

Report No.:**31550198.001***Page 1 of 40*

Electromagnetic Compatibility Test Report

Prepared in accordance with

FCC Part 15C, RSS-210 Issue 8 and ANSI C63.10

On

VirtualZone® Family

Model: CONTROLLER SSC

SmartStuff, Inc.

7001 Sassafrass CT

Summerville, SC 29485 USA

Prepared by:

TUV Rheinland of North America, Inc.

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Report No.:**31550198.001**

Page 2 of 40

Manufacturer's statement - attestation

The manufacturer; SmartStuff, Inc., as the responsible party for the equipment tested, hereby affirms:

- a) That he has reviewed and concurs that the test shown in this report are reflective of the operational characteristics of the device for which certification is sought;
- b) That the device in this test report will be representative of production units;
- c) That all changes (in hardware and software/firmware) to the subject device will be reviewed.
- d) That any changes impacting the attributes, functionality or operational characteristics documented in this report will be communicated to the body responsible for approving (certifying) the subject equipment.

Richard Day Jr.

Printed name of official

SmartStuff, Inc.
7001 Sassafrass CT
Summerville, SC 29485 USA

Address

860-202-1845

Telephone number



Signature of official

05 February 2015

Date

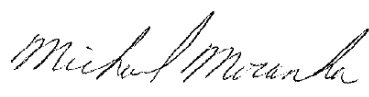
rday@SmartStff.com

Email address of official

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Report No.:
31550198.001

Page 3 of 40

Client:	 SmartStuff, Inc.		SmartStuff, Inc. 7001 Sassafrass CT Summerville, SC 29485 USA Richard Day Jr. Ph: 860-202-1845 Fax: Email: rday@SmartStff.com	
Identification:	VirtualZone® Family		Serial No.:	PRODUCTION PROTOTYPE
Test item:	Model CONTROLLER SSC		Date tested:	31 January 2015
Testing location:	TUV Rheinland of North America 762 Park Avenue Youngsville, NC 27596-9470 U.S.A.		Tel: (919) 554-3668 Fax: (919) 554-3542	
Test specification:	Emissions: FCC Part 15, Subpart C, RSS-210 Issue 8: FCC Part 15.207(a) and RSS-GEN FCC Parts 15.205, 15.209, 15.215(c), RSS-210 A8.5 FCC Part 15.247(a)(1) and RSS-GEN 4.6.1, FCC Part 15.247 and RSS-210 Annex 8.1, FCC Part 15.247(a)(1), RSS-210, Section A8.1(b), FCC Part 15.247(a)(1) and RSS-210 A8.1(b), FCC Part 15.247(b)(1) and RSS-210 A8.4(2), FCC Part 15.247(g) and RSS-210 A8.1, FCC Part 15.247(h) and RSS-210 A8.1			
Test Result	The above product was found to be Compliant to the above test standard(s)			
tested by: Mark Ryan			reviewed by: Michael Moranha	
 7 March 2015 Date Signature			 7 March 2015 Date Signature	
Other Aspects:	None			
Abbreviations: OK, Pass, Compliant, Complies = passed Fail, Not Compliant, Does Not Comply = failed N/A = not applicable				
				Industry Canada
90552 and 100881		Testing Cert #3331.05		2932H-1 and 2932H-2

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TABLE OF CONTENTS

1	GENERAL INFORMATION	5
1.1	SCOPE	5
1.2	PURPOSE	5
1.3	REVISION HISTORY.....	5
1.4	SUMMARY OF TEST RESULTS.....	6
2	LABORATORY INFORMATION	7
2.1	ACCREDITATIONS	7
2.2	MEASUREMENT UNCERTAINTY EMISSIONS	8
2.3	CALIBRATION TRACEABILITY	8
2.4	MEASUREMENT EQUIPMENT USED	9
3	PRODUCT INFORMATION	9
3.1	PRODUCT DESCRIPTION.....	9
3.2	EQUIPMENT MODIFICATIONS	9
4	RADIATED EMISSIONS IN TRANSMIT MODE	10
4.1	SPURIOUS EMISSIONS OUTSIDE THE BAND.....	10
4.2	CONDUCTED EMISSIONS ON AC MAINS – FCC 207(A) AND RSS-GEN 7.2.4.....	21
4.3	FHSS SYSTEMS	24
4.4	INCORPORATION OF INTELLIGENCE WITHIN A FHSS SYSTEM	24
5	ANTENNA PORT CONDUCTED EMISSIONS	25
5.1	PSEUDORANDOM HOPPING ALGORITHM.....	25
5.2	OCCUPIED BANDWIDTH AND CHANNEL SEPARATION	29
5.3	99% POWER BANDWIDTH	32
5.4	BAND EDGE REQUIREMENTS - FCC PART 15.247(D), RSS-210 A8.5	34
5.5	PEAK OUTPUT POWER	37
6	RF EXPOSURE.....	39
6.1	EXPOSURE REQUIREMENTS – FCC KDB # 447498 DO1 AND RSS-102 ISSUE 4	39

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1 General Information

1.1 Scope

This report is intended to document the status of conformance with the requirements of the FCC Part 15C, RSS-210 Issue 8 and ANSI C63.10 based on the results of testing performed on 31 January 2015 on the VirtualZone® Family, Model No. SENSOR SSS, manufactured by SmartStuff, Inc. This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components. This report is further intended to document changes and modifications to the EUT throughout its life cycle. All documentation will be included as a supplement.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT (Equipment Under Test) in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report.

1.3 Revision History

Revision	Date	Description of Revision
- -	05February2015	Initial Release
B	12February2015	Updated testing procedures to ANSI C63.10:2009
C	3 March 2015	Updated explanation of the Low Band-Edge measurements.
D	6 March 2015	Corrected typo in the FCC ID

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Report No.:
31550198.001

Page 6 of 40

1.4 Summary of Test Results

Applicant	SmartStuff, Inc. 7001 Sassafras CT Summerville, SC 29485 USA	Tel	860-202-1845	Contact	Richard Day Jr.
		Fax		e-mail	rday@SmartStff.com
Description	CONTROLLER	Model	CONTROLLER SSC		
Serial Number	Production Prototype	Test Voltage/Freq.	24 VAC		
Test Date Completed:	31 January 2015	Test Engineer	Mark Ryan		
Standards	Description	Severity Level or Limit		Worst-case Values	Test Result
FCC Part 15, Subpart C Standard	Radio Frequency Devices-Subpart C: Intentional Radiators	See called out parts below		See Below	Complies
RSS-210 Issue 8 Standard	Low-Power Licence-exempt Radiocommunication Devices Category I Equipment	See called out parts below		See Below	Complies
FCC Part 15.247 and RSS-210 Annex 8.1	Operation within the band 2400 to 2483.5 MHz	See called out parts below		See Below	Complies
FCC Parts 15.205, 15.209, 15.215(c), RSS-210 A8.5	Outside the Band Radiated Emissions EUT in Transmit Mode	Below specified limits of the standards		46.53 dBµV/m	Complies
FCC Part 15.207(a) and RSS-GEN	Conducted Emissions on AC Mains, EUT in Transmit Mode	Below the applicable limits		45.92 dBµV	Complies
FCC Part 15.247(a)(1), RSS-210, Section A8.1(b)	Channel Separation	99% BW ≤ 0.5% of center freq.		2.0 MHz	Complies
FCC Part 15.247(a)(1) and RSS-210 A8.1(b)	Pseudorandom Hopping Algorithm	25 hopping channels when the BW ≥ 250kHz		Bluetooth LE Protocol	Complies
FCC Part 15.247(a)(1) and RSS-GEN 4.6.1	Occupied Bandwidth	20dB 99% BW ≤ 0.5% of 2.4 GHz		1.22 MHz 1.07 MHz	Complies
FCC Part 15.247(d) and RSS-210 A8.5	Band Edge	Ensure 20dB bandwidth is Contained within the Frequency Band		64.87 dBµV	Complies
FCC Part 15.247(b)(1) and RSS-210 A8.4(2)	Transmitter Output Power	Shall not exceed 125.0 mW		0.997 mW	Complies
FCC Part 15.247(g) and RSS-210 A8.1	Frequency Hopping Spread Spectrum (FHSS) Systems	Description of Hopping System		Bluetooth LE Protocol	Complies
FCC Part 15.247(h) and RSS-210 A8.1	Incorporation of Intelligence within a FHSS System	Not Applicable: EUT does not incorporate hopping intelligence		NA	Not Applicable
FCC Part 2.1093 and RSS-102, Issue 4	RF Exposure and Antenna Gain Calculation	SAR or MPE Requirements		1.58 mW	Complies

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2 Laboratory Information

2.1 Accreditations

2.1.1 US Federal Communications Commission

TUV Rheinland of North America located at 762 Park Avenue, Youngsville, NC 27596-9470 is accredited by the commission for performing testing services for the general public on a fee basis. This laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (Registration No 90552 and 100881). The laboratory scope of accreditation includes: Title 47 CFR Part 15, and 18. The accreditation is updated every 3 years.

2.1.2 ILAC / A2LA

The laboratory has been assessed and accredited by A2LA in accordance with ISO Standard 17025:2005 (Certificate Number: 3331.05, Master Code: 134288). The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 Industry Canada

Registration No.: 2932H-1 The OATS has been accepted by Industry Canada to perform testing to 3 and to 10 meters, based on the test procedures described in ANSI C63.4-2009.

Registration No.: 2932H-2 The 5 meter chamber has been accepted by Industry Canada to perform testing to 3 meters, based on the test procedures described in ANSI C63.4-2009.

2.1.4 Japan – VCCI

The Voluntary Control Council for Interference by Information Technology Equipment (VCCI) is a group that consists of Information Technology Equipment (ITE) manufacturers and EMC test laboratories. The purpose of the Council is to take voluntary control measures against electromagnetic interference from Information Technology Equipment, and thereby contribute to the development of a socially beneficial and responsible state of affairs in the realm of Information Technology Equipment in Japan. TUV Rheinland at the 762 Park Ave. Youngsville, N.C 27596 address has been assessed and approved in accordance with the Regulations for Voluntary Control Measures. (Laboratory Registration No: A-0034).

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2.1.5 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

$$\text{Field Strength (dB}\mu\text{V/m)} = \text{RAW} - \text{AMP} + \text{CBL} + \text{ACF}$$

Where: RAW = Measured level before correction (dB μ V)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu\text{V/m} = 10^{\frac{\text{dB}\mu\text{V} / \text{m}}{20}}$$

Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dB μ V/m)

$$25 \text{ dB}\mu\text{V/m} + 17.5 \text{ dB} - 20 \text{ dB} + 1.0 \text{ dB} = 23.5 \text{ dB}\mu\text{V/m}$$

2.2 Measurement Uncertainty Emissions

	U_{lab}	U_{cispr}
Radiated Disturbance @ 10m		
30 MHz – 1,000 MHz	3.3 dB	5.2 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	1.18 dB	3.6 dB
Disturbance Power		
30 MHz – 300 MHz	3.88 dB	4.5 dB

2.3 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2005. Equipment calibration records are kept on file at the test facility.

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Report No.:
31550198.001

Page 9 of 40

2.4 Measurement Equipment Used

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal dd/mm/yy	Next Cal dd/mm/yy
Radiated Emissions (5 Meter Chamber)					
Receiver, EMI	Rohde & Schwarz	ESIB40	100043	19-Aug-14	19-Aug-15
Receiver, EMI	Rohde & Schwarz	ESCI 7	100917	19-Aug-14	19-Aug-15
Spectrum Analyzer	Agilent Tec.	E7405A	US39440161	20-Aug-14	20-Aug-15
Amplifier, preamp	Agilent Technologies	8449B	3008A01480	14-Aug-13	14-Aug-15
Ant. BiconiLog	Chase	CBL6140A	1108	16-Sep-13	16-Sep-15
Antenna Horn 1-18 GHz	EMCO	3115	3115	30-Dec-14	30-Dec-15
Antenna Horn 18-26.5 GHz	ATM	42-442-6/cal	G181104-01	31-Dec-14	31-Dec-15
Cable, Coax	MicroCaox	MKR300C-0-0-1200-500500	002	22-Aug-14	22-Aug-15
Cable, Coax	MicroCaox	MKR300C-0-1968-500310	005	22-Aug-14	22-Aug-15
Cable, Coax	MicroCaox	UFB29C-1-5905-50U-50U	009	22-Aug-14	22-Aug-15
Cable, Coax	Andrew	FSJ1-50A	045	22-Aug-14	22-Aug-15
3.0 GHz High Pass Filter	Bonn Elektronik	BHF 3000	025155	14-Aug-13	14-Aug-15
Notch Filter	Micro-tronics	BRM50702	049	14-Aug-13	14-Aug-15
General Laboratory Equipment					
Meter, Multi & Thermocouple	Fluke	179	90580752	19-Aug-14	19-Aug-15
Meter, Temp/Humid/Barom	ExTech	SD700	Q677933	06-May-13	06-May-15
Meter, Temp/Humid/Barom	ExTech	SD700	Q677942	06-May-13	06-May-15

3 Product Information

3.1 Product Description

The EUT is a family of wireless Zone Temperature Control System with a Bluetooth Low-Energy (BLE) transmitter. The models in the family are SENSOR SSS, CONTROLLER SSC and CONTROLLER SSC.

