# TEST REPORT

**Report Number: 101503619DEN-001B**
**Project Number: G101503619**

**Report Issue Date: March 10, 2014**

**Product Designation:** **Model: W0900-01 with PRO902-11 (Omni Antenna)**

**Standards:** **FCC Part 15 Subpart C (15.247)**
**Operation within the bands 902-928 MHz**

Tested by:
Intertek Testing Services NA, Inc.
1795 Dogwood St. Suite 200
Louisville, CO 80027

Client:
FreeWave Technologies, Inc.
5395 Pearl Parkway, Suite 100
Boulder, CO 80301

Report prepared by

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Senior Project Engineer

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# 1 Introduction and Conclusion

The tests indicated in section 2.0 were performed on the product constructed as described in section 3.0. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test Method, a list of the actual Test Equipment Used, documentation Photos, Results and raw Data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded **the product tested complies with the requirements of the standard(s) indicated.** The results obtained in this test report pertain only to the item(s) tested.

## 1.1 Test Report Scope

FCC Class II Permissive Change

The scope of this report was to qualify the existing approved radio module Model: W0900-01 with new antennas. This specific report covers the following antenna:

- Model: PRO902-11 (10' Omni antenna)

This radio operates in the following 802.11 b/g Tx Band: 902 – 928MHz.

The Model: W0900-01 has previously been fully qualified and documented in the following SPORTON LAB test reports:

- FCC Test Report Number: KNYPRW1001ER

Below is a summary of Intertek Test Reports associated with the Class II Permissive Change:

- **10' Omni Antenna (900MHz): 101503619DEN-001B (This Report)**

## 1.2 Test Methodology

All measurements were performed according to the procedures in the following documents:

- ANSI C63.10: 2013 – ANSI Standard for Testing Unlicensed Wireless Devices
- FCC Publication 558074, April 9, 2013 (Guidelines for Compliance Measurements on DTS Operating Under 15.247)

Radiated emissions tests were formed at an antenna-to-product distance of 3-meters.

## 1.3 Test Facility

Intertek Denver's testing facilities are located at 1795 Dogwood St. Suite 200 Louisville, CO 80027. The testing facility is ISO17025:2005 accredited by A2LA, our lab code is 2506.02, our VCCI registration numbers are. R-1643, C-1752 and T-1558, our FCC designation no. US1121 and our IC lab no. 2042N.

Testing contained in this test report may not be covered under the laboratories scope of accreditation. A note will be placed in the specific test section for testing not coved under the laboratories scope.

## 2 Test Summary

| TEST SECTION | TESTS | FCC REFERENCE | TEST DATE | RESULT |
|---|---|---|---|---|
| 5 | AC Voltage Variation | FCC 15.31(e) | ----- | N/A |
| 6 | Antenna Requirement | FCC 15.203 | ----- | N/A |
| 7 | DTS Requirement | FCC 15.247(a) | ----- | N/A |
| 8 | 6dB Bandwidth | FCC 15.247(a)(2) | ----- | N/A |
| 9 | RF Conducted Output Power (includes requirements for antenna gain > 6dBi) | FCC 15.247(b)(3)(4) FCC 15.247(c)(1) | ----- | N/A |
| 10 | RF Conducted Spurious Emissions (-20dBc) Includes Band Edge | FCC 15.247(d) | ----- | N/A |
| 11 | Transmitter Radiated Spurious Emissions (Restricted Bands – Band Edge) | FCC 15.247(d) FCC 15.209/ 15.205 | 02/25/2014 to 02/26/2014 | Complies |
| 12 | Power Spectral Density (PSD) | FCC 15.247(e) | ----- | N/A |
| 13 | Radiated Emissions – Digital Receiver | FCC 15.109 | ----- | N/A |
| 14 | Tx AC Line Conducted Emissions | FCC 15.207 | ----- | N/A |
| 15 | RF Exposure Requirement | FCC 15.247(i) FCC 15.1.1307(b)(1) | ----- | N/A |
| 16 | Duty Cycle/ Duty Cycle Correction Factor | FCC 15.35(c) | ----- | N/A |

Notes:

1) All Tx Radiated Emission measurements in this report utilized the transmit channels and worst-case band(s), modulation and data rates reported in the FCC test report(s) listed on page 3 of this report.

2) Only selected testing required for the specific Class II Permissive change was performed.

**General Radio Test Notes:**

- ANSI C63.10, Section 4.2.3.2/ FCC 15.35: Measurement detector functions and bandwidths utilized in this testing were per the preceding guidelines.
- ANSI C63.10, Section 4.2.3.2.2/ FCC 15.35(b): When an average limit is specified, the peak emission must also be measured to ensure the emissions is less than 20dB above the average limit and/or below the peak limit specified. This report includes both average and peak test data.
- ANSI C63.10, Section 5.3/ FCC 15.31: All radiated field strength measurements taken at an antenna-to-product test distance of 3-meters.
- ANSI C63.10, Section 6.3/ FCC 15.31(m): Measurements were taken at the lowest, near the middle and highest channels of the product tested.

## 3 Description of Product Under Test

| | |
|---|---|
| **Model:** | W0900-01 (900 MHz) |
| **Type of EUT:** | 802.11 b/g PCIe Radio Module |
| **Serial Number:** | DEN1402111313 |
| **FCC ID:** | KNYPRW1001ER |
| **Industry Canada ID:** | IC ID: ----- |
| **Related Submittal(s) Grants:** | ----- |
| **Company:** | FreeWave Technologies, Inc. |
| **Customer:** | FreeWave Technologies, Inc. |
| **Address:** | 5395 Pearl Parkway, Suite 100 |
| **Phone:** | (303) 962-7879 |
| **Fax:** | ----- |
| **e-mail:** | dbusch@freewave.com |
| **Test Standards:** | ☒ 47 CFR, Part 15C:§15.247 DTS<br>☐ RSS–210, Issue 8, 2010<br>☐ RSS-Gen, Issue 3, 2010<br>☐ 47 CFR, Part 15C:§15.207<br>☐ Other |
| **Type of radio:** | ☒ Stand -alone ☐ Module ☐ Hybrid |
| **Date Sample Submitted:** | 02/14/2014 |
| **Test Work Started:** | 02/25/2014 |
| **Test Work Completed:** | 02/27/2014 |
| **Test Sample Conditions:** | ☐ Damaged ☐ Poor (Usable) ☒ Good |

| | |
|---|---|
| **Product Description:** | Wireless router utilized in M2M industrial applications |
| **Transmitter Type:** | ☐ FHSS ☒ Digital Modulation ☐ WiFi ☐ Blue Tooth |
| **Operating Frequency Range(s):** | 902MHz to 928MHz |
| **Number of Channels:** | IEEE 802.11b, IEEE 802.11g, one channel at 915 MHz.<br>900 MHz – 928 MHz |
| **Modulation:** | 802.11b: DSSS-DBPSK, DQPSK, CCK<br>802.11g: OFDM-BPSK, QPSK, 16QAM, 64QAM |
| **Antenna(s) Info:** | Antenna: Type: 900 MHz Omni antenna<br>Gain: +11.0 dBi Connector Type: "N"<br>External Antenna(s) (Dedicated) – Point-to-Point |
| **Rated Power:** | EIRP 19 dBm (317 mW) : Omni |
| **Antenna Installation:** | ☐ User ☒ Professional ☐ Factory |
| **Transmitter power configuration:** | ☐ Internal battery ☒ External power source |
| **Special Test Arrangement:** | Mounted on antenna tripod: Omni |
| **Test Facility Accreditation:** | A2LA (Certificate No. 2506.02) |
| **Test Methodology:** | Measurements performed according to the procedures in ANSI C63.10-2013 and FCC Guidance Publication 558074 |

### 3.1 Channel Configurations

| CHANNELS IN THE 902 - 928 MHZ BAND | | | | |
|---|---|---|---|---|
| **Channel Number** | **Frequency (MHz)** | **802.11b and g** | **SISO $N_{TX=1}$** | **MIMO $N_{TX=2}$** |
| 1 | 915 | xt | tested | tested |

Note: x = available channels xt = tested channels

### 3.2 Product Description - Detailed

| Description of Equipment Under Test (provided by client) |
|---|
| The system tested is the Model: W0900-01 (900 MHz) radio module configured with:<br>▪ Model: PRO902-1 (10' Omni antenna)<br><br>The product is a wireless router utilized in M2M industrial applications<br><br>Signal & I/O Cables: Ethernet<br><br>The product is powered from an external power source. |

For the testing of this specific test report, the product supports the following data rates in the 902 – 928 MHz band:

- IEEE 802.11 b and g

In 802.11b and g mode, the nominal bandwidth is 20MHz.

