# Electromagnetic Emission

# FCC MEASUREMENT REPORT

## CERTIFICATION OF COMPLIANCE

### FCC Part 15 Certification Measurement

| | | |
|---|---|---|
| **PRODUCT** | : | IRF-Series |
| **MODEL/Serial No.** | : | IRF-90E / Proto type |
| **MULTIPLE MODEL** | : | - |
| **FCC ID** | : | O3BIRF-90E |
| **APPLICANT** | : | Epia Tech Co., Ltd.<br>3F Joeun B/D, 315-55, Seongsu 2-ga 3-dong,<br>Seongdong-gu, Seoul, Korea<br>Attn.: Chun, Ho Sang / Senior Researcher Engineer |
| **MANUFACTURER** | : | Epia Tech Co., Ltd.<br>3F Joeun B/D, 315-55, Seongsu 2-ga 3-dong,<br>Seongdong-gu, Seoul, Korea |
| **FCC CLASSIFICATION** | : | DXX (Part 15 Low Power Communication Device Transmitter) |
| **TYPE OF MODULATION** | : | GFSK |
| **FREQUENCY CHANNEL** | : | 902.250 MHz to 927.750 MHz and Channel Spacing 0.500 MHz (52 Ch) |
| **AIR DATE RATE** | : | 1.2 kbps ~ 38.4 kbps |
| **ANTENNA TYPE** | : | Dipole Antenna (Unique Type) |
| **ANTENNA GAIN** | : | 4.72 dBi max |
| **RULE PART(S)** | : | FCC Part 15 Subpart C |
| **FCC PROCEDURE** | : | ANSI C63.4-2003 |
| **TEST REPORT No.** | : | ETLE120504.0539 |
| **DATES OF TEST** | : | May 07, 2012 to May 09, 2012 |
| **REPORT ISSUE DATE** | : | May 17, 2012 |
| **TEST LABORATORY** | : | ETL Inc. (FCC Designation Number: KR0022) |

The IRF-Series, Model IRF-90E has been tested in accordance with the measurement procedures specified in ANSI C63.4-2003 at the ETL Test Laboratory and has been shown to be complied with the electromagnetic radiated emission limits specified in FCC Rule Part15 Subpart C section 15.249.
I attest to the accuracy of data. All measurement herein was performed by me or was made under my supervision and is correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.
The results of testing in this report apply to the product/system which was tested only. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

Prepared by:
Jeong Hwan, Pyo (Test Engineer)
May 17, 2012

Reviewed by:
Kug Kyoung, Yoon (Chief Engineer)
May 17, 2012

**ETL Inc.**
**#371-51, Gasan-dong, Geumcheon-gu, Seoul, 153-803, Korea**
**Tel: 82-2-858-0786 Fax: 82-2-858-0788**

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# FCC MEASUREMENT REPORT

**Scope** – *Measurement and determination of electromagnetic emission (EME) of radio frequency devices including intentional radiators and/or unintentional radiators for compliance with the technical rules and regulations of the U.S Federal Communications Commission(FCC)*

## General Information

| | |
|---|---|
| **Applicant Name** | **: Epia Tech Co., Ltd.** |
| **Address** | **: 3F Joeun B/D, 315-55, Seongsu 2-ga 3-dong, Seongdong-gu, Seoul, Korea** |
| **Attention** | **: Chun, Ho Sang / Senior Researcher Engineer** |

- **EUT Type** : IRF-Series
- **Model Number** : IRF-90E
- **S/N** : Proto type
- **Freq. Range** : 902.250 MHz - 927.750 MHz
- **Number of Channels** : 52
- **Modulation Technique** : GFSK
- **Frequency Channel** : 902.250 MHz to 927.750 MHz and Channel Spacing 0.500 MHz (52 Ch)
- **Air Data Rate** : 1.2 kbps ~ 38.4 kbps
- **Antenna Type** : Dipole Antenna (Unique Type)
- **Antenna Gain** : 4.72 dBi max
- **FCC Rule Part(s)** : FCC Part 15 Subpart C
- **Test Procedure** : ANSI C63.4-2003
- **FCC Classification** : DXX (Part 15 Low Power Communication Device Transmitter)
- **Place of Tests** : ETL Inc. Testing Lab.
  Radiated Emission test;
  #499-1, Sagot-ri, Seosin-myeon, Hwaseong-si, Gyeonggi-do, 445-882, Korea

  Conducted Emission test;
  ETL Inc. Testing Lab.
  371-51, Gasan-dong, Geumcheon-gu, Seoul, 153-803, Korea



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# 1. INTRODUCTION

The measurement test for radiated and conducted emission test was conducted at the ETL Inc. The site is constructed in conformance with the requirements of the ANSI C63.4-2003 and CISPR Publication 16. The ETL has site descriptions on file with the FCC for 3 m and 10 m site configurations. Detailed description of test facility was found to be in compliance with FCC Rules according to the ANSI C63.4-2003 and registered to the Federal Communications Commission (FCC Designation Number : KR0022).

The measurement procedure described in American National Standard for Method of Measurement of Radio-Noise Emission from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (ANSI C63.4-2003) was used in determining radiated and conducted emissions from the Epia Tech Co., Ltd. Model: IRF-90E



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# 2. PRODUCT INFORMATION

## 2.1 Equipment Description

The Equipment Under Test (EUT) is the IRF-Series (model: IRF-90E).

## 2.2 General Specification

**- Electrical specifications**

| Item | Specification |
|---|---|
| Operating voltage | DC 3.6 V |
| Consumption current | 5 W (Max.) |
| Connector | 12505WR-10 or PCB PAD |
| RF Connector | U.FL or PCB PAD |

**- RF specifications**

| Item | Specification |
|---|---|
| Frequency range | 902.250 MHz ~ 927.750 MHz |
| Modulation type | GFSK |
| Support type | LBT |
| Number of channels | 52 Channel |
| Channel bandwidth | 250 kHz |
| Data rate | 1.2 kbps ~ 38.4 kbps |
| Data Mechanism | Manchester |
| Frequency Error | ± 7 ppm (Max.) |
| Receiver sensitivity | -116 dBm at 1.2 kbps |



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**- Environmental specifications**

| Item | Specification |
|---|---|
| Dimensions | 49 mm (L) × 22 mm (W) × 4 mm (H) |
| Weight | 30 g |
| Operating temperature | (20 ± 50) ℃ |
| Storage temperature | (42.5 ± 107.5) ℃ |
| Humidity | (47.5 ± 47.5) % R.H. |
| Drop specification | concrete 1.5 M drop to concrete, 6 drops per 6 sides 3 angles over operating temperature range |

**- Antenna specifications**

| Item | Specification |
|---|---|
| Antenna type | Dipole Antenna (Unique) |
| Frequency range | 902.250 MHz ~ 927.750 MHz |
| Impedance | 50 Ω ± Normal |
| VSWR | Less Than 2.7:1 |
| Peak Gain | 4.72 dBi@Max. |
| Radiation pattern | Omni-Directional |
| Polarization | Vertical |
| Operating temperature | (25 ± 45) ℃ |

**- Frequency Channel Table**

| CH | MHz | CH | MHz | CH | MHz | CH | MHz | CH | MHz | CH | MHz |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 902.250 | 10 | 906.750 | 19 | 911.250 | 28 | 915.750 | 37 | 920.250 | 46 | 924.750 |
| 02 | 902.750 | 11 | 907.250 | 20 | 911.750 | 29 | 916.250 | 38 | 920.750 | 47 | 925.250 |
| 03 | 903.250 | 12 | 907.750 | 21 | 912.250 | 30 | 916.750 | 39 | 921.250 | 48 | 925.750 |
| 04 | 903.750 | 13 | 908.250 | 22 | 912.750 | 31 | 917.250 | 40 | 921.750 | 49 | 926.250 |
| 05 | 904.250 | 14 | 908.750 | 23 | 913.250 | 32 | 917.750 | 41 | 922.250 | 50 | 926.750 |
| 06 | 904.750 | 15 | 909.250 | 24 | 913.750 | 33 | 918.250 | 42 | 922.750 | 51 | 927.250 |
| 07 | 905.250 | 16 | 909.750 | 25 | 914.250 | 34 | 918.750 | 43 | 923.250 | 52 | 927.750 |
| 08 | 905.750 | 17 | 910.250 | 26 | 914.750 | 35 | 919.250 | 44 | 923.750 | | |
| 09 | 906.250 | 18 | 910.750 | 27 | 915.250 | 36 | 919.750 | 45 | 924.250 | | |



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# 3. DESCRIPTION OF TESTS

The tests documented in this report were performed in accordance with ANSI C63.4-2003 and FCC CFR 47 2.1046, 2.1047, 2.1049, 2.1051, 2.1053, 2.1055, 2.1057, 15.207, 15.209 and 15.249.

## 3.1 Radiated Emission Measurement

Radiated emission measurements were made in accordance with § 13 in ANSI C63.4-2003 "Measurement of Intentional radiators" The measurements were performed over the frequency range of 30 MHz to 40 GHz using antenna as the input transducer to a Spectrum analyzer or a Field Intensity Meter. The measurements were made with the detector set for "Peak, Quasi-peak, Average" within a bandwidth of 100 Hz, 9 kHz, 120 kHz and above 1 GHz is 1 MHz.

Preliminary measurements were made at 3 m using broadband antennas, and spectrum analyzer to determine the frequency producing the maximum emission in shielded room. Appropriate precaution was taken to ensure that all emission from the EUT were maximized and investigated. The system configuration, mode of operation, turntable azimuth and height with respect to the antenna were noted for each frequency found. The spectrum was scanned from 9 kHz to 30 MHz using Loop antenna and 30 MHz to 1 000 MHz using Log-Bicon antenna. Above 1 GHz, linearly polarized double ridge horn antennas were used. Final measurements were made open site at 3 m. The test equipment was laced on a wooden turn-table. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. Each frequency found during pre-scan measurements was re-examined by manual. The detector function was set to CISPR Quasi-peak mode and the bandwidth of the receiver was set to 100 Hz, 9 kHz, 120 kHz or 1 MHz depending on the frequency of type of signal. The EUT, support equipment and interconnecting cables were re-configured to the set-up producing the maximum emission for the frequency and were placed on top of a 0.8 m high nonmetallic 1.0 m x 1.5 m table. The EUT, support equipment, and interconnecting cables were re-arranged and manipulated to maximize each emission. The turntable containing the system was rotated; the antenna height was varied 1 m to 4 m and stopped at the azimuth or height producing the maximum emission.

Varying the mode of operating frequencies of the EUT maximized each emission. The system was tested in all the three orthogonal planes and changing the polarity of the antenna. The worst-case emissions are recorded in the data tables. If necessary, the radiated emission measurement could be performed at a closer distance to ensure higher accuracy and the results were extrapolated to the specified distance using an inverse linear distance extrapolation factor (20 dB/decade) as per section 15.31(f).

Photographs of the worst-case emission can be seen in Photographs of the worst-case emission test setup can be seen in Appendix B.



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## 3.2 Conducted Emission Measurement

Conducted emissions measurements were made in accordance with section § 13 in ANSI C63.4-2003 "measurement of intentional radiators" The measurements were performed over the frequency range of 0.15 MHz to 30 MHz using a 50 Ω/50 μH LISN as the input transducer to a Spectrum Analyzer or a Test Receiver. The measurements were made with the detector set for "Peak" amplitude within a bandwidth of 9 kHz or for "quasi-peak" within a bandwidth of 9 kHz.

The line-conducted emission test is conducted inside a shielded anechoic chamber room with 1 m x 1.5 m x 0.8 m wooden table which is placed 0.4 m away from the vertical wall and 1.5 m away from the side wall of the chamber room. Two LISN are bonded to the shielded room. The EUT is powered from the LISN and the support equipment is powered from the other LISN. Power to the LISNs are filtered by a noise cut power line filters. All electrical cables are shielded by braided tinned steel tubing with inner $\phi$ 1.2 cm. If the EUT is a DC-powered device, power will be derived from the source power supply it normally will be powered from and these supply lines will be connected to the LISN. Non-inductive bundling to a 1 m length shortened all interconnecting cables more than 1 m. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the EMI Test Receiver to determine the frequency producing the maximum emission from the EUT. The frequency producing the maximum level was reexamined using to set Quasi-Peak mode by manual, after scanned by automatic Peak mode from 0.15 MHz to 30 MHz. The bandwidth of the spectrum analyzer was set to 9 kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission.



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## 3.3 FCC Part 15.205 Restricted Bands of Operations

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090 - 0.110 | 16.42 - 16.423 | 399.9 - 410 | 4.5 - 5.15 |
| [1]0.495 - 0.505 | 16.694 75 - 16.695 25 | 608 - 614 | 5.35 - 5.46 |
| 2.173 5 - 2.190 5 | 16.804 25 - 16.804 75 | 960 - 1 240 | 7.25 - 7.75 |
| 4.125 - 4.128 | 25.5 - 25.67 | 1 300 - 1 427 | 8.025 - 8.5 |
| 4.177 25 - 4.177 75 | 37.5 - 38.25 | 1 435 - 1 626.5 | 9.0 - 9.2 |
| 4.207 25 - 4.207 75 | 73 - 74.6 | 1 645.5 - 1 646.5 | 9.3 - 9.5 |
| 6.215 - 6.218 | 74.8 - 75.2 | 1 660 - 1 710 | 10.6 - 12.7 |
| 6.267 75 - 6.268 25 | 108 - 121.94 | 1 718.8 - 1 722.2 | 13.25 - 13.4 |
| 6.311 75 - 6.312 25 | 123 - 138 | 2 200 - 2 300 | 14.47 - 14.5 |
| 8.291 - 8.294 | 149.9 - 150.05 | 2 310 - 2 390 | 15.35 - 16.2 |
| 8.362 - 8.366 | 156.524 75 - 156.525 25 | 2 483.5 - 2 500 | 17.7 - 21.4 |
| 8.376 25 - 8.386 75 | 156.7 - 156.9 | 2 690 - 2 900 | 22.01 - 23.12 |
| 8.414 25 - 8.414 75 | 162.012 5 - 167.17 | 3 260 - 3 267 | 23.6 - 24.0 |
| 12.29 - 12.293 | 167.72 - 173.2 | 3 332 - 3 339 | 31.2 - 31.8 |
| 12.519 75 - 12.520 25 | 240 - 285 | 3 345.8 - 3 358 | 36.43 - 36.5 |
| 12.576 75 - 12.577 25 | 322 - 335.4 | 3 600 - 4 400 | ([2]) |
| 13.36 - 13.41 | | | |

[1] Until February 1, 1999, this restricted band shall be 0.490 MHz - 0.510 MHz.
[2] Above 38.6

(b) Except as provided in paragraphs (d) and (e), the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209. At frequencies equal to or less than 1 000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1 000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.



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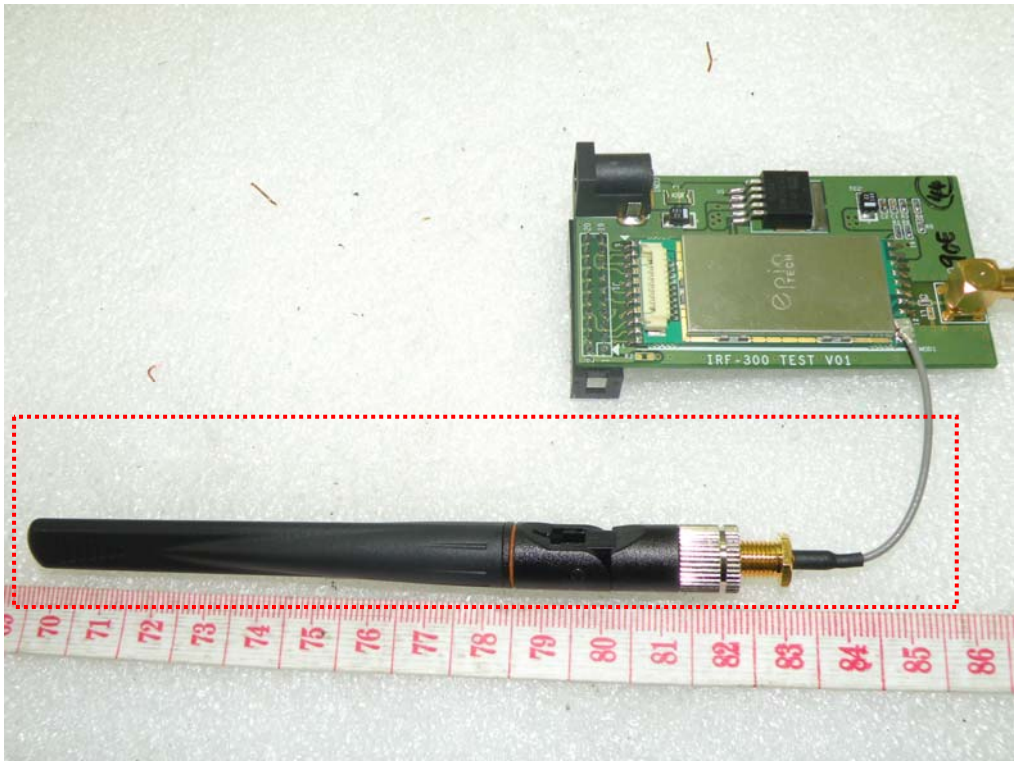
## 3.4 Antenna requirement

### (1) According to §15.203

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

Antenna Type: Unique



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# 4. TEST CONDITION

## 4.1 Test Configuration

The device was configured for testing in a typical fashion (as a customer would normally use it). During the tests, the following conditions and configurations were used.

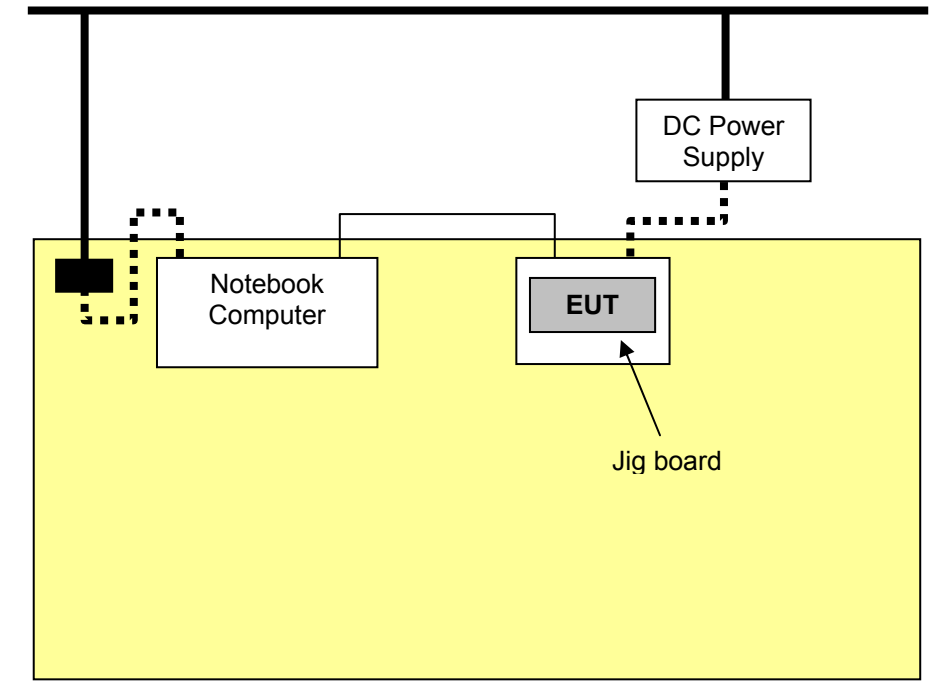
## 4.2 Description of Test modes

IRF-Series that has the control software.

- RF transmitting continuously during the tested at 902.250 MHz.
- RF transmitting continuously during the tested at 915.500 MHz.
- RF transmitting continuously during the tested at 927.750 MHz. (Worst case)

* Measurements were performed with the EUT oriented in 3 orthogonal(X, Y, Z) axis and rotated 360 degrees worst-case orientation for maximum emissions.

## 4.3 The setup drawing(s)




: Signal line

: AC Power line

: DC Power line

: Adapter



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# 5. TEST RESULTS

## 5.1 Summary of Test Results

The measurement results were obtained with the EUT tested in the conditions described in this report. Detailed measurement data and plots showing the maximum emission of the EUT are reported.

| 47 CFR Part 15, Subpart C Section 15.249 | Measurement Required | Limit | Result |
|---|---|---|---|
| 15.249(d) | Fundamental Radiated Emission | Peak: 114 [dB(μV/m)]<br>AV: 94 [dB(μV/m)] | **Pass** |
| 15.249(d) | Harmonic Radiated Emission | Peak: 74 [dB(μV/m)]<br>AV: 54 [dB(μV/m)] | **Pass** |
| 15.207(a) | Conducted Emissions | Various | **Pass** |
| 15.209 | Spurious Emissions | Various | **Pass** |
| 15.249(d) | Bandwidth of Frequency Band Edges | Peak: 74 [dB(μV/m)]<br>AV: 54 [dB(μV/m)] | **Pass** |

The data collected shows that the **Epia Tech Co., Ltd. / IRF-Series / IRF-90E** complied with technical requirements of above rules part 15.207, 209 and 15.249 Limits.

The equipment is not modified anything, mechanical or circuits to improve EMI status during a measurement. No EMI suppression device(s) was added and/or modified during testing.



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## 5.2 Fundamental Radiated Emission

| | |
|---|---|
| EUT | IRF-Series / IRF-90E |
| Limit apply to | FCC Part 15.249(d) |
| Test Date | May 08, 2012 |
| Operating Condition | RF transmitting continuously during the tested. |
| Result | Passed |

### Fundamental Radiated Emission Test Data

The following table shows the highest levels of radiated emissions on both polarizations of horizontal and vertical.

- Detector mode: Peak mode

| Frequency [MHz] | Reading [dB(μV)] | Polarization (*H/**V) | Ant. Factor [dBm] | Cable Loss [dB(μV)] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 902.250 | 44.19 | H | 23.39 | 4.72 | 72.30 | 114.00 | 41.70 |
| 902.250 | 41.99 | V | 23.39 | 4.72 | 70.10 | | 43.90 |
| 915.500 | 45.51 | H | 23.56 | 4.73 | 73.80 | 114.00 | 40.20 |
| 915.500 | 42.91 | V | 23.56 | 4.73 | 71.20 | | 42.80 |
| 927.750 | 45.44 | H | 23.72 | 4.74 | 73.90 | 114.00 | 40.10 |
| 927.750 | 43.54 | V | 23.72 | 4.74 | 72.00 | | 42.00 |

- Detector mode: Average mode

| Frequency [MHz] | Reading [dB(μV)] | Polarization (*H/**V) | Ant. Factor [dBm] | Cable Loss [dB(μV)] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 902.250 | 44.09 | V | 23.39 | 4.72 | 72.20 | 94.00 | 21.80 |
| 902.250 | 39.49 | H | 23.39 | 4.72 | 67.60 | | 26.40 |
| 915.500 | 45.51 | V | 23.56 | 4.73 | 73.80 | 94.00 | 20.20 |
| 915.500 | 42.51 | H | 23.56 | 4.73 | 70.80 | | 23.20 |
| 927.750 | 45.44 | V | 23.72 | 4.74 | 73.90 | 94.00 | 20.10 |
| 927.750 | 43.34 | H | 23.72 | 4.74 | 71.80 | | 22.20 |

**Result: No signal detect above second harmonic.**



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NOTES:

1. * H : Horizontal polarization , ** V : Vertical polarization
2. Result = Reading + Antenna factor + Cable loss
3. Margin value = Limit - Result
4. Spectrum setting:
   a. Peak Setting 1 GHz to fundamental, RBW = 1 MHz, VBW = 1 MHz, Sweep = Auto
   b. AV Setting 1 GHz to fundamental, RBW = 1 MHz, VBW = 10 Hz, Sweep = Auto



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## 5.3 Harmonic Radiated Emission

| | |
|---|---|
| EUT | IRF-Series / IRF-90E |
| Limit apply to | FCC Part 15.249(d) |
| Test Date | May 08, 2012 |
| Operating Condition | RF transmitting continuously during the tested. |
| Result | Passed |

### Harmonic Radiated Emission Test Data

The following table shows the highest levels of radiated emissions on both polarizations of horizontal and vertical.

- Detector mode: Peak mode

| Frequency [MHz] | Reading [dB(μV)] | Polarization (*H/**V) | Factor [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|---|---|---|---|---|---|
| 1 804.50 | 48.60 | V | -2.70 | 45.90 | 74.00 | 28.10 |
| 1 831.00 | 46.60 | V | -2.50 | 44.10 | | 29.90 |
| 1 855.50 | 45.90 | V | -2.40 | 43.50 | | 30.50 |

- Detector mode: Average mode

| Frequency [MHz] | Reading [dB(μV)] | Polarization (*H/**V) | Factor [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|---|---|---|---|---|---|
| 1 804.50 | 47.90 | V | -2.70 | 45.20 | 54.00 | 8.80 |
| 1 831.00 | 46.30 | V | -2.50 | 43.80 | | 10.20 |
| 1 855.50 | 45.50 | V | -2.40 | 43.10 | | 10.90 |

**Result: No signal detect above second harmonic.**

NOTES:

1. * H : Horizontal polarization , ** V : Vertical polarization
2. Factor = Antenna factor + Cable loss + Preamp
3. Result = Reading + Factor
4. Margin value = Limit - Result
5. Measuring frequencies from 1 GHz to the $10^{th}$ harmonic of highest fundamental frequency.
6. Spectrum setting:
   a. Peak Setting 1 GHz to $10^{th}$ harmonics of fundamental, RBW = 1 MHz, VBW = 1 MHz, Sweep = Auto
   b. AV Setting 1 GHz to $10^{th}$ harmonics of fundamental, RBW = 1 MHz, VBW = 10 Hz, Sweep = Auto



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## 5.4 Conducted Emissions Measurement

| | |
|---|---|
| EUT | IRF-Series / IRF-90E |
| Limit apply to | FCC Part 15.207(a) |
| Test Date | May 09, 2012 |
| Operating Condition | RF transmitting continuously during the tested. |
| Result | Passed by 13.70 dB |

**Limit**

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

| Frequency of Emission [MHz] | Conducted limit [dB(μV)] | |
|---|---|---|
| | Quasi-peak | Average |
| 0.15 - 0.5 | 66 to 56 * | 56 to 46 * |
| 0.5 - 5 | 56 | 46 |
| 5 - 30 | 60 | 50 |

* Decreases with the logarithm of the frequency.

**Test Results**

- Refer to see the measured plot in next page.



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## Conducted Emission Test Data

The following graph shows the highest levels of conducted emissions on both polarizations of hot and neutral line.
Detector mode: CISPR Quasi-Peak mode (6 dB Bandwidth: 9 kHz)

NOTES:

1. Please see the measured data in next page.
2. The c.f value was included the antenna factor and cable loss.
3. Result value = Reading + c.f
4. Margin value = Limit - Result
5. Measurements were performed at the AC Power Inlet in the frequency band of 150 kHz ~ 30 MHz according to the FCC Part 15 Class B.
6. If the average limit is met when using a Quasi-peak detector receiver, the EUT shall be deemed to meet both limits and measurement with the average detector receiver is unnecessary.



