

FCC IC Test Report

Report No.: FCC_IC_RF_SL19082201-JAD-011 Rev 2.0 FCC ID: QV5MERCURY6E-MH IC: 5407A-MERCURY6EMH Test Model: M6e-Micro-A Variant Model: M6e-M-A Received Date: 09/01/2019 Test Date: 09/05/2019/-09/24/2019 Issued Date: 01/14/2020 Applicant: JADAK, a business unit of Novanta Corporation Address: 125 Middlesex Turnpike, Bedford, MA 01730 Manufacturer: JADAK, a business unit of Novanta Corporation Address: 125 Middlesex Turnpike, Bedford, MA 01730 Issued By: Bureau Veritas Consumer Products Services, Inc. Lab Address: 775 Montague Expressway, Milpitas, CA 95035 **Test Location (1):** 775 Montague Expressway, Milpitas, CA 95035 FCC Registration / 540430 **Designation Number:** ISED# / CAB identifier: 4842D



This report is for your exclusive use. Any copying or replication of this report to or for any other person or entity, or use of our name or trademark, is permitted only with our prior written permission. This report sets forth our findings solely with respect to the test samples identified herein. The results set forth in this report are not indicative or representative of the quality or characteristics of the lot from which a test sample was taken or any similar or identical product unless specifically and expressly noted. Our report includes all of the tests requested by you and the results thereof based upon the information that you provided to us. You have 60 days from date of issuance of this report to notify us of any material error or omission caused by our negligence, provided, however, that such notice shall be in writing and shall specifically address the issue you wish to raise. A failure to raise such issue within the prescribed time shall constitute your unqualified acceptance of the completeness of this report, the tests conducted and the correctness of the report contents. Unless specification, the uncertainty of measurement has been explicitly taken into account to declare the compliance or non-compliance to the specification. The report must not be used by the client to claim product certification, approval, or endorsement by A2LA or any government agencies.



Table of Contents

R	Release Control Record 4					
1	Certificate of Conformity5					
2	S	ummary of Test Results	6			
	2.1 2.2	Measurement Uncertainty Modification Record	6			
3	G	ieneral Information	7			
Ŭ	2.4					
	3.1	Description of Test Modes	/ 8			
	3.3	Description of Support Units	9			
	3.3.1	Configuration of System under Test	9			
	3.4	General Description of Applied Standards	9			
4	т	est Types and Results	.10			
	4.1	Radiated Emission Measurement	. 10			
	4.1.1	Limits of Radiated Emission	. 10			
	4.1.2	Test Instruments	.11			
	4.1.3	Test Procedures	12			
	4.1.4	Deviation from Test Standard	.12			
	4.1.5	Test Setup	13			
	4.1.0	EUT Operating Conditions	14			
	4.1.7	Channel Bandwidth	23			
	421	Limits of Channel Bandwidth Measurement	23			
	4.2.2	Test Setup.	. 23			
	4.2.3	Test Instruments	. 23			
	4.2.4	Test Procedure	23			
	4.2.5	Deviation from Test Standard	23			
	4.2.6	EUT Operating Condition	23			
	4.2.7	Test Results	24			
	4.3	Hopping Channel Separation	27			
	4.3.1	Limits of Hopping Channel Separation Measurement	27			
	4.3.2	Test Instruments	27			
	4.3.4	Test Procedure	. 27			
	4.3.5	Deviation from Test Standard	. 27			
	4.3.6	Test Results	28			
	4.4	Conducted Output Power Measurement	31			
	4.4.1	Limits of Conducted Output Power Measurement	.31			
	4.4.2	Test Setup	31			
	4.4.3	Test Instruments	31			
	4.4.4	Deviation from Test Standard	31			
	446	Test Results	32			
	4.5	Number of Hopping Frequency Used	35			
	4.5.1	Limits of Hopping Frequency Used Measurement	35			
	4.5.2	Test Setup	35			
	4.5.3	Test Instruments	35			
	4.5.4	Test Procedure	35			
	4.5.5	Deviation from Test Standard	35			
	4.5.b 1 6	Iesi Results	30 27			
	4.61	Limits of Dwell Time on Each Channel Measurement	37			
	4.6.2	Test Setup.	37			



4.6.3	Test Instruments	37				
4.6.4	Test Procedures	37				
4.6.5	Deviation from Test Standard	37				
4.6.6	Test Results	38				
4.7	Conducted Out of Band Emission Measurement	42				
4.7.1	Limits of Conducted Out of Band Emission Measurement	42				
4.7.2	Test Instruments	42				
4.7.3	Test Procedure	42				
4.7.4	Deviation from Test Standard	42				
4.7.5	EUT Operating Condition	42				
4.7.6	Test Results	42				
4.7.7	Test Results	43				
Append	Appendix – Information on the Testing Laboratories					



Release Control Record

Issue No.	Description	Date Issued
FCC_IC_RF_SL19082201-JAD-011	Orignal Release	09/25/2019
FCC_IC_RF_SL19082201-JAD-011 Rev 1.0	Updated per client	09/30/2019
FCC_IC_RF_SL19082201-JAD-011 Rev 2.0	Updated IDs and model	01/14/2020



