

FCC REPORT

(WCDMA)

Applicant: Neutron Holdings, Inc.

Address of Applicant: 85 2nd St, San Francisco, CA 94105 USA

Equipment Under Test (EUT)

Product Name: Central controller

Model No.: Lime-4.0-US

Trade mark: Lime

FCC ID: 2APB2LIME-V4-US

Applicable standards: FCC CFR Title 47 Part 2
FCC CFR Title 47 Part 22 Subpart H
FCC CFR Title 47 Part 24 Subpart E

Date of sample receipt: 08 May, 2021

Date of Test: 08 May, to 04 Jun., 2021

Date of report issued: 04 Jun., 2021

Test Result: PASS*

* In the configuration tested, the EUT complied with the standards specified above.

Authorized Signature:



Bruce Zhang
Laboratory Manager

This report details the results of the testing carried out on one sample. The results contained in this test report do not relate to other samples of the same product and does not permit the use of the JYT product certification mark. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

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2. Version

Version No.	Date	Description
00	04 Jun., 2021	Original

Tested by:

YT Yang

Date:

04 Jun., 2021

Test Engineer

Reviewed by:

Winner Zhang

Date:

04 Jun., 2021

Project Engineer

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4. Test Summary

Test Item	Section in CFR 47	Result
RF Exposure (SAR)	Part 1.1307 Part 2.1093	Pass (Please refer to SAR Report)
RF Output Power	Part 2.1046 Part 22.913 (a)(5) Part 24.232 (c)	See section 6.1
Peak-to-Average Power Ratio	Part 24.232 (d)	Appendix B - WCDMA
Modulation Characteristics	Part 2.1047	Pass
99% & -26 dB Occupied Bandwidth	Part 2.1049 Part 22.917(b) Part 24.238(b)	Appendix C - WCDMA
Out of band emission at antenna terminals	Part 2.1053 Part 22.917 (a) Part 24.238 (a)	Appendix D – WCDMA Appendix E - WCDMA
Field strength of spurious radiation	Part 22.917 (a) Part 24.238 (a)	Pass
Frequency stability vs. temperature	Part 22.355 Part 24.235 Part 2.1055(a)(1)(b)	Appendix F - WCDMA
Frequency stability vs. voltage	Part 22.355 Part 24.235 Part 2.1055(d)(2)	Appendix F - WCDMA
Remark: 1. Pass: The EUT complies with the essential requirements in the standard. 2. The cable insertion loss used by "RF Output Power" and other conduction measurement items is 0.5dB(Fundamental Frequency below 1GHz)/1.0dB(Fundamental Frequency above 1GHz) (provided by the customer).		
Test Method:	ANSI/TIA-603-E-2016 ANSI C63.26-2015	

5. General Information

5.1 Client Information

Applicant:	Neutron Holdings, Inc.
Address:	85 2nd St, San Francisco, CA 94105 USA
Manufacturer:	Quectel Wireless Solutions Co., Ltd.
Address:	Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai 200233, China
Factory:	MeiG Smart Technology Co., Ltd.
Address:	1/2/3F A, Building A, B, No.5 Lingxia Road, 4th Fenghuang Industrial Park, Fuyong Street, Baoan District, Shenzhen, Guangdong, China

5.2 General Description of E.U.T.

Product Name:	Central controller
Model No.:	Lime-4.0-US
Operation Frequency range:	WCDMA Band V: 826.4MHz-846.6MHz WCDMA Band II: 1852.4 MHz-1907.6 MHz
Modulation type:	3G ☒ RMC(QPSK) ☒ HSUPA(QPSK) ☒ HSDPA(QPSK,16QAM)
Antenna type:	Internal Antenna
Antenna gain:	WCDMA Band V: 2 dBi(declare by Applicant) WCDMA Band II: 2 dBi(declare by Applicant)
Power supply:	Rechargeable Li-ion Battery DC3.7V, 1250mAh
External power supply:	DC 36V
Test Sample Condition:	The test samples were provided in good working order with no visible defects.

