REGULATORY TEST REPORT

TITLE: 2.4GZ FCC & IC Digital Transmission Device Compliance Report
AUTHOR: Dan Bomsta

REV	CCO	*DESCRIPTION OF CHANGE*	DATE	APPROVALS	
		INITIAL RELEASE		Engineering	
				Engineering	

REVISION HISTORY

				Engineering	
				Engineering	
				Engineering	

Test Data Summary

FCC 15.247 / IC RSS-210
IEEE 802.15.4™; ZigBee®
Digital Transmission Device, 2.405 - 2.475 GHz

FCC ID: EO924GZA
IC: 864D-24GZA
Model Number: 2.4GZ

OATS Registration Number: FCC 90716, IC 5615

Rule	Description	Max. Reading	Pass/Fail
Part 15.207 / RSS-Gen 7.2.2	AC Powerline Conducted Emissions	N/A (battery device)	N/A
Part 15.247(b)(3) / RSS-210 A8.4(4)	Peak RF Power Output – Conducted	0.037 W @ 2405 MHz	Pass
Part 15.247(a)(2) / RSS-210 A8.2(a)	6 dB Bandwidth - Conducted	1.625 MHz @ 2405 MHz	Pass
Part 15.247(e) / RSS-210 A8.2(b)	Peak Power Spectral Density – Conducted	1.35 dBm @ 2405 MHz	Pass
Part 15.247(d) / RSS-210 A8.5	Spurious Emissions – Conducted	-63.71dBc @ 7420 MHz	Pass
Parts 15.205 & 15.209 / RSS-210 2.2, 2.6 Tables 1 & 2	Restricted Bands / Spurious Emissions – Radiated	51.52 dBµV/m @ 3m (4810 MHz)	Pass
RSS-210 A.1.1.3 99% BW	Bandwidth of momentary signals	3.075 MHz @ 2405 MHz	Pass
RSS-Gen 7.2.3	Receiver Spurious Emissions – Radiated	38.3dBuV/m peak 27dBuV/m average	Pass

Rule versions: FCC Part 1 (10-2006), FCC Part 2 (10-2006), FCC Part 15 (05-04-2007), RSS-Gen Issue 2 (06-2007), RSS-210 Issue 7 (06-2007).
Reference docs: ANSI C63.4-2003, FCC KDB Publication, 558074, March 23, 2005, New Guidance on Measurement for Digital Transmission Systems in Section 15.247.

Cognizant Personnel	
Name Mark Kvamme	Title Test Technician
Name Dan Bomsta	Title 2.4GZ Regulatory Engineer

15.31 (e)

This is a battery powered device. Nominal battery voltage is 3.0 Vdc. In order to perform conducted testing of the device, the battery was removed and a DC supply was used in its place. The DC supply was varied between 2.55 Vdc and 3.40 Vdc. The maximum peak RF power was found with the DC supply at 3.40 Vdc. All conducted testing was performed at 3.40 Vdc. All radiated testing was performed using a new battery.

15.247(b) (3) / RSS-210 A8.4 (4): RF Power Output

The maximum peak conducted output power of the intentional radiator shall not exceed the following: For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt.

This is an RF conducted test. Use a direct connection between the antenna port of the transmitter and the spectrum analyzer, through suitable attenuation.

RBW > 6 dB bandwidth of the emission
VBW ≥ RBW
Span = > 6 dB bandwidth of the emission
Sweep = auto
Detector function = peak
Trace = max hold

Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power.

Equipment Used	Model Number	Serial Number	Cal Date	Due
Spectrum Analyzer	HP 8593E	MY45113415	Oct/07	Oct/08
RF Test Cable	SUCOFLEX 104	220057 002	03/08	03/09
Date		**Tested by**		
5/13/2008		Dan Bomsta		

Cable loss of 0.2 dB was added to the spectrum analyzer as a correction. The marker value in the plots is the true corrected value.

