

## EMC TEST REPORT

*for*

### NEC TOKIN Corporation

Chiyoda First Bldg., 8-1Nishi-Kanda 3-chome  
Chiyoda-ku, Tokyo 101-8362, Japan

Equipment Under Test: 2.4G ISM Band ZigBee RF Modules

Model Name: NT2400R56-2C

Standard: FCC Part 15 Sub.part C

Tokin Report No.: TXU106174

Date of Issue: January 25, 2011

Approved by

  
Hitoshi Aoki  
Manager, Tsukuba Testing Lab.  
Tokin EMC Engineering Co., Ltd.

10. June. 2011

**-- ATTENTION --**

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## 1 DESCRIPTION OF DEVICE (EUT)

FCC ID	YNCNT2400R56-2C	
Serial No.	N/A	
Manufacturer	NEC TOKIN Corporation Chiyoda First Bldg., 8-1 Nishi-Kanda 3-chome Chiyoda-ku, Tokyo 101-8362, Japan	
Type of Sample Tested	Pre-production	
Date of Manufacture	April 2010	
Date of Sample Received	May 10, 2010	
RF Compliant	IEEE Std 802.15.4™ - 2006, ZigBee® PRO	
Frequency Band	2400MHz - 2483.5MHz(16 channels)	
Interference Immunity	Direct Sequence Spread Spectrum (DSSS)	
Transmit Power	Typ. 1.2 mW/MHz (0 dBm)	
Data Rate	250 kb/s	
Indoor/Throw Wall Range	40m (vary according to the environmental conditions)	
Outdoor/RF Line-of-Sight Range	100m (vary according to the environmental conditions)	
Supply Voltage	20MHz:2.7-3.6VDC、5MHz:1.8-3.6VDC (Write operation of Flash:2.7-3.6VDC)	
Supply Current	Transmit Mode	Typ. 30.5mA @ 3VDC:20MHz、 25.4mA @ 3VDC:5MHz
	Receive Mode	Typ. 27.7mA @ 3VDC:20MHz、 22.6mA @ 3VDC:5MHz
	Power-down Mode	< 1.6 uA @ 25°C
Ambient Temperature Range	-20°C~+80°C	
Microcomputer	16bit 78K0R/KE3 uPD78F1146AF1 256KB Flash 12KB RAM	
CPU Clock	Max. 20MHz (Max. 5MHz @ 1.8VDC)	
I/F Connector	DF17(2.0)-060DP-0.5V(57) (HIROSE ELECTRIC CO., LTD)	
Digital I/O	42	
ADC Inputs	8 (10-bit ADC)	
PCB Antenna	Type	Omni-directional radiation
	Maximum Gain	+1.4 dBi
Dimension	30 × 80 × 3.2 mm (excluding connector)	
Weight	6.2g	
Operational Description	Refer to next page	

Report processed by

  
Sayo Tsuchida  
27/Oct./2010

Tested by

  
Yukio Nishimoto  
27/Oct./2010

## **2 Operational Description:**

### **2.4GHz RF module Working Principle Description**

1. It is a 2.4GHz RF module. It works at the frequency of ISM Band(2.4GHz) by Direct Sequence based on the IEEE802.15.4 standard. There are up to 16 channels. Operation frequency range 2405MHz to 2480MHz, and the frequency interval between each channel is 5MHz.
2. Transmit power is 1.2m W/MHz typical.
3. The module with host function is called a coordinator, and the module with terminal function is called an end device.

#### **The working procedures are:**

- a) When power on, the coordinator will do channel seeking to certain to a certain sequence, and then send the connection command.
- b) If there is an end device response, the HOST will judge whether it can be permitted to connect.
- c) It can be permitted to connect, then send the connection command to build up the connection.
- d) The coordinator and devices transmit and receive data according to the polling protocol.
- e) The ad-hoc multi-hop communication becomes possible by arranging two or more coordinators in the same network.

#### **Operation**

1. 2.4GHz RF modules incorporates a Transceiver IC, a MCU, a PCB Trace Antenna and Board-to-Board Connector.
2. The MCU controls the Transceiver IC.
3. The RF modules is connected to the Board-to-Board Connector connects the module with other equipment. Moreover, the power supply to the module through this connector is supplied.
4. This antenna is PCB antenna. The antenna gain of the small mono-pole type is +2.7dBi, and the antenna gain of the omni-directional radiation type is +1.4dBi.
5. It derives about 100m of peer-to-peer range(under the outdoor range) and a larger range using Zig Bee®/mesh or Ad-hoc topologies.

## **3 TEST FACILITY**

The semi anechoic chamber and conducted measurement facility are used for these testing, where are located following address. This chamber's FCC Test firm registration number: 91023. This laboratory is accredited by NVLAP for NVLAP Lab. Code : 200221-0.

Tokin EMC Engineering Co., Ltd.  
Tsukuba Testing Laboratory, Semi Anechoic Chamber No.1 and Shielded Room No.1

Address ; 28-1, Hanashimashinden, Tsukuba-city, Ibaraki 305-0875, Japan



## 4 SUMMARY OF RESULTS

### 4.1 Electromagnetic Emission

RFI Field Strength Measurement .....**PASS**

Conducted Emission Measurement.....**PASS**

### 4.2 Conducted Emission

Maximum Peak Output Power Measurement .....**PASS**

Band edges Measurement .....**PASS**

6dB Band Width Measurement.....**PASS**

Peak Power Spectral Density Measurement.....**PASS**

Radio Frequency Exposure Measurement.....**PASS**

Test results are traceable to PTB, NMI and NPL.

**4.3 Modifications to The EUT :**      None

## 5 TESTED SYSTEM DETAILS

### 5.1 Peripherals and Others :

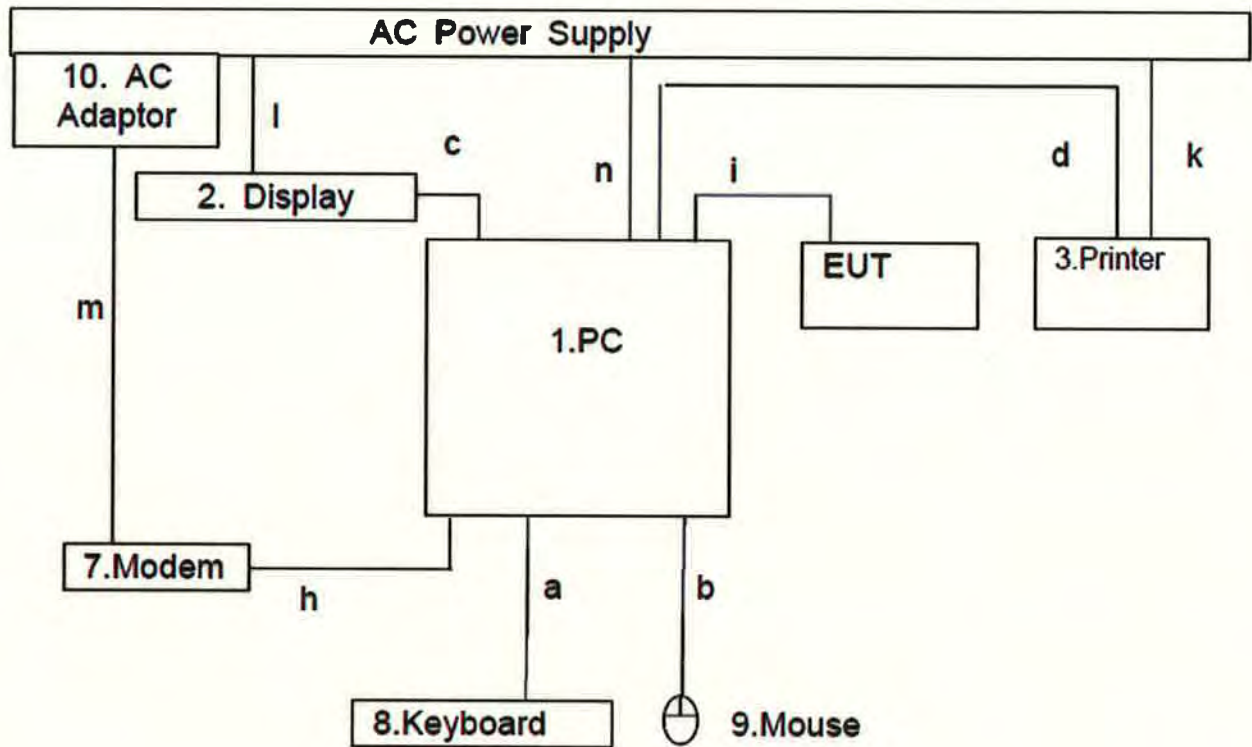
No.	Description	Model Name	Serial No.	Manufacturer	FCC ID
1.	PC	OptiplexGX240	CFHW41X	DELL	---
2.	Display	PE1212	128BN05AB014	Compaq	---
3.	Printer	BJ F660	---	Canon	---
7.	Modem	MODEM1414	9068682	ACEEX	---
8.	Keyboard	SK-8100	---	DELL	---
9.	Mouse	X06-08477	---	DELL	---
10.	AC Adaptor	JTA0302A	LF1R00093800438	JENTEC	---

*\*No.3/No.7 are used in Conducted Emission Measurement.*

### 5.2 Type of Cables Used:

No.	Description	Length	Type of shield	Model name	Manufacturer
a.	Keyboard cable	1.8m	Non-shielded	---	DELL
b.	Mouse cable	1.9m	Non-shielded	---	DELL
c.	Display cable	2.0m	Shielded	---	COMPAQ
d.	Printer cable	1.0m	Shielded	---	Canon
h.	RS-232C cable	1.0m	Shielded	---	I-O data
i.	USB cable	1.1m	Shielded	---	---
k.	AC cable	2.0m	Non-shielded	---	Canon
l.	AC cable	1.7m	Non-shielded	---	Compaq
m.	DC cable	2.0m	Non-shielded	---	JENTEC
n.	AC cable	3.0m	Non-shielded	---	---

*\* d/k/h/m are used in Conducted Emission Measurement.*



**Figure 5-1** System Configuration Diagram

**6 TECHNICAL COUNTERMEASURE:**

None



## 7 TEST RESULTS

### 7.1 RFI Field Strength Measurement

#### 7.1.1 Measurement Instrumentation Used

( model/serial no./manufacturer/Tokin control no./last calibration/next calibration )

<0.009MHz to 30MHz>

EMI Test Receiver.....( FCKL1528/237/Schwarzbeck/RE070/8 Jan.'10/Jan.'11 )  
 Loop Antenna .....( HFH2-Z2/100184/Rohde&Schwarz/AN051/10 Mar'10/Mar'11 )  
 Spectrum Analyzer .....( E7405A/MY45114337/Agilent Technology/SP062/26 Jan.'10/Jan.'11 )  
 Site establishment cable ....( 5D-2W/---/Tokin/DKT12/22 Jan.'10/Jan.'11 )  
 Coaxial cable.....( SUCOFLEX\_104A/43024-4A/SUCOFLEX/DK273/01 Apr.'10/Mar.'11 )  
 Software .....( Software Data Calculation Software TEPTO 2.00/---/AES/---/---/--- )  
 Semi anechoic chamber .....( Tsukuba AC/Tsukuba No.1 AC/Tokin/SA012/22 May'10/May'11 )

<30MHz to 1000MHz>

EMI Test Receiver.....( FCVU1534/143/Schwarzbeck/RE056/12 Dec'09/Dec'10 )  
 Bi-Log antenna .....( VULB9168/244/Schwarzbeck/TB036/22 May'10/May'11 )  
 Biconical antenna.....( BBA9106/2086/Schwarzbeck/TB007/09 Apr.'10/Apr.'11 )  
 Logperiodic antenna.....( UHALP9108-A/0268/Schwarzbeck/TL023/09 Apr.'10/Apr.11 )  
 Pre-amplifier.....( 8447D/2443A04605/Hewlett Packard/AM002/18 Sep.'09/Sep.'10 )  
 Spectrum analyzer .....( E7405A/MY45114337/Agilent Technology/SP062/26 Jan.'10/Jan.'11 )  
 Coaxial cable.....( 5D-2W/---/Tokin/DKT12/22 Jan.'10/Jan.'11 )  
 Software.....( Software Data Calculation Software 2.04/---/AES/SW003-1/---/--- )  
 Semi anechoic chamber .....( Tsukuba AC/Tsukuba No.1 AC/Tokin/SA012/22 May'10/May'11 )

## <1000MHz to 8000MHz>

EMI Test Receiver..... ( ESU8/100211/ROHDE & SCHWARZ/RE071/03 Mar.'10/Mar.'11 )

Double ridged guide

Horn antenna ..... ( BBHA9120A/378/Schwarzbeck/AN040/29 Mar.'10/Mar.'11 )

## <8000MHz to 18000MHz>

Double ridged guide

Horn antenna ..... ( BBHA9120C and HAP06-18W/390 and 00000022/Schwarzbeck/  
AN041/29 Mar.'10/Mar.'11 )

## <18000MHz to 26500MHz>

Standard gain

horn antenna..... ( 12A-18&HAP18-26N/2324&00000008//MI Technologies/  
AN042/11 Mar.'10/Mar.'11 )

## <1000MHz to 18000MHz>

Pre-amplifier ..... ( TPA0108-40/0609/TOYO Corporation/AM043/01 Dec.'09/Nov.'10 )

## <1000MHz to 26500MHz>

Spectrum analyzer ..... ( E7405A/MY45114337/Agilent Technology/SP062/26 Jan.'10/Jan.'11 )

Coaxial cable ..... ( SUCOFLEX\_104A/43881-4A/SUCOFLEX/DK271/01 Apr.'10/Mar.'11 )

Coaxial cable ..... ( SUCOFLEX\_104A/43023-4A/SUCOFLEX/DK272/01 Apr.'10/Mar.'11 )

Coaxial cable ..... ( SUCOFLEX\_104A/43024-4A/SUCOFLEX/DK273/01 Apr.'10/Mar.'11 )

Software..... ( Software Data Calculation Software 2.04/---/AES/SW003-1/---/--- )

Semi anechoic chamber.. ( Tsukuba AC/Tsukuba No.1 AC/Tokin/SA012/22 May'10/May'11 )

The measurement instrumentation used, are calibrated according to Quality Manual.

### 7.1.2 Measurement Procedure

Final test was performed according to FCC Part 15 Sub.part C in semi anechoic chamber No.1. There were no deviations from the standard.

The EUT was placed in a 0.8m high table along with the peripherals. The turntable was separated from the antenna distance 3 meter. Cables were placed in a position to produce maximum emissions as determined by experimentation, and operation mode was selected for maximum.

The frequencies and amplitudes of maximum emission were measured at varying azimuths, antenna heights and antenna polarities. Reported are maximized emission levels.

These tests were performed at 120kHz of 6dB bandwidth.

Test results were obtained from following equation.

$$\text{Result (dB}\mu\text{V/m)} = \text{Level (dB}\mu\text{V)} + \text{Ant. Factor (dB/m)} + \text{Cable Loss (dB)} - \text{Amp. Gain (dB)}$$

*\*Test Board : NTR2400R56-2-K, Test Soft-ware controlled by windows hyper terminal.*

**7.1.3 Deviation from the specification:**      None

### 7.1.4 Measurement Uncertainty

Measurement uncertainty of 30MHz to 300MHz is +/-4.04dB(k=2), 300MHz to 1000MHz is +/-3.97dB(k=2), 1000MHz to 26500MHz is +/-4.86dB(k=2) .

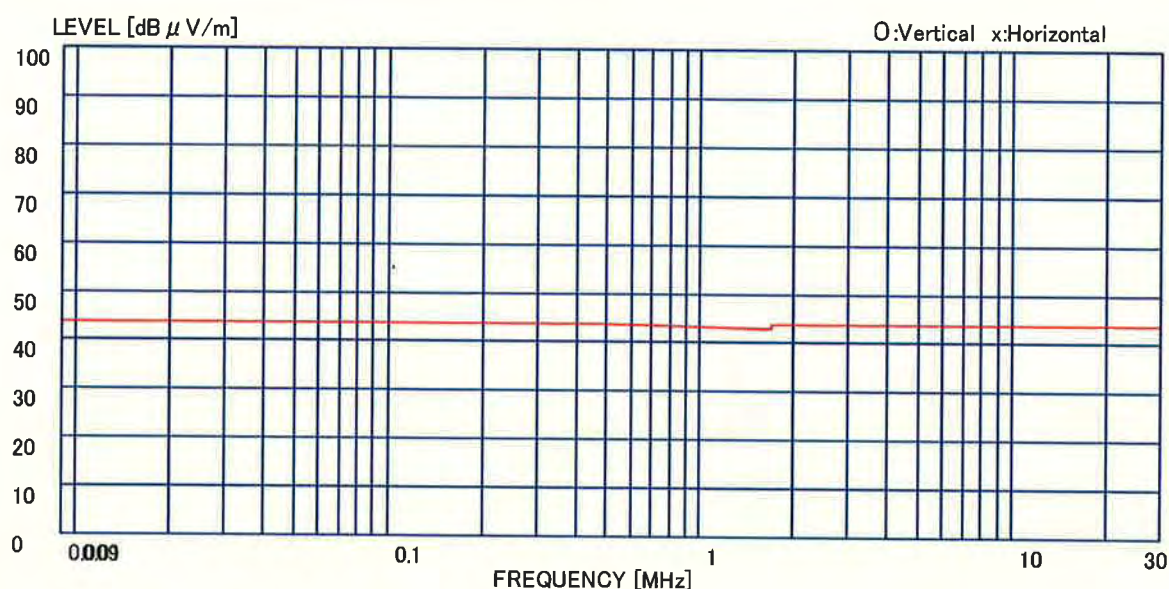
## 7.1.5 Test Data

**Table 7.1-1a** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<0.009MHz to 30MHz>

Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2405MHz

Frequency (MHz)	Level Ver. Hor. (dBμV)	Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result Ver. Hor. (dBμV/m)	Result Ver. Hor. (μV/m)	3 Meter Limit (dBμV/m)	Margin Ver. Hor. (dB)
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*Test results were under the required limit with 20dB margin or more.*



**Figure 7.1-1a** RFI Field Strength Measurement Results

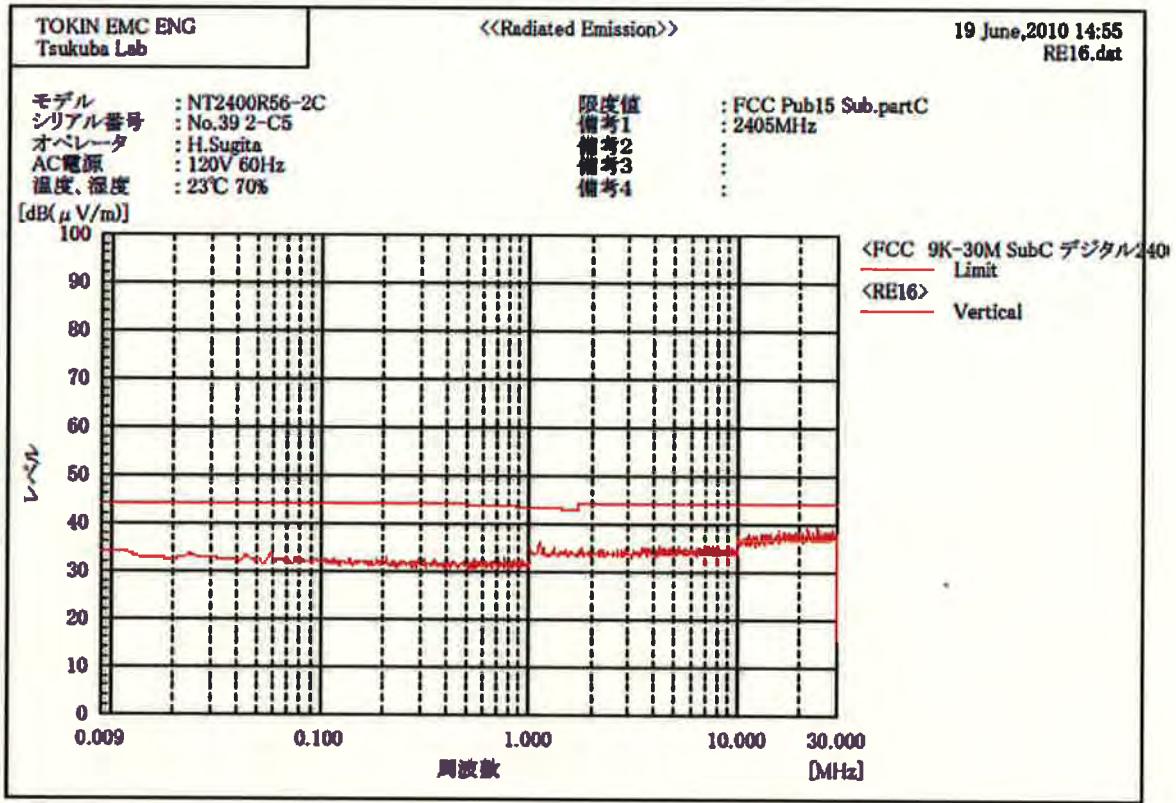
Frequency (MHz)	dBμV/m	Distance(m)
0.009 ~ 0.490	43.9	3
0.490 ~ 1.705	43.9 ~ 42.9	3
1.705 ~ 30	49.5 ~ 49.5	3

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-4a, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Subpart C requirement.



