Test Report No. 8812372861

Applicant: ***Wavion Ltd.***

Equipment Under Test:
2.4 GHz Band Outdoor WiFi
(802.11b/g) Wireless Base Station

Model: ***WBS-2400***
FCC ID: ***UGM-WBS2400-2***

From The Standards Institution
Of Israel
Industry Division
Electronics & Telematics Laboratory
EMC Section

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Test Report No.: 8812372861 **Page 1 of 82 Pages**
Title: Test on 2.4 GHz Band Outdoor WiFi (802.11b/g) Wireless Base Station
Model: WBS-2400 **FCC ID: UGM-WBS2400-2**

Applicant:	Wavion Ltd.
Address:	6 Ha'yetsira Street, Yoqne'am-Illit, 20692, Israel
Sample for test selected by:	The customer
The date of test:	November 2008

Description of Equipment Under Test (EUT): 2.4 GHz Band Outdoor WiFi (802.11b/g) Wireless Base Station

Model: WBS-2400

Manufactured by: Wavion Ltd.

Reference Documents:

- **CFR 47 FCC:** Rules and Regulations; Part 15. “Radio frequency devices”; Subpart C: “Intentional radiators” (2006).

- **Test Results:** The EUT was found meeting with the relevant requirements of CFR 47 FCC Part 15 Sections: 15.205, 15.207, 15.209, 15.247.

This Test Report contains 82 Pages and may be used only in full.	This Test Report applies only to the specimen tested and may not be applied to other specimens of the same product.

Table of Contents

1. Applicant information

Company: Wavion Ltd.
Address : 6 Ha'yetsira Street
City: Yoqne'am-Illit
Country : Israel

2. Test performance

Location: SII EMC Section
Wavion Ltd.
Purpose of test: Apparatus compliance verification in according with CFR 47 FCC Requirement
Test specification: CFR 47 FCC Part 15 Sections: 15.205, 15.207, 15.209, 15.247

Test	FCC Part 15	Test result
Radiated emissions in restricted bands	Sec.15.205	Complies
Radiated Emission on Radio Unit: spurious	Sec.15.209	Complies
Conducted emission	Sec.15.207	Complies
Radiated emission – general requirements	Sec.15.209	Complies
Minimum bandwidth	Sec. 15.247 (a) (2)	Complies
Maximum peak output power	Sec.15.247 (b)	Complies
Peak power spectral density	Sec.15.247 (d)	Complies
Conducted spurious emissions	Sec.15.247 (c)	Complies

Electronics &
Telematics Laboratory
26 December 2008

Approved by: Eng. Yuri Rozenberg
Position: Head of EMC Branch

Tested by: Albert Herzenshtein
Position: Test Engineer

3. Scope

This test report contains results measured on 2.4 GHz Band Outdoor WiFi (802.11b/g) Wireless Base Station (FCC ID: UGM-WBS2400-2 according to the relevant requirements of CFR 47 FCC Part 15 Subpart C.

4. EUT (equipment under test) description.

4.1. General Description

The WBS-2400 is a new category of Wi-Fi Wireless Base Station designed from the ground up for metro-Wi-Fi deployments. It is based on six antennas and radios and custom-built ASICs, utilizes Wavion's powerful multi-antenna signal processing technologies, and provides significant performance gains to off-the-shelf 802.11 standards-based Wi-Fi clients.
The WBS-2400 Wi-Fi Wireless Base Station uses six omni-directional antennas and beam-forming technology in order to provide significant performance gains to off-the-shelf 802.11 standards-based Wi-Fi clients.

4.2. EUT's sub-assemblies list.

The EUT ports and lines are detailed in Table 1.

No.	Description	P/N; Model	Manufacturer
1	Digital Board	PC00043	Wavion
2	RF Board	PC00045	Wavion
3	DC/DC PS	PKB4711PINB	Ericsson
4	DC/DC PS 1/8 brick	SQE48T20050	PowerOne
5	DC/DC PS 1/16 brick	SSQE48T13050	PowerOne
6	DC/DC PS	0RCY-85T050	Bel
7	Antenna	MT-341017/N/A	MTI
8	RF filter	DFCH52G43HFHAA-TM1	Murata
9	RF filter	SRP2437K8N50SB	Bitel

Table 1. Sub-assemblies list

4.3. EUT ports and lines.

The EUT ports and lines are detailed in Table 2.

Port Type	Port Description	Connected from / to	Connector type	Qty.	Cable Type	Cable Length
Data	**Data/PoE**	**PD-Client**	**RJ-45 shielded**	**4**	**CAT-5e**	**Up to 100m**

Table 2. The EUT ports and lines

4.4. Potential emission source:

The potential emission sources are detailed in Table 3.

Frequency	Location	Remarks
40 MHz	On board	Crystal Oscillator with PLL

Table 3. Potential emission sources

4.5. Auxiliary equipment used:

The auxiliary equipment used is detailed in Table 4 4.

Function	Manufacturer	Model	Remarks
Laptop	IBM	ThinkPad T23	-
PoE injector	Telkoor	0525B5555	-

Table 4. Auxiliary equipment used

4.6. EUT technical characteristic

Type of equipment								
	Stand-alone (Equipment with or without its own control provisions)							
Intended use	**Condition of use**							
	Fixed	Always at a distance more than 2 m from all people						
Assigned frequency range	2400MHz to 2483.5MHz							
Operating frequency range	2412MHz to 2462MHz (WLAN channels 1 to 11)							
RF channel spacing	5MHz							
Maximum rated output power	At transmitter 50 Ω RF output connector	19dBm@2412MHz						
		19dBm@2437MHz						
		19dBm@2462MHz						
Is transmitter output power variable?		**Transmitter output power per output**						
	Yes	minimum RF power	4dBm					
		maximum RF power	19dBm					
Antenna connection								
	unique coupling	V (N-Type)	standard connector		integral		with temporary RF connector	
						V	without temporary RF connector	

External antenna/s technical characteristics			
Type	Manufacturer	Model number	Gain / Frequency range
Omni-directional	MTI	MT-341017/N/A	7.4dBi / 2.4-2.4835 GHz

Transmitter 99% power bandwidth	12000kHz to 16000kHz
Transmitter aggregate data rate/s (min-maximum)	1Mbps to 54Mbps
Type of modulation	OFDM, DSSS, CCK
Type of multiplexing	CSMA/CA
Modulating test signal (baseband)	Random data

Maximum transmitter duty cycle in normal use	90.%	Tx ON time	…X….msec	Period	…X….msec
Transmitter duty cycle supplied for test	100%	Tx ON time	…X….msec	Period	…X….msec

Transmitter power source					
V	DC	**Nominal rated voltage**	PoE 55VDC		
V	AC power for PoE injector	**Nominal rated voltage**	90-240VAC	Frequency: 50/60Hz	

Spread spectrum technique used	Frequency hopping (FHSS)	
	Digital transmission system (DTS)	V
	Hybrid	

Spread spectrum parameters for transmitters tested per FCC 15.247 only		
DSSS	chip sequence length	11bits
	spectrum width	12MHz

5. Test configuration:

The WBS-2400 unit has 2 possible RF transmit filters and 4 DC/DC power supplies. The difference between all the RF transmit filters is the manufacturer of the transmit filter. Below is a list of all the supported filter manufacturers and DC/DC PS models:

RF board transmit filter manufacturers:
1) Murata;
2) Bitel

DC/DC power supply:
1) PowerOne1/8;
2) PowerOne 1/16;
3) Ericsson;
4) Bell

Both of the above filters have the same operating frequency range.
The transmission power of each RF board is calibrated during the production process to a predetermined level, which is independent of the transmit filter manufacturer.
To check compliance in every configuration and to use filters and boards in any combination for the WBS-2400 device the following tests have been performed:

1. Conducted intentional radiation test: the conducted test (Minimum bandwidth; Peak power spectral density and Conducted spurious emissions) was performed with all possible configurations of Murata and Bitel.
2. Conducted unintentional radiation test: conducted (per 15.205) and radiated (per 15.209) emissions tests were performed with all possible DC/DC PS configurations.
3. Find the worst case sample, where it is most critical at band edge for the RF filters and emissions for the PS.
4. Radiated (on the band edge) and repeat conducted intentional radiation tests of worst case sample.
5. Conducted/radiated unintentional radiation tests for the worst case sample.

