

FCC and Industry Canada Testing of the
STORZ & BICKEL GMBH & CO.KG
Model: Volcano HYBRID
In accordance with FCC 47 CFR Part 15B and
15C, Industry Canada RSS-247 and RSS-GEN
and ICES-003

Prepared for: STORZ & BICKEL GMBH & CO.KG
In Grubenäcker 5-9
78532 Tuttlingen
Germany

FCC ID: 2APJE-SB
IC: 23679-SB



Product Service

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Date: 2018-06-14
Document Number: TR-65350-25670-05 Ed. 3

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Matthias Stumpe	2018-06-06	
Authorised Signatory	Markus Biberger	2018-06-14	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

ENGINEERING STATEMENT

The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance with FCC 47 CFR Part 15B and 15C, Industry Canada RSS-247 and RSS-GEN and ICES-003. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Matthias Stumpe	2018-06-06	

Laboratory Accreditation

Laboratory recognition

Industry Canada test site registration

Registration No. BNetzA-CAB-16/21-15

3050A-2

EXECUTIVE SUMMARY

A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15B and 15C, Industry Canada RSS-247 and RSS-GEN:2016, Issue 2 (2017-02) and Issue 4 (2014-11) and ICES-003:2016.



Bundesznetzagentur

BNetzA-CAB-16/21-15

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DL-InfoV (Germany) at
www.tuev-sued.com/imprint

Managing Directors:
Dr. Peter Havel (CEO)
Dr. Jens Butenandt
Holger Lindner

Phone: +49 (0) 9421 55 22-0
Fax: +49 (0) 9421 55 22-99
www.tuev-sued.de

TÜV SÜD Product Service GmbH
Äußere Frühlingstraße 45
94315 Straubing
Germany



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1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	2018-05-16
2	Radio tests added to report	2018-06-06

Table 1

1.2 Introduction

Applicant	STORZ & BICKEL GMBH & CO.KG
Manufacturer	STORZ & BICKEL GMBH & CO.KG
Model Number(s)	Volcano HYBRID
Serial Number(s)	VH123456
FCC ID:	2APJE-SB
IC:	23679-SB
Hardware Version(s)	S&B Module: BLE 0.04
Software Version(s)	S&B Module: FW: 0.20.03
Number of Samples Tested	1 pcs Volcano HYBRID / 2 pcs S&B Radio Module
Test Specification/Issue/Date	FCC 47 CFR Part 15B and 15C, Industry Canada RSS-247 and RSS-GEN:2016, Issue 2 (2017-02) and Issue 4 (2014-11) and ICES-003:2016
Test Plan/Issue/Date	The S&B radio module has been test in the host STORZ & BICKEL GMBH & CO.KG, Volcano HYBRID, SN: VH123456
Order Number	---
Date	
Date of Receipt of EUT	2018-02-06
Start of Test	2018-02-08
Finish of Test	2018-05-08
Name of Engineer(s)	Matthias Stumpe
Related Document(s)	ANSI C63.4: 2014 and C63.10 (2013) KDB 662911 D01 v02r02



1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15B and 15C, Industry Canada RSS-247 and RSS-GEN and ICES-003 is shown below.

Section	Specification Clause	Test Description	Result	Comments/Base Standard
Configuration and Mode: 120 V / 60 Hz AC Powered, Air and Heat on, Bluetooth on				
2.1	15.107 and 6.1	Conducted Disturbance at Mains Terminals	Pass	ANSI C63.4: 2014---
2.2	15.109 and 6.2	Radiated Disturbance	Pass	ANSI C63.4: 2014---
2.3	15.247 (d), 15.205, 5.5 and 6.13	Spurious Radiated Emissions	Pass	ANSI C63.10 (2013)
2.4	15.247 (b), 5.4 and 6.12	Maximum Conducted Output Power	Pass	ANSI C63.10 (2013) KDB 662911 D01 v02r02
2.5	15.247 (e), 5.2 and 6.12	Power Spectral Density	Pass	ANSI C63.10 (2013) KDB 662911 D01 v02r02
2.6	15.247 (a)(2), 5.2 and 6.6	Emission Bandwidth	Pass	ANSI C63.10 (2013)
2.7	15.247 (d), 5.5 and N/A	Authorised Band Edges	Pass	ANSI C63.10 (2013)
2.8	15.205 N/A and 8.10	Restricted Band Edges	Pass	ANSI C63.10 (2013)

Table 2

1.4 Product Information

1.4.1 Technical Description

The EUT has a S&B Radio Module operating in the 2.4 GHz band and using Bluetooth Low Energy (BLE) technology.



Figure 1 - front



Figure 2 - left



Product Service



Figure 3 - right



Figure 4 - rear



1.4.2 EUT Port/Cable Identification

Port	Max Cable Length specified	Usage	Type	Screened
AC power input	>3m	1.5 m	AC power	No

Table 3

1.4.3 Test Configuration

Configuration	Description
120 V / 60 Hz AC Powered	---

Table 4

1.4.4 Modes of Operation

Mode	Description
Air and Heat on, Bluetooth on	---

Table 5

1.5 Deviations from the Standard

none

1.6 EUT Modification Record

The table below details modifications made to the EUT during the test programme.
The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
Serial Number: VH123456, Volcano Hybrid			
0	As supplied by the customer	Not Applicable	Not Applicable
Serial Number: NA, Test Sample 1, S&B Radio module– prepared with coaxial 50 Ohm interface			
0	As supplied by the customer	Not Applicable	Not Applicable
Serial Number: NA, Test Sample 2, S&B Radio module – with original PCB antenna			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 6



Product Service

1.7 Test Location

TÜV SÜD Product Service conducted the following tests at our Straubing Test Laboratory.

Test Name	Name of Engineer(s)
Conducted Disturbance at Mains Terminals	Michael Ingerl
Radiated Disturbance	Michael Ingerl
Spurious Radiated Emissions	Matthias Stumpe
Maximum Conducted Output Power	Matthias Stumpe
Power Spectral Density	Matthias Stumpe
Emission Bandwidth	Matthias Stumpe
Authorised Band Edges	Matthias Stumpe
Restricted Band Edges	Matthias Stumpe

Table 7

Office Address:

Äußere Frühlingstraße 45
94315 Straubing
Germany



2 Test Details

2.1 Conducted Disturbance at Mains Terminals

2.1.1 Specification Reference

FCC 47 CFR Part 15B and ICES-003, Clause 15.107 and 6.1

2.1.2 Equipment Under Test and Modification State

Volcano HYBRID, S/N: VH123456 - Modification State 0

2.1.3 Date of Test

2018-05-08

2.1.4 Test Method

The EUT was placed on a non-conductive table 0.8m above a reference ground plane and 0.4m away from a vertical coupling plane.

All power was connected to the EUT through an Artificial Mains Network (AMN). Conducted disturbance voltage measurements on mains lines were made at the output of the AMN. The AMN was placed 0.8m from the boundary of the EUT and bonded to the reference ground plane.

2.1.5 Environmental Conditions

Ambient Temperature 21,0 °C

Relative Humidity 33,0 %

2.1.6 Specification Limits

Required Specification Limits (Class B)			
Line Under Test	Frequency Range (MHz)	Quasi-peak (dBμV)	Average (dBμV)
AC Power Port	0.15 to 0.5	66 to 56*	56 to 46*
	0.5 to 5	56	46
	5 to 30	60	50
Supplementary information: *Decreases with the logarithm of the frequency.			

Table 8

2.1.7 Test Results

Results for Configuration and Mode: 120 V / 60 Hz AC Powered, Heat and Air on, Bluetooth on

Performance assessment of the EUT made during this test: Pass.

Detailed results are shown below.



