Test Report 2023-072

Version B
Issued 8 Dec 2023

Project GCL-0388
Model Identifier A04752
Primary Test Standard
FCC Part 15.249
RSS 210 Iss 10 Amd 1

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

Client-supplied Information

FCC ID: IPH-04752
IC ID: 1792A-04752

ACCREDITED
CERTIFICATE #6162.01

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

1. Summary

The equipment or product described in section 5 of this report was tested at the Garmin Compliance Lab according to standards listed in section 6. This report focuses on the Bluetooth Basic Rate / ANT transceiver(s).

References to other transmitters, or to their performance parameters may appear on this report but can be ignored. The one exception is the transmitter frequency stability data near page 34. The ANT, Bluetooth, and BLE radios use the same frequency-determining circuits. Frequency stability data for the worst case radio protocol among these three ensures compliance for all three.

The results are as follows.

Parameter	Description	Key Performance Values	Result	Data starts at page
Restricted Bands	The radio must not emit in certain designated restricted frequency bands above a set of limit values. [15.205; RSS-210 at 7.1]	Emissions in the restricted bands were at least 12.8 dB below the applicable limits.	PASS	12
Carrier and Harmonic Emissions	The field strength from the radio carrier and its harmonics must meet specific limits at a 3 m test distance. Other unwanted emissions also have to meet what is commonly called the Class B limit. [15.249(a); RSS-210 at B.10]	The limit is 50 mV/m (94 dBuV/m) in the carrier band, and 0.5 mV/m (54 dBuV/m) at all other frequencies. This sample demonstrated 3 dB of margin or greater. At other non-harmonic frequencies, unwanted emissions had at least 1.8 dB of margin.	PASS	16
Bandwidths	Regulatory agencies require the reporting of signal bandwidths. [2.202; RSS-GEN at 6.7]	These values are reported but have no actual performance requirements.	Reported	33
Frequency Stability	The radio tuning must be robust over a range of temperature and supply voltage conditions. [RSS-Gen at 6.11]	Radio emissions remained within the allowed radio band under all environmental conditions tested.	PASS	37
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 8.8 dB of margin.	PASS	40

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2023-076. That report is treated as a part of this document by way of this reference.

2. Test Background

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

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

Test Sample received: 01 Aug 2023
Test Start Date: 19 Sep 2023
Test End Date: 03 Nov 2023

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

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

3. Report History and Approval

This report was written by David Arnett and initially issued on 29 Nov 2023 as Version A.
Version B on 8 Dec 2023 included the results for signal bandwidth and radiated emissions below 1 GHz, removes a duplicate record, corrects references to the RSS standards, and minor editorial adjustments.

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:

Modification 1
Detailed Description: The audio cable from the docking unit was terminated, and the audio common wire in that cable was connected to the ground of the dc cable. Specifically, the black wire in the audio cable was connected the blue wire with a 200 Ohm resistor, to the White wire with a 10 kOhm resistor, to the Grey wire with a 10 kOhm resistor, and to the black wire of the Power/CAN bus cable with piece of wire 18 cm long.

Date applied: 25 Oct 2023
Reason for this modification: Without this modification, an emission at 247.62 MHz was above the limit and appeared to be radiating from the previously-unterminated audio cable.

The emission was determined to be unrelated to radio transmitter frequencies and uncorrelated to radio transmission activity. The emission was observed to be present whether the various radios were active or idle. The following tests were performed without this modification being present, and the presence or absence of the modification is judged by the lab and client to have no significant effect on these specific tests: All transmitter characterization tests (transmit power, bandwidths, spectral densities, and other emission tests above 1 GHz); Radiated emission tests above 1 GHz; AC Powerline emission tests. This modification was present during the spurious emission tests below and above 1 GHz for the 5 GHz radio services and no negative effect above 1 GHz was observed due to its presence.

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model	A04752
Serial Numbers Tested	3449554812 (unmodified, with memory data card), 3449554828 (modified)

This product tested is an information collection and distribution system for vehicular use.

The client affirmed that the test samples will be representative of production in all relevant aspects. The product design includes one antenna for the 2.5 GHz and a separate antenna for the 5 GHz radio band. Two test samples were modified to replace the antennas with RF cables. Each modified sample had two RF cables representing the different transmission paths.

5.2 Key Parameters

EUT Input Power:	12 Vdc Nominal (13.8 Vdc expected and generally used in test)
I/O Ports:	USB; micro-SD memory card; docking unit interface to power, audio, and CAN bus
Radio Transceivers:	IEEE 802.11 a/b/g/n/ac, Bluetooth, Bluetooth Low Energy, ANT/ANT+
Radio Receivers:	GNSS
Primary Functions:	Collecting and distributing information
Typical use:	Vehicle mounted in a set orientation
Highest internal frequency:	5.85 GHz
Firmware Revision	1.16

5.3 Operating modes

During test, the EUT was operated in one or more of the following modes. Note that 802.11 n and ac both use MCS-based modulation indices. They are treated as interchangeable in this report, meaning that where one of the two WiFi modes was selected it represents both.

Mode 1: M1 (BtcTx). The unit continuously transmits Bluetooth data packets on a selected channel. Note that for this test series, M1 only relates to EDR2 (2 Mbps using π/4 DPSK) and EDR3 (3 Mbps using 8DPSK modulation). The Bluetooth Basic Rate is handled under mode M6.

Mode 2: M2 (BleTx). The unit continuously transmits Bluetooth Low Energy (BLE) data packets on a selected channel at a 1 Mbps rate using frequency shift keying.

Mode 3: M3 (WiFi2Tx). The unit continuously transmits WiFi data packets on a selected channel in the 2.4 GHz band under the IEEE 802.11 b/g/n/ac protocols using 20 MHz or 40 MHz nominal channel bandwidths.

Mode 4: M4 (WiFi5Tx). The unit continuously transmits WiFi data packets on a selected channel in the 5 GHz band (U-NII-1 and U-NII-3 sub-bands) under the IEEE 802.11 a/n/ac protocols using 20 MHz or 40 MHz nominal channel bandwidths.

Mode 5: M5 (GNSS). The unit attempts to receive and decode GNSS signals from a variety of constellations. Where relevant, GPS signals were provided to the test sample.

Mode 6: M6 (AntTx). The unit continuously transmits Bluetooth Basic Rate data packets on a selected channel. The modulation scheme is GFSK. The client stated that this operating mode represents both Bluetooth Basic rate and ANT/ANT+ transmissions. See mode M1 for EDR2 and EDR3 transmissions.

5.4 EUT Arrangement

During test, the EUT components and associated support equipment were selected including the following arrangement sets. Test sample 3449554812 had a microSD data card installed in all configurations tested. The other test samples did not.

Arrangement 1: A1 (Mounted.) The test sample is connected to a docking interface unit. The docking interface unit connects for multiple functions. It connect the test sample to dc power. It connects the test sample to a typical accessory containing a VHF radio that is already certified and not exercised in this test series. The docking unit is

capable of connecting the test sample to a vehicle CAN bus interface and to an audio system. The CAN bus and audio interfaces were left unterminated per client instruction. See section 4 of this report related audio interface termination.

Arrangement 2: A2 (USB.) The test sample is connected to an AC/DC power converter via its USB port. The docking interface is not connected, and the USB port does not carry data.

Arrangement 3: A3 (PC.) The test sample is connected to a computer via its USB port and the USB interface carries data. The docking interface is not connected.

Arrangement 4: A4 (Dual.) The test sample is connected to computer via its USB port as in A3 (PC) and to the docking interface as in A1 (Mounted).

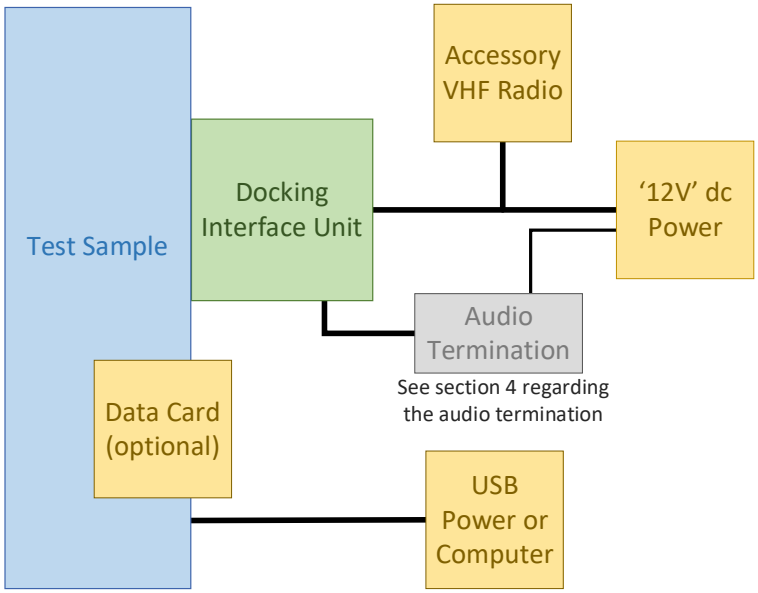

Figure 1: Block diagram of equipment present in arrangements A1 through A4

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
USB Power Adaptor	Phihong	PSAF10R-050Q	P183100844A1
Laptop	Dell	Inspiron	7DCR5R3
Power Supply	Dell	DA65NM191	CN-0KPVMF-DES00-233-EE1V-A00
Computer	Dell	Latitude 5410	5VSPFB3
Power Supply	Dell	HA65NM191	0BD-7TC0-A02
UHF Radio	Garmin	011-05234-84	75B005065
UHF Radio	Garmin	011-05234-84	75B004799
4G microSD memory card	Transcend	9193AB 4G 07SM1	None

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

5.6 Cables used

Note that the docking interface unit is treated as a cable because its function is interconnection.

Description	From	To	Length	EMC Treatment
Docking Interface 1	EUT port	Audio, CAN, Power, VHF radio	57 cm	None
Docking Interface 2	EUT port	Audio, CAN, Power, VHF radio	57 cm	None
Docking Interface 3	EUT port	Audio, CAN, Power, VHF radio	57 cm	Termination resistors placed on audio port, and ground wire included between audio common line and dc power ground
USB cable	EUT USB port	PC or USB power adapter	50 cm	None

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

6 Test Standards Applied

6.1. Accredited Standards

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

CFR 47, FCC Part 15.249
ANSI C63.10: 2013
RSS-GEN Issue 5 Amd 2
RSS-210 Issue 10 Amd 1

6.2. Non-accredited Standards

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

TRC-43 Issue 3

6.3 Variances

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

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

6.4 Laboratory Accreditation

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

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

7 Measurement Instrumentation Uncertainty

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

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

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

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

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

Note: *LSDPV stands for the Least Significant Digit Place Value reported. In the value 1470 msec, the least significant digit is the 7. It has a 10 msec place value. The LSDPV is thus 10 msec and the maximum error due to roundoff would be 5 msec. If the time value were reported as 147<u>0</u> msec, the underscore indicates that the 0 is a significant figure and the error due to roundoff would be 0.5 msec. All digits provided to the right of a decimal point radix are significant.*

8 Selected Example Calculations

Certain regulators require samples of the calculations that lead from the raw measurement to the final result for AC Mains conducted and unintended radiated emissions. The assumption is that the lab performs raw measurements, then adds, subtracts, multiplies, or divides based on transducer factors, amplifier gains, and losses in the signal transmission path. In this lab, our CISPR 16 Receiver does not work that way. The calibration factors and losses and gains are provided to the receiver as detailed data files. These factors are applied in the RF measurement path prior to the detector. But as a step in the lab measurement process, staff frequently verify that these factors are applied correctly. They make a measurement with the factors applied inside the receiver, then they disable the factors and remeasure the result manually adding in the various relevant factors.

The transmission loss is measured including the combined losses and gains of preamplifiers, cables, and any band-selective filters. In many cases above 1 GHz it is a negative value, indicating that the preamplifier gain is greater than these other losses.

Here are examples of these calculations. The data in these examples was not taken as part of this project:

8.1 AC Mains conducted emissions at 22 MHz

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

(7.145 dBuV) + (9.812 dB) + (0.216 dB) = 17.173 dBuV

8.2 Radiated Emissions at 630 MHz

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

(2.25 dBuV) + (27.80 dB/m) + (2.89 dB) = 32.94 dBuV/m

8.3 Radiated Emissions at 2.7 GHz

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

(43.72 dBuV) + (32.22 dB/m) + (-36.09 dB) = 39.85 dBuV/m

9 Environmental Conditions During Test

Environmental conditions in the test lab were monitored during the test period. Temperature and humidity are controlled by an air handling system. As information to the reader, the conditions were observed at the values or within the ranges noted below. For any tests where environmental conditions are critical to test results and require further constraints or details, the test records in the annex may provide more specific information.

