# Electromagnetic Emission

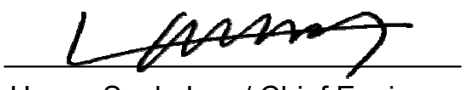
# F C C  M E A S U R E M E N T  R E P O R T

## CERTIFICATION OF COMPLIANCE

### FCC Part 15 Certification Measurement

| | | |
|---|---|---|
| **PRODUCT** | : | UHF RFID READER |
| **MODEL/Serial No.** | : | DOTR-221 / 02 |
| **Multi model** | : | NONE |
| **FCC ID** | : | QD5DOTR-221 |
| **APPLICANT** | : | D.O.Tel Co., Ltd.<br>#412, Kolon Science Valley II, 811 Guro-Dong,<br>Guro-gu, Seoul, Korea 152-878<br>Attn. : Hongmin, Shin / Senior Research Engineer |
| **MANUFACTURER** | : | D.O.Tel Co., Ltd.<br>#412, Kolon Science Valley II, 811 Guro-Dong,<br>Guro-gu, Seoul, Korea 152-878 |
| **FCC CLASSIFICATION** | : | DSS: Spread Spectrum Transmitter |
| **INTERFACE PROTOCOL** | : | ISO-18006C(EPC C1 Gen2) |
| **RULE PART(S)** | : | FCC Part 15 Subpart C Section 15.247 |
| **FCC PROCEDURE** | : | ANSI C63.4-2003 |
| **TEST REPORT No.** | : | ETLE080205.107 |
| **DATES OF TEST** | : | February 05, 2008 to February 21, 2008 |
| **REPORT ISSUE DATE** | : | March 28, 2008 |
| **TEST LABORATORY** | : | ETL Inc. (FCC Registration Number : 95422) |

This UHF RFID READER, Model DOTR-221 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 15.247
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.



Hyung Seok, Lee / Chief Engineer

**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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**Head Office:** # 371-51 Gasan-dong, Geumcheon-gu, Seoul, 153-803, Korea Tel : 82-2-858-0786 Fax : 82-2-858-0788
**EMC Lab :** #584 Sangwhal-ri, Ganam-myeon, Yoju-gun, Gyounggi-do, 469-885, Korea

# 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** | **: D.O.Tel Co., Ltd.** |
| **Address** | **: #412, Kolon Science Valley II, 811 Guro-Dong, Guro-gu, Seoul, Korea 152-878** |
| **Attention** | **: Hongmin, Shin / Senior Research Engineer** |

- **EUT Type** : UHF RFID READER
- **Model Number** : DOTR-221
- **S/N** : 02
- **Freq. Range** : 902,75 MHz – 927,25 MHz
- **Number of Channels** : 50
- **Modulation Technique** : FHSS (Frequency Hopping Spread Spectrum)
- **FCC Rule Part(s)** : FCC Part 15 Subpart C Section 15.247
- **Test Procedure** : ANSI C63.4-2003
- **FCC Classification** : DSS: Spread Spectrum Transmitter
- **EUT Condition** : Pre-Production Unit
- **Dates of Tests** : February 05, 2008 to February 21, 2008
- **Place of Tests** :

  ETL Inc. Testing Lab.
  Radiated Emission test;
  #584, Sangwhal-ri, Ganam-myeon, Yoju-gun,
  Gyeonggi-do, 469-885, Korea

  Conducted Emission test;
  ETL Inc. Testing Lab.
  371-51, Gasan-dong, Geumcheon-gu, Seoul, 153-803, Korea
- **Test Report No.** : ETLE080205.107



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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 Registration Number : 95422).

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 D.O.Tel Co., Ltd., Model: DOTR-221



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# 2. PRODUCT INFORMATION

## 2.1 Equipment Description

The Equipment Under Test (EUT) is a compact UHF RFID reader module which is compliant with the ISO18006C (EPC class1 Gen2) protocol.

It is intended to be used in conjunction with the accompanying antenna and a host computer (not supplied).

The small physical size allows the module to be easily integrated with a mobile host computer, such as a Personal Digital Assistant.

The module is designed to be operated off a single cell lithium ion battery (DC 3.7V), and has two host interface options: USB and UART.

## 2.2 General Specification

Electrical Specifications

ABSOLUTE MAXIMUM RATING:

- Power Supply Voltage: 3.8 V DC max
- Control / UART port voltage: 0.3 ~ +3.9VDC
- Operating Temperature: 55 deg C
- Storage Temperature: 40 to 70 deg C (non-operating)

Performance Characteristics Summary

- Power Supply Voltage: 3.8V DC (a single cell lithium ion battery)
- Power Consumption: 1.2A max.
- RF Output Power: 0.6W (27.8dBm) ± 1dB
- RF Frequency: 902.75MHz to 927.25MHz (50 frequency hopping channels)
- Antenna Port Impedance: 50 Unbalanced
- Recommended Return Loss of Antenna: 20dB
- Air Interface Protocol: ISO18006C (EPC C1 Gen2)
- Host Interface: UART (115.2kbps, 8N1, No Flow Control)
  Logic Level 3.3V nominal

Electrical Connector

- Manufacturer: Molex
- Part Number on Reader Module: 532611271
- Mating Connector: 510211200 (with 50125 terminals)

Antenna Connector: Hirose U.FL



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RF FREQUENCY CHANNELS

| CHANNEL | FREQ (MHz) | CHANNEL | FREQ (MHz) |
|---|---|---|---|
| 1 | 902.75 | 26 | 915.25 |
| 2 | 903.25 | 27 | 915.75 |
| 3 | 903.75 | 28 | 916.25 |
| 4 | 904.25 | 29 | 916.75 |
| 5 | 904.75 | 30 | 917.25 |
| 6 | 905.25 | 31 | 917.75 |
| 7 | 905.75 | 32 | 918.25 |
| 8 | 906.25 | 33 | 918.75 |
| 9 | 906.75 | 34 | 919.25 |
| 10 | 907.25 | 35 | 919.75 |
| 11 | 907.75 | 36 | 920.25 |
| 12 | 908.25 | 37 | 920.75 |
| 13 | 908.75 | 38 | 921.25 |
| 14 | 909.25 | 39 | 921.75 |
| 15 | 909.75 | 40 | 922.25 |
| 16 | 910.25 | 41 | 922.75 |
| 17 | 910.75 | 42 | 923.25 |
| 18 | 911.25 | 43 | 923.75 |
| 19 | 911.75 | 44 | 924.25 |
| 20 | 912.25 | 45 | 924.75 |
| 21 | 912.75 | 46 | 925.25 |
| 22 | 913.25 | 47 | 925.75 |
| 23 | 913.75 | 48 | 926.25 |
| 24 | 914.25 | 49 | 926.75 |
| 25 | 914.75 | 50 | 927.25 |



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# 3. DESCRIPTION OF TESTS

## 3.1 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 uH 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 ϕ 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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## 3.2 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 120 kHz and above 1GHz 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 30 MHz to 1000 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 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 1m 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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## 3.3 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 | 16.69475 - 16.69525 | 608 - 614 | 5.35 - 5.46 |
| 2.1735 - 2.1905 | 16.80425 - 16.80475 | 960 - 1240 | 7.25 - 7.75 |
| 4.125 - 4.128 | 25.5 - 25.67 | 1300 - 1427 | 8.025 - 8.5 |
| 4.17725 - 4.17775 | 37.5 - 38.25 | 1435 - 1626.5 | 9.0 - 9.2 |
| 4.20725 - 4.20775 | 73 - 74.6 | 1645.5 - 1646.5 | 9.3 - 9.5 |
| 6.215 - 6.218 | 74.8 - 75.2 | 1660 - 1710 | 10.6 - 12.7 |
| 6.26775 - 6.26825 | 108 - 121.94 | 1718.8 - 1722.2 | 13.25 - 13.4 |
| 6.31175 - 6.31225 | 123 - 138 | 2200 - 2300 | 14.47 - 14.5 |
| 8.291 - 8.294 | 149.9 - 150.05 | 2310 - 2390 | 15.35 - 16.2 |
| 8.362 - 8.366 | 156.52475 - 156.52525 | 2483.5 - 2500 | 17.7 - 21.4 |
| 8.37625 - 8.38675 | 156.7 - 156.9 | 2690 - 2900 | 22.01 - 23.12 |
| 8.41425 - 8.41475 | 162.0125 - 167.17 | 3260 - 3267 | 23.6 - 24.0 |
| 12.29 - 12.293 | 167.72 - 173.2 | 3332 - 3339 | 31.2 - 31.8 |
| 12.51975 - 12.52025 | 240 - 285 | 3345.8 - 3358 | 36.43 - 36.5 |
| 12.57675 - 12.57725 | 322 - 335.4 | 3600 - 4400 | ([2]) |
| 13.36 - 13.41 | | | |

[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 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 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 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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# 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

The EUT(model: DOTR-221) has been tested under operating condition.
Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.
After verification, all tests carried out are with the worst-case test modes as shown below except radiated spurious emission below 1 GHz's worst case is in normal link mode.
Channel low (902,75 MHz), Mid (914,75 MHz) and High (927,25 MHz) were chosen for full testing.

