FCC PART 22H, 24E, 27, ISEDC RSS-130, 132, 133, 139

TEST AND MEASUREMENT REPORT

For

HAP Innovations

2501 Aerial Center Parkway, Suite 100
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United States

FCC ID: 2AIA7-SPN02
IC: 21622-SPN02

Report Type: Original Report	**Model:** SPN02

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Report Number: R1706142-22

Report Date: 2017-07-11

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TABLE OF CONTENTS

DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R1706142-22	Original Report	2017-07-11

1 General Information

1.1 Product Description for Equipment under Test (EUT)

This test and measurement report was prepared on behalf of HAP Innovations and their product model: SPN02, or the "EUT" as referred to in this report. The device used Gemalto M2M GmbH's Module ELS61-US, FCC ID: QIPELS61-US; IC: 7830A-ELS61US, which support WCDMA Band II, IV, V and LTE Band II, IV, V, XII. The EUT is a spencer and contains a cellular radio (WCDMA Band II, IV, V and LTE Band II, IV, V, XII) and a Wi-Fi/Bluetooth radio (2400-2483.5MHz).

1.2 Mechanical Description

The EUT measures approximately 265 mm (L) x 125 mm (W) x 330 mm (H).

The test data gathered are from typical production sample, serial number: R1706142-1 assigned by BACL.

1.3 Objective

This type approval report was prepared on behalf of *HAP Innovations,* in accordance with Part 2, Subpart J, Part 22 Subpart H, Part 24 Subpart E, Part27 of the Federal Communication Commission's rules, RSS-130 Issue 1, October, 2013, RSS-132 Issue 3, January 2013, RSS-133 Issue 6, January 2013, RSS-139 Issue 3, July 2015.

The objective was to determine compliance with FCC and ISEDC 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)

R1706142-247

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, Part 24 Subpart E, Part 27, RSS130, RSS130, RSS132, RSS133, RSS139

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 Luminares 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

N/A

2.3 Equipment Modifications

No modifications were made to the EUT.

3 Summary of Test Results

FCC/ISEDC Rules	Description of Tests	Results
FCC §2.1053, § 22.917 (a); § 24.238 (a); §27.53 ISDEC RSS-130 §4.6, RSS-132 §5.5, RSS-133 §6.5, RSS-139 §6.6	Spurious Radiated Emissions	Compliant

4 FCC §2.1051, §22.917(a), §24.238 (a), §27.53, RSS-130 §4.6, RSS-132 §5.5 & RSS-133 §6.5, RSS-139 §6.6 - Spurious Radiated Emissions

4.1 Applicable Standards

According to FCC §22.917(a) The power of any emission 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.

According to FCC §24.238(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.

According to FCC §27.53

(g) For operations in the 600 MHz band and the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least 43 + 10 log (P) dB. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater. However, in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block, a resolution bandwidth of at least 30 kHz may be employed.

(h) AWS emission limits—(1) General protection levels. Except as otherwise specified below, for operations in the 1695-1710 MHz, 1710-1755 MHz, 1755-1780 MHz, 1915-1920 MHz, 1995-2000 MHz, 2000-2020 MHz, 2110-2155 MHz, 2155-2180 MHz, and 2180-2200 bands, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in watts by at least 43 + 10 log10 (P) dB.

(h)(3) *Measurement procedure.* (i) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 megahertz bands immediately outside and adjacent to the licensee's frequency block, a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

According to RSS-130 §4.6

4.6.1 The power of any unwanted emissions in any 100 kHz bandwidth on any frequency outside the frequency range(s) within which the equipment is designed to operate shall be attenuated below the transmitter power, P (dBW), by at least 43 + 10 log10 p (watts), dB. However, in the 100 kHz band immediately outside the equipment's operating frequency range, a resolution bandwidth of 30 kHz may be employed.