Operation Frequency List:

WCDMA Band V		WCDMA Band II	
Channel	Frequency (MHz)	Channel	Frequency (MHz)
4132	826.40	9262	1852.40
4133	826.60	9263	1852.60
....			
4182	836.40	9399	1879.80
4183	836.60	9400	1880.00
4184	836.80	9401	1880.20
...	...	...	...
4232	846.40	9537	1907.40
4233	846.60	9538	1907.60

Regards to the operating frequency range over 10 MHz, the Lowest frequency, the middle frequency, and the highest frequency of channel were selected to perform the test, and the selected channel see below:

WCDMA Band V			WCDMA Band II		
Channel		Frequency(MHz)	Channel		Frequency(MHz)
Lowest	4132	826.40	Lowest	9262	1852.40
Middle	4183	836.60	Middle	9400	1880.00
Highest	4233	846.60	Highest	9538	1907.60

5.3 Test environment and mode

Operating Environment:	
Temperature:	Normal: 15°C ~ 35°C, Extreme: -30°C ~ +50°C
Humidity:	20 % ~ 75 % RH
Atmospheric Pressure:	1008 mbar
Voltage:	Nominal: 3.70 Vdc, Extreme: Low 3.50 Vdc, High 4.2 Vdc
Test mode:	
RMC mode	Keep the EUT communication with simulated station in RMC mode
HSDPA	Keep the EUT communication with simulated station in HSDPA mode
HSUPA	Keep the EUT communication with simulated station in HSUPA mode
Remark: The EUT has been tested under continuous transmitting mode. Channel Low, Mid and High for each type band with rated data rate were chosen for full testing. The field strength of spurious radiation emission was measured as EUT stand-up position (H mode) and lie down position (E1, E2 mode) for these modes. Just the worst case position (H mode) shown in report.	

5.4 Description of Test Auxiliary Equipment

Test Equipment	Manufacturer	Model No.	Serial No.
Simulated Station	Anritsu	MT8820C	6201026545

5.5 Measurement Uncertainty

Parameters	Expanded Uncertainty
Radiated Emission (9kHz ~ 30MHz)	±3.12 dB (k=2)
Radiated Emission (30MHz ~ 1000MHz)	±4.32 dB (k=2)
Radiated Emission (1GHz ~ 18GHz)	±5.16 dB (k=2)
Radiated Emission (18GHz ~ 40GHz)	±3.20 dB (k=2)

5.6 Additions to, deviations, or exclusions from the method

No

5.7 Laboratory Facility

The test facility is recognized, certified, or accredited by the following organizations: ● FCC - Designation No.: CN1211 JianYan Testing Group Shenzhen Co., Ltd. has been accredited as a testing laboratory by FCC(Federal Communications Commission). The test firm Registration No. is 727551. ● ISED – CAB identifier.: CN0021 The 3m Semi-anechoic chamber of JianYan Testing Group Shenzhen Co., Ltd. has been Registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No.: 10106A-1. ● A2LA - Registration No.: 4346.01 This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories. The test scope can be found as below link: https://portal.a2la.org/scopepdf/4346-01.pdf
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5.8 Laboratory Location

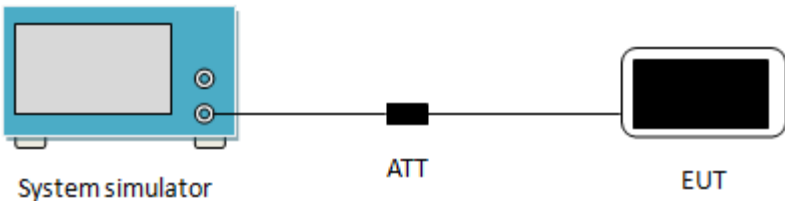
JianYan Testing Group Shenzhen Co., Ltd. Address: No.101, Building 8, Innovation Wisdom Port, No.155 Hongtian Road, Huangpu Community, Xinqiao Street, Bao'an District, Shenzhen, Guangdong, People's Republic of China. Tel: +86-755-23118282, Fax: +86-755-23116366 Email: info@ccis-cb.com, Website: http://www.ccis-cb.com
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5.9 Test Instruments list

