



FCC PART 22H

TEST AND MEASUREMENT REPORT

For

MS Magnet Solutions Ltd.

Agathonos 11, Kapsalos 3087
Limassol, Cyprus

FCC ID: 2AKJA-S1500W5

Report Type: Original Report	Product Type: PiXcell Smallcell Wi-Fi Router
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Report Number: <u>R16121419-22 (WCDMA band 5)</u>	
Report Date: <u>2017-02-20</u>	
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* This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk
** (Rev. 2)

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R16121419-22 (WCDMA band 5)	Original Report	-

1 General Information

1.1 Product Description for Equipment under Test (EUT)

This test and measurement report was prepared on behalf of *MS Magnet Solutions Ltd.* and their product model: S1500 W5, FCC ID: 2AKJA-S1500W5 which will henceforth be referred to as the EUT (Equipment under Test). The EUT operated in the frequency band of 871.4-891.6 MHz for WCDMA.

1.2 Mechanical Description

The EUT measures approximately 217 mm (L) x 135 mm (W) x 36 mm (H).

The test data gathered are from typical production sample, serial number: S02-14060312 assigned by MS Magnet Solutions Ltd.

1.3 Objective

This type approval report was prepared on behalf of *MS Magnet Solutions Ltd.* in accordance with Part 2, Subpart J, Part 22 Subpart H, of the Federal Communication Commission's rules.

The objective was to determine compliance with FCC rules for RF radiated output power, peak to average power ratio, occupied bandwidth, spurious emissions at antenna terminal, radiated spurious emission band edge and frequency stability.

1.4 Related Submittal(s)/Grant(s)

R16121419-247 DTS (Wi-Fi)

1.5 Test Methodology

All tests and measurements indicated in this document were performed in accordance with the Code of Federal Regulations Title 47 Part 2, Sub-part J as well as the following parts:

Part 22 Subpart H - Public Mobile Services

Applicable Standards: TIA/EIA603-D, FCC KDB 971168 D01 v02r02.

All radiated and conducted emissions measurement was performed at Bay Area Compliance Laboratory, Corp. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

1.6 Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in the field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

Based on CISPR16-4-2:2011, The Treatment of Uncertainty in EMC Measurements, the values ranging from ± 2.0 dB for Conducted Emissions tests and ± 4.0 dB for Radiated Emissions tests are the most accurate estimates pertaining to uncertainty of EMC measurements at BACL Corp.

1.7 Test Facility

Bay area compliance Laboratories Corp. (BACL) is:

1- An independent Commercial Test Laboratory accredited to **ISO 17025: 2005** by **A2LA**, in the fields of: Electromagnetic Compatibility & Telecommunications covering Emissions, Immunity, Radio, RF Exposure, Safety and Telecom. This includes NEBS (Network Equipment Building System), Wireless RF, Telecommunications Terminal Equipment (TTE); Network Equipment; Information Technology Equipment (ITE); Medical Electrical Equipment; Industrial, Commercial, and Medical Test Equipment; Professional Audio and Video Equipment; Electronic (Digital) Products; Industrial and Scientific Instruments; Cabled Distribution Systems and Energy Efficiency Lighting.

2- An ENERGY STAR Recognized Laboratory, for the LM80 Testing, a wide variety of Luminaires and Computers.

3- A NIST Designated Phase-I and Phase-II CAB including: ACMA (Australian Communication and Media Authority), BSMI (Bureau of Standards, Metrology and Inspection of Taiwan), IDA (Infocomm Development Authority of Singapore), IC(Industry Canada), Korea (Ministry of Communications Radio Research Laboratory), NCC (Formerly DGT; Directorate General of Telecommunication of Chinese Taipei) OFTA (Office of the Telecommunications Authority of Hong Kong), Vietnam, VCCI - Voluntary Control Council for Interference of Japan and a designated EU CAB (Conformity Assessment Body) (Notified Body) for the EMC and R&TTE Directives.

4- A Product Certification Body accredited to **ISO Guide 65:1996** by **A2LA** to certify:

- 1- Unlicensed, Licensed radio frequency devices and Telephone Terminal Equipment for the FCC. Scope A1, A2, A3, A4, B1, B2, B3, B4 & C.
2. Radio Standards Specifications (RSS) in the Category I Equipment Standards List and All Broadcasting Technical Standards (BETS) in Category I Equipment Standards List for Industry Canada.
3. Radio Communication Equipment for Singapore.
4. Radio Equipment Specifications, GMDSS Marine Radio Equipment Specifications, and Fixed Network Equipment Specifications for Hong Kong.
5. Japan MIC Telecommunication Business Law (A1, A2) and Radio Law (B1, B2 and B3).
6. Audio/Video, Battery Charging Systems, Computers, Displays, Enterprise Servers, Imaging Equipment, Set-Top Boxes, Telephony, Televisions, Ceiling Fans, CFLs (Including GU24s),Decorative Light Strings, Integral LED Lamps, Luminaires, Residential Ventilating Fans.

The test site used by BACL Corp. to collect radiated and conducted emissions measurement data is located at its facility in Sunnyvale, California, USA.

The test site at BACL Corp. has been fully described in reports submitted to the Federal Communication Commission (FCC) and Voluntary Control Council for Interference (VCCI). The details of these reports have been found to be in compliance with the requirements of Section 2.948 of the FCC Rules on February 11 and December 10, 1997, and Article 8 of the VCCI regulations on December 25, 1997. The test site also complies with the test methods and procedures set forth in CISPR 22:2008 §10.4 for measurements below 1 GHz and §10.6 for measurements above 1 GHz as well as ANSI C63.4-2009, ANSI C63.4-2009, TIA/EIA-603 & CISPR 24:2010.