Temperature:	20.5 to 24.0 °C
Relative Humidity:	19.9% to 55.7% (non-condensing)
Barometric Pressure	96.3 to 99.5 kPa

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

Table 4: Environmental monitoring device

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 RE01
Project GCL0388

Test Date(s)	19 Sep 2023
Test Personnel	David Kerr
Product Model	A04752
Serial Number tested	3449554812
Operating Mode	M6 (AntTx)
Arrangement	A1 (Mounted)
Input Power	13.8 Vdc
Test Standards:	FCC Part 15, RSS-Gen (as noted in Section 6 of the report).
Frequency Range:	Restricted Bands (2200-2300 MHz, 2310-2390 MHz, 2483.5-2500 MHz)
Pass/Fail Judgment:	**PASS**

Test record created by: **David A Kerr**
Date of this record: **8 Dec 2023**
Original record, Version A, issued 27 Sept 2023. Version B on 8 Dec 2023 corrects the list of standards.

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Wifi Filter	K&L	8NSL26-2437/E82.2-0/0	1	Calibration	Not Required

Table RE01.1: Test Equipment Used

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

Test Data

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.

Restricted band measurements in the lower band were made while the transmitter was tuned to its lowest frequency of 2402 MHz for the 1 Mbps data rate, and 2404 MHz for the 2 Mbps data rate. Measurements in the upper band were made while the transmitter was tuned to its highest frequency of 2480 MHz for the 1 Mbps data rate, and 2478 MHz for the 2 Mbps data rate.

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

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

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2389.8	54	74	35.826	60.835	18.174	13.165	-134	1410	HORZ
2389.5	54	74	35.827	60.686	18.173	13.314	-134	1410	HORZ

Table RE01.2: FCC restricted bands from 2200 to 2390 MHz

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2488.5	54	74	36.386	61.171	17.614	12.829	-136	1549	HORZ
2483.5	54	74	37.528	58.846	16.472	15.154	-136	1549	HORZ

Table RE01.3: FCC restricted band from 2483.5 to 2500 MHz

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

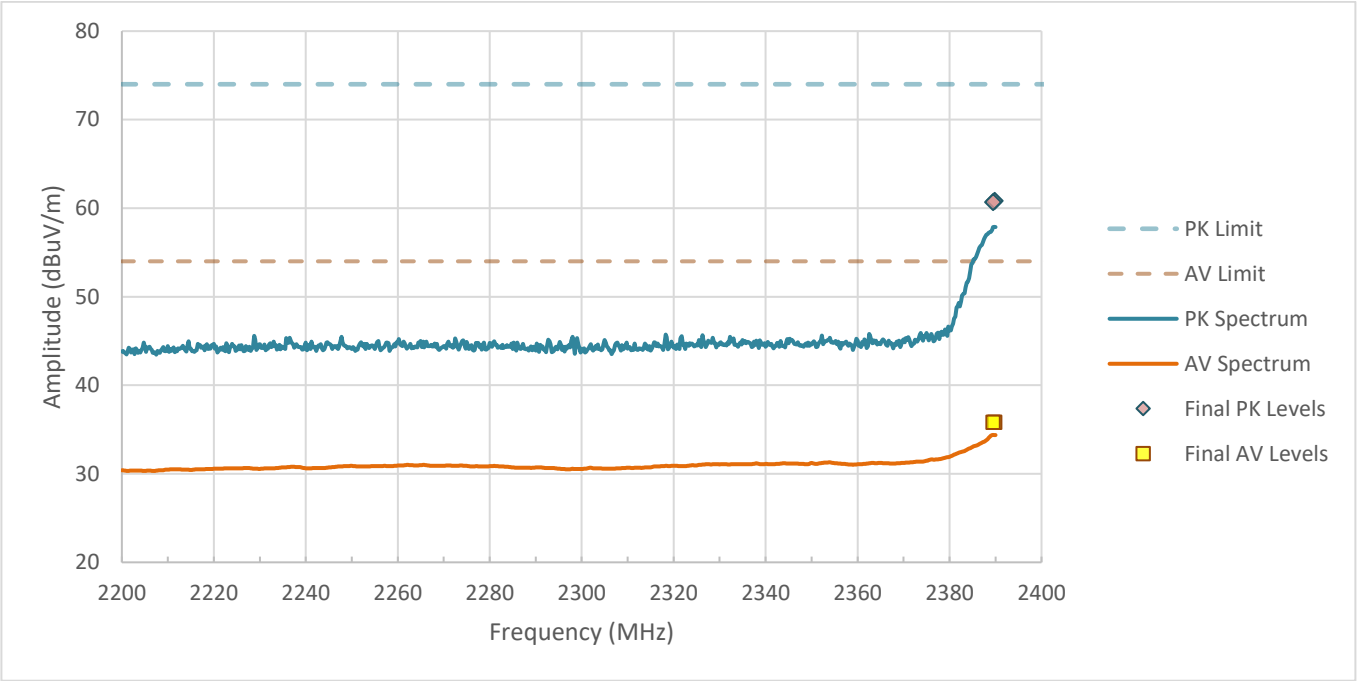

Figure RE01.1: FCC restricted band spectral data from 2200 to 2390 MHz

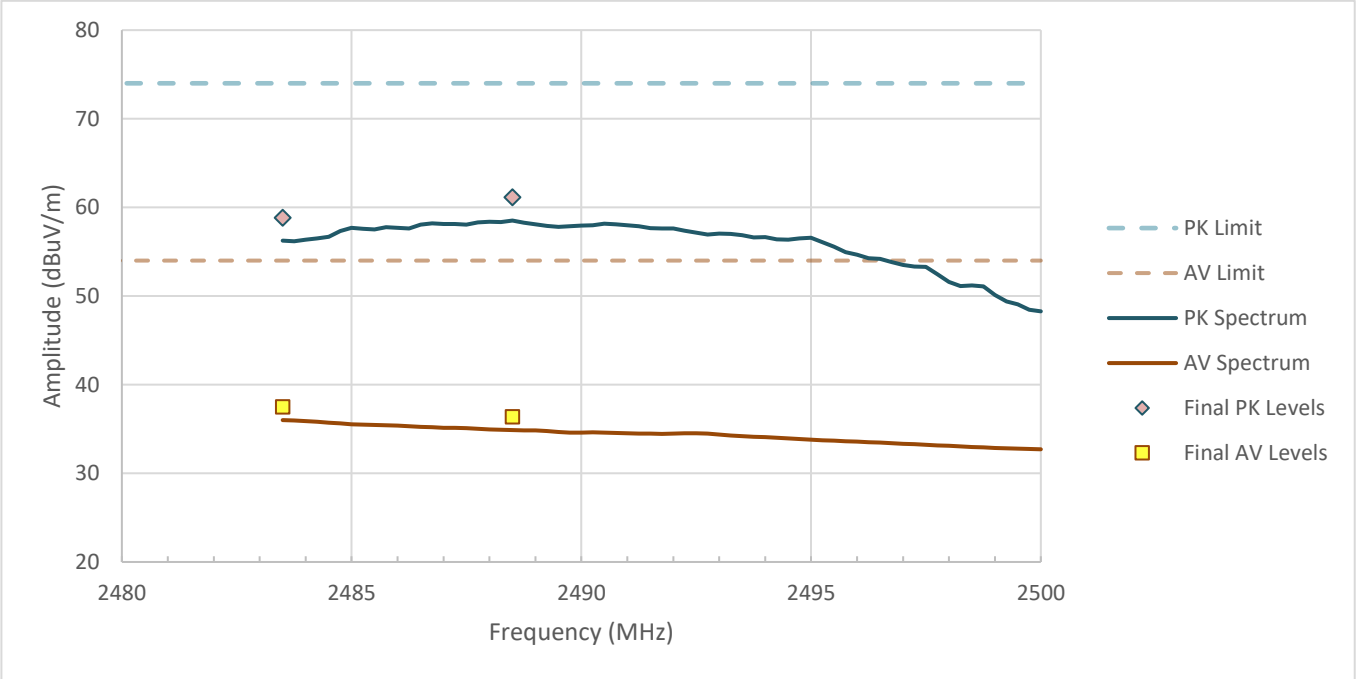

Figure RE01.2: FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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

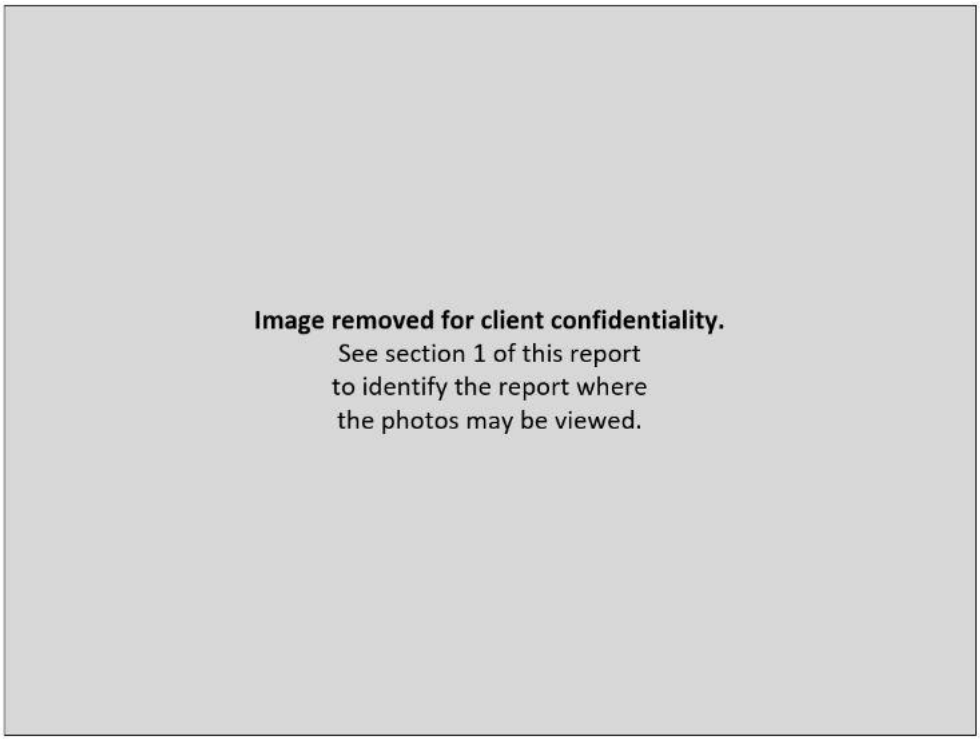

Figure RE01.3: EUT test setup (Front View)

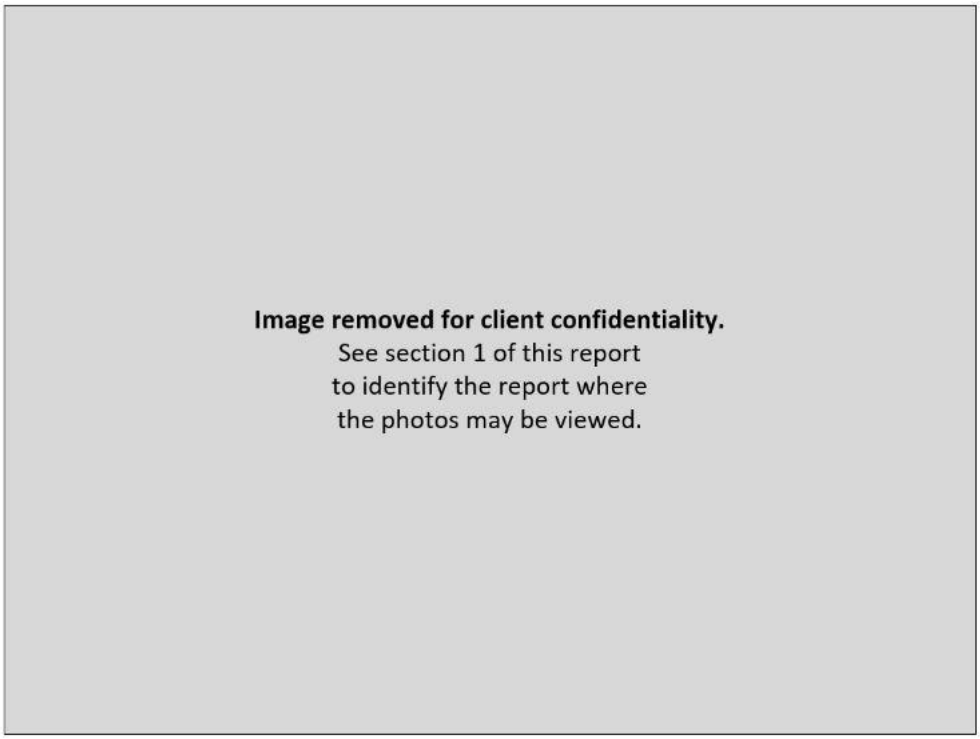

Figure RE01.4: EUT test setup (Rear View)

This line is the end of the test record.

