



Garmin International, Inc.
1200 East 151st Street
Olathe, Kansas 66062
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03-Feb-26

Manufacturer: Garmin International, Inc.
Address: 1200 E. 151st St.
Olathe, KS 66062-3426
U.S.A.
Chile Representative: Matías Rodríguez Correa
Rosario Norte 660 piso 24, Las Condes Santiago
Province CP 7550083, Chile
Contact Email: matias.rodriguez@garmin.com
Subject: SUBTEL, Chile (Resolution 737) Certification Compliance 2026
Commercial Name: Instinct 2X Solar

	Información (Information)
Tipo de equipo (Equipment type)	Portable Digital Transceiver
Marca (Brand)	Garmin 
Modelo (Model)	A04600
Tecnología o modulación (Technology or modulation)	ASK for NFC / GFSK for ANT/ GFSK for BLE
Frecuencias (Frequencies)	13.56 MHz / 2402-2480 MHz / 2402-2480 MHz
Ganancia de antena (dBi) (Antenna gain (dBi))	ANT -3.70 dBi / BLE -3.70 dBi
P.i.r.e. (E.I R P.)	-32.43 dBm, 0.0005mW / -1.24 dBm, 0.75 mW / -1.90 dBm, 0.64 mW
Módulos (Modules)	NFC, ANT, BLE

As all measurements for NFC are made in radiated mode to comply with the field strength limits, gain information is not required to be noted in the reports or any additional documentation.

Declaration of Conformity Statement: the equipment previously identified complies with the provisions established in the Technical Standard for Small Range Equipment, approved by Exempt Resolution No.1,985 of 2017, of the Undersecretary of Telecommunications.

Declaración de conformidad: El equipo anteriormente identificado cumple con las disposiciones establecidas en la Norma Técnica para Equipos de Corto Alcance, aprobada mediante la Resolución Exenta N° 1.985 de 2017, de la Subsecretaría de Telecomunicaciones.

Test Report 2022-034

Version C

Issued 27 Mar 2023

Project GCL-0305

Model Identifier A04600

Primary Test Standard

FCC part 15.225

RSS-210 Issue 10

ICES-003 Issue 7

Garmin Compliance Lab

Garmin International

1200 E 151st Street

Olathe Kansas 66062 USA

Client-supplied Information

FCC ID: IPH-04600

IC ID: 1792A-04600



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

1. Summary

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

Parameter	Description	Key Performance Values	Result	Data starts at page
Radiated emissions	Radio emissions that this device may generate via its structures and connected cables that are not necessary for its operation and that may affect other radio communication	25.1 dB of margin to the Class B limit.	PASS	9
Transmitter spurious emissions	Emissions beyond the intended radio band while transmitting must be suppressed according to a limit that varies with frequency.	The amplitude margin was 6 dB or greater.	PASS with caveat	21
Frequency stability under extreme Conditions	The ability for the radio to accurately maintain carrier frequency stable with changes in temperature and supply voltage. [FCC 15.225 (e) and RSS-Gen at 6.11]	The Carrier frequency was stable within 0.01% of the target frequency.	PASS with caveat	25
Other Bandwidths	Bandwidth values are presented for 99% Occupied Bandwidth and Necessary Bandwidth	There are requirements to report these numbers, but they do not have performance limits.	Reported	27

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

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

Table 1: Summary of results

Report Organization

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

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2022-40. That report is treated as a part of this document by way of this reference.

2. Test Background

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

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

Test Sample received: 23 Nov 2022
Test Start Date: 28 Nov 2022
Test End Date: 28 Feb 2023

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

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

3. Report History and Approval

This report was written by Majid Farah and initially issued on 03 Feb 2023 as Version A. Version B released on 1 Mar 2023 provides regulatory identifiers on the cover page, and removed some data regarding radios that are not within the subject of this report. It also provides additional bandwidth data. Version C issued 27 Mar 2023 transferred additional sensitive materials to GCL Test Report 2023-040.

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:

None

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model A04600
Serial Numbers Tested 3431708344, 3431708548, 3431708479, 3431708421, 3431708497

[Material removed for confidentiality. See section 1 of this report to identify the report where the material may be viewed]

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, ANT/ANT+, NFC
Radio Receivers: GNSS
Highest internal frequency: 2.484 GHz
Firmware Revision 1201

[Material removed for confidentiality. See section 1 of this report to identify the report where the material may be viewed]

5.3 Operating modes

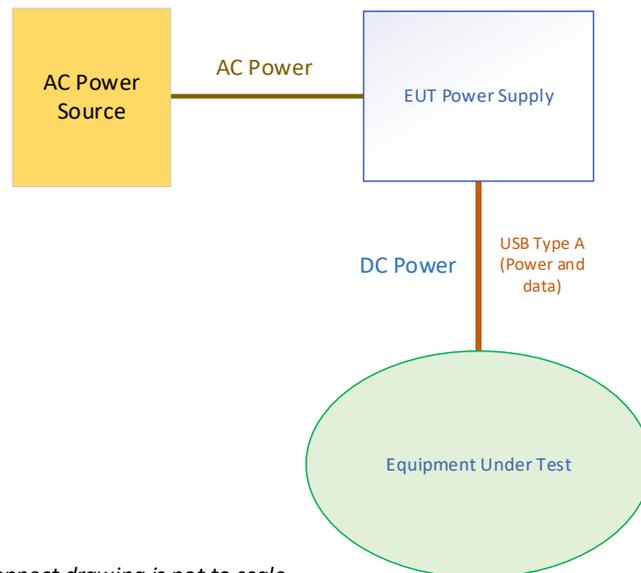
During test, the EUT was operated in the following modes.

Mode 2: M2 (NFC-L). EUT linked to NFC reader pad and transmit data
Mode 5: M5 (BLE Tx). EUT in test mode-BLE Tx always On
Mode 8: M8 (ANT Tx). EUT in test mode- ANT Tx always On

5.4 EUT Arrangement

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

Arrangement 1: A1 (PwrA) EUT powered up through a DC power supply with a type A USB connection

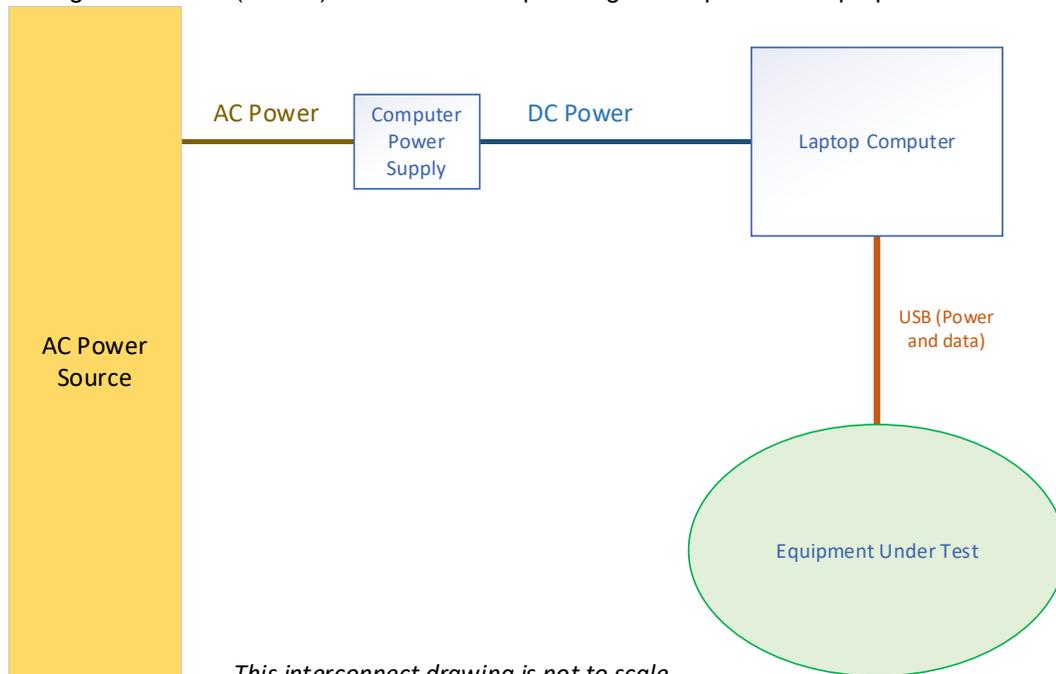


*This interconnect drawing is not to scale.
It does not indicate the placement of devices.*

Figure 1: Block diagram of equipment arrangement A1

Arrangement 2: A2 (NFC) EUT Powered up through arrangement A1, A3 or A4 in NFC mode and near to an NFC reader device

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



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

Figure 2: Block diagram of equipment arrangement A3

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

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
Smartwatch	Garmin	A04112	3400414926
Laptop	Dell	Latitude 5410	5VSPFB3
Laptop power supply	Dell	65 W	CN-oH374X-CH200-OB0-7TC0-A02
NFC reader	ACS	ACR1252	RR554-086776
USB Power type A	Garmin	PSAF10R-050Q	362-00096-00
iPad	Apple	iPad Pro (11-inch)	DMPZ7582KD6L
Smartwatch	Garmin	A04600	3423419439

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 A	Special	50 cm	None

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

5.7 Additional EUT Information Provided by the Requestor

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.

- FCC Part 15.225
- ANSI C63.4: 2014
- ANSI C63.10: 2013
- ICES-003 Issue 7: 2020
- RSS-GEN Issue 5 Amd 2
- RSS-210 Issue 10 Amd 1
- CISPR 32

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 test parameter or phenomenon, and the standards have compatible differences, the stricter of the requirements is typically applied. For example, a consolidated limit may be applied to emission tests selecting the strictest of the limits at each frequency. Likewise, if one standard requires a vertical antenna sweep with boresighting and another does not, swept motion with boresighting will typically be used as it is the more stringent requirement.

6.4 Laboratory Accreditation

The Garmin Compliance Lab, an organization within Garmin International, is registered with the US Federal Communication Commission as US1311. The lab is recognized by the Canada Department of Innovation, Science, and Economic Development (ISED) under CAB identifier US0233.

The Garmin Compliance Lab, an organization within Garmin International, is accredited by A2LA, Certificate No. 6162.01. The presence of the A2LA logo on the cover of this report indicates this is an accredited ISO/IEC 17025 test report. If the logo is absent, this report is not issued as an accredited report. Other marks and symbols adjacent to the A2LA logo are accreditation co-operations of which A2LA is a member under a mutual recognition agreement, and to which the Garmin Compliance Lab has been sublicensed.

7 Measurement Instrumentation Uncertainty

The lab has analyzed the sources of measurement instrumentation uncertainty. The analysis concludes that the actual measurement values cited in this report are accurate within the U_{LAB} intervals shown below with approximately 95% statistical confidence. Where the report shows a judgment that a test sample passes a test against a published limit based on these measured values, that judgment has a statistical confidence of 97.5% or greater. Measurement Instrumentation Uncertainty is one component of over-all measurement uncertainty, and other uncertainty components are not considered as part of this analysis.

The primary benchmark for measurement instrumentation uncertainty (MIU) in an electromagnetic compatibility (EMC) test lab is the set of U_{CISPR} values published in CISPR 16-4-2. In all cases where a U_{CISPR} value is published by CISPR, the analysis shows that U_{LAB} – this lab’s estimated MIU – is better than the U_{CISPR} benchmark.

The secondary benchmark for MIU in an EMC lab performing radio transceiver tests is a set of uncertainty limit values published in various ETSI standards. In this report, U_{ETSI} is the most restrictive of the values found in the ETSI EN standards listed in section 5 of this report. The analysis principles are described in the ETSI TR documents listed there. In most cases U_{LAB} is better than the U_{ETSI} benchmark. Where U_{LAB} exceeds the U_{ETSI} benchmark cited here, that entry is preceded by an asterisk. When required by the ETSI EN standards, excess uncertainty will be added to the measurand before comparison to a limit. In an individual test report, staff may re-evaluate that excess uncertainty based on the uncertainty of the method used and the uncertainty limits of the actual ETSI EN standard being applied, and the revised uncertainty values will be shown in the test report.

Some measurement uncertainties analyzed and reported here are not addressed in CISPR 16-4-2 or the ETSI standards, as indicated by the entry ‘None.’

Test Type	U_{LAB}	U_{CISPR}	U_{ETSI}
Conducted DC voltage	0.09% + 2 x LSDPV	None	1%
Conducted AC voltage below 500 Hz	1.0% + 3 x LSDPV	None	2%
Conducted Emissions, Mains Voltage	0.10% + 10 mV	None	None
Conducted Emissions, Mains Current	0.10% + 3 mA	None	None
Conducted Emissions, Mains Power	0.15% + 100 mW	None	None
Conducted Emissions, Power Mains, 9 kHz to 150 kHz	1.49 dB	3.8 dB	None
Conducted Emissions, Power Mains, 150 kHz to 30 MHz	1.40 dB	3.4 dB	None
Conducted Emissions, Cat 6 LCL, 150 kHz to 30 MHz	2.80dB	5 dB	None
Conducted Emissions, Cat 5 LCL, 150 kHz to 30 MHz	3.21 dB	5 dB	None
Conducted Emissions, Cat 3 LCL, 150 kHz to 30 MHz	4.24 dB	5 dB	None
Radiated Emissions, below 30 MHz	0.88 dB	None	6 dB
Radiated Emissions, 30 MHz to 1000 MHz	2.77 dB	6.3 dB	6 dB
Radiated Emissions, 1 GHz to 18 GHz	2.60 dB	5.2 & 5.5 dB	6 dB
Radiated Emissions, 18 GHz to 26.5 GHz	2.73 dB	None	6 dB
*Radio Signal Frequency Accuracy	*1.55 x 10 ⁻⁷	None	1.0 x 10 ⁻⁷
Radio Signal Occupied Bandwidth	0.95%	None	5%
Radio Power or Power Spectral Density	0.98 dB	None	1 dB
Temperature	0.38 °C	None	1 °C
Barometric Pressure	0.38 kPa	None	None
Relative Humidity	2.85% RH	None	±5% RH
Signal Timing	The greater of these three... 0.63 usec 0.01% of value 0.5 x LSDPV	None	None

Note: LSDPV stands for the Least Significant Digit Place Value reported. In the value 1470 msec, the least significant digit is the 7. It has a 10 msec place value. The LSDPV is thus 10 msec and the maximum error due to roundoff would be 5 msec. If the time value were reported as 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:	20.0 to 23.9 °C
Relative Humidity:	33.8% to 57.9% (non-condensing)
Barometric Pressure	96.0 to 99.7 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
Radiated Emission Test RE12
Project GCL0305

Test Date(s) 15 Dec 2022
 Test Personnel David Kerr assisted by Jim Solum

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M2 (NFC-L) Type A
 Arrangement A2 (NFC)
 Input Power USB 5 Vdc

Test Standards: FCC Part 15, CISPR 32, ANSI C63.10 (as noted in Section 6 of the report).

Frequency Range: 150K to 30MHz
Pass/Fail Judgment: PASS

Test record created by: David Kerr
Date of this record: 27 Dec 2022
 Original record, Version A.

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
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	25-Oct-2021	25-Oct-2024
Loop antenna, amplified	Schwarzbeck	FMZB 1519B	174	18-Jul-2022	15-Jul-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE12.1: Test Equipment Used

Software Used

PXE Firmware version A32.06
 RE 150k to 30M Signal Maximization Tool V1 2021Mar17.xlsx
 RE 150k to 30M XYZ_orientations_TemplateV6.xlsm
 GCL RE NFC 150k to 30M Data Analysis Template V1 2023Jan17.xlsx

Test Data

The radiated emission test process began with a preliminary scan at multiple turntable angles, and three antenna polarizations typically described as X, Y, and Z. Subsequent testing was done using the antenna polarization(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, 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. The designation of the X, Y, and Z antenna polarizations are reported by use of photographs.

The tables show the selected final measurement data between 150 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. The dBuA/m limits and measured dBuA/m values in the chart below are obtained from the dBuV/m limits and measured dBuV/m measured values. The two values differ by 51.52 dB based on the 377 Ohm characteristic impedance of free space. A positive margin value indicates that the emission was below the test limit. The test limits are for FCC & RSS-210 / ETSI 300 330 at 3m.

Frequency (MHz)	Limit (dBuV/m)	Limit (dBuA/m)	Measured (dBuV/m)	Measured (dBuA/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Orientation
0.746	N/A	N/A	49.0	-2.5	N/A	-75	1500	Z
1.493	N/A	N/A	40.4	-11.1	N/A	-86	1500	Z
2.321	N/A	N/A	28.9	-22.6	N/A	-73	1500	Z
2.328	N/A	N/A	30.1	-21.4	N/A	-136	1500	X
2.983	N/A	N/A	35.5	-16.0	N/A	-104	1500	Z
13.560	104.0	52.5	62.5	11.0	41.5	-9	1500	X

Table RE12.2: Emission summary Emission summary (FCC / Canada)

Frequency (MHz)	Limit (dBuA/m)	Measured (dBuA/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Orientation
0.746	26.2	-2.5	28.7	-75	1500	Z
1.493	25.7	-11.1	36.8	-86	1500	Z
2.321	25.2	-22.6	47.8	-73	1500	Z
2.328	25.2	-21.4	46.6	-136	1500	X
2.983	24.8	-16.0	40.8	-104	1500	Z
13.560	83.1	11.0	72.1	-9	1500	X

Table RE012.3: Emission summary (ETSI 300 330)

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

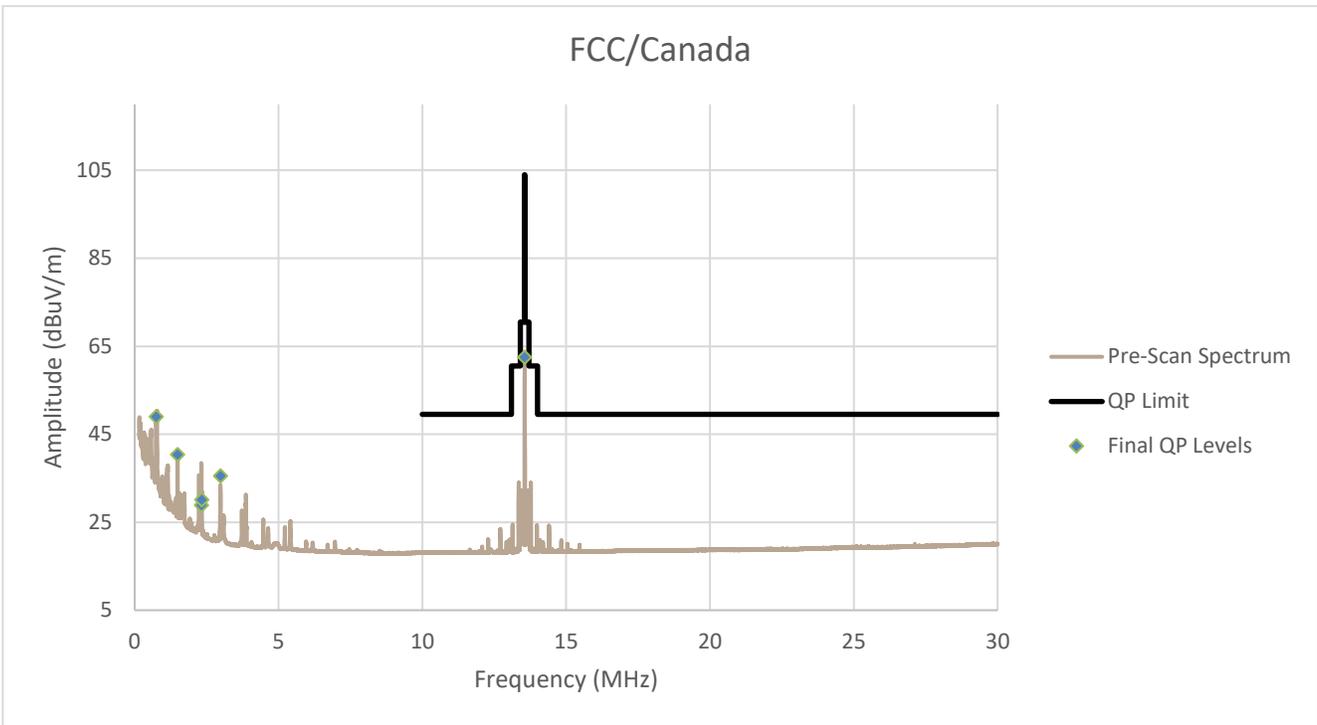


Figure RE12.1: Spectral data (FCC/Canada)

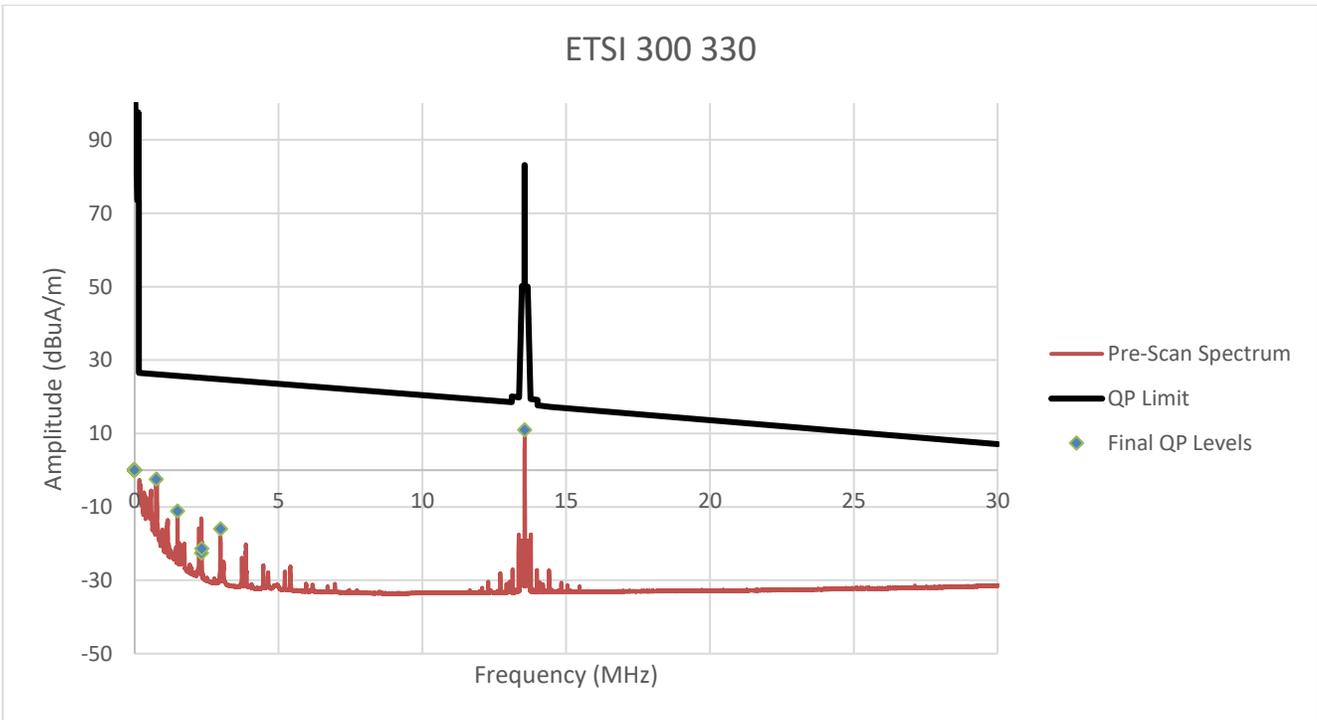


Figure RE12.2: (ETSI 300 330)

Setup Photographs

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



Figure RE012.3: EUT test setup (EUT Rear View, Antenna X Orientation)



Figure RE012.4: EUT test setup (EUT Front View, Antenna X Orientation)

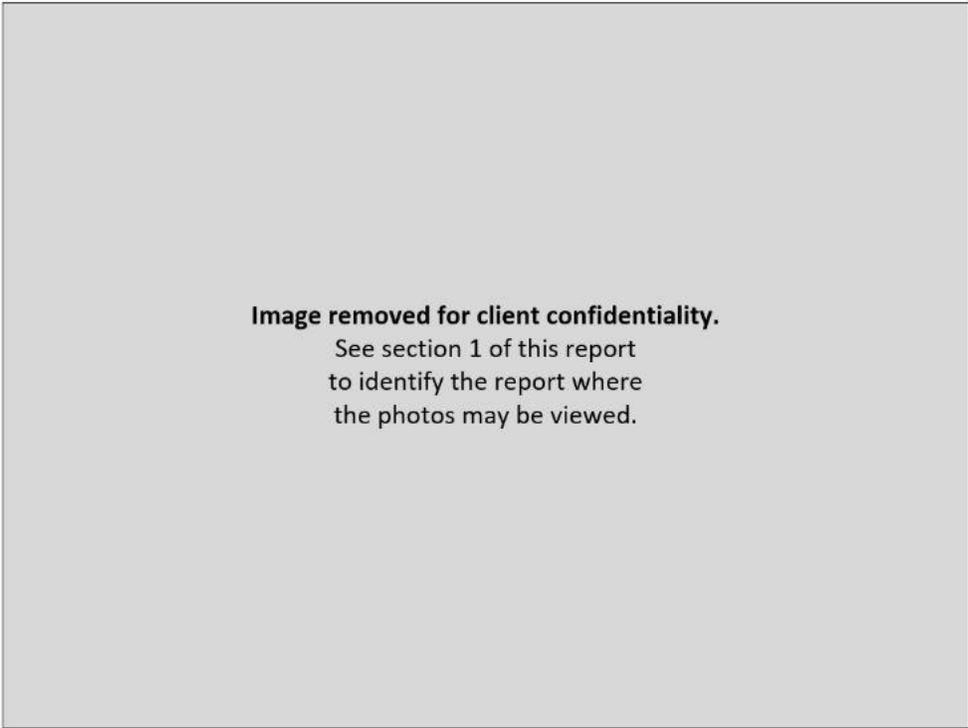


Figure RE012.5: EUT test setup (EUT Rear View, Antenna Y Orientation)



Figure RE012.6: EUT test setup (EUT Front View, Antenna Y Orientation)



Figure RE012.7: EUT test setup (EUT Rear View, Antenna Z Orientation)



Figure RE012.8: EUT test setup (EUT Front View, Antenna Z Orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE13
Project GCL0305

Test Date(s) 15 Dec 2022
 Test Personnel David Kerr assisted by Jim Solum
 Product Model A04600
 Serial Number tested 3431708344

Operating Mode M2 (NFC-L) Type B
 Arrangement A2 (NFC)
 Input Power USB 5 Vdc

Test Standards: FCC Part 15, ANSI C63.10, ETSI 300 330, RSS-210, RSS-GEN (as noted in Section 6 of the report).

Frequency Range: 150 kHz to 30 MHz
Pass/Fail Judgment: PASS

Test record created by: Jim Solum, David Kerr
Date of this record: 19 Jan 2023

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Loop antenna, amplified	Schwarzbeck	FMZB 1519B	00174	18-Jul-2022	15-Jul-2023
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	25-Oct-2021	25-Oct-2024
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023

Table RE13.1: Test Equipment Used

Software Used

PXE Firmware version A.32.06
 GCL RE 150k to 30M Signal Maximization Tool V1 2021Mar17.xlsx
 GCL RE 150k to 30M XYZ_orientations_TemplateV6.xlsm
 GCL RE NFC 150k to 30M Data Analysis Template V1 2023Jan17.xlsx

Test Data

The radiated emission test process began with a preliminary scan at multiple turntable angles, and three antenna polarizations typically described as X, Y, and Z. Subsequent testing was done using the antenna polarization(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, 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. The designation of the X, Y, and Z antenna polarizations are reported by use of photographs.

The tables show the selected final measurement data between 150 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. The dBuA/m limits and measured dBuA/m values in the chart below are obtained from the dBuV/m limits and measured dBuV/m measured values. The two values differ by 51.52 dB based on the 377 Ohm characteristic impedance of free space. A positive margin value indicates that the emission was below the test limit. The test limits are for FCC & RSS-210 / ETSI 300 330 at 3m.

