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24-Feb-26

Manufacturer: Garmin International, Inc.
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Olathe, KS 66062-3426
U.S.A.
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Contact Email: matias.rodriguez@garmin.com
Subject: SUBTEL, Chile (Resolution 737) Certification Compliance 2026
Commercial Name: Instinct 3,50mm, AMOLED

	Información (Information)
Tipo de equipo (Equipment type)	Portable Digital Transceiver
Marca (Brand)	Garmin 
Modelo (Model)	A05000
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 -1.54 dBi / BLE -1.54 dBi
P.i.r.e. (E.I R P.)	-31.4 dBm, 0.00 mW / 1.93 dBm, 1.56 mW / 1.93 dBm, 1.56 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

Report Number: R15444913-E1

Applicant : Garmin International Inc
1200 E 151st St
Olathe, Kansas 66062-3426, United States

Model : A05000

FCC ID : IPH-05000

IC : 1792A-05000

EUT Description : Device

Test Standard(s) : FCC 47 CFR PART 15 SUBPART C: 2024
ISED RSS-247 ISSUE 3: 2023
ISED RSS-GEN ISSUE 5 + A1 + A2: 2021
ISED RSS-210 ISSUE 11:2024

Date Of Issue:

2024-08-30

Prepared by:

UL LLC

12 Laboratory Dr.

Research Triangle Park, NC 27709 U.S.A.

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REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	2024-08-30	Initial Issue	Chandler Stanley

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Garmin International Inc
1200 E 151st St
Olathe, Kansas 66062-3426, United States

EUT DESCRIPTION: Device

MODEL: A05000

SERIAL NUMBER: 3477224577

SAMPLE RECEIPT DATE: 2024-08-13

DATE TESTED: 2024-08-15, 2024-08-16 and 2024-08-19

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C: 2024	Refer to Section 2
ISED RSS-247 Issue 3: 2023	Refer to Section 2
ISED RSS-GEN Issue 5 + A1 + A2: 2021	Refer to Section 2
ISED RSS-210 Issue 11:2024	Refer to Section 2

UL LLC tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

This document may not be altered or revised in any way unless done so by UL LLC and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC will constitute fraud and shall nullify the document.

Approved & Released For
UL LLC By:



Brian Kiewra
Project Engineer
Consumer, Medical and IT Segment
UL LLC

Prepared By:



Chandler Stanley
Engineer
Consumer, Medical and IT Segment
UL LLC

2. TEST RESULTS SUMMARY

This report contains data provided by the customer which can impact the validity of results. UL LLC is only responsible for the validity of results after the integration of the data provided by the customer. Below is a list of the data provided by the customer:

1. Antenna gain and type (see section 6.3)

BLE				
FCC Clause	ISED Clause	Requirement	Result	Comment
See Comment		Duty Cycle	Reporting purposes only	ANSI C63.10 Section 11.6.
-	RSS-GEN 6.7	99% OBW	Not Performed	ANSI C63.10 Section 6.9.3.
15.247 (a) (2)	RSS-247 5.2 (a)	6dB BW		None.
15.247 (b) (3)	RSS-247 5.4 (d)	Output Power		Per ANSI C63.10, Section 11.9.2.3.2.
See Comment		Average power		
15.247 (e)	RSS-247 5.2 (b)	PSD		None.
15.247 (d)	RSS-247 5.5	Conducted Spurious Emissions		
15.209, 15.205	RSS-GEN 8.9, 8.10	Radiated Emissions		
15.207	RSS-Gen 8.8	AC Mains Conducted Emissions	Not Performed	
ANT/ANT+				
FCC Clause	ISED Clause	Requirement	Result	Comment
15.249 (a)	RSS-210 B.10 (a)	Fundamental/harmonic measurements	Not Performed	None.
15.249 (d)	RSS-210 B.10 (b)	Radiated Emissions	See Comment	Band Edge is Compliant

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, ANSI C63.10-2020, KDB 558074 D01 15.247 Meas Guidance v05r02, KDB 414788 D01 Radiated Test Site v01r01, RSS-GEN Issue 5 + A1 + A2, RSS-210 Issue 11, and RSS-247 Issue 3.

4. FACILITIES AND ACCREDITATION

UL LLC is accredited by A2LA, certification # 0751.06, for all testing performed within the scope of this report. Testing was performed at the locations noted below.

	Address	ISED CABID	ISED Company Number	FCC Registration
<input type="checkbox"/>	Building: 12 Laboratory Dr RTP, NC 27709, U.S.A	US0067	2180C	825374
<input checked="" type="checkbox"/>	Building: 2800 Perimeter Park Dr. Suite B Morrisville, NC 27560, U.S.A		27265	

5. DECISION RULES AND MEASUREMENT UNCERTAINTY

5.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

5.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	U _{Lab}
Radio Frequency (Spectrum Analyzer)	141.2 Hz
Occupied Channel Bandwidth	1.22%
RF output power, conducted	1.3 dB (PK) 0.45 dB (AV)
Power Spectral Density, conducted	2.47 dB
Unwanted Emissions, conducted	1.94 dB
All emissions, radiated	6.01 dB
Conducted Emissions (0.150-30MHz) - LISN	3.40 dB
Temperature	0.57°C
Humidity	3.39%
DC Supply voltages	1.70%

Uncertainty figures are valid to a confidence level of 95%.

5.4. SAMPLE CALCULATION

RADIATED EMISSIONS

Where relevant, the following sample calculation is provided:

$$\text{Field Strength (dBuV/m)} = \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \text{Cable Loss (dB)} - \text{Preamp Gain (dB)}$$

$$36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} = 28.9 \text{ dBuV/m}$$

6. EQUIPMENT UNDER TEST

6.1. EUT DESCRIPTION

The EUT is a device that contains a BLE and ANT/ANT+ radio and a GNSS receiver. This report covers the full radiated emissions testing of the BLE and ANT/ANT+ radios with the exception for ranges above 1GHz for ANT/ANT+.

6.2. MAXIMUM OUTPUT POWER

Not Performed.

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The antenna(s) gain and type, as provided by the manufacturer' are as follows:

The radio utilizes an Inverted F antenna, with a maximum gain of -1.537 dBi.

6.4. SOFTWARE AND FIRMWARE

Software Version: 4.09

6.5. WORST-CASE CONFIGURATION AND MODE

Radiated emissions below 1GHz and above 18GHz were performed with the EUT set to transmit at the channel and mode that had the highest recorded power and PSD as the worst-case scenario.

Band edge and radiated emissions between 1GHz and 18GHz were performed with the EUT set to transmit on low and high channels, as well as middle channel for radiated spurious emissions. Band edge and radiated spurious emissions were performed on the worst-case power and PSD mode. For BLE, band edge was also tested at 2Mbps since this has the widest bandwidth.

ANT/ANT+ was tested at its only data-rate. ANT/ANT+ was only tested below 1GHz for spurious emissions, while full radiated testing was performed for BLE.

The fundamental of the EUT was investigated in three orthogonal orientations X,Y,Z, it was determined that Y orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in Y orientation.

6.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
AC adapter	Sony	XQZ-UC11-101-236-21	3223W09206247	NA

I/O CABLES

I/O Cable List						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	Proprietary	1	Proprietary	Shielded	<3m	Charges to USB C

TEST SETUP

For testing, the EUT was programmed to transmit at the desired frequencies and power settings. The EUT was connected to AC Line via a charging cable as worst-case.

SETUP DIAGRAMS

Please refer to 15444913-EP1 for setup diagrams

7. MEASUREMENT METHOD

On Time and Duty Cycle: ANSI C63.10, Section 11.6 : Zero-Span Spectrum Analyzer Method.

Radiated emissions restricted frequency bands: ANSI C63.10 Subclause -11.12.1, and 6.10.5

General radiated emissions: ANSI C63.10 Subclause - 6.3-6.6

8. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville – Chamber 4)

Equip. ID	Description	Manufacturer/Brand	Model Number	Last Cal.	Next Cal.
0.009-30MHz					
135144	Active Loop Antenna	ETS-Lindgren	6502	2024-01-24	2025-01-24
30-1000 MHz					
90628	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2024-01-02	2026-01-02
1-18 GHz					
89509	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2023-05-23	2025-05-23
Gain-Loss Chains					
207638	Gain-loss string: 0.009-30MHz	Various	Various	2024-05-22	2025-05-22
207639	Gain-loss string: 25-1000MHz	Various	Various	2024-05-22	2025-05-22
207640	Gain-loss string: 1-18GHz	Various	Various	2024-05-22	2025-05-22
Receiver & Software					
197955	Spectrum Analyzer	Rohde & Schwarz	ESW44	2024-04-16	2025-04-16
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
Additional Equipment used					
241204	Environmental Meter	Fisher Scientific	15-077-963	2023-09-05	2025-09-05

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville – Chamber 1)

Equip. ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
18-40 GHz					
204704	Horn Antenna, 18-26.5GHz	Com-Power	AH-826	2023-07-20	2025-07-20
Gain-Loss Chains					
135999	Gain-loss string: 18-40GHz	Various	Various	2024-05-08	2025-05-08
Receiver & Software					
81018	Spectrum Analyzer	Agilent	E4446A	2024-07-31	2025-07-31
SOFTEMI	EMI Software	UL	Version 9.5 (18 Oct 2021)		
Additional Equipment used					
241205	Environmental Meter	Fisher Scientific	15-077-963	2023-09-05	2025-09-05

9. ANTENNA PORT TEST RESULTS

9.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

PROCEDURE

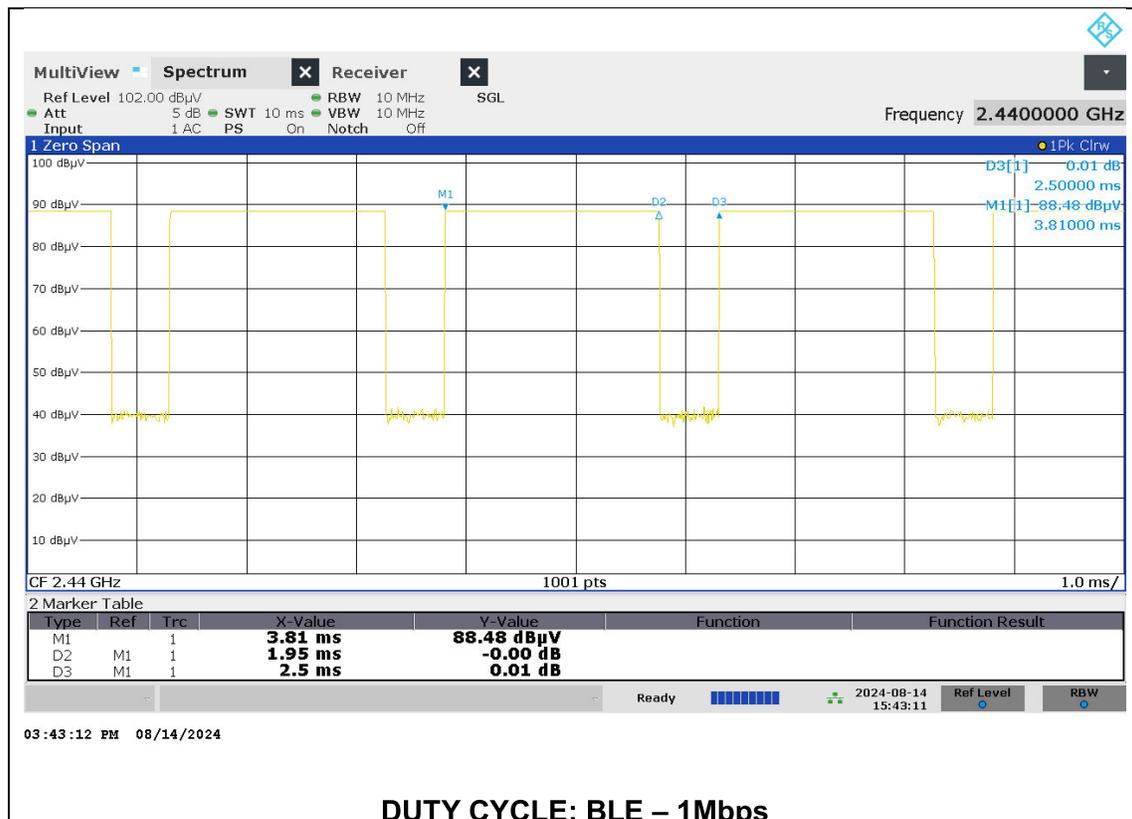
KDB 558074 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
2.4GHz Band						
BLE - 1 Mbps	1.950	2.500	0.780	78.00	2.16	0.513
BLE - 2 Mbps	0.985	1.250	0.788	78.80	2.07	1.015
ANT/ANT+	2.090	2.230	0.937	93.72	0.56	0.478

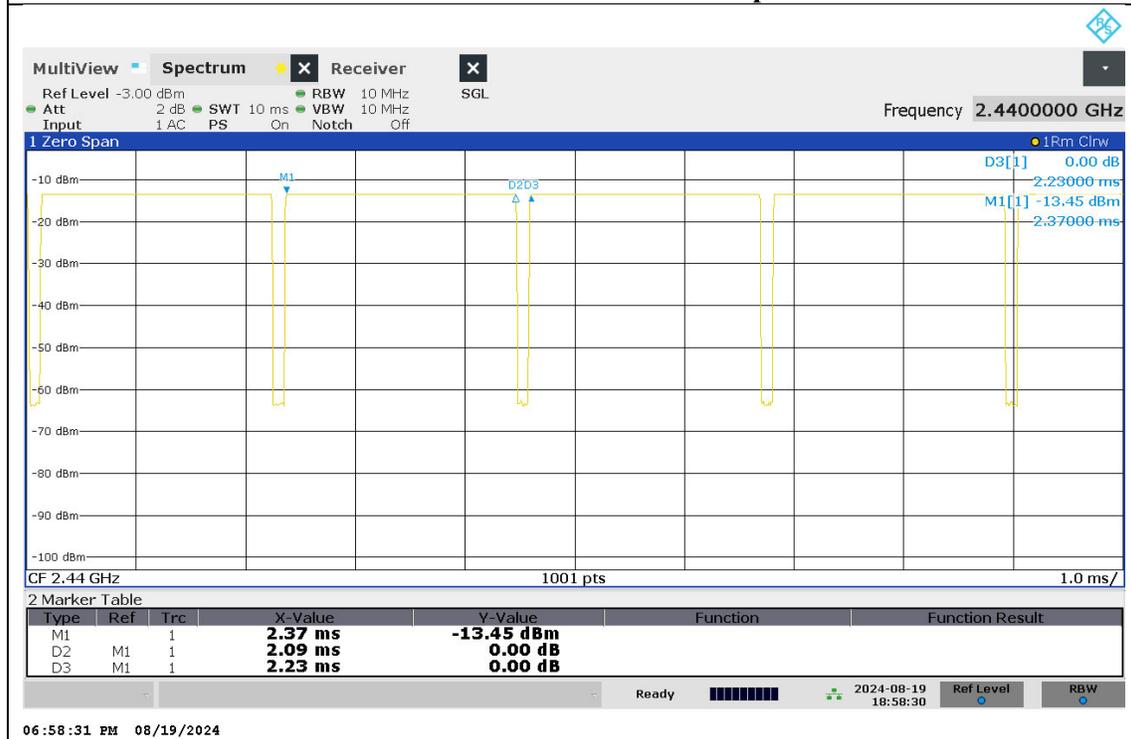
DUTY CYCLE PLOTS

Tested By: 11993 and 85501





DUTY CYCLE: BLE – 2Mbps



DUTY CYCLE: ANT/ANT+

10. RADIATED TEST RESULTS

10.1. LIMITS AND PROCEDURE

LIMITS

FCC §15.205 and §15.209
RSS-GEN, Section 8.9 and 8.10.

Frequency Range (MHz)	Field Strength Limit (uV/m) at 3 m	Field Strength Limit (dBuV/m) at 3 m
0.009-0.490	2400/F(kHz) @ 300 m	-
0.490-1.705	24000/F(kHz) @ 30 m	-
1.705 - 30	30 @ 30m	-
30 - 88	100	40
88 - 216	150	43.5
216 - 960	200	46
Above 960	500	54

RSS-GEN, Section 8.9 and 8.10.

Frequency Range (MHz)	Field Strength Limit (uA/m) at 3 m	Field Strength Limit (dBuA/m) at 3 m
0.009-0.490	6.37/F(kHz) @ 300 m	-
0.490-1.705	63.7/F(kHz) @ 30 m	-
1.705 - 30	0.08 @ 30m	-

TEST PROCEDURE

The EUT is placed on a non-conducting table 80 cm above the ground plane for measurement below 1GHz; 1.5 m above the ground plane for measurement above 1GHz. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.10. The EUT is set to transmit in a continuous mode.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements in the 30-1000MHz range, 9kHz for peak and/or quasi-peak detection measurements in the 0.15-30MHz range and 200Hz for peak and/or quasi-peak detection measurements in the 9 to 150kHz range. Peak detection is used unless otherwise noted as quasi-peak or average (9-90kHz and 110-490kHz).

For pre-scans above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz for peak measurements.

For final measurements above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz for peak measurements and as applicable for average measurements. Linear Voltage Averaging was used.

The spectrum from 1 GHz to 18 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in each applicable band. Below 1GHz and above 18GHz emissions, the channel with the highest power spectral density was tested.

The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

3D antenna use - For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel).

Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

KDB 414788 Open Field Site (OFS) and Chamber Correlation Justification

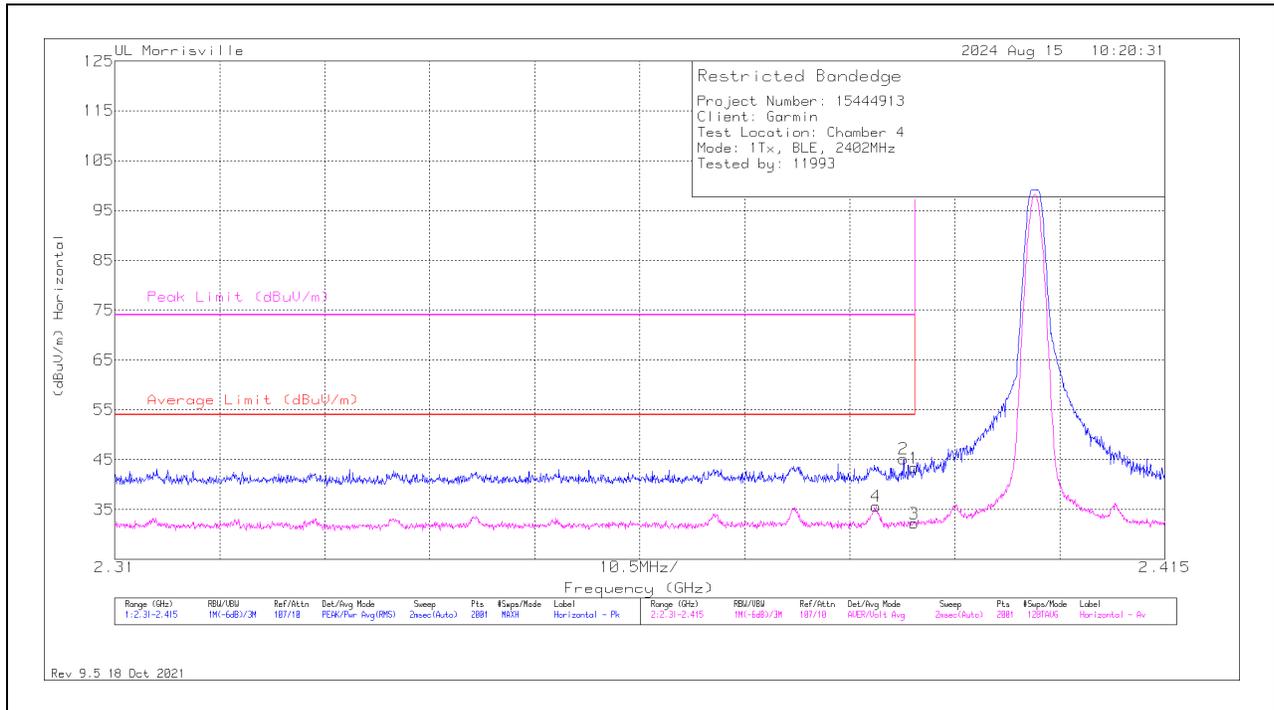
OFS and chamber correlation testing had been performed and chamber measured test result is the worst-case test result.

10.2. TRANSMITTER ABOVE 1 GHz

10.2.1. BLE (1Mbps)

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.38996	34.53	Pk	32	-23.2	0	43.33	-	-	74	-30.67	223	271	H
2	* ** 2.38886	36.35	Pk	32	-23.2	0	45.15	-	-	74	-28.85	223	271	H
3	* ** 2.38996	21.23	ADV	32	-23.2	2.16	32.19	54	-21.81	-	-	223	271	H
4	* ** 2.38613	24.76	ADV	32	-23.3	2.16	35.62	54	-18.38	-	-	223	271	H

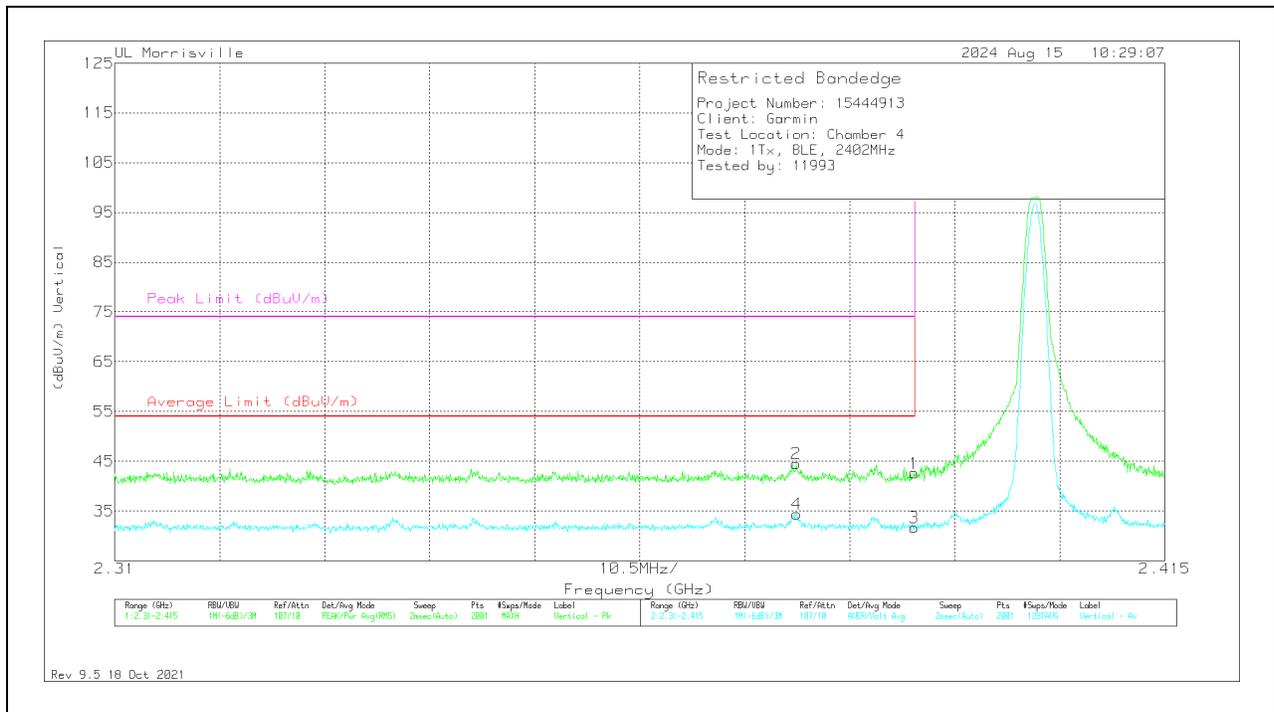
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

ADV - Linear Voltage Average

VERTICAL RESULT

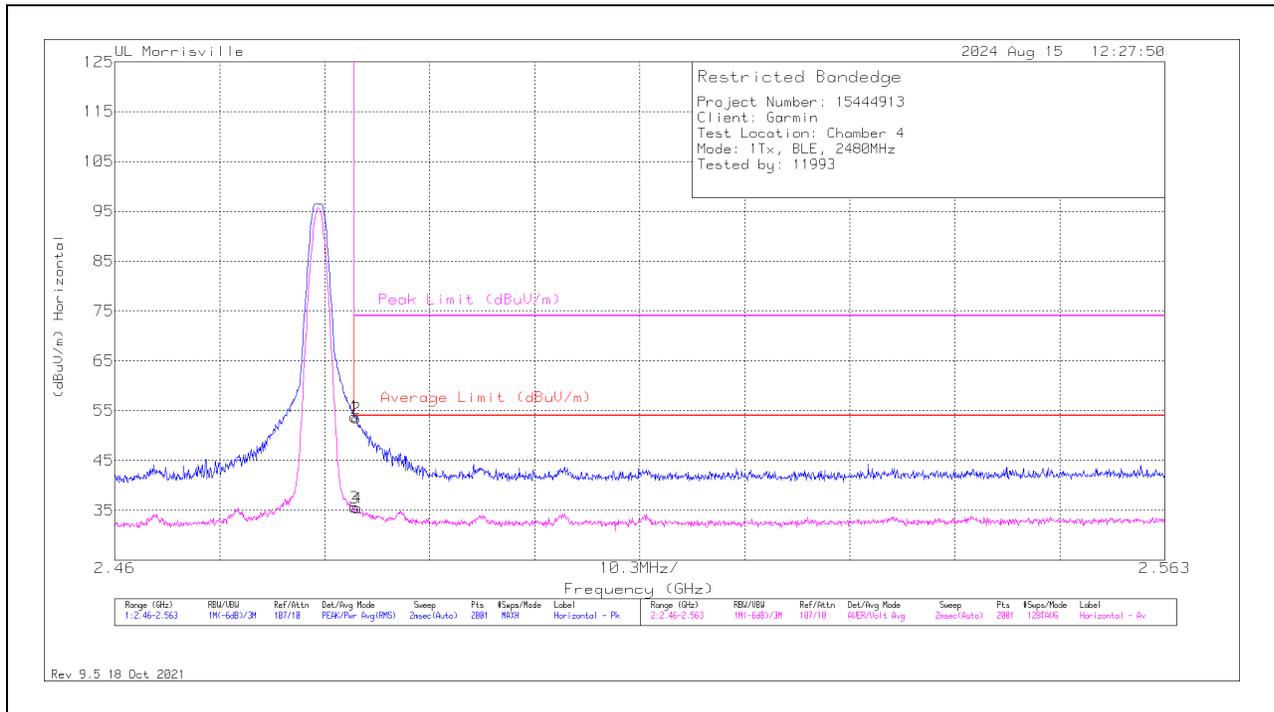


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 2.38996	33.78	Pk	32	-23.2	0	42.58	-	-	74	-31.42	275	284	V
2	** 2.37815	35.51	Pk	32	-23	0	44.51	-	-	74	-29.49	275	284	V
3	*** 2.38996	20.72	ADV	32	-23.2	2.16	31.68	54	-22.32	-	-	275	284	V
4	** 2.3782	23.23	ADV	32	-23	2.16	34.39	54	-19.61	-	-	275	284	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 ** - indicates frequency in Taiwan NCC LP0002 Restricted Band
 Pk - Peak detector
 ADV - Linear Voltage Average

BANDEDGE (HIGH CHANNEL)

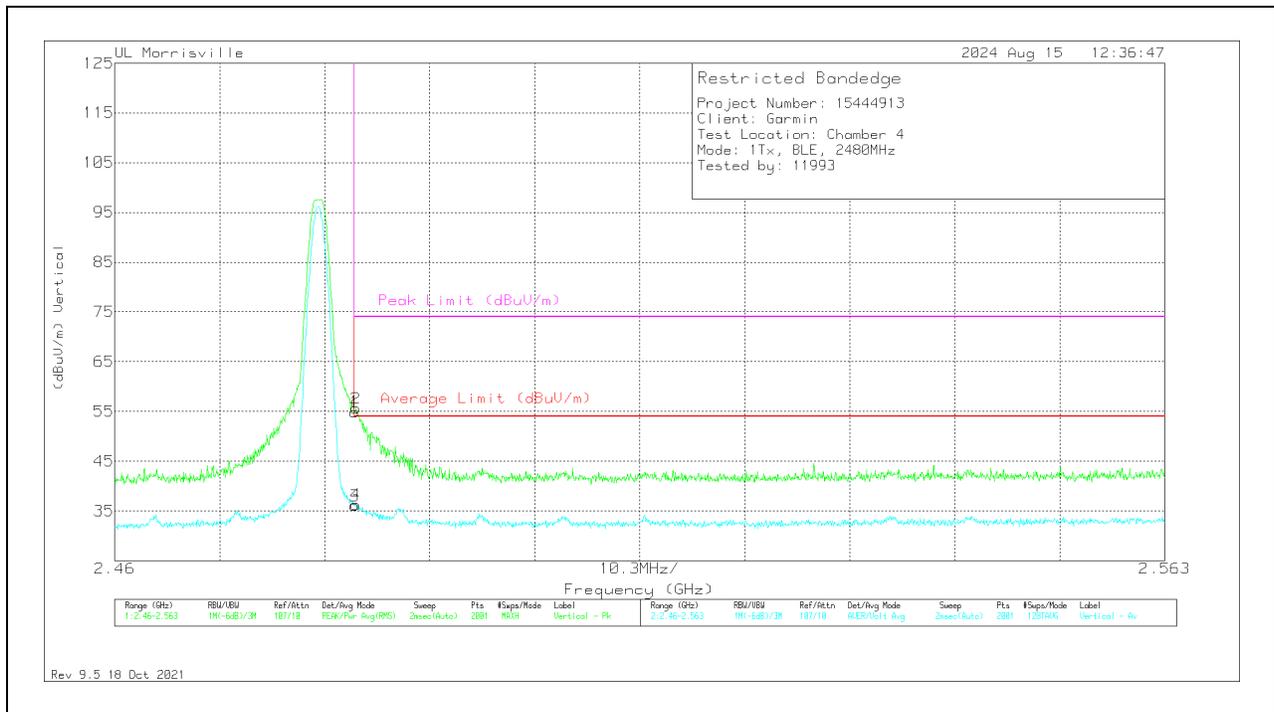
HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.48354	44.26	Pk	32.3	-22.8	0	53.76	-	-	74	-20.24	258	132	H
2	* ** 2.48369	43.97	Pk	32.3	-22.8	0	53.47	-	-	74	-20.53	258	132	H
3	* ** 2.48354	23.91	ADV	32.3	-22.8	2.16	35.57	54	-18.43	-	-	258	132	H
4	* ** 2.48379	23.79	ADV	32.3	-22.8	2.16	35.45	54	-18.55	-	-	258	132	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 ** - indicates frequency in Taiwan NCC LP0002 Restricted Band
 Pk - Peak detector
 ADV - Linear Voltage Average