The Federal Communications Commission and Voluntary Control Council for Interference have the reports on file and they are listed under FCC registration number: 90464 and VCCI Registration No.: A-0027. The test site has been approved by the FCC and VCCI for public use and is listed in the FCC Public Access Link (PAL) database.

Additionally, BACL Corp. is an American Association for Laboratory Accreditation (A2LA) accredited laboratory (Lab Code 3297-02). The current scope of accreditations can be found at

<http://www.a2la.org/scopepdf/3297-02.pdf?CFID=1132286&CFTOKEN=e42a3240dac3f6ba-6DE17DCB-1851-9E57-477422F667031258&jsessionid=8430d44f1f47cf2996124343c704b367816b>

2 System Test Configuration

2.1 Justification

The EUT was configured for testing according to TIA/EIA-603-D and FCC KDB 971168 D01 v02r02. The final qualification test was performed with the EUT operating at normal mode.

2.2 EUT Exercise Software

The test firmware used was SecureCRTPortable.exe, RT3050QA.exe and firmware files provided by MS Magnet Solutions Ltd., the software is comply with the standard requirements being tested against.

2.3 Equipment Modifications

No modifications were made to the EUT.

2.4 Local Support Equipment List and Details

Manufacturers	Descriptions	Models	Serial Numbers
Dell	Windows Laptop	E6410	-

2.5 Interface Ports and Cabling

Cable Description	Length (m)	From	To
RJ45	< 1 m	Windows Laptop	EUT
RF Cable	< 1 m	PSA	EUT

3 Summary of Test Results

FCC Rules	Description of Tests	Results
§2.1091	RF Exposure	Compliant
§22.913(a)	Radiated Output Power & PAPR	Compliant
§2.1049, §22.905, §22.917	Occupied Bandwidth	Compliant
§2.1053, §22.917(a)	Spurious Radiated Emissions	Compliant
§2.1051, §22.917(a)	Spurious Emissions at Antenna Terminals	Compliant
§22.917(a)	Band Edge	Compliant
§2.1055, §22.355	Frequency Stability	Compliant

4 FCC §2.1091 - RF Exposure

4.1 Applicable Standards

According to §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (minute)
Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f ²)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

Note: f = frequency in MHz

* = Plane-wave equivalent power density

4.2 MPE Prediction

Predication of MPE limit at a given distance, Equation from OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

Where: S = power density

P = power input to antenna

G = power gain of the antenna in the direction of interest relative to an isotropic radiator

R = distance to the center of radiation of the antenna

4.3 Test Results

Maximum peak output power at antenna input terminal (dBm): 30.50

Maximum peak output power at antenna input terminal (mW): 1122.018

Prediction distance (cm): 20

Prediction frequency (MHz): 871.4

Antenna Gain, typical (dBi): 3

Maximum Antenna Gain (numeric): 2.2387

Power density at predication frequency and distance (mW/cm²): 0.4456

MPE limit for uncontrolled exposure at predication frequency (mW/cm²): 0.5809

The device is compliant with the requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 20 cm is 0.4456 mW/cm². Limit is 0.5809 mW/cm². The percentage is 0.4456 mw/0.5809 mW = 76.7%. The total percentage is 76.7% (WWAN) + 4.55% (WLAN) = 81.25%.

5 FCC §2.1046 & §22.913(a) – RF Output Power

5.1 Applicable Standards

According to FCC §2.1046 & §22.913(a), the ERP of mobile transmitters and auxiliary test transmitters must not exceed 7 Watts.

The Peak to average power ratio (PAPR) of the transmitter output power must not exceed 13 dB.

5.2 Test Procedure

Conducted method:

The EUT was connected to the spectrum analyzer through sufficient attenuator.



Radiated Method:

TIA 603-D Section 2.2.17

5.3 Test Equipment List and Details

Manufacturers	Descriptions	Models	Serial Numbers	Calibration Dates	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US 42221851	2016-06-10	1 year
-	RF cable	-	-	Each time ¹	N/A
-	20dB attenuator	-	-	Each time ¹	N/A

Note¹: cable and attenuator included in the test set-up will be checked each time before testing.

Statement of Traceability: *BACL Corp.* attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.

5.4 Test Environmental Conditions

Temperature:	20-22° C
Relative Humidity:	39-42 %
ATM Pressure:	101.6-102 kPa

The testing was performed by Rudy Sun 2017-01-31 in the RF Site.

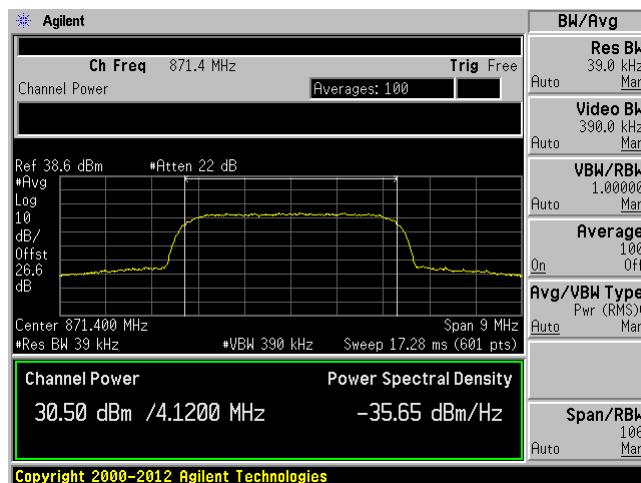
5.5 Test Results

Channel	Frequency (MHz)	Conducted Output Power (dBm)	Antenna Gain (dBi)	ERP (dBm)	Limit (dBm)
Low	871.4	30.50	3	31.35	38.45
Middle	881.6	30.16	3	31.01	38.45
High	891.6	30.06	3	30.91	38.45

