GARMIN
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1200 East 151st Street
Olathe, Kansas 66062
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02-Feb-26

Manufacturer: Garmin International, Inc.
Address: 1200 E. 151st St.
Olathe, KS 66062-3426
U.S.A.
Chile Representative: Matías Rodríguez Correa
Rosario Norte 660 piso 24, Las Condes Santiago
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Subject: SUBTEL, Chile (Resolution 737) Certification Compliance 2026

Commercial Name: Forerunner 165 Music

	Información (Information)
Tipo de equipo (Equipment type)	Portable Digital Transceiver
Marca (Brand)	Garmin GARMIN
Modelo (Model)	AA4714
Tecnología o modulación (Technology or modulation)	ASK for NFC / GFSK for ANT/ GFSK for BLE / GFSK for BTBR / π/4-DQPSK, 8DPSK for BTEDR / DSSS for 802.11b / OFDM for 802.11g/n
Frecuencias (Frequencies)	13.56 MHz / 2402-2480 MHz / 2402-2480 MHz / 2402-2480 MHz / 2402-2480 MHz / 2412-2462 MHz
Ganancia de antena (dBi) (Antenna gain (dBi)	ANT –0.30 dBi / BLE –0.30 dBi / 802.15.1 -0.30 dBi / 802.15.1 -0.30 dBi / 802.11b/g/n -0.30 dBi
P.i.r.e. (E.I R P.)	-29.2 dBm, 0.0012 mW /3.43 dBm, 2.20mW / 3.66 dBm, 2.32 mW / 9.19 dBm, 8.29 mW / 8.90 dBm, 7.76 mW /15.98 dBm, 39.62 mW
Módulos (Modules)	NFC, ANT, BLE, BTBR, BTEDR, WiFi

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 2023-070

Version A
Issued 8 Nov 2023

Project GCL-0457
Model Identifier: AA4714
Primary Test Standard(s)
FCC Part 15.225
RSS-210 Issue 10 Amd 1

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

Client-supplied Information

FCC ID: IPH-A4714
IC ID: 1792A-A4714

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 13.56 MHz Near Field Communication (NFC) Transceiver(s). 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]	22.8 dB of margin to the intentional emission limit.	PASS	11
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]	3.0 dB of margin to the Class B limit.	PASS	14
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	18
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	21
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	24

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

<u>Report Organization</u>

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 2023-056. 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 Sep 2023
Test Start Date: 07 Sep 2023
Test End Date: 19 Oct 2023

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

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

3. Report History and Approval

This report was written by Majid Farah and initially issued on 8 Nov 2023 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	AA4714
Serial Numbers Tested	3453413873, 3453413922

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:	IEEE 802.11(b/g/n), Bluetooth, Bluetooth Low Energy, ANT, NFC
Radio Receivers:	GPS L1, Galileo E1, BeiDou, GLONASS
Primary Functions:	Data collection and communication
Typical use:	Portable in multiple orientations
Highest internal frequency:	2.484 GHz
Firmware Revision	3.05

5.3 Operating modes

During test, the EUT was operated in one or more of the following modes. Some modes may not applicable for this product or in this report.

Mode 1: M1 (Bt Tx). Bluetooth, sometimes called Bluetooth Classic, radio is transmitting consistently on a selected channel sending data using the BR (Basic Rate of 1 Mbps), EDR2 (Extended Data Rate of 2 Mbps) or EDR3 (Extended Data Rate of 3 Mbps) modulation types.

Mode 2: M2 (Bt lnk). Bluetooth Classic 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 3: M3 (Ble Tx). Bluetooth Low Energy radio transmitting consistently on a selected channel at 1 Mbps or 2 Mbps

Mode 4: M4 (Ble lnk). 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 (ANT Tx). ANT radio transmitting consistently on a selected channel.

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

Mode 7: M7 (WiFi Tx). The IEEE 802.11 b/g/n radio was transmitting consistently on a selected channel, with a specified modulation type, and data rate.

Mode 8: M8 (WiFi Link). The IEEE 802.11 b/g/n radio is paired to a companion device, transmitting and receiving data on a selected channel in accordance with the protocol, and maintaining the paired relationship.

Mode 9: M9 (Rx 2.4). The radio was set to receive 2.4 GHz signals but not transmit. In this situation, it was specifically looking for Bluetooth Low Energy signals which cover the 2.4 GHz band and represent a worst-case scenario.

Mode 10: M10 (All2.4). This means the radio was tested in modes M1, M3, M5, and M7 if applicable.

Mode 11: M11 (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 12: M12 (NFC lnk). The NFC 13.56 MHz transceiver is in Card Emulation mode, and is actively linked to a companion NFC Reader.

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.

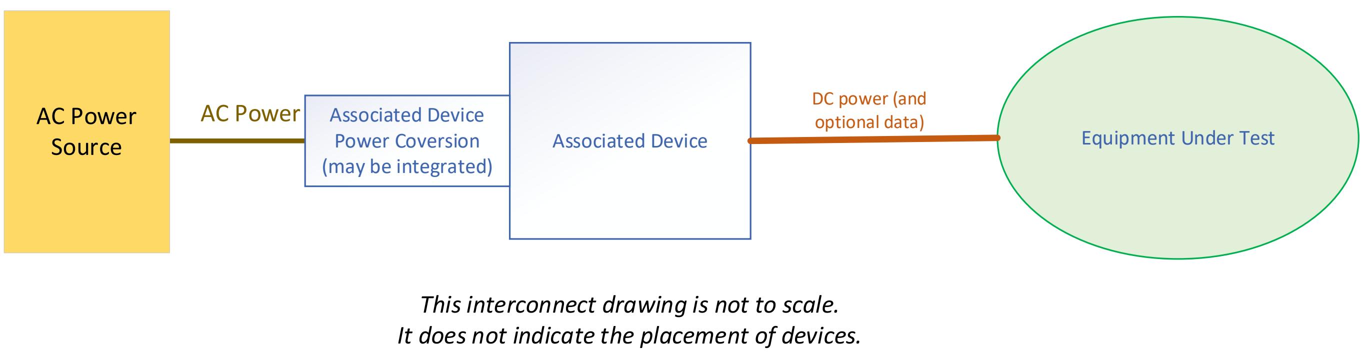


Figure 1: Block diagram of equipment for arrangements A2, A3, A4

Arrangement 5: A5 (NFCp) The test sample is placed near an NFC Card Reader. The NFC Card Reader is connected to a laptop computer. The test sample is powered by a device that does not include data over the cable, just as with A2. For clarity, test sample is NOT powered by, or connected to, the laptop computer that powers the NFC Card Reader.

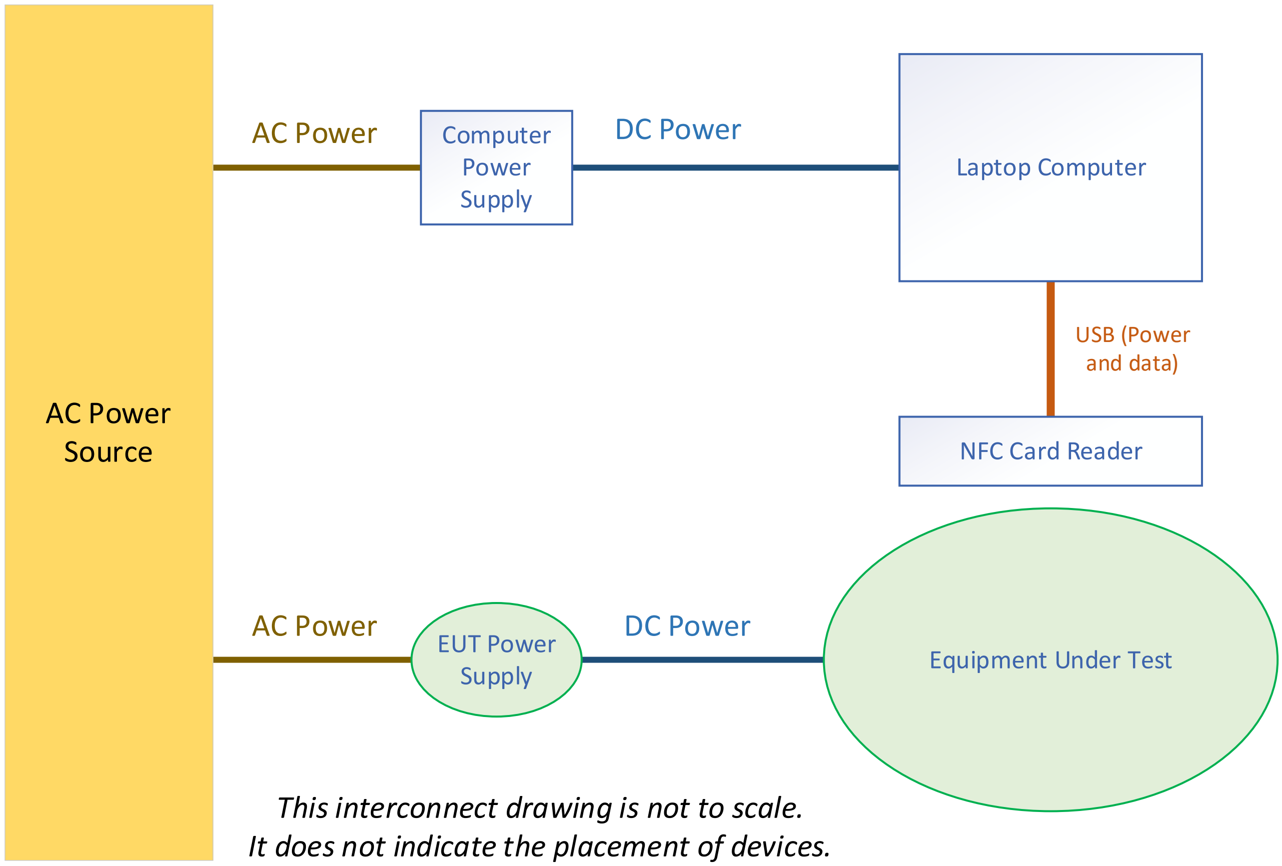


Figure 2: Block diagram of equipment arrangement A5

Arrangement 6: A6 (NFCu) The test sample is placed near an NFC Card Reader. The NFC Card Reader is connected to a laptop computer. The test sample is powered by its own batteries rather than an external power source. The test sample is NOT powered by, or connected to, the laptop computer that powers the NFC Card Reader.

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
NFC reader	ACS	ACR1252	RR554-086776
AC/DC Power Converter	Phihong technology	PSAF10R-050Q	None
Laptop Computer	Dell	Latitude 5410	5VSPFB3
Laptop Power Supply	Dell	HA65NM191	None

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

5.6 Cables used

Description	From	To	Length	EMC Treatment
USB	Power and/or Data source	EUT	54 cm	None

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

6 Test Standards Applied

6.1. Accredited Standards

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

AS/NZS 4268: 2017
CFR 47, FCC Part 15.225
ANSI C63.10: 2013 and ANSI C63.10: 2020
RSS-GEN Issue 5 Amd 2
RSS-210 Issue 10 Amd 1

6.2. Non-accredited Standards

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

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	None	None
		0.01% of value		
		0.5 x LSDPV		

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

8 Selected Example Calculations

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

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

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

8.1 AC Mains conducted emissions at 22 MHz

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

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

8.2 Radiated Emissions at 630 MHz

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

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

8.3 Radiated Emissions at 2.7 GHz

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

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

9 Environmental Conditions During Test

Environmental conditions in the test lab were monitored during the test period. Temperature and humidity are controlled by an air handling system. As information to the reader, the conditions were observed 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 23.6 °C
Relative Humidity:	34.3% to 55.7% (non-condensing)
Barometric Pressure	96.3 to 99.2 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

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 RE14
Project GCL0457

Test Date(s) 17 Oct 2023
Test Personnel Dave Kerr

Product Model AA4714
Serial Number tested 3453413922

Operating Mode M12 (NFC lnk)
Arrangement A6 (NFCu)
Input Power 5 Vdc

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: Jim Solum
Date of this record: 26 Oct 2023

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	27-Sep-2023	1-Oct-2024
Loop antenna, amplified	Schwarzbeck	FMZB 1519B	00174	12-Jun-2023	15-Jun-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

Table RE14.1: Test Equipment Used

Software Used

PXE Firmware version A.32.06
RE 150k to 30M Signal Maximization Tool V1 2021Mar17.xlsx
RE 150k to 30M XYZ_orientations_TemplateV6.xlsm
RE NFC 150k to 30M Data Analysis Template V21 2023Jun19.xlsx

Test Data

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

At azimuth angle 0° the 'front' reference mark of the turntable is pointed Southward. At 90° the reference mark points West. At -90° it points East. The designation of the X, Y, and Z antenna polarizations are reported by use of photographs.

The table shows the selected final measurement data between 10MHz 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 is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. The dbuA/m limits and measured dBuA/m values in the chart below are obtained from the dBuV/m limits and measured dBuV/m measured values. The two values differ by 51.52 dB based on the 377 Ohm characteristic impedance of free space. A positive margin value indicates that the emission was below the test limit. The test limits are for FCC Part 15 & RSS-210.

Frequency (MHz)	Limit (dBuV/m)	Limit (dBuA/m)	Measured (dBuV/m)	Measured (dBuA/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Orientation
12.712	49.5	-2.0	26.7	-24.8	22.8	-10	1500	X
13.560	104.0	52.5	66.0	14.5	38.0	-4	1500	X
13.772	60.5	9.0	37.4	-14.1	23.1	-8	1500	X
13.983	60.5	9.0	28.0	-23.5	32.5	0	1500	X
14.408	49.5	-2.0	26.4	-25.1	23.1	5	1500	X
27.121	49.5	-2.0	21.5	-30.0	28.0	-37	1500	X

Table RE14.2: Emission summary (FCC / Canada)

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

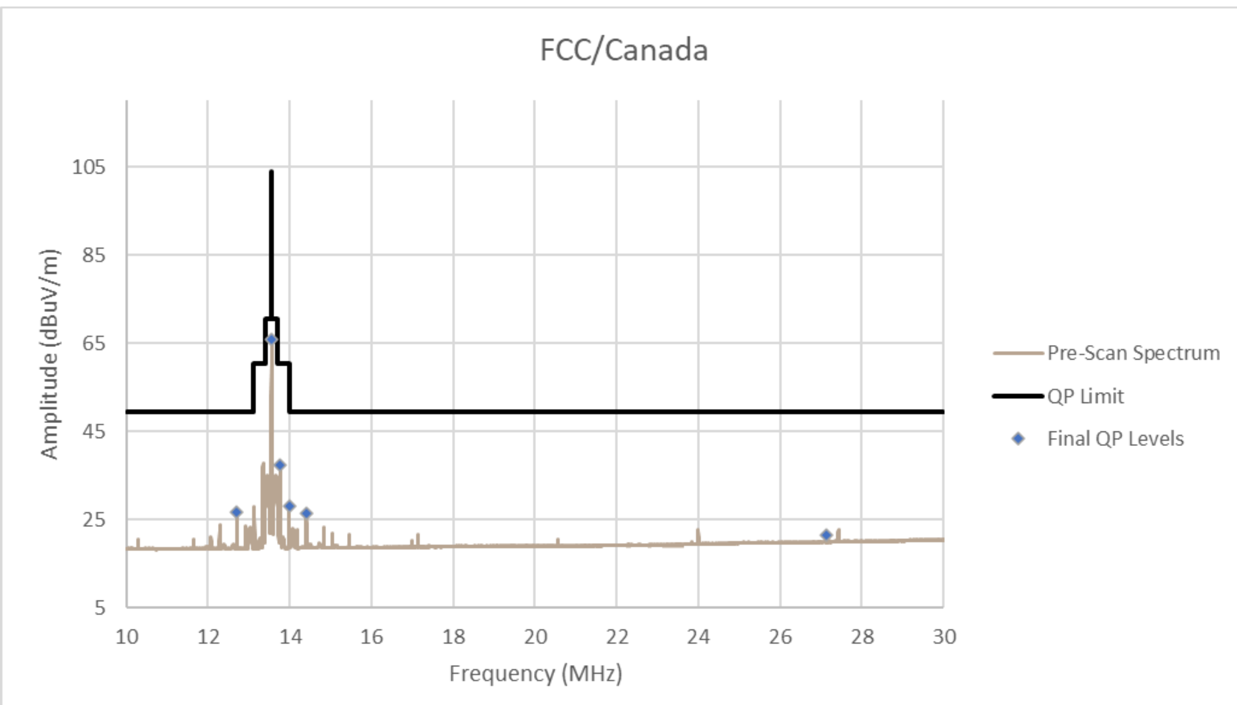


Figure RE14.1: Spectral data (FCC/Canada)

Setup Photographs

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

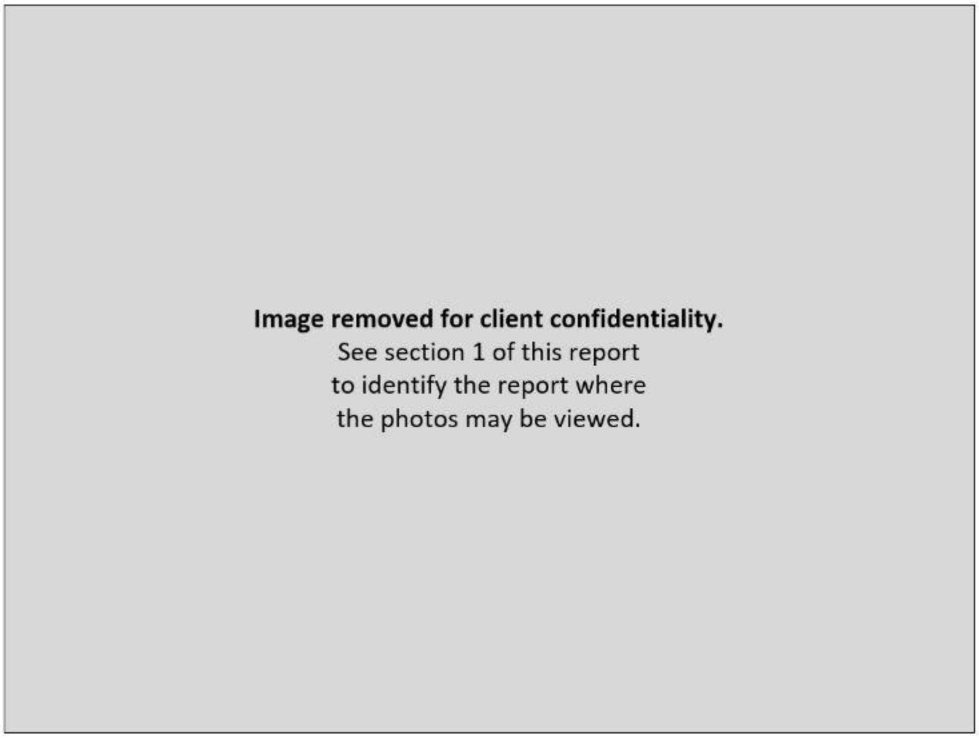


Figure RE14.2: EUT test setup, front view (Antenna X Orientation)

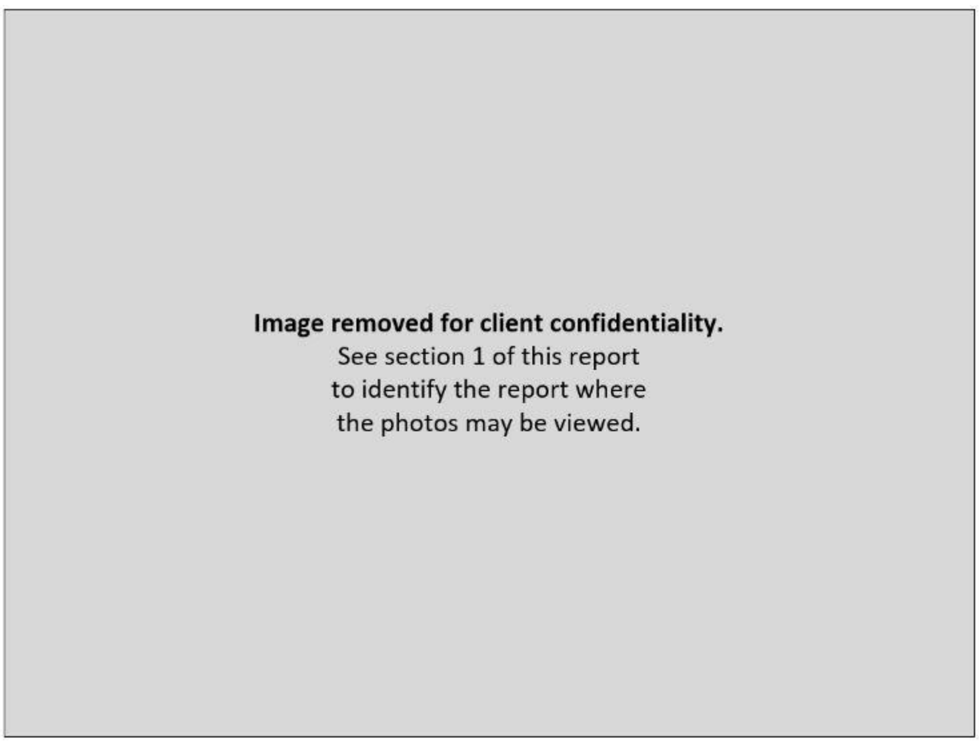


Figure RE14.3: EUT test setup, reverse view (Antenna X Orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE15
Project GCL0457

Test Date(s) 19 Oct 2023
Test Personnel David Kerr

Product Model AA4714
Serial Number tested 3453413922

Operating Mode M12 (NFC lnk)
Arrangement A6 (NFCu)
Input Power 5 Vdc (USB)

Test Standards: FCC Part 15, 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: David A Kerr
Date of this record: 19 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	00233201	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

RE15.1: Test Equipment Used

Software Used:
N9048B Keysight PXE firmware version 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 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.

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		
48.000	V	22.5	14.5	37.0	40.0	3.0	100.0	122.0
37.710	V	17.0	18.5	35.5	40.0	4.5	112.2	80.0
44.580	V	19.8	15.4	35.2	40.0	4.8	100.0	88.0
41.130	V	18.2	16.8	35.0	40.0	5.0	100.0	74.0
51.210	V	20.0	14.0	34.0	40.0	6.0	100.0	112.0
65.130	V	15.1	14.5	29.6	40.0	10.4	108.4	0.0
30.870	V	10.4	22.3	32.7	40.0	7.3	100.0	21.0
149.160	H	22.5	17.4	39.9	43.5	3.6	227.3	36.0
119.970	H	15.4	15.7	31.1	43.5	12.4	261.9	11.0

Table RE15.2: Emission summary

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

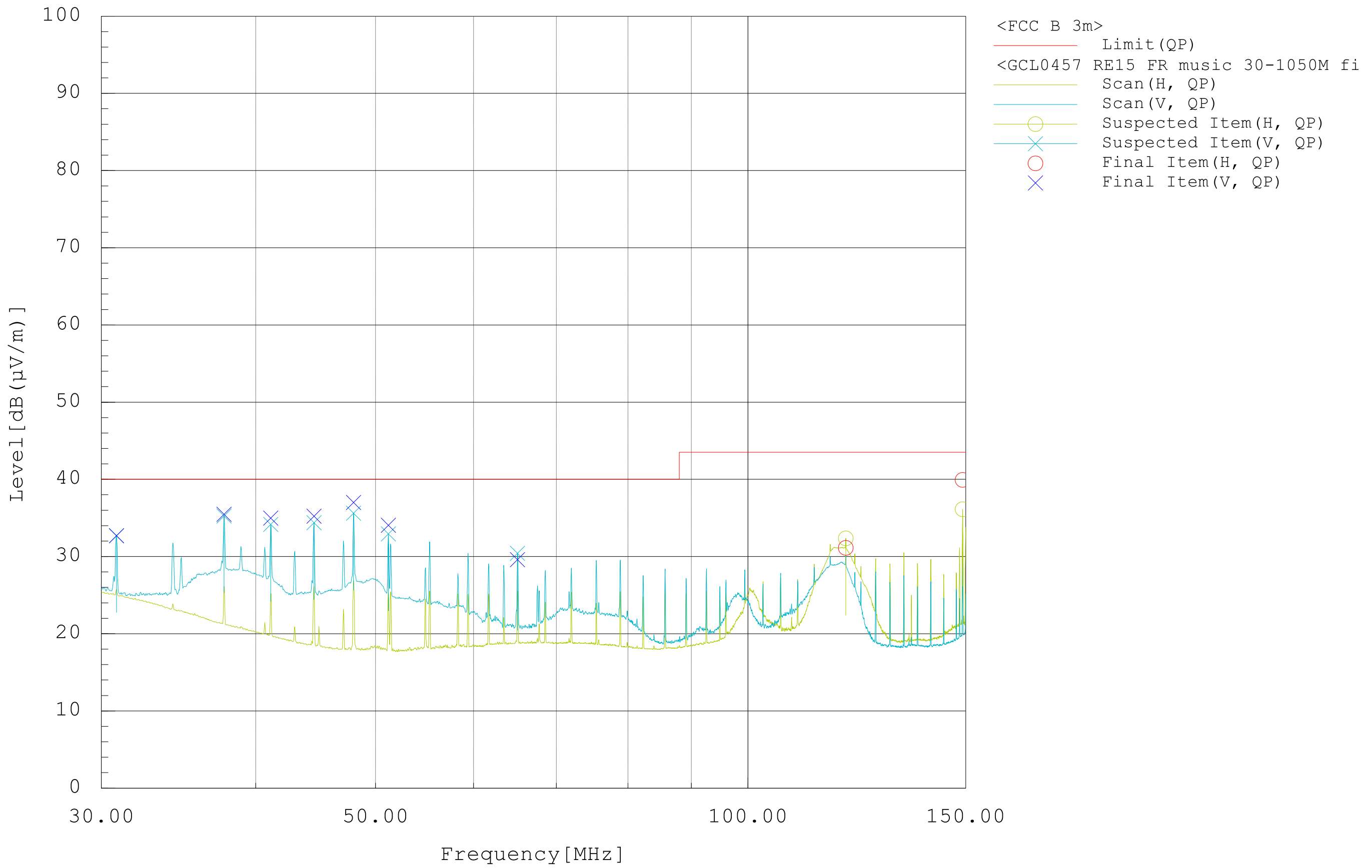


Figure RE15.1: Spectral data

Setup Photographs

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

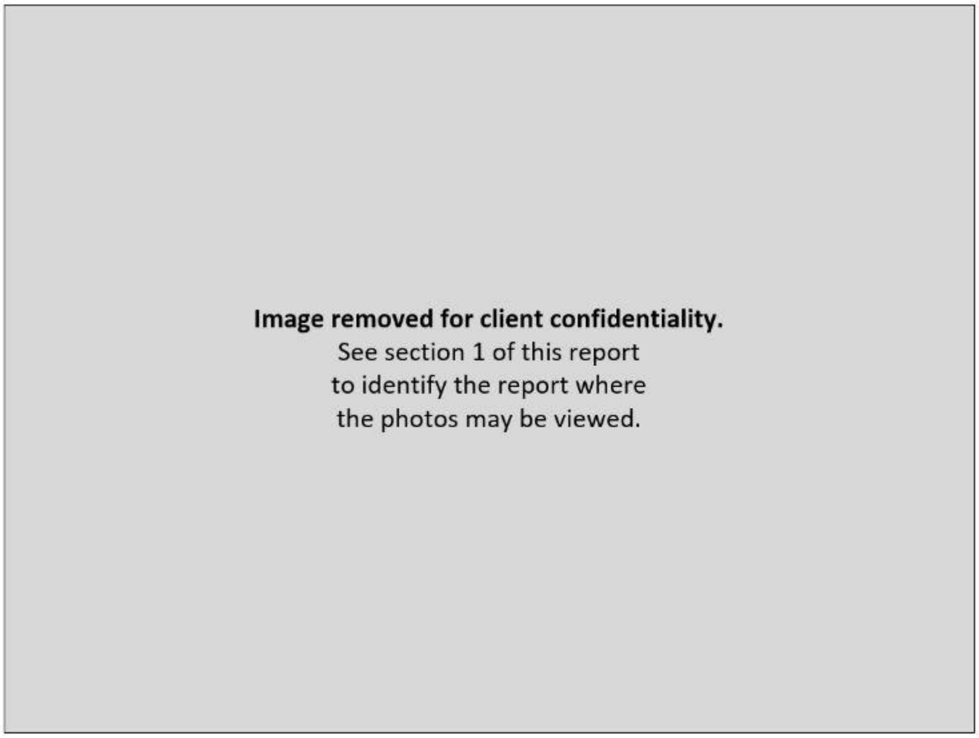


Figure RE15.2: EUT test setup, front view (X orientation)

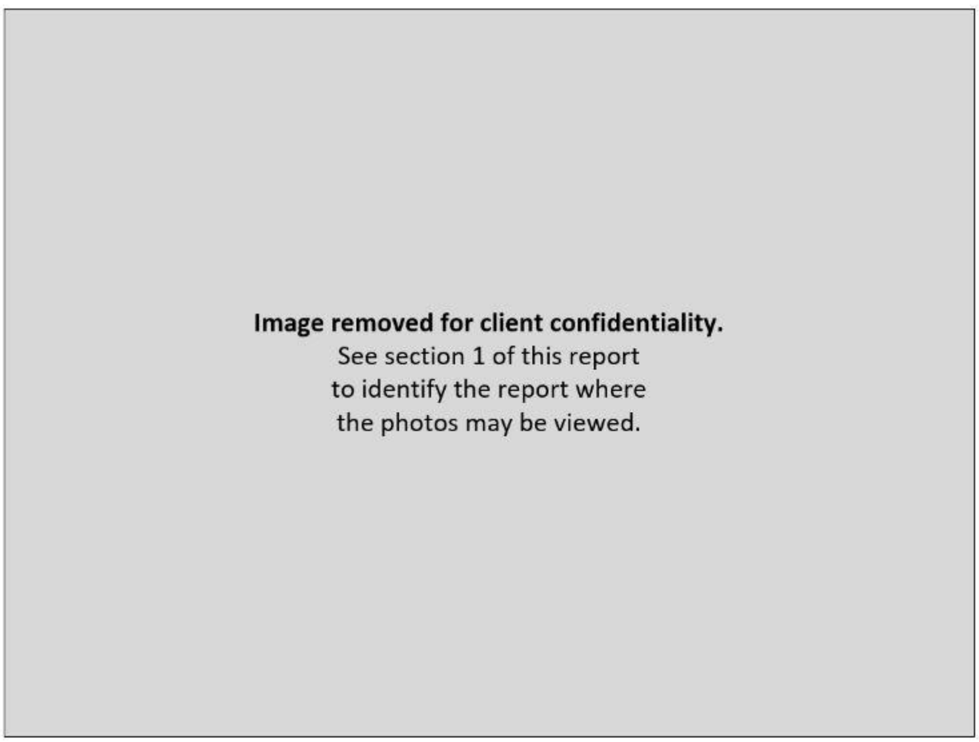


Figure RE15.3: EUT test setup, reverse view (X orientation)

This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE02
Project GCL0457

Test Date(s) 09 Oct 2023
Test Personnel David Kerr

Product Model AA4714
Serial Number tested 3453413873

Operating Mode M12 (NFC lnk)
Arrangement A5 (NFCp)
Input Power 115 V/ 60 Hz

Test Standards: FCC Part 15 (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: 10 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-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)
629	56.00	46.00	36.65	32.80	32.12	26.88	19.35	13.88
661	56.00	46.00	40.92	37.72	36.93	31.28	15.08	9.07
692	56.00	46.00	39.82	37.41	36.01	30.92	16.18	9.99
3428	56.00	46.00	43.61	42.46	40.74	39.05	12.39	5.26
10286	60.00	50.00	45.74	46.24	42.52	40.36	13.76	7.48
13715	60.00	50.00	39.74	37.28	36.50	34.05	20.26	13.50

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. This spectrum contains the 13.560 MHz transmitter signal for the NFC transceiver which is not subject to the limits.

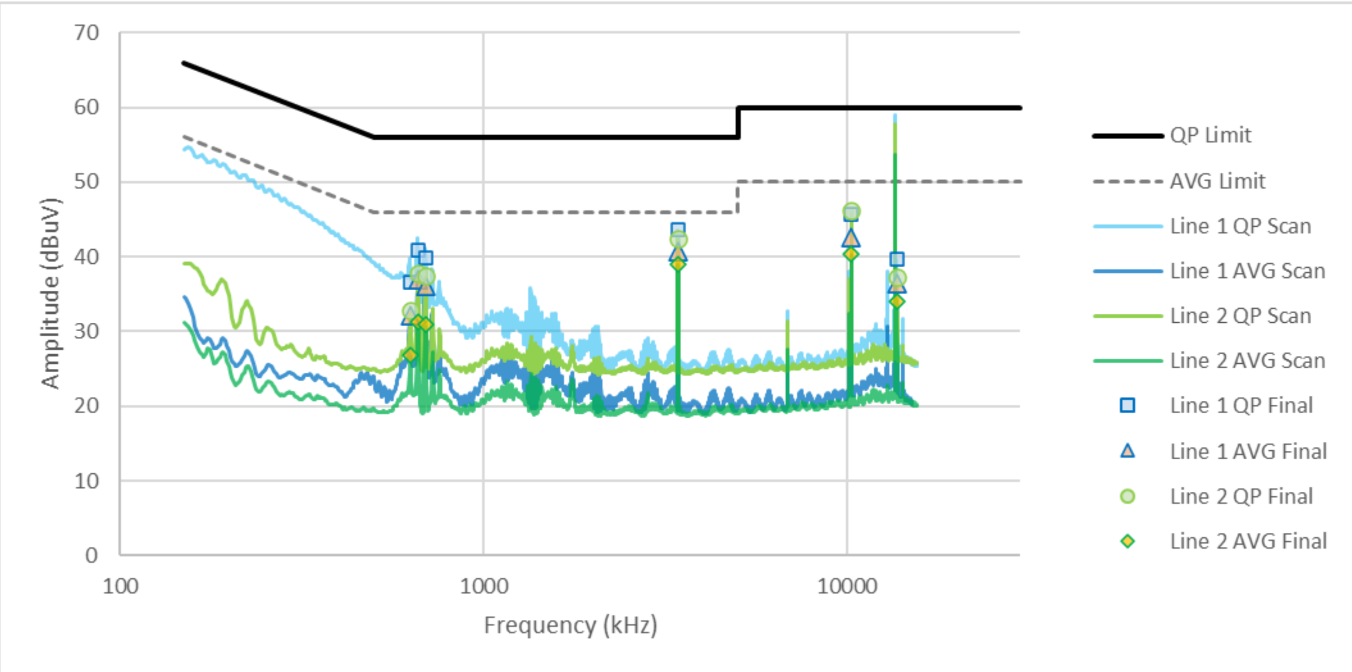


Figure CE02.1: Spectral data

Setup Photographs

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

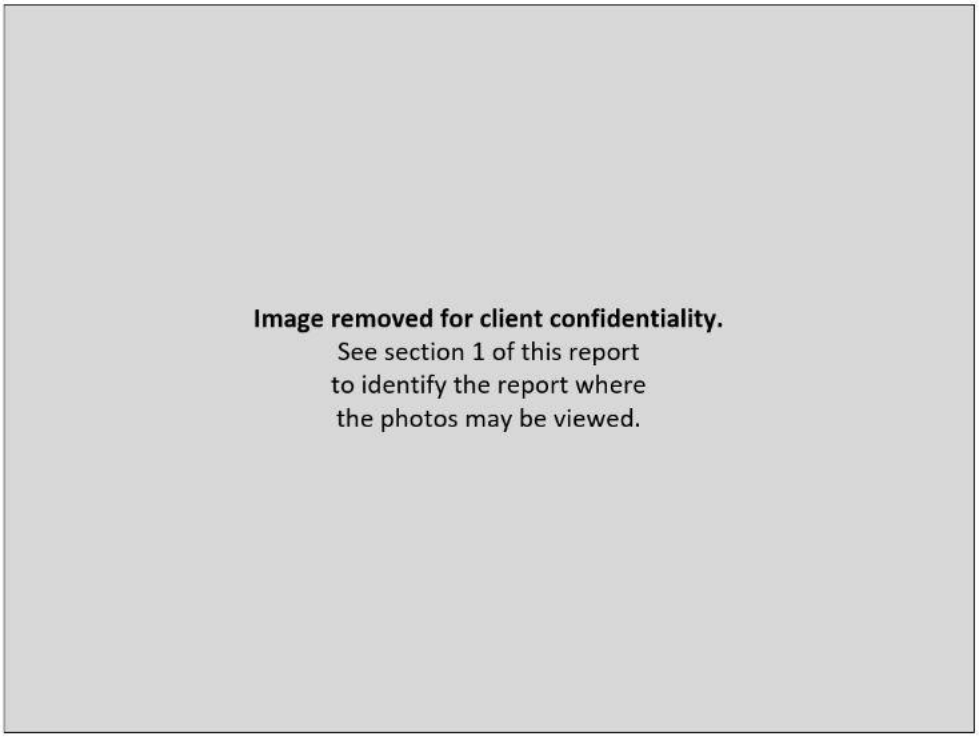


Figure CE02.2: Test setup, front view

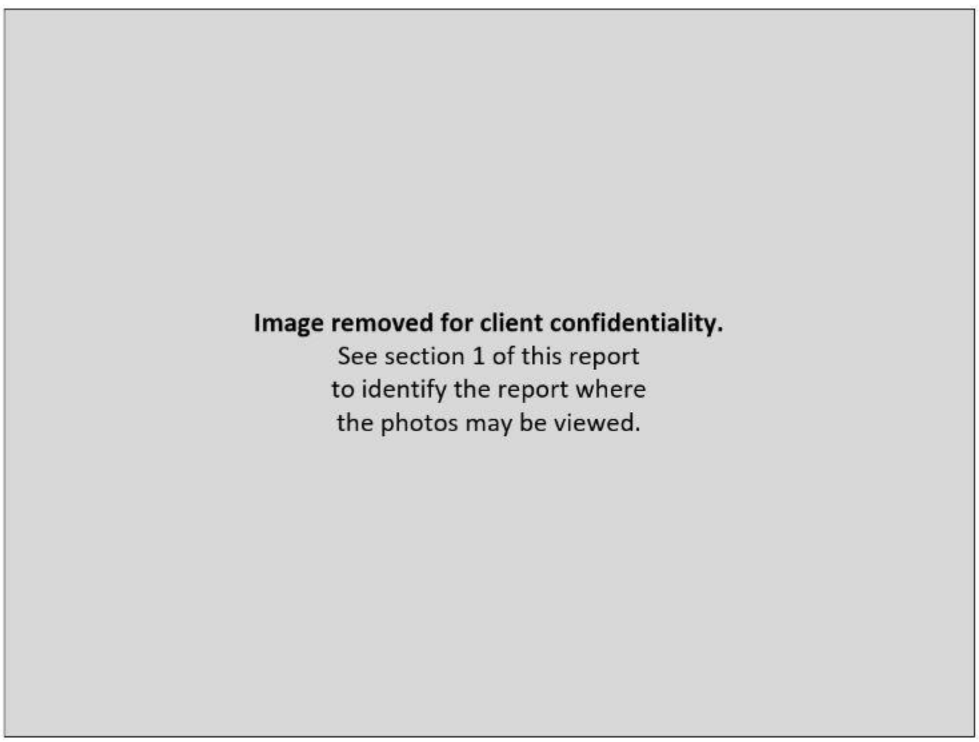


Figure CE02.3: Test setup, side view

This line is the end of the test record.

Test Record
Transmitter Stability in Extreme Conditions
Test IDs TR29
Project GCL-0457

Test Date(s)	15 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413873
Operating Mode	M12 (NFClnk)
Arrangement	A3 (Udata)
Nominal Input Power	5 Vdc
Test Standards:	FCC part 15, RSS-GEN, RSS-210, ANSI C63.10 (as noted in Section 6 of the report)
Radio Protocol	NFC
Pass/Fail Judgment:	**PASS with caveat**
Test record created by:	**Majid Farah**
Date this record:	**20 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
Near Field Probe Set	Com-Power	PS-400	151544	Calibration	Not Required

Table TR29.1: 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 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.

The modes utilized include those that showed emissions closest to the band edge during prior bandwidth testing.

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 13,559,942 Hz and the minimum was 13,559,801 Hz. The margin to high side of limit is 1414 Hz and margin for low side of the limit is 1157 Hz.

			NFC carrier frequency (Hz)			
Tx Mode	Temp	Volts	Time interval (minutes)			
	˚C	Vdc	0	2	5	10
NFC	50	5	13,559,801	13,559,801	13,559,801	13,559,801
NFC	40	5	13,559,815	13,559,815	13,559,815	13,559,814
NFC	30	5	13,559,841	13,559,842	13,559,842	13,559,842
NFC	20	5	13,559,864	13,559,866	13,559,869	13,559,873
NFC	20	4.25	13,559,877	N/A	N/A	N/A
NFC	20	5.75	13,559,877	N/A	N/A	N/A
NFC	10	5	13,559,913	13,559,912	13,559,912	13,559,912
NFC	0	5	13,559,932	13,559,933	13,559,933	13,559,934
NFC	-10	5	13,559,942	13,559,942	13,559,942	13,559,942
NFC	-20	5	13,559,936	13,559,932	13,559,931	13,559,930

Table TR29.2: Carrier frequency measurement for NFC transmission during temperature and voltage variations

Setup Block Diagram

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

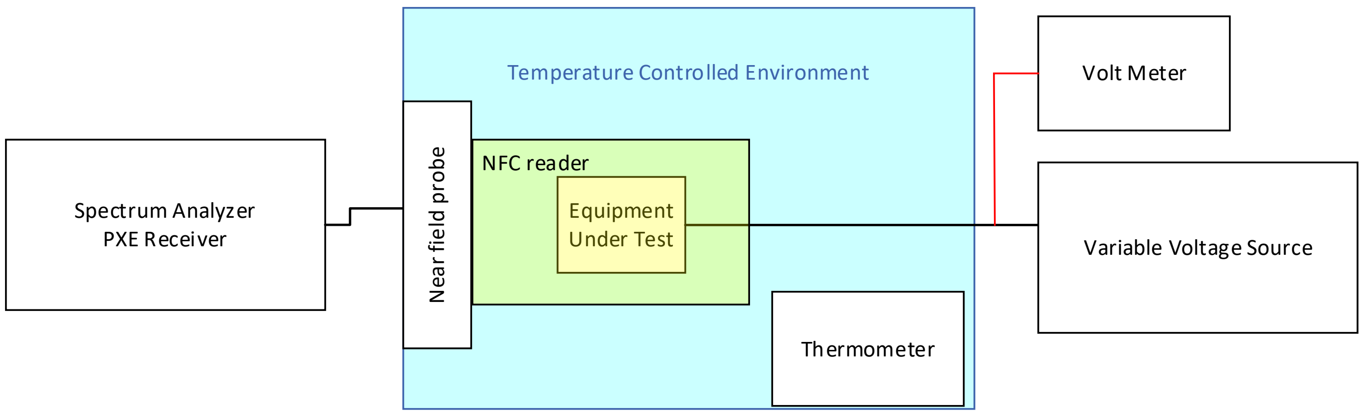


Figure TR29.1: Schematic drawing of the test equipment setup for NFC

This line is the end of the test record.

Test Record

Transmitter Bandwidth Tests
Test IDs TR30
Project GCL-0457

Test Date(s)	1 Nov 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413873
Test Standards:	ANSI C63.10, RSS-GEN (as noted in Section 6 of the report).
Radio Protocol	NFC
Radio Band	13.56 MHz
Pass/Fail Judgment:	**Reported**
Test record created by:	**Majid Farah**
Date of this record:	**1 Nov 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Near Field Probe Set	Com-Power	PS-400	151544	Calibration	Not Required

Table TR30.1: Equipment Used

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

Background
There are regulatory requirements to present an additional type of bandwidth analysis: 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.

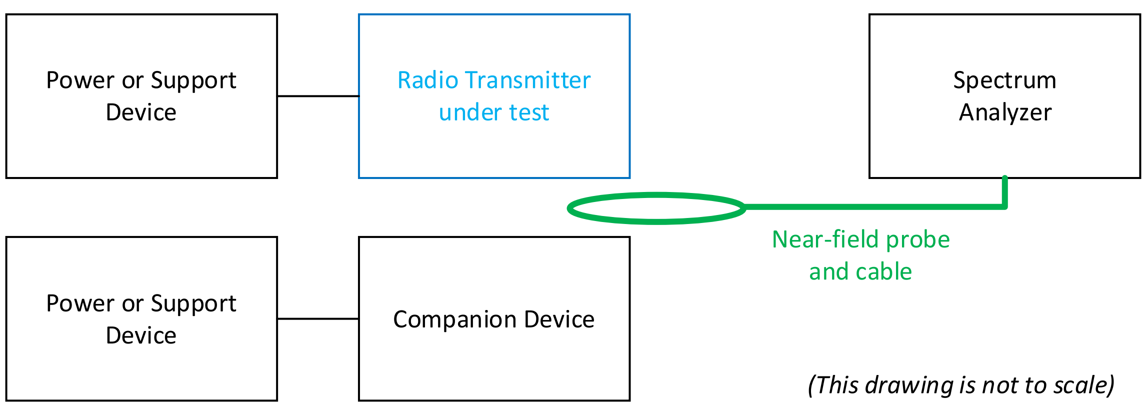


Figure TR30.1: Test setup

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 the 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 data transmission (A and B) is summarized below, followed by the spectral data for both types. 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	2.1443
Type B	1.7870

Table TR30.2: Summary of 99% Occupied Bandwidth Data for 13.56 MHz NFC modes

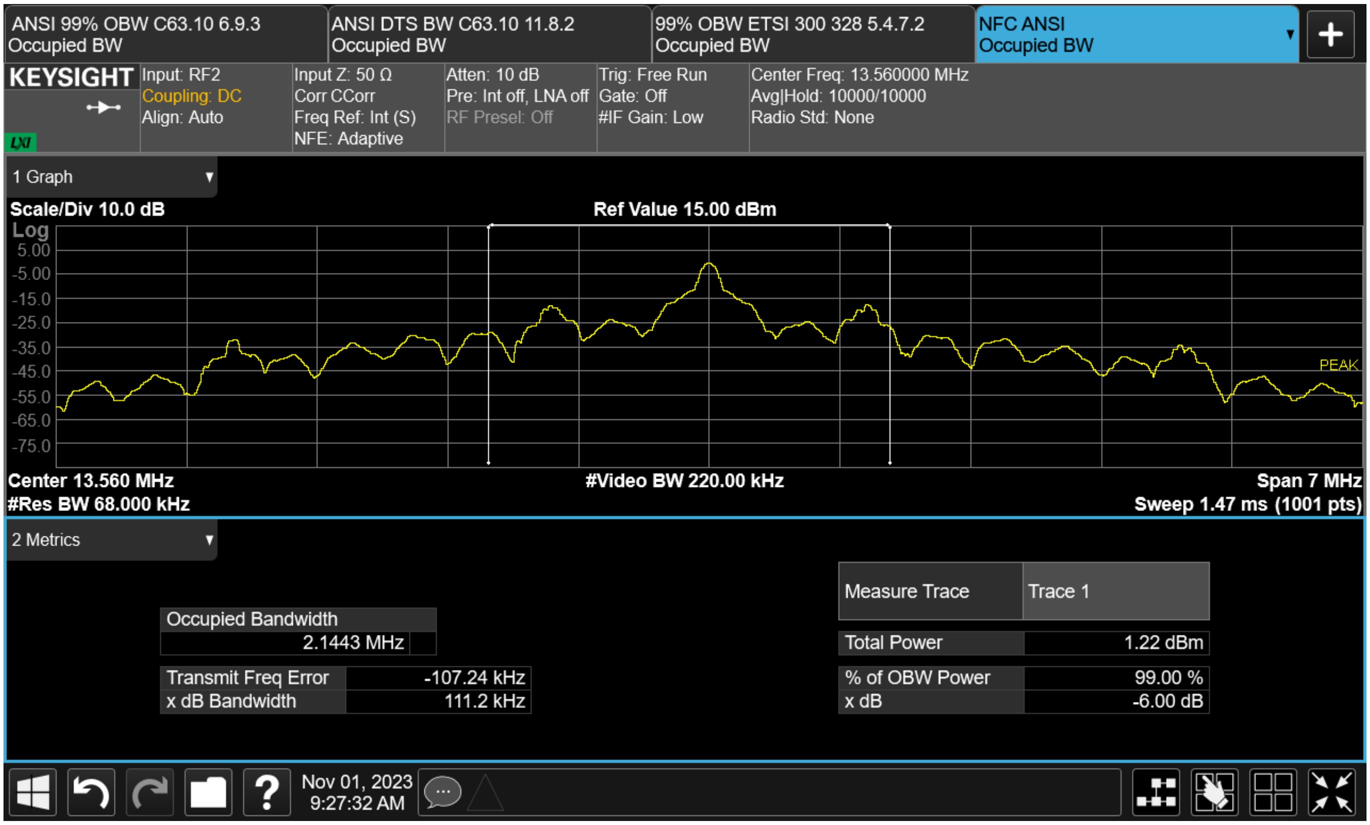


Figure TR30.2: Occupied bandwidth data for Type A transmissions

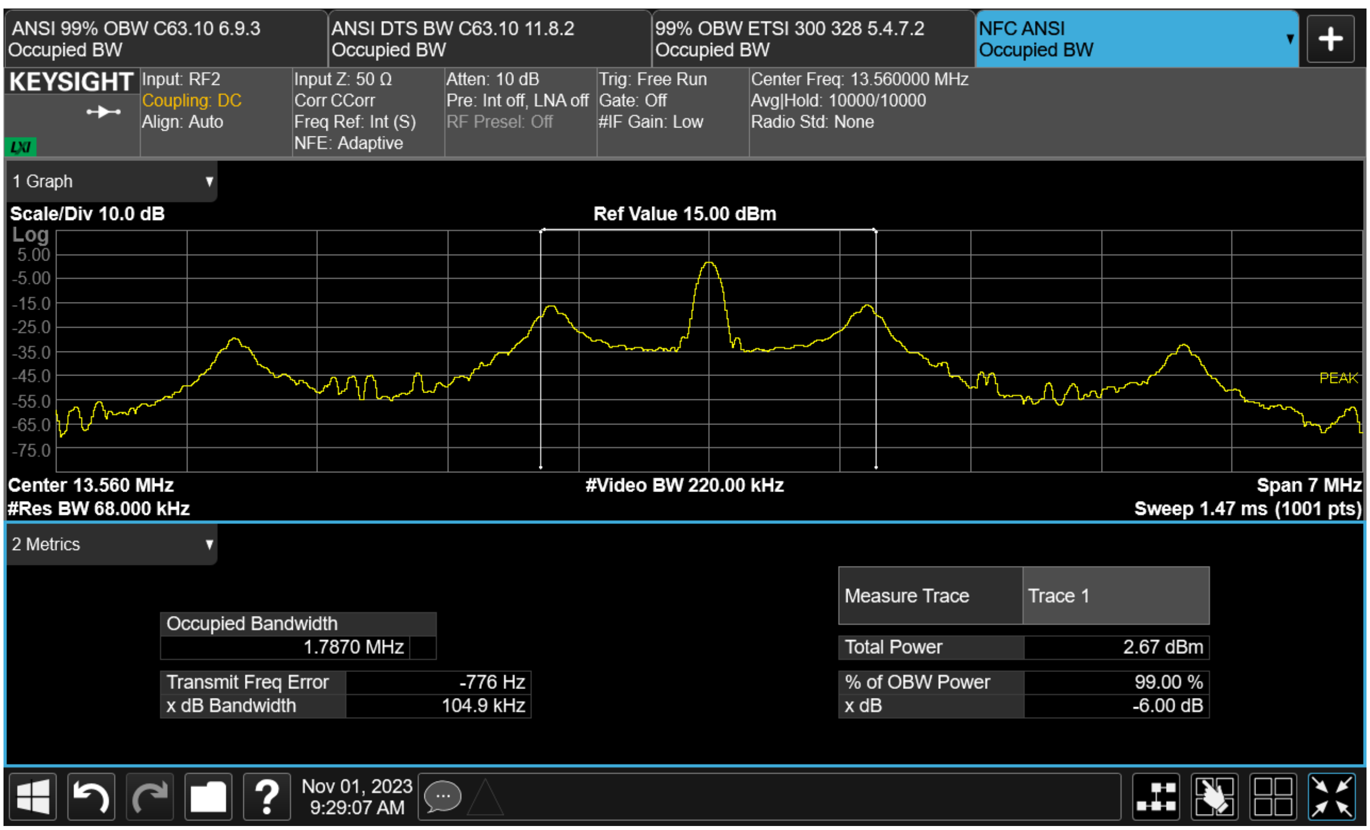


Figure TR30.3: Occupied bandwidth data for Type B transmissions

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 2023-069

Version A
Issued 8 Nov 2023

Project GCL-0457
Model Identifier: AA4714
Primary Test Standard(s)
CFR 47, FCC Part 15.247
RSS-247 Issue 2

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

Client-supplied Information

FCC ID: IPH-A4714
IC ID: 1792A-A4714

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 2.4 GHz transceiver(s). The Bluetooth radio is tested under the FHSS provisions. The WiFi, BLE, and ANT radios are treated as DTS devices. The results are as follows.