## 4.3 Support Equipment Used

| Description | Model Name | Serial No. | Manufacturer |
|---|---|---|---|
| PDA | AT570W | NONE | ATID Co.,Ltd. |

* PDA is certified by FCC(FCC ID: VUJAT570W)



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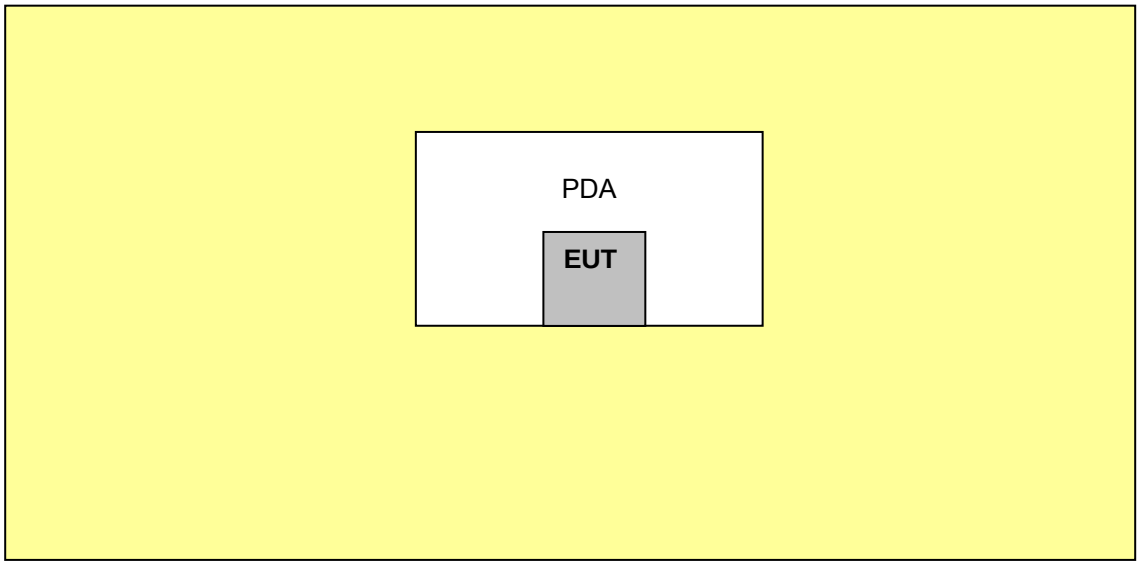
### 4.6 The setup drawing(s)




: Data Line

: Power Line

: Adapter

*EUT: UHF RFID MODULE



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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.

| Applied Standard : 47 CFR Part 15, Subpart C | | | |
|---|---|---|---|
| **FCC Rule** | **Measurement Required** | **Limit** | **Result** |
| 15.247(a)(1) | Carrier Frequency Separation | **More than > 25 kHz** | **Pass** |
| 15.247(a)(1)(i) | Number of Hopping Channels | **More than 50 channels** | **Pass** |
| 15.247(a)(1)(i) | 20 dB Bandwidth | **< 500 kHz** | **Pass** |
| 15.247(a)(1)(i) | Dwell Time | **< 0.4 s** | **Pass** |
| 15.247(b)(2) | Maximum Peak Output Power | **< 1 W** | **Pass** |
| 15.247(d) | Bandwidth of Frequency Band Edges | **More than 20 dBc** | **Pass** |
| 15.249 / 15.209 | Field Strength of Harmonics / Spurious Emissions | **< 54 dBuV/m (at 3m)** | **Pass** |
| 15.207 / 15.107 | AC Conducted Emissions | **Various** | ***N/A** |
| 15.247(i) 1.1307(b)(1) | RF Exposure | **< 20 cm** | **Pass** |

The data collected shows that the **D.O.Tel Co., Ltd. / UHF RFID READER / DOTR-221** complied with technical requirements of above rules part 15.209 and 15.247 Limits.

*N/A: Not Applicable – EUT is only power from to a single cell lithium ion battery (DC 3.8V)

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 Frequency Separation

| | |
|---|---|
| EUT | UHF RFID READER / DOTR-221 (S/N: 02) |
| Limit apply to | FCC Part 15.247(a)(1) |
| Test Date | February 05, 2008 |
| Operating Condition | RF transmitting continuously during the tested.( Frequency Hopping Spread Spectrum Transmission) |
| Result | Pass |

**Limit**

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

**Test Data**

| Carrier Frequencies Separation (kHz) | Limit |
|---|---|
| 500 | > 25 kHz |

NOTES:

1. **Measure frequency separation of relevant channel using spectrum analyzer.**
2. **RBW 10 kHz, VBW 10 kHz, span 2 MHz, Sweep time Auto.**
3. **Please see the measured plot in next page.**

Test Engineer : Kug Kyoung, Yoon



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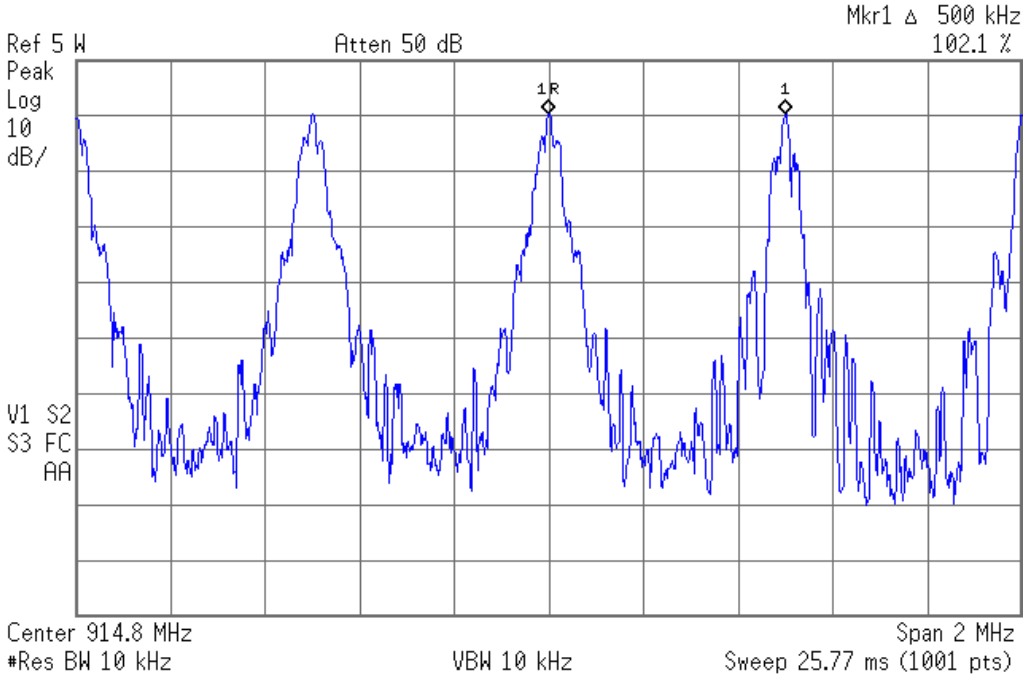
## Frequency Separation

[Channel Separation]



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## 5.3 Number of Hopping Channels

| | |
|---|---|
| EUT | UHF RFID READER / DOTR-221 (S/N: 02) |
| Limit apply to | FCC Part 15.247(a)(1)(i) |
| Test Date | February 05, 2008 |
| Operating Condition | RF transmitting continuously during the tested.( Frequency Hopping Spread Spectrum Transmission) |
| Result | Pass |

**Limit**

Frequency hopping systems in the 902.75-927.25 MHz band shall use at least 50 hopping frequencies.