The product operates in both SISO (1-transmit chain) and MIMO (2-transmit chains) modes.

| Equipment Under Test Power Configuration | | | |
|---|---|---|---|
| Rated Voltage | Rated Current | Rated Frequency | Number of Phases |
| AC Adapter Input: 100-240VAC | 0.9 A | 50/60 | 1 |
| AC Adapter Output: 12VDC | 3.0 A | --- | --- |

| Descriptions of EUT Exercising |
|---|
| ☐ Standby/Idle Mode |
| ☐ Continuous transmission, un-modulated carrier (CW) |
| ☒ Continuous transmission, modulated carrier (CW) utilizing worst-case data rate |
| ☐ Continuous Receive Mode |

Note: The chosen mode of operation described above is dependent upon the specific test to be performed.

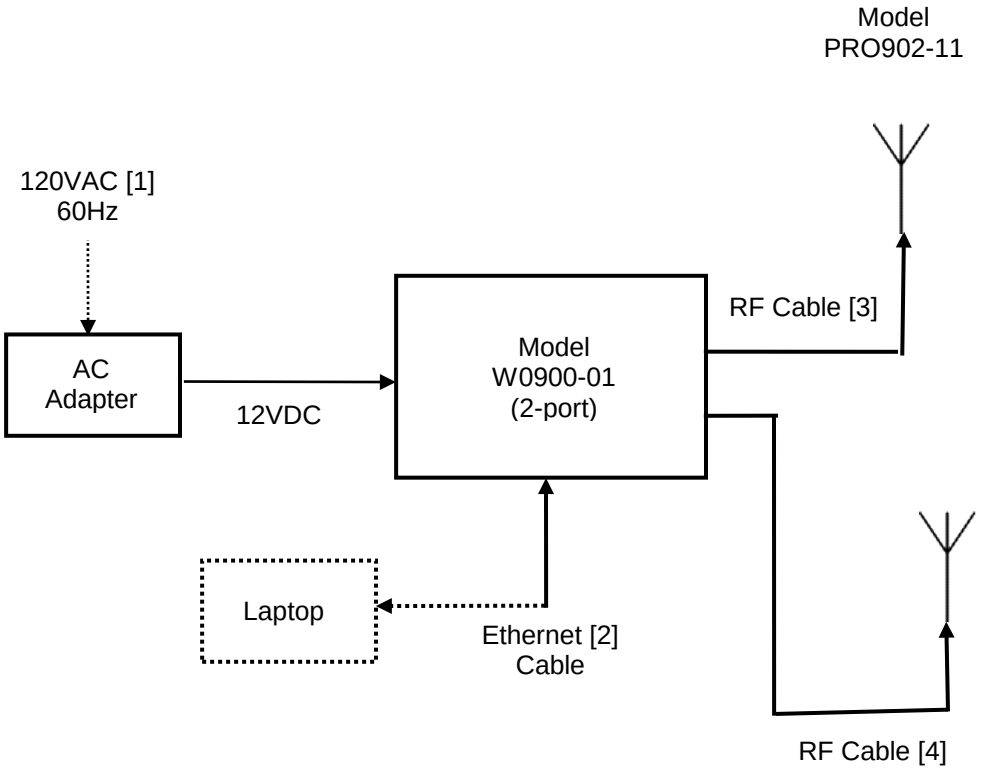
## 4 System setup including cable interconnection details, support equipment and simplified block diagram

### 4.1 Method:

Record the details of EUT cabling, document the support equipment, and show the interconnections in a block diagram.

### 4.2 EUT Block Diagram: )

Model: PRO902-1 (10' Omni antenna)




Note: Dashed lines indicate auxiliary/support equipment outside the test area. Ethernet cable was routed partially outside the test chamber with ~ 1-meter inside the test chamber – connected to the Model W0900-01 Ethernet port.

## 4.3 Antenna Specifications:

| 900MHz GHz | | | | | | |
|---|---|---|---|---|---|---|
| | | | Beamwidth (degrees) | | | |
| Model | Type | Gain (dBi) | Horizontal | Vertical | Polarization | Datasheet |
| PRO902-11 | 10' Omni antenna | 11 | 360 | 5 | Omni | Appendix A of this report |

## 4.4 Determination of RF Power supplied to antenna input for testing

Per FCC 15.247(b)(4): The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b) (2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Antenna tested:

- Model: PRO902-11 (10' Omni antenna) Gain: 11dBi

==========

Maximum Peak Conducted Output Power: If $G_{Tx} > 6$dBi, then $P_{Out} = 30 – ((G_{Tx} – 6))$ dBm

Where:

$P_{Out}$ = maximum peak conducted output power (dBm)

$G_{Tx}$ = maximum transmitting antenna directional gain (dBi)

==========

$P_{Out} = 30 – (G_{Tx} – 6)$ dBm = 30 – (11-6) dBm = 25 dBm

All Radiated measurements taken with the Model: W0900-01 transmitting at 20dBm. The actual rated maximum output power is less than the allowed 30dBm.

- Actual Rated Output Power: 27.86dBm (610.94 mW)

### 4.5 Support Data:

| ID | Description/ Function | Shield Type | Length | Connector | Connection | Ferrites |
|---|---|---|---|---|---|---|
| 1 | DC Cable (ac adapter) | none | 0.5 meter | DC | VDC – Model W2400-01 | none |
| 2 | Ethernet Cable | none | 4-meter | RJ45 | RJ-45 – Model W0900-01 | none |
| 3-4 | RF Cable(s) | Braid | 3-meter | SMA-to-N | Model W0900-01 to Antenna | none |
| | | | | | | |

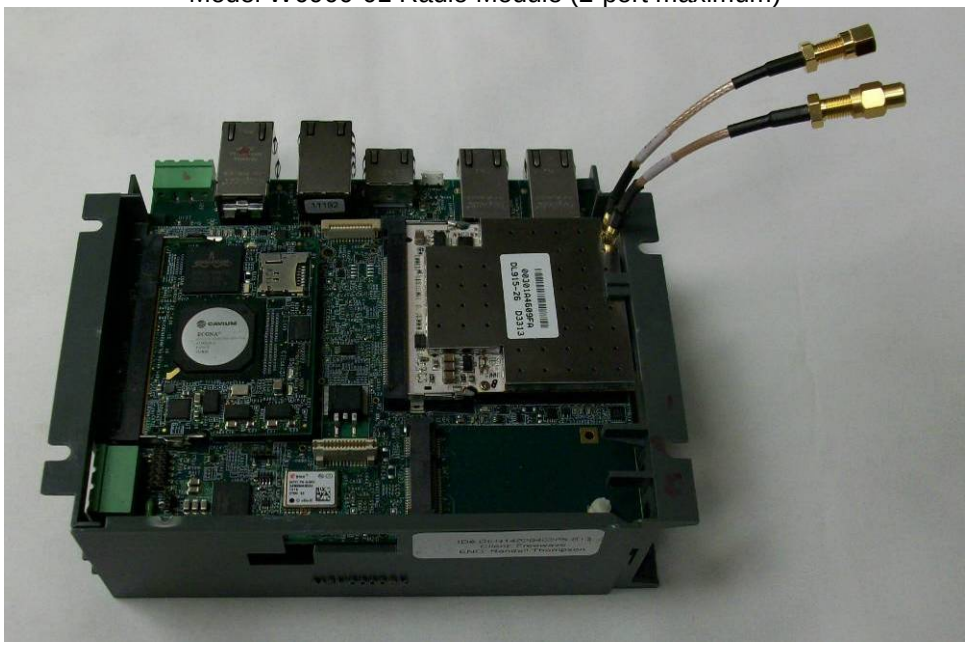
| Support Equipment | | | |
|---|---|---|---|
| Description | Manufacturer | Model Number | Serial Number |
| Laptop | HP | --- | --- |
| Switching Power Supply | Sceptre Power | S036CQ1200300 | --- |

Notes:

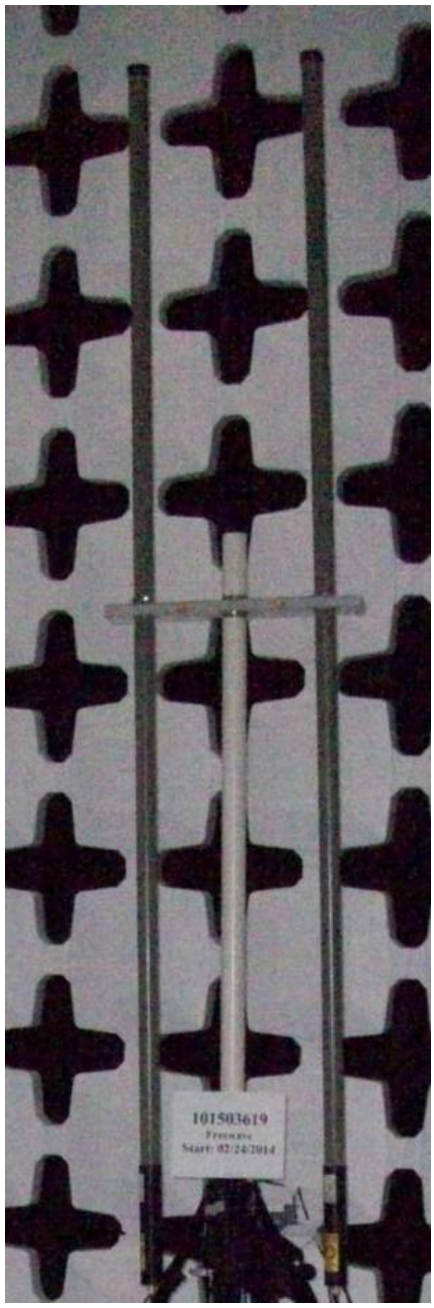
1) The laptop was utilized only to configure the product during testing (i.e. set channel, modulation, data rates, etc.).
2) The product has RF ports and Ethernet Cable ports.