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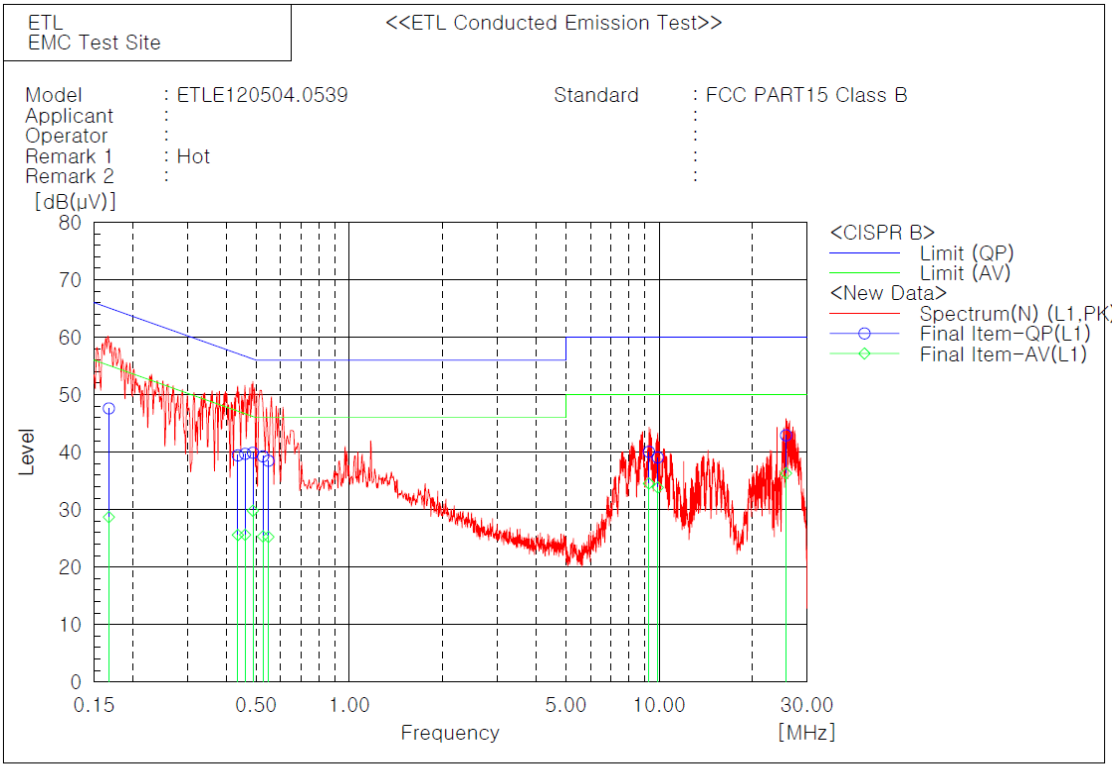
## Line: HOT Line




Final Result

--- L1 Phase ---

| No. | Frequency [MHz] | Reading QP [dB(μV)] | Reading AV [dB(μV)] | c.f [dB] | Result QP [dB(μV)] | Result AV [dB(μV)] | Limit QP [dB(μV)] | Limit AV [dB(μV)] | Margin QP [dB] | Margin AV [dB] |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.16751 | 37.9 | 19.0 | 9.7 | 47.6 | 28.7 | 65.1 | 55.1 | 17.5 | 26.4 |
| 2 | 0.43667 | 29.7 | 15.9 | 9.7 | 39.4 | 25.6 | 57.1 | 47.1 | 17.7 | 21.5 |
| 3 | 0.46132 | 30.0 | 15.9 | 9.7 | 39.7 | 25.6 | 56.7 | 46.7 | 17.0 | 21.1 |
| 4 | 0.48848 | 30.2 | 20.1 | 9.7 | 39.9 | 29.8 | 56.2 | 46.2 | 16.3 | 16.4 |
| 5 | 0.52625 | 29.6 | 15.6 | 9.7 | 39.3 | 25.3 | 56.0 | 46.0 | 16.7 | 20.7 |
| 6 | 0.5481 | 28.8 | 15.5 | 9.7 | 38.5 | 25.2 | 56.0 | 46.0 | 17.5 | 20.8 |
| 7 | 9.26784 | 30.2 | 24.6 | 9.9 | 40.1 | 34.5 | 60.0 | 50.0 | 19.9 | 15.5 |
| 8 | 9.89056 | 29.2 | 23.9 | 9.9 | 39.1 | 33.8 | 60.0 | 50.0 | 20.9 | 16.2 |
| 9 | 25.6704 | 32.7 | 26.1 | 10.2 | 42.9 | 36.3 | 60.0 | 50.0 | 17.1 | 13.7 |



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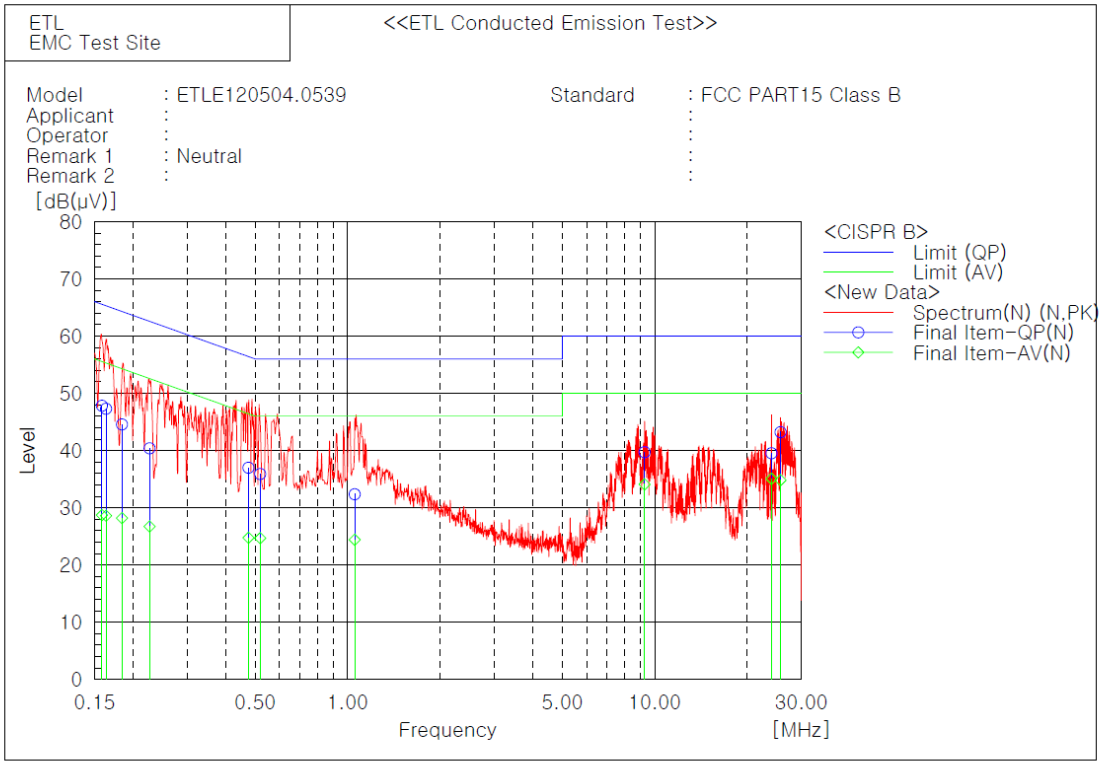
## Line: Neutral Line