Certificate of Conformity 1

Product:	RFID module		
Brand:	JADAK, a business unit of Novanta Corporation		
Test Model:	M6e-Micro-A, M6e-M-A		
Sample Status:	Engineering sample		
Applicant:	JADAK, a business unit of Novanta Corporation		
Test Date:	09/05/2019/-09/24/2019		
Standards:	47 CFR FCC Part 15, Subpart C (Section 15.247)		
	RSS-247 Issue 2, February 2017		
	ANSI C63.10: 2013		
	RSS-Gen Issue 5, March 2019		
	DA 00-705, 2000		

The above equipment has been tested by Bureau Veritas Consumer Products Services, Inc., Milpitas Branch, and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's EMC characteristics under the conditions specified in this report.

Deon Dai / Test Engineer

Prepared by :

, **Date:**_____09/25/2019

Approved by : _____

_____, **Date:**_____01/14/2020

Chen Ge / Engineer Reviewer



2 Summary of Test Results

47 CFR FCC Part 15, Subpart C (SECTION 15.247)						
FCC Clause	Test Item	Result	Remarks			
15.207	AC Power Conducted Emission	N/A	Device is DC powered.			
15.247(a)(1) (iii)	Number of Hopping Frequency Used	PASS	Meet the requirement of limit.			
15.247(a)(1) (iii)	Dwell Time on Each Channel	PASS	Meet the requirement of limit.			
15.247(a)(1)	 Hopping Channel Separation Spectrum Bandwidth of a Frequency Hopping Sequence Spread Spectrum System 	PASS	Meet the requirement of limit.			
15.247(b)	Maximum Peak Output Power	PASS	Meet the requirement of limit.			
15.247(d)	Band Edge Measurement	PASS	Meet the requirement of limit.			
15.205 & 209 & 15.247(d)	Radiated Emissions	PASS	Meet the requirement of limit.			
15.203	Antenna Requirement	PASS	Antenna connector is RP-TNC not a standard connector. Professional installation is required.			

2.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

N/s s s w s s s s s s s s s s s s s s s s	F	Expanded Uncertainty
ivieasurement	150kHz ~ 30MHz	(k=2) (±)
Conducted Emissions at mains ports	150kHz ~ 30MHz	3.51dB
Radiated Emissions up to 1 GHz	30MHz ~ 1GHz	3.73dB
	1GHz ~ 6GHz	4.64dB
Radiated Emissions above 1 GHz	6GHz ~ 18GHz	4.82dB
	150kHz ~ 30MHz 30MHz ~ 1GHz 1GHz ~ 6GHz 6GHz ~ 18GHz 18GHz ~ 40GHz	4.91dB

2.2 Modification Record

There were no modifications required for compliance.



3 General Information

3.1 General Description of EUT

Product	RFID module		
Brand	JADAK, a business unit of Novanta Corporation		
Test Model	M6e-Micro-A		
Variant Model	M6e-M-A		
Identification No. of EUT	N/A		
Status of EUT	Engineering sample		
Power Supply Rating	5Vdc		
Modulation Type	AM		
Modulation Technology	FHSS		
Transfer Rate	160kHz		
Operating Frequency	902.75-927.25MHz		
Number of Channel	50		
	Power at the output of module: 31.5 dBm		
Output Power	Output Power at the end of the cable: 29.45 dBm.		
	ANT 1:		
	Antenna Type: RHCP Patch Antenna		
	Gain: 9 dBiC Typical		
	Brand: MTI Wireless Edge Ltd.		
	Model No: MT-242043/TRH/A/K		
Antenna Info			
	ANT2:		
	Antenna Type: Dipole		
	Gain: 6 dBi		
	Brand: Laird Technologies		
	Model No: S8964B		
Antenna Connector	RP-TNC		

There is no hardware difference between the 2 model numbers. The only difference is in the number of UHF RFID tags that the device reads. The M6e-Micro-A is limited to 50 tags per second, once this limit is reached no new tags are stored in the tag buffer. The M6e-M-A has no limitation on the number of tags that enters its tag buffer. This limitation is implemented in software. There is no change in the configuration of the RF transmitter or receiver between the 2 models.



3.2 Description of Test Modes

50 channels are provided to this EUT:

Channel Low	Frequency (MHz)		
Low	902.75		
Mid	915.25		
High	927.25		



3.3 Description of Support Units

The RFID module (which is the EUT) is soldered to the CARRIER BOARD.

The M6E-DEVKIT provides power to the module and has Serial and USB interfaces to support both board-toboard and board-to-host connectivity.

