

Emission Test Report

Standard: FCC Part 15 Subpart E / IC RSS-210

Document Number : FCC 19-0278-1

Model Number: WM3B2915ABG

measured with IBM ThinkPad T40 Series
and IBM ThinkPad R50 Series

FCC ID: ANO20040601CX2
IC: 349E-WM3B29AG

October 5, 2004

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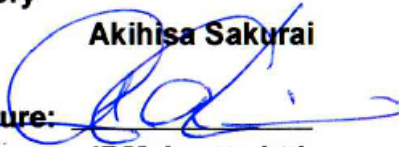
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Revision History

Revision	By Whom	Comment	Date
FCC 19-0278-0	Takeshi Asano	The original document for FCC certification approval	September 9, 2004,
FCC 19-0278-1	Takeshi Asano	Update of re-measurement results for Chapter 6.5 and 7.6 to add the radiated spurious emissions performed with the co-located Bluetooth transmitter (FCC ID: ANO20020100MTN).	October 5, 2004

MEASUREMENT / TECHNICAL REPORT – Part 15 Subpart E (Intentional Radiator)

Model: WM3B2915ABG MW2 (802.11a/b/g Wireless LAN Adapter)
with

IBM ThinkPad T40 Series

(Machine Type: 1871, 1875, 1873, 1874, 1875, 1876, 2373, 2374, 2375,
2376, 2378, 2379, 2668, 2669, 2678, 2679, 2686, 2687)

and

IBM ThinkPad R50 Series

(Machine Type: 1829, 1830, 1831, 1832, 1833, 1834, 1835, 1836, 1840,
1841, 1842, 2883, 2887, 2888, 2889, 2894, 2895)

FCC ID : ANO20040601CX2

October 5, 2004

This report concerns: (check one)

Original Grant ☒

Class I change ☐

Class II change ☐

Equipment type: Wireless LAN device

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The measurement results contained in this report relate only to the item which was tested.

Measurement procedure used is ANSI C63.4-2000 unless otherwise specified.

Other test procedure: _____

The FCC has issued provisional acceptance of this test laboratory for Declaration of Conformity testing per letter dated 1997.

APPLICANT ANTI-DRUG ABUSE CERTIFICATION:

By checking yes, the applicant certifies that, in the case of an individual applicant, he or she is not subject to a denial of federal benefits, that includes FCC benefits, pursuant to Section 5301 of the Anti-Drug Abuse of 1988, 21 U.S.C. 853(a), or, in the case of a non-individual applicant (e.g. corporation, partnership or other unincorporated association), no party to the application is subject to a denial of federal benefits, that includes FCC benefits, pursuant to that section. For the definition of a "party" for these purposes, see 47 CFR 1.2002(b).

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A. General Information

APPLICANT	: IBM Japan, Ltd.
TEST SITE	: IBM Japan, Ltd., Yamato Semi-anechoic chamber #1
TEST SITE 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 E Industry Canada RSS-210 (Issue No.5)
MODEL NUMBER (Advertising Name)	: WM3B2915ABG (Intel PRO/Wireless 2915 ABG Mini-PCI Adapter)
FCC ID IC Certification Number	: ANO20040601CX2 : 349E-WM3B29AG
SERIAL NUMBER	: 00S0SIT004
PHYSICAL CONDITION	: Preproduction
KIND OF EQUIPMENT	: Personal computer with a IEEE802.11a, 11b & 11g Wireless LAN Mini-PCI Combo Card (Composite application)
TESTED DATE	: August 23, 25, September 1, 2, 3, 6, 7, October 4 and 5, 2004

A.1 Test Methodology

Both conducted and radiated testing were performed according to the procedures in ANSI C63.4-2000. Radiated testing was performed at an antenna to EUT distance of 3 meters.

A.2 Test Facility / NVLAP Accreditation

The semi-anechoic chamber #1 used to correct the data are located in Yamato Laboratory, IBM Japan.

- This facility has been fully described in a report dated September 1998, submitted to the FCC office, and accepted in a letter, 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**)
- These facilities are accepted by **Industry Canada** as number **IC 4221** for chamber #1 (expiry date: January 25, 2005), and as number **IC 4221-1** for chamber #2 (expiry date: February 16, 2007).

A.3 EUT details

Table A EUT details

Model and S/N	FCC ID IC Certification Number	Description
WM3B2915ABG (s/n 00S0SIT004)	FCC ID: ANO20040601CX2 IC: 349E-WM3B29AG	Applying modular transmitter Built_in type IEEE802.11a/b/g Wireless LAN Mini-PCI card without antenna
BMDC200 (s/n 0020E04A4982)	FCC ID: ANO20020100MTN IC: 349E-BMDC200	Co-located Built-in type Bluetooth card without antenna
ThinkPad T40 Series M/T 2373-92U (14 inch) (s/n ZZ-00129) M/T 2373-PUU (15 inch) (s/n ZZ-22134)	N/A	Host equipment IBM Notebook PC with built_in antenna CPU: Intel® Pentium® M Processor, 1.7GHz
ThinkPad R50 Series M/T 1829-38x (14 inch) (s/n ZZ-08189) M/T 1829-62x (15 inch) (s/n ZZ-08233)		IBM Notebook PC with built_in antenna CPU: Intel® Pentium® M Processor, 1.5GHz
P/N 02K6746	N/A	Universal AC adapter 72W, Unshielded power cord

B. Summary of Test Results

Table-B presents the list of the measurement items for U-NII devices under FCC Part 15 Subpart E, and for LELAN devices under Industry Canada RSS-210.

The section numbers of upper portion are showing FCC codes, and the lower ones are for IC RSS-210.

Table-B List of the measurements

Section(s)	Test Items		Condition	Result
	Transmit mode (TX):			
15.407(a)(1), (2) 6.2.2 (q1)(i)(ii)	Bandwidth at 26 dB below	26dB BW was also taken for IC instead of 99% BW, according to RSS-210 6.2.2q(iv)(b).	Conducted	Pass
	Peak conducted transmit output power or EIRP for IC	5150-5250MHz: FCC: 50mW or (4+10logB)dBm IC : 200mW* or (10+10logB)dBm* *: EIRP		Pass
		5250-5350MHz: FCC: 250mW or (11+10logB)dBm IC : 250mW or (11+10logB)dBm IC : 1W* or (17+10logB)dBm* *: EIRP B: 26dB BW in MHz		Pass
	Peak Power Spectral Density	5150-5250MHz: FCC: 4 dBm in any 1MHz IC : 10 dBm in any 1MHz (EIRP) 5250-5350MHz: FCC: 11 dBm in any 1MHz IC : 11 dBm in any 1MHz		Pass
N/A 6.2.2 (q1)(iv)(b)	Peak Spectral Density	IC: 3 + 10logB dBm/MHz		Pass
15.407(a)(6) N/A	Peak Excursion	The ratio of the peak excursion of the modulation envelope to the peak transmit shall not exceed 13 dB across any 1 MHz .		Pass
15.207 / 407(b)(5) 6.2.2 (q1)(v) / 6.6	AC Wireline Conducted Emissions 150kHz- 30MHz	Class B: Freq.(MHz) QP(dBλV) Ave.(dBλV) 0.15 - 0.5 66 - 56 56 - 46 0.5 - 5 56 46 5 - 30 60 50		Pass
15.205 & 209 / 407(b)(1)(2)(5)(6) 6.2.1 / 6.2.2(q1)(i)(ii)(v) / 6.3	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Shall not exceed the limits specified in FCC 15.209 or RSS-210 Table3. Ave. 54dBλV/m, peak 74dBλV/m and	Radiated (30MHz - 1GHz)	Pass
		FCC 15.407(b)(1)(2) or RSS-210 6.2.2(q1)(i)(ii) : EIRP –27dBm/MHz	Radiated (1G - 40GHz)	Pass

	Receive mode (RX):			
15.207 / 407(b)(5) 6.2.2(q1)(v) / 7.4	AC Wireline Conducted Emissions 150kHz - 30MHz	Class B: Freq.(MHz) QP(dBλV) Ave.(dBλV) 0.15 - 0.5 66 - 56 56 - 46 0.5 - 5 56 46 5 - 30 60 50	Conducted	Pass
15.205 & 209 / 407(b)(1)(2)(5)(6) 6.2.1 / 6.2.2(q1)(i)(ii)(v) / 7.3	General Field Strength Limits (Radiated Emission Limits)	Shall not exceed the limits specified in FCC 15.209 or RSS-210 Table3. Ave. 54dBλV/m, peak 74dBλV/m and FCC 15.407(b)(1)(2) or RSS-210 6.2.2(q1)(i)(ii) : EIRP -27dBm/MHz	Radiated (30MHz - 1GHz)	Pass
			Radiated (1G - 25GHz)	Pass

	Other general requirements		Result
15.407(a)(1)(2) –	Antenna gain	Peak gain of the device : 2.84dBi in 5.2GHz band	N/A
– 5.2	Supply Voltage	Main power source: Universal AC adapter 72W Mini-PCI PC bus to applying card : DC 3.3V ! 0.3V	N/A
– 6.2.2(q1)(iv)(a)	Digital modulation	Applying equipment employs IEEE802.11a, 11g(OFDM) or 11b(DSSS) digital modulation technology.	complies
15.407(c) 6.2.2(q1)(iv)(d)	Automatic link disconnection in no transaction state	Refer to “Limited Modular Approval and U-NII Qualifications” or “Module Construction and LELAN Qualifications” documents.	complies
15.407(d) 6.2.2(q1)(i)	Integral antenna in the 5150M -5250MHz band	The device employs an unique electronic connector so called Electronic Handshake .	complies
15.407(e) 6.2.2(q1)(i) (q1)(iv)(g)	Indoor use in the 5150M - 5250MHz band, and interference from radars.	Refer to the manual (Regulatory Notice).	complies
15.407(f) 6.2.2(q1)(iv)(g)	RF Exposure Requirement	Refer to “RF Exposure Evaluation” or “Exposure of Humans to Radio Frequency Fields“ documents.	complies
15.407(g) 6.2.2(q1)(iv)(e)	Frequency stability	Refer to “Limited Modular Approval and U-NII Qualifications” or “Module Construction and LELAN Qualifications” documents.	complies

C. Operation mode of EUT

1. All tests were performed using the “CRTU III, version 3.2.15.0000” test program provided by Intel Corporation. This tool supports the continuous or burst transmission mode for the testing purpose. The parameter GAIN of the test software was set to the Intel’s power specification shown in Table-C below.
2. Three kinds of frequencies were chosen for the measurement. i.e. 5180MHz (lowest), 5260MHz(middle), and 5320MHz (highest).
3. As for the RF receiving test, the middle channels (5260MHz) were selected representatively.

Table-C Transmission mode of EUT (The measurement plots are shown in shading.)

Note) The table shows the specification of **average** power for the applying device in ‘dBm’.

Operation Frequency [GHz]	Designed average output power (conducted) [dBm]							
	6M bps	9M bps	12M bps	18M bps	24M bps	36M bps	48M bps	54M bps
5.180 (Ch. 36)	12	12	12	12	12	12	12	12
5.200 (Ch. 40)	12	12	12	12	12	12	12	12
5.220 (Ch. 44)	12	12	12	12	12	12	12	12
5.240 (Ch. 48)	12	12	12	12	12	12	12	12
5.260 (Ch. 52)	16	16	16	16	16	16	16	16
5.280 (Ch. 56)	16	16	16	16	16	16	16	16
5.300 (Ch. 60)	16	16	16	16	16	16	16	16
5.320 (Ch. 64)	16	16	16	16	16	16	16	16

Note) The power values of some higher transmission rates are reduced by the driver for best performance according EVM (Error Vector Magnitude) factor.

D. Justification

The host PCs (IBM ThinkPad T40 Series and R50 Series) are designed with the same conceptual hardware configuration of standard size laptop PC.

- The shading columns in the previous Table C show the transmission modes performed full testing. As for the higher Tx rates from 36Mbps to 54Mbps, the full test was performed with the primary power only.
- The host devices marked in shading in the Table-D below were used for EUT which have comparatively higher antenna gains and worse measurement results in each host PC series (T40 or R50). Then, the worst

case data were selected for this test report among the two host systems.

The actual highest emissions taken in this report in the Chapter 5 through 7 were found at 6Mbps on the main antenna of ThinkPad T40 Series (14 inch LCD model).

Refer to the Chapter 7.7 concerning the evaluation of the worst emission case.

Table-D Peak Antenna Gains of EUT

			14 inch LCD	15 inch LCD
5.2GHz band	ThinkPad T40 Series	Main Antenna gain	0.83 dBi (peak)	2.00 dBi (peak)
		Auxiliary Antenna gain	0.36 dBi (peak)	0.82 dBi (peak)
	ThinkPad R50 Series	Main Antenna gain	2.66 dBi (peak)	1.68 dBi (peak)
		Auxiliary Antenna gain	1.37 dBi (peak)	2.84 dBi (peak)

E. Test Instruments

Table-C List of Measuring Instruments

Description	Model	Serial Number	Calibration Date	Calibration Interval
Computer	IBM 6868-30J	97-901X3	N/A	N/A
Computer	IBM 6589-13J	97-15613	N/A	N/A
Spectrum Analyzer (100Hz-1.5GHz)	HP 85680B	2732A03651	07/21/04	1 year
Spectrum Analyzer (100Hz-1.5GHz)	HP 85680B	3019A05156	08/05/04	1 year
Spectrum Analyzer (100Hz-1.5GHz)	HP 85680B	2841A04254	08/25/04	1 year
Spectrum Analyzer Display	HP 85662A	2648A15255	07/21/04	1 year
Spectrum Analyzer Display	HP 85662A	3026A19366	08/05/04	1 year
Spectrum Analyzer Display	HP 85662A	2816A16831	08/25/04	1 year
Quasi-Peak Adapter	HP 85650A	2521A00968	07/20/04	1 year
Quasi-Peak Adapter	HP 85650A	2811A01433	08/05/04	1 year
Quasi-Peak Adapter	HP 85650A	2811A01156	08/25/04	1 year
Amplifier (100KHz - 1.3GHz)	MITEQ AM-3A	898433	04/23/04	1 year
- for 30-200MHz		898432	04/23/04	1 year
- for 200-1000MHz	HP 8449B	3008A00582	06/01/04	1 year
Amplifier (1GHz - 18GHz)	Agilent 83051A	3950M00193	01/27/04	1 year
Amplifier (18 – 40GHz)				
Spectrum Analyzer EMI Test Receiver	R&S ESI26	836119/003	05/10/04	1 year
Spectrum Analyzer	HP 8563E	3416A02248	08/21/04	1 year
Harmonic Mixer	Agilent 11970A	011269-001	08/04/04	1 year
Receiver (9kHz-30MHz)	R&S ESH3	891806/012	10/17/03	1 year
Receiver (20MHz-1.3GHz)	R&S ESVP	893202/018	02/10/04	1 year
Biconical Antenna (30-200MHz)	EMCO 3108	2536	04/23/04	1 year
Log-Periodic Antenna (200-1000MHz)	EMCO 3146	2849	04/23/04	1 year
Horn Antenna (1- 18GHz)	EMCO 3115	9903-5774	07/20/04	1 year
Horn Antenna (3.95- 5.85GHz)	EMCO 3160-5	1099	07/20/04	1 year
Horn Antenna (5.85- 8.20GHz)	EMCO 3160-6	9712-1044	07/20/04	1 year
Horn Antenna (8.20- 12.4GHz)	EMCO 3160-7	1156	07/20/04	1 year
Horn Antenna (12.4- 18GHz)	EMCO 3160-8	1143	07/20/04	1 year
Horn Antenna (18- 26.5GHz)	EMCO 3160-9	0004-1202	07/20/04	1 year

Horn Antenna (26.5- 40GHz)	EMCO 3160-10	1175	07/20/04	1 year
LISN	EMCO 3810/2NM	00022007	06/15/04	1 year
Switch/control unit	HP 3488A	2719A17226 2719A17228	N/A N/A	N/A N/A
Plotter	HP 7550A	2631A33619	N/A	N/A
Coaxial cables (1 – 18GHz):	Length:			
- Horn Ant <=> RF Amp.	6 m	- EM206SCO	03/25/04	1 year
- RF Amp. <=> Spectrum Analyzer(<12GHz)	16m	- GEM0101	03/25/04	1 year
- RF Amp. <=> Spectrum Analyzer(>12GHz)	3m	- SF102-20166	04/08/04	1 year
Coaxial cables (18 – 40GHz):				
- Horn Ant <=> RF Amp.	3m	- SF102-20167	04/08/04	1 year
- RF Amp. <=> Spectrum Analyzer	1m	- SF102-21105	04/08/04	1 year
N-Coax cables:				
- Bi-coni Ant <=> 10m Cable	9 m	- EM103L01	04/23/04	1 year
- 10m Cable <=> Shield Panel	10 m	- EM103L02	04/23/04	1 year
- Shield Panel <=> RF Amp	7 m	- EM103L03	04/23/04	1 year
- RF Amp <=> Power Splitter	0.5m	- EM103L04	04/23/04	1 year
- Log-peri Ant <=> 10m Cable	9 m	- EM103H01	04/23/04	1 year
- 10m Cable <=> Shield Panel	10 m	- EM103H02	04/23/04	1 year
- Shield Panel <=> RF Amp	7 m	- EM103H03	04/23/04	1 year
- RF Amp <=> Power Splitter	0.5m	- EM103H04	04/23/04	1 year
Coax cables:				
- Lisn-L <=> SW/Con.unit (SW100)	4 m	- EMIC-L	04/23/04	1 year
- Lisn-N <=> SW/Con.unit (SW101)	4 m	- EMIC-N	04/23/04	1 year
- SW/Con.unit <=> RCVR (Input)	1 m	- EMIC-R	04/23/04	1 year
- SW/Con.unit<=> Spe Ana.(Signal In)	1 m	- EMIC-S	04/23/04	1 year
- Power Splitter <=> SW/Con.unit (SW110)	1 m	- EM103L05	04/23/04	1 year
- Power Splitter <=> SW/Con.unit (SW300)	1 m	- EM103L06	04/23/04	1 year
- Power Splitter <=> SW/Con.unit (SW100)	1 m	- EM103H05	04/23/04	1 year
- Power Splitter <=> SW/Con.unit (SW301)	1 m	- EM103H06	04/23/04	1 year
- SW/Con.unit <=> Receiver (Input)	2 m	- EM1RCV	04/23/04	1 year
- SW/Con.unit <=> Spe Ana.(Signal In) for 30- 200MHz	2 m	- EM1SPL	04/23/04	1 year
- SW/Con.unit <=> Spe Ana.(Signal In) for 200-1000MHz	2 m	- EM1SPH	04/23/04	1 year

Notes.

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

F. Measurement Uncertainty

Uncertainties of the both, the Yamato EMI radiated test facilities (EMI chambers, #1 and #2) and the Yamato EMI conducted test facility are derived with the NIS 81 " Treatment of uncertainty in EMC measurements" 1994.

Estimated site uncertainty values are as follows.

EMI chamber #1 : 4.39dB

EMI chamber #2 : 4.40dB

EMI conducted measurement system : 2.4dB

Detail should be referred to "Treatment of Uncertainty, Calculations and Policy" report, document number TCR 10-0015.

G. Temperature and Humidity

The temperature is controlled within range of 17® to 28®.
The relative humidity is controlled within range of 40% to 70%.

H. Related Submittal(s)/Grant(s)/Notes

During the applying modular device stops RF transmission, the host unit with full peripheral devices including the applying modular device is classified as an unintentional radiator, Digital Device under the FCC Part 15 Subpart B or the Industry Canada Class B Emission Compliance (ICES-003), and subject to DoC.

1. Bandwidth at 26 dB below / Bandedge

[5150-5250MHz: FCC 15.407(a)(1), RSS 6.2.2q1(i) / q1(iV)(b)]
 [5250-5350MHz: FCC 15.407(a)(2), RSS 6.2.2q1(ii) / q1(iV)(b)]

1.1 Test Procedure

The bandwidth at 26 dB down from the peak of the RF emission was measured with a spectrum analyzer connected to the antenna terminal, while EUT was operating in continuous transmission mode at the appropriate center frequencies (5180 / 5260 / 5320MHz).

The spectrum analyzer was set to:

RBW=300kHz^{*1}, VBW=1MHz^{*2}, Span=50MHz, Sweep= 50ms, Mode= Peak detector

*1: approximately 1% of the emission bandwidth (15.403(c))

*2: VBW > RBW (To be adjusted accordingly based on the spectrum stability.)