In order to find the “worst case” sample, which can represent all kinds of RF filters & DC/DC PS, each of them was pre-tested as described above.
After all radio conducted tests the Bitel models were chosen as the “worst case”, all final measurements were performed with 6 Bitel filters.
After all unintentional emissions tests the Bell and PowerOne 1/8 models were chosen as the “worst case”, all final measurements were performed twice.

RF output terminated by 50Ω

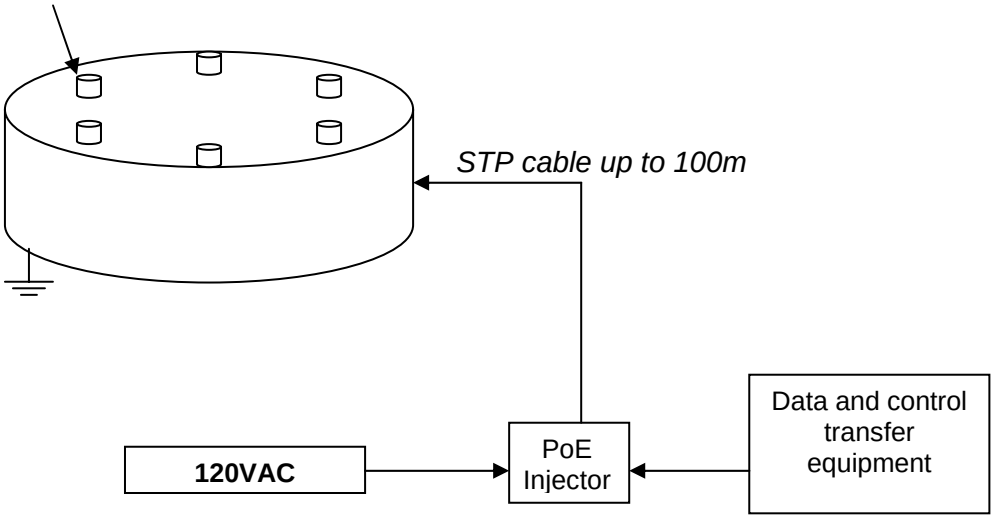


Figure 1. Radiated emission test setup

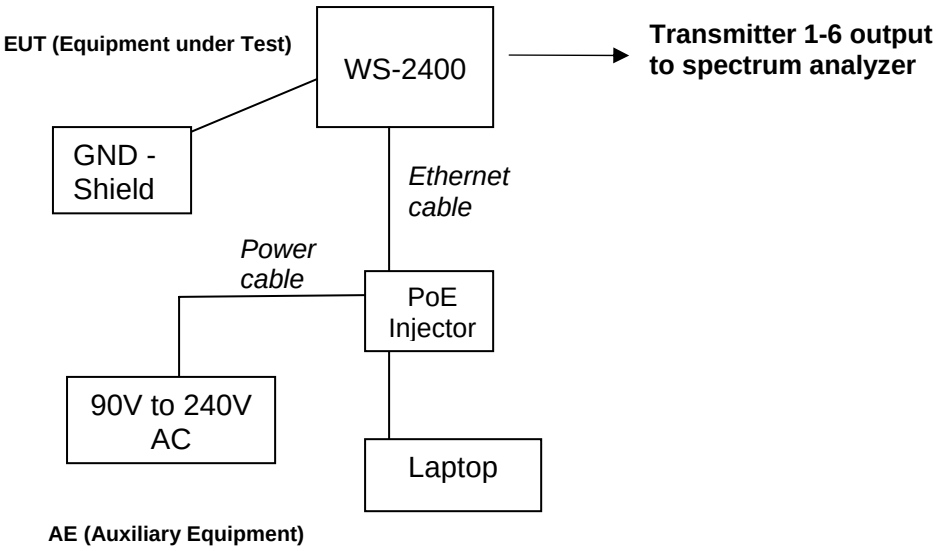


Figure 2. Transmitter measurements test setup

5.1. Environmental evaluation and exposure limit according to FCC CFR 47 part 1, §1.1307, §1.1310

Limit for power density for general population/uncontrolled exposure is 1 mW/cm^2.

The power density P (mW/cm^2) = Pt /4π r^2.

Where:

Pt – The transmitted power (EIRP) (mW)

Pt- the transmitted power whish is equal to the output power 19 dBm plus maximum antenna gain – 7.4 dBi

r – The distance from the unit (cm)

The 1(mW/cm^2) limit can be calculated from the above based on the following data:

The maximum EIRP for each transmit output = 26.4 dBm = 436.5mW

r = sqrt(436.5/4π) = 5.9 cm

For aggregate Pt- the transmitted power whish is equal to the output power 26.9 dBm plus maximum directional antenna gain – 15.2 dBi

The maximum aggregate EIRP = 42.1 dBm = 16218 mW:

r = sqrt(16218/4π) = 35.9 cm

The allowed distance “r”, where RF exposure limits may not be exceeded, is 35.9 cm from the unit antenna main lobe.

The EUT with the attached antenna are mounted only outside the building on the high level pole or wall, which are above general public, see the manufacturer instructions for installation provided in attached documentation.

6. Test specification, Methods and Procedures

Test Specification:

- CFR 47 FCC: Rules and Regulations; Part 15. "Radio frequency devices";
  Subpart B: "Unintentional radiators";
  Subpart CC: "Intentional radiators" (2006).

Methods and Procedures:

- ANSI C63/4/2003: "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz".

7. Measurements, examinations and derived results

7.1. Location of the Test Site:

The tests were conducted in the EMC laboratory of the Standards Institution of Israel in Tel-Aviv, in Wavion's laboratory and at open test site located at Kibbutz Native Halamed Hai in Emek HaEla, Israel.

7.2. Test condition:

Temperature: 22 °C
Humidity: 50 %

7.3. Conducted emission test (Subscriber Unit)(per Section 15.207):

7.3.1. Requirements:

The EUTs conducted emission within the band 150 kHz to 30 MHz shall not exceed value required in section 15.207 Subpart C.

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases with the logarithm of the frequency.

7.3.2. Pre-test scanning:

In order to find the "worst case" sample, which can represent WBS-2400, one sample of the device contains each DC/DC PS was pre-tested. After all conducted tests the model PowerOne 1/8 were chosen as the "worst case", all unintentional radiation measurements were performed on it.

7.3.3. Test procedure:

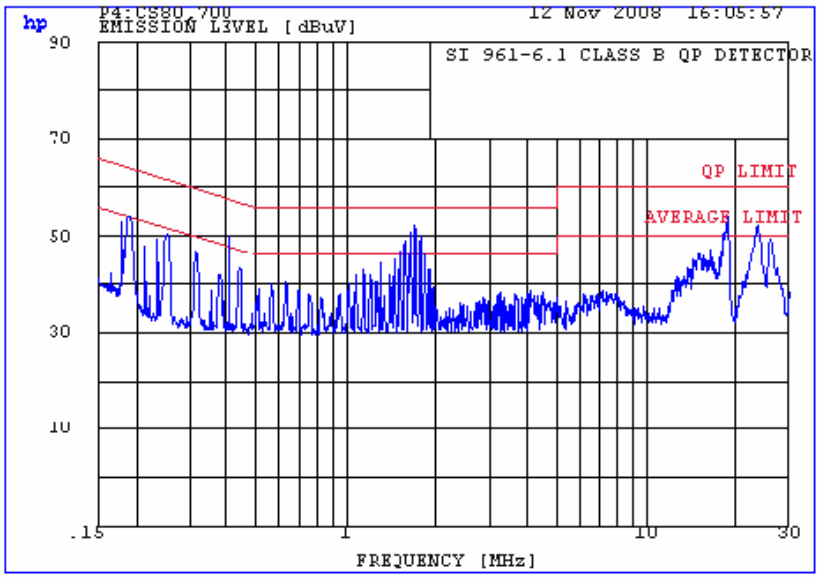
The EUT was operated to transmitting through the customer software.
First, initial scans were performed in normal (transmitting) mode of operation for carrier (channel) frequency at low, middle and the high of the 2.412 – 2.462 GHz frequency range under 4 data transfer bit rates. The worst results from all measurements (2412MHz frequency, 6Mbps bit rate) are presented at the plots 1 and 2.
The measurements were performed on the auxiliary PoE injector AC/DC PS 120 VAC mains input. The EUT was placed on a non-metallic table in a shielded chamber at a height of 80 cm from the floor and 40 cm from the nearest wall.
Test equipment (EMI receiver) setup was as follow:

Initial scan:	
Detector type	Peak
Mode	Max hold
Bandwidth	9 kHz
Step size	Continuous sweep
Sweep time	>100 msec
Measurements	
Detector type	Quasi-peak, Avg (CISPR)
Bandwidth	9 kHz
Measurement time	200 seconds/MHz
Observation	>15 seconds

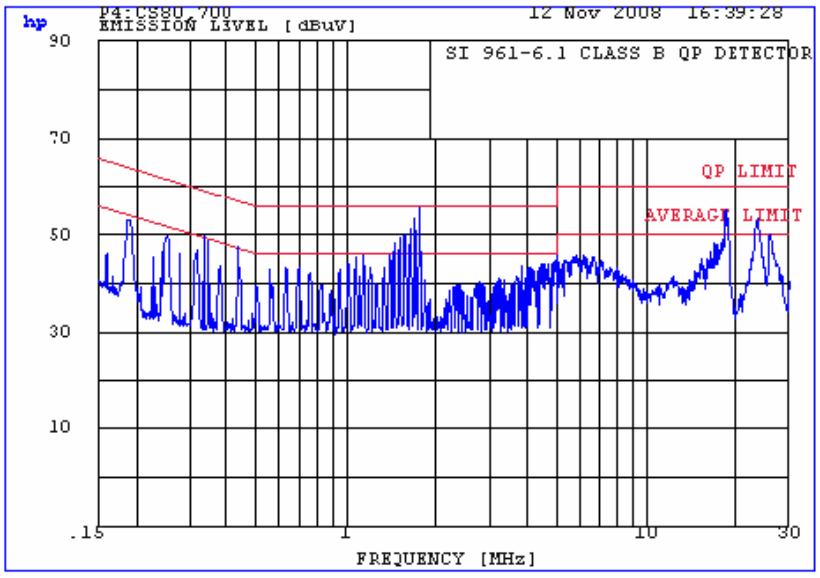
7.3.4. Test results:

Scans of pre-test scanning for 4 units are presented in Pots # 1-8.
Final test results are shown in Plots #9-16.
The test results were found complies with relevant standard requirements.

Bell Power Supply

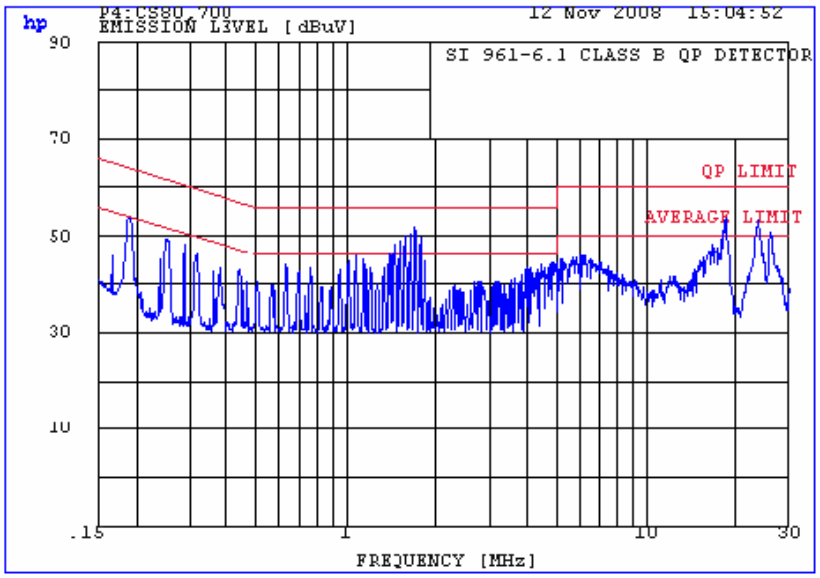


Plot # 1. Conducted emissions measurement result on 120 VAC power. Line- phase.

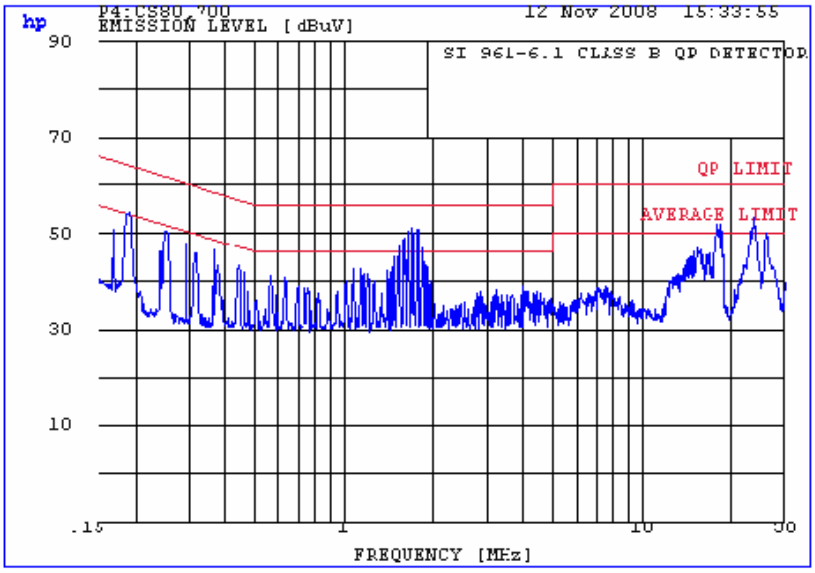


Plot # 2. Conducted emissions measurement result on 120 VAC power. Line- neutral.

Ericsson Power supply

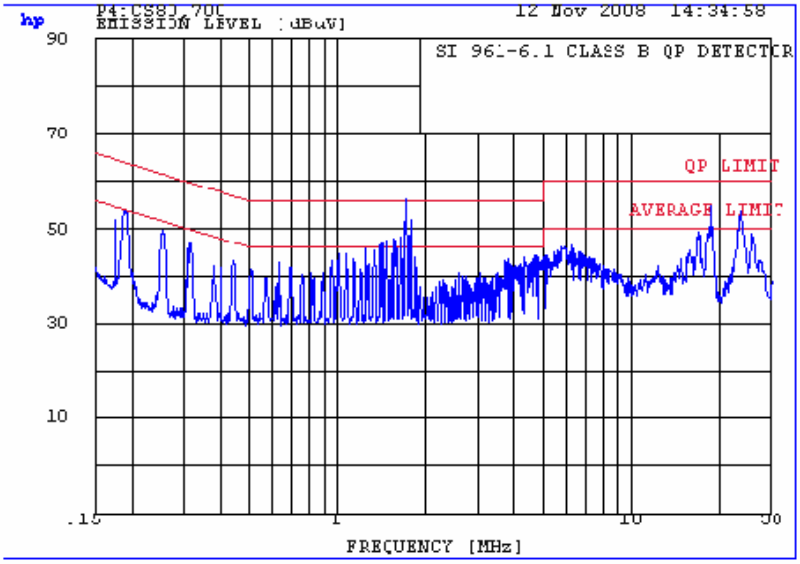


Plot # 3. Conducted emissions measurement result on 120 VAC power. Line- phase.

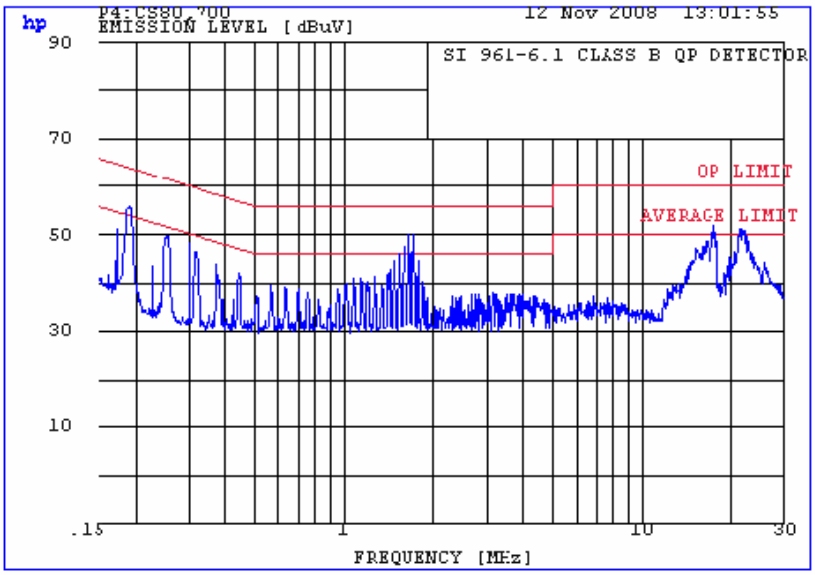


Plot # 4. Conducted emissions measurement result on 120 VAC power. Line- neutral.