Test Equipment	Manufacturer	Model No.	Serial No.	Cal. Date (mm-dd-yy)	Cal. Due date (mm-dd-yy)
3m SAC	ETS	9m*6m*6m	966	01-19-2021	01-18-2024
BiConiLog Antenna	SCHWARZBECK	VULB9163	497	03-03-2021	03-02-2022
Biconical Antenna	SCHWARZBECK	VUBA9117	359	06-18-2020	06-17-2021
Horn Antenna	SCHWARZBECK	BBHA9120D	916	03-03-2021	03-02-2022
Horn Antenna	SCHWARZBECK	BBHA9120D	1805	06-18-2020	06-17-2021
Horn Antenna	SCHWARZBECK	BBHA 9170	BBHA9170582	11-18-2020	11-17-2021
EMI Test Software	AUDIX	E3	Version: 6.110919b		
Pre-amplifier	HP	8447D	2944A09358	03-03-2021	03-02-2022
Pre-amplifier	CD	PAP-1G18	11804	03-03-2021	03-02-2022
Spectrum analyzer	Rohde & Schwarz	FSP30	101454	03-03-2021	03-02-2022
Spectrum analyzer	Rohde & Schwarz	FSP40	100363	11-18-2020	11-17-2021
EMI Test Receiver	Rohde & Schwarz	ESRP7	101070	03-03-2021	03-02-2022
Spectrum Analyzer	Agilent	N9020A	MY50510123	11-18-2020	11-17-2021
Signal Generator	Rohde & Schwarz	SMX	835454/016	03-03-2021	03-02-2022
Signal Generator	R&S	SMR20	1008100050	03-03-2021	03-02-2022
RF Switch Unit	MWRFTTEST	MW200	N/A	N/A	N/A
Test Software	MWRFTTEST	MTS8200	Version: 2.0.0.0		
Cable	ZDECL	Z108-NJ-NJ-81	1608458	03-03-2021	03-02-2022
Cable	MICRO-COAX	MFR64639	K10742-5	03-03-2021	03-02-2022
Cable	SUHNER	SUCOFLEX100	58193/4PE	03-03-2021	03-02-2022
DC Power Supply	XinNuoEr	WYK-10020K	1409050110020	09-25-2020	09-24-2021
Temperature Humidity Chamber	HengPu	HPGDS-500	20140828008	11-01-2020	10-31-2021
Simulated Station	Rohde & Schwarz	CMW500	140493	07-22-2020	07-21-2021

6. Test results

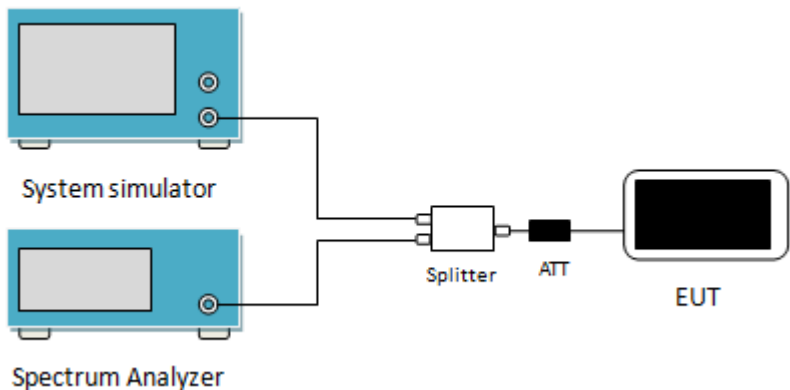
6.1 Conducted Output Power, ERP and EIRP