**Test Data**

| Result | Limit |
|---|---|
| 50 | > 50 Channel |

NOTES:

1. **Measure number of hopping channel of relevant channel using spectrum analyzer.**
2. **Set spectrum analyzer Start 902 MHz at 928 MHz.**
3. **RBW 100 kHz, VBW 100 kHz.**
4. **Please see the measured plot in next page.**

Test Engineer : Kug Kyoung, Yoon



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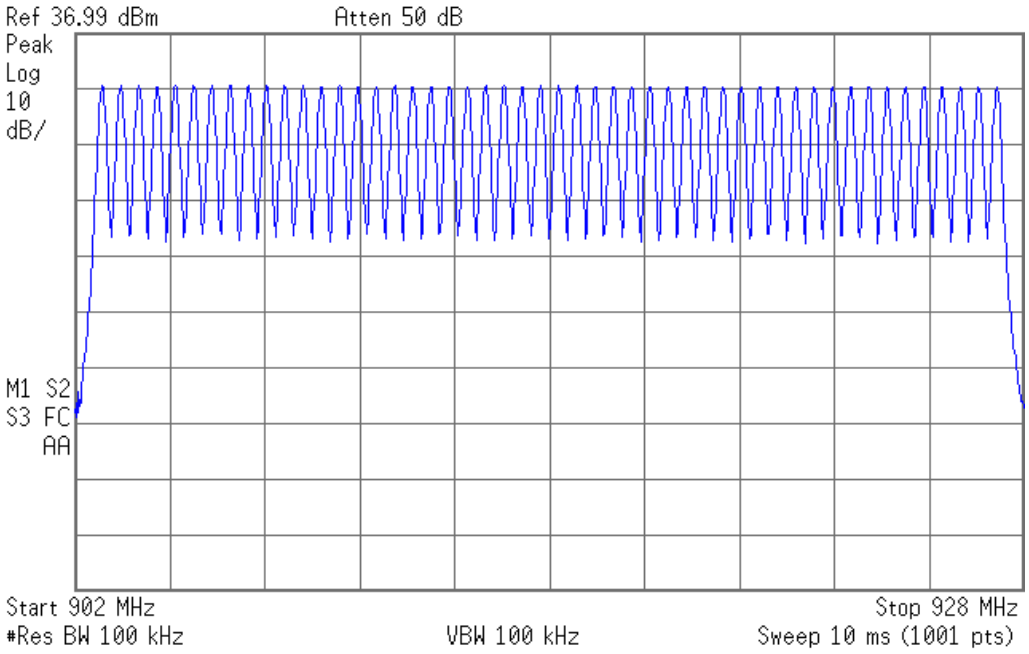
## Number of Hopping Channels

[Channel Separation]



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## 5.4 20 dB Bandwidth

| | |
|---|---|
| EUT | UHF RFID READER / DOTR-221 (S/N: 02) |
| Limit apply to | FCC Part 15.247(a)(1)(i) |
| Test Date | February 05, 2008 |
| Operating Condition | RF transmitting continuously during the tested. |
| Result | Pass |

**Limit**

The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

**Test Data**

| Frequency (MHz) | 20 dB bandwith (kHz) | Limit |
|---|---|---|
| 902.75 | 86.0 | 500 kHz |
| 914.75 | 82.5 | |
| 927.25 | 78.0 | |

NOTES:

4. **Measure frequency separation of relevant channel using spectrum analyzer.**
5. **RBW 3 kHz, VBW 3 MHz, span 500 kHz, Sweep time Auto.**
6. **Please see the measured plot in next page.**

Test Engineer : Kug Kyoung, Yoon



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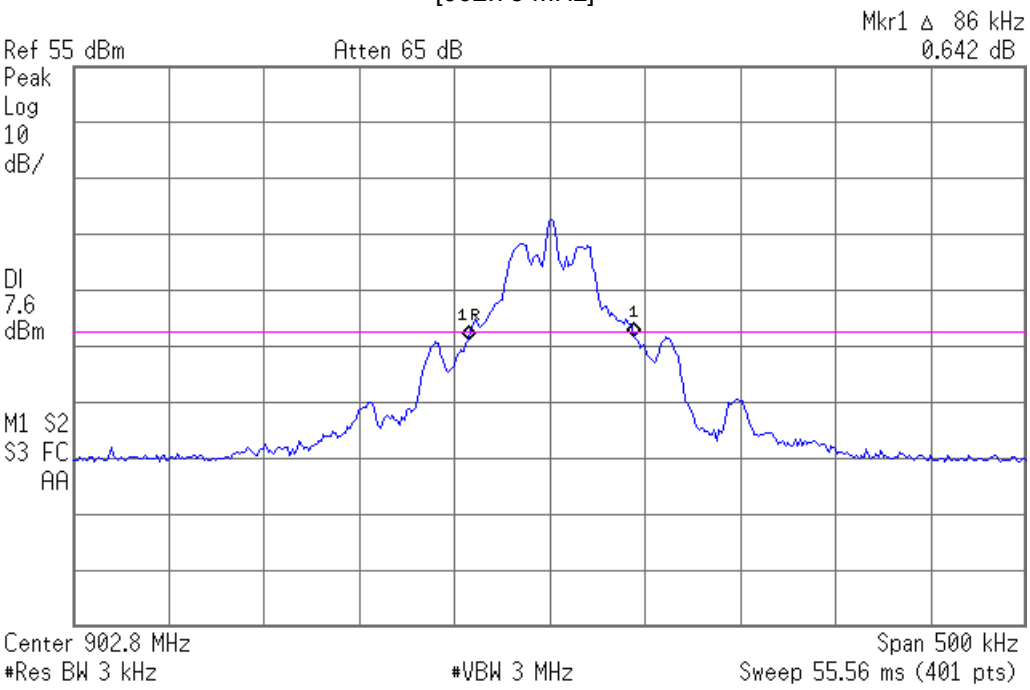
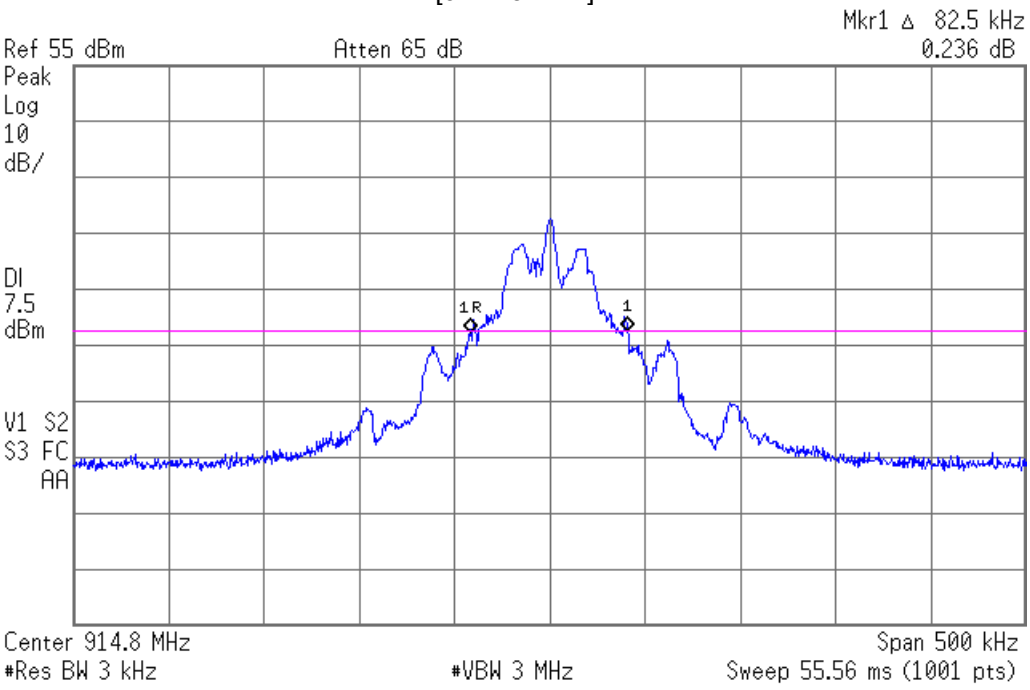
## 20 dB Bandwidth