PowerOne 1/8 Power supply

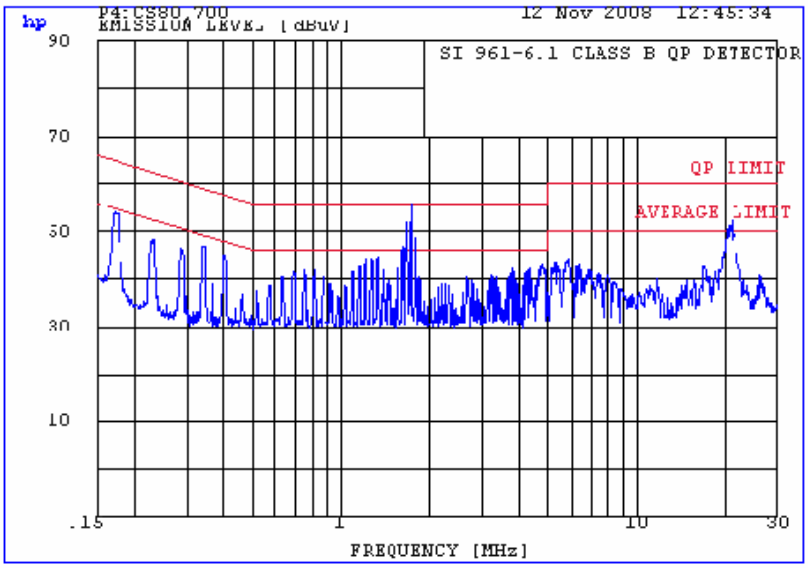


Plot # 5. Conducted emissions measurement result on 120 VAC power. Line- phase.

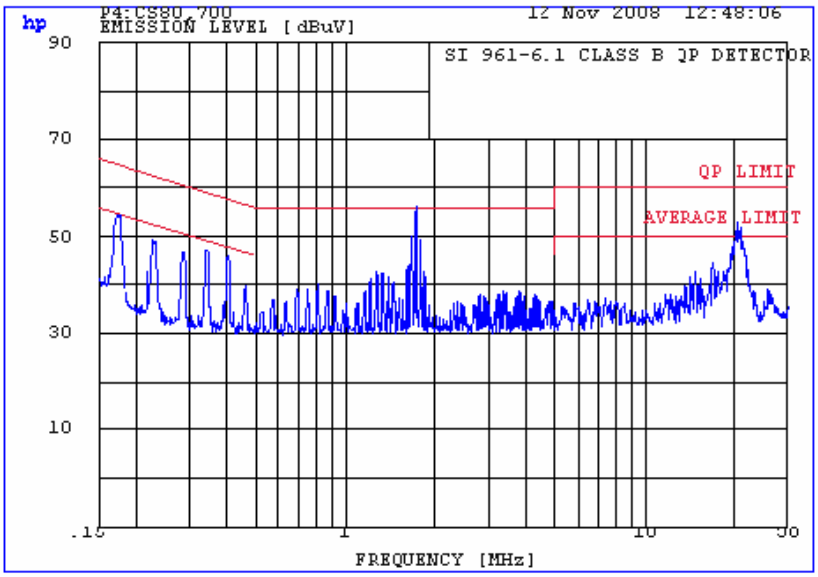


Plot # 6. Conducted emissions measurement result on 120 VAC power. Line- neutral.

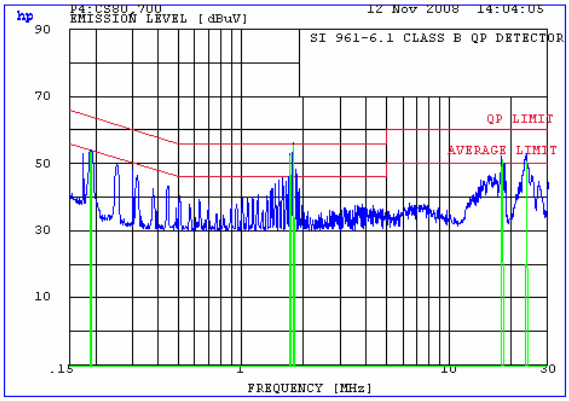
PowerOne 1/16 Power supply



Plot # 7. Conducted emissions measurement result on 120 VAC power. Line- phase.

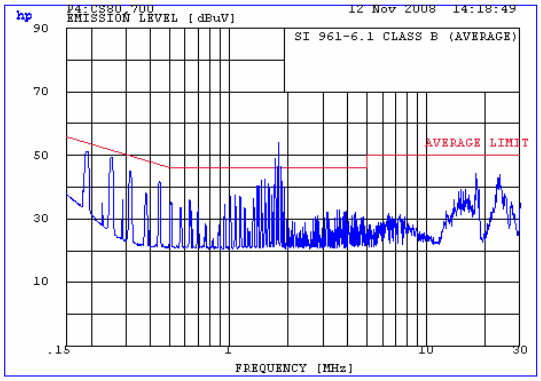


Plot # 8. Conducted emissions measurement result on 120 VAC power. Line- neutral.



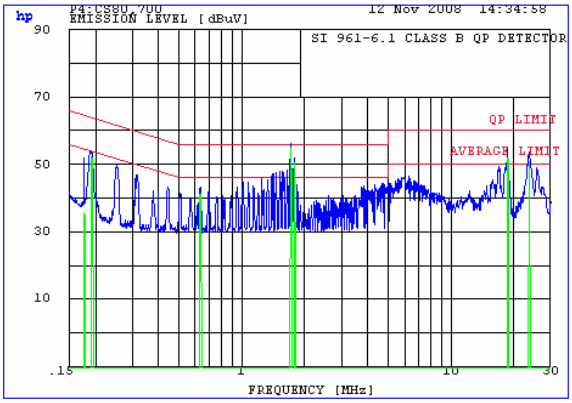
PEAK#	FREQ (MHz)	(dBuV)	DELTA
1	.1893	53.2	-10.8
2	1.721	52.3	-3.7
3	1.786	55.5	-.5
4	18.14	51.1	-8.9
5	23.52	50.6	-9.4

Plot # 9. POWER ONE DC/DC 1:8
LINE NEUTRAL QP detector



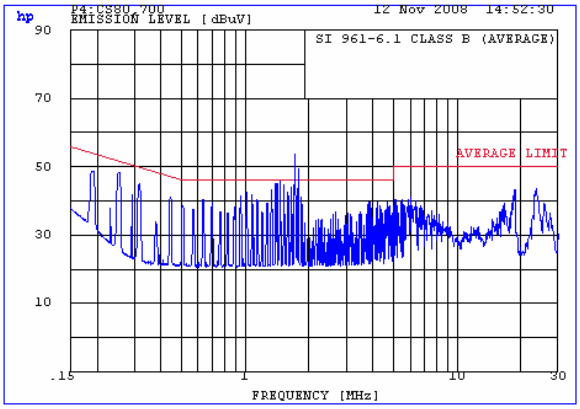
PEAK#	FREQ (MHz)	(dBuV)	DELTA
1	1.721	28.41	-17.59
2	1.786	32.7	-13.3

Plot # 10. POWER ONE DC/DC 1:8
LINE NEUTRAL AVG detector



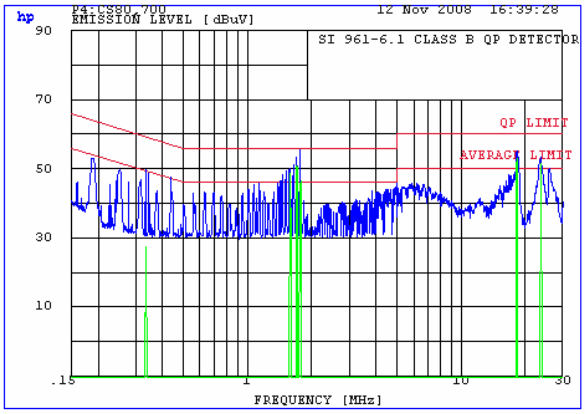
PEAK#	FREQ (MHz)	(dBuV)	DELTA
1	.1924	52.3	-11.6
2	.6363	41.1	-14.9
3	1.721	54.9	-1.1
4	1.786	50.6	-5.4
5	18.63	51.7	-8.3
6	23.64	50.8	-9.2