Test Requirement:	FCC part 22.913(a)(5), FCC part 24.232(c)
Limit:	WCDMA Band V: 7W, WCDMA Band II: 2W
Test setup:	 The diagram illustrates the test setup. On the left is a blue 'System simulator' box with two ports. A line connects one port to a black 'ATT' (attenuator) box. Another line connects the other port of the 'ATT' box to a black 'EUT' (Equipment Under Test) box on the right.
Test Procedure:	The transmitter output was connected to a calibrated attenuator, the other end of which was connected to the simulated station. Transmitter output power was read off in dBm.
Test Instruments:	Refer to section 5.9 for details
Test mode:	Refer to section 5.3 for details
Test results:	Passed

Measurement Data:

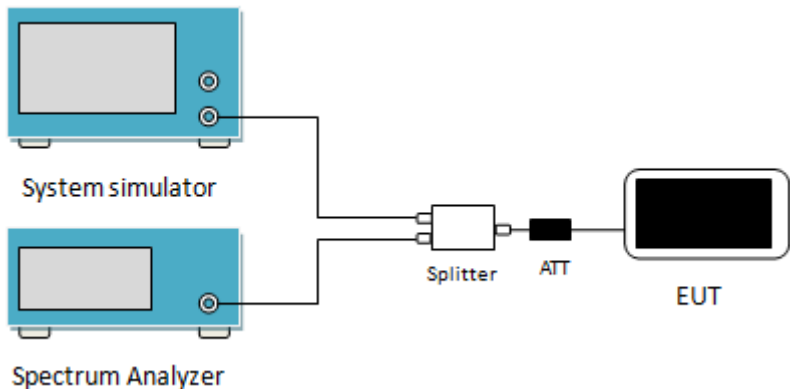
EUT Mode		Burst Average power (dBm)		
		4132	4183	4233
		826.40 (MHz)	836.60 (MHz)	846.60 (MHz)
UMTS 850 HSDPA	Subtest 1	22.57	22.45	22.47
	Subtest 2	22.13	21.96	21.92
	Subtest 3	22.03	21.98	21.92
	Subtest 4	22.06	21.96	21.93
UMTS 850 HSUPA	Subtest 1	20.61	20.51	20.48
	Subtest 2	21.13	21.02	20.99
	Subtest 3	21.63	21.53	21.50
	Subtest 4	20.65	20.53	20.51
	Subtest 5	22.11	21.97	21.96
UMTS 850 RMC	12.2kbps	23.57	23.43	23.46
Antenna Gain (dBi)		2.00		
Max. ERP (dBm)		23.42		
ERP Limit (dBm)		38.45		
EUT Mode		Burst Average power (dBm)		
		9262	9400	9538
		1852.40 (MHz)	1880.00 (MHz)	1907.60 (MHz)
UMTS 1900 HSDPA	Subtest 1	22.25	22.07	22.26
	Subtest 2	21.89	21.59	21.84
	Subtest 3	21.75	21.61	21.80
	Subtest 4	21.70	21.60	21.80
UMTS 1900 HSUPA	Subtest 1	20.24	20.06	20.30
	Subtest 2	20.80	20.61	20.85
	Subtest 3	21.29	21.10	21.34
	Subtest 4	20.28	20.12	20.37
	Subtest 5	21.84	21.60	21.85
UMTS 1900 RMC	12.2kbps	23.28	23.10	23.31
Antenna Gain (dBi)		2.00		
Max. EIRP (dBm)		25.31		
EIRP Limit (dBm)		33.00		
Note: EIRP (dBm) = Burst Average power (dBm) + Antenna Gain (dBi).				
ERP (dBm) = EIRP (dBm) - 2.15 (dB).				