VERTICAL RESULT

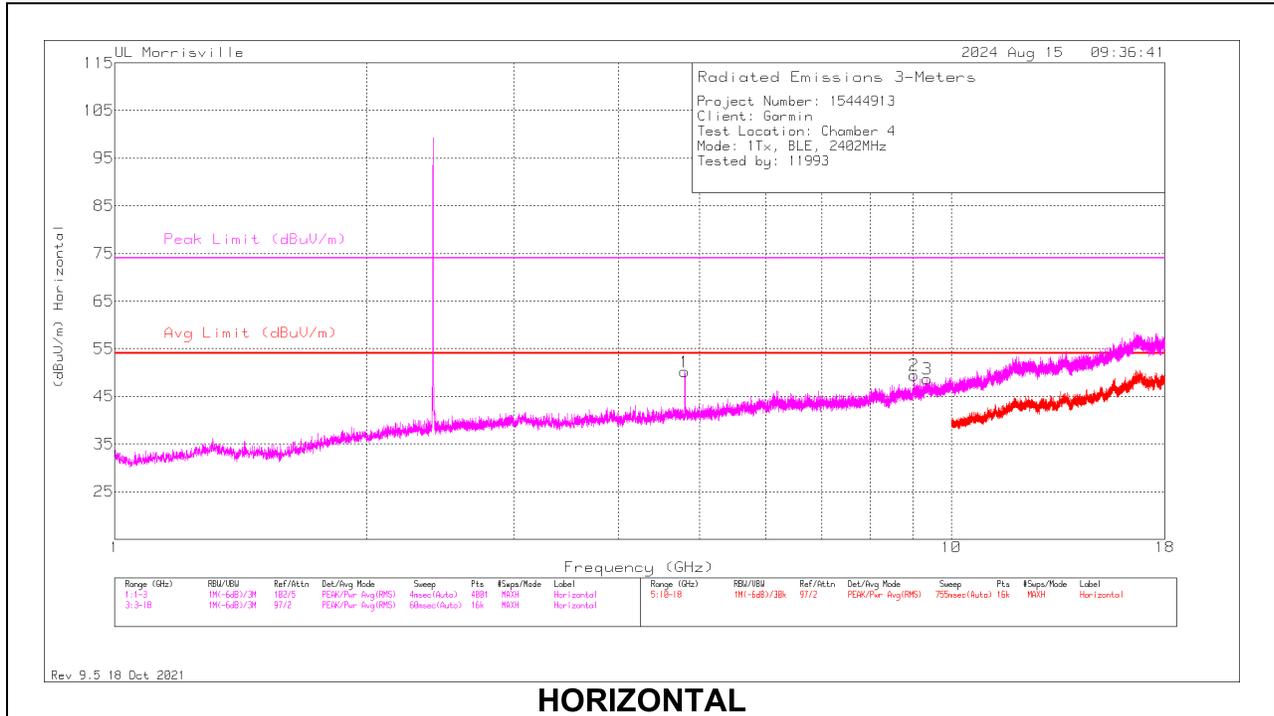


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.48354	45.37	Pk	32.3	-22.8	0	54.87	-	-	74	-19.13	225	120	V
2	* ** 2.48364	46.1	Pk	32.3	-22.8	0	55.6	-	-	74	-18.4	225	120	V
3	* ** 2.48354	24.41	ADV	32.3	-22.8	2.16	36.07	54	-17.93	-	-	225	120	V
4	* ** 2.48364	24.65	ADV	32.3	-22.8	2.16	36.31	54	-17.69	-	-	225	120	V

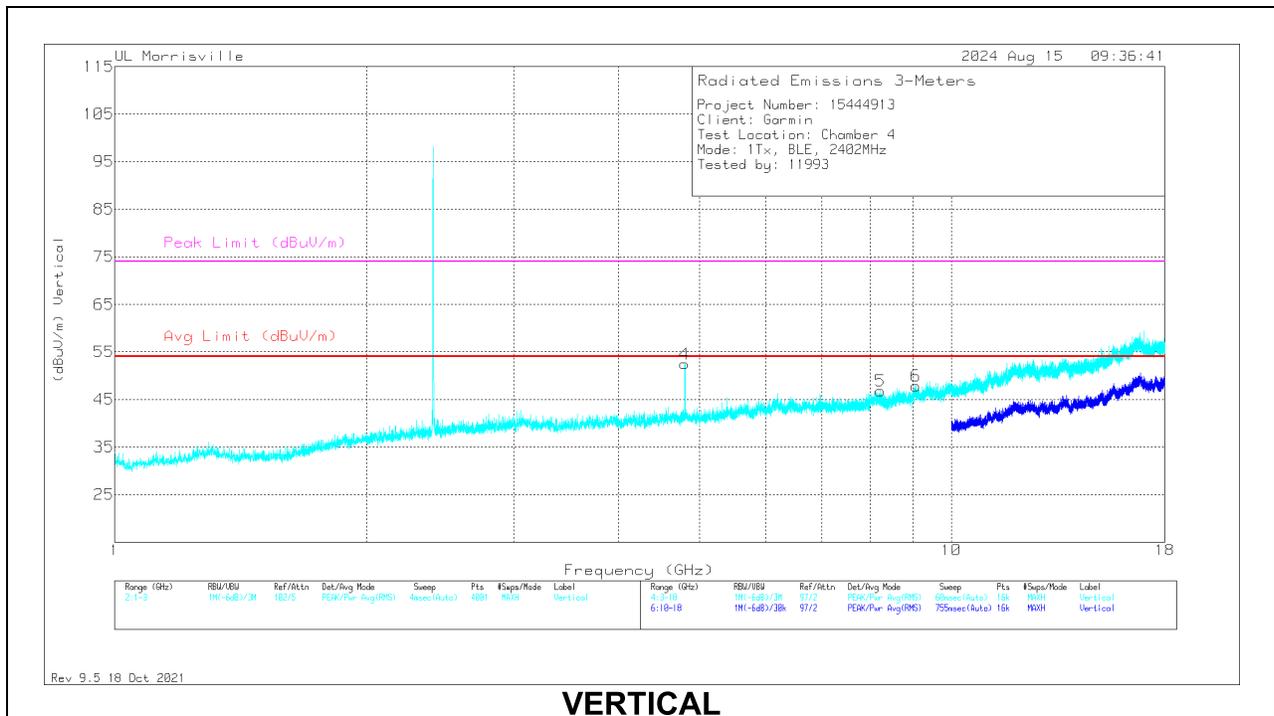
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 ** - indicates frequency in Taiwan NCC LP0002 Restricted Band
 Pk - Peak detector
 ADV - Linear Voltage Average

HARMONICS AND SPURIOUS EMISSIONS

LOW CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.80347	49.88	PK2	34.1	-31.4	0	52.58	-	-	74	-21.42	271	167	H
	* ** 4.80384	42.16	ADV	34.1	-31.4	2.16	47.02	54	-6.98	-	-	271	167	H
2	* ** 9.02347	37.08	PK2	36.2	-24.2	0	49.08	-	-	74	-24.92	289	280	H
	* ** 9.02358	24.21	ADV	36.2	-24.2	2.16	38.37	54	-15.63	-	-	289	280	H
3	* ** 9.35886	37.38	PK2	36.5	-24.5	0	49.38	-	-	74	-24.62	289	100	H
	* ** 9.36043	25.19	ADV	36.5	-24.5	2.16	39.35	54	-14.65	-	-	289	100	H
4	* ** 4.8045	52.59	PK2	34.1	-31.4	0	55.29	-	-	74	-18.71	253	229	V
	* ** 4.80418	45.78	ADV	34.1	-31.4	2.16	50.64	54	-3.36	-	-	253	229	V
5	* ** 8.22938	37.44	Pk	35.8	-26.4	0	46.84	54	-7.16	74	-27.16	0-360	200	V
6	* ** 9.07875	36.08	Pk	36.3	-24.5	0	47.88	54	-6.12	74	-26.12	0-360	200	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

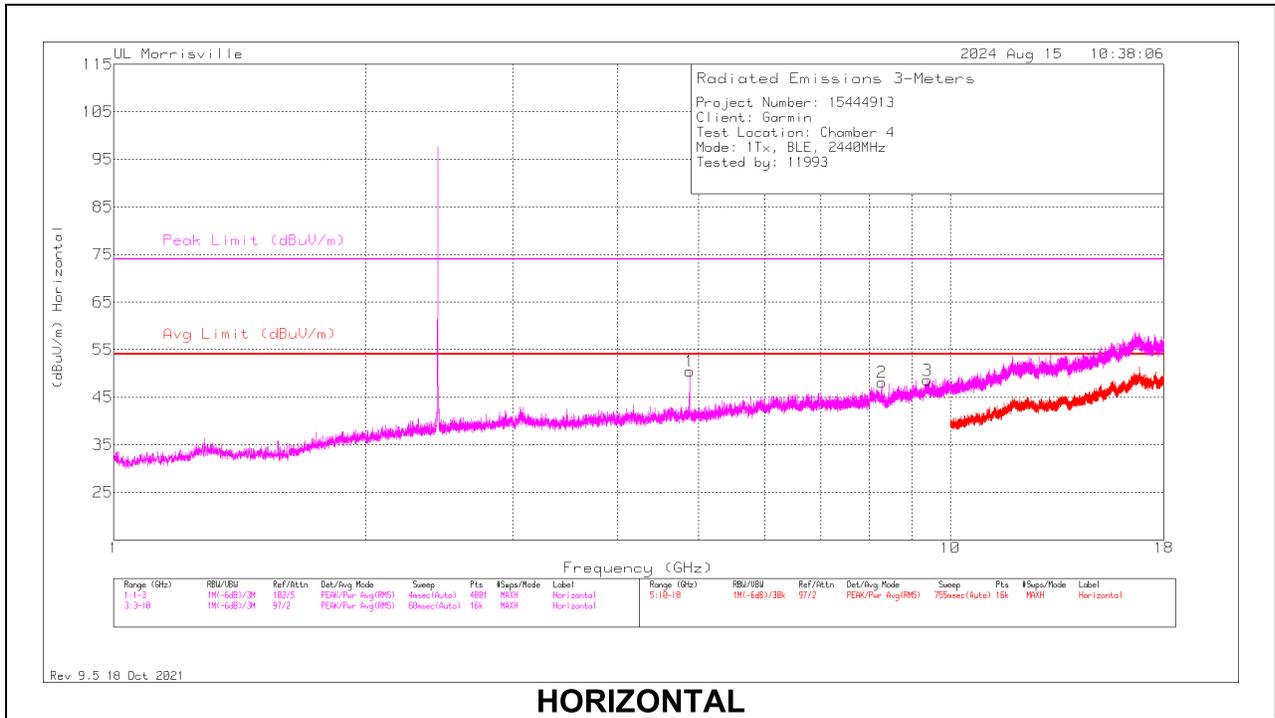
** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

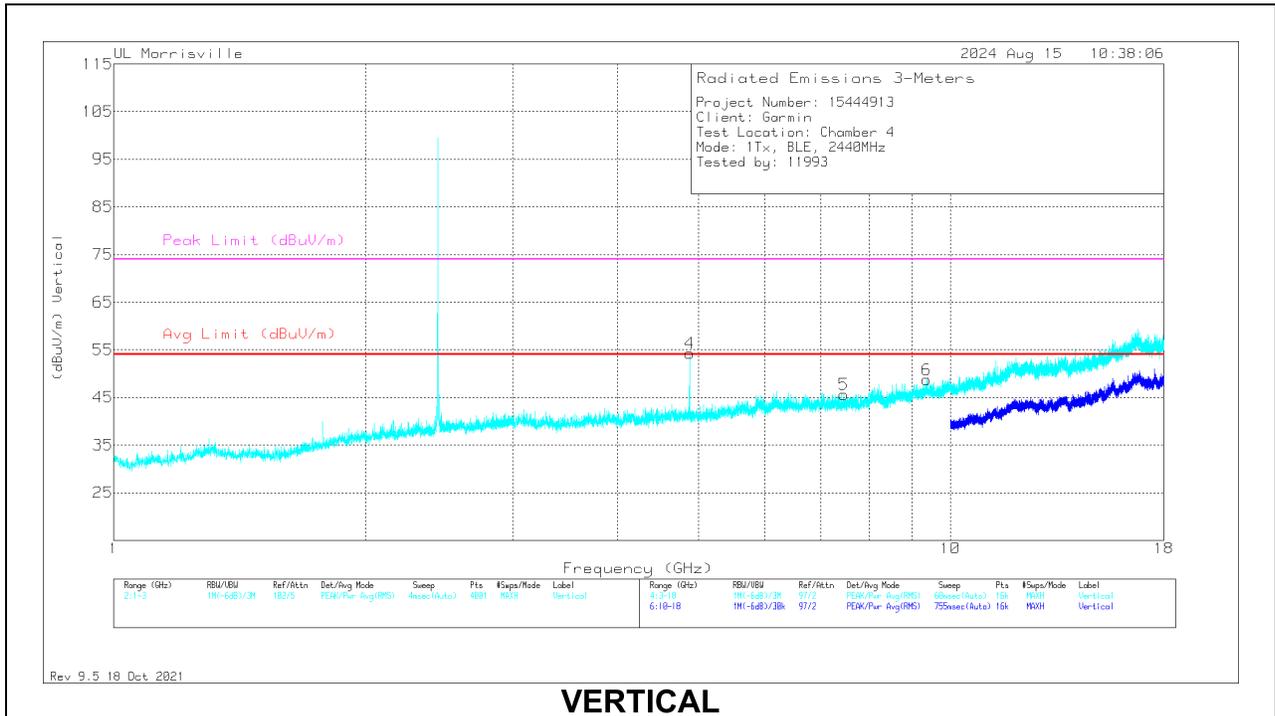
PK2 - Maximum Peak

ADV - Linear Voltage Average

MID CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 4.87934	50.16	PK2	34	-31	0	53.16	-	-	74	-20.84	277	100	H
	* ** 4.8798	42.25	ADV	34	-31	2.16	47.41	54	-6.59	-	-	277	100	H
2	* ** 8.28014	38.28	PK2	35.8	-26.4	0	47.68	-	-	74	-26.32	154	389	H
	* ** 8.28178	25.9	ADV	35.8	-26.4	2.16	37.46	54	-16.54	-	-	154	389	H
3	* ** 9.3909	38.96	PK2	36.6	-24.8	0	50.76	-	-	74	-23.24	96	343	H
	* ** 9.39086	25.05	ADV	36.6	-24.8	2.16	39.01	54	-14.99	-	-	96	343	H
4	* ** 4.88038	52.45	PK2	34	-31	0	55.45	-	-	74	-18.55	259	201	V
	* ** 4.87981	45.41	ADV	34	-31	2.16	50.57	54	-3.43	-	-	259	201	V
6	* ** 9.36564	36.83	PK2	36.5	-24.6	0	48.73	-	-	74	-25.27	122	141	V
	* ** 9.36834	24.63	ADV	36.5	-24.6	2.16	38.69	54	-15.31	-	-	122	141	V
5	* ** 7.45969	37.49	Pk	35.7	-27.6	0	45.59	54	-8.41	74	-28.41	0-360	200	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

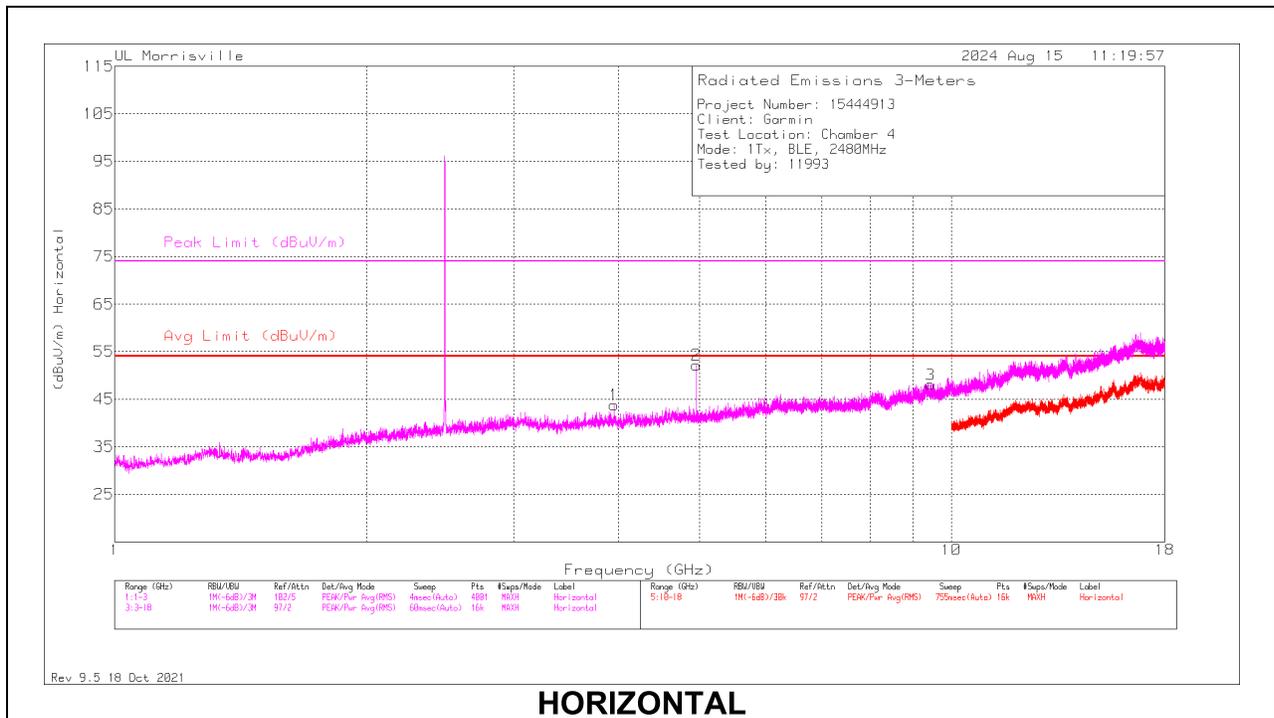
** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

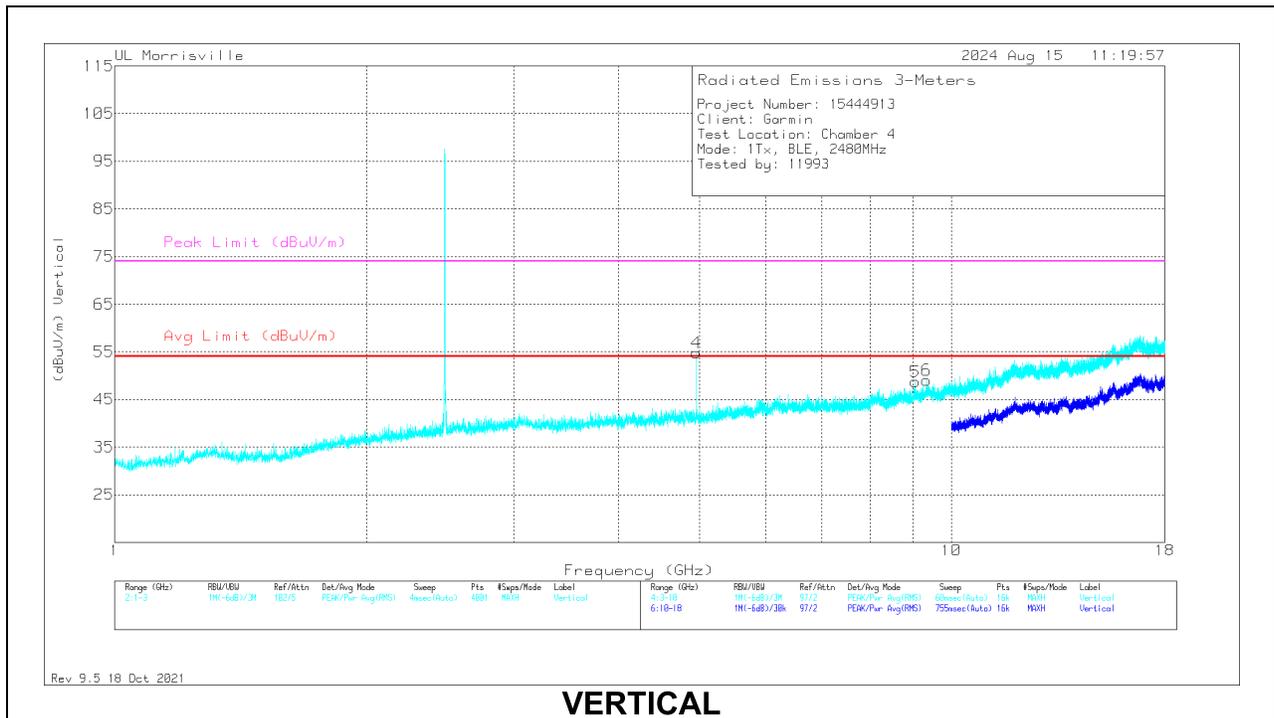
PK2 - Maximum Peak

ADV - Linear Voltage Average

HIGH CHANNEL RESULTS



HORIZONTAL



VERTICAL

RADIATED EMISSIONS

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Avg Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	* ** 4.95947	50.87	PK2	33.9	-30.8	0	53.97	-	-	74	-20.03	320	101	H
	* ** 4.9602	43.45	ADV	33.9	-30.8	2.16	48.71	54	-5.29	-	-	320	101	H
3	* ** 9.44846	37.31	PK2	36.7	-25.1	0	48.91	-	-	74	-25.09	281	193	H
	* ** 9.4483	25.04	ADV	36.7	-25.1	2.16	38.8	54	-15.2	-	-	281	193	H
4	* ** 4.96043	53.31	PK2	33.9	-30.8	0	56.41	-	-	74	-17.59	254	213	V
	* ** 4.95974	46.47	ADV	33.9	-30.8	2.16	51.73	54	-2.27	-	-	254	213	V
5	* ** 9.04865	37.14	PK2	36.2	-24	0	49.34	-	-	74	-24.66	191	397	V
	* ** 9.04792	24.03	ADV	36.2	-24	2.16	38.39	54	-15.61	-	-	191	397	V
6	* ** 9.34543	36.87	PK2	36.5	-24.3	0	49.07	-	-	74	-24.93	270	110	V
	* ** 9.34574	24.38	ADV	36.5	-24.3	2.16	38.74	54	-15.26	-	-	270	110	V
1	* ** 3.9525	41.73	Pk	33.4	-31.3	0	43.83	54	-10.17	74	-30.17	0-360	100	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

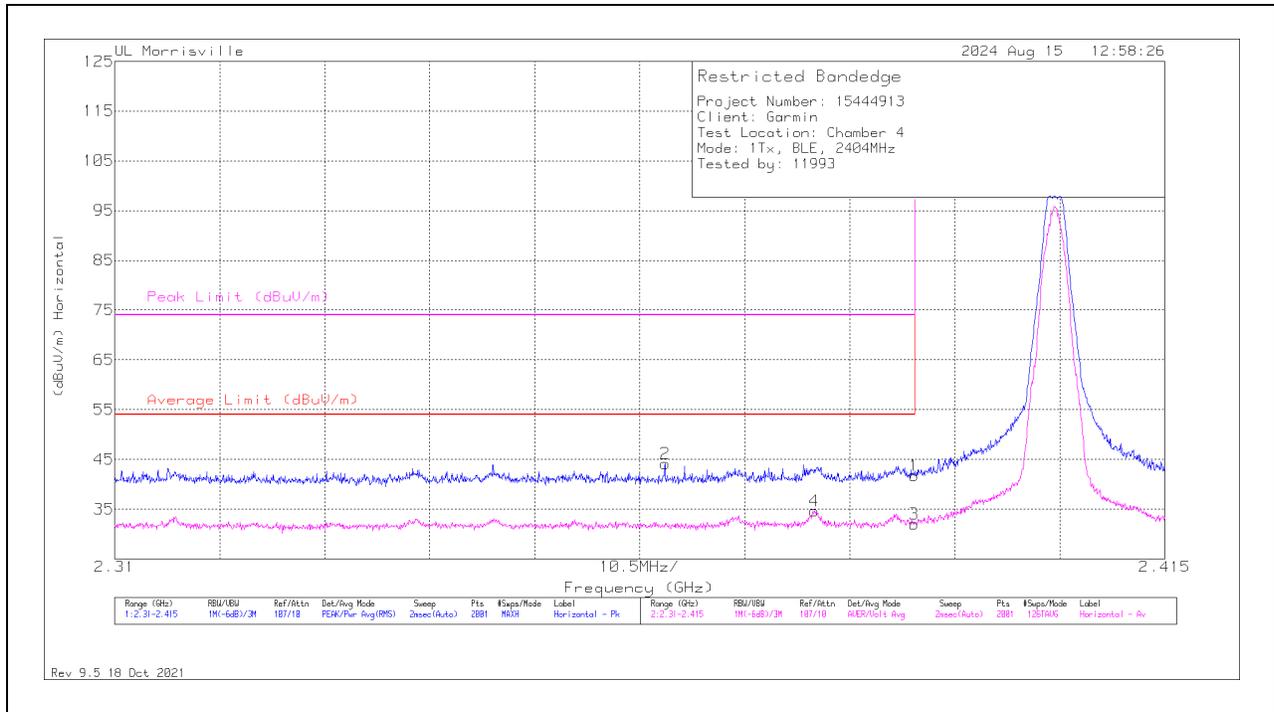
PK2 - Maximum Peak

ADV - Linear Voltage Average

10.2.2. BLE (2Mbps)

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 2.38996	32.94	Pk	32	-23.2	0	41.74	-	-	74	-32.26	254	101	H
2	*** 2.36502	35.37	Pk	31.9	-23.1	0	44.17	-	-	74	-29.83	254	101	H
3	*** 2.38996	21.17	ADV	32	-23.2	2.07	32.04	54	-21.96	-	-	254	100	H
4	*** 2.37993	23.56	ADV	32	-23	2.07	34.63	54	-19.37	-	-	254	100	H

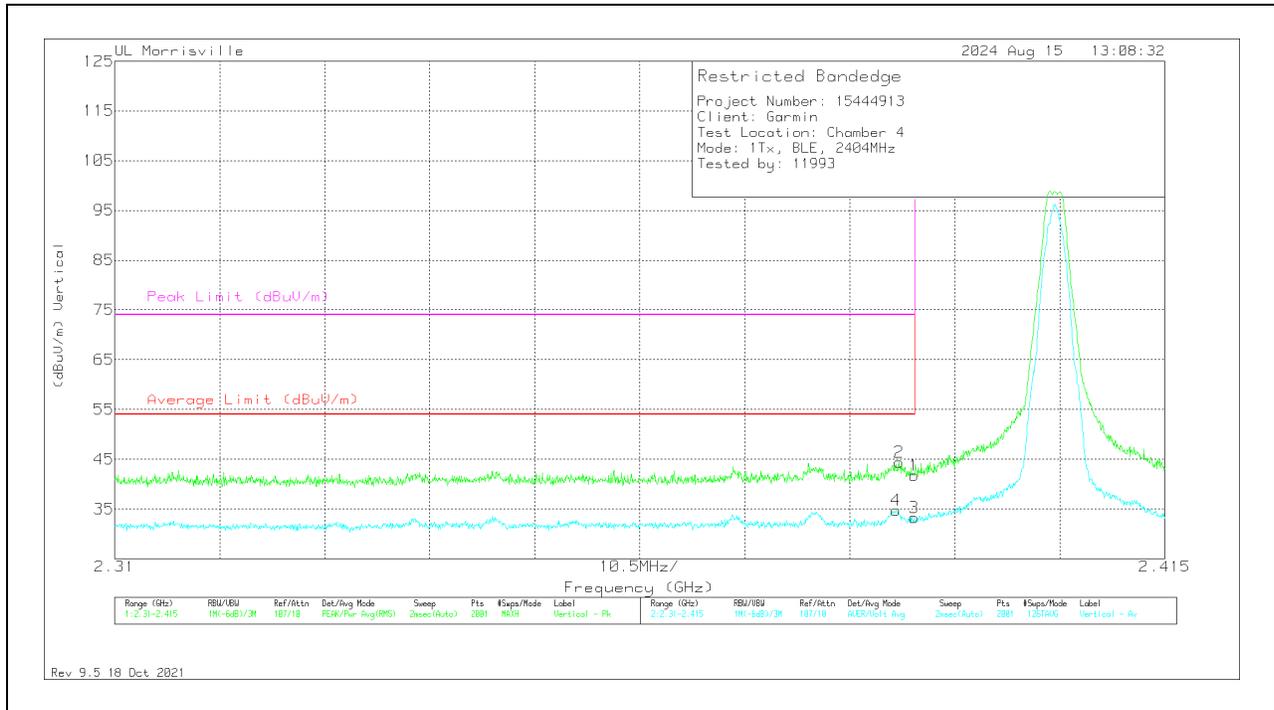
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