Test Record
Radiated Emission Test RE22
Project GCL0388

Test Date(s)	25 Oct 2023
Test Personnel	David Kerr assisted by Aditya Prakash
Product Model	A04752
Serial Number tested	3449554812
Operating Mode	M6 (AntTx)
Arrangement	A1 (Mounted)
Input Power	13.8 Vdc
Test Standards:	FCC Part 15, RSS GEN, ANSI C63.10 (as noted in Section 6 of the report).
Frequency Range:	30 MHz to 1000 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**25 Oct 2023**

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	233201	19-Jul-2022	15-Jul-2024
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
DMM Multimeter	FLUKE	79 III	71740743	5-Apr-2023	1-Apr-2024
Power supply	Samlex America	SEC1212	03051-7F03-00426	Calibration	Not Required

Table RE22.1: Test Equipment Used

Software Used:
Keysight PXE software A.32.06
EPX/RE automation software ver. 2023.01.001

Test Data

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

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

The table shows the selected final measurement data between 30 MHz and 1 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency	Pol.	Reading	Factor	Level	Limit	Margin	Height	Angle
MHz		dB(µV)	dB(1/m)	dB(µV/m)	dB(µV/m)	dB	cm	deg
		QP		QP	QP	QP		
823.860	H	7.8	34.6	42.4	46.0	3.6	100.0	349.0
274.620	H	22.3	21.9	44.2	46.0	1.8	100.0	205.0
237.360	H	14.3	21.0	35.3	46.0	10.7	127.7	281.0
114.030	H	8.8	16.2	25.0	43.5	18.5	283.7	256.0
823.890	V	5.5	34.6	40.1	46.0	5.9	198.7	351.0
31.410	V	8.5	22.0	30.5	40.0	9.5	100.0	0.0

Table RE22.2: Emission summary

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

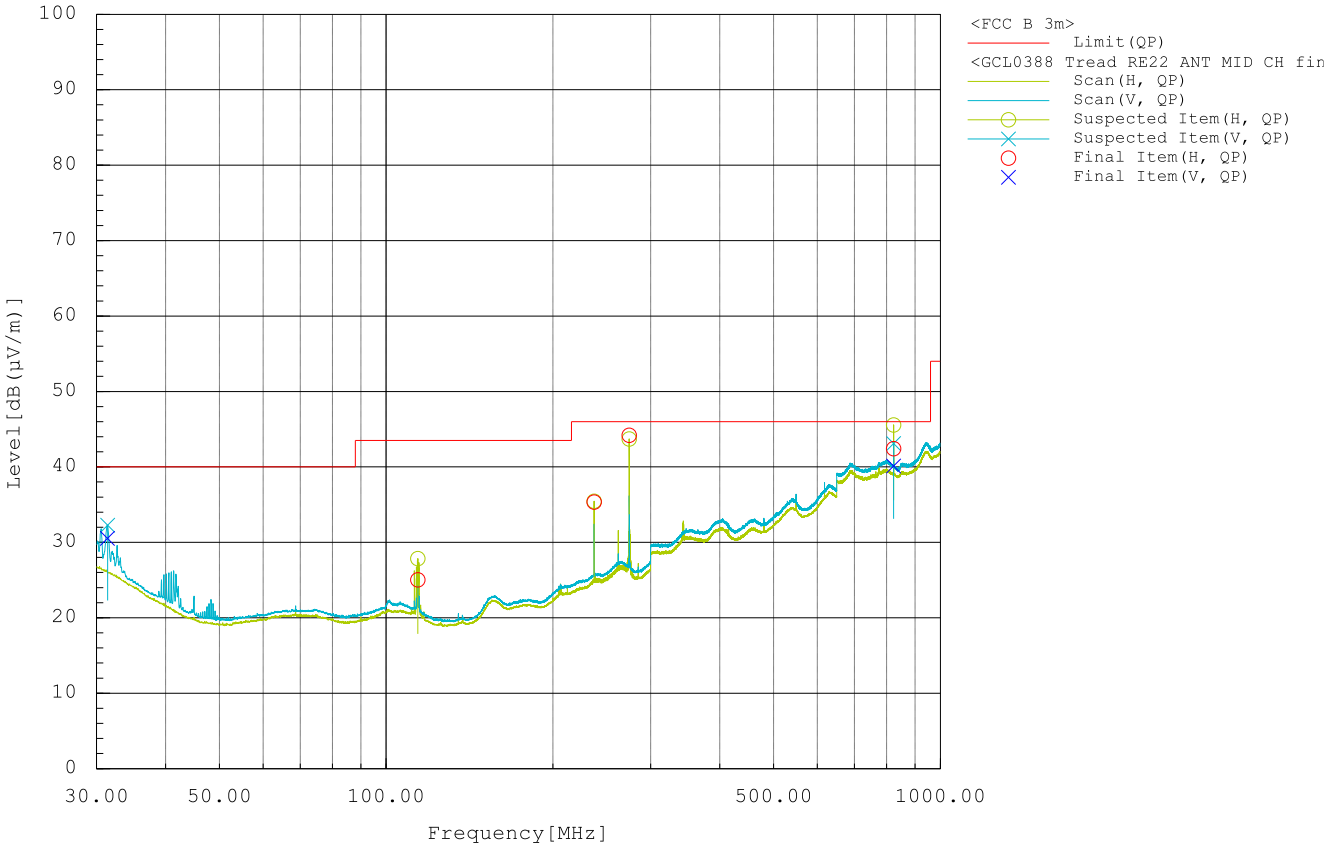

Figure RE22.1: Spectral data

Setup Photographs

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

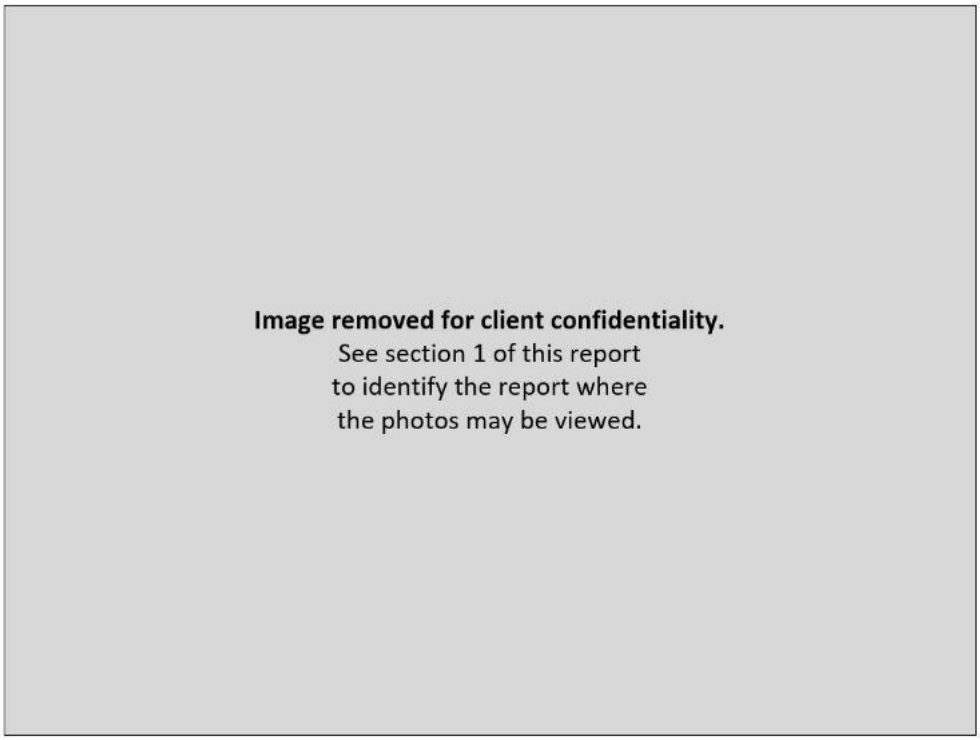

Figure RE22.2: EUT test setup, front view

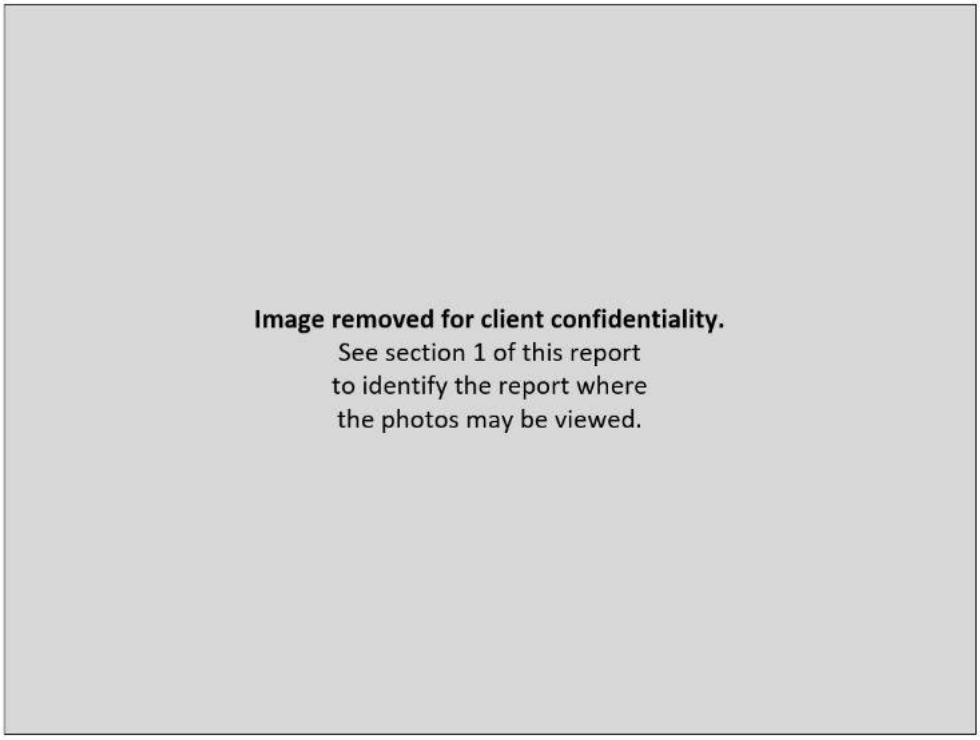

Figure RE22.3: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Radiated Emission Test RE19
Project GCL0388

Test Date(s)	04 Oct 2023
Test Personnel	David Kerr, Jim Solum
Product Model	A04752
Serial Number tested	3449554812
Operating Mode	M6 (Ant Tx)
Arrangement	A1 (Mounted)
Input Power	13.8 Vdc
Test Standards:	FCC Part 15, RSS 210, ANSI C63.10 (as noted in Section 6 of the report).
Frequency Range:	1 GHz to 18 GHz
Pass/Fail Judgment:	**PASS**

Test record created by: **David A Kerr**
Date of this record: **8 Dec 2023**
Original record, Version A, issued 9 Oct 2023. Version B on 8 Dec 2023 corrects the list of standards.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	259208	7-Jun-2023	1-Jun-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
3 GHz High Pass filter	Anatech Electronics	0K0R2	1	Calibration	Not Required
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	15-Apr-2024

Table RE19.1: Test Equipment Used

Software Used:
Keysight PXE software A.33.03
EPX/RE automation software ver. 2023.01.001

Test Data

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

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

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

The table shows the selected final measurement data between 1 GHz and 18 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the Composite FCC/CISPR Class B Limit at 3m.