Parameter	Description	Key Performance Values	Result	Data starts at page
Hopping Channels	The radio manages it use of channels appropriately. [15.247(a)(1); RSS-247 at 5.1]	The Bluetooth radio described in this report met the Frequency Hopping rules of 15.247(a)(1).	PASS	12
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 of the DTS radios is 703.2 kHz or greater.	PASS	16
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 for all radios but have no actual performance requirements.	Reported	21
Transmit Power	The peak transmit power presented to the antenna is no greater that 1 Watt or 30 dBm. The effective radiated power is limited to 4 Watts or 36 dBm EIRP. [15.247(b); RSS-247 at 5.4(d)]	The maximum transmit power for all radios is 16.3 dBm or 42.7 mW.	PASS	28
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 -0.3 dBi for all radios and will document antenna gain separately.	NT	NT
Unwanted Emissions (Conducted Spurious)	The radio should not provide too much radio energy to the antenna at frequencies beyond its intended frequency band. [15.247(d); RSS-247 at 5.5]	Emissions outside the band must be reduced at least 20 dB from in-band levels. The measured reduction was at least 36.8 dB for all radios.	PASS	34
Restricted Bands	The radio must not emit in certain designated restricted frequency bands above a set of limit values. [15.247(d) and 15.205; RSS-247 at 3.3]	Emissions in the restricted bands were at least 7.8 dB below the applicable limits for all radios.	PASS	46
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 for any DTS radio was 2.61 dBm in a band of at least 3 kHz.	PASS	70

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]	The frequency hopping rules of 15.247(g) and (h) are not testable requirements.	NT	NT
Radio Safety	The radio emissions must meet public health & safety guidelines related to human exposure. [15.247(i) and 1.1307; RSS-Gen at 3.4]	NT. Client will report radio energy safety results separately.	NT	NT
Frequency Stability	The radio tuning must be robust over a range of temperature and supply voltage conditions. [RSS-Gen at 6.11]	Radio emissions for all radios remained within the allowed radio band under all environmental conditions tested.	PASS	76
Unintended Radiated Emissions	Radio emissions that this device may generate via its structures and connected cables that are not necessary for its operation and that may affect other radio communication	8.3 dB of margin for all radios. Appropriate for use in homes, offices, and industrial facilities. [Class B]	PASS	82
AC Mains Conducted Emissions	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.	6.5 dB of margin for all radios. Appropriate for use in homes, offices, and industrial facilities. [Class B]	PASS	98

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 2023-056. 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 Sep 2023
Test Start Date: 07 Sep 2023
Test End Date: 19 Oct 2023

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

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

3. Report History and Approval

This report was written by Majid Farah and initially issued on 8 Nov 2023 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	AA4714
Serial Numbers Tested	3453413911, 3453413922, 3453413873

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:	IEEE 802.11(b/g/n), Bluetooth, Bluetooth Low Energy, ANT, NFC
Radio Receivers:	GPS L1, Galileo E1, BeiDou, GLONASS
Primary Functions:	Data collection and communication
Typical use:	Portable in multiple orientations
Highest internal frequency:	2.484 GHz
Firmware Revision	3.05

5.3 Operating modes

During test, the EUT was operated in one or more of the following modes. Some modes may not applicable for this product or in this report.

Mode 1: M1 (Bt Tx). Bluetooth, sometimes called Bluetooth Classic, radio is transmitting consistently on a selected channel sending data using the BR (Basic Rate of 1 Mbps), EDR2 (Extended Data Rate of 2 Mbps) or EDR3 (Extended Data Rate of 3 Mbps) modulation types.

Mode 2: M2 (Bt lnk). Bluetooth Classic 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 3: M3 (Ble Tx). Bluetooth Low Energy radio transmitting consistently on a selected channel at 1 Mbps or 2 Mbps

Mode 4: M4 (Ble lnk). 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 (ANT Tx). ANT radio transmitting consistently on a selected channel.

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

Mode 7: M7 (WiFi Tx). The IEEE 802.11 b/g/n radio was transmitting consistently on a selected channel, with a specified modulation type, and data rate.

Mode 8: M8 (WiFi Link). The IEEE 802.11 b/g/n radio is paired to a companion device, transmitting and receiving data on a selected channel in accordance with the protocol, and maintaining the paired relationship.

Mode 9: M9 (Rx 2.4). The radio was set to receive 2.4 GHz signals but not transmit. In this situation, it was specifically looking for Bluetooth Low Energy signals which cover the 2.4 GHz band and represent a worst-case scenario.

Mode 10: M10 (All2.4). This means the radio was tested in modes M1, M3, M5, and M7 if applicable.

Mode 11: M11 (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 12: M12 (NFC lnk). The NFC 13.56 MHz transceiver is in Card Emulation mode, and is actively linked to a companion NFC Reader.

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.

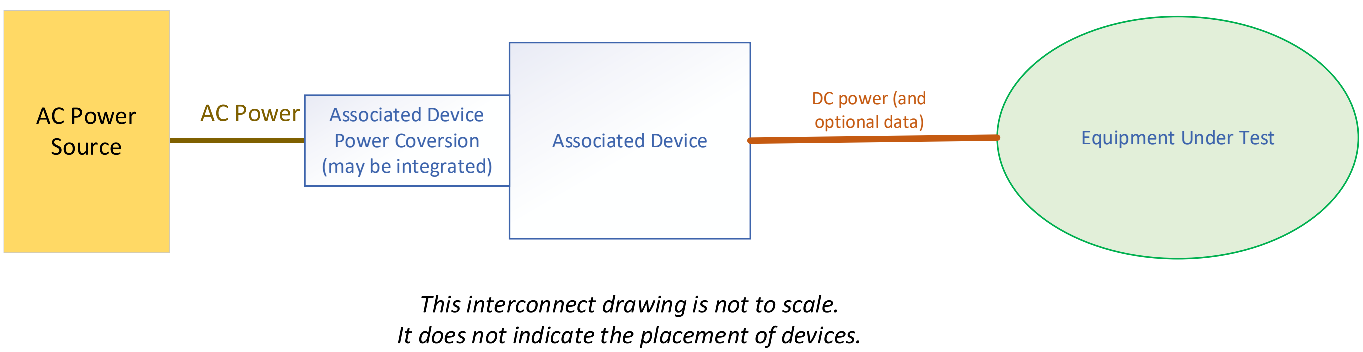


Figure 1: Block diagram of equipment for arrangements A2, A3, A4

Arrangement 5: A5 (NFCp) The test sample is placed near an NFC Card Reader. The NFC Card Reader is connected to a laptop computer. The test sample is powered by a device that does not include data over the cable, just as with A2. For clarity, test sample is NOT powered by, or connected to, the laptop computer that powers the NFC Card Reader.

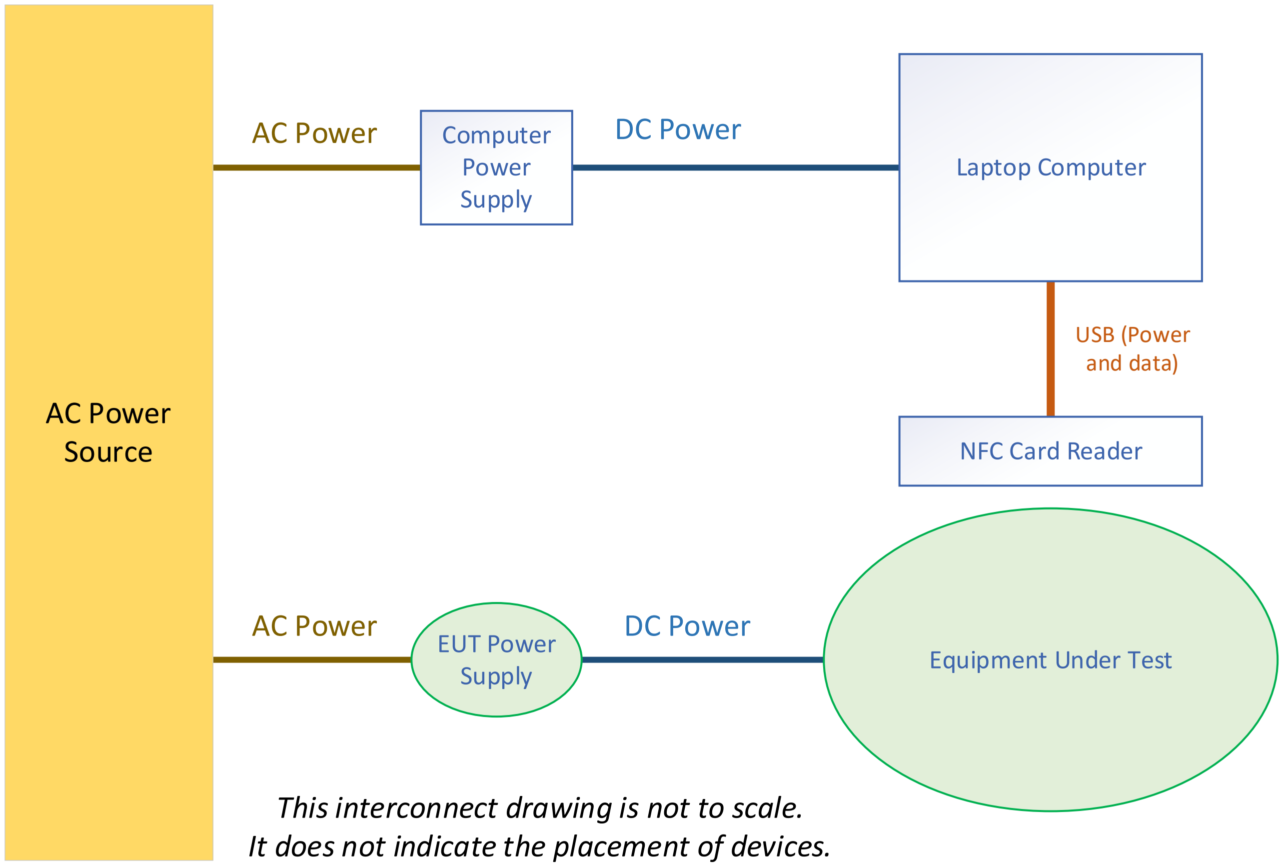


Figure 2: Block diagram of equipment arrangement A5

Arrangement 6: A6 (NFCu) The test sample is placed near an NFC Card Reader. The NFC Card Reader is connected to a laptop computer. The test sample is powered by its own batteries rather than an external power source.

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
AC/DC Power Converter	Phihong technology	PSAF10R-050Q	None
Laptop Computer	Dell	Latitude 5410	5VSPFB3
Laptop Power Supply	Dell	HA65NM191	None

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

5.6 Cables used

Description	From	To	Length	EMC Treatment
USB	Power and/or Data source	EUT	54 cm	None

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

6 Test Standards Applied

6.1. Accredited Standards

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

AS/NZS 4268: 2017
CFR 47, FCC Part 15.247
ANSI C63.10: 2013 and ANSI C63.10: 2020
RSS-GEN Issue 5 Amd 2
RSS-247 Issue 2

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	None	None
		0.01% of value		
		0.5 x LSDPV		

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

8 Selected Example Calculations

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

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

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

8.1 AC Mains conducted emissions at 22 MHz

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

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

8.2 Radiated Emissions at 630 MHz

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

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

8.3 Radiated Emissions at 2.7 GHz

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

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

9 Environmental Conditions During Test

Environmental conditions in the test lab were monitored during the test period. Temperature and humidity are controlled by an air handling system. As information to the reader, the conditions were observed 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 23.6 °C
Relative Humidity:	34.3% to 55.7% (non-condensing)
Barometric Pressure	96.3 to 99.2 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

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
FHSS ANSI Test TR31-33
Project GCL-0457

Test Date(s) 19 Oct 2023
Test Personnel Majid Farah

Product Model AA4714
Serial Number tested 3453413911

Operating Mode M1(BtTx)
Arrangement A3 (Udata)
Input Power 5V dc

RF Output Is not greater than 125 mW (21 dBm) conducted to the antenna

Test Standards: FCC Part 15.247, ANSI C63.10, AS/NZS 4268, RSS-GEN, RSS-247 (as noted in Section 6 of the report).

Pass/Fail Judgment: PASS

Test record created by: Majid Farah
Date of this test record: 19 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 TR31.1: Test equipment used

Test software used: Keysight PXE software 35.06, FHSS ANSI Occupancy Template v2.xlsx

Test Data

This test looks at details specific to frequency hopping systems in the referenced standards: the number of hopping channels; the relationship between 20 dB Occupied bandwidth and channel separation; and channel occupancy time.

This measurement requires that a coaxial feed line from the transmitter is available as a connector exterior to the test sample. This feed line and connector may be a part of the shipping product, or it may be a special modification to the product for testing purposes. The connector is attached via laboratory cables to the measurement instrument. Since the absolute signal amplitude is not relevant to these tests, the results may not have been adjusted to account for the losses in the laboratory cables.

Test Data: Hopping Channels

The test sample was placed in a test mode where it transmits on its various frequency channels while hopping. The spectrum analyzer scanned a frequency range that included these frequencies in Max Hold condition. The resulting spectra are attached, showing that the sample uses each of the 79 hopping frequencies from 2402 MHz to 2480 MHz, also confirming a channel separation of 1 MHz.

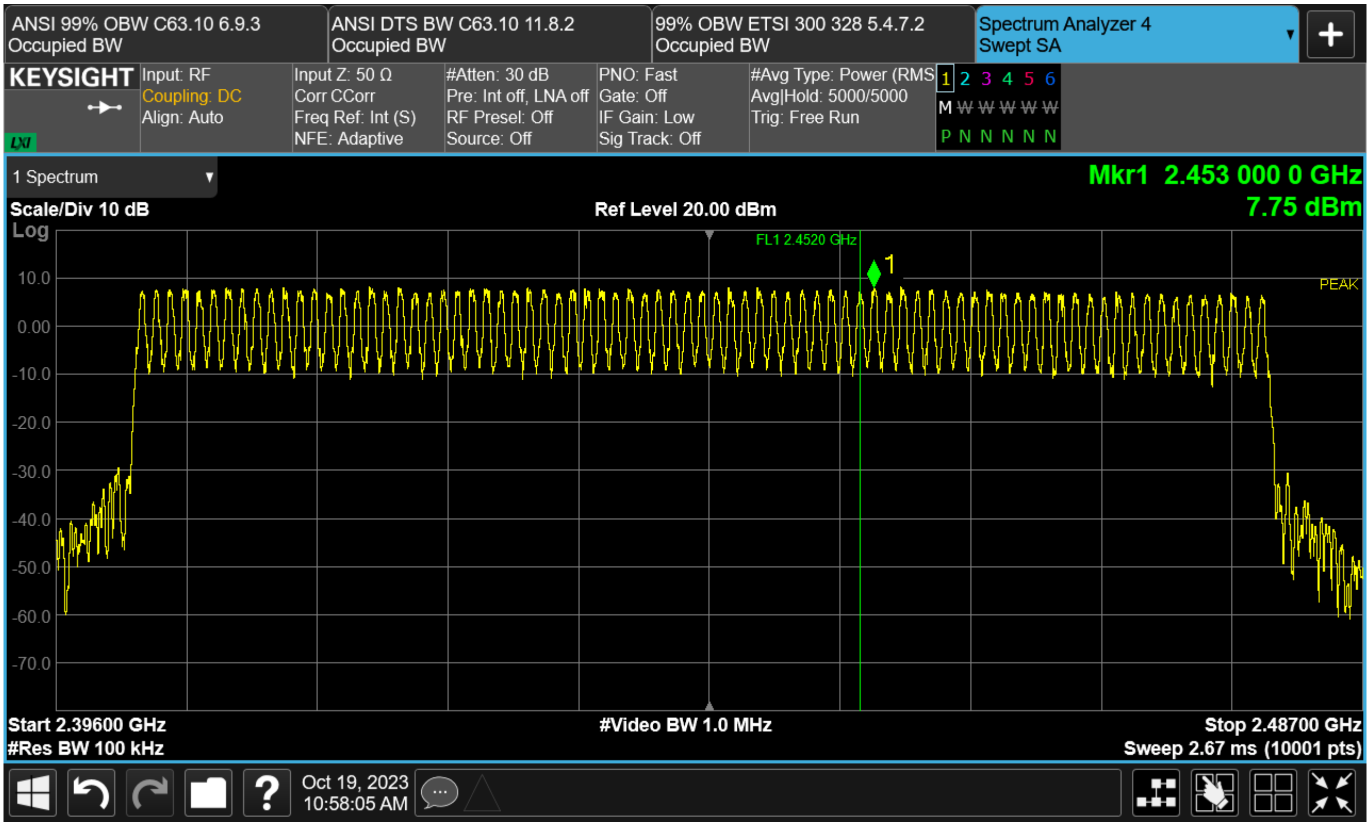


Figure TR31.1: Spectral data, Bluetooth Basic Rate transmission, showing channels used

Test Data: Bandwidth and Channel Separation

The 20 dB Occupied bandwidth (OBW20) was measured for each modulation type, with the transmission fixed on low, middle, and high channels. The maximum bandwidth observed is highlighted in yellow, and the spectrum image for that case is also provided.

The standards require that the hopping channel separation is no less than OBW20 if the transmitted power is above 125 mW. For lower power transmissions, the hopping channel separation must be no less than two-thirds of OBW20. This second case can also be expressed as limiting OBW20 to 1.5 times the channel separation. Based on the 1 MHz separation between hopping channel, and the output power of the transmitter, the 20 dB occupied bandwidth must be no greater than 1.5 MHz. The data below shows compliance with this limit.

	2402	2440	2480
Bluetooth BR	**1.037**	**1.038**	**1.039**

Table TR31.2: Summary of 20 dB Occupied Bandwidth results in MHz

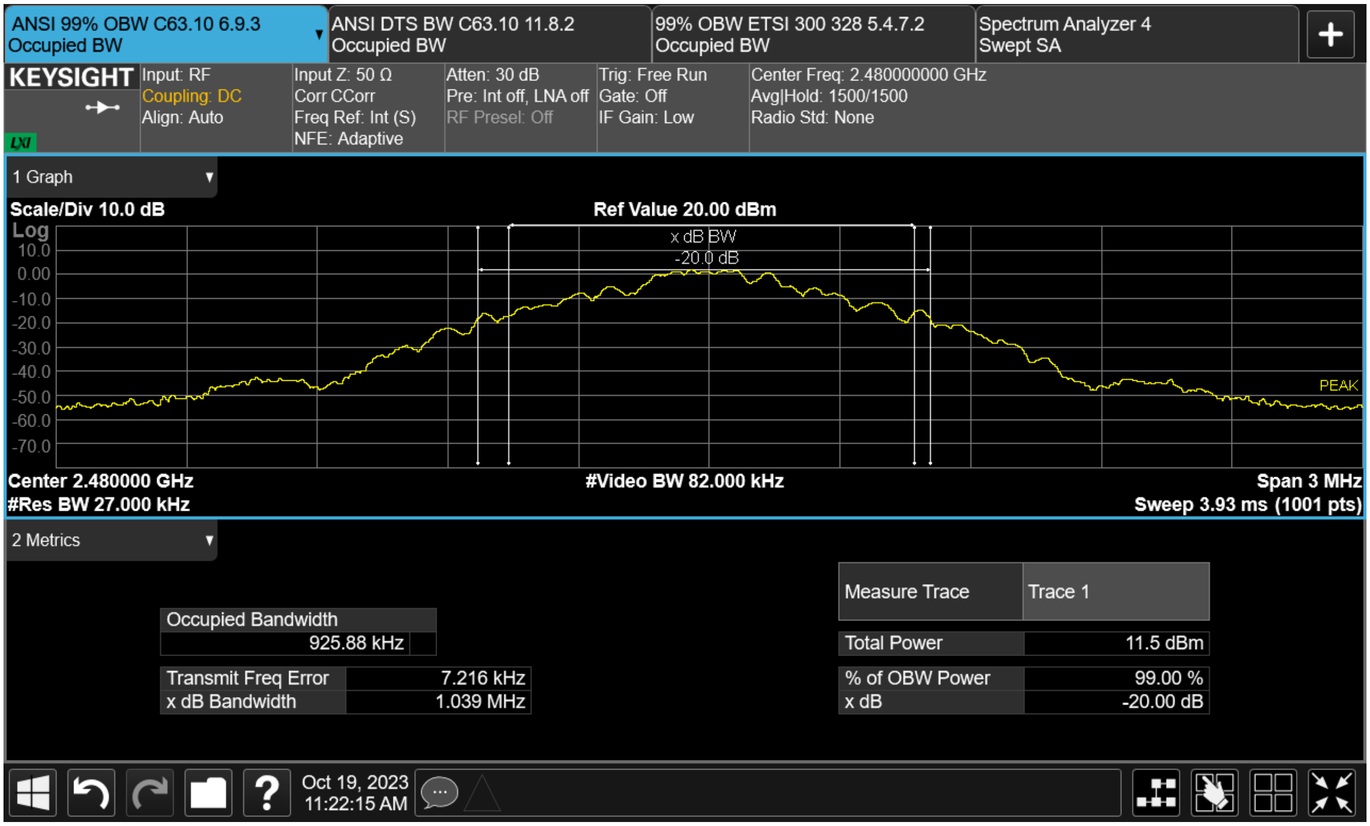


Figure TR31.2: Spectral data for Bluetooth Basic Rate modulation at 2480 MHz

Test Data: Channel Occupancy

The channel occupancy requirement ensures that the transmissions are distributed consistently across the hopping channels. The measurement is made on each of the three randomly selected channels for a period of 0.4 seconds multiplied by the number of hopping channels. For this product, that is a measurement period of 31.6 seconds. During that time, the sum of the transmission times on the selected channel cannot exceed the limit of 0.4 seconds.

This testing is performed at three test channel frequencies, randomly selected within a range. The first range is 2402 to 2427 MHz. The second test frequency range is 2428 to 2454 MHz. The final range is 2455 to 2480 MHz.

The test sample was placed in a test mode where it transmits on its various frequency channels while hopping. The transmissions were measured while the test equipment was tuned to each one of the three test channels using a detector more narrow than the OBW20 value. This provides a record of transmissions only on the selected channel over time. A spreadsheet analyzed the data to determine channel occupancy -- the total sum of time that the transmitter was on the selected channel. The maximum channel occupancy values is highlighted in yellow, and a zero-span time plot image for that case is also provided.

Freq (MHz)	2402	2440	2480
BTBR	0.213	0.215	0.215

Table TR31.3: Summary of Channel Occupancy results in seconds

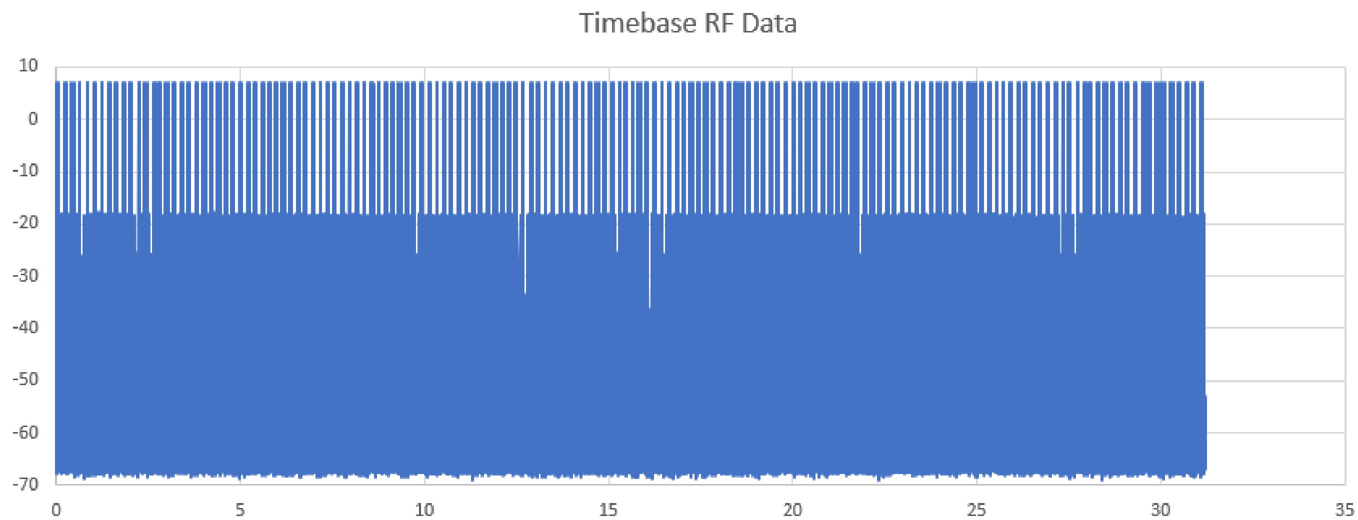


Figure TR31.3: Channel Occupancy time data for Bluetooth Basic Rate modulation at 2480 MHz

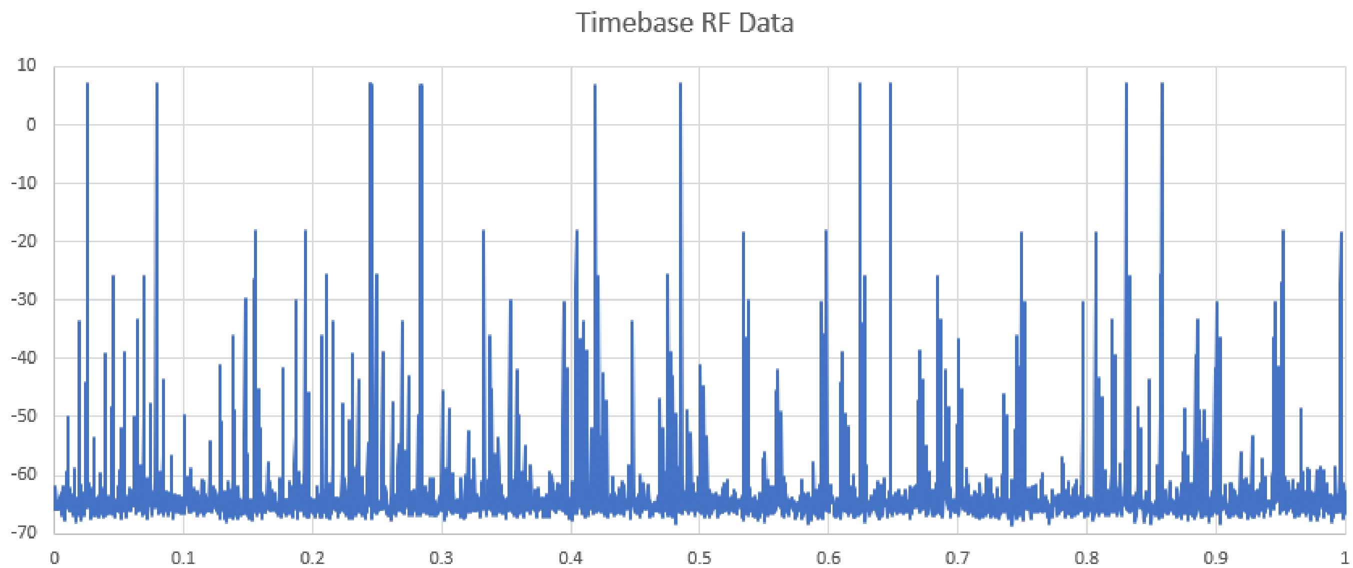


Figure TR31.4: First second of the Channel Occupancy time data for improved clarity

This line is the end of the test record.

Test Record
Transmitter Bandwidth Tests
Test IDs TR02
Project GCL0457

Test Date(s) 28-29 Sep and 04 Oct 2023
Test Personnel Majid Farah

Product Model AA4714
Serial Number tested 3453413911

Operating Mode M10 (All2.4)
Arrangement A3 (Udata)
Input Power 5 Vdc

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

Radio Protocol Bluetooth Low Energy (BLE), ANT, IEEE 802.11 b/g/n (WiFi)

Radio Band 2400 to 2483.5 MHz

Pass/Fail Judgment: PASS

Test record created by: Majid Farah
Date of this record: 06 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 TR02.1: List of test equipment used

Test Software Used: Keysight PXE firmware A.35.06

Test Method

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

Test Setup

This block diagram shows the test equipment setup.

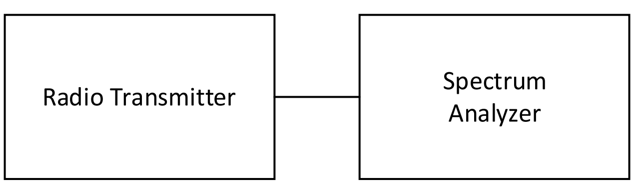


Figure TR02.1: Test setup

Test Data

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

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

	2402 (04)	2440	2480 (78)
Bluetooth BR	**484.9**	**487.4**	**494.2**
Bluetooth EDR2	**500.4**	**503.2**	**505.3**
Bluetooth EDR3	**500.7**	**502.9**	**505.1**
BLE 1 Mbps	**703.2**	**1273.0**	**704.2**
BLE 2 Mbps	**1444.0**	**1468.0**	**1155.0**
ANT	**932.9**	**905.0**	**941.8**

Table TR02.2: Summary of DTS bandwidth data in kHz for Bluetooth, ANT and BLE modes

	Ch1	Ch6	Ch11	Ch12	Ch13
B1	9.590	9.105	9.587	9.096	9.532
B2	9.089	9.121	9.108	9.106	8.853
B5.5	8.771	8.429	8.355	9.779	8.767
B11	9.092	8.872	9.061	9.159	9.080
G6	16.460	16.540	16.510	16.570	15.890
G9	16.560	16.530	16.560	16.580	16.320
G12	16.530	16.550	16.540	16.550	16.190
G18	16.510	16.530	16.500	16.510	15.780
G24	16.070	16.540	16.490	16.530	16.350
G36	16.050	16.550	16.550	16.550	16.130
G48	16.100	16.540	16.530	16.540	16.360
G54	15.840	16.540	16.530	16.530	16.120
NMCS0	16.290	17.640	17.640	17.640	16.370
NMCS1	16.010	17.690	17.660	17.680	16.350
NMCS2	15.840	17.700	17.670	17.670	16.420
NMCS3	16.090	17.640	17.680	17.690	16.130
NMCS4	15.830	17.710	17.690	17.690	16.330
NMCS5	16.270	17.670	17.680	17.660	16.300
NMCS6	16.130	17.670	17.720	17.720	16.130
NMCS7	16.040	17.480	17.690	17.630	16.320

Table TR02.3: Summary of DTS bandwidth data in MHz for WiFi

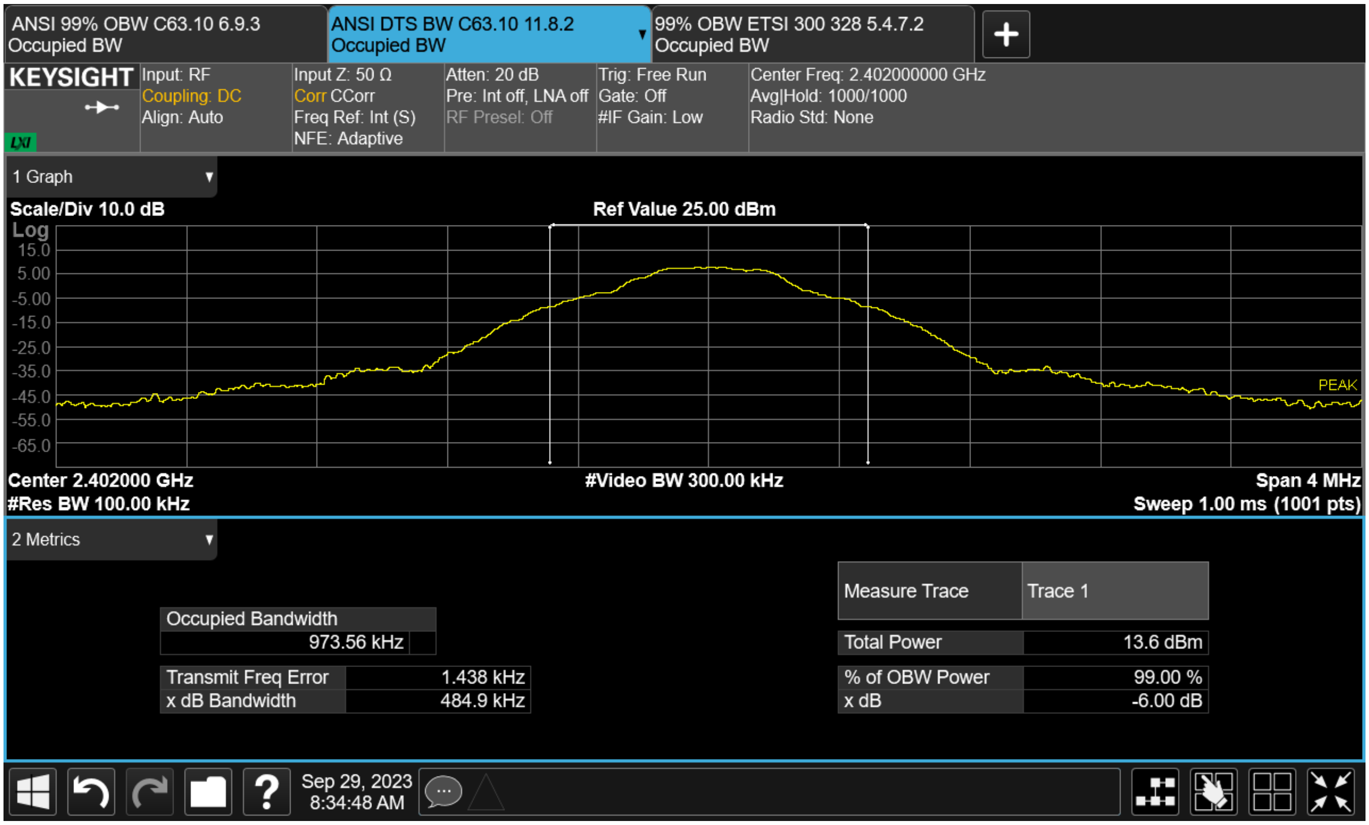


Figure TR02.2: Bandwidth data for Bluetooth BR at 2402 MHz

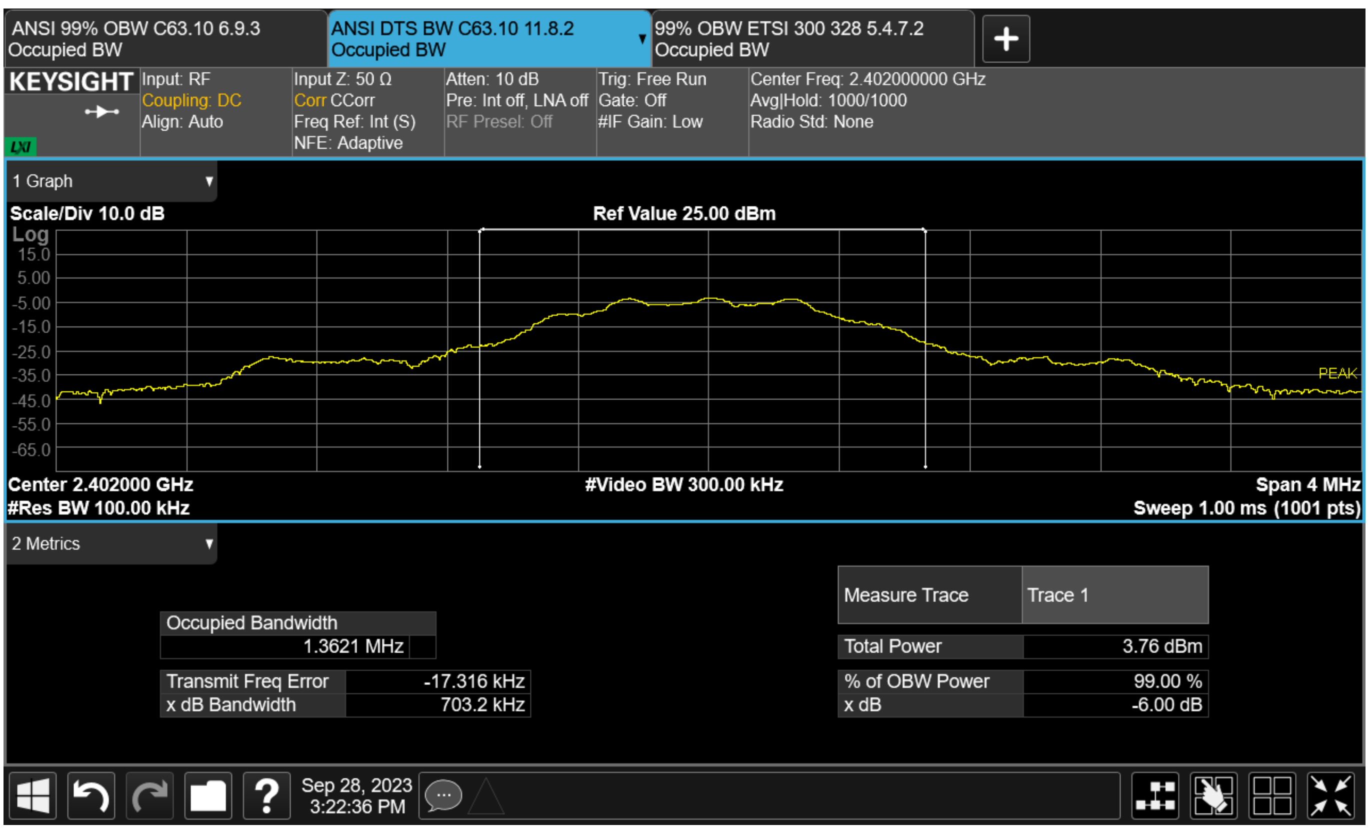


Figure TR02.3: Bandwidth data for BLE 1 Mbps at 2402 MHz

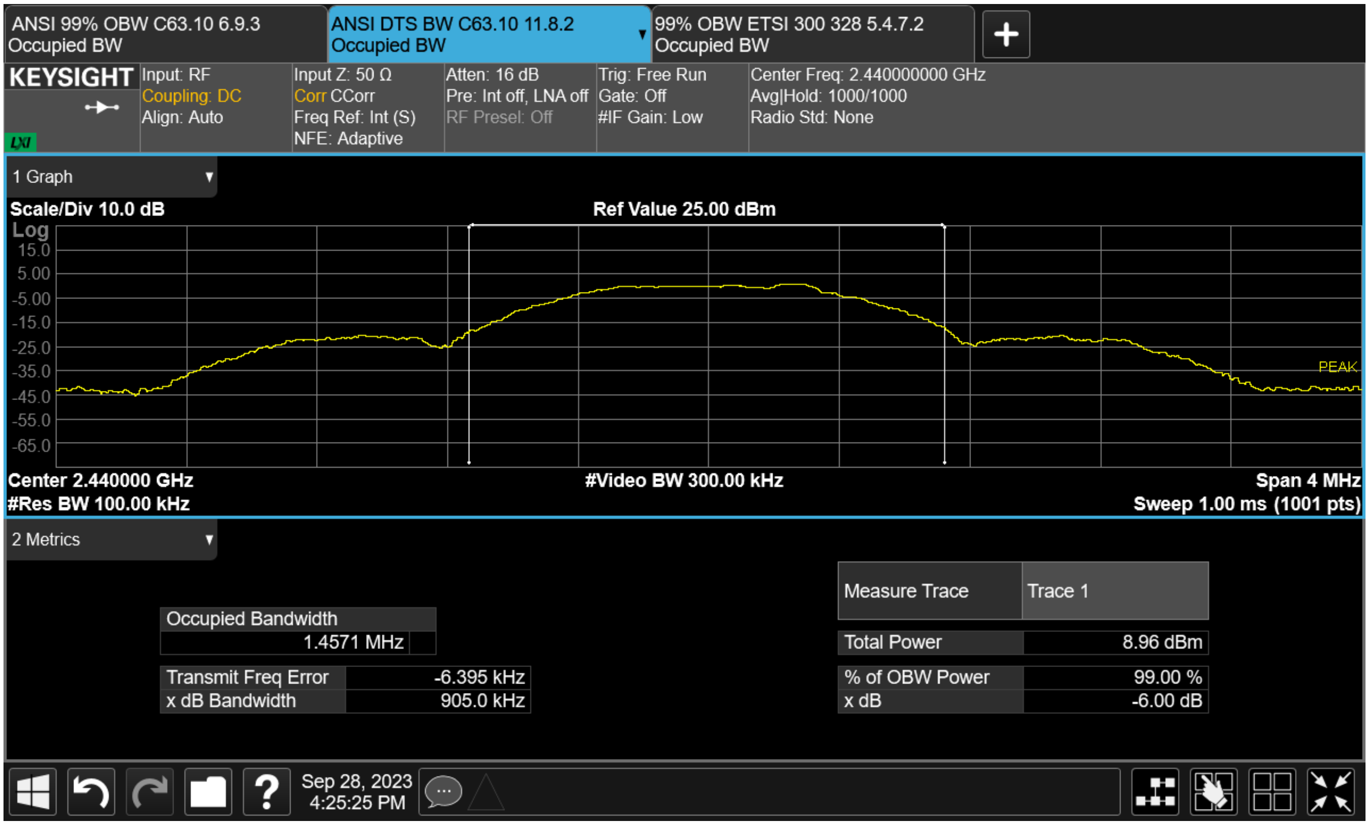


Figure TR02.4: Bandwidth data for ANT at 2440 MHz

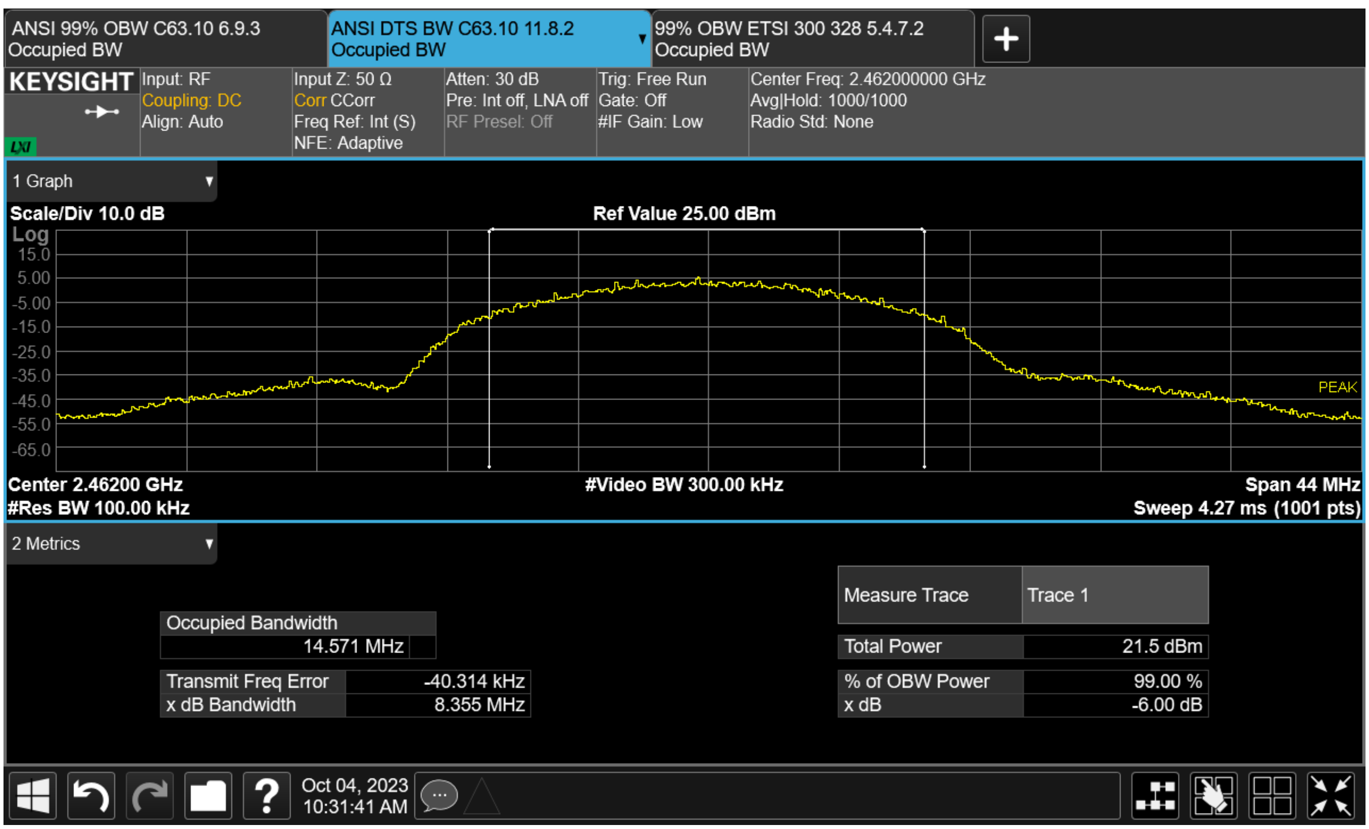


Figure TR02.5: Bandwidth data for B5.5 modulation at channel 11 (2462 MHz)

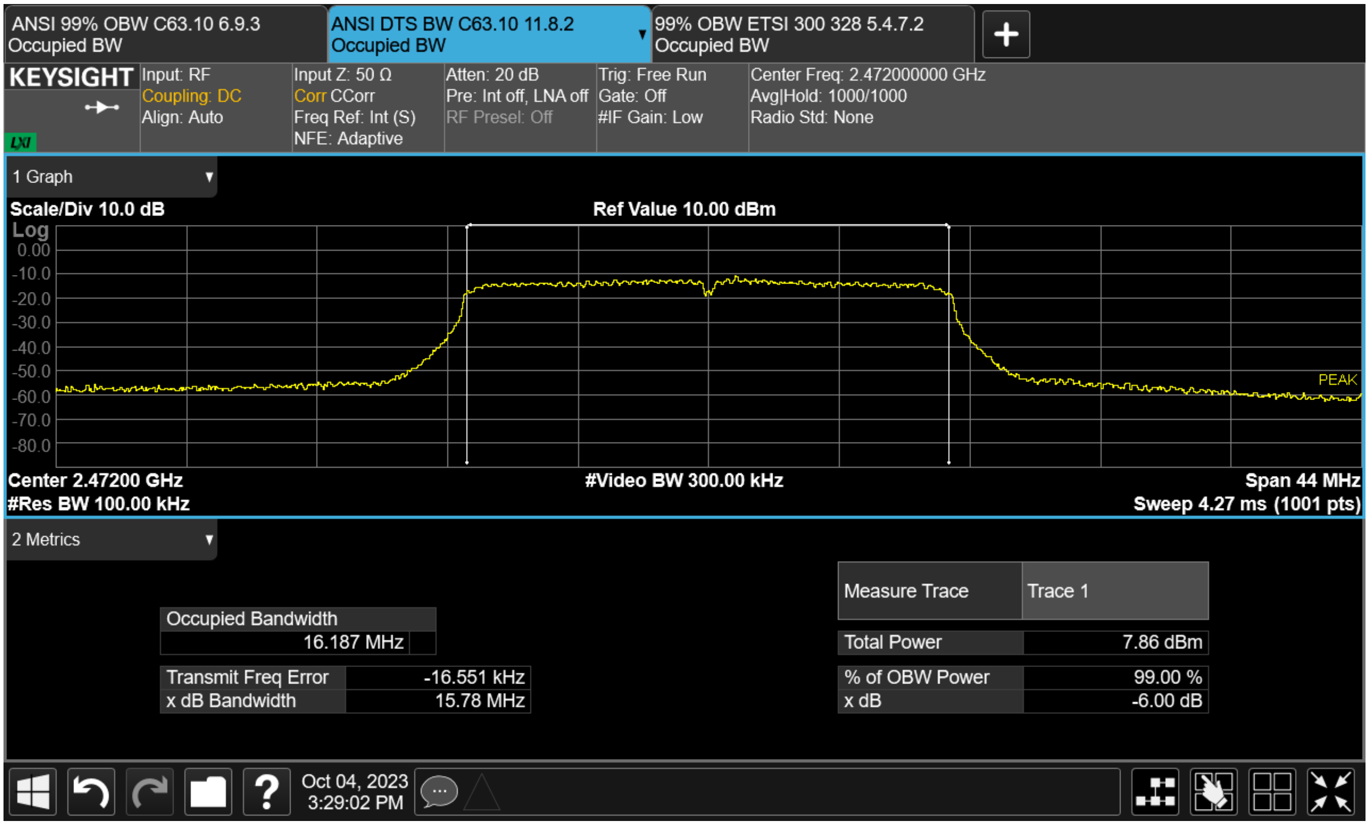


Figure TR02.6: Bandwidth data for G18 modulation at channel 13 (2472 MHz)

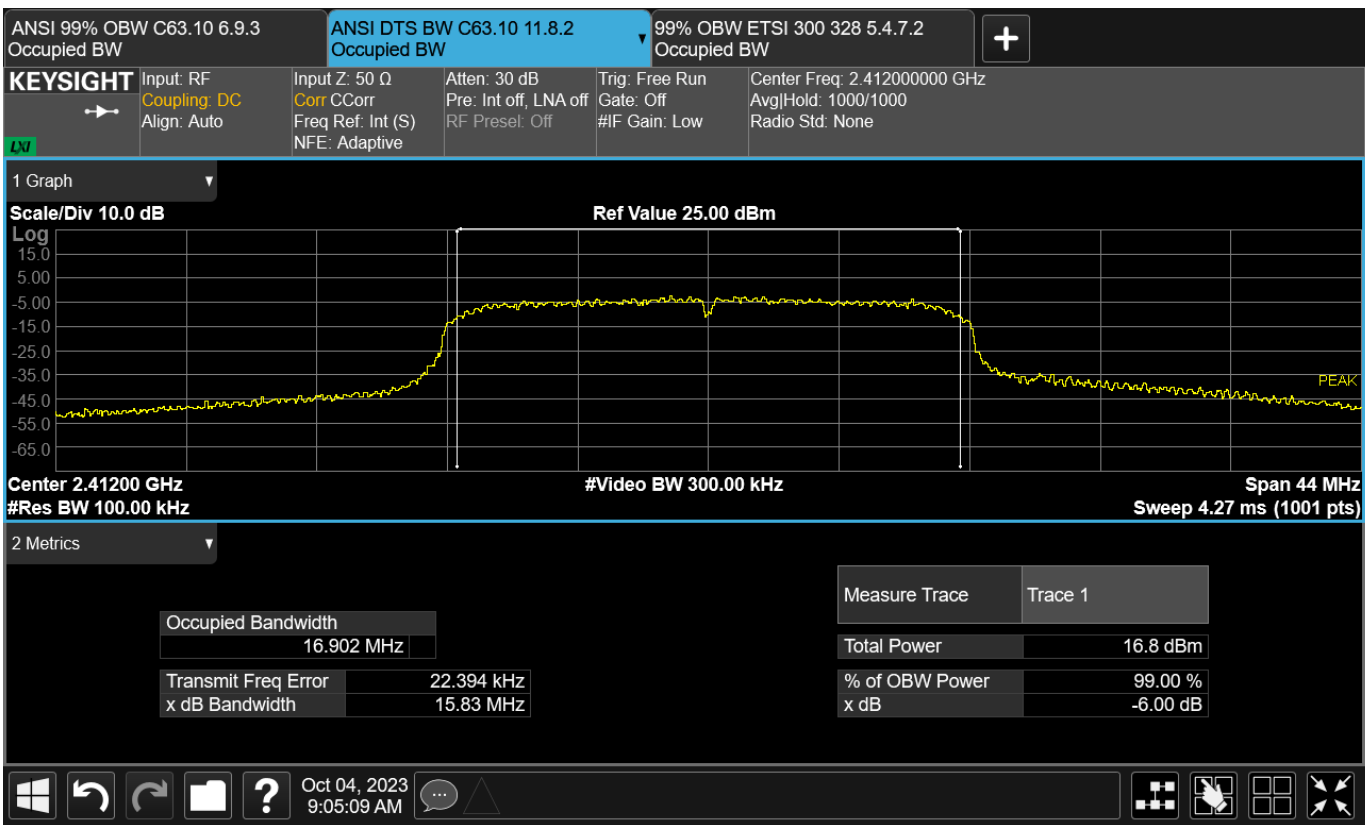


Figure TR02.7: Bandwidth data for NMCS4 modulation at channel 1 (2412 MHz)

This line is the end of the test record.

