

4740 Discovery Drive | Lincoln, NE 68521 tel- 402.323.6233 | tel -888.657.6860 | fax - 402.323.6238 info@nceelabs.com | http://nceelabs.com

Amended Test Report

Prepared for:

Inovonics

Address:

397 S. Taylor Ave. Louisville, CO 80027

Product:

FFR Module

Test Report No:

Approved by:

R20200311-21-E1A

Nic S. Johnson, NCE Technical Manager iNARTE Certified EMC Engineer #EMC-003337-NE

DATE:

26 August 2020

Total Pages:

50

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ncee.	Report Number:	R20200311-21-E1	Rev	A
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REVISION PAGE

Rev. No.	Date	Description
0	26 June 2020	Original – NJohnson Prepared by KVepuri/CFarrington
A	26 August 2020	Added conducted emissions plots
		Includes NCEE Labs report R20200311-21-E1 and its amendment in fullNJ



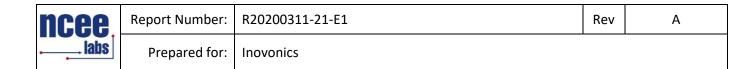
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1.0 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

- (1) US Code of Federal Regulations, Title 47, Part 15
- (2) ISED RSS-Gen, Issue 5
- (3) ISED RSS-247, Issue 2

SUMMARY					
Standard Section	Test Type and Limit	Result	Remark		
FCC 15.203	Unique Antenna Requirement	Pass	PCB antenna		
FCC 15.35 RSS-Gen, 6.10	Duty cycle of pulsed emissions	Pass	Pulsed emissions duty cycle was applied		
FCC 15.209 RSS-Gen, 7.1	Receiver Radiated Emissions	NA	The EUT has no receiver functionality		
FCC 15.247(a)(1)(i) RSS-247, 5.1(c)	Minimum Bandwidth, Limit: Min. 250kHz	Pass	Meets the requirement of the limit.		
FCC 15.247(b)(1) RSS-247, 5.1	Maximum Peak Output Power, Limit: Max. 24 dBm	Pass	Meets the requirement of the limit.		
FCC 15.209 RSS-Gen, 8.9 RSS-247, 5.5	Transmitter Radiated Emissions	Pass	Meets the requirement of the limit.		
FCC 15.247(a) (1) (i) RSS-247, 5.1(c)	Frequency hopping system, Limit: Max. 0.4 Seconds in 10 Second Period	Pass	Meets the requirement of the limit.		
FCC 15.209, 15.205 RSS-Gen, 8.9 RSS-247, 5.5	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement of the limit.		
FCC 15.207 RSS-Gen. 8.8	Conducted AC Emissions	Pass	Meets the requirement of the limit.		



2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a wireless FHSS transmitter.

EUT	FFR Module
EUT Received	5/4/2020
EUT Tested	5/19/2020 - 6/19/2020
Serial No.	00109 (Assigned by test lab)
Operating Band	902.0 – 928.0 MHz
Device Type	FHSS
Power Supply	GlobTek GT-21088-0805-W2 or 3.7V Battery

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.



2.2 DESCRIPTION OF TEST MODES

The EUT operates on, and was tested at the frequencies below:

Channel	Frequency
Low	902.4
Middle	914.8
High	927.6

These are the only three representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on the lowest, highest and one channel in the middle.

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2.3 DESCRIPTION OF SUPPORT UNITS

None



3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs) 4740 Discovery Drive Lincoln, NE 68521 Rev

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A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
CAB MRA Recognition Identification No:	US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of $35 \pm 4\%$ Temperature of $22 \pm 3^{\circ}$ Celsius



3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Nic Johnson	Technical Manager	Review of Results
2	Karthik Vepuri	EMC Test Engineer	Testing and Report
3	Caleb Farrington	EMC Test Engineer	Testing and Report
4	Fox Lane	EMC Test Engineer	Testing

Notes:

All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.



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3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer	N9038A	MY59050109	April 23, 2019	April 23, 2021
Keysight EXA Signal Analyzer	N9010A	MY56070862	December 14, 2018	December 14, 2020
SunAR RF Motion Hybrid Antenna	JB1	A091418	March 6, 2020	March 6, 2021
EMCO Horn Antenna	3115	6415	March 16, 2020	March 16, 2022
Rohde & Schwarz LISN	ESH3-Z5	836679/010	July 25, 2019	July 25, 2020
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	April 14, 2020	April 14, 2022
Trilithic High Pass Filter*	6HC330	23042	April 14, 2020	April 14, 2022
MiniCircuits High Pass Filter*	VHF-1320+	15542	April 14, 2020	April 14, 2022
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	April 14, 2020	April 14, 2022
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	April 14, 2020	April 14, 2022
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3874	April 14, 2020	April 14, 2022
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	April 14, 2020	April 14, 2022
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	April 14, 2020	April 14, 2022
N connector bulkhead (control room)*	PE9128	NCEEBH2	April 14, 2020	April 14, 2022
TDK Emissions Lab Software	V11.25	700307	NA	NA

*Internal Characterization

Notes:

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

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4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Prepared for:

Since the device featured pulsed emissions, a duty cycle correction factor was applied to peak measurements to calculate the average measurement per ANSI C63.10-2013, Section 7.5.

On time is 23.6% and Period is greater than 100 ms. The Duty Cycle Correction Factor is calculated to be $20*\log(23.6/100) = -12.54 \text{ dB}$

See the plots below for details.

