

Emission Test Report

Standard: FCC Part 15 Subpart C

Document Number : FCC 19-0161-0

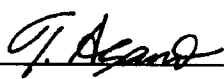
Product: IBM ThinkPad A22
Included IBM Internal High Rate Wireless LAN PC Card (P/N 26P8030)

FCC ID: ANOM380211B

March 27, 2001

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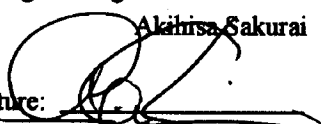
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A. GENERAL INFORMATION

APPLICANT : IBM Japan Ltd.

ADDRESS : 1623 – 14 Shimotsuruma, Yamato-shi, Kanagawa 242-8502 Japan
Tel: +81-46-215-4779, Fax: +81-46-273-7420

REGULATION : FCC Part 15 Subpart C

MODEL NUMBER : 2628 – W1U (ThinkPad A22)

SERIAL NUMBER : ZZ – 00029

PHYSICAL CONDITION : Preproduction

KIND OF EQUIPMENT : Personal computer with a built-in Wireless LAN card

TESTED DATE : March 16, 22, 23 and 26, 2001

TEST SITE : IBM Yamato semi-anechoic chamber #2
IBM Yamato conducted measurement facility

A.1 Test Methodology

Both conducted and radiated testing were performed according to the procedures in ANSI C63.4-1992. Radiated testing was performed at an antenna to EUT distance of 3 meters.

A.2 Test Facility / NVLAP Accreditation

The semi-anechoic chamber #2 and conducted measurement facility used to correct the data are located in Yamato Laboratory, IBM Japan. These facilities have been fully described in a report dated September 1998, submitted to your office, and accepted in a letters, dated Nov. 2, 1998(31040/SIT).

IBM Yamato EMC Engineering is recognized under the National Voluntary Laboratory Accreditation Program for satisfactory compliance with Criteria established in Title 15, Part 285 Code of Federal Regulations.(NVLAP Lab code: 200198-0)

A.3 EUT details

Table A EUT details

Model and S/N	FCC ID	Description	Cable Description
ThinkPad A22 M/T 2628-W1U (s/n ZZ-00029)	ANOM380211B	IBM Notebook PC CPU: Intel Mobile Geyserville 1GHz	
P/N 02K6657	N/A	Universal AC adapter 72W	Unshielded power cord

B. SUMMARY OF TEST RESULTS

Table-B presents the list of the measurement items for Spread Spectrum, Direct Sequence devices under FCC Part 15 Subpart C.

Table-B List of the measurements

Section(s)	Test Items		Condition	Result
	Transmit mode (TX):			
15.247(a)(2)	Bandwidth at 6 dB below		Conducted	Pass
15.247(c)	Occupied BW (or Band-edge) Out of Band Emissions (Bandwidth at 20 dB below)	The radiated emission in any 100KHz of outband shall be at least 20dB below the highest inband spectral density.	Conducted	Pass
15.247(b)	Transmitter output power	Shall not exceed 1.0 W.	Conducted	Pass
15.247(d)	Transmitter power spectral density	Shall not be greater than 8 dBm in any 3KHz band.	Conducted	Pass
15.247(e)	Processing gain	10 dB	Conducted	Pass*
15.207	AC Wireline Conducted Emissions 450kHz – 30MHz	Class B: 250uV	Conducted	Pass
15.205 / 209	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Shall not exceed the limits specified in FCC 15.209.	Radiated (30MHz - 1GHz)	Pass
			Radiated (1– 25GHz)	Pass

	Receive mode (RX):			
15.207	AC Wireline Conducted Emissions 450kHz – 30MHz	Class B: 250uV	Conducted	Pass
15.209	General Field Strength Limits (Radiated Emission Limits)	Shall not exceed the limits specified in FCC 15.209.	Radiated (30MHz - 1GHz)	Pass
			Radiated (1– 25GHz)	Pass

15.247.b(3)	Antenna gain measurement	6 dBi		Pass
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* See Lucent Test Report 015125 Rev. A

C. OPERATION MODE OF EUT

All tests were performed using the “WaveLAN-II Engineering Test Program”, Version v01.21 (Oct.11, 1999). Three kinds of modulation are used for transmission with appropriate bit rates:

Table C-1 Transmit mode (TX)

Operation Frequency [GHz]	Rated output power (conducted) [dBm]			Test performed*
	Bit rate 2Mbps	Bit rate 5.5Mbps	Bit rate 11Mbps	
2.412 (Ch. 1)	+15	+15	+15	X
2.417 (Ch. 2)	+15	+15	+15	
2.422 (Ch. 3)	+15	+15	+15	
2.427 (Ch. 4)	+15	+15	+15	
2.432 (Ch. 5)	+15	+15	+15	
2.437 (Ch. 6)	+15	+15	+15	X
2.442 (Ch. 7)	+15	+15	+15	
2.447 (Ch. 8)	+15	+15	+15	
2.452 (Ch. 9)	+15	+15	+15	
2.457 (Ch. 10)	+15	+15	+15	
2.462 (Ch. 11)	+15	+15	+15	X

* Full testing with bit rate 11Mbps only

Table C-2 Receive mode (RX)

Operation Frequency [GHz]	Test performed
2.412 (Ch. 1)	
2.417 (Ch. 2)	
2.422 (Ch. 3)	
2.427 (Ch. 4)	
2.432 (Ch. 5)	
2.437 (Ch. 6)	X
2.442 (Ch. 7)	
2.447 (Ch. 8)	
2.452 (Ch. 9)	
2.457 (Ch. 10)	
2.462 (Ch. 11)	

D. TEST INSTRUMENTS

Table-D List of Measuring Instruments

Description	Model	Serial Number	Calibration Date	Calibration Interval
Computer	IBM 5551-L	#4	N/A	N/A
Computer	IBM 6589-13J	97-15613	N/A	N/A
Spectrum Analyzer (100Hz-1.5GHz)	HP 85680B	2732A03651	01/16/01	1 year
Spectrum Analyzer (100Hz-1.5GHz)	HP 85680B	3019A05155	02/07/01	1 year
Spectrum Analyzer (100Hz-1.5GHz)	HP 85680B	2841A04254	04/17/00	1 year
Spectrum Analyzer Display	HP 85662A	2648A15255	01/16/01	1 year
Spectrum Analyzer Display	HP 85662A	3026A19353	02/07/01	1 year
Spectrum Analyzer Display	HP 85662A	2816A16831	04/17/00	1 year
Quasi-Peak Adapter	HP 85650A	2521A00968	01/16/01	1 year
Quasi-Peak Adapter	HP 85650A	3033A01449	02/07/01	1 year
Quasi-Peak Adapter	HP 85650A	2811A01156	04/17/00	1 year
Amplifier (100KHz - 1.3GHz)				
- for 30-200MHz	HP 8447D	2805A02919	04/14/00	1 year
- for 200-1000MHz	HP 8447D	2944A03506	04/14/00	1 year
Amplifier (1GHz - 26.5GHz)	HP 8449B	3008A00580	06/02/00	1 year
Spectrum Analyzer EMI Test Receiver	R&S ESI26	836119/003	07/12/00	1 year
Receiver (9kHz-30MHz)	R&S ESH3	891806/012	09/11/00	1 year
Receiver (9kHz-30MHz)	R&S ESH3	892108/003	10/04/00	1 year
Receiver (20MHz-1.3GHz)	R&S ESVP	892111/030	05/19/00	1 year
Biconical Antenna (30-200MHz)	EMCO 3108	2400	06/09/00	1 year
Log-Periodic Antenna (200-1000MHz)	EMCO 3146	2150	06/06/00	1 year
Horn Antenna (1- 18GHz)	EMCO 3115	6121	04/17/00	1 year
		5774	04/17/00	1 year
Horn Antenna (3.95- 5.85GHz)	EMCO 3160-5	1099	12/27/00	1 year
Horn Antenna (5.85- 8.20GHz)	EMCO 3160-6	1044	12/27/00	1 year
Horn Antenna (18- 26.5GHz)	EMCO 3160-9	1202	04/17/00	1 year
LISN	EMCO 3825/2	1426	09/01/00	1 year
Signal Generator	HP E4432B	GB38450342	09/07/00	1 year
Power Meter	HP 436A	2604A24191	12/12/00	1 year
Power Sensor	HP 8482A	2607A11105	12/13/00	1 year
Switch/control unit	HP 3488A	2719A17226	N/A	N/A
		2719A17228	N/A	N/A
Plotter	HP 7550A	2631A33619	N/A	N/A