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
2402.000	H	85.6	96.6	-1.7	83.9	94.9	94.0	114.0	10.1	19.1	116.4	49.0
4804.000	H	36.6	51.2	4.0	40.6	55.2	54.0	74.0	13.4	18.8	114.5	49.0
2394.000	H	35.4	57.5	-1.7	33.7	55.8	54.0	74.0	20.3	18.2	118.3	51.0
2407.000	H	35.3	54.8	-1.6	33.7	53.2	94.0	114.0	60.3	60.8	292.2	312.0

Table RE19.2: Emission summary (1-6GHz Ant Low 2402MHz)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
9923.500	H	29.2	43.2	16.1	45.3	59.3	54.0	74.0	8.7	14.7	381.1	303.0
7205.000	V	30.4	44.4	11.6	42.0	56.0	54.0	74.0	12.0	18.0	302.5	42.0
12471.000	V	27.8	42.0	18.6	46.4	60.6	54.0	74.0	7.6	13.4	108.5	105.0

Table RE19.3: Emission summary (6-18GHz Ant 2402MHz)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
1373.250	H	38.2	48.6	-5.7	32.5	42.9	54.0	74.0	21.5	31.1	100.0	310.0
2440.000	H	86.9	97.9	-1.4	85.5	96.5	94.0	114.0	8.5	17.5	116.5	52.0
4880.000	H	39.2	53.1	4.0	43.2	57.1	54.0	74.0	10.8	16.9	112.6	50.0

Table RE19.4: Emission summary (1-6GHz Ant Mid 2440MHz)

Frequency	Pol.	Reading	Factor	Level	Limit	Margin	Height	Angle

MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
7969.500	H	29.7	43.4	14.1	43.8	57.5	54.0	74.0	10.2	16.5	106.9	59.0
12471.250	H	27.7	41.9	18.6	46.3	60.5	54.0	74.0	7.7	13.5	390.8	76.0
7320.000	V	30.3	43.8	12.0	42.3	55.8	54.0	74.0	11.7	18.2	123.6	87.0

Table RE19.5: Emission summary (6-18GHz Ant Mid 2440MHz)

Frequency	**Pol.**	**Reading**		**Factor**	**Level**		**Limit**		**Margin**		**Height**	**Angle**
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
4960.000	H	38.6	52.6	4.2	42.8	56.8	54.0	74.0	11.2	17.2	134.2	48.0
1029.750	H	32.8	46.1	-6.8	26.0	39.3	54.0	74.0	28.0	34.7	136.3	330.0
2480.000	V	79.9	91.1	-1.3	78.6	89.8	94.0	114.0	15.4	24.2	319.7	168.0

Table RE19.6: Emission summary (1-6GHz Ant High 2480MHz)

Frequency	Pol.	Reading		Factor	Level		Limit		Margin		Height	Angle
MHz		dB(µV)		dB(1/m)	dB(µV/m)		dB(µV/m)		dB		cm	deg
		CAV	PK		CAV	PK	AV	PK	CAV	PK		
7116.500	H	30.0	43.6	11.5	41.5	55.1	54.0	74.0	12.5	18.9	106.6	111.0
7969.750	H	29.7	43.7	14.1	43.8	57.8	54.0	74.0	10.2	16.2	302.0	345.0
17098.500	V	25.3	40.3	25.7	51.0	66.0	54.0	74.0	3.0	8.0	334.4	300.0

Table RE19.7: Emission summary (6-18GHz Ant High 2480MHz)

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

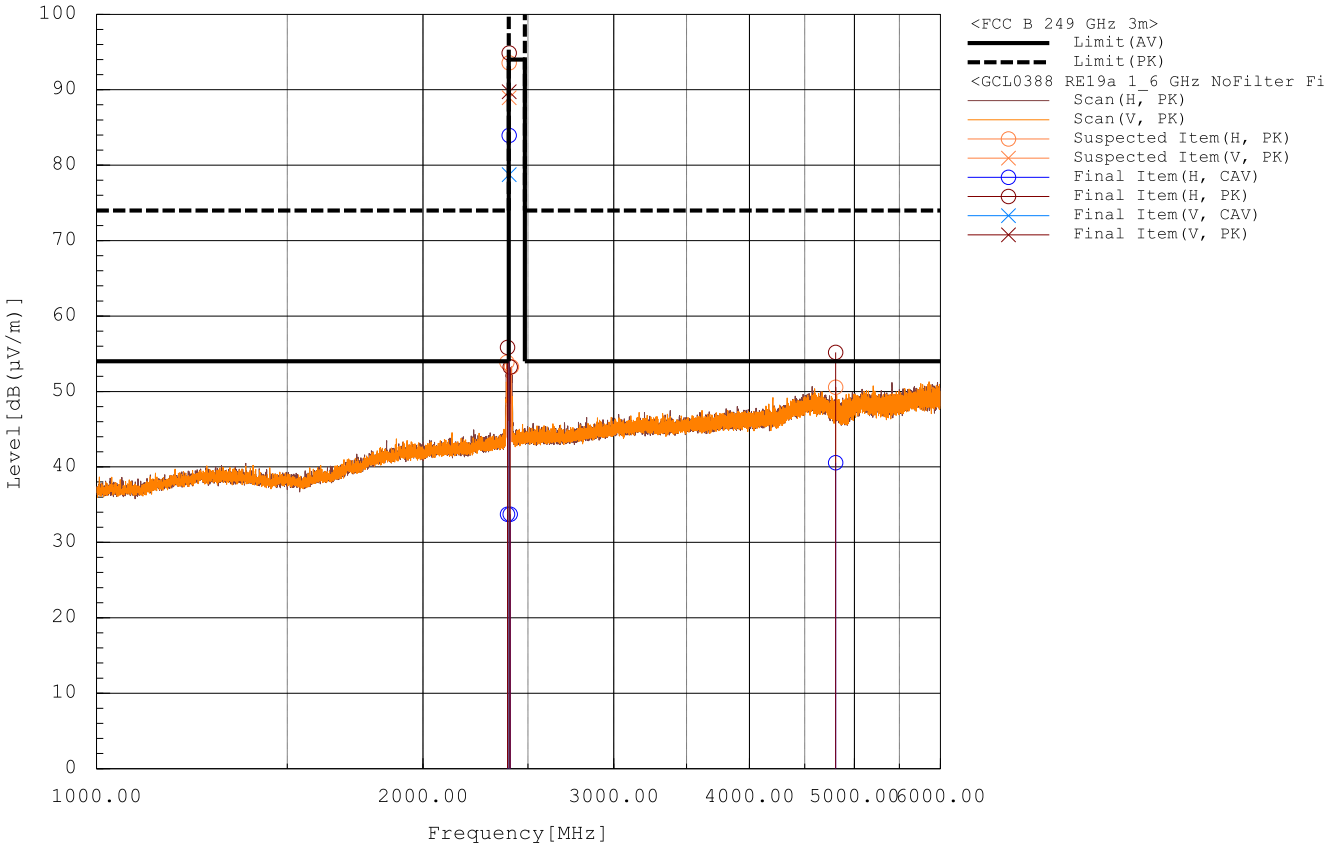

Figure RE19.1: Spectral data (1-6GHz Ant Low 2402MHz)

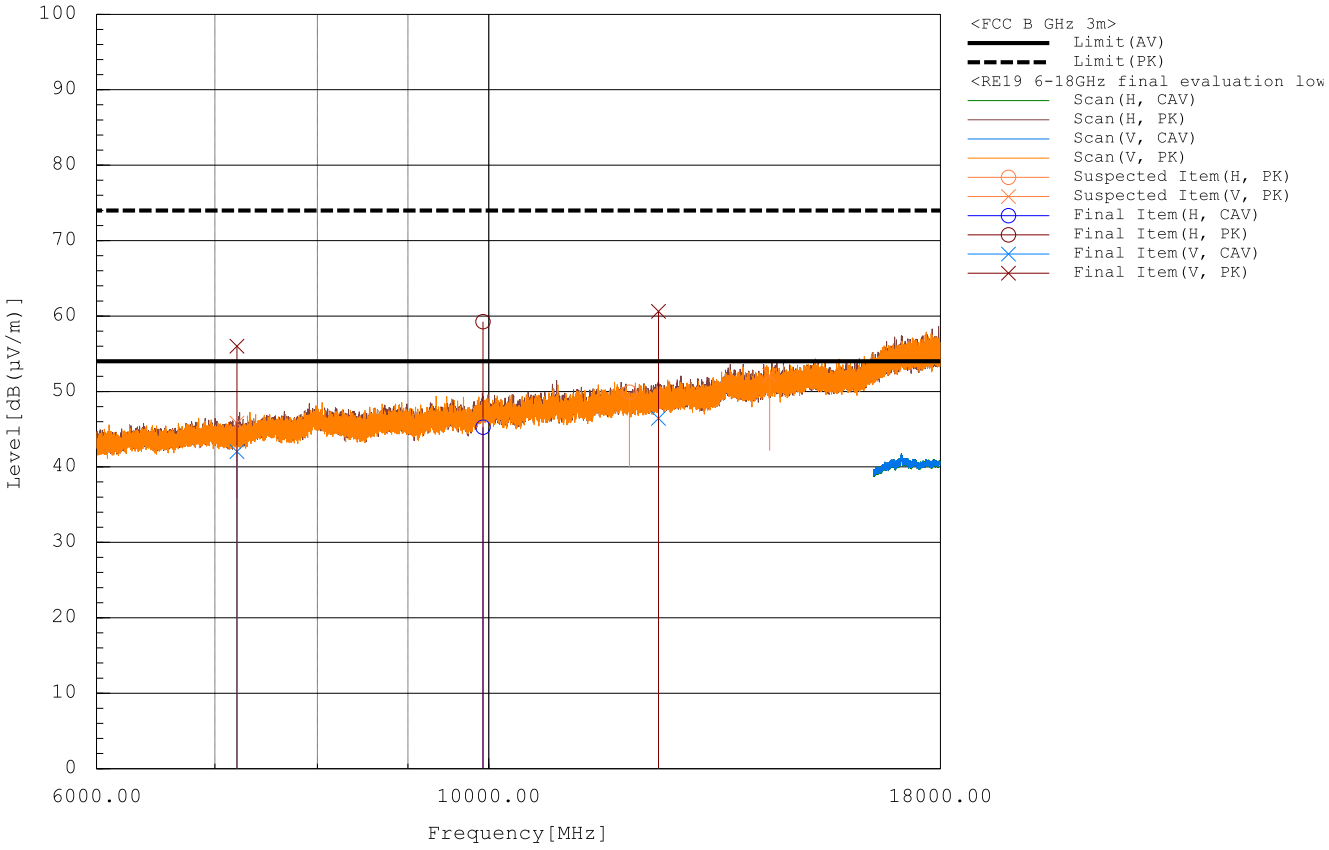

Figure RE19.2: Spectral data (6-18GHz Ant Low 2402MHz)

