APPLIED TEST LAB INC.

FCC Part 15C TEST REPORT

DTS (2400-2483.5 MHz)

Limits Applied: FCC 15.247

Report#: N001E043-S-31

Manufacturer: NovAtel Inc.
Model: SMART7-SPi
Serial Number: NMRT18060020P, NMPX18070015K
Test Start Date: 2018-03-07
Test Completion Date: 2018-03-25
Test Result: PASS
Report Issue Date: 2018-06-21

Tested by	Approved by:
Jaeheon Yun, Test specialist	Adiseshu Nyshadham, Quality Prime

Report Issued to	Report Issued by
NovAtel Inc. 1120 - 68 Avenue NE Calgary, AB, T2E 8S5	Applied Test Lab Inc. Unit 4174-3961 52 Ave NE Calgary, AB, T3J 0J8

Report Revision History

Rev	Description of Change	Date
Draft01	Initial	2018-05-07
Release	Title page and information(Page 1, 2, 5, 6, 8, 11-13, 22-27, 29, 31, 34, 38, 40, 41)	2018-05-30
Release 2	Title page and information(Page 1, 10, 22, 28, 29, 31, 33, 35, 39)	2018-06-21

Applied Test Lab Inc. (ATL) test facilities are recognized by FCC and Industry Canada to perform the test(s) listed in this report, except where noted otherwise. This report and the information contained herein represent the results of testing test articles identified and selected by the client performed to specifications and or procedures selected by the client. ATL makes no representations, expressed or implied, that such testing is adequate (or inadequate) to demonstrate efficiency, performance, reliability, or other characteristic of the article being tested, or similar products. This report should not be relied up on as an endorsement or certification by ATL of the equipment tested, nor does it represent any statement whatsoever as to its merchantability or fitness of the test article, or similar products, for a particular purpose. The report must not be used by client to claim product endorsement by FCC or Industry Canada. Any use which a third party makes of this report, or any reliance on or decisions to be made on it, are the responsibility of such third parties. ATL accepts no responsibility for damages suffered by any third party as a result of decisions made or actions based on this report. This report shall not be reproduced except in full without the written approval of ATL

This report contains **43** pages

Table of Contents

1.0 General....3
1.1 Purpose....3
1.2 Relevant Standards and References....3
1.3 Performance Requirement....3
1.4 Test Results Summary....4
1.5 Test Facility Information....4
1.6 Client Information....4
2.0Test Sample Information....5
2.1 Equipment Under Test (EUT)....5
2.2 Support Equipment and Details....6
2.3 I/O Ports and Details....6
2.4 I/O Cable Descriptions....6
3.0 Test Facilities....7
3.1 Semi-Anechoic Chamber Test Site Description....8
3.2 A diagram of the Semi-Anechoic Chamber Test Site....10
3.3 Test Equipment List....11
4.0 Test Setup Description....12
4.1 EUT System Block Diagram and Support Equipment....12
4.2 Test Setup Photographs Radiated Emission(0.009MHz - 30MHz)....14
4.3 Test Setup Photographs Radiated Emission(30MHz - 1000MHz)....15
4.4 Test Setup Photographs Radiated Emission(1000MHz - 18000MHz)....16
4.5 Test Setup Photographs Radiated Emission(18000MHz - 26000MHz)....17
4.6 Test Setup Photographs Antenna Conducted Emission(9kHz - 26000MHz)....18
5.0 Test Methodology....19
5.1 Method of measurement of radiated emissions or disturbance....19
5.2 Test Criteria....21
5.2.1 Radiated Emission Limits FCC Part 15.209/15.247(d) at a distance of 3 (m) 21
6.0 Test Results....22
6.1 FCC 15.247(b)(3) Output Power(2400-2483.5MHz DTS)....22
6.2 FCC 15.247(d) RF Conducted Emissions & Band Edge....26
6.3 FCC 15. 247(d) Radiated Emission & Band Edge....31
7.0 Appendix A – Test Sample Description....40
8.0 Appendix B – List of Abbreviations and Acronyms....42

1.0 General

1.1 Purpose

The purpose of this report is to document conformance with FCC Part 15 Subpart C – 15.247(DTS) and to detail the results of testing performed on the sample Model: **SMART7-SPi** manufactured by **NovAtel Inc.**. The test sample was received in good condition. Testing began **2018-03-07** on and was completed on **2018-03-25**.

1.2 Relevant Standards and References

One or more of the following standards were used to evaluate the EUT:

1. **ANSI C63.4-2014:** American National Standard for Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the 9 kHz to 40 GHz
2. **US Code of Federal Regulations (CFR):** Part 15 Sub part C Title 47, Radio Frequency Devices - Intentional Radiators
3. **KDB 558074 D01 DTS Meas Guidance v04 2017-04 –** Guidance for performing compliance measurements on Digital Transmission System(DTS) operating under section 15.247

1.3 Performance Requirement

The EUT is marketed as **FCC Part 15 Subpart C** equipment and must comply with the **FCC 15.247(DTS)** emission limits and requirements.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increase emission levels should be checked and verified to ensure continuous compliance has been maintained (i.e., printed circuit board layout changes, changes to filter performance, power supply changes, I/O cable and interface changes, critical component changes etc.)

1.4 Test Results Summary

Test Type	Basic Standard	Modifications	Result
6 dB Bandwidth	15.247(a)(2)	No	NP
Output power	15.247(b)(3)	No	PASS
Power Spectral Density	15.247(e)	No	NP
RF Conducted Emissions & Band edge	15.247(d)	No	PASS
Radiated Emissions & Band edge	15.247(d)	No	PASS

NP=ATL was not contracted to perform the test.

1.5 Test Facility Information

Name	Applied Test Lab Inc.		
Address	Unit 4174-3961 52nd Avenue NE, Calgary, Alberta, T3J 0J8, Canada		
Telephone	403 590 8701	**Fax**	403 590 8570
Email	emctesting@appliedtestlab.com	**Website**	www.appliedtestlab.com
FCC Registration	950875	**IC Recognition**	10988A

1.6 Client Information

Name	**NovAtel Inc.**		
Address	1120 - 68 Avenue NE Calgary, AB, T2E 8S5		
Telephone	403 295 4401	**Website**	www.novatel.com
Contact Name	Jim Turner	**Contact Email**	Jim.turner@novatel.com

2.0 Test Sample Information

The **SMART7-SPi** was only operated and exercised in the mode(s) and configuration(s) described in this report. All inputs and outputs to and from support equipment associated with the **SMART7-SPi** were provided or simulated under the direction and responsibility of **NovAtel Inc.**. A description of these signals and their provision is included in Appendix A.

2.1 Equipment Under Test (EUT)

Product Description	SMART7-SPi, Stand-Alone Equipment
Manufacturer	**NovAtel Inc.**
Trade Name	SMART7-SPi
Model Number	**SMART7-SPi**
Enclosure Part Number	**01019990**
Serial Number	**NMRT18060020P, NMPX18070015K**
Model discrepancy/Variations	N/A
Power Supply and Requirements	+7VDC to +30VDC, Nominal 14V DC
Firmware Version	OM7CR0302SN0002(GNSS Receiver), 1.7.0. RF module
Software Version	CPTERM(2.00V638) - Command Prompt Terminal, Slog.exe(2.00V663) - Scriptable Logging Tool, Skyplot(2.00V564) - GNSS Data Analyzer, WifiConfigSequencer.exe(Redpine WiFi Test Utility 3.0.2.0) - Utility to control Redpine WiFi Module
Antenna Type and Gain	Integral Trace, 3dBi
Antenna Connection Type	Integral (External connector with small cable provided to facilitate testing)
Type of Wideband System	802.11.b/g/n20
Operation Frequency Range	2400-2483.5MHz
Modulation type(s)	CCK, DQPSK, PBCC, BPSK, QPSK, OFDM, 16-QAM, 64-QAM
Maximum Duty Cycle	Tested 100%
Number of TX Chains	1
Other Information	See NovAtel document D22610
Product Manufacturing Status	☐Production Unit ☒Pre-Production Unit

2.2 Support Equipment and Details

☒**Applicable**

Manufacturer	Description	Model No.	Serial Number	Other Info
Panasonic	AC/DC Adaptor	CF-AA5713A M3	5713AM317110741D	Emission
Panasonic	Emission Laptop	CF-313A011KM	7EKWA16019	Emission
Instek	DC Power Supply	PC-3030	9572228	Emission
Kirkland	DC battery	207250	096612072511	Emission
Mini-circuit	BIAS TEE	ZFBT-4R2G-FT+	RUU01201741	Emission
Mini-circuit	Attenuator	2, 4, 8dB		
MOXA	USB to Serial hub	Uport 1450	TACJB1002376	Emission
Vector	CAN interface	VN1610	007150-028550	Emission
NovAtel	GNSS Active Antenna	702GGL	N/A	Emission
NovAtel	SMART7Spi Harness cable	01019944	N/A	Emission
NovAtel/Phoenix contract	SMART7Spi LAN cable	1404303	N/A	Emission

2.3 I/O Ports and Details

☒**Applicable**

Port Type	Description	Filter Info	Shielding Info	Other Info
14 Pin AMPSEAL Connector	RS232 COM port (1,2,3), CANBUS, EVENT	No	Shielded	UUT16
4 Pin M12-D Connector	Ethernet port	No	Shielded	UUT16

2.4 I/O Cable Descriptions

☒**Applicable**

Cable Description	Length (m)	Port From	Port To	Cable Type	Remarks
COM cable	2	Laptop	EUT	Shielded	UUT16
Power cable	2	DC battery	EUT	Unshielded	UUT16
Ethernet cable	5	Router	EUT	Shielded	UUT16
SMART7 Cable Harness Part# 01019944	2	Ext.cables	EUT	Shielded	UUT16

3.0 Test Facilities

Laboratory Location

The radiated and conducted emission test sites are located at the following address:

Applied Test Lab,
Unit 4174, 3961-52 Ave N.E., Calgary, AB T3J 0J8

Laboratory Accreditation/Recognitions/Certifications

The Semi-Anechoic Chamber Test Site and Conducted Emission Site have been fully described, submitted to, and accepted by the FCC and Industry Canada for testing Interference by information technology equipment. In addition, ATL has implemented an interim in-house quality system which is based on the ISO 17025 standard and is actively pursuing to achieve its accreditation. The following certification numbers have been issued in recognition of the certifications:

FCC Registration Number: **950875**
Industry Canada Lab Code: **IC 10988A**

Country	Agency	Accreditation/Certification	LOGO
USA	FCC	3 (m) Semi-Anechoic Chamber to perform FCC Part 15/18 measurements	
Canada	Industry Canada	3 (m) Semi-Anechoic Chamber to perform ICES-004 and RSS measurements	Industry Canada Industrie Canada

Note: Unless otherwise specified, ATL performs the tests using standard test methods to evaluate the EUT for compliance to the defined International standards. However, the report is not to be used to claim compliance, certification or endorsement by FCC or Industry Canada or any other government agency unless specifically submitted to such agency for such purpose.

3.1 Semi-Anechoic Chamber Test Site Description

The Semi-Anechoic Chamber Test Site consists of a 6.24 x 9.144 x 5.79 (m) shielded enclosure. The chamber is lined with SAMWAH Ferrite Grid Absorber, model number SN-20. The ferrite tile grid is 100 x 100x 6.7 (mm) thick and weighs approximately 200 (grams). These tiles are mounted on steel panels and installed directly on the inner walls of the chamber. Inner side Wall is lined by 600H Foam Absorber with White Cap. Chamber is illuminated by set of 12 LED Bulbs.

The turntable is 198 (cm) in diameter and is located 160 (cm) from the back wall of the chamber. The chamber is grounded via Utility Ground installed at the side of the back East wall, it is bound to the Chamber ground Stud using 1/2" copper braided cable.

The turntable is all aluminum, flush mounted table installed in an all steel frame. The table is remotely operated from the control area located outside the Semi Anechoic Chamber. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

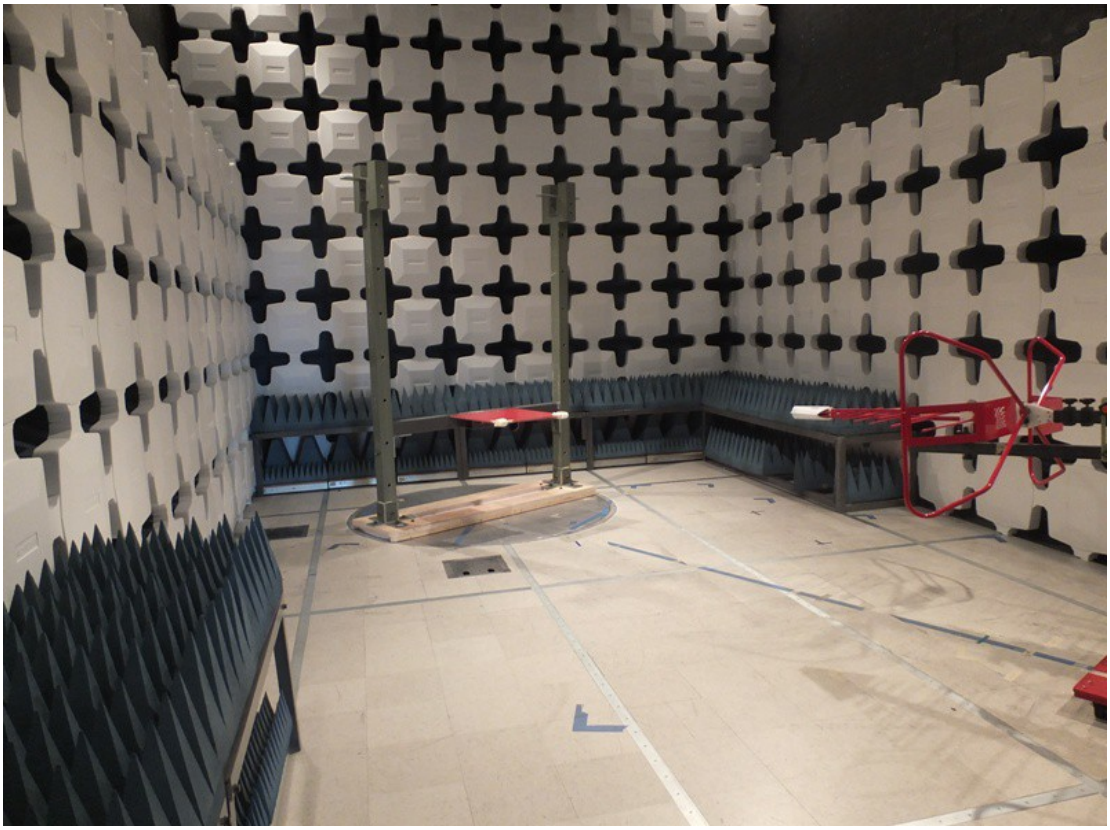

Figure 3.1 - Test Facility (Setup for 30MHz - 1000MHz)