SF106 cables:	Length:			
- Horn Ant <=> RF Amp.	6 m	- EM206SCO	08/10/00	1 year
- RF Amp.<=>Spectrum Analyzer	15m	- EM215SCO	08/10/00	1 year
N-Coax cables:				
- Bi-coni Ant <=> 10m Cable	9 m	- EM203L01	04/14/00	1 year
- 10m Cable <=> Shield Panel	10 m	- EM203L02	04/14/00	1 year
- Shield Panel <=> RF Amp	7 m	- EM203L03	04/14/00	1 year
- RF Amp <=> Power Splitter	0.5m	- EM203L04	04/14/00	1 year
- Log-peri Ant <=> 10m Cable	9 m	- EM203H01	04/14/00	1 year
- 10m Cable <=> Shield Panel	10 m	- EM203H02	04/14/00	1 year
- Shield Panel <=> RF Amp	7 m	- EM203H03	04/14/00	1 year
- RF Amp <=> Power Splitter	0.5m	- EM203H04	04/14/00	1 year
Coax cables:				
- Lism-L <=> SW/Con.unit (SW100)	4 m	- EMIC-L	04/14/00	1 year
- Lism-N <=> SW/Con.unit (SW101)	4 m	- EMIC-N	04/14/00	1 year
- SW/Con.unit <=> RCVR (Input)	1 m	- EMIC-R	04/14/00	1 year
- SW/Con.unit<=> Spe Ana.(Signal In)	1 m	- EMIC-S	04/14/00	1 year
- Power Splitter <=> SW/Con.unit (SW110)	1 m	- EM203L05	04/14/00	1 year
- Power Splitter <=> SW/Con.unit (SW300)	1 m	- EM203L06	04/14/00	1 year
- Power Splitter <=> SW/Con.unit (SW100)	1 m	- EM203H05	04/14/00	1 year
- Power Splitter <=> SW/Con.unit (SW301)	1 m	- EM203H06	04/14/00	1 year
- SW/Con.unit <=> Receiver (Input)	2 m	- EM2RCV	04/14/00	1 year
- SW/Con.unit <=> Spe Ana.(Signal In) for 30- 200MHz	2 m	- EM2SPL	04/14/00	1 year
- SW/Con.unit <=> Spe Ana.(Signal In) for 200-1000MHz	2 m	- EM2SPH	04/14/00	1 year

Notes.

- The above equipment calibration is traceable to National standards.
- HP: Hewlett Packard, R&S: Rohde & Schwarz

1. Bandwidth at 6 dB below

1.1 Test Procedure

The bandwidth at 6 dB down from the highest inband spectral density is measured with a spectrum analyzer connected to the antenna terminal, while EUT is operating in transmission mode at the appropriate center frequency.

The spectrum analyzer is set to :

RBW=100KHz, VBW=100KHz*1, Span=50MHz, Sweep=suitable duration based on the EUT specification

*1: To be adjusted accordingly based on the spectrum stability

1.2 Test Instruments and Measurement Setup

Table 1-1 : 6 dB Bandwidth Test Instruments

Description	Model	Serial Number
Spectrum Analyzer EMI Test Receiver	R&S ESI26	836119/003
Coax cables: - Spectrum Analyzer <=> EUT	Length: 130 cm Loss: 1.7 dB	

Notes: - R&S: Rohde & Schwarz

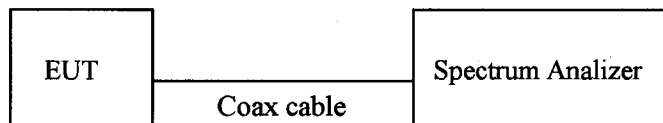


Figure 1: Measurement setup for 6dB bandwidth test

1.3 Measurement Results

Table 1-2. EUT: M/T 2628-W1U, s/n ZZ-00029, TX mode 11Mbps

Center Frequency (MHz)	Lower frequency (MHz)	Upper frequency (MHz)	Bandwidth at 6 dB below (MHz)
2412 (ch. 1)	2408.74	2416.16	7.42
2437 (ch. 6)	2433.74	2440.91	7.17
2462 (ch. 11)	2458.74	2465.76	7.02

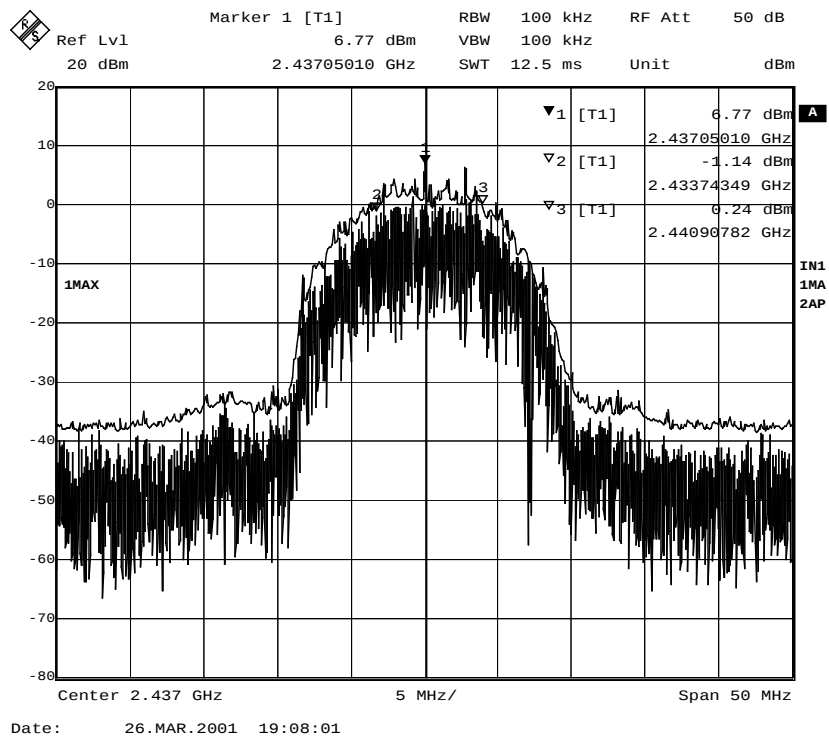
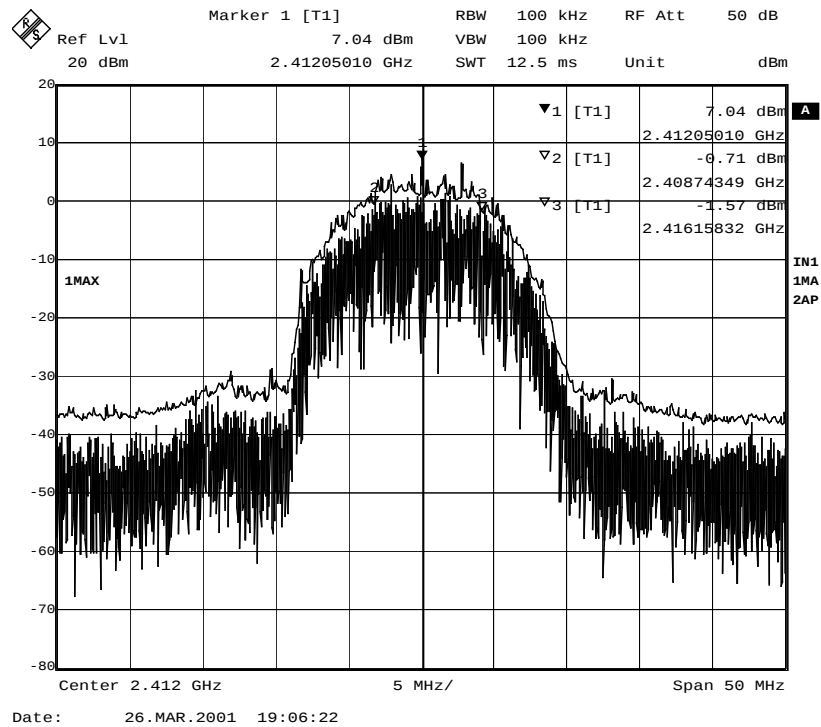
Test Personnel:

Tester Signature : T. Asano Date March 26, 2001

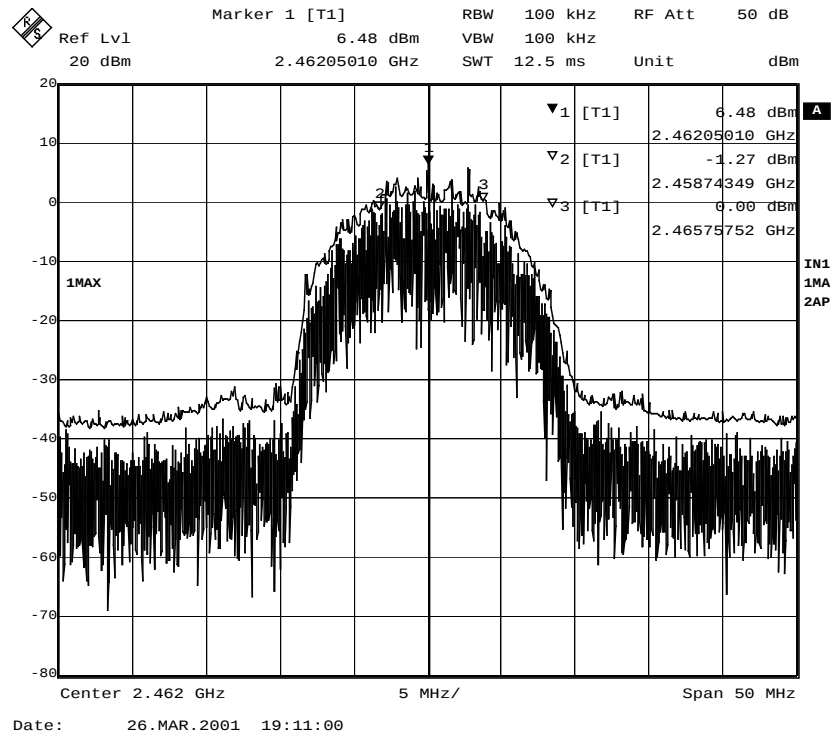
Tester Name : Takeshi Asano

Prepared by T. Asano

1.4 Trace Data



Prepared by T. Asano



2. Occupied Bandwidth / Band-edge (at 20 dB below), and Out of Band Emissions

2.1 Test Procedure

The bandwidth at 20 dB down from the highest inband spectral density is measured with a spectrum analyzer connected to the antenna terminal, while EUT is operating in transmission mode at the appropriate center frequency.

The spectrum analyzer is set to :

RBW=100KHz, VBW=100KHz*1, Span=50MHz, Sweep=suitable duration based on the EUT specification

*1: To be adjusted accordingly based on the spectrum stability

2.2 Test Instruments and Measurement Setup

Same as the Chapter 1(Table 1-1 & Figure 1).

2.3 Measurement Results of Occupied Bandwidth / Band-edge

Table 2-2. EUT: M/T 2628-W1U, s/n ZZ-00029, TX mode 11Mbps

Center Frequency (MHz)	Lower Frequency (MHz)	Upper Frequency (MHz)	Bandwidth at 20 dB below (MHz)	Margin to Lower limit (MHz)	Margin to Upper limit (MHz)
2412 (ch. 1)	2404.23	2419.57	15.34	4.23	
2437 (ch. 6)	2429.18	2444.67	15.49		
2462 (ch. 11)	2454.23	2469.57	15.34		13.93

2.4 Measurement Results of Out of Band Emissions

All conducted emission in any 100kHz bandwidth outside of the spread spectrum band was at least 20dB lower than the highest inband spectral density.

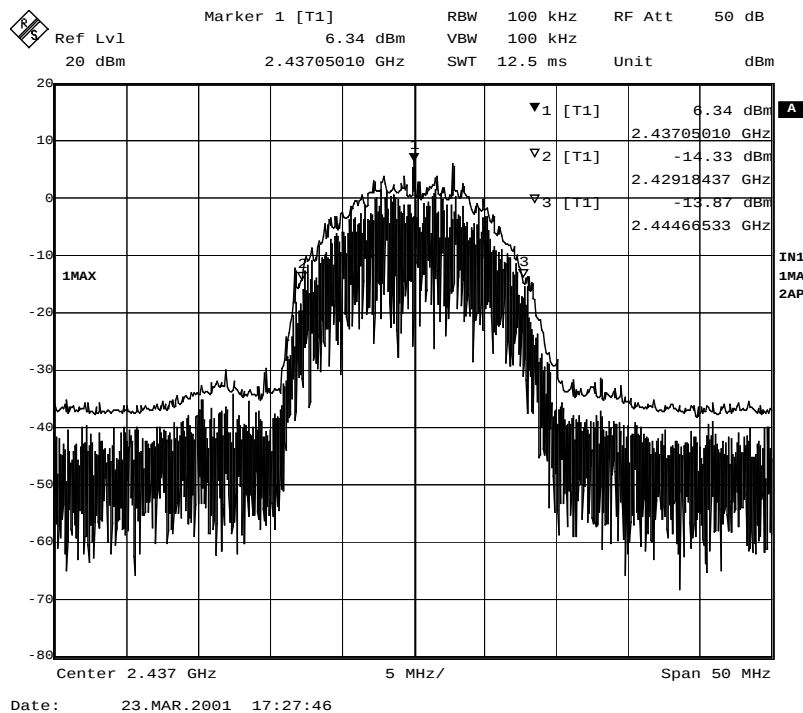
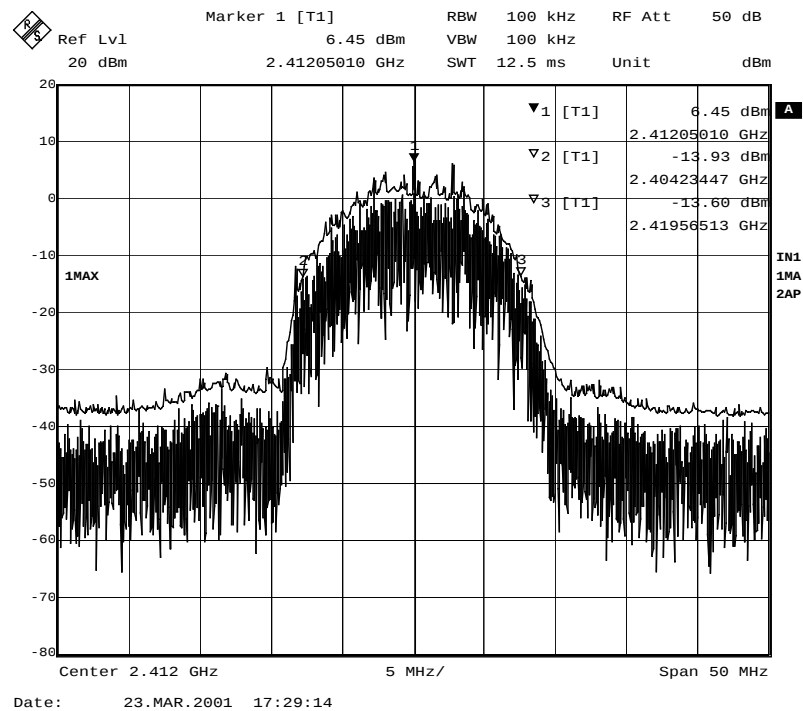
Test Personnel:

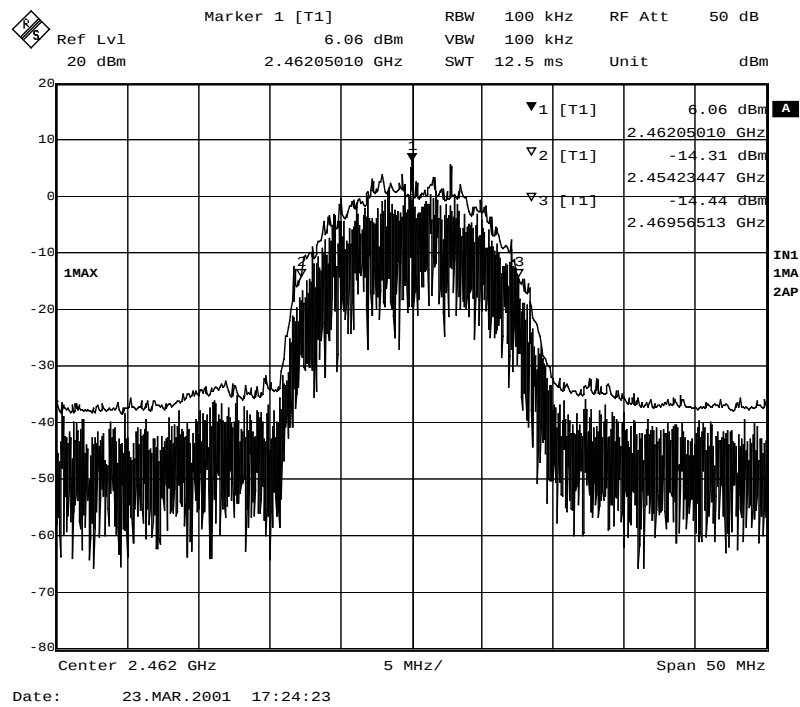
Tester Signature : T. Asano Date March 26, 2001

