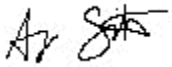
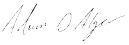
Test Report TR3680C

Equipment Under Test:	Sera NX040 - 802.15.4z HRP UWB + Bluetooth LE v5.4 Module
Requirement(s):	FCC 1.1310 ISED RSS-102
Test Date(s):	9/7/2023 – 10/2/2023
Prepared for:	Laird Connectivity, LLC. Attn: Jonathan Kaye W66 N220 Commerce Ct. Cedarburg, WI 53012

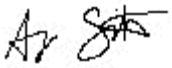
Report Issued by: Anthony Smith, EMC Engineering Specialist

Signature:  Date: 12/04/2023

Report Reviewed by: Adam Alger, Laboratory Manager

Signature:  Date: 12/04/2023

Report Constructed by: Anthony Smith, EMC Engineering Specialist

Signature:  Date: 12/02/2023

CONTENTS

Laird Connectivity Test Services in Review

The Laird Connectivity LLC laboratory located at W66 N220 Commerce Court Cedarburg, Wisconsin, 53012 USA is recognized through the following organizations:

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025:2017 with Electrical (EMC) Scope

A2LA Certificate Number: 1255.01

Scope of accreditation includes all test methods listed herein unless otherwise noted

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Federal Communications Commission (FCC) – USA

Accredited Test Firm Registration Number: 953492

Recognition of two 3 meter Semi-Anechoic Chambers

Government of Canada

Innovation, Science and Economic Development Canada

Accredited U.S. Identification Number: US0218

Recognition of two 3 meter Semi-Anechoic Chambers

1 TEST REPORT SUMMARY

During **9/7/2023 through 10/2/2023** the Equipment Under Test (EUT), **Sera NX040**, as provided by **Laird Connectivity** was tested to the following requirements:

Mobile Device

Requirements	Description	Method	Result
FCC 1.1310	Radiofrequency Radiation Exposure Limits	Distance ≤ 20cm 1g-SAR	Compliant
IC RSS-102	Radiofrequency Radiation Exposure Limits	Distance ≤ 20cm 1g-SAR	Compliant

Notice:

The results relate only to the item tested as configured and described in this report. Any additional configurations, modes of operation, or modifications made to the equipment under test after the specified test date(s) are at the decision of the client and may not apply to the data seen in this test report.

The decision rule for Pass / Fail assessment to the specification or standard listed in this test report has been agreed upon by the client and laboratory to be as follows:

Measurement Type	Rule
Emissions – Amplitude	1 dB below specified limit
Emissions – Frequency	1% less than the specification
Immunity	Tested at specified level

2 CLIENT INFORMATION

Company Name	Laird Connectivity
Contact Person	Jonathan Kaye
Address	W66 N220 Commerce Ct. Cedarburg, WI 53012

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	Sera NX040
Model Number	Sera NX040
Serial Number	Trace Antenna Version: 00016 External Antenna Version: 00029
FCC ID	SQG-SERANX040
IC ID	3147A-SERANX040

2.2 Product Description

802.15.4z HRP UWB + Bluetooth LE v5.4 Module

2.3 Modifications Incorporated for Compliance

None noted at time of test

2.4 Deviations and Exclusions from Test Specifications

None noted at time of test

2.5 Radio Information

Bluetooth Low Energy using Data Rates 125k, 500k, 1M, and 2M. All tested with 255 Packet Length configuration. Antenna Port terminated with 50Ω for radiated testing.

UWB Channels are 5 and 9, respective center frequencies of 6489.6 MHz and 7987.2 MHz. EUT uses pulse rates BPRF and HPRF.

2.6 Programming Software

Nordic nRF Connect for Desktop v.4.2.0 mode used to program radio utilizing Direct Test Mode v.2.1.0. UWB Radio test modes were set using provided Python scripts run via Windows Powershell on a laptop connected to the EUT using USB.

2.7 EUT Configuration

Device has two configurations: a trace antenna design and an external antenna design. Both were tested for radiated emissions. The external antenna design was tested with the BLE antenna port connected to a 50Ω terminator.

3 REFERENCES

Publication	Edition	Date	AMD 1
FCC eCFR	-	2023	-
RSS-102	5	2015	2021
KDB 447498	-	2015	-

4 UNCERTAINTY SUMMARY

Using the guidance of the following publications the calculated measurement uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k = 2.