ADV - Linear Voltage Average

VERTICAL RESULT

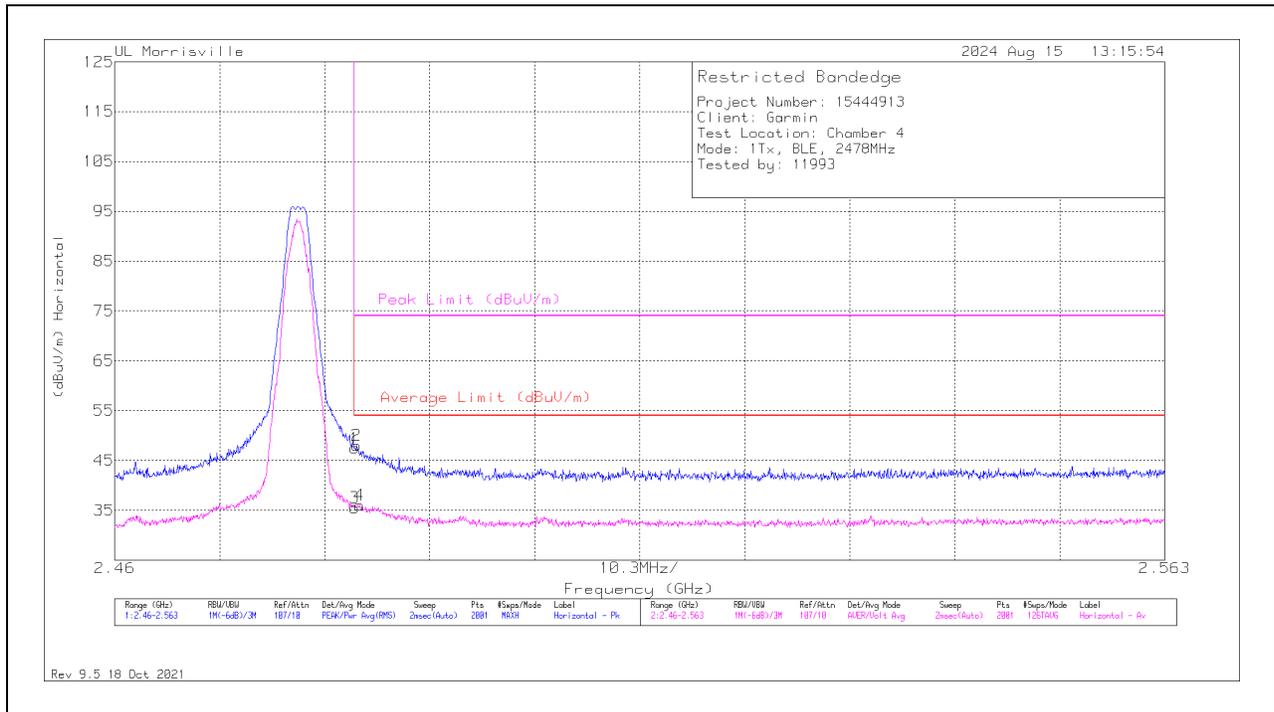


Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.38996	32.99	Pk	32	-23.2	0	41.79	-	-	74	-32.21	225	105	V
2	* ** 2.38844	35.55	Pk	32	-23.2	0	44.35	-	-	74	-29.65	225	105	V
3	* ** 2.38996	22.4	ADV	32	-23.2	2.07	33.27	54	-20.73	-	-	225	105	V
4	* ** 2.38812	23.85	ADV	32	-23.2	2.07	34.72	54	-19.28	-	-	225	105	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 ** - indicates frequency in Taiwan NCC LP0002 Restricted Band
 Pk - Peak detector
 ADV - Linear Voltage Average

BANDEDGE (HIGH CHANNEL)

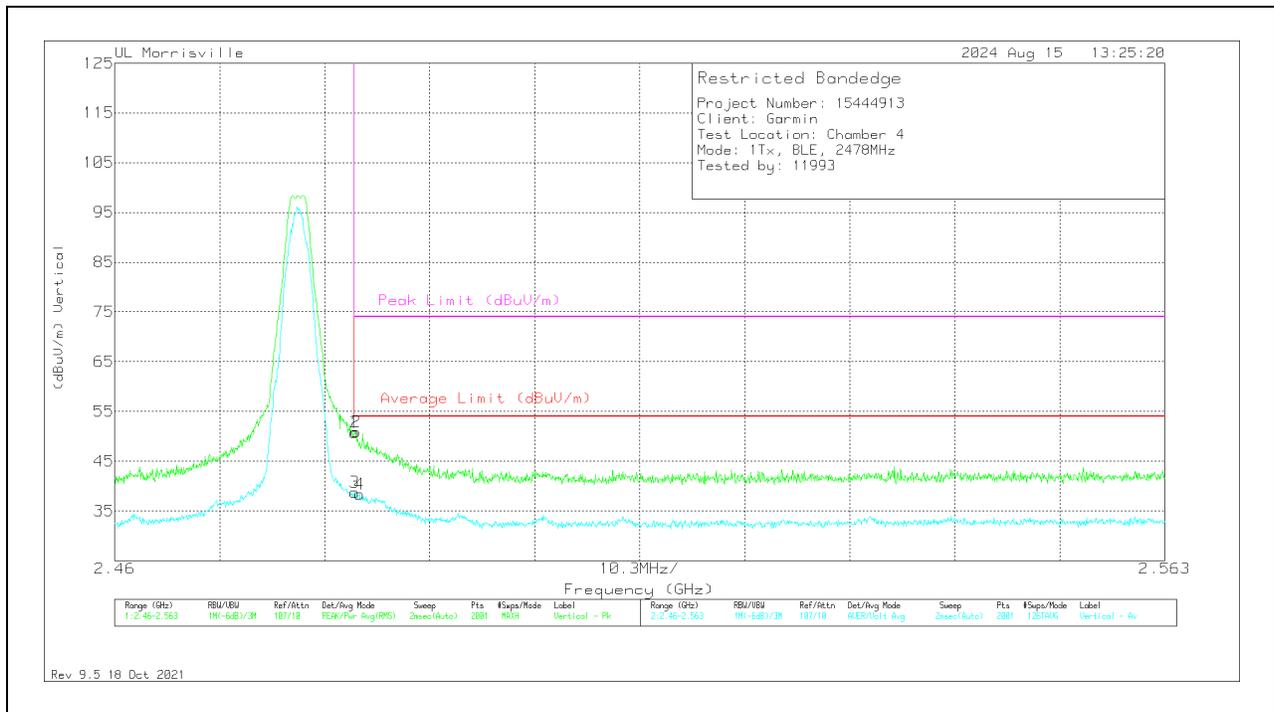
HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.48354	37.97	Pk	32.3	-22.8	0	47.47	-	-	74	-26.53	260	132	H
2	* ** 2.48374	38.5	Pk	32.3	-22.8	0	48	-	-	74	-26	260	132	H
3	* ** 2.48354	23.94	ADV	32.3	-22.8	2.07	35.51	54	-18.49	-	-	260	132	H
4	* ** 2.48405	24.43	ADV	32.3	-22.8	2.07	36	54	-18	-	-	260	132	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 ** - indicates frequency in Taiwan NCC LP0002 Restricted Band
 Pk - Peak detector
 ADV - Linear Voltage Average

VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.48354	41.23	Pk	32.3	-22.8	0	50.73	-	-	74	-23.27	225	118	V
2	* ** 2.48364	41.37	Pk	32.3	-22.8	0	50.87	-	-	74	-23.13	225	118	V
3	* ** 2.48354	27.16	ADV	32.3	-22.8	2.07	38.73	54	-15.27	-	-	225	118	V
4	* ** 2.484	26.8	ADV	32.3	-22.8	2.07	38.37	54	-15.63	-	-	225	118	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

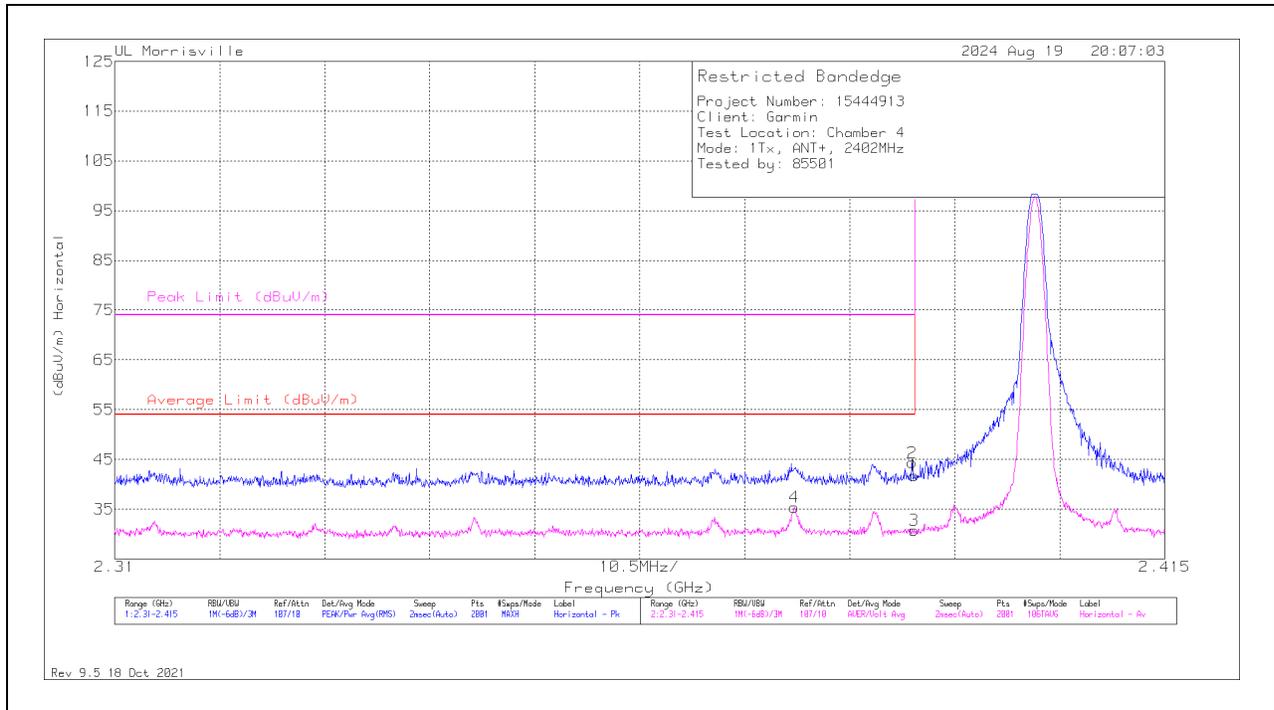
Pk - Peak detector

ADV - Linear Voltage Average

10.2.3. ANT/ANT+

BANDEDGE (LOW CHANNEL)

HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.38996	32.92	Pk	32	-23.2	0	41.72	-	-	74	-32.28	249	125	H
2	* ** 2.38975	35.53	Pk	32	-23.2	0	44.33	-	-	74	-29.67	249	125	H
3	* ** 2.38996	21.37	ADV	32	-23.2	.56	30.73	54	-23.27	-	-	249	125	H
4	* ** 2.37794	25.78	ADV	32	-23	.56	35.34	54	-18.66	-	-	249	125	H

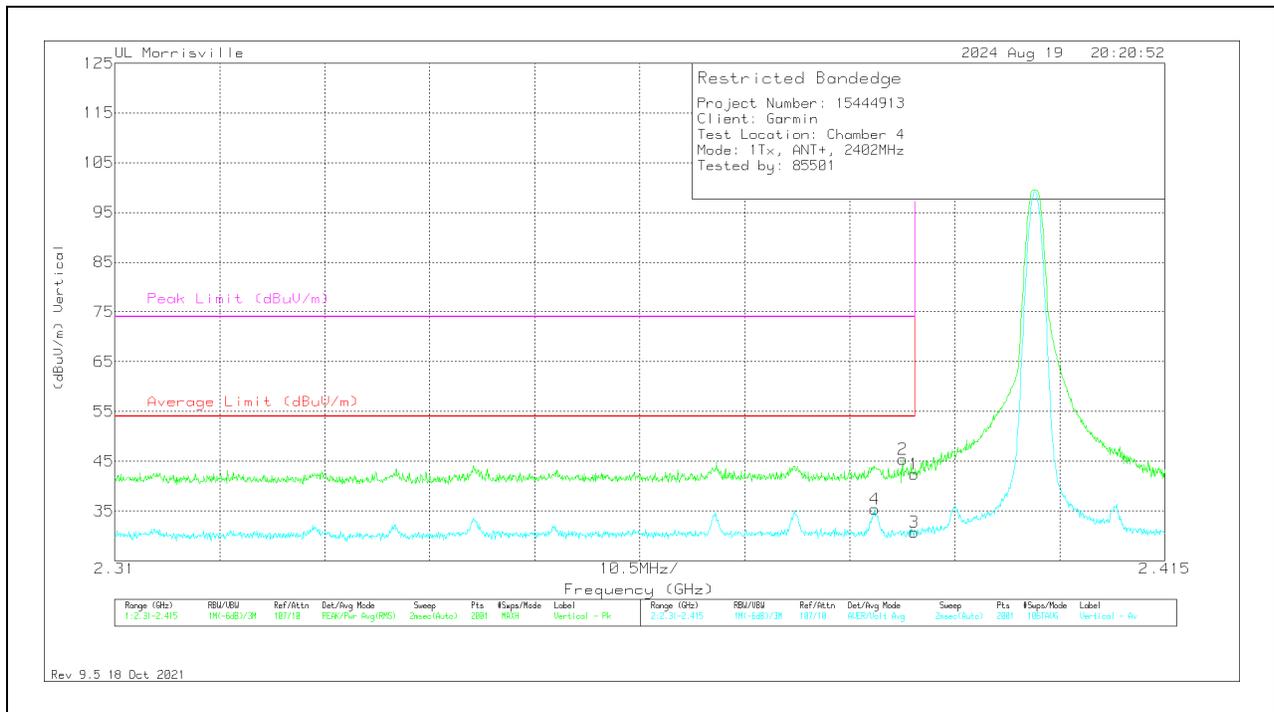
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

ADV - Linear Voltage Average

VERTICAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.38996	33.62	Pk	32	-23.2	0	42.42	-	-	74	-31.58	220	149	V
2	* ** 2.3888	36.6	Pk	32	-23.2	0	45.4	-	-	74	-28.6	220	149	V
3	* ** 2.38996	21.38	ADV	32	-23.2	.56	30.74	54	-23.26	-	-	220	149	V
4	* ** 2.38602	26.05	ADV	32	-23.2	.56	35.41	54	-18.59	-	-	220	149	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

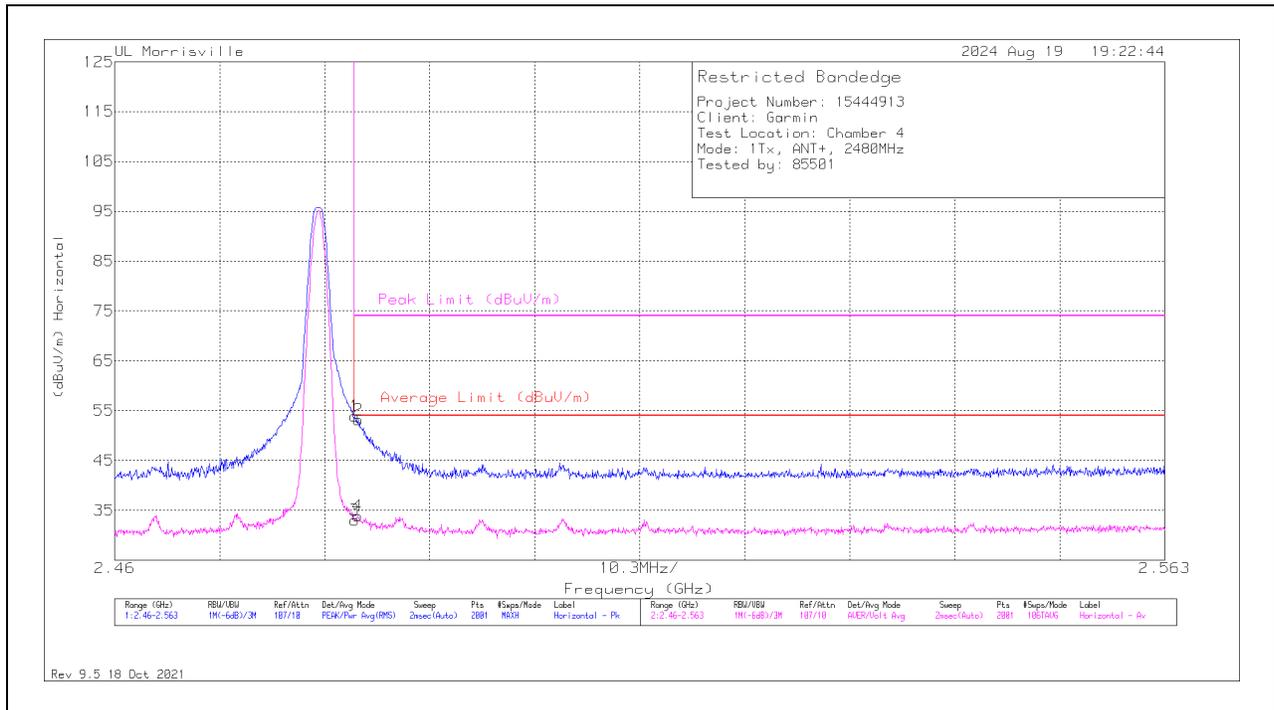
** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

ADV - Linear Voltage Average

BANDEDGE (HIGH CHANNEL)

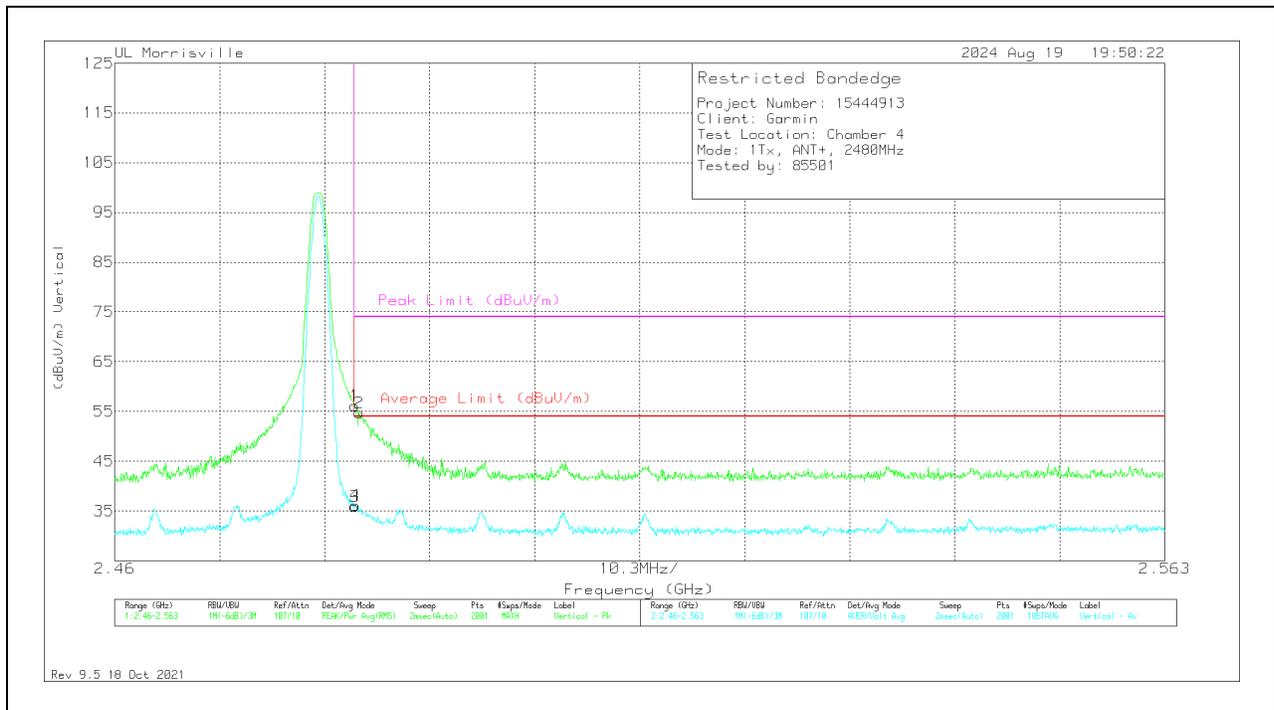
HORIZONTAL RESULT



Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.48354	44.43	Pk	32.3	-22.8	0	53.93	-	-	74	-20.07	193	102	H
2	* ** 2.4839	43.65	Pk	32.3	-22.8	0	53.15	-	-	74	-20.85	193	102	H
3	* ** 2.48354	22.95	ADV	32.3	-22.8	.56	33.01	54	-20.99	-	-	193	102	H
4	* ** 2.48384	23.77	ADV	32.3	-22.8	.56	33.83	54	-20.17	-	-	193	102	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 ** - indicates frequency in Taiwan NCC LP0002 Restricted Band
 Pk - Peak detector
 ADV - Linear Voltage Average

VERTICAL RESULT



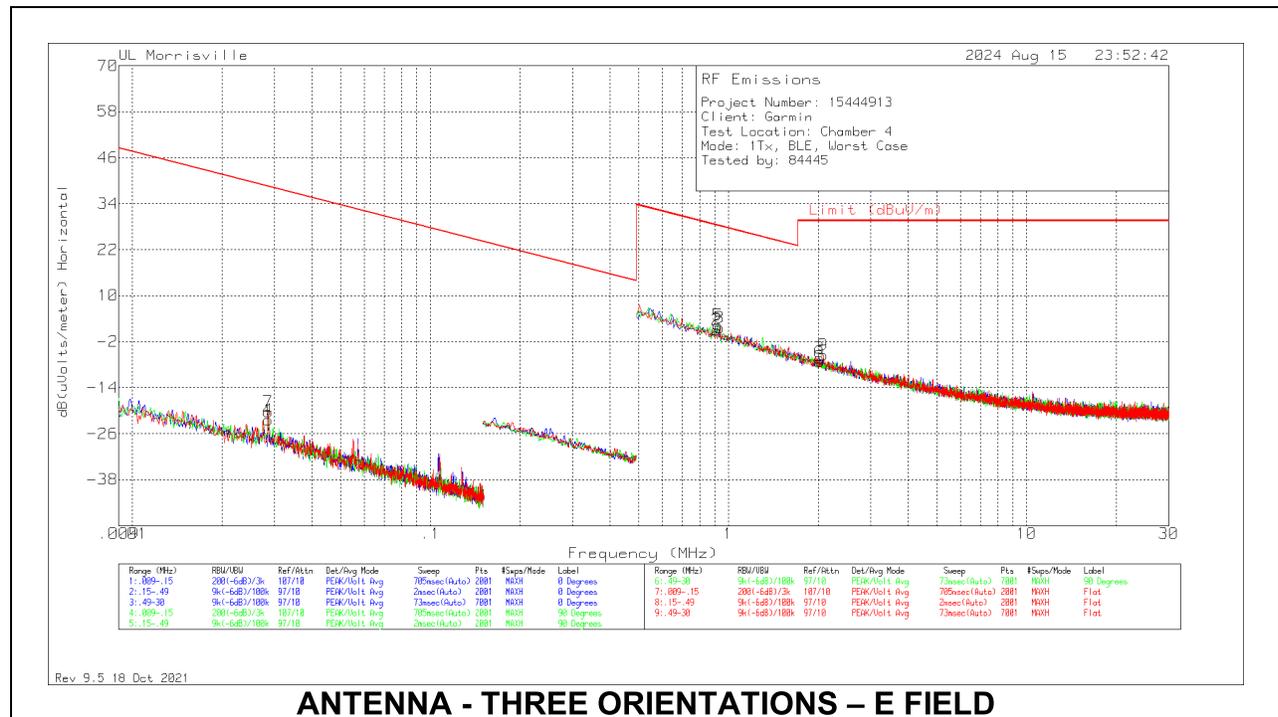
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	89509 ACF (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	PK Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 2.48354	46.64	Pk	32.3	-22.8	0	56.14	-	-	74	-17.86	237	104	V
2	* ** 2.48395	45.23	Pk	32.3	-22.8	0	54.73	-	-	74	-19.27	237	104	V
3	* ** 2.48354	25.84	ADV	32.3	-22.8	.56	35.9	54	-18.1	-	-	237	104	V
4	* ** 2.48359	26.08	ADV	32.3	-22.8	.56	36.14	54	-17.86	-	-	237	104	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 ** - indicates frequency in Taiwan NCC LP0002 Restricted Band
 Pk - Peak detector
 ADV - Linear Voltage Average

10.3. WORST CASE BELOW 30MHZ (BLE)

SPURIOUS EMISSIONS BELOW 30 MHz (WORST-CASE CONFIGURATION)

Note: All measurements were made at a test distance of 3 m. The measured data was extrapolated from the test distance (3m) to the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) to clearly show the relative levels of fundamental and spurious emissions and demonstrate compliance with the requirement that the level of any spurious emissions be below the level of the intentionally transmitted signal. The extrapolation factor for the limits were 40*Log (test distance / specification distance).

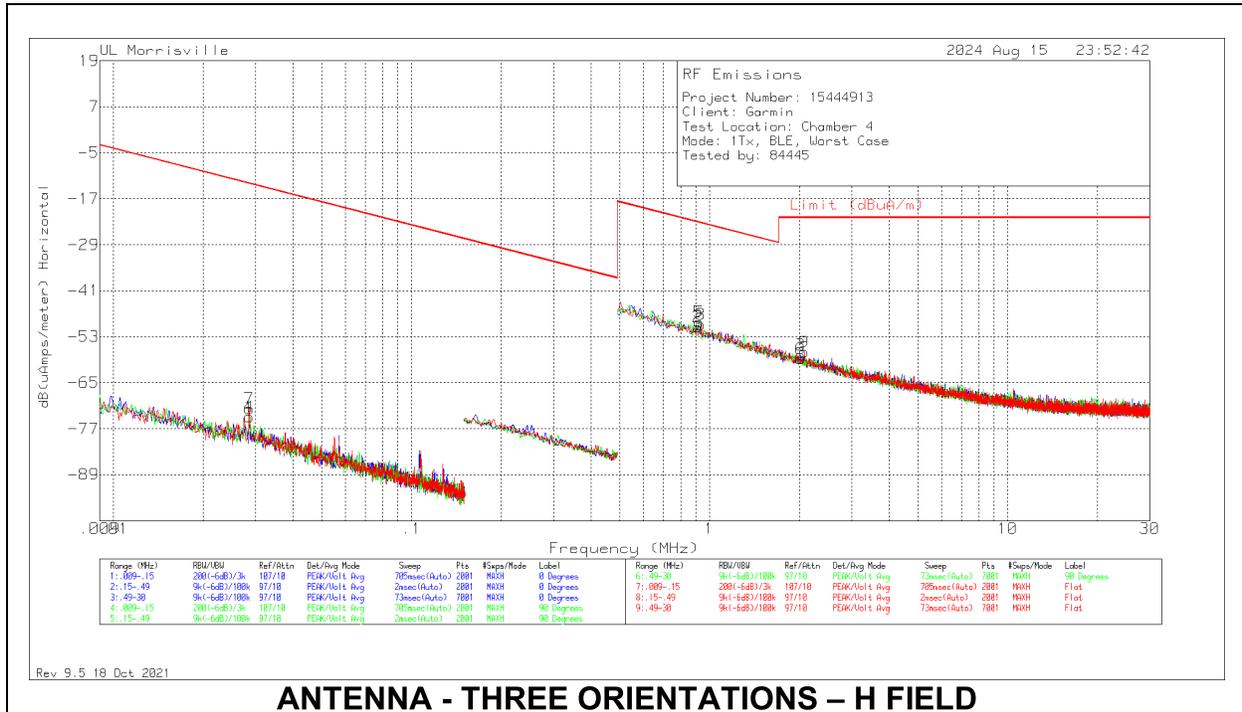


ANTENNA - THREE ORIENTATIONS – E FIELD

Below 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	135144 (dBuV/m)	Gain/Loss (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uVolts/meter)	QP/AV Limit (dBuV/m)	PK Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Loop Angle
1	.02853	43.9	Pk	13.6	.1	-80	-22.4	38.5	58.5	-60.9	0-360	0 degs
4	.02853	43.85	Pk	13.6	.1	-80	-22.45	38.5	58.5	-60.95	0-360	90 degs
7	.02853	46.08	Pk	13.6	.1	-80	-20.22	38.5	58.5	-58.72	0-360	Flat
2	.9116	29.59	Pk	11.2	.2	-40	.99	28.41	-	-27.42	0-360	0 degs
5	.92003	30.95	Pk	11.2	.2	-40	2.35	28.33	-	-25.98	0-360	90 degs
8	.93268	30.28	Pk	11.2	.2	-40	1.68	28.21	-	-26.53	0-360	Flat
6	2.02041	21.12	Pk	11.4	.2	-40	-7.28	29.54	-	-36.82	0-360	90 degs
3	2.02462	22.16	Pk	11.4	.2	-40	-6.24	29.54	-	-35.78	0-360	0 degs
9	2.08365	22.87	Pk	11.4	.2	-40	-5.53	29.54	-	-35.07	0-360	Flat