Tester Name : Takeshi Asano

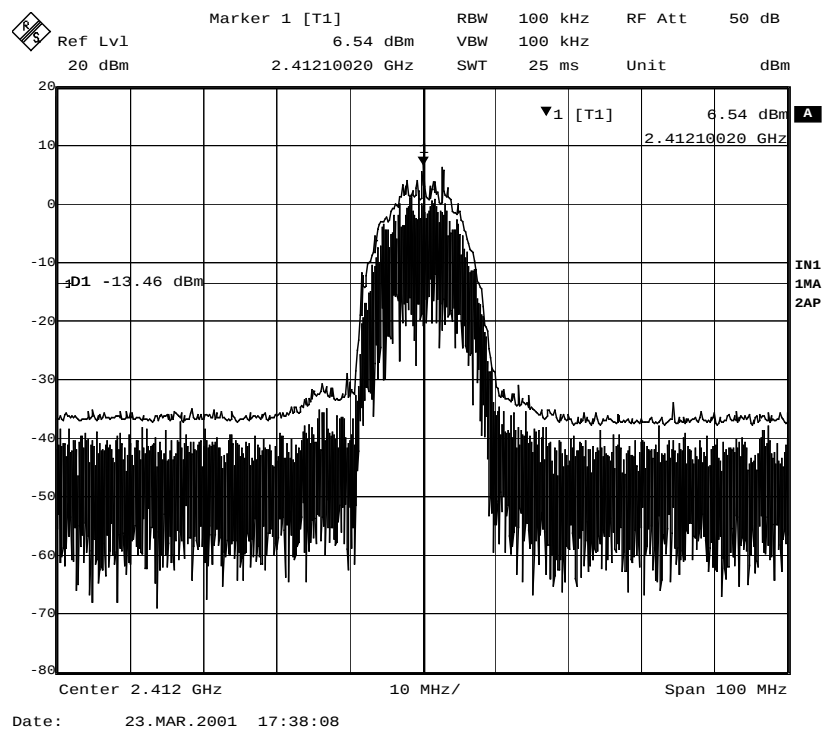
Prepared by T. Asano

2.5 Trace Data of Band-edge

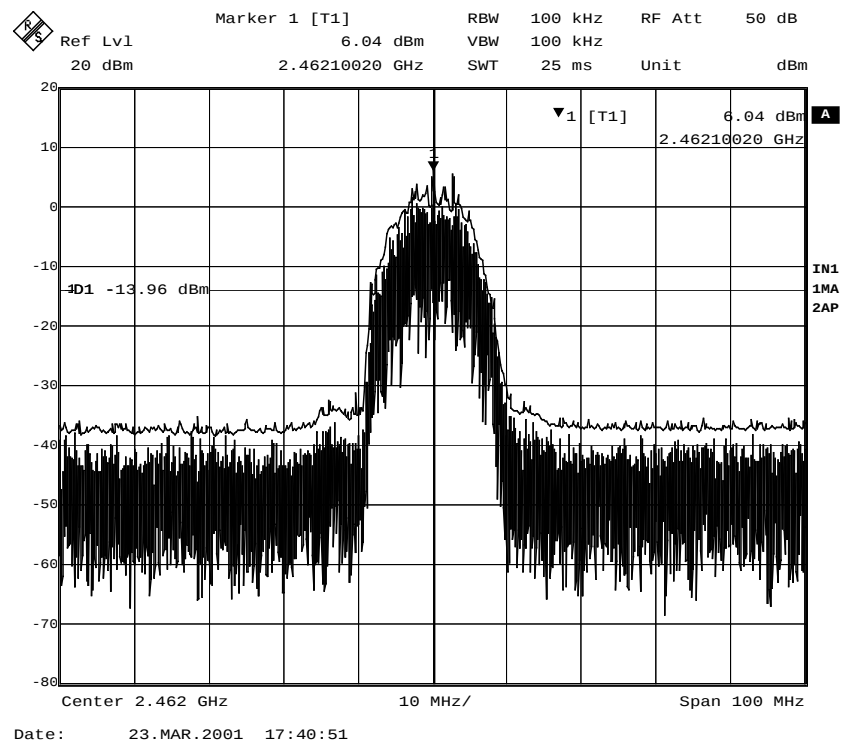
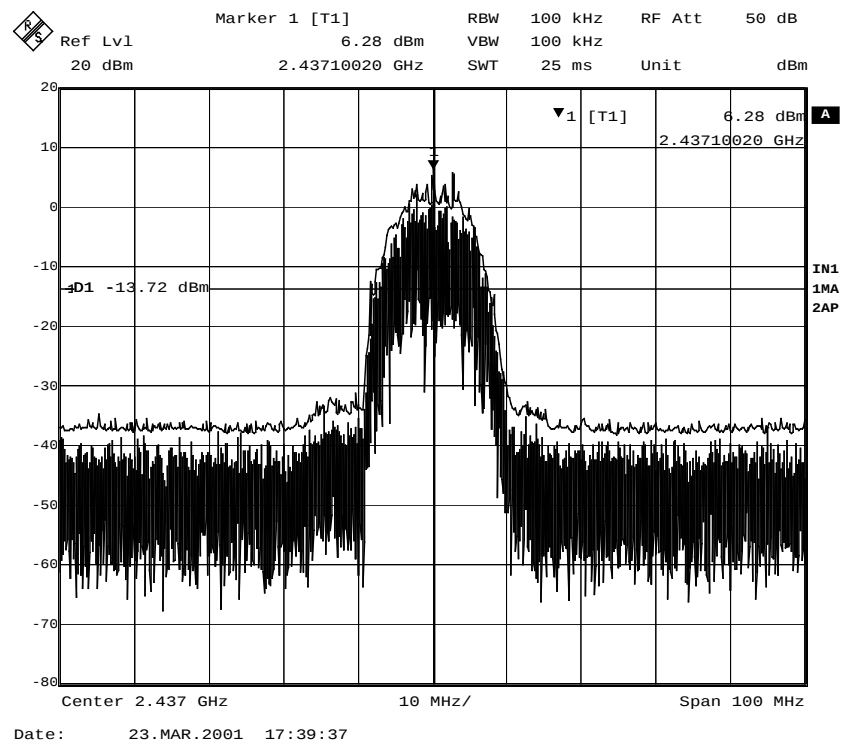




2.6 Trace Data of Out of Band Emissions



Prepared by T. Asano



3. Transmitter Output Power

3.1 Test Procedure

- A transmitter antenna terminal of EUT is connected to the input of a RF power sensor.
- Measurement is made while EUT is operating in transmission mode at the appropriate center frequency.

Table 3-1 : 6 dB Bandwidth Test Instruments

Description	Model	Serial Number
Power Meter	HP 436A	2604A24191
Power Sensor	HP 8482A	2607A11105
Coax cables: - Power Sensor <=> EUT	Length: 40 cm Loss: 1.1 dB	

Notes: - HP: Hewlett Packard

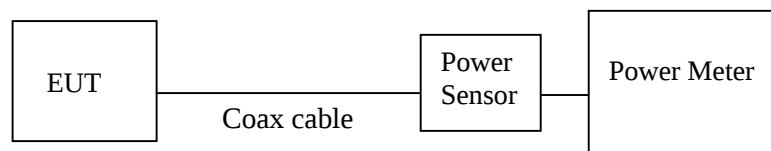


Figure 3: Measurement setup for RF output power

3.2 Measurement Results

Table 3-2. EUT: M/T 2628-W1U, s/n ZZ-00029, TX mode 11Mbps

Measured Frequency	Power Meter Reading	Cable Loss	Results		Limit [1W]	Margin
(MHz)	(dBm)	(dB)	(dBm)	(W)	(dBm)	(dB)
2412 (ch. 1)	14.5	1.1	15.6	0.0363	30.0	14.4
2437 (ch. 6)	14.4	1.1	15.5	0.0355	30.0	14.5
2462 (ch. 11)	14.1	1.1	15.2	0.0331	30.0	14.8

Table 3-3. EUT: M/T 2628-W1U, s/n ZZ-00029, TX mode 2Mbps

Measured Frequency	Power Meter Reading	Cable Loss	Results		Limit [1W]	Margin
(MHz)	(dBm)	(dB)	(dBm)	(W)	(dBm)	(dB)
2412 (ch. 1)	14.5	1.1	15.6	0.0363	30.0	14.4
2437 (ch. 6)	14.4	1.1	15.5	0.0355	30.0	14.5
2462 (ch. 11)	14.3	1.1	15.4	0.0347	30.0	14.6

Test Personnel:

Tester Signature : T. Asano Date March 26, 2001

Tester Name : Takeshi Asano

4. Transmitter Power Spectral Density

4.1 Test Procedure

The peak power density is measured with a spectrum analyzer connected to the antenna terminal, while EUT is operating in transmission mode at the appropriate center frequency.

