FCC Part 15 C-E
Transmitter Certification

Part 15 C - Direct Sequence Spread Spectrum Transmitter
Part 15 E – Unlicensed National Information Infrastructure Device

Test Report

FCC ID: SH5-CAP

FCC Rule Part: 15.247 & 15.407

ACS Report Number: 04-0273-15C/E D

Manufacturer: Miltope Corporation
Model: CAP (Cabin Access Point)
Model Variants: WAB (Wireless Access Bridge)

Test Begin Date: September 16, 2004
Test End Date: September 30, 2004

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FOR THE SCOPE OF ACCREDITATION UNDER LAB Code 200612

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This report contains 77 pages

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1.0 GENERAL

1.1 Purpose
The purpose of this report is to demonstrate compliance with Part 15, Subpart C of the FCC's Code of Federal Regulations.

1.2 Product Description

1.2.1 General
The CAP is a network distribution system designed specifically for rugged airborne applications. The CAP supports IEEE802.11a/b/g wireless applications utilizing two Commercial-Off-The-Shelf (COTS) transmitter/receiver modules communicating in the appropriately assigned radio frequency spectrum to facilitate wireless communications to other aircraft cabin devices on the network. The CAP provides a bridge between IEEE802.3 wired Ethernet LANs and IEEE802.11a/b/g compliant wireless networks.

Each transmitter/receiver module contains one RF output, which support either IEEE802.11a or IEEE802.11b/g operation; but not both simultaneously. The RF output of each module is brought out, via internal coax cable harnesses, to two external (50Ω) TNC connectors, (J2 & J3). A normal configuration would consist of one module being software selected for 802.11a operation and the other module being selected for 802.11b/g operation. This configuration would then provide simultaneous IEEE802.11a/b/g operation. Output power and input sensitivity for each module is controlled independently.

The variant Wireless Access Bridge (WAB) is identical in hardware to the Cabin Access Point (CAP) with the exception of the antenna assembly and firmware which allows for only 802.11b/g operation. In addition, only one radio module and RF output is utilized in this configuration. The WAB is used to form a wireless Local Area Network (LAN) connection between an aircraft and a ground based LAN, typically an airport, hanger, FBO facility, flight operations facility, tarmac, etc. The WAB is mounted on aircrafts. The WAB, by functioning as a Wi-Fi™ compatible client, provides a "wireless link" from the aircraft to ground based COTS access points (AP) that may be provided by multiple access point suppliers. By acting as a Wi-Fi™ client, the WAB relies on the "airport-side" AP to set to set the necessary configuration information including RF channel assignment ESSID, security settings, etc.

See Section 1.2.3 for details describing antenna assembles for CAP and WAB.

Detailed photographs of the EUT are filed separately with this filing.

1.2.2 Intended Use

The intended use of the Cabin Access Point (CAP) and its Wireless Access Bridge (WAB) variant is designed specifically for rugged airborne applications

1.2.3 Antennas

The CAP antenna assembly is a horizontally polarized, multi-band antenna designed to provide worldwide IEEE 802.11a/b/g WLAN coverage with minimum package size. It is designed to operate in the 2.39 – 2.49 GHz and 4.9 – 5.9 GHz frequency bands with a VSWR of less than 2.0:1 across all bands. The antenna is provided with one integral RF, TNC type coax connector.

DESCRIPTION	SPECIFICATION
Frequency Range	2.39-2.49 GHz and 4.9-5.9 GHz
Peak Gain (2.45 GHz)	2 dBi
Peak Gain (5.0 GHz)	2.5 dBi
Peak Gain (5.25 GHz)	3.5 dBi
Peak Gain (5.8 GHz)	3.5 dBi
Polarization	Horizontal
Coax Cable Type	RG-316/U
Cable Length	7.5" +/- 0.25"
Connector Type	Male TNC

The WAB antenna assembly Aluminum blade antenna designed for spread spectrum local area network communication utilizing IEEE 802.11. Common 4 hole base plate design provides a common installation for commercial airline application.

DESCRIPTION	SPECIFICATION
Frequency Range	2.2 – 2.5 GHz
Peak Gain	5.5 dBi
VSWR	1.5:1
Impedance	50 Ohms
Pattern	Omni-Directional
Polarization	Vertical
Connector Type	Male TNC

1.2.4 EUT Modifications and Configurations

For the WAB configuration, which only operates utilizing 802.11b/g, an RG-58 extension cable of 6ft in length was added between the antenna and EUT. This cable was not a modification to show compliance but was solely used to establish a link between the EUT and antenna. This setup is consistent with the final product installation.

For the CAP configuration either of two distinct test configurations were used to show compliance for the 802.11b/g radio modules for Part 15 Subpart C.

CAP Configuration 1- Required for compliance for 802.11b/g
An RG-58 extension cable of 6ft in length was added between the antennas and EUT to reduce spurious emission levels.

CAP Configuration 2- Required for compliance for 802.11b/g
No extension cable between the antennas and EUT was required but the power output was reduced to show compliance to the radiated emission limits.

Either configuration 1 or configuration 2 will be utilized with the final product and installed as required.

Tests performed for 802.11a did not require any modifications or unique configurations to show compliance to Part 15 Subpart E.

LOCATION OF TEST FACILTY
All testing was performed by qualified ACS personnel located at the following address:

ACS, Inc.
5015 B.U. Bowman Drive
Buford, GA 30518

2.1 DESCRIPTION OF TEST FACILITY
Both the Open Area Test Site (OATS) and Conducted Emissions site have been fully described, submitted to, and accepted by the FCC, Industry Canada and the Japanese Voluntary Control Council for Interference by information technology equipment.

The following certification numbers have been issued in recognition of these accreditations and certifications:

FCC Registration Number: 89450
Industry Canada Lab Code: IC 4175
VCCI Member Number: 1831
- VCCI OATS Registration Number R-1526
- VCCI Conducted Emissions Site Registration Number: C-1608

2.1.1 Open Area Test Site
The open area test site consists of a 40' x 66' concrete pad covered with a perforated electro-plated galvanized sheet metal. The perforations in the sheet metal are 1/8" holes that are staggered every 3/16". The individual sheets are placed to overlap each other by 1/4" and are riveted together to provide a continuous seam. Rivets are spaced every 3" in a 3 x 20 meter perimeter around the antenna mast and EUT area. Rivets in the remaining area are spaced as necessary to properly secure the ground plane and maintain the electrical continuity.

The entire ground plane extends 12' beyond the turntable edge and 16' beyond the antenna mast when set to a 10 meter measurement distance. The ground plane is grounded via 4 - 8' copper ground rods, each installed at a corner of the ground plane and bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is an all aluminum 10' flush mounted table installed in an all aluminum frame. The table is remotely operated from inside the control room located 40' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Adjacent to the turntable is a 7' x 7' square and 4' deep concrete pit used for support equipment if necessary. The pit is equipped with 5 - 4" PVC chases from the pit to the control room that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit. The pit is covered with 2 sheets of 1/4" diamond style re-enforced steel sheets. The sheets are painted to match the perforated steel ground plane; however the underside edges have been masked off to maintain the electrical continuity of the ground plane. All reflecting objects are located outside of the ellipse defined in ANSI C63.4.

A diagram of the Open Area Test Site is shown in Figure 3.2-1 below:

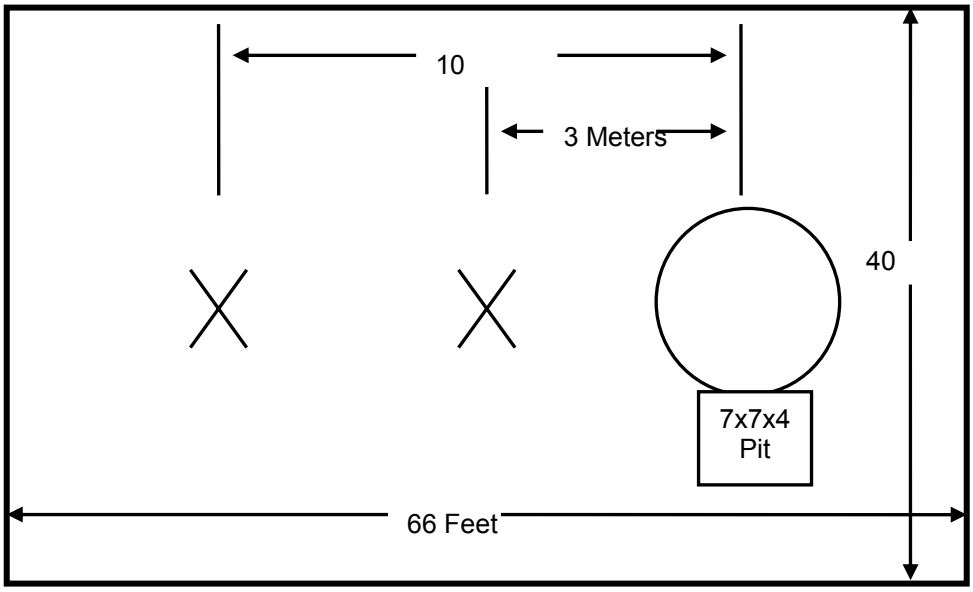

Figure 2.1.1-1: Open Area Test Site

2.1.2 Conducted Emissions Test Site Description
The AC mains conducted EMI site is a shielded room with the following dimensions:

- Height: 3.0 Meters
- Width: 3.6 Meters
- Length: 4.9 Meters

The room is manufactured by Rayproof Corporation and installed by Panashield, Inc. Earth ground is provided to the room via an 8' copper ground rod. Each panel of the room is connected electrically at intervals of 4".

Power to the room is filtered to prevent ambient noise from coupling to the EUT and measurement equipment. Filters are models 1B42-60P manufactured by Rayproof Corporation.

The room is of sufficient size to test table top and floor standing equipment in accordance with section 6.1.4 of ANSI C63.4.

A diagram of the room is shown below in figure 2.1.2-1:

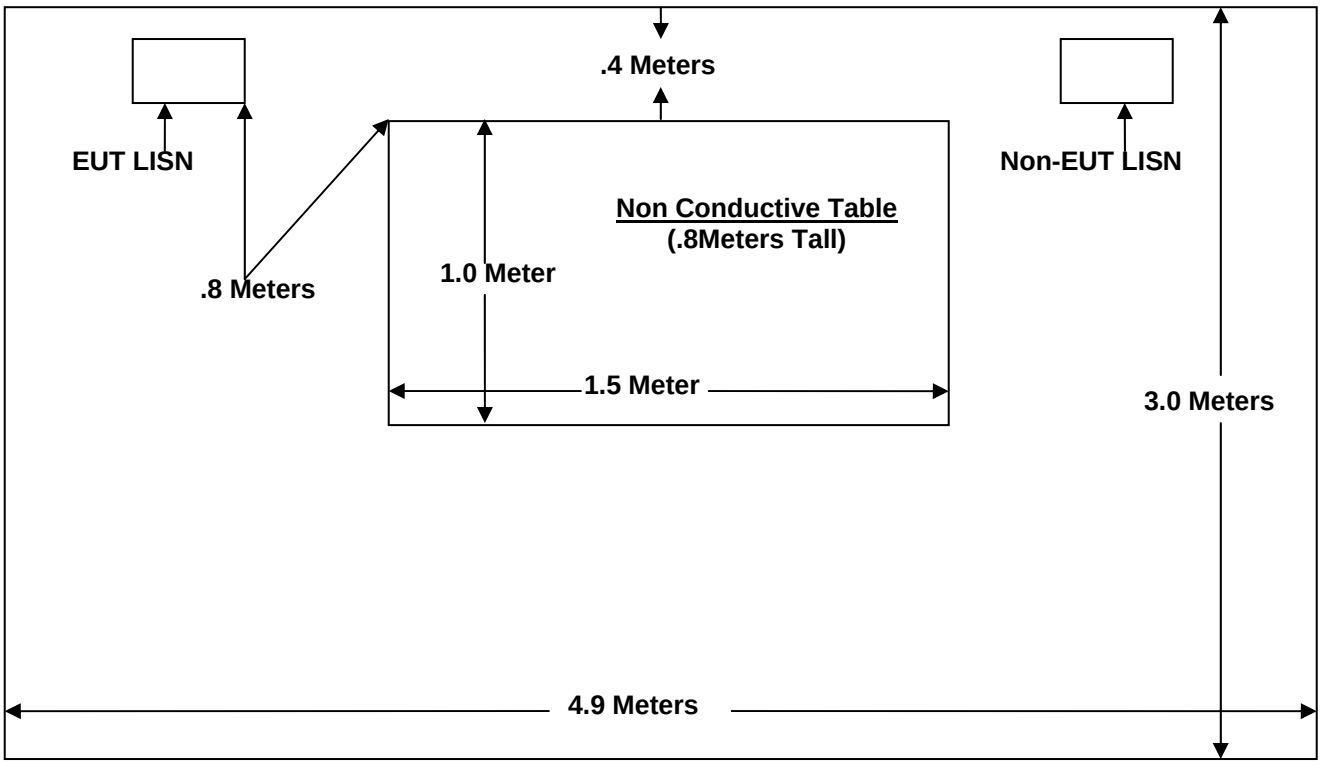

Figure 2.1.2-1: AC Mains Conducted EMI Site

3.0 APPLICABLE STANDARD REFERENCES
The following standards were used:

1 - ANSI C63.4-1992: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the 9 KHz to 40GHz

2 - US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators (October 2002)

3 - US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart E: Unlicensed National Information Infrastructure (October 2002)

4 - FCC OET Bulletin 65 Appendix C - Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

4.0 LIST OF TEST EQUIPMENT

All test equipment used for regulatory testing is calibrated yearly or according to manufacturer's specifications.

Table 4.0-1: Test Equipment

Equipment Calibration Information					
ACS#	**Mfg.**	**Eq. type**	**Model**	**S/N**	**Cal. Due**
---	Rohde & Schwarz	EMI Test Receiver	ESIB 40	100121	07/24/05
---	Agilent	Spectrum Analyzer	E7402A	US40240259	02/26/05
26	Chase	Bi-Log Antenna	CBL6111	1044	10/14/04
152	EMCO	LISN	3825/2	9111-1905	01/08/05
153	EMCO	LISN	3825/2	9411-2268	12/11/04
193	ACS	OATS Cable Set	RG8	193	01/09/05
167	ACS	Conducted EMI Cable Set	RG8	167	01/09/05
22	Agilent	Pre-Amplifier	8449B	3008A00526	05/12/05
73	Agilent	Pre-Amplifier	8447D	272A05624	04/30/05
30	Spectrum Technologies	Horn Antenna	DRH-0118	970102	05/08/05
105	Microwave Circuits	High Pass Filter	H1G810G1	2123-01 DC0225	06/09/05
209	Microwave Circuits	High Pass Filters	H3G020G2	4382-01 DC0421	06/09/05
1	Rohde & Schwarz	Receiver	804.8932.52	833771/007	02/26/05
2	Rohde & Schwarz	Receiver	1032.5640.53	839587/003	02/26/05
3	Rohde & Schwarz	ESMI Receiver	804.8932.52	839379/011	*
4	Rohde & Schwarz	ESMI Receiver	1032.5640.53	833827/003	*
213	Test Equipment Corp.	Pre-Amplifier	PA-102	44927	06/28/05
211	Eagle	Band Reject Filter	C7RFM3NFNM	n/a	06/28/05
168	Hewlett Packard	Pulse Limiter	11947A	3107A02268	04/30/05
93	Chase	EM Clamp	CIC 8101	65	01/12/05
184	ACS	Cable	RG8	184	01/09/05
169	Solar Electronics	LISN	9117-5-TS-50-N	031032	04/12/05
6	Harbour Industries	HF RF Cable	LL-335	00006	03/15/05
7	Harbour Industries	HF RF Cable	LL-335	00007	03/15/05
208	n/a	HF RF Cable	n/a	00208	06/14/05
5	ChaseRF Current Probe	Current Probe	CSP-8441	19	01/23/05

* Note: No calibration required – used for pre-scan data only

5.0 SUPPORT EQUIPMENT

Table 5-3: Support Equipment

Item	Equipment Type	Manufacturer	Model Number	Serial Number	FCC ID
1	EUT	Miltope	CAP/WAB	NA	SH5-CAP
2*	Laptop	IBM	ThinkPad - 2658	AK-VB0LZ 02/08	NA

* Equipment used for test mode setup only, not used in testing environment.

6.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

The Equipment Under Test Setup Block Diagram below is shown for the Cabin Access Point (CAB). The WAB variant differs only in the utilization of one RF port with a separate antenna assembly.

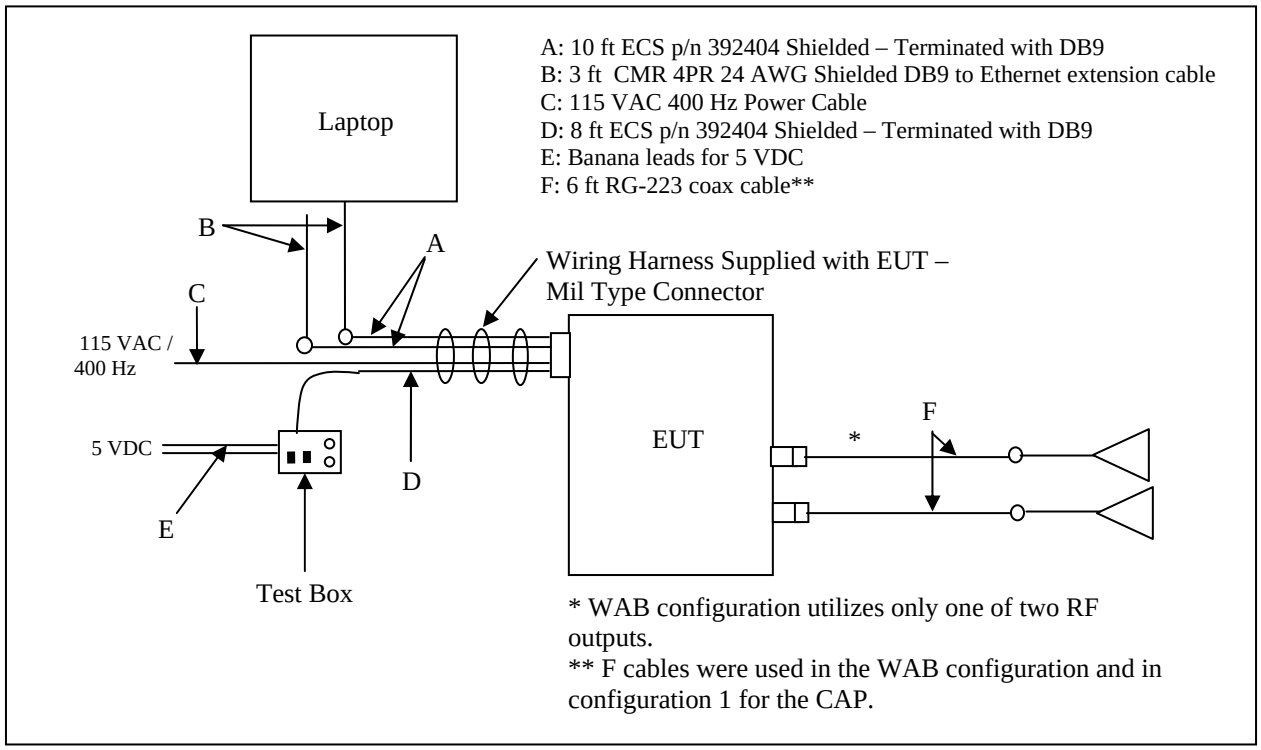

Figure 6-1: EUT Test Setup

7.0 SUMMARY OF TESTS – PART 15C - 802.11b/g

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

7.1 Antenna Requirement - FCC Section 15.203

The transmit antenna cable is permanently attached to the transmit antenna and terminated with a TNC connector. According to FCC Public Notice, DA 00-2225, the TNC does not qualify as a unique antenna coupler. Professional installation is specified by the manufacturer for the model CAP and WAB.

7.2 Power Line Conducted Emissions - FCC Section 15.207

The EUT intentional radiator was not designed to be connected to the public utility (AC) power line therefore no conducted emission testing was performed.

7.3 Radiated Emissions - FCC Section 15.109(Unintentional Radiation)

7.3.1 Test Methodology

Radiated emissions tests were performed over the frequency range of 30MHz to 1 GHz. Measurements of the radiated field strength were made at a distance of 3m from the boundary of the equipment under test (EUT) and the receiving antenna. The antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. Radiated measurements were made with the Spectrum Analyzer's resolution bandwidth set to 120 KHz for measurements above 30MHz. Average measurements are taken with the RBW and VBW were set to 1MHz and 10 Hz respectively for measurements above 1000MHz.

7.3.2 Test Results

Results of the test are given below in Table 7.3-1 for CAP and Table 7.3-2 for WAB:

Table 7.3-1: Radiated Emissions Tabulated Data - CAP

Frequency (MHz)	Antenna Polarity (H/V)	Antenna Height (cm)	Turntable Position (°)	Corrected Reading (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Results
31.04	V	100	281	29.30	40.00	10.70	PASS
175.98	H	132	241	31.10	46.02	14.92	PASS
267.20	H	118	0	29.10	46.02	16.92	PASS
286.32	H	112	198	26.80	46.02	19.22	PASS
494.56	H	100	0	20.80	46.02	25.22	PASS
683.13	H	100	0	22.60	46.02	23.42	PASS
754.24	H	100	296	44.10	46.02	1.92	PASS
945.07	H	100	0	26.80	46.02	19.22	PASS

* Note: All emissions above 945.07 MHz were attenuated at least 20 dB below the permissible limit.

Table 7.3-2: Radiated Emissions Tabulated Data – WAB

Frequency (MHz)	Antenna Polarity (H/V)	Antenna Height (cm)	Turntable Position (°)	Corrected Reading (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Results
30.63	V	100	360	28.00	40	12.0	**Pass**
267.25	H	114	28	26.44	46	19.6	**Pass**
286.29	H	128	181	29.04	46	17.0	**Pass**
314.80	H	100	360	24.97	46	21.0	**Pass**
494.52	H	100	0	20.97	46	25.0	**Pass**
675.58	H	100	360	22.21	46	23.8	**Pass**
925.49	H	120	0	35.23	46	10.8	**Pass**
944.75	H	125	0	27.49	46	18.5	**Pass**
30.63	V	100	360	28.00	40	12.0	**Pass**
267.25	H	114	28	26.44	46	19.6	**Pass**

* Note: All emissions above 944.75 MHz were attenuated at least 20 dB below the permissible limit.

7.4 6dB Bandwidth – FCC Section 15.247(a)(2)

7.4.1 Test Methodology

The 6dB bandwidth was measured in accordance with FCC 97-114 Appendix C. The RBW of the spectrum analyzer was set to 100 kHz and VBW 300 kHz. Span was set large enough to capture the entire emissions and >> RBW. All modes of 802.11b and 802.11g radios were evaluated for worst case. No significant differences were discovered in this evaluation. 11 Mb/s was used for 802.11b and 54 Mb/s was used for 802.11g.

7.4.2 Test Results

Results are shown below in table 7.4.2-1 and figures 7.4.2-1 to 7.4.2-3 for 802.11b and table 7.4.2-2 and figures 7.4.2-4 to 7.4.2-6 for 802.11g:

Table 7.4.2-1: 6dB Bandwidth 802.11b

Frequency [MHz]	Bandwidth [MHz]	Limit	Result
2412	12.02	≥ 500 kHz	PASS
2437	12.27	≥ 500 kHz	PASS
2462	12.12	≥ 500 kHz	PASS

Table 7.4.2-2: 6dB Bandwidth 802.11g

Frequency [MHz]	Bandwidth [MHz]	Limit	Result
2412	16.63	≥ 500 kHz	PASS
2437	16.63	≥ 500 kHz	PASS
2462	16.58	≥ 500 kHz	PASS