4.6.2 In addition to the limit outlined in Section 4.6.1 above, equipment operating in the frequency bands 746-756 MHzand 777-787 MHz shall also comply with the following restrictions:

- (a) The power of any unwanted emissions in any 6.25 kHz bandwidth for all frequencies between 763-775 MHzand 793-806 MHz shall be attenuated below the transmitter power, P (dBW), by at least:

  (i) 76 + 10 log10 p (watts), dB, for base and fixed equipment, and

  (ii) 65 + 10 log10 p (watts), dB, for mobile and portable equipment.

- (b) The e.i.r.p. in the band 1559-1610 MHz shall not exceed −70 dBW/MHz for wideband signal and −80 dBW for discrete emission with bandwidth less than 700 Hz.

According to RSS-132 §5.5

Mobile and base station equipment shall comply with the limits in (i) and (ii) below.

(i) In the first 1.0 MHz band immediately outside and adjacent to each of the sub-bands specified in Section 5.1, the power of emissions per any 1% of the occupied bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10 p (watts).

(ii) (ii) After the first 1.0 MHz immediately outside and adjacent to each of the sub-bands, the power of emissions in any 100 kHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10 p (watts). If the measurement is performed using 1% of the occupied bandwidth, power integration over 100 kHz is required.

According to RSS-133 §6.5

Equipment shall comply with the limits in (i) and (ii) below.

(i) In the 1.0 MHz bands immediately outside and adjacent to the equipment's operating frequency block, the emission power per any 1% of the emission bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10 p(watts).

(ii) After the first 1.0 MHz, the emission power in any 1 MHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10 p(watts). If the measurement is performed using 1% of the emission bandwidth, power integration over 1.0 MHz is required.

According to RSS-139 §6.6

i. In the first 1.0 MHz bands immediately outside and adjacent to the equipment's smallest operating frequency block,Footnote2 which can contain the equipment's occupied bandwidth, the emission power per any 1% of the emission bandwidth shall be attenuated below the transmitter output power P (in dBW) by at least43 + 10 log10 p (watts) dB.

ii. After the first 1.0 MHz outside the equipment's smallest operating frequency block, which can contain the equipment's occupied bandwidth, the emission power in any 1 MHz bandwidth shall be attenuated below the transmitter output power P (in dBW) by at least 43 + 10 log10 p (watts) dB.

4.2 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 (TX Power in Watts/0.001) – the absolute level
Spurious attenuation limit in dB = 43 + 10 Log_{10} (power out in Watts)

4.3 Test Equipment List and Details

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4440A	US45303156	2017-02-24	1 year
Sunol Science Corp	System Controller	SC99V	122303-1	N/R	N/R
HP/Agilant	Pre-Amplifier	8449BOPTHO2	3008A0113	2017-05-23	1 year
A.R.A.	Antenna, Horn	DRG-118/A	1132	2015-09-21	2 years
HP	Pre-Amplifier	8447D	2944A06639	2016-06-28	1 year
EMCO	Antenna, Horn	3115	9511-4627	2016-01-28	2 year
COM-POWER	Antenna, Dipole	AD-100	721033DB1, 2, 3, 4	2017-02-12	2 years
Keysight Technologies	Vector Signal Generator	N5182B	MY51350070	2017-01-06	1 year
-	SMA Cable	-	C0003	-	Each time
Sunol Sciences	Antenna, Biconi-Log	JB1	A013105-3	2015-07-11	2 year
IW Microwave	High Frequency Cable	DC-1438	SPS-2303-3840-SPS	2017-01-23	1 year

