Test Report 2023-017

Version B
Issued 19 Apr 2023

Project GCL-0304
Product Model A04431
Primary Test Standard
FCC part 15.225
RSS-210 Issue 10
ICES-003 Issue 7

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

Client-supplied Information
FCC ID: IPH-04431
IC ID: 1792A-04431

ACCREDITED
CERTIFICATE #6162.01

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

1. Summary

The equipment or product described in section 5 of this report was tested at the Garmin Compliance Lab according to standards listed in section 6. 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]	26.6 dB of margin to the intentional emission limit.	PASS	10
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]	11.80 dB of margin to the Class B limit.	PASS	10
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]	7.59 dB of margin to the appropriate limit. Tested 150 kHz to 30 MHz applying combined Class B limits.	PASS	19
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	23
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	26

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 2023-023. That report is treated as a part of this document by way of this reference.

2. Test Background

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

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

Test Sample received: 31 Jan 2023
Test Start Date: 07 Feb 2023
Test End Date: 19 Apr 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.

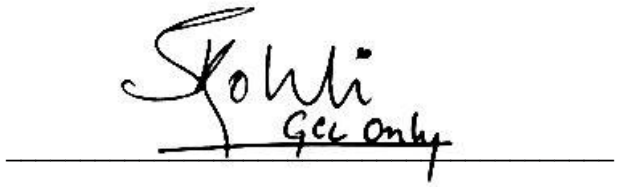
3. Report History and Approval

This report was written by Christian Shepherd and initially issued on 4 Apr 2023 as Version A.
David Arnett created Version B on 19 April 2023, correcting the test table height below 30 MHz.

Report Technical Review:

David Arnett
Technical Lead EMC Engineer

Report Approval:



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

4. Test Sample Modifications and Special Conditions

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

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

Modifications 1 and 2 only affected relevant Wi-Fi power levels. Other radio services were not changed, therefore not retested.

Modification 1
Detailed Description: Wi-Fi power table changed. Below are the following changes:
SW Version 12.58
Transmit power was reduced for Wi-Fi channels 1-4 and 8-11 in 802.11g mode, channels 1-4 and 9-11 in 802.11n mode, and channel 11 in 802.11b mode.
Date applied: 2/10/2023
Reason for this modification: Decrease Wi-Fi power levels to meet FCC restricted band limits.

Previous testing on modified channels was repeated. The test(s) that were affected and needed a retest on the modified channels only were: FCC restricted bands and transmit power.
Modification 2
Detailed Description: Wi-Fi power table changed. Below are the following changes:
SW Version 12.59
Transmit power was reduced for Wi-Fi channel 10 in 802.11n mode.
Date applied: 2/15/2023
Reason for this modification: Decrease Wi-Fi power levels to meet FCC restricted band limits.
Previous testing on modified channels was repeated. The test(s) that were affected and needed a retest on the modified channels only were: FCC restricted bands and transmit power.

Modification 3
Detailed Description: Software update. Below are the following changes:
SW Version 12.60
Date applied: 2/17/2023
Reason for this modification: Update to newest software version.
This change improved EUT functionality but did not affect EMC performance. No previous testing was affected.

Modification 4
Detailed Description: Functional updates.
SW Version 12.63
Date applied: 2/23/2023
Reason for this modification: Functional updates that were not relevant to radio performance under the US and Canadian rules. Previous US/Canada testing was not repeated.

5. Description of the Equipment Tested

5.1 Unique Identification

Product Model	A04431
Serial Numbers Tested	3437296994

This product tested is a portable device with Wi-Fi, BLE, NFC and other connectivity/electronic features used for various activities.

The client affirmed that the test samples will be representative of production in all relevant aspects.

5.2 Key Parameters

EUT Input Power:	5 Vdc
I/O Ports:	Digital data port with DC power
Radio Transceivers:	IEEE 802.11 b/g/n, Bluetooth, Bluetooth Low Energy, ANT, NFC
Highest internal frequency:	275 MHz
Firmware Revision	See section 4 of this report
Primary Functions:	Creation, collection, and transfer of data.

5.3 Operating modes

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

Mode 1: M1 (NFC Tx). EUT linked to NFC reader pad and transmitting data
Mode 2: M2 (NFC Lnk). EUT linked to NFC reader pad and transmitting data.
Mode 3: M3 (BLE Tx). EUT in test mode-BLE Tx always On.
Mode 4: M4 (BLE Lnk). EUT linked to companion device through BLE.
Mode 7: M7 (ANT Tx). EUT in test mode- ANT Tx always On.
Mode 8: M8 (ANT Lnk). EUT linked to companion device through ANT.
Mode 9: M9 (WiFi Tx). EUT in test mode- Wi-Fi Tx always On.
Mode 10: M10 (NFC Act.). EUT in operating mode linked to NFC reader pad.
Mode 11: M11 (NFC Stnd.). EUT in standby mode awaiting connection to NFC reader pad.
Mode 12: M12 (WiFi Lnk). EUT linked to access point and transmitting data
Mode 13: M13 (All). All relevant radios turned On.
Mode 14: M14 (BLE Rx). EUT in test mode- BLE Rx always On.
Mode 15: M15 (WiFi Rx). EUT in test mode- BLE Rx always On.
Mode 16: M16 (Tx Off). All transmitters turned off on EUT
Mode 17: M17 (BT Class Tx). EUT in test mode- BT Classic Tx always On.
Mode 18: M18 (BT Class Lnk). EUT linked to companion device through Bluetooth Classic.
Mode 19: M19 (BT Class Hop). EUT transmitting Bluetooth Classic while hopping channels.

5.4 EUT Arrangement

During test, the EUT components and associated support equipment were selected including the following arrangement sets.
Arrangement 1: A1 (PwrA) EUT powered up through a DC power supply

Arrangement 2: A2 (NFC) EUT is standalone in NFC mode and near to an NFC reader device

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

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

Arrangement 5: A5 (PwrA+NFC) EUT Powered up through arrangement A1 in NFC mode and near to an NFC reader device

5.5 Associated Equipment (AE) used

Description	Manufacturer	Model	Serial Number

Smartwatch	Garmin	A04112	3400414926
Laptop	Dell	Latitude 5410	5VSPFB3
Laptop power supply	Dell	65 W	CN-OH374X-CH200-OBD-7TC0-A02
NFC reader	ACS	ACR1252	RR554-086776
AC Power adaptor	Garmin	362-00096-00	N/A
iPad	Apple	iPad Pro (11-inch)	DMPZ7582KD6L
Smartwatch	Garmin	A04600	3423419439
Router	TP-Link	Archer C54	Y21C0A5009834
Headset	Garmin	DEZL 200	N/A
Modified Headset	Garmin	DEZL 200	N/A

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.