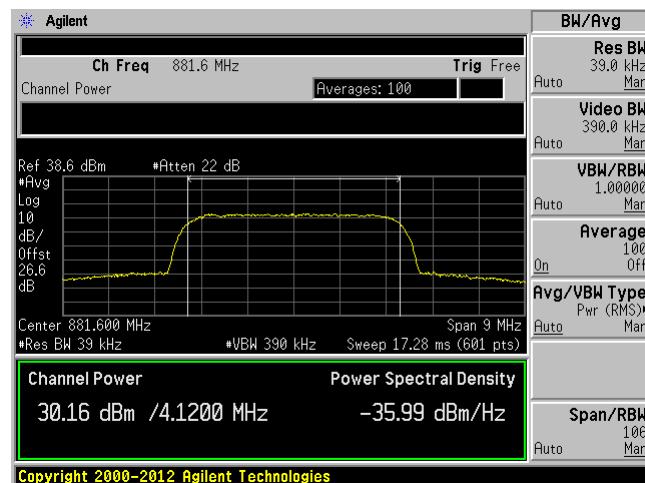
Note: ERP = Conducted Output Power (dBm) + Antenna Gain (dBi) - 2.15 (dB)

Please refer to the following plots for detailed test results of Conducted Output Power.

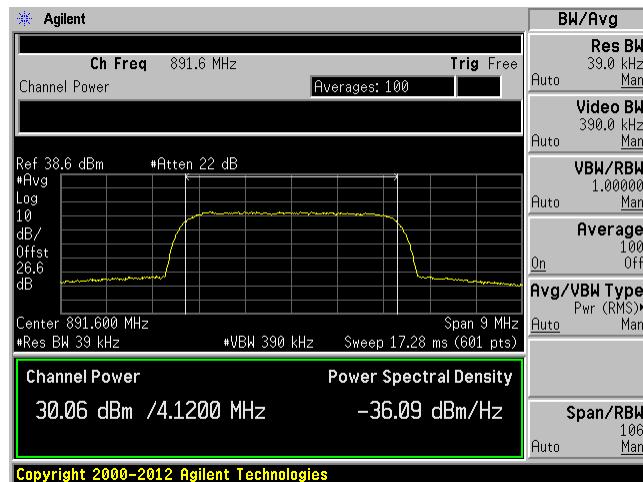
Low channel



Middle channel



High channel



Peak to Average Power Ratio (PAPR)

Channel	Frequency (MHz)	PAPR (dB)	Limit (dB)
WCDMA Band 5			
Low	871.4	7.76	13
Middle	881.6	7.95	13
High	891.6	8.04	13

Please refer to the following plots for detailed test results.

Low Channel



Middle Channel



High channel



6 FCC §2.1049, §22.905 §22.917 - Occupied Bandwidth

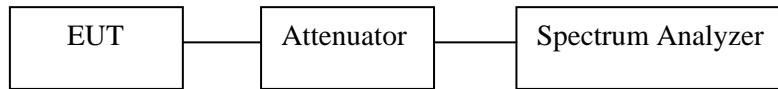
6.1 Applicable Standards

Requirements: FCC §2.1049, §22.905 and §22.917

6.2 Test Procedure

The EUT was connected to the spectrum analyzer through sufficient attenuator.

The resolution bandwidth of the spectrum analyzer was set to 5 kHz and the 26 dB & 99% bandwidth was recorded.



6.3 Test Equipment List and Details

Manufacturers	Descriptions	Models	Serial Numbers	Calibration Dates	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US 42221851	2016-06-10	1 year
-	RF cable	-	-	Each time ¹	N/A
-	20dB attenuator	-	-	Each time ¹	N/A

Statement of Traceability: BACL Corp. attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.

6.4 Test Environmental Conditions

Temperature:	21-23 °C
Relative Humidity:	42-48 %
ATM Pressure:	101.4-102 kPa

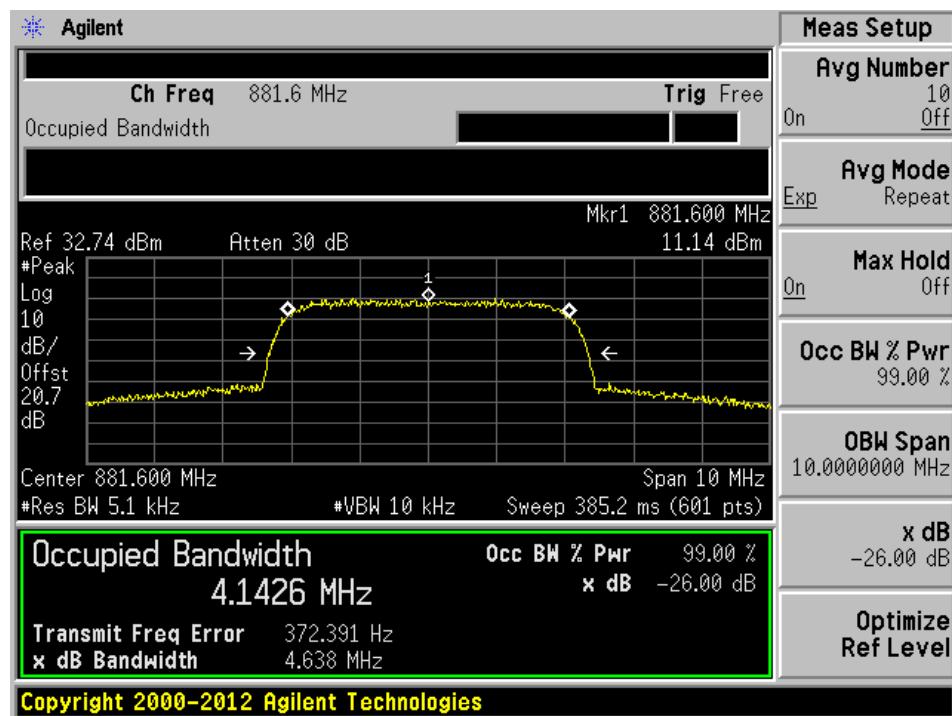
The testing was performed by Rudy Sun 2017-01-31 in the RF Site.