Two sets of each EUT were provided for testing. One is normal a configuration for unintentional cabinet radiation. The second was modified with test firmware to allow the low, medium and high hopping channels to continuously transmit with modulation. External batteries were included on the modified devices to allow long-term transmissions.

There is enough difference in size and layout of the circuit boards to require separate testing and certification. The Model CONTROLLER SSC was the device provided for testing in this report.

For the other members of the family, refer to TUV test report Number 31453815.001 for the Sensor and report number 31550197.001 for the Damper.

3.2 Equipment Modifications

No modifications were needed to bring product into compliance.

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4 Radiated Emissions in Transmit mode

4.1 Spurious Emissions Outside the band

In any 100kHz 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 desired power, based on either RF conducted or radiated measurements. Emissions within restricted bands shall meet the requirements of FCC Part 15.209 and RSS-GEN 7.2.1.

4.1.1 Over View of Test

Results	Complies (as tested per this report)					Date	27-30 January 2015		
Standard	FCC Parts 15.205, 15.209, 15.215(c) and RSS-210 A8.5								
Product Model	CONTROLLER SSC				Serial#	Production Prototype			
Test Set-up	Tested in a 5m Semi Anechoic chamber. For Emissions below 1 GHz, the EUT was placed on a 1.0m x 1.5m foam table 80cm above the ground plane on a turn-table. For Emissions above 1 GHz, the EUT was placed on a 1.0m x 1.5m foam table 1.5m above the ground plane								
EUT Powered By	24 VAC	Temp	74° F	Humidity	19%	Pressure	1008 mbar		
Perf. Criteria	(Below Limit)			Perf. Verification		Readings Under Limit			
Mod. to EUT	None			Test Performed By		Mark Ryan			

4.1.2 Test Procedure

Testing was performed in accordance with 47 CFR Part 15, ANSI C63.10:2009, RSS-GEN Issue 4. These test methods are listed under the laboratory's A2LA Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices. The scans will be at least ten times the highest transmitted frequency of 2.48GHz. Scans will be made to 25 GHz.

4.1.3 Deviations

Since all emissions outside the band are within the limits of FCC Part 15.209 and RSS-GEN 7.2.1, the emissions shown below are also compliant with FCC Parts 15.205, 15.209, 15.215(c), 15.249(d), RSS-210 A8.5, and RSS-GEN 7.2.1.

4.1.4 Final Test

All final radiated spurious emissions measurements were below (in compliance) the limits.

The worst –case emissions are shown below. All other emissions are on file at TUV Rheinland.

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Report No.:
31550198.001

Page 11 of 40

4.1.4.1 Final Graphs and Tabulated Data

Orientations:

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)
Orientation A								
2480.00	H	2	177	51.27	0.00	5.98	28.68	85.93
2480.00	V	1.5	169	64.08	0.00	5.98	28.68	98.74
2480.00	H	2	177	49.21	0.00	5.98	28.68	83.87
2480.00	V	1.5	169	62.82	0.00	5.98	28.68	97.48
Orientation B								
2440.00	H	1.7	304	63.69	0.00	5.95	28.56	98.20
2440.00	V	1.5	257	57.06	0.00	5.95	28.56	91.57
2440.00	H	1.7	304	62.37	0.00	5.95	28.56	96.88
2440.00	V	1.5	257	55.65	0.00	5.95	28.56	90.16
Orientation C								
2480.00	H	1.7	89	62.62	0.00	5.98	28.68	97.28
2480.00	V	1.6	287	50.76	0.00	5.98	28.68	85.42
2480.00	H	1.7	89	61.27	0.00	5.98	28.68	95.93
2480.00	V	1.6	287	48.36	0.00	5.98	28.68	83.02
Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor								
Notes: Red = Peak Detector , Blue = Average Detector								
The Limit using the Peak Detector is 20dB higher than the Average Detector limit.								
EUT in Orientation C is worst case as shown. All other data is on file at TUV Rheinland.								
This highlighted frequency and orientation was worst case (2480 MHz, Orientation A).								

Notes:

The maximum average Field Value of 97.48 dBuV/m exceeds the limit of FCC Part 15.249 and RSS-210 (A2.9).

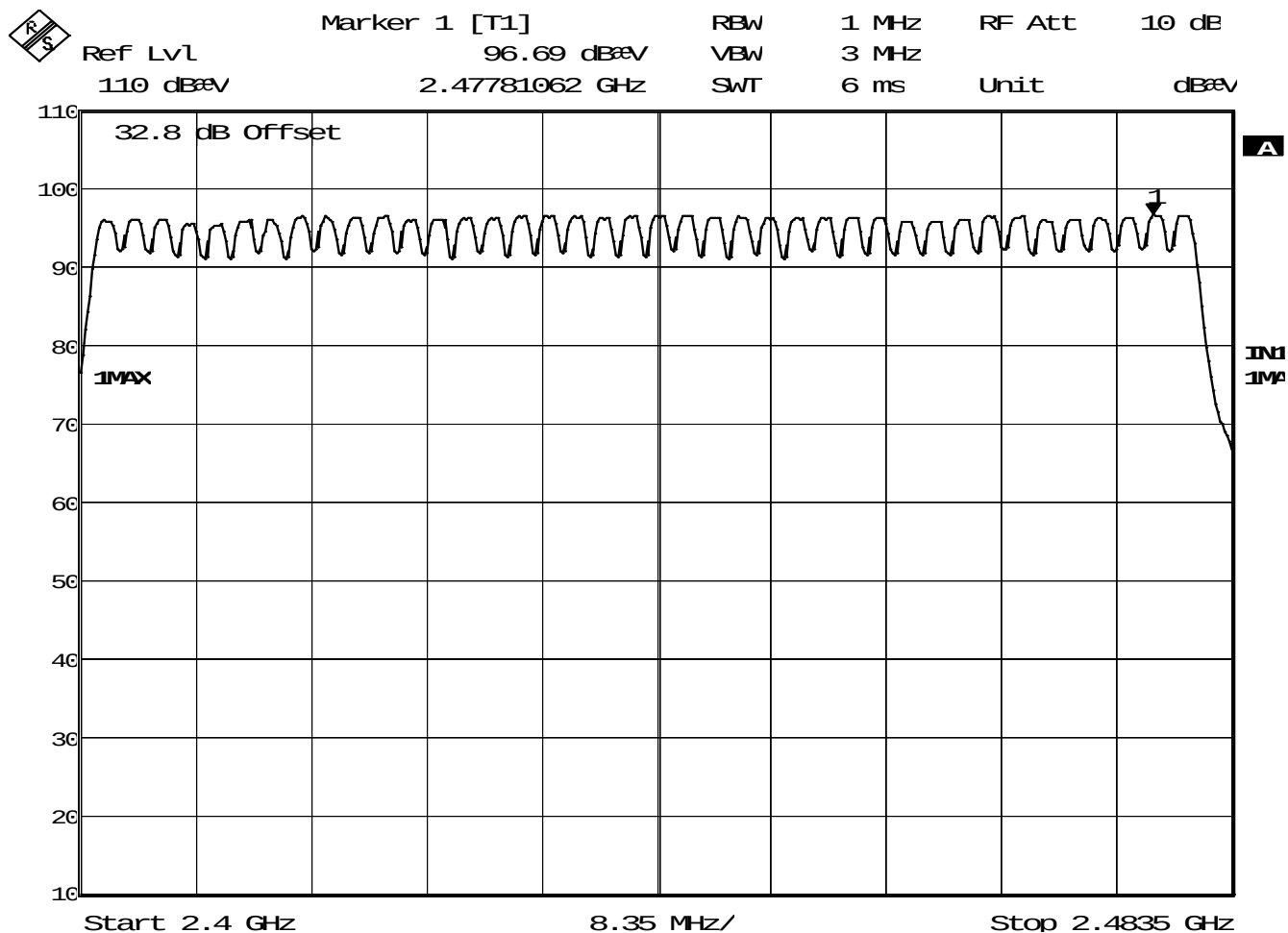
Therefore, this report is tested to the test requirements of FCC Part 15.247 and RSS-210 (A8)

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Report No.:

31550198.001

Page 12 of 40



Date: 28. JAN. 2015 11:14:23

Plot of all hopping frequencies, Showing Orientation A – Horizontal is worst case near the High channel.

Plots of the other orientations and polarities are on file at TUV Rheinland.

4.1.4.2 Maximum Time-weighted Emission:

The EUT was modified to transmit continuously at 100% Duty cycle.

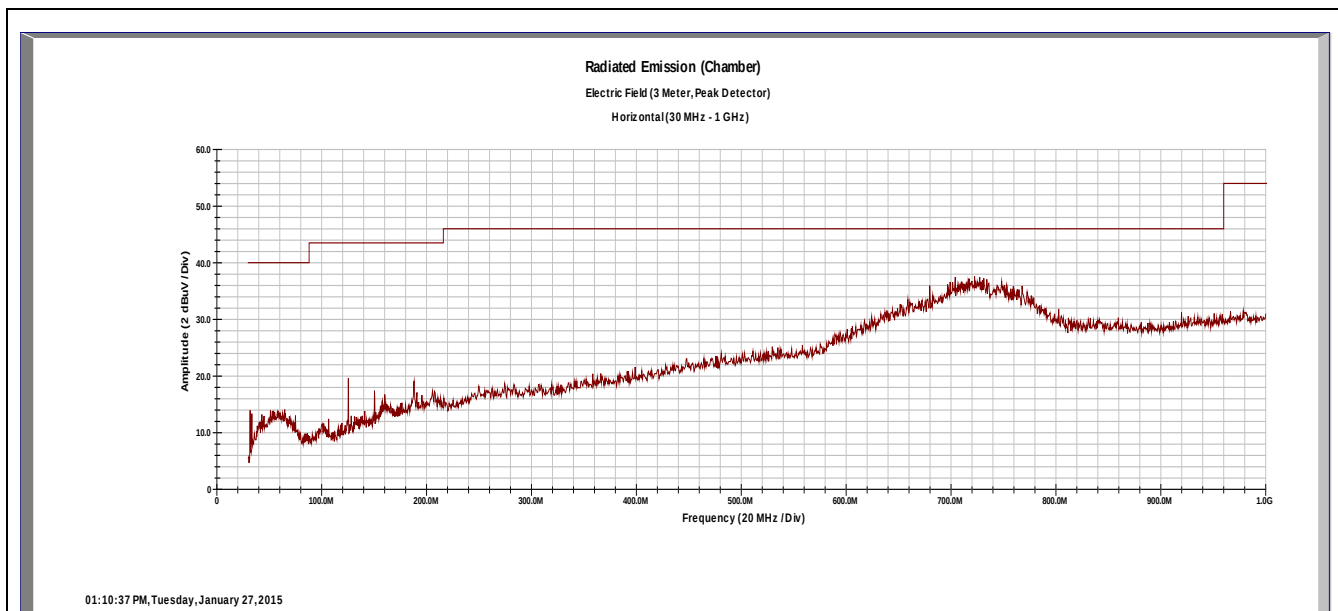
Even at 100% Duty Cycle the EUT is compliant to the rules.

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4.1.4.3 Emissions Outside the Frequency Band:

Radiated Emissions – 30 MHz to 1 GHz

Horizontal



Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)
739.24	H	1.7	355	9.08	0.00	3.16	21.28	33.52	46.00	-12.48

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor ± Uncertainty

Notes: All emissions were below the noise floor of the instrumentation.

The EUT was set to hopping all channels.

The signals shown below 200 MHz are anomalies in the preamp of the measuring instrument.

A notch filter at the transmitter fundamental frequency was used.