References
CISPR 16-4-1
CISPR 16-4-2
CISPR 32
ANSI C63.23
A2LA P103
A2LA P103c
ETSI TR 100-028

Measurement Type	Configuration	Uncertainty ±
Radiated Emissions	Biconical Antenna	5.0 dB
Radiated Emissions	Log Periodic Antenna	5.3 dB
Radiated Emissions	Horn Antenna	4.7 dB
AC Line Conducted Emissions	Artificial Mains Network	3.4 dB
Telecom Conducted Emissions	Asymmetric Artificial Network	4.9 dB
Disturbance Power Emissions	Absorbing Clamp	4.1 dB
Radiated Immunity	3 Volts/meter	2.2 dB
Conducted Immunity	CDN/EM/BCI	2.4/3.5/3.4 dB
EFT Burst/Surge	Peak pulse voltage	164 volts
ESD Immunity	15 kV level	1377 Volts

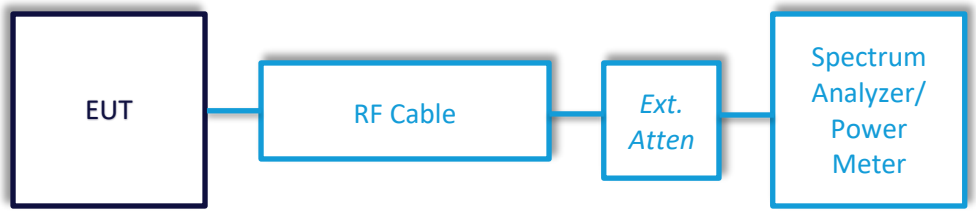
Parameter	ETSI U.C. ±	U.C. ±
Radio Frequency, from F0	$1x10^{-7}$	$0.55x10^{-7}$
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %

5 TEST DATA

5.1 Antenna Port Conducted Emissions

Description of Measurement	The direct measurement of emissions at the antenna port of the EUT is achieved by use of a RF connection to a spectrum analyzer or power meter. The cable and attenuator factors are loaded into the analyzer or power meter allowing for direct measurement readings without the need for further corrections.
Example Calculations	Measurement (dBm) + Cable factor (dB) + External Attenuator (dB) = Corrected Reading (dBm) Margin (dB) = Limit (dBm) – Corrected Reading (dBm)

Block Diagram



5.1.1 Antenna Port Conducted Emissions

Operator	Anthony Smith	**QA**	Adam Alger
Temperature	21.4°C	**R.H. %**	52.3
Test Date	9/21/2023	**Location**	Conducted RF Bench
Requirement	FCC 15.247 ISED RSS-247	**Method**	ANSI C63.10

Test Parameters

Frequency	2400-2483.5 MHz	**Setup**	Conducted
RBW	3 MHz	**VBW**	50 MHz
Detector(s)	Peak Max Hold	**Sweep Time**	Auto

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960173	Cable	A.H. Systems, Inc.	SAC-26G-1	388	6/13/2023	6/12/2024	Active Verification
EE 960087	Analyzer - Spectrum	Agilent	N9010A	MY53400296	4/11/2023	4/11/2024	Active Calibration

EUT Parameters

Input Power	5VDC	**Mode**	BLE
Data Rate	125k, 500k, 1M, 2M	**Channel**	Low, Mid, High
Transmit Power Setting	+8		