6.5 Test Results

Please refer to the following table and plots.

Channel	Frequency (MHz)	99% OBW (MHz)	26 dB BW (MHz)
Middle	881.6	4.143	4.638

Middle Channel



7 FCC §2.1053 & §22.917(a) - Spurious Radiated Emissions

7.1 Applicable Standards

According to FCC §22.917 the power of any emissions outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log(P)$ dB.

7.2 Test Procedure

The transmitter was placed on the turntable, and it was transmitting into a non-radiating load which was also placed on the turntable.

The measurement antenna was placed at a distance of 3 meters from the EUT. During the tests, the antenna height and polarization as well as EUT azimuth were varied in order to identify the maximum level of emissions from the EUT. The test was performed by placing the EUT on 3-orthogonal axis.

The frequency range up to tenth harmonic of the fundamental frequency was investigated.

Remove the EUT and replace it with substitution antenna. A signal generator was connected to the substitution antenna by a non-radiating cable. The absolute levels of the spurious emissions were measured by the substitution.

Spurious emissions in dB = $10 \log (\text{TX Power in Watts}/0.001)$ – the absolute level
 Spurious attenuation limit in dB = $43 + 10 \log_{10} (\text{power out in Watts})$

7.3 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US 42221851	2016-06-10	1 year
Sunol Science Corp	System Controller	SC99V	122303-1	N/R	N/R
Sunol Science Corp	Combination Antenna	JB3	A020106-2	2015-07-11	2 year
Sunol	Horn antenna	DRH-118	A052704	2015-03-09	2 year
A. H. Systems	Antenna, Horn	SAS-200/571	261	2015-03-19	2 year
HP	Signal Generator	83650B	18485-91	2016-09-09	1 year
COM-POWER	Antenna, Dipole	AD-100	721033DB1,721033DB2,721033DB3,721033DB4,	2015-01-16	2 year

Statement of Traceability: **BACL Corp.** attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.

7.4 Test Environmental Conditions

Temperature:	20-21°C
Relative Humidity:	47-49 %
ATM Pressure:	101.4-101.6 kPa

The testing was performed by Rudy Sun on 2017-01-30 in 5 Meter Chamber 3

7.5 Test Results

30MHz – 10GHz

Frequency (MHz)	Receiver Reading (dB μ V)	Turn Table Angle Degree	Rx Antenna		Substituted			Absolute Level (dBm)	FCC §22.913(a)	
			Height (m)	Polar (H/V)	SG Level (dBm)	Cable (dB)	Antenna Gain (dB)		Limit (dBm)	Margin (dB)
Low Channel										
103.95	41.28	222	153	H	-66.95	0.37	0	-67.32	-13	-54.32
50.82	44.23	112	105	V	-63.33	0.37	0	-63.7	-13	-50.7
2615.17	57.68	316	138	H	-45.78	1.08	8.75	-38.11	-13	-25.11
2615.17	66.83	160	206	V	-36.35	1.08	8.75	-28.68	-13	-15.68
Middle Channel										
103.95	40.87	222	153	H	-67.36	0.37	0	-67.73	-13	-54.73
50.82	43.93	112	105	V	-63.63	0.37	0	-64	-13	-51
2615.17	56.23	316	138	H	-53.39	1.08	8.75	-45.72	-13	-32.72
2615.17	65.13	160	206	V	-43.1	1.08	8.75	-35.43	-13	-22.43
High Channel										
103.95	41.11	222	153	H	-67.12	0.37	0	-67.49	-13	-54.49
50.82	44.01	112	105	V	-63.55	0.37	0	-63.92	-13	-50.92
2615.17	57.13	316	138	H	-52.49	1.08	8.75	-44.82	-13	-31.82
2615.17	66.26	160	206	V	-41.97	1.08	8.75	-34.3	-13	-21.3

8 FCC §2.1051 & §22.917- Spurious Emissions at Antenna Terminals

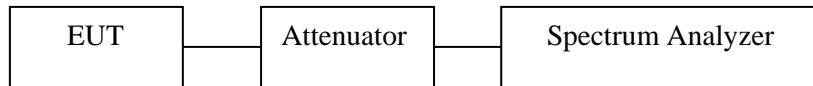
8.1 Applicable Standards

According to FCC §22.917 the power of any emissions outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log(P)$ dB.

8.2 Test Procedure

The EUT was connected to the spectrum analyzer through sufficient attenuator.

The resolution bandwidth of the spectrum analyzer was set 100 kHz. Sufficient scans were taken to show any out of band emissions up to 10th harmonic.



8.3 Test Equipment List and Details

Manufacturers	Descriptions	Models	Serial Numbers	Calibration Dates	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US 42221851	2016-06-10	1 year
-	RF cable	-	-	Each time ¹	N/A
-	20dB attenuator	-	-	Each time ¹	N/A

Statement of Traceability: BACL Corp. attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.