6.2 Peak-to-Average Power Ratio

Test Requirement:	FCC part 24.232(d)
Limit:	The peak-to-average ratio (PAR) of the transmission may not exceed 13 dB.
Test setup:	 The diagram illustrates the test setup. On the left, there are two blue rectangular devices: the top one is labeled 'System simulator' and the bottom one is labeled 'Spectrum Analyzer'. Both have a single output port. These two ports are connected to a central 'Splitter' block. From the right side of the Splitter, a line connects to an 'ATT' (Attenuator) block. Finally, a line connects the ATT block to the 'EUT' (Equipment Under Test), which is represented by a black rectangular device with a white border.
Test Procedure:	1 The RF output of the transceiver was connected to a spectrum analyzer through appropriate attenuation. 2 Set the CCDF option in spectrum analyzer, RBW $\geq$ OBW, 3 Set the EUT working in highest power level, measured and recorded the 0.1% as PAPR level. 4 Repeat step 1~3 at other frequency and modulations.
Test Instruments:	Refer to section 5.9 for details
Test mode:	Refer to section 5.3 for details
Test results:	Passed

Measurement Data: Refer to Appendix B - WCDMA

6.3 Occupy Bandwidth

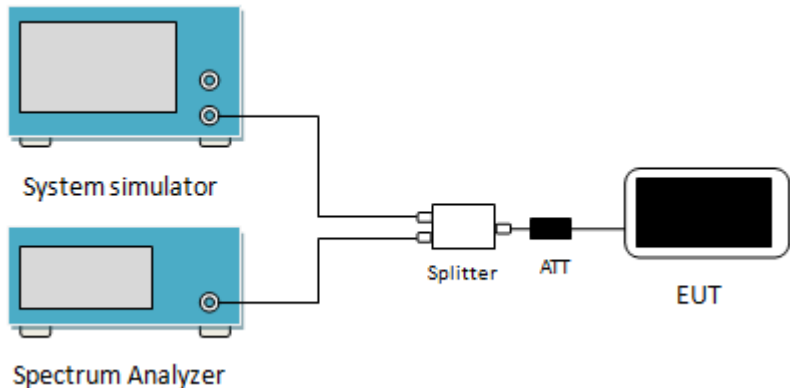
Test Requirement:	FCC part 22.917(b), FCC part 24.238(b)
Test setup:	 The diagram illustrates the test setup. On the left, there are two blue rectangular units: the top one is labeled 'System simulator' and the bottom one is labeled 'Spectrum Analyzer'. Both have a single output port. These two ports are connected to a central 'Splitter' unit. From the 'Splitter', one line goes to an 'ATT' (Attenuator) unit, and another line goes to the 'EUT' (Equipment Under Test), which is represented by a black rectangle with rounded corners.
Test Procedure:	1. The EUT's output RF connector was connected with a short cable to the spectrum analyzer 2. RBW was set to about 1% of emission BW, VBW= 3 times RBW. 3. -26dBc display line was placed on the screen (or 99% bandwidth), the occupied bandwidth is the delta frequency between the two points where the display line intersects the signal trace.
Test Instruments:	Refer to section 5.9 for details
Test mode:	Refer to section 5.3 for details
Test results:	Passed

Measurement Data: Refer to Appendix C - WCDMA

6.4 Modulation Characteristic

According to FCC § 2.1047(d), Part 22H & 24E & 27L there is no specific requirement for digital modulation, therefore modulation characteristic is not presented.