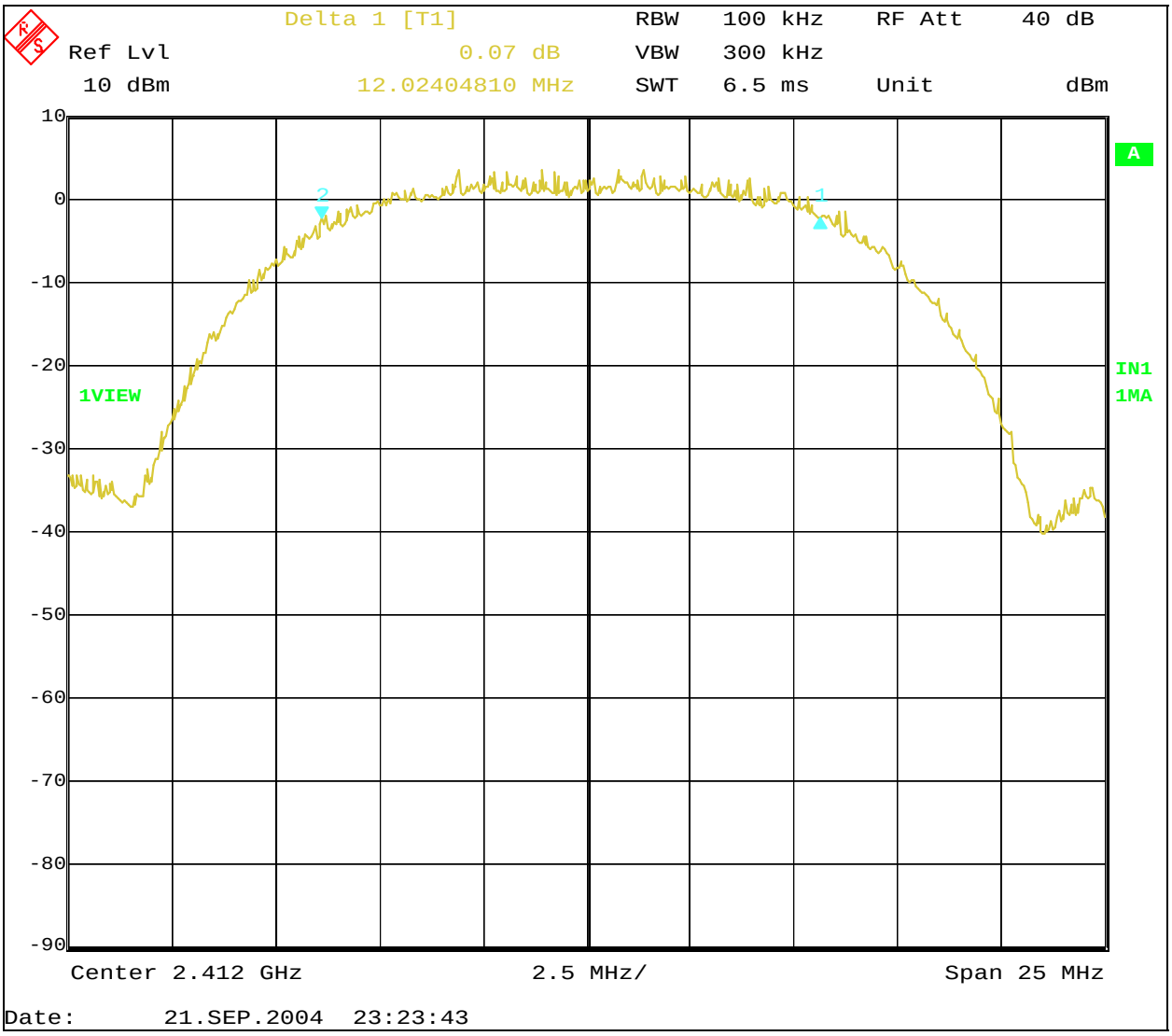

Figure 7.4.2-1: 6dB Bandwidth Plot Channel 1

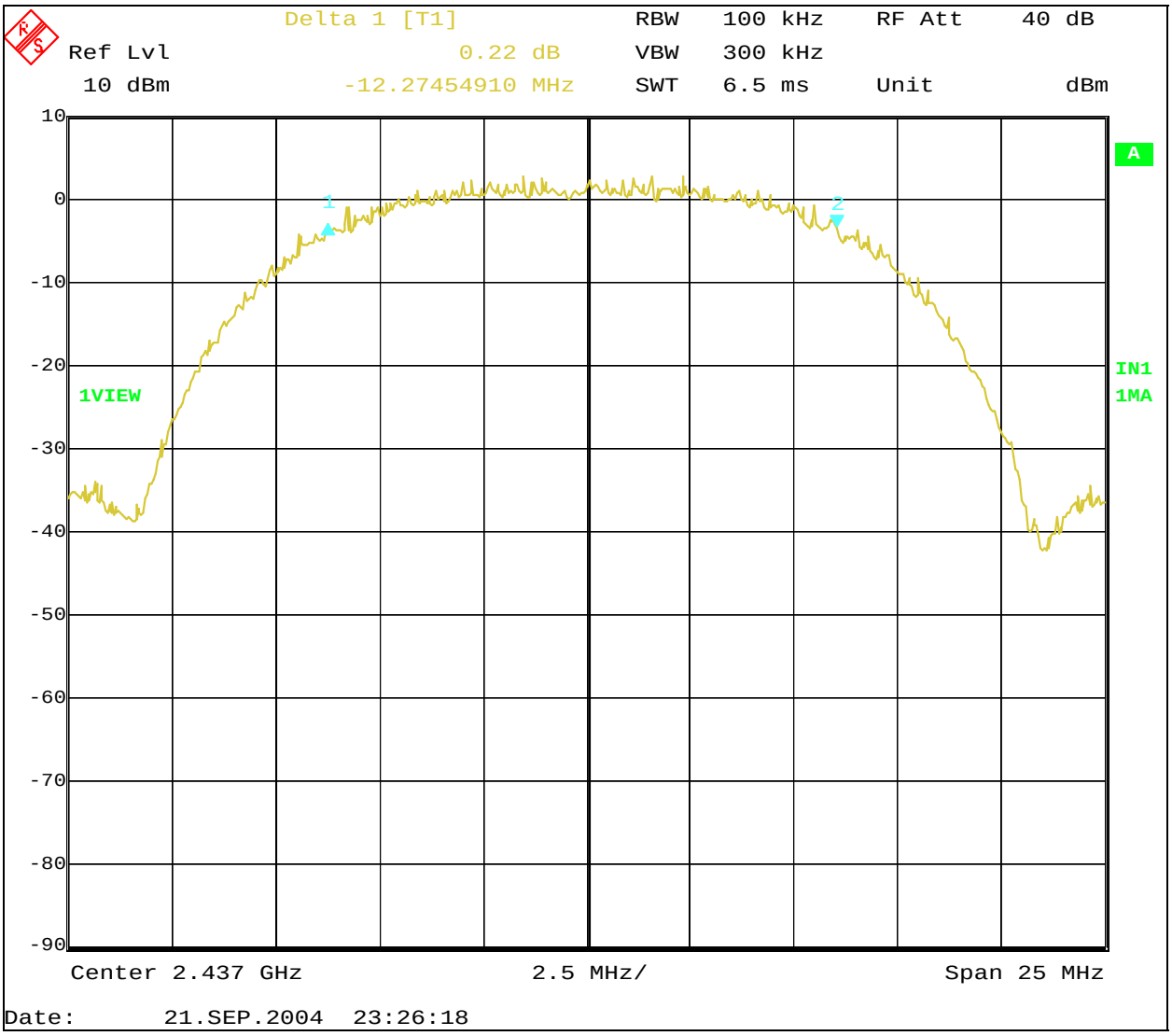

Figure 7.4.2-2: 6dB Bandwidth Plot Channel 6

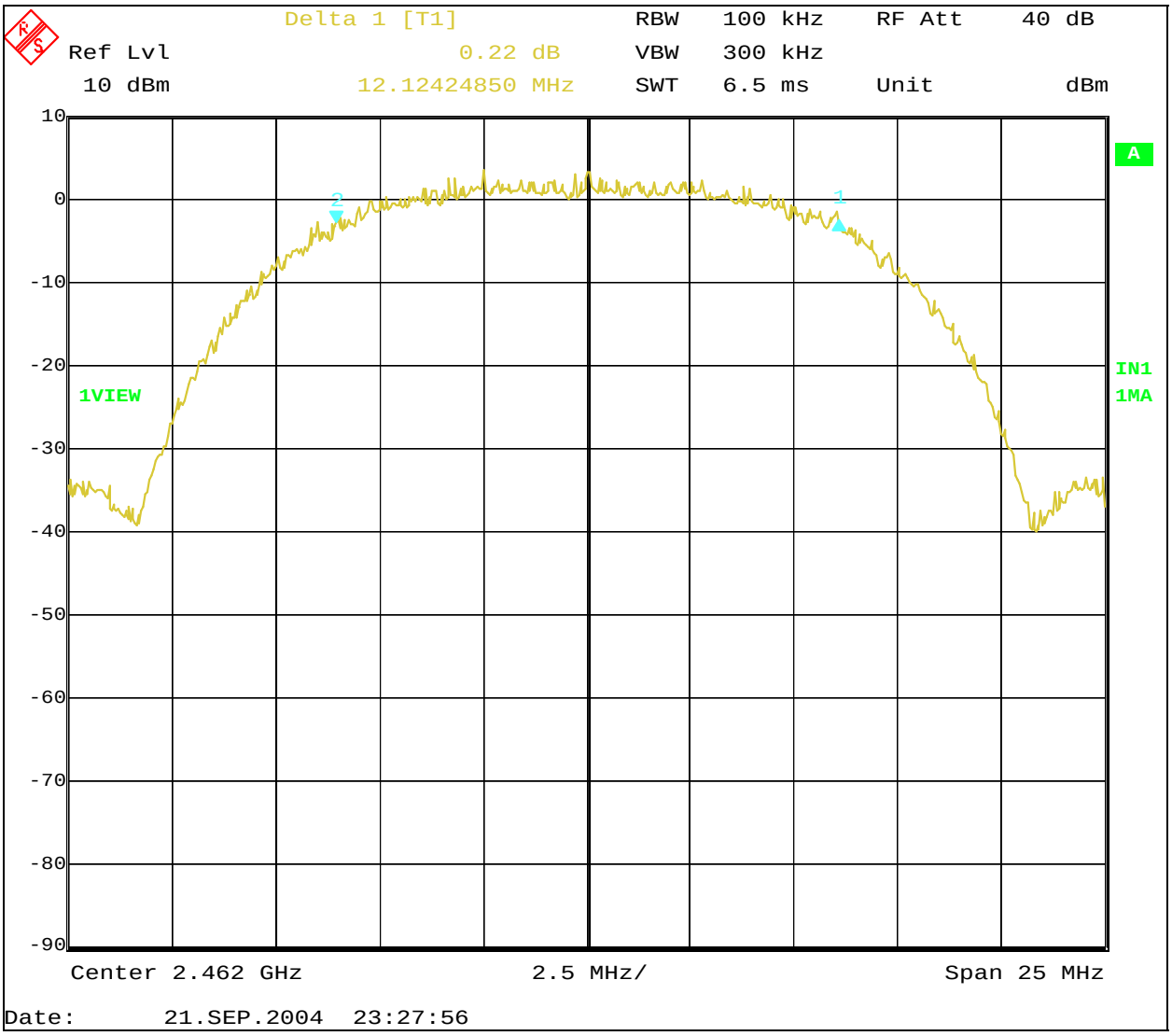

Figure 7.4.2-3: 6dB Bandwidth Plot Channel 11

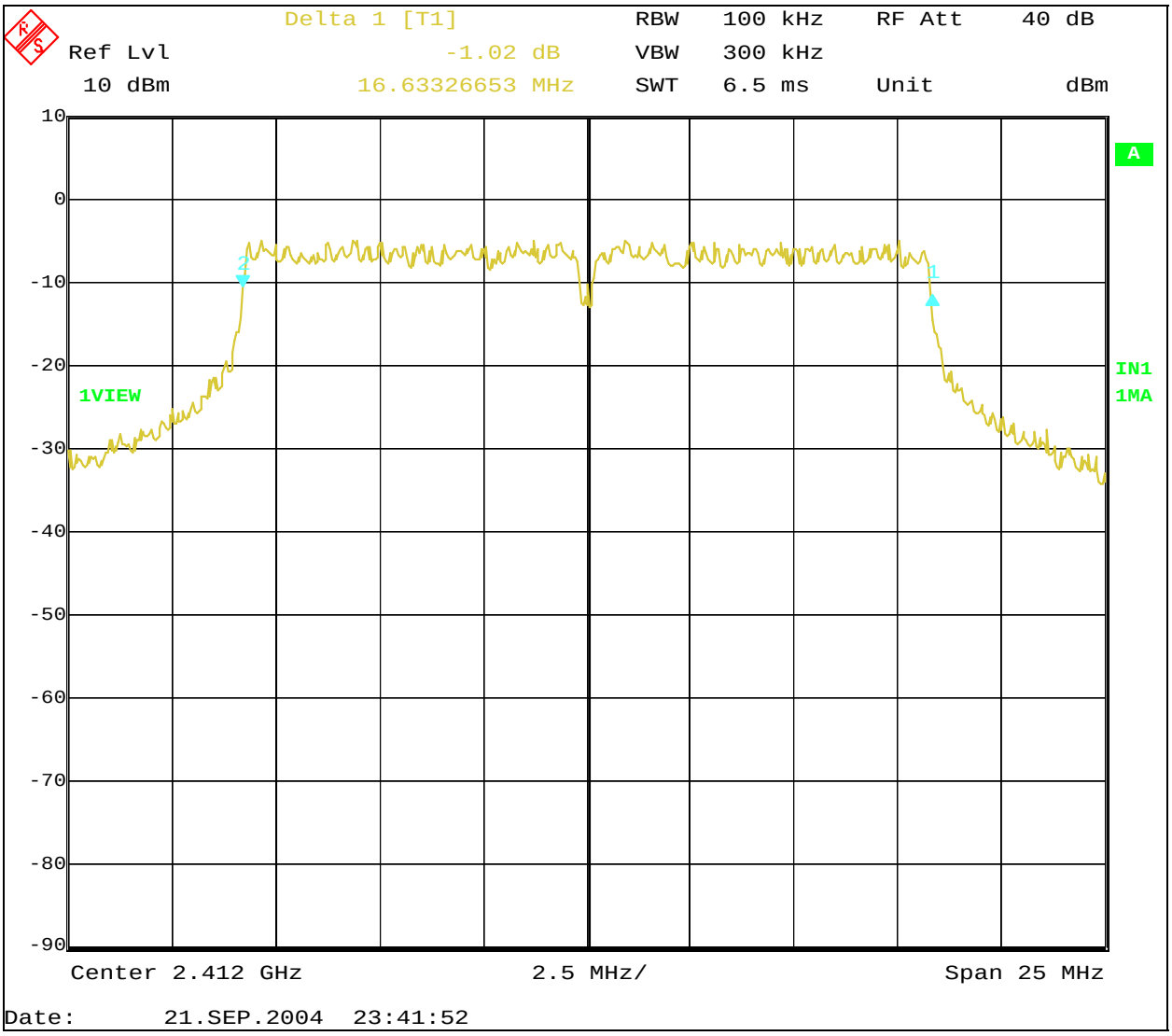

Figure 7.4.2-4: 6dB Bandwidth Plot Channel 1

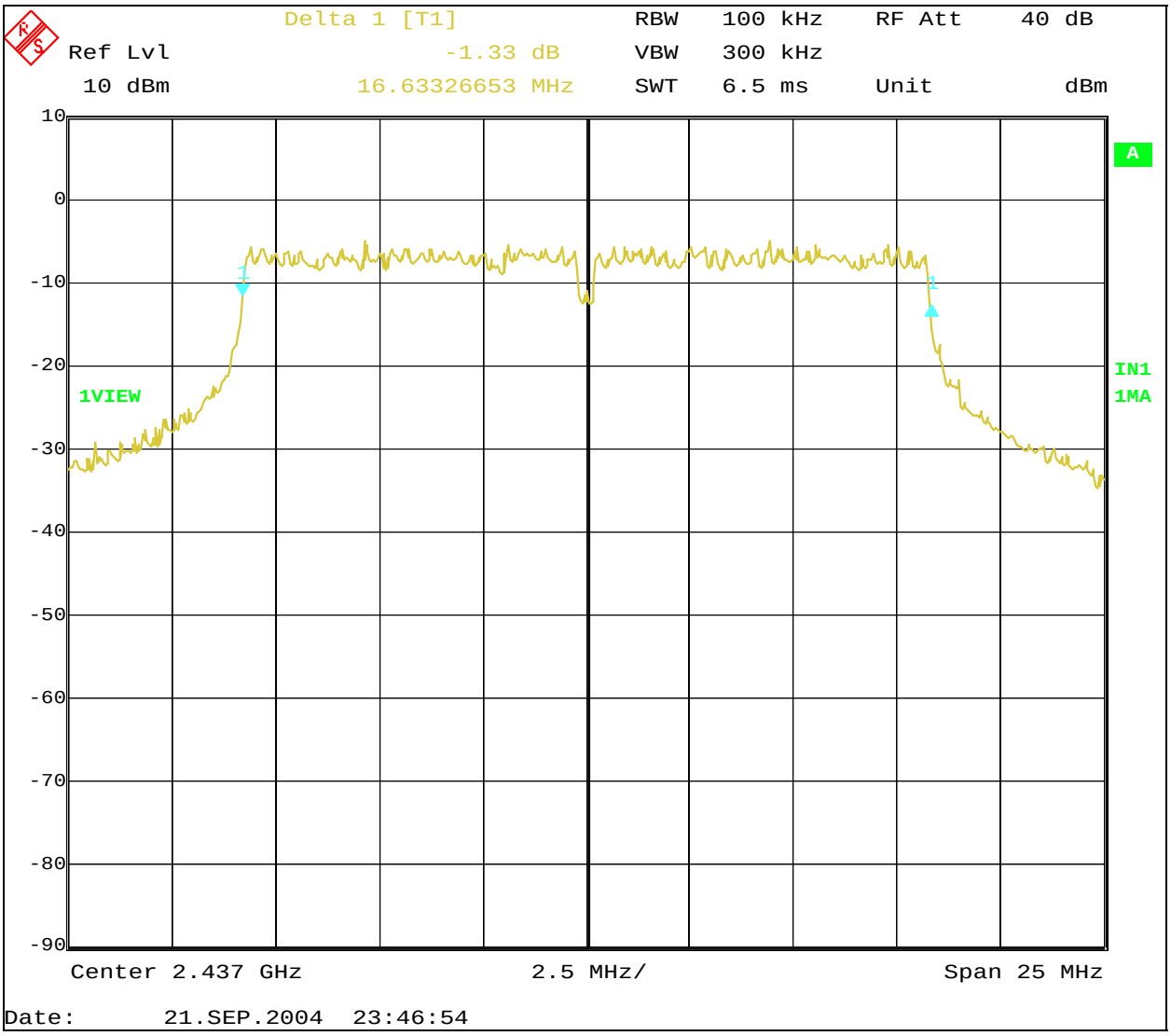

Figure 7.4.2-5: 6dB Bandwidth Plot Channel 6

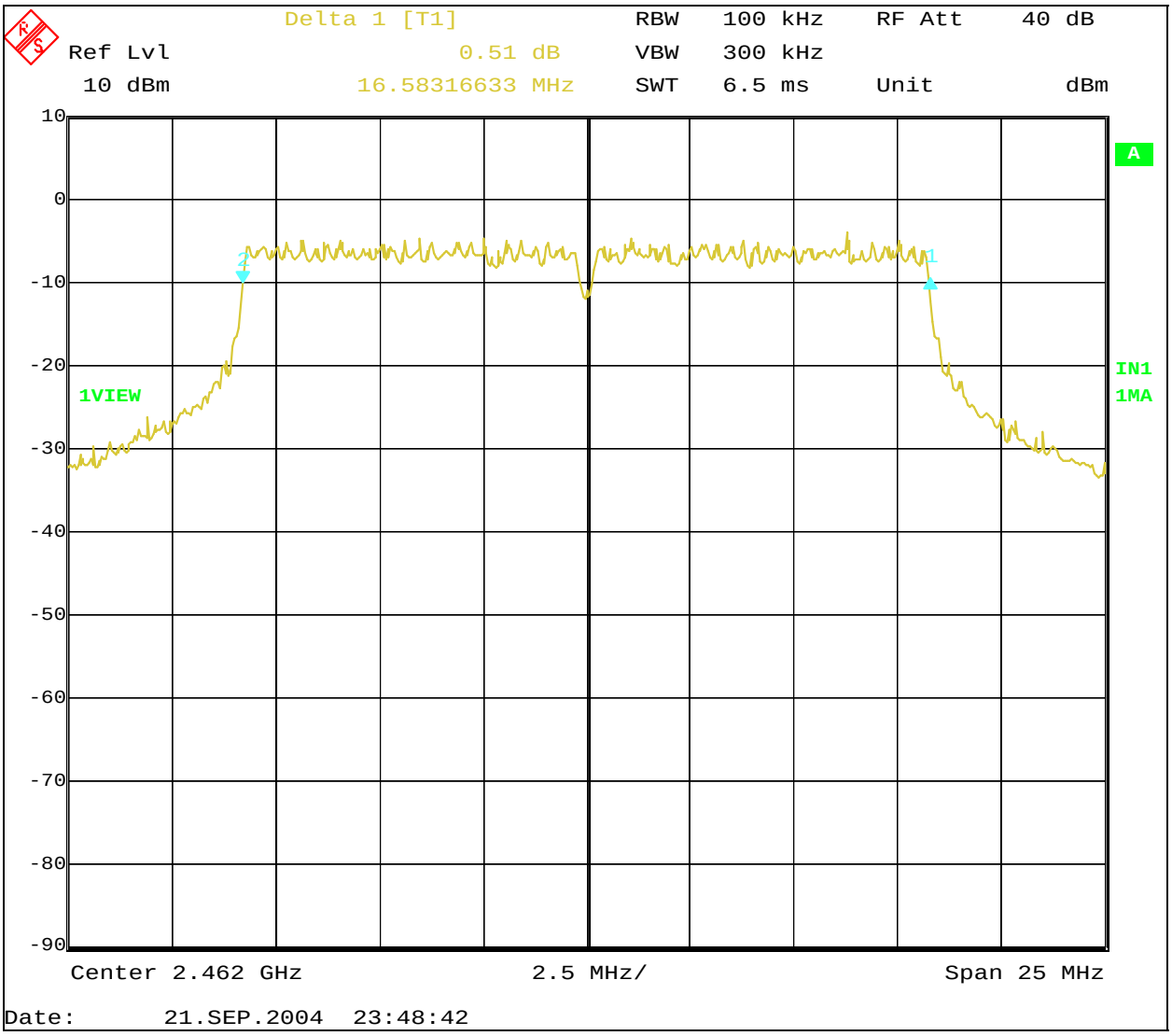

Figure 7.4.2-6: 6dB Bandwidth Plot Channel 11

7.5 Peak Output Power Requirement - FCC Section 15.247(b)

7.5.1 Test Methodology

The peak output power of the EUT was made at the antenna connector using an ESIB Spectrum Analyzer. Due to the wide bandwidth characteristics of the 802.11 device, the peak output power was measured utilizing the bandwidth power function of the spectrum analyzer or utilizing the bandwidth correction factor. The RBW and VBW were set to maximum available. When using the bandwidth power function of the spectrum analyzer, the band limits for measuring power were set according to the 6 dB bandwidth measured in section 7.4 and expanded by 0.5*RBW on each end (5 MHz). Sweep was set to auto and a peak detector was used with Max Hold set for the trace. The emission was allowed sufficient time to stabilize before the final reading. For the measurement, the EUT was caused to generate a continuous transmission.

Data was collected with the EUT operating at maximum power for the WAB and CAP Configuration 1. Output power was then reduced for CAP configuration 2 to show compliance to radiated emission limits for Part 15 Subpart C.

7.5.2 Test Results – WAB and CAP Configuration 1

Results are shown below in Table 7.5-1 and Figure 7.5-1 to 7.5-3 for 802.11b and Table 7.5-2 and Figure 7.5-4 to 7.5-6 for 802.11g.

Table 7.5-1: Peak Output Power 802.11b

Channel	Frequency (MHz)	Output Power (dBm)
Low	2412	19.65
Mid	2437	20.73
High	2462	20.10

Table 7.5-2: Peak Output Power 802.11g

Channel	Frequency (MHz)	Output Power (dBm)
Low	2412	25.40
Mid	2437	25.06
High	2462	24.40

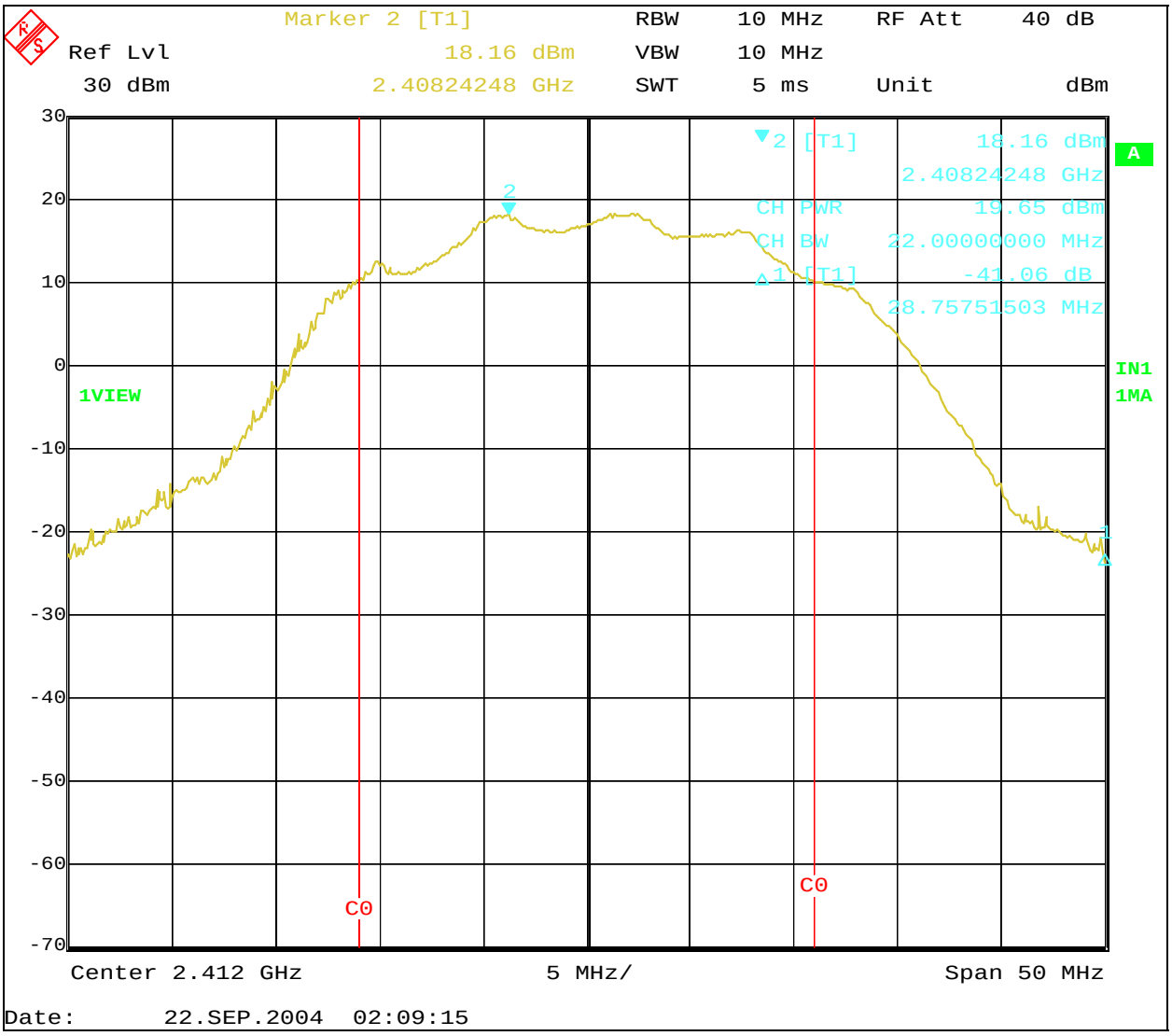

Figure 7.5-1: Output power – Low Channel - 802.11b

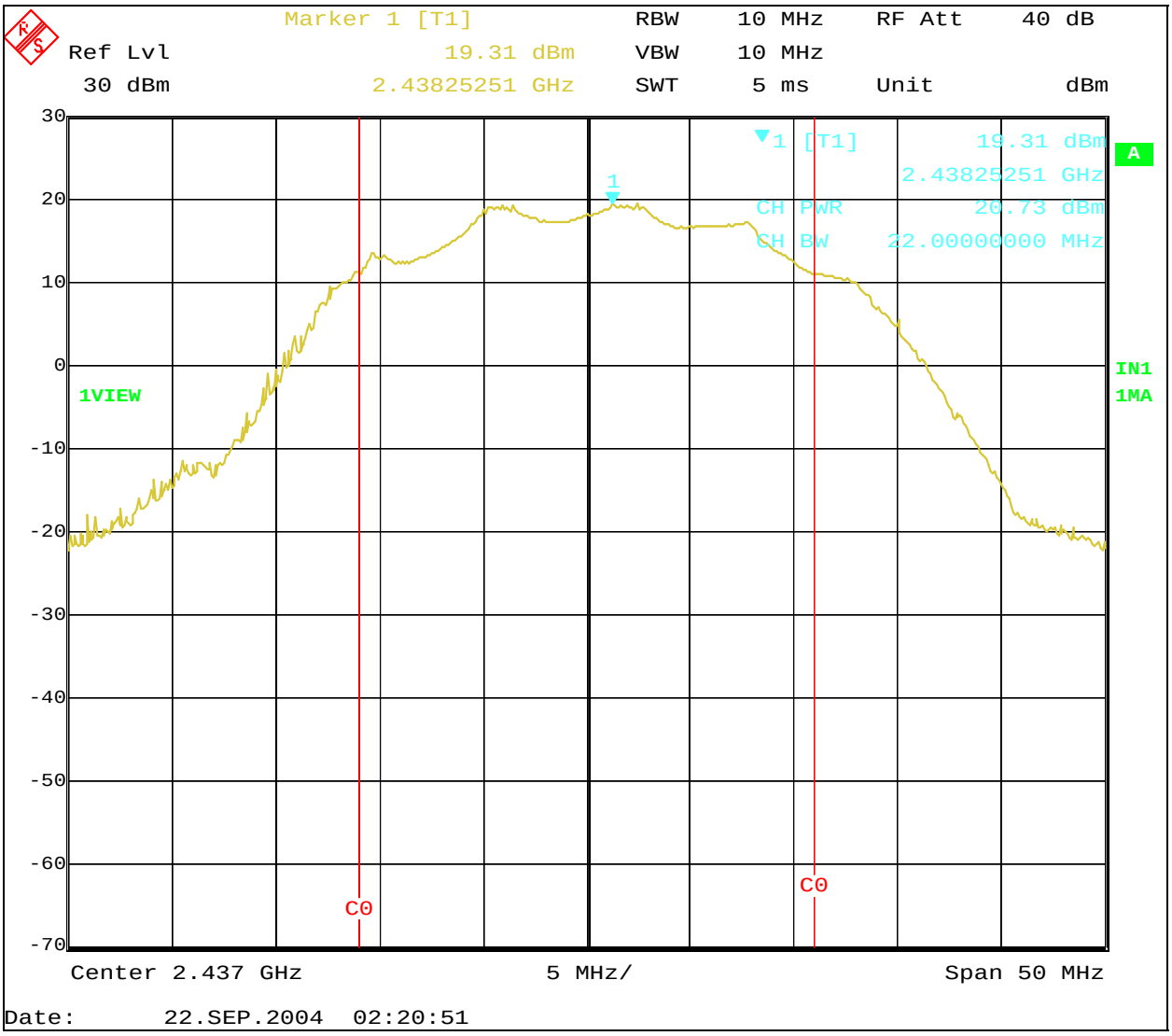

Figure 7.5-2: Output power – Mid Channel – 802.11b

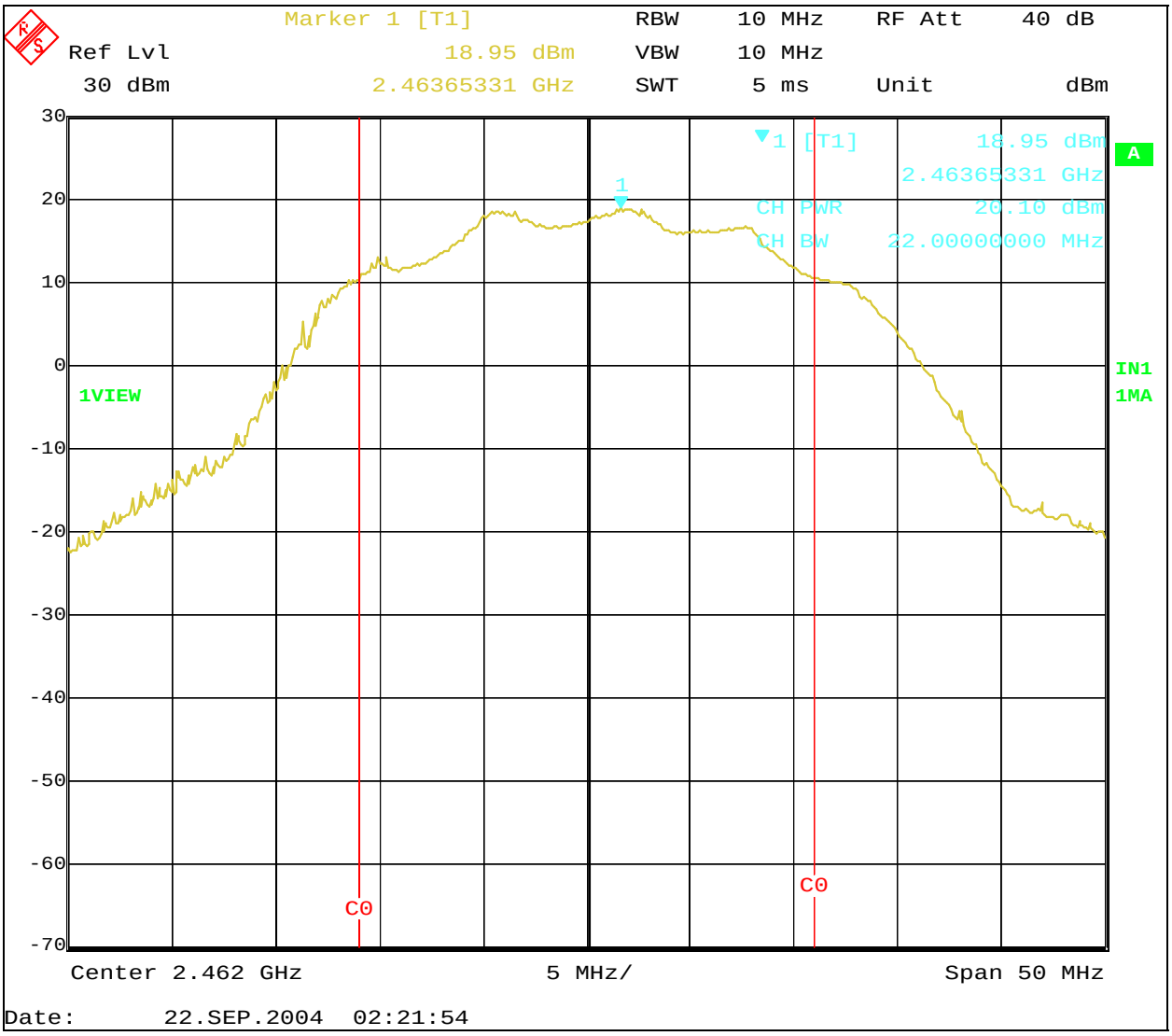

Figure 7.5-3: Output power – High Channel – 802.11b

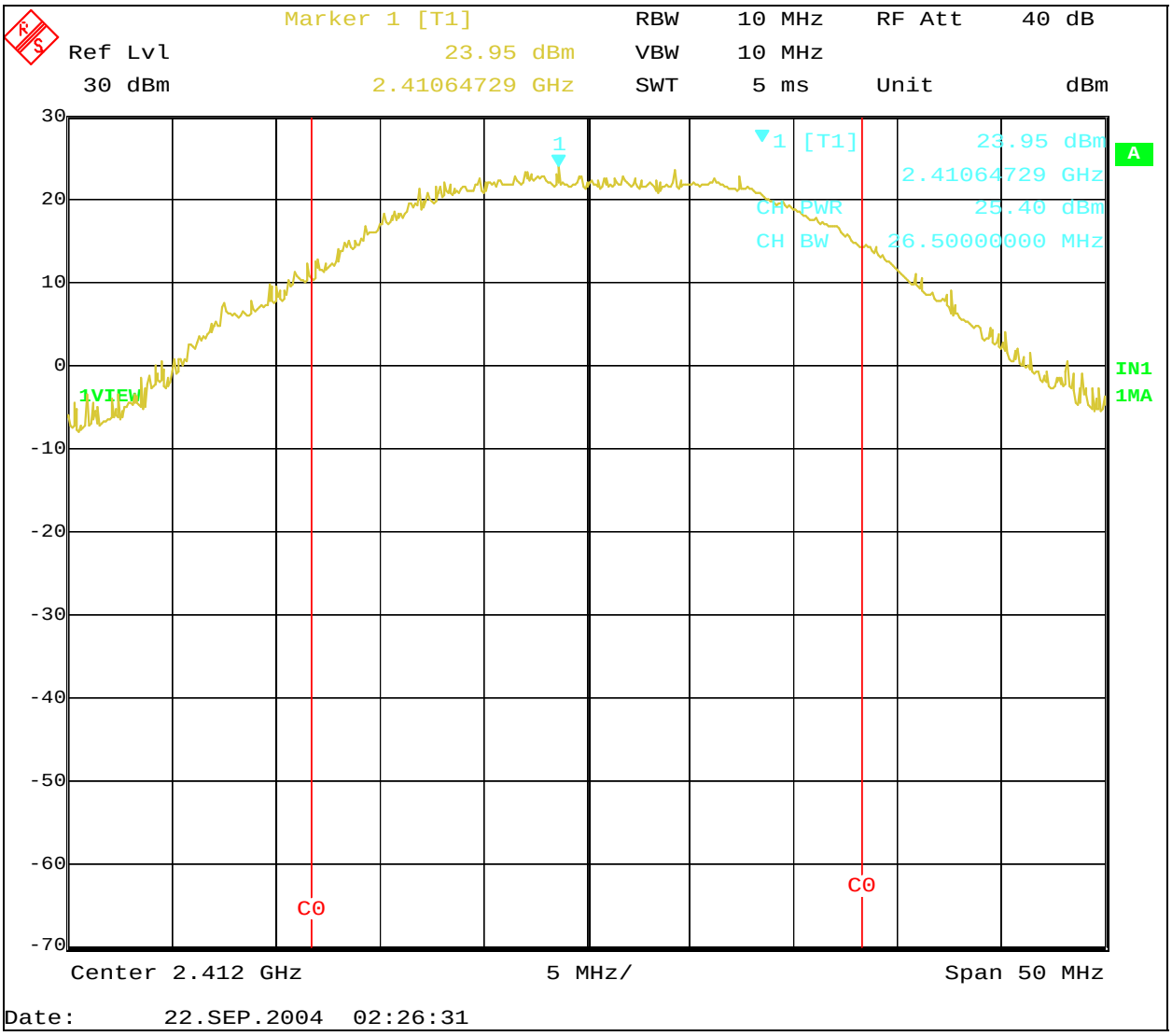

Figure 7.5-4: Output power – Low Channel – 802.11g

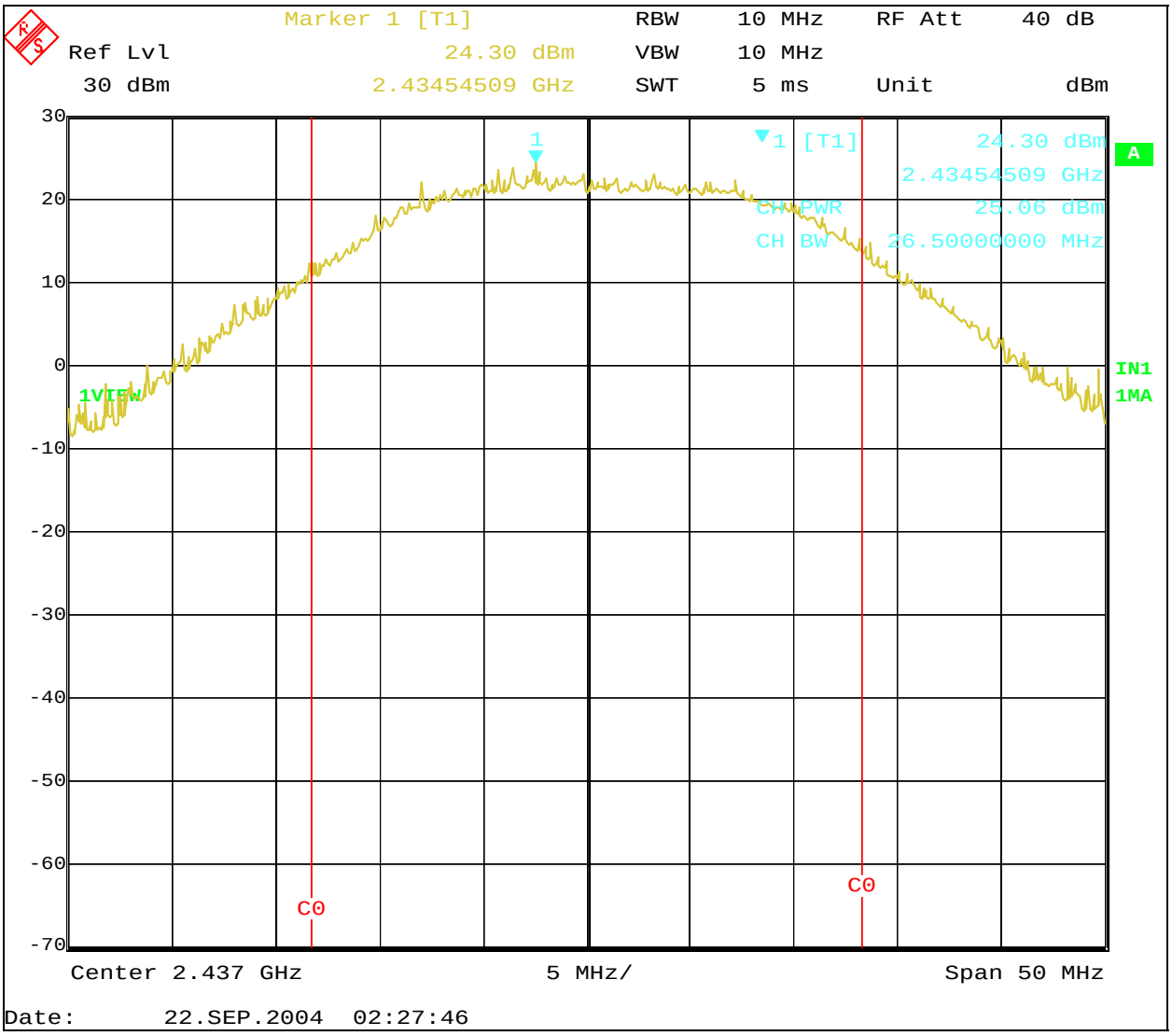

Figure 7.5-5: Output power – Mid Channel – 802.11g

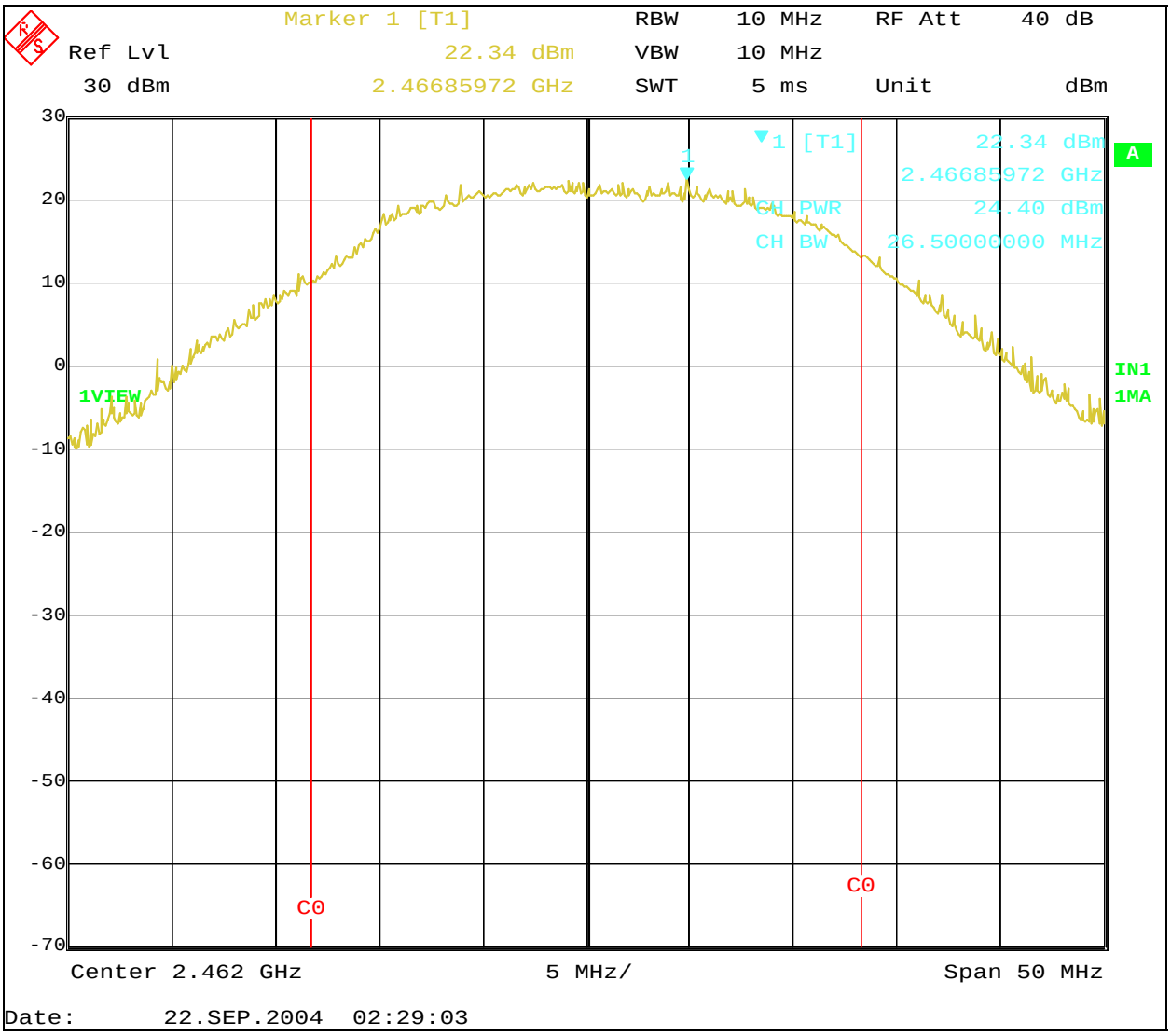

Figure 7.5-6: Output power – High Channel – 802.11g

7.5.3 Test Results – CAP Configuration 2

Results are shown below in Table 7.5-3 and Figure 7.5-7 to 7.5-9 for 802.11b and Table 7.5-4 and Figure 7.5-10 to 7.5-12 for 802.11g.

