



Test Report

Prepared for: Freewave Technologies, Inc.

Model: ZumLink Z9-C or Z9-T

Description: Digital Transmission System Radio Transceiver

Serial Number: N/A

FCC ID: KNYPM0101AB
IC: 2329B-PMT0101AB

To

FCC Part 15.247 FHSS
IC RSS-247

Date of Issue: June 22, 2016

On the behalf of the applicant:

Freewave Technologies, Inc.
5395 Pearl Parkway
Suite 100
Boulder, CO 80301

Attention of:

Dean Busch, Sr. Compliance Engineer
Ph: (303)962-7879
E-mail: dbusch@freewave.com

Prepared by
Compliance Testing, LLC
1724 S. Nevada Way
Mesa, AZ 85204
(480) 926-3100 phone / (480) 926-3598 fax
www.compliancetesting.com
Project No: p1660006

Alex Macon
Project Test Engineer

This report may not be reproduced, except in full, without written permission from Compliance Testing.
All results contained herein relate only to the sample tested.

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	June 10, 2016	Alex Macon	Original Document
2.0	June 21, 2016	Kenneth Lee	Added statement in Output Power section
3.0	August 28, 2019	Michelle O'Hern	Corrected FCC and IC ID on page 1

Table of Contents

<u>Description</u>	<u>Page</u>
Standard Test Conditions and Engineering Practices	6
Test Results Summary	8
Peak Output Power.....	9
Conducted RF Measurements (15.209)	10
Radiated Spurious Emissions.....	11
Conducted Spurious Emissions.....	12
Occupied Bandwidth.....	13
Dwell Time	14
Number of Hopping Channels	15
Test Equipment Utilized.....	16

ILAC / A2LA

Compliance Testing, LLC, has been accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to the joint ISO-ILAC-IAF Communiqué dated January 2009).

The tests results contained within this test report all fall within our scope of accreditation, unless noted in the table below.

Please refer to <http://www.compliancetesting.com/labscope.html> for current scope of accreditation.

Testing Certificate Number: **2152.01**



FCC Site Reg. #349717

IC Site Reg. #2044A-2

Non-accredited tests contained in this report:

N/A

The applicant has been cautioned as to the following

15.21 - Information to User

The user's manual or instruction manual for an intentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

15.27(a) - Special Accessories

Equipment marketed to a consumer must be capable of complying with the necessary regulations in the configuration in which the equipment is marketed. Where special accessories, such as shielded cables and/or special connectors are required to enable an unintentional or intentional radiator to comply with the emission limits in this part, the equipment must be marketed with, i.e. shipped and sold with, those special accessories. However, in lieu of shipping or packaging the special accessories with the unintentional or intentional radiator, the responsible party may employ other methods of ensuring that the special accessories are provided to the consumer, without an additional charge.

Information detailing any alternative method used to supply the special accessories for a grant of equipment authorization or retained in the verification records, as appropriate. The party responsible for the equipment, as detailed in 2.909 of this chapter, shall ensure that these special accessories are provided with the equipment. The instruction manual for such devices shall include appropriate instructions on the first page of text concerned with the installation of the device that these special accessories must be used with the device. It is the responsibility of the user to use the needed special accessories supplied with the equipment.

Standard Test Conditions and Engineering Practices

All tests and measurement data shown were performed in accordance with FCC Rules and Regulations, Volume II; Part 2 and the following individual Part: 15.247 Operation within bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

Except as noted herein, the following conditions and procedures were observed during the testing:

In accordance with ANSI C63.4-2009, ANSI C63.10-2009, FCC DA 00-705, and unless otherwise indicated in the specific measurement results, the ambient temperature of the actual EUT was maintained within the range of 10 to 40C (50 to 104F) unless the particular equipment requirements specified testing over a different temperature range. Also, unless otherwise indicated, the humidity levels were in the range of 10% to 90% relative humidity.

Environmental Conditions		
Temperature (°C)	Humidity (%)	Pressure (mbar)
23.2 – 4.4	27.2 – 32.6	965 - 967

Measurement results, unless otherwise noted, are worst case measurements.

EUT Description

Model: ZumLink Z9-C or Z9-T

Description: Digital Transmission System Radio Transceiver

Firmware: N/A

Software: N/A

Serial Number: N/A

Additional Information:

All tests are performed with a 6 dBi antenna in mind.

The data rate determines the frequency selected. Below are the high mid and low frequencies per data rate

115.2	250
902.477	902.534
914.918	914.976
927.821	927.418

EUT Operation during Tests

The EUT was controlled with test commands provided by the manufacturer.