Test Record
Transmitter Bandwidth Tests
Test IDs TR03
Project GCL0457

Test Date(s) 28-29 Sep and 04 Oct 2023
Test Personnel Majid Farah

Product Model AA4714
Serial Number tested 3453413911

Operating Mode M10 (All2.4)
Arrangement A3 (Udata)
Input Power 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 Classic (Including EDR2 and EDR3), Bluetooth Low Energy (BLE), ANT, IEEE 802.11 b/g/n (WiFi)

Radio Band 2400 to 2483.5 MHz

Pass/Fail Judgment: **Reported**

Test record created by: **Majid Farah**
Date of this record: **06 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 TR03.1: List of test equipment used

Test Software Used: Keysight PXE firmware A.35.06

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.

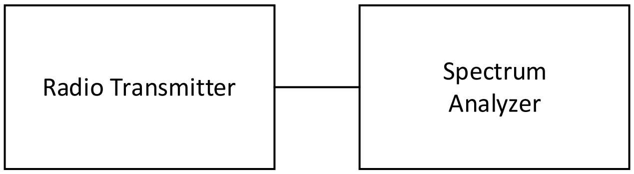


Figure TR03.1: Test setup

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

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

	2402 (04)	2440	2480 (78)
Bluetooth BR	**0.944**	**0.926**	**0.929**
Bluetooth EDR2	**1.117**	**1.103**	**1.106**
Bluetooth EDR3	**1.122**	**1.103**	**1.104**
BLE 1 Mbps	**1.263**	**1.424**	**1.272**
BLE 2 Mbps	**2.193**	**2.222**	**2.298**
ANT	**1.490**	**1.420**	**1.411**

Table TR03.2: Summary of 99% Occupied Bandwidth Data for Bluetooth, ANT and BLE modes

	Ch1	Ch6	Ch11	Ch12	Ch13
B1	15.046	15.126	15.032	14.941	14.218
B2	14.969	15.177	15.065	14.849	14.289
B5.5	14.622	14.715	14.736	14.762	14.103
B11	14.663	14.759	14.729	14.714	14.178
G6	17.025	17.129	17.059	17.082	16.327
G9	17.008	17.092	17.022	17.034	16.337
G12	16.802	16.904	16.796	16.797	16.233
G18	16.712	16.873	16.739	16.741	16.193
G24	16.269	16.873	16.695	16.700	16.272
G36	16.334	17.051	16.935	16.912	16.360
G48	16.282	16.934	16.769	16.809	16.278
G54	16.254	16.901	16.817	16.818	16.285
NMCS0	16.939	17.767	17.689	17.714	16.963
NMCS1	16.908	17.771	17.647	17.638	16.945
NMCS2	16.889	17.730	17.649	17.630	16.925
NMCS3	16.901	17.753	17.642	17.650	16.927
NMCS4	16.948	17.778	17.659	17.645	16.950
NMCS5	16.924	17.724	17.616	17.620	16.954
NMCS6	16.942	17.796	17.679	17.672	16.967
NMCS7	16.895	17.743	17.610	17.610	16.941

Table TR03.3: Summary of bandwidth data for WiFi modes

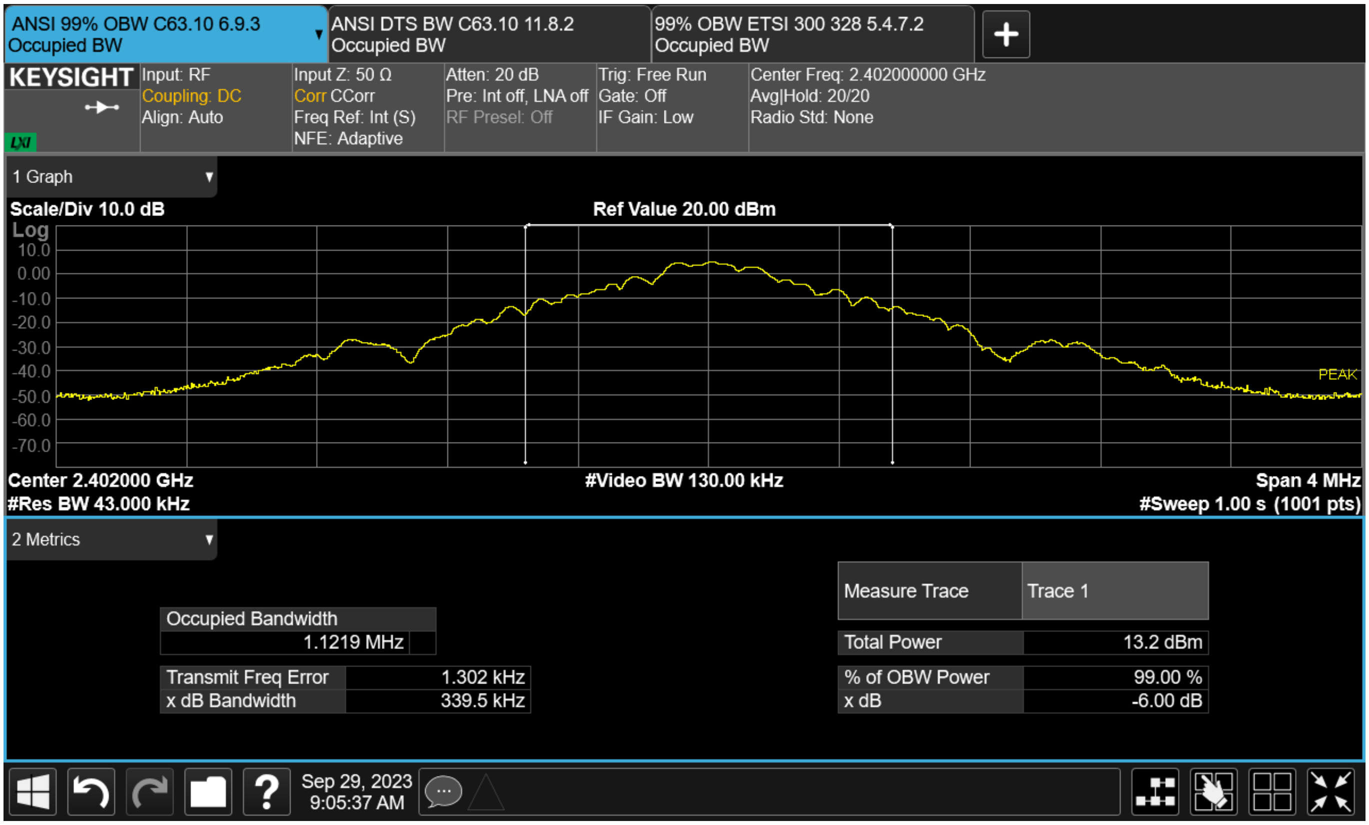


Figure TR03.2: Bandwidth data for Bluetooth EDR3 at 2402 MHz

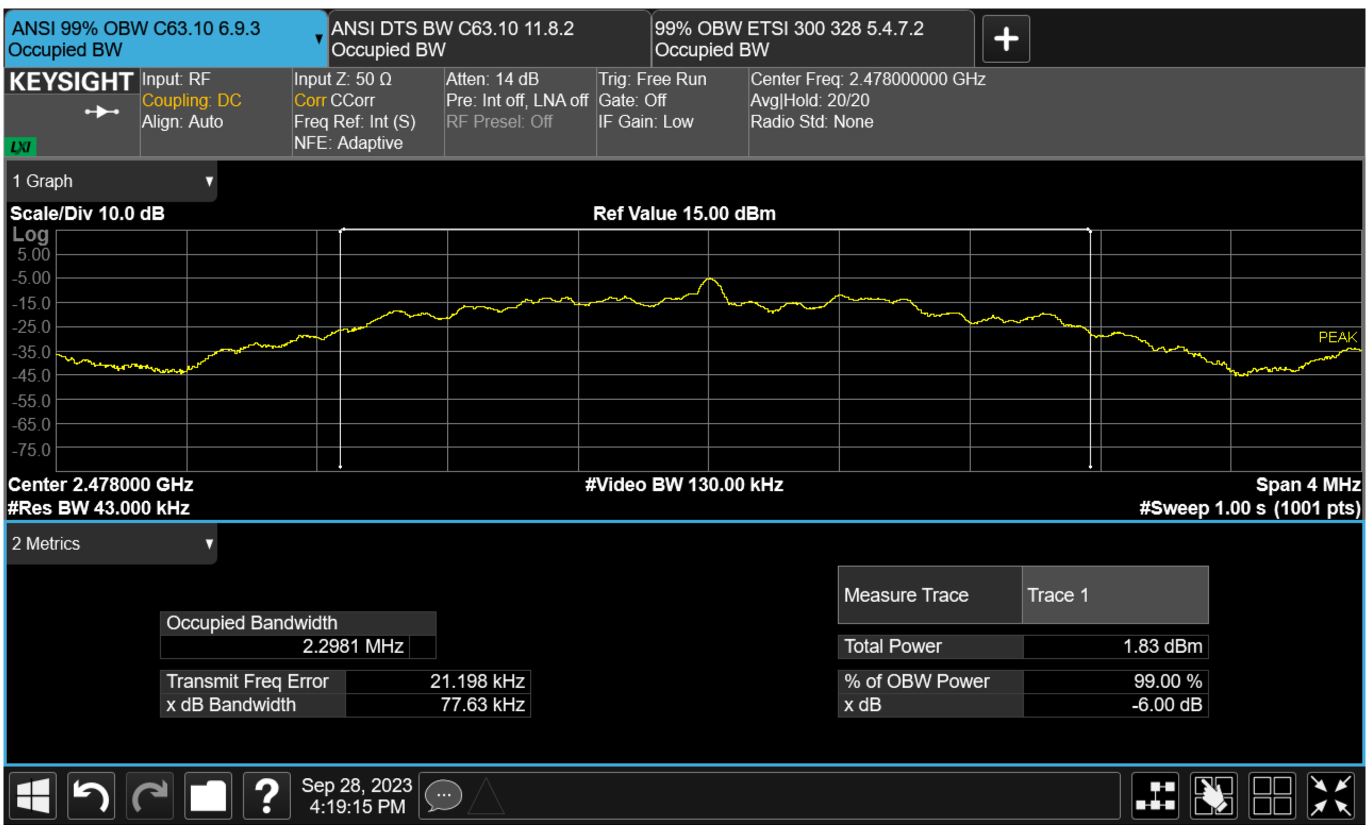


Figure TR03.3: Bandwidth data for BLE 2 Mbps at 2478 MHz

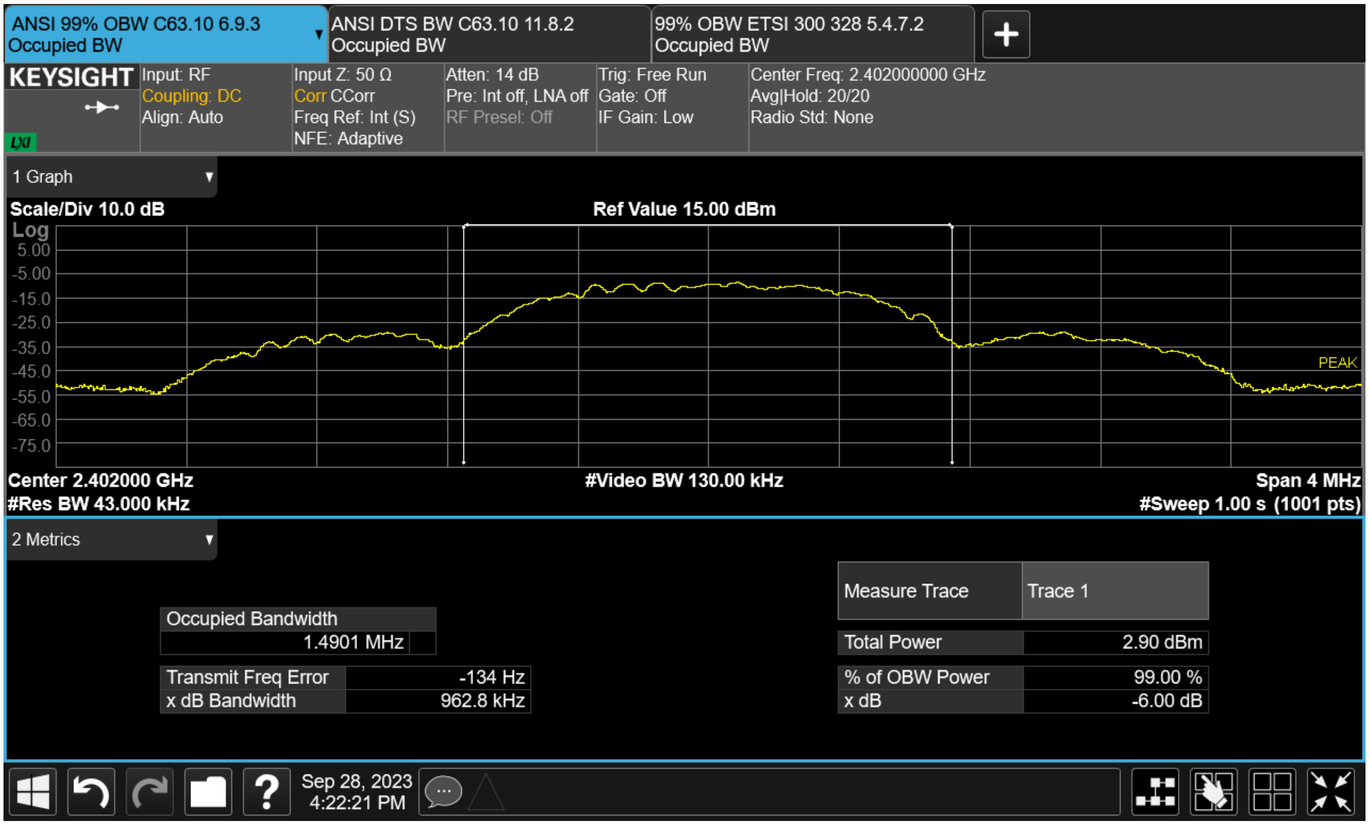


Figure TR03.4: Bandwidth data for ANT at 2402 MHz

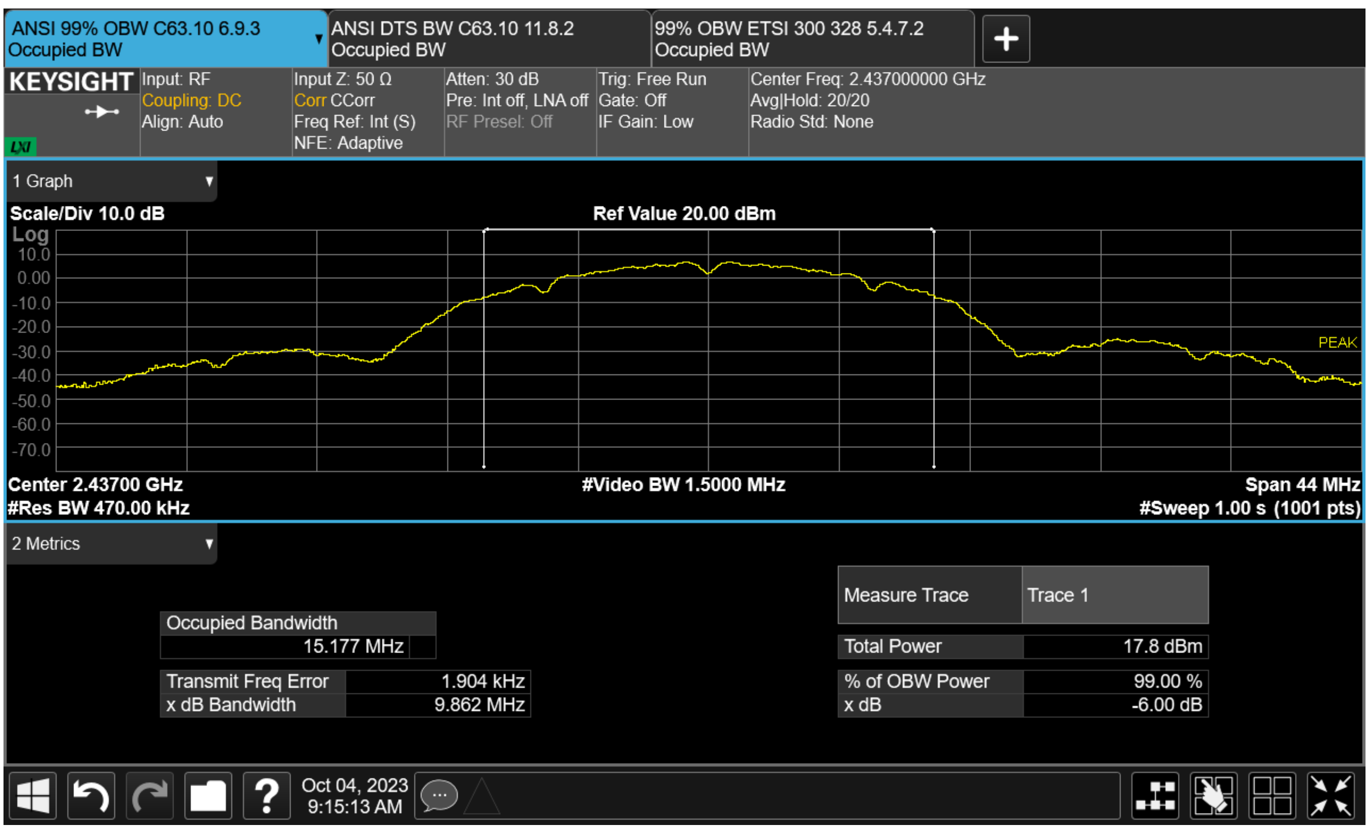


Figure TR03.5: Bandwidth data for B2 Modulation on WiFi Channel 6 (2440 MHz)

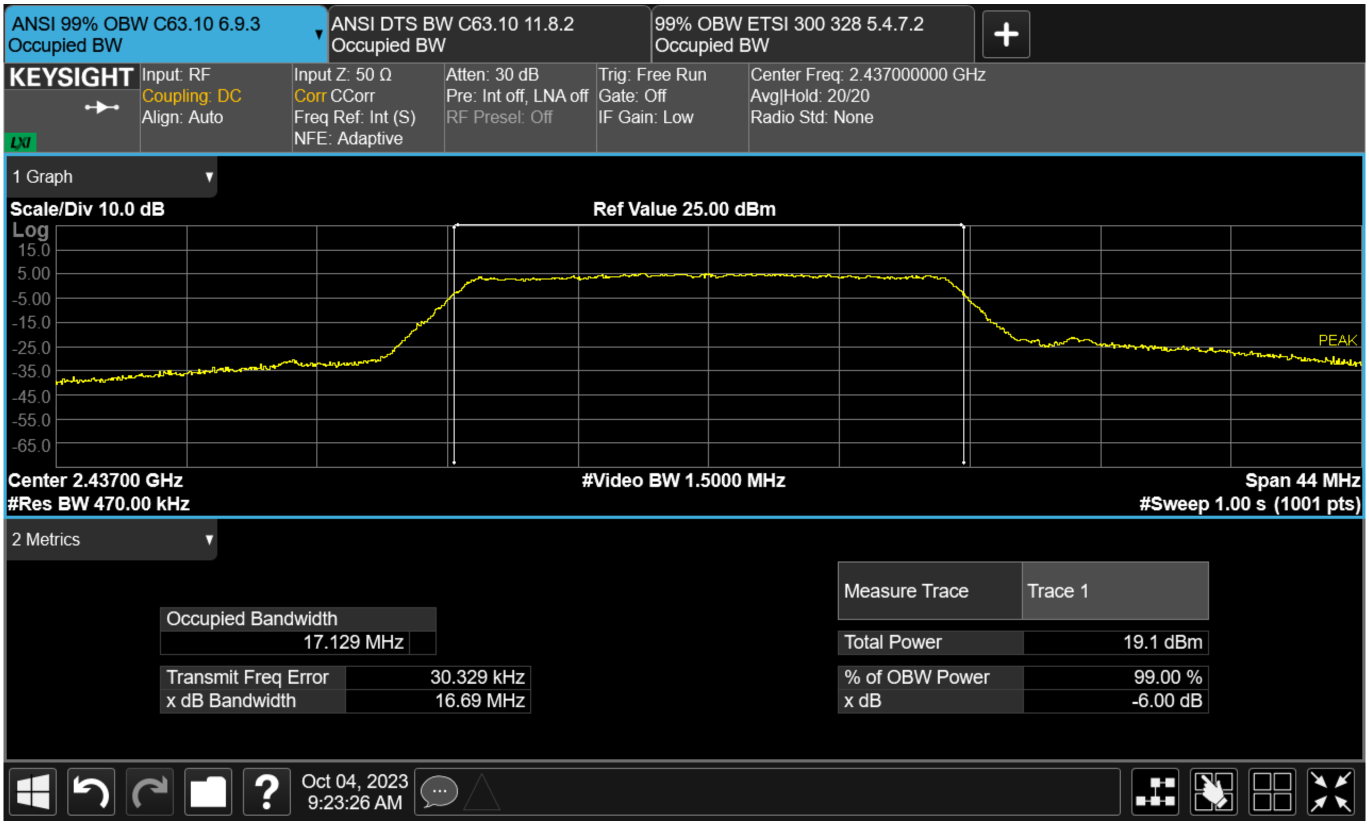


Figure TR03.6: Bandwidth data for G6 Modulation on WiFi Channel 6 (2440 MHz)

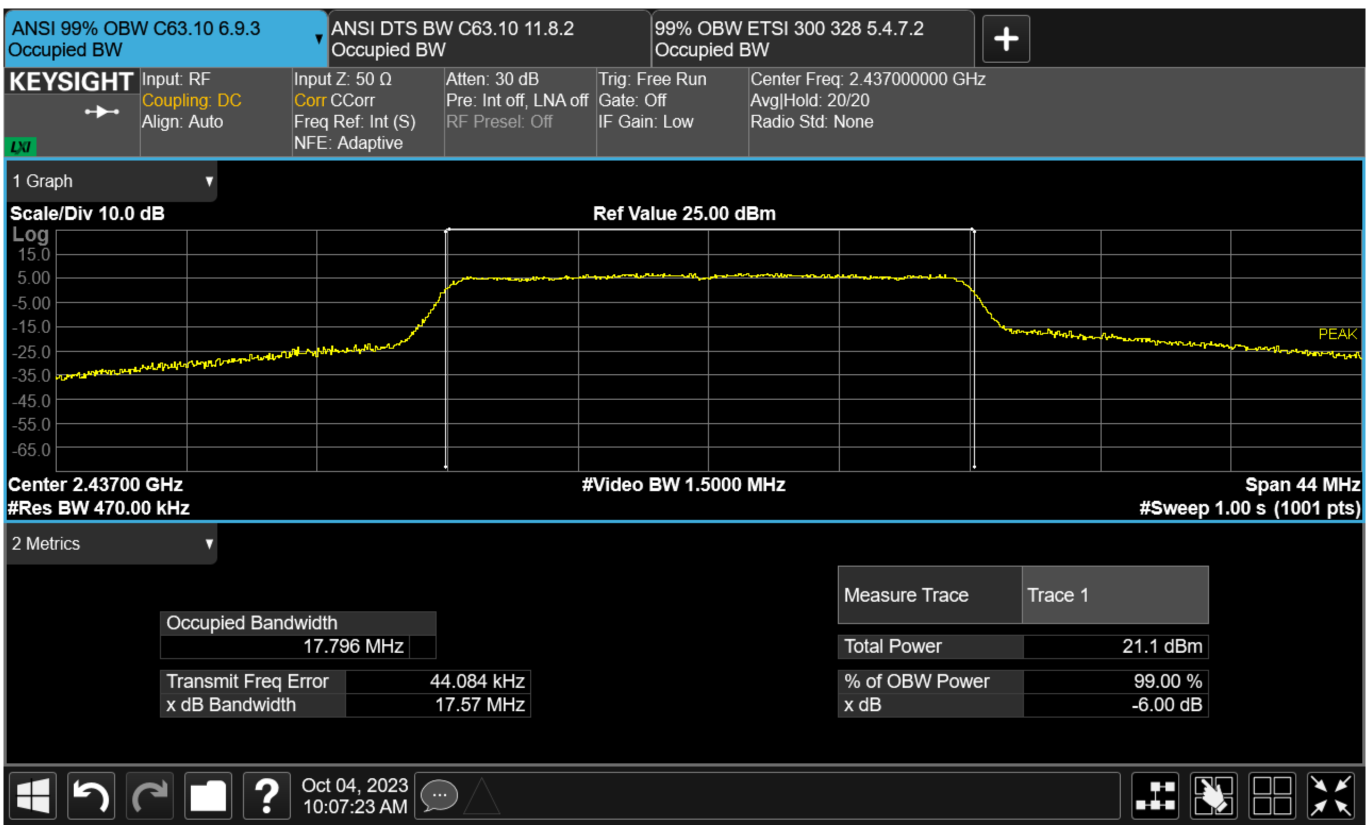


Figure TR03.7: Bandwidth data for NMCS6 Modulation on WiFi Channel 6 (2440 MHz)

Necessary Bandwidth Calculations

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

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

$B_N = 2R / \log_2(S)$

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

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

Table TR03.101: Necessary Bandwidth for ANT and ANT+ Radio Protocols (FCC and TRC-43)

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

Table TR03.102: Necessary Bandwidth for Bluetooth Radio Protocols (FCC and TRC-43)

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

Table TR03.103: Necessary Bandwidth for IEEE 802.11 b Radio Protocol (FCC and TRC-43)

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

Table TR03.104: Necessary Bandwidth for IEEE 802.11 g and n 20 MHz Radio Protocols (FCC)

As a note, the bit rate for IEEE 802.11 n WiFi is calculated based on the IEEE standard's short guard interval of 400 nsec. If only the long guard interval of 800 nsec were implemented, the bit rate for MCS7would decrease to 65 Mbps for a Necessary Bandwidth of 21.7 MHz.

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

Table TR03.105: Necessary Bandwidth for IEEE 802.11 g and n 20 MHz Radio Protocols (TRC-43)

This line is the end of the test record.

Test Record

Transmitter Power
Test IDs TR01b
Project GCL0457

Test Date(s)	7, 26 Sep 2023
Test Personnel	Majid Farah and Jim Solum
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M10 (All2.4)
Arrangement	A3 (Udata)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247, FCC Part 2.1091, FCC Part 2.1093, RSS-102, ANSI C95.3 (as noted in Section 6 of the report).
Antenna Gain	-0.3 dBi, as reported by the client
Radio Protocol	IEEE 802.11b/g/n
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date of this record:	**27 Sep 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	7-Jul-2023	1-Jul-2024

Table TR01b.1: List of test equipment used

Software used: Rohde & Schwarz Power Viewer V11.3; TimePowerAnalysisSpreadsheetv10.xls

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

ANSI C63.10: 11.9.1.3

Transmit Power 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.

The ANSI method finds the highest value (numerical peak) and applies the 30 dBm limit from the US and Canadian standards. All values met the limit with better than 10 dB of margin.

The results are shown below. Yellow highlighted cells indicate the highest power value for each radio protocol. An NT entry in a grey cell indicates a combination of data rate and transmit channel that were not tested.

Mode	Speed	1	2	3	4	5	6	7	8	9	10	11	12	13
B	1	15.33	16.28	16.22	15.21	15.34	15.32	15.53	15.56	15.16	15.05	14.29	8.27	5.60
B	2	15.10	NT	NT	NT	NT	15.25	NT	NT	NT	NT	14.26	8.18	5.57
B	5.5	15.14	NT	NT	NT	NT	15.39	NT	NT	NT	NT	14.33	8.16	5.60
B	11	15.12	15.96	15.95	15.09	15.05	15.19	15.32	15.37	15.02	14.90	14.38	8.14	5.60
G	6	11.25	NT	NT	NT	NT	13.00	NT	NT	NT	NT	7.09	3.66	1.73
G	9	11.29	NT	NT	NT	NT	13.02	NT	NT	NT	NT	7.03	3.64	1.70
G	12	11.69	NT	NT	NT	NT	13.45	NT	NT	NT	NT	7.50	4.09	2.24
G	18	11.81	12.81	14.03	13.51	13.41	13.45	13.60	12.43	11.49	10.85	7.57	4.12	2.26
G	24	11.67	NT	NT	NT	NT	13.40	NT	NT	NT	NT	7.49	4.03	2.21
G	36	11.58	NT	NT	NT	NT	13.34	NT	NT	NT	NT	7.43	3.99	2.15
G	48	11.63	NT	NT	NT	NT	13.35	NT	NT	NT	NT	7.48	4.01	2.21
G	54	11.63	12.81	13.96	13.44	13.41	13.34	13.55	12.37	11.91	11.19	7.48	4.03	2.18
N	MCS0	10.16	NT	NT	NT	NT	12.97	NT	NT	NT	NT	5.45	3.14	1.63
N	MCS1	10.68	NT	NT	NT	NT	13.46	NT	NT	NT	NT	5.98	3.73	2.27
N	MCS2	10.73	12.44	13.23	13.91	13.84	13.55	13.47	12.33	11.83	10.82	6.04	3.77	2.29
N	MCS3	10.71	NT	NT	NT	NT	13.45	NT	NT	NT	NT	6.02	3.73	2.28
N	MCS4	10.70	NT	NT	NT	NT	13.67	NT	NT	NT	NT	5.94	3.83	2.24
N	MCS5	10.71	NT	NT	NT	NT	13.71	NT	NT	NT	NT	6.00	3.80	2.29
N	MCS6	10.69	NT	NT	NT	NT	13.62	NT	NT	NT	NT	5.98	3.73	2.32
N	MCS7	10.71	12.19	13.00	13.77	13.66	13.59	13.38	12.20	11.70	10.57	5.97	3.77	2.26

Table TR01b.2: Transmit Power Summary, with units of dBm

Additional Transmit Power Data Analysis
The technical requirements for safety to RF exposure also look at transmitter power. Since data from this report may be compared with data from RF exposure reports, this lab has performed a further analysis of the same raw data for power over time used above. This analysis applies standards such as FCC Part 2.1091, FCC Part 2.1093, RSS-102, ANSI C95.3, EN/IEC 62311, or EN 62479.

These data analyses look at average power over time in linear milliwatt units. These data are averaged over a time period no longer than 1 second.

Mode	Speed	1	2	3	4	5	6	7	8	9	10	11	12	13
B	1	33.78	42.02	41.61	32.97	33.98	33.83	35.45	35.68	32.54	31.78	26.70	6.64	3.60
B	2	32.14	NT	NT	NT	NT	33.28	NT	NT	NT	NT	26.52	6.52	3.57
B	5.5	32.40	NT	NT	NT	NT	34.30	NT	NT	NT	NT	26.89	6.48	3.59
B	11	32.24	39.08	38.92	31.56	31.68	32.74	33.76	34.12	31.45	30.61	26.72	6.44	3.59
G	6	13.03	NT	NT	NT	NT	19.50	NT	NT	NT	NT	4.98	2.27	1.46
G	9	13.11	NT	NT	NT	NT	19.52	NT	NT	NT	NT	4.92	2.25	1.45
G	12	14.58	NT	NT	NT	NT	21.56	NT	NT	NT	NT	5.55	2.52	1.65
G	18	14.97	18.86	24.92	22.09	21.65	21.87	22.61	17.22	13.89	11.99	5.62	2.53	1.66
G	24	14.31	NT	NT	NT	NT	21.27	NT	NT	NT	NT	5.49	2.47	1.62
G	36	13.97	NT	NT	NT	NT	21.03	NT	NT	NT	NT	5.42	2.44	1.60
G	48	14.20	NT	NT	NT	NT	21.25	NT	NT	NT	NT	5.48	2.45	1.62
G	54	14.11	18.61	24.31	21.48	21.32	21.03	22.05	16.73	15.12	12.81	5.44	2.46	1.60
N	MCS0	10.08	NT	NT	NT	NT	19.38	NT	NT	NT	NT	3.42	2.01	1.42
N	MCS1	11.48	NT	NT	NT	NT	21.88	NT	NT	NT	NT	3.90	2.31	1.66
N	MCS2	11.63	17.20	20.59	24.20	23.82	22.27	21.82	16.79	14.98	11.87	3.95	2.34	1.66
N	MCS3	11.48	NT	NT	NT	NT	21.61	NT	NT	NT	NT	3.89	2.31	1.64
N	MCS4	11.47	NT	NT	NT	NT	22.70	NT	NT	NT	NT	3.85	2.35	1.64
N	MCS5	11.43	NT	NT	NT	NT	22.79	NT	NT	NT	NT	3.87	2.32	1.64
N	MCS6	11.41	NT	NT	NT	NT	22.38	NT	NT	NT	NT	3.87	2.30	1.66
N	MCS7	11.47	16.10	19.46	23.00	22.70	22.38	21.23	16.16	14.38	11.10	3.85	2.31	1.64

Table TR01b.3: Additional RF exposure power summary, with units of milliwatt

Setup Diagram
The following block diagrams show how the EUT and test equipment is arranged for test. The client provided a short length of cable to bring the signals out to a connector. This cable was found to have 0.7 dB of loss in this frequency range. This factor was taken into account during the data analysis.

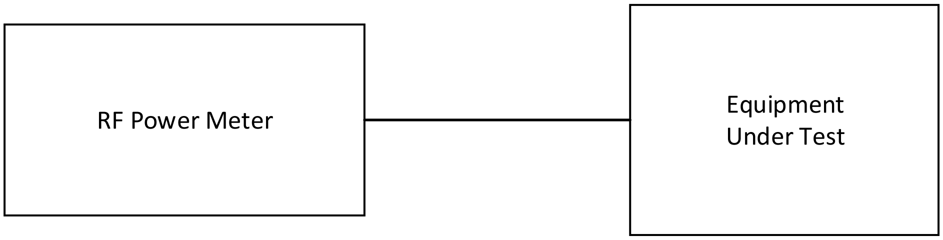


Figure TR01b.1: Test equipment setup

This line is the end of the test record.

Test Record

Transmitter Power
Test IDs TR01c
Project GCL0457

Test Date(s)	7, 26 Sep 2023
Test Personnel	Majid Farah and Jim Solum
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M10 (All2.4)
Arrangement	A3 (Udata)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, ETSI EN 300 328, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Antenna Gain	-0.3 dBi, as reported by the client.
Radio Protocol	Bluetooth, Bluetooth Low Energy, ANT
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date of this record:	**27 Sep 2023**

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	7-Jul-2023	1-Jul-2024

Table TR01c.1: List of test equipment used

Software used: Rohde & Schwarz Power Viewer V11.3; TimePowerAnalysisSpreadsheetv10.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
ANSI C63.10: 11.9.1.3

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.

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

The results are shown below. Yellow highlighted cells indicate the highest power value for each radio protocol. Bluetooth Low Energy at the 2 Mbps data has its lowest and highest channel frequencies set at 2404 MHz and 2478 MHz. The lowest and highest operating channel frequencies for the other protocols are 2402 MHz and 2480 MHz.

	Frequency (MHz)			ANSI Limit
	2402 (04)	2440	2478 (80)	(dBm)
ANT	-1.75	3.78	-3.25	30
BLE 1 Mbps	-2.24	3.47	-3.75	30
BLE 2 Mbps	4.02	3.77	-3.85	30
Bluetooth Basic	9.52	9.67	8.48	30
Bluetooth EDR2	8.91	9.37	8.35	30
Bluetooth EDR3	8.91	9.17	7.92	30

Table TR01c.2: Transmit Power Summary in dBm with ANSI C63.10 analytical methods

	Frequency (MHz)			ETSI Limit
	2402 (04)	2440	2480 (78)	(dBm EIRP)
ANT	-2.08	3.43	-3.58	20
BLE 1 Mbps	-2.57	3.12	-4.08	20
BLE 2 Mbps	3.66	3.41	-4.18	20
Bluetooth Basic	9.03	9.19	7.99	20
Bluetooth EDR2	8.47	8.90	7.88	20
Bluetooth EDR3	8.47	8.73	7.47	20

Table TR01c.3: Transmit Power Summary in dBm EIRP with ETSI analytical methods

Additional Transmit Power Data Analysis

The technical requirements for safety to RF exposure also look at transmitter power. Since data from this report may be compared with data from RF exposure reports, this lab has performed a further analysis of the same raw data for power over time used above. This analysis applies standards such as FCC Part 2.1091, FCC Part 2.1093, RSS-102, ANSI C95.3, EN/IEC 62311, or EN 62479.

These data analyses look at average power over time in linear milliwatt units. These data are averaged over a time period no longer than 1 second.

Frequency (Mhz)	2402 (04)	2442	2480 (78)
ANT	0.66	2.36	0.47
BLE 1Mbps	0.59	2.20	0.42
BLE 2Mbps	2.49	2.35	0.41
Bluetooth Basic	8.58	8.88	6.75
Bluetooth EDR2	7.54	8.32	6.58
Bluetooth EDR3	7.53	7.99	5.98

Table TR01c.4: Additional RF exposure power summary, with units of milliwatt

Setup Diagram

The following block diagrams show how the EUT and test equipment is arranged for test. The client provided a short length of cable to bring the signals out to a connector. This cable was found to have 0.7 dB of loss in this frequency range. This factor was taken into account during the data analysis.

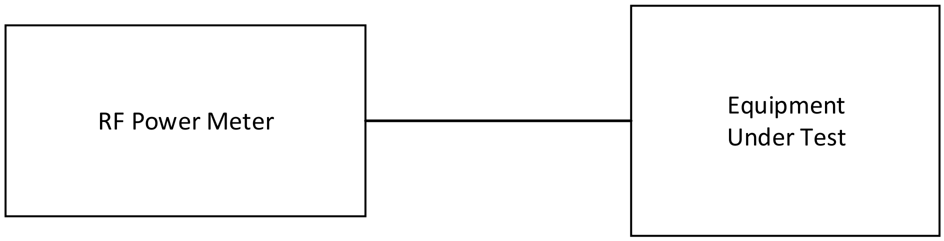


Figure TR01c.1: Test equipment setup

This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test IDs TR12 and TR13
Project GCL-0457

Test Date(s)	11 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M3 (Ble Tx) and M5 (ANT Tx)
Arrangement	A2 (Upwr)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this test record:	**24 Oct 2023**

Original record, Version A.

Test Equipment

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

Table TR13.1: Test equipment used

Software used: Keysight PXE software A.35.06

Test Method

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

ANSI C63.10: 11.11.2 and 11.11.3

Test Setup

This block diagram shows the test equipment setup.

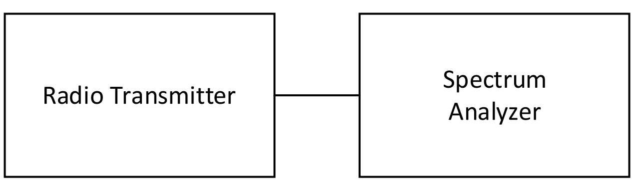


Figure TR13.1: Test setup

Test Data

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

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

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

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

The peak level of the fundamental is also identified. The harmonics or spurious emissions must be reduced from this fundamental level by 20 dBc. This harmonic limit is calculated and used to determine compliance. A reduction from the carrier that is greater that 20 is a passing result. The minimum margin from the peak level for each mode are highlighted in yellow.

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

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

		2402 (04)	2440	2480 (78)
BLE	2 Mb	47.73	47.16	40.36
ANT		42.74	44.46	39.18

Table TR13.2: Results Summary

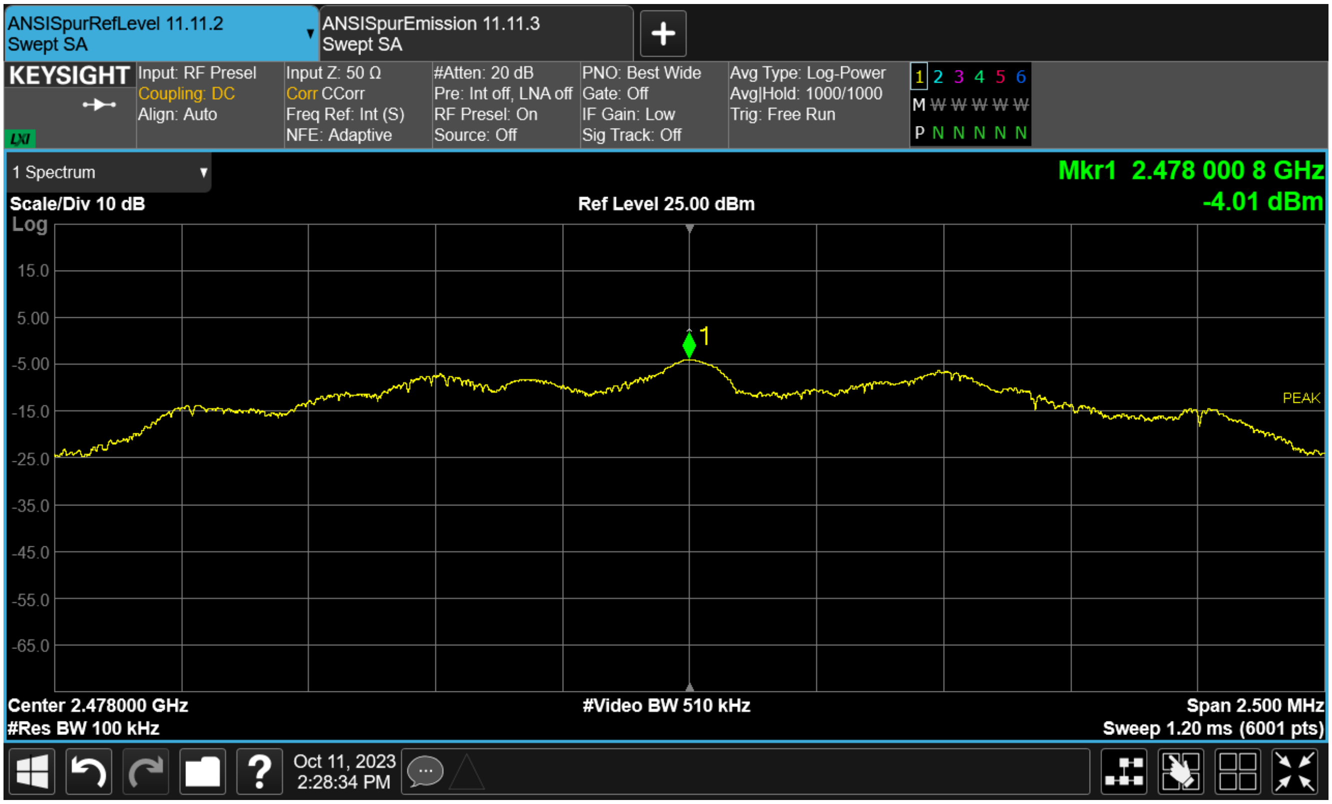


Figure TR13.2: Reference level measurement for Bluetooth BLE 2 Mbps at 2478 MHz

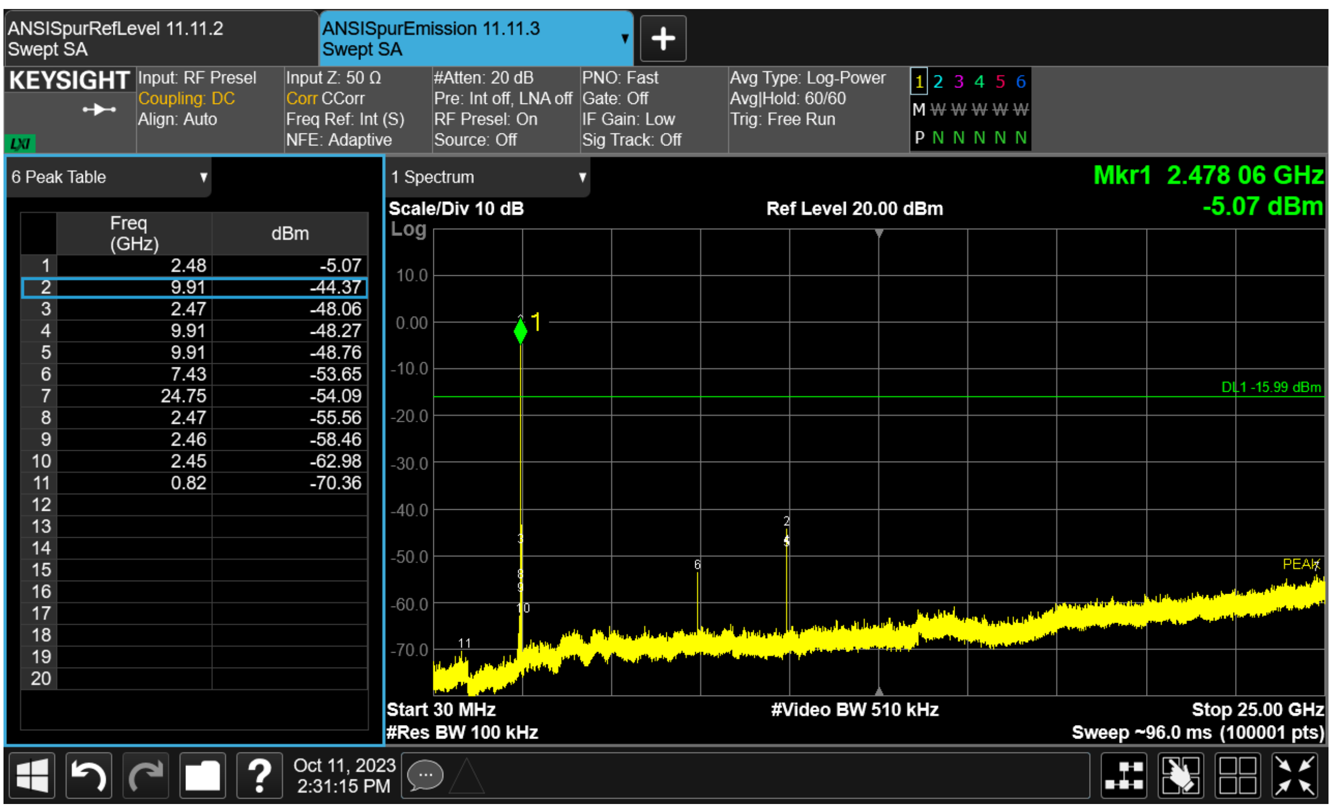


Figure TR13.3 Spectral data for Bluetooth BLE 2 Mbps at 2478 MHz

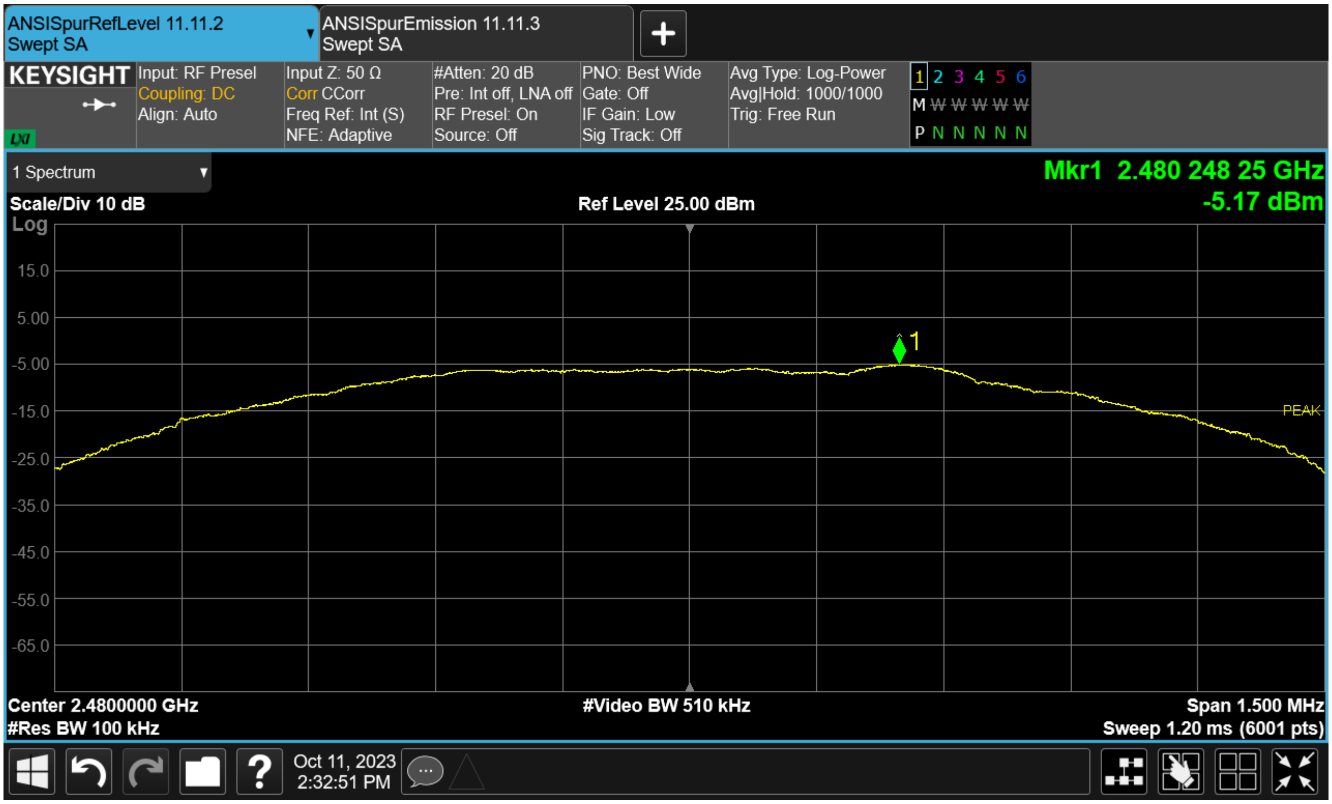
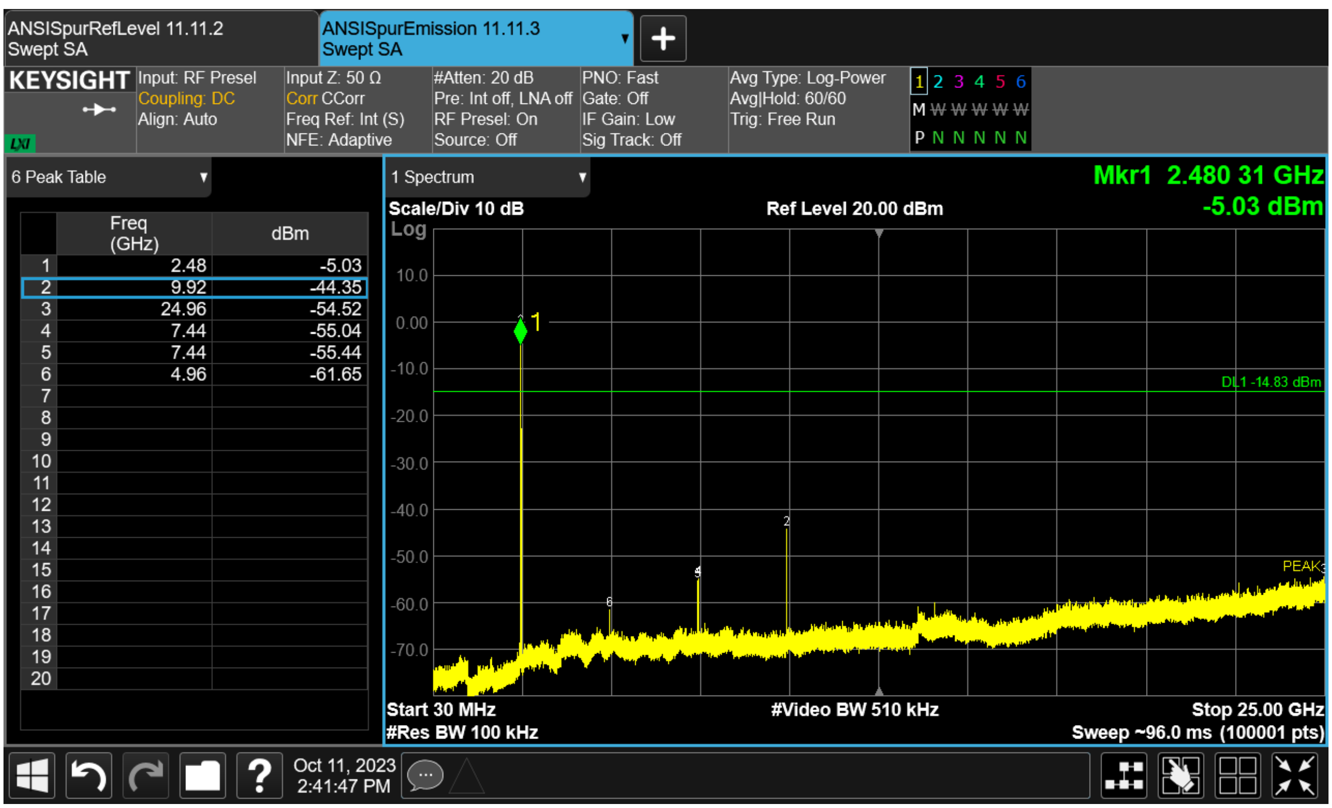


Figure TR13.4: Reference level measurement for ANT at 2480 MHz



	Freq (GHz)	dBm
1	2.48	-5.03
2	9.92	-44.35
3	24.96	-54.52
4	7.44	-55.04
5	7.44	-55.44
6	4.96	-61.65
7		
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Figure TR13.5 Spectral data for ANT at 2480 MHz

This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test ID TR14
Project GCL-0457

Test Date(s)	11 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M7 (WiFi Tx)
Arrangement	A2 (Upwr)
Input Power	5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-247 (as noted in Section 6 of the report).
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this test record:	**25 Oct 2023**

Original record, Version A.