Table 1-1: 26 dB Bandwidth Test Instruments

Description	Model	Serial Number
Spectrum Analyzer EMI Test Receiver	R&S ESI26	836119/003
Coax cables: - Spectrum Analyzer <=> EUT	Length: 110 cm Loss: 2.2 dB	

Notes: - R&S: Rohde & Schwarz

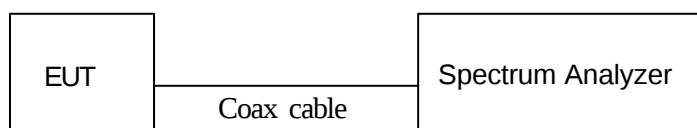


Figure 1: Measurement setup for 26dB bandwidth test

1.2 Measurement Results

Test Date: August 23 and 25, 2004

: the closest frequencies to the bandedge

: the widest bandedge plot in middle channels

Table 1-2-1. 26dB bandwidth, TX mode 6Mbps

Center Frequency (MHz)	Lower frequency (MHz)	Upper frequency (MHz)	Bandwidth at 26 dB below (MHz)	Plot data
5180 (ch. 36)	5168.23	5191.97	23.74	Plot 1-1
5240 (ch. 48)	5228.23	5252.27	24.04	omitted
5260 (ch. 52)	5248.13	5273.42	25.29	Plot 1-2
5320 (ch. 64)	5306.12	5335.68	29.56	Plot 1-3

Table 1-2-2. 26dB bandwidth, TX mode 18Mbps

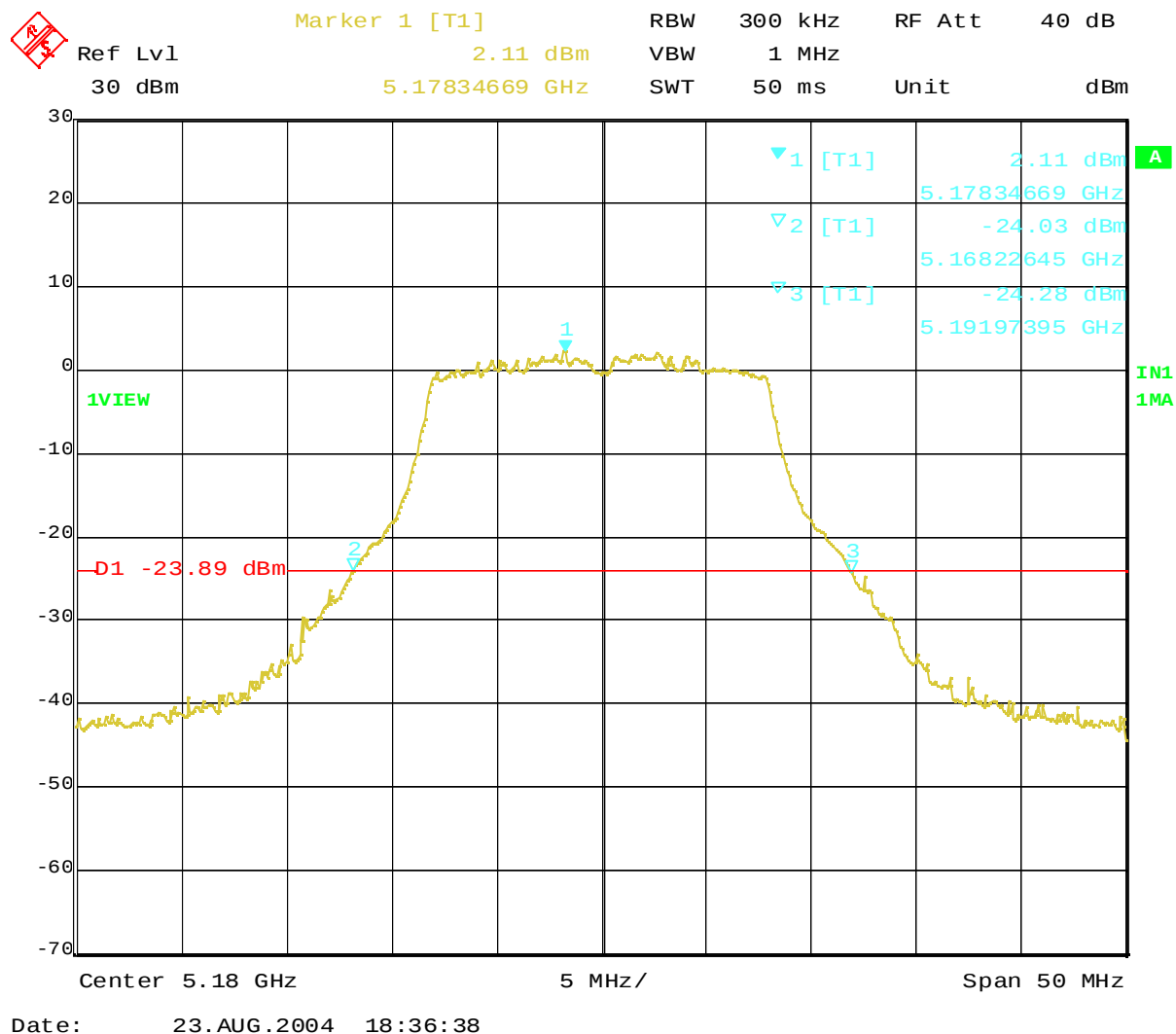
Center Frequency (MHz)	Lower frequency (MHz)	Upper frequency (MHz)	Bandwidth at 26 dB below (MHz)	Plot data
5180 (ch. 36)	5168.83	5191.37	22.54	omitted
5240 (ch. 48)	5228.83	5251.57	22.74	omitted
5260 (ch. 52)	5248.33	5271.51	23.18	omitted
5320 (ch. 64)	5306.82	5334.88	28.06	omitted

Table 1-2-3. 26dB bandwidth, TX mode 54Mbps

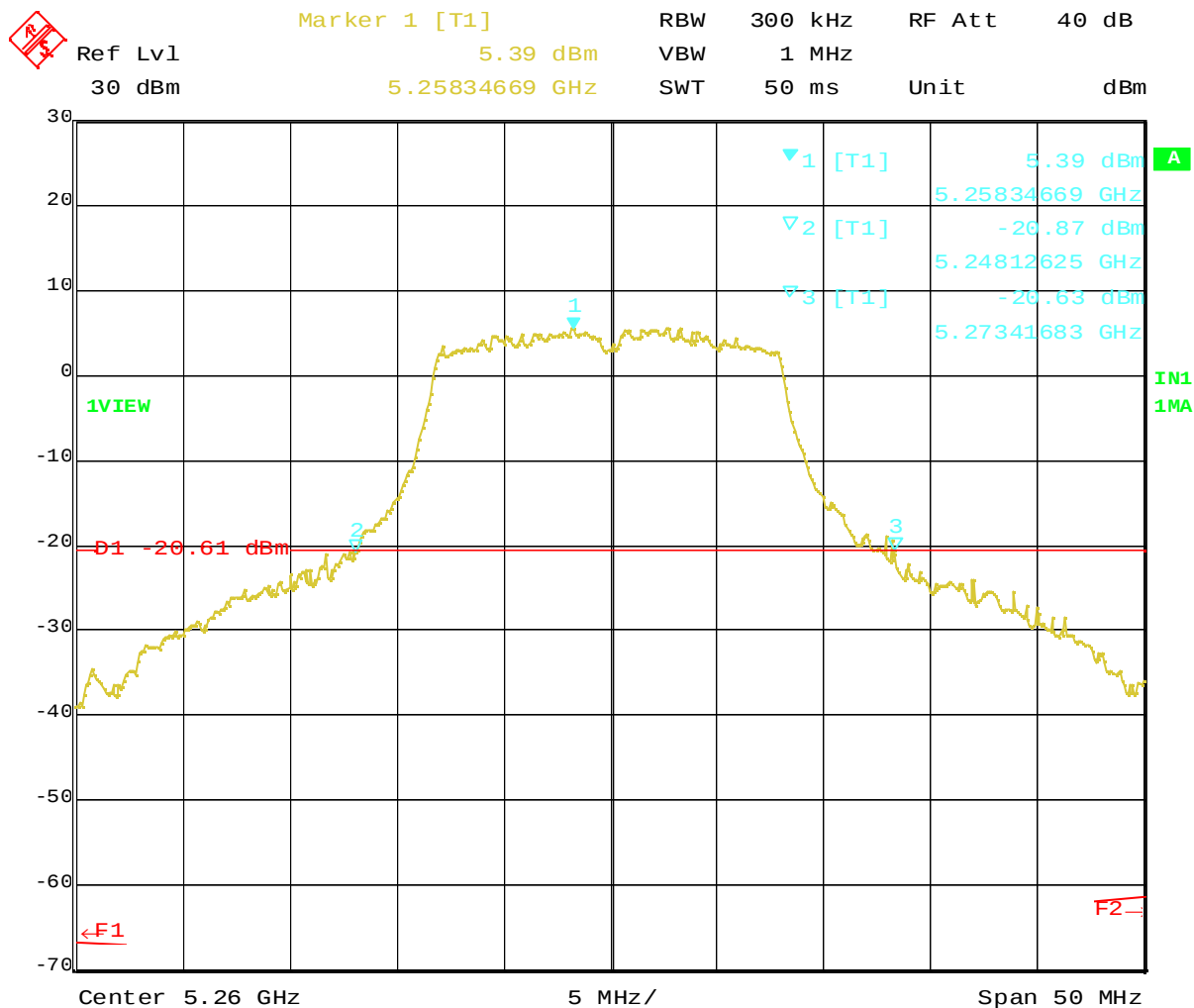
Center Frequency (MHz)	Lower frequency (MHz)	Upper frequency (MHz)	Bandwidth at 26 dB below (MHz)	Plot data
5180 (ch. 36)	5168.63	5191.47	22.84	omitted
5240 (ch. 48)	5228.82	5251.37	22.55	omitted
5260 (ch. 52)	5247.22	5271.61	24.39	omitted
5320 (ch. 64)	5305.72	5334.18	28.46	omitted

1.3 Trace Data

The plots are comparatively worse measurement cases of each measured frequency in the previous [Table 1-2-1](#) through [Table 1-2-3](#).

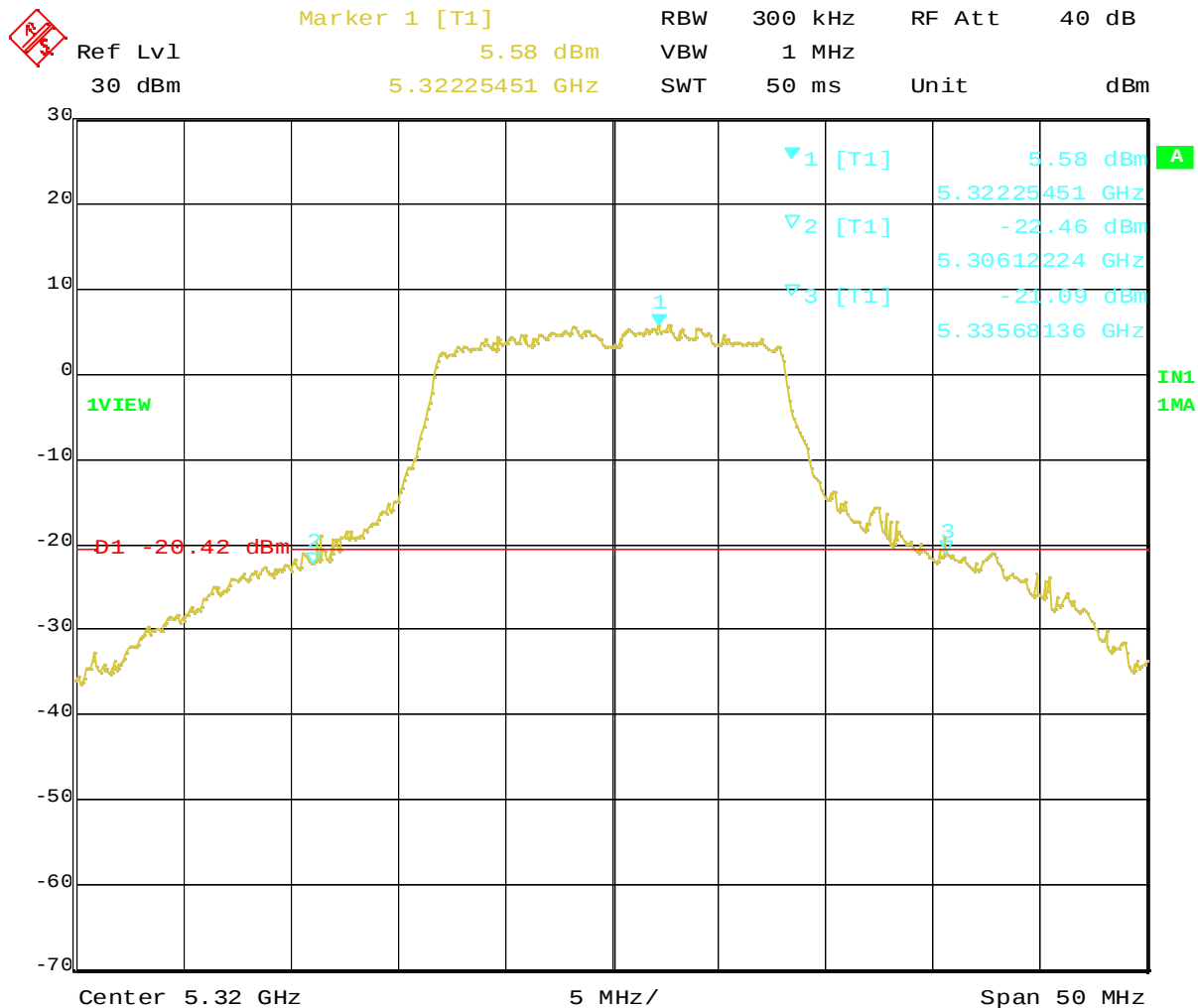


Plot 1-1. 26dB BW at 5180MHz (OFDM, 6Mbps)



Date: 25.AUG.2004 18:39:04

Plot 1-2. 26dB BW at 5260MHz (OFDM, 6Mbps)



Date: 23.AUG.2004 18:48:20

Plot 1-3. 26dB BW at 5320MHz (OFDM, 6Mbps)

2. Peak Conducted Transmit Output Power

[5150-5250MHz: FCC 15.407(a)(1), RSS 6.2.2q1(i) / q1(iV)(b)]

[5250-5350MHz: FCC 15.407(a)(2), RSS 6.2.2q1(ii) / q1(iV)(b)]

2.1 Test Procedure

The test was performed with a spectrum analyzer in accordance with the Method #3 of the FCC Public Notice, DA 02-2138, August/30/2002

The spectrum analyzer was connected to the antenna terminal, while EUT was operating in continuous transmission mode (shown in the Plot 2-0 below) at the appropriate center frequencies.

The spectrum analyzer was set to :

VBW= 30kHz (= 1/T, where T is transmission pulse duration. See Plot 2-0.), RBW=1MHz,

Span= 50MHz encompassing the entire 26dB emission bandwidth of the transmission signal,

Mode= sample detector, Trigger= free run

The band power measurement function was used to measure the peak power for each transmission mode (the lowest=6Mbps, middle=18Mbps and the highest=54Mbps). The analyzer computed the peak power by integrating the spectrum across the 26 dB emission bandwidth given by the previous chapter.

Table 2-1: Test instruments of spectrum analyzer method

Description	Model	Serial Number
Spectrum Analyzer EMI Test Receiver	R&S ESI26	836119/003
Coax cables: - Spectrum Analyzer <=> EUT	Length: 110 cm Loss: 2.2 dB	

Notes: - R&S: Rohde & Schwarz

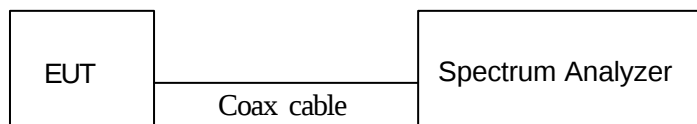


Figure 2-1 : Measurement setup of spectrum analyzer method

2.2 Measurement Results

Test Date: August 23 and 25, 2004

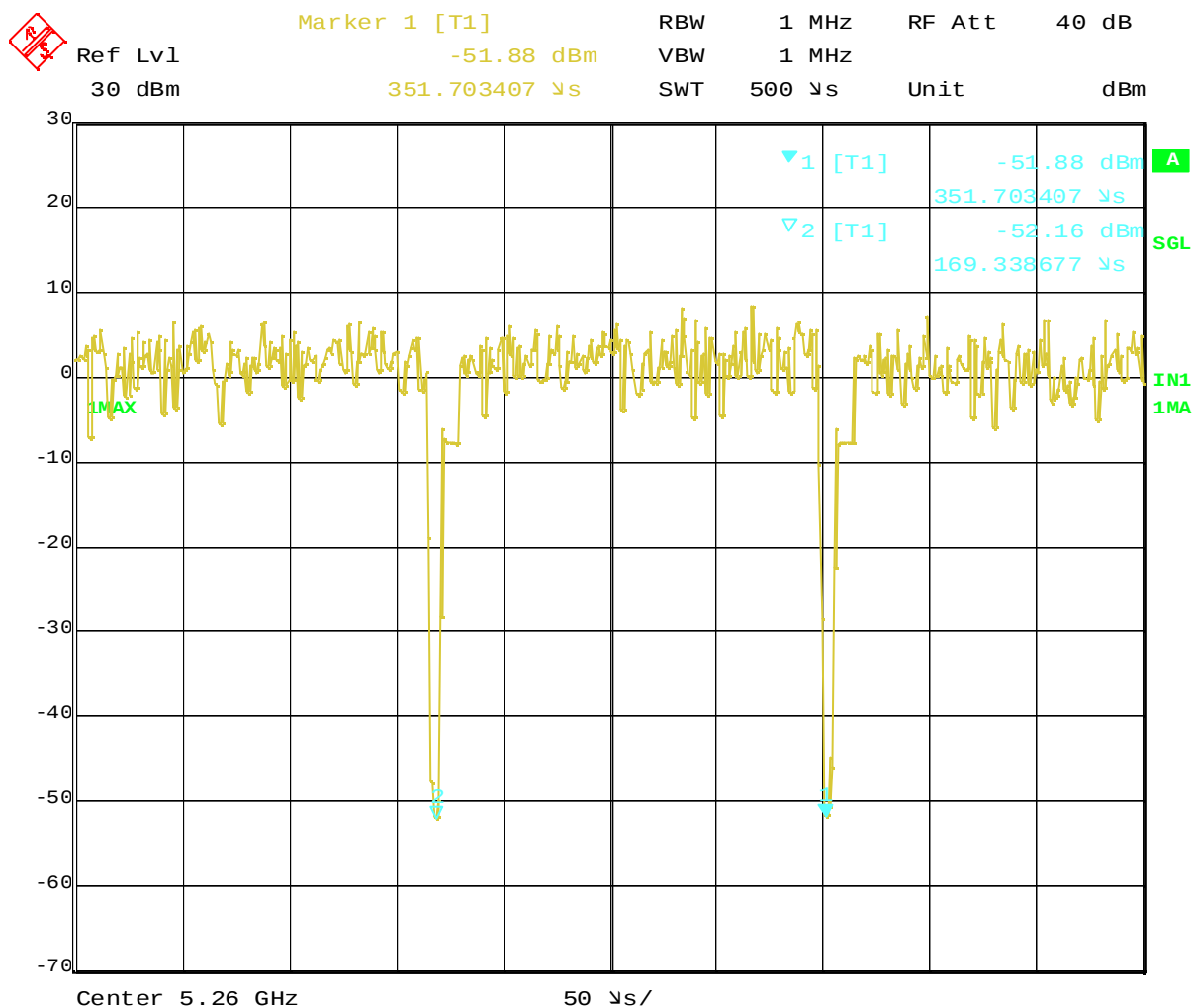
Table 2-2. Measurement results of peak conducted transmit output power

Measured Frequency (MHz)	Tx Rate (Mb/s)	Analyzer reading (dBm)	Trace number	Cable Loss (dB)	Results (dBm)	Limit		Peak antenna gain of EUT (dBi)	EIRP (dBm)	IC limit (dBm)
						FCC (dBm)	IC (dBm)			
5180	6	9.46	Plot 2-1	2.2	11.66	17	N/A	2.84	14.50	23
	18	9.22	omitted	2.2	11.42	17	N/A		14.26	23
	54 (primary)	9.41	omitted	2.2	11.61	17	N/A		14.45	23
	54 (secondary)	8.72	omitted	2.2	10.92	17	N/A		13.76	23
5240	6	9.57	Plot 2-2	2.2	11.77	17	N/A		14.61	23
	18	9.32	omitted	2.2	11.52	17	N/A		14.36	23
	54 (primary)	9.49	omitted	2.2	11.69	17	N/A		14.53	23
	54 (secondary)	8.84	omitted	2.2	11.04	17	N/A		13.88	23