ID	Product	Brand	Model No.	Serial No.	FCC ID	Remarks
Α.	DC power supply	RIGOL	DP712	SED234155	N/A	N/A
В.	Laptop	Dell	XPS	C1MR31G5G944	N/A	N/A
C.	M6E-DEVKIT	JADAK, a business unit of Novanta Corporation	540-0061-01	N/A	N/A	N/A
D.	M6e-Micro-A Carrier board	JADAK, a business unit of Novanta Corporation	450-0056-01	N/A	N/A	N/A
Ε.	12 ft. cable	ThingMagic	CBL-P12	N/A	N/A	N/A

ID	Descriptions	Qty.	Length (m)	Shielding (Yes/No)	Cores (Qty.)	Remarks
1.	USB console cable	1	0.8	Ν	0	Provided by Customer

Note: The core(s) is(are) originally attached to the cable(s).

3.3.1 Configuration of System under Test



3.4 General Description of Applied Standards

The EUT is a RF Product. According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

47 CFR FCC Part 15, Subpart C (Section 15.247) RSS 247 Issue2, February 2017 ANSI C63.10: 2013 RSS Gen Issue5, March 2019 DA 00-705, 2000

All test items have been performed and recorded as per the above standards.



4 Test Types and Results

4.1 Radiated Emission Measurement

4.1.1 Limits of Radiated Emission

Radiated emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table. Other emissions shall be at least 20dB below the highest level of the desired power:

Frequencies (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 ~ 0.490	2400/F(kHz)	300
0.490 ~ 1.705	24000/F(kHz)	30
1.705 ~ 30.0	30	30
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 (uV/m).

3. 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, specified above by more than 20dB under any condition of modulation.



4.1.2 Test Instruments

DESCRIPTION & MANUFACTURER	MODEL NO.	SERIAL NO.	DATE OF CALIBRATION	DUE DATE OF CALIBRATION
EMI Test Receiver ROHDE & SCHWARZ	ESIB 40	100179	08/28/2019	08/28/2020
Spectrum Analyzer KEYSIGHT	N9030B	MY57140374	07/22/2019	07/22/2020
Hybrid Antenna SUNAR	JB6	A111717	03/09/2019	03/09/2020
DRG Horn Antenna ETS LINDGREN	3117	214309	11/22/2018	11/22/2019
Preamplifier RF-LAMBDA	RAMP00M50GA	17032300047	10/19/2018	10/19/2019
Preamplifier RF-BAY	LPA-6-30	11170602	05/06/2019	05/06/2020



4.1.3 Test Procedures

For Radiated emission below 30MHz

- a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.
- 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. Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- e. The test-receiver system was set to Quasi-Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

NOTE:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9 kHz at frequency below 30MHz.

For Radiated emission above 30MHz

- a. The EUT was placed on the top of a rotating table 0.8 meters (for 30MHz ~ 1GHz) / 1.5 meters (for above 1GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.
- 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 height of antenna 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 set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- e. The test-receiver system was set to quasi-peak detect function and specified bandwidth with maximum hold mode when the test frequency is below 1 GHz.
- f. The test-receiver system was set to peak and average detects function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

Note:

- 1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasipeak detection (QP) at frequency below 1GHz.
- 2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.
- 3. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and the video bandwidth is ≥ 1/T (Duty cycle < 98%) or 10Hz (Duty cycle ≥ 98%) for Average detection (AV) at frequency above 1GHz.
- 4. All modes of operation were investigated and the worst-case emissions are reported.

4.1.4 Deviation from Test Standard

No deviation.



4.1.5 Test Setup







For the actual test configuration, please refer to the attached file (Test Setup Photo).

4.1.6 EUT Operating Conditions

- a. Connected the EUT with the Notebook Computer which is placed on remote site.
- b. Controlling software has been activated to set the EUT on specific status.



4.1.7 Test Results

BELOW 1GHz WORST-CASE DATA:

Antenna 1 RHCP Patch Antenna

CHANNEL	Middle Channel	DETECTOR	
FREQUENCY RANGE	30MHz – 1GHz	FUNCTION	Quasi Peak

	ANTENNA POLARITY & test distance: HORIZONTAL& VERTICAL at 3 m												
No	Freq.	Raw	Cale Loss	AF	Level	Measurement	Pol	Hgt	Azt	Limit	Margin	Pass /Fail	
	[MHz]	(dBuV)	(dB)	(dB/m)	(dBuV/m)	туре		(cm)	Deg	(dBuV/m)	(dB)	/i ali	
1	51.44	47.09	11.45	-26.43	32.11	Quasi Max	V	213	105	40	-7.89	Pass	
2	72.08	50.18	11.6	-27.64	34.14	Quasi Max	V	101	155	40	-5.86	Pass	
3	168.15	49.97	12.34	-24.16	38.15	Quasi Max	Н	204	18	43.5	-5.35	Pass	
4	216.17	50.2	12.77	-25.39	37.59	Quasi Max	Н	136	14	46	-8.41	Pass	
5	312.54	37.88	13.29	-21.79	29.38	Quasi Max	Н	114	356	46	-16.62	Pass	
6	114.95	37.08	12.01	-23.05	26.04	Quasi Max	V	157	191	43.5	-17.46	Pass	

REMARKS:

- 1. Emission level (dBuV/m) = Raw Value (dBuV) + Cable Loss (dB) + AF (dB)
- 2. AF (dB/m) = Antenna Factor (dB/m) Preamplifier Gain (dB).
- 3. The emission levels of other frequencies were less than 20dB margin against the limit.
- 4. Margin value = Emission level Limit value.