Data

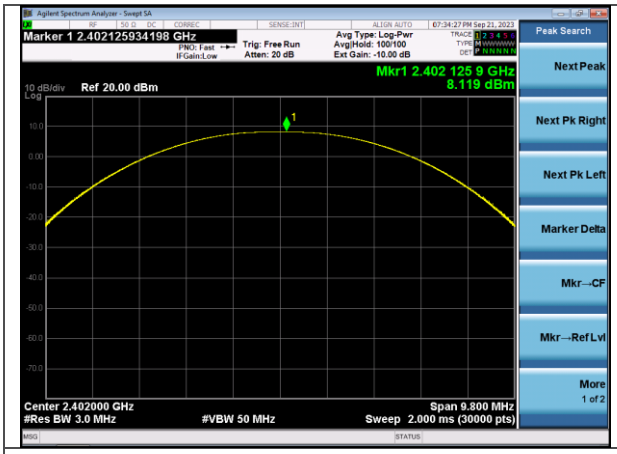
Table

Transmit Power Setting: +8

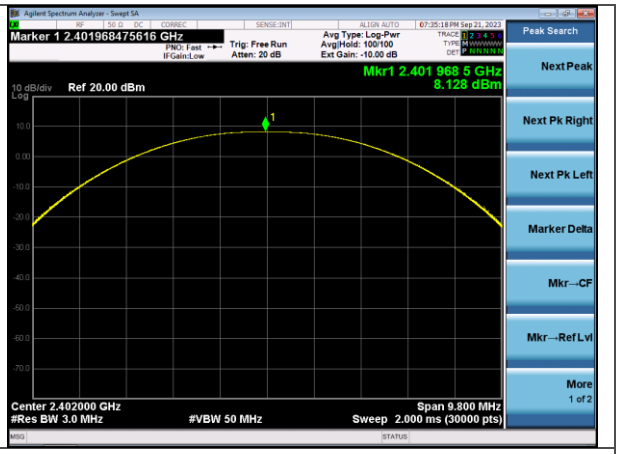
Channel	Data Rate	Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	125k	8.1	30.0	21.9
Mid	125k	8.4	30.0	21.6
High	125k	8.4	30.0	21.6
Low	500k	8.1	30.0	21.9
Mid	500k	8.4	30.0	21.6
High	500k	8.4	30.0	21.6
Low	1M	8.1	30.0	21.9
Mid	1M	8.4	30.0	21.6
High	1M	8.4	30.0	21.6
Low	2M	8.1	30.0	21.9
Mid	2M	8.4	30.0	21.6
High	2M	8.4	30.0	21.6