Line Under Test: AC power input - L1

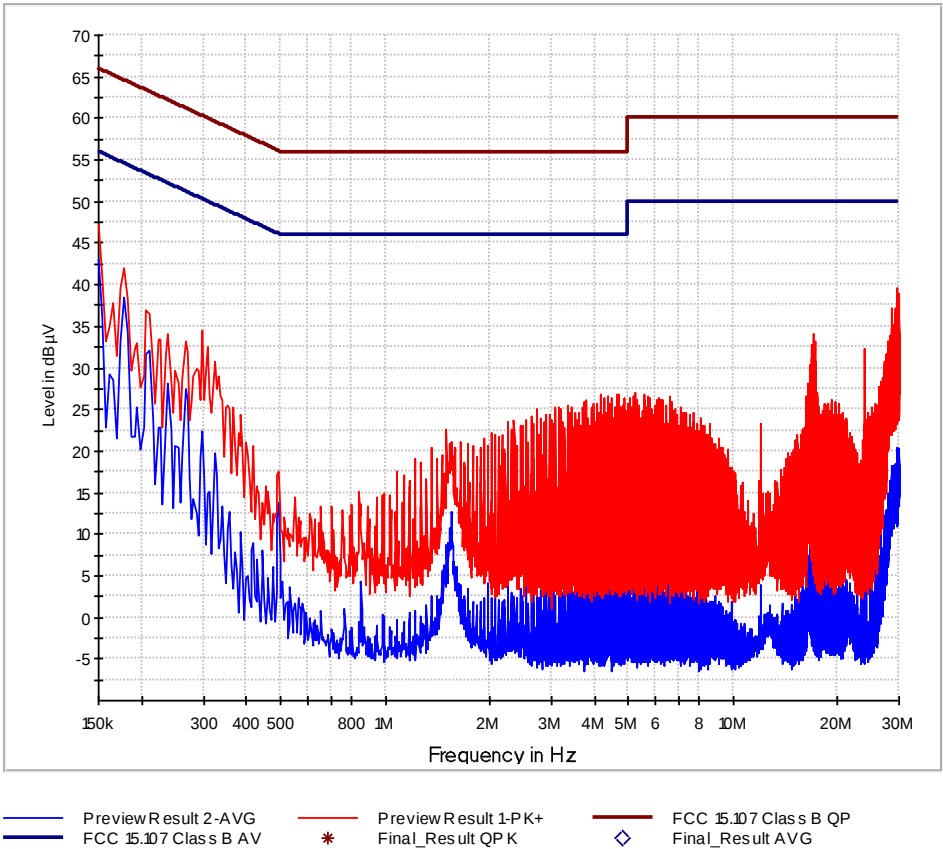


Figure 5 - Graphical Results - AC power input - L1



Line Under Test: AC power input - N

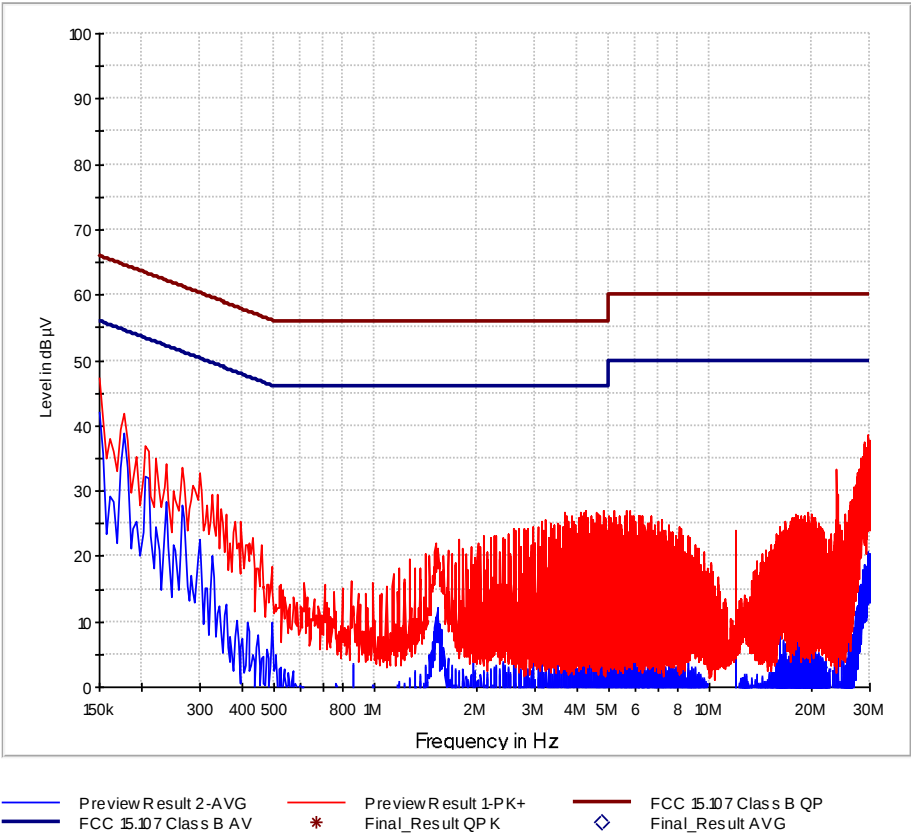


Figure 6 - Graphical Results - AC power input - N

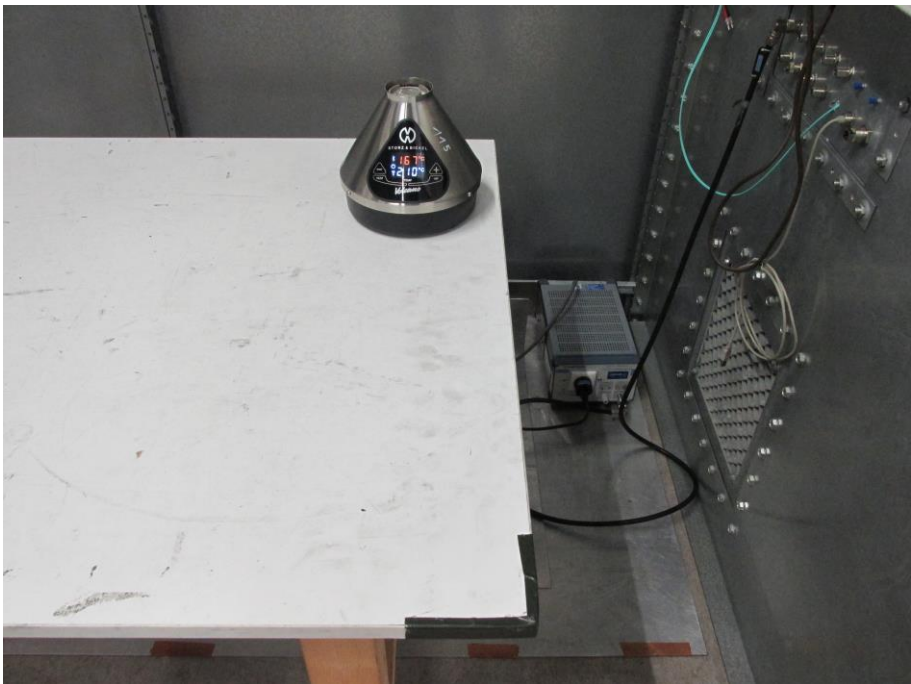


Figure 7 - Test Setup - Test Setup

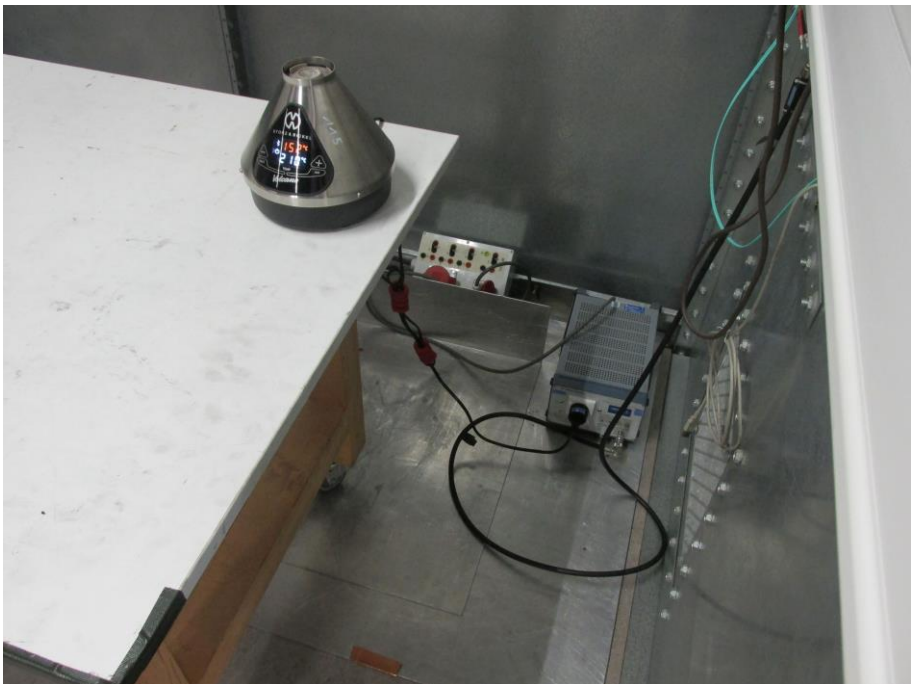


Figure 8 - Test Setup - Test Setup

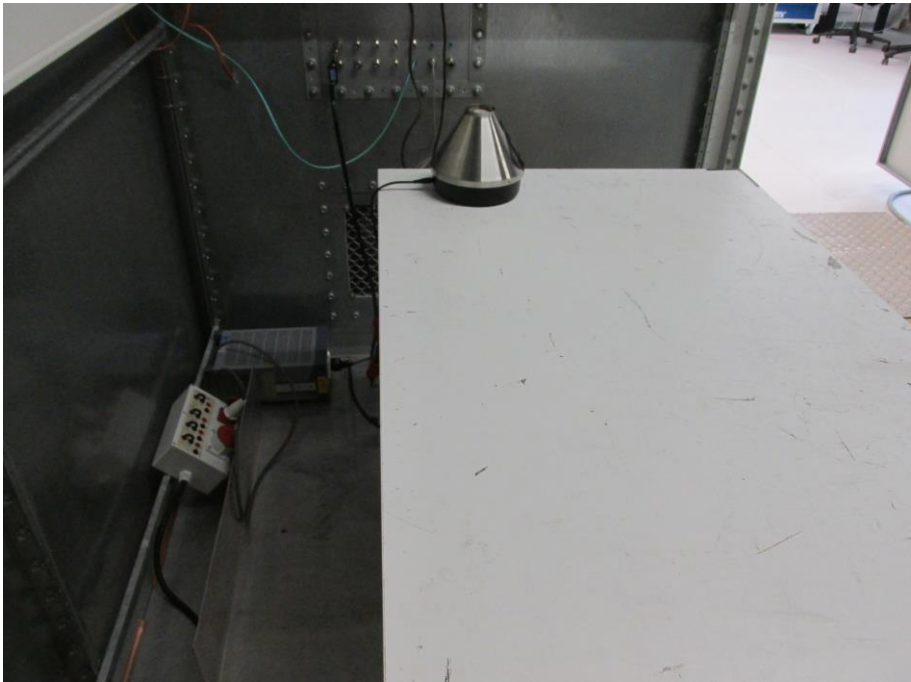


Figure 9 - Test Setup - Test Setup

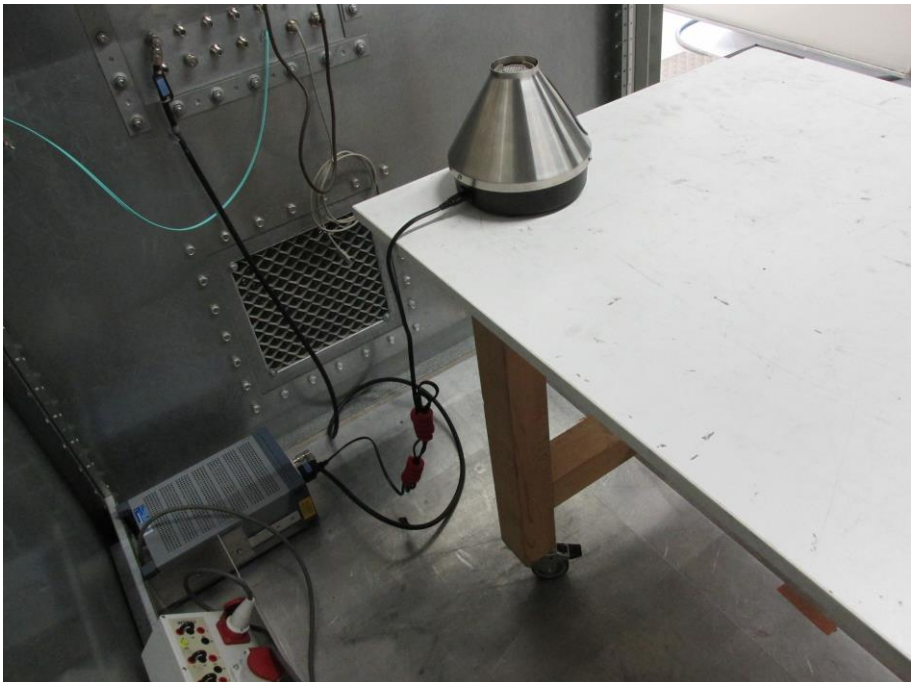


Figure 10 - Test Setup - Test Setup



Product Service

2.1.8 Test Location and Test Equipment Used

This test was carried out in Shielded room - cabin no. 1.

Type	Designation	T-ID	Serial No. or ID	Manufacturer
EMI test receiver	ESU8	19904	100232	Rohde & Schwarz
V-network	ESH 3-Z5	18919	894785/005	Rohde & Schwarz

Table 9

TU - Traceability Unscheduled
O/P Mon – Output Monitored using calibrated equipment
N/A - Not Applicable



2.2 Radiated Disturbance

2.2.1 Specification Reference

FCC 47 CFR Part 15B and ICES-003, Clause 15.109 and 6.2

2.2.2 Equipment Under Test and Modification State

Volcano HYBRID, S/N: VH123456 - Modification State 0

2.2.3 Date of Test

2018-05-08

2.2.4 Test Method

The EUT was set up in a semi-anechoic chamber on a remotely controlled turntable and placed on a non-conductive table 0.8m above a reference ground plane. A prescan of the EUT emissions profile was made while varying the antenna-to-EUT azimuth and antenna -to-EUT polarization using a peak detector; measurements were taken at a 3m distance. Using the prescan list of the highest emissions detected, their bearing and associated antenna polarization, the EUT was then formally measured using a Quasi-Peak, Peak, Average detector as appropriate. The readings were maximized by adjusting the antenna height, polarization and turntable azimuth, in accordance with the specification.

2.2.5 Environmental Conditions

Ambient Temperature 22,0 °C
Relative Humidity 34,0 %

2.2.6 Specification Limits

Required Specification Limits, Field Strength (Class B @ 3m)		
Frequency Range (MHz)	($\mu\text{V/m}$)	(dB $\mu\text{V/m}$)
30 to 88	100	40
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54
Supplementary information: Quasi-peak detector to be used for measurements < 1GHz Average detector to be used for measurements > 1GHz		

Table 10

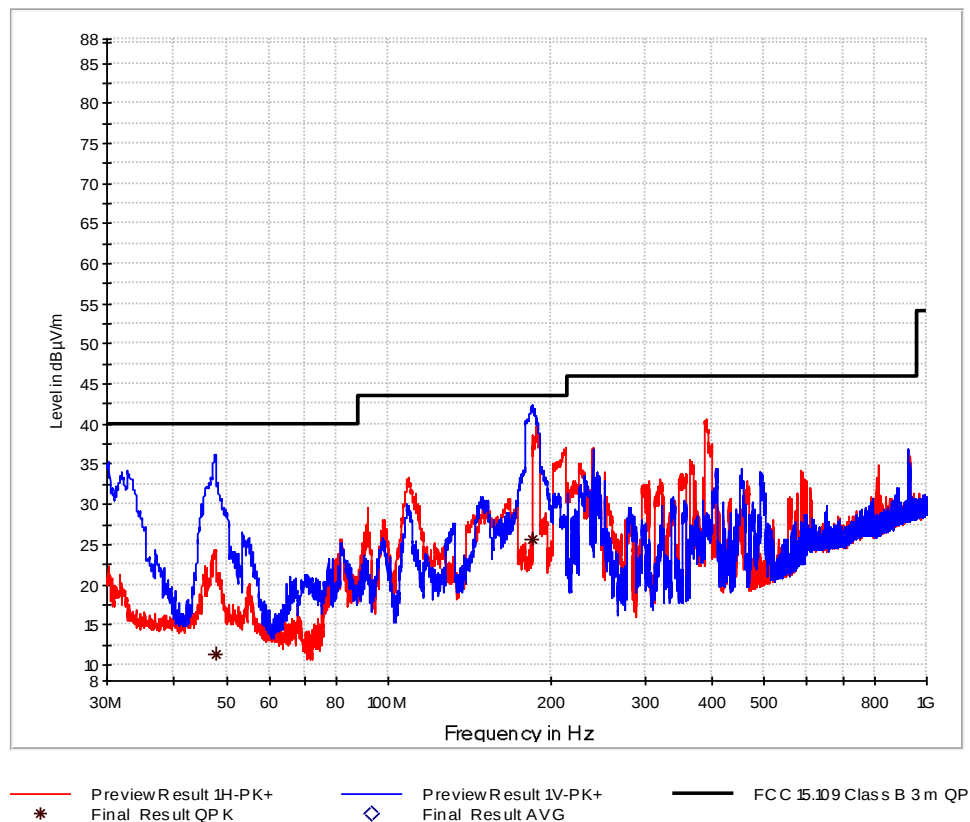
2.2.7 Test Results

Results for Configuration and Mode: 120 V / 60 Hz AC Powered, Heat and Air on, Bluetooth on

Performance assessment of the EUT made during this test: Pass.

Detailed results are shown below.