Test Equipment

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

Table TR14.1: Test equipment used

Software used: Keysight PXE software A.35.06

Test Method

The basic test standards provide options for the test method. The following test methods were applied.
ANSI C63.10: 11.11.2 and 11.11.3

Test Setup

This block diagram shows the test equipment setup.

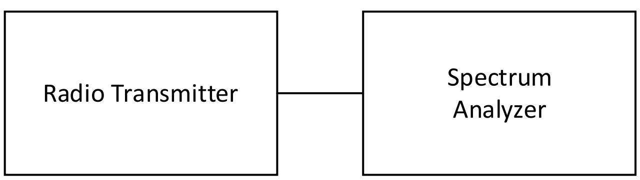


Figure TR14.1: Test setup

Test Data

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

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

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

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

The peak level of the fundamental is also identified. The harmonics or spurious emissions must be reduced from this fundamental level by 20 dBc. This harmonic limit is calculated and used to determine compliance. A reduction from the carrier that is greater that 20 is a passing result. The minimum margin from the peak level for each mode are highlighted in yellow.

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

		Channel No.				
Mode	Data rate (Mbps)	1	6	11	12	13
B	1	47.83	54.76	53.92	46.4	44.19
G	18	46.89	48.10	41.80	38.29	36.95
N	MCS2	46.00	48.36	41.31	38.17	36.78

Table TR14.2: Results Summary

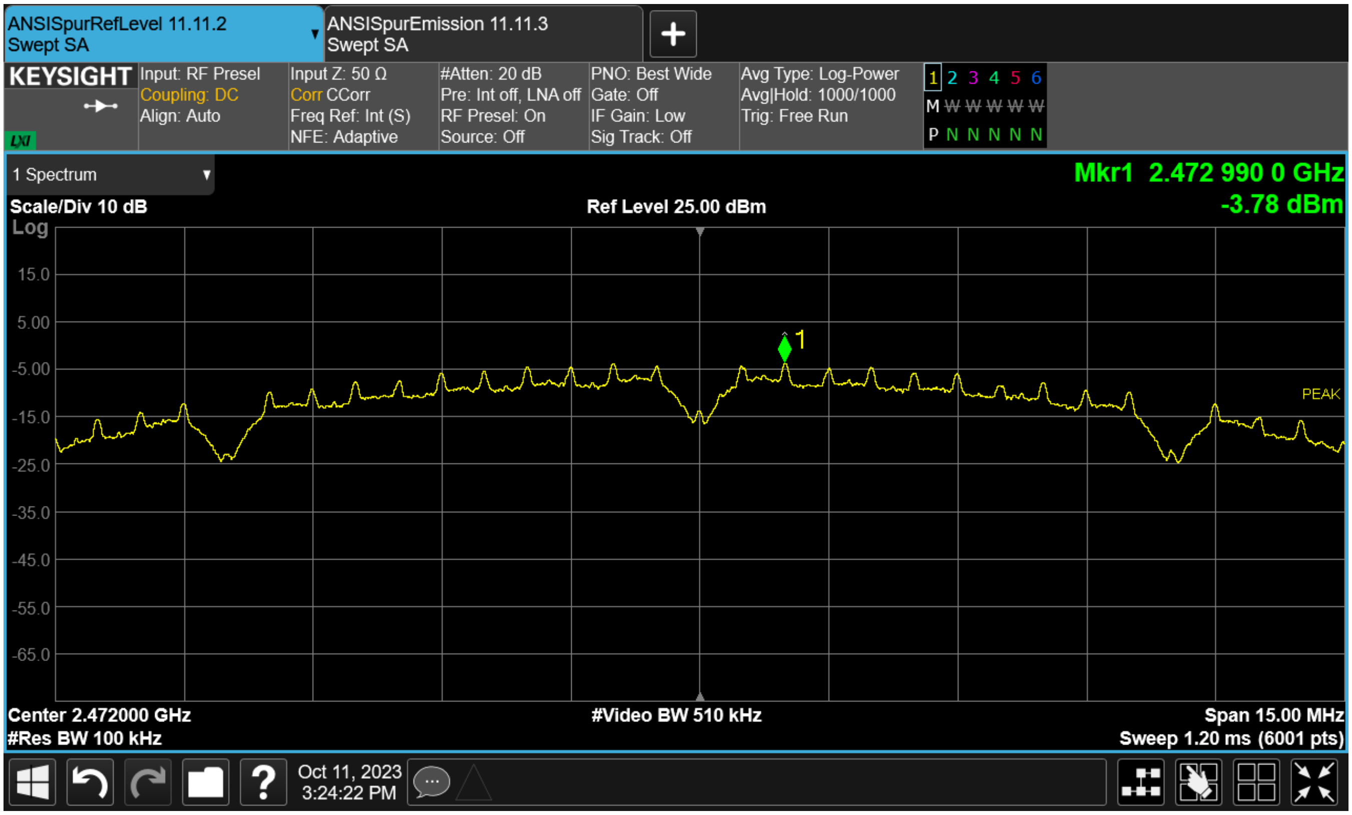


Figure TR14.2: Reference level measurement for IEEE 802.11 B 1 Mbps on Ch.13

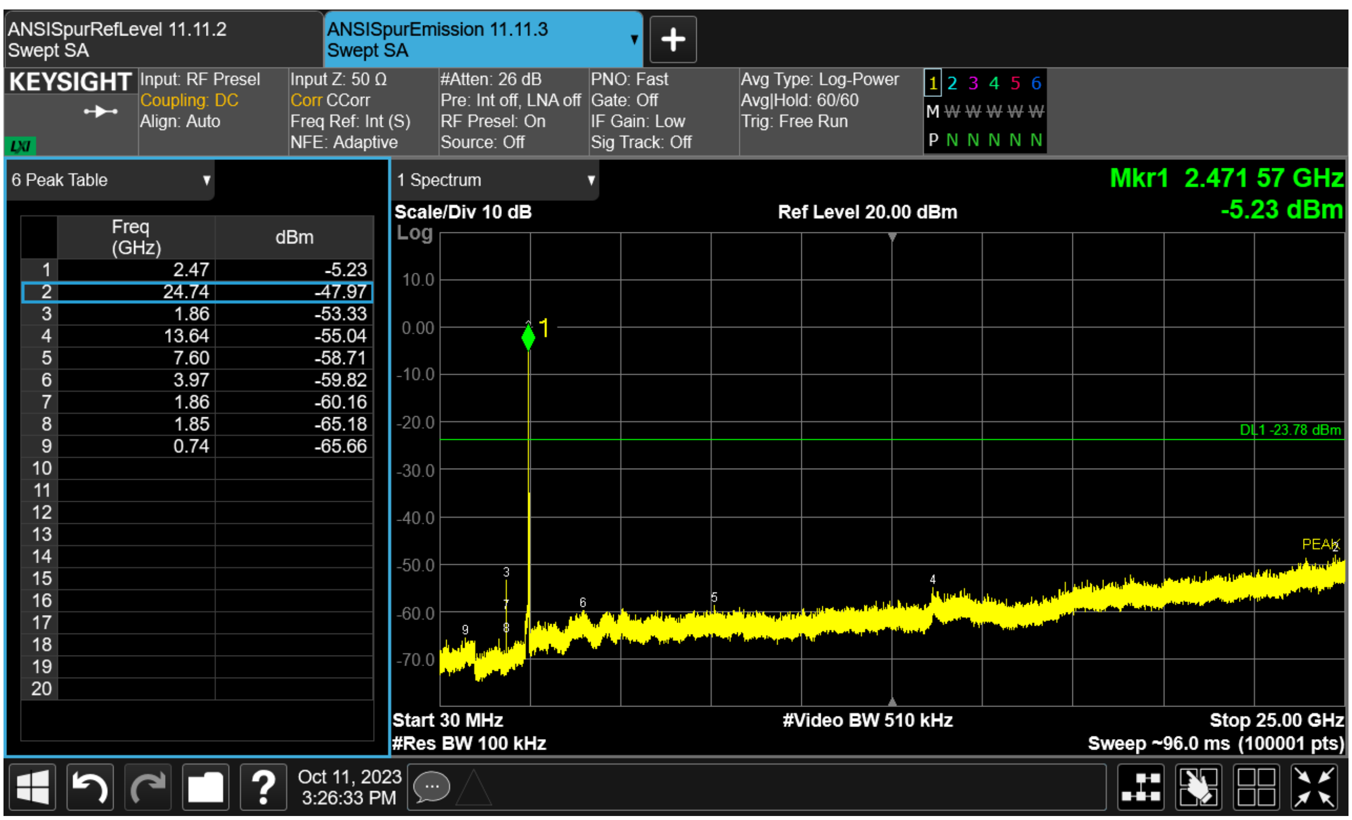


Figure TR14.3: Spectral data for IEEE 802.11 B 1 Mbps on Ch.13

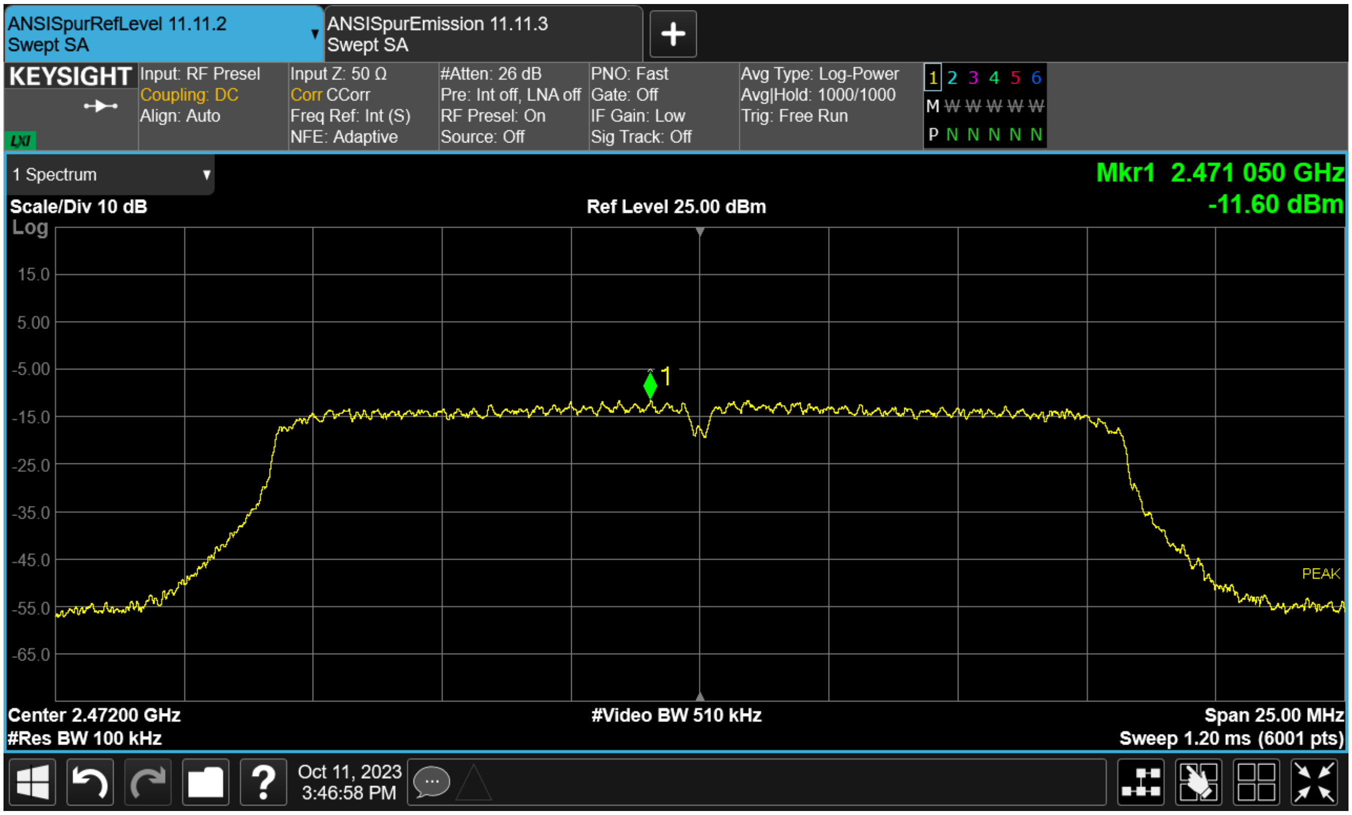


Figure TR14.4: Reference level measurement for IEEE 802.11 G 18 Mbps on Ch.13

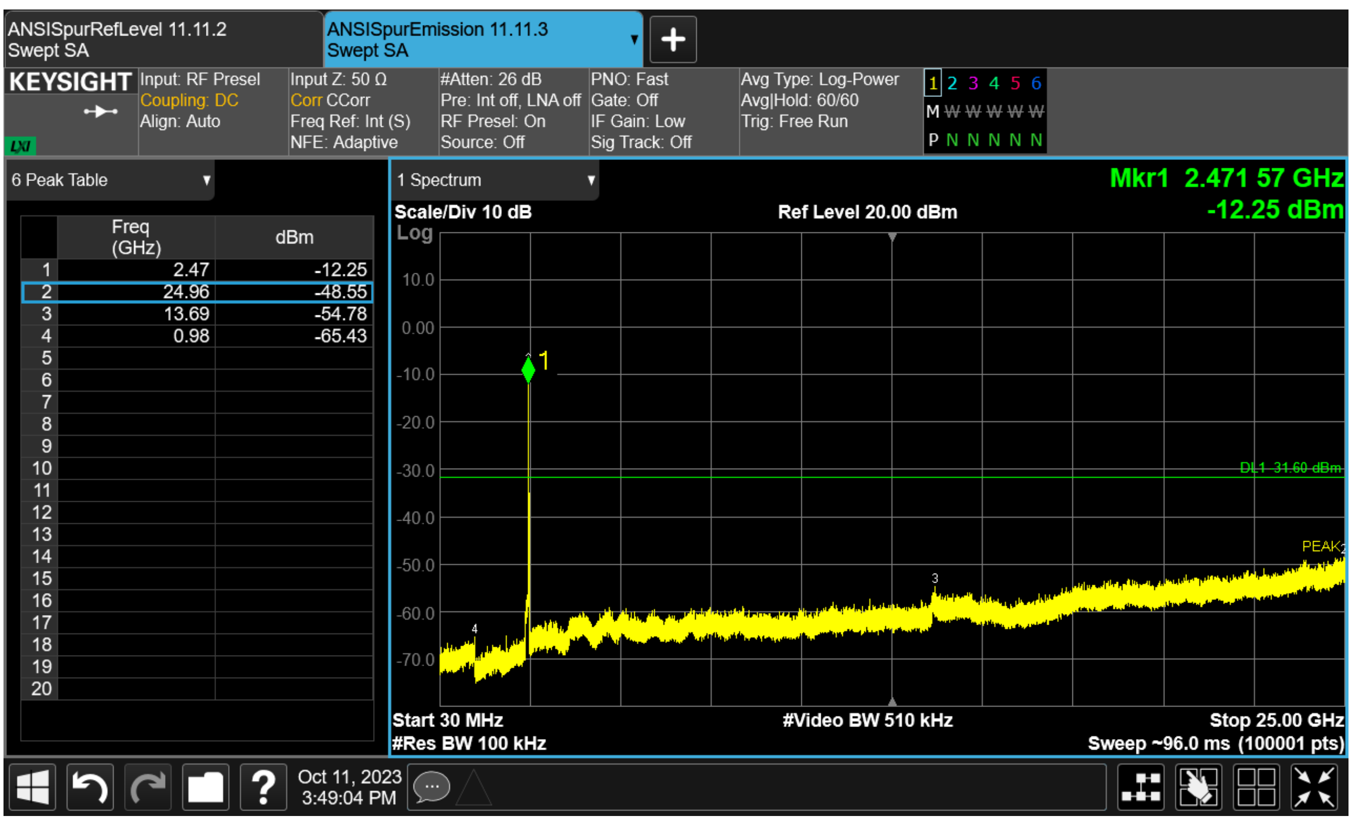


Figure TR14.5 Spectral data for IEEE 802.11 G 18 Mbps on Ch.13

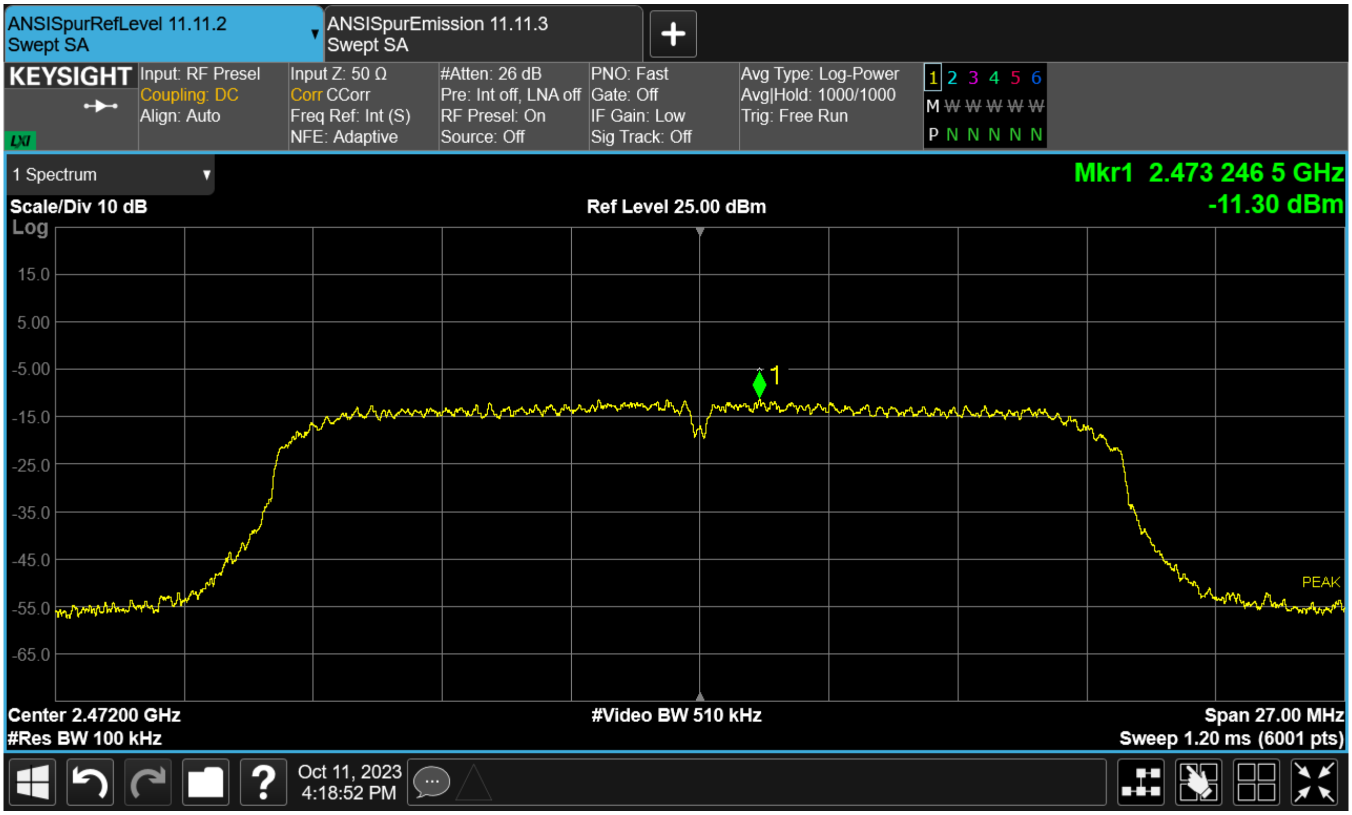
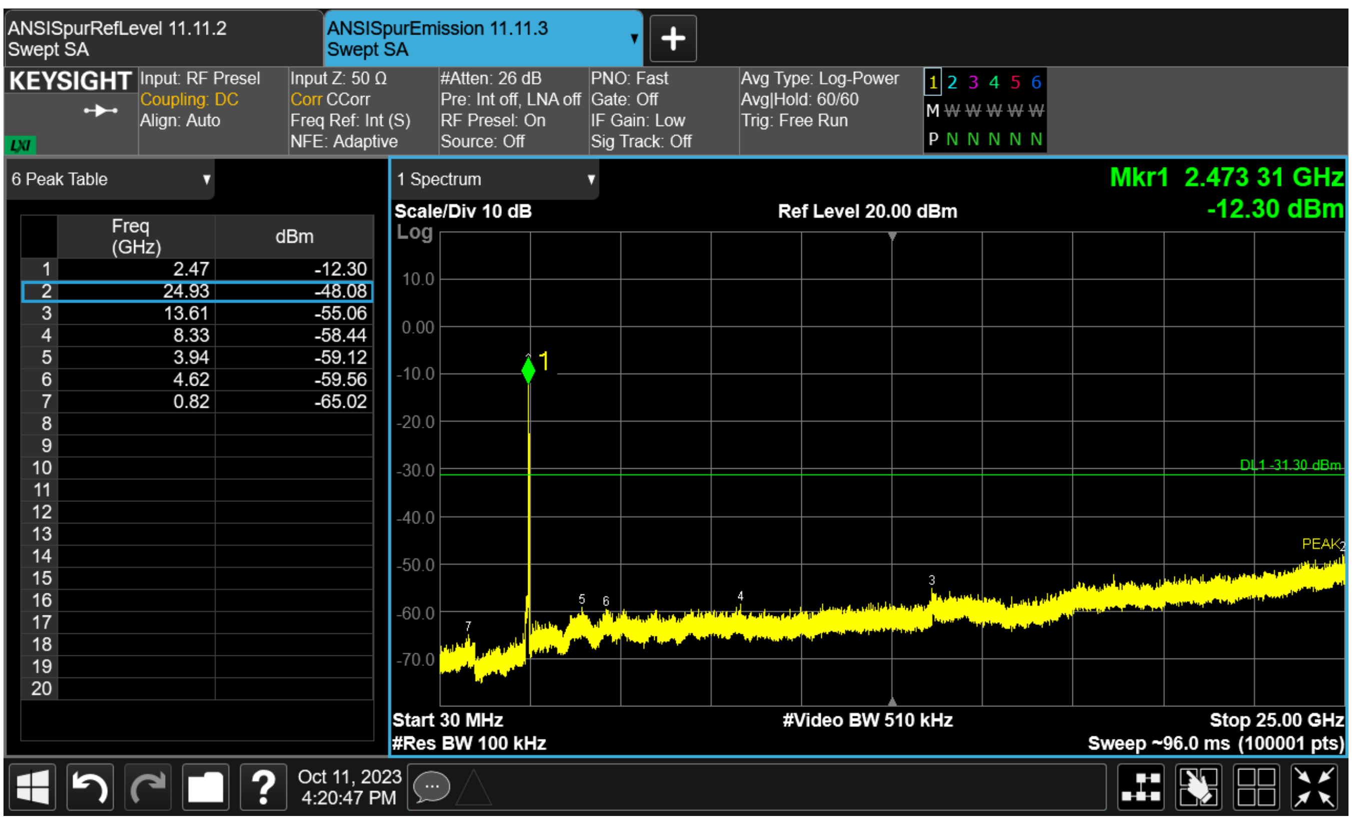


Figure TR14.6: Reference level measurement for IEEE 802.11 N MCS2 on Ch.13



	Freq (GHz)	dBm
1	2.47	-12.30
2	24.93	-48.08
3	13.61	-55.06
4	8.33	-58.44
5	3.94	-59.12
6	4.62	-59.56
7	0.82	-65.02
8		
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Figure TR14.7 Spectral data for IEEE 802.11 N MCS2 on Ch.13

This line is the end of the test record.

Test Record
Conducted Spurious Emissions
Test ID TR34
Project GCL-0457

Test Date(s) 11 Oct 2023
Test Personnel Majid Farah

Product Model AA4714
Serial Number tested 3453413911

Operating Mode M1 (Bt Tx)
Arrangement A2 (Upwr)
Input Power 5 Vdc

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

Pass/Fail Judgment: PASS

Test record created by: Jim Solum
Date of this test record: 24 Oct 2023

Original record, Version A.

Test Equipment

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

Table TR34.1: Test equipment used

Software used: Keysight PXE software A.35.06

Test Method

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

ANSI C63.10: 11.11.2 and 11.11.3

Test Setup

This block diagram shows the test equipment setup.

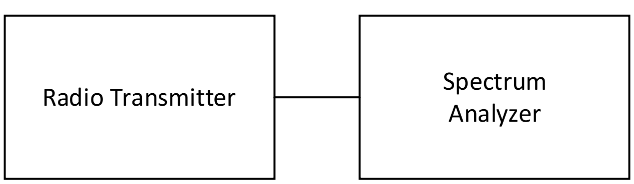

Figure TR34.1: Test setup

Test Data

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

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

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

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

The peak level of the fundamental is also identified. The harmonics or spurious emissions must be reduced from this fundamental level by 20 dBc. This harmonic limit is calculated and used to determine compliance. A reduction from the carrier that is greater that 20 is a passing result. The minimum margin from the peak level for each mode are highlighted in yellow.

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

	Frequency (MHz)		
	2402	2440	2480
Bluetooth BR	62.79	62.34	59.36

Table TR34.2: Results Summary

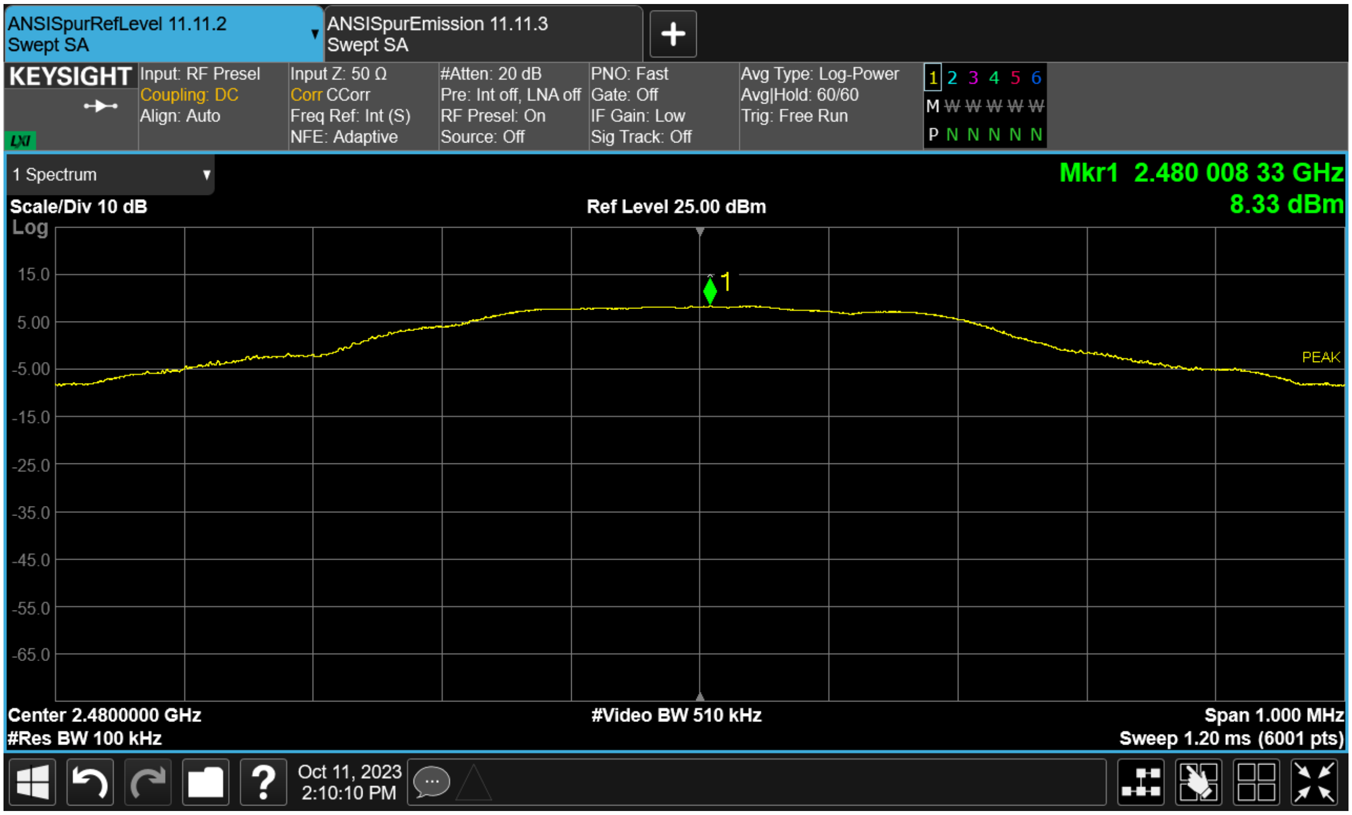

Figure TR13.2: Reference level measurement for Bluetooth Basic Rate at 2480 MHz

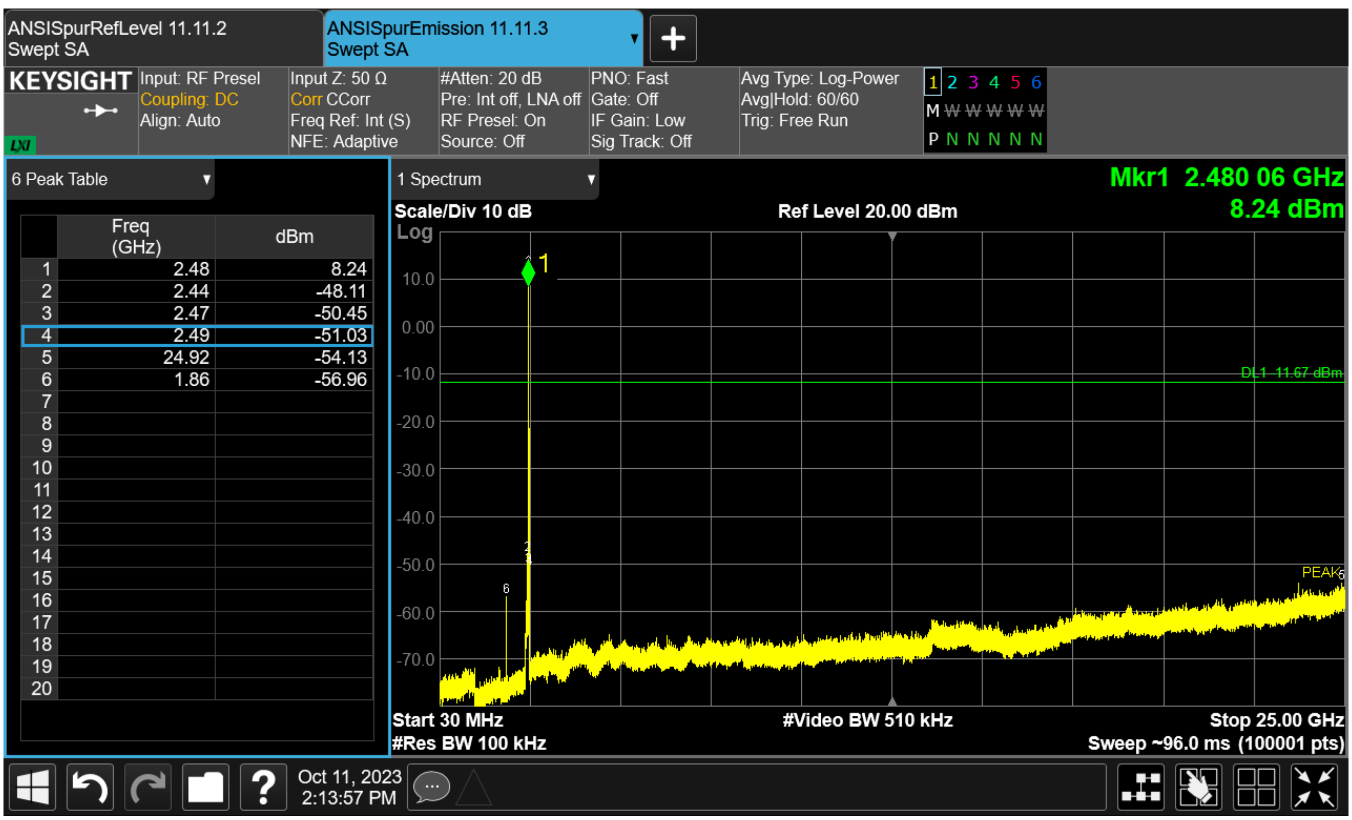

Figure TR13.3 Spectral data for Bluetooth Basic Rate at 2480 MHz

This line is the end of the test record.

Test Record
Radiated Emission Test RE01
Project GCL0457

Test Date(s)	15 Sep 2023, 18 Sep 2023
Test Personnel	David Kerr, Jim Solum
Product Model	AA4714
Serial Number tested	3453413922
Operating Mode	M1 (Bt Tx)
Arrangement	A2 (Upwr)
Input Power	USB 5 Vdc
Test Standards:	FCC Part 15, RSS-Gen (as noted in Section 6 of the report).
Frequency Range:	2200-2390 MHz and 2483.5 to 2500 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**22-Sep-2023**

Original record, Version A.

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. Measurements in the upper band were made while the transmitter was tuned to its highest frequency of 2480 MHz.

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 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	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2387.8	54	74	34.852	48.205	19.148	25.795	170	1785	VERT	Z
2390	54	74	35.222	48.658	18.778	25.342	170	1785	VERT	Z

Table RE01.2: FCC restricted band from 2200 to 2390 MHz (Z orientation) Basic Rate

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2483.5	54	74	40.779	54.606	13.221	19.394	0	1050	HORZ	X
2483.5	54	74	40.751	54.826	13.249	19.174	0	1050	HORZ	X

Table RE01.3: FCC restricted band from 2483.5 to 2500 MHz (X orientation) Basic Rate

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2389.5	54	74	35.248	49.093	18.752	24.907	170	1785	VERT	Z
2390	54	74	35.311	48.995	18.689	25.005	170	1785	VERT	Z

Table RE01.4: BT EDR2 FCC restricted band from 2200 to 2390 MHz (Z orientation)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2483.5	54	74	41.108	55.573	12.892	18.427	0	1050	HORZ	X
2483.5	54	74	41.116	56.29	12.884	17.71	0	1050	HORZ	X

Table RE01.5: BT EDR2 FCC restricted band from 2483.5 to 2500 MHz (X orientation)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2388.5	54	74	35.909	49.952	18.091	24.048	170	1785	VERT	Z
2390	54	74	36.183	50.403	17.817	23.597	170	1785	VERT	Z

Table RE01.6: BT EDR3 FCC restricted band from 2200 to 2390 MHz (Z orientation)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2483.5	54	74	41.339	55.763	12.661	18.237	0	1050	HORZ	X
2483.5	54	74	41.318	55.513	12.682	18.487	0	1050	HORZ	X

Table RE01.7: BT EDR3 FCC restricted band from 2483.5 to 2500 MHz (X orientation)

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

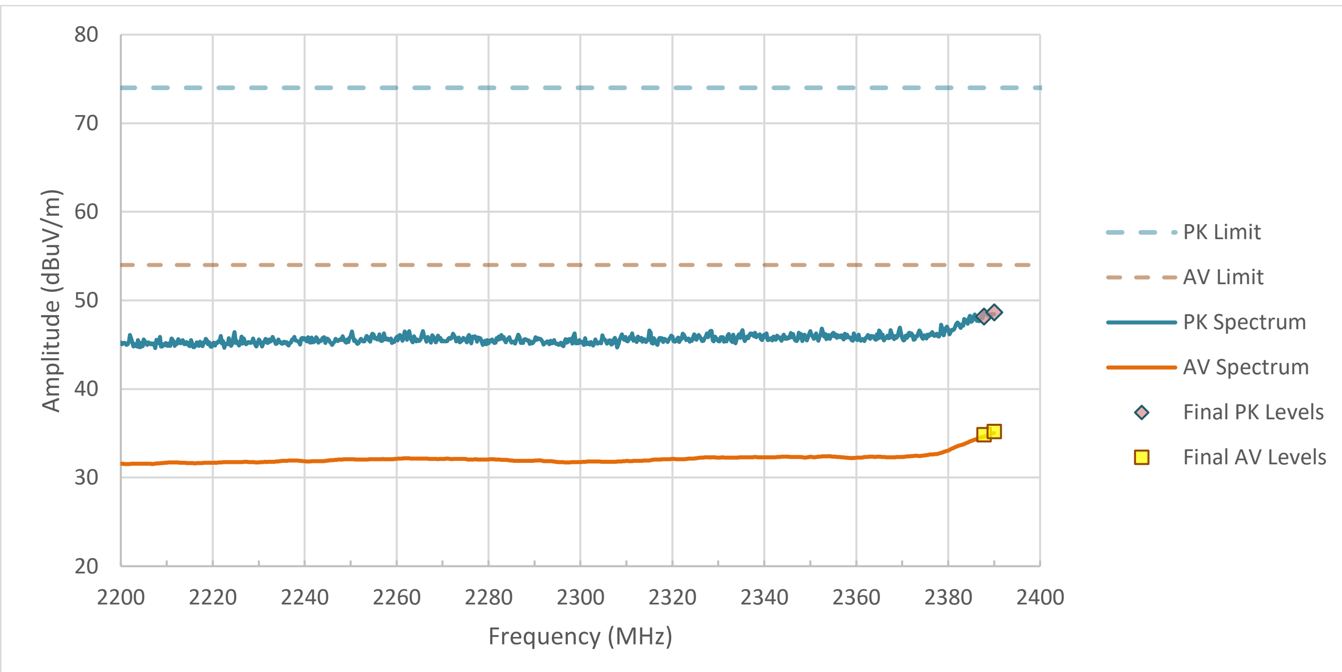

Figure RE01.1: FCC restricted band spectral data from 2200 to 2390 MHz (Basic Rate)

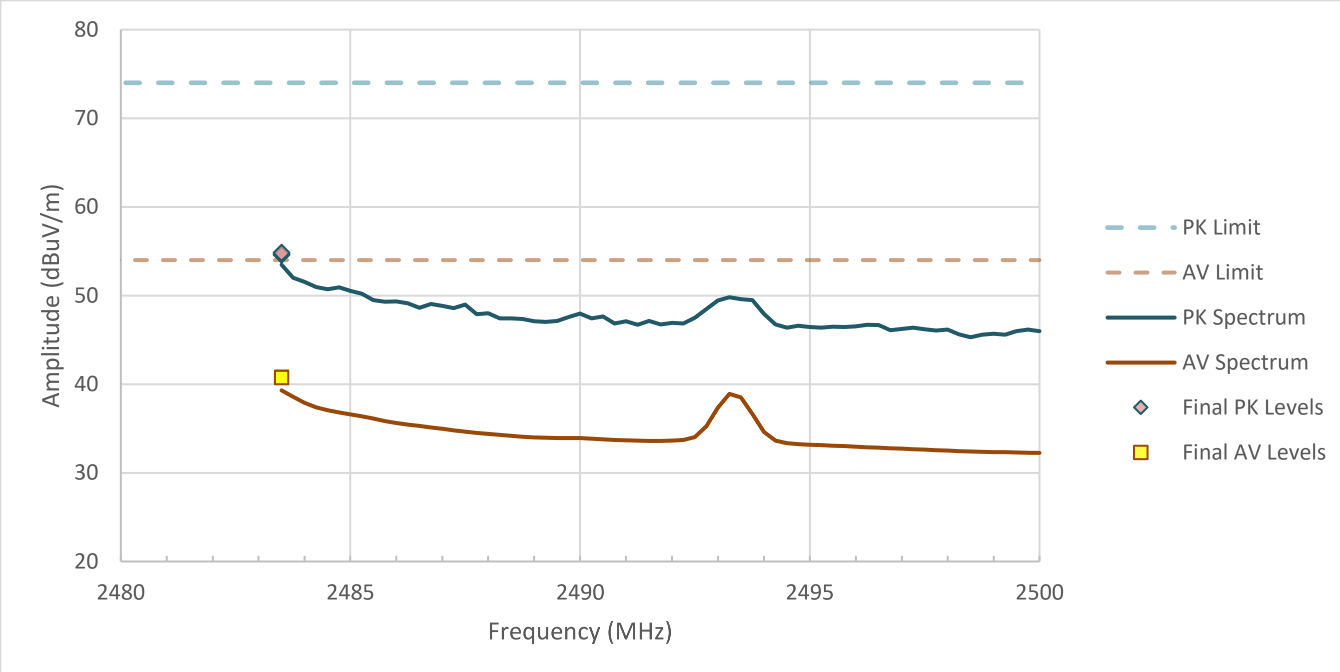

Figure RE01.2: FCC restricted band spectral data from 2483.5 to 2500 MHz (Basic Rate)