Frequency (MHz)	Limit (dBuV/m)	Limit (dBuA/m)	Measured (dBuV/m)	Measured (dBuA/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Orientation
0.746	N/A	N/A	51.0	-0.5	N/A	-156	1500	X
1.493	N/A	N/A	44.3	-7.2	N/A	-129	1500	X
2.328	N/A	N/A	23.7	-27.8	N/A	-39	1500	Z
2.983	N/A	N/A	36.0	-15.5	N/A	-132	1500	X
13.560	104.0	52.5	62.8	11.3	41.2	-9	1500	X
14.408	49.5	-2.0	24.4	-27.1	25.1	-10	1500	X

Table RE013.2: Emission summary (FCC / Canada)

Frequency (MHz)	Limit (dBuA/m)	Measured (dBuA/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Orientation
0.746	26.2	-0.5	26.7	-156	1500	X
1.493	25.7	-7.2	32.9	-129	1500	X
2.328	25.2	-27.8	53.0	-39	1500	Z
2.983	24.8	-15.5	40.3	-132	1500	X
13.560	83.1	11.3	71.8	-9	1500	X
14.408	17.3	-27.1	44.4	-10	1500	X

Table RE013.3: Emission summary (ETSI 300 330)

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

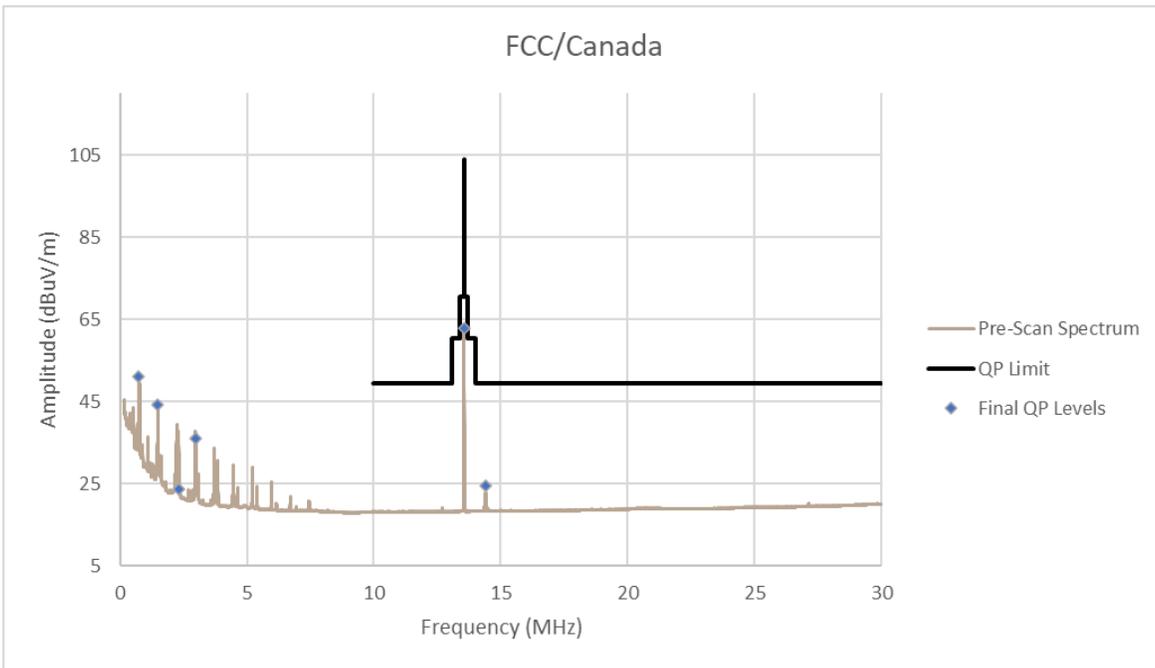


Figure RE013.1: Spectral data (FCC/Canada)

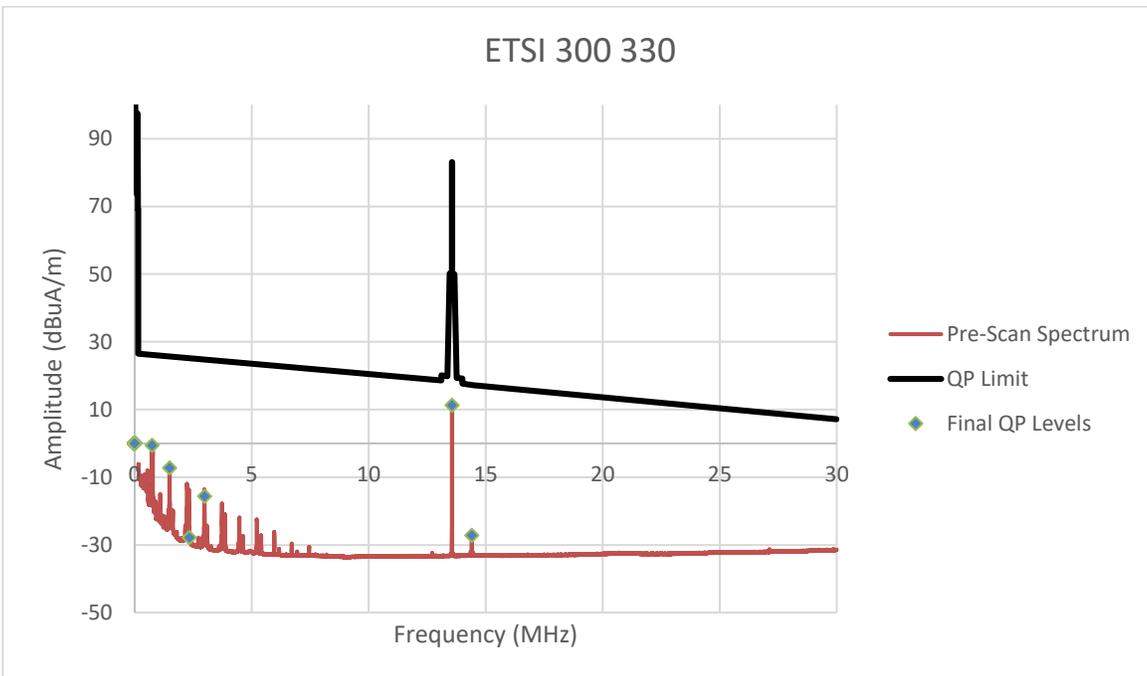


Figure RE013.2: Spectral data (ETSI 300 330)

Setup Photographs

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

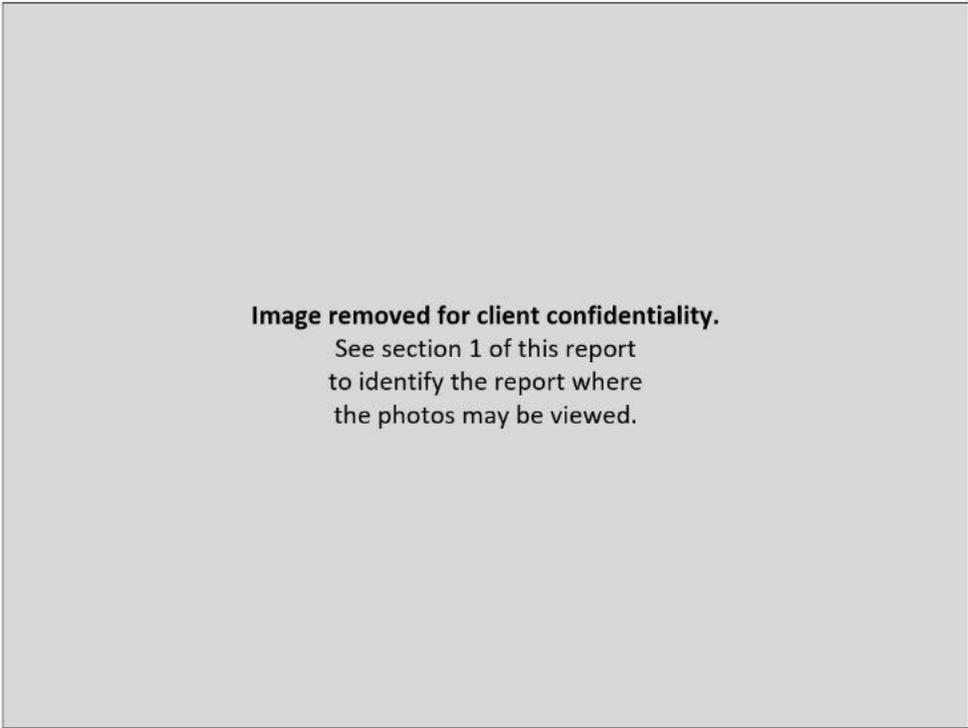


Figure RE013.3: EUT test setup (EUT Rear View, Antenna X Orientation)



Figure RE013.4: EUT test setup (EUT Front View, Antenna X Orientation)

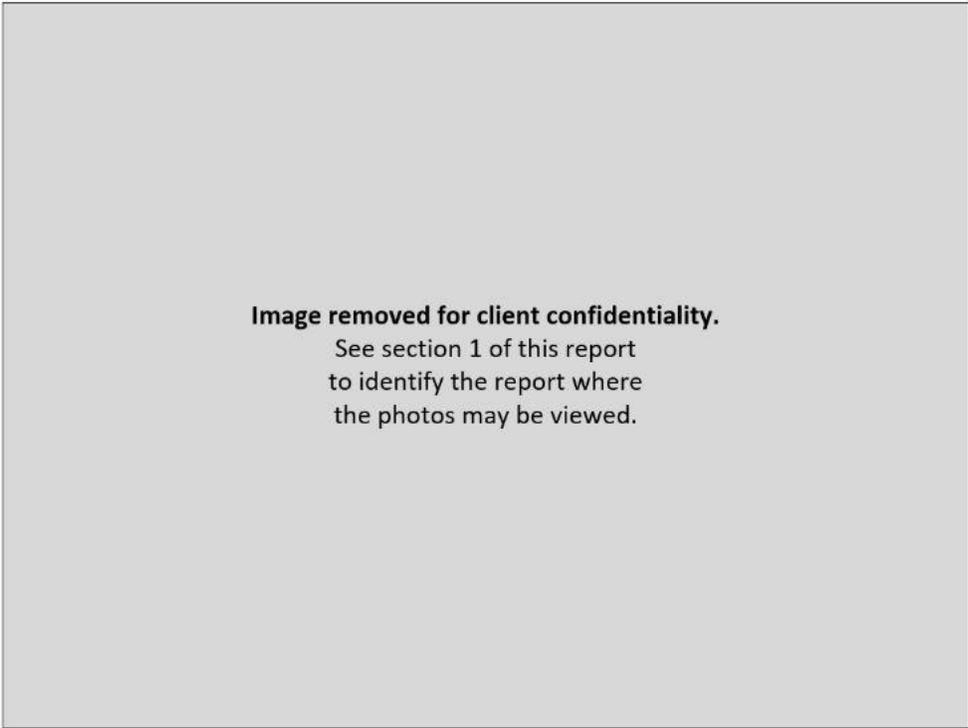


Figure RE013.5: EUT test setup (EUT Rear View, Antenna Y Orientation)

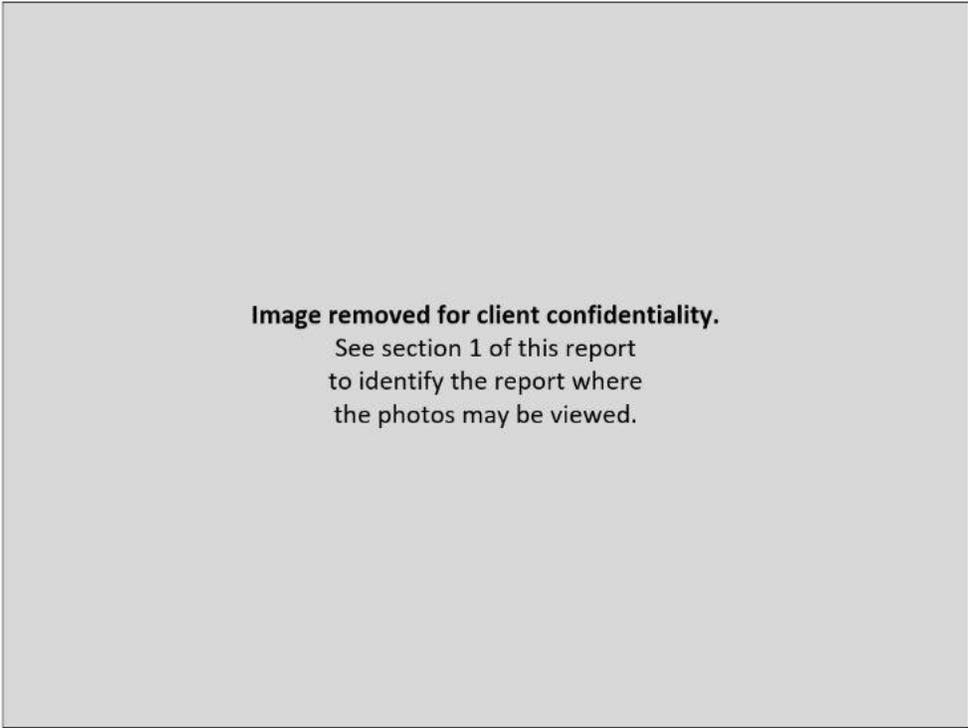


Figure RE013.6: EUT test setup (EUT Front View, Antenna Y Orientation)



Figure RE013.7: EUT test setup (EUT Rear View, Antenna Z Orientation)



Figure RE013.8: EUT test setup (EUT Front View, Antenna Z Orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE03E
Project GCL0305

Test Date(s) 31 Jan – 1 Feb 2023
 Test Personnel David Kerr assisted by Jim Solum

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M1 (NFC)
 Arrangement A2 (NFC)
 Input Power Internal battery power

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

Frequency Range: 30 MHz to 140 MHz
Pass/Fail Judgment: PASS

Test record created by: David Arnett
Date of this record:
 Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	3-Jan-2020	7-Jan-2023
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	25-Oct-2021	25-Oct-2024
Antenna, Biconilog, 30M-6 GHz	ETS Lindgren	3142E	00233201	19-Jul-2022	15-Jul-2024

Table RE03E.1: Test Equipment Used

Software Used: Keysight PXE software A.32.06, RE Signal Maximization Tool v2021Feb25.xlsx

Test Data

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

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

The table shows the selected final measurement data between 30 MHz and 140 MHz, covering the 10th harmonic of the NFC radio. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the Composite FCC Class B Limit at 3m.

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity	Sample Orientation
30.000	40.0	34.0	6.0	-182	2465	VERT	Z
40.680	40.0	25.4	14.6	45	2667	VERT	Y
55.290	40.0	17.8	22.2	-128	1891	HORZ	Y
59.400	40.0	18.7	21.3	135	2847	VERT	Y
63.480	40.0	17.4	22.6	-83	2195	VERT	Y
67.590	40.0	17.8	22.2	-108	1624	VERT	Y
121.200	43.5	29.0	14.5	65	1751	HORZ	Z

Table RE03E.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.

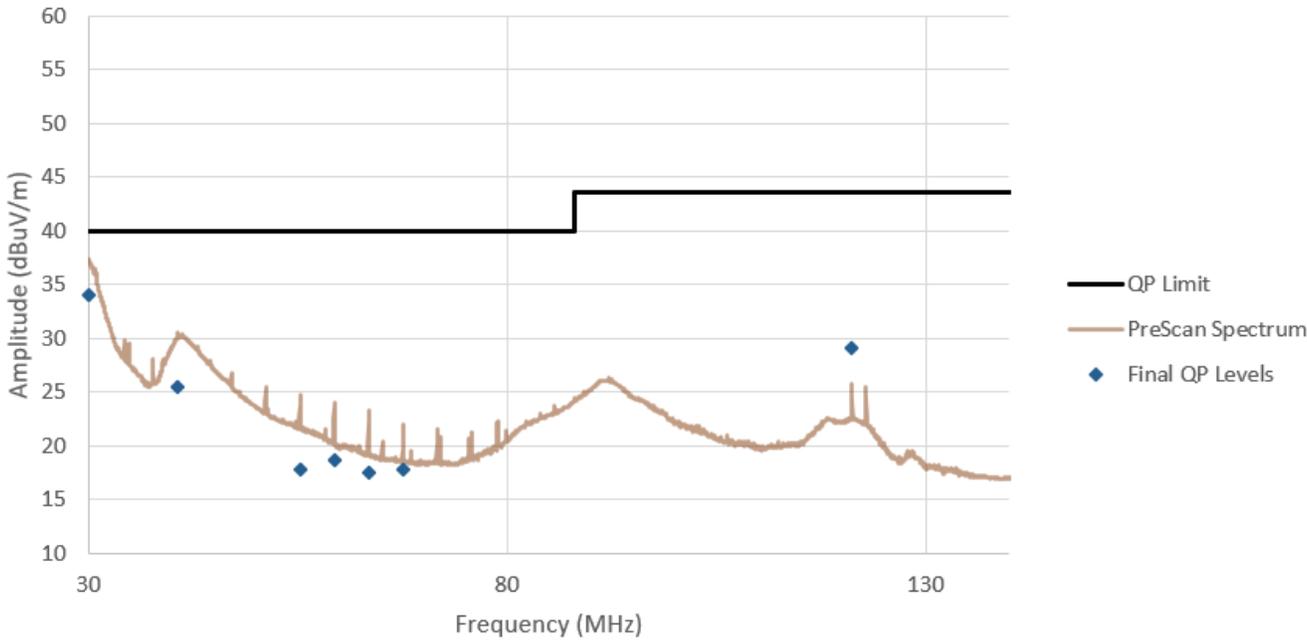


Figure RE03E.1: Spectral data

Setup Photographs

The following photographs show the EUT configured and arranged in the manner in which it was measured. The sample was strapped to the face of an NFC reader, and this pair of items placed in a green support vise for stable 3-axis mechanical positioning. The reader was attached by its ferrited USB cable to a laptop computer that enabled its NFC Reading activity.

Figure RE03E.4 shows the unit in the Y orientation. In the X orientation, the square green face of the support vise closest to the computer would have been on the table. The vise handle, pointing left in figure RE03E.3 farthest from the computer, would have been pointing up. In that X orientation, the operational face of the black NFC reader would have been parallel with the chamber floor. The Z orientation is mutually orthogonal to these two, so that the face of the green vise facing the camera in figure RE03E.4 would have been on the table.

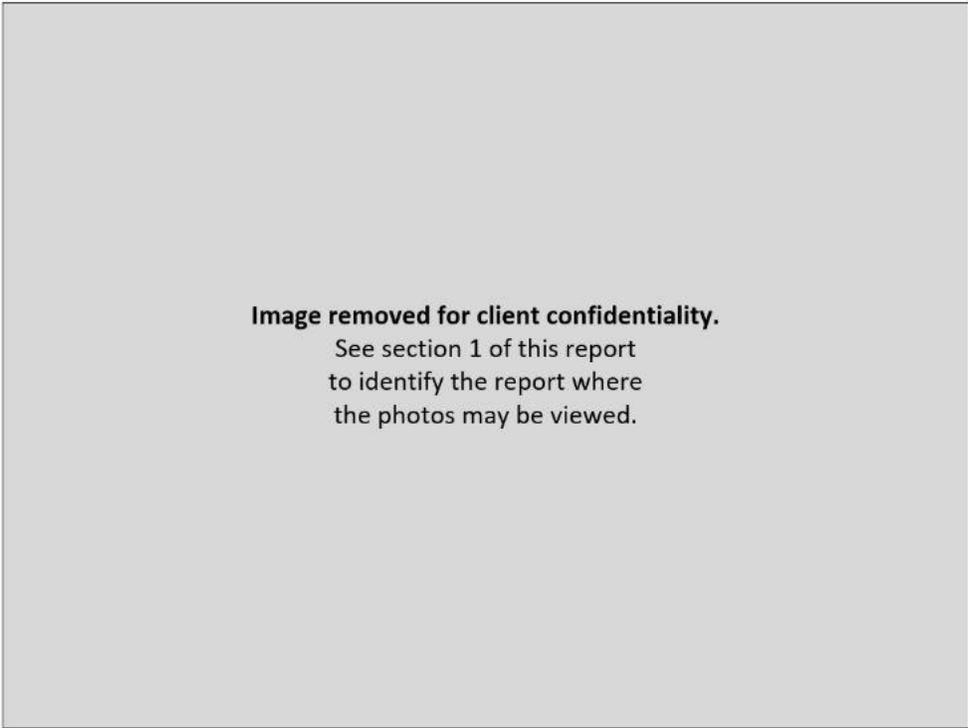


Figure RE03E.2: EUT test setup, front view

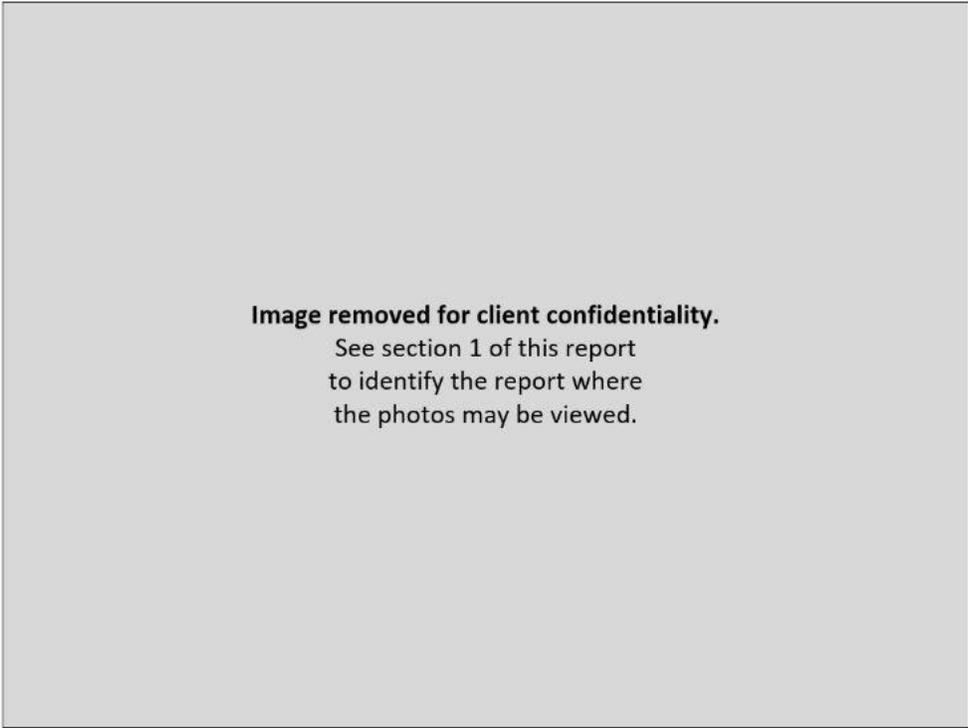


Figure RE03E.3: EUT test setup, reverse view

Image removed for client confidentiality.

See section 1 of this report
to identify the report where
the photos may be viewed.

Figure RE03E.4: EUT test setup detail, Y orientation

This line is the end of the test record.

Test Record
Transmitter Frequency Stability
Test IDs TR21
Project GCL-0305

Test Date(s) 12 - 13 Jan 2023
 Test Personnel Majid Farah and Jim Solum supervised by David Arnett
 Product Model A04600
 Serial Number tested 3431708497 and 3431708344

Operating Mode M2 (NFC-L)
 Arrangement A1 (PwrA)
 Nominal Input Power 5 Vdc

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

Radio Protocol NFC

Pass/Fail Judgment: PASS with caveat

Test record created by: Majid Farah
Date this record: 19 Jan 2023

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
DMM Multimeter	FLUKE	79 III	71740743	18-Apr-2022	15-Apr-2023
Signal analyzer PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Thermometer	Thermco	ACCD370P	210607316	11-Aug-2021	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Programmable DC power source	Keithley	2260B-30-72 720 W	14911917	6-Nov-2021	15-Feb-2023
Thermal Chamber	TPS	T2RC	611000116	21-Apr-22	15-Apr-2024
Near Field Probe set	Com-Power	PS-400	151679	Calibration	Not Required
NFC Reader	acs	ACR1252	RR554-086776	Calibration	Not Required

Table TR21.1: Equipment used

Software Used: PXE Software Revision A.32.06, FrequencyStabilityAnalysistemplateV1.xlsx

Test Method

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

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

The sample uses NFC technology with a carrier at 13.56 GHz. For continuous transmission, the sample needs to be at a close distance with an NFC card Reader along entire test. 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 then

connected by a cable to the PXE analyzer. The analyzer was set up to detect radio signals from the test sample in a way to read carrier frequency with high resolution. The Standard indicated carrier frequency stability shall not exceed 0.01% of operation frequency.

The test temperatures range is from +50 °C to -20 °C by 10 °C decrement at each test step for nominal input voltage (5 V). The NFC carrier frequency was recorded four times at each temperature by 2, 5 and 10 minutes interval from first record. For the voltage variation test at +20 °C, the voltage is to be varied 15% above and below nominal input voltage. Data was taken at 5 Vdc and 15% lower at 4.25 Vdc plus 15% higher at 5.75 Vdc.

Caveat

The NFC transceiver under test only operates when in the close vicinity of an NFC Reader. In this test, the client provided the ACR1252 manufactured by Advanced Card Systems as described in section 5.5 of the test report.

Emissions presented here show the combined signals from the NFC reader and the device under test. Signals for each were not distinguishable during test. Per the client, the device under test matches its transmitting frequency to correspond to that of the reader device. The data presented here, and the conclusions drawn, apply to the device under test and the NFC Reader when tested together as a system.

Test Data

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

During NFC test mode, each measurement was made conducted from a near field probe located at a close distance to the sample and NFC reader. The sample needs to be attached to an NFC reader for continuous transmission.

Yellow highlight indicates the maximum and minimum measured carrier frequency. The maximum frequency measured was 13,559,949 Hz and the minimum was 13,559,792 Hz. The margin to high side of limit is 1407 Hz and margin for low side of the limit is 1148 Hz.

Tx Mode	Temp °C	Volts Vdc	NFC carrier frequency (HZ)			
			Time interval (minute)			
			0	2	5	10
NFC	50	5	13,559,796	13,559,794	13,559,793	13,559,792
NFC	40	5	13,559,796	13,559,800	13,559,803	13,559,805
NFC	30	5	13,559,825	13,559,828	13,559,832	13,559,836
NFC	20	5	13,559,868	13,559,867	13,559,869	13,559,872
NFC	20	4.25	13,559,873	N/A	N/A	N/A
NFC	20	5.75	13,559,873	N/A	N/A	N/A
NFC	10	5	13,559,908	13,559,907	13,559,907	13,559,908
NFC	0	5	13,559,938	13,559,937	13,559,936	13,559,937
NFC	-10	5	13,559,946	13,559,948	13,559,949	13,559,949
NFC	-20	5	13,559,927	13,559,934	13,559,935	13,559,935

Table TR21.6 Carrier frequency measurement for NFC transmission during temperature and voltage variations

Setup Block Diagram

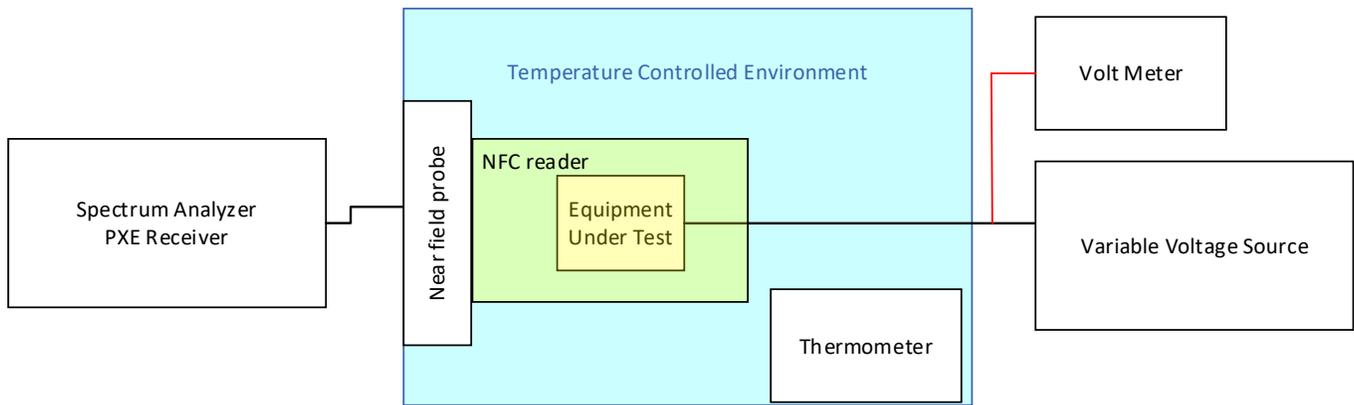


Figure TR21.6: Schematic drawing of the test equipment setup for NFC

This line is the end of the test record.

Test Record
Other Bandwidth Tests
Test IDs TR22
Project GCL-0305

Test Date(s) 27 Feb 2023
 Test Personnel David Arnett

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M2 (NFC-L)
 Arrangement A1 (PwrA)
 Input Power 5V dc

Test Standards: FCC Part 2.202, ANSI C63.10, TRC-43, RSS-GEN (as noted in Section 6 of the report).

Radio Protocol NFC
 Radio Band 13.56 MHz

Pass/Fail Judgment: Reported

Test record created by: David Arnett
Date of this record: 28 Feb 2023
 Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	10-Mar-2023

Table TR22.1

Test Software used: Keysight MXE System Code rev. A.33.03.

Background

There are regulatory requirements to present two additional types of bandwidth analyses: 99% Occupied Bandwidth and Necessary Bandwidth. There are no limits or functional requirements around these data, beyond a reporting requirement. The contents of this test record are for information, and do not affect compliance of the devices that are the subject of this report.

Test Setup

This block diagram shows the test equipment setup.

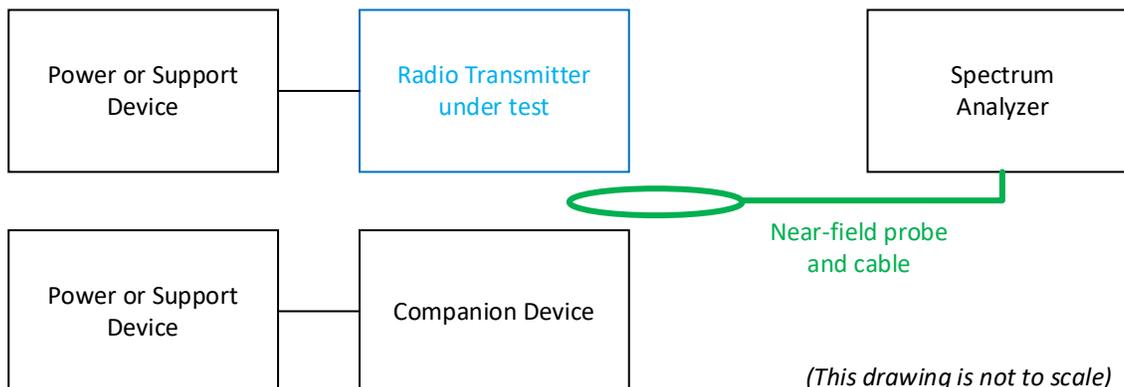


Figure TR22.1: Test setup

Caveat

The NFC transceiver under test only operates when in the close vicinity of an NFC Reader. In this test, the client provided the ACR1252 manufactured by Advanced Card Systems as described in section 5.5 of the test report.

Emissions presented here show the combined signals from the NFC reader and the device under test. Signals for each were not distinguishable during test. Per the client, the device under test matches its transmitting frequency to correspond to that of the reader device. The data presented here, and the conclusions drawn, apply to the device under test and the NFC Reader when tested together as a system.

Occupied Bandwidth, 99% Test Method

During this test the transmitter is coupled to a companion device. A link established and maintained. A near-field loop probe is placed between the device under test and the companion device. The probe output is fed directly 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. The analysis threshold for this test was the bandwidth containing 99% of the observed power using the ANSI C63.10 method. The measured bandwidth data are in bold font and have kHz as their units of measure.

NFC Type	99% OBW
----	kHz
A	4.949
B	3531

Table TR22.2: Summary of 99% Occupied Bandwidth Data, Type A and Type B NFC modes



Figure TR22.1: Occupied bandwidth data for Type A NFC



Figure TR22.2: Occupied bandwidth data for Type B NFC

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 approach for NFC is also different but is consistent between the US and Canadian standards. The tables below will show the analysis for most of the radios signals as a combined approach, then separately analyze the results for IEEE 802.11g and n systems. The tables below may include radio protocols that are not part of the product being evaluated.

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

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

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 TR22.101: 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 TR22.102: 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 TR22.103: 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 TR22.104: 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 TR22.105: Necessary Bandwidth for IEEE 802.11 g and n 20 MHz Radio Protocols (TRC-43)

NFC is a 13.56 MHz communication protocol that uses telegraphy-style amplitude modulation of the carrier to transmit data. It uses Miller (Type A) or Manchester (Type B) encoding. In Miller coding, one symbol occurs in each bit time, whereas in Manchester coding two symbols are typically used for each data bit to improve synchronization. This aspect of the Manchester-encoded baud rate is quantified here using the variable C (for coding).

The standards cited define the Necessary Bandwidth, BN, for telegraphy amplitude modulation as:

$$B_N = B * K$$

where B is the Baud Rate and K is 3 for a non-fading channel. Since Manchester encoding doubles the underlying Baud rate, we will set C = 2 for Manchester encoding and C = 1 for Miller encoding. The formula then becomes:

$$B_N = B * C * K$$

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

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.

