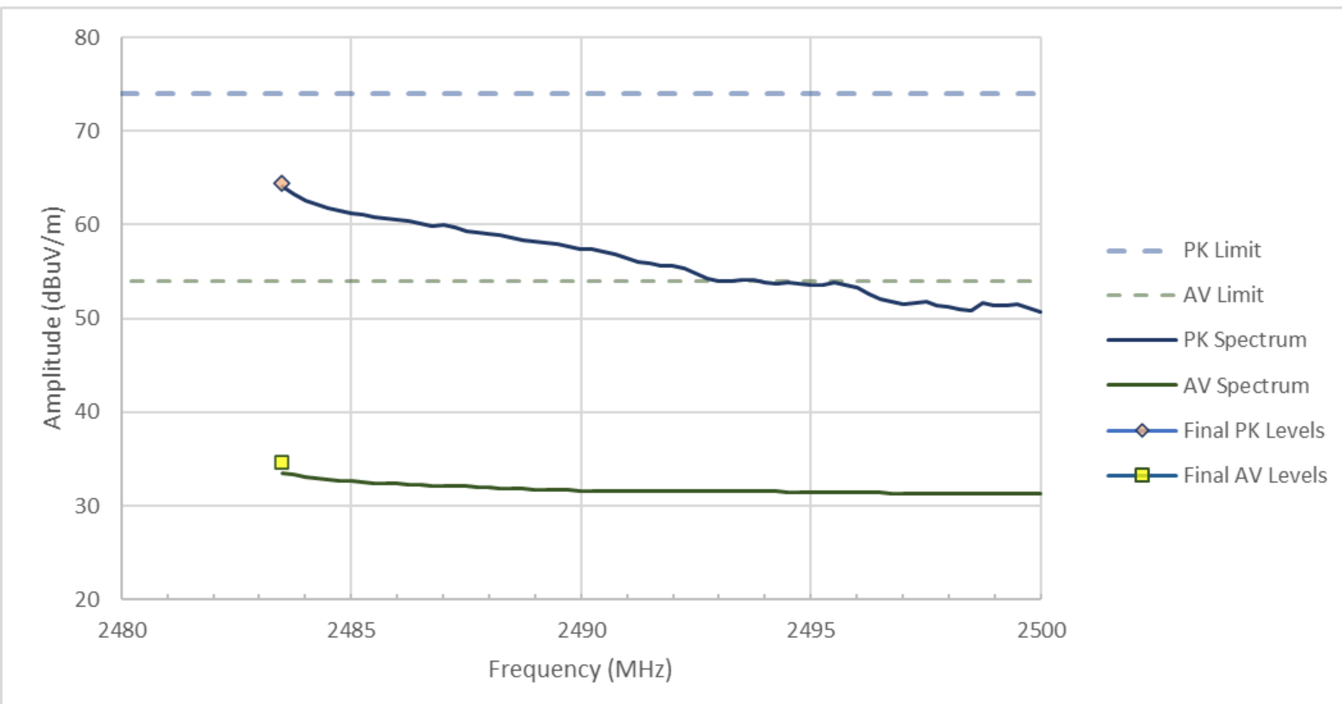


Figure RE03.2: FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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

Image removed for client confidentiality.
See section 1 of this report
to identify the report where
the photos may be viewed.

Figure RE03.3: EUT X orientation

Image removed for client confidentiality.
See section 1 of this report
to identify the report where
the photos may be viewed.