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

6.2. Non-accredited Standards

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

TRC-43 Issue 3

6.3 Variances

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

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

6.4 Laboratory Accreditation

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

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

7 Measurement Instrumentation Uncertainty

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

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

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

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

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

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

8 Selected Example Calculations

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

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

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

8.1 AC Mains conducted emissions at 22 MHz

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

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

8.2 Radiated Emissions at 630 MHz

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

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

8.3 Radiated Emissions at 2.7 GHz

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

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

9 Environmental Conditions During Test

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

Temperature:	20.3 to 28.4 °C
Relative Humidity:	39.1% to 59.2% (non-condensing)
Barometric Pressure	94.9 to 99.9 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
Radiated Emission Test RE14
Project GCL0304

Test Date(s)	18 Apr 2023
Test Personnel	David Kerr
Product Model	A04431
Serial Number tested	3437296994
Operating Mode	M1 (NFC Tx) Type A
Arrangement	A2 (NFC)
Input Power	USB 5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-210, RSS-GEN (as noted in Section 6 of the report).
Frequency Range:	10 MHz to 30 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	Jim Solum
Date of this record:	18 Apr 2023

Original record, Version A. Dated 21 Mar 2023
Version B. Corrected EUT table height. Frequency range 10MHz to 30MHz

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	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	10721	15-Aug-2022	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE14.1: Test Equipment Used

Software Used

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

Test Data

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

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

The table shows the selected final measurement data between 10 MHz and 30 MHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted 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
12.711	49.5	-2.0	20.5	-31.0	29.0	-7	1500	x
13.137	60.5	9.0	20.6	-30.9	39.9	173	1500	x
13.348	60.5	9.0	26.3	-25.2	34.2	-7	1500	x
13.454	70.5	19.0	25.5	-26.0	45.0	-1	1500	x
13.560	104.0	52.5	55.7	4.2	48.3	-3	1500	x
13.985	60.5	9.0	20.5	-31.0	40.0	152	1500	x

Table RE014.2: 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.

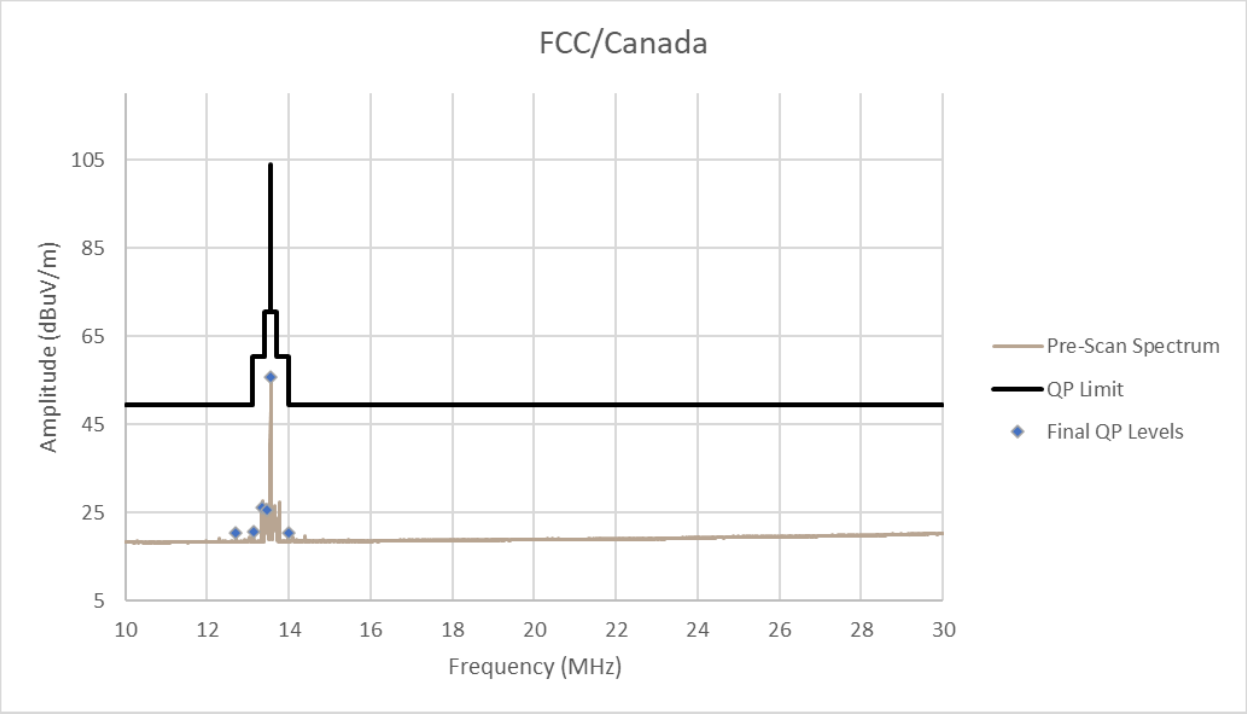


Figure RE014.3: Spectral data (FCC/Canada)

Setup Photographs

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

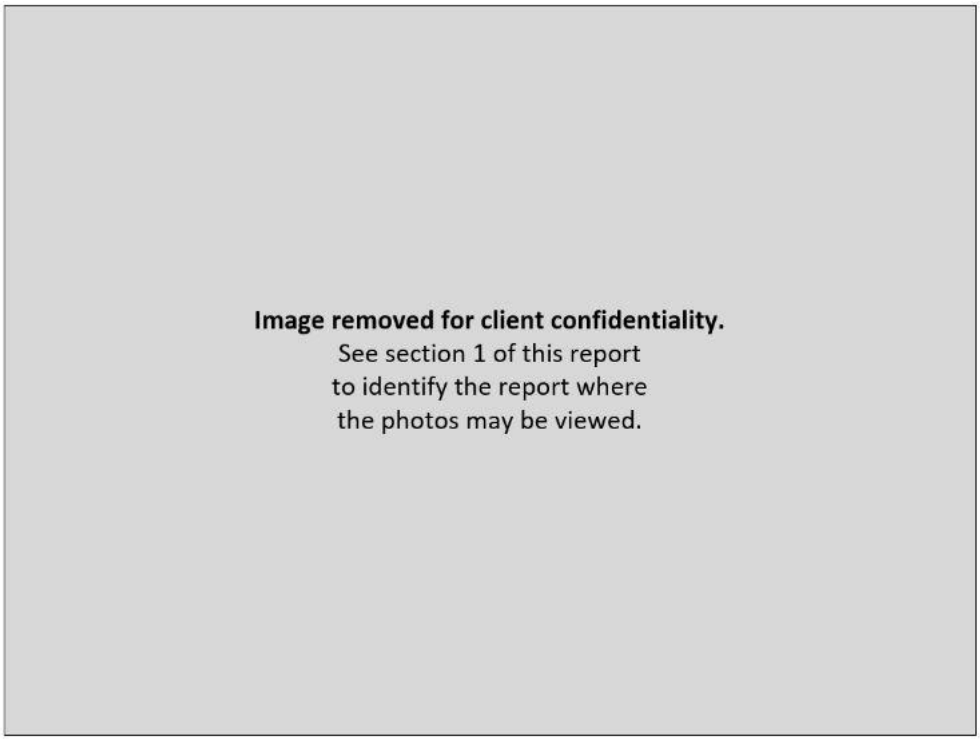


Figure RE014.4: EUT test setup, front view (Antenna X Orientation)