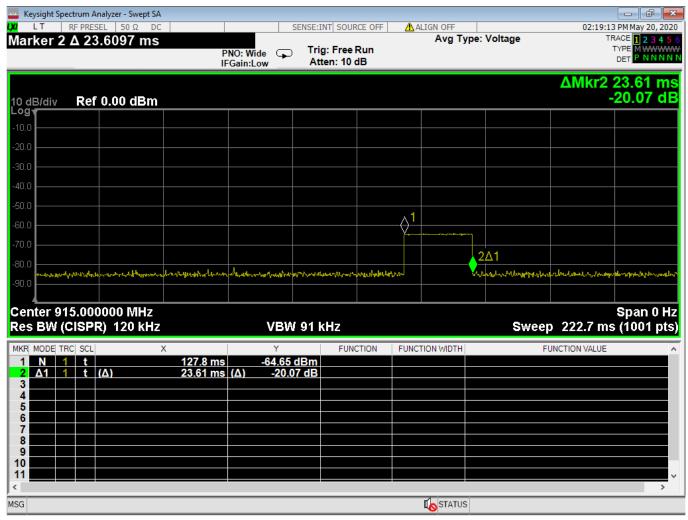


Figure 1 – Duty Cycle, ON Time

ncee.	Report Number:	R20200311-21-E1	Rev	А
labs	Prepared for:	Inovonics		

LT RF PRESEL 50 Ω DC	SET	NSE:INT SOURCE OFF	ALIGN OFF	02:24:10 PM May 20, 2
arker 2 ∆ 2.78000 s	PNO: Wide 😱 IFGain:Low	Trig: Free Run Atten: 10 dB	Avg Type: Voltage	TRACE 1 2 3 4 TYPE WWWW DET P N N N
dB/div Ref 0.00 dBm				ΔMkr2 2.780 -0.31 c
.0				
.0				
.0				
.0	^ 1	2∆1		<mark>3∆1</mark>
0				
hteranskeptingenetingenetingenetingenetingenetingenetingenetingenetingenetingenetingenetingenetingenetingeneting 0	general but an alara and a gain and a gain and a gain a	Adertant western produced by the or	adhaanhaanaankaanaanha	لمراجع والمراجع المستعلم والمستعلم والمعالية المحالية المحالية والمحالية والمحالية المحالية والمحالية والمحالية
enter 915.000000 MHz s BW (CISPR) 120 kHz	VBW 9	91 kHz	Sv	Span 0 veep 10.00 s (1001 p
MODE TRC SCL X	2.760 s -64.27 dE		CTION WIDTH	FUNCTION VALUE
$\Delta 1$ 1 t (Δ)	2.780 s (Δ) -0.31 5.550 s (Δ) -0.10	dB		
Δ1 1 t (Δ)				

Figure 2 – Duty Cycle, Period



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4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10-2013, Section 6.5, 6.6

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (µV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:

1. The lower limit shall apply at the transition frequencies.

2. Emission level (dBuV/m) = 20 * log * Emission level (μ V/m).

3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.



Test procedures:

a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semianechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements form 30MHz-1GHz and 1.5m for measurements from 1GHz to 10 GHz.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.



NOTE:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.

2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

Deviations from test standard:

No deviation.

Test setup:

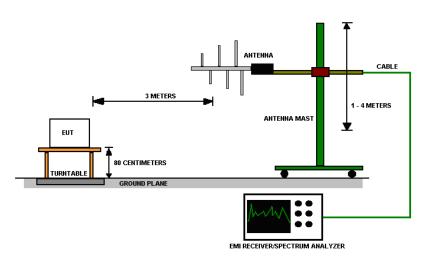


Figure 3 - Radiated Emissions Test Setup

EUT operating conditions

The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.



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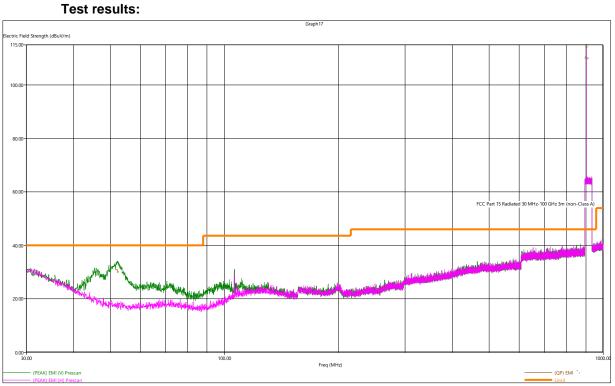
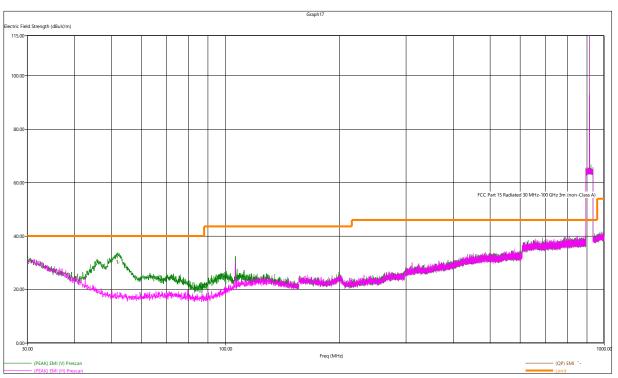


Figure 4 - Radiated Emissions Plot, Low Channel







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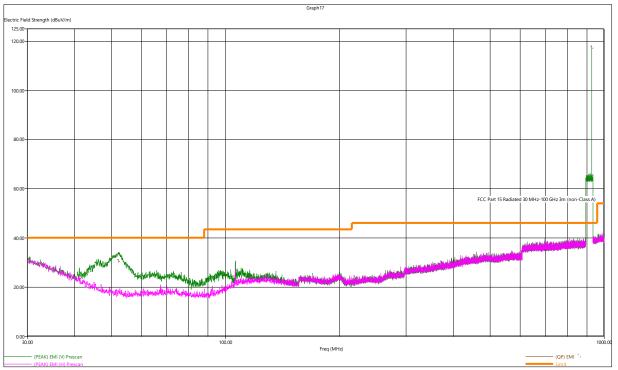


Figure 6 - Radiated Emissions Plot, High Channel





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Quasi-Peak Measurements								
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
52.194960	30.29	40.00	9.71	119	216	V	Low	
902.400400	114.47	N/A	N/A	111	51	V	Low	
51.942000	30.26	40.00	9.74	107	256	V	Mid	
914.798320	115.36	N/A	N/A	112	24	V	Mid	
52.220400	30.53	40.00	9.47	112	245	V	High	
927.598240	117.28	N/A	N/A	110	26	V	High	
47.100000	19.98	40.00	20.02	142	124	V	Receive	
48.030000	37.36	40.00	2.64	110	261	V	Receive	
49.010000	29.64	40.00	10.36	114	116	V	Receive	
72.020000	28.76	40.00	11.24	123	189	V	Receive	
96.040000	30.63	43.52	12.89	122	247	V	Receive	



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Peak Measurements							
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
1599.960000	45.22	73.98	28.76	182	64	Н	Low
2411.840000	48.93	73.98	25.05	122	92	V	Low
3200.070000	48.12	73.98	25.86	225	84	V	Low
4019.128000	54.46	73.98	19.52	121	34	Н	Low
5414.414000	53.93	73.98	20.05	180	52	Н	Low
6316.820000	56.99	73.98	16.99	171	19	Н	Low
7219.180000	64.07	73.98	9.91	157	8	Н	Low
8121.644000	54.27	73.98	19.71	255	15	V	Low
1599.890000	44.97	73.98	29.01	153	64	Н	Mid
1829.570000	50.59	73.98	23.39	111	277	Н	Mid
1999.920000	46.62	73.98	27.36	198	244	Н	Mid
2410.150000	44.61	73.98	29.37	126	104	V	Mid
3200.080000	47.82	73.98	26.16	194	87	V	Mid
5488.720000	52.72	73.98	21.26	200	65	Н	Mid
6403.650000	57.25	73.98	16.73	200	23	Н	Mid
7318.390000	60.65	73.98	13.33	199	359	Н	Mid
8233.290000	55.00	73.98	18.98	199	22	V	Mid
3165.610000	51.67	73.98	22.31	176	29	Н	High
1600.100000	46.01	73.98	27.97	148	286	V	High
1855.190000	52.78	73.98	21.20	196	268	V	High
2409.240000	45.87	73.98	28.11	153	271	V	High
3710.350000	50.32	73.98	23.66	114	35	Н	High
6493.216000	63.69	73.98	10.29	176	62	Н	High
7420.744000	61.70	73.98	12.28	147	6	Н	High
8348.388000	59.60	73.98	14.38	223	359	V	High