Measured Frequency (MHz)	Tx Rate (Mb/s)	Analyzer reading (dBm)	Trace number	Cable Loss (dB)	Results (dBm)	Limit		Peak antenna gain of EUT (dBi)	EIRP (dBm)	IC limit (dBm)
						FCC (dBm)	IC (dBm)			
5260	6	13.27	Plot 2-3	2.2	15.47	24	24	2.84	18.31	30
	18	13.00	omitted	2.2	15.20	24	24		18.04	30
	54 (primary)	13.15	omitted	2.2	15.35	24	24		18.19	30
	54 (secondary)	9.16	omitted	2.2	11.36	24	24		14.20	30
5320	6	13.56	Plot 2-4	2.2	15.76	24	24		18.60	30
	18	13.33	omitted	2.2	15.53	24	24		18.37	30
	54 (primary)	13.46	omitted	2.2	15.66	24	24		18.50	30
	54 (secondary)	9.25	omitted	2.2	11.45	24	24		14.29	30

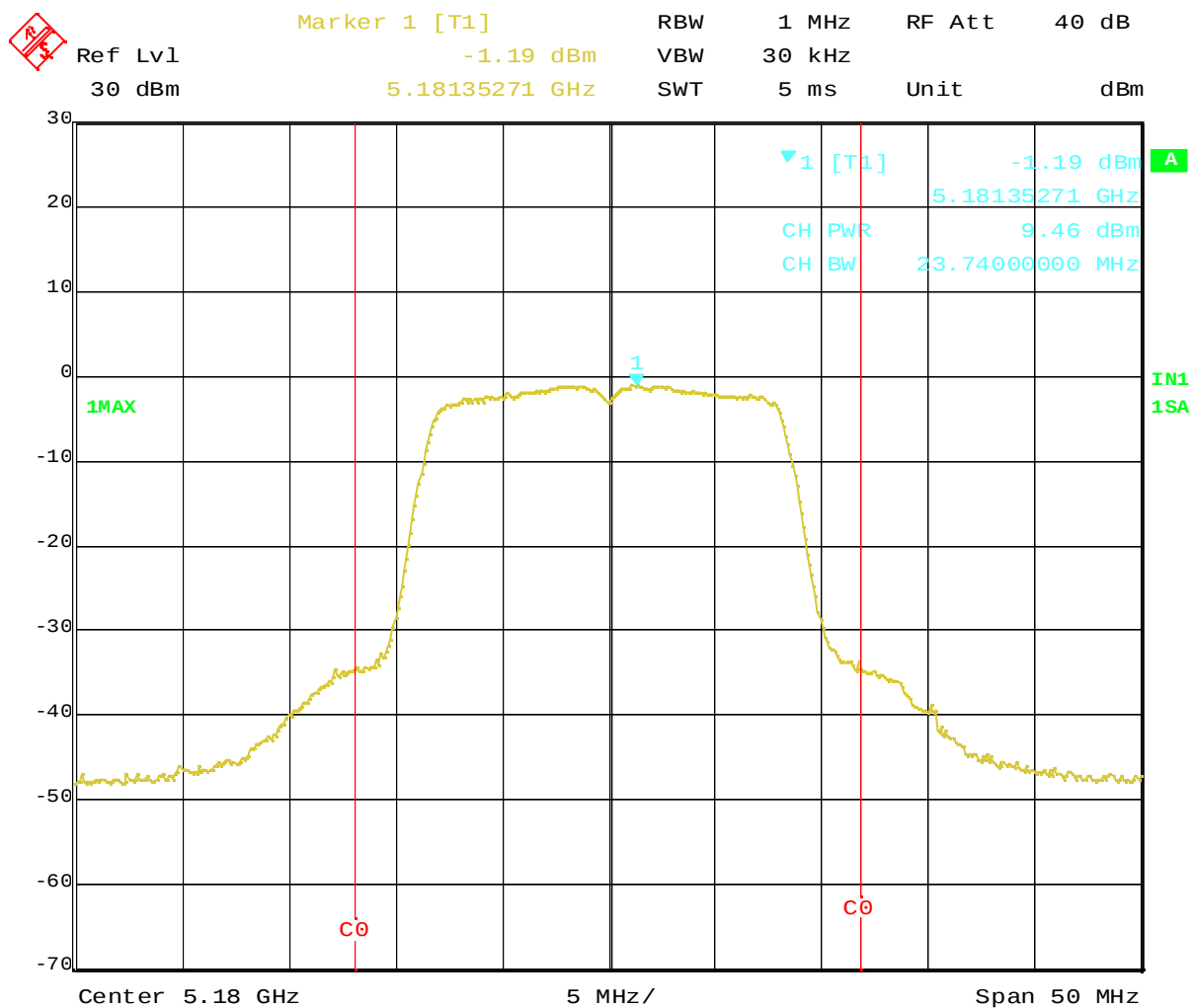
2.3 Trace Data

$$T \text{ (transmission pulse duration)} = 351.7 - 169.3 = 182.4 \text{ mS}$$



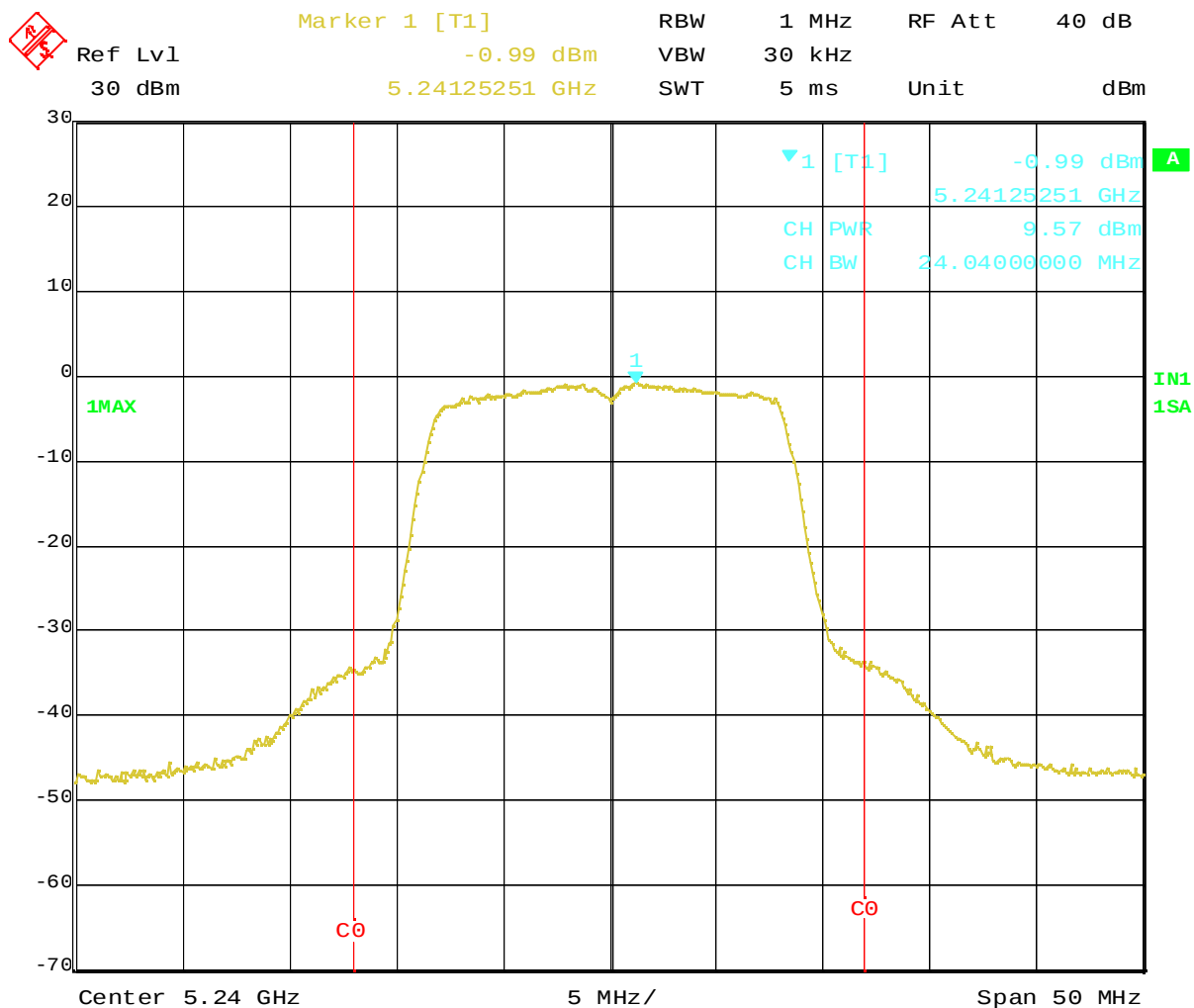
Plot 2-0 Transmission Pulse Duration

Hereafter, comparatively worse measurement cases of each measured frequency in the previous Table 2.2 are selected.



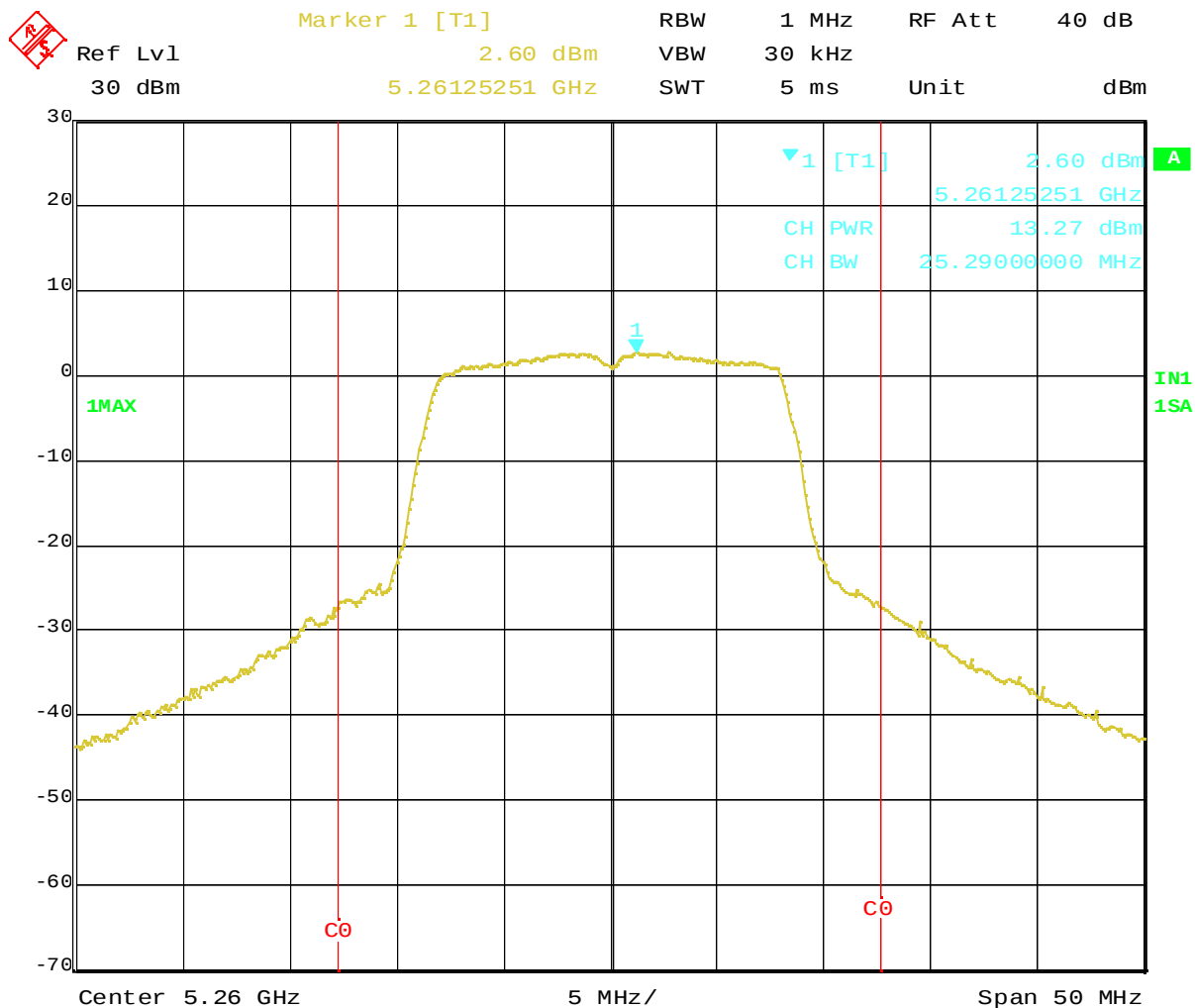
Date: 23.AUG.2004 22:35:50

Plot 2-1 Conducted Peak Power at 5180MHz (OFDM, 6Mbps)



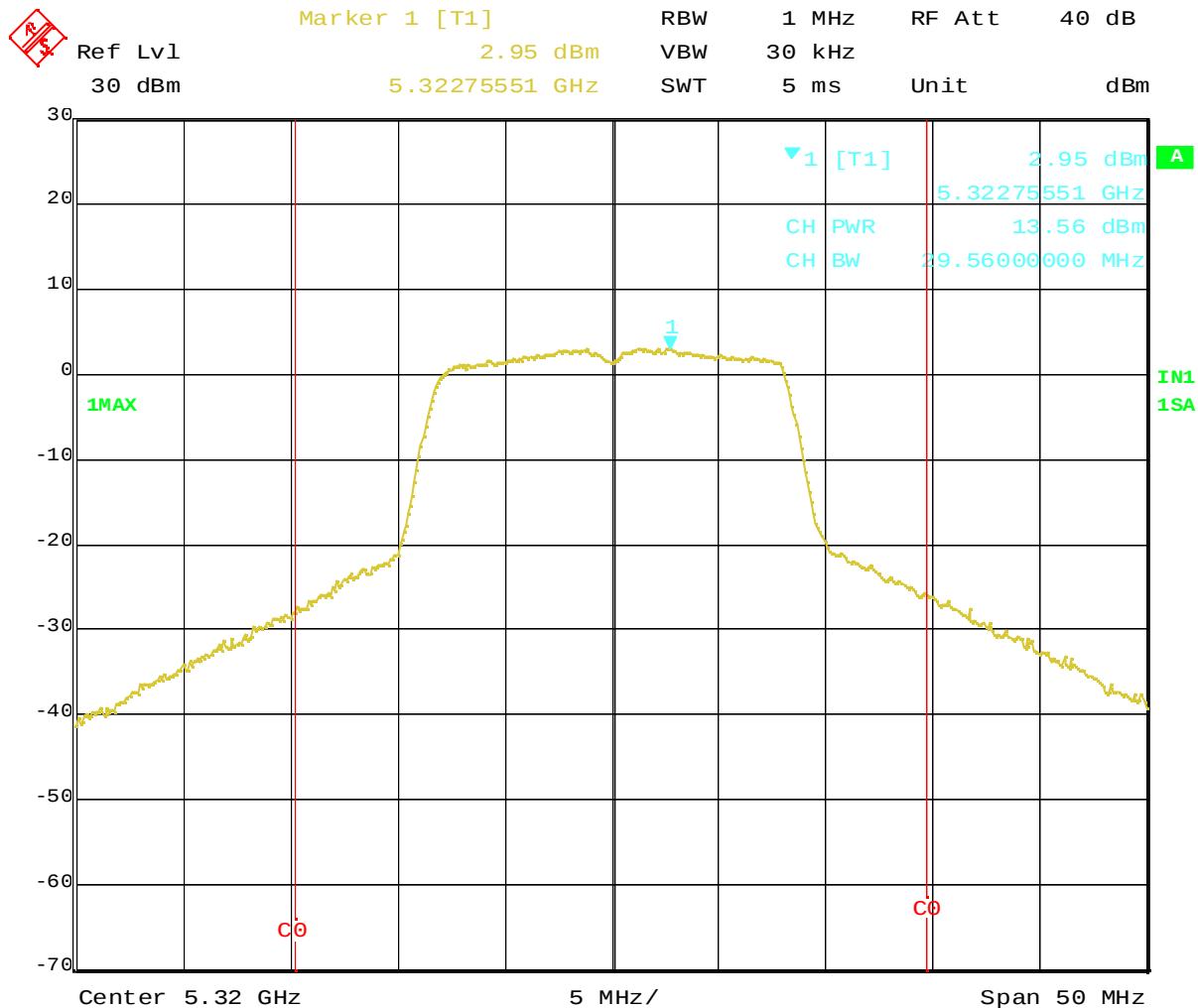
Date: 25.AUG.2004 20:20:10

Plot 2-2 Conducted Peak Power at 5240MHz (OFDM, 6Mbps)



Date: 25.AUG.2004 20:40:37

Plot 2-3 Conducted Peak Power at 5260MHz (OFDM, 6Mbps)



Date: 23.AUG.2004 22:52:02

Plot 2-4 Conducted Peak Power at 5320MHz (OFDM, 6Mbps)

3. Peak Power Spectral Density

[5150-5250MHz: FCC 15.407(a)(1), RSS 6.2.2q1(i), (iv)(b)]

[5250-5350MHz: FCC 15.407(a)(2), RSS 6.2.2q1(ii), (iv)(b)]

3.1 Test Procedure

The peak power spectral density was measured in accordance with the Method 2 shown in FCC Public Notice DA 02-2138.

The spectrum analyzer was connected to the antenna terminal, while EUT was operating in continuous transmission mode at the appropriate center frequencies.

The spectrum analyzer was set to :
RBW= 1MHz, VBW=3MHz, Span=20MHz, Mode= sample detector,
The analyzer averaged 100 traces in power averaging mode, then the marker was set to the highest position in the spectrum.

Also the Canadian PPSP was examined with the following spectrum analyzer setting.
RBW= 1MHz, VBW=1MHz, Span=20MHz, Mode= sample detector, averaging off

The test instruments and setup configuration are the same as the Table 2-1 and Figure 2-1.

3.2 Measurement Results

The measurement was performed with the worst case that tend to have higher conducted peak power based on the results of previous Chapter 2 “Peak Conducted Transmit Output Power” measurement.
i.e. 6Mbps was the worst case.

