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03-Feb-26

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Olathe, KS 66062-3426  
U.S.A.  
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**Contact Email:** [matias.rodriguez@garmin.com](mailto:matias.rodriguez@garmin.com)  
**Subject:** SUBTEL, Chile (Resolution 737) Certification Compliance 2026  
**Commercial Name:** Vivoactive 5

	Información (Information)
<b>Tipo de equipo (Equipment type)</b>	Portable Digital Transceiver
<b>Marca (Brand)</b>	Garmin 
<b>Modelo (Model)</b>	A04724
<b>Tecnología o modulación (Technology or modulation)</b>	ASK for NFC / GFSK for ANT/ GFSK for BLE/ GFSK for BTBR / $\pi/4$ -DQPSK, 8DPSK for BTEDR / DSSS for 802.11b / OFDM for 802.11g/n
<b>Frecuencias (Frequencies)</b>	13.56 MHz / 2402-2480 MHz / 2402-2480 MHz / 2402-2480 MHz / 2402-2480 MHz / 2412-2462 MHz
<b>Ganancia de antena (dBi) (Antenna gain (dBi))</b>	ANT -0.37 dBi / BLE -0.37 dBi / 802.15.1 -0.37 dBi / 802.15.1 -0.37 dBi / 802.11b/g/n -0.37 dBi
<b>P.i.r.e. (E.I R P.)</b>	-28.03 dBm, 0.001mW / -1.74 dBm, 0.66 mW / -1.54 dBm, 0.70 mW / 9.21 dBm, 8.28 mW / 5.06 dBm, 3.21 mW / 19.30 dBm, 85.11 mW
<b>Módulos (Modules)</b>	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 2023-032

**Version B**  
**Issued 14 July 2023**

**Project GCL-0385**  
**Model Identifier: A04724**  
**Primary Test Standards**  
CFR 47, FCC Part 15.247  
RSS-247 Issue 2

**Garmin Compliance Lab**  
Garmin International  
1200 E 151<sup>st</sup> Street  
Olathe Kansas 66062 USA

## Client-supplied Information

FCC ID: IPH-04724  
IC ID: 1792A-04724



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 results are as follows.

Parameter	Description	Key Performance Values	Result	Data starts at page
Hopping Channels	The radio manages its use of channels appropriately. [15.247(a)(1); RSS-247 at 5.1]	N/A. The radios described in this report are not subjected to the Frequency Hopping rules.	N/A	N/A
DTS Bandwidth	The nature of the radio signal is broadband, being at least 500 kHz wide. [15.247(a)(2); RSS-247 at 5.2(a)]	The 6dB bandwidth is 516 kHz or greater.	PASS	12
Other Bandwidths	Regulatory agencies also require the reporting of signal bandwidths using alternate processes. [2.202; RSS-GEN at 6.7]	These values are reported but have no actual performance requirements.	Reported	19
Transmit Power	The peak transmit power presented to the antenna is no greater than 1 Watt or 30 dBm. The effective radiated power is limited to 4 Watts or 36 dBm EIRP. [15.247(b); RSS-247 at 5.4(d)]	The maximum transmit power is 19.67 dBm or 92.7 mW.	PASS	26
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 0.37 dBi and will document antenna gain separately.	NT	NT
Unwanted Emissions (Conducted Spurious)	The radio should not provide too much radio energy to the antenna at frequencies beyond its intended frequency band. [15.247(d); RSS-247 at 5.5]	Emissions outside the band must be reduced at least 20 dB from in-band levels. The measured reduction was at least 39 dB.	PASS	31
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 0.3 dB below the applicable limits.	PASS	41
Power Spectral Density	The radio must not focus too much radio energy in a narrow frequency band. [15.247(e); RSS-247 at 5.2(b)]	The limit is 8 dBm in a 3 kHz band. The strongest emission level was 5.55 dBm in a band of at least 3 kHz.	PASS	64

Hybrid Systems	A radio that is both frequency hopping and digitally modulated should satisfy a combination of system rules. [15.247(f); RSS-247 at 5.3]	N/A. The radios described in this report are not subjected to the Hybrid System rules.	N/A	N/A
Frequency Hopping Rules	Frequency hopping systems have additional functional requirements. [15.247(g) and (h); RSS-247 at 5.1]	N/A. The radios described in this report are not subjected to the Frequency Hopping rules.	N/A	N/A
Radio Safety	The radio emissions must meet public health & safety guidelines related to human exposure. [15.247(i) and 1.1307; RSS-Gen at 3.4]	NT. Client will report radio energy safety results separately.	NT	NT
Frequency Stability	The radio tuning must be robust over a range of temperature and supply voltage conditions. [RSS-Gen at 6.11]	Radio emissions remained within the allowed radio band under all environmental conditions tested.	PASS	73
AC Mains Conducted Emissions	Radio emissions that this device may generate via long connected cables that are not necessary for its operation and that may affect other radio communication	9.66 dB of margin. Appropriate for use in homes, offices, and industrial facilities. [Class B]	PASS	83
Unintended Radiated Emissions	Radio emissions that this device may generate via its structures and connected cables not necessary for its operation and that may affect other radio communication	12.2 dB of margin. Appropriate for use in homes, offices, and industrial facilities. [Class B]	PASS	86

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

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

**Table 1: Summary of results**

Report Organization

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

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2023-034. 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 151<sup>st</sup> 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 151<sup>st</sup> St, Olathe Kansas, USA. Witnesses from the business group included: None.

Test Sample received: 6 Apr 2023  
Test Start Date: 11 May 2023  
Test End Date: 9 Jun 2023

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

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

## 3. Report History and Approval

This report was written by David Arnett and initially issued on 6 July 2023 as Version A. Version B issued 14 July 2023 to correct editorial errors identified during TCB review.

### Report Technical Review:



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David Arnett  
Technical Lead EMC Engineer

### Report Approval:



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

## 4. Test Sample Modifications and Special Conditions

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

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

### Modification 1

Detailed Description: Update of unit software from version 2.14 to version 2.15

Date applied: 22 May 2023

Reason for this modification: The new software changed the transmit power for WiFi Channel 13 under particular conditions.

Radiated emission and transmit power tests performed on 22 May or earlier that did not involve WiFi channel 13 were performed using firmware version 2.14 and are unaffected by this change. Radiated emission and transmit power tests performed on 22 May or earlier that included channel 13 but not the particular conditions affected by this change were likewise performed using firmware version 2.14 and are unaffected by this change. All other tests used version 2.15.

## 5. Description of the Equipment Tested

### 5.1 Unique Identification

Product Model A04724  
Serial Numbers Tested 441084880, 441085073, 441085328

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 are 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 location: Mobile, in variable orientation  
Highest internal frequency: 2.484 GHz  
Firmware Revision 2.14, 2.15 (see section 4)

### 5.3 Operating modes

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

Mode 1: M1 (BLE Tx). Bluetooth Low Energy radio transmitting consistently on a selected channel at 1 Mbps or 2 Mbps

Mode 2: M2 (BLE Link). 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 3: M3 (ANT Tx). ANT radio transmitting consistently on a selected channel.

Mode 4: M4 (ANT Link). ANT radio is paired to a companion device, transmitting and receiving data in accordance with the protocol, and maintaining the paired relationship.

Mode 5: M5 (NFC). The NFC 13.56 MHz transceiver is in Card Emulation mode, and is actively linked to a companion NFC Reader.

Mode 6: M6 (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 7: Void – not used.

Mode 8: M8 (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 9: M9 (BLE 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 10: M10 (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 11: M11 (BT Link). 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 12: M12 (All2.4). This means the radio was tested in modes M1, M3, M8, and M10.

Mode 13: M13 (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.

### 5.4 EUT Arrangement

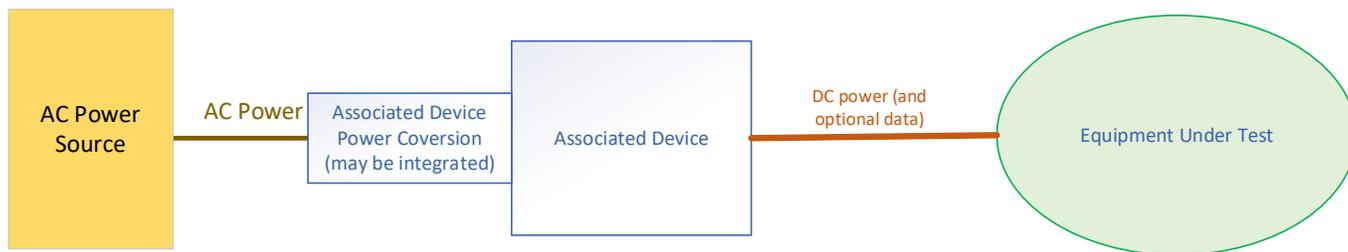
During test, the EUT components and associated support equipment were selected including the following arrangement sets.

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

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

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

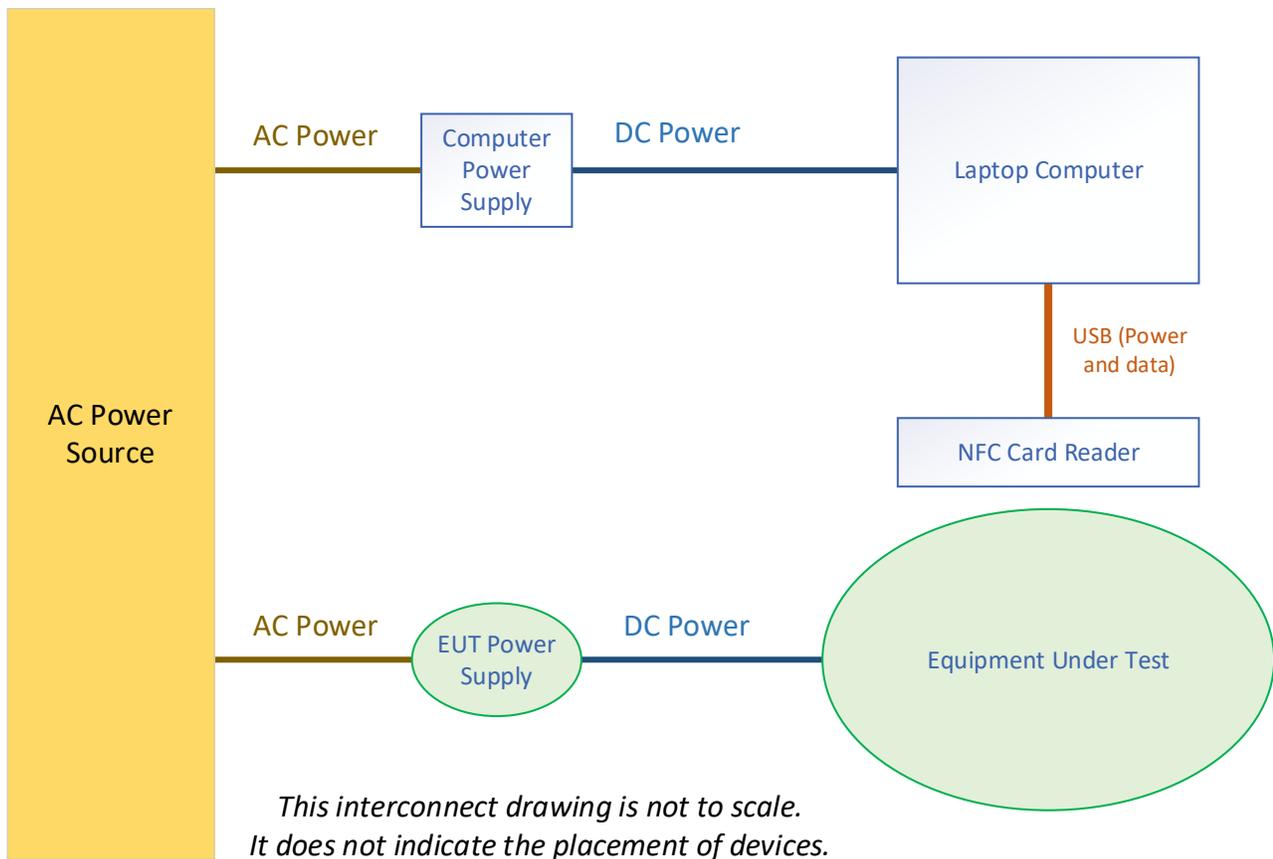
Arrangement 4: A4 (Udc). The test sample is attached to a Mains-powered device connected that provides dc power to the sample and may or may not provide user data. This arrangement is specified in the test plan to provide staff flexibility when the presence or absence of data on the cable is not pertinent.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



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

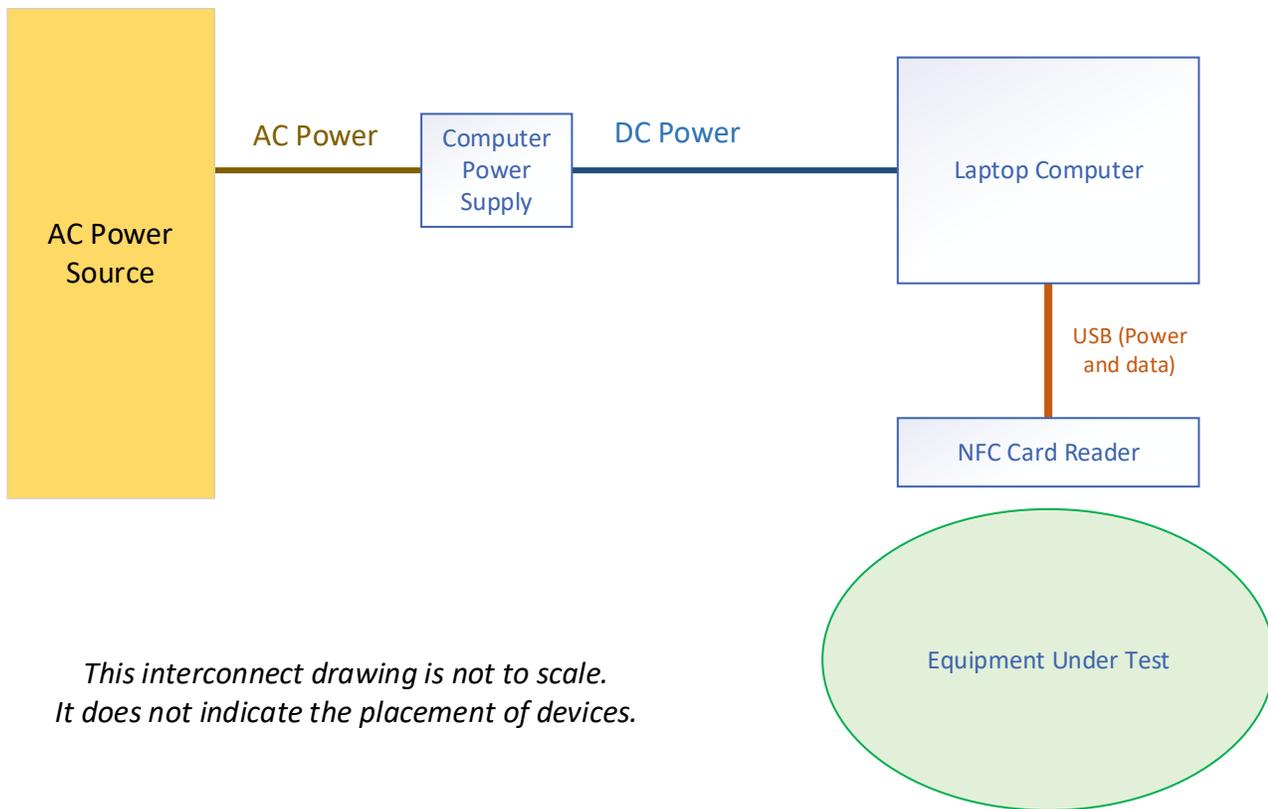
**Figure 1: Block diagram of equipment for arrangements A2, A3, A4**

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.



**Figure 3: Block diagram of equipment arrangement A6**

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
AC/DC Power Converter	Garmin	362-00118-00	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	$*1.55 \times 10^{-7}$	None	$1.0 \times 10^{-7}$
Radio Signal Occupied Bandwidth	0.95%	None	5%
Radio Power or Power Spectral Density	0.98 dB	None	1 dB
Temperature	0.38 °C	None	1 °C
Barometric Pressure	0.38 kPa	None	None
Relative Humidity	2.85% RH	None	±5% RH
Signal Timing	The greater of these three... 0.63 usec 0.01% of value 0.5 x LSDPV	None	None

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

## 8 Selected Example Calculations

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

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

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

### 8.1 AC Mains conducted emissions at 22 MHz

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

$$(7.145 \text{ dBuV}) + (9.812 \text{ dB}) + (0.216 \text{ dB}) = 17.173 \text{ dBuV}$$

### 8.2 Radiated Emissions at 630 MHz

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

$$(2.25 \text{ dBuV}) + (27.80 \text{ dB/m}) + (2.89 \text{ dB}) = 32.94 \text{ dBuV/m}$$

### 8.3 Radiated Emissions at 2.7 GHz

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

$$(43.72 \text{ dBuV}) + (32.22 \text{ dB/m}) + (-36.09 \text{ dB}) = 39.85 \text{ dBuV/m}$$

## 9 Environmental Conditions During Test

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

Temperature:	20.7 to 24.7 °C
Relative Humidity:	33.2% to 67.4% (non-condensing)
Barometric Pressure	97.2 to 98.9 kPa

## ANNEX

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

**Test Record**  
**Transmitter Bandwidth Tests - DTS**  
**Test IDs TR03a**  
**Project GCL-0385**

Test Date(s) 25 May 2023  
 Test Personnel David Arnett

Product Model A04724  
 Serial Number tested 441085328

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

Radio Protocol Bluetooth Classic (Including Basic Rated, Extended Data Rate 2 and Extended Data Rate 3), Bluetooth Low Energy (BLE), ANT  
 Radio Band 2480 to 2483.5 MHz

**Pass/Fail Judgment: PASS**

**Test record created by: David Arnett**  
**Date of this record: 31 May 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

Table TR03a.1: List of test equipment used

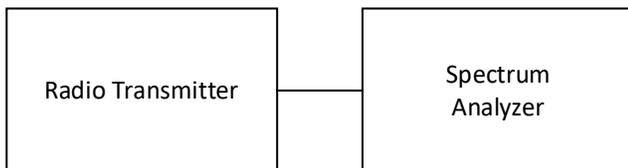
**Test Software Used:** Keysight PXE firmware A.33.03

**Test Method**

During this test the transmitter output is fed directly, or through RF attenuators, to the spectrum analyzer. The analyzer has a built-in capability to identify the minimum bandwidth that contains a specified 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 TR03a.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. All radios reported here are judged to have met this requirement.

		2402 (04)	2440	2480 (78)
BT	BR	0.517	0.518	0.518
	EDR2	1.085	1.088	1.085
	EDR3	1.092	1.091	1.089
BLE	1 Mb	0.757	0.764	0.761
	2 Mb	1.080	1.085	1.084
ANT		0.516	0.519	0.518

Table TR03a.2: Summary of bandwidth data in MHz for Bluetooth, ANT and BLE modes



Figure TR03a.2: Bandwidth data for ANT at low channel (2402 MHz)



Figure TR03a.3: Bandwidth data for BLE 1 Mb at low channel (2402 MHz)



Figure TR03a.4: Bandwidth data for Bluetooth Basic Rate at low channel (2402 MHz)

This line is the end of the test record.

**Test Record**  
**Transmitter Bandwidth Tests - DTS**  
**Test IDs TR03b**  
**Project GCL-0385**

Test Date(s) 25 May 2023  
 Test Personnel David Arnett

Product Model A04724  
 Serial Number tested 441085073

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

Radio Protocol IEEE 802.11b/g/n (WiFi)  
 Radio Band 2400 to 2483.5 MHz

**Pass/Fail Judgment: PASS**

**Test record created by: David Arnett**  
**Date of this record: 7 Jul 2023**

Version A was released 1 June 2023. Version B released 7 July 2023 corrects the frequency range.

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024

Table TR03b.1: List of test equipment used

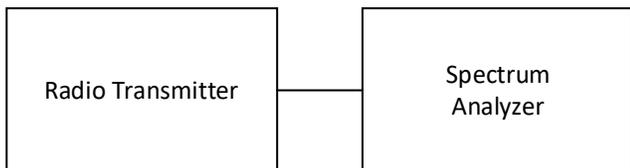
**Test Software Used:** Keysight PXE firmware A.33.03

**Test Method**

During this test the transmitter output is fed directly, or through RF attenuators, to the spectrum analyzer. The analyzer has a built-in capability to identify the minimum bandwidth that contains a specified 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 TR03b.1: Test setup**

**Test Data**

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

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

Channel	1	6	11	12	13
B1	11.16	11.16	12.09	11.17	12.11
B2	11.45	11.45	11.46	11.45	11.46
B5.5	12.08	12.07	12.09	12.08	12.09
B11	11.72	11.72	11.72	11.72	11.73
G06	16.51	16.50	16.49	16.48	16.49
G09	16.49	16.49	16.48	16.50	16.50
G12	16.49	16.53	16.52	16.53	16.52
G18	16.51	16.51	16.53	16.51	16.52
G24	16.55	16.51	16.51	16.54	16.55
G36	16.50	16.53	16.52	16.52	16.49
G48	16.52	16.54	16.50	16.52	16.50
G54	16.49	16.52	16.51	16.50	16.50
N0	17.76	17.75	17.78	17.76	17.74
N1	17.74	17.75	17.76	17.76	17.76
N2	17.77	17.77	17.76	17.71	17.77
N3	17.73	17.70	17.76	17.71	17.77
N4	17.74	17.77	17.77	17.75	17.75
N5	17.69	17.76	17.73	17.77	17.76
N6	17.73	17.74	17.73	17.75	17.74
N7	17.76	17.76	17.75	17.74	17.75

**Table TR03b.2: Summary of bandwidth data in MHz for WiFi modes**



Figure TR03b.2: Bandwidth data for B1 modulation, on channel 1 (2412 MHz)

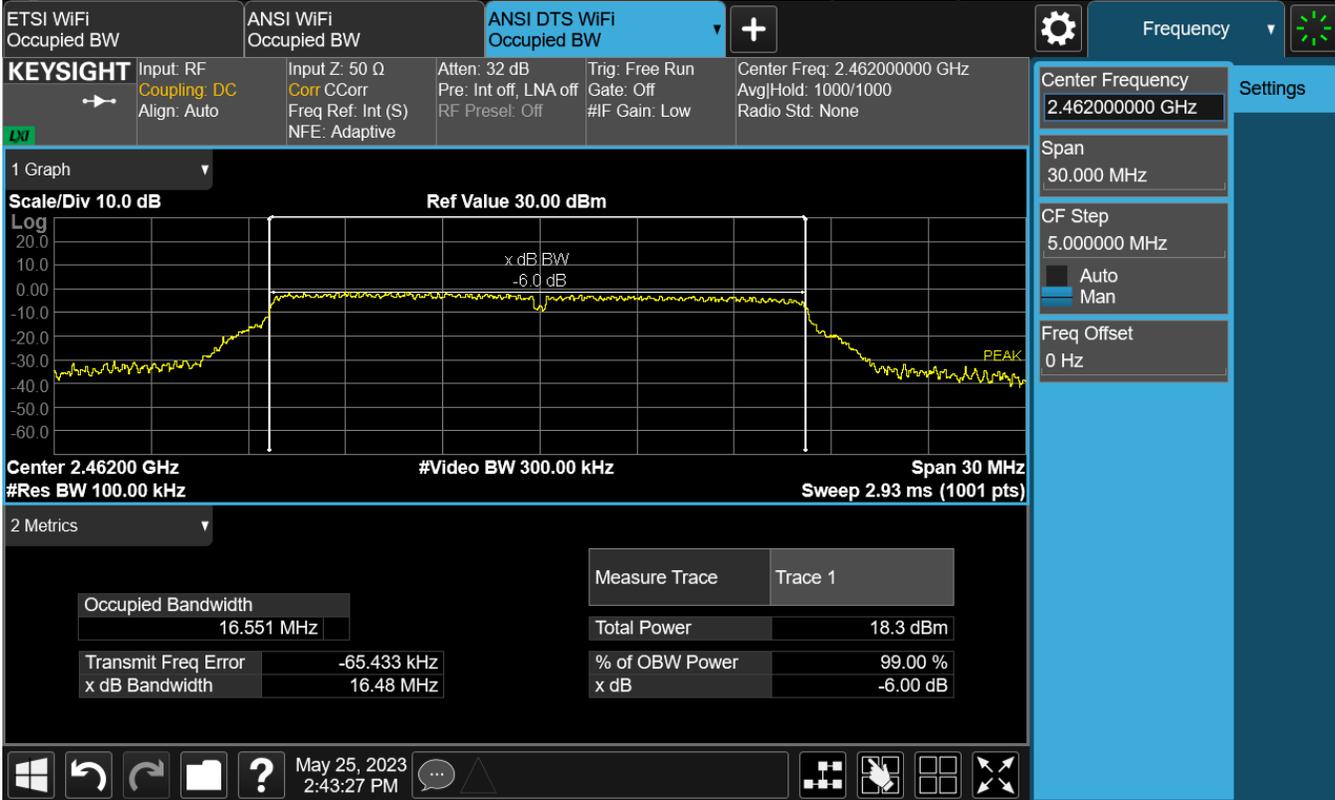


Figure TR03b.3: Bandwidth data for G9 modulation, on channel 11 (2462 MHz)

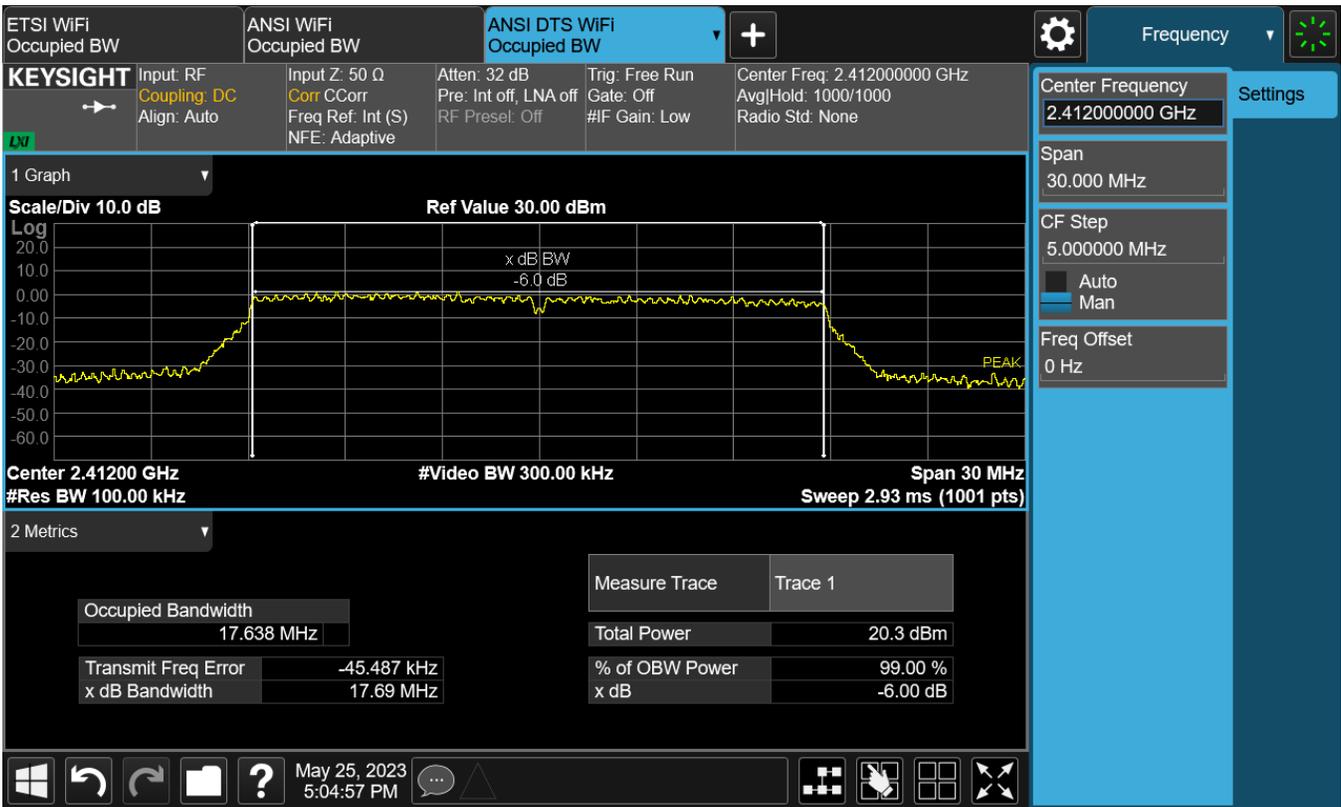


Figure TR03b.4: Bandwidth data for N MCS5 modulation, on channel 1 (2412 MHz))

This line is the end of the test record.

**Test Record**  
**Transmitter Bandwidth Tests - Other**  
**Test IDs TR04a**  
**Project GCL-0385**

Test Date(s) 25 May 2023  
 Test Personnel David Arnett

Product Model A04724  
 Serial Number tested 441085073, 441085328

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 2480 to 2483.5 MHz

**Pass/Fail Judgment: Reported**

**Test record created by: David Arnett**  
**Date of this record: 1 Jun 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

**Table TR04a.1**

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

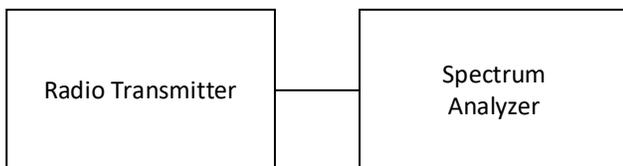
**Background**

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

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 TR04a.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)
BT	BR	0.950	0.943	0.924
	EDR2	1.293	1.277	1.278
	EDR3	1.286	1.300	1.247
BLE	1 Mb	1.062	1.069	1.066
	2 Mb	2.060	2.062	2.062
ANT		0.904	0.962	0.888

**Table TR04a.2: Summary of 99% Occupied Bandwidth Data for Bluetooth, ANT and BLE modes**

	1	6	11	12	13
B1	14.10	14.31	14.02	14.02	13.92
B2	14.02	14.26	14.02	14.01	13.92
B5.5	13.83	13.90	13.84	13.84	13.83
B11	13.87	13.99	13.87	13.87	13.84
G06	17.28	18.03	17.24	17.24	17.11
G09	17.23	17.98	17.21	17.20	17.10
G12	17.05	17.41	17.02	16.99	16.94
G18	17.02	17.37	17.04	17.01	16.98
G24	16.99	17.30	16.96	16.95	16.91
G36	16.95	17.30	16.99	16.95	16.86
G48	16.96	17.36	16.96	16.97	16.88
G54	17.00	17.34	16.97	16.96	16.87
N0	17.94	18.13	17.90	17.92	17.90
N1	17.93	18.16	17.92	17.91	17.88
N2	17.93	18.17	17.96	17.93	17.88
N3	17.94	18.22	17.93	17.94	17.88
N4	17.96	18.29	17.94	17.94	17.89
N5	17.93	18.18	17.92	17.94	17.89
N6	18.04	18.57	18.06	18.05	17.97
N7	17.94	18.16	17.93	17.93	17.88

**Table TR04a.3: Summary of 99% Occupied Bandwidth Data for IEEE 802.11 WiFi modes**



Figure TR04a.1: Occupied bandwidth data for ANTI at mid channel (2440 MHz)



Figure TR04a.2: Occupied bandwidth data for BLE 2 Mbps at mid channel (2440 MHz)



Figure TR04a.3: Occupied bandwidth data for Bluetooth EDR3 at mid channel (2440 MHz)



Figure TR04a.4: Occupied bandwidth data for 802.11b 1 Mbps at channel 6

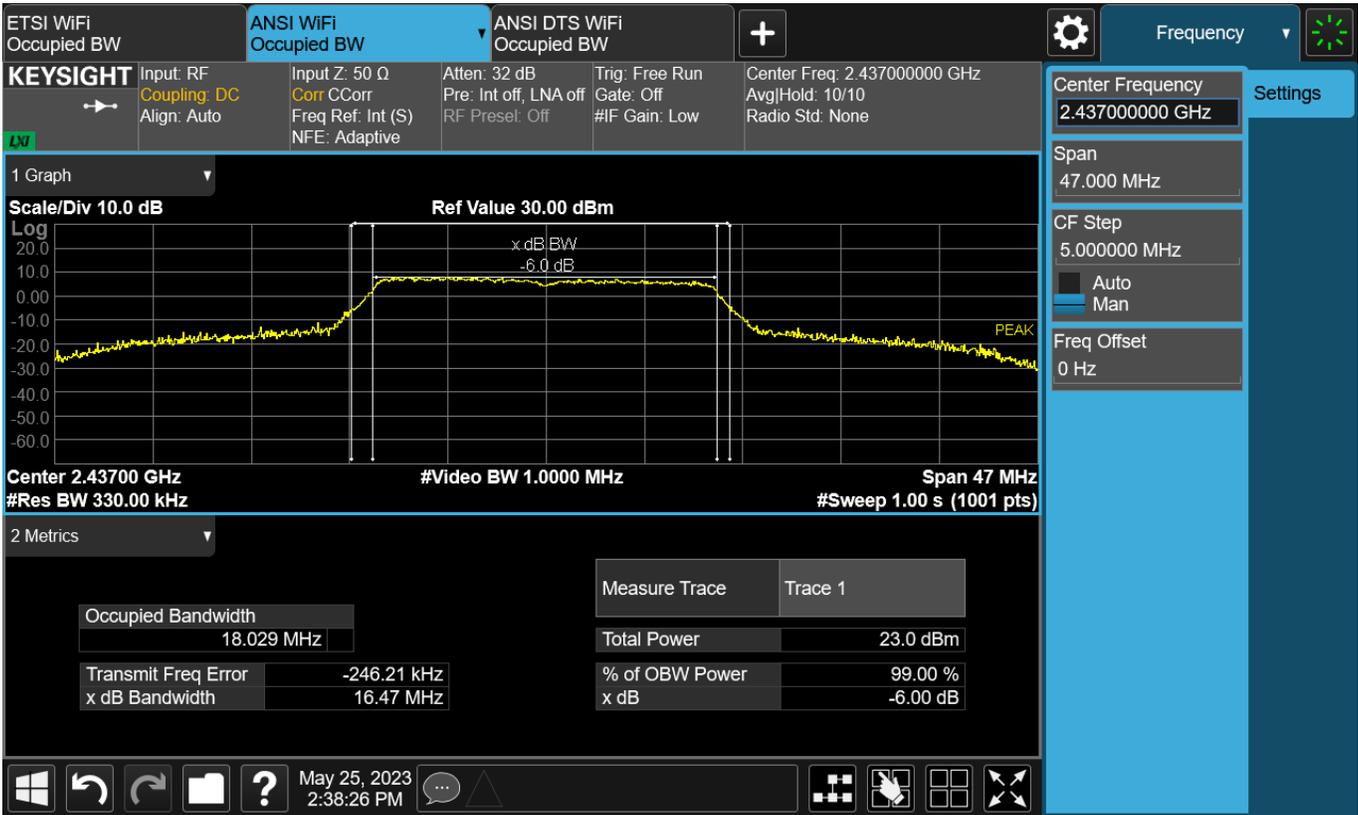


Figure TR04a.5: Occupied bandwidth data for 802.11g 6 Mbps at channel 6

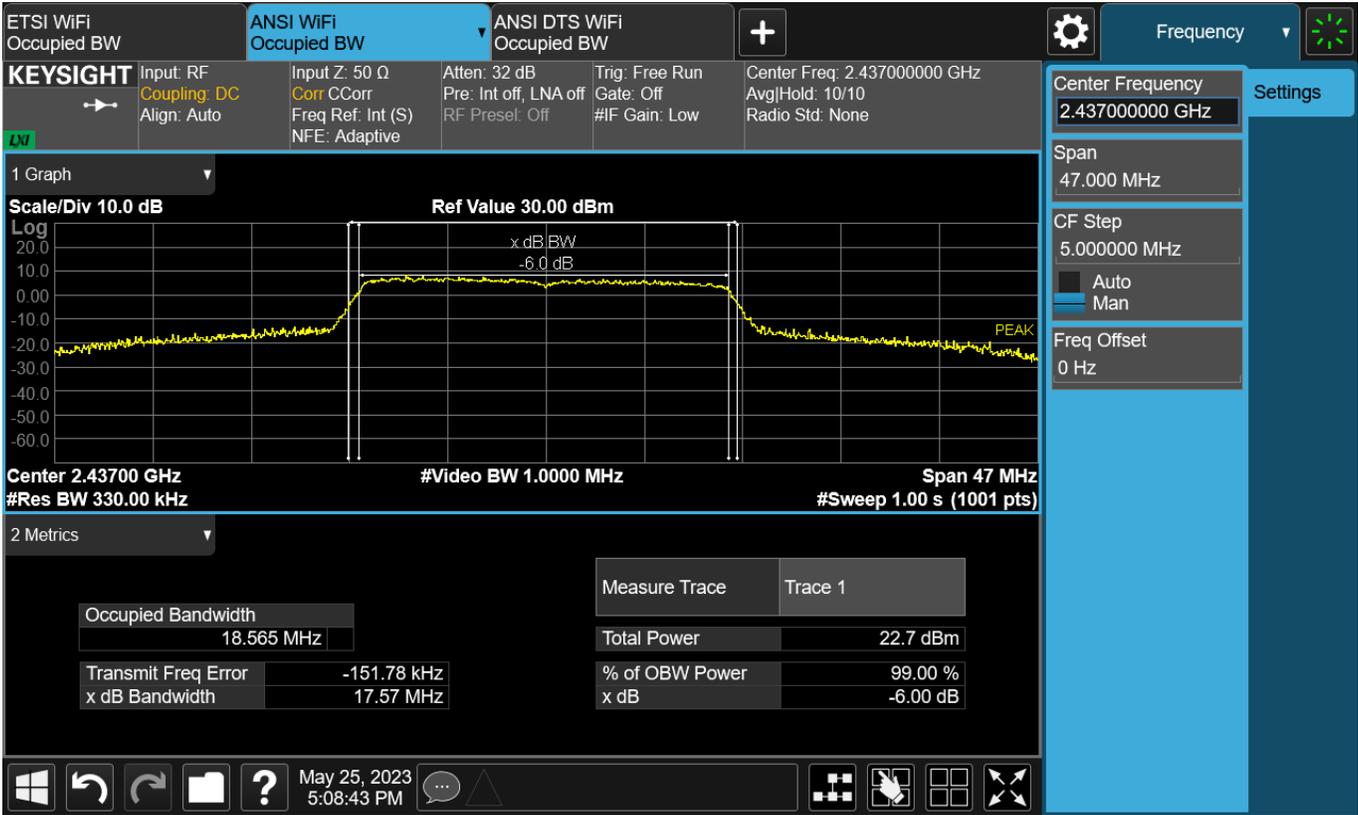


Figure TR04a.6: Occupied bandwidth data for 802.11n MCS6 at channel 6

### Necessary Bandwidth Calculations

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

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

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

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

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

Table TR04a.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 TR04a.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 TR04a.103: Necessary Bandwidth for IEEE 802.11 b Radio Protocol (FCC and TRC-43)

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

Table TR04a.104: Necessary Bandwidth for IEEE 802.11 g and n 20 MHz Radio Protocols (FCC)

As a note, the bit rate for IEEE 802.11 n WiFi is calculated based on the IEEE standard's short guard interval of 400 nsec. If only the long guard interval of 800 nsec were implemented, the bit rate for MCS7 would decrease to 65 Mbps for a Necessary Bandwidth of 21.7 MHz.

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

$$B_N = N_s * K$$

Radio Type	N <sub>s</sub> (MHz)	K	BN (MHz)
802.11g	0.3125	53	16.6
802.11n	0.3125	57	17.8

Table TR04a.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 TR01a**  
**Project GCL0385**

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

Product Model A04724  
 Serial Number tested 441085073

Operating Mode M1 (BLE Tx), M3 (ANT Tx), M10 (BT Tx)  
 Arrangement A3 (Udata)  
 Input Power 5Vdc

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 -0.37 dBi, as reported by the client  
 Radio Protocol Bluetooth, Bluetooth Low Energy, ANT

**Pass/Fail Judgment: PASS**

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

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	13-Jul-2022	15-Jul-2023

Table TR01a.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)	Lowest	2420	2440	2460	Highest
Bluetooth	Basic	<b>8.80</b>	<b>8.94</b>	<b>9.07</b>	<b>9.58</b>	<b>9.58</b>
Bluetooth	EDR2	<b>4.09</b>	<b>4.49</b>	<b>4.31</b>	<b>4.79</b>	<b>5.53</b>
Bluetooth	EDR3	<b>4.03</b>	<b>4.47</b>	<b>4.28</b>	<b>4.76</b>	<b>5.45</b>
BT Low Energy	1 Mbps	<b>-2.01</b>	<b>-2.02</b>	<b>-1.94</b>	<b>-1.92</b>	<b>-1.94</b>
BT Low Energy	2 Mbps	<b>-2.01</b>	<b>-2.02</b>	<b>-1.95</b>	<b>-1.92</b>	<b>-1.93</b>
ANT	----	<b>-1.10</b>	<b>-1.11</b>	<b>-1.14</b>	<b>-1.00</b>	<b>-1.00</b>

Table TR01a.2: Transmit Power Summary in dBm with ANSI C63.10 analytical methods

Frequency	(MHz)	Lowest	2420	2440	2460	Highest
Bluetooth	Basic	<b>8.39</b>	<b>8.53</b>	<b>8.66</b>	<b>9.18</b>	<b>9.18</b>
Bluetooth	EDR2	<b>3.62</b>	<b>4.01</b>	<b>3.84</b>	<b>4.32</b>	<b>5.06</b>
Bluetooth	EDR3	<b>3.55</b>	<b>3.99</b>	<b>3.81</b>	<b>4.30</b>	<b>4.95</b>
BT Low Energy	1 Mbps	<b>-2.79</b>	<b>-2.80</b>	<b>-2.73</b>	<b>-2.70</b>	<b>-2.73</b>
BT Low Energy	2 Mbps	<b>-3.02</b>	<b>-3.04</b>	<b>-2.96</b>	<b>-2.93</b>	<b>-2.95</b>
ANT	----	<b>-1.48</b>	<b>-1.48</b>	<b>-1.52</b>	<b>-1.37</b>	<b>-1.37</b>

Table TR01a.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)	Lowest	2420	2440	2460	Highest
Bluetooth	Basic	<b>7.52</b>	<b>7.77</b>	<b>8.00</b>	<b>9.02</b>	<b>9.02</b>
Bluetooth	EDR2	<b>2.51</b>	<b>2.74</b>	<b>2.63</b>	<b>2.95</b>	<b>3.49</b>
Bluetooth	EDR3	<b>2.47</b>	<b>2.73</b>	<b>2.62</b>	<b>2.93</b>	<b>3.41</b>
BT Low Energy	1 Mbps	<b>0.26</b>	<b>0.26</b>	<b>0.26</b>	<b>0.26</b>	<b>0.26</b>
BT Low Energy	2 Mbps	<b>0.14</b>	<b>0.14</b>	<b>0.14</b>	<b>0.14</b>	<b>0.14</b>
ANT	----	<b>0.78</b>	<b>0.77</b>	<b>0.77</b>	<b>0.79</b>	<b>0.79</b>

Table TR01a.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 0.78 dB of loss in this frequency range. This factor was taken into account during the data analysis.

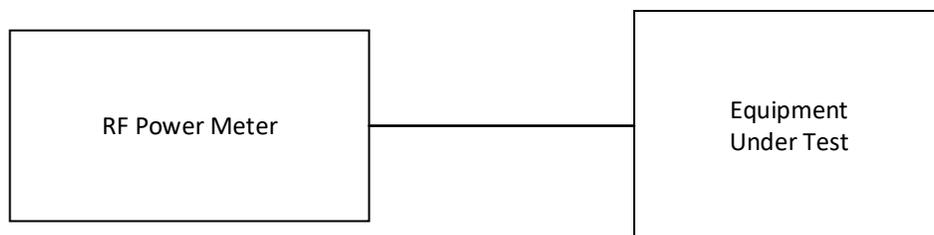


Figure TR01a.1: Test equipment setup

This line is the end of the test record.

**Test Record**  
**Transmitter Power**  
**Test IDs TR01b**  
**Project GCL0385**

Test Date(s) 12, 23 May 2023  
 Test Personnel David Arnett

Product Model A04724  
 Serial Number tested 441085073

Operating Mode M8 (WiFi Tx)  
 Arrangement A3 (Udata)  
 Input Power 5Vdc

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

FCC Part 2.1091, FCC Part 2.1093, RSS-102, ANSI C95.3

Antenna Gain -0.37 dBi, as reported by the client  
 Radio Protocol IEEE 802.11b/g/n

**Pass/Fail Judgment: PASS**

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

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
RF Power Sensor	Rohde&Schwarz	NRP8S	109927	13-Jul-2022	15-Jul-2023

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.

Data shown here for channels 1 through 11 are from the 12 May data set, measured while the test sample used firmware version 2.14. In 2.14, channels 11, 12, and 13 had the same power setting. Data shown here for channels 12 and 13 were collected on 23 May while the test sample used firmware version 2.15. As stated in the main test report, the change in firmware only lowered the transmit power on channel 13. Channel 12 power was then greater than channel 13 power. Lab staff felt it helpful to include channel 12 power results in the test sequence for a complete view of transmitter operations beyond the typical Channel 1 – 11 range used in North America.