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	Average Measurements							
Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel	
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
1599.960000	32.68	53.98	21.30	182	64	Н	Low	
2411.840000	36.39	53.98	17.59	122	92	V	Low	
3200.070000	35.58	53.98	18.40	225	84	V	Low	
4019.128000	41.92	53.98	12.06	121	34	Н	Low	
5414.414000	41.39	53.98	12.59	180	52	Н	Low	
6316.820000	44.45	53.98	9.53	171	19	Н	Low	
7219.180000	51.53	53.98	2.45	157	8	н	Low	
8121.644000	41.73	53.98	12.25	255	15	V	Low	
1599.890000	32.43	53.98	21.55	153	64	Н	Mid	
1829.570000	38.05	53.98	15.93	111	277	Н	Mid	
1999.920000	34.08	53.98	19.90	198	244	Н	Mid	
2410.150000	32.07	53.98	21.91	126	104	V	Mid	
3200.080000	35.28	53.98	18.70	194	87	V	Mid	
5488.720000	40.18	53.98	13.80	200	65	Н	Mid	
6403.650000	44.71	53.98	9.27	200	23	Н	Mid	
7318.390000	48.11	53.98	5.87	199	359	Н	Mid	
8233.290000	42.46	53.98	11.52	199	22	V	Mid	
3165.610000	39.13	53.98	14.85	176	29	Н	High	
1600.100000	33.47	53.98	20.51	148	286	V	High	
1855.190000	40.24	53.98	13.74	196	268	V	High	
2409.240000	33.33	53.98	20.65	153	271	V	High	
3710.350000	37.78	53.98	16.20	114	35	Н	High	
6493.216000	51.15	53.98	2.83	176	62	Н	High	
7420.744000	49.16	53.98	4.82	147	6	Н	High	
8348.388000	47.06	53.98	6.92	223	359	V	High	
	,	Average Le	vel=Peak L	evel- Duy	Cycle		-	

REMARKS:

- 1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
- 2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
- 3. The other emission levels were very low against the limit.
- 4. Margin value = Emission level Limit value.
- 5. The EUT was measured in all 3 orthogonal axes. See the test setup photo exhibit for details on the orientations.

Test Method: ANSI C63.10, Section(s) 7.8.5

Limits of bandwidth measurements:

Per FCC Part 15

For an FHSS system with 25 channels, the output power is required to be less than 250 mW or 24 dBm.

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Test procedures:

Spectrum analyzer was set with a resolution bandwidth greater than occupied bandwidth and centered on the operating channel.

Deviations from test standard:

No deviation.

Test setup:

Device was connected to a spectrum analyzer with a low loss shielded cable. All attenuators and cables were accounted for.

EUT operating conditions:

The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	Method	RESULT
Low	902.4	22.272	Conducted	PASS
Middle	914.8	22.294	Conducted	PASS
High	927.6	21.920	Conducted	PASS

Peak Output Power

ncee.	Report Number:	R20200311-21-E1	Rev	А
labs	Prepared for:	Inovonics		
Keysight Spectrum	Analyzer - Swent SA			

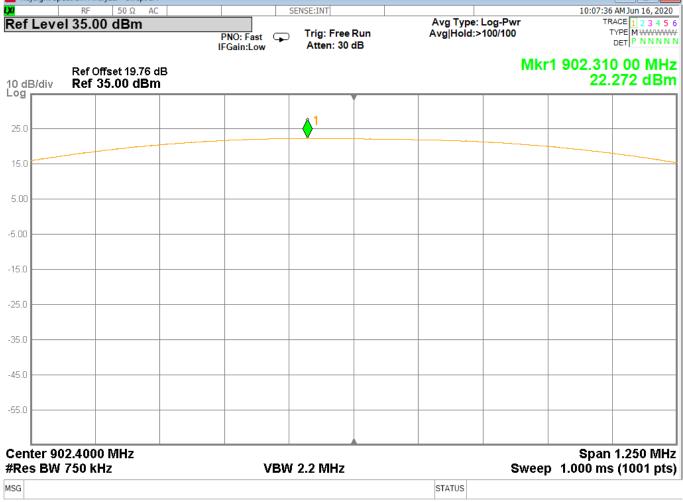
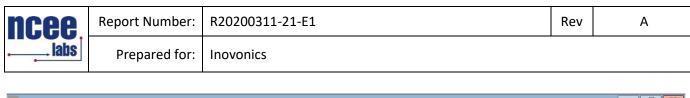


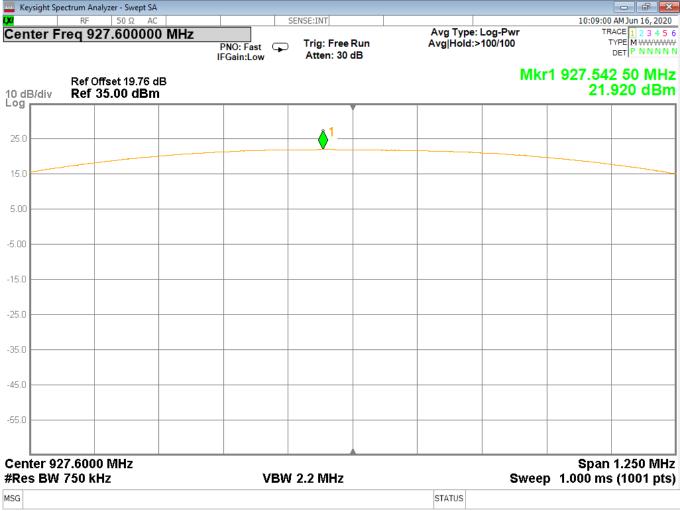
Figure 8 – Output Power, Low Channel

ncee.	Report Number:	R20200311-21-E1	Rev	А
labs	Prepared for:	Inovonics		

	pectrum Analyzer - Swept SA				
w Center F	RF 50 Ω AC Freq 914.800000 MHz	PNO: Fast IFGain:Low Atten: 30	Run Avg Hold	e: Log-Pwr :>100/100	10:08:11 AM Jun 16, 2020 TRACE 1 2 3 4 5 6 TYPE M WWWW DET P N N N N N
10 dB/div Log	Ref Offset 19.76 dB Ref 35.00 dBm			Mkr1 91	4.708 75 MHz 22.294 dBm
25.0		1			
15.0					
5.00					
-5.00					
-15.0					
-25.0					
-45.0					
-55.0					
	14.8000 MHz / 750 kHz	VBW 2.2 MHz		Sweep 1.0	Span 1.250 MHz 000 ms (1001 pts)
MSG			STATUS		









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4.4 **BANDWIDTH**

Test Method: ANSI C63.10, Section(s) 6.9.2

Limits of bandwidth measurements:

The allowed 20 dB bandwidth of the hopping channel is 250 kHz \leq BW \leq 500 kHz.