Table 7.5-3: Peak Output Power 802.11b

Channel	Frequency (MHz)	Measured Power (dBm)	6 dB Bandwidth (MHz)	BW Correction Factor (dB)	Output Power (dBm)
Low	2412	12.72	12.02	6.03	18.75
Mid	2437	11.47	12.27	6.12	17.59
High	2462	8.99	12.12	6.06	15.05

Table 7.5-4: Peak Output Power 802.11g

Channel	Frequency (MHz)	Measured Power (dBm)	6 dB Bandwidth (MHz)	BW Correction Factor (dB)	Output Power (dBm)
Low	2412	14.52	16.63	7.44	21.96
Mid	2437	13.81	16.63	7.44	21.25
High	2462	10.25	16.58	7.42	17.67

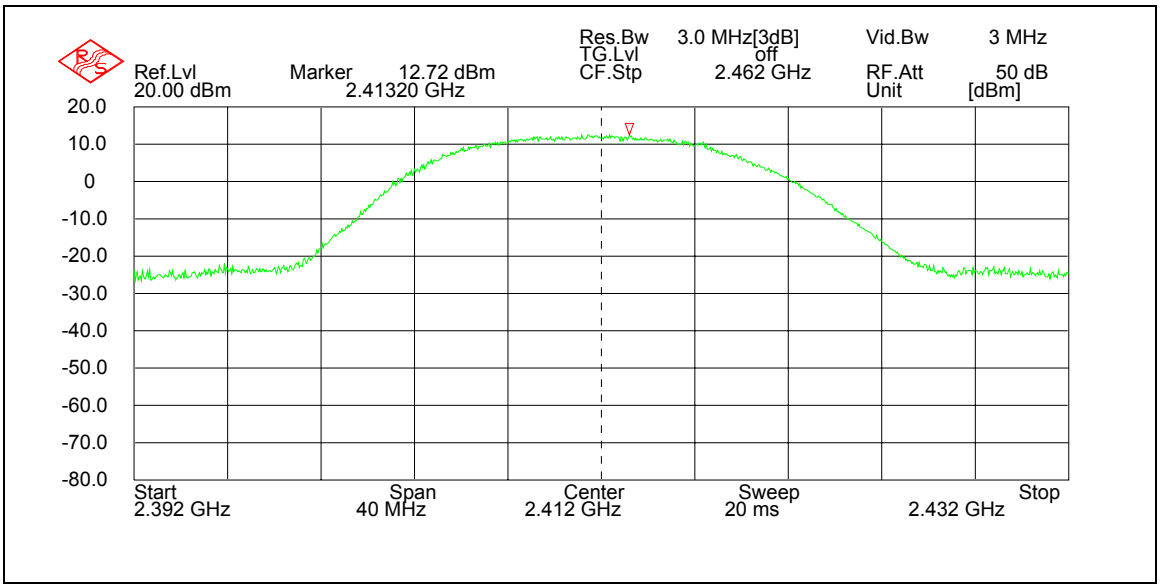

Figure 7.5-7: Output power – Low Channel - 802.11b

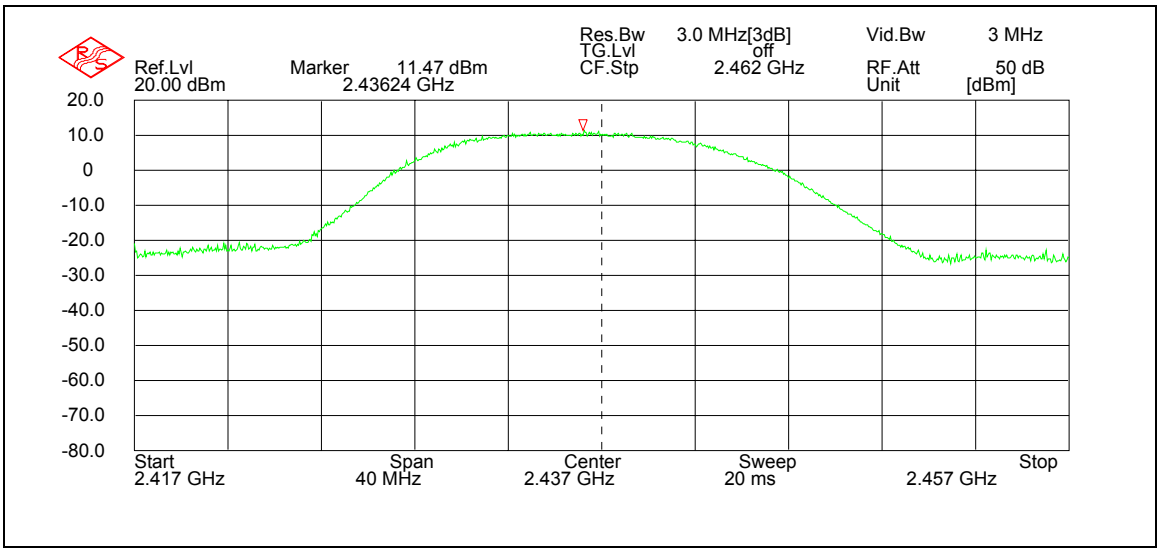

Figure 7.5-8: Output power – Mid Channel – 802.11b

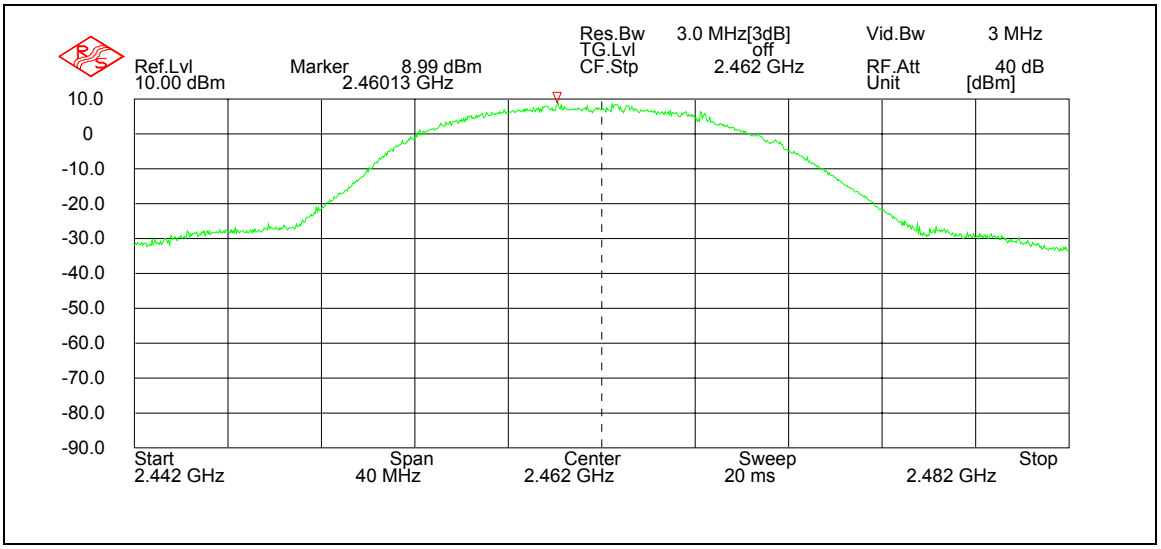

Figure 7.5-9: Output power – High Channel – 802.11b

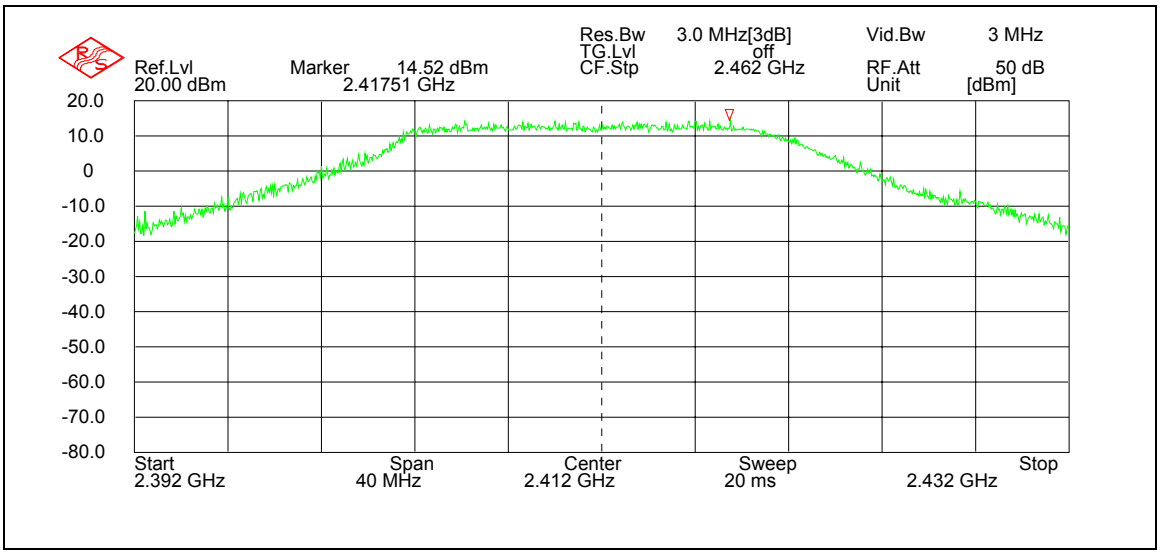

Figure 7.5-10: Output power – Low Channel – 802.11g

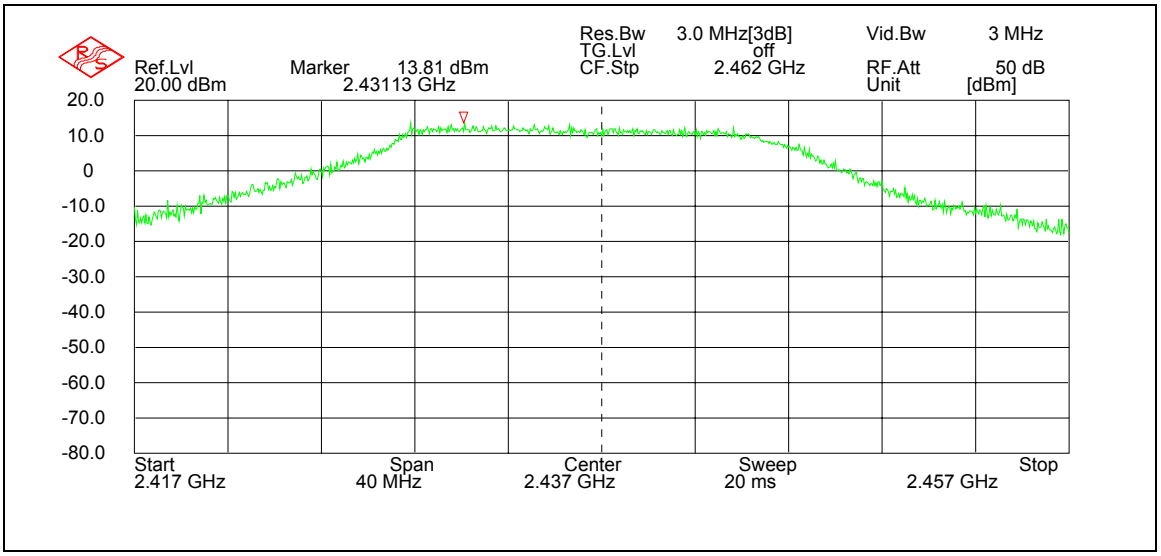

Figure 7.5-11: Output power – Mid Channel – 802.11g

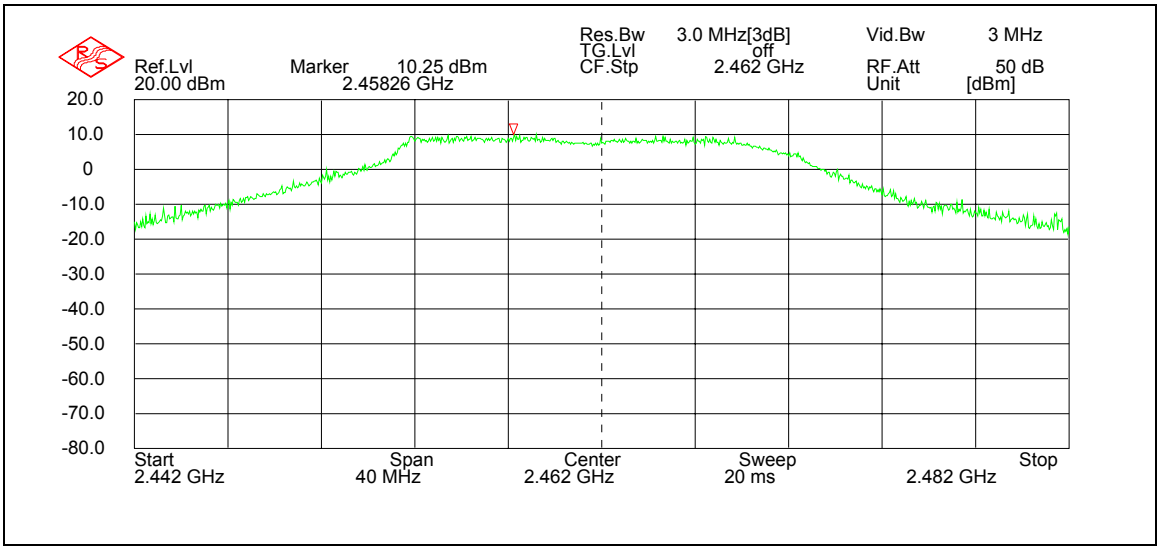

Figure 7.5-12: Output power – High Channel – 802.11g

7.6 Conducted Band-Edge Compliance and Spurious Emissions - FCC Section 15.247(c)

7.6.1 Band-Edge Compliance of RF Conducted Emissions

7.6.1.1 Test Methodology

The EUT was investigated at the lowest and highest channel available to determine band-edge compliance for each mode available. For each measurement the spectrum analyzer's RBW was set to 100 kHz and the VBW was set to 300 kHz. All modes of 802.11b and 802.11g radios were evaluated for worst case. No significant differences were discovered in this evaluation. 11 Mb/s was used for 802.11b and 6 Mb/s was used for 802.11g.

7.6.1.2 Test Results

In a 100 kHz bandwidth at the lower and upper band-edge, the radio frequency power that was produced by the EUT is at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power. Band-edge compliance is displayed in Figures 7.6.1.2-1 and 7.6.1.2-4

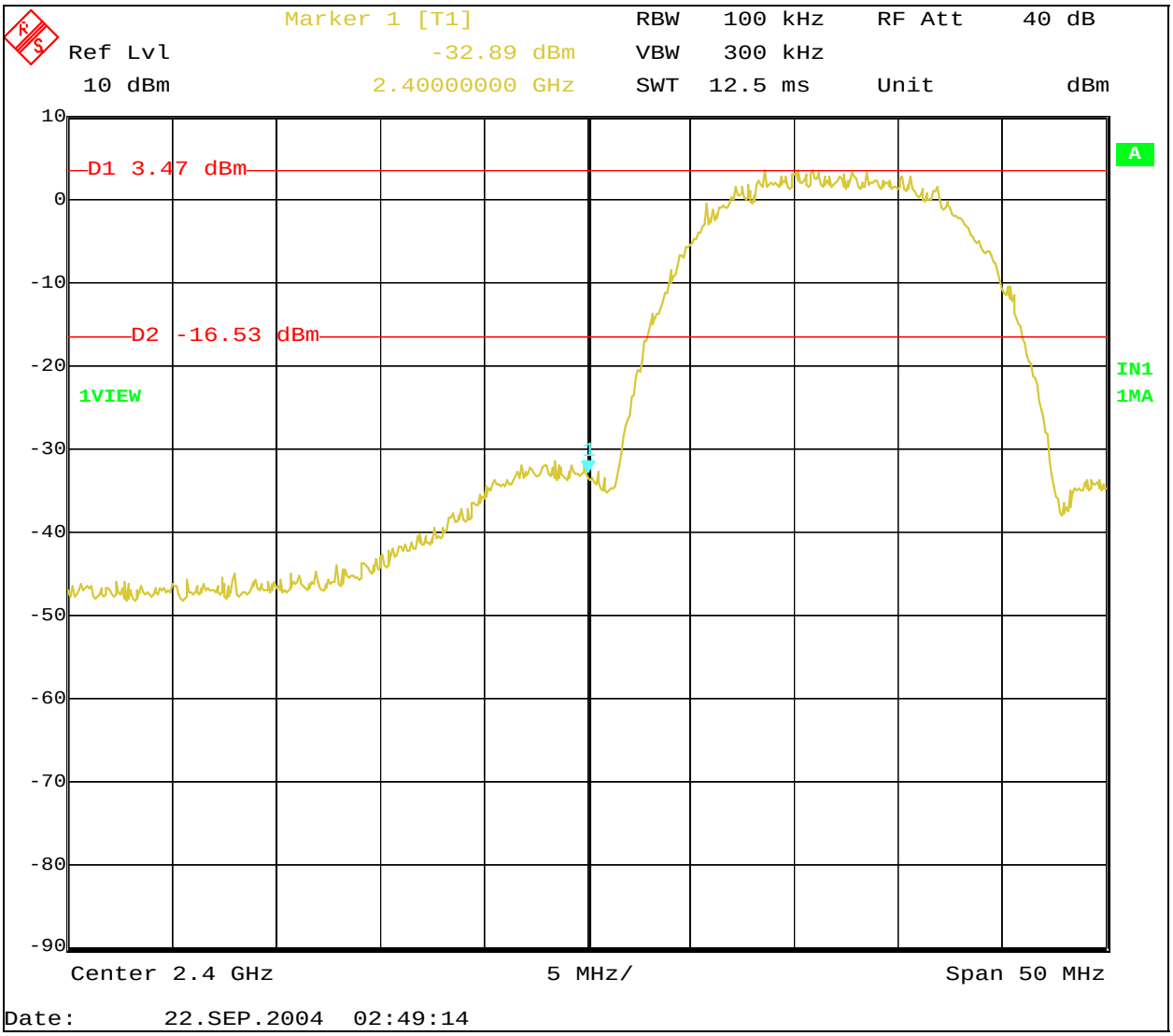

Figure 7.6.1.2-1: Lower Band-edge – Channel 1 802.11b

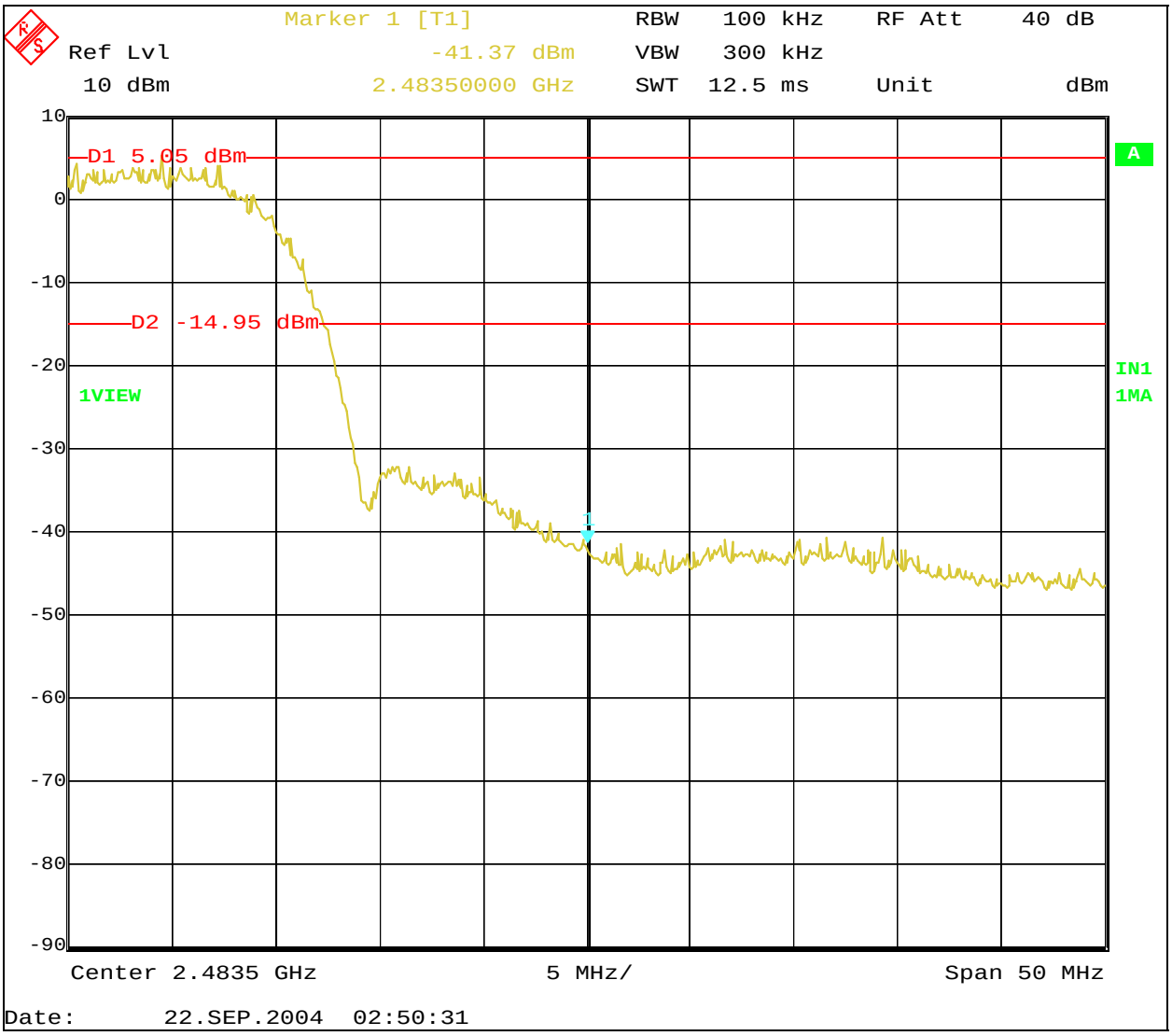

Figure 7.6.1.2-2: Upper Band-edge – Channel 11 802.11b

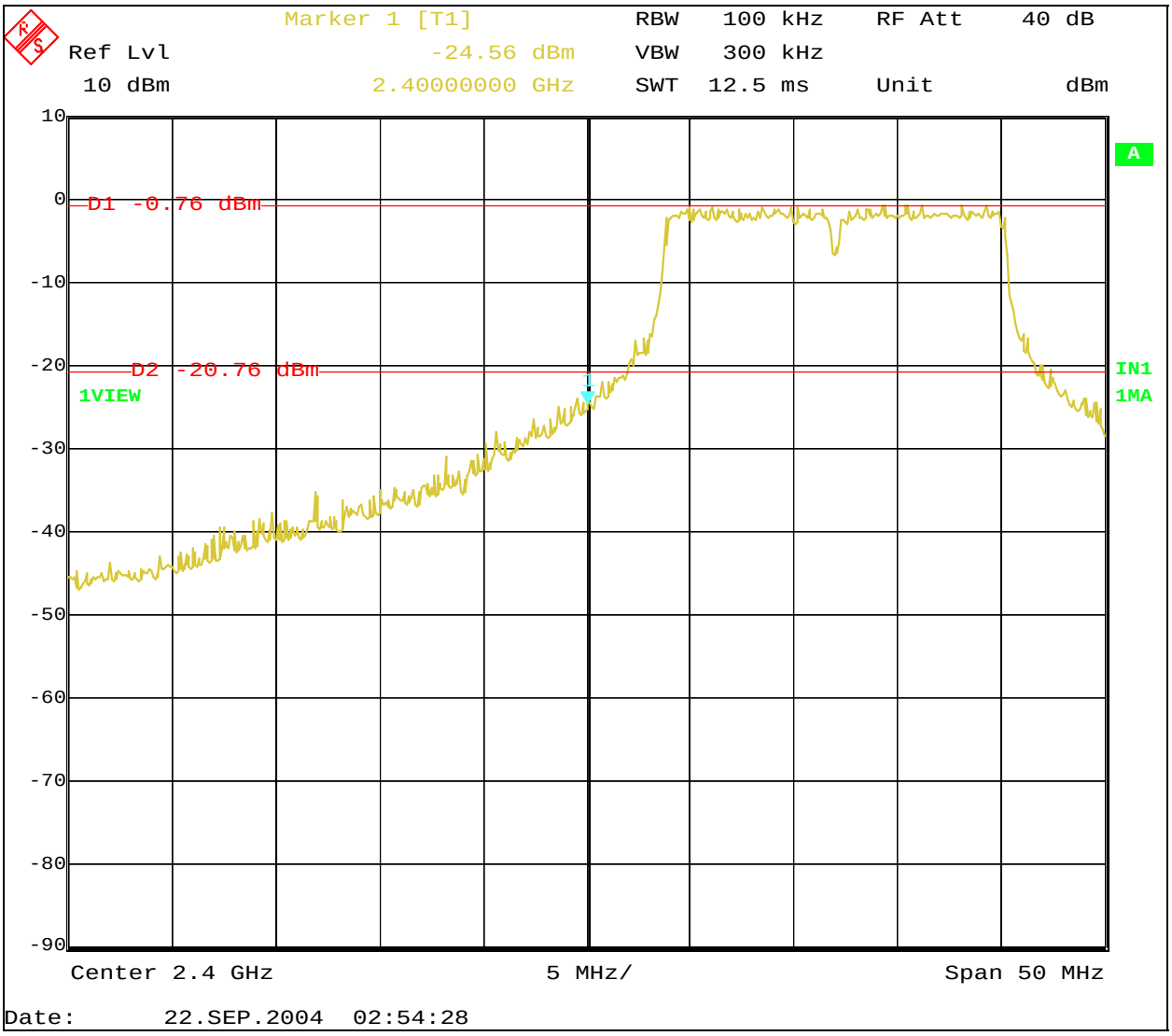

Figure 7.6.1.2-3: Lower Band-edge – Channel 1 802.11g

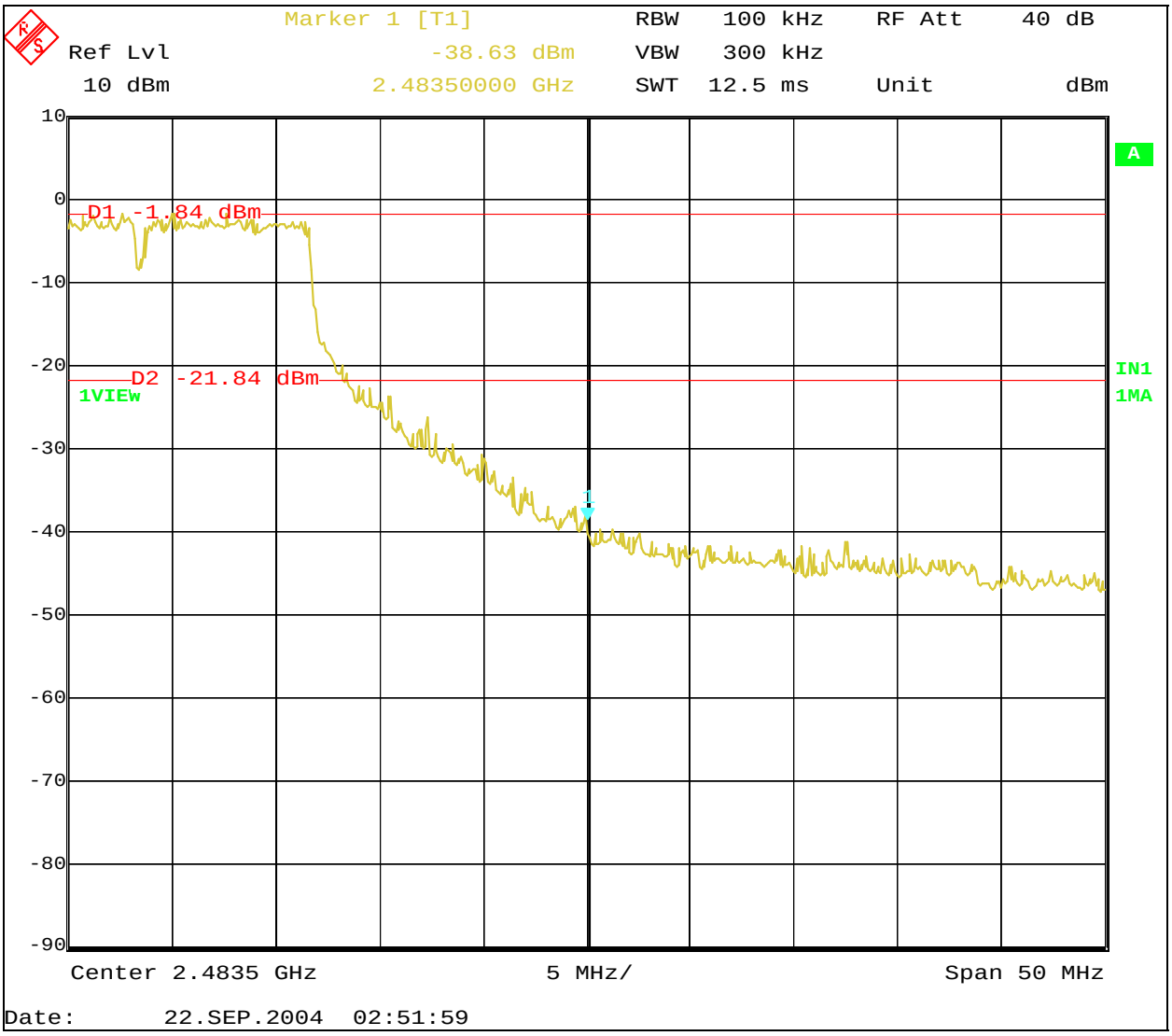

Figure 7.6.1.2-4: Upper Band-edge – Channel 11 802.11g

7.6.2 RF Conducted Spurious Emissions

The EUT was investigated for conducted spurious emissions from 30MHz to 25GHz, 10 times the highest fundamental frequency. For each measurement, the spectrum analyzer's RBW was set to 100 kHz and the VBW was set to 300 kHz.

7.6.2.1 Test Results

The magnitude of all emissions were attenuated greater than 15 dB below the permissible level. The permissible level is 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power. The graphical results of the RF conducted spurious emissions are reported separately with this filing.

7.6.3 Radiated Spurious Emissions (Restricted Bands) - FCC Section 15.205

7.6.3.1 Test Methodology

Radiated emissions tests were made over the frequency range of 30MHz to 25GHz, 10 times the highest fundamental frequency.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000MHz, quasi-peak measurements were made using a resolution bandwidth (RBW) of 120 kHz and a video bandwidth (VBW) of 300 kHz. For frequencies above 1000MHz, average measurements were made using an RBW of 1 MHz and a VBW of 10 Hz and peak measurements were made with RBW of 1 MHz and a VBW of 1 MHz.

The band edge closest to the restricted band at 2483.5 MHz was also evaluated to show compliance with the emission limits.

All modes of 802.11b and 802.11g radios were evaluated for worst case. It was determined that 802.11b 1 Mb/s displayed worst case emissions for all modes. The data in this report reflects worst case emissions for each configuration (CAP antenna assembly and WAB antenna assembly).

Because the CAP configuration is capable of operating both radio modules in the 2.4 GHz band simultaneously, inter-modulation products were also evaluated. One radio module of the EUT was set to the lowest channel available and the other radio module set to the next adjacent channel. Any inter-modulation products observed were maximized and recorded. All modes of 802.11b and 802.11g radios were evaluated for worst case. This was repeated with two radio modules set to the highest possible channel and next adjacent channel available respectively.

7.6.3.2 Test Results

Radiated spurious emissions found in the band of 30MHz to 25GHz are reported in Table 7.6.3-1 for CAP Configuration 1, Table 7.6.3-2 for CAP Configuration 2, and 7.6.3-2 for WAB. Each emission found to be in a restricted band as defined by section 15.205, was compared to the radiated emission limits as defined in section 15.209.

The results of the band edge measurements are also shown in Table 7.6.3-1 for CAP Configuration 1 and Table 7.6.3-2 for WAB as well as figures 7.6.3-1 to 7.6.3-2 for CAP and figures 7.6.3-3 to 7.6.3.4 for WAB. The magnitude in each figure is not corrected for cable, antenna, or amp correction factors. See Tables for corrected data values.

No inter-modulation products were detected for any combinations of channel selections or modes.

Table 7.6.3-1: Radiated Spurious Emissions - CAP Configuration 1

Frequency (MHz)	Level (dBuV/m)	Detector (P/A)	Antenna Polarity (H/V)	Turntable Position (o)	Correction Factors (dB)	Corrected Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
Low Channel								
4.824	44.8	p	v	21	9.33	54.13	74.00	19.87
4.824	36.83	a	v	21	9.33	46.16	54.00	7.84
Middle Channel								
4.867	41.02	p	v	0	9.53	50.55	74.00	23.45
4.867	27.08	a	v	0	9.53	36.61	54.00	17.39
High Channel								
2.492	46.44	p	v	63	1.08	47.52	74.00	26.48
2.492	35.8	a	v	63	1.08	36.88	54.00	17.12
4.923	40.94	p	v	0	9.78	50.72	74.00	23.28
4.923	27.33	a	v	0	9.78	37.11	54.00	16.89

Table 7.6.3-2: Radiated Spurious Emissions - CAP Configuration 2

Frequency (MHz)	Level (dBuV/m)	Detector (P/A)	Antenna Polarity (H/V)	Turntable Position (o)	Correction Factors (dB)	Corrected Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
Low Channel								
4.824	45.97	p	v	18	9.33	55.30	74.00	18.70
4.824	42.26	a	v	18	9.33	51.59	54.00	2.41
Middle Channel								
4.874	46.73	p	v	20	9.56	56.29	74.00	17.71
4.874	43.79	a	v	20	9.56	53.35	54.00	0.65
High Channel								
4.924	45.77	p	v	14	9.78	55.55	74.00	18.45
4.924	39.87	a	v	14	9.78	49.65	54.00	4.35

Table 7.6.3-3: Radiated Spurious Emissions - WAB

Frequency (MHz)	Level (dBuV/m)	Detector (P/A)	Antenna Polarity (H/V)	Turntable Position (o)	Correction Factors (dB)	Corrected Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
Low Channel								
2.787	54.19	p	v	337	2.66	56.85	74.00	17.15
2.787	38.4	a	v	337	2.66	41.06	54.00	12.94
4.824	46.64	p	h	273	9.33	55.97	74.00	18.03
4.828	38.02	a	h	273	9.35	47.37	54.00	6.63
Middle Channel								
4.873	48.83	p	h	109	9.55	58.38	74.00	15.62
4.873	43.17	a	h	109	9.55	52.72	54.00	1.28
High Channel								
2.488	48.7	p	v	76	1.06	49.76	74.00	24.24
2.488	43.67	a	v	76	1.06	44.73	54.00	9.27
4.923	46.19	p	h	116	9.78	55.97	74.00	18.03
4.923	36.59	a	h	116	9.78	46.37	54.00	7.63

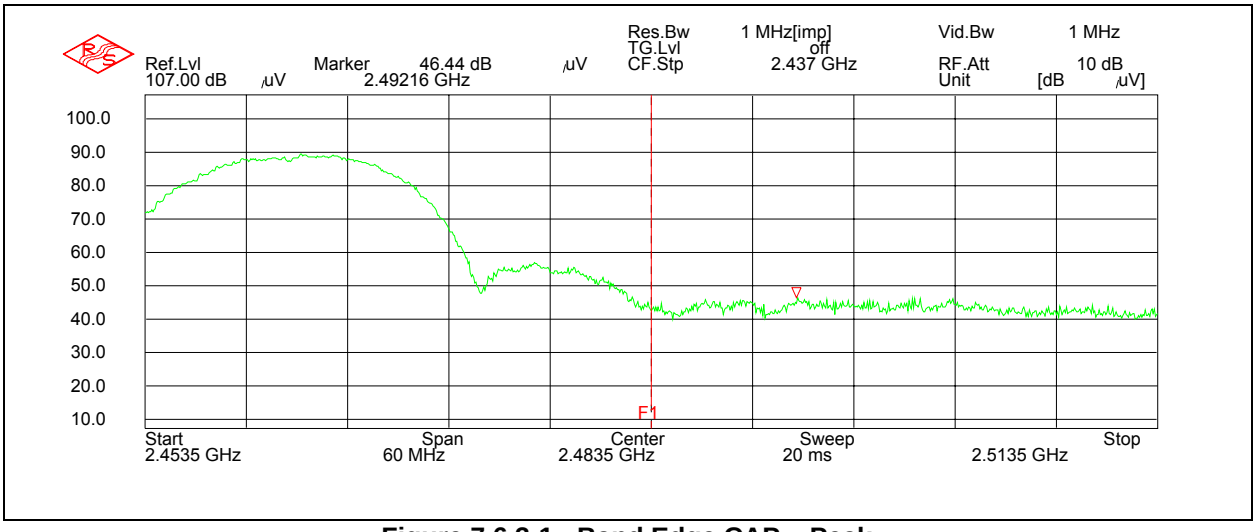

Figure 7.6.3-1: Band Edge CAP – Peak

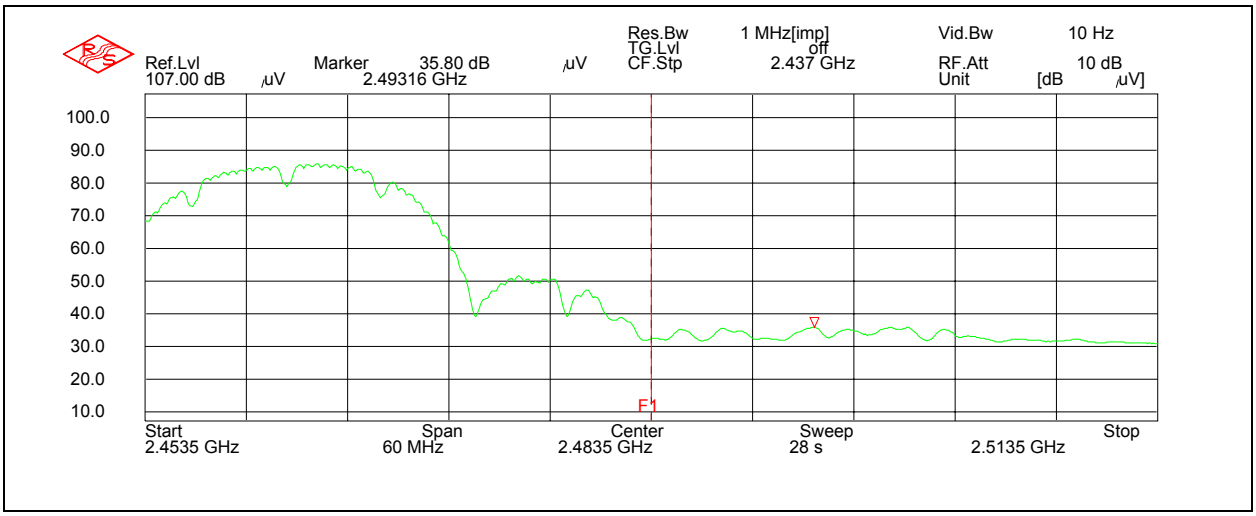

Figure 7.6.3-2: Band Edge CAP - Average

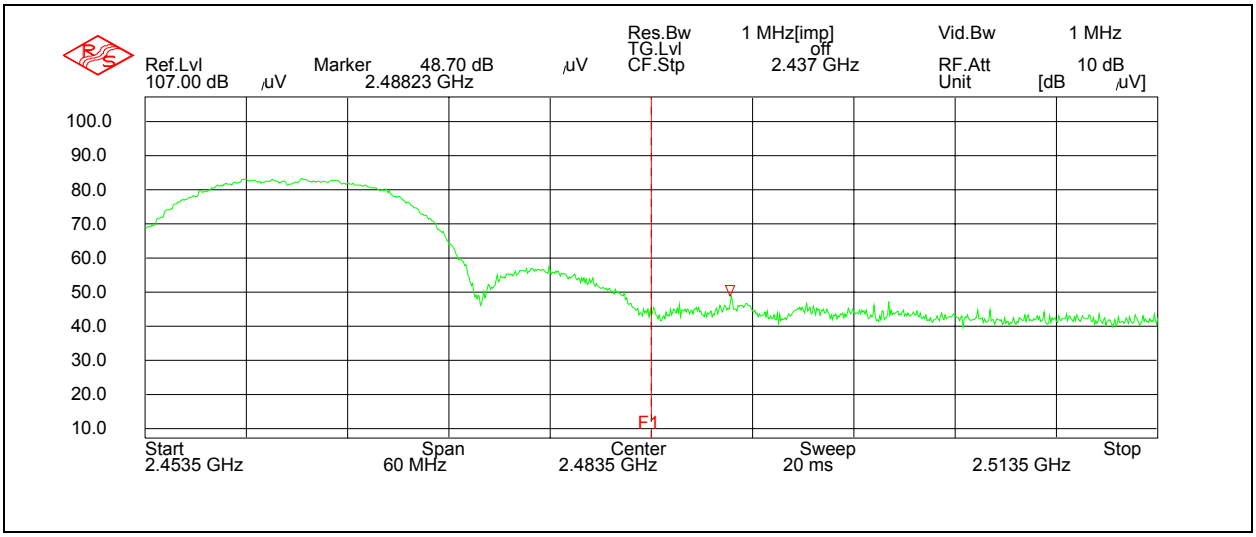

Figure 7.6.3-3: Band Edge WAB – Peak

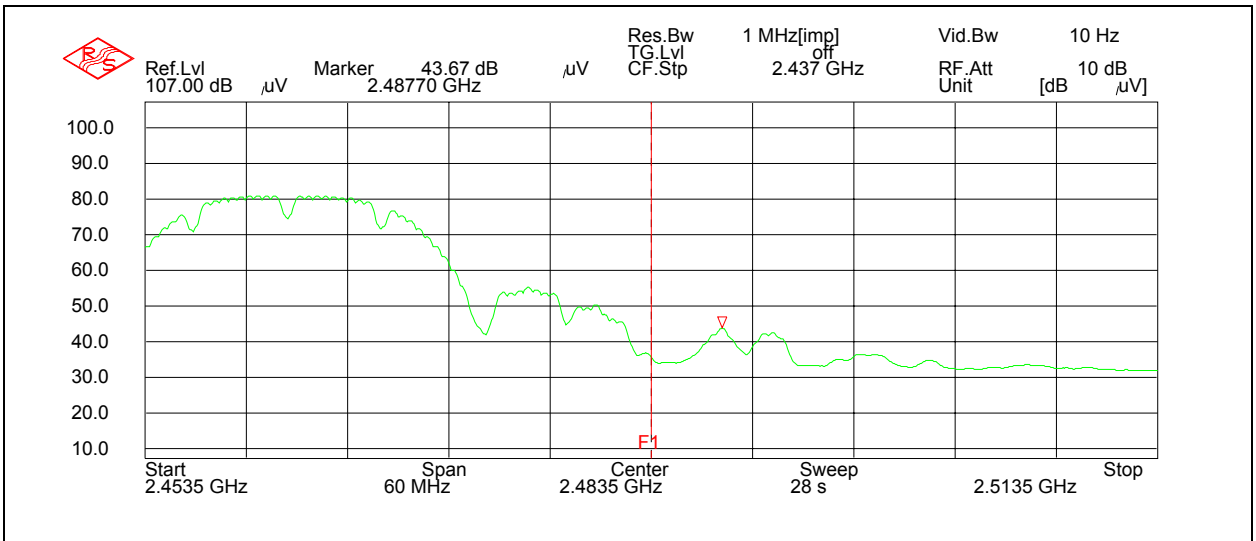

Figure 7.6.3-4: Band Edge WAB - Average

7.6.3.3 Sample Calculation:

$R_C = R_U + CF_T$

Where:

CF_T	=	Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only)
R_U	=	Uncorrected Reading
R_C	=	Corrected Level
AF	=	Antenna Factor
CA	=	Cable Attenuation
AG	=	Amplifier Gain
DC	=	Duty Cycle Correction Factor

Example Calculation:

Corrected Level: 44.80 + 9.33 = 54.13 dBuV
Margin: 74dBuV – 54.13 dBuV = 19.87 dB

7.7 Peak Power Spectral Density- FCC Section 15.247(d)

7.7.1 Test Methodology

The power spectral density was measured in accordance with OET bulletin 97-114, appendix C. The emission peaks within the pass band were located and zoomed in on. The spectrum analyzer RBW was set to 3 kHz and VBW 10 kHz. Span was adjusted to 300 kHz and the sweep time was calculated to be 100s (Span/3 kHz). The EUT was caused to transmit continuously on the low, middle and high fundamental channels.

All modes of 802.11b and 802.11g radios were evaluated for worst case. It was determined that 1 Mb/s was worst case for 802.11b and 6 Mb/s for 802.11g. The data reflects worst case operation.

7.7.2 Test Results

Results are shown below in table 7.7.2-1 and figure 7.7.2-1 to 7.7.2-3 for 802.11b and table 7.7.2-2 and figure 7.7.2-4 to 7.7.2-6.

Table 7.7.2-1: Peak Power Spectral Density 802.11b

Frequency [MHz]	Level [dBm]	Limit [dBm]	Result
2412	-9.42	8	PASS
2437	-8.67	8	PASS
2462	-8.26	8	PASS

Table 7.7.2-2: Peak Power Spectral Density 802.11g

Frequency [MHz]	Level [dBm]	Limit [dBm]	Result
2412	-11.92	8	PASS
2437	-11.97	8	PASS
2462	-11.55	8	PASS