The spectrum analyzer is set to:

RBW= 3KHz, VBW=100KHz, Span=10MHz, Sweep = 2.8 seconds

4.2 Test Instruments and Measurement Setup

Same as the Chapter 1(Table 1-1 & Figure 1).

4.3 Measurement Results

Table 4-1. EUT: M/T 2628-W1U, s/n ZZ-00029, TX mode 11Mbps

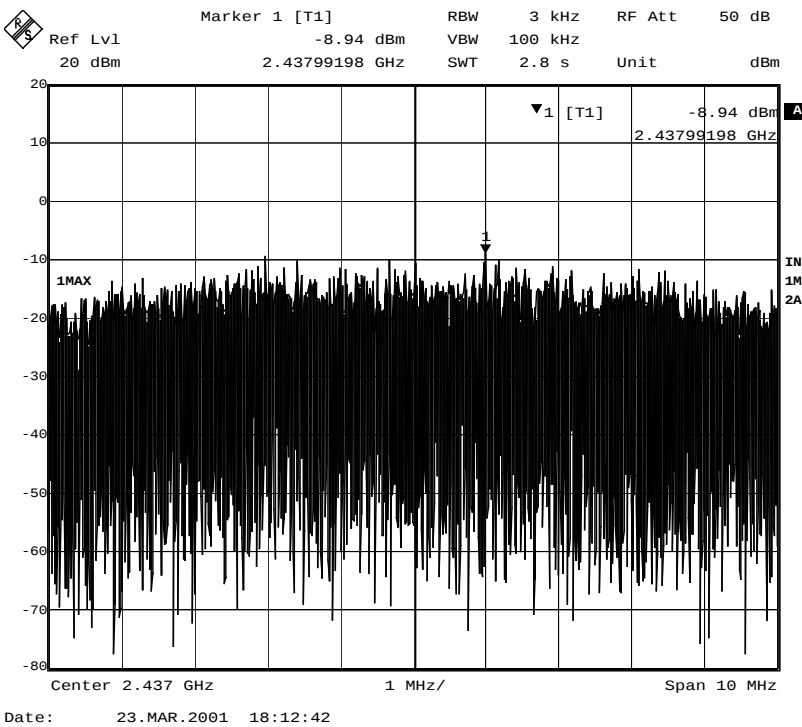
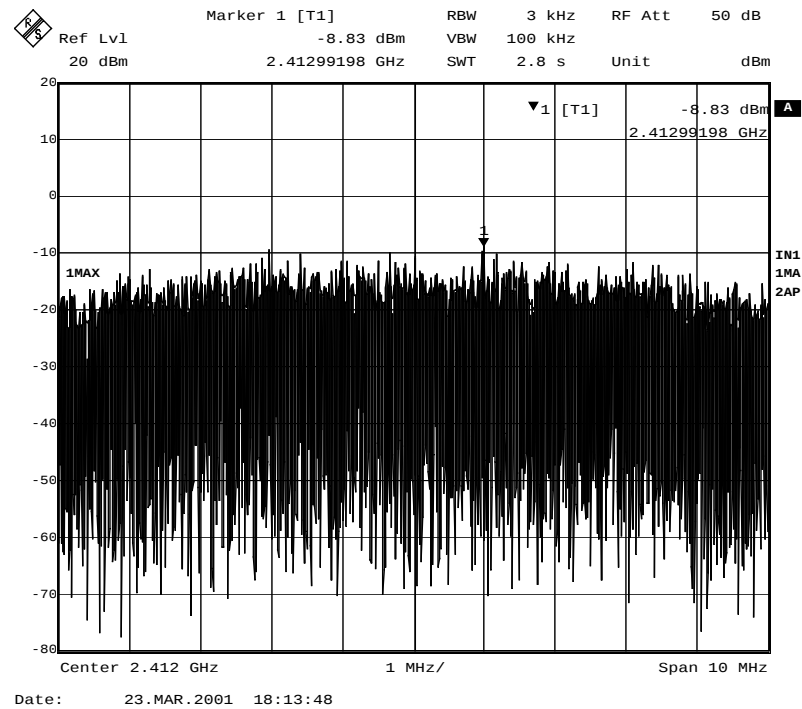
Ch No.	Frequency (MHz)	Spectrum Analyzer Reading (dBm)	Cable loss (dB)	Result (dBm)	Limit (dBm)	Margin (dB)
1	2412.99	-8.8	1.7	-7.1	8.0	15.1
6	2437.99	-8.9	1.7	-7.2	8.0	15.2
11	2462.99	-9.1	1.7	-7.4	8.0	15.4

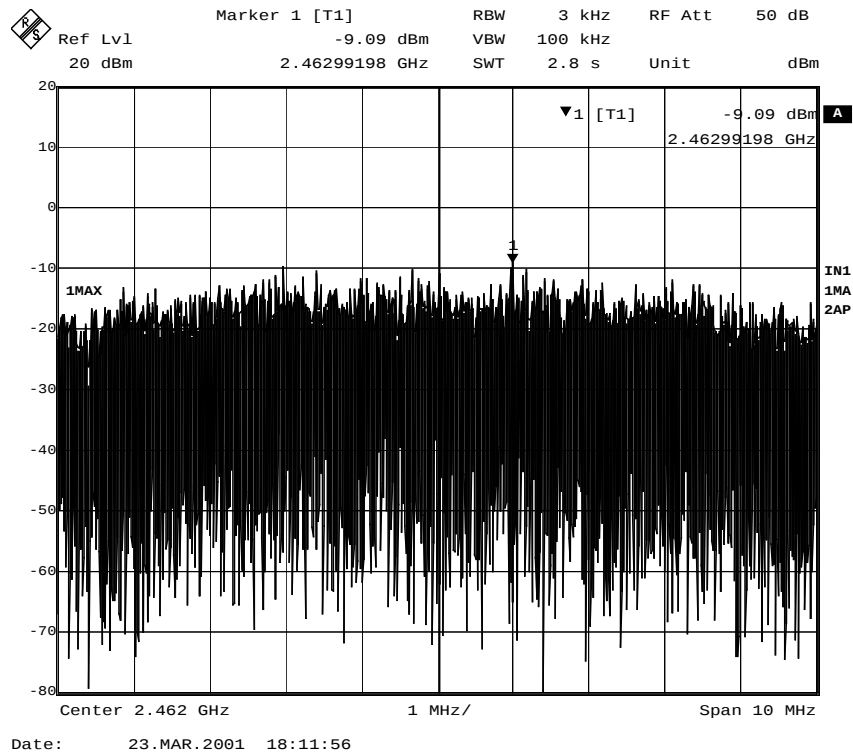
Test Personnel:

Tester Signature : T. Asano Date March 26, 2001

Tester Name : Takeshi Asano

4.4 Trace Data





5. AC WIRELINE CONDUCTED EMISSIONS (450KHz – 30MHz)

5.1 Test Procedure

The conducted emissions are measured in the IBM shielded room with a spectrum analyzer in peak hold. Emissions closest to the limit are measured in the quasi-peak mode (QP) with the tuned receiver using a bandwidth of 9KHz. The emissions are maximized further by cable manipulation. The highest emissions relative to the limit are listed.

