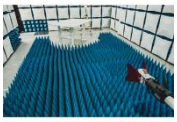
Element Materials Technology
(formerly PCTEST)
18855 Adams Court, Morgan Hill, CA 95037 USA
Tel. 408 538 5600
http://www.element.com



MEASUREMENT REPORT
FCC PART 15.519 / ISED RSS-220 Ultra-Wideband

Applicant Name:
Apple Inc.
One Apple Park Way
Cupertino, CA 95014
United States

Date of Testing:
5/5/2023 - 8/2/2023
Test Report Issue Date:
8/14/2023
Test Site/Location:
Element Materials Technology, Morgan Hill, CA, USA
Test Report Serial No.:
1C2305110023-02.BCG

FCC ID:	**BCG-A2968**
IC:	**579C-A2968**
APPLICANT:	**Apple Inc.**

Application Type:	Certification
Model/HVIN:	A2968
EUT Type:	Charging Case
Operational Frequency:	7987.2MHz (Ch 9)
FCC Classification:	Ultra-Wideband Transmitter (UWB)
FCC Rule Part(s):	Part 15 Subpart F (15.519)
ISED Specification:	RSS-Gen Issue 5, RSS-220 Issue 1
RSS-220 Subclass:	Hand-held Communication Devices
Test Procedure(s):	ANSI C63.10-2013, KDB 393764 D01 v02r01

This equipment has been shown to be capable of compliance with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in ANSI C63.10-2013 and KDB 393764 D01 v02r01. Test results reported herein relate only to the item(s) tested.

I attest to the accuracy of data. All measurements reported herein were performed by me 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.

RJ Ortanez
Executive Vice President

ACCREDITED
CERT #2041.02

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

TABLE OF CONTENTS

1.0 Introduction 3
1.1 Scope 3
1.2 Element Materials Technology Test Location 3
1.3 Test Facility / Accreditations 3
2.0 PRODUCT INFORMATION 4
2.1 Equipment Description 4
2.2 Device Capabilities 4
2.3 Antenna Description 5
2.4 Test Support Equipment 5
2.5 Test Configuration 6
2.6 Software and Firmware 6
2.7 EMI Suppression Device(s)/Modifications 6
3.0 DESCRIPTION OF TESTS 7
3.1 Evaluation Procedure 7
3.2 AC Line Conducted Emissions 7
3.3 Radiated Emissions 8
3.4 Environmental Conditions 8
4.0 ANTENNA REQUIREMENTS 9
5.0 MEASUREMENT UNCERTAINTY 10
6.0 TEST EQUIPMENT CALIBRATION DATA 11
7.0 TEST RESULTS 12
7.1 Summary 12
7.2 10dBc Bandwidth Measurement 13
7.3 Bandwidth Measurement 16
7.4 Maximum Peak and Average Radiated Power (EIRP) 19
7.4.1 Peak Radiated Power Measurement 21
7.4.2 Average Radiated Power Measurement 22
7.5 Cease Transmission Time 23
7.6 Radiated Spurious Emissions - Above 960MHz 26
7.6.1 Radiated Spurious Emissions (960MHz-18GHz) 29
7.6.2 Simultaneous Tx Radiated Spurious Emission Measurements 37
7.7 Radiated Spurious Emissions Measurements – Below 960MHz 39
7.7.1 Radiated Spurious Emissions (Below 960MHz) 42
7.7.2 Simultaneous Tx Radiated Spurious Emissions (30 - 960MHz) 43
7.8 AC Line-Conducted Emission Measurement 44
8.0 CONCLUSION 48

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

1.0 INTRODUCTION

1.1 Scope

Measurement and determination of electromagnetic emissions (EMC) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission and the Innovation, Science and Economic Development Canada.

1.2 Element Materials Technology Test Location

These measurement tests were conducted at the Element Materials Technology facility located at 18855 Adams Court, Morgan Hill, CA 95037. The measurement facility is compliant with the test site requirements specified in ANSI C63.4-2014 and KDB 414788 D01 v01r01.

1.3 Test Facility / Accreditations

Measurements were performed at Element Materials Technology located in Morgan Hill, CA 95037, U.S.A.

- Element Materials Technology is an ISO 17025-2017 accredited test facility under the American Association for Laboratory Accreditation (A2LA) with Certificate number 2041.02 for Specific Absorption Rate (SAR), Hearing Aid Compatibility (HAC) testing, where applicable, and Electromagnetic Compatibility (EMC) testing for FCC and Innovation, Science, and Economic Development Canada rules.

- Element Washington DC LLC TCB is a Telecommunication Certification Body (TCB) accredited to ISO/IEC 17065-2012 by A2LA (Certificate number 2041.03) in all scopes of FCC Rules and ISED Standards (RSS).

- Element Materials Technology facility is a registered (22831) test laboratory with the site description on file with ISED.

- Element Washington DC LLC is a Recognized U.S. Certification Assessment Body (CAB # US0110) for ISED Canada as designated by NIST under the U.S. and Canada Mutual Recognition Agreements (MRAs).

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

2.0 PRODUCT INFORMATION

2.1 Equipment Description

The Equipment Under Test (EUT) is the **Apple Charging Case FCC ID: BCG-A2968** and **IC: 579C-A2968**. The test data contained in this report pertains only to the emissions due to the EUT's Ultra-Wideband (UWB) transmitter.

Test Device Serial No.: DDX96KT9CH, L097F1Q3NH, RQC34XXGP3, CJH2F0GX34

2.2 Device Capabilities

This device contains the following capabilities:

Bluetooth (LE1M, LE 2M), UWB

For ISED, this device is under subclass 5.3 Hand-held Communication Devices of RSS-220

Data Port UWB Radio Terminal Access: No

Ch.	Frequency (MHz)	Config	Payload
9	8000	0	25
			65
			125
		1	45
			85
			125
		4	0
		5	0

Table 2-1. UWB Frequency / Channel Operations

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Notes:

1. This device supports simultaneous transmission feature, which allows multiple radios to transmit simultaneously at the same antenna. The table below shows all the possible.

Simultaneous Tx Config	Bluetooth	UWB
	LE1M/2M	Ch.9
Config 1	✓	✓

✓= Support; ✗ = NOT Support

2. Additionally, this device is sold together in the same package as a system with **FCC IDs**: **BCG-A3047** and **BCG-A3048**. Simultaneous Tx Configurations were tested, and the worst case has been included in the RF BTLE report.

2.3 Antenna Description

Following antenna gain provided by manufacturer was used for the testing.

Frequency [GHz]	Antenna Gain (dBi)
7.750-8.250	4.1

Table 2-2. Highest Antenna Gain

2.4 Test Support Equipment

1	Apple Macbook Pro	Model:	A1989	S/N:	C02YVA2VLVDD
	w/ AC/DC Adapter	Model:	A2166	S/N:	C4H22720425PM0WA1
	Apple iPhone	Model:	N/A	S/N:	XNW7JQ441M
2	Apple Airpod (Right)	Model:	A3047	S/N:	GFJKJ15X26K0
	Apple Airpod (Left)	Model:	A3048	S/N:	GX1KJ4EG26JY
3	Apple USB-C Cable	Model:	N/A	S/N:	N/A
	w/ AC/DC Adapter	Model:	A2305	S/N:	C4H951600E8PF4F4H
4	Spartan Cable	Model:	N/A	S/N:	GXK1382000CKTR023

Table 2-3. Test Support Equipment List

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

2.5 Test Configuration

The EUT was tested per the guidance of ANSI C63.10-2013 and KDB 393764 D01 v02r01. ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing. See Sections 3.2 for AC line conducted emissions test setups, 3.3 for radiated emissions test setups.

For emissions from 960MHz – 18GHz, channel 9 was tested with highest power and worst case configuration. The emissions below 960MHz and above 18GHz were tested with the highest transmitting power and the worst case configuration.

The EUT was manipulated through three orthogonal planes of X-orientation (flatbed), Y-orientation (landscape), and Z-orientation (portrait) during the testing. Only the worst case emissions were reported in this test report.

For AC line conducted and radiated test below 1GHz, following configuration were investigated and the worst case was reported.

- EUT powered by AC/DC adaptor via USB-C cable with wire charger
- EUT powered by host PC via USB-C cable with wire charger

2.6 Software and Firmware

The test was conducted with firmware version 5B70551c installed on the EUT.

2.7 EMI Suppression Device(s)/Modifications

No EMI suppression device(s) were added and/or no modifications were made during testing.

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

3.0 DESCRIPTION OF TESTS

3.1 Evaluation Procedure

The measurement procedures described in the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices (ANSI C63.10-2013) and the guidance provided in KDB 393764 D01 v02R01 were used in the measurement of the EUT**.**

Deviation from measurement procedure…….....None

3.2 AC Line Conducted Emissions

The line-conducted facility is located inside a 7m x 3.66m x 2.7m shielded enclosure. The shielded enclosure is manufactured by AP Americas. The shielding effectiveness of the shielded room is in accordance with MIL-Std-285 or NSA 65-5. A 1m x 1.5m wooden table 80cm high is placed 40cm away from the vertical wall and 80cm away from the sidewall of the shielded room. Two 10kHz-30MHz, 50Ω/50μH Line-Impedance Stabilization Networks (LISNs) are bonded to the shielded room floor. Power to the LISNs is filtered by external high-current high-insertion loss power line filters. The external power line filter is EPCOS 2X60A Power Line Filter (100dB Attenuation, 14kHz-18GHz) and the two EPCOs 2X48A filters (100dB Minimum Insertion Loss, 14kHz – 10GHz). These filters attenuate ambient signal noise from entering the measurement lines. These filters are also bonded to the shielded enclosure.

The EUT is powered from one LISN and the support equipment is powered from the second LISN. If the EUT is a DC-powered device, power will be derived from the source power supply it normally will be powered from and this supply line(s) will be connected to the second LISN. All interconnecting cables more than 1 meter were shortened to a 1 meter length by non-inductive bundling (serpentine fashion) and draped over the back edge of the test table. All cables were at least 40cm above the horizontal reference groundplane. Power cables for support equipment were routed down to the second LISN while ensuring that that cables were not draped over the second LISN.

Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the spectrum analyzer and exploratory measurements were made to determine the frequencies producing the maximum emission from the EUT. The spectrum was scanned from 150kHz to 30MHz with a spectrum analyzer. The detector function was set to peak mode for exploratory measurements while the bandwidth of the analyzer was set to 10kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Once the worst case emissions have been identified, the one EUT cable configuration/arrangement and mode of operation that produced these emissions is used for final measurements on the same test site. The analyzer is set to CISPR quasi-peak and average detectors with a 9kHz resolution bandwidth for final measurements.

Line conducted emissions test results are shown in Section 7.8. Automated test software was used to perform the AC line conducted emissions testing. Automated measurement software utilized is Rohde & Schwarz EMC32, Version 10.50.40.

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

3.3 Radiated Emissions

The radiated test facilities consisted of an indoor 3 meter semi-anechoic chamber used for final measurements and exploratory measurements, when necessary. The measurement area is contained within the semi-anechoic chamber which is shielded from any ambient interference. The test site inside the chamber is a 6m x 5.2m elliptical, obstruction-free area in accordance with Figure 5.7 of Clause 5 in ANSI C63.4-2014. Absorbers are arranged on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections for measurements above 1GHz. An 80cm tall test table made of Styrodur is placed on top of the turn table. For measurements above 1GHz, an additional Styrodur pedestal is placed on top of the test table to bring the total table height to 1.5m.

Per KDB 414788, radiated emission test sites other than open-field test sites (e.g., shielded anechoic chambers), may be employed for emission measurements below 30MHz if characterized so that the measurements correspond to those obtained at an open-field test site. To determine test site equivalency, a reference sample transmitting at 149kHz was measured on an open field test site (asphalt with no ground plane) and then measured in the 3m semi-anechoic chamber. A calibrated 60cm loop antenna was rotated about its vertical axis while the reference device was rotated through the X, Y and Z axis in order to capture the worst case level. A maximum deviation of 2.77dB at 149kHz was measured when comparing the 3 meter semi-anechoic chamber to the open field site.

For all measurements, the spectrum was scanned through all EUT azimuths and from 1 to 4 meter receive antenna height using a broadband antenna from 30MHz up to the upper frequency shown in 15.33 depending on the highest frequency generated or used in the device or on which the device operates or tunes. For frequencies above 1GHz, linearly polarized double ridge horn antennas were used. For frequencies below 30MHz, a calibrated loop antenna was used. When exploratory measurements were necessary, they were performed at 1 meter test distance inside the semi-anechoic chamber using broadband antennas, broadband amplifiers, and spectrum analyzers to determine the frequencies and modes producing the maximum emissions. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The test set-up was placed on top of the 1 x 1.5 meter table. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Appropriate precaution was taken to ensure that all emissions from the EUT were maximized and investigated. The system configuration, mode of operation, turntable azimuth, and receive antenna height was noted for each frequency found.

Final measurements were made in the semi-anechoic chamber using calibrated, linearly polarized broadband and horn antennas. The test setup was configured to the setup that produced the worst case emissions. The spectrum analyzer was set to investigate all frequencies required for testing to compare the highest radiated disturbances with respect to the specified limits. The turntable containing the EUT was rotated through 360 degrees and the height of the receive antenna was varied 1 to 4 meters and stopped at the azimuth and height producing the maximum emission. Each emission was maximized by changing the orientation of the EUT through three orthogonal planes and changing the polarity of the receive antenna, whichever produced the worst-case emissions.

3.4 Environmental Conditions

The temperature is controlled within range of 15ºC to 35ºC. The relative humidity is controlled within range of 10% to 75%. The atmospheric pressure is monitored within the range 86-106kPa (860-1060mbar).

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

4.0 ANTENNA REQUIREMENTS

Excerpt from §15.203 of the FCC Rules/Regulations:
"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section."

- The antenna(s) of the EUT are **permanently attached.**
- There are no provisions for connection to an external antenna.

Conclusion:

The EUT complies with the requirement of §15.203.

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

5.0 MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.23-2012. All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95% level of confidence. The measurement uncertainty shown below meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Contribution	Expanded Uncertainty (±dB)
Conducted Bench Top Measurements	1.77
Line Conducted Disturbance	2.70
Radiated Disturbance (<30MHz)	4.38
Radiated Disturbance (30MHz - 1GHz)	4.75
Radiated Disturbance (1 - 18GHz)	5.20
Radiated Disturbance (>18GHz)	4.72

Parameter	Expanded Uncertainty
Time	± 0.2%

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

6.0 TEST EQUIPMENT CALIBRATION DATA

Test Equipment Calibration is traceable to the National Institute of Standards and Technology (NIST). Measurements antennas used during testing were calibrated in accordance to the requirements of ANSI C63.5-2017.