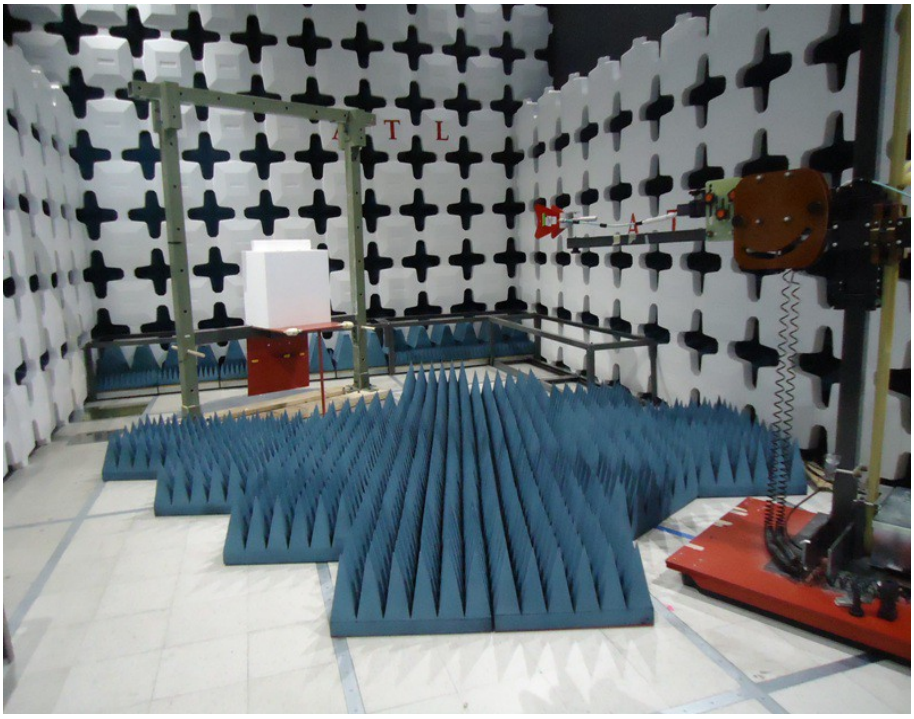

Figure 3.2 - Test Facility (Setup for 1GHz - 18GHz)

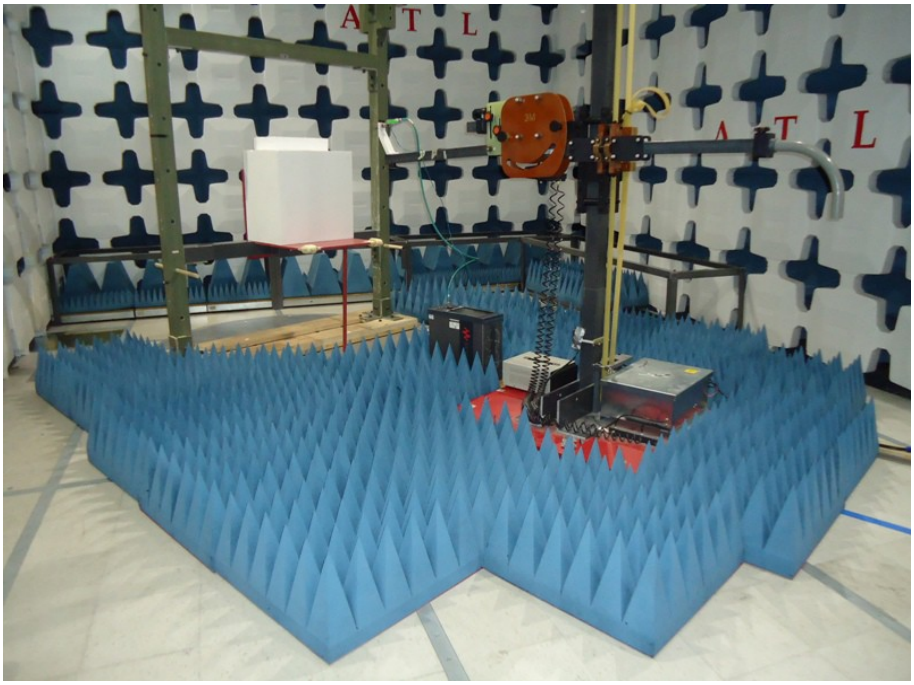

Figure 3.3 - Test Facility (Setup for 18GHz - 26GHz)

3.2 A diagram of the Semi-Anechoic Chamber Test Site

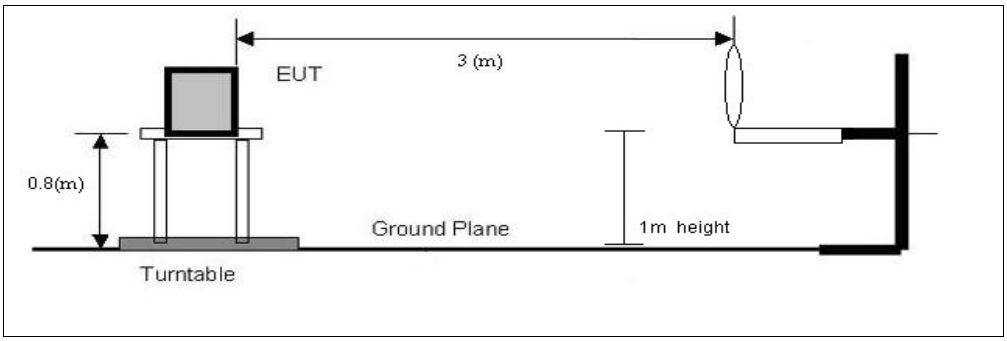

Figure 3.4 - Semi- Anechoic chamber diagram(0.009MHz - 30MHz)

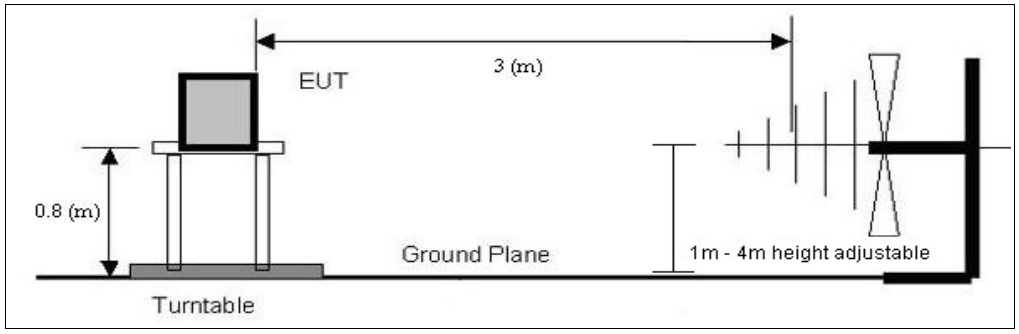

Figure 3.5 - Semi- Anechoic chamber diagram(30MHz - 1000MHz)

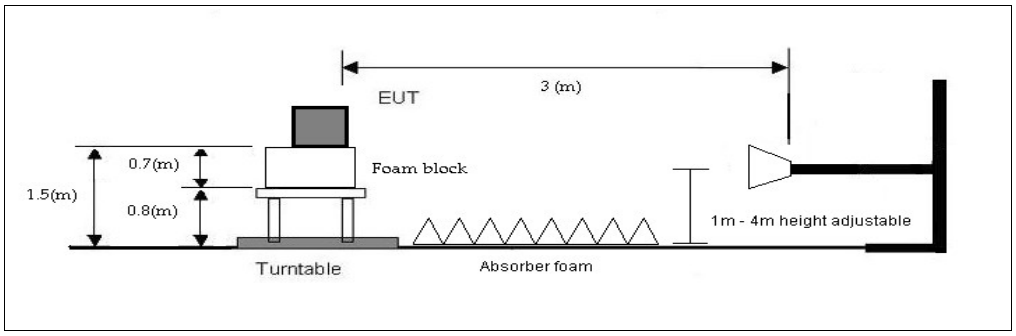

Figure 3.6 - Semi- Anechoic chamber diagram(1000MHz – 18000MHz)

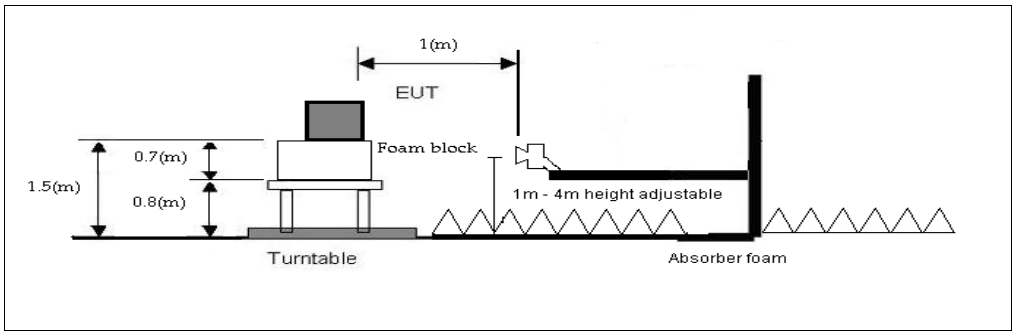

Figure 3.7 - Semi- Anechoic chamber diagram(18000MHz – 26000MHz)

3.3 Test Equipment List

Table 3.1 - Test Equipment used for Radiated Emission

Description	Manufacturer	Model Number	Serial Number	Next Cal
Bi-Log antenna	ETS Lindgren	3142E	144760	April 29, 2018
Double Ridged Horn	ETS Lindgren	3117	143094	May 5, 2019
Spectrum Analyzer	Hewlett Packard	Hp8593EM	3639A00172	Mar 21, 2020
EMI Receiver & RF filter section	Hewlett Packard	8546A, 85460A	3448A00267, 3448A00245	May 13, 2018
MXA Signal Analyzer	Keysight	N9020B-526	SG56080714	October 13, 2019
Cable	Micro Coax UTIFLEX	UFB293C	303	PV
Cable	Micro Coax UTIFLEX	UFB311A	SFC220863	PV
Cable	Micro Coax UTIFLEX	UFA210B-0-0120-50250	96G1557	PV
Turntable	ETS Lindgren	2187	NA	NCR
Antenna Bore-sight Mast	ETS Lindgren	2071B	136243	NCR
Multi Device Controller	ETS Lindgren	ETS 2090	148017	NCR
3 Meter chamber	ETS Lindgren	FACT 3-2.0	N/A	July 18, 2019
LNA	MITEQ	AMF-7D-01001800-22-10P	1782797	PV
LNA	Wenteq Microwave CORP	ABL0300-00-4030	N/A	PV
DC power supply	Instek	PC-3030	9503310	PV
Test SW	DVT Solutions Inc	REDvtAtlV3p29.exe - (20170610)		

NOTE: The measurement uncertainty is less than +/- 4.4 (dB) which is evaluated as per the NAMAS NIS 81 and CISPR 16-4-2
NCR: No Calibration required.
PV:Periodic Verification

4.0 Test Setup Description

4.1 EUT System Block Diagram and Support Equipment

☐ **Applicable**

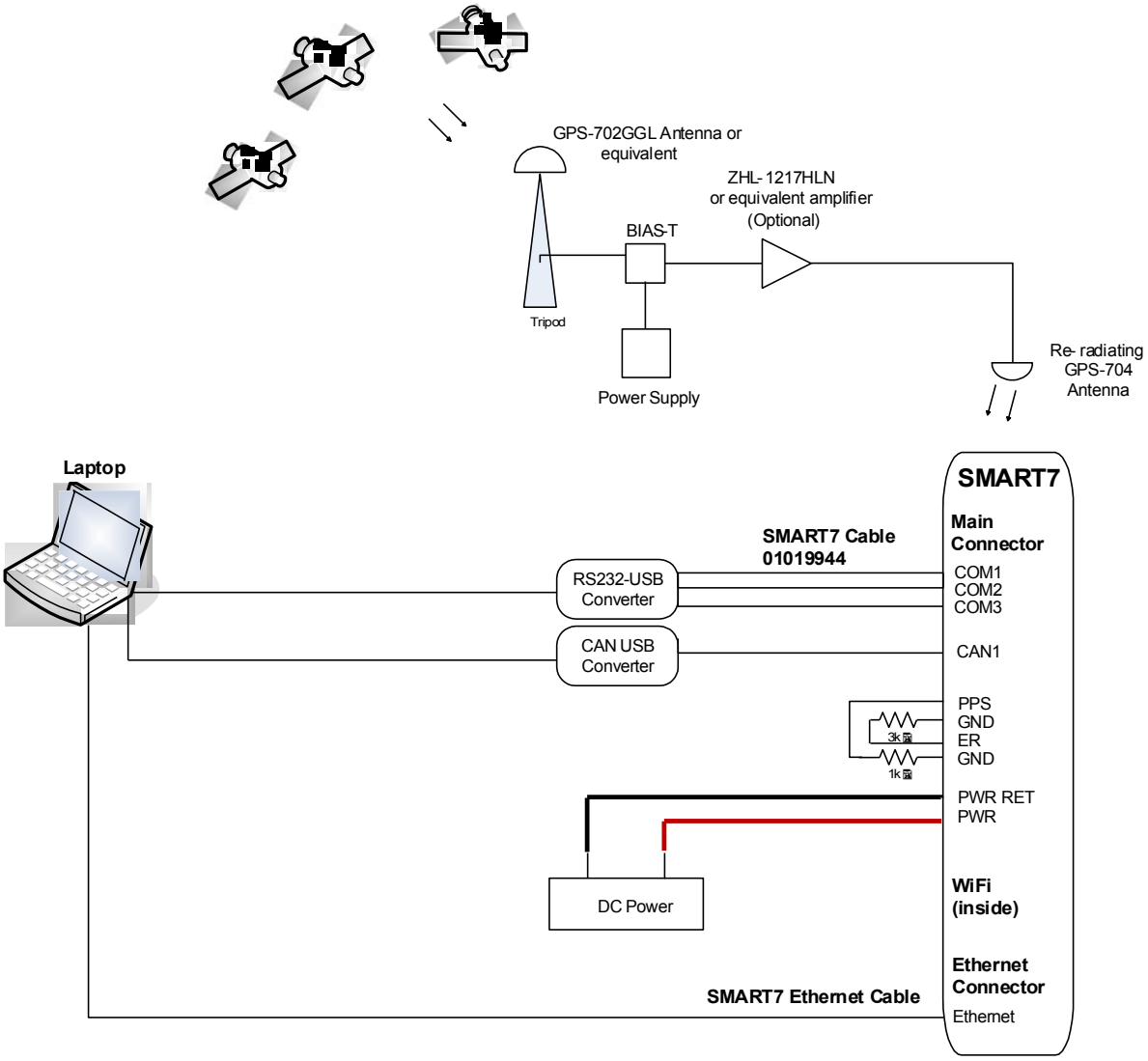

Figure 4.1a – Test setup for Radiated Emission measurement in Data Collection Mode Only.

