FCC/ISED RF Test Report
As per

RSS-247 Issue 2

FCC Part 15.247 Subpart C

Unlicensed Intentional Radiators (FHSS)
ZX High Voltage

IC:8410A-ZXHV; FCC ID: XEY-ZX-HV

Prepared to:

Verdant. Environmental Technologies, Inc.

1850 – 55th Avenue, Lachine, Quebec, H8T 3J5
CANADA

Product Service

Choose certainty.
Add value.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Test Specialist	Jose Martinez	12-09-2019	
Authorised Signatory	Scott Drysdale	12-09-2019	

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

EXECUTIVE SUMMARY
A sample of this product was tested and found to be in compliance with FCC Part 15.247 Subpart C/ ICES 003 Issue 6 and RSS-247 Issue 2.

A2LA Cert. No. 2955.20

TÜV SÜD Product Service
is a trading name of TUV SUD Ltd
2972 Joseph-A-Bombardier
Laval, QC H7P 6E3 Canada

TUV SUD Ltd is a
TÜV SÜD Group Company

Phone: +450-687-4976
www.tuv-sud.ca

Contents

TABLE OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF GRAPHS

1 Report Summary

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	July 02, 2020

Table 1 – Modification Records

Acronyms & Definitions

The following definitions and acronyms are applicable in this report. See also ANSI C63.14.

Acronyms

AM	Amplitude Modulation
DTS	Digital Transmission System
EIRP	Equivalent Isotropical Radiated Power
ETSI	European Telecommunications Standards Institute
EUT	Equipment Under Test
FVIN	Firmware Version Identification Number
HVIN	Hardware Version Identification Number(s)
OOB	Out of Band
PKPSD	Peak Power Spectrum Density
RBW	Resolution Bandwidth
RF	Radio Frequency of oscillation rate of electromagnetic fields (e.g. radio waves: 9kHz to 300GHz)
RMS	Root mean square, i.e., $V_p / \sqrt{2}$
Rx	Referred as antennae for receiving RF signals
SD	Spurious Domain
TR	Technical Report
Tx	Referred as antenna for transmitting RF signals
VBW	Video Bandwidth
Vp	Peak Voltage

2 Introduction

Applicant:	Verdant Environmental Technologies, Inc.
Manufacturer:	Verdant Environmental Technologies, Inc.
Number of Samples Tested:	1
Test Specification/Issue/Date:	RSS-247 Issue 2: February 2017 FCC Part 15 Subpart C.247 2016 ICES 003 Issue 6:2019
Test Plan/Issue/Date:	N/A
Project Number:	7169005898
Date:	2019-03-15
Date of Receipt of EUT:	2019-02-10
Start of Test:	2020-06-17
Finish of Test:	2020-07-02
Name of Tester(s):	Jose Martinez
Related Documents:	ANSI C63.10:2013 FCC 15. Subpart 15 Subpart C/RSS-247

EUT description

The Low Voltage Verdant ZX Thermostat is a device designed to be used in conjunction with a HVAC device to control the temperature of the immediate space. It implements a multiband radio SOC (U2) with 2 signal outputs.

The U2 is a frequency hopping transceiver FHSS device, which hope at 915MHz band (see frequencies of hopping in Table 6). The Frequency Hopping algorithm uses 67 channels at 380KHz intervals. The frequency hopping algorithm is in pre-defined randomly generated sequence multiplexed with a pre-defined sequence of 67 offsets providing a repeating sequence after 4489 hops with an interval of 1s per channel.

In addition, U2 has a DTS internal transceiver with a 2.4GHz RF output (see Table 5 for specific frequencies). This output is coupled to the antenna with a low pass filter. The tuned circuit act as a filter to remove undesired harmonic radiation. Clock base Y2 at 38.4MHz is also used for the time base. This transceiver outputs uses the BLE Specifications using a BLE certified stack. Frequency Range: 2402-2480 MHz.

Brief Summary of Results

A brief summary of the tests carried out in accordance with RSS-247 Issue 2, FCC Part 15 Subpart 15.247, FCC Part 15 Subpart 15.207 & FCC Part 15 Subpart 15.209 is summarized in Table 2.

Report Section	FCC Rule	IC Rule	Description	Class/Limit	Result
6	15.247(a)(1)(i)	RSS-247.5.1	99% Bandwidth Hopping System	≤500kHz	Pass
7	15.247(a)(1)(i)	RSS 247 5.1 (c)	Hopping Channels	≥50	Pass
8	15.247(a)(1)	RSS 247 5.1 (2)	Channel Separation	> 25 kHz or 20 dB BW	Pass
90	15.247(a)(1)(i)	RSS 247 5.1 (c)	Time of occupancy	<0.4 s in 20s period	Pass
10	15.247(b)(2)	RSS-247.5.4(a)	Maximum Peak Output Power (FHSS)	< 1W	Pass
11	§15.247(d)	RSS-247 5.5	Band-Edge Spurious Conducted Emission	≤ 20dBc	Pass
12	§15.209(a)	RSS-247 5.5	Tx Spurious Radiated Emission	Quasi-Peak Average	Pass

-	15.247(h)	RSS 247 5.1	FHSS Intelligence	Note 3	No Applicable
-	15.247(b)(4)	RSS 247 5.4 (3)	Antenna Gain	<6dBi <Note 2>	Pass
-	15.203 & 15.247(b)	RSS-210	Antenna Requirement	Note 1	Not Applicable

Note 1: Manufacture uses a SMA antenna connector for unique coupling to the intentional radiator
Note 2: For the Antenna requirement specified in FCC 15.203 (RSS-247 section 5.5), the unit uses a trace antenna with a gain of 2dBi.
Note 3: The EUT does not coordinate transmission with any other FHSS to avoid simultaneous occupation of hopping frequencies
Note 4: For maximum permissible exposure, this device operates at less than 1 Watt at 902 - 928MHz. It is designed to operate less than 20 cm from any personnel during normal operation. No testing is required; however, it complies with SAR exemption evaluation as determined the RF Exposure exhibits

Table 2 – Test Summary Table

Declaration of Build Status

This report addresses the Radio verification testing and test results of the ZX HIGH VOLTAGE and is herein referred to as EUT (Equipment Under Test). The EUT was tested for compliance against the following standards:

RSS-247 Issue 2:2017
FCC Part 15 Subpart C 15.247:2016
ICES 003 Issue 6: 2019

Test procedures, results, justifications, and engineering considerations, if any, follow later in this report.

This report does not imply product endorsement by any government, accreditation agency, or TÜV SÜD Canada Inc.

Opinions or interpretations expressed in this report, if any, are outside the scope of TÜV SÜD Canada Inc accreditations. Any opinions expressed do not necessarily reflect the opinions of TÜV SÜD Canada Inc, unless otherwise stated.

For a more detailed list of the standards and the revision used, see the "Applicable Standards, Specifications and Methods" section of this report.

Notes, Justification

The following notes, justifications for tests not performed or deviations from the above listed specifications apply:

For the Antenna requirement specified in FCC 15.203 (RSS-247 section 5.5), the unit uses two permanently soldered to the PCB with a gain of 2dBi.

For the Restricted Bands of operation, the EUT is designed to only operate between 902.46MHz – 927.52MHz.

The EUT does not coordinate transmission with any other FHSS to avoid simultaneous occupation of hopping frequencies.

For maximum permissible exposure, this device operates at less than 1 Watt at 902.46MHz – 927.52MHz. It is designed to operate less than 20 cm from any personnel during normal operation. No testing is required; however, it complies with SAR exemption evaluation as determined the RF Exposure exhibits.

For antenna requirements, the antenna is soldered to a printed circuit board (see internal photos in Exhibits). Therefore, complies with section 15.203 2a (i).

For the scope of this test report, the EUT was mounted in three orthogonal axes to maximize emissions. Worst case results are presented

3 EUT: ZX HIGH VOLTAGE

3.1 Radio Specifications:

PRODUCT NAME:	HV Thermostat
MANUFACTURER:	Verdant Environmental Technologies, Inc
MODEL	900 MHz
TUV NUMBER:	499900
PART NUMBER:	N/A
SOFTWARE VERSION	1.51
HARDWARE VERSION	0.1
FREQUENCY RANGE (MHz)	See Table 5
NUMBER OF CHANNELS	0-66 [67]
DATA RATE	600bps
CHANNEL BANDWIDTH	380kHz
MODULATION TYPE	GFSK
VOLTAGE RATING:	90 – 277AC

Table 3 – EUT – ZX High Voltage Thermostat – Specifications for 900 MHz

PRODUCT NAME:	HV Thermostat
MANUFACTURER:	Verdant Environmental Technologies, Inc
MODEL	2.4GHz
TUV NUMBER:	499901
PART NUMBER:	N/A
SOFTWARE VERSION	1.51
HARDWARE VERSION	0.1
FREQUENCY RANGE (MHz)	See Table 6.
CHANNEL NUMBER	0-39 [40]
DATA RATE	1Mbps
CHANNEL BANDWIDTH	2MHz
MODULATION TYPE	GFSK
VOLTAGE RATING:	90 – 277AC

Table 4 – EUT – ZX High Voltage Thermostat – Specifications for 2.4GHz

3.2 Frequency Specifications:

Channels	Frequency (MHz)	Channels	Frequency (MHz)	Channels	Frequency (MHz)
#0	902.46	#31	914.24	#62	926.02
#1	902.84	#32	914.62	#63	926.4
#2	903.22	#33	915	#64	926.78
#3	903.6	#34	915.38	#65	927.16
#4	903.98	#35	915.76	#66	927.52
#5	904.36	#36	916.14		
#6	904.74	#37	916.52		
#7	905.12	#38	916.90		
#8	905.5	#39	917.28		
#9	905.88	#40	917.66		
#10	906.26	#41	918.04		
#11	906.64	#42	918.42		
#12	907.02	#43	918.8		
#13	907.4	#44	919.18		
#14	907.78	#45	919.56		
#15	908.16	#46	919.94		
#16	908.54	#47	920.32		
#17	908.92	#48	920.7		
#18	909.3	#49	921.08		
#19	909.68	#50	921.46		
#20	910.06	#51	921.84		
#21	910.44	#52	922.22		
#22	910.82	#53	922.6		
#23	911.2	#54	922.98		
#24	911.58	#55	923.36		
#25	911.96	#56	923.74		
#26	912.34	#57	924.12		
#27	912.72	#58	924.5		
#28	913.1	#59	924.88		
#29	913.48	#60	925.26		
#30	913.86	#61	925.64		

Table 5 List of Channels for ZX High Voltage 900 MHz Band

Channels	Frequency (GHz)	Channels	Frequency (GHz)
Channel #0	2.402GHz	Channel #20	2.442GHz
Channel #1	2.404GHz	Channel #21	2.444GHz
Channel #2	2.406GHz	Channel #22	2.446GHz
Channel #3	2.408GHz	Channel #23	2.448GHz
Channel #4	2.410GHz	Channel #24	2.450GHz
Channel #5	2.412GHz	Channel #25	2.452GHz
Channel #6	2.414GHz	Channel #26	2.454GHz
Channel #7	2.416GHz	Channel #27	2.456GHz
Channel #8	2.418GHz	Channel #28	2.458GHz
Channel #9	2.420GHz	Channel #29	2.460GHz
Channel #10	2.422GHz	Channel #30	2.462GHz
Channel #11	2.424GHz	Channel #31	2.464GHz
Channel #12	2.426GHz	Channel #32	2.466GHz
Channel #13	2.428GHz	Channel #33	2.468GHz
Channel #14	2.430GHz	Channel #34	2.470GHz
Channel #15	2.432GHz	Channel #35	2.472GHz
Channel #16	2.434GHz	Channel #36	2.474GHz
Channel #17	2.436GHz	Channel #37	2.476GHz
Channel #18	2.438GHz	Channel #38	2.478GHz
Channel #19	2.440GHz	Channel #39	2.480GHz

Table 6 List of Channels for ZX High Voltage 2.4 GHz Band

3.3 Modes of Operation

The ZX HIGH VOLTAGE is operating at 915 MHz and for operation, wireless was configured to transmit at 100% duty cycle:

The transmitter was provided in 2 different settings:

- A configuration with special test firmware was installed on the EUT to control hopping through its pseudo random sequence and single channel
- A configuration with low, medium and high channels transmitting continuously at a 100% duty cycle.
- EUT was configured with continuous transmission with 1s interval per channel.

3.4 Setup Diagram

During the EUT was exercised by powering to the rated voltage and connecting according to Figure 1.

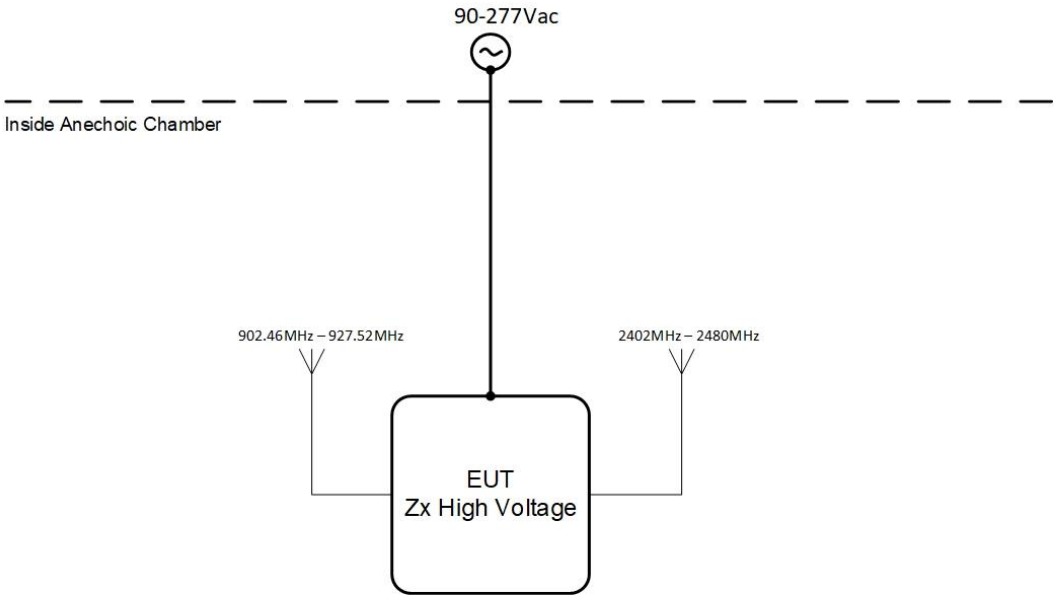


Figure 1: EUT Setup Diagram – ZX HIGH VOLTAGE – Spurious emissions

4 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

5 Measurement Uncertainty

The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2. For instance, for the range of 0.15MHz-30MHz, 30MHz – 1GHz and 1GHz – 18GHz is ±3.3 dB, ±4.25dB and ±4.93dB, respectively with a 'k=2' coverage factor and a 95% confidence level.

Parameter	Uncertainty
Occupied channel Bandwidth	± 5%
RF output power, conducted	± 1.5dB
Power Spectral Density, conducted	± 3dB
Unwanted Emission, conducted	± 3dB
All emission, radiated	± 6dB
Temperature	± 3°C
Time Occupancy	± 3%

Table 7 Acceptable Uncertainties

6 99% Bandwidth

6.1 Purpose & Methods

The Purpose & Methods of this test is to ensure that the bandwidth occupied exceeds a stated minimum. This helps ensure the utilization of the frequency allocation is sufficiently wide. This also helps prevent corruption of data by ensuring adequate data separation to distinguish the reception of the intended information. The test method is a defined in ANSI C63.10.

6.2 Test Specifications

REFERENCE STANDARD	FCC 15.247(a)(1) ANSI C63.10-2013 Clause 6.9 RSS-247.5.1		
SPECIFICATIONS			
Limit – Bandwidth (kHz)	99%		
Frequency range (MHz)	902.46 915 927.54	2402 2440 2480	
Data Rate	1Mbps		
RBW (kHz):	Set to 1% to 3% of the 99% bandwidth		
VBW (kHz)	3xRBW		
EUT			
Identification	ZX High Voltage (915MHz) ZX High Voltage (2.4GHz)		
Voltage Input	120Vac		
ENVIROMENTAL & TEST INFO			
Test Date (YYYY-MM-DD)	2020-06-26	2020-06-30	2020-07-02
Temperature (°C)	23.4± 2	21.4± 2	24.1± 2
Humidity (%)	23 ± 5	30 ± 5	20 ± 5
Atmospheric Pressure kPa (For Info Only)	101.2	100.1	101.5
Tester	Jose Martinez		

6.3 Test Results

ZX High Voltage (900Mz)

The mid-channel gave a maximum of 233.53kHz for 99% BW. Details are depicted in Table 8.

Channel	Frequency (MHz)	99% Bandwidth (kHz)	Limits (kHz)	Results
Low channel	902.67	233.53	≤500	Pass
Middle Channel	915	232.34	≤500	Pass
Highest Channel	927.52	231.14	≤500	Pass

Table 8 – 99% Bandwidth Results – 915MHz

ZX High Voltage (2.4GHz)

The Channel #39 gave a maximum of 1.080MHz for 99% BW. Details are depicted in Table 9.

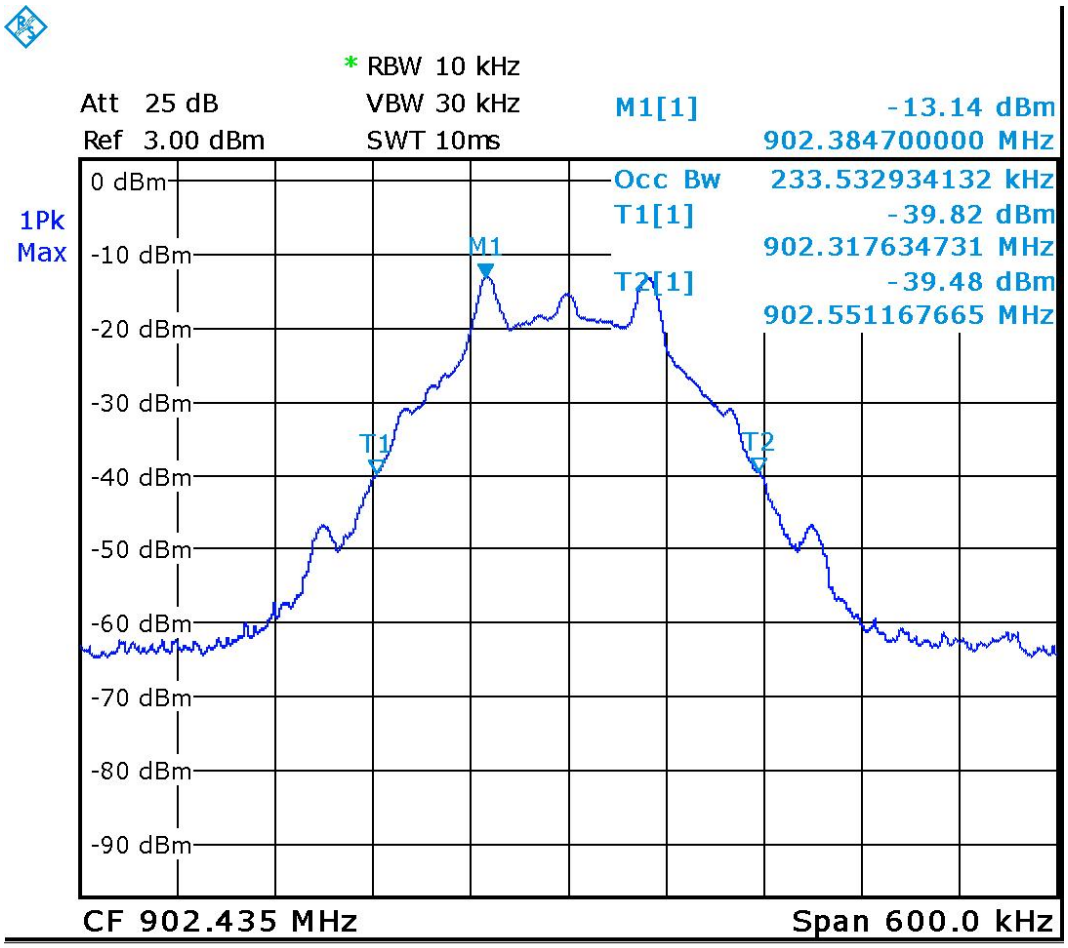
Channel	Frequency (MHz)	99% Bandwidth (MHz)	Results <Note 1>
Low channel:	2402	1.080	Pass
Middle Channel:	2426	1.050	Pass
Highest Channel:	2480	1.054	Pass
Note 1: No Limit is applicable, but according to RSS GEN 5 the RBW has to be set to 1% to 3% of the 99% bandwidth			

Table 9 – 99% Bandwidth Results – 2.4GHz

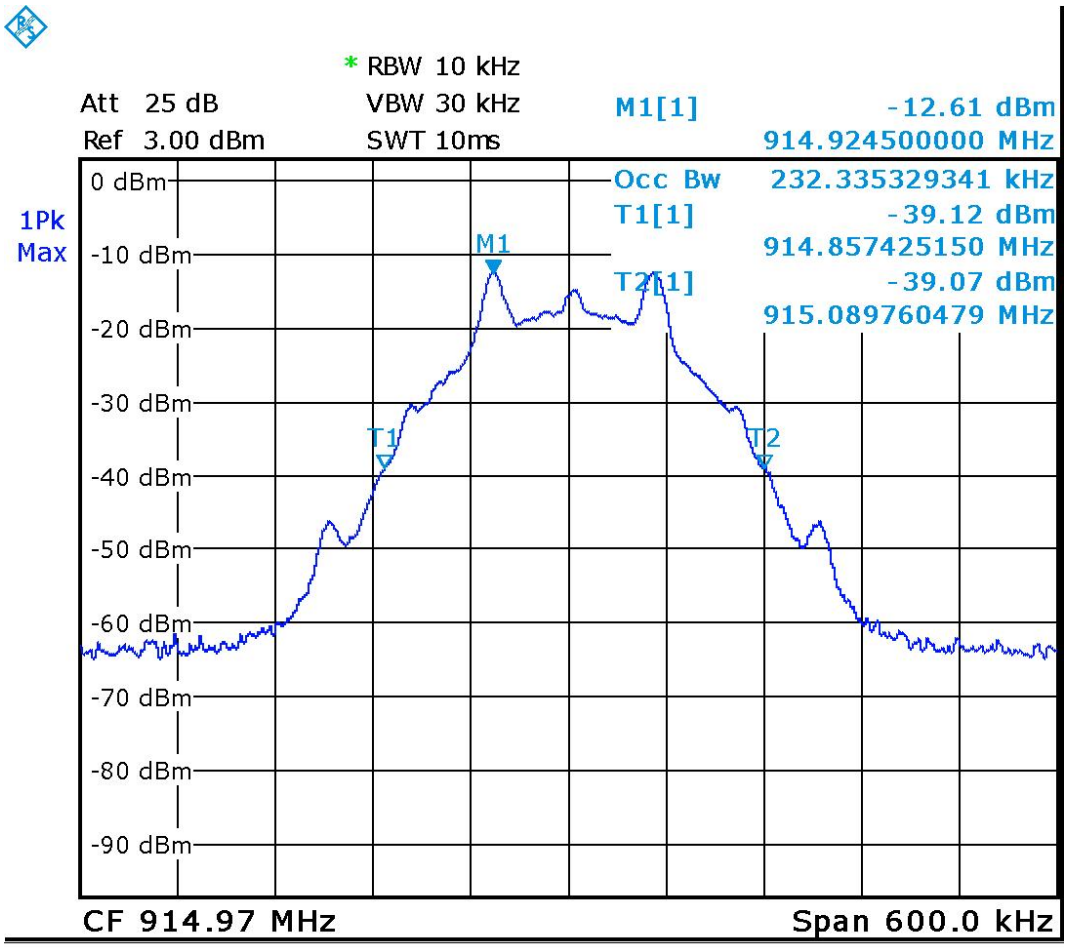
6.4 Graphs

High Voltage (915MHz)

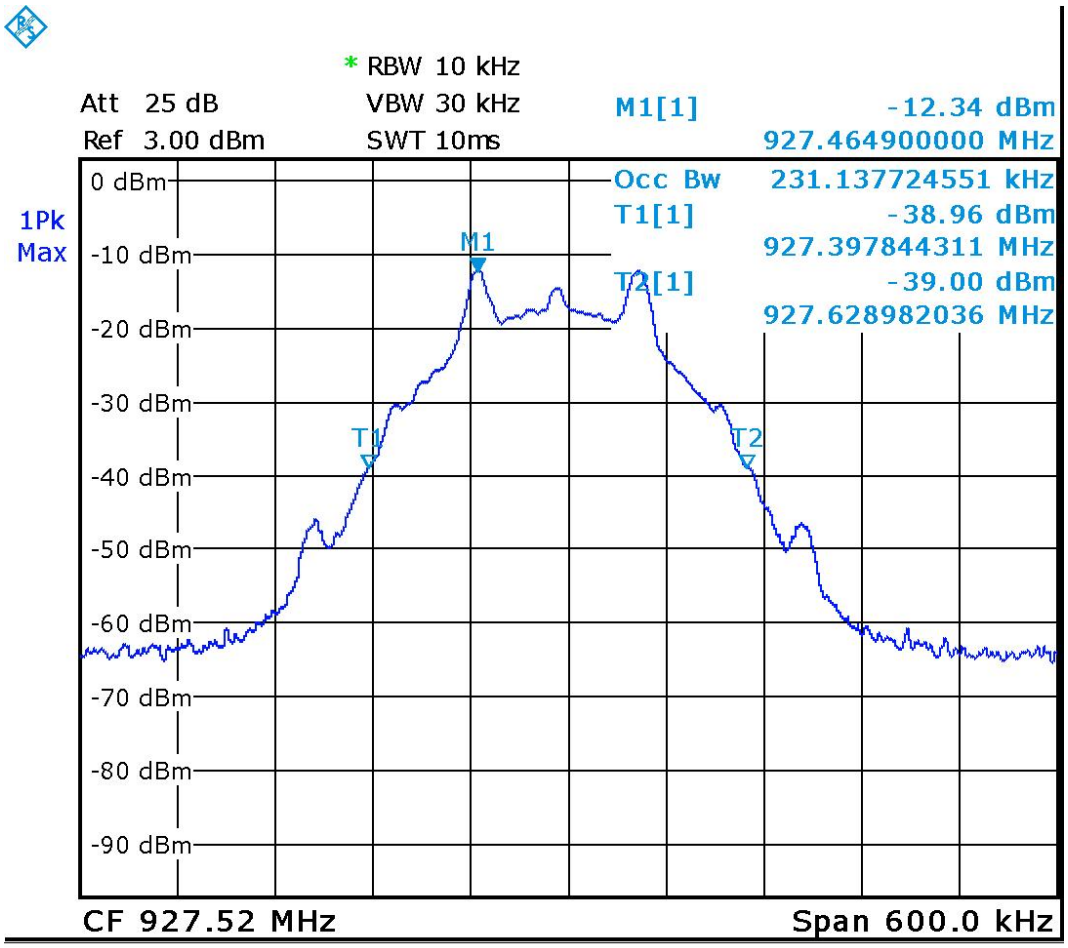
The graphs showed below show the OBW during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the 99% bandwidth of a channel during operation of the EUT. Max hold is performed for a duration of not less than 1 minute. No attenuator was used between the EUT and the Spectrum Analyzer.