Antenna 2 (Dipole antenna)

CHANNEL	Middle Channel	DETECTOR	
FREQUENCY RANGE	30MHz – 1GHz	FUNCTION	Quasi Peak

	ANTENNA POLARITY & test distance: HORIZONTAL& VERTICAL at 3 m											
No	Freq.	Raw	Cale Loss	AF	Level	Measurement	Pol	Hgt	Azt	Limit	Margin	Pass /Fail
	[MHz]	(dBuV)	(dB)	(dB/m)	(dBuV/m)	турс		(cm)	Deg	(dBuV/m)	(dB)	/1 011
1	51.42	47.66	11.45	-26.43	32.68	Quasi Max	V	100	259	40	-7.32	Pass
2	168.16	41.9	12.34	-24.16	30.08	Quasi Max	Н	147	106	43.5	-13.42	Pass
3	72.06	50.51	11.6	-27.64	34.47	Quasi Max	V	111	89	40	-5.53	Pass
4	120.13	41.86	12.07	-22.73	31.2	Quasi Max	V	146	116	43.5	-12.3	Pass
5	216.25	51.37	12.77	-25.38	38.76	Quasi Max	Н	146	8	46	-7.25	Pass
6	264.24	46.15	13.04	-23.79	35.4	Quasi Max	Н	110	110	46	-10.61	Pass

REMARKS:

- 1. Emission level (dBuV/m) = Raw Value (dBuV) + Cable Loss (dB) + AF (dB)
- 2. AF (dB/m) = Antenna Factor (dB/m) Preamplifier Gain (dB).
- 3. The emission levels of other frequencies were less than 20dB margin against the limit.
- 4. Margin value = Emission level Limit value.





ABOVE 1GHz TEST DATA:

Antenna 1 RHCP Patch Antenna

CHANNEL	Low Channel	DETECTOR	Peak
FREQUENCY RANGE	1GHz ~ 10GHz	FUNCTION	Average

		ANTE	INNA I	POLAR	ITY & test	distance: HO	RIZO	NTAL&	VERTICA	AL at 3 m		
No	Freq.	Raw	Cale Loss	AF	Level	Measurement	Pol	Hgt	Azt	Limit	Margin	Pass /Eail
	[MHz]	(dBuV)	(dB)	(dB/m)	(dBuV/m)	туре		(cm)	Deg	(dBuV/m)	(dB)	/1 aii
1	4515.78	50.74	5.21	-11.59	44.36	Peak Max	V	139	360	74	-29.64	Pass
2	16851.59	45.78	9.59	1.85	57.21	Peak Max	V	120	134	74	-16.79	Pass
3	6322.94	49.78	6.04	-8.32	47.51	Peak Max	V	142	60	74	-26.49	Pass
4	5420.92	50.42	5.55	-10.33	45.64	Peak Max	V	125	179	74	-28.36	Pass
5	4515.78	38.8	5.21	-11.59	32.42	Average Max	V	139	360	54	-21.58	Pass
6	16851.59	33.61	9.59	1.85	45.05	Average Max	V	120	134	54	-8.95	Pass
7	6322.94	36.88	6.04	-8.32	34.61	Average Max	V	142	60	54	-19.4	Pass
8	5420.92	38.17	5.55	-10.33	33.39	Average Max	V	125	179	54	-20.61	Pass

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Cable Loss (dB) + AF (dB)

2. AF (dB/m) = Antenna Factor (dB/m) – Preamplifier Gain (dB).

3. The emission levels of other frequencies were less than 20dB margin against the limit.



CHANNEL	Middle Channel	DETECTOR	Peak
FREQUENCY RANGE	1GHz ~ 10GHz	FUNCTION	Average

		ANTE	INNA I	POLAR	ITY & test	distance: HO	RIZOI	NTAL&	VERTICA	AL at 3 m		
No	Freq.	Raw	Cale Loss	AF	Level	Measurement	Pol	Hgt	Azt	Limit	Margin	Pass /Eail
	[MHz]	(dBuV)	(dB)	(dB/m)	(dBuV/m)	туре		(cm)	Deg	(dBuV/m)	(dB)	/1 ali
1	6406.56	64.85	6.12	-8.18	62.78	Peak Max	V	130	257	74	-11.22	Pass
2	4580.41	51.67	5.2	-11.35	45.52	Peak Max	V	140	186	74	-28.48	Pass
3	16641.86	45.42	9.57	1.7	56.69	Peak Max	Н	140	305	74	-17.31	Pass
4	5493.58	49.74	5.7	-10.31	45.14	Peak Max	V	157	4	74	-28.86	Pass
5	6406.56	47.36	6.12	-8.18	45.3	Average Max	V	130	257	54	-8.7	Pass
6	4580.41	38.42	5.2	-11.35	32.28	Average Max	V	140	186	54	-21.73	Pass
7	16641.86	33.08	9.57	1.7	44.35	Average Max	Н	140	305	54	-9.65	Pass
8	5493.58	37.81	5.7	-10.31	33.21	Average Max	V	157	4	54	-20.79	Pass