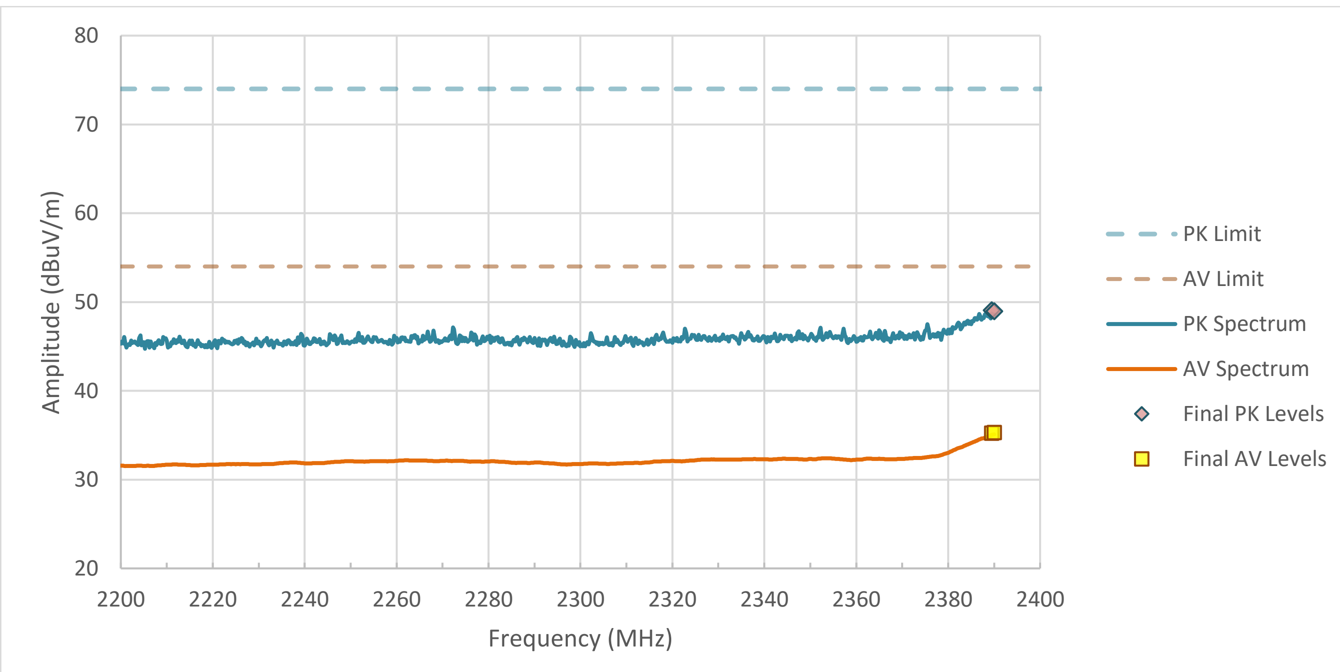

Figure RE01.3: BT EDR2 FCC restricted band spectral data from 2200 to 2390 MHz

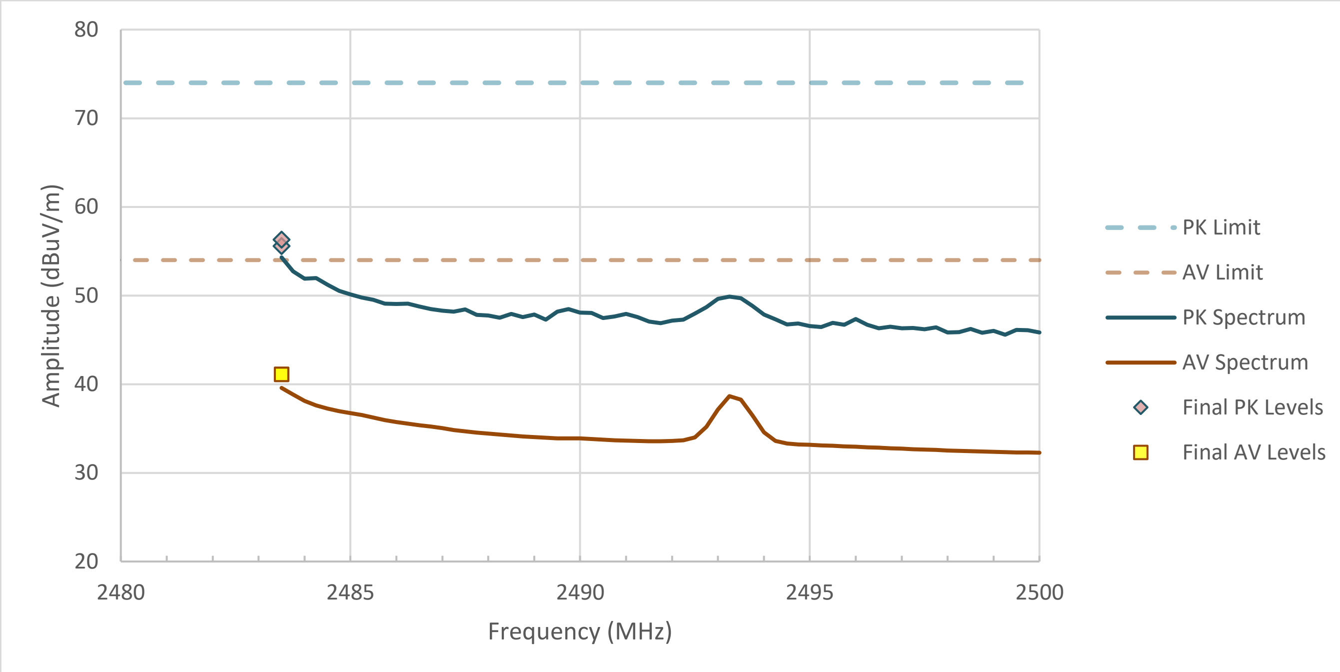

Figure RE01.4: BT EDR2 FCC restricted band spectral data from 2483.5 to 2500 MHz

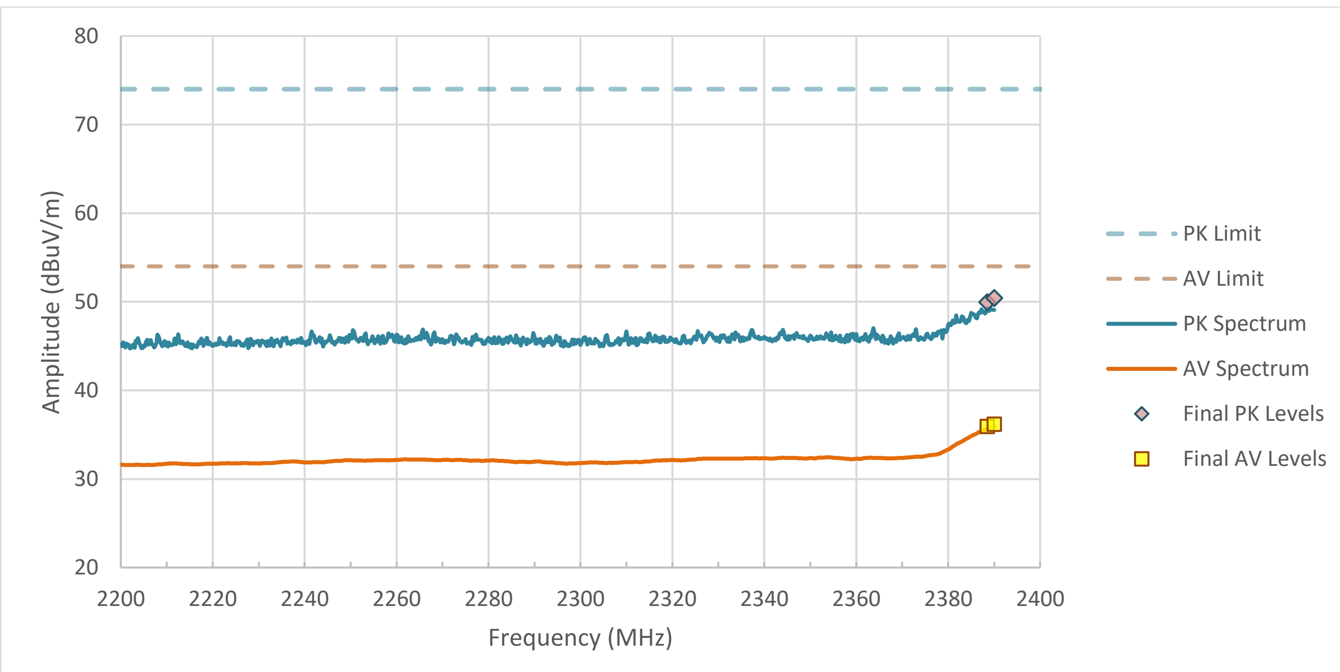

Figure RE01.5: BT EDR3 FCC restricted band spectral data from 2200 to 2390 MHz

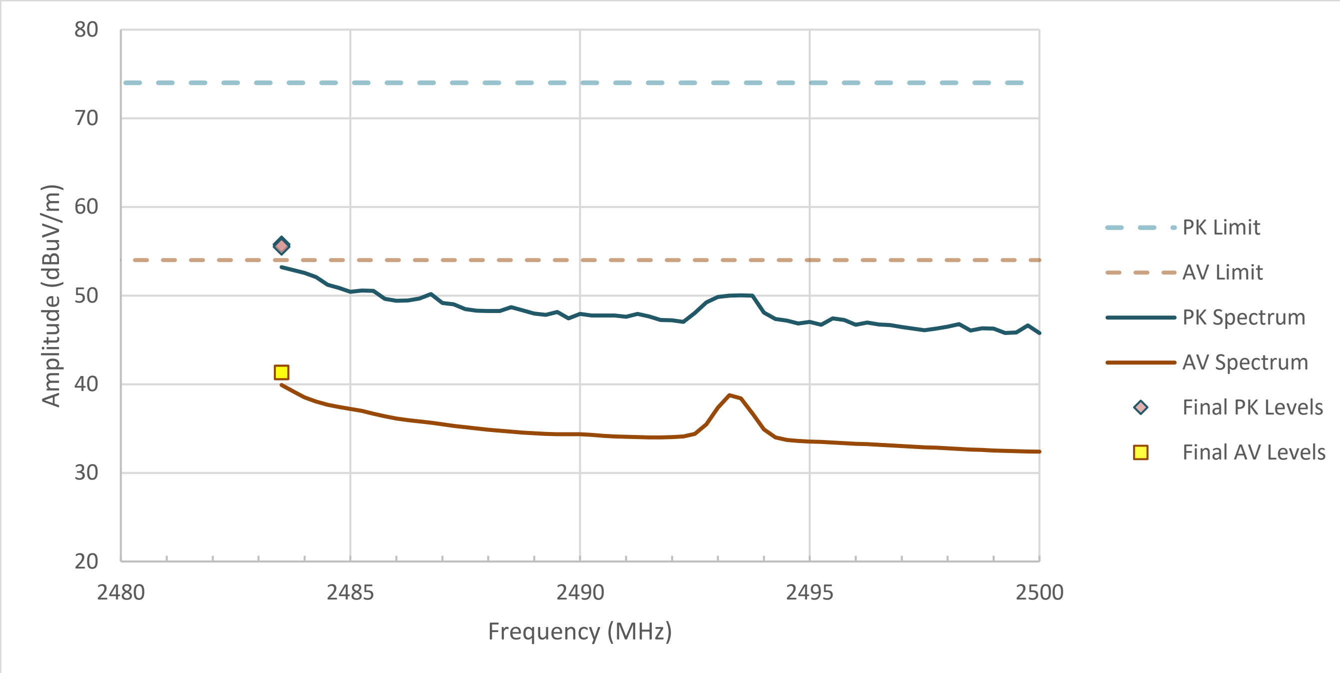

Figure RE01.6: BT EDR3 FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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

Figure RE01.7: EUT test setup X orientation (front view)

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

Figure RE01.8: EUT test setup X orientation (rear view)

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

Figure RE01.9: EUT test setup Z orientation (front view)

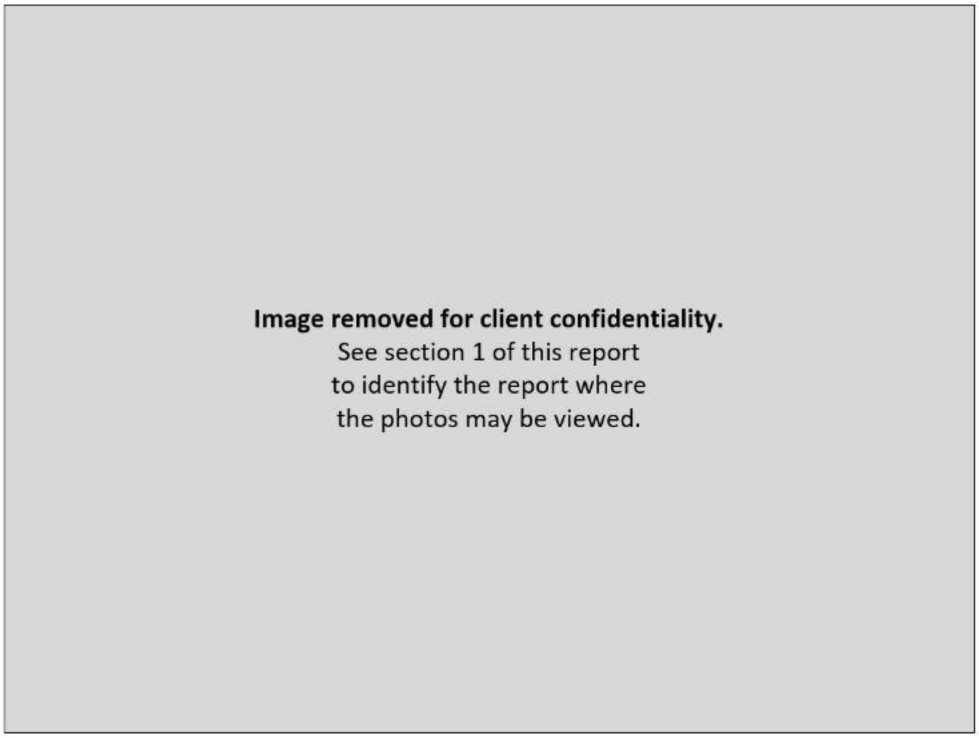

Figure RE01.10: EUT test setup Z orientation (rear view)

This line is the end of the test record.

Test Record
Radiated Emission Test RE02
Project GCL0457

Test Date(s)	15 Sep 2023, 18 Sep 2023
Test Personnel	David Kerr, Jim Solum
Product Model	AA4714
Serial Number tested	3453413922
Operating Mode	M3 (BLE Tx)
Arrangement	A2 (Upwr)
Input Power	USB 5 Vdc
Test Standards:	FCC Part 15, RSS-Gen (as noted in Section 6 of the report).
Frequency Range:	2200-2390 MHz and 2483.5 to 2500 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**22-Sep-2023**

Original record, Version A.

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 RE02.1: 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 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	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2389.3	54	74	38.424	49.964	15.576	24.036	170	1785	VERT	Z
2389	54	74	38.518	49.849	15.482	24.151	170	1785	VERT	Z

Table RE02.2: FCC restricted band from 2200 to 2390 MHz (Z orientation)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2483.5	54	74	46.212	56.989	7.788	17.011	0	1050	HORZ	X
2483.5	54	74	46.2	56.783	7.8	17.217	0	1050	HORZ	X

Table RE02.3: FCC restricted band from 2483.5 to 2500 MHz (X orientation)

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

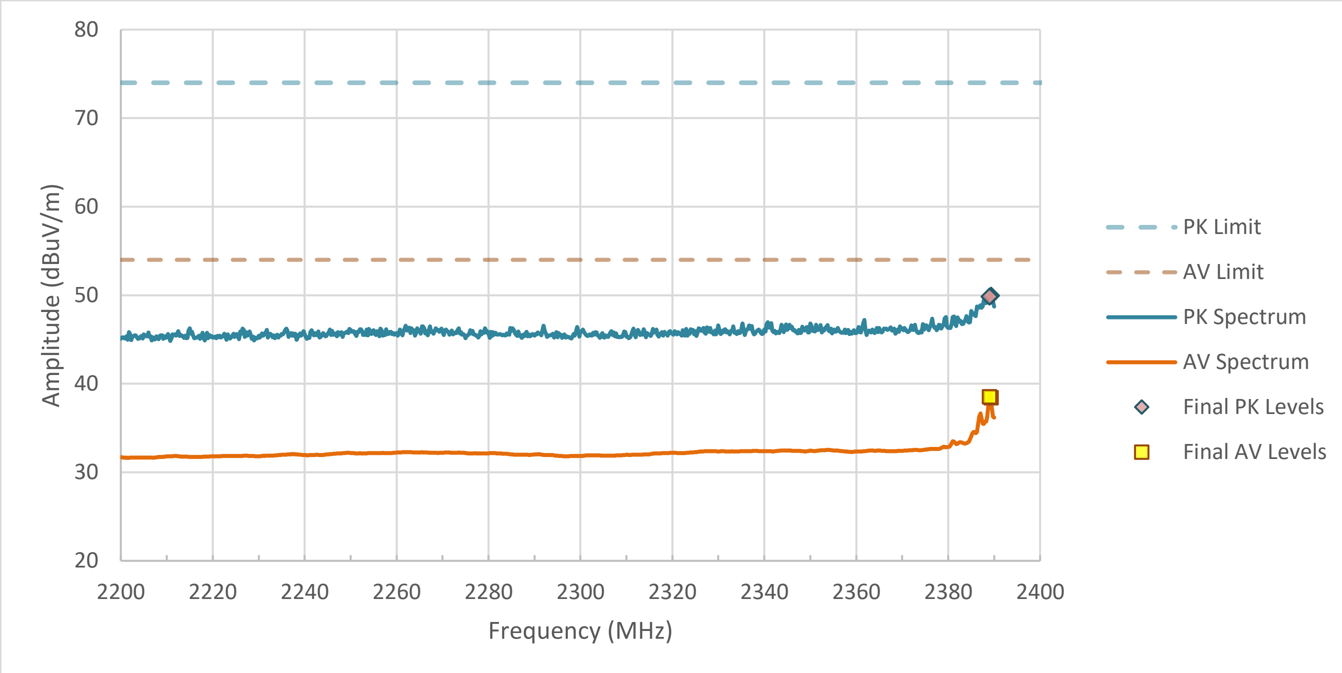

Figure RE02.1: FCC restricted band spectral data from 2200 to 2390 MHz

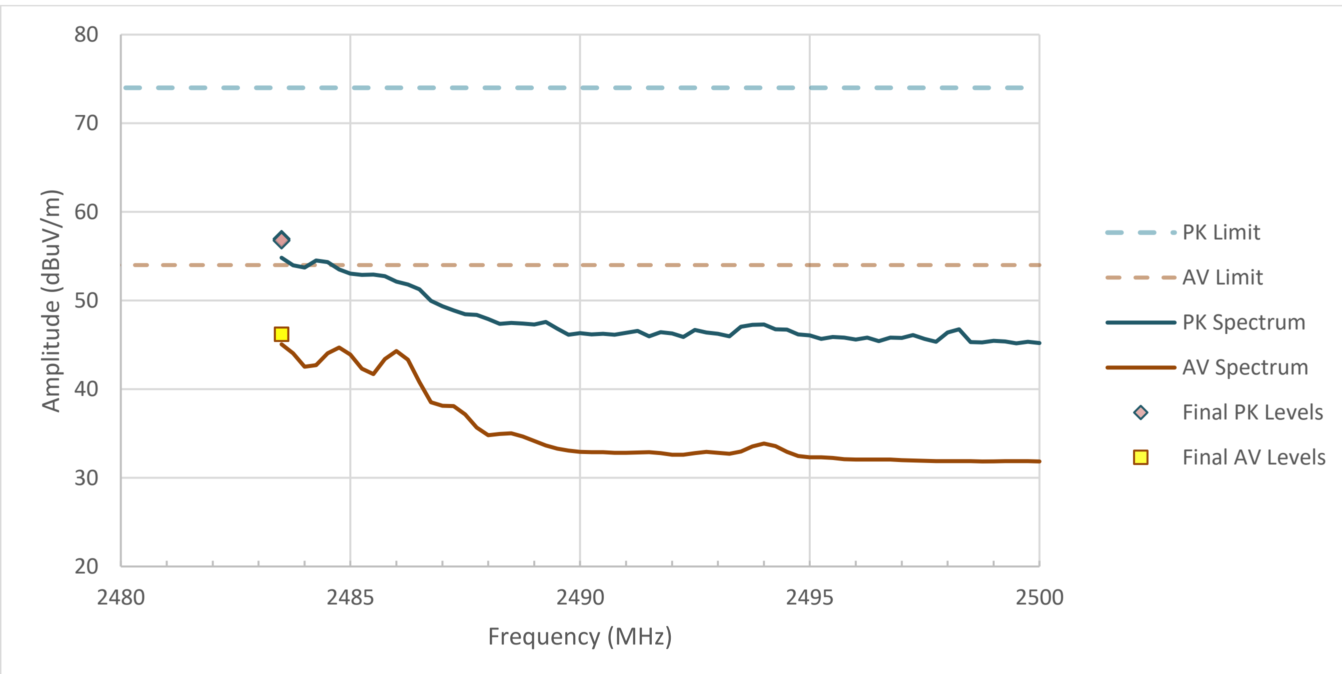

Figure RE02.2: FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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

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

Figure RE02.3: EUT test setup X orientation (front view)

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

Figure RE02.4: EUT test setup X orientation (rear view)

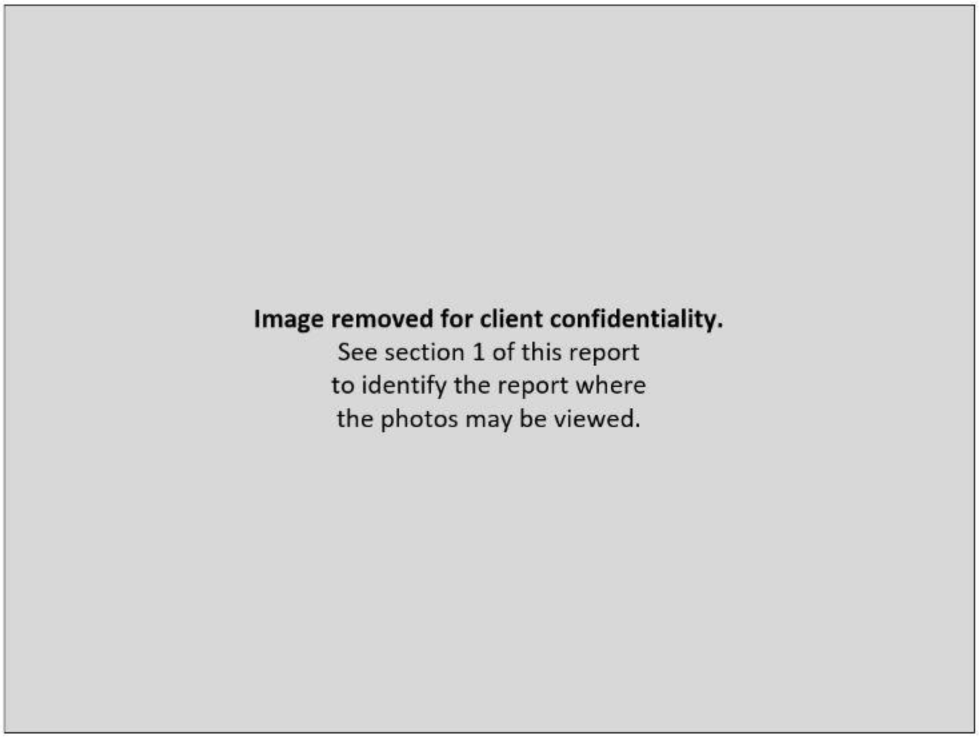

Figure RE02.5: EUT test setup Z orientation (front view)

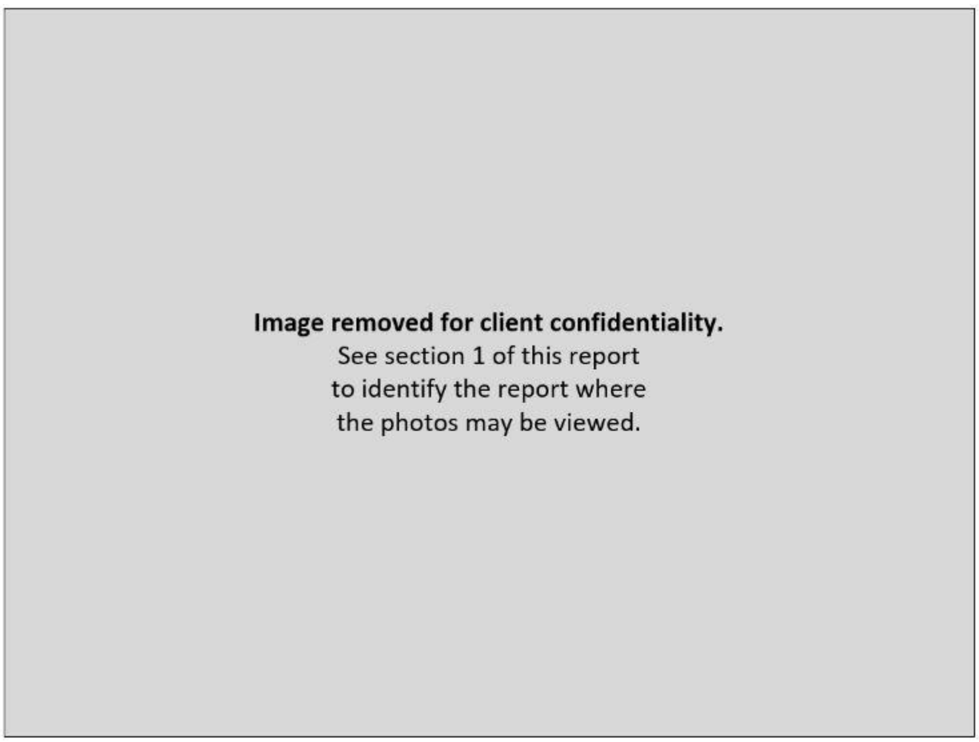

Figure RE02.6: EUT test setup Z orientation (rear view)

This line is the end of the test record.

Test Record
Radiated Emission Test RE03
Project GCL0457

Test Date(s)	15 Sep 2023, 18 Sep 2023
Test Personnel	David Kerr, Jim Solum
Product Model	AA4714
Serial Number tested	3453413922
Operating Mode	M5 (ANT Tx)
Arrangement	A2 (Upwr)
Input Power	USB 5 Vdc
Test Standards:	FCC Part 15, RSS-Gen (as noted in Section 6 of the report).
Frequency Range:	2200-2390 MHz and 2483.5 to 2500 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**David A Kerr**
Date of this record:	**27-Sep-2023**

Original record, Version A.

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 RE03.1: 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. Measurements in the upper band were made while the transmitter was tuned to its highest frequency of 2480 MHz.

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 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	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2389.8	54	74	33.715	47.8	20.285	26.2	170	1785	VERT	Z
2390	54	74	33.74	47.48	20.26	26.52	170	1785	VERT	Z

Table RE03.2: FCC restricted band from 2200 to 2390 MHz (Z orientation)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2484.3	54	74	40.518	52.185	13.482	21.815	0	1050	HORZ	X
2484	54	74	41.048	52.007	12.952	21.993	0	1050	HORZ	X

Table RE03.3: FCC restricted band from 2483.5 to 2500 MHz (X orientation)

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

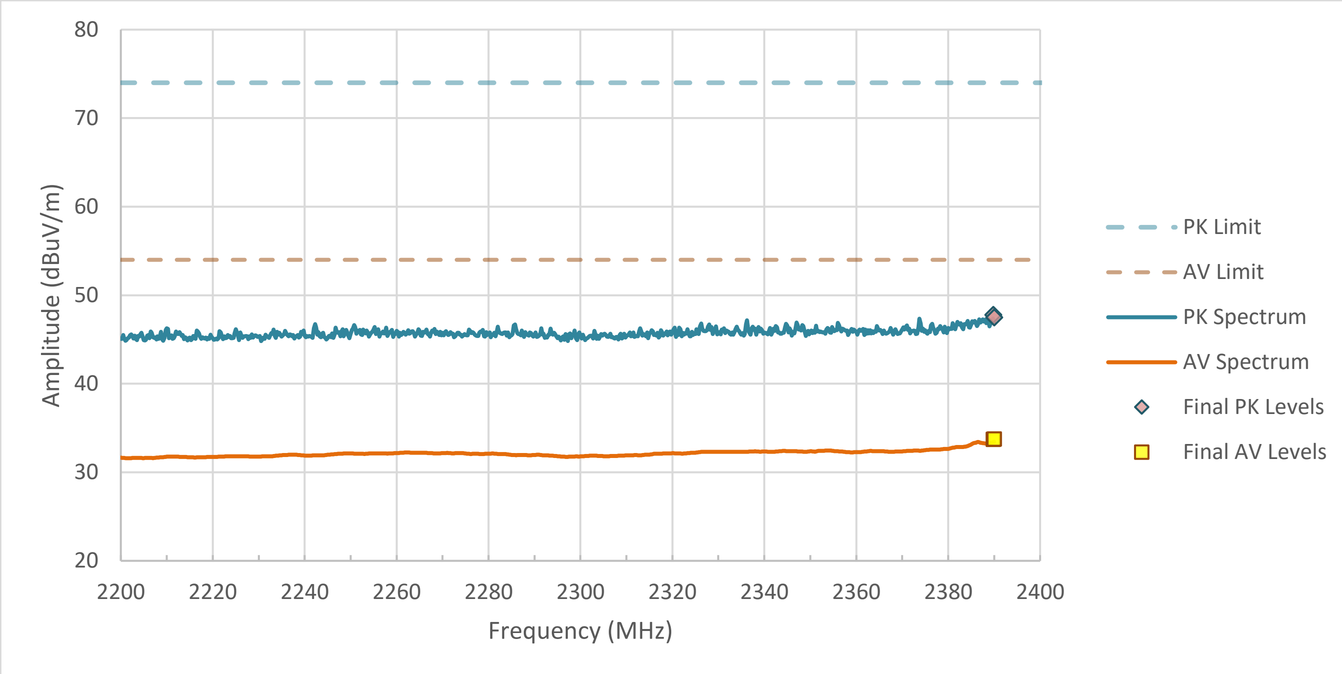

Figure RE03.1: FCC restricted band spectral data from 2200 to 2390 MHz

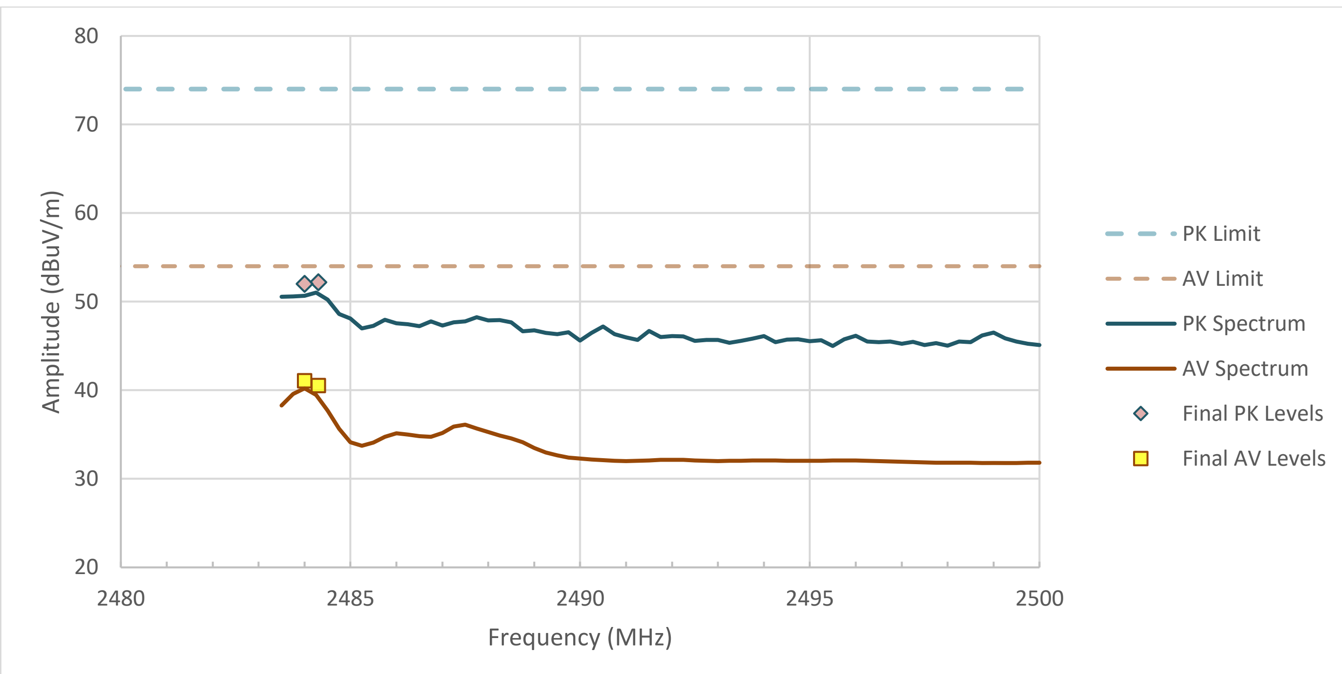

Figure RE03.2: FCC restricted band spectral data from 2483.5 to 2500 MHz

Setup Photographs

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

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

Figure RE03.3: EUT test setup X orientation (front view)

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

Figure RE03.4: EUT test setup X orientation (rear view)

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

Figure RE03.5: EUT test setup Z orientation (front view)

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

Figure RE03.6: EUT test setup Z orientation (rear view)

This line is the end of the test record.

Test Record
Radiated Emission Test RE04
Project GCL0457

Test Date(s) 15 Sep 2023, 18 Sep 2023
Test Personnel David Kerr, Jim Solum

Product Model AA4714
Serial Number tested 3453413922

Operating Mode M7 (WiFi Tx)
Arrangement A2 (Upwr)
Input Power USB 5 Vdc

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

Frequency Range: 2200-2390 MHz and 2483.5 to 2500 MHz
Pass/Fail Judgment: PASS

Test record created by: David A Kerr
Date of this record: 27-Sep-2023
Original record, Version A.

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 RE04.1: 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 channel 1. Measurements in the upper band were made while the transmitter was tuned to channels 11,12 and 13.

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 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	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2389	54	74	39.796	53.656	14.204	20.344	170	1785	VERT	Z
2390	54	74	39.979	53.966	14.021	20.034	170	1785	VERT	Z

Table RE04.2: FCC restricted band from 2200 to 2390 MHz (Z orientation) B11, Ch1

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2484.5	54	74	41.718	55.2	12.282	18.8	0	1050	HORZ	X
2483.5	54	74	42.265	55.862	11.735	18.138	0	1050	HORZ	X

Table RE04.3: FCC restricted band from 2483.5 to 2500 MHz (X orientation) B11, Ch 11

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2483.8	54	74	43.642	56.354	10.358	17.646	0	1050	HORZ	X
2483.5	54	74	44.047	56.305	9.953	17.695	0	1050	HORZ	X

Table RE04.4: FCC restricted band from 2483.5 to 2500 MHz (X orientation) B11, Ch 12

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity	Orientation
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---	
2484	54	74	41.695	55.19	12.305	18.81	0	1050	HORZ	X
2485.3	54	74	42.085	54.481	11.915	19.519	0	1050	HORZ	X

Table RE04.5: FCC restricted band from 2483.5 to 2500 MHz (X orientation) B11, Ch 13

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

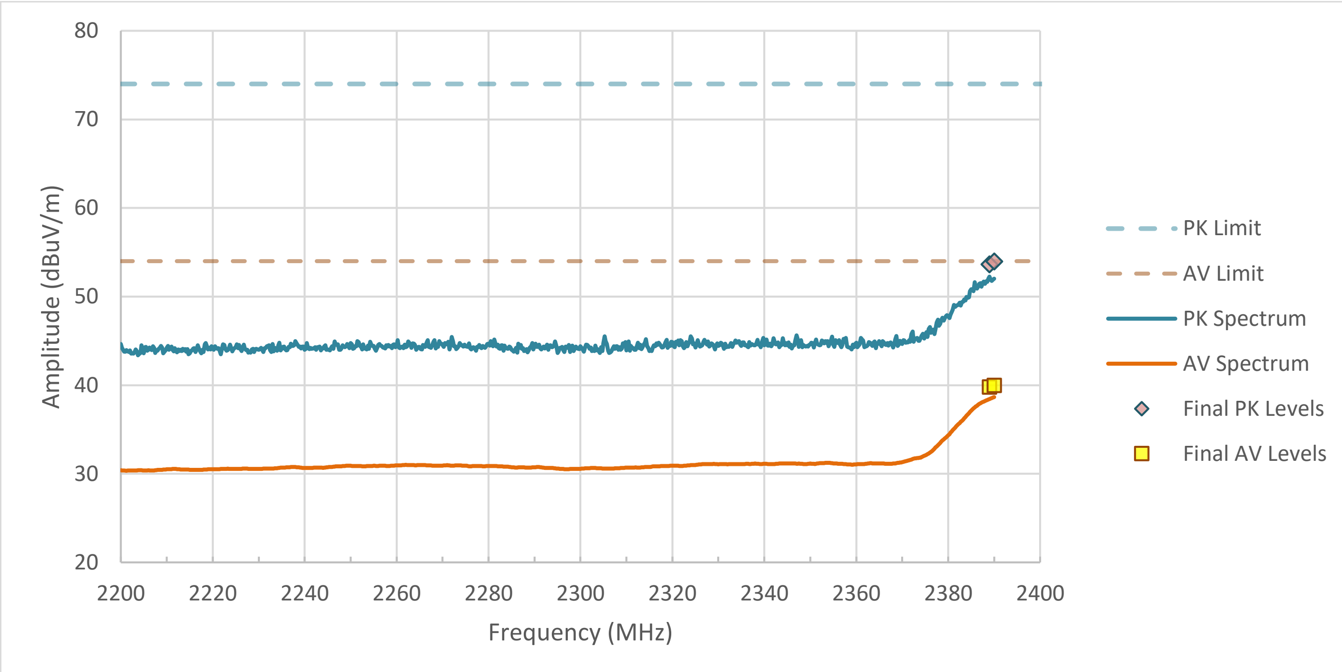

Figure RE04.1: FCC restricted band spectral data from 2200 to 2390 MHz Ch 1

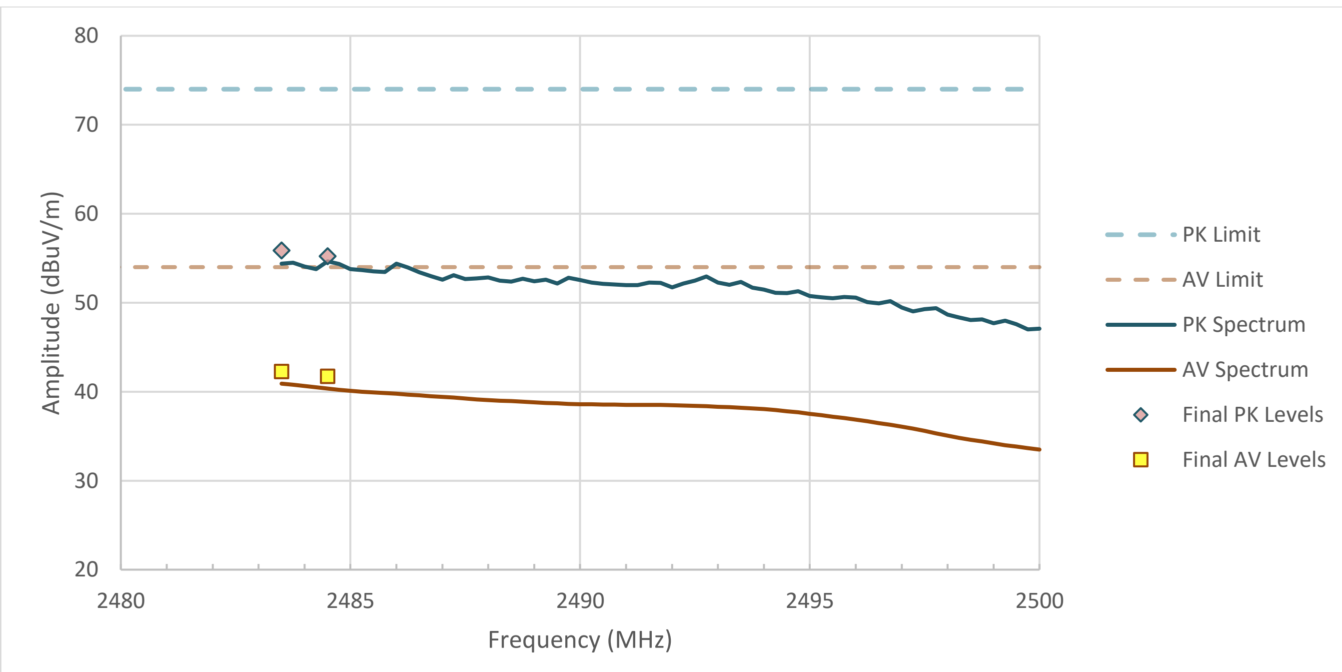

Figure RE04.2: FCC restricted band spectral data from 2483.5 to 2500 MHz Ch 11

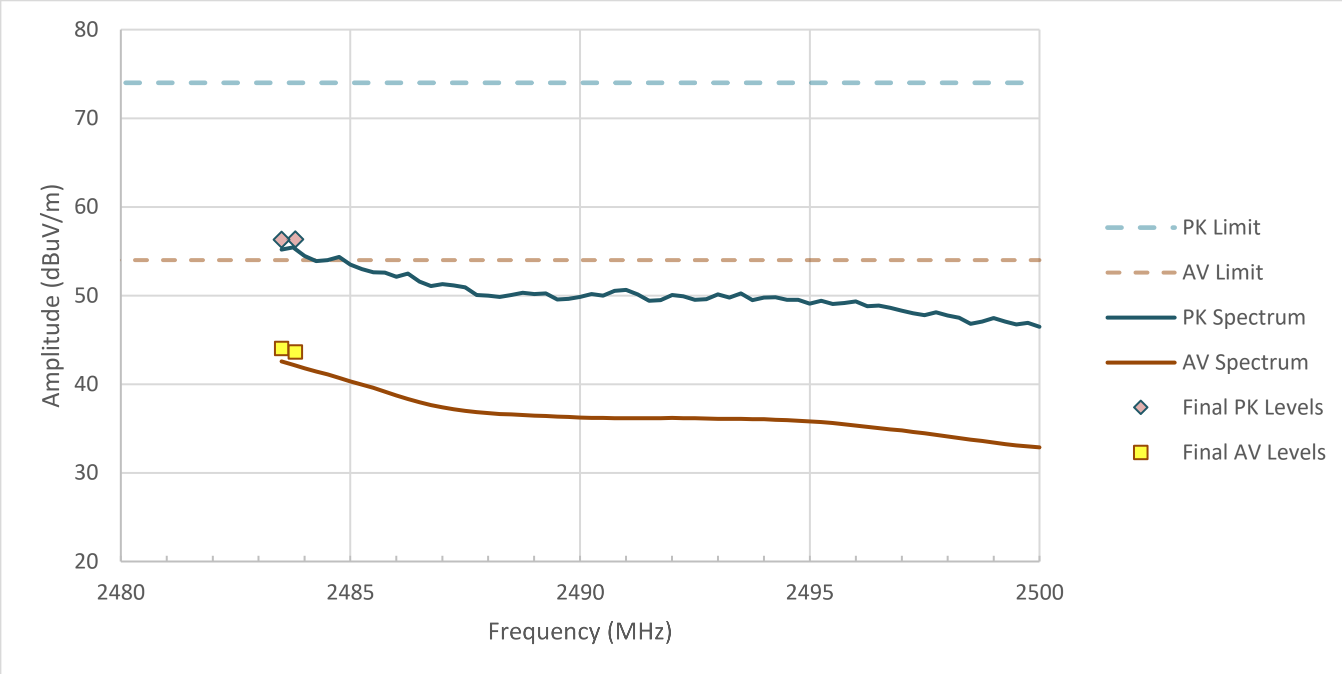

Figure RE04.3: FCC restricted band spectral data from 2483.5 to 2500 MHz Ch 12

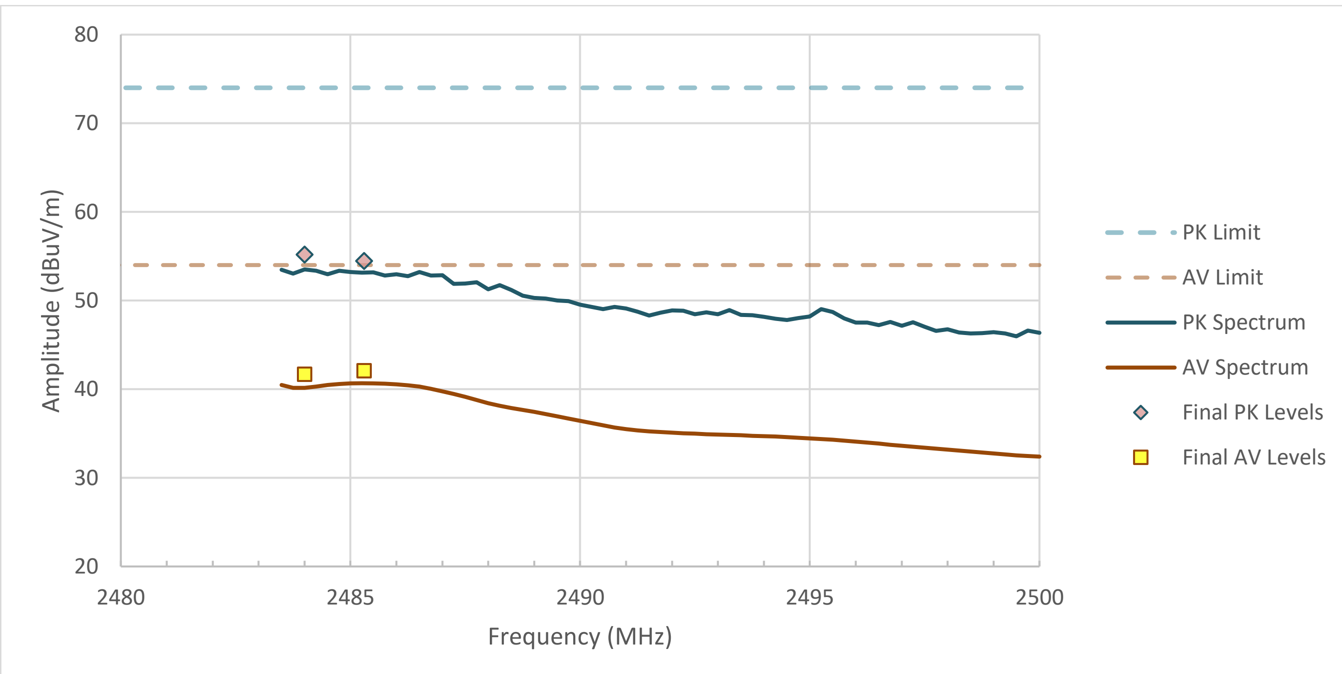

Figure RE04.4: FCC restricted band spectral data from 2483.5 to 2500 MHz Ch 13

Setup Photographs

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

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

Figure RE04.5: EUT test setup X orientation (front view)

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

Figure RE04.6: EUT test setup X orientation (rear view)

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

Figure RE04.7: EUT test setup Z orientation (front view)

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

Figure RE04.8: EUT test setup Z orientation (rear view)

This line is the end of the test record.

Test Record

Transmitter Power Spectral Density
Test IDs TR05, TR06
Project GCL-0457

Test Date(s) 10 Oct 2023
Test Personnel Majid Farah

Product Model AA4714
Serial Number tested 3453413911

Operating Mode M3 (Ble Tx), M5 (ANT Tx)
Arrangement A2 (Upwr)
Input Power 5Vdc

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

Antenna Gain -0.3 dBi, as reported by the client
Radio Protocol Bluetooth Low Energy (BLE), ANT

Pass/Fail Judgment: PASS

Test record created by: Jim Solum
Date of this record: 25 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 TR05.1: Test equipment used

Software Used: Keysight PXE software A.35.06

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.

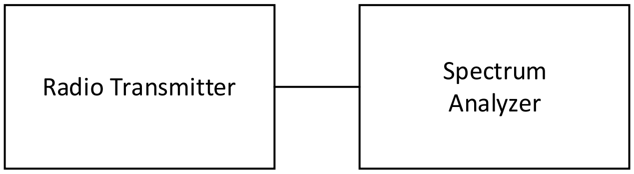

Figure TR05.1: Test setup

Test Data

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

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

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

	2402 (04)	2440	2480 (78)
BLE 1 Mbps	**-16.31**	**-11.01**	**-18.54**
BLE 2 Mbps	**-13.17**	**-12.94**	**-18.89**
ANT	**-18.79**	**-12.57**	**-20.24**

Table TR05.2: Summary of results

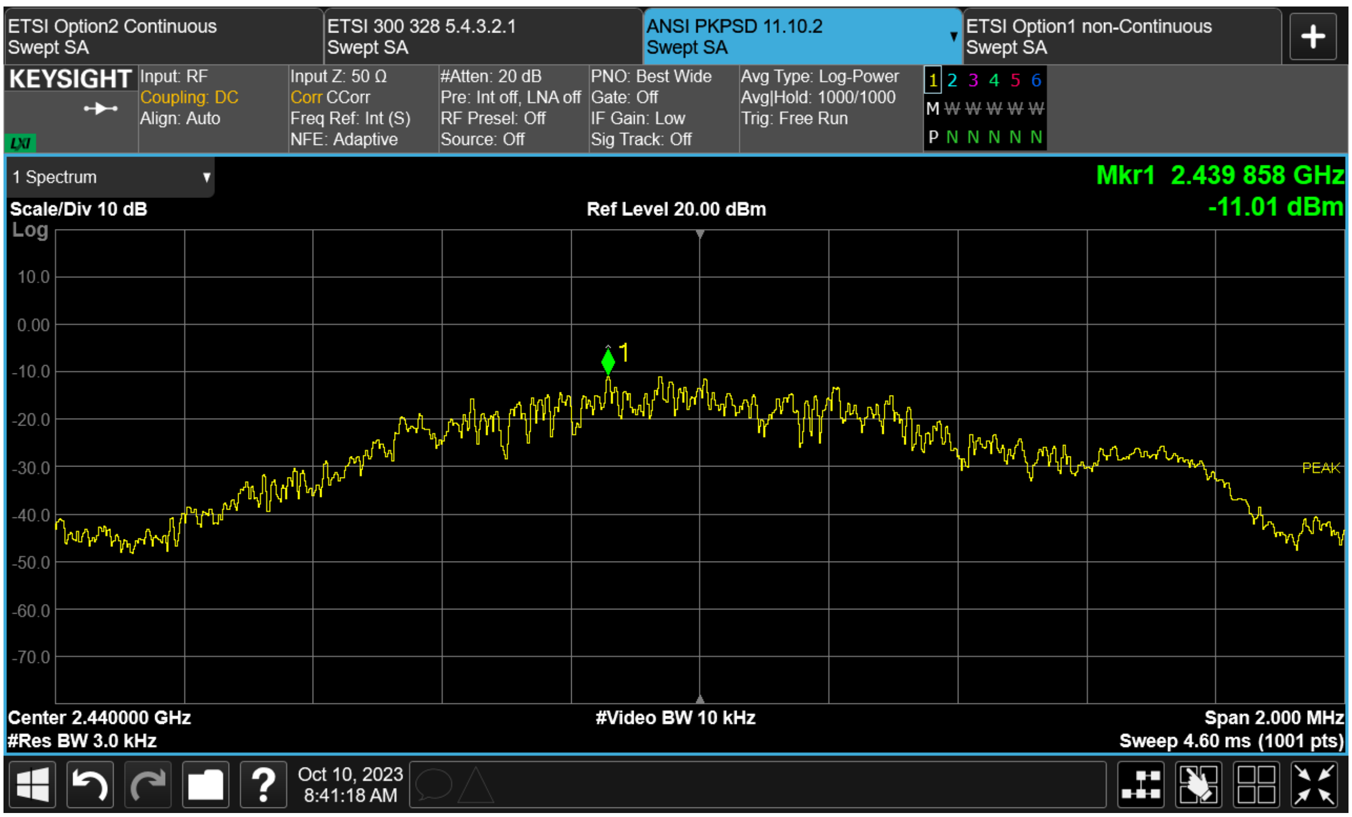

Figure TR05.2: Test data for BLE 1 Mbps, 2440 MHz

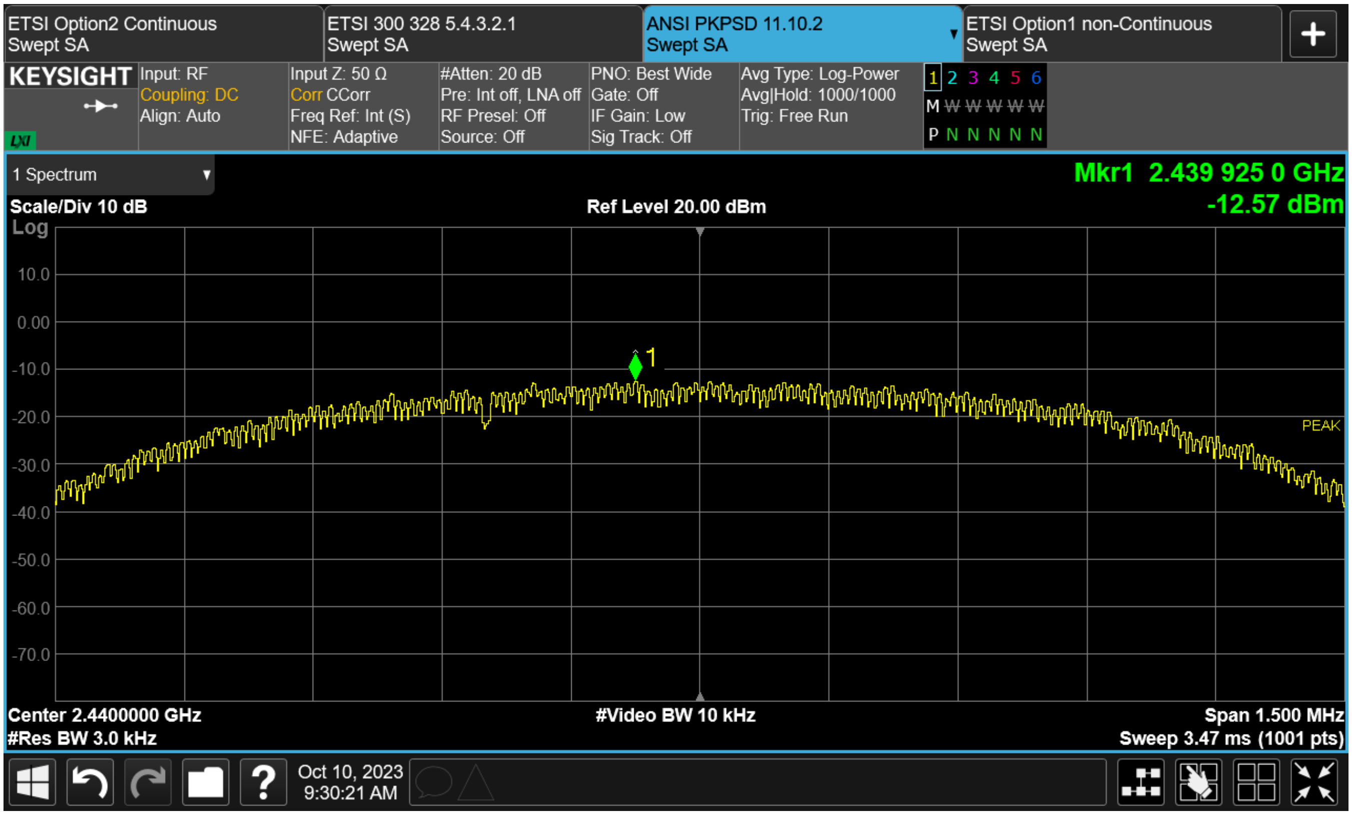

Figure TR05.3: Test data for ANT, 2440 MHz

This line is the end of the test record.