Graph 1 Test Results – 99% Bandwidth Results – Low Channel ZX High Voltage



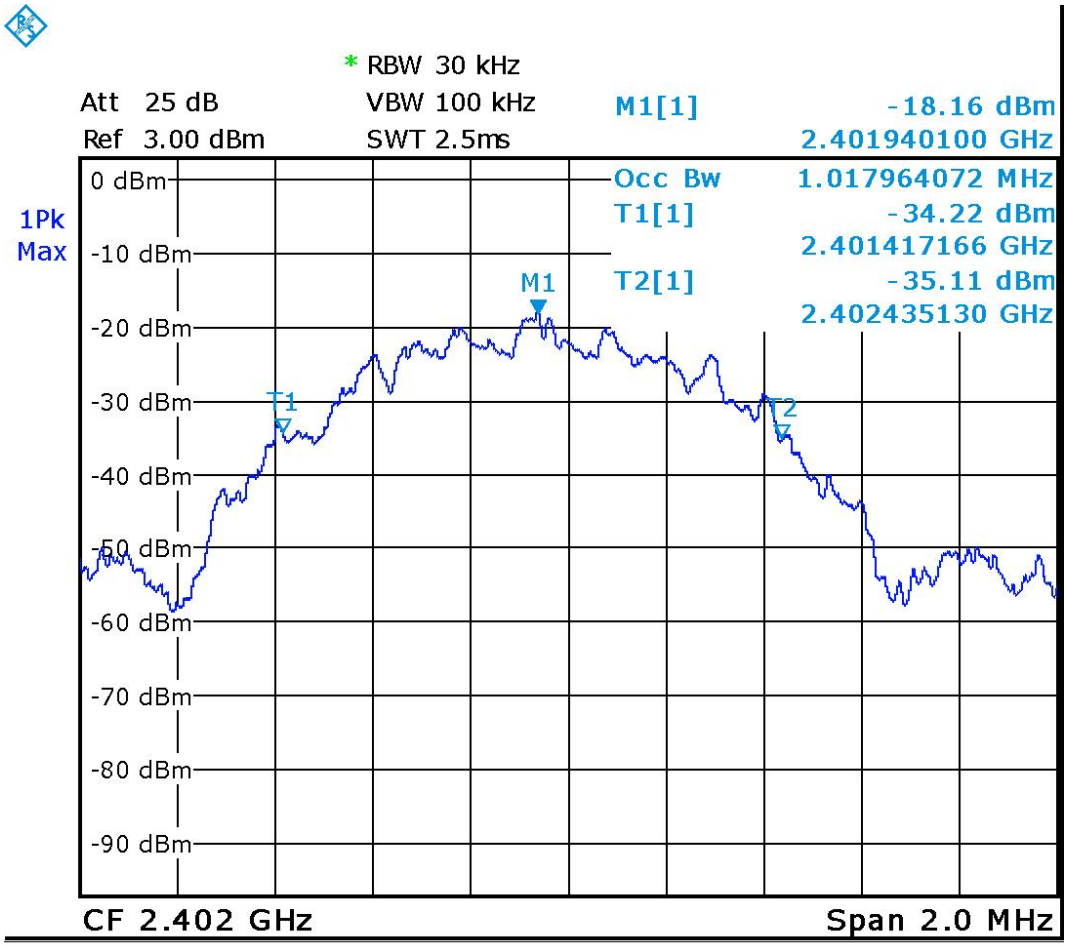
Graph 2 Test Results – 99% Bandwidth Results – Mid Channel ZX High Voltage



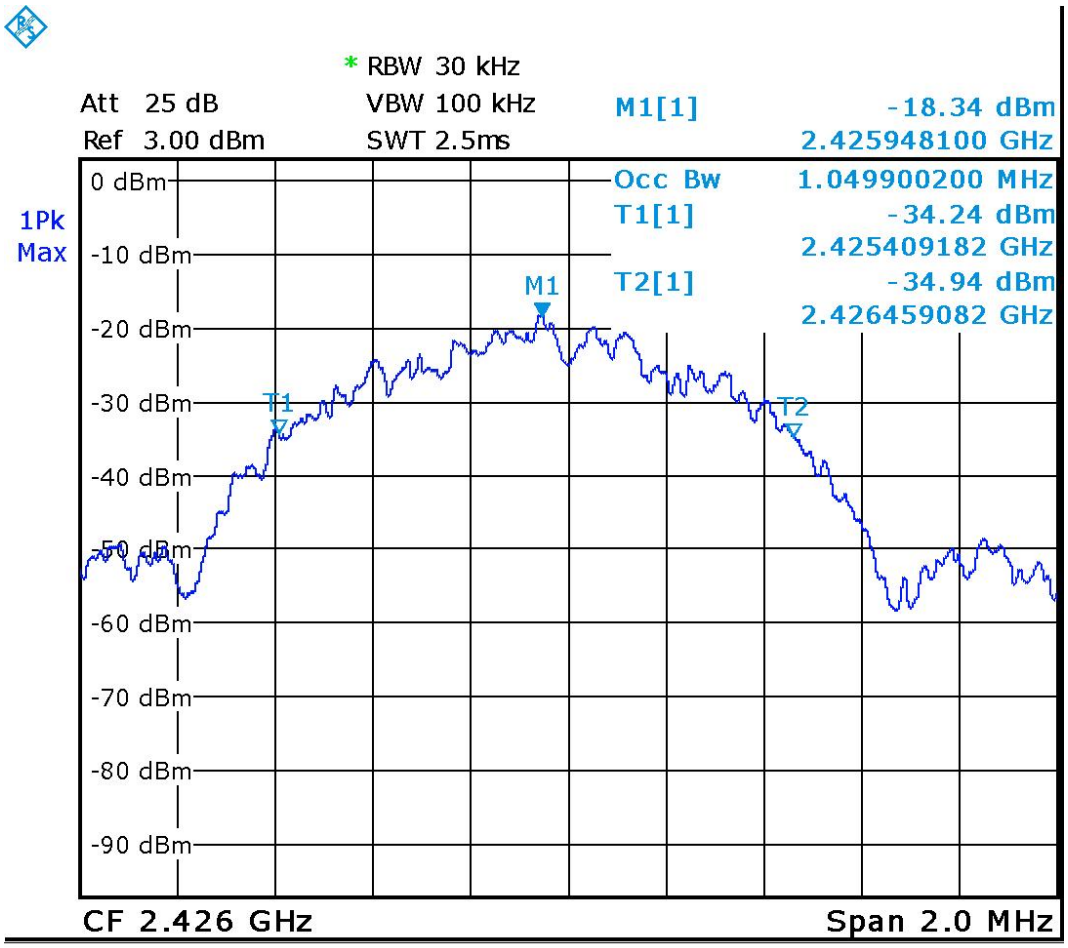
Date: 13.JUL.2020 14:59:47

Graph 3 Test Results – 99% Bandwidth Results – High Channel ZX High Voltage

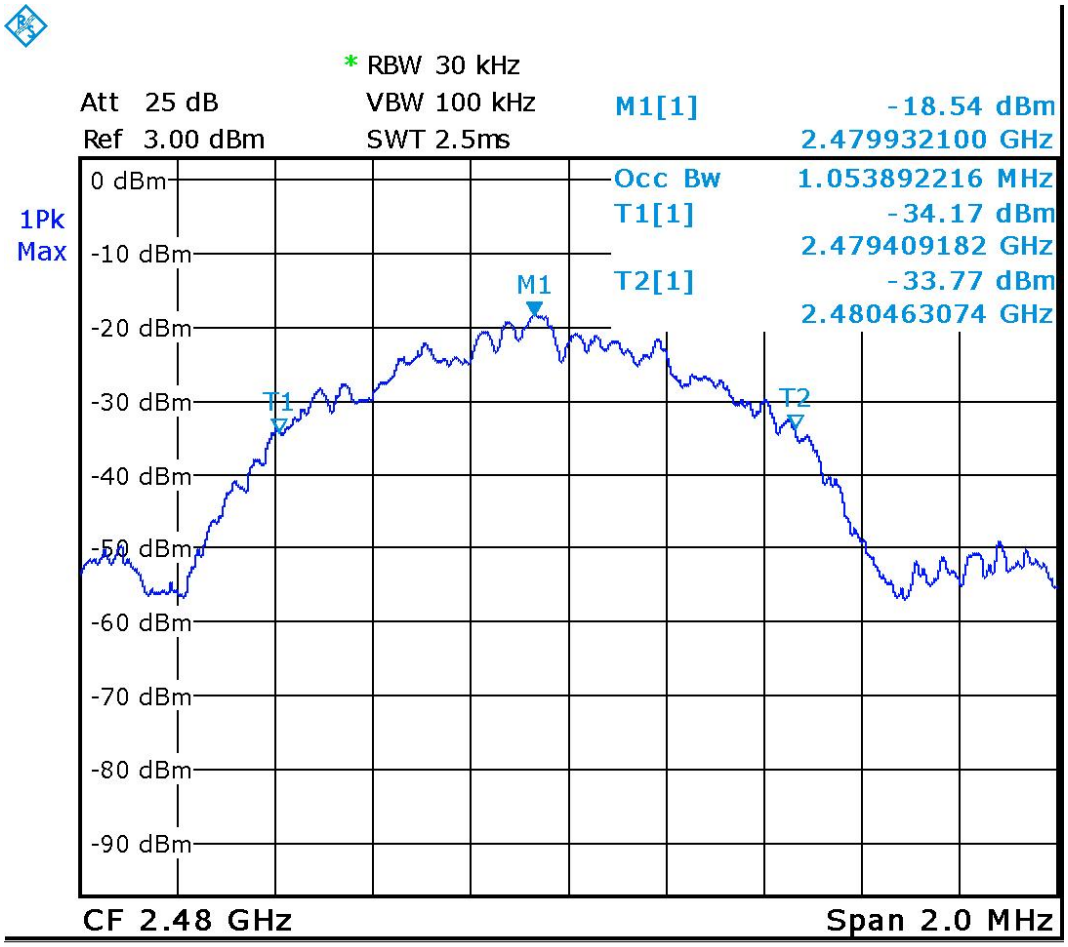
High Voltage (2.4GHz)



Graph 4 Test Results – 99% Bandwidth Results – Lower Channel ZX High Voltage (2.4GHz)



Graph 5 Test Results – 99% Bandwidth Results – Middle Channel ZX High Voltage (2.4GHz)



Graph 6 Test Results – 99% Bandwidth Results – High Channel ZX High Voltage (2.4GHz)

6.5 Test Setup

The Setup 99% Bandwidth is depicted in Photo 1.

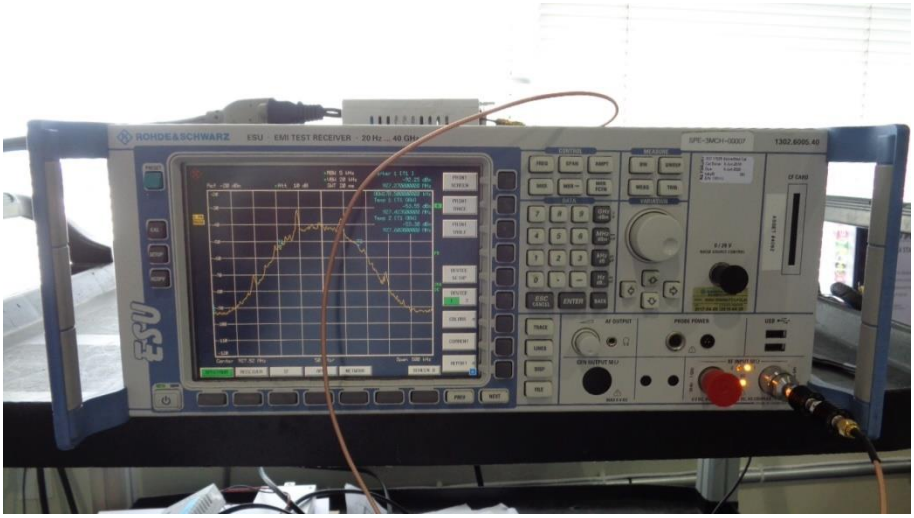


Photo 1: Test Setup – Conductive Method - ZX High Voltage (900MHz/2.4GHz)

6.6 Test Instruments

This test was carried out in Laval test location. Instrumentation used is depicted in Table 10.

Equipment	Model No.	Manufacturer	Calibration Period (months)	Calibration Due (YYY-MM-DD)	Asset No: LAVE
Spectrum Analyzer	ESU-40	Rohde & Schwarz	24	2021-04-20	4092
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4130
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4131

Table 10: 99%BW Test Equipment

7 6dB Bandwidth of Digitally Modulated Systems

7.1 Purpose & Methods

The Purpose & Methods of this test is to ensure that the bandwidth occupied exceeds a stated minimum. This helps ensure the utilization of the frequency allocation is sufficiently wide. This also helps prevent corruption of data by ensuring adequate data separation to distinguish the reception of the intended information. The test method is a defined in ANSI C63.10.

7.2 Test Specifications

REFERENCE STANDARD	FCC Part 15.247(a)2 RSS-247 5.2(a)
SPECIFICATIONS	
Limit – 6dB Bandwidth	≥500kHz
Frequency range (MHz)	2402 2440 2480
Data rate	1Mbps
RBW (kHz):	100
VBW (kHz)	300
EUT	
Identification	ZX High Voltage (2.4GHz)
Voltage Input	120VAC
ENVIROMENTAL & TEST INFO	
Test Date (YYYY-MM-DD)	2020-06-30
Temperature (°C)	21.4 ± 2
Humidity (%)	30 ± 5
Atmospheric Pressure kPa (For Info Only)	100.1
Tester	Jose Martinez-Ortega

7.3 Test Setup

The Setup for the 6dB Bandwidth testing is identical to the 99% bandwidth setup of Photo 1.

7.4 Test Results

ZX High Voltage (2.4GHz)

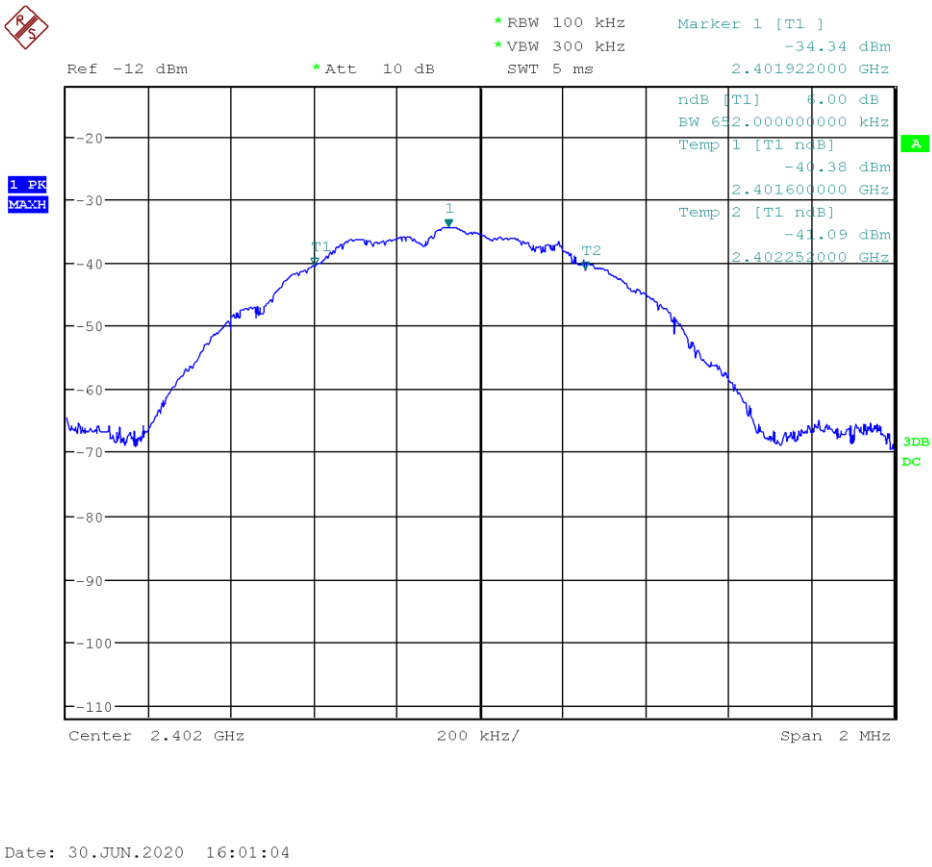
The Channel #39 gave a maximum of 674kHz for 6dB bandwidth. Test results are depicted in Table 11

Channel	Frequency (MHz)	6dB Bandwidth (kHz)	Limit (kHz)	Results
Lowest channel:	2402	652	≥500	Pass
Middle Channel:	2426	662	≥500	Pass
Highest Channel:	2480	674	≥500	Pass

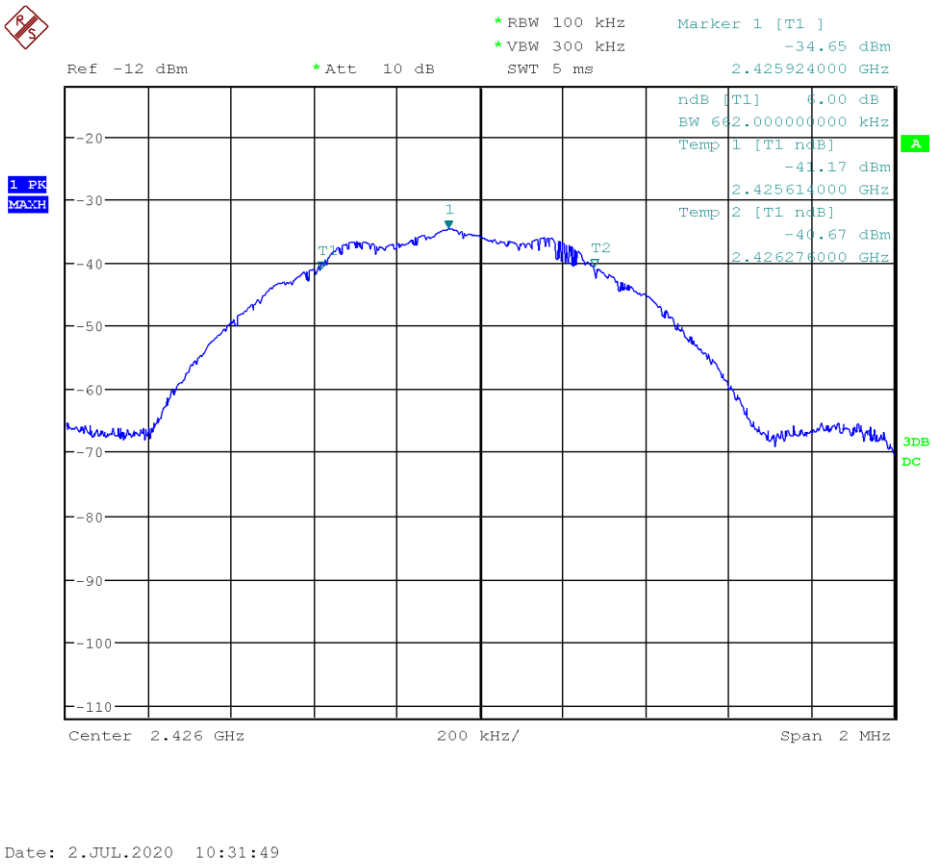
Table 11 – 6dB Bandwidth Results

7.5 Graphs

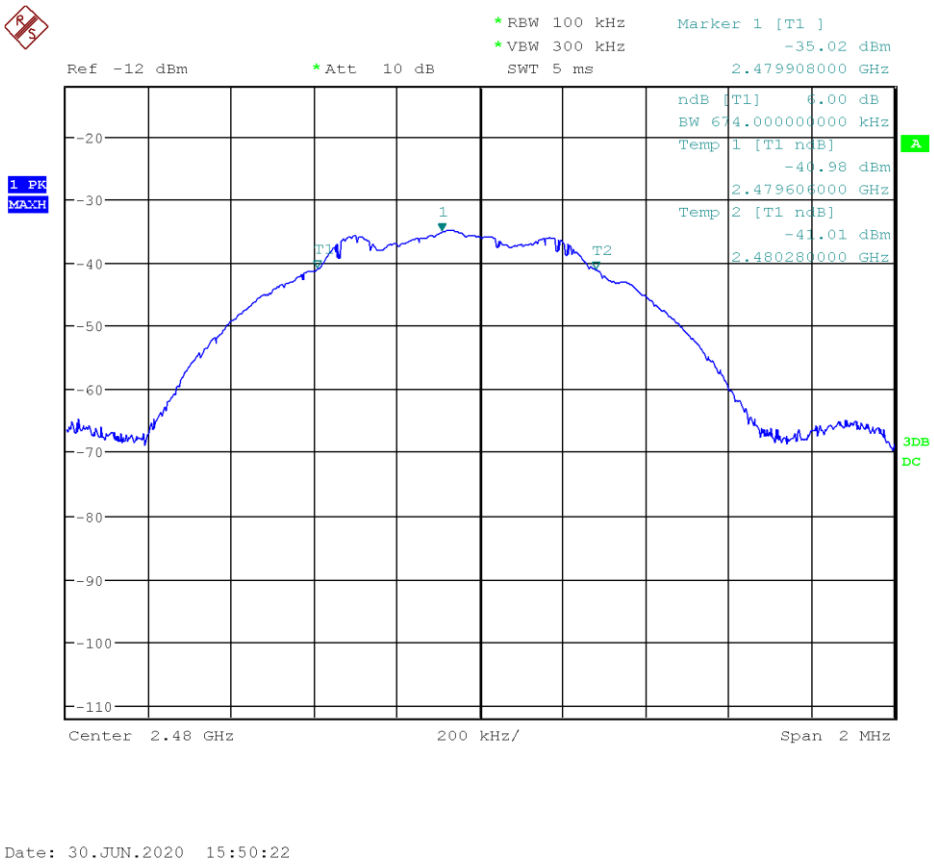
The graphs showed below show the OBW during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the 99% bandwidth of a channel during operation of the EUT. Max hold is performed for a duration of not less than 1 minute. No attenuator was used between the EUT and the Spectrum Analyzer.



Graph 7 Test Results – 6dB Bandwidth Results – Lower Channel ZX HV (2.4GHz)



Graph 8 Test Results – 6dB Bandwidth Results – Mid-Channel ZX HV (2.4GHz)



Graph 9 Test Results – 6dB Bandwidth Results – Highest Channel ZX HV (2.4GHz)

7.6 Test Instruments

This test was carried out in Laval test location. Test instrument used are depicted in Table 12.

Equipment	Model No.	Manufacturer	Calibration Period (months)	Calibration Due (YYY-MM-DD)	Asset No: LAVE
Spectrum Analyzer	ESU-40	Rohde & Schwarz	24	2021-04-20	4092
Cable 254mm SMA	Minibend-10	Huber+ Suhner	NCR	NCR	4080
Spectrum Analyzer	FSL 6	Rohde & Schwarz	24	2020-09-02	4095
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4130
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4131

Table 12. 6dB Test Equipment

8 Hopping Channel

8.1 Purpose & Methods

The Purpose & Methods of this test is to ensure that the RF energy of frequency hopping systems is sufficiently spread over a spectrum and that the radio energy is not overly dense. This limit helps allow for other spread spectrum devices to co-exist in the same frequency spectrum. This also helps prevent corruption of data by ensuring adequate channel separation to distinguish the reception of the intended information. The test method is a defined in ANSI C63.10.