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Cable Loss (dB) + AF (dB)

2. AF (dB/m) = Antenna Factor (dB/m) – Preamplifier Gain (dB).

3. The emission levels of other frequencies were less than 20dB margin against the limit.



CHANNEL	High Channel	DETECTOR	Peak
FREQUENCY RANGE	1GHz ~ 10GHz	FUNCTION	Average

		ANTE	INNA I	POLAR	ITY & test	distance: HO	rizoi	NTAL&	VERTICA	AL at 3 m		
No	Freq.	Raw	Cale Loss	AF	Level	Measurement	Pol	Hgt	Azt	Limit	Margin	Pass /Eail
	[MHz]	(dBuV)	(dB)	(dB/m)	(dBuV/m)	туре		(cm)	Deg	(dBuV/m)	(dB)	/1 ali
1	6491.14	60.67	6.2	-8.03	58.84	Peak Max	V	122	257	74	-15.16	Pass
2	16266.87	46.32	9.4	0.74	56.46	Peak Max	Н	193	340	74	-17.54	Pass
3	4635.71	61.12	5.19	-11.2	55.12	Peak Max	V	183	245	74	-18.89	Pass
4	5556.91	50.53	5.63	-10.22	45.95	Peak Max	V	159	139	74	-28.05	Pass
5	1850.63	53.18	3.13	-14.03	42.28	Peak Max	V	116	111	74	-31.72	Pass
6	6491.14	44.47	6.2	-8.03	42.64	Average Max	V	122	257	54	-11.36	Pass
7	16266.87	34.28	9.4	0.74	44.42	Average Max	Н	193	340	54	-9.58	Pass
8	4635.71	49.28	5.19	-11.2	43.27	Average Max	V	183	245	54	-10.73	Pass

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Cable Loss (dB) + AF (dB)

2. AF (dB/m) = Antenna Factor (dB/m) – Preamplifier Gain (dB).

3. The emission levels of other frequencies were less than 20dB margin against the limit.



ABOVE 1GHz TEST DATA:

Antenna 2 (Dipole antenna)

CHANNEL	Low Channel	DETECTOR	Peak
FREQUENCY RANGE	1GHz ~ 10GHz	FUNCTION	Average

		ANTE	INNA I	POLAR	ITY & test	distance: HO	RIZOI	NTAL&	VERTICA	AL at 3 m		
No	Freq.	Raw	Cale Loss	AF	Level	Measurement	Pol	Hgt	Azt	Limit	Margin	Pass /Eail
	[MHz]	(dBuV)	(dB)	(dB/m)	(dBuV/m)	туре		(cm)	Deg	(dBuV/m)	(dB)	/1 aii
1	4518.67	51.14	5.21	-11.58	44.77	Peak Max	V	191	66	74	-29.23	Pass
2	16627.38	45.53	9.57	1.68	56.77	Peak Max	V	107	360	74	-17.23	Pass
3	6324.90	49.31	6.04	-8.31	47.04	Peak Max	V	100	240	74	-26.96	Pass
4	5418.99	50.65	5.55	-10.33	45.87	Peak Max	V	145	171	74	-28.13	Pass
5	4518.67	38.38	5.21	-11.58	32.02	Average Max	V	191	66	54	-21.99	Pass
6	16627.38	33.09	9.57	1.68	44.34	Average Max	V	107	360	54	-9.67	Pass
7	6324.90	36.77	6.04	-8.31	34.5	Average Max	V	100	240	54	-19.5	Pass
8	5418.99	38.23	5.55	-10.33	33.44	Average Max	V	145	171	54	-20.56	Pass

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Cable Loss (dB) + AF (dB)

2. AF (dB/m) = Antenna Factor (dB/m) – Preamplifier Gain (dB).

3. The emission levels of other frequencies were less than 20dB margin against the limit.



CHANNEL	Middle Channel	DETECTOR	Peak
FREQUENCY RANGE	1GHz ~ 10GHz	FUNCTION	Average

	ANTENNA POLARITY & test distance: HORIZONTAL& VERTICAL at 3 m											
No	Freq.	Raw	Cale Loss	AF	Level	Measurement	Pol	Hgt	Azt	Limit	Margin	Pass /Eail
	[MHz]	(dBuV)	(dB)	(dB/m)	(dBuV/m)	туре		(cm)	Deg	(dBuV/m)	(dB)	/1 ali
1	6406.48	64.67	6.12	-8.18	62.61	Peak Max	V	141	258	74	-11.4	Pass
2	4579.53	50.55	5.2	-11.35	44.41	Peak Max	V	125	255	74	-29.59	Pass
3	16787.42	46.01	9.56	1.9	57.47	Peak Max	Н	125	240	74	-16.53	Pass
4	5496.13	49.43	5.71	-10.3	44.83	Peak Max	V	158	51	74	-29.17	Pass
5	6406.48	46.73	6.12	-8.18	44.67	Average Max	V	141	258	54	-9.34	Pass
6	4579.53	38.46	5.2	-11.35	32.31	Average Max	V	125	255	54	-21.69	Pass
7	16787.42	33.61	9.56	1.9	45.07	Average Max	Н	125	240	54	-8.94	Pass
8	5496.13	37.9	5.71	-10.3	33.3	Average Max	V	158	51	54	-20.7	Pass