Figure RE03.4: EUT Y orientation

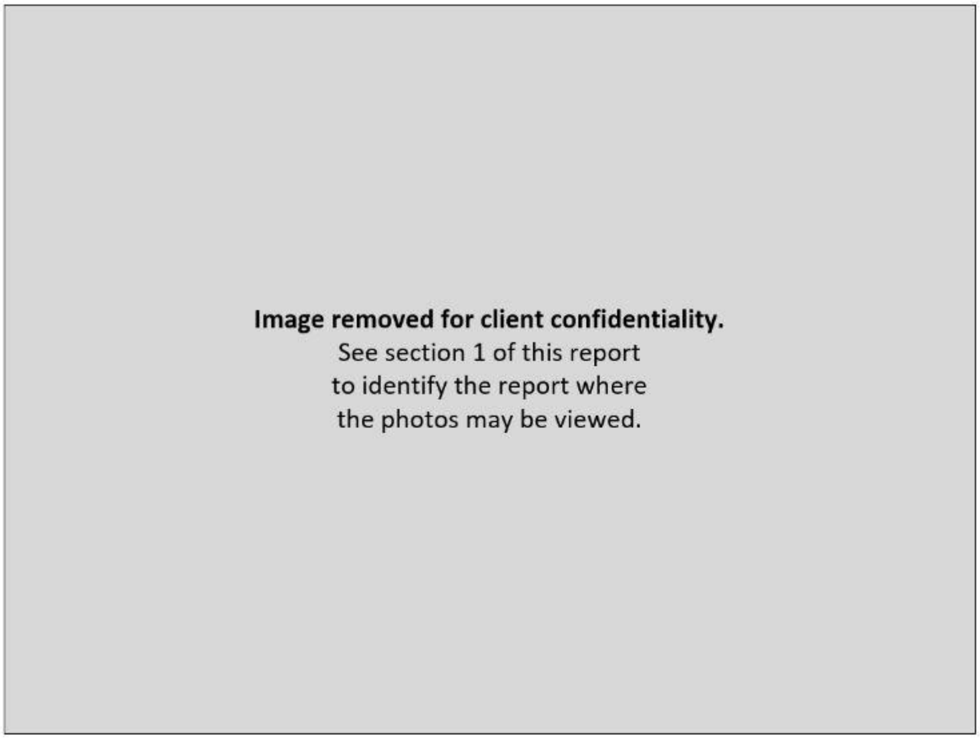


Figure RE03.5: EUT Z orientation

This line is the end of the test record.

Test Record
Power Spectral Density Test
Test ID TR02
Project GCL0291

Test Date 18 Oct 2022
Test Personnel Majid Farah supervised by Dave Arnett

Product Model A04408
Serial Number tested 3420635585

Operating Mode M1 (BLE Tx)
Arrangement A1 (Standalone)
Nominal Input Power 3 Vdc replaceable battery

Test Standards: FCC Part 15.247, ANSI C63.10, RSS-247 (as noted in Section 6 of the report).

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

Pass/Fail Judgment: PASS

Test record created by: Majid Farah
Date of this record: 18 Oct 2022

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Thermohygrometer	Mannix	CMM880	10319186	26-May-2021	1-Jun-2024
PXE Receiver 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023

TableTR02.1: Test Equipment Used

Software used: Keysight PXE firmware A.32.06

Test Method

ANSI C63.10 section 11.10.2

During this test the transmitter output is fed directly to the PXE receiver. The data is corrected for the cable loss between the sample and the receiver. The spectrum is scanned several hundred times so that the varied effects of modulation are appropriately assessed. The maximum power spectral density of EUT has been measured using a 100 kHz resolution bandwidth as permitted by ANSI C63.10.

The test is executed at lower, middle and higher frequencies within the 2.4 GHz radio band. The screen image has been captured and stored for each test.

Test Data

The figures that follow show Power Spectral Density for above mentioned frequency within the 2.4 GHz radio band. The maximum power spectral density has been observed for the middle frequency (2442 MHz) which is 4.21 dBm/100 KHz. All measured power spectral density within the 2.4 GHz radio band is below the limit of 8 dBm/3kHz.