Plots

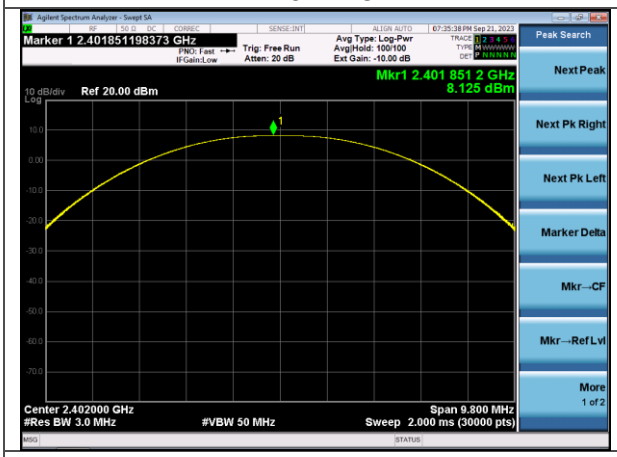
Transmit Power Setting: +8



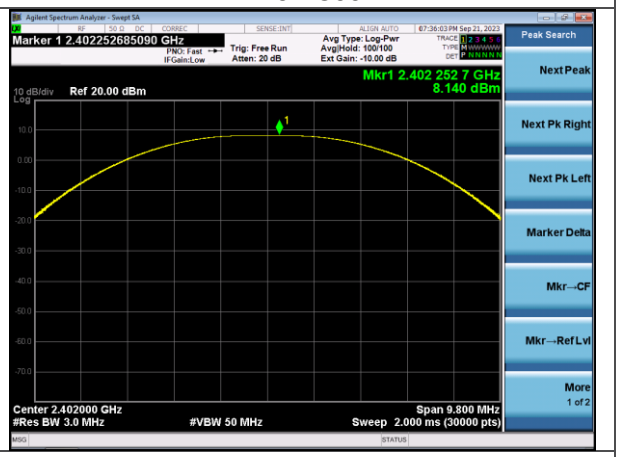
Tx Low 125k



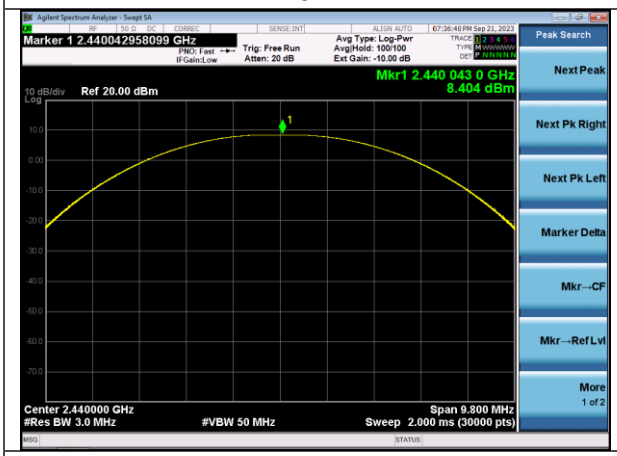
Tx Low 500k



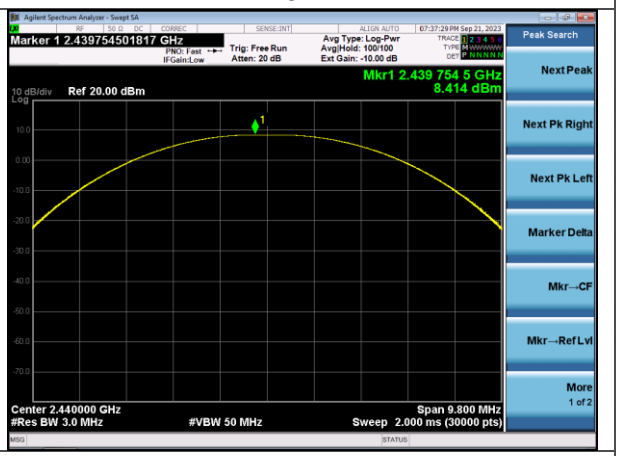
Tx Low 1M



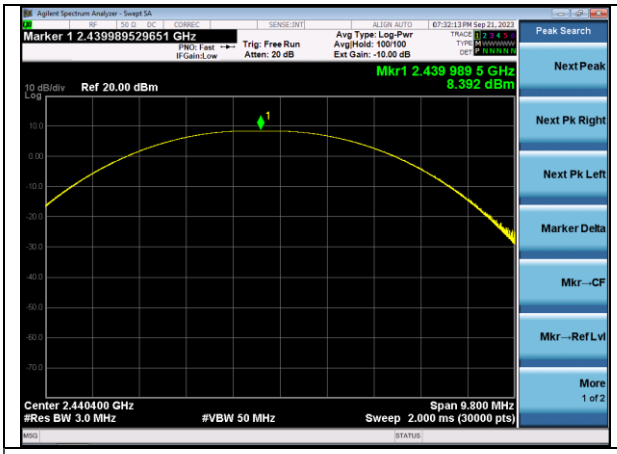
Tx Low 2M



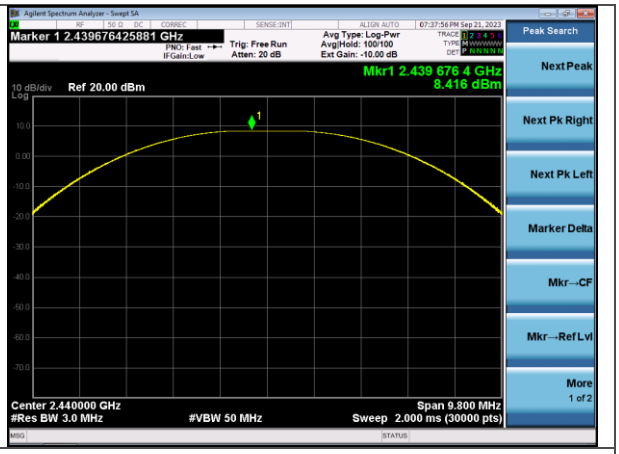
Tx Mid 125k



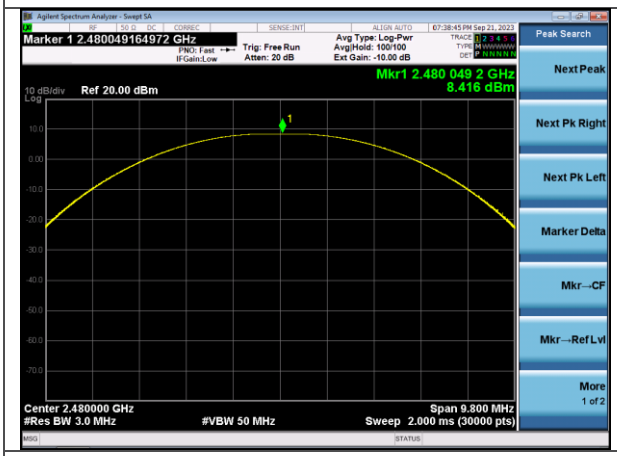
Tx Mid 500k



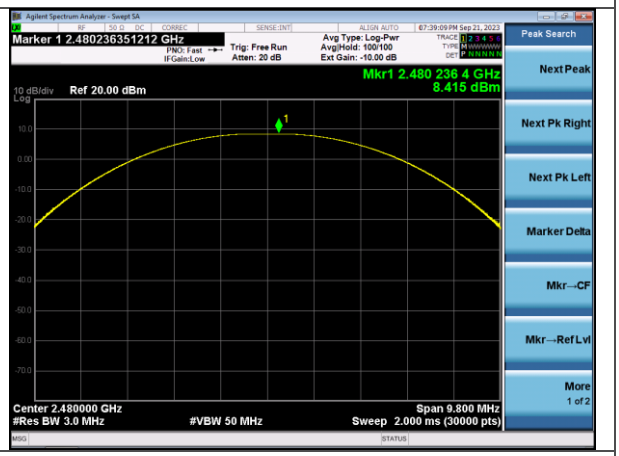
Tx Mid 1M



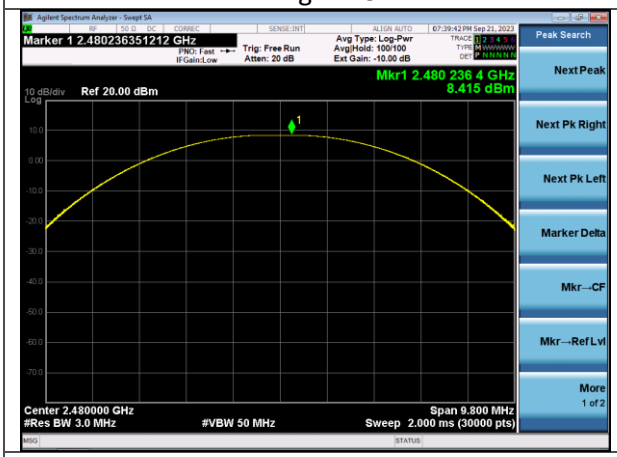
Tx Mid 2M



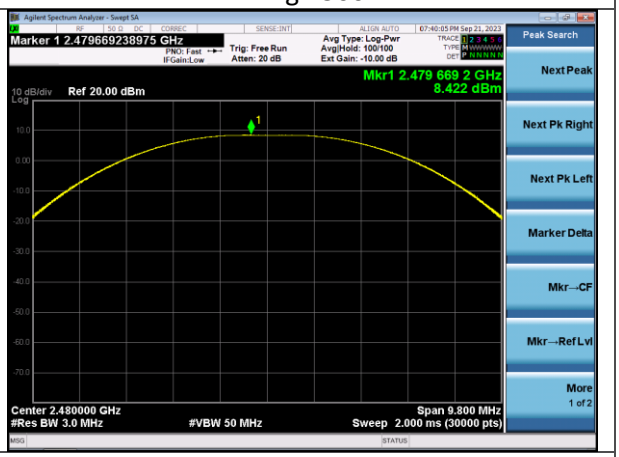
Tx High 125k



Tx High 500k



Tx High 1M

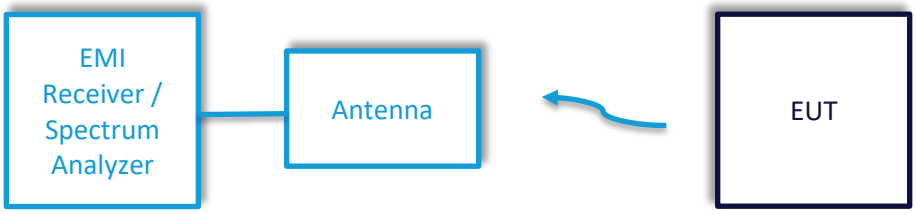


Tx High 2M

5.2 Radiated Emissions

Description of Measurement	The frequency spectrum is investigated for intentional and / or unintentional signals emanating from the EUT by use of a standardized test site and measurement antenna. The antenna, cable, pre-amp, and other necessary measurement system correction factors are loaded onto the EMI receiver / spectrum analyzer when the measurements are performed allowing the data to be gathered and reported as corrected values. The maximum emissions from the EUT are