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Cable Loss (dB) + AF (dB)

2. AF (dB/m) = Antenna Factor (dB/m) – Preamplifier Gain (dB).

3. The emission levels of other frequencies were less than 20dB margin against the limit.



CHANNEL	High Channel	DETECTOR	Peak
FREQUENCY RANGE	1GHz ~ 10GHz	FUNCTION	Average

	ANTENNA POLARITY & test distance: HORIZONTAL& VERTICAL at 3 m												
No	Freq.	Raw	Cale Loss	AF	Level	Measurement	Pol	Hgt	Azt	Limit	Margin	Pass /Eail	
	[MHz]	(dBuV)	(dB)	(dB/m)	(dBuV/m)	туре	туре		(cm)	Deg	(dBuV/m)	(dB)	/1 ali
1	6491.16	60.26	6.2	-8.03	58.42	Peak Max	V	134	284	74	-15.58	Pass	
2	17639.82	45.4	9.55	1.73	56.68	Peak Max	Н	189	279	74	-17.32	Pass	
3	4634.53	51.03	5.19	-11.2	45.02	Peak Max	V	148	351	74	-28.98	Pass	
4	5558.40	50.2	5.63	-10.22	45.61	Peak Max	V	151	347	74	-28.39	Pass	
5	1850.49	54.38	3.13	-14.03	43.47	Peak Max	V	182	326	74	-30.53	Pass	
6	6491.16	45.24	6.2	-8.03	43.41	Average Max	V	134	284	54	-10.59	Pass	
7	17639.82	33.21	9.55	1.73	44.48	Average Max	Н	189	279	54	-9.52	Pass	
8	4634.53	38.74	5.19	-11.2	32.74	Average Max	V	148	351	54	-21.26	Pass	

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Cable Loss (dB) + AF (dB)

- 2. AF (dB/m) = Antenna Factor (dB/m) Preamplifier Gain (dB).
- 3. The emission levels of other frequencies were less than 20dB margin against the limit.
- 4. Margin value = Emission level Limit value.



4.2 Channel Bandwidth

4.2.1 Limits of Channel Bandwidth Measurement

For frequency hopping system operating in the 2400-2483.5MHz, If the 20dB bandwidth of hopping channel is greater than 25kHz, two-thirds 20dBbandwidth of hopping channel shell be a minimum limit for the hopping channel separation.

4.2.2 Test Setup



4.2.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.2.4 Test Procedure

- a. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
- b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
- c. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
- d. Repeat above procedures until all frequencies measured were complete.

4.2.5 Deviation from Test Standard

No deviation.

4.2.6 EUT Operating Condition

The software provided by client enabled the EUT to transmit and receive data at lowest, middle and highest channel frequencies individually.



4.2.7 Test Results

Channel	Frequency (MHz)	20dB Bandwidth (kHz)
Low	902.25	73.94
Mid	915.25	72.94
High	927.25	73.51



Sp	ectrum Analyzer 1					*	T	
K	Cupied BW	Input Z: 50 Ω Atten: 20 dB Corrections: Off uW Path: Sta	Trig: Free Run andard Gate: Off	Center Freq: 90 AvaiHold:>10/10	2.750000 MHz	Trace Typ	e	Trace
	Align: Auto/No RF	Freq Ref: Int (S) NFE: Adaptive	#IF Gain: Low	Radio Std: None	,	Clear	Write	Detector
So	Graph v ale/Div 10.0 dB	Ref LvI Offse Ref Value 35.	t 31.50 dB 00 dBm			Max H	Average old	
24 14 5.	5.0 5.0 00					Min H	old	
-5. -11 -29	00 5.0					Restart	Max Hold	
-3: -4!	5.0							
Ce #R	nter 902.8 MHz es BW 10.000 kHz	#Video BW 3	0.000 kHz	Sweep	Span 100 kHz 1.00 ms (1001 pts)			
21	Netrics v							
	Occupied Bandwidth 65.369	kHz	Total Power		33.0 dBm			
	Transmit Freq Error x dB Bandwidth	1.684 kHz 73.94 kHz	% of OBW Pov x dB	/er	99.00 % -20.00 dB			
		Sep 25, 2019						
		12.33. 13 AW	Low Cha	nnel				
Sp	ectrum Analyzer 1	·				0	Trace	v El
K	EYSIGHT Input: RF Coupling: DC Align: Auto/No RE	Input Z: 50 Ω Atten: 20 dB Corrections: Off μW Path: Sta Free Ref. Int (S)	Trig: Free Run andard Gate: Off #IF Gain: Low	Center Freq: 91 Avg Hold:>10/10 Radio Std: None	5.250000 MHz	Trace Typ	e	Trace Control
1	Graph v	NFE: Adaptive Ref Lvl Offse	t 31.50 dB		, 	Trace	vvrite Average	Detector
So Lo 25	ale/Div 10.0 dB	Ref Value 35.	00 dBm			OMax H	old	
11 5. -5.	5.0 00 00					Min H	old	
-1: -2: -3:	5.0					Restart	Max Hold	
-4:	5.0							
21	nter 915.3 MHZ es BW 10.000 kHz /letrics	#video BW 3	0.000 KHZ	Sweep	5 1.00 ms (1001 pts)			
	Occupied Bandwidth							
	64.651 Transmit Freq Error	kHz 1.452 kHz	Total Power % of OBW Pow	/er	32.9 dBm 99.00 %			
	x dB Bandwidth	72.94 kHz	x dB		-20.00 dB			
	1 77 1 ?	Sep 25, 2019 12:32:33 AM						
			Middle Cha	annel				