Test Date: August 25, 2004

Table 3-1. Measurement results of PPSP

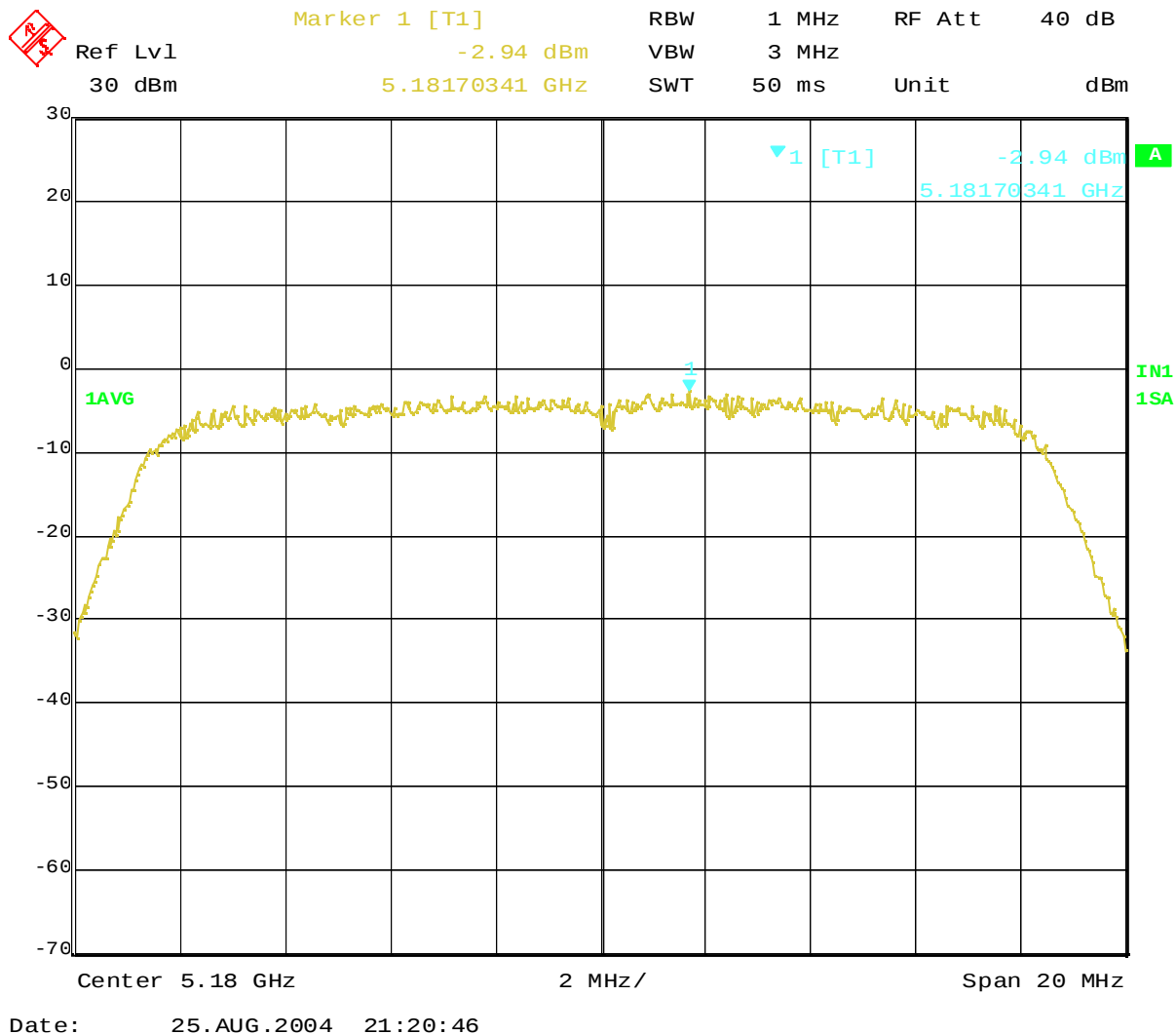
Measured Frequency (MHz)	Analyzer reading (dBm)	Trace number	Cable Loss (dB)	Results (dBm)	FCC Limit (dBm)	IC Limit q1(ii) (dBm)	Peak Antenna Gain (dBm)	IC EIRP (dBm)	IC Limit q1(i) (dBm)
5181.70	-2.94	Plot 3-1	2.2	-0.7	4.0	N/A	2.84	2.1	10
5242.34	-2.88	Plot 3-2	2.2	-0.7				2.1	
5258.42	0.92	Plot 3-3	2.2	3.1	11.0	11.0			N/A
5318.90	0.84	Plot 3-4	2.2	3.0					

Table 3-2. Measurement results of Canadian PPSP

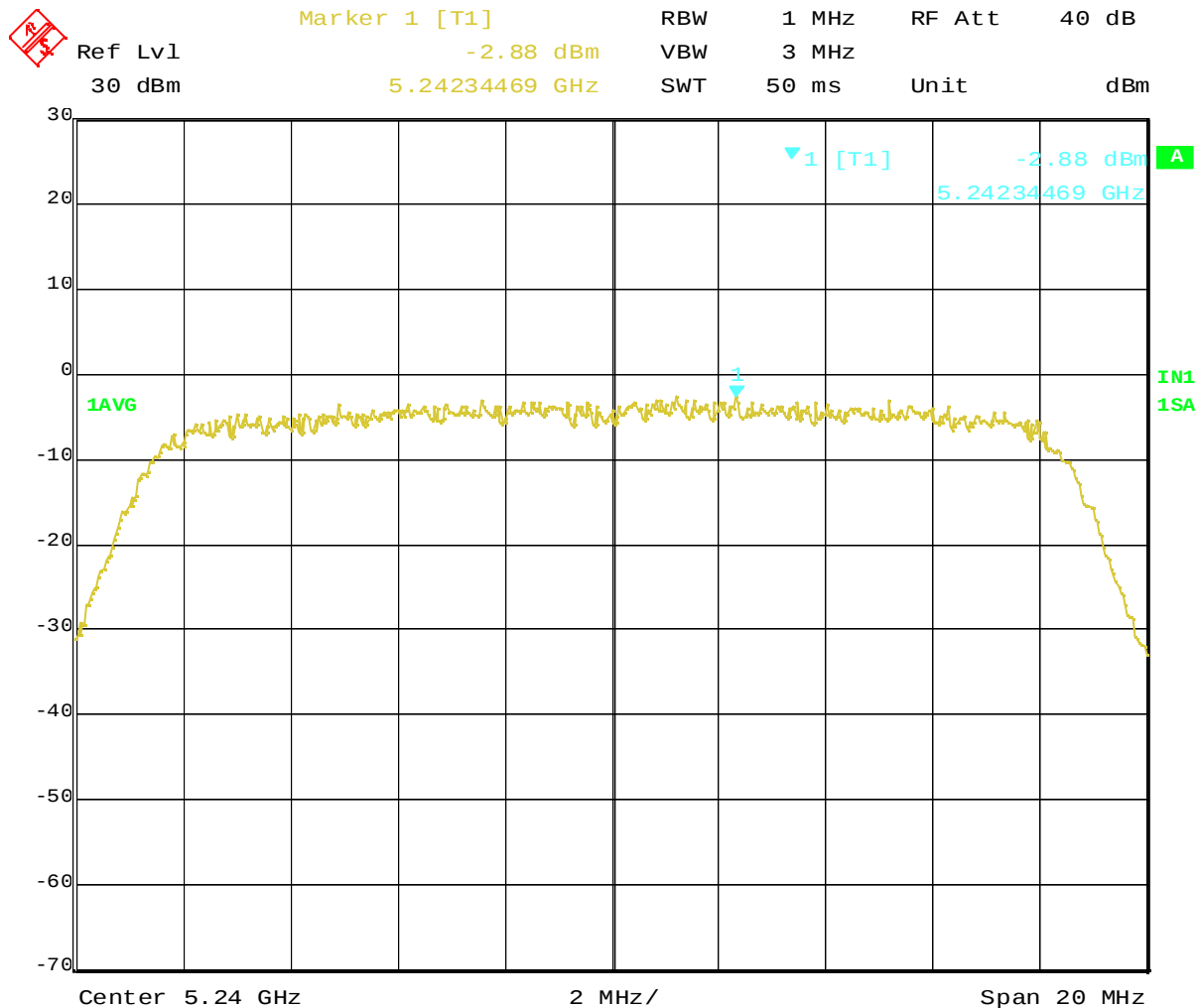
Measured Frequency (MHz)	Analyzer reading (dBm)	Trace number	Cable Loss (dB)	Results (dBm)	IC Limit q1(iv)(b) 3 + 10logB* (dBm)
5174.97	6.21	Plot 3-5	2.2	8.4	16.75
5235.17	6.36	Plot 3-6	2.2	8.6	16.81
5255.13	10.01	Plot 3-7	2.2	12.2	17.03
5315.13	9.80	Plot 3-8	2.2	12.0	17.71

* B = 26dB Bandwidth

3.3 Trace Data

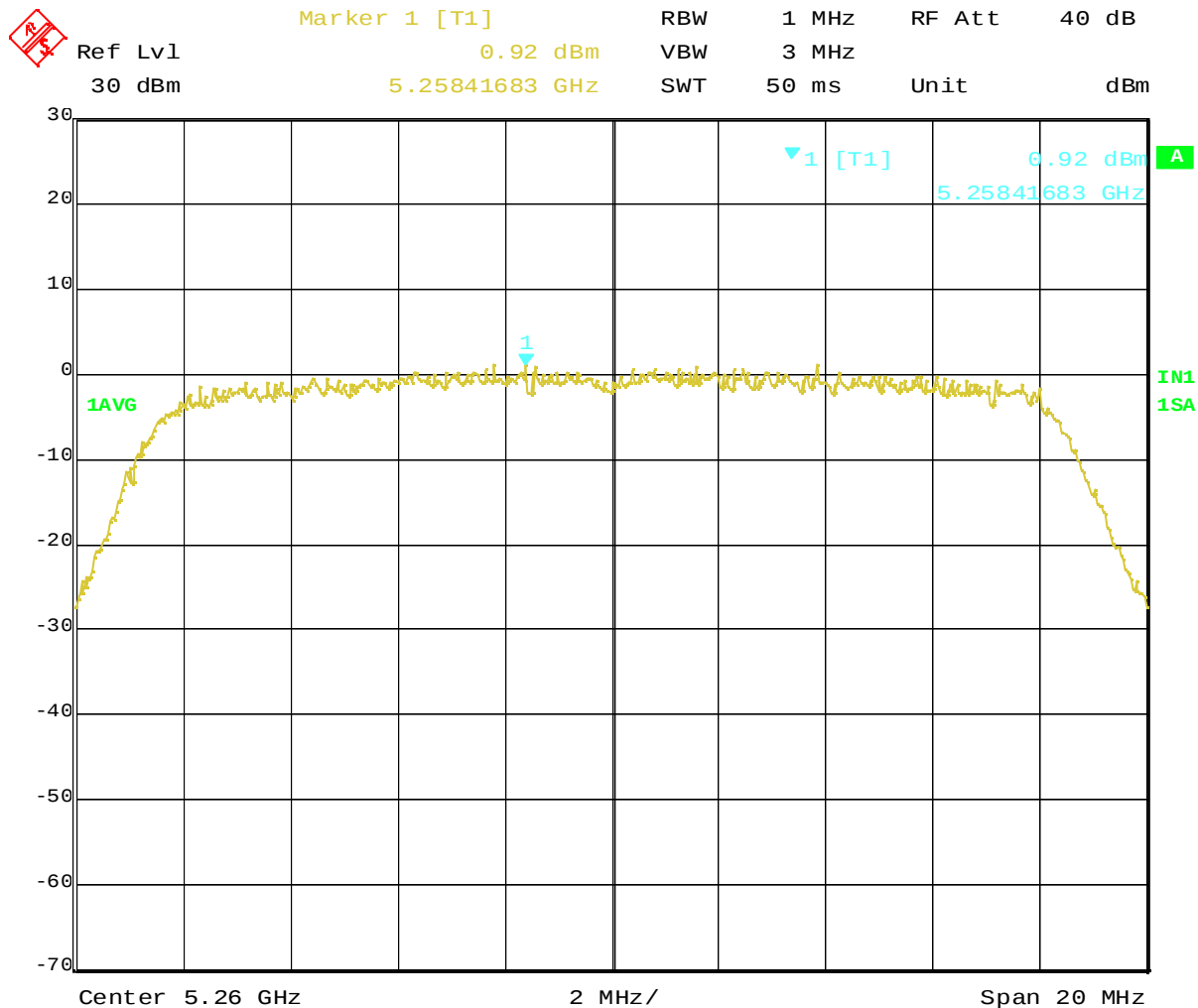


Plot 3-1 Peak Power Spectral Density at 5180MHz



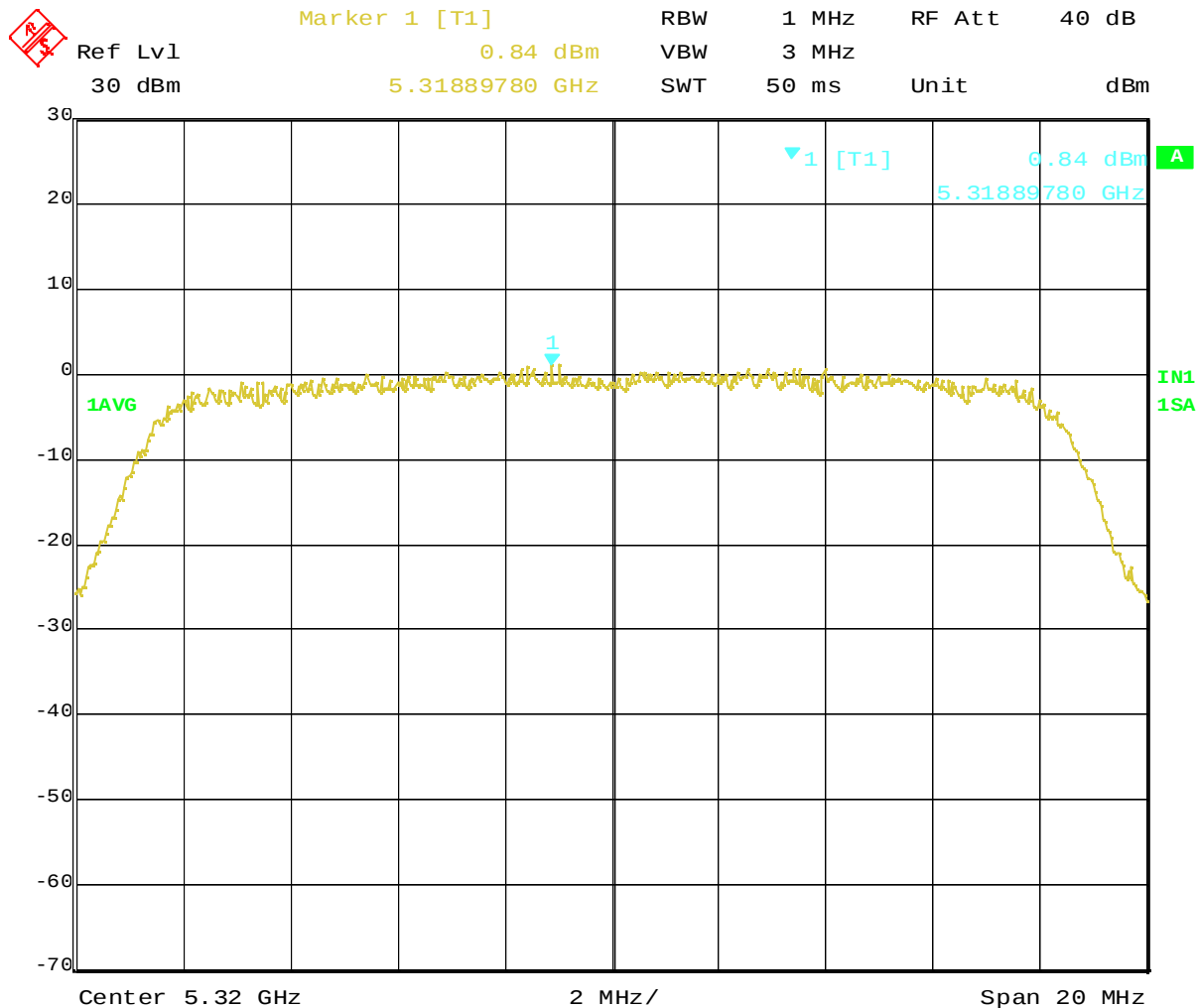
Date: 25.AUG.2004 21:21:55

Plot 3-2 Peak Power Spectral Density at 5240MHz



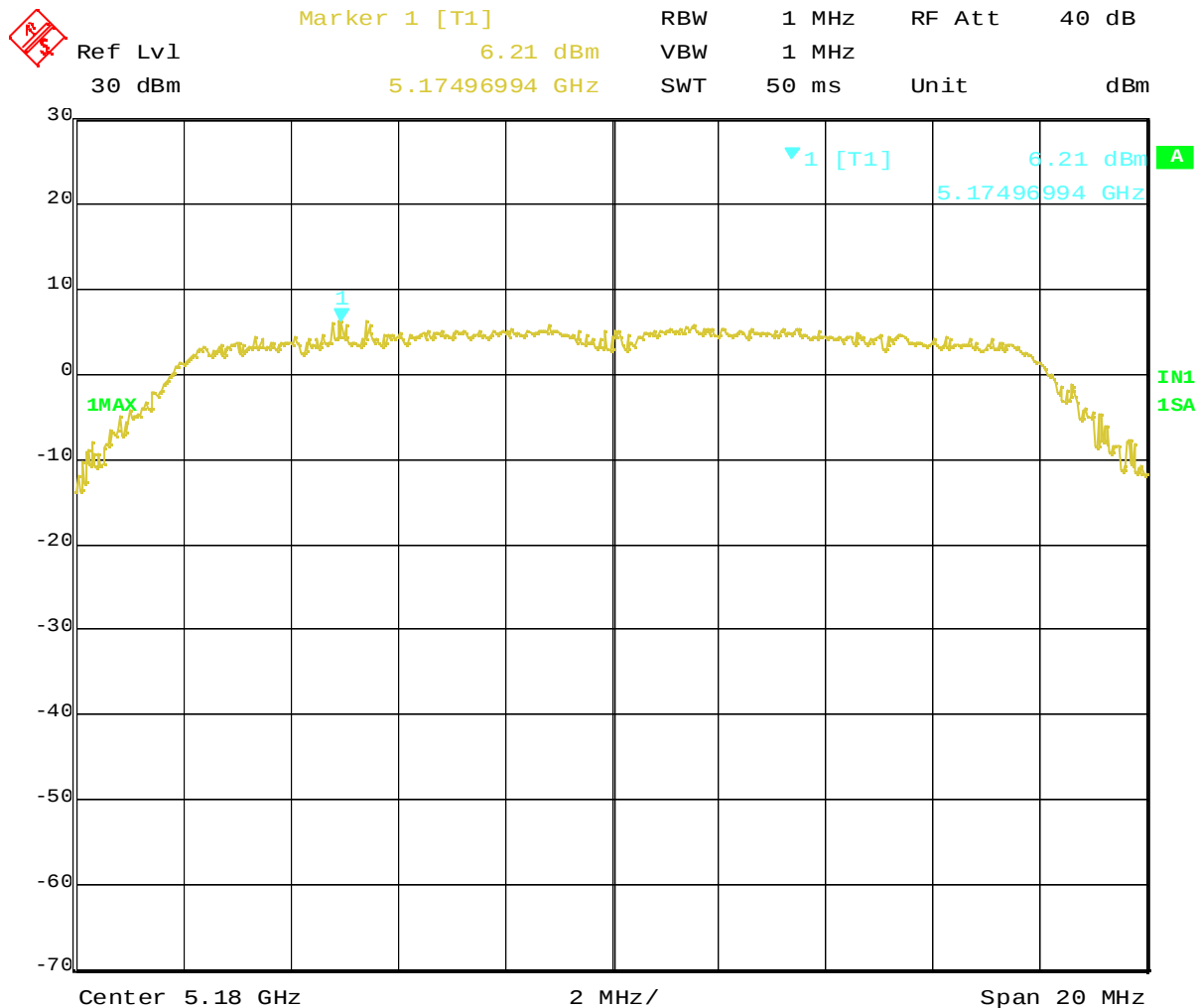
Date: 25.AUG.2004 21:23:14

Plot 3-3 Peak Power Spectral Density at 5260MHz



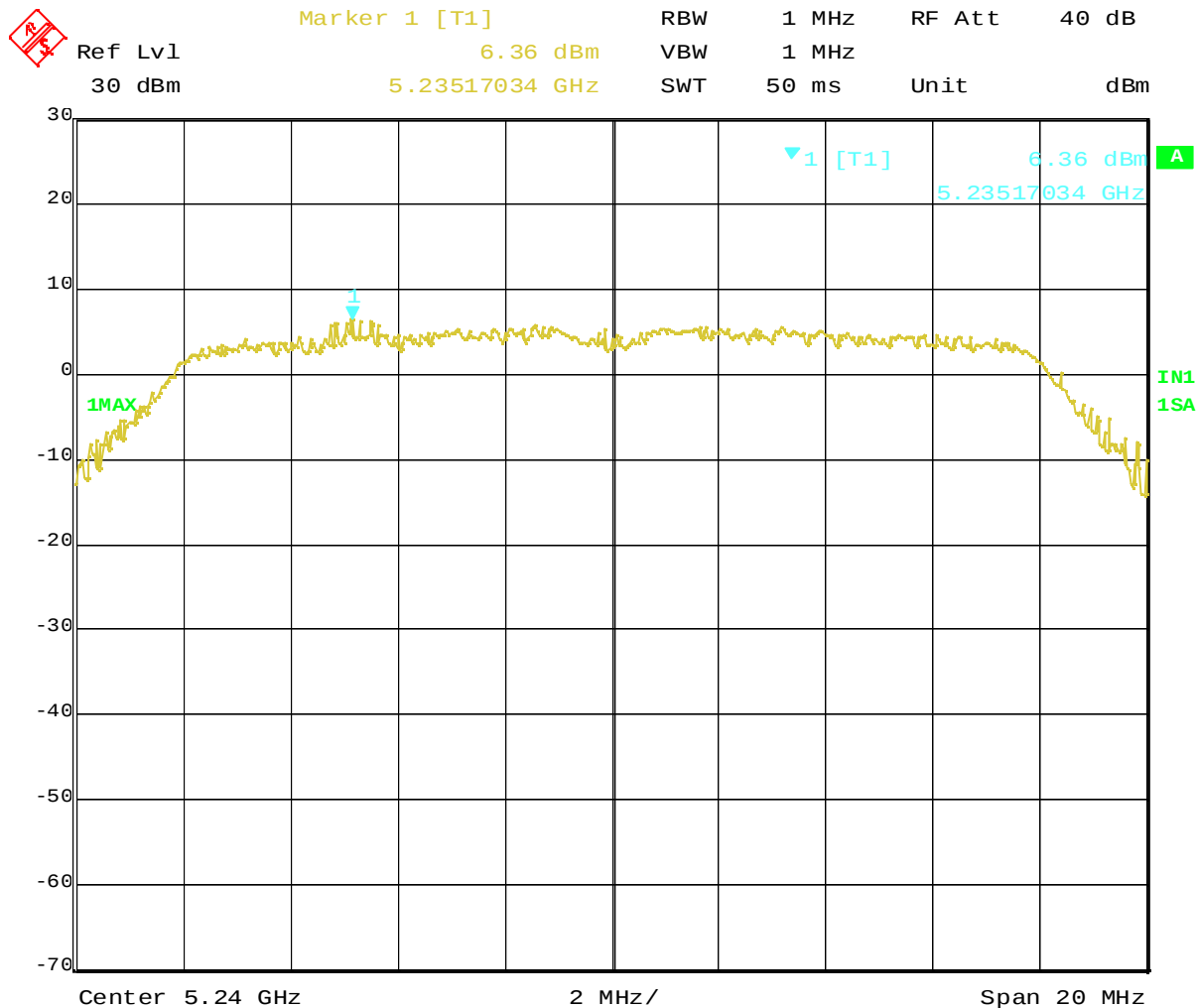
Date: 25.AUG.2004 21:24:13

Plot 3-4 Peak Power Spectral Density at 5320MHz



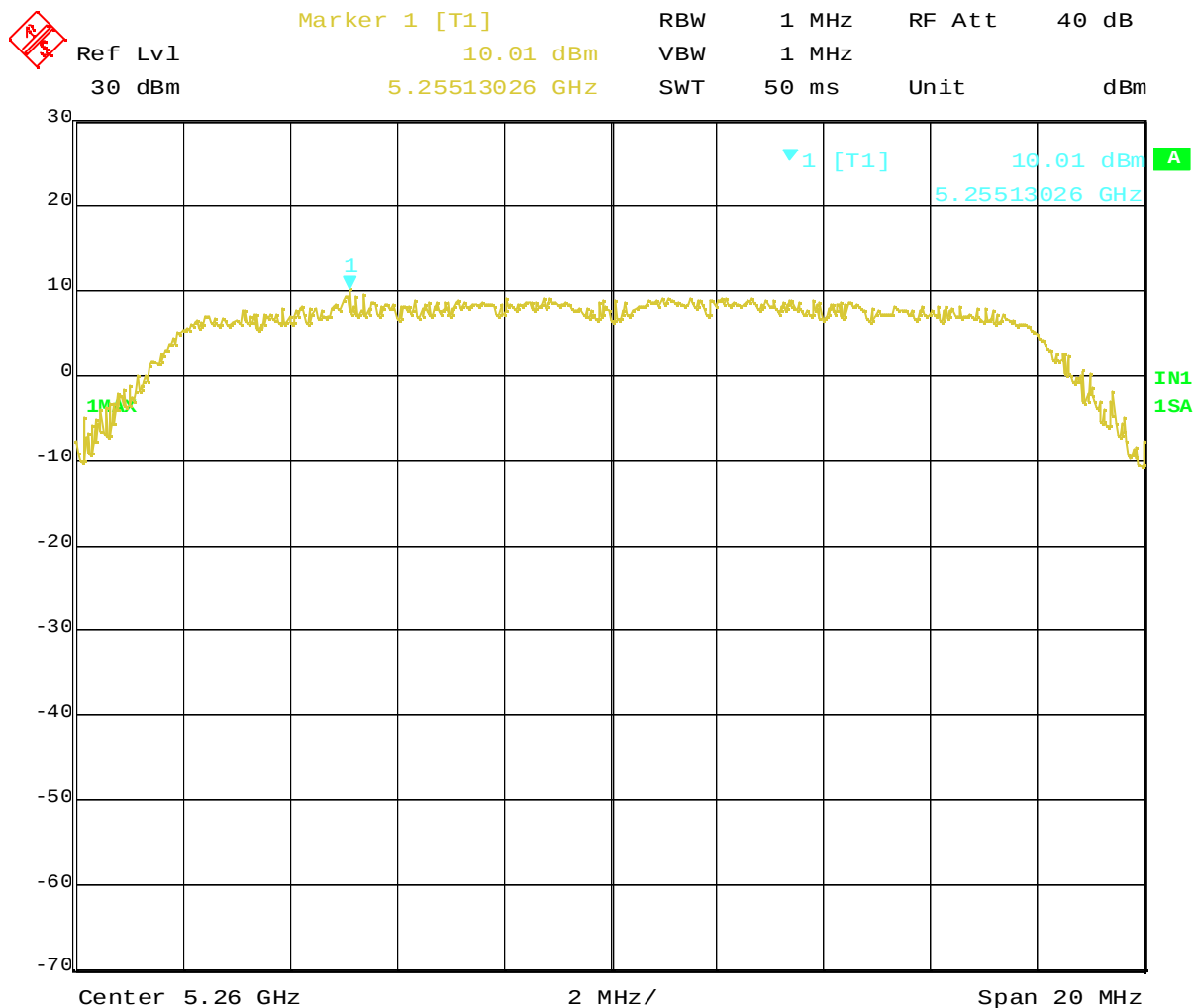
Date: 25.AUG.2004 21:31:21

Plot 3-5 Peak Power Spectral Density at 5180MHz (IC RSS-210)



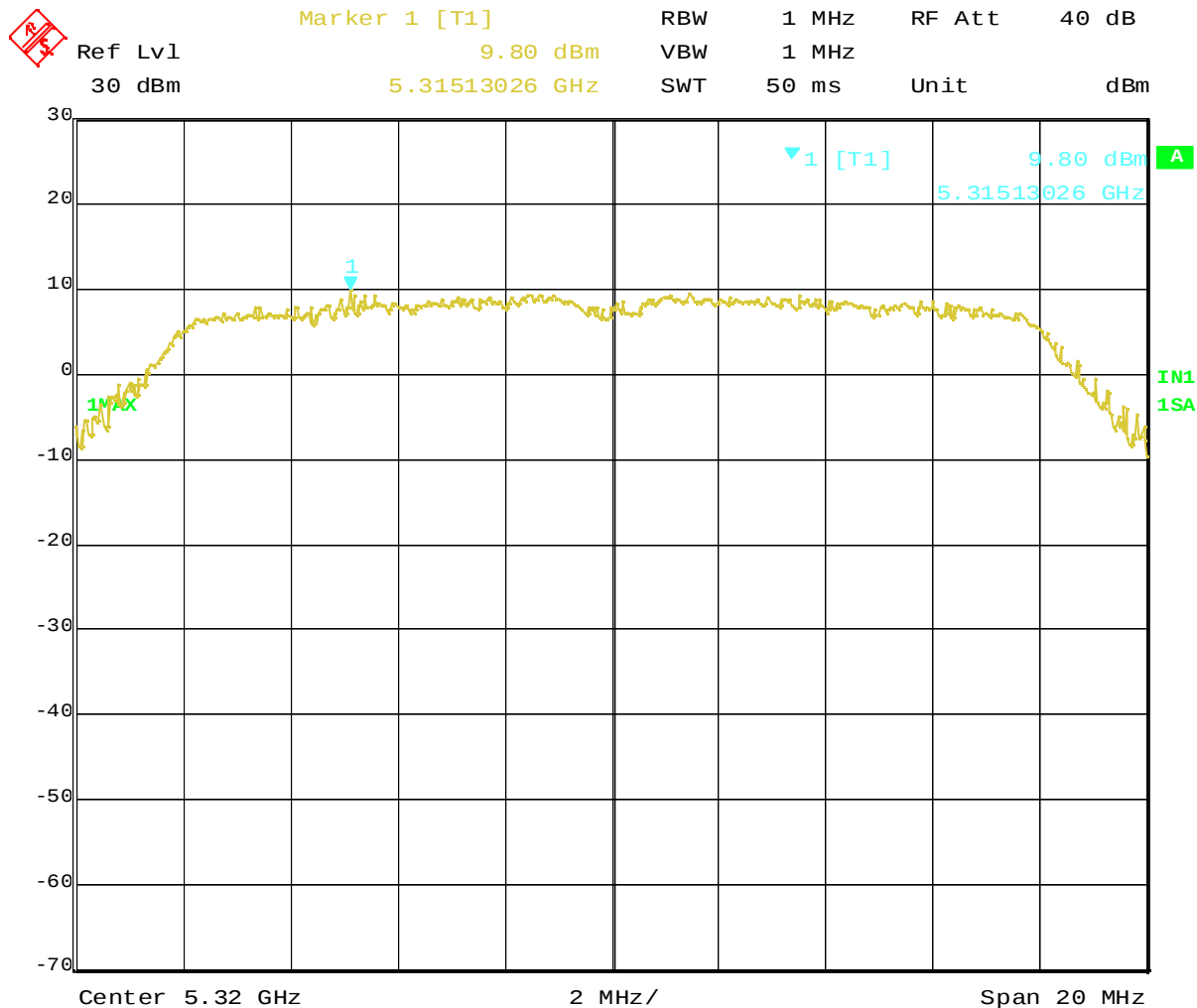
Date: 25.AUG.2004 21:29:31

Plot 3-6 Peak Power Spectral Density at 5240MHz (IC RSS-210)



Date: 25.AUG.2004 21:27:53

Plot 3-7 Peak Power Spectral Density at 5260MHz (IC RSS-210)



Date: 25.AUG.2004 21:26:42

Plot 3-8 Peak Power Spectral Density at 5320MHz (IC RSS-210)

4. Peak Excursion Ratio

[FCC 15.407(a)(6)]

4.1 Test Procedure

The spectrum analyzer was connected to the antenna terminal, while EUT was operating in continuous transmission mode at the appropriate center frequencies.

- 1st trace :
The spectrum analyzer was set to :
RBW= 1MHz, VBW=3MHz, Mode= peak detector and max hold
then to view.
- 2nd trace :
The same setting of spectrum analyzer as Chapter 2.1 for the measurement of peak conducted transmit output power was used for the 2nd trace.
i.e. VBW= 30kHz, RBW=1MHz, Span=30-40MHz, Trigger= free run,
Mode= sample detector

The largest difference of amplitude delta between the two trances is the peak excursion.

The test instruments and setup configuration are the same as the Table 2-1 and Figure 2-1.

4.2 Measurement Results

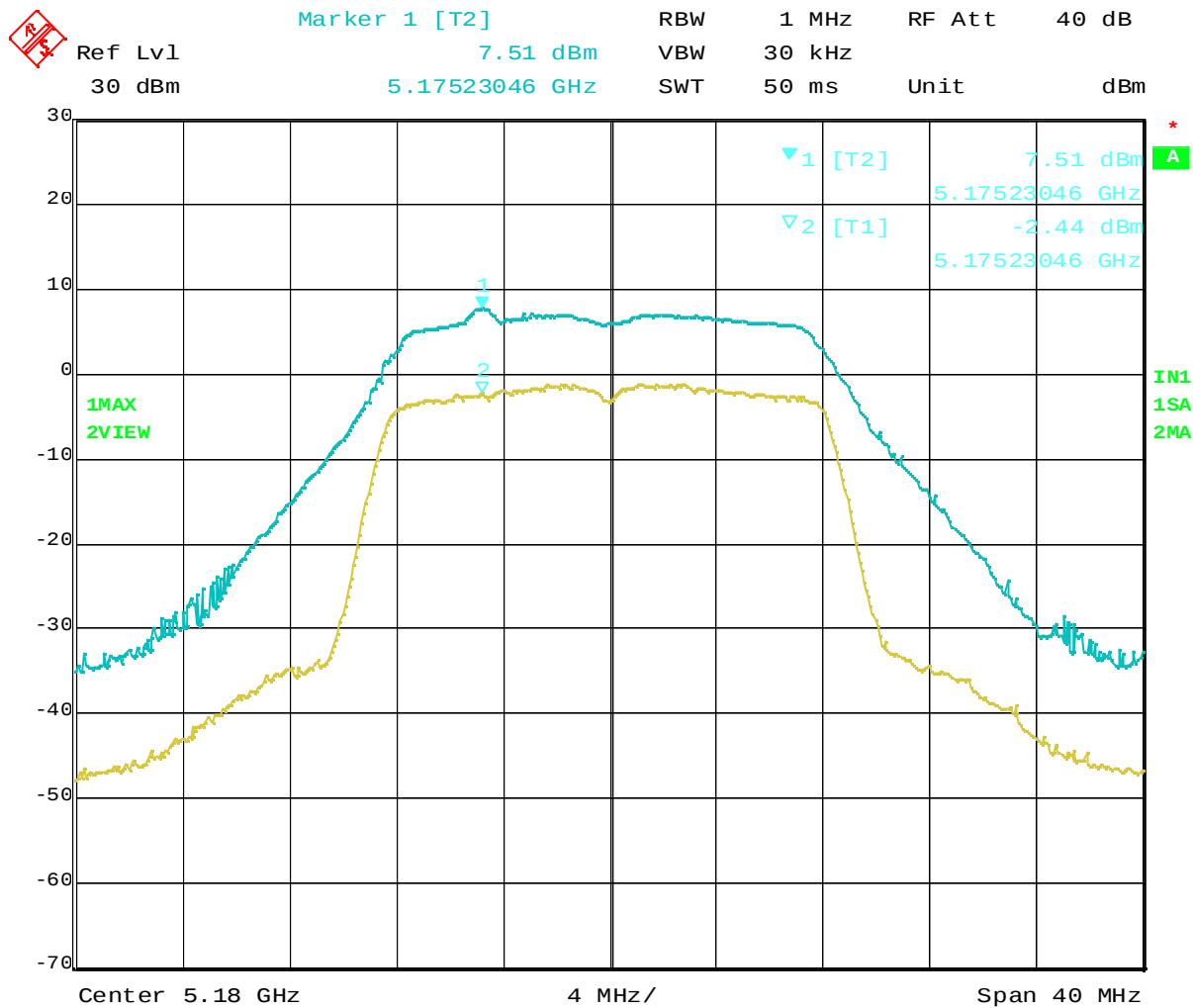
The measurement was performed with the worst case that tend to have higher conducted peak power based on the results of previous Chapter 2 “Peak Conducted Transmit Output Power” measurement.
i.e. 6Mbps was the worst case.

Test Date: August 25, 2004

Table 4-2. Measurement results of Peak Excursion Ratio

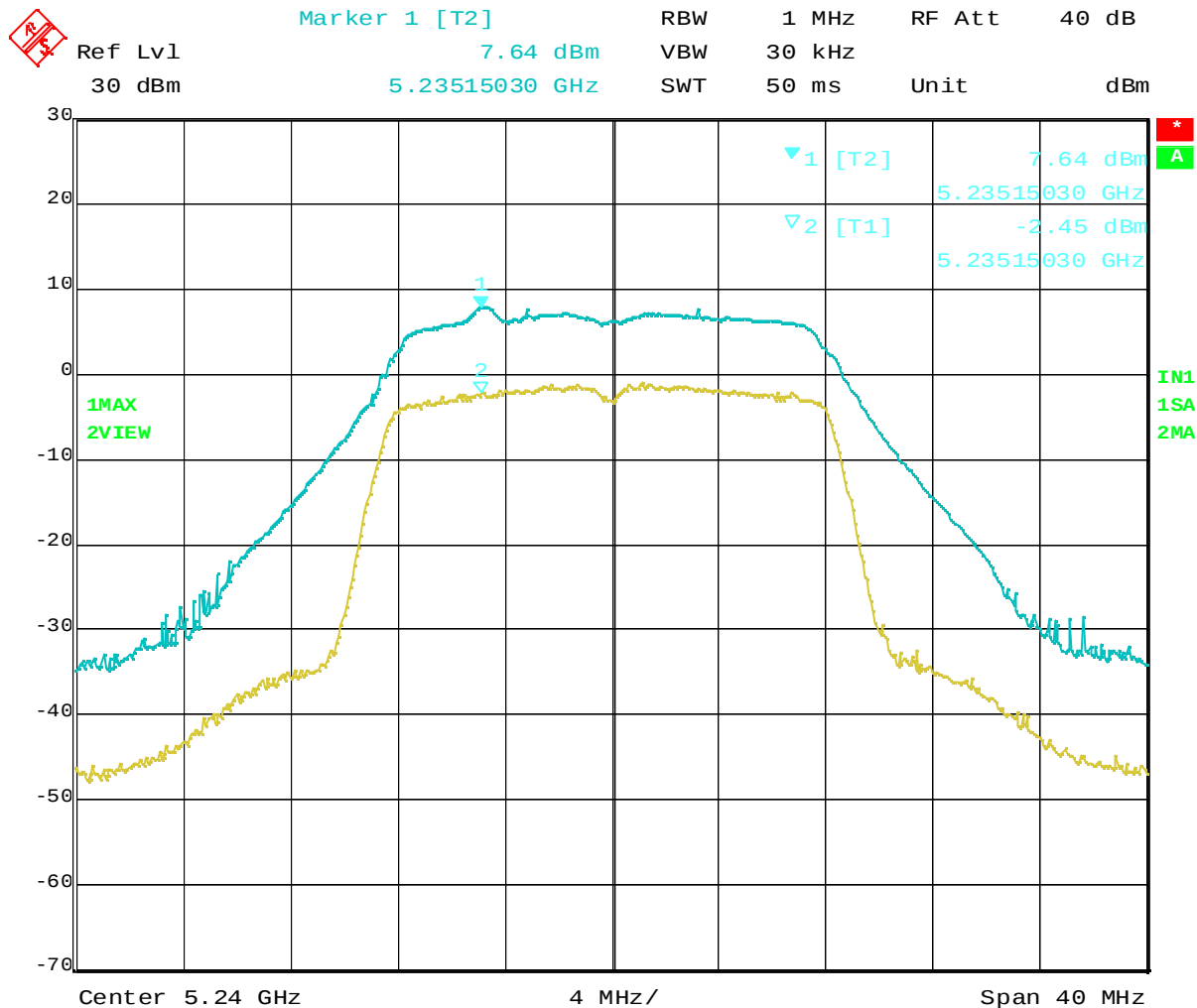
Measured Frequency (MHz)	Analyzer Reading delta (dB)	FCC Limit (dB)	Margin (dB)	Trace number
5175.23	9.95	13	3.05	Plot 4-1
5235.15	10.09		2.91	Plot 4-2
5255.31	9.91		3.09	Plot 4-3
5321.48	8.59		4.41	Plot 4-4