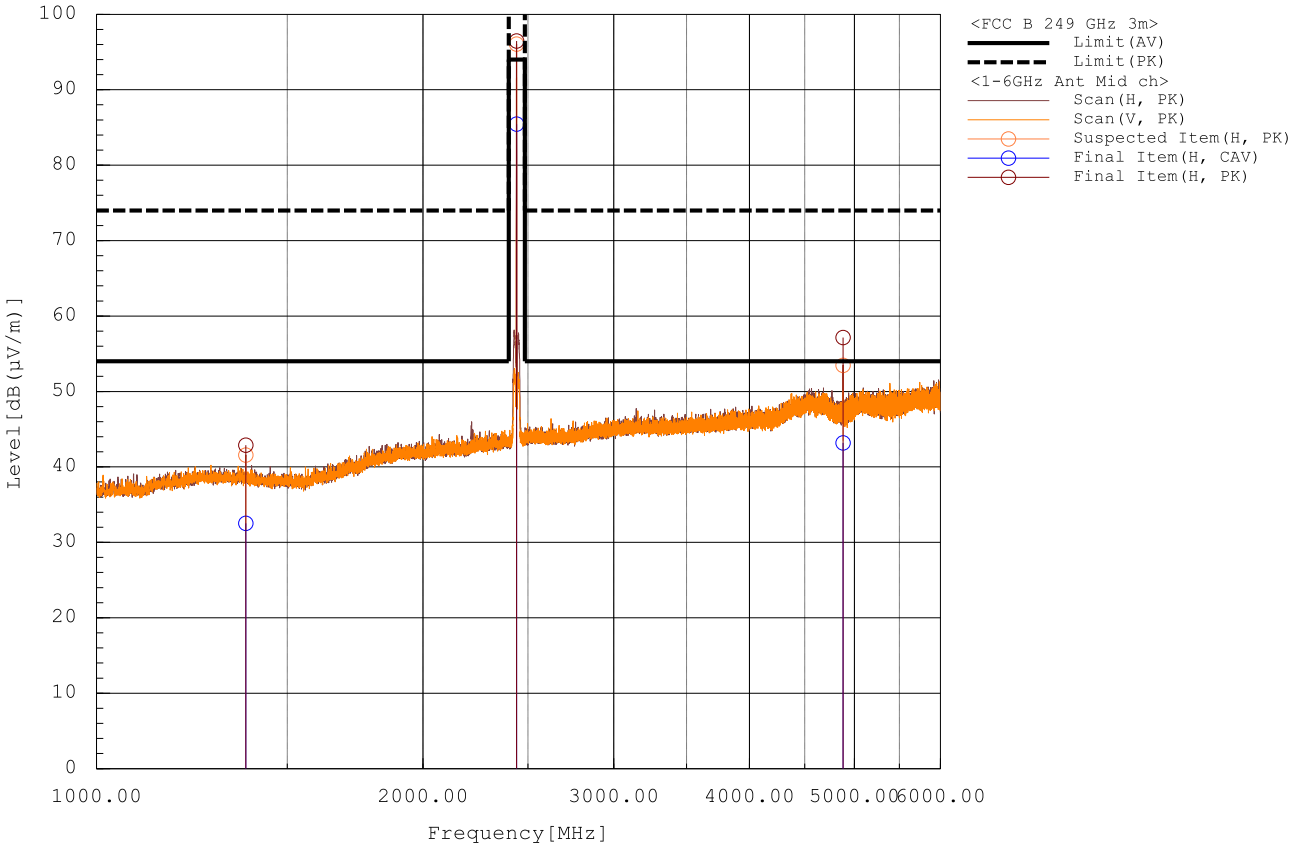

Figure RE19.3: Spectral data (1-6GHz Ant Mid 2440MHz)

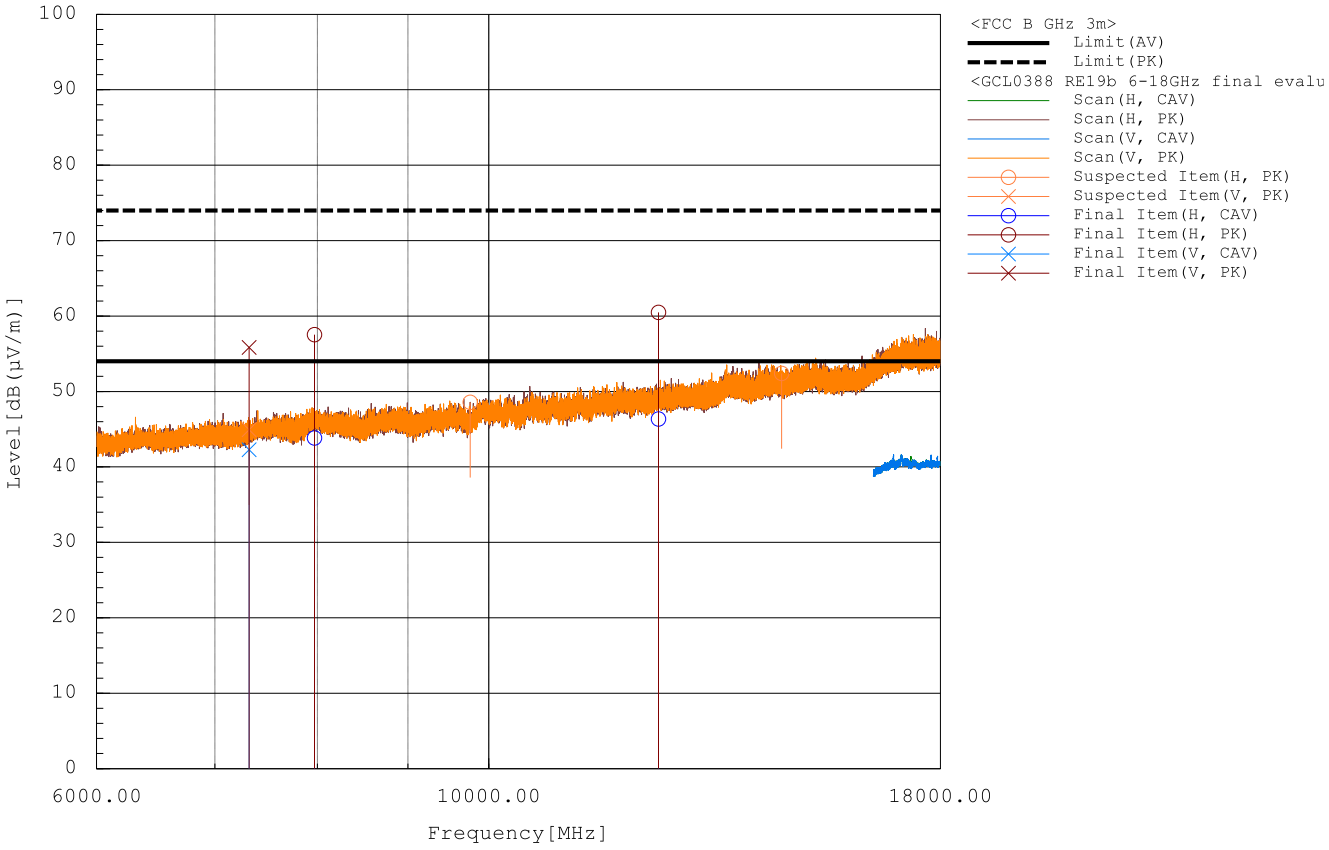

Figure RE19.4: Spectral data (6-18GHz Mid 2440MHz)

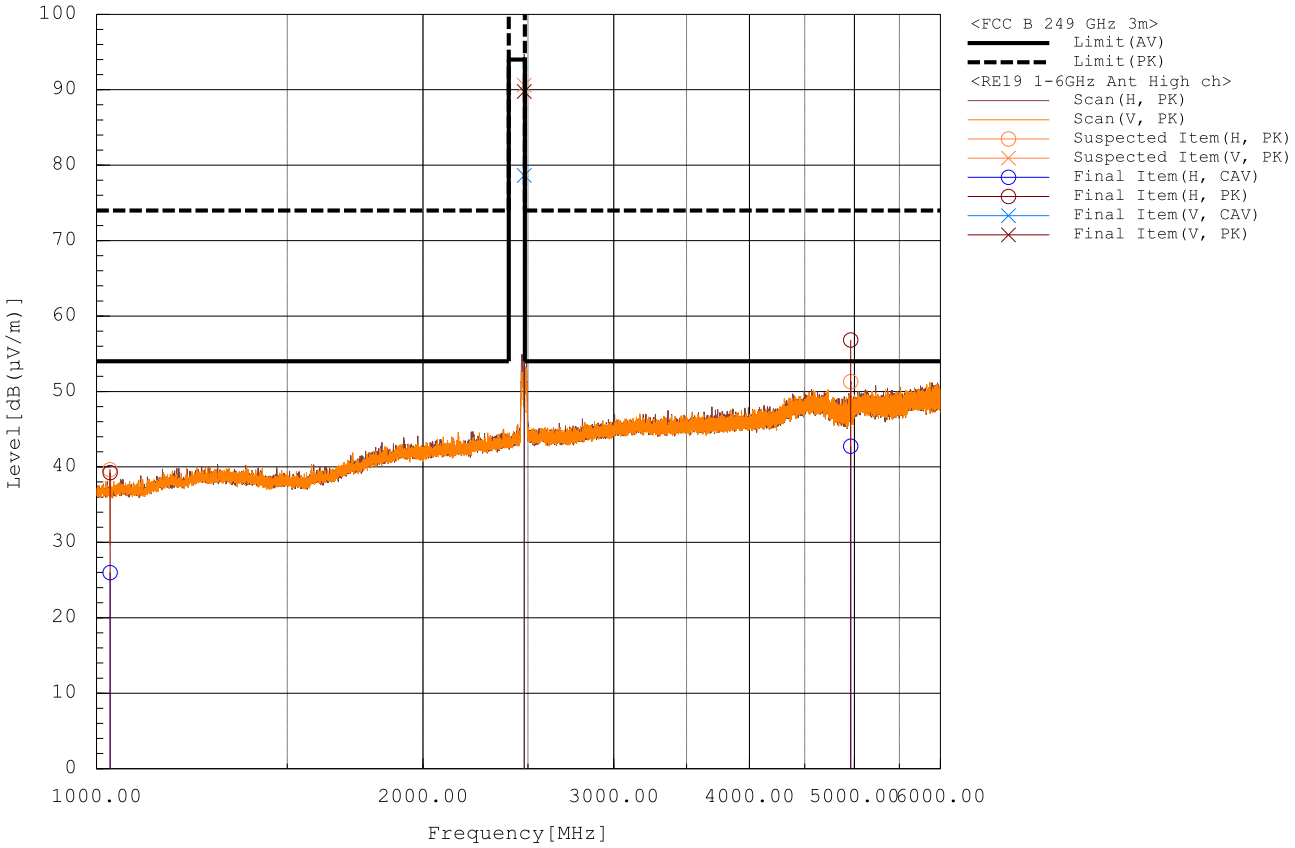

Figure RE19.5: Spectral data (1-6GHz Ant High 2480MHz)

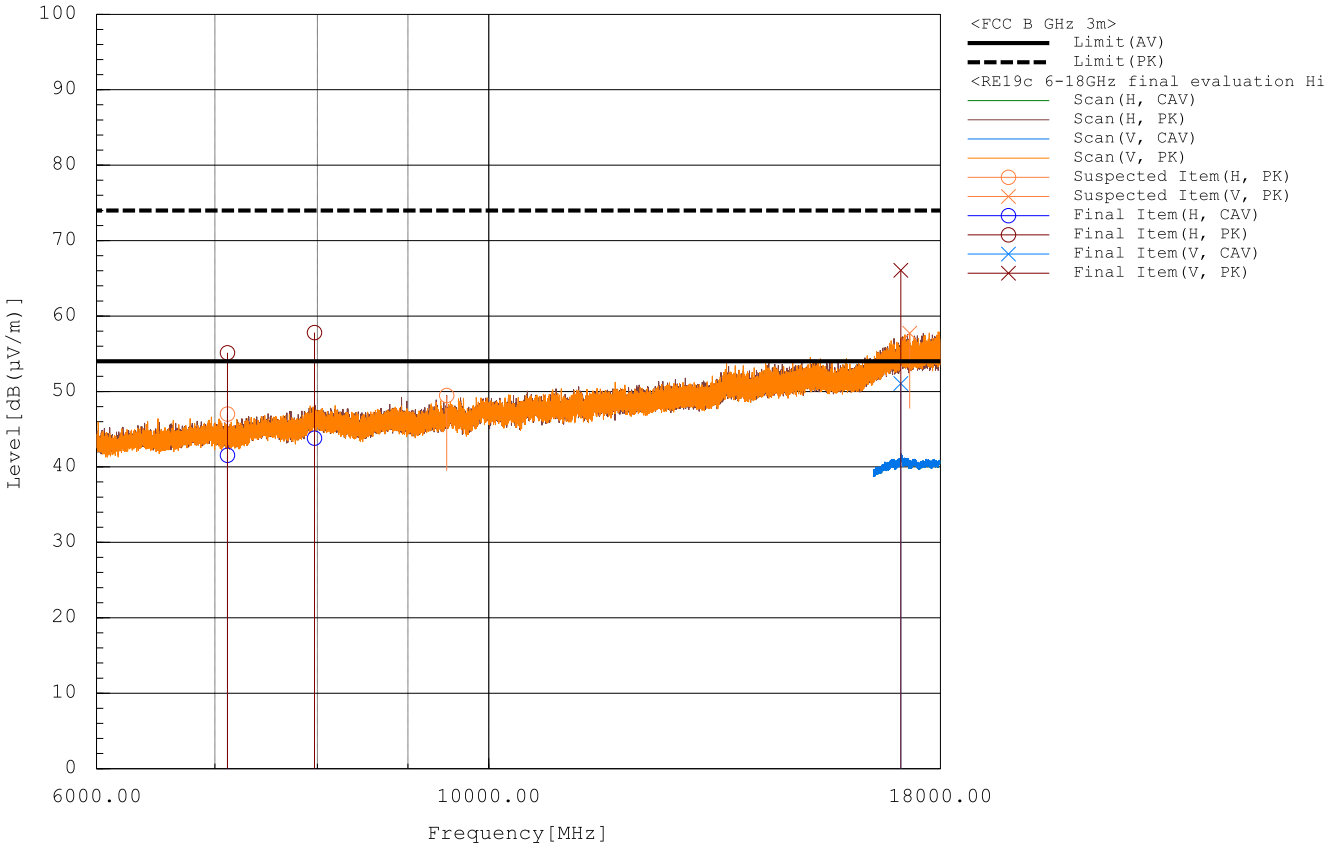

Figure RE19.6: Spectral data (6-18GHz Ant High 2480MHz)