[902.75 MHz]




[914.75 MHz]



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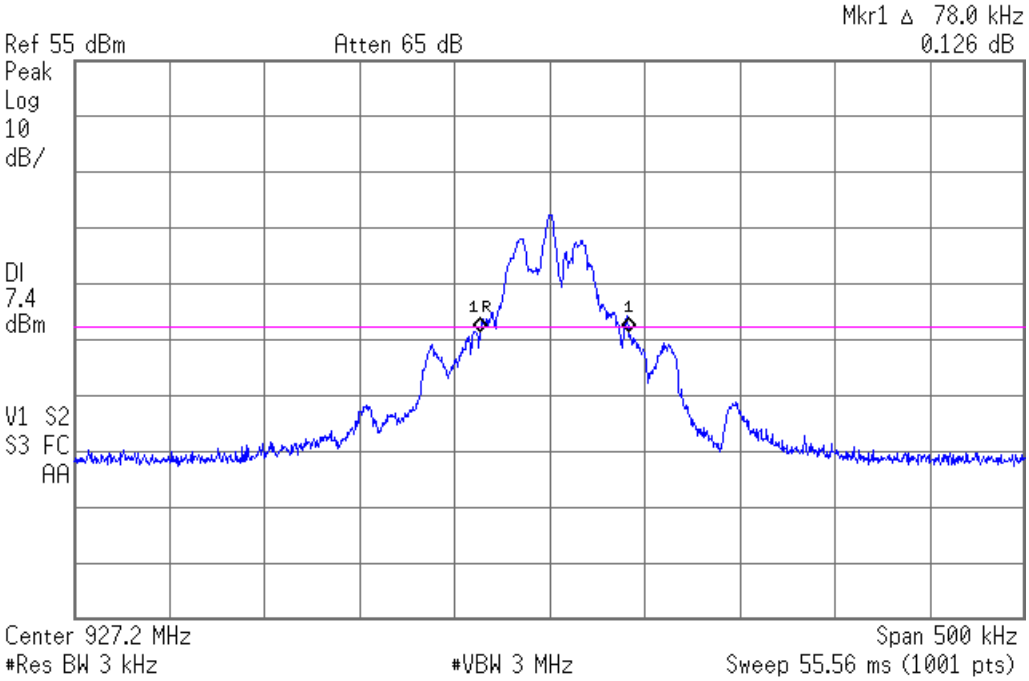
[927.25 MHz]



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## 5.5 Time of Occupancy (Dwell Time)

| | |
|---|---|
| EUT | UHF RFID READER / DOTR-221 (S/N: 02) |
| Limit apply to | FCC Part 15.247(a)(1)(i) |
| Test Date | February 05, 2008 |
| Operating Condition | RF transmitting continuously during the tested.( Frequency Hopping Spread Spectrum Transmission) |
| Result | Pass |

**Limit**

Frequency hopping systems in the 902.75-927.25 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

**The average time of occupancy;**

Dwell time = 0.404 s

Time between occupancy = 20.82 s

Time of occupancy = period / time between occupancy x dwell time

Therefore -> (20 / 20) x 0.386 = **0.386** s < 0.4 s

NOTES:

1. **Measure time of occupancy of relevant channel using spectrum analyzer.**
2. **RBW 100 kHz, VBW 3 MHz, Span 0 Hz, Sweep time Auto.**
3. **Please see the measured plot in next page.**

Test Engineer : Kug Kyoung, Yoon



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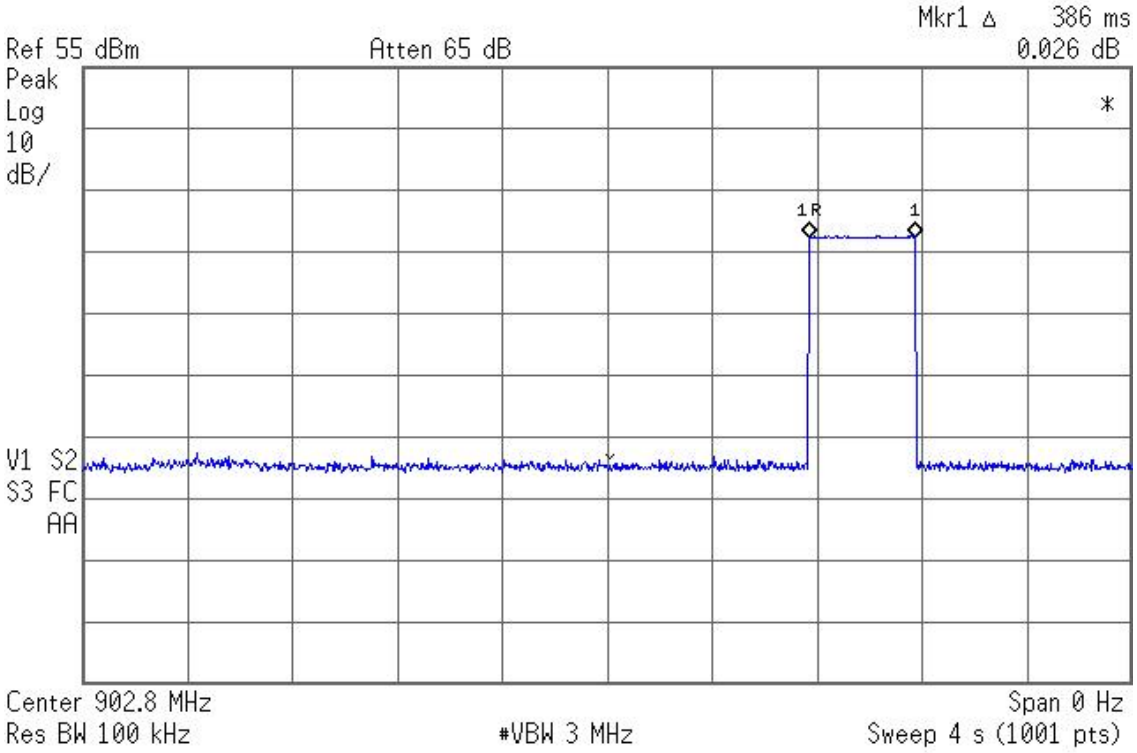
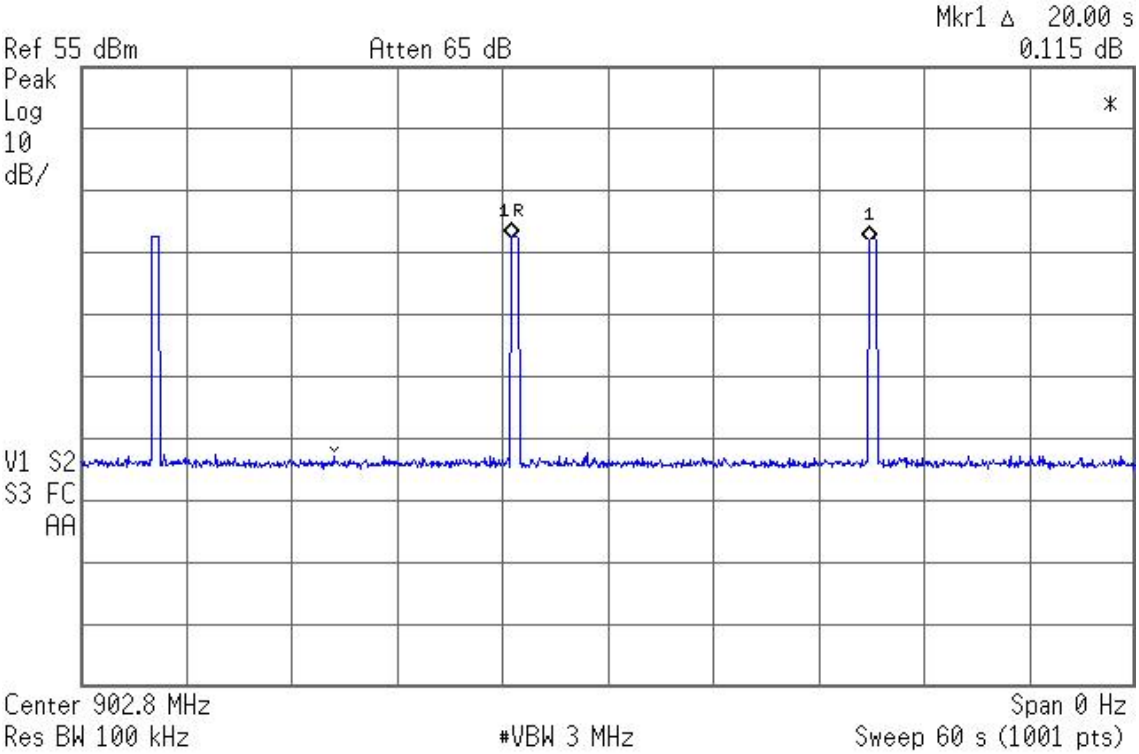
## Time of Occupancy (Dwell Time)