Pk - Peak detector



ANTENNA - THREE ORIENTATIONS – H FIELD

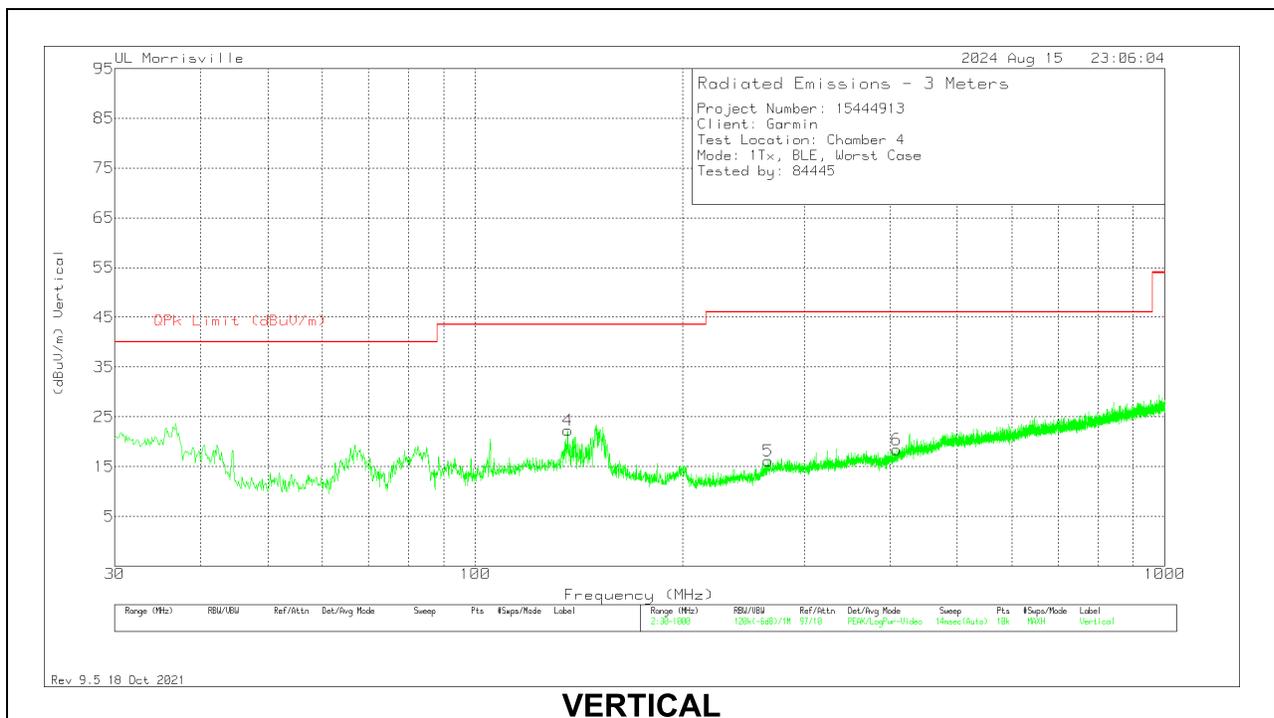
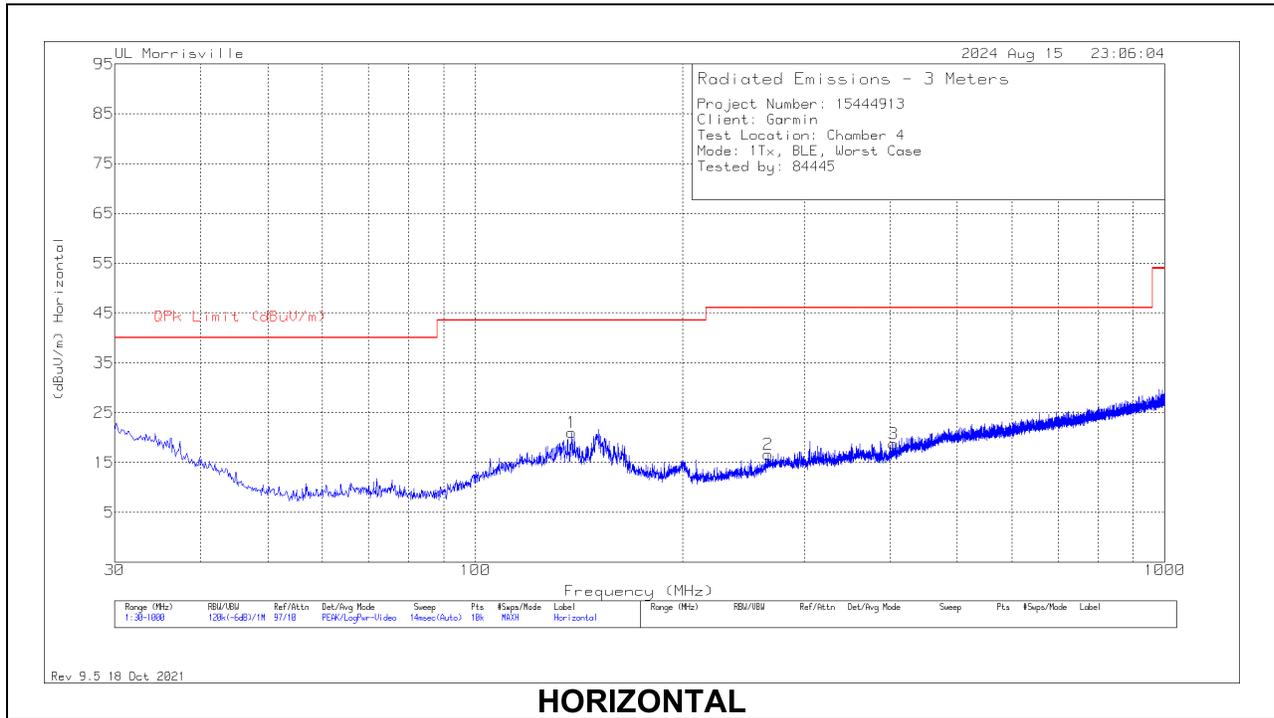
Below 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	135144 (dBuV/m)	Gain/Loss (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uAmps/meter)	QP/AV Limit (dBuA/m)	PK Limit (dBuA/m)	Margin (dB)	Azimuth (Degs)	Loop Angle
1	.02853	43.9	Pk	-37.9	.1	-80	-73.9	-13	7	-60.9	0-360	0 degs
4	.02853	43.85	Pk	-37.9	.1	-80	-73.95	-13	7	-60.95	0-360	90 degs
7	.02853	46.08	Pk	-37.9	.1	-80	-71.72	-13	7	-58.72	0-360	Flat
2	.9116	29.59	Pk	-40.3	.2	-40	-50.51	-23.09	-	-27.42	0-360	0 degs
5	.92003	30.95	Pk	-40.3	.2	-40	-49.15	-23.17	-	-25.98	0-360	90 degs
8	.93268	30.28	Pk	-40.3	.2	-40	-49.82	-23.29	-	-26.53	0-360	Flat
6	2.02041	21.12	Pk	-40.1	.2	-40	-58.78	-21.96	-	-36.82	0-360	90 degs
3	2.02462	22.16	Pk	-40.1	.2	-40	-57.74	-21.96	-	-35.78	0-360	0 degs
9	2.08365	22.87	Pk	-40.1	.2	-40	-57.03	-21.96	-	-35.07	0-360	Flat

Pk - Peak detector

10.4. WORST CASE BELOW 1 GHZ (BLE)

SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION)



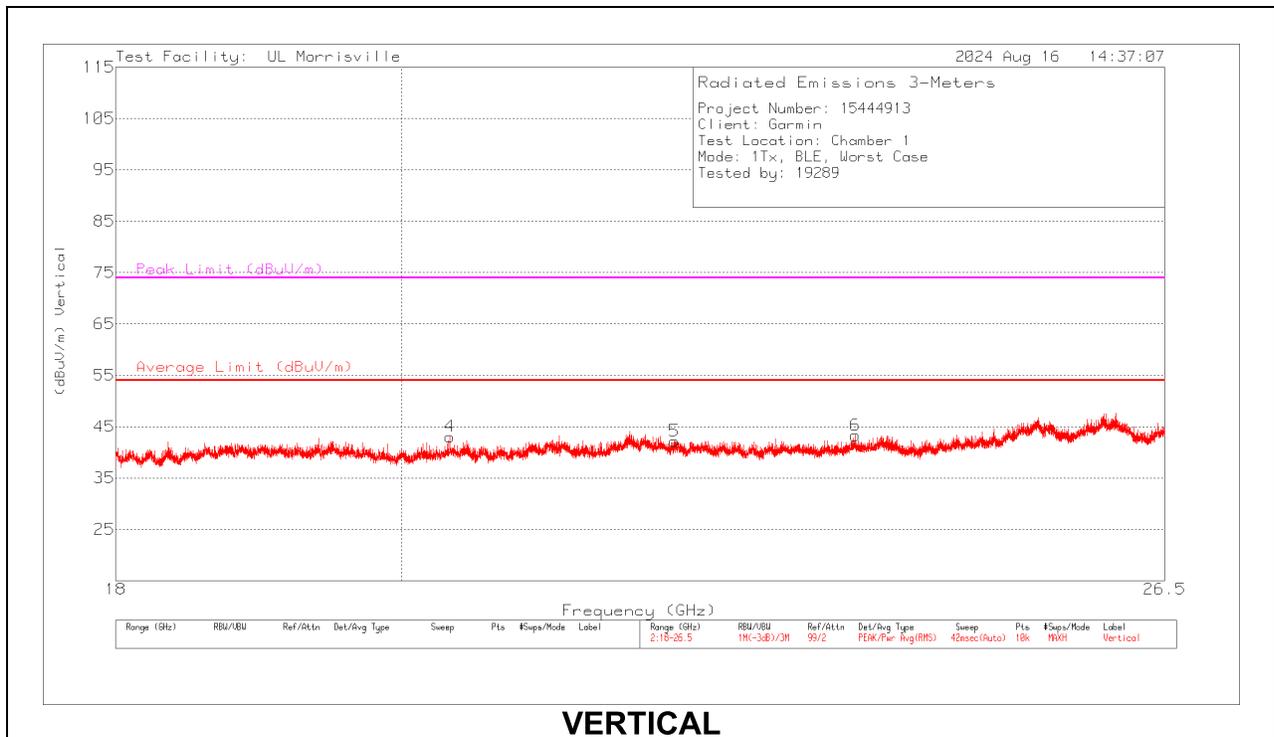
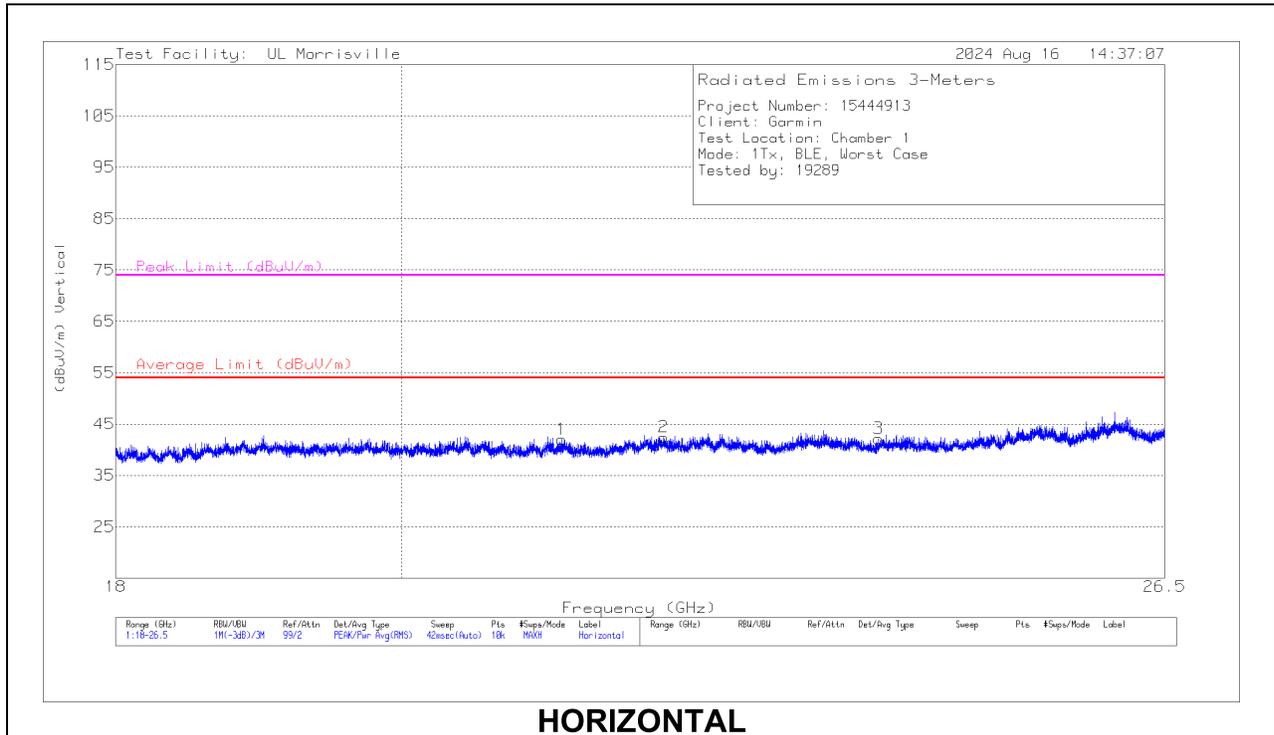
Below 1GHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	90628 (dB/m)	Gain/Loss (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	*** 137.864	32.76	Pk	19.4	-31.1	21.06	43.52	-22.46	0-360	100	H
2	*** 265.807	28	Pk	19	-30.3	16.7	46.02	-29.32	0-360	100	H
3	*** 403.935	26.84	Pk	21.8	-29.9	18.74	46.02	-27.28	0-360	100	H
4	*** 136.215	33.92	Pk	19.6	-31.2	22.32	43.52	-21.2	0-360	100	V
5	*** 265.807	27.46	Pk	19	-30.3	16.16	46.02	-29.86	0-360	100	V
6	*** 408.3	26.35	Pk	21.9	-29.8	18.45	46.02	-27.57	0-360	100	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 ** - indicates frequency in Taiwan NCC LP0002 Restricted Band
 Pk - Peak detector

10.5. WORST CASE 18-26 GHZ (BLE)

SPURIOUS EMISSIONS 18-26 GHZ (WORST-CASE CONFIGURATION)



18 – 26GHz Data

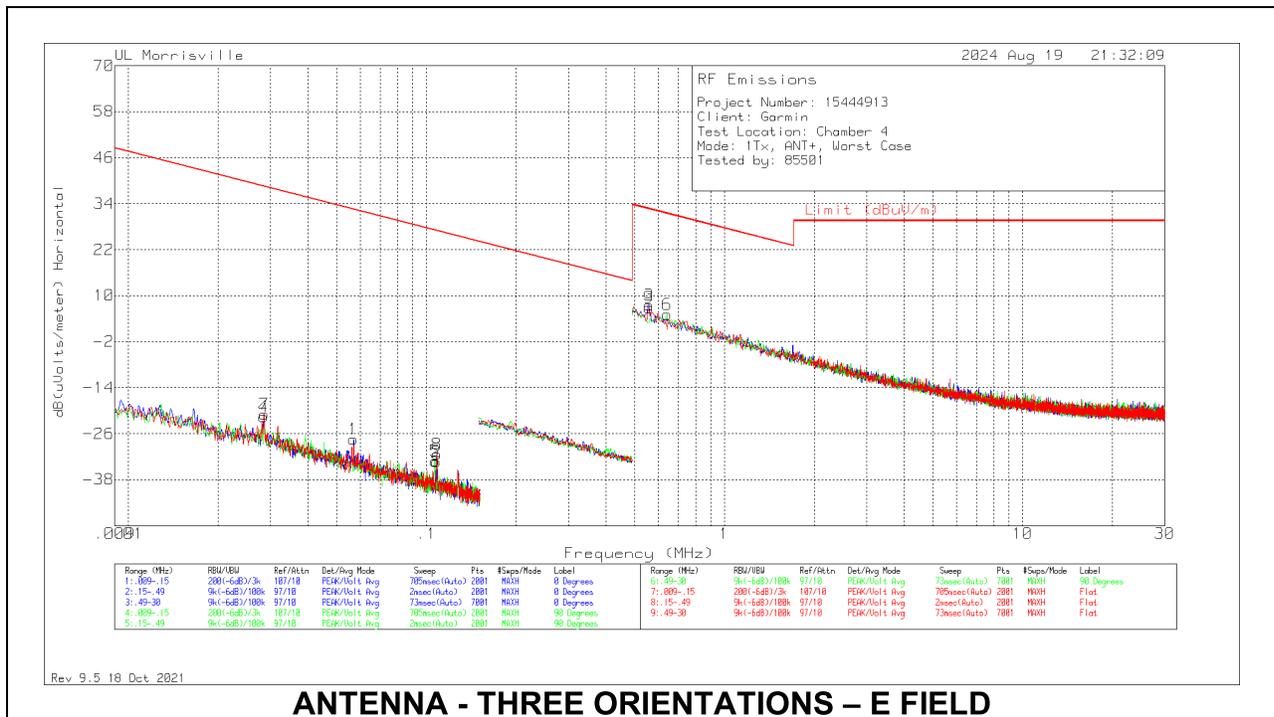
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	204704 (dB/m)	Gain/Loss (dB)	DC Corr (dB)	Corrected Reading (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 21.21693	48.4	Pk	33.6	-40	0	42	54	-12	74	-32	0-360	249	H
2	* ** 22.02775	48.45	Pk	34.2	-40.2	0	42.45	54	-11.55	74	-31.55	0-360	200	H
3	* ** 23.84487	47.69	Pk	34.4	-39.9	0	42.19	54	-11.81	74	-31.81	0-360	249	H
4	* ** 20.36106	49.55	Pk	33.6	-40.1	0	43.05	54	-10.95	74	-30.95	0-360	200	V
5	* ** 22.11784	48.05	Pk	34.3	-40.2	0	42.15	54	-11.85	74	-31.85	0-360	300	V
6	* ** 23.64174	48.62	Pk	34.6	-39.9	0	43.32	54	-10.68	74	-30.68	0-360	250	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
 ** - indicates frequency in Taiwan NCC LP0002 Restricted Band
 Pk - Peak detector

10.6. WORST CASE BELOW 30MHz (ANT/ANT+)

SPURIOUS EMISSIONS BELOW 30 MHz (WORST-CASE CONFIGURATION)

Note: All measurements were made at a test distance of 3 m. The measured data was extrapolated from the test distance (3m) to the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) to clearly show the relative levels of fundamental and spurious emissions and demonstrate compliance with the requirement that the level of any spurious emissions be below the level of the intentionally transmitted signal. The extrapolation factor for the limits were 40*Log (test distance / specification distance).

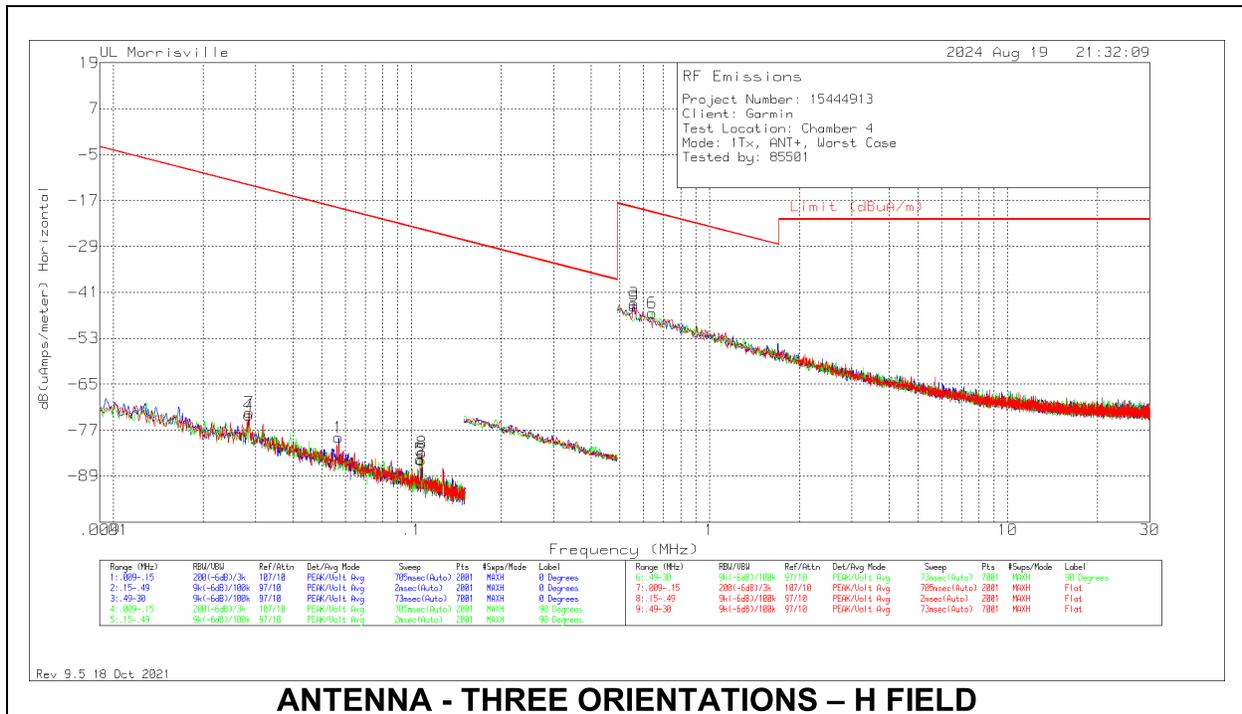


ANTENNA - THREE ORIENTATIONS – E FIELD

Below 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	135144 (dBuV/m)	Gain/Loss (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uVolts/meter)	QP/AV Limit (dBuV/m)	PK Limit (dBuV/m)	Margin (dB)	Loop Angle
4	.02845	44.75	Pk	13.6	.1	-80	-21.55	38.52	58.52	-60.07	90 degs
7	.02853	45.4	Pk	13.6	.1	-80	-20.9	38.5	58.5	-59.4	Flat
1	.057	40.86	Pk	11.6	.1	-80	-27.44	32.49	52.49	-59.93	0 degs
5	.1067	35.74	Pk	11.1	.1	-80	-33.06	27.04	-	-60.1	90 degs
2	.10776	35.43	Pk	11.1	.1	-80	-33.37	26.96	-	-60.33	0 degs
8	.10861	37.47	Pk	11.1	.1	-80	-31.33	26.89	-	-58.22	Flat
3	.55746	36.35	Pk	11.1	.1	-40	7.55	32.68	-	-25.13	0 degs
9	.55746	35.63	Pk	11.1	.1	-40	6.83	32.68	-	-25.85	Flat
6	.64178	33.83	Pk	11.2	.1	-40	5.13	31.46	-	-26.33	90 degs

Pk - Peak detector



ANTENNA - THREE ORIENTATIONS – H FIELD

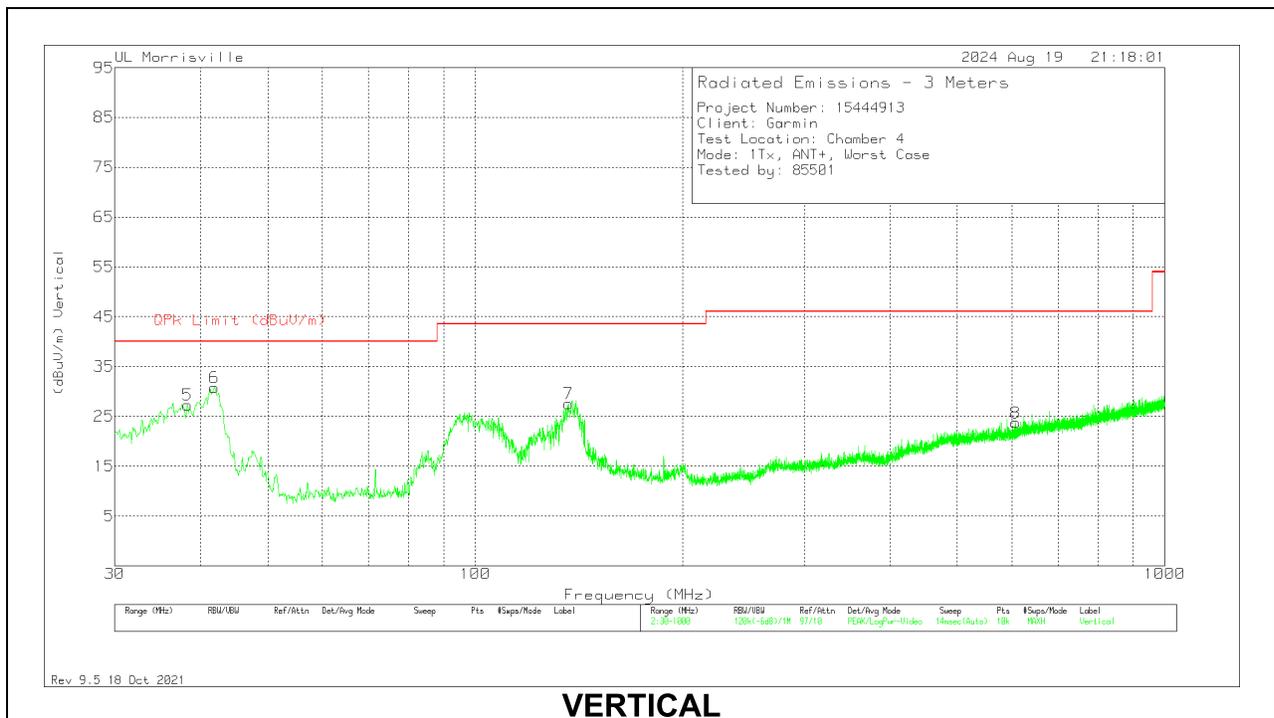
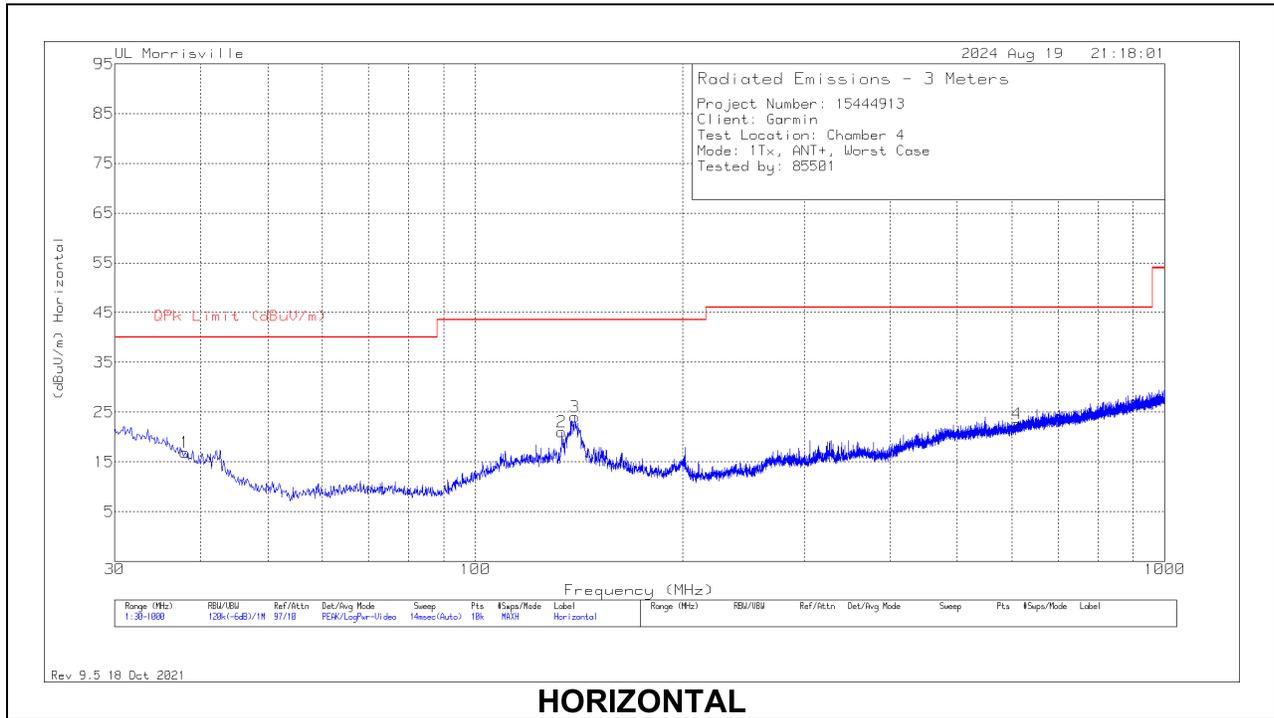
Below 30MHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	135144 (dBuV/m)	Gain/Loss (dB)	Dist. Corr. Factor (dB)	Corrected Reading dB(uAmps/meter)	QP/AV Limit (dBuA/m)	PK Limit (dBuA/m)	Margin (dB)	Azimuth (Degs)	Loop Angle
4	.02845	44.75	Pk	-37.9	.1	-80	-73.05	-12.98	7.02	-60.07	0-360	90 degs
7	.02853	45.4	Pk	-37.9	.1	-80	-72.4	-13	7	-59.4	0-360	Flat
1	.057	40.86	Pk	-39.9	.1	-80	-78.94	-19.01	.99	-59.93	0-360	0 degs
5	.1067	35.74	Pk	-40.4	.1	-80	-84.56	-24.46	-	-60.1	0-360	90 degs
2	.10776	35.43	Pk	-40.4	.1	-80	-84.87	-24.54	-	-60.33	0-360	0 degs
8	.10861	37.47	Pk	-40.4	.1	-80	-82.83	-24.61	-	-58.22	0-360	Flat
3	.55746	36.35	Pk	-40.4	.1	-40	-43.95	-18.82	-	-25.13	0-360	0 degs
9	.55746	35.63	Pk	-40.4	.1	-40	-44.67	-18.82	-	-25.85	0-360	Flat
6	.64178	33.83	Pk	-40.3	.1	-40	-46.37	-20.04	-	-26.33	0-360	90 degs

Pk - Peak detector

10.7. WORST CASE BELOW 1 GHZ (ANT/ANT+)

SPURIOUS EMISSIONS 30 TO 1000 MHz (WORST-CASE CONFIGURATION)



Below 1GHz Data

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	90628 (dB/m)	Gain/Loss (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	* ** 37.954	27.47	Pk	21.5	-32.1	16.87	40	-23.13	0-360	200	H
2	* ** 133.499	32.42	Pk	19.8	-31.2	21.02	43.52	-22.5	0-360	100	H
4	* ** 609.769	26.91	Pk	25	-29.2	22.71	46.02	-23.31	0-360	100	H
5	* ** 38.245	38.08	Pk	21.3	-32.1	27.28	40	-12.72	0-360	100	V
7	* ** 136.603	39.26	Pk	19.5	-31.2	27.56	43.52	-15.96	0-360	100	V
8	* ** 608.023	27.92	Pk	24.9	-29.1	23.72	46.02	-22.3	0-360	100	V
6	41.834	43.99	Pk	18.7	-31.9	30.79	40	-9.21	0-360	100	V
3	139.416	35.82	Pk	19.3	-31.1	24.02	43.52	-19.5	0-360	100	H

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

** - indicates frequency in Taiwan NCC LP0002 Restricted Band

Pk - Peak detector

11. SETUP PHOTOS

Please refer to R15444913-EP1 for setup photos

END OF TEST REPORT

Test Report 2024-108

Version A

Issued 6 Sept 2024

Project: GCL-0580

Model Identifier: A05000

Primary Test Standard(s):

CFR 47, FCC Part 15.225

RSS-210 Issue 11

Garmin Compliance Lab

Garmin International

1200 E 151st Street

Olathe Kansas 66062 USA

Client-supplied Information

FCC ID: IPH-05000
IC ID: 1792A-05000



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

1. Summary

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

Parameter	Description	Key Performance Values	Result	Data starts at page
Transmitter intentional emissions	Emissions while transmitting must be limited according to a mask that varies across the frequency range 13.110 to 14.010 MHz.[15.225(a) through (c), RSS-210 B.6]	24.9 dB of margin to the intentional emission limit.	PASS	12
Transmitter spurious emissions	Emissions beyond the intended radio band while transmitting must be suppressed a general limit. [FCC 15.225 (d) and RSS 210 B.6]	5.9 dB of margin to the Class B limit.	PASS	22
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. [FCC Part 15.205 and RSS-GEN 8.8]	5.3 dB of margin to the appropriate limit. Tested 150 kHz to 30 MHz applying combined Class B limits.	PASS	25
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 210 B.6]	The Carrier frequency was stable within 0.01% of the target frequency.	PASS with caveat	28
Other Bandwidths	Bandwidth values are presented for 99% Occupied Bandwidth	There are requirements to report these numbers, but they do not have performance limits.	Reported	30

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

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

Table 1: Summary of results

Report Organization

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

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2024-116. That report is treated as a part of this document by way of this reference.