5.2 Test Instruments and Measurement Setup

Table 5-1. Conducted Emission Test Instrumentation

Description	Model	Serial Number
Computer	IBM 6589-13J	97-15613
Spectrum Analyzer (100Hz-1.5GHz)	HP 8568B	2732A03651
Spectrum Analyzer Display	HP 8568B	2648A15255
Quasi-Peak Adapter	HP 85650A	2521A00968
Receiver (9kHz-30MHz)	R&S ESH3	891806/012
LISN	EMCO 3825/2	1426
Switch/control unit	HP 3488A	2719A17228
Plotter	HP 7550A	2631A33619
Coax cables: - Lisn-L <=> SW/Con.unit (SW100) - Lisn-N <=> SW/Con.unit (SW101) - SW/Con.unit <=> RCVR (Input) - SW/Con.unit<=> Spe Ana.(Signal In)	Length: 4 m 4 m 1 m 1 m	- EMIC-L - EMIC-N - EMIC-R - EMIC-S

Notes: - HP: Hewlett Packard, R&S: Rohde & Schwarz

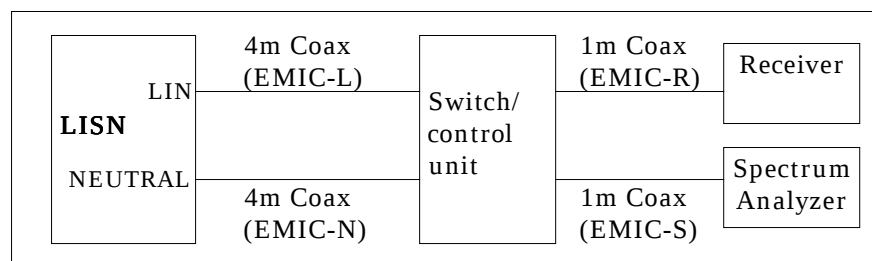


Figure 5. Cables for Conducted Emission Test

5.3 Measurement Results

The EUT was found to comply to the limits of FCC Part 15 Subpart C for transmitter and receiver with a margin of 17.0 dB. The 6 highest emissions relative to the limits are reported.

1) EUT in transmission mode

Table 5-2-1. EUT: M/T 2628-W1U, s/n ZZ-00029, Ch.1(2412MHz) TX mode 11Mbps

Frequency (MHz)	QP Voltage (dB μ V)	QP Limit (dB μ V)	QP Voltage (μ V)	QP Limit (μ V)	Phase
0.4830	31.0	48.0	35.5	250	Line
0.6007	27.1	48.0	22.6	250	Neutral
0.7265	25.3	48.0	18.4	250	Line
0.8492	25.3	48.0	18.4	250	Line
0.9952	24.7	48.0	17.2	250	Line
1.4436	21.9	48.0	12.43	250	Neutral

Table 5-2-2. EUT: M/T 2628-W1U, s/n ZZ-00029, Ch.6(2437MHz) TX mode 11Mbps

Frequency (MHz)	QP Voltage (dB μ V)	QP Limit (dB μ V)	QP Voltage (μ V)	QP Limit (μ V)	Phase
0.4656	28.3	48.0	26.0	250	Line
0.6148	26.9	48.0	22.1	250	Line
0.7673	24.9	48.0	17.6	250	Line
0.8424	24.2	48.0	16.2	250	Line
1.3124	23.6	48.0	15.1	250	Line
1.4318	24.2	48.0	17.6	250	Line

Table 5-2-3. EUT: M/T 2628-W1U, s/n ZZ-00029, Ch.11(2462MHz) TX mode 11Mbps

Frequency (MHz)	QP Voltage (dB μ V)	QP Limit (dB μ V)	QP Voltage (μ V)	QP Limit (μ V)	Phase
0.4791	30.0	48.0	31.6	250	Line
0.6022	28.7	48.0	27.2	250	Line
0.7271	25.9	48.0	19.7	250	Line
0.9768	24.1	48.0	16.0	250	Line
1.3124	24.6	48.0	17.0	250	Neutral
6.8571	25.0	48.0	17.8	250	Line

2) EUT in receiving mode

Table 5-2-4. EUT: M/T 2628-W1U, s/n ZZ-00029, RX mode

Frequency (MHz)	QP Voltage (dB μ V)	QP Limit (dB μ V)	QP Voltage (μ V)	QP Limit (μ V)	Phase
0.4654	28.8	48.0	27.5	250	Line
0.6026	28.7	48.0	27.2	250	Line
0.7222	25.4	48.0	18.6	250	Line
1.3099	24.8	48.0	17.4	250	Line
1.5987	24.2	48.0	16.2	250	Line
6.7366	24.6	48.0	17.0	250	Line

Test Personnel:

Tester Signature : T. Asano Date March 26, 2001

Tester Name : Takeshi Asano

6. RESTRICTED BANDS RADIATIONS (30MHz – 1GHz)

6.1 Test Procedure

Preliminary radiated emissions are measured in the semi-anechoic chamber at a 3 meter distance on every azimuth in both horizontal and vertical polarity. The antennas are also scanned in height. The emissions are recorded with a spectrum analyzer in peak hold mode. The identified emissions are further maximized by a cable manipulation. Emissions closest to the limits are measured in the quasi-peak mode with the tuned receiver using a bandwidth of 120kHz. The highest emissions relative to the limit are listed.

6.2 Test Instruments and Measurement Setup

Table 6-1 Radiated Emission Test Instrumentation

Description	Model	Serial Number
Computer	IBM 5551-L	#4
Spectrum Analyzer (100Hz-1.5GHz) for 30-200MHz	HP 85680B	3019A05155
Spectrum Analyzer Display for 30-200MHz	HP 85662A	3026A19353
Quasi-Peak Adapter for 30-200MHz	HP 85650A	3033A01449
Spectrum Analyzer (100Hz-1.5GHz) for 200-1000MHz	HP 85680B	2841A04254
Spectrum Analyzer Display for 200-1000MHz	HP 85662A	2816A16831
Quasi-Peak Adapter for 200-1000MHz	HP 85650A	2811A01156
Amplifier (100KHz-1.3GHz)		
- for 30-200MHz	HP 8447D	2805A02919
- for 200-1000MHz	HP 8447D	2944A03506
Biconical Antenna (30-200MHz)	EMCO 3108	2400
Log-Periodic Antenna (200-1000MHz)	EMCO 3146	2150
Receiver (20MHz-1.3GHz)	R&S ESVP	892111/030
Switch/control unit	HP 3488A	2719A17226
N-Coax cables:	Length:	
- Bi-coni Ant <=> 10m Cable	9 m	- EM203L01
- 10m Cable <=> Shield Panel	10 m	- EM203L02
- Shield Panel <=> RF Amp	7 m	- EM203L03
- RF Amp <=> Power Splitter	0.5m	- EM203L04
- Log-peri Ant <=> 10m Cable	9 m	- EM203H01
- 10m Cable <=> Shield Panel	10 m	- EM203H02
- Shield Panel <=> RF Amp	7 m	- EM203H03
- RF Amp <=> Power Splitter	0.5m	- EM203H04
Coax cables:		
- Power Splitter <=> SW/Con.unit (SW110)	1 m	- EM203L05

- Power Splitter <=> SW/Con.unit (SW300)	1 m	- EM203L06
- Power Splitter <=> SW/Con.unit (SW100)	1 m	- EM203H05
- Power Splitter <=> SW/Con.unit (SW301)	1 m	- EM203H06
- SW/Con.unit <=> Receiver (Input)	2 m	- EM2RCV
- SW/Con.unit <=> Spe Ana.(Signal In) for 30- 200MHz	2 m	- EM2SPL
- SW/Con.unit <=> Spe Ana.(Signal In) for 200-1000MHz	2 m	- EM2SPH

Notes:
- HP: Hewlett Packard, R&S: Rohde & Schwarz

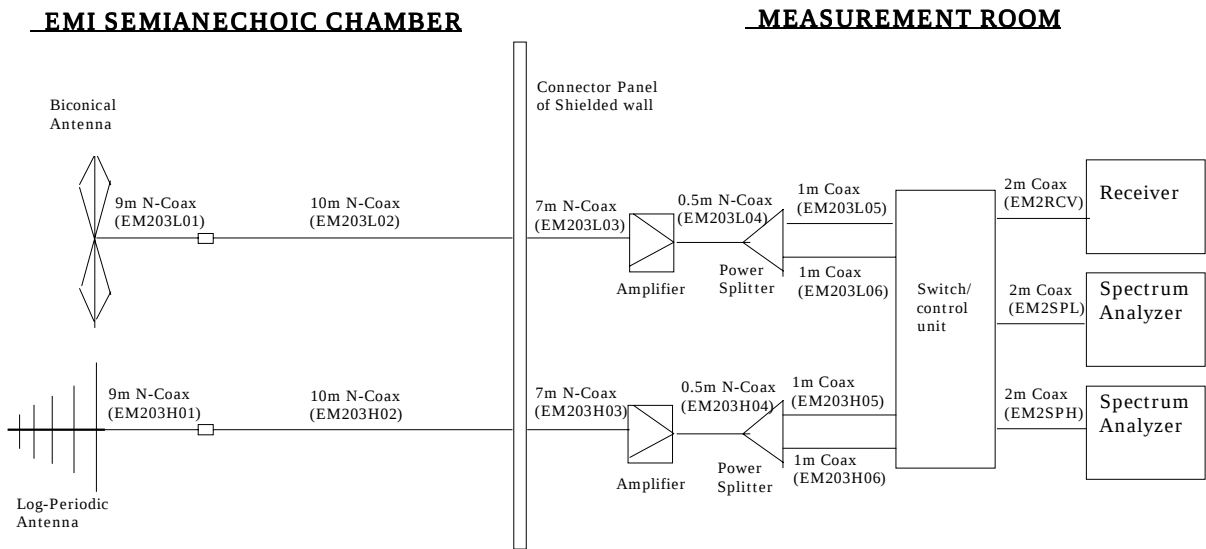


Figure 6 Cables for Radiated Emission Test

6.3 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. In this test facility, the Antenna Factor, Cable Loss, and Amplifier Gains are loaded into the Rohde & Schwarz Receiver and the corrected field strength can be read directly on the receiver. All factors are included in the reported data.