	Input: RF II Coupling: DC C Align: Auto/No RF F N	nput Z: 50 Ω Atten: 2 corrections: Off μW Pati req Ref: Int (S) IFE: Adaptive	0 dB Trig: Free Run n: Standard Gate: Off #IF Gain: Low	Center Freq: 927.25000 Avg Hold:>10/10 Radio Std: None	IO MHz	Center Frequency 927.250000 MHz	Se
1 Graph Scale/Div 10.0 o Log 25.0	dB	Ref LvI O Ref Value	ffset 31.50 dB 35.00 dBm			Span 100.00 kHz CF Step 10.000 kHz	
15.0						Auto Man	
-15.0 -25.0 -35.0						Freq Offset 0 Hz	
-45.0							
Center 927.3 Mi #Res BW 10.000	Hz 0 kHz	#Video E	W 30.000 kHz	Sweep 1.00	Span 100 kHz ns (1001 pts)		
2 Metrics Occupi	▼ ied Bandwidth						
Transn x dB B	64.814 k nit Freq Error andwidth	Hz 1.457 kHz 73.51 kHz	Total Power % of OBW Pov x dB	33.2 ver 99.0 -20.0	dBm 00 % 0 dB		
		0 05 0040					



4.3 Hopping Channel Separation

4.3.1 Limits of Hopping Channel Separation Measurement

At least 25kHz or 20dB hopping channel bandwidth (whichever is greater).

4.3.2 Test Setup



4.3.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.3.4 Test Procedure

Measurement Procedure REF

- a. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
- b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range.
- c. By using the MaxHold function record the separation of two adjacent channels.
- d. Measure the frequency difference of these two adjacent channels by SA MARK function. And then plot the result on SA screen.
- e. Repeat above procedures until all frequencies measured were complete.
- 4.3.5 Deviation from Test Standard No deviation.



4.3.6 Test Results

Channel	Frequency (MHz)	Adjacent Channel Separation (kHz)	20dB Bandwidth (kHz)	Minimum Limit (kHz)	Pass / Fail
Low	902.25	500	73.94	73.94	Pass
Mid	915.25	500	72.94	72.94	Pass
High	927.25	500	73.51	73.51	Pass

NOTE: The minimum limit is two-third 20dB bandwidth.



Test Plots:







4.4 Conducted Output Power Measurement

4.4.1 Limits of Conducted Output Power Measurement

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels.

4.4.2 Test Setup



4.4.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.4.4 Test Procedures

- a. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
- b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
- c. The center frequency of the spectrum analyzer is set to the fundamental frequency and using 3MHz RBW and 10 MHz VBW.
- d. Measure the captured power within the band and recording the plot.
- e. Repeat above procedures until all frequencies required were complete.
- 4.4.5 Deviation from Test Standard

No deviation.



4.4.6 Test Results

The power transmitted at the output port of the module is 31.5 dBm.

Channel	Frequency (MHz)	Conducted Power at the end of the cable (dBm)"	Limit (dBm)	Pass/Fail
Low	902.25	29.37	30	Pass
Mid	915.25	29.40	30	Pass
High	927.25	29.45	30	Pass

Note: The power result is measured at antenna port, the actual power from module is 1.5dB higher, a cable with 1.3dB loss is connected between the module and antenna.



Test Plots:









4.5 Number of Hopping Frequency Used

4.5.1 Limits of Hopping Frequency Used Measurement

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

4.5.2 Test Setup



4.5.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.5.4 Test Procedure

- a. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
- b. Turn on the EUT and connect its antenna terminal to measurement via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
- c. Set the SA on MaxHold Mode, and then keep the EUT in hopping mode. Record all the signals from each channel until each one has been recorded.
- d. Set the SA on View mode and then plot the result on SA screen.
- e. Repeat above procedures until all frequencies measured were complete.
- 4.5.5 Deviation from Test Standard

No deviation.