2. Test Background

2.1 The Test Lab

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

2.2 The Client

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

2.3 Other Information

Test Sample received: 22 July 2024
Test Start Date: 24 July 2024
Test End Date: 22 Aug 2024

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

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

3. Report History and Approval

This report was written by Andy Heier and initially issued on 6 Sept 2024 as Version A.

Report Technical Review:

David Arnett
Technical Lead EMC Engineer



Report Approval:

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



4. Test Sample Modifications and Special Conditions

The following special conditions or usage attributes were judged during test to be necessary to achieve compliance with one or more of the standards listed in section 6 of this report:

None

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

None

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model A05000
Serial Number tested 477224793, 477224584

This product tested is a mobile device for collecting and sharing data with the user and nearby electronic devices.

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, NFC
Radio Receivers: GPS L1, GPS L5, Galileo E1, Galileo E5a/b, BeiDou, GLONASS
Primary Functions: Data collection and communication
Typical use: Portable in multiple orientations
Highest internal frequency: 2.484 GHz
Firmware Revision 4.03

5.3 Operating modes

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

Mode 3: M3 (BleTx). Bluetooth Low Energy radio transmitting consistently on a selected channel at 1 Mbps or 2 Mbps.

Mode 4: M4 (BleLnk). Bluetooth Low Energy radio is paired to a companion device, transmitting and receiving data on various channels in accordance with the protocol, and maintaining the paired relationship.

Mode 5: M5 (AntTx). ANT radio transmitting consistently on a selected channel.

Mode 6: M6 (AntLnk). ANT radio is paired to a companion device, transmitting and receiving data in accordance with the protocol, and maintaining the paired relationship.

Mode 9: M9 (RxBtBIA). The radio was set to receive 2.4 GHz signals but not transmitting in Bluetooth, Bluetooth low energy or ANT.

Mode 12: M12 (NfcLnk). The NFC radio was transmitting and actively linked to a NFC Card Reader.

Mode 13: M13 (GNSS). The Global Navigation Satellite System receiver is monitoring the GNSS bands, attempting to detect a constellation and determine location. Unless otherwise noted, the EUT was provided simulated GNSS signals representing one of more constellation types. In addition, the EUT may have been reporting signal levels and satellite data to an attached computer to monitor link health.

Mode 14: M14 (Nfclidle). The NFC Radio was powered, but not transmitting or linked to any devices.

Mode 19: M19 (ML1). Multiple link, combining modes M4 & M6. The EUT is actively paired to both a BLE and an ANT companion device, used for Immunity tests.

Mode 20: M20 (ML2). Multiple link, combining modes M12 & M13. The EUT is actively linked to a NFC card reader and the specified satellite system, used for immunity tests.

5.4 EUT Arrangement

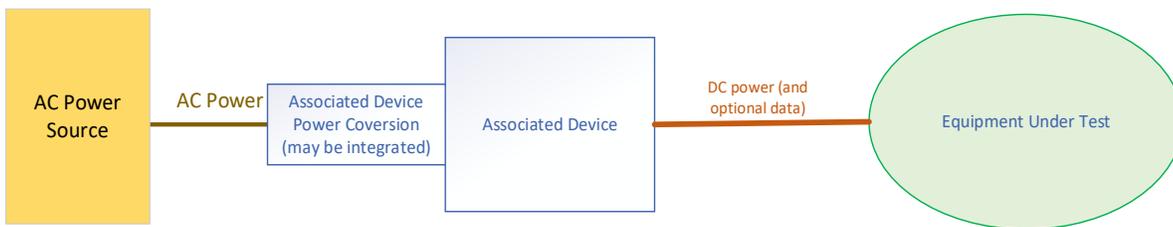
During test, the EUT components and associated support equipment were selected including the following arrangement sets.

Arrangement 1: A1 (Solo). The test sample operates from its battery and no external physical connections. No block diagram is needed for this arrangement.

Arrangement 2: A2 (Upwr). The test sample is attached to a Mains-powered device connected that provides dc power to the sample over a cable but no user data. See the block diagram in Figure 1.

Arrangement 3: A3 (Udata). The test sample is attached to a Mains-powered device connected that provides dc power to the sample and user data over a cable. See the block diagram in Figure 1.

Arrangement 4: A4 (Udc). The test sample is attached to a Mains-powered device connected that provides dc power to the sample and may or may not provide user data. This arrangement is specified in the test plan to provide staff flexibility when the presence or absence of data on the cable is not pertinent. See the block diagram in Figure 1.



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

Figure 1: Block diagram of equipment arrangements A2, A3, A4

Arrangement 6: A6 (NFCu). The test sample is powered via internal battery and actively linked to a NCR reader powered by a laptop PC.

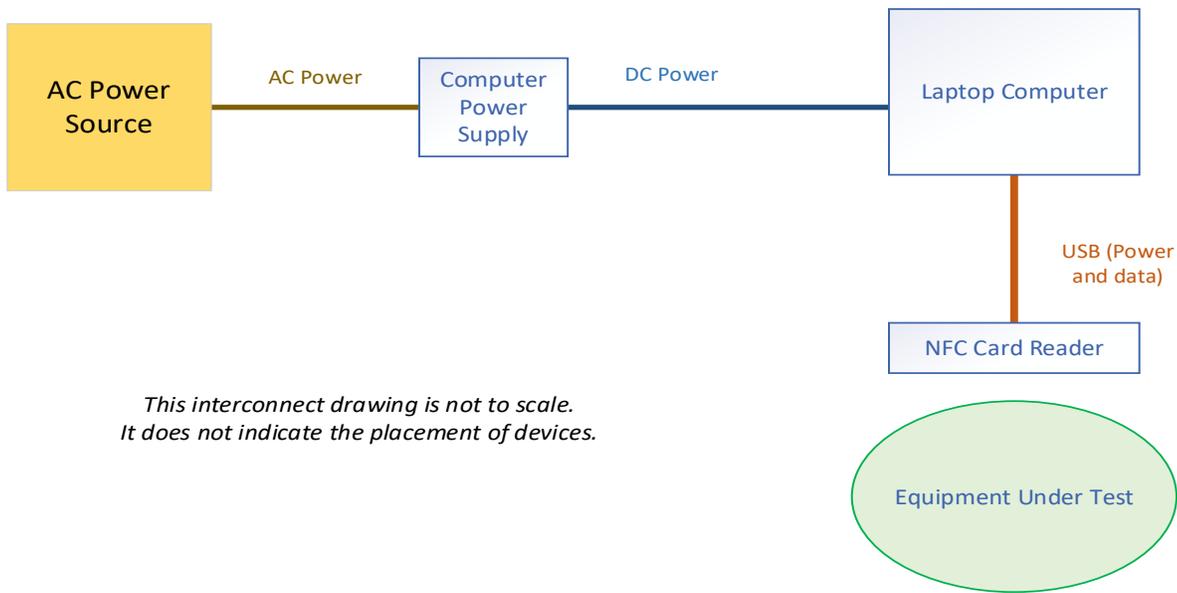


Figure 2: Block diagram of equipment arrangement A6

Arrangement 7: A7 (NFCu). The test sample is powered via internal battery and actively linked to a passive NFC tag.

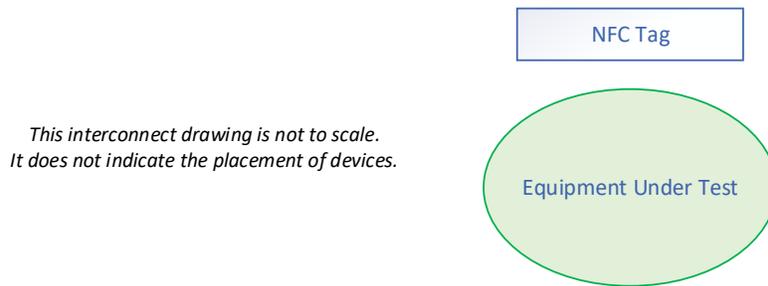


Figure 2: Block diagram of equipment arrangement A7

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial/Part Number
USB C power adaptor	Phihong (Garmin)	AQ27A-59CFA	362-00118-00
Tablet	Apple	iPad Pro 11 inch	DMPZ7582KD6L
Laptop	Dell	Latitude 5410	5VSPFB3
Power Supply	Dell	HA65NM191	0BD-7TC0-A02
Phone	Samsung	SM-G973U (S10)	RF8MC0W9XVR
NFC Card Reader	ACS	ACR1252U-M1	RR554-118449
Auxiliary Device	Garmin	A04600	3423419439
Auxiliary Device	Garmin	A04883	3477207518

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

5.6 Cables used

Description	From	To	Length	EMC Treatment
USB C to custom cable	Power and/or Data source	EUT	0.5m	None

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

6. Test Standards Applied

6.1. Accredited Standards

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

CFR 47, FCC Part 15, Subpart C
ANSI C63.10: 2020 and ANSI C63.10: 2020 +Cor 1: 2023
RSS-210 Issue 11

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	$*1.55 \times 10^{-7}$	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 to 21 °C
Relative Humidity:	49% to 61% (non-condensing)
Barometric Pressure	98 to 110 kPa

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

Table 4: Environmental monitoring device

10. Immunity Performance Criteria

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

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

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

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

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

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

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

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 RE18
Project GCL0580

Test Date(s) 20 Aug 2024
 Test Personnel David Kerr

Product Model A05000
 Serial Number tested 477224793

Operating Mode M12 (NfcLnk),Type A .
 Arrangement A6 (NFCu)
 Input Power Battery

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

Frequency Range: 10 MHz to 30 MHz
Pass/Fail Judgment: PASS

Test record created by: David A Kerr
Date of this record: 21 Aug 2024

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Loop antenna, amplified	Schwarzbeck	FMZB 1519B	174	18-Jul-2024	18-Jul-2026
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	7-Nov-2022	7-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

Table RE18.1: Test Equipment Used

Software Used: Keysight PXE software A.32.06, 150k to 30M Signal Maximization Tool V1 2021Mar17.xlsx, 150k to 30M XYZ_orientations_TemplateV6.xlsm

Test Data

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

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

The table shows the selected final measurement data between 10 MHz and 30 MHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m. Any unintentional radio emission limits are not applied to intentional radio signals.

Frequency (MHz)	Limit (dBμV/m)	Limit (dBμA/m)	Measured (dBμV/m)	Measured (dBμA/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Orientation
13.348	60.5	9.0	29.9	-21.6	30.6	-4	1500	X
13.461	70.5	19.0	30.1	-21.4	40.4	-3	1500	X
13.560	104.0	52.5	63.8	12.3	40.2	-6	1500	X
13.771	60.5	9.0	30.2	-21.3	30.3	180	1500	X
13.985	60.5	9.0	22.9	-28.6	37.6	180	1500	X
24.000	49.5	-2.0	23.8	-27.7	25.7	-154	1500	Y
27.429	49.5	-2.0	24.1	-27.4	25.4	-148	1500	Y

Table RE18.2: Emission summary

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

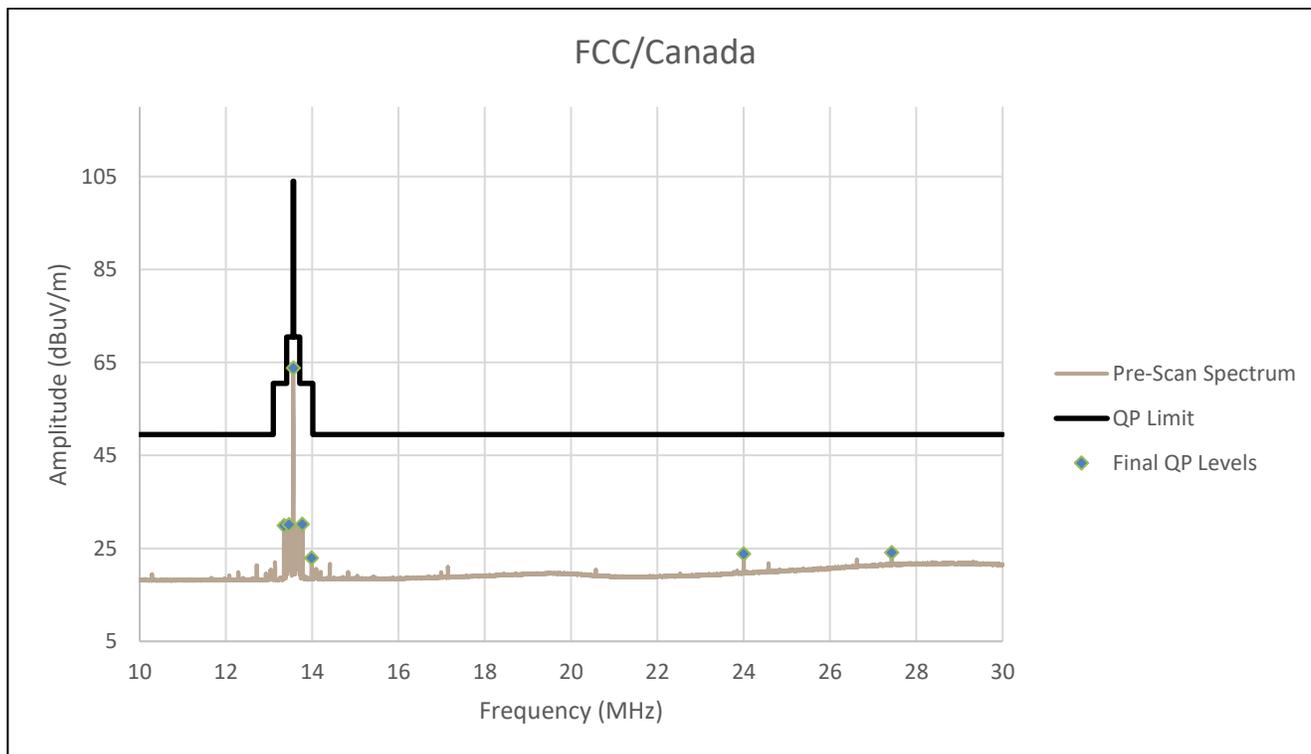


Figure RE18.1: Spectral data

Setup Photographs

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



Figure RE18.2: EUT test setup, device orientation (EUT X orientation)



Figure RE18.3: EUT test setup, first view (Antenna X orientation)



Figure RE18.4: EUT test setup, second view (Antenna X orientation)



Figure RE18.5: EUT test setup, first view (Antenna Y orientation)

Image removed for client confidentiality.

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

Figure RE18.6: EUT test setup, second view (Antenna Y orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE19
Project GCL0580

Test Date(s) 20 Aug 2024
 Test Personnel David Kerr

Product Model A05000
 Serial Number tested 477224793

Operating Mode M12 (NfcLnk),Type B .
 Arrangement A6 (NFCu)
 Input Power Battery

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

Frequency Range: 10 MHz to 30 MHz
Pass/Fail Judgment: PASS

Test record created by: David A Kerr
Date of this record: 21 Aug 2024

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Loop antenna, amplified	Schwarzbeck	FMZB 1519B	174	18-Jul-2024	18-Jul-2026
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	7-Nov-2022	7-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

Table RE19.1: Test Equipment Used

Software Used: Keysight PXE software A.32.06, 150k to 30M Signal Maximization Tool V1 2021Mar17.xlsx, 150k to 30M XYZ_orientations_TemplateV6.xlsm

Test Data

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

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

The table shows the selected final measurement data between 10 MHz and 30 MHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m. Any unintentional radio emission limits are not applied to intentional radio signals.

Frequency (MHz)	Limit (dBV/m)	Limit (dBμA/m)	Measured (dBμV/m)	Measured (dBμA/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Orientation
12.714	49.5	-2.0	20.3	-31.2	29.2	-9	1500	X
13.560	104.0	52.5	63.8	12.3	40.2	-3	1500	X
14.410	49.5	-2.0	21.5	-30.0	28.0	-8	1500	X
24.000	49.5	-2.0	23.9	-27.6	25.6	-120	1500	Y
26.623	49.5	-2.0	23.5	-28.0	26.0	-126	1500	Y
27.429	49.5	-2.0	24.6	-26.9	24.9	180	1500	y

Table RE19.2: Emission summary

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

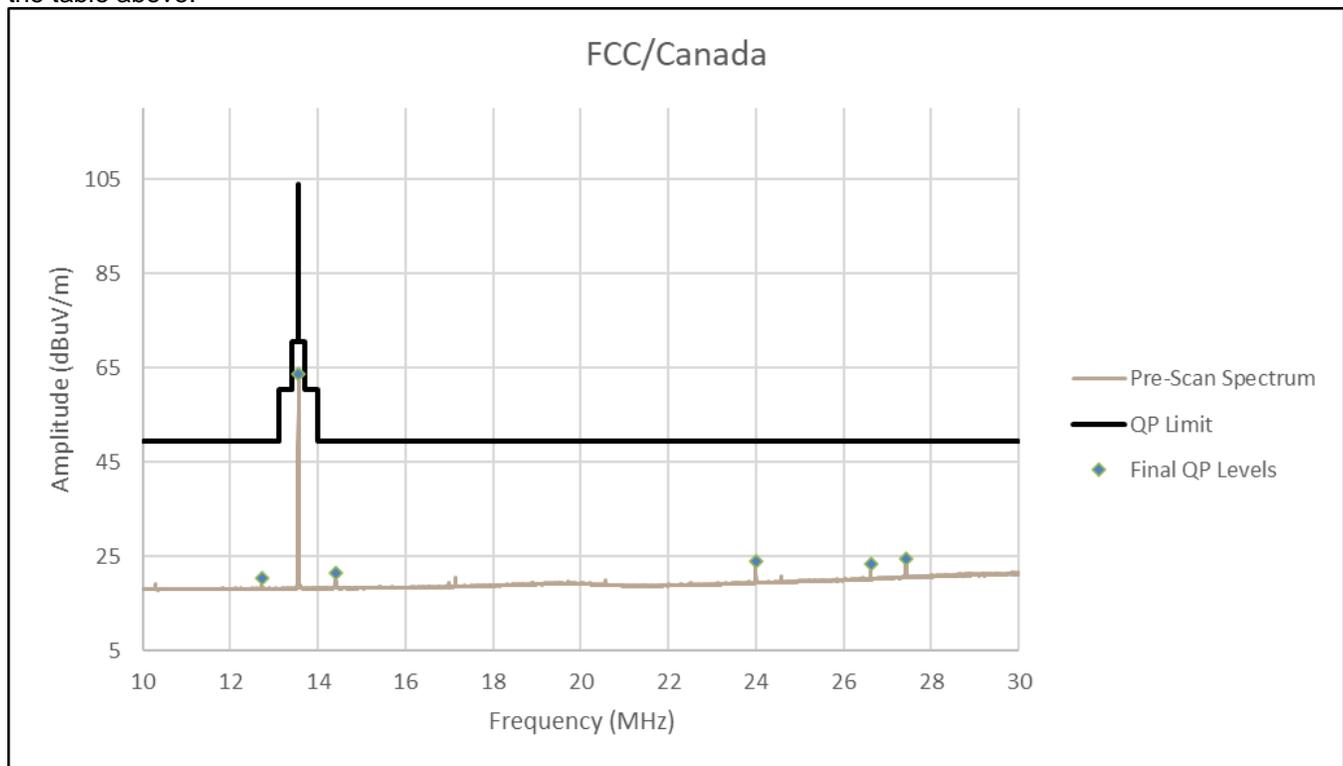


Figure RE19.1: Spectral data

Setup Photographs

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



Figure RE19.2: EUT test setup, device orientation (EUT X orientation)



Figure RE19.3: EUT test setup, first view (Antenna X orientation)



Figure RE19.4: EUT test setup, second view (Antenna X orientation)



Figure RE19.5: EUT test setup, first view (Antenna Y orientation)

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

Figure RE19.6: EUT test setup, second view (Antenna Y orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE20
Project GCL00580

Test Date(s) 20 Aug 2024
 Test Personnel Vladimir Tolstik supervised by Jim Solum

Product Model A05000
 Serial Number tested 477224793

Operating Mode M12 (NfcLnk), Type A
 Arrangement A6 (NFCu)
 Input Power Battery

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

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

Test record created by: Vladimir Tolstik
Date of this record: 03 Sep 2024

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Antenna, Biconilog, 30M-6 GHz	ETS Lindgren	3142E	00233204	2-Nov-2023	1-Nov-2025
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	7-Nov-2022	7-Nov-2025
Shockforce G1 Tape Measure	Crecent Lufkin	L1135CME-02	GMN0013784	26-Jun-2024	26-Jun-2027

Table RE20.1: Test Equipment Used

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

Test Data

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

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

The table shows the selected final measurement data between 30 MHz and 150 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 is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive

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

Frequency	Pol.	Reading	Factor	Level	Limit	Margin	Height	Angle
MHz		$\text{dB}(\mu\text{V})$	$\text{dB}(1/\text{m})$	$\text{dB}(\mu\text{V}/\text{m})$	$\text{dB}(\mu\text{V}/\text{m})$	dB	cm	deg
		QP		QP	QP	QP		
30.840	V	11.8	22.3	34.1	40.0	5.9	112.1	40.0
41.910	V	13.6	16.5	30.1	40.0	9.9	100.0	102.0
51.210	V	12.9	14.0	26.9	40.0	13.1	104.3	188.0
81.420	V	16.3	14.4	30.7	40.0	9.3	104.3	8.0
92.160	V	18.6	15.3	33.9	43.5	9.6	108.7	326.0
135.600	H	13.8	16.4	30.2	43.5	13.3	228.4	117.0

Table RE20.2: Emission summary

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

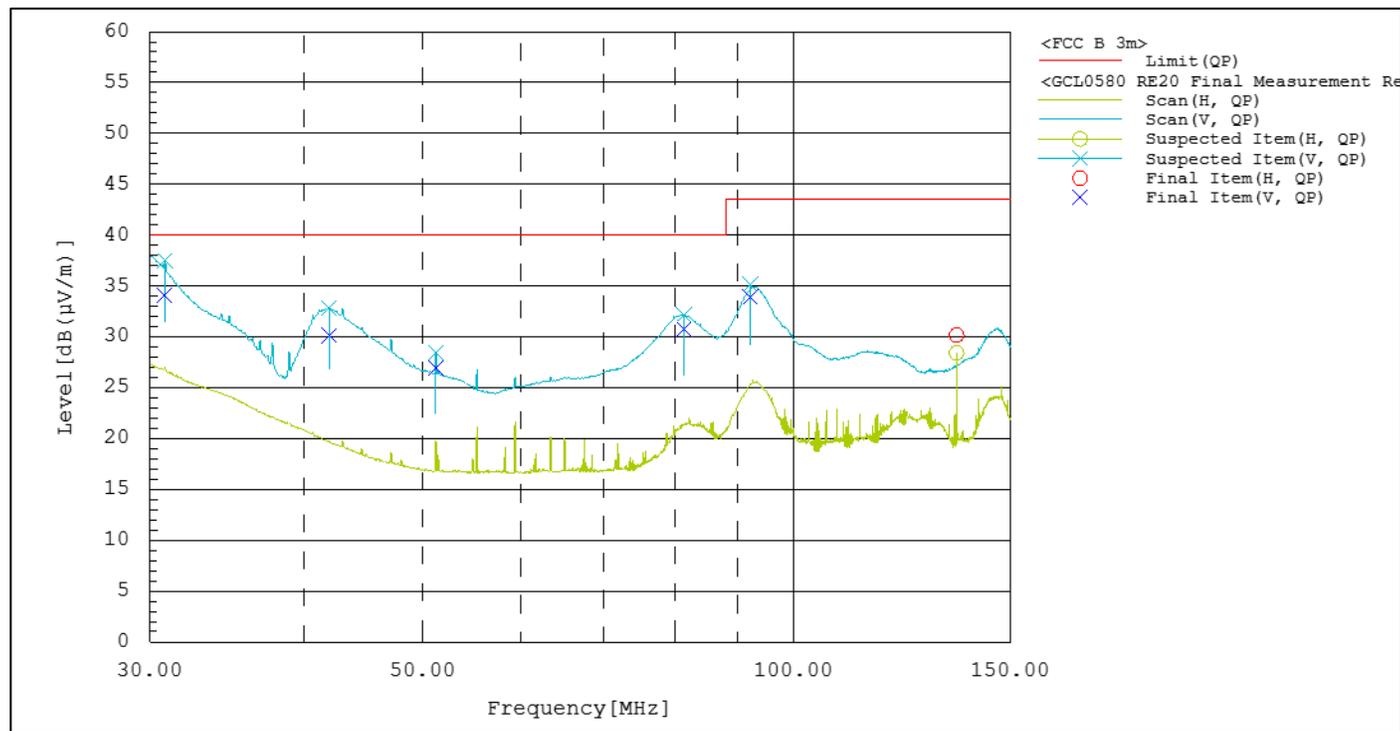


Figure RE20.1: Spectral data

Setup Photographs

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

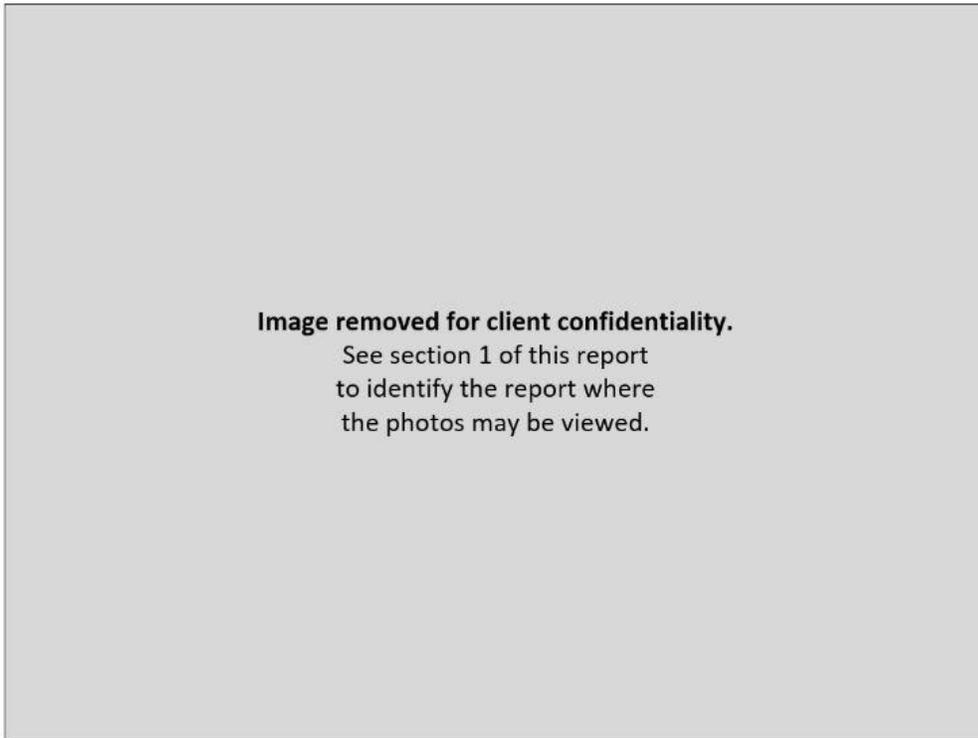


Figure RE20.2: EUT test setup, first view (X orientation, Type A NFC)



Figure RE20.3: EUT test setup, second view (X orientation, Type A NFC)

This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE04
Project GCL00580

Test Date(s) 26 July 2024
 Test Personnel Andy Heier supervised by Dave Arnett

Product Model A05000
 Serial Number tested 477224793

Operating Mode M12 (NfcLnk)
 Arrangement A2 (Upwr)
 Input Power 120 Vac 60 Hz

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

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

Test record created by: Andy Heier
Date of this record: 30 July 2024

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	13-Mar-2024	15-Mar-2025
LISN multiline; 20A 50uH	Com-Power	LIN-120C	20160005	3-Apr-2024	1-Apr-2027

Table CE04.1: Test Equipment Used

Software Used

Keysight PXE software A.33.03; CE Mains 150kHz to 30M Data Analysis V3 2024May23.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 Composite FCC/CISPR Class B Limit.