Frequency Range of Test: 30 MHz to 1 GHz



Final Results 1:

Frequency MHz	QuasiPeak dBµV/m	Limit dBµV/m	Margin dB	Meas. Time ms	Bandwidth kHz	Height cm	Pol	Azimuth deg	Corr. dB
47,715000	11,23	40,00	28,77	1000,0	120,000	122,0	V	-4,0	14,8
185,540000	25,62	43,50	17,88	1000,0	120,000	103,0	V	90,0	12,0

Table 11

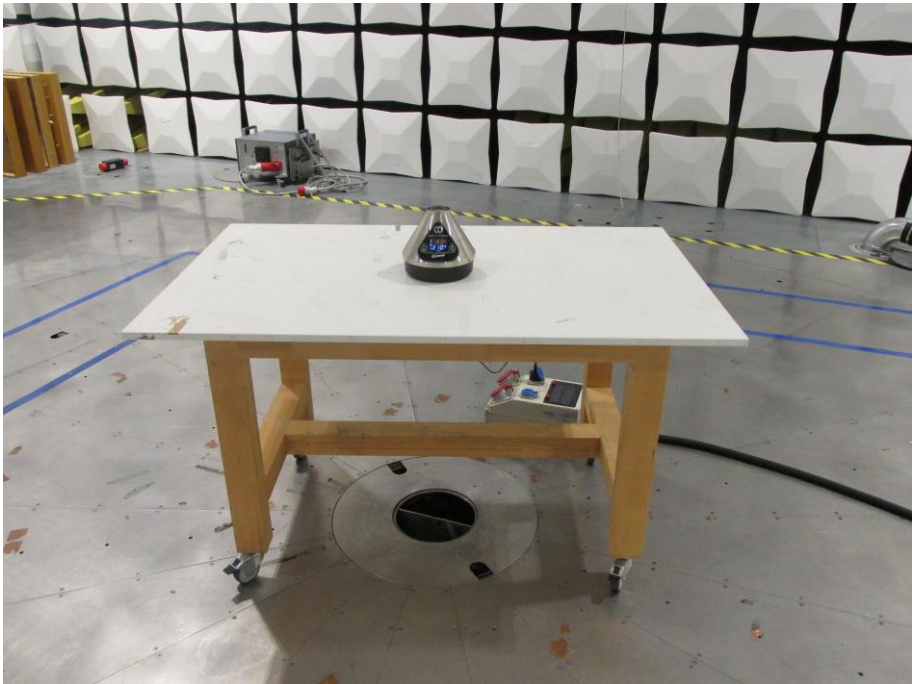


Figure 11 - Test Setup



Figure 12 - Test Setup

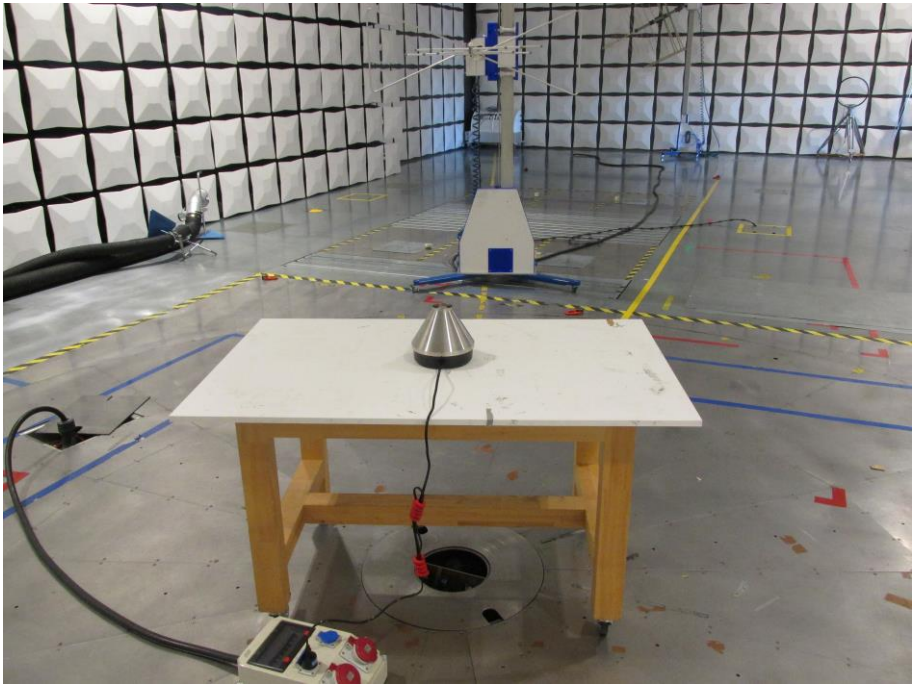


Figure 13 - Test Setup

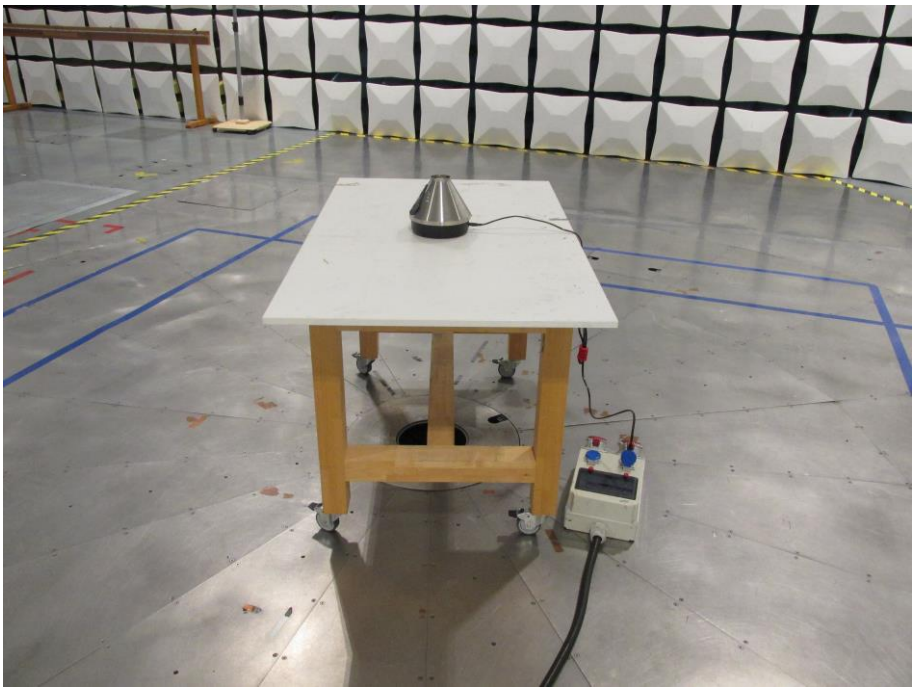


Figure 14 - Test Setup



Product Service

2.2.8 Test Location and Test Equipment Used

This test was carried out in Semi anechoic room - cabin no. 8.

Type	Designation	T-ID	Serial No. or ID	Manufacturer
EMI test receiver	ESW26	28268	101315	Rohde & Schwarz
Trilog antenna	VULB 9163	19918	9163-408	Schwarzbeck
Semi anechoic room	No. 8	19917	---	Albatross

Table 12



2.3 Spurious Radiated Emissions

2.3.1 Specification Reference

FCC 47 CFR Part 15C, Industry Canada RSS-247 and Industry Canada RSS-GEN, Clause 15.247 (d), 15.205, 5.5 and 6.13

2.3.2 Equipment Under Test and Modification State

S&B Module, S/N: NA, Test Sample 1 - Modification State 0

2.3.3 Date of Test

2018-02-08 to 2018-02-09

2.3.4 Test Method

Testing was performed in accordance with ANSI C63.10-2013 clause 6.3, 6.5 and 6.6.

Plots for average measurements were taken in accordance with ANSI C63.10-2013 clause 4.1.4.2.3 to characterize the EUT. Where emissions were detected, final average measurements were taken in accordance with ANSI C63.10-2013 clause 4.1.4.2.2.

The plots shown are the characterization of the EUT. The limits on the plots represent the most stringent case for restricted bands, (54/74 dBuV/m) when compared to 20 dBc outside restricted bands. The limits shown have been used as a threshold to determine where further measurements are necessary. Where results are within 10 dB of the limits shown on the plots, further investigation was carried out and reported in results tables.

The following conversion can be applied to convert from dBuV/m to uV/m:
 $10^{(\text{Field Strength in dBuV/m}/20)}$

Test distance:

<u>Frequency Range</u>	<u>Test Distance</u>	<u>Correction of Final Result</u>
0.03 to 6.0 GHz	3 m	No correction
6.0 to 26.5 GHz	1 m	Final result corrected by -10 dB

2.3.5 Environmental Conditions

Ambient Temperature	22,0 °C
Relative Humidity	25,0 %



2.3.6 Test Results

BLE-Module in Testing Mode

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
46.140	24.35	40.00	15.65	1000.0	120.000	103.0	V	63.0	15.3
213.420	29.84	43.50	13.66	1000.0	120.000	116.0	H	-82.0	13.1
298.770	32.31	46.00	13.69	1000.0	120.000	103.0	H	-104.0	15.5

Table 13 - 2402 MHz - 30 MHz to 1 GHz Emissions Results

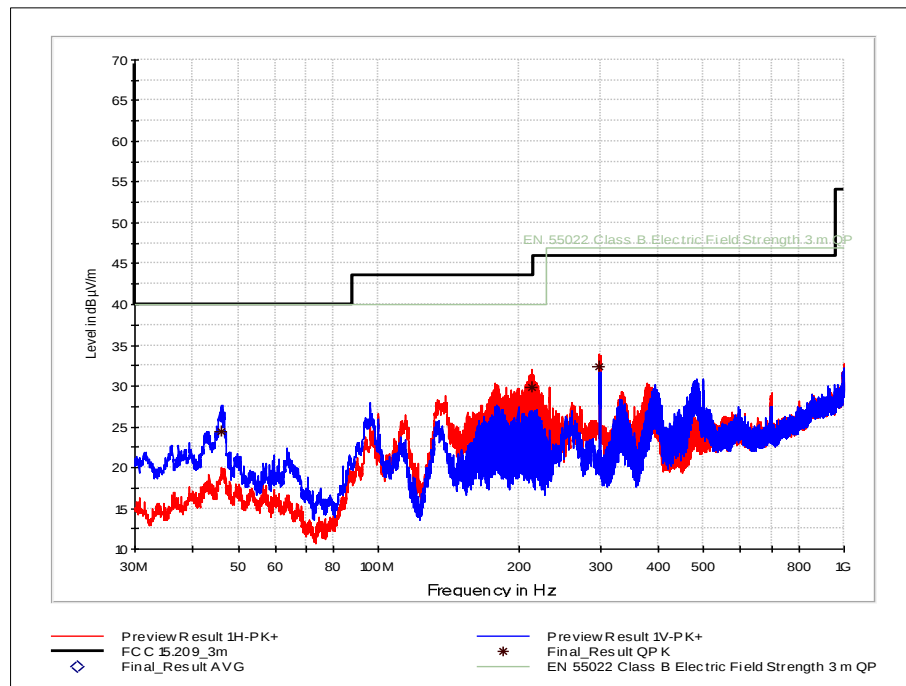


Figure 15 - 2402 MHz - 30 MHz to 1 GHz - Horizontal and Vertical



Frequency (MHz)	Result (dBμV/m)		Limit (dBμV/m)		Margin (dBμV/m)	
	Peak	Average	Peak	Average	Peak	Average
2401.750 GHz	89.32	83.93	NA #1	NA #1	NA #1	NA #1
4803.750 GHz	56.96	42.76	74	54	17.04	11.24
7206.150 GHz	42.83	---	74	54	31.17	---
9607.525 GHz	40.72	38.57	74	54	33.28	15.43
24936.00 GHz	47.43	---	74	54	26.57	---

NA #1: Intentional Radiation, Limit acc.to. 15.209 not applicable

Table 14 - 2402 MHz - 1 GHz to 26.5 GHz Emissions Results

No other emissions were detected within 6 dB of the limit.