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	16.80	18.92	19.11	19.14	19.67	18.59	19.62	18.71	18.81	18.82	16.50	16.84	13.20
B	2	17.01	NT	NT	NT	NT	19.00	NT	NT	NT	NT	16.73	16.91	13.39
B	5.5	17.28	NT	NT	NT	NT	19.33	NT	NT	NT	NT	16.91	17.03	13.43
B	11	17.24	19.30	19.30	19.21	19.14	19.14	19.11	19.07	19.10	19.00	16.79	16.94	13.37
G	6	14.85	17.64	17.58	17.52	17.48	17.49	17.46	17.39	17.33	17.29	14.43	14.59	10.41
G	9	14.87	NT	NT	NT	NT	17.45	NT	NT	NT	NT	14.43	14.59	10.37
G	12	14.86	NT	NT	NT	NT	17.48	NT	NT	NT	NT	14.48	14.63	10.38
G	18	14.92	NT	NT	NT	NT	17.49	NT	NT	NT	NT	14.54	14.59	10.36
G	24	14.96	NT	NT	NT	NT	17.54	NT	NT	NT	NT	14.49	14.59	10.41
G	36	14.89	NT	NT	NT	NT	17.50	NT	NT	NT	NT	14.53	14.60	10.39
G	48	14.88	NT	NT	NT	NT	17.48	NT	NT	NT	NT	14.49	14.59	10.38
G	54	14.91	17.63	17.58	17.52	17.46	17.45	17.40	17.37	17.33	17.31	14.44	14.59	10.40
N	MCS0	14.78	17.55	17.50	17.49	17.43	17.37	17.35	17.34	17.27	17.24	14.38	14.52	10.32
N	MCS1	14.82	NT	NT	NT	NT	17.41	NT	NT	NT	NT	14.42	14.55	10.36
N	MCS2	14.70	NT	NT	NT	NT	17.36	NT	NT	NT	NT	14.34	14.47	10.25
N	MCS3	14.75	NT	NT	NT	NT	17.39	NT	NT	NT	NT	14.41	14.50	10.29
N	MCS4	14.73	NT	NT	NT	NT	17.34	NT	NT	NT	NT	14.28	14.45	10.23
N	MCS5	14.75	NT	NT	NT	NT	17.39	NT	NT	NT	NT	14.37	14.50	10.28
N	MCS6	14.71	NT	NT	NT	NT	17.37	NT	NT	NT	NT	14.31	14.44	10.24
N	MCS7	14.77	17.51	17.48	17.49	17.45	17.41	17.34	17.33	17.27	17.25	14.39	14.48	10.27

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	47.30	77.17	78.93	78.96	81.00	72.04	79.95	73.30	74.45	74.48	44.11	47.56	20.48
B	2	49.38	NT	NT	NT	NT	78.45	NT	NT	NT	NT	46.15	48.31	21.37
B	5.5	52.46	NT	NT	NT	NT	84.40	NT	NT	NT	NT	48.17	49.76	21.61
B	11	52.14	84.13	84.15	82.41	81.02	80.91	80.36	79.67	79.89	78.49	46.94	48.70	21.31
G	6	29.69	56.34	55.75	54.94	54.43	54.52	53.95	53.42	52.69	52.25	26.93	28.12	10.69
G	9	29.75	NT	NT	NT	NT	54.27	NT	NT	NT	NT	27.02	27.98	10.61
G	12	29.82	NT	NT	NT	NT	54.49	NT	NT	NT	NT	27.18	28.08	10.59
G	18	30.16	NT	NT	NT	NT	54.86	NT	NT	NT	NT	27.59	27.89	10.55
G	24	29.99	NT	NT	NT	NT	54.55	NT	NT	NT	NT	27.07	27.63	10.47
G	36	29.54	NT	NT	NT	NT	54.01	NT	NT	NT	NT	27.16	27.71	10.45
G	48	29.52	NT	NT	NT	NT	53.95	NT	NT	NT	NT	26.92	27.54	10.41
G	54	29.46	55.61	55.09	54.39	53.84	53.55	53.08	52.52	52.11	51.44	26.57	27.54	10.40
N	MCS0	28.96	55.04	54.43	54.05	53.38	52.89	52.56	52.18	51.66	51.14	26.35	27.26	10.35
N	MCS1	28.98	NT	NT	NT	NT	53.02	NT	NT	NT	NT	26.37	27.31	10.36
N	MCS2	28.67	NT	NT	NT	NT	53.04	NT	NT	NT	NT	26.34	27.21	10.27
N	MCS3	28.72	NT	NT	NT	NT	53.01	NT	NT	NT	NT	26.35	27.17	10.26
N	MCS4	28.88	NT	NT	NT	NT	52.86	NT	NT	NT	NT	26.13	27.14	10.23
N	MCS5	28.54	NT	NT	NT	NT	52.73	NT	NT	NT	NT	26.10	26.89	10.21
N	MCS6	28.85	NT	NT	NT	NT	53.18	NT	NT	NT	NT	26.26	27.05	10.20
N	MCS7	28.90	54.58	54.30	54.08	53.54	53.02	52.48	52.20	51.62	51.11	26.31	27.05	10.16

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 0.78 dB of loss in this frequency range. This factor was taken into account during the data analysis.

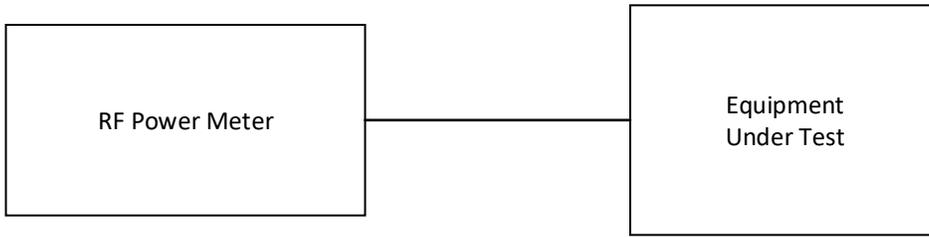


Figure TRxx.1: Test equipment setup

**This line is the end of the test record.**

**Test Record**  
**Conducted Spurious Emissions**  
**Test IDs TR18, TR20 and TR22**  
**Project GCL-0385**

Test Date(s) 9 Jun 2023  
 Test Personnel Majid Farah

Product Model A04724  
 Serial Number tested 441085073  
 Operating Mode M1 (BLE Tx), M3 (ANT Tx) and M10 (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: Majid Farah**  
**Date of this test record: 14 Jun 2023**  
 Original record, Version A.

**Test Equipment**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Signal analyzer PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024

**Table TR18.1: Test equipment used**

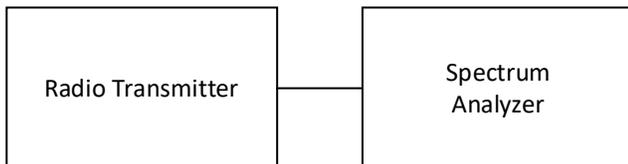
**Software used:** Keysight PXE software A.33.03.

**Test Method**

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

**Test Setup**

This block diagram shows the test equipment setup.



**Figure TR18.1: 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 than 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	54.53	54.97	55.35
BLE 1 Mbps	43.71	43.88	43.85
ANT	39.99	41.86	43.72

**Table TR18.2: Results Summary**

NT: (Not tested) means the requirement is or may not be applicable by EUT or it is not required by standards.

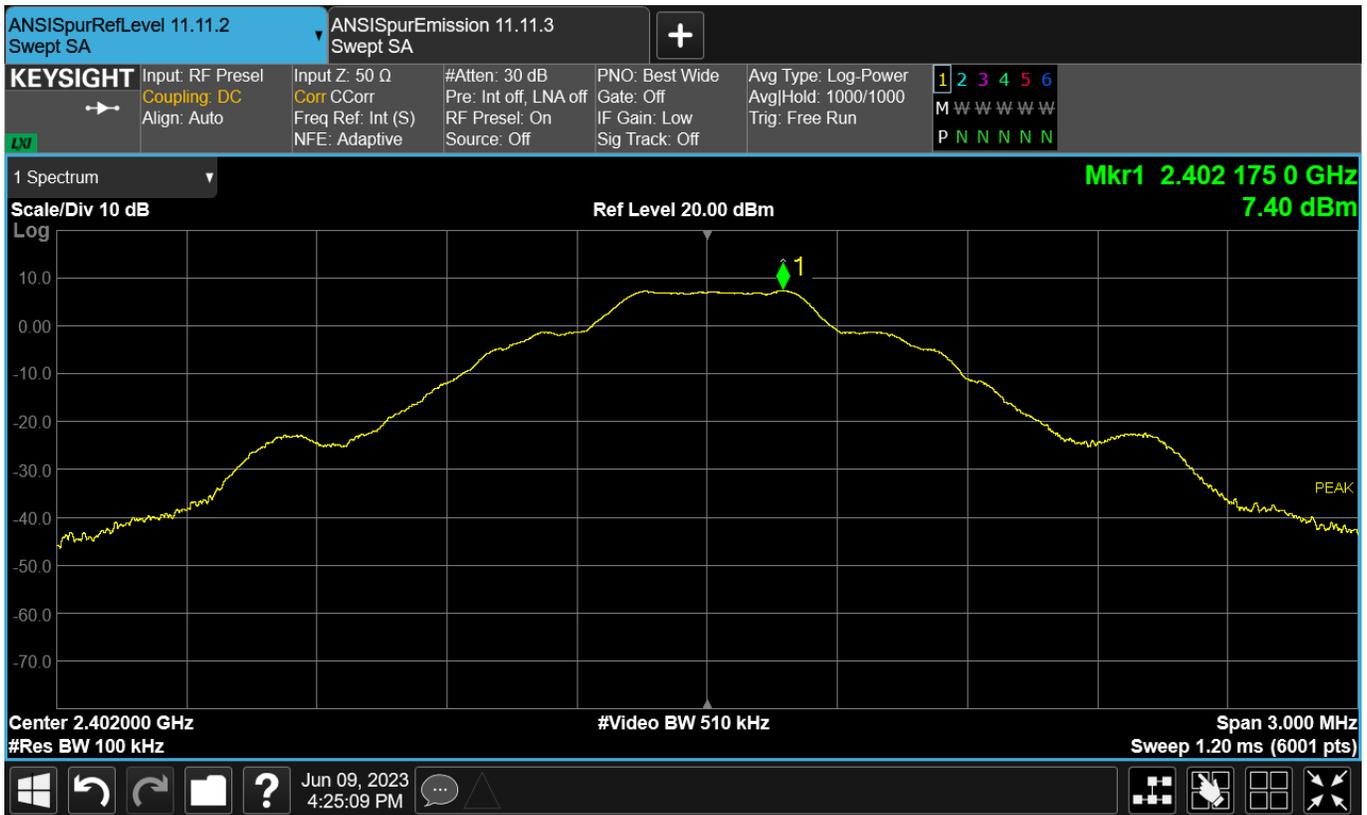


Figure TR18.2: Reference level measurement for Bluetooth BR at 2402 MHz

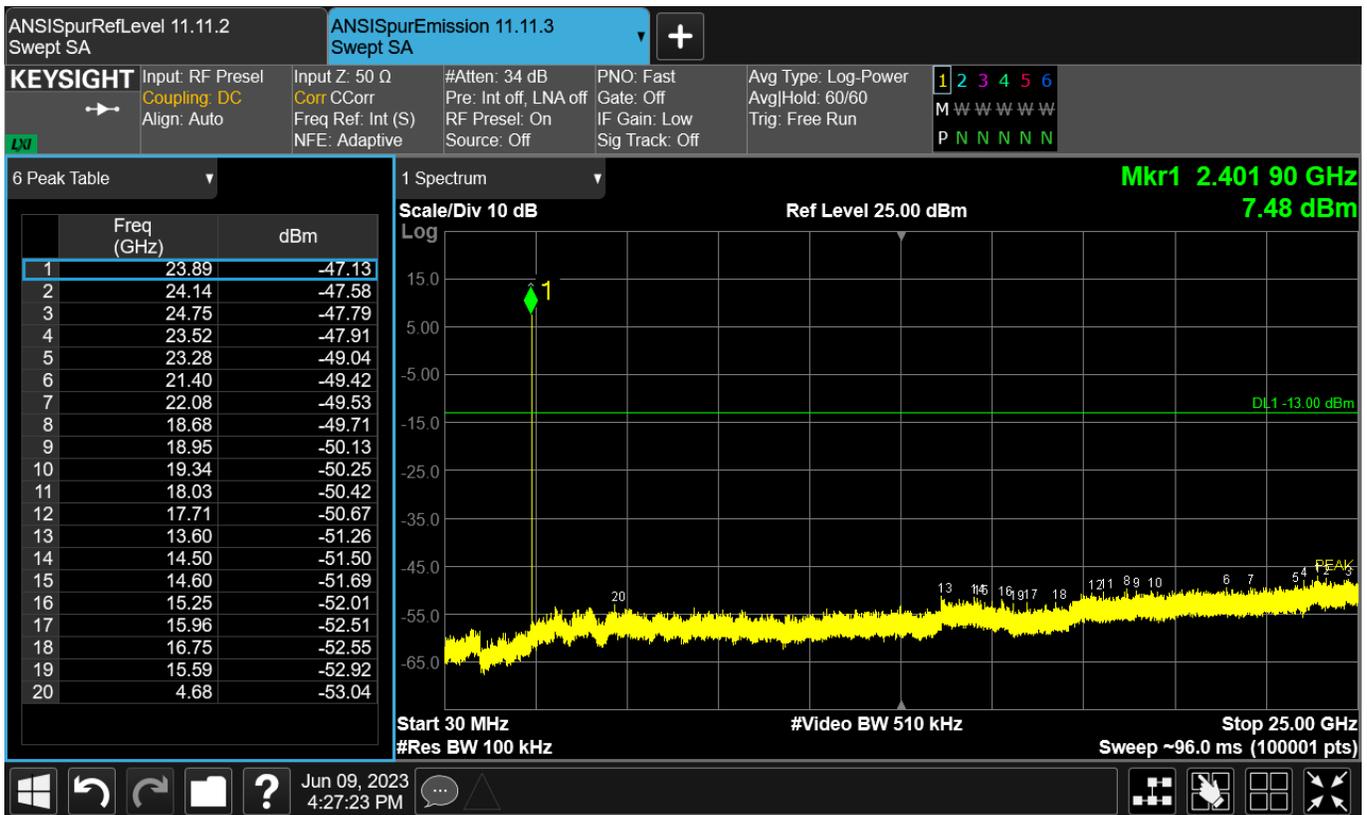


Figure TR18.3: Spectral data for Bluetooth BR at 2402 MHz

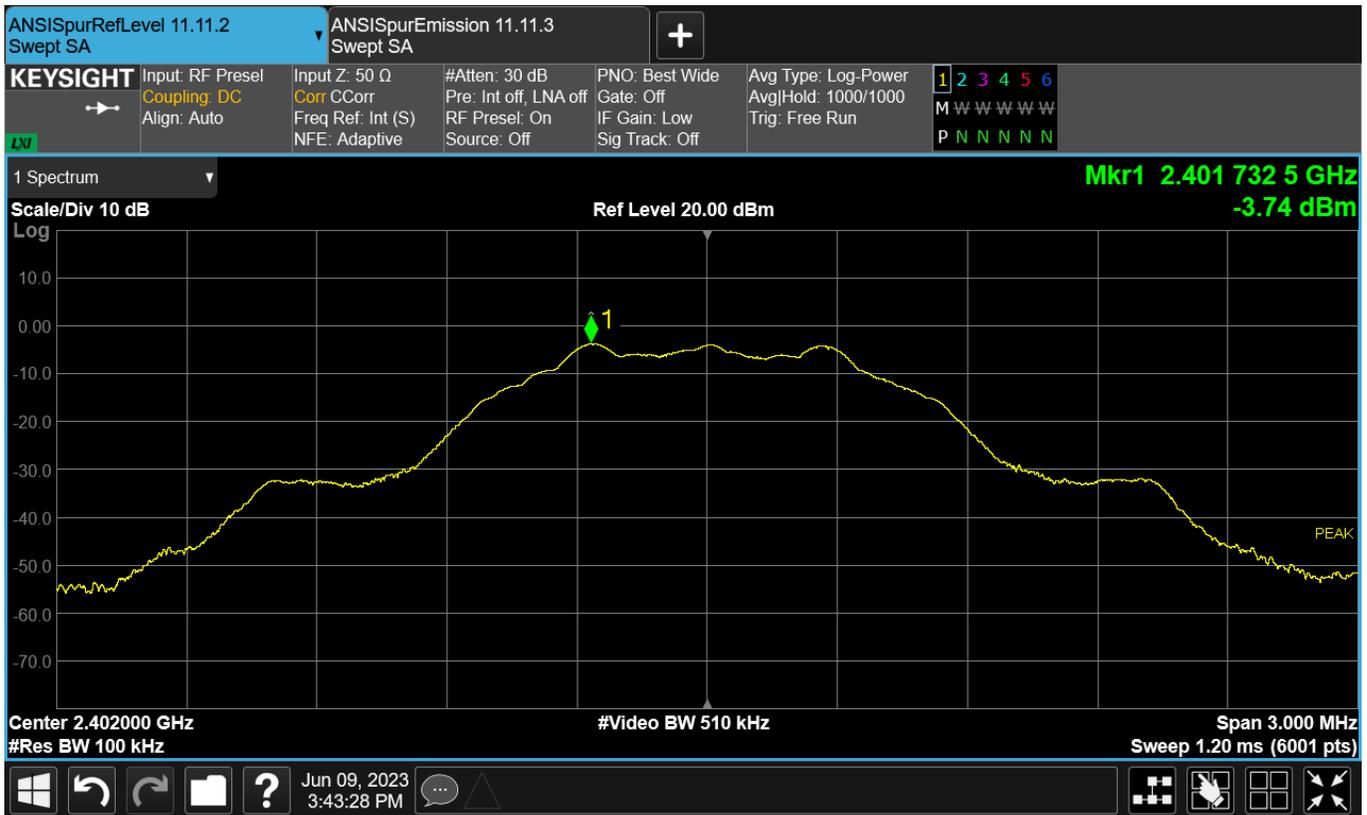


Figure TR18.4: Reference level measurement for Bluetooth BLE 1 Mbps at 2402 MHz

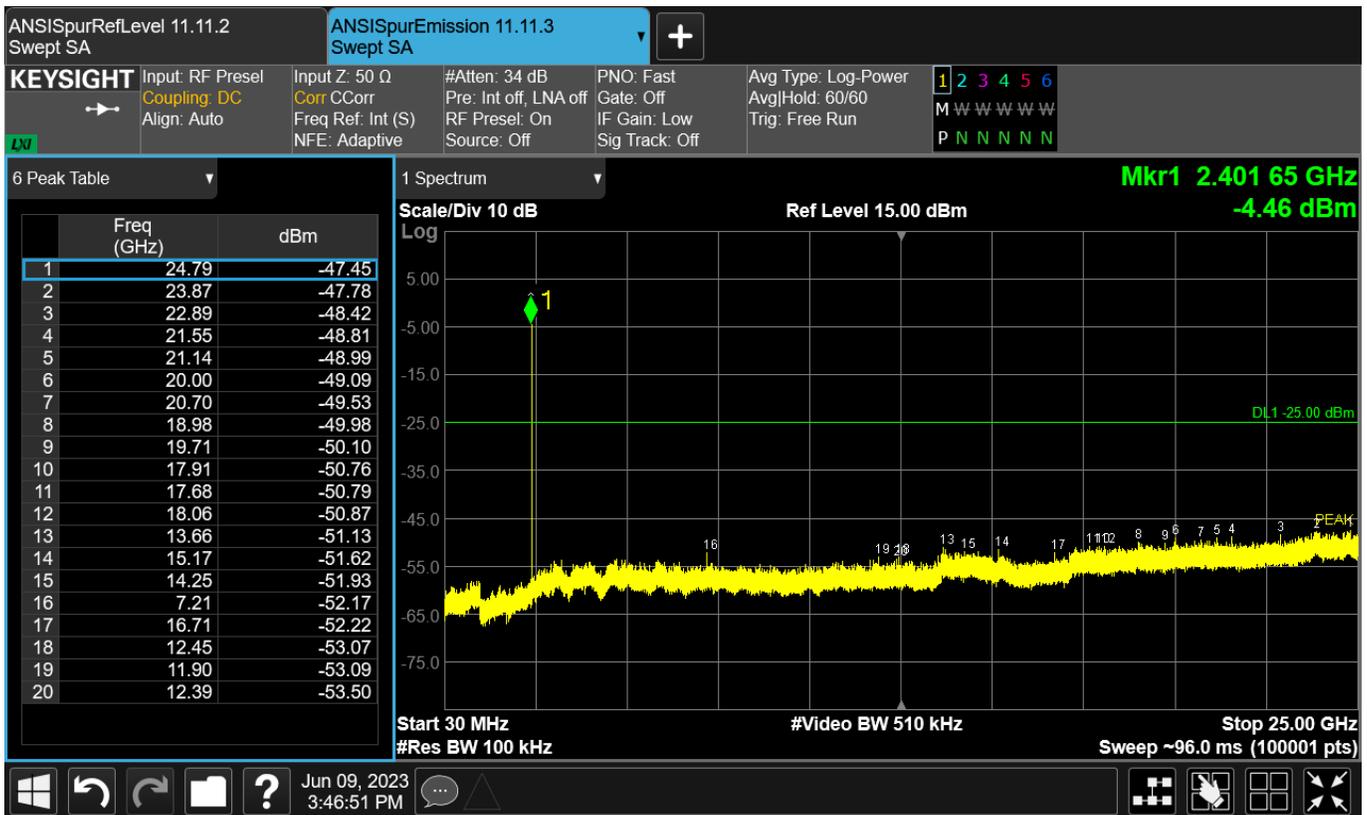


Figure TR18.5 Spectral data for Bluetooth BLE 1 Mbps at 2402 MHz

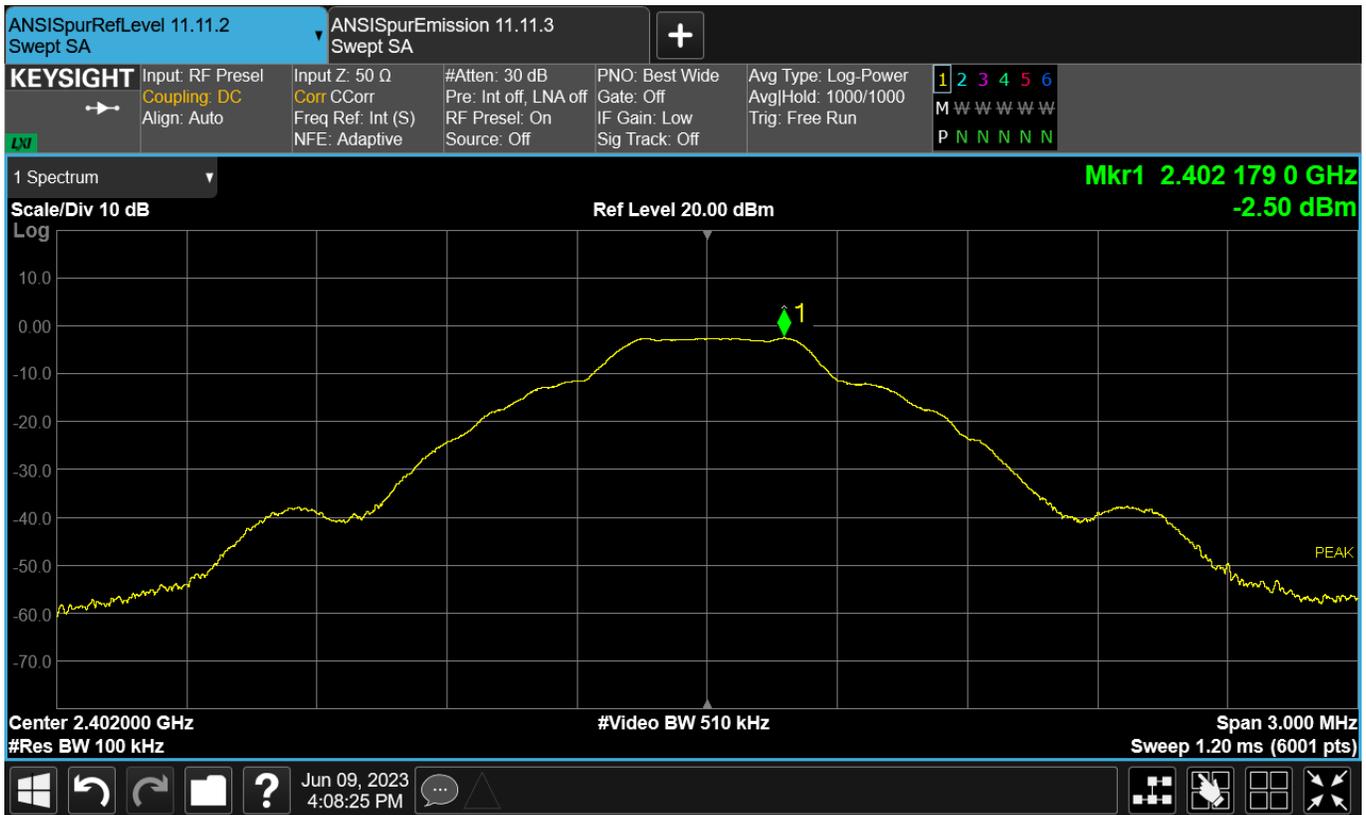


Figure TR18.6: Reference level measurement for ANT at 2402 MHz

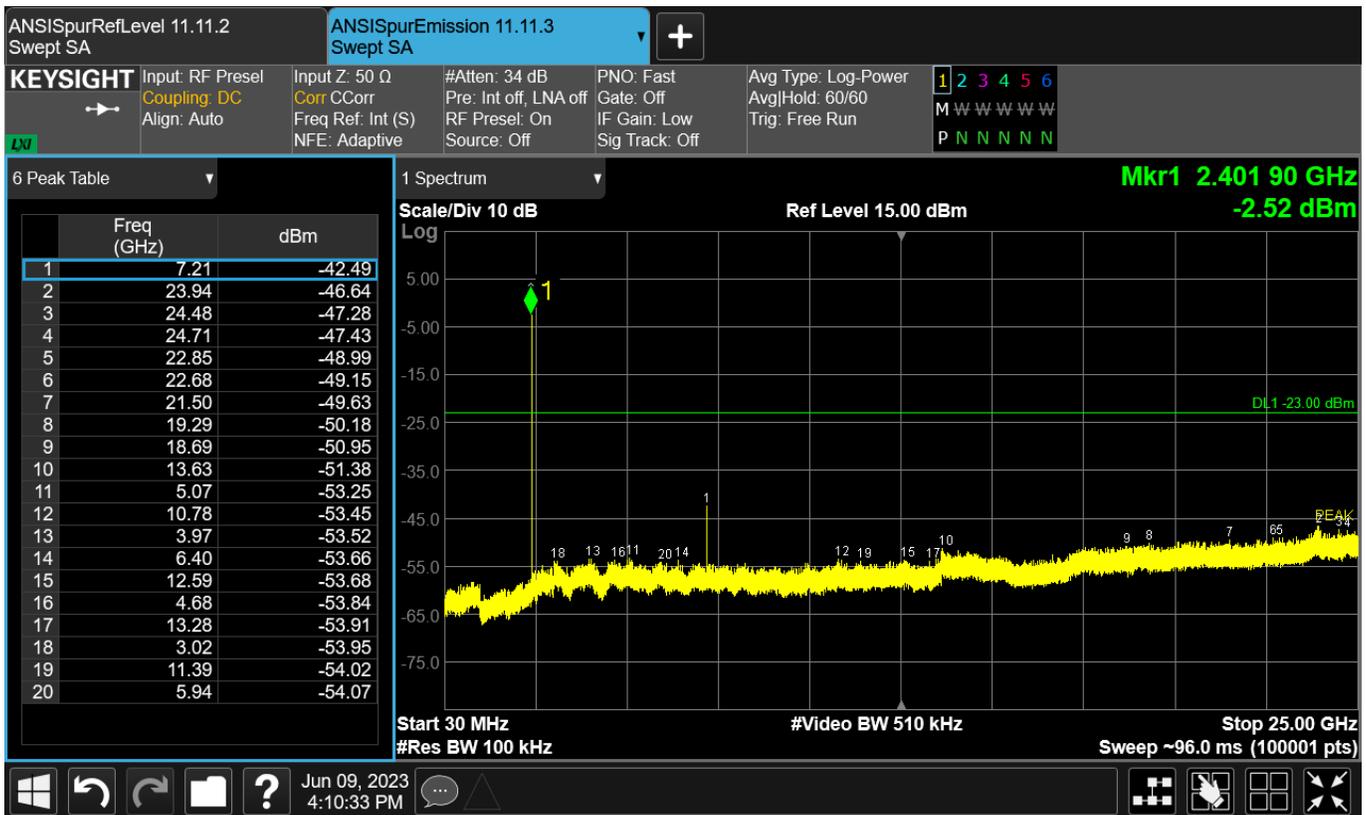


Figure TR18.7 Spectral data for ANT at 2402 MHz

This line is the end of the test record.

**Test Record**  
**Conducted Spurious Emissions**  
**Test IDs TR24, TR26 and TR28**  
**Project GCL-0385**

Test Date(s) 9 Jun 2023  
 Test Personnel Majid Farah

Product Model A04724  
 Serial Number tested 441085073

Operating Mode M8 (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: Majid Farah**  
**Date of this test record: 14 Jun 2023**  
 Original record, Version A.

**Test Equipment**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
Signal analyzer PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024

**Table TR24.1: Test equipment used**

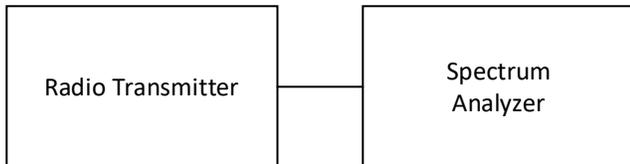
**Software used:** Keysight PXE software A.33.03.

**Test Method**

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

**Test Setup**

This block diagram shows the test equipment setup.



**Figure TR24.1: 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 than 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.

Mode	Data rate (Mbps)	Channel No.				
		1	6	11	12	13
B	1	39.77	52.67	48.82	49.54	42.90
G	6	46.03	49.10	45.50	45.25	41.30
N	MCS0	46.97	49.73	45.18	46.65	42.64

**Table TR24.2: Results Summary**

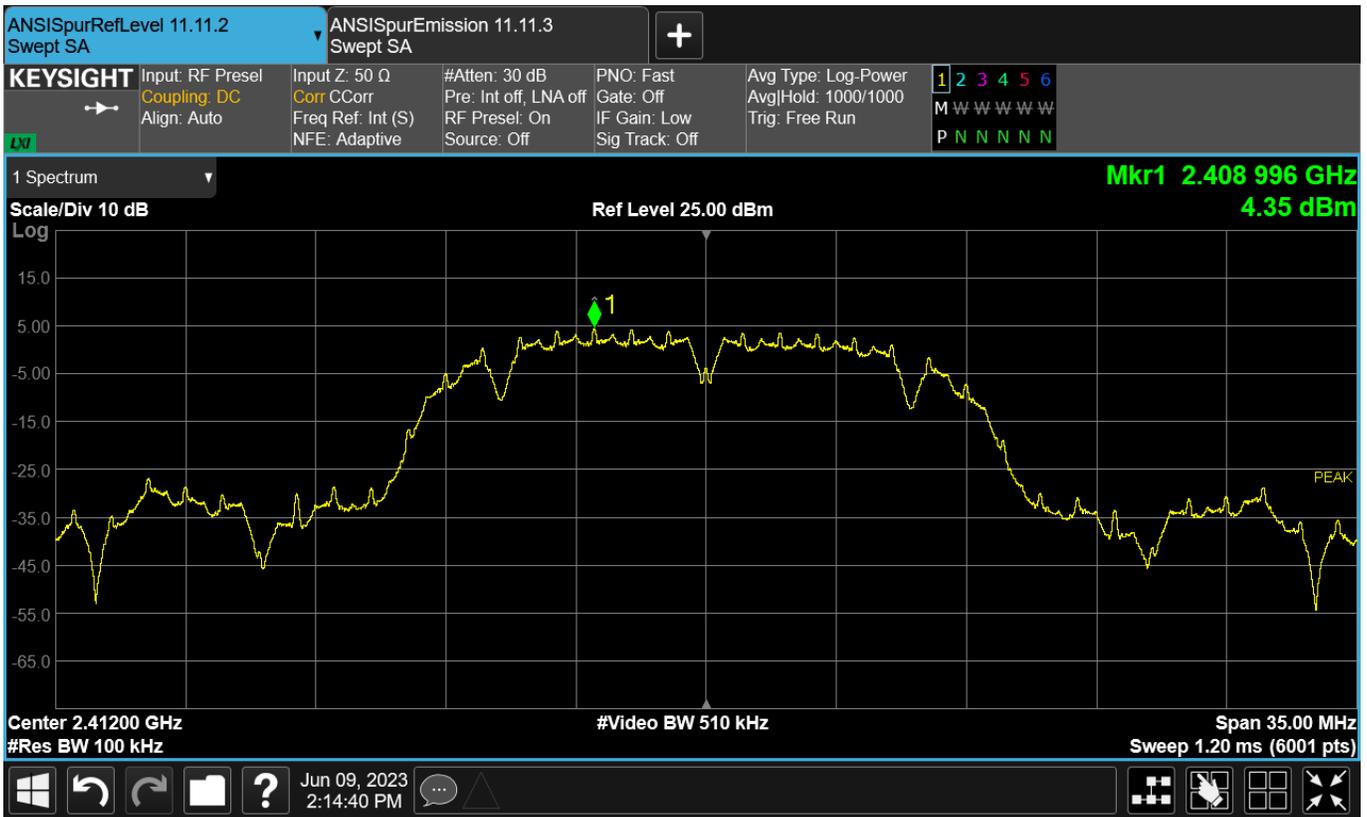


Figure TR25.2: Reference level measurement for IEEE 802.11 b 1 Mbps on Ch.1

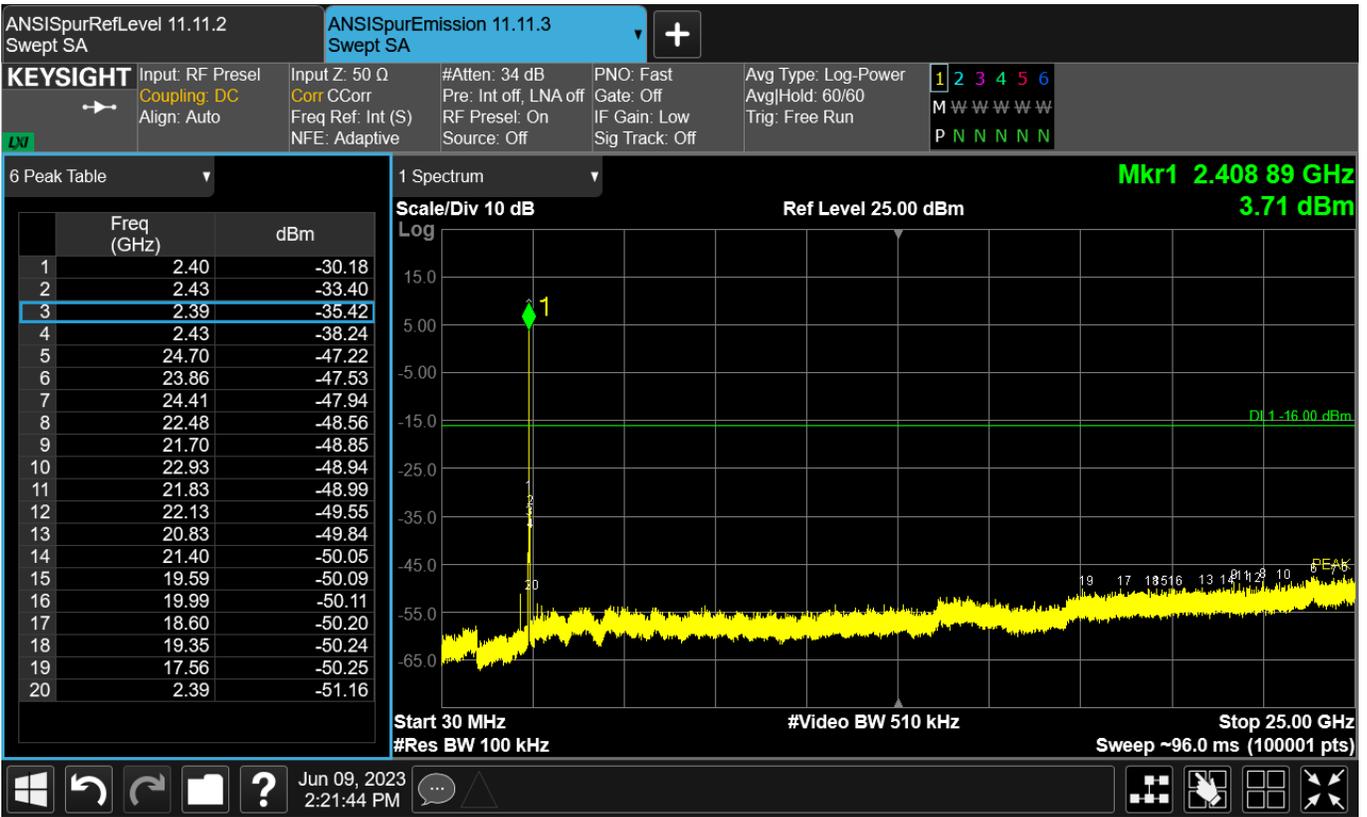


Figure TR25.3: Spectral data for IEEE 802.11 b 1 Mbps on Ch.1

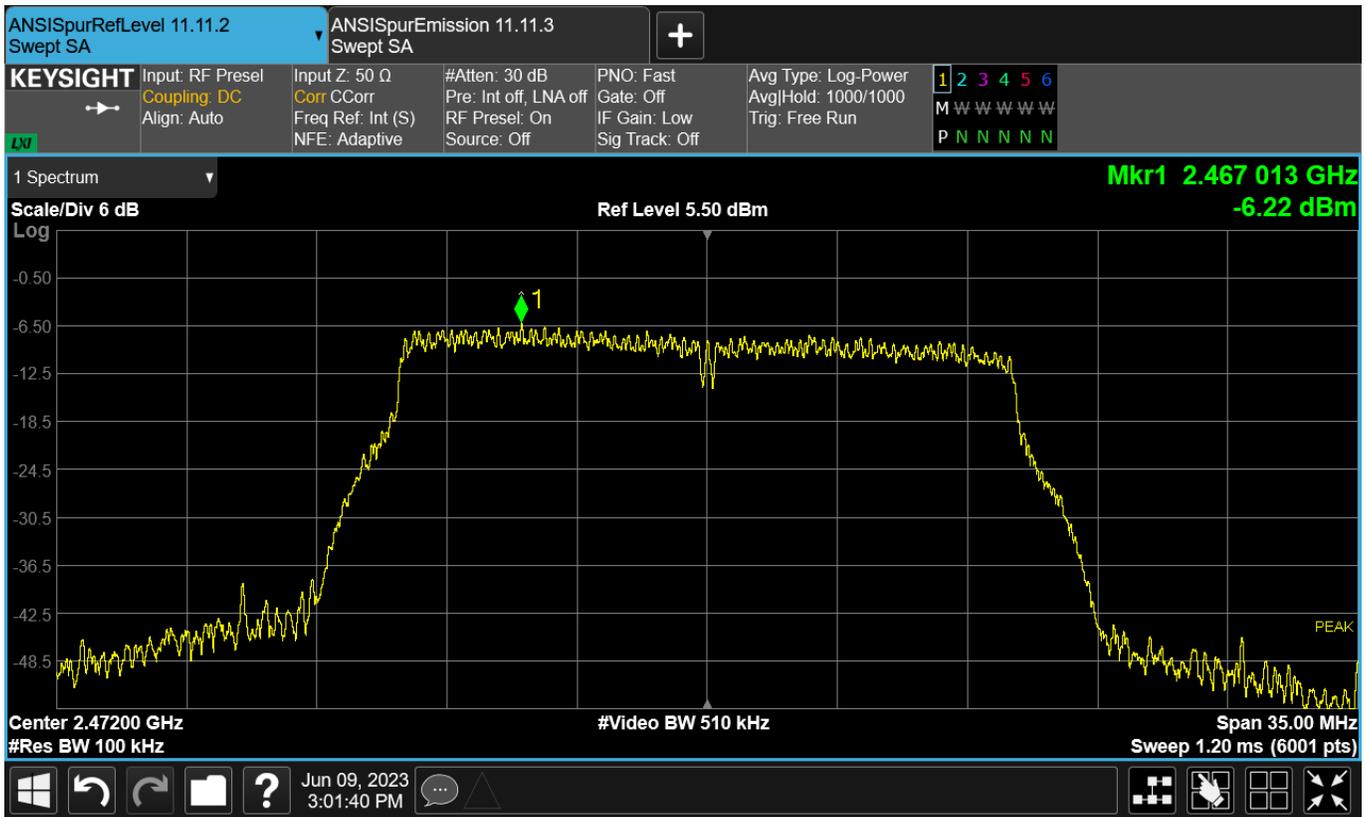


Figure TR25.4: Reference level measurement for IEEE 802.11 g 6 Mbps on Ch.13

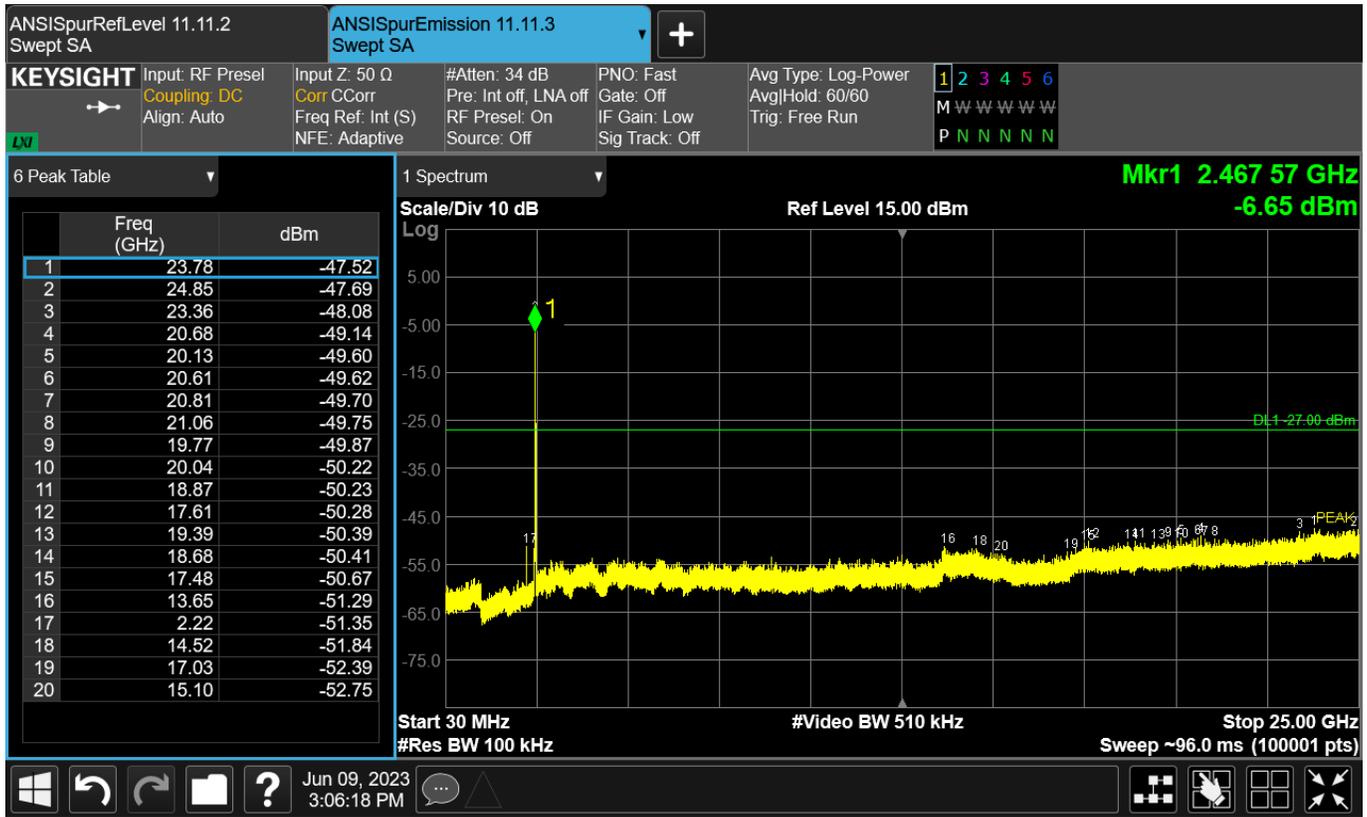


Figure TR25.5 Spectral data for IEEE 802.11 g 6 Mbps on Ch.13

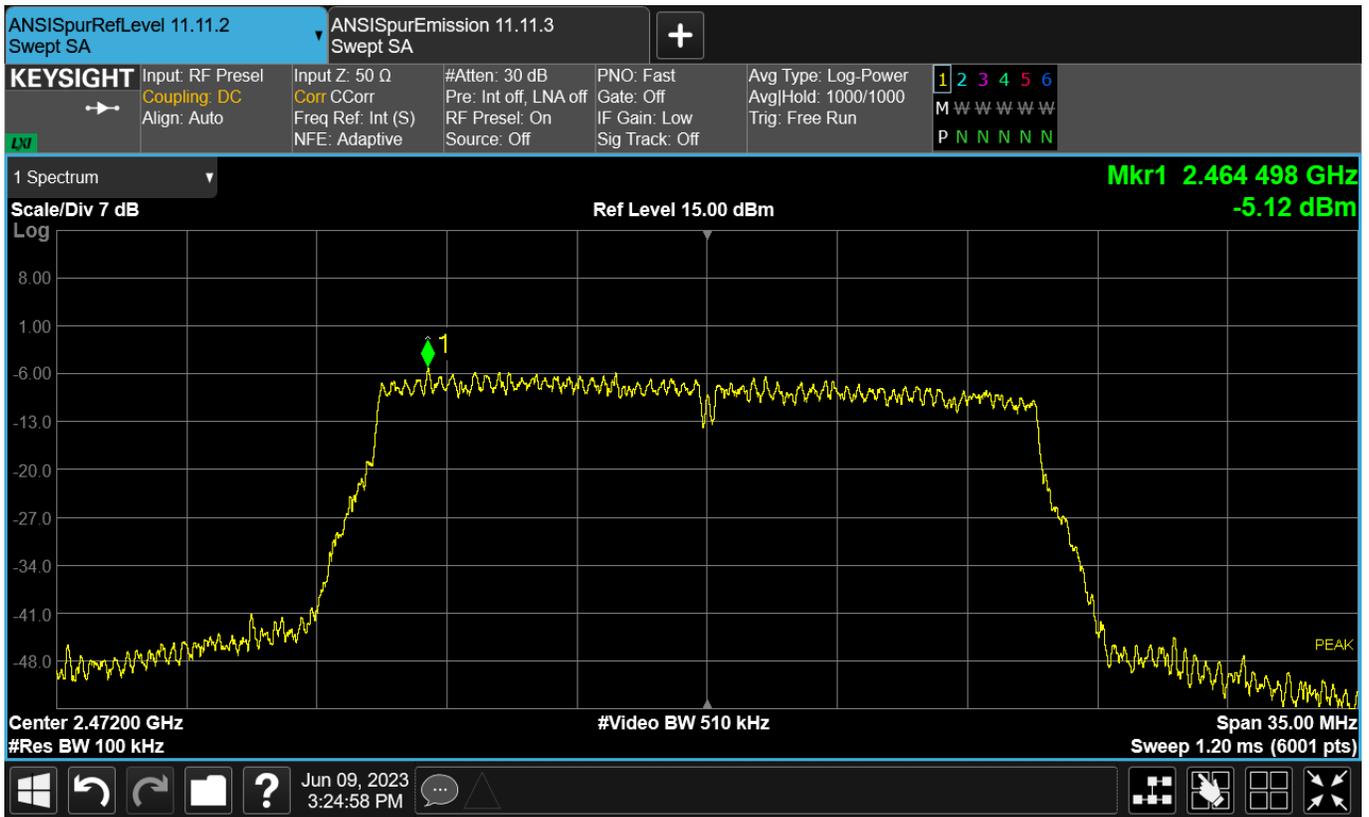


Figure TR25.6: Reference level measurement for IEEE 802.11 n MCS0 on Ch.13

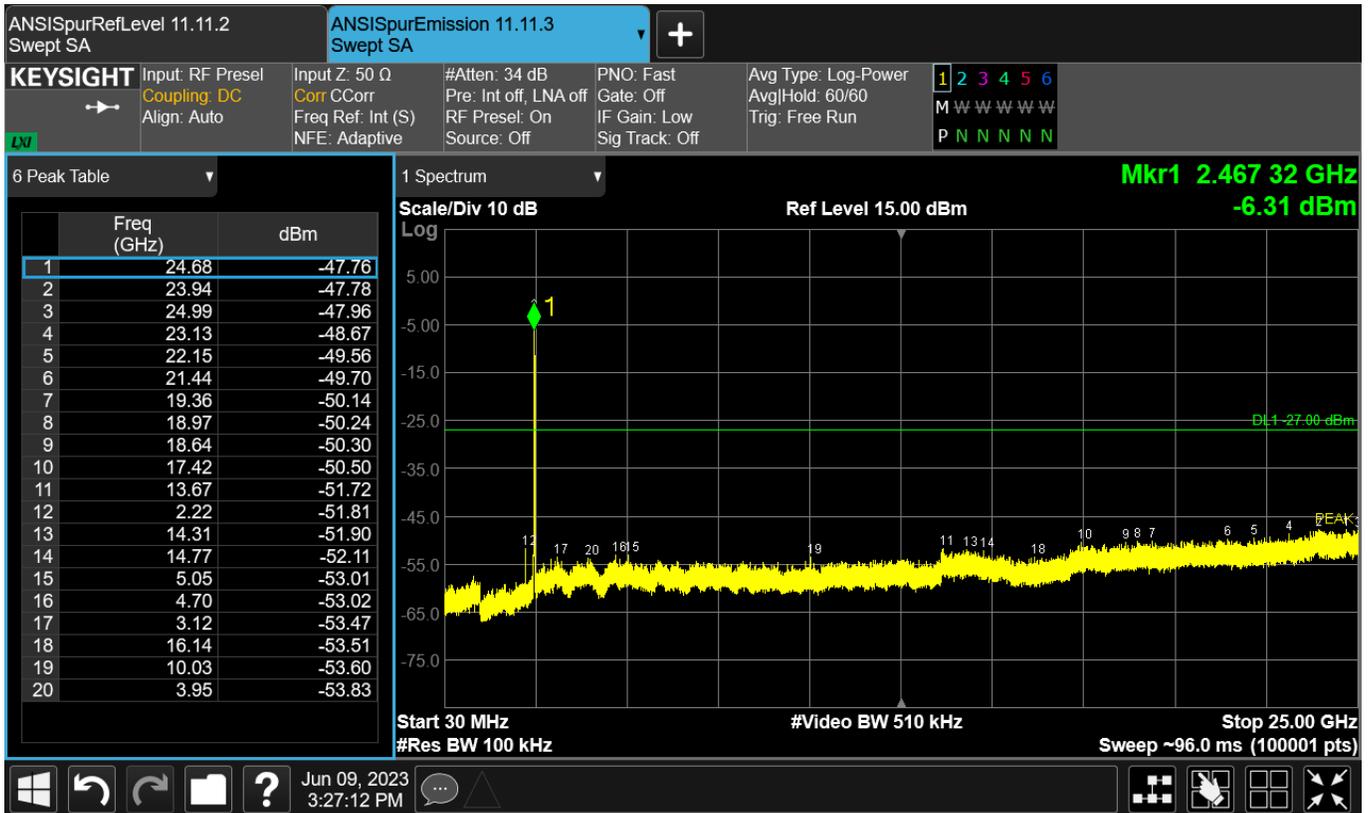


Figure TR25.7 Spectral data for IEEE 802.11 n MCS0 on Ch.13

This line is the end of the test record.