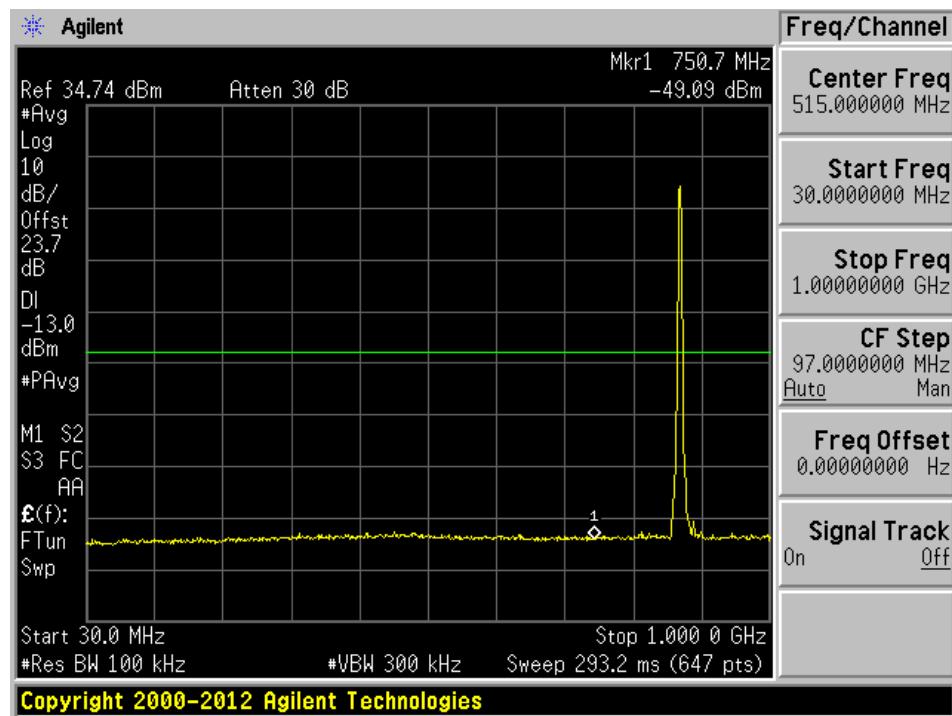
8.4 Test Environmental Conditions

Temperature:	21-23° C
Relative Humidity:	42-48 %
ATM Pressure:	101.4-102 kPa

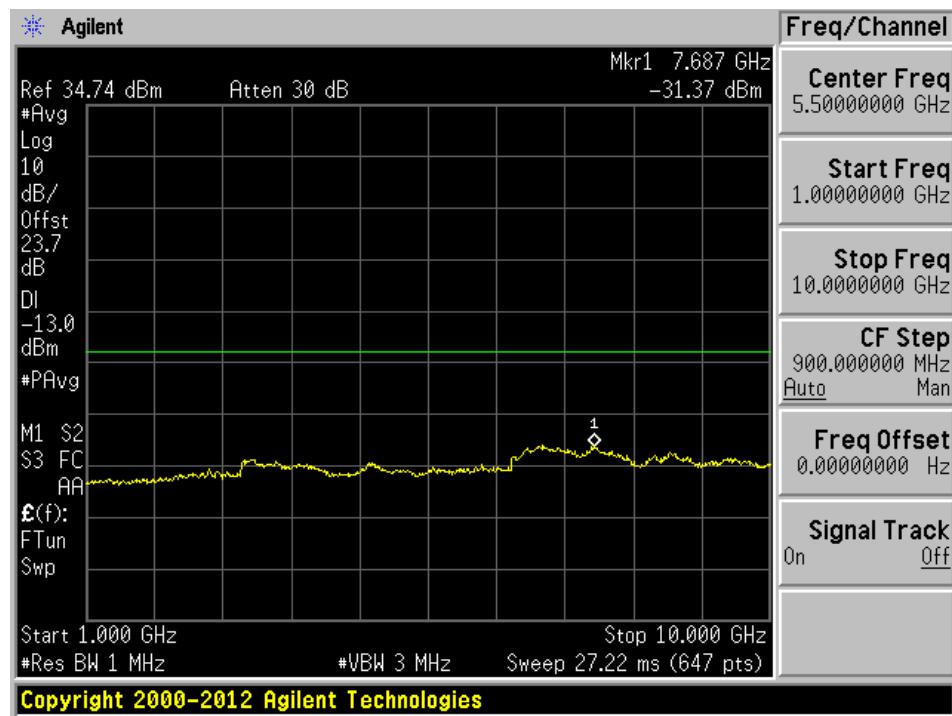
The testing was performed by Rudy Sun 2017-01-30 in the RF Site.