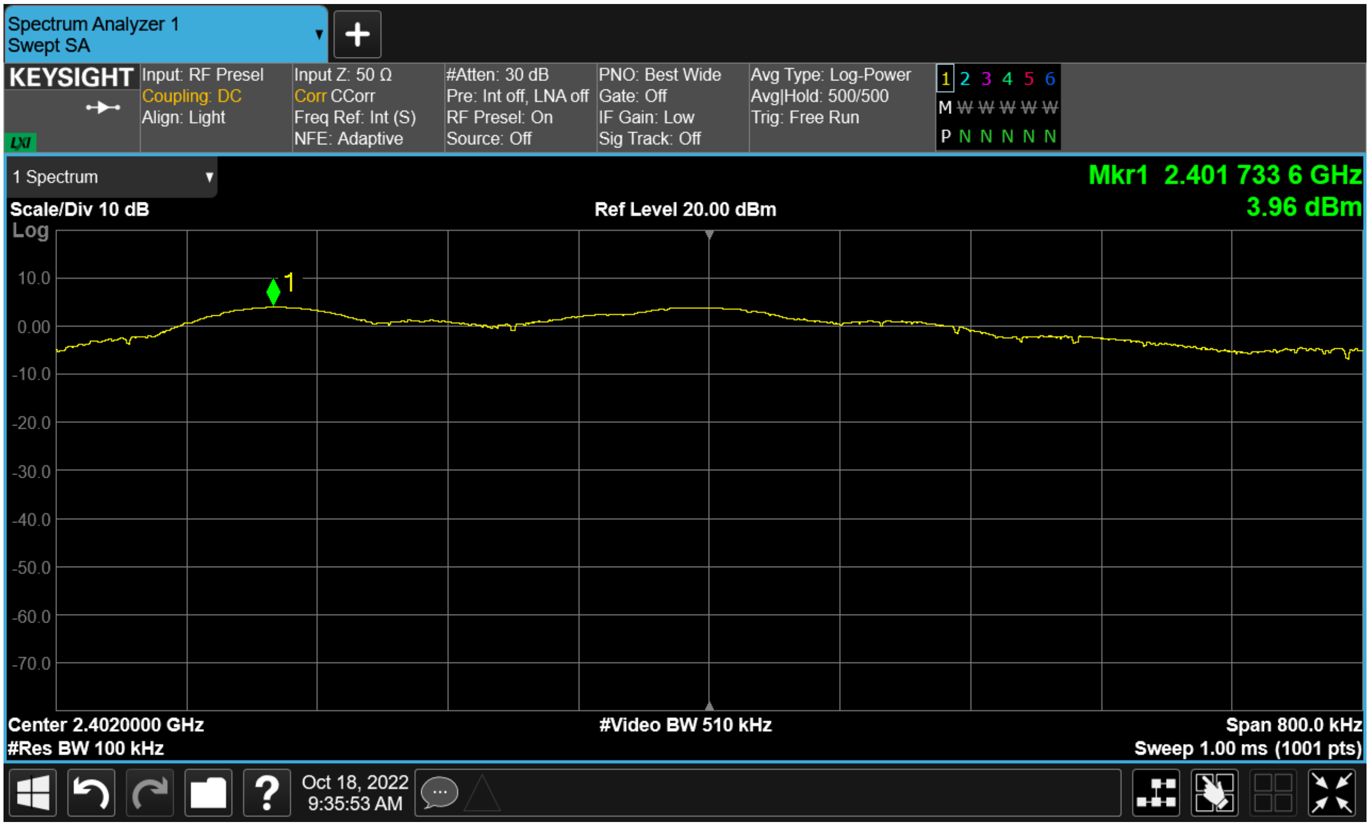


Figure TR02.1: BLE Carrier Frequency 2402 MHz Power Spectral Density

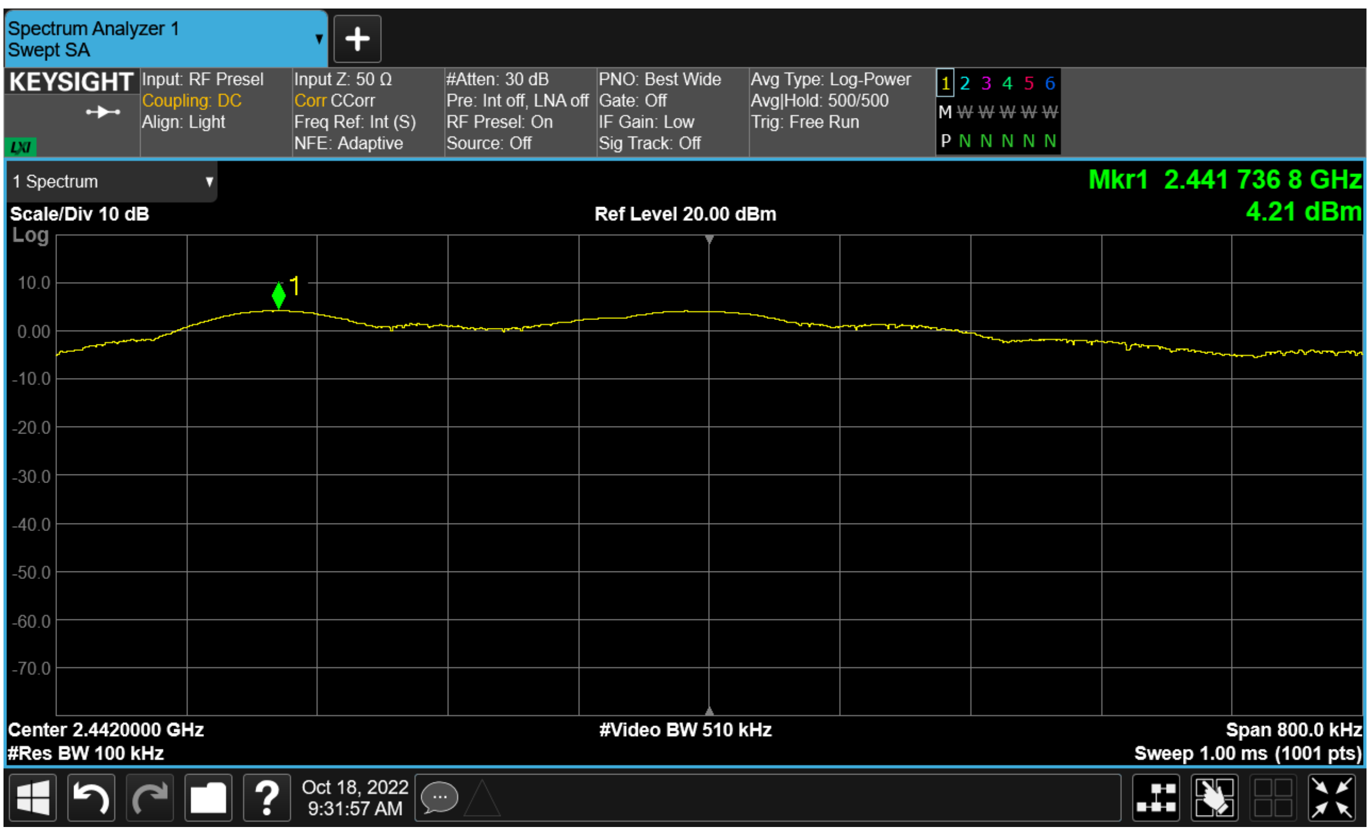


Figure TR02.2: BLE Carrier Frequency 2442 MHz Power Spectral Density

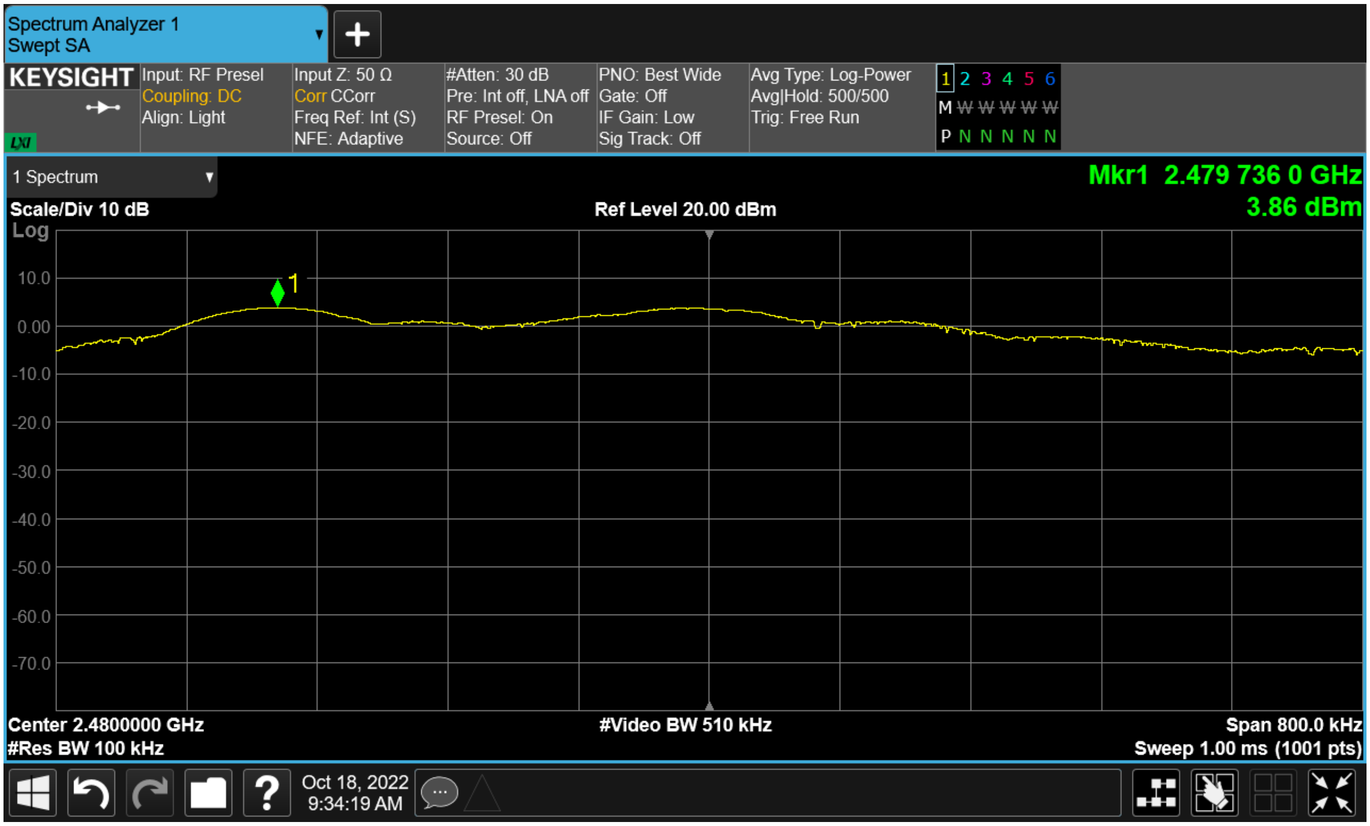


Figure TR02.3: BLE Carrier Frequency 2480 MHz Power Spectral Density

This line is the end of the test record.

Test Record
Transmitter Frequency Stability
Test ID TR11
Project GCL-0291

Test Date(s)	04 Oct 2022
Test Personnel	Majid Farah supervised by David Arnett
Product Model	A04408
Serial Number tested	3420635533
Operating Mode	M1 BLE Tx
Arrangement	A1 (Standalone)
Nominal Input Power	5 Vdc USB, 3 Vdc replaceable battery
Test Standards:	RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Radio Protocol	BLE

Pass/Fail Judgment: **PASS**

Test record created by: **Majid Farah**
Date this record: **05 Oct 2022**

Original record, Version A.

Table TR11.1: Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Thermohygrometer	Mannix	CMM880	10319186	26-May-2021	1-Jun-2024
Thermometer	Thermco	ACCD370P	210607316	11-Aug-2021	15-Aug-2023