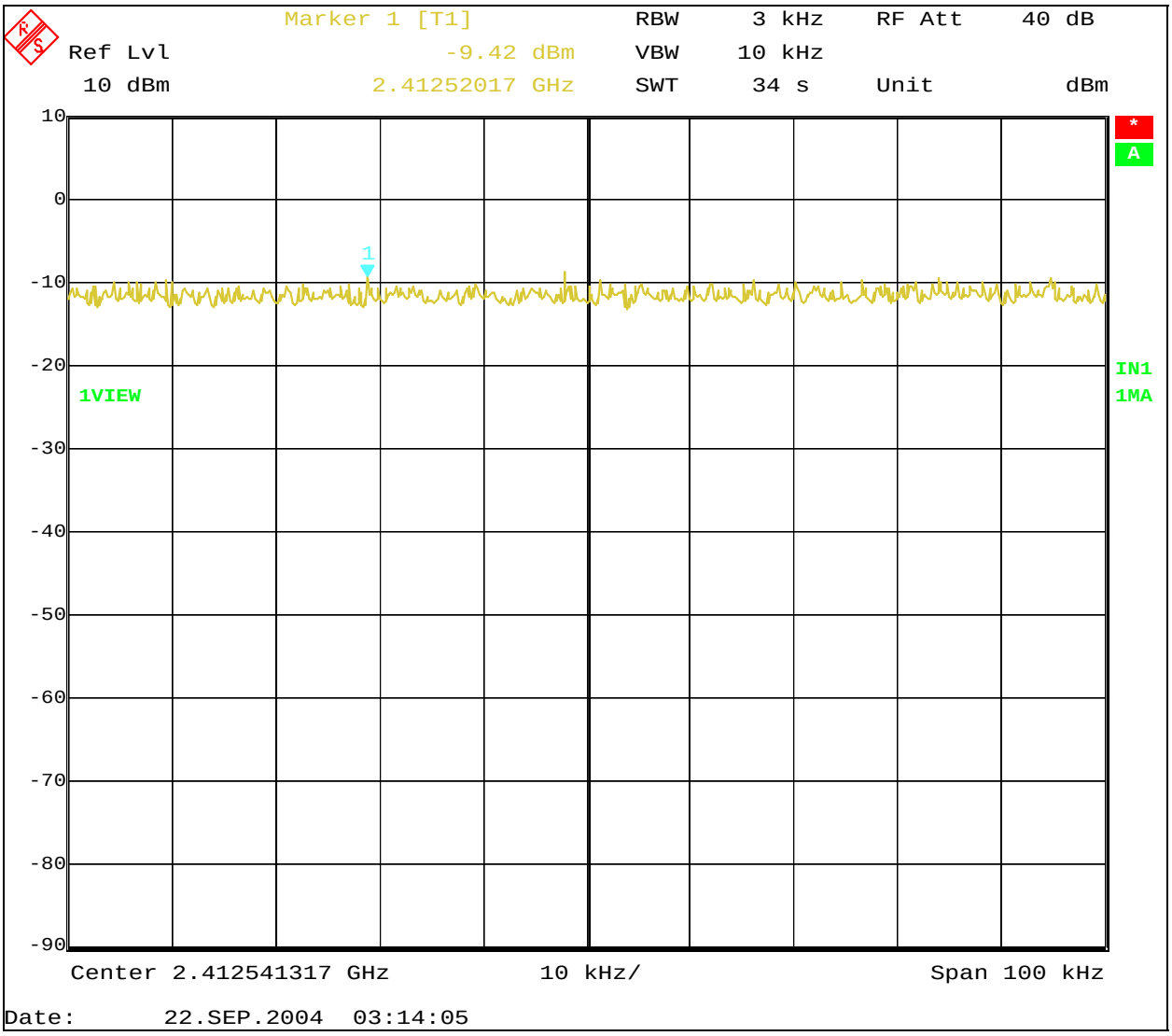

Figure 7.7.2-1: Peak Power Spectral Density Low Channel 802.11b

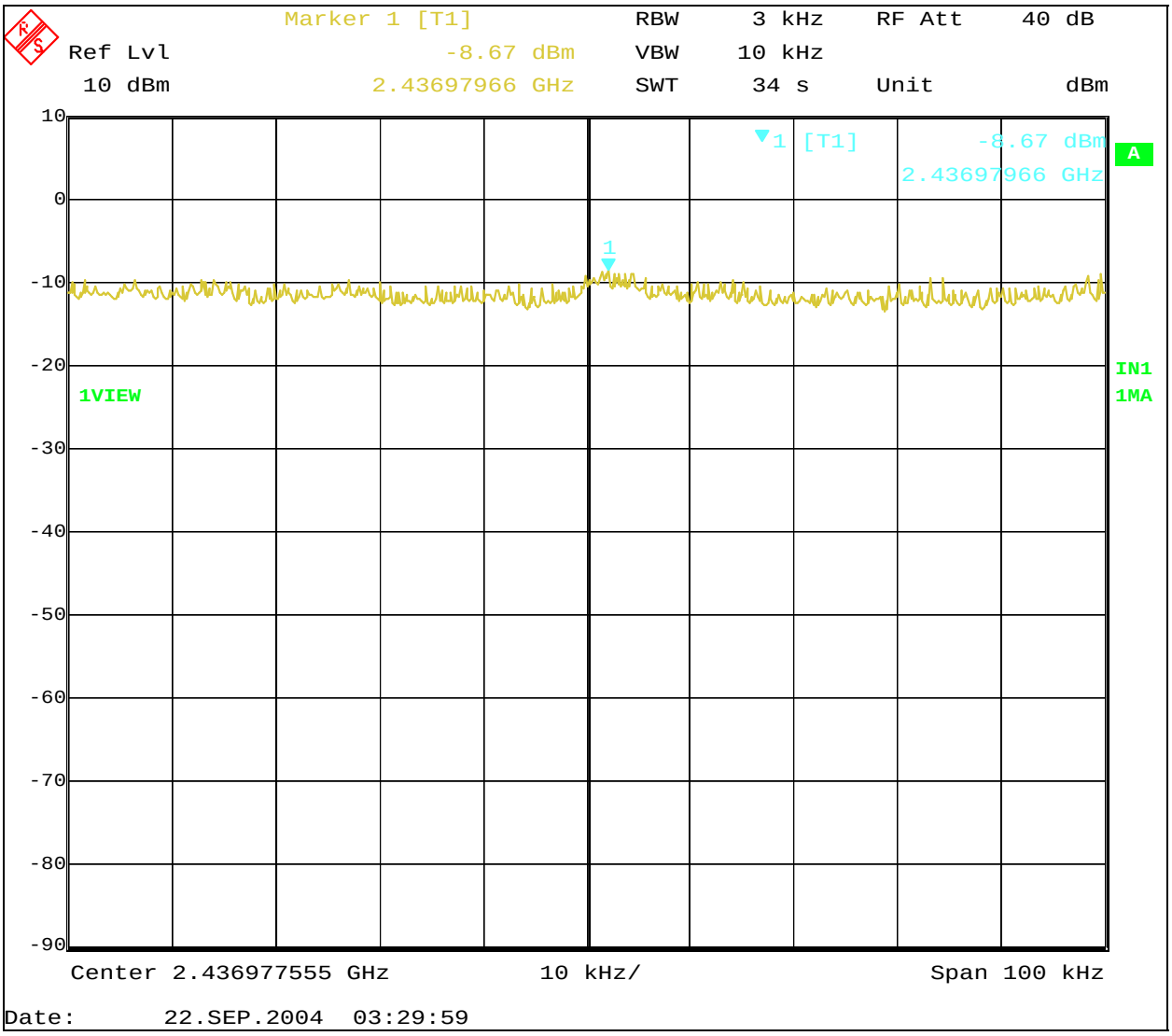

Figure 7.7.2-2: Peak Power Spectral Density Mid Channel 802.11b

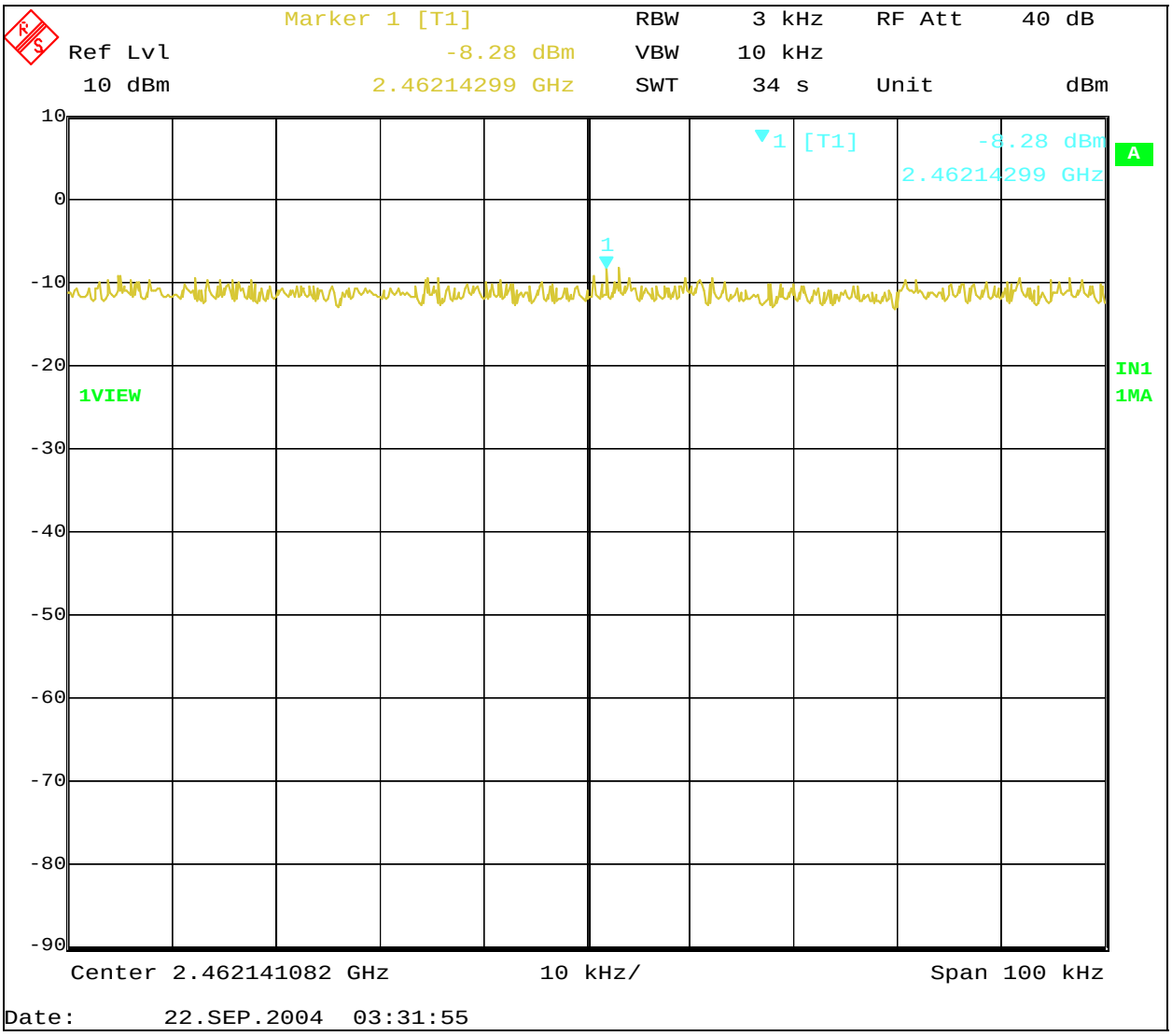

Figure 7.7.2-3: Peak Power Spectral Density High Channel 802.11b

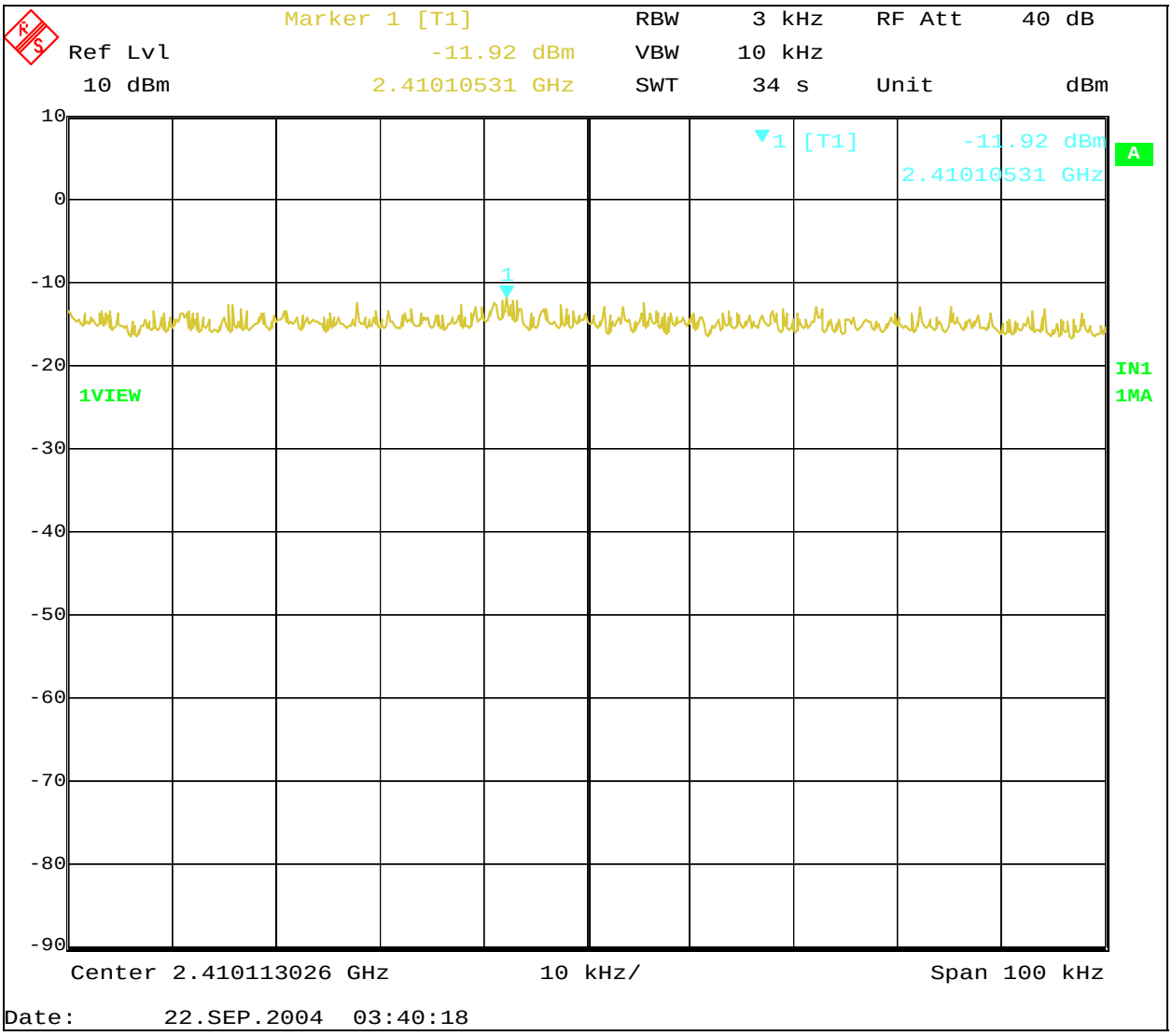

Figure 7.7.2-4: Peak Power Spectral Density Low Channel 802.11g

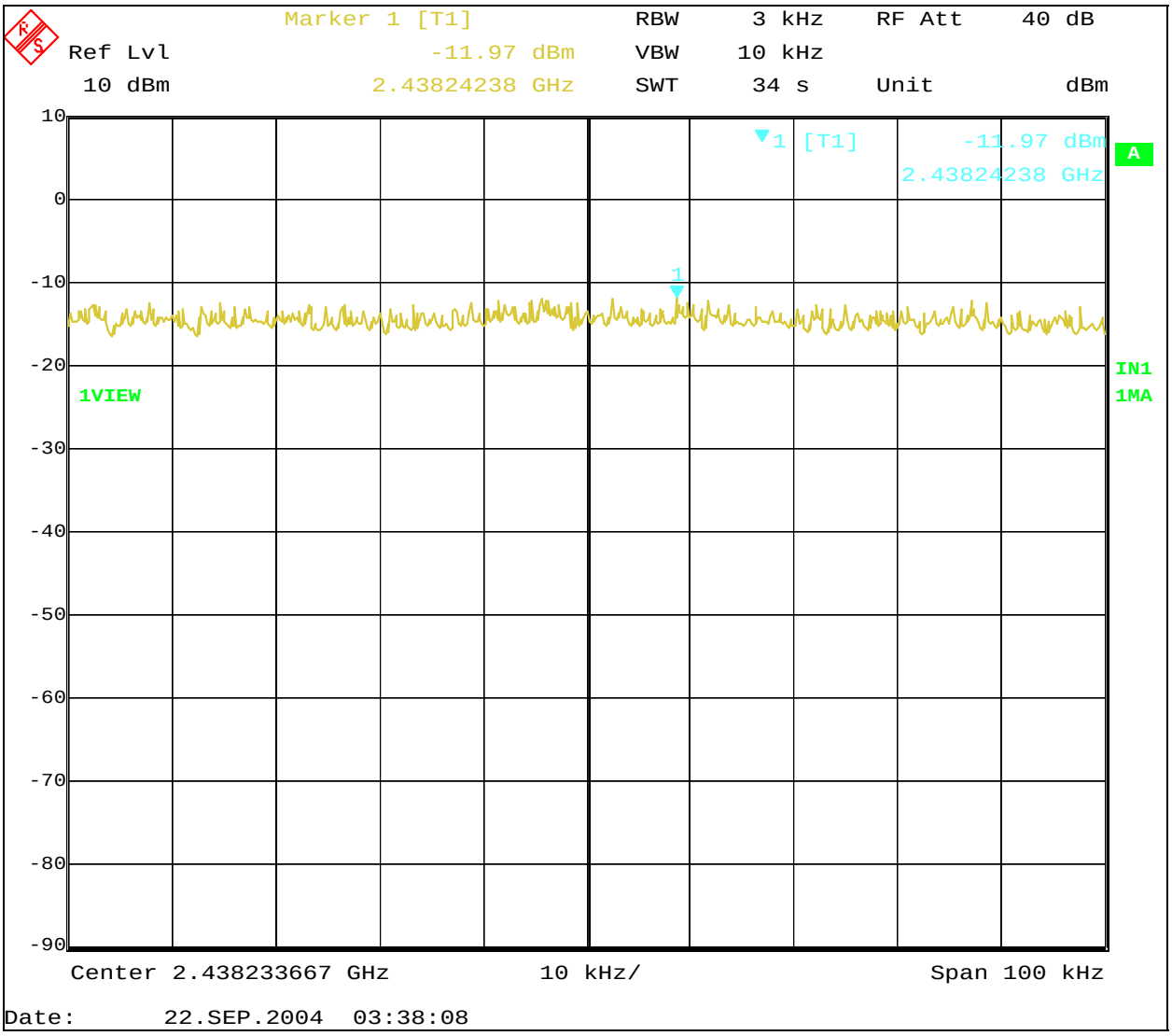

Figure 7.7.2-5: Peak Power Spectral Density Mid Channel 802.11g

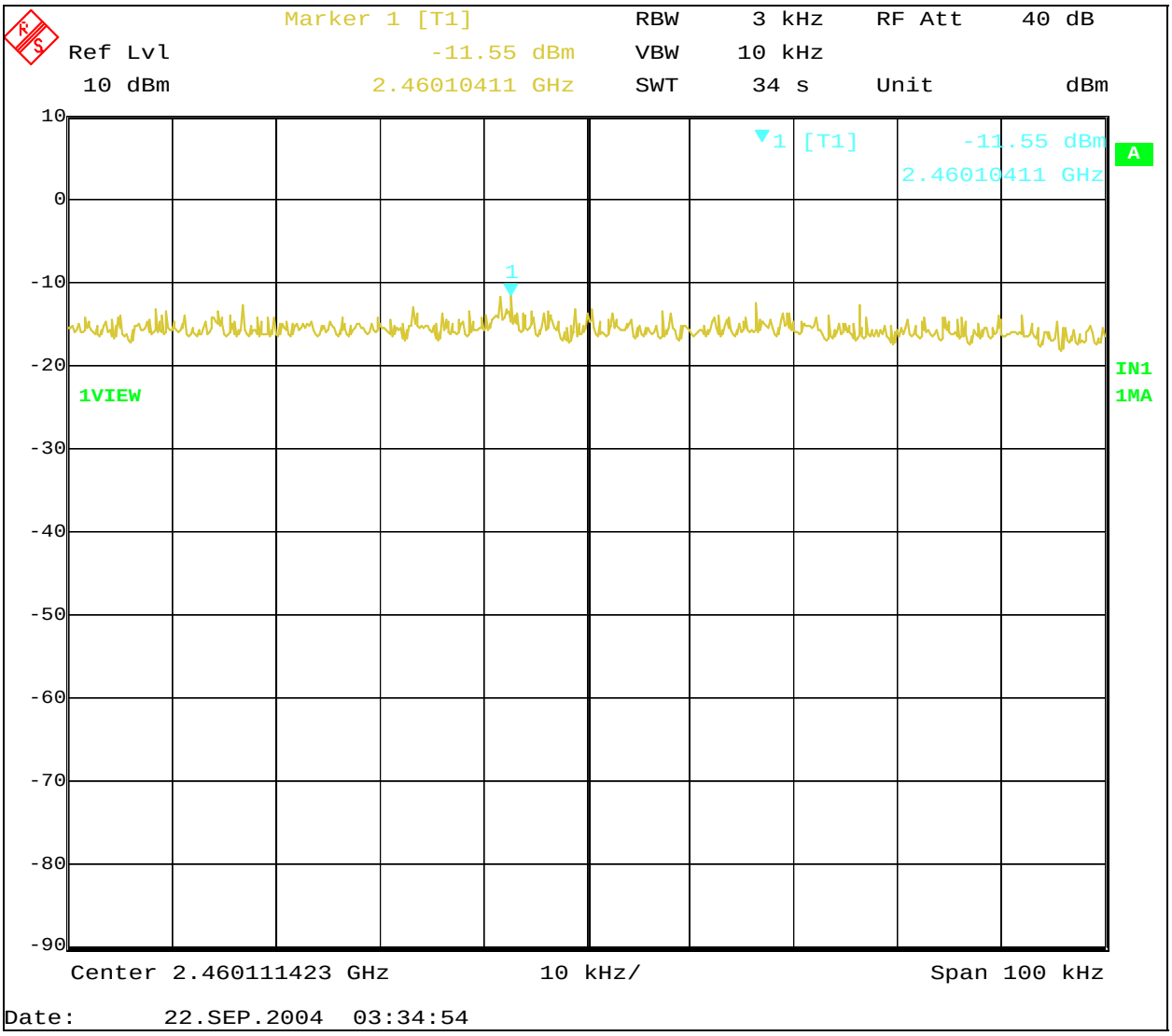

Figure 7.7.2-6: Peak Power Spectral Density high Channel 802.11g

8.0 Summary of Tests - Part 15E - 802.11a

8.1 Section 15.407 (a) – Bandwidth Determination

8.1.1 Test Methodology

The bandwidth is determined by measuring the maximum width of the emission that is 26 dB down from the peak of the emission. Using the ESIB EMI Test Receiver, the RBW was set to 300 kHz which is approximately 1% of the emission bandwidth. The VBW was set to 1 MHz and the peak detector was enabled. The emission was captured by using the View function of the trace and not Max Hold. Display Line 1 was set to the peak of the emission and Display Line 2 was set 26 dB down. The Delta Marker function was used to determine the 26 dB bandwidth.

All modes of operation were evaluated and it was determined that no significant differences in bandwidth were observed. The final results were performed with continuous transmission using a modulation rate of 6 Mb/s.

8.1.2 Test Results

Results are shown below in table 8.1.2-1 and figures 8.1.2-1 to 8.1.2-6:

Table 8.1.2-1: 26dB Bandwidth

Channel	Frequency [MHz]	Bandwidth [MHz]
36	5180	27.92
52	5260	31.56
64	5320	29.25
149	5745	27.28
157	5785	27.63
161	5805	28.48

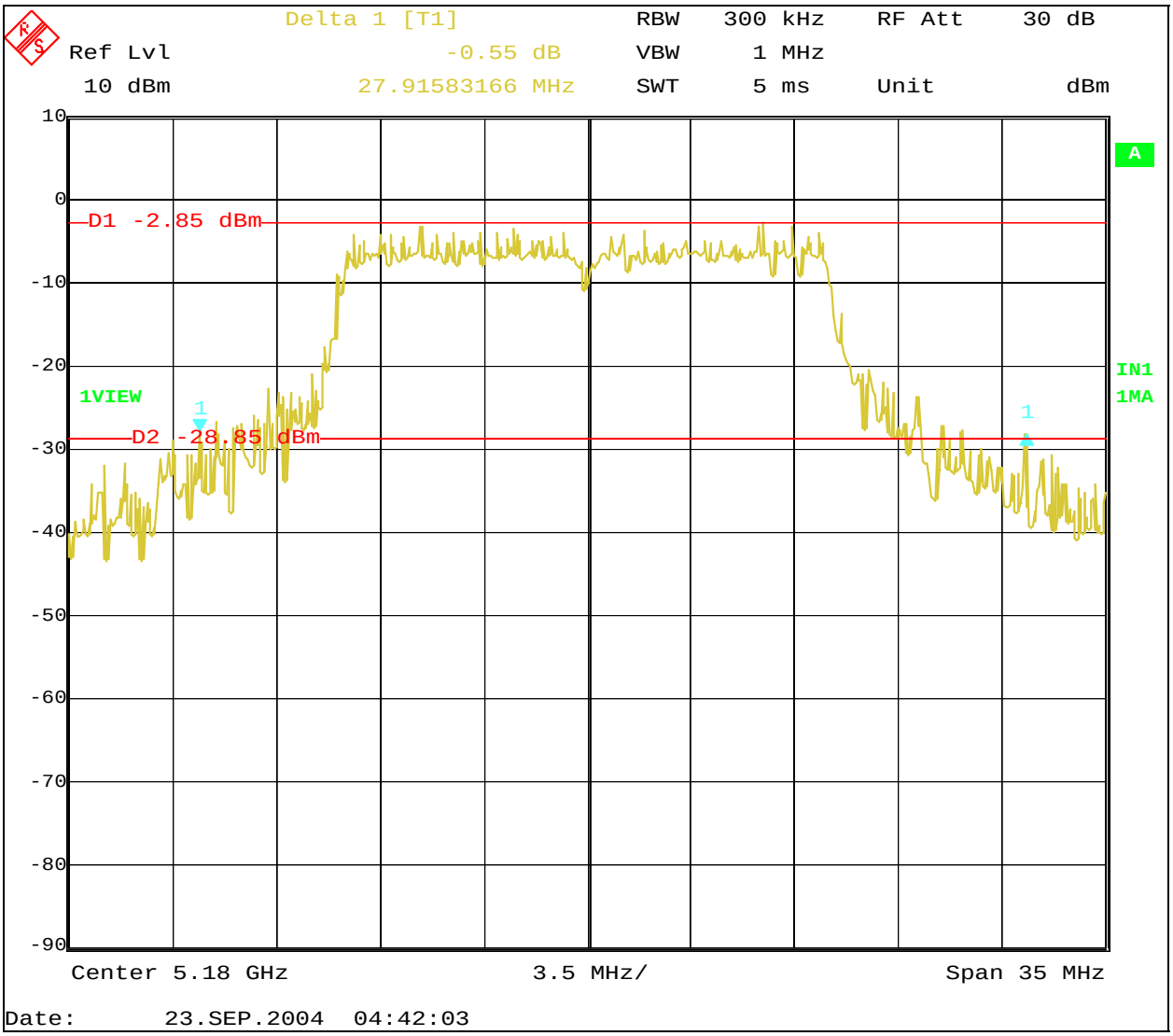

Figure 8.1.2-1: 26 dB Bandwidth – Channel 36

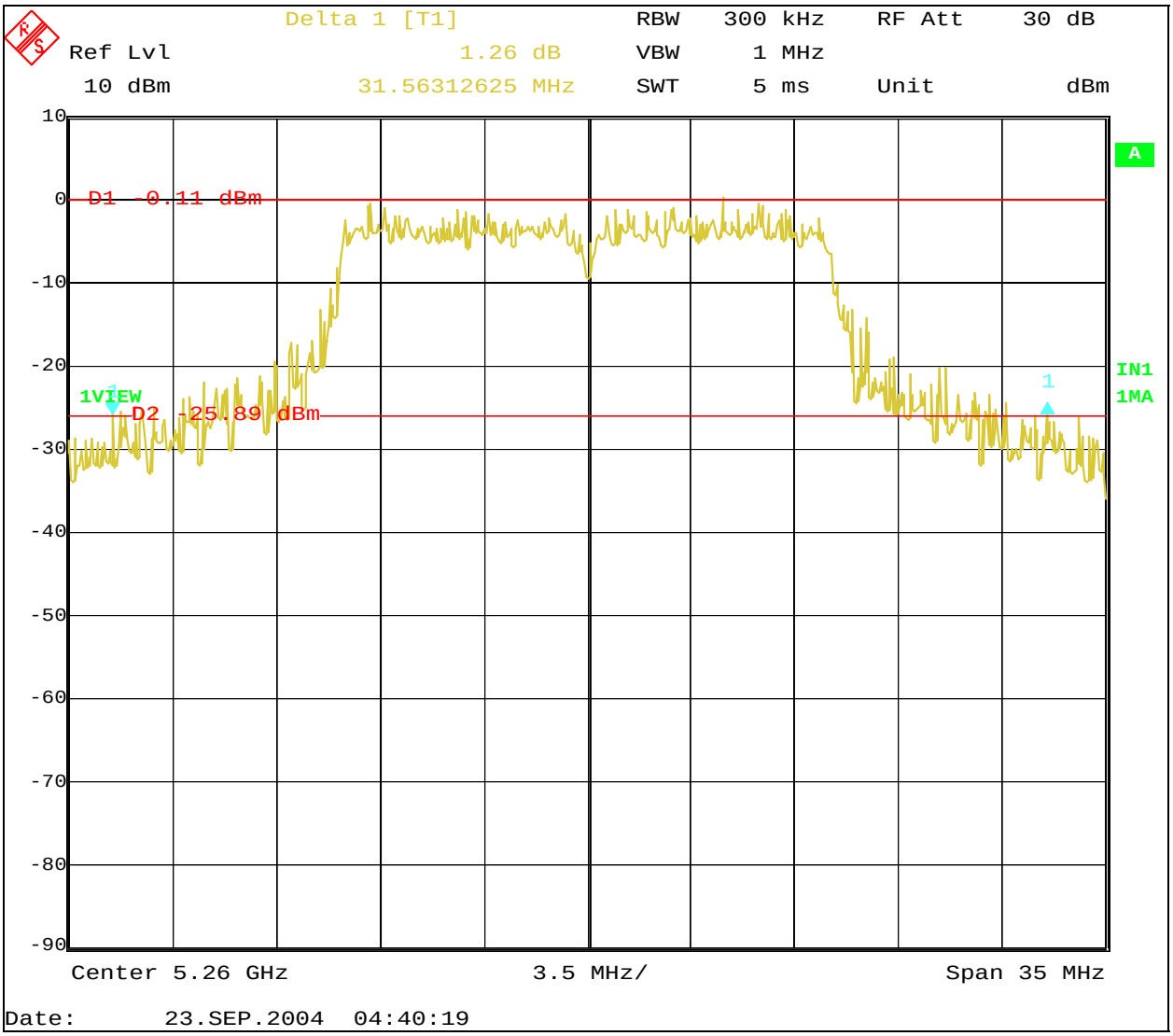

Figure 8.1.2-2: 26 dB Bandwidth – Channel 52

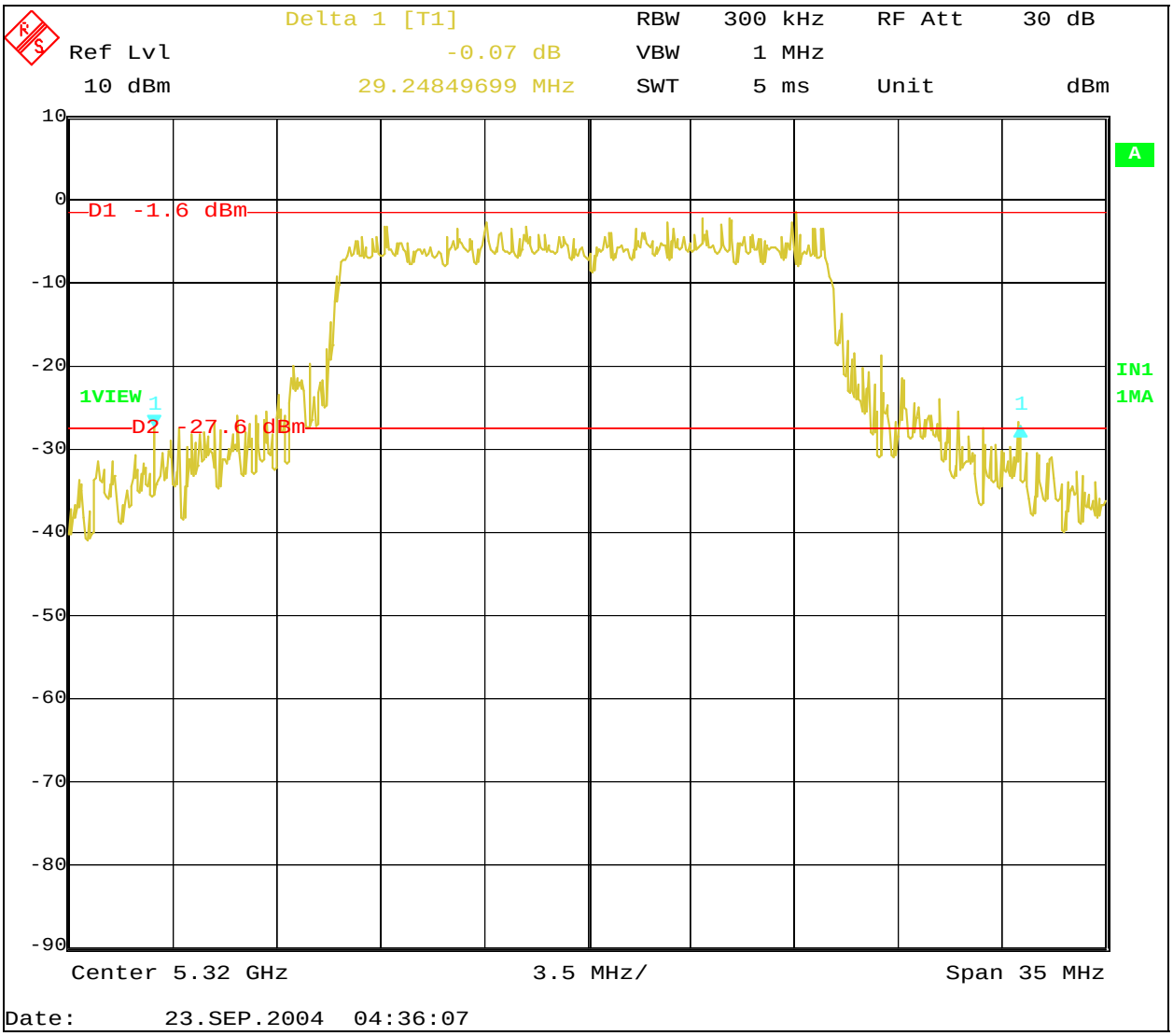

Figure 8.1.2-3: 26 dB Bandwidth – Channel 64

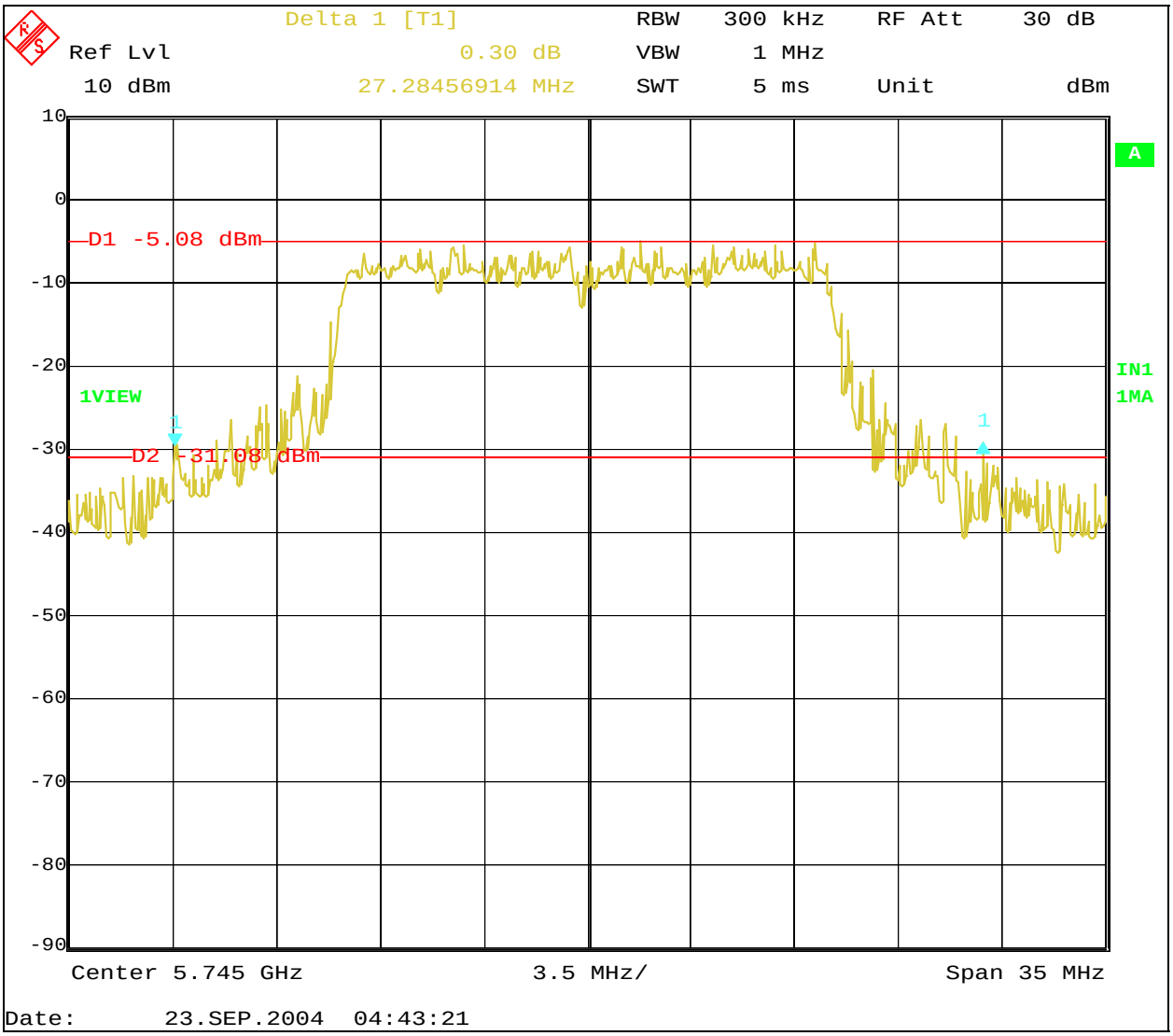

Figure 8.1.2-4: 26 dB Bandwidth – Channel 149

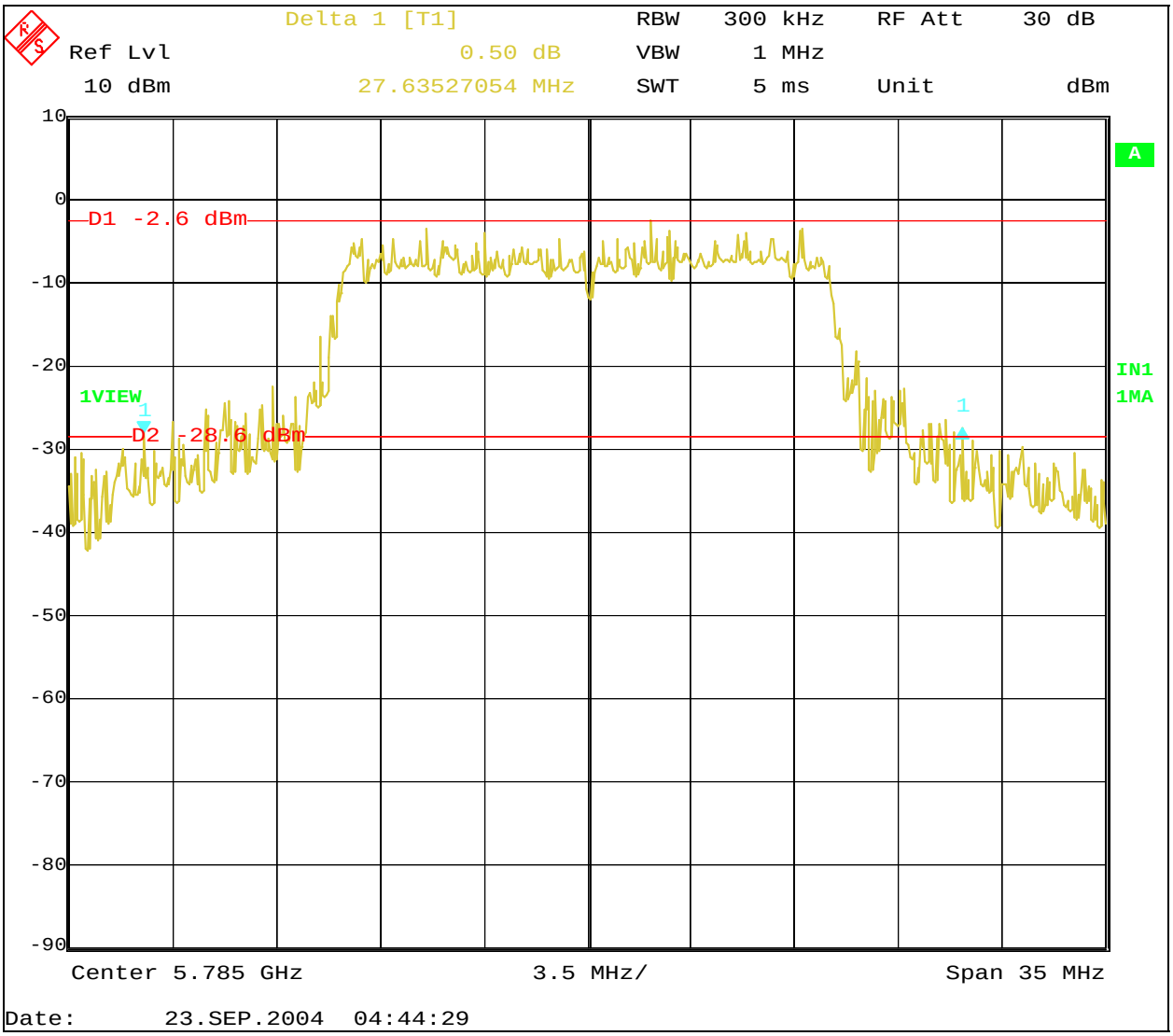

Figure 8.1.2-5: 26 dB Bandwidth – Channel 157

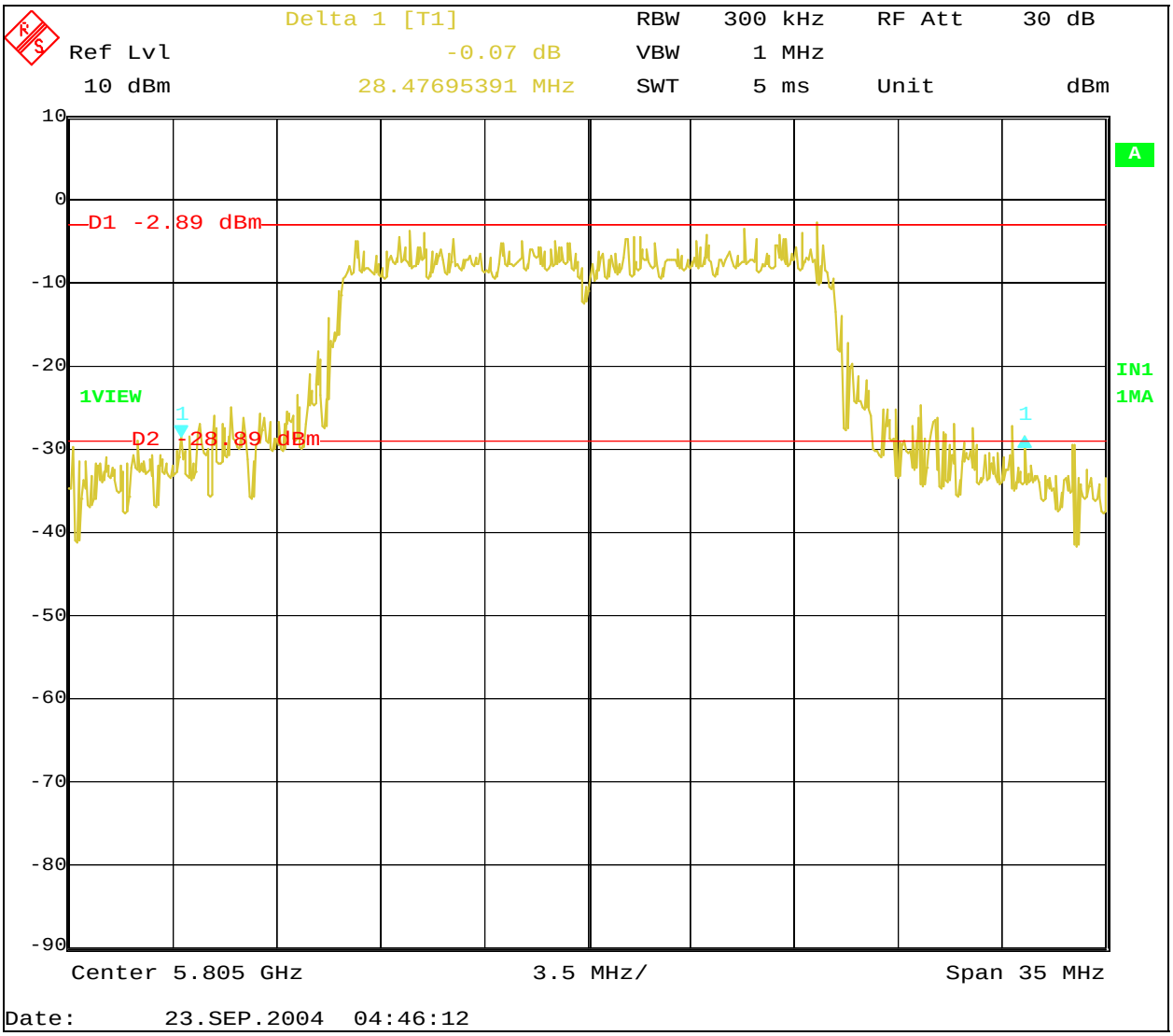

Figure 8.1.2-6: 26 dB Bandwidth – Channel 161

8.2 Section 15.407 (a)(1)(2)(3) – Peak Transmitter Power

8.2.1 Test Methodology

The peak transmit power was measured according to method #3 of FCC DA02-2138 "Measurement Procedure Updated for Peak Transmit Power in the Unlicensed National Information Infrastructure (U-NII) Bands". Using the ESIB EMI Test Receiver, the RBW was set to 1 MHz and VBW 300 kHz (VBW ≥ 1/T where T is the transmission pulse duration over which the transmitter is on and transmitting at its maximum power control level). The span was adjusted to encompass the entire emission bandwidth of the signal as measured in section 8.1. The detector was set to sample and trace Max Hold. The trace was allowed to settle for 60 second until the final measurement was made. The bandwidth correction factor of 10*Log(EBW/1 MHz) was applied to the spectral peak of the emission where the emission bandwidth (EBW) of 26 dB was measured in section 8.1.

All modes of operation were evaluated and it was observed that a modulation rate of 6 Mb/s created maximum peak transmitter power. The final results were performed with continuous transmission using a modulation rate of 6 Mb/s.