**Table 7.1-1b** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<0.009MHz to 30MHz>

Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2405MHz

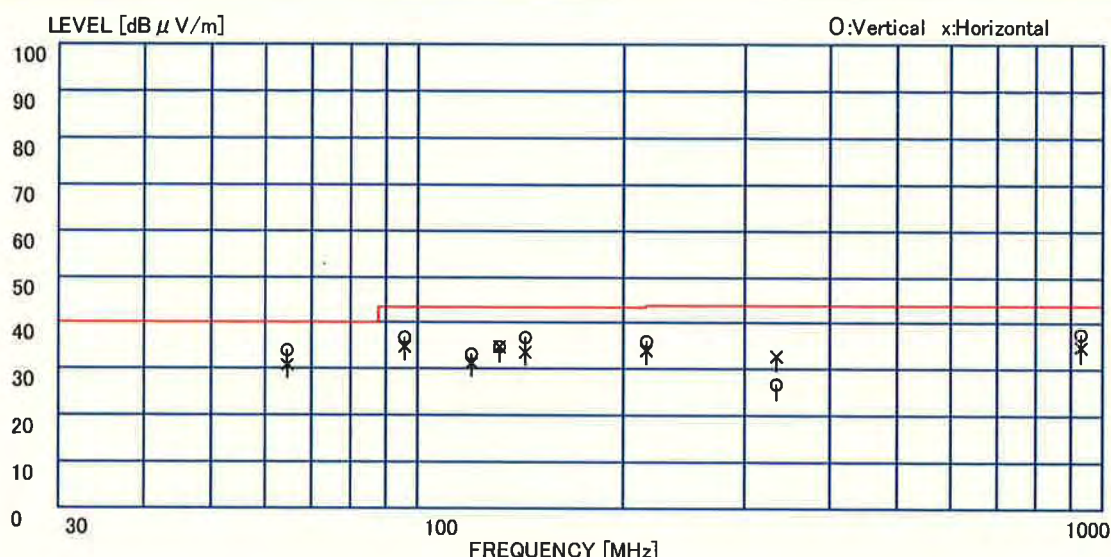




**Table 7.1-1c** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<30MHz to 1000MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2405MHz

Frequency (MHz)	Level		Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result		3m Limit (dBμV/m)	Margin	
	Ver. (dBμV)	Hor. (dBμV)				Ver. (dBμV/m)	Hor. (dBμV/m)		Ver. (dB)	Hor. (dB)
64.85	52.0	49.0	1.7	-27.0	7.4	34.1	31.1	40.0	5.9	8.9
96.00	52.0	50.0	2.1	-27.0	9.9	37.0	35.0	43.5	6.5	8.5
120.00	45.0	43.0	2.4	-27.0	13.1	33.5	31.5	43.5	10.0	12.0
132.00	45.0	45.0	2.5	-26.9	14.3	34.9	34.9	43.5	8.6	8.6
144.00	46.0	43.0	2.7	-26.9	15.2	37.0	34.0	43.5	6.5	9.5
216.00	42.0	40.0	3.4	-26.9	17.9	36.4	34.4	43.5	7.1	9.1
332.75	34.0	40.0	4.4	-27.0	15.5	26.9	32.9	43.9	17.0	11.0
930.55	33.0	30.0	7.8	-26.1	23.2	37.9	34.9	43.9	6.0	9.0



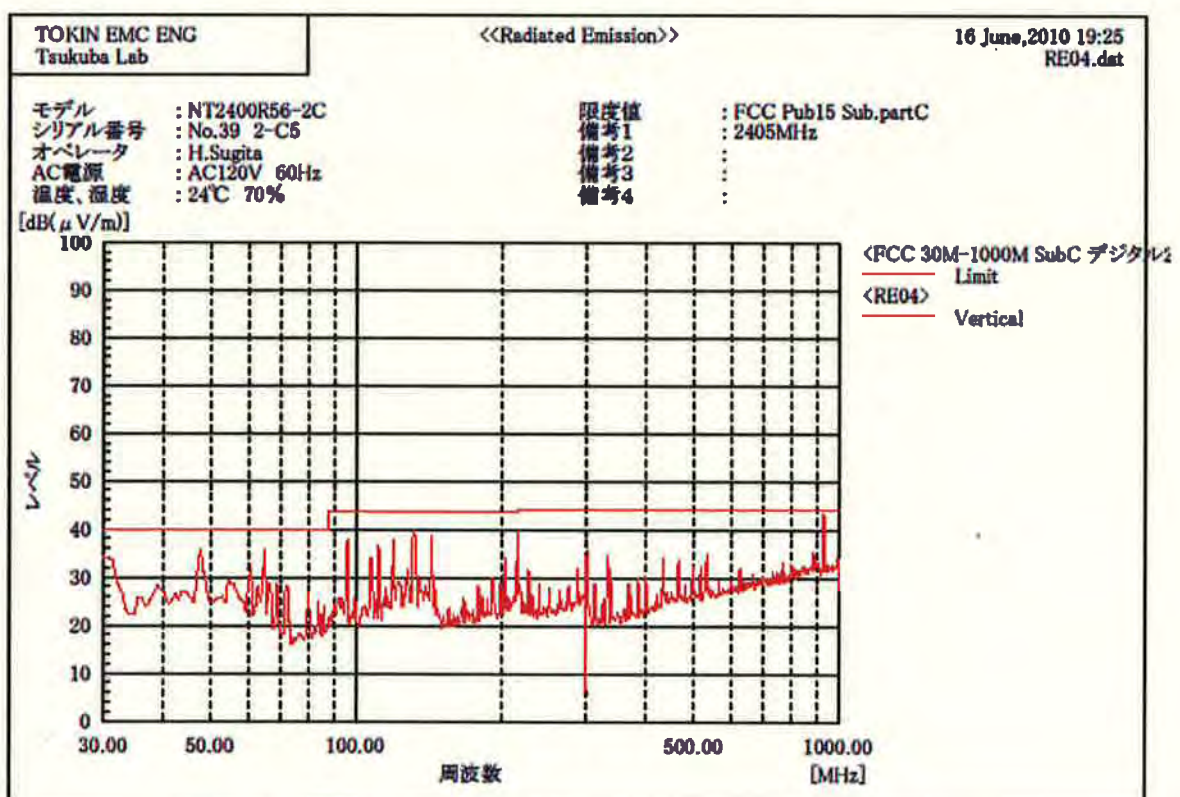
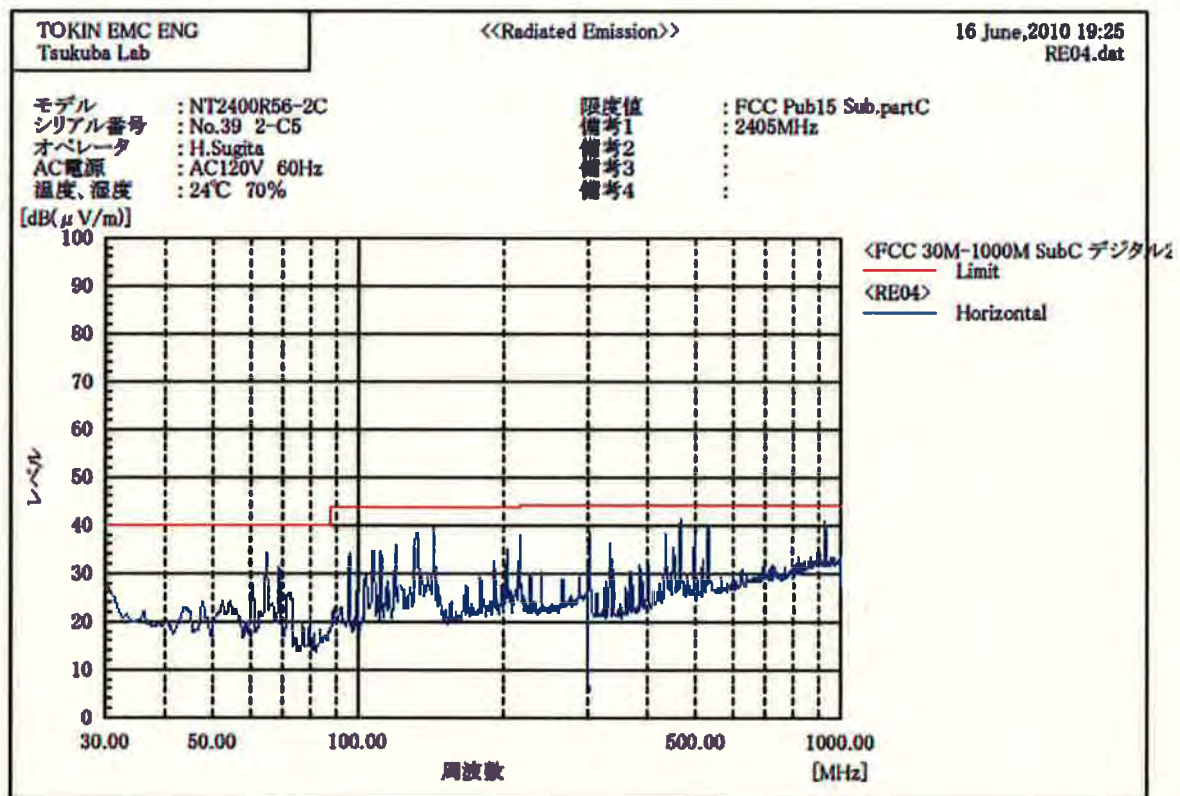
**Figure 7.1-1b** RFI Field Strength Measurement Results

Frequency (MHz)	dBμV/m	Distance(m)
30 ~ 88	40	3
88 ~ 216	43.5	3
216 ~ 960	43.9	3
960 ~ 26500	43.9	3

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-4b, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.

**Table 7.1-1d** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<30MHz to 1000MHz>

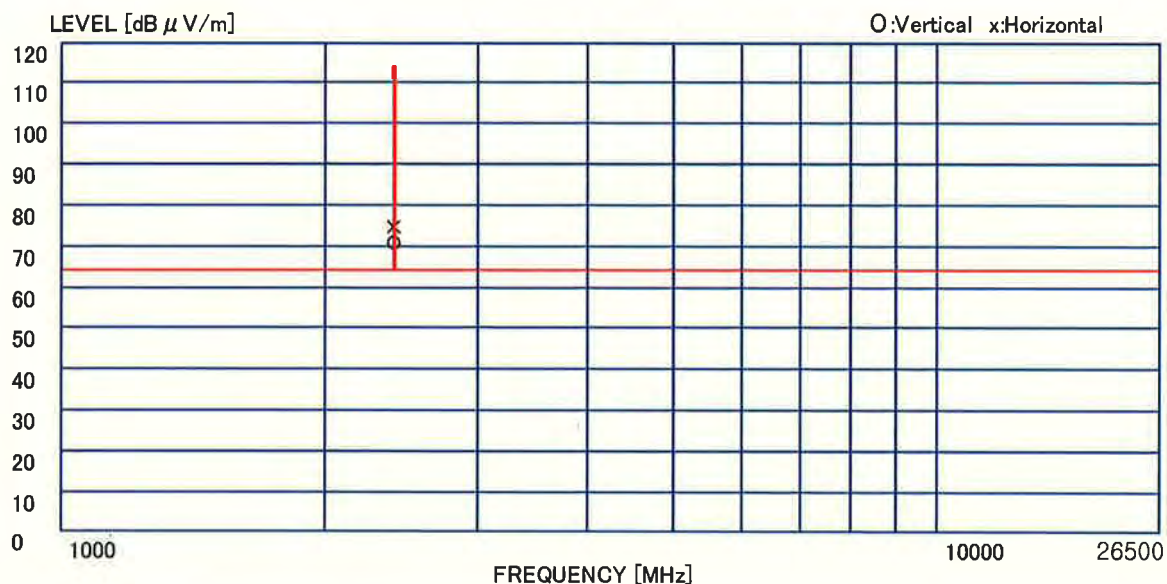
Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2405MHz



**Table 7.1-1e** RFI Field Strength Measurement Results (Peak Measurement)  
<1000MHz to 26500MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2405MHz

Frequency (MHz)	Level		Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result		3m Limit (dBμV/m)	Margin	
	Ver. (dBμV)	Hor. (dBμV)				Ver. (dBμV/m)	Hor. (dBμV/m)		Ver. (dB)	Hor. (dB)
2405.00	83.1	86.7	5.3	-44.0	26.5	70.9	74.5	113.9	43.0	39.4



**Figure 7.1-1c** RFI Field Strength Measurement Results

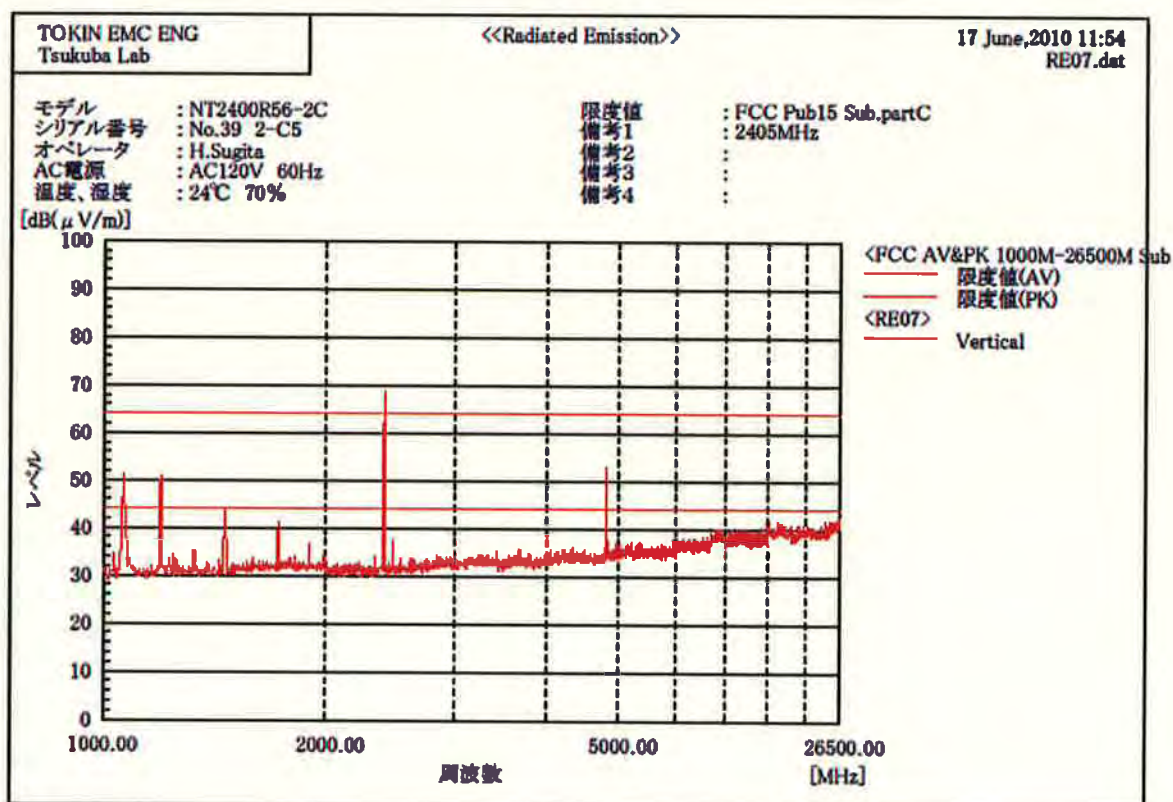
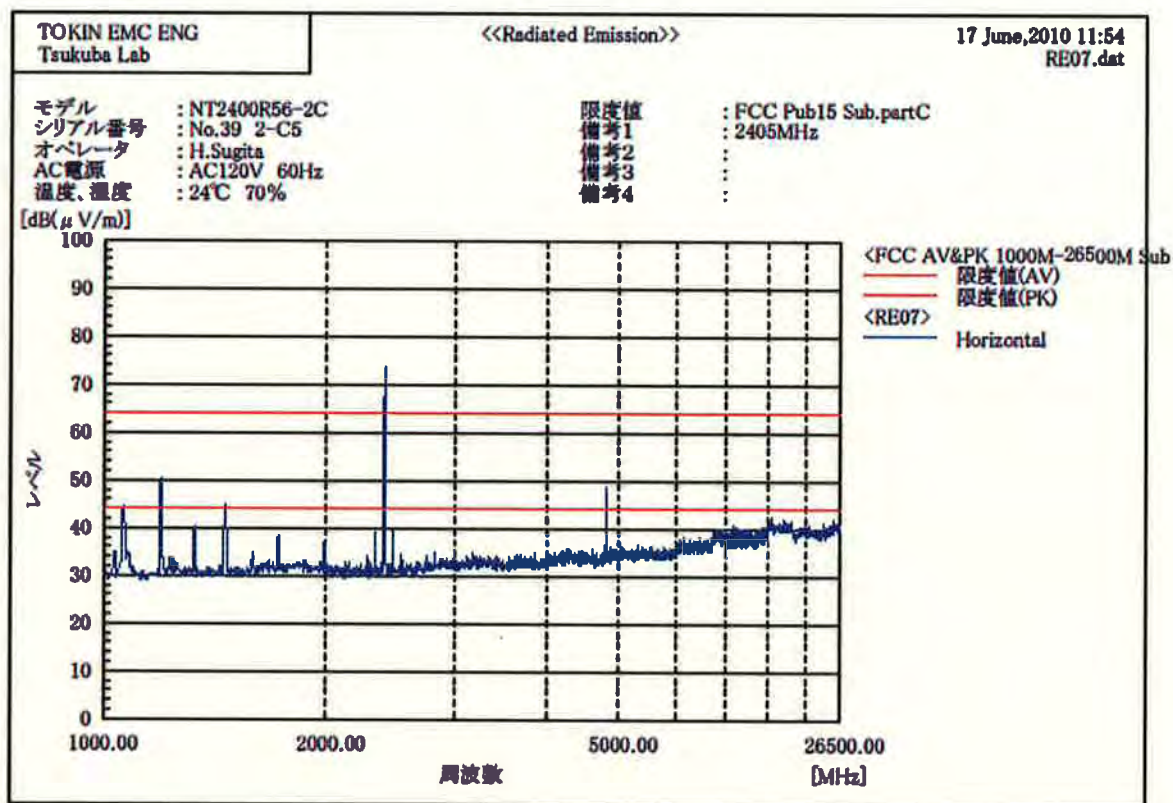
Frequency (MHz)	dBμV/m	Distance(m)
1000 ~ 26500	113.9	3

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-4c, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.