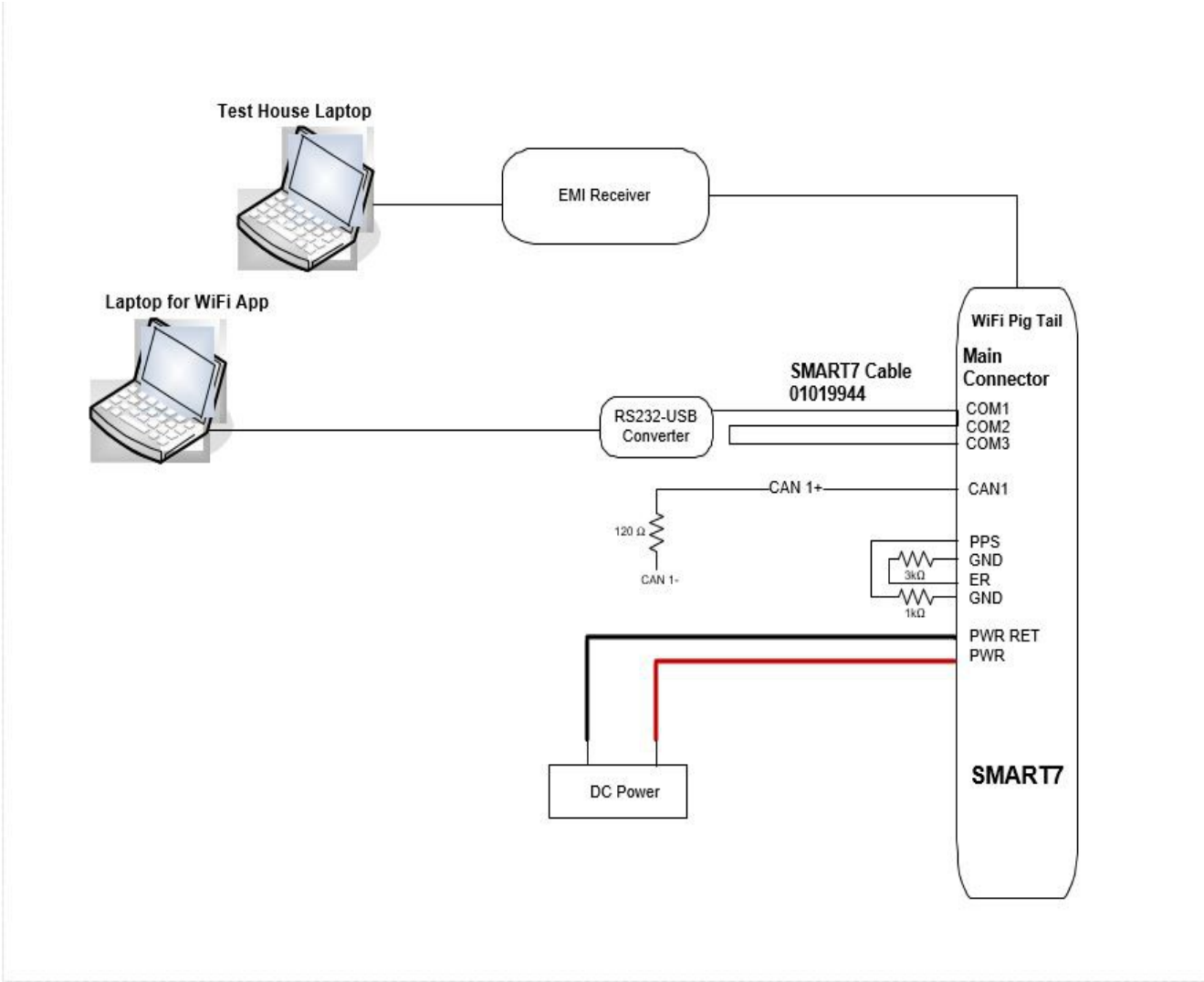

Figure 4.1b - Test setup for Conducted Emission measurement – Antenna port

4.2 Test Setup Photographs Radiated Emission(0.009MHz - 30MHz)

☒**Applicable**

Figure 4.2 - Radiated Emission Test Setup - Front View

Figure 4.3 - Radiated Emission Test Setup - Side View

4.3 Test Setup Photographs Radiated Emission(30MHz - 1000MHz)

☒**Applicable**

Figure 4.4 - Radiated Emission Test Setup - Front View

Figure 4.5 - Radiated Emission Test Setup - Side View

4.4 Test Setup Photographs Radiated Emission(1000MHz - 18000MHz)

☒**Applicable**

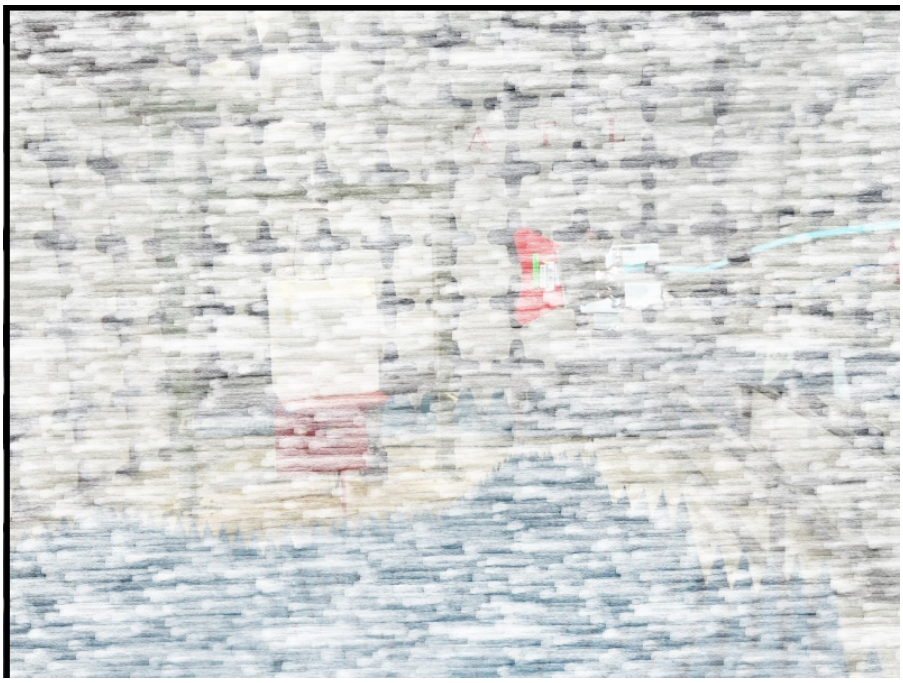

Figure 4.6 - Radiated Emission Test Setup - Front View

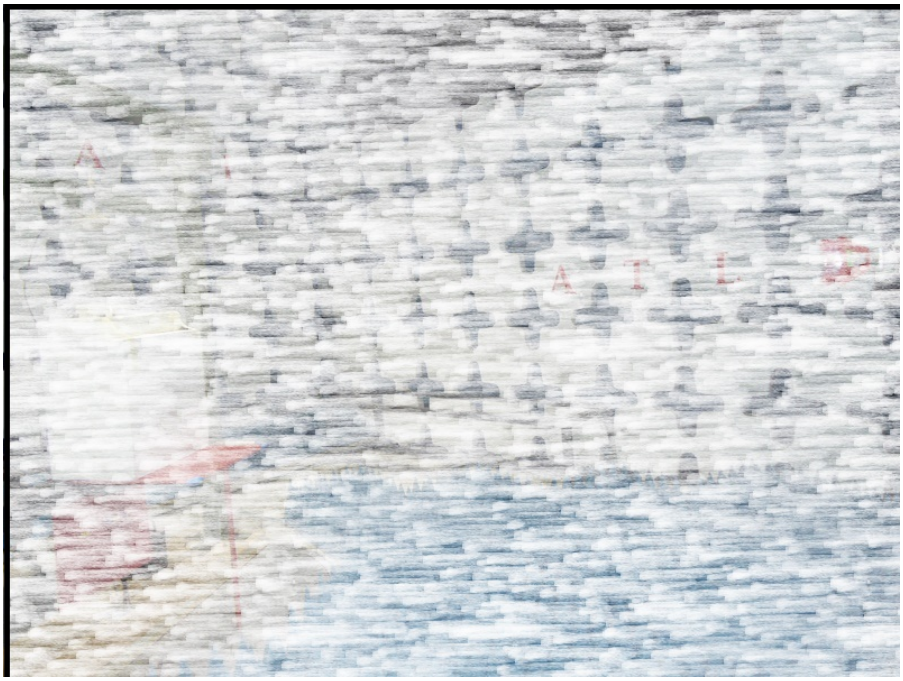

Figure 4.7 - Radiated Emission Test Setup - Side View

4.5 Test Setup Photographs Radiated Emission(18000MHz - 26000MHz)

☒**Applicable**

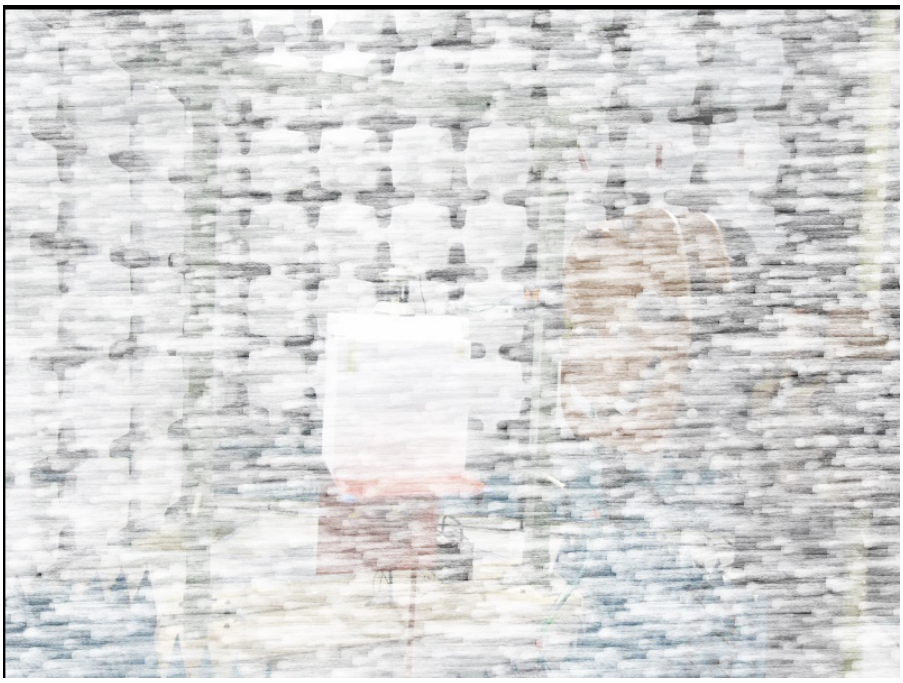

Figure 4.8 - Radiated Emission Test Setup - Front View

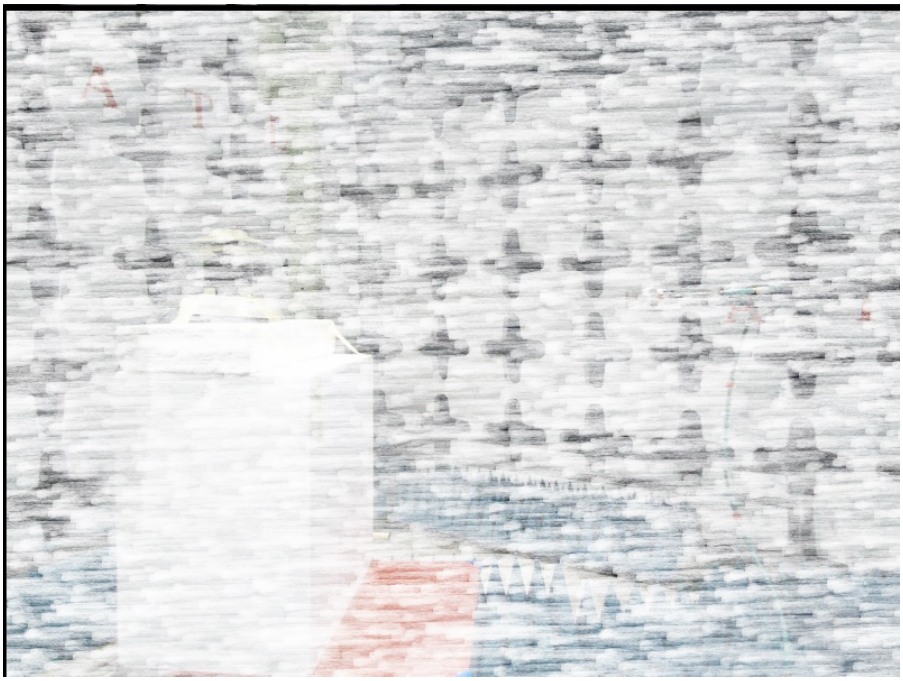

Figure 4.9 - Radiated Emission Test Setup - Side View

4.6 Test Setup Photographs Antenna Conducted Emission(9kHz - 26000MHz)

☒**Applicable**

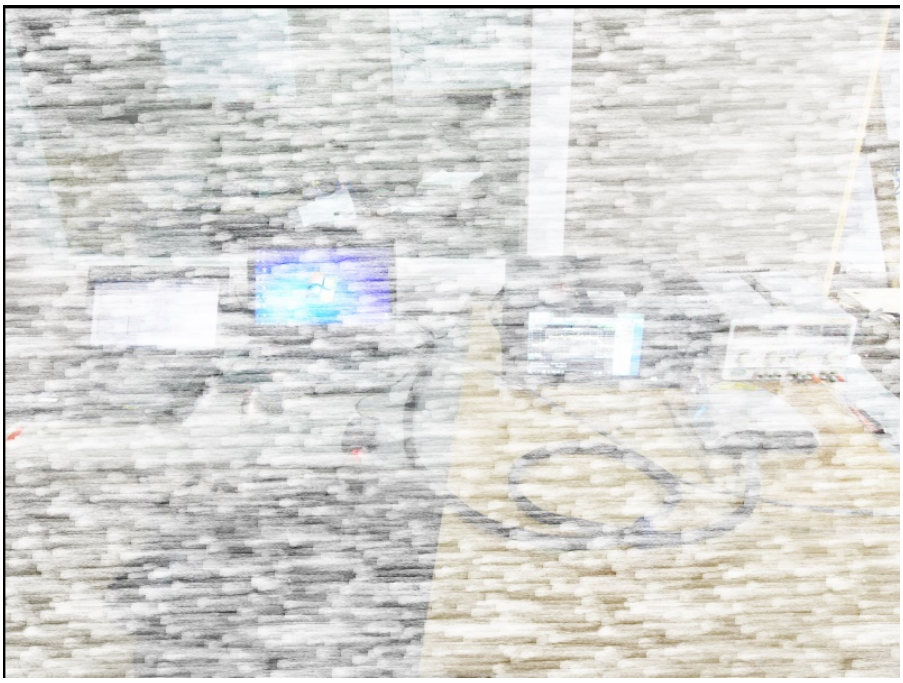

Figure 4.10 – Antenna Conducted Emission Test Setup

5.0 Test Methodology

5.1 Method of measurement of radiated emissions or disturbance

Testing Setup/Configuration

Unless otherwise indicated, the following configuration steps are used for the equipment setup: The cable(s) were routed consistent with the typical application and installation instructions provided with the test sample. Interface cables were connected to the available ports of the test unit. The effect of varying the position of the cable(s) was investigated to find the configuration that produced maximum emissions. Cable(s) were of the type and length as specified in the individual requirements. The length(s) of cable(s) that produced maximum emissions was selected.

The equipment under test(EUT) was set up in a manner that is represented its normal use, as shown in the setup photographs. Any special conditions required for the EUT to operate normally are identified in the comments that accompany the emissions tables.

The emissions data was measured with a spectrum analyzer or receiver using the applicable correction factors for distance, antenna, cable loss and amplifier gain, the data was reduced as shown below. The corrected data was then compared to the applicable emission limits. Preliminary and final measurements were performed in order to ensure that all emissions from the EUT were detected and maximized.

Correction Factors

The highest emission reading from spectrum analyzer was converted using correction factors as shown (Analyzer/Receiver) in the formula. For radiated emissions in dBuV/m, the spectrum analyzer reading in dBuV was corrected by using the following formula. This corrected reading was then compared to the applicable specification limit and the results are presented in the margin column. The margin was calculated based on subtracting the specification limit value from the corrected measurement data; a positive margin represents a measurement exceeding the specification limit, while a negative margin represents a measurement less the the specification limit.

Corrected Reading (dBuV/m) = Analyzer/Receiver Reading(dBuV) + Correction Factor(dB/m)
Correction Factor (dB/m) = Cable Loss(dB) + Antenna Factor(dB/m)-((Preamplifier Gain)(dB))
Margin (dB) = Corrected Reading(dBuV/m) - Applicable Limit(dBuV/m)

Test Instrumentation and Analyzer settings

The test instrumentation and equipment listed were used to collect the emissions data. A spectrum analyzer or receiver was used for all measurements. Unless otherwise specified, the following table shows the measuring equipment bandwidth settings that were in designated frequency bands. For testing emissions, an appropriate reference level and a vertical scale size of 10dB per division were used.

Measuring equipment bandwidth setting per frequency range			
Test	Start	Stop	Band width setting
Conducted Emissions	150kHz	30MHz	9kHz
Radiated Emissions	9kHz	150kHz	200Hz
Radiated Emissions	150kHz	30MHz	9kHz
Radiated Emissions	30MHz	1000MHz	120kHz
Radiated Emissions	1000MHz	>1GHz	1MHz

Spectrum Analyzer / Receiver Detector Functions