PXE Receiver 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023
Thermal chamber	TPS	T2RC	32774-01	Calibration	Not Required
Near field probe Kit	Com-Power	PS400	151679	Calibration	Not Required
Programmable DC power source	Keithley	2260B-30-72 720 W	14911917	6-Nov-2021	15-Feb-2023

Software Used: PXE Receiver A32.06, FrequencyStabilityAnalysistemplateV1.xlsx

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

The temperature stability of these transmissions was observed for the lowest and the highest channel plan used. BLE uses channel plan with a minimum transmission center frequency at 2402 MHz and a maximum at 2480 MHz.

The test sample was placed in a thermal chamber and connected to an appropriate dc power source. A near-field probe was placed near the sample and connected by cable to the PXE analyzer. The analyzer was set up to detect radio signals from the test sample.

The test temperatures are -20 °C, +20 °C, and +50 °C, all at rated voltages. However, the rated voltage has two possible values.

The test sample is powered by user-replaceable batteries. The client stated that the nominal cell voltage is 3.0 Vdc and the endpoint voltage for spent batteries is 2.4 Vdc. The unit can also be powered at 5 Vdc via a USB port that is hidden behind the battery door. Under certain USB-connected conditions, significant radio capabilities are automatically disabled. The verbiage in RSS-Gen prefers the externally powered operating mode and does not directly address the scenario where battery mode is available and affects functionality. The test was executed to be robust against either interpretation of the standard. For the temperature variation test series, the test sample was powered by the USB port at the expect 5 Vdc level and good batteries were also present. For the voltage variation test at +20 °C, the USB voltage was varied 15% above and below the rated voltage (4.25 Vdc and 5.75 Vdc). The USB power and batteries were then removed, and an external voltage source provided either the 3.0 Vdc nominal voltage or the 2.4 Vdc endpoint voltage at the battery terminals for additional +20 °C testing. In any mode where USB power was supplied, it was done in a way that left the radio systems fully enabled.