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N9020A	MXA Signal Analyzer	4/26/2022	Biennial	4/26/2024	MY56470202
ETS-Lindgren	3117	Double Ridged Guide Antenna (1-18 GHz)	3/30/2023	Annual	3/30/2024	00218555
Keysight Technologies	N9030A	3Hz-44Ghz PXA Signal Analyzer	6/21/2023	Annual	6/21/2024	MY49430244
Rohde & Schwarz	180-442A-KF	Horn (Small)	11/1/2022	Annual	11/1/2023	T058701-1
Rohde & Schwarz	ENV216	Two-Line V-Network	6/20/2023	Annual	6/20/2024	101363
Rohde & Schwarz	FSW67	Signal and Spectrum Analyzer (2Hz-67GHz)	4/4/2023	Annual	4/4/2024	101366
Rohde & Schwarz	ESW44	EMI Test Receiver 2Hz - 44GHz	3/6/2023	Annual	3/6/2024	101867
Rohde & Schwarz	HFH2-Z2	Loop Antenna	5/1/2023	Annual	5/1/2024	100519
Rohde & Schwarz	TS-PR8	Pre-Amplifier (30MHz - 8GHz)	6/22/2023	Annual	6/22/2024	102356
Rohde & Schwarz	TS-PR18	Pre-Amplifier (1GHz - 18GHz)	3/3/2023	Annual	3/3/2024	102130
Rohde & Schwarz	TS-PR1840	Pre Amplifier 18-40GHz	6/2/2023	Annual	6/2/2024	100050
Schwarzbeck	VULB 9162	Bilog Antenna (30MHz - 6GHz)	4/17/2023	Annual	4/17/2024	00304

Table 6-1. Test Equipment List

Note:

For equipment listed above that has a calibration date or calibration due date that falls within the test date range, care was taken to ensure that this equipment was used after the calibration date and before the calibration due date.

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.0 TEST RESULTS

7.1 Summary

Company Name: Apple Inc.

FCC ID: BCG-A2968

IC: 579C-A2700

FCC Classification: Ultra-Wideband Transmitter

FCC Part Section(s)	RSS Section(s)	Test Description	Test Limit	Test Condition	Test Result	Reference
§15.503, §15.519 (b)	RSS-220 [2]	10dBc Bandwidth	≥ 500MHz	RADIATED	PASS	Section 7.2, 7.3
§ 2.1049	RSS-Gen [6.7]	Occupied Bandwidth	N/A		N/A	Section 7.3
§15.519 (e)	RSS-220 [5.3.1(g)]	Maximum Peak Power Spectral Density (Peak EIRP)	< 0 dBm/50MHz EIRP		PASS	Section 7.4.1
§15.519 (c)	RSS-220 [5.3.1(d)]	Maximum Average Emission (Average EIRP)	< -41.3 dBm/MHz EIRP		PASS	Section 7.4.2
§15.519 (a)(1)	RSS-220 [5.3.1(b)]	Cease Transmission Time	See §15.519 (a)(1) and RSS-220 [5.3.1(b)] for details		PASS	Section 7.5
§15.519 (c)	RSS-220 [5.3.1(d)]	Radiated Emissions Above 960MHz	See §15.519 (c) and RSS-220 [5.3.1(d)] for details		PASS	Sections 7.6
§15.519 (d)	RSS-220 [5.3.1(e)]	Radiated Emissions in the 1164 – 1240Mhz and 1559 – 1610MHz GPS Bands	See §15.519 (d) and RSS-220 [5.3.1(e)] for details		PASS	Sections 7.6
§15.519 (c), §15.209	RSS-220 [3.4] RSS-Gen [8.9]	Radiate Emissions Below 960MHz	Emissions in restricted bands must meet the radiated limits detailed in §15.209 (RSS-Gen [8.9])		PASS	Sections 7.7
§15.207	RSS-Gen [8.8]	AC Line Conducted Emissions 150kHz – 30MHz	< FCC 15.207 limits (RSS-Gen [8.8])	AC LINE CONDUCTED	PASS	Section 7.8

Table 7-1. Summary of Test Results

Notes:

1. All modes of operation were investigated. The test results shown in the following sections represent the worst case emissions.
2. The analyzer plots shown in this section were all taken with a correction table loaded into the analyzer. The correction table was used to account for the losses of the cables and attenuators used as part of the system to connect the EUT to the analyzer at all frequencies of interest.

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.2 10dBc Bandwidth Measurement

§15.503 §15.519 (b)

Test Overview and Limit

The UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna. The upper boundary is designated F_H and the lower boundary is designated F_L. The Frequency at which the highest radiated emission occurs is designated F_M.

- The center frequency, F_C, equals $(F_H + F_L) / 2$
- The fractional bandwidth equals $2(F_H - F_L) / (F_H + F_L)$

The UWB bandwidth of a device operating under provisions of this section must be contained between 3100MHz and 10,600MHz.

a) The minimum permissible 10dBc Bandwidth is 500MHz
b) Fractional bandwidth is equal or greater than 0.20

Test Procedure Used

ANSI C63.10-2013 – Section 10.1
KDB 393764 D01 v02r01

Test Settings

1. RBW = 1MHz
2. VBW = 3MHz
3. Detector = Peak
4. Trade mode = Max Hold
5. Sweep = auto couple
6. The trace was allowed to stabilize

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

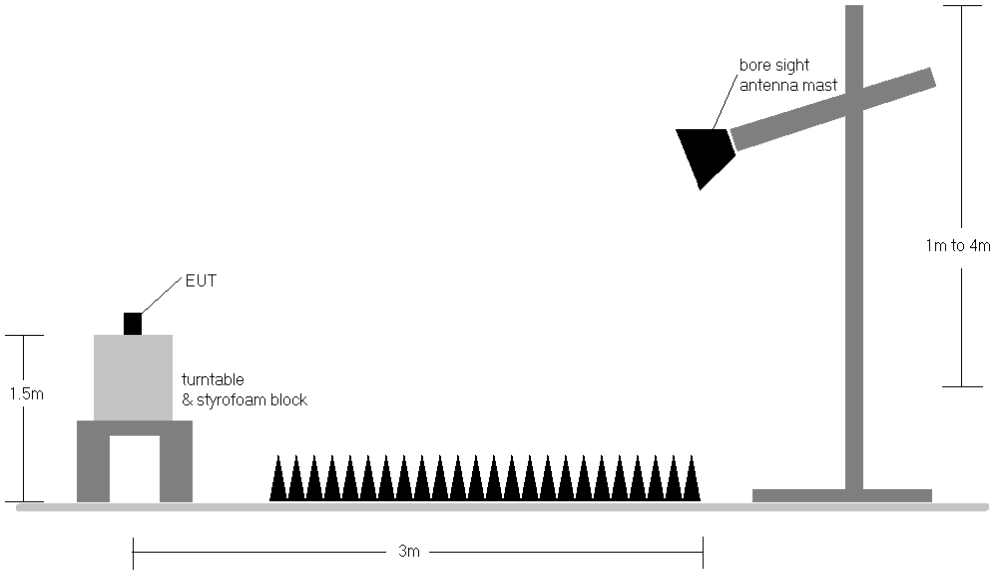


Figure 7-1. Test Setup

Test Notes

1. In those cases where the measured emission spectrum contains multiple (more than two) -10dBc points, the outermost points define the UWB bandwidth (i.e., the widest bandwidth is reported).

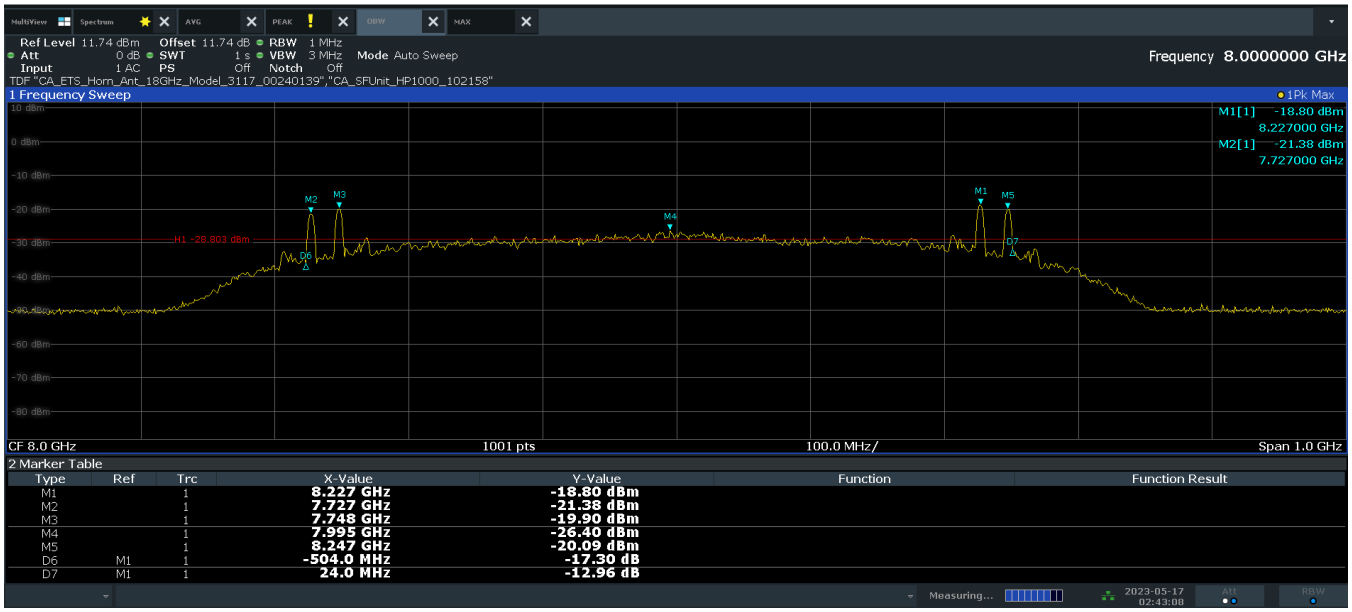
2. All modes of operation were investigated and the worst-case emissions are reported.

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Frequency [GHz]	Channel	Config	Payload	F_M [GHz]	F_L [GHz]	F_H [GHz]	Fc [GHz]	Measured Bandwidth [MHz]	Minimum Bandwidth [MHz]	Pass / Fail
8	9	0	125	8.227	7.723	8.251	7.995	**528.0**	500	Pass

Table 7-2. 10dBc Bandwidth Measurements (UWB, Ch.9, 8GHz)

ZZ2220 1Q3NH UWB ch9 Config 0 Payload 125 OBW D2 FF.PNG



Plot 7-1. 10dBc Bandwidth Plot (UWB, Ch. 9, Config 0/Payload 125)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.3 Bandwidth Measurement

RSS-220 [2], RSS-Gen [6.7]

Test Overview

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured. All modes of operation were investigated and the worst case configuration results are reported in this section.

Test Procedure Used

ANSI C63.10-2013 – Section 6.9
RSS-Gen [6.7]

Test Settings

1. The signal analyzer's automatic bandwidth measurement capability was used to perform the 99% occupied bandwidth and the 10dB bandwidth. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. RBW = 1 – 5% of the expected OBW
3. VBW ≥ 3 x RBW
4. Detector = Peak
5. Trace mode = max hold
6. Sweep = auto couple
7. The trace was allowed to stabilize
8. If necessary, steps 2 – 7 were repeated after changing the RBW such that it would be within 1 – 5% of the 99% occupied bandwidth observed in Step 7

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

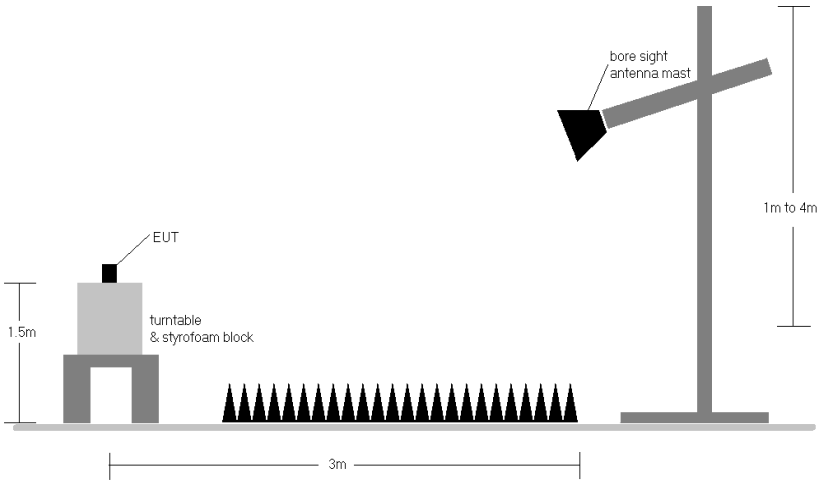


Figure 7-2. Test Instrument & Measurement Setup

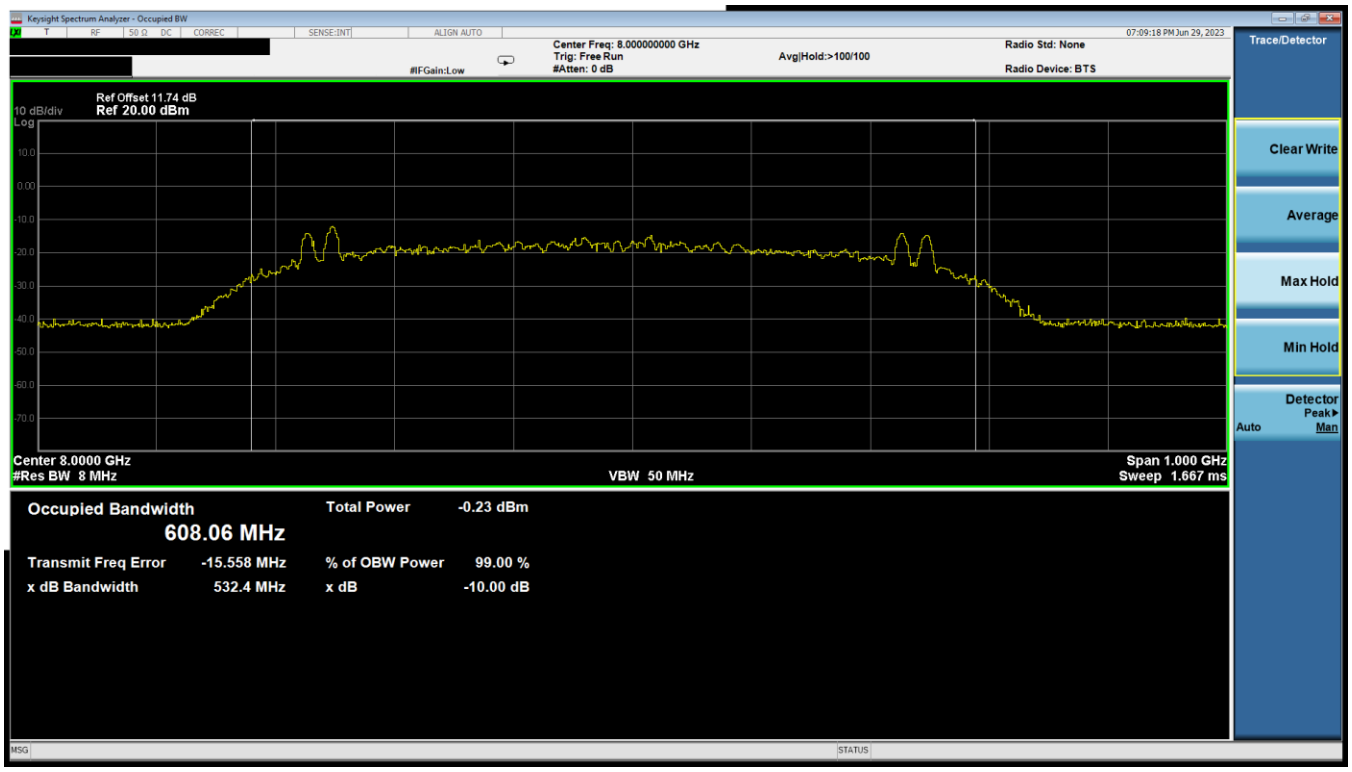
Test Notes:

1. All modes of operation were investigated and the worst-case emissions are reported.

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Frequency [GHz]	Channel	Config	Payload	Measured OBW [MHz]	Measured 10dBc Bandwidth [MHz]	Minimum Bandwidth [MHz]	Pass / Fail
8	9	0	125	**608.06**	**532.40**	500	Pass

Table 7-3. ISED 10dBc Bandwidth & 99% OBW Measurements (UWB, Ch.9, 8GHz)



Plot 7-2. ISED 10dBc Bandwidth & 99% OBW (UWB, Ch. 9, Config 0/Payload 125)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.4 Maximum Peak and Average Radiated Power (EIRP)

§15.519 (c) §15.519 (e); RSS-220 [5.3.1(d)] RSS-220 [5.3.1(g)]

Test Overview and Limits

15.519 (e) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, F_M. That limit is 0 dBm for Peak EIRP.