Test procedures:

The bandwidth of the fundamental frequency was measured by spectrum analyzer with 9 kHz RBW and 30 kHz VBW.

The 20 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 20dB. The 99% bandwidth is defined as the bandwidth that contains 99% of the power.

Deviations from test standard:

No deviation.

Test setup:

Device was connected to a spectrum analyzer with a low loss shielded cable. All attenuators and cables were accounted for.

EUT operating conditions:

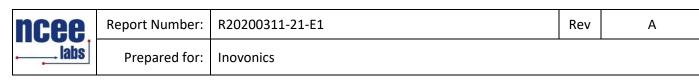
The EUT was powered by 5 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

CHANNEL	CHANNEL FREQUENCY (MHz)	20dB BW (kHz)
Low	902.4	260.7
Mid	914.8	261.4
High	927.6	262.4

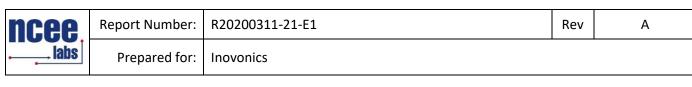
99% dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% BW (kHz)
Low	902.4	246.78
Mid	914.8	245.21
High	927.6	244.92



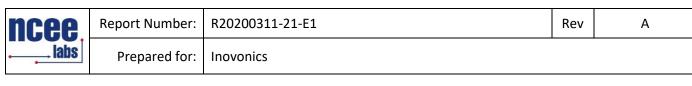
Keysight Spectrum Analyzer - Occupied Bar				- F
RF 50 Ω AC		SENSE:INT		10:02:24 AM Jun 16, 2
ch Atten 40 dB		Center Freq: 902.400000 M Trig: Free Run	MHz Avg Hold:>10/10	Radio Std: None
SS	#IFGain:Low	#Atten: 40 dB		Radio Device: BTS
dB/div Ref 25.00 dBm 9 0 0 0 0 0 0 0 0 0 0 0 0 0			MMMMM	
o hulling and here an	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\		- • • • • • • • • • • • • • • • • • • •	www.www.
0				
nter 902.4 MHz		#VBW 30 kHz		Span 2 M
nter 902.4 MHz es BW 9.1 kHz			25.8 dBm	Span 2 M
nter 902.4 MHz es BW 9.1 kHz Occupied Bandwidt		#VBW 30 kHz		Span 2 M
enter 902.4 MHz es BW 9.1 kHz Occupied Bandwidt	h	#VBW 30 kHz	25.8 dBm	Span 2 M Sweep 23 i
onter 902.4 MHz les BW 9.1 kHz Occupied Bandwidth 24	^h 46.78 kHz	#VBW 30 kHz Total Power	25.8 dBm	Span 2 M
nter 902.4 MHz es BW 9.1 kHz Occupied Bandwidt 24 Transmit Freq Error	h 46.78 kHz -2.224 kHz	#VBW 30 kHz Total Power % of OBW Power	25.8 dBm 99.00 %	Span 2 M

Figure 11 – Bandwidth, Low Channel



Keysight Spectrum Analyzer - Occupied Ba	indwidth - C63.10 2013 Sec. 6.9.2			
RF 50 Ω AC		SENSE:INT Center Freg: 914.800000) MH=	10:03:05 AM Jun 16, 20 Radio Std: None
enter Freq 914.800000		Trian Eres Dun	Avg Hold:>10/10	Radio Sta. None
ISS	#IFGain:Low	#Atten: 40 dB		Radio Device: BTS
dB/div Ref 25.00 dBr	n			
9				
	~./V		WWA -	
0	A ANY		* WhA	
	nava .		1 What	
	ΥΥ			MAMAAAAA
° WAAA.				
.0				MMMMMM
enter 914.8 MHz				Span 2 Mi
tes BW 9.1 kHz		#VBW 30 kHz	<u>.</u>	Sweep 23 r
Occupied Bandwidt	th	Total Power	26.1 dBm	
-	45.21 kHz			
2	4J.21 KHZ			
Transmit Freq Error	-2.124 kHz	% of OBW Powe	r 99.00 %	
x dB Bandwidth	261.4 kHz	x dB	-20.00 dB	
I			STATUS	

Figure 12 - Bandwidth, Mid Channel



RF 50 Ω AC	ndwidth - C63.10 2013 Sec. 6.9.2	SENSE:INT		10:03:49 AM Jun 16, 20
nter Freq 927.600000 I	MHz	Center Freq: 927.600000 I	MHz	Radio Std: None
SS	G	Trig: Free Run	Avg Hold:>10/10	
199	#IFGain:Low	#Atten: 40 dB		Radio Device: BTS
dB/div Ref 25.00 dBn	n	· · · · · · · · · · · · · · · · · · ·		
.0				
0				
0	n M		M.	
0	- ANN		WWW.	
			· · · · · · · · · · · · · · · · · · ·	
	<u> </u>			MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
				MMMMMM
0				
enter 927.6 MHz tes BW 9.1 kHz		#VBW 30 kHz		Span 2 Mi Sweep 23 r
				011000 201
Occupied Bandwidt	h	Total Power	25.7 dBm	
2	44.92 kHz			
Transmit Freq Error	-1.755 kHz	% of OBW Power	99.00 %	
-				
x dB Bandwidth	262.4 kHz	x dB	-20.00 dB	
			STATUS	

Figure 13 - Bandwidth, High Channel



4.5 BANDEDGES

Prepared for:

Test Method: ANSI C63.10, Section(s) 6.10.6

Limits of band edge measurements:

For emissions outside of the allowed band of operation (902 - 928MHz), the emission level needs to be 20dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

Test procedures:

The EUT was tested in the same method as described in section *4.4* - *Bandwidth*. The resolution bandwidth was set to 100kHz and the EMI receiver was used to scan from the band edge to the fundamental frequency with a quasi-peak detector. The highest emissions level beyond the band edge was measured and recorded. For restricted band edge measurements, the unit was tested to the same method as section 4.2 of this report.