determined by turn-table azimuth rotation (360°) and scanning of the measurement antenna. Maximized levels are noted at degree values of azimuth, measurement antenna height, and measurement antenna polarity.
Example Calculations	Measurement (dBµV) + Cable factor (dB) + Other (dB) + Antenna Factor (dB/m) = Corrected Reading (dBµV/m) Margin (dB) = Limit (dBµV/m) - Corrected Reading (dBµV/m) Example at 4000 MHz: Reading = 40 dBµV + 3.4 dB + 0.9 dB + 6.5 dB/m = 50.8 dBµV/m Average Limit = 20 log (500) = 54 dBµV/m Margin = 54 dBµV/m - 50.8 dBµV/m = 3.2 dB

Block Diagram



5.2.1 Radiated Emissions – Transmitter Emissions

Operator	Anthony Smith	**QA**	Jon Dilley
Temperature	22.0-23.9°C	**R.H. %**	43.7-58.2%
Test Date	9/7/2023-10/2/2023	**Location**	Chamber 5, Chamber 3
Requirement	FCC 15.209, 15.519 (e)	**Method**	ANSI C63.10

Test Parameters

Frequency	6000-9000 MHz	**Distance**	3m
Detector(s)	Peak	**Table height**	150cm Above 1 GHz
RBW	10 MHz	**VBW**	50 MHz
Example Calculations	Peak Power Conversion: $EIRP_{10\ MHz} = EIRP_{50\ MHz} + 20\log(10\ MHz/50\ MHz) = 0\ dBm + (-13.98\ dB) = -13.98\ dBm$ EIRP to Field Strength: E (dBµV/m) = EIRP (dBm) + 95.3		