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

4.4 Test Environmental Conditions

Temperature:	22 °C
Relative Humidity:	48 %
ATM Pressure:	101.3 kPa

The testing was performed by Dean Liu on 2017- 06-28 in 5 Meter Chamber 3

4.5 Test Results

WCDMA Band 2

30MHz – 20GHz

Frequency (MHz)	Receiver Reading (dBµV)	Turn Table Angle Degree	Rx Antenna		Substituted			Absolute Level (dBm)	Limit (dBm)	Margin (dB)
			Height (m)	Polar (H/V)	SG Level (dBm)	Antenna Gain (dB)	Cable (dB)			
Low Channel										
91.4	21.29	111	190	H	-59.23	0	0.22	-59.45	-13	-46.45
38.33	23.1	296	100	V	-65.23	0	0.18	-65.41	-13	-52.41
3700	29.65	43	160	H	-38.59	10.59	1.22	-29.22	-13	-16.22
3742.1	30.11	29	172	V	-37.82	10.7	1.25	-28.37	-13	-15.37
Middle Channel										
91.4	21.56	111	190	H	-58.96	0	0.22	-59.18	-13	-46.18
38.33	22.74	296	100	V	-65.59	0	0.18	-65.77	-13	-52.77
3700	30.28	43	160	H	-37.96	10.59	1.22	-28.59	-13	-15.59
3742.1	30.92	29	172	V	-37.01	10.7	1.25	-27.56	-13	-14.56
High Channel										
91.4	21.29	111	190	H	-59.23	0	0.22	-59.45	-13	-46.45
38.33	22.89	296	100	V	-65.44	0	0.18	-65.62	-13	-52.62
3700	29.89	43	160	H	-38.35	10.59	1.22	-28.98	-13	-15.98
3742.1	30.44	29	172	V	-37.49	10.7	1.25	-28.04	-13	-15.04

WCDMA Band 5

30MHz – 10GHz

Frequency (MHz)	Receiver Reading (dBµV)	Turn Table Angle Degree	Rx Antenna		Substituted			Absolute Level (dBm)	Limit (dBm)	Margin (dB)
			Height (m)	Polar (H/V)	SG Level (dBm)	Antenna Gain (dB)	Cable (dB)			
Low Channel										
91.4	20.95	111	190	H	-59.57	0	0.22	-59.79	-13	-46.79
38.33	22.61	296	100	V	-65.72	0	0.18	-65.9	-13	-52.9
3700	30.21	43	160	H	-38.03	10.59	1.22	-28.66	-13	-15.66
3742.1	31	29	172	V	-36.93	10.7	1.25	-27.48	-13	-14.48
Middle Channel										
91.4	21.33	111	190	H	-55.77	0	0.37	-56.14	-13	-43.14
38.33	22.74	296	100	V	-56.89	0	0.37	-57.26	-13	-44.26
3700	29.71	43	160	H	-60.33	10.319	3.259	-53.27	-13	-40.27
3742.1	30.45	29	172	V	-58.51	10.319	3.259	-51.45	-13	-38.45
High Channel										
91.4	21.02	111	190	H	-58.77	0	0.37	-59.14	-13	-46.14
38.33	22.85	296	100	V	-56.6	0	0.37	-56.97	-13	-43.97
3700	29.5	43	160	H	-59.43	10.319	3.396	-52.507	-13	-39.507
3742.1	31.36	29	172	V	-58.29	10.319	3.396	-51.367	-13	-38.367

WCDMA Band 4
30MHz – 20GHz

Frequency (MHz)	Receiver Reading (dBµV)	Turn Table Angle Degree	Rx Antenna		Substituted			Absolute Level (dBm)	Limit (dBm)	Margin (dB)
			Height (m)	Polar (H/V)	SG Level (dBm)	Antenna Gain (dB)	Cable (dB)			
Low Channel										
91.4	21.22	111	190	H	-59.3	0	0.22	-59.52	-13	-46.52
38.33	20.87	296	100	V	-67.46	0	0.18	-67.64	-13	-54.64
3700	30.25	43	160	H	-37.99	10.59	1.22	-28.62	-13	-15.62
3742.1	29.44	29	172	V	-38.49	10.7	1.25	-29.04	-13	-16.04
Middle Channel										
91.4	20.94	111	190	H	-59.58	0	0.22	-59.8	-13	-46.8
38.33	21.35	296	100	V	-66.98	0	0.18	-67.16	-13	-54.16
3700	29.83	43	160	H	-38.41	10.59	1.22	-29.04	-13	-16.04
3742.1	30.22	29	172	V	-37.71	10.7	1.25	-28.26	-13	-15.26
High Channel										
91.4	20.65	111	190	H	-59.87	0	0.22	-60.09	-13	-47.09
38.33	20.84	296	100	V	-67.49	0	0.18	-67.67	-13	-54.67
3700	30.25	43	160	H	-37.99	10.59	1.22	-28.62	-13	-15.62
3742.1	29.68	29	172	V	-38.25	10.7	1.25	-28.8	-13	-15.8