15.519 (c) The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency [MHz]	EIRP [dBm]
3100-10600	−41.3

Table 7-4. FCC 15.519 Average EIRP limit

Frequency [MHz]	EIRP [dBm]
4750-10600	−41.3

Table 7-5. RSS-220 Average EIRP limit

Test Procedure Used

ANSI C63.10-2013 – Section 10.3.5 and 10.3.7
KDB 393764 D01 v02r01

Test Settings

Average EIRP Measurements

1. RBW = 1MHz
2. VBW = 3MHz
3. Detector = Average (RMS)
4. Sweep time = No more than a 1 ms integration period over each measurement bin
5. Trace mode = Max hold
6. Trace was allowed to stabilize

Peak EIRP Measurements

1. RBW = 50MHz
2. VBW = 50MHz
3. Detector = Peak
4. Sweep time = auto couple
5. Trace mode = Max hold
6. Trace was allowed to stabilize

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

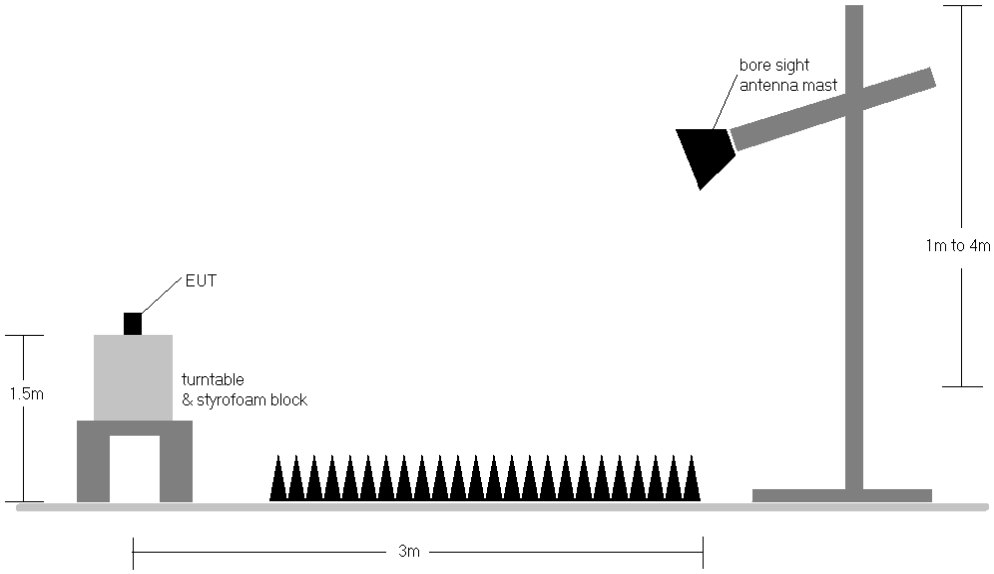


Figure 7-3. Test Instrument & Measurement Setup

Test Notes

1. The antenna is manipulated through typical positions, polarity and length during the tests. The EUT is manipulated through three orthogonal planes.

2. All modes of operation were investigated and the worst-case emissions are reported.

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

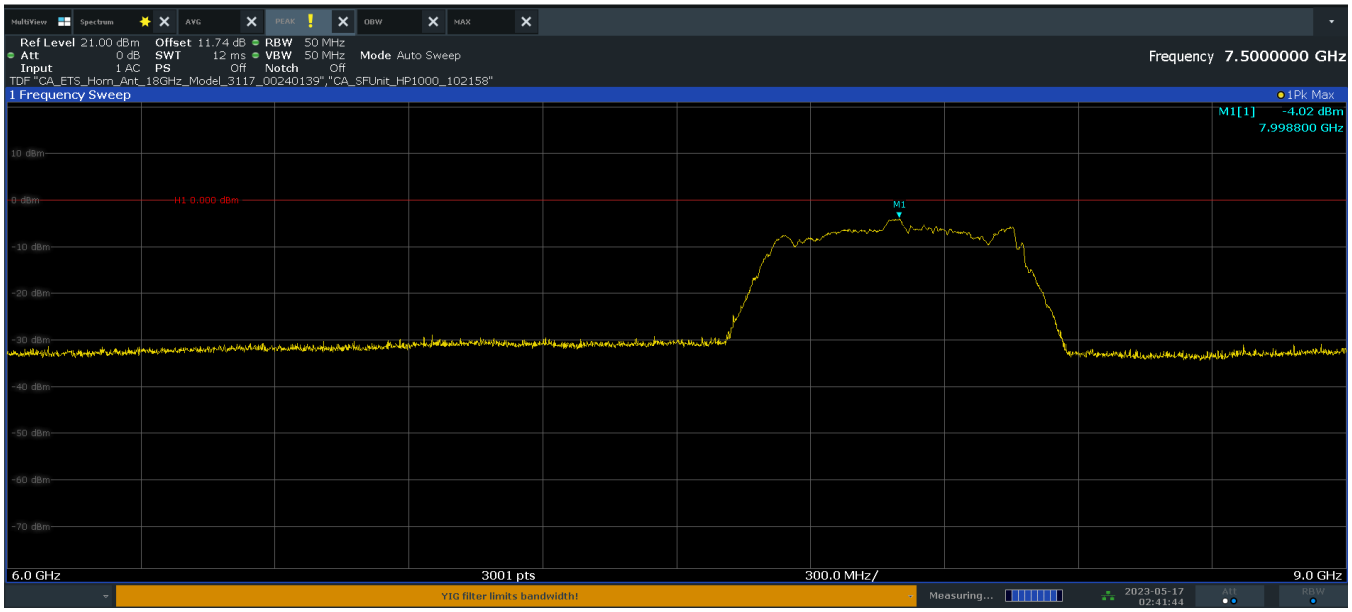
7.4.1 Peak Radiated Power Measurement

§15.519(e)); RSS-220 [5.3.1(g)]

Frequency [GHz]	Channel	Config	Payload	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	F_M [GHz]	Peak EIRP [dBm/50MHz]	Peak EIRP [dBm/50MHz]	Margin [dB]
8	9	0	125	V	245	224	7.9988	-4.02	0.00	-4.02

Table 7-6. Peak EIRP Measurements (UWB, Ch.9, 8GHz)

ZZ2220 1Q3NH UWB ch9 Config 0 Payload 125 EIRP D2 FF Peak.PNG



Plot 7-3. Peak Radiated Power (UWB, Ch. 9, Config 0/Payload 125)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

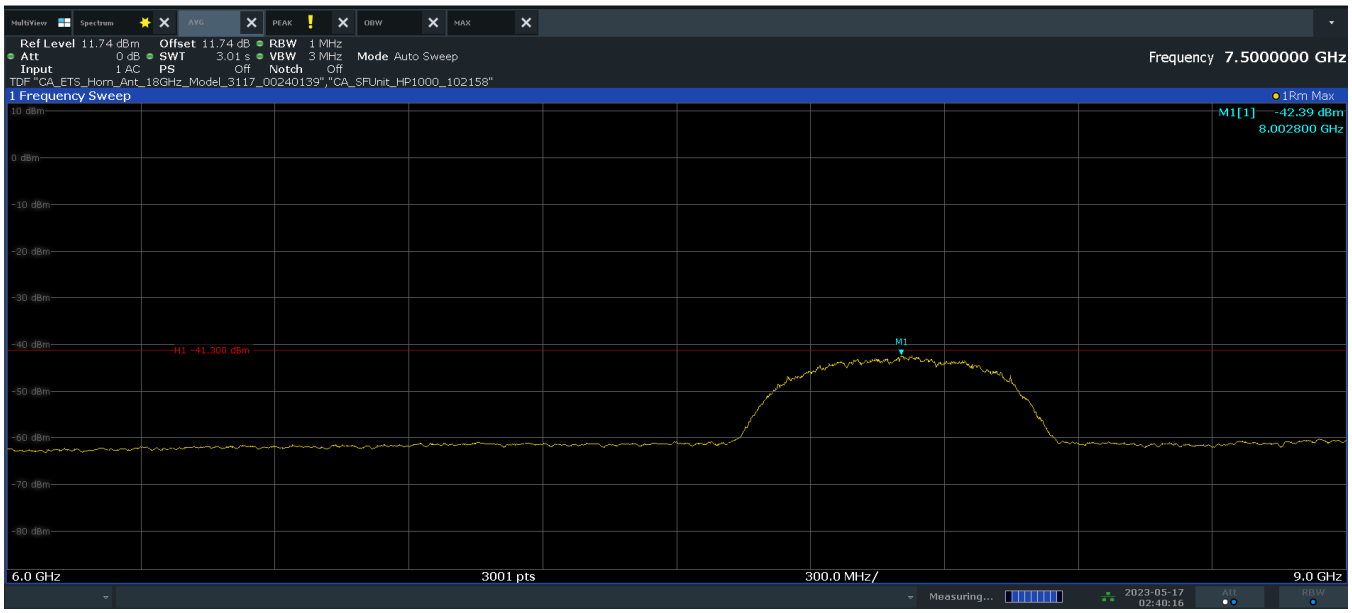
7.4.2 Average Radiated Power Measurement

§15.519(c); RSS-220 [5.3.1(d)]

Frequency [GHz]	Channel	Config	Payload	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	F_M [GHz]	Average EIRP [dBm/MHz]	Average EIRP Limit [dBm/MHz]	Margin [dB]
8	9	0	125	V	243	222.0	8.0028	-42.39	-41.30	-1.09

Table 7-7. Average EIRP Measurements (UWB, Ch.9, 8GHz)

ZZ2220 1Q3NH UWB ch9 Config 0 Payload 125 EIRP D2 FF AVG.PNG



Plot 7-4. Average Radiated Power (UWB, Ch. 9, Config 0/Payload 125)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.5 Cease Transmission Time

§15.519(a)(1); RSS-220 [5.3.1(b)]

Test Overview and Limit

A UWB device operating under the provisions of this section shall transmit only when it is sending information to an associated receiver. The UWB intentional radiator shall cease transmission within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgment of reception must continue to be received by the UWB intentional radiator at least every 10 seconds or the UWB device must cease transmitting.

Test Procedures Used

KDB 393764 D01 v02r01

Test Settings

1. RBW = 1MHz
2. VBW = 3MHz
3. Span = Zero Span Mode
4. Sweep time shall be sufficient to demonstrate EUTs compliance with the rule part.

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

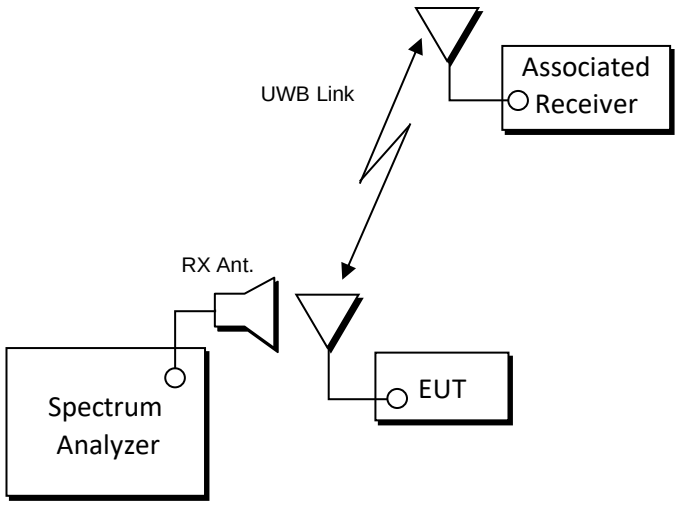


Figure 7-4. Test Setup

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Test Configurations

The EUT was monitored under the following test configurations:

- Mode 1: EUT initiates the UWB link to the associated receiver (phone),
    - Associated receiver ends the link, and EUT ceases transmission of any information other than periodic signals (polling) for use in the establishment or re-establishment of a communications link with an associated receiver

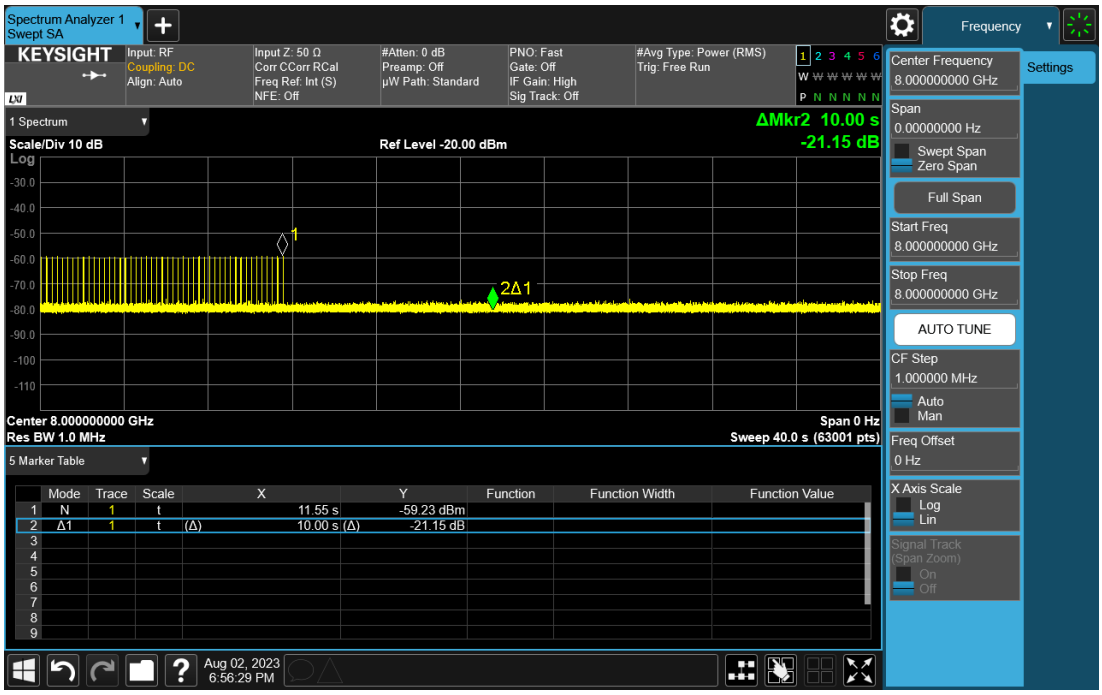
Result

Parameter	Limit	Result
Cessation Time - Mode1	1) The UWB intentional radiator shall cease transmission within 10 seconds 2) An acknowledgment of reception must continue to be received by the UWB intentional radiator at least every 10 seconds or the UWB device must cease transmitting.	Pass