8.2 Test Specifications

REFERENCE STANDARD	FCC Part 15.247(a)(1)(i) RSS 247 5.1 (c)
SPECIFICATIONS	
Limits	See Section 15.247(a)(1)
Test Frequency (MHz):	902.46 915 927.52
RBW (kHz)	200
VBW (kHz)	500
EUT	
Identification	ZX High Voltage (915MHz)
Voltage Input	120Vdac
Environmental	Normal Conditions
Test Date (YYYY-MM-DD)	2020-06-17
Temperature (°C)	23.4 ± 1
Humidity (%)	36.3 ± 5
Atmospheric Pressure kPa (For Info Only)	109.7
Tester(s)	Jose Martinez

8.3 Limits

The limits are as defined in 47 CFR FCC Part 15 Section 15.247(a)(1) and depicted in Table 13. The test method is defined in ANSI C63.10.

Frequency Band (MHz)	20 dB Bandwidth of the hopping channel	Hopping Number
902 – 928	≤250kHz	≥ 50 channels
	≥250 kHz	≥ 25 channels
	≥250 kHz	≥ 75 channels

Table 13 – Hopping Channel Results

8.4 Test Results

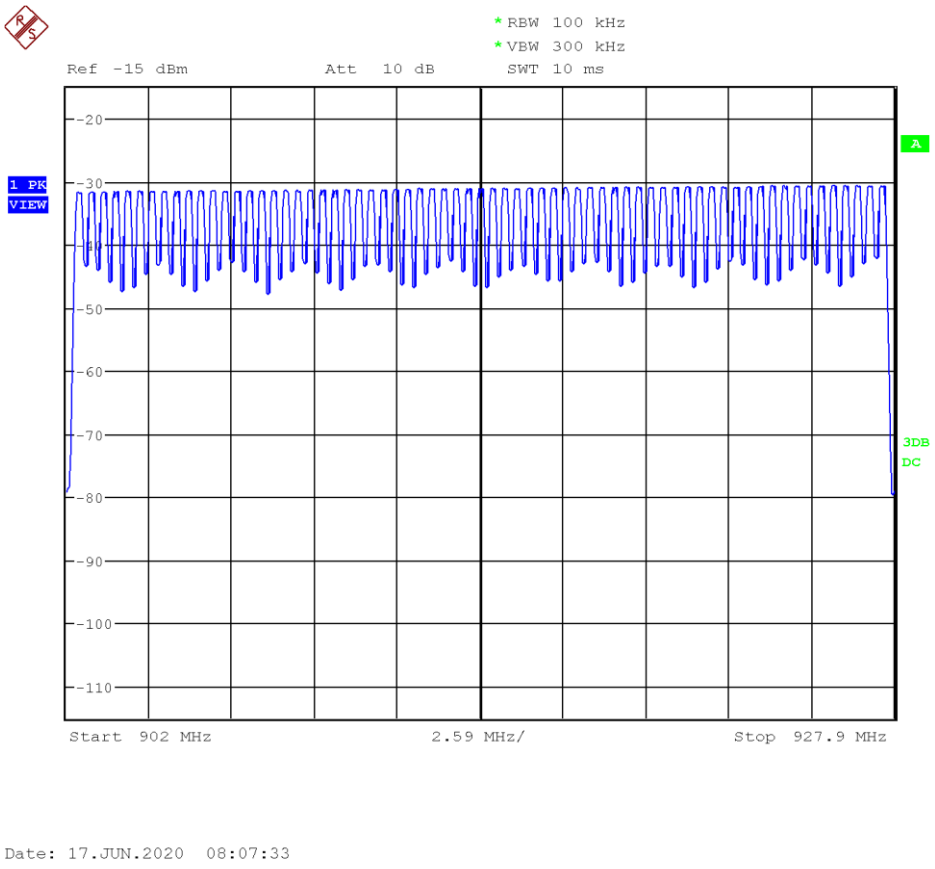
The EUT passed the requirements of the number of channels. The number of channels occupied by the EUT and 67 channels in the allocation band of 902 MHz to 928 MHz. Results are depicted in Table 14.

Channel	Range (MHz)	Number of Hopping Measured	Limits	Results
Middle Channel:	902 – 927.9	67	≥50 channels	Pass

Table 14 – Hopping Channel Results

8.5 Graphs

The graphs below show the number of occupied channels during the operation of the device. This is measured by a max hold on the spectrum analyser and the highest resolution bandwidth that is sufficiently low to exhibit the channel spacing of the signal being measured. This measurement is a peak measurement. Max hold is performed for a duration of not less than 10 minutes, or as sufficient to capture the channels occupied.



Graph 10: Hopping Channel – ZX High Voltage –902MHz to 927.9MHz

8.6 Test Instruments

This test was carried out in Laval test location. And the test instrumentation used is depicted in Table 15.

Equipment	Model No.	Manufacturer	Calibration Period (months)	Calibration Due (YYY-MM-DD)	Asset No: LAVE
Spectrum Analyzer	ESU-40	Rohde & Schwarz	24	2021-04-20	4092
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4130
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4131

Table 15: Hopping Channel Test Equipment

9 Channel Separation

9.1 Purpose & Methods

The Purpose & Methods of this test is to ensure that the RF energy of frequency hopping systems is sufficiently spread over a spectrum and that the radio energy is not overly dense. This limit helps allow for other spread spectrum devices to co-exist in the same frequency spectrum. This also helps prevent corruption of data by ensuring adequate channel separation to distinguish the reception of the intended information. The test method is a defined in ANSI C63.10.

9.2 Test Specifications

REFERENCE STANDARD	FCC Part 15.247(a)(1). RSS 247 5.1 (2)
SPECIFICATIONS	
Limit	≥20 dB Bandwidth
Frequency range (MHz)	902.46 915 927.52
RBW (kHz):	100
VBW (kHz)	300
EUT	
Identification	ZX High Voltage (915MHz)
Voltage Input	120Vac
ENVIROMENTAL & TEST INFO	
Test Date (YYYY-MM-DD)	2020-06-22
Temperature (°C)	23.4 ± 1
Humidity (%)	36.3 ± 5
Atmospheric Pressure kPa (For Info Only)	109.7
Tester	Jose Martinez
Client Witness	No Witness

9.3 Limits

The limits are as defined in 47 CFR FCC Part 15 Section 15.247(a)(1). The test method is defined in ANSI C63.10 as shown in the Table 16, below.

Frequency Band	20 dB Bandwidth of the hopping channel	Limits <Note 1>
902 - 928	≤250kHz	25kHz or 20dB BW
Note 1: The minimum channel separation is given by the greater of 25 kHz or 20 dB BW for unconditional operation. The 20 dB BW of the system was measured to be 233.53kHz (see Table 8 and Graph 1 in section 6.4). Therefore channel separation of 233.53kHz applies		

Table 16 – Channel Separation Results

9.4 Test Results

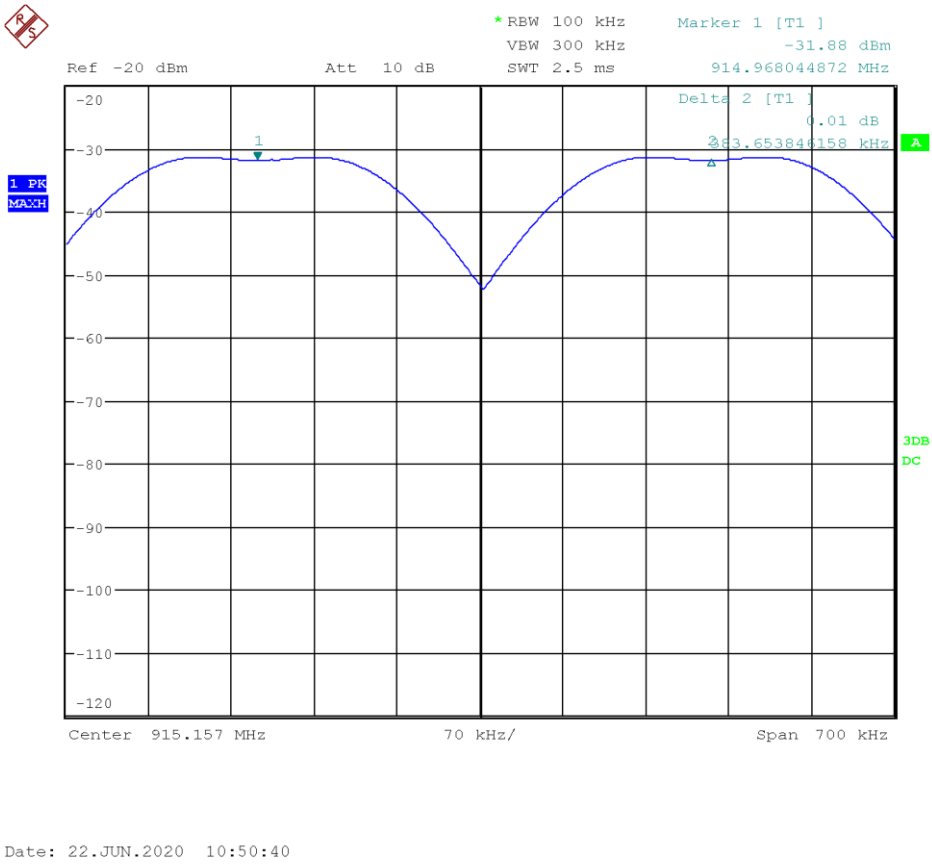
The results of the EUT are detailed in Table 17.

Channel	Central Frequency (MHz)	Channel Separation Measured (kHz)	Limits < kHz>	Results
Middle Channel:	915	383	≥233.53	Pass

Table 17 – Channel Separation Results

9.5 Graphs

The graphs shown below shows the channel spacing during the operation of the device. This is measured by a max hold on the spectrum analyser and the highest resolution bandwidth that is sufficiently low to exhibit the channel spacing of the signal being measured. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute, as the device is stepping through its hopping table.



Graph 11: Channel Separation – ZX High Voltage

9.6 Test Instruments

This test was carried out in Laval test location. The test instrumentation used is depicted in Table 18.

Equipment	Model No.	Manufacturer	Calibration Period (months)	Calibration Due (YYY-MM-DD)	Asset No: LAVE
Spectrum Analyzer	ESU-40	Rohde & Schwarz	24	2021-04-20	4092
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4130
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4131

Table 18: Channel Separation Test Equipment

10 Time of Occupancy

10.1 Purpose & Methods

The purpose of this test is to ensure that the RF energy of frequency hopping systems is hopping at a minimum defined rate. This helps ensure sufficient time off to enable other frequency hopping devices to co-operate within this allocated band.

10.2 Test Specifications

REFERENCE STANDARD	FCC Part 15.247(a)(1). RSS 247 5.1 (2)
SPECIFICATIONS	
Limit	See FCC 15.247(a)(1)(i).
Frequency range (MHz)	902.46 915 927.52
RBW (kHz):	200
VBW (kHz)	500
EUT	
Identification	ZX HIGH VOLTAGE (915MHz)
Voltage Input	120Vac
ENVIROMENTAL & TEST INFO	
Test Date (YYYY-MM-DD)	2020-07-02
Temperature (°C)	23.4 ± 1
Humidity (%)	36.3 ± 5
Atmospheric Pressure kPa (For Info Only)	109.7
Tester	Jose Martinez
Client Witness	No Witness

10.3 Limits

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

10.4 Test Results

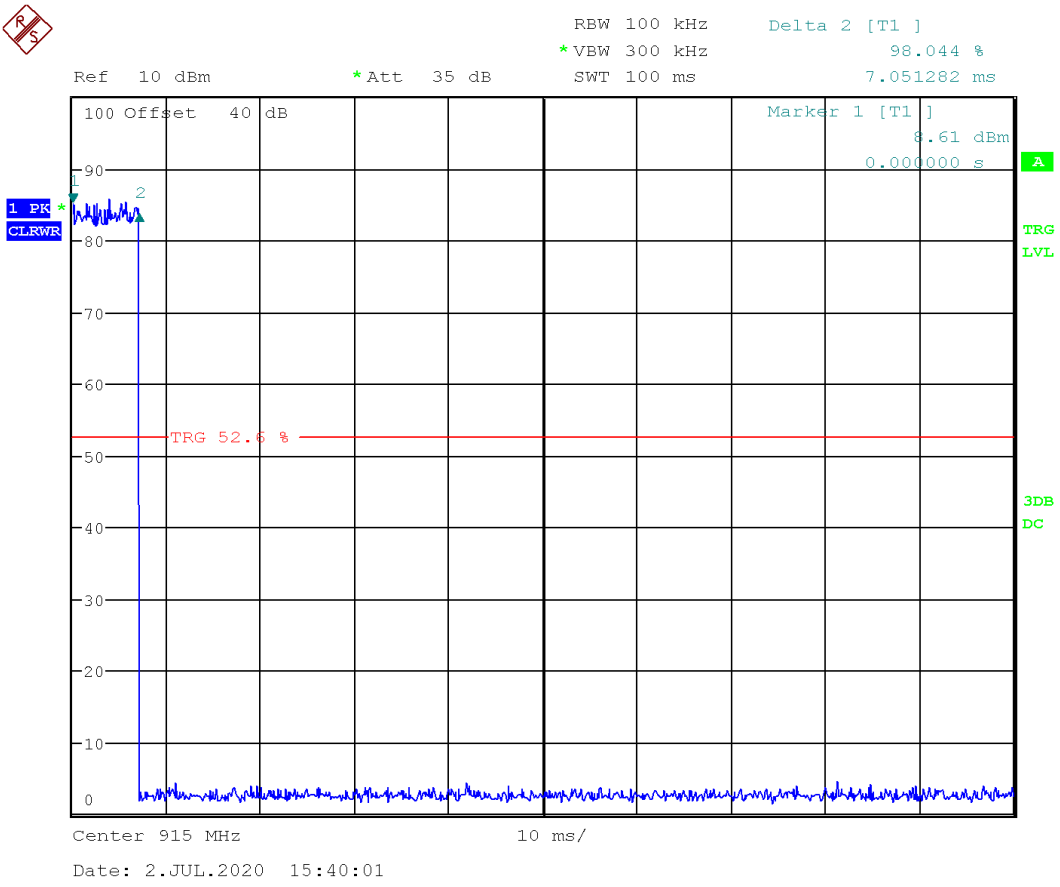
The EUT cycles through its pseudo-random generated list of hopping frequencies. There are 67 channels occupied in total. The average transmit time is 6.7ms per channel and each channel is repeated approximately every 1s. Thus, the average time of occupancy is equal to: 20 × 6.7ms = 134ms within 20s period. Results are depicted in Table 19.

Channel	Frequency (MHz)	Average Transmit Time/ Channel (ms)	Number of Hops in 20s	Average Time of Occupancy (ms)	Limit (ms)	Results
Middle	915	6.7	20	134	≤400	Pass

Table 19 – Time Occupancy Results

10.5 Graphs

The graphs shown below shows the Time of Occupancy during the operation of the device. This is measured by a max hold on the spectrum analyser and the highest resolution bandwidth that is sufficiently low to exhibit the Time of Occupancy of the signal being measured. This measurement is a peak measurement.



Graph 12: Time of Occupancy – ZX High Voltage

10.6 Test Instruments

This test was carried out in Laval test location. Instrumentation used is depicted in Table 20.

Equipment	Model No.	Manufacturer	Calibration Period (months)	Calibration Due (YYY-MM-DD)	Asset No: LAVE
Spectrum Analyzer	ESU-40	Rohde & Schwarz	24	2021-04-20	4092
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4130
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4131

Table 20: Time of Occupancy Test Equipment

11 Maximum Peak Envelope Conducted Power – Digital Modulated

11.1 Purpose & Methods

The purpose of this test is to ensure that the maximum power conducted to the radiating element does not exceed the limits specified. The test method is a defined in ANSI C63.10.

11.2 Test Specifications

REFERENCE STANDARD	FCC Part 15.247(b)(3) FCC Part 15.247(b)(2) RSS-247.5.4(d) ANSI C63.10. Clause 11.9.1	
SPECIFICATIONS		
Limit – Power (W)	<1	
Frequencies (MHz)	2402 2440 2480x	902.46 915 927.52
RBW (MHz):	3	1
VBW (MHz)	10	3
Span (MHz)	10	4
EUT		
Identification	ZX HIGH VOLTAGE	
Voltage Input	120Vac	
Test Date (YYYY-MM-DD)	2020-06-30	
Temperature (°C)	21.4± 2	
Humidity (%)	30 ± 5	
Atmospheric Pressure kPa (For Info Only)	100.1	
Tester	Jose Martinez	
Client Witness	No Witness	

11.3 Limits

The limits are defined in 15.247(b)(2) and 15.247(b)(3). For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.
For systems using digital modulation in the 902-928 MHz, and 2400-2483.5 MHz, 5725-5850 MHz bands: 1 Watt.

11.4 Tests Results

ZX High Voltage (915MHz)

The maximum peak power at the antenna connector gave 6.67dBm or 4.64mW. All conductive measurements of the peak power measurements are depicted in Table 21.

Channel	Frequency (MHz)	Attenuation (dB)	Measured Peak Power (dBm)	Peak Power (dBm)	Peak Power (mW)	Limit (mW)	Result
Low	902.44	40	-38.67	1.33	1.36	1000	Pass
Middle	915.00	40	-37.40	2.60	1.82	1000	Pass
High	927.39	40	-33.33	6.67	4.64	1000	Pass

Table 21 – Test Results Peak-Power Measurements ZX High Voltage

ZX High Voltage (2.4GHz)

All peak power measurements were carried out by the conductive method and results are in Table 22.

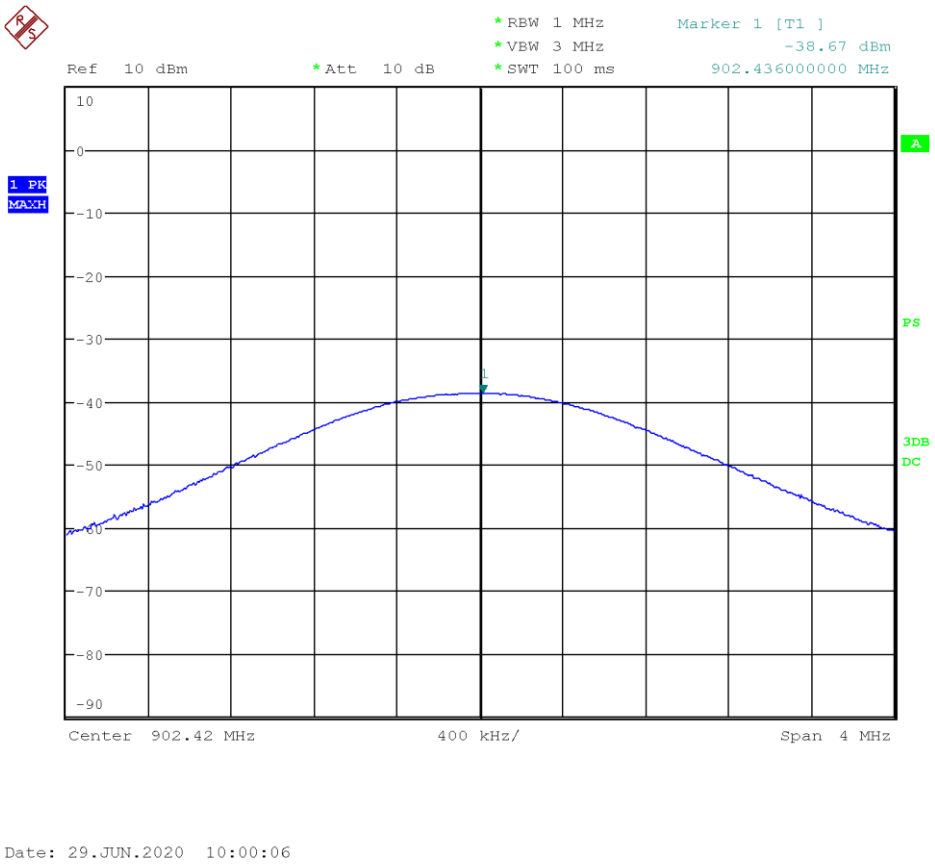
Channel	Frequency (MHz)	Measured Peak Power (dBm)	External Attenuation +Cable (dB)	Corrected Peak Power (dBm)	Peak Power (mW)	Limit (mW)	Result
Lowest	2402	-33.27	40	6.59	4.56	1000	Pass
Middle	2440	-33.69	40	6.31	4.28	1000	Pass
Highest	2480	-33.77	40	6.23	4.20	1000	Pass

Table 22 – Test Results Peak-Power Measurements ZX HV (2.4GHz)

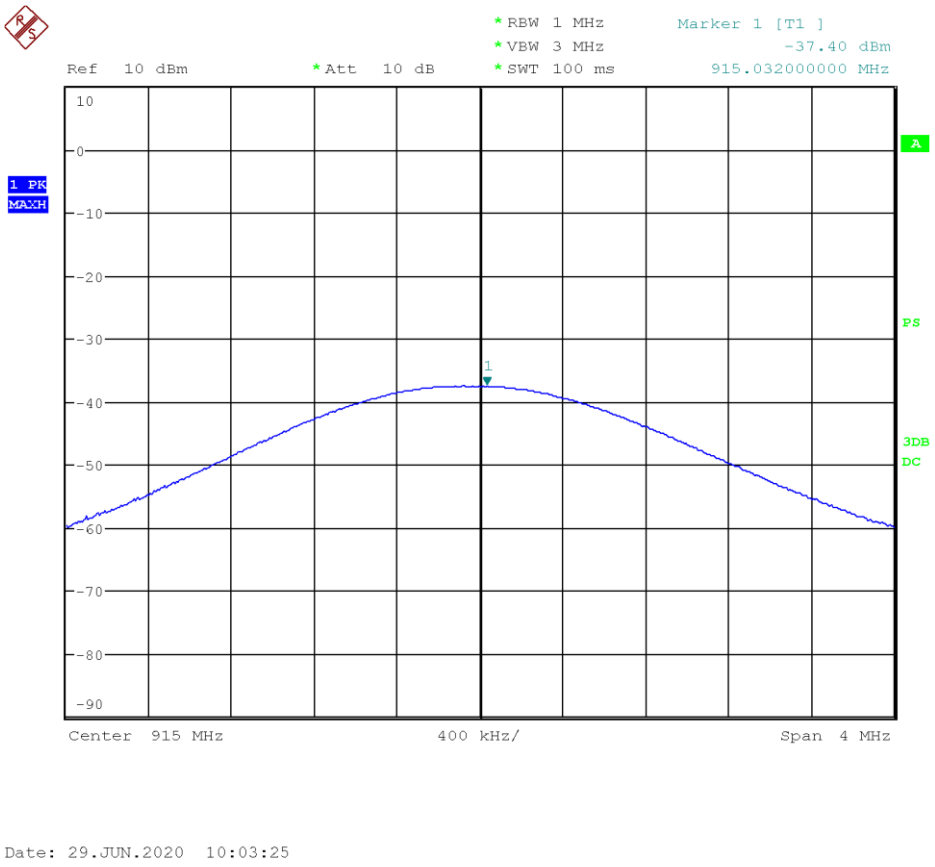
11.5 Graphs

The plots shown below show the Peak Power Output of the device during the antenna conducted measurements during transmit operation of the EUT. Note that 40dB attenuator was used between the EUT and the Spectrum Analyzer.