Setup Photographs

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

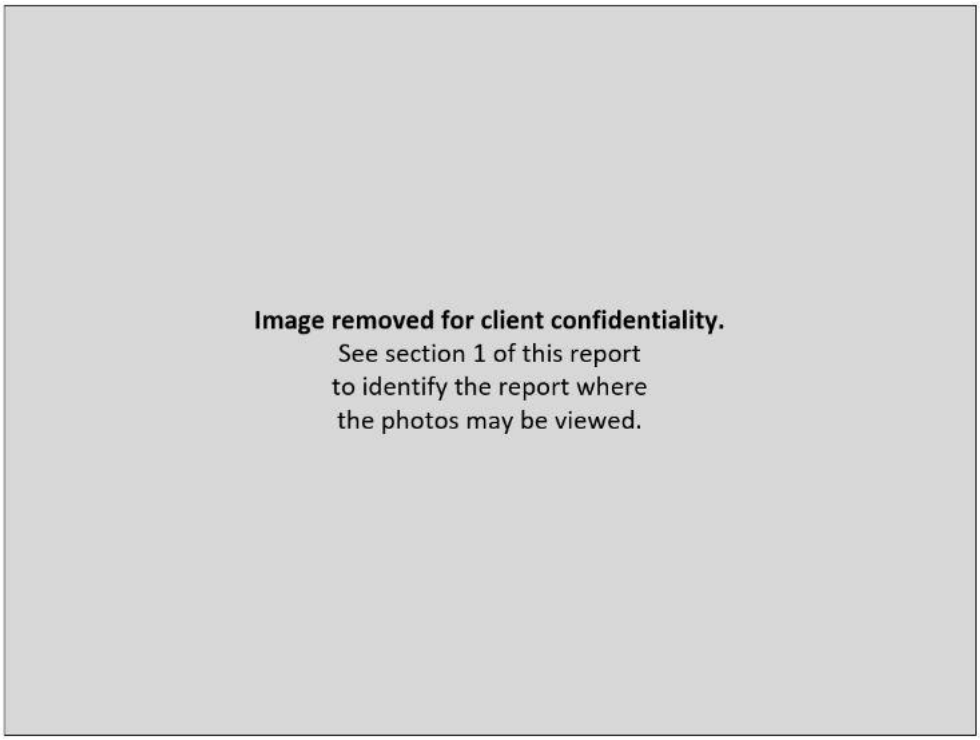

Figure RE19.7: EUT test setup, front view

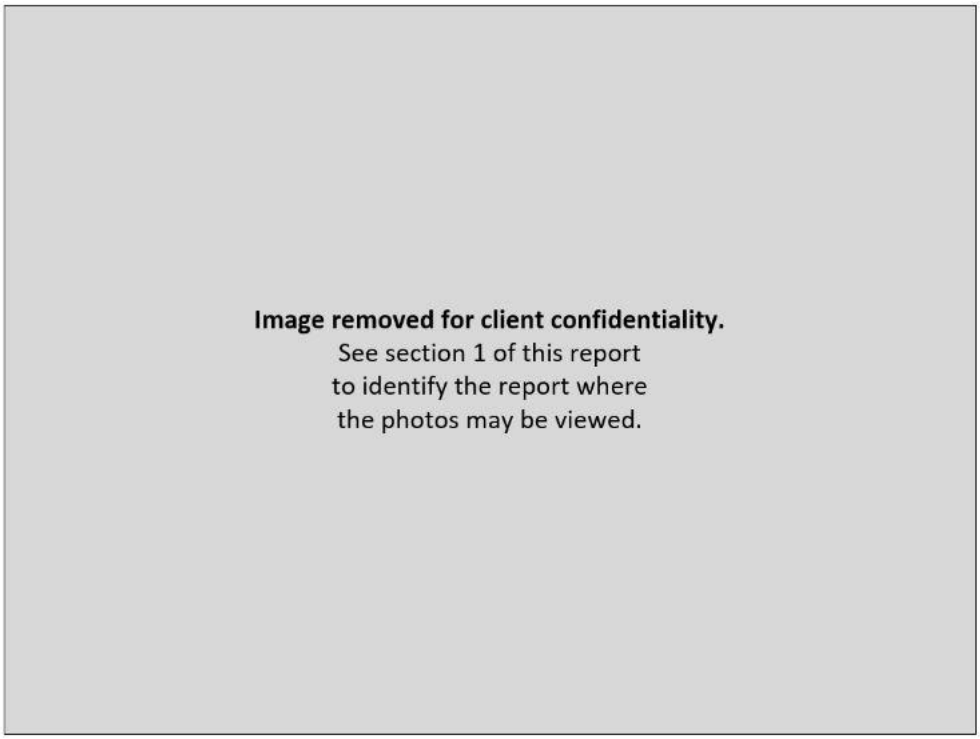

Figure RE19.8: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Radiated Emission Test RE20
Project GCL0388

Test Date(s)	06 Oct 2023
Test Personnel	David Kerr
Product Model	A04752
Serial Number tested	3449554812
Operating Mode	M6 (Ant Tx)
Arrangement	A1 (Mounted)
Input Power	13.8VDC
Test Standards:	FCC Part 15, ANSI C63.10 (as noted in Section 6 of the report).
Frequency Range:	18 GHz to 25 GHz
Pass/Fail Judgment:	**PASS**

Test record created by: **David A Kerr**
Date of this record: **8 Dec 2023**
Original record, Version A, issued 10 Oct 2023. Version B on 8 Dec 2023 corrects the list of standards

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Antenna, Horn, 10-40 GHz	ETS Lindgren	3116C	259186	23-Mar-2023	1-Apr-2024
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Preamplifier, 18 Ghz to 40 Ghz	Com-Power	PAM-840A	461364	Calibration	Not Required

Table RE20.1: Test Equipment Used

Software Used:
Keysight PXE software A.33.03
RE Signal Maximization Tool v2023Jul14.xlsx

Test Data

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

In the 18 GHz to 25 GHz frequency range, pre-scan spectral data was taken at 1 meter and extrapolated to a 3 meter distance. Final measurements were made at 3 meters.

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

The table shows the selected final measurement data between 18 GHz and 25 GHz. It includes the strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity	EUT Polarity
19520.000	54.00	74.00	44.40	58.20	9.60	15.80	70	3430	VERT	Z

Table RE20.2: Emission summary (18-26GHz)

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

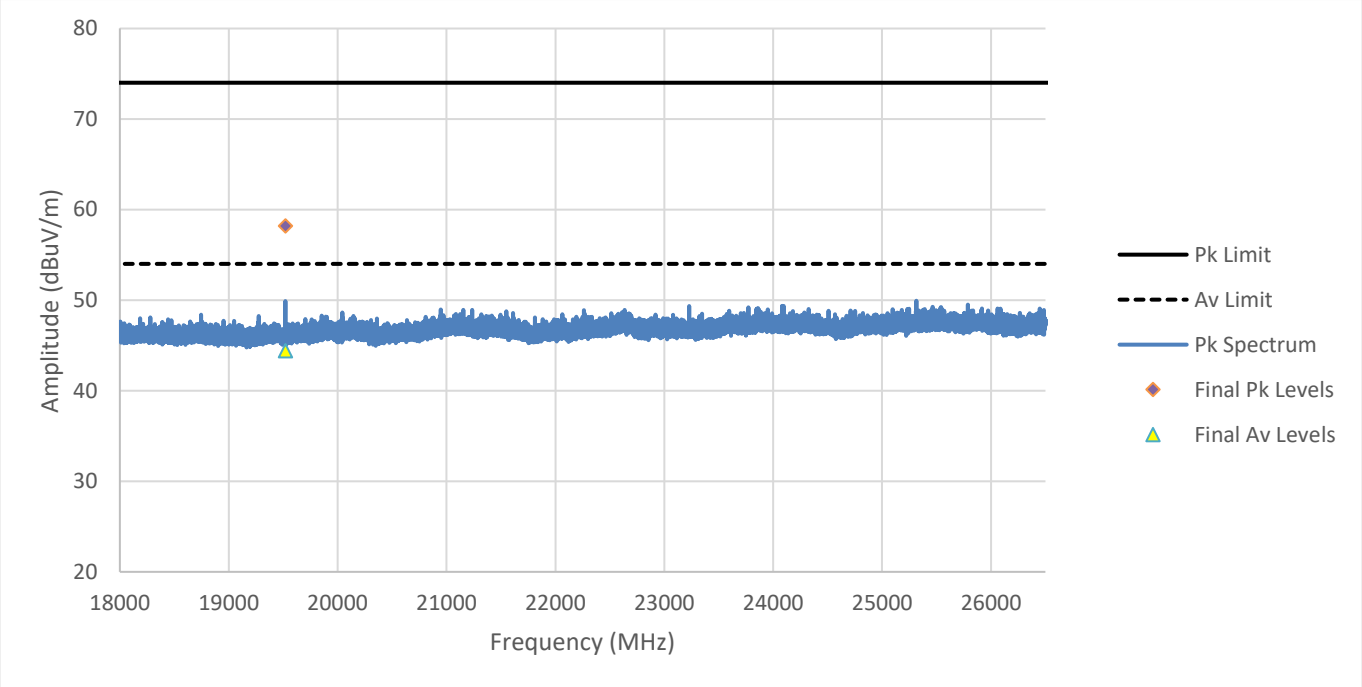

Figure RE20.1: Spectral data (18-26GHz)

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

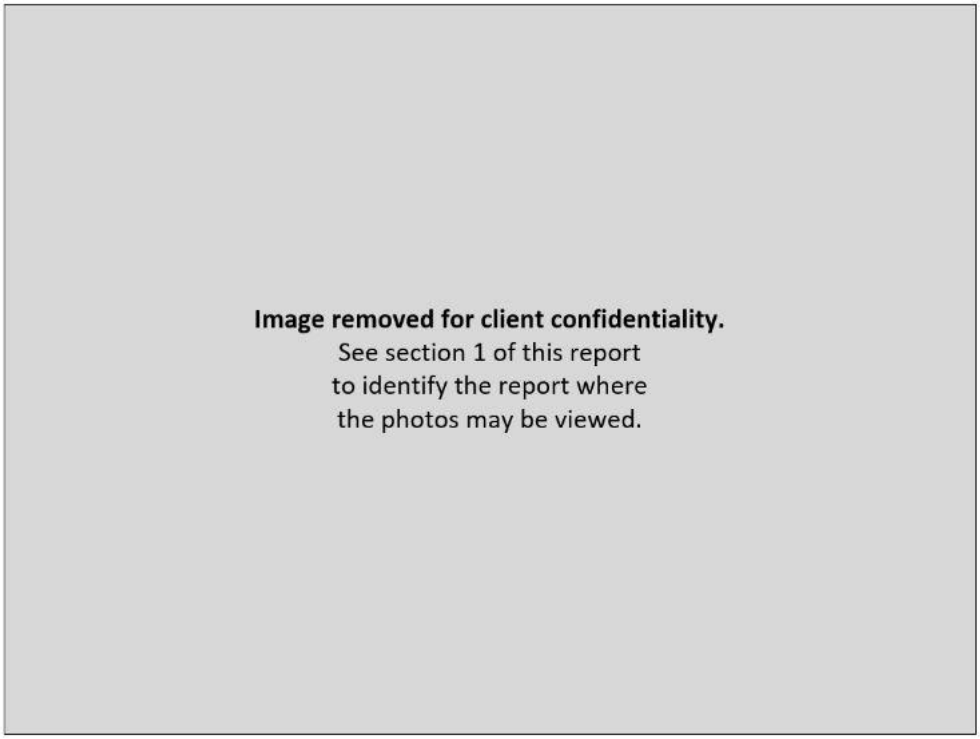

Figure RE20.2: EUT test setup, front view

Figure RE20.3: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Transmitter Bandwidth Tests
Test IDs TR09
Project GCL0388

Test Date(s)	2 Oct 2023
Test Personnel	David Arnett
Product Model	A04752
Serial Number tested	3449554852
Operating Mode	M6 (AntTx)
Arrangement	A4 (Dual)
Input Power	13.8 Vdc
Test Standards:	FCC Part 2.202, ANSI C63.10, TRC-43, RSS-GEN (as noted in Section 6 of the report).
Radio Protocol	ANT, including Bluetooth Basic Rate
Radio Band	2480 to 2483.5 MHz
Pass/Fail Judgment:	**Reported**
Test record created by:	**David Arnett**
Date of this record:	**5 Oct 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220146	3-Jun-2023	3-Jun-2024

Table TR09.1 Equipment Used

Test Software used: Keysight PXE System Code rev A.35.06

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

Test Setup

This block diagram shows the test equipment setup.