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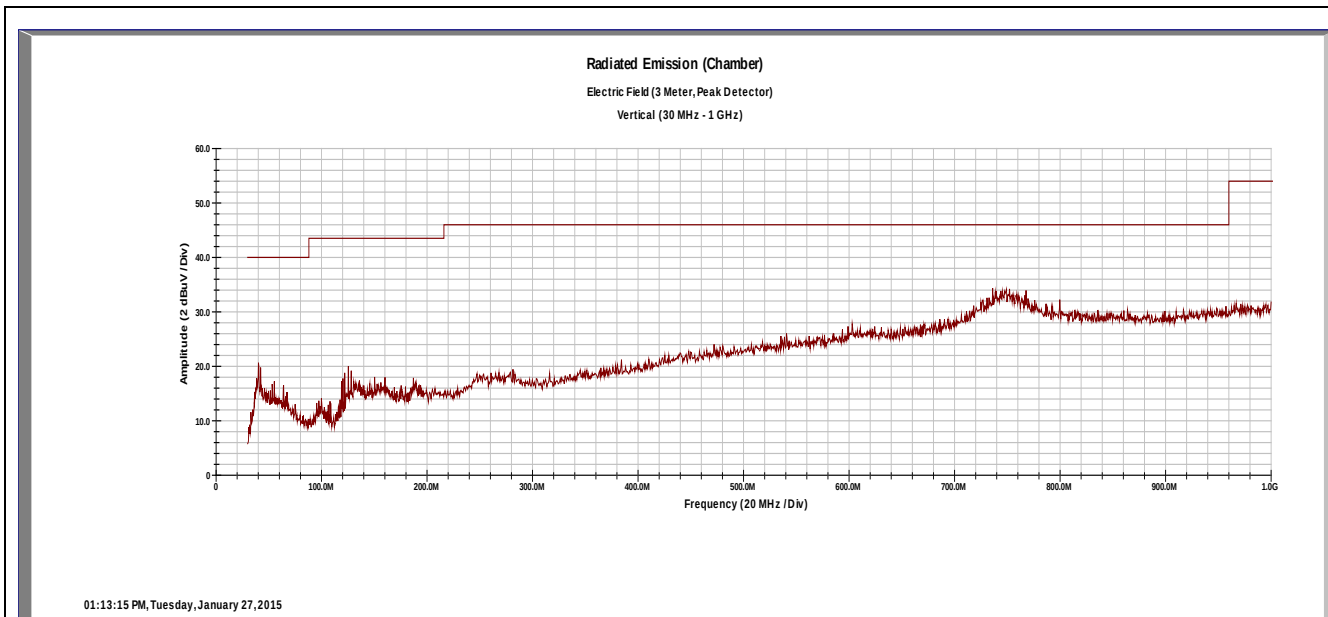
Report No.:

31550198.001

Page 14 of 40

Radiated Emissions – 30 MHz to 1 GHz

Vertical



Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)
40.56	V	1.2	0	6.52	0.00	0.75	9.19	16.45	40.00	-23.55
744.64	V	1	312	6.34	0.00	3.17	21.30	30.81	46.00	-15.19

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor ± Uncertainty

Notes: All emissions were below the noise floor of the instrumentation.

The EUT was set to hopping all channels.

The signals shown below 200 MHz are anomalies in the preamp of the measuring instrument.

A notch filter at the transmitter fundamental frequency was used.

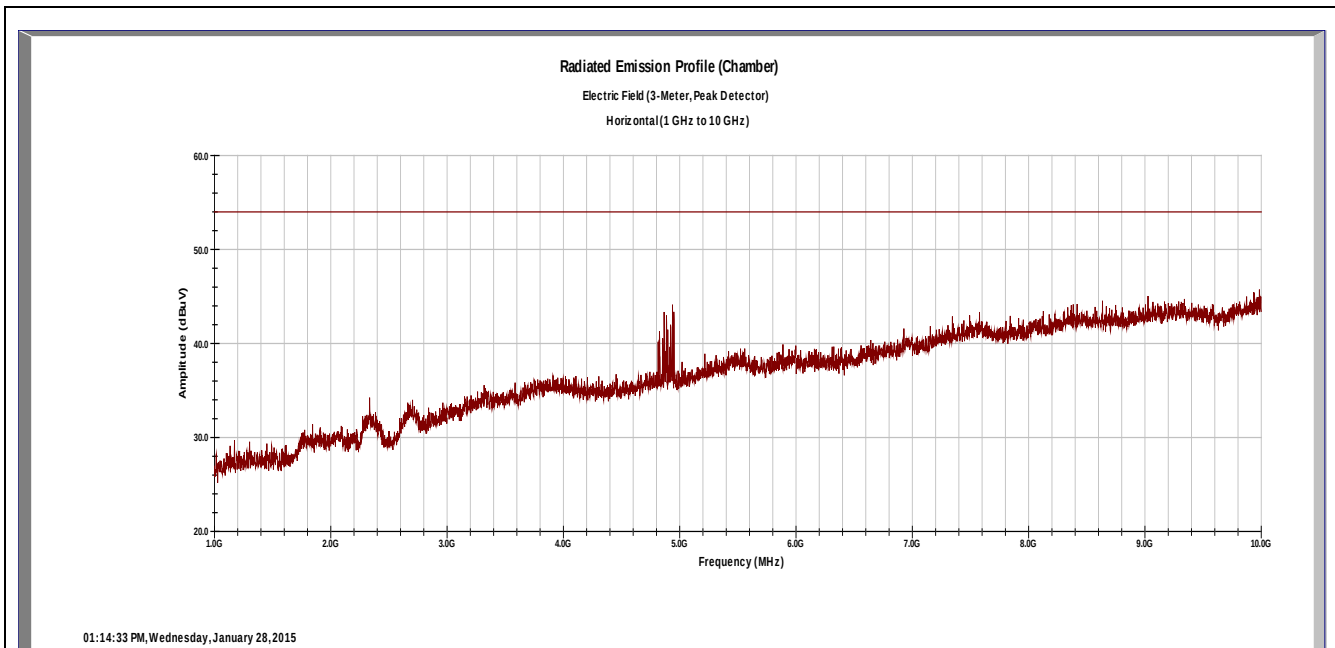
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Report No.:

31550198.001

Page 15 of 40

Radiated Emissions – 1 GHz to 10 GHz
Horizontal



Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBUV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBUV/m)	Spec Limit (dBUV/m)	Spec Margin (dB)
4804.00	H	1.6	330	33.33	33.84	11.60	32.88	43.97	54.00	-10.03
4804.00	H	1.6	330	41.86	33.84	11.60	32.88	52.50	74.00	-21.50
Mid:										
4880.00	H	1.5	331	33.92	33.77	11.71	33.03	44.88	54.00	-9.12
4880.00	H	1.5	331	41.82	33.77	11.71	33.03	52.78	74.00	-21.22
Hi:										
4960.00	H	1.7	332	33.83	33.66	11.81	33.19	45.18	54.00	-8.82
4960.00	H	1.7	332	43.32	33.66	11.81	33.19	54.67	74.00	-19.33

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor ± Uncertainty

Notes: A Band-Notch filter was used to attenuate the fundamental frequency.

Worst case emission is in the Horizontal Polarity (see next page)

A Band- Notch filter was used to attenuate the fundamental frequency

The EUT was set to hopping all channels

The **Blue** emissions are using the Average detector

The **RED** emissions are using the Peak detector

Worst-Case Plot shown. Plots for other channels are on file at TUV Rheinland.

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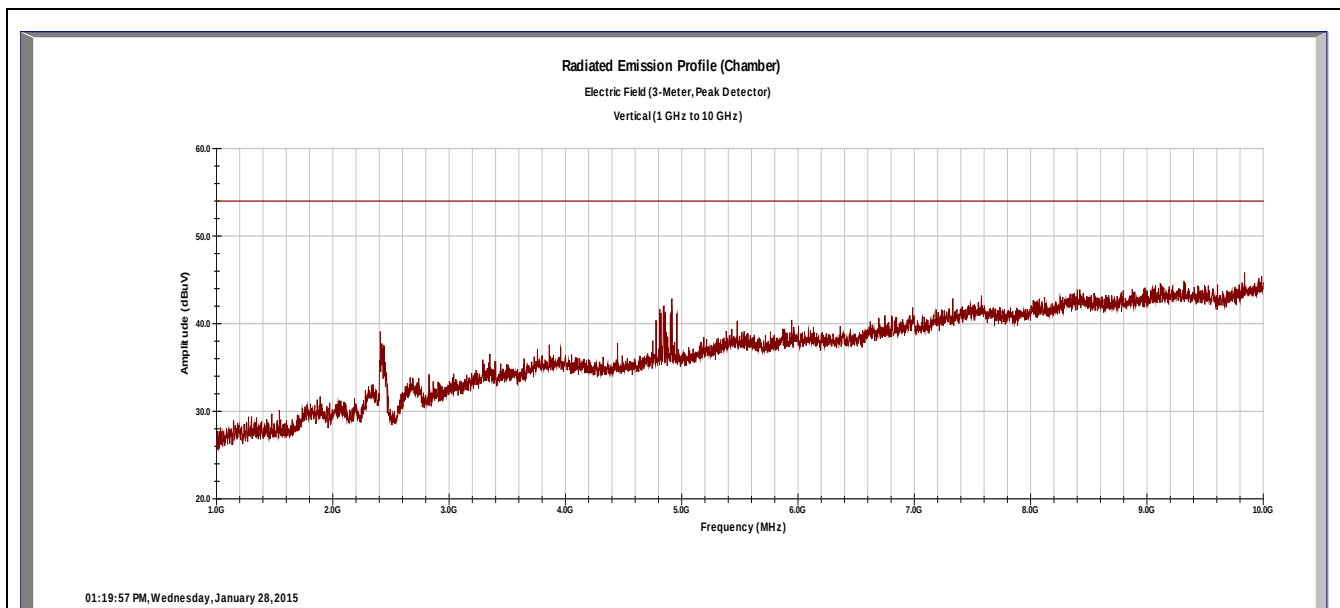
Report No.:

31550198.001

Page 16 of 40

Radiated Emissions – 1 GHz to 10 GHz

Vertical



Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)
4804.00	V	1.8	10	33.58	33.84	11.60	32.88	44.22	54.00	-9.78
4804.00	V	1.8	10	41.82	33.84	11.60	32.88	52.46	74.00	-21.54
Mid:										
4880.00	V	1.8	15	35.39	33.77	11.71	33.03	46.35	54.00	-7.65
4880.00	V	1.8	15	42.87	33.77	11.71	33.03	53.83	74.00	-20.17
Hi:										
4960.00	V	1.8	18	34.57	33.66	11.81	33.19	45.92	54.00	-8.08
4960.00	V	1.8	18	43.09	33.66	11.81	33.19	54.44	74.00	-19.56

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor ± Uncertainty

Notes:

Worst case emission is in the Horizontal Polarity (see previous page)

The **Blue** emissions are using the Average detector

The **Red** emissions are using the Peak detector

All spurious and harmonic emissions are below the level of Part 15.209, including those not in restricted bands.
A Band- Notch filter was used to attenuate the fundamental frequency.

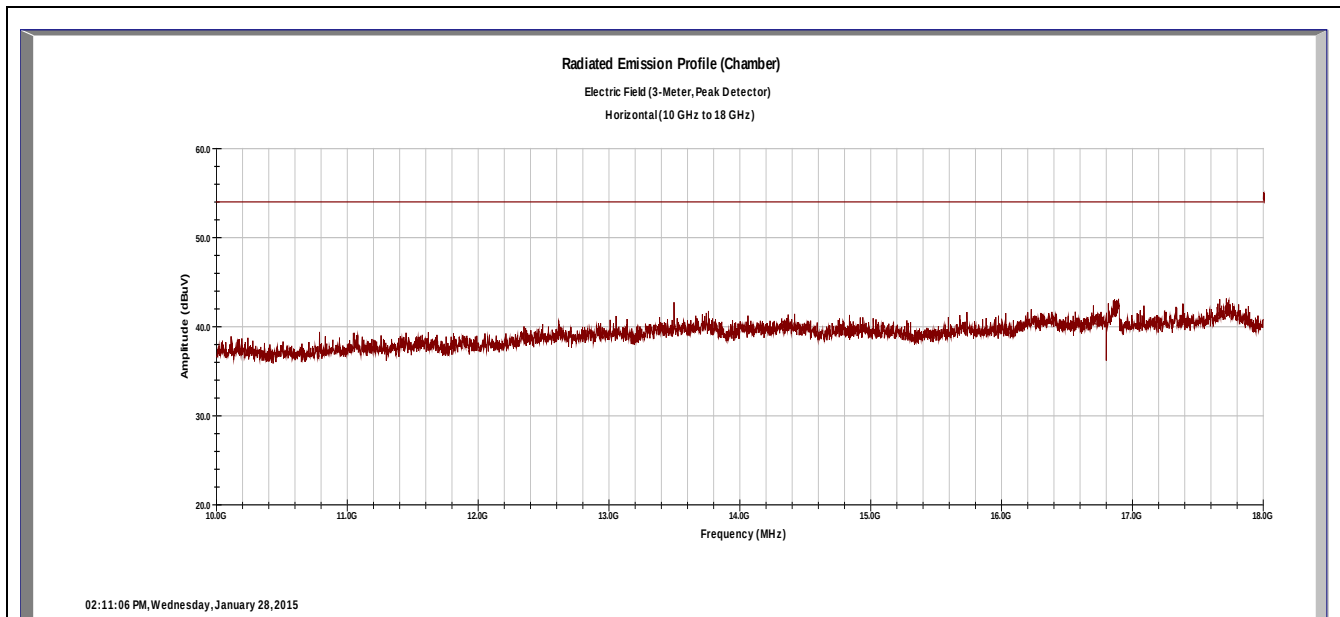
The test results contained in this report refer exclusively to the product(s) presented for testing. No liability may be assumed for models or products not referred to herein. This test report may not be published or duplicated in part without permission of the testing body. This test report by itself does not constitute authorization for the use of any TUV Rheinland test mark. The report must not be used by the client to claim product certification, approval, or endorsement by A2LA.