**Test Record**  
**Radiated Emission Test RE01**  
**Project GCL0385**

Test Date(s) 11-12,15-16, 23 May 2023  
 Test Personnel Jim Solum

Product Model A04724  
 Serial Number tested 441084880

Operating Mode M8 (WiFi Tx)  
 Arrangement A2 (Upwr)  
 Input Power 5 Vdc

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

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

**Test record created by: Jim Solum**  
**Date of this record: 31 May 2023**

Original record, Version A.

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
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
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

**Table RE01.1: Test Equipment Used**

**Software Used**

Keysight PXE N9048B Firmware version A.32.06  
 RE Signal Maximization Tool v2021Feb25.xlsx  
 WiFi FCC Restricted Band 2p4GHz Template v2.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. The turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings for each of the restricted band ranges. Final field strength measurements were taken in that set of positions. Full maximization was not performed at frequencies that are noise floor measurements included per the test standard requirements.

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

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

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
B1 Mode Peak	2390	54	74	39.416	69.486	14.584	4.514	162	1500	HORZ
B1 Mode Average	2389.8	54	74	39.801	69.389	14.199	4.611	162	1500	HORZ
G9 Mode Peak	2389	54	74	44.56	71.285	9.44	2.715	162	1500	HORZ
G9 Mode Average	2390	54	74	45.671	72.04	8.329	1.96	162	1500	HORZ
N6 Mode Peak	2390	54	74	46.627	72.247	7.373	1.753	162	1500	HORZ
N6 Mode Average	2390	54	74	46.626	72.842	7.374	1.158	162	1500	HORZ

**Table RE01.2: Emission summary FCC restricted band from 2200 to 2390 MHz (Ch01)**

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
B2 Mode Peak	2390	54	74	39.861	67.508	14.139	6.492	162	1500	HORZ
B2 Mode Average	2390	54	74	39.844	67.549	14.156	6.451	162	1500	HORZ
G9 Mode Peak	2388.5	54	74	49.064	69.872	4.936	4.128	162	1500	HORZ
G9 Mode Average	2390	54	74	50.624	71.912	3.376	2.088	162	1500	HORZ
N0 Mode Peak	2390	54	74	51.463	72.625	2.537	1.375	162	1500	HORZ
N0 Mode Average	2390	54	74	51.459	71.123	2.541	2.877	162	1500	HORZ

**Table RE01.3: Emission summary FCC restricted band from 2200 to 2390 MHz (Ch02)**

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
B11 Mode Peak	2484.5	54	74	34.408	63.212	19.592	10.788	-135	1500	HORZ
B11 Mode Average	2483.5	54	74	34.952	63.597	19.048	10.403	-135	1500	HORZ
G24 Mode Peak	2484	54	74	48.341	66.685	5.659	7.315	-135	1500	HORZ
G24 Mode Average	2483.5	54	74	48.678	66.877	5.322	7.123	-135	1500	HORZ
N0 Mode Peak	2483.5	54	74	50.421	69.5	3.579	4.5	-135	1500	HORZ
N0 Mode Average	2483.5	54	74	50.376	69.263	3.624	4.737	-135	1500	HORZ

**Table RE01.4: Emission summary FCC restricted band from 2483.5 to 2500 MHz (Ch10)**

Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
B11 Mode Peak	2484	54	74	34.75	68.741	19.25	5.259	-135	1500	HORZ
B11 Mode Average	2484	54	74	34.746	64.675	19.254	9.325	-135	1500	HORZ
G18 Mode Peak	2483.5	54	74	46.912	69.207	7.088	4.793	-135	1500	HORZ
G18 Mode Average	2483.5	54	74	46.884	69.085	7.116	4.915	-135	1500	HORZ
N6 Mode Peak	2483.5	54	74	46.513	68.647	7.487	5.353	-135	1500	HORZ
N6 Mode Average	2483.5	54	74	46.514	70.554	7.486	3.446	-135	1500	HORZ

**Table RE01.5: Emission summary FCC restricted band from 2483.5 to 2500 MHz (Ch11)**

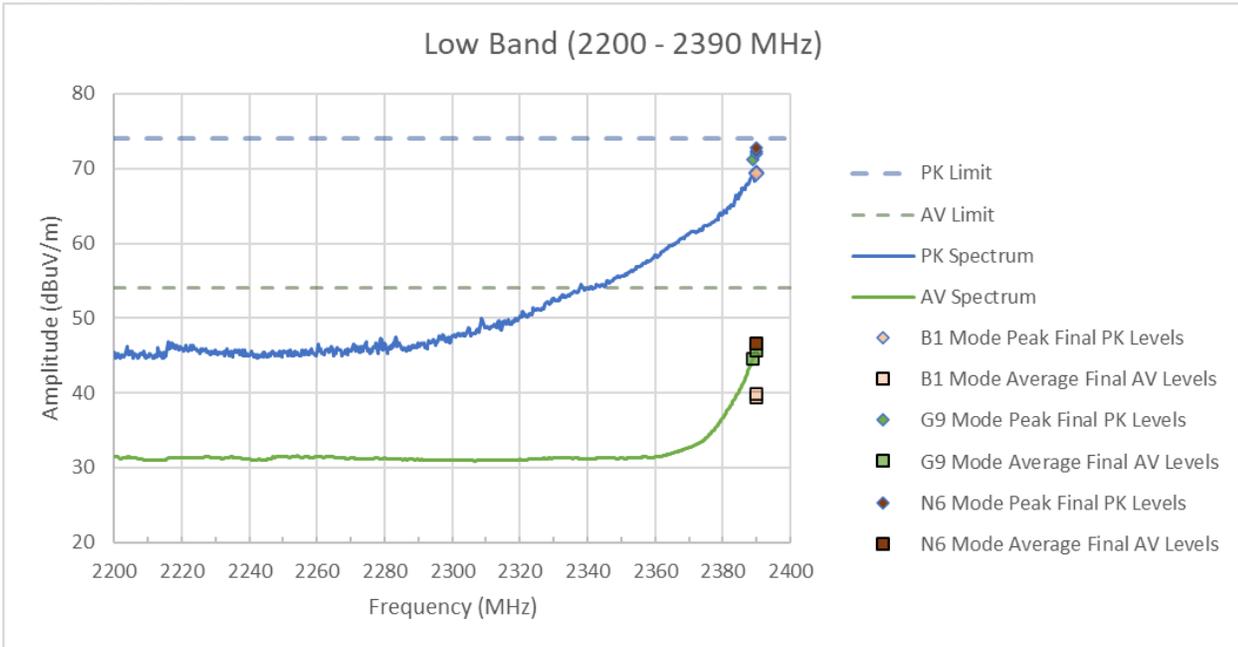
Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
B11 Mode Peak	2484.3	54	74	48.737	68.847	5.263	5.153	-135	1500	HORZ
B11 Mode Average	2483.5	54	74	50.323	69.392	3.677	4.608	-135	1500	HORZ
G9 Mode Peak	2483.8	54	74	49.499	72.124	4.501	1.876	-135	1500	HORZ
G9 Mode Average	2483.5	54	74	49.689	72.69	4.311	1.31	-135	1500	HORZ
N6 Mode Peak	2484.5	54	74	49.355	72.571	4.645	1.429	-135	1500	HORZ
N6 Mode Average	2483.5	54	74	50.049	73.692	3.951	0.308	-135	1500	HORZ

**Table RE01.6: Emission summary FCC restricted band from 2483.5 to 2500 MHz (Ch12)**

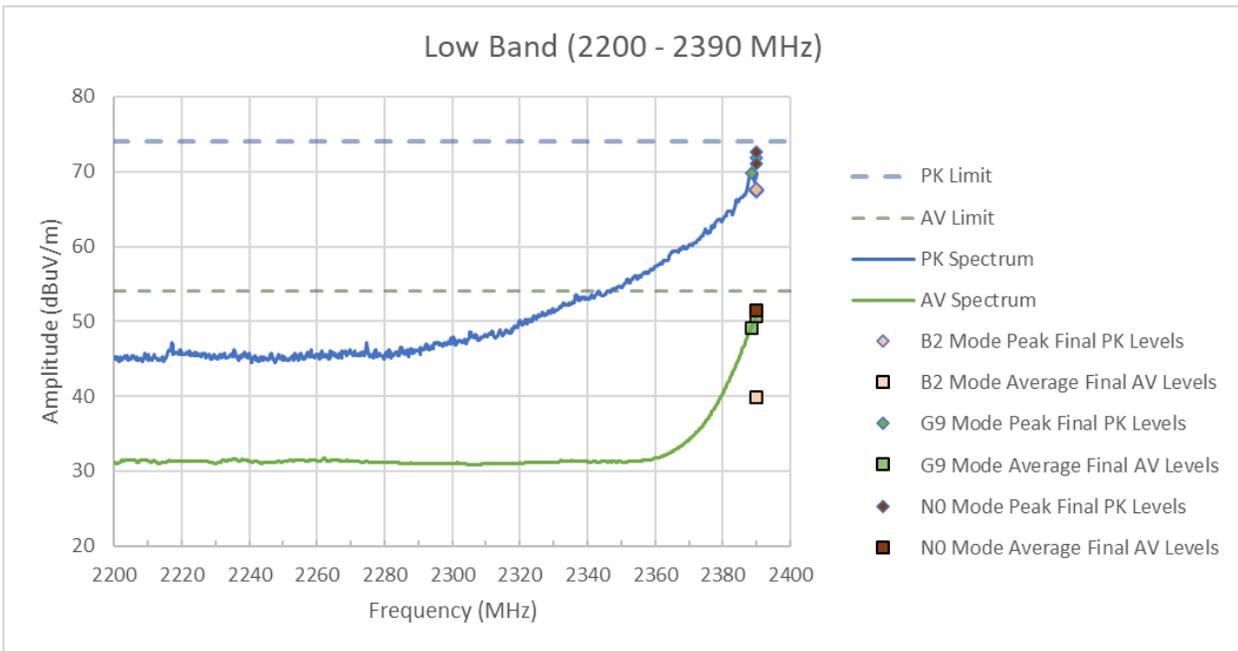
Channel & Modulation	Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
B5.5 Mode Peak	2484.8	54	74	43.289	69.274	10.711	4.726	-136	1566	HOR
B5.5 Mode Average	2484.3	54	74	43.624	69.504	10.376	4.496	-136	1566	HOR
G9 Mode Peak	2483.5	54	74	43.89	70.247	10.11	3.753	-136	1566	HOR
G9 Mode Average	2483.5	54	74	43.888	70.75	10.112	3.25	-136	1566	HOR
N4 Mode Peak	2484	54	74	43.757	70.57	10.243	3.43	-136	1566	HOR
N4 Mode Average	2483.5	54	74	44.602	71.334	9.398	2.666	-136	1566	HOR

**Table RE01.7: Emission summary FCC restricted band from 2483.5 to 2500 MHz (Ch13)**

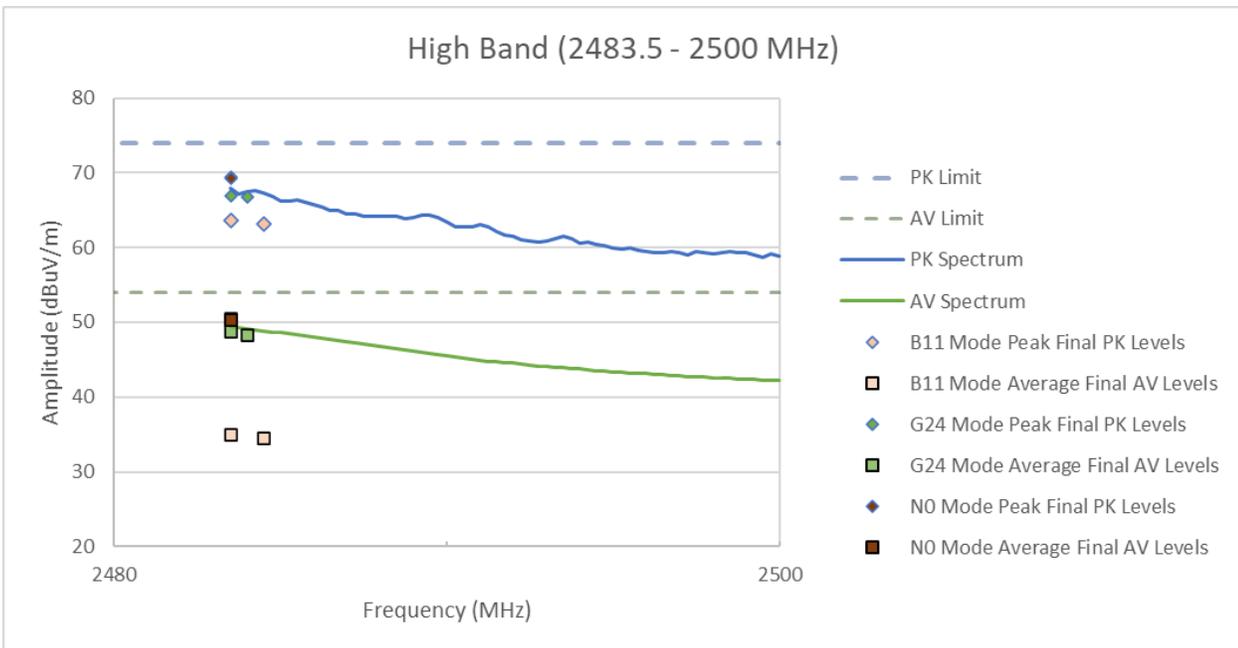
The graphs below show the background spectrum observed during pre-scan, as well as the final data points from the table above.



**Figure RE01.1: Spectral data FCC restricted band from 2200 to 2390 MHz (Ch01)**



**Figure RE01.2: Spectral data FCC restricted band from 2200 to 2390 MHz (Ch02)**



**Figure RE01.3: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Ch10)**

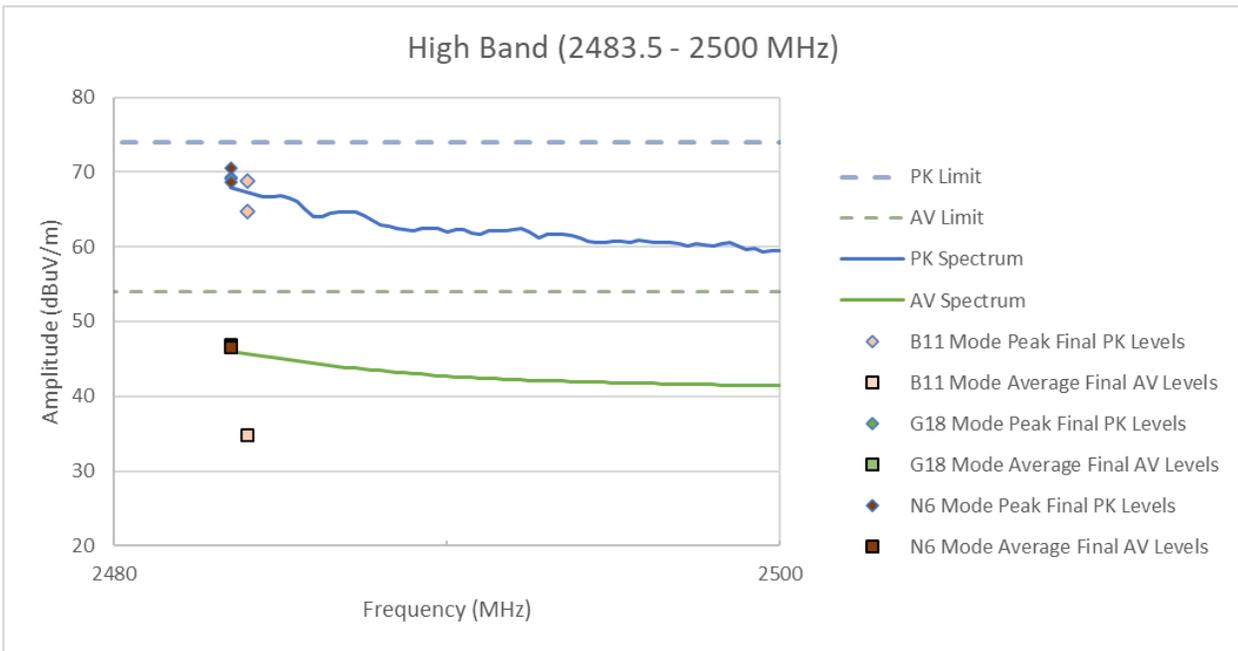


Figure RE01.4: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Ch11)

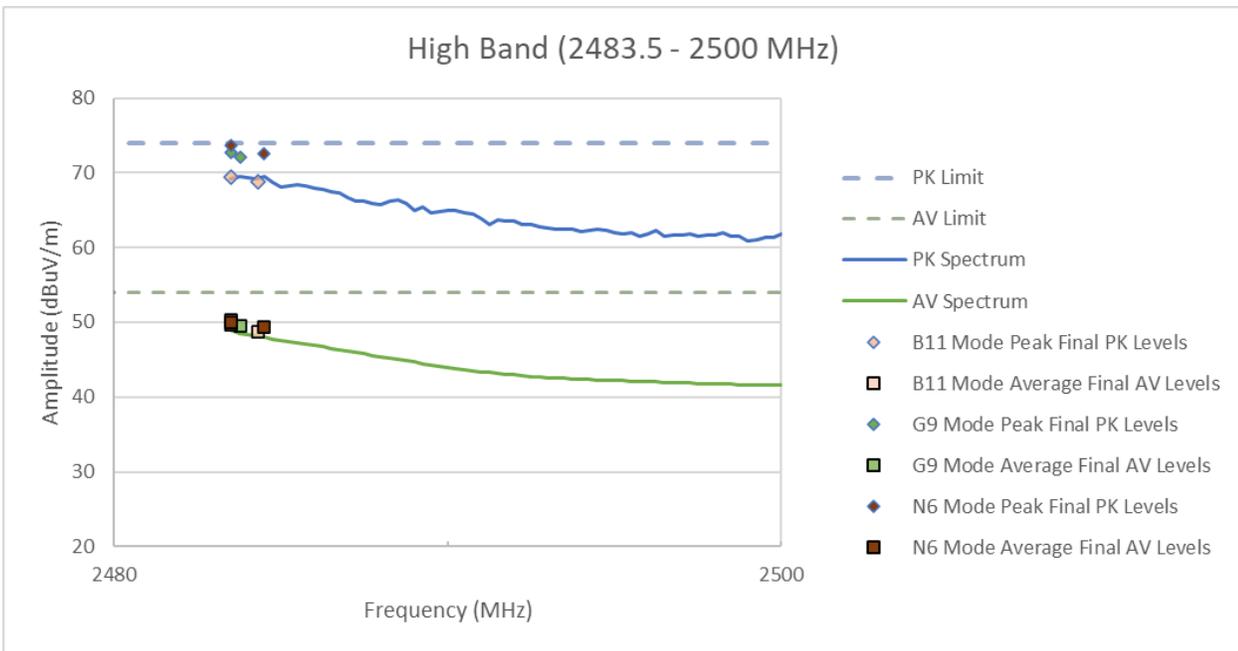
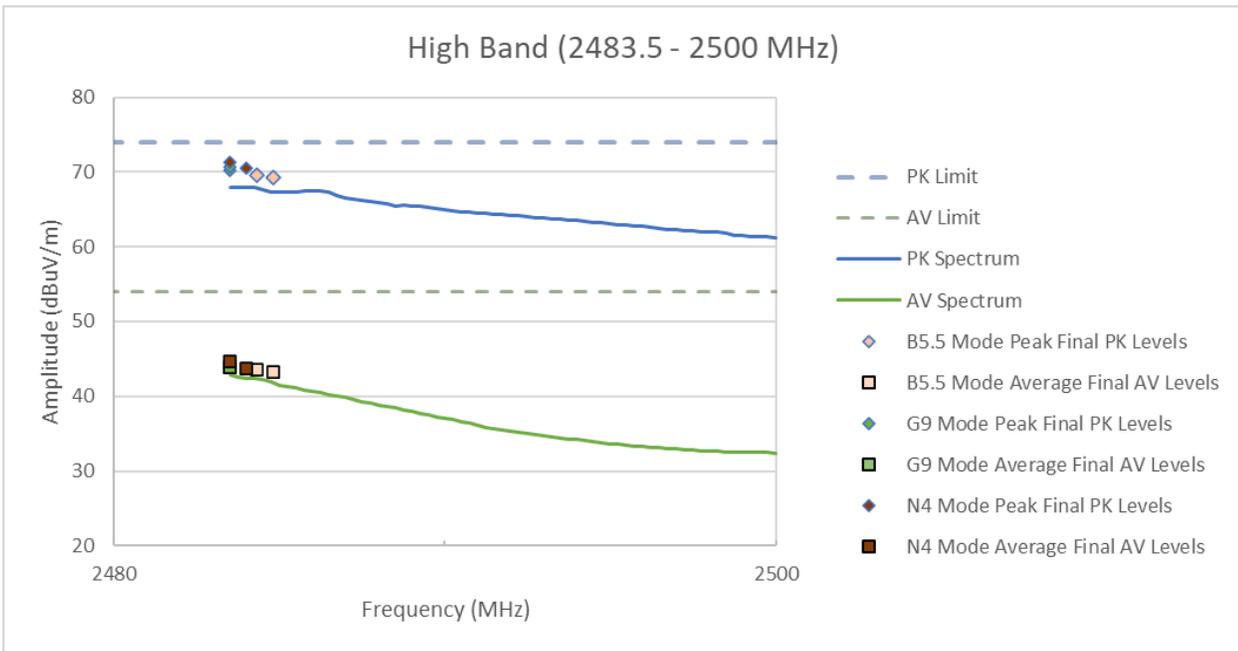


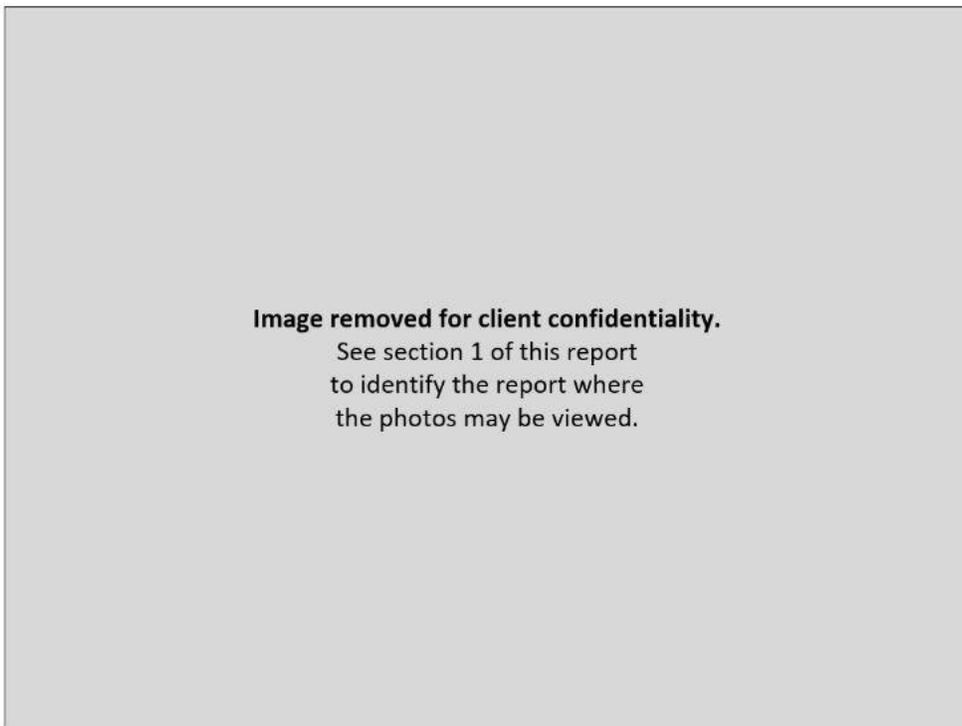
Figure RE01.5: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Ch12)



**Figure RE01.6: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Ch13)**

**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, front view (Y orientation)**



**Figure RE01.8: EUT test setup, reverse view (Y orientation)**

**This line is the end of the test record.**

**Test Record**  
**Radiated Emission Test RE04**  
**Project GCL0385**

Test Date(s) 19 May 2023  
 Test Personnel Jim Solum

Product Model A04724  
 Serial Number tested 441084880

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

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

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

**Test record created by: Jim Solum**  
**Date of this record: 26 May 2023**

Original record, Version A.

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
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
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

**Table RE04.1: Test Equipment Used**

**Software Used**

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

**Test Data**

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using on the orientation(s) producing the highest result relative to the test limit. Where the test standard requires cable manipulation, this was done at one of more likely worst case frequencies selected by the test personnel while observing the receiver display. The turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings for each of the restricted band ranges. 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 in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC restricted band Class B Limit at 3m.

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
2222.5	54	74	31.969	46.342	22.031	27.658	158	1500	HORZ
2390	54	74	32.684	46.391	21.316	27.609	158	1500	HORZ

**Table RE04.2: Emission summary FCC restricted band from 2200 to 2390 MHz (1 Mbps)**

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
2484	54	74	33.58	47.687	20.42	26.313	-135	1580	HORZ
2483.5	54	74	33.692	48.628	20.308	25.372	-135	1580	HORZ

**Table RE04.3: Emission summary FCC restricted band from 2483.5 to 2500 MHz (1Mbps)**

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
2223.8	54	74	32.004	46.212	21.996	27.788	158	1500	HORZ
2390	54	74	32.674	46.585	21.326	27.415	158	1500	HORZ

**Table RE04.4: Emission summary FCC restricted band from 2200 to 2390 MHz (2 Mbps)**

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity
2496	54	74	33.076	46.947	20.924	27.053	-135	1580	HORZ
2483.5	54	74	33.533	47.199	20.467	26.801	-135	1580	HORZ

**Table RE04.5: Emission summary FCC restricted band from 2483.5 to 2500 MHz (2 Mbps)**

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

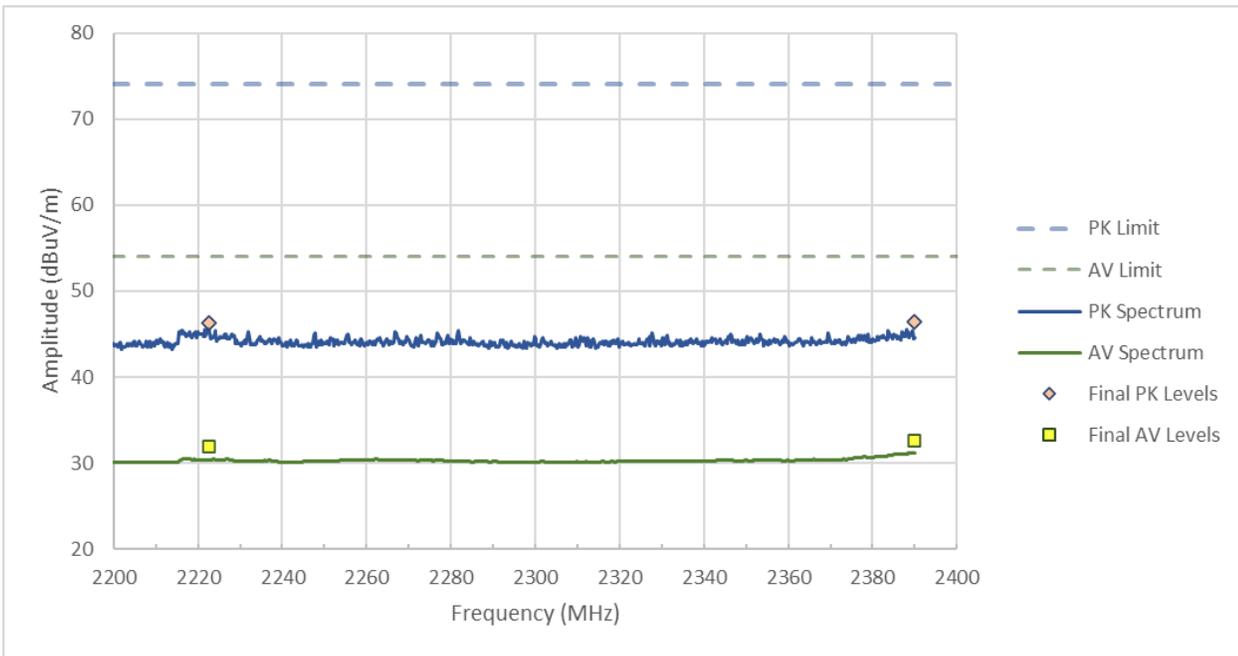


Figure RE04.1: Spectral data FCC restricted band from 2200 to 2390 MHz (1Mbps)

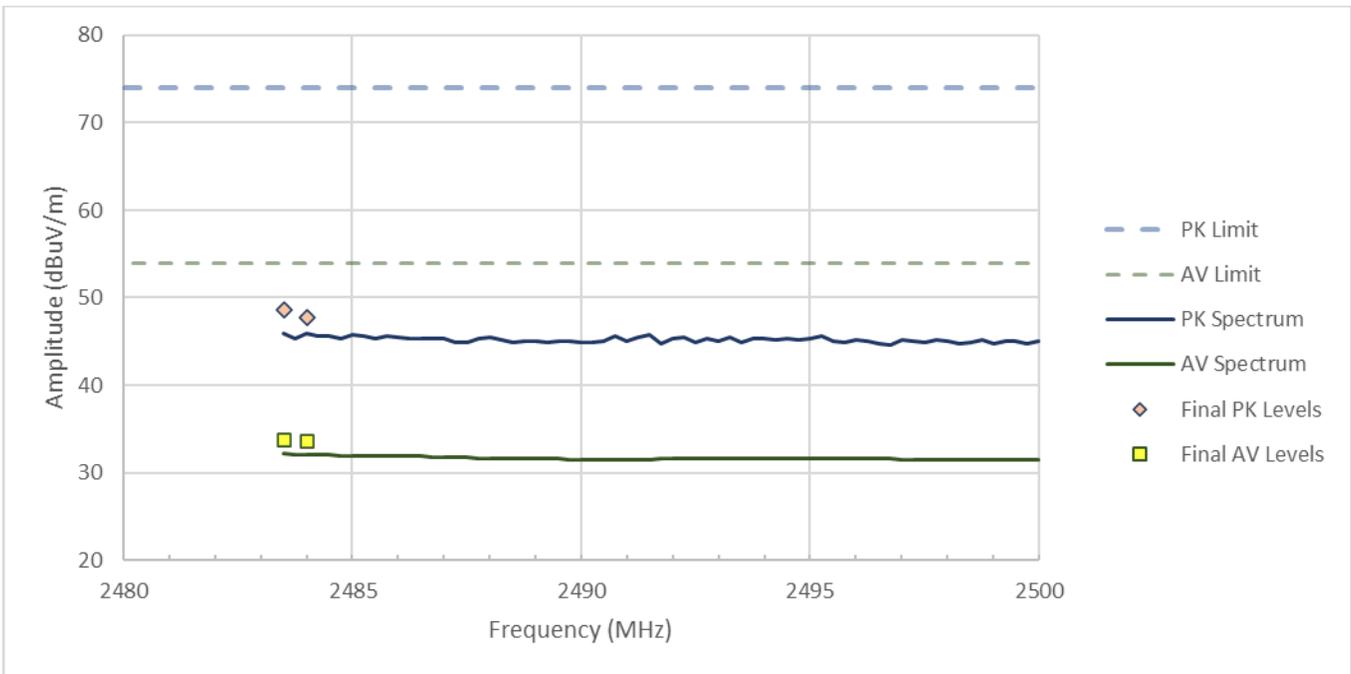


Figure RE04.2: Spectral data FCC restricted band from 2483.5 to 2500 MHz (1 Mbps)

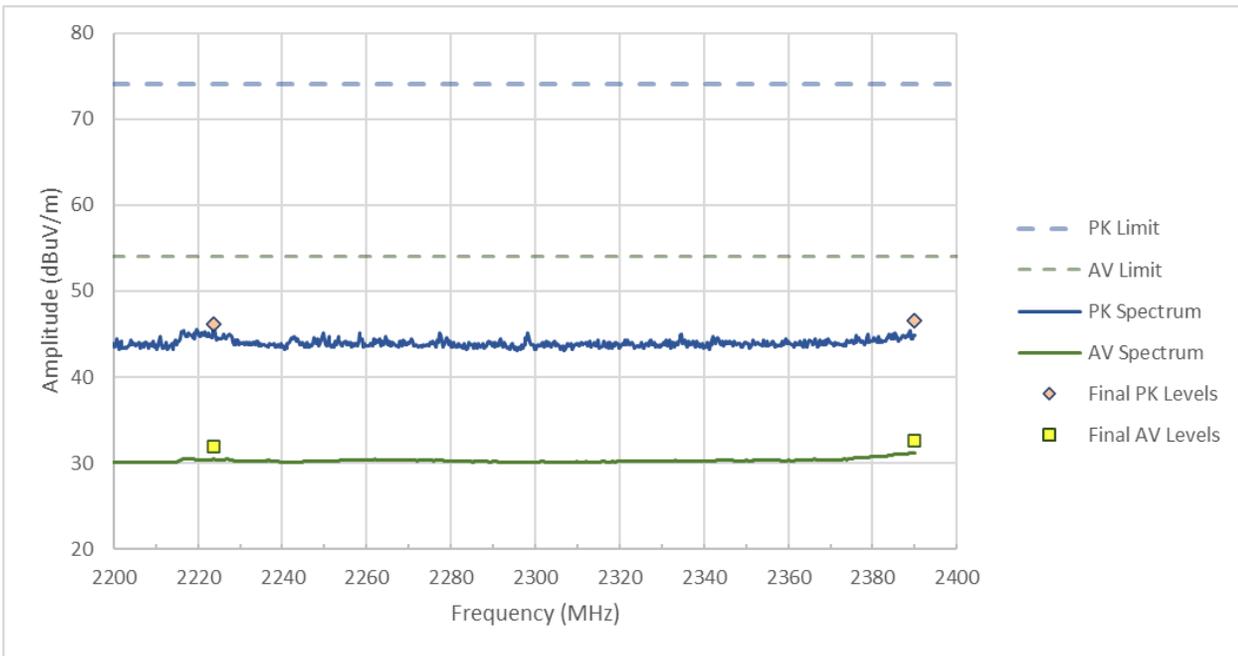


Figure RE04.3: Spectral data FCC restricted band from 2200 to 2390 MHz (2 Mbps)

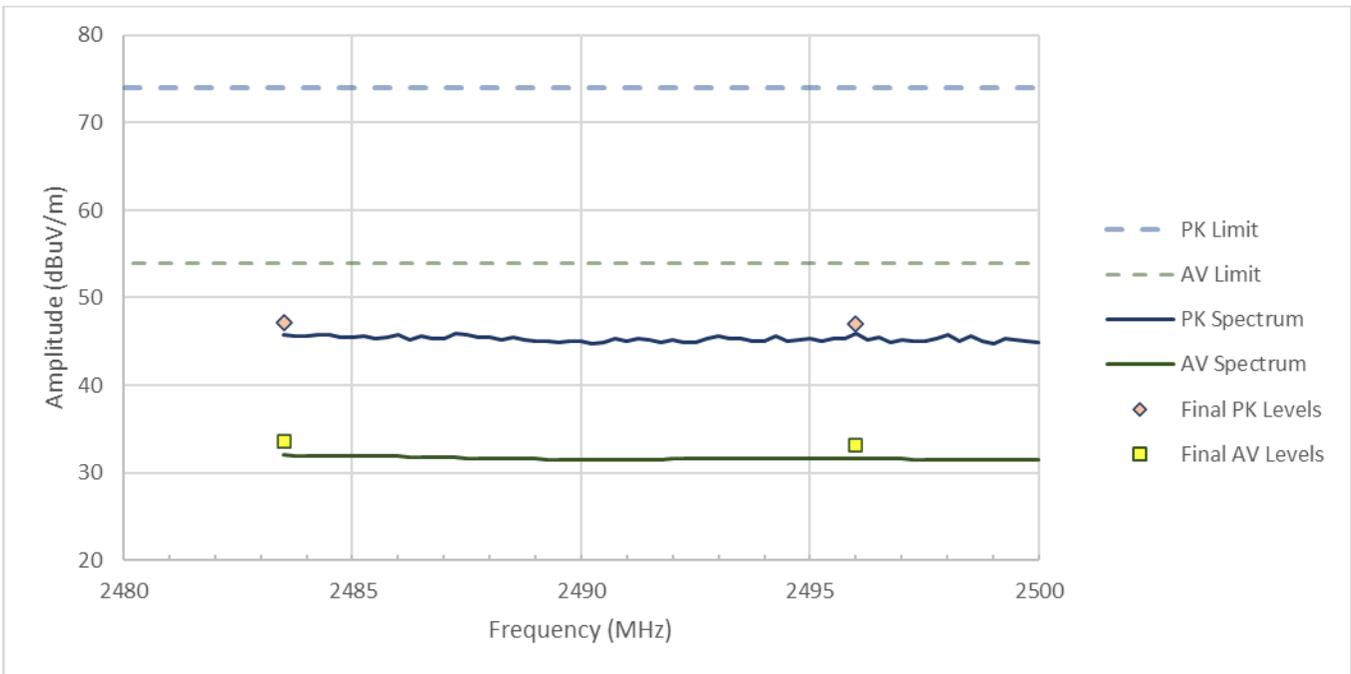
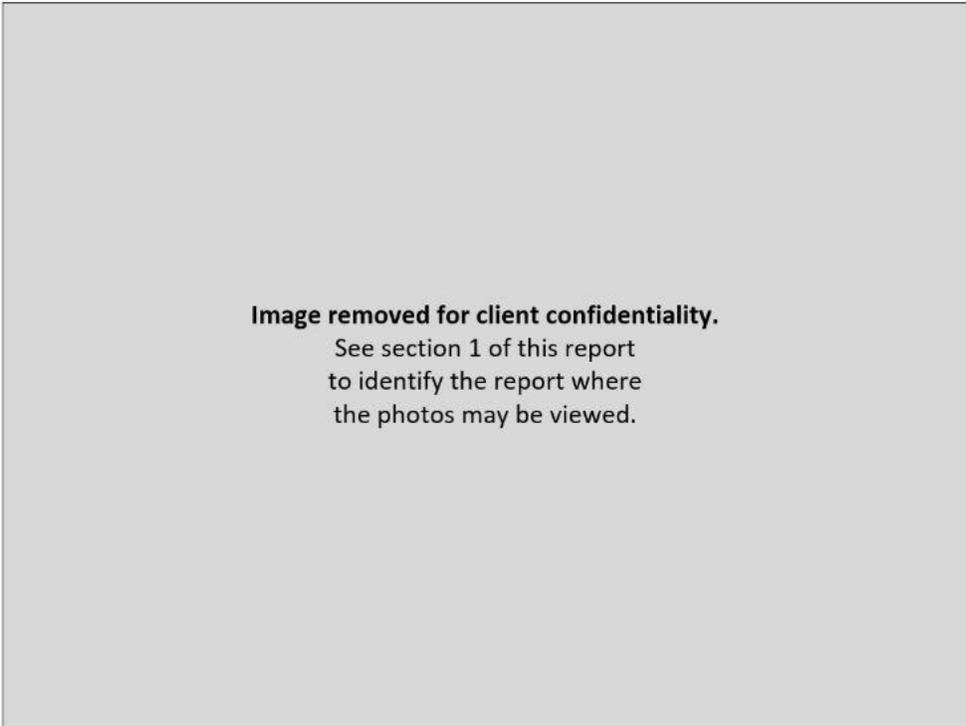


Figure RE04.4: Spectral data FCC restricted band from 2483.5 to 2500 MHz (2 Mbps)

**Setup Photographs**

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



**Figure RE04.5: EUT test setup, front view (Y orientation)**



**Figure RE04.6: EUT test setup, reverse view (Y orientation)**

**This line is the end of the test record.**

**Test Record**  
**Radiated Emission Test RE06**  
**Project GCL0385**

Test Date(s) 19 May 2023  
 Test Personnel Jim Solum

Product Model A04724  
 Serial Number tested 441084880

Operating Mode M10 (BT Tx)  
 Arrangement A2 (Upwr)  
 Input Power 5 Vdc

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

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

**Test record created by: Jim Solum**  
**Date of this record: 30 May 2023**

Original record, Version A.