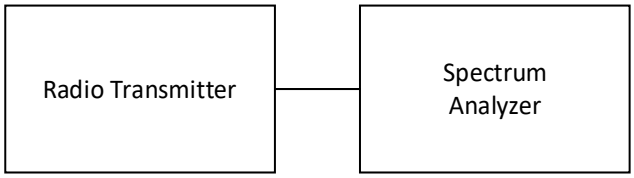

Figure TR09.1: Test setup

Occupied Bandwith, 99% Test Method
During this test the transmitter output is fed directly, or through RF attenuators, to the spectrum analyzer. The analyzer has a built-in capability to identify the minimum bandwidth that contains a specified percentage of the total power observed. The spectrum is scanned hundreds of times so that the varied effects of modulation are appropriately assessed. Since the focus is on the relative distribution of energy across a range of frequencies, the absolute amplitudes recorded during this test are not relevant and may not include cable losses or attenuation factors.

Occupied Bandwith, 99% Test Data

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

Frequency (MHz)	2402	2440	2480
BTBR and ANT	**0.856**	**0.856**	**0.855**

Table TR09.2: Summary of 99% Occupied Bandwidth Data for ANT/Bluetooth Basic Rate

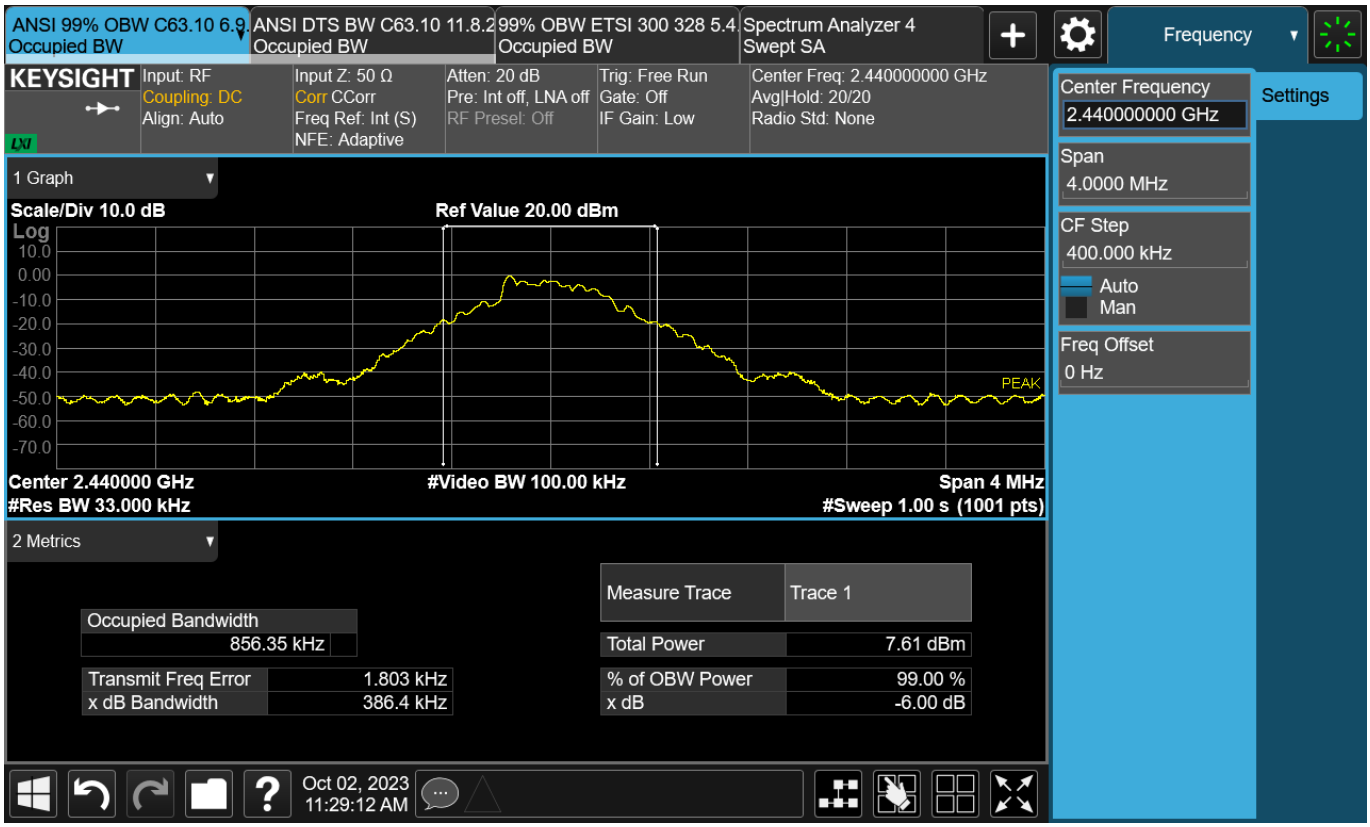

Figure TR09.1: Occupied bandwidth data for ANT at midband channel (2440 MHz)

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 TR09.100: Necessary Bandwidth for NFC

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

$B_N = 2R / Log_2(S)$

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

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

Table TR09.101: 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 TR09.102: 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 TR09.103: Necessary Bandwidth for IEEE 802.11 b Radio Protocol (FCC and TRC-43)

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

Table TR09.104: 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 TR09.105: Necessary Bandwidth for IEEE 802.11 n and ac 40 MHz Radio Protocols (FCC)

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

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

$$B_N = N_S * K$$

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

Table TR09.106: 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 Stability in Extreme Conditions
Test IDs TR24
Project GCL-0388

Test Date(s)	16 and 17 Oct 2023
Test Personnel	Majid Farah
Product Model	A04752
Serial Number tested	3449554828
Operating Mode	M3 (BtcTx)
Arrangement	A4 (Dual)
Nominal Input Power	12 Vdc
Test Standards:	FCC part 15, RSS-GEN, ANSI C63.10 (as noted in Section 6 of the report)
Radio Protocol	Bluetooth (BR, EDR2, EDR3), BLE (Bluetooth Low Energy)
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date this record:	**18 Oct 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Thermometer	Thermco	ACCD370P	220608121	26-Aug-2022	1-Sep-2024
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
DMM Multimeter	FLUKE	79 III	71740743	5-Apr-2023	1-Apr-2024
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	15-Apr-2024
Thermal Chamber	Tenney	T2RC	31244	Calibration	Not Required

Table TR24.1: Equipment used

Software Used: PXE Software Revision A.33.03, FrequencyStabilityAnalysistemplateV1.xlsx

Test Method

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

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

Test Data

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

Tx Mode	Temp	Volts	Low Ch.	High Ch.
Bluetooth	˚C	Vdc	dBc	dBc
BT EDR2	55.0	12.0	18.0	26.0
BT EDR2	50.0	12.0	27.6	28.2
BT EDR2	40.0	12.0	27.5	28.0
BT EDR2	30.0	12.0	31.0	28.4
BT EDR2	20.0	12.0	18.6	52.5
BT EDR2	10.0	12.0	18.9	22.8
BT EDR2	0.0	12.0	14.8	22.4
BT EDR2	-10.0	12.0	14.5	21.7
BT EDR2	-20.0	12.0	14.0	22.1

Table TR24.2 Difference between peak and band edge levels for Bluetooth EDR2 transmissions during temperature variations

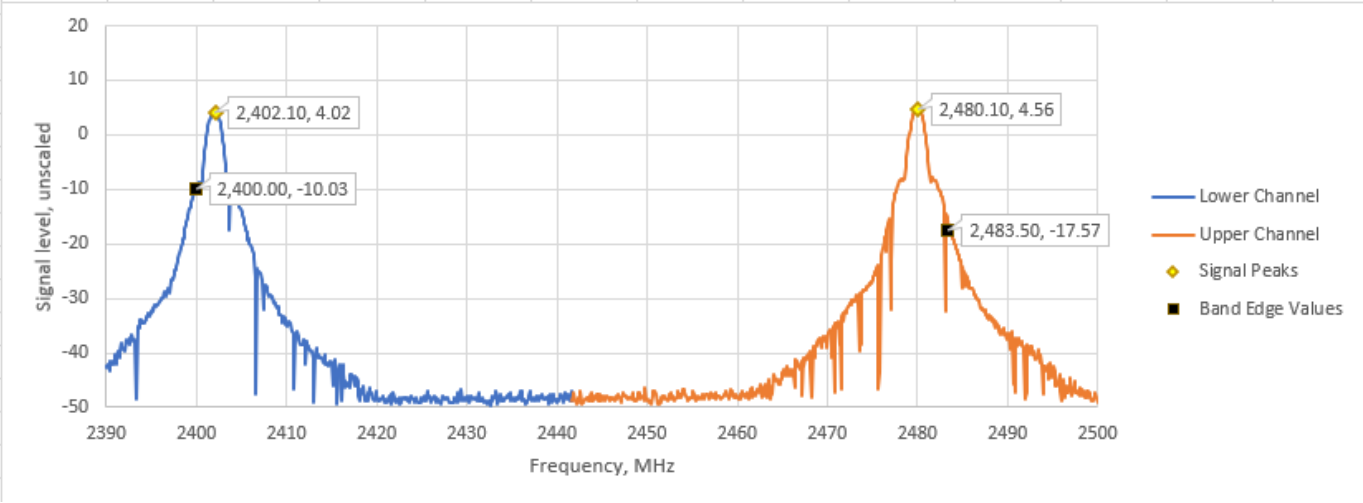

Figure TR24.1: Spectral data for Bluetooth EDR2 at -20 °C which represent low and high channel

Tx Mode	Temp	Volts	Low Ch.	High Ch.
Bluetooth	˚C	Vdc	dBc	dBc
BT EDR2	20	10.2	15.6	23.5
BT EDR2	20	12	18.6	52.5
BT EDR2	20	13.8	15.6	23.2

Table TR24.3 Difference between peak and band edge levels for Bluetooth EDR2 transmissions at 20 °C during voltage variations

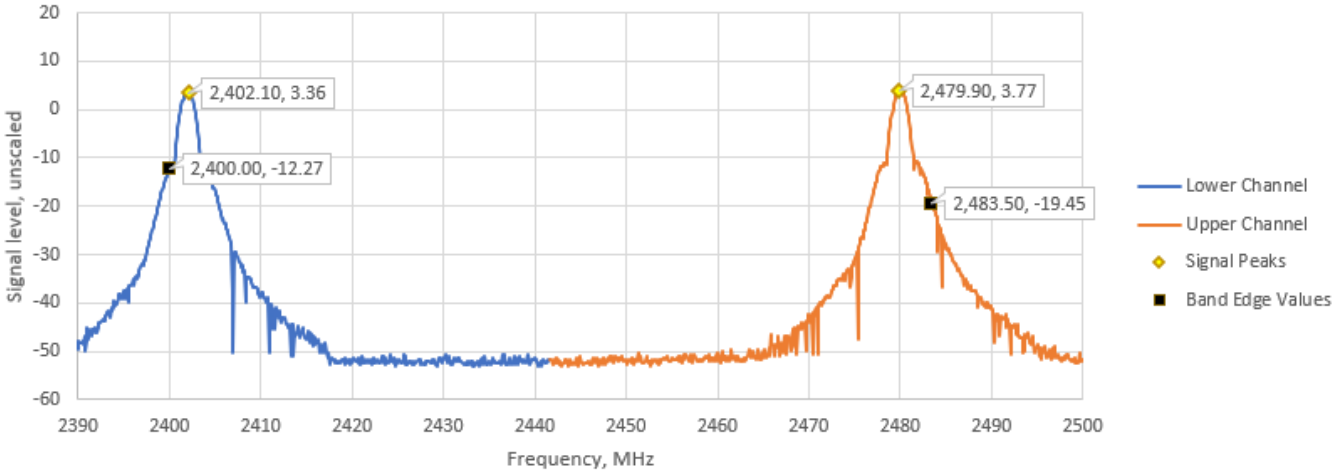

Figure TR24.2: Spectral data for Bluetooth EDR2 at 20 °C and 13.8 Vdc which represent low and high channel