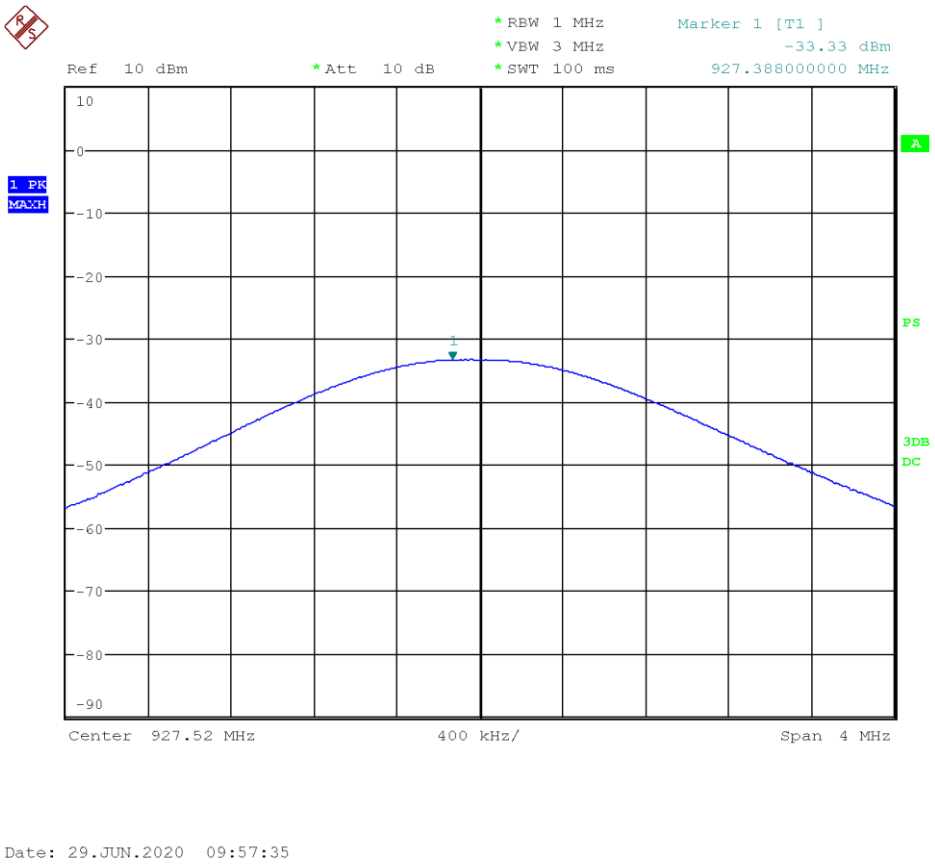
ZX High Voltage (900MHz)



Graph 13 Test Results – Conducted Peak Power Measurements – Low Channel

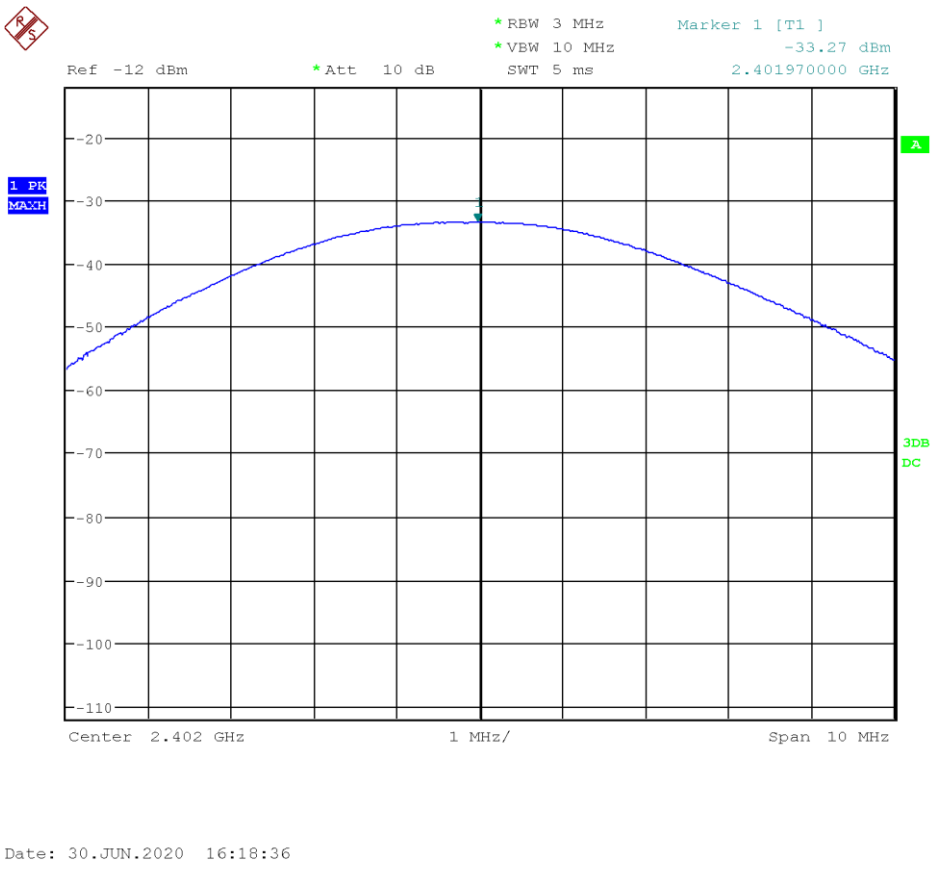


Graph 14 Test Results – Conducted Peak Power Measurements – Mid Channel

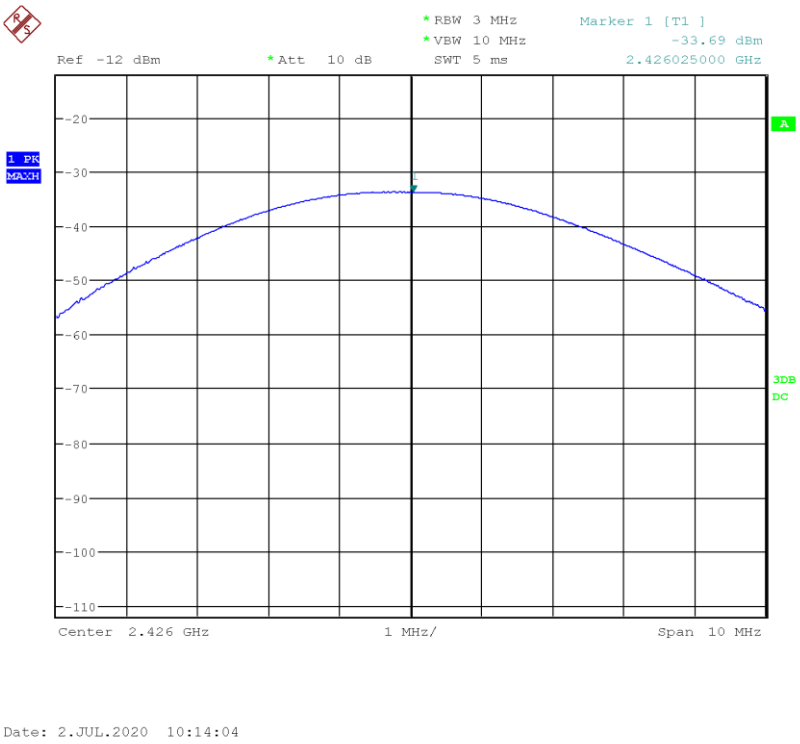


Graph 15 Test Results – Conducted Peak Power Measurements – High Channel

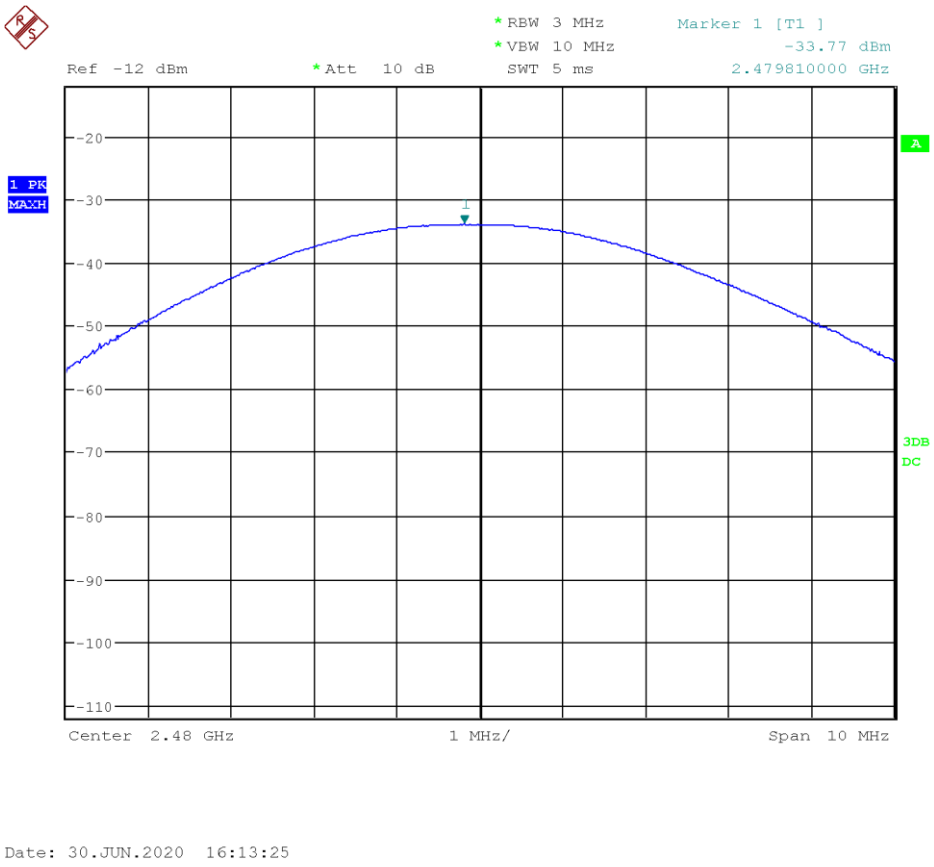
ZX High Voltage (2.4GHz)



Graph 16 Test Results – Conducted Peak Power Measurements – Low Channel



Graph 17 Test Results – Conducted Peak Power Measurements – Middle Channel



Graph 18 Test Results – Conducted Peak Power Measurements – High Channel

11.6 Test Instruments

This test was carried out in Laval test location. Instrumentation used is depicted in Table 23.

Equipment	Model No.	Manufacturer	Calibration Period (months)	Calibration Due (YYY-MM-DD)	Asset No: LAVE
Spectrum Analyzer	ESU-40	Rohde & Schwarz	24	2021-04-20	4092
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4130
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4131

Table 23: Conducted Peak Power Test Equipment

12 Power Spectral Density

12.1 Purpose & Methods

The Purpose & Methods of this test is to ensure that the maximum power spectral density to the radiating element does not exceed the limits specified. This ensures that the modulation is significantly wide enough, or low enough in power that it will allow for co-operation of other wireless devices operating within this frequency allocation. The method applied is the PKPSD described in ANSI C63.10-2013 in Clause 11.10.

12.2 Test Specifications

REFERENCE STANDARD	FCC Part 15.247(F) RSS-247 5.2(b) ANSI C63.10. Clause 11.10	
SPECIFICATIONS		
Limit (dBm)	<8	
Frequencies (MHz)	2402 2442 2480	902.46 914.62 927.54
RBW (kHz):	3	10
VBW (kHz)	10	30
Span (MHz)	4	4
EUT		
Identification	ZX HV	
Voltage Input	120Vac	
ENVIROMENTAL & TEST INFO		
Test Date (YYYY-MM-DD)	2020-03-16	2020-06-30
Temperature (°C)	23.4 ± 2	21.4± 2
Humidity (%)	23.4 ± 5	30 ± 5
Atmospheric Pressure kPa (For Info Only)	103.34	100.1
Tester	Abdoulaye Ndiaye Jose Martinez-Ortega	

12.3 Limits

The limits are defined according to FCC rule 15.247(f).The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

12.4 Test Setup

The Setup for the Maximum Peak Power testing is identical to the 20dB Bandwidth setup. For more details refer to photo 1

12.5 Test Results

ZX HV (915MHz)

The EUT was tested on: Low, medium, and high bands. The worst-case value is 2.2dBm as measured with a RBW of 10 kHz resolution for the highest channel. The results of the peak power of channels tested are depicted in Table 24.

Channel	Frequency (MHz)	Measured PSD (dBm)	External Attenuation +Cable (dB)	Corrected PSD (dBm)	Limit (dBm)	Result
Low	902.46	-41.38	40.0	-1.38	<8	Pass
Middle	914.97	-39.39	40.0	0.61	<8	Pass
High	927.54	-17.82	40.0	2.22	<8	Pass

Table 24- Results – PKPSD

ZX High Voltage (2.4GHz)

The EUT was tested on: Low, medium, and high bands. The worst-case value is -8.84 dBm as measured with a 3 kHz resolution bandwidth (peak power) on the highest channel. The results of the peak power of channels tested are depicted in Table 24.

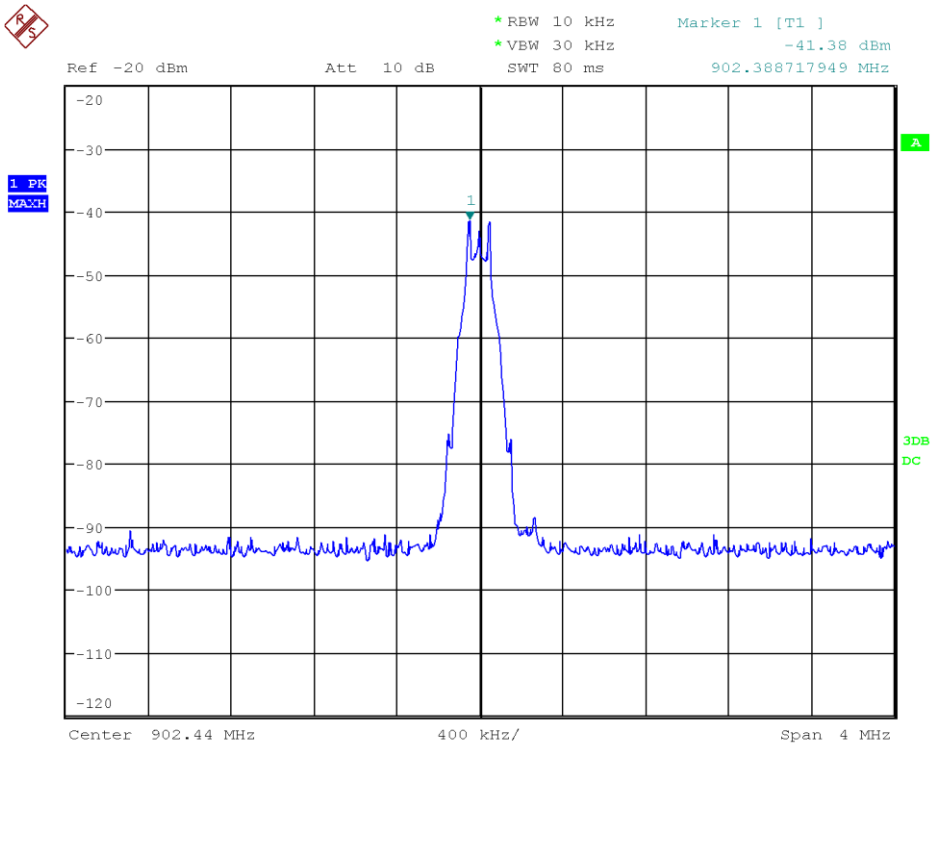
Channel	Frequency (MHz)	Measured PSD (dBm)	External Attenuation +Cable (dB)	Corrected Peak Power (dBm)	Limit (dBm)	Result
Low	2402	-50.17	40	-10.17	<8	Pass
Middle:	2425	-49.16	40	-9.16	<8	Pass
High	2480	-48.84	40	-8.84	<8	Pass

Table 25- Results – PKPSD

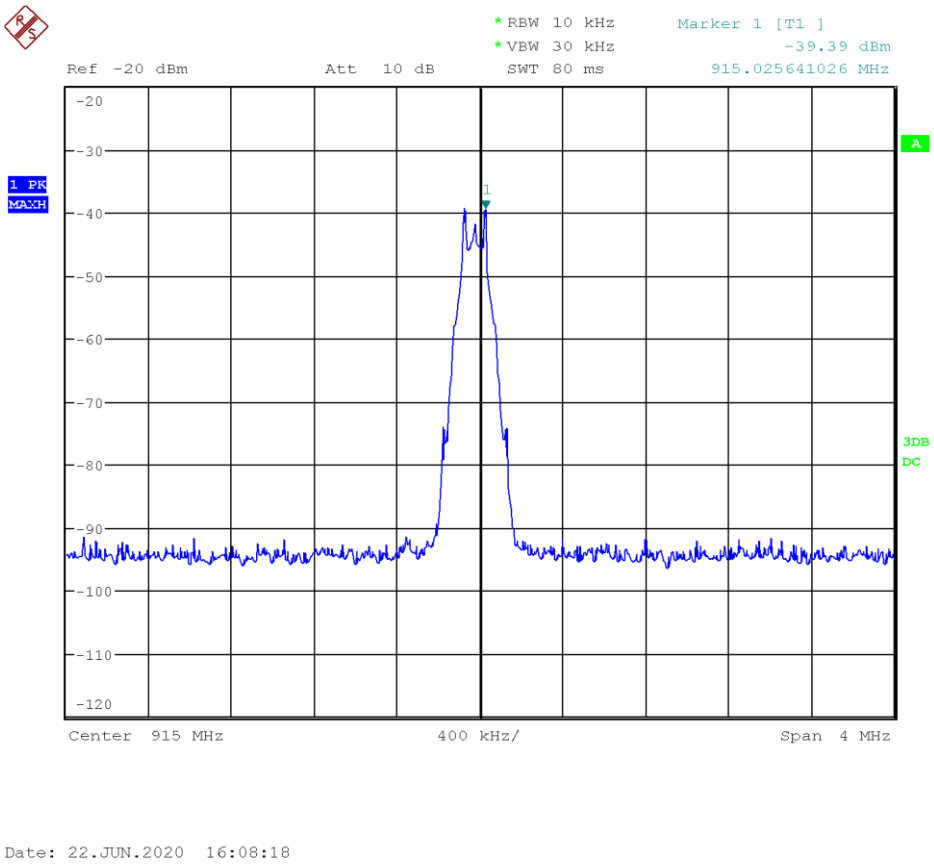
12.6 Graphs

The graphs shown below show the power spectral density of the device during the conducted measurement operation of the EUT. Low, middle, and high channel was investigated. Note that 40dB attenuator was used between the EUT and the Spectrum Analyzer.

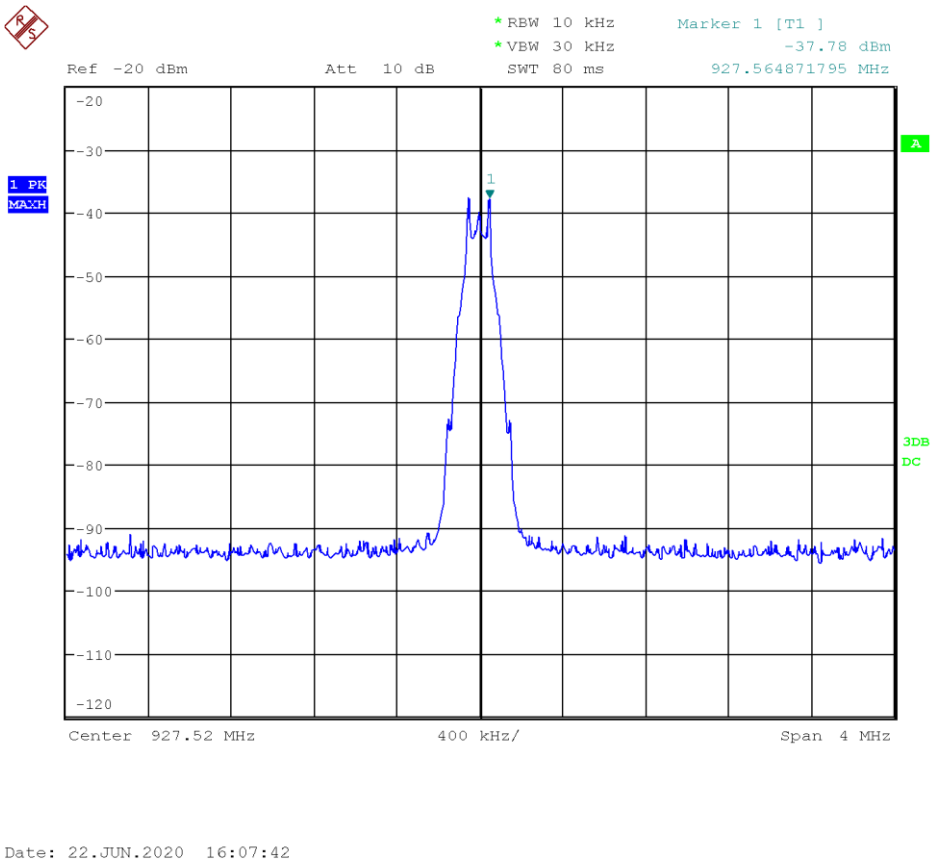
ZX HV (900MHz)



Graph 19 Test Results – PKPSD – Lower Channel

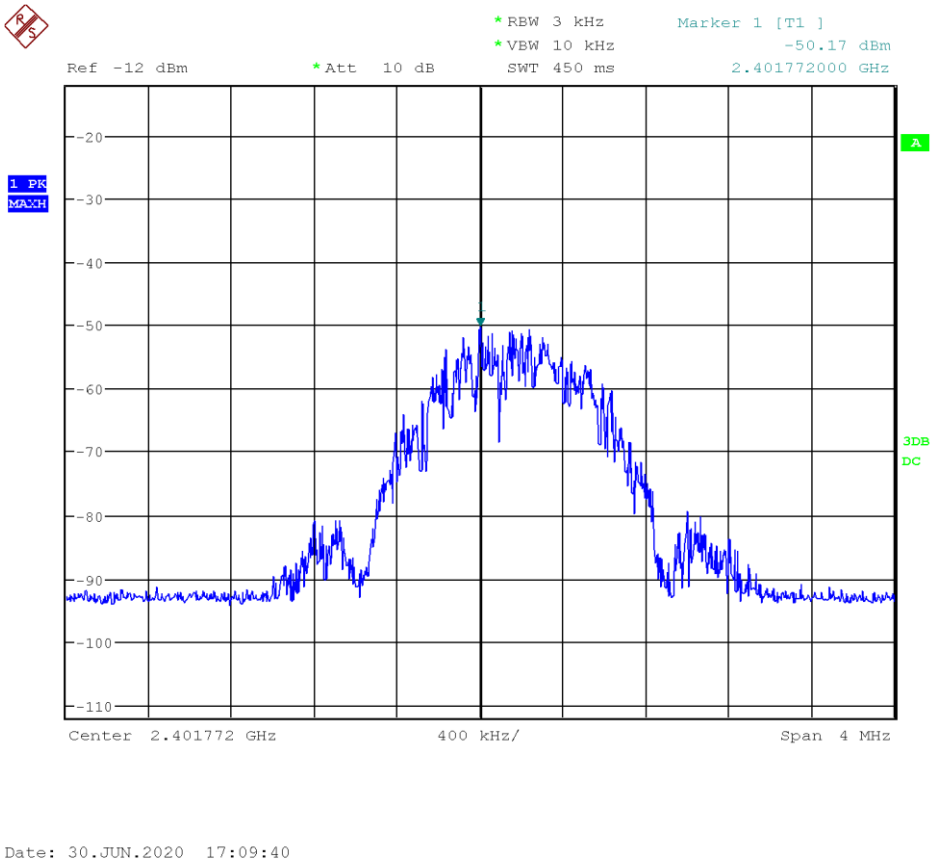


Graph 20 Test Results – PKPSD – Channel #34

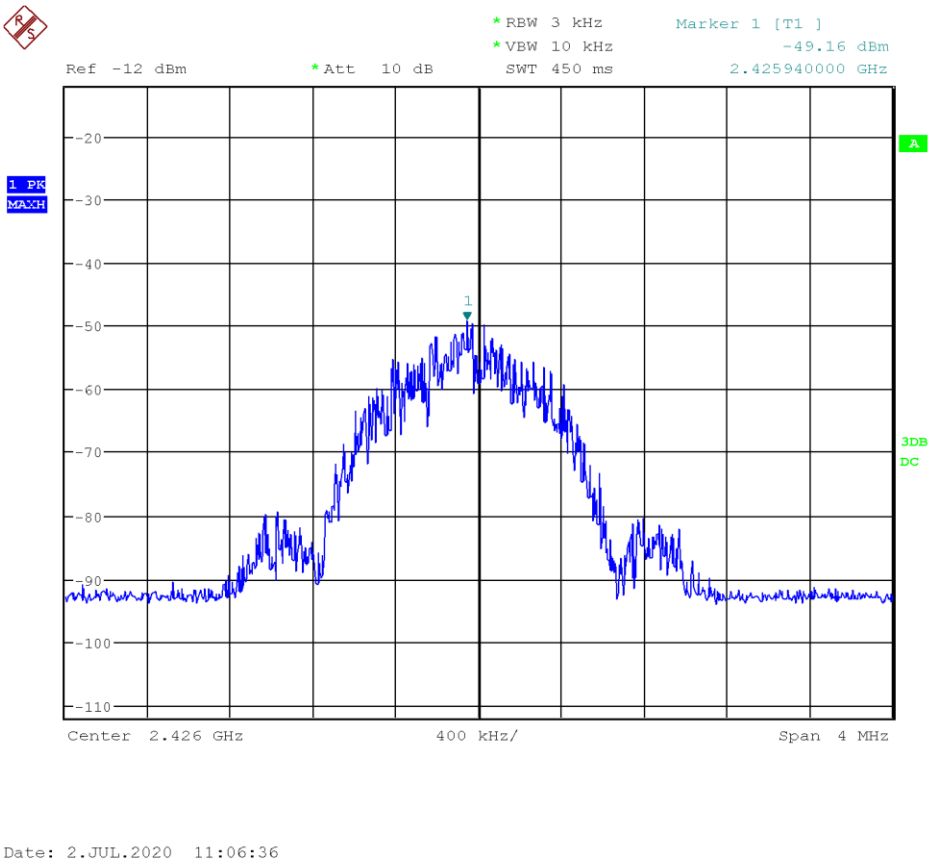


Graph 21 Test Results – PKPSD – Channel #67

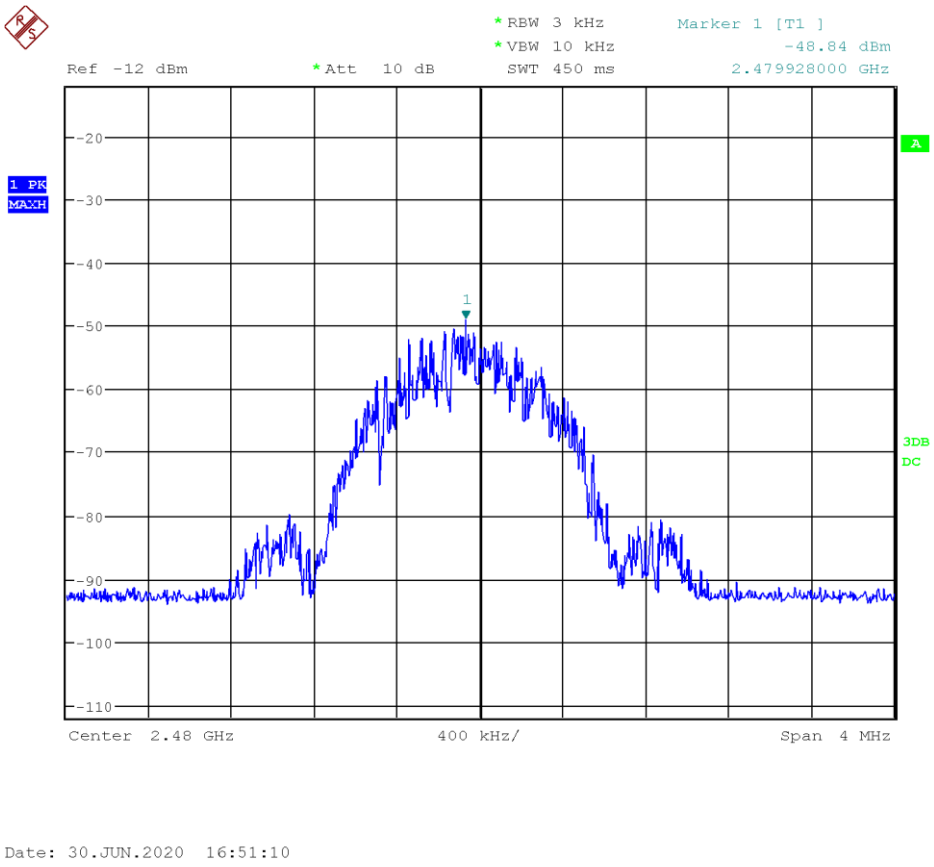
ZX HV (2.4GHz)



Graph 22 Test Results – PKPSD – Lower Channel



Graph 23 Test Results – PKPSD – Mid-Channel



Graph 24 Test Results – PKPSD – Channel #39

12.7 Test Instruments

This test was carried out in Laval test location. And the test instrumentation used is depicted in Table 26.