Frequency	QP Limit	AV Limit	L1 QP	L2 QP	L1 AV	L2 AV	QP Margin	AV Margin
(kHz)	(dBuV)	(dBuV)	(dBuV)	(dBuV)	(dBuV)	(dBuV)	(dB)	(dB)
3428	56.00	46.00	42.73	39.74	40.68	38.00	13.27	5.32
10286	60.00	50.00	42.03	39.58	40.03	37.89	17.97	9.97
13560	N/A	N/A	57.74	54.96	55.08	52.84	N/A	N/A
16989	60.00	50.00	36.66	35.09	34.90	33.21	23.34	15.10
17142	60.00	50.00	40.54	38.64	38.85	37.19	19.46	11.15
24000	60.00	50.00	38.25	36.72	36.70	35.13	21.75	13.30

Table CE04.1: Emission summary (NFC)

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

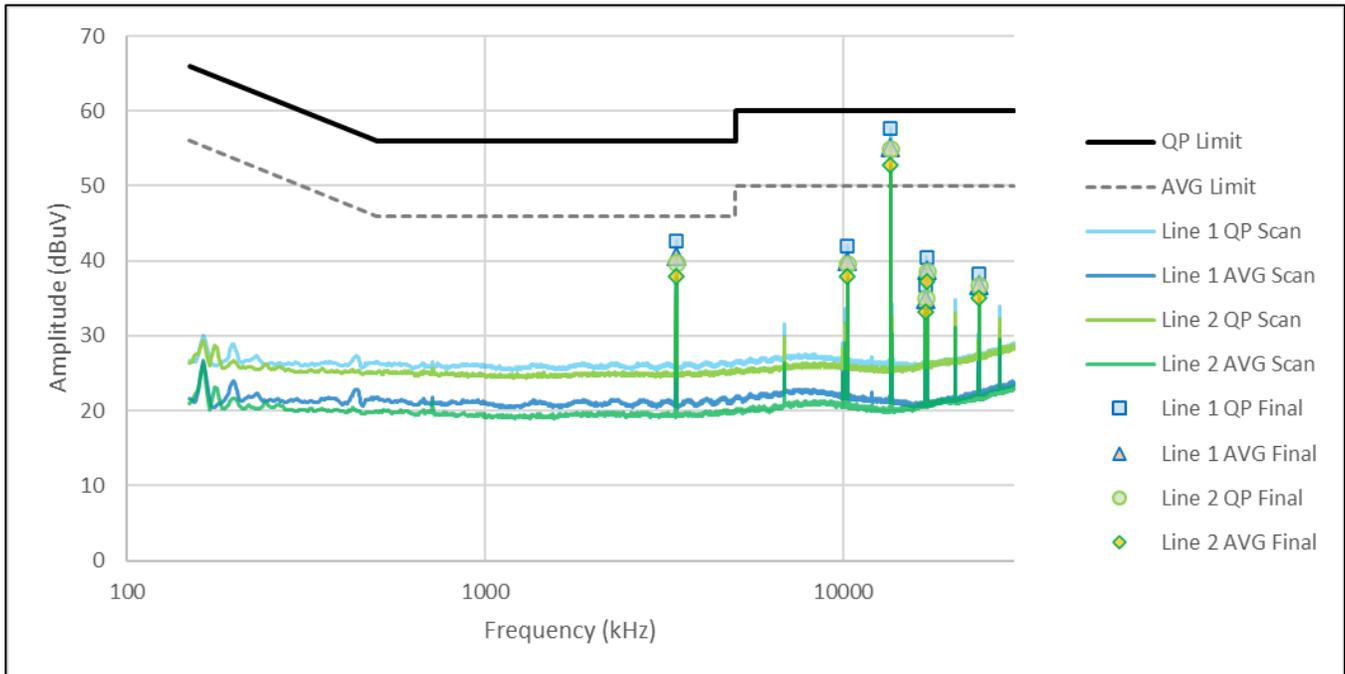


Figure CE04.1: Spectral data

Setup Photographs

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



Figure CE04.2: Test setup, first view

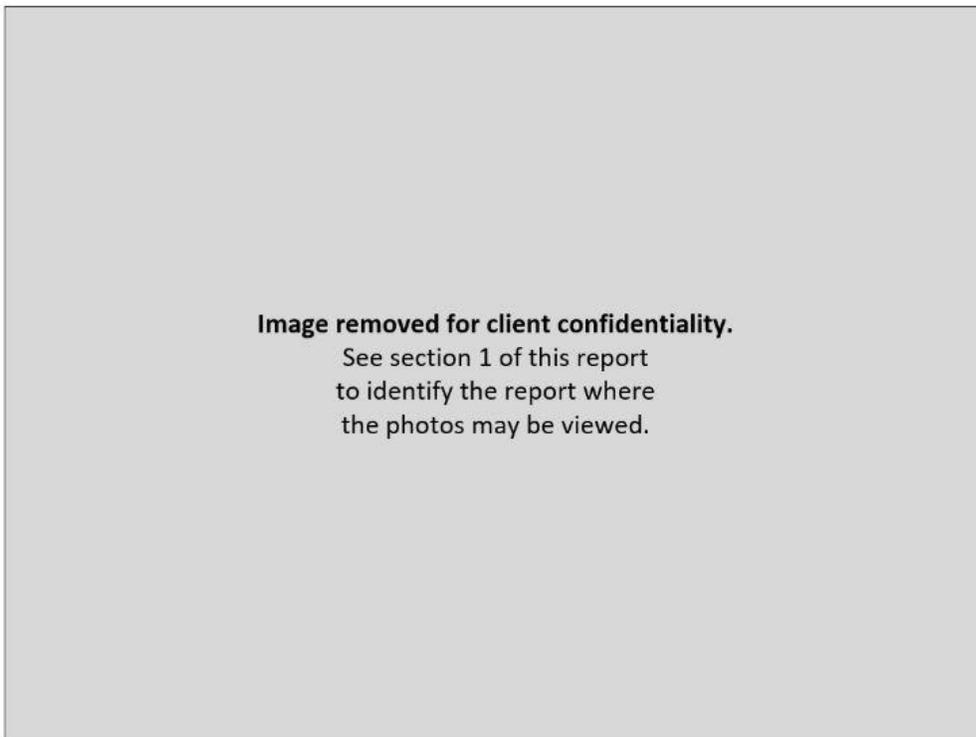


Figure CE04.3: Test setup, second view

This line is the end of the test record.

Test Record

Transmitter Stability in Extreme Conditions

Test IDs TR45

Project GCL0580

Test Date(s) 01 Aug 2024
Test Personnel Vladimir Tolstik supervised by Majid Farah and Jim Solum

Product Model A05000
Serial Number tested 477224584

Operating Mode M12 (NfcLnk), A Mode
Arrangement A4 (Udc)
Input Power 5 Vdc

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

Radio Protocol NFC

Pass/Fail Judgment: PASS with caveat

Test record created by: Vladimir Tolstik
Date of this record: 03 Sep 2024

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
MXE Receiver 8.4 GHz	Keysight	N9038B	MY63460112	28-Feb-2024	1-Mar-2025
Near Field Probe Set	Com-Power	PS-400	151544	Calibration	Not Required
Thermometer	Thermco	ACCD370P	210607316	21-Sep-2023	15-Sep-2025
Thermal Chamber	Tenney	T2RC	32774-02	Calibration	Not Required
DMM Multimeter 87V	Fluke	87V	63490051	21-Jun-2024	21-Jun-2025

Table TR45.1: List of test equipment used

Software Used: MXE Software Revision A.37.02

Test Method

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

The Standard indicated carrier frequency stability shall not exceed 0.01% of operation frequency. The frequency was required to remain between the limits of 13.558644 and 13.561356 MHz.

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 the 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 test sample(s) were subjected to extreme conditions and performed as shown below. 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 highlights indicate the maximum and minimum measured carrier frequency. The maximum frequency measured was 13,559,925 Hz and the minimum was 13,559,770 Hz. The margin to high side of limit is 1431 Hz and margin for low side of the limit is 1126 Hz.

Tx Mode	Temp °C	Volts Vdc	NFC carrier frequency (Hz)			
			Time interval (minutes)			
			0	2	5	10
NFC	60	5	13,559,770	13,559,771	13,559,773	13,559,774
NFC	50	5	13,559,770	13,559,770	13,559,770	13,559,770
NFC	40	5	13,559,794	13,559,791	13,559,789	13,559,788
NFC	30	5	13,559,826	13,559,823	13,559,821	13,559,820
NFC	20	5	13,559,862	13,559,859	13,559,857	13,559,855
NFC	20	4.25	13,559,859	N/A	N/A	N/A
NFC	20	5.75	13,559,857	N/A	N/A	N/A
NFC	10	5	13,559,881	13,559,882	13,559,885	13,559,887
NFC	0	5	13,559,917	13,559,916	13,559,915	13,559,915
NFC	-10	5	13,559,925	13,559,925	13,559,925	13,559,923
NFC	-20	5	13,559,908	13,559,909	13,559,910	13,559,910

Table TR45.2: Carrier frequency measurement for NFC transmission during temperature and voltage variations

Setup Block Diagram

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

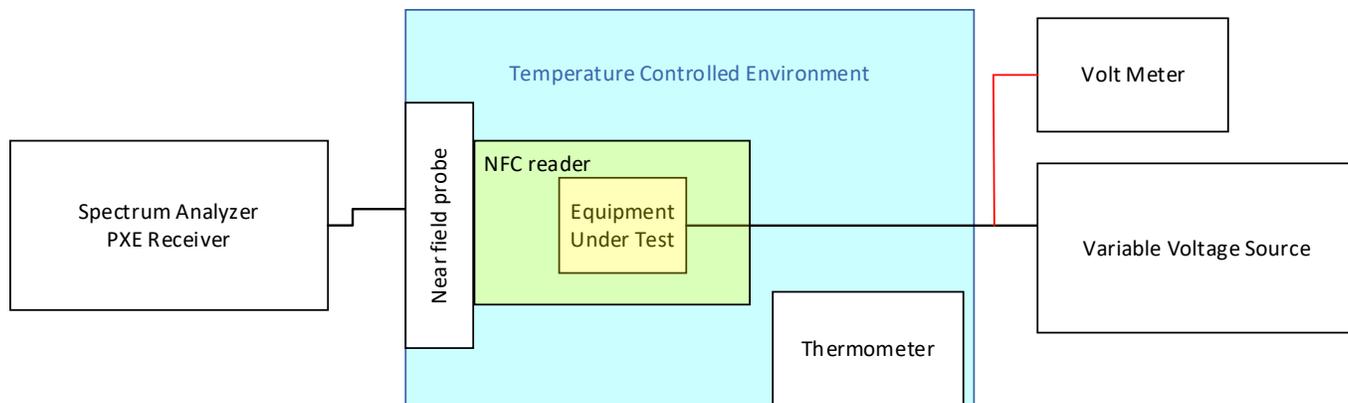


Figure TR45.1: Schematic drawing of the test equipment setup for NFC

This line is the end of the test record.

Test Record
Transmitter Bandwidth Tests
Test IDs TR13
Project GCL0580

Test Date(s) 25 Jul 2024
Test Personnel Vladimir Tolstik supervised by Jim Solum

Product Model A05000
Serial Number tested 477224793

Operating Mode M12 (NfcLnk), Type A and Type B
Arrangement A4 (Udc)
Input Power USB 5 Vdc

Test Standards: FCC Part 15.225; RSS-210; RSS-GEN; ANSI-C63.10 (as noted in Section 6 of the report).

Radio Protocol NFC
Radio Band 13.56 MHz

Pass/Fail Judgment: PASS

Test record created by: Vladimir Tolstik
Date of this record: 03 Sep 2024

Original record, Version A.

Test Equipment Used

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

Table TR13.1 Equipment Used

Software used: Keysight PXE firmware A.37.02

Background

There are regulatory requirements to present additional type of bandwidth analyses: 99% Occupied 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.

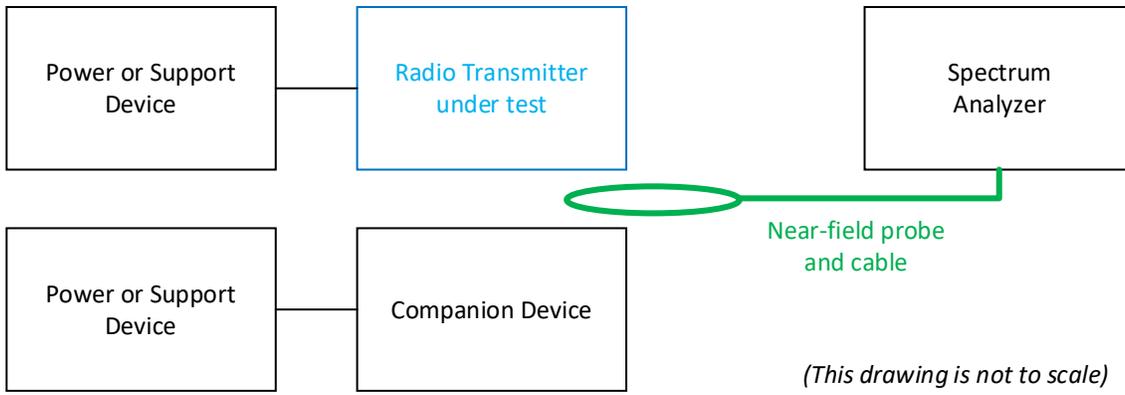


Figure TR13.1: Test setup

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 the 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 a small loop probe is placed between transmitter and companion device because the test sample only transmits in response to a nearby NFC reader. This loop probe is then connected by cables 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.

	Bandwidth
NFC Mode	MHz
Type A	2.3253
Type B	2.0002

Table TR13.2: Summary of 99% Occupied Bandwidth Data for 13.56 MHz NFC modes

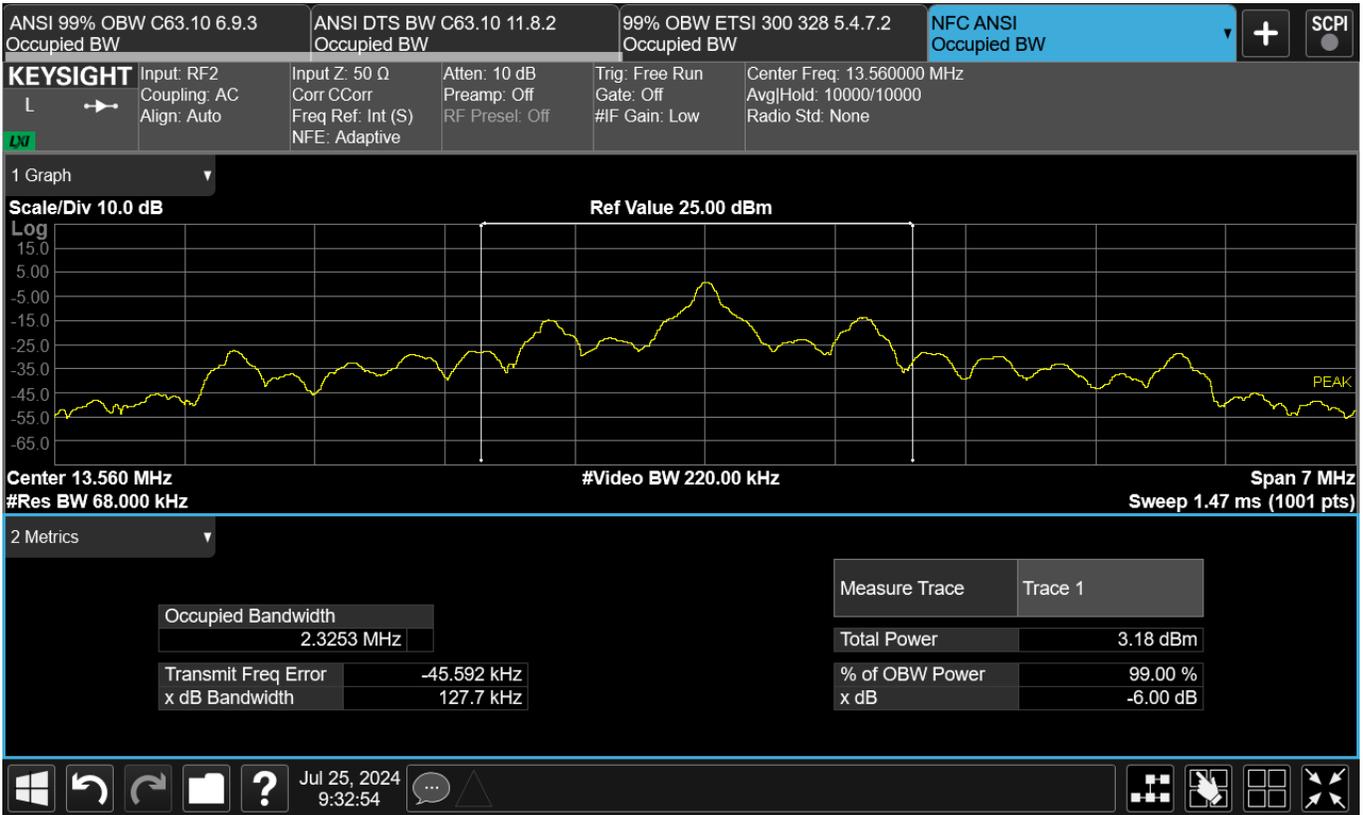


Figure TR13.2: Occupied bandwidth data NFC Type A transmission



Figure TR13.3: Occupied bandwidth data for NFC Type B transmission

Necessary Bandwidth Calculations

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

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

$$B_N = BCK$$

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

Table TRxx.100: Necessary Bandwidth for NFC

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

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

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)	B _N (MHz)
ANT / ANT+	1	1	2	1	2

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

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

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

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

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

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

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

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

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

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

The TRC-43 method for OFDM signals simply multiplies the number of subcarriers, K, and the subcarrier spacing, N_s. In both cases, 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	Mode	N _s (MHz)	K	B _N (MHz)
802.11a/g	20 MHz	0.3125	53	16.6
802.11n/ac	20 MHz	0.3125	57	17.8
802.11n/ac	40 MHz	0.3125	117	36.6

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

This line is the end of the test record.

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 2024-110

Version A

Issued 6 Sept 2024

Project: GCL-0580

Model Identifier: A05000

Primary Test Standard(s):

CFR 47, FCC Part 15.247

RSS-247 Issue 3

Garmin Compliance Lab

Garmin International

1200 E 151st Street

Olathe Kansas 66062 USA

Client-supplied Information

FCC ID: IPH-05000
IC ID: 1792A-05000



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

1. Summary

The equipment or product described in section 5 of this report was tested at the Garmin Compliance Lab according to standards listed in section 6. This report focuses on the 2.4 GHz Bluetooth Low Energy (BLE) transceiver(s). Test records within this report may include data for the ANT transmitter, but ANT is addressed in a separate report. The results are as follows.

Parameter	Description	Key Performance Values	Result	Data starts at page
Radio Modulation	Summary of the kinds of communication this radio can achieve, as stated by the client. [RSS-GEN at Annex A item 10b]	Digitally modulated spread spectrum at rates as high as 2 Mbps.	Reported	N/A
Hopping Channels	The radio manages its use of channels appropriately. [15.247(a)(1); RSS-247 at 5.1]	N/A. The radios described in this report are not subjected to the Frequency Hopping rules.	N/A	N/A
DTS Bandwidth	The nature of the radio signal is broadband, being at least 500 kHz wide. [15.247(a)(2); RSS-247 at 5.2(a)]	The 6dB bandwidth is 1080 kHz or greater.	PASS	13
Other Bandwidths	Regulatory agencies also require the reporting of signal bandwidths using alternate processes. [2.202; RSS-GEN at 6.7]	These values are reported but have no actual performance requirements.	Reported	16
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 3.46 dBm or 1.73 mW.	PASS	21
Antenna Gain	The radio should not focus too much energy in any direction. Unless additional rules are applied, the antenna gain is no greater than 6 dBi. [15.247(b)(4) and (c)]	NT. The client stated that the antenna gain was -1.537 dBi and will document antenna gain separately.	NT	NT
Unwanted Emissions (Conducted Spurious)	The radio should not provide too much radio energy to the antenna at frequencies beyond its intended frequency band. [15.247(d); RSS-247 at 5.5]	NT. Emissions outside the band must be reduced at least 20 dB from in-band levels.	NT	NT
Restricted Bands	The radio must not emit in certain designated restricted frequency bands above a set of limit values. [15.247(d) and 15.205; RSS-247 at 3.3]	NT	NT	NT
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 -11.36 dBm in a band of at least 3 kHz.	PASS	23
Hybrid Systems	A radio that is both frequency hopping and digitally modulated should satisfy a combination of system rules. [15.247(f); RSS-247 at 5.3]	N/A. The radios described in this report are not subjected to the Hybrid System rules.	N/A	N/A

Frequency Hopping Rules	Frequency hopping systems have additional functional requirements. [15.247(g) and (h); RSS-247 at 5.1]	N/A. The radios described in this report are not subjected to the Frequency Hopping rules.	N/A	N/A
Radio Safety	The radio emissions must meet public health & safety guidelines related to human exposure. [15.247(i) and 1.1307; RSS-Gen at 3.4]	NT. Client will report radio energy safety results separately.	NT	NT
Unwanted Emissions (Radiated Spurious)	While transmitting, the radiated emissions must not be too strong. [15.209, RSS-Gen at 8.9]	NT	NT	NT
Unwanted Emissions (Mains Conducted)	While transmitting, the emissions conducted into the power mains must not be too strong. [15.207, RSS-Gen at 8.8]	Emissions other than the fundamental and harmonics must meet the 'Class B' limits. The measured emissions had at least 24.68 dB of margin.	PASS	25

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

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

Table 1: Summary of results

Report Organization

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

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2024-116. That report is treated as a part of this document by way of this reference.

2. Test Background

2.1 The Test Lab

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

2.2 The Client

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

2.3 Other Information

Test Sample received: 22 July 2024
Test Start Date: 24 July 2024
Test End Date: 22 Aug 2024

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

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

3. Report History and Approval

This report was written by Andy Heier and initially issued on 6 Sept 2024 as Version A.

Report Technical Review:

David Arnett
Technical Lead EMC Engineer



Report Approval:

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



4. Test Sample Modifications and Special Conditions

The following special conditions or usage attributes were judged during test to be necessary to achieve compliance with one or more of the standards listed in section 6 of this report:

None

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

None

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model A05000
Serial Number tested 477224758

This product tested is a mobile device for collecting and sharing data with the user and nearby electronic devices.

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, NFC
Radio Receivers: GPS L1, GPS L5, Galileo E1, Galileo E5a/b, BeiDou, GLONASS
Primary Functions: Data collection and communication
Typical use: Portable in multiple orientations
Highest internal frequency: 2.484 GHz
Firmware Revision 4.03

5.3 Operating modes

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

Mode 3: M3 (BleTx). Bluetooth Low Energy radio transmitting consistently on a selected channel at 1 Mbps or 2 Mbps.

Mode 4: M4 (BleLnk). Bluetooth Low Energy radio is paired to a companion device, transmitting and receiving data on various channels in accordance with the protocol, and maintaining the paired relationship.

Mode 5: M5 (AntTx). ANT radio transmitting consistently on a selected channel.

Mode 6: M6 (AntLnk). ANT radio is paired to a companion device, transmitting and receiving data in accordance with the protocol, and maintaining the paired relationship.

Mode 9: M9 (RxBtBIA). The radio was set to receive 2.4 GHz signals but not transmitting in Bluetooth, Bluetooth low energy or ANT.

Mode 12: M12 (NfcLnk). The NFC radio was transmitting and actively linked to a NFC Card Reader.

Mode 13: M13 (GNSS). The Global Navigation Satellite System receiver is monitoring the GNSS bands, attempting to detect a constellation and determine location. Unless otherwise noted, the EUT was provided simulated GNSS signals representing one of more constellation types. In addition, the EUT may have been reporting signal levels and satellite data to an attached computer to monitor link health.

Mode 14: M14 (Nfcldle). The NFC Radio was powered, but not transmitting or linked to any devices.

Mode 19: M19 (ML1). Multiple link, combining modes M4 & M6. The EUT is actively paired to both a BLE and an ANT companion device, used for Immunity tests.

Mode 20: M20 (ML2). Multiple link, combining modes M12 & M13. The EUT is actively linked to a NFC card reader and the specified satellite system, used for immunity tests.

5.4 EUT Arrangement

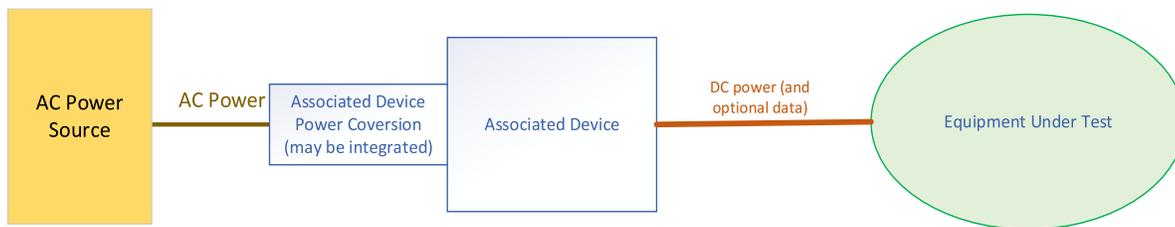
During test, the EUT components and associated support equipment were selected including the following arrangement sets.

Arrangement 1: A1 (Solo). The test sample operates from its battery and no external physical connections. No block diagram is needed for this arrangement.

Arrangement 2: A2 (Upwr). The test sample is attached to a Mains-powered device connected that provides dc power to the sample over a cable but no user data. See the block diagram in Figure 1.

Arrangement 3: A3 (Udata). The test sample is attached to a Mains-powered device connected that provides dc power to the sample and user data over a cable. See the block diagram in Figure 1.

Arrangement 4: A4 (Udc). The test sample is attached to a Mains-powered device connected that provides dc power to the sample and may or may not provide user data. This arrangement is specified in the test plan to provide staff flexibility when the presence or absence of data on the cable is not pertinent. See the block diagram in Figure 1.



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

Figure 1: Block diagram of equipment arrangements A2, A3, A4

Arrangement 6: A6 (NFCu). The test sample is powered via internal battery and actively linked to a NCR reader powered by a laptop PC.

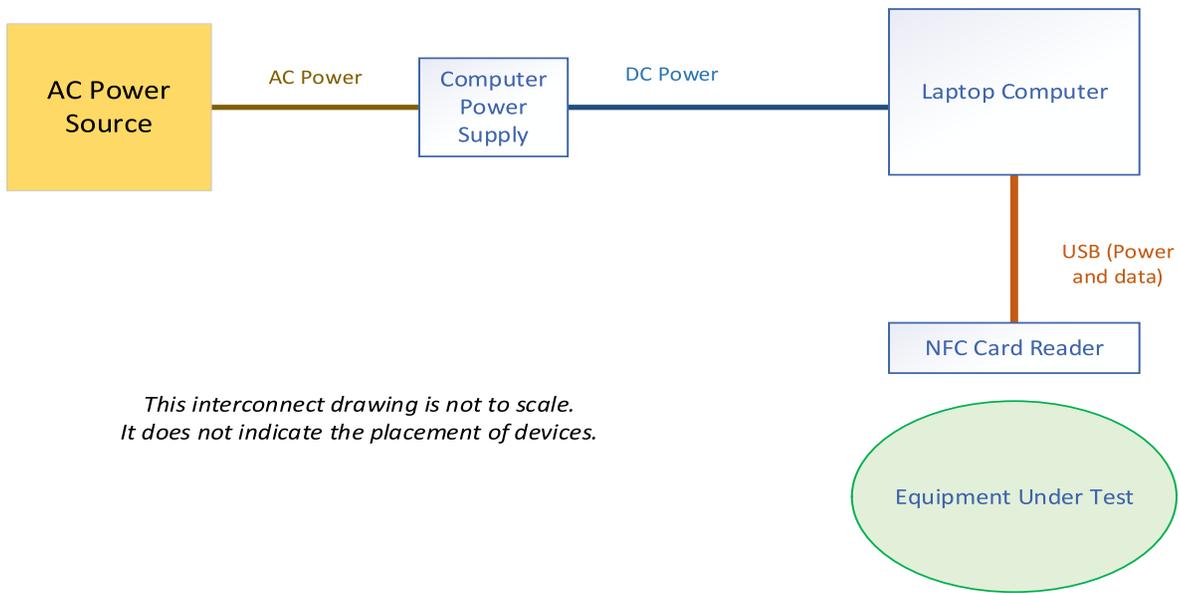


Figure 2: Block diagram of equipment arrangement A6

Arrangement 7: A7 (NFCu). The test sample is powered via internal battery and actively linked to a passive NFC tag.