The notes that accompany the measurements contained in the emissions tables indicate the type of the detector function used to obtain the given readings. Unless otherwise noted, all readings were made in the “positive peak” detector mode. Whenever a “quasi-peak” or “average” reading was recorded, the measurement was annotated with a “QP or an “AVG” on appropriate rows of the data sheets. In case where quasi-peak or average limits were employed and exits for multiple measurement types for the same frequency then the peak measurement was retained in the report for reference.

5.2 Test Criteria

5.2.1 Radiated Emission Limits FCC Part 15.209/15.247(d) at a distance of 3 (m)

Frequency range of radiated measurements.
(a) Unless otherwise noted in the specific rule section under which the equipment operates for an intentional radiator the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:

(1) If the intentional radiator operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

(2) If the intentional radiator operates at or above 10 GHz and below 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.

(3) If the intentional radiator operates at or above 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 200 GHz, whichever is lower, unless specified otherwise elsewhere in the rules.

(4) If the intentional radiator contains a digital device, regardless of whether this digital device controls the functions of the intentional radiator or the digital device is used for additional control or function purposes other than to enable the operation of the intentional radiator, the frequency range shall be investigated up to the range specified in paragraphs (a)(1)-(a)(3) of this section or the range applicable to the digital device, as shown in paragraph (b)(1) of this Section, whichever is the higher frequency range of investigation.

☒**Applicable**

Table 5.6 - Radiated Emission Part 15.209 Limits(FCC)

Emission Type	Frequency Range (MHz)	FCC @ 3 (m) (dBuV/m)	
		Quasi-peak	Average
Radiated Emission	0.009 - 0.490	-	128.52 to 93.8
	0.490 – 1.705	-	73.8 to 62.97
	1.705 - 30	-	69.54
	30 - 88	40	-
	88 - 216	43.52	-
	216 - 960	46.02	-
	960 - 1000	53.98	-
	Above 1000	-	53.98
	2400 – 2483.5	-	137

6.0 Test Results

6.1 FCC 15.247(b)(3) Output Power(2400-2483.5MHz DTS)

☒**Applicable**

Table 6.1 – Output Power(2400-2483.5MHz DTS) information

CLIENT:	**NovAtel Inc.**	**TEST STANDARD:**	**FCC 15.247(b)(3)**
MODEL NUMBER:	**SMART7-SPi**	**PRODUCT:**	SMART7-SPi
SERIAL NUMBER:	**NMPX18070015K**	**CLASS:**	**FCC 15.247**
TEMPERATURE:	24.5°C	**HUMIDITY:**	21%
TESTED BY:	Taekyun Kim	**DATE OF TEST:**	2018-03-07
TESTREFERENCE:	ANSI C63.10(2013) Clause 11.9.2.2 Method AVGSA-1, KDB 558074 (April 5, 2017)		
TEST VOLTAGE:	7VDC, 14VDC, 28VDC, 36VDC (The rated voltage specifications are +7V to +30V DC Only)		
SETUP:	The EUT is DC powered through a DC power supply. The EUT is connected to a MOXA using RS232 port, MOXA is then connected to Laptop using USB port. The EUT is continuously transmitting. Low, Mid and High channels as well as all data rates were investigated, worst case data reported. The EUT was fitted with a temporary antenna port for direct conducted measurements.		
FREQUENCY RANGE	Fundamental		
FREQUENCY TESTED:	2412MHz, 2442MHz, 2462MHz		
FIRMWARE POWER SETTING	10 dBm (Maximum power)		
EUT FIRMWARE	OM7CR0302SN0002, 1.7.0. RF module		
MODULATION/DATA RATE	All data rates were investigated, 1M data rate was found to be worst case.		
ANTENNA TYPE/GAIN	Integral Trace/ 3dBi		
DUTY CYCLE	100%		
RESULTS:	**PASS**		

Table 6.2 – Test Data Summary – Output Power with Voltage Variations

Voltage Variations						
Frequency (MHz)	**Modulation**	**7VDC (dBm)**	**14VDC (dBm)**	**28VDC (dBm)**	**36VDC (dBm)**	**Max Deviation from 14VDC (dB)**
2412	1M Data Rate	8.87	8.50	9.21	8.80	0.71
2442	1M Data Rate	8.45	8.46	8.58	8.42	0.13
2462	1M Data Rate	8.96	8.86	8.98	8.81	0.11

Table 6.3 – Power Output Test Data Summary – RF Conducted Measurement

Power Output Test Data Summary – RF Conducted Measurement				
Frequency	**Modulation**	**Measured (dBm)**	**Limit (dBm)**	**Result**
2412	1M Data Rate	8.50	30	PASS
2442	1M Data Rate	8.46	30	PASS
2462	1M Data Rate	8.86	30	PASS

Table 6.3a – Antenna Conducted Output Power Measurement

Frequency (MHz)	**Measured Reading (dBuV)**	**Correction Factor (dB)**	**Corrected Reading (dBuV)**	**Corrected Reading (dBm) dBm = dBuV-107.0**	**FCC 15.247(d) Limit (dBm)**	**Margin (dB)**
2412	114.78	0.72	115.50	8.50	30	-21.50
2442	114.74	0.72	115.46	8.46	30	-21.54
2462	115.14	0.72	115.86	8.86	30	-21.14
Note: The correction factor is the insertion loss of the 7.6cm coaxial RF cable that was a temporary antenna port for conducted measurements. Worse case insertion loss value used.						

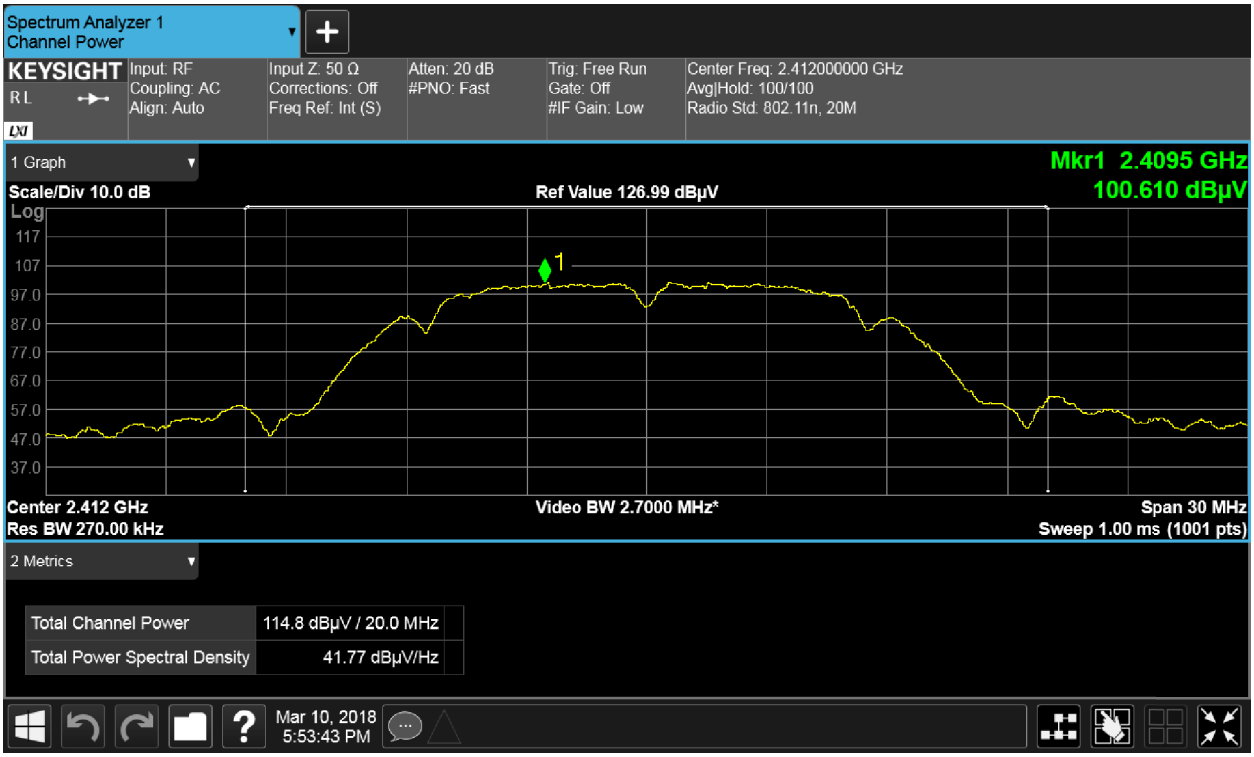

Figure 6.1 – Channel 1, Data rate 1M Data.