**Table 7.1-1f** RFI Field Strength Measurement Results (Peak Measurement)  
<1000MHz to 26500MHz>

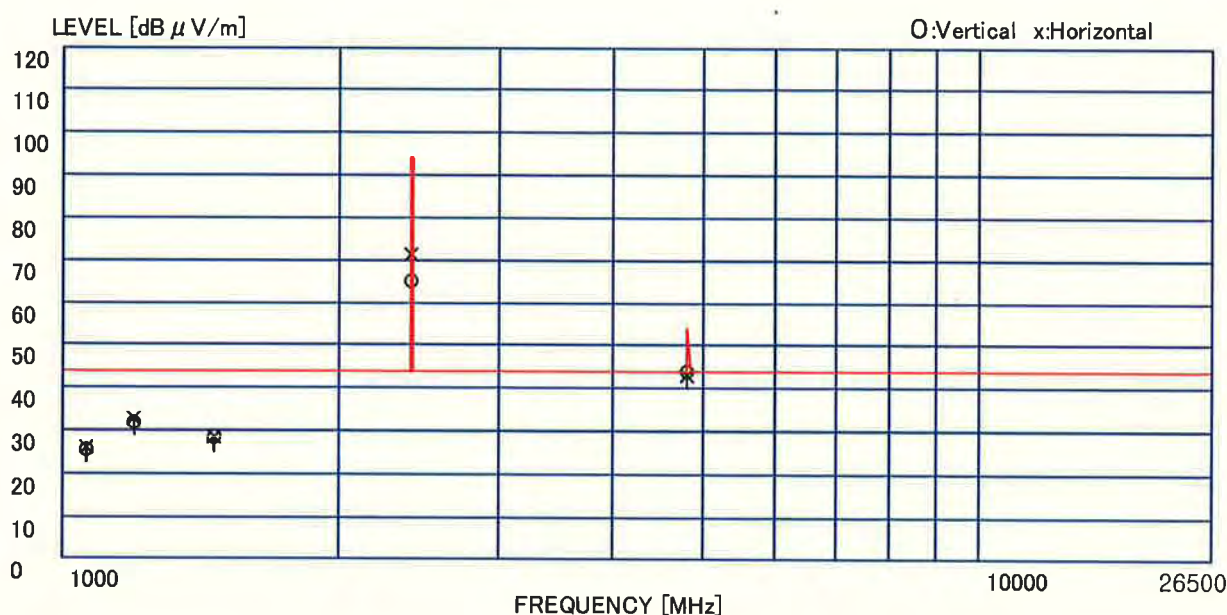
Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2405MHz



**Table 7.1-1g** RFI Field Strength Measurement Results (Average Measurement)  
<1000MHz to 26500MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2405MHz

Frequency (MHz)	Level		Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result		3m Limit (dBμV/m)	Margin	
	Ver. (dBμV)	Hor. (dBμV)				Ver. (dBμV/m)	Hor. (dBμV/m)		Ver. (dB)	Hor. (dB)
1064.50	42.1	42.5	3.5	-45.4	25.6	25.8	26.2	43.9	18.1	17.7
1197.50	47.2	48.4	3.8	-45.1	26.1	32.0	33.2	43.9	11.9	10.7
1462.20	43.1	42.8	4.1	-44.6	26.0	28.6	28.3	43.9	15.3	15.6
2405.00	77.2	83.5	5.3	-44.0	26.5	65.0	71.3	93.9	28.9	22.6
4810.00	51.0	50.2	7.7	-43.7	28.7	43.7	42.9	53.9	10.2	11.0



**Figure 7.1-1d** RFI Field Strength Measurement Results

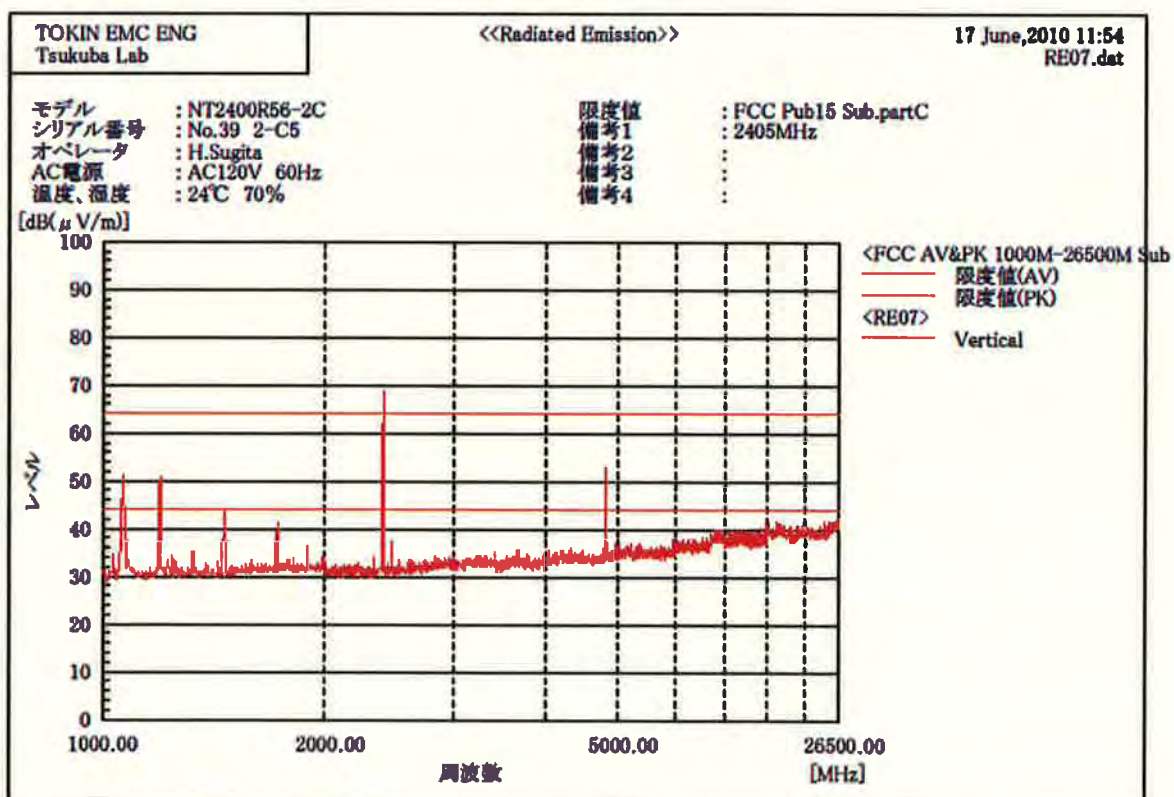
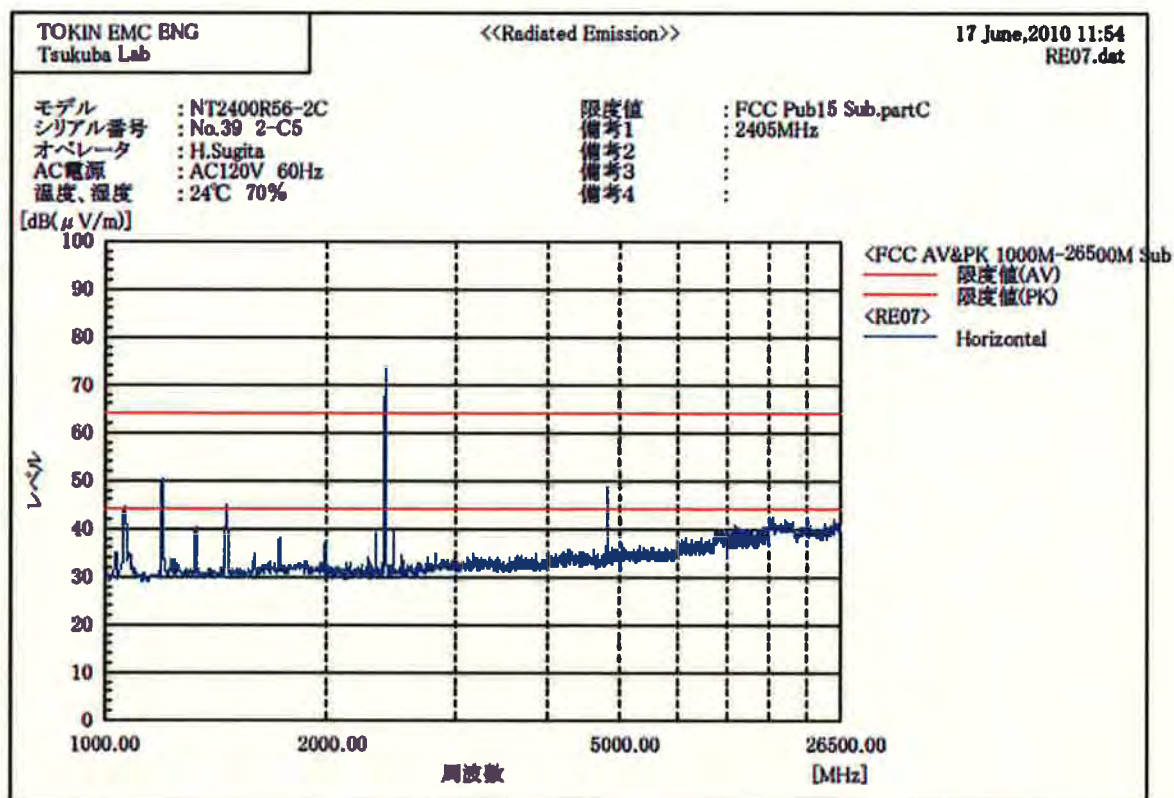
Frequency (MHz)	dBμV/m	Distance(m)
1000 ~ 26500	93.9	3(Fundamental wave)
1000 ~ 26500	53.9	3(Higher harmonics wave)

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-4d, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.



**Table 7.1-1h** RFI Field Strength Measurement Results (Average Measurement)  
<1000MHz to 26500MHz>

Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2405MHz

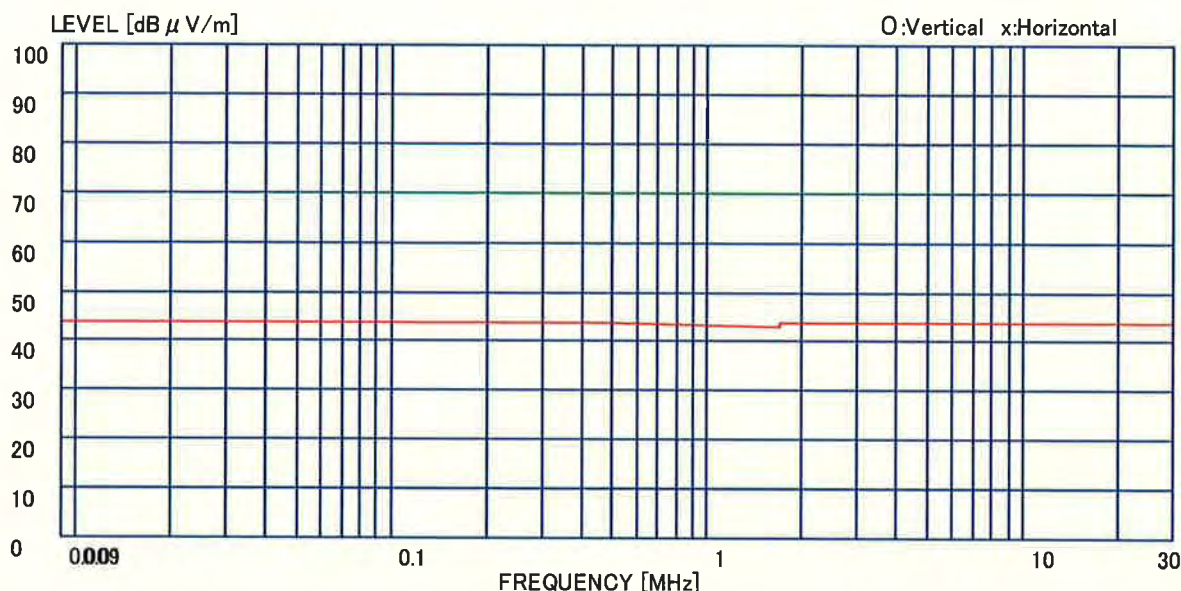


**Table 7.1-2a** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<0.009MHz to 30MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2440MHz

Frequency (MHz)	Level Ver. Hor. (dBμV)	Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result Ver. Hor. (dBμV/m)	Result Ver. Hor. (μV/m)	3 Meter Limit (dBμV/m)	Margin Ver. Hor. (dB)
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*Test results were under the required limit with 20dB margin or more.*



**Figure 7.1-2a** RFI Field Strength Measurement Results

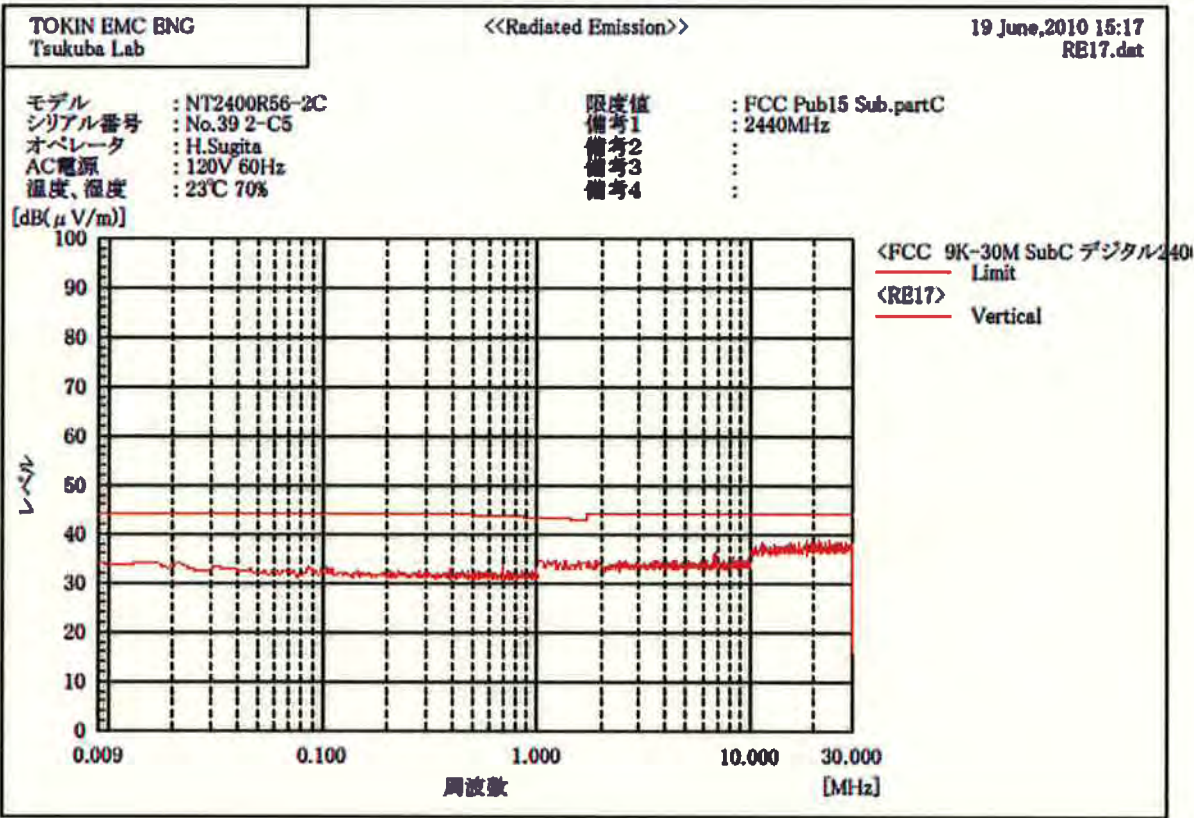
Frequency (MHz)	dBμV/m	Distance(m)
0.009 ~ 0.490	43.9	3
0.490 ~ 1.705	43.9 ~ 42.9	3
1.705 ~ 30	49.5 ~ 49.5	3

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-5a, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.



Table 7.1-2b RFI Field Strength Measurement Results (Q-Peak Measurement)  
<0.009MHz to 30MHz>

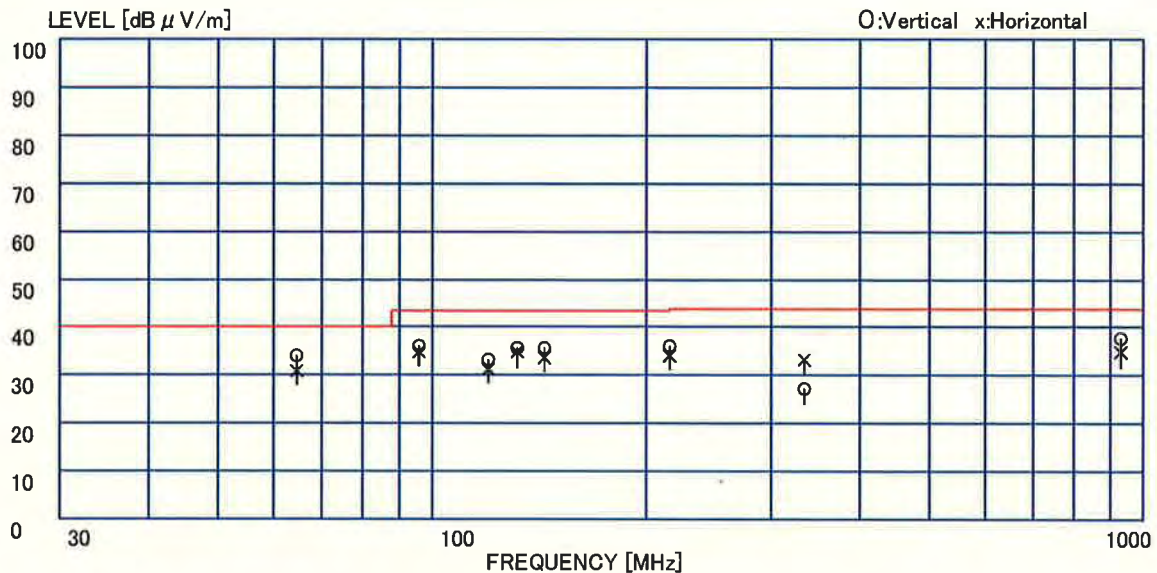
Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2440MHz



**Table 7.1-2c** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<30MHz to 1000MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2440MHz

Frequency (MHz)	Level		Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result		3m Limit (dBμV/m)	Margin	
	Ver. (dBμV)	Hor. (dBμV)				Ver. (dBμV/m)	Hor. (dBμV/m)		Ver. (dB)	Hor. (dB)
64.85	52.0	49.0	1.7	-27.0	7.4	34.1	31.1	40.0	5.9	8.9
96.00	51.0	50.0	2.1	-27.0	9.9	36.0	35.0	43.5	7.5	8.5
120.00	45.0	43.0	2.4	-27.0	13.1	33.5	31.5	43.5	10.0	12.0
132.00	46.0	45.0	2.5	-26.9	14.3	35.9	34.9	43.5	7.6	8.6
144.00	45.0	43.0	2.7	-26.9	15.2	36.0	34.0	43.5	7.5	9.5
216.00	42.0	40.0	3.4	-26.9	17.9	36.4	34.4	43.5	7.1	9.1
332.75	34.5	40.5	4.4	-27.0	15.5	27.4	33.4	43.9	16.5	10.5
930.55	33.0	30.0	7.8	-26.1	23.2	37.9	34.9	43.9	6.0	9.0