Test Record
Transmitter Power Spectral Density
Test ID TR07
Project GCL-0457

Test Date(s)	10 Oct 2023
Test Personnel	Majid Farah assisted by David Kerr
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M7 (WiFi TX)
Arrangement	A2 (Upwr)
Input Power	5Vdc
Test Standards:	FCC Part 15, ANSI C63.10, AS/NZS 4268, RSS-GEN, RSS-210, RSS-247 (as noted in Section 6 of the report).
Antenna Gain	-0.3 dBi, as reported by the client
Radio Protocol	IEEE 802.11 b/g/n (WiFi)
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**25 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 TR07.1: Test equipment used

Software Used: Keysight PXE software A.35.06

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.

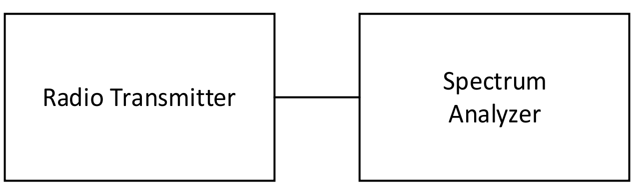

Figure TR07.1: Test setup

Test Data

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

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

	Ch1	Ch6	Ch11	Ch12	Ch13
B1	2.61	1.88	1.79	-4.50	-7.16
G18	-13.00	-11.18	-17.36	-21.00	-22.31
NMCS2	-13.21	-10.76	-17.52	-20.52	-22.20

Table TR07.2: Summary of results

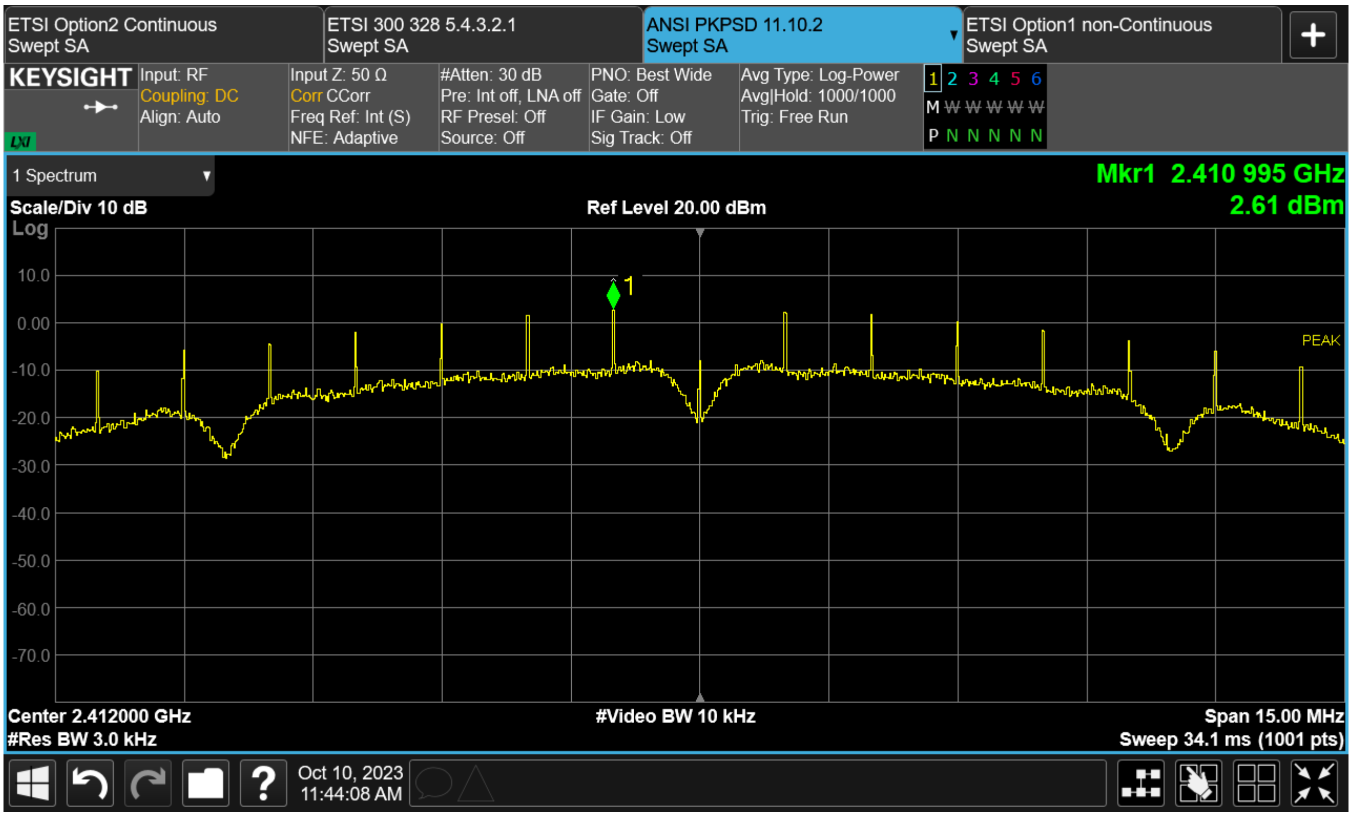

Figure TR07.2: Test data for IEEE 802.11 B1 modulation, channel 1

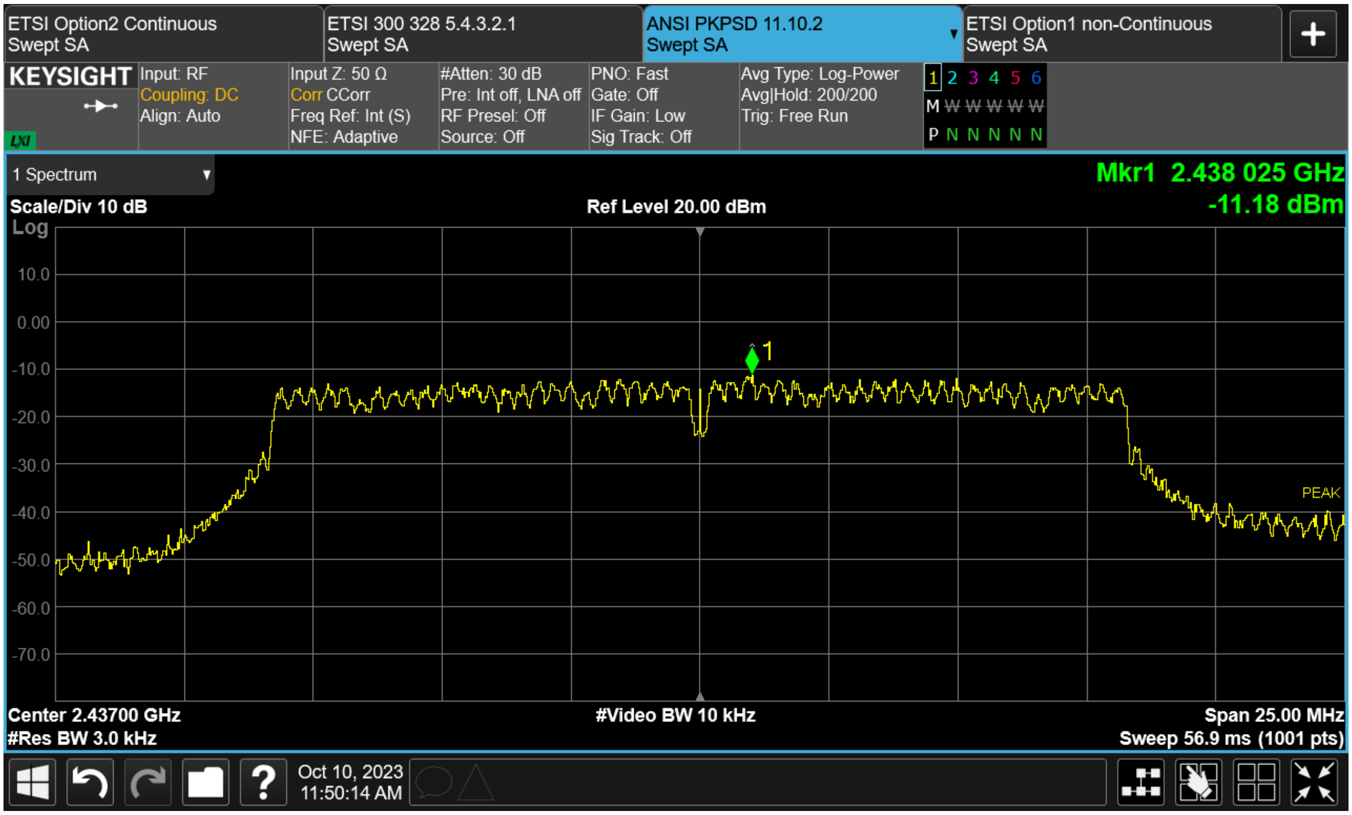

Figure TR07.3: Test data for IEEE 802.11 G18 modulation, Channel 6

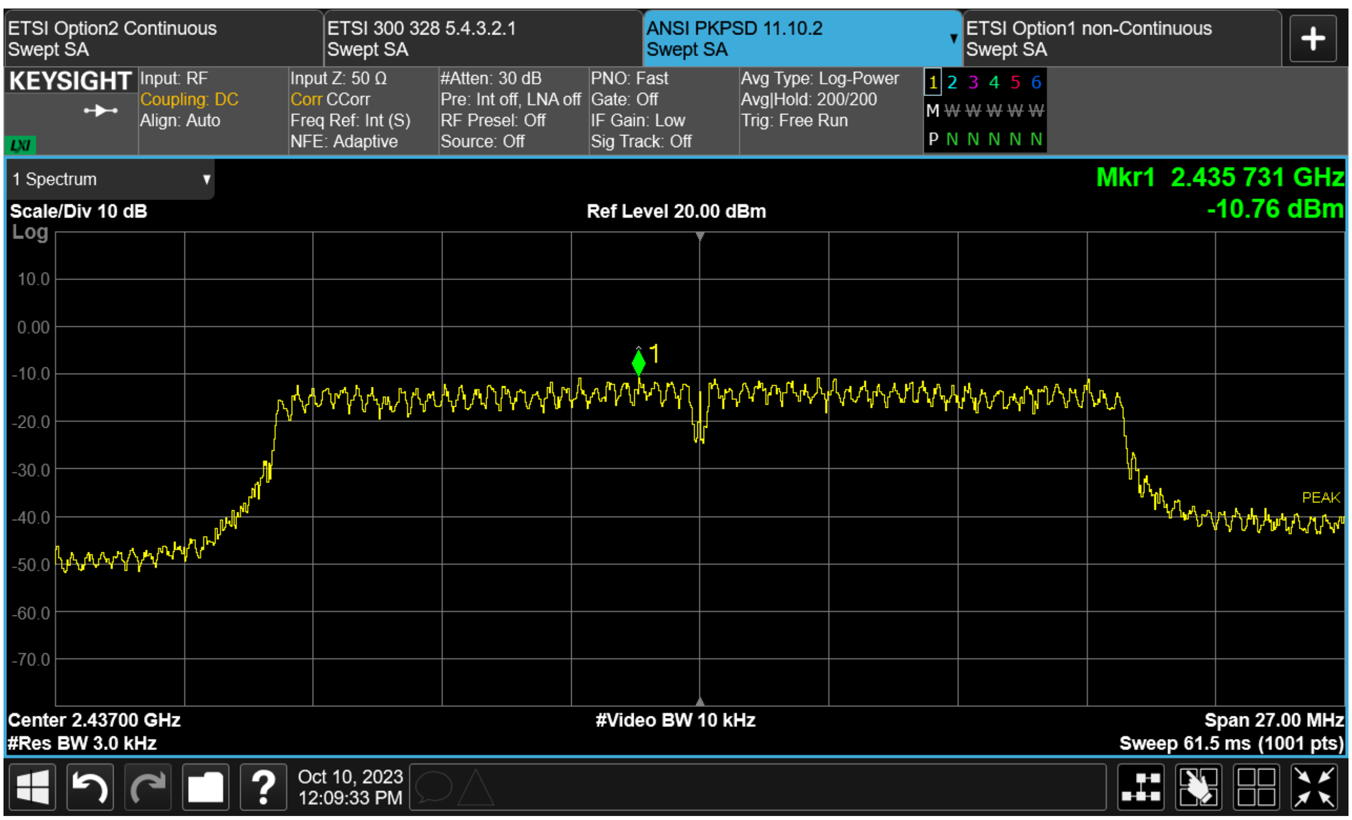

Figure TR07.5: Test data for IEEE 802.11 N MSC2 modulation, channel 6

This line is the end of the test record.

Test Record
Transmitter Stability in Extreme Conditions
Test IDs TR27
Project GCL-0457

Test Date(s)	15 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M5 (ANTTx)
Arrangement	A3 (Udata)
Nominal Input Power	5 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), ANT
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date this record:	**20 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	32774-02	Calibration	Not Required

Table TR27.1: 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 ANT transmit mode was selected to also represent Bluetooth and BLE because they use the same transmitting hardware and ANT 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
ANT	50	5	25.6	41.6
ANT	40	5	24.3	41.6
ANT	30	5	25.2	41.0
ANT	20	5	25.4	40.8
ANT	10	5	25.6	43.1
ANT	0	5	23.9	42.1
ANT	-10	5	24.0	42.7
ANT	-20	5	24.3	42.0

Table TR27.2 Difference between peak and band edge levels for ANT transmissions during temperature variations

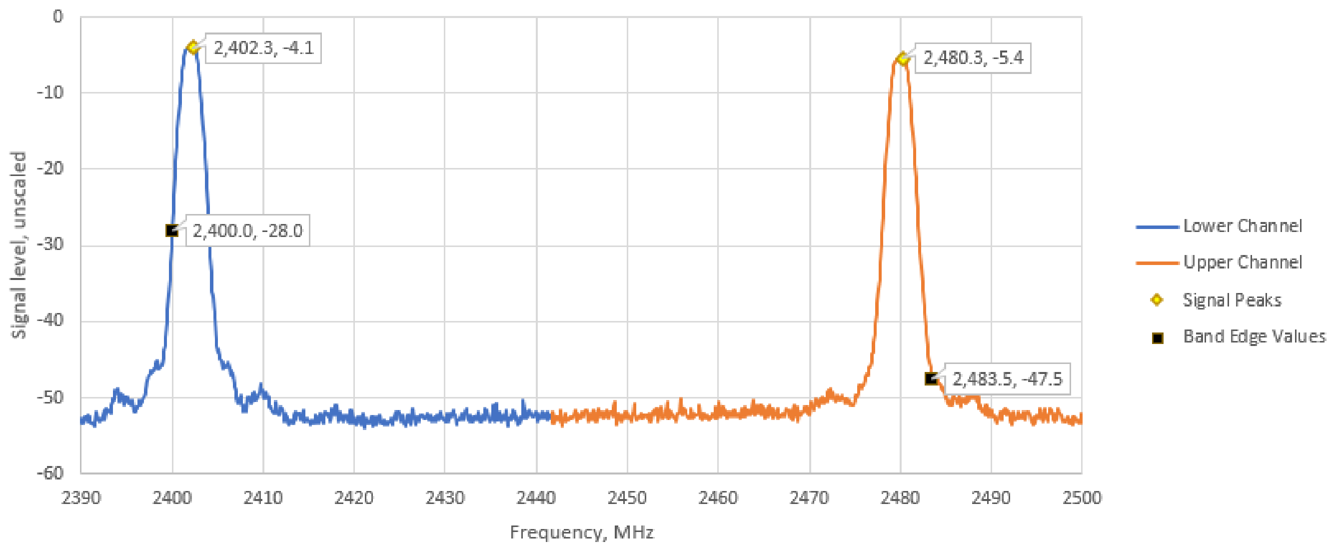

Figure TR27.1: Spectral data for ANT at 0°C which represent low and high channel

Tx Mode	Temp	Volts	Low Ch.	High Ch.
Bluetooth	˚C	Vdc	dBc	dBc
ANT	20	4.25	25.5	42.4
ANT	20	5	25.4	40.8
ANT	20	5.75	25.5	42.5

Table TR27.3 Difference between peak and band edge levels for ANT transmissions at 20 °C during voltage variations

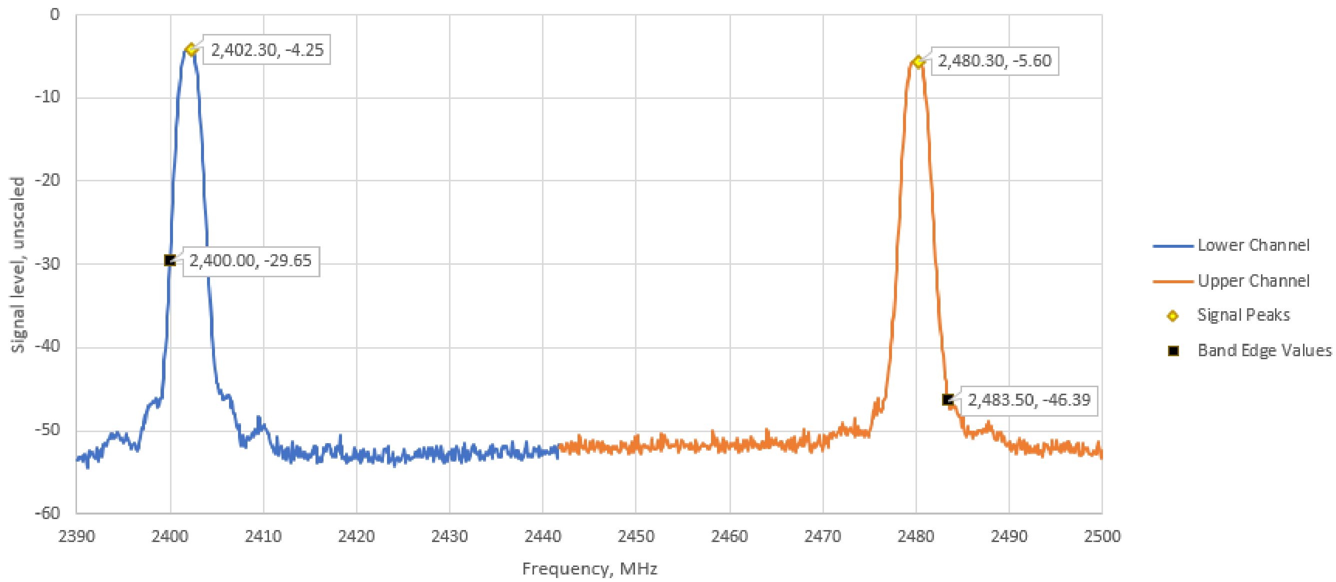

Figure TR27.2: Spectral data for ANT at 20 °C which represent low and high channel

Setup Block Diagram

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

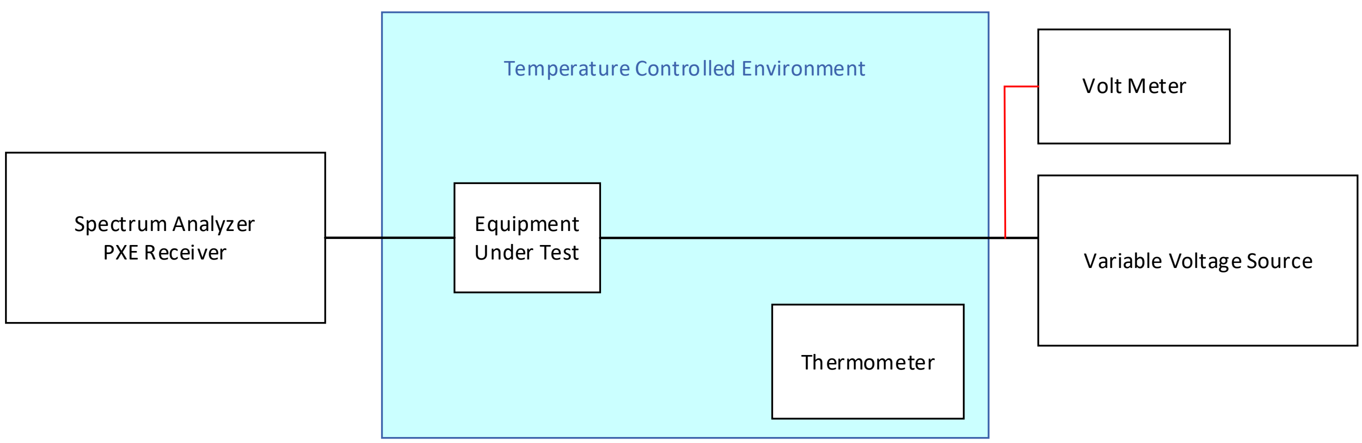

Figure TR27.3: Schematic drawing of the test equipment setup

This line is the end of the test record.

Test Record

Transmitter Stability in Extreme Conditions
Test IDs TR28
Project GCL-0457

Test Date(s)	15 Oct 2023
Test Personnel	Majid Farah
Product Model	AA4714
Serial Number tested	3453413911
Operating Mode	M5 (WifiTx)
Arrangement	A3 (Udata)
Nominal Input Power	5 Vdc
Test Standards:	FCC part 15, RSS-GEN, ANSI C63.10 (as noted in Section 6 of the report)
Radio Protocol	WiFi (IEEE 802.11 b/g/n)
Pass/Fail Judgment:	**PASS**
Test record created by:	**Majid Farah**
Date this record:	**20 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	32774-02	Calibration	Not Required

Table TR28.1: 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	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
N MCS0	50	5	41.5	47.6	41.8
N MCS0	40	5	41.1	44.8	41.4
N MCS0	30	5	41.1	45.2	42.5
N MCS0	20	5	39.7	45.4	41.9
N MCS0	10	5	40.5	45.5	41.2
N MCS0	0	5	40.4	46.2	42.2
N MCS0	-10	5	41.3	46.3	41.9
N MCS0	-20	5	40.6	43.9	42.9

Table TR28.2 Difference between peak and band edge levels for IEEE 802.11 n MCS0 at 20 °C transmissions during temperature variations

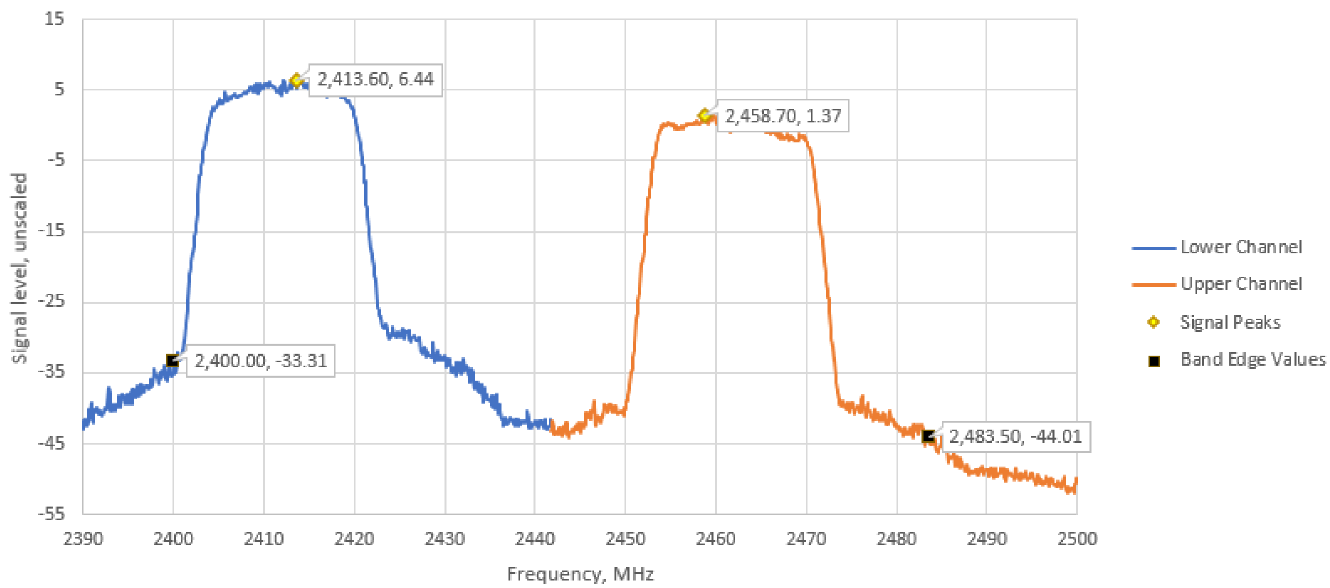

Figure TR28.1: Spectral data for IEEE 802.11 n MCS0 at 20 °C at 0°C which represent Ch1 and Ch11

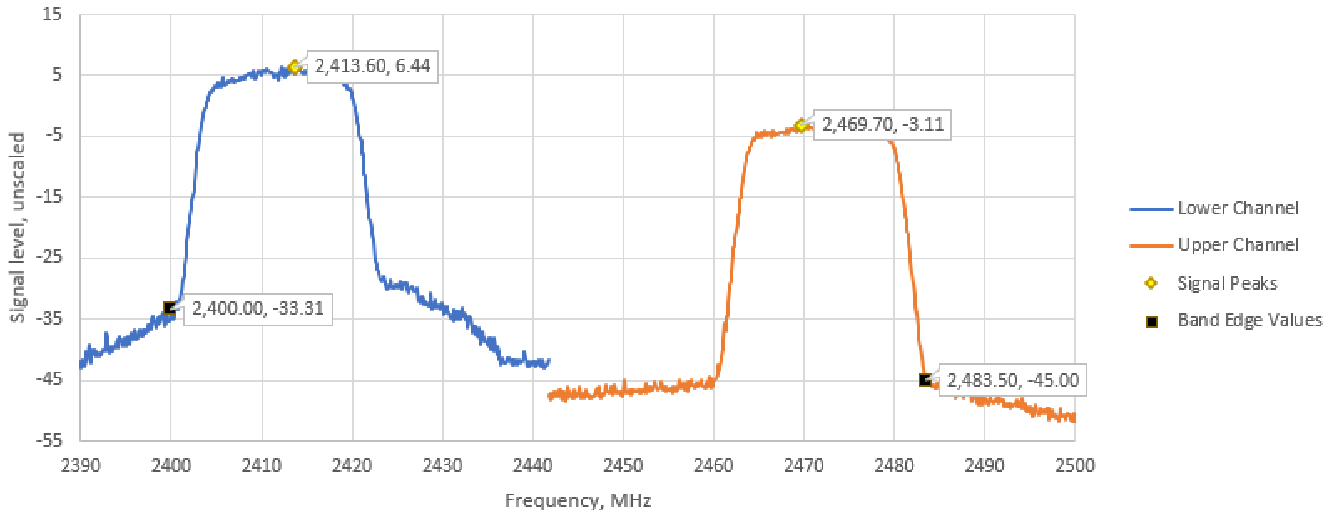

Figure TR28.2: Spectral data for IEEE 802.11 n MCS0 at 20 °C at 0°C which represent Ch1 and Ch13

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	˚C	Vdc	dBc	dBc	dBc
N MCS6	20	4.25	41.1	46.6	41.9
N MCS6	20	5	39.7	45.4	41.9
N MCS6	20	5.75	40.1	46.8	41.8

Table TR28.3 Difference between peak and band edge levels for IEEE 802.11 n MCS0 transmissions at 20 °C during voltage variations

Spectral data for IEEE 802.11 n MCS0 at 20 °C which represent Ch1, Ch11 and Ch13 are same as shown in figure TR28.1 and figure TR28.2.

Setup Block Diagram

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

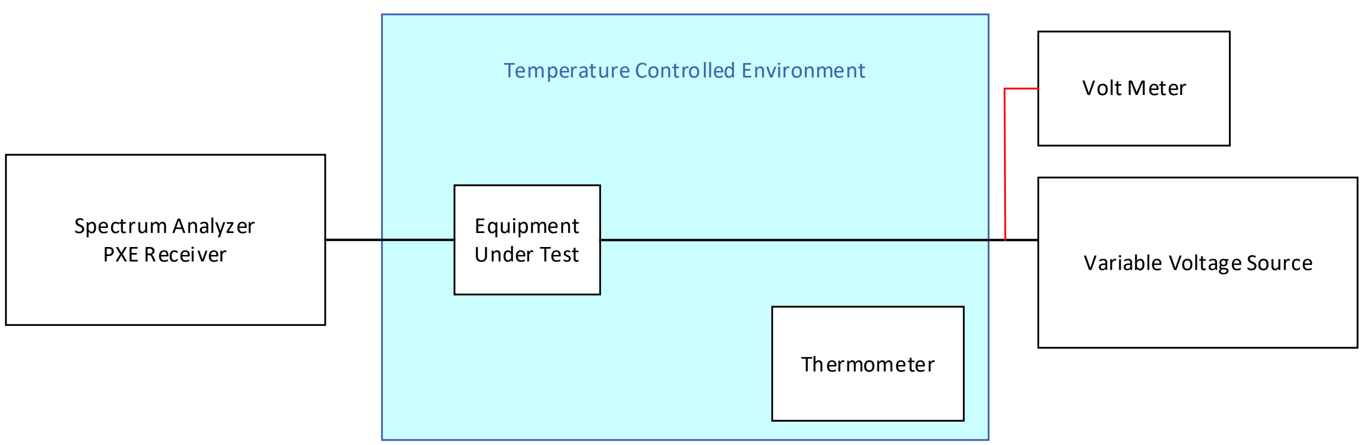

Figure TR28.3: Schematic drawing of the test equipment setup

This line is the end of the test record.

Test Record
Radiated Emission Test RE05
Project GCL0457

Test Date(s) 14 Oct 2023
Test Personnel David Kerr

Product Model AA4714
Serial Number tested 3453413922

Operating Mode M7 (Wifi Tx)
Arrangement A2 (Upwr)
Input Power 5 Vdc (USB)

Test Standards: FCC Part 15, 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: 14 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	00233201	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

RE05.1: Test Equipment Used

Software Used:
N9048B Keysight PXE firmware version 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		
942.870	H	0.9	36.8	37.7	46.0	8.3	379.4	67.0
52.050	V	7.7	13.9	21.6	40.0	18.4	100.0	208.0
76.860	V	4.8	14.5	19.3	40.0	20.7	104.4	333.0
52.020	V	7.5	13.9	21.4	40.0	18.6	104.4	129.0
107.610	V	6.5	16.6	23.1	43.5	20.4	104.4	353.0
266.010	V	1.5	22.5	24.0	46.0	22.0	151.4	319.0
51.420	V	8.1	14.0	22.1	40.0	17.9	100.0	204.0

Table RE05.2: Emission summary (Ch1 B11)

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		
194.340	H	7.8	18.3	26.1	43.5	17.4	166.3	269.0
47.370	V	8.7	14.6	23.3	40.0	16.7	100.0	126.0
53.640	V	9.5	14.0	23.5	40.0	16.5	100.0	169.0
81.180	V	5.9	14.3	20.2	40.0	19.8	135.2	56.0
107.640	V	6.5	16.6	23.1	43.5	20.4	100.0	354.0
942.480	V	0.9	36.8	37.7	46.0	8.3	383.4	179.0

Table RE05.3: Emission summary (Ch6 B11)

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		
194.340	H	8.3	18.3	26.6	43.5	16.9	174.9	106.0
47.340	V	8.3	14.6	22.9	40.0	17.1	100.0	130.0
53.700	V	9.0	14.0	23.0	40.0	17.0	100.0	136.0
944.430	V	0.7	36.8	37.5	46.0	8.5	363.9	20.0
107.730	V	6.5	16.6	23.1	43.5	20.4	100.0	354.0
81.300	V	5.8	14.3	20.1	40.0	19.9	119.9	353.0

Table RE05.4: Emission summary (Ch11 B11)

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		
204.000	H	10.3	19.1	29.4	43.5	14.1	153.0	101.0
938.700	H	0.7	36.7	37.4	46.0	8.6	114.1	0.0
47.280	V	8.6	14.6	23.2	40.0	16.8	100.0	176.0
53.640	V	9.9	14.0	23.9	40.0	16.1	100.0	169.0
95.400	V	6.6	15.6	22.2	43.5	21.3	100.0	235.0
107.520	V	6.4	16.6	23.0	43.5	20.5	104.4	55.0

Table RE05.5: Emission summary (Ch13 B11)

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

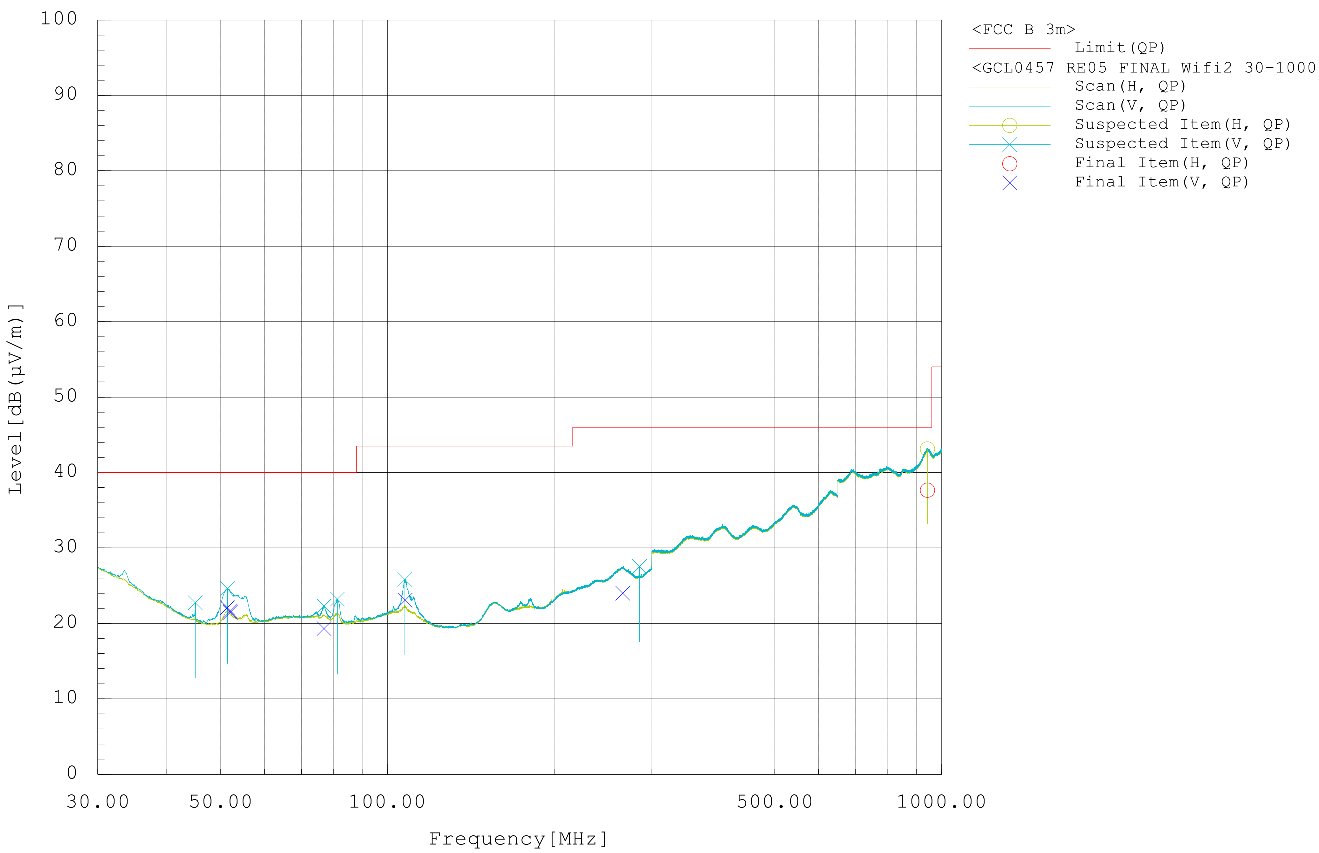

Figure RE05.1: Spectral data (Ch1 B11)

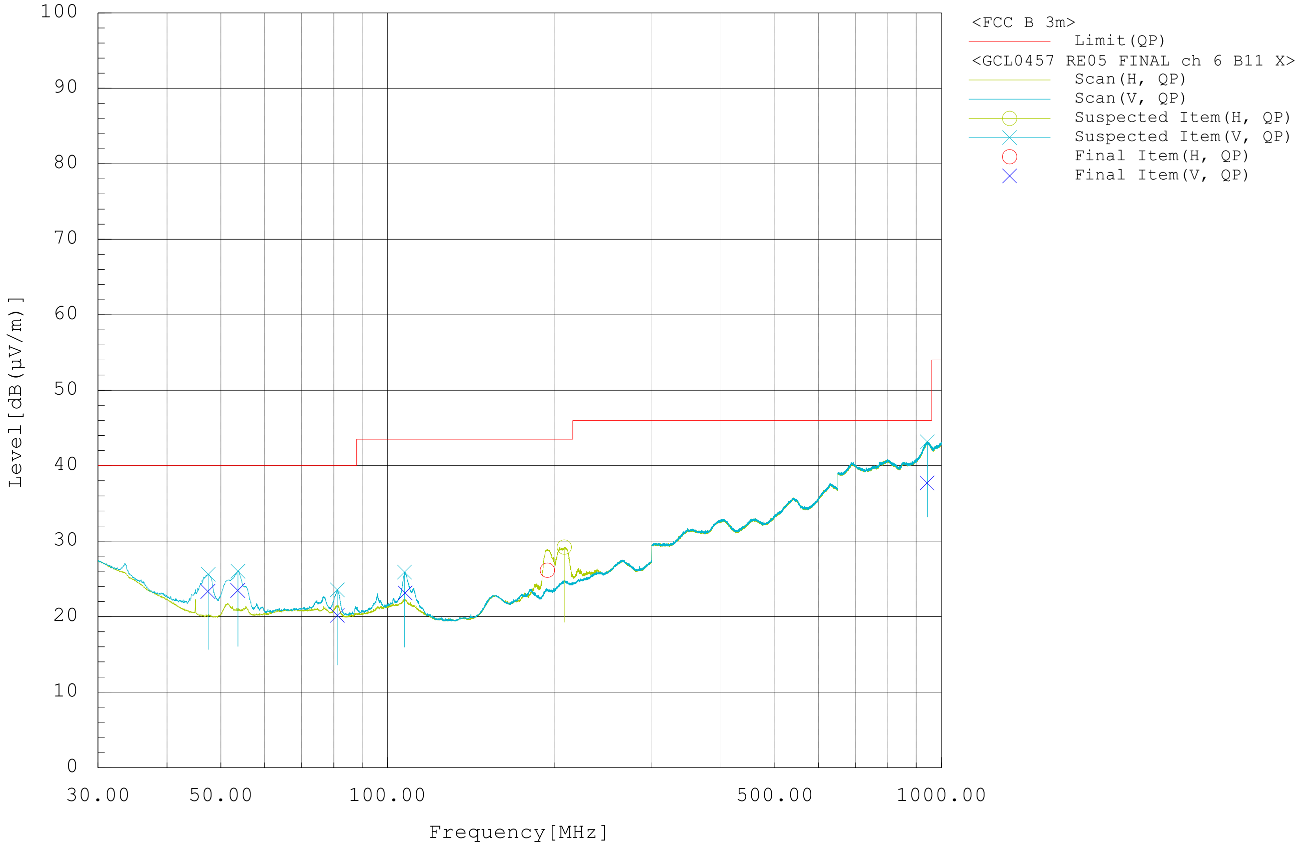

Figure RE05.2: Spectral data (Ch6 B11)

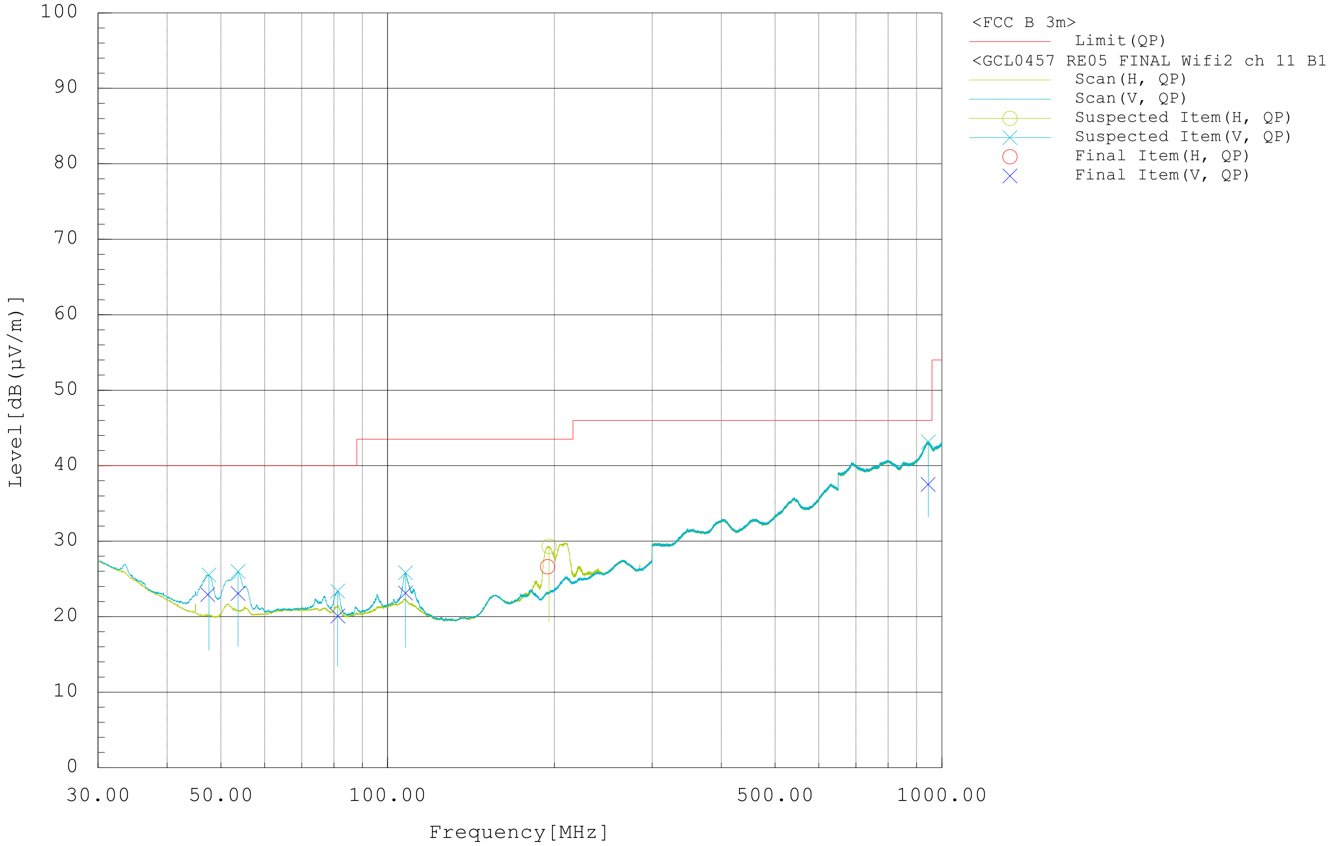

Figure RE05.3: Spectral data (Ch11 B11)

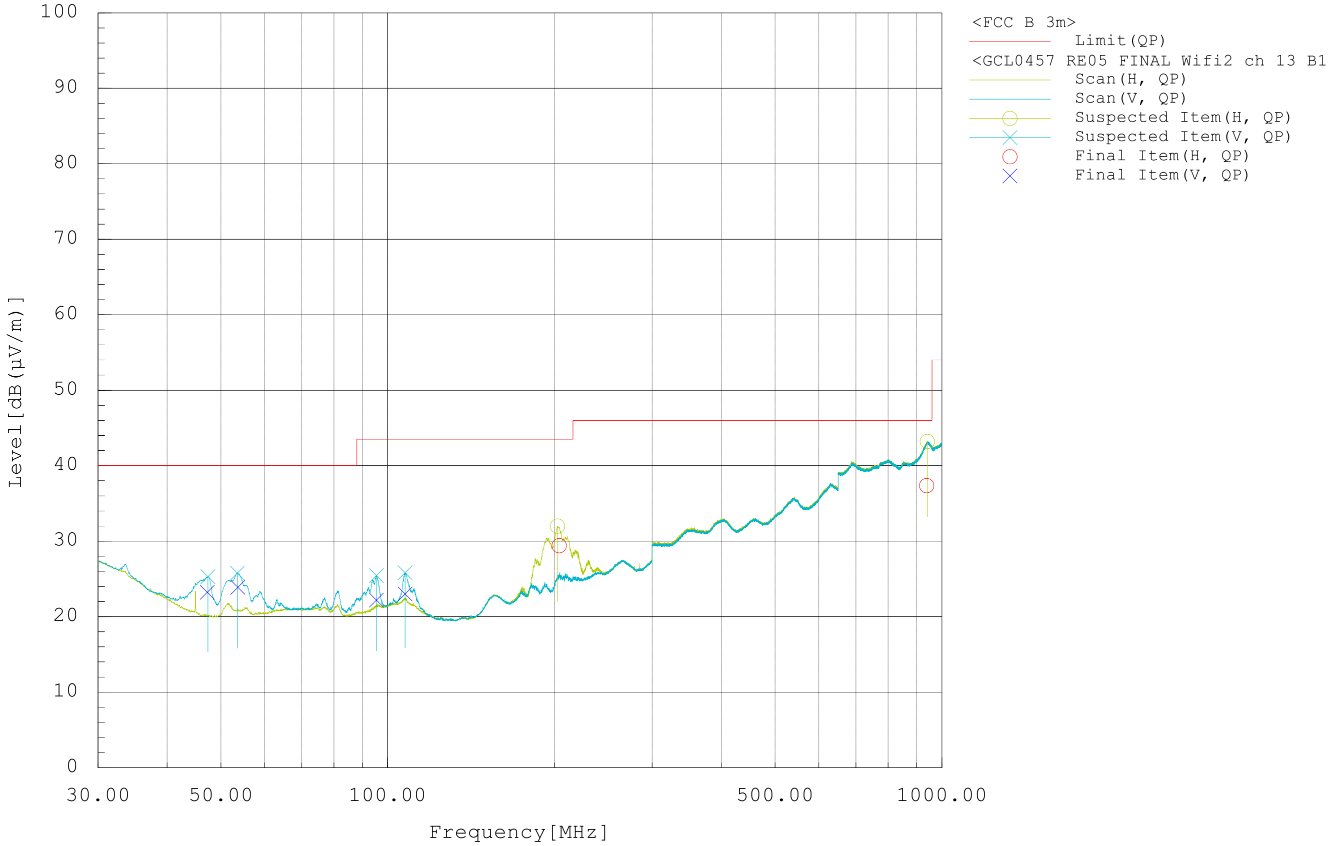

Figure RE05.4: Spectral data (Ch13 B11)

Setup Photographs

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

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

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Figure RE05.5: EUT test setup, front view (Z orientation)

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

Figure RE05.6: EUT test setup, reverse view (Z orientation)

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

Figure RE05.7: EUT test setup, front view (X orientation)

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

Figure RE05.8: EUT test setup, reverse view (X orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE06
Project GCL0457

Test Date(s)	09 Oct 2023
Test Personnel	Dave Kerr, Jim Solum
Product Model	AA4714
Serial Number tested	3453413922
Operating Mode	M7 (WiFi Tx)
Arrangement	A2 (Upwr)
Input Power	5 Vdc (USB)
Test Standards:	FCC Part 15, ANSI C63.10 (as noted in Section 6 of the report).
Frequency Range:	1 GHz to 2.2 GHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Dave Kerr, Jim Solum**
Date of this record:	**10 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
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	10721	30-Aug-2023	1-Sep-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 RE06.1: Test Equipment Used

Software Used: N9048B Keysight PXE firmware version 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.

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 tables show the selected final measurement data between 1000 MHz and 2200 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.