Plot # 11. POWER ONE DC/DC 1:8
LINE Phase QP detector



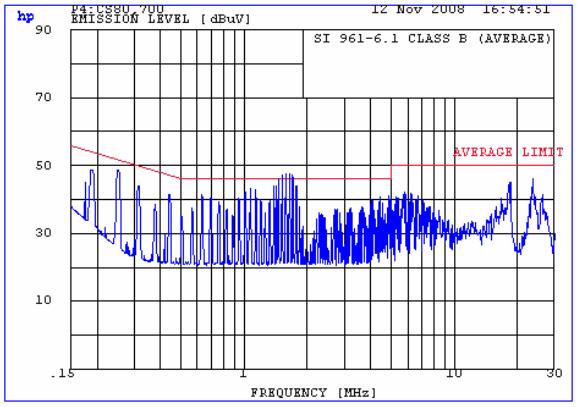
PEAK#	FREQ (MHz)	(dBuV)	DELTA
1	1.721	33.86	-12.14
2	1.786	31.4	-14.6

Plot # 12. POWER ONE DC/DC 1:8
LINE Phase AVG detector



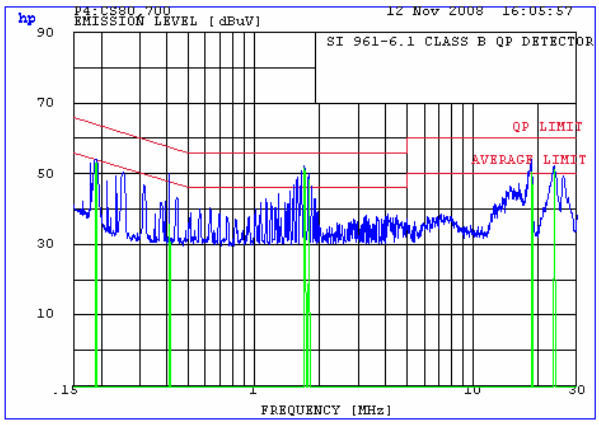
PEAK#	FREQ (MHz)	(dBuV)	DELTA
1	1.581	48.8	-7.2
2	1.703	50.8	-5.2
3	1.777	46.3	-9.7
4	18.34	52.8	-7.2
5	23.52	51.6	-8.4

Plot # 13. Bell DC/DC PS
LINE NEUTRAL QP detector



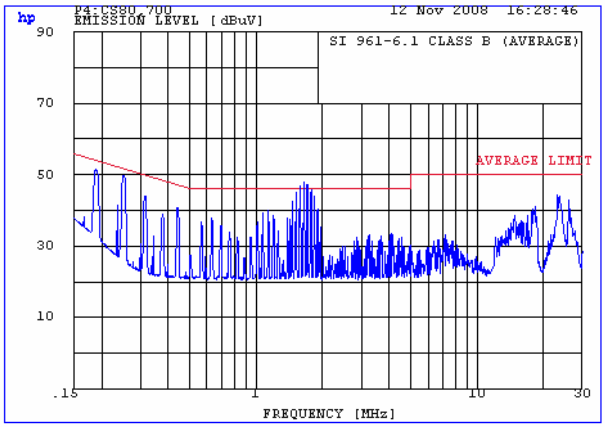
PEAK#	FREQ (MHz)	(dBuV)	DELTA
1	1.581	23.5	-22.5
2	1.703	32.8	-13.2
3	1.777	29.1	-16.9

Plot # 14. Bell DC/DC PS
LINE NEUTRAL AVG detector



PEAK#	FREQ (MHz)	(dBuV)	DELTA
1	.1893	53.1	-10.9
2	1.703	51.4	-4.6
3	1.777	48.1	-7.9
4	18.63	50.5	-9.5
5	23.52	51	-9.0

Plot # 15. Bell DC/DC PS
LINE Phase QP detector



PEAK#	FREQ (MHz)	(dBuV)	DELTA
1	1.703	32.7	-17.9
2	1.777	28.1	-13.3

Plot # 16. Bell DC/DC PS
LINE Phase AVG detector

7.4. Radiated emission test (per section 15.209):

7.4.1. Requirements:

The EUTs radiated emission shall not exceed value required in section 15.209.

7.4.2. Pre-test scanning:

In order to find the "worst case" sample, which can represent WBS-2400, one sample of the device contains each DC/DC PS was pre-tested. After all radiated emission preliminary tests the model Bell was chosen as the "worst case", all unintentional radiation tests were performed on it.

7.4.3. Test description:

The measurements were performed at the Open Area Test Site.
The test configuration is shown in Fig.2.
The EUT was arranged on a non-metallic table 0.8 m placed on the turn-table.
The measurements were performed at a 10 m measurement distance.
The Biconilog 30 MHz-2 GHz antenna was used.
The frequency range was investigated from 30 MHz to 2 GHz.
The measurements were performed at each frequency at which the signal was 20 dB below the limit or less.
The level were maximized by initially rotating turntable through 360°, varying the antenna height between 1 m and 4 m, rerouting EUT cables and changing antenna polarization from vertical to horizontal. The measuring equipment settings were:

Initial scan:	
Detector type	Peak
Mode	Max hold
Bandwidth	120 kHz
Step size	Continuous sweep
Sweep time	>1 seconds/MHz
Measurements:	
Detector type	Quasi-peak (CISPR 16)
Bandwidth	120 kHz
Measurement time	20 seconds/MHz
Observation	>15 seconds

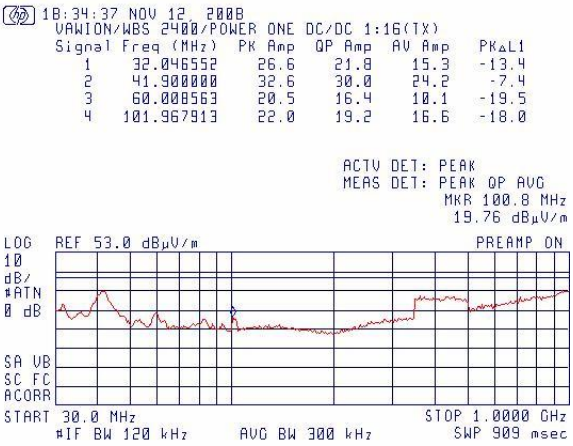
7.4.4. Radiated emission test results:

Scans of pre-test scanning for 4 units are presented in Pots # 17-20.
Test results are presented in Table 5.
The test results were found complies with relevant standard requirements.

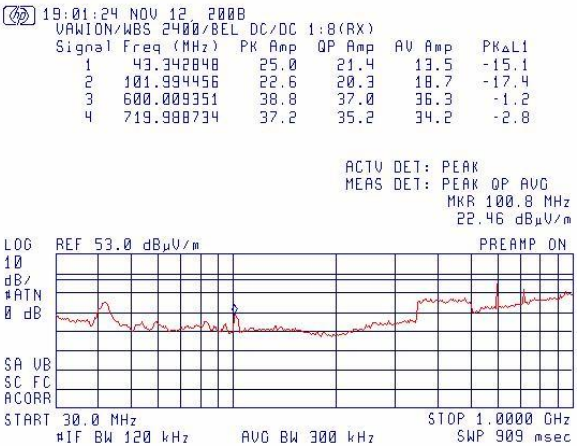
Plot # 17.
Power One 1/8 DC/DC PS

Frequency MHz	Peak dBuV/m	Limit Line dB	Peak-Limit dB	Comment
560.010	37.7	0.0	-13.3	

Plot # 18.
Ericsson DC/DC PS



Plot # 19.
Power One 1/16 DC/DC PS



Plot # 20.
Bel DC/DC PS

Table 5. Radiated emission test results
FCC Part 15 section 15.209

PowerOne 1/8 PS

Frequency (MHz)	Antenna Polariz. V/H	Antenna Height (m)	Turn-table Angle (°)	Emission Level Note 1 (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin Note 2 (dB)	Results
32.0	V	1.0	86	33.2	39.0	5.8	Complies
32.9	V	1.0	86	34.0	39.0	5	Complies
39.4	V	1.0	304	35.2	39.0	3.8	Complies
40.3	V	1.0	304	35.5	39.0	3.5	Complies
42.4	V	1.0	355	32.9	39.0	6.1	Complies
45.0	V	1.0	96	30.1	39.0	8.9	Complies
63.9	V	1.0	283	25.1	39.0	13.9	Complies

Bell 1/8 PS

Frequency (MHz)	Antenna Polariz. V/H	Antenna Height (m)	Turn-table Angle (°)	Emission Level Note 1 (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin Note 2 (dB)	Results
31.5	V	1.0	255	32.5	39.0	6.5	Complies
32.5	V	1.0	255	33.7	39.0	5.3	Complies
39.8	V	1.0	354	35.4	39.0	3.6	Complies
41.1	V	1.0	8	34.0	39.0	5	Complies
42.3	V	1.0	300	33.0	39.0	6	Complies
49.0	V	1.0	161	29.7	39.0	9.3	Complies
63.4	V	1.0	93	25.3	39.0	13.7	Complies

Note 1: Emission level = E Reading (dBμV) + Cable loss (dB) + Antenna Factor (dB/m) + 10 dB

Where 10 dB is an extrapolation to 3m distance factor.
For Cable Loss and Antenna Factor refer to Appendix 2.