Report No.:

31550198.001

Page 17 of 40

Radiated Emissions – 10 GHz to 18 GHz
Horizontal



Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor ± Uncertainty

Notes: The EUT was set to hopping all channels.

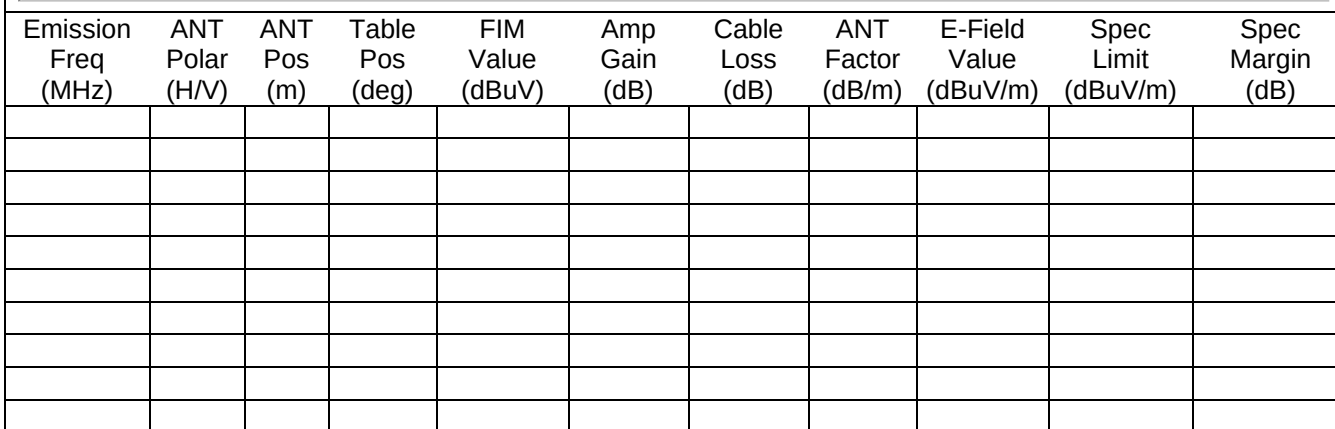
No measureable emissions were noted.

A High-Pass filter was used to attenuate the fundamental frequency.

No emissions were seen above the noise floor of the instrumentation.

The test results contained in this report refer exclusively to the product(s) presented for testing. No liability may be assumed for models or products not referred to herein. This test report may not be published or duplicated in part without permission of the testing body. This test report by itself does not constitute authorization for the use of any TUV Rheinland test mark. The report must not be used by the client to claim product certification, approval, or endorsement by A2LA.

Vertical



No emissions were seen above the noise floor of the instrumentation.

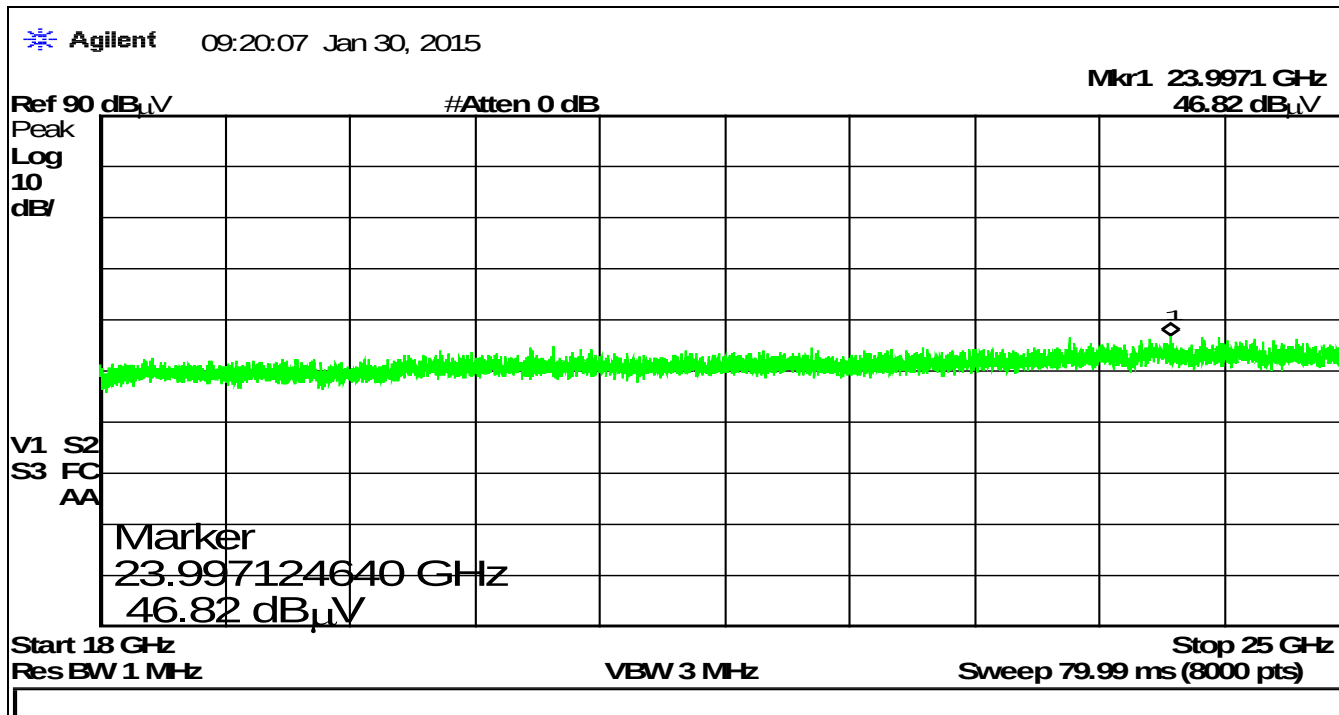
Report No.:

31550198.001

Page 19 of 40

Radiated Emissions – 18 GHz to 25 GHz

Horizontal

[illegible]

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor $\pm$ Uncertainty

Notes: The EUT was set to hopping all channels.

No measureable emissions were noted.

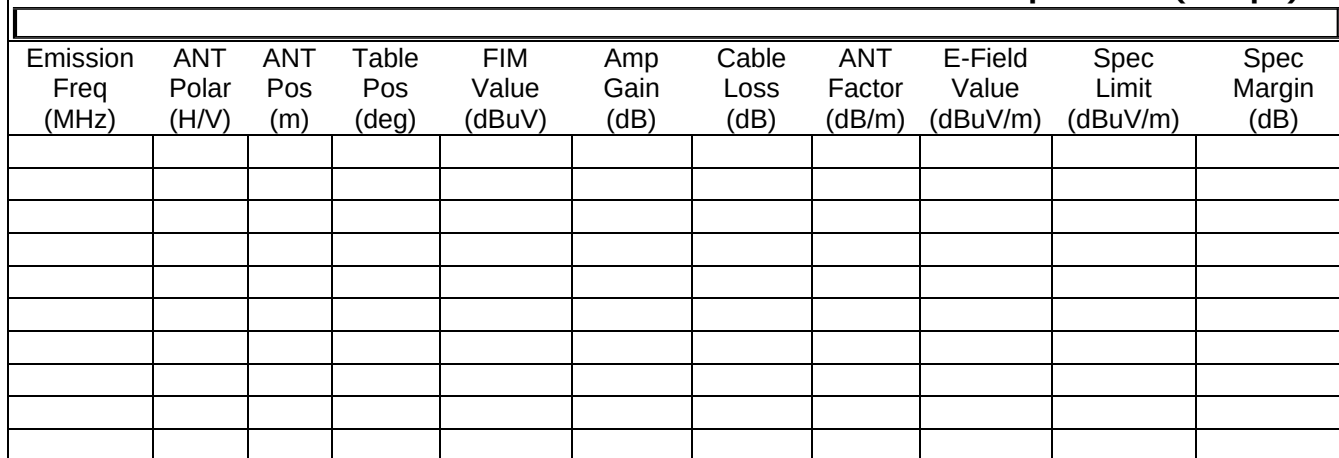
No correction factors were used for the above graph. The number of Sweep Points was increased to 8000.

The Measuring distance was decreased to 1 meter.

No notch filter was used for this frequency range.

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Vertical



No notch filter was used for this frequency range.

Report No.:
31550198.001

Page 21 of 40

4.2 Conducted Emissions on AC Mains – FCC 207(a) and RSS-GEN 7.2.4

This test measures the electromagnet levels of spurious signals generated by the EUT on the AC power line that may affect the performance of other nearby electronic equipment.

4.2.1 Over View of Test

Results	Complies (as tested per this report)					Date	27 January 2015	
Standard	FCC Part 15.207(a) and RSS-GEN							
Product Model	CONTROLLER SSC				Serial#	NA		
Test Set-up	Tested in shielded room. EUT placed on table, see test plans for details							
EUT Powered By	24 VAC	Temp	71° F	Humidity	28%	Pressure	994 mbar	
Frequency Range	150 kHz – 30 MHz							
Perf. Criteria	(Below Limit)	Perf. Verification			Readings Under Limit for L1 & Neutral			
Mod. to EUT	None	Test Performed By			Engineer's Name			

4.2.1 Test Procedure

Conducted and FCC emissions tests were performed using the procedures of ANSI C63.10 including methods for signal maximizations and EUT configuration. The photos included with the report show the EUT in its maximized configuration.

The frequency range from 150kHz – 30MHz was investigated for conducted emissions.

Conducted Emissions measurements were performed in either the shielded room or ground plane location (with attached vertical ground plane) using procedures specified in the test plan and standard.

The EUT was powered by a 24 VAC transformer. The emissions were made on the AC Mains side of the transformer.

4.2.2 Deviations

There were no deviations from the test methodology listed in the test plan for the conducted emission test.

4.2.3 Final Test

All final conducted emissions measurements were below (in compliance) the limits. It lists the final measurement data under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories.

The test results contained in this report refer exclusively to the product(s) presented for testing. No liability may be assumed for models or products not referred to herein. This test report may not be published or duplicated in part without permission of the testing body. This test report by itself does not constitute authorization for the use of any TUV Rheinland test mark. The report must not be used by the client to claim product certification, approval, or endorsement by A2LA.

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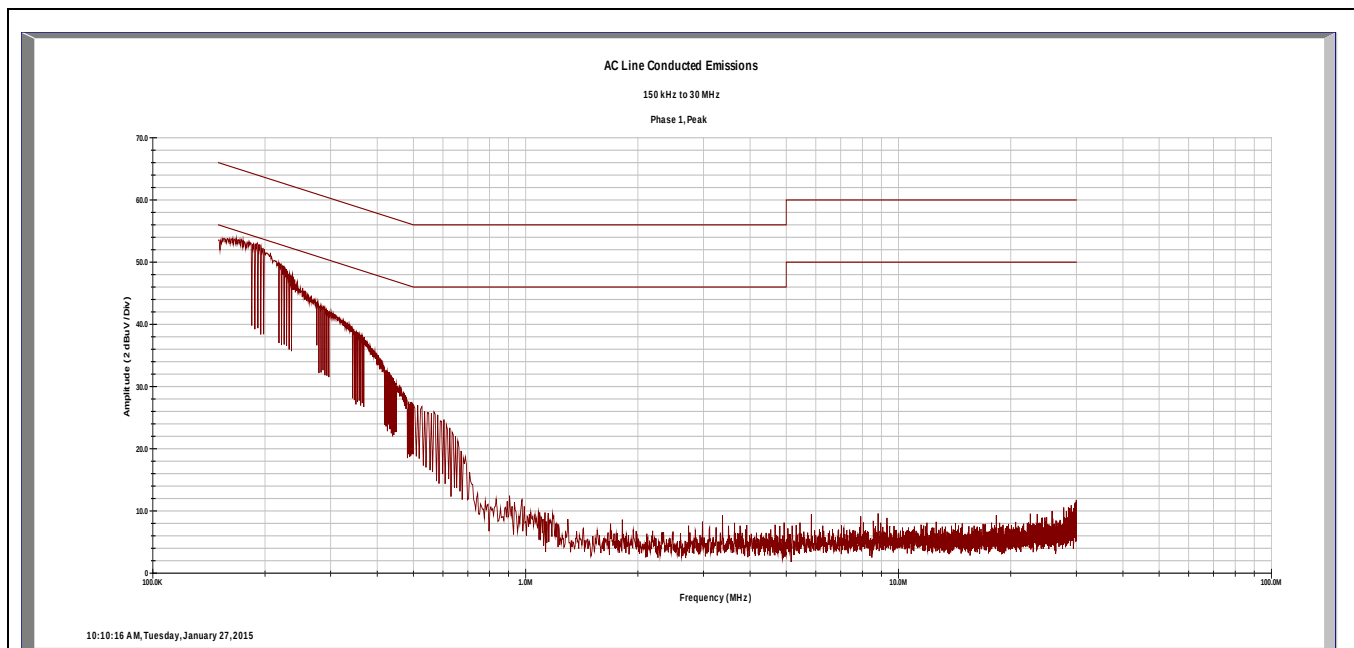
31550198.001

Page 22 of 40

4.2.4 Final Graphs and Tabulated Data

Conducted Emissions @ 120V/60Hz

Line 1



Freq (MHz)	ID (1,2,3,N)	Quasi (dBuV)	Ave (dBuV)	Loss (dB)	T Limiter (dB)	Limit (dBuV)	Limit (dBuV)	Margin (dB)	Margin (dB)
0.15	1	35.95	3.37	0.02	9.97	66.00	56.00	-20.05	-42.63
0.30	1	23.48	0.09	0.03	9.97	60.24	50.24	-26.76	-40.15
0.50	1	8.73	0.02	0.04	9.99	56.00	46.00	-37.24	-35.95
	1								
	1								
	1								

Quasi Spec Margin = Quasi FIM + Cable Loss + LISN CF - Quasi Limit $\pm$ Uncertainty

Ave Spec Margin = Ave FIM + Cable Loss + LISN CF - Ave Limit $\pm$ Uncertainty

Combined Standard Uncertainty $u_c(y) = \pm 1.66\text{dB}$ Expanded Uncertainty $U = k u_c(y)$ $k = 2$ for 95% confidence

Notes: EUT in continuous hopping mode.