**Figure 7.1-2b** RFI Field Strength Measurement Results

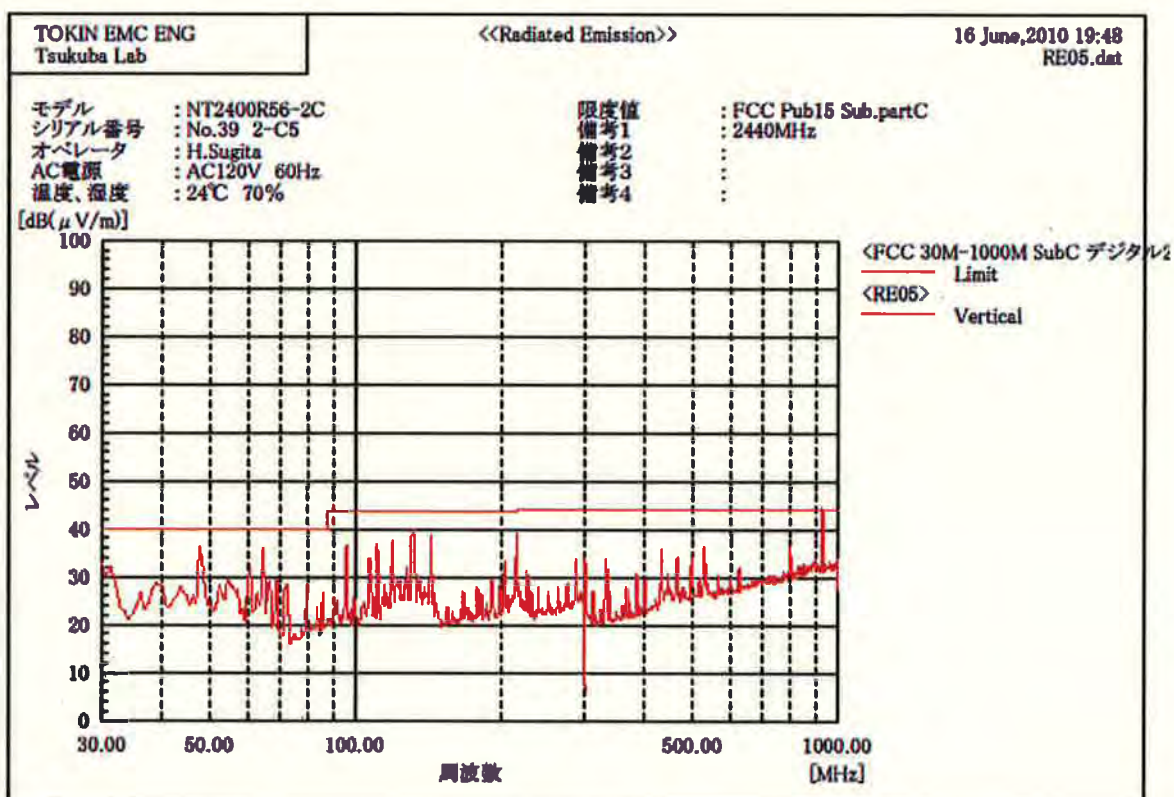
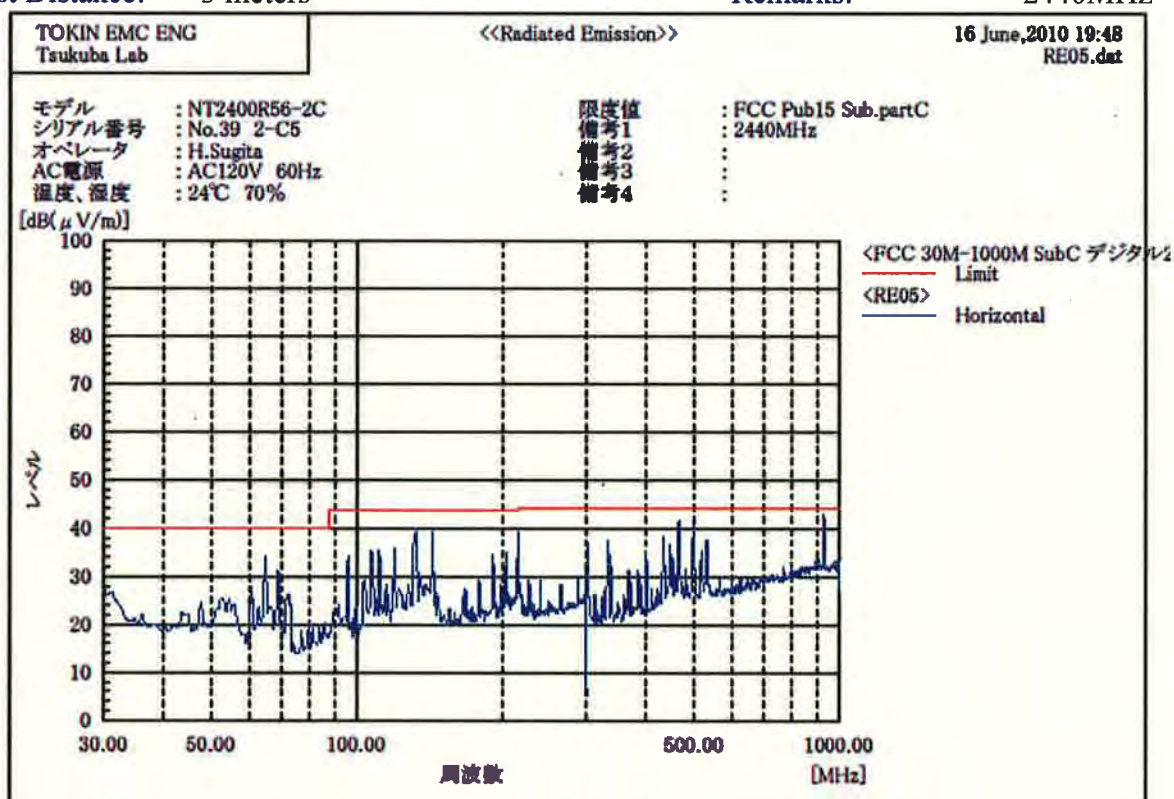
Frequency (MHz)	dBμV/m	Distance(m)
30 ~ 88	40	3
88 ~ 216	43.5	3
216 ~ 960	43.9	3
960 ~ 26500	43.9	3

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-5b, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.



**Table 7.1-2d** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<30MHz to 1000MHz>

Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2440MHz

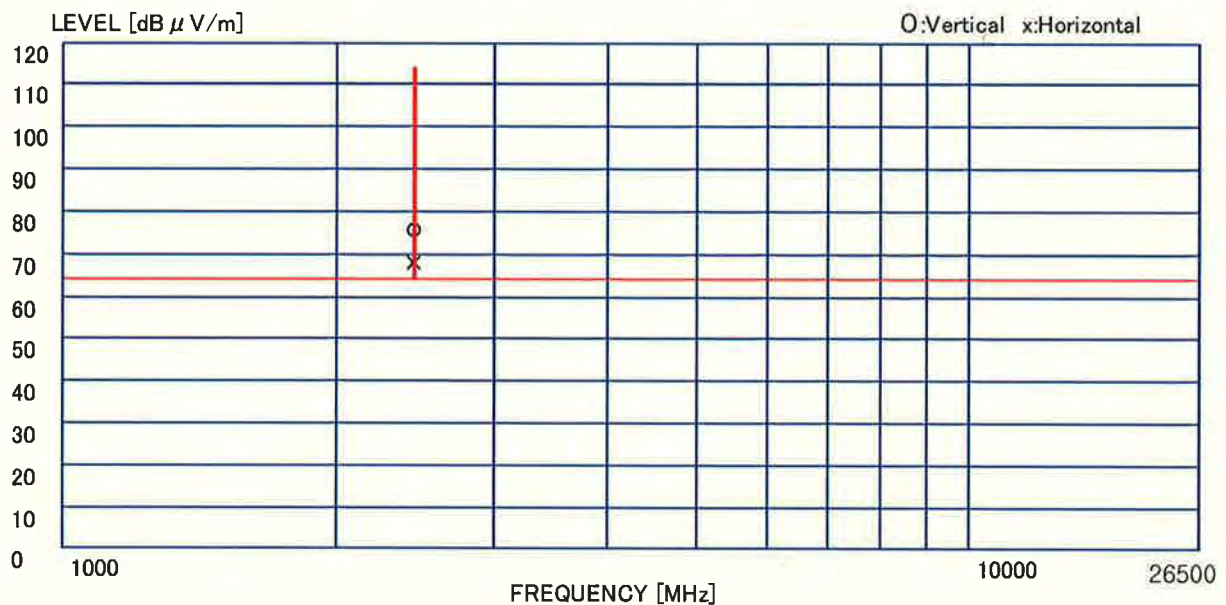




**Table 7.1-2e** RFI Field Strength Measurement Results (Peak Measurement)  
<1000MHz to 26500MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2440MHz

Frequency (MHz)	Level		Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result		3m Limit (dBμV/m)	Margin	
	Ver. (dBμV)	Hor. (dBμV)				Ver. (dBμV/m)	Hor. (dBμV/m)		Ver. (dB)	Hor. (dB)
2440.00	87.6	80.1	5.3	-44.0	26.6	75.5	68.0	113.9	38.4	45.9



**Figure 7.1-2c** RFI Field Strength Measurement Results

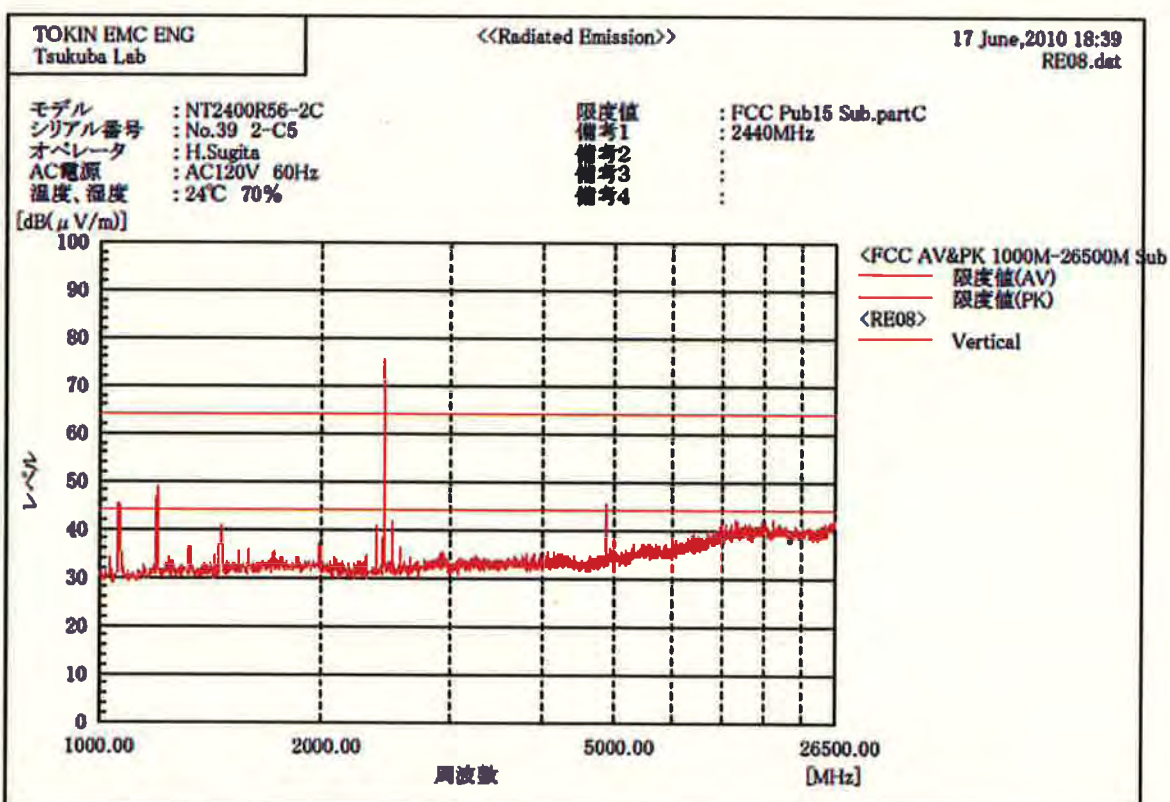
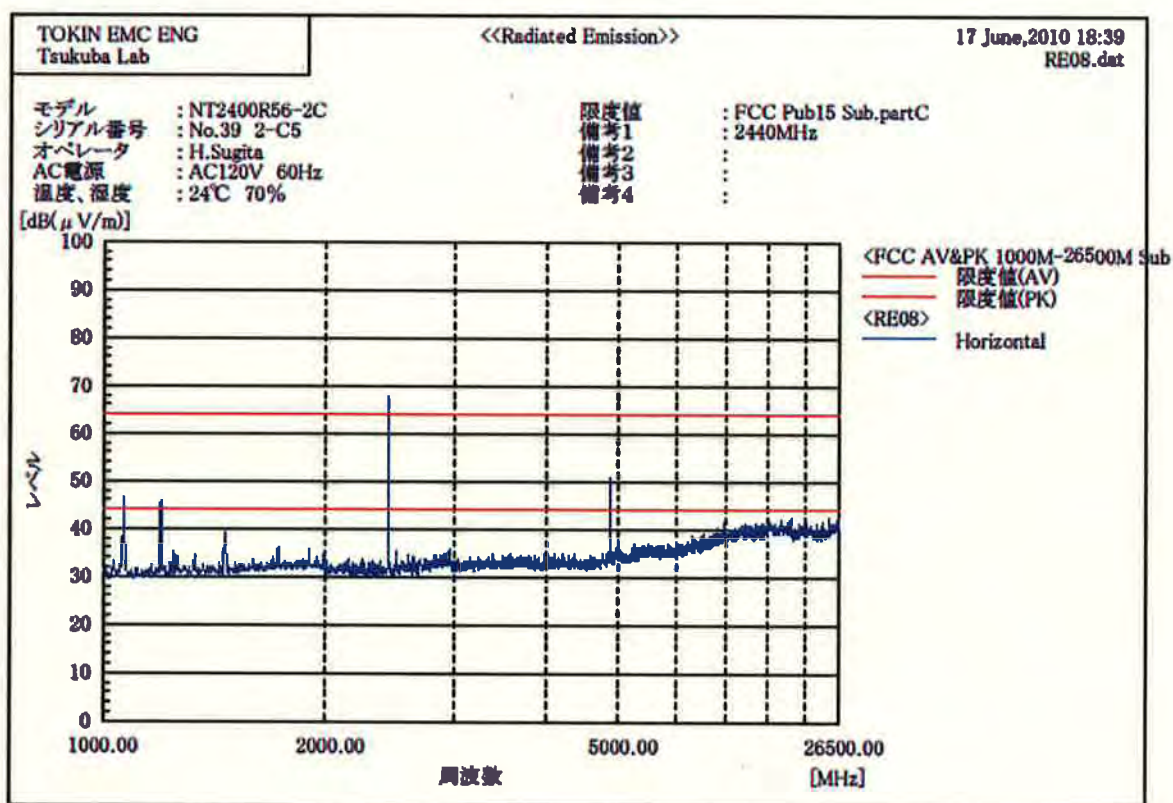
Frequency (MHz)	dBμV/m	Distance(m)
1000 ~ 26500	113.9	3

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-5c, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.

**Table 7.1-2f** RFI Field Strength Measurement Results (Peak Measurement)  
<1000MHz to 26500MHz>

Model Name: NT2400R56-2C  
Operating mode: Modulation Mode  
Test condition: Power input DC\_1.8V  
Test Distance: 3 meters\*

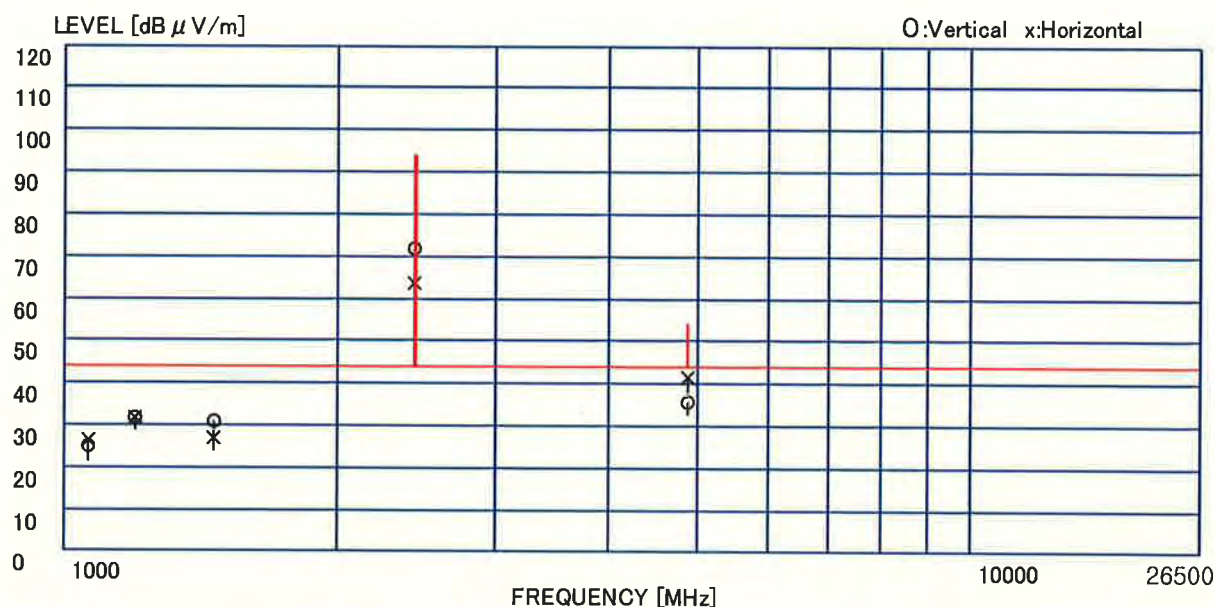
Date of measurement: June 23, 2010  
Temperature: 24 degree C  
Humidity: 70 %  
Remarks: 2440MHz



**Table 7.1-2g** RFI Field Strength Measurement Results (Average Measurement)  
<1000MHz to 26500MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2440MHz

Frequency (MHz)	Level		Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result		3m Limit (dBμV/m)	Margin	
	Ver. (dBμV)	Hor. (dBμV)				Ver. (dBμV/m)	Hor. (dBμV/m)		Ver. (dB)	Hor. (dB)
1064.50	41.2	42.8	3.5	-45.4	25.6	24.9	26.5	43.9	19.0	17.4
1197.50	47.3	47.1	3.8	-45.1	26.1	32.1	31.9	43.9	11.8	12.0
1462.10	45.5	41.5	4.1	-44.6	26.0	31.0	27.0	43.9	12.9	16.9
2440.00	83.7	75.4	5.3	-44.0	26.6	71.6	63.3	93.9	22.3	30.6
4880.00	42.6	48.2	7.8	-43.7	29.0	35.7	41.3	53.9	18.2	12.6



**Figure 7.1-2d** RFI Field Strength Measurement Results

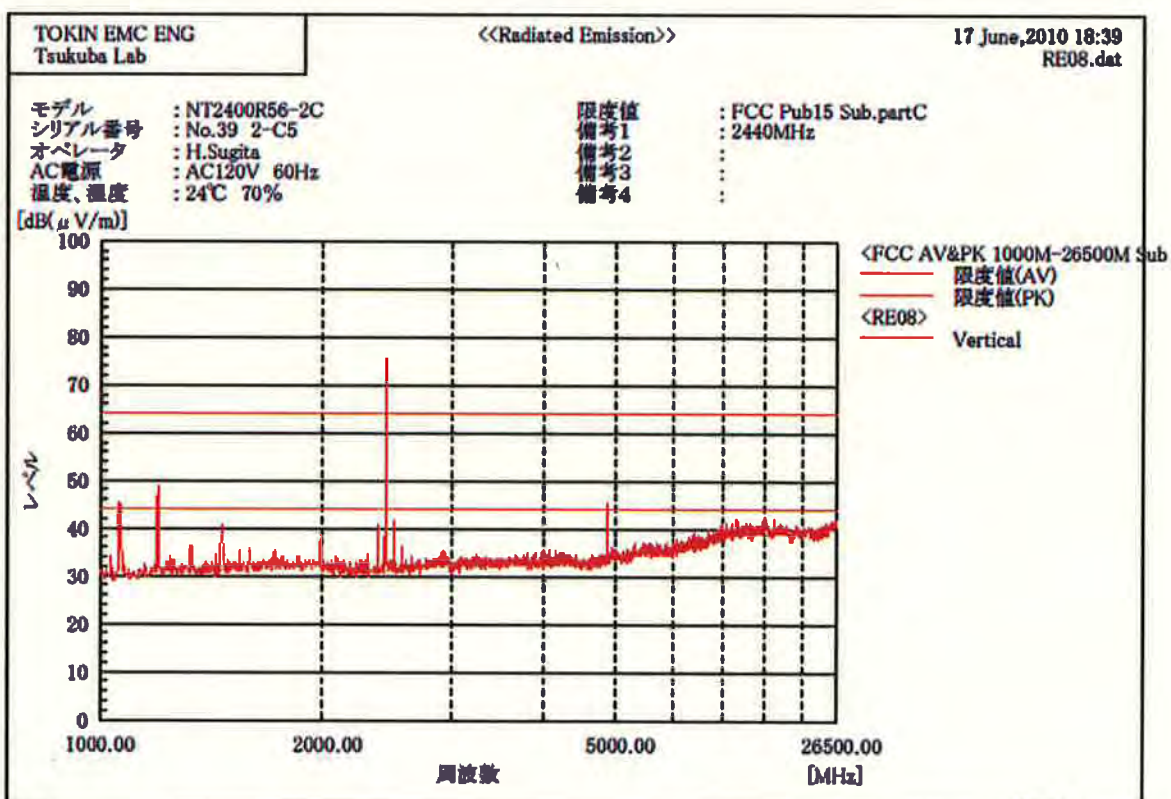
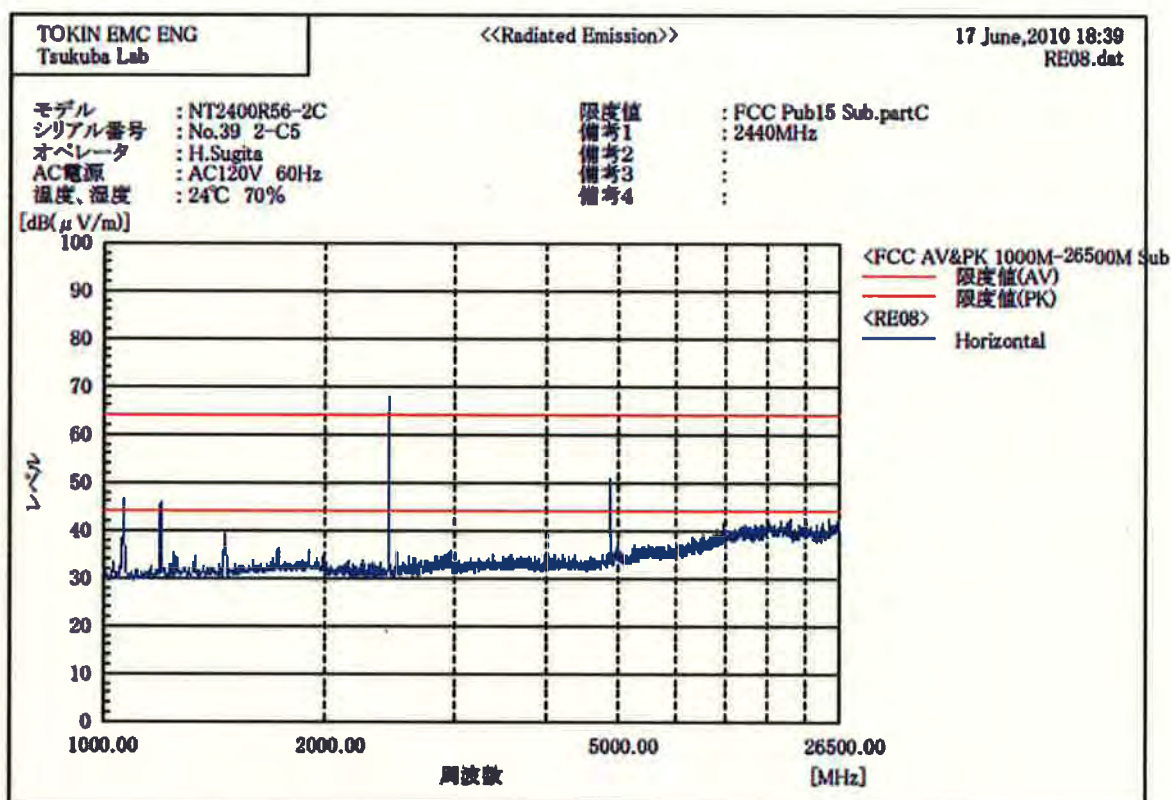
Frequency (MHz)	dBμV/m	Distance(m)
1000 ~ 26500	93.9	3(Fundmental wave)
1000 ~ 26500	53.9	3(Higher harmonics wave)

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-5d, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.