Deviations from test standard:

No deviation.

Test setup:

The plots shown below indicate whether the measurement was performed radiated or conducted. For radiated setup, see section 4.2 of this report. For conducted setup, see section 4.3 of this report.

EUT operating conditions:

The EUT was powered by 5 VDC unless specified and set to transmit both continuously on the lowest and highest frequency channel and in normal hopping operation.



Α

Prepared for: Inovonics

Test results:

		Un	restricted Ba	nd-Edge, US			
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level (dBm)	Relative Fundamental (dBm)	Delta (dB)	Min Delta (dB)	Result
Low	Continuous	902.00	-33.480	54.991	55.013	20.00	PASS
Low	Hopping	902.00	-14.171	24.728	38.899	20.00	PASS
High	Continuous	928.00	-33.203	21.809	55.013	20.00	PASS
High	Hopping	928.00	-16.279	20.719	36.999	20.00	PASS
Levels are u	ncorrected and	are used only in rel	ative calculation	ons.			
		R	estricted Ban	d-Edge, US			
CHANNEL	Mode	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m @ 3m)	Detector	Limit (dBuV/m @ 3m)	Margin (dB)	Result
Low	Continuous	612.08	36.170	Peak	46.020	9.85	PASS
Low	Hopping	613.46	38.560	Peak	46.020	7.46	PASS
High	Continuous	977.16	41.370	Peak	53.980	12.61	PASS
High	Hopping	975.54	40.190	Peak	53.980	13.79	PASS
*Limits show	n are the quasi-	peak limits taken fr	om FCC Part	15.209. Peak leve	els are compli	ant with quasi	-peak limit.



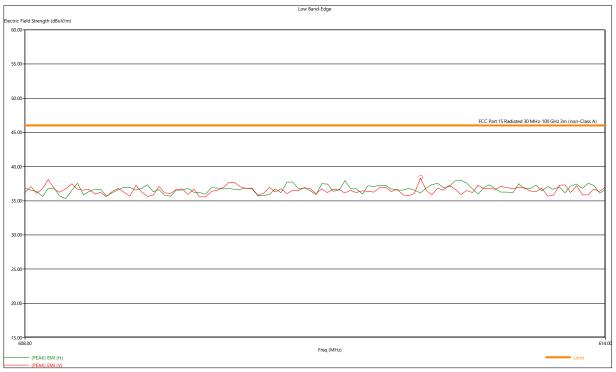
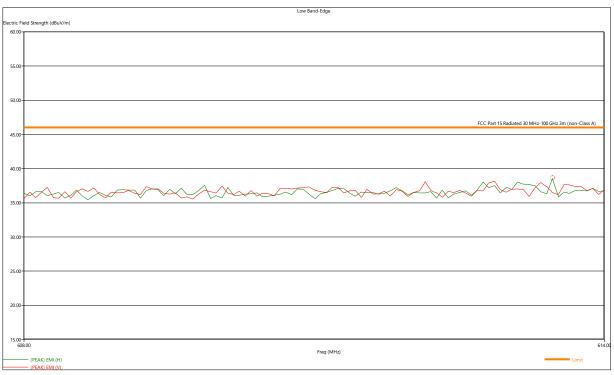


Figure 14 - Band-edge Measurement, Low Channel, Restricted Frequency, Continuous Transmit





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cee	Report Numbe	er: R202003	11-21-E1				Rev	А
labs	Prepared fo	or: Inovonics	;					
Keysight Spectru	ım Analyzer - Swept SA							
out Mech	RF 50 Ω AC Atten 30 dB	PNO: Fast	SENSE:INT	Run A	Avg Type: L Avg Hold:>1		10	17:04 AM Jun 16, 20 TRACE 1 2 3 4 TYPE M WWW DET P N N N
		IFGain:Lov	w #Atten: 30	dB				,
dB/div	Ref Offset 19.76 dB Ref 35.00 dBm	IFGain:Lov	v #Atten: 30	dB		ľ		02.000 MH 33.480 dB
dB/div		IFGain:Lov	w #Atten: 30	dB		Ν		
dB/div		IFGain:Lov	v #Atten: 30			Γ		
dB/div		IFGain:Lov	v #Atten: 30			Γ		
dB/div 9 0.0 00		IFGain:Lov	v #Atten: 30			ľ		
dB/div 9 9 .0 .0 .0		IFGain:Lov	v #Atten: 30			N		
dB/div 9 5.0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .		IFGain:Lov	v #Atten: 30			N		
dB/div Image: state							-	33.480 dB

	rt 84 es B						VBW 1.0	MHz			Stop 905.00 Sweep 1.166 ms (350	0 pts
MKR	MODE	TRC	SCL		Х		Y	FUNCTION	FUNCTION	WIDTH	FUNCTION VALUE	/
1	Ν	1	f		902.391 MHz		21.511 dBm					
2	Δ1	1	f	(Δ)	-391 kHz	(Δ)	-54.991 dB					
3	Ν	1	f		902.000 MHz		-33.480 dBm					
4												
5												
6												
7												
8												
9												
10												
11												
<												>
ISG										STATUS		

Figure 16 - Band-edge Measurement, Low Channel, Fundamental, Continuous The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 55.013 dB > 20 dB Passing unrestricted band edge

nce	Report Number	: R20200311-21-E1		Rev	А
	Prepared for	: Inovonics		·	
🔤 Keysight Sp	ectrum Analyzer - Swept SA				
LXI	RF 50 Ω AC	SENSE:INT		10	:18:15 AM Jun 16, 2020
Start Fre	q 850.000000 MHz		Avg Type: Log-Pwr		TRACE 1 2 3 4 5 6
		PNO: Fast Trig: Free Run IFGain:Low #Atten: 30 dB	Avg Hold:>100/100		DET P N N N N
10 dB/div	Ref Offset 19.76 dB Ref 35.00 dBm		Avg Hold:>100/100		
Log			Avg Hold:>100/100		02.000 MHz
			Avg Hold:>100/100		02.000 MHz
Log			Avg Hold:>100/100		02.000 MHz
25.0 15.0			Avg Hold:>100/100		02.000 MHz
25.0			Avg Hold:>100/100		02.000 MHz

					Sweep 1.166 ms (3500
IKR MODE TRC SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1 N 1 f	902.391 MHz	24.728 dBm			
2 Δ1 1 f (Δ)	-391 kHz (Δ) -38.899 dB			
3 N 1 f	902.000 MHz	-14.171 dBm			
4					
5					
6					
7					
8					
9					
10					
11					

Figure 17 - Band-edge Measurement, Low Channel, Fundamental, Hopping Transmit The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 38.899 dB > 20 dB Passing unrestricted band edge