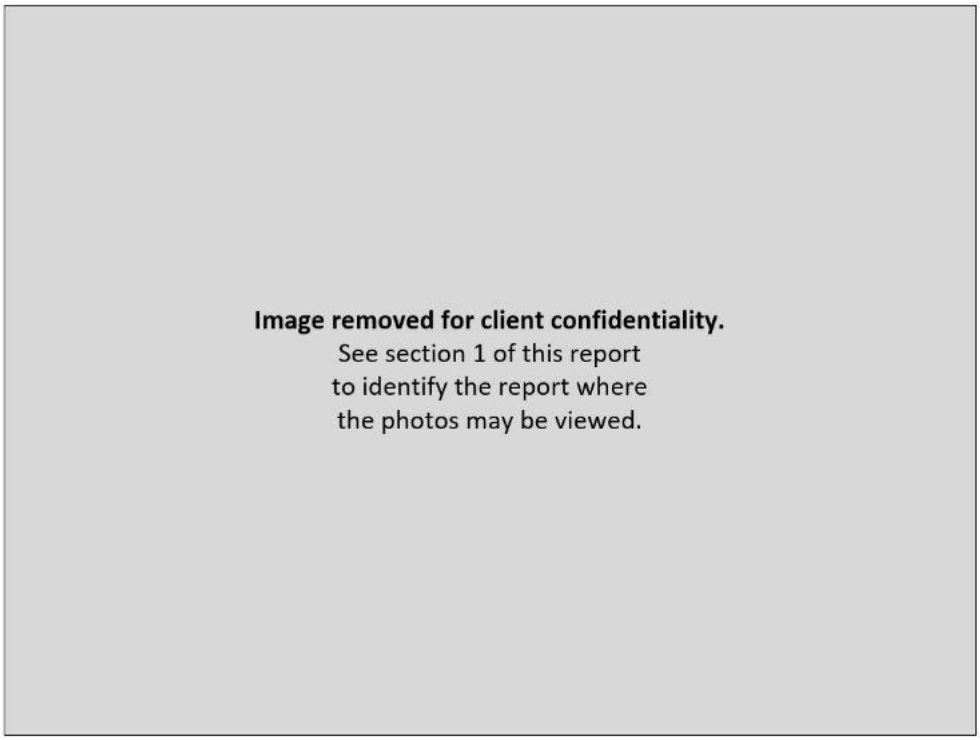


Figure RE014.5: EUT test setup, rear view (Antenna X Orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE15
Project GCL0304

Test Date(s)	19 Apr 2023
Test Personnel	David Kerr
Product Model	A04431
Serial Number tested	3437296994
Operating Mode	M1 (NFC Tx) Type B
Arrangement	A2 (NFC)
Input Power	USB 5 Vdc
Test Standards:	FCC Part 15, ANSI C63.10, RSS-210, RSS-GEN (as noted in Section 6 of the report).
Frequency Range:	10 MHz to 30 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	Jim Solum
Date of this record:	19 Apr 2023

Original record, Version A. Dated 21 Mar 2023
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Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
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Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE15.1: Test Equipment Used

Software Used

PXE Firmware version A.32.06
GCL RE 150k to 30M Signal Maximization Tool V1 2021Mar17.xlsx
GCL RE 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.

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The table shows the selected final measurement data between 10 MHz and 30 MHz. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted 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
10.286	49.5	-2.0	22.9	-28.6	26.6	-79	1500	X
13.515	70.5	19.0	19.7	-31.8	50.8	-85	1500	X
13.560	104.0	52.5	55.6	4.1	48.4	-1	1500	X
15.920	49.5	-2.0	19.9	-31.6	29.6	88	1500	X
16.316	49.5	-2.0	19.9	-31.6	29.6	176	1500	X
29.904	49.5	-2.0	21.5	-30.0	28.0	10	1500	X

Table RE015.2: 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.

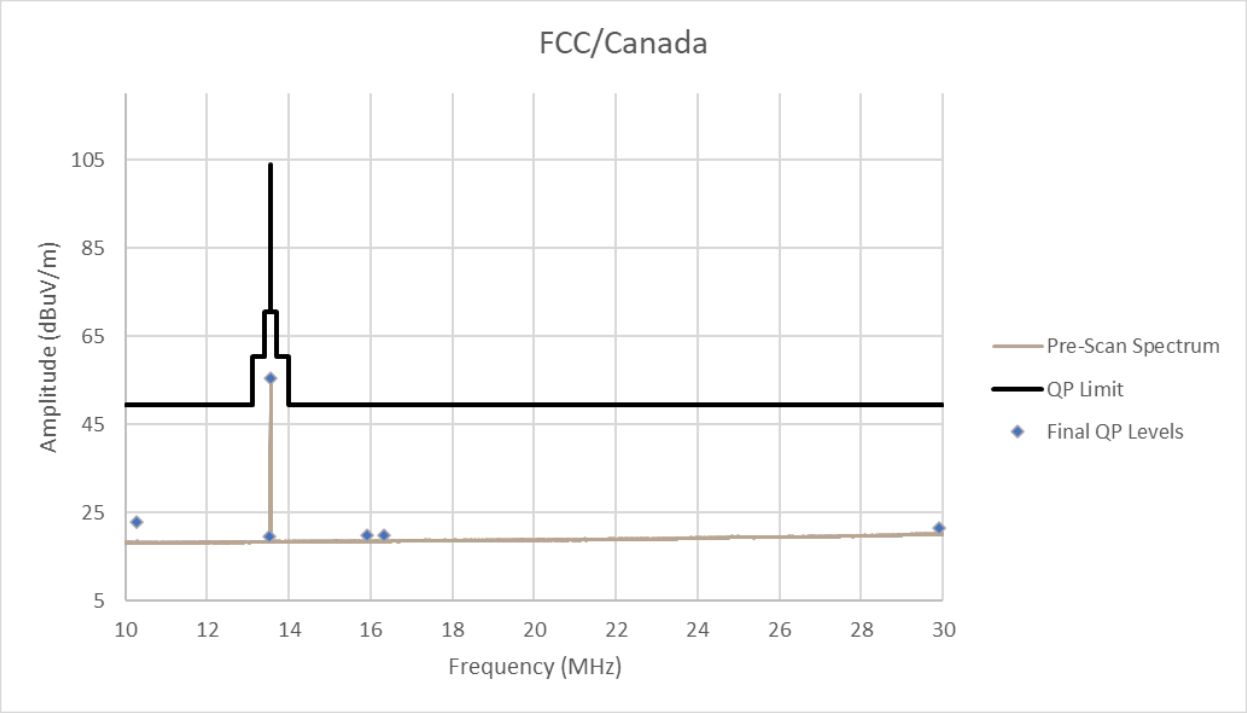

Figure RE015.3: Spectral data (FCC/Canada)

Setup Photographs

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

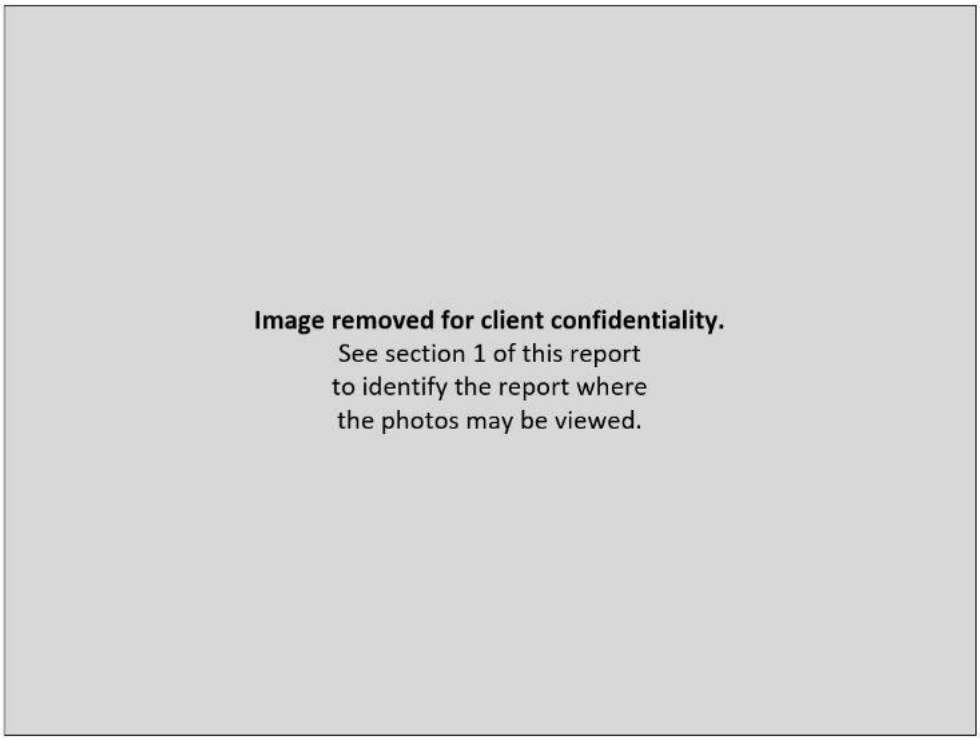

Figure RE015.4: EUT test setup, front view (Antenna X Orientation)