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
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
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

**Table RE06.1: Test Equipment Used**

**Software Used**

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

**Test Data**

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using on the orientation(s) producing the highest result relative to the test limit. Where the test standard requires cable manipulation, this was done at one of more likely worst case frequencies selected by the test personnel while observing the receiver display. The turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings for each of the restricted band ranges. 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
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2218.3	54	74	32.041	46.123	21.959	27.877	158	1500	HORZ
2390	54	74	33.167	46.4	20.833	27.6	158	1500	HORZ

Table RE06.2: Emission summary FCC restricted band from 2200 to 2390 MHz (Basic Rate)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2483.8	54	74	36.574	50.087	17.426	23.913	-135	1580	HORZ
2483.5	54	74	36.842	50.423	17.158	23.577	-135	1580	HORZ

Table RE06.3: Emission summary FCC restricted band from 2483.5 to 2500 MHz (Basic Rate)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2217	54	74	32.105	46.458	21.895	27.542	158	1500	HORZ
2258	54	74	32.744	45.886	21.256	28.114	158	1500	HORZ

Table RE06.4: Emission summary FCC restricted band from 2200 to 2390 MHz (EDR2)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2483.5	54	74	38.711	63.195	15.289	10.805	-135	1580	HORZ
2483.5	54	74	38.717	63.49	15.283	10.51	-135	1580	HORZ

Table RE06.5: Emission summary FCC restricted band from 2483.5 to 2500 MHz (EDR2)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2222	54	74	32.093	46.713	21.907	27.287	158	1500	HORZ
2258	54	74	32.75	46.471	21.25	27.529	158	1500	HORZ

Table RE06.6: Emission summary FCC restricted band from 2200 to 2390 MHz (EDR3)

Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2483.5	54	74	37.92	64.844	16.08	9.156	-135	1580	HORZ
2483.5	54	74	37.926	65	16.074	9	-135	1580	HORZ

Table RE06.7: Emission summary FCC restricted band from 2483.5 to 2500 MHz (EDR3)

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

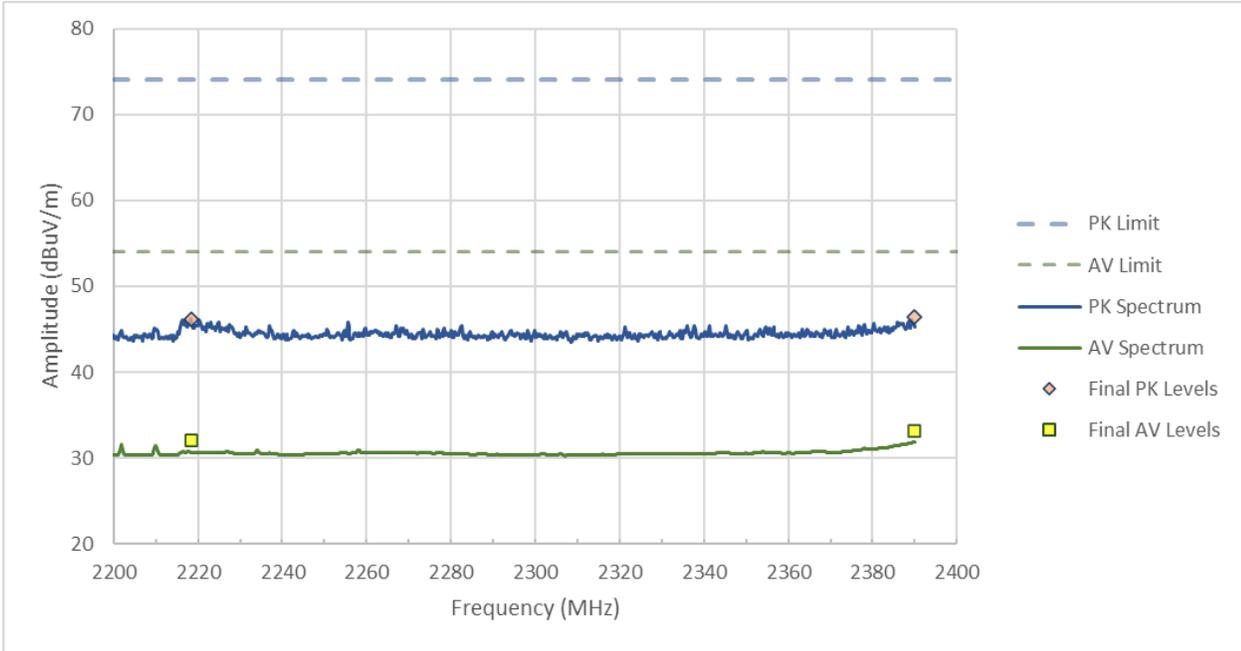


Figure RE06.1: Spectral data FCC restricted band from 2200 to 2390 MHz (Basic Rate)

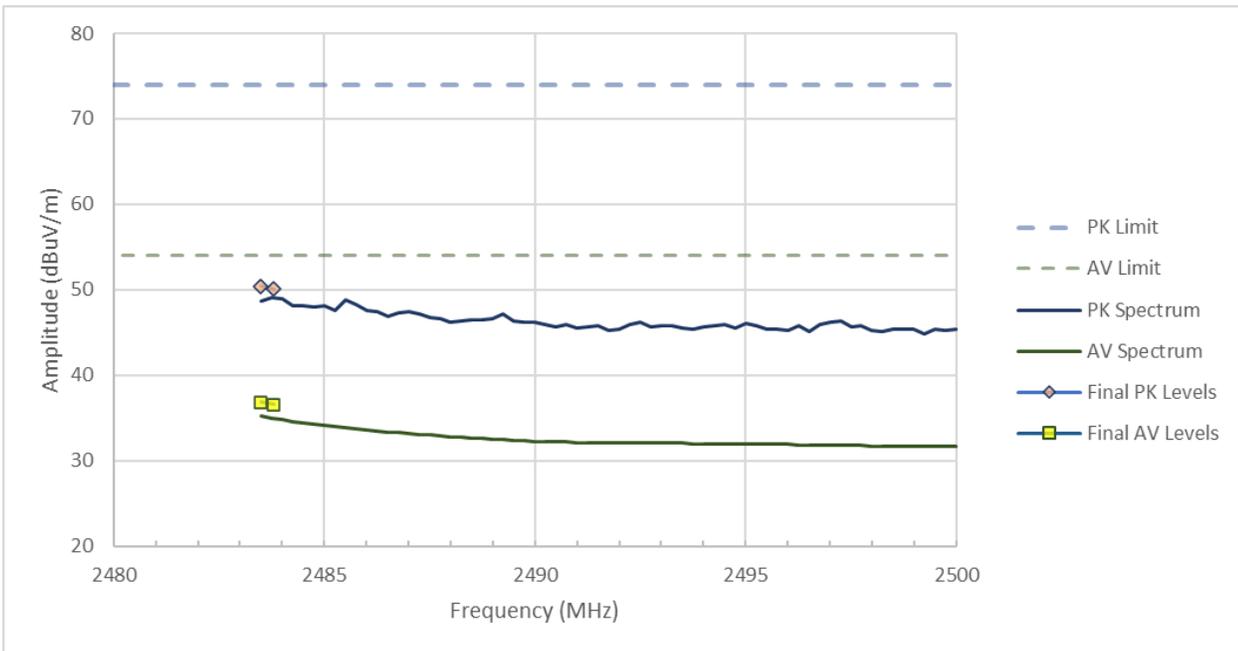


Figure RE06.2: Spectral data FCC restricted band from 2483.5 to 2500 MHz (Basic Rate)

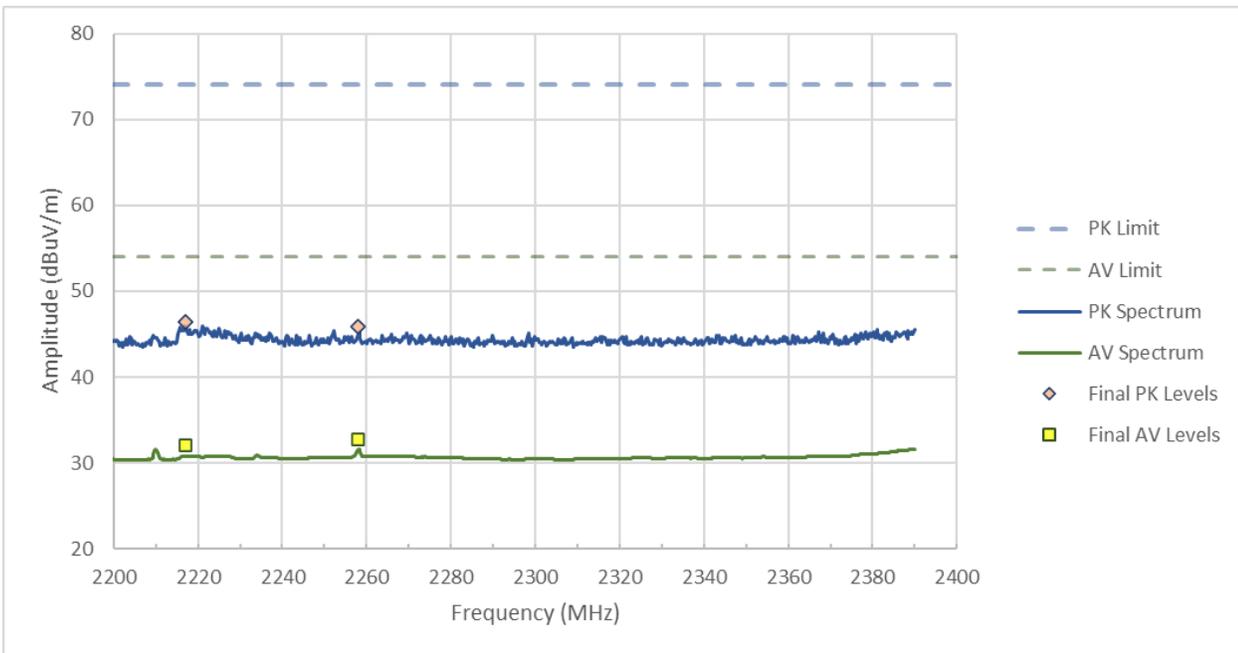


Figure RE06.3: Spectral data FCC restricted band from 2200 to 2390 MHz (EDR2)

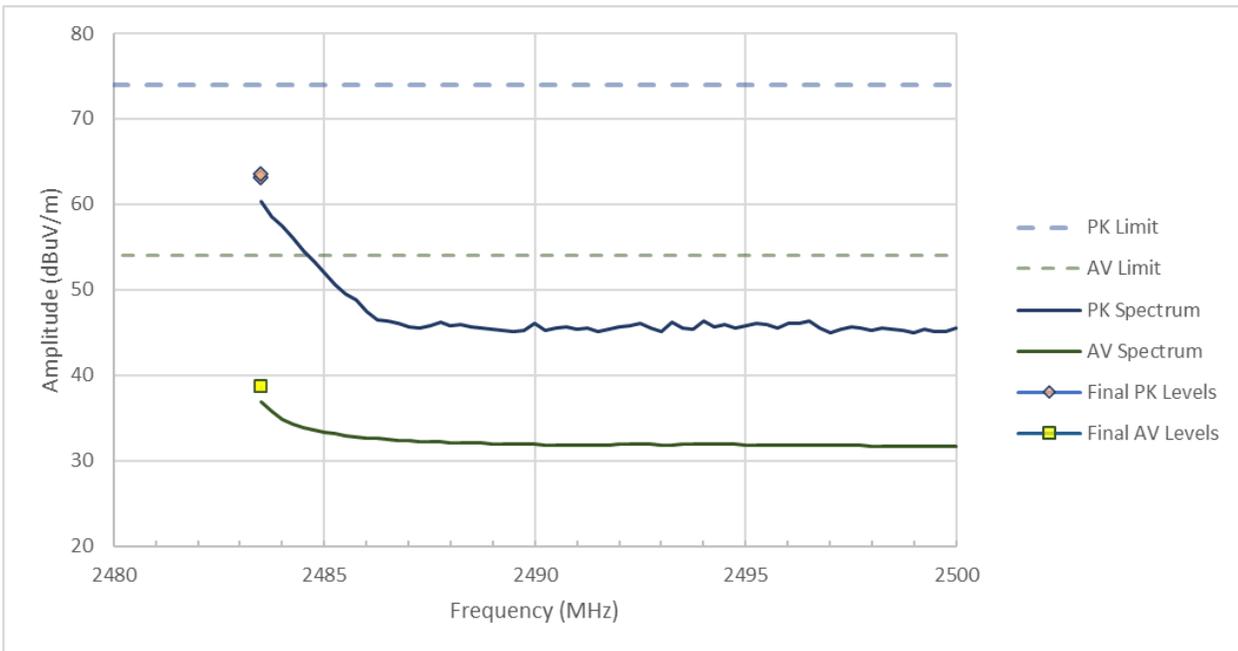


Figure RE06.4: Spectral data FCC restricted band from 2483.5 to 2500 MHz (EDR2)

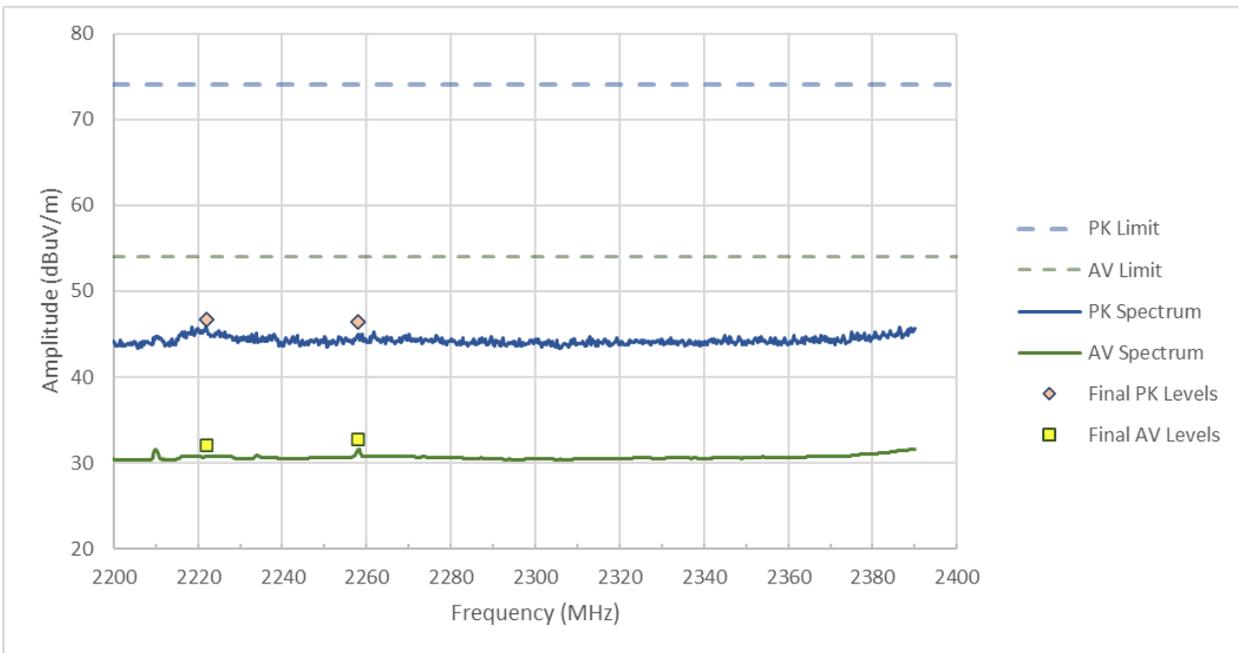
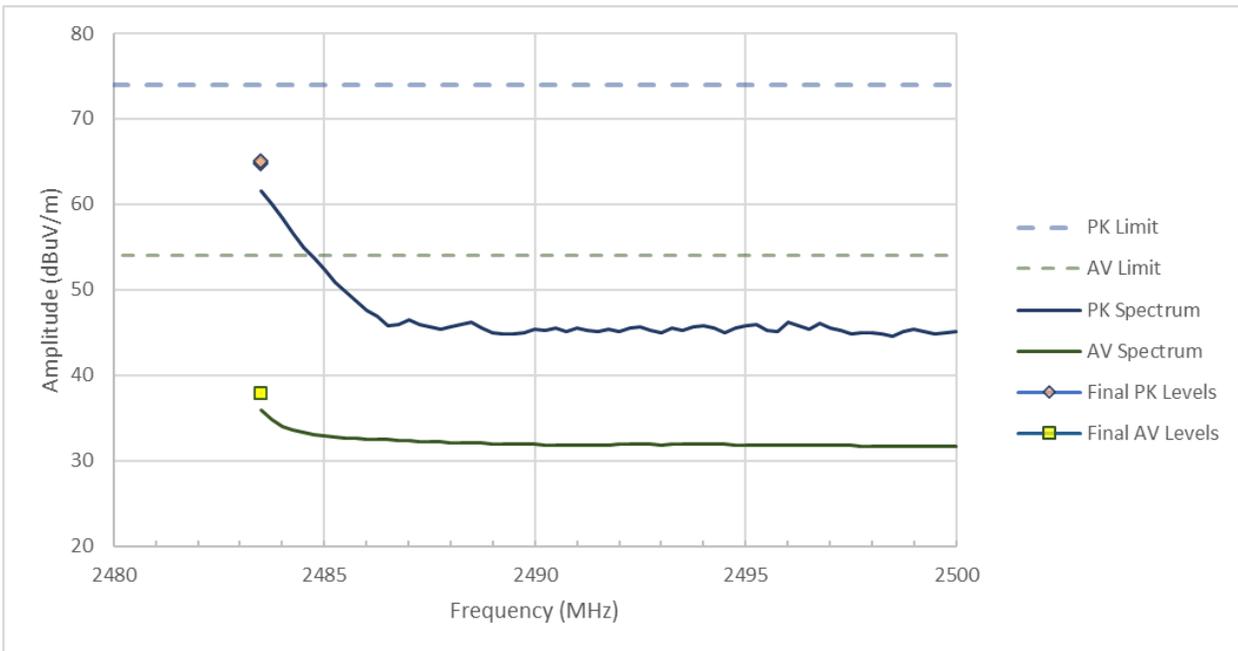


Figure RE06.5: Spectral data FCC restricted band from 2200 to 2390 MHz (EDR3)



**Figure RE06.6: Spectral data FCC restricted band from 2483.5 to 2500 MHz (EDR3)**

**Setup Photographs**

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



**Figure RE06.7: EUT test setup, front view (Y orientation)**



**Figure RE06.8: EUT test setup, reverse view (Y orientation)**

**This line is the end of the test record.**

**Test Record**  
**Radiated Emission Test RE09**  
**Project GCL0385**

Test Date(s) 19 May 2023  
 Test Personnel Jim Solum

Product Model A04724  
 Serial Number tested 441084880

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

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

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

**Test record created by: Jim Solum**  
**Date of this record: 25 May 2023**

Original record, Version A.

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
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
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

**Table RE09.1: Test Equipment Used**

**Software Used**

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

## Test Data

The radiated emission test process began with a preliminary scan at multiple turntable angles, antenna heights, and both antenna polarizations. For test standards that require reorienting the test sample, further preliminary scans were taken in those alternate orientations typically described as X, Y, and Z. Subsequent testing was done using 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. The turntable angle, antenna height, and antenna polarization were explored to find the worst-case settings for each of the restricted band ranges. 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.

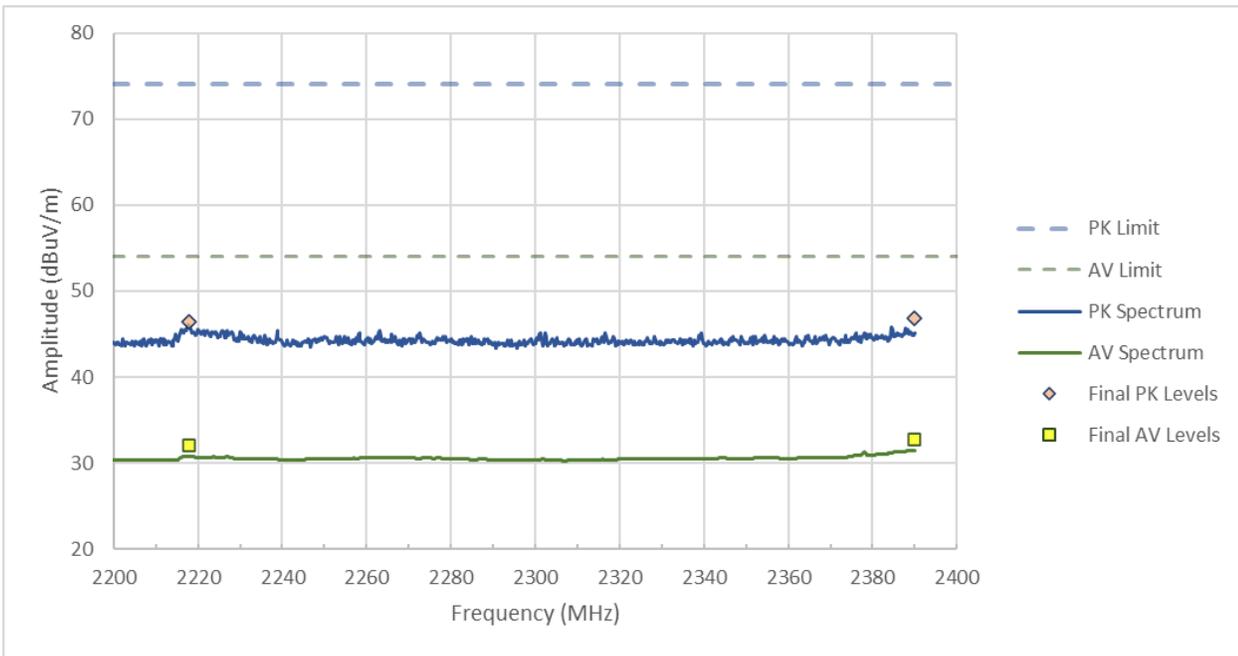
Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2217.8	54	74	32.061	46.391	21.939	27.609	158	1500	HORZ
2390	54	74	32.809	46.857	21.191	27.143	158	1500	HORZ

**Table RE09.2: FCC restricted band from 2200 to 2390 MHz**

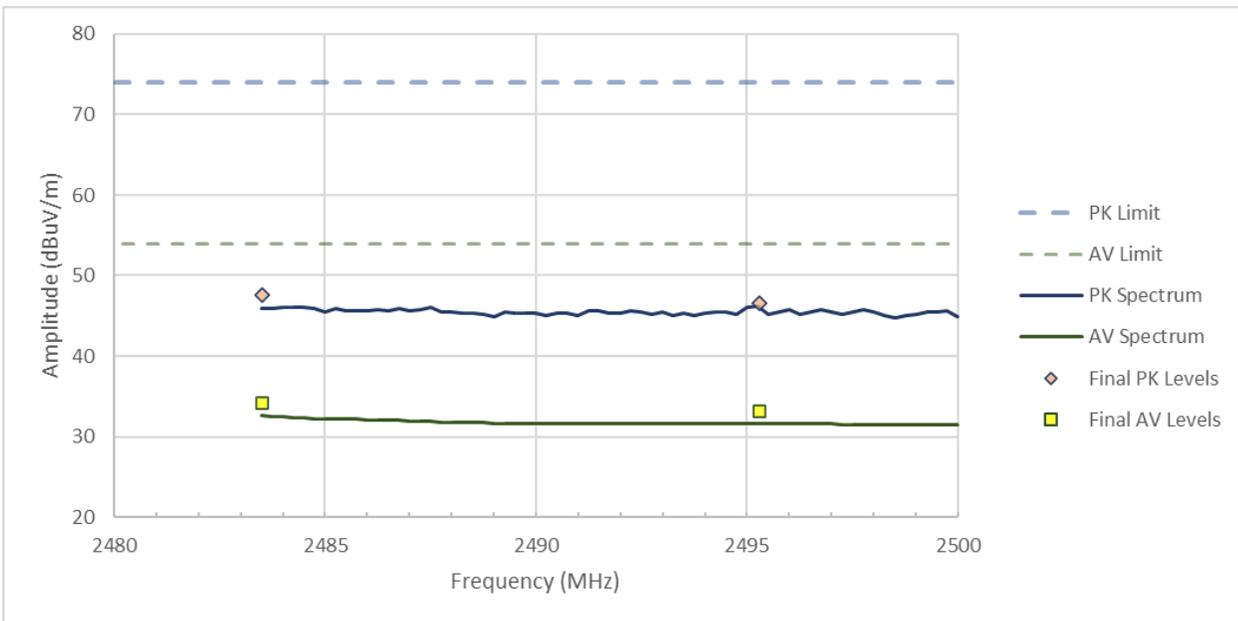
Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
2495.3	54	74	33.122	46.576	20.878	27.424	-135	1580	HORZ
2483.5	54	74	34.119	47.624	19.881	26.376	-135	1580	HORZ

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

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



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



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

**Setup Photographs**

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



**Figure RE09.3: EUT test setup, front view (Y orientation)**



**Figure RE09.4: EUT test setup, reverse view (Y orientation)**

**This line is the end of the test record.**

**Test Record**  
**Transmitter Power Spectral Density**  
**Test IDs TR06, TR08, TR10**  
**Project GCL-0385**

Test Date(s) 26 May 2023  
 Test Personnel David Arnett

Product Model A04724  
 Serial Number tested 441085073

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

Antenna Gain -0.37 dBi, as reported by the client  
 Radio Protocol IEEE 802.11b/g/n (WiFi)

**Pass/Fail Judgment: PASS**

**Test record created by: David Arnett**  
**Date of this record: 13 July 2023**

Version A was created on 2 June 2023. Version B was created on 13 July 2023 to remove an unneeded reference to RSS-210.

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024

**Table TR06.1: Test equipment used**

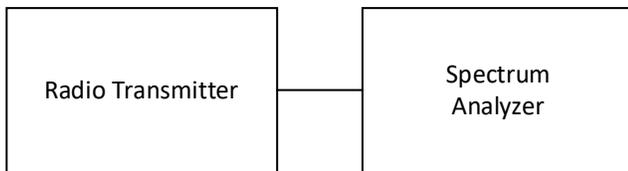
**Software Used:** Keysight PXE software A.33.03

**Test Method**

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

**Test Setup**

This block diagram shows the test equipment setup.



**Figure TR06.1: Test setup**

**Test Data**

The standards require measuring Power Spectral Density on the low, mid, and high channels. PSD is primarily affected by the process of modulation and the total power. Since it was known from previous testing that the mid channel has higher power than the edge channels, PSD was measured at the mid channel, channel 6, for all modulations. PSD for channels 1, 11, and 13 were then added for the modulation in each group (B, G, N) with the highest channel 6 PSD. Other channel and modulation combinations were not tested (NT in the summary table).

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 30 kHz resolution bandwidth.

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

	1	6	11	13
B1	NT	-0.73	NT	NT
B2	NT	0.74	NT	NT
B5.5	NT	1.27	NT	NT
B11	0.27	1.74	-0.03	-4.03
G06	NT	0.13	NT	NT
G09	NT	-0.44	NT	NT
G12	NT	0.33	NT	NT
G18	NT	-0.34	NT	NT
G24	NT	-0.22	NT	NT
G36	NT	0.11	NT	NT
G48	-2.28	0.89	-2.83	-7.28
G54	NT	-0.74	NT	NT
N0	NT	-0.5	NT	NT
N1	-2.32	-0.2	-3.45	-7.47
N2	NT	-1.37	NT	NT
N3	NT	-0.9	NT	NT
N4	NT	-0.85	NT	NT
N5	NT	-1.06	NT	NT
N6	NT	-1.06	NT	NT
N7	NT	-0.82	NT	NT

**Table TR06.2: Summary of results**

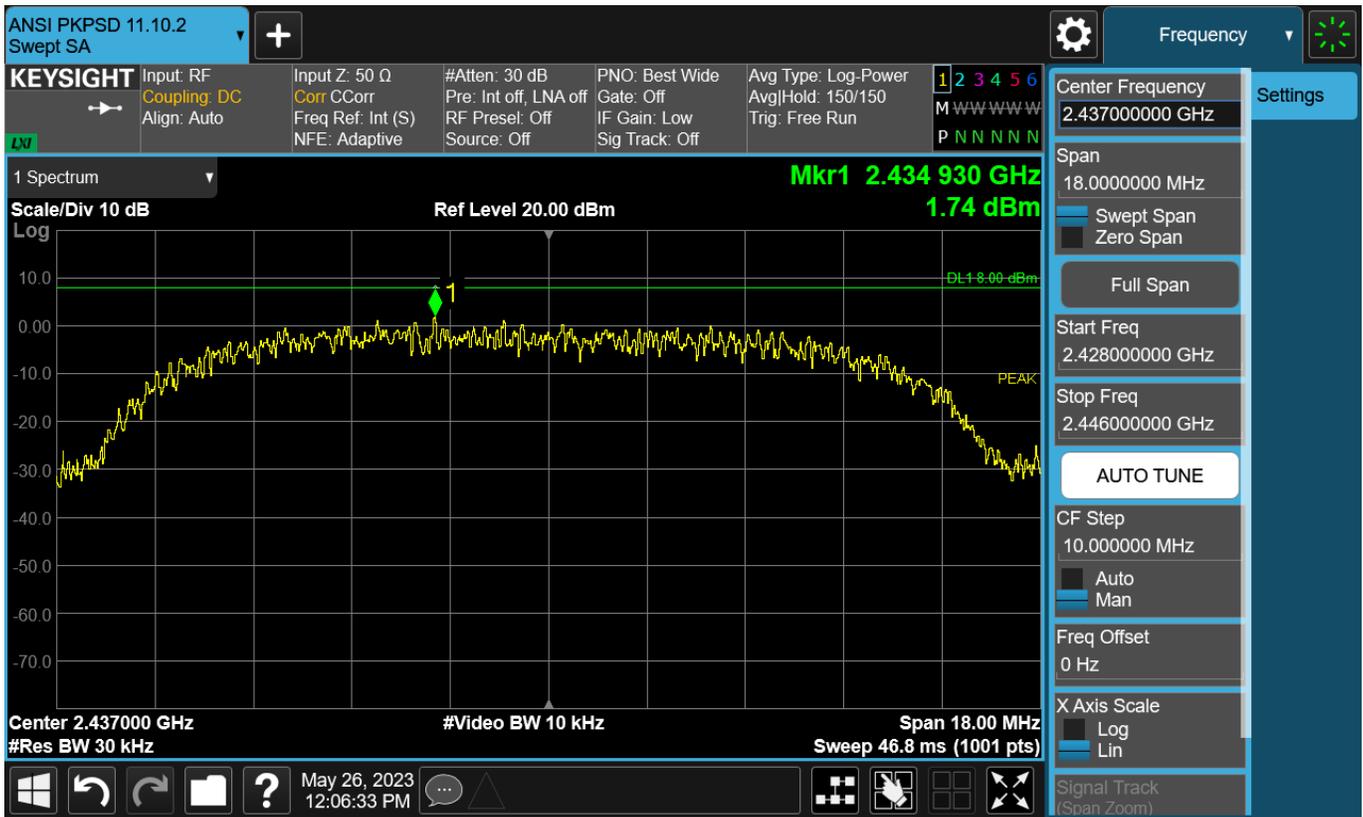


Figure TR06.3: Test data for B11 modulation, channel 6

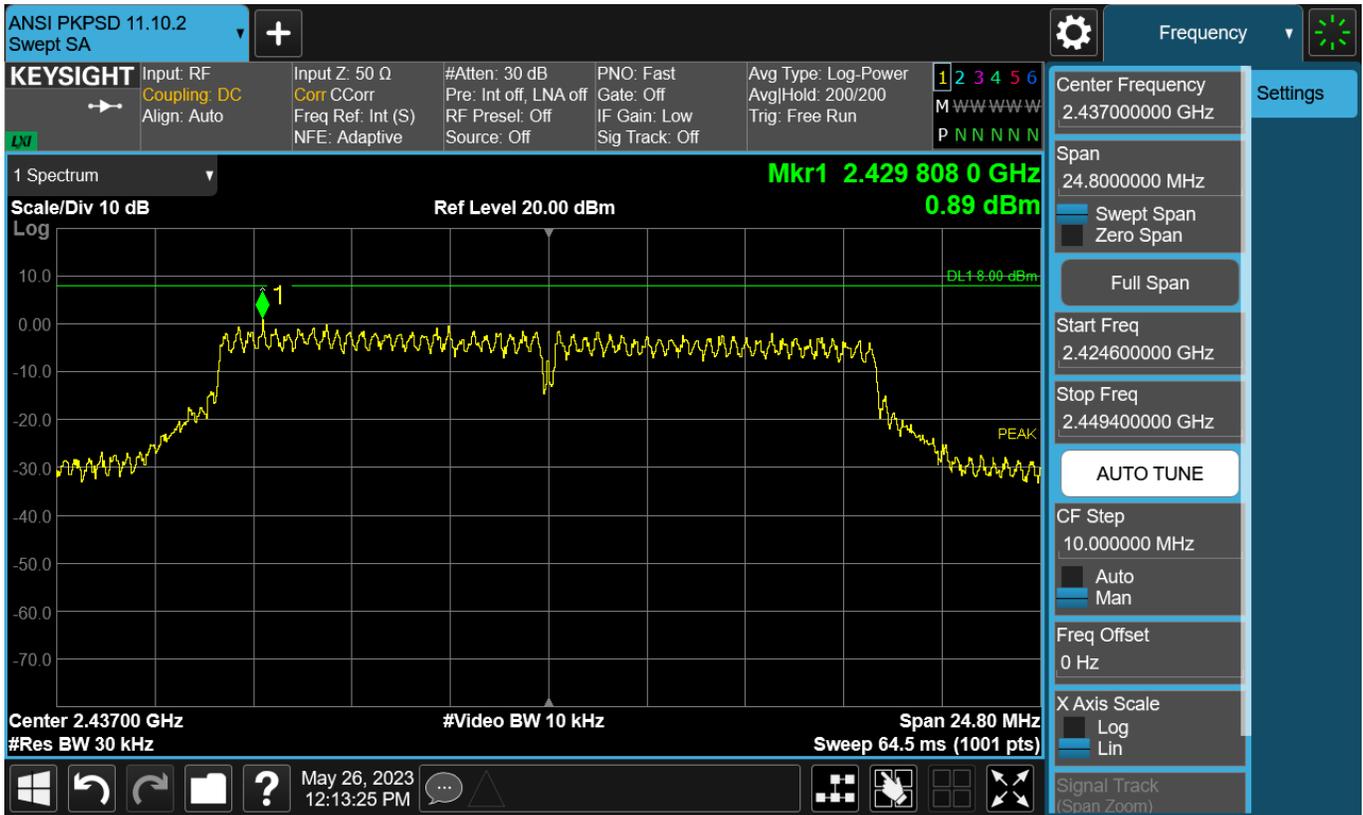


Figure TR06.4: Test data for G48 modulation, channel 6



Figure TR06.5: Test data for N MSC1 modulation, channel 6

This line is the end of the test record.

**Test Record**  
**Transmitter Power Spectral Density**  
**Test IDs TR12, TR14, TR16**  
**Project GCL-0385**

Test Date(s) 26 May 2023  
 Test Personnel David Arnett

Product Model A04724  
 Serial Number tested 441085073

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

Antenna Gain -0.37 dBi, as reported by the client  
 Radio Protocol Bluetooth Classic (Including EDR2 and EDR3), Bluetooth Low Energy (BLE), ANT

**Pass/Fail Judgment: PASS**

**Test record created by: David Arnett**  
**Date of this record: 13 July 2023**

Version A was created on 2 June 2023. Version B was created on 13 July 2023 to remove an unneeded reference to RSS-210.

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024

**Table TR12.1: Test equipment used**

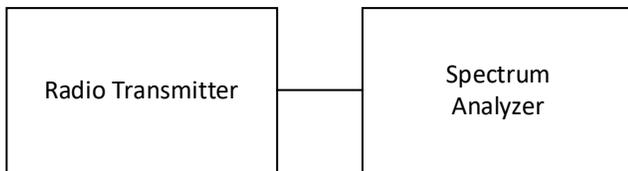
**Software Used:** Keysight PXE software A.33.03

**Test Method**

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

**Test Setup**

This block diagram shows the test equipment setup.



**Figure TR12.1: 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 30 kHz resolution bandwidth.

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

		2402 (04)	2440	2480 (78)
BT	BR	4.44	4.82	5.55
	EDR2	-3.2	-3.7	-2.03
	EDR3	-2.28	-2.98	-1.53
BLE	1 Mb	-9.39	-9.45	-9.36
	2 Mb	-12.18	-12.38	-12.28
ANT		-4.97	-5.09	-4.87

Table TR12.2: Summary of results

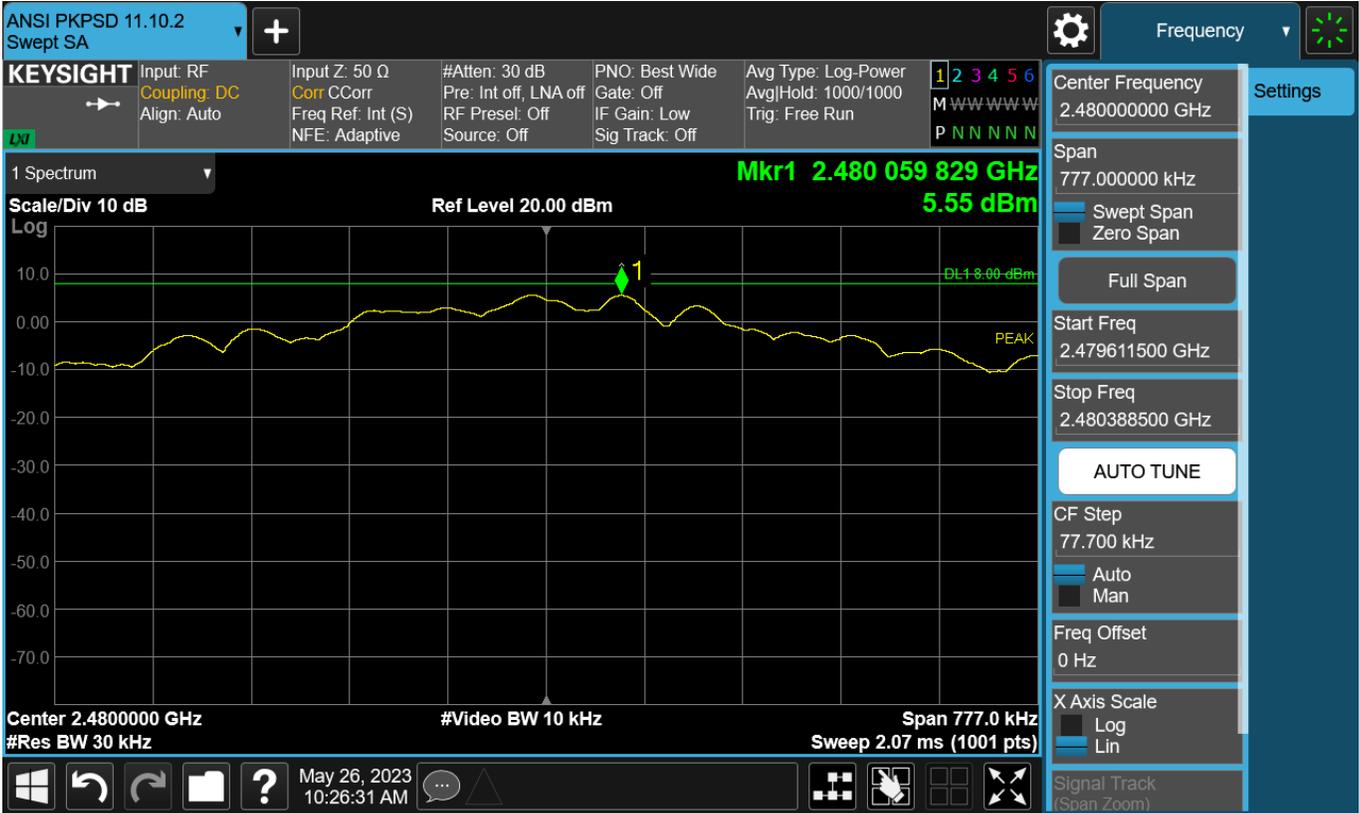


Figure TR12.2: Test data for Bluetooth Basic Rate, 2480 MHz



Figure TR12.3: Test data for Bluetooth Extended Data Rate 2, 2480 MHz



Figure TR12.4: Test data for Bluetooth Extended Data Rate 3, 2480 MHz

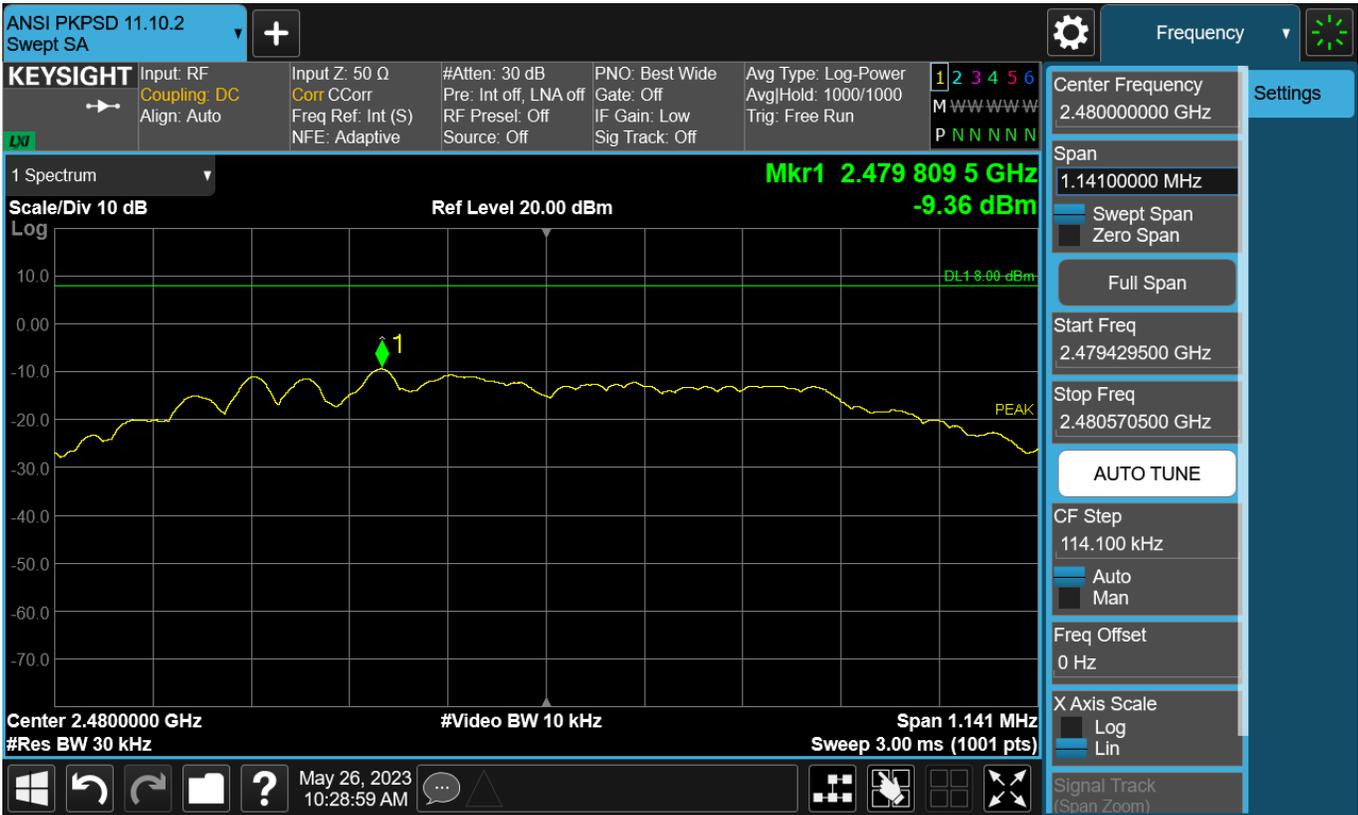


Figure TR12.5: Test data for BLE at 1 Mb/s, 2480 MHz

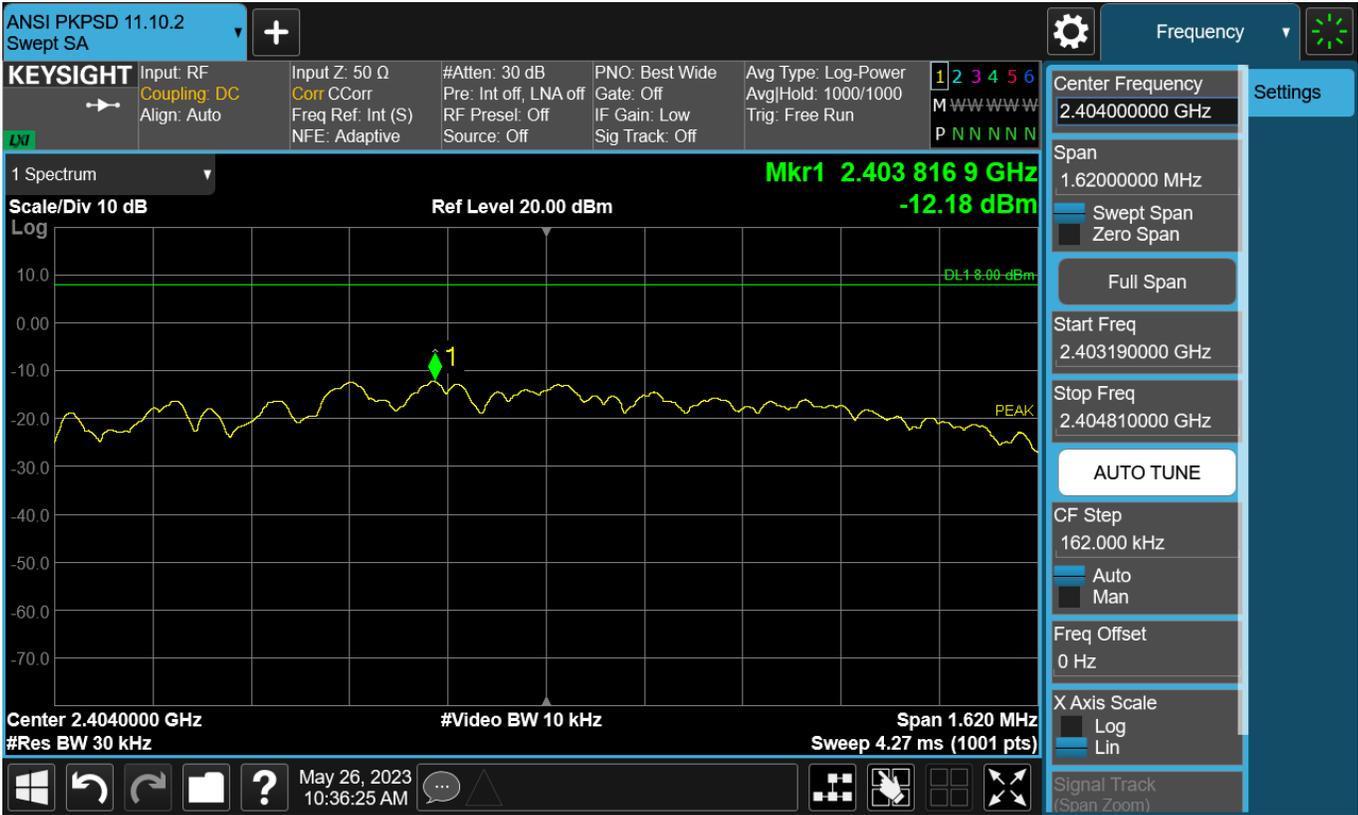


Figure TR12.6: Test data for BLE at 2 Mb/s, 2404 MHz



Figure TR12.7: Test data for ANT, 2480 MHz

This line is the end of the test record.

**Test Record**  
**Transmitter Frequency Stability**  
**Test IDs TR38**  
**Project GCL-0385**

Test Date(s) 7 and 8 Jun 2023  
 Test Personnel Majid Farah  
 Product Model A04724  
 Serial Number tested 441085073

Operating Mode M8 (WifiT)  
 Arrangement A2 (Upwr)  
 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: 13 Jul 2023**

Version A was created on 13 Jun 2023. Version B was created on 13 July 2023 to remove an unneeded reference to RSS-210.

**Test Equipment**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
DMM Multimeter	FLUKE	79 III	71740743	5-Apr-2023	1-Apr-2024
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Thermometer	Thermco	ACCD370P	210607316	11-Aug-2021	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Thermal Chamber	TPS	T2RC	32774-02	Calibration	Not Required
Programmable DC power source	Keithley	2260B-30-72	1411917	21-Apr-2023	15-Apr-2024

**Table TR38.1: Equipment used**

Software Used: PXE Software Revision A.33.03, FrequencyStabilityAnalysisTemplateV1.xlsx

**Test Method**

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

The EUT has a minimum transmission center frequency at 2412 MHz (channel 1) and a maximum at 2472 MHz (channel 13). The temperature stability of the transmissions was observed for channel 1, 11 and 13 of n MCS6 modulations were selected as the worst case to investigate due to their high occupied bandwidth.