4.3 Trace Data



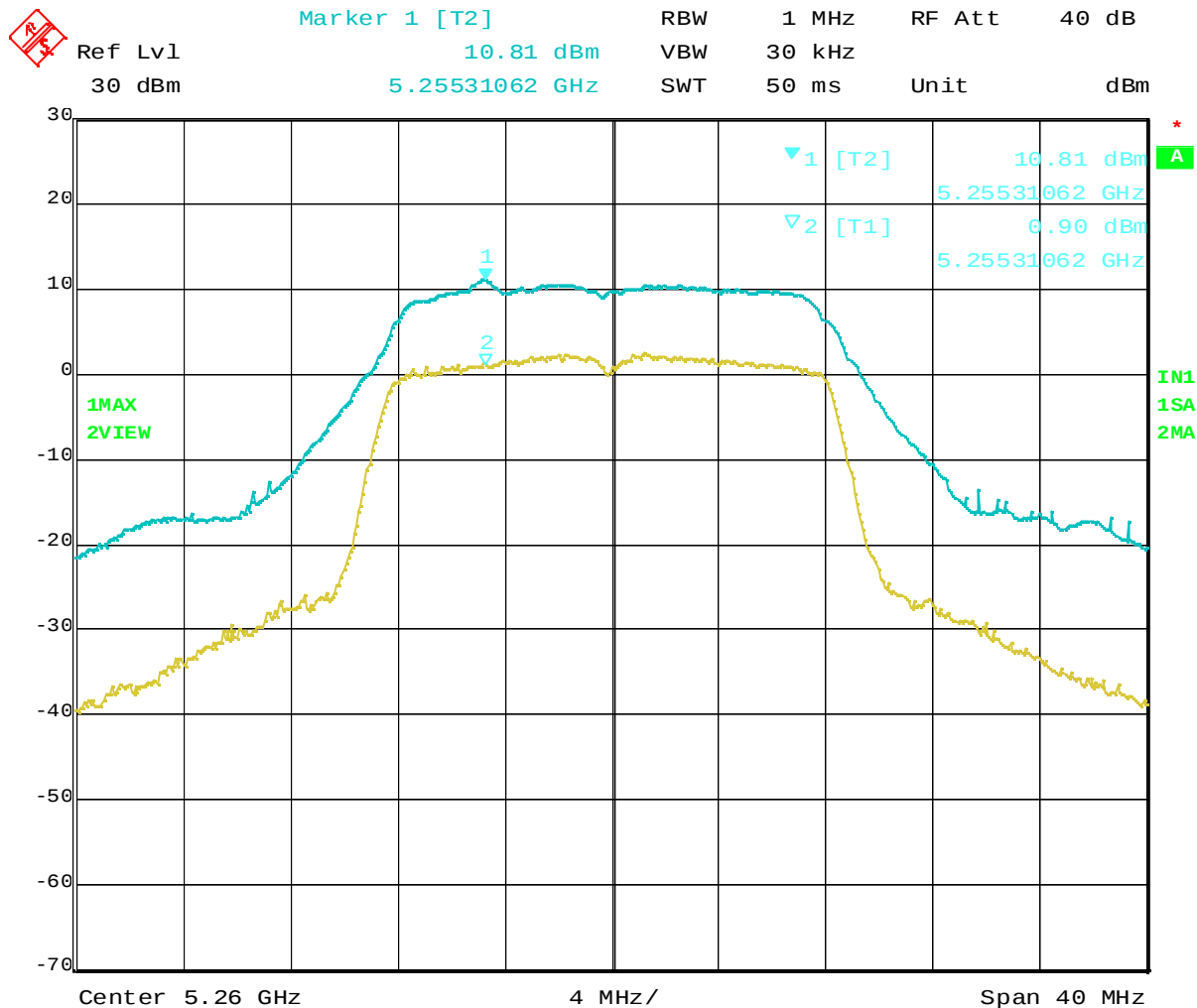
Date: 25.AUG.2004 21:41:52

Plot 4-1 Peak Excursion Ratio at 5180MHz



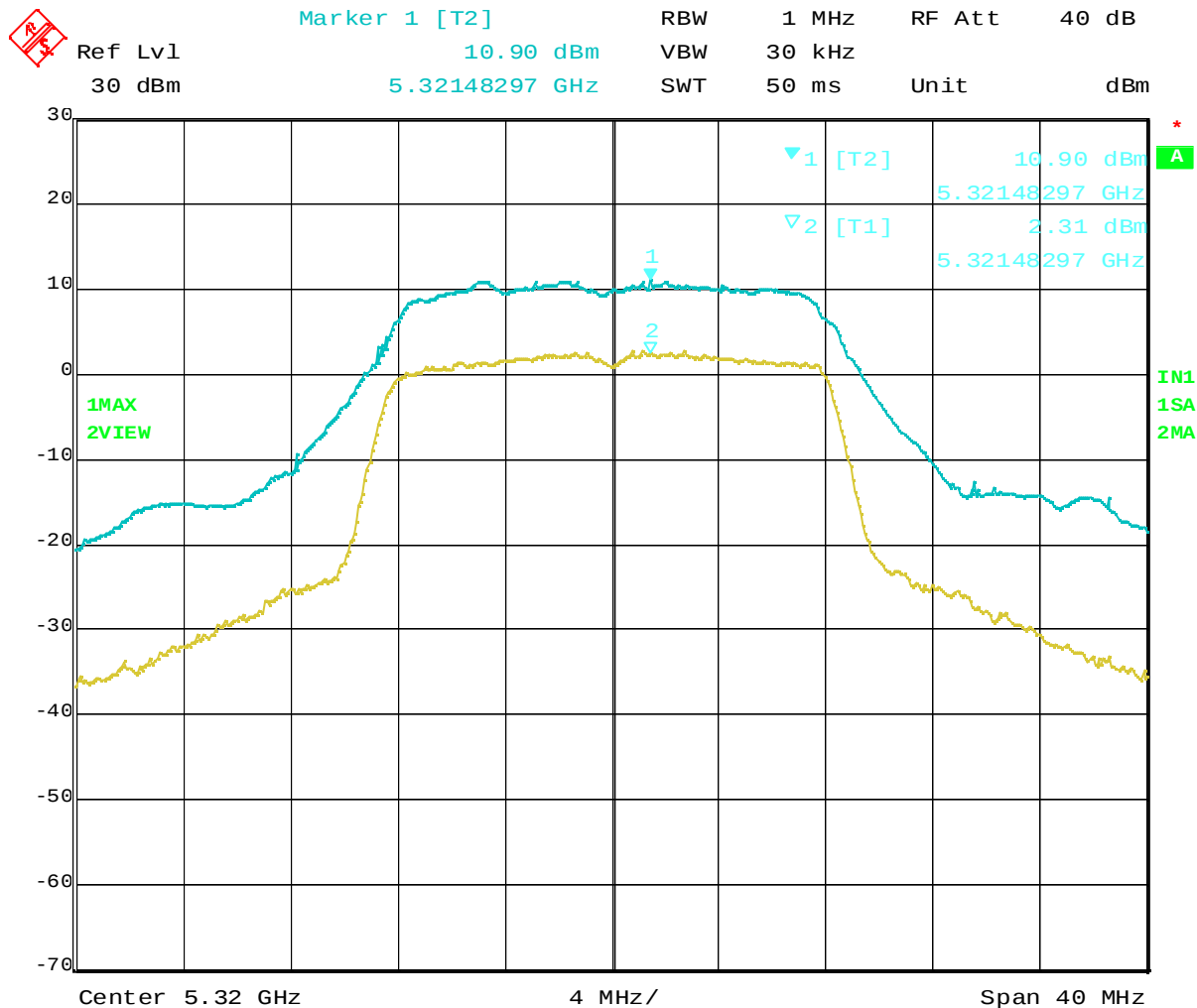
Date: 25.AUG.2004 21:44:02

Plot 4-2 Peak Excursion Ratio at 5240MHz



Date: 25.AUG.2004 21:45:58

Plot 4-3 Peak Excursion Ratio at 5260MHz



Date: 25.AUG.2004 21:50:19

Plot 4-4 Peak Excursion Ratio at 5320MHz

5. AC Wireline Conducted Emissions (150KHz – 30MHz)

[FCC 15.207/ 15.407(b)(5)]

[RSS-210 6.2.2(q1)(v) / 6.6 / 7.4]

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 85680B	3019A05156
Spectrum Analyzer Display	HP 85662A	3026A19366
Quasi-Peak Adapter	HP 85650A	2811A01433
Receiver (9kHz-30MHz)	R&S ESH3	891806/012
LISN	EMCO 3810/2NM	00022007
Switch/control unit	HP 3488A	2719A17228
Plotter	HP 7550A	2631A33619
Coax cables: - Lisen-L <=> SW/Con.unit (SW100) - Lisen-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

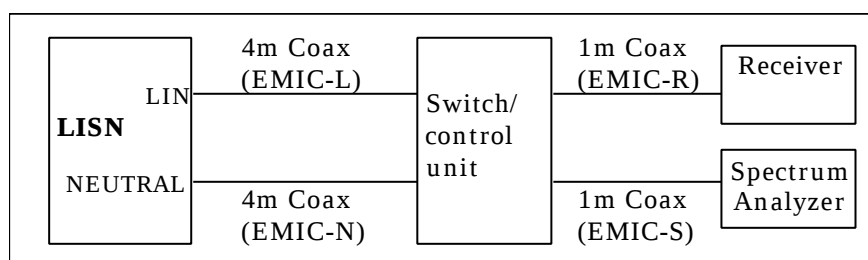


Figure 5. Cables for Conducted Emission Test

5.3 Powerline Voltage Calculation

The powerline voltage is calculated by adding insertion losses of LISN, Cable, Switch control unit and Pulse limiter to the measured reading. All factors are included in the reported data.

$$PV = R + CORR$$

where:

$$PV = \text{Powerline Voltage (dB}\mu\text{V)}$$

$$R = \text{Measured Receiver Input Amplitude (dB}\mu\text{V)}$$

$$CORR = \text{Correction Factor (dB) = LL+CL+SWL+PLL}$$

$$LL = \text{Insertion loss of LISN (dB)}$$

$$CL = \text{Insertion loss of Cable (dB)}$$

$$SWL = \text{Insertion loss of Switch control unit (dB)}$$

$$PLL = \text{Insertion loss of Pulse Limiter (dB)}$$

Given a Receiver input reading of 50.0 dB μ V, LISN loss of 0.6 dB, Cable loss of 0.1dB, Switch control unit loss of 0.1dB and Pulse limiter loss of 0.2dB. The Powerline Voltage of the measured emission is:

$$CORR = 0.6 + 0.1 + 0.1 + 0.2 = 1.0 \text{ (dB)}$$

$$PV = 50.0 + 1.0 = 51.0 \text{ (dB}\mu\text{V)}$$

5.4 Measurement Results

The EUT was found to comply to the limits of FCC Part 15 Subpart E and RSS-210 with a margin of 10.2dB. The 6 highest emissions relative to the limits are reported.

Test Date: September 7, 2004

The actual highest emissions hereafter were found at 6Mbps on the auxiliary antenna of ThinkPad T40 Series 14 inch LCD model.

Table 5-2-1. Ch.36 (5180MHz) **TX** mode 6Mbps

Frequency (MHz)	QP			AV			CISPR22 QP Limit (dBμV)	CISPR22 AV Limit (dBμV)	Phase
	Measured Reading (dBμV)	Corr. Factor (dB)	Powerline Voltage (dBμV)	Measured Reading (dBμV)	Corr. Factor (dB)	Powerline Voltage (dBμV)			
0.2082	46.6	0.5	47.1	36.2	0.5	36.7	63.3	53.3	Neutral
0.2750	39.5	0.6	40.1	33.0	0.6	33.6	61.0	51.0	Line
0.3426	37.7	0.6	38.3	34.0	0.6	34.6	59.1	49.1	Neutral
0.4111	39.4	0.6	40.0	36.8	0.6	37.4	57.6	47.6	Line
0.4809	32.8	0.6	33.4	25.4	0.6	26.0	56.3	46.3	Line
5.3579	37.1	0.7	37.8	26.3	0.7	27.0	60.0	50.0	Neutral

Table 5-2-2. Ch.52 (5260MHz) **TX** mode 6Mbps

Frequency (MHz)	QP			AV			CISPR22 QP Limit (dBμV)	CISPR22 AV Limit (dBμV)	Phase
	Measured Reading (dBμV)	Corr. Factor (dB)	Powerline Voltage (dBμV)	Measured Reading (dBμV)	Corr. Factor (dB)	Powerline Voltage (dBμV)			
0.2079	47.0	0.5	47.5	36.2	0.5	36.7	63.3	53.3	Neutral
0.2752	39.7	0.6	40.3	32.9	0.6	33.5	61.0	51.0	Line
0.3414	37.4	0.6	38.0	33.5	0.6	34.1	59.2	49.2	Neutral
0.4137	38.8	0.6	39.4	35.8	0.6	36.4	57.6	47.6	Line
0.4784	32.2	0.6	32.8	23.7	0.6	24.3	56.4	46.4	Line
0.5479	29.8	0.6	30.4	24.6	0.6	25.2	56.0	46.0	Line

Table 5-2-3. Ch.64 (5320MHz) **TX** mode 6Mbps

Frequency (MHz)	QP			AV			CISPR22 QP Limit (dBμV)	CISPR22 AV Limit (dBμV)	Phase
	Measured Reading (dBμV)	Corr. Factor (dB)	Powerline Voltage (dBμV)	Measured Reading (dBμV)	Corr. Factor (dB)	Powerline Voltage (dBμV)			
0.2082	46.8	0.5	47.3	36.1	0.5	36.6	63.3	53.3	Neutral
0.2779	37.2	0.6	37.8	30.3	0.6	30.9	60.9	50.9	Line
0.3409	37.0	0.6	37.6	33.2	0.6	33.8	59.2	49.2	Line
0.4158	36.1	0.6	36.7	33.0	0.6	33.6	57.5	47.5	Line
0.4799	32.9	0.6	33.5	24.5	0.6	25.1	56.3	46.3	Line
0.5502	29.2	0.6	29.8	24.4	0.6	25.0	56.0	46.0	Line

Table 5-2-4. Ch. 52 (5260MHz) **RX** mode

Frequency (MHz)	QP			AV			CISPR22 QP Limit (dBµV)	CISPR22 AV Limit (dBµV)	Phase
	Measured Reading (dBµV)	Corr. Factor (dB)	Powerline Voltage (dBµV)	Measured Reading (dBµV)	Corr. Factor (dB)	Powerline Voltage (dBµV)			
0.2085	46.0	0.5	46.5	35.3	0.5	35.8	63.3	53.3	Neutral
0.2760	39.4	0.6	40.0	32.8	0.6	33.4	60.9	50.9	Line
0.3444	37.5	0.6	38.1	33.5	0.6	34.1	59.1	49.1	Neutral
0.4141	37.9	0.6	38.5	33.8	0.6	34.4	57.6	47.6	Line
0.4800	34.2	0.6	34.8	28.9	0.6	29.5	56.3	46.3	Line
0.5501	30.3	0.6	30.9	26.0	0.6	26.6	56.0	46.0	Line

6. Restricted Bands Radiations (30MHz – 1GHz)

[FCC 15.205&209 / 15.407(b)(1),(2),(5),(6)]

[RSS-210 6.2.1 / 6.2.2(q1)(i),(ii),(v) / 6.3 / 7.3]

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 6868-30J	97-901X3
Spectrum Analyzer (100Hz-1.5GHz) for 30-200MHz	HP 85680B	2732A03651
Spectrum Analyzer Display for 30-200MHz	HP 85662A	2648A15255
Quasi-Peak Adapter for 30-200MHz	HP 85650A	2521A00968
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	MITEQ AM-3A	898433
- for 200-1000MHz	MITEQ AM-3A	898432
Biconical Antenna (30-200MHz)	EMCO 3108	2536
Log-Periodic Antenna (200-1000MHz)	EMCO 3146	2849
Receiver (20MHz-1.3GHz)	R&S ESVP	893202/018
Switch/control unit	HP 3488A	2719A17226
N-Coax cables:	Length:	
- Bi-coni Ant <=> 10m Cable	9 m	- EM103L01
- 10m Cable <=> Shield Panel	10 m	- EM103L02
- Shield Panel <=> RF Amp	7 m	- EM103L03
- RF Amp <=> Power Splitter	0.5m	- EM103L04
- Log-peri Ant <=> 10m Cable	9 m	- EM103H01
- 10m Cable <=> Shield Panel	10 m	- EM103H02
- Shield Panel <=> RF Amp	7 m	- EM103H03
- RF Amp <=> Power Splitter	0.5m	- EM103H04
Coax cables:		
- Power Splitter <=> SW/Con.unit (SW110)	1 m	- EM103L05
- Power Splitter <=> SW/Con.unit (SW300)	1 m	- EM103L06
- Power Splitter <=> SW/Con.unit (SW100)	1 m	- EM103H05
- Power Splitter <=> SW/Con.unit (SW301)	1 m	- EM103H06
- SW/Con.unit <=> Receiver (Input)	2 m	- EM1RCV
- SW/Con.unit <=> Spe Ana.(Signal In) for 30- 200MHz	2 m	- EM1SPL
- SW/Con.unit <=> Spe Ana.(Signal In) for 200-1000MHz	2 m	- EM1SPH

Notes:

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

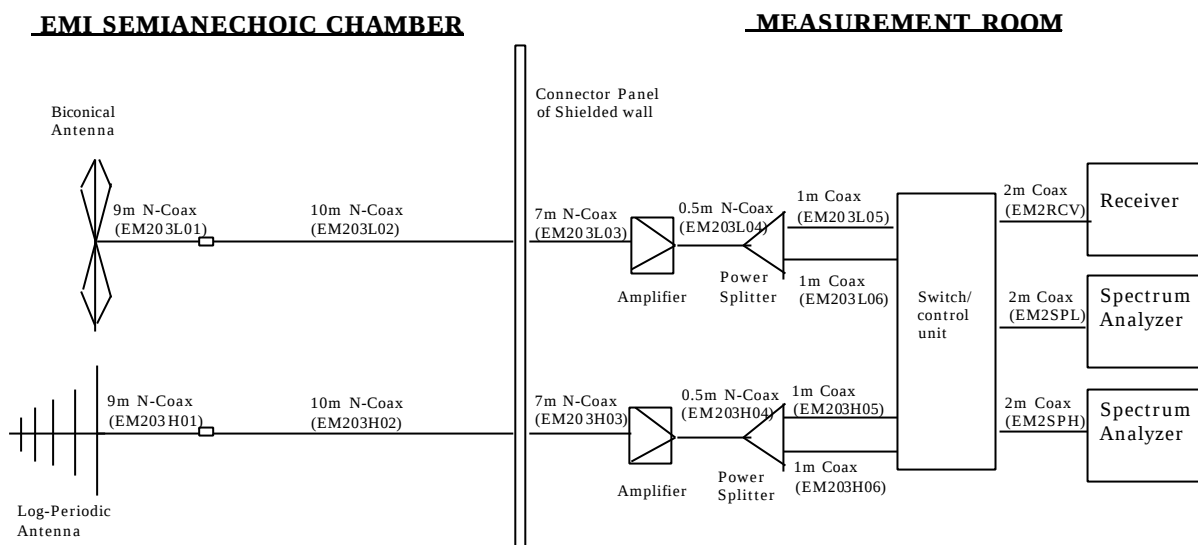


Figure 6 Cables for Radiated Emission Test

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 51.5dBμV; 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 dBμV/m (or dBμV) and λV/m (or μV) are done as:

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

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

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

6.4 Measurement Results of the applying device

The EUT was found to comply to the limits of FCC Part 15 Subpart E and RSS-210 with a margin of 3.2 dB at 30MHz - 1000MHz band. The 6 highest emissions relative to the limits are reported.

The actual highest emissions hereafter were found at 6Mbps on the auxiliary antenna of ThinkPad T40 Series 14 inch LCD model.

Test Date: September 7, 2004

Table 6-2-1. Ch.36 (5180MHz) **TX** mode 6Mbps

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)
68.443	V	49.0	8.6	-28.4	29.2	40.0	28.8	100
195.800	H	42.7	13.6	-26.6	29.7	43.5	30.5	150
255.941	H	43.9	11.9	-24.0	31.8	46.0	38.9	200
400.504	H	41.3	15.3	-22.4	34.2	46.0	51.3	200
756.007	V	31.4	21.0	-18.6	33.8	46.0	49.0	200
801.008	V	38.9	21.2	-18.5	41.6	46.0	120.2	200

Table 6-2-2. Ch.52 (5260MHz) **TX** mode 6Mbps

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)
195.799	H	41.1	13.6	-26.6	28.1	43.5	25.4	150
255.940	H	43.5	11.9	-24.0	31.4	46.0	37.2	200
400.505	V	45.8	15.3	-22.4	38.7	46.0	86.1	200
600.756	V	36.1	18.7	-19.8	35.0	46.0	56.2	200
756.008	V	31.6	21.0	-18.6	34.0	46.0	50.1	200
801.007	V	39.4	21.2	-18.5	42.1	46.0	127.4	200

Table 6-2-3. Ch.64 (5320MHz) **TX** mode 6Mbps

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)
195.799	H	41.9	13.6	-26.6	28.9	43.5	27.9	150
257.065	H	44.4	12.0	-24.1	32.3	46.0	41.2	200
400.504	V	49.6	15.3	-22.4	42.5	46.0	133.4	200
600.757	V	35.7	18.7	-19.8	34.6	46.0	53.7	200
756.008	V	35.0	21.0	-18.6	37.4	46.0	74.1	200
801.008	V	39.3	21.2	-18.5	42.0	46.0	125.9	200

Table 6-2-4. Ch.52 (5260MHz) **RX** mode

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)
195.799	H	42.7	13.6	-26.6	29.7	43.5	30.5	150
255.941	H	43.3	11.9	-24.0	31.2	46.0	36.3	200
400.505	V	49.9	15.3	-22.4	42.8	46.0	138.0	200
599.529	V	33.3	18.7	-19.8	32.2	46.0	40.7	200
756.008	V	32.1	21.0	-18.6	34.5	46.0	53.1	200
801.009	V	39.0	21.2	-18.5	41.7	46.0	121.6	200

6.5 Measurement Results with co-located Bluetooth device

The test was performed with the representative worse cases in the previous Table 6-2-1 through Table 6-2-4 while both the applying WLAN transmitter and the co-located Bluetooth transmitter (FCC ID: ANO20020100MTN) were active and emitted radio frequencies simultaneously.

The EUT was found to comply to the limits of FCC Part 15 Subpart E and RSS-210 with a margin of 4.1 dB at 30MHz - 1000MHz band. The 6 highest emissions relative to the limits are reported.

The actual highest emissions hereafter were found at 6Mbps on the auxiliary antenna of ThinkPad T40 Series 14 inch LCD model.

Test Date: October 4, 2004

Table 6-2-5. Ch.64 (5320MHz) **TX** mode 6Mbps with the co-located Bluetooth transmitter

Frequency (MHz)	Polarity (H/V)	Measured (dBμV)	Antenna Factor (dB/m)	Corr. Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin to limit (dB)	Field Strength (μV/m)	Limit (μV/m)
65.408	V	41.9	8.6	-28.6	21.9	40.0	18.1	12.4	100
257.066	H	44.5	12.0	-24.1	32.4	46.0	13.6	41.7	200
400.504	V	48.8	15.3	-22.4	41.7	46.0	4.3	121.6	200
511.693	V	29.6	18.7	-20.5	27.8	46.0	18.2	24.5	200
730.215	V	29.4	21.0	-18.8	31.6	46.0	14.4	38.0	200
801.008	V	33.8	21.2	-18.5	36.5	46.0	9.5	66.8	200

Table 6-2-6. Ch.52 (5260MHz) **RX** mode with the co-located Bluetooth transmitter

Frequency (MHz)	Polarity (H/V)	Measured (dBμV)	Antenna Factor (dB/m)	Corr. Factor (dB)	Field Strength (dBμV/m)	Limit (dBμV/m)	Margin to limit (dB)	Field Strength (μV/m)	Limit (μV/m)
78.584	H	40.6	7.7	-28.5	19.8	40.0	20.2	9.8	100
199.352	V	42.8	13.7	-26.8	29.7	43.5	13.8	30.5	150
257.066	H	44.1	12.0	-24.1	32.0	46.0	14.0	39.8	200
400.509	V	49.0	15.3	-22.4	41.9	46.0	4.1	124.5	200
428.442	V	33.1	15.8	-21.4	27.5	46.0	18.5	23.7	200
801.008	V	33.6	21.2	-18.5	36.3	46.0	9.7	65.3	200

7. Restricted Bands Radiations (1GHz – 40GHz)

[FCC 15.205&209 / 15.407(b)(1),(2),(5),(6)]

[RSS-210 6.2.1 / 6.2.2(q1)(i),(ii),(v) / 6.3 / 7.3]

7.1 Test Procedure

Radiated emissions were measured in the frequency range with 1 GHz to 40GHz in transmitting mode and 1 GHz to 25GHz 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 40 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 resolution bandwidth of 1MHz / video bandwidth of 1MHz, and the average setting mode with the tuned spectrum analyzer using resolution bandwidth of 1MHz / video bandwidth of 100Hz or 10Hz. The highest emissions relative to the limit are listed.