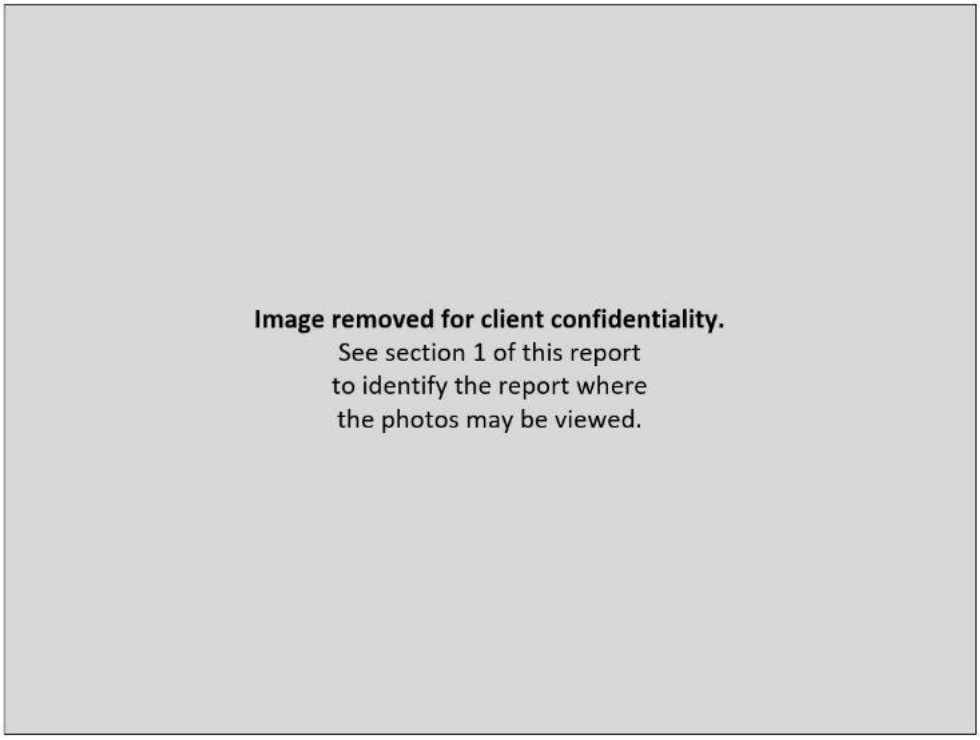

Figure RE015.5: EUT test setup, reverse view (Antenna X Orientation)

This line is the end of the test record.

Test Record
Radiated Emission Test RE03
Project GCL0304

Test Date(s)	23 Feb 2023
Test Personnel	David Kerr
Product Model	A04431
Serial Number tested	3437296994
Operating Mode	M1 (NFC Tx)
Arrangement	A2 (NFC)
Input Power	Internal battery power
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN, RSS-210 (as noted in Section 6 of the report).
Frequency Range:	30 MHz to 150 MHz
Pass/Fail Judgment:	**PASS**
Test record created by:	**Jim Solum**
Date of this record:	**03 Mar 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Antenna, Biconilog, 30M-6 GHz	ETS Lindgren	3142E	00233201	19-Jul-2022	15-Jul-2024
SAC 3m, below 1 GHz	Frankonia	SAC3	F199004	7-Nov-2022	7-Nov-2025
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10720	16-Jan-2023	15-Jan-2026
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024

Table RE03.1: Test Equipment Used

Software Used

Keysight PXE software A.32.06
RE SUB Signal Maximization Tool V4.xlsx (Test)
RE Substitution Signal Maximization Tool V1.xlsx (Analysis)

Test Data

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

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

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

The table shows the selected final measurement data between 30 MHz and 150 MHz, covering the 10th harmonic of the NFC radio. It includes at least the six strongest emissions observed relative to the test limit, along with other data points of interest. Where a data point is highlighted is yellow, this is an aid to indicate the data point(s) with the least margin to the test limit. A positive margin value indicates that the emission was below the test limit. The test limit is the Composite FCC Class B Limit at 3m.

Frequency	Field	Rx Height	Turntable	Q-Peak	QP Limit	QP Margin
MHz	Polarity	mm	Angle	dBuV/m	dBuV/m	dB
40.680	VERT	1434	-170	26.29	40.0	13.71
47.100	VERT	1012	10	25.14	40.0	14.86
51.210	VERT	1034	46	20.92	40.0	19.08
55.290	VERT	1074	55	19.24	40.0	20.76
77.520	VERT	3328	75	16.87	40.0	23.13
102.690	VERT	2189	-131	31.70	43.5	11.80