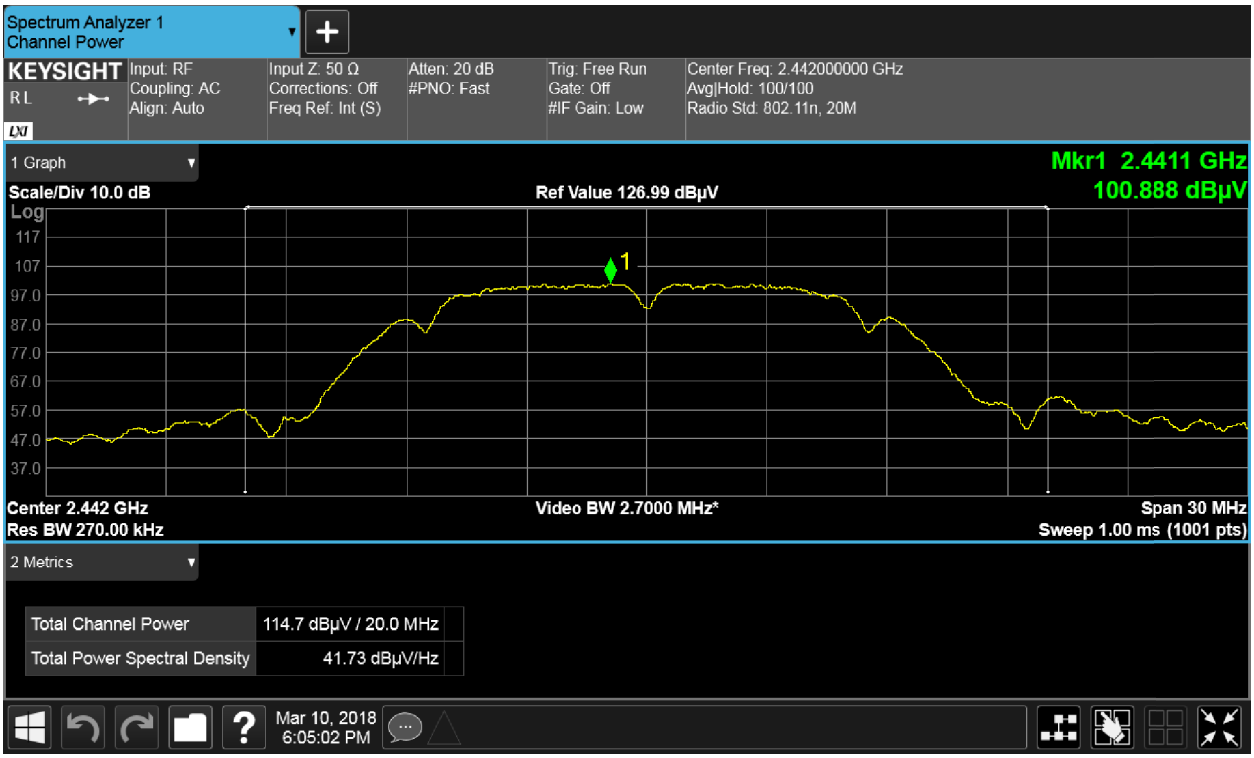

Figure 6.2 - Channel 7, Data rate 1M Data.

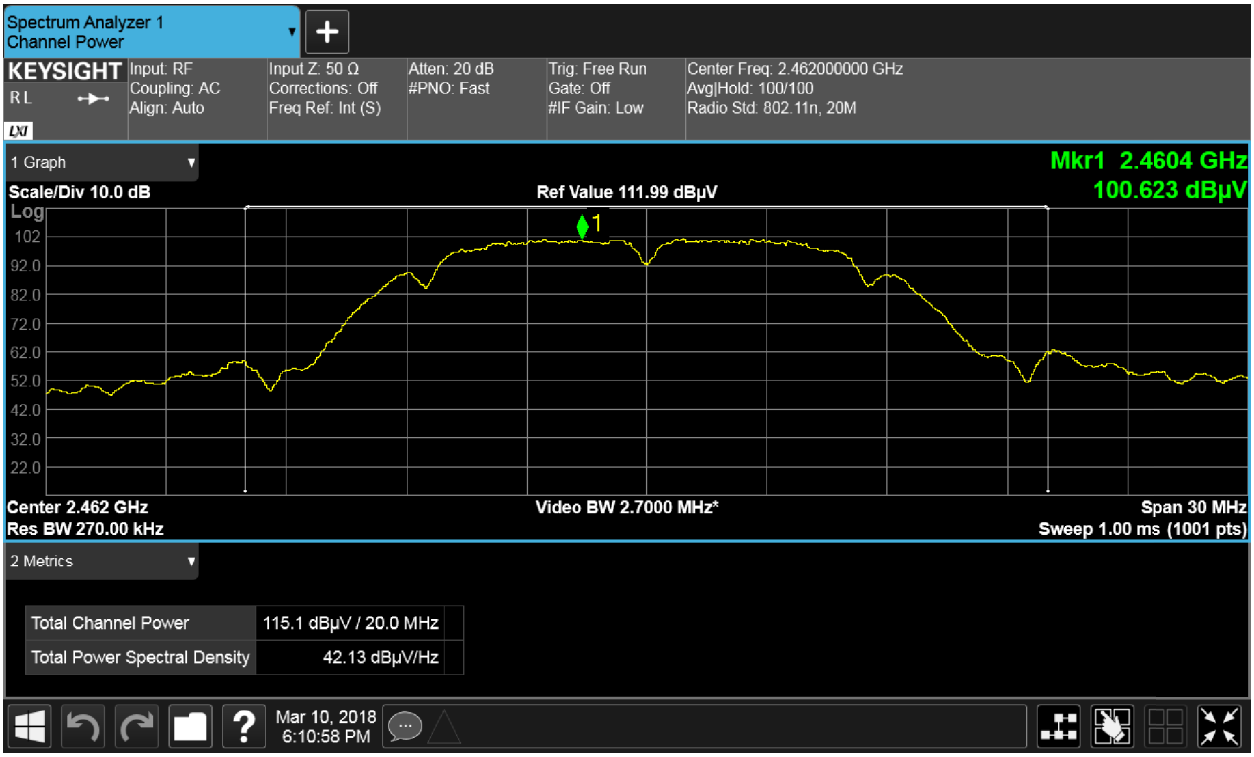

Figure 6.3 – Channel 11, Data rate 1M Data.

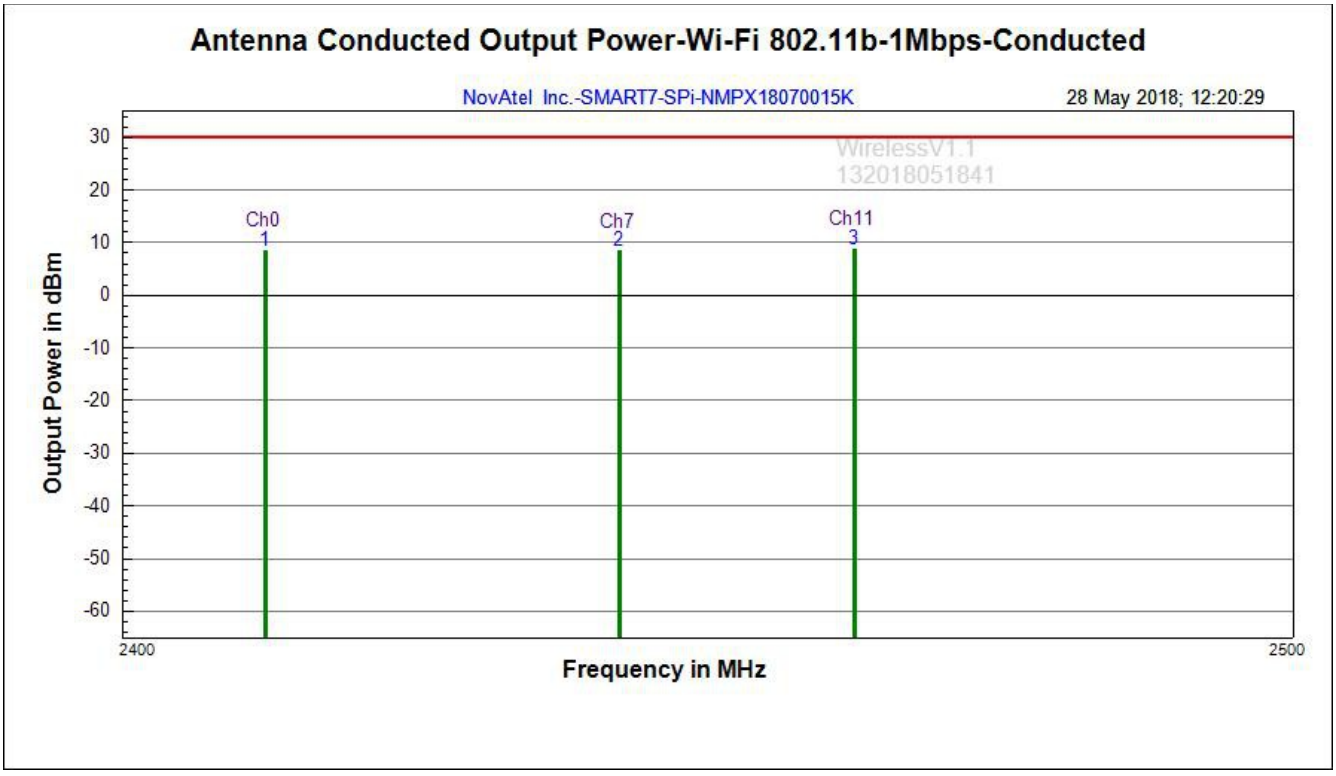

Figure 6.4 - Antenna Conducted Out Put Power (2400MHz – 2500MHz)

6.2 FCC 15.247(d) RF Conducted Emissions & Band Edge

☒**Applicable**

Table 6.4 – RF Conducted Emission Test Setup Information (FCC 15.247(d))

CLIENT:	**NovAtel Inc.**	**TEST STANDARD:**	**FCC 15.247(d)**
MODEL NUMBER:	**SMART7-SPi**	**PRODUCT:**	SMART7-SPi
SERIAL NUMBER:	**NMPX18070015K**	**CLASS:**	**FCC 15.247**
TEMPERATURE:	24°C	**HUMIDITY:**	21%
TESTED BY:	Taekyun Kim	**DATE OF TEST:**	2018-03-10 – 2018 -03-25
TESTREFERENCE:	ANSI C63.10(2013), KDB 558074 (April 5, 2017)		
TEST VOLTAGE:	14VDC		
SETUP:	The EUT is DC powered through a DC power supply. The EUT is connected to a MOXA using RS232 port, MOXA is then connected to Laptop using USB port. The EUT is continuously transmitting. Low, Mid and High channels as well as all data rates were investigated, worst case data was reported. The EUT was fitted with a temporary antenna port for direct conducted measurements.		
FREQUENCY RANGE	Fundamental		
FREQUENCY TESTED:	2412MHz, 2442MHz, 2462MHz		
FIRMWARE POWER SETTING	10 dBm (Maximum Power)		
EUT FIRMWARE	OM7CR0302SN0002, 1.7.0. RF module		
MODULATION/DATA RATE	All data rates were investigated, 1Mbps data rate was found to be worst case.		
ANTENNA TYPE/GAIN	Integral Trace/ 3dBi		
DUTY CYCLE	100%		
RESULTS:	**PASS**		

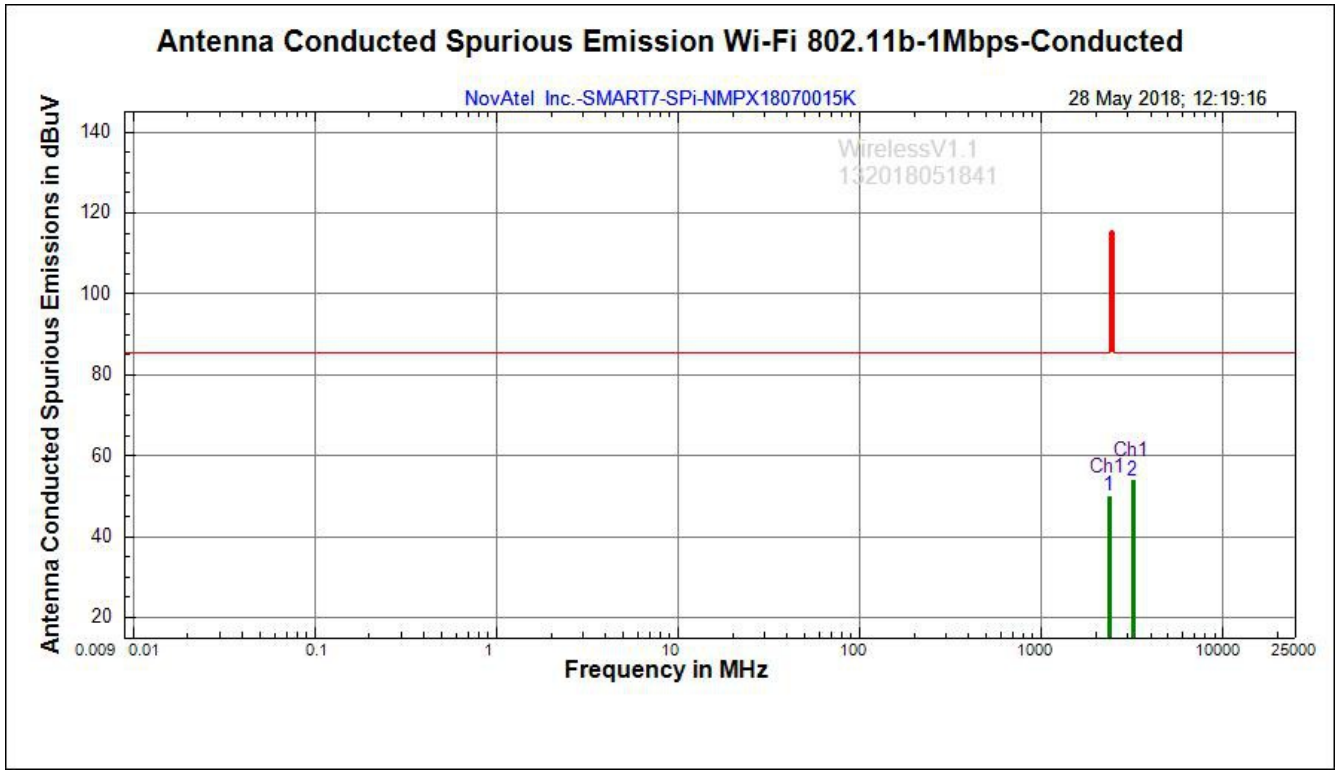

Figure 6.5 - Antenna Conducted Spurious Emission (9kHz - 25GHz)

Table 6.5 – Antenna Conducted Spurious Emission Measurement (FCC 15.247(d))

Frequency (MHz)	Measured Reading (dBuV)	Correction Factor (dB)	Corrected Reading (dBuV/m)	FCC 15.247(d) Limit (dBuV/m)	Margin (dB)
2395	49.29	0.72	50.01	85.46	-35.45
3216	53.27	0.72	53.99	85.46	-31.47

Limit for Spurious Emissions = Average channel Power (dBuV)-30 dB

Ex: 114.74 (dBuV) + 0.72(dB) - 30dB = 85.46 dBuV

where 114.74 dBuV is the measured reading of Antenna Conducted Output Power at 2442 MHz, shown in Table 6.3 (a).