7.2 Test Instruments and Measurement Setup

Table 7 Radiated Emission Test Instrumentation (1GHz – 40GHz)

Description	Model	Serial Number
Spectrum Analyzer EMI Test Receiver	R&S ESI26	836119/003
Spectrum Analyzer	HP 8563E	3416A02248
Harmonic Mixer (26.5 – 40GHz)	Agilent 11970A	011269-001
Amplifier (1 - 26.5GHz)	HP 8449B	3008A00582
Amplifier (26.5 – 40GHz)	Agilent 83051A	3950M00193
Horn Antenna (1 - 18GHz)	EMCO 3115	9903-5774
Horn Antenna (3.95 – 5.85GHz)	EMCO 3160-5	1099
Horn Antenna (5.85 – 8.2GHz)	EMCO 3160-6	9712-1044
Horn Antenna (8.2 – 12.4GHz)	EMCO 3160-7	1156
Horn Antenna (12.4 – 18GHz)	EMCO 3160-8	1143
Horn Antenna (18 - 26.5GHz)	EMCO 3160-9	0004-1202
Horn Antenna (26.5 - 40GHz)	EMCO 3160-10	1175
Coaxial cables: - Horn Ant <=> RF Amp. (1-18GHz) - RF Amp. <=> Spectrum Analyzer (1-12.4GHz) - RF Amp. <=> Spectrum Analyzer (12.4-18GHz) - Horn Ant <=> RF Amp. (18-40GHz) - RF Amp. <=> Spectrum Analyzer (18-40GHz)	Length: 6 m 16 m 3m 3m 1m	- EM206SCO - GEM0101 - SF102-20166 - SF102-20167 - SF102-21105

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

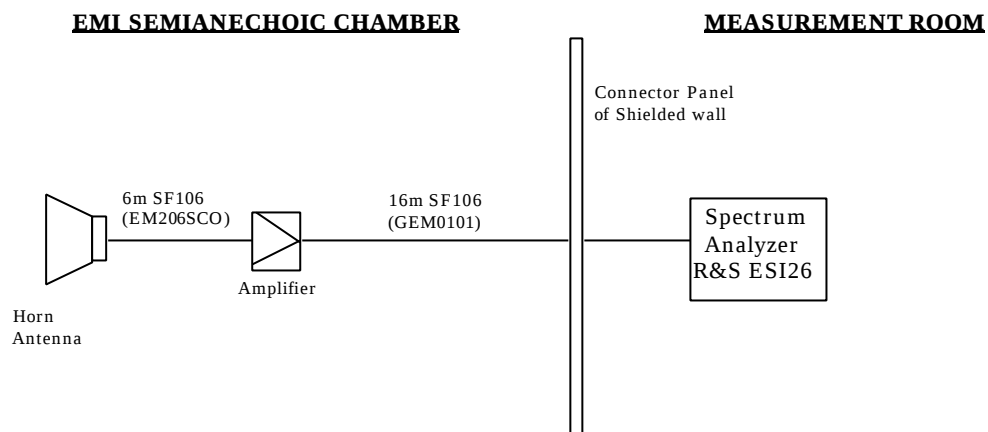


Figure 7-1. Cables for Radiated Emission Test (1 – 12.4 GHz)

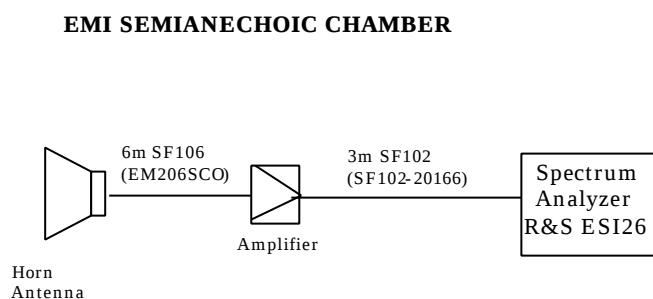


Figure 7-2. Cables for Radiated Emission Test (12.4 - 18GHz)

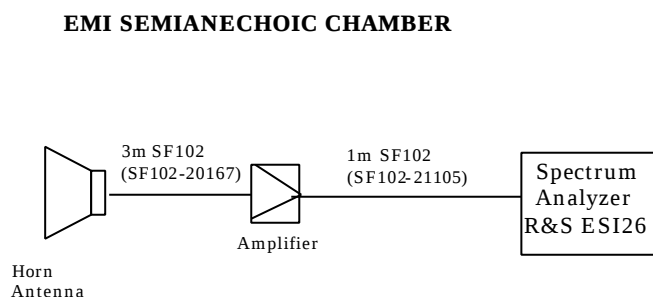


Figure 7-3. Cables for Radiated Emission Test (18 - 26.5GHz)

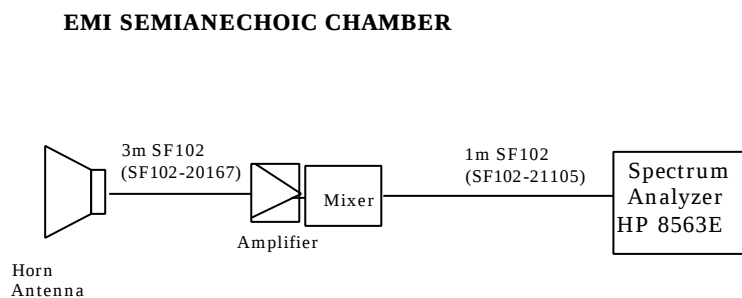


Figure 7-4. Cables for Radiated Emission Test (26.5 - 40GHz)

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 dBμV; 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 dBμV/m (or dBμV) and λV/m (or μV) are done as :

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

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

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

7.4 Limits

Table 7-1. Limits for EIRP emissions

Limit for emissions in restricted bands FCC 15.205&209 / RSS-210 6.3&7.3	54 dBμV/m (average)	74 dBμV/m (peak)
Limit for emissions in non_restricted bands FCC 15.407(b)(1)&(2) / RSS-210 (q1)(i)&(ii)	EIRP 68.2 dBμV/m (-27 dBm/MHz)	

7.5 Measurement Results of the applying device

The EUT was found to comply to the limits of FCC Part 15 Subpart E and RSS-210 with a margin of 3.5 dB. The measurement was done for the frequency range of 1 GHz to 40 GHz in TX mode and 1 GHz to 25GHz in RX mode.

The actual highest emissions hereafter were found at 6Mbps on the auxiliary antenna of ThinkPad T40 Series 14 inch LCD model.

Test Date: September 2, 3 and 6, 2004

Table 7-2-1. Ch.36 (5180MHz) **TX** mode 6Mbps

Frequency (GHz)	Polarity (H/V)	Measured (dBμV) (<i>peak</i>)	Measured (dBμV) (<i>average</i>)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dBμV/m) (<i>peak</i>)	FCC Limit (dBμV/m) (<i>peak</i>)	Field Strength (dBμV/m) (<i>average</i>)	FCC Limit (dBμV/m) (<i>average</i>)
OB										
5.175 bandedge	H	101.0	88.3	33.7	-26.1	0.0	108.6	N/A	95.9	N/A
5.134	H	49.6	36.5	33.7	-26.0	0.0	57.3	74.0	44.2	54.0
5.148	H	50.9	36.7	33.6	-26.1	0.0	58.4	74.0	44.2	54.0
5.150	H	48.8	36.6	33.6	-26.1	0.0	56.3	74.0	44.1	54.0
1.000	V	49.6	-	24.1	-31.9	0.0	41.8	74.0	-	54.0
1.134	V	50.3	-	24.6	-31.4	0.0	43.5	74.0	-	54.0
1.200	V	49.6	-	25.2	-31.3	0.0	43.5	74.0	-	54.0
1.329	V	53.3	-	25.6	-31.0	0.0	47.9	74.0	-	54.0
6.906	H	51.8	-	29.9	-24.9	0.0	56.8	68.2	-	NRB

Note: OB means "operation band" (5150-5250MHz).

NRB means "non restricted band": The limit of FCC Part 15.407(b)(1),(2) and RSS-210 6.2.2(q1)(I),(ii) apply.

Table 7-2-2. Ch.52 (5260MHz) **TX** mode 6Mbps

Frequency (GHz)	Polarity (H/V)	Measured (dBμV) (<i>peak</i>)	Measured (dBμV) (<i>average</i>)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dBμV/m) (<i>peak</i>)	FCC Limit (dBμV/m) (<i>peak</i>)	Field Strength (dBμV/m) (<i>average</i>)	FCC Limit (dBμV/m) (<i>average</i>)
OB										
5.255 bandedge	H	103.0	92.7	33.7	-26.0	0.0	110.7	N/A	100.4	N/A
5.150	H	48.5	36.7	33.6	-26.1	0.0	56.0	74.0	44.2	54.0
5.350	H	51.9	40.0	33.9	-25.6	0.0	60.2	74.0	48.3	54.0
5.391	H	57.3	42.0	33.9	-25.6	0.0	65.6	74.0	50.3	54.0
1.000	V	50.1	-	24.1	-31.9	0.0	42.3	74.0	-	54.0
1.136	V	49.7	-	24.6	-31.4	0.0	42.9	74.0	-	54.0
1.200	V	49.3	-	25.2	-31.3	0.0	43.2	74.0	-	54.0
1.329	V	52.5	-	25.6	-31.0	0.0	47.1	74.0	-	54.0
7.014	H	50.2	-	30.0	-24.5	0.0	55.7	68.2	-	NRB

Note: OB means "operation band" (5250-5350MHz).

NRB means "non restricted band": The limit of FCC Part 15.407(b)(1),(2) and RSS-210 6.2.2(q1)(I),(ii) apply.

Table 7-2-3. Ch.64 (5320MHz) **TX** mode 6Mbps

Frequency (GHz)	Polarity (H/V)	Measured (dBμV) (<i>peak</i>)	Measured (dBμV) (<i>average</i>)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dBμV/m) (<i>peak</i>)	FCC Limit (dBμV/m) (<i>peak</i>)	Field Strength (dBμV/m) (<i>average</i>)	FCC Limit (dBμV/m) (<i>average</i>)
OB										
5.318 bandedge	H	102.0	92.2	33.7	-25.7	0.0	110.0	N/A	100.2	N/A
5.350	H	56.8	42.2	33.9	-25.6	0.0	65.1	74.0	50.5	54.0
5.351	H	61.0	41.6	33.9	-25.6	0.0	69.3	74.0	49.9	54.0
5.355	H	57.0	40.6	33.9	-25.6	0.0	65.3	74.0	48.9	54.0
1.000	V	50.4	-	24.1	-31.9	0.0	42.6	74.0	-	54.0
1.136	V	50.3	-	24.6	-31.4	0.0	43.5	74.0	-	54.0
1.200	V	49.9	-	25.2	-31.3	0.0	43.8	74.0	-	54.0
1.329	V	51.6	-	25.6	-31.0	0.0	46.2	74.0	-	54.0
7.094	V	42.7	-	30.0	-24.8	0.0	47.9	68.2	-	NRB

*Note: OB means “operation band” (5250-5350MHz).

NRB means “non restricted band”: The limit of FCC Part 15.407(b)(1),(2) and RSS-210 6.2.2(q1)(I),(ii) apply.

Table 7-2-4 Ch.52 (5260MHz) **RX** mode

Frequency (GHz)	Polarity (H/V)	Measured (dBμV) (<i>peak</i>)	Measured (dBμV) (<i>average</i>)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dBμV/m) (<i>peak</i>)	FCC Limit (dBμV/m) (<i>peak</i>)	Field Strength (dBμV/m) (<i>average</i>)	FCC Limit (dBμV/m) (<i>average</i>)
1.000	V	49.0	-	24.1	-31.9	0.0	41.2	74.0	-	54.0
1.136	V	50.1	-	24.6	-31.4	0.0	43.3	74.0	-	54.0
1.200	V	49.5	-	25.2	-31.3	0.0	43.4	74.0	-	54.0
1.325	V	52.9	-	25.6	-31.0	0.0	47.5	74.0	-	54.0

Note: NRB means “non restricted band”: The limit of FCC Part 15.407(b)(1),(2) and RSS-210 6.2.2(q1)(I),(ii) apply.

7.6 Measurement Results with co-located Bluetooth device

The test was performed with the representative worst case in the previous Table 7-2-1 through Table 7-2-4 while both the applying WLAN transmitter and the co-located Bluetooth transmitter (FCC ID: ANO20020100MTN) were active and emitted radio frequencies simultaneously.

The EUT was found to comply to the limits of FCC Part 15 Subpart E and RSS-210 with a margin of 1.6 dB.

The actual highest emissions hereafter were found at 6Mbps on the auxiliary antenna of ThinkPad T40 Series 14 inch LCD model.

Test Date: October 4 and 5, 2004

Table 7-2-5. Ch.64 (5320MHz) **TX** mode 6Mbps with the co-located Bluetooth transmitter

Frequency (GHz)	Polarity (H/V)	Measured (dBμV) (peak)	Measured (dBμV) (average)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dBμV/m)	FCC Limit (dBμV/m)	Margin to limit (dB)	Field Strength (dBμV/m)	FCC Limit (dBμV/m)	Margin to limit (dB)
							(peak)			(average)		
OB												
5.315 bandedge	H	103.6	93.4	33.7	-25.7	0.0	111.6	N/A	-	101.4	N/A	-
5.350	H	59.7	44.1	33.9	-25.6	0.0	68.0	74.0	6.0	52.4	54.0	1.6
5.353	H	59.2	42.6	33.9	-25.6	0.0	67.5	74.0	6.5	50.9	54.0	3.1
5.355	H	58.5	42.1	33.9	-25.6	0.0	66.8	74.0	7.2	50.4	54.0	3.6
1.066	V	51.7	-	24.6	-31.7	0.0	44.6	74.0	29.4	-	54.0	-
1.129	V	51.1	-	24.5	-31.5	0.0	44.1	74.0	29.9	-	54.0	-
1.232	V	49.6	-	25.2	-31.3	0.0	43.5	74.0	30.5	-	54.0	-
1.331	V	54.3	-	25.6	-31.0	0.0	48.9	74.0	25.1	-	54.0	-
7.263	H	41.5	-	30.0	-24.8	0.0	46.7	74.0	27.3	-	54.0	-

*Note: OB means "operation band" (5250-5350MHz).

NRB means "non restricted band": The limit of FCC Part 15.407(b)(1),(2) and RSS-210 6.2.2(q1)(I),(ii) apply.

7.7 Measurement plots of adjacent restricted band

7.7.1 List of Measurement Results

The measurement was performed with the worst case that tend to have higher peak output power based on the results of previous Chapter 2 “Peak Conducted Transmit Output Power” measurement.

i.e. 6Mbps showed the highest peak power.

And each antenna port with the highest gain was selected for each host device.

Table 7-3. Radiated peak emission in 5.2GHz OFDM transmission mode, 6Mbps

Measured host device: IBM ThinkPad **T40** Series, 14” & 15” LCD model, main antenna

IBM ThinkPad **R50** Series, 14” LCD model, main antenna

IBM ThinkPad **R50** Series, 15” LCD model, auxiliary antenna

Host Device	Frequency (GHz)	Polarity (H/V)	Reading (dBμV) (<i>peak</i>)	Rading (dBμV) (<i>average</i>)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dBμV/m) (<i>peak</i>)	Margin to Limit (dBμV/m) (<i>peak</i>)	Field Strength (dBμV/m) (<i>average</i>)	Margin to Limit (dBμV/m) (<i>average</i>)
T40 14”	5.148	H	50.9	36.7	33.6	-26.1	0.0	58.4	15.6	44.2	9.8
	5.350	H	56.8	42.2	33.9	-25.6	0.0	65.1	8.9	50.5	3.5
T40 15”	5.139	H	49.6	36.7	33.6	-26.1	0.0	57.1	16.9	44.2	9.8
	5.350	H	54.7	39.6	33.9	-25.6	0.0	63.0	11.0	47.9	6.1
R50 14”	5.149	H	50.5	36.7	33.6	-26.1	0.0	58.0	16.0	44.2	9.8
	5.350	H	57.0	41.8	33.9	-25.6	0.0	65.3	8.7	50.1	3.9
R50 15”	5.137	H	49.3	36.6	33.6	-26.1	0.0	56.8	17.2	44.1	9.9
	5.350	H	52.3	37.9	33.9	-25.6	0.0	60.6	13.4	46.2	7.8

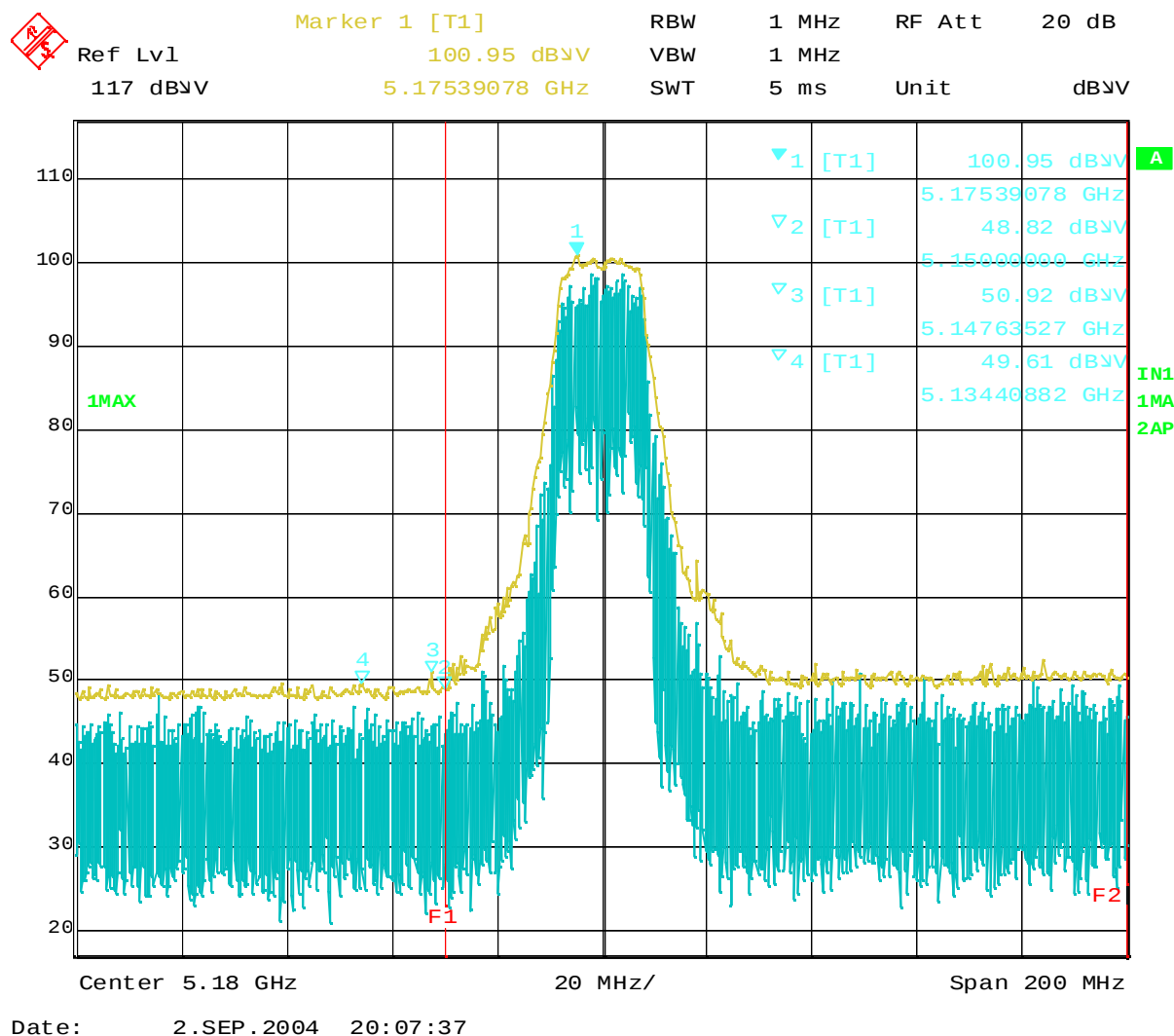
Table 7-4. Radiated peak emission in 5.2GHz OFDM transmission mode, 6Mbps
with co-located Bluetooth device