Equipment	Model No.	Manufacturer	Calibration Period (months)	Calibration Due (YYY-MM-DD)	Asset No: LAVE
Spectrum Analyzer	ESU-40	Rohde & Schwarz	24	2021-04-20	4092
Cable 254mm SMA	Minibend-10	Huber+ Suhner	NCR	NCR	4080
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4130
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4131

Table 26 – Test Instrumentation – Power Spectral Density

13 Band Edge Spurious Emission (-20 dBc Requirement)

13.1 Purpose & Methods

The Purpose of this test is to ensure that the maximum power conducted to the radiating element at frequencies outside of the authorized spectrum does not exceed the limits specified. This ensures that the only the intended signal is delivered to the radiating element. The method applied is described in ANSI C63.10-2013 in Clause 11.11.1.

13.2 Test Specifications

REFERENCE STANDARD	FCC Part 15.247(d) RSS-247 5.5 ANSI C63.10 Clause 11.11.1		
SPECIFICATIONS			
Limit (dBc)	<20		
RBW	100kHz	100kHz	
Frequencies (MHz)	902.46 915 927.52	2402 2440 2483.5	
EUT			
Identification	ZX HIGH VOLTAGE (915MHz) ZX HIGH VOLTAGE (2.4GHz)		
Voltage Input	120Vac		
ENVIROMENTAL & TEST INFO			
Test Date (YYYY-MM-DD)	2020-06-29	2020-07-02	2020-09-28
Temperature (°C)	23.4 ± 2	20.1 ± 2	23.4
Humidity (%)	36.3 ± 5	30.1 ± 5	35.1 ± 5
Atmospheric Pressure kPa (For Info Only)	102.7	102.1	100.1
Tester	Jose Martinez		
Client Witness	No Witness		

13.3 Limits

The limits are defined in 15.247(d). In any 100 kHz band, the peak spurious harmonics emissions must be at least 20 dB below the fundamental. Band Edge is to be evaluated up to the 10th harmonic. This -20 dBc requirement also applies at the 'band edge' of 2.4 GHz and 2.4835 GHz.

13.4 Test Setup

The Setup for the Maximum Peak Power testing is identical to the 99% Bandwidth setup.

13.5 Test Results

The EUT was tested on: Low, medium, and high bands. The worst-case value is -31.36dBm on in the low band of the hopping system, i.e., ZX High Voltage (915MHz). The peak power of channels tested are depicted in Table 27.

Channel	Frequency (MHz)	Measured Spurious Conducted (dBm)	Results
Low	0.009-0.15	-56.15	Pass
Low	0.15-30	-68.32	Pass
Low & Middle	30-927	-70.92	Pass
Low Band – No Hopping	927-927.5	-43.74	Pass
Low Band – Hopping	901-915	-31.36	Pass
High Band No Hopping	927.5 – 928	-38.13	Pass
High Band Hopping	915-935	-37.91	Pass
High	928- 10000	-70.0	Pass

Table 27- Results – ZX High Voltage – Band Edge – 900MHz

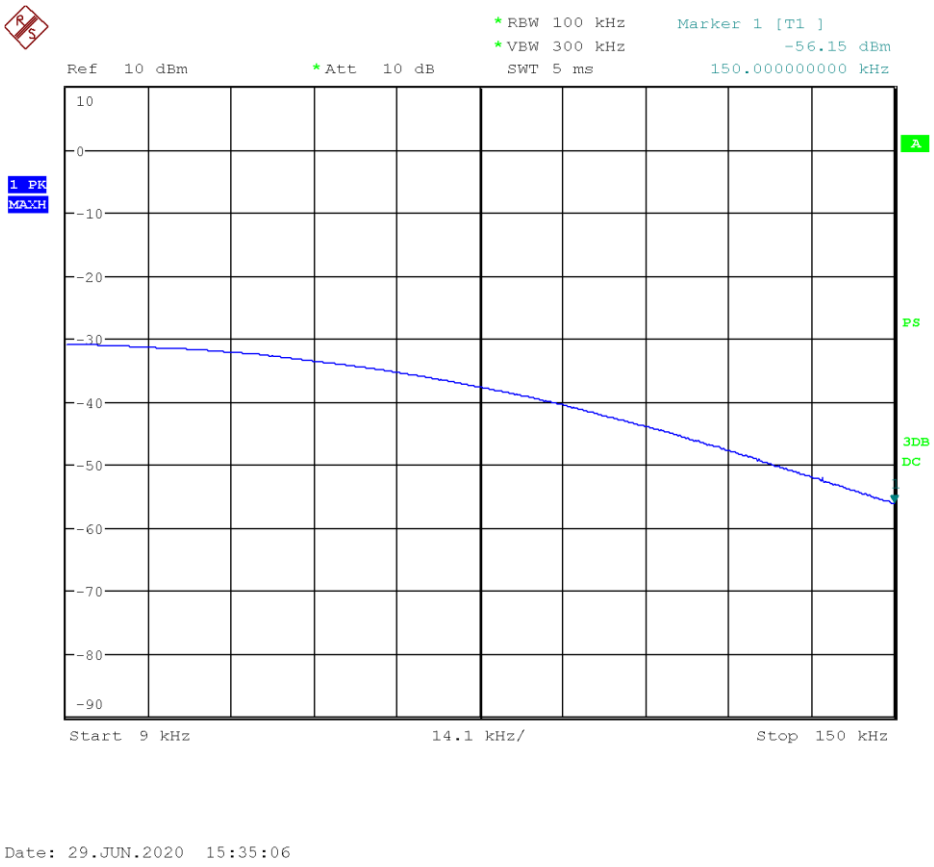
Channel	Frequency (MHz)	Measured Spurious Conducted (dBm)	Results
Low	0.009-0.15	-50.12	Pass
Low	0.15-30	-75.44	Pass
Low & Middle	30-2402	-75.24	Pass
Low Band – No Hopping	2380-2490	-41.62	Pass
Low Band – Hopping	2490-10,000	-73.52	Pass

Table 28- Results – ZX High Voltage – Band Edge – 2.4GHz

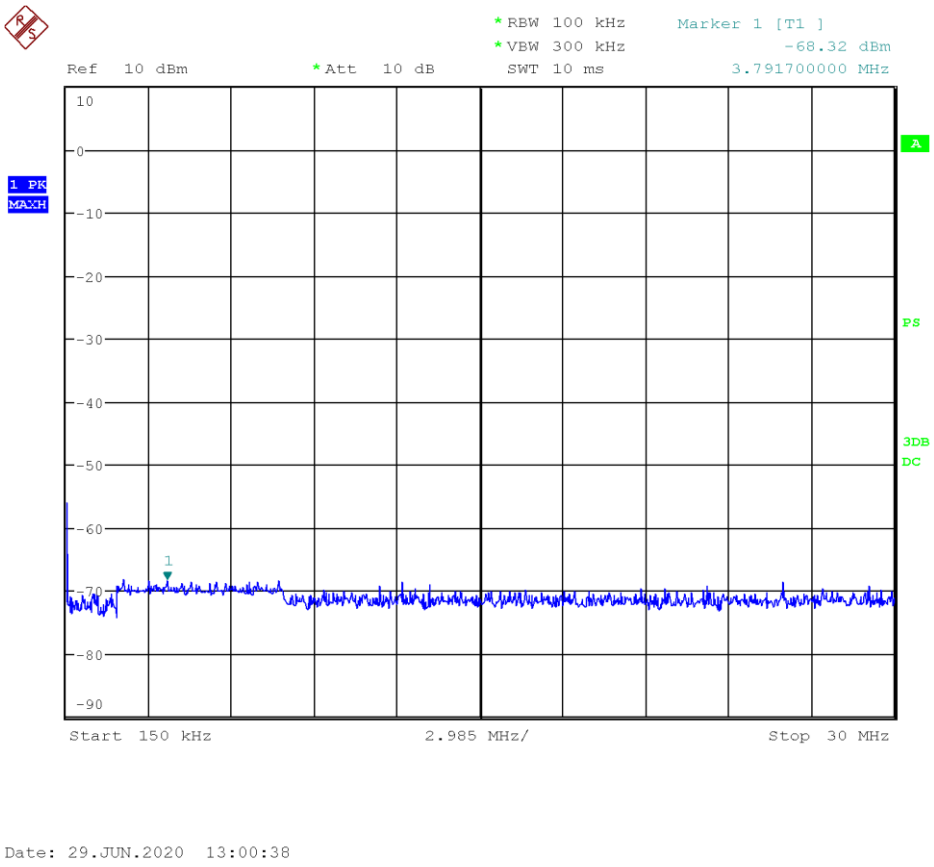
13.6 Graphs

The graphs shown below show the worst-case peak power output of the device during the antenna conducted measurement during transmit operation of the EUT. No attenuator was used between the EUT and the Spectrum Analyzer.

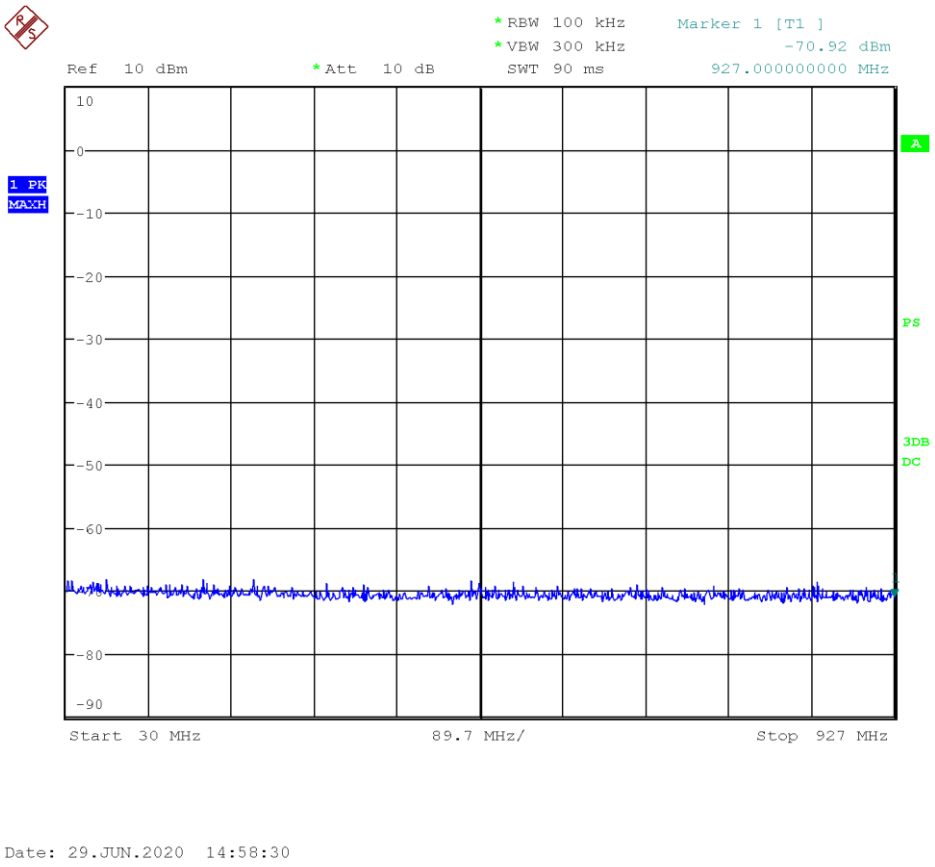
ZX HIGH VOLTAGE (900MHz)



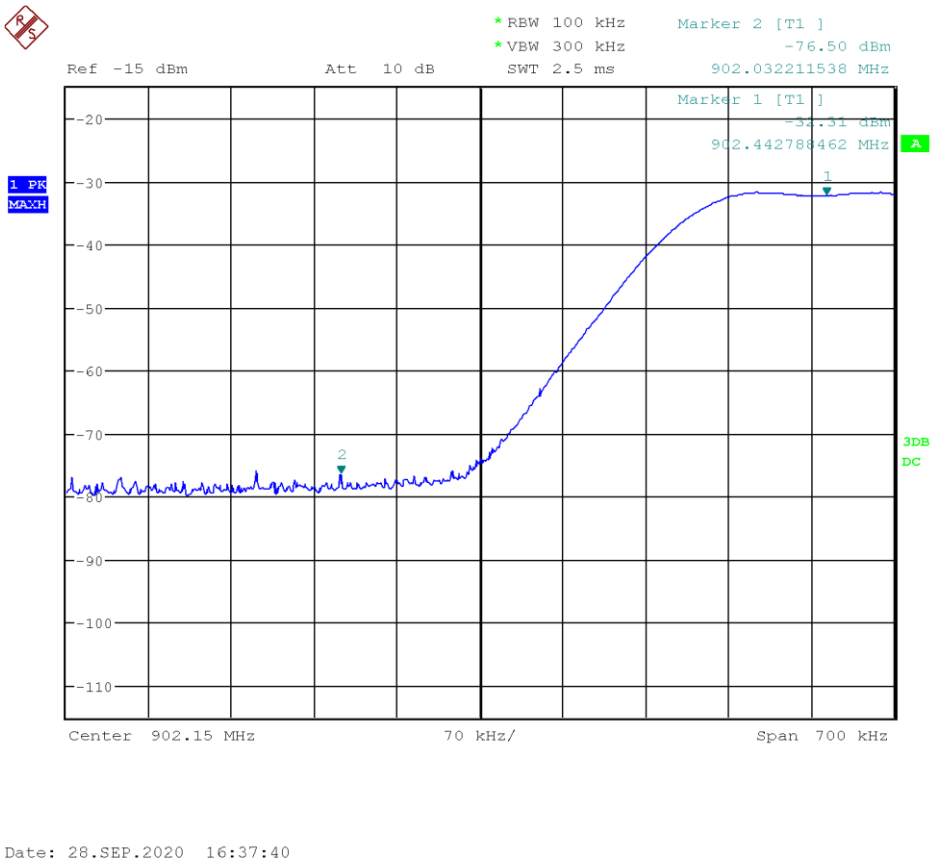
Graph 25 Test Results – Band Edge – 9kHz to 150kHz – Low Channel



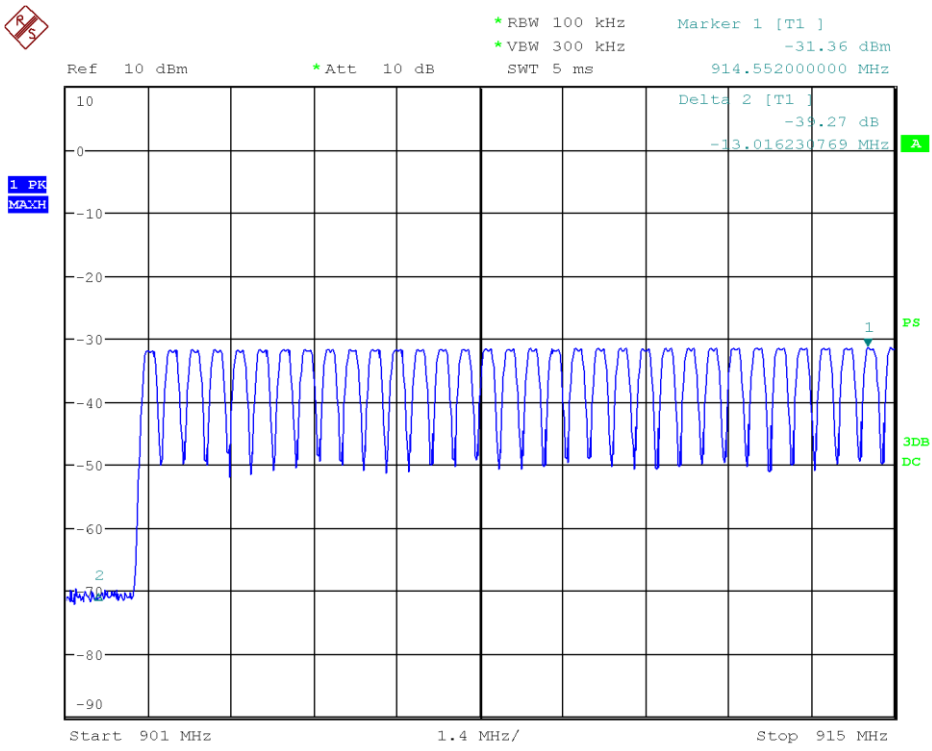
Graph 26 Test Results – Band Edge –150kHz to 30MHz – Low Channel



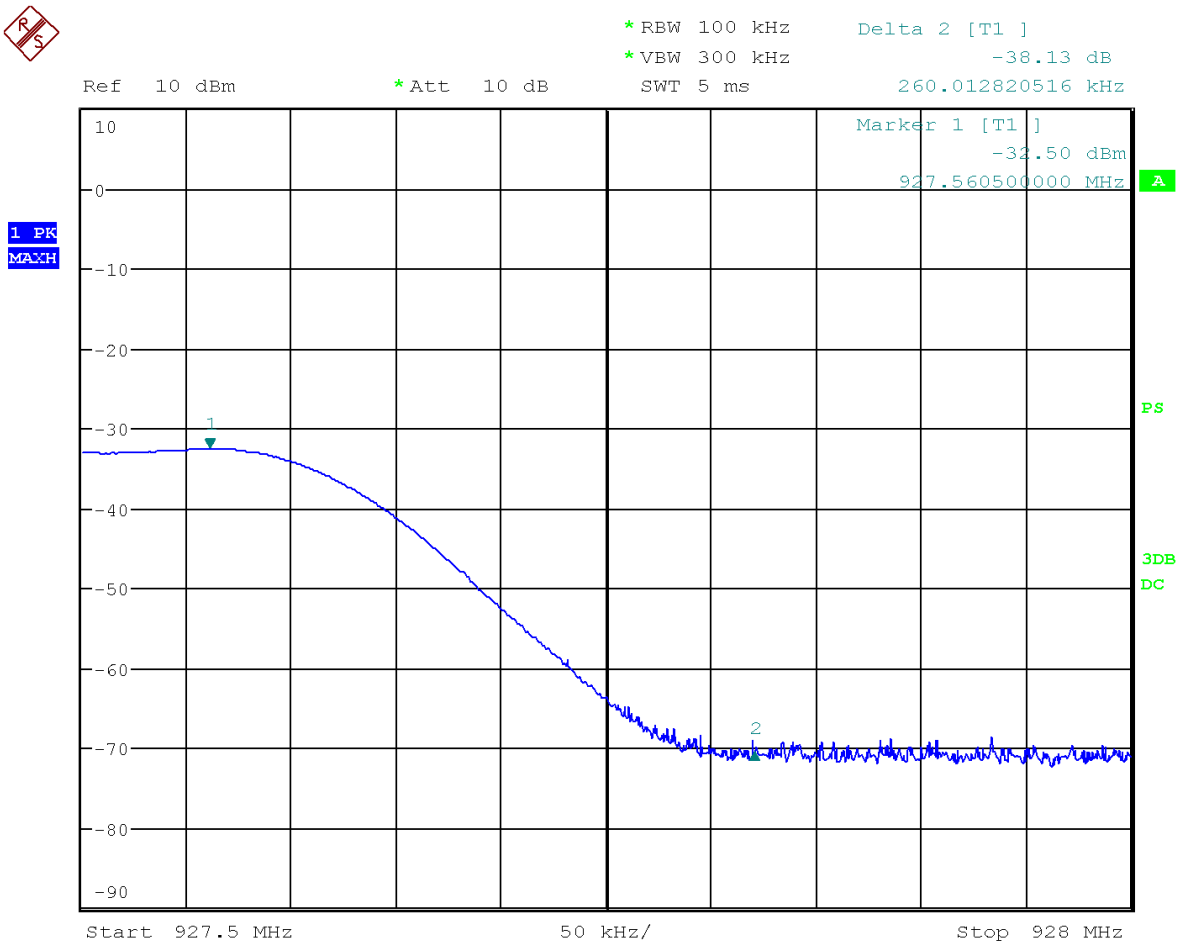
Graph 27 Test Results – Low Band Edge –30MHz to 927MHz – Low Channel



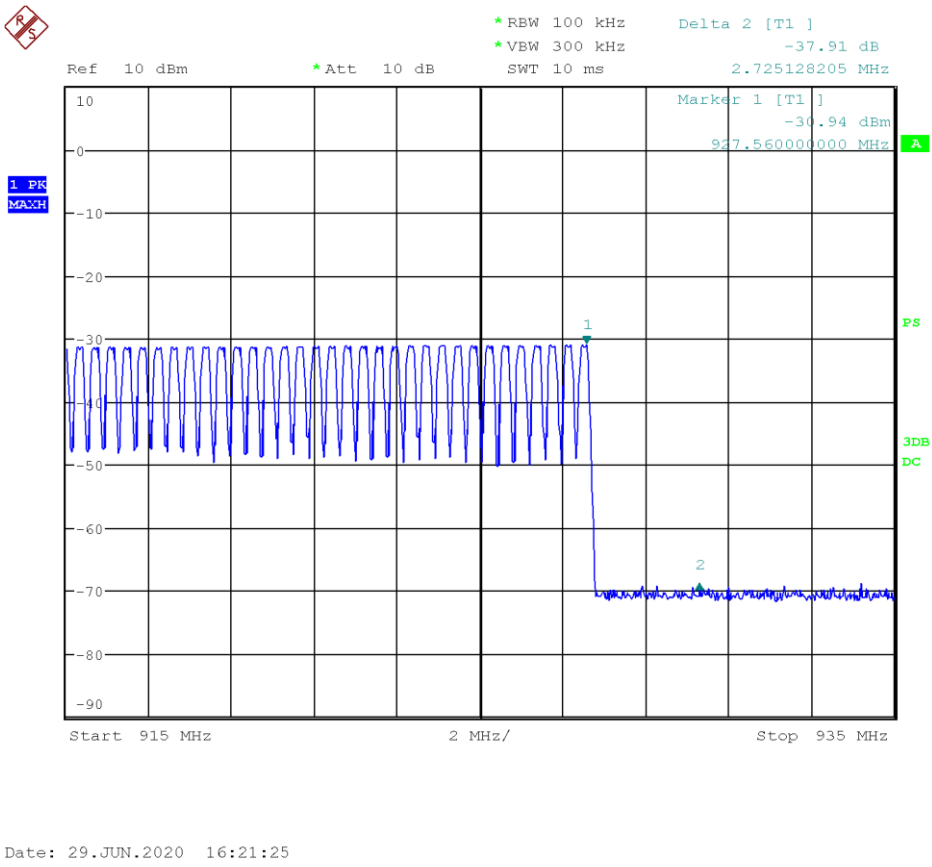
Graph 28 Test Results – Low Band Edge – 902MHz– Low Channel (No Hopping)