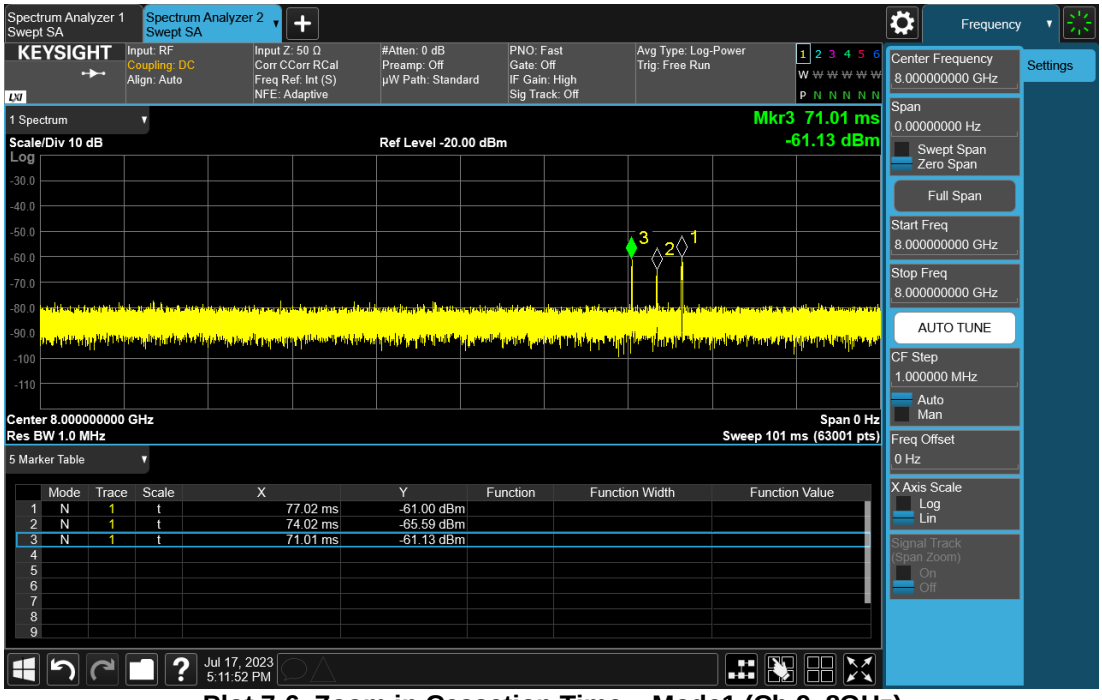
Plots Description

- Cessation Time - Mode1 plot:
    - Marker 1 shows stop time of sending acknowledgement from the associated receiver. UWB Transmission ceases promptly.
    - Marker 2 is placed to show that UWB Cease Tx has stopped before the maximum 10 s limit.
- Zoom in Cessation Time - Mode1 plot:
    - Marker 1 and Marker 3 show EUT traffic level
    - Marker 2 shows Associated receiver (Phone) traffic level

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.



Plot 7-5. Cessation Time – Mode1 (Ch.9, 8GHz)



Plot 7-6. Zoom in Cessation Time – Mode1 (Ch.9, 8GHz)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.6 Radiated Spurious Emissions - Above 960MHz

§15.519 (c) §15.519 (d); RSS-220 [5.3.1(d)] RSS-220 [5.3.1(e)]

Test Overview and Limit

All out of band radiated spurious emissions are measured with a spectrum analyzer connected to a receive antenna while the EUT is operating at maximum power and at the appropriate frequencies. Only the radiated emissions of the configuration that produced the worst case emissions are reported in this section.

All out of band emissions must not exceed the average limits shown in Table 7-8 and Table 7-9 per Section 15.519 (C) and RSS-220[5.3.1(d)]) when measured using a resolution bandwidth of 1 MHz:

Frequency [MHz]	EIRP [dBm]
960-1610	-75.3
1610-1990	-63.3
1990-3100	-61.3
3100-10600	-41.3
Above 10600	-61.3

Table 7-8. FCC 15.519 Radiated Spurious Emissions Limits

Frequency [MHz]	EIRP [dBm]
960-1610	-75.3
1610-4750	-70.0
4750-10600	-41.3
Above 10600	-61.3

Table 7-9. RSS 220 Radiated Spurious Emissions Limits

All out of band emissions must not exceed the average limits shown in Table 7-10 per Section 15.519 (d) and RSS-220(5.3.1)(e) when measured using a resolution bandwidth greater than or equal to 1 kHz. The measurements shall demonstrate compliance with the stated limits at whatever resolution bandwidth is used.

Frequency [MHz]	EIRP [dBm]
1164-1240	-85.3
1559-1610	-85.3

Table 7-10. FCC 15.519/RSS-220 Radiated Spurious Emissions Limits for GPS frequency bands

Test Procedures Used

ANSI C63.10-2013 – Section 10.3
KDB 393764 D01 v02r01

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Test Settings

Average RSE Measurements

1. RBW = 1MHz (30kHz for emissions in the GPS band)
2. VBW = 3MHz (100kHz for emissions in the GPS band)
3. Detector = Average (RMS)
4. Sweep time = No more than a 1 ms integration period over each measurement bin
5. Trace mode = Max hold
6. Trace was allowed to stabilize

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

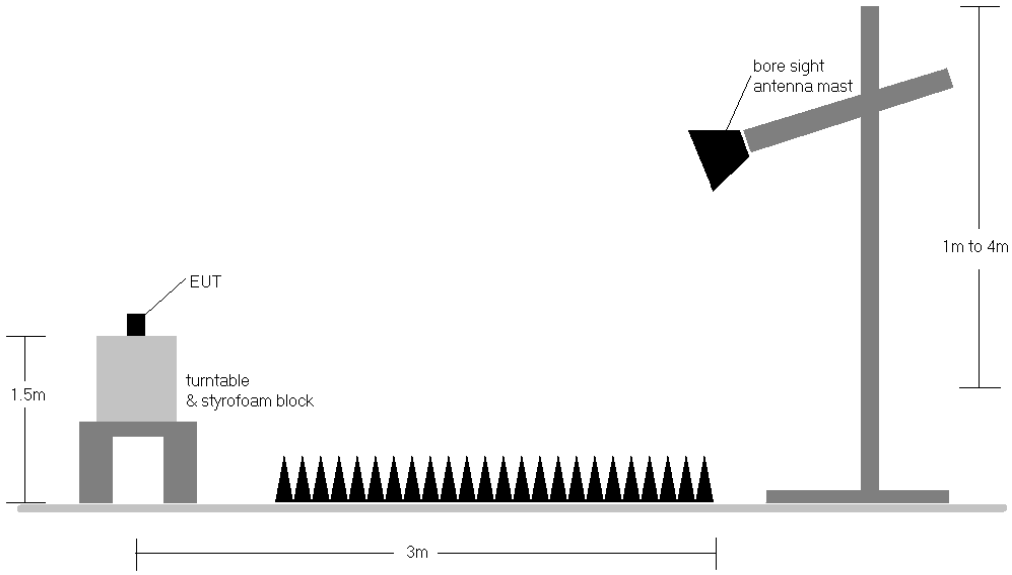


Figure 7-5. Radiated Test Setup > 960MHz

Test Notes

1. All modes of operation were investigated and the worst-case emissions are reported.
2. This unit was tested with its standard battery.
3. The RBW for measurements in the GPS Bands were reduced to 30kHz in order to show compliance.
4. D is the measurement test distance and emissions from 960MHz - 18GHz were measured at 0.6 meter test distance while emissions above 18GHz were measured at 0.5 meter test distance with the application of a distance correction factor.
5. The "-" shown in the following RSE tables are used to denote a noise floor measurement.
6. 6GHz - 9GHz RSE is covered in EIRP section (Section 7.4).

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Sample Calculations

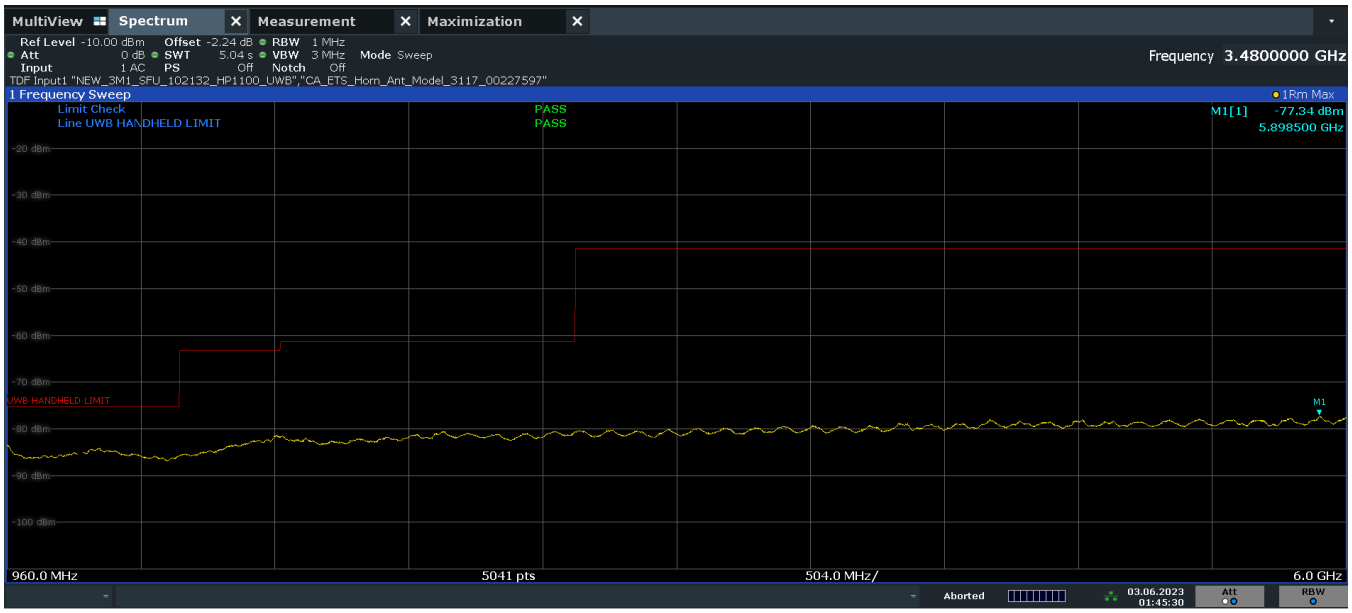
Determining Spurious Emissions Levels

- $E_{[dB\mu V/m]} = \text{Analyzer level}_{[dBm]} + 107 + AFCL_{[dB/m]}$
- $\text{Spurious Emission Level}_{[dBm]} = E_{[dB\mu V/m]} + 20 \log (D_{Meas}) - 104.8$
- $\text{Spurious Emission Level}_{[dBm]} = \text{Analyzer Level}_{[dBm]} + AFCL_{[dB/m]} + \text{Conversion Factor}_{[dB]}$
- $AFCL_{[dB/m]} = (\text{Antenna Factor}_{[dB/m]} + \text{Cable Loss}_{[dB]} + \text{Attenuator}_{[dB]}) - \text{Preamplifier Gain}_{[dB]}$
- $\text{Conversion Factor}_{[dB]} = 107 - 104.8 + 20 \log (D_{Meas})$
- $\text{Margin}_{[dB]} = \text{Spurious Emission Level}_{[dBm]} - \text{Limit}_{[dBm]}$

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

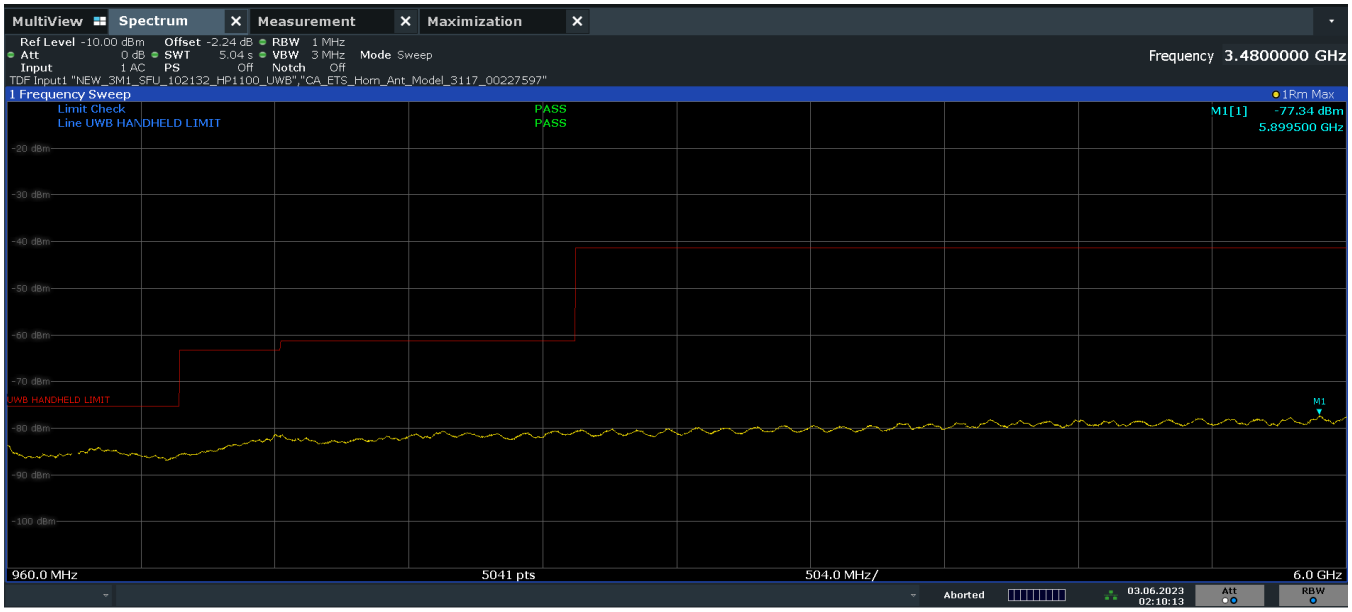
7.6.1 Radiated Spurious Emissions (960MHz-18GHz)

§15.519(c); RSS-220 [5.3.1(d)]



01:45:31 03.06.2023

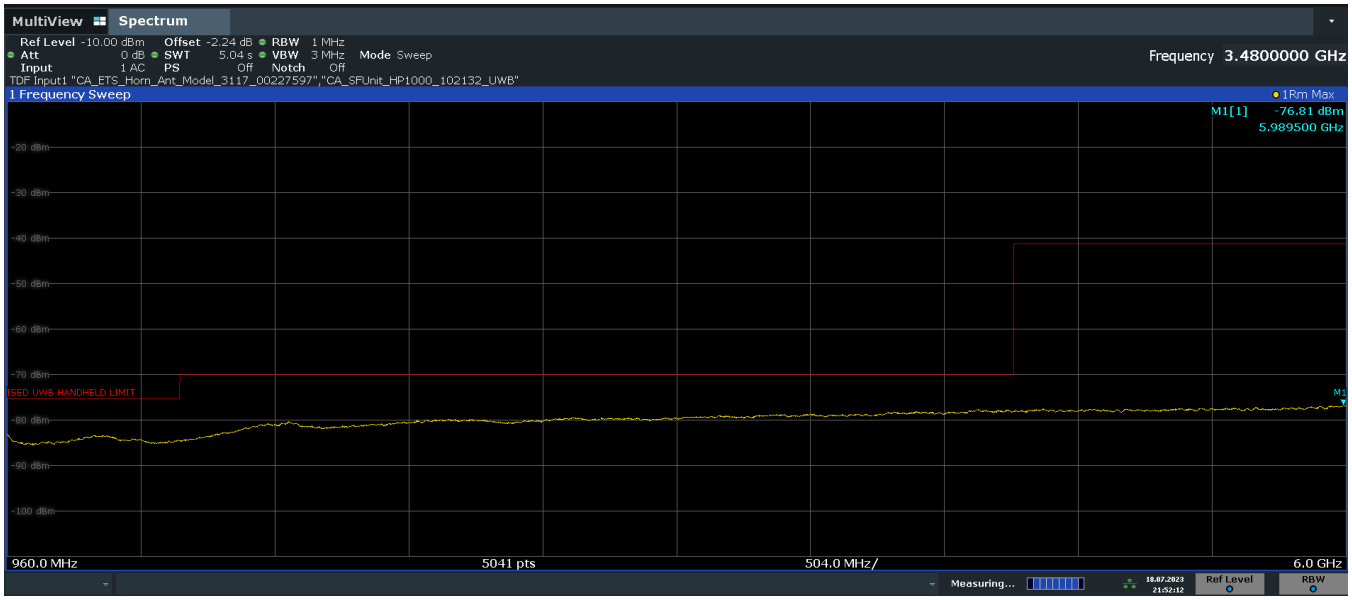
Plot 7-7. FCC Radiated Spurious Emission 960-6000MHz (Ch. 9, Config 0, Payload 125 Ant. Pol. H)