Accessories:

Qty	Description	Manufacturer	Model	S/N
1	AC DC power supply	Spectre Power	S036CQ1200300	N/A
1	Laptop	Dell	Latitude E6520	N/A

Cables:

Qty	Description	Length (M)	Shielding Y/N	Shielded Hood Y/N	Ferrite Y/N
1	Serial to USB	<3m	N	N	N
1	Power	<3m	N	N	N

15.203: Antenna Requirement:

- The antenna is permanently attached to the EUT
- The antenna uses a unique coupling
- The EUT must be professionally installed
- The antenna requirement does not apply



Test Results Summary

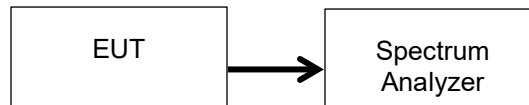
Specification	Test Name	Pass, Fail, N/A	Comments
15.247(b)	Peak Output Power	Pass	
15.247(d)	Conducted Spurious Emissions	Pass	
15.247(d), 15.209(a), 15.205	Radiated Spurious Emissions	Pass	
15.247(d), 15.209(a), 15.205	Emissions At Band Edges	Pass	
15.247(a)	Occupied Bandwidth	Pass	
15.247(a)	Dwell Time	Pass	
15.247(a)	Number of Hopping Channels	Pass	
15.207	A/C Powerline Conducted Emissions	N/A	
RSS-GEN §7	Receiver Spurious Emissions	N/A	

Peak Output Power
Engineer: Alex Macon

Test Date: 6/8/16

Test Procedure

The EUT was connected directly to the input of a spectrum analyzer. The peak readings were taken and the result was then compared to the limit.

Test Setup

Transmitter Peak Output Power

Channel	115.2 kb		
	Recorded Measurement (dBm)	Specification Limit (W)	Result
Low	29.82	1	Pass
Mid	29.82	1	Pass
High	29.46	1	Pass

Channel	250 kb		
	Recorded Measurement (dBm)	Specification Limit (W)	Result
Low	29.86	1	Pass
Mid	29.80	1	Pass
High	29.43	1	Pass

Note: For all antenna gains greater than 6dBi the output power must be reduced per the tables in Annex F.

Conducted RF Measurements (15.209)

Engineer: Alex Macon

Test Date: 6/9/16

Test Procedure

Antenna-port conducted measurements were performed as an alternative to radiated measurements for demonstrating compliance in the restricted frequency bands for 15.209.

The following offsets were added to the measurements:

The maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP level

A maximum ground reflection factor to the EIRP level, 6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive and 0 dB for frequencies > 1000 MHz.

The following equations were used to determine the field strength from the conducted values.

$E[\text{dB}\mu\text{V}/\text{m}] = \text{EIRP}[\text{dBm}] - 20 \log(d[\text{meters}]) + 104.77$, where E = field strength and d = 3m

$E[\text{dB}\mu\text{V}/\text{m}] = \text{EIRP}[\text{dBm}] + 95.2$, for d = 3 meters.

The Spectrum Analyzer was set to the following:

The Spectrum Analyzer was set to the following for emissions > 1000 MHz:

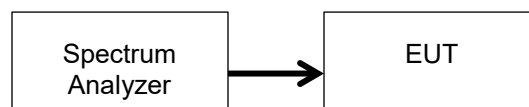
- a. RBW = 1 MHz
- b. VBW ≥ 3 MHz
- c. Detector = Peak.
- d. Sweep time = auto
- e. Trace mode = max hold
 1. Note: For emissions where the peak exceeded that of the average 15.209 emission limit the following was performed.
- f. RBW = 1 MHz
- g. VBW $\leq \text{RBW}/100$ (i.e., 10 kHz) but not less than 10 Hz

For emissions below 1000 MHz the Spectrum Analyzer settings were as follows:

- a. RBW = 100 kHz
- b. VBW ≥ 300 kHz
- c. Detector = Peak
- d. Sweep time = auto
- e. Trace mode = max hold

The EUT was connected to a spectrum analyzer to verify that the EUT met the requirements for spurious emissions. The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. The frequency range from 30 MHz to the 10th harmonic of the fundamental transmitter was investigated.

Test Setup



See Annex A for test results

Radiated Spurious Emissions

Engineer: Alex Macon

Test Date: 6/9/16

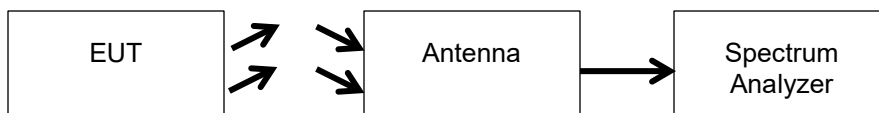
Test Procedure
Radiated Spurious Emissions: 30 – 1000 MHz

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The output of the transmitter was connected to a non-radiating balance load. The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. A spectrum analyzer was used to verify that the EUT met the requirements for Radiated Emissions. The EUT was tested by rotating it 360° with the antennas in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized.