Final Result

--- N Phase ---

| No. | Frequency [MHz] | Reading QP [dB(μV)] | Reading AV [dB(μV)] | c.f [dB] | Result QP [dB(μV)] | Result AV [dB(μV)] | Limit QP [dB(μV)] | Limit AV [dB(μV)] | Margin QP [dB] | Margin AV [dB] |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.15855 | 38.1 | 19.0 | 9.7 | 47.8 | 28.7 | 65.5 | 55.5 | 17.7 | 26.8 |
| 2 | 0.1635 | 37.6 | 18.9 | 9.7 | 47.3 | 28.6 | 65.3 | 55.3 | 18.0 | 26.7 |
| 3 | 0.18423 | 34.9 | 18.5 | 9.7 | 44.6 | 28.2 | 64.3 | 54.3 | 19.7 | 26.1 |
| 4 | 0.22667 | 30.7 | 17.0 | 9.7 | 40.4 | 26.7 | 62.6 | 52.6 | 22.2 | 25.9 |
| 5 | 0.47572 | 27.3 | 15.1 | 9.7 | 37.0 | 24.8 | 56.4 | 46.4 | 19.4 | 21.6 |
| 6 | 0.51895 | 26.2 | 15.0 | 9.7 | 35.9 | 24.7 | 56.0 | 46.0 | 20.1 | 21.3 |
| 7 | 1.054 | 22.7 | 14.7 | 9.7 | 32.4 | 24.4 | 56.0 | 46.0 | 23.6 | 21.6 |
| 8 | 9.26736 | 29.8 | 24.2 | 9.9 | 39.7 | 34.1 | 60.0 | 50.0 | 20.3 | 15.9 |
| 9 | 24.001 | 29.3 | 24.9 | 10.2 | 39.5 | 35.1 | 60.0 | 50.0 | 20.5 | 14.9 |
| 10 | 25.6734 | 33.0 | 24.6 | 10.2 | 43.2 | 34.8 | 60.0 | 50.0 | 16.8 | 15.2 |



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## 5.5 Spurious Emissions

### 5.5.1 Radiated Emissions

| | |
|---|---|
| EUT | IRF-Series / IRF-90E |
| Limit apply to | FCC Part 15.209 |
| Test Date | May 07, 2012 to May 08, 2012 |
| Operating Condition | RF transmitting continuously during the tested at 902.250 MHz. |
| Result | Passed |

**Limit**

Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

| Frequencies [MHz] | Field Strength [μV/m] | Measurement Distance [m] |
|---|---|---|
| 0.009 - 0.490 | 2 400/F(kHz) | 300 |
| 0.490 - 1.705 | 24 000/F(kHz) | 30 |
| 1.705 - 30.0 | 30 | 30 |
| 30 - 88 | 100 | 3 |
| 88 - 216 | 150 | 3 |
| 216 - 960 | 200 | 3 |
| Above 960 | 500 | 3 |

* Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54 MHz - 72 MHz, 76 MHz - 88 MHz, 174 MHz - 216 MHz or 470 MHz - 806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

**Test Results**

- Refer to see the measured plot in next page.



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## Radiated Emissions Test data

### - 9 kHz to 30 MHz

The following table shows the highest levels of radiated emissions on both polarizations of horizontal and vertical.
Detector mode: CISPR Quasi-Peak mode (100 Hz, 9 kHz)

| Frequency [MHz] | Reading [dB(μV)] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | **Emission attenuated more than 20 dB below the limit are not reported.** | | | | | | |
| | | | | | | | |
| | | | | | | | |

**Result: All emissions below noise floor of 20 dB(μV/m).**

NOTES:

1. * H : Horizontal polarization , ** V : Vertical polarization
2. Result = Reading + Antenna factor + Cable loss
3. Margin = Limit - Result
4. The measurement was performed for the frequency range 9 kHz to 30 MHz according to FCC Part 15.209.



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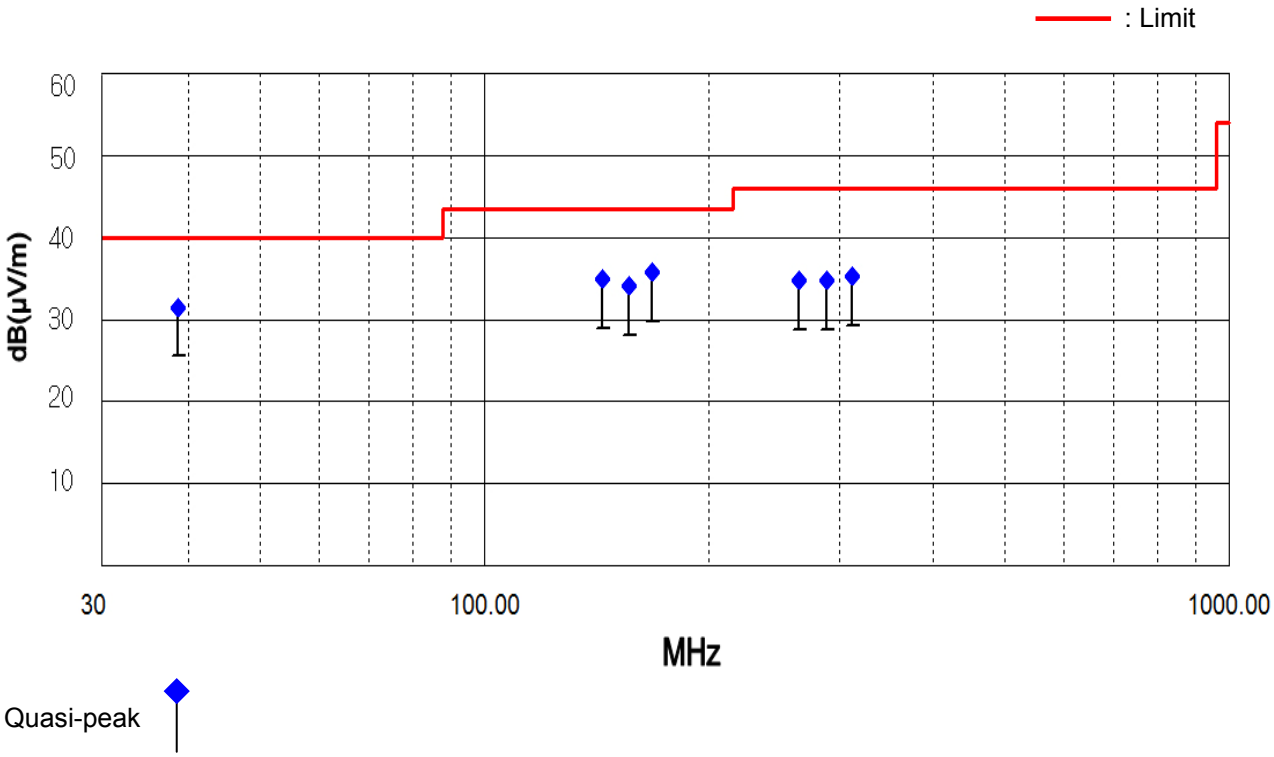
**- Below 1 GHz (30 MHz to 1 GHz)**

The following table shows the highest levels of radiated emissions on both polarizations of horizontal and vertical.
Detector mode: CISPR Quasi-Peak mode (6 dB Bandwidth: 120 kHz)

| Frequency [MHz] | Reading [dB(μV)] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 38.77 | 18.37 | V | 11.74 | 1.39 | 31.50 | 40.00 | 8.50 |
| 144.07 | 20.28 | V | 12.64 | 1.98 | 34.90 | 43.50 | 8.60 |
| 156.22 | 18.98 | V | 13.07 | 2.05 | 34.10 | 43.50 | 9.40 |
| 167.70 | 21.13 | H | 12.56 | 2.11 | 35.80 | 43.50 | 7.70 |
| 264.22 | 20.14 | H | 12.15 | 2.51 | 34.80 | 46.00 | 11.20 |
| 287.85 | 19.14 | H | 12.92 | 2.64 | 34.70 | 46.00 | 11.30 |
| 311.25 | 18.89 | H | 13.58 | 2.73 | 35.20 | 46.00 | 10.80 |

NOTES:

1. * H : Horizontal polarization , ** V : Vertical polarization
2. Result = Reading + Antenna factor + Cable loss
3. Margin value = Limit - Result
4. The measurement was performed for the frequency range above 30 MHz according to FCC Part 15.209.