**Table 7.1-2h** RFI Field Strength Measurement Results (Average Measurement)  
<1000MHz to 26500MHz>

Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2440MHz

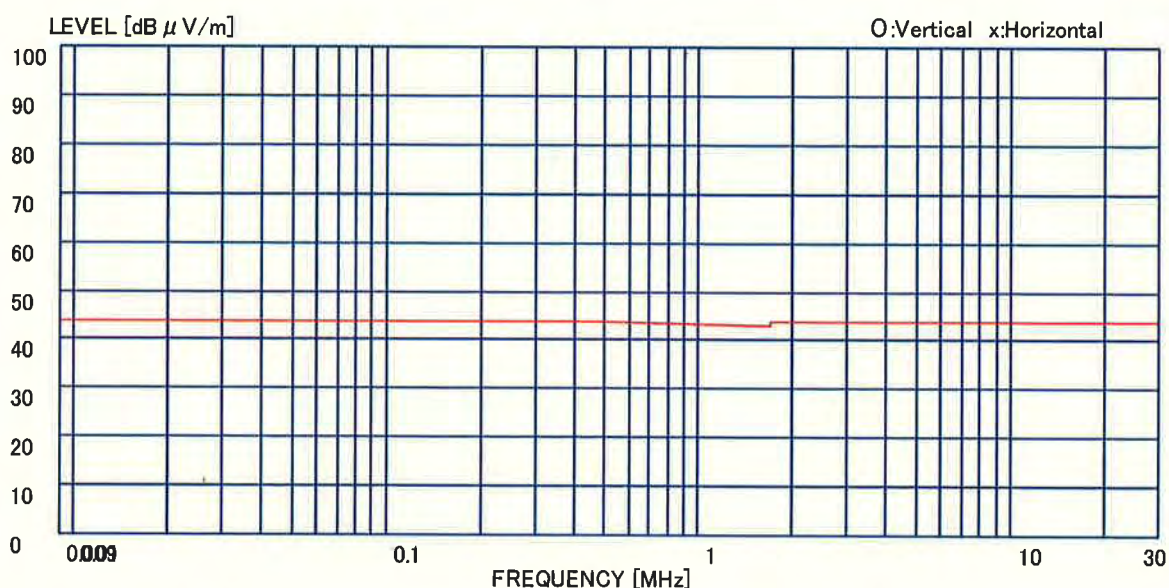


**Table 7.1-3a** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<0.009MHz to 30MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2480MHz

Frequency (MHz)	Level		Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result		Result		3 Meter Limit (dBμV/m)	Margin	
	Ver.	Hor.				Ver.	Hor.	Ver.	Hor.		Ver.	Hor.
	(dBμV)	(dBμV)				(dBμV/m)	(dBμV/m)	(μV/m)	(μV/m)		(dB)	(dB)

*Test results were under the required limit with 20dB margin or more.*



**Figure 7.1-3a** RFI Field Strength Measurement Results

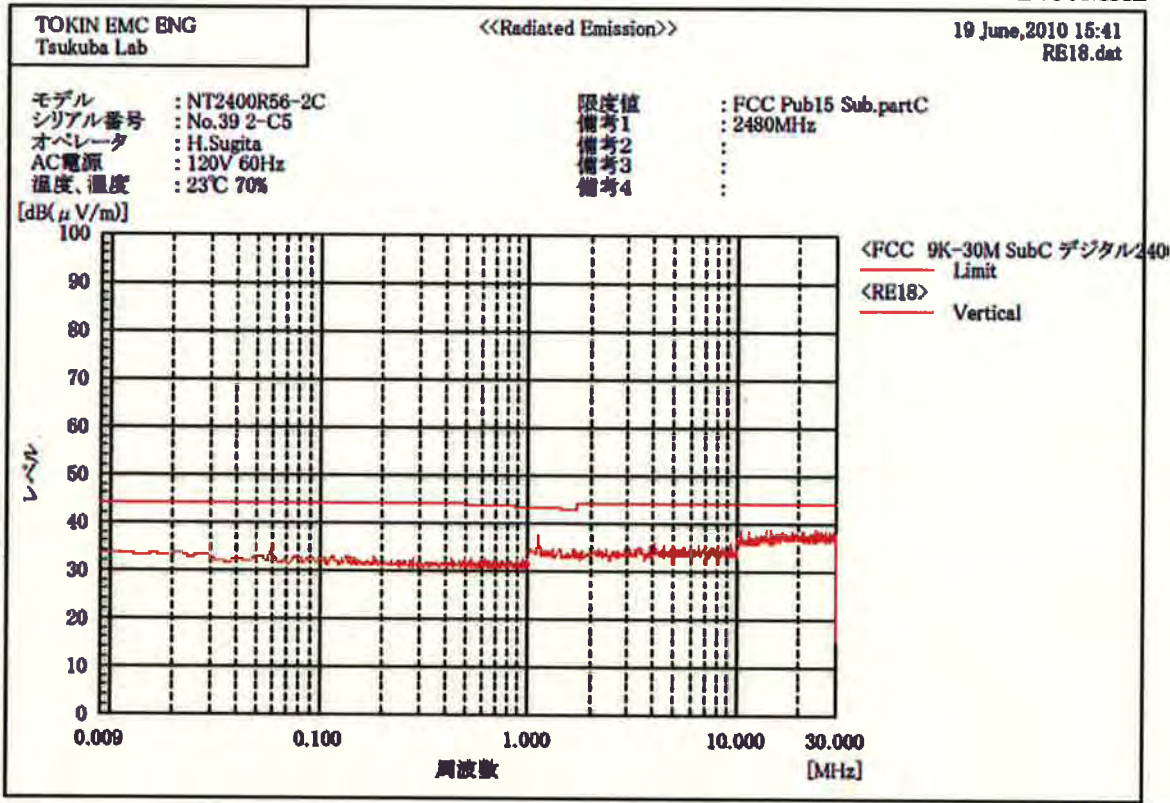
Frequency (MHz)	dBμV/m	Distance(m)
0.009 ~ 0.490	43.9	3
0.490 ~ 1.705	43.9 ~ 42.9	3
1.705 ~ 30	49.5 ~ 49.5	3

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-6a, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.



**Table 7.1-3b** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<0.009MHz to 30MHz>

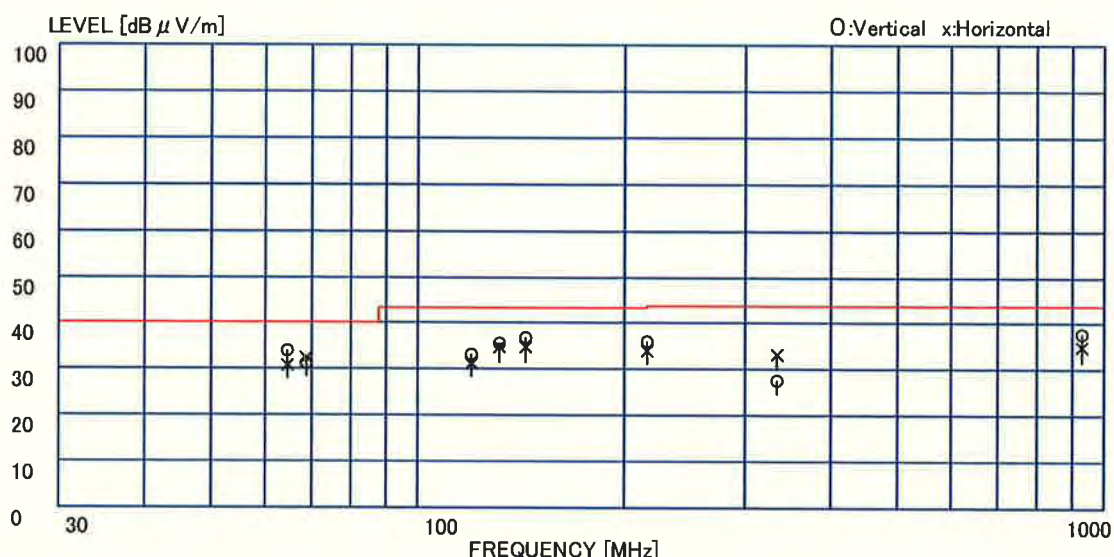
Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2480MHz



**Table 7.1-3c** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<30MHz to 1000MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2480MHz

Frequency (MHz)	Level		Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result		3m Limit (dBμV/m)	Margin	
	Ver. (dBμV)	Hor. (dBμV)				Ver. (dBμV/m)	Hor. (dBμV/m)		Ver. (dB)	Hor. (dB)
64.85	52.0	49.0	1.7	-27.0	7.4	34.1	31.1	40.0	5.9	8.9
68.90	50.0	51.0	1.8	-27.0	6.6	31.4	32.4	40.0	8.6	7.6
120.00	45.0	43.0	2.4	-27.0	13.1	33.5	31.5	43.5	10.0	12.0
132.00	46.0	45.0	2.5	-26.9	14.3	35.9	34.9	43.5	7.6	8.6
144.00	46.0	44.0	2.7	-26.9	15.2	37.0	35.0	43.5	6.5	8.5
216.00	42.0	40.0	3.4	-26.9	17.9	36.4	34.4	43.5	7.1	9.1
332.75	35.0	40.5	4.4	-27.0	15.5	27.9	33.4	43.9	16.0	10.5
930.55	33.0	30.0	7.8	-26.1	23.2	37.9	34.9	43.9	6.0	9.0



**Figure 7.1-3b** RFI Field Strength Measurement Results

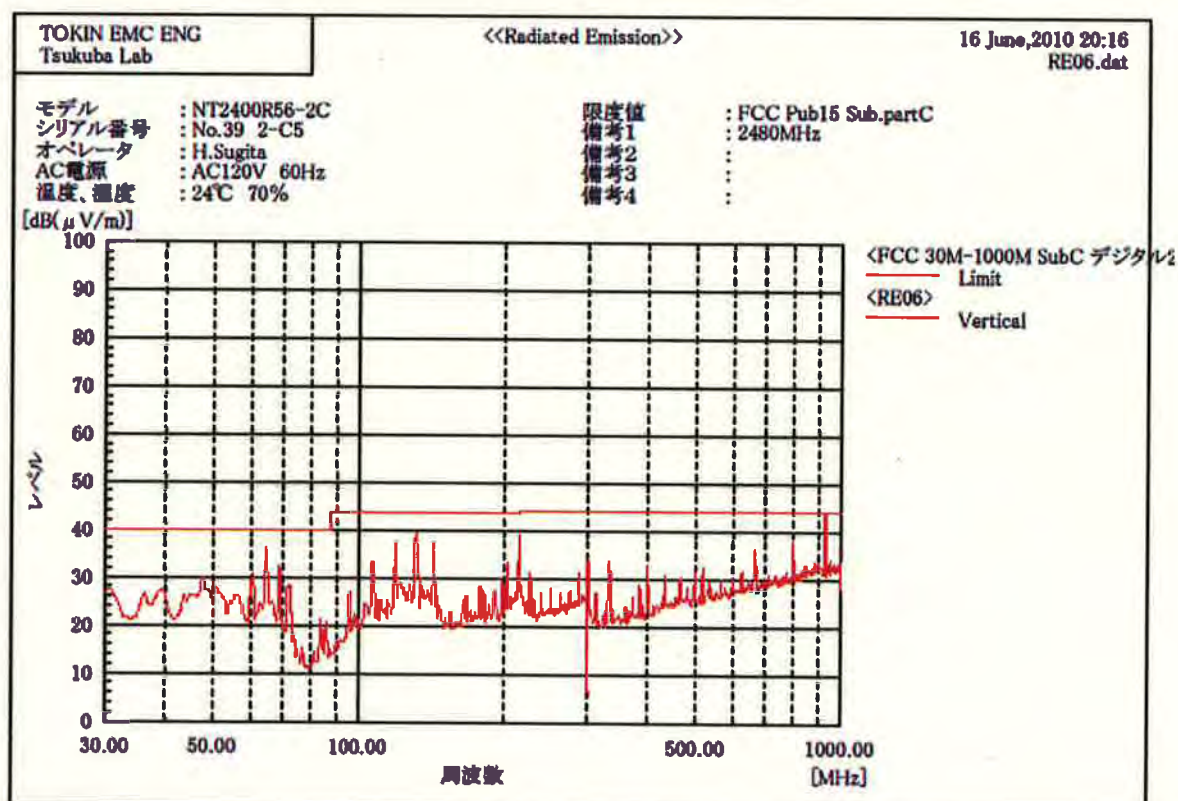
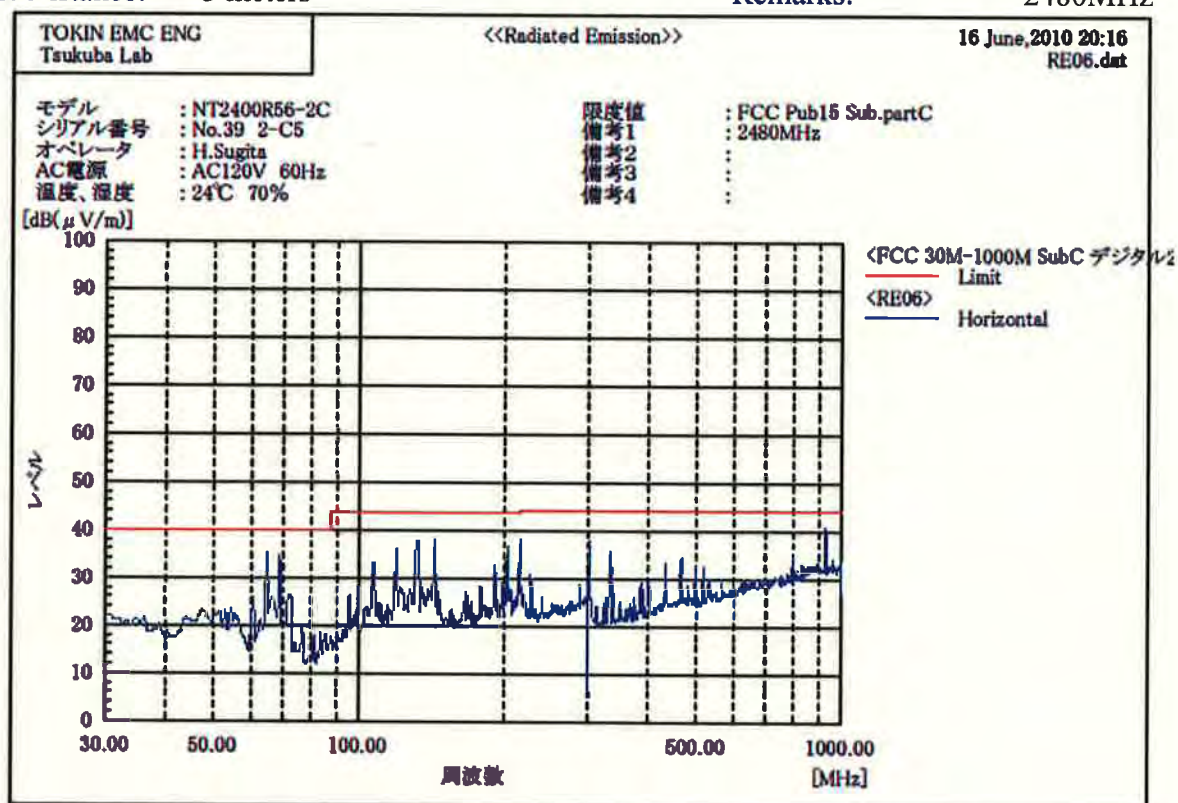
Frequency (MHz)	dBμV/m	Distance(m)
30 ~ 88	40	3
88 ~ 216	43.5	3
216 ~ 960	43.9	3
960 ~ 26500	43.9	3

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-6b, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.