Instrumentation

Asset #	Description	Manufacturer	Model #	Serial #	Date	Due Date	Status
AA 960081	Antenna - Double Ridge Horn	EMCO	3115	6907	1/11/2023	1/11/2024	Active Calibration
AA 960162	Cable	MegaPhase	EM2-S1S1-120	51503501 001	6/13/2023	6/13/2024	Active Verification
AA 960163	Antenna - Log Periodic	A.H. Systems, Inc.	SAS-512-2	500	8/10/2023	8/10/2024	Active Calibration
AA 960174	Antenna - Small Horn	ETS Lindgren	3116C-PA	00206880	8/30/2023	8/30/2024	Active Calibration
AA 960210	Antenna - Low Noise Amplifier	Mini-Circuits	ZVA-213X-S+	037101808	1/11/2023	1/11/2024	Active Calibration
AA 960218	Antenna - Biconical	A.H. Systems, Inc.	SAS-540	853	7/17/2023	7/17/2024	Active Calibration
AA 960222	Cable	A.H. Systems, Inc.	SAC-26G-6	525	6/13/2023	6/13/2024	Active Verification
AA 960223	Filter - High Pass UWB	Mini-Circuits	ZHSS-K15G+	3 2304	8/8/2023	8/8/2024	Active Verification
EE 960085	Analyzer - EMI Receiver	Agilent	N9038A	MY51210148	4/27/2023	4/27/2024	Active Calibration
EE 960203	Analyzer - EMI Receiver	Keysight	N9038A	MY56400072	4/11/2023	4/11/2024	Active Calibration
LSC-300	Cable	Chamber 3 Emissions	-	-	8/22/2023	8/22/2024	Active Verification

Data

Table

Fundamental Emission - Peak

Config 1

Frequency (MHz)	Antenna Polarity	Height (cm)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Radio	EUT Orientation
6582.3	V	180	93	79.1	81.3	2.2	Ch 5 BPRF	Vertical
7893.9	V	100	270	75.7	81.3	5.6	Ch 9 BPRF	Vertical
6550.8	V	180	93	80.8	81.3	0.6	Ch 5 HPRF	Vertical
7924.7	V	100	270	77.2	81.3	4.1	Ch 9 HPRF	Vertical

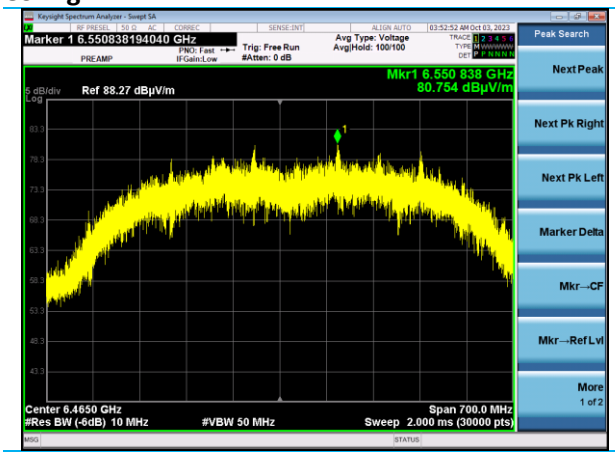
Config 2

Frequency (MHz)	Antenna Polarity	Height (cm)	Azimuth (degree)	Peak Reading (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Radio	EUT Orientation
6583.0	V	150	220	77.4	81.3	3.9	Ch 5 BPRF	Vertical
8018.3	H	100	160	76.4	81.3	4.9	Ch 9 BPRF	Flat
6552.2	V	150	220	80.1	81.3	1.2	Ch 5 HPRF	Vertical
8050.2	H	100	160	78.0	81.3	3.3	Ch 9 HPRF	Flat