-15.0 -25.0 -35.0 -45.0 -55.0



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	High Band-Edge
Electric F	ield Strength (dBuV/m)
60.00	
55.00	FCC Part 15 Radiated 30 MHz-100 GHz 3m (non-Class A)
50.00	
45.00	
40.00	I wanted a second dealer the second
40.00	Lange that All her man her was free as we at a short her mark the statement of a short and the short
35.00	
55.00	
30.00	
25.00	
20.00	
15.00 96	
	Freq (MHz)

Figure 18 - Band-edge Measurement, High Channel, Restricted Frequency, Continuous Transmit



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	High Band-Edge
Electric Fi	ield Strength (dBuV/m)
60.00-	
55.00-	FCC Part 15 Radiated 30 MHz-100 GHz 3m (non-Class A)
50.00-	
45.00-	
40.00-	I THE ALM A THE ATTENDED TO A THE AND A THE ADDRESS AND A THE ADDRESS AND A THE ADDRESS AND A THE ADDRESS AND A
40.00-	where the Allow to many and the second a
35.00-	
55.00	
30.00-	
25.00-	
20.00-	
15.00- 96	
50	Freq (MHz)
	(PAD (MI (h) (mit (mit (mit

Figure 19 - Band-edge Measurement, High Channel, Restricted Frequency, Hopping

ncee	Report Number:	R20200311-21-E1			Rev	А
labs	Prepared for:	Inovonics				
	n Analyzer - Swept SA F 50 Ω AC 5.00 dBm	PNO: Fast Trig: Free Run IFGain:Low #Atten: 30 dB	Avg Type Avg Hold	:: Log-Pwr :>100/100	10	20:40 AMJun 16, 2020 TRACE 1 2 3 4 5 6 TYPE M WWWW DET P N N N N
	ef Offset 19.76 dB ef 35.00 dBm					28.000 MHz 33.203 dBm

			T				
3∆1							
m manan	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	hallower allower have the	warder ward ward	have a second and the second second	Marina and a star and a star a st	where we are a second and a second	hand
rt 926.00 MHz		VBW 1.0 M	H7		Sweer		
rt 926.00 MHz es BW 100 kHz		VBW 1.0 M			-	0 1.166 ms	
rt 926.00 MHz Is BW 100 kHz Mode TRC SCL	×	Y		TION WIDTH	-		
nt 926.00 MHz Is BW 100 kHz Mode TRC SCL	927.603 MHz	Y 21.809 dBm		TION WIDTH	-	0 1.166 ms	
rt 926.00 MHz es BW 100 kHz MODE TRC SCL N 1 f Δ1 1 f (Δ)	927.603 MHz 397 kHz (/	21.809 dBm Δ) -55.013 dB		TION WIDTH	-	0 1.166 ms	960.00 N \$ (3500
nt 926.00 MHz Is BW 100 kHz Mode TRC SCL	927.603 MHz	Y 21.809 dBm		TION WIDTH	-	0 1.166 ms	
rt 926.00 MHz s BW 100 kHz MODE TRO SQU N 1 f Δ1 1 f (Δ)	927.603 MHz 397 kHz (/	21.809 dBm Δ) -55.013 dB		TION WIDTH	-	0 1.166 ms	
rt 926.00 MHz es BW 100 kHz Mode tree Set N 1 f Δ1 1 f (Δ)	927.603 MHz 397 kHz (/	21.809 dBm Δ) -55.013 dB		TION WIDTH	-	0 1.166 ms	
rt 926.00 MHz es BW 100 kHz Mode tree Set N 1 f Δ1 1 f (Δ)	927.603 MHz 397 kHz (/	21.809 dBm Δ) -55.013 dB		TION WIDTH	-	0 1.166 ms	
rt 926.00 MHz es BW 100 kHz MODE TRC SCL N 1 f Δ1 1 f (Δ)	927.603 MHz 397 kHz (/	21.809 dBm Δ) -55.013 dB		TION WIDTH	-	0 1.166 ms	
rt 926.00 MHz es BW 100 kHz Mode tree Set N 1 f Δ1 1 f (Δ)	927.603 MHz 397 kHz (/	21.809 dBm Δ) -55.013 dB		TION WIDTH	-	0 1.166 ms	
rt 926.00 MHz es BW 100 kHz MODE TRC SCL N 1 f Δ1 1 f (Δ)	927.603 MHz 397 kHz (/	21.809 dBm Δ) -55.013 dB		TION WIDTH	-	0 1.166 ms	
Δ1 1 f (Δ)	927.603 MHz 397 kHz (/	21.809 dBm Δ) -55.013 dB			-	0 1.166 ms	
rt 926.00 MHz es BW 100 kHz MODE TRC SCL N 1 f Δ1 1 f (Δ)	927.603 MHz 397 kHz (/	21.809 dBm Δ) -55.013 dB		TION WIDTH	-	0 1.166 ms	

Figure 20 - Band-edge Measurement, High Channel, Fundamental, Continuous Transmit

The plot shows an uncorrected measurement, used for relative measurements only. Delta = 55.013 dB > 20 dB Passing unrestricted band edge

	of Offset 19.76 dB of 35.00 dBm						28.000 MHz 16.279 dBm
Ref Level 35	F 50 Ω AC 5.00 dBm	PNO: Fast	Trig: Free Run #Atten: 30 dB	Avg Type Avg Hold:	: Log-Pwr >100/100	10	21:47 AM Jun 16, 2020 TRACE 1 2 3 4 5 6 TYPE M WWWW DET P N N N N
Keysight Spectrum) Analyzer - Swept SA						
	Prepared for:	Inovonics					
ncee.	Report Number:	R20200311-21-I	E1			Rev	А