All other Quasi-Peak and Average emissions are below 0 dBuV.

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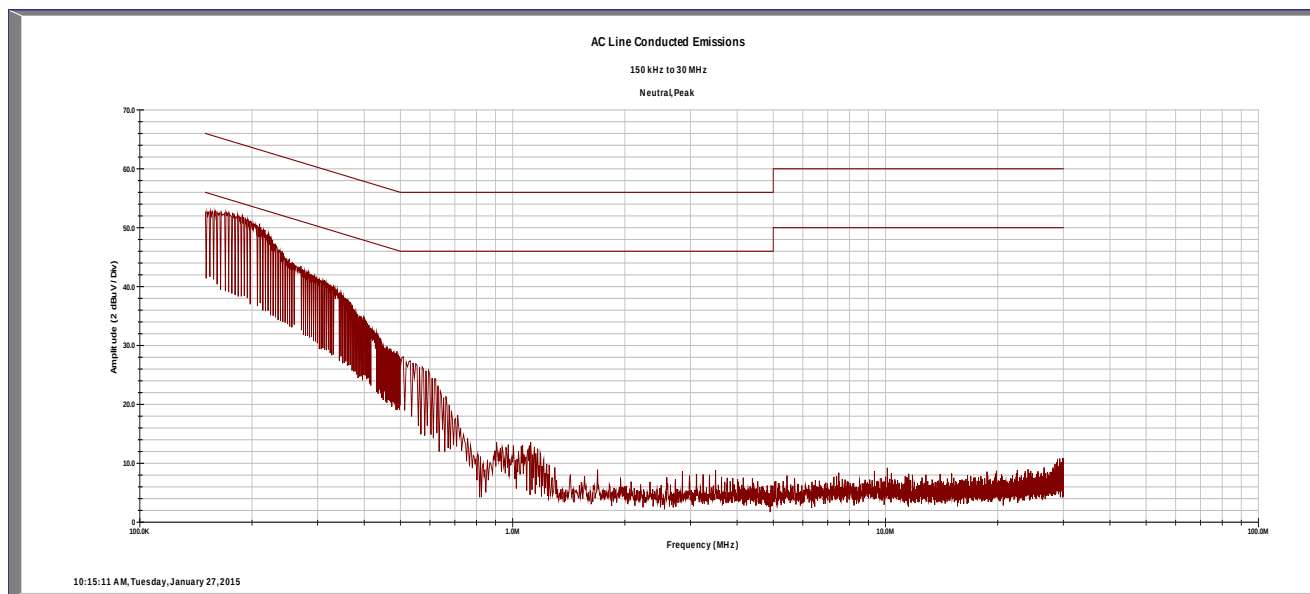
Report No.:

31550198.001

Page 23 of 40

Conducted Emissions @ 120V/60Hz

Neutral



Freq (MHz)	ID (1,2,3,N)	Quasi (dBuV)	Ave (dBuV)	Loss (dB)	T Limiter (dB)	Limit (dBuV)	Limit (dBuV)	Margin (dB)	Margin (dB)
0.15	N	35.14	4.20	0.02	9.97	66.00	56.00	-20.86	-41.80
0.17	N	34.61	2.40	0.03	9.97	64.77	54.77	-20.16	-42.37
0.50	N	10.94	1.37	0.04	9.98	56.00	46.00	-35.04	-34.61

Quasi Spec Margin = Quasi FIM + Cable Loss + LISN CF - Quasi Limit ± Uncertainty

Ave Spec Margin = Ave FIM + Cable Loss + LISN CF - Ave Limit ± Uncertainty

Notes: EUT in continuous hopping mode.

All other Quasi-Peak and Average emissions are below 0 dBuV.

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4.3 FHSS Systems

4.3.1 FCC Part 15.247(g) and RSS-210 A8.1

Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

The EUT utilizes the standard 40 channel Bluetooth LE protocol

4.4 Incorporation of Intelligence within a FHSS System

4.4.1 FCC Part 15.247(h) and RSS-210 A8.1

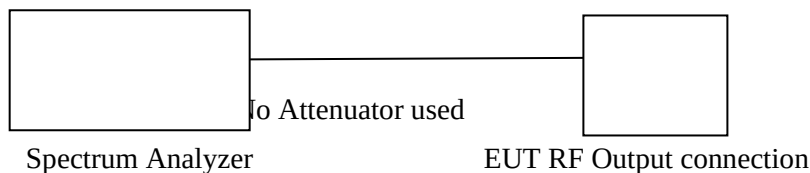
The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

The EUT does not incorporate intelligence relating to the hopping pattern as described above. Rather, the EUT always distributes its transmissions across the same 25 channels. A channel is not re-used until a transmission has occurred on each of the other 24 channels.

5 Antenna Port Conducted Emissions

Testing was performed in accordance with 47 CFR Part 15, ANSI C63.10:2009, RSP-100 Issue 9. These test methods are listed under the laboratory's NVLAP Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

Test Setup:



5.1 Pseudorandom Hopping Algorithm

5.1.1 Test Over View

Results	Complies (as tested per this report)					Date	26 January 2015	
Standard	FCC Part 15.247(a)(1) and RSS-210, A8.1(b)							
Product Model	CONTROLLER SSC				Serial#	Production Sample		
Test Set-up	Direct Measurement from antenna port							
EUT Powered By	24 VAC	Temp	72° F	Humidity	32%	Pressure	988 mbar	
Perf. Criteria	(Below Limit)			Perf. Verification		Readings Under Limit		
Mod. to EUT	None			Test Performed By		Mark Ryan		

5.1.2 Test Procedure

The channel bandwidth for this system is greater than 250 kHz. Therefore the system must use at least 25 channels that are selected at the system hopping rate, from a pseudo-randomly ordered list of hopping frequencies. Each frequency must be used equally on average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their transmitters and shall shift frequencies in synchronization with the transmitted signals.

The EUT utilizes the standard Bluetooth LE 40 hopping channels and pseudo-random protocols.

5.1.3 Deviations

There were no deviations from the test methodology listed in the test plan for this test. Final Test

The EUT met the performance criteria requirement as specified in the test plan of this report and in the standards.

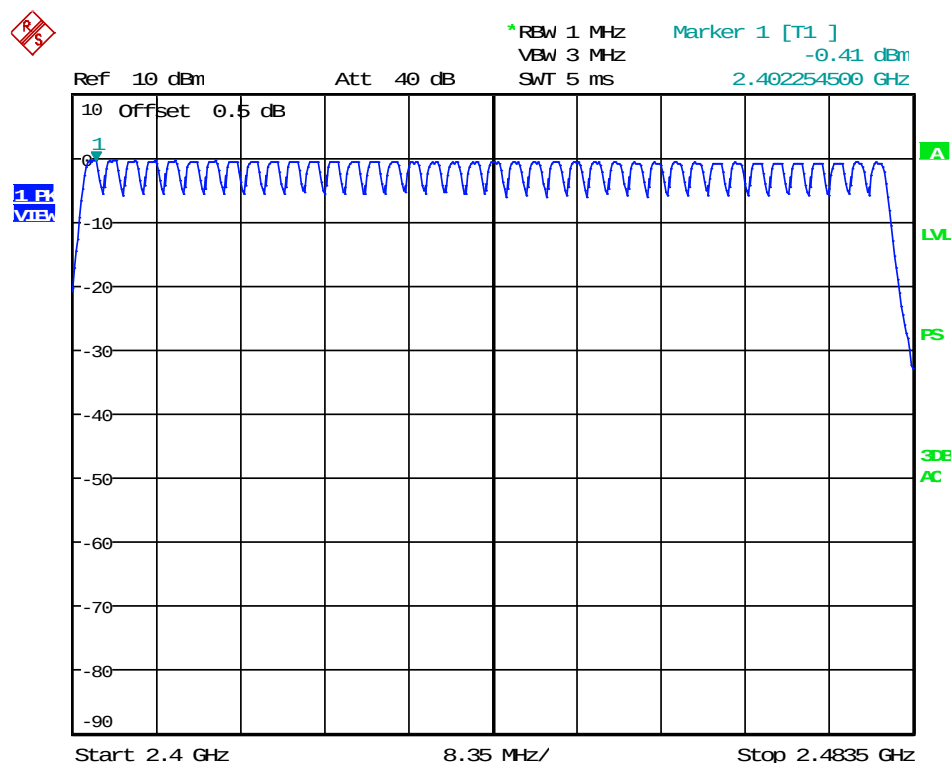
The test results contained in this report refer exclusively to the product(s) presented for testing. No liability may be assumed for models or products not referred to herein. This test report may not be published or duplicated in part without permission of the testing body. This test report by itself does not constitute authorization for the use of any TUV Rheinland test mark. The report must not be used by the client to claim product certification, approval, or endorsement by A2LA.

Report No.:

31550198.001

Page 26 of 40

5.1.4 Final Data



Date: 26.JAN.2015 15:50:22

Figure 1: Plot showing all 40 hopping Channels

Spectrum Analyzer Parameters:

RBW=1 MHz

Span=83.5MHz

VBW= 3 MHz

LOG dB/div.= 10dB

Sweep = Auto

Detector = Peak detector, Max hold

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Report No.:

31550198.001

Page 27 of 40

Time of Occupancy FCC Part 15.247(a)(1) and RSS-210 A8.1(b)

Frequency Band (MHz)	20 dB Bandwidth	Number of Hopping Channels	Average Time of Occupancy
2400 – 2483.5	≥250 kHz	40	≤ 0.4 sec. In 16 sec.

Time of Occupancy limit = 0.400 seconds in any 16 second period.