6.5 Out of band emission at antenna terminals

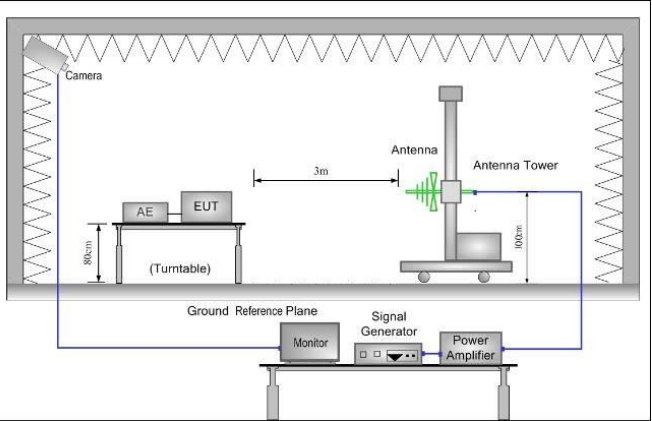
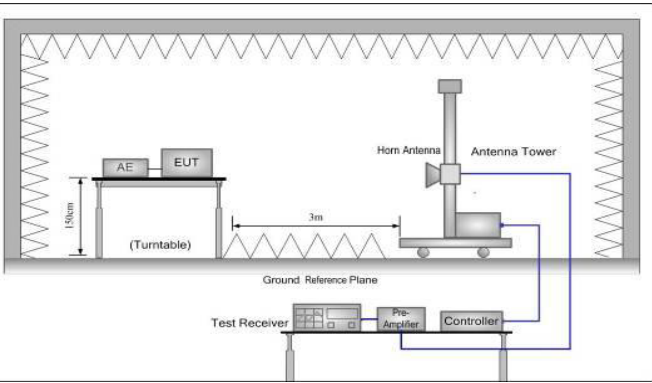
Test Requirement:	FCC part 22.917(a), FCC part 24.238(a)
Limit:	-13dBm
Test setup:	 The diagram illustrates the test setup for out-of-band emission measurement. A System simulator is connected to a Splitter. The other output of the Splitter is connected to an ATT (Attenuator). The output of the ATT is connected to the EUT (Equipment Under Test). A Spectrum Analyzer is also connected to the Splitter to measure the out-of-band emissions.
Test Procedure:	1 The RF output of the transceiver was connected to a spectrum analyzer through appropriate attenuation. 2 For the out of band: For GSM850&WCDMA850 set the RBW=100 kHz, VBW=300 kHz and for PCS1900 & WCDMA1900 set the RBW=1MHz, VBW=3MHz when below 1 GHz, RBW =1 MHz, VBW=3 MHz when above 1 GHz, Start=30MHz, Stop= 10th harmonic. 3 Band Edge Requirements: In the 1 MHz bands immediately outside and adjacent to the frequency block, a resolution bandwidth of at least 1 percent of the emission bandwidth of the fundamental emission of the transmitter may be employed to measure the out of band Emissions.
Test Instruments:	Refer to section 5.9 for details
Test mode:	Refer to section 5.3 for details
Test results:	Passed

Measurement Data:

Band edge emission: Refer to Appendix D - WCDMA

Spurious emission: Refer to Appendix E - WCDMA

6.6 Field strength of spurious radiation measurement

Test Requirement:	FCC part 22.917(a), FCC part 24.238(a)
Limit:	-13dBm
Test setup:	Below 1GHz  Above 1GHz 
Test Procedure:	1. The EUT was placed on the top of a rotating table 0.8m(below 1GHz)/1.5m(above 1GHz) above the ground at a 3 meter camber. The radiated emission at the fundamental frequency was measured at 3 m with a test antenna and EMI spectrum analyzer. 2. During the tests, the antenna height and the EUT azimuth were varied in order to identify the maximum level of emissions from the EUT. This maximization process was repeated with the EUT positioned in each of its three orthogonal orientations. 3. The frequency range up to tenth harmonic was investigated for each of three fundamental frequency (low, middle and high channels). Once spurious emission was identified, the power of the emission was determined using the substitution method. 4. The spurious emissions attenuation was calculated as the difference between radiated power at the fundamental frequency and the spurious emissions frequency. $ERP / EIRP = S.G. \text{ output (dBm) } + \text{Antenna Gain(dB/dBi) } - \text{Cable Loss (dB)}$
Test Instruments:	Refer to section 5.9 for details
Test mode:	Refer to section 5.3 for details.
Test results:	Passed

Measurement Data (worst case):

WCDMA BAND V 12.2k RMC							
Lowest channel							
Frequency (MHz)	Level at antenna terminals (dBm)	Substitute antenna gain (dBi)	Cable Loss (dBi)	Spurious Emission level (dBm)	Limit Line (dBm)	Over Limit (dBm)	Polarization
1652.80	-52.03	9.58	0.20	-42.65	-13.00	-29.65	Vertical
2479.20	-48.90	10.87	0.44	-38.47	-13.00	-25.47	Vertical
3305.60	-47.51	12.01	0.65	-36.15	-13.00	-23.15	Vertical
1652.80	-51.90	9.58	0.20	-42.52	-13.00	-29.52	Horizontal
2479.20	-53.69	10.87	0.44	-43.26	-13.00	-30.26	Horizontal
3305.60	-47.55	12.01	0.65	-36.19	-13.00	-23.19	Horizontal
Middle channel							
Frequency (MHz)	Level at antenna terminals (dBm)	Substitute antenna gain (dBi)	Cable Loss (dBi)	Spurious Emission level (dBm)	Limit Line (dBm)	Over Limit (dBm)	Polarization
1673.20	-53.97	9.66	0.21	-44.52	-13.00	-31.52	Vertical
2509.80	-51.63	10.91	0.46	-41.18	-13.00	-28.18	Vertical
3346.40	-46.65	12.09	0.66	-35.22	-13.00	-22.22	Vertical
1673.20	-56.13	9.66	0.21	-46.68	-13.00	-33.68	Horizontal
2509.80	-58.26	10.91	0.46	-47.81	-13.00	-34.81	Horizontal
3346.40	-46.65	12.09	0.66	-35.22	-13.00	-22.22	Horizontal
Highest channel							
Frequency (MHz)	Level at antenna terminals (dBm)	Substitute antenna gain (dBi)	Cable Loss (dBi)	Spurious Emission level (dBm)	Limit Line (dBm)	Over Limit (dBm)	Polarization
1697.60	-54.02	9.74	0.24	-44.52	-13.00	-31.52	Vertical
2546.40	-56.78	12.09	0.50	-45.19	-13.00	-32.19	Vertical
3395.20	-46.73	12.19	0.68	-35.22	-13.00	-22.22	Vertical
1697.60	-53.79	9.74	0.24	-44.29	-13.00	-31.29	Horizontal
2546.40	-57.10	12.09	0.50	-45.51	-13.00	-32.51	Horizontal
3395.20	-48.18	12.19	0.68	-36.67	-13.00	-23.67	Horizontal
Remark: 1. The emission levels of below 1 GHz are lower than the limit 20dB and not show in test report.							