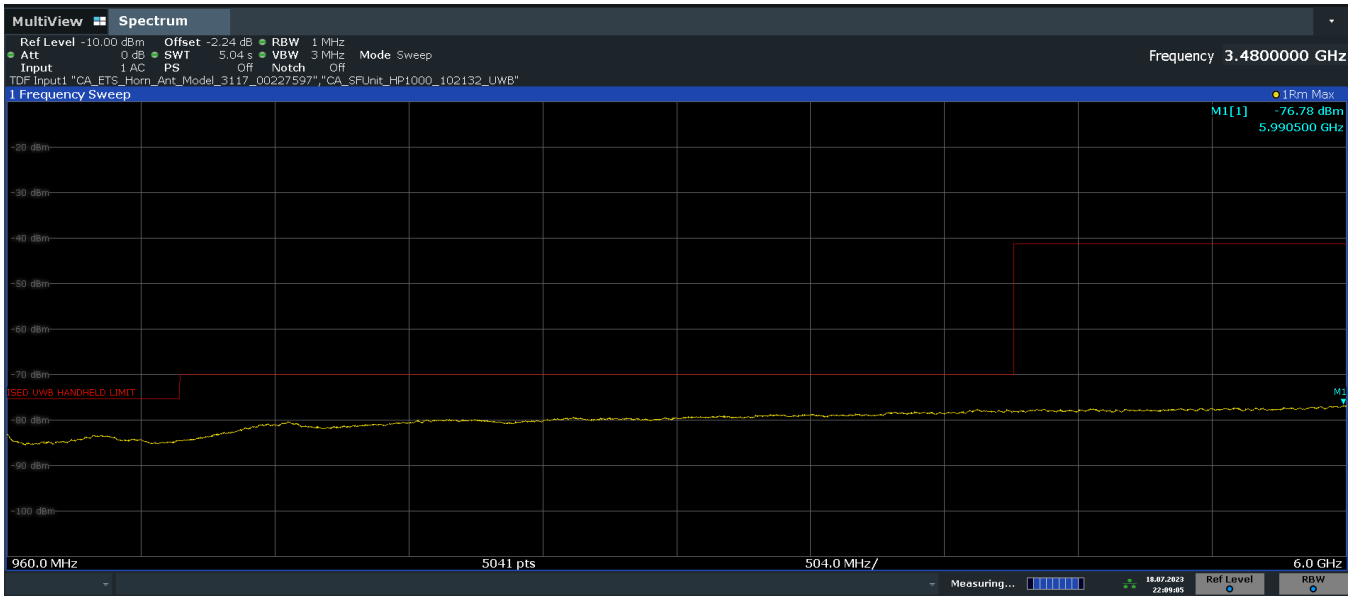
02:10:13 03.06.2023

Plot 7-8. FCC Radiated Spurious Emission 960-6000MHz (Ch. 9, Config 0, Payload 125 Ant. Pol. V)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

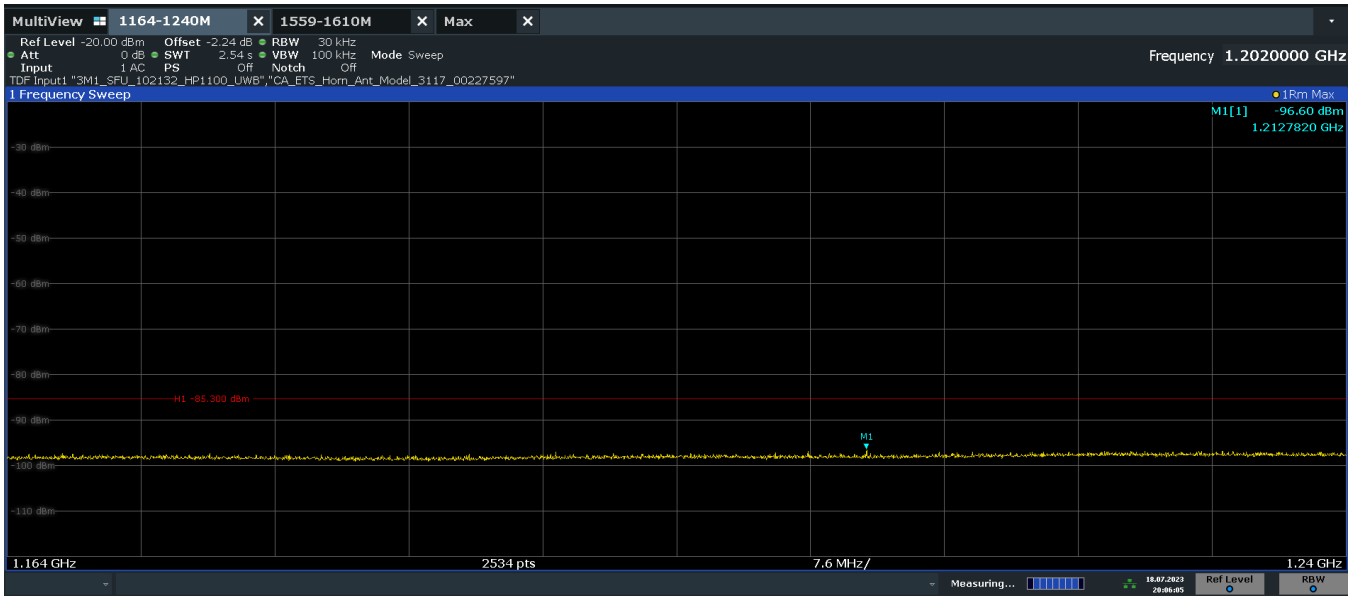


Plot 7-9. ISED Radiated Spurious Emission 960-6000MHz (Ch. 9, Config 0, Payload 125 Ant. Pol. H)

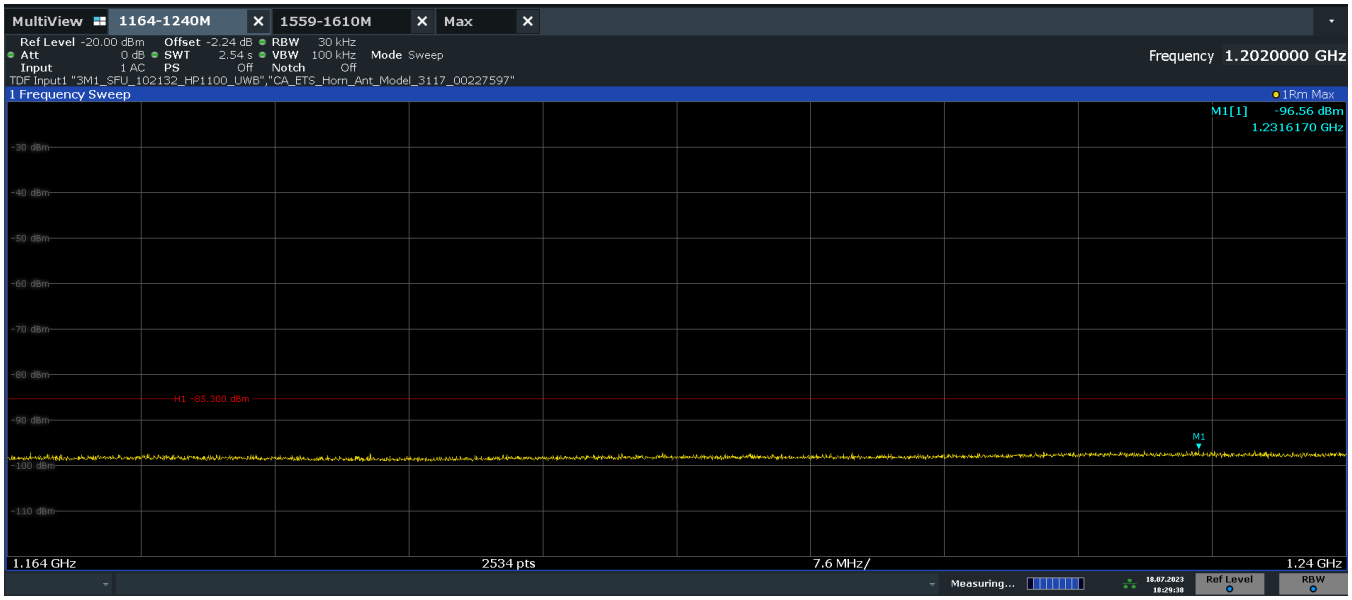


Plot 7-10. ISED Radiated Spurious Emission 960-6000MHz (Ch. 9, Config 0, Payload 125 Ant. Pol. V)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

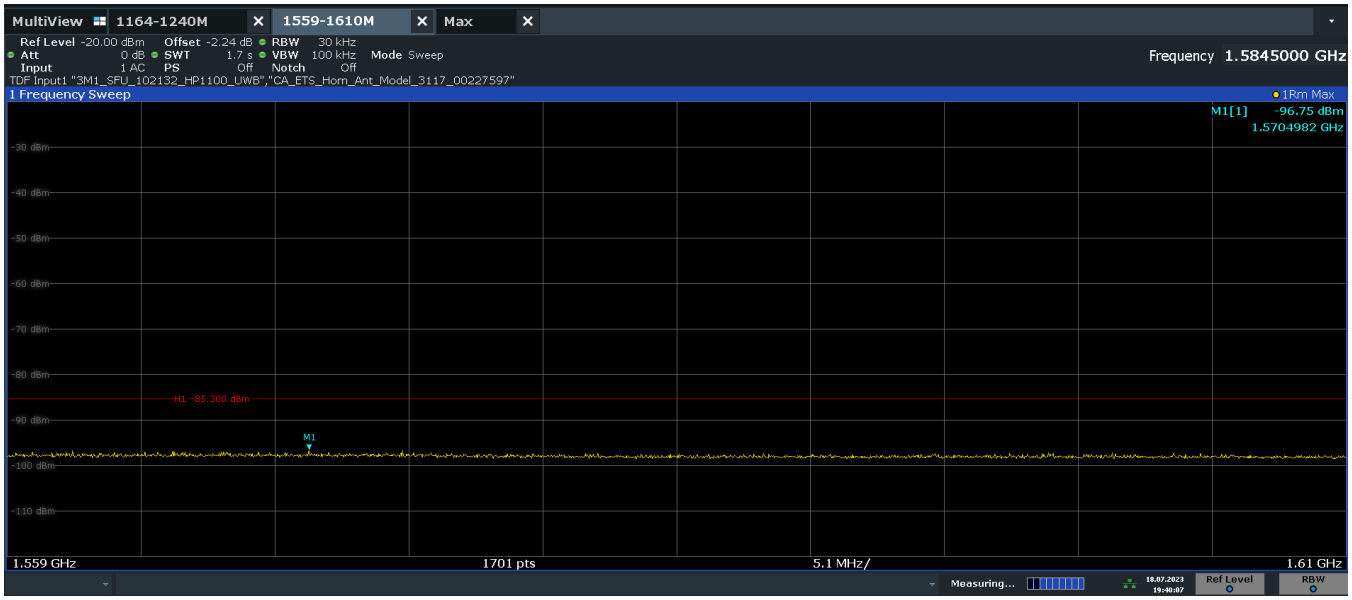


Plot 7-11. Radiated Spurious Emission 1164-1240MHz (Ch. 9, Config 0, Payload 125 Ant. Pol H)

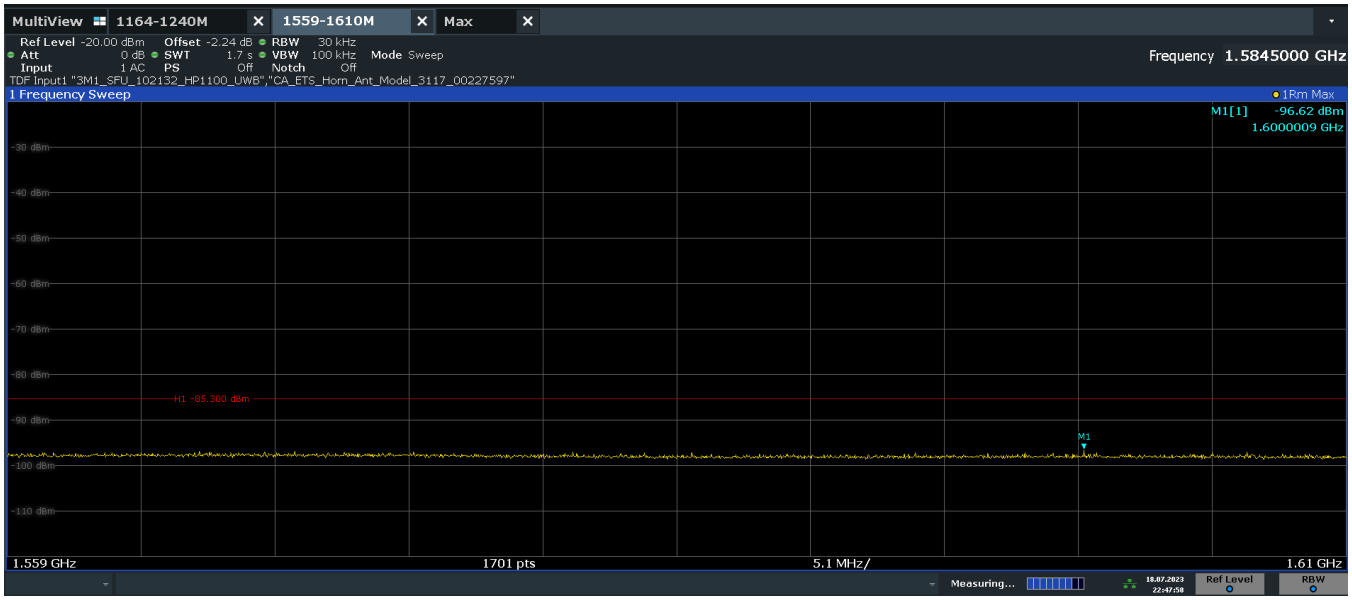


Plot 7-12. Radiated Spurious Emission 1164-1240MHz (Ch. 9, Config 0, Payload 125 Ant. Pol V)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

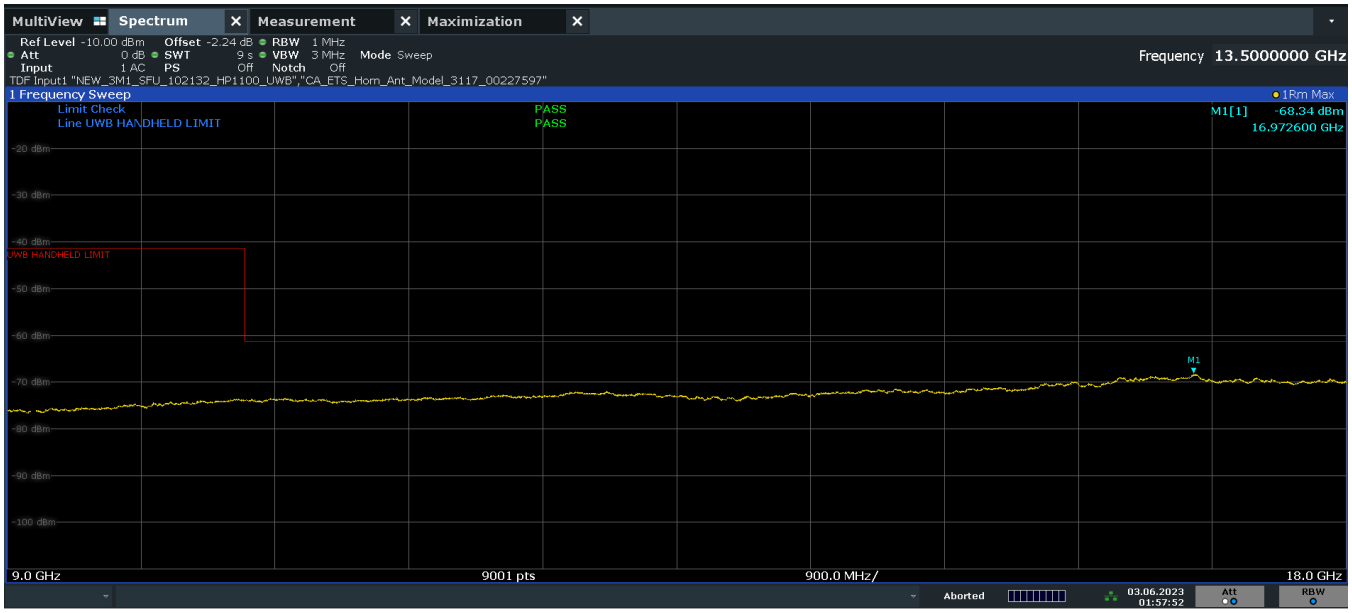


Plot 7-13. Radiated Spurious Emission 1559-1610MHz (Ch. 9, Config 0, Payload 125 Ant. Pol H)



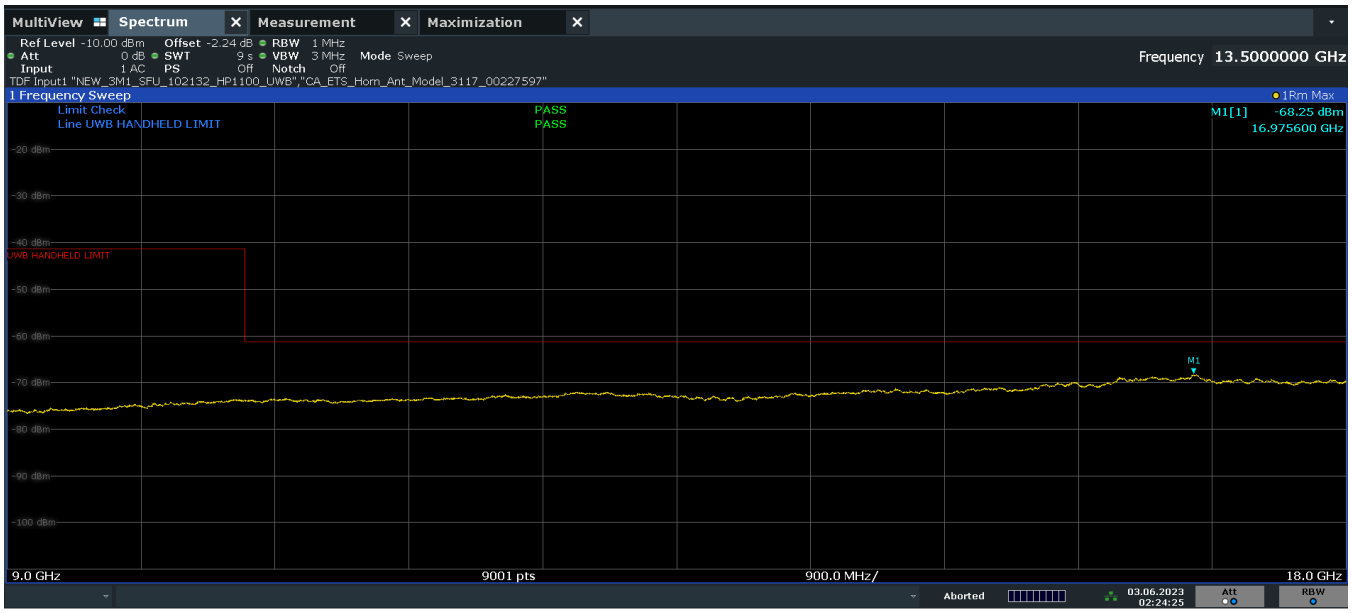
Plot 7-14. Radiated Spurious Emission 1559-1610MHz (Ch. 9, Config 0, Payload 125 Ant. Pol V)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.



01:57:53 03.06.2023

Plot 7-15. Radiated Spurious Emission 9-18GHz (Ch. 9, Config 0, Payload 125 Ant. Pol. H)



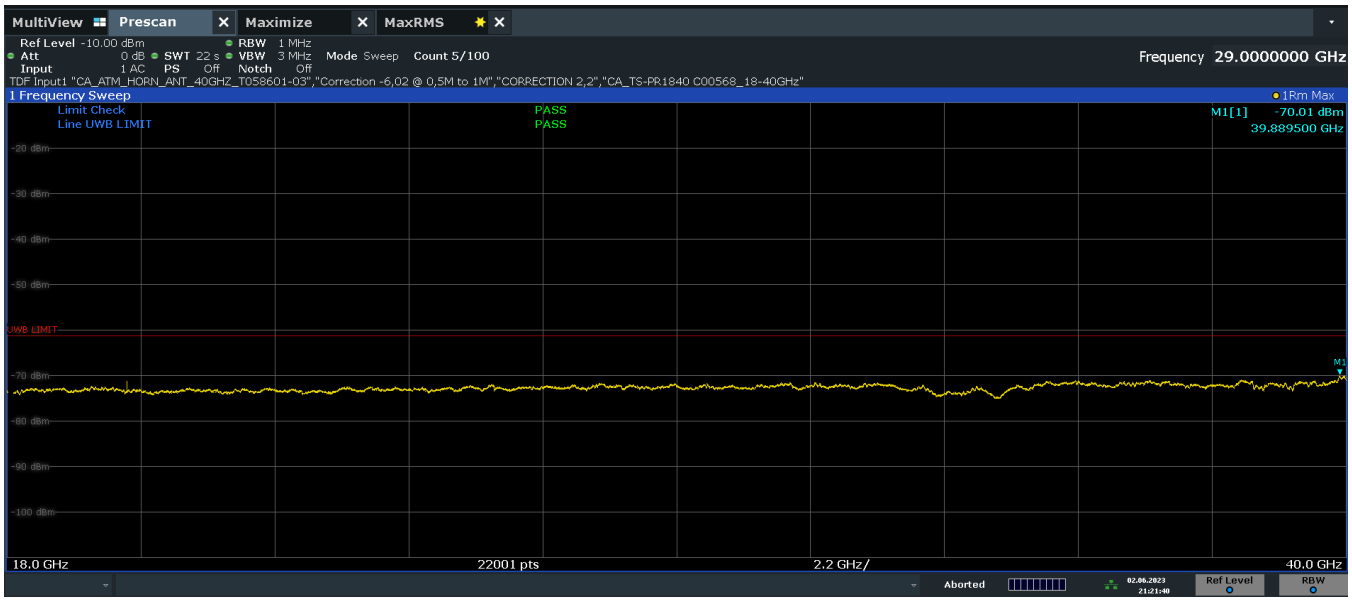
02:24:26 03.06.2023

Plot 7-16. Radiated Spurious Emission 9-18GHz (Ch. 9, Config 0, Payload 125 Ant. Pol. V)

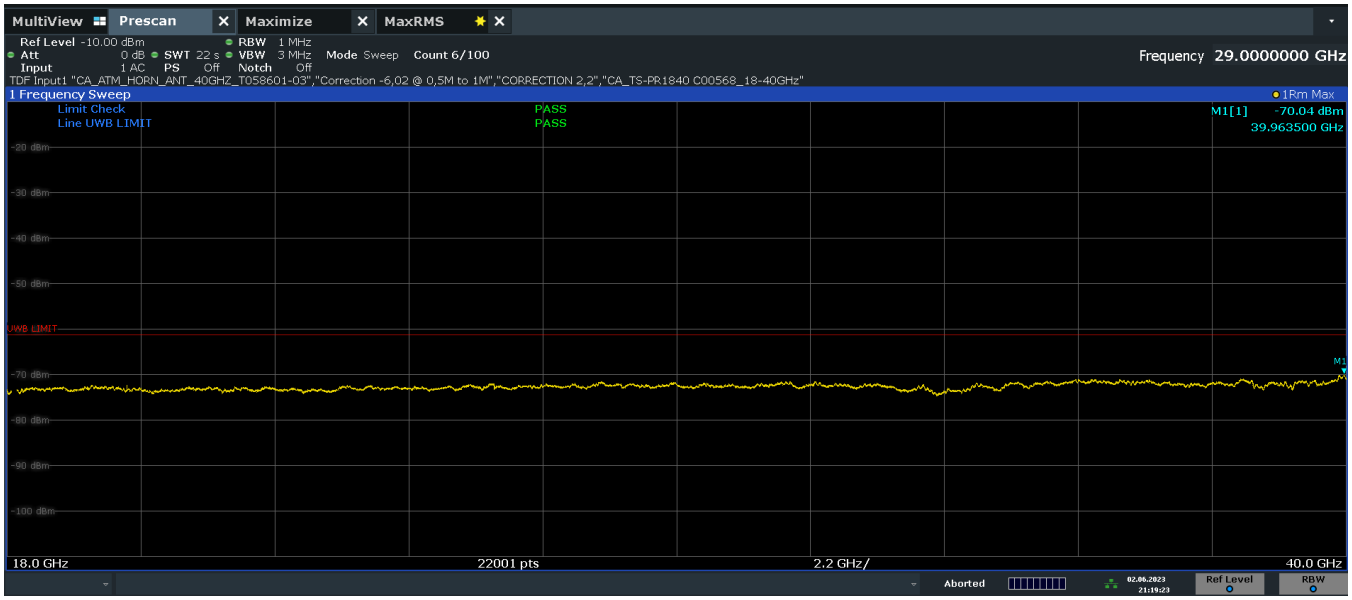
Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Radiated Spurious Emission (Above 18GHz)

§15.519(c); RSS-220 [5.3.1(d)]



Plot 7-17. Radiated Spurious Emission 18-40GHz (Ch.9, Config 0, Payload 125 Ant. Pol. H)



Plot 7-18. Radiated Spurious Emission 18-40GHz (Ch.9, Config 0, Payload 125 Ant. Pol. V)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Radiated Spurious Emission Measurements (960MHz-18GHz)

§15.519(c); RSS-220 [5.3.1(d)]

Distance of Measurements:	0.6 Meters
Operating Frequency:	8000 MHz
Channel:	9
Config	0
Payload	125

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Conversion Factor [dB]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
1256	Avg	V	-	-	-76.51	-5.54	-2.24	-84.29	-75.30	-8.99
1726	Avg	V	-	-	-77.18	-5.25	-2.24	-84.67	-63.30	-21.37
2034	Avg	V	-	-	-77.74	-2.45	-2.24	-82.43	-61.30	-21.13
11251	Avg	V	-	-	-77.85	5.91	-2.24	-74.18	-61.30	-12.88
15238	Avg	V	-	-	-79.93	9.83	-2.24	-72.34	-61.30	-11.04
17610	Avg	V	-	-	-80.89	13.23	-2.24	-69.90	-61.30	-8.60

Table 7-11. Radiated Spurious Emission Measurements 960MHz-18GHz (FCC)

Distance of Measurements:	0.6 Meters
Operating Frequency:	8000 MHz
Channel:	9
Config	0
Payload	125

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Conversion Factor [dB]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
1256	Avg	V	-	-	-76.51	-5.54	-2.24	-84.29	-75.30	-8.99
1726	Avg	V	-	-	-77.18	-5.25	-2.24	-84.67	-70.00	-14.67
2034	Avg	V	-	-	-77.74	-2.45	-2.24	-82.43	-70.00	-12.43
11251	Avg	V	-	-	-77.85	5.91	-2.24	-74.18	-61.30	-12.88
15238	Avg	V	-	-	-79.93	9.83	-2.24	-72.34	-61.30	-11.04
17610	Avg	V	-	-	-80.89	13.23	-2.24	-69.90	-61.30	-8.60

Table 7-12. Radiated Spurious Emission Measurements 960MHz-18GHz (ISED)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Radiated Spurious Emission Measurements (Above 18GHz)

§15.519(c); RSS-220 [5.3.1(d)]

Distance of Measurements:	0.5 Meters
Operating Frequency:	8000 MHz
Channel:	9
Config	0
Payload	125

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Conversion Factor [dB]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
19968	Avg	H	243	96	-58.57	-7.09	-3.82	-69.48	-61.30	-8.18
23686	Avg	H	-	-	-62.53	-6.49	-3.82	-72.84	-61.30	-11.54
27930	Avg	H	-	-	-63.86	-4.47	-3.82	-72.15	-61.30	-10.85
33100	Avg	H	-	-	-64.52	-4.69	-3.82	-73.03	-61.30	-11.73
37293	Avg	H	-	-	-62.07	-5.31	-3.82	-71.20	-61.30	-9.90

Table 7-13. Radiated Spurious Emission Measurements 18-40GHz

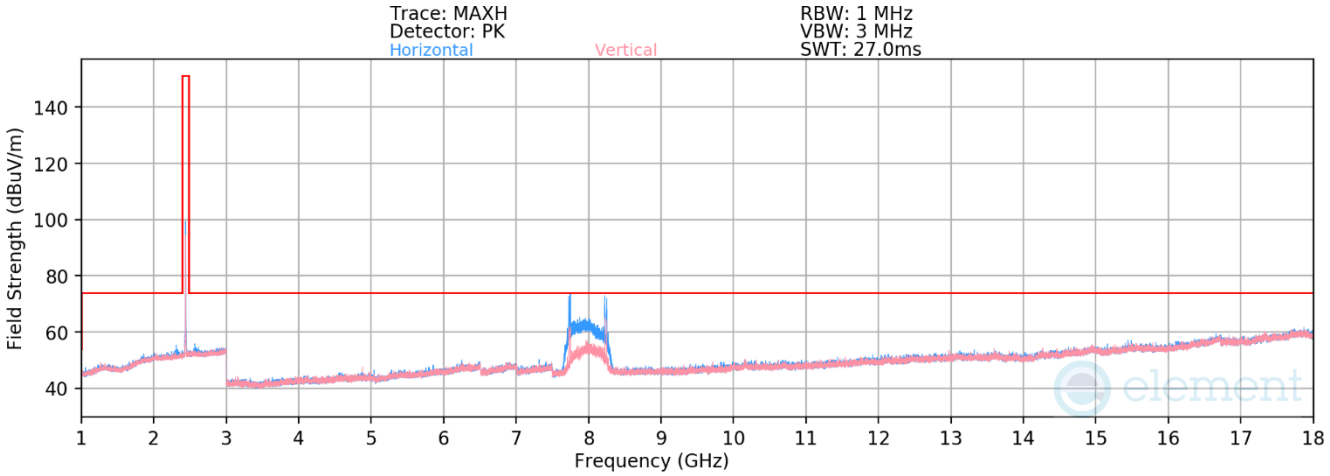
Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.6.2 Simultaneous Tx Radiated Spurious Emission Measurements