Low Channel: 871.4 MHz

30 MHz – 1GHz

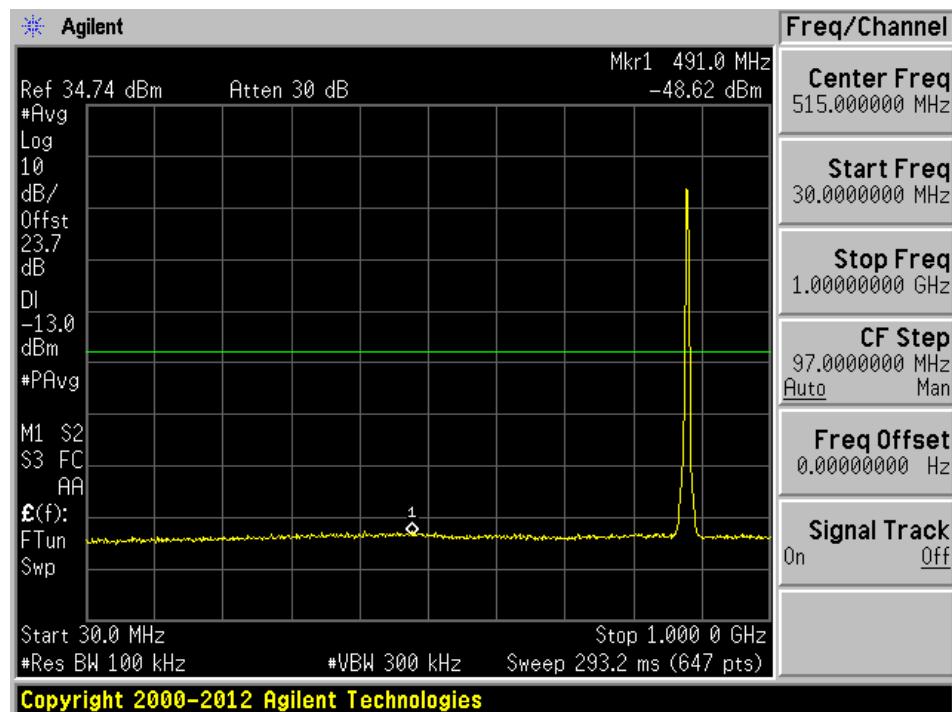


1 GHz – 10 GHz

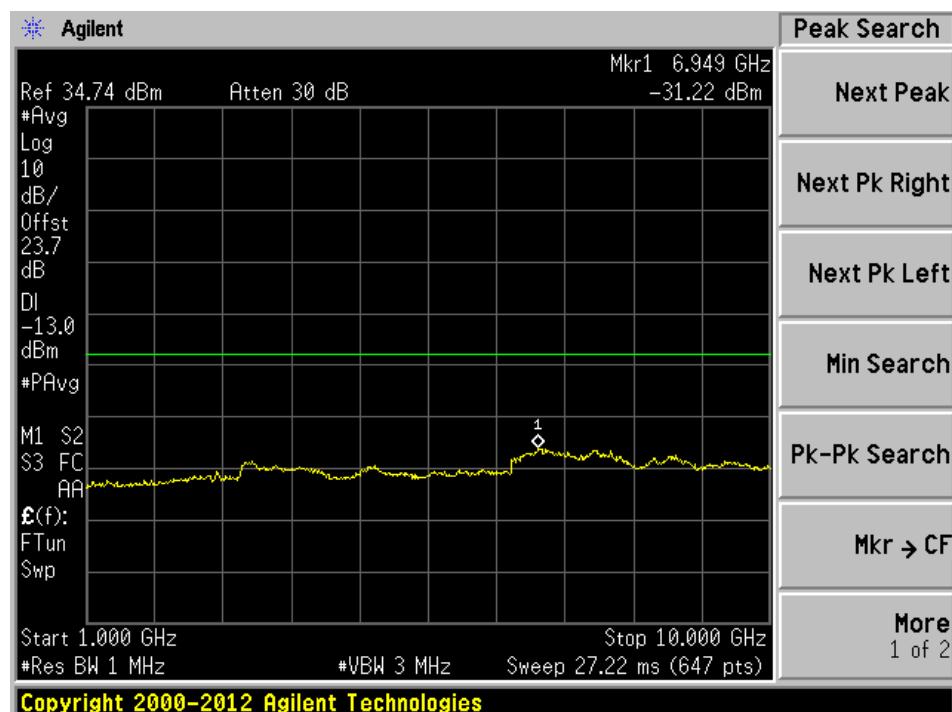


Middle Channel: 881.6 MHz

30 MHz – 1 GHz

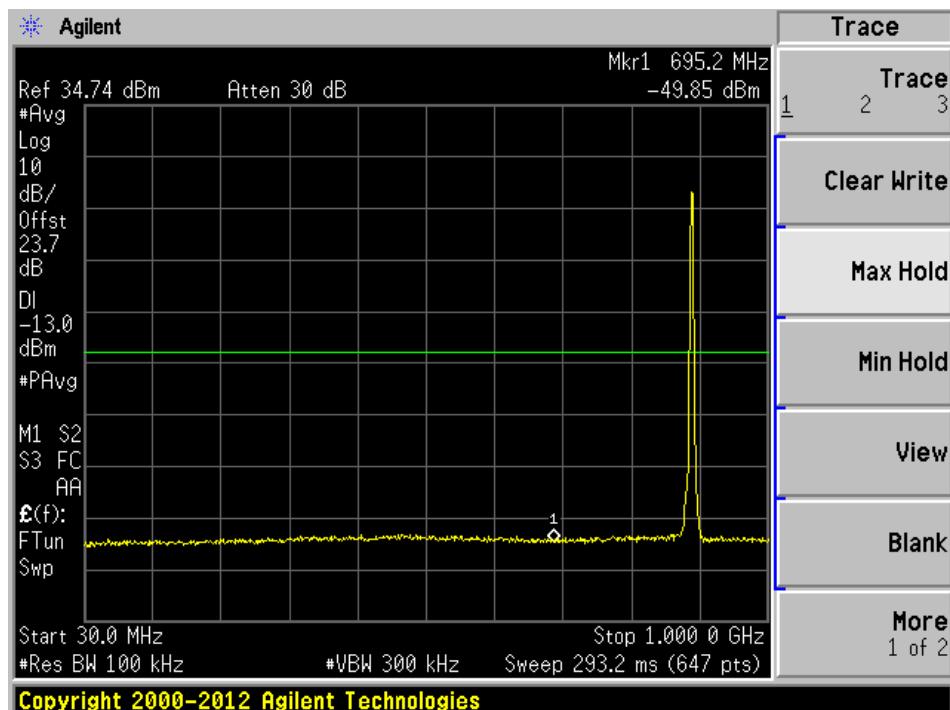


1 GHz – 10 GHz

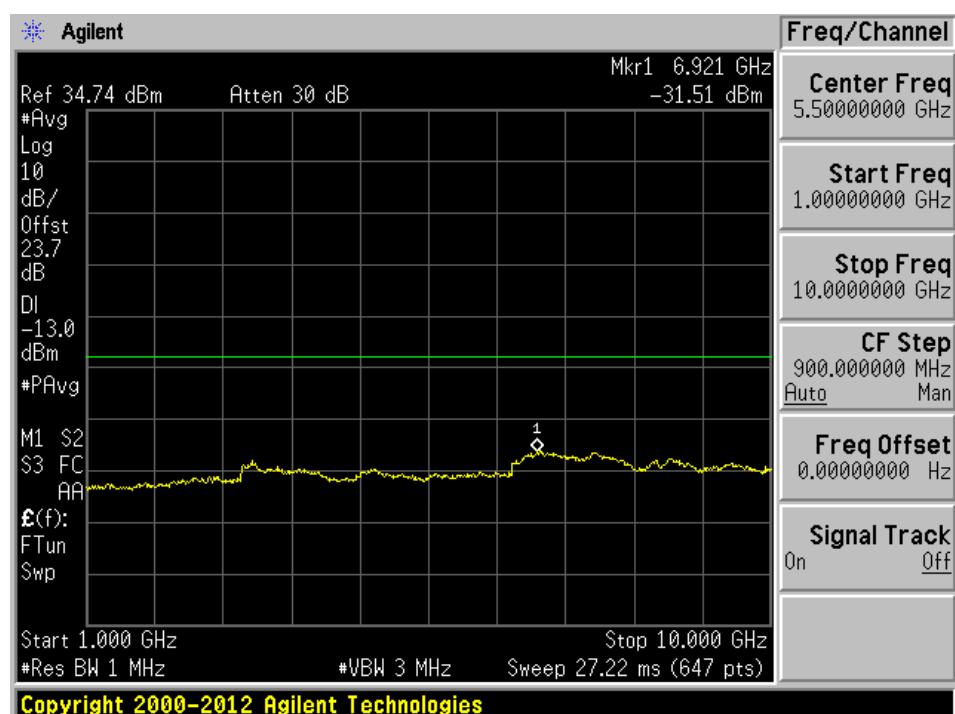


High Channel: 891.6 MHz

30 MHz – 1 GHz



1 GHz – 10 GHz



9 FCC §22.917 - Band Edge

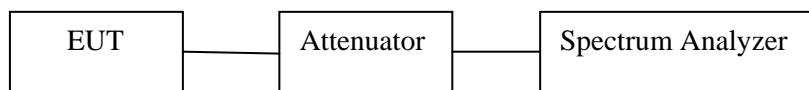
9.1 Applicable Standards

According to FCC §22.917 (a) the power of any emissions outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log(P)$ dB.

9.2 Test Procedure

The EUT was connected to the spectrum analyzer through sufficient attenuation.

The center frequency of the spectrum analyzer was set to block edge frequency.



9.3 Test Equipment List and Details

Manufacturers	Descriptions	Models	Serial Numbers	Calibration Dates	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US 42221851	2016-06-10	1 year
-	RF cable	-	-	Each time ¹	N/A
-	20dB attenuator	-	-	Each time ¹	N/A

Statement of Traceability: BACL Corp. attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.