$$FS = R + AF + CORR$$

where:

FS	=	Field Strength
R	=	Measured Receiver Input Amplitude
AF	=	Antenna Factor
CORR	=	Correction Factor = CL - AG
CL	=	Cable Loss
AG	=	Amplifier Gain

For example:

Given a Receiver input reading of 51.5dB μ V; Antenna Factor of 8.5dB/m; Cable Loss of 1.3dB; and an Amplifier Gain of 26dB. The Field Strength of the measured emission is:

$$FS = 51.5 + 8.5 + 1.3 - 26.0 = 35.3\text{dB}\mu\text{V/m}$$

Conversion between dB μ V/m (or dB μ V) and μ V/m (or μ V) are done as:

$$\text{Level}(\text{dB}\mu\text{V/m}) = 20 \times \text{Log}(\text{Level}(\mu\text{V/m}))$$

$$40\text{dB}\mu\text{V/m} = 100\mu\text{V/m}$$

$$48\text{dB}\mu\text{V/m} = 250\mu\text{V/m}$$

6.4 Measurement Results

The EUT was found to comply to the limits of FCC Part 15 Subpart C for transmitter and receiver with a margin of 4.8 dB at 30MHz - 1000MHz band.

The 6 highest emissions relative to the limits are reported.

1) EUT in transmission mode

Table 6-2-1. EUT: M/T 2628-W1U, s/n ZZ-00029, Ch.1(2412MHz) TX mode 11Mbps

Frequency (MHz)	Polarity (H/V)	Measured (dBμV)	Antenna Factor (dB/m)	Corr. Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
192.017	H	29.7	13.6	-20.3	23.0	43.5	14.1	150
595.977	V	25.3	18.7	-16.0	28.0	46	25.1	200
645.222	V	31.6	19.5	-15.7	35.4	46	58.9	200
695.476	V	26.3	20.7	-15.4	31.6	46	38.0	200
746.696	V	31.3	20.7	-15.0	37.0	46	70.8	200
928.057	V	23.2	22.9	-13.7	32.4	46	41.7	200

Table 6-2-2. EUT: M/T 2628-W1U, s/n ZZ-00029, Ch.6(2437MHz) TX mode 11Mbps

Frequency (MHz)	Polarity (H/V)	Measured (dBμV)	Antenna Factor (dB/m)	Corr. Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
132.437	V	36.7	11.8	-20.9	27.6	43.5	24.0	150
456.008	V	39.3	16.8	-16.8	39.3	46	92.3	200
699.909	V	26.6	20.8	-15.3	32.1	46	40.3	200
746.695	V	30.0	20.7	-15.0	35.7	46	61.0	200
893.860	V	26.2	22.6	-14.0	34.8	46	55.0	200
900.160	V	26.2	22.7	-13.3	35.6	46	60.3	200

Table 6-2-3. EUT: M/T 2628-W1U, s/n ZZ-00029, Ch.11(2462MHz) TX mode 11Mbps

Frequency (MHz)	Polarity (H/V)	Measured (dBμV)	Antenna Factor (dB/m)	Corr. Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Field Strength (μV/m)	Limit (μV/m)
132.420	V	36.9	11.8	-20.9	27.8	43.5	24.5	150
195.432	H	35.2	13.7	-20.2	28.7	43.5	27.2	150
456.008	V	38.8	16.8	-16.8	38.8	46	87.1	200
699.135	V	26.4	20.8	-15.4	31.8	46	38.9	200
746.696	V	32.5	20.7	-15.0	38.2	46	81.3	200
899.701	V	25.8	22.7	-13.4	35.1	46	56.9	200

2) EUT in receiving mode

Table 6-2-4. EUT: M/T 2628-W1U, s/n ZZ-00029, RX mode

Frequency (MHz)	Polarity (H/V)	Measured (dB μ V)	Antenna Factor (dB/m)	Corr. Factor (dB)	Field Strength (dB μ V/m)	Limit (dB μ V/m)	Field Strength (μ V/m)	Limit (μ V/m)
176.000	H	36.6	13.1	-20.2	29.5	43.5	30.0	150
195.431	H	35.3	13.7	-20.2	28.8	43.5	27.5	150
456.007	V	41.2	16.8	-16.8	41.2	46	114.8	200
860.494	V	25.1	22.2	-14.8	32.5	46	42.2	200
893.925	V	24.4	22.6	-14.0	33.0	46	44.7	200
899.203	V	26.2	22.7	-13.4	35.5	46	59.6	200

Test Personnel:

Tester Signature : T. Asano Date March 26, 2001

Tester Name : Takeshi Asano

7. RESTRICTED BANDS RADIATIONS (1GHz – 25GHz)

7.1 Test Procedure

Radiated emissions were measured in the frequency range with 1 GHz to 25GHz in transmitting mode and 1 GHz to 12.5 GHz in receiving mode. All tests were performed in the semi-anechoic chamber at a 3-meter distance (except for the frequency range with 18 GHz to 25 GHz where test distance was reduced to 1 meter) on both horizontal and vertical polarities. The antenna was also scanned in height. The emissions are recorded with a spectrum analyzer in peak hold mode. The identified emissions are further maximized as a function of cable manipulation, azimuth, and antenna height. The emissions closest to the limits are measured in the peak mode with the tuned spectrum analyzer using a bandwidth of 1MHz and the average setting mode with the tuned spectrum analyzer using resolution bandwidth of 1MHz / video bandwidth of 1kHz. The highest emissions relative to the limit are listed.

7.2 Test Instruments and Measurement Setup

Table 7 Radiated Emission Test Instrumentation (1GHz – 25GHz)

Description	Model	Serial Number
Spectrum Analyzer EMI Test Receiver	R&S ESI26	836119/003
Amplifier (1-26.5GHz)	HP 8449B	3008A00580
Horn Antenna (1- 18GHz)	EMCO 3115	6121
Horn Antenna (3.95 – 5.85GHz)	EMCO 3160-5	1099
Horn Antenna (5.85 – 8.20GHz)	EMCO 3160-6	1044
Horn Antenna (18- 26.5GHz)	EMCO 3160-9	1202
SF106 cables: - Horn Ant <=> RF Amp. - RF Amp.<=>Spectrum Analyzer	Length: 6 m 15 m	- EM206SCO - EM215SCO

Notes: - HP: Hewlett Packard, R&S: Rohde & Schwarz

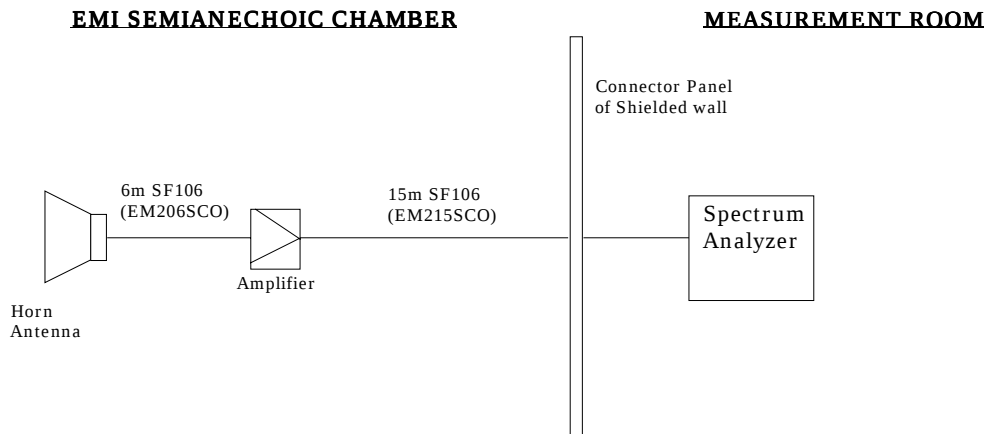


Figure 7 Cables for Radiated Emission Test

7.3 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. All factors are included in the reported data.