Note 2: Margin (dB) = Limit (dBμV/m) – Emission level (dBμV/m)

7.5. Conducted spurious emission

7.5.1. Requirements:

Clause 15.247(c). In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

7.5.2. Pre-test scanning:

In order to find the "worst case" sample, which can represent all kinds of RF filters, each filter (Murata and Bitel filters) was pre-tested.

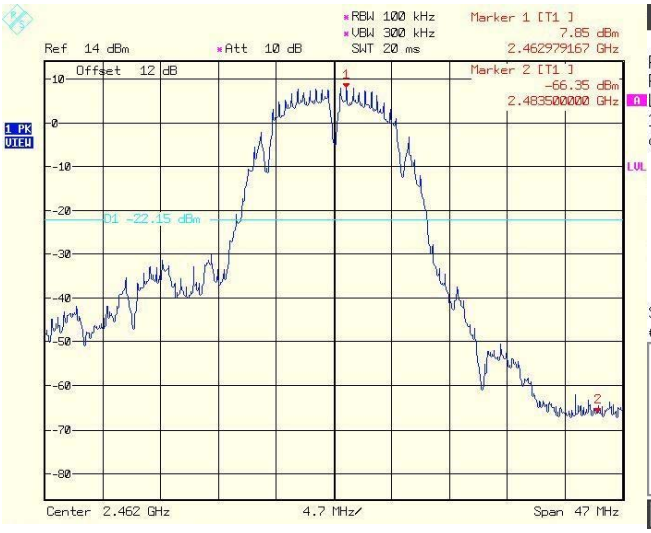
After all conducted spurious emissions tests the Bitel model was chosen as the "worst case", all final measurements were performed with 6 Bitel filters (see 7.5.4).

7.5.3. Test Procedure:

The transmitter output is connected to a spectrum analyzer.
The RBW is set to 100 kHz.
The VBW is set to 300 kHz.
The spectrum from 30MHz to 26GHz is investigated with the transmitter set to the low, middle and high frequencies.

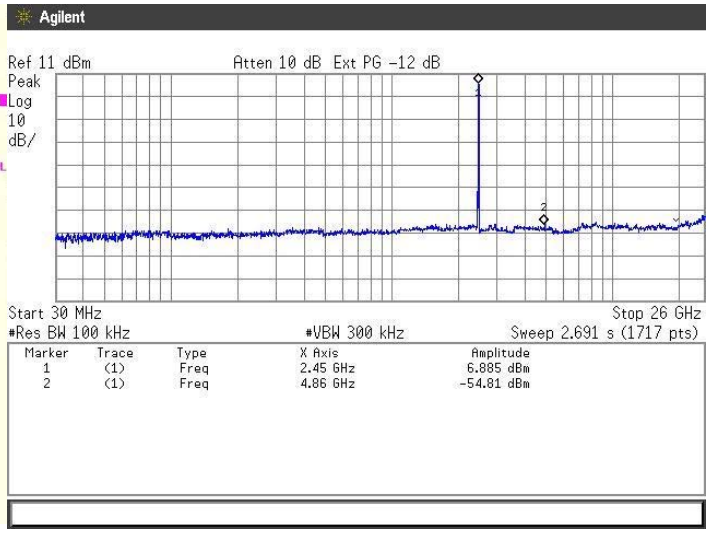
7.5.4. Test Results:

The WBS-2400 configurations for preliminary tests were as following: 2 RF filters Murata (outputs 1 & 2), 4 RF filter Bitel (outputs 3 -6).
The plots of conducted spurious emissions pre-scan for each RF filters (outputs 1-6 accordantly) are presented on the plots # 21-40. The most differences in spurious emissions were found. Following pre-scan tests results the "worst case" from the point of view of spurious emissions is Bitel filter.



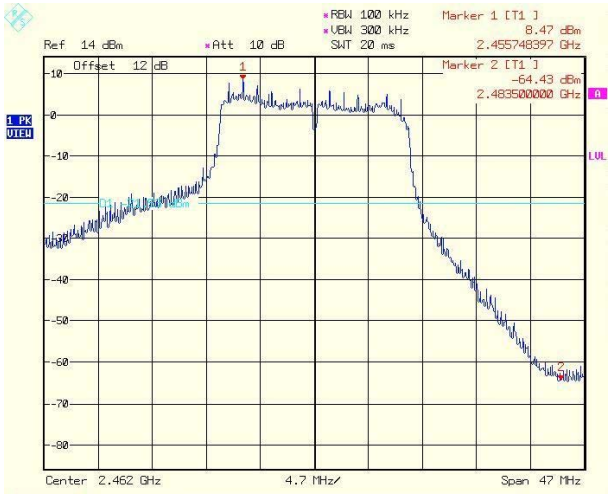
Plot # 21.

Output 1. High frequency bandedge.
802.11b mode. 1 bps rate.



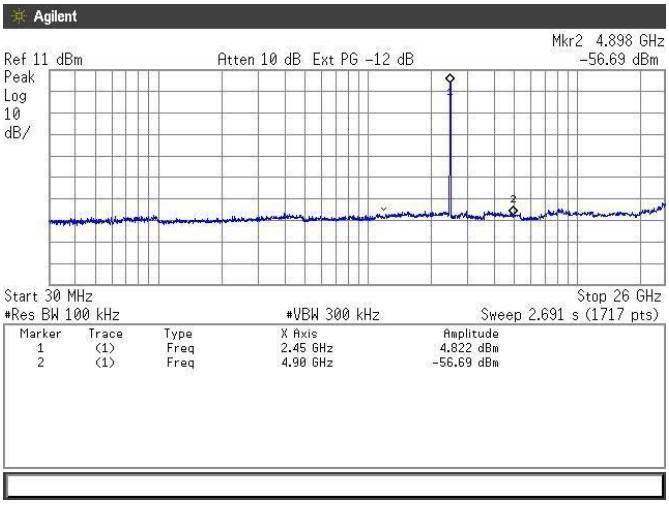
Plot # 22.

Output 1. High frequency spurious.
802.11b mode. 1 bps rate.



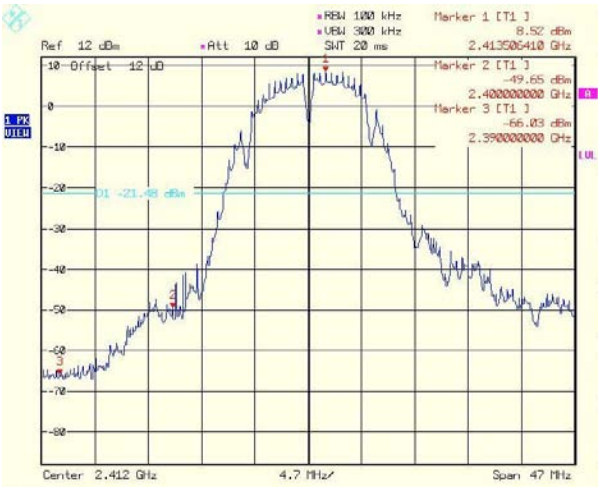
Plot # 23.

Output 1. High frequency bandedge.
802.11b mode. 6 bps rate.