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**- Above 1 GHz (1 GHz to 10 GHz)**

Detector mode: Peak mode

| Frequency [MHz] | Reading [dB(μV)] | Polarization (*H/**V) | Factor [dB] | Result [dB(μV/m)] | Limit [dB(μV/m)] | Margin [dB] |
|---|---|---|---|---|---|---|
| 1 064.64 | 46.10 | V | -3.60 | 42.50 | 74.00 | 31.50 |
| 1 597.92 | 44.40 | V | -2.80 | 41.60 | 74.00 | 32.40 |
| 1 844.36 | 44.30 | V | -2.50 | 41.80 | 74.00 | 32.20 |
| 2 494.80 | 46.70 | V | 0.50 | 47.20 | 74.00 | 26.80 |

**Result: No signal detect above second harmonic.**

NOTES:

1. * H : Horizontal polarization , ** V : Vertical polarization
2. Factor = Antenna factor + Cable loss + Preamp
3. Result = Reading + Factor
4. Margin = Limit - Result
5. Measuring frequencies from 1 GHz to the $10^{th}$ harmonic of highest fundamental frequency.
6. Measurements above show only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded(ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.
7. Spectrum setting:
   a. Peak Setting 1 GHz to $10^{th}$ harmonics of fundamental, RBW = 1 MHz, VBW = 1 MHz, Sweep = Auto
   b. AV Setting 1 GHz to $10^{th}$ harmonics of fundamental, RBW = 1 MHz, VBW = 10 Hz, Sweep = Auto



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## 5.5 Bandwidth of Frequency Band Edges

| | |
|---|---|
| EUT | IRF-Series / IRF-90E |
| Limit apply to | FCC Part 15.249(d) |
| Test Date | May 08, 2012 |
| Operating Condition | RF transmitting continuously during the tested. |
| Result | Passed |

**Limit**

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

**Test Results**

- Refer to see the measured plot in next page.

NOTES:

1. The test was performed to make a direct field strength measurement at the band edge frequencies.



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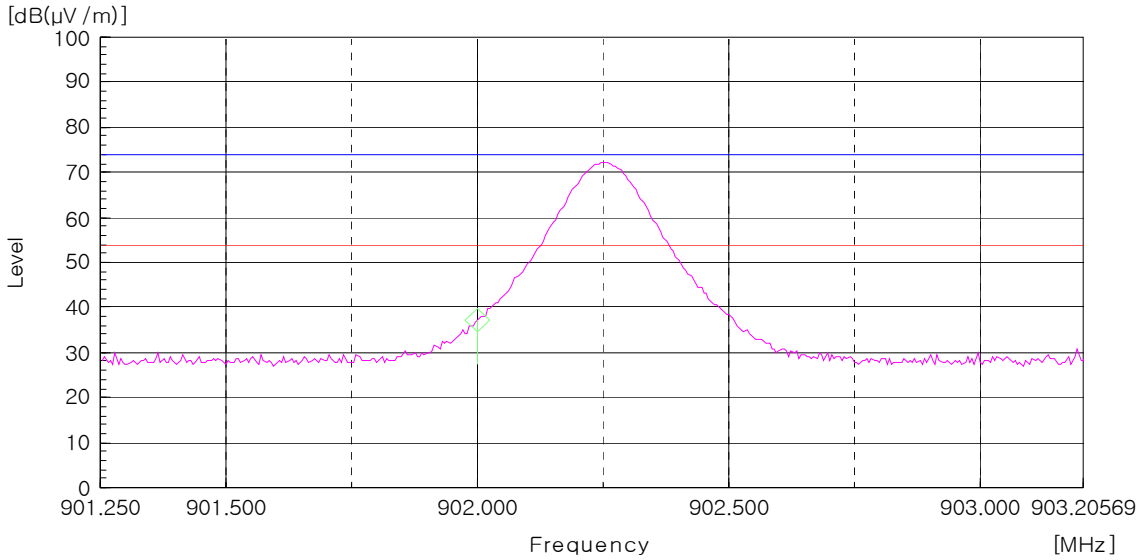
## Plots of Bandwidth of Frequency Band Edges

### Radiated

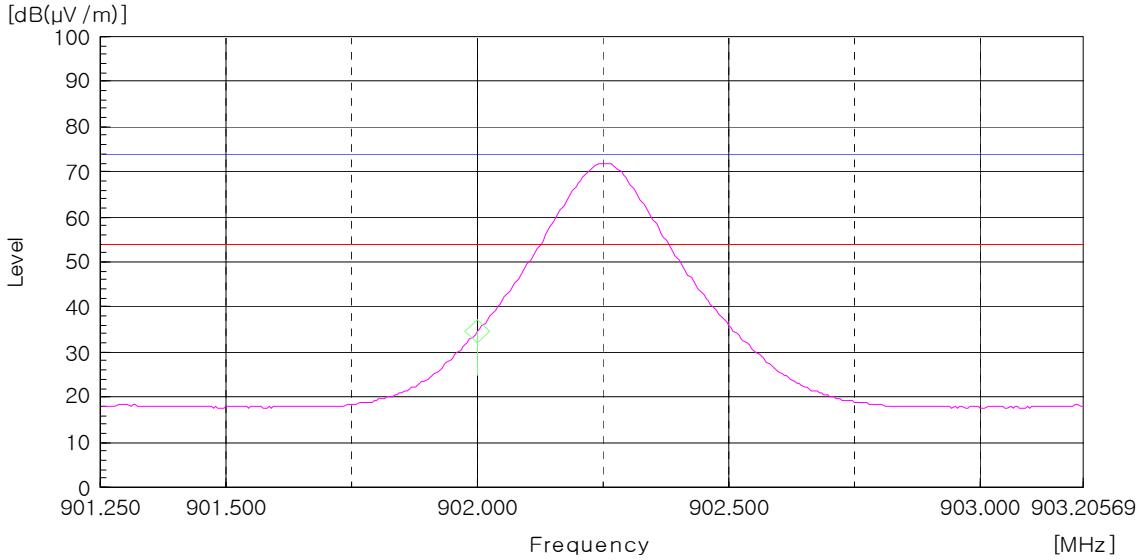
Peak Detector: RBW: 1 MHz, VBW: 1 MHz (901.250 MHz - 903.205 MHz), Worst case (Low, Vertical)

Peak Limit Line
AV Limit Line




AV Detector: RBW: 1 MHz, VBW: 10 Hz (901.250 MHz - 903.205 MHz), Worst case (Low, Vertical)