Table RE03.2: Emission summary

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

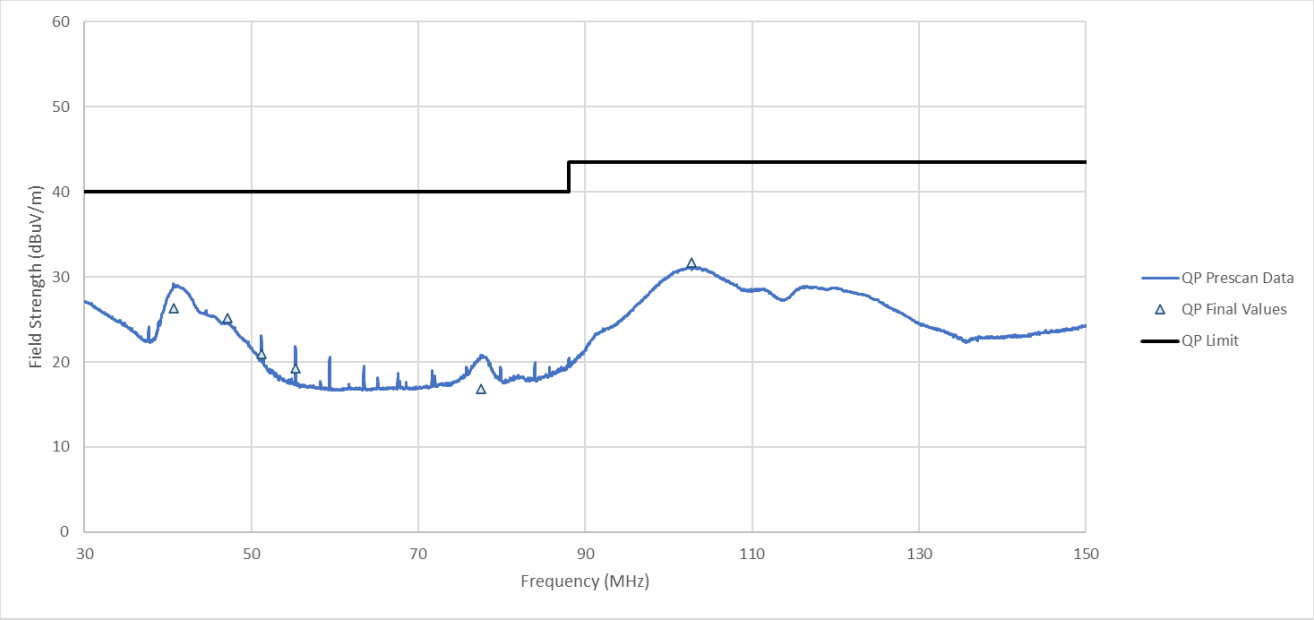

Figure RE03.1: Spectral data

Setup Photographs

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

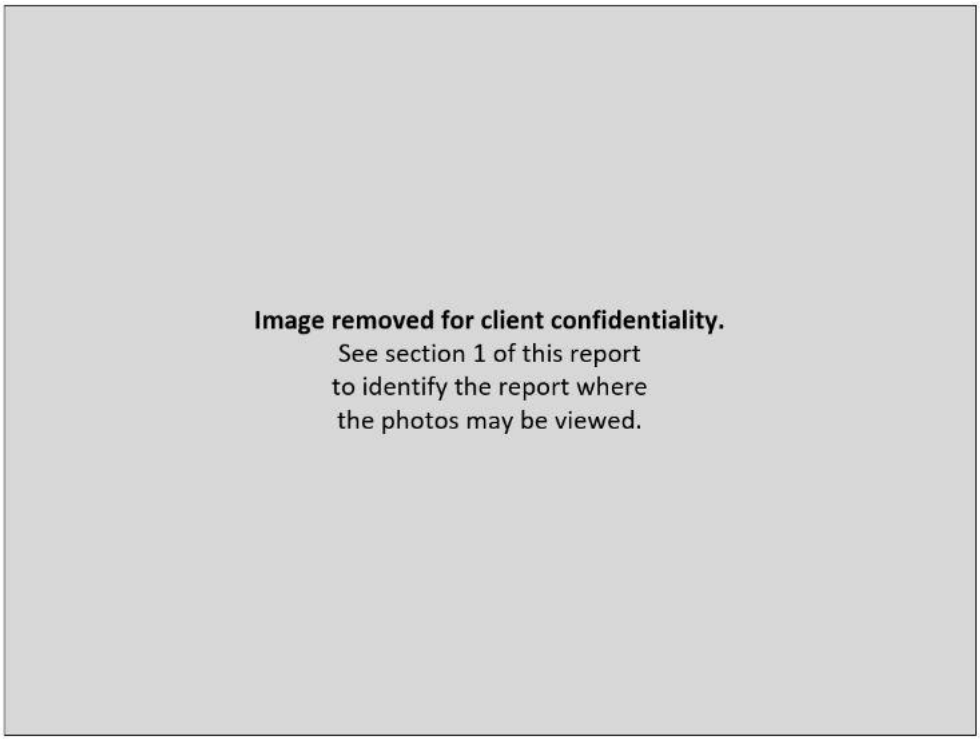

Figure RE03.2: EUT test setup, front view

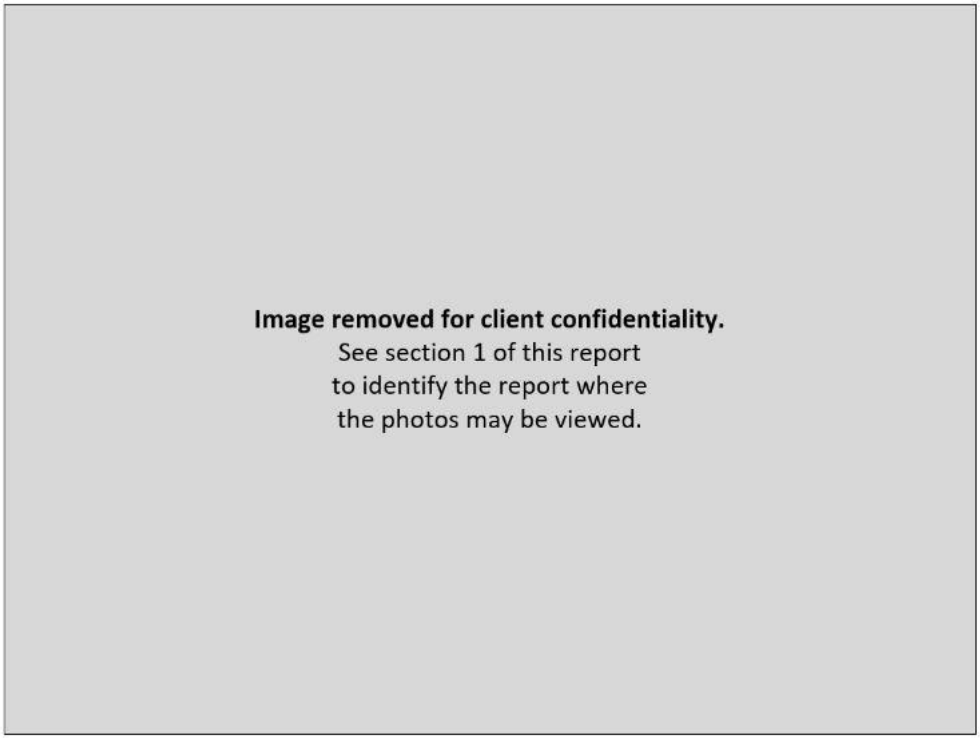

Figure RE03.3: EUT test setup, reverse view

This line is the end of the test record.

Test Record
Conducted Emissions Mains Test CE04
Project GCL0304

Test Date(s)	20 Feb 2023
Test Personnel	Christian Shepherd assisted by Jim Solum
Product Model	A04431
Serial Number tested	3437296994
Operating Mode	M1 (NFC Tx)
Arrangement	A2 (PwrA)
Input Power	120 Vac 60 Hz
Test Standards:	FCC Part 15, ANSI C63.4, RSS-210, RSS-GEN (as noted in Section 6 of the report).
Frequency Range:	150 kHz to 30 MHz
Pass/Fail Judgment:	**PASS**

Test record created by: Christian Shepherd
Date of this record: 02 Mar 2023

Original record, Version A.

Test Equipment Used

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
PXE Receiver	Keysight	N9048B	MY59290135	21-Sep-2022	15-Sep-2023
Tape measure, 1" x 33'	Lufkin	PHV1410CMEN	10721	15-Aug-2022	15-Aug-2023
DMM Multimeter	FLUKE	79 III	71740743	18-Apr-2022	15-Apr-2023
Barometer	Traceable	6453	221702700	3-Aug-2022	1-Aug-2024
LISN multiline; 15A to 9kHz	Com-Power	LI-215A	192027	22-Aug-2022	15-Aug-2023

Table CE04.1: Test Equipment Used

Software Used
PXE Receiver firmware version A.32.06

Test Data

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

The table shows the selected final measurement data. It includes at least the six strongest emissions observed relative to the limit lines, along with other data points of interest. The yellow highlight indicate the data points with the least margin to the quasi-peak detector limit and the average detector limit. A positive margin value indicates that the emission was below the test limit. The test limit is the Composite FCC/CISPR Class B Limit. There is no limit for the 13.56 MHz signal because it is the intentional transmission of the NFC transmitter.