## 4.6 Photograph: Product Tested - Model W0900-01 with PRO902-1 (10' Omni antenna)

Model W0900-01 Radio Module (2-port maximum)



PRO902-11 (10’ Omni antenna, two Antennae shown – 1-port per antenna)



## 5 AC Voltage Variation/ Battery Requirement

### 5.1 Results:

Test not required for Class II Permissive Change.

## 6 Antenna Requirement

### 6.1 Results:

Test not required for Class II Permissive Change.

## 7 DTS Requirement

### 7.1 Results:

Test not required for Class II Permissive Change.

## 8 DTS Bandwidth (6dB Bandwidth)

### 8.1 Test Results:

Test not required for Class II Permissive Change.

## 9 RF Conducted Output Power

### 9.1 Results:

Not required for Class II permissive change. However, the software utility utilized to configure the radio output power supplied to the antenna(s) during testing was verified to provide at least the minimum output power selected for testing.

## 10 RF Conducted Spurious Emissions (-20dBc) – Including Band Edge

### 10.1 Test Results:

Test not required for Class II Permissive Change.

# 11 Transmitter Radiated Spurious Emissions – Restricted Band/ Band Edge

## 11.1 Method

Unless otherwise stated no deviations were made from FCC Part 15.209/205.

This testing was performed at Intertek Denver, located at 1795 Dogwood St. Suite 200, Louisville, CO 80027.

## 11.2 Test Requirement/ Specification:

Radiated emissions which fall in the restricted bands, as defined in FCC Part 15.205(a), must also comply with the radiated emission limits specified in Part 15.209(a) and Part 15.205(c). Measurements in the restricted bands include both peak detector and average detector measurements.
Measurements in non-restricted bands include peak detector measurements.

Unwanted emissions below 1GHz must comply with the general field strength limits defined in FCC Part 15.209, when measured with a quasi-peak detector.

## 11.3 Test Equipment Used:

| Asset ID | Description | Manufacturer | Model | Serial | Cal Date | Cal Due |
|---|---|---|---|---|---|---|
| DEN-073 | EMI Receiver (10Hz – 26.5GHz) | RHODE & SCHWARZ | ESU 26 | 100265 | 01/29/2014 | 01/29/2015 |
| 18913 | Spectrum Analyzer | Hewlett-Packard | E7405A | My44211889 | 07/26/2013 | 07/26/2014 |
| 18912 | 9 kHz- 1.3GHz Pre Amp | Hewlett-Packard | 8447F | 3113A05545 | 06/07/2013 | 06/07/2014 |
| 18906 | RF Pre-Amp (1-4GHz) | Mini-Circuits Lab | ZHL-42 | N052792-2 | 06/10/2013 | 06/10/2014 |
| DEN-032 | 4-18GHz Preamp (LNA) | Narda | DBL-0618N615 | 031 | 03/07/2013 | 03/07/2014 |
| DEN-155 | 900MHz Notch Filter | Micro-Tronics | BRC50722 | 004 | 09/24/2013 | 09/24/2014 |
| DEN-153 | High Pass Filter | Mini-Circuits | VHF-3100+ | 3 1222 | 09/24/2013 | 09/24/2014 |
| 19937 | Bilog Antenna 30MHz – 6GHz | Sunol Sciences | JB6 | A050707-2 | 03/20/2013 | 03/20/2014 |
| 18887 | Horn Antenna 1-18GHz | EMCO | 3115 | 9205-3886 | 03/19/2013 | 03/19/2014 |
| SW-6 | Software for Radiated and Conducted emissions. | Intertek | OATS vba | V. 3.0 | VBU | VBU |

## 11.4 Test Procedure:

The Resolution Bandwidth is 120 kHz or greater for frequencies 30 MHz -1000 MHz and 1 MHz for frequencies above 1000 MHz. The Video Bandwidth was at least 3x the RBW.

The EUT is placed on a plastic turntable that is 80 cm in height. If the EUT attaches to peripherals, they are connected and operational (as typical as possible). During testing, all cables are manipulated to produce worst-case emissions. The signal is maximized by rotating the turntable through a 360º rotation. The antenna height is varied from 1-4 meters. Both vertical and horizontal antenna configurations are utilized in the testing.

Radiated emissions 30MHz to 18GHz are taken at 3-meter antenna-to-product test distance.

Radiated emissions above 18GHz are taken using a harmonic mixer antenna/pre-amp setup at 1-meter antenna-to-product test distance.

Data is included for the worst-case configuration - the configuration which resulted in the highest emission levels.

The following procedures described in FCC Publication 558074 (Guidelines for Compliance Measurements on DTS Operating Under 15.247), were used:

- 558074, Section 12.1 & 13.1
- ANSI C63.10: 2013 – General Guidance

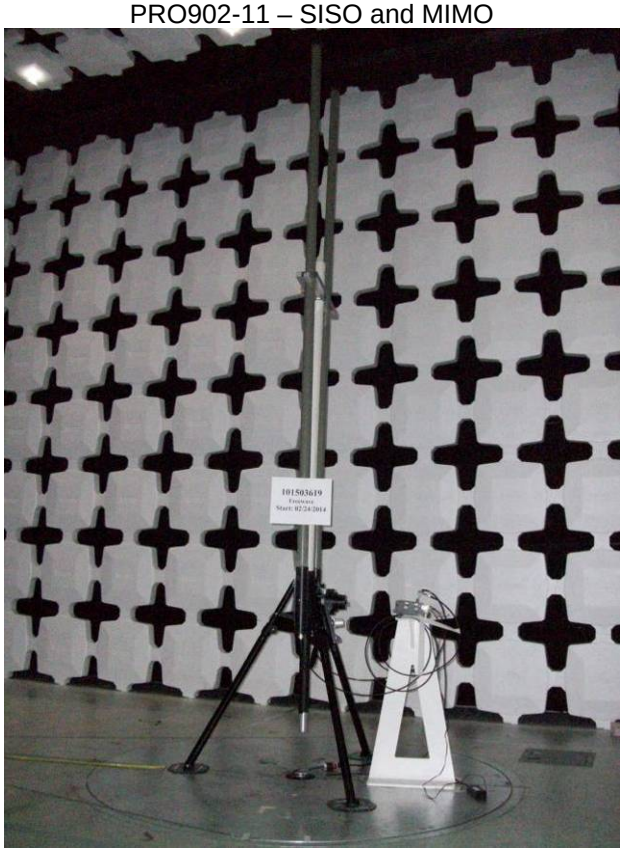
### 11.5 Test Results:

The sample tested was found to Comply.

## 11.6 Setup Photographs: SIMO and MIMO Mode of Operation, PRO901-11 antenna

Transmitter Spurious Radiated Emissions - Test Setup (Rear View)

PRO902-11 – SISO and MIMO

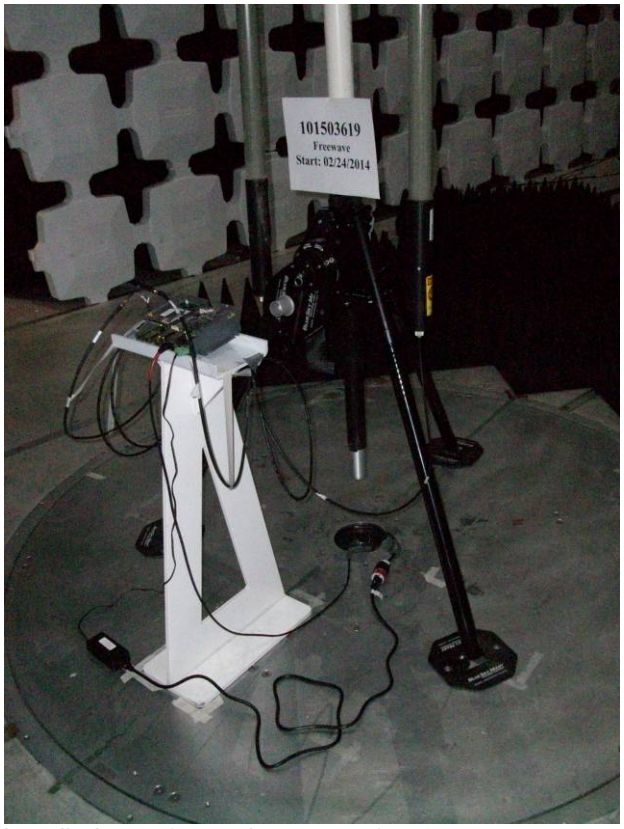



Note: For SISO setup, only one of the antenna was disconnected from the W0900-1 module. The unconnected antenna remained in the setup as shown.