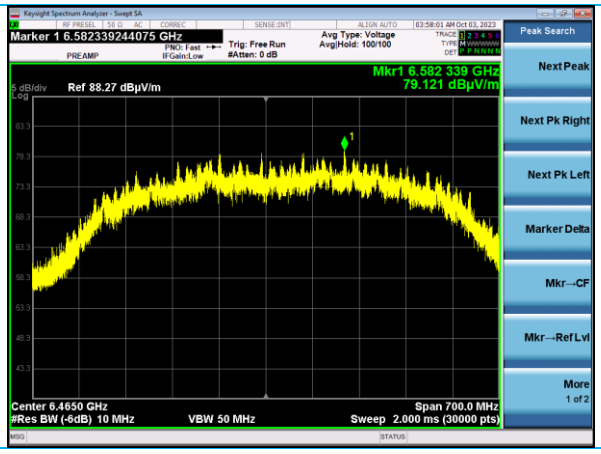
Plots

Fundamental Emission – Peak

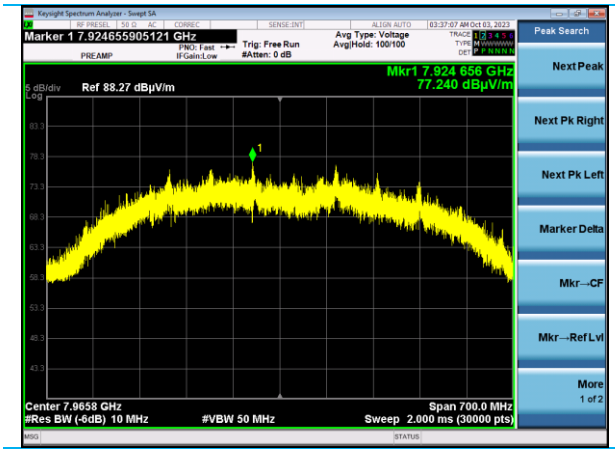
Config 1



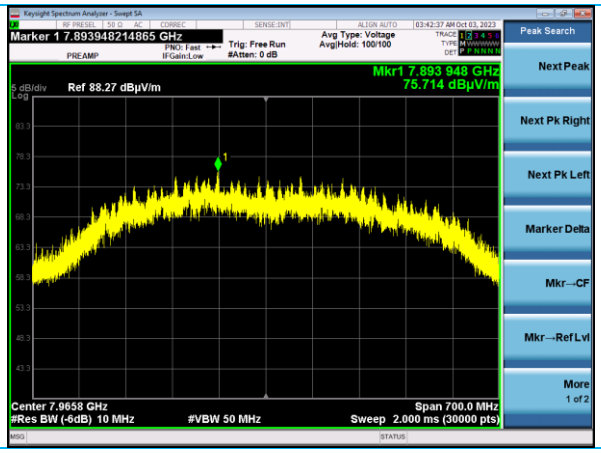
Ch 5 HPRF



Ch 5 BPRF

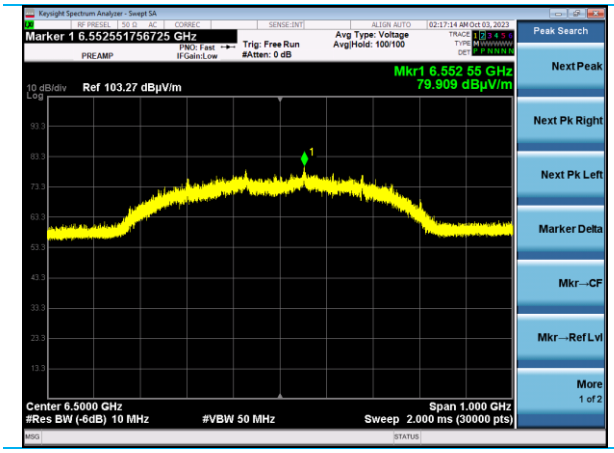


Ch 9 HPRF

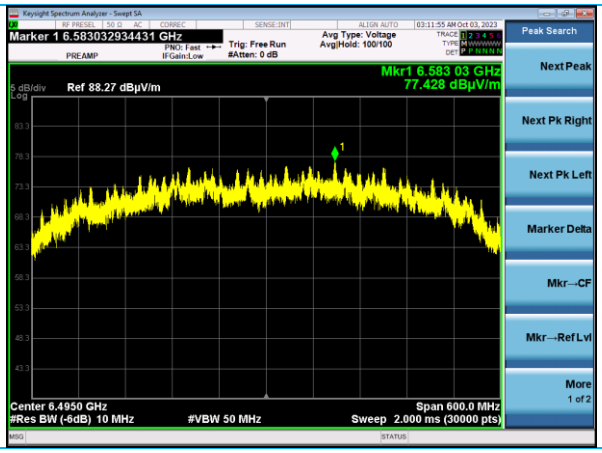


Ch 5 BPRF

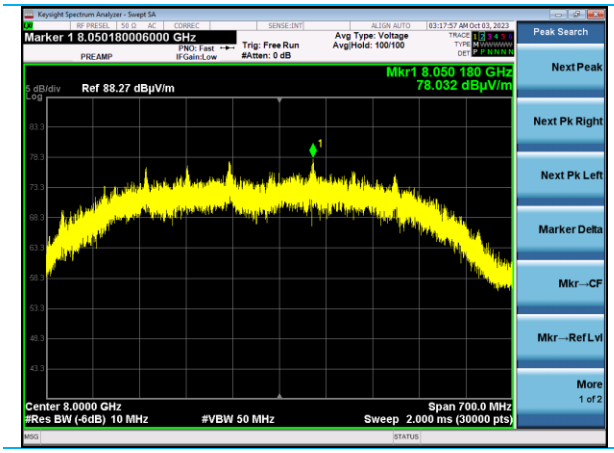
Config 2



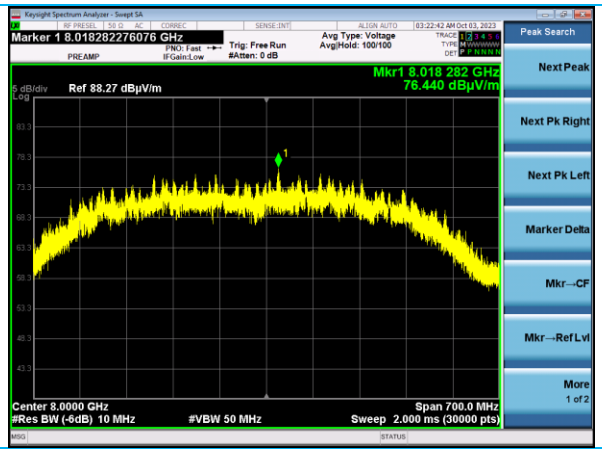
Ch 5 HPRF



Ch 5 BPRF



Ch 9 HPRF



Ch 9 BPRF

6 FCC 1-G SAR Test Exclusion Calculations

6.1 Power Calculations

BLE

Max Power of Channel = 8.4 dBm

Tune Up Tolerance = 1 dB

Antenna Gain = 3.1 dBi

Total Channel Power = 12.5 dBm = 17.78279 mW

UWB

Max Power of Channel = -0.5 dBm

Total Channel Power = -0.5 dBm = 0.89125 mW

6.2 Distance

≤20 cm

6.3 1.1310(e)(1) Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(i) Limits for Occupational/Controlled Exposure				
0.3–3.0	614	1.63	*(100)	≤6
3.0–30	1842/f	4.89/f	*($900/f^2$)	<6
30–300	61.4	0.163	1.0	<6
300–1,500			f/300	<6
1,500–100,000			5	<6
(ii) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	<30
1.34–30	824/f	2.19/f	*($180/f^2$)	<30
30–300	27.5	0.073	0.2	<30
300–1,500			f/1500	<30
1,500–100,000			1.0	<30

6.4 MPE (Power Density) Equation

$S = (P*G)/(4\pi R^2)$

Where: S = Power Density

P = Power Input to the Antenna

G = Power Gain of the antenna in the direction of interest relative to an isotropic radiator