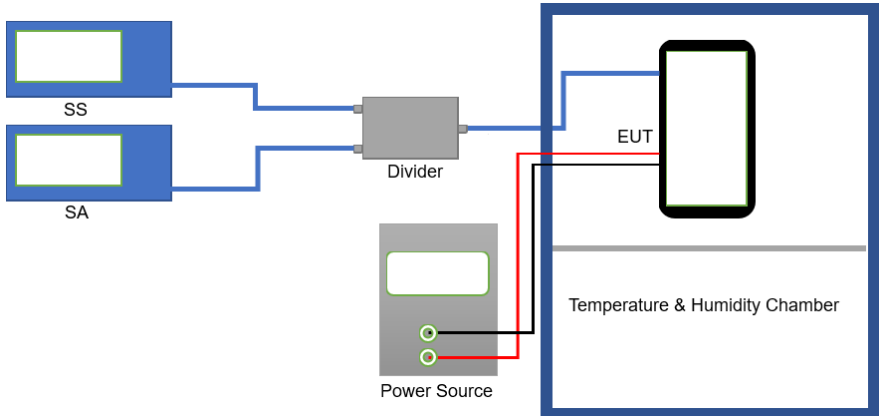
WCDMA Band II 12.2k RMC							
Lowest channel							
Frequency (MHz)	Level at antenna terminals (dBm)	Substitute antenna gain (dBi)	Cable Loss (dBi)	Spurious Emission level (dBm)	Limit Line (dBm)	Over Limit (dBm)	Polarization
3704.80	-57.41	12.65	0.76	-45.52	-13.00	-32.52	Vertical
5557.20	-52.89	12.77	1.14	-41.26	-13.00	-28.26	Vertical
7409.60	-48.41	11.45	1.63	-38.59	-13.00	-25.59	Vertical
3704.80	-57.40	12.65	0.76	-45.51	-13.00	-32.51	Horizontal
5557.20	-57.02	12.77	1.14	-45.39	-13.00	-32.39	Horizontal
7409.60	-46.47	11.45	1.63	-36.65	-13.00	-23.65	Horizontal
Middle channel							
Frequency (MHz)	Level at antenna terminals (dBm)	Substitute antenna gain (dBi)	Cable Loss (dBi)	Spurious Emission level (dBm)	Limit Line (dBm)	Over Limit (dBm)	Polarization
3760.00	-58.23	12.71	0.77	-46.29	-13.00	-33.29	Vertical
5640.00	-57.53	12.87	1.15	-45.81	-13.00	-32.81	Vertical
7520.00	-46.44	11.48	1.66	-36.62	-13.00	-23.62	Vertical
3760.00	-59.78	12.71	0.77	-47.84	-13.00	-34.84	Horizontal
5640.00	-58.31	12.87	1.15	-46.59	-13.00	-33.59	Horizontal
7520.00	-44.95	11.48	1.66	-35.13	-13.00	-22.13	Horizontal
Highest channel							
Frequency (MHz)	Level at antenna terminals (dBm)	Substitute antenna gain (dBi)	Cable Loss (dBi)	Spurious Emission level (dBm)	Limit Line (dBm)	Over Limit (dBm)	Polarization
3815.20	-56.16	12.78	0.80	-44.18	-13.00	-31.18	Vertical
5722.80	-58.17	12.97	1.19	-46.39	-13.00	-33.39	Vertical
7630.40	-45.51	11.34	1.70	-35.87	-13.00	-22.87	Vertical
3815.20	-57.63	12.78	0.80	-45.65	-13.00	-32.65	Horizontal
5722.80	-56.89	12.97	1.19	-45.11	-13.00	-32.11	Horizontal
7630.40	-44.93	11.34	1.70	-35.29	-13.00	-22.29	Horizontal
Remark:							
1. The emission levels of below 1 GHz are lower than the limit 20dB and not show in test report.							

6.7 Frequency stability V.S. Temperature measurement

Test Requirement:	FCC Part 22.355, FCC Part 24.235 FCC Part 2.1055(a)(1)(b)
Limit:	±2.5 ppm for WCDMA 850 Within authorized band for WCDMA 1900
Test setup:	
Test procedure:	1. The equipment under test was connected to an external DC power supply and input rated voltage. 2. RF output was connected to a frequency counter or spectrum analyzer via feed through attenuators. 3. The EUT was placed inside the temperature chamber. 4. Set the spectrum analyzer RBW low enough to obtain the desired frequency resolution and measure EUT 25°C operating frequency as reference frequency. 5. Turn EUT off and set the chamber temperature to -30°C. After the temperature stabilized for approximately 30 minutes recorded the frequency. 6. Repeat step measure with 10°C increased per stage until the highest temperature of +50°C reached
Test Instruments:	Refer to section 5.9 for details
Test mode:	Refer to section 5.3 for details
Test results:	Passed

Measurement Data: Refer to Appendix F - WCDMA

6.8 Frequency stability V.S. Voltage measurement

Test Requirement:	FCC Part 22.355, FCC Part 24.235, FCC Part 2.1055(d)(2)
Limit:	±2.5 ppm for WCDMA 850 Within authorized band for WCDMA 1900
Test setup:	
Test procedure:	1. Set chamber temperature to 25°C. Use a variable DC power source to power the EUT and set the voltage to rated voltage. 2. Set the spectrum analyzer RBW low enough to obtain the desired frequency resolution and recorded the frequency. 3. Reduce the input voltage to specify extreme voltage variation (+/- 15%) and endpoint, record the maximum frequency change.
Test Instruments:	Refer to section 5.9 for details
Test mode:	Refer to section 5.3 for details
Test results:	Passed

Measurement Data: Refer to Appendix F - WCDMA