Performed with the worst case in the above Table 7-3 using IBM ThinkPad **T40** Series, 14” model

Host Device	Frequency (GHz)	Polarity (H/V)	Reading (dBμV) (<i>peak</i>)	Rading (dBμV) (<i>average</i>)	Antenna Factor (dB/m)	Corr. Factor (dB)	Falloff Factor (dB)	Field Strength (dBμV/m) (<i>peak</i>)	Margin to Limit (dBμV/m) (<i>peak</i>)	Field Strength (dBμV/m) (<i>average</i>)	Margin to Limit (dBμV/m) (<i>average</i>)
T40 14”	5.350	H	59.7	44.1	33.9	-25.6	0.0	68.0	6.0	52.4	1.6

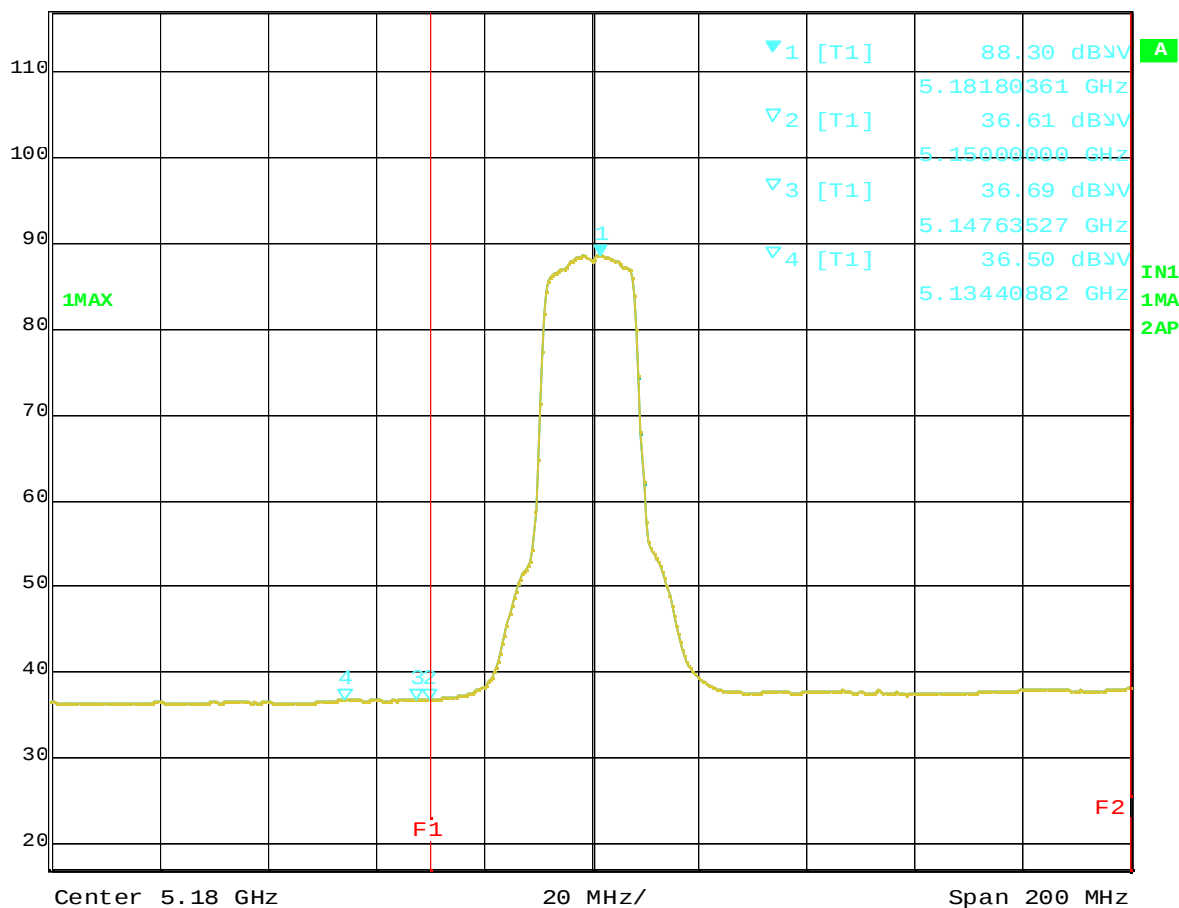
7.7.2 Bandedge Measurement Plots

The plots were the worse cases measured with the ThinkPad T40 Series (14" model) in the previous Table 7-3.



Plot 7-1 5180MHz TX mode (Peak). T40 series (14" model)

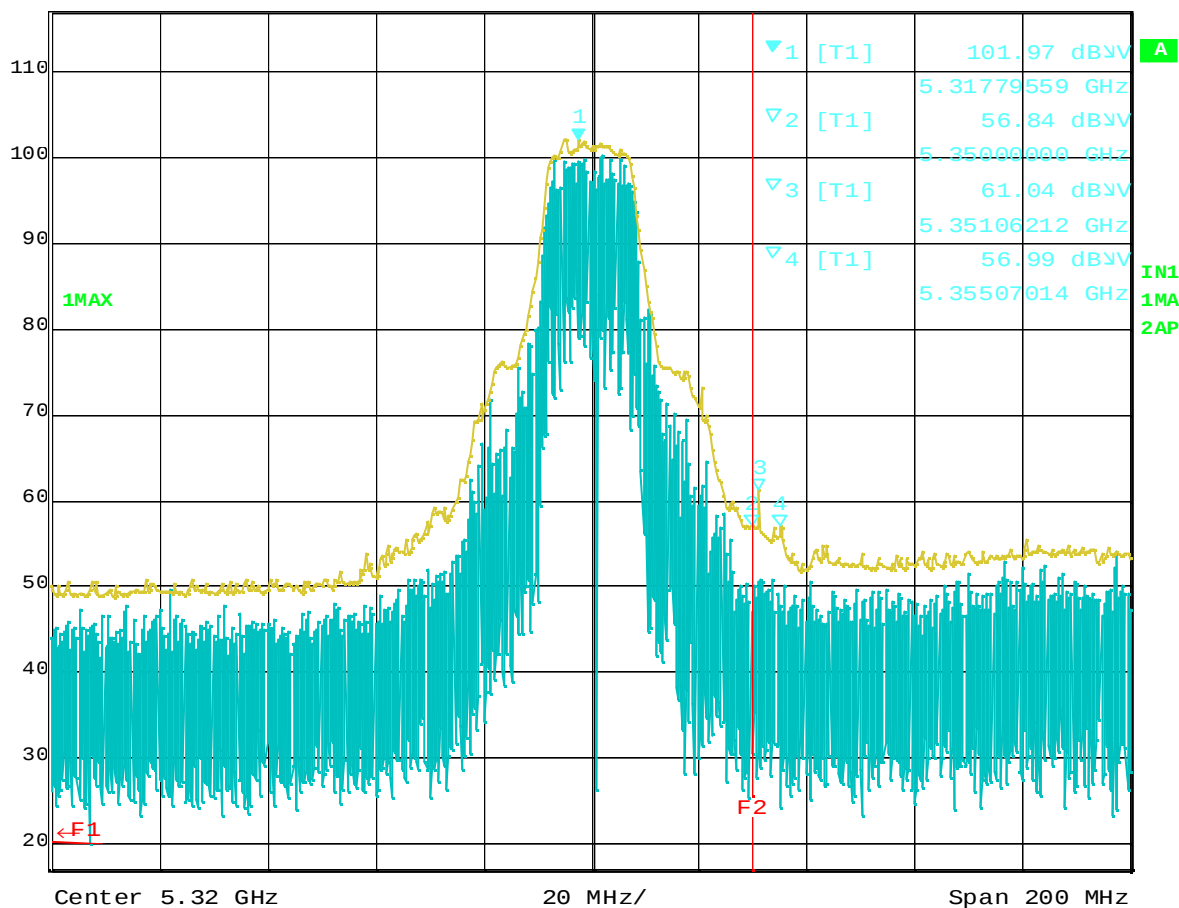
(the applying transmitter only)

Ref Lvl
117 dBμVMarker 1 [T1]
88.30 dBμV
5.18180361 GHzRBW 1 MHz RF Att 20 dB
VBW 10 Hz
SWT 50 s Unit dBμV

Date: 2.SEP.2004 20:16:39

Plot 7-2 5180MHz TX mode (Average) . T40 series (14" model)

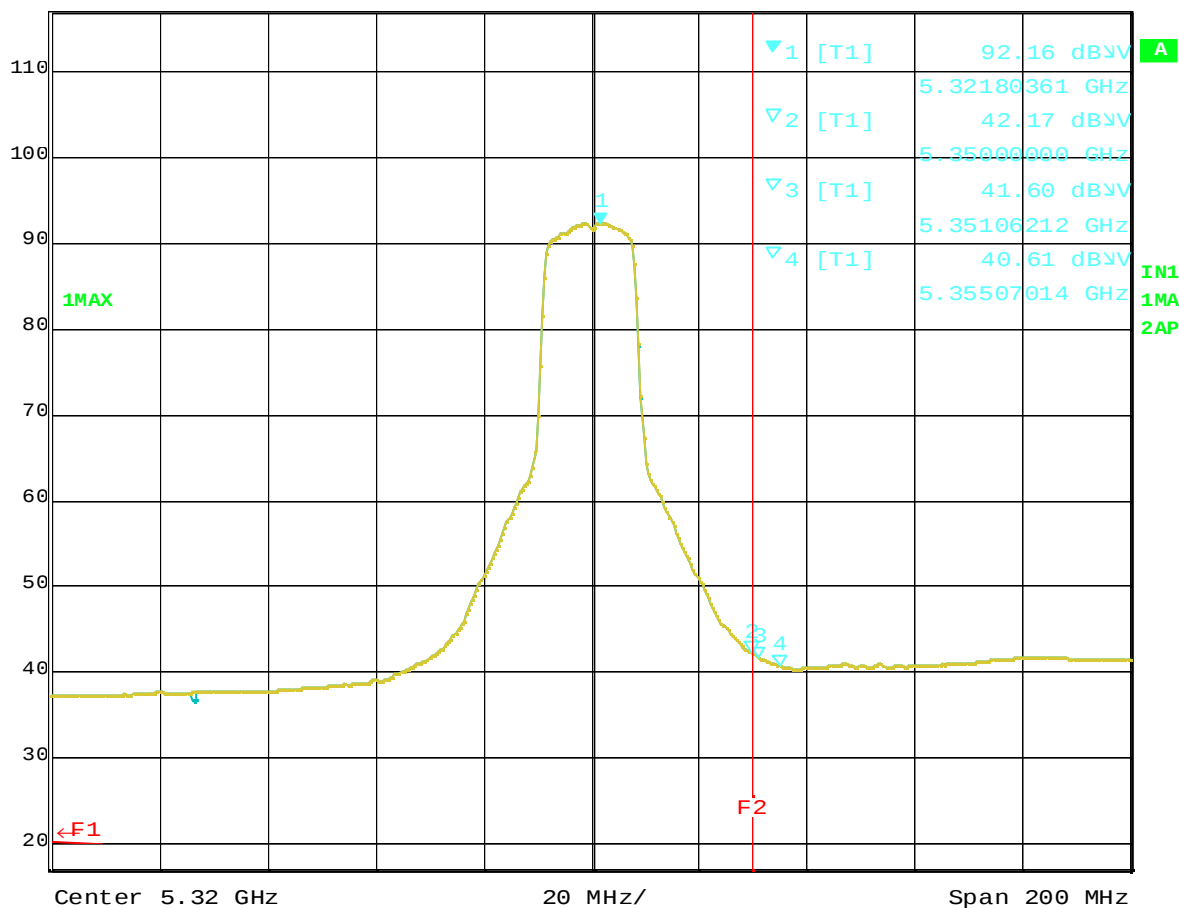
(the applying transmitter only)

Ref Lvl
117 dBμVMarker 1 [T1]
101.97 dBμV
5.31779559 GHzRBW 1 MHz RF Att 20 dB
VBW 1 MHz
SWT 5 ms Unit dBμV

Date: 2.SEP.2004 20:19:18

Plot 7-3 5320MHz TX mode (Peak) . T40 series (14" model)

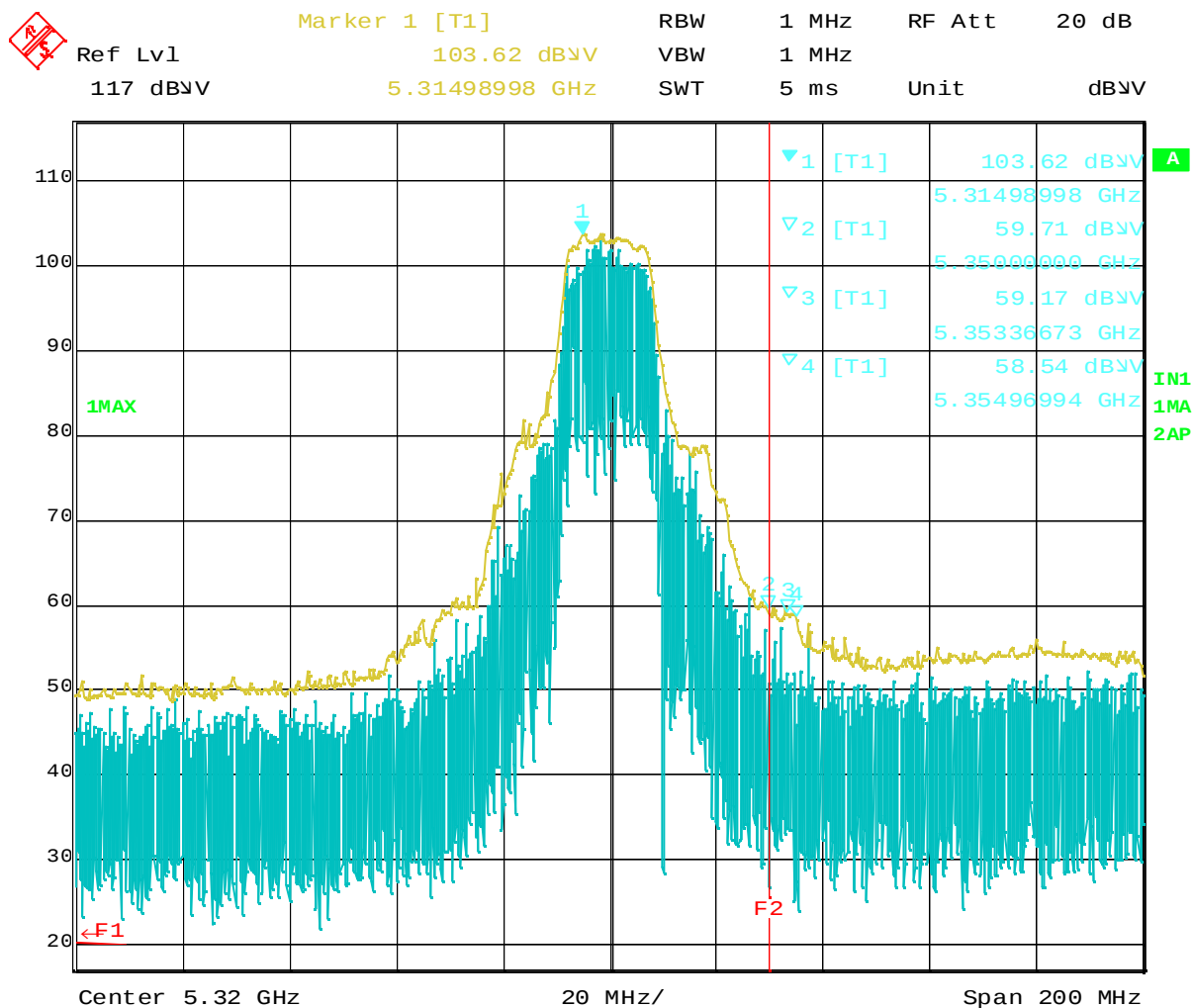
(the applying transmitter only)

Ref Lvl
117 dBμVMarker 1 [T1]
92.16 dBμV
5.32180361 GHzRBW 1 MHz RF Att 20 dB
VBW 10 Hz
SWT 50 s Unit dBμV

Date: 2.SEP.2004 20:22:23

Plot 7-4 5320MHz TX mode (Average) . T40 series (14" model)

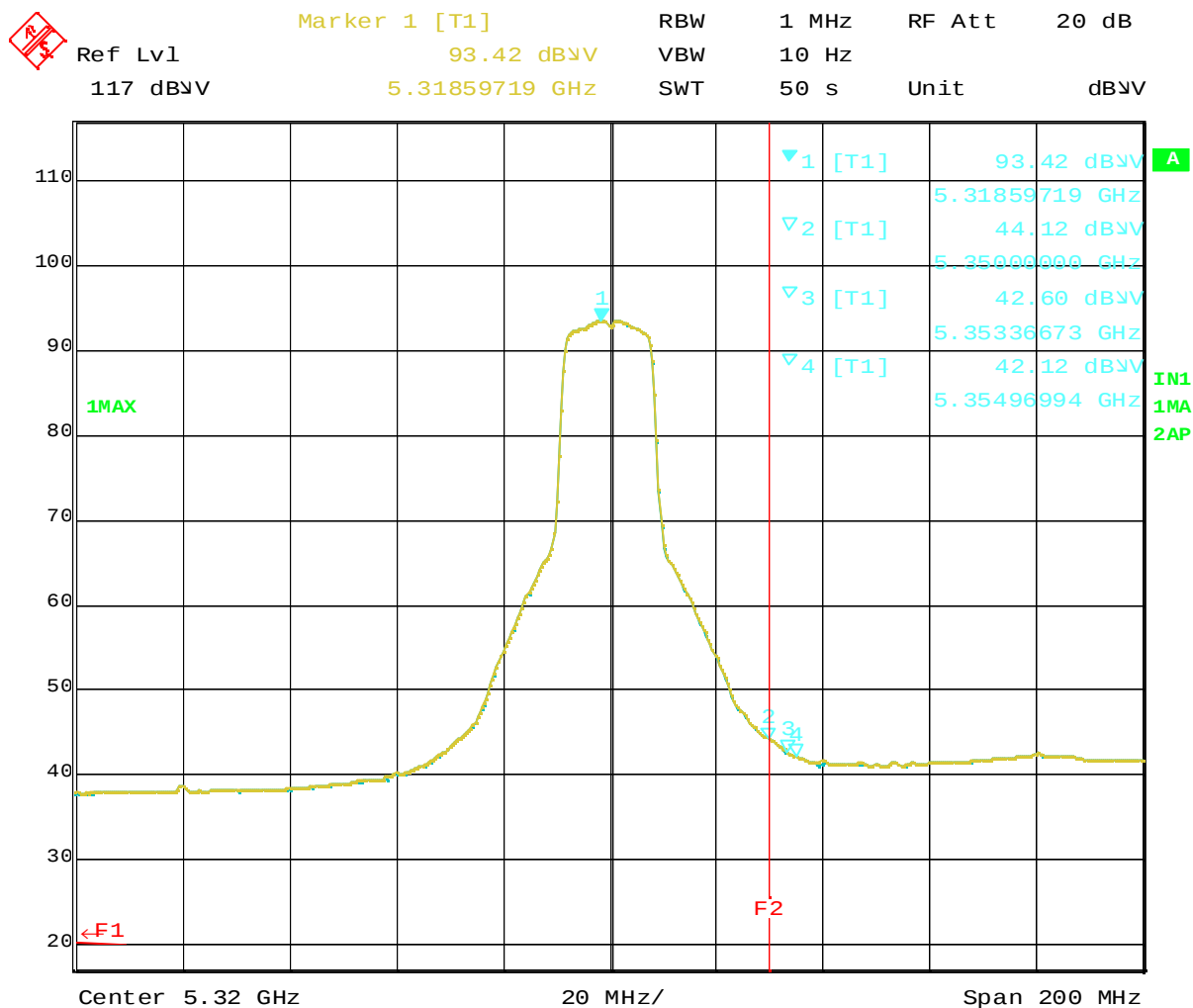
(the applying transmitter only)



Date: 4.OCT.2004 14:22:23

Plot 7-5 5320MHz TX mode (Peak). T40 series (14" model)

(the applying transmitter with co-located Bluetooth device)



Date: 4.OCT.2004 14:25:07

Plot 7-6 5320MHz TX mode (Average) . T40 series (14" model)

(the applying transmitter with co-located Bluetooth device)