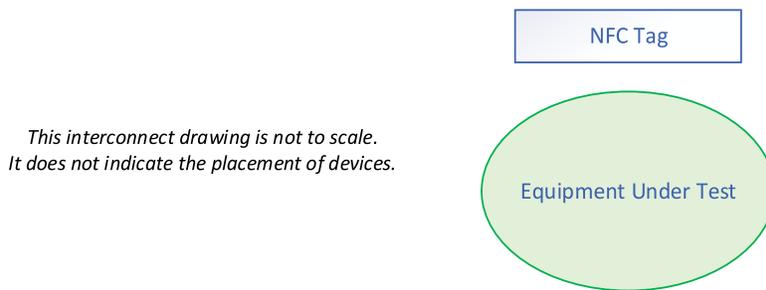


Figure 2: Block diagram of equipment arrangement A7

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial/Part Number
USB C power adaptor	Phihong (Garmin)	AQ27A-59CFA	362-00118-00
Tablet	Apple	iPad Pro 11 inch	DMPZ7582KD6L
Laptop	Dell	Latitude 5410	5VSPFB3
Power Supply	Dell	HA65NM191	0BD-7TC0-A02
Phone	Samsung	SM-G973U (S10)	RF8MC0W9XVR
NFC Card Reader	ACS	ACR1252U-M1	RR554-118449
Auxiliary Device	Garmin	A04600	3423419439
Auxiliary Device	Garmin	A04883	3477207518

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

5.6 Cables used

Description	From	To	Length	EMC Treatment
USB C to custom cable	Power and/or Data source	EUT	0.5m	None

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

6. Test Standards Applied

6.1. Accredited Standards

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

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

6.2 Non-accredited Standards

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

(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 to 21 °C
Relative Humidity:	49% to 61% (non-condensing)
Barometric Pressure	98 to 110 kPa

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

Table 4: Environmental monitoring device

10. Immunity Performance Criteria

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

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

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

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

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

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

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

ANNEX

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

Test Record
Transmitter Bandwidth Tests
Test IDs TR06
Project GCL-0580

Test Date(s) 24 Jul 2024
 Test Personnel Vladimir Tolstik supervised by Jim Solum

Product Model A05000
 Serial Number tested 477224758

Operating Mode M3 (BleTx)
 Arrangement A4 (Udc)
 Input Power USB 5Vdc

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 (BLE)
 Radio Band 2400 to 2483.5 MHz

Pass/Fail Judgment: PASS

Test record created by: Vladimir Tolstik
Date of this record: 03 Sep 2024

Original record, Version A.

Test Equipment Used

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

Table TR06.1: List of test equipment used

Test Software Used: Keysight PXE firmware A.37.02

Test Method

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

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

Test Setup

This block diagram shows the test equipment setup.

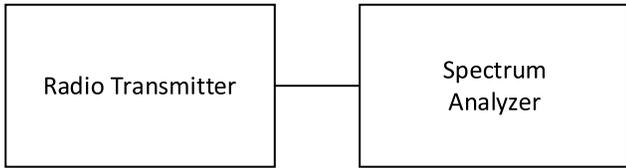


Figure TR06.1: Test setup

Test Data

The data for each test is summarized below, followed by the spectral data for each case highlighted in yellow.

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

Frequency	(MHz)	2402	2404	2440	2478	2480
BT Low Energy	1 Mbps	712.30	NT	699.30	NT	712.70
BT Low Energy	2 Mbps	NT	1197.00	1198.00	1190.00	NT

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

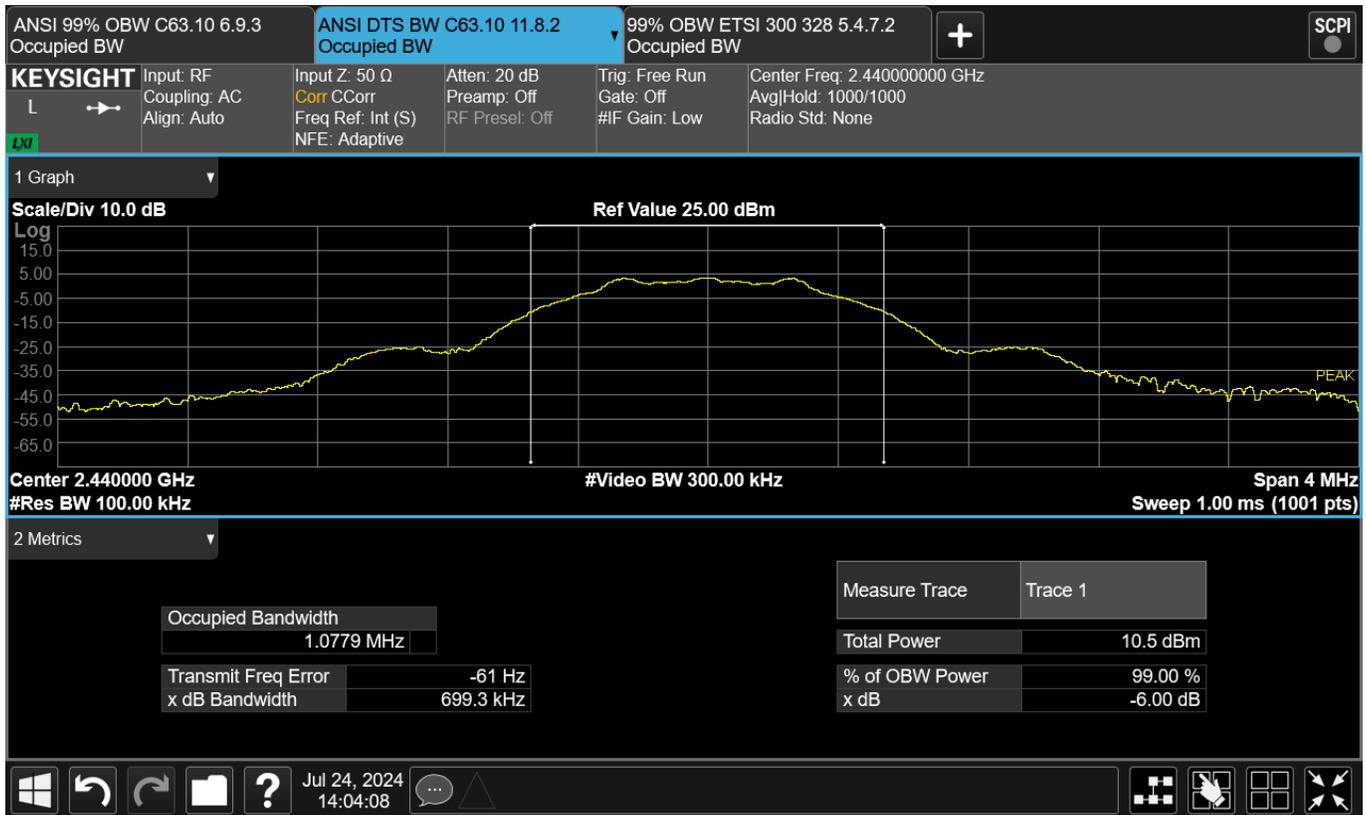


Figure TR06.2: Bandwidth data for BLE 1 at mid channel (2440 MHz)

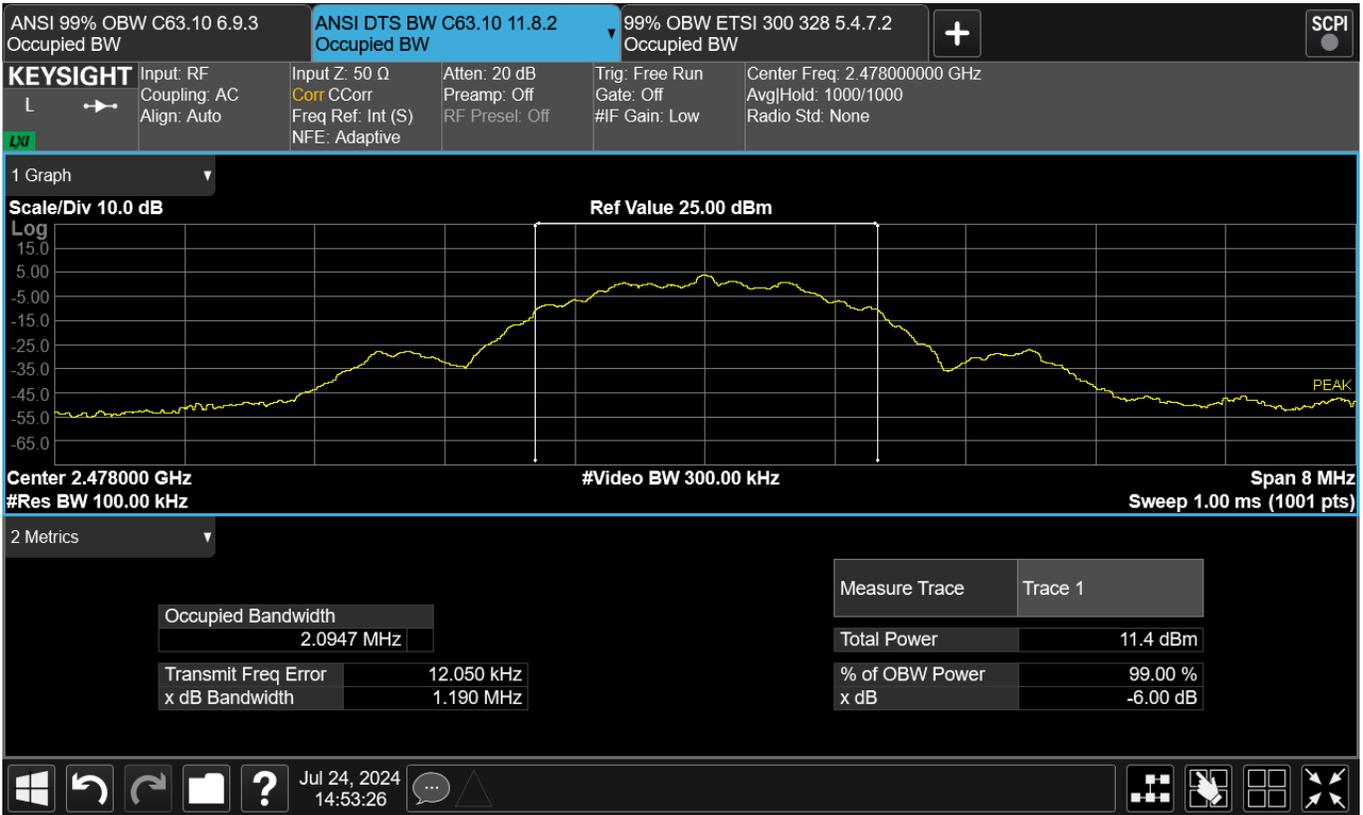


Figure TR06.3: Bandwidth data for BLE 2 at high channel (2478 MHz)

This line is the end of the test record.

Test Record
Transmitter Bandwidth Tests
Test IDs TR10 – TR11
Project GCL0580

Test Date(s) 24 Jul 2024
 Test Personnel Vladimir Tolstik supervised by Jim Solum

Product Model A05000
 Serial Number tested 477224758

Operating Mode M3 (BleTx), M5 (AntTx)
 Arrangement A4 (Udc)
 Input Power USB 5 Vdc

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), ANT
 Radio Band 2480 to 2483.5 MHz

Pass/Fail Judgment: Reported

Test record created by: Vladimir Tolstik
Date of this record: 26 Jul 2024

Original record, Version A.

Test Equipment Used

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

Table TR10.1 Equipment Used

Software used: Keysight PXE software A.37.02,

Background

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

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

Test Setup

This block diagram shows the test equipment setup.

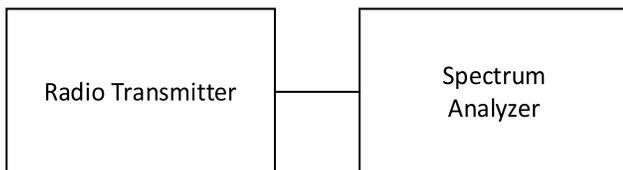


Figure TR10.1: Test setup

Occupied Bandwidth, 99% Test Method

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

Occupied Bandwidth, 99% Test Data

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

Frequency	(MHz)	2402	2404	2440	2478	2480
BT Low Energy	1 Mbps	1.0571	NT	1.0618	NT	1.0622
BT Low Energy	2 Mbps	NT	2.0711	2.0784	2.0783	NT
ANT	----	0.9880	NT	0.9890	NT	0.9877

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



Figure TR10.2: Occupied bandwidth data for BLE 1 Mbps at high channel (2480 MHz)



Figure TR10.3: Occupied bandwidth data for BLE 2 Mbps at mid channel (2440 MHz)

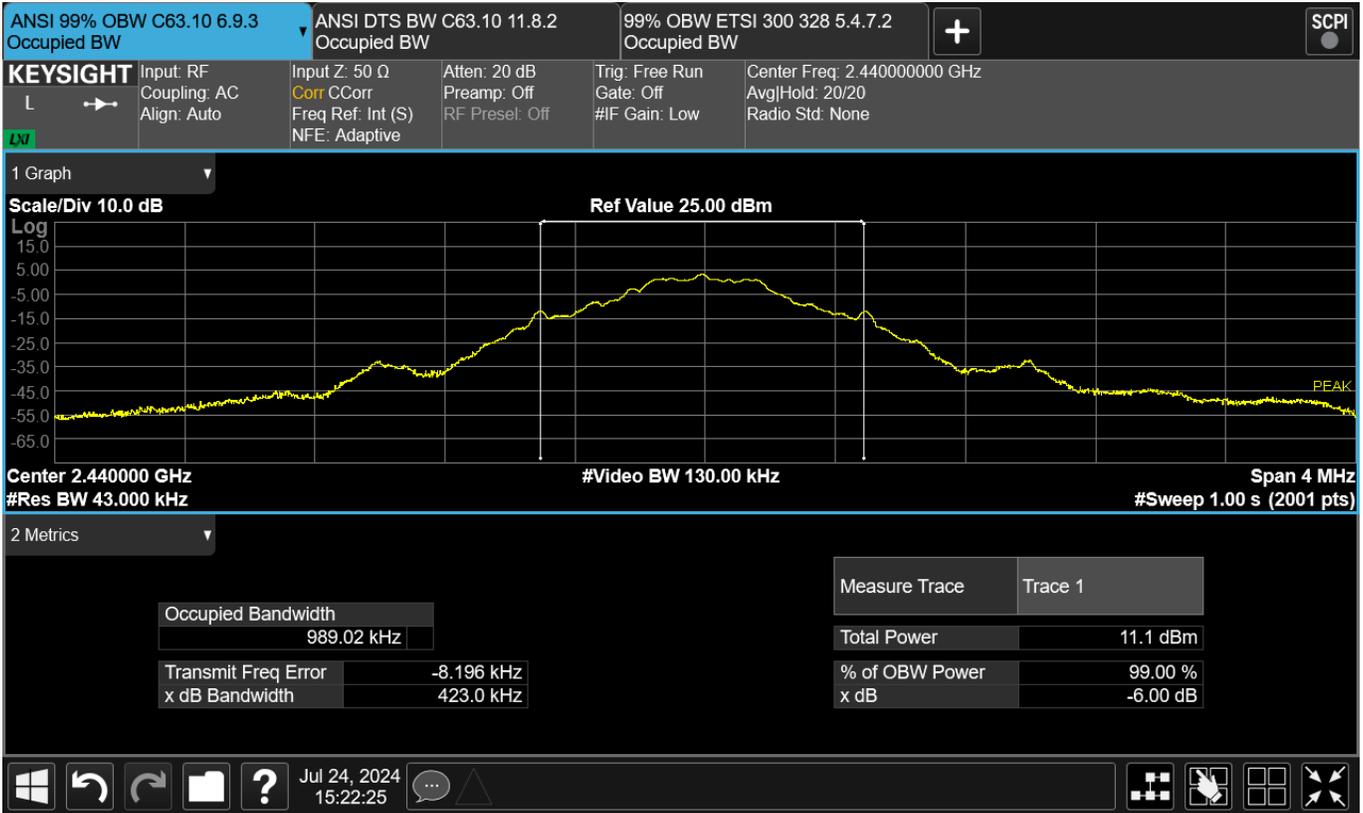


Figure TR10.4: Occupied bandwidth data for ANT at mid channel (2440 MHz)

Necessary Bandwidth Calculations

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

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

$$B_N = BCK$$

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

Table TR10.100: Necessary Bandwidth for NFC

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

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

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)	B _N (MHz)
ANT / ANT+	1	1	2	1	2

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

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

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

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

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

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

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

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

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

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

The TRC-43 method for OFDM signals simply multiplies the number of subcarriers, K, and the subcarrier spacing, N_s. In both cases, 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	Mode	N _s (MHz)	K	B _N (MHz)
802.11a/g	20 MHz	0.3125	53	16.6
802.11n/ac	20 MHz	0.3125	57	17.8
802.11n/ac	40 MHz	0.3125	117	36.6

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

This line is the end of the test record.

Test Record
Transmitter Power, Duty Cycle
Test IDs TR02, TR03
Project GCL0580

Test Date(s) 24 Jul 2024
 Test Personnel Vladimir Tolstik supervised by Jim Solum

Product Model A05000
 Serial Number 477224758

Operating Mode M3 (BleTx), M5 (AntTx)
 Arrangement A4 (Udc)
 Input Power 5Vdc

Test Standards: FCC Part 15, ANSI C63.10, ETSI EN 300 328, RSS-GEN, RSS-247, FCC Parts 1.1310 and Part 2.1093, RSS-102, IEC/EN 62479 (as noted in Section 6 of the report).

Antenna Gain -1.537 dBi, as reported by the client
 Radio Protocol Bluetooth Low Energy, ANT

Pass/Fail Judgment: PASS

Test record created by: Jim Solum, Vladimir Tolstik
Date of this record: 05 Sept 2024

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
MXE Receiver 8.4 GHz	Keysight	N9038B	MY63460112	28-Feb-2024	1-Mar-2025
RF Power Sensor	Rohde&Schwarz	NRP8S	109124	18-Jul-2023	15-Jul-2025
Thermometer	Thermco	ACCD370P	210607316	21-Sep-2023	15-Sep-2025
Thermal Chamber	Tenney	T2RC	32774-02	Calibration	Not Required
DMM Multimeter 87V	Fluke	87V	63490051	21-Jun-2024	21-Jun-2025

Table TR02.1: List of test equipment used

Software used: Rohde & Schwarz Power Viewer V11.3; TimePowerAnalysisSpreadsheetv11a.xls

Test Method

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

ETSI EN 300 328: 5.4.2.2.1.3
 ANSI C63.10: 11.9.1.3

Under the ETSI standard, the parameters of duty cycle, transmitter timing, or medium utilization are typically not required for adaptive transceivers or transceivers emitting at 10 dBm EIRP or less, so those results will be omitted from the data set. Duty Cycle data will be included if it is relevant to test methods used for other standards such as Average Detector methods in the ANSI standards that apply duty cycle correction or certain kinds of analysis under the RF exposure standards.

Transmit Power and Timing Data

Each measurement is made conducted from the antenna port with the transmitter on a specified channel and in a selected transmission protocol. Where standards cited here apply harmonized test methods and different limits, the more strict limit has applied.

This test record will show results based on one or more of the following methods of analyzing the same set of raw power data vs. time. The ANSI peak power method looks for the highest power in the data record, with results in dBm units. Under the US and Canadian rules a limit of 30 dBm is applied.

The ETSI 300 328 method looks at the individual transmission bursts within the data record and reports the power level from the burst with the for the highest average power. The ETSI result is presented in dBm EIRP units, and a 20 dBm EIRP limit is applied. The RF exposure analysis asks for the average power observed over time, with results in linear power units such as milliwatts. RF exposure limits are not addressed in this test record. Many of these standards also care about duty cycle, the portion of the time when the transmitter was actually transmitting. That is presented as a pure number less than 1, and no limit applies. All of these results are drawn from the same power data. The results are shown below.

Frequency	(MHz)	2402	2404	2440	2478	2480
BT Low Energy	1 Mbps	3.46	NT	3.42	NT	3.38
BT Low Energy	2 Mbps	NT	3.46	3.43	3.39	NT
ANT	----	3.47	NT	3.43	NT	3.39

Table TR02.2: Transmit Power, ANSI method, in dBm

Frequency	(MHz)	2402	2404	2440	2478	2480
BT Low Energy	1 Mbps	1.85	NT	1.81	NT	1.77
BT Low Energy	2 Mbps	NT	1.82	1.79	1.76	NT
ANT	----	1.82	NT	1.79	NT	1.75

Table TR02.3: Transmit Power, ETSI method, in dBm EIRP

The ETSI method also requires that transmit power be verified for stability at the extremes of operating temperature. The BLE1 transmitter was verified for power stability vs temperature on 2402 MHz.

Tx Mode	Temp	Power	Limit	Result
	°C	dBm EIRP	dBm EIRP	
BLE 1 Mbps	60	1.5	20	Pass
BLE 1 Mbps	20	2.05	20	Pass
BLE 1 Mbps	-20	2.51	20	Pass

Table TR02.4: Transmit Power over temperature, ETSI method, in dBm EIRP

Frequency	(MHz)	2402	2404	2440	2478	2480
BT Low Energy	1 Mbps	1.71	NT	1.70	NT	1.68
BT Low Energy	2 Mbps	NT	1.73	1.72	1.71	NT
ANT	----	2.08	NT	2.06	NT	2.04

Table TR02.5: Transmit Power, RF exposure method, in mW

Frequency	(MHz)	2402	2404	2440	2478	2480
BT Low Energy	1 Mbps	0.787	NT	0.787	NT	0.787
BT Low Energy	2 Mbps	NT	0.813	0.813	0.813	NT
ANT	----	0.963	NT	0.963	NT	0.963

Table TR02.6: Duty cycle, radio

Setup Diagram

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

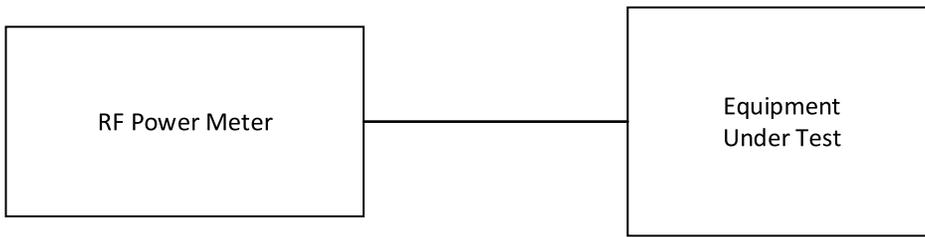


Figure TR02.1: Test equipment setup

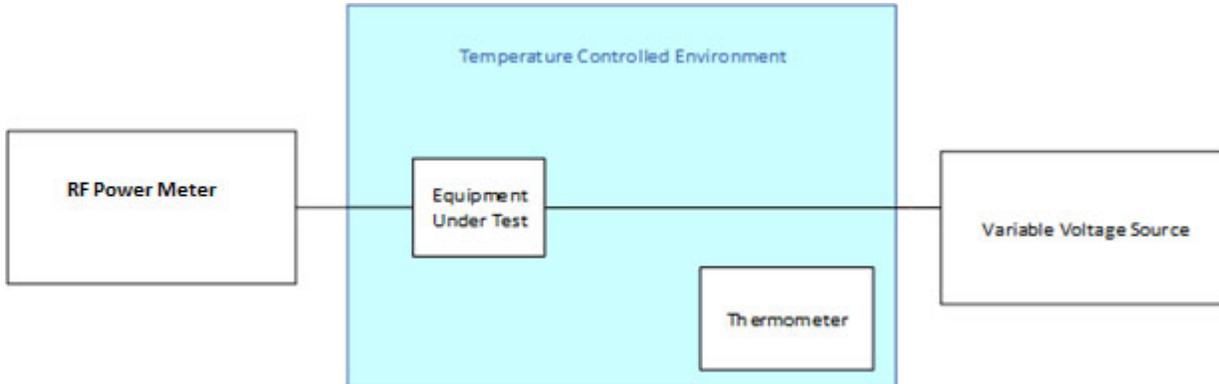


Figure TR02.2: Transmit Power over temperature test equipment setup

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test IDs TR19
Project GCL-0580

Test Date(s) 26 Jul 2024
 Test Personnel Vladimir Tolstik supervised by Jim Solum

Product Model A05000
 Serial Number tested 477224758

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

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

Antenna Gain -1.537 dBi, as reported by the client
 Radio Protocol Bluetooth Low Energy (BLE)

Pass/Fail Judgment: PASS

Test record created by: Jim Solum
 Date of this record: 29 Jul 2024

Original record, Version A.

Test Equipment Used

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

Table TR19.1: Test equipment used

Software Used: Keysight PXE software A.37.02

Test Method

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

Test Setup

This block diagram shows the test equipment setup.

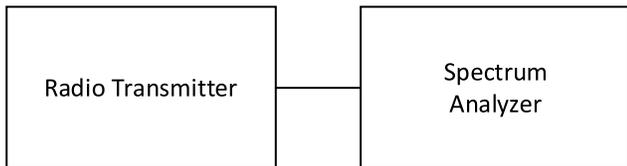


Figure TR19.1: Test setup

Test Data

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

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

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

	2402 (04)	2440	2480 (78)
BLE 1 Mbps	-11.63	-11.80	-11.36
BLE 2 Mbps	-14.51	-14.31	-14.30

Table TR19.2: Summary of results

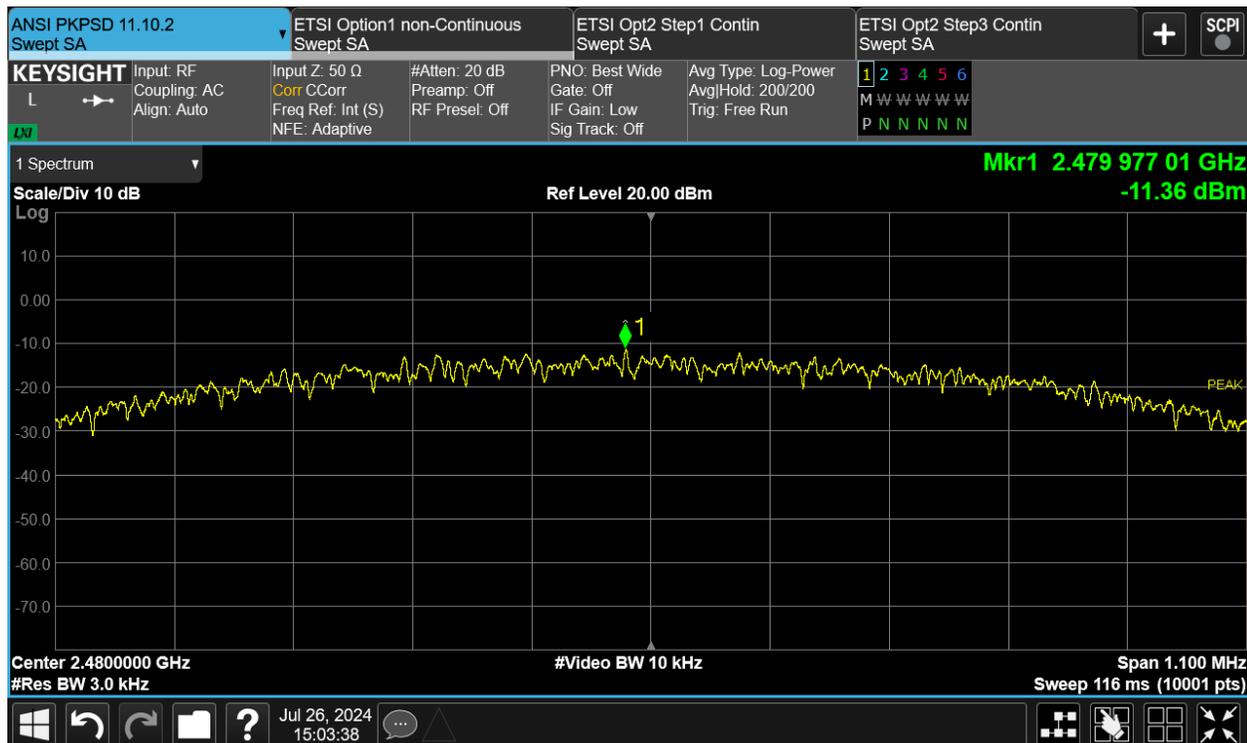


Figure TR19.2: Test data for BLE 1 Mbps 2480 MHz

This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE01
Project GCL0580

Test Date(s) 26 July 2024
 Test Personnel Andy Heier supervised by Dave Arnett

Product Model A05000
 Serial Number tested 477224793

Operating Mode M3 (BleTx)
 Arrangement A2 (Upwr)
 Input Power 120 Vac 60 Hz

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

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

Test record created by: Andy Heier
Date of this record: 30 July 2024

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	13-Mar-2024	15-Mar-2025
LISN multiline; 20A 50uH	Com-Power	LIN-120C	20160005	3-Apr-2024	1-Apr-2027

Table CE01.1: Test Equipment Used

Software Used

Keysight PXE software A.33.03; CE Mains 150kHz to 30M Data Analysis V3 2024May23.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 Composite FCC/CISPR Class B Limit.