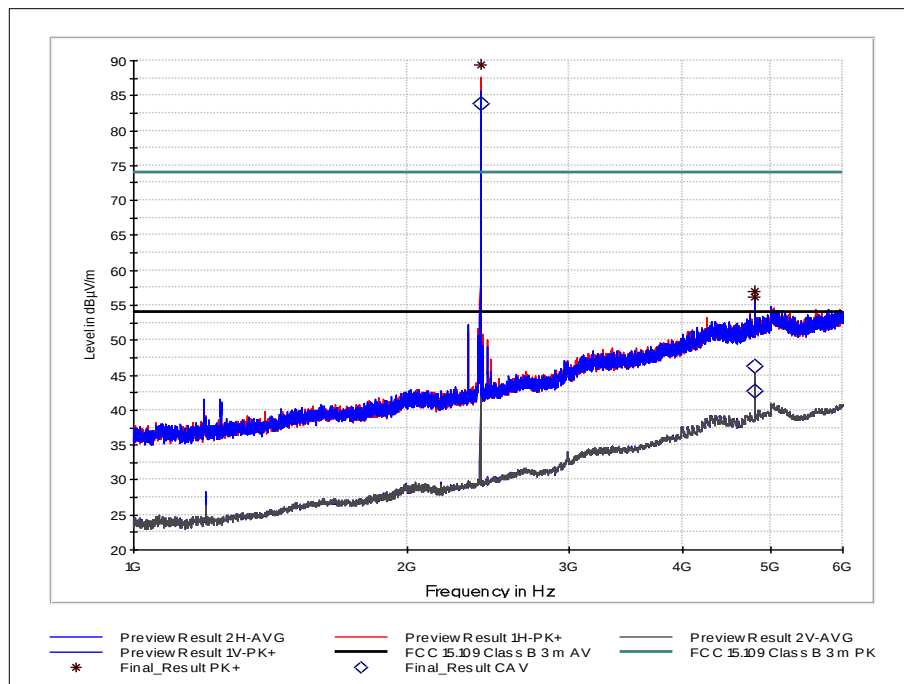


Figure 16 - 2402 MHz - 1.0 GHz to 6.0 GHz - Horizontal and Vertical

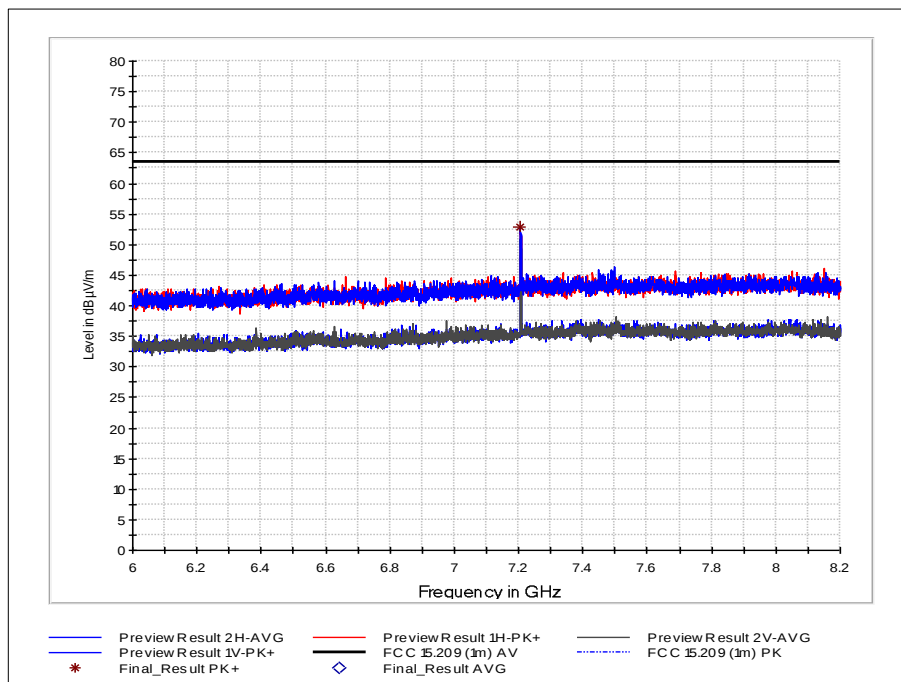


Figure 17 - 2402 MHz - 6.0 GHz to 8.2 GHz - Horizontal and Vertical

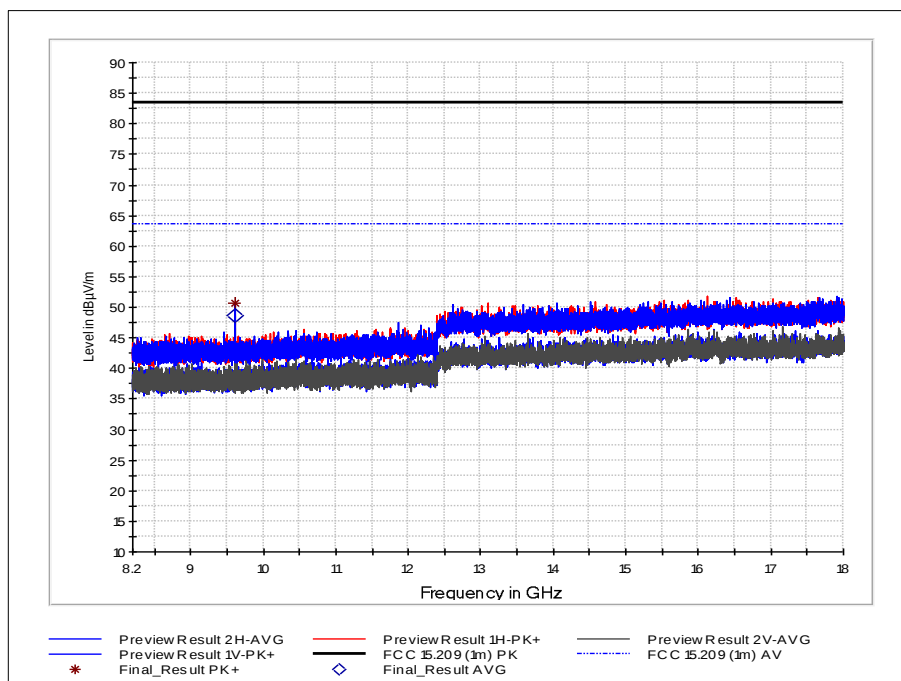


Figure 18 - 2402 MHz - 8.2 GHz to 18.0 GHz - Horizontal and Vertical



Product Service

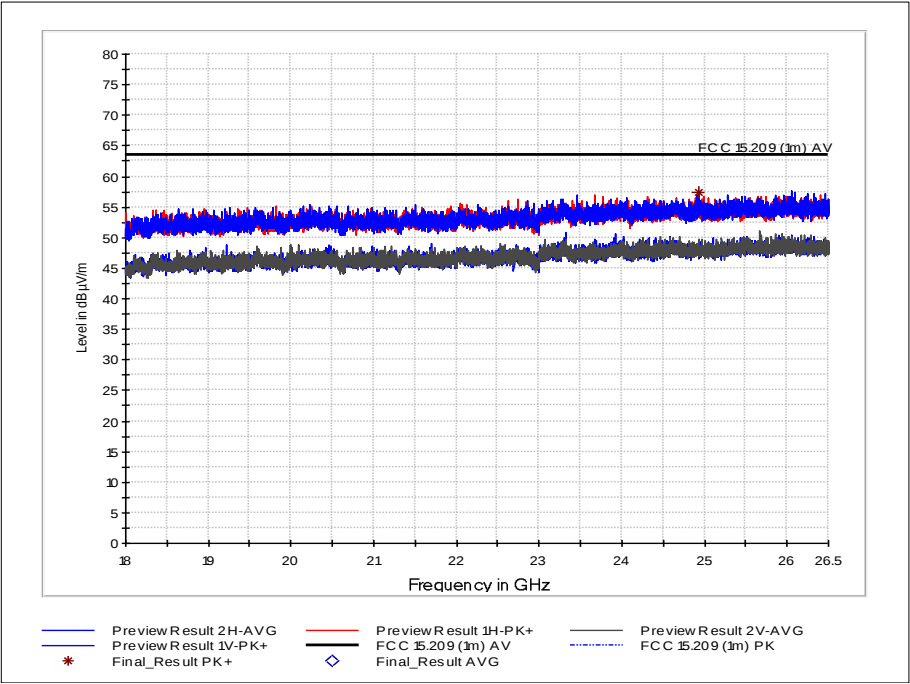


Figure 19 - 2402 MHz - 18.0 GHz to 26.5 GHz - Horizontal and Vertical



Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
46.175	23.98	40.00	16.02	1000.0	120.000	113.0	V	88.0	15.3
212.615	28.33	43.50	15.17	1000.0	120.000	122.0	H	-67.0	13.1
299.8500	32.04	46.00	13.96	1000.0	120.000	103.0	H	-102.0	15.5

Table 15 - 2442 MHz - 30 MHz to 1 GHz Emissions Results

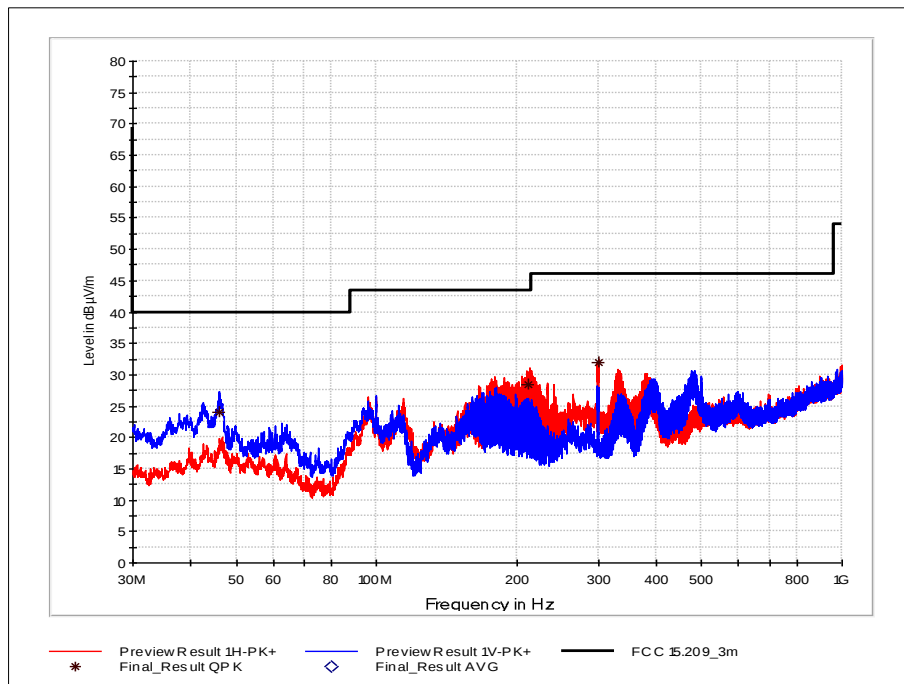


Figure 20 - 2442 MHz - 30 MHz to 1 GHz - Horizontal and Vertical



Frequency (MHz)	Result (dBμV/m)		Limit (dBμV/m)		Margin (dBμV/m)	
	Peak	Average	Peak	Average	Peak	Average
2442.000 MHz	89.87	85.26	NA #1	NA #1	NA #1	NA #1
7327.150 MHz	41.55	---	74	54	32.45	---
9768.700 MHz	37.50	35.71	74	54	36.50	18.29
15996.60 MHz	41.95	---	74	54	32.05	---
21406.38 MHz	46.79	---	74	54	27.21	---