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		
2056.500	V	32.5	45.7	-1.5	31.0	44.2	54.0	74.0	23.0	29.8	338.0	95.0
1964.750	V	32.5	46.0	-1.7	30.8	44.3	54.0	74.0	23.2	29.7	221.9	25.0
1781.000	H	32.2	45.5	-2.7	29.5	42.8	54.0	74.0	24.5	31.2	305.9	126.0
2149.000	H	32.5	46.3	-1.2	31.3	45.1	54.0	74.0	22.7	28.9	332.7	0.0
1306.000	H	31.7	45.5	-4.3	27.4	41.2	54.0	74.0	26.6	32.8	117.7	180.0
1194.000	H	31.9	45.4	-5.3	26.6	40.1	54.0	74.0	27.4	33.9	100.0	1.0

Table RE06.2: Emission summary (WiFi B11 Ch1)

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		
1274.250	V	31.8	45.1	-4.3	27.5	40.8	54.0	74.0	26.5	33.2	132.4	285.0
2034.000	V	32.3	45.6	-1.5	30.8	44.1	54.0	74.0	23.2	29.9	169.7	352.0
1568.500	H	31.9	45.4	-4.0	27.9	41.4	54.0	74.0	26.1	32.6	400.0	245.0
1766.750	H	32.1	45.5	-2.9	29.2	42.6	54.0	74.0	24.8	31.4	365.0	63.0
2126.000	H	32.5	46.0	-1.3	31.2	44.7	54.0	74.0	22.8	29.3	293.2	240.0
2157.250	H	32.4	45.8	-1.2	31.2	44.6	54.0	74.0	22.8	29.4	336.7	242.0

Table RE06.3: Emission summary (WiFi B11 Ch6)

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		
1409.250	V	31.8	45.3	-3.9	27.9	41.4	54.0	74.0	26.1	32.6	207.1	293.0
1047.250	H	31.4	44.8	-6.0	25.4	38.8	54.0	74.0	28.6	35.2	132.3	0.0
1132.750	H	31.8	45.5	-5.8	26.0	39.7	54.0	74.0	28.0	34.3	126.5	234.0
1597.000	H	32.0	45.4	-3.9	28.1	41.5	54.0	74.0	25.9	32.5	231.1	242.0
1996.500	H	32.3	46.0	-1.6	30.7	44.4	54.0	74.0	23.3	29.6	226.7	356.0
2067.750	H	32.4	46.0	-1.5	30.9	44.5	54.0	74.0	23.1	29.5	298.1	285.0

Table RE06.4: Emission summary (WiFi B11 Ch11)

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		
1052.500	V	31.2	44.5	-6.0	25.2	38.5	54.0	74.0	28.8	35.5	332.7	60.0
1493.500	V	31.9	45.2	-3.5	28.4	41.7	54.0	74.0	25.6	32.3	346.1	97.0
1857.750	V	32.1	45.3	-2.2	29.9	43.1	54.0	74.0	24.1	30.9	332.9	210.0
1222.000	H	31.6	45.3	-4.8	26.8	40.5	54.0	74.0	27.2	33.5	137.0	0.0
1493.000	H	31.9	45.7	-3.5	28.4	42.2	54.0	74.0	25.6	31.8	272.5	329.0
2132.500	H	32.4	46.1	-1.3	31.1	44.8	54.0	74.0	22.9	29.2	297.0	70.0

Table RE06.5: Emission summary (WiFi B11 Ch13)

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

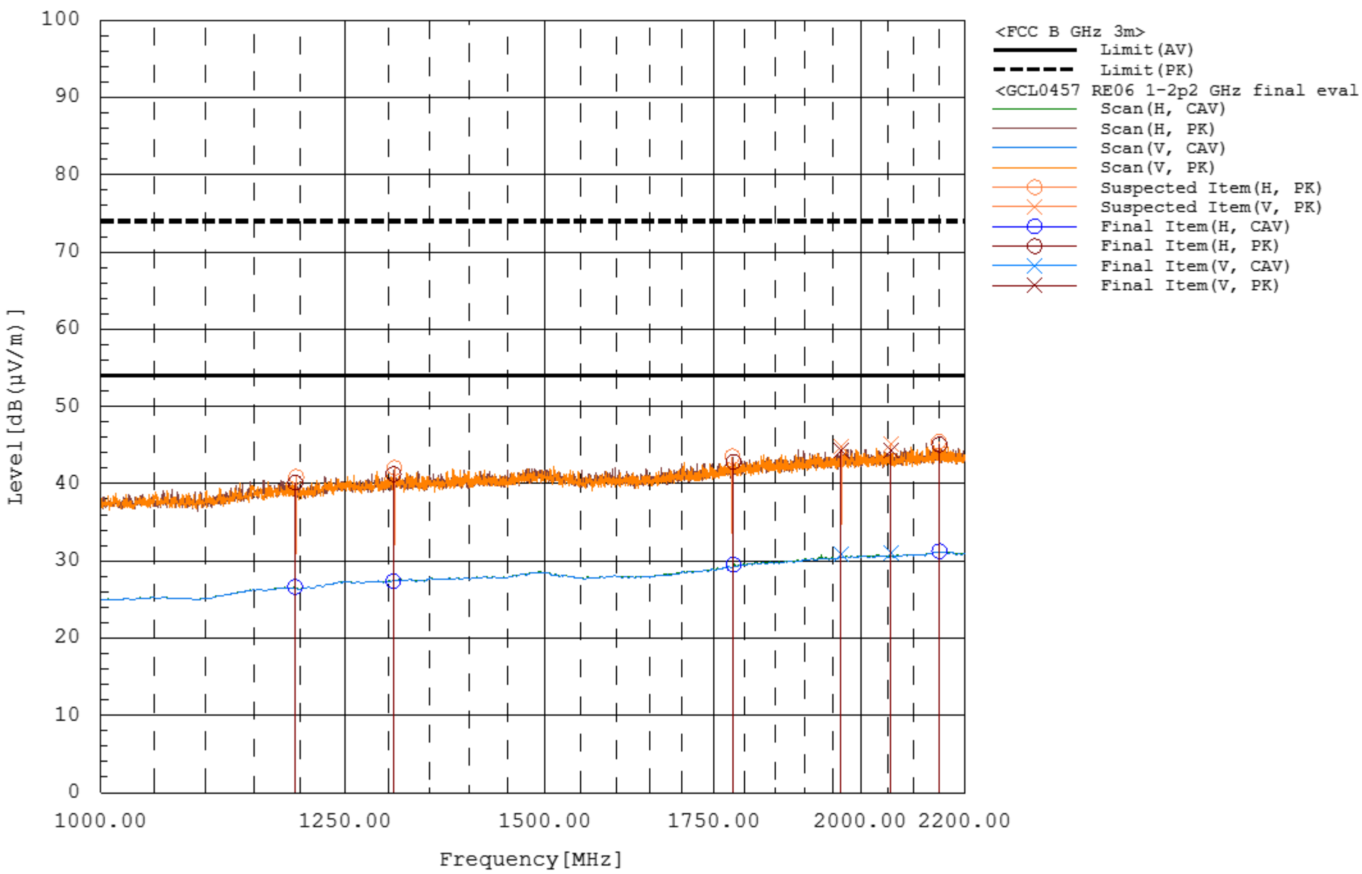

Figure RE06.1: Spectral data (WiFi B11 Ch1)

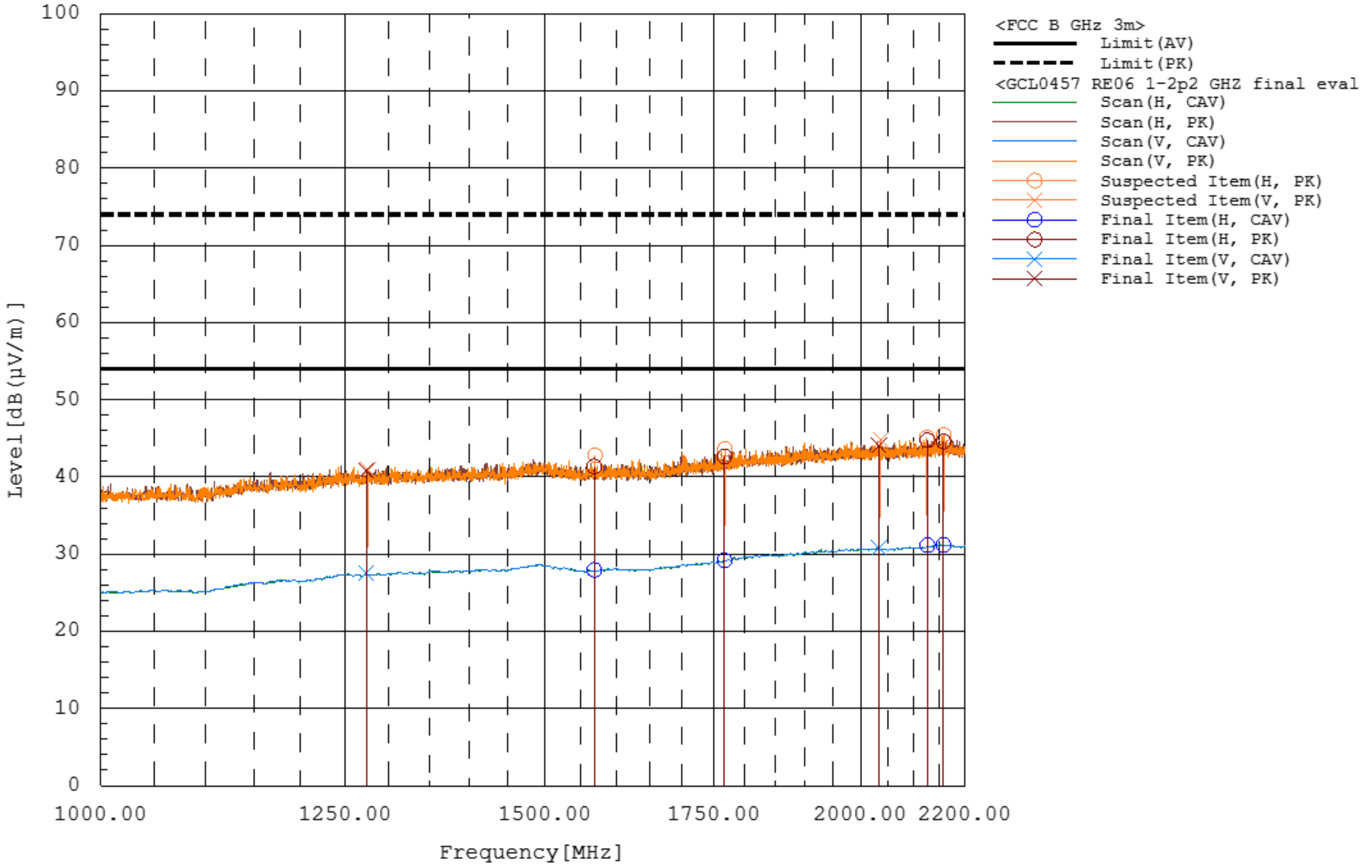

Figure RE06.2: Spectral data (WiFi B11 Ch6)

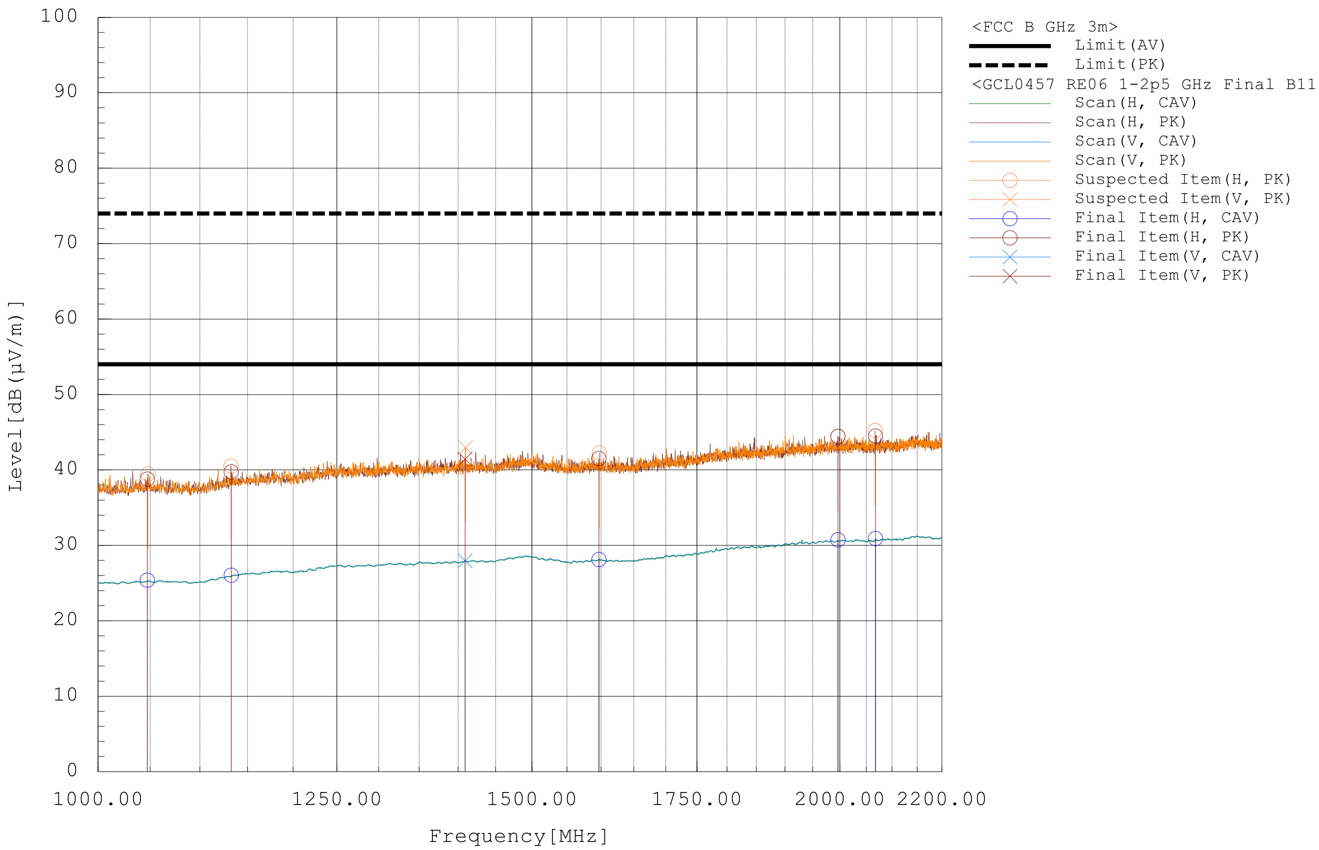

Figure RE06.3: Spectral data (WiFi B11 Ch11)

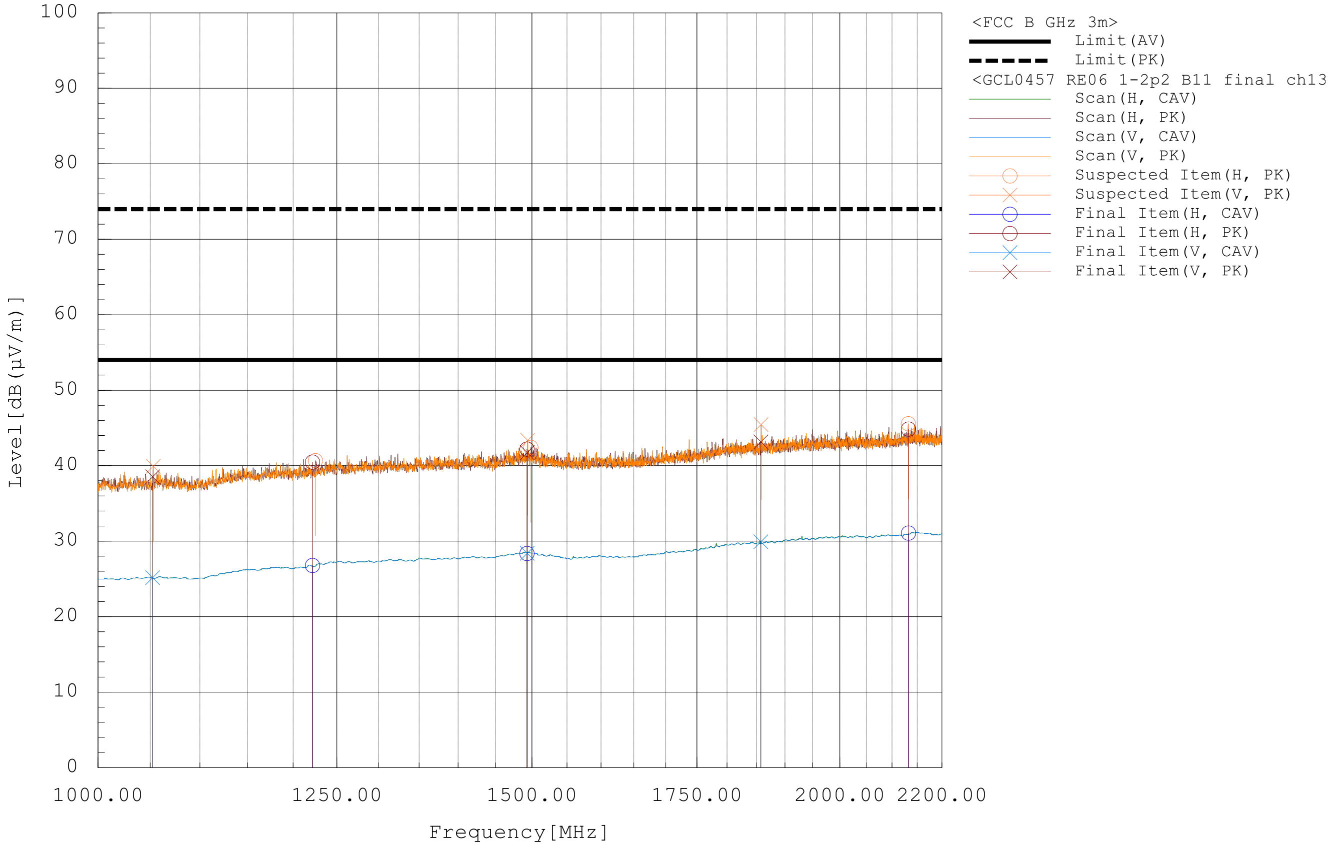

Figure RE06.4: Spectral data (WiFi B11 Ch13)

Setup Photographs

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

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

Figure RE06.5: EUT test setup, (WiFi B11 Ch1) Z orientation front view

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

Figure RE06.6: EUT test setup, (WiFi B11 Ch1) Z orientation reverse view

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

Figure RE06.7: EUT test setup, (WiFi B11 Ch6, Ch11, Ch13) X orientation front view

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

Figure RE06.8: EUT test setup, (WiFi B11 Ch6, Ch11, Ch13) X orientation reverse view

This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE01
Project GCL0457

Test Date(s)	06 Oct 2023
Test Personnel	David Kerr
Product Model	AA4714
Serial Number tested	3453413873
Operating Mode	M7 (Wifi Tx)
Arrangement	A2 (Upwr)
Input Power	115 V/ 60 Hz
Test Standards:	FCC Part 15 (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:	**10 Oct 2023**

Original record, Version A.

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 CE01.1: 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)
645	56.00	46.00	28.12	26.59	22.96	21.15	27.88	23.04
683	56.00	46.00	43.80	39.03	39.53	32.40	12.20	6.47
717	56.00	46.00	28.80	27.33	24.27	22.06	27.20	21.73
1327	56.00	46.00	29.50	26.63	23.88	21.34	26.50	22.12
1363	56.00	46.00	31.22	27.09	26.27	21.95	24.78	19.73
1399	56.00	46.00	29.90	27.38	25.23	21.98	26.10	20.77

Table CE01.2: Emission summary

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

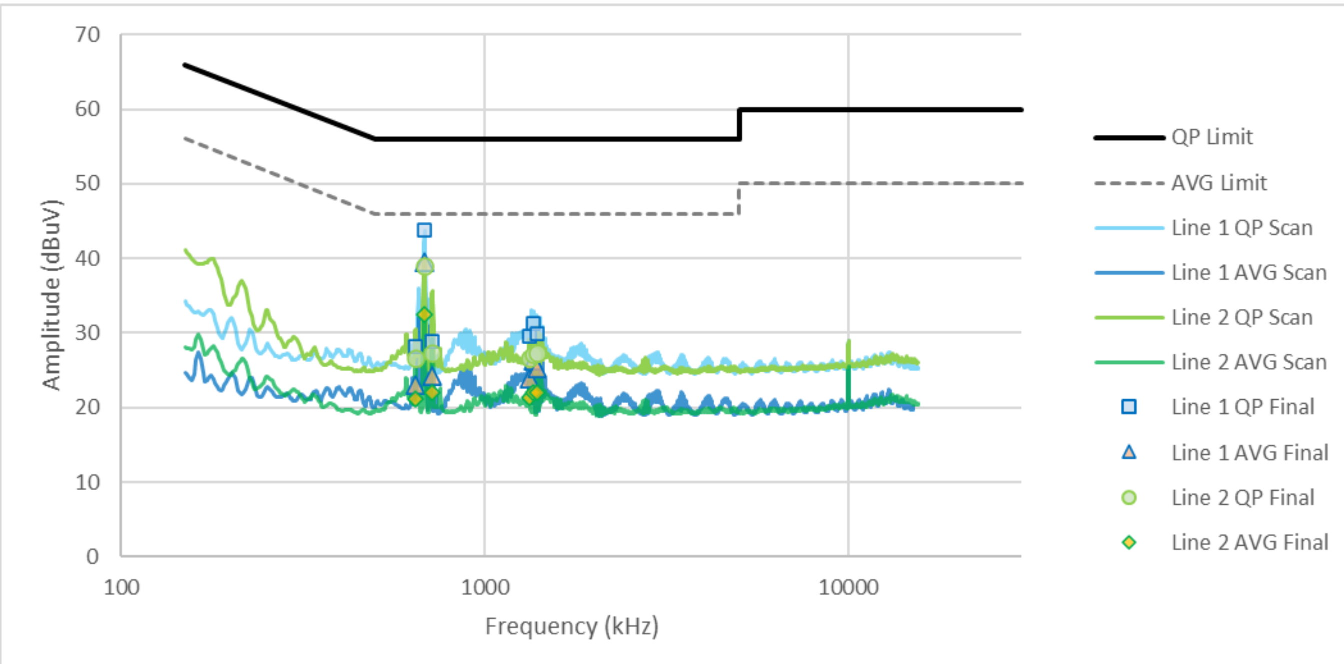

Figure CE01.1: Spectral data

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

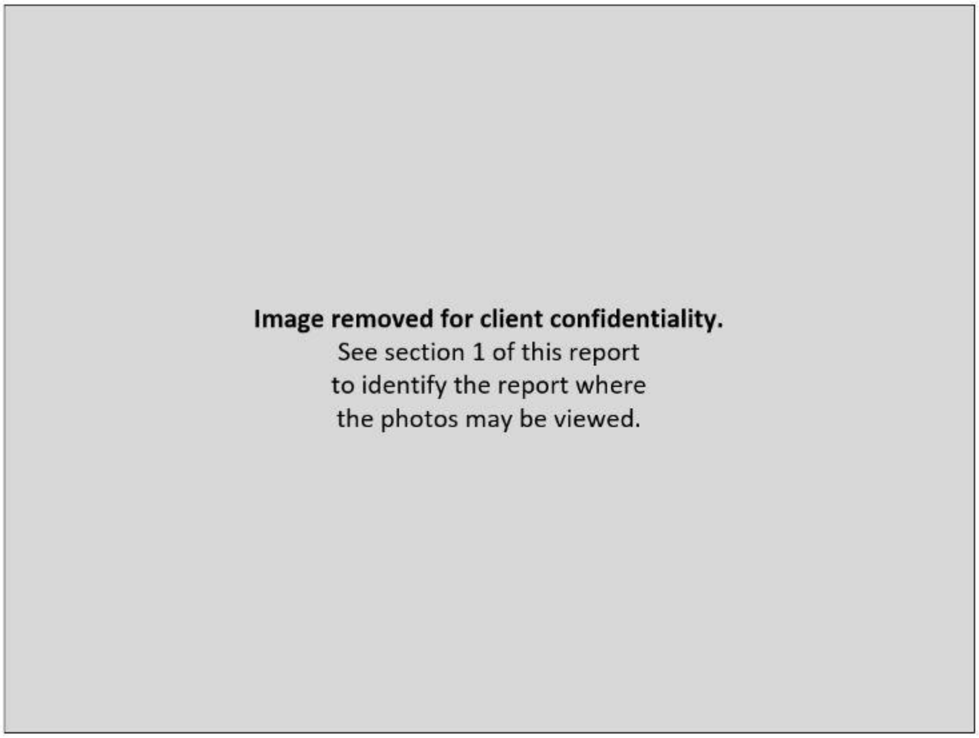

Figure CE01.2: Test setup, front view

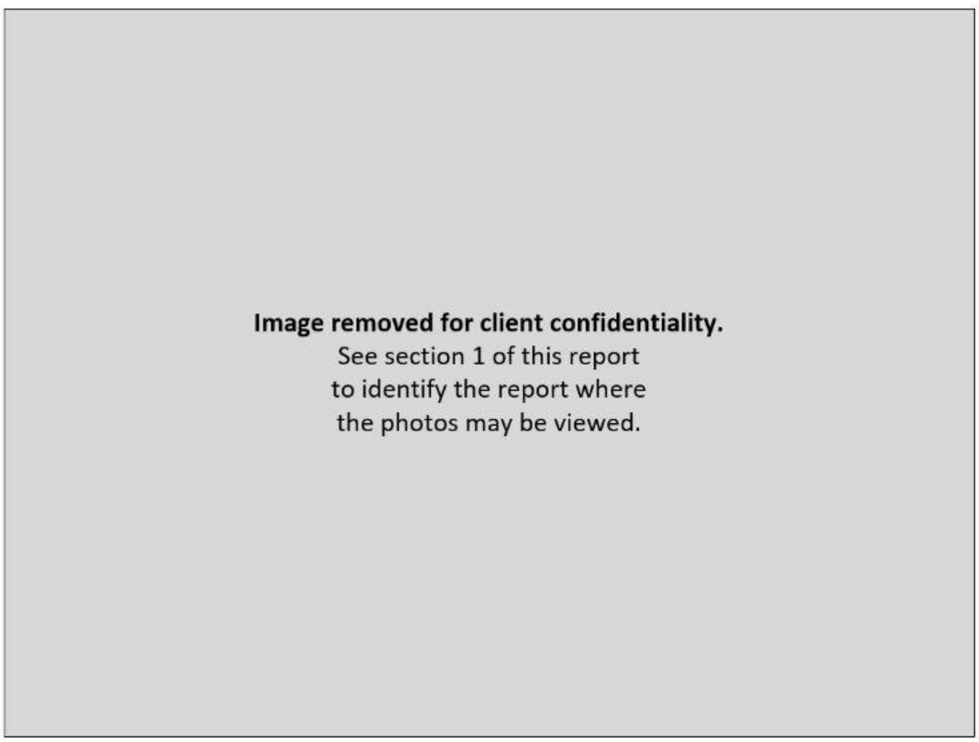

Figure CE01.3: Test setup, side view

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.

RF Exposure Lab

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TEL (760) 471-2100 • FAX (760) 471-2121
http://www.rfexposurelab.com

CERTIFICATE OF COMPLIANCE
SAR EVALUATION

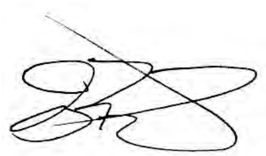
Garmin International, Inc.	Dates of Test:	September 21, 2023
1200 E. 151st Street	Test Report Number:	SAR.20230909
Olathe, KS 66062		Revision A
	Lab Designation Number:	US1195(FCC) & US0194(ISED)

FCC ID:	IPH-A4714
IC Certificate:	1792A-A4714
Model(s):	AA4714
Test Sample:	Engineering Unit Same as Production
Serial No.:	453413899
Equipment Type:	Digital Transmission System Transceiver
Classification:	Portable Transmitter Next to Extremity
TX Frequency Range:	2402 – 2480 MHz; 2412 – 2462 MHz
Frequency Tolerance:	± 2.5 ppm
Maximum RF Output:	2450 MHz (b) – 16.5 dBm, 2450 MHz (g) – 14.5 dBm, 2450 MHz (n) – 14.0 dBm, 2450 MHz (BT) – 10.0 dBm, 2450 MHz (ANT) – 4.0 dBm, 13.56 MHz – <0 dBm Conducted
Signal Modulation:	GFSK, DSSS, OFDM
Antenna Type:	Internal Antenna
Application Type:	Certification
FCC Rule Parts:	Part 2, 15C
KDB Test Methodology:	KDB 447498 D01 v06, KDB 865664 D01 v01r04, KDB 865664 D02 v01r02
Industry Canada:	RSS-102 Issue 5, Safety Code 6
Max. Stand Alone SAR Value:	0.39 W/kg Reported
Separation Distance:	0 mm

This wireless mobile and/or portable device has been shown to be compliant for localized specific absorption rate (SAR) for uncontrolled environment/general exposure limits specified in ANSI/IEEE Std. C95.1-1992 and had been tested in accordance with the measurement procedures specified in IEC 62209-1528:2020 (See test report).

I attest to the accuracy of the data. All measurements were performed by myself or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

RF Exposure Lab, LLC certifies that no party to this application has been denied FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. 853(a).



Jay M. Moulton
Vice President

ACCREDITED
Testing Cert. # 2387.01

Table of Contents

Comment/Revision	Date
Original Release	September 27, 2023
Revision A – Correct DUT Type on Page 30	November 10, 2023

Note: The latest version supersedes all previous versions listed in the above table. The latest version shall be used.

1. Introduction

This measurement report shows compliance of the Garmin International, Inc. Model AA4714 FCC ID: IPH-A4714 with FCC Part 2, 1093, ET Docket 93-62 Rules for mobile and portable devices and IC Certificate: 1792A-A4714 with RSS102 Issue 5 & Safety Code 6. The FCC/ISED have adopted the guidelines for evaluating the environmental effects of radio frequency radiation to protect the public and workers from the potential hazards of RF emissions due to FCC/ISED regulated portable devices. [1], [6]

The test results recorded herein are based on a single type test of Garmin International, Inc. Model AA4714 and therefore apply only to the tested sample.

The test procedures and limits, as described in ANSI C95.1 – 1999 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz [2], ANSI C95.3 – 2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields [3], IEC 62209-1528 – 2020 Recommended Practice [4], and Industry Canada Safety Code 6 Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3kHz to 300 GHz were employed.

The following table indicates all the wireless technologies operating in the AA4714 Digital Transmission System Transceiver. The table also shows the tolerance for the power level for each mode.

Band	Technology	Rel.	Class	3GPP Nominal Power dBm	Setpoint Nominal Power dBm	Tolerance dBm	Lower Tolerance dBm	Upper Tolerance dBm
WiFi – 2.4 GHz	802.11b	N/A	N/A	N/A	N/A	N/A	N/A	16.5
WiFi – 2.4 GHz	802.11g	N/A	N/A	N/A	N/A	N/A	N/A	14.5
WiFi – 2.4 GHz	802.11n	N/A	N/A	N/A	N/A	N/A	N/A	14.0
Bluetooth	BT BR	N/A	N/A	N/A	N/A	N/A	N/A	10.0
Bluetooth	BLE	N/A	N/A	N/A	N/A	N/A	N/A	4.5
Ant	Ant	N/A	N/A	N/A	N/A	N/A	N/A	4.0
13.56 MHz	13.56 MHz	N/A	N/A	N/A	N/A	N/A	N/A	< 0.0

SAR Definition [5]

Specific Absorption Rate is defined as the time derivative (rate) of the incremental energy (*dW*) absorbed by (dissipated in) an incremental mass (*dm*) contained in a volume element (*dV*) of a given density (ρ).

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dV}\right)$$

SAR is expressed in units of watts per kilogram (W/kg). *SAR* can be related to the electric field at a point by

$$SAR = \frac{\sigma |E|^2}{\rho}$$

where:

σ = conductivity of the tissue (S/m)

ρ = mass density of the tissue (kg/m^3)

E = rms electric field strength (V/m)

2. SAR Measurement Setup

Robotic System

These measurements are performed using the DASY52 automated dosimetric assessment system. The DASY52 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, Intel Core2 computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the brain equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. 2.1).

System Hardware

A cell controller system contains the power supply, robot controller teach pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the HP Intel Core2 computer with Windows XP system and SAR Measurement Software DASY52, A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

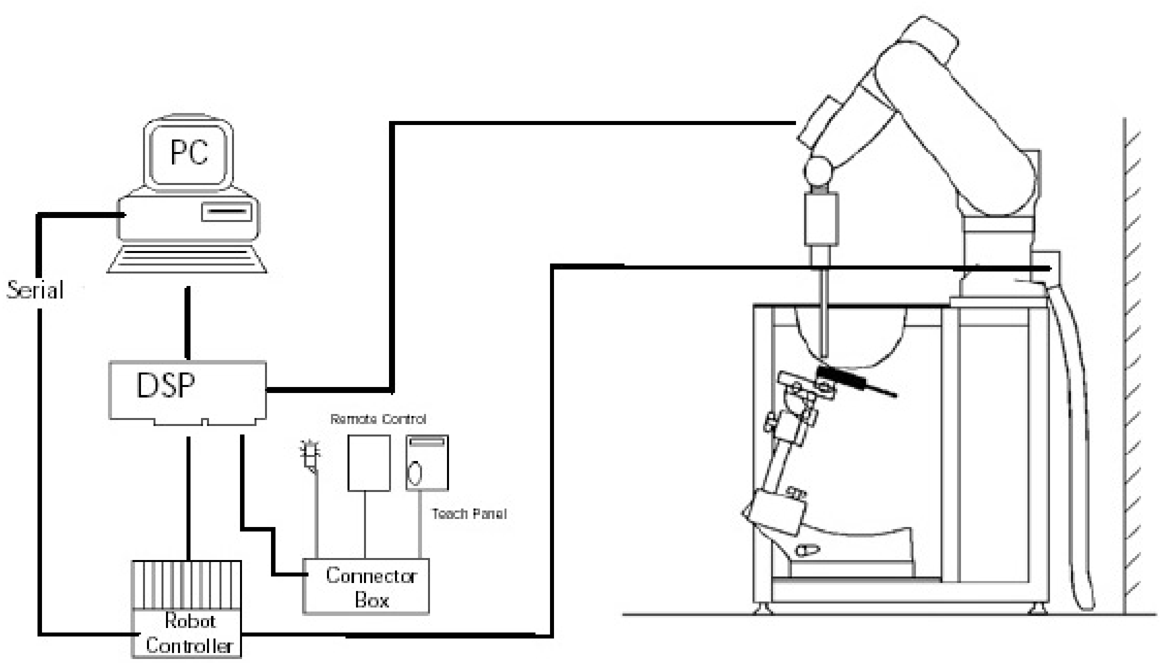


Figure 2.1 SAR Measurement System Setup

System Electronics

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail in.

Probe Measurement System

The SAR measurements were conducted with the dosimetric probe EX3DV4, designed in the classical triangular configuration (see Fig. 2.2) and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multi fiber line ending at the front of the probe tip. (see Fig. 2.3) It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY52 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped at reaching the maximum.

DAE System

Probe Specifications

Calibration: In air from 10 MHz to 6.0 GHz
In brain and muscle simulating tissue at Frequencies of 450 MHz, 835 MHz, 1750 MHz, 1900 MHz, 2450 MHz, 2600 MHz, 3500 MHz, 5200 MHz, 5300 MHz, 5600 MHz, 5800 MHz

Frequency: 10 MHz to 6 GHz

Linearity: ±0.2dB (30 MHz to 6 GHz)

Dynamic: 10 mW/kg to 100 W/kg

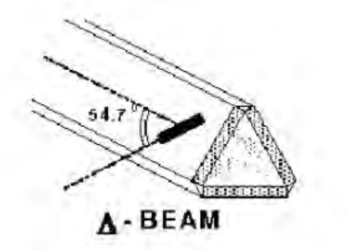


Figure 2.2 Triangular Probe Configurations

Range: Linearity: ±0.2dB

Dimensions: Overall length: 330 mm

Figure 2.3 Probe Thick-Film Technique

Tip length: 20 mm

Body diameter: 12 mm

Tip diameter: 2.5 mm

Distance from probe tip to sensor center: 1 mm

Application: SAR Dosimetry Testing
Compliance tests of wireless device

Probe Calibration Process

Dosimetric Assessment Procedure

Each probe is calibrated according to a dosimetric assessment procedure described in with accuracy better than +/- 10%. The spherical isotropy was evaluated with the procedure described in and found to be better than +/-0.25dB. The sensitivity parameters (Norm X, Norm Y, Norm Z), the diode compression parameter (DCP) and the conversion factor (Conv F) of the probe is tested.

Free Space Assessment

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies below 1 GHz, and in a waveguide above 1GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1 mW/cm^2.

Temperature Assessment *

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The measured free space E-field in the medium, correlates to temperature rise in a dielectric medium. For temperature correlation calibration a RF transparent thermistor based temperature probe is used in conjunction with the E-field probe

$$SAR = C\frac{\Delta T}{\Delta t}$$

where:

Δt = exposure time (30 seconds),

C = heat capacity of tissue (brain or muscle),

ΔT = temperature increase due to RF exposure.

$$SAR = \frac{|E|^2 \cdot \sigma}{\rho}$$

where:

σ = simulated tissue conductivity,

ρ = Tissue density (1.25 g/cm^3 for brain tissue)

SAR is proportional to $\Delta T / \Delta t$, the initial rate of tissue heating, before thermal diffusion takes place.
Now it's possible to quantify the electric field in the simulated tissue by equating the thermally derived SAR to the E- field;

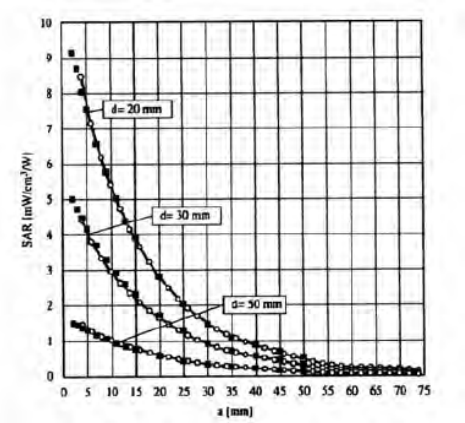


Figure 2.4 E-Field and Temperature Measurements at 900MHz

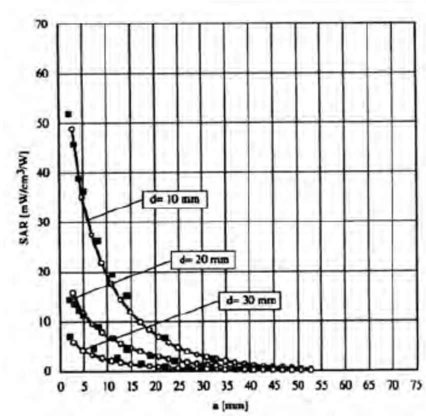


Figure 2.5 E-Field and Temperature Measurements at 1800MHz

Data Extrapolation

The DASY52 software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given like below;

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

with V_i = compensated signal of channel i (i=x,y,z)
U_i = input signal of channel i (i=x,y,z)
cf = crest factor of exciting field (DASY parameter)
dcp_i = diode compression point (DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes:

$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

with V_i = compensated signal of channel i (i = x,y,z)
$Norm_i$ = sensor sensitivity of channel i (i = x,y,z) $\mu V/(V/m)^2$ for E-field probes
ConvF = sensitivity of enhancement in solution
E_i = electric field strength of channel i in V/m

The RSS value of the field components gives the total field strength (Hermetian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with SAR = local specific absorption rate in W/g
E_{tot} = total field strength in V/m
σ = conductivity in [mho/m] or [Siemens/m]
ρ = equivalent tissue density in g/cm^3

The power flow density is calculated assuming the excitation field to be a free space field.

$$P_{pwe} = \frac{E_{tot}^2}{3770}$$

with P_{pwe} = equivalent power density of a plane wave in W/cm^2
E_{tot} = total electric field strength in V/m

Scanning procedure

- The DASY installation includes predefined files with recommended procedures for measurements and system check. They are read-only document files and destined as fully defined but unmeasured masks. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.

- The „reference“ and „drift“ measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the DUT's output power and should vary max. +/- 5 %.

- The highest integrated SAR value is the main concern in compliance test applications. These values can mostly be found at the inner surface of the phantom and cannot be measured directly due to the sensor offset in the probe. To extrapolate the surface values, the measurement distances to the surface must be known accurately. A distance error of 0.5mm could produce SAR errors of 6% at 1800 MHz. Using predefined locations for measurements is not accurate enough. Any shift of the phantom (e.g., slight deformations after filling it with liquid) would produce high uncertainties. For an automatic and accurate detection of the phantom surface, the DASY5 system uses the mechanical surface detection. The detection is always at touch, but the probe will move backward from the surface the indicated distance before starting the measurement.

- The „area scan“ measures the SAR above the DUT or verification dipole on a parallel plane to the surface. It is used to locate the approximate location of the peak SAR with 2D spline interpolation. The robot performs a stepped movement along one grid axis while the local electrical field strength is measured by the probe. The probe is touching the surface of the SAM during acquisition of measurement values. The scan uses different grid spacings for different frequency measurements. Standard grid spacing for head measurements in frequency ranges ≤ 2GHz is 15 mm in x - and y- dimension. For higher frequencies a finer resolution is needed, thus for the grid spacing is reduced according the following table:

Area scan grid spacing for different frequency ranges	
Frequency range	Grid spacing
≤ 2 GHz	≤ 15 mm
2 – 4 GHz	≤ 12 mm
4 – 6 GHz	≤ 10 mm

Grid spacing and orientation have no influence on the SAR result. For special applications where the standard scan method does not find the peak SAR within the grid, e.g. mobile phones with flip cover, the grid can be adapted in orientation. Results of this coarse scan are shown in annex B.

- A „zoom scan” measures the field in a volume around the 2D peak SAR value acquired in the previous „coarse“ scan. It uses a fine meshed grid where the robot moves the probe in steps along all the 3 axis (x,y and z-axis) starting at the bottom of the Phantom. The grid spacing for the cube measurement is varied according to the measured frequency range, the dimensions are given in the following table:

Zoom scan grid spacing and volume for different frequency ranges			
Frequency range	Grid spacing for x, y axis	Grid spacing for z axis	Minimum zoom scan volume
≤ 2 GHz	≤ 8 mm	≤ 5 mm	≥ 30 mm
2 – 3 GHz	≤ 5 mm	≤ 5 mm	≥ 28 mm
3 – 4 GHz	≤ 5 mm	≤ 4 mm	≥ 28 mm
4 – 5 GHz	≤ 4 mm	≤ 3 mm	≥ 25 mm
5 – 6 GHz	≤ 4 mm	≤ 2 mm	≥ 22 mm

DASY is also able to perform repeated zoom scans if more than 1 peak is found during area scan. In this document, the evaluated peak 1g and 10g averaged SAR values are shown in the 2D-graphics in annex B. Test results relevant for the specified standard (see section 3) are shown in table form in section 7.

Spatial Peak SAR Evaluation

The spatial peak SAR - value for 1 and 10 g is evaluated after the Cube measurements have been done. The basis of the evaluation are the SAR values measured at the points of the fine cube grid consisting of all points in the three directions x, y and z. The algorithm that finds the maximal averaged volume is separated into three different stages.

- The data between the dipole center of the probe and the surface of the phantom are extrapolated. This data cannot be measured since the center of the dipole is 1 to 2.7 mm away from the tip of the probe and the distance between the surface and the lowest measuring point is about 1 mm (see probe calibration sheet). The extrapolated data from a cube measurement can be visualized by selecting 'Graph Evaluated'.

- The maximum interpolated value is searched with a straight-forward algorithm. Around this maximum the SAR - values averaged over the spatial volumes (1g or 10 g) are computed using the 3d-spline interpolation algorithm. If the volume cannot be evaluated (i.e., if a part of the grid was cut off by the boundary of the measurement area) the evaluation will be started on the corners of the bottom plane of the cube.

- All neighbouring volumes are evaluated until no neighbouring volume with a higher average value is found.

Extrapolation

The extrapolation is based on a least square algorithm [W. Gander, Computermathematik, p.168-180]. Through the points in the first 3 cm along the z-axis, polynomials of order four are calculated. These polynomials are then used to evaluate the points between the surface and the probe tip. The points, calculated from the surface, have a distance of 1 mm from each other.

Interpolation

The interpolation of the points is done with a 3d-Spline. The 3d-Spline is composed of three one-dimensional splines with the "Not a knot"-condition [W. Gander, Computermathematik, p.141-150] (x, y and z -direction) [Numerical Recipes in C, Second Edition, p.123ff].

Volume Averaging

At First the size of the cube is calculated. Then the volume is integrated with the trapezoidal algorithm. 8000 points (20x20x20) are interpolated to calculate the average.

Advanced Extrapolation

DASY uses the advanced extrapolation option which is able to compensate boundary effects on E-field probes.

SAM PHANTOM

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents the evaporation of the liquid. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. (see Fig. 2.6)

Phantom Specification

Phantom: SAM Twin Phantom (V4.0)
Shell Material: Vivac Composite
Thickness: 2.0 ± 0.2 mm

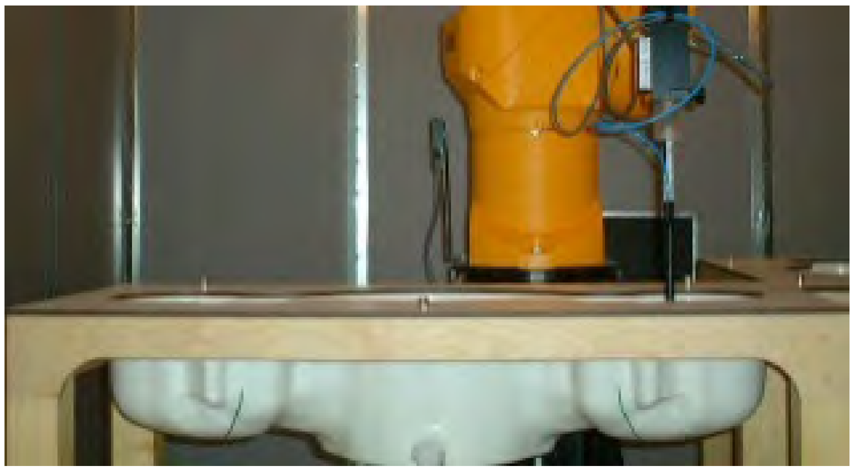


Figure 2.6 SAM Twin Phantom

Device Holder for Transmitters

In combination with the SAM Twin Phantom V4.0 the Mounting Device (see Fig. 2.7), enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation point is the ear opening. The devices can be easily, accurately, and repeat ably be positioned according to the FCC, CENELEC, IEC and IEEE specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).

Figure 2.7 Mounting Device

Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

3. Probe and Dipole Calibration

See Appendix D and E.

4. Phantom & Simulating Tissue Specifications

Head & Body Simulating Mixture Characterization

The head mixtures consist of the material based on the table listed below. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue.

Table 4.1 Typical Composition of Ingredients for Tissue

Ingredients		Simulating Tissue
		2450 MHz Head
Mixing Percentage		
Water		Proprietary Purchased From Speag
Sugar		
Salt		
HEC		
Bactericide		
DGBE		
Dielectric Constant	Target	39.20
Conductivity (S/m)	Target	1.80

5. ANSI/IEEE C95.1 – 1999 RF Exposure Limits [2]

Uncontrolled Environment

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

Controlled Environment

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

Table 5.1 Human Exposure Limits

	UNCONTROLLED ENVIRONMENT General Population (W/kg) or (mW/g)	CONTROLLED ENVIROMENT Professional Population (W/kg) or (mW/g)
SPATIAL PEAK SAR[1] Brain	1.60	8.00
SPATIAL AVERAGE SAR[2] Whole Body	0.08	0.40
SPATIAL PEAK SAR[3] Hands, Feet, Ankles, Wrists	4.00	20.00

[1] The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
[2] The Spatial Average value of the SAR averaged over the whole body.
[3] The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

6. Measurement Uncertainty

Measurement uncertainty table is not required per KDB 865664 D01 v01 section 2.8.2 page 12. SAR measurement uncertainty analysis is required in the SAR report only when the highest measured SAR in a frequency band is ≥ 1.5 W/kg for 1-g SAR. The equivalent ratio (1.5/1.6) should be applied to extremity and occupational exposure conditions. The highest reported value is less than 1.5 W/kg. Therefore, the measurement uncertainty table is not required.

7. System Validation

Tissue Verification

Table 7.1 Measured Tissue Parameters

		2450 MHz Head	
Date(s)		Sep. 20, 2023	
Liquid Temperature (˚C)	20.0	Target	Measured
Dielectric Constant: ε		39.20	38.43
Conductivity: σ		1.80	1.83

See Appendix A for data printout.

Test System Verification

Prior to assessment, the system is verified to the ±10% of the specifications at the test frequency by using the system kit. Power is extrapolated to 1 watt. (Graphic Plots Attached)

Table 7.2 System Dipole Validation Target & Measured

	Test Frequency	Targeted SAR_{10g} (W/kg)	Measure SAR_{10g} (W/kg)	Tissue Used for Verification	Deviation (%)	Plot Number
20-Sep-2023	2450 MHz	25.00	25.40	Head	+ 1.60	1

See Appendix A for data plots.

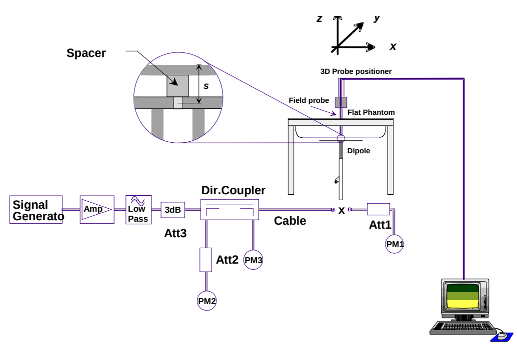


Figure 7.1 Dipole Validation Test Setup

8. SAR Test Data Summary

See Measurement Result Data Pages

See Appendix B for SAR Test Data Plots.
See Appendix C for SAR Test Setup Photos.

Procedures Used To Establish Test Signal

The device was placed into simulated transmit mode using the manufacturer's test codes. Such test signals offer a consistent means for testing SAR and are recommended for evaluating SAR. When test modes are not available or inappropriate for testing a device, the actual transmission is activated through a base station simulator or similar equipment. See data pages for actual procedure used in measurement.

Device Test Condition

In order to verify that the device was tested at full power, conducted output power measurements were performed before and after each SAR measurement to confirm the output power unless otherwise noted. If a conducted power deviation of more than 5% occurred, the test was repeated. The power drift of each test is measured at the start of the test and again at the end of the test. The drift percentage is calculated by the formula ((end/start)-1)*100 and rounded to three decimal places. The drift percentage is calculated into the resultant SAR value on the data sheet for each test.