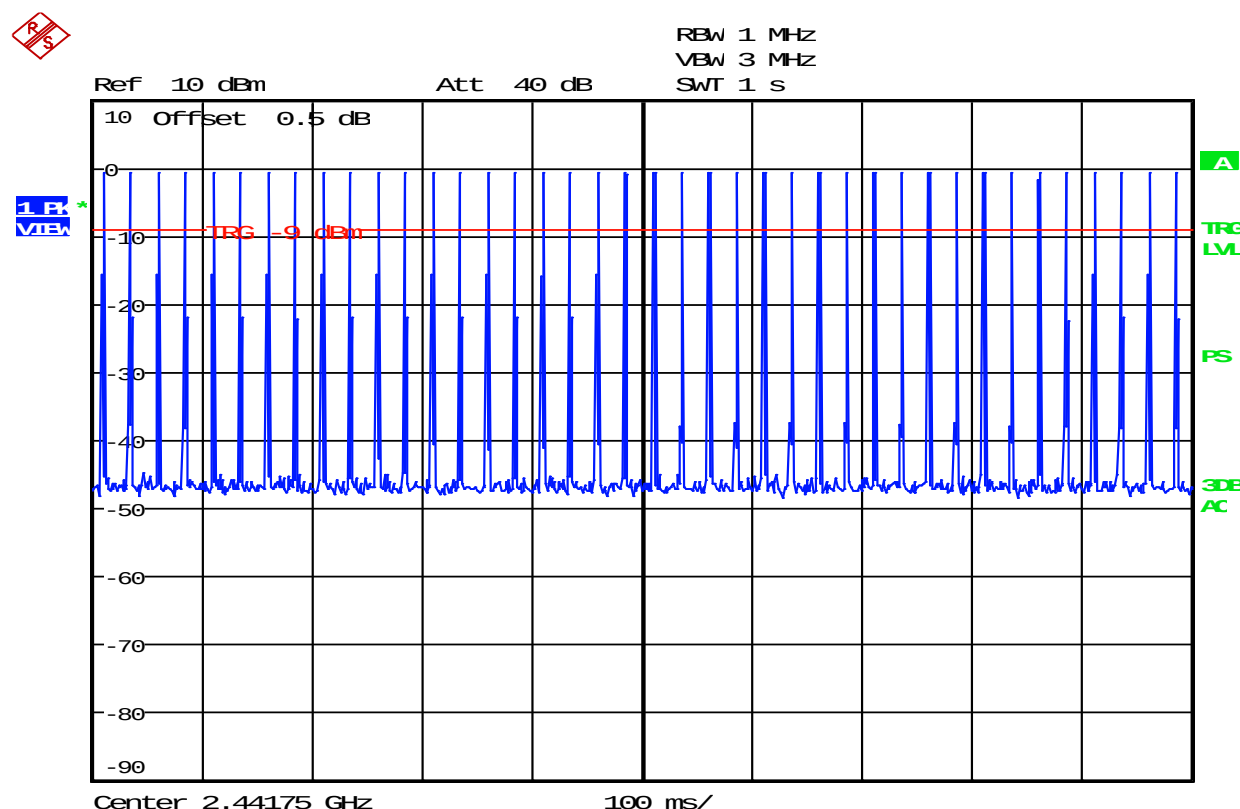
Calculated Time of Occupancy = Time Occupancy ≤ 0.4 seconds in 40 Channels * 0.4 seconds (16 seconds)

There were 40 hops at 53.5 μs per hop for any 1 second period. Or 640 hops for 16 seconds

Time of occupancy equals number of hops multiplied by the duration of one hop.

$$640 \text{ hops} * 53.5 \mu\text{s per hop} = \underline{0.034 \text{ Seconds}}$$

The EUT Complies with the standard



Date: 26.JAN.2015 16:23:52

Figure 2: 1 second sweep of 2441.75 MHz

Note: There are 40 on-channel traces as shown.

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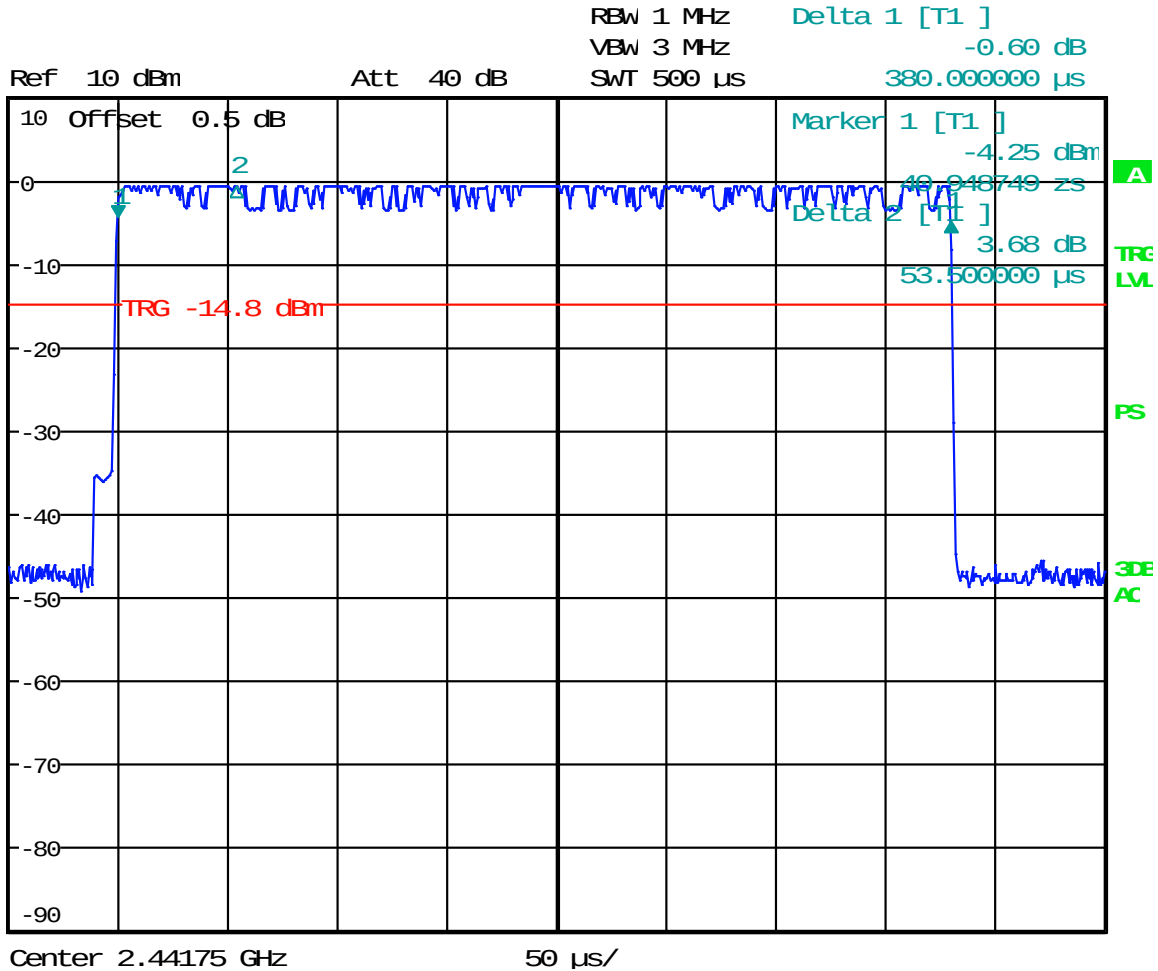
Report No.:

31550198.001

Page 28 of 40



1 F.
VIEW



Date: 26.JAN.2015 16:01:21

Figure 3: Measurement of 1 hop at 2441.75 MHz

Time on Frequency = 53.5 μ s

Spectrum Analyzer Parameters:

RBW=100kHz

Span=zero

VBW= 100kHz

LOG dB/div.= 10dB

Sweep = 200 ms

Detector = sample detector, max hold

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Report No.:
31550198.001

Page 29 of 40

5.2 Occupied Bandwidth and Channel Separation

5.2.1 Test Over View

Results	Complies (as tested per this report)					Date	26 January 2015	
Standard	FCC Part 15.247(a)(1)							
Product Model	CONTROLLER SSC				Serial#	Production Sample		
Test Set-up	Direct Measurement from antenna port							
EUT Powered By	24 VAC	Temp	72° F	Humidity	32%	Pressure	988 mbar	
Perf. Criteria	(Below Limit)			Perf. Verification		Readings Under Limit		
Mod. to EUT	None			Test Performed By		Mark Ryan		

5.2.2 Test Procedure

Frequency hopping Systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Channel Separation = 25 kHz Min. or the 20 dB bandwidth of the hopping channel, whichever is greater

The channel separation is greater than the measured maximum 20 dB bandwidth. Therefore the EUT is compliant with this section.

5.2.3 Deviations

There were no deviations from the test methodology listed in the test plan for this test.

5.2.4 Final Test

The EUT met the performance criteria requirement as specified in the test plan of this report and in the standards.

Frequency (MHz)	20dB BW (MHz)
2402	1.224
2440	1.224
2480	1.218

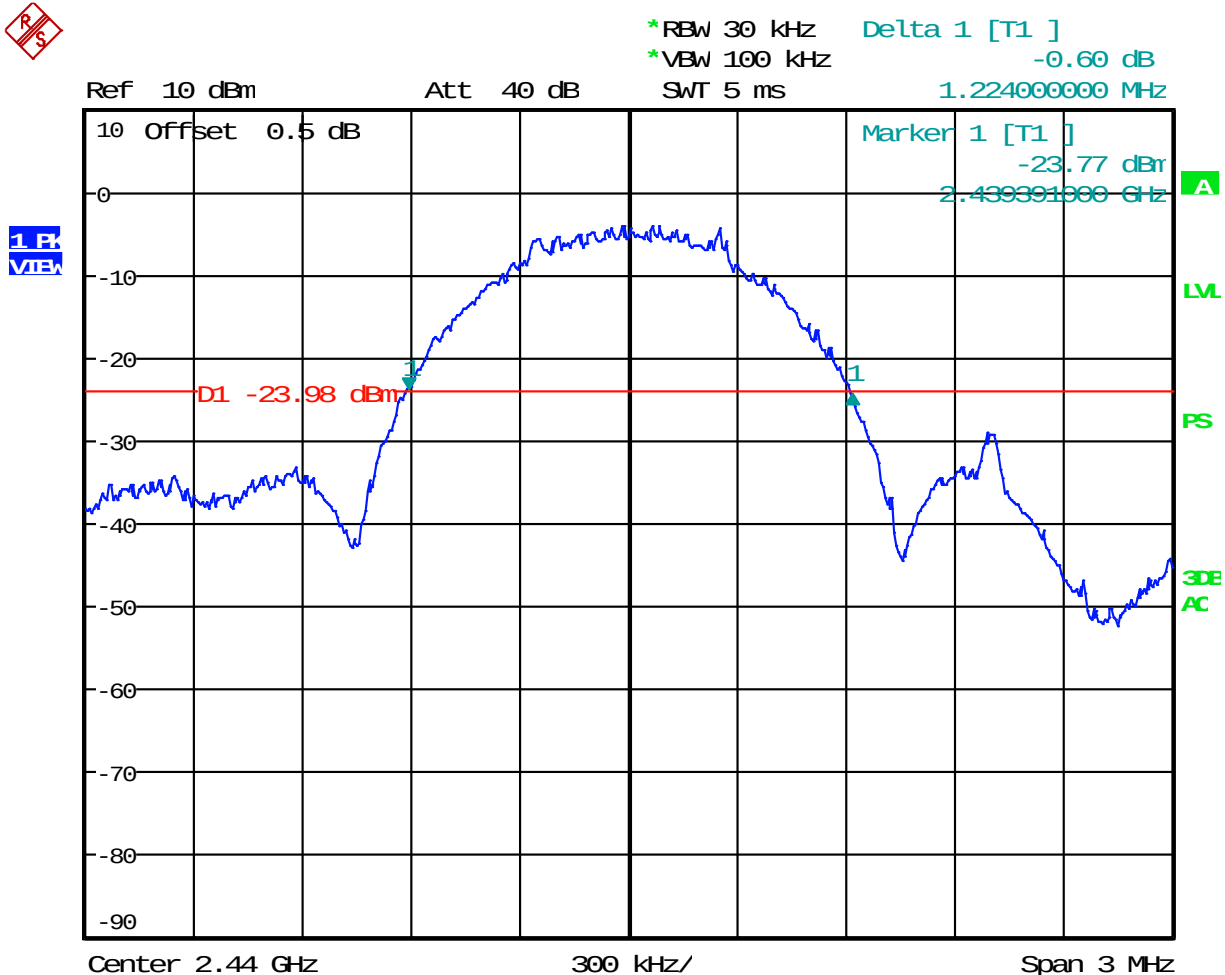
20dB Power Band Width.

Note: Minimum Channel Separation shall be 1.224 MHz

Measured Channel Separation is 2.0 MHz. this complies with the rules.

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5.2.5 Final Data – 20dB Occupied Bandwidth



Date: 26.JAN.2015 14:40:46

Line D1 is the -20 dBc for making the 20dB bandwidth measurement.