NA #1: Intentional Radiation, Limit acc.to. 15.209 not applicable

Table 16 - 2442 MHz - 1 GHz to 26.5 GHz Emissions Results

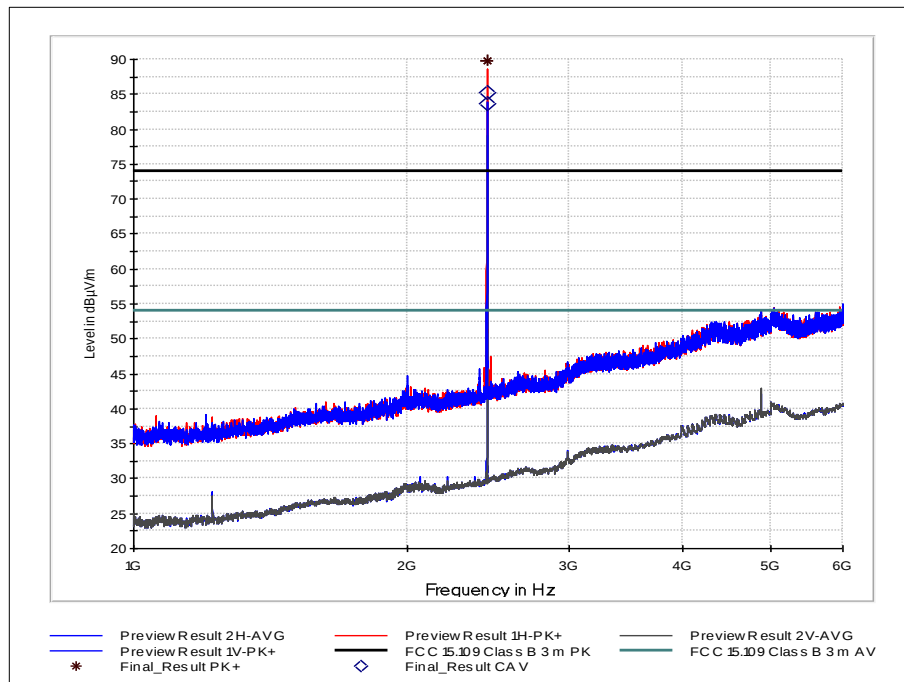


Figure 21 - 2442 MHz - 1.0 GHz to 6.0 GHz - Horizontal and Vertical

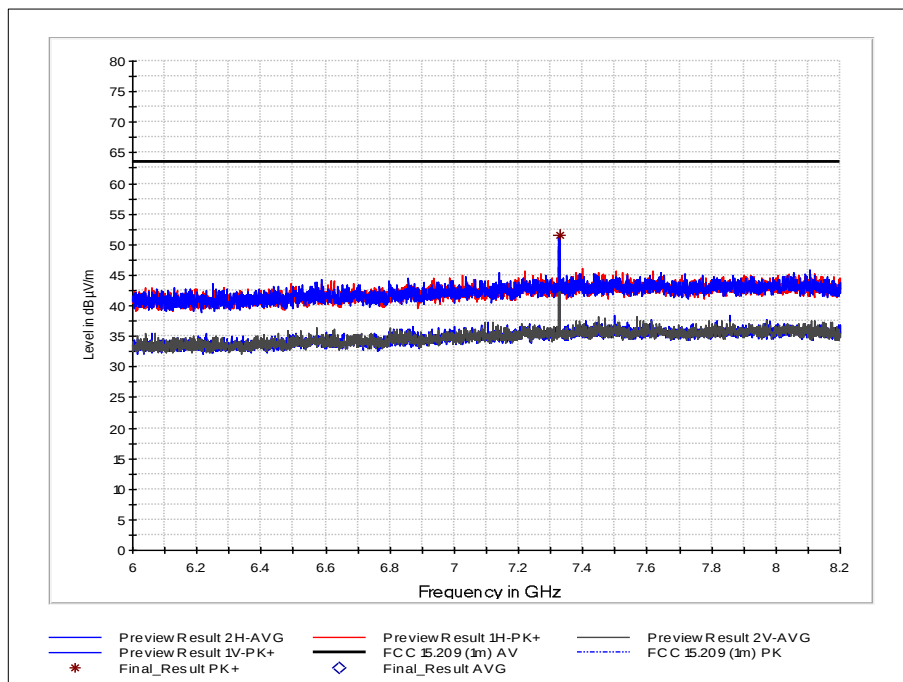


Figure 22 - 2442 MHz - 6.0 GHz to 8.2 GHz - Horizontal and Vertical

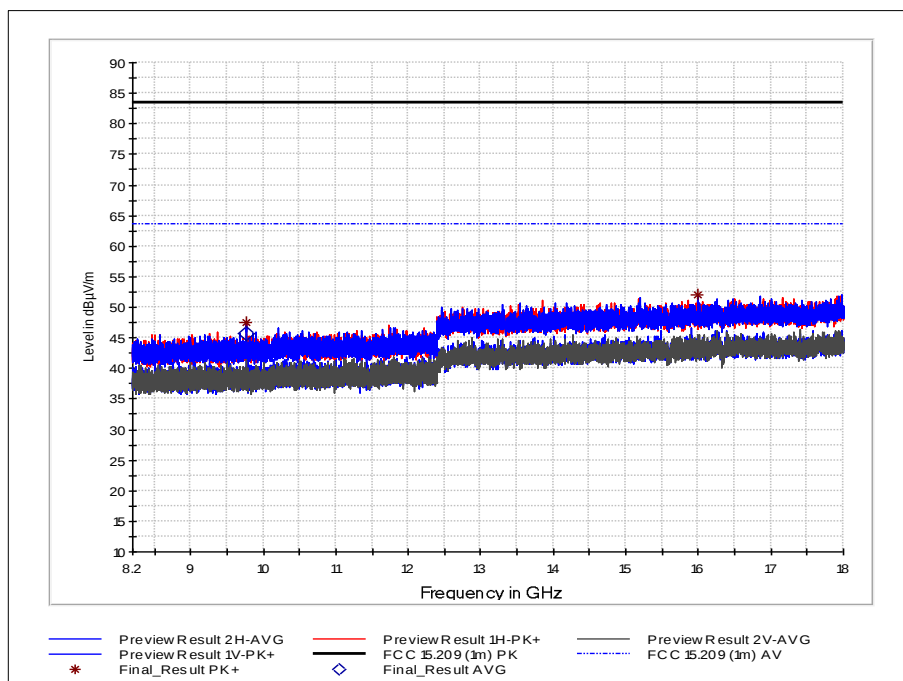


Figure 23 - 2442 MHz - 8.2 GHz to 18.0 GHz - Horizontal and Vertical



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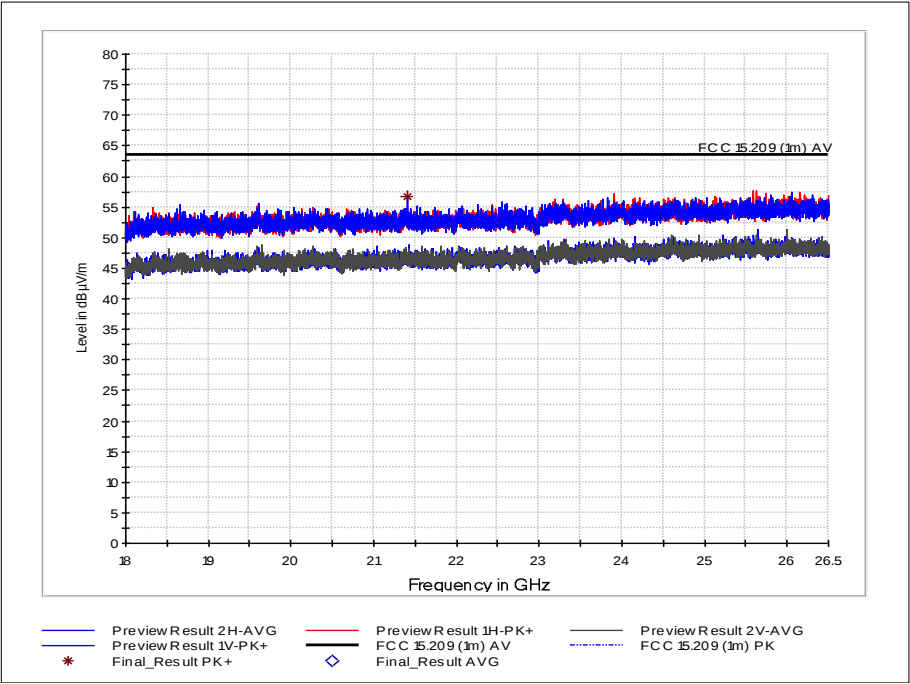


Figure 24 - 2442 MHz - 18.0 GHz to 26.5 GHz - Horizontal and Vertical



Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
45.820	18.65	40.00	21.35	1000.0	120.000	103.0	V	-128.0	15.3
199.690	23.86	43.50	19.64	1000.0	120.000	132.0	H	-104.0	13.6
298.765	31.03	46.00	14.97	1000.0	120.000	106.0	H	-107.0	15.5

Table 17 - 2480 MHz - 30 MHz to 1 GHz Emissions Results

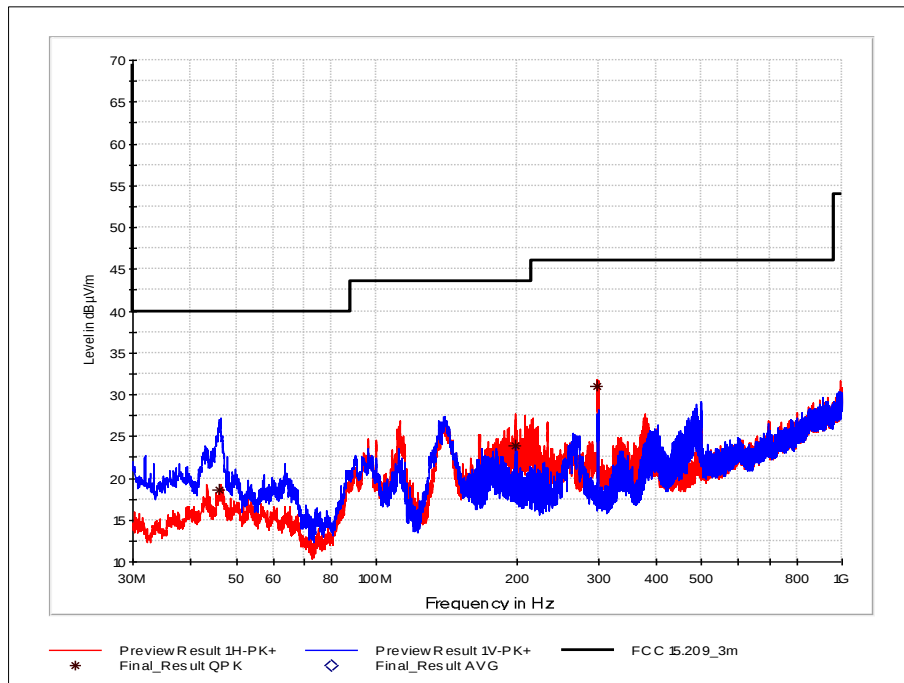


Figure 25 - 2480 MHz - 30 MHz to 1 GHz - Horizontal and Vertical



Frequency (MHz)	Result (dBμV/m)		Limit (dBμV/m)		Margin (dBμV/m)	
	Peak	Average	Peak	Average	Peak	Average
2480.000 MHz	86.09	81.41	NA #1	NA #1	NA #1	NA #1
7440.450 MHz	39.04	---	74	54	34.96	---
16839.40 MHz	41.70	37.02	74	54	32.30	16.98
25254.75 MHz	47.91	---	74	54	26.09	---

NA #1: Intentional Radiation, Limit acc.to. 15.209 not applicable

Table 18 - 2480 MHz - 1 GHz to 26.5 GHz Emissions Results

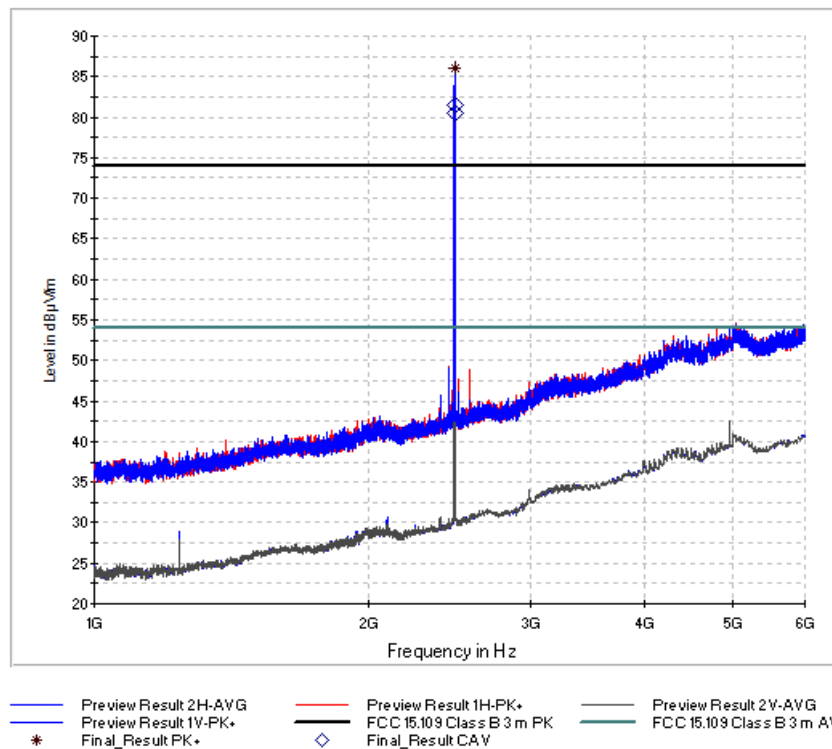


Figure 26 - 2480 MHz - 1.0 GHz to 6.0 GHz - Horizontal and Vertical



Product Service

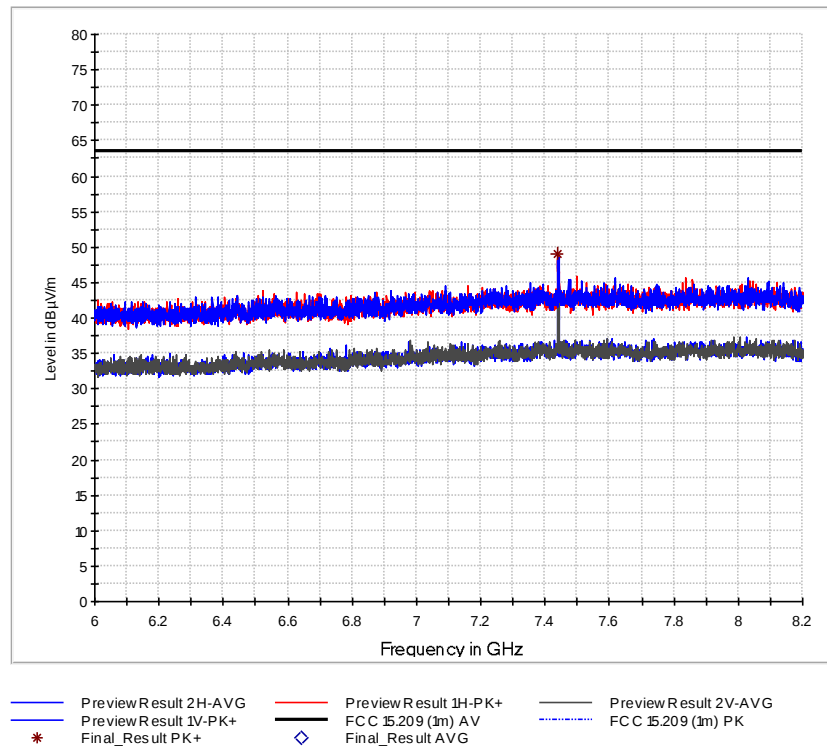


Figure 27 - 2480 MHz - 6.0 GHz to 8.2 GHz - Horizontal and Vertical

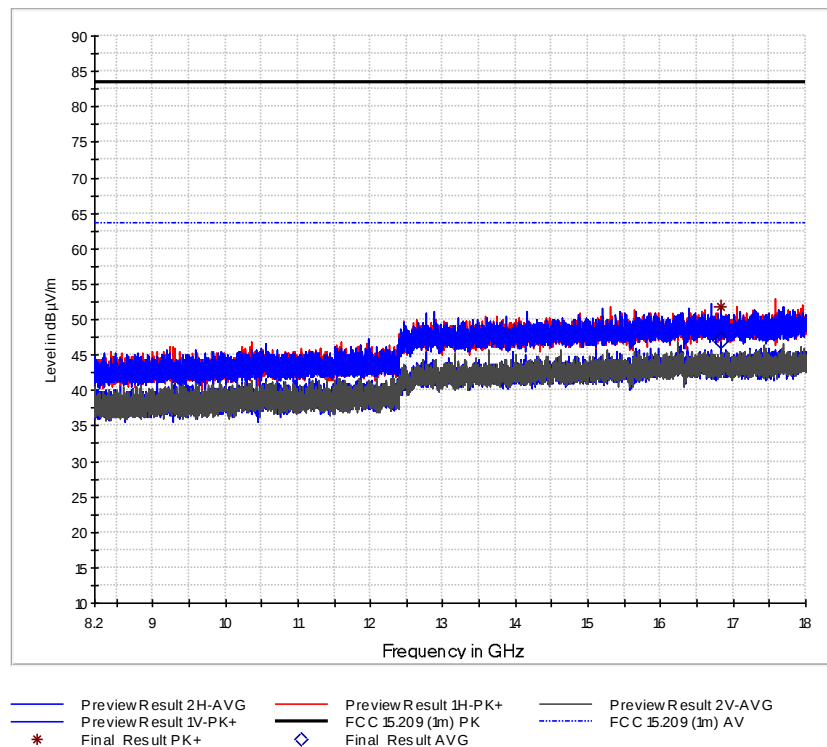


Figure 28 - 2480 MHz - 8.2 GHz to 18.0 GHz - Horizontal and Vertical

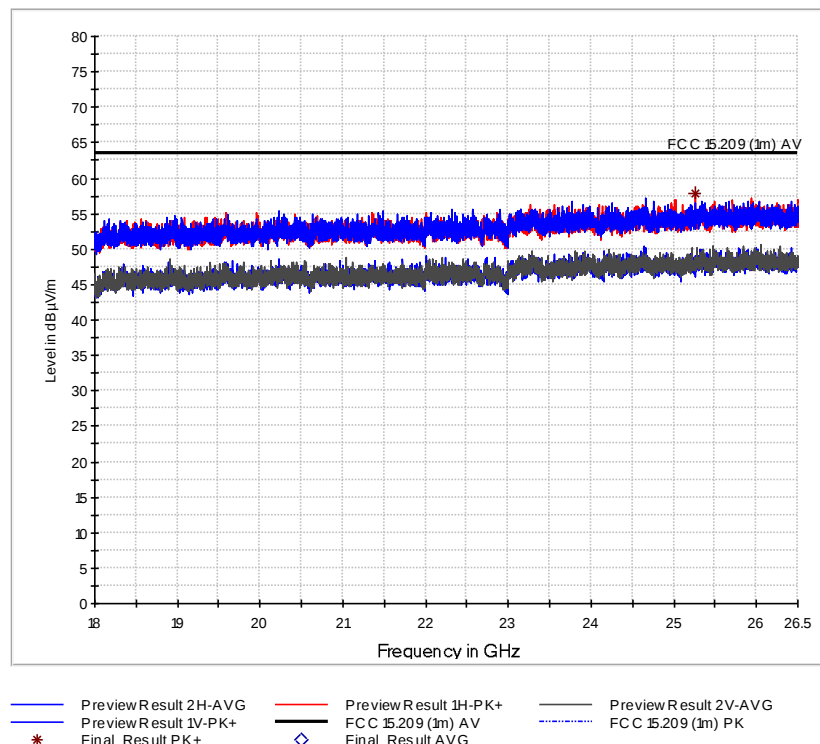


Figure 29 - 2480 MHz - 18.0 GHz to 26.5 GHz - Horizontal and Vertical

FCC 47 CFR Part 15, Limit Clause 15.247 (d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in 15.209(a)

Industry Canada RSS-247, Limit Clause 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.