Setup Block Diagram

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

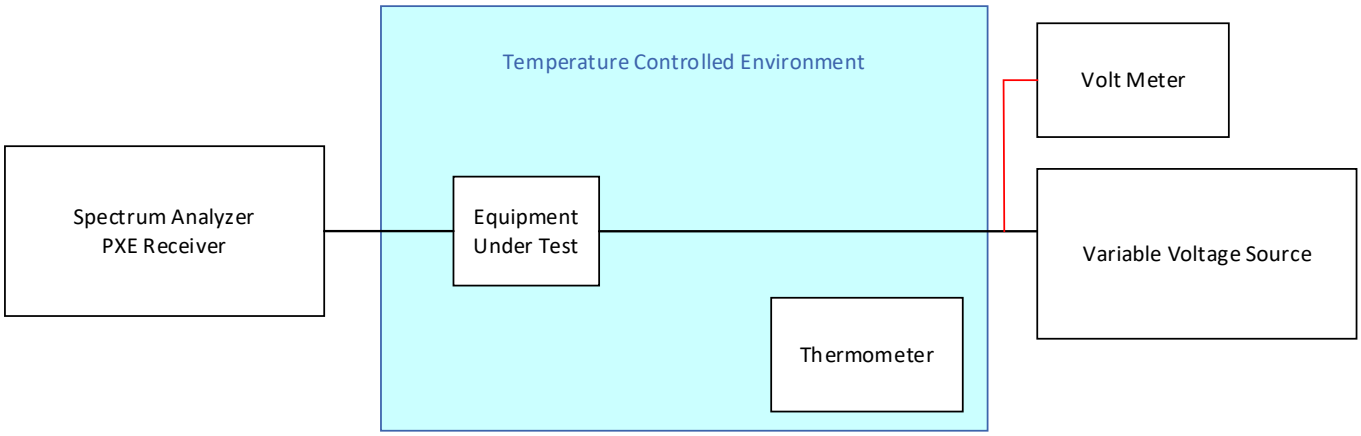

Figure TR24.3: Schematic drawing of the test equipment setup

This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE02
Project GCL0388

Test Date(s)	06 Oct 2023
Test Personnel	David Kerr
Product Model	A04752
Serial Number tested	3449554812
Operating Mode	M1 (BtcTx)
Arrangement	A2 (USB)
Input Power	115 V/ 60 Hz
Test Standards:	FCC Part 15, RSS GEN (as noted in Section 6 of the report).
Frequency Range:	150 kHz to 30 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Aditya Prakash**
Date of this record:	**8 Dec 2023**

Original record, Version A, issued 10 Oct 2023. Version B on 8 Dec 2023 corrects the list of standards.

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-23	1-Feb-24
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	30-Aug-23	1-Sep-26
DMM Multimeter	FLUKE	79 III	71740743	5-Apr-23	1-Apr-24
LISN multiline; 20A 50uH	Com-Power	LIN-120C	20160005	10-Feb-23	15-Feb-24

Table CE02.1: Test Equipment Used

Software Used
Keysight PXE software A.33.03; CE Mains 150k to 30M Data Analysis V2 2021Jun10.xlsx

Test Data

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

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

Frequency (kHz)	QP Limit (dBuV)	AV Limit (dBuV)	L1 QP (dBuV)	L2 QP (dBuV)	L1 AV (dBuV)	L2 AV (dBuV)	QP Margin (dB)	AV Margin (dB)
620	56	46	44.07	39.46	37.01	31.37	11.93	8.99
674	56	46	44.42	40.35	37.19	31.48	11.58	8.81
728	56	46	37.87	32.73	31.09	26.38	18.13	14.91
1241	56	46	41.06	34.29	32.46	28.23	14.94	13.54
1295	56	46	44.07	36.26	32.73	28.37	11.93	13.27
1347	56	46	41.22	34.49	32.04	27.85	14.78	13.96

Table CE02.2: Emission summary

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

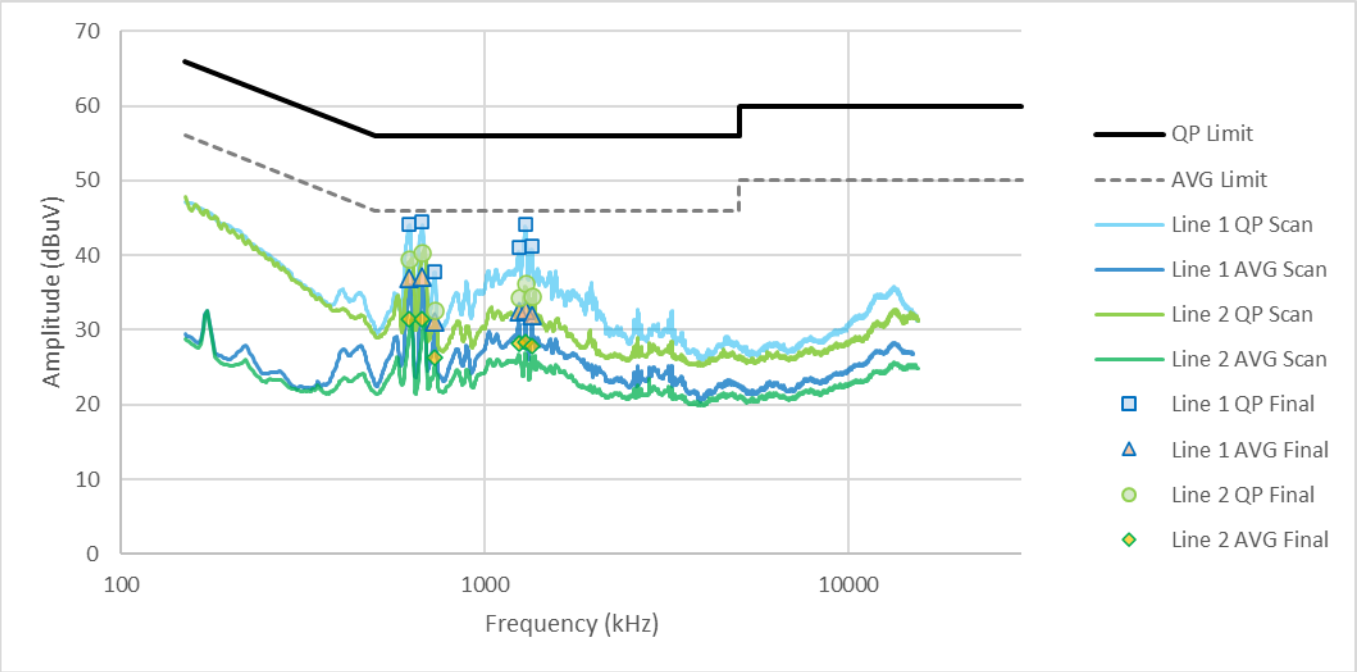

Figure CE02.1: Spectral data

Setup Photographs

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

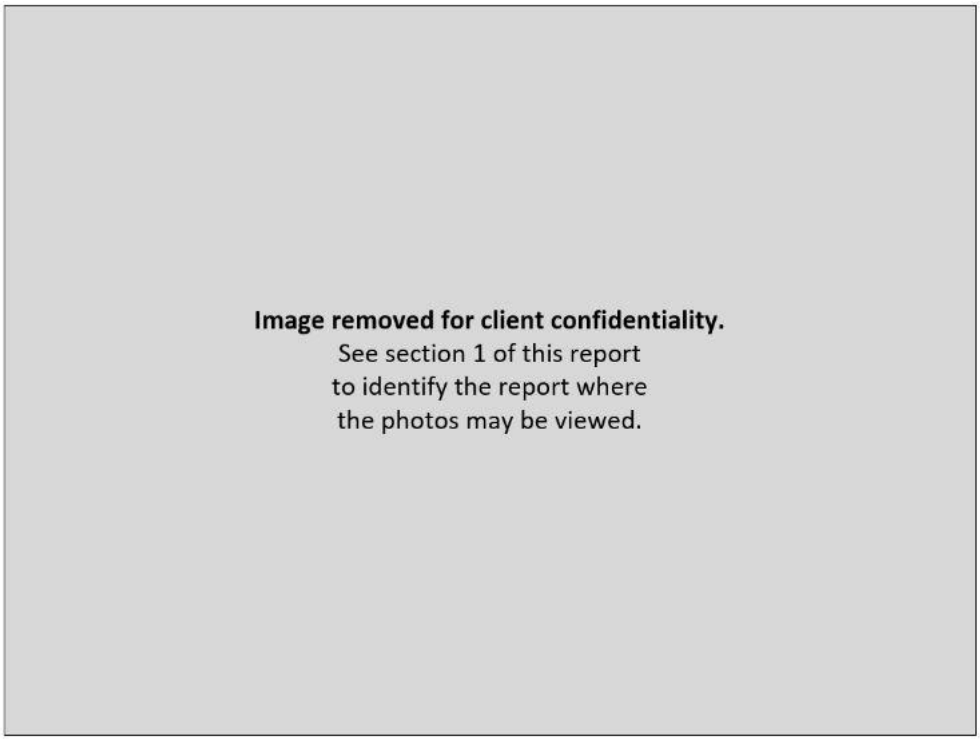

Figure CE02.2: Test setup, front view

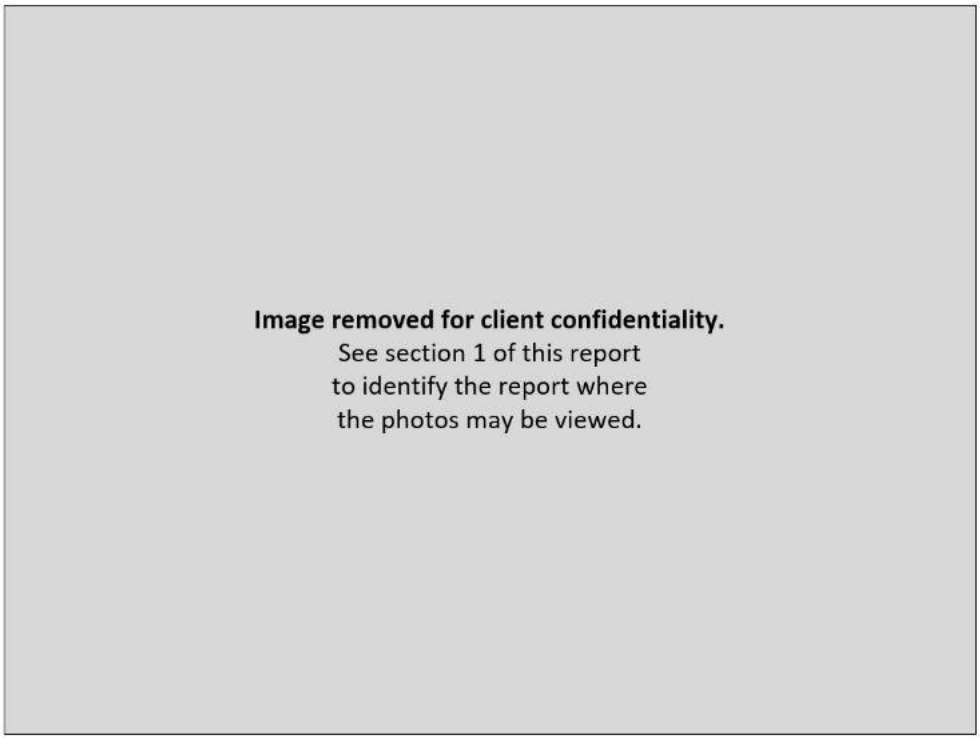

Figure CE02.3: Test setup, side view

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.