8.2.2 Test Results

Results are shown below in table 8.2.2-1 and figures 8.2.2-1 to 8.2.2-6:

Table 8.2.2-1: Peak Transmitter Power

Channel	Frequency (MHz)	Spectral Peak (dBm)	BW Correction Factor (dB)	Peak Transmit Power (dBm)	Limit (dBm)	Result
36	5180	-0.14	14.46	14.43	17	PASS
52	5260	2.70	14.99	17.69	24	PASS
64	5320	1.19	14.66	15.85	24	PASS
149	5745	-1.68	14.36	12.68	30	PASS
157	5785	-0.52	14.41	13.89	30	PASS
161	5805	-0.53	14.55	14.02	30	PASS

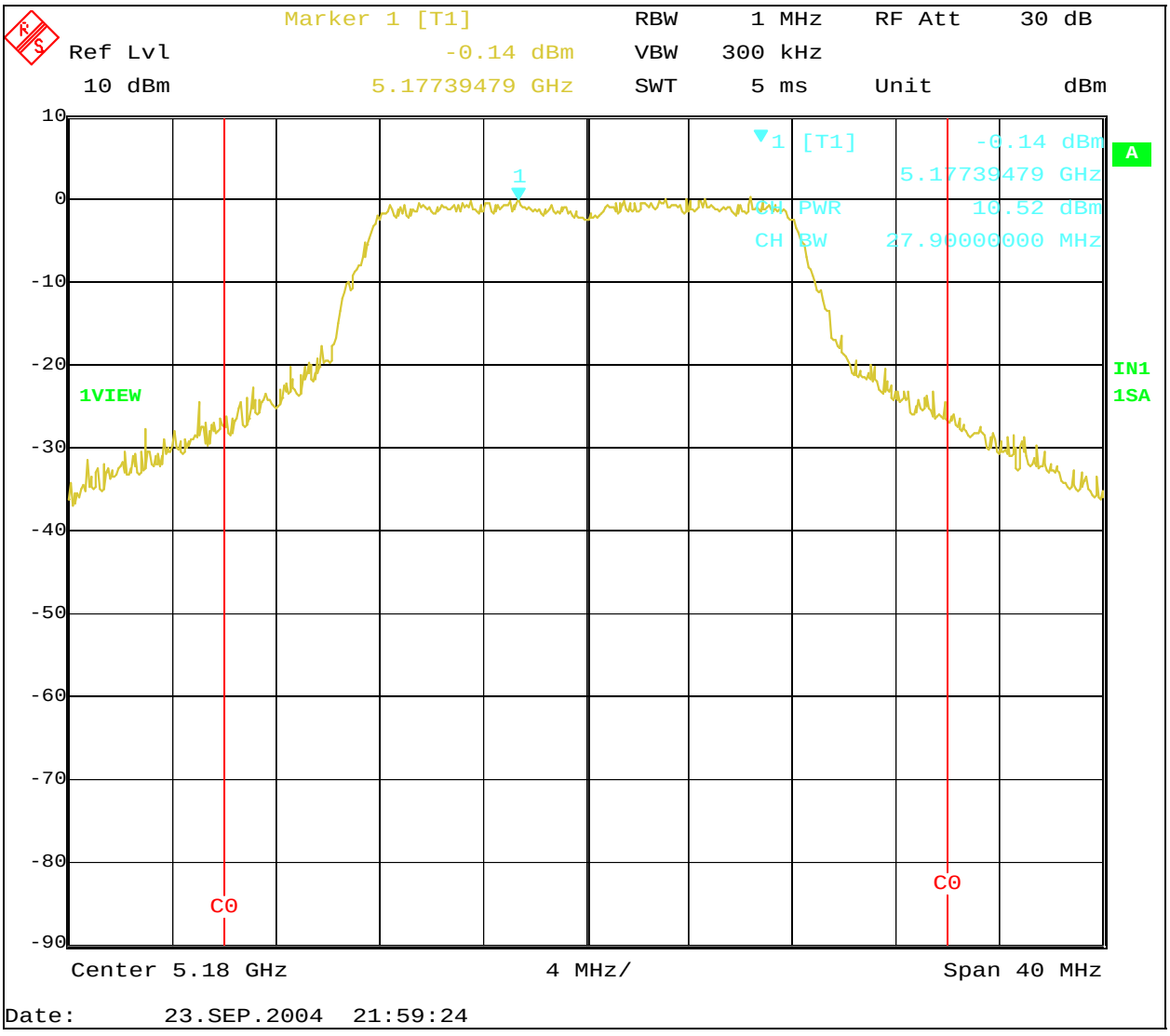

Figure 8.2.2-1: Peak Transmit Power – Channel 36

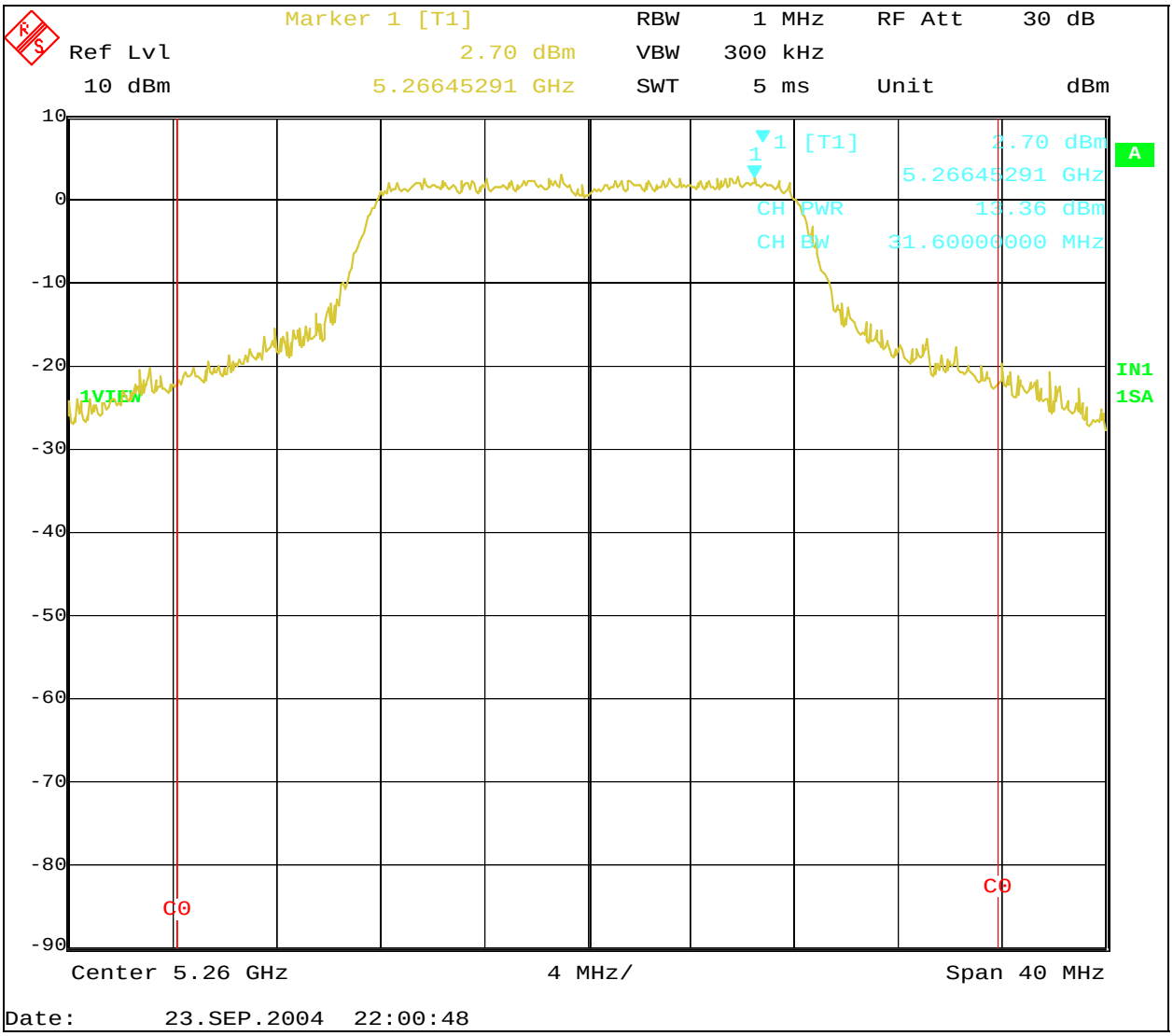

Figure 8.2.2-2: Peak Transmit Power – Channel 52

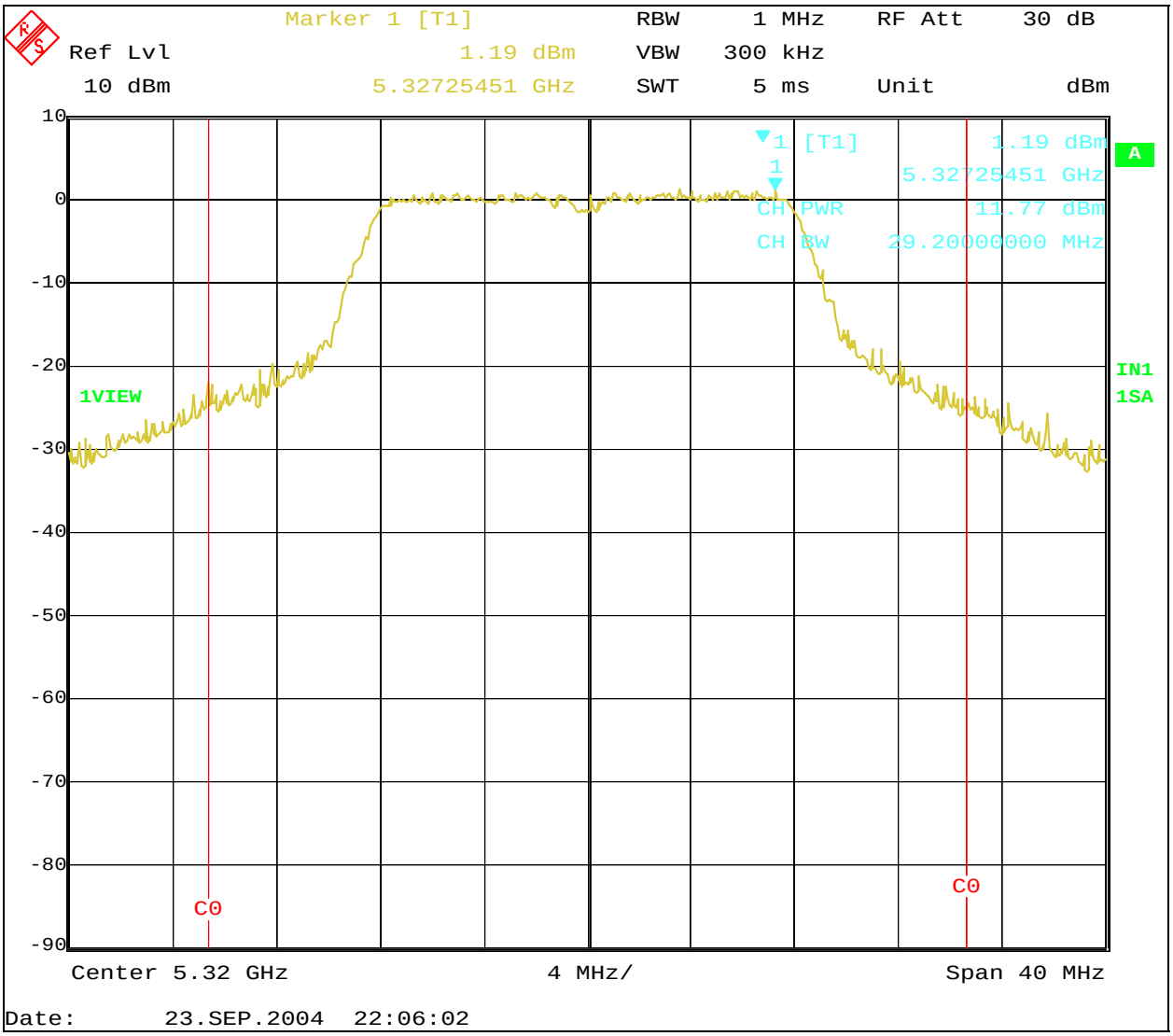

Figure 8.2.2-3: Peak Transmit Power – Channel 64

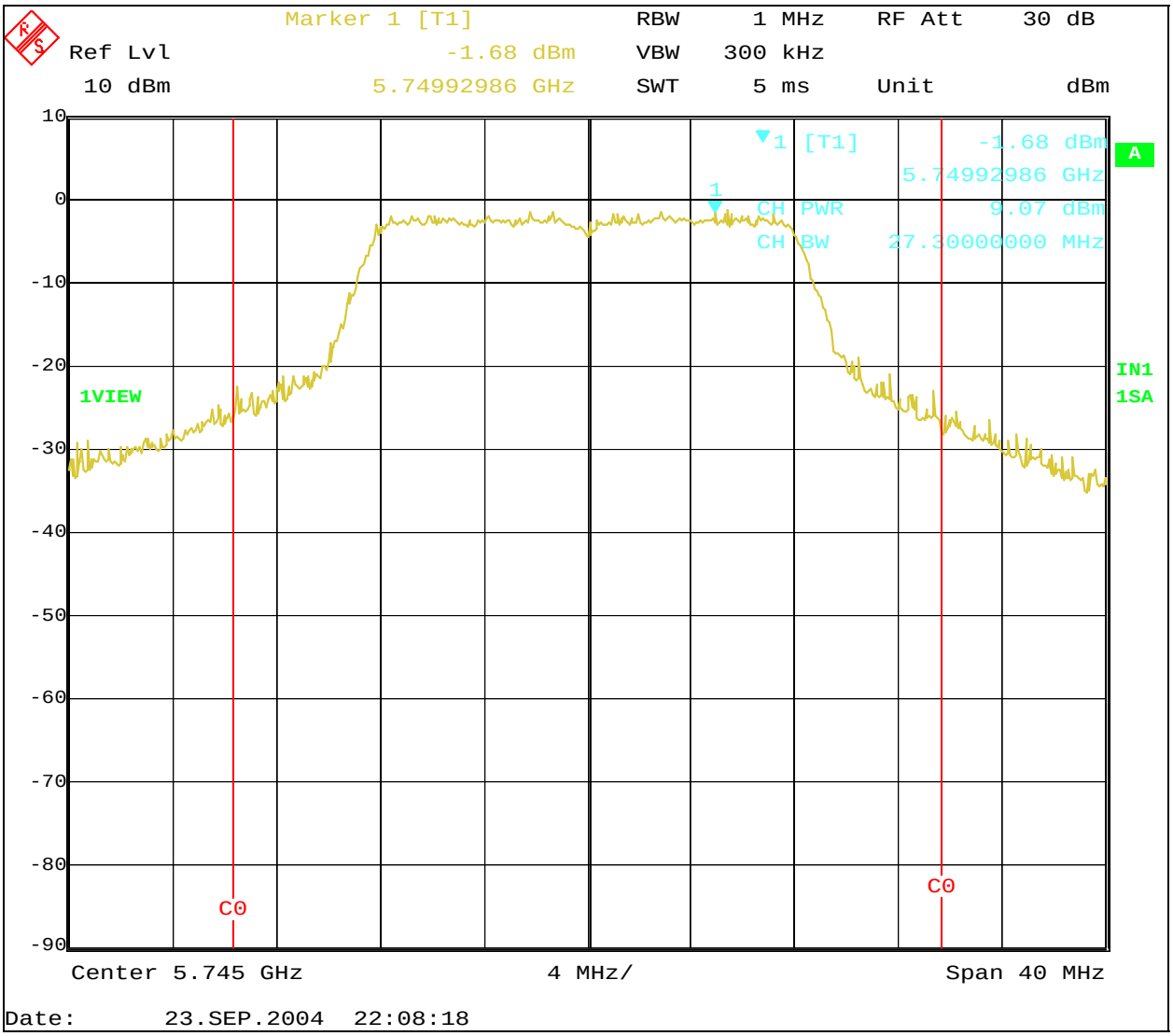

Figure 8.2.2-4: Peak Transmit Power – Channel 149

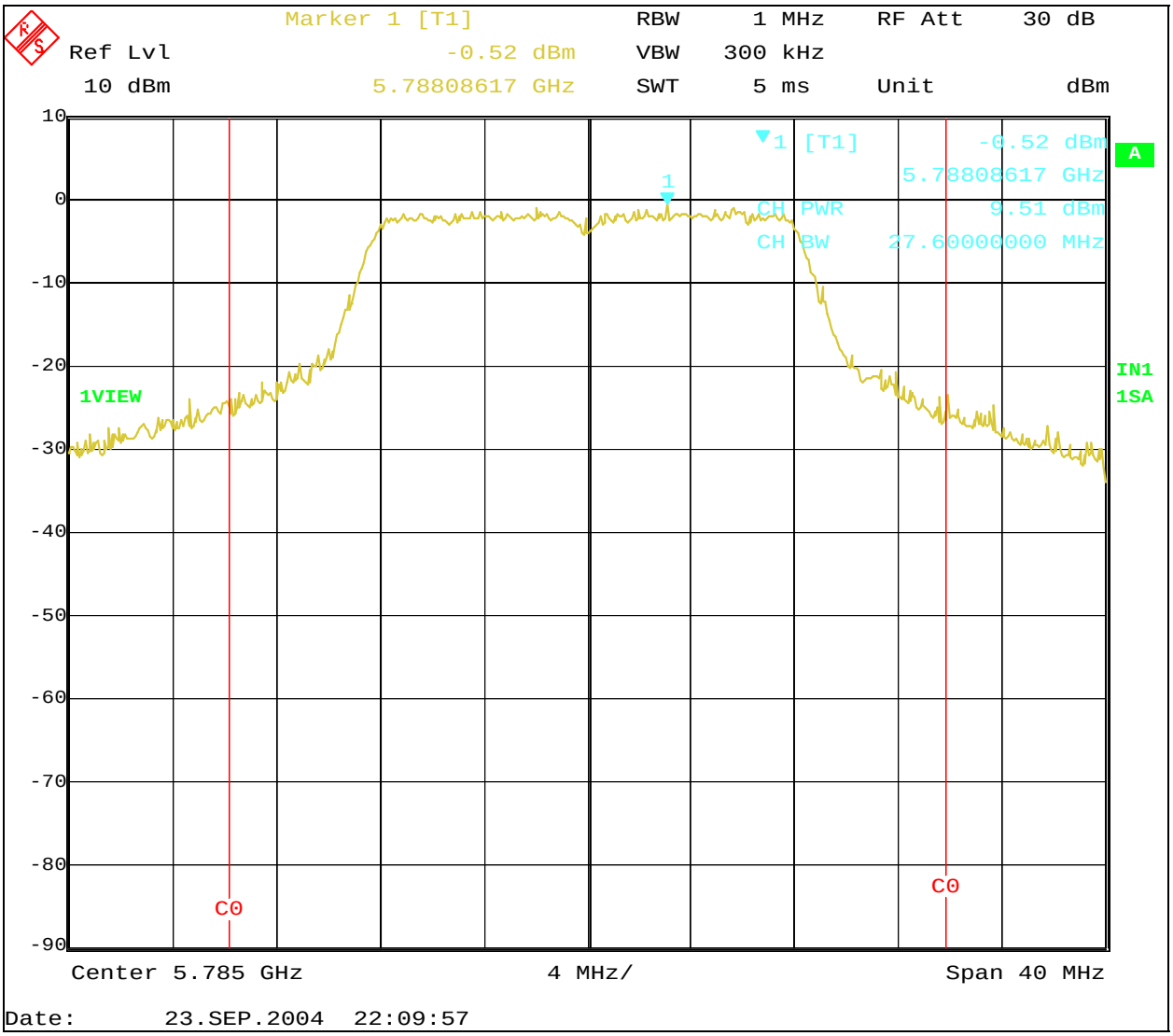

Figure 8.2.2-5: Peak Transmit Power – Channel 157

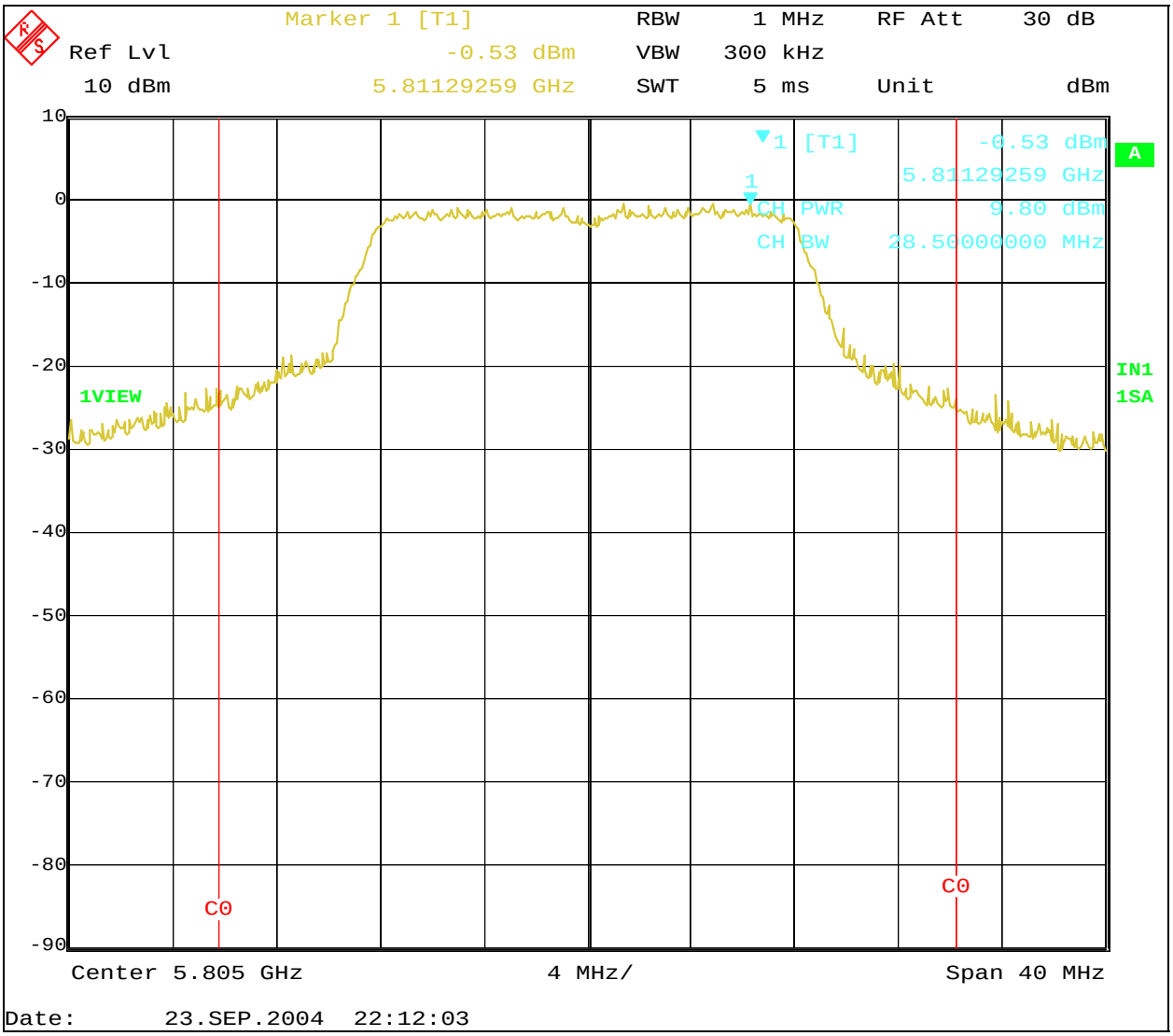

Figure 8.2.2-6: Peak Transmit Power – Channel 161

8.3 Section 15.407 (a)(5) – Peak Power Spectral Density

8.3.1 Test Methodology

The peak power spectral density was measured according to method #2 of FCC DA02-2138 "Measurement Procedure Updated for Peak Transmit Power in the Unlicensed National Information Infrastructure (U-NII) Bands". Using the ESIB EMI Test Receiver, the RBW was set to 1 MHz and VBW of 3 MHz. A sample detector was used and the power averaging function was enabled. The sweep count was set for 100 sweeps. The transmitter was operated continuously at maximum peak transmit power.

The final results were performed with continuous transmission using a modulation rate of 6 Mb/s based on the peak transmit power measurements of section 8.2.

8.3.2 Test Results

Results are shown below in table 8.3.2-1 and figure 8.3.2-1 to 8.3.2-6.

Table 7.7.2-1: Peak Power Spectral Density

Channel	Frequency [MHz]	Level [dBm]	Limit [dBm]	Result
36	5180	0.30	4	PASS
52	5260	3.54	11	PASS
64	5320	1.60	11	PASS
149	5745	-1.12	17	PASS
157	5785	-0.14	17	PASS
161	5805	0.09	17	PASS