Product Service

2.3.7 Test Location and Test Equipment Used

This test was carried out in Semi anechoic room - cabin no. 8.

Instrument	Manufacturer	Type No	T-ID	Calibration Period (months)	Calibration Due
TRILOG Antenna	Schwarzbeck	VULB 9163	19691	24	2020-12-31
EMI test receiver	Rohde & Schwarz	ESW26	28268	12	2018-06-30

Table 19

TU - Traceability Unscheduled

O/P Mon – Output Monitored using calibrated equipment

N/A - Not Applicable



2.4 Maximum Conducted Output Power

2.4.1 Specification Reference

FCC 47 CFR Part 15C, Industry Canada RSS-247 and Industry Canada RSS-GEN, Clause 15.247 (b), 5.4 and 6.12

2.4.2 Equipment Under Test and Modification State

S&B Module, S/N: NA, Test Sample 2 - Modification State 0

2.4.3 Date of Test

2018-02-08

2.4.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.9.1.1.

2.4.5 Environmental Conditions

Ambient Temperature 23,0 °C
Relative Humidity 25,0 %

2.4.6 Test Results

BLE-Module in Testing Mode

Frequency (MHz)	dBm	mW
2402	1.13	1.30
2442	1.97	1.57
2480	2.13	1.63

Table 20

FCC 47 CFR Part 15, Limit Clause 15.247 (b)(3)

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt.

Industry Canada RSS-247, Limit Clause 5.4 (d)

For DTSS employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e) of the specification.



2.4.7 Test Location and Test Equipment Used

This test was carried out in Non shielded room.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSV40	20219	12	2019-01-31

Table 21

TU - Traceability Unscheduled

O/P Mon – Output Monitored using calibrated equipment

N/A - Not Applicable



2.5 Power Spectral Density

2.5.1 Specification Reference

FCC 47 CFR Part 15C, Industry Canada RSS-247 and Industry Canada RSS-GEN, Clause 15.247 (e), 5.2 and 6.12

2.5.2 Equipment Under Test and Modification State

S&B Module, S/N: NA, Test Sample 2 - Modification State 0

2.5.3 Date of Test

2018-02-08

2.5.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.10.2.

2.5.5 Environmental Conditions

Ambient Temperature 23,0 °C
Relative Humidity 25,0 %

2.5.6 Test Results

BLE-Module in Testing Mode

Modulation/Packet Type: GFSK/DH1

Frequency (MHz)	Power Spectral Density (dBm)
2402	1.1
2442	1.9
2480	2.1

Table 22

FCC 47 CFR Part 15, Limit Clause 15.247 (e)

The power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Industry Canada RSS-247, Limit Clause 5.2(b)

The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.



Product Service

2.5.7 Test Location and Test Equipment Used

This test was carried out in Non shielded room.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSV40	20219	12	2019-01-31

Table 23

TU - Traceability Unscheduled

O/P Mon – Output Monitored using calibrated equipment

N/A - Not Applicable



2.6 Emission Bandwidth

2.6.1 Specification Reference

FCC 47 CFR Part 15C, Industry Canada RSS-247 and Industry Canada RSS-GEN, Clause 15.247 (a)(2), 5.2 and 6.6

2.6.2 Equipment Under Test and Modification State

S&B Module, S/N: NA, Test Sample 2 - Modification State 0

2.6.3 Date of Test

2018-02-08

2.6.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 11.8.2.

2.6.5 Environmental Conditions

Ambient Temperature 23,0 °C
Relative Humidity 25,0 %

2.6.6 Test Results

BLE-Module in Testing Mode

Modulation/Packet Type: GFSK/DH1

Frequency (MHz)	6 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)
2402 MHz	0.685 MHz	0.912 MHz
2442 MHz	0.673 MHz	0.824 MHz
2480 MHz	0.669 MHz	0.824 MHz