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

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

**Test Data**

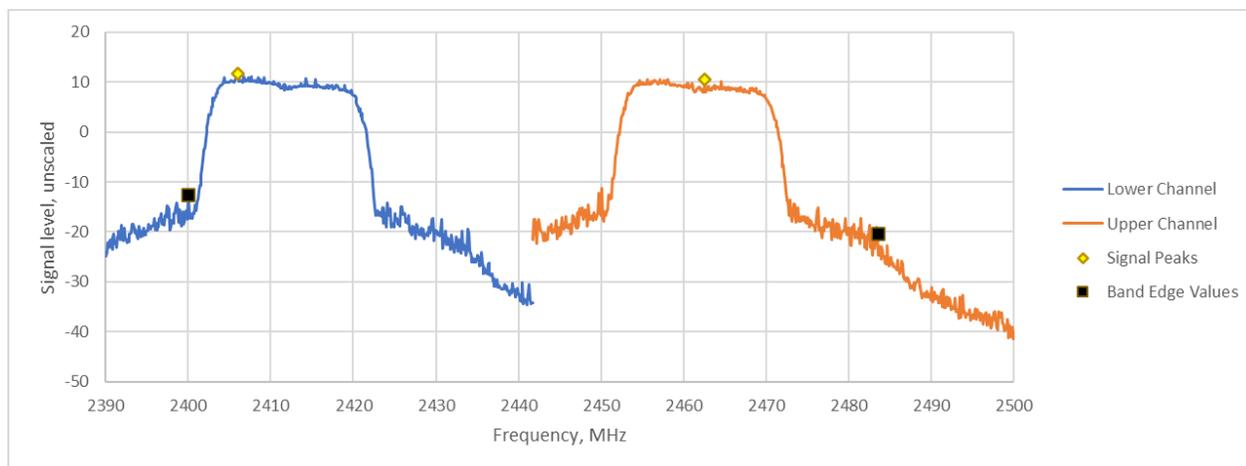
The various standards require observation of the stability for transmission frequency and/or power at certain environmental extremes. The reference is performance on nominal input voltage and a temperature of 20 °C. Where the standards cited here apply to different limits or conditions, the most stringent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

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

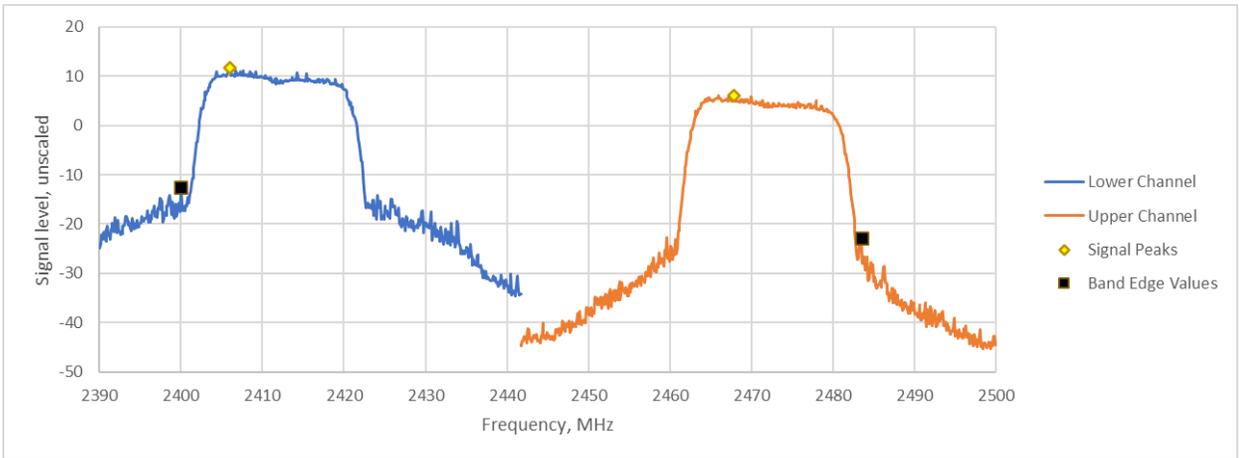
Yellow highlights indicate the highest level for a protocol, for which an image of the spectrum is also provided. In the spectral plots, the data sets have been combined to present the low and high channel results side by side. Orange diamond markers indicate the spectral peak, which the black square 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 MCS6	50	5	26.4	37.3	33.1
N MCS6	40	5	27.1	34.8	28.3
N MCS6	30	5	27.1	35.8	31.8
N MCS6	20	5	26.5	35.0	34.5
N MCS6	10	5	24.2	31.0	28.9
N MCS6	0	5	24.4	34.2	35.5
N MCS6	-10	5	26.5	32.3	29.0
N MCS6	-20	5	26.0	33.6	29.0

**Table TR38.2 Difference between peak and band edge levels for IEEE 802.11 n MCS6 transmissions during temperature variations**



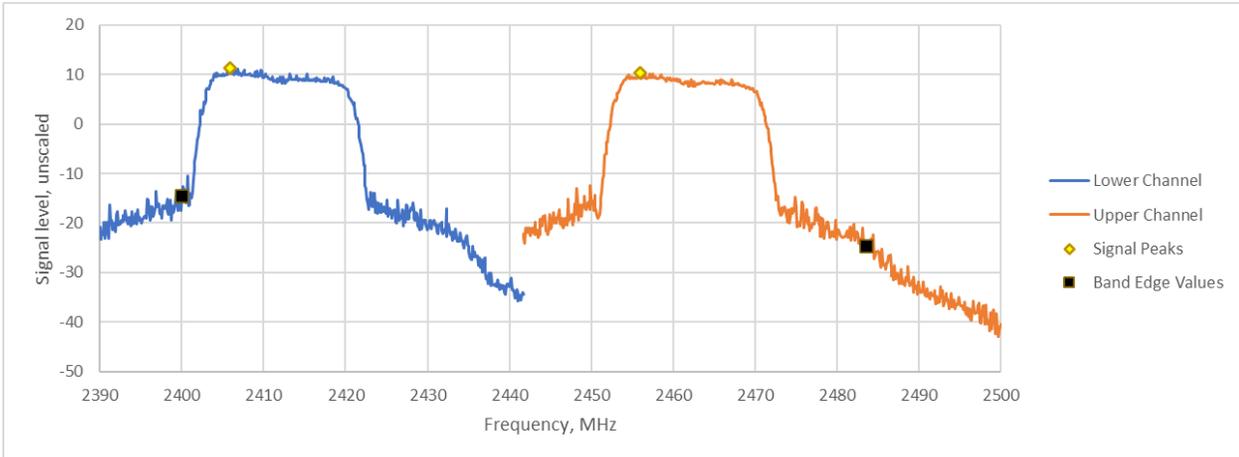
**Figure TR38.1: Spectral data for IEEE 802.11 n MCS6 at 10 °C which represent Ch1 and Ch11**



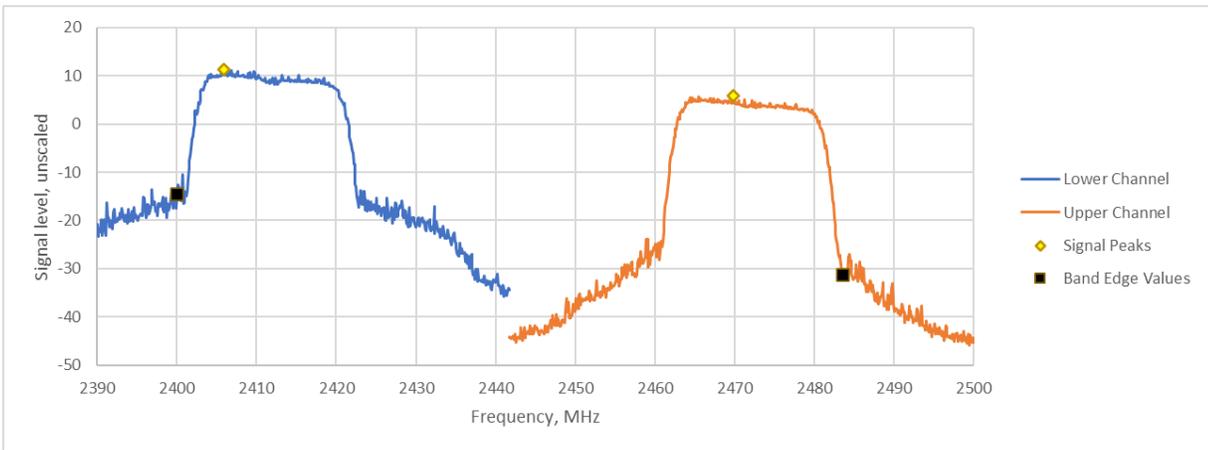
**Figure TR38.2: Spectral data for IEEE 802.11 n MCS6 at 10 °C which represent Ch1 and Ch13**

Tx Mode	Temp	Volts	Ch. 1	Ch. 11	Ch. 13
WiFi	°C	Vdc	dBc	dBc	dBc
N MCS6	20	4.25	26.3	34.8	38.1
N MCS6	20	5	26.5	35.0	34.5
N MCS6	20	5.75	25.9	35.0	37.1

**Table TR38.3 Difference between peak and band edge levels for IEEE 802.11 n MCS6 transmissions at 20 °C during voltage variations**



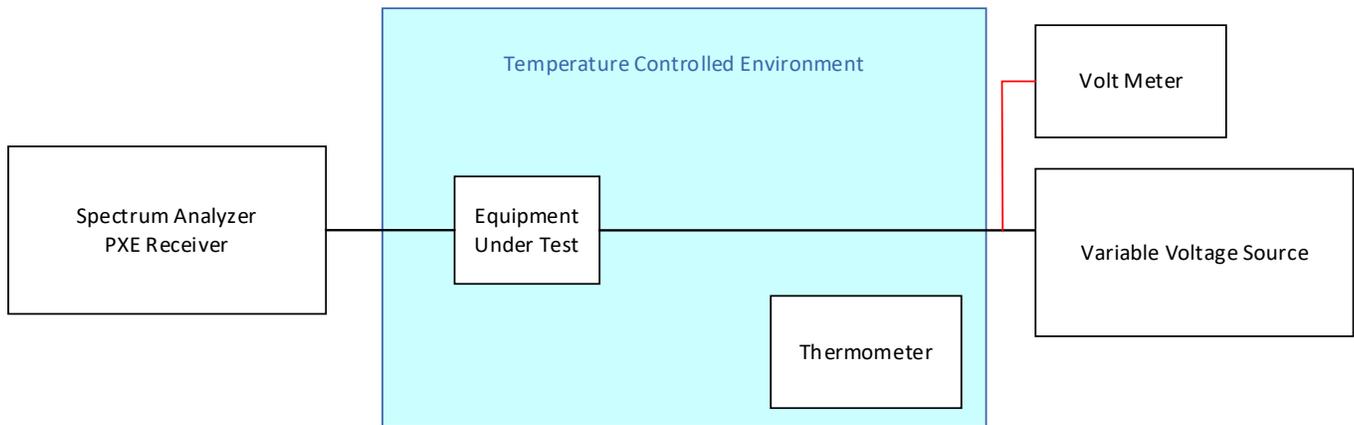
**Figure TR38.3: Spectral data for IEEE 802.11 n MCS6 Mbps at 20 °C and 5.75 Vdc which represent Ch1 and Ch11**



**Figure TR38.4: Spectral data for IEEE 802.11 n MCS6 Mbps at 20 °C and 5.75 Vdc which represent Ch1 and Ch13**

**Setup Block Diagram**

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



**Figure TR38.5: Schematic drawing of the test equipment setup for WiFi (IEEE 802.11 b/g/n)**

This line is the end of the test record.

**Test Record**  
**Transmitter Frequency Stability**  
**Test IDs TR39 and TR40**  
**Project GCL-0385**

Test Date(s) 7 and 8 Jun 2023  
 Test Personnel Majid Farah  
 Product Model A04724  
 Serial Number tested 441085073

Operating Mode M1 (BleT) and M10 (BtcT)  
 Arrangement A2 (Upwr)  
 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 and EDR3), BLE (Bluetooth Low Energy), ANT

**Pass/Fail Judgment: PASS**

**Test record created by: Majid Farah**  
**Date this record: 13 Jul 2023**

Version A was created on 13 Jun 2023. Version B was created on 13 July 2023 to remove an unneeded reference to RSS-210.

**Test Equipment**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
DMM Multimeter	FLUKE	79 III	71740743	5-Apr-2023	1-Apr-2024
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Thermometer	Thermco	ACCD370P	210607316	11-Aug-2021	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Thermal Chamber	TPS	T2RC	32774-02	Calibration	Not Required
Programmable DC power source	Keithley	2260B-30-72	1411917	21-Apr-2023	15-Apr-2024

**Table TR39.1: Equipment used**

Software Used: PXE Software Revision A.33.03, FrequencyStabilityAnalysisTemplateV1.xlsx

**Test Method**

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

Bluetooth, BLE and ANT use channel plans with a minimum transmission center frequency at 2402 MHz and a maximum at 2480 MHz. Bluetooth EDR3 and BLE1 were selected as the worst case among radios to investigate, due to its higher occupied bandwidth. Additional information regarding Bluetooth, BLE and ANT technologies is provided in the following table.



	First Channel	Last Channel	Channel spacing	Data rate
	MHz	MHz	MHz	Mb/s
Bluetooth BR	2402	2480	1	1
Bluetooth EDR2	2402	2480	1	2
Bluetooth EDR3	2402	2480	1	3
BLE1	2402	2480	2	1
BLE2	2404	2478	2	2
ANT	2402	2402	1	60 Kb/s

**Table TR39.2 Bluetooth, BLE and ANT overview**

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

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

### Test Data

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

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

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

Tx Mode	Temp	Volts	Low Ch.	High Ch.
Bluetooth	°C	Vdc	dBc	dBc
BT EDR3	50	5	23.4	37.6
BT EDR3	40	5	22.9	36.8
BT EDR3	30	5	22.1	37.3
BT EDR3	20	5	24.8	37.0
BT EDR3	10	5	26.0	36.3
BT EDR3	0	5	23.7	37.1
BT EDR3	-10	5	22.7	36.7
BT EDR3	-20	5	23.0	37.9

**Table TR39.3 Difference between peak and band edge levels for Bluetooth EDR3 transmissions during temperature variations**

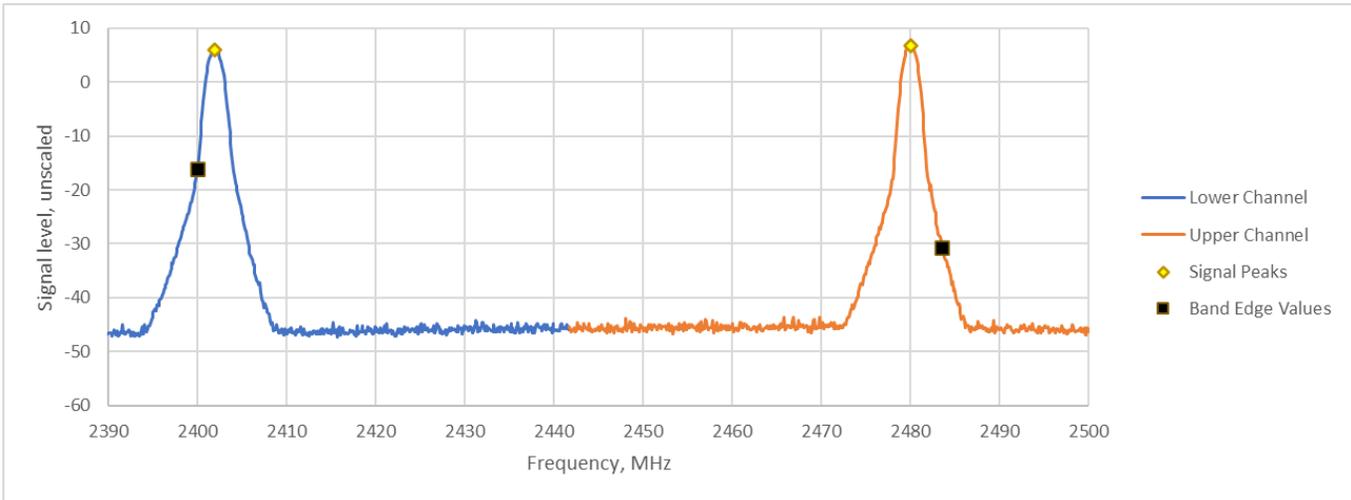


Figure TR39.1: Spectral data for Bluetooth EDR3 at 30 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
Bluetooth	°C	Vdc	dBc	dBc
BT EDR3	20	4.25	24.3	37.4
BT EDR3	20	5	24.8	37.0
BT EDR3	20	5.75	25.7	36.9

Table TR39.4 Difference between peak and band edge levels for Bluetooth EDR3 transmissions at 20 °C during voltage variations

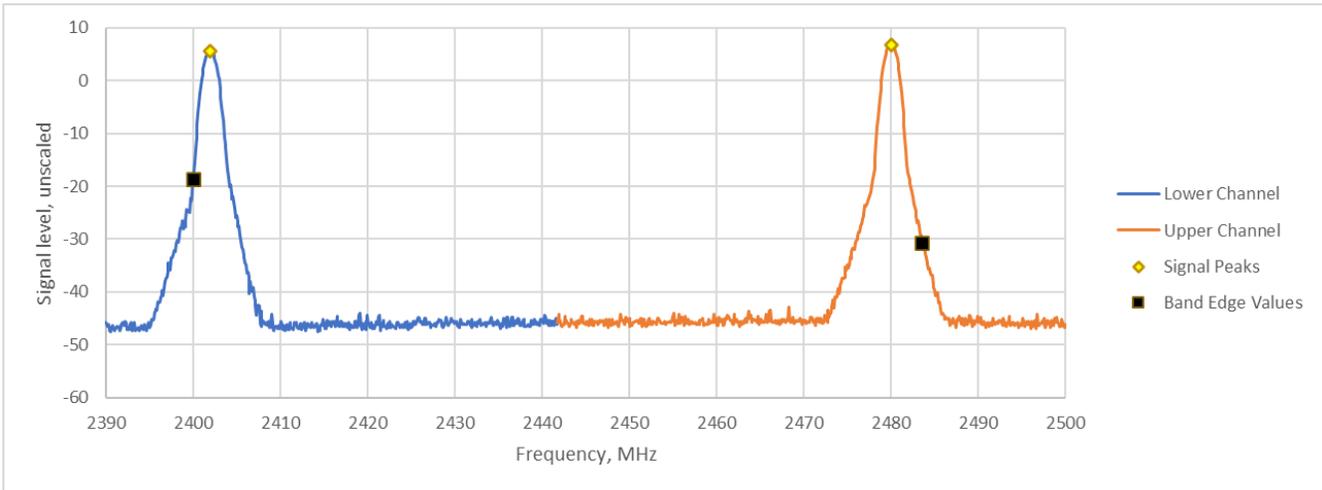


Figure TR39.2: Spectral data for Bluetooth EDR3 at 20 °C and 4.25 Vdc

Tx Mode	Temp	Volts	Low Ch.	High Ch.
Bluetooth	°C	Vdc	dBc	dBc
BLE 1 Mbps	50	5	29.9	42.3
BLE 1 Mbps	40	5	30.9	41.5
BLE 1 Mbps	30	5	30.3	41.6
BLE 1 Mbps	20	5	30.8	42.1
BLE 1 Mbps	10	5	30.7	43.0
BLE 1 Mbps	0	5	30.6	42.4
BLE 1 Mbps	-10	5	30.2	43.5
BLE 1 Mbps	-20	5	30.4	42.3

Table TR39.5 Difference between peak and band edge levels for BLE 1 Mbps transmissions during temperature variations

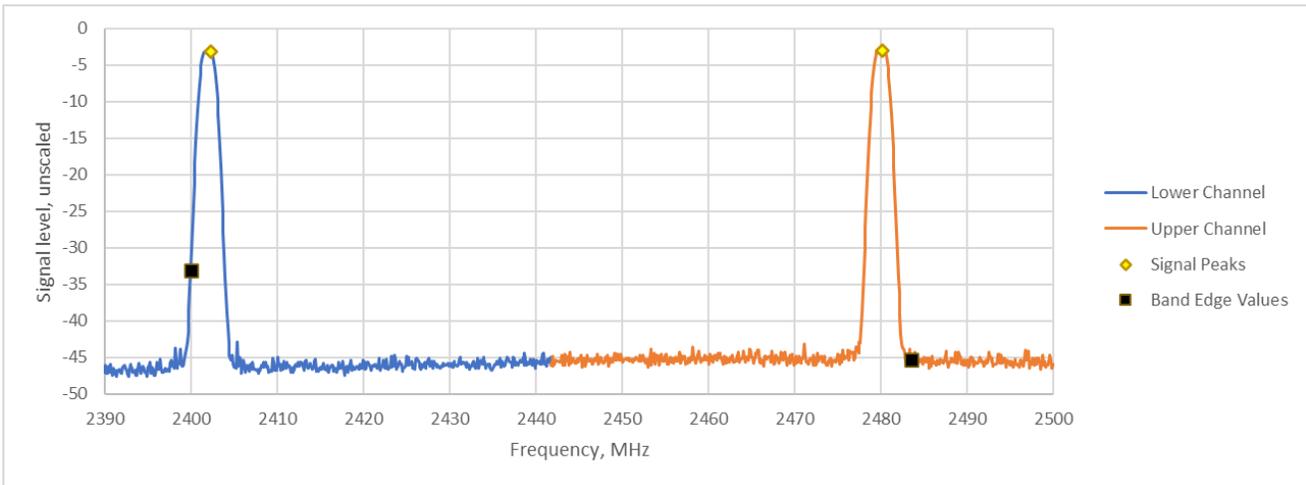
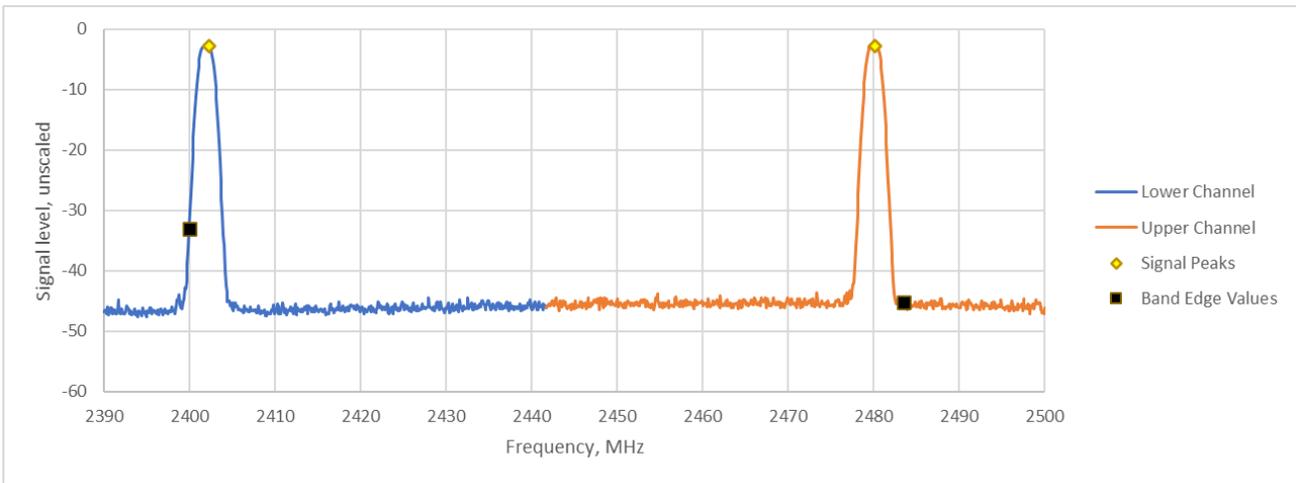


Figure TR39.3: Spectral data for BLE 1 Mbps at 50 °C

Tx Mode	Temp	Volts	Low Ch.	High Ch.
Bluetooth	°C	Vdc	dBc	dBc
BLE 1 Mbps	20	4.25	30.2	42.4
BLE 1 Mbps	20	5	30.8	42.1
BLE 1 Mbps	20	5.75	30.8	42.4

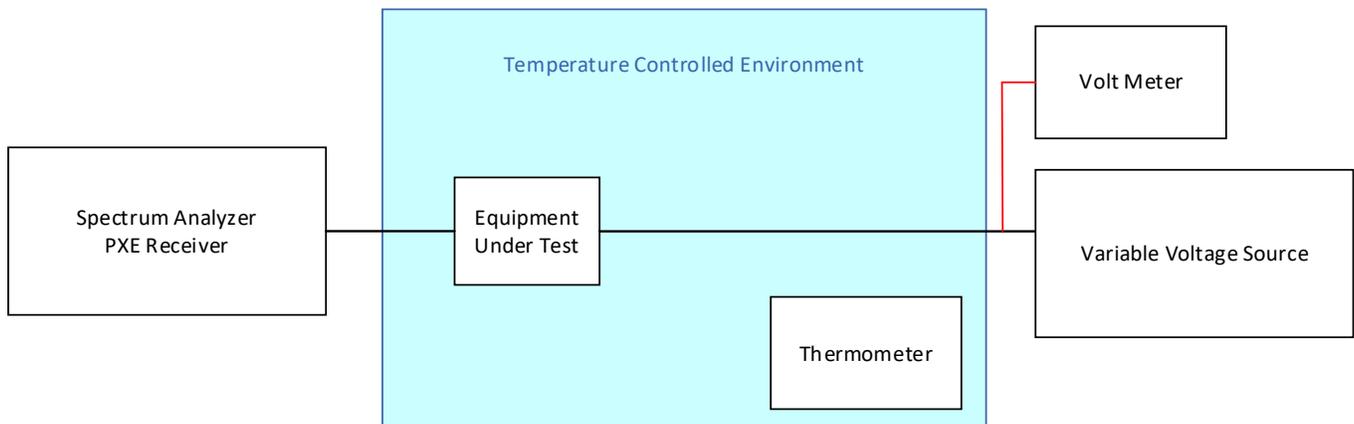
Table TR39.6 Difference between peak and band edge levels for BLE 1 Mbps transmissions at 20 °C during voltage variations



**Figure TR39.4: Spectral data for BLE 1 Mbps at 20 °C and 4.25 Vdc**

**Setup Block Diagram**

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



**Figure TR39.5: Schematic drawing of the test equipment setup for Bluetooth, BLE and ANT**

This line is the end of the test record.

**Test Record**  
**Conducted Emissions Mains Test CE01**  
**Project GCL0385**

Test Date(s) 06 Jun 2023  
 Test Personnel David Kerr

Product Model A04724  
 Serial Number tested 441084880

Operating Mode M8 (WifiT)  
 Arrangement A2 (Upwr)  
 Input Power 115 Vac 60 Hz

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

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

**Test record created by: Ryan Townsend**  
**Date of this record: 15 Jun 2023**  
 Original record, Version A.

**Table CE01.1: Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
DMM Multimeter	FLUKE	79 III	71740743	18-Apr-2022	1-Apr-2023
Power Source	Elgar	1001B-167	1618	Calibration	Not Required
LISN multiline; 20A 50uH	Com-Power	LIN-120C	20160005	22-Aug-2022	15-Aug-2023

**Software Used**

Keysight PXE software A.32.06  
 CE Mains 150k to 30M Data Analysis.xlsx

**Test Data**

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

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

Frequency	QP Limit	AV Limit	L1 QP	L2 QP	L1 AV	L2 AV	QP Margin	AV Margin
(kHz)	(dBuV)	(dBuV)	(dBuV)	(dBuV)	(dBuV)	(dBuV)	(dB)	(dB)
150	66.00	56.00	47.30	55.34	25.81	27.78	10.66	28.22
175	64.73	54.73	52.41	55.07	28.81	29.23	9.66	25.50
200	63.63	53.63	44.52	48.89	30.45	29.70	14.75	23.18
200	63.63	53.63	46.95	46.87	30.61	29.82	16.68	23.02
224	62.66	52.66	45.23	43.70	26.72	25.49	17.43	25.94
299	60.28	50.28	39.08	42.70	25.24	23.64	17.58	25.04
323	59.62	49.62	41.03	40.97	26.96	23.77	18.59	22.66
353	58.90	48.9	38.77	36.44	25.03	24.3	20.13	23.87
713	56.00	46.00	31.15	30.68	26.45	26.39	24.85	19.55
1424	56.00	46.00	27.49	27.33	23.11	22.63	28.51	22.89

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.

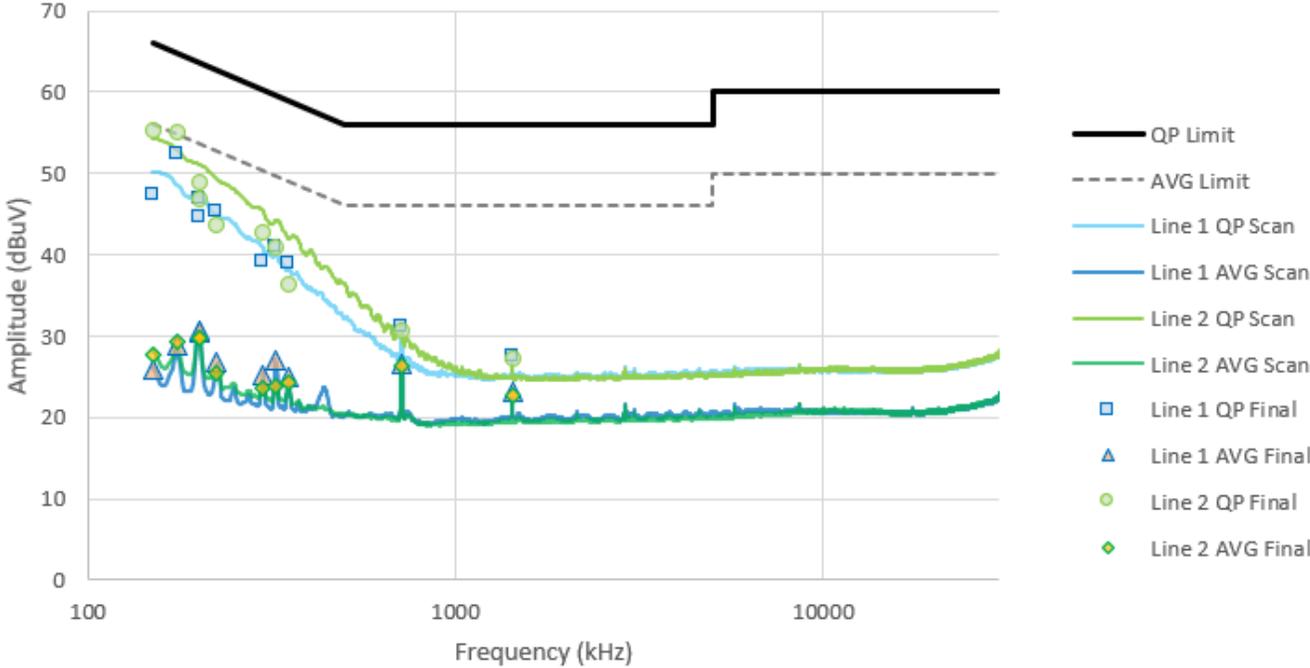
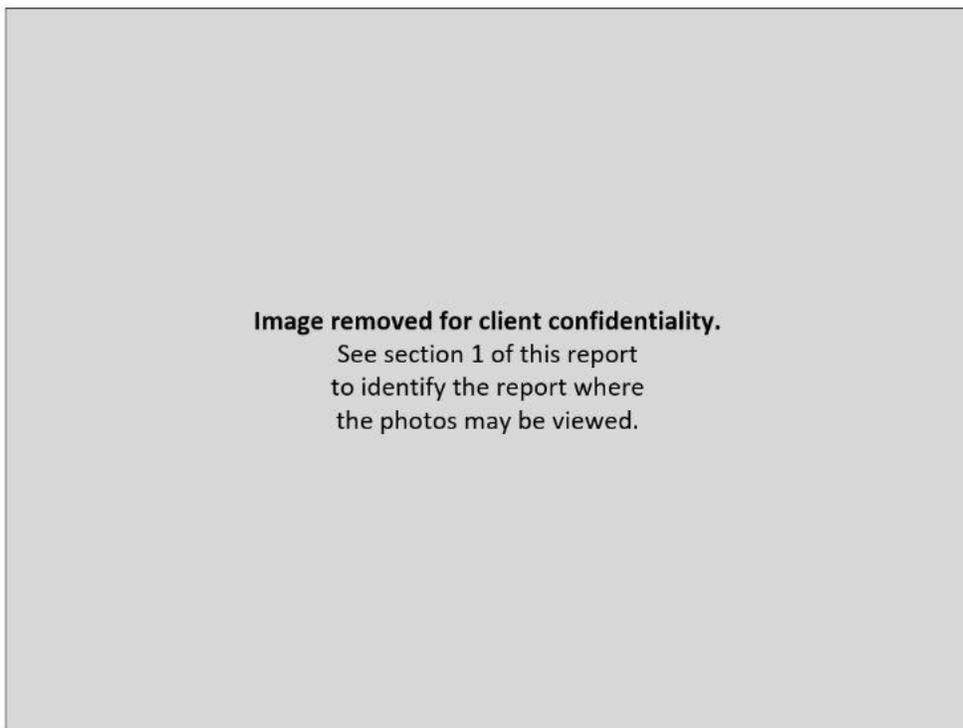


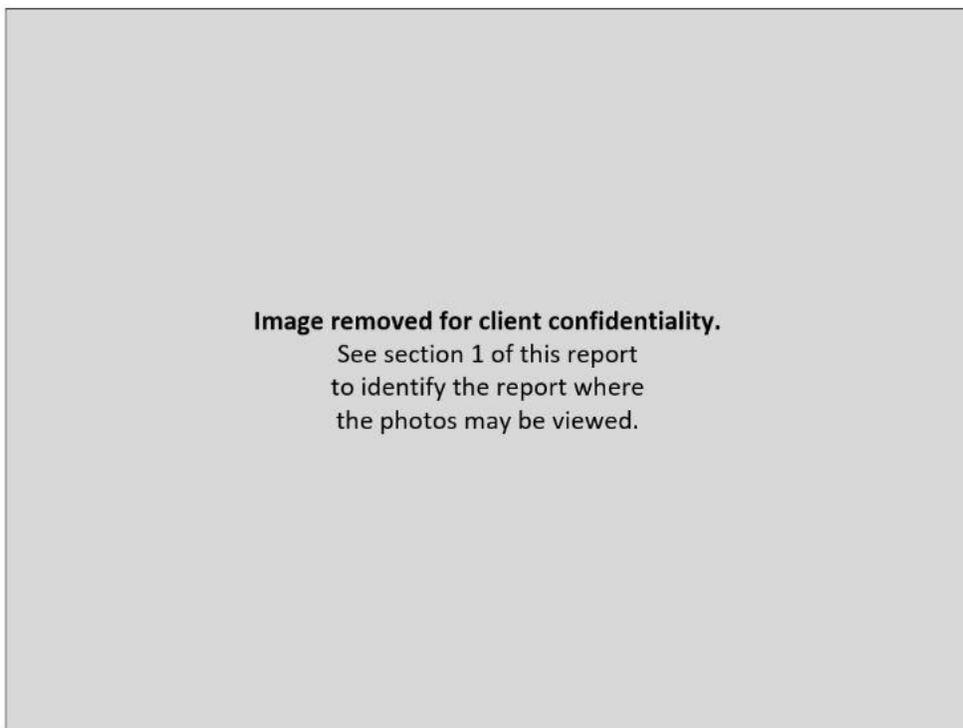
Figure CE01.1: Spectral data

### Setup Photographs

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



**Figure CE01.2: EUT test setup**



**Figure CE01.3: EUT test setup cont.**

This line is the end of the test record.

**Test Record**  
**Radiated Emission Test RE13**  
**Project GCL0385**

Test Date(s) 01 Jun 2023  
 Test Personnel David Kerr

Product Model A04724  
 Serial Number tested 441084880

Operating Mode M8 (WifiT)  
 Arrangement A2 (Upwr)  
 Input Power 5 Vdc  
 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: Ryan Townsend**  
**Date of this record: 13 Jun 2023**

Original record, Version A.

**Test Equipment**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CM	10720	16-Jan-2023	15-Jan-2026
Antenna, Bicon, 30 - 300 MHz	Schwarzbeck	VHBB9124	01434	2-Sep-2021	1-Sep-2023

**Table RE13.1: Test Equipment Used**

**Software Used:**

Keysight PXE software A.32.06  
 RE Signal Maximization Tool v2021Feb25.xlsx  
 RE 30M to 1G Data AnalysisV1 2022May10.xlsx

**Test Data**

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

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

The tables show 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 (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.000	40.00	27.50	12.50	160.00	3979.00	HORZ
187.470	43.50	21.20	22.30	59.00	2524.00	HORZ
469.710	46.00	25.70	20.30	-147.00	1497.00	VERT
549.990	46.00	28.20	17.80	-127.00	1137.00	VERT
580.020	46.00	27.20	18.80	35.00	1677.00	VERT
945.270	46.00	32.60	13.40	-3.00	3495.00	HORZ

Table RE13.2: Emission summary (B5.5 CH 1)

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
160.560	43.50	19.70	23.80	151.00	3858.00	VERT
188.430	43.50	23.50	20.00	-130.00	1742.00	HORZ
399.990	46.00	24.40	21.60	-180.00	3883.00	HORZ
589.980	46.00	26.90	19.10	-197.00	4000.00	VERT
809.910	46.00	31.20	14.80	-188.00	1497.00	HORZ
937.320	46.00	32.40	13.60	-42.00	1140.00	HORZ

Table RE13.3: Emission summary (B5.5 CH 6)

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
160.530	43.50	19.60	23.90	-28.00	4000.00	VERT
187.620	43.50	23.50	20.00	-107.00	1853.00	HORZ
541.800	46.00	28.30	17.70	-123.00	3399.00	HORZ
580.020	46.00	27.30	18.70	-200.00	1813.00	VERT
804.090	46.00	32.00	14.00	-124.00	3439.00	HORZ
945.210	46.00	33.20	12.80	-63.00	1397.00	VERT

Table RE13.4: Emission summary (B5.5 CH 11)

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
151.830	43.50	20.60	22.90	111.00	1987.00	HORZ
202.710	43.50	22.20	21.30	-114.00	1087.00	HORZ
399.990	46.00	24.30	21.70	-150.00	2639.00	HORZ
541.590	46.00	27.80	18.20	-142.00	2086.00	HORZ
806.550	46.00	30.50	15.50	-114.00	1611.00	HORZ
944.820	46.00	33.00	13.00	159.00	2040.00	HORZ

Table RE13.5: Emission summary (B5.5 CH 13)

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

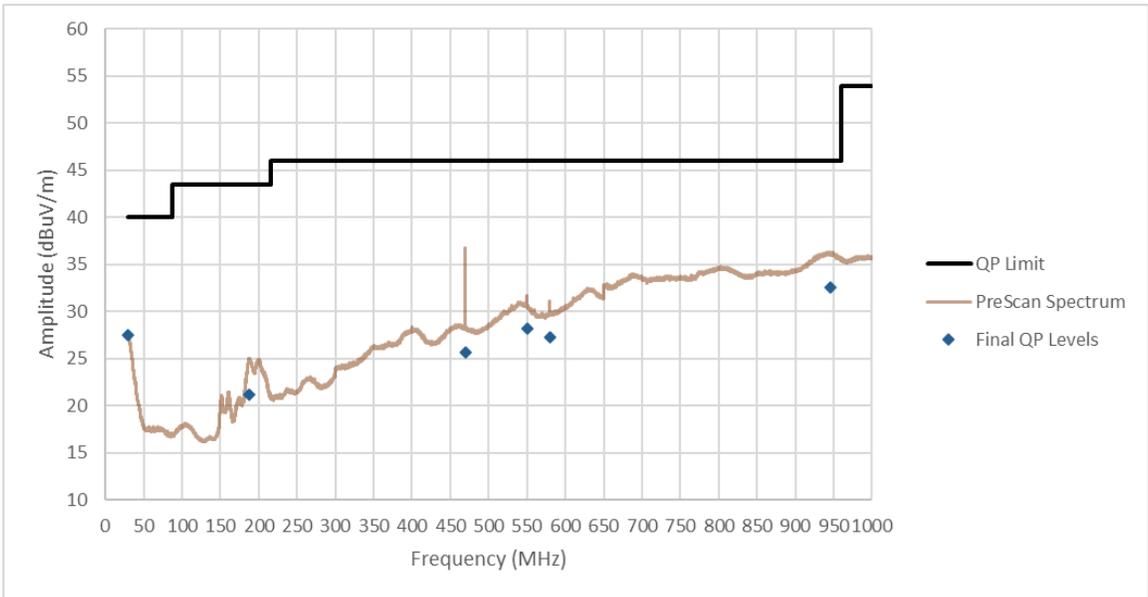


Figure RE13.1: Spectral data (B5.5 CH1)

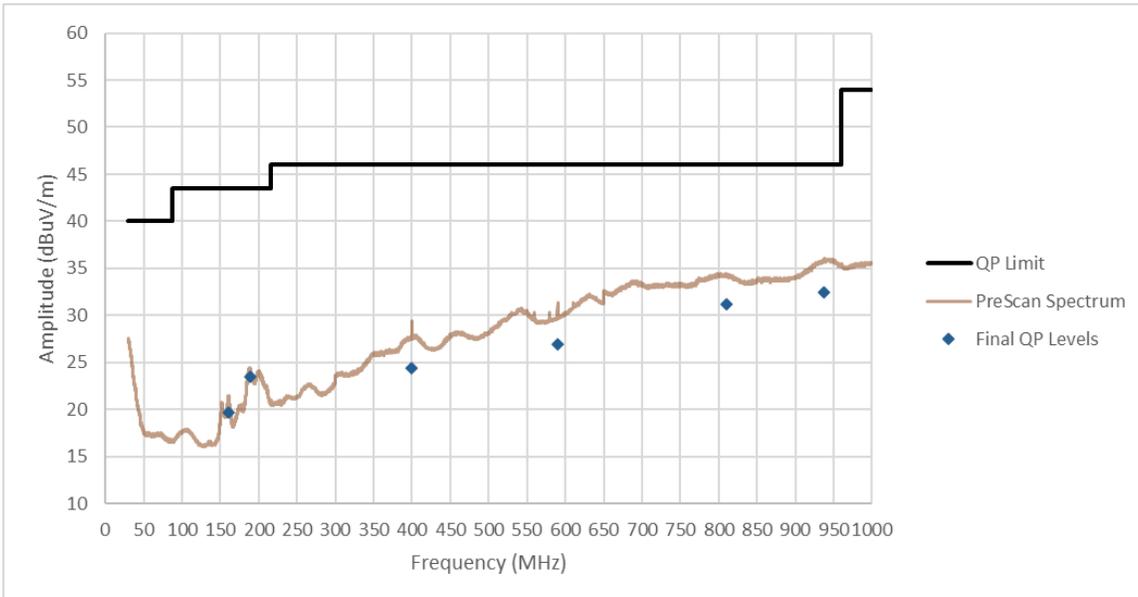


Figure RE13.2: Spectral data (B5.5 CH6)

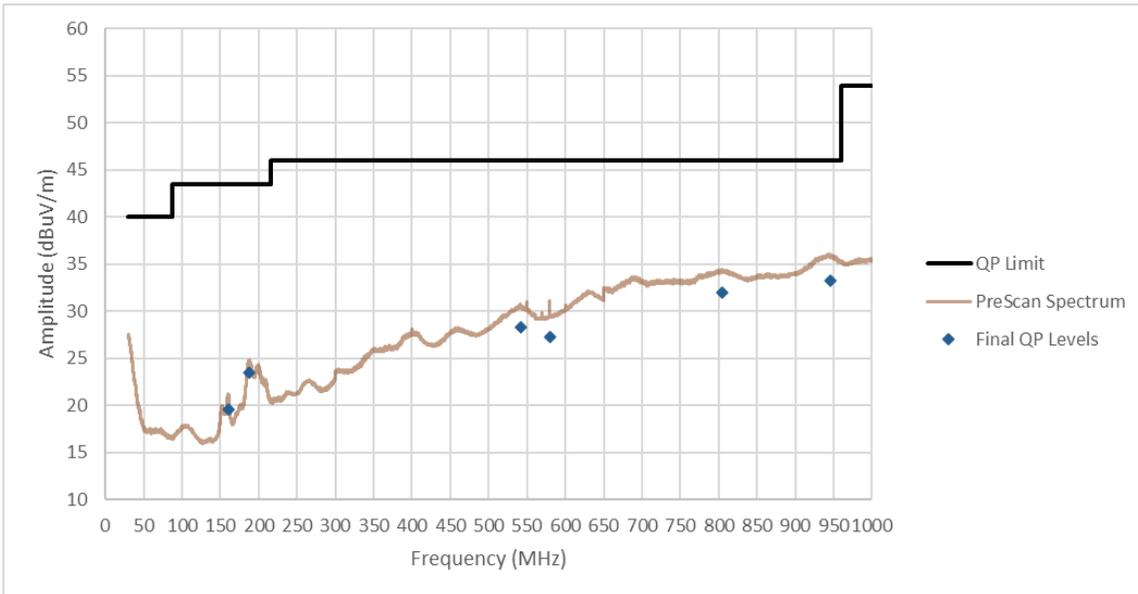
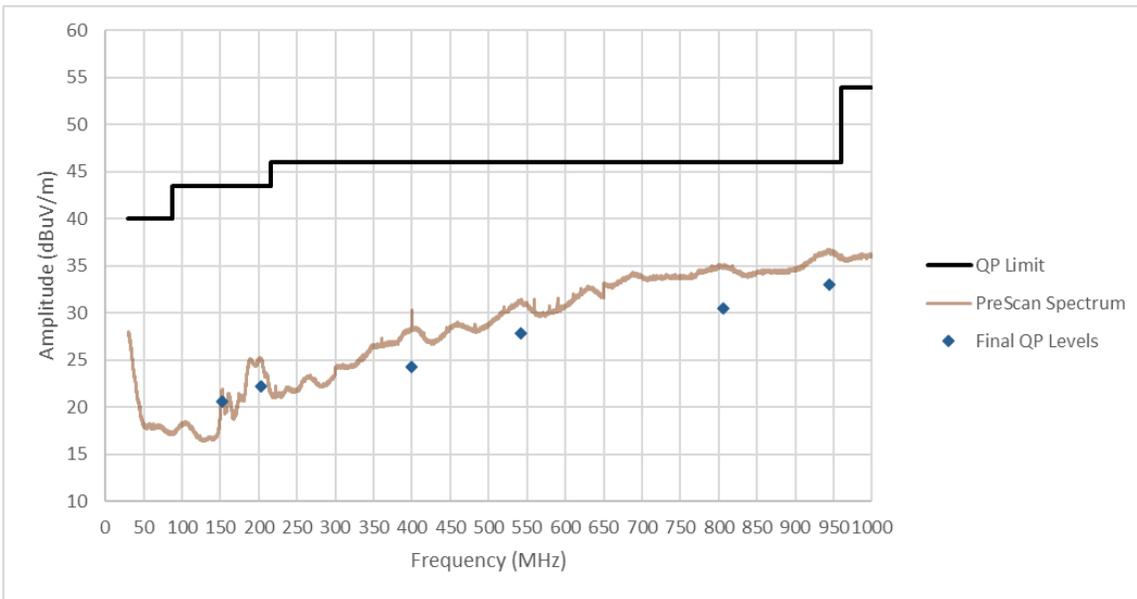


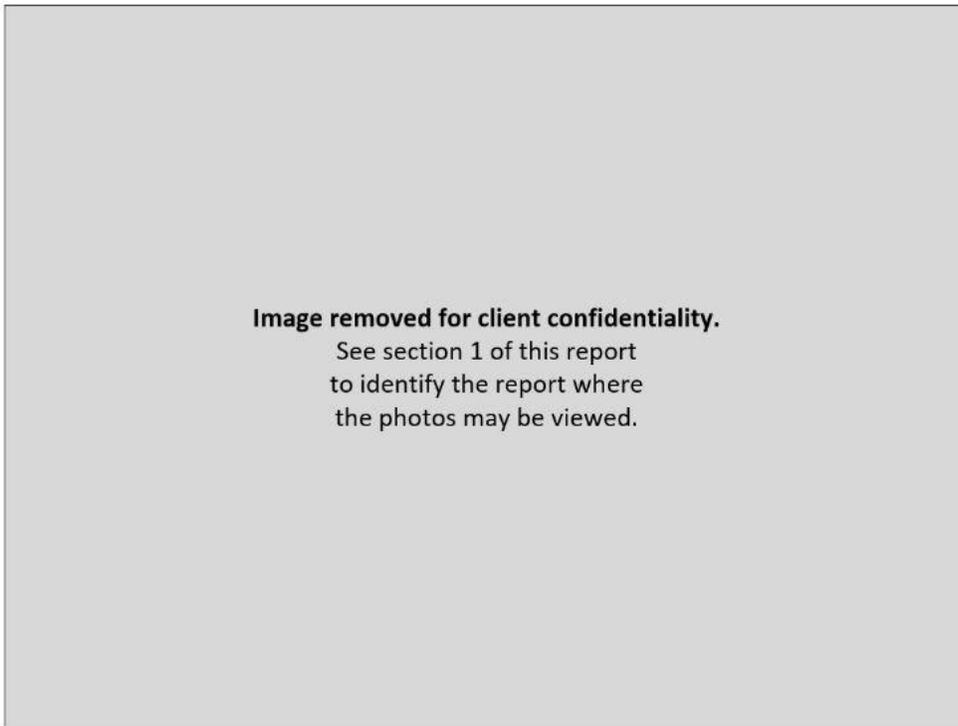
Figure RE13.3: Spectral data (B5.5 CH11)



**Figure RE13.4: Spectral data (B5.5 CH13)**

**Setup Photographs**

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



**Figure RE13.5: EUT test setup, front view**



**Figure RE13.6: EUT test setup, reverse view**

**This line is the end of the test record.**

**Test Record**  
**Radiated Emission Test RE10**  
**Project GCL385**

Test Date(s) 25 May 2023  
 Test Personnel David Kerr

Product Model A04724  
 Serial Number tested 441084880

Operating Mode M8 (WiFi Tx)  
 Arrangement A2 (Upwr)  
 Input Power 5 Vdc

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

Frequency Range: 1 GHz to 2 GHz  
**Pass/Fail Judgment: PASS**

**Test record created by: Jim Solum**  
**Date of this record: 13 Jun 2023**

Original record, Version A.