Test Report 2022-035

Version C

Issued 27 Mar 2023

Project GCL-0305

Model Identifier A04600

Primary Test Standard

FCC part 15

RSS-247 Issue 2

ICES-003 Issue 7

Garmin Compliance Lab

Garmin International

1200 E 151st Street

Olathe Kansas 66062 USA

Client-supplied Information

FCC ID: IPH-04600

IC ID: 1792A-04600



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

1. Summary

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

Parameter	Description	Key Performance Values	Result	Data starts at page
Hopping Channels	The radio manages its 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
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 707.4 kHz or greater.	PASS	11
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 2.63 dBm (0.00183 W) or -1.24 dBm EIRP (0.00075 W EIRP).	PASS	16
Antenna Gain	The radio should not focus too much energy in any direction. Unless additional rules are applied, the antenna gain is no greater than 6 dBi. [15.247(b)(4) and (c)]	NT	NT	NT
Unwanted Emissions (Conducted Spurious)	The radio should not provide too much radio energy to the antenna at frequencies beyond its intended frequency band. [15.247(d); RSS-247 at 5.5]	Emissions outside the band must be reduced at least 20 dB from in-band levels. The measured reduction was at least 50.5 dB.	PASS	18
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 21.04 dB below the applicable limits.	PASS	22
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 2.2 dBm in a band of at least 30 kHz.	PASS	32
Hybrid Systems	A radio that is both frequency hopping and digitally modulated should have 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 with caveat	35

Other Bandwidths	Bandwidth values are presented for 99% Occupied Bandwidth and Necessary Bandwidth	There are requirements to report these numbers, but they do not have performance limits.	Reported	39
Radiated Emissions	Radio emissions that this device may generate via its structures and connected cables that are not necessary for its operation and that may affect radio communication	12.1 dB of margin to the Class B limit. Tested 30 MHz to 6 GHz applying combined Class B limits.	PASS	44
Conducted Emissions AC Power Port	Radio emissions that this device may generate via its ac power network connections that are not necessary for its operation and that may affect radio communication	9.17 dB of margin to the appropriate limit. Tested 150 kHz to 30 MHz applying combined Class B limits.	PASS	50

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

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

Table 1: Summary of results

Report Organization

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

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2022-040. That report is treated as a part of this document by way of this reference.

2. Test Background

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

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

Test Sample received: 23 Nov 2022
Test Start Date: 28 Nov 2022
Test End Date: 01 Feb 2023

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

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

3. Report History and Approval

This report was written by Majid Farah and initially issued on 03 Feb 2023 as Version A. Version B released on 1 Mar 2023 provides regulatory identifiers on the cover page, and removed some data regarding radios that are not within the subject of this report. Version C issued 27 Mar 2023 transferred additional sensitive materials to GCL Test Report 2023-040.

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:

None

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model A04600
Serial Numbers Tested 3431708344, 3431708548, 3431708479, 3431708421, 3431708497

[Material removed for confidentiality. See section 1 of this report to identify the report where the material may be viewed]

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, ANT/ANT+, NFC
Radio Receivers: GNSS
Highest internal frequency: 2.484 GHz
Firmware Revision 1201

[Material removed for confidentiality. See section 1 of this report to identify the report where the material may be viewed]

5.3 Operating modes

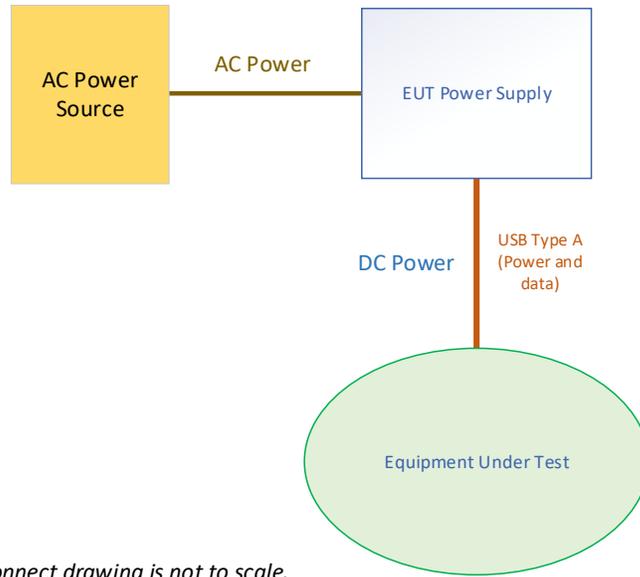
During test, the EUT was operated in the following modes.

Mode 2: M2 (NFC-L). EUT linked to NFC reader pad and transmit data
Mode 5: M5 (BLE Tx). EUT in test mode-BLE Tx always On
Mode 6: M6 (BLE-L). EUT linked to companion device through BLE
Mode 7: M7 (GNSS). EUT in GNSS test mode
Mode 8: M8 (ANT Tx). EUT in test mode- ANT Tx always On
Mode 9: M9 (ANT-L). EUT linked to companion device through ANT
Mode 10: M10 (ALL). all relevant radios On
Mode 11: M11 (BLE Rx). EUT in test mode- BLE Rx always On for Rx spurious emission test

5.4 EUT Arrangement

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

Arrangement 1: A1 (PwrA) EUT powered up through a DC power supply with a type A USB connection

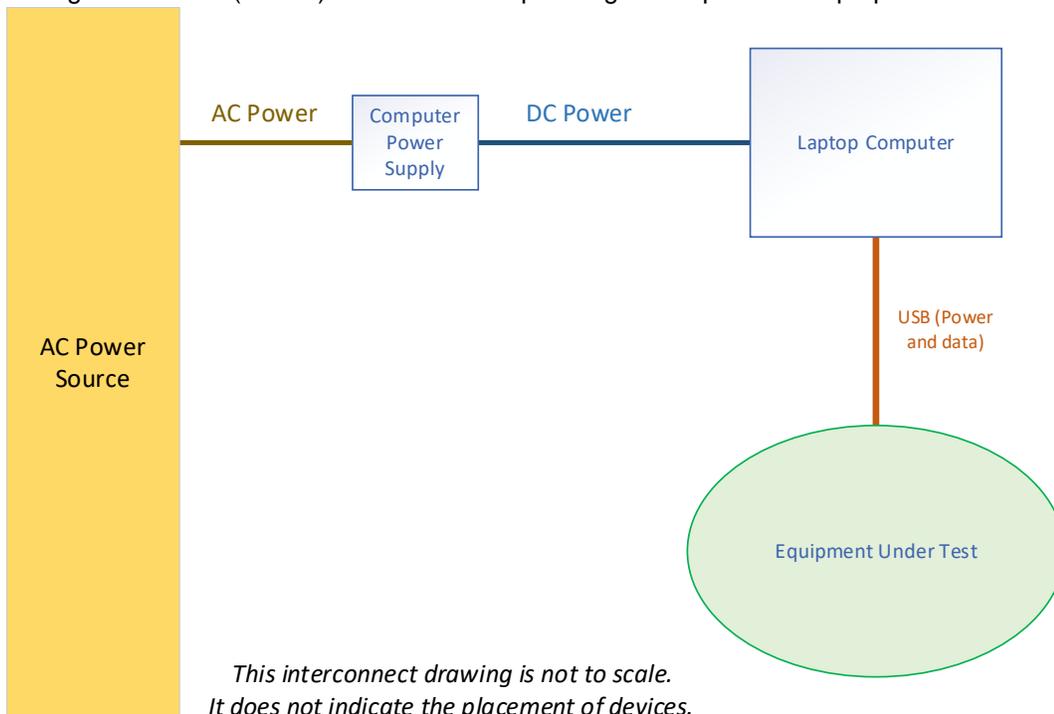


*This interconnect drawing is not to scale.
It does not indicate the placement of devices.*

Figure 1: Block diagram of equipment arrangement A1

Arrangement 2: A2 (NFC) EUT Powered up through arrangement A1, A3 or A4 in NFC mode and near to an NFC reader device

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



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

Figure 2: Block diagram of equipment arrangement A3

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

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
Smartwatch	Garmin	A04112	3400414926
Laptop	Dell	Latitude 5410	5VSPFB3
Laptop power supply	Dell	65 W	CN-oH374X-CH200-OB0-7TC0-A02
NFC reader	ACS	ACR1252	RR554-086776
USB Power type A	Garmin	PSAF10R-050Q	362-00096-00
iPad	Apple	iPad Pro (11-inch)	DMPZ7582KD6L
Smartwatch	Garmin	A04600	3423419439

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 A	Special	50 cm	None

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

6 Test Standards Applied

6.1. Accredited Standards

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

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

6.2. Non-accredited Standards

The following test or measurement standards were applied and are either outside the scope of the lab's accreditation, or were performed in such a way that results are not presented as being fully accredited.

FCC Part 2.202
TRC-43

6.3 Variances

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

Where different test standards cover the same test parameter or phenomenon, and the standards have compatible differences, the stricter of the requirements is typically applied. For example, a consolidated limit may be applied to emission tests selecting the strictest of the limits at each frequency. Likewise, if one standard requires a vertical antenna sweep with boresighting and another does not, swept motion with boresighting will typically be used as it is the more stringent requirement.

6.4 Laboratory Accreditation

The Garmin Compliance Lab, an organization within Garmin International, is registered with the US Federal Communication Commission as US1311. The lab is recognized by the Canada Department of Innovation, Science, and Economic Development (ISED) under CAB identifier US0233.

The Garmin Compliance Lab, an organization within Garmin International, is accredited by A2LA, Certificate No. 6162.01. The presence of the A2LA logo on the cover of this report indicates this is an accredited ISO/IEC 17025 test report. If the logo is absent, this report is not issued as an accredited report. Other marks and symbols adjacent to the A2LA logo are accreditation co-operations of which A2LA is a member under a mutual recognition agreement, and to which the Garmin Compliance Lab has been sublicensed.

7 Measurement Instrumentation Uncertainty

The lab has analyzed the sources of measurement instrumentation uncertainty. The analysis concludes that the actual measurement values cited in this report are accurate within the U_{LAB} intervals shown below with approximately 95% statistical confidence. Where the report shows a judgment that a test sample passes a test against a published limit based on these measured values, that judgment has a statistical confidence of 97.5% or greater. Measurement Instrumentation Uncertainty is one component of over-all measurement uncertainty, and other uncertainty components are not considered as part of this analysis.

The primary benchmark for measurement instrumentation uncertainty (MIU) in an electromagnetic compatibility (EMC) test lab is the set of U_{CISPR} values published in CISPR 16-4-2. In all cases where a U_{CISPR} value is published by CISPR, the analysis shows that U_{LAB} – this lab’s estimated MIU – is better than the U_{CISPR} benchmark.

The secondary benchmark for MIU in an EMC lab performing radio transceiver tests is a set of uncertainty limit values published in various ETSI standards. In this report, U_{ETSI} is the most restrictive of the values found in the ETSI EN standards listed in section 5 of this report. The analysis principles are described in the ETSI TR documents listed there. In most cases U_{LAB} is better than the U_{ETSI} benchmark. Where U_{LAB} exceeds the U_{ETSI} benchmark cited here, that entry is preceded by an asterisk. When required by the ETSI EN standards, excess uncertainty will be added to the measurand before comparison to a limit. In an individual test report, staff may re-evaluate that excess uncertainty based on the uncertainty of the method used and the uncertainty limits of the actual ETSI EN standard being applied, and the revised uncertainty values will be shown in the test report.

Some measurement uncertainties analyzed and reported here are not addressed in CISPR 16-4-2 or the ETSI standards, as indicated by the entry ‘None.’

Test Type	U_{LAB}	U_{CISPR}	U_{ETSI}
Conducted DC voltage	0.09% + 2 x LSDPV	None	1%
Conducted AC voltage below 500 Hz	1.0% + 3 x LSDPV	None	2%
Conducted Emissions, Mains Voltage	0.10% + 10 mV	None	None
Conducted Emissions, Mains Current	0.10% + 3 mA	None	None
Conducted Emissions, Mains Power	0.15% + 100 mW	None	None
Conducted Emissions, Power Mains, 9 kHz to 150 kHz	1.49 dB	3.8 dB	None
Conducted Emissions, Power Mains, 150 kHz to 30 MHz	1.40 dB	3.4 dB	None
Conducted Emissions, Cat 6 LCL, 150 kHz to 30 MHz	2.80dB	5 dB	None
Conducted Emissions, Cat 5 LCL, 150 kHz to 30 MHz	3.21 dB	5 dB	None
Conducted Emissions, Cat 3 LCL, 150 kHz to 30 MHz	4.24 dB	5 dB	None
Radiated Emissions, below 30 MHz	0.88 dB	None	6 dB
Radiated Emissions, 30 MHz to 1000 MHz	2.77 dB	6.3 dB	6 dB
Radiated Emissions, 1 GHz to 18 GHz	2.60 dB	5.2 & 5.5 dB	6 dB
Radiated Emissions, 18 GHz to 26.5 GHz	2.73 dB	None	6 dB
*Radio Signal Frequency Accuracy	*1.55 x 10 ⁻⁷	None	1.0 x 10 ⁻⁷
Radio Signal Occupied Bandwidth	0.95%	None	5%
Radio Power or Power Spectral Density	0.98 dB	None	1 dB
Temperature	0.38 °C	None	1 °C
Barometric Pressure	0.38 kPa	None	None
Relative Humidity	2.85% RH	None	±5% RH
Signal Timing	The greater of these three... 0.63 usec 0.01% of value 0.5 x LSDPV	None	None

Note: LSDPV stands for the Least Significant Digit Place Value reported. In the value 1470 msec, the least significant digit is the 7. It has a 10 msec place value. The LSDPV is thus 10 msec and the maximum error due to roundoff would be 5 msec. If the time value were reported as 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:	20.0 to 23.9 °C
Relative Humidity:	33.8% to 57.9% (non-condensing)
Barometric Pressure	96.0 to 99.7 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 IDs TR8
Project GCL-0305

Test Date(s) 12 Jan 2021
 Test Personnel David Arnett

Product Model A04600
 Serial Number tested 3431708548

Operating Mode M5 (BLE Tx)
 Arrangement A1 (PwrA)
 Input Power 5V dc

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

Radio Protocol Bluetooth Low Energy
 Radio Band 2480 to 2483.5 MHz

Pass/Fail Judgment: PASS

Test record created by: David Arnett
Date of this record: 25 Jan 2023
 Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023

Table TR8.1: Test equipment used

Software Used: Keysight PXE software A.33.03

Test Method

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

Test Setup

This block diagram shows the test equipment setup.

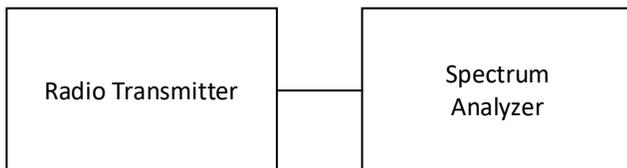


Figure TR8.1: Test setup

Test Data

The data for each test is summarized in the table(s) below. The spectral data is also provided for each case.

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

In some cases, a key requirement is that the occupied band be within the allowed range (2400 – 2483.5 MHz). This is analyzed by taking the center frequency, adding the frequency error, then adding (high channel) or subtracting (low channel) half of the measured bandwidth. The result tells us the edge of the bandwidth closest to the band edge. This calculation will be presented where applicable.

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

The channel frequencies for BLE at 1 Mbps are 2402, 2442, and 2480 MHz. The channel frequencies for BLE at 2 Mbps are 2404, 2442, and 2478 MHz. These are called the Low, Mid, and High frequencies.

	BLE 1Mbps	BLE 2Mbps
Low	707.4	1163.0
Mid	716.0	1167.0
High	720.1	1168.0
Mean	714.5	1166.0
Unit	kHz	kHz

Table TR8.2: Summary of DTS Bandwidth test results for ANSI method

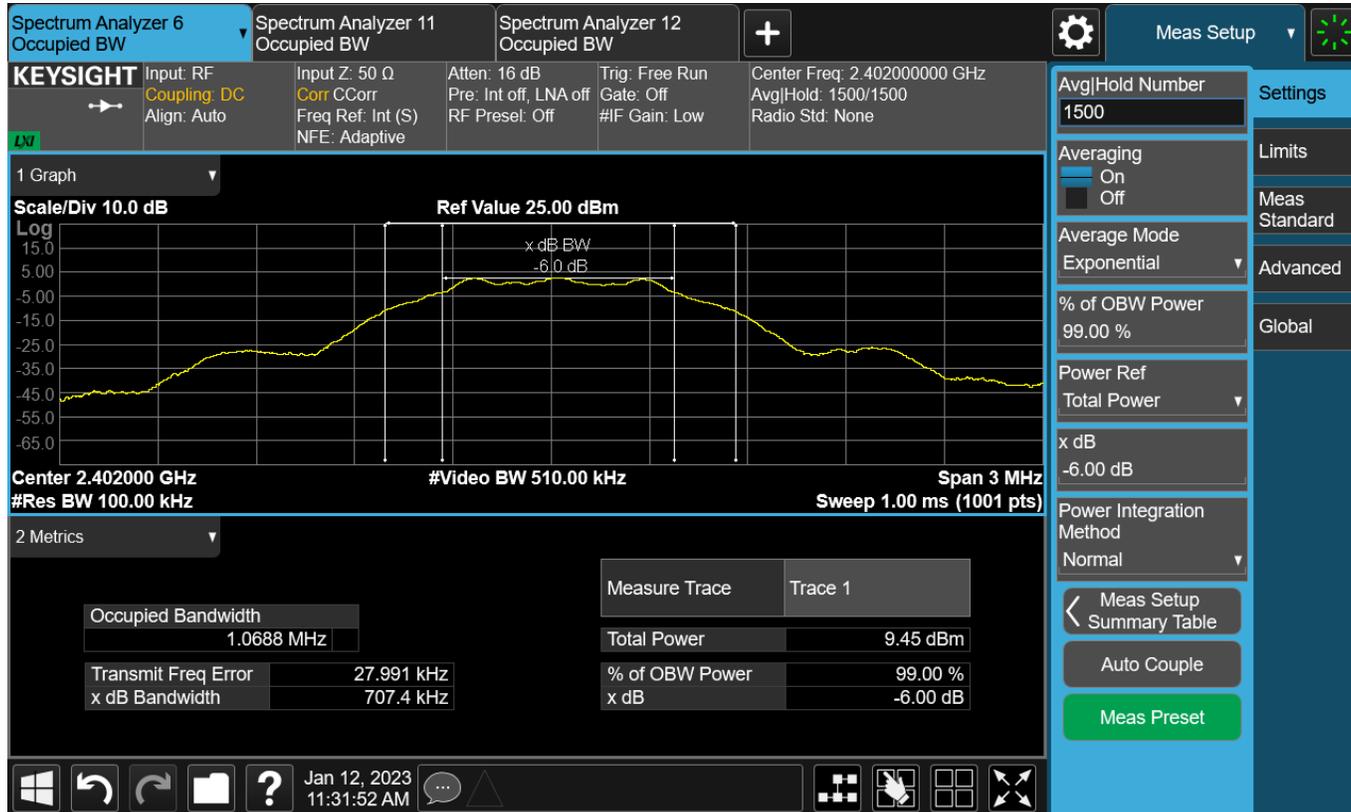


Figure TR8.2: Spectral data for BLE 1 Mbps on the Low frequency.



Figure TR8.3: Spectral data for BLE 1 Mbps on the Mid frequency.



Figure TR8.4: Spectral data for BLE 1 Mbps on the High frequency.



Figure TR8.5: Spectral data for BLE 2 Mbps on the Low frequency.



Figure TR8.6: Spectral data for BLE 2 Mbps on the Mid frequency.

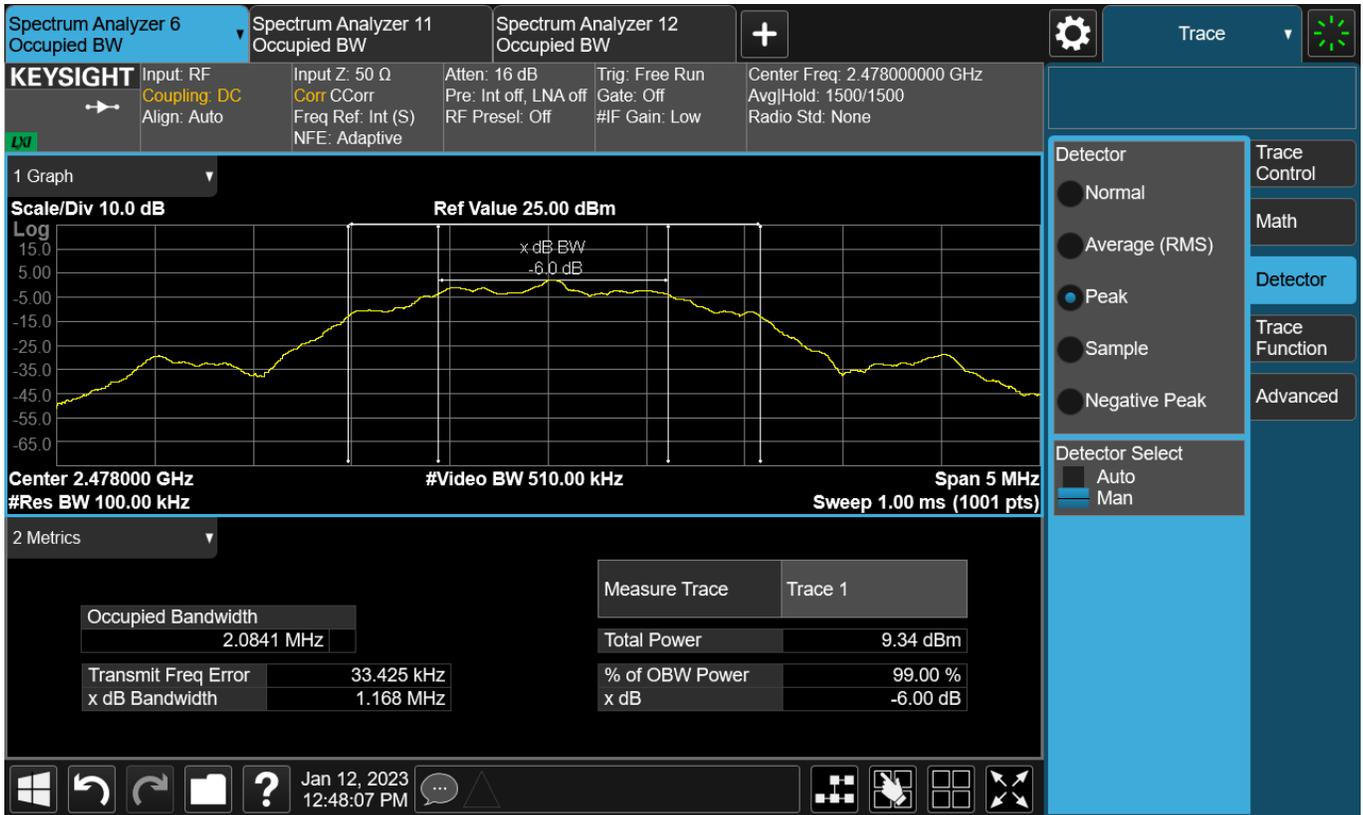


Figure TR8.7: Spectral data for BLE 2 Mbps on the High frequency.

This line is the end of the test record.

Test Record
Transmitter Power
Test ID TR01
Project GCL-0305

Test Date(s) 13 Dec 2022
Test Personnel Majid Farah supervised by David Arnett

Product Model A04600
Serial Number tested 3431708548

Operating Mode M10 (all relevant radios ON)
Arrangement Standalone
Input Power Internal Battery

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

Antenna Gain -3.7 dBi (as reported by the client)
Radio Protocol BLE (Bluetooth Low Energy), ANT
Hopping Frequencies Treated as a non-hopping system

Pass/Fail Judgment: PASS

Test record created by: Majid Farah
Date of this record: 21 Dec 2022
Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	13-Jul-2022	15-Jul-2023

Table TR01.1 Equipment used

Software used: R&S Power Viewer V11.3. 3.2.2020., TimePowerAnalysisSpreadsheetV7.xlsx

Test Method

The basic test standards provide options for the test method. The measurements here are the peak of the power measured with an RF Power Sensor. The following test methods were applied.

ETSI EN 300 328: 5.4.2.2.1.2 , 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.

BLE and ANT operate on channels from 2402 to 2480 MHz. BLE channels are every 1 or 2 MHz apart and ANT channels are 1 MHz apart. The channels tested were 2402, 2403, 2404, 2422, 2442, 2444, 2462, 2472, 2478, 2779 and 2480 MHz when applicable.

The highest power values for each type of radio signals with consideration of antenna gain are highlighted in below.

Freq., MHz	2402	2404	2422	2442	2462	2478	2480
Tx Power,dBm EIRP	-1.29	-1.30	-1.34	-1.39	-1.44	-1.50	-1.50
Tx Peak Power, dBm	2.62	2.61	2.60	2.51	2.47	2.41	2.40

Table TR01.2 BLE 1 Mbps

Freq., MHz	2402	2404	2422	2442	2462	2478	2480
Tx Power,dBm EIRP	N/A	-1.90	-1.97	-1.94	-2.03	-2.07	N/A
Tx Peak Power, dBm	N/A	2.63	2.55	2.59	2.49	2.45	N/A

Table TR01.3 BLE 2 Mbps

Freq., MHz	2402	2403	2404	2422	2442	2462	2478	2479	2480
Tx Power,dBm EIRP	-1.24	-1.24	-1.24	-1.34	-1.39	-1.38	-1.42	-1.43	-1.43
Tx Peak Power, dBm	2.58	2.56	2.56	2.57	2.51	2.42	2.38	2.37	2.39

Table TR01.4 ANT GFSK

Setup Diagram

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

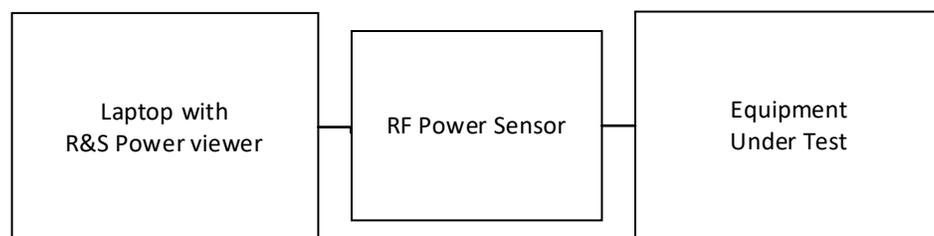


Figure TR01.1 Setup Diagram

This line is the end of the test record.

Test Record
Conducted Spurious Emissions Test TR12
Project GCL0305

Test Date(s) 18 Jan 2023
 Test Personnel David Arnett

Product Model A04600
 Serial Number tested 3431708548

Operating Mode M5 (BLE Tx)
 Arrangement A1 (PwrA)
 Input Power 5V dc

Test Standards: FCC Part 15, ANSI C63.10, AS/NZS 4268, RSS-GEN, RSS-247 (as noted in Section 6 of the report).

Pass/Fail Judgment: PASS

Test record created by: David Arnett
Date of this test record: 27 Jan 2023

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023

Table TR12.1: Test equipment used

Test Software used: Keysight MXE System Code rev. A.33.03.