All emissions from 30 MHz to 1 GHz were examined.
Measured Level includes antenna and receiver cable correction factors.
Correction factors were input into the spectrum analyzer before recording “Measured Level”.

RBW = 100 KHz
VBW = 300 KHz
Detector –Peak

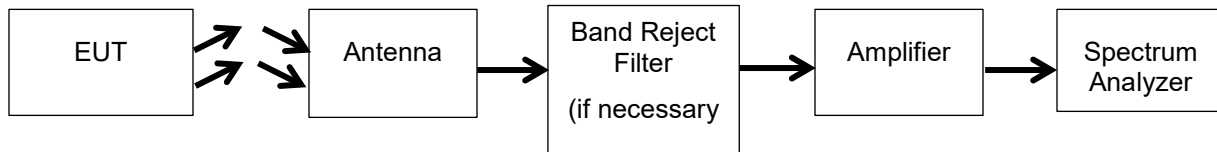
Test Setup



Test Procedure for
Radiated Spurious Emissions above 1 GHz

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The output of the transmitter was connected to a non-radiating balance load. The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. A spectrum analyzer was used to verify that the EUT met the requirements for Radiated Emissions. The EUT was tested by rotating it 360° with the antennas in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized.

Test Setup



See Annex B for test results

Conducted Spurious Emissions

Engineer: Alex Macon

Test Date: 6/8/16

Test Procedure

The EUT was connected directly to a spectrum analyzer. The Spectrum Analyzer was set to the following:

RBW = 100 kHz

VBW $\geq 3 \times$ RBW

Peak Detector

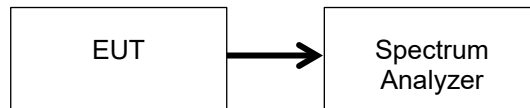
Trace mode = max hold

Sweep = auto couple

Frequency Range = 30MHz – 10th Harmonic of the fundamental

The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. The trace was allowed to stabilize. All emission were investigated to insure they were attenuated from the peak fundamental by at least 20dB. If the average power levels were measured then the out-of-band emissions needed to be attenuated by 30dB. In addition emissions were investigated at the band edges to insure all out-of-band emissions were attenuated 20 or 30dB as necessary.

Test Setup



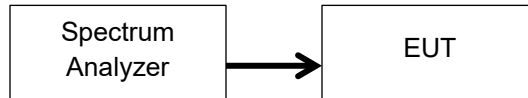
See Annex C for test results

Occupied Bandwidth
Engineer: Alex Macon

Test Date: 6/8/16

Test Procedure

The EUT was connected directly to a spectrum analyzer. The Span was set wide enough to capture the entire transmitting spectrum and the resolution bandwidth was set to at least 1% of the span. The analyzer was set to max hold and when the entire spectrum was captured, the 99% bandwidth was measured to verify that the bandwidth met the specification.

Test Setup

99% Bandwidth Summary
115.2 kb

Frequency (MHz)	Recorded Measurement (kHz)	Specification Limit	Result
Low	127.63	<500k	Pass
Mid	126.00	<500k	Pass
High	127.67	<500k	Pass

250 kb

Frequency (MHz)	Recorded Measurement (kHz)	Specification Limit	Result
Low	267.30	<500k	Pass
Mid	266.07	<500k	Pass
High	273.32	<500k	Pass

See Annex D for test results

Dwell Time

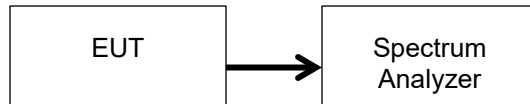
Engineer: Alex Macon

Test Date: 6/8/16

Test Procedure

The EUT was connected directly to a spectrum analyzer. The EUT was set to hopping mode with the spectrum analyzer set to a 0 Hz span. A single transmission was captured and the dwell time was recorded.