Note: The correction factor is the insertion loss of the 7.6cm coaxial RF cable that was a temporary antenna port for conducted measurements. Worse case insertion loss value used.

Table 6.6- Conducted Spurious Emission Test Setup Information (FCC 15.247(d))

CLIENT:	**NovAtel Inc.**	**TEST STANDARD:**	**FCC 15.247(d)**
MODEL NUMBER:	**SMART7-SPi**	**PRODUCT:**	SMART7-SPi
SERIAL NUMBER:	**NMPX18070015K**	**CLASS:**	**FCC 15.247**
TEMPERATURE:	24°C	**HUMIDITY:**	21%
TESTED BY:	Taekyun Kim	**DATE OF TEST:**	2018-03-10 – 2018 -03-25
TESTREFERENCE:	ANSI C63.10(2013), KDB 558074 (April 5, 2017)		
TEST VOLTAGE:	14VDC		
SETUP:	The EUT is DC powered through a DC power supply. The EUT is connected to a MOXA using RS232 port, MOXA is then connected to Laptop using USB port. The EUT is continuously transmitting. Low and High channels as well as all data rates were investigated, worst case data reported. The EUT was fitted with a temporary antenna port for direct conducted measurements.		
FREQUENCY RANGE	Fundamental		
FREQUENCY TESTED:	2412MHz, 2462MHz		
FIRMWARE POWER SETTING	10 dBm (Maximum Power)		
EUT FIRMWARE	OM7CR0302SN0002(GNSS Receiver), 1.7.0. RF module		
MODULATION/DATA RATE	All data rates were investigated. 6Mbps(CH1), MCS7(CH11)data rate was found to be worst case.		
ANTENNA TYPE/GAIN	Integral Trace/ 3dBi		
DUTY CYCLE	100%		
RESULTS:	**PASS**		

Table 6.7– Band Edge Summary (FCC 15.247(d))

Frequency (MHz)	Modulation	Measured In-Band Level		Measured Band Edge Level		Corrected Band edge Level (dBm)	Limit (dBm)	Margin (dB)	Result
		(dBuV)	(dBm)	(dBuV)	(dBm)				
2400	6Mbps Data rate	108.22	1.22	76.18	-30.82	-30.1	-28.06	-2.04	PASS
2483.5	MCS07 Data rate	113.3	6.3	76.15	-30.85	-30.13	-22.98	-7.15	PASS

Limit Applied: In-Band Max power – 30dB (with 100k RBW)

Ex: The limit at 2400 MHz, 1.22 dBm+0.72dB-30.00dB = -28.06 dBm; where 0.72 dB is the the insertion loss of the 7.6cm coaxial RF cable that was a temporary antenna port for conducted measurements. Worse case insertion loss value used.

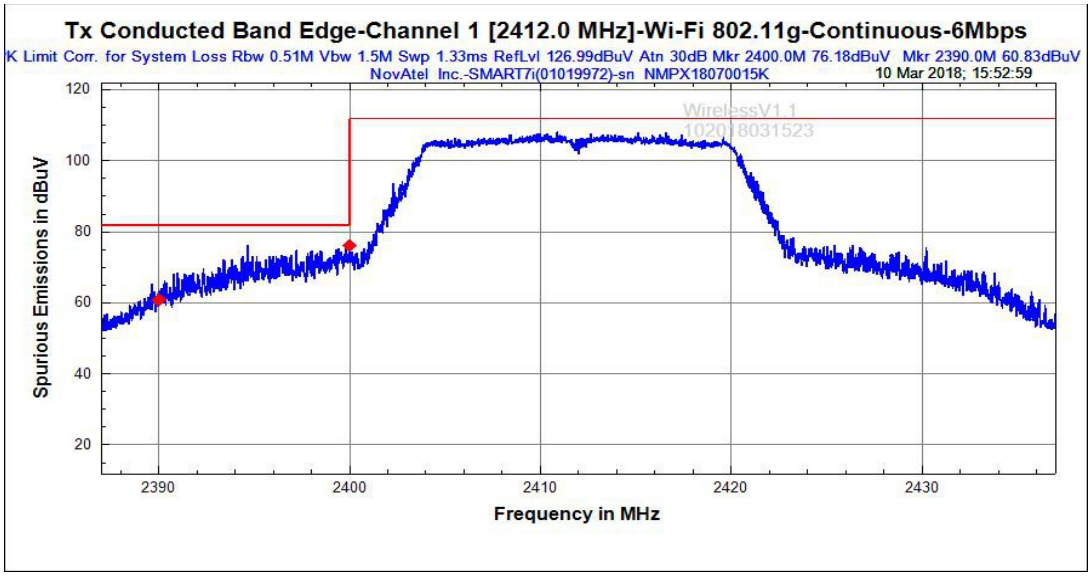

Figure 6.6 – Band Edge Plots (FCC Part 15,247(d))

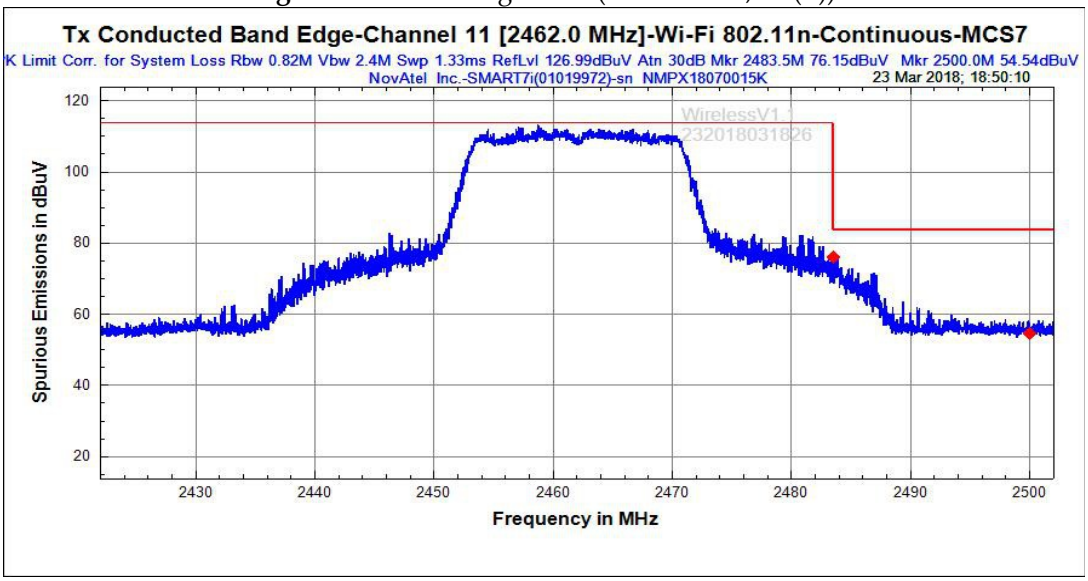

Figure 6.7 - Band Edge Plots (FCC Part 15,247(d))

Band Edge Emission Calculations

Worst Case Data Rate: 6Mbps(CH1), MCS7(CH11)

	Channel 01 (2412 MHz)	**Channel 11-(2462MHz)**
100k in-band level (dBuV)	108.22	113.3
100k BW Band edge level (dBuV)	76.18	76.15
Fundamental-Band edge) level (dB down)	32.04	37.15
Fundamental-Band edge) Frequency (MHz)	2400.00	2483.50
Limit Applied (dB down)	30.00	30.00
Margin (dB)	2.04	7.15

6.3 FCC 15. 247(d) Radiated Emission & Band Edge

☒**Applicable**

Table 6.9 - Radiated Spurious Emission Test Setup Information (FCC 15.247(d)/15.209)

CLIENT:	**NovAtel Inc.**	**TEST STANDARD:**	**FCC 15.247(d)/ 15.209**
MODEL NUMBER:	**SMART7-SPi**	**PRODUCT:**	SMART7-SPi
SERIAL NUMBER:	**NMRT18060020P**	**CLASS:**	**FCC 15.247**
TEMPERATURE:	24°C	**HUMIDITY:**	25%
TESTED BY:	Jaeheon Yun	**DATE OF TEST:**	2018-03-14 - 2018-03-21
TESTREFERENCE:	ANSI C63.10(2013), KDB 558074 (April 5, 2017)		
TEST VOLTAGE:	14VDC		
SETUP:	The EUT is DC powered through a DC power supply. The EUT is connected to an external GNSS active antenna which is located remotely with an open view of the sky. The active antenna on the rooftop is powered by a Bias Tee coupler. The Bias Tee coupler is powered by a AC/DC output power supply. The EUT is connected to a support laptop through a MOXA, 14 Pin AMPSEAL connector IO cable Harness Part # 01019944 and 4 Pin M12-D Connector Ethernet cable. I/O port contained 1 x CAN Interface and 3 x RS-232 ports and event IN and OUT tied together. The RS-232 ports which were connected to a serial to USB 2 port hub which is then connected to the laptop. During the testing, COM1, COM3 were looped back circulating the DATA, CAN port is loaded with 120 Ohms. The EUT is continuously transmitting. Low, Mid and High channels as well as all data rates were investigated, worst case data was reported. The EUT is fully exercised with communication and data transfer between the EUT and support laptop. Below 1GHz, the EUT is on the test table 80cm high. Above 1GHz, the EUT is on the test table 150cm high connected to the internal trace antenna.		
FREQUENCY RANGE	9k - 25GHz		
FREQUENCY TESTED:	2412MHz, 2442MHz, 2462MHz RBW:120kHz (30MHz – 1000MHz), 1MHz(above 1GHz)		
FIRMWARE POWER SETTING	10 dBm (Maximum Power)		
EUT FIRMWARE	OM7CR0302SN0002(GNSS Receiver), 1.7.0. RF module		
MODULATION/DATA RATE	Spurious: All data rates were investigated, Ch1, 1Mbps data rate was found to be worst case.(30MHz – 1000MHz), All data rates were investigated, Ch7, 1Mbps data rate was found to be worst case. (1GHz – 18GHz) Band edge: All data rates were investigated, MCS1 data rate was found to be worst case.		
ANTENNA TYPE/GAIN	Integral Trace/ 3dBi		
DUTY CYCLE	100%		
RESULTS:	**PASS**		

Table 6.10 - Radiated Emission - **Horizontal** Polarization Quasi-peak

Frequency (MHz)	Azimuth Angle (deg)	Antenna Height (cm)	Measured Reading (dBuV)	Correction Factor (dB)	Corrected Reading (dBuV/m)	FCC 15.209 Limit (dBuV/m)	Margin (dB)
58.69	110.7	400	29.89	-17.96	11.93	40	-28.07
62.25	131.4	400	30.21	-17.89	12.32	40	-27.68
71.4	87.6	400	30.24	-17.71	12.53	40	-27.47
81.2	114.5	400	32.6	-17.63	14.97	40	-25.03
194.74	225	164.8	40.79	-14.19	26.60	43.52	-16.92
205.94	227.1	148.9	35.28	-13.33	21.95	43.52	-21.57

Table 6.11 - Radiated Emission - **Vertical** Polarization Quasi-peak

Frequency (MHz)	Azimuth Angle (deg)	Antenna Height (cm)	Measured Reading (dBuV)	Correction Factor (dB)	Corrected Reading (dBuV/m)	FCC 15.209 Limit (dBuV/m)	Margin (dB)
58.69	345	100	42.83	-17.96	24.87	40	-15.13
62.25	339.7	100	45.7	-17.89	27.81	40	-12.19
71.4	17.6	100	38.24	-17.71	20.53	40	-19.47
81.2	16.3	100	42.7	-17.63	25.07	40	-14.93
194.74	356.5	100	42.5	-14.19	28.31	43.52	-15.21
205.94	90.9	100	36.42	-13.33	23.09	43.52	-20.43

Table 6.12a - Radiated Emission - **Horizontal** Polarization AVG

Frequency (MHz)	Azimuth Angle (deg)	Antenna Height (cm)	Measured Reading (dBuV)	Correction Factor (dB)	Corrected Reading (dBuV/m)	FCC 15. 209 Limit (dBuV/m)	Margin (dB)
2440	167.4	140.7	52.66	-21.82	30.84	53.98	-23.14
6512	164.7	100	53.23	-15.68	37.55	53.98	-16.43
13024	238.4	150	39.97	-5.9	34.07	53.98	-19.91

Table 6.12b- Radiated Emissions - Horizontal Polarization Peak

Frequency (MHz)	Azimuth Angle (deg)	Antenna Height(cm)	Measured Reading (dBuV)	Correction Factor (dB)	Corrected Reading (dBuV/m)	FCC 15. 209 Limit (dBuV/m)	Margin (dB)
2440	167.4	140.7	60.9	-21.82	39.08	74	-34.92
6512	164.7	100	57.89	-15.68	42.21	74	-31.79
13024	238.4	150	49.19	-5.9	43.29	74	-30.71

Table 6.13a - Radiated Emission - **Vertical** Polarization AVG

Frequency (MHz)	Azimuth Angle (deg)	Antenna Height (cm)	Measured Reading (dBuV)	Correction Factor (dB)	Corrected Reading (dBuV/m)	FCC 15. 209 Limit (dBuV/m)	Margin (dB)
2440	150	110.3	46.98	-21.82	25.16	53.98	-28.82
6512	164.1	127.4	55.6	-15.68	39.92	53.98	-14.06
13024	165.8	100	42.72	-5.9	36.82	53.98	-17.16

Table 6.13b - Radiated Emissions - Vertical Polarization Peak

Frequency (MHz)	Azimuth Angle (deg)	Antenna Height(cm)	Measured Reading (dBuV)	Correction Factor (dB)	Corrected Reading (dBuV/m)	FCC 15. 209 Limit (dBuV/m)	Margin (dB)
2440	150	110.3	57.09	-21.82	35.27	74	-38.73
6512	164.1	127.4	59.91	-15.68	44.23	74	-29.77
13024	165.8	100	49.77	-5.9	43.87	74	-30.13

Note: The emissions with peak detector were measured and found to meet average limits.

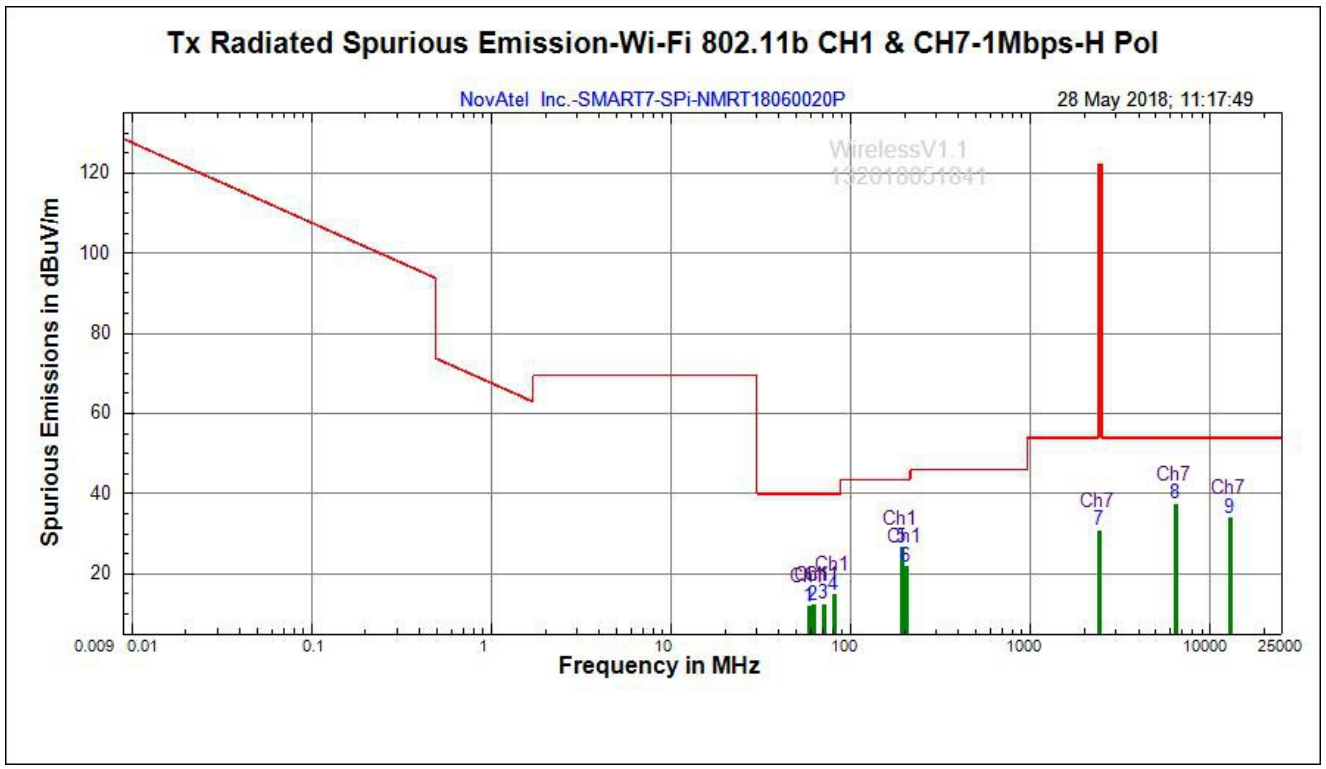

Figure 6.8 - Radiated Spurious Emission data(Ch1, 7, 1Mbps -H-Pol

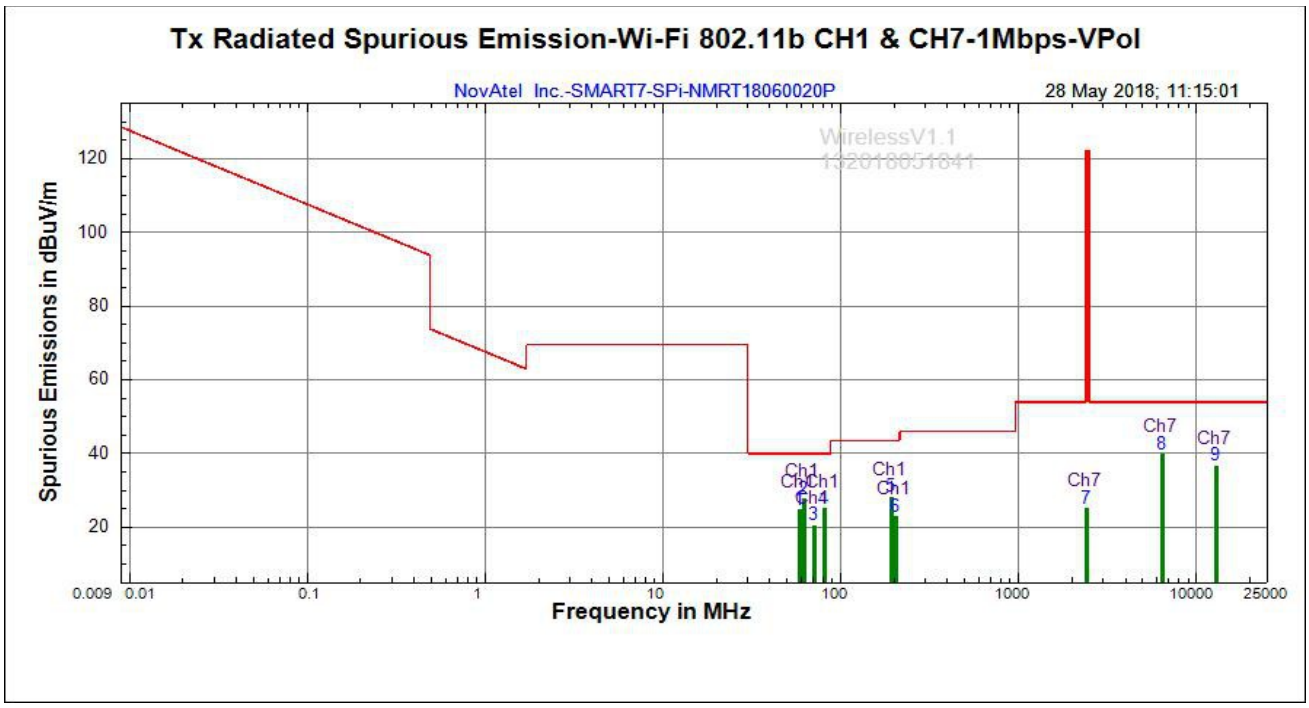

Figure 6.9 - Radiated Spurious Emission data(Ch 1, 7, 1Mbps) – V-pol.

Table 6.14 – Radiated Band Edge Summary (FCC 15.247(d)) -MCS1 data

Frequency (MHz)	Measurement (dBuV)	Factor (dB)	Field Strength (dBuV/m@ 3m)	Limit (dBuV/m @ 3m)	Margin (dB)	Detector	Result
2400	53.27	7.16	60.43	74	-13.57	Peak	PASS
2483.5	61.94	8.04	69.98	74	-4.02	Peak	PASS
2400	45.05	7.16	52.21	54	-1.79	AVG	PASS
2483.5	39.46	8.04	47.5	54	-6.5	AVG	PASS

[NOTE] All data rates were investigated, worst case data (MCS1) was reported.

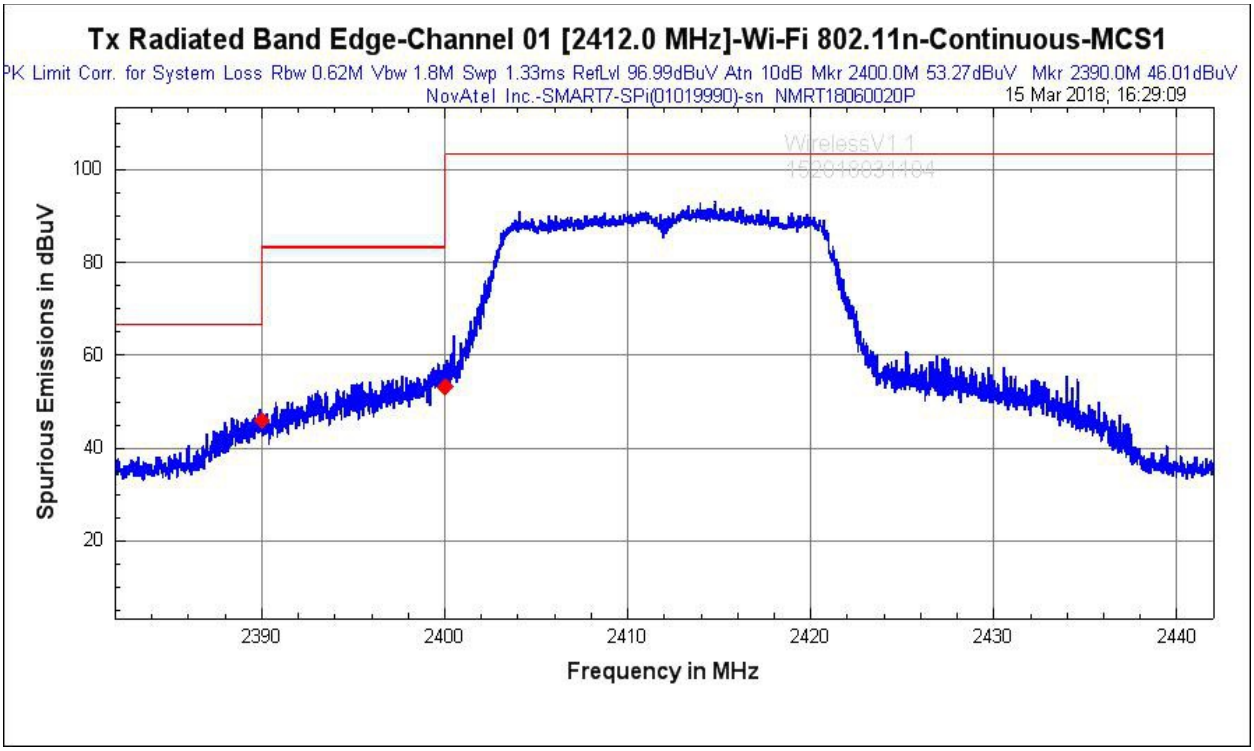

Figure 6.10 – Radiate Band Edge data (Channel 1, MCS1, Peak)

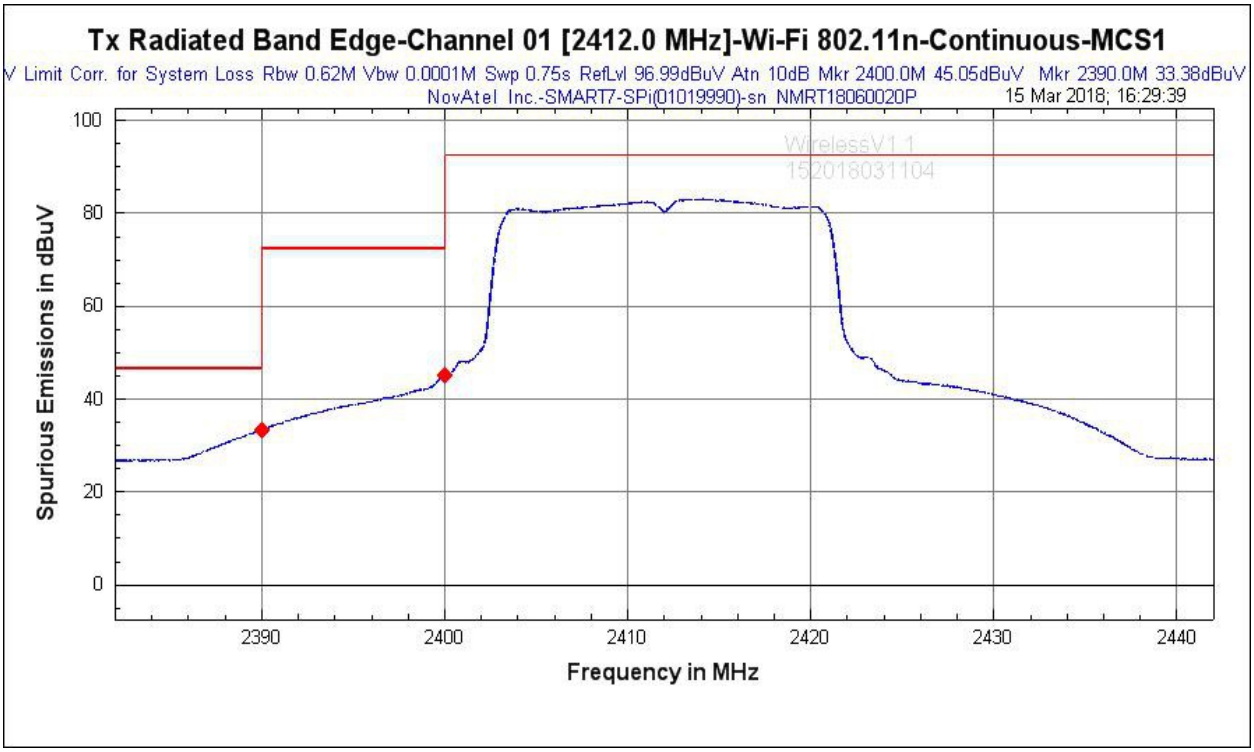

Figure 6.11 – Radiated Band Edge data (Channel 1, MCS1, Average)

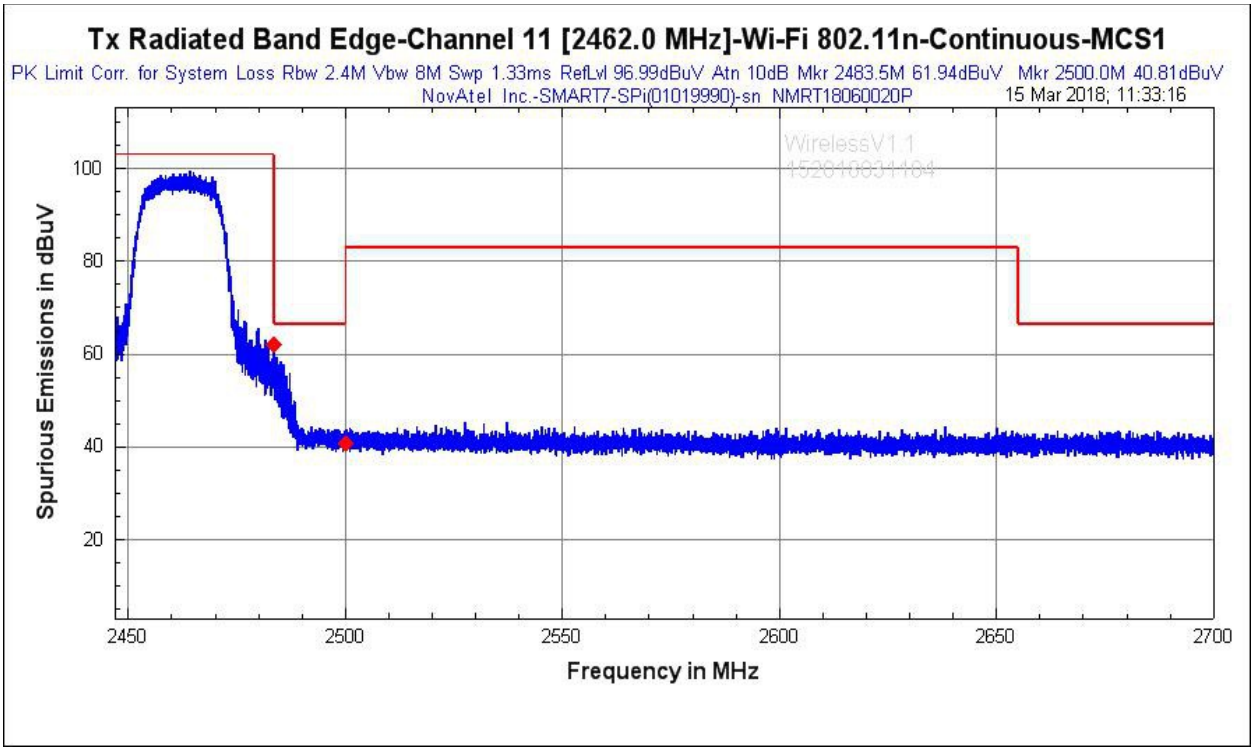

Figure 6.12 – Radiated Band Edge data (Channel 11, MCS1, Peak)

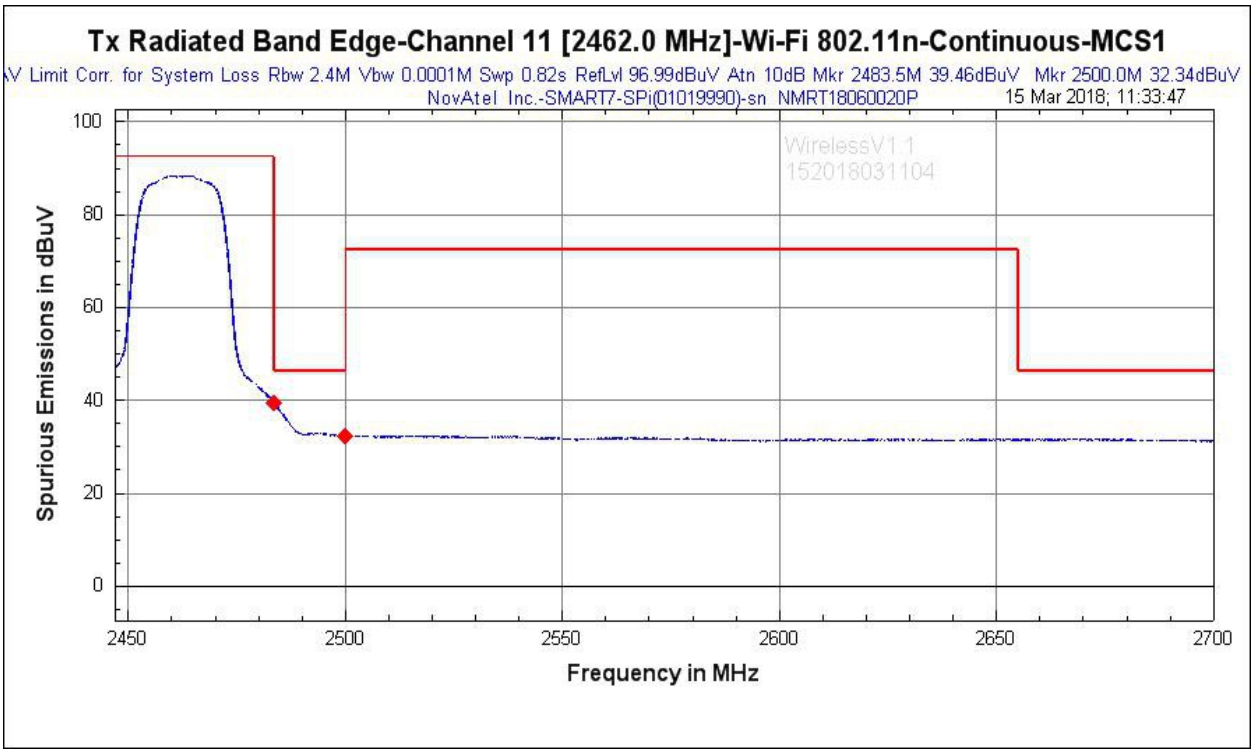

Figure 6.13 – Radiated Band Edge data (Channel 11, MCS1, Average)

☒**Applicable**

Table 6.15 - Radiated Spurious Emissions AVG Setup Information (FCC 15.247(d)/15.209)

CLIENT:	**NovAtel Inc.**	**TEST STANDARD:**	**FCC 15.247(d)/ 15.209**
MODEL NUMBER:	**SMART7-SPi**	**PRODUCT:**	SMART7-SPi
SERIAL NUMBER:	**NMRT18060020P**	**CLASS:**	**FCC 15.247**
TEMPERATURE:	24.5°C	**HUMIDITY:**	26%
TESTED BY:	Jaeheon Yun	**DATE OF TEST:**	2018-03-15
TESTREFERENCE:	ANSI C63.10(2013), KDB 558074 (April 5, 2017)		
TEST VOLTAGE:	14VDC		
SETUP:	The EUT is DC powered through a DC power supply. The EUT is connected to an external GNSS active antenna which is located remotely with an open view of the sky. The active antenna on the rooftop is powered by a Bias Tee coupler. The Bias Tee coupler is powered by a AC/DC output power supply. The EUT is connected to a support laptop through a MOXA, 14 Pin AMPSEAL connector IO cable Harness Part # 01019944 and 4 Pin M12-D Connector Ethernet cable. I/O port contained 1 x CAN Interface and 3 x RS-232 ports and event IN and OUT tied together. The RS-232 ports which were connected to a serial to USB 2 port hub which is then connected to the laptop. During the testing, COM1, COM3 were looped back circulating the DATA, CAN port is loaded with 120 Ohms. The EUT is continuously transmitting. Low, Mid and High channels as well as all data rates were investigated, worst case data was reported. The EUT is fully exercised with communication and data transfer between the EUT and support laptop. Below 1GHz, the EUT is on the test table 80cm high. Above 1GHz, the EUT is on the test table 150cm high connected to the internal trace antenna.		
FREQUENCY RANGE	2.38GHz – 2.7GHz		
FREQUENCY TESTED:	2412MHz, 2462MHz		
FIRMWARE POWER SETTING	10 dBm (Maximum power)		
EUT FIRMWARE	OM7CR0302SN0002(GNSS Receiver), 1.7.0. RF module		
MODULATION/DATA RATE	All data rates were investigated,MCS1 data rate was found to be worst case.		
ANTENNA TYPE/GAIN	Integral Trace/ 3dBi		
DUTY CYCLE	100%		
RESULTS:	**PASS**		

Table 6.16 - Radiated Emission - **Horizontal** Polarization AVG FCC

Frequency (MHz)	Azimuth Angle (deg)	Antenna Height (cm)	Measured Reading (dBuV)	Correction Factor (dB)	Corrected Reading (dBuV/m)	FCC 15. 209 Limit (dBuV/m)	Margin (dB)
2400	233.3	154.8	45.05	7.16	52.21	54	-1.79
2483.5	349.4	106	39.46	8.04	47.50	54	-6.50

Table 6.17 - Radiated Emission - **Vertical** Polarization AVG FCC

Frequency (MHz)	Azimuth Angle (deg)	Antenna Height (cm)	Measured Reading (dBuV)	Correction Factor (dB)	Corrected Reading (dBuV/m)	FCC 15. 209 Limit (dBuV/m)	Margin (dB)
2400	349.4	106	41.45	7.16	48.61	54	-5.39
2483.5	127.7	115.3	37.93	8.04	45.97	54	-8.03

7.0 Appendix A – Test Sample Description

(From Data Provided by the Customer)

PRODUCT FAMILY DESCRIPTION

SMART7 is a Smart Antenna based upon the proven positioning technologies from NovAtel. These technologies include the OEM7 GNSS receiver, inertial navigation system integration (SPAN technology), and a high performance antenna.

The receiver will track GPS and GLONASS L1, L2 signals and will optionally track GPS L5, Beidou B1, B2 and Galileo E1, E5ab signals. The SMART7 can also receive L-band signals providing easy access to the world-wide correction signals currently provided by Terrastar and Veripos. The Smart Antenna also supports NovAtel's CORRECT suite of Positioning Solutions (PPP, RTK and DGPS).

The SMART7 product family includes a precision GNSS antenna that offers wideband signal tracking, excellent multipath rejection and highly stable phase centres making it ideal for high precision agriculture applications.

The SMART7 product portfolio includes variants with integrated inertial measurement units (IMU) using NovAtel's proven Synchronous Position and Attitude Navigation (SPAN) technology.

The product variant that integrates a Value-added IMU will provide a reliable solution for terrain compensation.

The SMART7 variant integrating a higher quality IMU provides superior positioning performance with the following feature characteristics:

- Full position and attitude output
- Capability to bridge short GNSS outages
- Output of raw IMU measurements for use with external steering solutions

Daylight-viewable LED indicators will provide indication of power, positioning mode and receiver status.

The primary machine interface port to the product will use one 14-pin AMPSEAL automotive connector providing:

- One CAN port, working at 250kbps or 500kbps,
- Three RS-232 serial ports (COM1, 2 and 3) supporting baud rates up to 230400
- One PPS Output
- One Emulated Radar Output
- Power Input. (Main supply)

The ISOBUS (CANbus) ports of the User Interface will be used to communicate proprietary messages between the receiver, steering controller, display and any NMEA2000 precision agriculture functions on the implement.

A dedicated second machine interface port is recommended for the Ethernet port. The characteristics of this interface are the following:

- Standard 4-wire Ethernet supporting 10/100Base-T
- Rugged and IP67 rated connector when mated
- Pin configuration to allow the use of off-the-shelf cable assemblies

A connection over the Ethernet port can be used to send commands and obtain logs from the Smart Antenna.

8.0 Appendix B – List of Abbreviations and Acronyms

Industrial, scientific and medical (ISM) applications (of radio frequency energy)
operation of equipment or appliances designed to generate and use locally radio frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications

ISM equipment and appliances
equipment or appliances designed to generate and/or use locally radio-frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications and information technology and other applications covered by other CISPR publications

Electromagnetic radiation

1. phenomenon by which energy in the form of electromagnetic waves emanates from a source into space
2. energy transferred through space in the form of electromagnetic waves

Boundary of the equipment under test
imaginary straight line periphery describing a simple geometric configuration encompassing the equipment under test. All interconnecting cables are included within this boundary

Electro-discharge machining (EDM) equipment
all the necessary units for the spark erosion process including the machine tool, the generator, control circuits, the working fluid container and integral devices

Spark erosion
removal of material in a dielectric working fluid by electro-discharges, which are separated in time and randomly distributed in space, between two electrically conductive electrodes (the tool electrode and the work piece electrode), and where the energy in the discharge is controlled

Arc welding equipment
equipment for applying current and voltage and having the required characteristics suitable for arc welding and allied processes

Equipment for resistance welding and allied processes
all equipment associated with carrying out the processes of resistance welding or allied processes consisting of e.g. power source, electrodes, tooling and associated control equipment, which may be a separate unit or part of a complex machine

Low voltage LV
a set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1 000 V a.c.

End of document