§15.519(c) §15.247 §15.205 & §15.209; RSS-220 [5.3.1(d)] & RSS-Gen [8.9]

Description	Bluetooth	UWB
Channel	0	9
Operating Frequency (MHz)	2402	8000
Mode/Modulation	BLE1M	Config 0 / Payload 125

Table 7-14. Worst Case Simultaneous Transmission Configuration

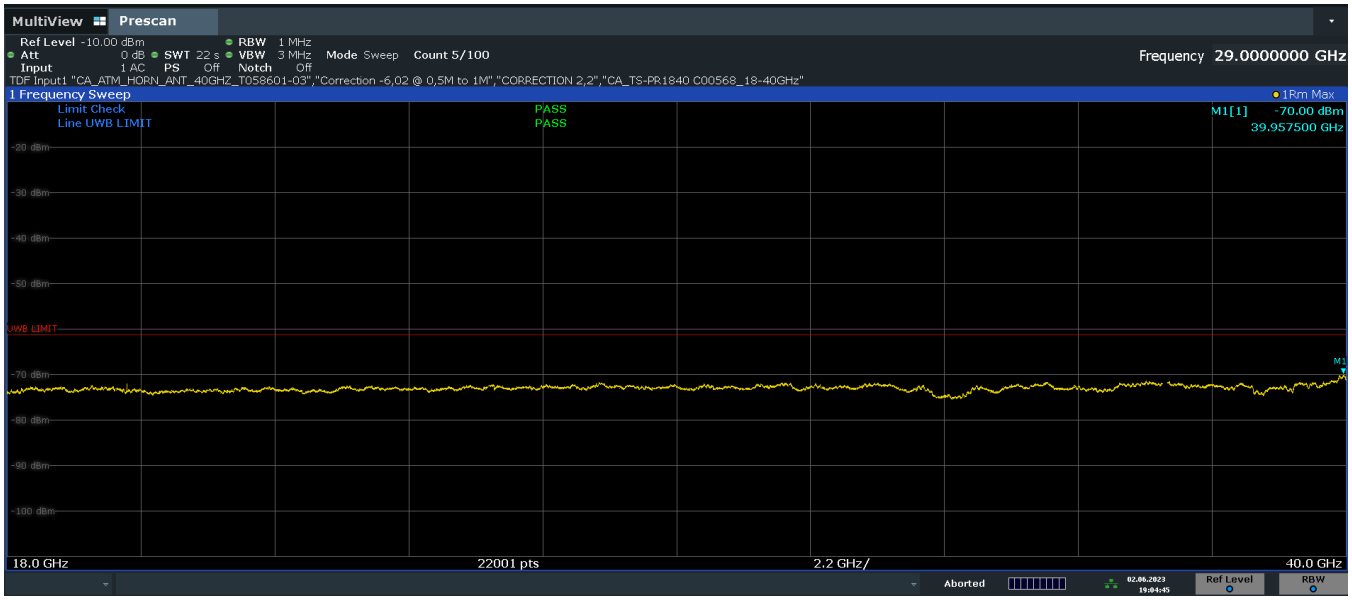


Plot 7-19. Radiated Spurious Simultaneous Transmission 1-18GHz (Ch.9, Config 3, Payload 125)

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Duty Cycle Correction [dB]	Field Strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]
4880.00	Avg	V	117	93	-73.33	6.24	2.04	41.95	53.98	-12.03
4880.00	Peak	V	117	93	-65.16	6.24	0.00	48.08	73.98	-25.90
7320.00	Avg	H	291	214	-77.31	9.97	2.04	41.70	53.98	-12.28
7320.00	Peak	H	291	214	-67.43	9.97	0.00	49.54	73.98	-24.44
12200.00	Avg	-	-	-	-82.23	14.86	0.00	39.63	53.98	-14.35
12200.00	Peak	-	-	-	-71.72	14.86	0.00	50.14	73.98	-23.84

Table 7-15. BLE1M Harmonics Emissions Measurement in Simultaneous Transmission

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.



Plot 7-20. Radiated Spurious Simultaneous Transmission 18-40GHz (Ch.9, Config 3, Payload 125)

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Dist. Corr. Factor [dB]	Spurious Emission Level [dBm]	Limit [dBm]	Margin [dB]
19968	Avg	H	356	117	-57.53	-7.09	-3.82	-68.44	-61.30	-7.14
23971	Avg	H	-	-	-62.60	-6.33	-3.82	-72.75	-61.30	-11.45
27756	Avg	H	-	-	-64.15	-4.12	-3.82	-72.09	-61.30	-10.79
32928	Avg	H	-	-	-65.35	-4.16	-3.82	-73.33	-61.30	-12.03
39957	Avg	H	-	-	-63.75	-2.43	-3.82	-70.00	-61.30	-8.70

Table 7-16. Radiated Spurious Emission – Simultaneous Transmission 18-40GHz

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.7 Radiated Spurious Emissions Measurements – Below 960MHz

§15.209; RSS-Gen [8.9]

Test Overview and Limit

All out of band radiated spurious emissions are measured with a spectrum analyzer connected to a receive antenna while the EUT is operating at its maximum duty cycle, at maximum power, and at the appropriate frequencies. All data rates and modes were investigated for radiated spurious emissions. Only the radiated emissions of the configuration that produced the worst case emissions are reported in this section.

All out of band emissions appearing in a restricted band as specified in Section 15.205 of the Title 47 CFR and Table 6 of RSS-Gen (8.10) must not exceed the limits shown in Table 7-17 per Section 15.209 and RSS-Gen (8.9).

Frequency	Field Strength [µV/m]	Measured Distance [Meters]
0.009 – 0.490 MHz	2400/F (kHz)	300
0.490 – 1.705 MHz	24000/F (kHz)	30
1.705 – 30.00 MHz	30	30
30.00 – 88.00 MHz	100	3
88.00 – 216.0 MHz	150	3
216.0 – 960.0 MHz	200	3
Above 960.0 MHz	500	3

Table 7-17. Radiated Limits

Test Procedures Used

ANSI C63.10-2013

Test Settings

Quasi-Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 120kHz (for emissions from 30MHz – 1GHz)
3. Detector = quasi-peak
4. Sweep time = auto couple
5. Trace mode = max hold
6. Trace was allowed to stabilize

Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 120kHz (for emissions from 30MHz – 1GHz)
3. VBW = 300kHz
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Test Setup

The EUT and measurement equipment were set up as shown in the diagrams below.

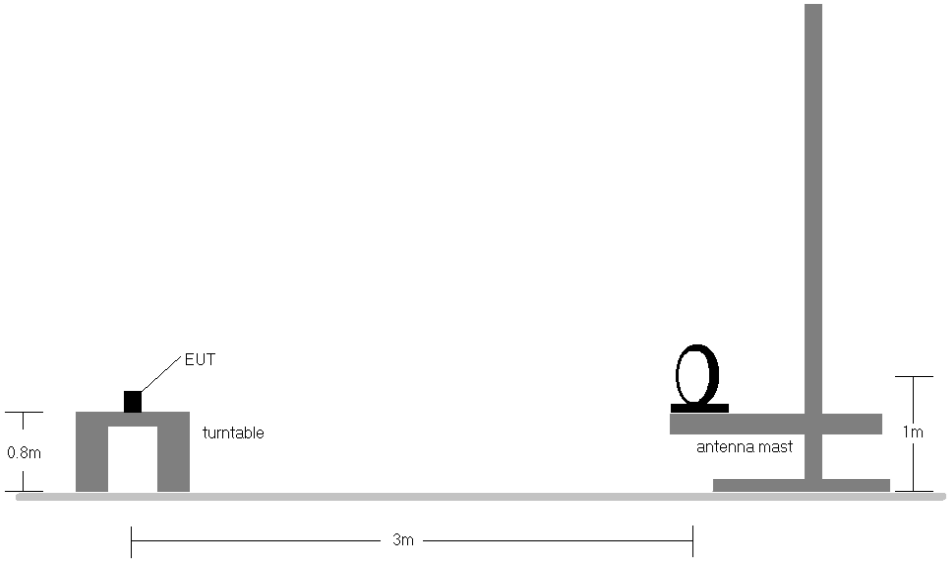


Figure 7-6. Radiated Test Setup < 30Mhz

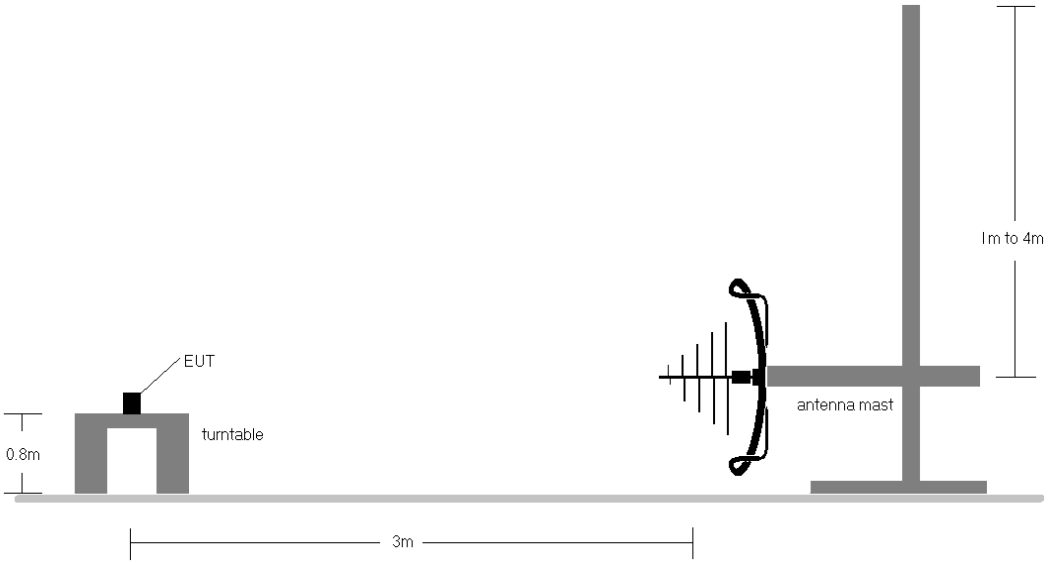


Figure 7-7. Radiated Test Setup < 1GHz

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Test Notes

1. All emissions lying in restricted bands specified in §15.205 and RSS-Gen(8.10) are below the limit shown in Table 7-17.
2. The broadband receive antenna is manipulated through vertical and horizontal polarizations during the tests. The EUT is manipulated through three orthogonal planes. For below 30MHz the loop antenna was positioned in 3 orthogonal planes X front, Y side, Z top) to determine the orientation resulting in the worst-case emissions.
3. This unit was tested with its standard battery.
4. The spectrum is investigated using a peak detector and final measurements are recorded using CISPR quasi peak detector for emissions within 6dB of the limit.
5. Emissions were measured at a 3-meter test distance.
6. Emissions are investigated while operating on the center channel of the mode, band, and modulation that produced the worst-case results during the transmitter spurious emissions testing.
7. No spurious emissions were detected within 20dB of the limit below 30MHz.
8. The results recorded using the broadband antenna is known to correlate with the results obtained by using a tuned dipole with an acceptable degree of accuracy. The VSWR for the measurement antenna was found to be less than 2:1.
9. Both configurations below were investigated, and the worst case has been reported.
    a. EUT powered by AC/DC adapter via USB-C cable.
    b. EUT powered by host PC via USB-C cable.
10. All modes of operation were investigated and the worst-case emissions are reported.

Sample Calculations

Determining Spurious Emissions Levels

o Field Strength Level $_{[dB\mu V/m]}$ = Analyzer Level $_{[dBm]}$ + 107 + AFCL $_{[dB/m]}$

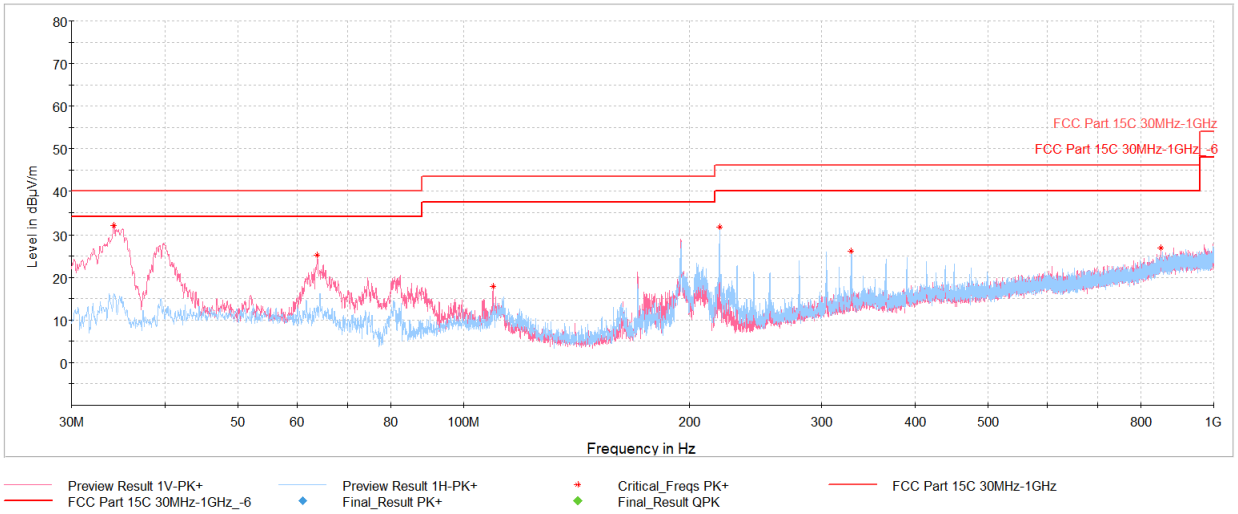
o AFCL $_{[dB/m]}$ = (Antenna Factor $_{[dB/m]}$ + Cable Loss $_{[dB]}$ + Attenuator $_{[dB]}$) – Preamplifier Gain $_{[dB]}$

o Margin $_{[dB]}$ = Field Strength Level $_{[dB\mu V/m]}$ – Limit $_{[dB\mu V/m]}$

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.7.1 Radiated Spurious Emissions (Below 960MHz)

§15.209; RSS-Gen [8.9]



Plot 7-21. Radiated Spurious Emission 30-960MHz (Ch. 9, Config 0, Payload 125 with AC/DC Adapter)

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Field Strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]
34.17	Max Peak	V	100	340	-60.12	-14.82	32.06	40.00	-7.94
63.85	Max Peak	V	200	214	-67.93	-13.92	25.15	40.00	-14.85
109.54	Max Peak	V	100	174	-75.88	-13.28	17.84	43.52	-25.68
219.15	Max Peak	H	100	1	-62.77	-12.63	31.60	46.02	-14.42
328.66	Max Peak	H	100	280	-71.71	-9.09	26.20	46.02	-19.82
850.86	Max Peak	V	100	294	-81.98	1.79	26.81	46.02	-19.21