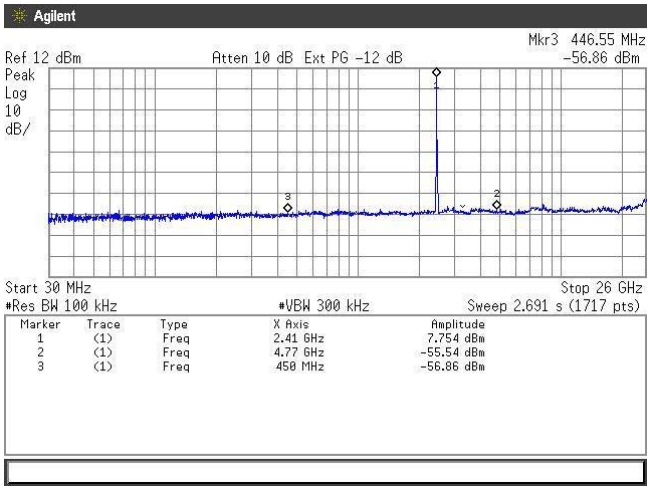
Plot # 24.

Output 1. High frequency spurious.
802.11b mode. 6 bps rate.



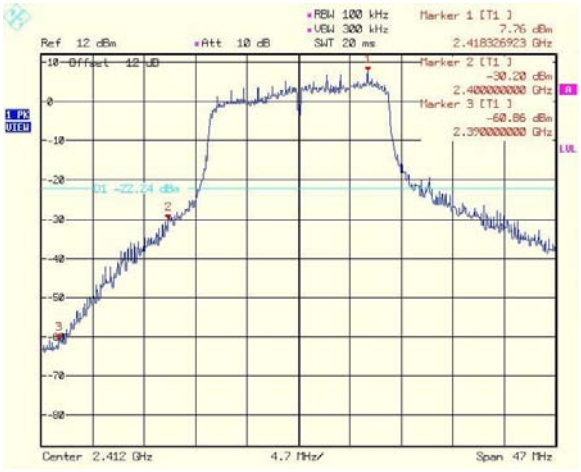
Plot # 25.

Output 2. Low frequency bandedge.
802.11b mode. 1 bps rate.



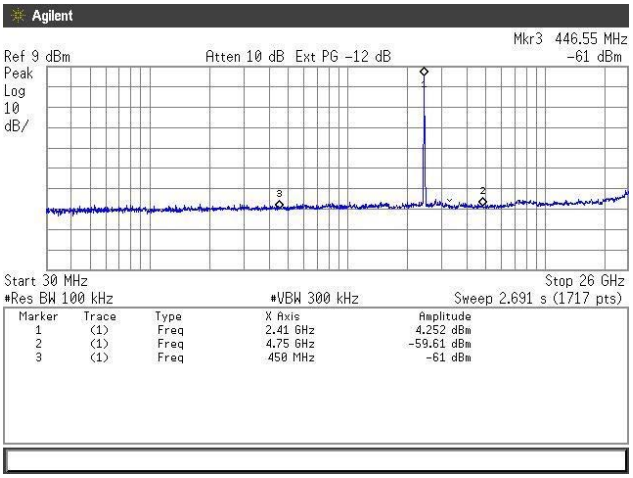
Plot # 26.

Output 2. Low frequency spurious.
802.11b mode. 1 bps rate.



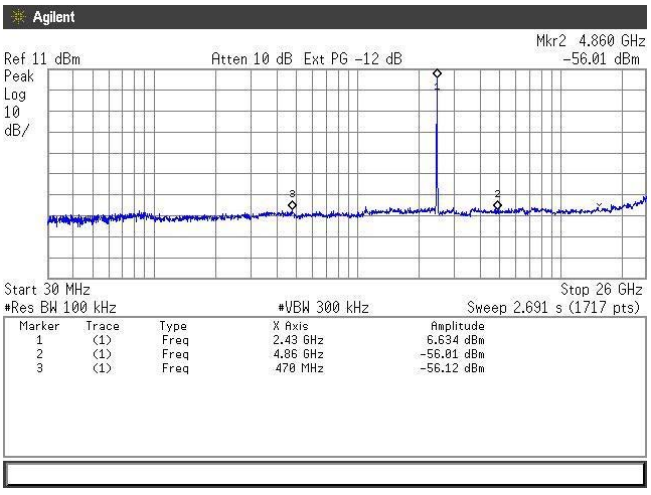
Plot # 27.

Output 2. Low frequency bandedge.
802.11b mode. 6 bps rate.



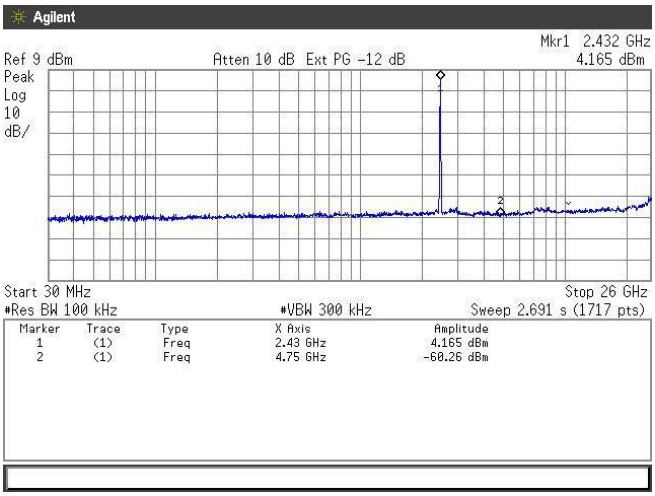
Plot # 28.

Output 2. Low frequency spurious.
802.11b mode. 6 bps rate.



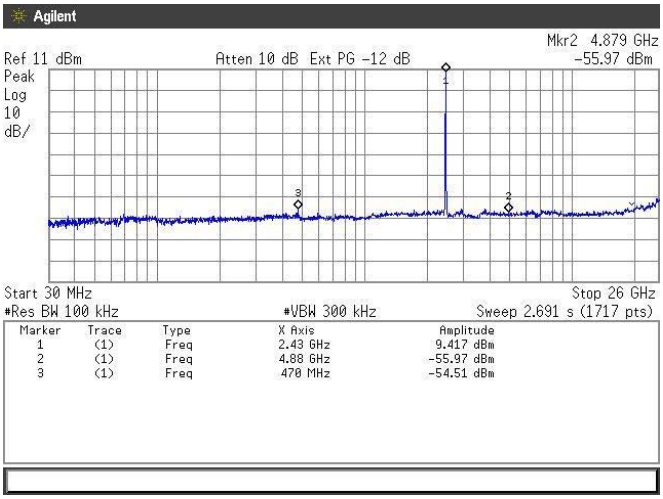
Plot # 29.

Output 2. Middle frequency bandedge.
802.11b mode. 1 bps rate.



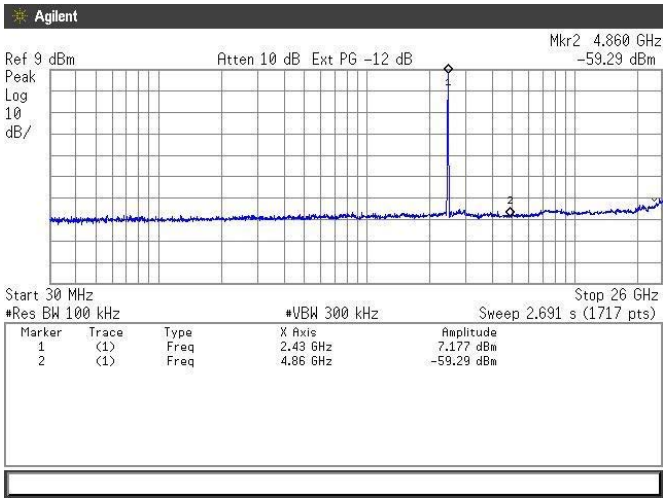
Plot # 30.

Output 2. Middle frequency bandedge.
802.11b mode. 6 bps rate.