Single-RF Port – PRO902 SISO


Note: One antenna cable removed from one antenna for SISO

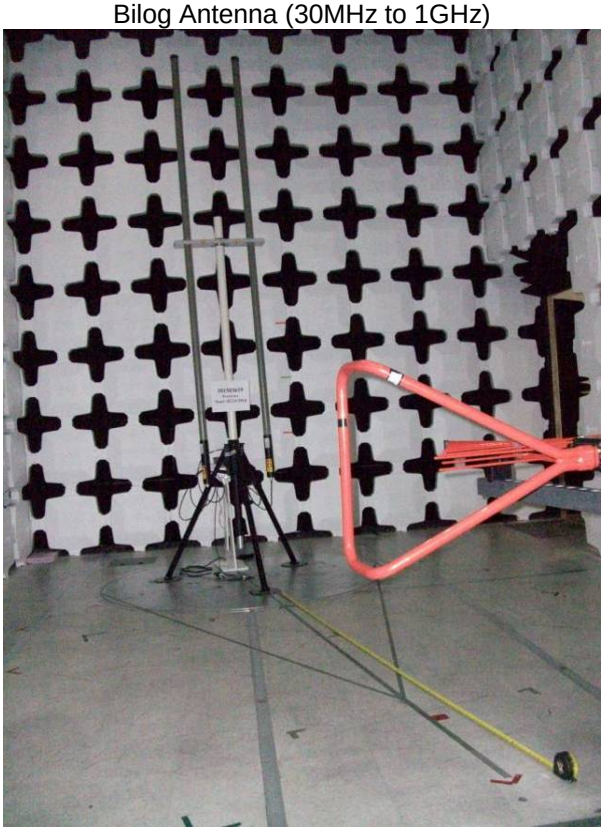
Two-RF Port – PRO902 MIMO




Note: Two antenna cables installed, one for each antenna for MIMO.

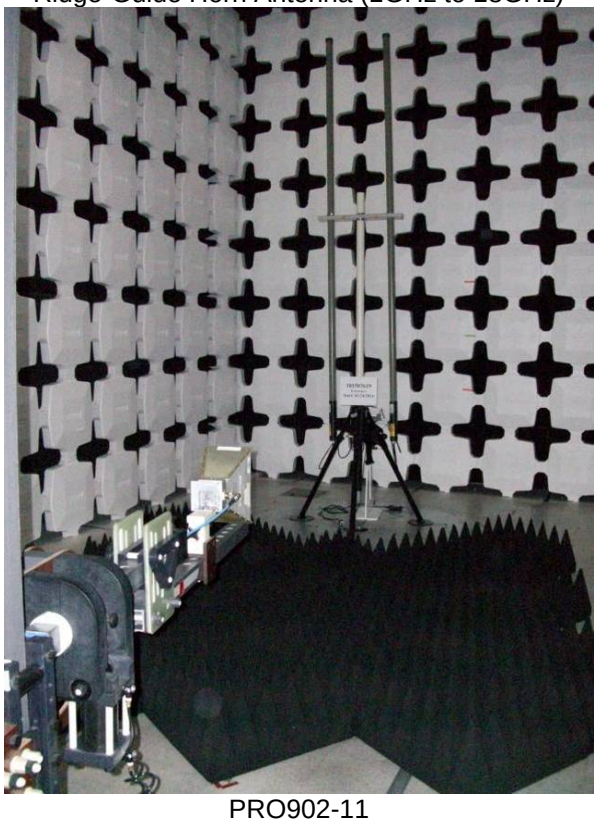
### 11.7 Antenna Setups:

Bilog Antenna (30MHz to 1GHz)



PRO902-11

Ridge-Guide Horn Antenna (1GHz to 18GHz)