Test Data

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

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

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

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

The peak level of the fundamental is also identified. The harmonics 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

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

Channel	Low		Channel	Mid		Channel	High	
Frequency	Level	Reduction	Frequency	Level	Reduction	Frequency	Level	Reduction
GHz	dBm	dBc	GHz	dBm	dBc	GHz	dBm	dBc
2.40202	2.74	0	2.44202	2.29	0	2.48002	2.32	0
4.80401	-48.59	51.33	4.88342	-49.56	51.85	4.96008	-48.18	50.50
20.75810	-51.62	54.36	21.53541	-51.53	53.82	22.28202	-51.43	53.75
23.89058	-49.98	52.72	24.37051	-50.88	53.17	24.20645	-50.66	52.98
24.20520	-50.57	53.31	24.83894	-51.27	53.56	24.76653	-50.95	53.27

Table TR12.2: Results Summary for BLE at 1 Mbps data rate

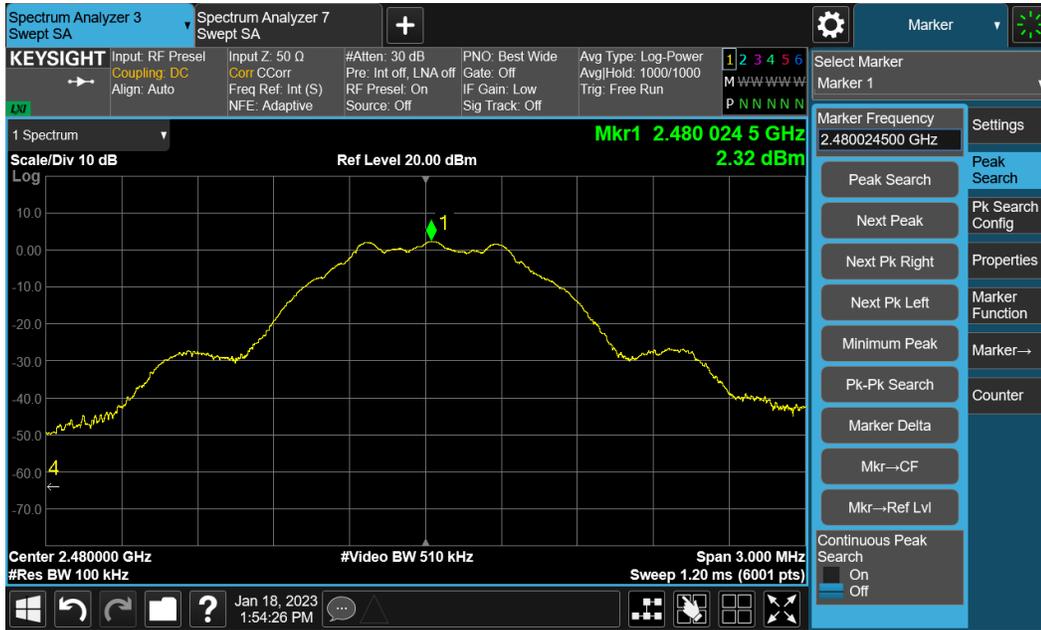


Figure TR12.1: BLE carrier at 1 Mbps data rate, 2480 MHz channel

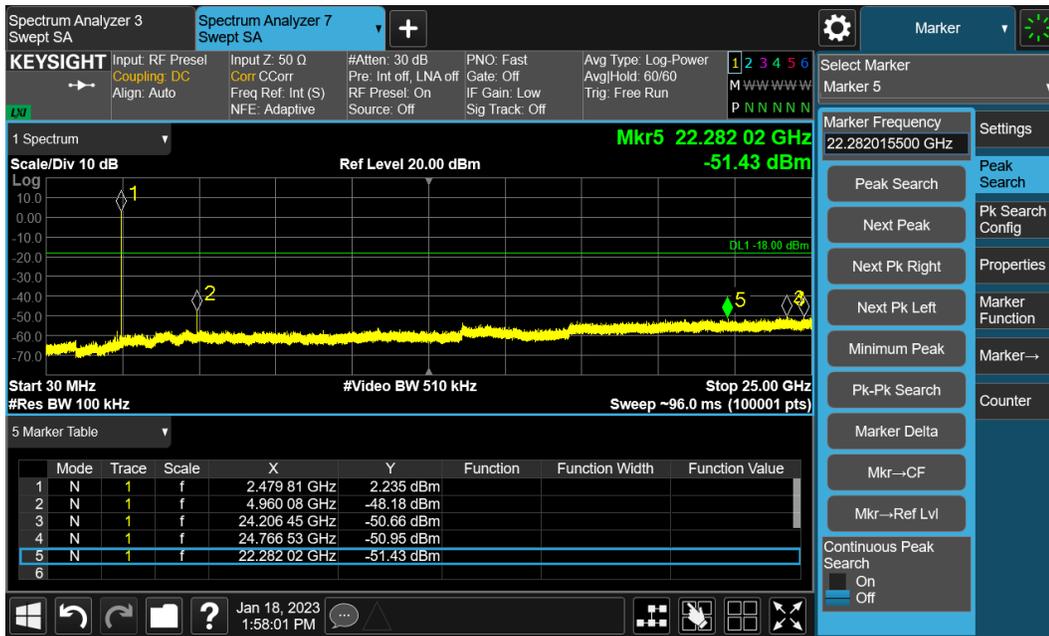


Figure TR12.2: Spectral data, BLE at 1 Mbps data rate, 2480 MHz channel

Channel	Low		Channel	Mid		Channel	High	
Frequency	Level	Reduction	Frequency	Level	Reduction	Frequency	Level	Reduction
GHz	dBm	dBc	GHz	dBm	dBc	GHz	dBm	dBc
2.40402	2.64	0	2.44202	2.29	0	2.47802	2.39	0
4.80801	-49.05	51.69	4.88492	-51.58	53.87	4.95508	-50.09	52.48
19.19622	-51.21	53.85	21.34239	-51.01	53.30	20.28966	-51.73	54.12
24.01393	-51.08	53.72	24.22169	-50.39	52.68	24.30683	-50.68	53.07
24.88494	-50.40	53.04	24.96904	-50.43	52.72	24.97203	-50.54	52.93

Table TR12.3: Results Summary for BLE at 2 Mbps data rate



Figure TR12.3: BLE carrier at 2 Mbps data rate, 2404 MHz channel

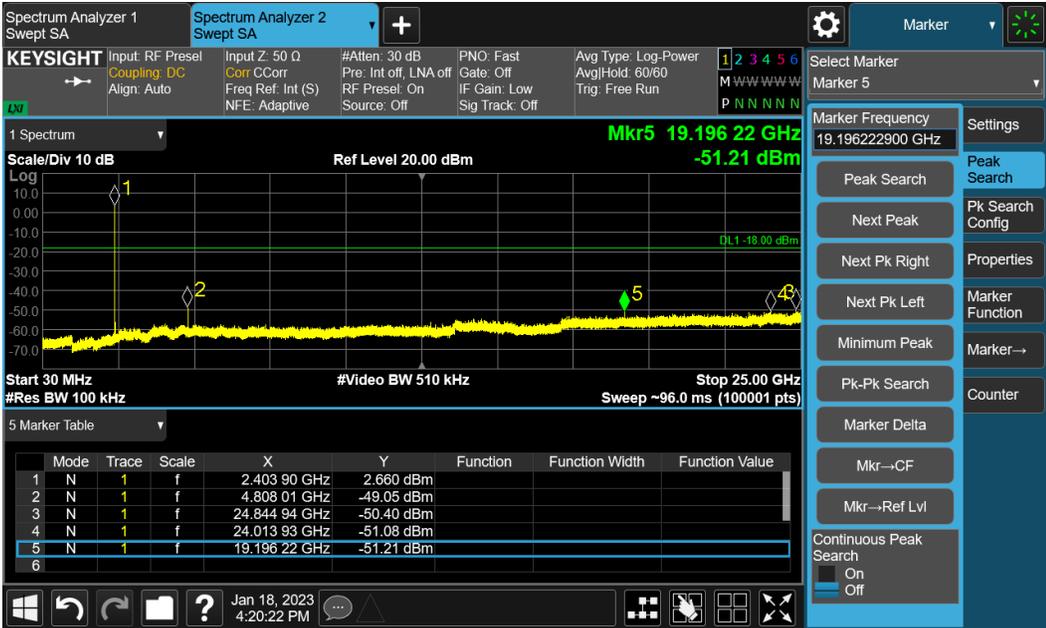


Figure TR12.4: Spectral data, BLE at 1 Mbps data rate, 2404 MHz channel

Test Setup

This block diagram shows the test equipment setup.

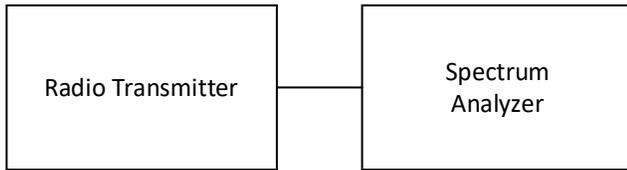


Figure TR12.5: Test setup

This line is the end of the test record.

Test Record
Radiated Emission Test RE07
Project GCL0305

Test Date(s) 28 Nov 2022 – 29 Nov 2022
 Test Personnel David Kerr, Jim Solum (Assisted)

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M5 (BLE Tx) 1Mbps
 Arrangement A1 (PwrA)
 Input Power USB 5 Vdc

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

Frequency Range: FCC Restricted Bands (2200-2390MHz, 2483.5-2500MHz)
Pass/Fail Judgment: PASS

Test record created by: David Kerr, Jim Solum
Date of this record: 05 DEC 2022

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	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
3 GHz High Pass filter	Anatech Electro	0K0R2	01	Calibration	Not Required
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE07.1: Test Equipment Used

Software Used

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

Test Data

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

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

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

Frequency (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	32.76	52.959	21.24	21.041	-146	1597	VERT	X
2386	54	74	32.808	49.909	21.192	24.091	-181	1525	VERT	X

Table RE07.2: 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
2484	54	74	31.452	45.03	22.548	28.97	-44	3821	VERT	Z
2483.5	54	74	31.501	44.902	22.499	29.098	0	3163	VERT	Z

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

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

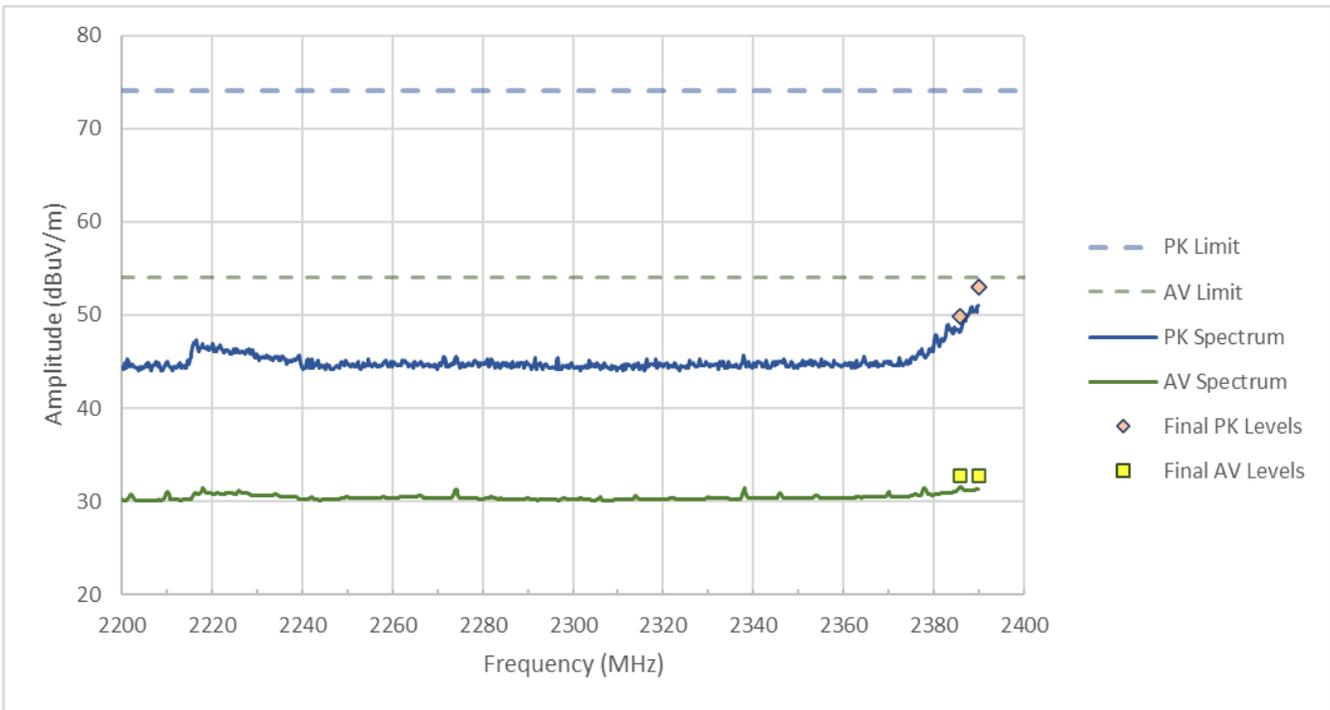


Figure RE07.1: FCC restricted band spectral data from 2200 to 2390 MHz

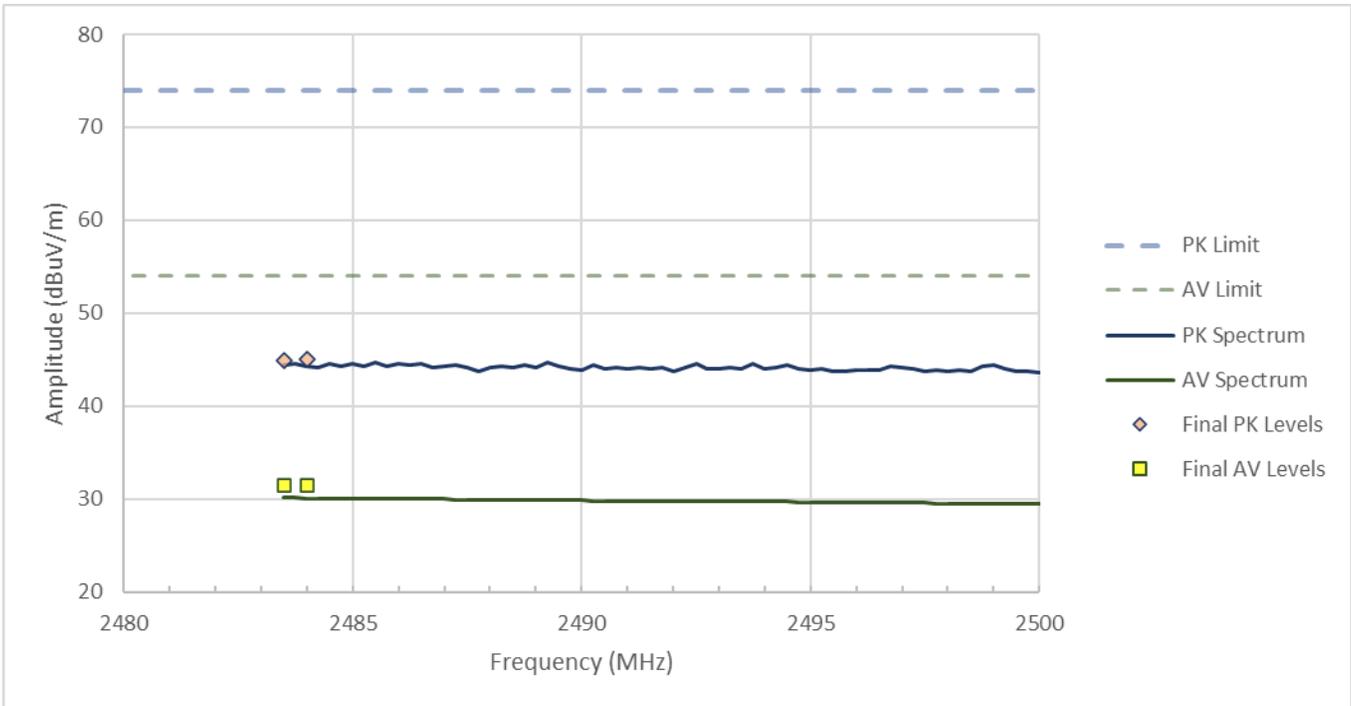


Figure RE07.2: FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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



Figure RE07.3: Z orientation front of EUT



Figure RE07.4: Z orientation rear of EUT



Figure RE07.5: X orientation front of EUT



Figure RE07.6: X orientation rear of EUT

This line is the end of the test record.

Test Record
Radiated Emission Test RE08
Project GCL0305

Test Date(s) 28 Nov 2022 – 29 Nov 2022
 Test Personnel David Kerr, Jim Solum (Assisted)

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M5 (BLE Tx) 2Mbps
 Arrangement A1 (PwrA)
 Input Power USB 5 Vdc

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

Frequency Range: FCC Restricted Bands (2200-2390MHz, 2483.5-2500MHz)
Pass/Fail Judgment: PASS

Test record created by: David Kerr, Jim Solum
Date of this record: 05 DEC 2022

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	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
3 GHz High Pass filter	Anatech Elect	OK0R2	01	Calibration	Not Required
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE08.1: Test Equipment Used

Software Used

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

Test Data

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using on the orientation(s) producing the highest result relative to the test limit. Where the test standard requires cable manipulation, this was done at one of more likely worst case frequencies selected by the test personnel while observing the receiver display. At each of the frequencies selected for final measurements, the turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings. Final field strength

measurements were taken in that set of positions. Full maximization was not performed at frequencies that are noise floor measurements included per the test standard requirements.

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

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

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	EUT
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	Orientation
2390	54	74	32.69	51.201	21.31	22.799	-155	1506	VERT	X
2388	54	74	32.631	49.666	21.369	24.334	-180	1537	HORZ	X

Table RE08.2: FCC restricted band from 2200 to 2390 MHz

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	EUT
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	Orientation
2487	54	74	31.251	44.907	22.749	29.093	80	1673	HORZ	Z
2483.5	54	74	31.544	44.96	22.456	29.04	-109	1581	HORZ	Z

Table RE08.3: FCC restricted band from 2483.5 to 2500 MHz

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

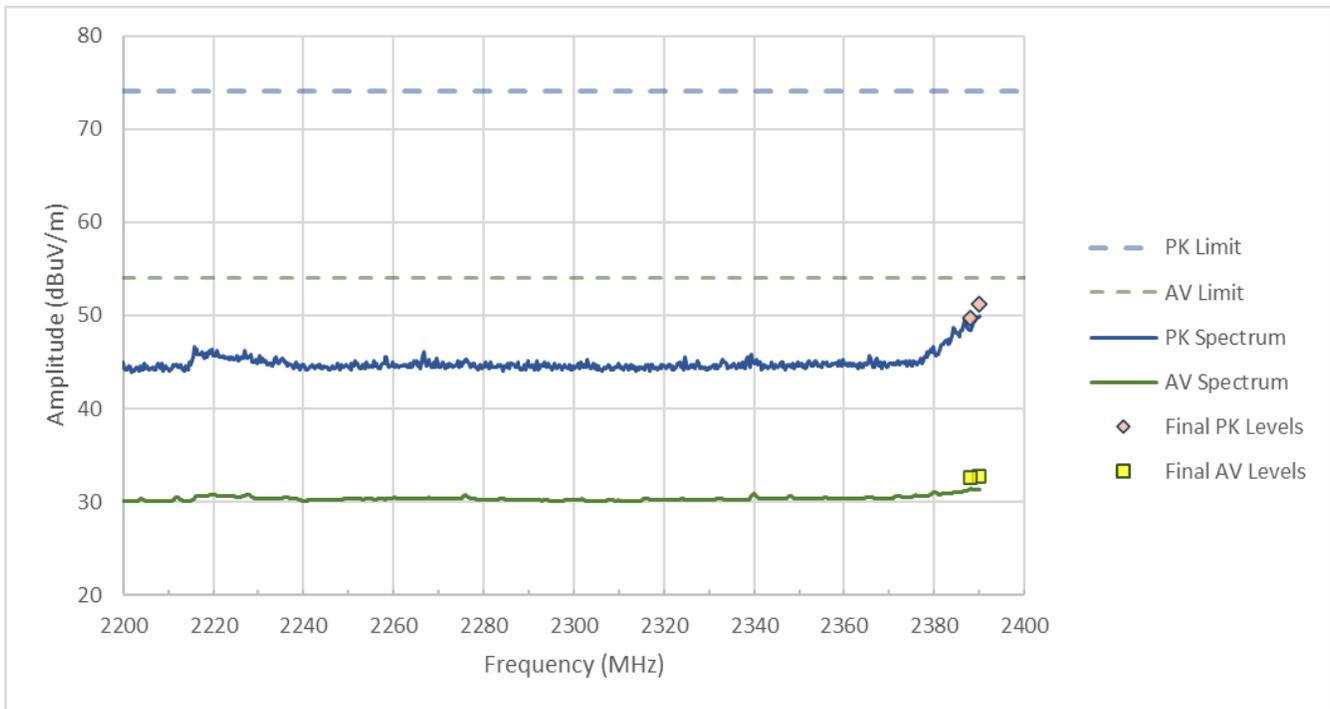


Figure RE08.1: FCC restricted band spectral data from 2200 to 2390 MHz

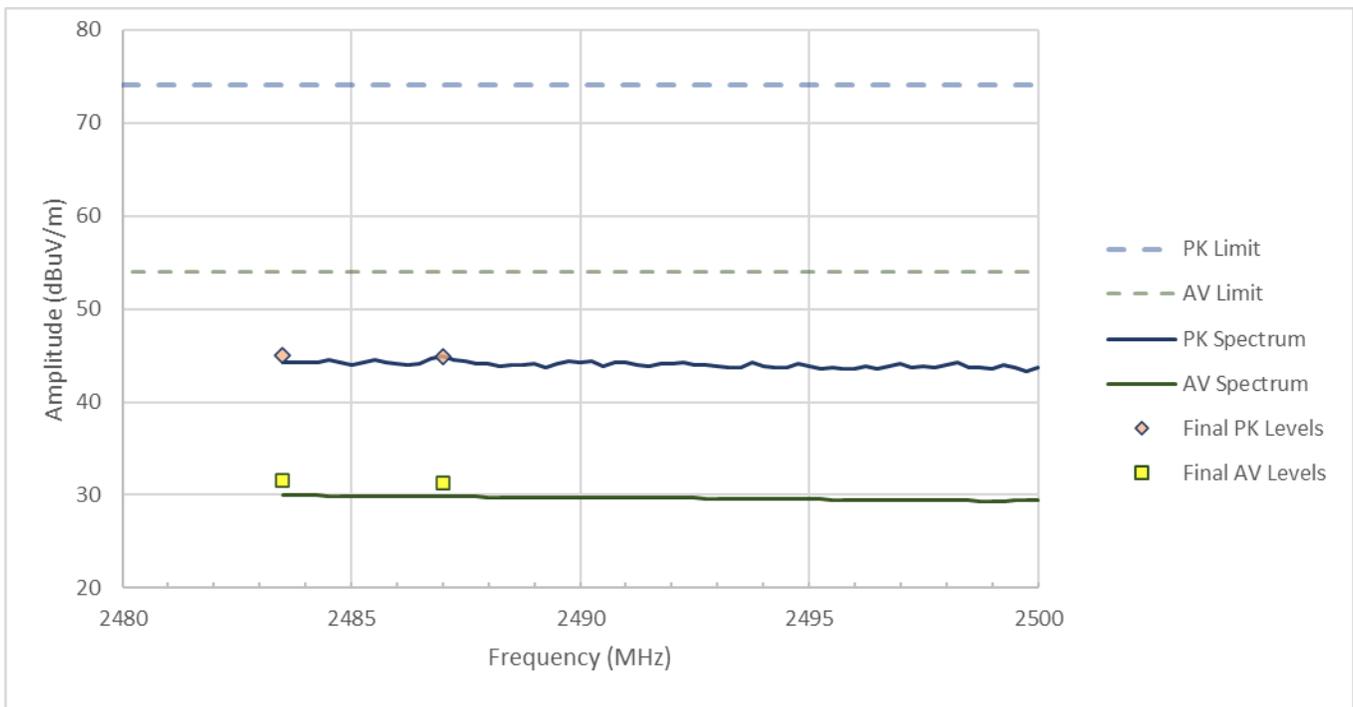


Figure RE08.2: FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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

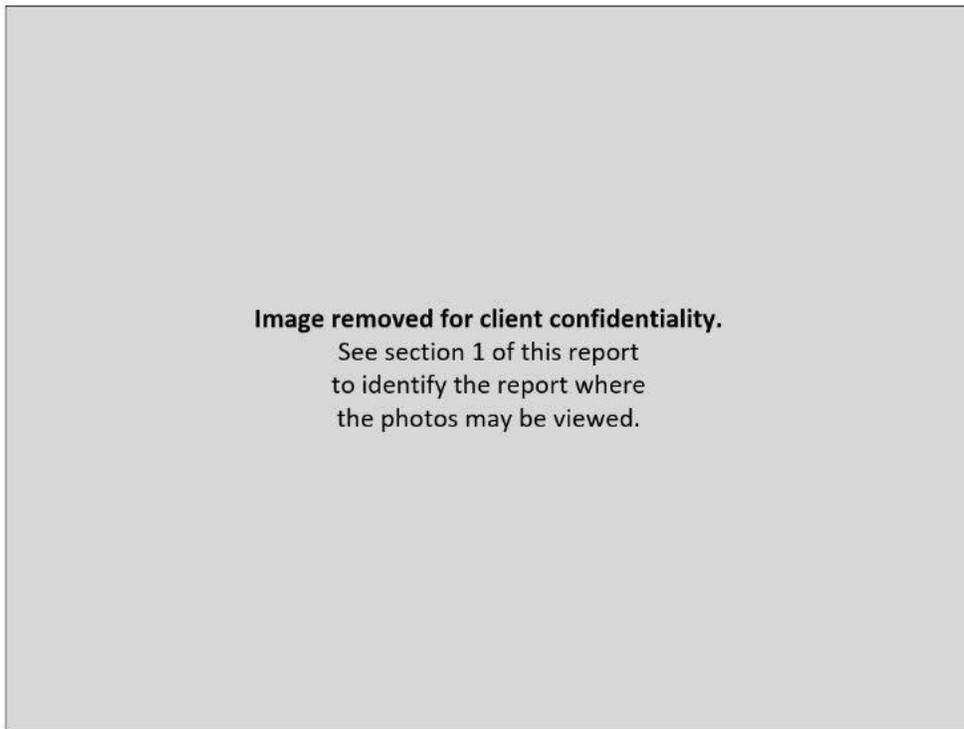


Figure RE08.3: Z orientation front of EUT



Figure RE08.4: Z orientation rear of EUT

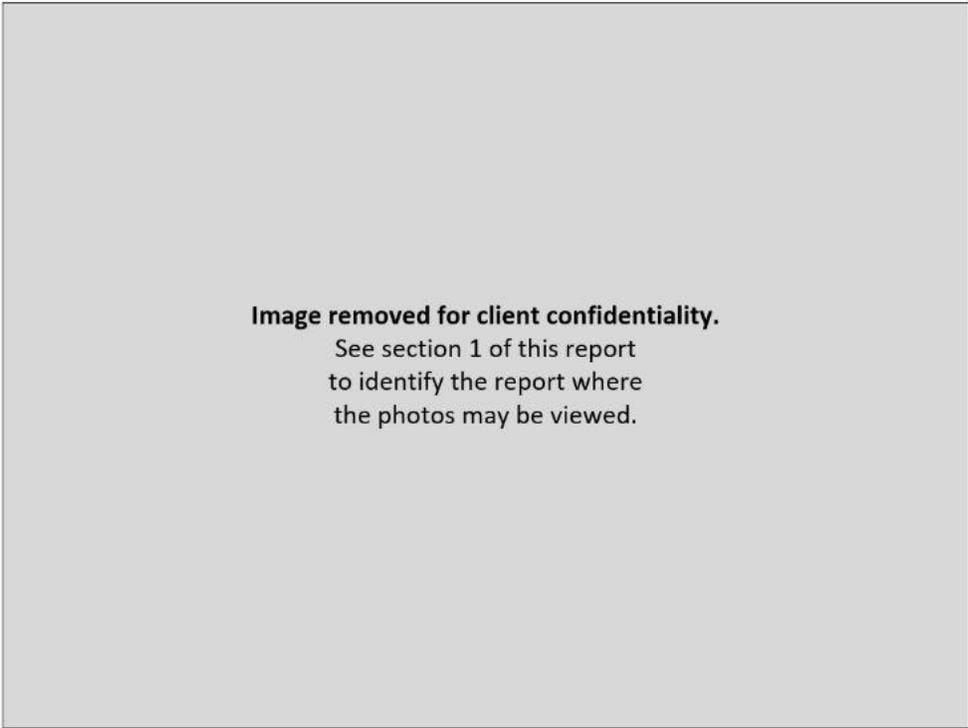


Figure RE08.5: X orientation front of EUT

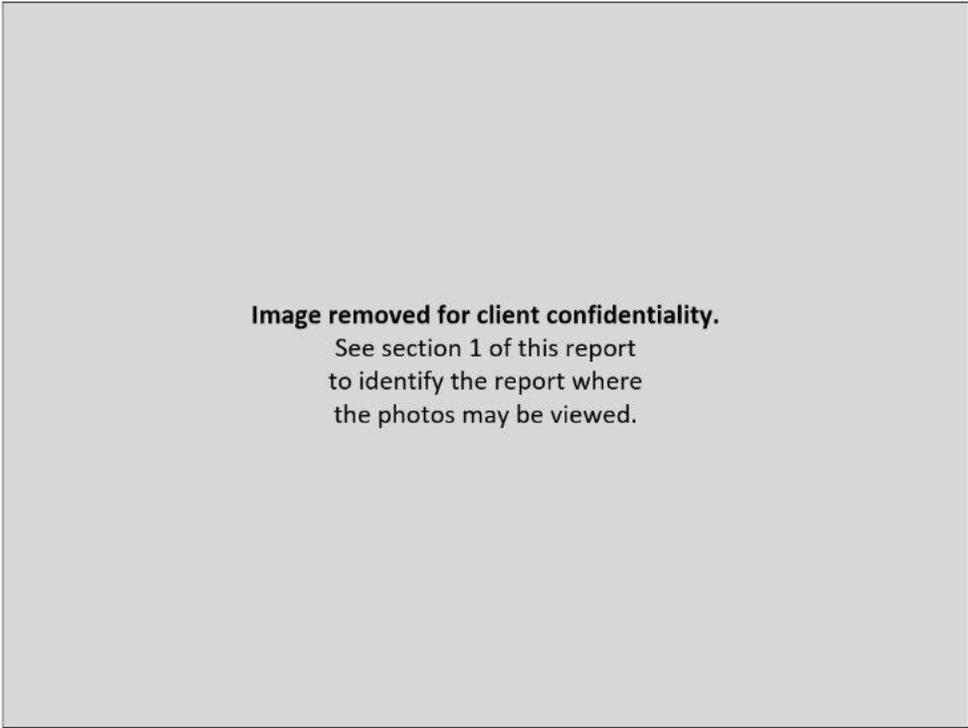


Figure RE08.6: X orientation rear of EUT

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test IDs TR4
Project GCL-0305

Test Date(s) 12 Jan 2023
 Test Personnel David Arnett

Product Model A04600
 Serial Number tested 3431708548

Operating Mode M5 (BLE Tx)
 Arrangement A1 (PwrA)
 Input Power 5V dc

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 -3.7 dBi, as reported by the client
 Radio Protocol Bluetooth Low Energy (BLE)

Pass/Fail Judgment: PASS

Test record created by: David Arnett
Date of this record: 24 Jan 2023
 Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023

Table TR4.1: Test equipment used

Software Used: Keysight PXE software A.33.03

Test Method

The basic test standards provide options for the test method. The following test methods were applied.
 ANSI C63.10: PKPSD (11.10.2)

Test Setup

This block diagram shows the test equipment setup.

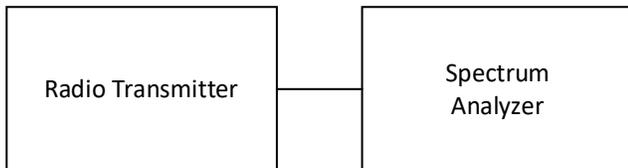


Figure TR4.1: Test setup

Test Data

Each measurement is made conducted from the antenna port with the transmitter on a specified channel and in a selected transmission protocol. The results include the effects of any measurement cable losses. Results reported as EIRP include the effect of antenna gain.

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

Mode	Tx Freq.	SA Level
-----	(MHz)	(dBm)
1 Mbps	2402	2.2
1 Mbps	2442	1.8
1 Mbps	2480	2.03
2 Mbps	2404	-0.4
2 Mbps	2442	-0.87
2 Mbps	2478	-0.66

Table TR4.2: Summary of results



Figure TR4.3: Test data for 1 Mbps BLE on 2402 MHz

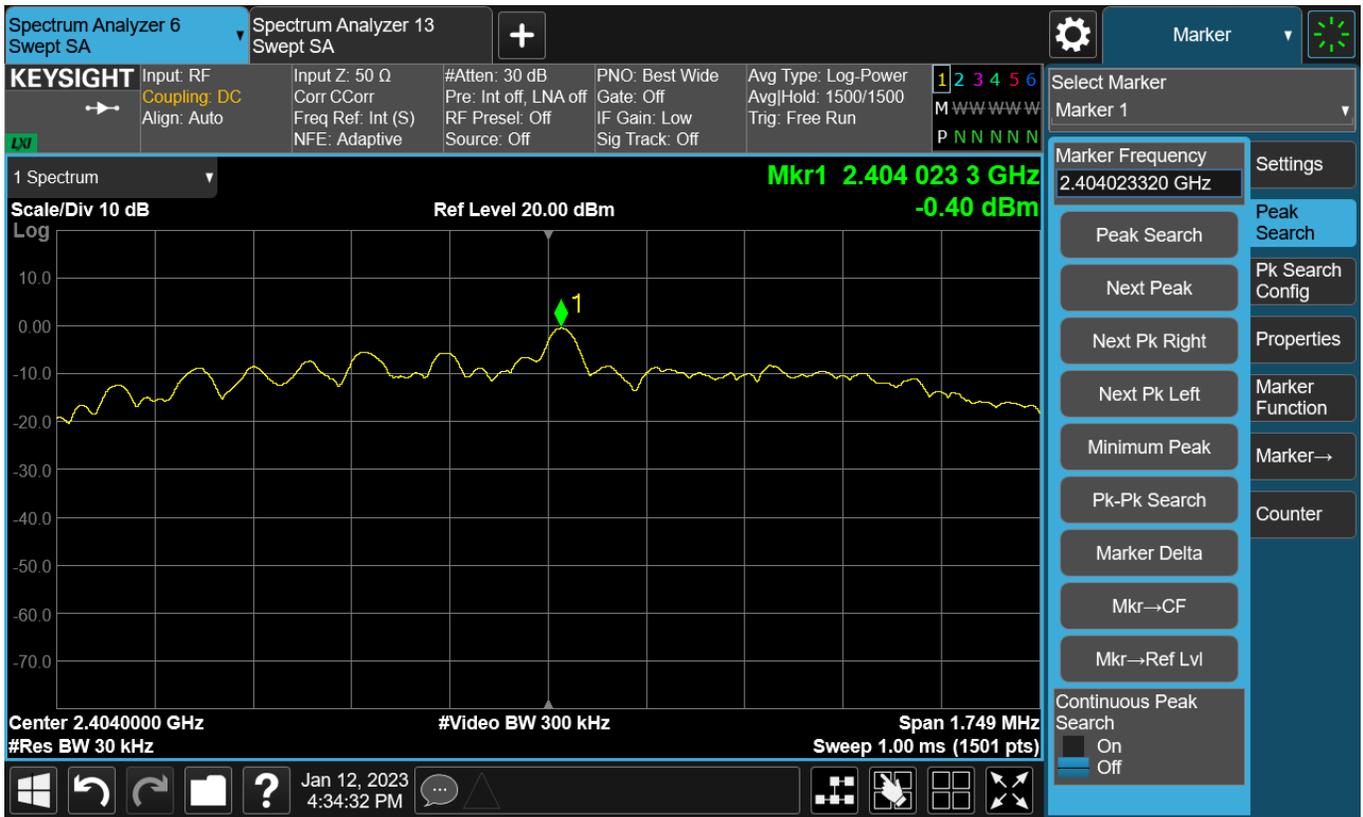


Figure TR4.4: Test data for 2 Mbps BLE on 2404 MHz

This line is the end of the test record.

Test Record
Transmitter Frequency Stability
Test IDs TR17
Project GCL-0305

Test Date(s) 12 - 13 Jan 2023
 Test Personnel Majid Farah and Jim Solum supervised by David Arnett
 Product Model A04600
 Serial Number tested 3431708497 and 3431708344

Operating Mode M5 (BLE Tx)
 Arrangement A1 (PwrA)
 Nominal Input Power 5 Vdc

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

Radio Protocol BLE (Bluetooth Low Energy)

Pass/Fail Judgment: PASS

Test record created by: Majid Farah, assisted by Dave Arnett
Date this record: 28 Feb 2023

Original record, Version A, was created on 19 Jan 2023.
 Version B created on 28 Feb 2023 excludes data from radios other than BLE.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
DMM Multimeter	FLUKE	79 III	71740743	18-Apr-2022	15-Apr-2023
Signal analyzer PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Thermometer	Thermco	ACCD370P	210607316	11-Aug-2021	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Programmable DC power source	Keithley	2260B-30-72 720 W	14911917	6-Nov-2021	15-Feb-2023
Thermal Chamber	TPS	T2RC	611000116	21-Apr-22	15-Apr-2024
Near Field Probe set	Com-Power	PS-400	151679	Calibration	Not Required
NFC Reader	acs	ACR1252	RR554-086776	Calibration	Not Required

Table TR17.1: Equipment used

Software Used: PXE Software Revision A.32.06, 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 and ANT protocols have carriers that are intentionally closer to the band edge. The basic concept applied here is that the 6 dBc Occupied Bandwidth of the modulated signal should remain within the 2400-2483.5 MHz radio band. To evaluate this, the peak carrier level and the level at the band edge are compared to ensure that signal at the band edge is reduced at least 6 dB across the specified range of voltages and temperatures. The data is reported in terms of dBc as a positive value, meaning we report the ratio between the peak carrier signal level and the level at the band edge to demonstrate that the resulting intentional signals remained within the allowed band.

BLE and ANT use channel plan with a minimum transmission center frequency at 2402 MHz and a maximum at 2480 MHz. Although BLE has two data rate mode 1 Mbps and 2 Mbps and ANT has 1 Mbps.

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

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

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 then connected by a cable to the PXE analyzer. The analyzer was set up to detect radio signals from the test sample in a way to read carrier frequency with high resolution. The Standard indicated carrier frequency stability shall not exceed 0.01% of operation frequency.

The test temperatures range is from +50 °C to -20 °C by 10 °C decrement at each test step for nominal input voltage (5 V). The NFC carrier frequency was recorded four times at each temperature by 2, 5 and 10 minutes interval from first record. For the voltage variation test at +20 °C, the voltage is to be varied 15% above and below nominal input voltage. Data was taken at 5 Vdc and 15% lower at 4.25 Vdc plus 15% higher at 5.75 Vdc.

Test Data

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

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

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

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	°C	Vdc	dBc	dBc
BLE 1 Mbps	50	5	33.3	39.5
BLE 1 Mbps	40	5	32.3	38.9
BLE 1 Mbps	30	5	33.5	37.4
BLE 1 Mbps	20	5	32.2	37.1
BLE 1 Mbps	10	5	33.5	36.4
BLE 1 Mbps	0	5	33.6	35.1
BLE 1 Mbps	-10	5	33.9	34.8
BLE 1 Mbps	-20	5	33.2	33.9

Table TR17.2 Difference between peak and band edge levels for BLE 1 Mbps transmissions during temperature variations

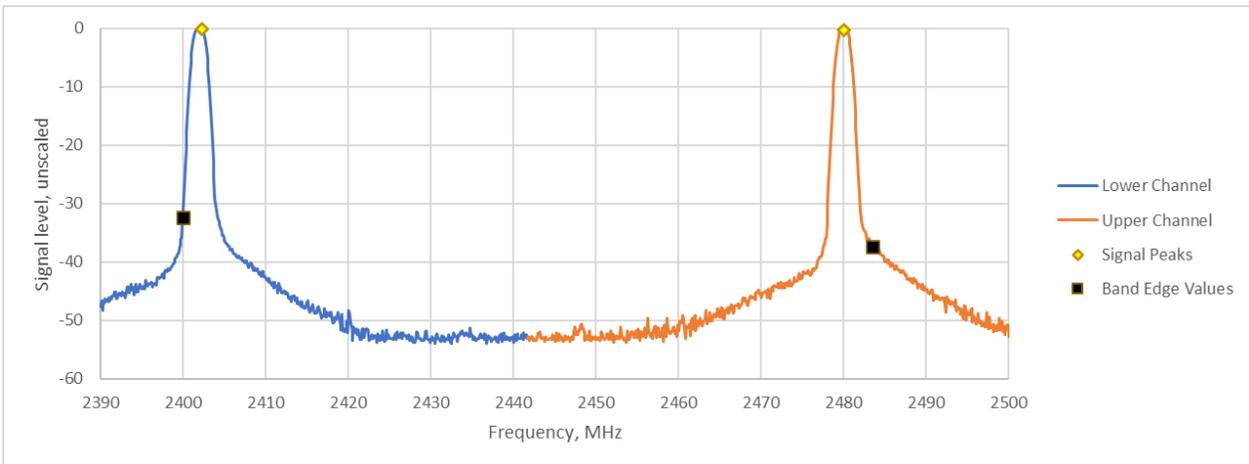


Figure TR17.1: Spectral data for BLE1 Mbps at 20 °C

Tx Mode	Temp °C	Volts Vdc	Low Ch. dBc	High Ch. dBc
BLE 2 Mbps	50	5	43.3	44.4
BLE 2 Mbps	40	5	43.5	42.2
BLE 2 Mbps	30	5	43.5	41.1
BLE 2 Mbps	20	5	42	39.6
BLE 2 Mbps	10	5	40.8	38.9
BLE 2 Mbps	0	5	38.1	36.9
BLE 2 Mbps	-10	5	37.1	36.2
BLE 2 Mbps	-20	5	36.3	35.4

Table TR17.3 Difference between peak and band edge levels for BLE 2 Mbps transmissions during temperature variations

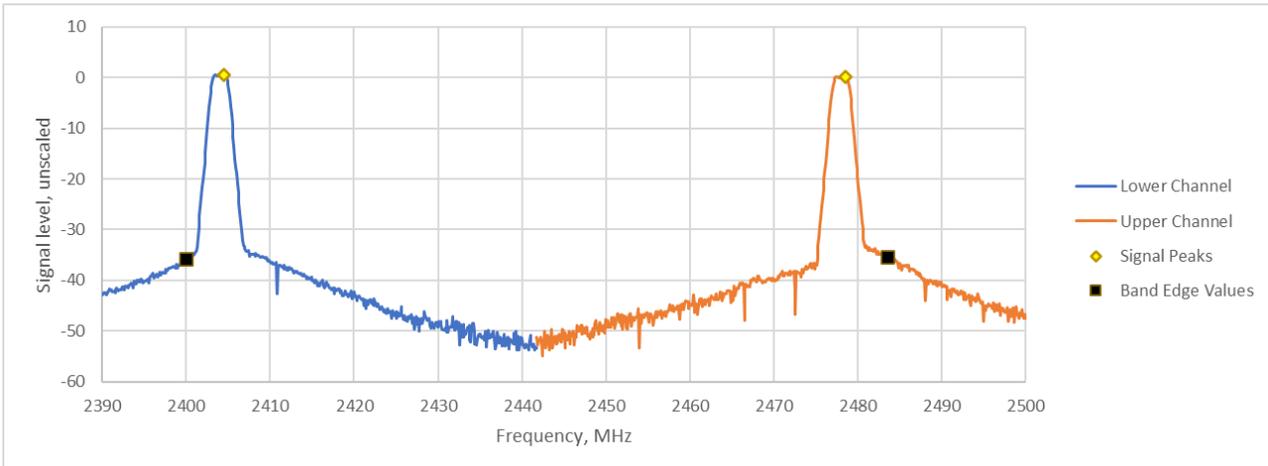


Figure TR17.2: Spectral data for BLE2 Mbps at -20 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	°C	Vdc	dBc	dBc
BLE 1 Mbps	20	4.25	33.2	37.1
BLE 1 Mbps	20	5	32.2	37.1
BLE 1 Mbps	20	5.75	33.7	37
BLE 2 Mbps	20	4.25	41.6	39.6
BLE 2 Mbps	20	5	42	39.6
BLE 2 Mbps	20	5.75	42.2	40.3

Table TR17.5 Difference between peak and band edge levels for BLE transmissions at 20 °C during voltage variations

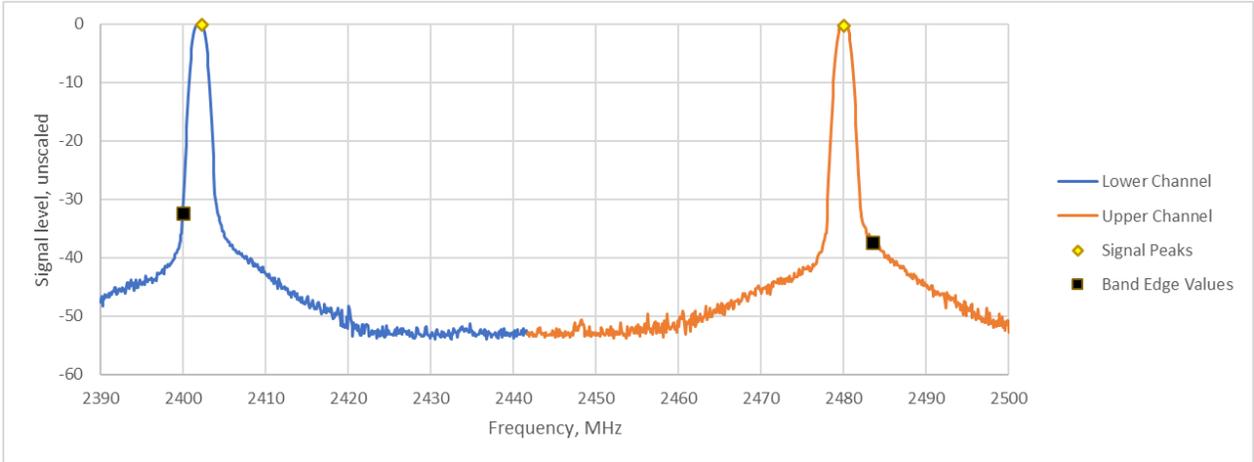


Figure TR17.4: Spectral data for BLE1 Mbps at 20 °C and 5 Vdc

Setup Block Diagram

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

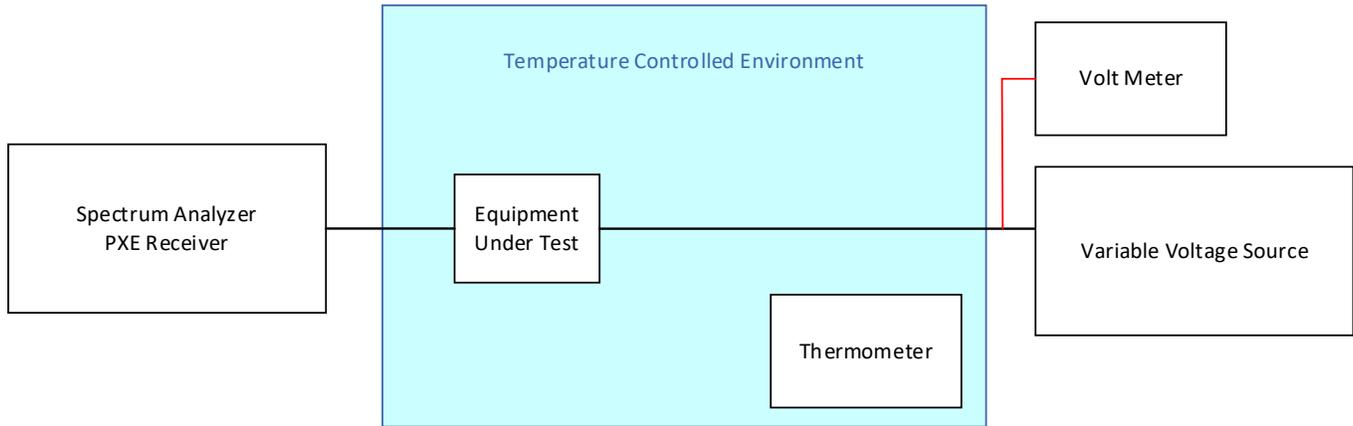


Figure TR17.5: Schematic drawing of the test equipment setup

This line is the end of the test record.

Test Record
Other Bandwidth Tests
Test IDs TR9A
Project GCL-0305

Test Date(s) 12 Jan 2021
 Test Personnel David Arnett

Product Model A04600
 Serial Number tested 3431708548

Operating Mode M5 (BLE Tx)
 Arrangement A1 (PwrA)
 Input Power 5V dc

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 2480 to 2483.5 MHz

Pass/Fail Judgment: Reported

Test record created by: David Arnett
Date of this record: 28 Feb 2023
 Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023

Table TR9A.1

Test Software used: Keysight MXE System Code rev. A.33.03.

Background

There are regulatory requirements to present two additional types of bandwidth analyses: 99% Occupied Bandwidth and Necessary Bandwidth. There are no limits or functional requirements around these data, beyond a reporting requirement. The contents of this test record are for information, and do not affect compliance of the devices that are the subject of this report.

Test Setup

This block diagram shows the test equipment setup.

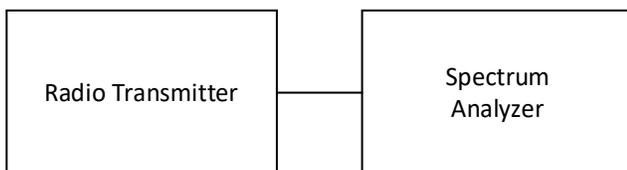


Figure TR9A.1: Test setup

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 are in bold font and have MHz as their units of measure.

The channel frequencies for BLE at 1 Mbps are 2402, 2442, and 2480 MHz. The channel frequencies for BLE at 2 Mbps are 2404, 2442, and 2478 MHz. These are called the Low, Mid, and High frequencies.

	BLE 1Mbps	BLE 2Mbps
Low	1048.5	2036.9
Mid	1053.7	2038.6
High	1054.4	2040.2
Mean	1052.2	2038.6
Unit	kHz	kHz

Table TR9A.2: Summary of 99% Occupied Bandwidth Data, BLE modes

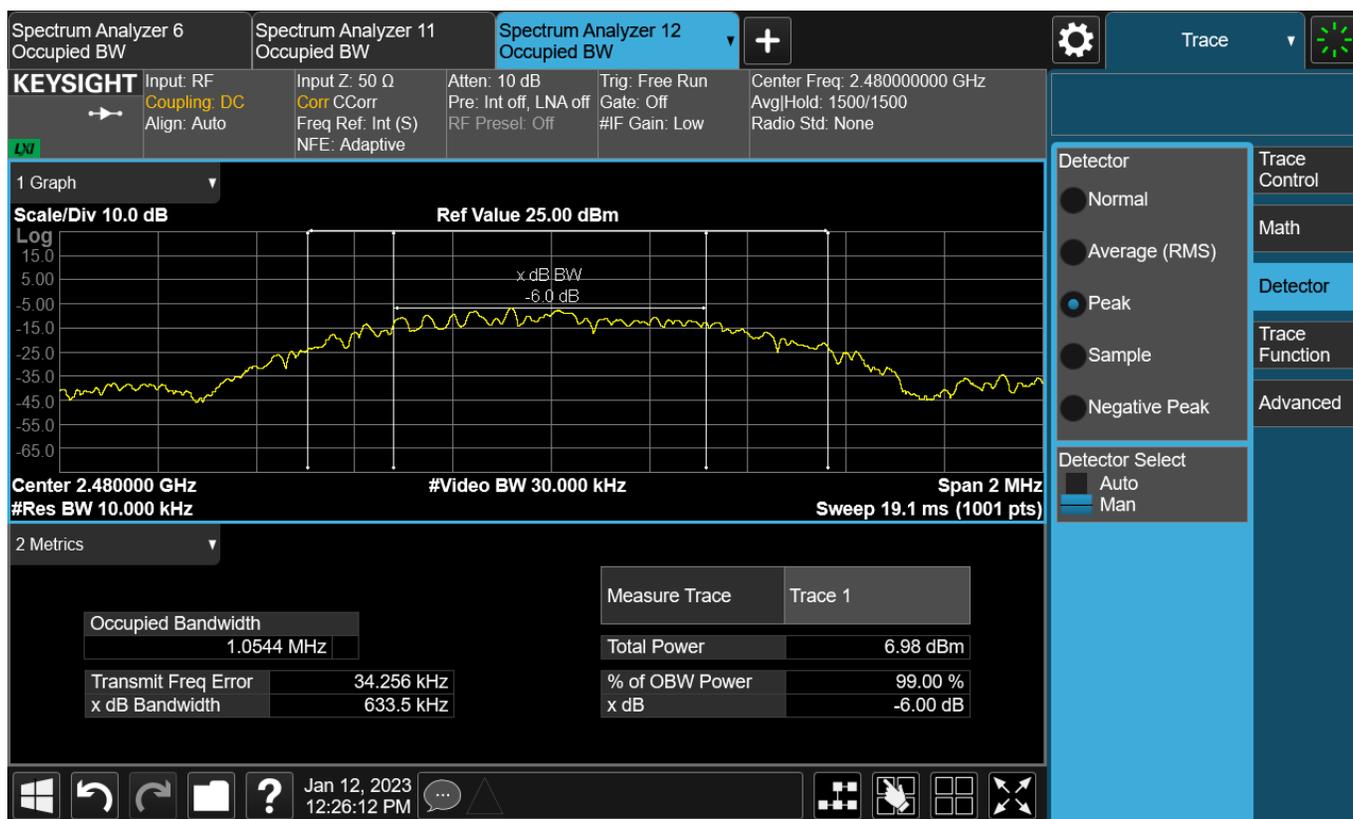


Figure TR9A.2: Occupied bandwidth data for BLE 1 Mbps at high channel (2480 MHz)



Figure TR9A.3: Occupied bandwidth data for BLE 2 Mbps at high channel (2478 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 radios signals as a combined approach, then separately analyze the results for IEEE 802.11g and n systems. The tables below may include radio protocols that are not part of the product being evaluated.

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

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

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 TR9A.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 TR9A.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 TR9A.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
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 TR9A.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 TR9A.105: Necessary Bandwidth for IEEE 802.11 g and n 20 MHz Radio Protocols (TRC-43)

This line is the end of the test record.

Test Record
Radiated Emission Test RE01
Project GCL0305

Test Date(s) 07 Dec 2022
 Test Personnel David Kerr

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M5 BLE Tx
 Arrangement A1 PwrA
 Input Power USB 5 Vdc

Test Standards: FCC Part 15, ANSI C63.10, CISPR 32, EN 55032, AS/NZS 4268, RSS-210 (as noted in Section 6 of the report).

Frequency Range: 30 MHz to 1000 MHz
Pass/Fail Judgment: PASS

Test record created by: David Kerr, Jim Solum
Date of this record: 08 Dec 2022

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Antenna, Biconilog, 30M-6 GHz	ETS Lindgren	3142E	00233201	19-Jul-2022	15-Jul-2024
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	25-Oct-2021	25-Oct-2024
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE01.1: Test Equipment Used

Software Used

Keysight PXE N9048B Firmware version A.32.06
 RE Signal Maximization Tool v2021Feb25.xlsx
 RE 30M to 1G Data Analysis Template V3 2022May10.xlsx

Test Data

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

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

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

The table shows the selected final measurement data between 30 MHz and 1 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted 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 Composite FCC/CISPR Class B Limit at 3m.

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.120	40.0	27.4	12.6	0	1000	*
95.700	40.0	18.9	21.1	-68	1012	VERT
404.100	46.0	24.2	21.8	0	1000	*
687.780	46.0	30.8	15.2	0	1000	*
851.550	46.0	30.3	15.7	0	1000	*
944.130	46.0	33.9	12.1	-38	3616	HORZ

Table RE01.2: Emission summary

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

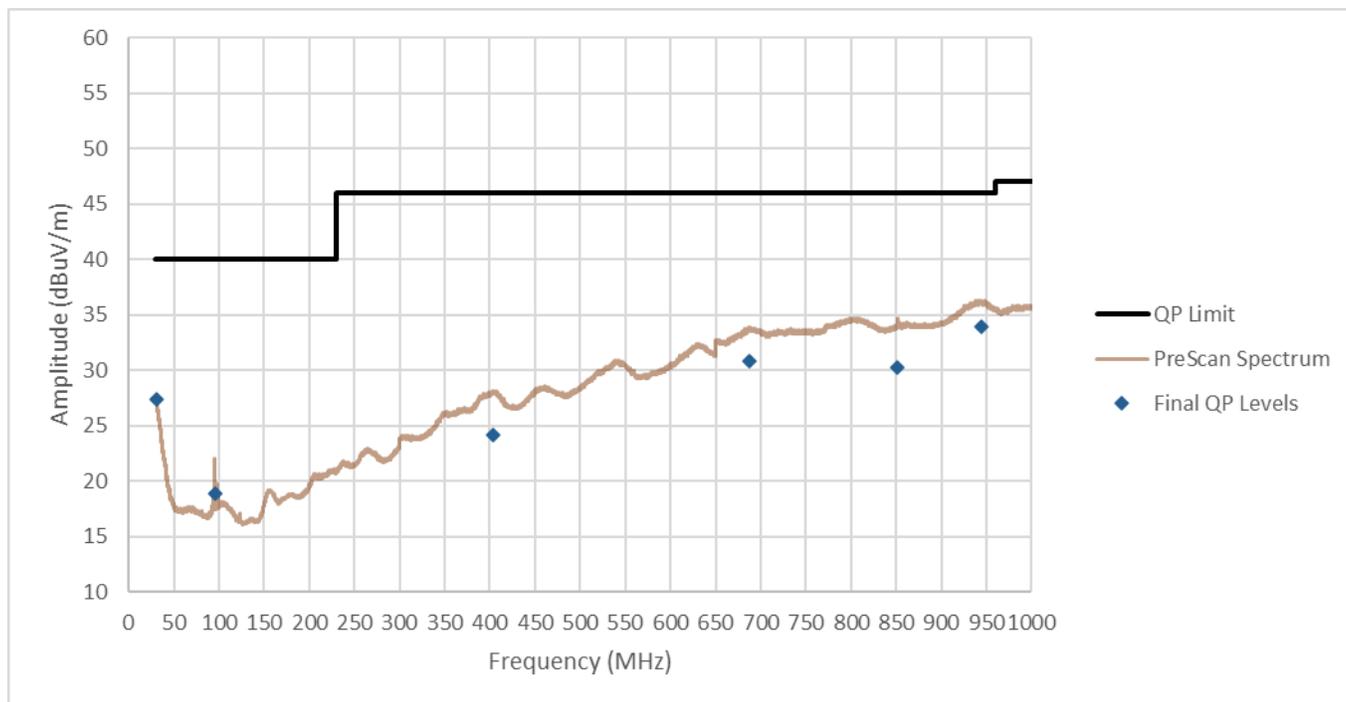


Figure RE01.1: Spectral data

Setup Photographs

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



Figure RE01.2: Front EUT test setup



Figure RE01.3: Rear EUT test setup

This line is the end of the test record.

Test Record
Radiated Emission Test RE04
Project GCL0305

Test Date(s) 05 Dec 2022
 Test Personnel David Kerr (assisted by Jim Solum)

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M7 GNSS
 Arrangement A3 PwrPC (Powered thru USB port of Laptop)
 Input Power 5 Vdc

Test Standards: FCC Part 15, ANSI C63.4, ICES-003, CISPR 32, EN 55032, AS/NZS 4268, RSS-GEN, RSS-210 (as noted in Section 6 of the report).

Frequency Range: 1 GHz to 6 GHz
Pass/Fail Judgment: PASS

Test record created by: David Kerr, Jim Solum
Date of this record: 05 Dec 2022

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	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
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE04.1: Test Equipment Used

Software Used

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

Test Data

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

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

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

The table shows the selected final measurement data between 1 GHz and 6 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 Composite FCC/CISPR Class B Limit at 3m.

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
1329.000	50.0	70.0	29.4	50.7	20.6	19.3	-12	1304	VERT
1495.250	50.0	70.0	29.6	49.0	20.4	21.0	-21	1202	VERT
1663.750	50.0	70.0	29.5	48.4	20.5	21.6	-21	1127	VERT
1961.750	50.0	70.0	37.1	51.8	12.9	18.2	68	2347	HORZ
1993.500	50.0	70.0	32.1	53.5	17.9	16.5	-45	3948	VERT
5908.750	54.0	74.0	38.8	52.7	15.2	21.3	69	3511	HORZ

Table RE04.2: Emission summary

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

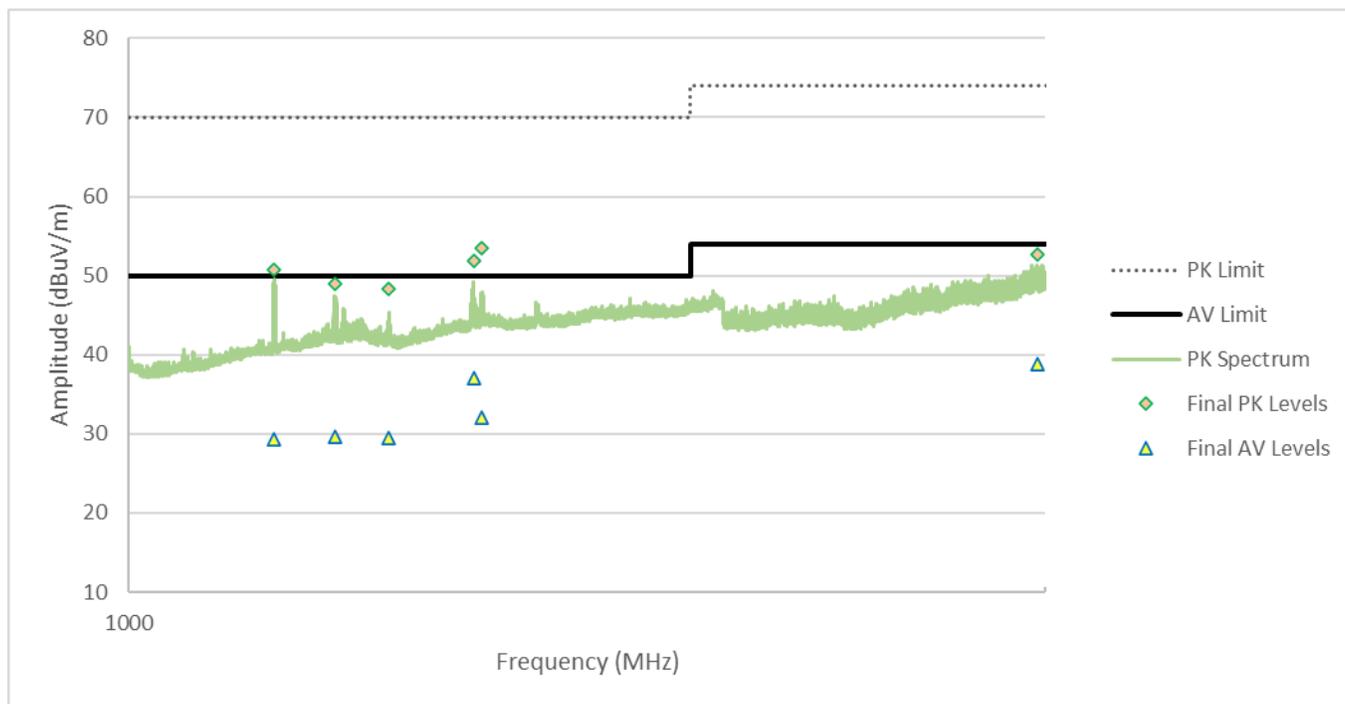


Figure RE04.1: Spectral data

Setup Photographs

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



Figure RE04.2: EUT test setup front



Figure RE04.3: EUT test setup back
This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE02
Project GCL0305

Test Date(s) 20 Dec 2022
 Test Personnel Christian Shepherd (assisted by Jim Solum)

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M5 BLE Tx
 Arrangement A1 (PwrA) USB adapter input power 120V / 60 Hz
 Input Power USB 5 Vdc

Test Standards: FCC Part 15, ANSI C63.4 (as noted in Section 6 of the report).