Frequency (kHz)	QP Limit (dBuV)	AV Limit (dBuV)	L1 QP (dBuV)	L2 QP (dBuV)	L1 AV (dBuV)	L2 AV (dBuV)	QP Margin (dB)	AV Margin (dB)
150	66	56	34.28	37.02	20.21	19.53	28.98	35.79
659	56	46	42.77	39.46	32.5	32.29	13.23	13.50
690	56	46	43.45	38.76	33.55	32.23	12.55	12.45
1347	56	46	34.07	27.4	23.27	20.72	21.93	22.73
3428	56	46	42.95	38.71	38.41	34.63	13.05	7.59
10131	60	50	34.6	30.54	29.04	26.49	25.40	20.96
10286	60	50	44.71	40.87	39.82	37.27	15.29	10.18
13560	N/A	N/A	56.58	52.42	50.04	47.86	N/A	N/A
17142	60	50	42.55	39.68	36.16	34.05	17.45	13.84
24000	60	50	32.33	32.67	32.3	31.42	27.33	17.70

Table CE04.2: Emission summary

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

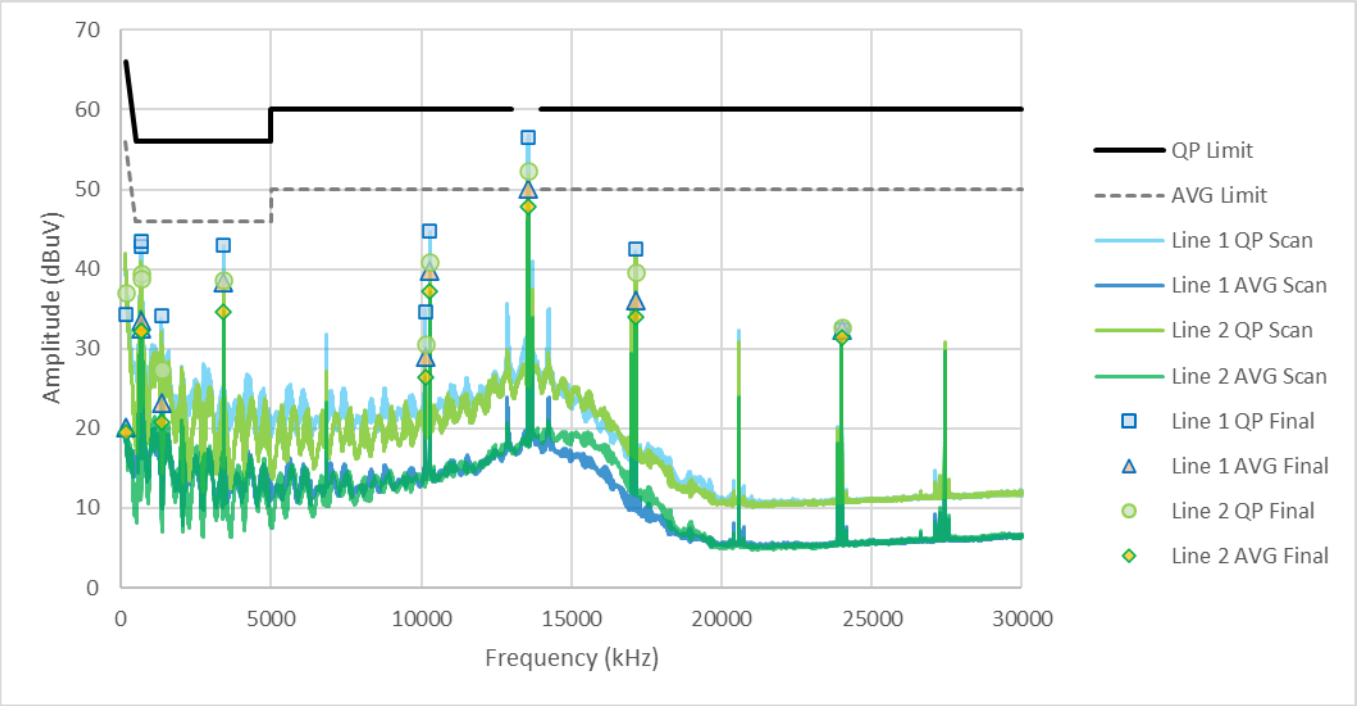

Figure CE04.1: Spectral data

Setup Photographs

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

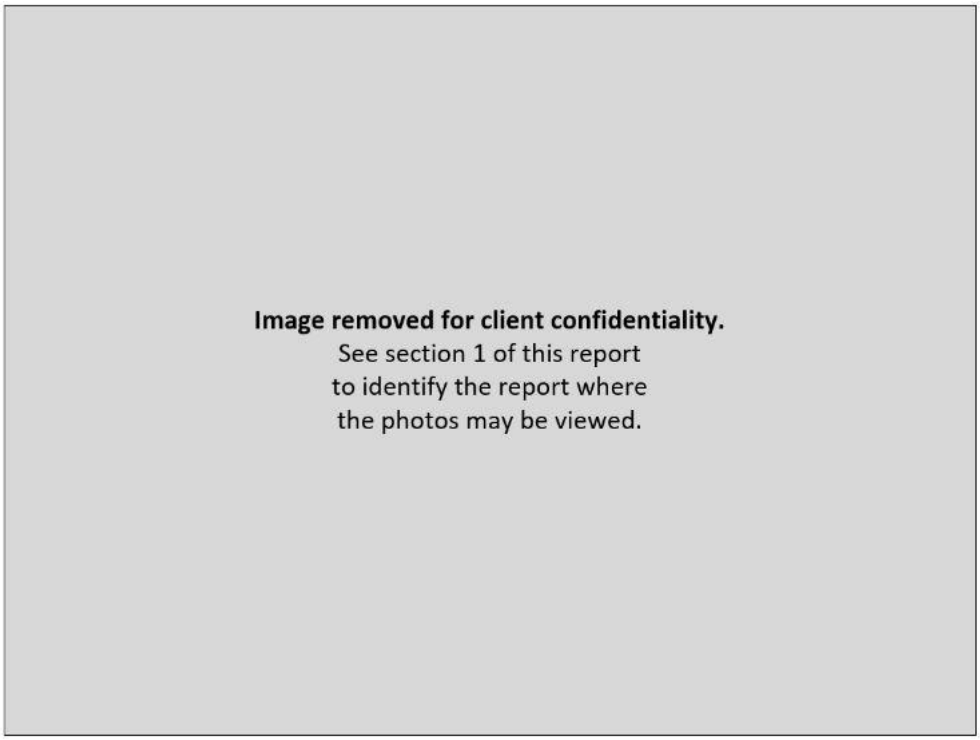

Figure CE04.2: EUT test setup

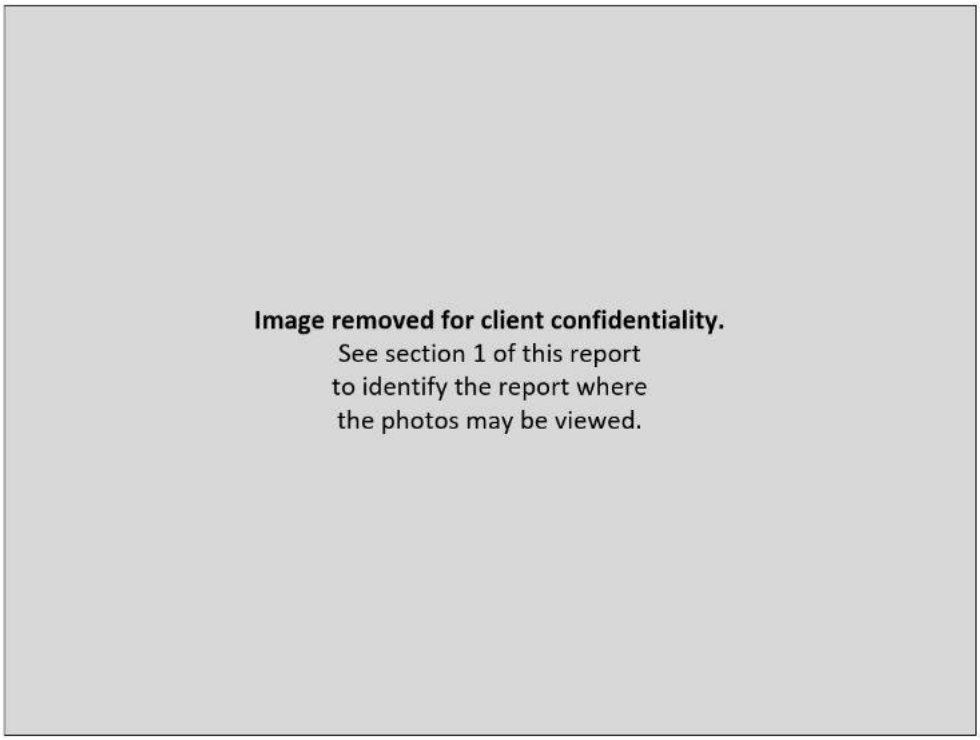

Figure CE04.3: EUT test setup

This line is the end of the test record.