R = Distance to the center of radiation of the antenna

Radio	EIRP (dBm)	Total Power (mW)	Distance (cm)	Power Density (mW/cm2)	Limit of Power Density (mW/cm2)	Result
UWB	-0.5	0.89125	20	0.00018	1	Compliant
BLE	12.5	17.78279	20	0.00354	1	Compliant

6.5 Result

The power density levels at a distance of 20 cm or greater are below the MPE Limits for General Population/Uncontrolled Exposure.

7 ISED RF EXPOSURE EVALUATION EXEMPTION

7.1 Power Calculations

BLE

Max Power of Channel = 8.4 dBm

Tune Up Tolerance = 1 dB

Antenna Gain = 3.1 dBi

Total Channel Power = 12.5 dBm = 17.78279 mW

UWB

Max Power of Channel = -0.5 dBm

Total Channel Power = -0.5 dBm = 0.89125 mW

7.2 Distance

≤20 cm

7.3 Exemption Limits

2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz[6] and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

BLE Limit: $1.31 * 10^{-2} * 2440\ \text{MHz}^{0.6834} = 2.7$ W

UWB Limit: Above 6 GHz = 5 W

7.4 RF Exposure Evaluation Exemption Calculation

BLE: 17.8 mW ≤ 2.7 W

UWB: 0.9 mW ≤ 5 W

7.5 Result

The EUT is excluded from routine RF Exposure Evaluation at ≤20 cm as 17.8 mW is less than 5 W and 0.9 mW is less than 5 W.

8 REVISION HISTORY

Version	Date	Notes	Person
1	10/5/2023	Initial Draft	Anthony Smith
2	10/12/2023	Revised Draft	Anthony Smith
3	11/27/2023	Revised Draft	Anthony Smith
4	12/02/2023	Revised Draft	Anthony Smith

END OF REPORT