The EUT was tested on the back side of the device in contact with the ELI Flat phantom for measurements. All measurements were conducted with the side of the device in direct contact with the phantom. All further test reductions are shown on page 21. The device does not allow for simultaneous Tx with the radios. See the photo in Appendix C for a pictorial of the setups.

The strap has been removed for the testing as it is made of plastic. The plastic will not have any effect on the SAR value.

The BLE and ANT transmitters are excluded from SAR testing. The both antennas has a minimum separation distance of 5 mm. Both transmitters are in the same band and the maximum power for BT/BLE is 10.0 dBm (10.0 mW) and for ANT is 4.0 dBm (2.5 mW). Therefore, if the BT/BLE transmitter is excluded, the ANT transmitter would also be excluded. The calculations are listed below.

For the FCC, the exclusion is based on the formula listed in KDB447498 D01 v06 section 4.3.1 a). For extremity, the exclusion limit is 23 mW. The maximum power for the transmitters is 10.0 mW which is below the 23 mW limit.

For ISED, the limit is based on Table 1 in RSS-102 Issue 5 section 2.5.1. The table numbers are multiplied by 2.5 for extremity devices. Therefore, the maximum power for the transmitters is 10.0 mW to be excluded. The maximum power for the transmitters is 10.0 mW which is equal to the 10.0 mW limit.

The 13.56 MHz band has a transmit power of less the 1 mW which is categorically excluded from SAR testing for both the FCC and ISED.

The device was on a minimum of 10 cm of Styrofoam during each test.

Table 8.1 Test Reduction Table

Mode	Side	Required Channel	Tested/Reduced
802.11b	Back	1 – 2412 MHz	Tested
		6 – 2437 MHz	Tested
		11 – 2462 MHz	Tested
	All Other Sides	1 – 2412 MHz	Reduced[3]
		6 – 2437 MHz	Reduced[3]
		11 – 2462 MHz	Reduced[3]
802.11g	Back	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	All Other Sides	1 – 2412 MHz	Reduced[3]
		6 – 2437 MHz	Reduced[3]
		11 – 2462 MHz	Reduced[3]
802.11n	Back	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	All Other Sides	1 – 2412 MHz	Reduced[3]
		6 – 2437 MHz	Reduced[3]
		11 – 2462 MHz	Reduced[3]

Reduced[1] – When the reported SAR is >1.0 W/kg, test the next highest configuration until the SAR value is ≤ 2.0 W/kg per KDB 248227 D01 v02r02 section 5.1.1 2) page 9.
Reduced[2] – When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 3.0 W/kg, SAR is not required per KDB 248227 D01 v02r02 section 5.2.2 2) page 10.
Reduced[3] - The remaining sides are not used next to the body.

Figure 8.2 Test Reduction Table Body Measurements

Band/ Frequency (MHz)	Technology	Side	Required Channel	Tested/ Reduced
2450 MHz	BT BR	Back	1	Reduced[3]
			40	Reduced[3]
			78	Reduced[3]
		All Other Sides	1	Reduced[2]
			40	Reduced[2]
			78	Reduced[2]
	BLE	Back	0	Reduced[3]
			17	Reduced[3]
			36	Reduced[3]
		All Other Sides	0	Reduced[2]
			17	Reduced[2]
			36	Reduced[2]
	ANT	Back	1	Reduced[3]
			39	Reduced[3]
			78	Reduced[3]
		All Other Sides	1	Reduced[2]
			39	Reduced[2]
			78	Reduced[2]

Reduced[1] – When the reported SAR is ≤1.0 W/kg, the remaining channels are not required per KDB 248227 D01 v02r02 section 5.1.1 1) page 9.
Reduced[2] - The remaining sides are not used next to the body.
Reduced[3] – Reduced per equations described on page 20 of this report.

Band	Mode	Bandwidth (MHz)	Channel	Frequency (MHz)	Data Rate	Avg Power (dBm)	Tune-up Pwr (dBm)
2450 MHz	802.11b	20	1	2412	1 Mbps	15.33	16.50
			6	2437		15.32	16.50
			11	2462		14.29	16.50
	802.11g	20	1	2412	6 Mbps	Not Required	14.50
			6	2437			14.50
			11	2462			14.50
	802.11n	20	1	2412	HT0		14.00
			6	2437			14.00
			11	2462			14.00

Band	Mode	Channel	Frequency (MHz)	Avg Power (dBm)	Tune-up Pwr (dBm)
2450 MHz	BT BR	1	2402	Not Required	10.00
		40	2442		10.00
		78	2480		10.00
	BLE	0	2404		4.50
		17	2440		4.50
		36	2478		4.50
	ANT	1	2402		4.00
		39	2440		4.00
		78	2480		4.00

SAR Data Summary – 2450 MHz Extremity 802.11b

MEASUREMENT RESULTS								
Plot	**Gap**	**Position**	**Frequency**		**Modulation**	**End Power**	**Measured SAR (W/kg)**	**Reported SAR (W/kg)**
			MHz	**Ch.**		**(dBm)**		
-----	0 mm	Back	2412	1	DSSS	15.33	0.274	0.36
1			2437	6	DSSS	15.32	0.298	0.39
-----			2462	11	DSSS	14.29	0.223	0.37
					Extremity **4.0 W/kg (mW/g)** averaged over 10 gram			

1. Battery is fully charged for all tests.
   Power Measured ☒Conducted ☐ERP ☐EIRP
2. SAR Measurement
   Phantom Configuration ☐Left Head ☒Eli4 ☐Right Head
   SAR Configuration ☐Head ☒Body
3. Test Signal Call Mode ☒Test Code ☐Base Station Simulator
4. Test Configuration ☐With Belt Clip ☐Without Belt Clip ☒N/A
5. Tissue Depth is at least 15.0 cm

Jay M. Moulton
Vice President

9. Test Equipment List

Table 9.1 Equipment Specifications

Type	Calibration Due Date	Calibration Done Date	Serial Number
Staubli Robot TX60L	N/A	N/A	F07/55M6A1/A/01
Measurement Controller CS8c	N/A	N/A	1012
ELI5 Flat Phantom	N/A	N/A	2037
Device Holder	N/A	N/A	N/A
Data Acquisition Electronics 4	04/19/2024	04/19/2023	1416
SPEAG E-Field Probe EX3DV4	01/17/2024	01/17/2023	7530
Speag Validation Dipole D2450V2	06/03/2024	06/03/2021	881
Agilent N1911A Power Meter	03/14/2024	03/14/2023	GB45100254
Agilent N1922A Power Sensor	03/13/2024	03/13/2023	MY45240464
Agilent (HP) 8596E Spectrum Analyzer	03/13/2024	03/13/2023	3826A01468
Agilent (HP) 83752A Synthesized Sweeper	03/14/2024	03/14/2023	3610A01048
Agilent (HP) 8753C Vector Network Analyzer	03/14/2024	03/14/2023	3135A01724
Agilent (HP) 85047A S-Parameter Test Set	03/14/2024	03/14/2023	2904A00595
Copper Mountain R140 Vector Reflectometer	03/13/2024	03/13/2023	21390004
Agilent 778D Dual Directional Coupler	N/A	N/A	MY48220184
MiniCircuits BW-N20W5+ Fixed 20 dB Attenuator	N/A	N/A	N/A
MiniCircuits SPL-10.7+ Low Pass Filter	N/A	N/A	R8979513746
Aprel Dielectric Probe Assembly	N/A	N/A	0011
Head Equivalent Matter (2450 MHz)	N/A	N/A	N/A

10. Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC/IC. These measurements are taken to simulate the RF effects exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters subject to the test. The test results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body is a very complex phenomena that depends on the mass, shape, and size of the body; the orientation of the body with respect to the field vectors; and, the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because innumerable factors may interact to determine the specific biological outcome of an exposure to electromagnetic fields, any protection guide shall consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables. [3]

11. References

[1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radio Frequency Radiation, August 1996

[2] ANSI/IEEE C95.1 – 1992, American National Standard Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300kHz to 100GHz, New York: IEEE, 1992.

[3] ANSI/IEEE C95.3 – 1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave, New York: IEEE, 1992.

[4] International Electrotechnical Commission, IEC 62209-2 (Edition 1.0), Human Exposure to radio frequency fields from hand-held and body mounted wireless communication devices – Human models, instrumentation, and procedures – Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz), March 2010.

[5] IEC 62209-1528 – 2020, Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body mounted wireless communication device, October 2020.

[6] Industry Canada, RSS – 102 Issue 5 Draft, Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands), March 2014.

[7] Health Canada, Safety Code 6, Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3kHz to 300 GHz, 2009.

Appendix A – System Validation Plots and Data

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************************************************************
Test Result for UIM Dielectric Parameter
Wed 20/Sep/2023
Freq    Frequency(GHz)
FCC_eH Limits for Head Epsilon
FCC_sH Limits for Head Sigma
Test_e Epsilon  of  UIM
Test_s Sigma of UIM
************************************************************
```

Freq	FCC_eH	FCC_sH	Test_e	Test_s
2.4100	39.26	1.76	38.53	1.78
2.4120	39.258	1.762	38.526	1.782*
2.4200	39.25	1.77	38.51	1.79
2.4300	39.24	1.78	38.49	1.80
2.4370	39.226	1.787	38.483	1.814*
2.4400	39.22	1.79	38.48	1.82
2.4420	39.216	1.792	38.47	1.822*
2.4500	39.20	1.80	38.43	1.83
2.4600	39.19	1.81	38.43	1.84
2.4620	39.186	1.812	38.426	1.842*
2.4700	39.17	1.82	38.41	1.85
2.4720	39.168	1.822	38.406	1.856*
2.4800	39.16	1.83	38.39	1.88

* value interpolated

RF Exposure Lab

Plot 1

DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN: 881

Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1
Medium: HSL2450; Medium parameters used: f = 2450 MHz; σ = 1.83 S/m; ε_r = 38.43; ρ = 1000 kg/m^3
Phantom section: Flat Section

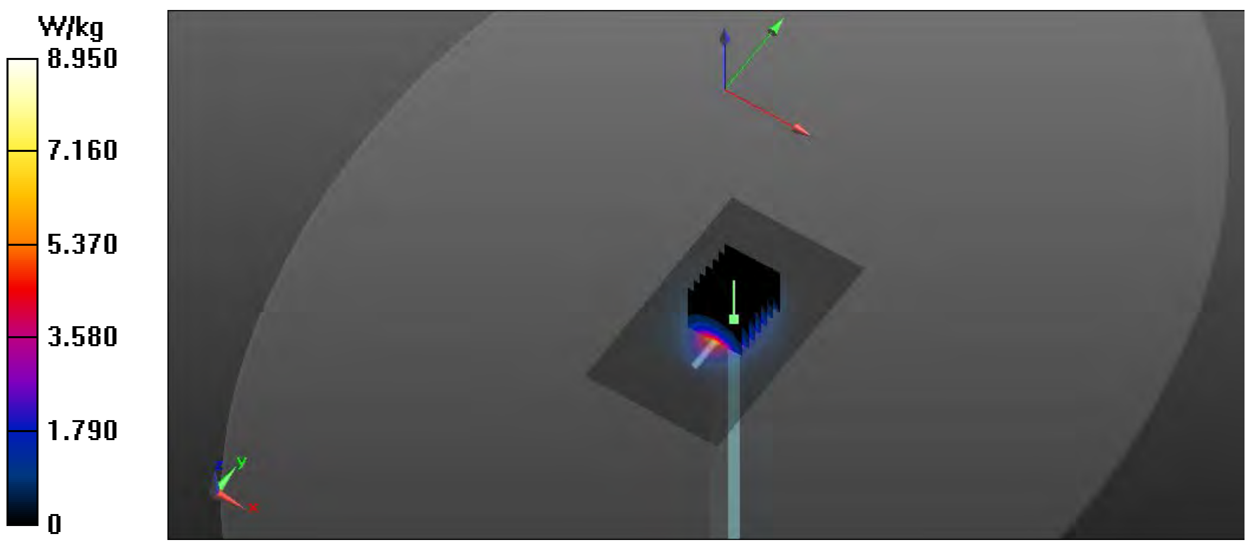
Test Date: Date: 9/20/2023; Ambient Temp: 23 °C; Tissue Temp: 21 °C

Probe: EX3DV4 – SN7530; ConvF(7.18, 7.11, 7.21); Calibrated: 1/17/2023;
Sensor-Surface: 2mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1416; Calibrated: 4/19/2023
Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 2037
Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

Procedure Notes:

Head Verification/2450 MHz/Area Scan (61x101x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 8.34 W/kg

Head Verification/2450 MHz/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 54.967 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 11.24 W/kg
P_{in}= 100 mW
SAR(1 g) = 5.45 W/kg; SAR(10 g) = 2.54 W/kg
Maximum value of SAR (measured) = 8.95 W/kg



Appendix B – SAR Test Data Plots

RF Exposure Lab

Plot 1

DUT: AA4714; Type: Portable Transceiver; Serial: 453413899

Communication System: WiFi 802.11b (DSSS, 1 Mbps); Frequency: 2437 MHz; Duty Cycle: 1:1
Medium: HSL2450; Medium parameters used (interpolated): f = 2437 MHz; σ = 1.814 S/m; ε_r = 38.483; ρ = 1000 kg/m^3
Phantom section: Flat Section

Test Date: Date: 9/20/2023; Ambient Temp: 23 °C; Tissue Temp: 21 °C

Probe: EX3DV4 - SN7530; ConvF(7.18, 7.11, 7.21); Calibrated: 1/17/2023
Sensor-Surface: 2mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1416; Calibrated: 4/19/2023
Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 2037
Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

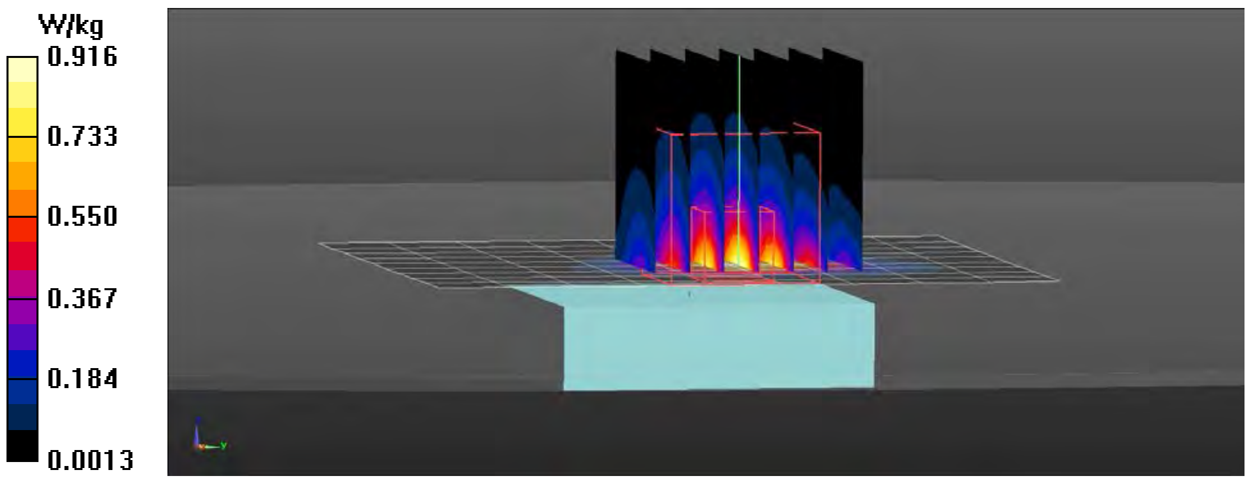
Procedure Notes:

2.4 GHz WiFi AA4714/Back Mid 6/Area Scan (10x10x1): Measurement grid: dx=10mm, dy=10mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.940 W/kg

2.4 GHz WiFi AA4714/Back Mid 6/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 17.26 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 1.15 W/kg
SAR(1 g) = 0.637 W/kg; SAR(10 g) = 0.298 W/kg

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.916 W/kg



Appendix C – SAR Test Setup Photos

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Test Position Back 0 mm Gap

Photo Removed

Front of Device

Photo Removed

Back of Device

Appendix D – Probe Calibration Data Sheets

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S **Schweizerischer Kalibrierdienst**
C **Service suisse d'étalonnage**
Servizio svizzero di taratura
S **Swiss Calibration Service**

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **RF Exposure Lab**

Certificate No **EX-7530_Jan23**

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:7530

Calibration procedure(s): QA CAL-01.v10, QA CAL-12.v10, QA CAL-14.v7, QA CAL-23.v6, QA CAL-25.v8
Calibration procedure for dosimetric E-field probes

Calibration date: January 17, 2023

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
OCP DAK-3.5 (weighted)	SN: 1249	20-Oct-22 (OCP-DAK3.5-1249_Oct22)	Oct-23
OCP DAK-12	SN: 1016	20-Oct-22 (OCP-DAK12-1016_Oct22)	Oct-23
Reference 20 dB Attenuator	SN: CC2552 (20x)	04-Apr-22 (No. 217-03527)	Apr-23
DAE4	SN: 660	10-Oct-22 (No. DAE4-660_Oct22)	Oct-23
Reference Probe ES3DV2	SN: 3013	06-Jan-23 (No. ES3-3013_Jan23)	Jan-24

Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-22)	In house check: Jun-24
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24

	Name	Function	Signature
Calibrated by	Joanna Lleshaj	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: January 23, 2023

Glossary

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices – Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- *DCPx,y,z*: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. DCP does not depend on frequency nor media.
- *PAR*: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters*: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ±50 MHz to ±100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

Parameters of Probe: EX3DV4 - SN:7530

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.42	0.53	0.42	±10.1%
DCP (mV) [B]	96.0	95.0	98.0	±4.7%

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B $dB\sqrt{\mu V}$	C	D dB	VR mV	Max dev.	Max Unc[E] $k = 2$
0	CW	X	0.00	0.00	1.00	0.00	128.4	±2.5%	±4.7%
		Y	0.00	0.00	1.00		120.9		
		Z	0.00	0.00	1.00		104.7		

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Page 5).
[B] Linearization parameter uncertainty for maximum specified field strength.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

Parameters of Probe: EX3DV4 - SN:7530

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	35.7°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

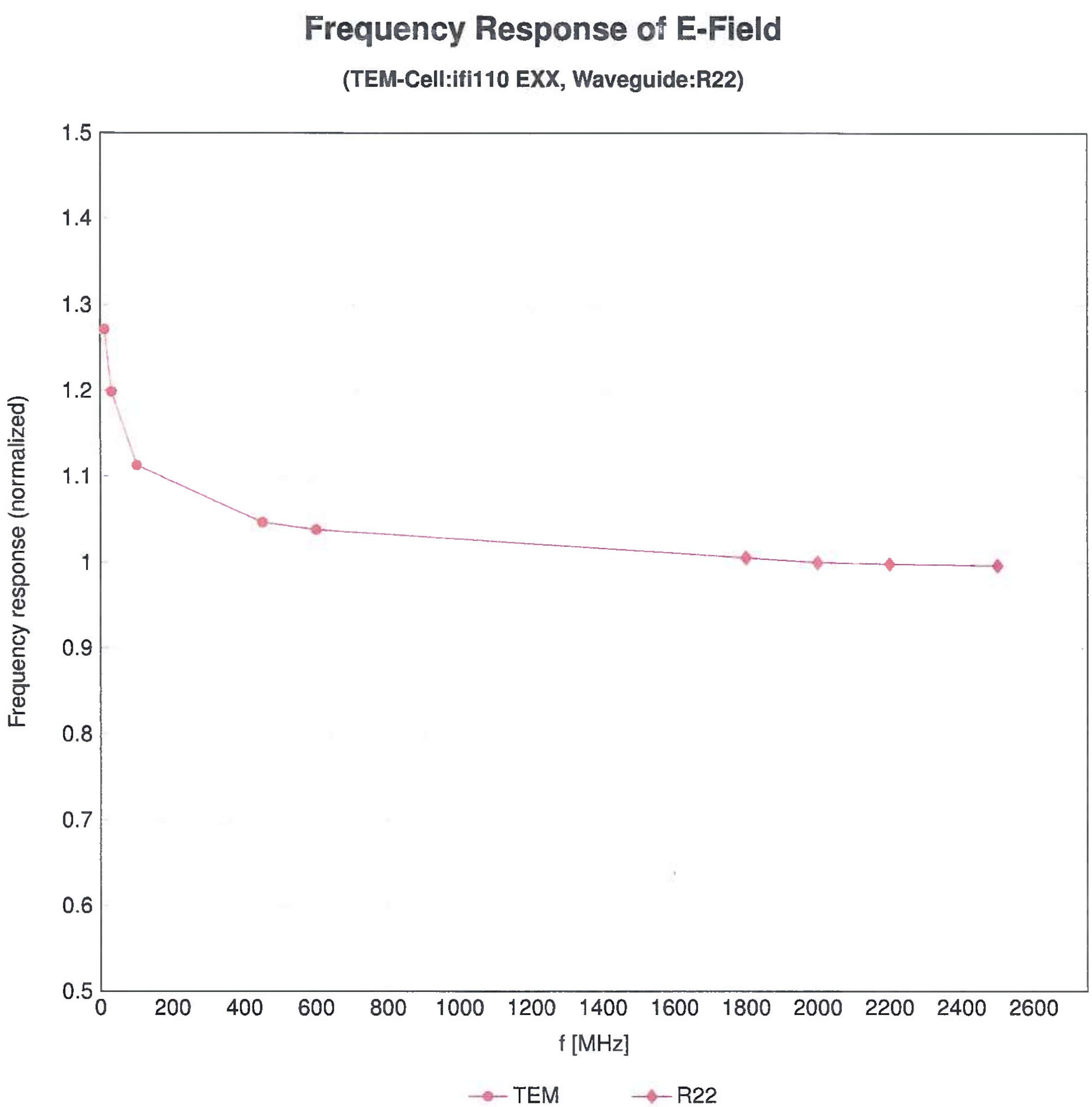
Note: Measurement distance from surface can be increased to 3–4 mm for an *Area Scan* job.

Parameters of Probe: EX3DV4 - SN:7530

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz)[C]	Relative Permittivity[F]	Conductivity[F] (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unc ($k = 2$)
13	55.0	0.75	22.02	22.02	22.02	0.00	1.25	±13.3%
30	55.0	0.75	19.87	19.87	19.87	0.00	1.25	±13.3%
750	41.9	0.89	9.62	9.26	10.37	0.35	1.27	±12.0%
900	41.5	0.97	9.50	9.25	9.30	0.35	1.27	±12.0%
1300	40.8	1.14	8.19	8.15	8.38	0.40	1.27	±12.0%
1750	40.1	1.37	8.28	8.22	8.47	0.28	1.27	±12.0%
1900	40.0	1.40	8.14	8.08	8.31	0.29	1.27	±12.0%
2300	39.5	1.67	7.59	7.55	7.71	0.30	1.27	±12.0%
2450	39.2	1.80	7.18	7.11	7.21	0.32	1.27	±12.0%
2600	39.0	1.96	7.54	7.33	7.61	0.32	1.27	±12.0%
3300	38.2	2.71	6.92	6.92	7.03	0.35	1.27	±14.0%
3500	37.9	2.91	6.65	6.65	6.76	0.36	1.27	±14.0%
3700	37.7	3.12	6.51	6.52	6.65	0.37	1.27	±14.0%
3900	37.5	3.32	6.83	6.80	6.94	0.37	1.27	±14.0%
4200	37.1	3.63	6.47	6.47	6.61	0.37	1.27	±14.0%
4600	36.7	4.04	6.22	6.23	6.35	0.40	1.27	±14.0%
4950	36.3	4.40	5.65	5.58	5.83	0.43	1.36	±14.0%
5250	35.9	4.71	5.26	5.20	5.38	0.34	1.62	±14.0%
5600	35.5	5.07	4.49	4.39	4.63	0.41	1.67	±14.0%
5750	35.4	5.22	4.60	4.58	4.72	0.43	1.75	±14.0%

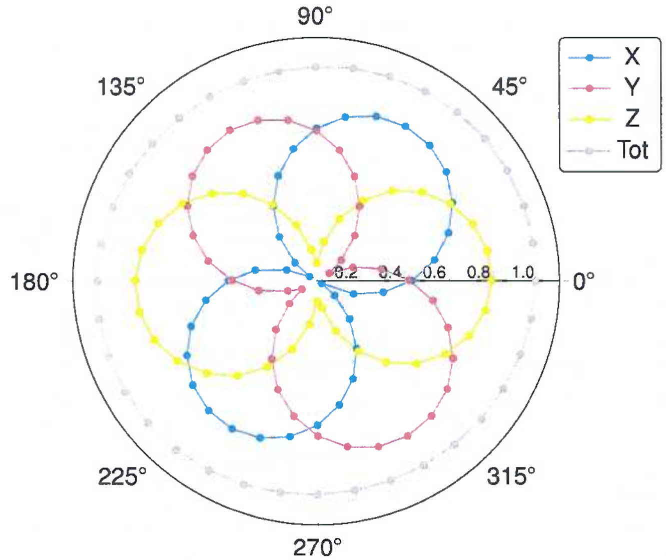
[C] Frequency validity above 300 MHz of ±100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10%. If TSL with deviations from the target of less than ±5% are used, the calibration uncertainties are 11.1% for 0.7 - 3 GHz and 13.1% for 3 - 6 GHz.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.



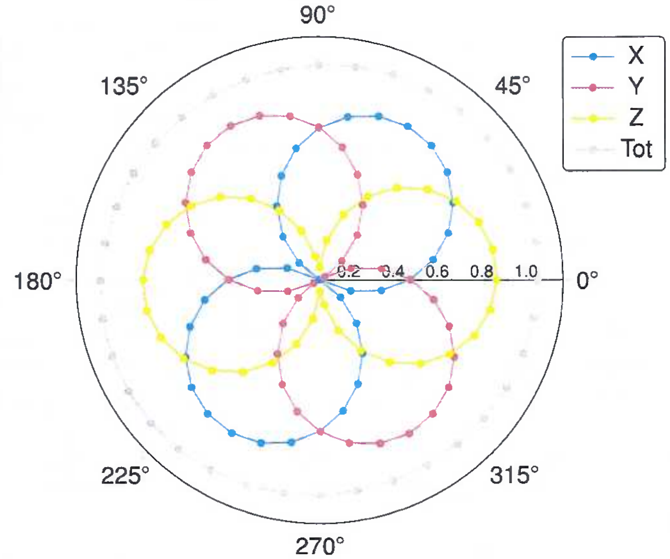
Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

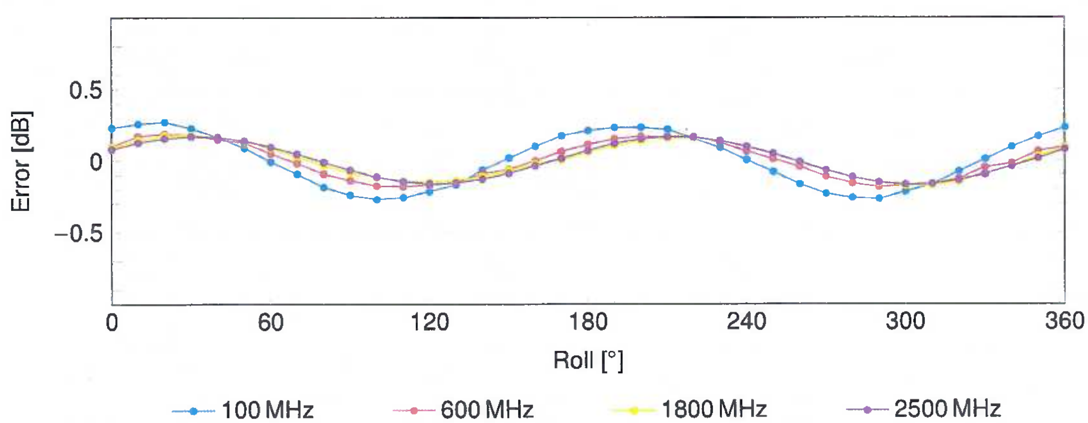
Receiving Pattern (ϕ), $\vartheta = 0°$

f=600 MHz, TEM, 0°



f=1800 MHz, R22, 0°

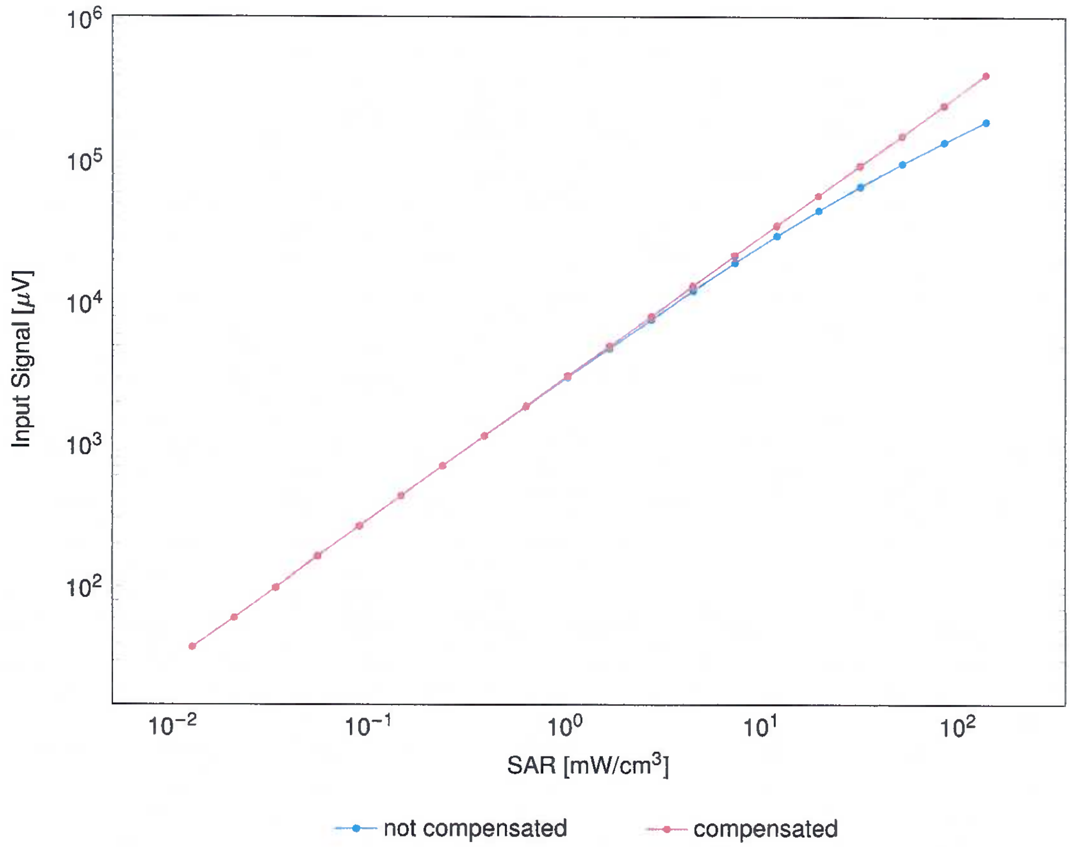


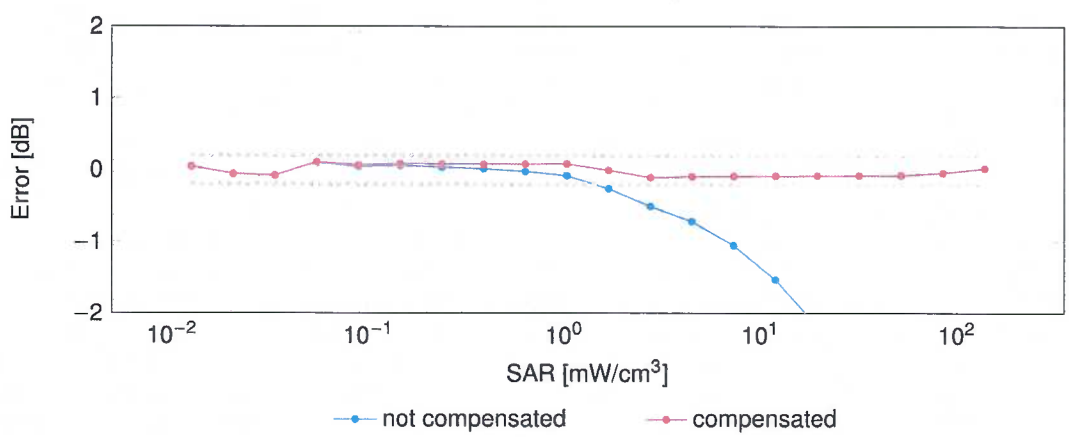


Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)

Dynamic Range f(SAR_{head})

(TEM cell, f_{eval} = 1900 MHz)

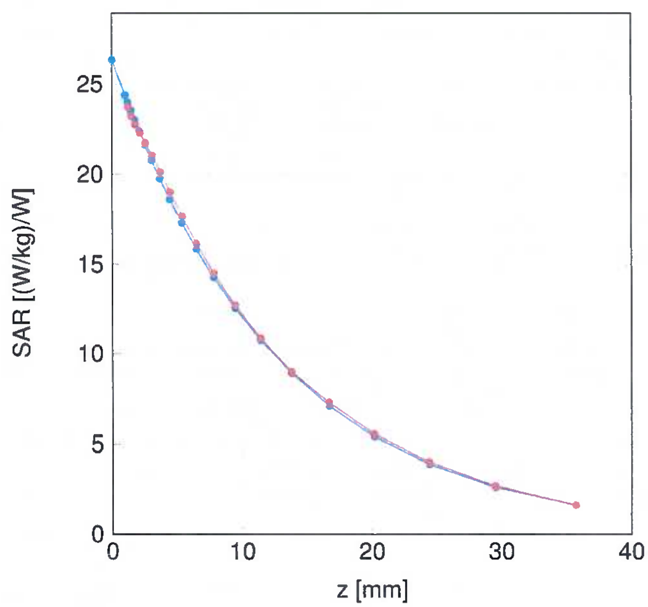




Uncertainty of Linearity Assessment: ±0.6% (k=2)

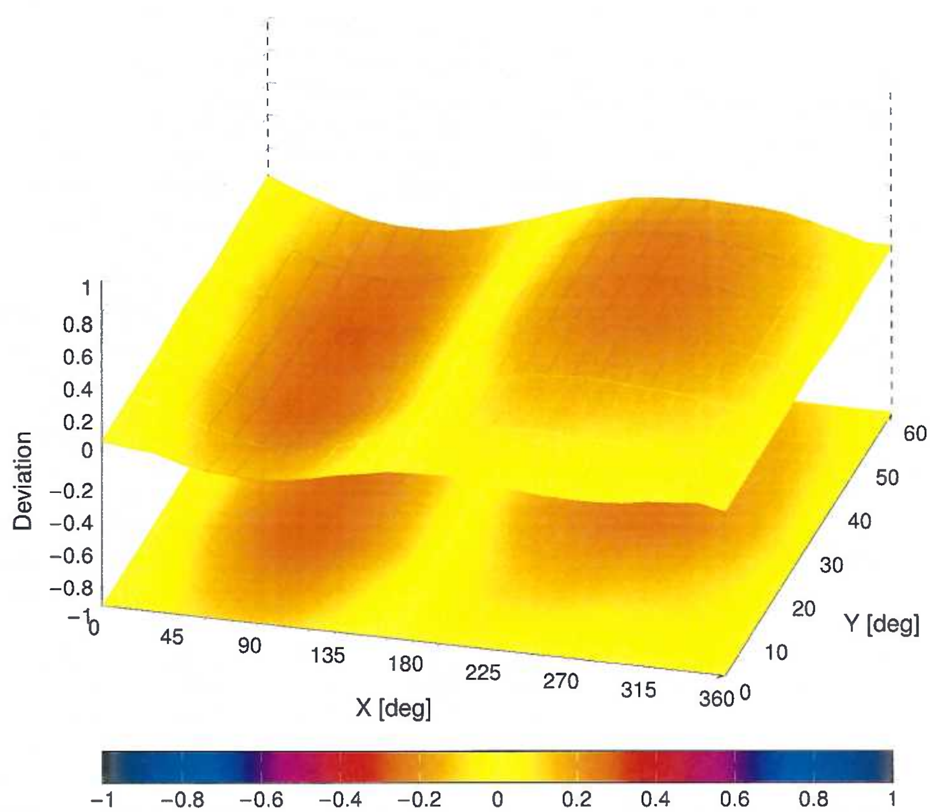
Conversion Factor Assessment

f=1900 MHz, WGLS R22 (H_convF)



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ±2.6% (k=2)

Appendix E – Dipole Calibration Data Sheets

gm

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client RF Exposure Lab

Certificate No: D2450V2-881_Jun21

CALIBRATION CERTIFICATE

Object	D2450V2 - SN:881
Calibration procedure(s)	QA CAL-05.v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz
Calibration date:	June 03, 2021

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 7349	28-Dec-20 (No. EX3-7349_Dec20)	Dec-21
DAE4	SN: 601	02-Nov-20 (No. DAE4-601_Nov20)	Nov-21

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21

	Name	Function	Signature
Calibrated by:	Jeffrey Katzman	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: June 8, 2021

Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.7 ± 6 %	1.87 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.9 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**54.1 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**25.0 W/kg ± 16.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.3 Ω + 4.3 jΩ
Return Loss	- 24.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.156 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG

Extended Calibration
Usage of SAR dipoles calibrated less than 3 years ago but more than 1 year ago were confirmed in maintaining return loss (<-20 dB, within 20% of prior calibration) and impedance (within 5 ohm from prior calibration) requirements per extended calibrations in KDB Publication 865664 D01 v01r04.

D2450V2 SN: 829 - Head						
Date of Measurement	Return Loss (dB)	Δ%	Impedance Real (Ω)	ΔΩ	Impedance Imaginary (jΩ)	ΔΩ
6/3/2021	-24.7		54.3		4.3	
6/3/2022	-25.3	2.4	55.2	0.9	4.1	-0.2
6/6/2023	-26.2	6.1	53.1	-1.2	4.2	-0.1

DASY5 Validation Report for Head TSL

Date: 03.06.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:881

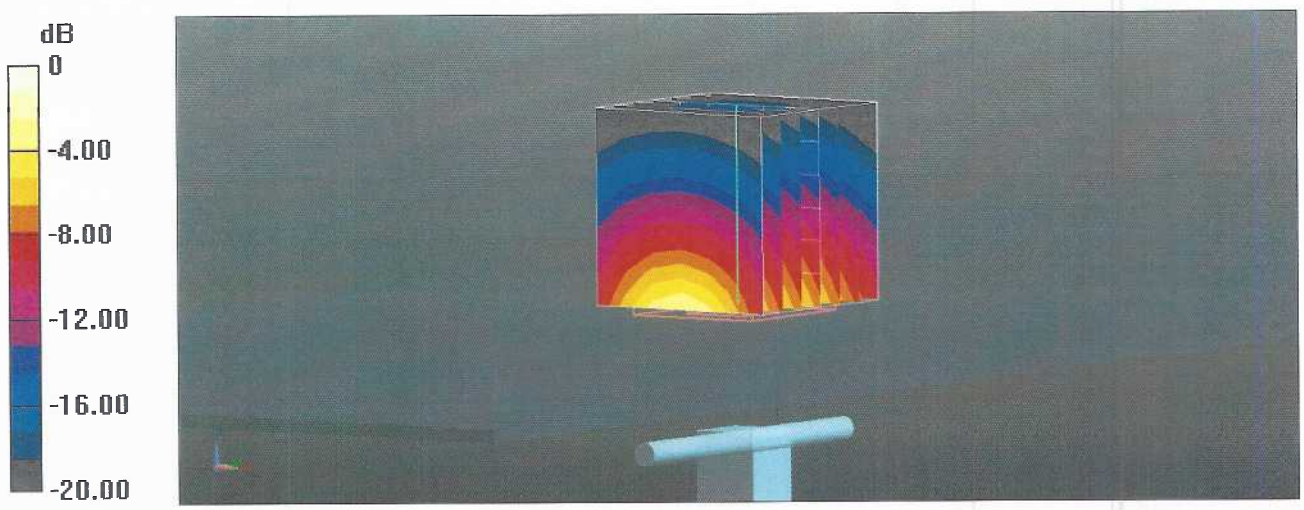
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.87 S/m; ε_r = 37.7; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

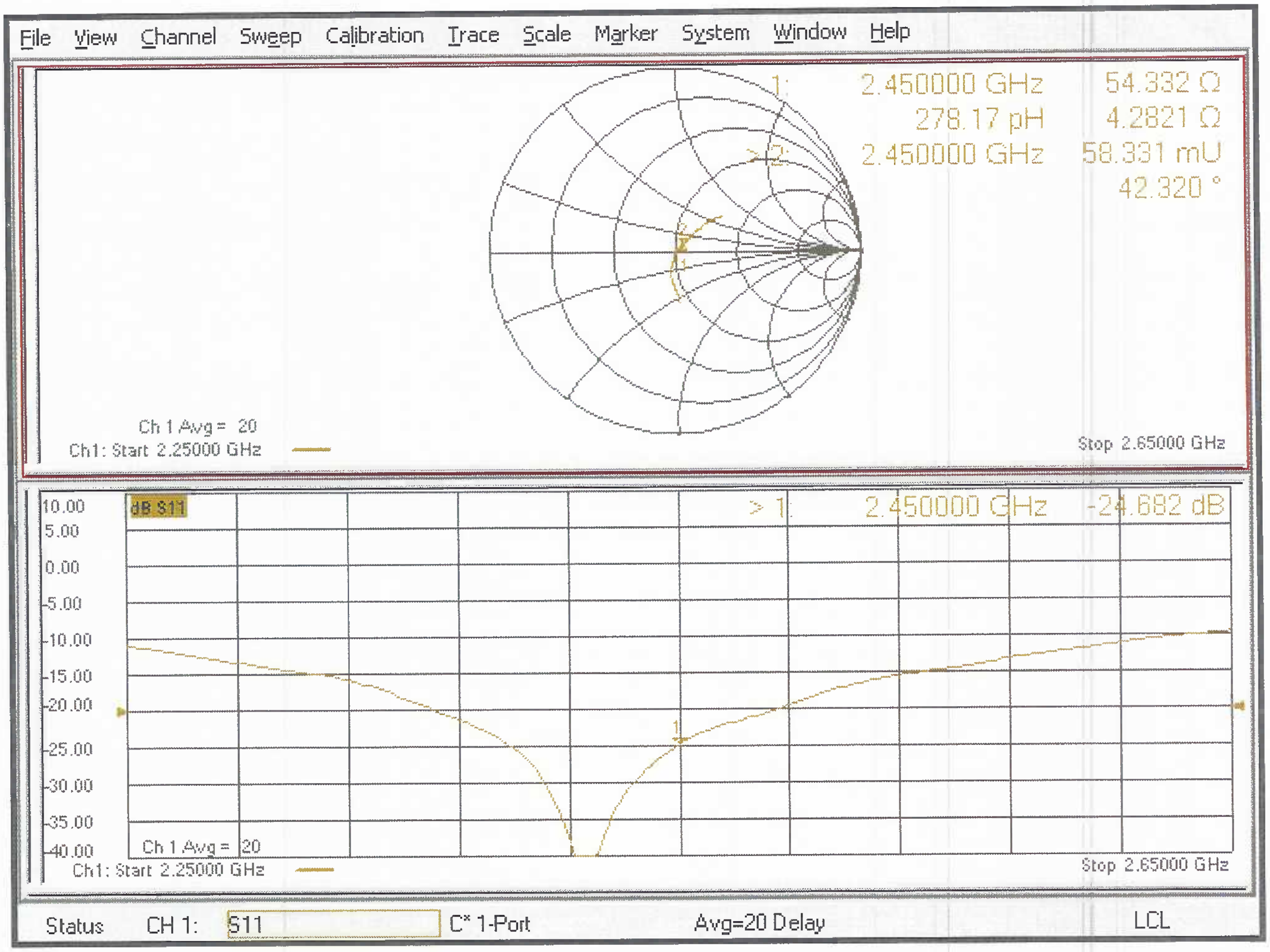
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 119.0 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 28.0 W/kg
SAR(1 g) = 13.9 W/kg; SAR(10 g) = 6.34 W/kg
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 49.5%
Maximum value of SAR (measured) = 23.1 W/kg



0 dB = 23.1 W/kg = 13.64 dBW/kg

Impedance Measurement Plot for Head TSL



Appendix F – DAE Calibration Data Sheets

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **RF Exposure Lab**
San Marcos, USA

Certificate No: DAE4-1416_Apr23

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BM - SN: 1416
Calibration procedure(s)	QA CAL-06.v30 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	April 19, 2023

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	29-Aug-22 (No:34389)	Aug-23
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	27-Jan-23 (in house check)	In house check: Jan-24
Calibrator Box V2.1	SE UMS 006 AA 1002	27-Jan-23 (in house check)	In house check: Jan-24

	Name	Function	Signature
Calibrated by:	Adrian Gehring	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	i.V.

Issued: April 19, 2023

Glossary

DAE	data acquisition electronics
Connector angle	information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

DC Voltage Measurement

A/D - Converter Resolution nominal

High Range:	1LSB =	6.1μV ,	full range =	-100...+300 mV
Low Range:	1LSB =	61nV ,	full range =	-1.......+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	403.576 ± 0.02% (k=2)	403.882 ± 0.02% (k=2)	404.149 ± 0.02% (k=2)
Low Range	3.97826 ± 1.50% (k=2)	3.99531 ± 1.50% (k=2)	3.97142 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	181.0 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	199994.69	-0.41	-0.00
Channel X	+ Input	20001.60	-1.04	-0.01
Channel X	- Input	-20000.15	1.22	-0.01
Channel Y	+ Input	199996.57	1.52	0.00
Channel Y	+ Input	20000.09	-2.36	-0.01
Channel Y	- Input	-20003.05	-1.65	0.01
Channel Z	+ Input	199995.51	0.44	0.00
Channel Z	+ Input	19999.49	-2.93	-0.01
Channel Z	- Input	-20003.45	-2.02	0.01

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2001.59	-0.18	-0.01
Channel X	+ Input	202.16	0.15	0.07
Channel X	- Input	-197.31	0.40	-0.20
Channel Y	+ Input	2001.43	-0.20	-0.01
Channel Y	+ Input	201.00	-0.84	-0.42
Channel Y	- Input	-198.62	-0.66	0.33
Channel Z	+ Input	2001.53	-0.06	-0.00
Channel Z	+ Input	200.32	-1.54	-0.76
Channel Z	- Input	-199.56	-1.57	0.79

2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	-3.92	-4.61
	- 200	7.37	4.65
Channel Y	200	-5.88	-7.43
	- 200	6.96	5.86
Channel Z	200	-23.77	-23.62
	- 200	21.74	21.52

3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Input Voltage (mV)	Channel X (μV)	Channel Y (μV)	Channel Z (μV)
Channel X	200	-	2.98	-4.77
Channel Y	200	7.89	-	2.79
Channel Z	200	9.17	6.36	-

4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	15996	17581
Channel Y	16150	16491
Channel Z	16130	15361

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	0.78	-0.03	1.52	0.32
Channel Y	-0.79	-1.76	0.77	0.41
Channel Z	-0.57	-1.39	0.58	0.37

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	–0.01	-8	-9

Appendix G – Phantom Calibration Data Sheets

Zeughausstrasse 43, 8004 Zurich, Switzerland
Phone +41 44 245 9700, Fax +41 44 245 9779
info@speag.com, http://www.speag.com

Certificate of Conformity / First Article Inspection

Item	Oval Flat Phantom ELI 4.0
Type No	QD OVA 001 B
Series No	1003 and higher
Manufacturer	Untersee Composites Knebelstrasse 8 CH-8268 Mannenbach, Switzerland

Tests

Complete tests were made on the prototype units QD OVA 001 AA 1001, QD OVA 001 AB 1002, pre-series units QD OVA 001 BA 1003-1005 as well as on the series units QD OVA 001 BB, 1006 ff.

Test	Requirement	Details	Units tested
Material thickness	Compliant with the standard requirements	Bottom plate: 2.0mm +/- 0.2mm	all
Material parameters	Dielectric parameters for required frequencies	< 6 GHz: Rel. permittivity = 4 +/-1, Loss tangent ≤ 0.05	Material sample
Material resistivity	The material has been tested to be compatible with the liquids defined in the standards if handled and cleaned according to the instructions.	DGBE based simulating liquids. Observe Technical Note for material compatibility.	Equivalent phantoms, Material sample
Shape	Thickness of bottom material, Internal dimensions, Sagging compatible with standards from minimum frequency	Bottom elliptical 600 x 400 mm Depth 190 mm, Shape is within tolerance for filling height up to 155 mm, Eventual sagging is reduced or eliminated by support via DUT	Prototypes, Sample testing

Standards

[1] CENELEC EN 50361-2001, « Basic standard for the measurement of the Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz – 3 GHz) », July 2001

[2] IEEE 1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques, December 2003

[3] IEC 62209 – 1, "Specific Absorption Rate (SAR) in the frequency range of 300 MHz to 3 GHz – Measurement Procedure, Part 1: Hand-held mobile wireless communication devices", February 2005

[4] IEC 62209 – 2, Draft, "Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices – Human models, Instrumentation and Procedures – Part 2: Procedure to determine the Specific Absorption Rate (SAR) in the head and body for 30 MHz to 6 GHz Handheld and Body-Mounted Devices used in close proximity to the Body.", February 2005

[5] OET Bulletin 65, Supplement C, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition January 2001

Based on the tests above, we certify that this item is in compliance with the standards [1] to [5] if operated according to the specific requirements and considering the thickness. The dimensions are fully compliant with [4] from 30 MHz to 6 GHz. For the other standards, the minimum lower frequency limit is limited due to the dimensional requirements ([1]: 450 MHz, [2]: 300 MHz, [3]: 800 MHz, [5]: 375 MHz) and possibly further by the dimensions of the DUT.

Date 28.4.2008 **Signature / Stamp**

s p e a g
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info@speag.com, http://www.speag.com

Appendix H – Validation Summary

Per FCC KDB 865664 D02 v01r02, SAR system validation status should be documented to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles were used with the required tissue equivalent media for system validation according to the procedures outlined in FCC KDB 865664 D01 v01r04 and IEEE 1528-2013. Since SAR probe calibrations are frequency dependent, each probe calibration point was validated at a frequency within the valid frequency range of the probe calibration point using the system that normally operates with the probe for routine SAR measurements and according to the required tissue equivalent media.

A tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters has been included.

Table H-1
SAR System Validation Summary

SAR System #	Freq. (MHz)	Date	Probe S/N	Probe Type	Probe Cal. Point		Cond. (σ)	Perm. (ε_r)	CW Validation			Modulation Validation		
									Sens-itivity	Probe Linearity	Probe Isotropy	Modulation Type	Duty Factor	PAR
3	2450	01/31/2023	7530	EX3DV4	2450	Head	1.85	38.76	Pass	Pass	Pass	OFDM/TDD	Pass	Pass