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

Test record created by: Jim Solum
Date of this record: 21 Dec 2022

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
LISN multiline; 20A 50uH	Com-Power	LIN-120C	20160005	22-Aug-2022	15-Aug-2023
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023

Table CE02.1: Test Equipment Used

Software Used

Keysight PXE N9048B Firmware version A.32.06
 CE Mains 150k to 30M Data Analysis V2 2021Jun10.xlsx

Test Data

The conducted emission test process began with a set of preliminary scans on both power conductors using both Quasi-Peak and Average detectors across the frequency range. Where the test standard requires cable manipulation, one or more likely worst case frequencies selected by the test personnel. Cables were manipulated to find the maximal signal strength while observing the receiver levels at those selected frequencies. At each of the frequencies selected for final measurements, Quasi-peak and Average detector readings were taken on each conductor.

The table shows the selected final measurement data. It includes at least the six strongest emissions observed relative to the limit lines, along with other data points of interest. The yellow highlight indicate the data points with the least margin to the quasi-peak detector limit and the average detector limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit.

Frequency (kHz)	QP Limit (dBuV)	AV Limit (dBuV)	L1 QP (dBuV)	L2 QP (dBuV)	L1 AV (dBuV)	L2 AV (dBuV)	QP Margin (dB)	AV Margin (dB)
150	66.00	56.00	55.02	50.42	27.84	25.25	10.98	28.16
173	64.84	54.84	50.88	47.08	24.38	22.49	13.96	30.46
195	63.82	53.82	54.65	42.93	25.92	22.46	9.17	27.90
218	62.91	52.91	50.06	47.23	26.54	24.43	12.85	26.37
276	60.94	50.94	37.09	50.59	19.54	22.64	10.34	28.29
292	60.47	50.47	48.65	42.65	22.52	21	11.83	27.96

Table CE02.2: Emission summary

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

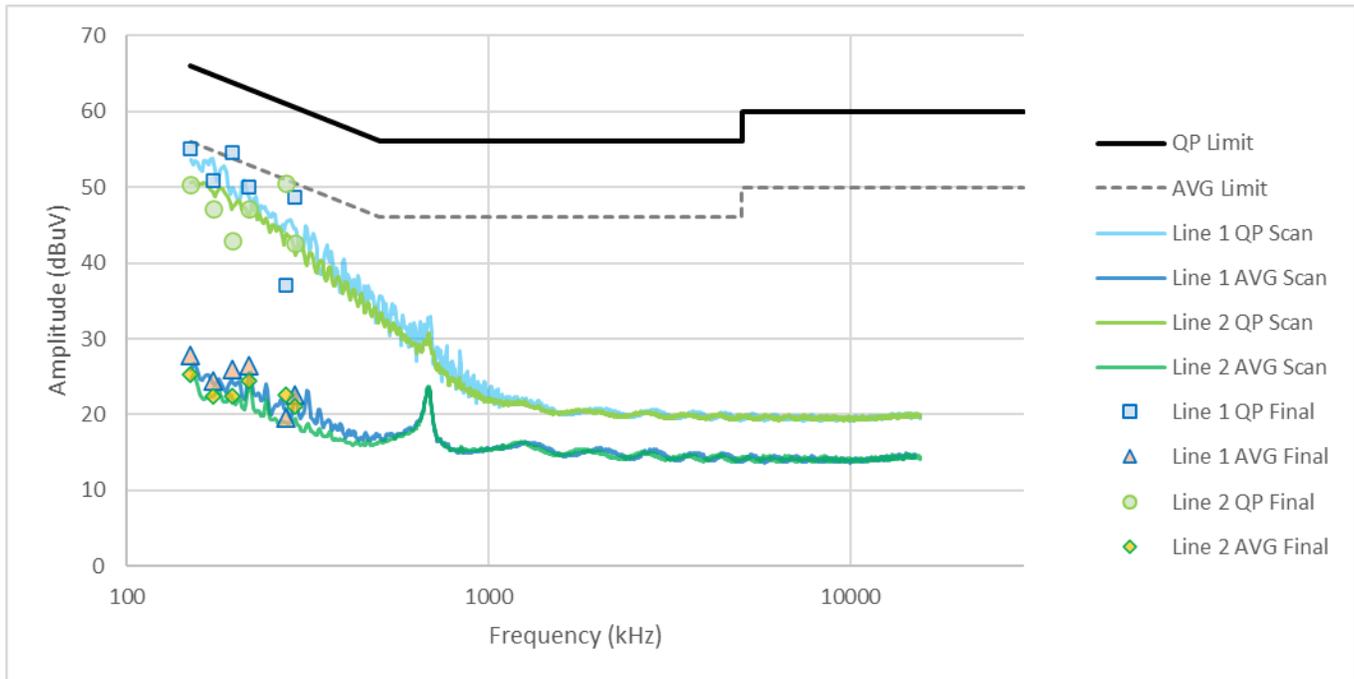


Figure CE02.1: Spectral data

Setup Photographs

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



Figure CE02.2: EUT test setup (Front View)



Figure CE02.3: EUT test setup (Side View)



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

Figure CE02.4: EUT test setup (Back 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.

Test Report 2022-032

Version C

Issued 27 Mar 2023

Project GCL-0305

Model Identifier A04600

Primary Test Standard

FCC part 15

RSS-210 Issue 10

ICES-003 Issue 7

Garmin Compliance Lab

Garmin International

1200 E 151st Street

Olathe Kansas 66062 USA

Client-supplied Information

FCC ID: IPH-04600

IC ID: 1792A-04600



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

1. Summary

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

Parameter	Description	Key Performance Values	Result	Data starts at page
Restricted Bands	The radio must not emit in certain designated restricted frequency bands above a set of limit values. [15.205; RSS-210 at 7.1]	Emissions in the restricted bands were at least 21.48 dB below the applicable limits.	PASS	10
Carrier and Harmonic Emissions	The field strength from the radio carrier and its harmonics must meet specific limits at a 3 m test distance. [15.249(a); RSS-210 at B.10]	The limit is 50 mV/m (94 dBuV/m) in the carrier band, and 0.5 mV/m (54 dBuV/m) at all other frequencies. This sample demonstrated 9.40 dB of margin or greater.	PASS	15
Frequency Stability	The radio tuning must be robust over a range of temperature and supply voltage conditions. [RSS-Gen at 6.11]	Radio emissions remained within the allowed radio band under all environmental conditions tested.	PASS with caveat	32
Other Bandwidths	Bandwidth values are presented for 99% Occupied Bandwidth and Necessary Bandwidth	There are requirements to report these numbers, but they do not have performance limits.	Reported	36

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

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

Table 1: Summary of results

Report Organization

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

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2023-040. That report is treated as a part of this document by way of this reference.

2. Test Background

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

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

Test Sample received: 23 Nov 2022
Test Start Date: 28 Nov 2022
Test End Date: 01 Feb 2023

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

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

3. Report History and Approval

This report was written by Majid Farah and initially issued on 03 Feb 2023 as Version A. Version B was released on 1 Mar 2023. The FCC ID and IC ID numbers were added to the cover page per client request, and removed some data regarding radios that are not within the subject of this report.. Updates were made to the frequency axes of figures 14.1 through 14.6 and figures 15.1 through 15.6. Version C issued 27 Mar 2023 transferred additional sensitive materials to GCL Test Report 2023-040.

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:
None.

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model A04600
Serial Numbers Tested 3431708344, 3431708548, 3431708479, 3431708421, 3431708497

[Material removed for confidentiality. See section 1 of this report to identify the report where the material may be viewed]

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, ANT/ANT+, NFC
Radio Receivers: GNSS
Highest internal frequency: 2.484 GHz
Firmware Revision 1201

[Material removed for confidentiality. See section 1 of this report to identify the report where the material may be viewed]

5.3 Operating modes

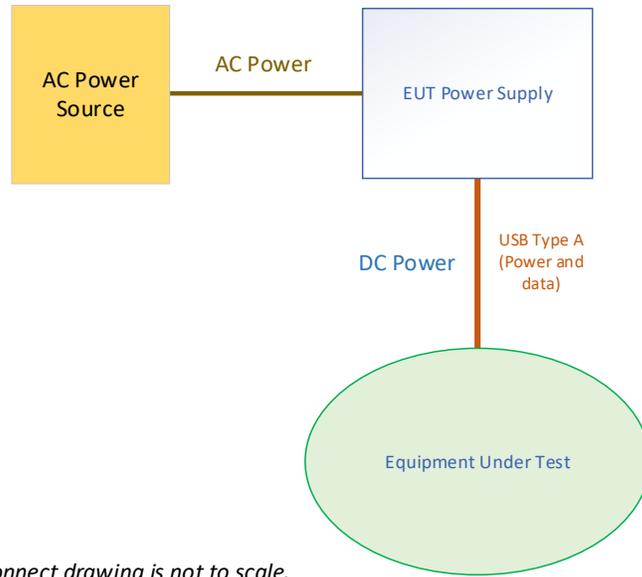
During test, the EUT was operated in the following modes.

Mode 2: M2 (NFC-L). EUT linked to NFC reader pad and transmit data
Mode 5: M5 (BLE Tx). EUT in test mode-BLE Tx always On
Mode 6: M6 (BLE-L). EUT linked to companion device through BLE
Mode 7: M7 (GNSS). EUT in GNSS test mode
Mode 8: M8 (ANT Tx). EUT in test mode- ANT Tx always On
Mode 9: M9 (ANT-L). EUT linked to companion device through ANT
Mode 10: M10 (ALL). all relevant radios On
Mode 11: M11 (BLE Rx). EUT in test mode- BLE Rx always On for Rx spurious emission test

5.4 EUT Arrangement

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

Arrangement 1: A1 (PwrA) EUT powered up through a DC power supply with a type A USB connection

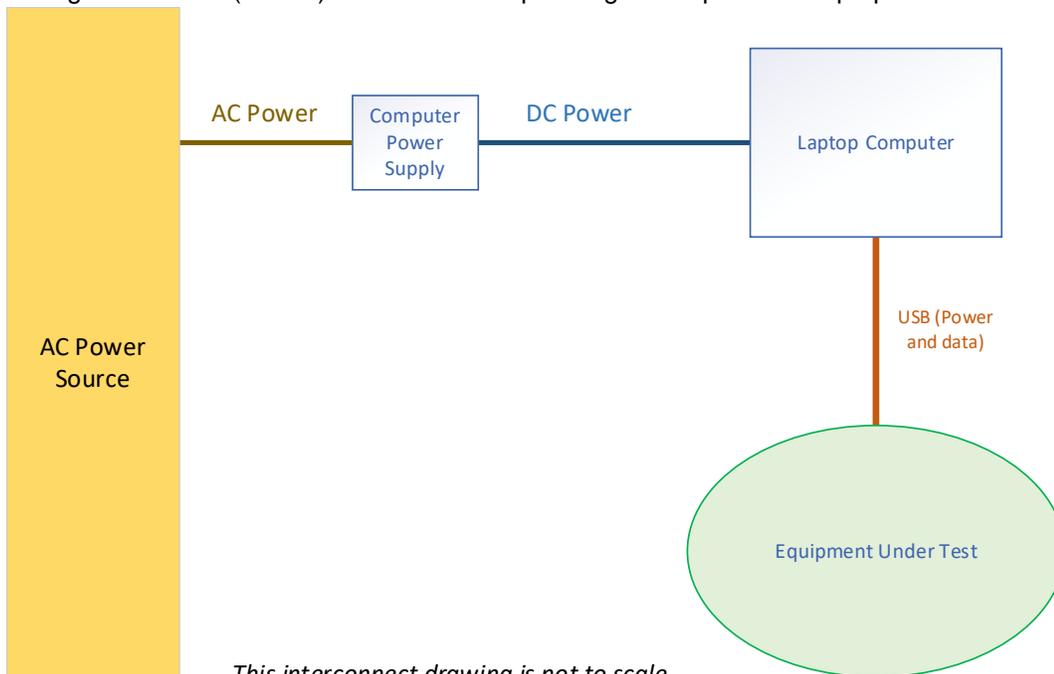


*This interconnect drawing is not to scale.
It does not indicate the placement of devices.*

Figure 1: Block diagram of equipment arrangement A1

Arrangement 2: A2 (NFC) EUT Powered up through arrangement A1, A3 or A4 in NFC mode and near to an NFC reader device

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



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

Figure 2: Block diagram of equipment arrangement A3

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

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
Smartwatch	Garmin	A04112	3400414926
Laptop	Dell	Latitude 5410	5VSPFB3
Laptop power supply	Dell	65 W	CN-oH374X-CH200-OB0-7TC0-A02
NFC reader	ACS	ACR1252	RR554-086776
USB Power type A	Garmin	PSAF10R-050Q	362-00096-00
iPad	Apple	iPad Pro (11-inch)	DMPZ7582KD6L
Smartwatch	Garmin	A04600	3423419439

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 A	Special	50 cm	None

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

6 Test Standards Applied

6.1. Accredited Standards

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

FCC Part 15.249, Subpart B
ANSI C63.4: 2014
ANSI C63.10: 2013
ICES-003 Issue 7: 2020
RSS-GEN Issue 5 Amd 2
RSS-210 Issue 10 Amd 1

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

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.

The ANT and Bluetooth Low Energy (BLE) transmissions use the same hardware and differ on in matters of protocol. Since BLE emissions are stronger than ANT emissions, certain spurious emission tests using BLE transmissions are also use to demonstrate compliance of the ANT transmitter.

During tests of radiated harmonic emissions, the data are adjusted downward 16.83 dB before comparison to the Average Detector limit. This adjustment is intended to compensate for the maximum possible transmitter duty cycle. The adjustment value is calculated using $20 \log(1/D)$ where D is the duty cycle. ANSI C63.10 would seem to prefer any adjustment be based on $10 \log(1/D)$. The details around this choice are discussed more fully in Test Record SP01 which appears at about page 30. No adjustment is made when comparing data to a Peak Detector limit, consistent with ANSI C63.10.

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	$*1.55 \times 10^{-7}$	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:	20.0 to 23.9 °C
Relative Humidity:	33.8% to 57.9% (non-condensing)
Barometric Pressure	96.0 to 99.7 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
Radiated Emission Test RE09
Project GCL0305

Test Date(s) 28 Nov 2022 – 29 Nov 2022
 Test Personnel David Kerr, Jim Solum (Assisted)

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M8 (Ant Tx)
 Arrangement A1 (PwrA)
 Input Power USB 5 Vdc

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

Frequency Range: FCC Restricted Bands (2200-2390MHz, 2483.5-2500MHz)
Pass/Fail Judgment: PASS

Test record created by: David Kerr, Jim Solum
Date of this record: 05 DEC 2022

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	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
3 GHz High Pass filter	Anatech Electro	OK0R2	01	Calibration	Not Required
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE09.1: Test Equipment Used

Software Used

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

Test Data

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

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

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

Frequency (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
2216	54	74	32.019	47.376	21.981	26.624	-144	3582	HORZ	X
2390	54	74	32.515	46.455	21.485	27.545	-29	4000	HORZ	X

Table RE09.2: 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
2491	54	74	31.086	45.135	22.914	28.865	59	2300	HORZ	Z
2483.5	54	74	31.493	45.106	22.507	28.894	-122	2679	VERT	Z

Table RE09.3: FCC restricted band from 2483.5 to 2500 MHz

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

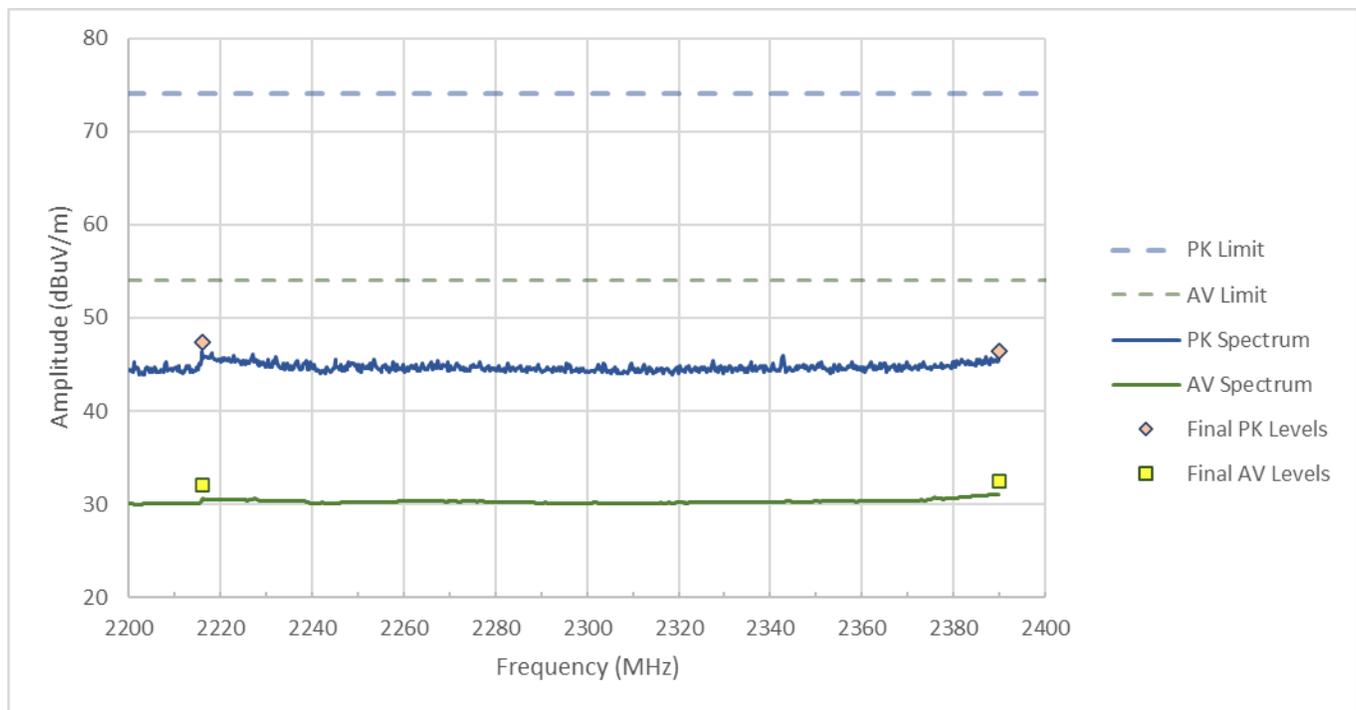


Figure RE09.1: : FCC restricted band spectral data from 2200 to 2390 MHz

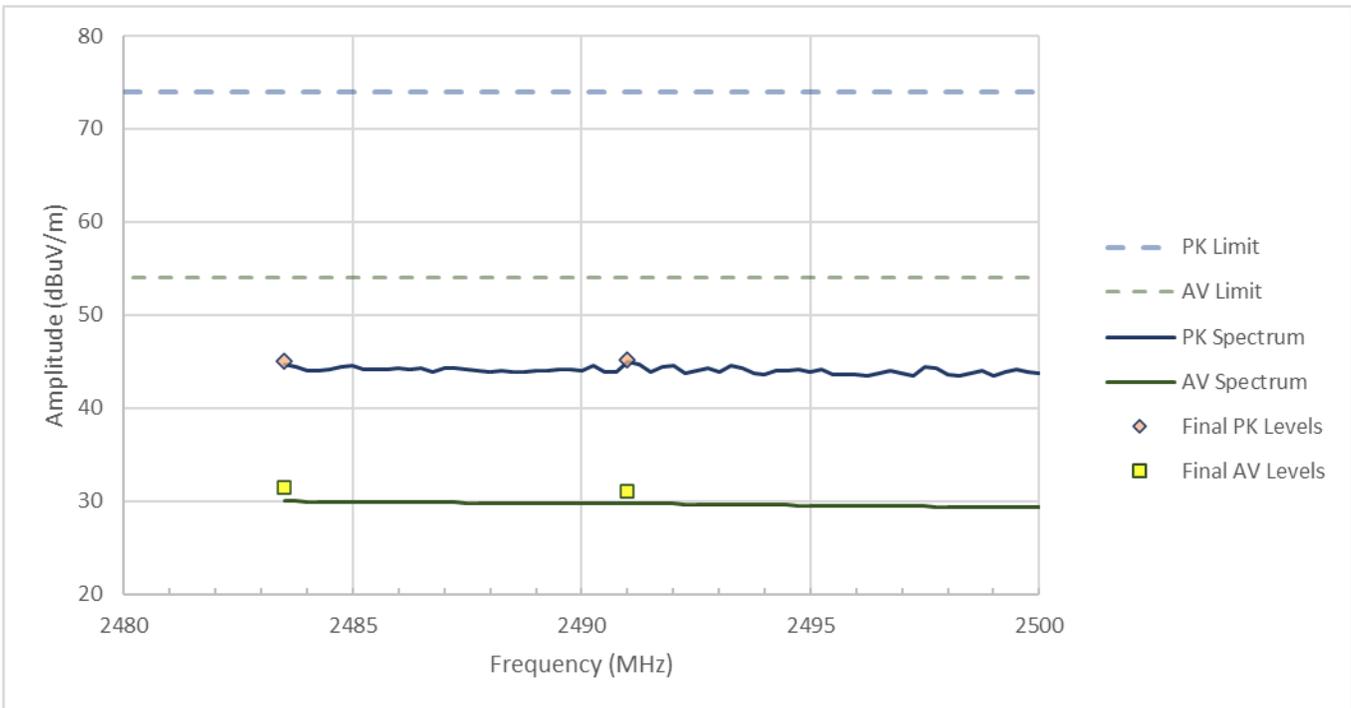


Figure RE09.2: FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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



Figure RE09.3: Z orientation front of EUT



Figure RE09.4: Z orientation rear of EUT



Figure RE09.5: X orientation front of EUT

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

Figure RE09.6: X orientation rear of EUT

This line is the end of the test record.

Test Record
Radiated Emission Test RE01
Project GCL0305

Test Date(s) 07 Dec 2022
 Test Personnel David Kerr

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M5 (BLE Tx)
 Arrangement A1 (PwrA)
 Input Power USB 5 Vdc

Test Standards: FCC Part 15, ANSI C63.10, CISPR 32, EN 55032, AS/NZS 4268, RSS-210 (as noted in Section 6 of the report).

Frequency Range: 30 MHz to 1000 MHz
Pass/Fail Judgment: PASS

Test record created by: David Kerr, Jim Solum
Date of this record: 08 Dec 2022

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Antenna, Biconilog, 30M-6 GHz	ETS Lindgren	3142E	00233201	19-Jul-2022	15-Jul-2024
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	25-Oct-2021	25-Oct-2024
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE01.1: Test Equipment Used

Software Used

Keysight PXE N9048B Firmware version A.32.06
 RE Signal Maximization Tool v2021Feb25.xlsx
 RE 30M to 1G Data Analysis Template V3 2022May10.xlsx

Test Data

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

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

The table shows the selected final measurement data between 30 MHz and 1 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted 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 Composite FCC/CISPR Class B Limit at 3m.

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.120	40.0	27.4	12.6	0	1000	*
95.700	40.0	18.9	21.1	-68	1012	VERT
404.100	46.0	24.2	21.8	0	1000	*
687.780	46.0	30.8	15.2	0	1000	*
851.550	46.0	30.3	15.7	0	1000	*
944.130	46.0	33.9	12.1	-38	3616	HORZ

Table RE01.2: Emission summary

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

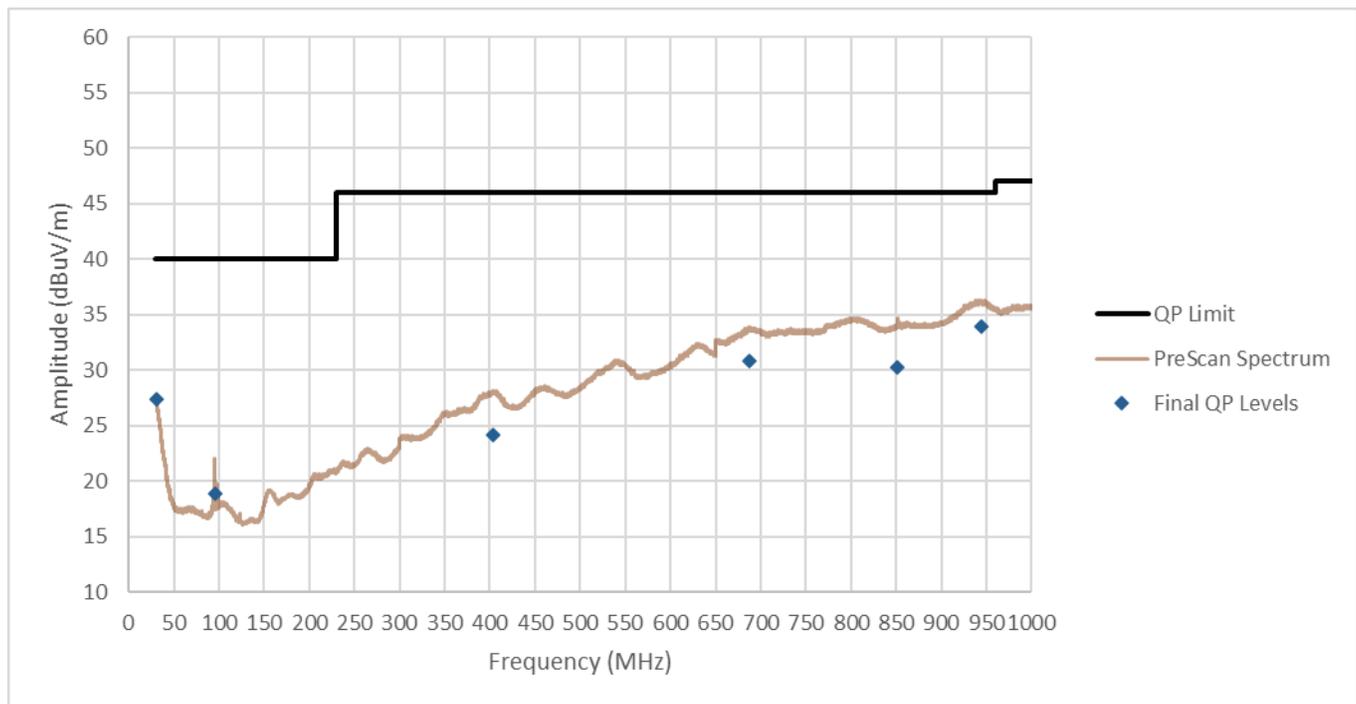


Figure RE01.1: Spectral data

Setup Photographs

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



Figure RE01.2: Front EUT test setup



Figure RE01.3: Rear EUT test setup
This line is the end of the test record.

Test Record
Radiated Emission Test RE14
Project GCL0305

Test Date(s) 17 - 19 Jan 2023
 Test Personnel Christian Shepherd

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M8 (Ant Tx)
 Arrangement A1 (PwrA)
 Input Power USB 5 Vdc

Test Standards: FCC Part 15 C (as noted in Section 6 of the report).

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

Test record created by: Christian Shepherd
Date of this record: 23 Jan 2023

Original record, Version A released 23 Jan 2023.
 Version B released 27 Feb 2023 adjusted the frequency scale on figures 14.1 through 14.6.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	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
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE14.1: Test equipment used

Software Used

PXE Software Revision A.32.06

Test Data

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

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

The tables show the selected final measurement data between 1 GHz and 18 GHz. Final measurements were performed for three ANT frequencies on the EUT: 2402 MHz (Low Channel), 2442 MHz (Middle Channel), and 2480 MHz (High Channel). Each table includes at least six of the strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

For the ANT test mode, the EUT is operating in a 'continuous' mode with a 96.3% duty cycle. The client reports that the ANT protocol has a maximum duty cycle of 13.8%. The duty cycle adjustment applied subtracts 16.83 dB from the measured data when comparing against average limits. No adjustment is applied when comparing measured data against peak limits. See test record SP01 for further details.