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마											
0											
1							1				
	5 BW 1					V 1.0 MHz			•	0 1.166 ms	· ·
	IODE TOO	CCL		×	V	ET IN	CTION LINE		-		
				X	Y 20 740		CTION FUNC	TION WIDTH	F	JNCTION VALUE	
	N 1	f		927.603 MHz	20.719	dBm	CTION FUNC	TION WIDTH	FL	JNCTION VALUE	
	Ν 1 Δ1 1	f f	(Δ)	927.603 MHz 397 kHz	20.719 (Δ) -36.99	dBm 99 dB	CTION FUNC	TION WIDTH	F	JNCTION VALUE	
4	N 1	f	(Δ)	927.603 MHz	20.719	dBm 99 dB	CTION FUNC	TION WIDTH	E	JNCTION VALUE	
1	Ν 1 Δ1 1	f f	(Δ)	927.603 MHz 397 kHz	20.719 (Δ) -36.99	dBm 99 dB	CTION FUNC	TION WIDTH	E	UNCTION VALUE	
1	Ν 1 Δ1 1	f f	(Δ)	927.603 MHz 397 kHz	20.719 (Δ) -36.99	dBm 99 dB	CTION FUNC	TION WIDTH	F	JNCTION VALUE	
	Ν 1 Δ1 1	f f	(Δ)	927.603 MHz 397 kHz	20.719 (Δ) -36.99	dBm 99 dB	CTION FUNC	TION WIDTH	F	JNCTION VALUE	
	Ν 1 Δ1 1	f f	(Δ)	927.603 MHz 397 kHz	20.719 (Δ) -36.99	dBm 99 dB	CTION FUNC	TION WIDTH	F	JNCTION VALUE	
	Ν 1 Δ1 1	f f	(Δ)	927.603 MHz 397 kHz	20.719 (Δ) -36.99	dBm 99 dB	CTION FUNC	TION WIDTH	F	JNCTION VALUE	
	Ν 1 Δ1 1	f f	(Δ)	927.603 MHz 397 kHz	20.719 (Δ) -36.99	dBm 99 dB	CTION FUNC	TION WIDTH	F	JNCTION VALUE	
2 4	Ν 1 Δ1 1	f f	(Δ)	927.603 MHz 397 kHz	20.719 (Δ) -36.99	dBm 99 dB			F	JNCTION VALUE	>

Figure 21 - Band-edge Measurement, High Channel, Fundamental, Hopping Transmit The plot shows an uncorrected measurement, used for relative measurements only.

Delta = 36.999 dB > 20 dB Passing unrestricted band edge



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4.6 CARRIER FREQUENCY SEPERATION, NUMBER OF HOPPING CHANNELS, TIME OF OCCUPANCY

Test Method: ANSI C63.10, Section 7.8.2, 7.8.3, 7.8.4

Limits for Time of Occupancy

Average time of occupancy on any frequency, not to exceed 0.4 seconds within a 10 second period.

Test procedures:

The method from KDB 558074 D01 v05

Test setup:

All measurements were performed with the EUT connected directly to a spectrum analyzer with a low loss shielded cable and attenuator. All losses were accounted for.

EUT operating conditions:

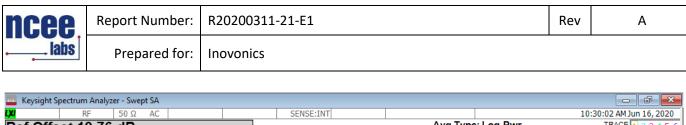
The EUT was powered by 5VDC unless specified and set to transmit while hopping.

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Test results:

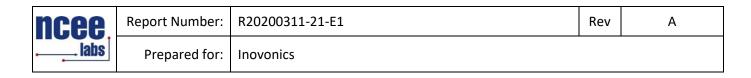


Figure 22 – Frequency Separation, Minimum



Ref Offse	et 19.	.76 dB	P	PNO: Wide Gain:Low		: Free Run en: 30 dB	A	Avg Type: L .vg Hold:>1	₋og-Pwr 100/100	T	TRACE 1 2 3 4 5 TYPE MWWW DET P N N N N
10 dB/div		Offset 19.76 35.00 dB									2.336 MH .520 dBn
- og 25.0		1									
5.00											
5.00											
25.0											
35.0											
15.0 55.0											
	000									Oton 0	04.000 844
tart 902 Res BW				v	'BW 750	kHz			Sweep	1.000 m	04.000 MH s (1001 pts
KR MODE TI	f		x 902.336 MHz	22.	Y 520 dBm	FUNCTION	FUNCTION	WIDTH	FUI	ICTION VALUE	
2 Δ1 1 3 4	f	(Δ)	1.190 MHz	(Δ)	0.409 dB						
5											
7 8 9											
10 11											
sg								STATUS			>

Figure 23 – Frequency Separation, Maximum



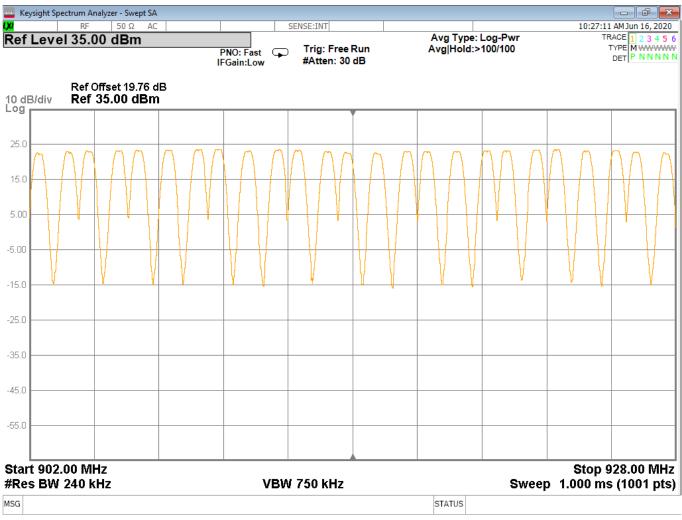


Figure 24 – Hop Count, 25 Hops





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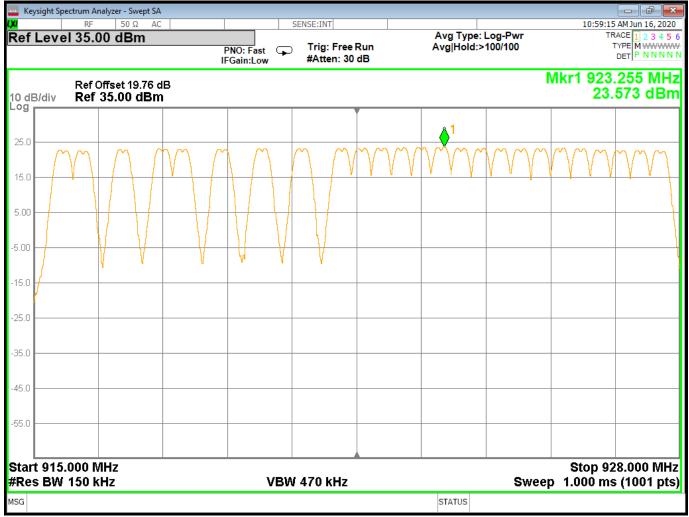
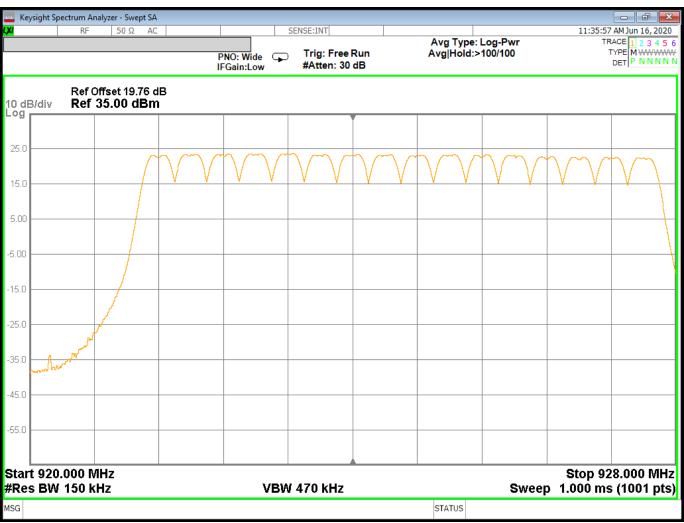