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## 5.6 Maximum peak conducted output power

| | |
|---|---|
| EUT | UHF RFID READER / DOTR-221 (S/N: 02) |
| Limit apply to | FCC Part 15.247(b)(2) |
| Test Date | February 05, 2008 |
| Operating Condition | RF transmitting continuously during the tested. |
| Result | Pass |

**Limit**

The maximum peak conducted output power of the intentional radiator shall not exceed the following:

- For frequency hopping systems operating in the 902.75-927.25 MHz band: 1 watt for systems employing at least 50 hopping channels.

**Test Data**

| Channel | Frequency (MHz) | Output Power (W) | Limit |
|---|---|---|---|
| Low | 902.75 | 0.5833 | < 1 W |
| Mid | 914.75 | 0.6055 | |
| High | 927.25 | 0.5948 | |

NOTES:

1. **The transmitter output is connected to the Power Meter.**

Test Engineer : Kug Kyoung, Yoon



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## 5.7 Bandwidth of Frequency Band Edges

| | |
|---|---|
| EUT | UHF RFID READER / DOTR-221 (S/N: 02) |
| Limit apply to | FCC Part 15.247(d) |
| Test Date | February 05, 2008 |
| Operating Condition | RF transmitting continuously during the tested. |
| Result | Pass |

**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.**
2. **Set the spectrum analyzer in the following setting in order to capture the lower and upper band edges of the emission: (a)Peak: RBW 1 MHz, VBW 1 MHz, Sweep time Auto; (b) Average: RBW 1 MHz, VBW 10 Hz, Sweep time Auto.**
3. **Repeat the procedures until all the Peak and Average versus Polarization are measured.**

Test Engineer : Kug Kyoung, Yoon



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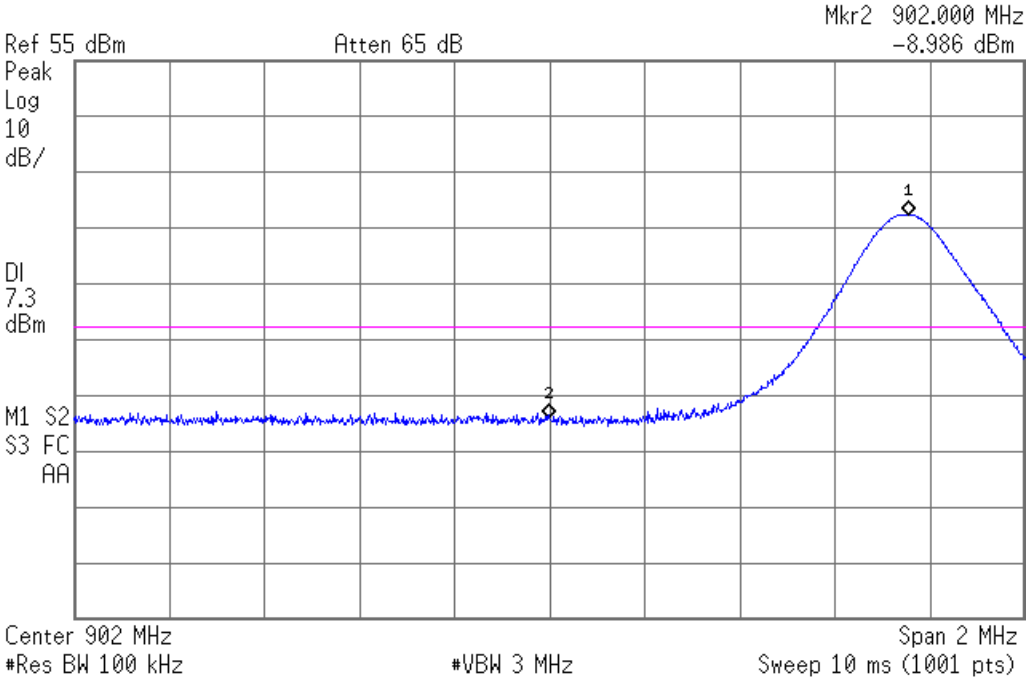
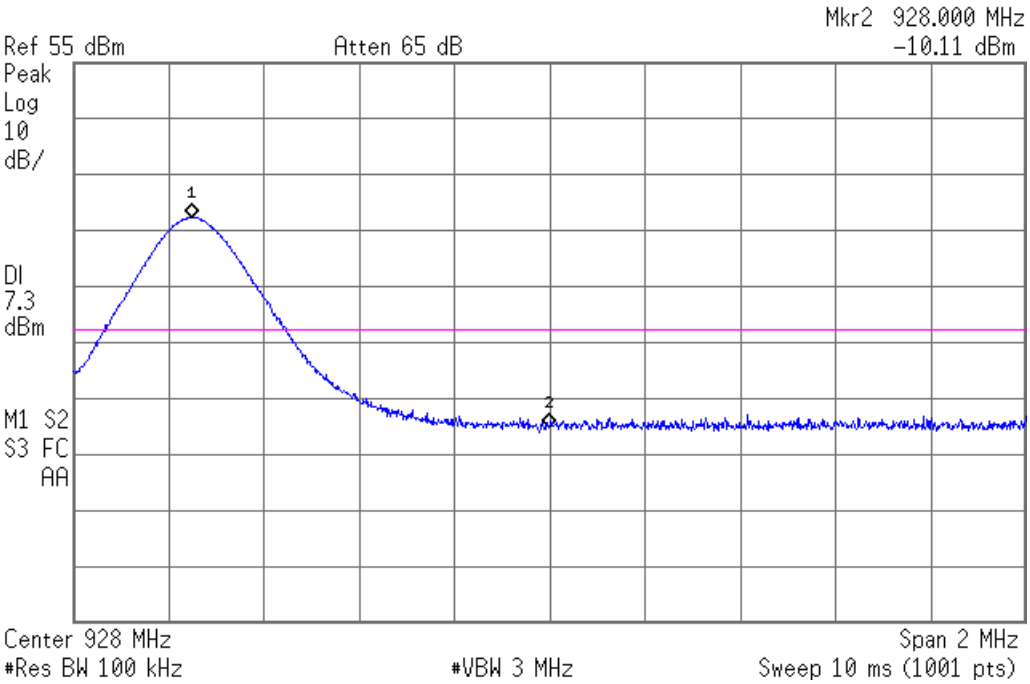
## Bandwidth of Frequency Band Edges



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## 5.8 Radio Frequency Exposure

Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See § 1.1307(b)(1) of this Chapter.

**Limit**

Limits for general population/Uncontrolled exposure

| Frequency Range (MHz) | Electric Field Strength (E) (V/m) | Magnetic Field Strength (H) (A/m) | Power Density (S) ($mW/cm^2$) | Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes) |
|---|---|---|---|---|
| 0.3-1.34 | 614 | 1.63 | (100) | 30 |
| 1.34-30 | 824/f | 2.19/f | ($180/f^2$) | 30 |
| 30-300 | 27.5 | 0.073 | 0.2 | 30 |
| 300-1500 | -- | -- | f/1500 | 30 |
| 1500-100 000 | -- | -- | 1.0 | 30 |

f = frequency in MHz *Plane-wave equivalent power density

MPE Prediction

Predication of MPE limit at a given distance.

Equation from page 18 of OET Bulletin 65, Edition 97-01

$S=PG/4\pi R^2$

Where: S = power density (in appropriate units, e.g. $mW/cm^2$)
P = power input to the antenna (in appropriate units, e.g., mW)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

| | | |
|---|---|---|
| Maximum peak output power at antenna input | : | 27.82 dBm (605.50 mW) |
| Prediction distance | : | 20 cm |
| Predication frequency | : | 914.75 MHz |
| Antenna gain(Max) | : | 2.27 dBi (1.68 numeric) / 2.49 dBi (1.77 numeric) |
| Power density at predication frequency at 20 cm | : | 0.000899 $mW/cm^2$ / 0.000948 $mW/cm^2$ |
| MPE Limit for | : | 0.6 $mW/cm^2$ |

**Test Result**

The EUT is a portable device. The power density level at 20 cm is 0.000948 $mW/cm^2$, which is below the uncontrolled exposure limit of 0.6 $mW/cm^2$ at 902 MHz to 928 MHz.



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## 5.9 Spurious Emissions

### 5.9.1 Conducted Measurement

| | |
|---|---|
| EUT | UHF RFID READER / DOTR-221 (S/N: 02) |
| Limit apply to | FCC Part 15.247(d) |
| Test Date | February 05, 2008 |
| Operating Condition | RF transmitting continuously during the tested. |
| Result | Pass |

**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. **Measure conducted measurement channel using spectrum analyzer.**
2. **RBW 100 kHz, VBW 3 MHz, Frequency range 30 MHz to 10 GHz.**

Test Engineer : Kug Kyoung, Yoon



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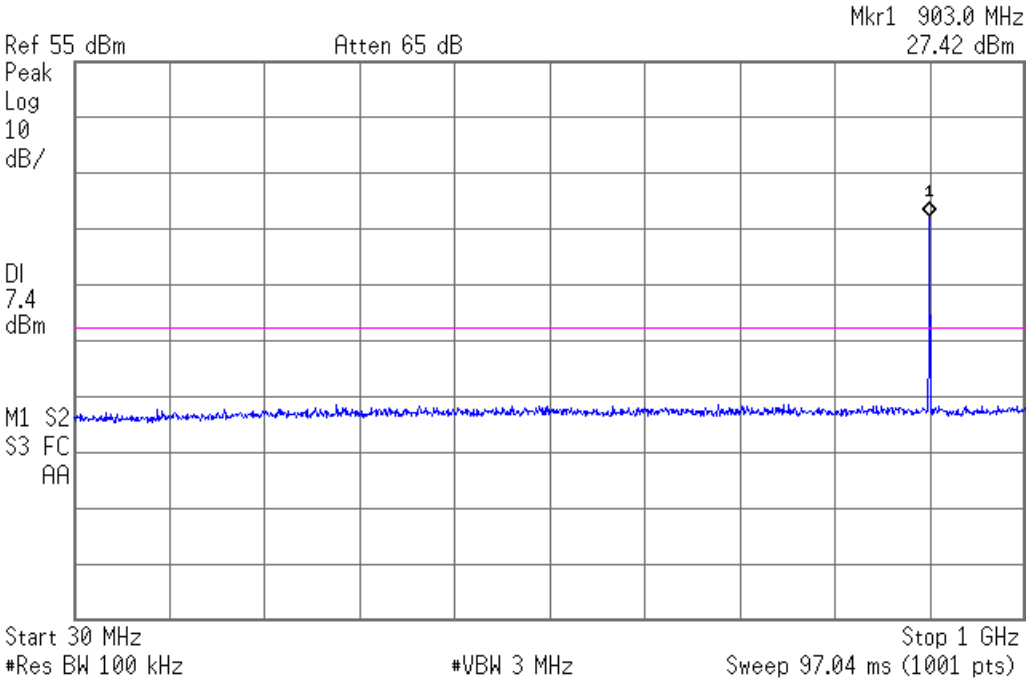
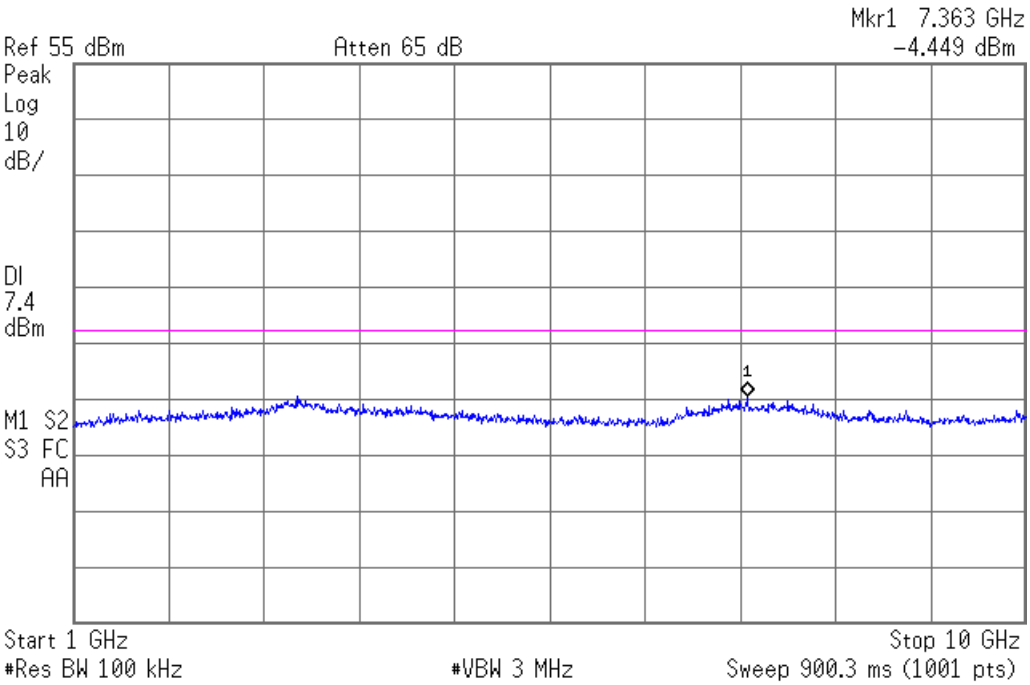
## Spurious Emissions (Conducted Measurement)

[ Low channel: 30 MHz – 10th harmonics]



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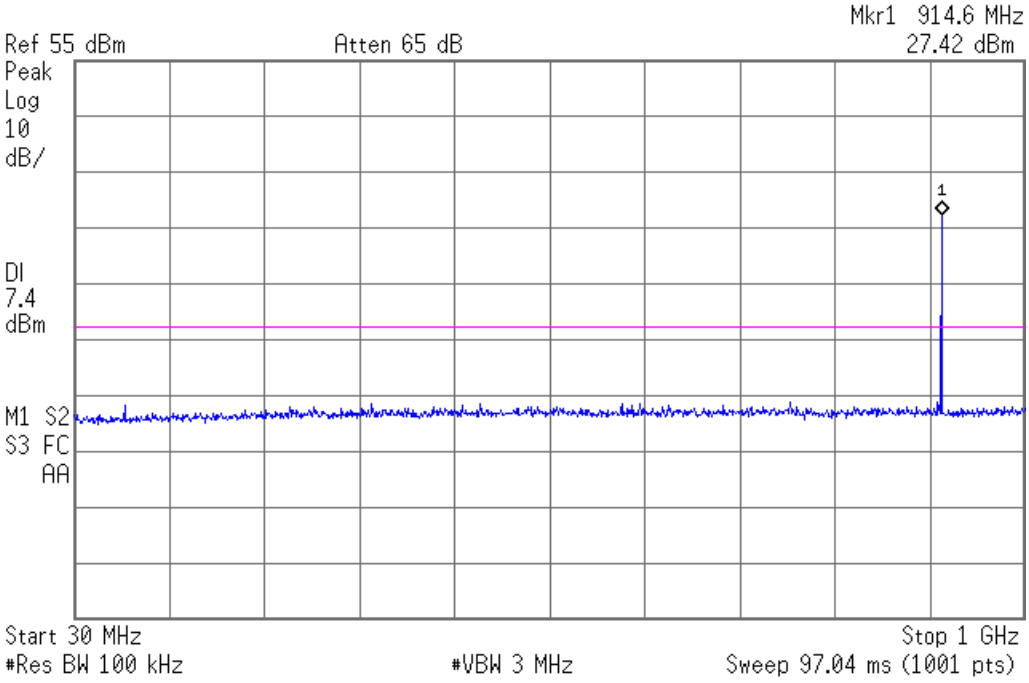
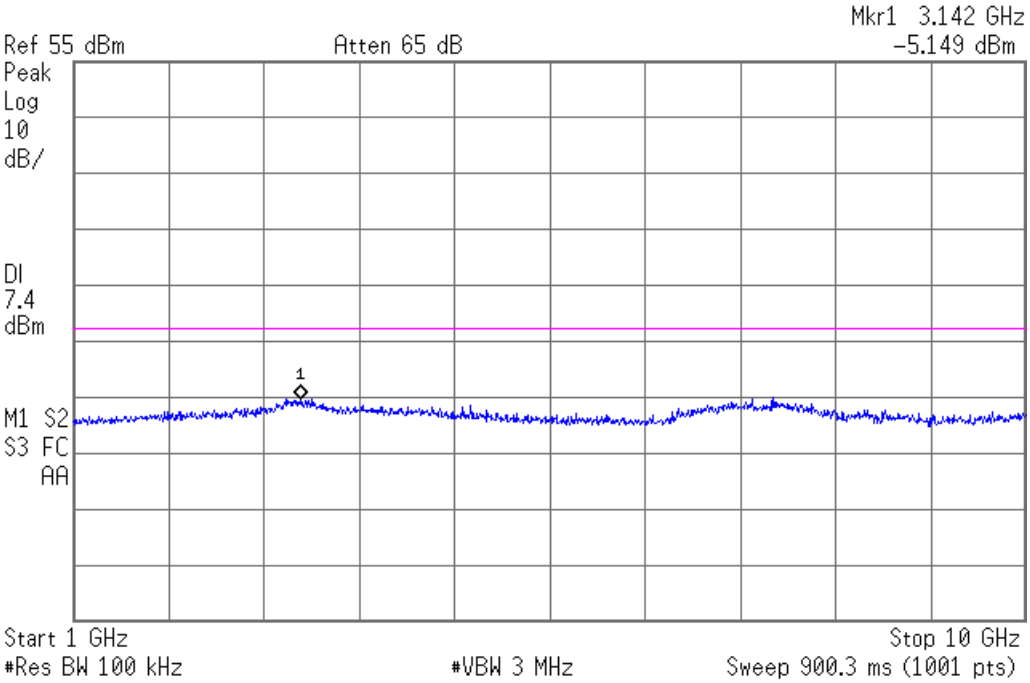
[ Mid channel: 30 MHz – 10th harmonics]



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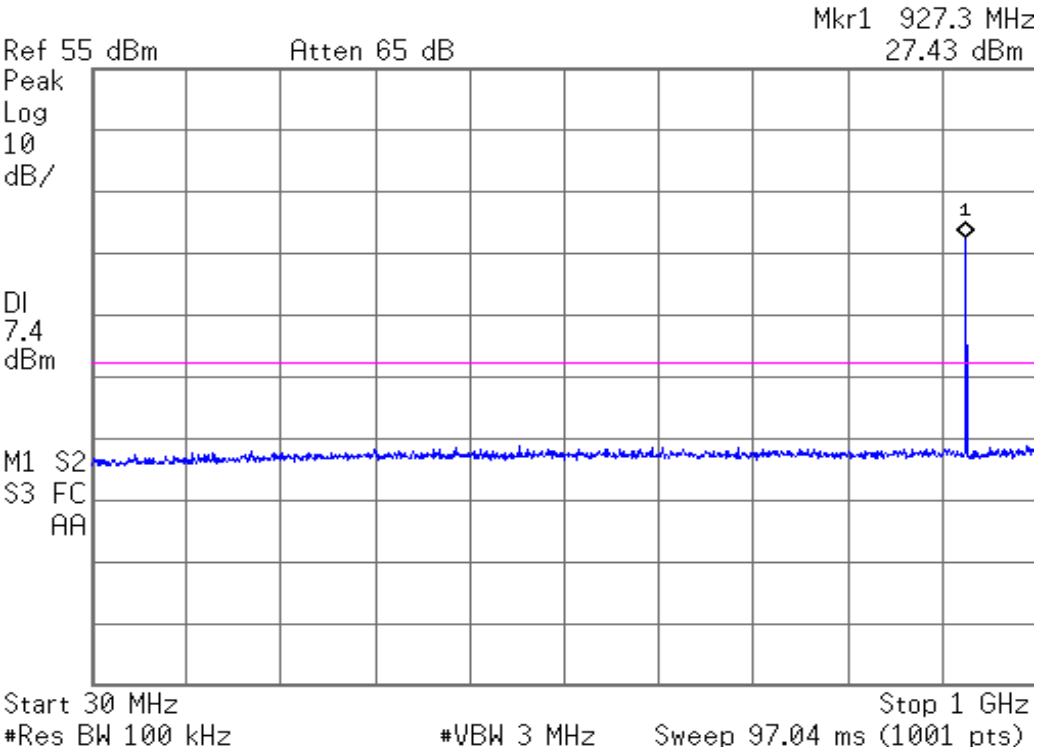
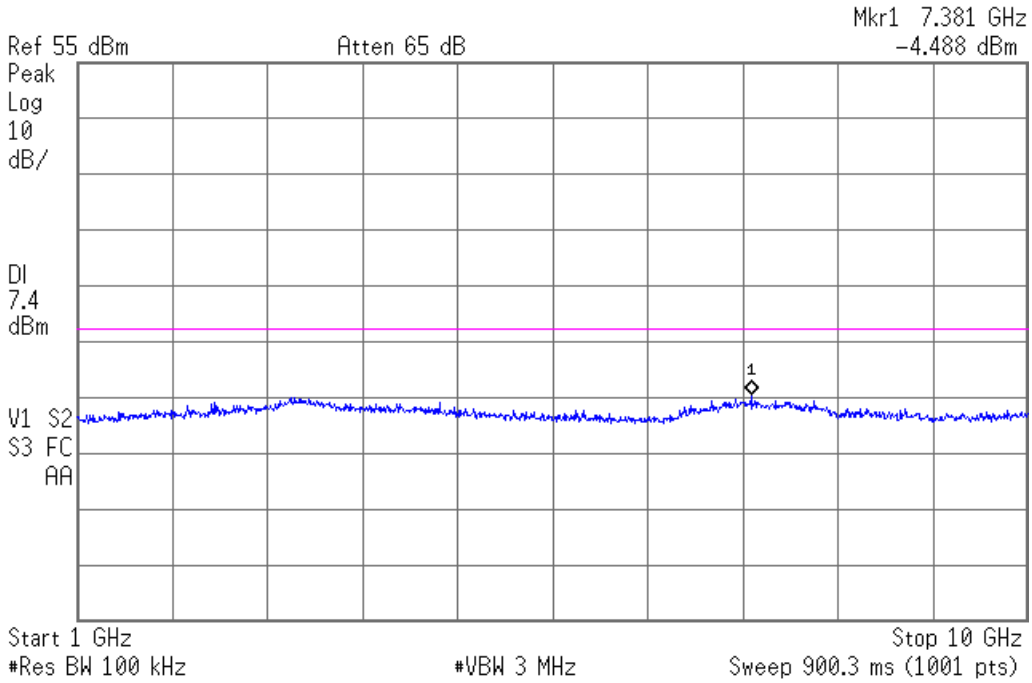
[ High channel: 30 MHz – 10th harmonics]



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### 5.9.2 Radiated Emissions

| | |
|---|---|
| EUT | UHF RFID READER / DOTR-221 (S/N: 02) |
| Limit apply to | FCC Part 15.209 |
| Test Date | February 05, 2008 |
| Operating Condition | Low CH, Middle CH, High CH Transmission |
| Result | Pass |

**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 (uV/m) | Field Strength (dBuV/m) | Measurement Distance (m) |
|---|---|---|---|
| 30 – 88 | 100* | 40 | 3 |
| 88 – 216 | 150* | 43.5 | 3 |
| 216 – 960 | 200* | 46 | 3 |
| Above 960 | 500 | 54 | 3 |

* Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 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.