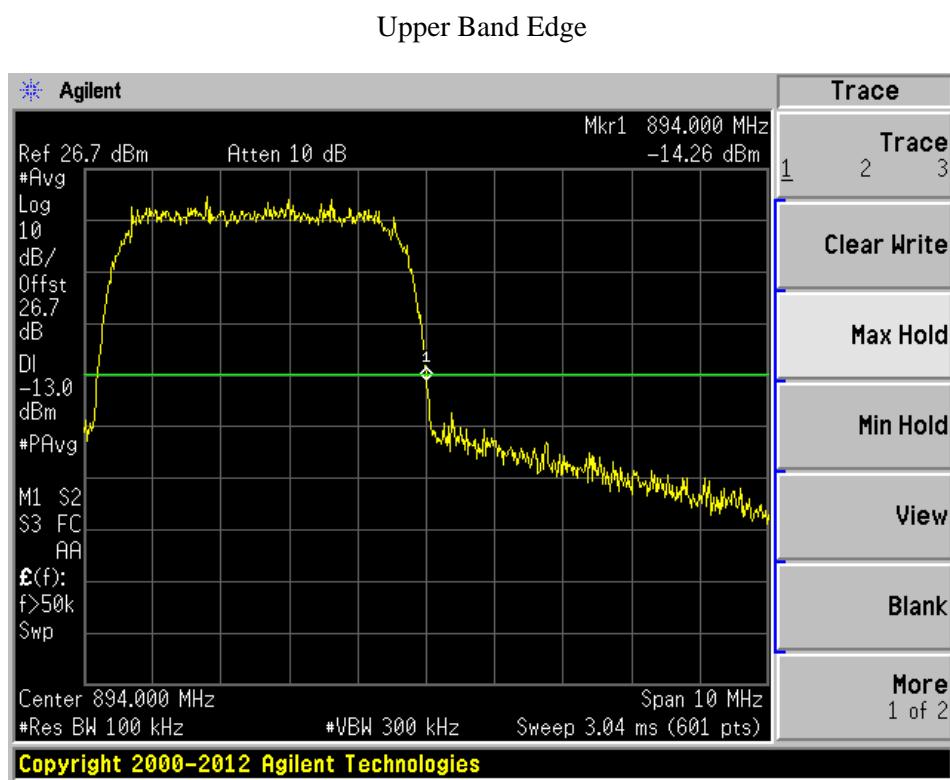
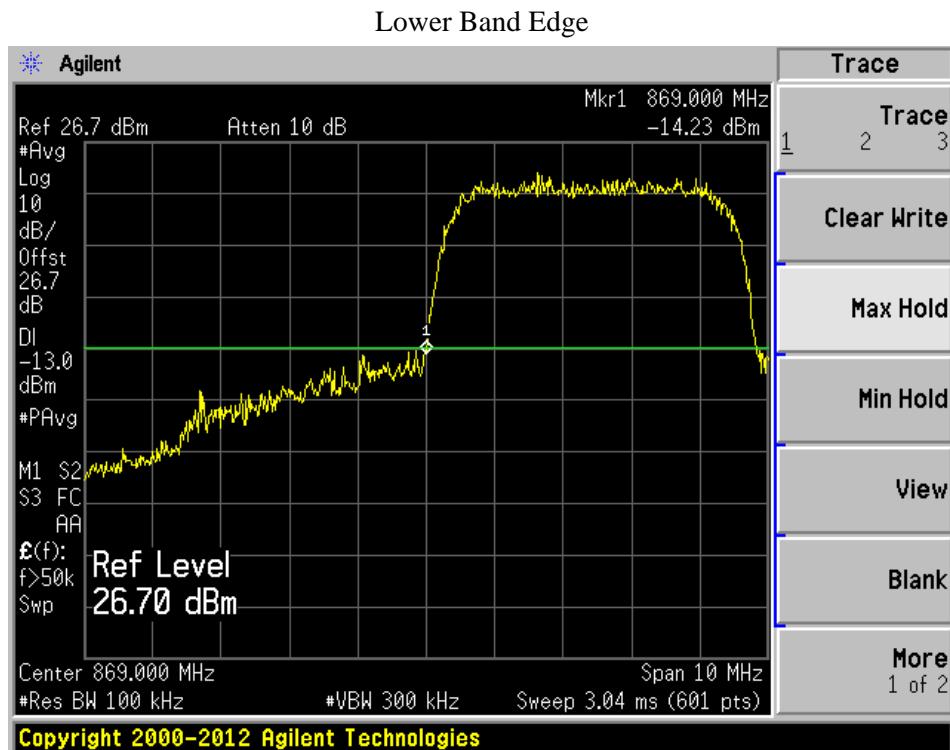
9.4 Test Environmental Conditions

Temperature:	21-23° C
Relative Humidity:	42-48 %
ATM Pressure:	101.4-102 kPa

The testing was performed by Rudy Sun 2017-01-30 in the RF Site.

9.5 Test Results

Please refer to the following plots.



10 FCC §2.1055 & §22. 355– Frequency Stability

10.1 Applicable Standard

According to FCC §22.355, the carrier frequency of each transmitter in the Public Mobile Services must be maintained within the tolerances given in the table below:

Frequency Tolerance for Transmitters in the Public Mobile Services

Frequency range (MHz)	Base, fixed (ppm)	Mobile >3 watts (ppm)	Mobile ≤3 watts (ppm)
25 to 50	20.0	20.0	50.0
50 to 450	5.0	5.0	50.0
450 to 512	2.5	5.0	5.0
821 to 896	1.5	2.5	2.5
928 to 929	5.0	n/a	n/a
929 to 960	1.5	n/a	n/a
2110 to 2220	10.0	n/a	n/a

10.2 Test Procedure

Frequency Stability vs. Temperature: the equipment under test was connected to an external DC power supply and the RF output was connected to communication test set via feed-through attenuators. The EUT was placed inside the temperature chamber. The DC leads and RF output cable exited the chamber through an opening made for the purpose.

After the temperature stabilized for approximately 20 minutes, the frequency output was recorded from the communication test set.

Frequency stability vs. voltage: for hand carried, battery powered equipment; reduce primary supply voltage to the battery operating end point which shall be specified by manufacturer.

10.3 Test Equipment List and Details

Manufacturers	Descriptions	Models	Serial Numbers	Calibration Dates	Calibration Interval
Agilent	Analyzer, Spectrum	E4440A	US 42221851	2016-06-10	1 year
-	RF cable	-	-	Each time ¹	N/A
-	20dB attenuator	-	-	Each time ¹	N/A
Espec	Chamber, Humidity	ESL-4CA	18010	2016-02-24	1 year
KEPCO	Source, DC	25-10M	H1334526	N/A	N/A
Fluke	Multimeter	287	11820006	2016-04-05	1 year

Statement of Traceability: BACL Corp. attests that all calibrations have been performed per the A2LA requirements, traceable to the NIST.

10.4 Test Environmental Conditions

Temperature:	21-23° C
Relative Humidity:	42-48 %
ATM Pressure:	101.4-102 kPa

The testing was performed by Rudy Sun on 2017-01-30 in the RF Site.

10.5 Test Results

Middle Channel (881.6MHz)			
Temperature (° C)	Power Supplied (Vdc)	Frequency Error (ppm)	Limit (ppm)
-15	12	1.633402426	2.5
-10		0.794015068	2.5
0		1.526777546	2.5
10		0.555810548	2.5
20		0	2.5
30		1.905636164	2.5
40		1.395197906	2.5
20	10.2	1.678774716	2.5
	13.8	1.848920802	2.5

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