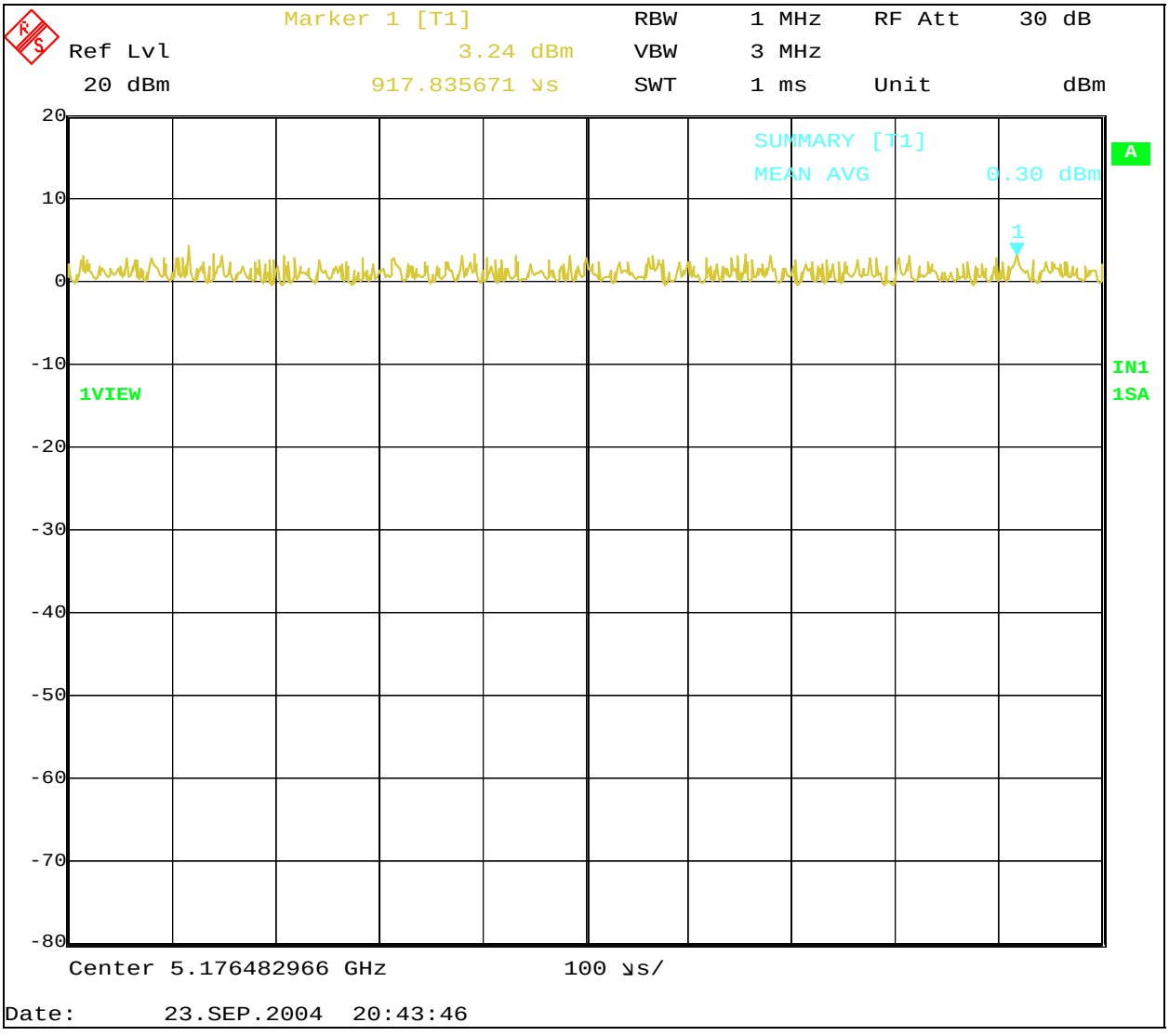

Figure 8.3.2-1: Peak Power Spectral Density – Channel 36

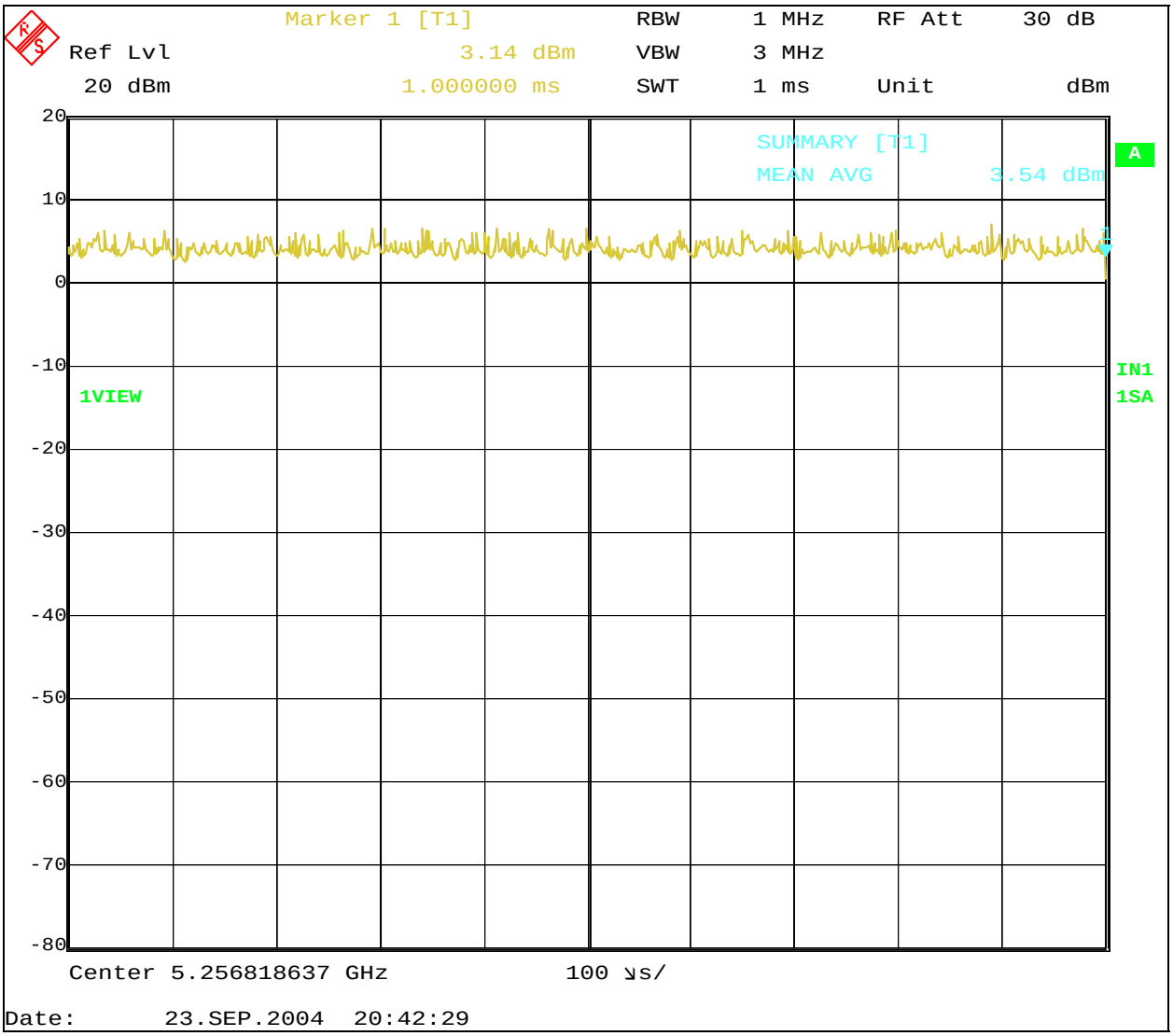

Figure 8.3.2-2: Peak Power Spectral Density – Channel 52

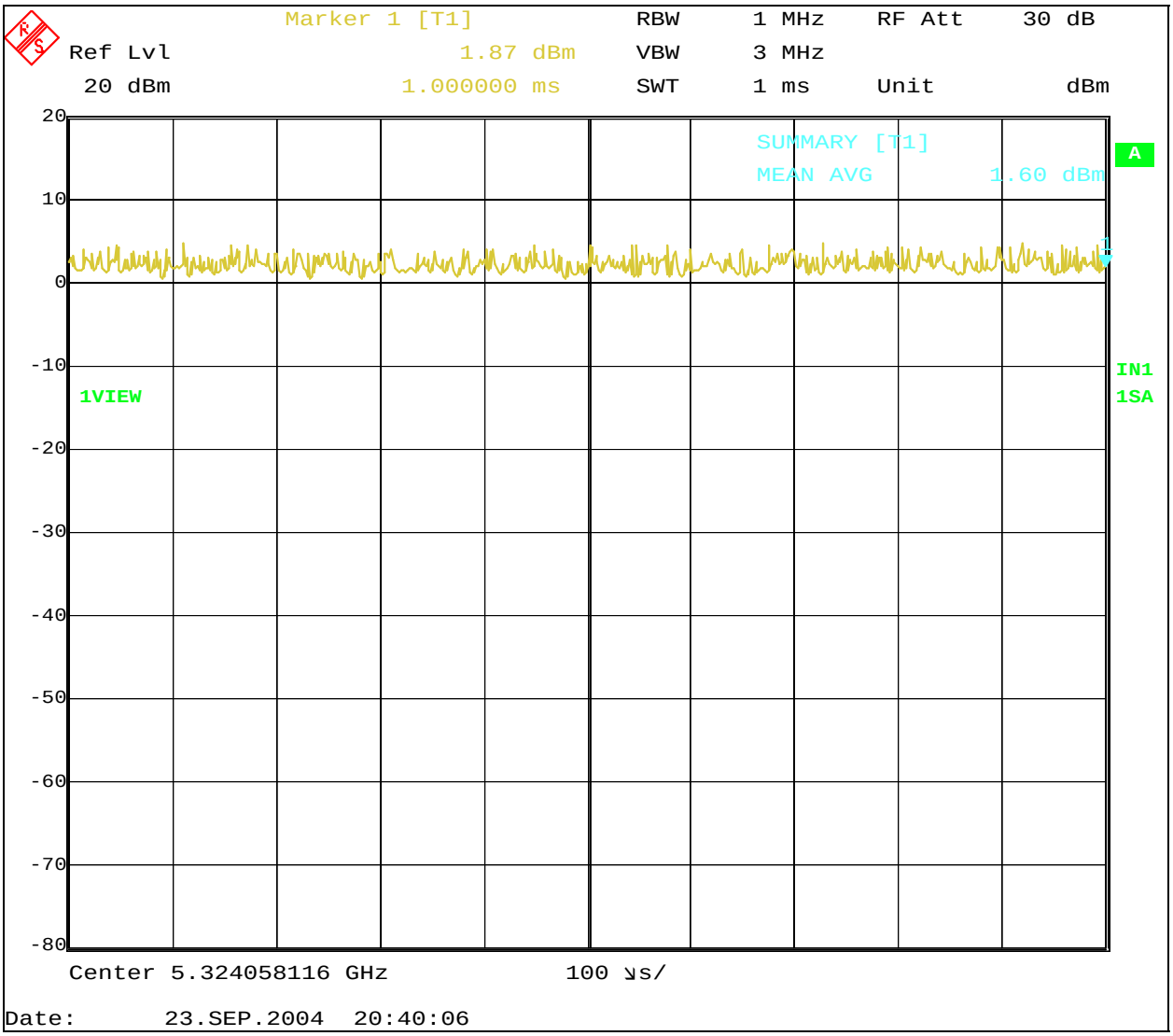

Figure 8.3.2-3: Peak Power Spectral Density – Channel 64

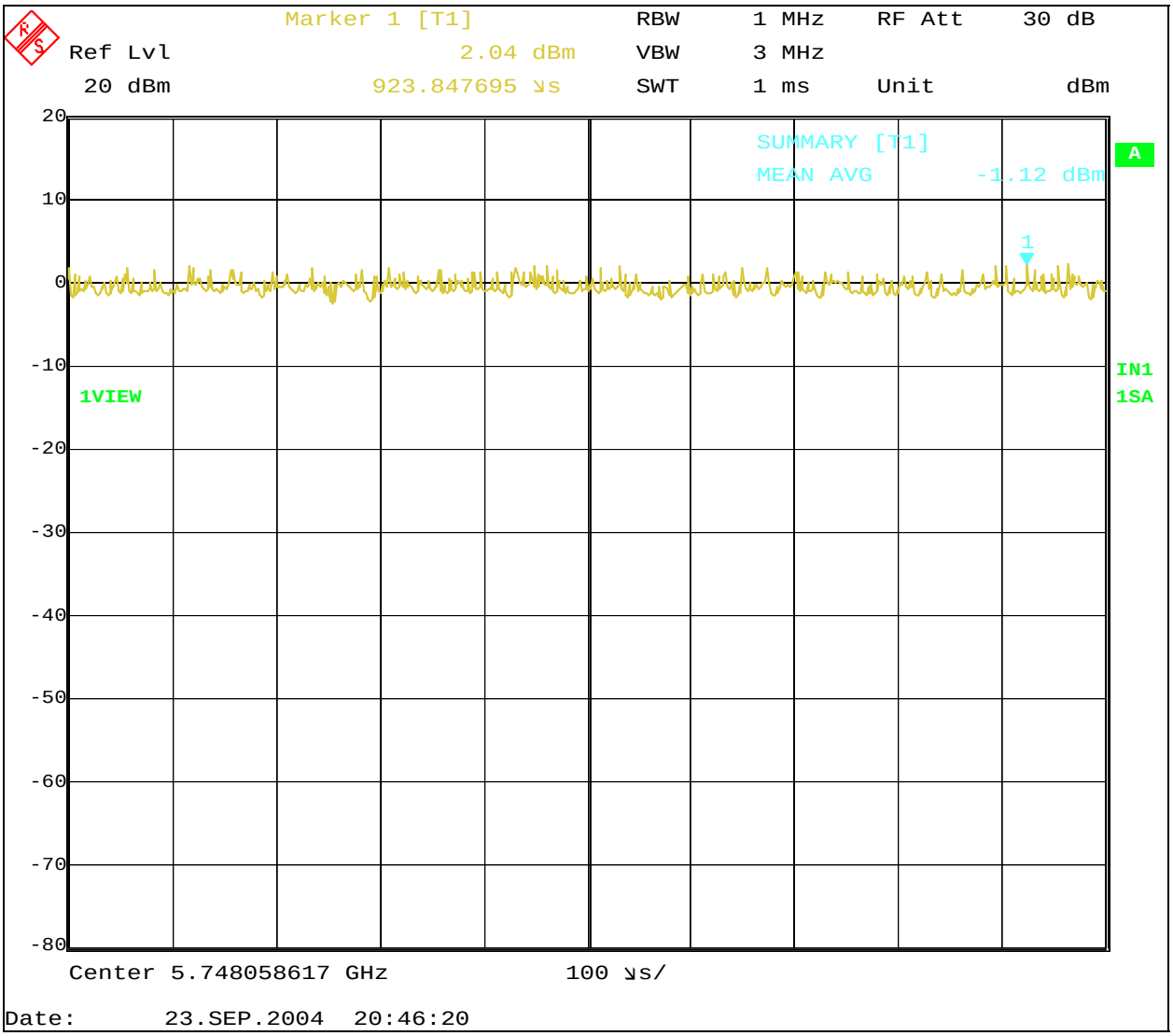

Figure 8.3.2-4: Peak Power Spectral Density – Channel 149

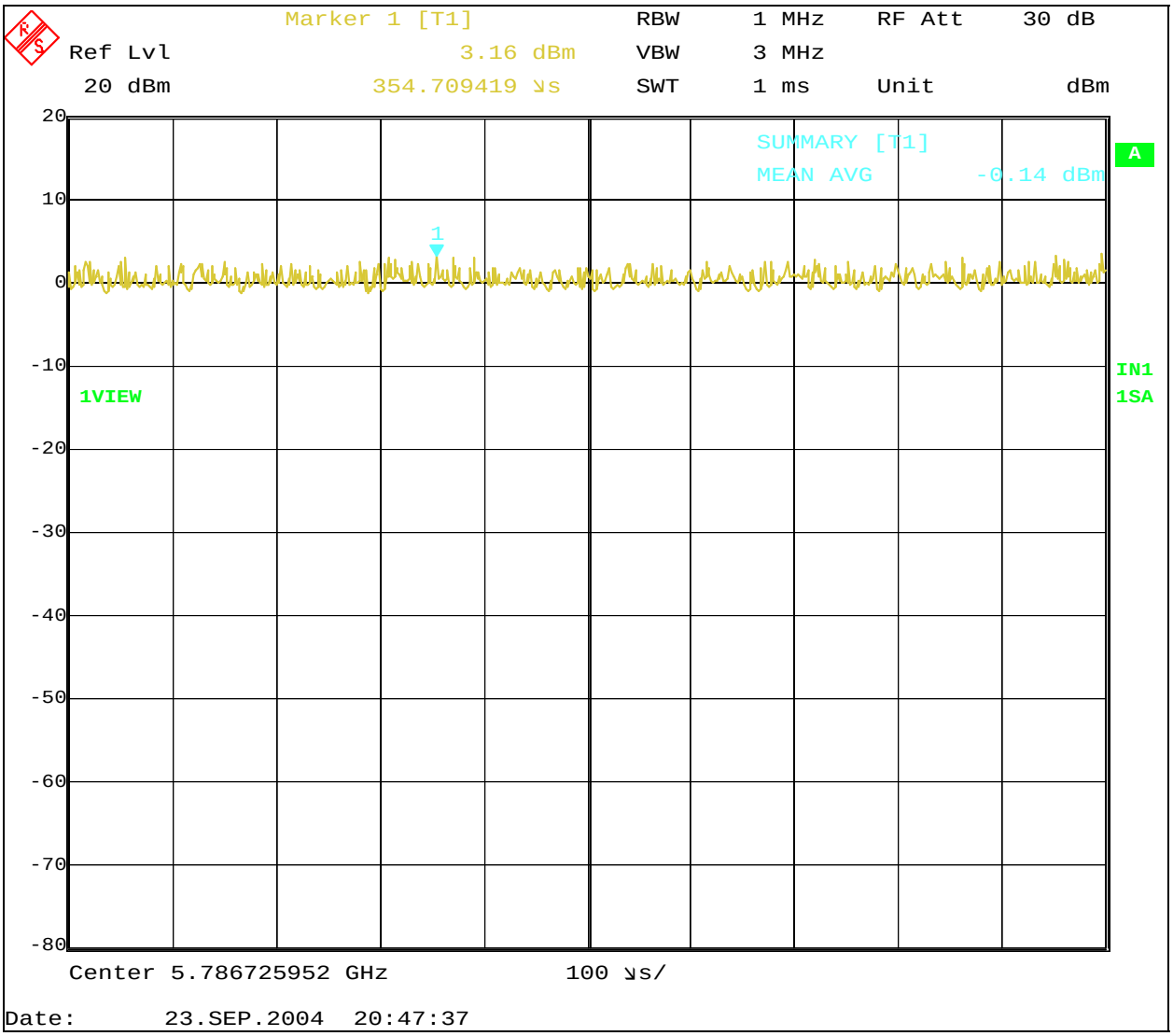

Figure 8.3.2-5: Peak Power Spectral Density – Channel 157

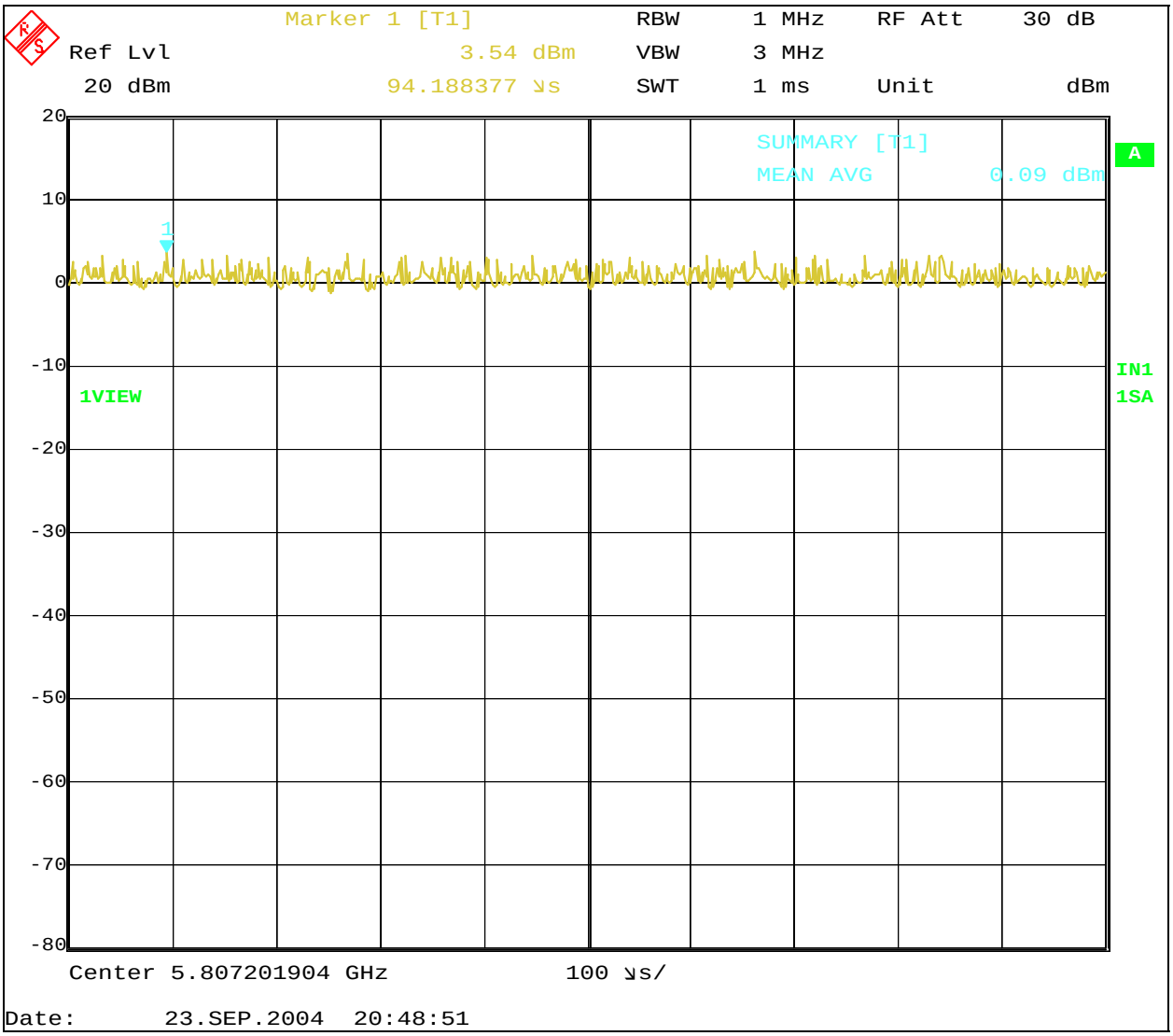

Figure 8.3.2-6: Peak Power Spectral Density – Channel 161

8.4 Section 15.407 (a)(6) – Peak Power Excursion

8.4.1 Test Methodology

The peak power excursion was measured according to FCC DA02-2138 “Measurement Procedure Updated for Peak Transmit Power in the Unlicensed National Information Infrastructure (U-NII) Bands”. Using the ESIB EMI Test Receiver, he span was adjusted to encompass the entire emission bandwidth of the signal as measured in section 8.1. Trace 1 was configured using a RBW of 1 MHz and VBW of 3 MHz with a peak detector and Max Hold. Trace 2 was configured using a RBW of 1 MHz and VBW 300 kHz with a sample and trace Max Hold. The transmitter was operated continuously at maximum peak transmit power.

The final results were performed with continuous transmission using a modulation rate of 6 Mb/s based on the peak transmit power measurements of section 8.2.

8.4.2 Test Results

Results are shown below in table 8.4.2-1 and figure 8.4.2-1 to 8.4.2-6.

Table 8.4.2-1: Peak Power Excursion

Channel	Frequency [MHz]	Limit [dBm]	Result
36	5180	≤ 13	PASS
52	5260	≤ 13	PASS
64	5320	≤ 13	PASS
149	5745	≤ 13	PASS
157	5785	≤ 13	PASS
161	5805	≤ 13	PASS

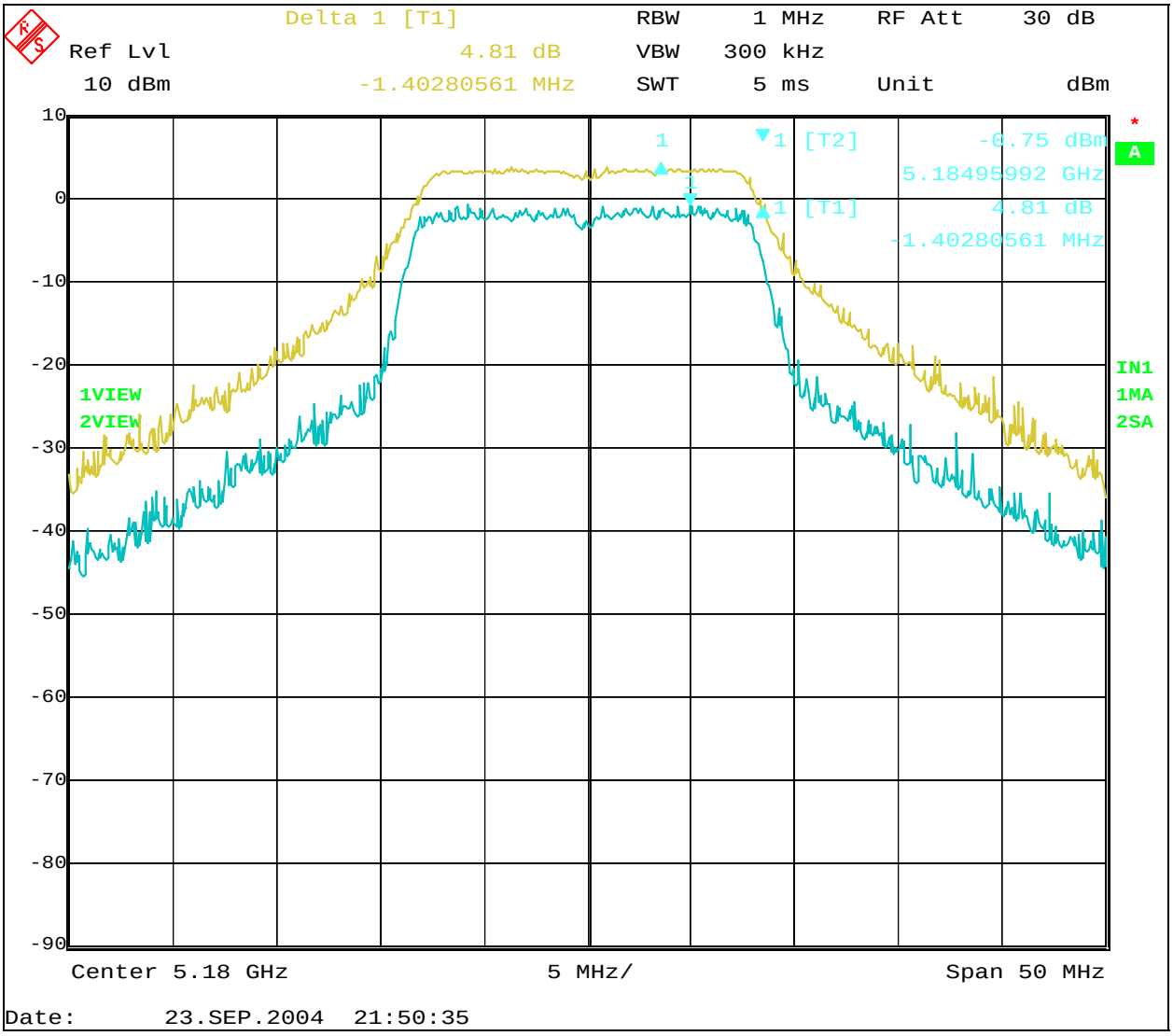

Figure 8.4.2-1: Peak Power Excursion – Channel 36

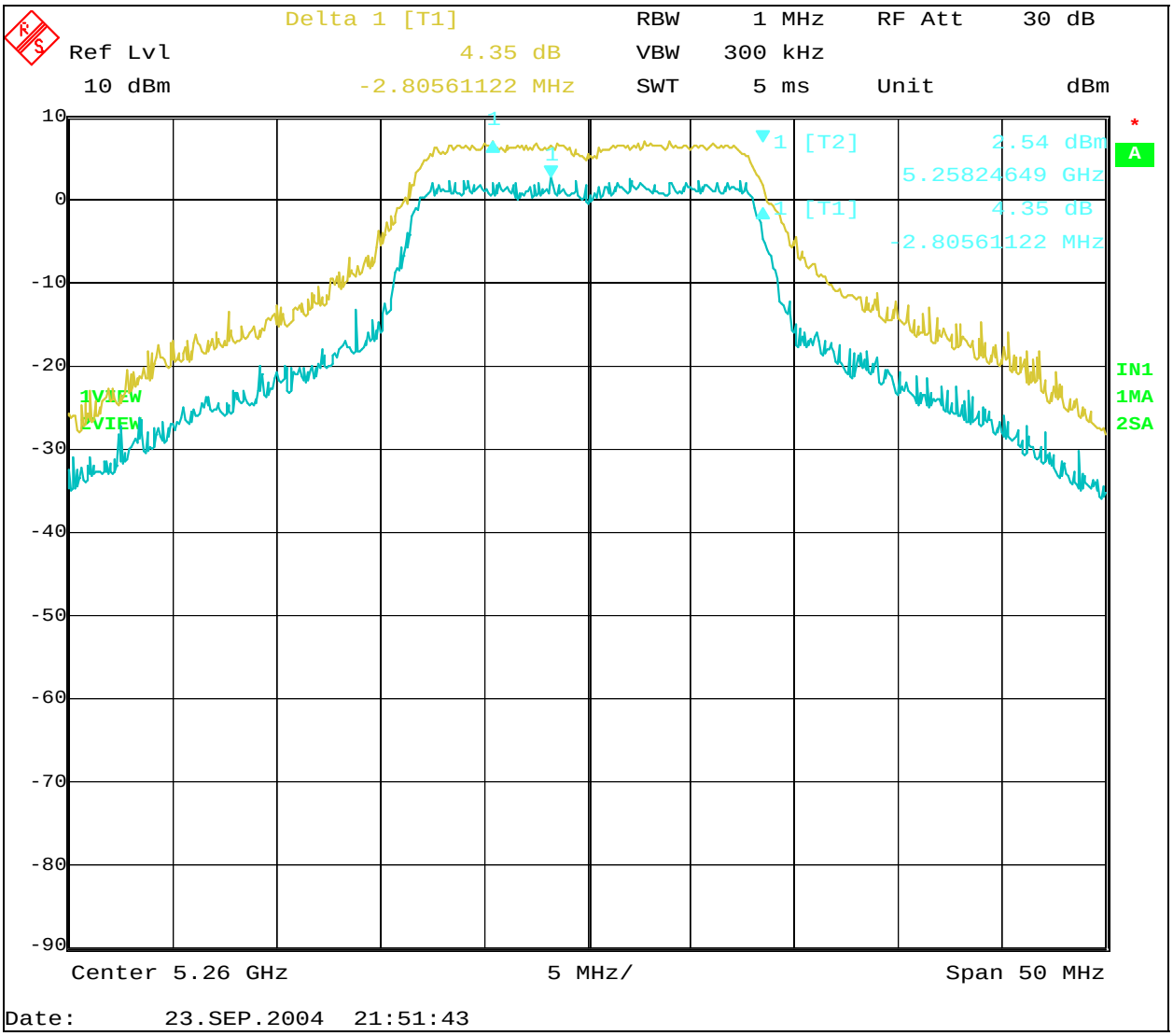

Figure 8.4.2-2: Peak Power Excursion – Channel 52

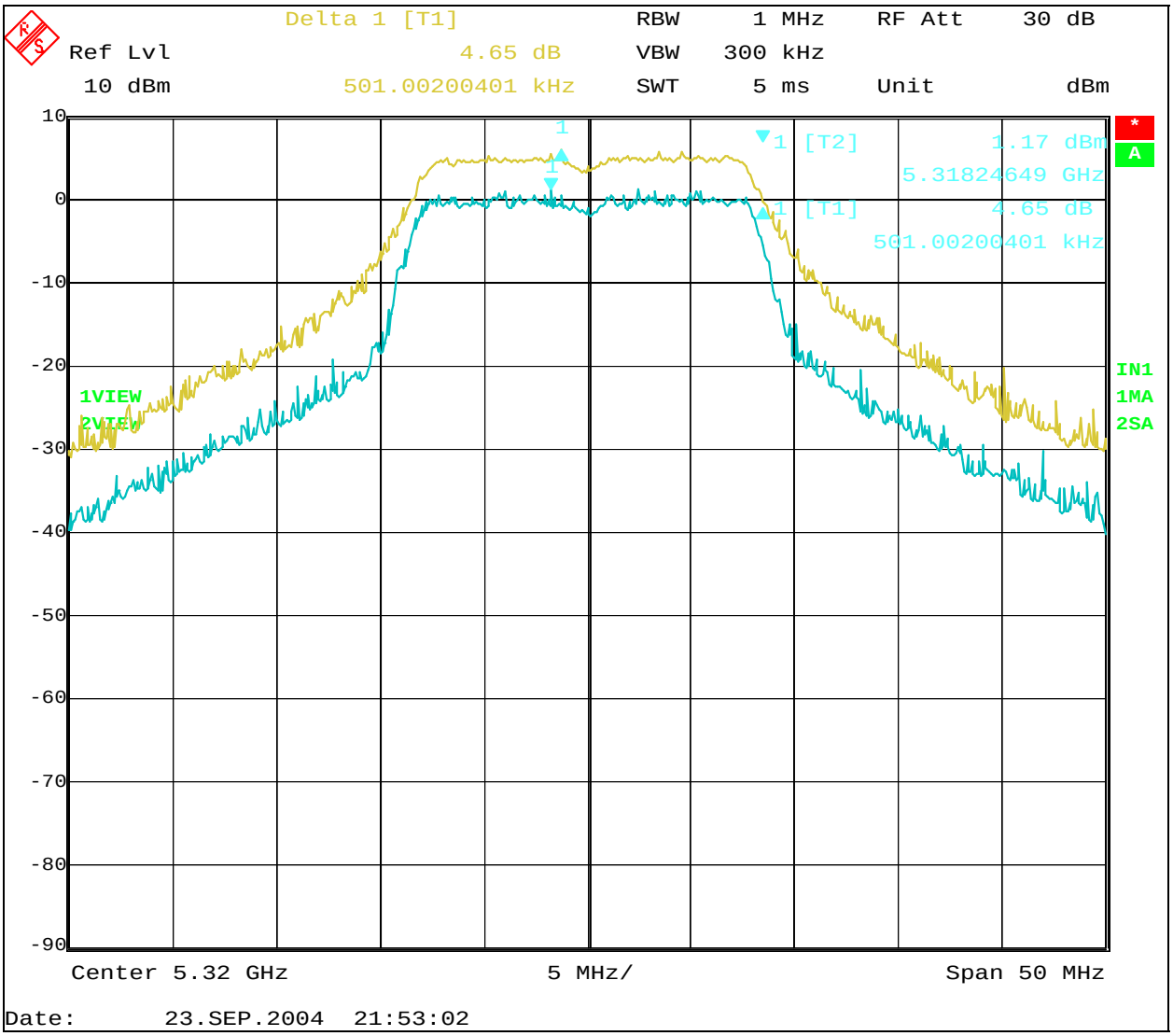

Figure 8.4.2-3: Peak Power Excursion – Channel 64

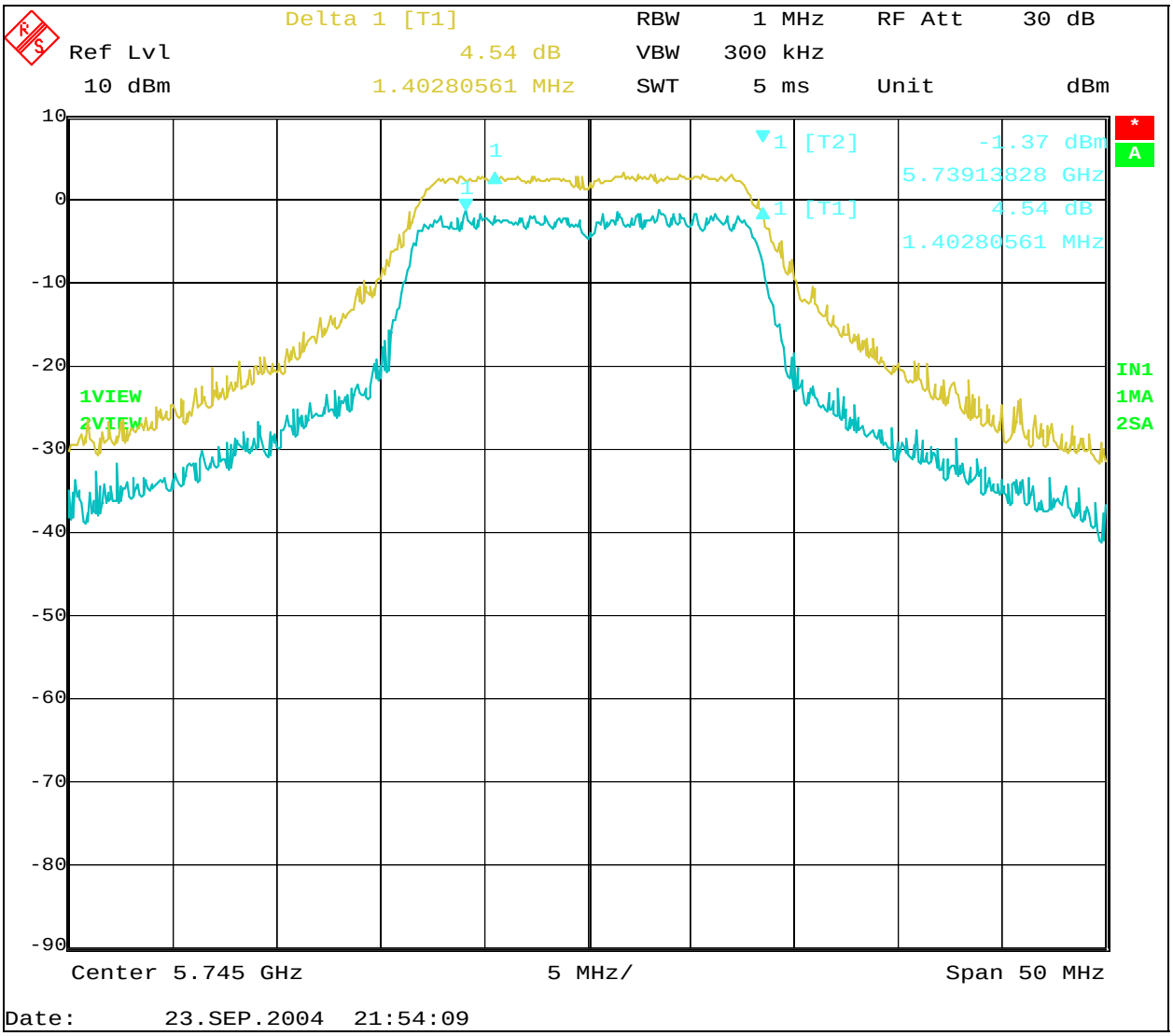

Figure 8.4.2-4: Peak Power Excursion – Channel 149

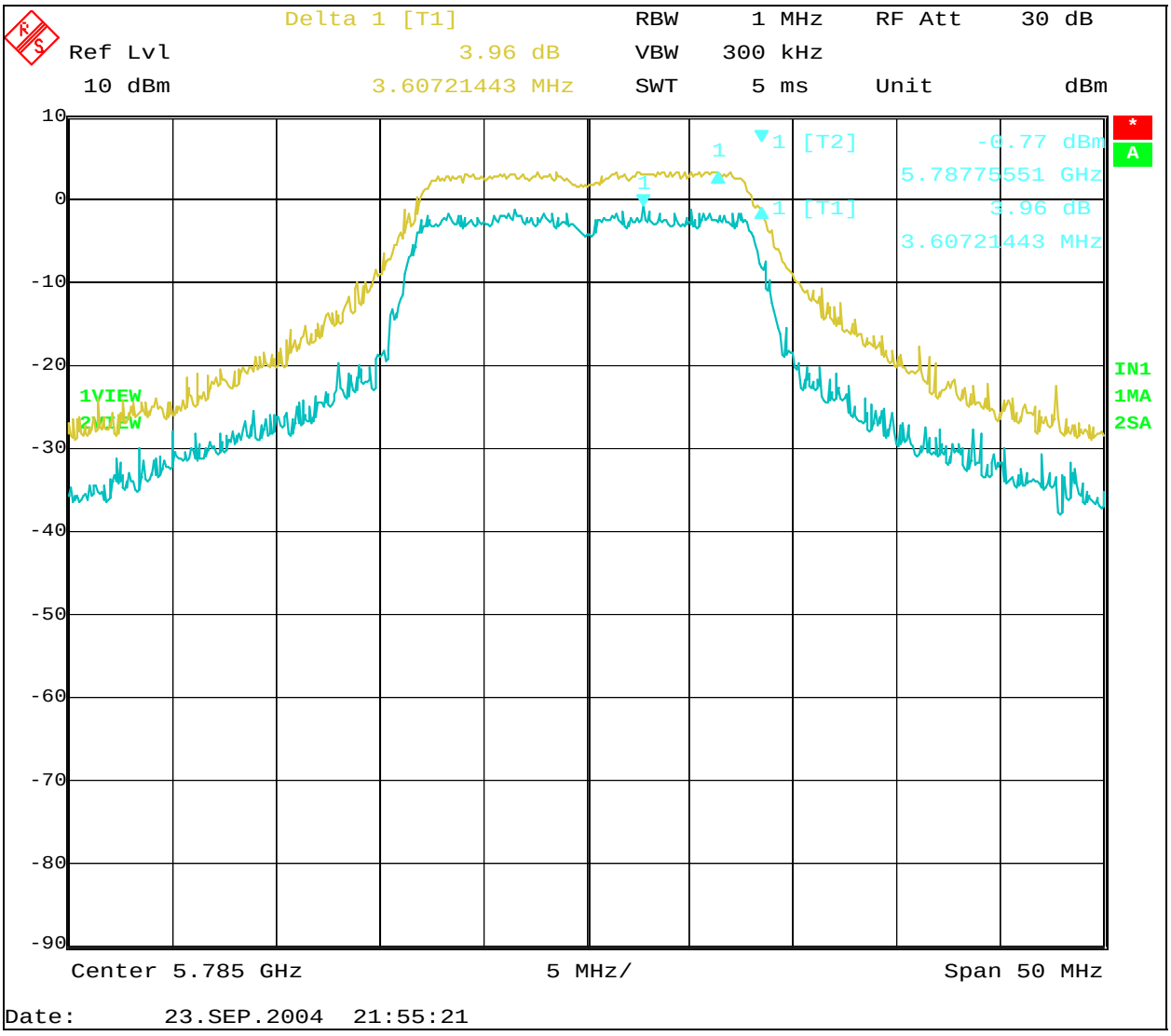

Figure 8.4.2-5: Peak Power Excursion – Channel 157

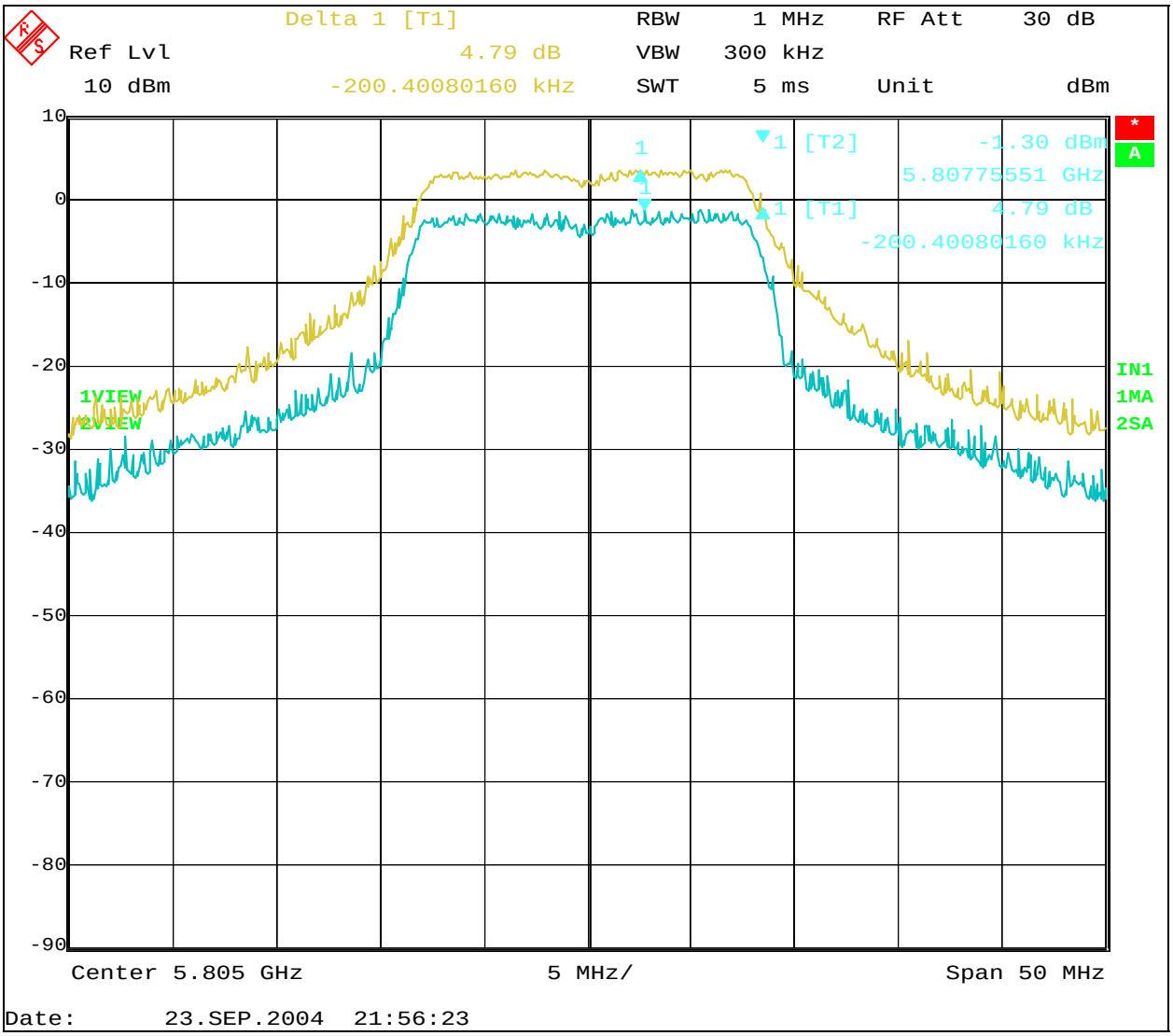

Figure 8.4.2-6: Peak Power Excursion – Channel 161

8.5 Section 15.407 (b), 15.207 - Power Line Conducted Emissions

The EUT intentional radiator was not designed to be connected to the public utility (AC) power line therefore no conducted emission testing was performed.