Figure 4: 20 dB Occupied Bandwidth

*BW = 324.65 KHZ

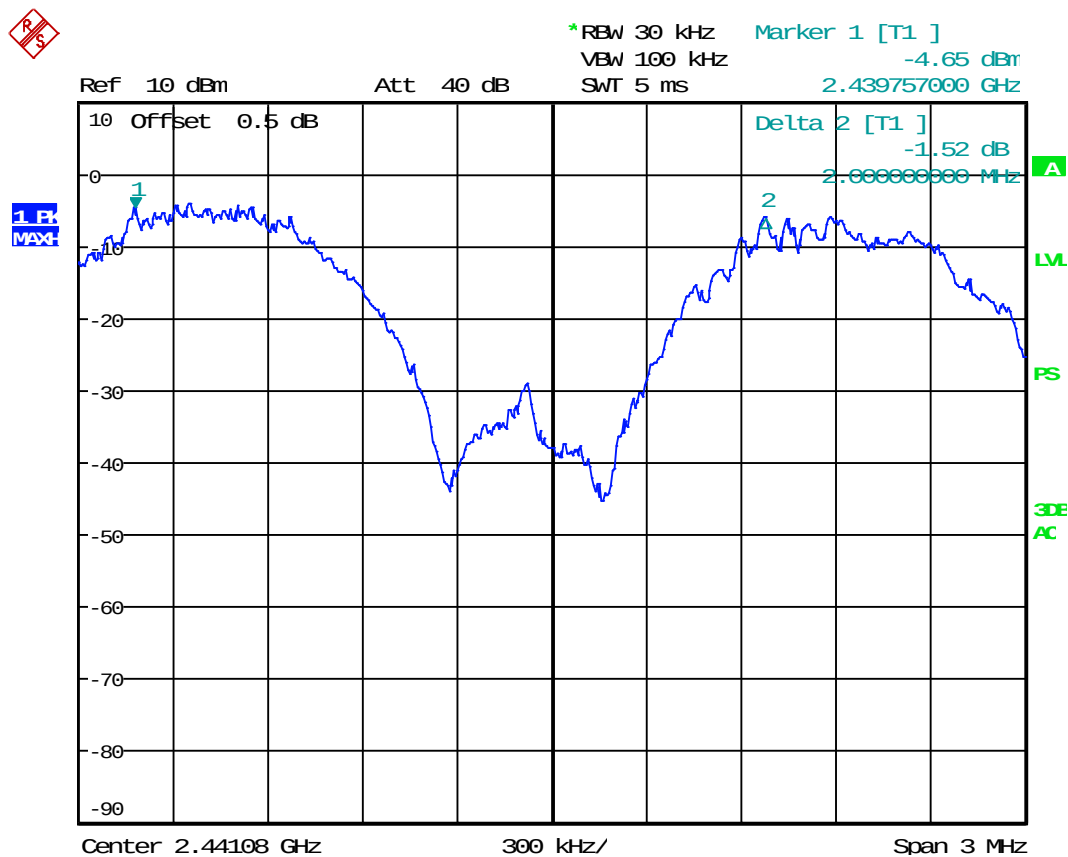
The test results contained in this report refer exclusively to the product(s) presented for testing. No liability may be assumed for models or products not referred to herein. This test report may not be published or duplicated in part without permission of the testing body. This test report by itself does not constitute authorization for the use of any TUV Rheinland test mark. The report must not be used by the client to claim product certification, approval, or endorsement by A2LA.

Report No.:

31550198.001

Page 31 of 40

5.2.6 Final Data – Channel Separation



Date: 26.JAN.2015 15:46:48

Figure 5: Channel Separation = 2 MHz

Spectrum Analyzer Parameters:

RBW=30kHz (1% of the Span)

Span=3 MHz

VBW= 100 kHz ($\geq 3 * \text{RBW}$)

LOG dB/div.= 10dB

Sweep = Auto

Detector = Peak, max hold

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Report No.:
31550198.001

Page 32 of 40

5.3 99% Power Bandwidth

For the purpose of Section A1.1, the 99% bandwidth shall be no wider than .25% of the center frequency for devices operating between 70-900MHz. For devices operating above 900 MHz, the emission shall be no wider than 0.5% of the center frequency. This device operates above 900 MHz.

5.3.1 Test Over View

Results	Complies (as tested per this report)					Date	29 January 2015	
Standard	RSS-GEN 4.6.1							
Product Model	CONTROLLER				Serial#	Production Prototype		
Test Set-up	Direct Measurement from antenna port							
EUT Powered By	24 VAC	Temp	73° F	Humidity	18%	Pressure	1010 mbar	
Perf. Criteria	(Below Limit)			Perf. Verification		Readings Under Limit		
Mod. to EUT	None			Test Performed By		Mark Ryan		

5.3.2 Test Procedure

Using the procedures of RSS-GEN section 4.6.1, the 3 kHz resolution bandwidth is 1% of the 300 kHz span. The 10 kHz video bandwidth is over 3 times that of the resolution bandwidth.

5.3.3 Deviations

There were no deviations from the test methodology listed in the test plan for the Electrical Fast transients (EFT) Immunity test.

5.3.4 Final Results

The maximum measured 99% bandwidth is 1.07 MHz.

Frequency (MHz)	99% BW (MHz)
2402	1.068
2440	1.065
2480	1.062

99% Power Band Width.

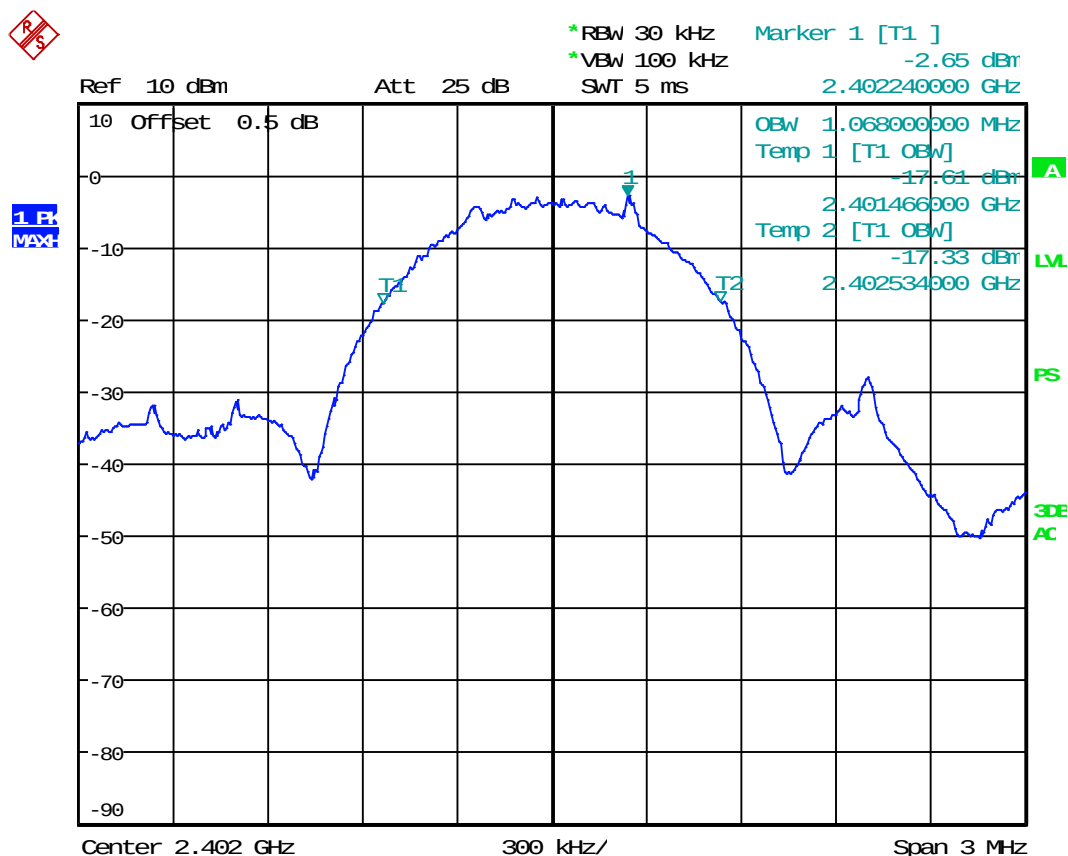
The test results contained in this report refer exclusively to the product(s) presented for testing. No liability may be assumed for models or products not referred to herein. This test report may not be published or duplicated in part without permission of the testing body. This test report by itself does not constitute authorization for the use of any TUV Rheinland test mark. The report must not be used by the client to claim product certification, approval, or endorsement by A2LA.

Report No.:

31550198.001

Page 33 of 40

5.3.5 Final Data



Date: 26.JAN.2015 14:19:37

Figure 6 – 99% Power Bandwidth = 1.068 MHz. The Worst-Case shown.
Span = 3MHz, RBW = 30 kHz (1% of Span), VBW = 100 kHz ($\geq 3 \times$ RBW)

The EUT is compliant to the requirements of RSS-210 A1.1.3

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Report No.:
31550198.001

Page 34 of 40

5.4 Band Edge requirements - FCC Part 15.247(d), RSS-210 A8.5

5.4.1 Test Over View

Results	Complies (as tested per this report)					Date	28 January 2015	
Standard	FCC Part 15.247(d) and RSS 210 A8.5							
Product Model	CONTROLLER SSC				Serial#	Production Prototype		
Test Set-up	Direct Measurement from antenna port							
EUT Powered By	24 VAC	Temp	74° F	Humidity	19%	Pressure	1008 mbar	
Perf. Criteria	(Below Limit)			Perf. Verification		Readings Under Limit		
Mod. to EUT	None			Test Performed By		Mark Ryan		

5.4.2 Test Procedure

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 20 dB below the level of the fundamental or to the general radiated emission limits in Sec. 15.209, whichever is the lesser attenuation. All emissions that fall inside a restricted band shall comply with the limits of 15.209.

5.4.3 Deviations

There were no deviations from the test methodology listed in the test plan.

5.4.4 Final Test

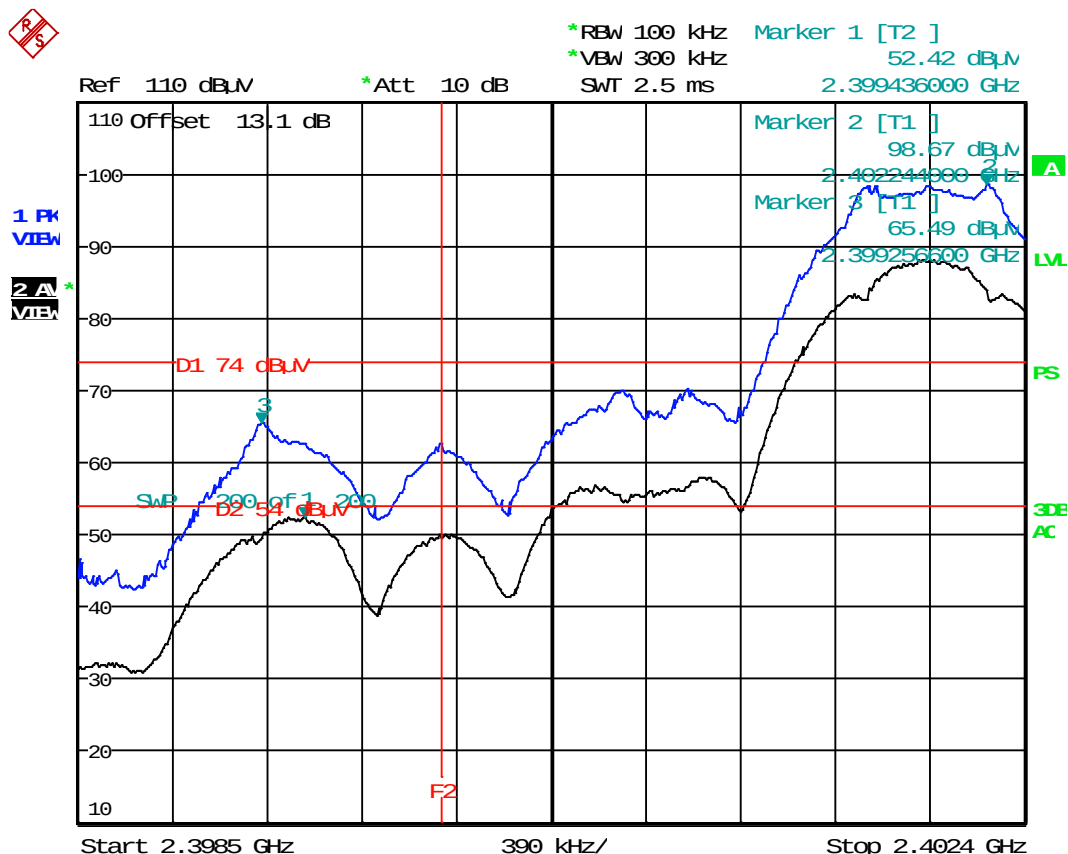
The EUT met the performance criteria requirement as specified in the standards.

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Report No.:

31550198.001

Page 35 of 40



Date: 3.MAR.2015 10:14:53

Notes: Measured using the Peak Detector, Line F1 is the Band Edge is at 2.4 GHz. Line D1 is the Restricted Band Peak limit line and line D2 is the Restricted Band Average limit line.

Plot includes Correction Factors.

The nearest restricted band (2390MHz) is 10 MHz below the band edge

The Highest frequency outside the band is at 65.49 dBμV (using the Peak Detector) which is 8.51 dB below peak Limit. The Highest frequency outside the band is at 52.42 dBμV (using the Average Detector) which is 1.58dB below Average Limit.