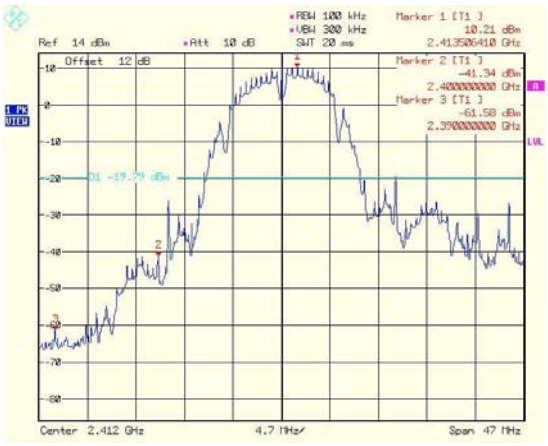
Plot # 31.

Output 6. Middle frequency bandedge.
802.11b mode. 1 bps rate.



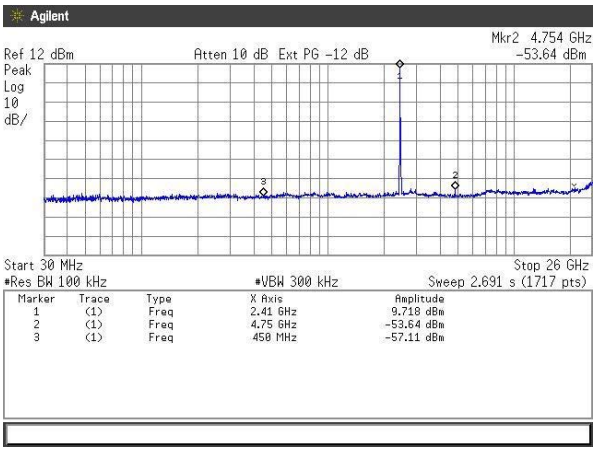
Plot # 32.

Output 6. Middle frequency bandedge.
802.11b mode. 6 bps rate.



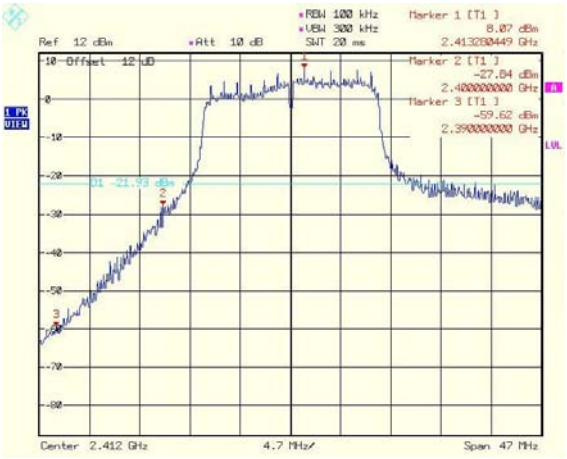
Plot # 33.

Output 3. Low frequency bandedge.
802.11b mode. 1 bps rate.



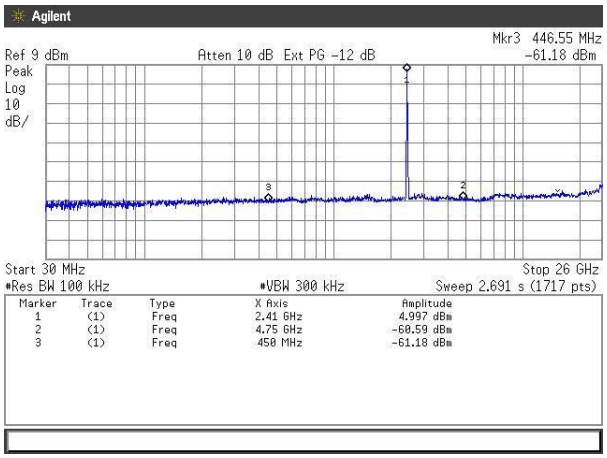
Plot # 34.

Output 3. Low frequency bandedge.
802.11b mode. 1 bps rate.



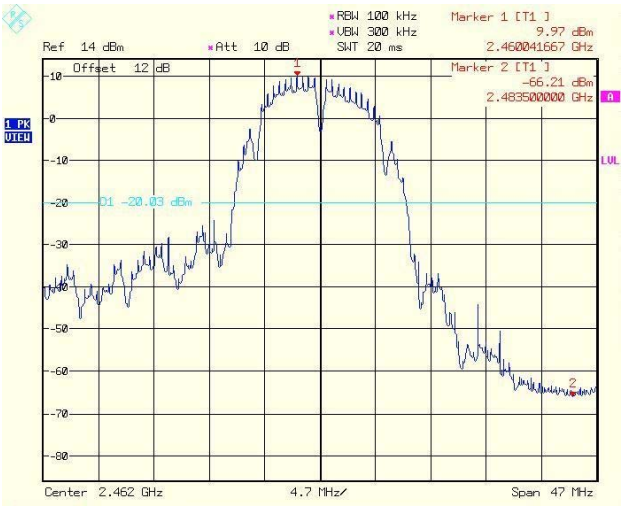
Plot # 35.

Output 3. Low frequency bandedge.
802.11g mode. 6 bps rate.



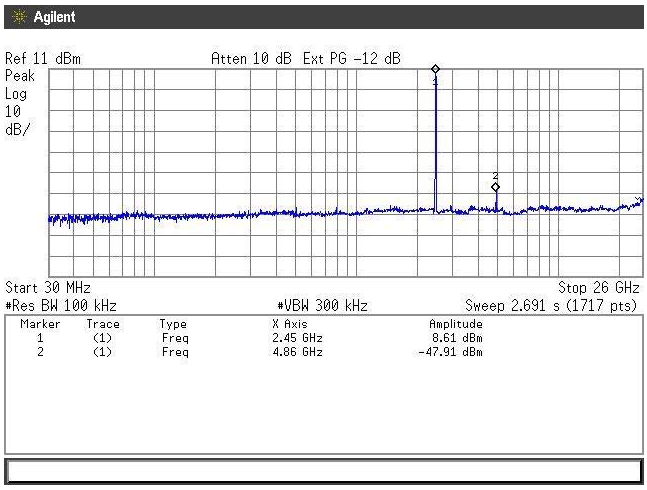
Plot # 36.

Output 3. Low frequency bandedge.
802.11g mode. 6 bps rate.



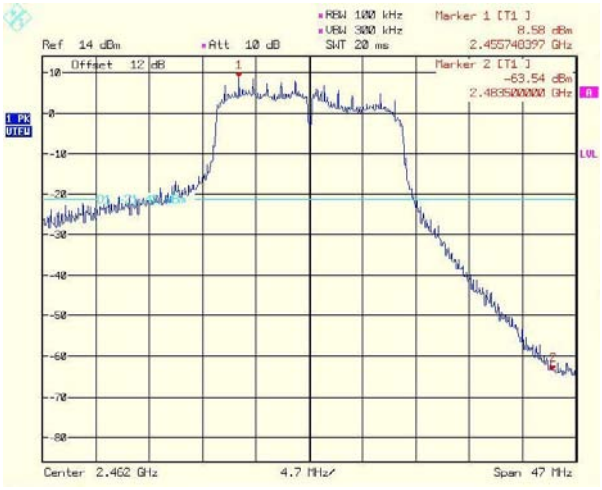
Plot # 37.

Output 3. High frequency spurious.
802.11b mode. 1 bps rate.



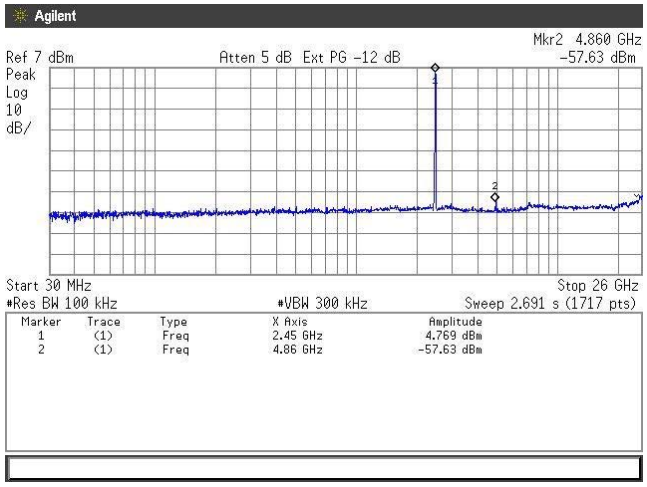
Plot # 38.

Output 3. High frequency spurious.
802.11b mode. 1 bps rate.



Plot # 39.

Output 3. High frequency spurious.
802.11g mode. 6 bps rate.



Plot # 40.

Output 3. High frequency spurious.
802.11g mode. 6 bps rate.