8.6 Section 15.407 (b)(1)(2)(3)(6), 15.205, 15.209 – Radiated Spurious Emissions

8.6.1 Test Methodology

Unwanted radiated emissions were measured below 1 GHz and compared to general field strength limits set forth in 15.209. Quasi-peak measurements were made using a resolution bandwidth (RBW) of 120 kHz and a video bandwidth (VBW) of 300 kHz. All channels and modes of 802.11a were evaluated for worst case. No significant differences were discovered in this evaluation. Channel 36 at 1 Mb/s was used for final testing.

Unwanted radiated emissions were also measured above 1 GHz and compared to emission limits set forth in 15.407(b) and 15.209 as applicable to the restricted band requirements of 15.205. As the gain of the antenna outside the pass band is uncertain, or the emissions may radiate from the case of the EUT, the EIRP limit is converted to field strength for comparison to the limit. The calculated limit for -27dBm EIRP is obtained for 68.3dBuV/m at 3m. Average measurements were made using an RBW of 1 MHz and a VBW of 10 Hz and peak measurements were made with RBW of 1 MHz and a VBW of 1 MHz. All modes of 802.11a were evaluated for worst case. No significant differences were discovered in this evaluation. 6 Mb/s was used for final testing.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected.

All channels and modes of 802.11a were evaluated for worst case. No significant differences were discovered in this evaluation. Channel 36 at 1 Mb/s was used for final testing.

Because the CAP configuration is capable of operating both radio modules in the 5 GHz band simultaneously, inter-modulation products were also evaluated. One radio module of the EUT was set to the lowest channel available and the other radio module set to the next adjacent channel. Any inter-modulation products observed were maximized and recorded. All modes of the 802.11a radios were evaluated for worst case. This was repeated with two radio modules set to the highest possible channel and next adjacent channel available respectively.

8.6.2 Test Results - Below 1 GHz

Radiated spurious emissions found in the band of 30 MHz to 1GHz are reported in Table 8.6.2-1 and Table 8.6.2-2.

Table 8.6.2-1: Radiated Spurious Emissions – Below 1GHz - Channel 36

Frequency (MHz)	Uncorrected Reading (dBµV/m)	Antenna Polarity (H/V)	Antenna Height (cm)	Turntable Position (°)	Total Correction Factor (dB)	Corrected Reading (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Results
30.11	24.33	V	100	0	-4.86	19.47	40	20.5	**Pass**
35.25	31.36	V	100	360	-7.62	23.74	40	16.3	**Pass**
334.05	22.37	H	100	169	-5.52	16.85	46	29.1	**Pass**
343.63	32.51	H	100	165	-4.99	27.52	46	18.5	**Pass**
362.76	24.79	H	100	360	-3.74	21.05	46	24.9	**Pass**
925.91	31.16	H	205	0	4.24	35.40	46	10.6	**Pass**
945.12	30.02	H	24	360	5.31	35.33	46	10.7	**Pass**

8.6.3 Test Results - Above 1 GHz

Radiated spurious emissions found in the band above 1GHz are reported in Table 8.6.3-1.

Table 8.6.3-1: Radiated Spurious Emissions

Frequency (MHz)	Level (dBuV/m)	Detector (P/A)	Antenna Polarity (H/V)	Turntable Position (o)	Correction Factors (dB)	Corrected Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
Channel 36								
10.3644	49.8	p	v	0	15.03	64.83	68.3	3.47
Channel 64								
10.6599	52.13	P	v	20	17.85	69.98	74.00	4.02
10.6599	35.83	a	v	20	17.85	53.68	54.00	0.32
Channel 149								
4.5933	48.20	p	v	345	7.28	55.48	74.00	18.52
4.5933	40.73	a	v	345	7.28	48.01	54.00	5.99
Channel 161								
4.6399	48.30	p	v	0	7.50	55.80	74.00	18.20
4.6399	41.75	a	v	0	7.50	49.25	54.00	4.75

8.6.4 Test Results - Inter-Modulation Products

No inter-modulation products were detected for any combinations of channel selections or modes.

8.6.4 Test Results – Band Edge Compliance Restricted Bands

Results are shown below in table 8.6.4-1 and figure 8.6.4-1 to 8.6.4-4

Table 8.6.4-1: Band Edge Compliance Restricted Bands

Frequency (MHz)	Level (dBuV/m)	Detector (P/A)	Antenna Polarity (H/V)	Turntable Position (o)	Correction Factors (dB)	Corrected Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
Low Channel								
5.15	41.08	p	v	46	10.69	51.77	74.00	22.23
5.15	26.67	a	v	46	10.69	37.36	54.00	16.64
5.35	40.99	p	v	259	10.43	51.42	74.00	22.58
5.35	26.57	a	v	259	10.43	37.00	54.00	17.00

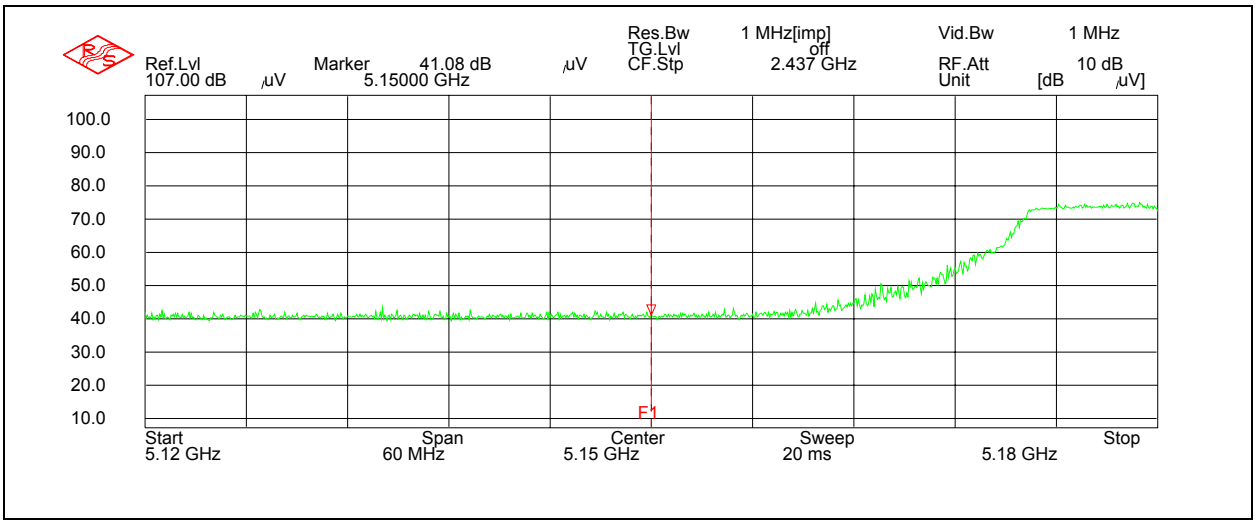

Figure 8.6.4-1: Band Edge Restricted Bands – Channel 36 – Peak

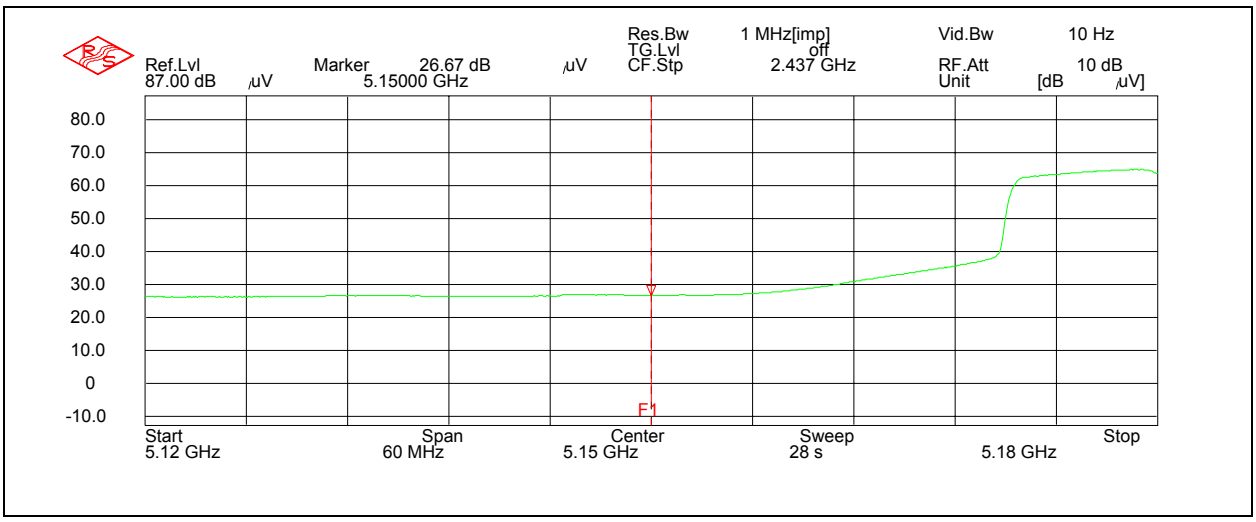

Figure 8.6.4-2: Band Edge Restricted Bands – Channel 36 – Average

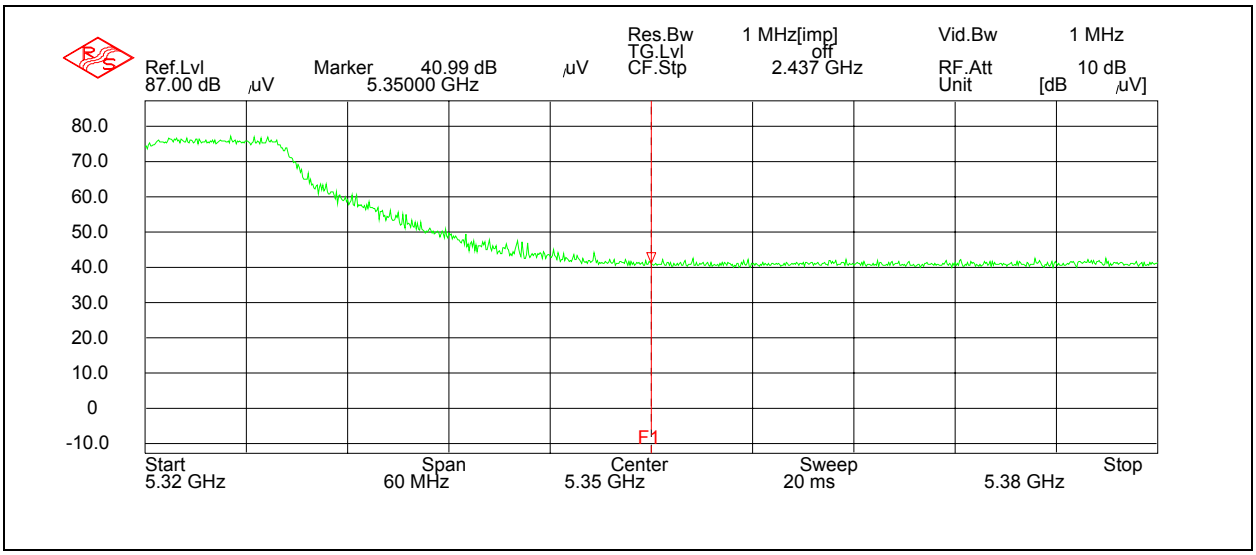

Figure 8.6.4-3: Band Edge Restricted Bands – Channel 64 – Peak

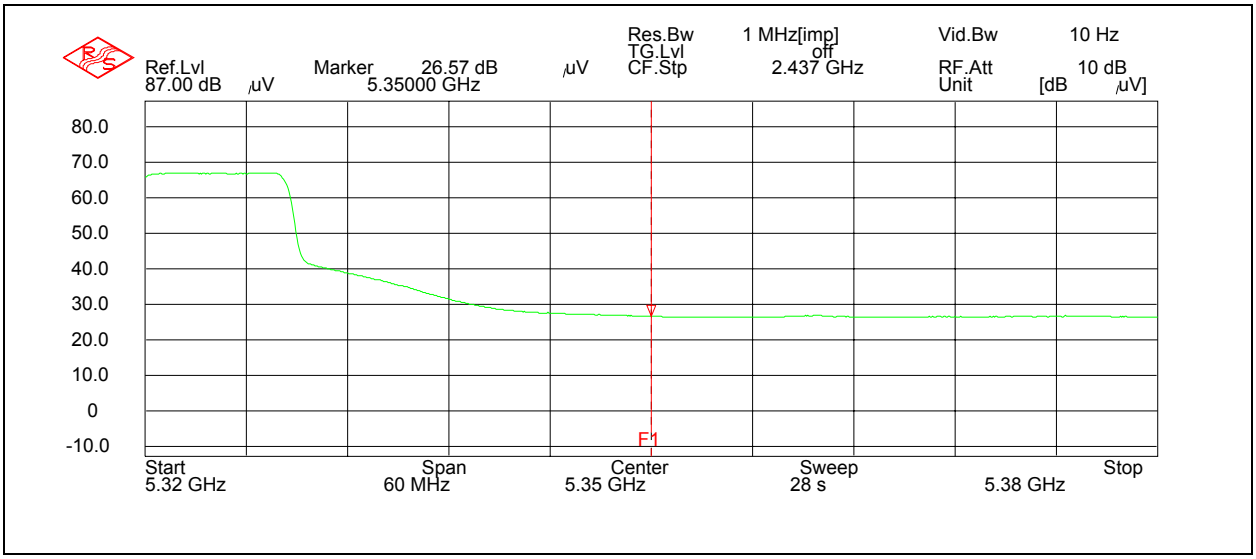

Figure 8.6.4-4: Band Edge Restricted Bands– Channel 64 - Average

8.6.5 Sample Calculations:

$R_C = R_U + CF_T$
Where:

CF_T	=	Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only)
R_U	=	Uncorrected Reading
R_C	=	Corrected Level
AF	=	Antenna Factor
CA	=	Cable Attenuation
AG	=	Amplifier Gain
DC	=	Duty Cycle Correction Factor

Corrected Level: 44.80 + 9.33 = 54.13 dBuV
Margin: 74dBuV – 54.13 dBuV = 19.87 dB

8.7 Section 15.407 (b)(1)(2)(3)(7) – Band Edge Compliance (Conducted)

8.7.1 Test Methodology

The EUT was investigated at the lowest and highest channel available to determine band-edge compliance. For each measurement the spectrum analyzer's RBW and VBW was set to 1 MHz. The carrier was adjusted as close to the upper and lower band edge as the design permitted. The peak level above and below the band edge was measured and compared to the limit.

The final results were performed with continuous transmission using a modulation rate of 6 Mb/s.

8.7.2 Test Results

Results are shown below in table 8.7.2-1 and figure 8.7.2-1 to 8.7.2-4.

Table 8.7.2-1: Band Edge Compliance

Channel	Frequency [MHz]	Level [dBm]	Limit at Band Edge [dBm/ MHz] E.I.R.P	Result
36	5180	-35.33	-27	PASS
64	5320	-34.53	-27	PASS
149	5745	-26.64 < -27	< 10 MHz from BE -17 > 10 MHz from BE -27	PASS
161	5805	-25.48 < -27	< 10 MHz from BE -17 > 10 MHz from BE -27	PASS

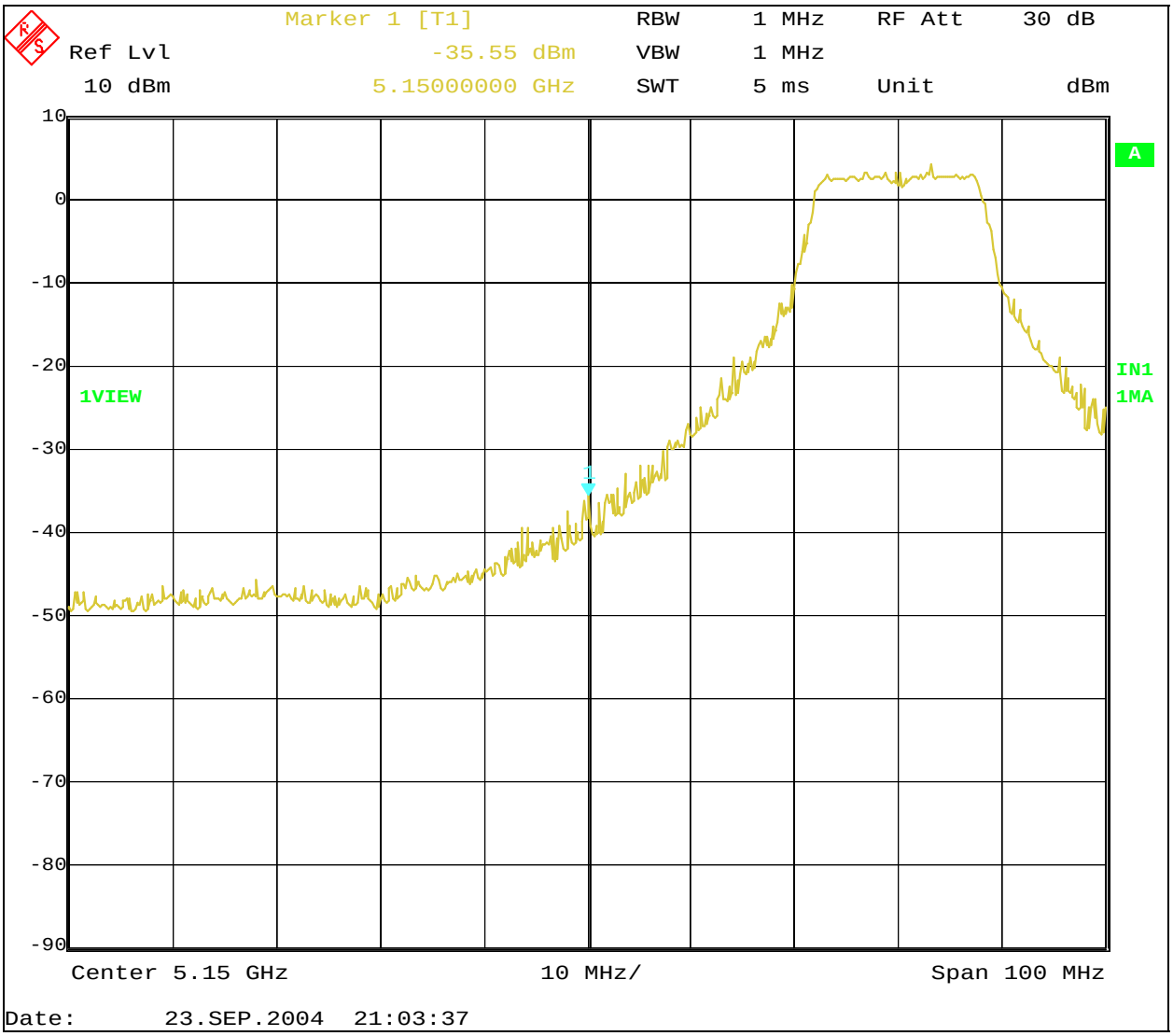

Figure 8.7.2-1: Band Edge – Channel 36

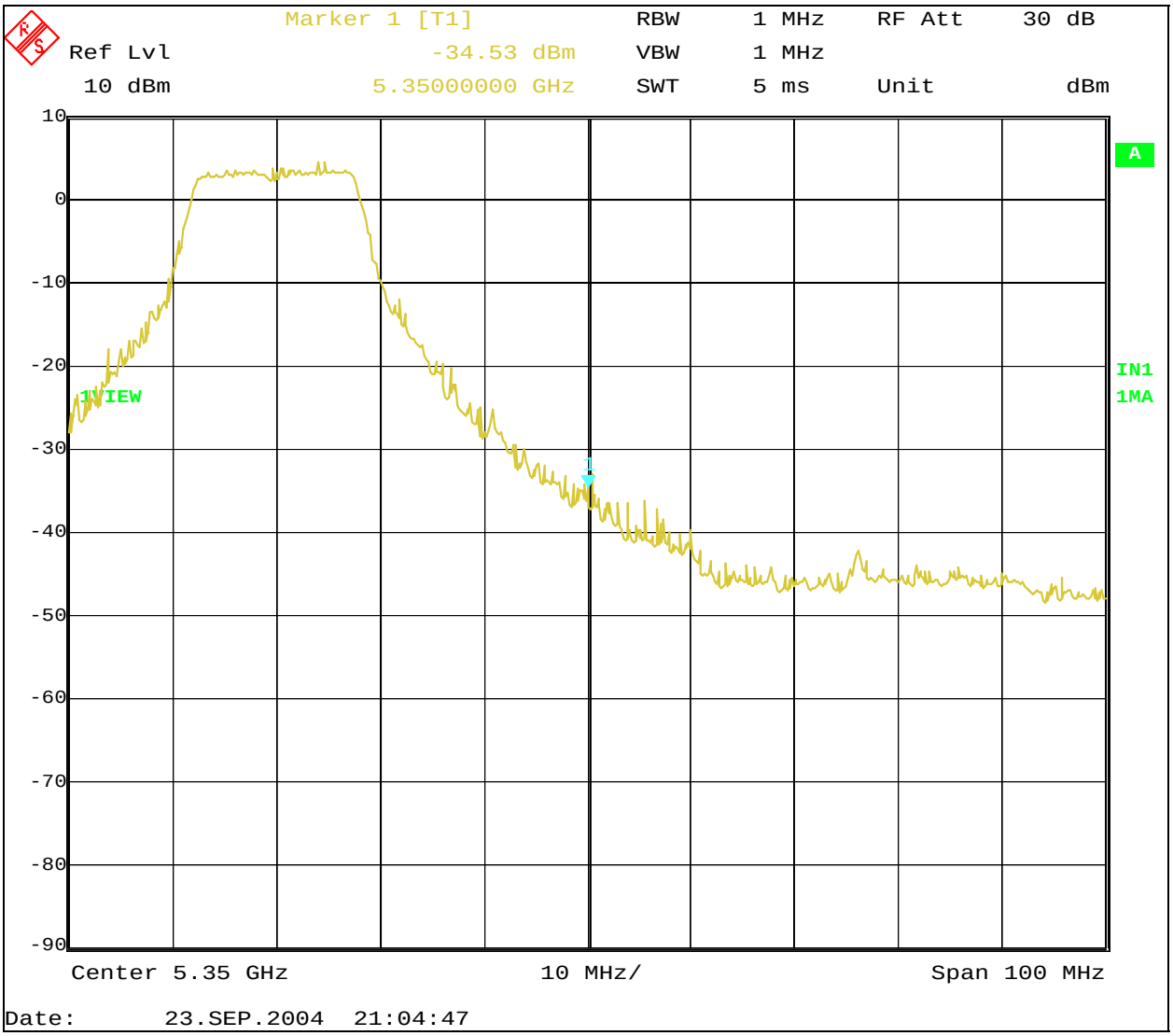

Figure 8.7.2-2: Band Edge – Channel 64

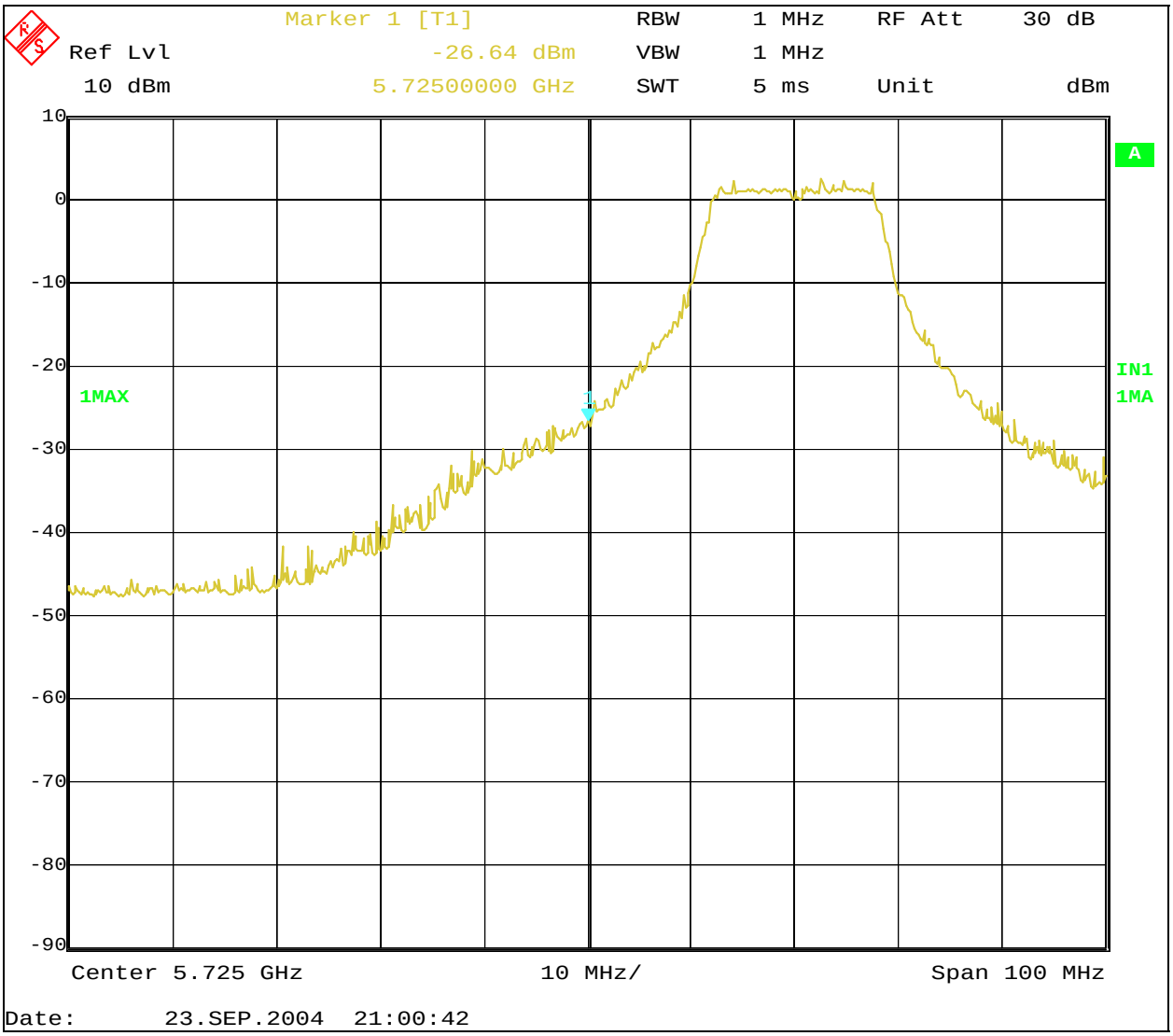

Figure 8.7.2-3: Band Edge – Channel 149

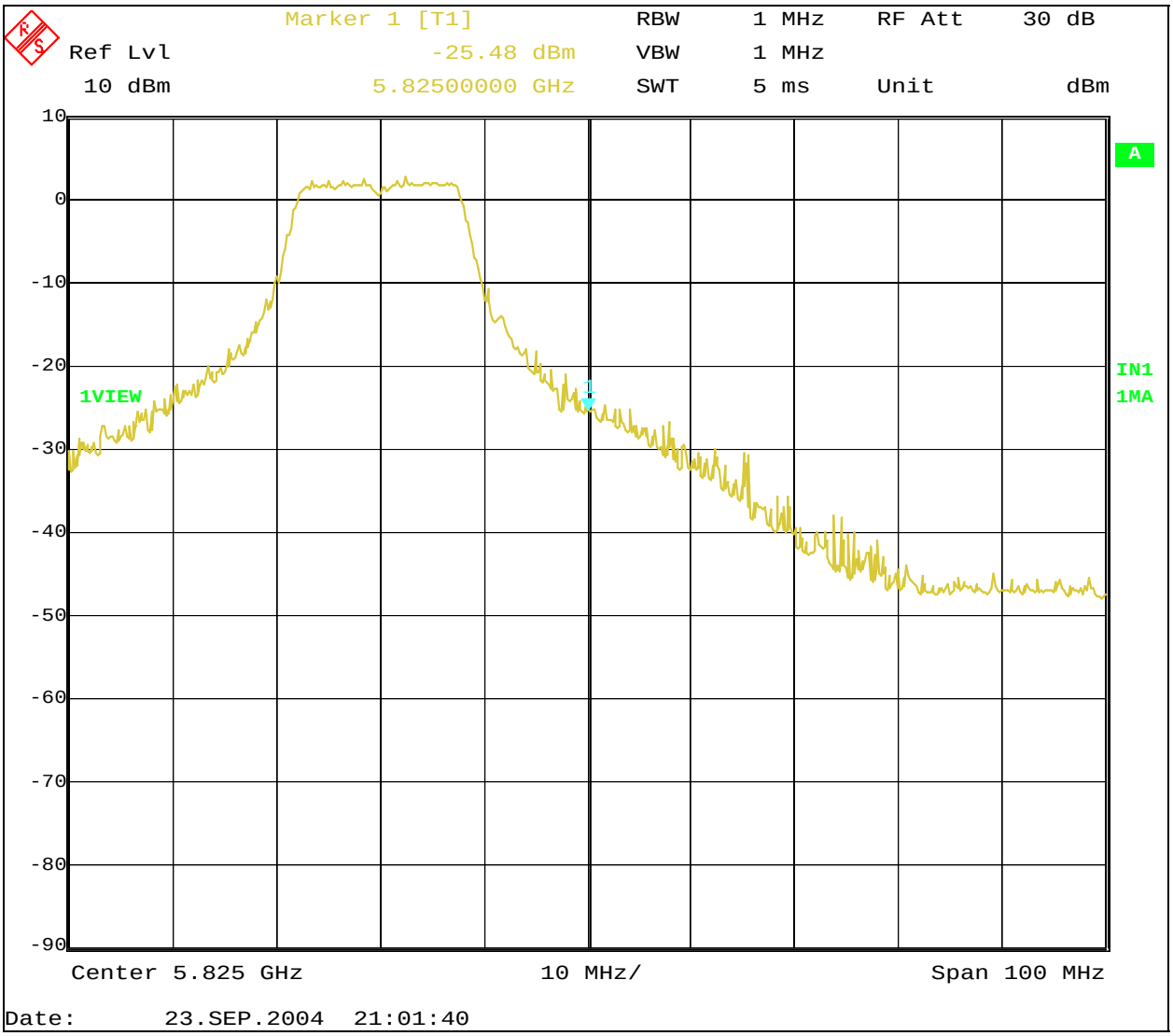

Figure 8.7.2-4: Band Edge – Channel 161

8.8 Section 15.407 (g) – Frequency Stability

8.8.1 Test Methodology

The EUT was placed inside a temperature humidity chamber and the output connected to the input of the spectrum analyzer. Measurements were made at room temperature and at the extremes temperatures of -15° and 55°C with the AC supply voltage varied by +/- 15%. To ensure that the emission was maintained within the band of operation, measurements were made at band edge frequencies within the bands 5.15 – 5.35 GHz and 5.725 – 5.825 GHz. The EUT was allowed sufficient time to stabilize at each temperature (approximately 30 minutes) and measurements were made within 1 minute of startup.

The final results were performed with continuous transmission using a modulation rate of 6 Mb/s.

8.8.2 Test Results

Results are shown below in table 8.8.2-1.

Table 8.8.2-1: Frequency Stability – 5180 MHz

Operating Frequency : 5180 MHz				Limit: +/- 0.02%		
Temp (C°)	Supply Voltage (VAC)	Freq. (MHz)	Max. Deviation (kHz)	Max. Deviation (%)	Limit +/-(kHz)	Results
-15	132	5180.133	133	0.0026	1036	PASS
	115	5180.106	106	0.0020	1036	PASS
	97	5179.819	-181	-0.0035	1036	PASS
0	132	5180.173	173	0.0033	1036	PASS
	115	5179.865	-135	-0.0026	1036	PASS
	97	5180.191	191	0.0037	1036	PASS
55	132	5180.260	260	0.0050	1036	PASS
	115	5180.172	172	0.0033	1036	PASS
	97	5180.176	176	0.0034	1036	PASS

Table 8.8.2-2: Frequency Stability – 5805 MHz

Operating Frequency : 5805 MHz				Limit: +/- 0.02%		
Temp (C°)	Supply Voltage (VAC)	Freq. (MHz)	Max. Deviation (kHz)	Max. Deviation (%)	Limit +/-(kHz)	Results
-15	132	5805.162	162	0.0028	1161	PASS
	115	5804.891	-109	-0.0019	1161	PASS
	97	5805.135	135	0.0023	1161	PASS
0	132	5804.866	-134	-0.0023	1161	PASS
	115	5804.881	-119	-0.0020	1161	PASS
	97	5805.175	175	0.0030	1161	PASS
55	132	5804.889	-111	-0.0019	1161	PASS
	115	5804.883	-117	-0.0020	1161	PASS
	97	5804.890	-110	-0.0019	1161	PASS

9.0 CONCLUSION

In the opinion of ACS, Inc. the CAP and variant WAB, manufactured by Miltope Corporation., meets the requirements of FCC Part 15 subpart C and Part subpart E.