**Test Equipment**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Antenna, Horn, 1-18 GHz	ETS Lindgren	3117	00227596	27-Aug-2021	1-Sep-2023
FSOATS 3m, above 1 GHz	Frankonia	SAC3	F199004	16-Nov-2022	16-Nov-2025
Preamplifier, 500 MHz 18 GHz	Com-Power	PAM-118A	18040133	Calibration	Not Required
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023

**Table RE10.1: Test Equipment Used**

**Software Used:**

Keysight PXE software A.32.06  
 RE Signal Maximization Tool v2021Feb25.xlsx  
 RE 1G to 18G Data AnalysisV1 2022May10.xlsx

**Test Data**

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

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

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

The tables show the selected final measurement data between 1 GHz and 2 GHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
1928.000	50.0	70.0	31.2	44.7	18.8	25.3	0	1000	*
1995.500	50.0	70.0	31.9	45.7	18.1	24.3	0	1000	*
2018.500	50.0	70.0	32.0	45.4	18.0	24.6	0	1000	*
2170.750	50.0	70.0	37.8	47.9	12.2	22.1	174	1751	HORZ
2176.000	50.0	70.0	33.2	46.8	16.8	23.2	-181	2242	HORZ
2200.000	50.0	70.0	32.0	45.6	18.0	24.4	0	1000	*

Table RE10.2: Emission summary (B5.5 CH 1)

Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
1980.750	50.0	70.0	31.8	45.6	18.2	24.4	149	3030	VERT
2049.750	50.0	70.0	31.8	45.1	18.2	24.9	-147	2288	VERT
2057.750	50.0	70.0	31.8	45.4	18.2	24.6	-106	2394	VERT
2083.500	50.0	70.0	31.6	45.3	18.4	24.7	-80	3839	HORZ
2193.500	50.0	70.0	31.6	45.4	18.4	24.6	88	3899	VERT
2198.000	50.0	70.0	31.7	45.7	18.3	24.3	-109	3883	HORZ

Table RE10.3: Emission summary (B5.5 CH 6)

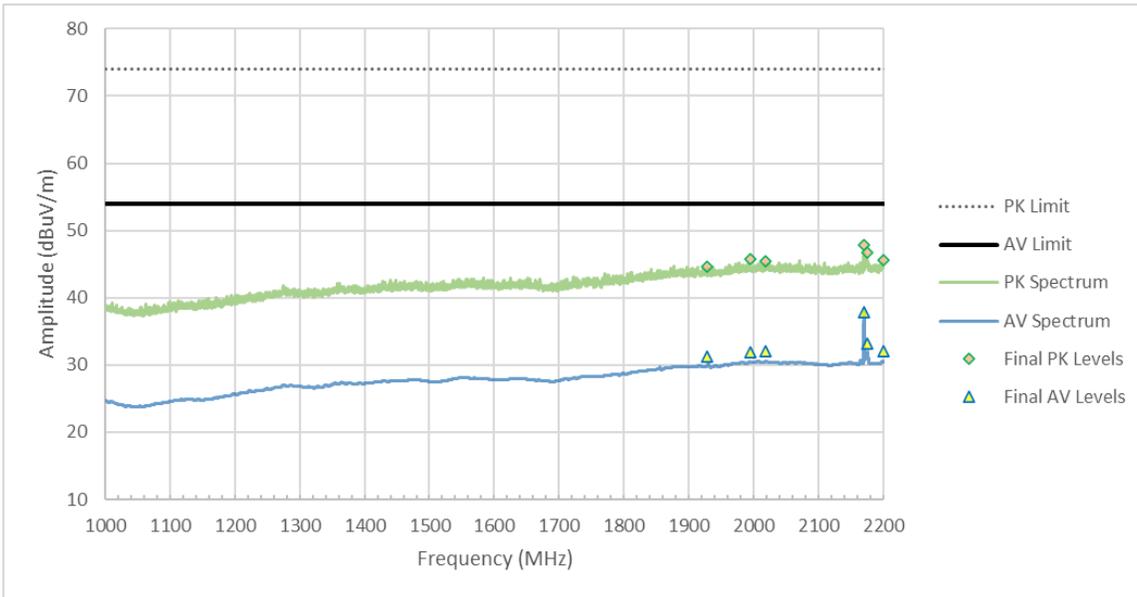
Frequency (MHz)	Avg Limit (dBuV/m)	Pk Limit (dBuV/m)	Avg Level (dBuV/m)	Pk Level (dBuV/m)	Av Margin (dB)	Pk Margin (dB)	Azimuth (degree)	Height (mm)	Polarity ---
2002.750	54.0	74.0	32.2	46.1	21.8	27.9	80	3291	HORZ
2008.500	54.0	74.0	32.3	45.7	21.7	28.3	0	3291	*
2019.500	54.0	74.0	32.3	46.1	21.7	27.9	0	3291	*
2057.000	54.0	74.0	32.1	46.0	21.9	28.0	0	3291	*
2066.250	54.0	74.0	32.0	45.7	22.0	28.3	0	3291	*
2158.000	54.0	74.0	31.9	45.1	22.1	28.9	0	3291	*

Table RE10.4: Emission summary (B5.5 CH 11)

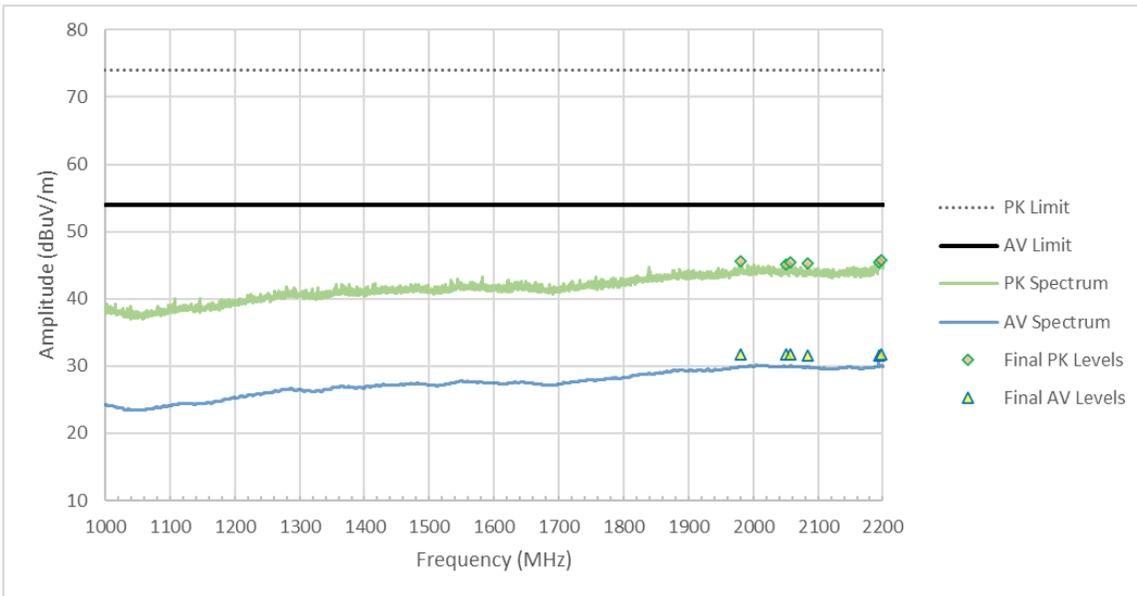
Frequency	Avg Limit	Pk Limit	Avg Level	Pk Level	Av Margin	Pk Margin	Azimuth	Height	Polarity
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(degree)	(mm)	---
1968.500	54.0	74.0	32.0	45.8	22.0	28.2	21	3530	*
1973.000	54.0	74.0	31.9	45.7	22.1	28.3	21	3530	*
2016.750	54.0	74.0	32.2	45.9	21.8	28.1	21	3530	*
2156.000	54.0	74.0	31.8	45.7	22.2	28.3	21	3530	*
2164.500	54.0	74.0	31.7	45.1	22.3	28.9	21	3530	HORZ
2175.000	54.0	74.0	31.8	45.4	22.2	28.6	21	3530	*

Table RE10.5: Emission summary (B5.5 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 RE10.1: Spectral data (B5.5 CH 1)**



**Figure RE10.2: Spectral data (B5.5 CH 6)**

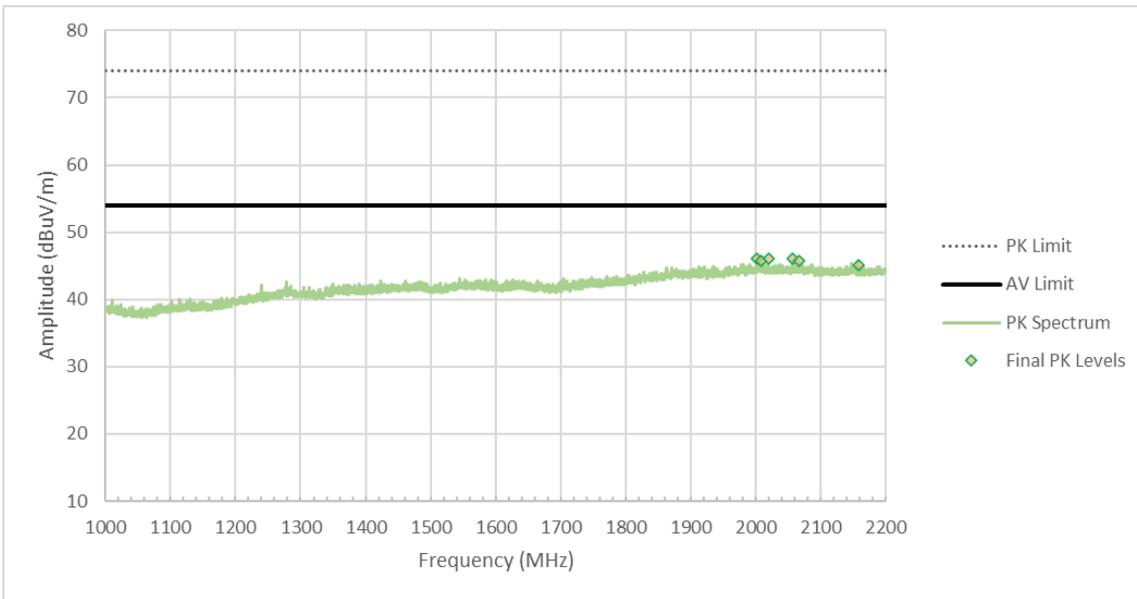


Figure RE10.3: Spectral data (B5.5 CH 11)

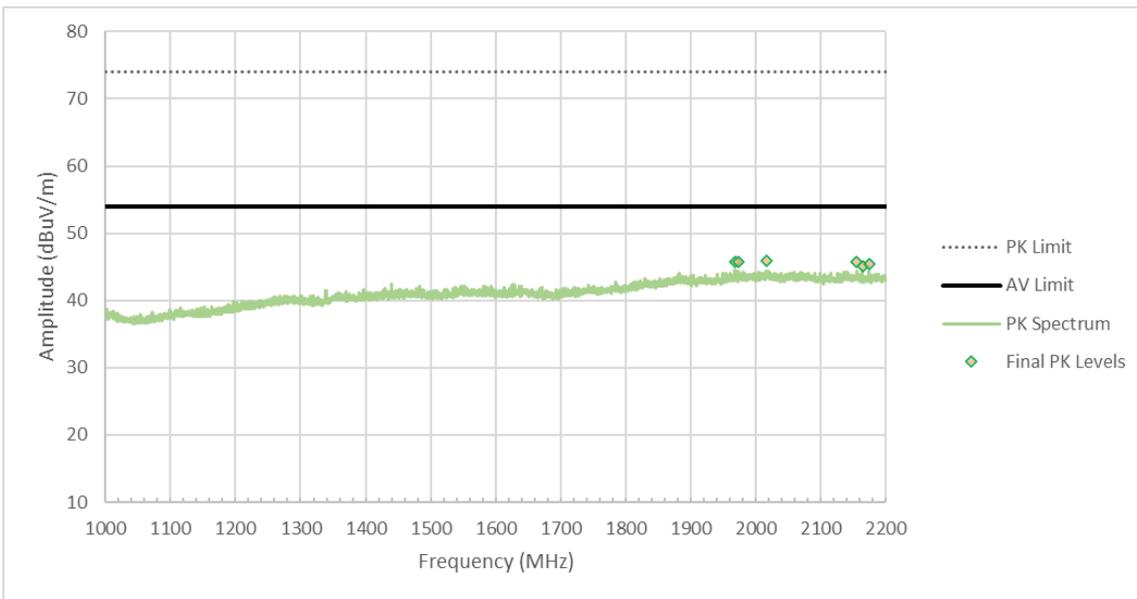


Figure RE10.4: Spectral data (B5.5 CH 13)

## Setup Photographs

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



**Figure RE10.5: EUT test setup, front view**



**Figure RE10.6: EUT test setup, reverse view**

This line is the end of the test record.

**Concluding Notes**

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

**This is the final page of the report.**

# Test Report 2023-033

**Version A**

**Issued 6 July 2023**

**Project GCL-0385**

**Model Identifier: A04724**

**Primary Test Standard**

FCC Part 15.225

RSS-210 Issue 10 Amd 1

## Garmin Compliance Lab

Garmin International

1200 E 151<sup>st</sup> Street

Olathe Kansas 66062 USA

### Client-supplied Information

FCC ID: IPH-04724

IC ID: 1792A-04724



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 NFC transceiver. The results are as follows.

Parameter	Description	Key Performance Values	Result	Data starts at page
Transmitter intentional emissions	Emissions while transmitting must be limited according to a mask that varies across the frequency range 13.110 to 14.010 MHz.[15.225(a) through (c), RSS-210 B.6]	21 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]	12.6 dB of margin to the Class B limit.	PASS	11
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]	3.3 dB of margin to the appropriate limit.  Tested 150 kHz to 30 MHz applying combined Class B limits.	PASS	29
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	32
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	35

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

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

### Table 1: Summary of results

#### Report Organization

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

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

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

Due to confidentiality, certain material (such as test setup photographs) has been removed from this report and placed in GCL Test Report 2023-034. 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 151<sup>st</sup> 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 151<sup>st</sup> St, Olathe Kansas, USA. Witnesses from the business group included: None.

Test Sample received: 6 Apr 2023  
Test Start Date: 6 Jun 2023  
Test End Date: 20 Jun 2023

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

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

## 3. Report History and Approval

This report was written by David Arnett and initially issued on 6 July 2023 as Version A.

### Report Technical Review:

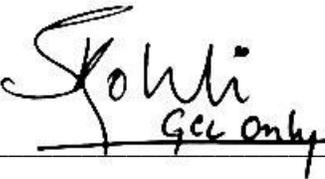
David Arnett  
Technical Lead EMC Engineer



---

### Report Approval:

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



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## 4. Test Sample Modifications and Special Conditions

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

None

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

## 5. Description of the Equipment Tested

### 5.1 Unique Identification

Product Model A04724  
Serial Numbers Tested 441084880

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 are 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 location: Mobile, in variable orientation  
Highest internal frequency: 2.484 GHz  
Firmware Revision 2.15

### 5.3 Operating modes

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

Mode 1: M1 (BLE Tx). Bluetooth Low Energy radio transmitting consistently on a selected channel at 1 Mbps or 2 Mbps

Mode 2: M2 (BLE Link). 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 3: M3 (ANT Tx). ANT radio transmitting consistently on a selected channel.

Mode 4: M4 (ANT Link). ANT radio is paired to a companion device, transmitting and receiving data in accordance with the protocol, and maintaining the paired relationship.

Mode 5: M5 (NFC). The NFC 13.56 MHz transceiver is in Card Emulation mode, and is actively linked to a companion NFC Reader.

Mode 6: M6 (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 7: Void – not used.

Mode 8: M8 (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 9: M9 (BLE 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 10: M10 (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 11: M11 (BT Link). 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 12: M12 (All2.4). This means the radio was tested in modes M1, M3, M8, and M10.

Mode 13: M13 (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.

### 5.4 EUT Arrangement

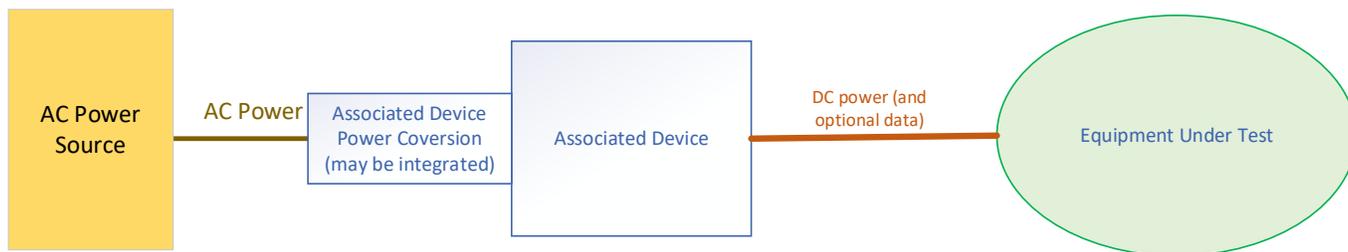
During test, the EUT components and associated support equipment were selected including the following arrangement sets.

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

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

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

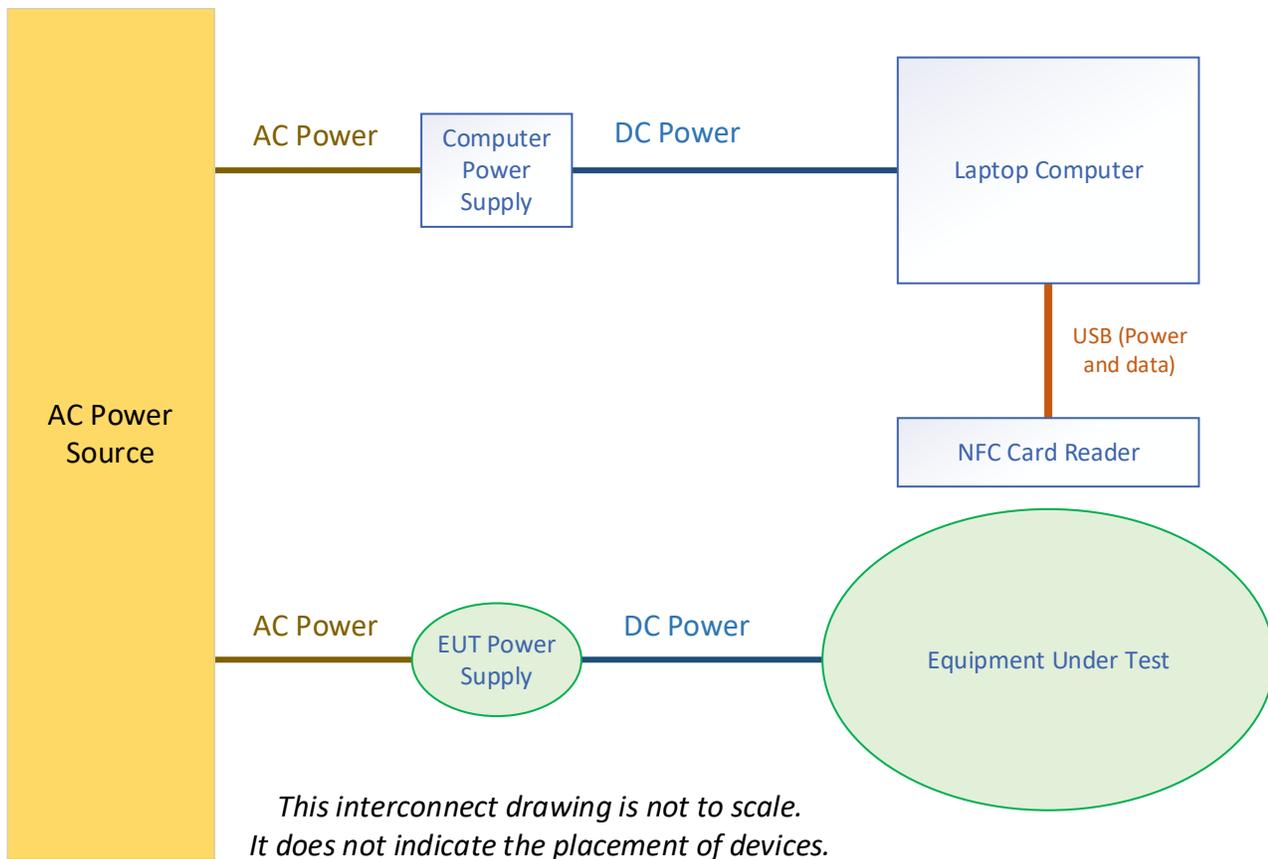
Arrangement 4: A4 (Udc). The test sample is attached to a Mains-powered device connected that provides dc power to the sample and may or may not provide user data. This arrangement is specified in the test plan to provide staff flexibility when the presence or absence of data on the cable is not pertinent.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



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

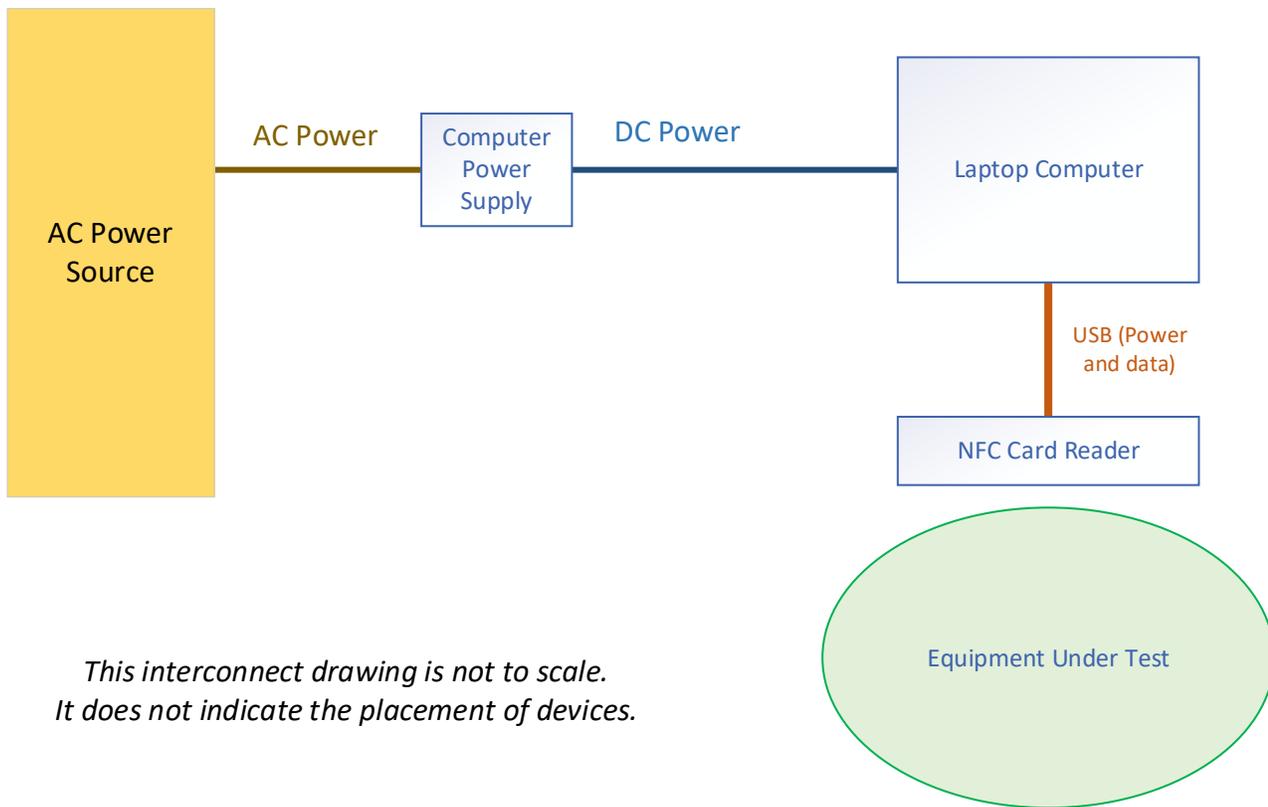
**Figure 1: Block diagram of equipment for arrangements A2, A3, A4**

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.



**Figure 3: Block diagram of equipment arrangement A6**

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number
NFC reader	ACS	ACR1252	RR554-086776
AC/DC Power Converter	Garmin	362-00118-00	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
Shielded data & power	Computer or power source	EUT	50 cm	None

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

## 6 Test Standards Applied

### 6.1. Accredited Standards

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

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	$*1.55 \times 10^{-7}$	None	$1.0 \times 10^{-7}$
Radio Signal Occupied Bandwidth	0.95%	None	5%
Radio Power or Power Spectral Density	0.98 dB	None	1 dB
Temperature	0.38 °C	None	1 °C
Barometric Pressure	0.38 kPa	None	None
Relative Humidity	2.85% RH	None	±5% RH
Signal Timing	The greater of these three... 0.63 usec 0.01% of value 0.5 x LSDPV	None	None

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

## 8 Selected Example Calculations

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

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

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

### 8.1 AC Mains conducted emissions at 22 MHz

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

$$(7.145 \text{ dBuV}) + (9.812 \text{ dB}) + (0.216 \text{ dB}) = 17.173 \text{ dBuV}$$

### 8.2 Radiated Emissions at 630 MHz

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

$$(2.25 \text{ dBuV}) + (27.80 \text{ dB/m}) + (2.89 \text{ dB}) = 32.94 \text{ dBuV/m}$$

### 8.3 Radiated Emissions at 2.7 GHz

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

$$(43.72 \text{ dBuV}) + (32.22 \text{ dB/m}) + (-36.09 \text{ dB}) = 39.85 \text{ dBuV/m}$$

## 9 Environmental Conditions During Test

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

Temperature:	20.7 to 24.1 °C
Relative Humidity:	33.2% to 67.4% (non-condensing)
Barometric Pressure	96.9 to 98.9 kPa

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

**Table 4: Environmental monitoring device**

## ANNEX

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

**Test Record**  
**Radiated Emission Test RE21**  
**Project GCL0385**

Test Date(s) 19-20 Jun 2023  
 Test Personnel Jim Solum

Product Model A04724  
 Serial Number tested 441084880

Operating Mode M5 (NFC) Type A  
 Arrangement A6 (NFCp)  
 Input Power Battery

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

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

**Test record created by:** Jim Solum  
**Date of this record:** 20 Jun 2023

Original record, Version A.

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Loop antenna, amplified	Schwarzbeck	FMZB 1519B	00174	18-Jul-2022	15-Jul-2023
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 RE21.1: 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 V1 2023Jan17.xlsx

**Test Data**

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

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

The 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
12.000	49.5	-2.0	26.4	-25.1	23.1	-113	1000	Y
12.003	49.5	-2.0	25.4	-26.1	24.1	180	1000	X
13.137	60.5	9.0	28.8	-22.7	31.7	-176	1000	X
13.348	60.5	9.0	38.7	-12.8	21.8	180	1000	X
13.463	70.5	19.0	37.9	-13.6	32.6	180	1000	X
13.560	104.0	52.5	67.1	15.6	36.9	180	1000	X
13.656	70.5	19.0	37.9	-13.6	32.6	180	1000	X
13.771	60.5	9.0	39.0	-12.5	21.5	180	1000	X
13.983	60.5	9.0	19.3	-32.2	41.2	-84	1000	X
14.408	49.5	-2.0	27.3	-24.2	22.2	34	1000	X

Table RE21.2: 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.

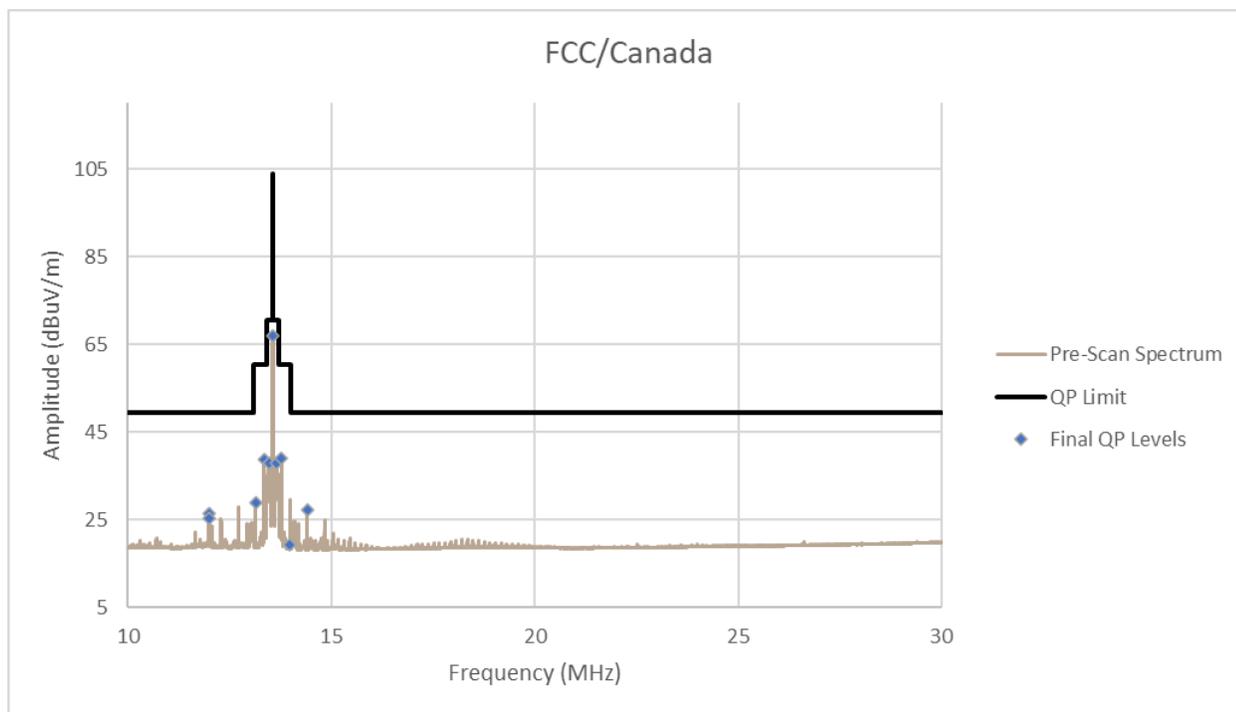
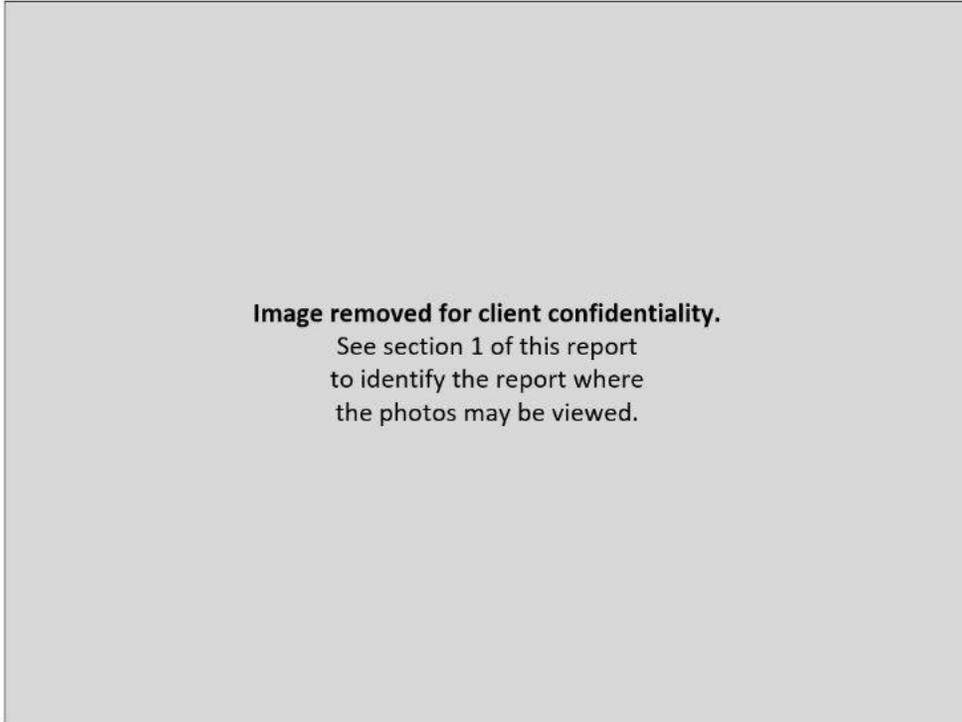


Figure RE21.1: Spectral data (FCC/Canada)

**Setup Photographs**

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



**Figure RE21.2: EUT test setup, front view (Antenna X Orientation)**



**Figure RE21.3: EUT test setup, reverse view (Antenna Y Orientation)**  
This line is the end of the test record.

**Test Record**  
**Radiated Emission Test RE22**  
**Project GCL0385**

Test Date(s) 20 Jun 2023  
 Test Personnel Jim Solum

Product Model A04724  
 Serial Number tested 441084880

Operating Mode M5 (NFC) Type B  
 Arrangement A6 (NFCp)  
 Input Power Battery

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

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

**Test record created by:** Jim Solum  
**Date of this record:** 20 Jun 2023

Original record, Version A.

**Test Equipment Used**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Loop antenna, amplified	Schwarzbeck	FMZB 1519B	00174	18-Jul-2022	15-Jul-2023
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 RE22.1: 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 V1 2023Jan17.xlsx

**Test Data**

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

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

The 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 in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. The dbuA/m limits and measured dbuA/m values in the chart below are obtained from the dBuV/m limits and measured dBuV/m measured values. The two values differ by 51.52 dB based on the 377 Ohm characteristic impedance of free space. A positive margin value indicates that the emission was below the test limit. The test limits are for FCC 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
11.982	49.5	-2.0	20.3	-31.2	29.2	-145	1000	X
12.003	49.5	-2.0	24.3	-27.2	25.2	72	1000	Y
12.005	49.5	-2.0	24.4	-27.1	25.1	-74	1000	Y
13.560	104.0	52.5	67.2	15.7	36.8	-172	1000	X
14.406	49.5	-2.0	26.1	-25.4	23.4	16	1000	X
14.410	49.5	-2.0	25.9	-25.6	23.6	-5	1000	X

Table RE22.2: 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.

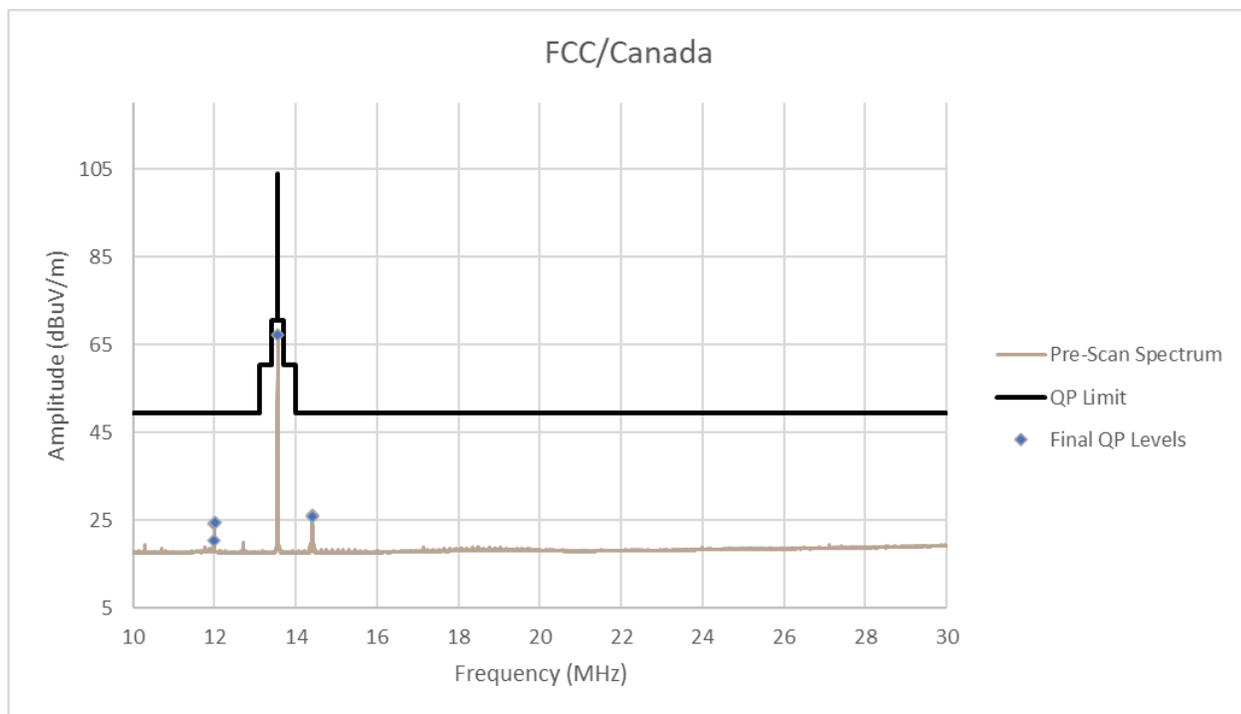
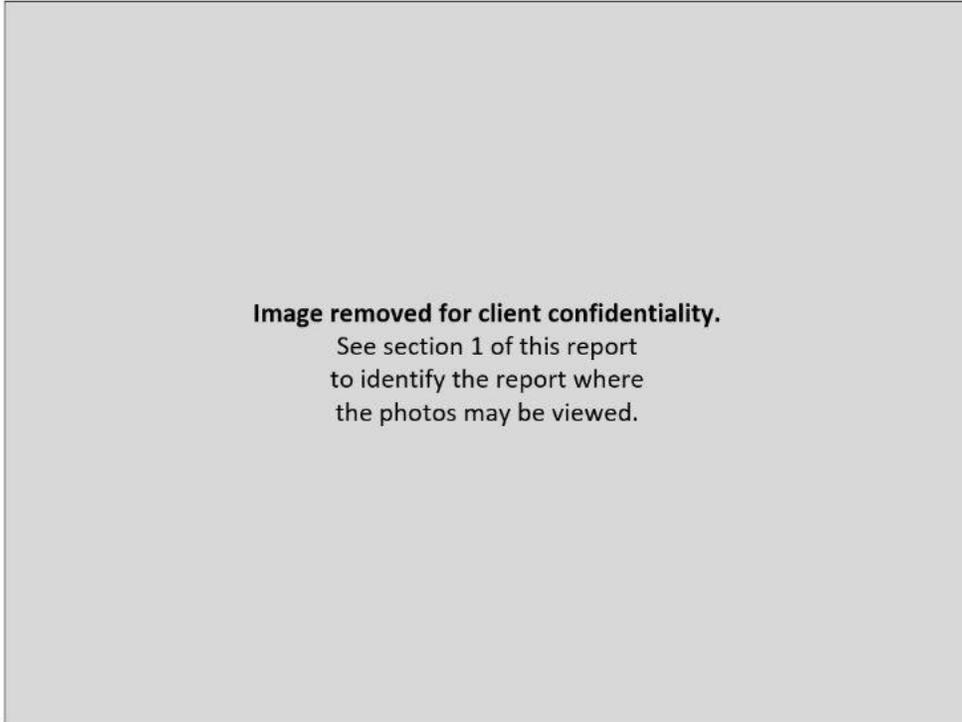


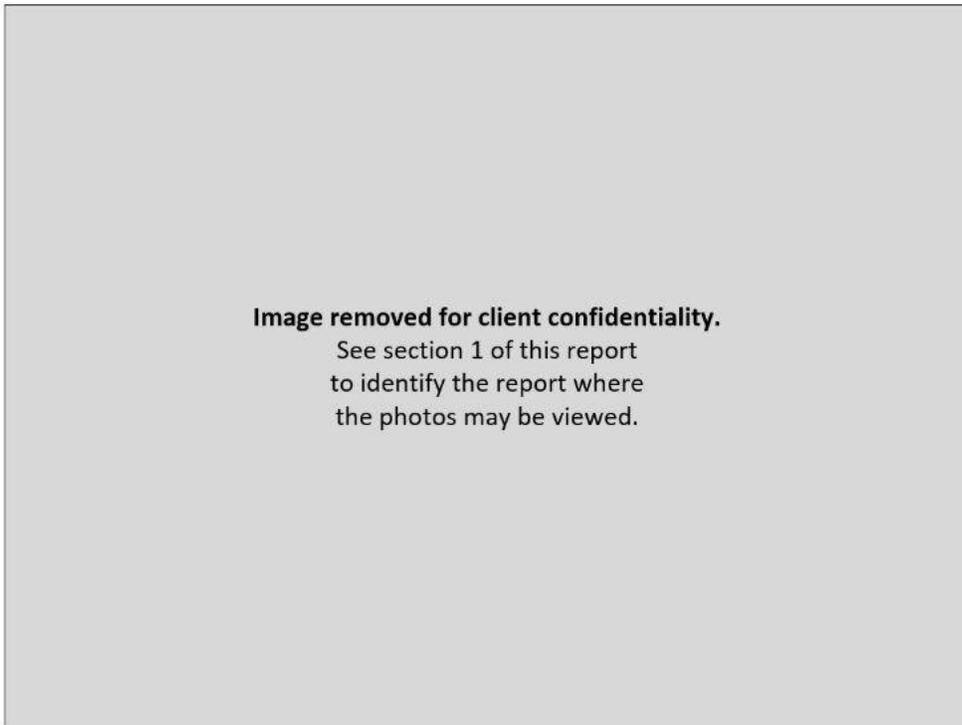
Figure RE22.1: Spectral data (FCC/Canada)

**Setup Photographs**

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



**Figure RE22.2: EUT test setup, reverse view (Antenna X Orientation)**



**Figure RE22.3: EUT test setup, front view (Antenna Y Orientation)**  
This line is the end of the test record.

**Test Record**  
**Radiated Emission Test RE23**  
**Project GCL0385**

Test Date(s) 20 Jun 2023  
 Test Personnel David Kerr

Product Model A04724  
 Serial Number tested 441084880

Operating Mode M5 (NfcL)  
 Arrangement A6 (NFCu)  
 Input Power Battery

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:** 21 Jun 2023  
 Original record, Version A.

**Test Equipment**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Antenna, Biconilog, 30M-6 GHz	ETS Lindgren	3142E	233201	19-Jul-2022	15-Jul-2024
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	7-Nov-2022	7-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

**Table RE23.1: Test Equipment Used**

**Software Used:** Keysight PXE software A.32.06  
 RE Signal Maximization Tool v2021Feb25.xlsx.  
 RE 30M to 1G XYZ\_orientations\_TemplateV8.xlsm  
 RE 30M to 1G Data Analysis Template V3 2022May10.xlsx

## Test Data

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

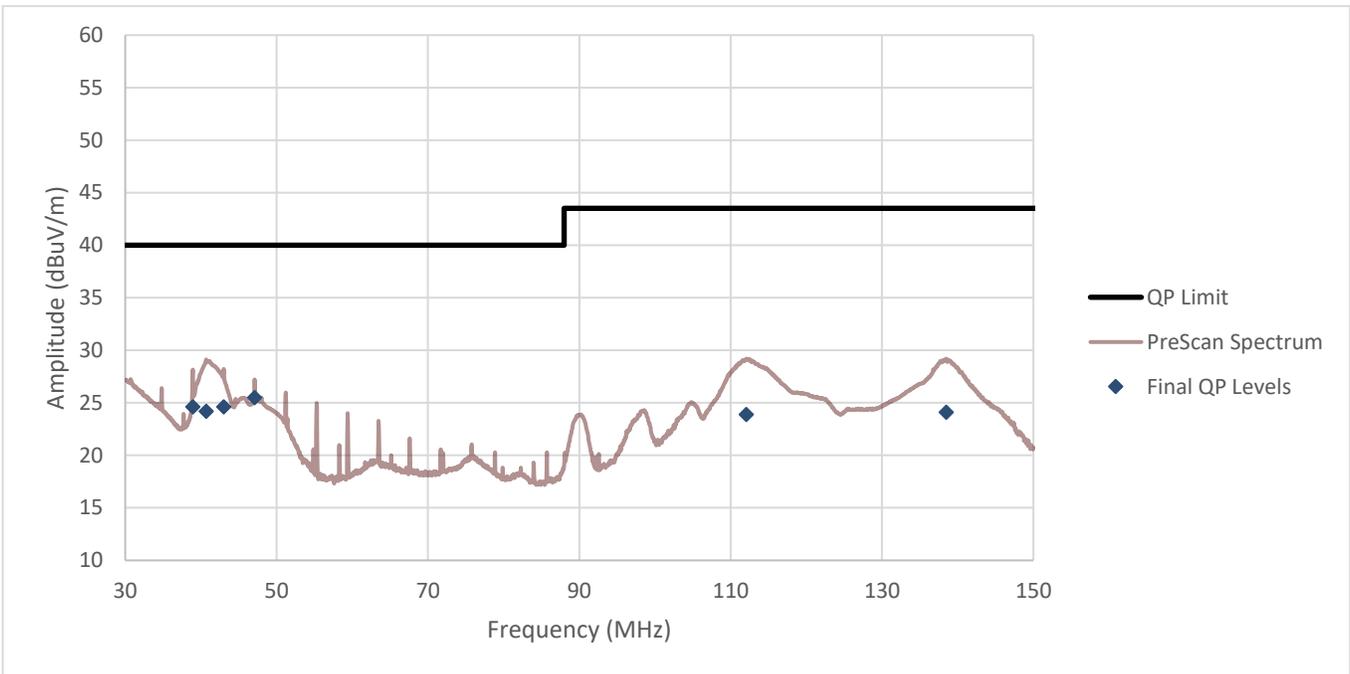
At azimuth angle 0° the ‘front’ reference mark of the turntable is pointed Southward. At 90° the reference mark points West. At -90° it points East. At -7° the turntable reference mark is pointed directly at the antenna. The designation of the X, Y, and Z orientations of the test sample are sample dependent,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

The table shows the selected final measurement data between 30 MHz and 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 in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
38.910	40.0	24.6	15.4	169	1102	VERT
40.680	40.0	24.2	15.8	68	1112	VERT
43.020	40.0	24.6	15.4	171	1053	VERT
47.100	40.0	25.5	14.5	158	1056	VERT
112.050	43.5	23.9	19.6	-172	1155	VERT
138.480	43.5	24.1	19.4	140	1202	VERT

**Table RE23.2: Emission summary**

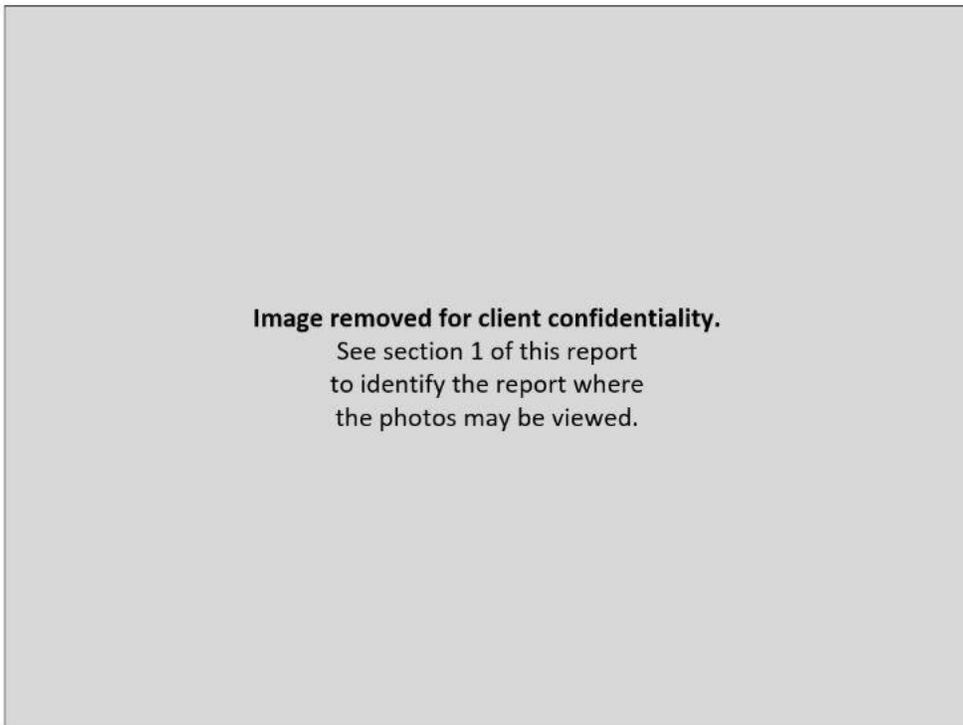
The graph below shows the background spectrum observed during pre-scan, as well as the final data points from the table above.