Test Record
Transmitter Frequency Stability
Test IDs TR37
Project GCL-0304

Test Date(s)	17 and 20 Mar 2023
Test Personnel	Majid Farah
Product Model	A04431
Serial Number tested	3437296994
Operating Mode	M2 (NFC-Lnk)
Arrangement	A5 (PwrA+NFC)
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:	**23 Mar 2023**

Original record, Version A.

Test Equipment

Description	Make	Model #	Serial #	Last Cal/Ver	Next Due
DMM Multimeter	FLUKE	79 III	71740743	18-Apr-2022	15-Apr-2023
Signal analyzer PXE Receiver 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	19-Oct-2022	15-Oct-2023
Near Field Probe set	Com-Power	PS-400	151679	Calibration	Not Required
Power source	TENMA	72-2080	2440	Calibration	Not Required

Table TR37.1: 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 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 13,559,938 Hz and the minimum was 13,559,786 Hz. The allowed range was 13,558,644 to 13,561,356 Hz. The margin to high side of limit is 1415 Hz and margin for low side of the limit is 1142 Hz.

			NFC carrier frequency (HZ)			
Tx Mode	Temp	Volts	Time interval (minute)			
	˚C	Vdc	0	2	5	10
NFC	50	5	13,559,786	13,559,786	13,559,786	13,559,786
NFC	40	5	13,559,801	13,559,801	13,559,800	13,559,800
NFC	30	5	13,559,832	13,559,831	13,559,830	13,559,830
NFC	20	5	13,559,862	13,559,862	13,559,863	13,559,862
NFC	20	4.25	13,559,860	N/A	N/A	N/A
NFC	20	5.75	13,559,861	N/A	N/A	N/A
NFC	10	5	13,559,879	13,559,886	13,559,893	13,559,898
NFC	0	5	13,559,926	13,559,927	13,559,928	13,559,928
NFC	-10	5	13,559,938	13,559,940	13,559,941	13,559,941
NFC	-20	5	13,559,938	13,559,937	13,559,935	13,559,934

Table TR37.2: Carrier frequency measurement for NFC transmission during temperature and voltage variations

Setup Block Diagram

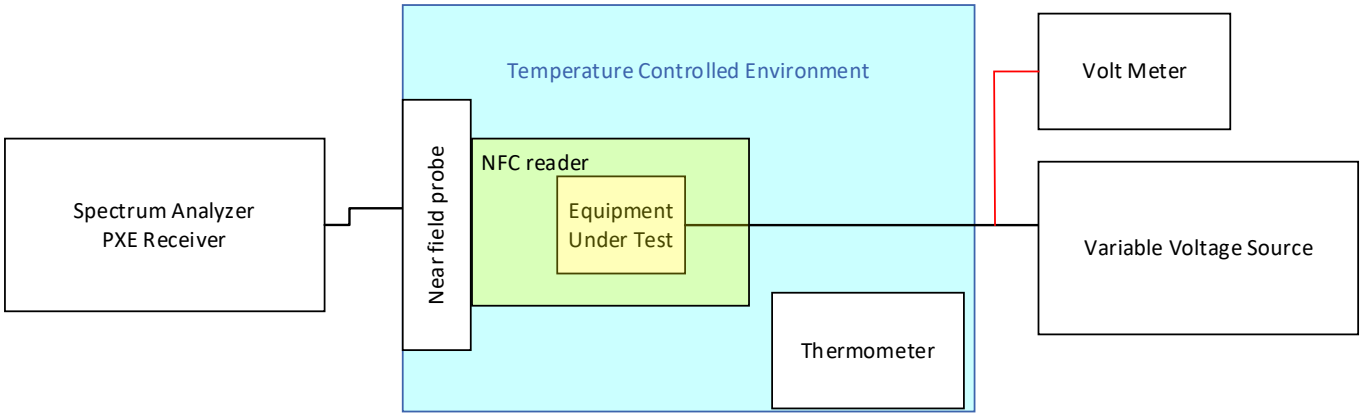

Figure TR37.1: Schematic drawing of the test equipment setup for NFC

This line is the end of the test record.

Test Record
Transmitter Occupied Bandwidth Tests
Test IDs RE10, RE11
Project GCL-0304

Test Date(s)	9 Mar 2023
Test Personnel	David Arnett
Product Model	A04431
Serial Number tested	3437296994
Test Standards:	FCC Part 15, ANSI C63.10, RSS-GEN (as noted in Section 6 of the report).
Operating Mode	M1 (NFC Tx) Type A and Type B
Arrangement	A2 (NFC)
Input Power	5 Vdc
Radio Band	13.56 MHz ISM

Pass/Fail Judgment: **Reported**

Test record created by: **David Arnett**
Date of this record: **22 Mar 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 Probe	Com-Power	PS-400	151679	Calibration	Not Required

Table RE10.1: List of test equipment used

Test Software Used: Keysight PXE firmware A.32.06

Test Method

The test sample is placed on top of a magnetic loop probe, which is on top of an NFC Reader. The test sample and reader establish a communication link. The loop probe output is fed via a cable to a spectrum analyzer. The analyzer has a built-in capability to identify the minimum bandwidth that contains a specified percentage of the total power observed, and also identify the center frequency error. The spectrum is scanned several hundred times so that the varied effects of modulation are appropriately assessed. Since the focus is on the relative distribution of energy across a range of frequencies, the absolute amplitudes recorded during this test are not relevant and may not include cable losses or probe factors.

This is special test in that certain government agencies require the measurement and reporting of the Occupied Bandwidth, but no limits are applied. With no limits, this is not a Pass/Fail test.

Caveat

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

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

Test Data

The data for each test is summarized below, followed by the spectral data for each case analyzed and reported.

The analysis threshold for the occupied test was the bandwidth containing 99% of the observed power.