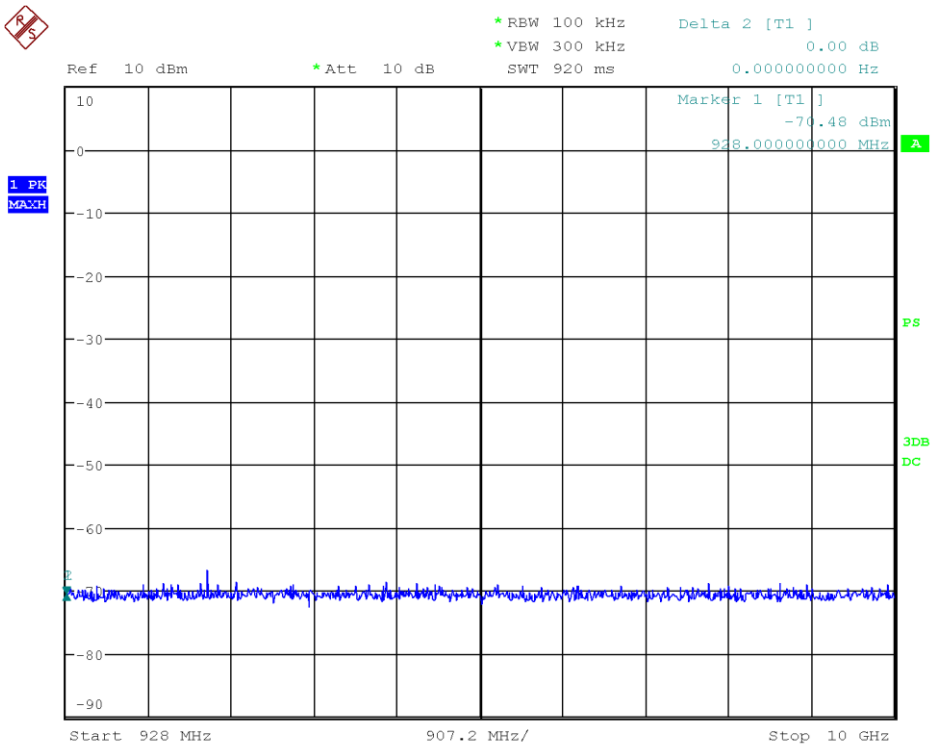
Graph 29 Test Results – Low Band Edge – Hopping



Graph 30 Test Results – High Band Edge – 927MHz – High Channel (No hopping)

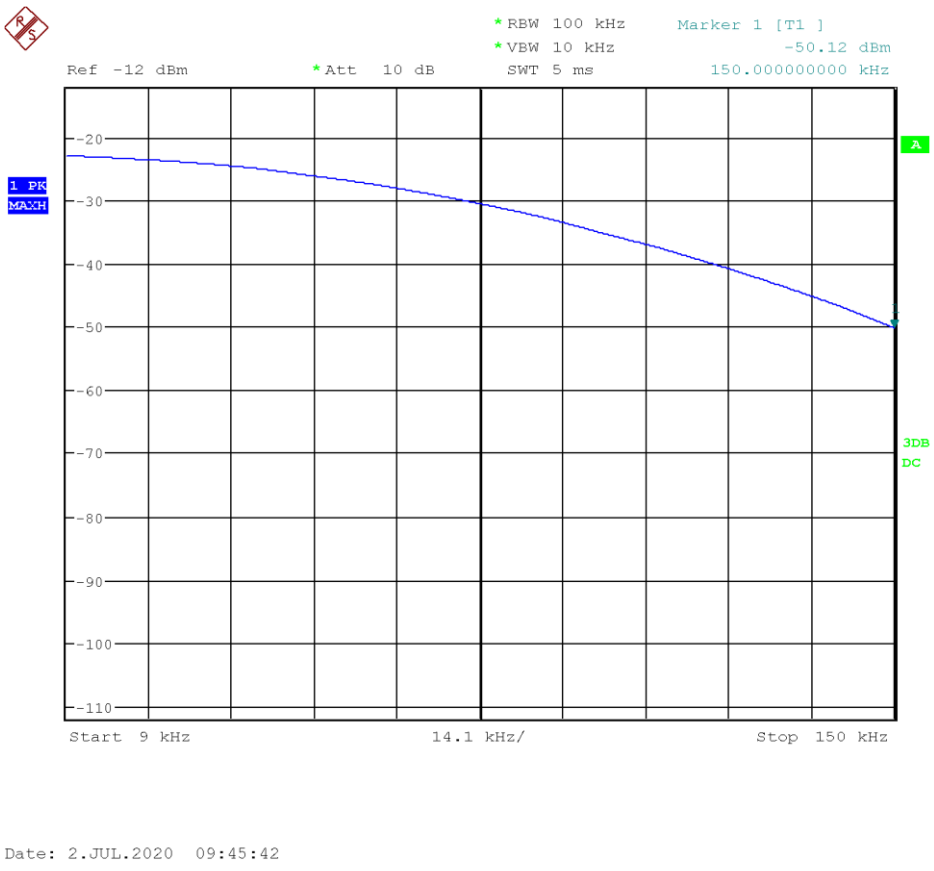


Graph 31 Test Results – High Band Edge – Hopping

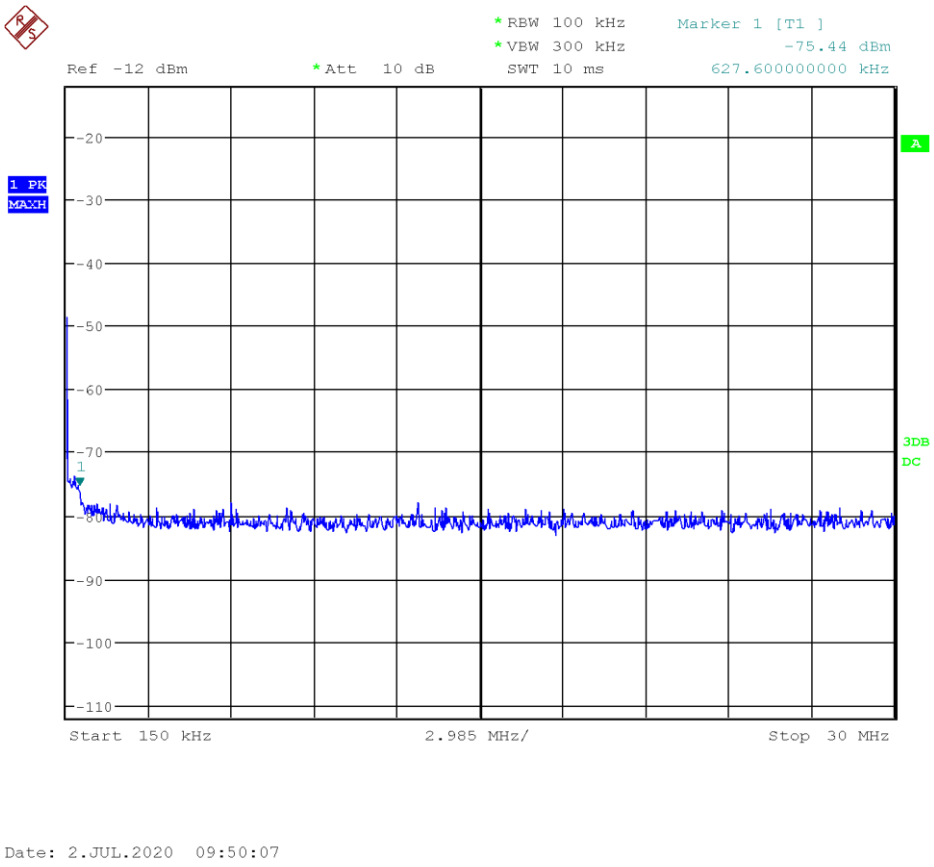


Graph 32 Test Results – Band Edge 928MHz to 10GHz

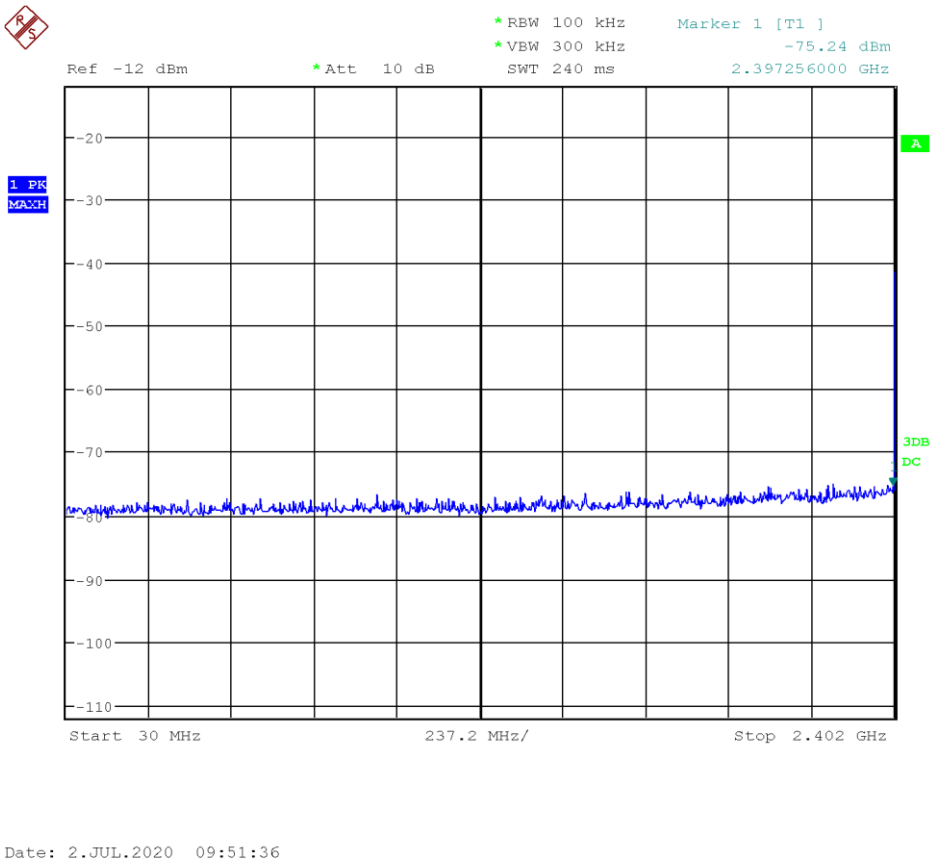
ZX HIGH VOLTAGE (2.4GHz)



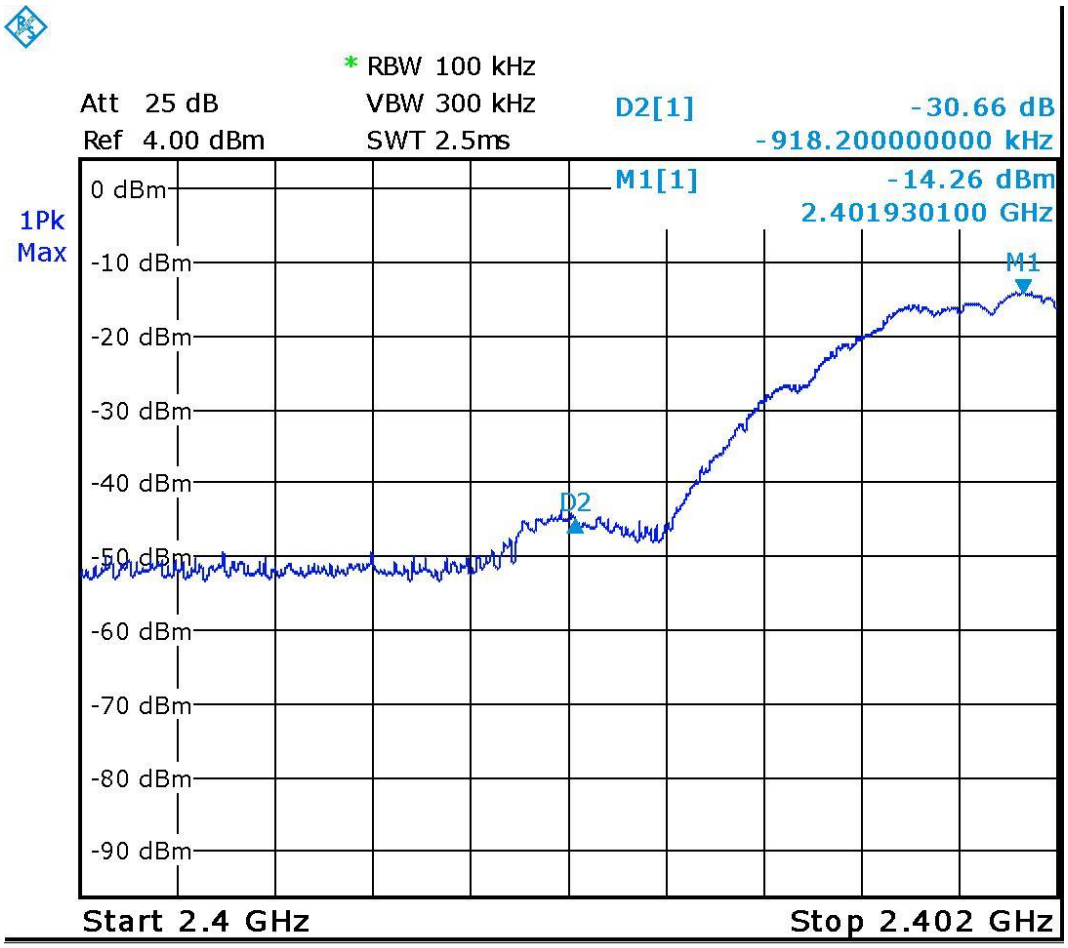
Graph 33 Test Results – Band Edge 9kHz to 150kHz



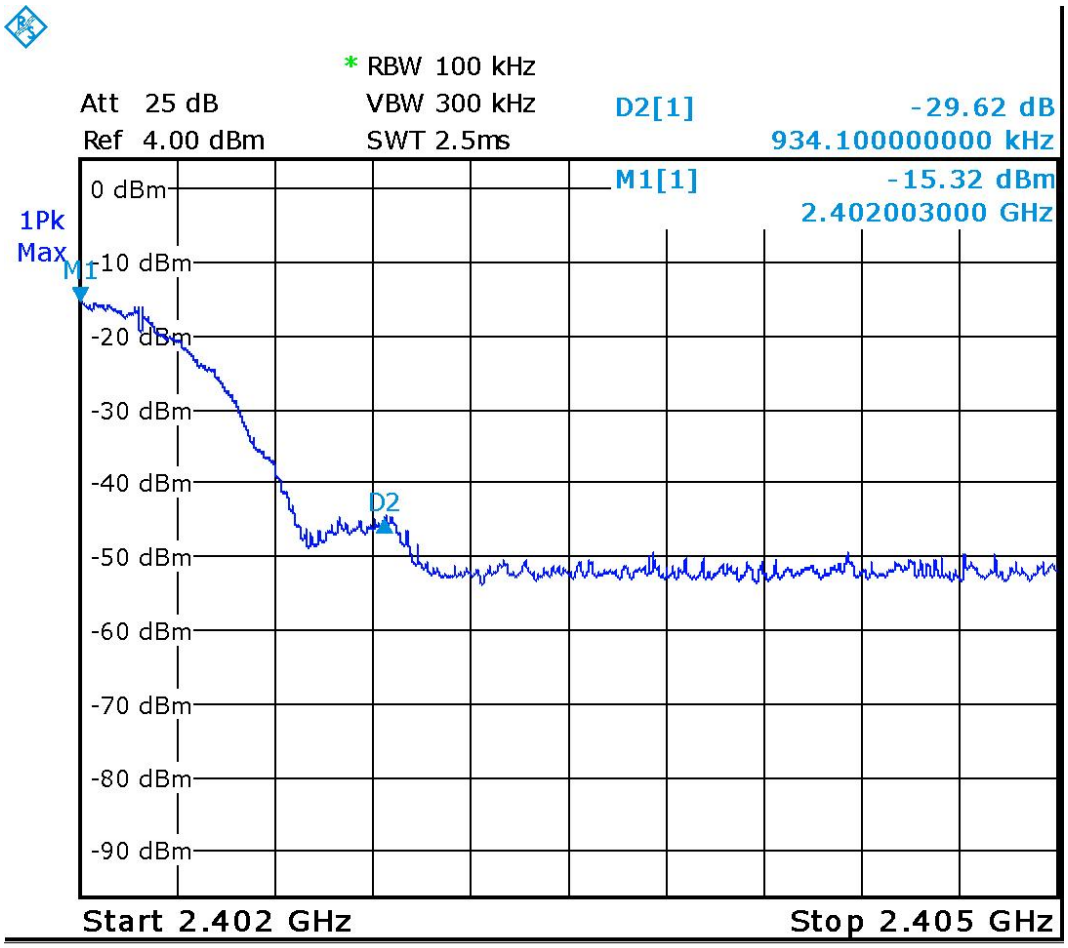
Graph 34 Test Results – Band Edge 150kHz to 30MHz



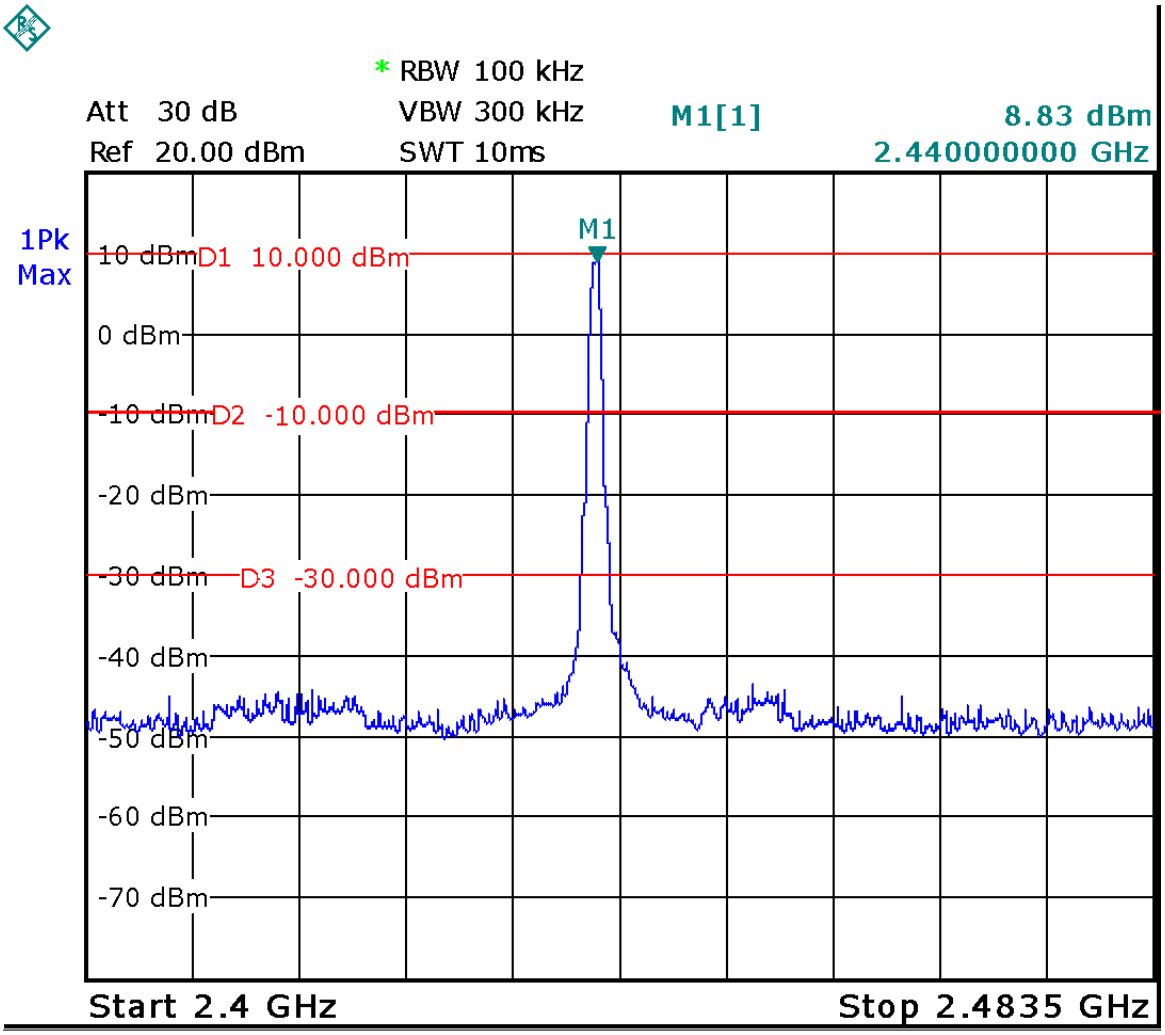
Graph 35 Test Results – Band Edge 30MHz to 2.4GHz



Graph 36 Test Results – Low Band Edge –2.4GHz to 2.402GHz – Low Channel



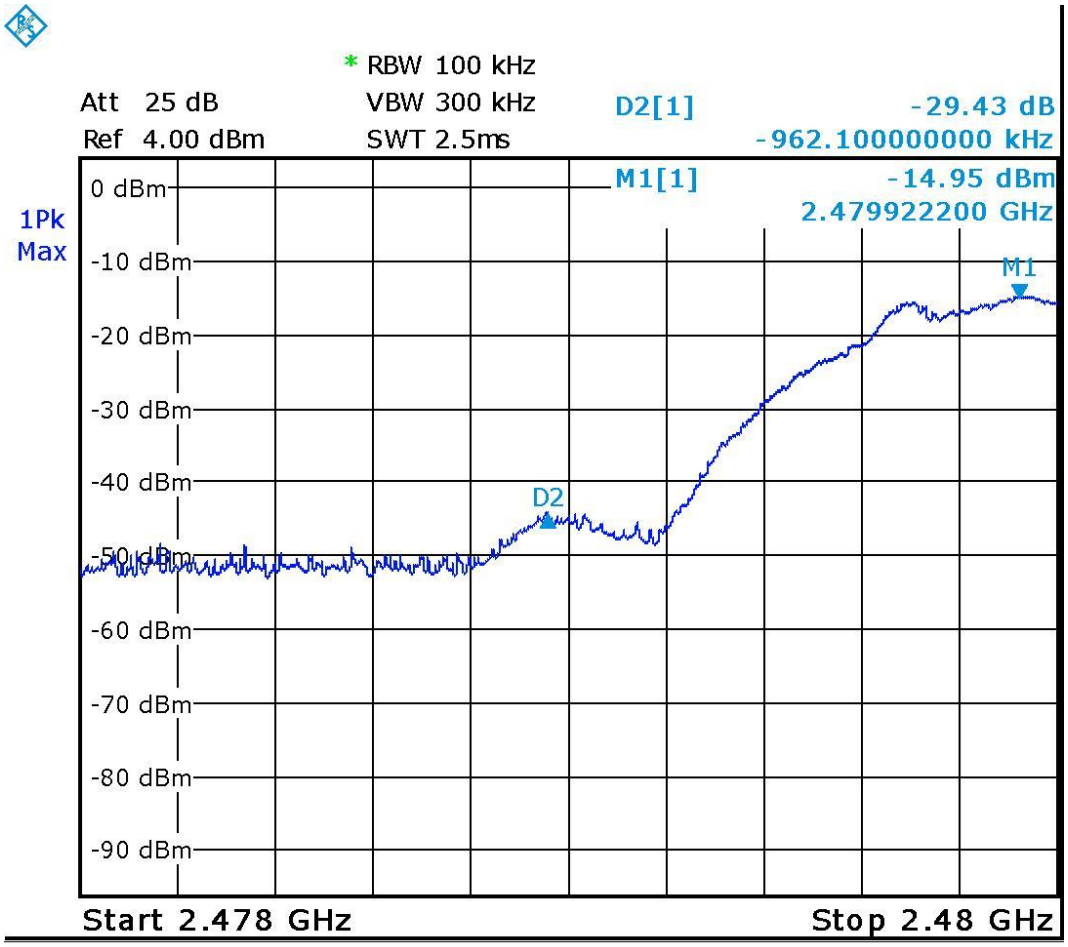
Graph 37 Test Results – Low Band Edge –2.402GHz to 2.405GHz – Low Channel



D1=Fondamental level; D2= 20dB limit

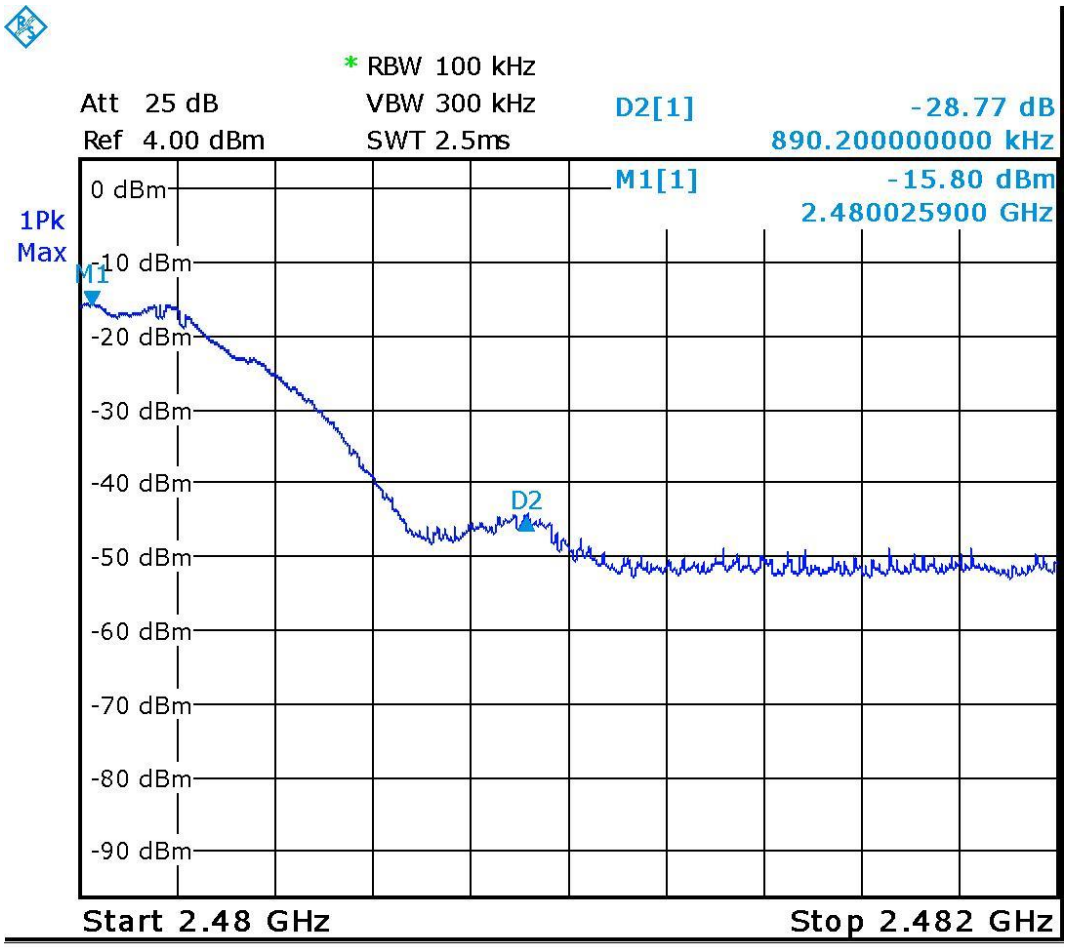
Date: 16.MAR.2020 10:51:00

Graph 38 Test Results – Band Edge –2.4GHz to 2.4835GHz– Channel #34

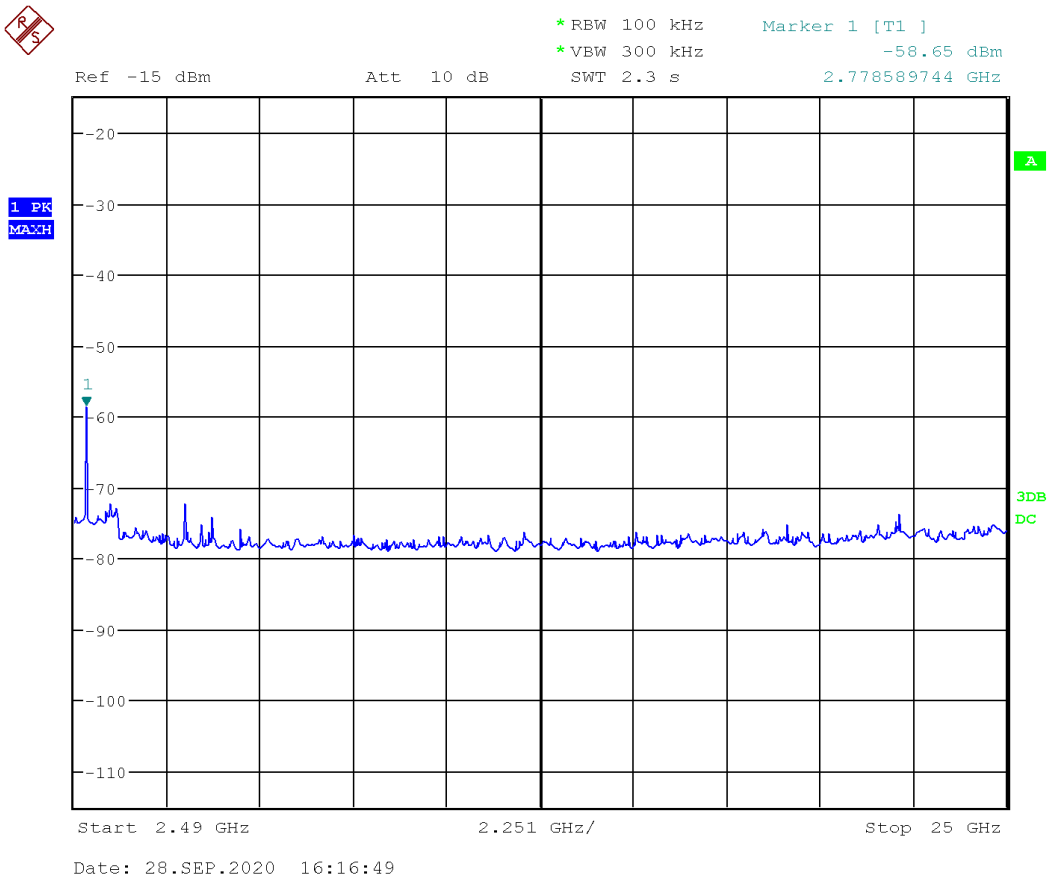


Date: 14.JUL.2020 11:35:14

Graph 39 Test Results – Low Band Edge –22.478GHz to 2.480GHz – High Channel



Graph 40 Test Results – High Band Edge –22.478GHz to 2.480GHz – High Channel



Graph 41 Test Results – Band Edge 2.49GHz to 25GHz

13.7 Test Instruments

This test was carried out in Laval test location. And the test iinstrumentation used is depicted in Table 29.

Equipment	Model No.	Manufacturer	Calibration Period (months)	Calibration Due (YYY-MM-DD)	Asset No: LAVE
Spectrum Analyzer	ESU-40	Rohde & Schwarz	24	2021-04-20	4092
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4130
Attenuator 20 dB	4779-10	Narda	NCR	NCR	4131

Table 29 – Test Instrumentation – Band Edge

14 Tx Spurious Radiated Emissions

14.1 Purpose & Methods

The Purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT does not exceed the limits listed below as defined in the applicable test standard, as measured from a receiving antenna. This helps protect broadcast radio services such as television, FM radio, pagers, cellular telephones, emergency services, and so on, from unwanted interference. The method is as defined in Section 12.1 of FCC KDB 558074 and ANSI C63.10.

All unintentional emissions must also meet the 'Spurious Conducted Emissions' requirements of -20 dBc or greater. See also 'Band Edge' for further details. Limits are depicted in Table 20.

Frequency	Limit
0.009 MHz – 0.490 MHz	2400/F(kHz) uV/m at 300m([1])
0.490 MHz – 1.705 MHz	24000/F(kHz) uV/m at 30m ([1])
1.705 MHz – 30 MHz	30 uV/m at 30m([1])
30 MHz – 88 MHz	100 uV/m (40.0 dBuV/m) at 3m ([1])
88 MHz – 216 MHz	150 uV/m (43.5 dBuV/m) at 3m ([1])
216 MHz – 960 MHz	200 uV/m (46.0 dBuV/m) at 3m ([1])
Above 960 MHz	500 uV/m (54.0 dBuV/m) at 3m ([1])
Above 1000 MHz	500 uV/m (54 dBuV/m) at 3m ([2])
Above 1000 MHz	500 uV/m (74 dBuV/m) at 3m ([3])
[1]Limit is with Quasi Peak detector with bandwidths as defined in CISPR-16-1-1 [2]Limit is with 1 MHz measurement bandwidth and using an Average detector [3]Limit is with 1 MHz measurement bandwidth and using a Peak detector	

Table 30 Limits – Tx Spurious

Based on ANSI C63.4 Section 4.2, if the Peak detector measurements do not exceed the Quasi-Peak limits, where defined, then the EUT is deemed to have passed the requirements.

14.2 Test Specifications

REFERENCE STANDARD	FCC Part 15.209(a) RSS-247 5.5 ANSI C63.10 Clause 5.5		
SPECIFICATIONS			
Limit (dBµV/m)	Table 20		
Frequencies (MHz)	902.46 915 927.52		
EUT			
Identification	ZX High Voltage (915MHz)		
Voltage Input	120Vac		
ENVIROMENTAL & TEST INFO			
Test Date (YYYY-MM-DD)	2020-06-18	2020-06-30	0
Temperature (°C)	19.1± 2	21.4± 2	
Humidity (%)	32 ± 5	30 ± 5	
Atmospheric Pressure kPa (For Info Only)	100.5	100.1	
Tester	Jose Martinez		
Client Witness	No Witness		

14.3 Limits

The limits, as defined in 15.247(d) for intentional radiated emissions, apply for those emissions that fall in the restricted bands, as defined in Section 15.205(a). These emissions must comply with the radiated emission limits specified in Section 15.209(a).

14.4 Results

The EUT passed. Low, medium, and high bands were tested. The worst-case are only presented and final measurements are given in Appendix A.

Channel	Frequency Range (MHz)	Frequency (MHz)	Polarization	Detector	Limit	Margin	Results <Note 2>
Low	0.009 – 0.015	-	-	-	See Table 20	<Note 1>	Pass
	0.015 – 30						Pass
	30 – 1000						Pass
	>1000						Pass
Mid	0.009 – 0.015	-	-	-		<Note 1>	Pass
	0.015 – 30						Pass
	30 – 1000	819.89	Horizontal	QP		18.1	Pass
	>1000	2280.71	Horizontal	PEAK		11.8	Pass
High	0.009 – 0.015	-	-	-		<Note 1>	Pass
	0.015 – 30						Pass
	30 – 1000			-			Pass
	>1000			-			Pass

Note 1: No significant emission, i.e., 10dB below the FCC limit was measured.
Note 2: For Worst cases based on Peak measurements can be found in Appendix A: Table A1 to Table A2.

Table 31 – Test Results for Tx Spurious Emission – Lowest Margin – Peak Measurements

Channel	Frequency Range (MHz)	Frequency (MHz)	Polarization	Detector	Limit	Margin	Results <Note 2>
#0	0.009 – 0.015	-	-	-	See Table 20	Note 1	
	0.015 – 30					Note 1	
	30 – 1000	863.967	Vertical	Quasi-Peak		9.5	Pass
	>1000	17976.8	Vertical/ horizontal	Average		13.3	Pass
#19	0.009 – 0.015	-	-	Quasi-Peak		Note 1	
	0.015 – 30			Quasi-Peak		Note 1	
	30 – 1000	98.6476	Vertical	Quasi-Peak		3.8	Pass
	>1000	4879.88	Vertical	Average		4.8	Pass
#39	0.009 – 0.015	-	-	-		Note 1	
	0.015 – 30					Note 1	
	30 – 1000	188.268	Horizontal	Quasi-Peak		18.4	Pass
	>1000	17992.3	Horizontal	Average		12.9	Pass
Note 1: No significant emission, i.e., 10dB below the limit was noted Note 2: For Worst cases final measurement please refer to Appendix A: Table A1 to Table A9							

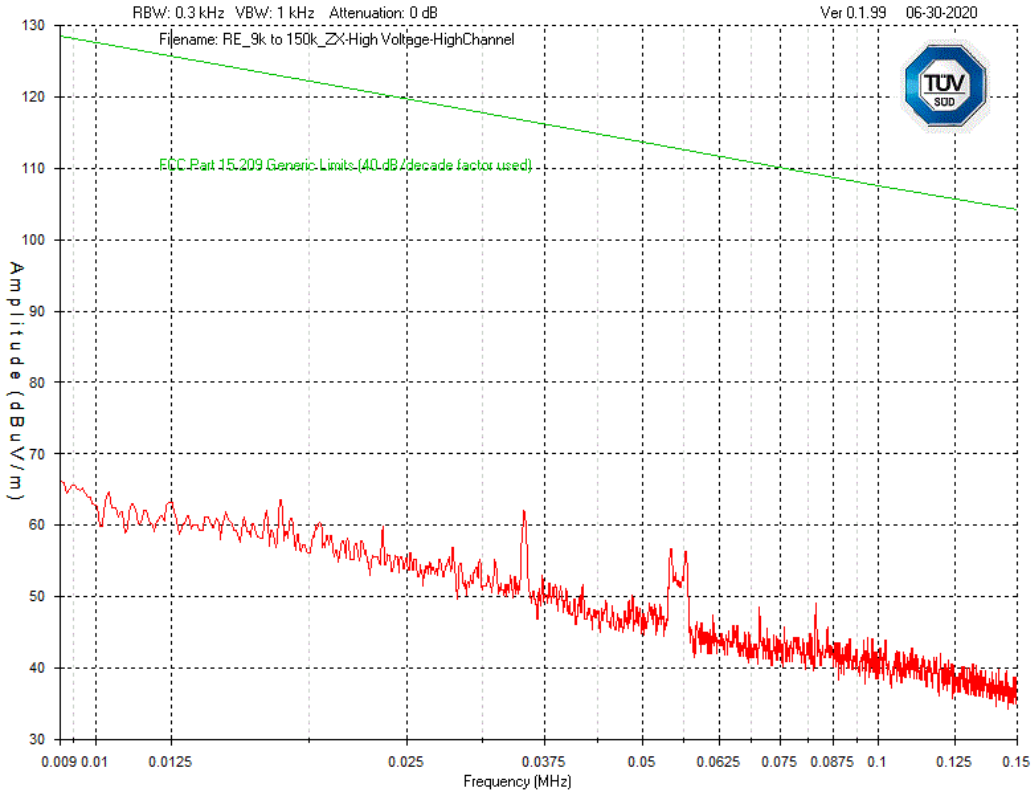
Table 32 – Test Results for Tx Spurious Emission – Worst Cases(2.4GHz)

14.5 Graphs

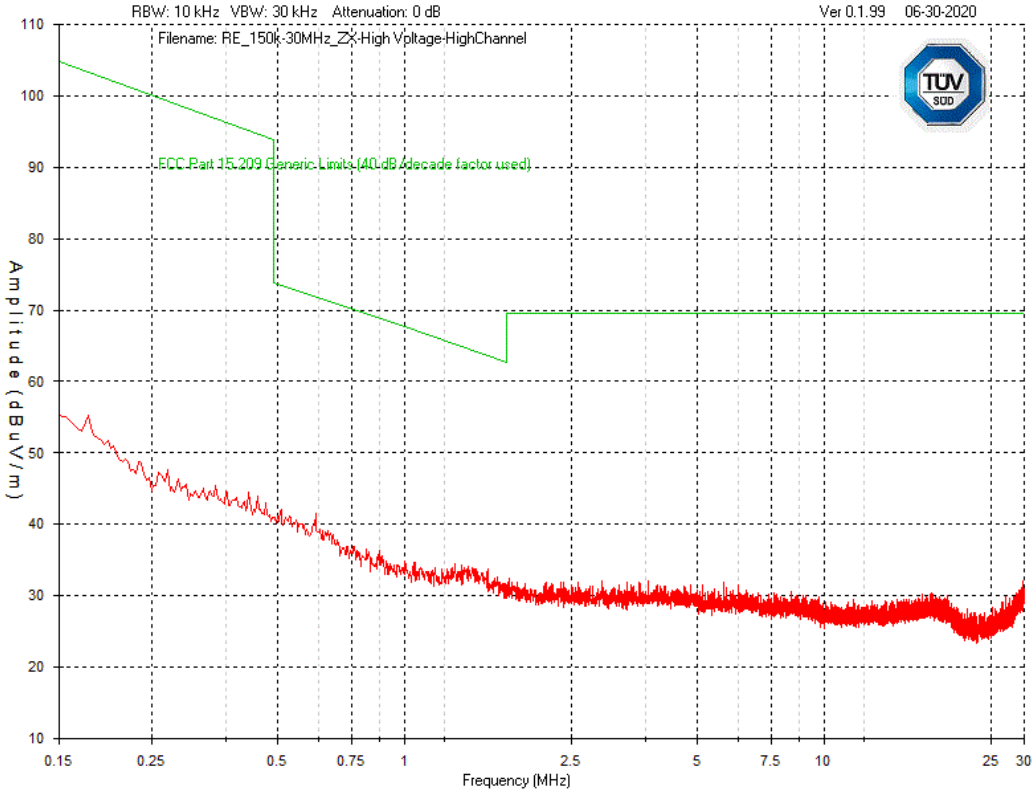
The graphs shown below are maximized peak measurement graphs measured with a resolution bandwidth greater than or equal to the final required detector over a full 0-360°. This peaking process is done as a worst-case measurement and enables the detection of frequencies of concern for final measurement. For final measurements with the appropriate detector, where applicable, please refer to the tables under Final Measurements.

Devices scanned may be scanned at alternate test distances and in accordance with FCC Part 15, Subpart A, Section 15.31, an extrapolation factor of 20 dB/decade was used above 30 MHz and 40 dB/decade below 30 MHz for example, for 1-meter measurements, an extrapolation factor 9.5 dB from 20 Log (1m / 3m) is applied. Low, middle and high channels. However, the worst-case graphs are presented.

Frequency range from 9kHz to 150kHz

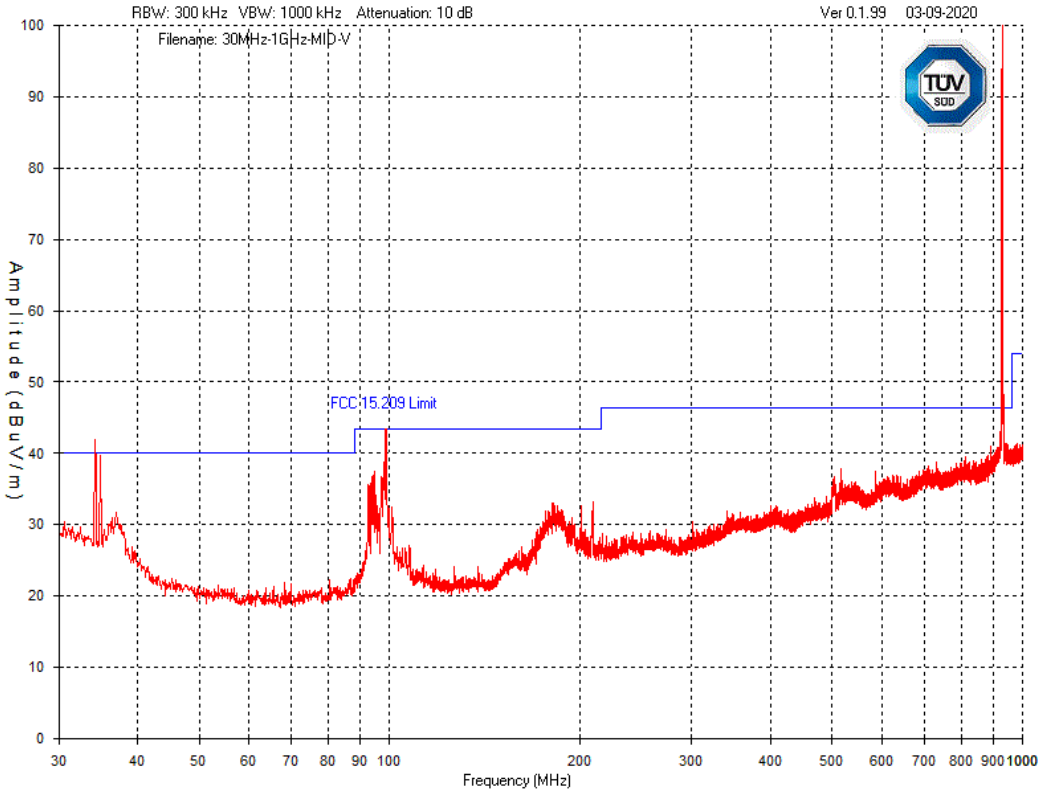


Graph 42 Test Results – Tx Spurious 9kHz to 150kHz – High Channel



Graph 43 Test Results – Tx Spurious 150kHz 30MHz – High Channel

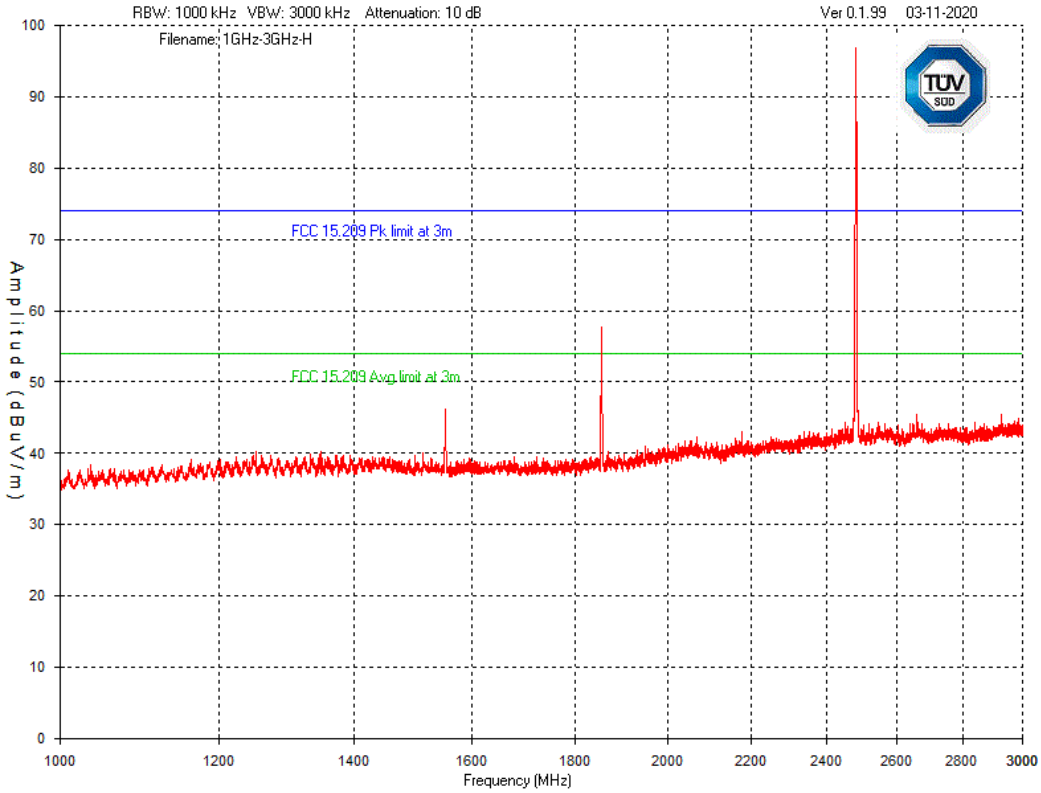
Frequency Range from 30MHz to 1GHz – Worst case – Channel #19 & Channel #34



Graph 44 Test Results – Tx Spurious emission 30MHz to 1GHz – High Channel – Vertical Polarization – Peak Values (Channel #19 & Channel #34)

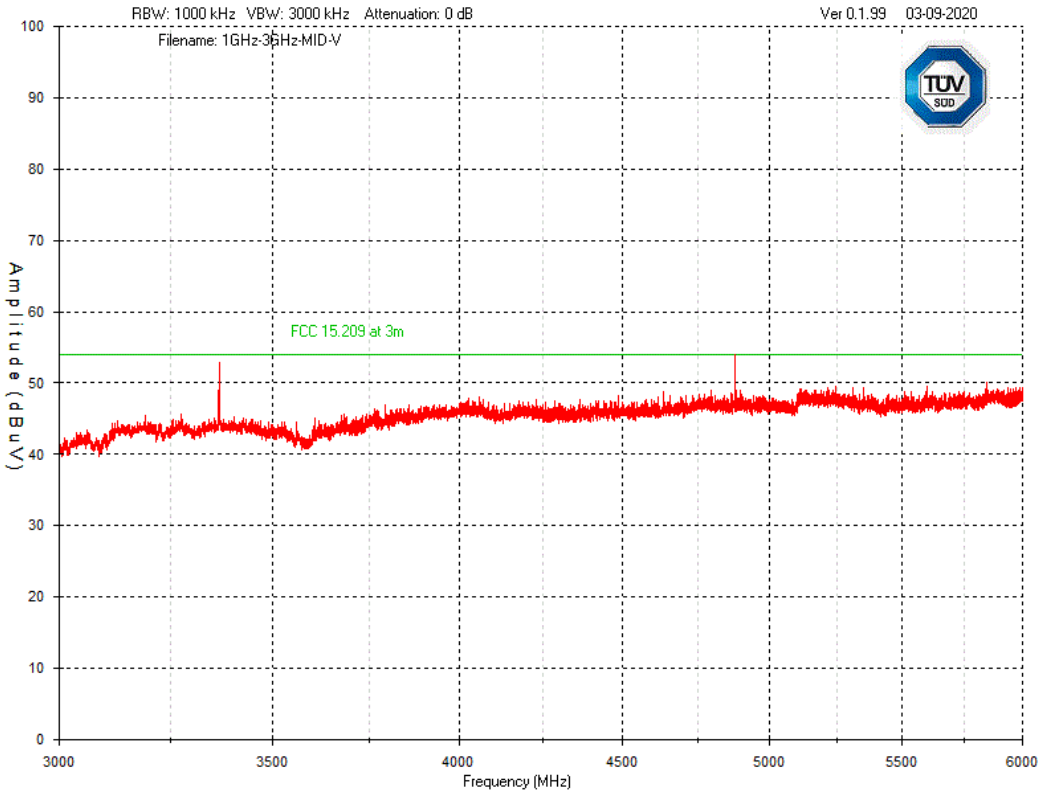
Note. From the above Graph, the peak measurement of the emission is recorded at 927.5Mz (see Table **A1** in Appendix A) and corresponds to 99.9dBµV/m.