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 transmissions were continuous with a 16% duty cycle. The amplitude results are unscaled and may not include the effects such as near field probe coupling or cable losses. Such effects are minimal when comparing two nearby data points in a single spectral scan. Probe coupling may vary between scans due to test sample movement which adjusting the operating modes.

Yellow highlight in each table below indicates the worst case level for the test results, for which an image of the spectrum is also provided. In the spectral plots, the data sets have been combined to present the low and high channel results side by side. Orange diamond markers indicate the spectral peak, while the black square markers are at the 2400 MHz or 2483.5 MHz band edge.

Temp	Volts	Low Ch.	High Ch.
˚C	Vdc	dBc	dBc
-20	5	42.5	54.5
20	5	42.9	39.8
50	5	45.6	50.4

Table TR11.2 Difference between peak and band edge levels for BLE transmission during temperature variations with 5 Vdc provided via USB port

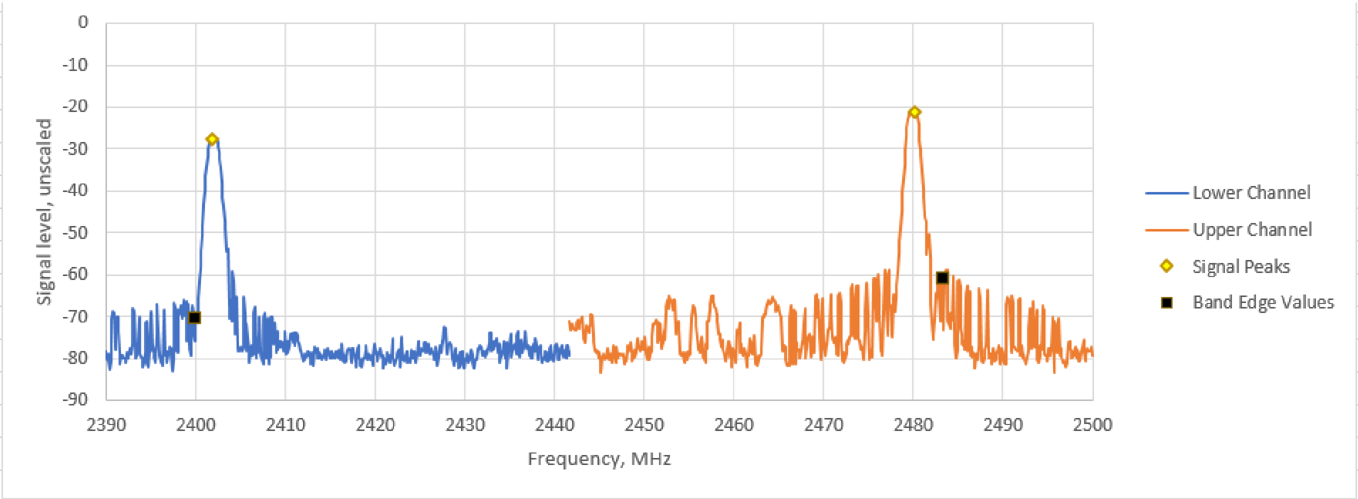


Figure TR11.1: Measured data with 5 Vdc provided via USB port at 20 °C

Temp	Volts	Low Ch.	High Ch.
˚C	Vdc	dBc	dBc
20	4.25	43.1	56.4
20	5	42.9	39.8
20	5.75	47.4	51.3

Table TR11.3 Difference between peak and band edge levels during USB voltage variations at 20 °C

Figure TR11.1 shows the worst case level during USB voltage variations at 20 °C.