Table 24



Product Service

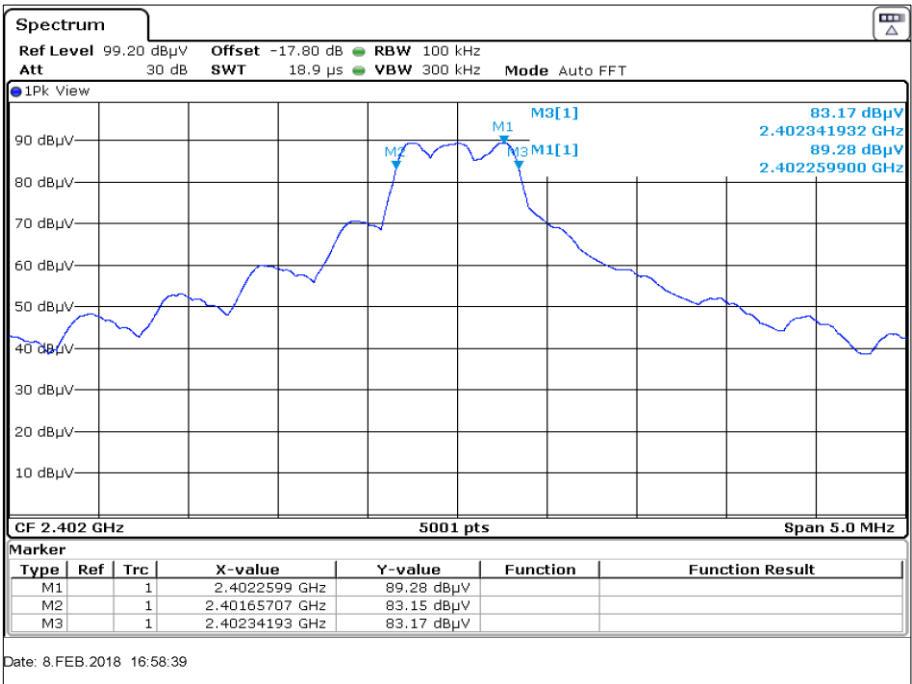


Figure 30 - 2402 MHz – 6 dB Bandwidth

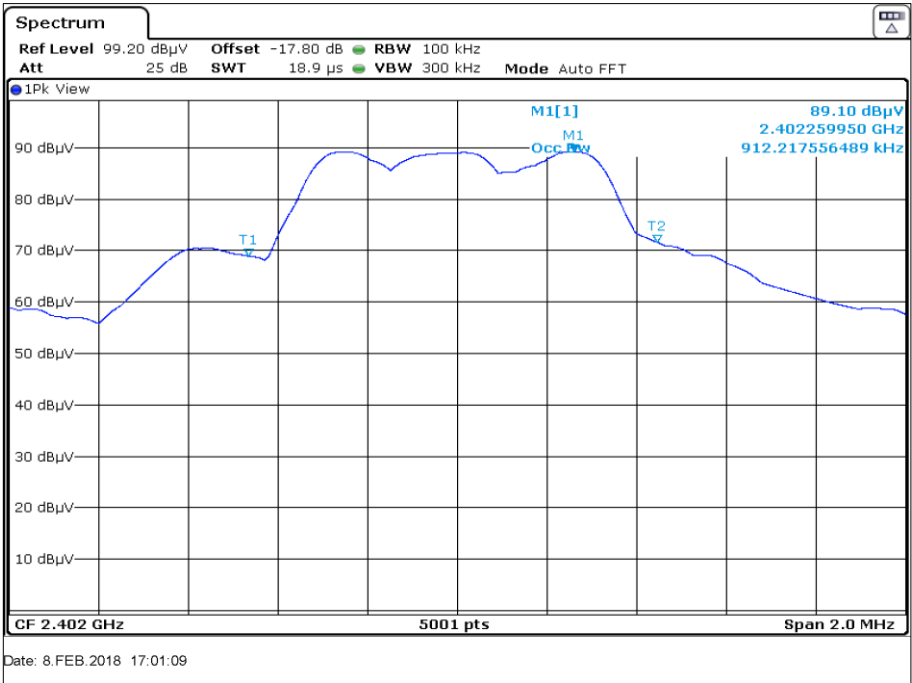


Figure 31 - 2402 MHz – 99% Occupied Bandwidth

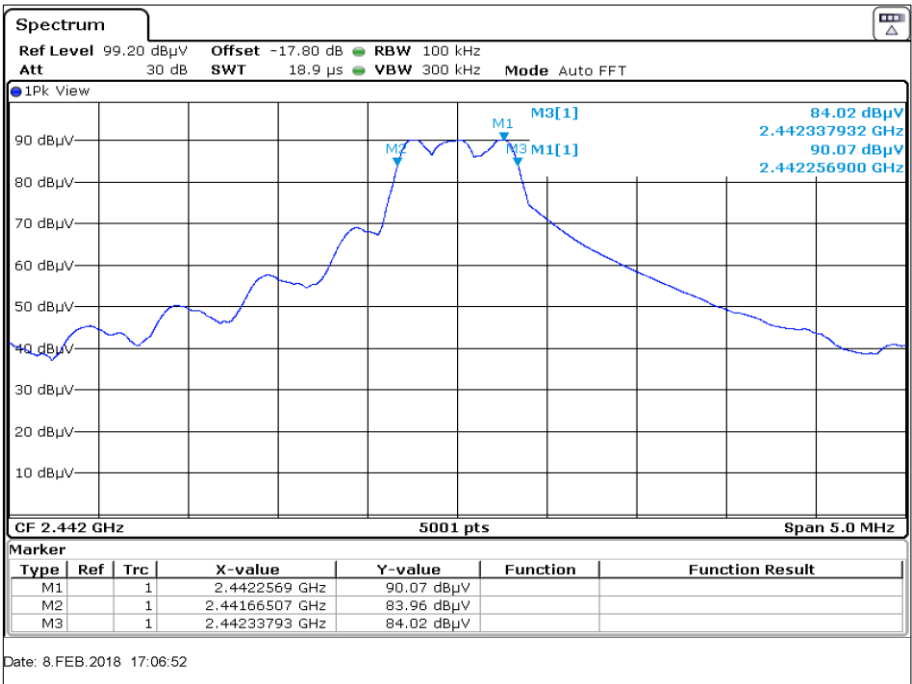


Figure 32 - 2442 MHz – 6 dB Bandwidth

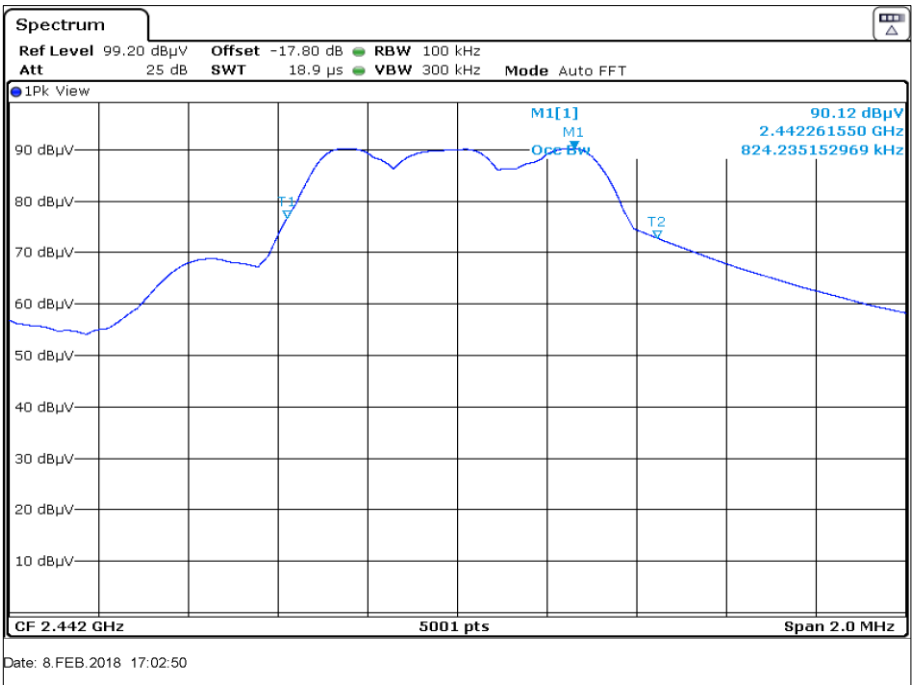


Figure 33 - 2442 MHz – 99% Occupied Bandwidth

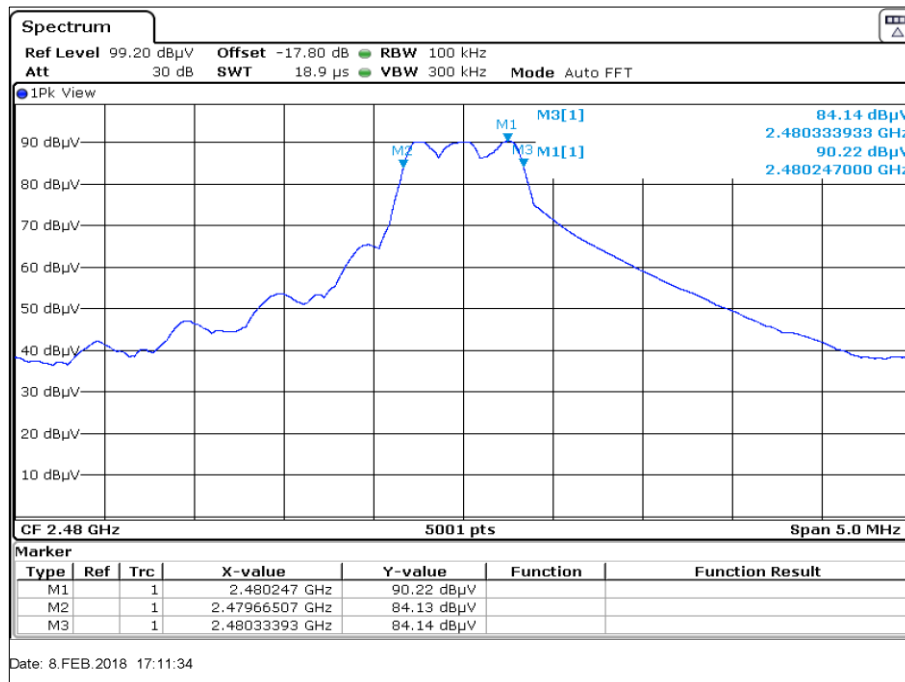


Figure 34 - 2480 MHz – 6 dB Bandwidth

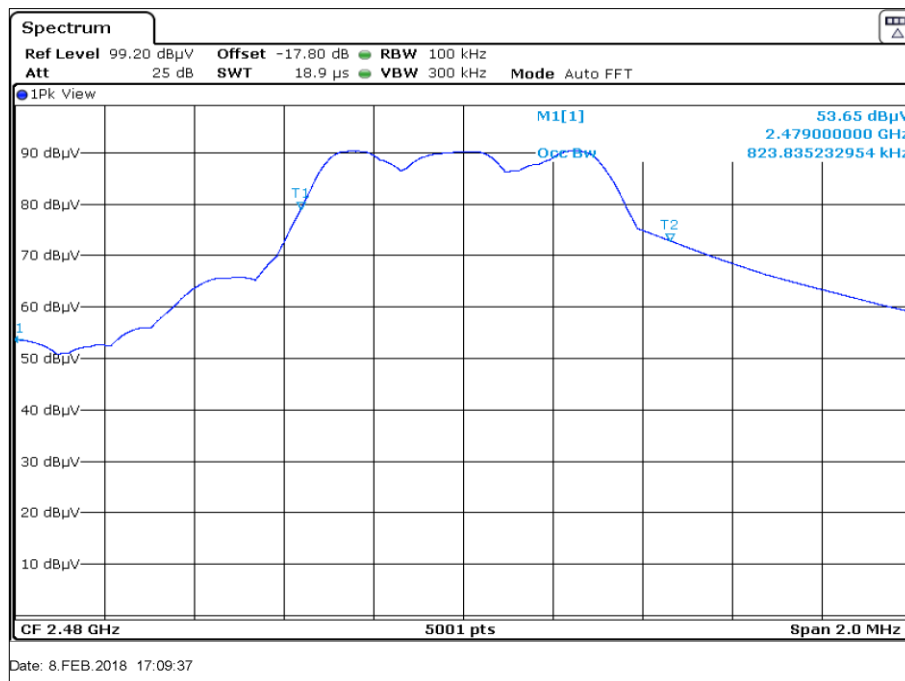


Figure 35 - 2480 MHz – 99% Occupied Bandwidth

FCC 47 CFR Part 15, Limit Clause 15.247(a)(2) and Industry Canada RSS-247, Clause 5.2(a)

The minimum 6 dB Bandwidth shall be at least 500 kHz.



Product Service

2.6.7 Test Location and Test Equipment Used

This test was carried out in Non shielded room.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSV40	20219	12	2019-01-31

Table 25

TU - Traceability Unscheduled

O/P Mon – Output Monitored using calibrated equipment

N/A - Not Applicable



2.7 Authorised Band Edges

2.7.1 Specification Reference

FCC 47 CFR Part 15C, Industry Canada RSS-247 and Industry Canada RSS-GEN, Clause 15.247 (d), 5.5 and N/A

2.7.2 Equipment Under Test and Modification State

S&B Module, S/N: NA, Test Sample 2 - Modification State 0

2.7.3 Date of Test

2018-02-08

2.7.4 Test Method

The test was performed in accordance with ANSI C63.10, clause 6.10.4.

2.7.5 Environmental Conditions

Ambient Temperature 23,0 °C
Relative Humidity 25,0 %

2.7.6 Test Results

BLE-Module in Testing Mode

Operational Mode	Frequency (MHz)	Measured Frequency (MHz)	Peak Level (dBc)
Continuous modulated BLE Transmission	2402	2400.0	-42.6 dBc
Continuous modulated BLE Transmission	2480	2483.5	-57.5 dBc

Table 26



Product Service

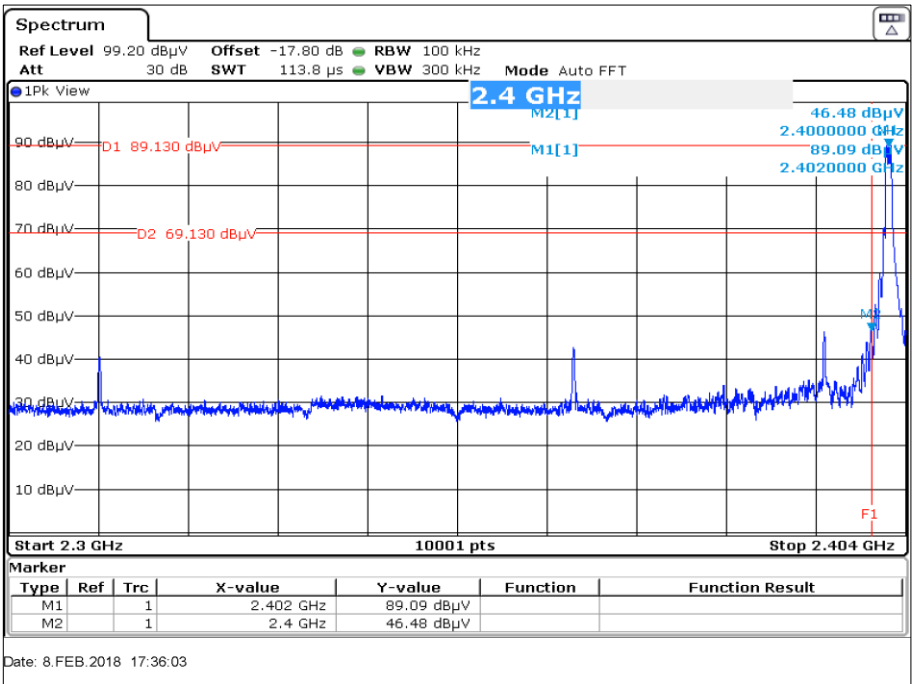


Figure 36 - GFSK/ - 2402 MHz - Measured Frequency 2400.0 MHz

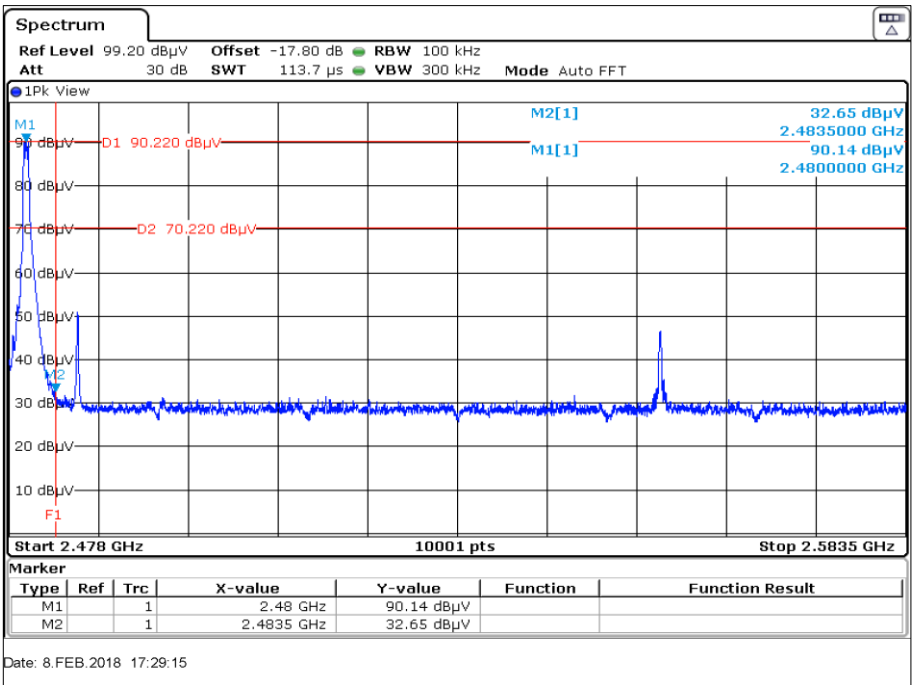


Figure 37 - GFSK/ - 2480 MHz - Measured Frequency 2483.5 MHz



FCC 47 CFR Part 15, Limit Clause 15.247 (d)

20 dB below the fundamental measured in a 100 kHz bandwidth using a peak detector. If the transmitter complies with the conducted power limits, based on the use of RMS averaging over a time interval, the attenuation required shall be 30 dB below the fundamental instead of 20 dB.

Industry Canada RSS-247, Limit Clause 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

2.7.7 Test Location and Test Equipment Used

This test was carried out in Non shielded room.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSV40	20219	12	2019-01-31

Table 27

TU - Traceability Unscheduled

O/P Mon – Output Monitored using calibrated equipment

N/A - Not Applicable



2.8 Restricted Band Edges

2.8.1 Specification Reference

FCC 47 CFR Part 15C, Industry Canada RSS-247 and Industry Canada RSS-GEN, Clause 15.205 N/A and 8.10

2.8.2 Equipment Under Test and Modification State

S&B Module, S/N: NA, Test Sample 1 - Modification State 0

2.8.3 Date of Test

2018-02-08

2.8.4 Test Method

This test was performed in accordance with ANSI C63.10, clause 6.10.5.

Plots for average measurements were taken in accordance with ANSI C63.10 clause 4.1.4.2.3. These are shown for information purposes and were used to determine the worst case measurement point. Final average measurements were then taken in accordance with ANSI C63.10 clause 4.1.4.2.2. to obtain the measurement result recorded in the test results tables.

The following conversion can be applied to convert from dB μ V/m to μ V/m:
 $10^{(\text{Field Strength in dB}\mu\text{V/m}/20)}$.

2.8.5 Environmental Conditions

Ambient Temperature 21,0 °C
Relative Humidity 27,0 %

2.8.6 Test Results

BLE-Module in Testing Mode

Operational Mode	Frequency (MHz)	Measured Frequency (MHz)	Peak Level (dB μ V/m)	Average Level (dB μ V/m)
Continuous modulated BLE Transmission	2402	2390.0	< 47	< 45
Continuous modulated BLE Transmission	2480	2483.5	< 45	< 54