$$FS = R + AF + CORR - FO$$

where:

FS = Field Strength

R = Measured Spectrum analyzer Input Amplitude

AF = Antenna Factor

CORR = Correction Factor = CL-AG

CL = Cable Loss

AG = Amplifier Gain

FO = Distance Falloff Factor

For example:

Given a Spectrum Analyzer input reading of 51.5 dB μ V; Antenna Factor of 8.5 dB/m; Cable Loss of 1.3 dB; Falloff Factor of 0 dB; and an Amplifier Gain of 26 dB. The Field Strength of the measured emission is:

$$FS = 51.5 + 8.5 + 1.3 - 26 - 0.0 = 35.6 \text{ dB}\mu\text{V/m}$$

Conversions between dB μ V/m (or dB μ V) and μ V/m (or μ V) are done as :

$$\text{Level(dB}\mu\text{V/m)} = 20 \times \text{Log}(\text{Level}(\mu\text{V/m}))$$

$$40 \text{ dB}\mu\text{V/m} = 100 \mu\text{V/m}$$

$$48 \text{ dB}\mu\text{V/m} = 250 \mu\text{V/m}$$

7.4 Measurement Results

The EUT was found to comply to the limits of FCC Part 15 Subpart C for transmitter and receiver with a margin of 13.9 dB. The measurement was done for the frequency range of 1 GHz to 25 GHz in TX mode and 1 GHz to 12.5GHz in RX mode.

1) EUT in transmission mode

Table 7-2-1. EUT: M/T 2628-W1U, s/n ZZ-00029, Ch.1(2412MHz) TX mode 11Mbps

Frequency (GHz)	Polarity (H/V)	Measured (dB μ V) (<i>peak</i>)	Measured (dB μ V) (<i>average</i>)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dB μ V/m) (<i>peak</i>)	FCC Limit (dB μ V/m) (<i>peak</i>)	Field Strength (dB μ V/m) (<i>average</i>)	FCC Limit (dB μ V/m) (<i>average</i>)
1.098	V	60.2	-	25.1	-32.4	0.0	52.9	74.0	-	54.0
1.267	V	66.3	46.5	25.1	-32.1	0.0	59.3	74.0	39.5	54.0
1.337	H	59.1	-	25.1	-31.9	0.0	52.3	74.0	-	54.0
1.375	V	63.1	45.6	25.1	-31.8	0.0	56.4	74.0	38.9	54.0
1.493	V	57.5	-	25.1	-31.6	0.0	51.0	74.0	-	54.0
4.824	V	49.0	-	27.3	-27.9	0.0	48.4	74.0	-	54.0
7.236	H	41.2	30.6	29.9	-26.2	0.0	44.9	NRB*	34.3	NRB*

* NRB: Non Restricted Band

Table 7-2-2. EUT: M/T 2628-W1U, s/n ZZ-00029, Ch.6(2437MHz) TX mode 11Mbps

Frequency (GHz)	Polarity (H/V)	Measured (dB μ V) (<i>peak</i>)	Measured (dB μ V) (<i>average</i>)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dB μ V/m) (<i>peak</i>)	FCC Limit (dB μ V/m) (<i>peak</i>)	Field Strength (dB μ V/m) (<i>average</i>)	FCC Limit (dB μ V/m) (<i>average</i>)
1.098	V	59.6	-	25.1	-32.4	0.0	52.3	74.0	-	54.0
1.273	V	65.6	46.6	25.1	-32.0	0.0	58.7	74.0	39.7	54.0
1.379	V	65.5	45.8	25.1	-31.8	0.0	58.8	74.0	39.1	54.0
1.493	V	58.1	-	25.1	-31.6	0.0	51.6	74.0	-	54.0
4.874	V	49.2	-	27.3	-27.9	0.0	48.6	74.0	-	54.0
7.311	H	40.7	-	29.9	-26.2	0.0	44.4	74.0	-	54.0

Table 7-2-3. EUT: M/T 2628-W1U, s/n ZZ-00029, Ch.11(2462MHz) TX mode 11Mbps

Frequency (GHz)	Polarity (H/V)	Measured (dB μ V) (<i>peak</i>)	Measured (dB μ V) (<i>average</i>)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dB μ V/m) (<i>peak</i>)	FCC Limit (dB μ V/m) (<i>peak</i>)	Field Strength (dB μ V/m) (<i>average</i>)	FCC Limit (dB μ V/m) (<i>average</i>)
1.098	V	59.6	-	25.1	-32.4	0.0	52.3	74.0	-	54.0
1.269	V	64.3	47.1	25.1	-32.1	0.0	57.3	74.0	40.1	54.0
1.339	V	61.2	45.8	25.1	-31.9	0.0	54.4	74.0	39.0	54.0
1.381	H	61.5	43.7	25.1	-31.8	0.0	54.8	74.0	37.0	54.0
1.493	V	58.1	-	25.1	-31.6	0.0	51.6	74.0	-	54.0
4.924	V	49.8	-	27.3	-27.9	0.0	49.2	74.0	-	54.0
7.386	H	40.1	-	29.9	-26.1	0.0	43.9	74.0	-	54.0

2) EUT in receiving mode

Table 7-2-4. EUT: M/T 2628-W1U, s/n ZZ-00029, RX mode

Frequency (GHz)	Polarity (H/V)	Measured (dB μ V) (peak)	Measured (dB μ V) (average)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dB μ V/m) (peak)	FCC Limit (dB μ V/m) (peak)	Field Strength (dB μ V/m) (average)	FCC Limit (dB μ V/m) (average)
1.094	V	59.2	-	25.1	-32.4	0.0	51.9	74.0	-	54.0
1.244	V	56.5	-	25.1	-32.1	0.0	49.5	74.0	-	54.0
1.337	V	60.6	-	25.1	-31.9	0.0	53.8	74.0	-	54.0
1.369	V	57.5	-	25.1	-31.9	0.0	50.7	74.0	-	54.0

No other
peak was
detected

Test Personnel:

Tester Signature : T. AsanoDate March 26, 2001

Tester Name : Takeshi Asano

8. ANTENNA GAIN MEASUREMENT

8.1 Test Procedure

- Two EMCO 3115 horns with known gains were placed 3 meters apart and 1 meter above the ground plane. A signal was fed into one of the antennas using a 2.437 GHz signal source. The second horn was connected to the input of a spectrum analyzer.
- The following settings were made to the spectrum analyzer for all measurements:
 - The resolution bandwidth and video bandwidth were both set to 1 MHz.
 - Logarithmic amplifiers were selected for the detector function
- The horn to horn signal level, SHH , was measured in both horizontal and vertical polarities.
- The horn connected to the signal source was removed and replaced with the antenna of ThinkPad A22.
- The horn to ThinkPad antenna signal level, SHR , was measured with the horn in both horizontal and vertical polarities.
- The gain of the ThinkPad antenna, GR, was calculated by adding $SHR - SHH$ to the gain of the horn.

8.2 Test Instruments and Measurement Setup

Table 8-1 Antenna Gain Measurement Instrumentation

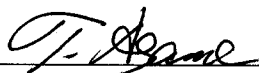
Description	Model	Serial Number
Spectrum Analyzer	R&S ESI26	836119/003
Amplifier (1-26.5GHz)	HP 8449B	3008A00580
Signal Generator	HP E4432B	GB38450342
Horn Antenna (1- 18GHz)	EMCO 3115	6121
Horn Antenna (1- 18GHz)	EMCO 3115	5774

8.3 Measurement Results

Table 8-2 Antenna Gain Measurement Result

Polarity	3115 to 3115 Signal Level (dBm)	3115 to ThinkPad Signal Level (dBm)	3115 Gain (dBi)	ThinkPad Antenna Gain (dBi)
Horizontal	-2.33	-10.24	9.3	1.4

Test Personnel:

Tester Signature :  Date March 26, 2001

Tester Name : Takeshi Asano

Prepared by T. Asano