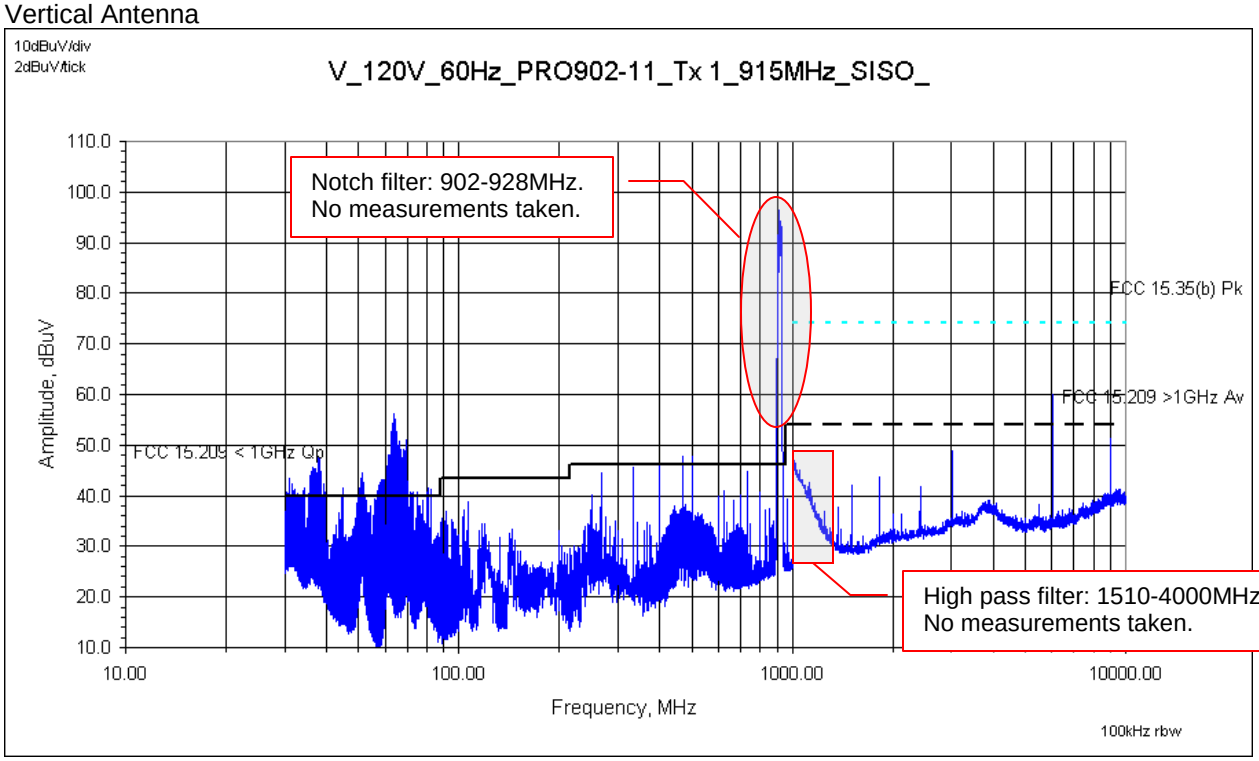


PRO902-11

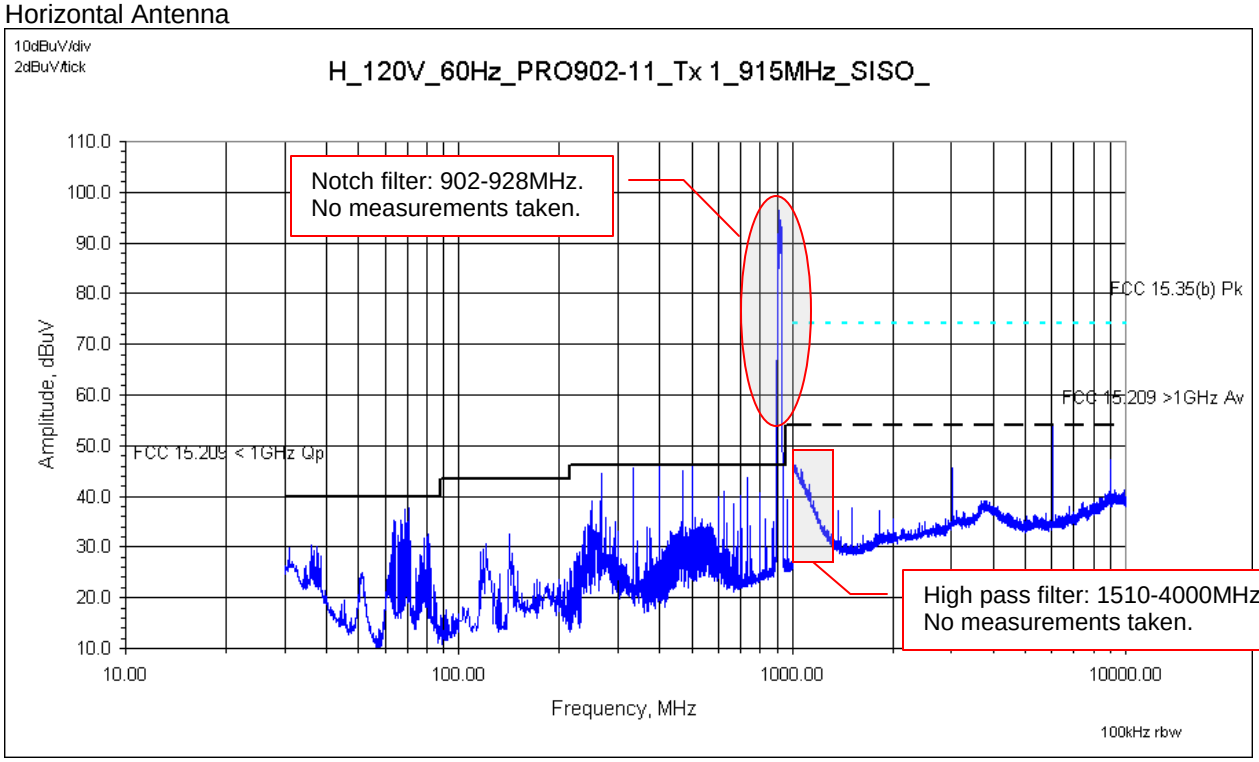
## 11.8 Plots: SISO Mode of Operation – PRO902-11: 900 MHz

30MHz to 10GHz

Vertical Antenna




Horizontal Antenna

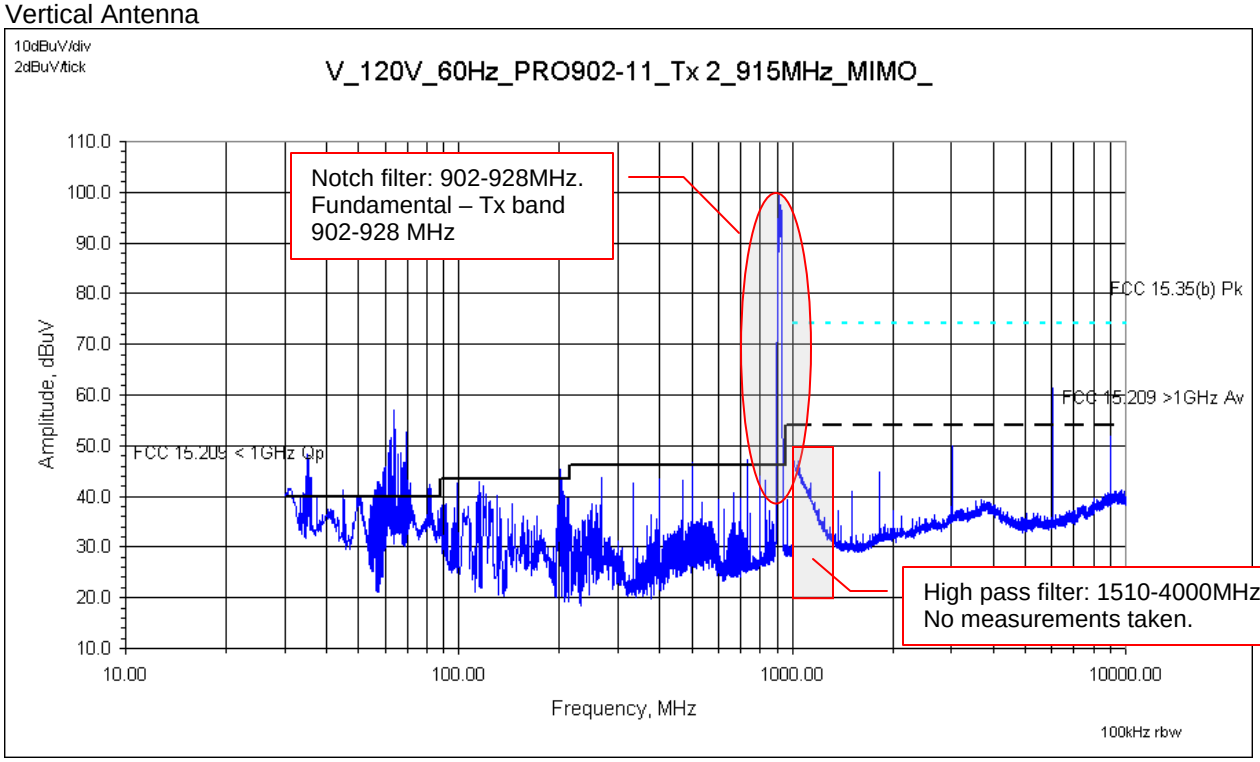



Reference only – max hold peak detector measurements referenced to quasi-peak, average & peak limits.

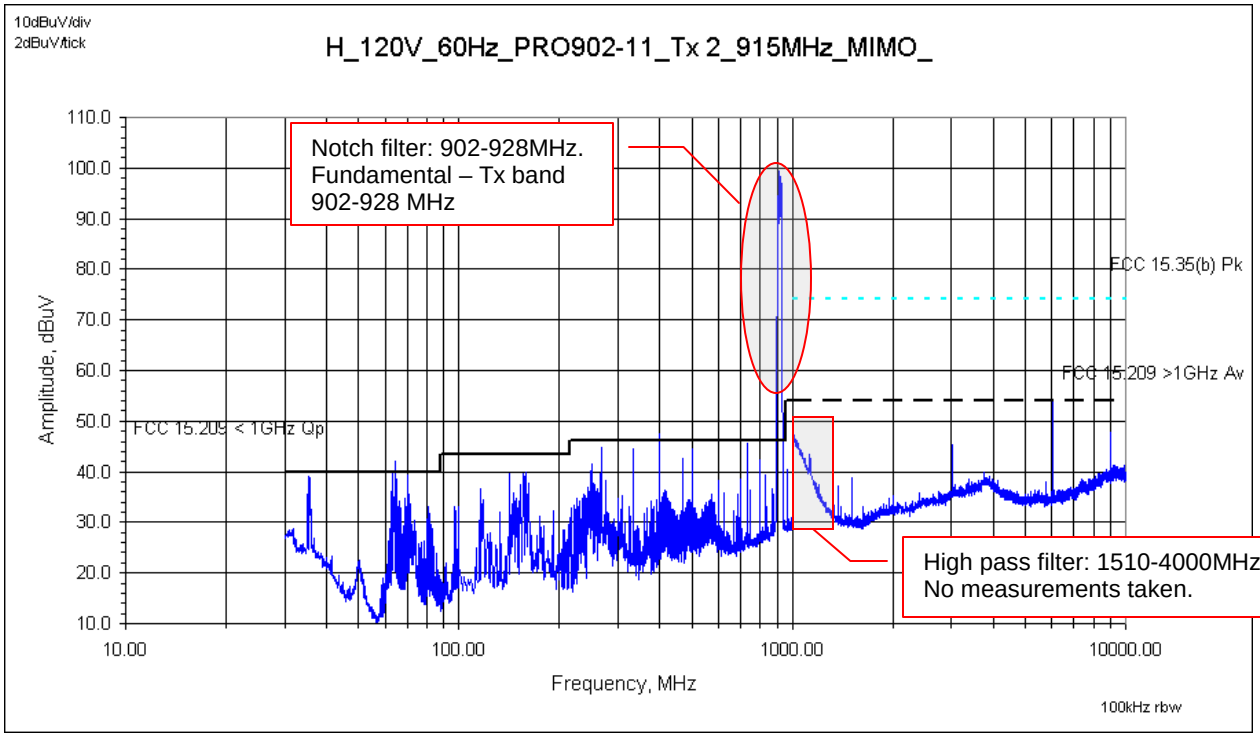
## 11.9 Plots: MIMO Mode of Operation – PRO902-11: 900 MHz

30MHz to 10GHz

Vertical Antenna




Horizontal Antenna




Reference only – max hold peak detector measurements referenced to quasi-peak, average & peak limits

### 11.10 Test Data: SISO and MIMO Mode of Operation – PRO902-12: 900 MHz

## Tx Spurious Radiated Electromagnetic Emissions

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Test Report #: | 101503619DEN-001B | Test Area: | CC1 | | Temperature: | 24.1<br>24.0 | C |
| Test Method: | FCC 15.209/ 15.205/ 15.35(b) | Test Date: | 2/25/2014<br>2/26/2014 | | Relative Humidity: | 18.2<br>20.9 | % |
| EUT Model #: | Radio: W0900-01<br>Omni Antenna: PRO902-11 | EUT Power: | 120VAC/60Hz | | Air Pressure: | 841.8<br>833.7 | mBars |
| EUT Serial #: | Radio: DEN1402111313<br>Omni Antenna(s): DEN1402111313-001 / -001a | | | | | Page: | --- |
| | | | | | | | |
| Manufacturer: | FreeWave Technologies, Inc. | | | | Level Key | | |
| EUT Description: | Wireless router utilized in M2M industrial applications | | | | Pk - Peak | Nb - Narrow Band | |
| Notes: | Product tested in SISO mode: single transmit chain/port – single antenna. | | | | Qp - QuasiPeak | Bb - Broad Band | |
| | Product tested in MIMO mode: single transmit chain/port – two antennae. | | | | Av - Average | | |
| | Product continuously transmitting during all testing – worst-case modulation/data. | | | | | | |
| | Conducted port power set at 20dBm. | | | | | | |

| FREQ | LEVEL | DET | CABLE | ANT | PREAMP | ATTEN | FINAL | POL | HGT | AZ | DELTA1 | DELTA2 | RBW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | dBuV | Qp<br>Av<br>Pk<br>Rms | + [dB] | + [dB/m] | - [dB] | + [dB] | = [dBuV] | (V/H) | (m) | (DEG) | FCC 15.209 < 1GHz Qp | FCC 15.109 A < 1GHz Qp | (MHz) |
| Note: Unless otherwise noted, all frequencies observed, were generated from the base module. | | | | | | | | | | | | | |
| Frequencies that have been marked as over the FCC 15.209 limit are not in the restricted band, therefore the product under test complies with the requirements. | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| **SISO. One Omni antenna.** | | | | Antenna model: PRO902-11 | | | | | | | | | |
| | | | | Module type: 900MHz | | | Center transmit frequency: single channel, 915MHz | | | | | | |
| **30-1000MHz** | | | | | | | | | | | | | |
| V_120V_60Hz_PRO902-11_Tx 1_915MHz_SISO_ | | | | | | | | | | | | | |
| 38.317 | 42.26 | **Qp** | 0.40 | 14.87 | 28.28 | 4.94 | 34.19 | V | 1.00 | 50.9 | - 5.81 | - 15.35 | 0.120 |
| 51.314 | 57.15 | **Qp** | 0.77 | 8.07 | 28.24 | 0.13 | 37.88 | V | 1.00 | 192.2 | - 2.12 | - 11.66 | 0.120 |
| 64.663 | 47.90 | **Qp** | 0.77 | 7.80 | 28.20 | 0.11 | 28.38 | V | 1.00 | 168.8 | - 11.62 | - 21.16 | 0.120 |
| 400.002 | 55.28 | **Qp** | 1.37 | 15.70 | 27.89 | 0.34 | 44.80 | V | 1.00 | 99.6 | - 1.22 | - 12.10 | 0.120 |
| 480.069 | 45.26 | **Qp** | 1.50 | 17.40 | 28.46 | 0.48 | 36.18 | V | 1.00 | 209.4 | - 9.84 | - 20.72 | 0.120 |
| 684.135 | 24.38 | **Qp** | 1.83 | 19.75 | 28.50 | 0.83 | 18.29 | V | 1.00 | 270.2 | - 27.73 | - 38.61 | 0.120 |
| 733.333 | 49.62 | **Qp** | 1.89 | 20.47 | 28.34 | 0.91 | 44.55 | V | 1.00 | 280.4 | - 1.47 | - 12.35 | 0.120 |
| 999.974 | 48.56 | **Qp** | 2.21 | 22.60 | 27.59 | 0.97 | 46.76 | V | 1.00 | 181.6 | - 7.22 | - 13.24 | 0.120 |
| | | | | | | | | | | | | | |
| H_120V_60Hz_PRO902-11_Tx 1_915MHz_SISO_ | | | | | | | | | | | | | |
| 70.946 | 34.64 | **Qp** | 0.77 | 8.10 | 28.17 | 1.13 | 16.47 | H | 2.98 | 282.4 | - 23.53 | - 33.07 | 0.120 |
| 250.000 | 53.04 | **Qp** | 1.07 | 11.50 | 27.37 | 0.22 | 38.45 | H | 1.50 | 151.6 | - 7.57 | - 18.45 | 0.120 |
| 569.471 | 38.88 | **Qp** | 1.65 | 18.66 | 28.74 | 0.63 | 31.07 | H | 1.50 | 199.0 | - 14.95 | - 25.83 | 0.120 |
| 800.016 | 46.53 | **Qp** | 1.97 | 21.30 | 28.12 | 1.03 | 42.71 | H | 1.41 | 268.9 | - 3.31 | - 14.19 | 0.120 |
| 999.974 | 48.74 | **Qp** | 2.21 | 22.60 | 27.59 | 0.97 | 46.94 | H | 1.50 | 174.9 | - 7.04 | - 13.06 | 0.120 |

| FREQ | LEVEL | DET | CABLE | ANT | PREAMP | ATTEN | FINAL | POL | HGT | AZ | DELTA1 | DELTA2 | RBW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | dBuV | Qp<br>Av<br>Pk<br>Rms | + [dB] | + [dB/m] | - [dB] | + [dB] | = [dBuV] | (V/H) | (m) | (DEG) | FCC 15.209 >1GHz Av | FCC 15.36(b) >1GHz Pk | (MHz) |
| **SISO. One Omni antenna.** | | | | | | | | | | | | | |
| **1-4GHz** | | | | | | | | | | | | | |
| V_120V_60Hz_PRO902-11_Tx 1_915MHz_SISO_ | | | | | | | | | | | | | |
| 1506.923 | 53.95 | **Pk** | 2.73 | 25.37 | 36.62 | 0.92 | 46.35 | V | 1.00 | 175.2 | - 7.63 | - 27.63 | 1.000 |
| 1829.904 | 55.63 | **Pk** | 3.04 | 26.95 | 37.08 | 0.69 | 49.24 | V | 1.00 | 359.9 | - 4.74 | - 24.74 | 1.000 |
| 3013.839 | 55.82 | **Pk** | 4.00 | 30.46 | 37.56 | 0.46 | 53.18 | V | 1.00 | 70.6 | - 0.80 | - 20.80 | 1.000 |
| 1506.923 | 48.39 | **Av** | 2.73 | 25.37 | 36.62 | 0.92 | 40.79 | V | 1.00 | 175.2 | - 13.19 | - 33.19 | 1.000 |
| 1829.904 | 35.86 | **Av** | 3.04 | 26.95 | 37.08 | 0.69 | 29.47 | V | 1.00 | 359.9 | - 24.51 | - 44.51 | 1.000 |
| 3013.839 | 51.26 | **Av** | 4.00 | 30.46 | 37.56 | 0.46 | 48.62 | V | 1.00 | 70.6 | - 5.36 | - 25.36 | 1.000 |
| | | | | | | | | | | | | | |
| H_120V_60Hz_PRO902-11_Tx 1_915MHz_SISO_ | | | | | | | | | | | | | |
| 1506.923 | 51.66 | **Pk** | 2.73 | 25.37 | 36.62 | 0.92 | 44.06 | H | 1.00 | 133.7 | - 9.92 | - 29.92 | 1.000 |
| 1829.904 | 50.91 | **Pk** | 3.04 | 26.95 | 37.08 | 0.69 | 44.52 | H | 1.47 | 359.9 | - 9.46 | - 29.46 | 1.000 |
| 3013.839 | 53.78 | **Pk** | 4.00 | 30.46 | 37.56 | 0.46 | 51.14 | H | 1.14 | 137.4 | - 2.84 | - 22.84 | 1.000 |
| 1506.923 | 43.87 | **Av** | 2.73 | 25.37 | 36.62 | 0.92 | 36.27 | H | 1.00 | 133.7 | - 17.71 | - 37.71 | 1.000 |
| 1829.904 | 35.20 | **Av** | 3.04 | 26.95 | 37.08 | 0.69 | 28.81 | H | 1.47 | 359.9 | - 25.17 | - 45.17 | 1.000 |
| 3013.839 | 48.26 | **Av** | 4.00 | 30.46 | 37.56 | 0.46 | 45.62 | H | 1.14 | 137.4 | - 8.36 | - 28.36 | 1.000 |
| | | | | | | | | | | | | | |
| **4-10GHz** | | | | | | | | | | | | | |
| **SISO. One Omni antenna.** | | | | | | | | | | | | | |
| V_120V_60Hz_PRO902-11_Tx 1_915MHz_SISO_ | | | | | | | | | | | | | |
| 6027.676 | 69.41 | **Pk** | 5.80 | 34.65 | 45.04 | 0.00 | 64.82 | V | 2.51 | 186.6 | --- | - 9.16 | 1.000 |
| 9041.507 | 57.94 | **Pk** | 7.35 | 38.37 | 47.39 | 0.00 | 56.27 | V | 1.41 | 99.1 | --- | - 17.71 | 1.000 |
| 6027.676 | 68.69 | **Av** | 5.80 | 34.65 | 45.04 | 0.00 | 64.10 | V | 2.51 | 186.6 | --- | - 9.88 | 1.000 |
| 9041.507 | 53.49 | **Av** | 7.35 | 38.37 | 47.39 | 0.00 | 51.82 | V | 1.41 | 99.1 | - 2.16 | - 22.16 | 1.000 |
| | | | | | | | | | | | | | |
| H_120V_60Hz_PRO902-11_Tx 1_915MHz_SISO_ | | | | | | | | | | | | | |
| 6027.676 | 62.58 | **Pk** | 5.80 | 34.65 | 45.04 | 0.00 | 57.99 | H | 1.77 | 140.7 | --- | - 15.99 | 1.000 |
| 9041.507 | 56.40 | **Pk** | 7.35 | 38.37 | 47.39 | 0.00 | 54.73 | H | 1.00 | 186.5 | --- | - 19.25 | 1.000 |
| 6027.676 | 59.74 | **Av** | 5.80 | 34.65 | 45.04 | 0.00 | 55.15 | H | 1.77 | 140.7 | --- | - 18.83 | 1.000 |
| 9041.507 | 49.72 | **Av** | 7.35 | 38.37 | 47.39 | 0.00 | 48.05 | H | 1.00 | 186.5 | - 5.93 | - 25.93 | 1.000 |
| | | | | | | | | | | | | | |

| FREQ | LEVEL | DET | CABLE | ANT | PREAMP | ATTEN | FINAL | POL | HGT | AZ | DELTA1 | DELTA2 | RBW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | dBuV | Qp Av Pk Rms | + [dB] | + [dB/m] | - [dB] | + [dB] | = [dBuV] | (V/H) | (m) | (DEG) | FCC 15.209 < 1GHz Qp | FCC 15.109 A < 1GHz Qp | (MHz) |
| Note: Unless otherwise noted, all frequencies observed, were generated from the base module. | | | | | | | | | | | | | |
| Frequencies that have been marked as over the FCC 15.209 limit are not in the restricted band, therefore the product under test complies with the requirements. | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| **MIMO. Two dipoies 40cm apart.** | | | | Antenna model: PRO902-11 | | | | | | | | | |
| | | | | Module type: 900MHz | | | Center transmit frequency: single channel, 915MHz | | | | | | |
| **30-1000MHz** | | | | | | | | | | | | | |
| V_120V_60Hz_PRO902-11_Tx 2_915MHz_SISO_ | | | | | | | | | | | | | |
| 31.538 | 43.74 | **Qp** | 0.40 | 19.72 | 28.30 | 1.79 | 37.36 | V | 1.00 | 181.1 | - 2.64 | - 12.19 | 0.120 |
| 35.160 | 36.82 | **Qp** | 0.40 | 17.07 | 28.29 | 4.81 | 30.82 | V | 1.00 | 164.7 | - 9.18 | - 18.73 | 0.120 |
| 44.920 | 41.82 | **Qp** | 0.77 | 10.34 | 28.26 | 1.75 | 26.42 | V | 1.00 | 181.8 | - 13.58 | - 23.12 | 0.120 |
| 50.112 | 53.26 | **Qp** | 0.77 | 8.38 | 28.24 | 0.31 | 34.47 | V | 1.00 | 192.9 | - 5.53 | - 15.07 | 0.120 |
| 63.766 | 51.30 | **Qp** | 0.77 | 7.78 | 28.20 | - 0.03 | 31.61 | V | 1.00 | 224.2 | - 8.39 | - 17.93 | 0.120 |
| 69.712 | 46.36 | **Qp** | 0.77 | 8.10 | 28.18 | 0.99 | 28.04 | V | 1.29 | 285.1 | - 11.96 | - 21.50 | 0.120 |
| 82.051 | 47.17 | **Qp** | 0.77 | 7.60 | 28.13 | 1.76 | 29.17 | V | 1.00 | 180.6 | - 10.83 | - 20.38 | 0.120 |
| 200.962 | 37.82 | **Qp** | 0.95 | 11.83 | 27.55 | 0.35 | 23.40 | V | 1.00 | 84.6 | - 20.12 | - 30.58 | 0.120 |
| 733.365 | 50.93 | **Qp** | 1.89 | 20.47 | 28.34 | 0.91 | 45.86 | V | 1.00 | 99.0 | - 0.16 | - 11.04 | 0.120 |
| 400.042 | 50.63 | **Qp** | 1.37 | 15.70 | 27.89 | 0.34 | 40.15 | V | 1.00 | 225.3 | - 5.87 | - 16.75 | 0.120 |
| 533.337 | 45.59 | **Qp** | 1.59 | 18.60 | 28.69 | 0.57 | 37.66 | V | 1.00 | 184.0 | - 8.36 | - 19.25 | 0.120 |
| 833.339 | 44.21 | **Qp** | 2.01 | 21.63 | 28.02 | 1.09 | 40.93 | V | 1.00 | 116.0 | - 5.09 | - 15.97 | 0.120 |
| 999.972 | 50.57 | **Qp** | 2.21 | 22.60 | 27.59 | 0.97 | 48.77 | V | 1.64 | 210.0 | - 5.21 | - 11.23 | 0.120 |
| | | | | | | | | | | | | | |
| H_120V_60Hz_PRO902-11_Tx 2_915MHz_SISO_ | | | | | | | | | | | | | |
| 63.894 | 47.19 | **Qp** | 0.77 | 7.79 | 28.20 | - 0.02 | 27.53 | H | 1.80 | 185.0 | - 12.47 | - 22.01 | 0.120 |
| 266.683 | 57.94 | **Qp** | 1.11 | 12.97 | 27.31 | 0.12 | 44.82 | H | 1.50 | 264.0 | - 1.20 | - 12.08 | 0.120 |
| 500.048 | 50.70 | **Qp** | 1.53 | 17.70 | 28.60 | 0.51 | 41.84 | H | 1.10 | 336.0 | - 4.18 | - 15.06 | 0.120 |
| 733.365 | 51.07 | **Qp** | 1.89 | 20.47 | 28.34 | 0.91 | 46.00 | H | 1.36 | 131.0 | - 0.02 | - 10.90 | 0.120 |
| 999.999 | 48.95 | **Qp** | 2.21 | 22.60 | 27.59 | 0.97 | 47.15 | H | 1.50 | 171.0 | - 6.83 | - 12.85 | 0.120 |

| FREQ | LEVEL | DET | CABLE | ANT | PREAMP | ATTEN | FINAL | POL | HGT | AZ | DELTA1 | DELTA2 | RBW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | dBuV | Qp Av Pk Rms | + [dB] | + [dB/m] | - [dB] | + [dB] | = [dBuV] | (V/H) | (m) | (DEG) | FCC 15.209 >1GHz Av | FCC 15.36(b) >1GHz Pk | (MHz) |
| **1-4GHz** | | | | | | | | | | | | | |
| **MIMO. Two Omni antennas. 40cm apart.** | | | | | | | | | | | | | |
| V_120V_60Hz_PRO902-11_Tx 2_915MHz_MIMO_ | | | | | | | | | | | | | |
| 1506.915 | 53.19 | **Pk** | 2.73 | 25.37 | 36.62 | 0.92 | 45.59 | V | 1.00 | 146.8 | - 8.39 | - 28.39 | 1.000 |
| 1829.920 | 55.43 | **Pk** | 3.04 | 26.95 | 37.08 | 0.69 | 49.04 | V | 1.00 | 359.9 | - 4.94 | - 24.94 | 1.000 |
| 3013.831 | 56.06 | **Pk** | 4.00 | 30.46 | 37.56 | 0.46 | 53.42 | V | 1.71 | 55.9 | - 0.56 | - 20.56 | 1.000 |
| 1506.915 | 47.75 | **Av** | 2.73 | 25.37 | 36.62 | 0.92 | 40.15 | V | 1.00 | 146.8 | - 13.83 | - 33.83 | 1.000 |
| 1829.920 | 35.82 | **Av** | 3.04 | 26.95 | 37.08 | 0.69 | 29.43 | V | 1.00 | 359.9 | - 24.55 | - 44.55 | 1.000 |
| 3013.831 | 52.12 | **Av** | 4.00 | 30.46 | 37.56 | 0.46 | 49.48 | V | 1.71 | 55.9 | - 4.50 | - 24.50 | 1.000 |
| | | | | | | | | | | | | | |
| H_120V_60Hz_PRO902-11_Tx 2_915MHz_MIMO_ | | | | | | | | | | | | | |
| 1506.915 | 52.34 | **Pk** | 2.73 | 25.37 | 36.62 | 0.92 | 44.74 | H | 1.66 | 135.7 | - 9.24 | - 29.24 | 1.000 |
| 3013.831 | 55.32 | **Pk** | 4.00 | 30.46 | 37.56 | 0.46 | 52.68 | H | 1.25 | 121.2 | - 1.30 | - 21.30 | 1.000 |

| FREQ | LEVEL | DET | CABLE | ANT | PREAMP | ATTEN | FINAL | POL | HGT | AZ | DELTA1 | DELTA2 | RBW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | dBuV | Qp<br>Av<br>Pk<br>Rms | + [dB] | + [dB/m] | - [dB] | + [dB] | = [dBuV] | (V/H) | (m) | (DEG) | FCC 15.209 >1GHz Av | FCC 15.36(b) >1GHz Pk | (MHz) |
| 1506.915 | 45.27 | **Av** | 2.73 | 25.37 | 36.62 | 0.92 | 37.67 | H | 1.66 | 135.7 | - 16.31 | - 36.31 | 1.000 |
| 3013.831 | 50.75 | **Av** | 4.00 | 30.46 | 37.56 | 0.46 | 48.11 | H | 1.25 | 121.2 | - 5.87 | - 25.87 | 1.000 |
| | | | | | | | | | | | | | |
| **4-10GHz** | | | | | | | | | | | | | |
| **MIMO. Two Omni antennas. 40cm apart.** | | | | | | | | | | | | | |
| V_120V_60Hz_PRO890-16_Tx 2_915MHz_MIMO_ | | | | | | | | | | | | | |
| 6027.676 | 67.64 | **Pk** | 5.80 | 34.65 | 45.04 | 0.00 | 63.05 | V | 1.00 | 188.1 | --- | - 10.93 | 1.000 |
| 9041.507 | 58.25 | **Pk** | 7.35 | 38.37 | 47.39 | 0.00 | 56.58 | V | 1.00 | 99.8 | --- | - 17.40 | 1.000 |
| 6027.676 | 66.61 | **Av** | 5.80 | 34.65 | 45.04 | 0.00 | 62.02 | V | 1.00 | 188.1 | ( 8.04 ) | - 11.96 | 1.000 |
| 9041.507 | 53.58 | **Av** | 7.35 | 38.37 | 47.39 | 0.00 | 51.91 | V | 1.00 | 99.8 | - 2.07 | - 22.07 | 1.000 |
| | | | | | | | | | | | | | |
| H_120V_60Hz_PRO890-16_Tx 2_915MHz_MIMO_ | | | | | | | | | | | | | |
| 6027.676 | 62.25 | **Pk** | 5.80 | 34.65 | 45.04 | 0.00 | 57.66 | H | 1.00 | 232.5 | --- | - 16.32 | 1.000 |
| 9041.507 | 56.55 | **Pk** | 7.35 | 38.37 | 47.39 | 0.00 | 54.88 | H | 1.00 | 186.7 | --- | - 19.10 | 1.000 |
| 6027.676 | 60.31 | **Av** | 5.80 | 34.65 | 45.04 | 0.00 | 55.72 | H | 1.00 | 232.5 | ( 1.74 ) | - 18.26 | 1.000 |
| 9041.507 | 49.84 | **Av** | 7.35 | 38.37 | 47.39 | 0.00 | 48.17 | H | 1.00 | 186.7 | - 5.81 | - 25.81 | 1.000 |

Example calculation:

| **Measured Level** | + | **Cable Loss** | + | **Antenna Factor** | - | **Pre-Amp** | + | **Atten** | = | **Final Corrected Reading** | **Specification Limit** | - | **Final Corrected Reading** | = | **Delta Specification** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (dBµV) | | (dB) | | (dB) | | (dB) | | (dB) | | (dBµV/m) | (dBµV/m) | | (dBµV/m) | | |
| **20.0** | | **3.0** | | **5.0** | | **10.0** | | **0.0** | | **18.0** | **40.0** | | **18.0** | | **- 22.0** |

Notes:

1) The highest signals – as determined from pre-scan plots – were fully-maximized and measured.
2) For the general pre-scan plots 1-4GHz, a notch filter was utilized.

Deviations, Additions, or Exclusions: None

## 12 Power Spectral Density – PSD

### 12.1 Test Results:

Test not required for Class II Permissive Change.

## 13 Radiated Emissions (Digital Part of Receiver)

### 13.1 Test Results:

Test not required for Class II Permissive Change.

## 14 AC Mains Conducted Emissions - Transmitter

### 14.1 Test Results:

Test not required for Class II Permissive Change.

## 15 RF Exposure Requirement

### 15.1 Test Results:

Test not required for Class II Permissive Change.

## 16 Duty Cycle/ Duty Cycle Correction Factor

### 16.1 Results:

Test not required for Class II Permissive Change.

## 17 Appendix A: Antenna Specifications

WaveLink
Antenna Systems Inc.

# PROFESSIONAL GRADE OMNI
## PRO902-11

902-928 MHz

### ANTENNA SPECIFICATIONS

| | |
|---|---|
| Operating Frequency (VSWR ≤ 1.5) MHz | 902-928 |
| Nominal Gain (dBi) | 11 |
| Horizontal Beamwidth (Deg-3dB) | 360 |
| Vertical Beamwidth (Deg-3dB) | 5 |
| Power Rating (W) | 200 |
| Length (inches) | 120.5 |
| Width (inches) | 2.5 |
| Antenna Weight (lbs.) | 12.5 |
| Cross Sectional Area (Max. Ft²) | 1.9 |
| Lateral Thrust at 100mph (lbs.) | 47.5 |
| Rated Wind Velocity (mph) | 120 |
| Rated Wind Velocity with 1/2" radial ice (mph) | 90 |

PRO902-11 equipped with integrated N-Female connector

The **PRO902-11** is engineered to meet or exceed the requirements for a rugged, high gain outdoor omni-directional antenna. This antenna provides **11 dBi** gain and operates effectively across the operating range of **902- 928 MHz** with a VSWR of 1.5:1 or less. Every **WaveLink** *Professional Grade* Omni is built using a UV-resistant fiberglass radome, coupled to a machined, heavy duty aluminum base. The 6061-T6 aluminum base is anodized to protect against environmental degradation. The elongated N-Female connector is recessed within the base to minimize exposure, while the large inside diameter allows easy access for the connection. The antenna is supplied with two heavy duty mounting brackets.

Includes mounting brackets C1002 (2 included)

Phone: 1 800.805.6922 (Toll Free USA & Canada)
Visit us online at WavelinkAntenna.com

WaveLink
Antenna Systems Inc.

## 18 Measurement Uncertainty

The measured value related to the corresponding limit will be used to decide whether the equipment meets the requirements.

The measurement uncertainty figures were calculated and correspond to a coverage factor of k = 2, providing a confidence level of respectively 95.45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian).

Measurement uncertainty Table

| Parameter | Uncertainty ± | Notes |
|---|---|---|
| Radiated emissions, 10kHz to 30 MHz | 3.4 dB | |
| Radiated emissions, 30 to 200 MHz HP | 2.2 dB | |
| Radiated emissions, 30 to 200 MHz VP | 3.8 dB | |
| Radiated emissions, 200 to 1000 MHz HP | 2.8 dB | |
| Radiated emissions, 200 to 1000 MHz VP | 2.7 dB | |
| Radiated emissions, 1 to 18 GHz | 5.2 dB | |
| Conducted port emissions 10kHz to 1000 MHz | 1.0 dB | |
| Conducted port emissions 1 – 26.5 GHz | 1.6 dB | |
| AC mains Conducted emissions, 9kHz to 30 MHz | 3.14 dB | |

## 19 Revision History

| Revision Level | Date | Report Number | Notes |
|---|---|---|---|
| 0 | 03/10/2014 | 101503619DEN-001B | Original Issue |
| 1 | 05/28/2014 | 101503619DEN-001B | Administrative change<br><br>Page: 3<br>Change: This radio operates in the following 802.11 b/g/n Tx Band: 902 – 928MHz<br>To: This radio operates in the following 802.11 b/g Tx Band: 902 – 928MHz<br><br>Page 6:<br>Change: 802.11 b/g/n PCIe Radio Module<br>To: 802.11 b/g PCIe Radio Module<br><br>Change: KNYASM1101CR<br>To: KNYPRW1001ER<br><br>Page 7:<br>Change: 802.11a and g<br>To: 802.11b and g<br><br>Change: 802.11 g/n:<br>To: 802.11 g<br><br>Change: A2LA (Certificate No. 2506.01)<br>To: A2LA (Certificate No. 2506.02)<br><br>Page 8:<br>Change: 902 – 902 MHz band:<br>▪ IEEE 802.11 a and g<br>To: 902 – 928 MHz band:<br>▪ IEEE 802.11 b and g<br><br>Change: In 802.11a and g mode, the nominal bandwidth is 20MHz.<br>To: In 802.11b and g mode, the nominal bandwidth is 20MHz.<br><br>Responsible engineer:<br>Richard Georgerian<br><br>Reviewer:<br><br>Michael Spataro |
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