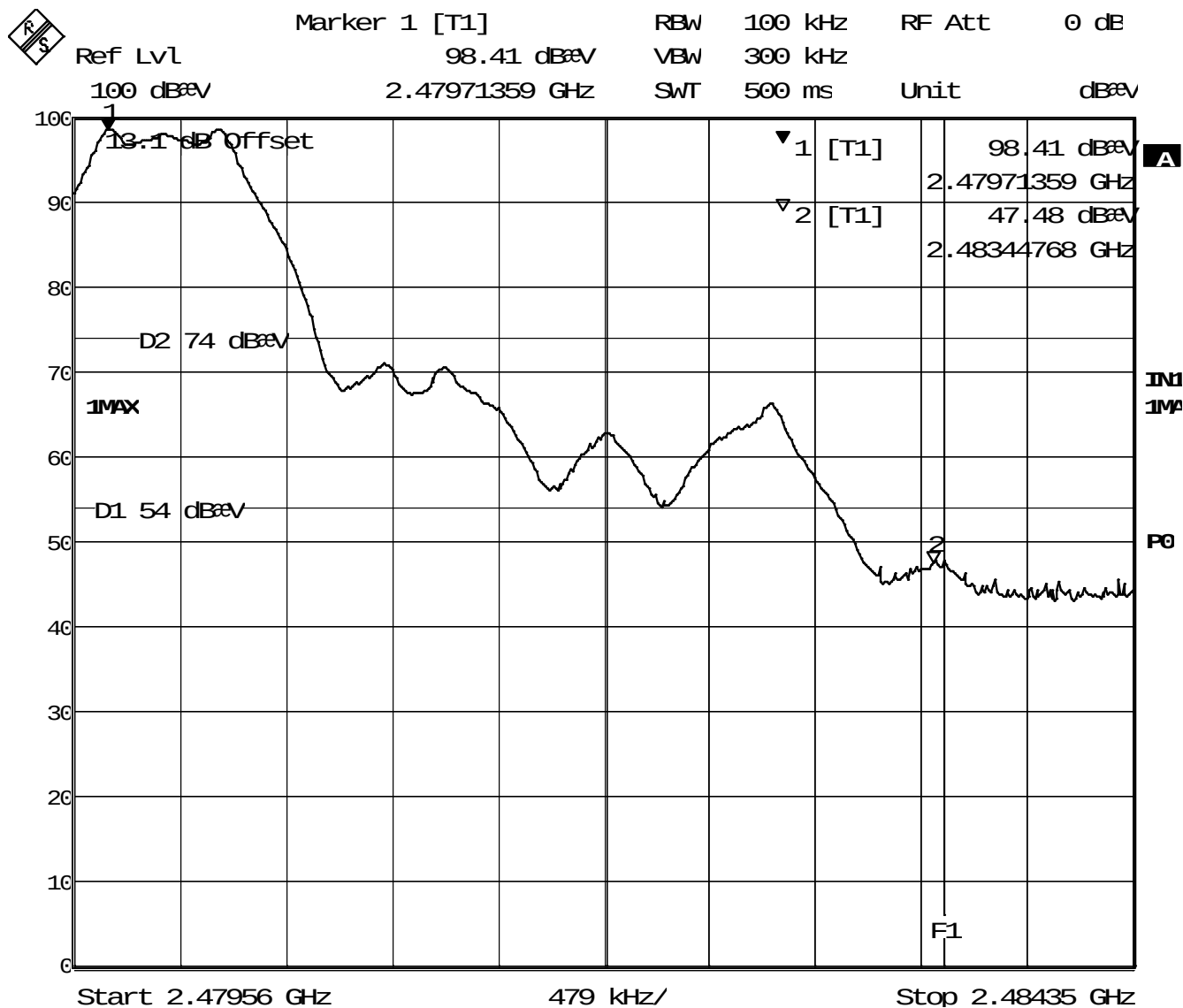
Figure 7: Lower Band Edge Measurement (Radiated Emission)

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Report No.:

31550198.001

Page 36 of 40



Date: 28. JAN. 2015 14:44:46

Note: Measured using the Peak detector. Band Edge is at 2.483.5 MHz (Line F1), line D1 is the average restricted band limit and line D2 is the peak restricted band limit.

Band edge at 2483.5 MHz is also the start of a restricted band, so the restricted band rules apply.

The Highest frequency outside the band is at 47.48 dBμV (using the Peak Detector) which is below the Average restricted-band limits)

Figure 8: Upper Band Edge Measurement (Radiated Emission)

The EUT is compliant with the rules.

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Report No.:
31550198.001

Page 37 of 40

5.5 Peak Output Power

The maximum peak output power of the intentional radiator shall not exceed 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels. (Conducted Measurement)

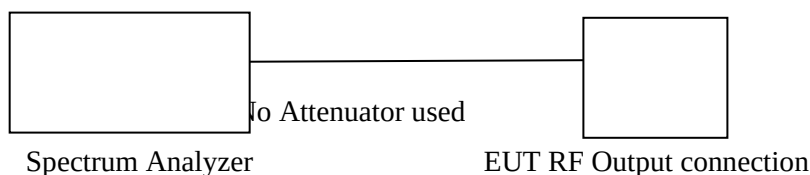
5.5.1 Test Over View

Results	Complies (as tested per this report)					Date	26 January 2015	
Standard	FCC Part 15.247(b)(1) and RSS-210 A8.4(2)							
Product Model	CONTROLLER SSC				Serial#	Production Sample		
Test Set-up	Direct Measurement from antenna port							
EUT Powered By	24 VAC	Temp	72° F	Humidity	32%	Pressure	988 mbar	
Perf. Criteria	(Below Limit)			Perf. Verification		Readings Under Limit		
Mod. to EUT	None			Test Performed By		Mark Ryan		

5.5.2 Test Procedure

The peak output power was measured at CH01, CH34, CH48, and at CH63. The measurements were made using a direct connection between the RF output of the EUT and the spectrum analyzer. The cable loss and the attenuator was measured and added in the reference level offset in the spectrum analyzer. The spectrum analyzer's resolution bandwidth was greater than the 20dB bandwidth of the modulated carrier and the video bandwidth was equal to the resolution bandwidth.

Test Setup:



5.5.3 Deviations

There were no deviations from the test methodology listed in the test plan for this test.

5.5.4 Final Test

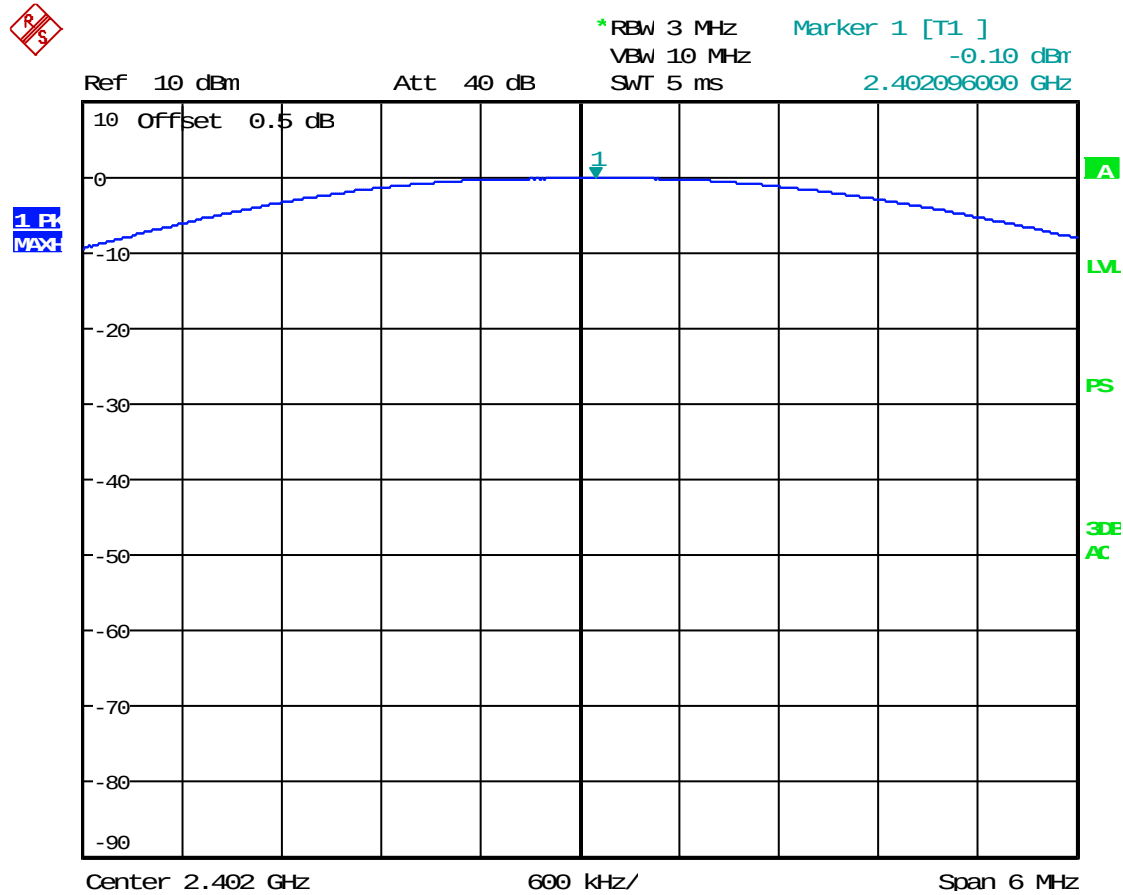
Frequency (MHz)	Power Out (dBm)	Power Out (mW)	Limit (mW)	Result
2402	-0.10	0.977	125.0	PASS
2440	-0.43	0.906	125.0	PASS
2480	-0.50	0.891	125.0	PASS

Conducted Power Output.

The EUT met the performance criteria requirement as specified in the test plan of this report and in the standards.

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5.5.5 Final Data - Peak Power Output



Date: 26.JAN.2015 15:06:46

Figure 9: CH 34 (916.0 MHz) Peak Output Power - Worst Case Shown.

Plots of other channels are on file at TUV Rheinland.

Antenna Gain

The external dipole antenna gain data was supplied separately by the manufacturer with the following data:

Results; External Antenna data

Freq. (MHz)	Peak (dBi)	Gain (Numeric)
2.4 to 2.4835	2.0	1.58

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6 RF Exposure

6.1 Exposure Requirements – FCC KDB # 447498 DO1 and RSS-102 Issue 4

FCC KDB # 447498 DO1 V05r02 - Mobile and Portable Device RF Exposure and Procedures and Equipment, Appendix A shows that the SAR Text Exclusion Threshold for a device with a separation distance of 5 mm at 2450 MHz is 10 mW.

RSS-102 section 2.5.1 states that a device is exempt from SAR evaluation if the frequency is “above 2.2 GHz and up to 3 GHz inclusively, and with output power (i.e. the higher of the conducted or radiated (EiRP.) source-based, time-averaged output power) that is less than or equal to 20 mW for general public use...”.

6.1.1 Test Procedure

If the antenna is located > 20cm from the user, then an MPE calculation is acceptable.

If the antenna is located < 20cm (portable / mobile / hand-held device) from the user, then SAR evaluation is required.

6.1.2 Evaluation

The EUT will be used as a portable device where the antenna may be located less than 20cm from the user, therefore a SAR evaluation is required.

6.1.2.1 Evaluation for FCC

FCC 447498 DO1 Mobile Portable RF Exposure V05r02, Appendix A shows that the SAR Text Exclusion Threshold for a device with a worst-case separation distance of 5mm at 2450 MHz is 10 mW.

The minimum power that requires SAR testing with a separation distance of 5mm at 2.445 GHz is 10 mW.

The maximum EiRP peak power output of the EUT is: 1.58 mW (See calculation next page).

The EUT is well below the 25mW power level.

6.1.2.2 Evaluation for Industry Canada

The maximum EiRP peak power output of the EUT is: 1.58 mW (See calculation next page).

The EUT is well below the 20mW power level.

6.1.3 Conclusion

SAR data is not required for either FCC or Industry Canada.

Note: The 1.58 mW power level has not been time-averaged. (100% Duty Cycle).
This is considered to be the absolute worst case.

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6.1.4 Calculated EiRP Level

This EiRP calculation was made using the maximum peak value in section 5.6.4 of this report (Page 39) which is 0.997mW.

The manufacturer of the chipset used in this device states that the power output is 1.0mW. This is the value used for this calculation.

6.1.5 Antenna Gain Calculation:

The antenna used in the EUT is a Pulse Electronics W1030 dipole antenna that utilizes a reverse SMA connector.

6.1.6 Maximum Output Power (EiRP):

The stated Maximum output power, by the Manufacturer of the chipset, is 1 mW or 0 dBm.

The Published Gain of the antenna is **2.0 dBi** or a numeric gain of: **1.58**.

The Maximum EiRP output is 0 dBm + 2 dBi = **2 dBm** EiRP

Or $1 \text{ mW} * 1.58 = \mathbf{\underline{1.58mW}}$ EiRP

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