**Table 7.1-3d** RFI Field Strength Measurement Results (Q-Peak Measurement)  
<30MHz to 1000MHz>

Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2480MHz

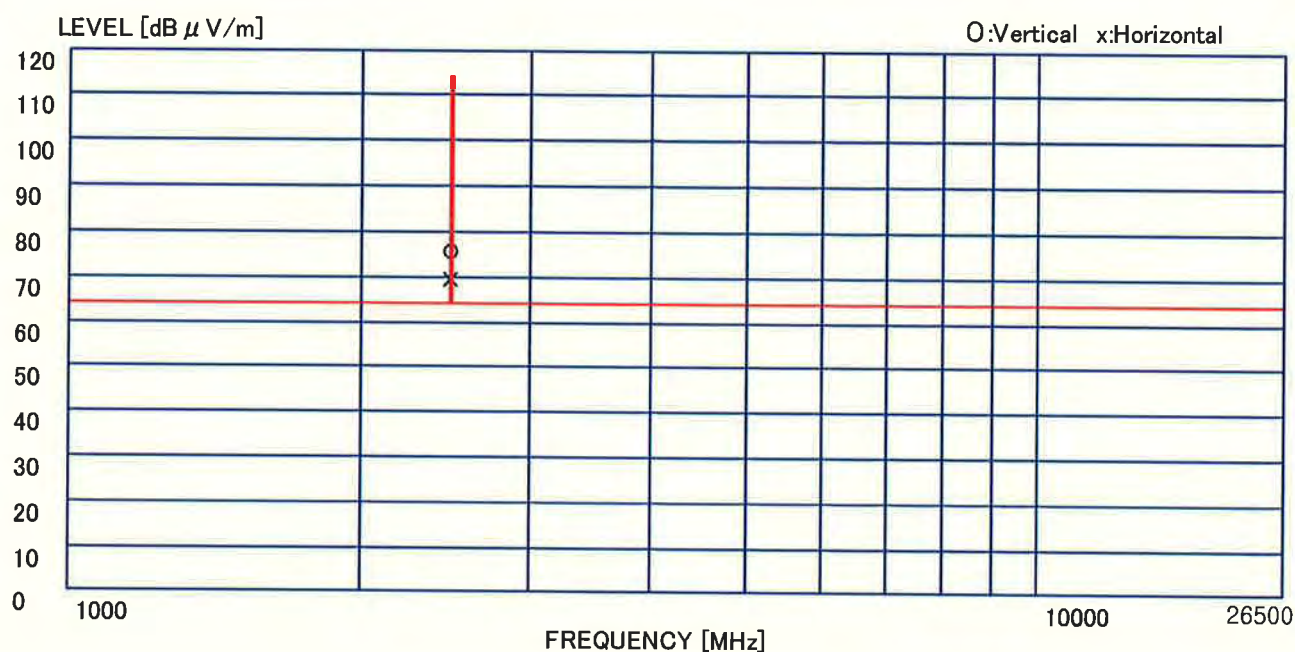




**Table 7.1-3e** RFI Field Strength Measurement Results (Peak Measurement)  
<1000MHz to 26500MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2480MHz

Frequency (MHz)	Level		Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result		3m Limit (dBμV/m)	Margin	
	Ver. (dBμV)	Hor. (dBμV)				Ver. (dBμV/m)	Hor. (dBμV/m)		Ver. (dB)	Hor. (dB)
2480.00	87.6	81.1	5.4	-44.0	26.7	75.7	69.2	113.9	38.2	44.7



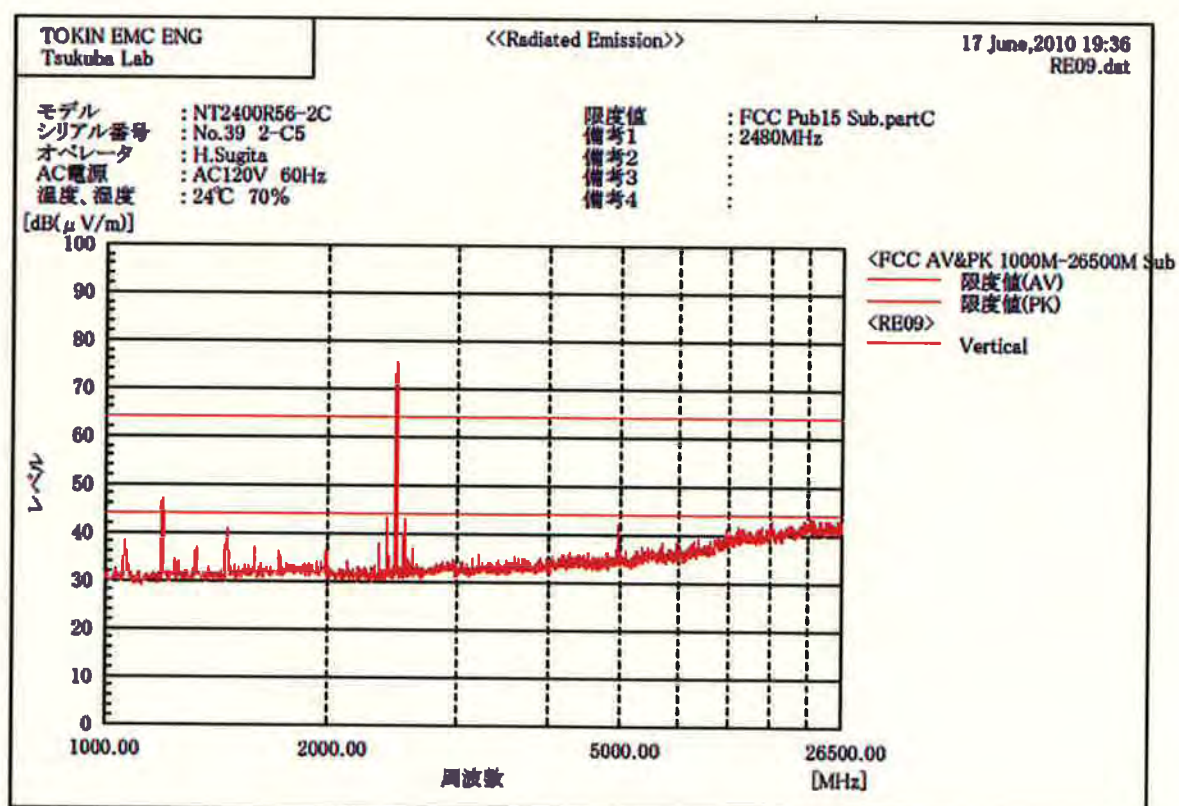
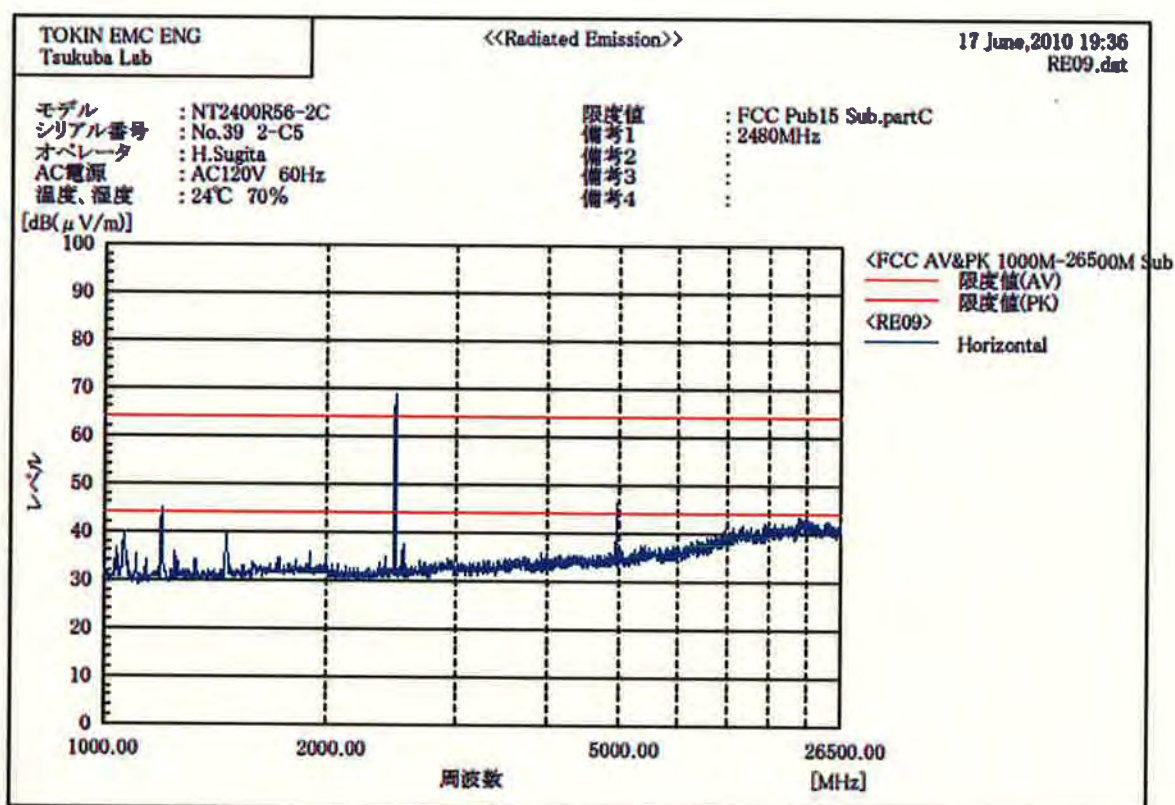
**Figure 7.1-3c** RFI Field Strength Measurement Results

Frequency (MHz)	dBμV/m	Distance(m)
1000 ~ 26500	113.9	3

\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-6c, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.

**Table 7.1-3f** RFI Field Strength Measurement Results (Peak Measurement)  
<1000MHz to 26500MHz>

Model Name:	NT2400R56-2C	Date of measurement:	June 23, 2010
Operating mode:	Modulation Mode	Temperature:	24 degree C
Test condition:	Power input DC_1.8V	Humidity:	70 %
Test Distance:	3 meters*	Remarks:	2480MHz

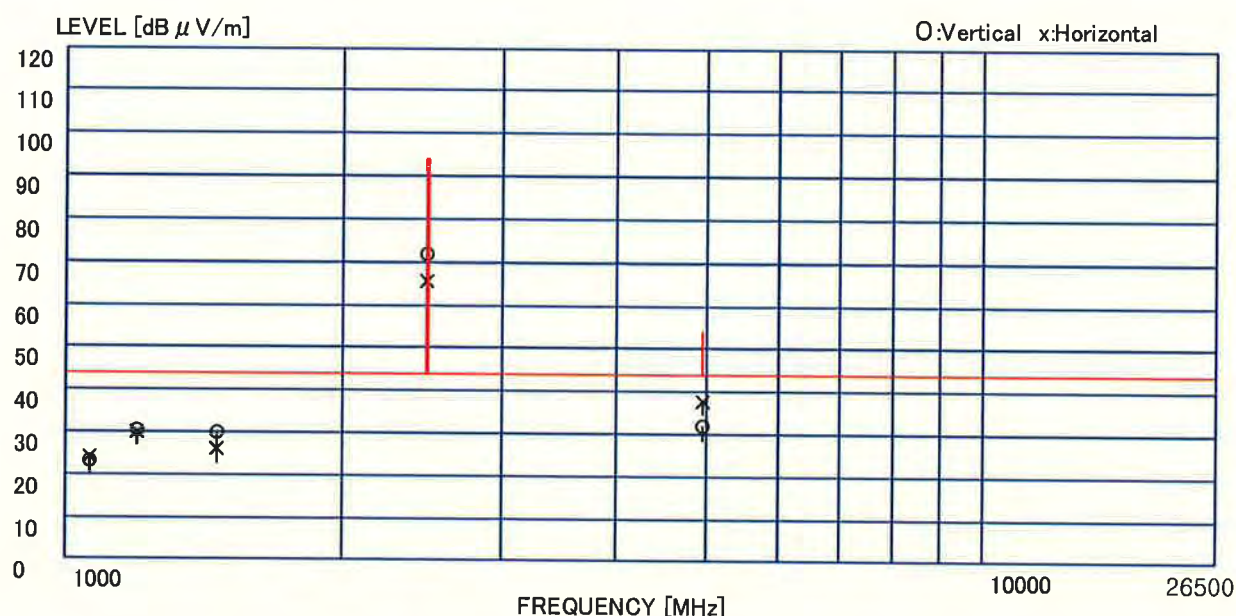




**Table 7.1-3g** RFI Field Strength Measurement Results (Average Measurement)  
<1000MHz to 26500MHz>

Model Name: NT2400R56-2C Date of measurement: June 23, 2010  
Operating mode: Modulation Mode Temperature: 24 degree C  
Test condition: Power input DC\_1.8V Humidity: 70 %  
Test Distance: 3 meters\* Remarks: 2480MHz

Frequency (MHz)	Level		Cable Loss (dB)	Amp. Gain (dB)	Ant. Factor (dB/m)	Result		3m Limit (dBμV/m)	Margin	
	Ver. (dBμV)	Hor. (dBμV)				Ver. (dBμV/m)	Hor. (dBμV/m)		Ver. (dB)	Hor. (dB)
1064.50	39.5	40.2	3.5	-45.4	25.6	23.2	23.9	43.9	20.7	20.0
1197.50	45.9	45.4	3.8	-45.1	26.1	30.7	30.2	43.9	13.2	13.7
1462.15	44.5	40.4	4.1	-44.6	26.0	30.0	25.9	43.9	13.9	18.0
2480.00	83.7	77.6	5.4	-44.0	26.7	71.8	65.7	93.9	22.1	28.2
4960.00	38.4	44.2	7.9	-43.7	29.2	31.8	37.6	53.9	22.1	16.3



**Figure 7.1-3d** RFI Field Strength Measurement Results

Frequency (MHz)	dBμV/m	Distance(m)
1000 ~ 26500	93.9	3(Fundamental wave)
1000 ~ 26500	53.9	3(Higher harmonics wave)

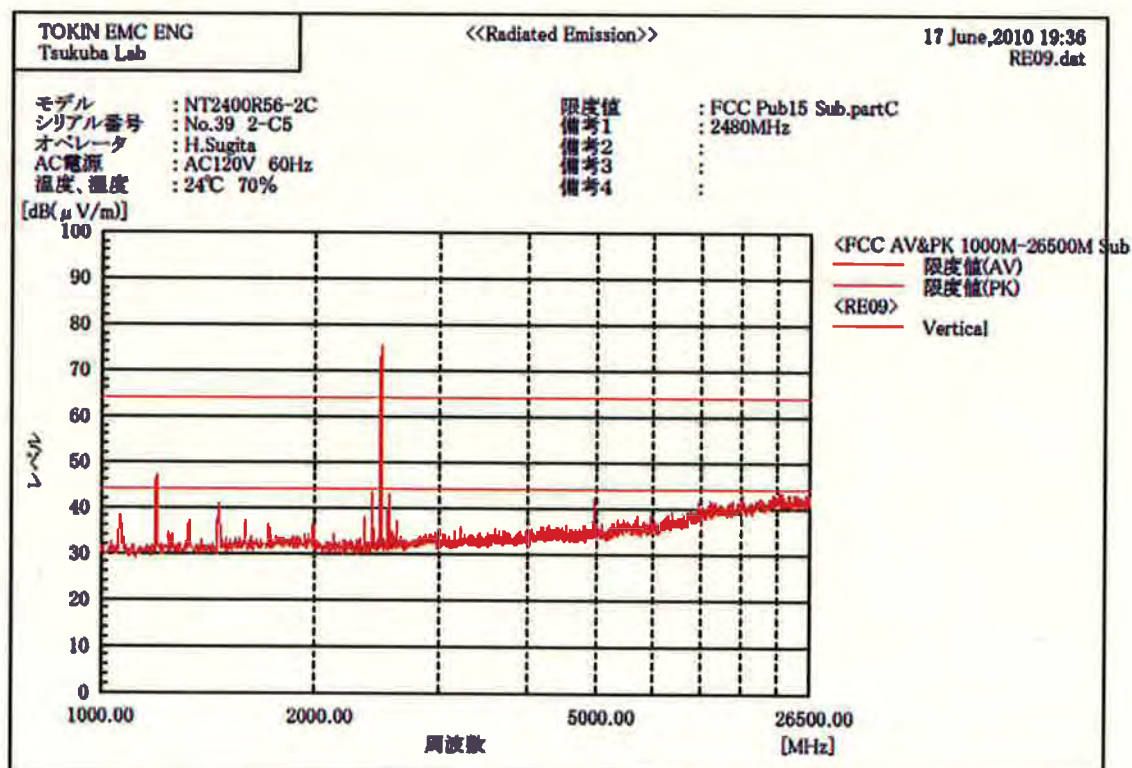
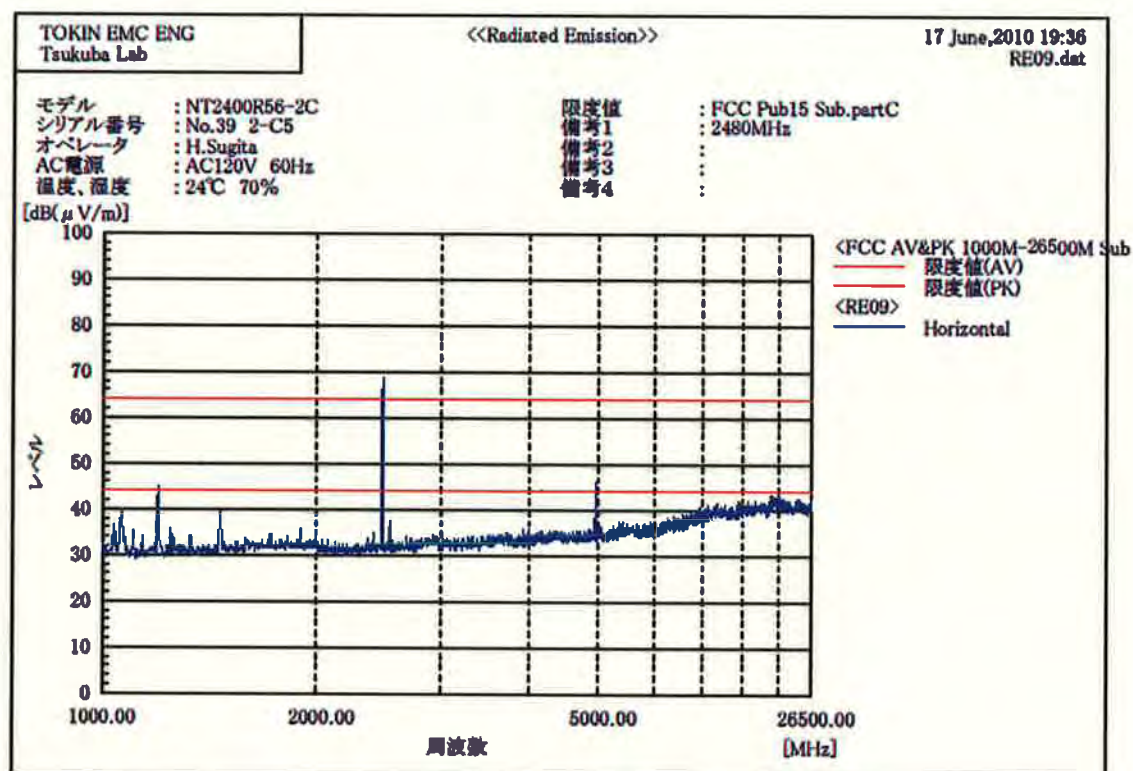
\* For 2400MHz to 2483.5MHz band operation, the limit (Figure 6.1-6d, red line) had been converted to 3.0meters. Therefore, the EUT had complied with FCC Part 15 Sub.part C requirement.



**Table 7.1-3h** RFI Field Strength Measurement Results (Average Measurement)  
<1000MHz to 26500MHz>

Model Name: NT2400R56-2C  
Operating mode: Modulation Mode  
Test condition: Power input DC\_1.8V  
Test Distance: 3 meters\*

Date of measurement: June 23, 2010  
Temperature: 24 degree C  
Humidity: 70 %  
Remarks: 2480MHz



## 7.2 Conducted Emission Measurement

### 7.2.1 Maximum Peak Output Power Measurement

#### 7.2.1.1 Measurement Instrumentation Used

( model/serial no./manufacturer/Tokin control no./last calibration/next calibration )

Spectrum Analyzer..... ( E4402A/MY45171076/Agilent Technology  
/XME010/07 Jan.'11/06 Jan.'12 )

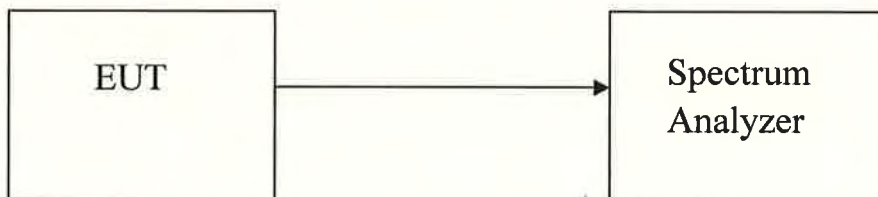
The measurement instrumentation used, are calibrated according to Quality Manual.

#### 7.2.1.2 Measurement Procedure

##### LIMIT

The Maximum peak output power of the intentional radiator shall not exceed the following;  
According to 15.247(b)(3), for systems using digital modulation in the bands of 2400MHz ,  
-2480MHz:1 watt(30dBm).