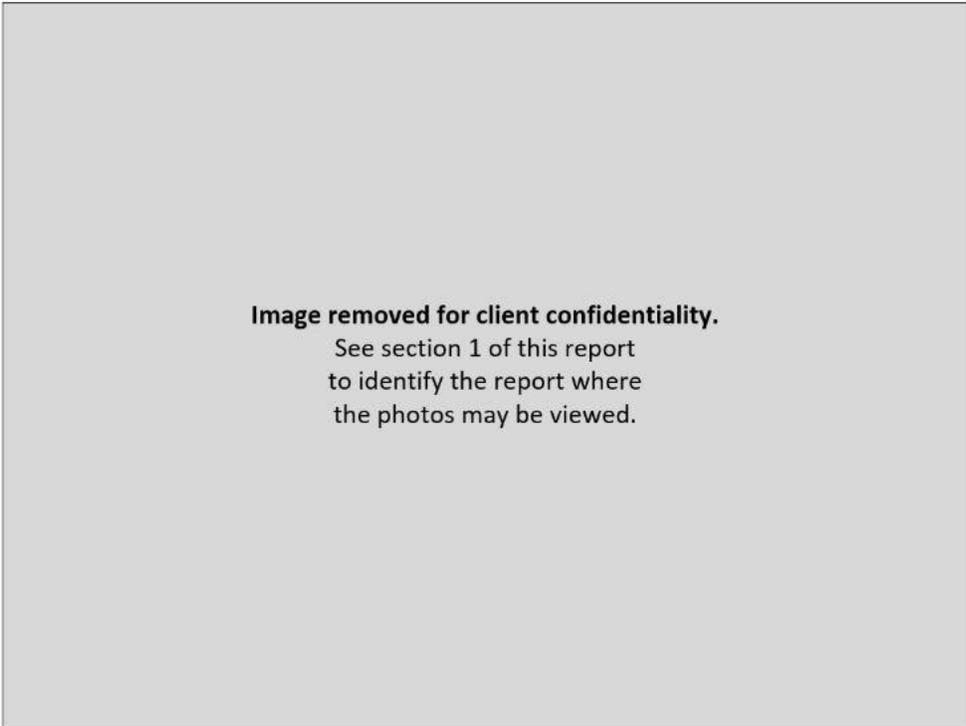
**Figure RE23.1: Spectral data**

**Setup Photographs**

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



**Figure RE23.2: EUT test setup, front view Z orientation**



**Figure RE23.3: EUT test setup, reverse view Z orientation**



**Figure RE23.4: EUT test setup, front view X orientation**

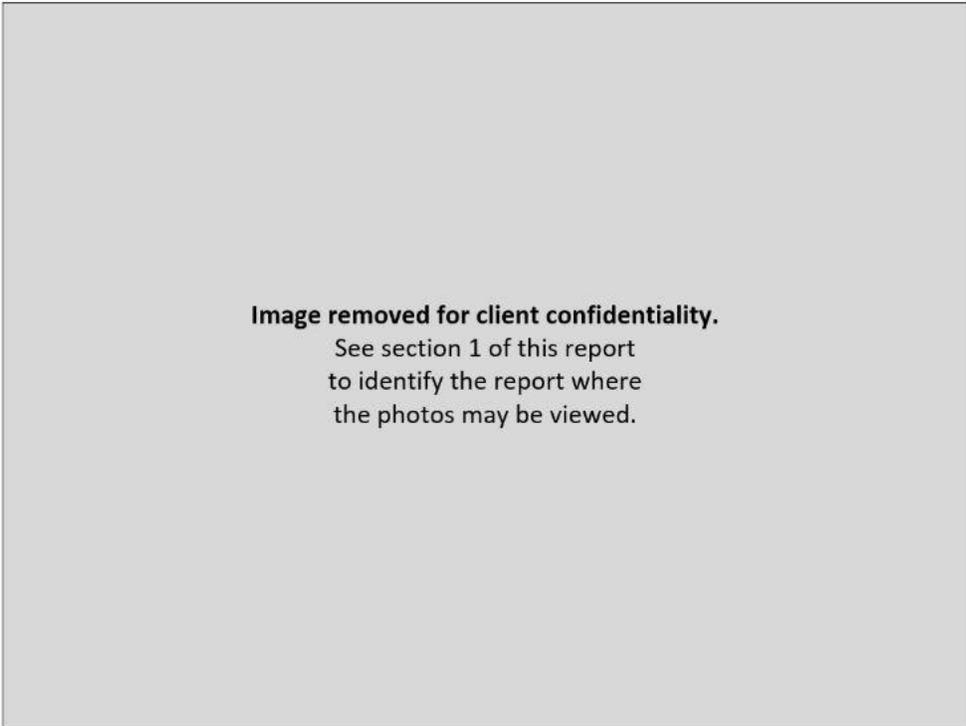


Figure RE23.5: EUT test setup, reverse view X orientation



Figure RE23.6: EUT test setup, front view Y orientation

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

**Figure RE23.7: EUT test setup, reverse view Y orientation**

**This line is the end of the test record.**

**Test Record**  
**Radiated Emission Test RE24**  
**Project GCL0385**

Test Date(s) 20 Jun 2023  
 Test Personnel David Kerr

Product Model A04724  
 Serial Number tested 441084880

Operating Mode M5 (NfcL)  
 Arrangement A6 (NFCu)  
 Input Power Battery

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:** 21 Jun 2023  
 Original record, Version A.

**Test Equipment**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Antenna, Biconilog, 30M-6 GHz	ETS Lindgren	3142E	233201	19-Jul-2022	15-Jul-2024
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	7-Nov-2022	7-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026

**Table RE24.1: Test Equipment Used**

**Software Used** Keysight PXE software A.32.06  
 RE Signal Maximization Tool v2021Feb25.xlsx.  
 RE 30M to 1G XYZ\_orientations\_TemplateV8.xlsm  
 RE 30M to 1G Data Analysis Template V3 2022May10.xlsx

## Test Data

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

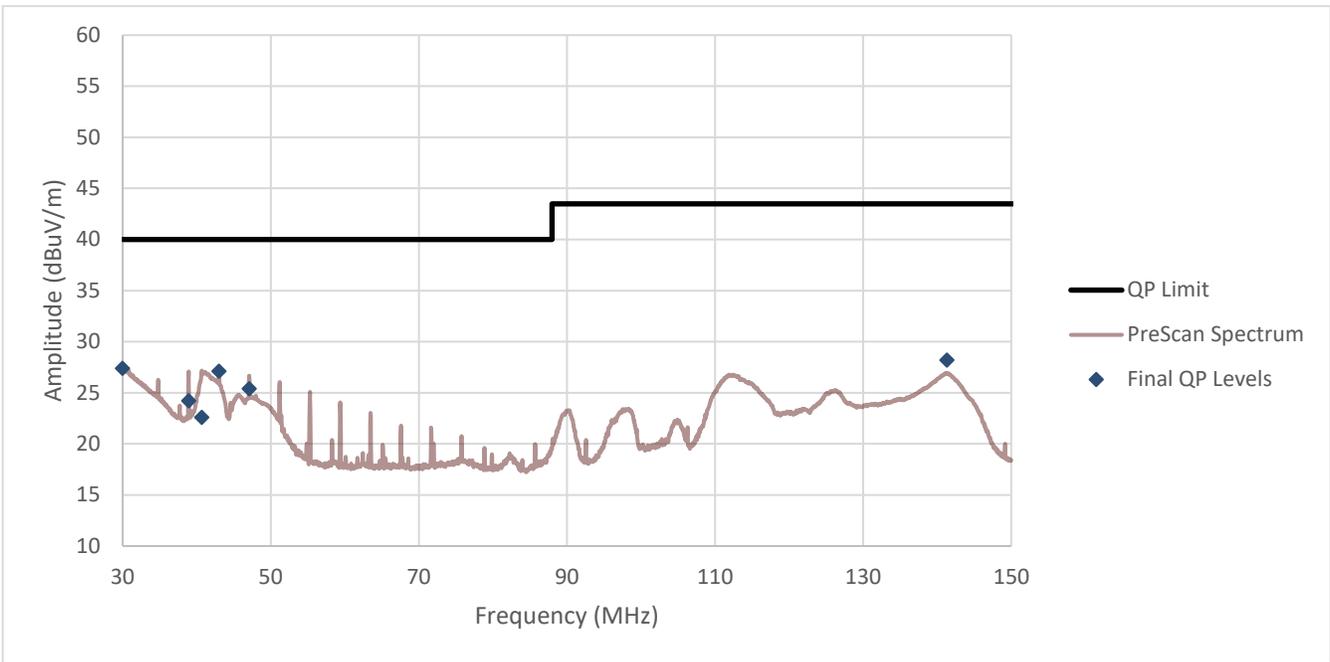
At azimuth angle 0° the 'front' reference mark of the turntable is pointed Southward. At 90° the reference mark points West. At -90° it points East. At -7° the turntable reference mark is pointed directly at the antenna. The designation of the X, Y, and Z orientations of the test sample are sample dependent,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

The table shows the selected final measurement data between 30 MHz and 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 in yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

Frequency (MHz)	Limit (dBuV/m)	Measured (dBuV/m)	Margin (dB)	Azimuth (degree)	Height (mm)	Antenna Polarity
30.000	40.0	27.4	12.6	9	4000	VERT
38.910	40.0	24.2	15.8	137	1037	VERT
40.680	40.0	22.6	17.4	59	1248	VERT
43.020	40.0	27.1	12.9	186	1031	VERT
47.100	40.0	25.4	14.6	161	1037	VERT
141.330	43.5	28.2	15.3	-9	1050	VERT

**Table RE24.2: Emission summary**

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



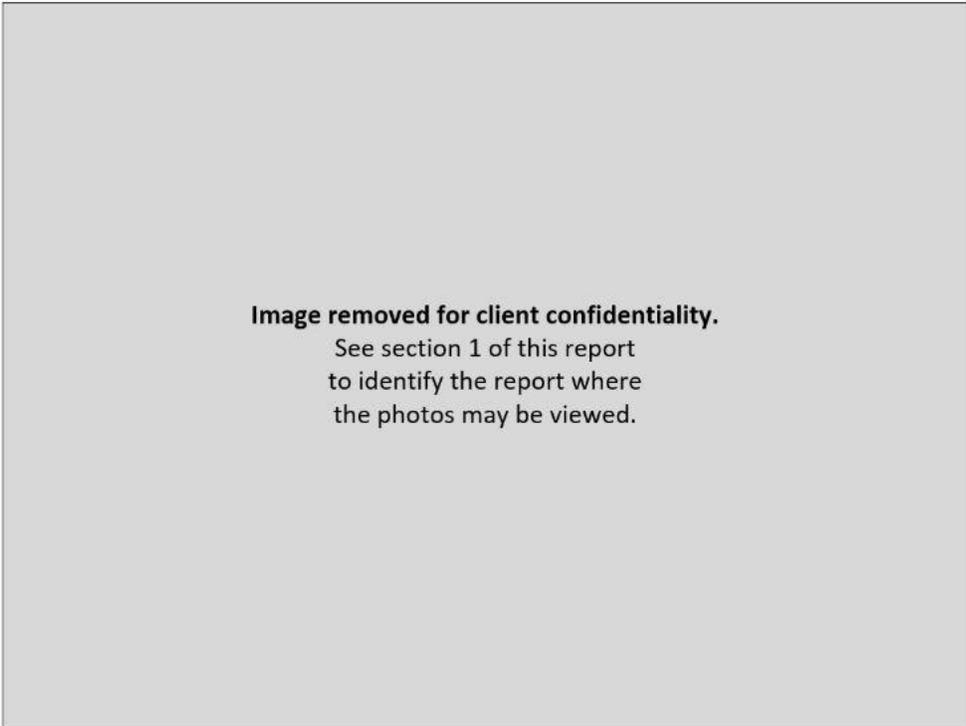
**Figure RE24.1: Spectral data**

**Setup Photographs**

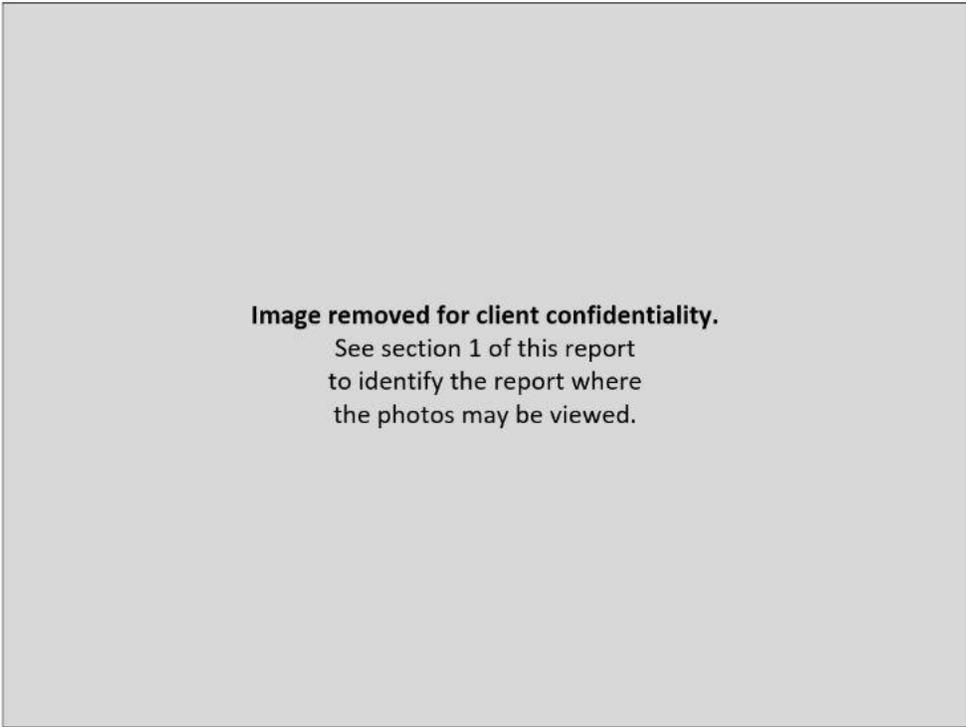
The following photographs show the EUT configured and arranged in the manner in which it was measured.



**Figure RE24.2: EUT test setup, front view Z orientation**



**Figure RE24.3: EUT test setup, reverse view Z orientation**



**Figure RE24.4: EUT test setup, front view X orientation**



Figure RE24.5: EUT test setup, reverse view X orientation



Figure RE24.6: EUT test setup, front view Y orientation

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

**Figure RE24.7: EUT test setup, reverse view Y orientation**

**This line is the end of the test record.**

**Test Record**  
**Conducted Emissions Mains Test CE02**  
**Project GCL0385**

Test Date(s) 06 Jun 2023  
 Test Personnel David Kerr

Product Model A04724  
 Serial Number tested 441084880

Operating Mode M5 (NfcL)  
 Arrangement A5 (Nfcp)  
 Input Power 115 Vac 60 Hz

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

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

**Test record created by: Ryan Townsend**  
**Date of this record: 16 June 2023**  
 Original record, Version A.

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver 26 GHz	Keysight	N9048B	MY59290139	21-Sep-2022	15-Sep-2023
DMM Multimeter	FLUKE	79 III	71740743	18-Apr-2022	1-Apr-2023
Power Source	Elgar	1001B-167	1618	Calibration	Not Required
LISN multiline; 20A 50uH	Com-Power	LIN-120C	20160005	22-Aug-2022	15-Aug-2023

**Table CE01.1: Test Equipment Used**

**Software Used**

Keysight PXE software A.32.06  
 CE Mains 150k to 30M Data Analysis.xlsx

**Test Data**

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

The table shows the selected final measurement data. It includes at least the six strongest emissions observed relative to the limit lines, along with other data points of interest. The yellow highlight indicate the data points with the least margin to the quasi-peak detector limit and the average detector limit. A positive margin value indicates that the emission was below the test limit. The test limit is the FCC Class B Limit at 3m.

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)
197	63.73	53.73	44.49	45.99	30.07	29.27	17.73	23.65
713	56	46	31.13	30.73	26.76	26.68	24.87	19.24
3428	56	46	46.35	42.23	42.7	39.72	9.65	3.30
10286	60	50	45.3	41.6	41.87	39.48	14.70	8.13
13560	60	50	48.31	46.43	44.46	42.79	11.69	5.54
13715	60	50	37.21	34.47	34.31	32.18	22.79	15.69
17142	60	50	43.8	40.53	40.66	38.8	16.20	9.34
20571	60	50	37.5	35.23	34.94	33.28	22.50	15.06
24000	60	50	41.22	38.56	38.69	37.18	18.78	11.31
27429	60	50	36.2	34.47	33.67	32.1	23.80	16.33

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.

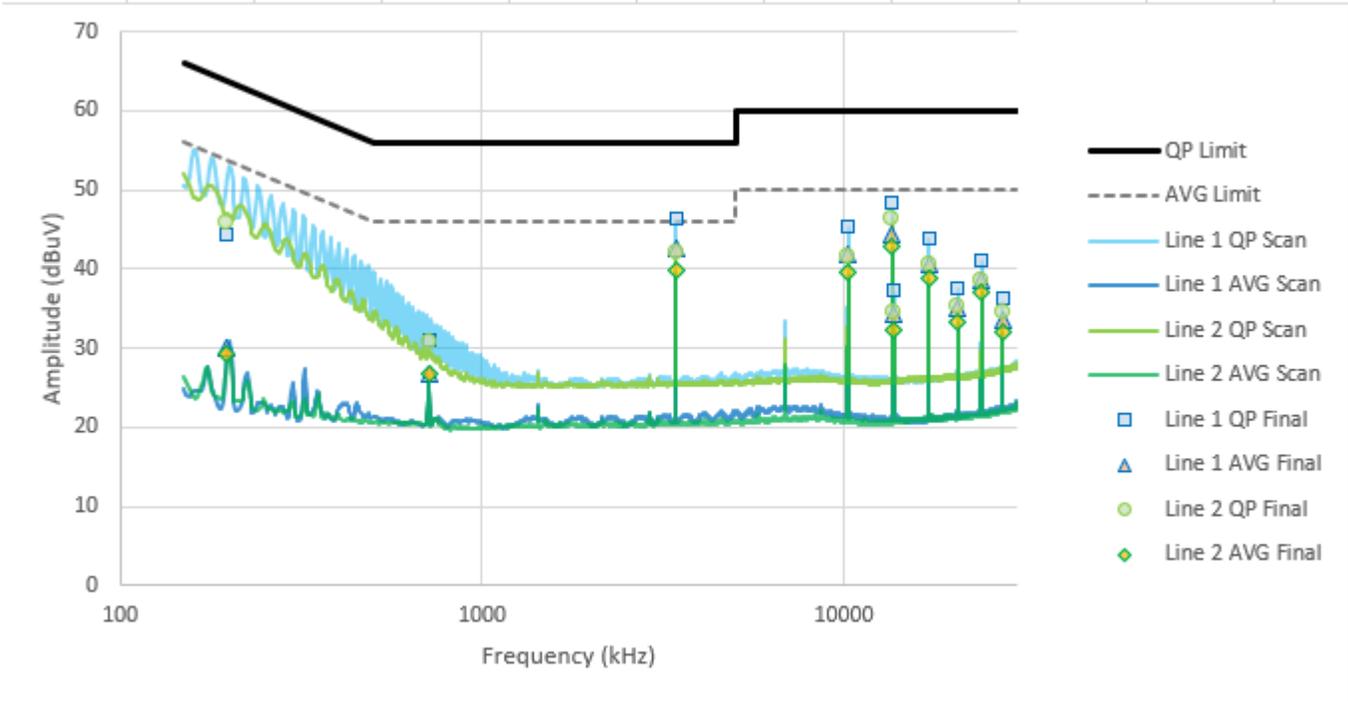


Figure CE01.1: Spectral data

Setup Photographs

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



**Figure CE01.2: EUT test setup**



**Figure CE01.3: EUT test setup cont.**

**This line is the end of the test record.**

**Test Record**  
**Transmitter Frequency Stability**  
**Test IDs TR41**  
**Project GCL-0385**

Test Date(s) 7 and 8 Jun 2023  
 Test Personnel Majid Farah  
 Product Model A04724  
 Serial Number tested 441084880

Operating Mode M5 (NfcL)  
 Arrangement A6 (NFCu)  
 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: 13 Jun 2023**

Original record, Version A.

**Test Equipment**

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
DMM Multimeter	FLUKE	79 III	71740743	5-Apr-2023	1-Apr-2024
Near Field Probe Set	Com-Power	PS-400	151544	Calibration	Not Required
PXE Receiver 44GHz	Keysight	N9048B	MY62220139	30-Jan-2023	1-Feb-2024
Thermometer	Thermco	ACCD370P	210607316	11-Aug-2021	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
Programmable DC power source	Keithley	2260B-30-72 720 W	1411917	21-Apr-2023	15-Apr-2024
Thermal chamber	TPS	T2RC	32774-02	Calibration	Not Required

**Table TR41.1: Equipment used**

Software Used: PXE Software Revision A.33.03

**Test Method**

The test sample was placed in a thermal chamber and connected to an appropriate dc power source. The analyzer was set up to detect radio signals from the test sample.

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

The sample uses NFC technology with a carrier at 13.56 MHz. For continuous transmission, the sample needs to be at a close distance with an NFC card Reader along entire test. The test sample was placed in a thermal chamber and connected to an appropriate dc power source. A near-field probe was placed near the sample then connected by a cable to the PXE analyzer. The analyzer was set up to detect radio signals from the test sample in a way to read carrier frequency with high resolution. The Standard indicated carrier frequency stability shall not

exceed 0.01% of operation frequency. The frequency was required to remain between the limits of 13.558644 and 13.561356 MHz.

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

**Caveat**

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

Emissions presented here show the combined signals from the NFC reader and the device under test. Signals for each were not distinguishable during 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 various standards require observation of the stability for transmission frequency and/or power at certain environmental extremes. The reference is performance on nominal input voltage and a temperature of 20 °C. Where the standards cited here apply to different limits or conditions, the most stringent limits and conditions have been applied.

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

Yellow highlights indicate the maximum and minimum measured carrier frequency. The maximum frequency measured was 13,559,939 Hz and the minimum was 13,559,783 Hz. The margin to high side of limit is 1417 Hz and margin for low side of the limit is 1139 Hz.

Tx Mode	Temp °C	Volts Vdc	NFC carrier frequency (Hz)			
			Time interval (minute)			
			0	2	5	10
NFC	50	5	13,559,785	13,559,784	13,559,783	13,559,783
NFC	40	5	13,559,802	13,559,800	13,559,797	13,559,796
NFC	30	5	13,559,819	13,559,822	13,559,826	13,559,828
NFC	20	5	13,559,871	13,559,867	13,559,865	13,559,864
NFC	20	4.25	13,559,864	N/A	N/A	N/A
NFC	20	5.75	13,559,864	N/A	N/A	N/A
NFC	10	5	13,559,909	13,559,905	13,559,904	13,559,902
NFC	0	5	13,559,926	13,559,928	13,559,928	13,559,927
NFC	-10	5	13,559,936	13,559,939	13,559,939	13,559,939
NFC	-20	5	13,559,922	13,559,924	13,559,923	13,559,923

**Table TR41.2: Carrier frequency measurement for NFC transmission during temperature and voltage variations**

### Setup Block Diagram

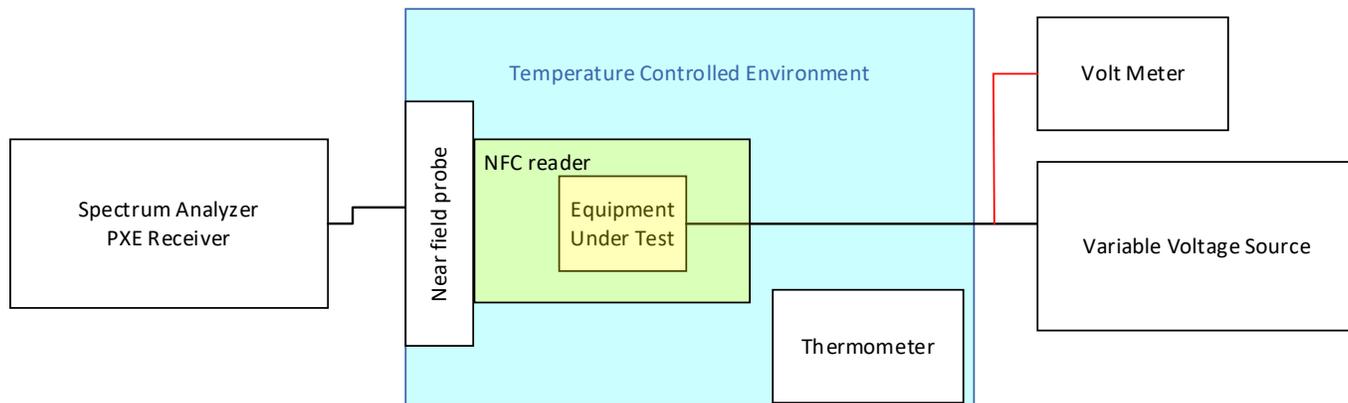


Figure TR41.1: Schematic drawing of the test equipment setup for NFC

This line is the end of the test record.

**Test Record**  
**Transmitter Bandwidth Tests**  
**Test IDs TR04b**  
**Project GCL-0385**

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

Product Model A04724  
 Serial Number tested 441084880

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: David Arnett**  
**Date of this record: 13 Jun 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	151679	Calibration	Not Required

**Table TR04b.1**

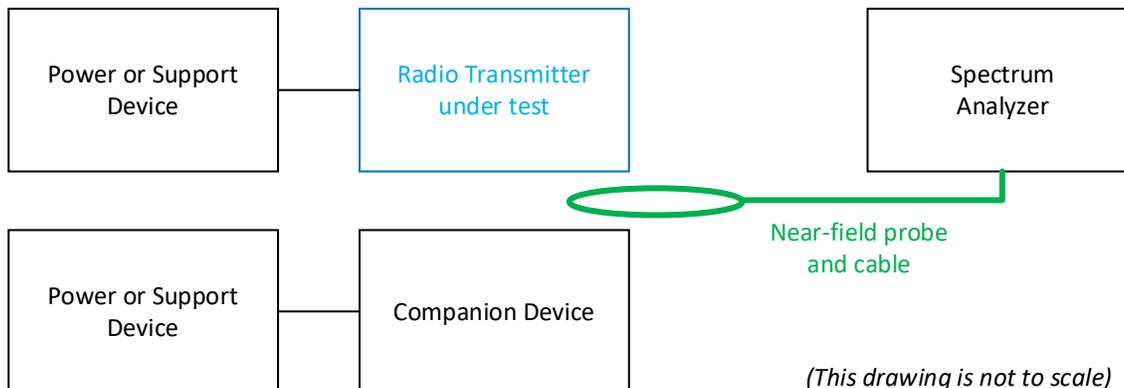
**Test Software used:** Keysight PXE System Code rev. A.33.03.

**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 TR04b.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.

NFC Mode	Bandwidth
Type A	4.08 MHz
Type B	5.04 MHz

Table TR04b.2: Summary of 99% Occupied Bandwidth Data for 13.56 MHz NFC modes

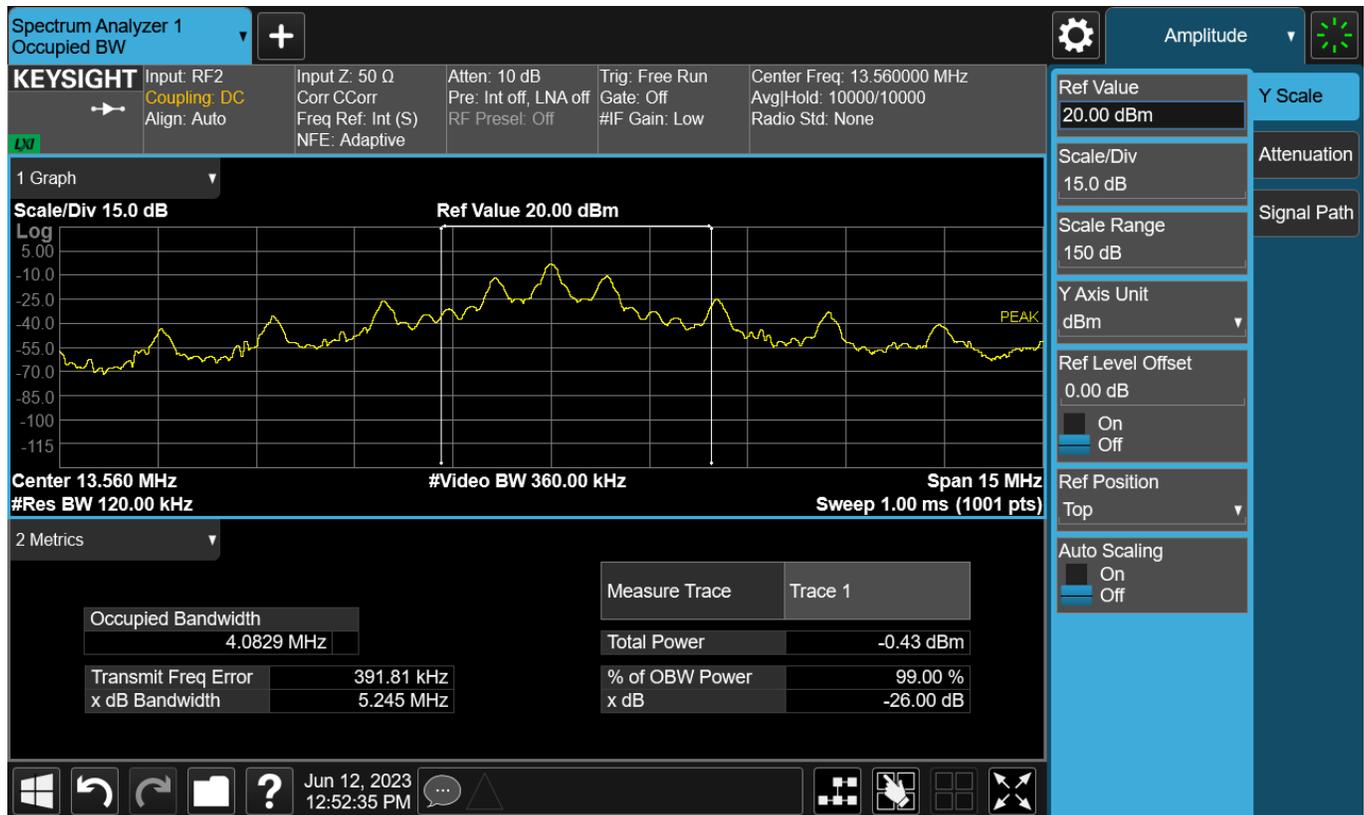


Figure TR04b.1: Occupied bandwidth data for Type A transmissions

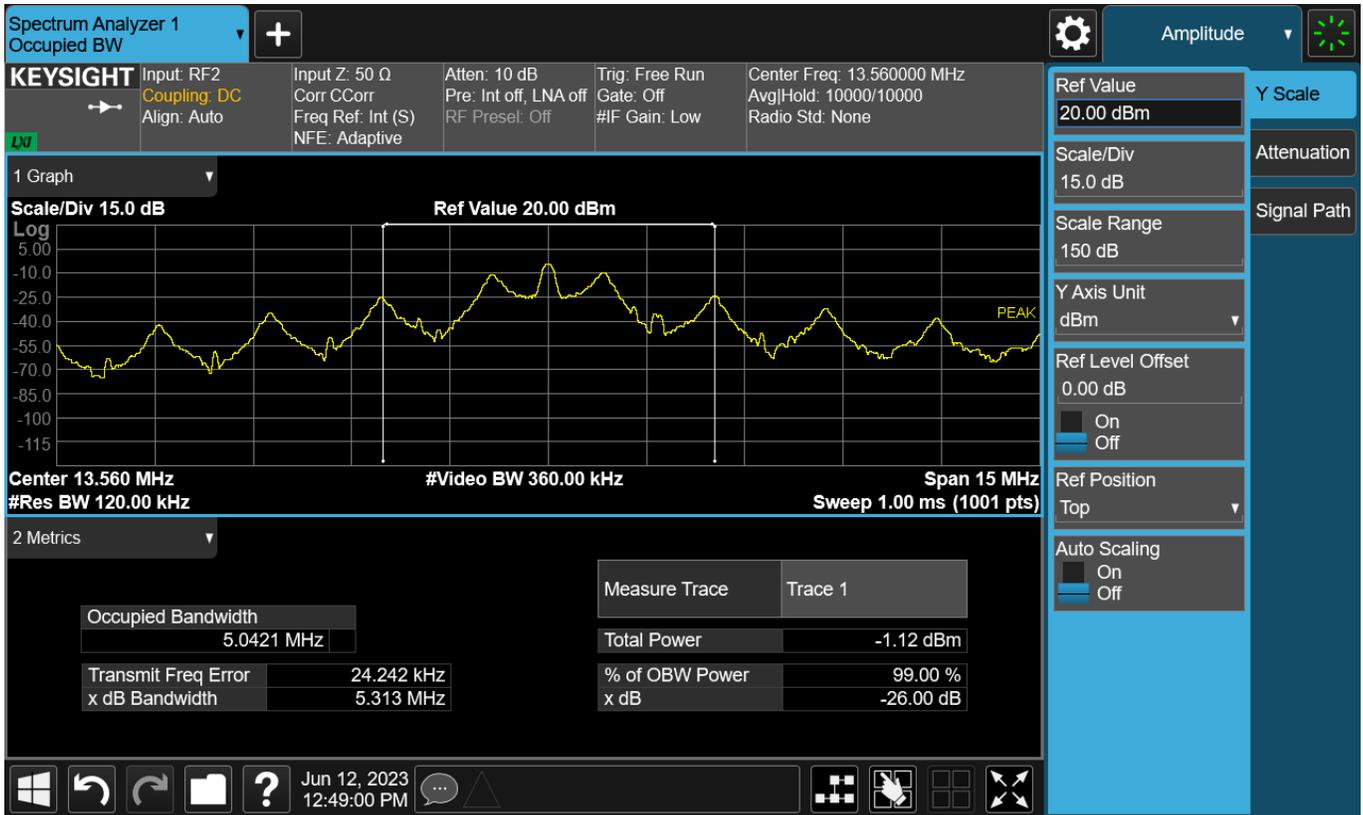


Figure TR04b.2: Occupied bandwidth data for Type B transmissions

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.**

# 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.  
1200 E. 151<sup>st</sup> Street  
Olathe, KS 66062

Dates of Test:  
Test Report Number:

April 17-18, 2023  
SAR.20230410

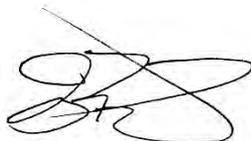
Lab Designation Number: US1195(FCC) & US0194(ISED)

FCC ID:	IPH-04724
IC Certificate:	1792A-04724
Model(s):	A04724
Test Sample:	Engineering Unit Same as Production
Serial No.:	441084957
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) – 20.0 dBm, 2450 MHz (g) – 18.0 dBm, 2450 MHz (n) – 18.0 dBm, 2450 MHz (BT) – 10.0 dBm, 2450 MHz (ANT) – 1.0 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:	0.33 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



Testing Cert. # 2387.01

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Comment/Revision	Date
Original Release	June 2, 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 A04724 FCC ID: IPH-04724 with FCC Part 2, 1093, ET Docket 93-62 Rules for mobile and portable devices and IC Certificate: 1792A-04724 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 A04724 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 A04724 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	20.0
WiFi – 2.4 GHz	802.11g	N/A	N/A	N/A	N/A	N/A	N/A	18.0
WiFi – 2.4 GHz	802.11n	N/A	N/A	N/A	N/A	N/A	N/A	18.0
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	0.0
Ant	Ant	N/A	N/A	N/A	N/A	N/A	N/A	1.0
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 ( $\rho$ ).

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

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:

$\sigma$  = conductivity of the tissue (S/m)

$\rho$  = mass density of the tissue (kg/m<sup>3</sup>)

$E$  = rms electric field strength (V/m)

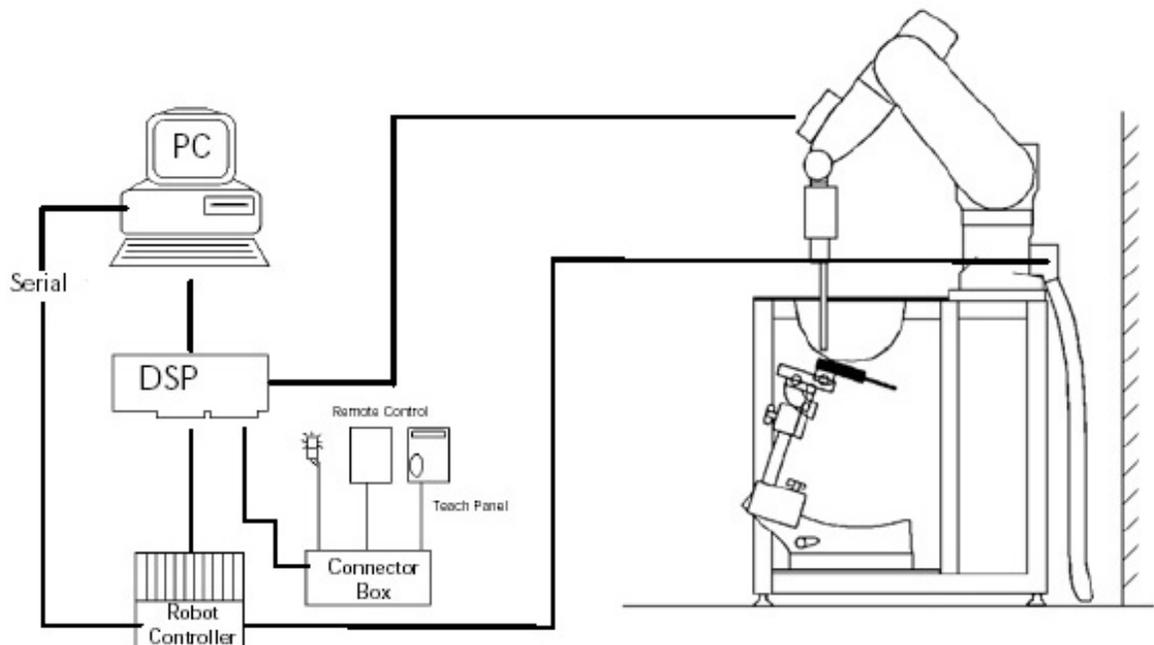
## 2. SAR Measurement Setup

### 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:**  $\pm 0.2$ dB (30 MHz to 6 GHz)

**Dynamic:** 10 mW/kg to 100 W/kg

**Range:** Linearity:  $\pm 0.2$ dB

**Dimensions:** Overall length: 330 mm

**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

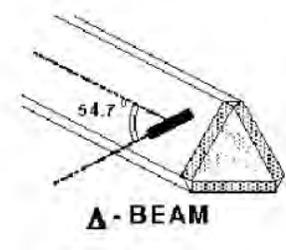


Figure 2.2 Triangular Probe Configurations



Figure 2.3 Probe Thick-Film Technique

**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<sup>2</sup>.

**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

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

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

where:

where:

$\Delta t$  = exposure time (30 seconds),

$\sigma$  = simulated tissue conductivity,

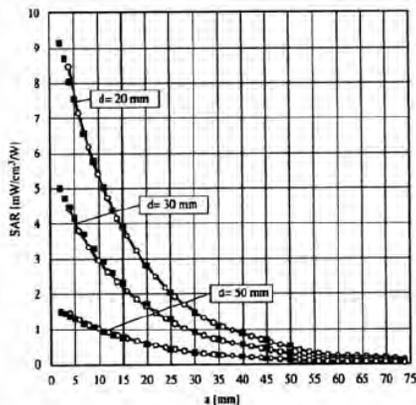
C = heat capacity of tissue (brain or muscle),

$\rho$  = Tissue density (1.25 g/cm<sup>3</sup> for brain tissue)

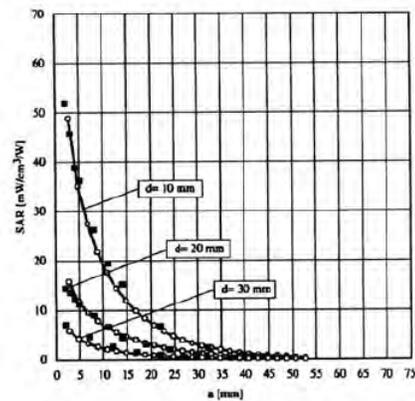
$\Delta T$  = temperature increase due to RF exposure.

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  
 $\sigma$  = conductivity in [mho/m] or [Siemens/m]  
 $\rho$  = equivalent tissue density in  $g/cm^3$

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

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

with  $P_{pwc}$  = 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:

<b>Area scan grid spacing for different frequency ranges</b>	
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:

<b>Zoom scan grid spacing and volume for different frequency ranges</b>			
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

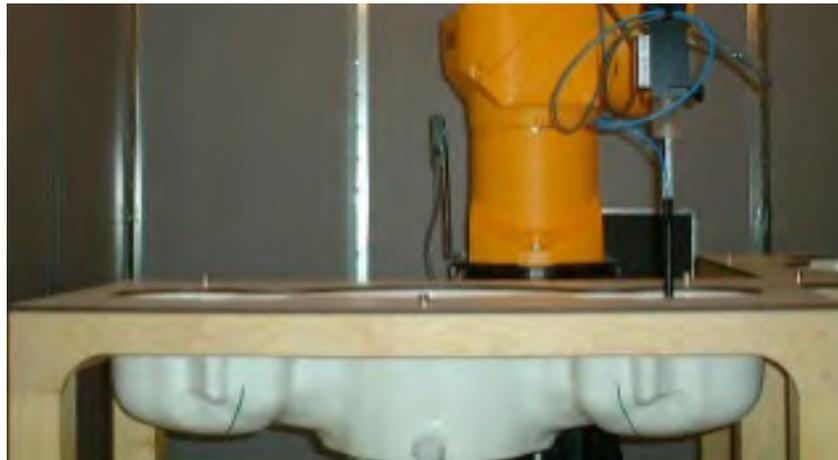
DASY uses the advanced extrapolation option which is able to compensate boundary effects on E-field probes.

**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:**  $2.0 \pm 0.2$  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 repeatedly 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 <sup>1</sup> Brain	1.60	8.00
SPATIAL AVERAGE SAR <sup>2</sup> Whole Body	0.08	0.40
SPATIAL PEAK SAR <sup>3</sup> Hands, Feet, Ankles, Wrists	4.00	20.00

<sup>1</sup> 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.

<sup>2</sup> The Spatial Average value of the SAR averaged over the whole body.

<sup>3</sup> 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  $\geq 1.5$  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)		Apr. 17, 2023	
Liquid Temperature (°C)	20.0	Target	Measured
Dielectric Constant: $\epsilon$		39.20	38.21
Conductivity: $\sigma$		1.80	1.81

See Appendix A for data printout.

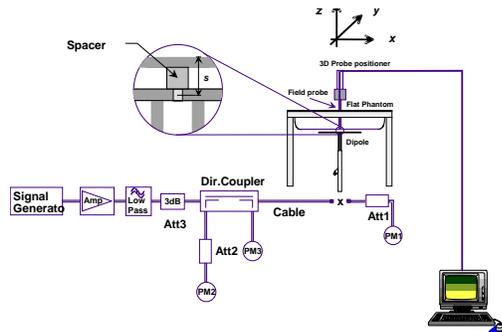
### Test System Verification

Prior to assessment, the system is verified to the  $\pm 10\%$  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 <sub>10g</sub> (W/kg)	Measure SAR <sub>10g</sub> (W/kg)	Tissue Used for Verification	Deviation (%)	Plot Number
17-Apr-2023	2450 MHz	25.00	25.30	Head	+ 1.20	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  $((\text{end}/\text{start})-1)*100$  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 22. 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. Both antennas have a minimum separation distance of 5 mm. Both transmitters are in the same band and the maximum power for BLE is 0.0 dBm (1.0 mW) and for ANT is 1.0 dBm (1.3 mW). Therefore, if the ANT transmitter is excluded, the BLE transmitter would also be excluded. The calculations are listed below.