Temp	Volts	Low Ch.	High Ch.
˚C	Vdc	dBc	dBc
20	3	38.5	48.6
20	2.4	42.5	47.6

Table TR11.4 Difference between peak and band edge levels during battery terminal voltage variations at 20 °C

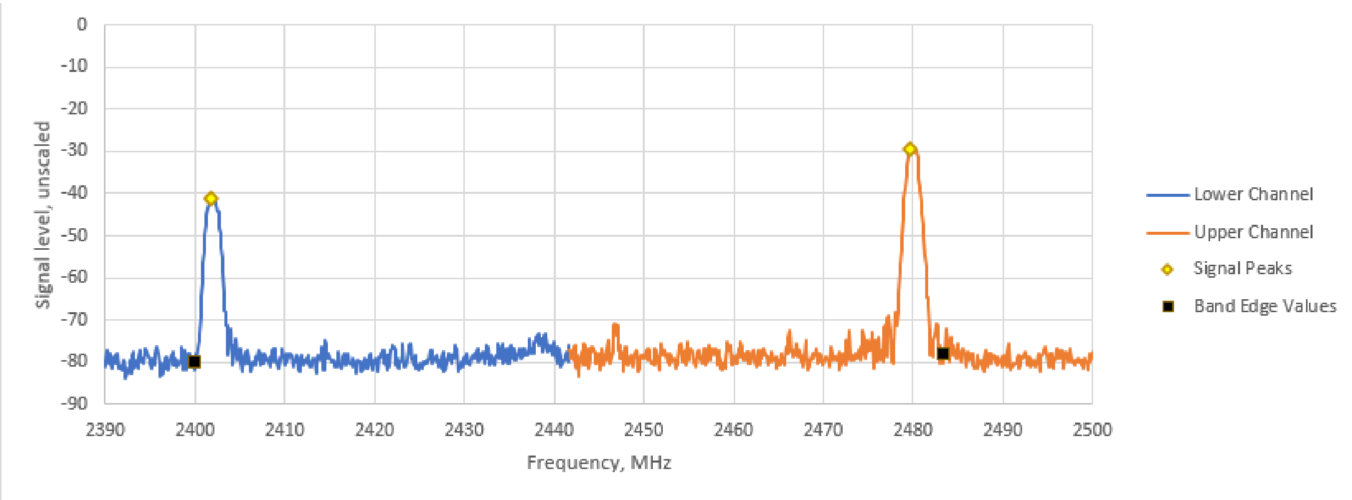


Figure TR11.2: Measured data battery terminal voltage of 3 Vdc at 20 °C

Setup Block Diagram

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

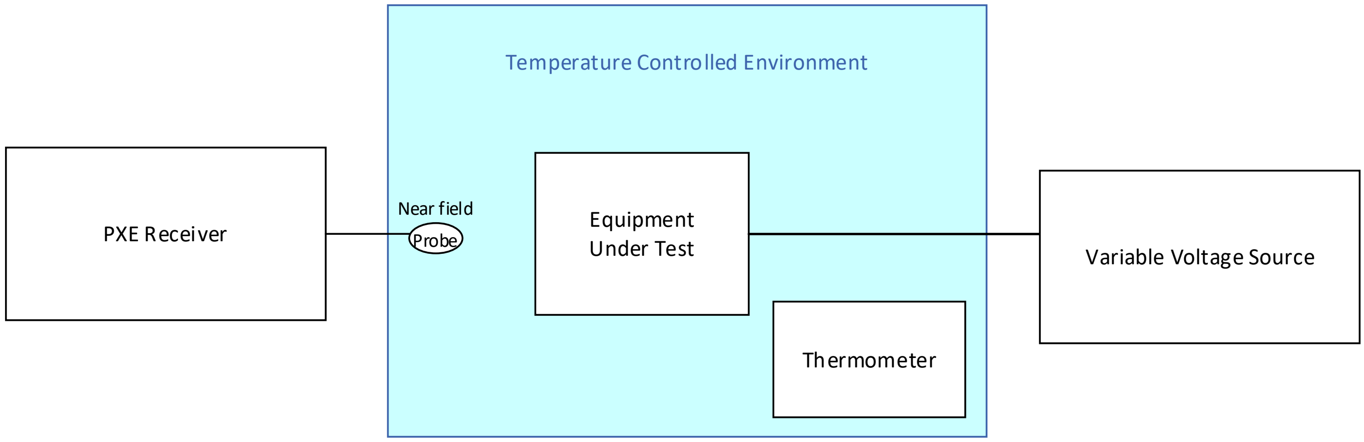


Figure TR11.3: Schematic drawing of the test equipment setup.

This line is the end of the test record.

Concluding Notes

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

This is the final page of the report.