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Adjusted Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Ant. Polarity	EUT Polarity
2402.00	94.00	114.00	97.60	80.77	97.80	13.23	16.20	137	1071	HORZ	Z
4804.00	54.00	74.00	35.70	18.87	49.50	35.13	24.50	137	1071	HORZ	Z
7206.00	54.00	74.00	40.20	23.37	54.10	30.63	19.90	137	1071	HORZ	Z
9608.00	54.00	74.00	42.90	26.07	57.00	27.93	17.00	137	1071	HORZ	Z
12010.00	54.00	74.00	45.80	28.97	60.10	25.03	13.90	137	1071	HORZ	Z
14412.00	54.00	74.00	47.50	30.67	61.40	23.33	12.60	137	1071	HORZ	Z
16814.00	54.00	74.00	50.90	34.07	64.60	19.93	9.40	137	1071	HORZ	Z

Table RE14.2: Low Channel Emission summary

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Adjusted Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Ant. Polarity	EUT Polarity
2442.00	94.00	114.00	96.80	79.97	97.00	14.03	17.00	-70	1438	VERT	X
4884.00	54.00	74.00	35.80	18.97	49.50	35.03	24.50	-70	1438	VERT	X
7326.00	54.00	74.00	40.10	23.27	53.50	30.73	20.50	-70	1438	VERT	X
9768.00	54.00	74.00	43.40	26.57	57.20	27.43	16.80	-70	1438	VERT	X
12210.00	54.00	74.00	45.80	28.97	59.50	25.03	14.50	-70	1438	VERT	X
14652.00	54.00	74.00	48.10	31.27	61.60	22.73	12.40	-70	1438	VERT	X
17094.00	54.00	74.00	50.80	33.97	64.20	20.03	9.80	-70	1438	VERT	X

Table RE14.3: Middle Channel Emission summary

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Adjusted Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Ant. Polarity	EUT Polarity
2480.00	94.00	114.00	97.80	80.97	98.00	13.03	16.00	-70	1438	VERT	X
4960.00	54.00	74.00	36.00	19.17	49.80	34.83	24.20	-70	1438	VERT	X
7440.00	54.00	74.00	40.50	23.67	54.00	30.33	20.00	-70	1438	VERT	X
9920.00	54.00	74.00	42.90	26.07	56.90	27.93	17.10	-70	1438	VERT	X
12400.00	54.00	74.00	46.00	29.17	60.30	24.83	13.70	-70	1438	VERT	X
14880.00	54.00	74.00	48.20	31.37	61.90	22.63	12.10	-70	1438	VERT	X
17360.00	54.00	74.00	50.60	33.77	64.50	20.23	9.50	-70	1438	VERT	X

Table RE14.4: High Channel Emission summary

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

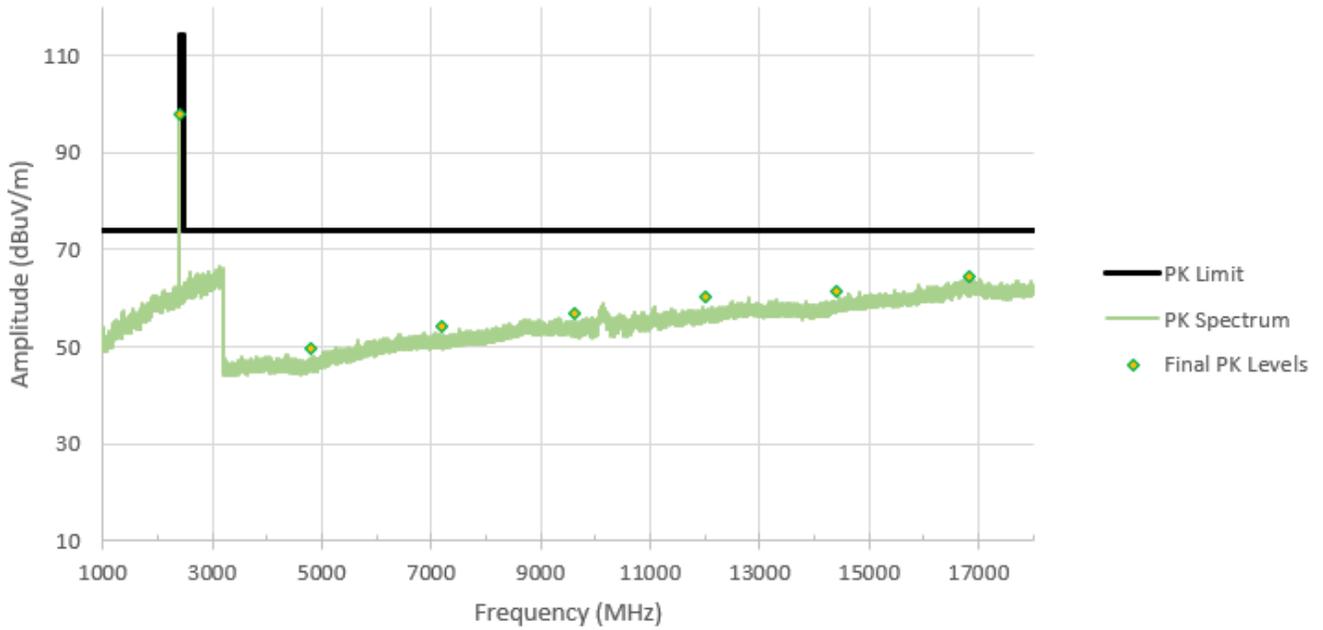


Figure RE14.1: Low Channel Final Peak Level Data

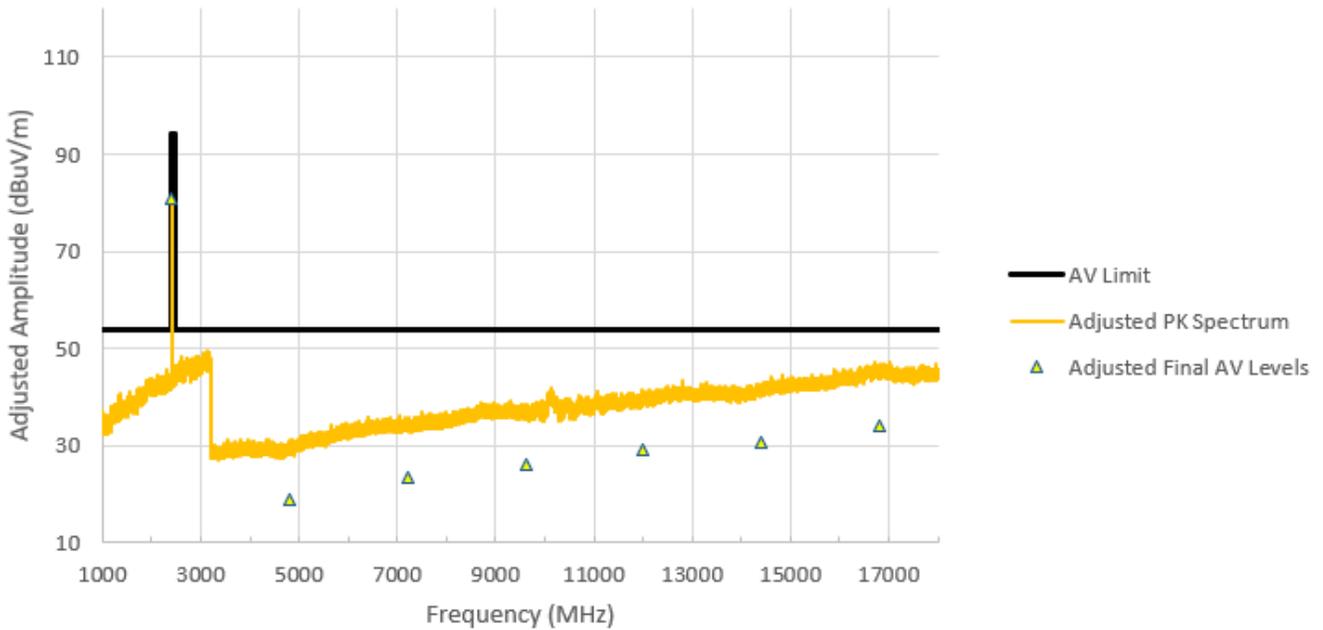


Figure RE14.2: Low Channel Final Adjusted Average Level Data

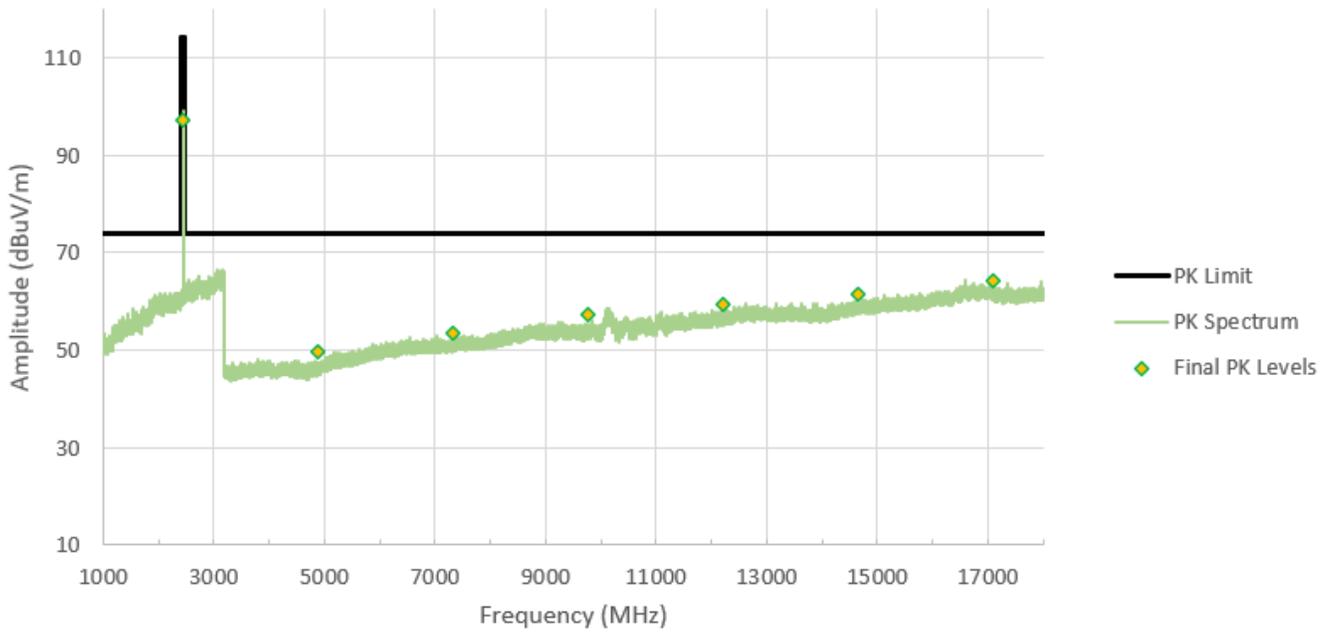


Figure RE14.3: Middle Channel Final Peak Level Data

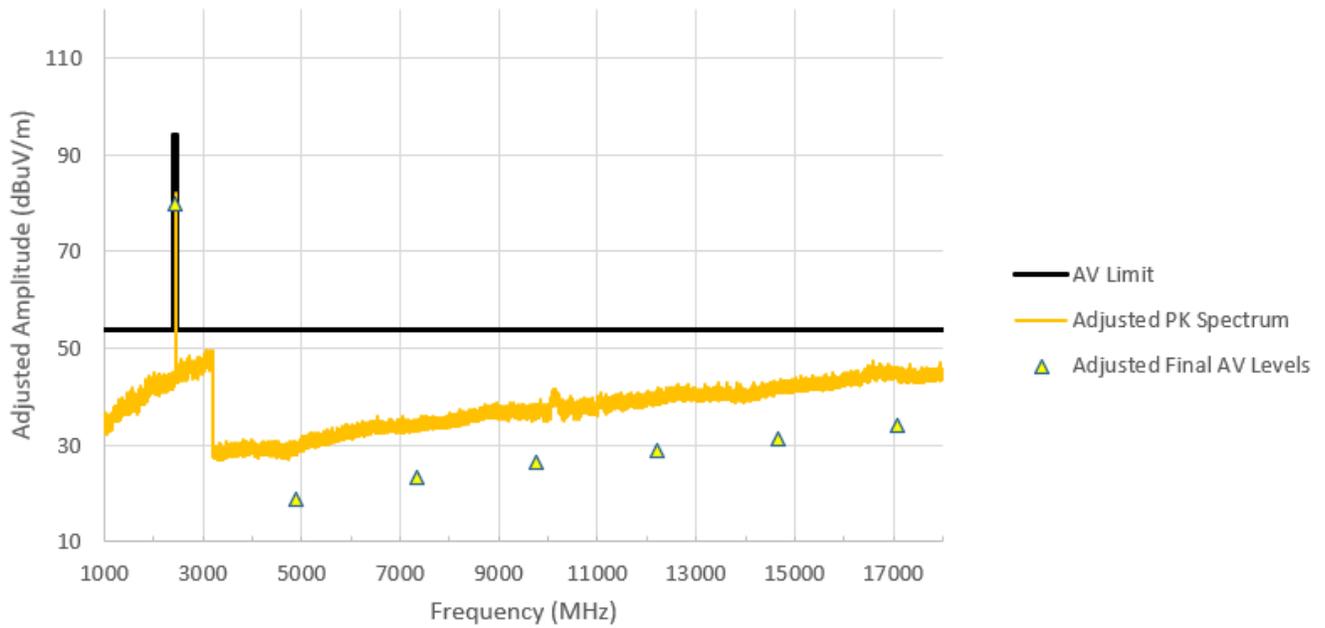


Figure RE14.4: Middle Channel Final Adjusted Average Level Data

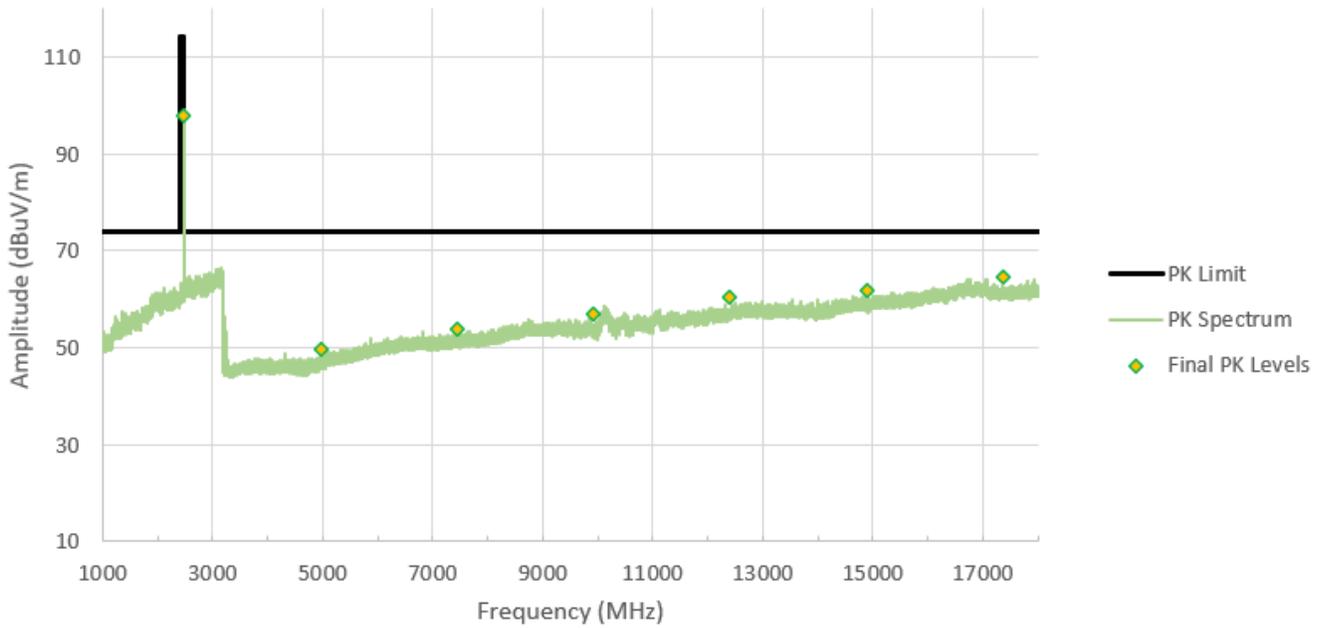


Figure RE14.5: High Channel Final Peak Level Data

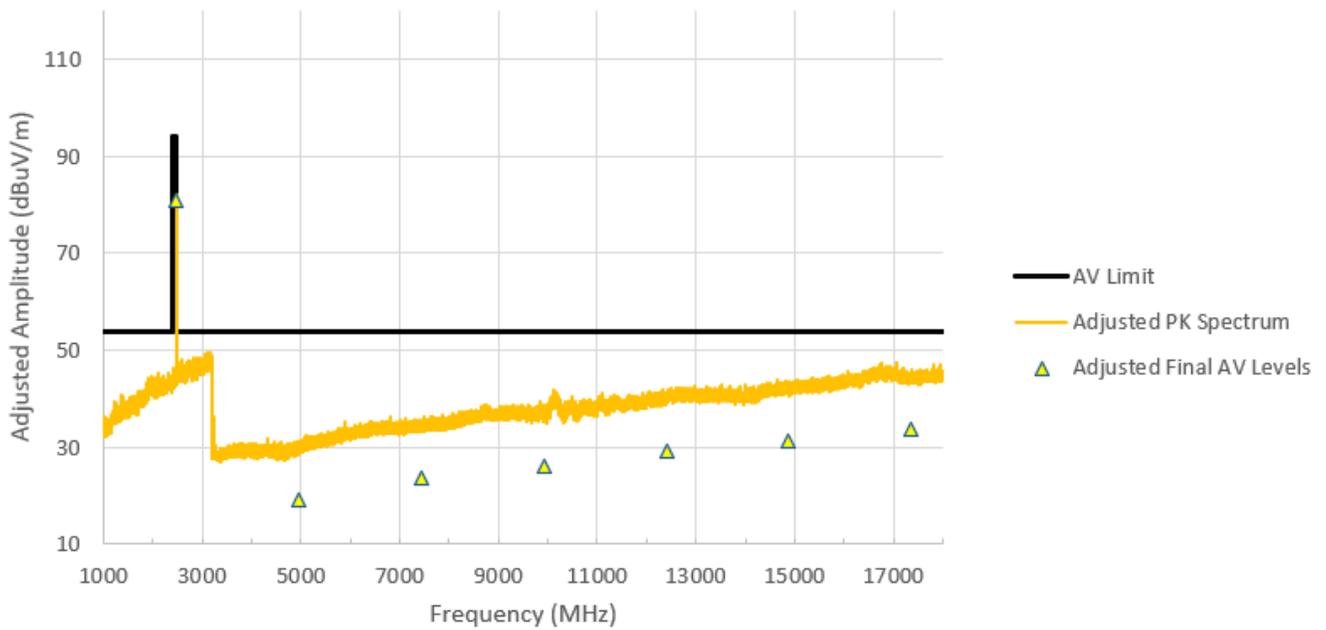


Figure RE14.6: High Channel Final Adjusted Average Level Data

Setup Photographs

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



Figure RE14.7: EUT Z orientation test setup



Figure RE14.8: EUT X orientation test setup

This line is the end of the test record.

Page 23 of 40	GCL Test Report 2022-032	Version C
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Garmin		

Test Record
Radiated Emission Test RE15
Project GCL0305

Test Date(s) 20 Jan 2023
 Test Personnel Christian Shepherd

Product Model A04600
 Serial Number tested 3431708344

Operating Mode M8 (Ant Tx)
 Arrangement A1 (PwrA)
 Input Power USB 5 Vdc

Test Standards: FCC Part 15 C (as noted in Section 6 of the report).

Frequency Range: 18 GHz to 26.5 GHz
Pass/Fail Judgment: PASS

Test record created by: Christian Shepherd
Date of this record: 27 Jan 2023

Original record, Version A, was released 27 Jan 2023.
 Version B released 27 Feb 2023 adjusts the frequency scale on figures 15.1 through 15.6.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	4-Nov-2021	4-Nov-2024
Antenna, Horn, 10-40 GHz	ETS Lindgren	3116C	00227673	26-Aug-2021	1-Sep-2023
Preamplifier, 18 Ghz to 40 Ghz	Com-Power	PAM-840A	461364	Calibration	Not Required
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
PXE 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE15.1: Test Equipment Used

Software Used

PXE Software Revision A.33.03

Test Data

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

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

The tables show the selected final measurement data between 1 GHz and 18 GHz. Final measurements were performed for three ANT frequencies on the EUT: 2402 MHz (Low Channel), 2442 MHz (Middle Channel), and 2480 MHz (High Channel). Each table includes the harmonics of the ANT frequencies in the selected frequency range. 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.

For the ANT test mode, the EUT is operating in a 'continuous' mode with a 96.3% duty cycle. The client reports that the ANT protocol has a maximum duty cycle of 13.8%. The duty cycle adjustment applied subtracts 16.83 dB from the measured data when comparing against average limits. No adjustment is applied when comparing measured data against peak limits. See test record SP01 for further details.

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Adjusted Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Ant. Polarity	EUT Polarity
19216.00	54.00	74.00	43.40	26.57	56.60	27.43	17.40	137	1071	HORZ	Z
21618.00	54.00	74.00	44.60	27.77	57.80	26.23	16.20	137	1071	HORZ	Z
24020.00	54.00	74.00	45.20	28.37	58.80	25.63	15.20	137	1071	HORZ	Z
26422.00	54.00	74.00	44.60	27.77	58.40	26.23	15.60	137	1071	HORZ	Z

Table RE15.2: Low Channel Emission Summary

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Adjusted Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Ant. Polarity	EUT Polarity
19536.00	54.00	74.00	43.20	26.37	57.60	27.63	16.40	-70	1438	VERT	X
21978.00	54.00	74.00	43.50	26.67	56.90	27.33	17.10	-70	1438	VERT	X
24420.00	54.00	74.00	44.10	27.27	58.10	26.73	15.90	-70	1438	VERT	X

Table RE15.3: Middle Channel Emission Summary

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Adjusted Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Ant. Polarity	EUT Polarity
19840.00	54.00	74.00	42.80	25.97	55.90	28.03	18.10	-70	1438	VERT	X
22320.00	54.00	74.00	43.80	26.97	57.50	27.03	16.50	-70	1438	VERT	X
24800.00	54.00	74.00	44.30	27.47	57.60	26.53	16.40	-70	1438	VERT	X