LTE Band 2

30MHz – 20GHz

Frequency (MHz)	Receiver Reading (dBµV)	Turn Table Angle Degree	Rx Antenna		Substituted			Absolute Level (dBm)	Limit (dBm)	Margin (dB)
			Height (m)	Polar (H/V)	SG Level (dBm)	Antenna Gain (dB)	Cable (dB)			
Low Channel, 20 MHz,1RB#0, QPSK										
52.69	22.03	111	190	H	-58.49	0	0.22	-58.71	-13	-45.71
44.5	20.38	296	100	V	-67.95	0	0.18	-68.13	-13	-55.13
3700.4	30.22	43	160	H	-38.02	10.59	1.22	-28.65	-13	-15.65
3700.4	30.79	29	172	V	-37.14	10.7	1.25	-27.69	-13	-14.69

LTE Band 4

30MHz – 20GHz

Frequency (MHz)	Receiver Reading (dBµV)	Turn Table Angle Degree	Rx Antenna		Substituted			Absolute Level (dBm)	Limit (dBm)	Margin (dB)
			Height (m)	Polar (H/V)	SG Level (dBm)	Antenna Gain (dB)	Cable (dB)			
Middle Channel, 15 MHz,1RB#0, QPSK										
91.4	21.02	111	190	H	-59.5	0	0.22	-59.72	-13	-46.72
38.33	21.05	296	100	V	-67.28	0	0.18	-67.46	-13	-54.46
3700	29.89	43	160	H	-38.35	10.59	1.22	-28.98	-13	-15.98
3742.1	31.24	29	172	V	-36.69	10.7	1.25	-27.24	-13	-14.24

LTE Band 5

30MHz – 10GHz

Frequency (MHz)	Receiver Reading (dBµV)	Turn Table Angle Degree	Rx Antenna		Substituted			Absolute Level (dBm)	Limit (dBm)	Margin (dB)
			Height (m)	Polar (H/V)	SG Level (dBm)	Antenna Gain (dB)	Cable (dB)			
Low Channel, 1.4 MHz,1RB#0, QPSK										
91.4	20.37	111	190	H	-60.15	0	0.22	-60.37	-13	-47.37
38.33	21.52	296	100	V	-66.81	0	0.18	-66.99	-13	-53.99
3700	31.56	43	160	H	-36.68	10.59	1.22	-27.31	-13	-14.31
3742.1	29.21	29	172	V	-38.72	10.7	1.25	-29.27	-13	-16.27

LTE Band 12

30MHz – 10 GHz

Frequency (MHz)	Receiver Reading (dBµV)	Turn Table Angle Degree	Rx Antenna		Substituted			Absolute Level (dBm)	Limit (dBm)	Margin (dB)
			Height (m)	Polar (H/V)	SG Level (dBm)	Antenna Gain (dB)	Cable (dB)			
Low Channel, 1.4 MHz,1RB#0, QPSK										
91.4	22.03	111	190	H	-58.49	0	0.22	-58.71	-13	-45.71
38.33	20.38	296	100	V	-67.95	0	0.18	-68.13	-13	-55.13
3700	30.22	43	160	H	-38.02	10.59	1.22	-28.65	-13	-15.65
3742.1	30.79	29	172	V	-37.14	10.7	1.25	-27.69	-13	-14.69