##### Test Configuration



##### Test Procedure

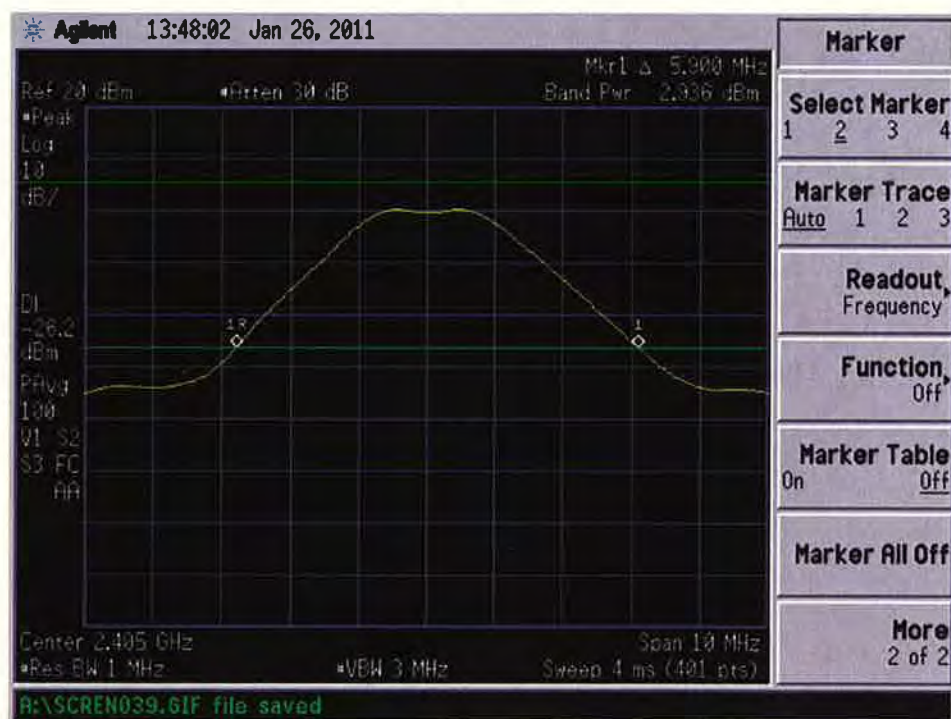
1. Set span to enclosure the entire emission bandwidth(EBW) of the signal.
2. Set RBW=1MHz.
3. Set VBW≥3MHz.
4. Set sweep time auto mode.
5. Use peak detector mode.
5. Trace average 100traces in power averaging mode.
6. Compute power by integrating the spectrum Across the 26dB EBW.  
The integration can be performed using the spectrum analyzer's band Power measurement function with band limits set equal to the EBW band edges.

### 7.2.1.3 Test Data

**Table 7.2-1.3a** Maximum Peak Output Power Measurement

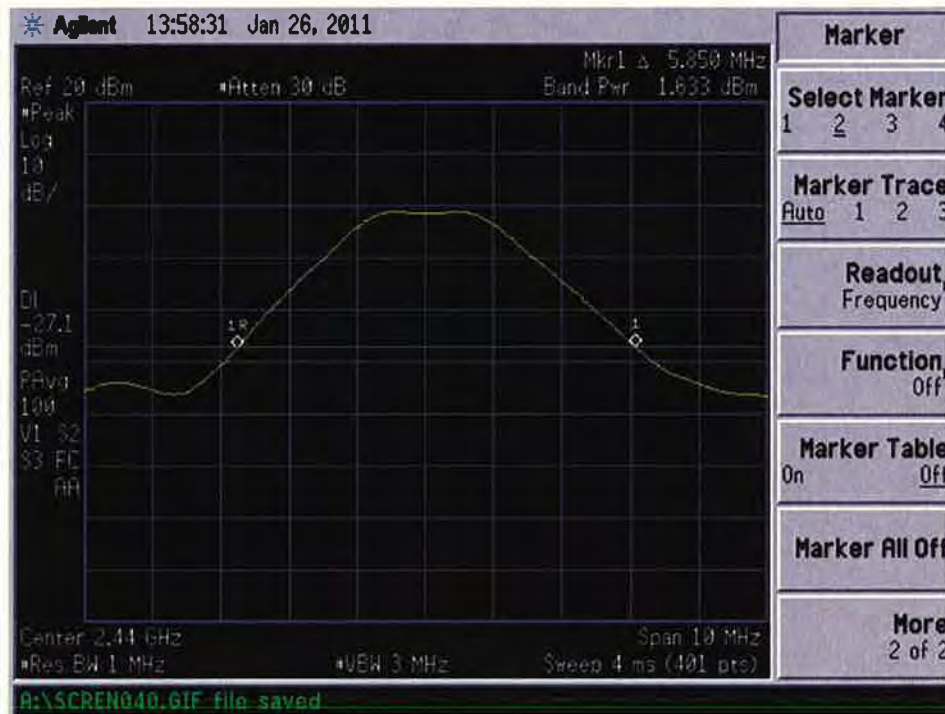
Model Name: NT2400R56-2C		Date of measurement: October 10, 2010		
Operating mode: Modulation Mode		Temperature: 22 degree C		
Test condition: Power input DC 1.8V		Humidity: 37 %		
Frequency (GHz)	SPA Read (dBm)	Cable Loss (dB)	Power (dBm)	Limit (dBm)
2.405	2.94	0.77	3.66	30.0
2.440	1.63	0.74	2.34	30.0
2.480	0.49	0.78	1.27	30.0

**< NT2400R56-2C /CH11 2.405GHz>**

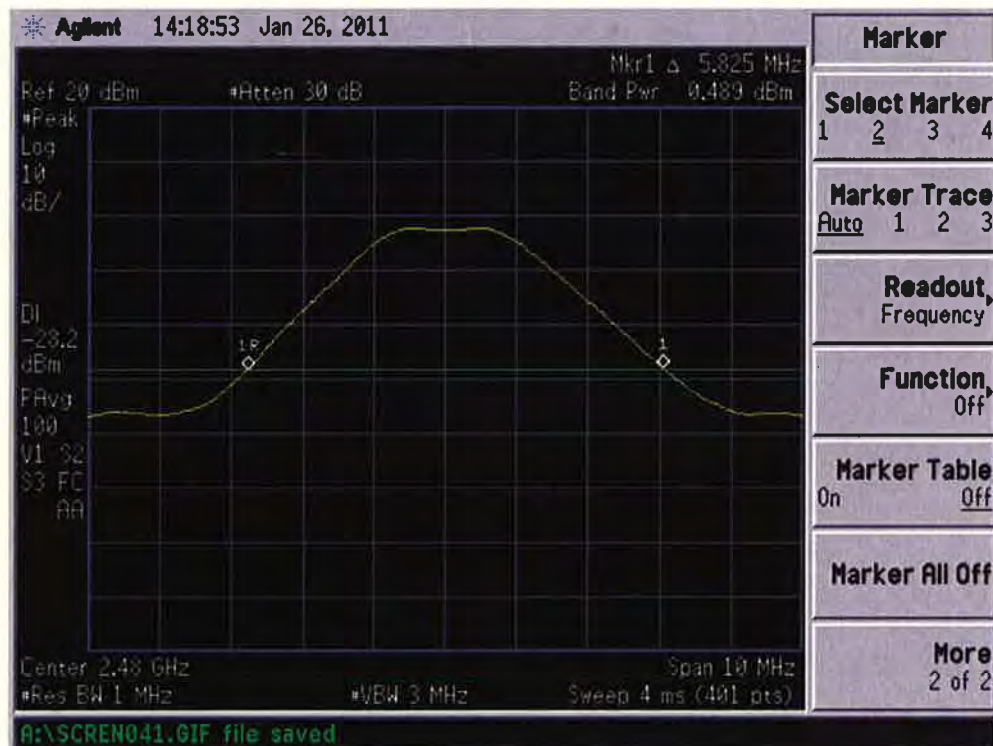




< NT2400R56-2C /CH18 2.440GHz>



< NT2400R56-2C /CH26 2.480GHz>



## 7.2.2 Band Edges Measurement

### 7.2.2.1 Measurement Instrumentation Used

( model/serial no./manufacturer/Tokin control no./last calibration/next calibration )

Spectrum Analyzer..... ( E7405A/MY45114252/Agilent Technology  
/SP061/11 Aug.'10/Aug.'11 )

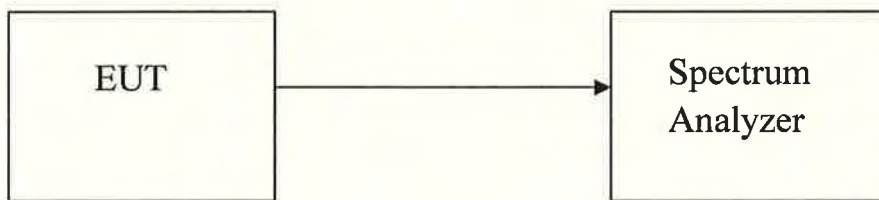
The measurement instrumentation used, are calibrated according to Quality Manual.

### 7.2.2.2 Measurement Procedure

#### LIMIT (15.247(C))

All Harmonics /Spurious emission must be at least 20dB down from the highest emission level.

#### Test Configuration



#### Test Procedure

1. Place the EUT on the table and set it in transmitting mode. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
2. Set the spectrum analyzer as RBW=100kHz, VBW=100kHz, Span=20MHz, Sweep=Auto with suitable frequency span from bandage.
3. Record the max reading with peak detector mode..
4. Repeat the above procedure until the measurements for all frequencies are completed.

**7.2.2.3 Deviation from the specification:** None

### 7.2.2.4 Measurement Uncertainty

Measurement uncertainty of 2.4GHz to 5.0GHz is +/-3.46dB(k=2).

### 7.2.2.5 Test Data

Model Name: NT2400R56-2C  
Operating mode: Modulation Mode  
Test condition: Power input DC\_1.8V

Date of measurement: January,14 2011  
Temperature: 23 degree C  
Humidity: 34 %

Peak fundamental frequency at 2480MHz: 75.7dB  $\mu$  V/m

Average fundamental frequency at 2480MHz: 71.8 dB  $\mu$  V/m

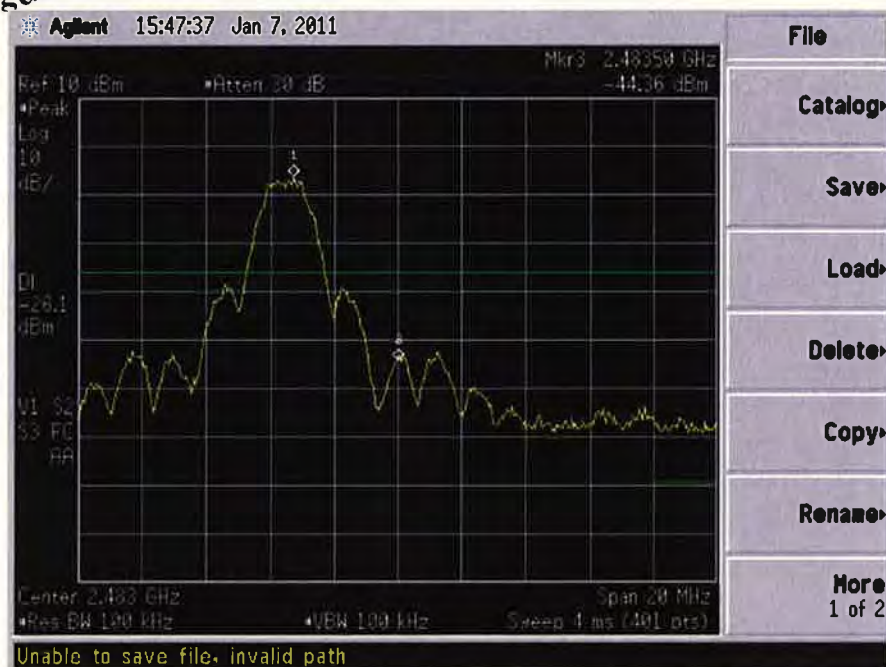
Peak fundamental frequency at 2405MHz: 74.5dB  $\mu$  V/m

Average fundamental frequency at 2405MHz: 71.3 dB  $\mu$  V/m

<Below Band edge>



<Upper Band edge>



Frequency (MHz)	Delta value(dB)	Peak caluculated field strength (dB $\mu$ V/m)	Average caluculated field strength (dB $\mu$ V/m)	Peak Limit (dB $\mu$ V/m)	AV Limit (dB $\mu$ V/m)
2483.5	38.26	37.44	33.54	74	54
2400	40.08	34.42	31.22	74	54



## 7.2.2 6dB Band Width Measurement(FCC 15,247)

### 7.2.2.1 Measurement Instrumentation Used

( model/serial no./manufacturer/Tokin control no./last calibration/next calibration )

Spectrum Analyzer..... ( E7405A/MY45114252/Agilent Technology  
/SP061/11 Aug.'10/Aug.'11 )

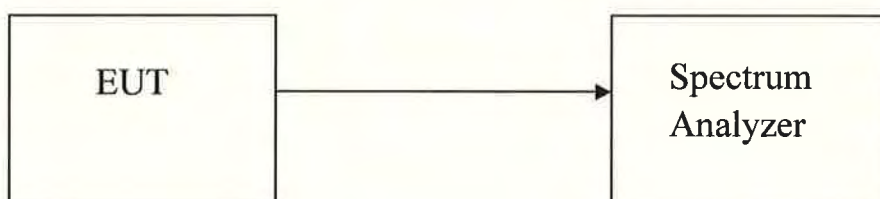
The measurement instrumentation used, are calibrated according to Quality Manual.

### 7.2.2.2 Measurement Procedure

#### LIMIT

According to 15.247(a)(2), systems using digital modulation techniques may operate in the 2405MHz,2440MHz ,2480MHz bands. The minimum 6dB bandwidth shall be at least 500kHz.

#### Test Configuration



#### Test Procedure

The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the selected span.

1. Set span to enclosure the entire emission bandwidth(EBW) of the signal.
2. Set RBW=100kHz.
3. Set VBW=300KHz.
4. 6dB bandwidth is measured with a delta marker.

## 7.2.2.3 Test Data

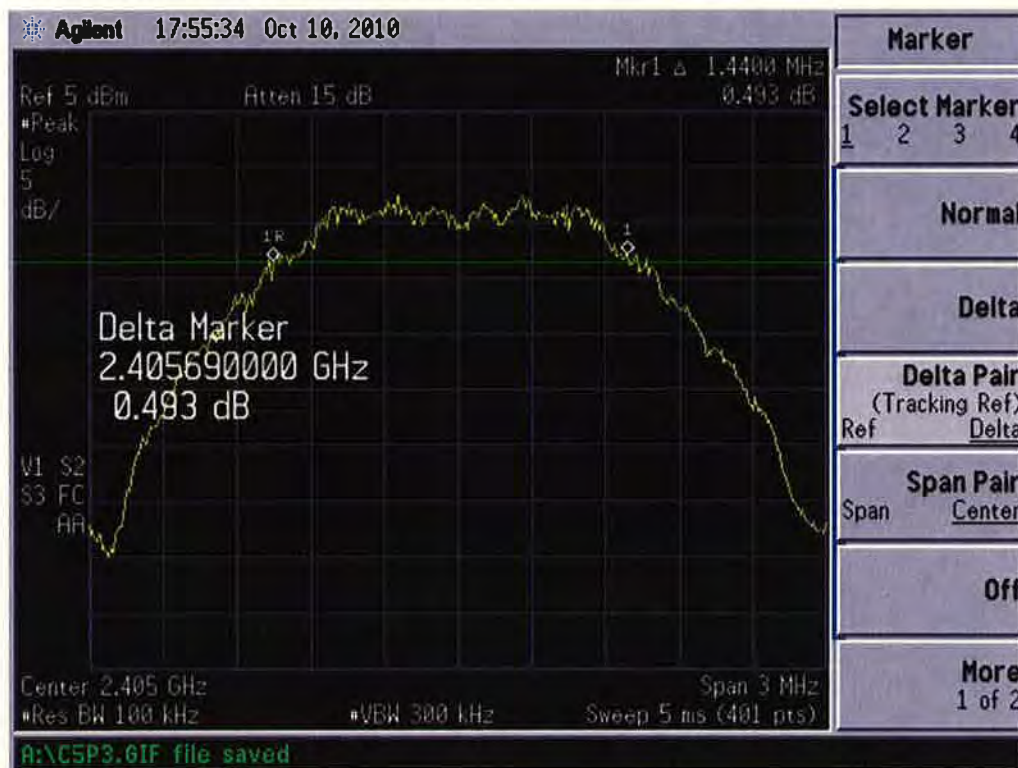
**Table 7.2-2.3a** 6dB Band Width Measurement

Model Name:	NT2400R56-2C	Date of measurement:	October 10, 2010
Operating mode:	Modulation Mode	Temperature:	23 degree C
Test condition:	Power input DC 1.8V	Humidity:	67 %

Frequency (GHz)	Band Width (MHz)	Limit (MHz)
2.405	1.4400	>0.5
2.440	1.5150	>0.5
2.480	1.4475	>0.5

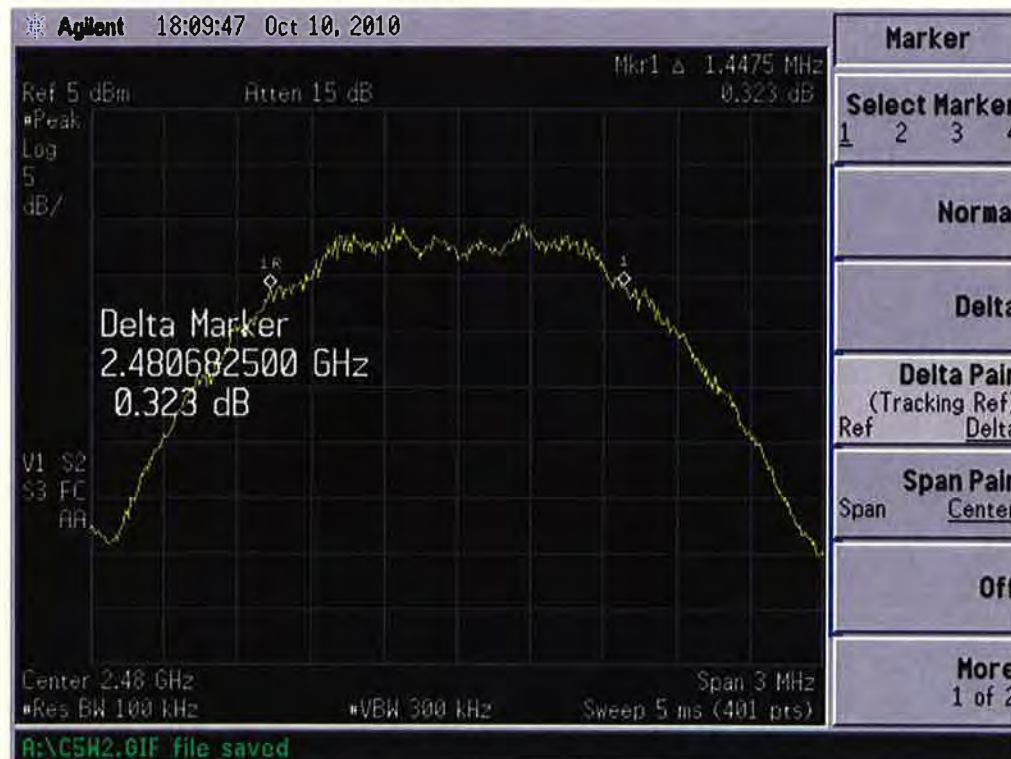
### < NT2400R56-2C /CH11 2.405GHz>



## < NT2400R56-2C /CH18 2.440GHz>



## < NT2400R56-2C /CH26 2.480GHz>





### 7.2.3 Peak Power Spectral Density Measurement

#### 7.2.3.1 Measurement Instrumentation Used

( model/serial no./manufacturer/Tokin control no./last calibration/next calibration )

Spectrum Analyzer..... ( E7405A/MY45114252/Agilent Technology  
/SP061/11 Aug.'10/Aug.'11 )

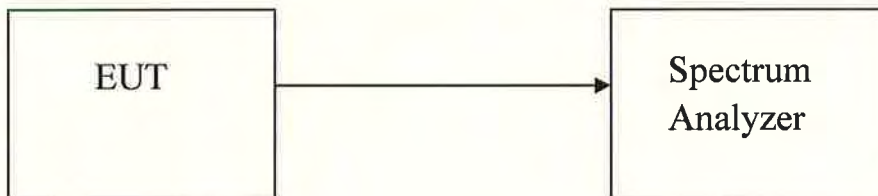
The measurement instrumentation used, are calibrated according to Quality Manual.

#### 7.2.3.2 Measurement Procedure

##### LIMIT

1. According to 15.247(e), for digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dB m in any kHz band during any time interval of continuous transmission.
2. According to 15.247(f), the digital modulation operation of the hybrid system, with the frequency hopping turned off, shall comply with the power density requirements of paragraph (d) of this section.

##### Test Configuration



##### Test Procedure

1. Place the EUT on the table and set it in transmitting mode. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
2. Set the spectrum analyzer as RBW=3kHz, VBW=10kHz, Span=300kHz, Sweep=100s
3. Record the max reading.
4. Repeat the above procedure until the measurements for all frequencies are completed.