Table RE15.4: High Channel Emission Summary

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

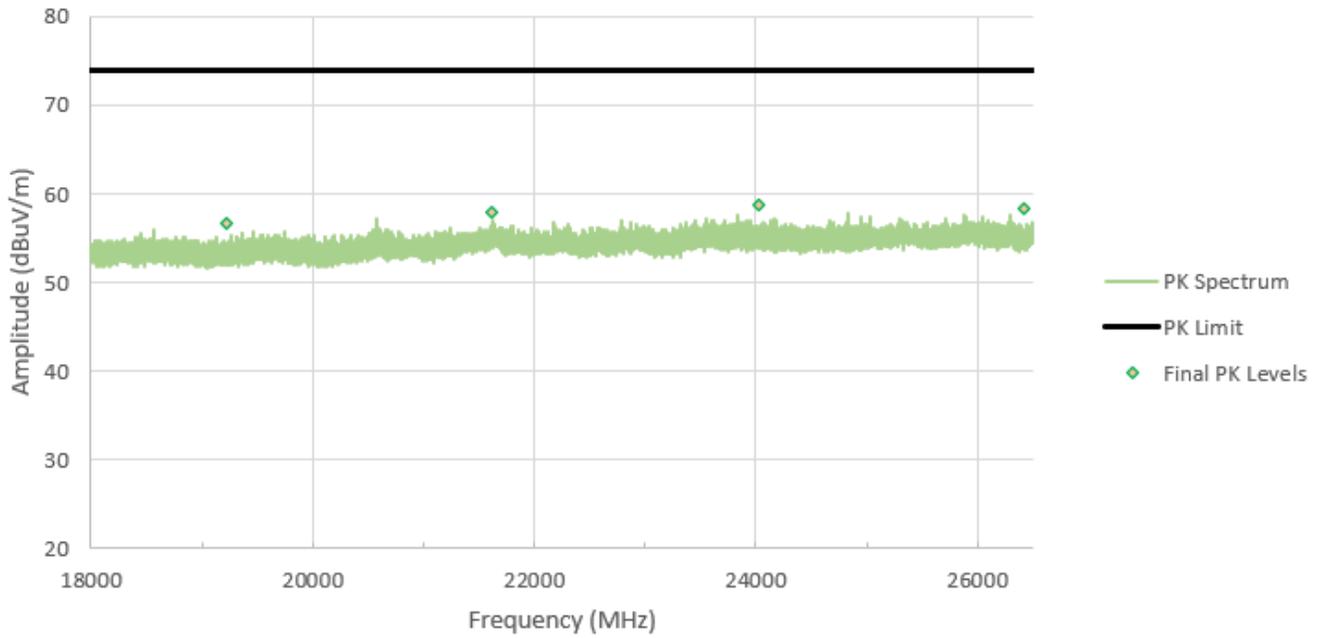


Figure RE15.1: Low Channel Final Peak Level Data

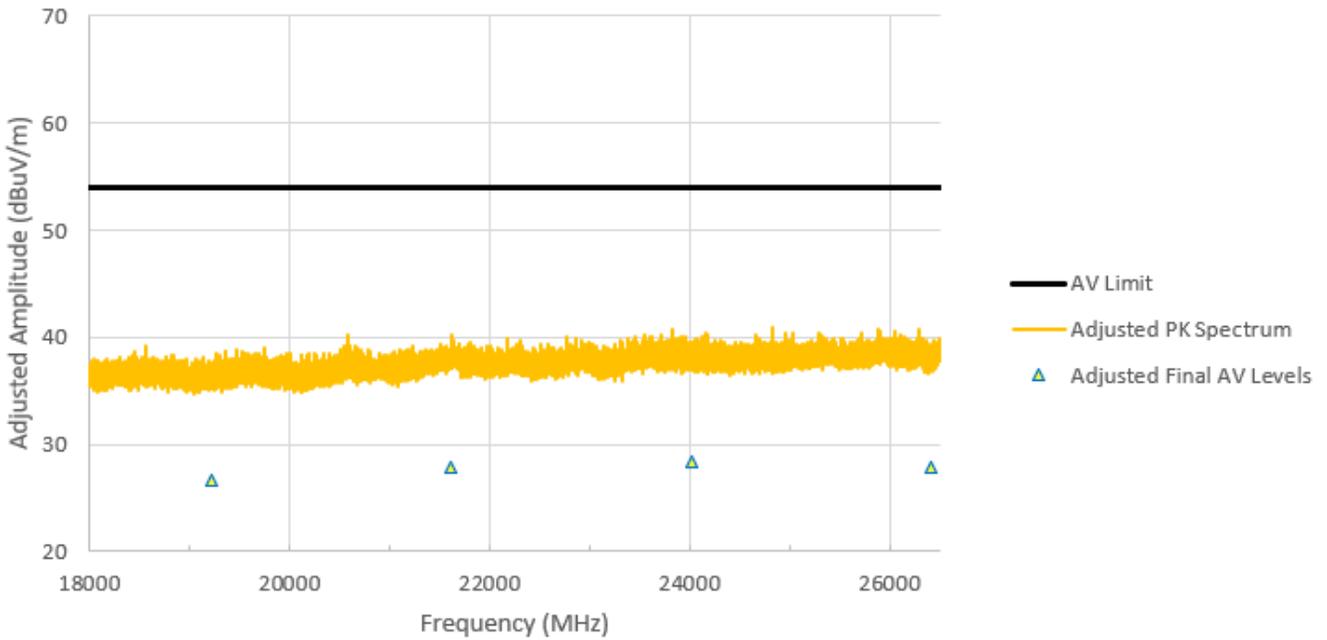


Figure RE15.2: Low Channel Final Adjusted Average Level Data

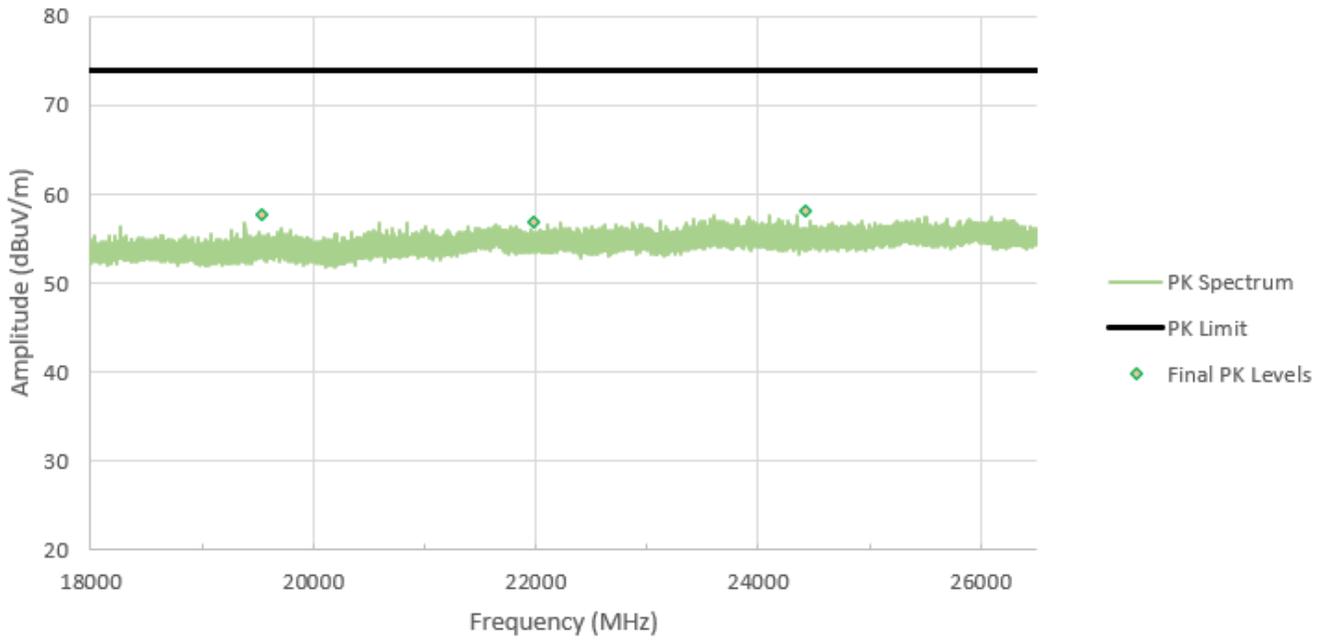


Figure RE15.3: Middle Channel Final Peak Level Data

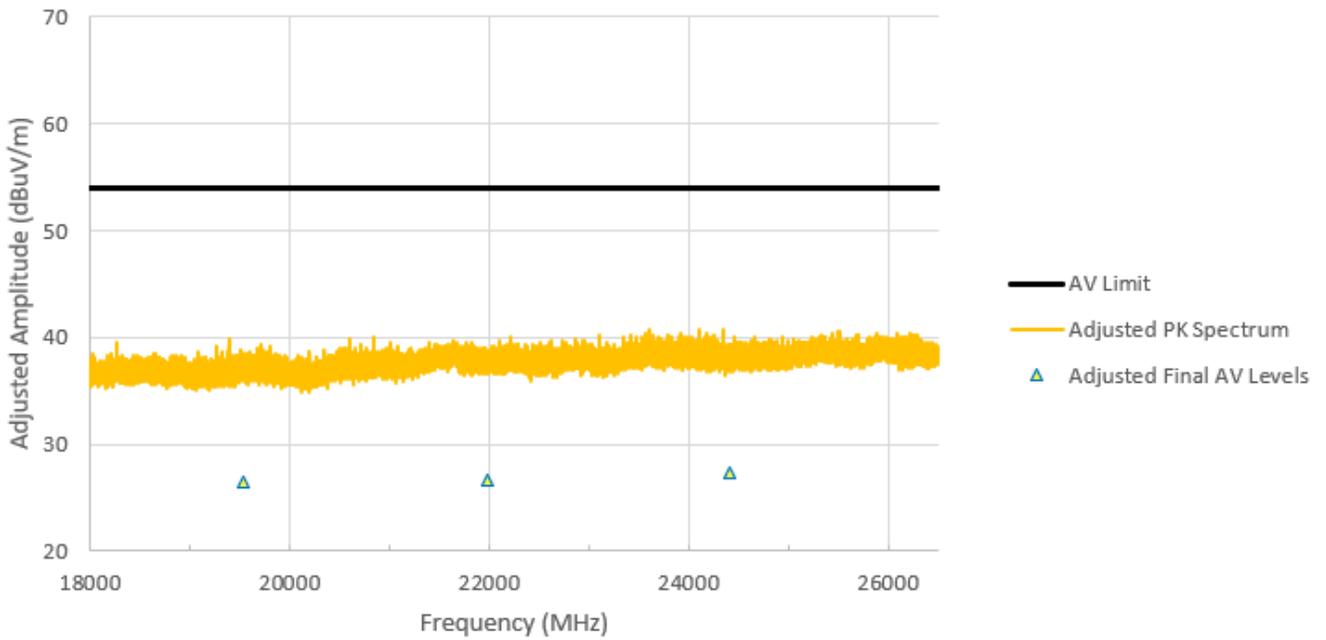


Figure RE15.4: Middle Channel Final Adjusted Average Level Data

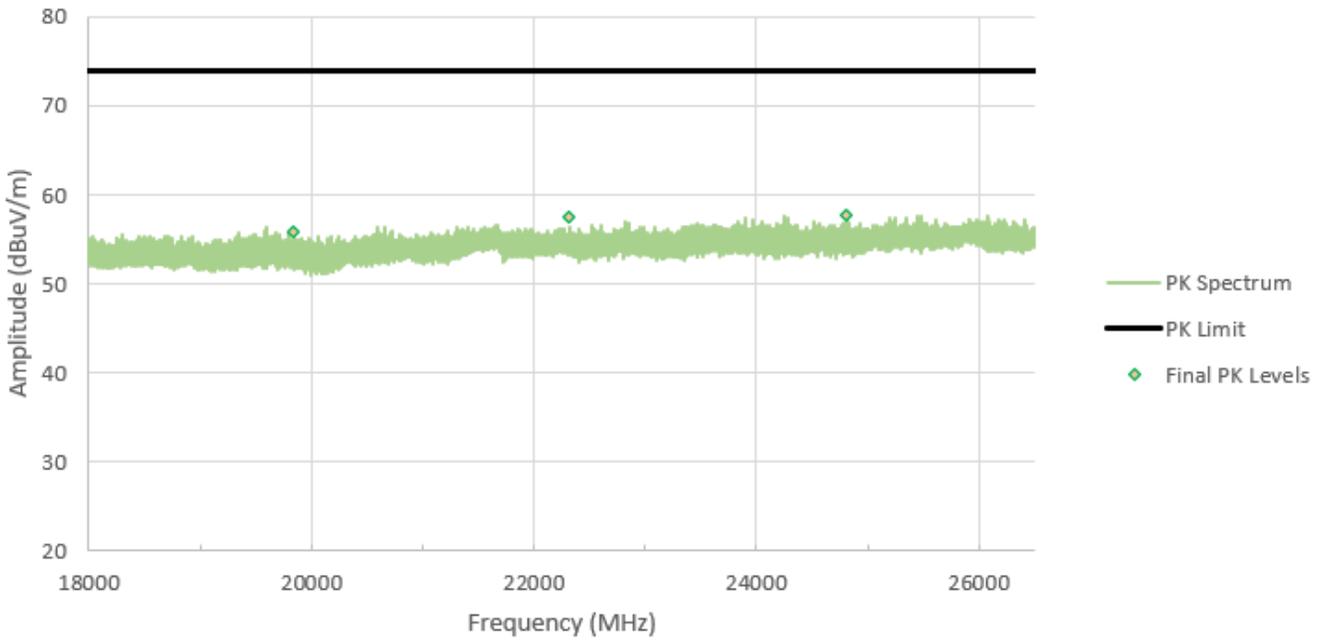


Figure RE15.5: High Channel Final Peak Level Data

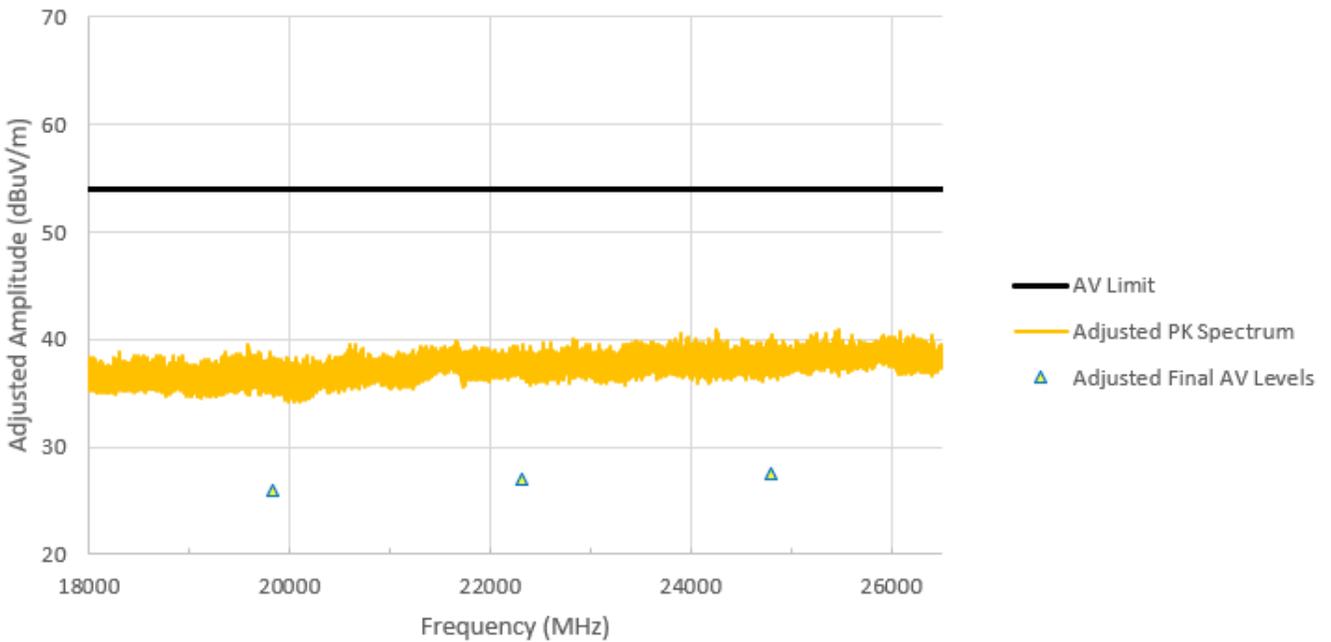


Figure RE15.6: High Channel Final Adjusted Average Level Data

Setup Photographs

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



Figure RE15.7: EUT Z orientation test setup



Figure RE15.8: EUT X orientation test setup

This line is the end of the test record.

Page 29 of 40	GCL Test Report 2022-032	Version C
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Garmin		

Test Record
Duty Cycle Effects SP01
Project GCL0305

Test Date(s) 19 Jan 2023
 Test Personnel David Arnett

Product Model A04600
 Serial Number tested 3431708548

Operating Mode M8 (ANT Tx)
 Arrangement A1 (PwrA)
 Input Power 5V dc

Test Standards: None

Pass/Fail Judgment: Reported

Test record created by: David Arnett
Date of this test record: 27 Jan 2023
 Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	13-Jul-2022	15-Jul-2023
PXE 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023

Table SP01.1: Test equipment used

Test Software used: Keysight MXE System Code rev. A.33.03, R&S Power Viewer V11.3

Background

The question this test record addresses is how the radiated emission results above 1 GHz are affected by a change in transmission duty cycle.

ANSI C63.10 at various locations (such as 11.9.2.2.5.j) indicates that adjustment of measured average values using the measured duty cycle (D) is to be based on a linear law: $10 \log(1/D)$. However, CISPR 16-1-1:2019 shows that a CISPR Average detector has square law pulse repetition response: $20 \log(1/D)$. See, for example, figure 9 of CISPR 16-1-1, showing that a change in pulse repetition by a factor of 10 results in a 20 dB change in the instrument reading. The same figure shows that the reading of a CISPR peak detector should not be affected by the pulse repetition rate. This assumes the pulses are of sufficient duration to be detected.

The test application software in the test sample has two relevant modes for ANT radio transmissions. One is the regular ANT transmit test mode which produces near-continuous data. This is the operating mode used during radiated emission tests. The other is Packet mode which produces packets of a fixed length at a specified rate. That rate is expressed in units of packets-per-Hertz. These modes can be used to understand how the ANT duty cycle affects the Average Detector emission results, and whether it follows a linear or square law response.

Test Data

The client reported that the ANT radio protocol has a maximum duty cycle of 13.8%, which is much lower than the duty cycle during radiated emission testing. The test modes discussed above allow a range of duty cycles to be evaluated above and below this protocol-limited value.

The duty cycles available in the various modes were first evaluated using the NRP8S, which is a fast diode RF power meter. This sample was one of the modified units providing a coaxial output from the transmitter rather than using the internal antenna. The packet length in Packet mode was measured at 156 usec, and duty cycles were measured for each available setting. The transmit power level from this sample was then evaluated in the same

modes in a conducted manner by feeding the transmitter output through a coaxial cable to the input of the PXE Receiver. Data was recorded at the carrier frequency using peak and average detectors as they are usually set up during radiated emission tests above 1 GHz. All amplitude data in dBm units was then normalized to the Peak detector level as measured at the maximum duty cycle.

The resulting duty cycle and normalized amplitude data are presented in Table SP01.2.

Packet Rate (Hz)	Duty Cycle (%)	Peak (dB)	Avg (db)
Ant Tx Mode	96.300%	0	-1.2
255	3.978%	0	-27.98
128	1.997%	0	-33.89
64	0.998%	0.1	-39.69
32	0.499%	0	-45.4
16	0.250%	0.1	-50.62
8	0.125%	0	-55.42
4	0.062%	0.1	-58.95
2	0.031%	0	-61.33
1	0.016%	0.1	-61.99

Table SP01.2: Duty Cycle and Normalized Amplitude for ANT transmitter

Figure SP01.1 below plots this data along with the curves for the linear law response in ANSI C63.10 (green) and the square law response for a CISPR 16-1-1 Average detector (yellow). The average data is observed to follow the square law response for duty cycles above 0.5%, and the Peak detector data is unaffected by the duty cycle.

The orange triangles in the plot show the factors that can be used for converting measured data in ANT Transmit test mode to the levels one would find when ANT has the maximum duty cycle permitted by the radio protocol. For comparison of data to a peak detector limit, that adjustment is 0 dB. For comparison of data to an average detector limit, that ratio is $20 * \log(13.8\% / 96.3\%)$ or -16.83 dB.

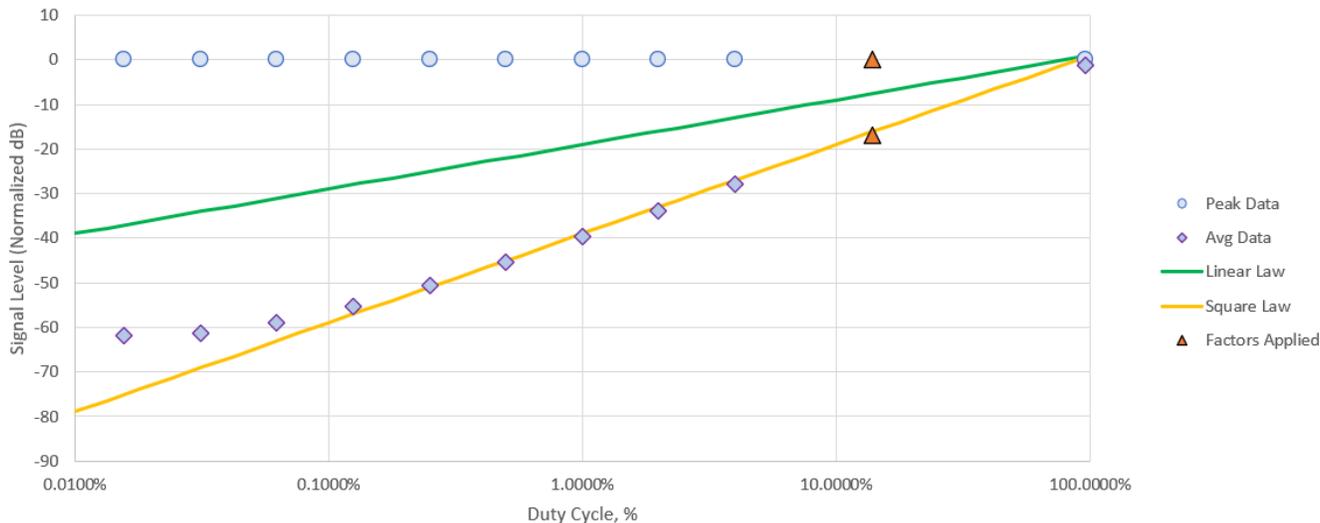


Figure SP01.1: Normalized Amplitude for ANT transmitter and linear or square law references

This line is the end of the test record.

Test Record
Transmitter Frequency Stability
Test IDs TR18
Project GCL-0305

Test Date(s) 12 - 13 Jan 2023
 Test Personnel Majid Farah and Jim Solum supervised by David Arnett
 Product Model A04600
 Serial Number tested 3431708497 and 3431708344

Operating Mode M8 (ANT Tx)
 Arrangement A1 (PwrA)
 Nominal Input Power 5 Vdc

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

Radio Protocol ANT/ANT+

Pass/Fail Judgment: PASS

Test record created by: Majid Farah and David Arnett
Date this record: 28 Feb 2023

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
DMM Multimeter	FLUKE	79 III	71740743	18-Apr-2022	15-Apr-2023
Signal analyzer PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Thermometer	Thermco	ACCD370P	210607316	11-Aug-2021	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Programmable DC power source	Keithley	2260B-30-72 720 W	14911917	6-Nov-2021	15-Feb-2023
Thermal Chamber	TPS	T2RC	611000116	21-Apr-22	15-Apr-2024
Near Field Probe set	Com-Power	PS-400	151679	Calibration	Not Required
NFC Reader	acs	ACR1252	RR554-086776	Calibration	Not Required

Table TR18.1: Equipment used

Software Used: PXE Software Revision A.32.06, 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 and ANT protocols have carriers that are intentionally closer to the band edge. The basic concept applied here is that the 6 dBc Occupied Bandwidth of the modulated signal should remain within the 2400-2483.5 MHz radio band. To evaluate this, the peak carrier level and the level at the band edge are compared to ensure that signal at the band edge is reduced at least 6 dB across the specified range of voltages and temperatures. The data is reported in terms of dBc as a positive value, meaning we report the ratio between the peak carrier signal level and the level at the band edge to demonstrate that the resulting intentional signals remained within the allowed band.

BLE and ANT use channel plan with a minimum transmission center frequency at 2402 MHz and a maximum at 2480 MHz. Although BLE has two data rate mode 1 Mbps and 2 Mbps and ANT has 1 Mbps.

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

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

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 then connected by a cable to the PXE analyzer. The analyzer was set up to detect radio signals from the test sample in a way to read carrier frequency with high resolution. The Standard indicated carrier frequency stability shall not exceed 0.01% of operation frequency.

The test temperatures range is from +50 °C to -20 °C by 10 °C decrement at each test step for nominal input voltage (5 V). The NFC carrier frequency was recorded four times at each temperature by 2, 5 and 10 minutes interval from first record. For the voltage variation test at +20 °C, the voltage is to be varied 15% above and below nominal input voltage. Data was taken at 5 Vdc and 15% lower at 4.25 Vdc plus 15% higher at 5.75 Vdc.

Test Data

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

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

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

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	°C	Vdc	dBc	dBc
ANT	50	5	34.3	40.9
ANT	40	5	34.3	39
ANT	30	5	34.2	37.9
ANT	20	5	34.7	37
ANT	10	5	41.1	37.4
ANT	0	5	34.9	34.9
ANT	-10	5	35	34.3
ANT	-20	5	34.5	33.9

Table TR18.4 Difference between peak and band edge levels for ANT transmissions during temperature variations

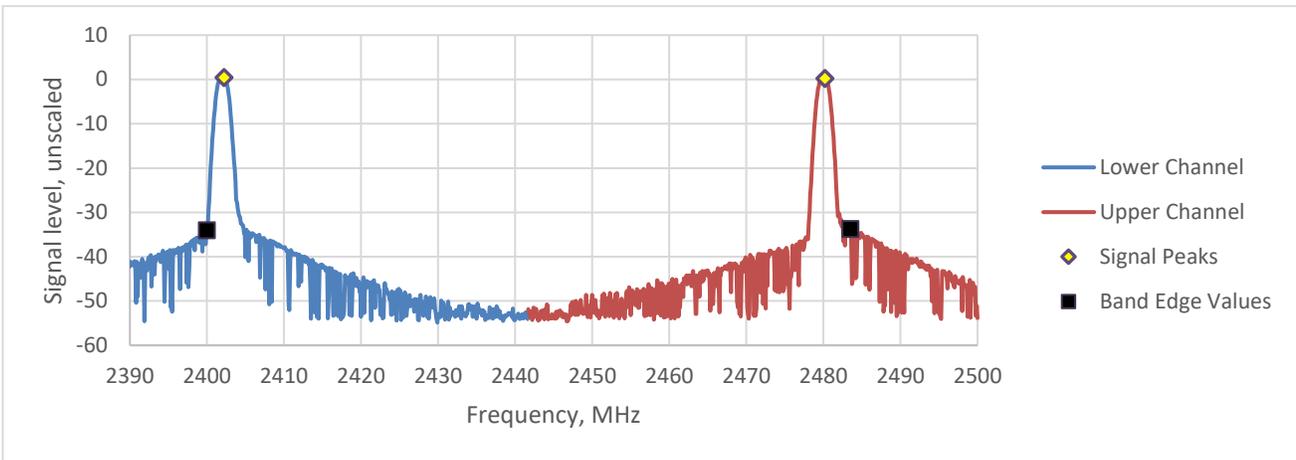


Figure TR18.3: Spectral data for ANT at -20 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
	°C	Vdc	dBc	dBc
ANT	20	4.25	34.9	37.3
ANT	20	5	34.7	37
ANT	20	5.75	36.5	40.3

Table TR18.5 Difference between peak and band edge levels for ANT transmissions at 20 °C during voltage variations

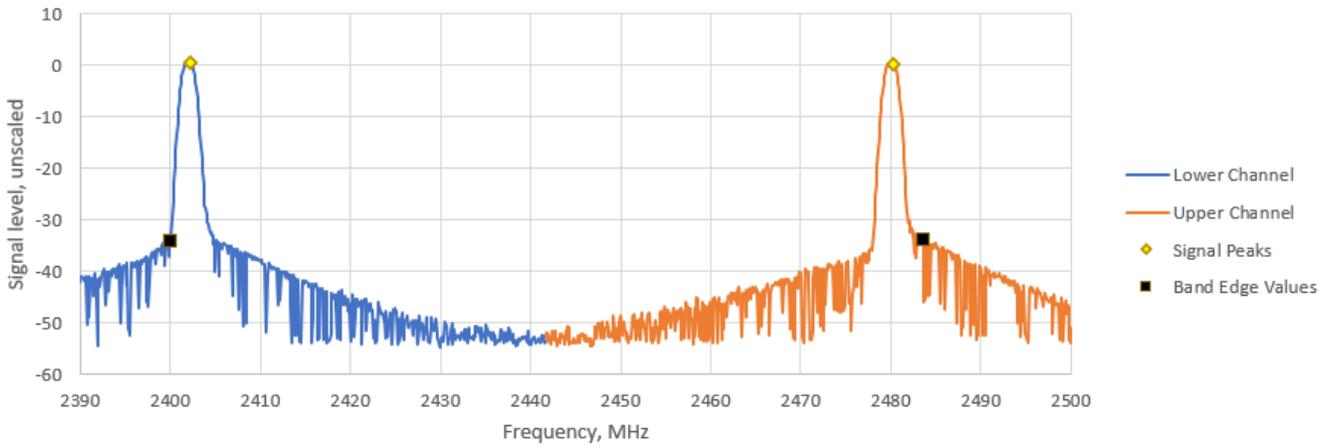


Figure TR18.4: Spectral data for ANT at 20 °C and 5 Vdc

Setup Block Diagram

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

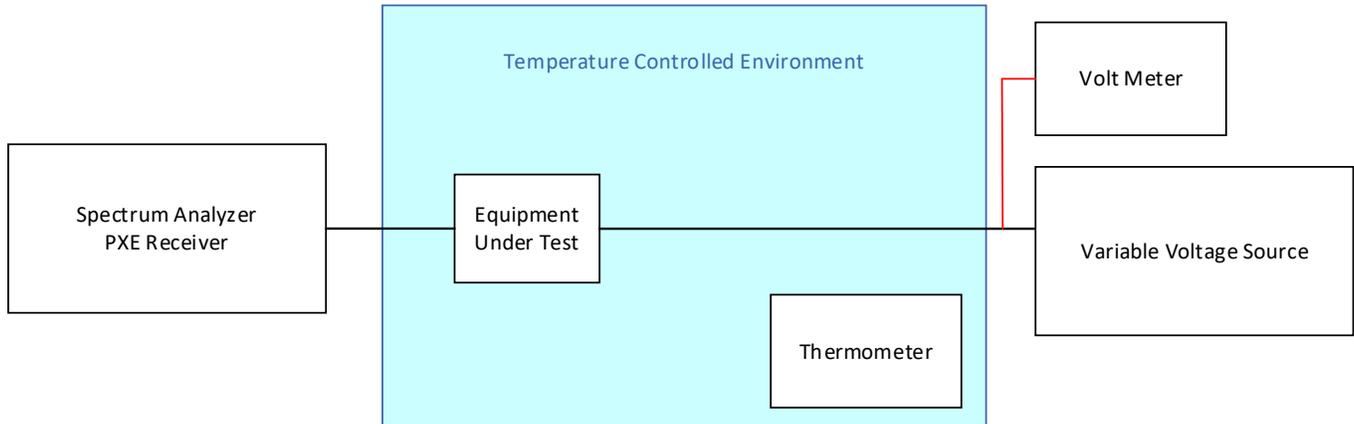


Figure TR18.5: Schematic drawing of the test equipment setup for BLE and ANT

This line is the end of the test record.

Test Record
Other Bandwidth Tests
Test IDs TR9B
Project GCL-0305

Test Date(s) 12 Jan 2021
 Test Personnel David Arnett

Product Model A04600
 Serial Number tested 3431708548

Operating Mode M8 (ANT Tx)
 Arrangement A1 (PwrA)
 Input Power 5V dc

Test Standards: FCC Part 2.202, ANSI C63.10, TRC-43, RSS-GEN (as noted in Section 6 of the report).

Radio Protocol ANT
 Radio Band 2480 to 2483.5 MHz

Pass/Fail Judgment: Reported

Test record created by: David Arnett
Date of this record: 25 Jan 2023
 Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE 44GHz	Keysight	N9048B	MY59500016	2-Feb-2022	2-Feb-2023

Table TR9B.1

Test Software used: Keysight MXE System Code rev. A.33.03.

Background

There are regulatory requirements to present two additional types of bandwidth analyses: 99% Occupied Bandwidth and Necessary Bandwidth. There are no limits or functional requirements around these data, beyond a reporting requirement. The contents of this test record are for information, and do not affect compliance of the devices that are the subject of this report.

Test Setup

This block diagram shows the test equipment setup.

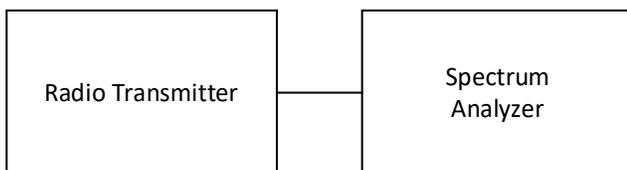


Figure TR9B.1: Test setup

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 are in bold font and have MHz as their units of measure.

The channel frequencies for ANT are 2402, 2442, and 2480 MHz. These are called the Low, Mid, and High frequencies.

	ANT
Low	990.3
Mid	992.6
High	991.4
Mean	991.4
Unit	kHz

Table TR9B.2: Summary of 99% Occupied Bandwidth Data, ANT mode

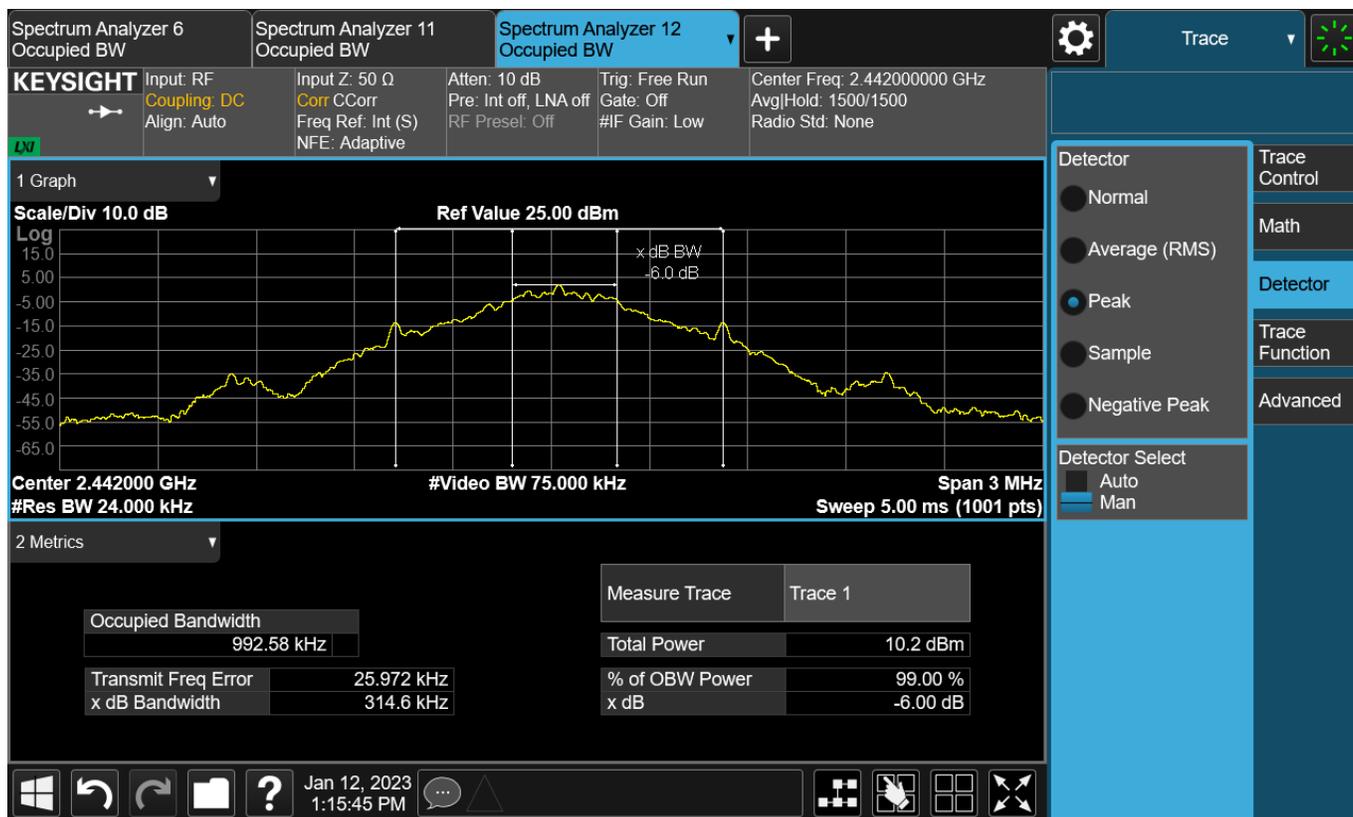


Figure TR9B.1: Occupied bandwidth data for ANT at mid channel (2442 MHz)

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 radios signals as a combined approach, then separately analyze the results for IEEE 802.11g and n systems. The tables below may include radio protocols that are not part of the product being evaluated.

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

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

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 TR9B.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 TR9B.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 TR9B.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
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 TR9B.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 TR9B.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.

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.

RF Exposure Evaluation Report

Client: **Garmin International**
1200 E 151st Street
Olathe Kansas 66062 USA

Model: **A04600**

FCC ID: **IPH-04600**
IC: **1792A-04600**

Test Report No.: **RFE20221116-20-01**

ISED CAB Identifier: **US0177**

Approved By:



Nic S. Johnson, NCE
Technical Manager
iNARTE certified EMC Engineer EMC-003337-NE

Date: **February 14, 2023**

Total Pages: **6**

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Revision Page

Rev. No.	Date	Description
Original	11 February 2023	Approved by – NJohnson Prepared by – KVepuri

Regulatory Requirements:

FCC Part 1.1310, 2.1091, 2.1093
KDB 447498 D01
RSS-102, Issue 5

Summary:

The EUT's EIRP and conducted output power were used to evaluate for exemption from routine SAR testing.

EUT:

FCC ID: IPH-04600
IC: 1792A-04600

MPE Lab Nebraska Center for Excellence in Electronics
MPE Labs FCC Cab Designation: US1060
MPE Labs ISED Cab Designation: US0177

EMC Report references:

2402 – 2480 MHz

EMC Report: 2022-035 Version A
EMC Laboratory: Garmin International
FCC designation number (EMC lab): US1311
ISED CAB Identifier (EMC Lab) US0233

EIRP: 2.63 dBm / 0.001832 W
Conducted Power: 2.63 dBm / 0.001832 W
MaxPower + 10% tune-up tolerance: 2.893 dBm / 0.001947W
Antenna gain: -3.7 dBi (rounded up to zero for cacluation)

EIRP (mW) = Conducted power (mW) + antenna gain (numeric)

13.56 MHz

EMC Report: 2022-034 Version A
EMC Laboratory: Garmin International
FCC designation number (EMC lab): US1311
ISED CAB Identifier (EMC Lab) US0233

Field Strength: 62.5 dBuV/m
EIRP: -32.73 dBm / 0.000000533 W
EIRP + 10% tune-up tolerance: -36.003 dBm / 0.000000251W
Antenna gain: NA

EIRP (dBm) = Field Strength-95.23

All antenna gain was declared by manufacturer with a separate document to describe as stated in the referenced test report.

Calculations:

FCC

Parameters:

Test separation < 5 mm

2402 – 2480 MHz, maximum channel power, including tune-up tolerance, mW = 1.947 mW

13.56 MHz maximum channel power, including tune-up tolerance, mW = 0.000251 mW

f(GHz) = 2.480 GHz (highest frequency of range chosen for worse-case)

EIRP + 10% tolerance was used as it is higher than the conducted value.

KDB 447498 D01, Section 4.3.1(a):

For 100 MHz to 6 GHz and *test separation distances* ≤ 50 mm, the 1-g and 10-g SAR test exclusion thresholds are determined by the following:

$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f_{(\text{GHz})}}] \leq 3.0$ for 1-g SAR, and ≤ 7.5 for 10-g extremity SAR,³⁰ where

- $f_{(\text{GHz})}$ is the RF channel transmit frequency in GHz

Limit / numeric threshold = 7.5 for extremity SAR

2402 – 2480MHz: $[2 / 5] \times \text{SQRT}(2.480) = 0.63(8.4\% \text{ of the limit}) \leq 7.5$

13.56 MHz: $[1 / 5] \times \text{SQRT}(.01356) = 0.07(1\% \text{ of the limit}) \leq 7.5$

Total % 8.4%+1% = 9.4% < 100% therefore it is **Exempt**

EIRP + power tolerance was rounded up to the nearest mW as instructed in the KDB

ISED

RSS 102, Issue 5, Section 2.5.1

2.5.1 Exemption Limits for Routine Evaluation — SAR Evaluation

SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in Table 1. f(MHz) = 2.400 GHz (lowest limit frequency within range)

Table 1: SAR evaluation — Exemption limits for routine evaluation based on frequency and separation distance ^{4,5}					
Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Exemption limit = 2 mW (worse-case in 2402 – 2480 MHz range)

2.4 Ghz Max power with 10% tolerance = 1.947 mW = 97.35% of worst case Limit (3500 MHz limit was used)

NFC Max power with 10% tolerance = 0.000251 mW = 0.00035 % of worst-case Limit (≤300 MHz limit was used)

Total % = BLE % +NFC % = 97.35%+0.00035% = 97.35% <100%, therefore it is **Exempt**

For limb-worn devices where the 10 gram value applies, the exemption limits for routine evaluation in Table 1 are multiplied by a factor of 2.5

Both EIRP and conducted power with tolerance are **EXEMPT**

Result:

The EUT was found to be exempt from routine SAR testing and **COMPLIANT** with RF exposure requirements.

REPORT END