Data Type	Bandwidth
A	2.24 MHz
B	4.93 MHz

Table RE10.2: Summary of 99% Occupied Bandwidth results

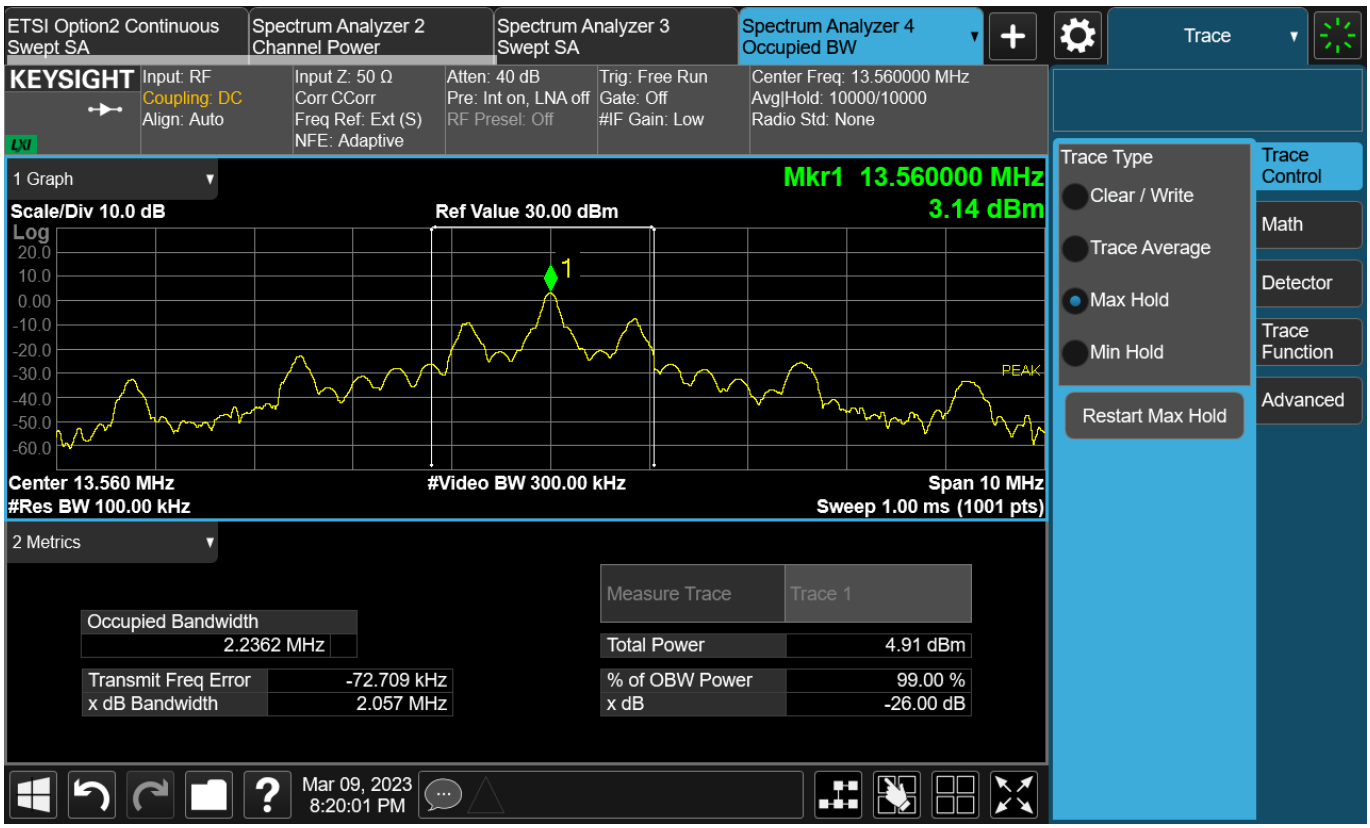

Figure RE10.1: Type A modulation

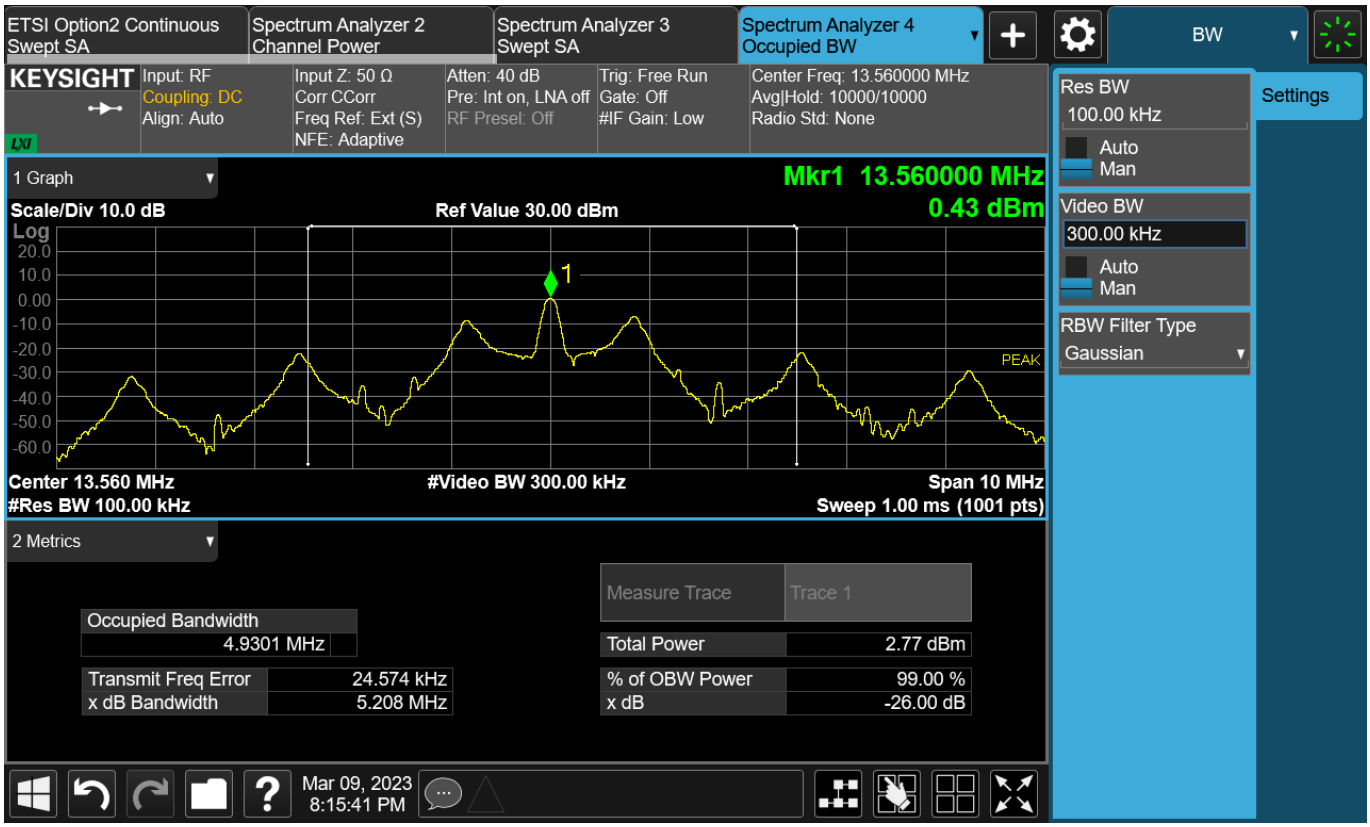

Figure RE10.2: Type B modulation

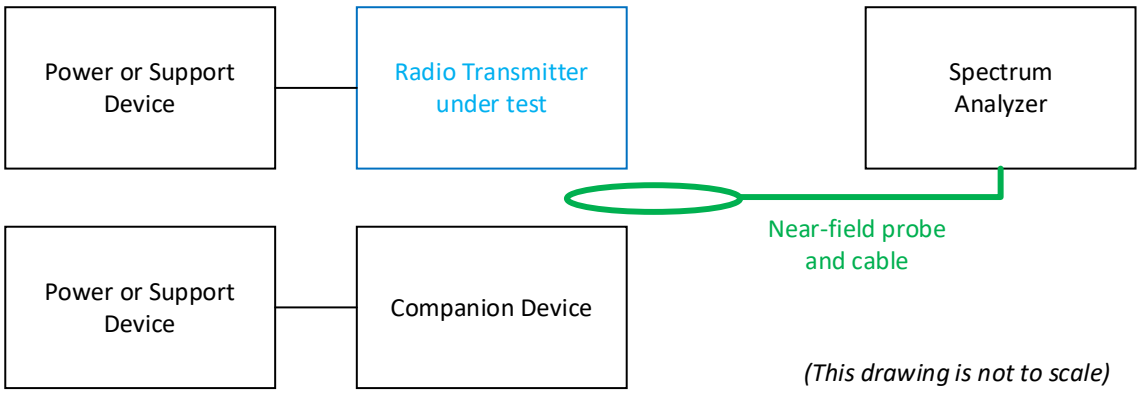

Figure RE10.3: Measurement setup

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.