Peak Limit Line
AV Limit Line



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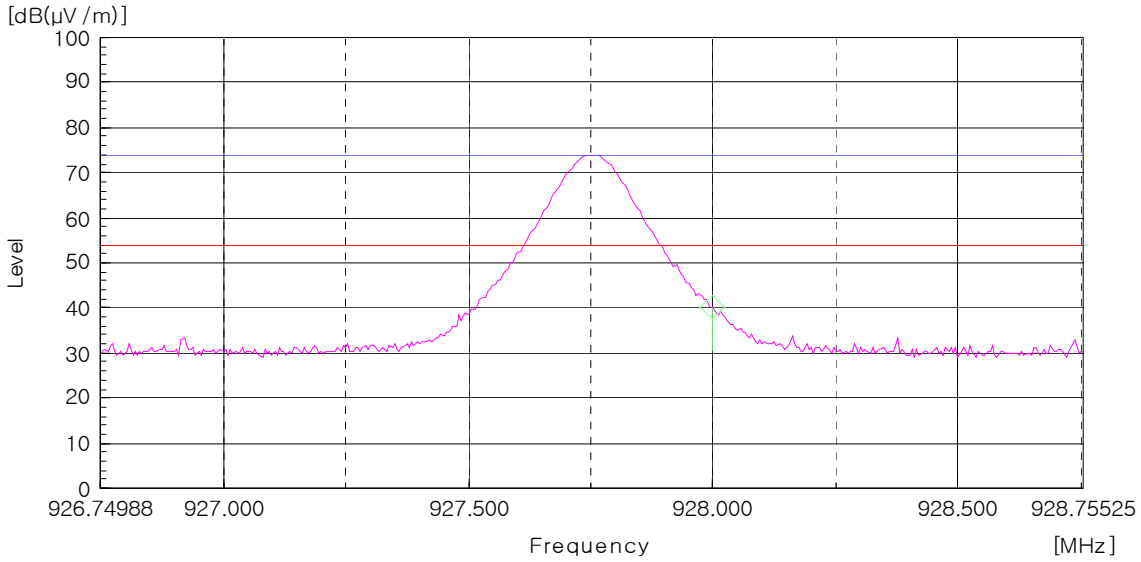
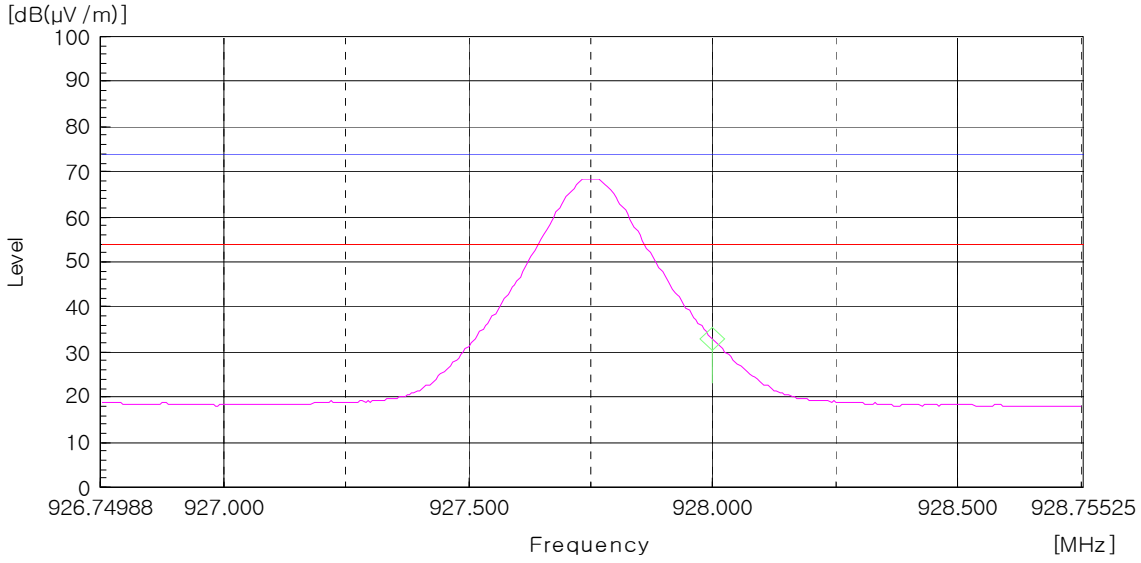
Peak Detector: RBW: 1MHz, VBW: 1 MHz (926.749 MHz - 928.755 MHz), Worst case (High, Vertical)

Peak Limit Line
AV Limit Line




AV Detector: RBW: 1MHz, VBW: 10 Hz (926.749 MHz - 928.755 MHz), Worst case (High, Vertical)

Peak Limit Line
AV Limit Line



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# 6. SAMPLE CALCULATION

## Sample Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor.
The basic equation with a sample calculation is as follows:

FS = RA + AF + CF

Where FS = Field Strength
RA = Receiver Amplitude
AF = Antenna Factor
CF = Cable Attenuation Factor

$dB(\mu V) = 20 \log_{10} (\mu V)$ : Equation
dB(μV) = dBm + 107

Example : @ 167.70 MHz

Class B Limit = 43.50 dB(μV/m)

Reading = 21.13 dB(μV)

Antenna Factor + Cable Loss = 12.56 + 2.11 = 14.67 dB(μV/m)

Total = 35.80 dB(μV/m)

Margin = 43.50 – 35.80 = 7.70 dB

= 7.70 dB below Limit



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## 7. List of test equipments used for measurements

| Test Equipment | | Model | Mfg. | Serial No. | Cal. Date | Cal. Due Date |
|---|---|---|---|---|---|---|
| ☒ | EMI Test Receiver | ESVS 10 | R&S | 835165/001 | 12.03.20 | 13.03.20 |
| ☒ | EMI Test Receiver | ESPI3 | R&S | 100478 | 11.09.15 | 12.09.15 |
| ☒ | Two-Line V-Network | ENV216 | R&S | 958599/106 | 12.03.19 | 13.03.19 |
| ☒ | LISN | 3816-2 | EMCO | 1002 | 11.09.15 | 12.09.15 |
| ☒ | Loop Antenna | 6502 | EMCO | 00033743 | 10.10.13 | 12.10.13 |
| ☒ | LogBicon Antenna | VULB9160 | Schwarzbeck | 3128 | 12.02.22 | 14.02.22 |
| ☒ | Horn Antenna | BBHA 9120D | Schwarzbeck | 227 | 11.03.22 | 13.03.22 |
| ☒ | PSA Series Spectrum Analyzer | E4440A | Agilent | US40420382 | 12.03.19 | 13.03.19 |
| ☒ | Amplifier | AFS42-01001800-28-10P-42 | MITEQ Inc. | 1565819 | 12.02.06 | 13.02.06 |
| ☒ | Controller | HD2000 | HD GmbH | C/125 | N/A | N/A |
| ☒ | Antenna Master | MA2400 | HD GmbH | N/A | N/A | N/A |
| ☒ | Turn-Table | MFT-120S | Max-Full Antenna Corp | - | N/A | N/A |
| ☒ | Antenna Master | MFA-440E | Max-Full Antenna Corp | - | N/A | N/A |



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