Frequency Range from 1GHz to 3GHz – Worst case



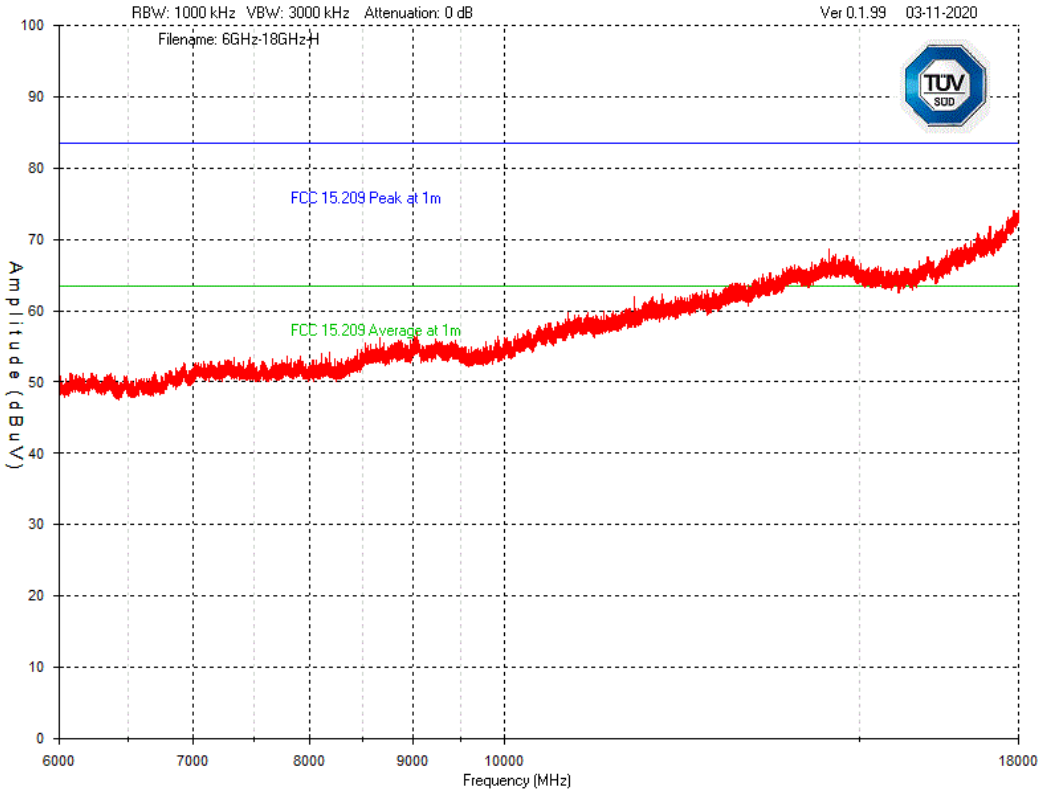
Graph 45 Test Results – Tx Spurious emission 1GHz to 3GHz – High Channel – Horizontal Polarization (Channel #19 & Channel #34)

Frequency Range from 3GHz – 6GHz – Worst case (Channel #19 & Channel #34)



Graph 46 Test Results – Tx Spurious emission 3GHz – 6GHz – High Channel – Horizontal Polarization (Vertical polarisation): Channel #19 & Channel #34)

Frequency Range from 63GHz – 18GHz – Worst case (Channel #39 & Channel #67)



Graph 47 Test Results – Tx Spurious emission 6GHz – 18GHz – High Channel – Horizontal polarisation (Channel #39 & Channel #67)

14.6 Test Instruments

This test was carried out in Laval test location. Instrumentation used is depicted in Table 32.

Equipment	Model No.	Manufacturer	Calibration Period (months)	Calibration Due (YYY-MM-DD)	Asset No LAV0
Spectrum Analyzer	ESU-40	Rohde & Schwarz	24	2021-04-20	4092
BiLog Antenna	3142-E	ETS	24	2021-11-29	4002
Attenuator 4 dB	20181128A	KLP	24	2021-11-29	4300
Horn Antenna	ATH1G18G	AR	24	2021-04-25	4005
Attenuator 6 dB	FP-50-3	Trilithic	NCR	NCR	4125
LPA pre-amp	Keysight	LPA-10-20	24	2021-02-28	244
1-26.5GHz preamp	Agilent	8449B	NCR	NCR	4006
RF Cable 10m	LMR-400-10M-50OHM-MN-MN	LexTec	NCR	NCR	4025
RF Cable 7m	LMR-400-7M-50OHM-MN-MN	LexTec	NCR	NCR	4026
Emission software	0.1.94	Global EMC	NCR	NCR	4058

Table 33 – Test Instrumentation – Tx Spurious Emission

15 Conducted Emissions

15.1 Purpose & Methods

The Purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT trough conducted lines does not exceed the limits listed below as defined in the applicable test standard, as measured from a LISN. This helps protect broadcast radio services such as television, FM radio, pagers, cellular telephones, emergency services, and so on, from unwanted interference. The method is as defined in ANSI C63.10 Section 6.2.

Frequency (MHz)	Average Limit	Quasi-Peak Limit
0.15 MHz – 0.5 MHz	56 to 46*	66 to 56*
0.5 MHz – 5 MHz	56	46
5 MHz – 30 MHz	60	50
*Decrease with the Logarithm of the frequency		

Table 34 Limits – Conducted Emissions

15.2 Test Specifications

REFERENCE STANDARD	FCC Part 15.207(a) RSS-247 GEN 8.8 ANSI C63.10 Clause 6.2	
SPECIFICATIONS		
Limit (dBuV/m)	See Table 32	
Frequencies (MHz)	2402 2440 2480	902.46 914.62 927.54
EUT		
Identification	ZX High Voltage (915MHz) ZX High Voltage (2.4GHz)	
Voltage Input	120 Vac	
ENVIROMENTAL & TEST INFO		
Test Date (YYYY-MM-DD)	2020-06-19	
Temperature (°C)	23.6 ± 2	
Humidity (%)	18.8 ± 5	
Atmospheric Pressure kPa (For Info Only)	100.85	
Tester	Jose Martinez-Ortega	
Client Witness	No witness	

15.3 Limits

The limits, as defined in 15.207(a) for conducted emissions. These emissions must comply with the conducted emission limits specified in Section 15.207(a).

15.4 Test Setup

As per ANSI C63.10 Clause 6.2.2, the EUT was set to 80cm from the LISN. and 40cm from the VCP

Photo 2: – Test Setup – Side View

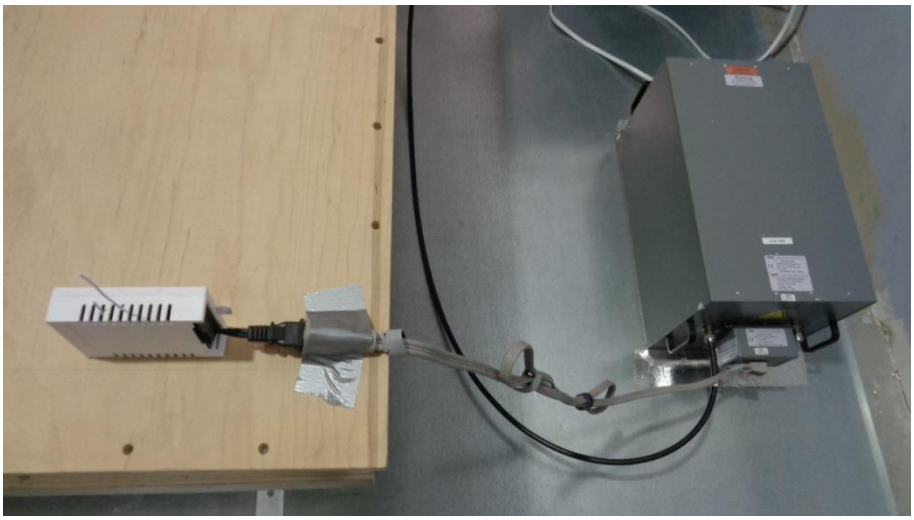


Photo 3: – Test Setup – Side View

15.5 Results

This test is performed in accordance with the method defined in FCC 15 207 Subpart C and results are depicted in Table 33

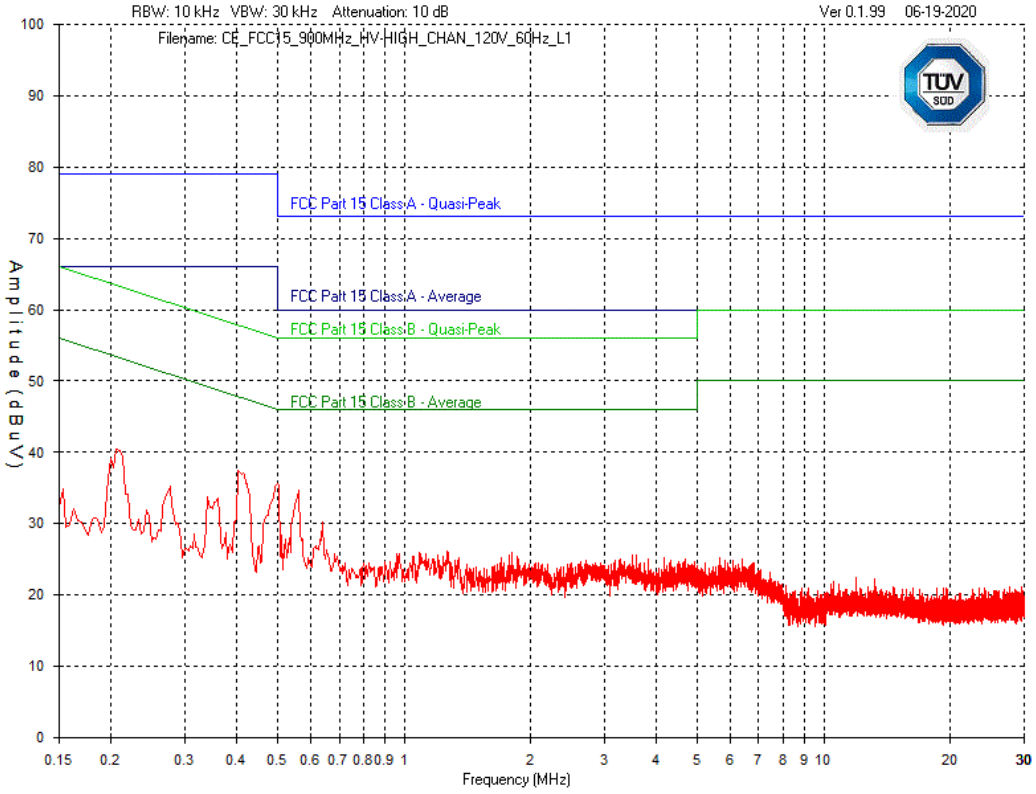
Tested Line	Frequency (MHz)	Quasi-Peak Limit dB(µV)	Average Limit dB(µV)	Results <Note 2>
Power – Phase (120V/60Hz)	0.150 – 0.50 <Note 1>	66 - 56	56 - 46	Pass
	0.50 – 5	56	46	Pass
	5 - 30	60	50	Pass
Power – Neutral (120V/60Hz)	0.150 – 0.50 <Note 1>	66 - 56	56 - 46	Pass
	0.5 – 5	56	46	Pass
	5 - 30	60	50	Pass
Note 1. The lower limit shall apply at the transition frequency Note 2. No significant emissions (below 10dB) was noted.				

Table 35 – Test Results for Conducted Emission – High Voltage(2.4GHz/900MHz)

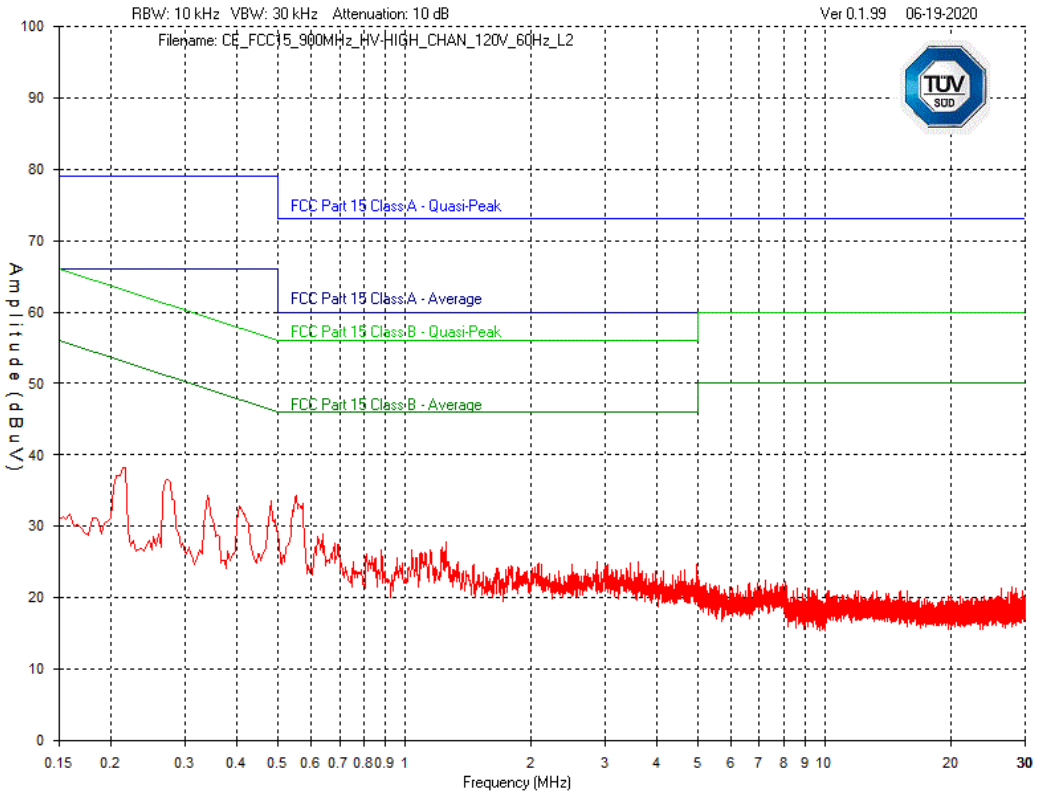
15.6 Graphs

The graphs shown below are maximized peak measurement graphs measured with a resolution bandwidth greater than or equal to the final required detector. This peaking process is done as a worst-case measurement and enables the detection of frequencies of concern for final measurement. For final measurements with the appropriate detector, where applicable, please refer to the tables under Final Measurements.

Only middle channel was tested as worst case. However, the worst-case graphs are presented.



Graph 48: Conducted Emissions Power – Phase – ZX High Voltage (2.4GHz/900MHz)



Graph 49: Conducted Emissions Power – Neutral – ZX High Voltage (2.4GHz/900MHz)

Tested Line	Frequency (MHz)	Detector	Limit dB(µV)	Level (dBµV)	Bandwidth (kHz)	Measurement Time (s)	Margin
Power – Phase (120V/60Hz)	-	-	-	-	9 kHz	15	Note 1
Power – Neutral (120V/60Hz)	-	-	-	-	9 kHz	15	Note 1
Conducted emission level (dBµV) = Value reading at the EMI receiver (dBµV) + Correction factor (dB) Correction factor (dB) = LISN attenuation (dB) + cable loss (dB) – amplifier gain (dB) + attenuator (dB) Note 1: No significant emission was noted.							

Table 36: Test Results Lowest Margin according to FCC 15.207

15.7 Test instruments

This test was carried out in Laval test location. And the test instrumentation is depicted in Table 37.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due (YYY-MM-DD)
Spectrum Analyzer	ESU-40	Rohde & Schwarz	4092	24	2021-04-20
LISN	FCC-LISN-50/250-16-2-01	FCC	4005	12	2021-02-27
RF Cable 2.5m	LMR-400-1M-50OHM-MN-MN	LexTec	4039	NCR	NCR
Attenuator 10 dB	FP-50-10	Trilithic	4027	NCR	NCR
Emission software	0.1.95	Global EMC	58	NCR	NCR

Table 37: Conducted Emission Test Equipment

APPENDIX A: Tx Spurious Emissions – Worst Cases

Frequency	Detector	Raw Reading	Attenuation 6dB	Cable RE	Current to Voltage 51.5 Factor	Loop - EM6879 9k to 30M Factor	Preamp-LNA1450 Factor	Level	FCC 15.209 Limit	FCC 15.209 Limit Margin
0.0353	QP	15.4	6	0	51.5	18.7	-30.9	60.7	76.7	16
0.0545	QP	14.5	6	0	51.5	13	-30.9	54.1	72.9	18.8
0.0095	QP	12.2	6	0	51.5	28.8	-30.1	68.4	88	19.6
0.0429	QP	11.8	6	0	51.5	15.9	-30.9	54.3	75	20.7
0.1103	QP	10.4	6	0.1	51.5	9.1	-30.9	46.2	66.8	20.6
0.078	QP	10.8	6	0.1	51.5	11.3	-30.9	48.8	69.8	21
0.1118	QP	9.7	6	0.1	51.5	9	-30.9	45.4	66.6	21.2
0.047	QP	11.2	6	0	51.5	14.4	-30.9	52.2	74.2	22

Table A.1 Tx Spurious Emission Channel #19 & Channel #34 (2.4GHz/900MHz) – 9kHz- 150kHz – Vertical Polarization

Frequency	Detector	Raw Reading	Attenuation 6dB	Cable RE	Current to Voltage 51.5 Factor	Loop - EM6879 9k to 30M Factor	Preamp-LNA1450 Factor	Level	FCC 15.209 Limit	FCC 15.209 Limit Margin
4.8345	QP	18.6	6	0.3	51.5	-13.4	-31.3	31.7	69.5	37.8
15.6643	QP	17.3	6	0.4	51.5	-13.8	-31.7	29.7	69.5	39.8
17.6198	QP	16.7	6	0.4	51.5	-14	-31.8	28.8	69.5	40.7
11.179	QP	16.3	6	0.4	51.5	-14.2	-31.5	28.5	69.5	41
19.7545	QP	16.6	6	0.4	51.5	-14.3	-31.9	28.3	69.5	41.2
11.0927	QP	15.9	6	0.4	51.5	-14.2	-31.5	28.1	69.5	41.4
25.1362	QP	17.5	6	0.4	51.5	-16.6	-32.1	26.7	69.5	42.8
0.1533	QP	24	6	0.1	51.5	6.1	-30.9	56.8	104.6	47.8

Table A.2 Tx Spurious Emission Channel #19 & Channel #34 (2.4GHz/900MHz) – 150kHz- 30MHz

Frequency	Detector	Raw Reading	Antenna - Bilog3142E_V Factor	Atten 10dB Factor	Cable 27 - 10m LMR400 Factor	Cable 28 - 7m LMR400 Factor	Preamp-LNA1450 Factor	Level	FCC 15.209 Limit	FCC 15.209 Limit Margin
34.1752	QP	28.1	17.3	10	0.3	0.2	-32.5	23.4	40	16.6
98.6476	QP	49.2	13.2	10	0.5	0.3	-33.5	39.7	43.5	3.8
34.952	QP	34.9	16.7	10	0.3	0.2	-32.6	29.5	40	10.5
94.4725	QP	37.4	12.5	10	0.4	0.3	-33.5	27.1	43.5	16.4
927.468	QP	96.1	27.5	10	1.4	1	-32.2	103.8	46.4	-57.4
923.876	QP	34.1	27.5	10	1.4	1	-32.2	41.8	46.4	4.6

Table A.3 Tx Spurious Emission Channel #19 & channel #34 (2.4GHz/900MHz) –30MHz – 1GHz: Vertical Polarization

Frequency	Detector	Raw Reading	Antenna - Bilog3142E_V Factor	Atten 10dB Factor	Cable 27 - 10m LMR400 Factor	Cable 28 - 7m LMR400 Factor	Cable 30 - 0.5m LMR400 Factor	Preamp-LNA1450 Factor	Level	FCC 15.209 Limit	FCC 15.209 Limit Margin
902.612	QP	74.3	28	10	1.3	0.9	0.2	-32.3	82.4	46.4	-36
35.3403	QP	21.3	18.1	10	0.3	0.2	0	-32.6	17.3	40	22.7
34.952	QP	27.5	18.3	10	0.3	0.2	0	-32.6	23.7	40	16.3
35.9229	QP	20.9	17.8	10	0.3	0.2	0	-32.6	16.6	40	23.4
34.1752	QP	26.8	18.9	10	0.3	0.2	0	-32.5	23.7	40	16.3
863.967	QP	30.4	26.6	10	1.3	0.9	0.2	-32.5	36.9	46.4	9.5

Table A.4 Tx Spurious Emission Channel #0 (2.4GHz/900MHz) –30MHz – 1GHz: Vertical Polarization

Frequency	Detector	Raw Reading	Antenna - Bilog3142E_H Factor	Atten 10dB Factor	Cable 27 - 10m LMR400 Factor	Cable 28 - 7m LMR400 Factor	Cable 30 - 0.5m LMR400 Factor	Preamp-LNA1450 Factor	Level	FCC 15.209 Limit	FCC 15.209 Limit Margin
927.566	QP	95.7	28.2	10	1.4	1	0.2	-32.2	104.3	46.4	-57.9
837.362	QP	20.4	26.8	10	1.3	0.9	0.2	-32.7	26.9	46.4	19.5
188.268	QP	32.7	14.6	10	0.6	0.4	0.1	-33.3	25.1	43.5	18.4

Table A.5 Tx Spurious Emission Channel #39 & Channel # 67 (2.4GHz/900MHz) –30MHz – 1GHz: Horizontal Polarization

Frequency	Detector	Raw Reading	Ant DRG 1GHz to 18GHz Factor	Cable 27 - 10m LMR400 Factor	Cable 28 - 7m LMR400 Factor	Cable 30 - 0.5m LMR400 Factor	Preamp - HP 8449B 4006 Factor	Level	FCC 15.209 Average at 3m Limit	FCC 15.209 Average at 3m Margin
4879.88	AVE	42.3	33.2	3.4	2.5	0.6	-32.8	49.2	54	4.8
3367.27	AVE	22.6	30.3	2.9	2.2	0.5	-33	25.5	54	28.5
5849.25	AVE	19.1	33.3	4	2.7	0.6	-32.8	26.9	54	27.1
5243.24	AVE	19.5	33.2	3.6	2.5	0.6	-32.7	26.7	54	27.3
5350.15	AVE	18.9	33	3.7	2.6	0.6	-32.7	26.1	54	27.9
4634.23	AVE	19.8	31.9	3.3	2.4	0.6	-32.8	25.2	54	28.8
4057.96	AVE	20.3	31.4	3.1	2.4	0.6	-32.9	24.9	54	29.1

Table A.6 Tx Spurious Emission Channel #19 & Channel # 34 (2.4GHz/900MHz) –3GHz - 6GHz: Vertical Polarization

Frequency	Detector	Raw Reading	Ant DRG 1GHz to 18GHz Factor	Cable 27 - 10m LMR400 Factor	Cable 28 - 7m LMR400 Factor	Preamp - HP 8449B 4006 Factor	Level	FCC 15.209 Average at 1m Limit	FCC 15.209 Average at 1m Limit
17992.3	AVE	17.8	45.1	10	10	-32.3	50.6	63.5	12.9
14479.7	AVE	17.9	41.9	7.8	7.6	-31.9	43.3	63.5	20.2
16239.3	AVE	18.8	40	8.9	8.8	-33.2	43.3	63.5	20.2
11588.3	AVE	17.9	39.4	5.9	5.7	-32.8	36.1	63.5	27.4
10745.9	AVE	10.6	39.4	5.4	5.1	-33	27.5	63.5	36

Table A.7 Tx Spurious Emission Channel #39 & Channel # 67 (2.4GHz/900MHz) –6GHz - 18GHz: Horizontal Polarization

Frequency	Detector	Raw Reading	Ant DRG 1GHz to 18GHz Factor	Cable 27 - 10m LMR400 Factor	Cable 28 - 7m LMR400 Factor	Preamp - HP 8449B 4006 Factor	Level	FCC 15.209 Average at 1m Limit	FCC 15.209 Average at 1m Limit
17962.8	AVE	17.5	45	10	10	-32.3	50.2	63.5	13.3
14866	AVE	18.2	41.2	8	7.9	-32.3	43	63.5	20.5
12912.3	AVE	18.2	39.9	6.8	6.6	-31.8	39.7	63.5	23.8
10031.8	AVE	17.9	38.7	4.9	4.7	-33.6	32.6	63.5	30.9

Table A.8 Tx Spurious Emission Channel #0 (2.4GHz/900MHz) –6GHz - 18GHz: Vertical Polarization

Frequency	Detector	Raw Reading	Ant DRG 1GHz to 18GHz Factor	Cable 27 - 10m LMR400 Factor	Cable 28 - 7m LMR400 Factor	Preamp - HP 8449B 4006 Factor	Level	FCC 15.209 Average at 1m Limit	FCC 15.209 Average at 1m Limit
17976.8	AVE	17.5	45	10	10	-32.3	50.2	63.5	13.3
14800.5	AVE	18.4	41.5	8	7.9	-32.3	43.5	63.5	20
14016.7	AVE	17.6	41	7.5	7.3	-31.3	42.1	63.5	21.4
10501.8	AVE	18	39.4	5.2	5	-33.2	34.4	63.5	29.1

Table A.9 Tx Spurious Emission Channel #0 (2.4GHz/900MHz) –6GHz - 18GHz: Horizontal Polarization

Frequency	Detector	Raw Reading	Ant DRG 1GHz to 18GHz Factor	Cable 27 - 10m LMR400 Factor	Cable 28 - 7m LMR400 Factor	Cable 30 - 0.5m LMR400 Factor	Preamp - HP 8449B 4006 Factor	Level	FCC 15.209 Avg limit at 3m Limit	FCC 15.209 Pk limit at 3m Limit	FCC 15.209 Avg limit at 3m Margin
2402.26	PEAK	101.8	28.2	2.3	1.7	0.4	-33.1	101.3	54	74	-47.3
1855.71	PEAK	61	25.1	2	1.4	0.3	-33.1	56.7	54	74	-2.7
1475.05	PEAK	51.1	25.2	1.8	1.3	0.4	-33.5	46.3	54	74	7.7

Table A.10 Tx Spurious Emission Channel #0 (2.4GHz/900MHz) –1GHz – 3GHz: Vertical Polarization