Table 7-18. Radiated Spurious Emission 30-960MHz (Ch. 9, Config 0, Payload 125 with AC/DC Adapter)

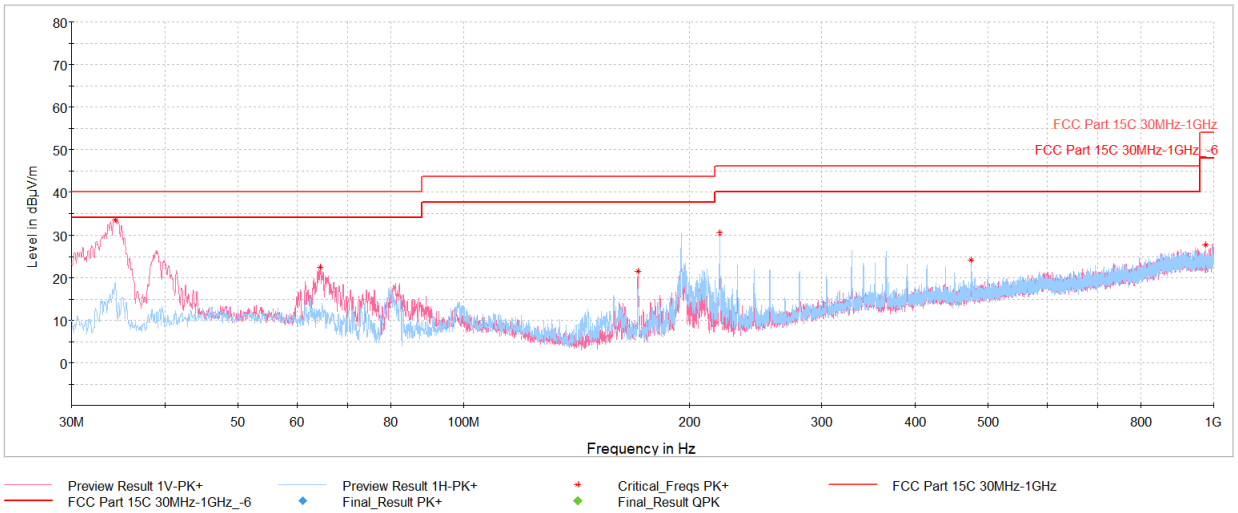
Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.7.2 Simultaneous Tx Radiated Spurious Emissions (30 - 960MHz)

§15.209 & §27.53(m); RSS-Gen [8.9] & RSS-199 [4.5]

Description	Bluetooth	UWB
Channel	19	9
Operating Frequency (MHz)	2440	8000
Mode/Modulation	BLE1M	Config0/Payload 125

Table 7-19.Worst Case Simultaneous Transmission Configuration



Plot 7-22. Radiated Spurious Emission – Simultaneous Transmission below 960MHz with AC/DC Adapter

Frequency [MHz]	Detector	Ant. Pol. [H/V]	Antenna Height [cm]	Turntable Azimuth [degree]	Analyzer Level [dBm]	AFCL [dB/m]	Field Strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]
34.37	Max Peak	V	100	225	-58.89	-14.75	33.36	40.00	-6.64
64.48	Max Peak	V	200	76	-70.52	-14.07	22.41	40.00	-17.59
170.60	Max Peak	V	100	63	-70.47	-15.09	21.44	43.52	-22.08
219.30	Max Peak	H	100	315	-64.02	-12.62	30.36	46.02	-15.66
474.79	Max Peak	V	200	231	-76.64	-6.13	24.23	46.02	-21.79
975.36	Max Peak	H	100	97	-81.05	1.76	27.71	53.98	-26.27

Table 7-20. Radiated Spurious Emission – Simultaneous Transmission below 960MHz with AC/DC Adapter

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

7.8 AC Line-Conducted Emission Measurement

§15.207; RSS-Gen [8.8]

Test Overview and Limit

All AC line conducted spurious emissions are measured with a receiver connected to a grounded LISN while the EUT is operating at its maximum duty cycle, at maximum power, and at the appropriate frequencies. All data rates and modes were investigated for conducted spurious emissions. Only the conducted emissions of the configuration that produced the worst case emissions are reported in this section.

All conducted emissions must not exceed the limits shown in the table below, per Section 15.207 and RSS-Gen (8.8).

Frequency of emission (MHz)	Conducted Limit (dBµV)	
	Quasi-peak	Average
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30	60	50

Table 7-21. Conducted Limits

*Decreases with the logarithm of the frequency.

Test Procedures Used

ANSI C63.10-2013, Section 6.2

Test Settings

Quasi-Peak Measurements

1. Analyzer center frequency was set to the frequency of the spurious emission of interest
2. RBW = 9kHz (for emissions from 150kHz – 30MHz)
3. Detector = quasi-peak
4. Sweep time = auto couple
5. Trace mode = max hold
6. Trace was allowed to stabilize

Average Measurements

1. Analyzer center frequency was set to the frequency of the spurious emission of interest
2. RBW = 9kHz (for emissions from 150kHz – 30MHz)
3. Detector = RMS
4. Sweep time = auto couple
5. Trace mode = max hold
6. Trace was allowed to stabilize

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

Test Setup

The EUT and measurement equipment were set up as shown in the diagram below.

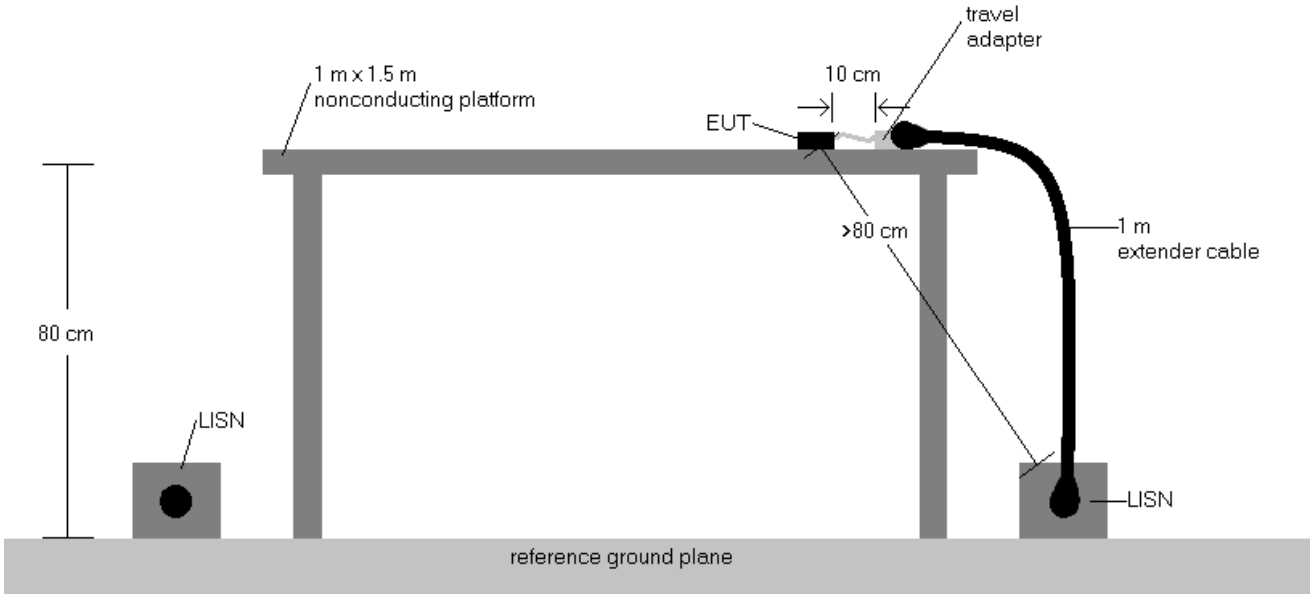
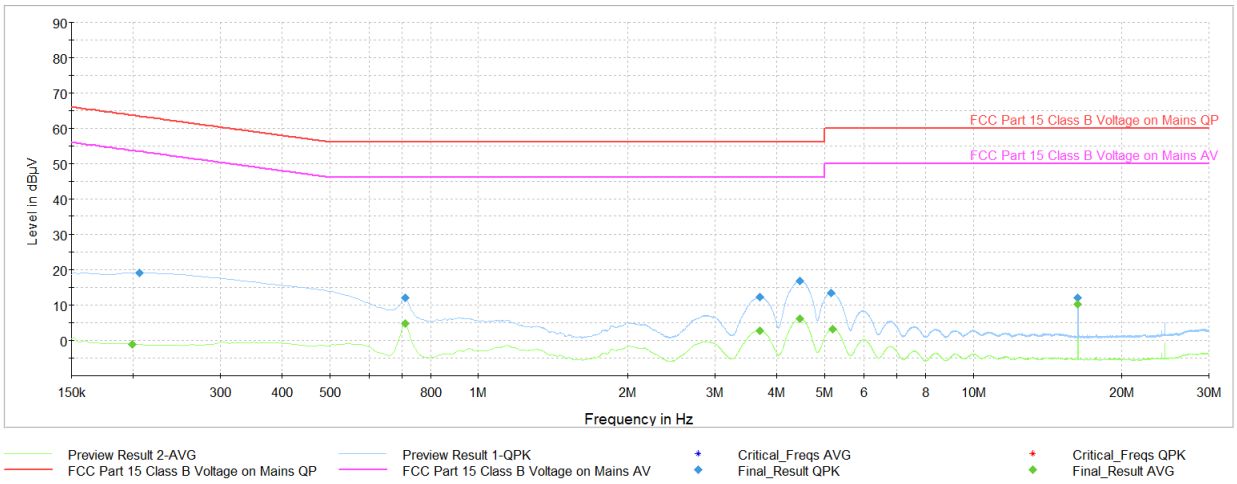


Figure 7-8. Test Instrument & Measurement Setup

Test Notes

1. All modes of operation were investigated and the worst-case emissions are reported. The emissions found were not affected by the choice of channel used during testing.
2. The limit for an intentional radiator from 150kHz to 30MHz are specified in Part 15.207 and RSS-Gen (8.8).
3. Corr. (dB) = Cable loss (dB) + LISN insertion factor (dB)
4. QP/AV Level (dBμV) = QP/AV Analyzer/Receiver Level (dBμV) + Corr. (dB)
5. Margin (dB) = QP/AV Level (dBμV) - QP/AV Limit (dBμV)
6. Traces shown in plot are made using a quasi-peak and average detectors
7. Both configurations below were investigated, and the worst case has been reported.
    a. EUT powered by AC/DC adapter via USB-C cable.
    b. EUT powered by host PC via USB-C cable.
8. Deviations to the Specifications: None.

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

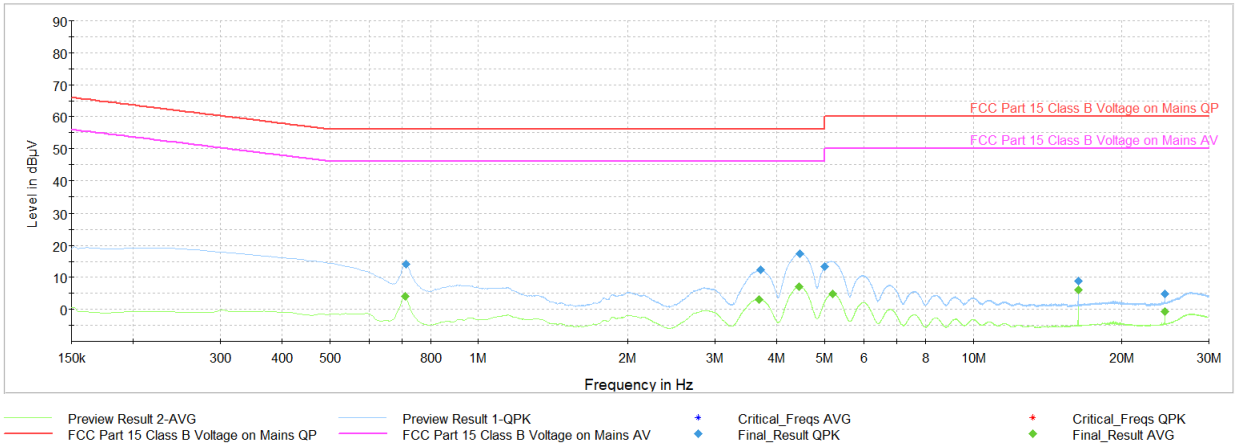


Plot 7-23. AC Line Conducted (Ch.9, Config 0, Payload 125, L1, with AC/DC Adapter)

Frequency [MHz]	Process State	QuasiPeak [dBµV]	Average [dBµV]	Limit [dBµV]	Margin [dB]	Line	PE
0.200	FINAL	---	-1.06	53.63	-54.69	L1	GND
0.206	FINAL	19.2	---	63.36	-44.15	L1	GND
0.710	FINAL	---	4.83	46.00	-41.17	L1	GND
0.710	FINAL	12.1	---	56.00	-43.86	L1	GND
3.694	FINAL	---	2.81	46.00	-43.19	L1	GND
3.705	FINAL	12.3	---	56.00	-43.73	L1	GND
4.452	FINAL	---	6.16	46.00	-39.84	L1	GND
4.454	FINAL	16.8	---	56.00	-39.18	L1	GND
5.154	FINAL	13.5	---	60.00	-46.51	L1	GND
5.201	FINAL	---	3.31	50.00	-46.69	L1	GND
16.294	FINAL	12.2	---	60.00	-47.80	L1	GND
16.296	FINAL	---	10.25	50.00	-39.75	L1	GND

Table 7-22. AC Line Conducted Data (Ch.9, Config 0, Payload 125, L1, with AC/DC Adapter)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.



Plot 7-24. AC Line Conducted (Ch.9, Config 0, Payload 125, N, with AC/DC Adapter)

Frequency [MHz]	Process State	QuasiPeak [dBµV]	Average [dBµV]	Limit [dBµV]	Margin [dB]	Line	PE
0.710	FINAL	---	4.06	46.00	-41.94	N	GND
0.713	FINAL	14.1	---	56.00	-41.92	N	GND
3.687	FINAL	---	3.16	46.00	-42.84	N	GND
3.716	FINAL	12.3	---	56.00	-43.75	N	GND
4.443	FINAL	---	7.03	46.00	-38.97	N	GND
4.459	FINAL	17.5	---	56.00	-38.49	N	GND
4.999	FINAL	13.3	---	56.00	-42.71	N	GND
5.192	FINAL	---	4.81	50.00	-45.19	N	GND
16.307	FINAL	8.9	---	60.00	-51.15	N	GND
16.307	FINAL	---	6.12	50.00	-43.88	N	GND
24.459	FINAL	---	-0.73	50.00	-50.73	N	GND
24.459	FINAL	4.9	---	60.00	-55.08	N	GND

Table 7-23. AC Line Conducted Data (Ch.9, Config 0, Payload 125, N, with AC/DC Adapter)

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.

8.0 CONCLUSION

The data collected relate only the item(s) tested and show that the **Apple Charging Case FCC ID: BCG-A2968** and **IC: 579C-A2968** is in compliance with Part 15 Subpart F (15.519) of the FCC Rules and RSS-220 of the Innovation, Science and Economic Development Canada Rules.

Unless otherwise specified, no part of this report may be reproduced or utilized in any part, form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from Element Materials Technology Morgan Hill. If you have any questions about this or have an enquiry about obtaining additional rights to this report or assembly of contents thereof, please contact ct.info@element.com.