Frequency (kHz)	QP Limit (dBuV)	AV Limit (dBuV)	L1 QP (dBuV)	L2 QP (dBuV)	L1 AV (dBuV)	L2 AV (dBuV)	QP Margin (dB)	AV Margin (dB)
150	66.00	56.00	35.56	34.30	24.94	24.07	30.44	31.06
443	57.01	47.01	27.37	26.38	22.28	21.17	29.64	24.74
715	56.00	46.00	26.39	26.27	21.32	21.22	29.61	24.68
3930	56.00	46.00	25.84	25.60	20.50	20.10	30.16	25.50
10001	60.00	50.00	29.03	29.05	24.97	25.17	30.95	24.83
30000	60.00	50.00	29.08	29.51	23.70	24.12	30.49	25.88

Table CE01.1: Emission summary (BLE 2 Mbps)

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

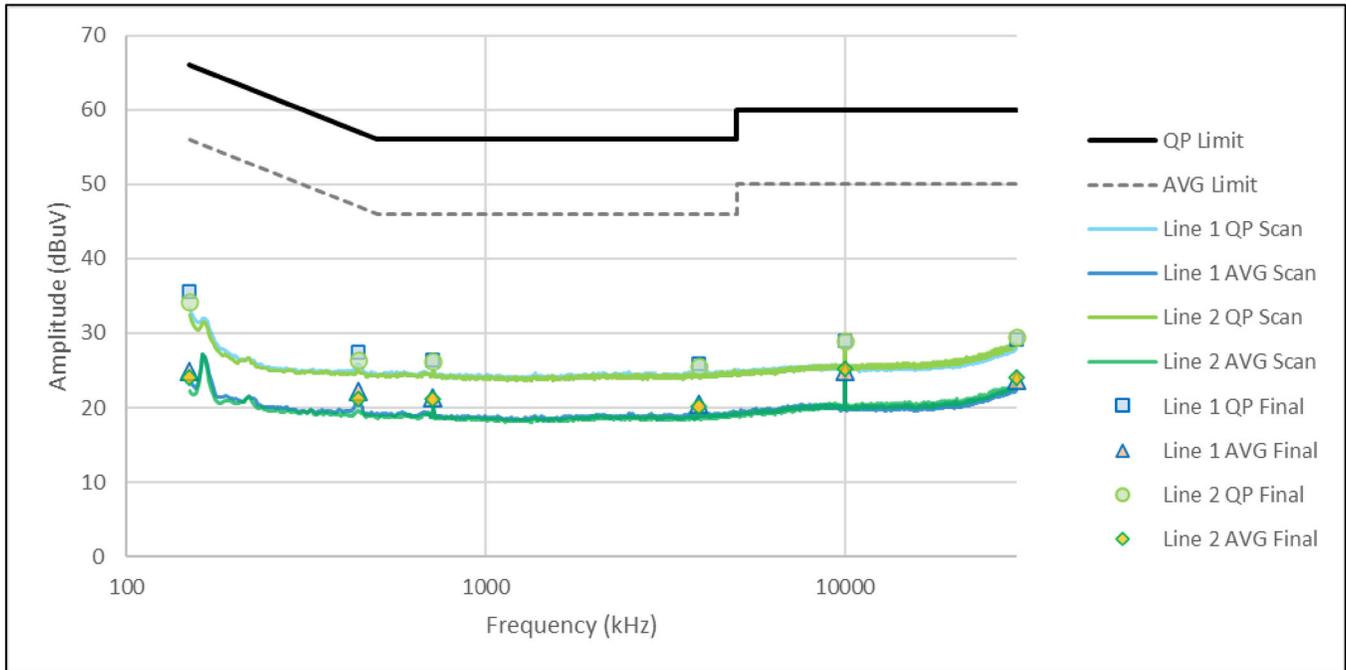


Figure CE01.1: Spectral data (BLE 2 Mbps)

Setup Photographs

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



Figure CE01.2: Test setup, first view



Figure CE01.3: Test setup, second view

This line is the end of the test record.

Concluding Notes

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

This is the final page of the report.



SAR EVALUATION REPORT

IEEE Std 1528-2013
IEC/IEEE 62209-1528:2020

For
Low Power Digital Device Transmitter

FCC ID: **IPH-05000**
Model Name: **A05000**

Report Number: **R15485855-S5**
Issue Date: **2024-09-24**

Prepared for
Garmin International Inc
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Prepared by
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Revision History

Rev.	Date	Revisions	Revised By
V1	2024-09-24	Initial Issue	--

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1. Attestation of Test Results

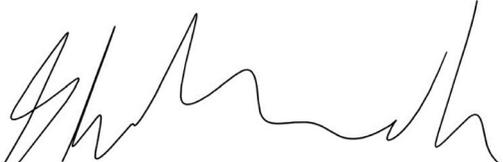
Applicant Name	Garmin International Inc	
FCC ID	IPH-05000	
Model Name	A05000	
Applicable Standards	Published RF exposure KDB procedures. IEEE Std 1528-2013 IEC/IEEE 62209-1528:2020	
Exposure Category	SAR Limits (W/Kg)	
	Extremities (hands, wrists, ankles, etc.) (10g of tissue)	
General population / Uncontrolled exposure	4	
RF Exposure Conditions	Equipment Class - Highest Reported SAR (W/kg)	
	DSS	DXX
Extremity	0.067	0.000
Simultaneous TX	0.067	0.067
Date Tested	2024-09-16	
Test Results	Pass	

UL LLC tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested can demonstrate compliance with the requirements as documented in this report.

This report contains data provided by the customer which can impact the validity of results. UL LLC is only responsible for the validity of results after the integration of the data provided by the customer.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to ensure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not considered unless noted otherwise.

This document may not be altered or revised in any way unless done so by UL LLC and all revisions are noted in the revisions section. Any alteration of this document not carried out by UL LLC will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the U.S. Government, or any agency of the U.S. government.

Approved & Released By:	Prepared By:
	
Richard Jankovics Staff Engineer UL LLC	Sarah Kuhaneck Engineer Project Associate UL LLC

2. Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with FCC 47 CFR § 2.1093, IEEE 1528-2013, IEC/IEEE 62209-1528:2020, the following FCC Published RF exposure [KDB](#) procedures:

- 447498 D01 General RF Exposure Guidance v06
- 447498 D03 Supplement C Cross-Reference v01
- 865664 D02 RF Exposure Reporting v01r02

In addition to the above, the following information was used:

- TCB Workshop October 2016; RF Exposure Procedures (DUT Holder Perturbations)
- TCB Workshop April 2019; RF Exposure Procedures (Tissue Simulating Liquids (TSL))

3. Facilities and Accreditation

UL LLC is accredited by A2LA, cert. # 0751.06 for all testing performed within the scope of this report. Testing was performed at the locations noted below.

The test sites and measurement facilities used to collect data are located at 2800 Perimeter Park Dr, Morrisville, NC, USA.

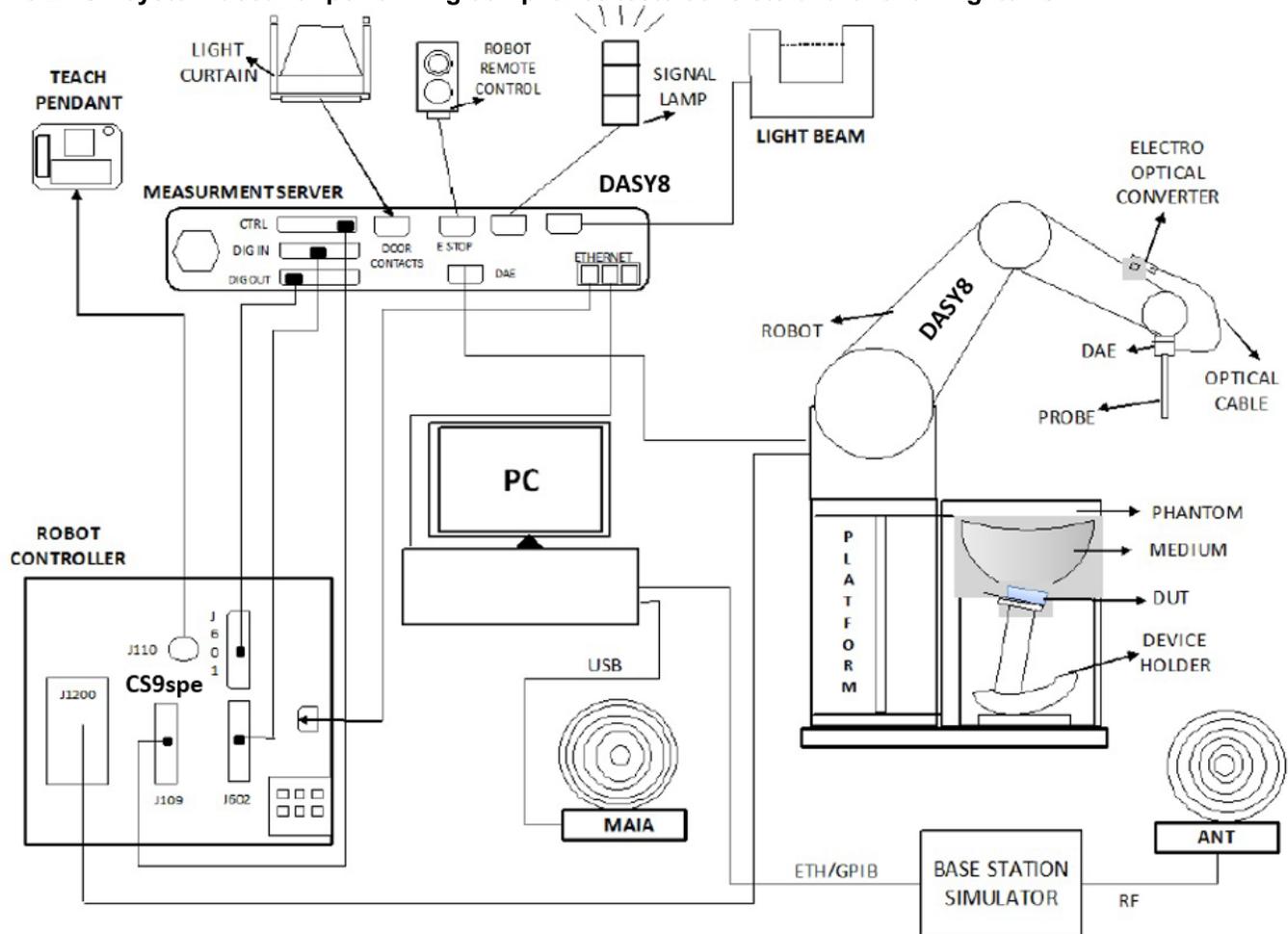
- SAR Lab 1A

	Address	ISED CABID	ISED Company Number	FCC Registration
<input type="checkbox"/>	Building: 12 Laboratory Dr RTP, NC 27709, U.S.A	US0067	2180C	825374
<input checked="" type="checkbox"/>	Building: 2800 Perimeter Park Dr. Suite B Morrisville, NC 27560, U.S.A	US0067	27265	825374

4. SAR Measurement System & Test Equipment

4.1. SAR Measurement System

The DASY system used for performing compliance tests consists of the following items:



- A standard high precision 6-axis robot with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic Field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running Win10 and the DASY8¹ software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

¹ DASY8 software used: DASY16.4.0 and older generations.

4.2. SAR Scan Procedures

Step 1: Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. The minimum distance of probe sensors to surface is 2.1 mm. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

Step 2: Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maximal found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEC/IEEE 62209-1528, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan). If only one Zoom Scan follows the Area Scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of Zoom Scans has to be increased accordingly.

Area Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
Maximum area scan spatial resolution: Δx_{Area} , Δy_{Area}	≤ 2 GHz: ≤ 15 mm $2 - 3$ GHz: ≤ 12 mm	$3 - 4$ GHz: ≤ 12 mm $4 - 6$ GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be \leq the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

Step 3: Zoom Scan

Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. The Zoom Scan measures points (refer to table below) within a cube whose base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the Zoom Scan evaluates the averaged SAR for 1 g and 10 g and displays these values next to the job's label.

Zoom Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

		≤ 3 GHz	> 3 GHz	
Maximum zoom scan spatial resolution: $\Delta x_{Zoom}, \Delta y_{Zoom}$		≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*	
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$	≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm	
	graded grid	$\Delta z_{Zoom}(1)$: between 1 st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{Zoom}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z	≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm	
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details. * When zoom scan is required and the <i>reported</i> SAR from the <i>area scan based 1-g SAR estimation</i> procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.				

Step 4: Power drift measurement

The Power Drift Measurement measures the field at the same location as the most recent power reference measurement within the same procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. This allows a user to monitor the power drift of the device under test within a batch process. The measurement procedure is the same as Step 1.

4.3. Test Equipment

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

Dielectric Property Measurements

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Date	Cal. Due Date
Network Analyzer	Keysight	E5063A	MY54100681	2024-07-31	2025-07-31
Dielectric Probe	SPEAG	DAKS-12	1037	2024-03-11	2025-03-11
Shorting Block	SPEAG	DAK-12 Short	2044	2024-03-11	2025-03-11
Thermometer	Fisher Scientific	15-078-181	181705017	2023-03-30	2025-03-30

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Date	Cal. Due Date
Signal Generator	Keysight	N5181A	MY50140788	2024-08-01	2025-08-01
3-Path Diode Power Sensor	Rohde & Schwarz	NRP8S	112236	2024-07-12	2025-07-12
3-Path Diode Power Sensor	Rohde & Schwarz	NRP8S	112237	2024-07-12	2025-07-12
Dual Directional Coupler	Werlatone	C5100-10	92249	N/A	N/A

Lab Equipment

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Date	Cal. Due Date
E-Field Probe	SPEAG	EX3DV4	7710	2024-01-16	2025-01-16
Data Acquisition Electronics	SPEAG	DAE4	1715	2024-02-12	2025-02-12
System Validation Dipole	SPEAG	CLA13	1017	2024-03-07	2025-03-07
Environmental Indicator	Control Company	06-662-4	240072459	2024-01-24	2026-01-24

5. Measurement Uncertainty

Per KDB 865664 D01, when the highest measured 1-g SAR within a frequency band is < 1.5 W/kg and the measured 10-g SAR within a frequency band is < 3.75 W/kg. The expanded SAR measurement uncertainty must be $\leq 30\%$, for a confidence interval of $k = 2$. If these conditions are met, extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

Therefore, the measurement uncertainty is not required.

6. Device Under Test (DUT) Information

6.1. DUT Description

Device Dimension	Overall (Length x Width x Thickness): 57 mm x 53 mm x 15 mm This is a an extremity wrist-worn wearable device	
Back Cover	The Back Cover is not removable	
Battery Options	The rechargeable battery is not user accessible.	
Test sample information	S/N 3477224577	Notes Radiated NFC
Hardware Version	A05000	
Software Version	4.09	

6.2. Wireless Technologies

Wireless technologies	Frequency bands	Operating mode	Duty Cycle used for SAR testing
Bluetooth	2.4 GHz	LE	N/A ²
ANT/ANT+	2.4 GHz	GFSK	N/A ²
NFC	13.56 MHz	Type A/B	100% (Type A) ¹

Notes:

1. Duty cycle for NFC is referenced from §9.3
2. Measured Duty Cycle is not required due to SAR test exemption.

7. RF Exposure Conditions (Test Configurations)

Refer to “SAR Photos and Ant locations” Appendix for the specific details of the antenna-to-antenna and antenna-to-edge(s) distances.

Wireless technologies	RF Exposure Conditions	DUT-to-User Separation	Test Position	Antenna-to-edge/surface	SAR Required	Note
Bluetooth LE	Extremity	0	Back	N/A	No	1
ANT/ANT+	Extremity	0	Back	N/A	No	1
NFC	Extremity	0	Back	N/A	Yes	

Notes:

SAR is not required per KDB 447498 D01 §4.2.3

SAR Test Exclusion Calculations for WLAN

Antennas < 50mm to adjacent edges

Tx Interface	Frequency (MHz)	Output Power		Separation Distances (mm)	Calculated Threshold Value
		dBm	mW		
Bluetooth LE	2480	6.00	4	0	1.3 -EXEMPT-
ANT/ANT+	2480	6.00	4	0	1.3 -EXEMPT-

Note(s):

According to KDB 447498, if the calculated threshold value is >7.5 then SAR testing is required.

8. Dielectric Property Measurements & System Check

8.1. Dielectric Property Measurements

The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within $\pm 2^\circ\text{C}$ of the temperature when the tissue parameters are characterized.

The dielectric parameters must be measured before the tissue-equivalent medium is used in a series of SAR measurements. The parameters should be re-measured after each 3 – 4 days of use; or earlier if the dielectric parameters can become out of tolerance; for example, when the parameters are marginal at the beginning of the measurement series.

Tissue dielectric parameters were measured at the low, middle and high frequency of each operating frequency range of the test device.

The dielectric constant (ϵ_r) and conductivity (σ) of typical tissue-equivalent media recipes are expected to be within $\pm 5\%$ of the required target values; but for SAR measurement systems that have implemented the SAR error compensation algorithms documented in IEC/IEEE 62209-1528:2020, to automatically compensate the measured SAR results for deviations between the measured and required tissue dielectric parameters, the tolerance for ϵ_r and σ may be relaxed to $\pm 10\%$. This is limited to frequencies ≤ 3 GHz.

Tissue Dielectric Parameters IEC/IEEE 62209-1528

Table 2 – Dielectric properties of the tissue-equivalent medium

Frequency MHz	Real part of the complex relative permittivity, ϵ_r'	Conductivity, σ S/m	Penetration depth (E-field), δ mm
4	55,0	0,75	293,0
13	55,0	0,75	165,5
30	55,0	0,75	112,8
150	52,3	0,76	62,0
300	46,3	0,87	46,1
450	43,5	0,87	43,0
750	41,9	0,89	39,8
835	41,5	0,90	39,0
900	41,5	0,97	36,2
1 450	40,5	1,20	28,6
1 800	40,0	1,40	24,3
1 900	40,0	1,40	24,3
1 950	40,0	1,40	24,3
2 000	40,0	1,40	24,3
2 100	39,8	1,49	22,8
2 450	39,2	1,80	18,7
2 600	39,0	1,96	17,2
3 000	38,5	2,40	14,0
3 500	37,9	2,91	11,4
4 000	37,4	3,43	10,0
4 500	36,8	3,94	9,7

Frequency MHz	Real part of the complex relative permittivity, ϵ_r'	Conductivity, σ S/m	Penetration depth (E-field), δ mm
5 000	36,2	4,45	1,5
5 200	36,0	4,66	8,4
5 400	35,8	4,86	8,1
5 600	35,5	5,07	7,5
5 800	35,3	5,27	7,3
6 000	35,1	5,48	7,0
6 500	34,5	6,07	6,7
7 000	33,9	6,65	6,4
7 500	33,3	7,24	6,1
8 000	32,7	7,84	5,9
8 500	32,1	8,46	5,3
9 000	31,6	9,08	4,8
9 500	31,0	9,71	4,4
10 000	30,4	10,40	4,0

NOTE: For convenience, permittivity and conductivity values are linearly interpolated for frequencies that are not a part of the original data from Drossos et al. [2]. They are shown in italics in Table 2. The italicized values are linearly interpolated (below 5800 MHz) or extrapolated (above 5800 MHz) from the non-italicized values that are immediately above and below these values.

Dielectric Property Measurements Results:

SAR Lab	Date	Tissue Type	Band (MHz)	Freq. (MHz)	Relative Permittivity (ϵ_r)			Conductivity (σ)		
					Measured	Target	Delta	Measured	Target	Delta
SAR 1A	2024-09-16	Head	13	13	52.8	55.0	-3.95%	0.72	0.75	-4.48%
				12	52.8	55.0	-3.96%	0.72	0.75	-4.49%
				14	52.8	55.0	-3.98%	0.72	0.75	-4.47%

8.2. System Check

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device. The same SAR probe(s) and tissue-equivalent media combinations used with each specific SAR system for system verification must be used for device testing. When multiple probe calibration points are required to cover substantially large transmission bands, independent system verifications are required for each probe calibration point. A system verification must be performed before each series of SAR measurements using the same probe calibration point and tissue-equivalent medium. Additional system verification should be considered according to the conditions of the tissue-equivalent medium and measured tissue dielectric parameters, typically every three to four days when the liquid parameters are re-measured or sooner when marginal liquid parameters are used at the beginning of a series of measurements.

System Performance Check Measurement Conditions:

- The measurements were performed in the flat section of the TWIN SAM or ELI phantom, shell thickness: 2.0 \pm 0.2 mm (bottom plate) filled with Body or Head simulating liquid of the following parameters.
- The depth of tissue-equivalent liquid in a phantom must be \geq 15.0 cm for SAR measurements \leq 3 GHz and \geq 10.0 cm for measurements $>$ 3 GHz.
- The DASY system with an E-Field Probe was used for the measurements.
- The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10 mm (above 1 GHz) and 15 mm (below 1 GHz) from dipole center to the simulating liquid surface.
- The coarse grid with a grid spacing of 15 mm was aligned with the dipole.
For 5 GHz band - The coarse grid with a grid spacing of 10 mm was aligned with the dipole.
- Special 7x7x7 (below 3 GHz) and/or 8x8x7 (above 3 GHz) fine cube was chosen for the cube.
- Distance between probe sensors and phantom surface was set to 3 mm.
For 5 GHz band - Distance between probe sensors and phantom surface was set to 2.5 mm
- The dipole/CLA input power (forward power) was recorded.
- The results are normalized to 1 W input power.

System Check Results

The 1-g and 10-g SAR measured with a reference dipole, using the required tissue-equivalent medium at the test frequency, must be within $\pm 10\%$ of the manufacturer calibrated dipole SAR target. Refer to Appendix B for the SAR System Check Plots.

SAR Lab	Date	Dipole Type & Serial Number	Dipole Cal. Due Date	Input Power (dBm)	Measured results for 1-g SAR				Measured results for 10-g SAR				Plot No.
					Meas. Zoom Scan	Normalize to 1 W	Target (Ref. Value)	Delta $\pm 10\%$	Meas. Zoom Scan	Normalize to 1 W	Target (Ref. Value)	Delta $\pm 10\%$	
1A	2024-09-16	CLA13 SN: 1017	2025-03-07	16.0	0.020	0.502	0.548	-8.33%	0.013	0.327	0.342	-4.52%	1

9. Conducted Output Power Measurements

9.1. Bluetooth LE

Maximum Output Power (Tune-up Limit) for Bluetooth LE

Maximum tune-up tolerance limit is 6 dBm. This power level qualifies for exclusion of SAR testing. Please refer to section 10.2. Standalone SAR Test Exclusion Considerations & Estimated SAR.

Band	Mode	Channel	Frequency (MHz)	Tune-up PowerLimit (dBm)
Bluetooth 2.4 GHz	LE	0	2402	6.0
		19	2440	6.0
		39	2480	6.0

9.2. ANT/ANT+

Maximum Output Power (Tune-up Limit) for ANT/ANT+

Maximum tune-up tolerance limit is 6 dBm. This power level qualifies for exclusion of SAR testing. Please refer to section 10.2. Standalone SAR Test Exclusion Considerations & Estimated SAR.

Band	Mode	Frequency (MHz)	Tune-up PowerLimit (dBm)
ANT/ANT+ 2.4 GHz	GFSK	2402	6.0
		2440	6.0
		2480	6.0

9.3. NFC

Conducted output power cannot be measured for NFC, therefore a 2 dB scaling factor shall be used to account for potential variations between samples.

Duty Factor Measured Results

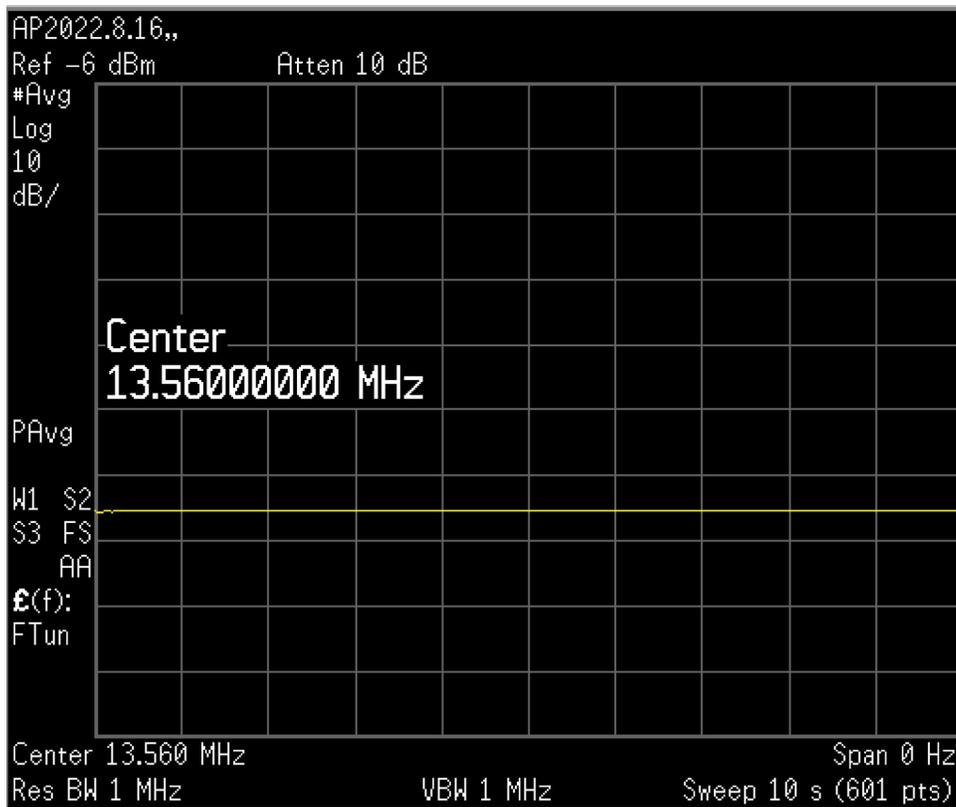
Mode	T on (ms)	Period (ms)	Duty Cycle	Crest Factor (1/duty cycle)
Type A	1.000	1.000	100.0%	1.00

Note(s):

Duty Cycle = (T on / period) * 100%

Duty Cycle plots

Type A



10. Measured and Reported (Scaled) SAR Results

SAR Test Reduction criteria are as follows:

- Reported SAR(W/kg) for NFC = Measured SAR * Tune-up scaling factor (2 dB)

10.1. NFC

RF Exposure Conditions	Mode	Dist. (mm)	Test Position	Freq. (MHz)	10-g SAR (W/kg)		Plot No.
					Meas.	Scaled	
Extremity	Type A	0	Back	13.56	0.000	0.000	1

Note(s):

Conducted output power measurements for NFC are not practical, therefore a 2 dB scaling factor shall be used to account for potential variations between samples.

10.2. Standalone SAR Test Exclusion Considerations & Estimated SAR

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

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

- $f_{(\text{GHz})}$ is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

When the standalone SAR test exclusion is applied to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to following to determine simultaneous transmission SAR test exclusion:

- $(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm}) \cdot [\sqrt{f_{(\text{GHz})}/x}]$ W/kg for test separation distances ≤ 50 mm; where $x = 7.5$ for 1-g SAR, and $x = 18.75$ for 10-g SAR.
- 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distances is > 50 mm.

RF Air interface	RF Exposure Conditions	Frequency (GHz)	Max. tune-up tolerance Power		Min. test separation distance (mm)	SAR test exclusion Result*	Estimated 10-g SAR (W/kg)
			(dBm)	(mW)			
Bluetooth LE	Extremity	2.480	6.0	4	5	1.3	0.067
ANT/ANT+	Extremity	2.480	6.0	4	5	1.3	0.067

Conclusion:

*: The computed value is ≤ 7.5 ; therefore, this qualifies for Standalone SAR test exclusion.

11. Simultaneous Transmission Conditions

RF Exposure Condition	Item	Capable Transmit Configurations	
Extremity	1	DSS	+ DXX

11.1. Simultaneous transmission SAR test exclusion considerations

KDB 447498 D01 General RF Exposure Guidance provides two procedures for determining simultaneous transmission SAR test exclusion: Sum of SAR and SAR to Peak Location Ratio (SPLSR)

Sum of SAR

To qualify for simultaneous transmission SAR test exclusion based upon Sum of SAR the sum of the reported standalone SARs for all simultaneously transmitting antennas shall be below the applicable standalone SAR limit. If the sum of the SARs is above the applicable limit then simultaneous transmission SAR test exclusion may still apply if the requirements of the SAR to Peak Location Ratio (SPLSR) evaluation are met.

11.2. Estimated SAR for Simultaneous Transmission SAR Analysis

Considerations for SAR estimation

- When standalone SAR test exclusion applies, standalone SAR must also be estimated to determine simultaneous transmission SAR test exclusion.
- Dedicated Host Approach criteria for SAR test exclusion is likewise applied to SAR estimation, with certain distinctions between test exclusion and SAR estimation:
 - When the separation distance from the antenna to an adjacent edge is ≤ 5 mm, a distance of 5 mm is applied for SAR estimation; this is the same between test exclusion and SAR estimation calculations.
 - When the separation distance from the antenna to an adjacent edge is > 5 mm but ≤ 50 mm, the actual antenna-to-edge separation distance is applied for SAR estimation.
 - When the minimum test separation distance is > 50 mm, the estimated SAR value is 0.4 W/kg
- Please refer to Estimated SAR Tables to see which test positions are inherently compliant as they consist of only estimated SAR values for all applicable transmitters and consequently will always have sum of SAR values < 1.2 W/kg. Simultaneous transmission SAR analysis was therefore not performed for these test positions.
-

Estimated SAR for Bluetooth LE:

RF Air interface	RF Exposure Conditions	Frequency (GHz)	Max. tune-up tolerance Power		Min. test separation distance (mm)	Estimated 10-g SAR (W/kg)
			(dBm)	(mW)		
Bluetooth LE	Extremity	2.480	6.0	4	5	0.067

Estimated SAR for Bluetooth LE:

RF Air interface	RF Exposure Conditions	Frequency (GHz)	Max. tune-up tolerance Power		Min. test separation distance (mm)	Estimated 10-g SAR (W/kg)
			(dBm)	(mW)		
ANT/ANT+	Extremity	2.480	6.0	4	5	0.067

11.3. Sum of SAR for DSS & DXX

RF Exposure conditions	Test Position	Standalone SAR (W/kg)			Σ 1-g SAR (W/kg)	
		1	2	2	1+3	2+3
		Bluetooth LE	ANT/ANT+	NFC		
Extremity	Back	0.067	0.067	0.000	0.067	0.067

Appendixes

Refer to separated files for the following appendixes.

Appendix A: SAR Setup Photos

Appendix B: SAR System Check Plots

Appendix C: SAR Highest Test Plots

Appendix D: SAR Tissue Ingredients

Appendix E: SAR Probe Certificates

Appendix F: SAR CLA Certificate

END OF REPORT