**7.2.3.3 Deviation from the specification:**      None

#### 7.2.3.4 Measurement Uncertainty

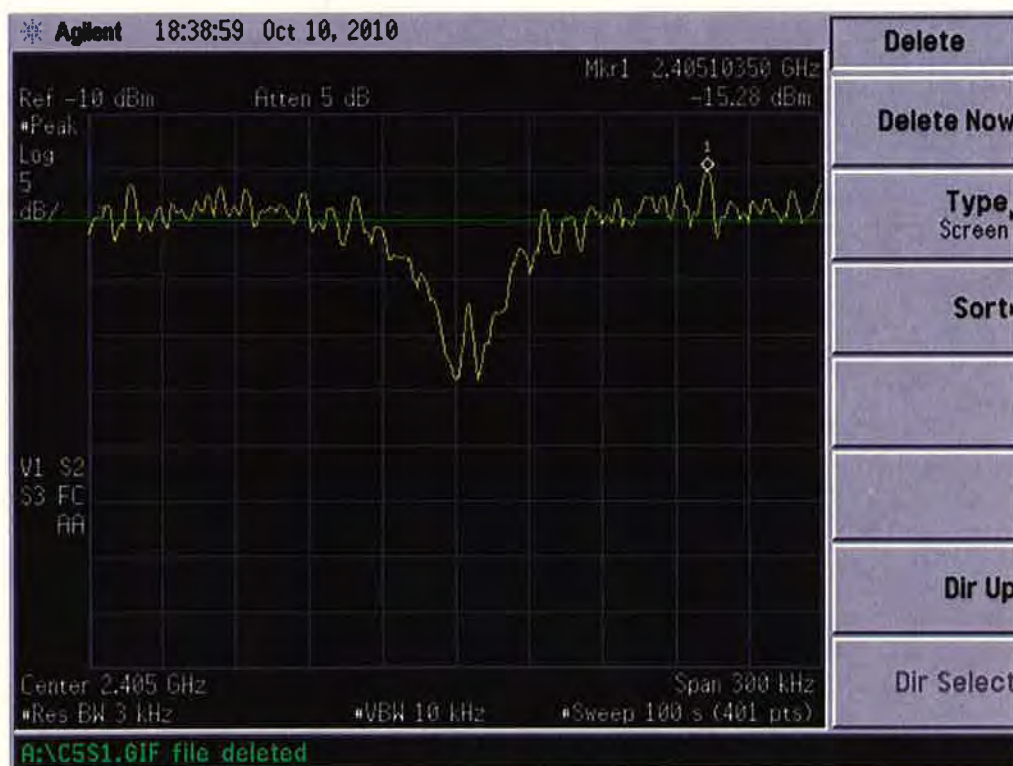
Measurement uncertainty of 2.4GHz to 5.0GHz is +/-3.46dB(k=2).

## 7.2.3.5 Test Data

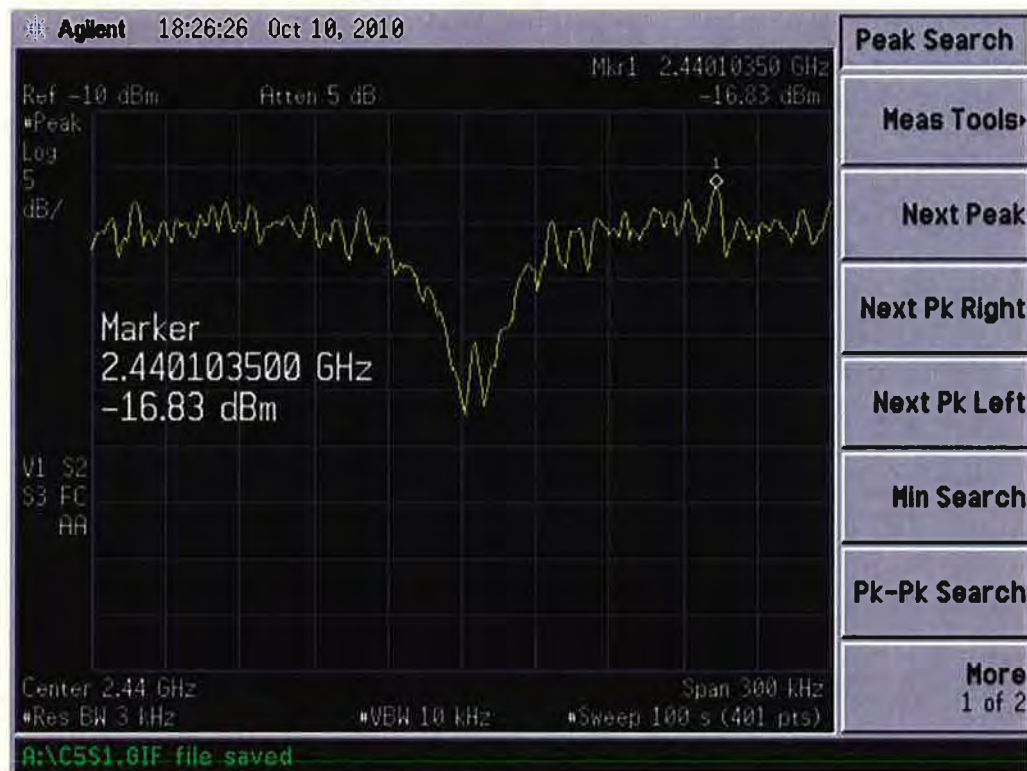
**Table 7.2-3.5a** Peak Power Spectral Density Measurement

Model Name:	NT2400R56-2C	Date of measurement:	October 10, 2010	
Operating mode:	Modulation Mode	Temperature:	23 degree C	
Test condition:	Power input DC 1.8V	Humidity:	67 %	
Frequency (GHz)	SPA Read (dB/m)	Cable Loss (dB)	Power (dBm)	Limit (dB/m)
2.405	-15.28	0.77	-14.51	30.0
2.440	-16.83	0.74	-16.09	30.0
2.480	-18.2	0.78	-17.42	30.0

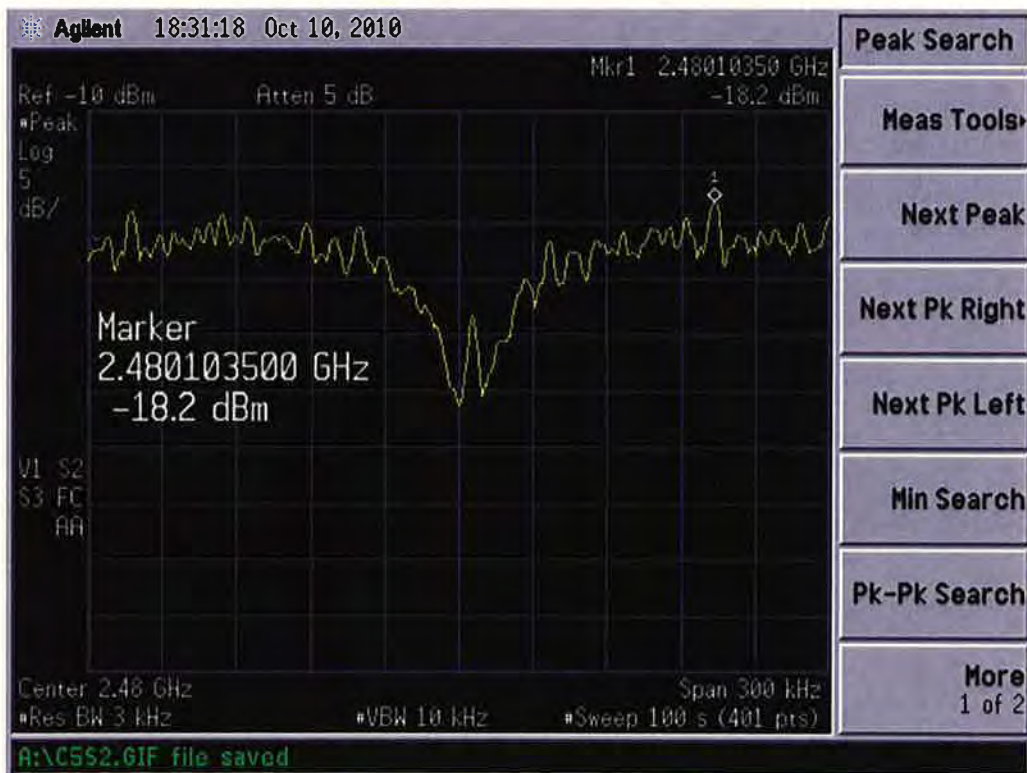
< NT2400R56-2C /CH11 2.405GHz>



## < NT2400R56-2C /CH18 2.440GHz>



## < NT2400R56-2C /CH26 2.480GHz>





**7.2.4 Radio Frequency Exposure Measurement****7.2.4.1 Measurement Instrumentation Used**

*( model/serial no./manufacturer/Tokin control no./last calibration/next calibration )*

Spectrum Analyzer..... ( E7405A/MY45114252/Agilent Technology  
/SP061/11 Aug.'10/Aug.'11 )

The measurement instrumentation used, are calibrated according to Quality Manual.

#### 7.2.4.2 Measurement Procedure

##### Calculation

Given  $E = \frac{\sqrt{30 \times P \times G}}{d}$  &  $S = \frac{E^2}{3770}$

Where  $E$  = Field strength in Volts / meter

$P$  = Power in Watts

$G$  = Numeric antenna gain

$d$  = Distance in meters

$S$  = Power density in milliwatts / square centimeter

Combining equations and re-arranging the terms to express the distance as a function of the remaining variables yields:

$$S = \frac{30 \times P \times G}{3770d^2}$$

Changing to units of mW and cm, using:

$$P (mW) = P (W) / 1000 \text{ and}$$

$$d (cm) = d(m) / 100$$

Yields

$$S = \frac{30 \times (P/1000) \times G}{3770 \times (d/100)^2} = 0.0796 \times \frac{P \times G}{d^2} \quad \text{Equation 1}$$

Where  $d$  = Distance in cm

$P$  = Power in mW

$G$  = Numeric antenna gain

$S$  = Power density in mW / cm<sup>2</sup>

##### Maximum Permissible Exposure

Substituting the MPE safe distance using  $d = 20$  cm into Equation 1:

Yields

$$S = 0.000199 \times P \times G$$

Where  $P$  = Power in mW

$G$  = Numeric antenna gain

$S$  = Power density in mW / cm<sup>2</sup>

**NT2400R56-2C** : Out put power=1.2mW, Numeric Antenna gain=1.38

Power density= 0.000330mW/cm<sup>2</sup>

*(For mobile or fixed location transmitters, the maximum power density is 1.0mW/cm<sup>2</sup> even if the calculation indicates that the power density would be larger.)*

**7.2.4.3 Deviation from the specification:**      None

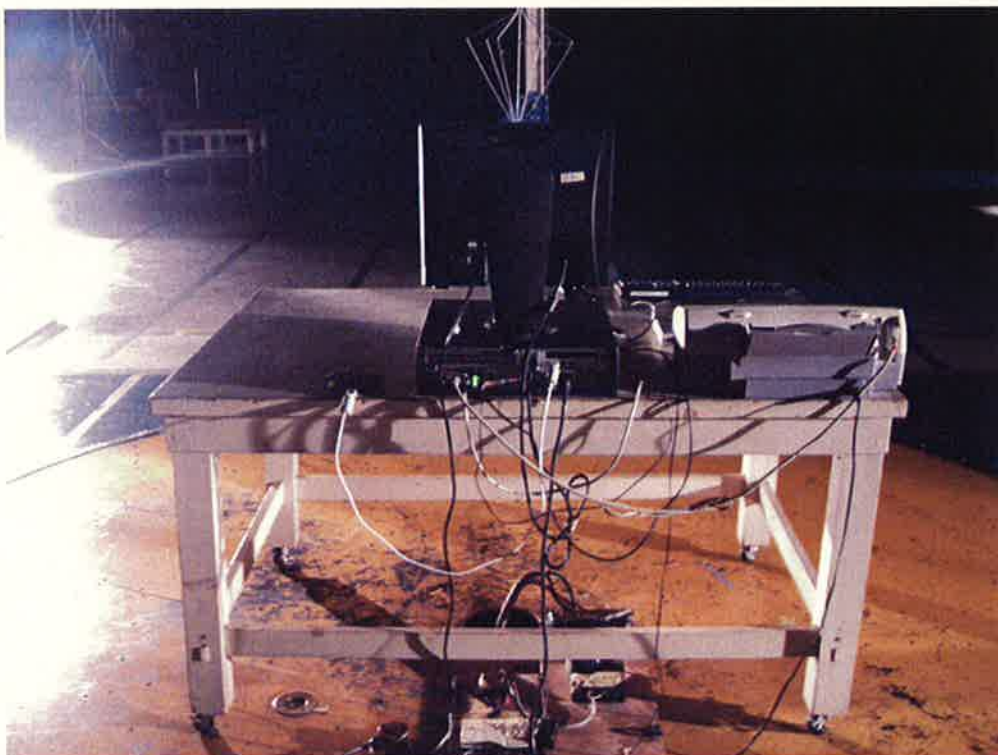
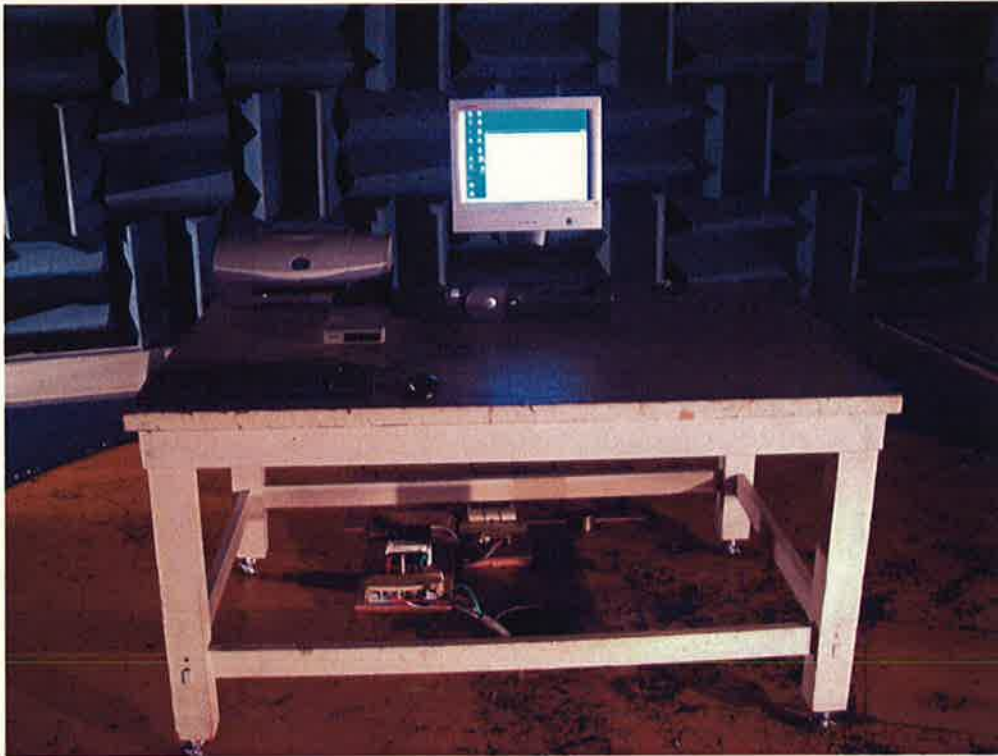


## 8 MEASUREMENT PHOTOS

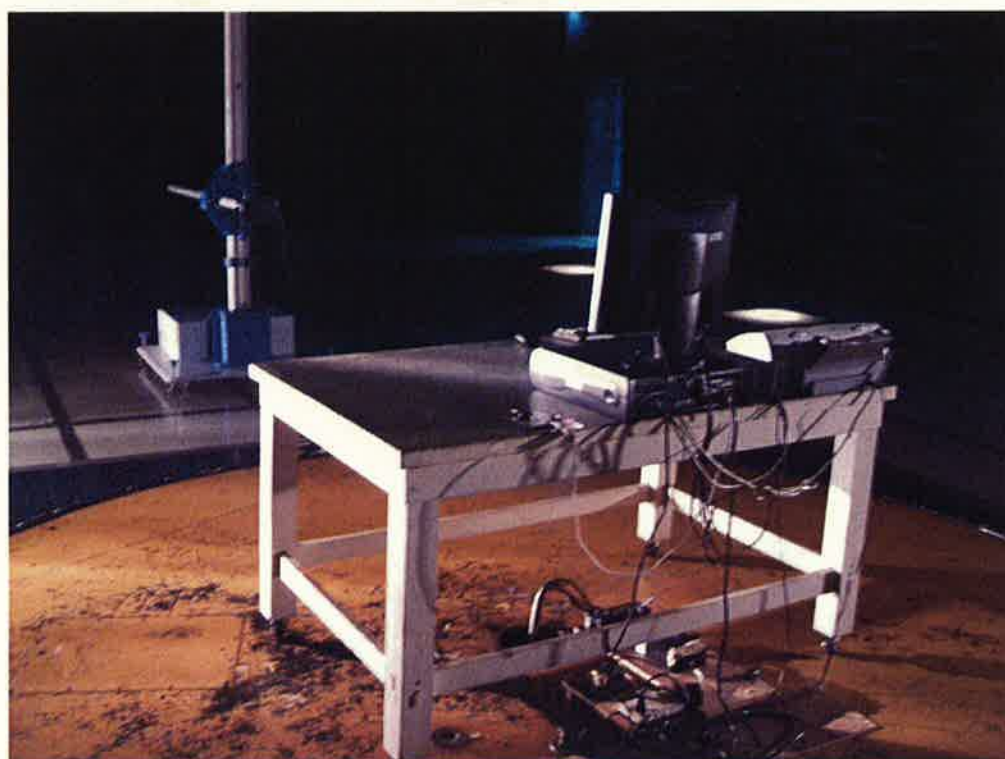
**Photo 8.1a** Setup with Maximized RFI Field Strength Measurement  
<0.009MHz to 30MHz>



**Photo 8.1b** Setup with Maximized RFI Field Strength Measurement  
<30MHz to 1000MHz>

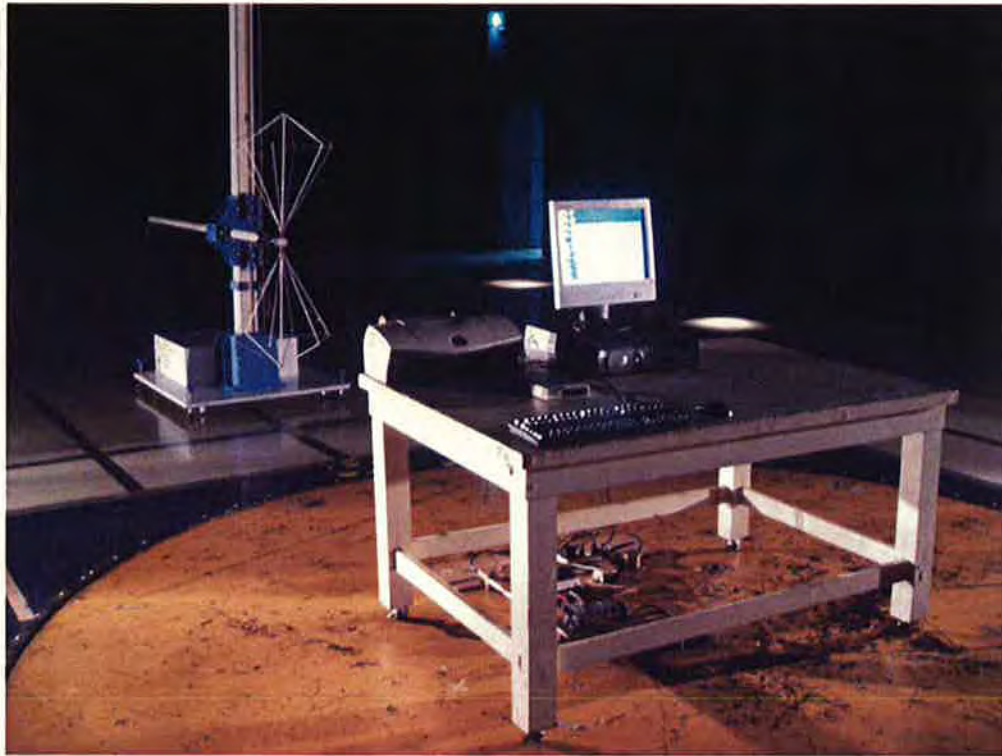


**Photo 8.1c** Setup with Maximized RFI Field Strength Measurement  
<1000MHz to 26500MHz>





**Photo 8.1d** Setup with Maximized RFI Field Strength Measurement (*Worst Case*)



**Photo 8.2** Conducted Emission Measurement