4.5.6 Test Results

			Hopping	Channel	Numbers			
Spectr Occup	um Analyzer 1 ied BW	Spectrum Analyzer 2 Swept SA	Spectrum Ana Swept SA	alyzer 3 🗸	+		Marker	· 米
KEY: RL	SIGHT Input: RF Coupling: DC Align: Auto/No	Input Z: 50 Ω Corrections: Off Freq Ref: Int (S) NFE: Adaptive	Atten: 20 dB P µW Path: Standard G Source: Off IF S	NO: Best Wide ate: Off Gain: Low ig Track: Off	Avg Type: Log-Power Avg Hold:>100/100 Trig: Free Run	1 2 3 4 5 6 M WWWWW P N N N N N	Select Marker Marker 1	•
1 Spec	ctrum v	F	Ref Lvi Offset 31.50 c	IB	ΔMkr1 24	.492 MHz	Marker ∆ Frequency 24.492000 MHz	Settings
Scale Log	/Div 10 dB	F	Ref Level 41.50 dBm			0.04 dB	Marker Mode	Peak Search
31.5	Xananana					142	Normal	Pk Search Config
21.5		AAAAAAAAA.	AAAAAAAAA	VVVVVV	AAAAAAAA	/ / / / /	ODelta (Δ)	Properties
11.5							Fixed	Marker
1.50							Off	Function
-8.50							Delta Marker (Reset Delta)	Marker→
-18.5							Marker Table	Counter
-28.5							Off	
-38.5							Karker Settings Diagram	
-48.5							All Markers Off	
Start 9 #Res	902.00 MHz BW 300 kHz		#Video BW 1.0 MHz		Sto Sweep 1.00 r	p 928.00 MHz ns (1001 pts)	Couple Markers On Off	
	2	? Sep 25, 2019 12:56:32 AM						

There are 50 hopping frequencies in the hopping mode.



4.6 Dwell Time on Each Channel

4.6.1 Limits of Dwell Time on Each Channel Measurement

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

4.6.2 Test Setup



4.6.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.6.4 Test Procedures

- a. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
- b. Turn on the EUT and connect its antenna terminal to measurement via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
- c. Adjust the center frequency of SA on any frequency be measured and set SA to zero span mode. And then, set RBW and VBW of spectrum analyzer to proper value.
- d. Measure the time duration of one transmission on the measured frequency. And then plot the result with time difference of this time duration.
- e. Repeat above procedures until all different time-slot modes have been completed.

4.6.5 Deviation from Test Standard

No deviation.



4.6.6 Test Results

Mode	Number of transmission in a 20 sec	Length of transmission time (msec)	Result (msec)	Limit (msec)
Low	14 times	28.48	398.72	400
Middle	14 times	27.28	381.92	400
High	14 times	28.28	395.92	400

NOTE: Test plots of the transmitting time slot are shown on next page.















4.7 Conducted Out of Band Emission Measurement

4.7.1 Limits of Conducted Out of Band Emission Measurement

Below –20dB of the highest emission level of operating band (in 100kHz Resolution Bandwidth).

4.7.2 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.7.3 Test Procedure

The transmitter output was connected to the spectrum analyzer via a low lose cable. Set both RBW and VBW of spectrum analyzer to 100 kHz and 300 kHz with suitable frequency span including 100 MHz bandwidth from band edge. The band edges was measured and recorded.

4.7.4 Deviation from Test Standard

No deviation.

4.7.5 EUT Operating Condition

The software provided by client enabled the EUT to transmit and receive data at lowest, middle and highest channel frequencies individually.

4.7.6 Test Results

The spectrum plots are attached on the following images. D1 line indicates the highest level, D2 line indicates the 20dB offset below D1. It shows compliance with the requirement.



4.7.7 Test Results









Appendix – Information on the Testing Laboratories

Bureau Veritas is a global leader in testing, inspection and certification (TIC) services. We help businesses improve safety, sustainability and productivity; and our clients include the majority of leading brands in retail, manufacturing and other industries. With a presence in every major country around the world, our quality assurance and compliance solutions are vital in helping our customers enhance product quality and concept-to-consumer journeys. We also assist with increasing speed to market, profitability and brand equity throughout the supply chain. Bureau Veritas is a leading wireless/IoT testing, inspection, audit and certification provider, with a global network of test laboratories to support the IoT industry in areas of connectivity, security, interoperability as well as quality, health & safety, and environmental/chemical requirements.

If you have any comments, please feel free to contact us at the following:

Milpitas EMC/RF/Safety/Telecom Lab 775 Montague Expressway, Milpitas, CA 95035 Tel: +1 408 526 1188	Sunnyvale OTA/Bluetooth Lab 1293 Anvilwood Avenue, Sunnyvale, CA 94089 Tel: +1 669 600 5293
Littleton EMC/RF/Safety/Environmental Lab 1 Distribution Center Cir #1, Littleton, MA 01460 Tel: +1 978 486 8880	Irvine OTA/PTCRB/Bluetooth/V2X Lab 15 Musick, Irvine, CA 92618 Tel: +1 949 716 6512
Email: <u>sales.eaw@us.bureauveritas.com</u> Web Site: <u>www.cpsusa-bureauveritas.com</u>	

The address and road map of all our labs can be found in our web site also.

---- END ----