Test Setup



See Annex E for test results

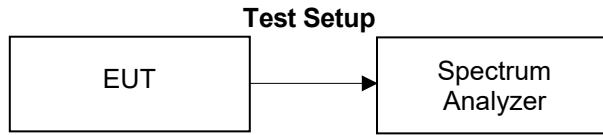
Number of Hopping Channels

Engineer: Alex Macon

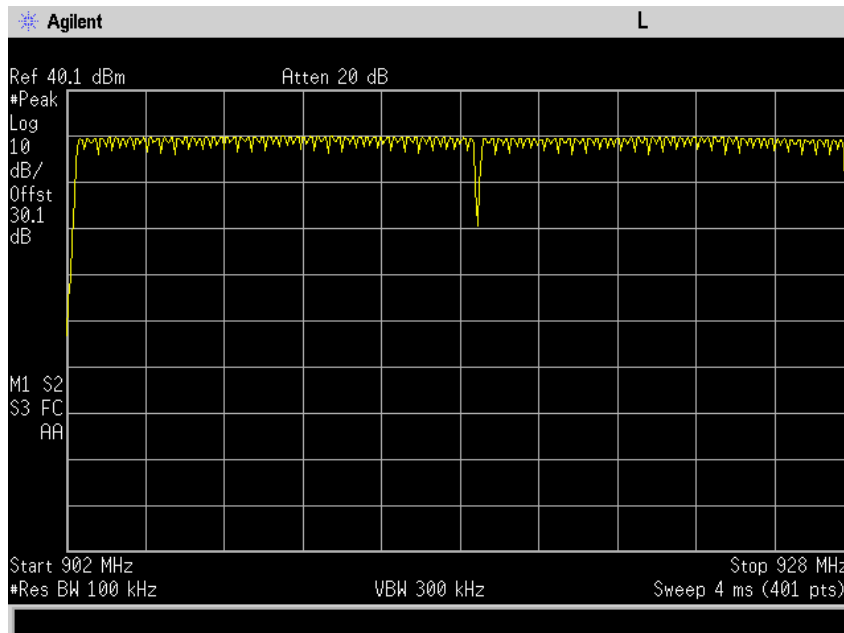
Test Date: 6/8/16

Test Procedure

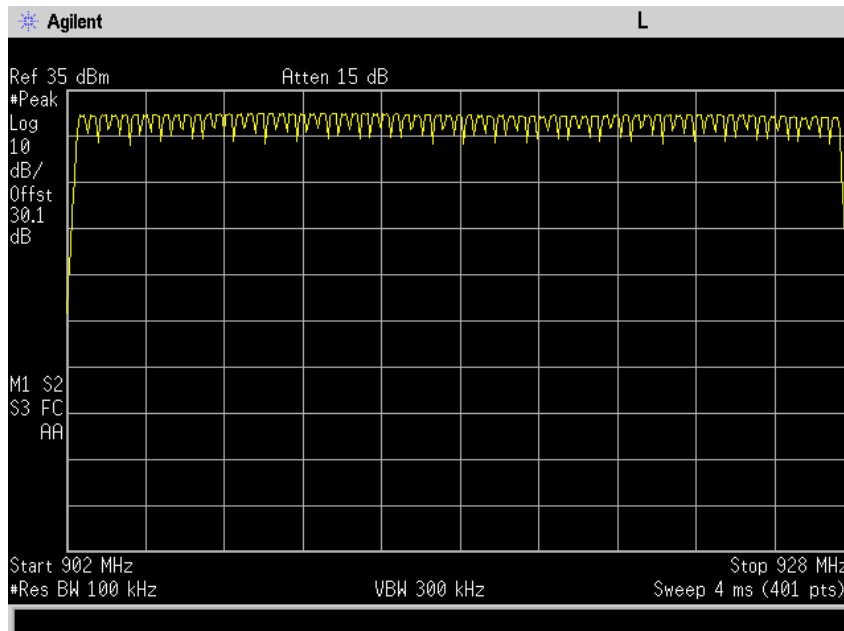
The EUT was connected directly to a spectrum analyzer. The Span was set to the specified band end points. The EUT was then set to operate in hopping mode. The MAX HOLD function of the spectrum analyzer was utilized to verify the number of hopping channels.



115.2 number of channels_109



250 number of channels_73



Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
Horn Antenna	EMCO	3115	i00103	1/20/15	1/20/17
High Pass Filter	Trilithic	4HX3400-3-XX	i00177	Verified on:6/8/16	
Horn Antenna, Amplified	ARA	DRG-118/A	i00271	5/8/14	5/8/16*
Spectrum Analyzer	Agilent	E4407B	i00331	9/18/15	9/18/16
Bi-Log Antenna	Schaffner	CBL 6111D	i00349	10/19/15	10/19/17
Tunable Notch Filter	Eagle	TNF-240MFMF	i00364	Verified on:6/8/16	
Oscilloscope	Tektronix	DPO 3012	i00366	2/29/16	2/28/17
EMI Analyzer	Agilent	E7405A	i00379	2/11/16	2/11/17
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	7/27/14	7/27/16

In addition to the above listed equipment standard RF connectors and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT