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# *EMC Test Report*

## *Application for FCC Grant of Equipment Authorization*
## *Canada Certification*
## *Class II Permissive Change/Reassessment*

## *Innovation, Science and Economic Development Canada*
## *RSS-Gen Issue 4 / RSS-247 Issue 2*
## *FCC Part 15 Subpart C*

## *Model: GR-5*

| | |
|---|---|
| IC CERTIFICATION #: | 6050B-F90901 |
| FCC ID: | LCB-F90901 |
| APPLICANT: | Topcon Positioning Systems<br>7400 National Dr.<br>Livermore, CA 94550 |
| TEST SITE(S): | National Technical Systems<br>41039 Boyce Road.<br>Fremont, CA. 94538-2435 |
| IC SITE REGISTRATION #: | 2845B-4 |
| PROJECT NUMBER: | JD103485 |
| REPORT DATE: | March 2, 2018 |
| FINAL TEST DATES: | March 3, 15 and 16, 2017 |
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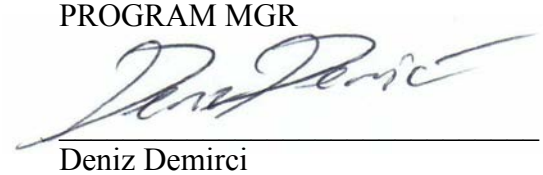
ACCREDITED
Testing Cert #0214.26

## *VALIDATING SIGNATORIES*

PROGRAM MGR



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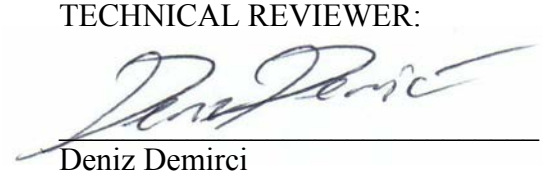

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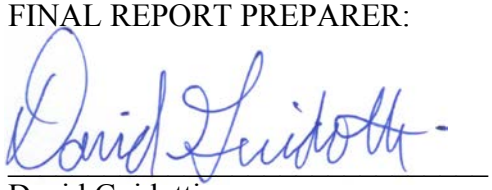

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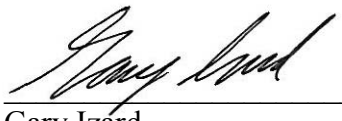

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## REVISION HISTORY

| Rev# | Date | Comments | Modified By |
|---|---|---|---|
| - | March 2, 2018 | First release | |

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## SCOPE

An electromagnetic emissions test has been performed on the Topcon Positioning Systems model GR-5, pursuant to the following rules:

RSS-Gen Issue 4 " General Requirements for Compliance of Radio Apparatus"
RSS 247 Issue 2 "Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices"
FCC Part 15 Subpart C

Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in the following reference standards and as outlined in National Technical Systems test procedures:

ANSI C63.4: 2014
ANSI C63.10: 2013
FHSS test procedure DA 00-0705A1

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant Industry Canada performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

National Technical Systems is accredited by the A2LA, certificate number 0214.26, to perform the test(s) listed in this report, except where noted otherwise.

## OBJECTIVE

The primary objective of the manufacturer is compliance with the regulations outlined in the previous section.

Prior to marketing in the USA, all unlicensed transmitters and transceivers require certification. Receive-only devices operating between 30 MHz and 960 MHz are subject to either certification or a manufacturer's declaration of conformity, with all other receive-only devices exempt from the technical requirements.

Prior to marketing in Canada, Class I transmitters, receivers and transceivers require certification. Class II devices are required to meet the appropriate technical requirements but are exempt from certification requirements.

Certification is a procedure where the manufacturer submits test data and technical information to a certification body and receives a certificate or grant of equipment authorization upon successful completion of the certification body's review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units, which are subsequently manufactured.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

Testing was performed only on model GR-5.

## *STATEMENT OF COMPLIANCE*

The tested sample of Topcon Positioning Systems model GR-5 complied with the requirements of the following regulations:

RSS-Gen Issue 4 " General Requirements for Compliance of Radio Apparatus"
RSS 247 Issue 2 "Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices"
FCC Part 15 Subpart C

Maintenance of compliance is the responsibility of the manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the device with respect to the standards detailed in this test report.

The test results recorded herein are based on a single type test of Topcon Positioning Systems model GR-5 and therefore apply only to the tested sample. The sample was selected and prepared by Ferdinand Riodique of Topcon Positioning Systems.

## *DEVIATIONS FROM THE STANDARDS*

No deviations were made from the published requirements listed in the scope of this report.

## TEST RESULTS SUMMARY

***FREQUENCY HOPPING SPREAD SPECTRUM (902 – 928 MHz, 50 channels or more)***

| FCC Rule Part | RSS Rule Part | Description | Measured Value / Comments | Limit / Requirement | Result |
|---|---|---|---|---|---|
| 15.247 (a) (1) (i) | RSS 247 5.1 (1) & (3) | 20dB Bandwidth | Same as original filing. | <= 500 kHz | Complies |
| 15.247 (a) (1) | RSS 247 5.1 (2) | Channel Separation | Same as original filing. | Channel spacing > 20dB bandwidth (minimum 25kHz) | Complies |
| 15.247 (a) (1) (i) | RSS 247 5.1 (3) | Number of Channels | Same as original filing. | 50 or more | Complies |
| 15.247 (a) (1) (i) | RSS 247 5.1 (3) | Channel Dwell Time | Same as original filing. | <0.4 second within a 20 second period | Complies |
| 15.247 (a) (1) | RSS 247 5.1 (1) | Channel Utilization | All channels are used equally - refer to the operational description for full explanation | All channels shall, on average, be used equally | Complies |
| 15.247 (b) (3) | RSS 247 5.4 (1) | Output Power | 29.1 dBm (0.813 W) EIRP = 2.57 W Note 1 | 1Watt, EIRP <= 4 Watts | Complies |
| 15.247 (d) | RSS 247 5.5 | Antenna Port Spurious Emissions 30MHz – 9.28 GHz | Same as original filing. | < -20dBc | Complies |
| 15.247 (d) / 15.209 | RSS 247 5.5 | Radiated Spurious Emissions 30MHz – 9.28 GHz | 32.7 dBµV/m @ 85.39 MHz (-7.3 dB) | Refer to the limits section (p19) for restricted bands, all others < -20dBc | Complies |
| 15.247 (a) (1) | RSS 247 5.1(2) | Receiver bandwidth | Same as original filing. | Shall match the channel bandwidth | Complies |
| Note 1: EIRP calculated using antenna gain of 5.0 dBi for the highest EIRP system. | | | | | |

**FREQUENCY HOPPING SPREAD SPECTRUM (2400 – 2483.5 MHz, less than 75 channels)**
Same as original filing.

***GENERAL REQUIREMENTS APPLICABLE TO ALL BANDS***

| FCC Rule Part | RSS Rule part | Description | Measured Value / Comments | Limit / Requirement | Result (margin) |
|---|---|---|---|---|---|
| 15.203 | - | RF Connector | 900 MHz Reverse TNC BT Integral antenna. | Unique or integral antenna required | Complies |
| 15.407 (b) (6) | RSS-Gen Table 3 | AC Conducted Emissions | Same as original filing. | Refer to page 18 | Complies |
| 15.109 | RSS GEN Table 2 | Receiver spurious emissions | 35.8 dBµV/m @ 500.00 MHz (-10.2 dB) | Refer to page 19 | Complies |
| 15.247 (i) 15.407 (f) | RSS 102 | RF Exposure Requirements | Refer to MPE calculations in separate exhibit, RSS 102 declaration and User Manual statements. | Refer to OET 65, FCC Part 1 and RSS 102 | Complies |
| - | RSS-Gen 8.3 | User Manual | | Statement for products with detachable antenna | Complies |
| - | RSS-Gen 8.4 | User Manual | | Statement for all products | Complies |
| - | RSP-100 RSS-Gen 6.6 | Occupied Bandwidth | Same as original filing | Information only | N/A |

***MEASUREMENT UNCERTAINTIES***

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level and were calculated in accordance with UKAS document LAB 34.

| Measurement Type | Measurement Unit | Frequency Range | Expanded Uncertainty |
|---|---|---|---|
| RF power, conducted (power meter) | dBm | 25 to 7000 MHz | ± 0.52 dB |
| Radiated emission (field strength) | dBµV/m | 25 to 1000 MHz | ± 3.6 dB |
| | | 1000 to 40000 MHz | ± 6.0 dB |

## EQUIPMENT UNDER TEST (EUT) DETAILS

### GENERAL

The Topcon Positioning Systems model GR-5 is a GNSS receiver with 900 MHz FHSS and Bluetooth 2.0/2.1 radio functions. Since the EUT would be placed on a pole in normal operation, for the purpose of testing the EUT was treated as tabletop equipment, to simulate the end-user environment. The EUT is typically battery powered but is provided with an optional AC/DC adapter. The electrical rating of the adapter is 100-240 Volts, 50-60 Hz, 0.8 Amps.

The sample was received on March 3, 2017 and tested on March 3, 15 and 16, 2017. The EUT consisted of the following component(s):

| Company | Model | Description | Serial Number | FCC ID |
|---|---|---|---|---|
| Topcon | GR5 | GNSS receiver with 900 MHz FHSS and BT radios | 800-21193 | LCB-F90901 / IC: 6050B-F90901 |
| Laird | 5 dBi (900 MHz) | Antenna | - | N/A |
| PhiHong | PSC30U-120 | AC/DC Adapter | P01702775C2 | N/A |

### OTHER EUT DETAILS

C2PC to increase antenna gain (2.5 dBi) to 5 dBi for 900 MHz FHSS Radio. BT antenna remains the same.

### ANTENNA SYSTEM

Monopole antenna with coaxial cable (Vehicle mount)

### ENCLOSURE

The EUT enclosure is primarily constructed of magnesium extrusion and a Xenoy radome. It measures approximately 158.1 mm wide by 158.1 mm deep by 253.0 mm high.

### MODIFICATIONS

No modifications were made to the EUT during the time the product was at NTS Silicon Valley.

### SUPPORT EQUIPMENT

No local support equipment was used during testing.

The following equipment was used as remote support equipment for emissions testing:

| Company | Model | Description | Serial Number | FCC ID |
|---|---|---|---|---|
| IBM Laptop | T42 | Laptop Computer | 2373R32 | - |

***EUT INTERFACE PORTS***

The I/O cabling configuration during testing was as follows:

| Port | Connected To | Cable(s) | | |
|---|---|---|---|---|
| | | Description | Shielded or Unshielded | Length(m) |
| EUT - Serial | Remote Laptop | multiconductor | shielded | 5.0 m |
| EUT - Power | AC/DC Adapter | multiconductor | shielded | 2.0 m |
| EUT - USB | Not connected | - | - | - |
| AC/DC Adapter | AC Mains | 3wire | unshielded | 1.5 m |

Note: The USB port was not connected during testing. The manufacturer stated that this port is not supported and therefore would not normally be connected.

***EUT OPERATION***

900 FHSS radio - unless otherwise stated, the EUT was configured to continuously transmit a modulated signal at the noted channel. All tests were performed at the high power state. The BT radio was configured to be active and transmitting.

## TEST SITE

### GENERAL INFORMATION

Final test measurements were taken at the test sites listed below. Pursuant to section 2.948 of the FCC's Rules and section 3.3 of RSP-100, construction, calibration, and equipment data has been filed with the Commission and with industry Canada.

| Site | Designation / Registration Numbers | | Location |
|---|---|---|---|
| | FCC | Canada | |
| Chamber 4 | US0027 | 2845B-4 | 41039 Boyce Road<br>Fremont,<br>CA 94538-2435 |

ANSI C63.4 recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement. The test site(s) contain separate areas for radiated and conducted emissions testing. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent requirements of ANSI C63.4.

### RADIATED EMISSIONS CONSIDERATIONS

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated measurements are performed in an open field environment or in a semi-anechoic chamber. The test sites are maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4 guidelines and meet the Normalized Site Attenuation (NSA) requirements of ANSI C63.4.

## MEASUREMENT INSTRUMENTATION

### RECEIVER SYSTEM

An EMI receiver as specified in CISPR 16-1-1 is used for emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 2000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the CISPR detector used during measurements. If the repetition frequency of the signal being measured is below 20Hz, peak measurements are made in lieu of Quasi-Peak measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. Average measurements above 1000MHz are performed on the spectrum analyzer using the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz, unless the signal is pulsed in which case the average (or video) bandwidth of the measuring instrument is reduced to onset of pulse desensitization and then increased.

### INSTRUMENT CONTROL COMPUTER

Software is used to view and convert receiver measurements to the field strength at an antenna or voltage developed at the LISN measurement port, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate. A personal computer is used to record all measurements made with the receivers. The software used for radiated and conducted emissions measurements is NTS EMI Test Software (rev 2.10)

### FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or LISN and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

### ANTENNAS

A loop antenna is used below 30 MHz. For the measurement range 30 MHz to 1000 MHz either a combination of a biconical antenna and a log periodic or a bi-log antenna is used. Above 1000 MHz, horn antennas are used. The antenna calibration factors to convert the received voltage to an electric field strength are included with appropriate cable loss and amplifier gain factors to determine an overall site factor, which is then programmed into the test receivers or incorporated into the test software.

### ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height. Measurements below 30 MHz are made with the loop antenna at a fixed height of 1m above the ground plane.

ANSI C63.10 specifies that the test height above ground for table mounted devices shall be 80 centimeters for testing below 1 GHz and 1.5m for testing above 1 GHz. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor as specified in ANSI C63.4. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

### INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An exhibit of this report contains the list of test equipment used and calibration information.

## TEST PROCEDURES

### EUT AND CABLE PLACEMENT

The regulations require that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.10, and the worst-case orientation is used for final measurements.

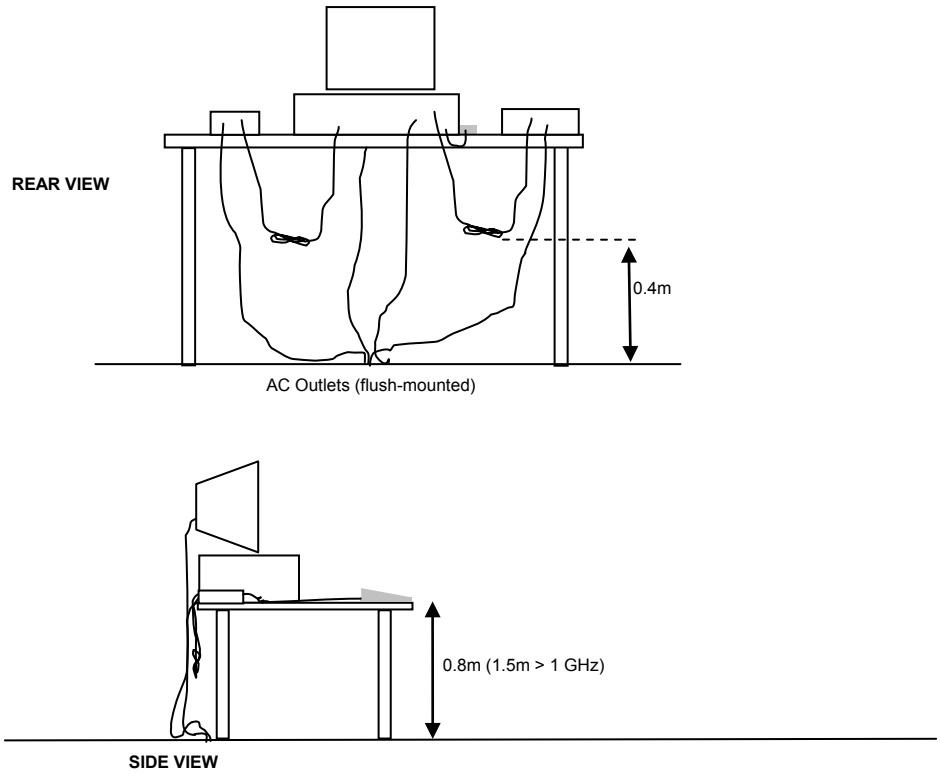
### RADIATED EMISSIONS

A preliminary scan of the radiated emissions is performed in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed, one scan for each antenna polarization (horizontal and vertical; loop parallel and perpendicular to the EUT). During the preliminary scans, the EUT is rotated through 360˚, the antenna height is varied (for measurements above 30 MHz) and cable positions are varied to determine the highest emission relative to the limit. Preliminary scans may be performed in a fully anechoic chamber for the purposes of identifying the frequencies of the highest emissions from the EUT.

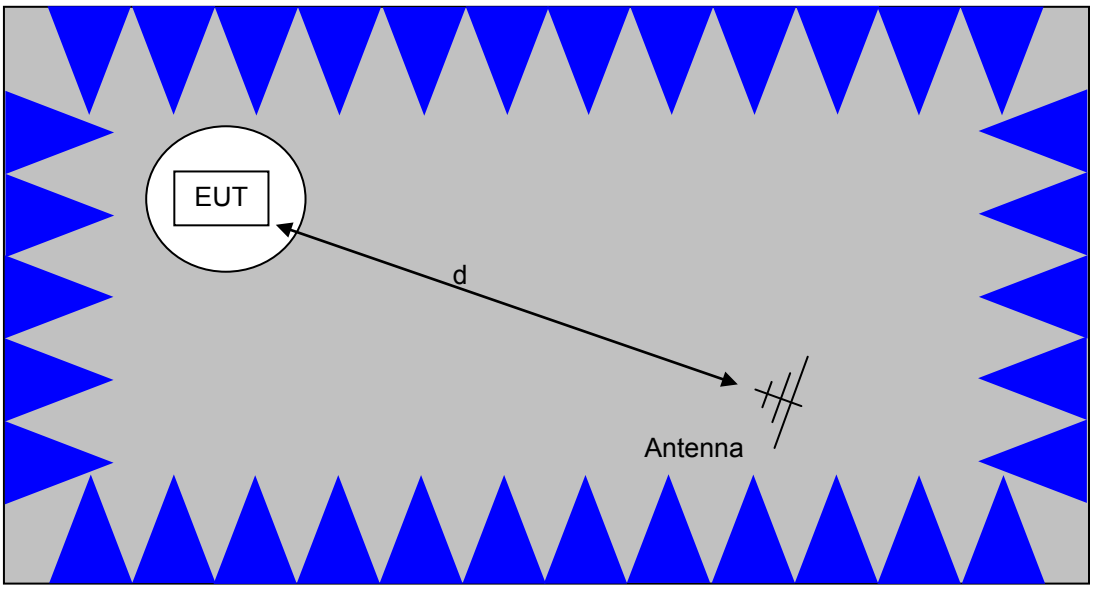
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth, which results in the highest emission is then maintained while varying the antenna height from one to four meters (for measurements above 30 MHz, measurements below 30 MHz are made with the loop antenna at a fixed height of 1m). The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain.

When testing above 18 GHz, the receive antenna is located at 1meter from the EUT and the antenna height is restricted to a maximum of 2.5 meters.

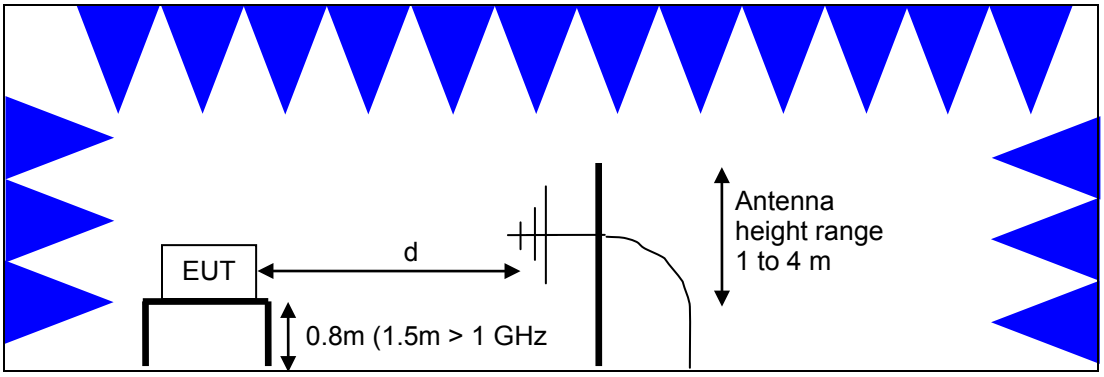



Typical Test Configuration for Radiated Field Strength Measurements




The anechoic materials on the walls and ceiling ensure compliance with the normalized site attenuation requirements of CISPR 16 / CISPR 22 / ANSI C63.4 for an alternate test site at the measurement distances used.

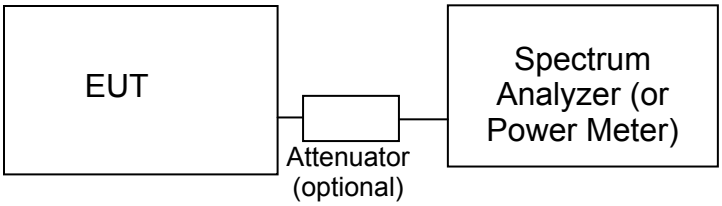
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.




Test Configuration for Radiated Field Strength Measurements
Semi-Anechoic Chamber, Plan and Side Views

***CONDUCTED EMISSIONS FROM ANTENNA PORT***

Direct measurements of power, bandwidth and power spectral density are performed, where possible, with the antenna port of the EUT connected to either the power meter or spectrum analyzer via a suitable attenuator and/or filter. These are used to ensure that the front end of the measurement instrument is not overloaded by the fundamental transmission.




Test Configuration for Antenna Port Measurements

Measurement bandwidths (video and resolution) are set in accordance with the relevant standards and NTS Silicon Valley's test procedures for the type of radio being tested. When power measurements are made using a resolution bandwidth less than the signal bandwidth the power is calculated by summing the power across the signal bandwidth using either the analyzer channel power function or by capturing the trace data and calculating the power using software. In both cases the summed power is corrected to account for the equivalent noise bandwidth (ENBW) of the resolution bandwidth used.

If power averaging is used (typically for certain digital modulation techniques), the EUT is configured to transmit continuously. Power averaging is performed using either the built-in function of the analyzer or, if the analyzer does not feature power averaging, using external software. In both cases the average power is calculated over a number of sweeps (typically 100). When the EUT cannot be configured to continuously transmit then either the analyzer is configured to perform a gated sweep to ensure that the power is averaged over periods that the device is transmitting or power averaging is disabled and a max-hold feature is used.

If a power meter is used to make output power measurements the sensor head type (peak or average) is stated in the test data table.

***SPECIFICATION LIMITS AND SAMPLE CALCULATIONS***

The limits for conducted emissions are given in units of microvolts, and the limits for radiated emissions are given in units of microvolts per meter at a specified test distance. Data is measured in the logarithmic form of decibels relative to one microvolt, or dB microvolts (dBuV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBuV/m). The results are then converted to the linear forms of uV and uV/m for comparison to published specifications.

For reference, converting the specification limits from linear to decibel form is accomplished by taking the base ten logarithm, then multiplying by 20. These limits in both linear and logarithmic form are as follows:

***CONDUCTED EMISSIONS SPECIFICATION LIMITS: FCC 15.207; FCC 15.107(a), RSS GEN***

The table below shows the limits for the emissions on the AC power line from an intentional radiator and a receiver.

| Frequency (MHz) | Average Limit (dBuV) | Quasi Peak Limit (dBuV) |
|---|---|---|
| 0.150 to 0.500 | Linear decrease on logarithmic frequency axis between 56.0 and 46.0 | Linear decrease on logarithmic frequency axis between 66.0 and 56.0 |
| 0.500 to 5.000 | 46.0 | 56.0 |
| 5.000 to 30.000 | 50.0 | 60.0 |

***GENERAL TRANSMITTER RADIATED EMISSIONS SPECIFICATION LIMITS***

The table below shows the limits for the spurious emissions from transmitters that fall in restricted bands[1].

| Frequency Range (MHz) | Limit (uV/m) | Limit (dBuV/m @ 3m) |
|---|---|---|
| 0.009-0.490 | $2400/F_{KHz}$ @ 300m | $67.6-20*\log_{10}(F_{KHz})$ @ 300m |
| 0.490-1.705 | $24000/F_{KHz}$ @ 30m | $87.6-20*\log_{10}(F_{KHz})$ @ 30m |
| 1.705 to 30 | 30 @ 30m | 29.5 @ 30m |
| 30 to 88 | 100 @ 3m | 40 @ 3m |
| 88 to 216 | 150 @ 3m | 43.5 @ 3m |
| 216 to 960 | 200 @ 3m | 46.0 @ 3m |
| Above 960 | 500 @ 3m | 54.0 @ 3m |

***RECEIVER RADIATED SPURIOUS EMISSIONS SPECIFICATION LIMITS***

The table below shows the limits for the spurious emissions from receivers as detailed in FCC Part 15.109 and RSS GEN Table 2. Note that receivers operating outside of the frequency range 30 MHz – 960 MHz are exempt from the requirements of 15.109 and receivers that are not stand-alone are exempt from the ISED Canada requirements per RSS-GEN.

| Frequency Range (MHz) | Limit (uV/m @ 3m) | Limit (dBuV/m @ 3m) |
|---|---|---|
| 30 to 88 | 100 | 40 |
| 88 to 216 | 150 | 43.5 |
| 216 to 960 | 200 | 46.0 |
| Above 960 | 500 | 54.0 |

[1] The restricted bands are detailed in FCC 15.205 and RSS-Gen Table 6

### OUTPUT POWER LIMITS – FHSS SYSTEMS

The table below shows the limits for output power based on the number of channels available for the hopping system.

| Operating Frequency (MHz) | Number of Channels | Output Power |
|---|---|---|
| 902 – 928 | ≥ 50 | 1 Watt (30 dBm) |
| 902 – 928 | 25 to 49 | 0.25 Watts (24 dBm) |
| 2400 – 2483.5 | ≥ 75 | 1 Watt (30 dBm) |
| 2400 – 2483.5 | < 75 | 0.125 Watts (21 dBm) |
| 5725 – 5850 | 75 | 1 Watt (30 dBm) |

The maximum permitted output power is reduced by 1dB for every dB the antenna gain exceeds 6dBi. Fixed point-to-point applications using the 5725 – 5850 MHz band are not subject to this restriction.

### TRANSMIT MODE SPURIOUS RADIATED EMISSIONS LIMITS – FHSS and DTS SYSTEMS

The limits for unwanted (spurious) emissions from the transmitter falling in the restricted bands are those specified in the general limits sections of FCC Part 15 and RSS 210. All other unwanted (spurious) emissions shall be at least 20dB below the level of the highest in-band signal level (30dB if the power is measured using the sample detector/power averaging method).

### SAMPLE CALCULATIONS - RADIATED EMISSIONS

Receiver readings are compared directly to the specification limit (decibel form). The receiver internally corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

A distance factor, when used for electric field measurements above 30MHz, is calculated by using the following formula:

$$F_d = 20*LOG_{10}(D_m/D_s)$$

where:

$F_d$ = Distance Factor in dB
$D_m$ = Measurement Distance in meters
$D_s$ = Specification Distance in meters

For electric field measurements below 30MHz the extrapolation factor is either determined by making measurements at multiple distances or a theoretical value is calculated using the formula:

$$F_d = 40*LOG_{10}(D_m/D_s)$$

Measurement Distance is the distance at which the measurements were taken and Specification Distance is the distance at which the specification limits are based. The antenna factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:

$R_r$ = Receiver Reading in dBuV/m
$F_d$ = Distance Factor in dB
$R_c$ = Corrected Reading in dBuV/m
$L_s$ = Specification Limit in dBuV/m
M = Margin in dB Relative to Spec

***SAMPLE CALCULATIONS - FIELD STRENGTH TO EIRP CONVERSION***

Where the radiated electric field strength is expressed in terms of the equivalent isotropic radiated power (eirp), or where a field strength measurement of output power is made in lieu of a direct measurement, the following formula is used to convert between eirp and field strength at a distance of d (meters) from the equipment under test:

$$E = \frac{1000000 \sqrt{30 P}}{d} \text{ microvolts per meter}$$

where P is the eirp (Watts)

For a measurement at 3m the conversion from a logarithmic value for field strength (dBuV/m) to an eirp power (dBm) is -95.3dB.

# Appendix A Test Equipment Calibration Data

| Manufacturer | Description | Model | Asset # | Calibrated | Cal Due |
|---|---|---|---|---|---|
| **Radiated Spurious Emissions, 30 - 10,000 MHz, 03-Mar-17** | | | | | |
| National Technical Systems | NTS EMI Software (rev 2.10) | N/A | 0 | | N/A |
| EMCO | Antenna, Horn, 1-18 GHz | 3115 | 1561 | 7/8/2016 | 7/8/2018 |
| Sunol Sciences | Biconilog, 30-3000 MHz | JB3 | 1657 | 7/27/2016 | 7/27/2018 |
| Rohde & Schwarz | EMI Test Receiver, 20 Hz-7 GHz | ESI 7 | 1756 | 6/29/2016 | 6/29/2017 |
| Hewlett Packard | High Pass filter, 1.5 GHz (Purple System) | P/N 84300-80037 | 1769 | 9/9/2016 | 9/9/2017 |
| Hewlett Packard | Microwave Preamplifier, 1-26.5GHz | 8449B | 2199 | 9/30/2016 | 9/30/2017 |
| Hewlett Packard | Spectrum Analyzer (SA40) Purple 9 kHz - 40 GHz, | 8564E (84125C) | 2415 | 3/1/2017 | 3/1/2018 |
| Com-Power | Preamplifier, 30-1000 MHz | PA-103 | 2465 | 9/16/2016 | 9/16/2017 |
| **Radio Antenna Port (Power and Spurious Emissions), 03-Mar-17** | | | | | |
| Rohde & Schwarz | Power Meter, Dual Channel | NRVD | 1539 | 10/27/2016 | 10/27/2017 |
| Rohde & Schwarz | Peak Power Sensor 100 uW - 2 Watts use with 20dB attenuator sn:1031.6959.00 only | NRV-Z32 | 3225 | 10/27/2016 | 10/27/2017 |
| Rohde & Schwarz | 20dB attenuator sn:1031.6959.00 only for Peak Power Sensor 100 uW - 2 Watts | NRV-Z32 atten | 3226 | 10/27/2016 | 10/27/2017 |
| **Radiated Spurious Emissions, 15-Mar-17** | | | | | |
| National Technical Systems | NTS EMI Software (rev 2.10) | N/A | 0 | | N/A |
| Hewlett Packard | Microwave Preamplifier, 1-26.5GHz | 8449B | 785 | 10/5/2016 | 10/5/2017 |
| Hewlett Packard | High Pass filter, 1.5 GHz (Blu System) | P/N 84300-80037 (84125C) | 1389 | 9/9/2016 | 9/9/2017 |
| Hewlett Packard | Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz | 8564E (84125C) | 1393 | 3/28/2016 | 3/28/2017 |
| EMCO | Antenna, Horn, 1-18 GHz | 3115 | 2870 | 8/31/2015 | 8/31/2017 |
| **Radiated Spurious Emissions, 16-Mar-17** | | | | | |
| National Technical Systems | NTS EMI Software (rev 2.10) | N/A | 0 | | N/A |
| Hewlett Packard | Microwave Preamplifier, 1-26.5GHz | 8449B | 785 | 10/5/2016 | 10/5/2017 |
| Hewlett Packard | High Pass filter, 1.5 GHz (Blu System) | P/N 84300-80037 (84125C) | 1389 | 9/9/2016 | 9/9/2017 |
| Hewlett Packard | Spectrum Analyzer (SA40) Blue 9 kHz - 40 GHz | 8564E (84125C) | 1393 | 3/28/2016 | 3/28/2017 |
| Micro-Tronics | Band Reject Filter, 2400-2500 MHz 18GHz | BRM50702-02 | 2238 | 10/14/2016 | 10/14/2017 |
| EMCO | Antenna, Horn, 1-18 GHz | 3115 | 2870 | 8/31/2015 | 8/31/2017 |
| HP / Miteq | SA40 B Head HF preAmplifier, 18-40 GHz (w/1393) | TTA1840-45-5P-HG-S | 1620 | 2/13/2017 | 2/13/2018 |

| Manufacturer | Description | Model | Asset # | Calibrated | Cal Due |
|---|---|---|---|---|---|
| A. H. Systems | Red System Horn, 18-40GHz | SAS-574, p/n: 2581 | 2161 | 7/16/2015 | 7/16/2017 |
| Rohde & Schwarz | EMI Test Receiver, 20 Hz-7 GHz | ESIB 7 | 1538 | 2/11/2017 | 2/11/2018 |
| Sunol Sciences | Biconilog, 30-3000 MHz | JB3 | 1657 | 7/27/2016 | 7/27/2018 |
| Com-Power | Preamplifier, 30-1000 MHz | PA-103 | 2465 | 9/16/2016 | 9/16/2017 |

# *Appendix B Test Data*

T103567 Pages 25 - 45

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Account Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | | |
| Emissions Standard(s): | FCC Part 15.247, RSS-247 | Class: | - |
| | | Environment: | - |

# EMC Test Data

For The

# Topcon Positioning Systems

Model

GR-5 GNSS Receiver with FH915

Date of Last Test: 3/16/2017

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

# RSS-247 and FCC 15.247 (FHSS) Power

## Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

## General Test Configuration

When measuring the conducted emissions, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators used.

## Ambient Conditions:

Temperature: 22 °C
Rel. Humidity: 40 %

## Summary of Results - Device Operating in the 900 MHz Band

| Run # | Test Performed | Limit | Pass / Fail | Result / Margin |
|---|---|---|---|---|
| 1 | Output Power | 15.247(b) | Pass | 29.1 dBm (0.813 W) |

## Modifications Made During Testing

No modifications were made to the EUT during testing

## Deviations From The Standard

No deviations were made from the requirements of the standard.

## Sample Notes

Sample S/N: 800-21193
Driver: -
Antenna: Laird 5 dBi gain

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

Run #1: Output Power

Date of Test: 3/3/2017 Test Location: Chamber 4
Test Engineer: John Caizzi

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels.

Maximum antenna gain: 5 dBi

High power setting

| Channel | Frequency (MHz) | Res BW | Output Power (dBm) | Output Power (W) | EIRP (W) |
|---|---|---|---|---|---|
| Low | 902.2 | 300 kHz | 28.8 | 0.759 | 2.399 |
| Mid | 915.0 | 300 kHz | 29.1 | 0.813 | 2.570 |
| High | 927.6 | 300 kHz | 28.8 | 0.759 | 2.399 |

Peak power measured with peak power meter.

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

# RSS-247 and FCC 15.247 (FHSS) Radiated Spurious Emissions

## Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

## General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.
For radiated emissions testing the measurement antenna was located 3 meters from the EUT, unless otherwise noted.

## Ambient Conditions:

Temperature: 20 °C
Rel. Humidity: 38 %

## Summary of Results - Device Operating in the 900 MHz Band

| Run # | Mode | Channel | Power Setting | Measured Power | Test Performed | Limit | Result / Margin |
|---|---|---|---|---|---|---|---|
| 1a | Tx | Low 902.2 MHz | Max | 28.8 dBm | Radiated Emissions, 30 MHz-10 GHz | FCC Part 15.209 / 15.247( c) | 46.0 dBµV/m @ 2706.6 MHz (-8.0 dB) |
| 1b | | Center 915 MHz | | 29.1 dBm | | | 31.2 dBµV/m @ 78.72 MHz (-8.8 dB) |
| 1c | | High 927.6 MHz | | 28.8 dBm | | | 32.7 dBµV/m @ 85.39 MHz (-7.3 dB) |
| | | | | 28.8 dBm | Restricted Band at 960 MHz | | 44.1 dBµV/m @ 993.03 MHz (-9.9 dB) |
| 2a | Rx | Low 902.2 MHz | NA | - | Radiated Emissions, 30 MHz-3 GHz | | 35.1 dBµV/m @ 500.01 MHz (-10.9 dB) |
| 2b | | Center 915 MHz | | - | | | 34.5 dBµV/m @ 500.01 MHz (-11.5 dB) |
| 2c | | High 927.6 MHz | | - | | | 35.8 dBµV/m @ 500.00 MHz (-10.2 dB) |

## Modifications Made During Testing

No modifications were made to the EUT during testing

## Deviations From The Standard

No deviations were made from the requirements of the standard.

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

## Procedure Comments:

Measurements performed in accordance with FCC KDB 558074
Peak measurements performed with: RBW=1MHz, VBW=3MHz, peak detector, max hold, auto sweep time
Unless otherwise stated/noted, emission has duty cycle ≥ 98% and was measured using RBW=1MHz, VBW=10Hz, peak detector, linear average mode, auto sweep time, max hold.

| Mode | Data Rate | Duty Cycle (x) | Constant DC? | T (ms) | Pwr Cor Factor* | Lin Volt Cor Factor** | Min VBW for FS (Hz) |
|---|---|---|---|---|---|---|---|
| FHSS | - | 1.00 | Yes | - | 0 | 0 | 10 |

Hopping stopped.

## Sample Notes

Sample S/N: 800-21193
Driver: -
Antenna: Laird 5 dBi gain

## Measurement Specific Notes:

| | |
|---|---|
| Note 1: | Emission in non-restricted band, but limit of 15.209 used. |
| Note 2: | Emission in non-restricted band, the limit was set 30dB below the level of the fundamental and measured in 100kHz. |
| Note 3: | Emission has a duty cycle ≥ 98%, average measurement performed: RBW=1MHz, VBW=3MHz, RMS, Power averaging, auto sweep, trace average 100 traces |

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

Run #1: Radiated Spurious Emissions, 30 - 10,000 MHz. Operating Mode: Tx

Date of Test: 3/3 & 3/15/17
Test Engineer: John Caizzi
Test Location: Chamber 4

Config. Used: 1
Config Change: none
EUT Voltage: 120V / 60Hz

Run #1a: Low Channel @ 902.2 MHz

Preliminary peak readings captured during pre-scan (peak readings vs. QP or average limit)

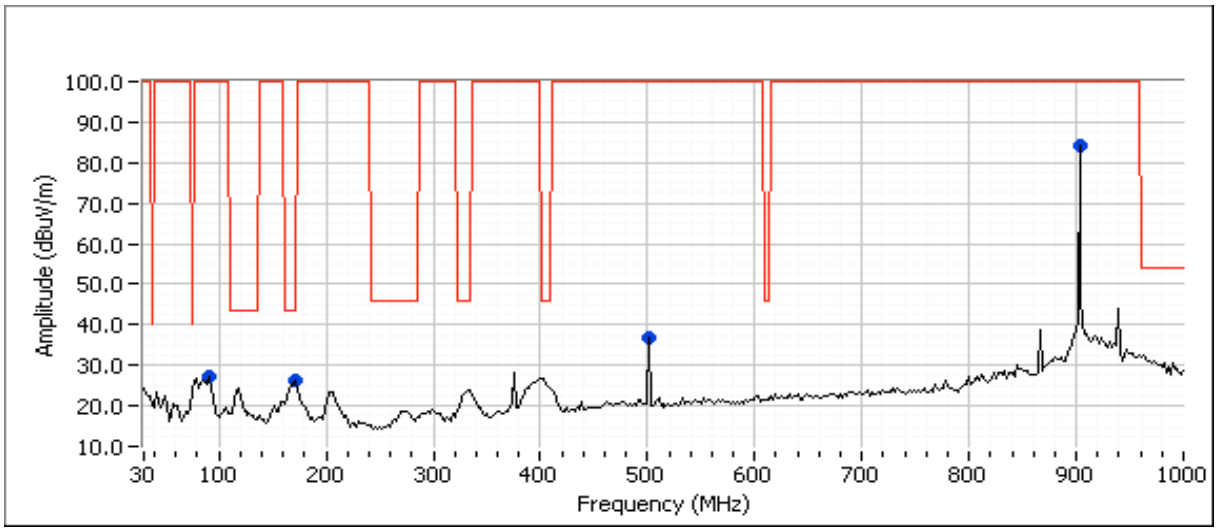
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 90.835 | 27.2 | H | 43.5 | -16.3 | Peak | 137 | 2.0 | Note 1 |
| 170.919 | 26.1 | V | 43.5 | -17.4 | Peak | 182 | 1.0 | |
| 499.993 | 36.8 | V | 46.0 | -9.2 | Peak | 256 | 1.0 | Note 1 |
| *902.806* | *84.4* | *V* | *NA* | *NA* | *Peak* | *96* | *1.5* | *Fundamental* |
| *1800.000* | *45.6* | *V* | *54.0* | *-8.4* | *Peak* | *36* | *1.0* | |
| *2700.000* | *46.3* | *V* | *54.0* | *-7.7* | *Peak* | *254* | *1.5* | |
| *2440.000* | *60.9* | *V* | *NA* | *NA* | *Peak* | *231* | *1.0* | *BT advertising* |

Final readings

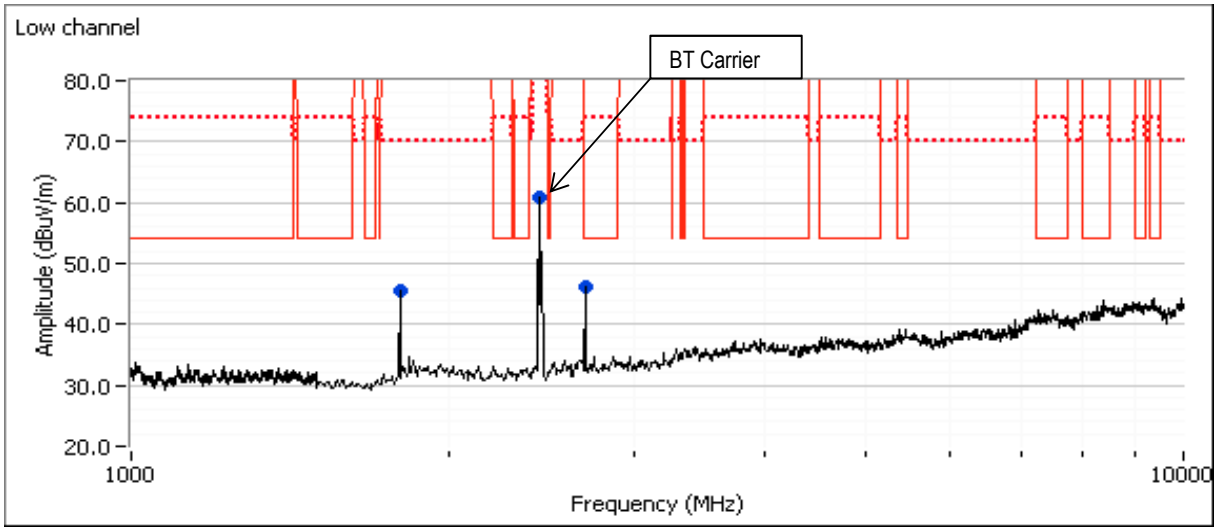
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 499.993 | 36.8 | V | 46.0 | -9.2 | QP | 253 | 1.00 | Note 1 |
| 170.919 | 24.9 | V | 43.5 | -18.6 | QP | 198 | 1.00 | |
| 90.835 | 32.6 | H | 43.5 | -10.9 | QP | 135 | 2.01 | Note 1 |
| 1804.400 | 44.9 | V | 54.0 | -9.1 | AVG | 32 | 1.00 | Note 1 |
| 1804.480 | 47.3 | V | 74.0 | -26.7 | PK | 32 | 1.00 | Note 1 |
| 2706.630 | 46.0 | V | 54.0 | -8.0 | AVG | 264 | 1.50 | |
| 2706.600 | 48.6 | V | 74.0 | -25.4 | PK | 264 | 1.50 | |

Note: No spurious emissions observed between 10 GHz and 25 GHz during pre-scans.

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |




Note: The narrow band tunable band reject filter K&L 3 TNF-800/1000 was used and tuned to suppress fundamental signal.



| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

Run #1b: Center Channel @ 915 MHz

Preliminary peak readings captured during pre-scan (peak readings vs. QP or average limit)

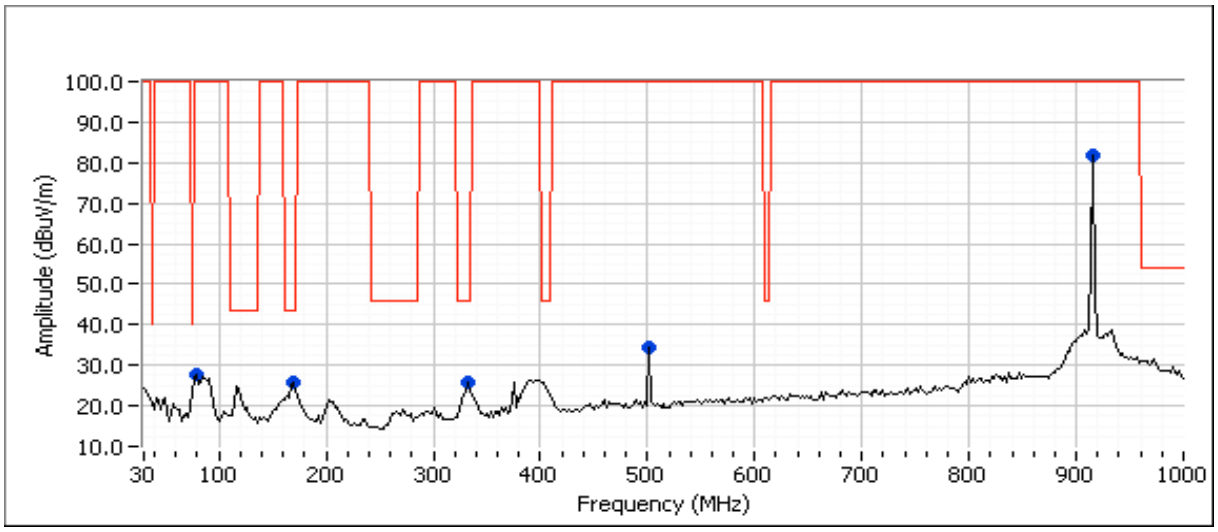
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 78.716 | 27.6 | V | 40.0 | -12.4 | Peak | 172 | 1.0 | Note 1 |
| 170.815 | 25.8 | V | 43.5 | -17.7 | Peak | 187 | 1.0 | |
| 332.196 | 25.6 | V | 46.0 | -20.4 | Peak | 3 | 1.0 | |
| 499.997 | 34.5 | V | 46.0 | -11.5 | Peak | 261 | 1.0 | Note 1 |
| *916.413* | *81.9* | *V* | *NA* | *NA* | *Peak* | *277* | *1.0* | *Fundamental* |
| *1826.670* | *42.1* | *V* | *54.0* | *-11.9* | *Peak* | *320* | *1.0* | *Note 1* |
| *2740.000* | *39.2* | *V* | *54.0* | *-14.8* | *Peak* | *134* | *2.5* | |
| *2440.000* | *63.7* | *V* | *NA* | *NA* | *Peak* | *5* | *2.0* | *BT advertising* |

Final readings

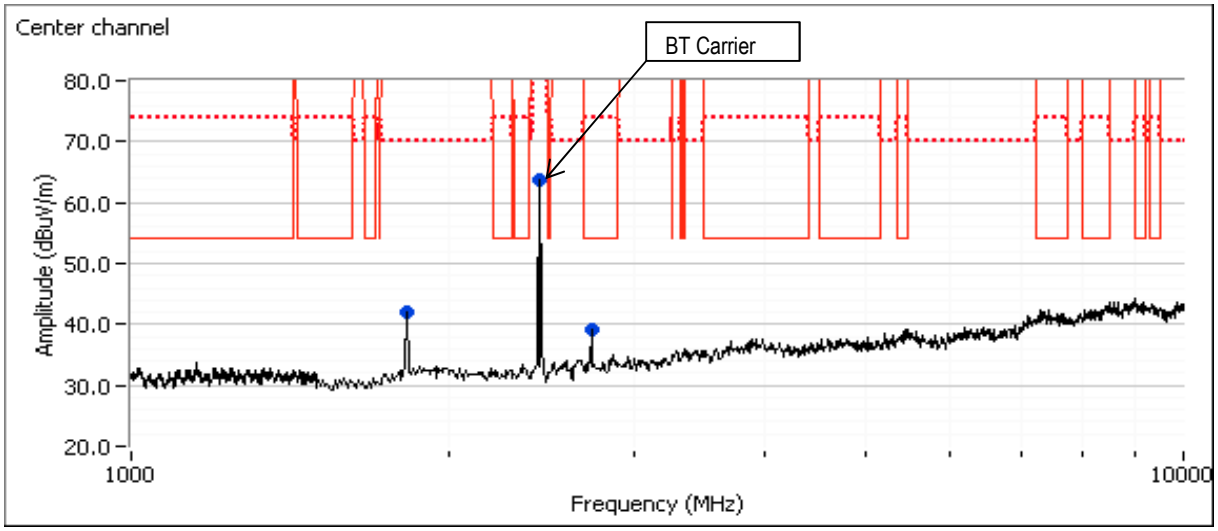
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 499.997 | 36.5 | V | 46.0 | -9.5 | QP | 250 | 1.02 | Note 1 |
| 170.815 | 25.1 | V | 43.5 | -18.4 | QP | 187 | 1.00 | |
| 78.716 | 31.2 | V | 40.0 | -8.8 | QP | 131 | 1.00 | Note 1 |
| 332.196 | 22.7 | V | 46.0 | -23.3 | QP | 2 | 1.00 | |
| 1829.950 | 41.7 | V | 54.0 | -12.3 | AVG | 321 | 1.28 | Note 1 |
| 1830.050 | 45.5 | V | 74.0 | -28.5 | PK | 321 | 1.28 | Note 1 |
| 2745.050 | 35.8 | V | 54.0 | -18.2 | AVG | 135 | 2.50 | |
| 2745.050 | 42.4 | V | 74.0 | -31.6 | PK | 135 | 2.50 | |

Note: No spurious emissions observed between 10 GHz and 25 GHz during pre-scans.

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |




Note: The narrow band tunable band reject filter K&L 3 TNF-800/1000 was used and tuned to suppress fundamental signal.



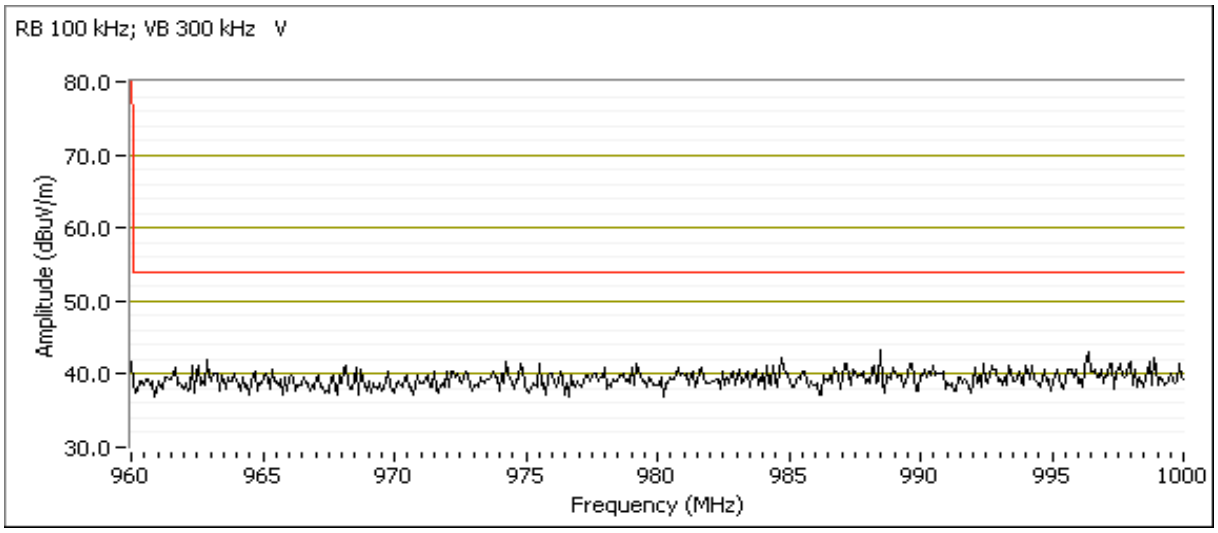
| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

Run #1c: High Channel @ 927.6 MHz

Band Edge Signal Field Strength - Direct measurement of field strength

| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 993.026 | 44.1 | V | 54.0 | -9.9 | Pk | 359 | 3.01 | RB 100 kHz, VB 300 kHz, note 2 |
| 975.471 | 43.0 | H | 54.0 | -11.0 | Pk | 0 | 1.00 | RB 100 kHz, VB 300 kHz, note 2 |

| | |
|---|---|
| Note 2 | Peak reading vs QP limit. |




| | |
|---|---|
| Note: | No filter was used during the band edge test. |

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

Preliminary peak readings captured during pre-scan (peak readings vs. QP or average limit)

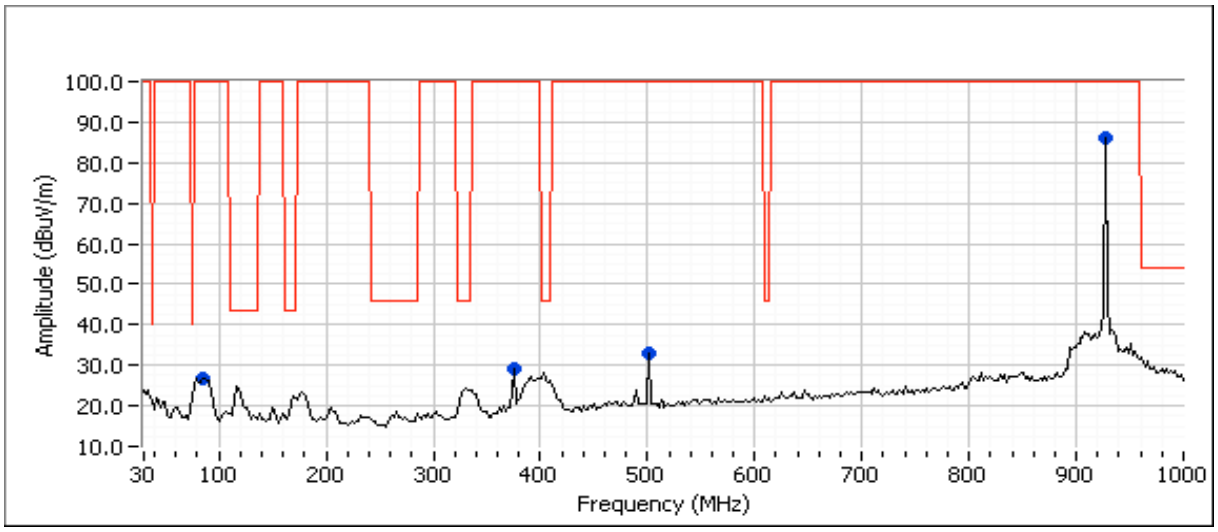
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 85.392 | 26.9 | V | 40.0 | -13.1 | Peak | 86 | 1.0 | Note 1 |
| 374.990 | 29.1 | V | 46.0 | -16.9 | Peak | 60 | 1.0 | Note 1 |
| 499.997 | 33.1 | V | 46.0 | -12.9 | Peak | 264 | 1.0 | Note 1 |
| *928.076* | *86.2* | *V* | *NA* | *NA* | *Peak* | *105* | *1.5* | *Fundamental* |
| *1853.330* | *44.7* | *V* | *54.0* | *-9.3* | *Peak* | *318* | *1.5* | *Note 1* |
| *2780.000* | *38.6* | *V* | *54.0* | *-15.4* | *Peak* | *280* | *1.5* | |
| *2440.000* | *63.9* | *V* | *NA* | *NA* | *Peak* | *359* | *2.5* | *BT advertising* |

Final readings

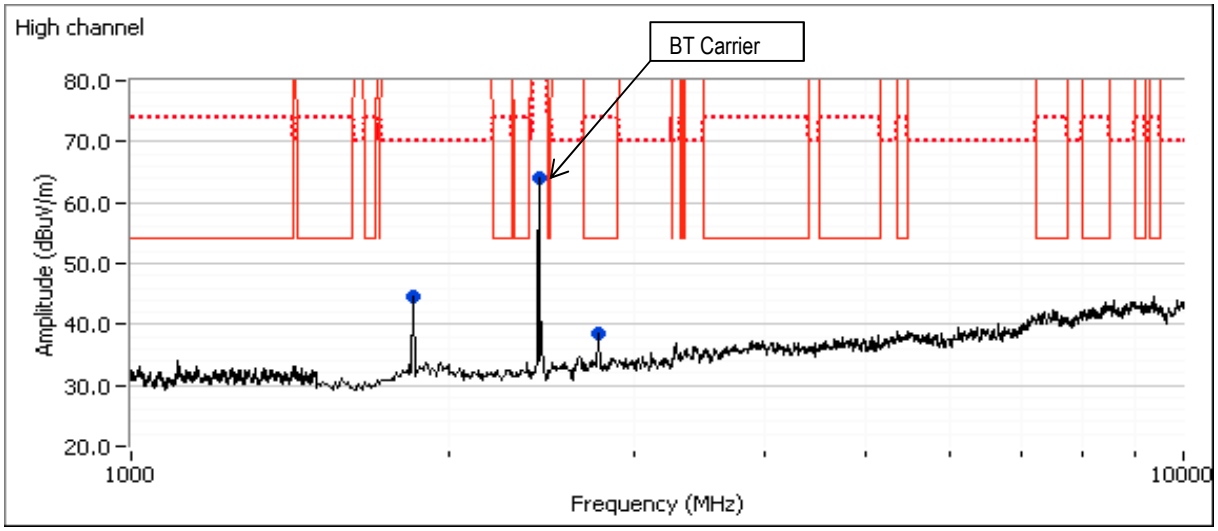
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 499.997 | 35.3 | V | 46.0 | -10.7 | QP | 264 | 1.00 | |
| 85.392 | 32.7 | V | 40.0 | -7.3 | QP | 124 | 1.00 | |
| 374.990 | 29.0 | V | 46.0 | -17.0 | QP | 46 | 1.00 | |
| 2782.870 | 37.7 | V | 54.0 | -16.3 | AVG | 257 | 1.51 | |
| 2782.750 | 43.3 | V | 74.0 | -30.7 | PK | 257 | 1.51 | |
| 1855.180 | 44.6 | V | 54.0 | -9.4 | AVG | 317 | 1.52 | Note 1 |
| 1855.380 | 47.4 | V | 74.0 | -26.6 | PK | 317 | 1.52 | Note 1 |

Note: No spurious emissions observed between 10 GHz and 25 GHz during pre-scans.

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |




Note: The narrow band tunable band reject filter K&L 3 TNF-800/1000 was used and tuned to suppress fundamental signal.



| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

Run #2: Radiated Spurious Emissions, 30 - 3000 MHz. Operating Mode: Rx

Date of Test: 3/3 & 3/16/17
Test Engineer: John Caizzi
Test Location: Chamber 4

Config. Used: 1
Config Change: none
EUT Voltage: 120V / 60Hz

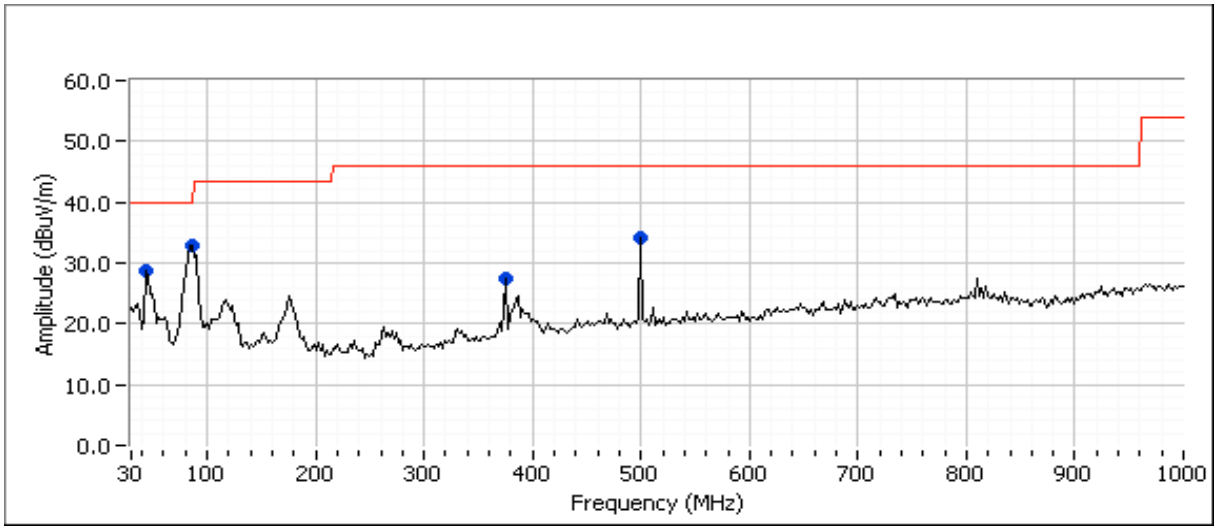
Run #2a: Low Channel @ 902.2 MHz

Preliminary peak readings captured during pre-scan (peak readings vs. QP or average limit)

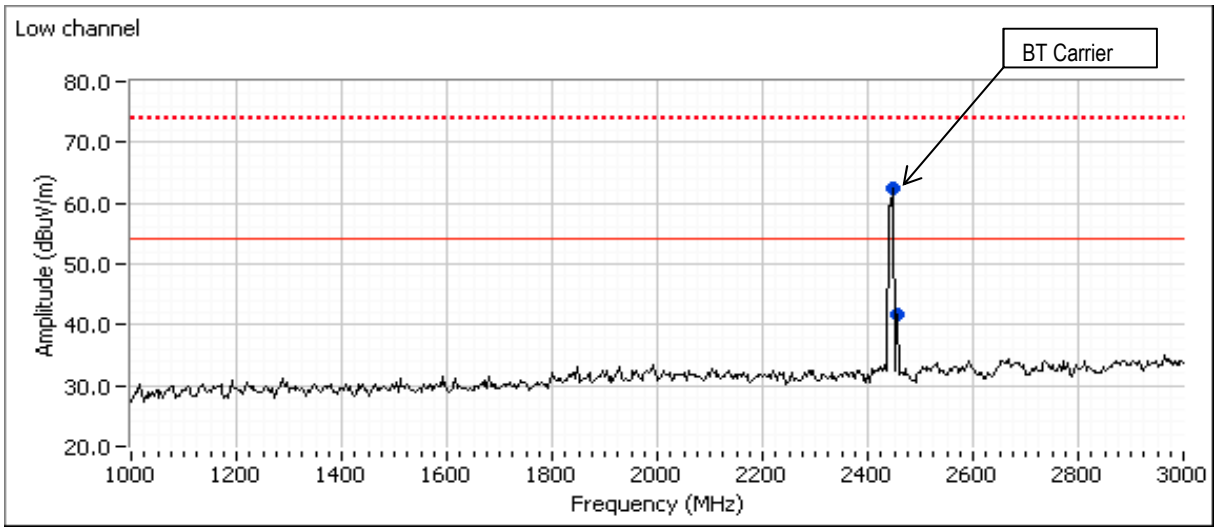
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 45.046 | 28.8 | V | 40.0 | -11.2 | Peak | 32 | 1.0 | |
| 85.864 | 33.0 | V | 40.0 | -7.0 | Peak | 116 | 1.0 | |
| 500.005 | 34.0 | H | 46.0 | -12.0 | Peak | 77 | 2.0 | |
| 374.997 | 27.6 | V | 46.0 | -18.4 | Peak | 82 | 1.0 | |
| *2446.670* | *62.3* | *V* | *54.0* | *8.3* | *Peak* | *290* | *2.0* | *BT advertising* |
| *2456.670* | *41.7* | *V* | *54.0* | *-12.3* | *Peak* | *112* | *1.5* | *BT advertising* |

Final readings

| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 500.005 | 35.1 | H | 46.0 | -10.9 | QP | 82 | 2.03 | |
| 85.860 | 20.7 | V | 40.0 | -19.3 | QP | 182 | 1.00 | |
| 45.046 | 22.1 | V | 40.0 | -17.9 | QP | 62 | 1.00 | |



| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |



| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

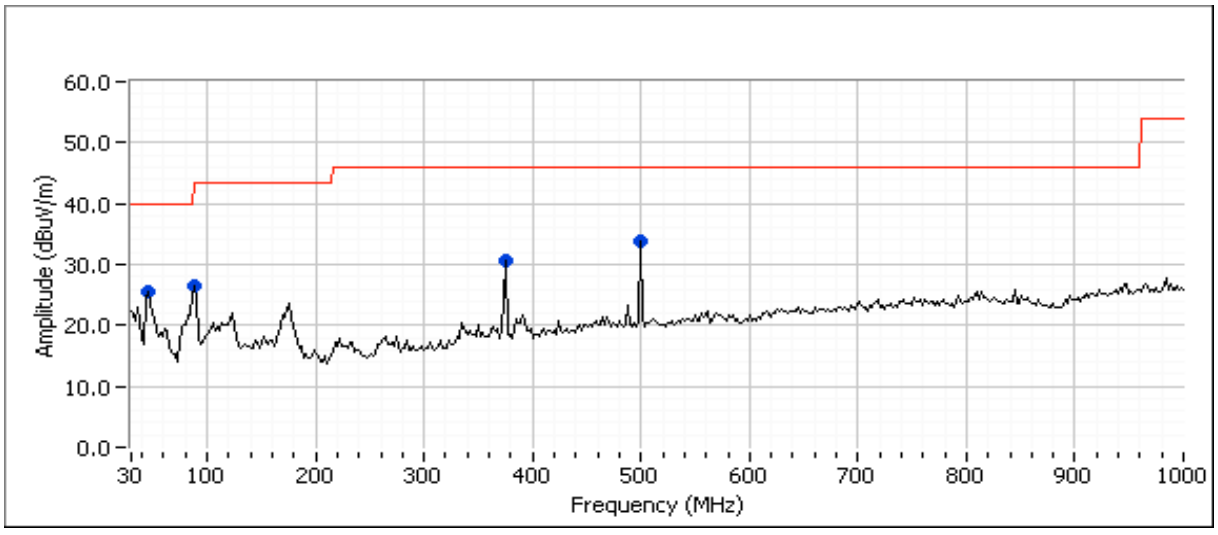
Run #2b: Center Channel @ 915 MHz

Preliminary peak readings captured during pre-scan (peak readings vs. QP or average limit)

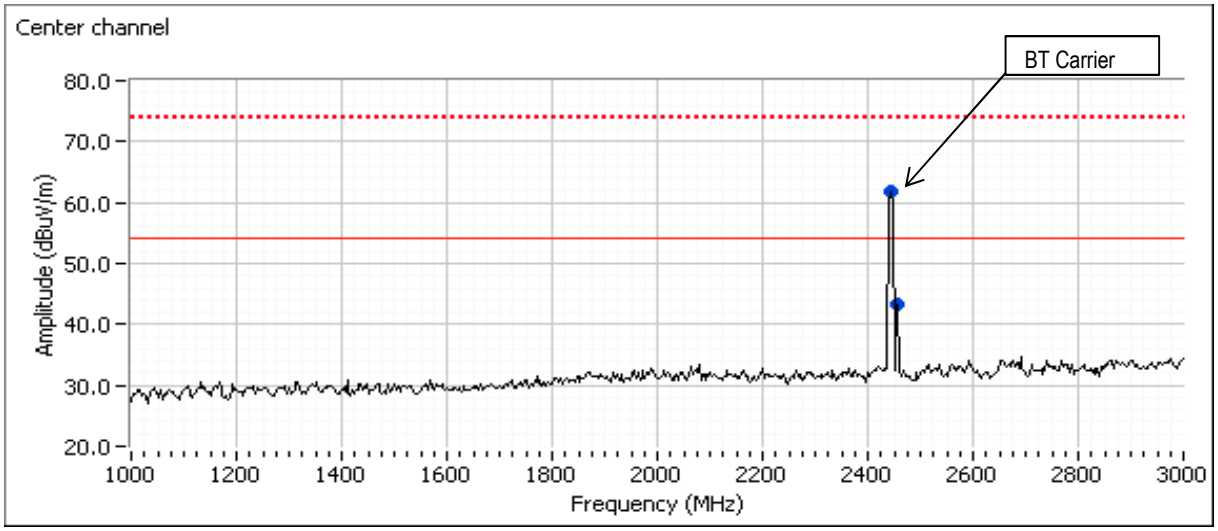
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 46.406 | 25.6 | V | 40.0 | -14.4 | Peak | 57 | 1.0 | |
| *88.317* | *26.5* | *V* | *43.5* | *-17.0* | *Peak* | *186* | *1.0* | |
| *376.012* | *30.7* | *V* | *46.0* | *-15.3* | *Peak* | *241* | *1.0* | |
| 500.005 | 33.7 | H | 46.0 | -12.3 | Peak | 106 | 2.0 | |
| *2443.330* | *61.7* | *V* | *54.0* | *7.7* | *Peak* | *17* | *1.0* | *BT advertising* |
| *2456.670* | *43.2* | *V* | *54.0* | *-10.8* | *Peak* | *37* | *1.0* | *BT advertising* |

Final readings

| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 500.005 | 34.5 | H | 46.0 | -11.5 | QP | 93 | 2.02 | |
| 46.406 | 23.2 | V | 40.0 | -16.8 | QP | 96 | 1.00 | |



| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |



| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

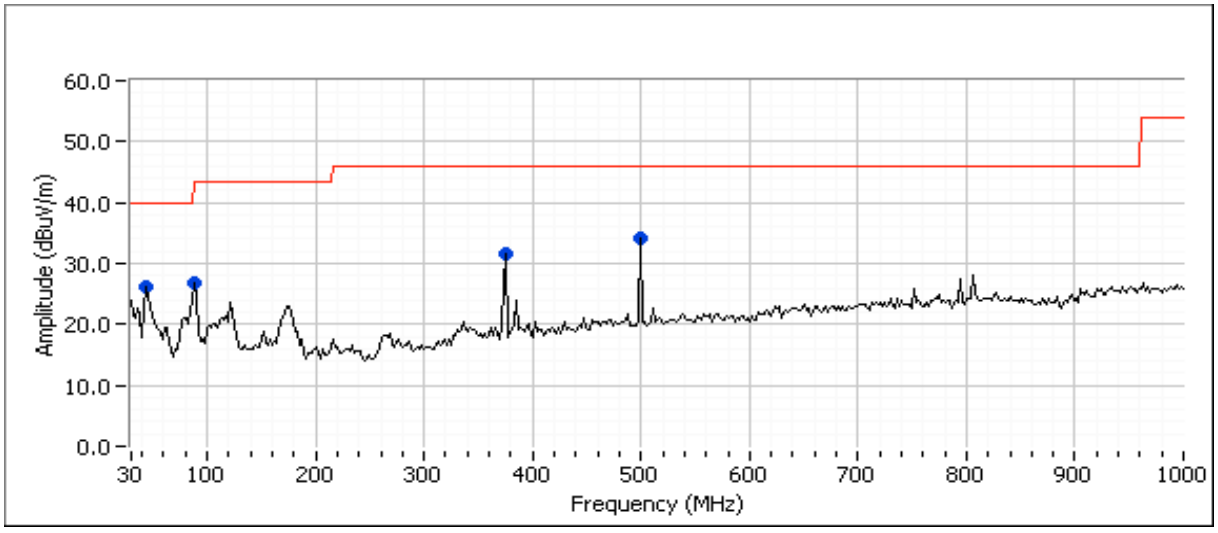
Run #2c: High Channel @ 927.6 MHz

Preliminary peak readings captured during pre-scan (peak readings vs. QP or average limit)

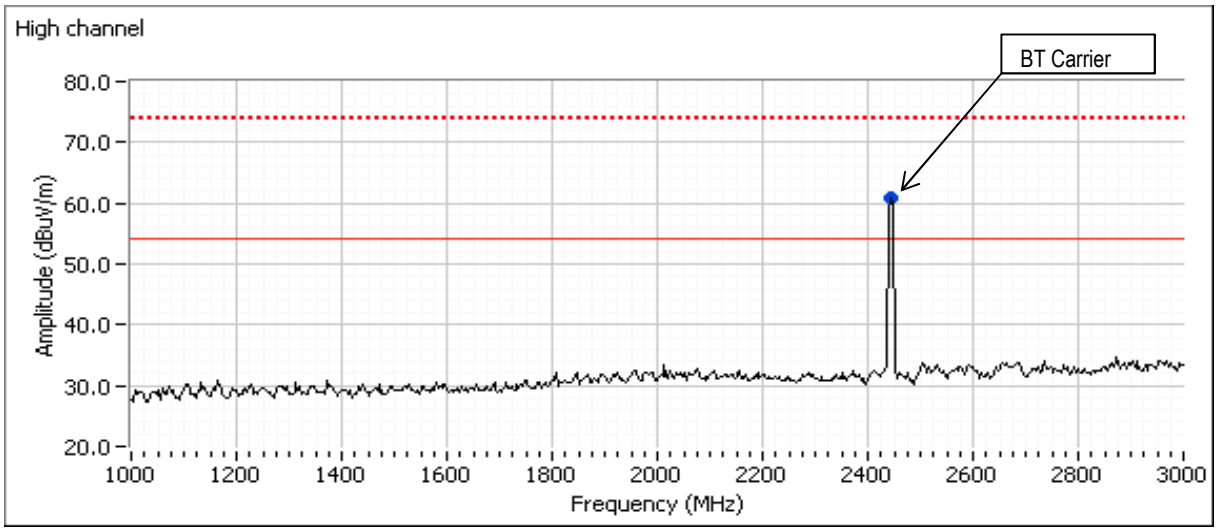
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 43.726 | 26.3 | V | 40.0 | -13.7 | Peak | 47 | 1.0 | |
| *88.317* | *26.7* | *V* | *43.5* | *-16.8* | *Peak* | *211* | *1.0* | |
| *376.012* | *31.6* | *V* | *46.0* | *-14.4* | *Peak* | *27* | *1.0* | |
| 499.997 | 34.0 | V | 46.0 | -12.0 | Peak | 92 | 1.0 | |
| *2443.330* | *61.0* | *V* | *54.0* | *7.0* | *Peak* | *9* | *1.5* | *BT advertising* |

Final readings

| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 499.997 | 35.8 | V | 46.0 | -10.2 | QP | 104 | 1.31 | |
| 43.726 | 22.7 | V | 40.0 | -17.3 | QP | 38 | 1.00 | |



| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |



| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

# RSS 247 and FCC 15.247 (FHSS) Radiated Spurious Emissions

## Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

## General Test Configuration

The EUT was located on the turntable for radiated emissions testing.

For radiated emissions testing the measurement antenna was located 3 meters from the EUT.

## Ambient Conditions:

Temperature: 22 °C

Rel. Humidity: 44 %

## Summary of Results - Intermodulation

| Run # | Mode | Channel | Power Setting | Measured Power | Test Performed | Limit | Result / Margin |
|---|---|---|---|---|---|---|---|
| 1 | Intermod check | BT @ 2441 Tx @ 915 | | - | Radiated Emissions 30 MHz - 25 GHz | FCC Part 15.209 / 15.247( c) | 39.4 dBµV/m @ 499.99 MHz (-6.6 dB) |

## Modifications Made During Testing

No modifications were made to the EUT during testing

## Deviations From The Standard

No deviations were made from the requirements of the standard.

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |

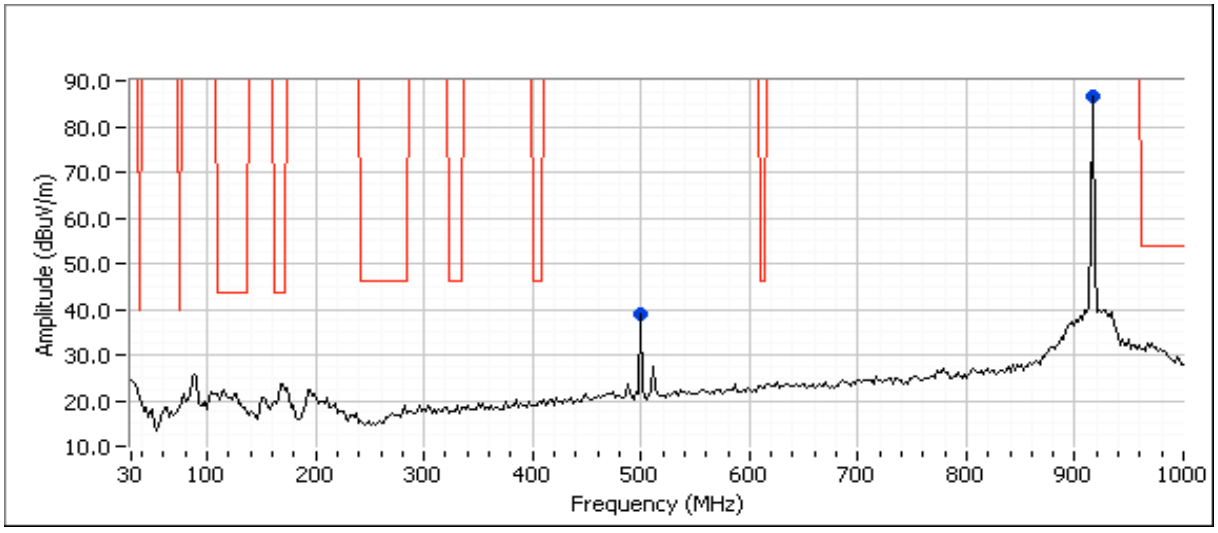
Run #1: Radiated Spurious Emissions, 30 MHz - 25 GHz.
BT - Basic mode 2441 MHz and UHF 30 dBm, modulated, 915 MHz

Date of Test: 3/16/2017 Test Location: Chamber 4
Test Engineer: John Caizzi

Other Spurious Emissions

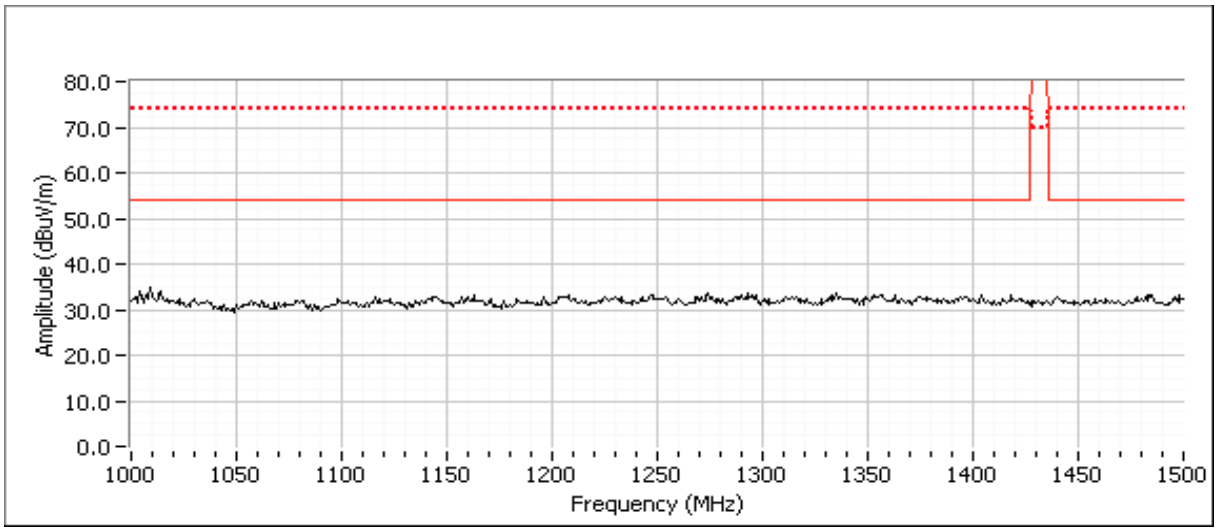
| Frequency | Level | Pol | 15.209 / 15.247 | | Detector | Azimuth | Height | Comments |
|---|---|---|---|---|---|---|---|---|
| MHz | dBµV/m | v/h | Limit | Margin | Pk/QP/Avg | degrees | meters | |
| 499.989 | 39.1 | V | 100.0 | -60.9 | Peak | 348 | 1.5 | |
| *916.413* | *86.4* | *V* | *100.0* | *-13.6* | *Peak* | *286* | *1.0* | *UHF fundamental* |
| *1822.500* | *41.9* | *V* | *54.0* | *-12.1* | *Peak* | *273* | *1.0* | *Note 2* |
| | | | | | | | | |
| 499.989 | 39.4 | V | 46.0 | -6.6 | QP | 360 | 1.42 | Note 2 |
| 1830.030 | 40.6 | V | 54.0 | -13.4 | AVG | 267 | 1.00 | |
| 1830.020 | 44.4 | V | 74.0 | -29.6 | PK | 267 | 1.00 | |

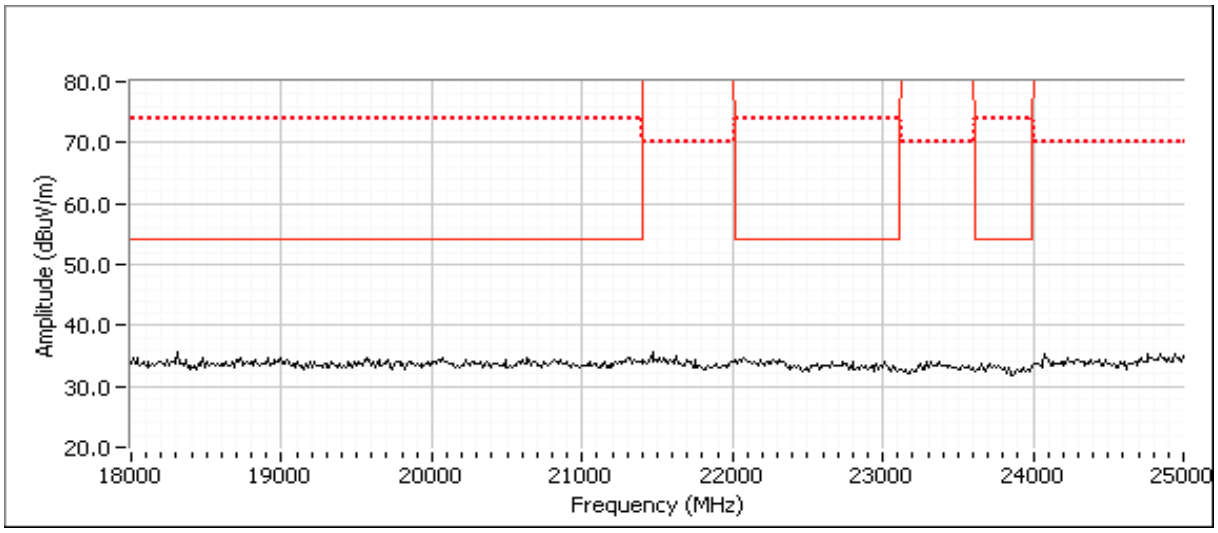
| | |
|---|---|
| Note 1: | For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 30dB below the level of the fundamental and measured in 100kHz. |
| Note 2: | Signal is not in a restricted band but the more stringent restricted band limit was used. |
| Note 3: | There was only one emission above the noise floor in the range 1.5-18 GHz. No plots for this frequency range. |




| | |
|---|---|
| Note: | The narrow band tunable band reject filter K&L 3 TNF-800/1000 was used and tuned to suppress fundamental signal. |

| | | | |
|---|---|---|---|
| Client: | Topcon Positioning Systems | Job Number: | JD103485 |
| Model: | GR-5 GNSS Receiver with FH915 | T-Log Number: | T103567 |
| | | Project Manager: | Deepa Shetty |
| Contact: | Ferdinand Riodique | Project Coordinator: | - |
| Standard: | FCC Part 15.247, RSS-247 | Class: | N/A |



***End of Report***

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