Figure 25 – Hop Count, Australia





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Figure 26 – Hop Count, New Zealand



	ctrum Analyzer - Swept SA								- 6 ×
	RF 50 Ω AC			SENSE:INT		Avg Type: I	og-Pwr		AM Jun 16, 2020 ACE 1 2 3 4 5 6
Refleve	l 35.00 dBm		NO: Wide ↔ Gain:Low	Trig: Video #Atten: 30	dB	Avg Hold: 1	/1	1	TYPE MWWWW DET P NNNNN
10 dB/div Log	Ref Offset 19.76 dB Ref 35.00 dBm							Mkr1 22.	23.20 ms 834 dBm
		<u>ـ ۱</u>							
25.0		•							
15.0									
5.00									
-5.00									TRIG LVL
-15.0									
-25.0									
-35.0									
-45.0			un high the description	Hat the state of t	a the physical states and the second states and the second states and the second states and the second states a	M north When	ppp hurphly	ullow we have	allow have the
-55.0									
Center 90 Res BW 1	2.400000 MHz 00 kHz		VBV	V 300 kHz			Sweep		Span 0 Hz (1001 pts)
MSG						STATUS			

Figure 27 – Time of Occupancy, On Time

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uuu Ke	eysight Spe	ctrum Anal	lyzer - Swept SA								
LXI		RF	50 Ω AC			SENSE:INT					AM Jun 16, 2020
RB\	N 240	kHz			PNO: Wide ↔→→ IFGain:Low	Trig: Video #Atten: 30		Avg Type: Avg Hold:	Log-Pwr 1/1	1	ACE 1 2 3 4 5 6 TYPE M WWWW DET P N N N N N
10 d Log	B/div		fset 19.76 d 5.00 dBm								20.00 ms 956 dBm
25.0	1 1										
15.0											
5.00											
-5.00											TRIG LVL
-15.0											
-25.0											
-35.0	morespher	wathrown	priladablerar	mphallmand	manuf	and and a state of	1-Mahanah	hanna han Na mana hanna ha		hele ware and the second se	www.howwolynalyna
-45.0											
-55.0											
	ter 90: BW 24		00 MHz	1	VBW	/ 750 kHz	1	1	Swe	ep 10.00 s	Span 0 Hz (1001 pts)
MSG								STATUS			

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Figure 28 – Time of Occupancy, Period



4.7 CONDUCTED AC MAINS EMISSIONS

Test Method: ANSI C63.10-2013, Section(s) 6.2

Limits for conducted emissions measurements:

FREQUENCY OF EMISSION (MHz)	CONDUCTE (dBµ\	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

Notes:

1. The lower limit shall apply at the transition frequencies.

The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
 All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

Test Procedures:

- a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
- c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
- d. Results were compared to the 15.207 limits.

Deviation from the test standard:

No deviation

EUT operating conditions:

Details can be found in section 2.1 of this report.

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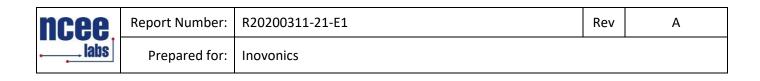
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	Prepared for:	Inovonics		

Test Results:



Figure 29 - Conducted Emissions Plot, Line



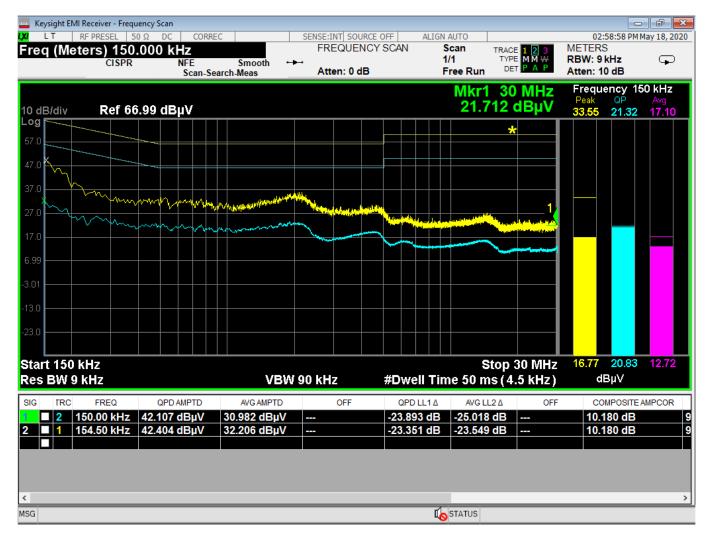
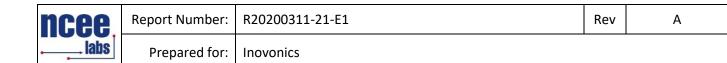


Figure 30 - Conducted Emissions Plot, Neutral



APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows: FS = RA + AF - (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude AF = Antenna Factor CF = Cable Attenuation Factor AG = Amplifier Gain AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dB μ V is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dB μ V/m.

 $FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$

The 48.1 dB μ V/m value can be mathematically converted to its corresponding level in μ V/m.

Level in μ V/m = Common Antilogarithm [(48.1 dB μ V/m)/20]= 254.1 μ V/m

AV is calculated by the taking the $20^{100}(T_{on}/100)$ where T_{on} is the maximum transmission time in any 100ms window.

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EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]² / 30

Power (watts) = 10^[Power (dBm)/10] / 1000

Voltage ($dB\mu V$) = Power (dBm) + 107 (for 50 Ω measurement systems)

Field Strength (V/m) = 10^{Field} Strength (dB μ V/m) / 20] / 10^{6}

Gain = 1 (numeric gain for isotropic radiator)

Conversion from 3m field strength to EIRP (d=3):

 $EIRP = [FS(V/m) \times d^2]/30 = FS[0.3]$ for d = 3

 $EIRP(dBm) = FS(dB\mu V/m) - 10(log 10^9) + 10log[0.3] = FS(dB\mu V/m) - 95.23$

10log(10^9) is the conversion from micro to milli



APPENDIX B - MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB

Expanded uncertainty values are calculated to a confidence level of 95%.

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