Table 28

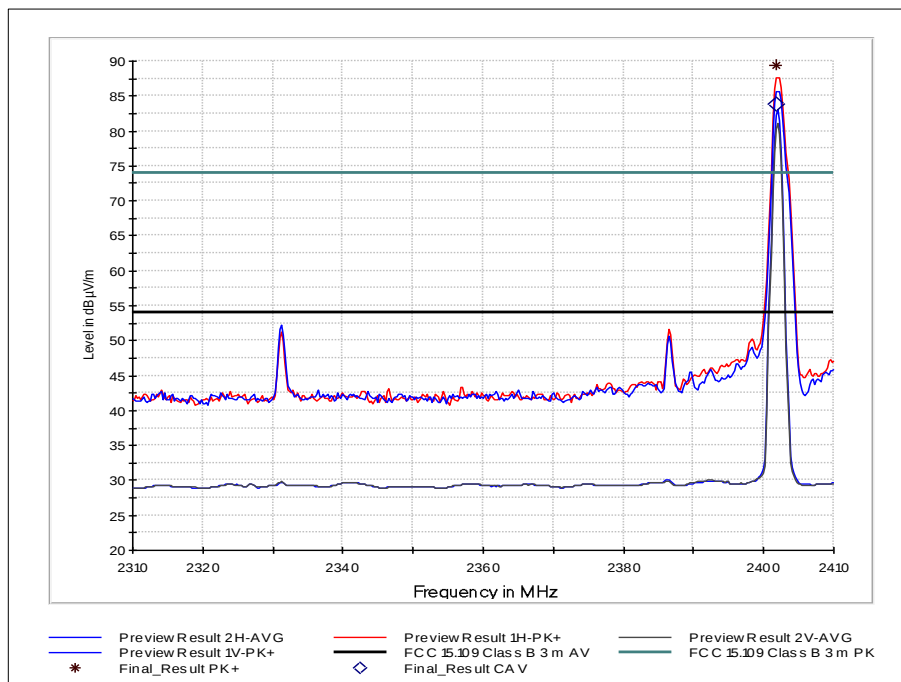


Figure 38 - GFSK/ - 2402 MHz - Measured Frequency 2390.0 MHz - Peak

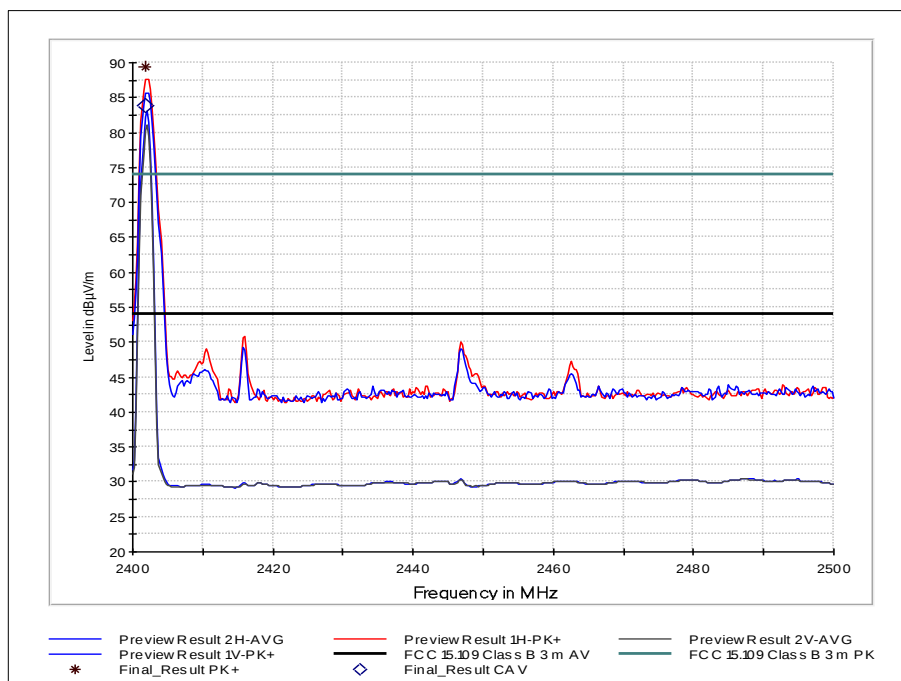


Figure 39 - GFSK/ - 2402 MHz - Measured Frequency 2390.0 MHz - Average

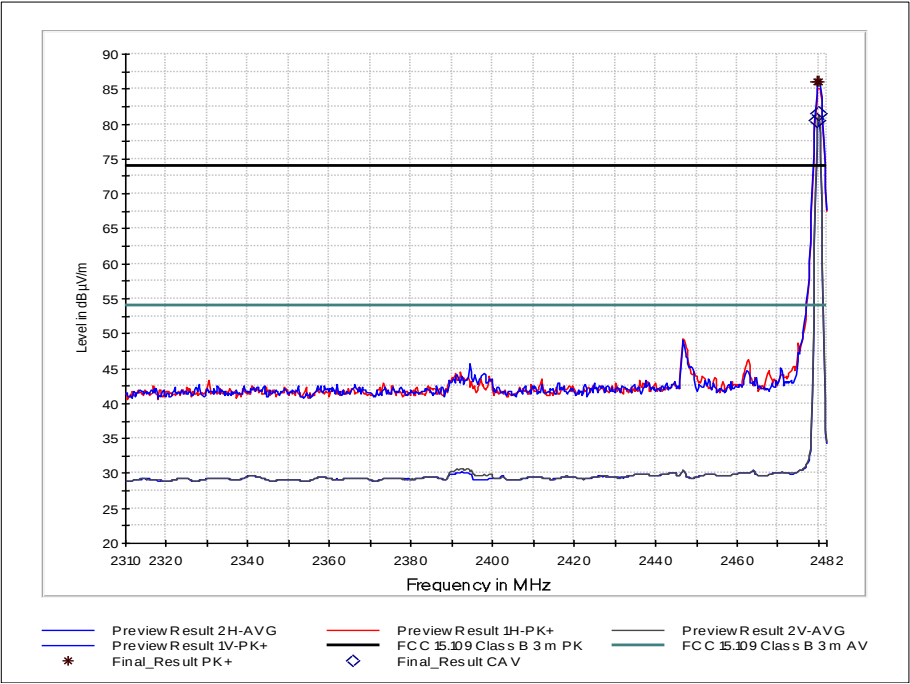


Figure 40 - GFSK/ - 2480 MHz - Measured Frequency 2483.5 MHz - Peak

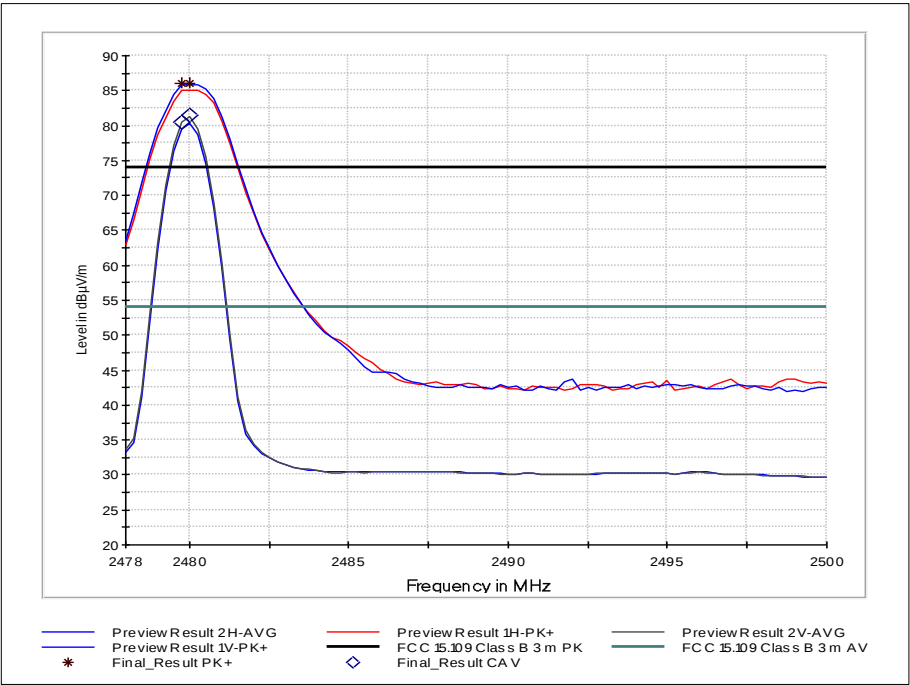


Figure 41 - GFSK/ - 2480 MHz - Measured Frequency 2483.5 MHz - Average



FCC 47 CFR Part 15, Limit Clause 15.209

Frequency (MHz)	Field Strength ($\mu\text{V}/\text{m}$ at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

Table 29

Industry Canada RSS-GEN, Limit Clause 8.9

Frequency (MHz)	Field Strength ($\mu\text{V}/\text{m}$ at 3 metres)
30-88	100
88-216	150
216-960	200
Above 960*	500

Table 30

*Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

2.8.7 Test Location and Test Equipment Used

This test was carried out in Semi anechoic room - cabin no. 8.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Spectrum Analyzer	Rohde & Schwarz	FSV40	20219	12	2019-01-31

Table 31

TU - Traceability Unscheduled

O/P Mon – Output Monitored using calibrated equipment

N/A - Not Applicable



3 Test Equipment Information

3.1 General Test Equipment Used

Type	Designation	T-ID	Serial No. or ID	Manufacturer
EMI test receiver	ESW26	28268	101315	Rohde & Schwarz
Trilog antenna	VULB 9163	19918	9163-408	Schwarzbeck
Semi anechoic room	No. 8	19917	---	Albatross
EMI test receiver	ESU8	19904	100232	Rohde & Schwarz
V-network	ESH 3-Z5	18919	894785/005	Rohde & Schwarz
Spectrum Analyzer	FSV40	20219	---	Rohde & Schwarz

Table 32

4 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Radio Testing			
Test Name	kp	Expanded Uncertainty	Note
Occupied Bandwidth	2.0	$\pm 1.14 \%$	2
RF-Frequency error	1.96	$\pm 1 \cdot 10^{-7}$	7
RF-Power, conducted carrier	2	$\pm 0.079 \text{ dB}$	2
RF-Power uncertainty for given BER	1.96	$+0.94 \text{ dB} / -1.05$	7
RF power, conducted, spurious emissions	1.96	$+1.4 \text{ dB} / -1.6 \text{ dB}$	7
RF power, radiated			
25 MHz – 4 GHz	1.96	$+3.6 \text{ dB} / -5.2 \text{ dB}$	8
1 GHz – 18 GHz	1.96	$+3.8 \text{ dB} / -5.6 \text{ dB}$	8
18 GHz – 26.5 GHz	1.96	$+3.4 \text{ dB} / -4.5 \text{ dB}$	8
40 GHz – 170 GHz	1.96	$+4.2 \text{ dB} / -7.1 \text{ dB}$	8
Spectral Power Density, conducted	2.0	$\pm 0.53 \text{ dB}$	2
Maximum frequency deviation			
300 Hz – 6 kHz	2	$\pm 2.89 \%$	2
6 kHz – 25 kHz	2	$\pm 0.2 \text{ dB}$	2
Maximum frequency deviation for FM	2	$\pm 2.89 \%$	2
Adjacent channel power 25 MHz – 1 GHz	2	$\pm 2.31 \%$	2
Temperature	2	$\pm 0.39 \text{ K}$	4
(Relative) Humidity	2	$\pm 2.28 \%$	2
DC- and low frequency AC voltage			
DC voltage	2	$\pm 0.01 \%$	2
AC voltage up to 1 kHz	2	$\pm 1.2 \%$	2
Time	2	$\pm 0.6 \%$	2

Table 33



Radio Interference Emission Testing			
Test Name	kp	Expanded Uncertainty	Note
Conducted Voltage Emission			
9 kHz to 150 kHz (50Ω/50μH AMN)	2	± 3.8 dB	1
150 kHz to 30 MHz (50Ω/50μH AMN)	2	± 3.4 dB	1
100 kHz to 200 MHz (50Ω/5μH AMN)	2	± 3.6 dB	1
Discontinuous Conducted Emission			
9 kHz to 150 kHz (50Ω/50μH AMN)	2	± 3.8 dB	1
150 kHz to 30 MHz (50Ω/50μH AMN)	2	± 3.4 dB	1
Conducted Current Emission			
9 kHz to 200 MHz	2	± 3.5 dB	1
Magnetic Fieldstrength			
9 kHz to 30 MHz (with loop antenna)	2	± 3.9 dB	1
9 kHz to 30 MHz (large-loop antenna 2 m)	2	± 3.5 dB	1
Radiated Emission			
Test distance 1 m (ALSE)			
9 kHz to 150 kHz	2	± 4.6 dB	1
150 kHz to 30 MHz	2	± 4.1 dB	1
30 MHz to 200 MHz	2	± 5.2 dB	1
200 MHz to 2 GHz	2	± 4.4 dB	1
2 GHz to 3 GHz	2	± 4.6 dB	1
Test distance 3 m			
30 MHz to 300 MHz	2	± 4.9 dB	1
300 MHz to 1 GHz	2	± 5.0 dB	1
1 GHz to 6 GHz	2	± 4.6 dB	1
Test distance 10 m			
30 MHz to 300 MHz	2	± 4.9 dB	1
300 MHz to 1 GHz	2	± 4.9 dB	1
Radio Interference Power			
30 MHz to 300 MHz	2	± 3.5 dB	1
Harmonic Current Emissions			4
Voltage Changes, Voltage Fluctuations and Flicker			4

Table 34



Immunity Testing			
Test Name	kp	Expanded Uncertainty	Note
Electrostatic Discharges			4
Radiated RF-Field			
Pre-calibrated field level	2	+32.2 / -24.3 %	5
Dynamic feedback field level	2.05	+21.2 / -17.5 %	3
Electrical Fast Transients (EFT) / Bursts			4
Surges			4
Conducted Disturbances, induced by RF-Fields			
via CDN	2	+15.1 / -13.1 %	6
via EM clamp	2	+42.6 / -29.9 %	6
via current clamp	2	+43.9 / -30.5 %	6
Power Frequency Magnetic Field	2	+20.7 / -17.1 %	2
Pulse Magnetic Field			4
Voltage Dips, Short Interruptions and Voltage Variations			4
Oscillatory Waves			4
Conducted Low Frequency Disturbances			
Voltage setting	2	± 0.9 %	2
Frequency setting	2	± 0.1 %	2
Electrical Transient Transmission in Road Vehicles			4

Table 35

Note 1:

The expanded uncertainty reported according to CISPR 16-4-2:2003-11 is based on a standard uncertainty multiplied by a coverage factor of $k_p = 2$, providing a level of confidence of $p = 95.45\%$

Note 2:

The expanded uncertainty reported according to UKAS Lab 34 (Edition 1, 2002-08) is based on a standard uncertainty multiplied by a coverage factor of $k_p = 2$, providing a level of confidence of $p = 95.45\%$

Note 3:

The expanded uncertainty reported according to UKAS Lab 34 (Edition 1, 2002-08) is based on a standard uncertainty multiplied by a coverage factor of $k_p = 2.05$, providing a level of confidence of $p = 95.45\%$

Note 4:

It has been demonstrated that the used test equipment meets the specified requirements in the standard with at least a 95% confidence.

Note 5:

The expanded uncertainty reported according to IEC 61000-4-3 is based on a standard uncertainty multiplied by a coverage factor of $k_p = 2$, providing a level of confidence of $p = 95.45\%$

Note 6:

The expanded uncertainty reported according to IEC 61000-4-6 is based on a standard uncertainty multiplied by a coverage factor of $k_p = 2$, providing a level of confidence of $p = 95.45\%$

Note 7:

The expanded uncertainty reported according to ETSI TR 100 028 V1.4.1 (all parts) is based on a standard uncertainty multiplied by a coverage factor of $k_p = 1.96$, providing a level of confidence of $p = 95.45\%$

Note 8:

The expanded uncertainty reported according to ETSI TR 102 273 V1.2.1 (all parts) is based on a standard uncertainty multiplied by a coverage factor of $k_p = 1.96$, providing a level of confidence of $p = 95.45\%$