For the FCC, the exclusion is based on the formula listed in 47 CFR 1.1310. For body, the exclusion limit is 3 mW and for extremity, it is 2.5 times the body limit which is 7.5 mW. The maximum power for the ANT transmitter is 1.3 mW which is below the 7.5 mW limit shown below.

$$P_{th}(\text{mW}) = \begin{cases} ERP_{20\text{cm}} (d/20 \text{ cm})^x & 0.5 \text{ cm} \leq d \leq 20 \text{ cm} \\ ERP_{20\text{cm}} & 20 \text{ cm} < d \leq 40 \text{ cm} \end{cases}$$

$$x = -\log_{10} \left( \frac{60}{ERP_{20\text{cm}} \sqrt{f}} \right)$$

$$ERP_{20\text{cm}}(\text{mW}) = \begin{cases} 2040f & 0.3 \text{ GHz} \leq f \leq 1.5 \text{ GHz} \\ 3060 & 1.5 \text{ GHz} < f \leq 6.0 \text{ GHz} \end{cases}$$

$d$  = separation distance (cm)

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 are 10.0 mW to be excluded. The maximum power for the transmitters is 1.3 mW which is below 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 <sup>3</sup>
		6 – 2437 MHz	Reduced <sup>3</sup>
		11 – 2462 MHz	Reduced <sup>3</sup>
802.11g	Back	1 – 2412 MHz	Reduced <sup>2</sup>
		6 – 2437 MHz	Reduced <sup>2</sup>
		11 – 2462 MHz	Reduced <sup>2</sup>
	All Other Sides	1 – 2412 MHz	Reduced <sup>3</sup>
		6 – 2437 MHz	Reduced <sup>3</sup>
		11 – 2462 MHz	Reduced <sup>3</sup>
802.11n	Back	1 – 2412 MHz	Reduced <sup>2</sup>
		6 – 2437 MHz	Reduced <sup>2</sup>
		11 – 2462 MHz	Reduced <sup>2</sup>
	All Other Sides	1 – 2412 MHz	Reduced <sup>3</sup>
		6 – 2437 MHz	Reduced <sup>3</sup>
		11 – 2462 MHz	Reduced <sup>3</sup>

Reduced<sup>1</sup> – 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<sup>2</sup> – 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<sup>3</sup> - The remaining sides are not used next to the body.

Mode	Side	Required Channel	Tested/Reduced
BT BR	Back	0 – 2402 MHz	Tested
		40 – 2442 MHz	Tested
		78 – 2480 MHz	Tested
	All Other Sides	0 – 2402 MHz	Reduced <sup>3</sup>
		40 – 2442 MHz	Reduced <sup>3</sup>
		78 – 2480 MHz	Reduced <sup>3</sup>
BLE	Back	0 – 2402 MHz	Reduced <sup>2</sup>
		40 – 2442 MHz	Reduced <sup>2</sup>
		78 – 2480 MHz	Reduced <sup>2</sup>
	All Other Sides	0 – 2402 MHz	Reduced <sup>2</sup>
		40 – 2442 MHz	Reduced <sup>2</sup>
		78 – 2480 MHz	Reduced <sup>2</sup>
ANT	Back	0 – 2402 MHz	Reduced <sup>2</sup>
		40 – 2442 MHz	Reduced <sup>2</sup>
		78 – 2480 MHz	Reduced <sup>2</sup>
	All Other Sides	0 – 2402 MHz	Reduced <sup>2</sup>
		40 – 2442 MHz	Reduced <sup>2</sup>
		78 – 2480 MHz	Reduced <sup>2</sup>

Reduced<sup>1</sup> – 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<sup>2</sup> – The transmitter is excluded per KDB447498 D01 v06 section 4.3.1 a) on page 12. See calculation on page 20-21 of this report.

Reduced<sup>3</sup> - The remaining sides are not used next to the body.

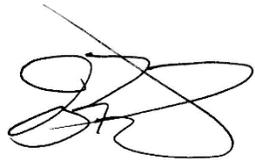
Band	Mode	Bandwidth (MHz)	Channel	Frequency (MHz)	Data Rate	Avg Power (dBm)	Tune-up Pwr (dBm)
2450 MHz	802.11b	20	1	2412	1 Mbps	18.92	20.00
			6	2437		19.11	20.00
			11	2462		19.14	20.00
	802.11g	20	1	2412	6 Mbps	Not Required	18.00
			6	2437			18.00
			11	2462			18.00
	802.11n	20	1	2412	HT0		18.00
			6	2437			18.00
			11	2462			18.00

Band	Mode	Channel	Frequency (MHz)	Avg Power (dBm)	Tune-up Pwr (dBm)
2450 MHz	Basic	1	2402	8.94	10.00
		40	2442	9.07	10.00
		78	2480	9.58	10.00
	BLE	0	2404	Not Required	0.00
		17	2440		0.00
		36	2478		0.00
	ANT	1	2402		1.00
		39	2440		1.00
		78	2480		1.00

**SAR Data Summary – 2450 MHz Extremity 802.11b & BT BR**

MEASUREMENT RESULTS								
Plot	Gap	Position	Frequency		Modulation	End Power (dBm)	Measured SAR (W/kg)	Reported SAR (W/kg)
			MHz	Ch.				
-----	0 mm	Back	2412	1	DSSS	18.92	0.218	0.28
1			2437	6	DSSS	19.11	0.266	0.33
-----			2462	11	DSSS	19.14	0.227	0.28
-----		Back	2402	1	Basic	8.94	0.0826	0.11
2			2442	40	Basic	9.07	0.0959	0.12
-----			2480	78	Basic	9.58	0.0887	0.10
						<b>Extremity</b> <b>4.0 W/kg (mW/g)</b> 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




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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	02/14/2024	02/14/2023	1217
SPEAG E-Field Probe EX3DV4	02/10/2024	02/10/2023	3662
Speag Validation Dipole D2450V2	06/03/2023	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
Apriel 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

```
*****  
Test Result for UIM Dielectric Parameter  
Mon 17/Apr/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  
2.4000         39.27  1.75   38.30  1.75  
2.4020         39.268 1.752  38.302 1.752*  
2.4100         39.26  1.76   38.31  1.76  
2.4120         39.258 1.762  38.306 1.762*  
2.4200         39.25  1.77   38.29  1.77  
2.4300         39.24  1.78   38.27  1.78  
2.4370         39.226 1.787  38.263 1.794*  
2.4400         39.22  1.79   38.26  1.80  
2.4420         39.216 1.792  38.25  1.802*  
2.4500         39.20  1.80   38.21  1.81  
2.4600         39.19  1.81   38.21  1.82  
2.4620         39.186 1.812  38.206 1.822*  
2.4700         39.17  1.82   38.19  1.83  
2.4720         39.168 1.822  38.186 1.836*  
2.4800         39.16  1.83   38.17  1.86  
2.4900         39.15  1.84   38.15  1.87
```

\* value interpolated

# RF Exposure Lab

## Plot 1

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

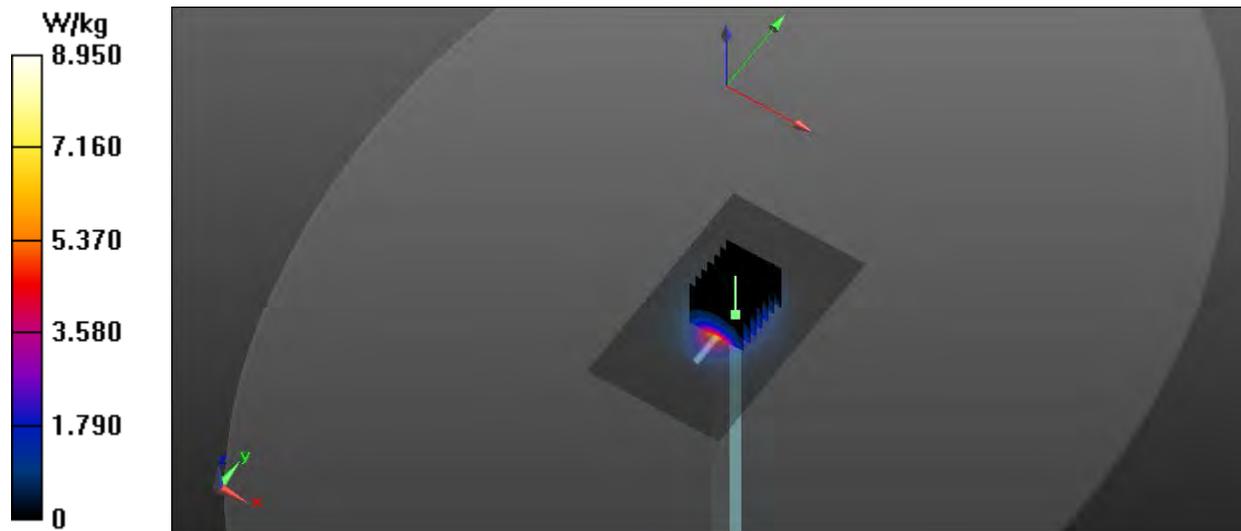
Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1  
Medium: HSL2450; Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.81$  S/m;  $\epsilon_r = 38.21$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section

Test Date: Date: 4/17/2023; Ambient Temp: 23 °C; Tissue Temp: 21 °C  
Probe: EX3DV4 – SN3662; ConvF(7.26, 7.26, 7.26); Calibrated: 2/10/2023;  
Sensor-Surface: 2mm (Mechanical Surface Detection)  
Electronics: DAE4 Sn1217; Calibrated: 2/14/2023  
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) = 8.41 W/kg

**Head Verification/2450 MHz/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm  
Reference Value = 59.112 V/m; Power Drift = -0.03 dB  
Peak SAR (extrapolated) = 11.06 W/kg  
 $P_{in} = 100$  mW  
**SAR(1 g) = 5.42 W/kg; SAR(10 g) = 2.53 W/kg**  
Maximum value of SAR (measured) = 8.94 W/kg



## **Appendix B – SAR Test Data Plots**

# RF Exposure Lab

## Plot 1

**DUT: A04724; Type: Transceiver; Serial: 441084957**

Communication System: WiFi 802.11b (DSSS, 1 Mbps); Frequency: 2437 MHz; Duty Cycle: 1:1  
Medium: HSL2450; Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 1.794$  S/m;  $\epsilon_r = 38.263$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section

Test Date: Date: 4/17/2023; Ambient Temp: 23 °C; Tissue Temp: 21 °C

Probe: EX3DV4 - SN3662; ConvF(7.26, 7.26, 7.26); Calibrated: 2/10/2023  
Sensor-Surface: 2mm (Mechanical Surface Detection)  
Electronics: DAE4 Sn1217; Calibrated: 2/14/2023  
Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 2037  
Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

### Procedure Notes:

**WiFi A04724/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) = 0.677 W/kg

**WiFi A04724/Back Mid 6/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

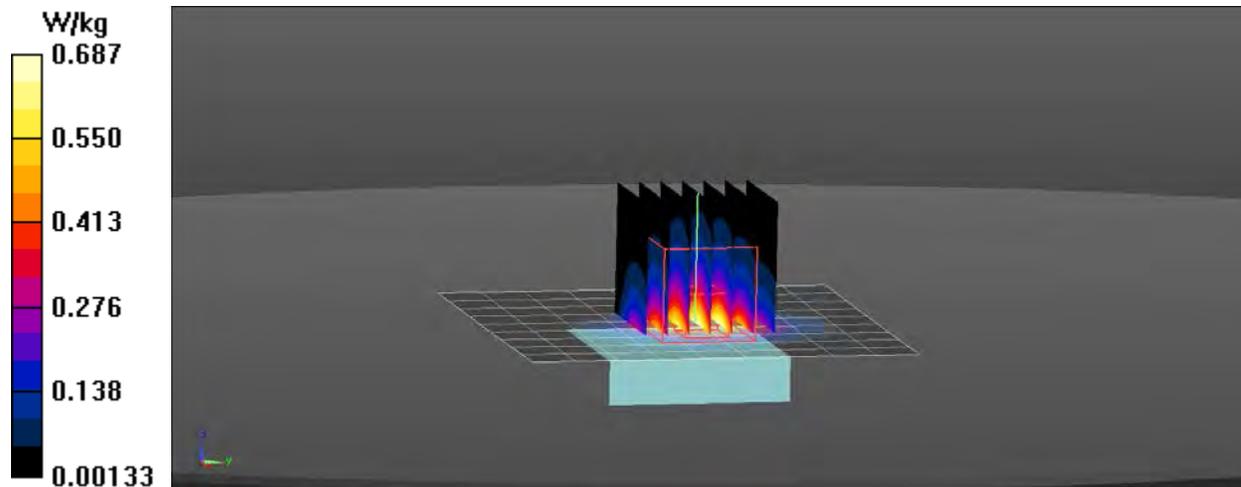
Reference Value = 17.07 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 0.872 W/kg

**SAR(1 g) = 0.522 W/kg; SAR(10 g) = 0.266 W/kg**

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.687 W/kg



# RF Exposure Lab

## Plot 2

**DUT: A04724; Type: Transceiver; Serial: 441084957**

Communication System: Bluetooth; Frequency: 2442 MHz; Duty Cycle: 1:1  
Medium: HSL2450; Medium parameters used (interpolated):  $f = 2442$  MHz;  $\sigma = 1.802$  S/m;  $\epsilon_r = 38.25$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section

Test Date: Date: 4/18/2023; Ambient Temp: 23 °C; Tissue Temp: 21 °C

Probe: EX3DV4 - SN3662; ConvF(7.26, 7.26, 7.26); Calibrated: 2/10/2023  
Sensor-Surface: 2mm (Mechanical Surface Detection)  
Electronics: DAE4 Sn1217; Calibrated: 2/14/2023  
Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 2037  
Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

### Procedure Notes:

**BT A04724/Back Mid 40/Area Scan (10x10x1):** Measurement grid: dx=10mm, dy=10mm

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.795 W/kg

**BT A04724/Back Mid 40/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

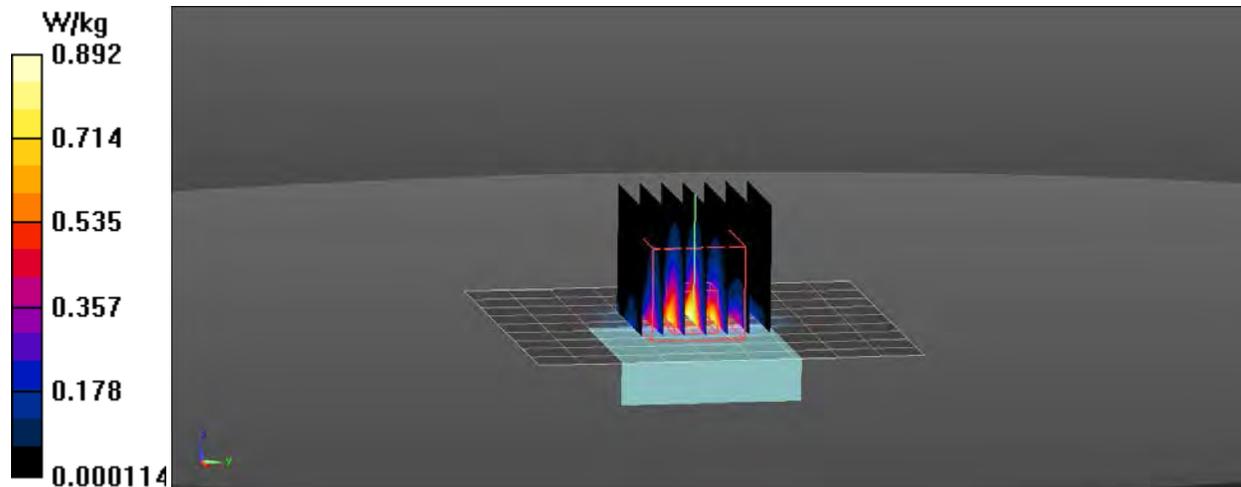
Reference Value = 19.98 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 1.32 W/kg

**SAR(1 g) = 0.671 W/kg; SAR(10 g) = 0.275 W/kg**

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.892 W/kg



## **Appendix D – Probe Calibration Data Sheets**



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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-3662\_Feb23**

**CALIBRATION CERTIFICATE**

Object **EX3DV4 - SN:3662**

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 **February 10, 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	Michael Weber	Laboratory Technician	
Approved by	Sven Kühn	Technical Manager	

Issued: February 10, 2023

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



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**

## Glossary

TSL	tissue simulating liquid
NORM <sub>x,y,z</sub>	sensitivity in free space
ConvF	sensitivity in TSL / NORM <sub>x,y,z</sub>
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization $\varphi$	$\varphi$ rotation around probe axis
Polarization $\vartheta$	$\vartheta$ 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:

- 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.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the E<sup>2</sup>-field uncertainty inside TSL (see below ConvF).
- NORM(f)<sub>x,y,z</sub>** = NORM<sub>x,y,z</sub> \* 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.
- DCP<sub>x,y,z</sub>**: 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
- A<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; D<sub>x,y,z</sub>; VR<sub>x,y,z</sub>**: 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 NORM<sub>x,y,z</sub> \* 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  $\pm 50$  MHz to  $\pm 100$  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 NORM<sub>x</sub> (no uncertainty required).

**Parameters of Probe: EX3DV4 - SN:3662****Basic Calibration Parameters**

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	0.41	0.49	0.48	±10.1%
DCP (mV) <sup>B</sup>	101.0	102.5	98.0	±4.7%

**Calibration Results for Modulation Response**

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Max dev.	Max Unc <sup>E</sup> k = 2
0	CW	X	0.00	0.00	1.00	0.00	150.8	±3.0%	±4.7%
		Y	0.00	0.00	1.00		161.2		
		Z	0.00	0.00	1.00		147.6		

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%.

<sup>A</sup> The uncertainties of Norm X,Y,Z do not affect the E<sup>2</sup>-field uncertainty inside TSL (see Page 5).

<sup>B</sup> Linearization parameter uncertainty for maximum specified field strength.

<sup>E</sup> 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:3662****Other Probe Parameters**

Sensor Arrangement	Triangular
Connector Angle	-96.9°
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:3662****Calibration Parameter Determined in Head Tissue Simulating Media**

f (MHz) <sup>C</sup>	Relative Permittivity <sup>F</sup>	Conductivity <sup>F</sup> (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha <sup>G</sup>	Depth <sup>G</sup> (mm)	Unc (k = 2)
150	52.3	0.76	11.68	11.68	11.68	0.00	1.00	±13.3%
220	49.0	0.81	11.50	11.50	11.50	0.00	1.00	±13.3%
300	45.3	0.87	11.22	11.22	11.22	0.09	1.00	±13.3%
450	43.5	0.87	10.79	10.79	10.79	0.16	1.30	±13.3%
600	42.7	0.88	10.35	10.35	10.35	0.10	1.25	±13.3%
750	41.9	0.89	9.28	9.28	9.28	0.53	0.80	±12.0%
900	41.5	0.97	8.80	8.80	8.80	0.51	0.80	±12.0%
1450	40.5	1.20	8.26	8.26	8.26	0.33	0.80	±12.0%
1640	40.2	1.31	8.10	8.10	8.10	0.37	0.86	±12.0%
1750	40.1	1.37	7.91	7.91	7.91	0.31	0.86	±12.0%
1900	40.0	1.40	7.67	7.67	7.67	0.34	0.86	±12.0%
2300	39.5	1.67	7.60	7.60	7.60	0.33	0.90	±12.0%
2450	39.2	1.80	7.26	7.26	7.26	0.44	0.90	±12.0%
2600	39.0	1.96	7.11	7.11	7.11	0.45	0.90	±12.0%
5250	35.9	4.71	5.00	5.00	5.00	0.40	1.80	±14.0%
5600	35.5	5.07	4.70	4.70	4.70	0.40	1.80	±14.0%
5750	35.4	5.22	4.85	4.85	4.85	0.40	1.80	±14.0%

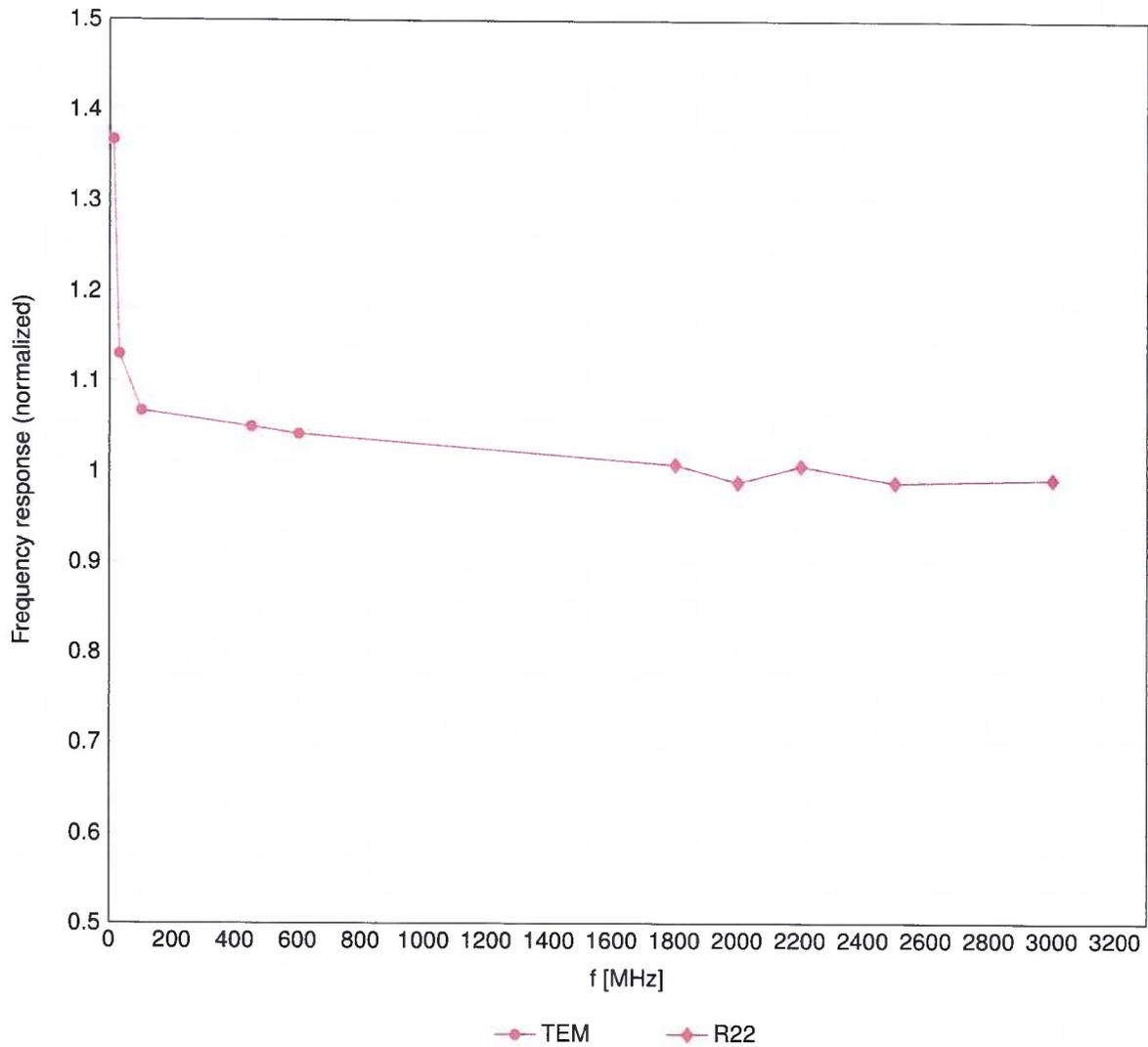
<sup>C</sup> Frequency validity above 300 MHz of ±100 MHz only applies for DASYS v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 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.

<sup>F</sup> The probes are calibrated using tissue simulating liquids (TSL) that deviate for  $\epsilon$  and  $\sigma$  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.

<sup>G</sup> 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.

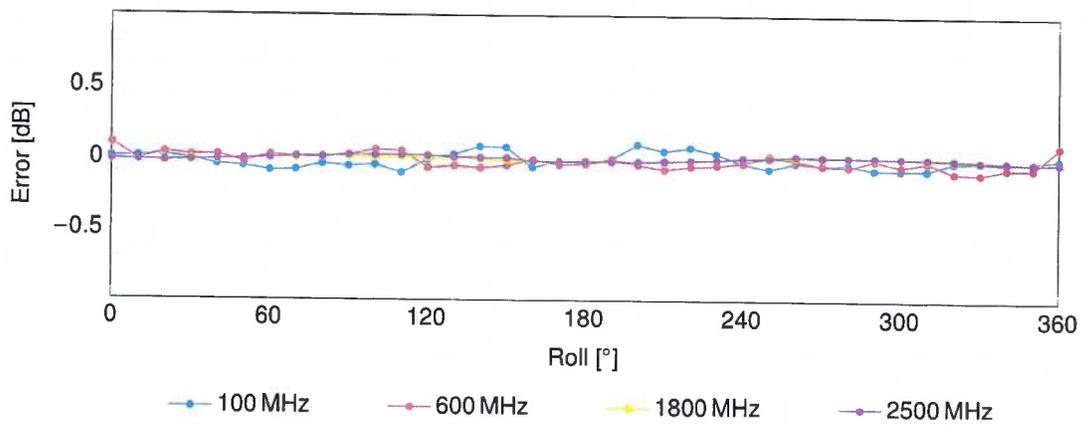
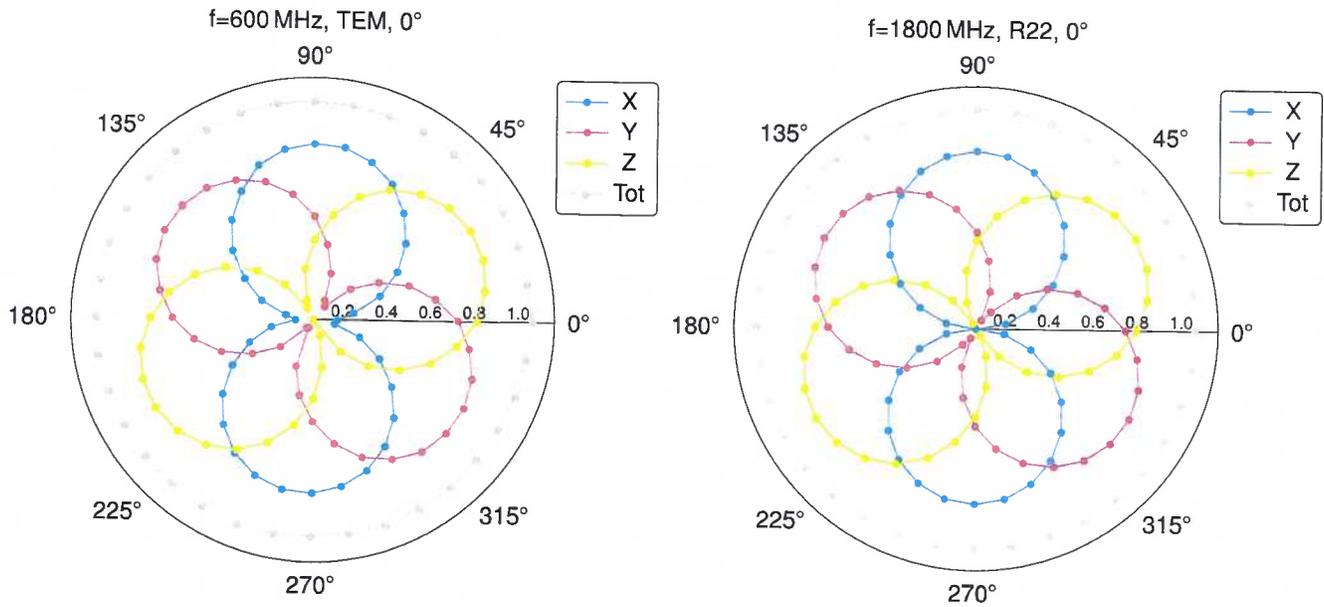
### Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

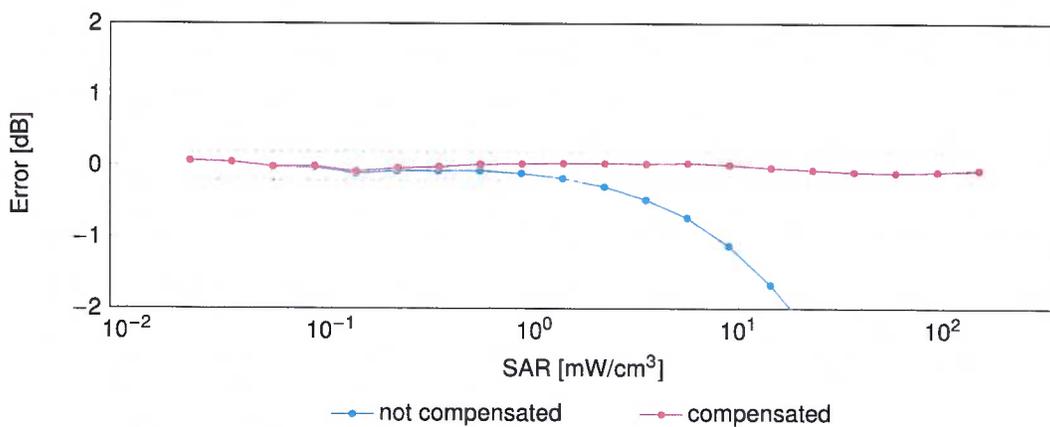
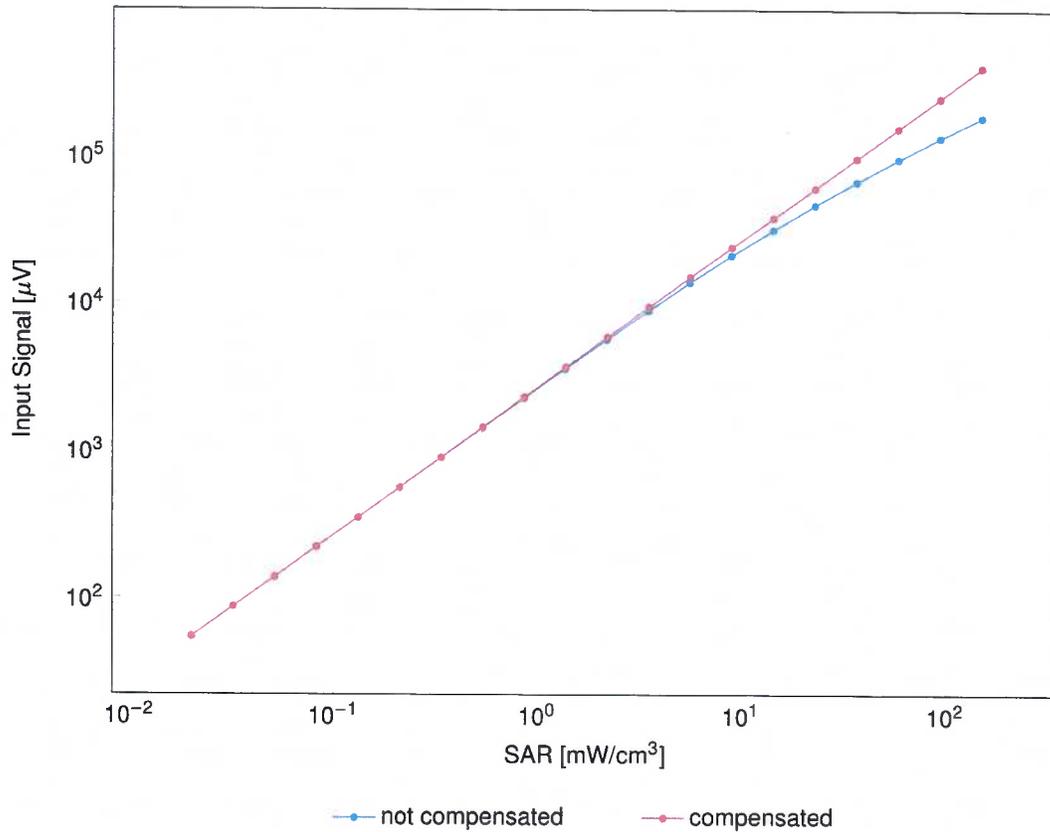
### Receiving Pattern ( $\phi$ ), $\theta = 0^\circ$



Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

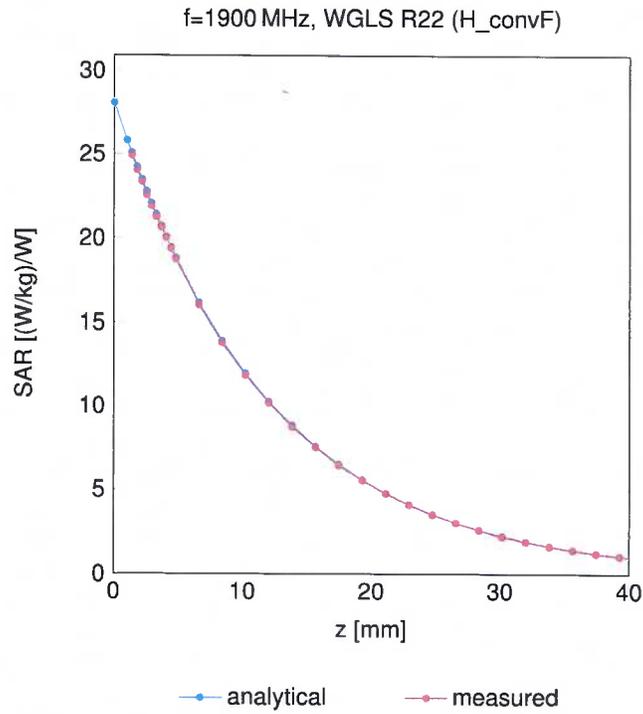
### Dynamic Range f(SAR<sub>head</sub>)

(TEM cell, f<sub>eval</sub> = 1900 MHz)



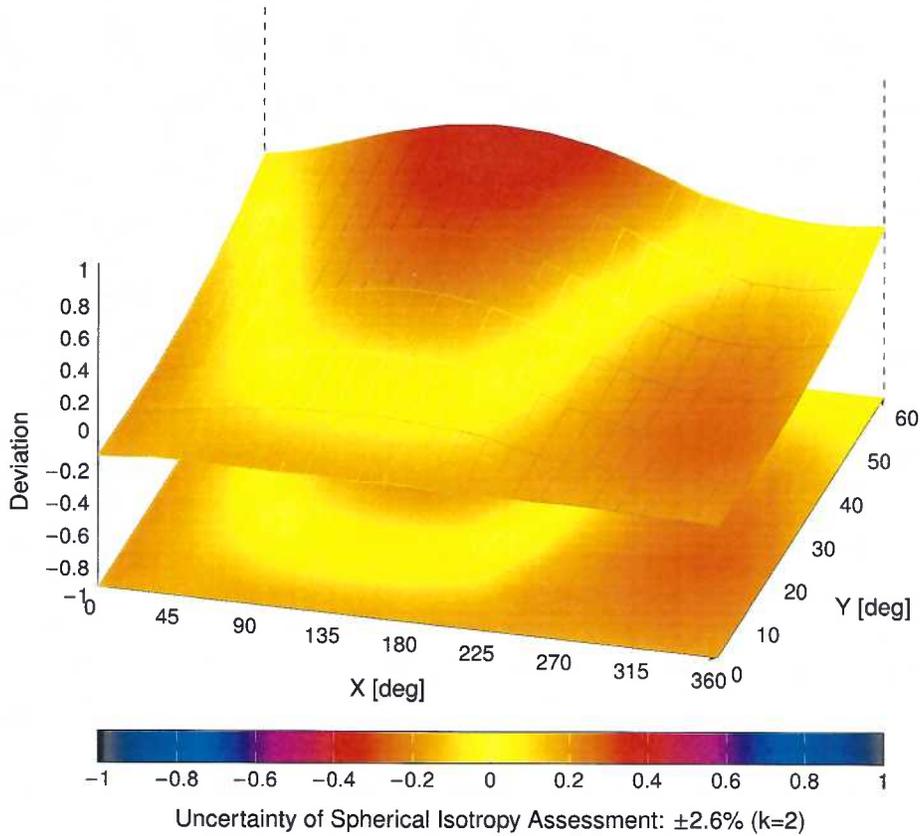
Uncertainty of Linearity Assessment: ±0.6% (k=2)

### Conversion Factor Assessment



### Deviation from Isotropy in Liquid

Error ( $\phi, \theta$ ), f = 900 MHz



## **Appendix E – Dipole Calibration Data Sheets**

*Jm*

**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  
**S** Swiss Calibration Service

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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	<i>J. Katzman</i>

Approved by:	Katja Pokovic	Technical Manager	<i>K. Pokovic</i>
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Issued: June 8, 2021

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Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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### 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:

- 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
- 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
- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- 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.

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

## Head TSL parameters

The following parameters and calculations were applied.

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

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	13.9 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>54.1 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>25.0 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.3 $\Omega$ + 4.3 j $\Omega$
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
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#### 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)	$\Delta\%$	Impedance Real ( $\Omega$ )	$\Delta\Omega$	Impedance Imaginary (j $\Omega$ )	$\Delta\Omega$
6/3/2021	-24.7		54.3		4.3	
6/3/2022	-25.3	2.4	55.2	0.9	4.1	-0.2

# 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;  $\sigma = 1.87$  S/m;  $\epsilon_r = 37.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>

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

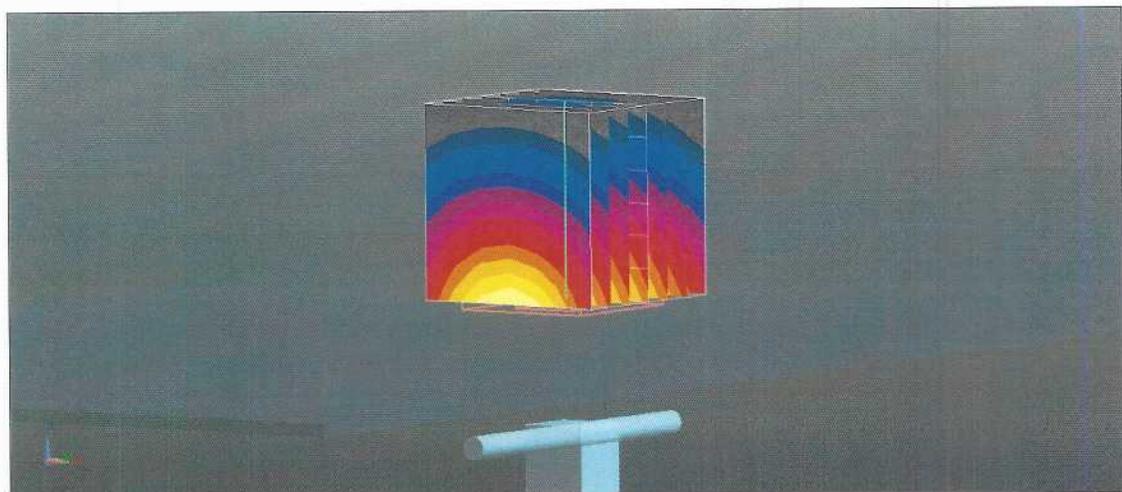
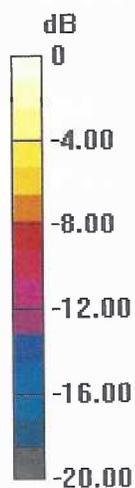
Peak SAR (extrapolated) = 28.0 W/kg

**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

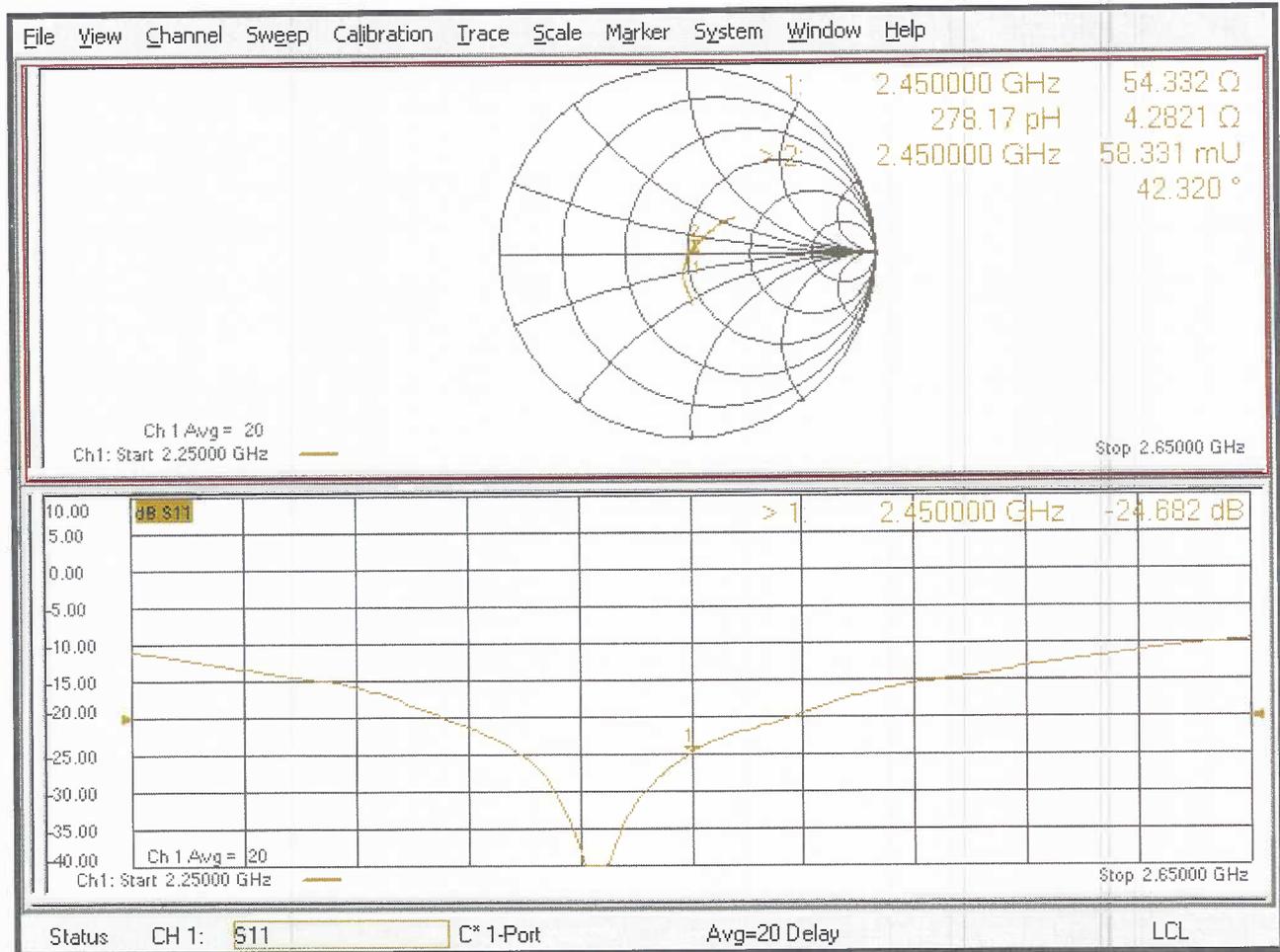
Ratio of SAR at M2 to SAR at M1 = 49.5%

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



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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: **DAE4-1217\_Feb23**

**CALIBRATION CERTIFICATE**

Object **DAE4 - SD 000 D04 BJ - SN: 1217**

Calibration procedure(s) **QA CAL-06.v30  
Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **February 14, 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

Calibrated by: **Name** Adrian Gehring **Function** Laboratory Technician

**Signature**

Approved by: **Name** Sven Kühn **Function** Technical Manager

Issued: February 14, 2023

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



Accredited by the Swiss Accreditation Service (SAS)  
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## 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 = 6.1 $\mu$ V, 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	403.728 $\pm$ 0.02% (k=2)	404.159 $\pm$ 0.02% (k=2)	403.544 $\pm$ 0.02% (k=2)
Low Range	3.96075 $\pm$ 1.50% (k=2)	3.99910 $\pm$ 1.50% (k=2)	3.95128 $\pm$ 1.50% (k=2)

## Connector Angle

Connector Angle to be used in DASY system	282.0 $^{\circ}$ $\pm$ 1 $^{\circ}$
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## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

High Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	199998.06	3.61	0.00
Channel X + Input	20004.03	1.44	0.01
Channel X - Input	-19999.29	1.91	-0.01
Channel Y + Input	199998.59	4.10	0.00
Channel Y + Input	20003.11	0.68	0.00
Channel Y - Input	-20001.61	-0.37	0.00
Channel Z + Input	199993.34	-1.05	-0.00
Channel Z + Input	20000.75	-1.64	-0.01
Channel Z - Input	-20002.31	-0.99	0.00

Low Range	Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X + Input	2003.09	1.39	0.07
Channel X + Input	202.30	0.39	0.19
Channel X - Input	-197.64	0.35	-0.18
Channel Y + Input	2002.61	1.16	0.06
Channel Y + Input	201.33	-0.48	-0.24
Channel Y - Input	-198.30	-0.26	0.13
Channel Z + Input	2002.06	0.74	0.04
Channel Z + Input	200.23	-1.45	-0.72
Channel Z - Input	-199.25	-1.07	0.54

### 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 ( $\mu\text{V}$ )	Low Range Average Reading ( $\mu\text{V}$ )
Channel X	200	-1.27	-3.91
	- 200	5.04	3.07
Channel Y	200	17.98	17.91
	- 200	-19.51	-19.36
Channel Z	200	-13.62	-13.42
	- 200	11.84	11.45

### 3. Channel separation

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

	Input Voltage (mV)	Channel X ( $\mu\text{V}$ )	Channel Y ( $\mu\text{V}$ )	Channel Z ( $\mu\text{V}$ )
Channel X	200	-	0.66	-4.91
Channel Y	200	7.42	-	0.76
Channel Z	200	10.20	5.17	-

#### 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	16287	14305
Channel Y	15792	14215
Channel Z	16818	15854

#### 5. Input Offset Measurement

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

Input 10M $\Omega$

	Average ( $\mu$ V)	min. Offset ( $\mu$ V)	max. Offset ( $\mu$ V)	Std. Deviation ( $\mu$ V)
Channel X	0.55	-0.41	1.58	0.43
Channel Y	-0.44	-2.12	0.86	0.55
Channel Z	-0.77	-2.07	0.55	0.49

#### 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**

**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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## 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 G-1  
SAR System Validation Summary**

SAR System #	Freq. (MHz)	Date	Probe S/N	Probe Type	Probe Cal. Point	Cond. ( $\sigma$ )	Perm. ( $\epsilon_r$ )	CW Validation			Modulation Validation			
								Sensitivity	Probe Linearity	Probe Isotropy	Modulation Type	Duty Factor	PAR	
3	2450	4/22/2023	3662	EX3DV4	2450	Head	1.83	38.56	Pass	Pass	Pass	BT BR	Pass	Pass
3	2450	4/22/2023	3662	EX3DV4	2450	Head	1.85	38.76	Pass	Pass	Pass	OFDM/TDD	Pass	Pass