Test Engineer : Kug Kyoung, Yoon



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## Radiated Emissions Test data

### Below 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)

Patch antenna 1

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dB] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 180,53 | 21,24 | V | 10,05 | 3,91 | 35,20 | 43,50 | 8,30 |
| 200,78 | 19,43 | H | 9,85 | 4,02 | 33,30 | 43,50 | 10,20 |
| 204,15 | 21,65 | H | 9,95 | 4,10 | 35,70 | 43,50 | 7,80 |
| 252,08 | 19,59 | H | 11,33 | 4,88 | 35,80 | 46,00 | 10,20 |
| 276,38 | 21,42 | H | 12,03 | 5,25 | 38,70 | 46,00 | 7,30 |
| 340,25 | 23,44 | H | 13,38 | 5,98 | 42,80 | 46,00 | 3,20 |
| 408,50 | 14,40 | H | 14,60 | 6,70 | 35,70 | 46,00 | 10,30 |

Patch antenna 2

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dB] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 180,55 | 19,24 | V | 10,05 | 3,91 | 33,20 | 43,50 | 10,30 |
| 200,78 | 22,43 | H | 9,85 | 4,02 | 36,30 | 43,50 | 7,20 |
| 252,08 | 20,59 | H | 11,33 | 4,88 | 36,80 | 46,00 | 9,20 |
| 276,35 | 23,42 | H | 12,03 | 5,25 | 40,70 | 46,00 | 5,30 |
| 288,50 | 21,74 | H | 12,38 | 5,38 | 39,50 | 46,00 | 6,50 |
| 408,50 | 18,40 | H | 14,60 | 6,70 | 39,70 | 46,00 | 6,30 |

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**

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

1. Low CH

Patch antenna 1

Detector mode: Peak mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 805,50 | 24,50 | V | 26,10 | 3,50 | 54,10 | 74,00 | 19,90 |
| 2 708,25 | 19,61 | V | 28,35 | 4,85 | 52,81 | 74,00 | 21,19 |

Patch antenna 2

Detector mode: Peak mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 805,50 | 25,50 | V | 26,10 | 3,50 | 55,10 | 74,00 | 20,90 |
| 2 708,25 | 20,61 | V | 28,35 | 4,85 | 53,81 | 74,00 | 22,19 |

Patch antenna 1

Detector mode: Average mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 805,50 | 22,25 | V | 26,10 | 3,50 | 51,85 | 54,00 | 2,15 |
| 2 708,25 | 17,56 | V | 28,35 | 4,85 | 50,76 | 54,00 | 3,24 |

Patch antenna 2

Detector mode: Average mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 805,50 | 22,50 | V | 26,10 | 3,50 | 52,10 | 54,00 | 1,95 |
| 2 708,25 | 17,80 | V | 28,35 | 4,85 | 51,00 | 54,00 | 3,00 |



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2. Middle CH

Patch antenna 1

Detector mode: Peak mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 829,50 | 23,51 | V | 26,30 | 3,60 | 53,41 | 74,00 | 20,59 |
| 2 744,25 | 18,65 | V | 28,40 | 4,90 | 51,95 | 74,00 | 22,05 |

Patch antenna 2

Detector mode: Peak mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 829,50 | 22,51 | V | 26,30 | 3,60 | 52,41 | 74,00 | 21,59 |
| 2 744,25 | 17,65 | V | 28,40 | 4,90 | 50,95 | 74,00 | 23,05 |

Patch antenna 1

Detector mode: Average mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 829,50 | 21,65 | V | 26,30 | 3,60 | 51,55 | 54,00 | 2,45 |
| 2 744,25 | 17,21 | V | 28,40 | 4,90 | 50,51 | 54,00 | 3,49 |

Patch antenna 2

Detector mode: Average mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 829,50 | 21,90 | V | 26,30 | 3,60 | 51,80 | 54,00 | 2,20 |
| 2 744,25 | 17,41 | V | 28,40 | 4,90 | 50,71 | 54,00 | 3,29 |



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3. High CH

Patch antenna 1

Detector mode: Peak mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 854,50 | 23,93 | V | 26,40 | 3,80 | 54,13 | 74,00 | 19,87 |
| 2 781,75 | 18,89 | V | 28,65 | 5,00 | 52,54 | 74,00 | 21,46 |

Patch antenna 2

Detector mode: Peak mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 854,50 | 24,03 | V | 26,40 | 3,80 | 55,13 | 74,00 | 18,87 |
| 2 781,75 | 18,99 | V | 28,65 | 5,00 | 52,64 | 74,00 | 21,36 |

Patch antenna 1

Detector mode: Average mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 854,50 | 21,53 | V | 26,40 | 3,80 | 51,73 | 54,00 | 2,27 |
| 2 781,75 | 17,11 | V | 28,65 | 5,00 | 50,76 | 54,00 | 3,24 |

Patch antenna 2

Detector mode: Average mode

| Frequency [MHz] | Reading [dBμV] | Polarization (*H/**V) | Ant. Factor [dB/m] | Cable Loss [dBμV] | Result [dBμV/m] | Limit [dBμV/m] | Margin [dB] |
|---|---|---|---|---|---|---|---|
| 1 854,50 | 21,73 | V | 26,40 | 3,80 | 51,93 | 54,00 | 2,07 |
| 2 781,75 | 17,20 | V | 28,65 | 5,00 | 50,85 | 54,00 | 3,15 |



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Result: Pass

NOTES :

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



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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

$dB(\mu V) = 20 \log_{10} (uV)$ : Equation

Example : @ 340,25 MHz

Class B Limit = 46,00 dBuV/m

Reading = 23,44 dBuV

Antenna Factor + Cable Loss = 13,38 + 5,98 = 19,36 dBuV/m

Total = 42,80 dBuV/m

Margin = 46,00 – 42,80 = 3,20 dB

= 3,20 dB below Limit



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## 7. List of test equipments used for measurements

| Test Equipment | | Model | Mfg. | Serial No. | Cal. Due Date |
|---|---|---|---|---|---|
| ☒ | EMI TEST Receiver | ESVS10 | R & S | 835165/001 | 08.05.03 |
| ☒ | EMI TEST Receiver | ESPI3 | R & S | 100478 | 08.10.04 |
| ☒ | Spectrum Analyzer | E7405A | H.P | US41160290 | 08.10.05 |
| ☒ | LogBicon Antenna | VULB9165 | Schwarz Beck | 2023 | 08.08.28 |
| ☒ | Broad band Horn antenna | BBHA 9120D | Schwarz Beck | 227 | 09.03.15 |
| ☒ | Broad band Horn antenna | BBHA 9120D | Schwarz Beck | 285 | 09.03.15 |
| ☒ | Preamplifier | 8447D | H.P | 3307A02865 | 08.10.05 |
| ☒ | Turn-Table | DETT-03 | Daeil EMC | - | N/A |
| ☒ | Antenna Master | DEAM-03 | Daeil EMC | - | N/A |

End of test report



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