Frequency (MHz)	Corrected Conducted Power (W)
2405	0.037
2440	0.035
2475	0.034

Table 1: Summary Table of Output Power

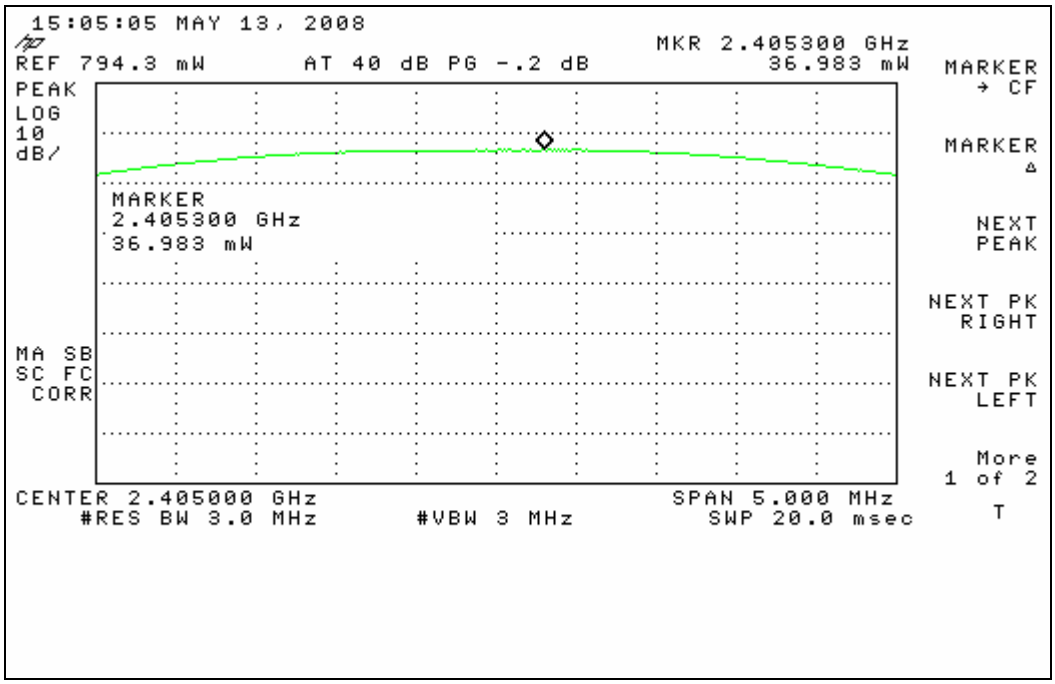


Figure 1: Conducted Power Measurement: f = 2.405GHz

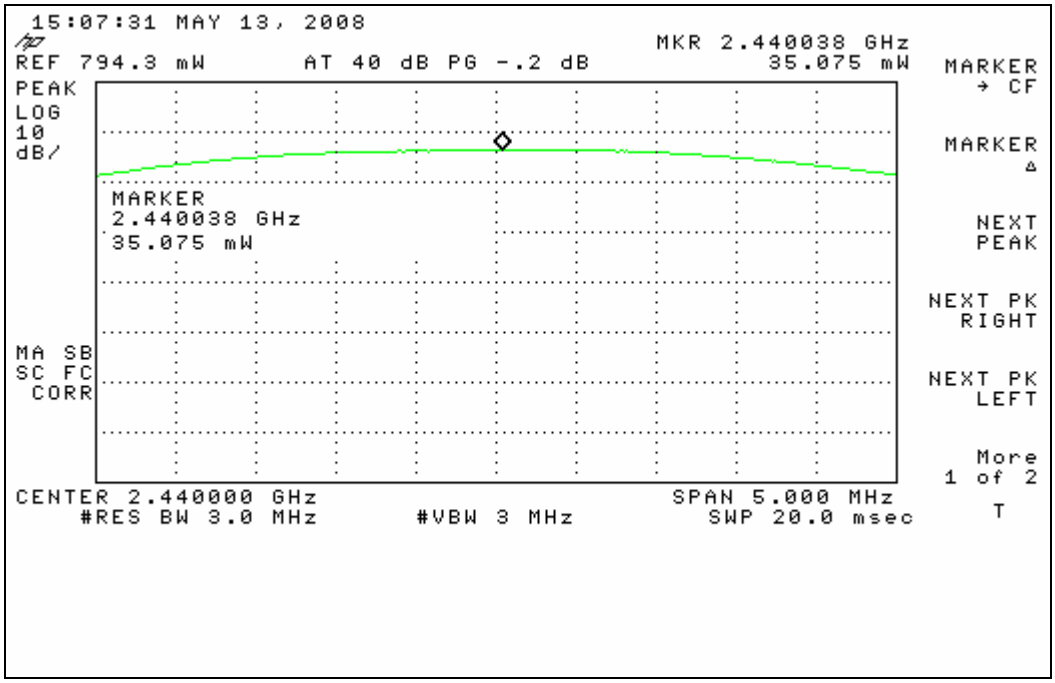


Figure 2: Conducted Power Measurement: f = 2.440GHz

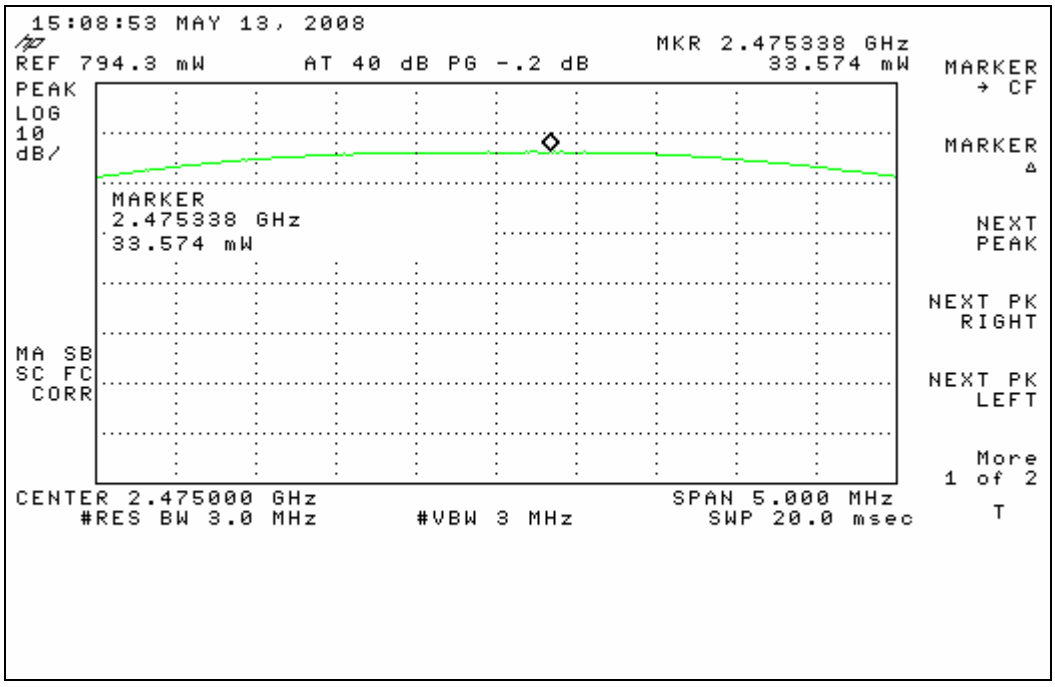


Figure 3: Conducted Power Measurement: f = 2.475GHz

Part 15.247(a) (2) / RSS-210 A8.2 (a): 6 dB Bandwidth

Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

Use the following spectrum analyzer settings:

RBW = 100 kHz
VBW ≥ RBW
Span = 5 MHz
Sweep = auto
Detector function = Peak
Trace = max hold

The EUT should be transmitting at its maximum data rate. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. Use the marker-delta function to measure 6 dB down one side of the emission. Reset the marker-delta function, and move the marker to the other side of the mission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is the 6 dB bandwidth of the emission. If this value varies with different modes of operation (e.g., data rate, modulation format, etc.), repeat this test for each variation.

Equipment Used	Model Number	Serial Number	Cal Date	Due
Spectrum Analyzer	HP 8593E	MY45113415	Oct/07	Oct/08
RF Test Cable	SUCOFLEX 104	220057 002	03/08	03/09
Date				**Tested by**
5/13/2008				Dan Bomsta

Frequency (MHz)	6 dB Bandwidth (MHz)
2405	1.625
2440	1.599
2475	1.599

Table 2: Summary table of 6dB Bandwidth

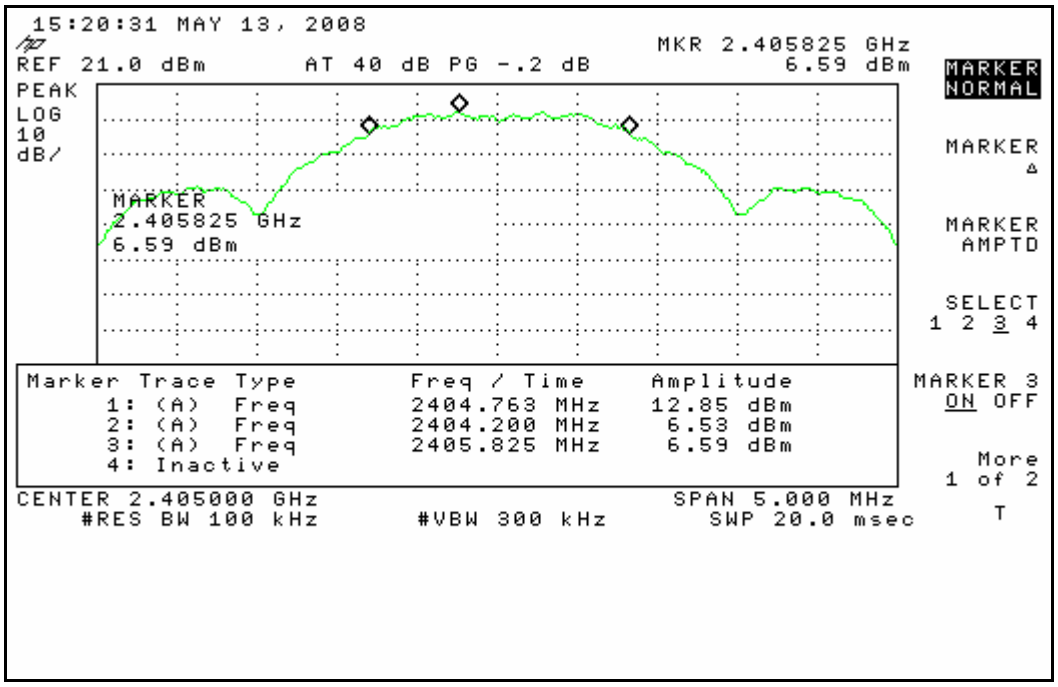


Figure 4: 6 dB Bandwidth f = 2.405 GHz

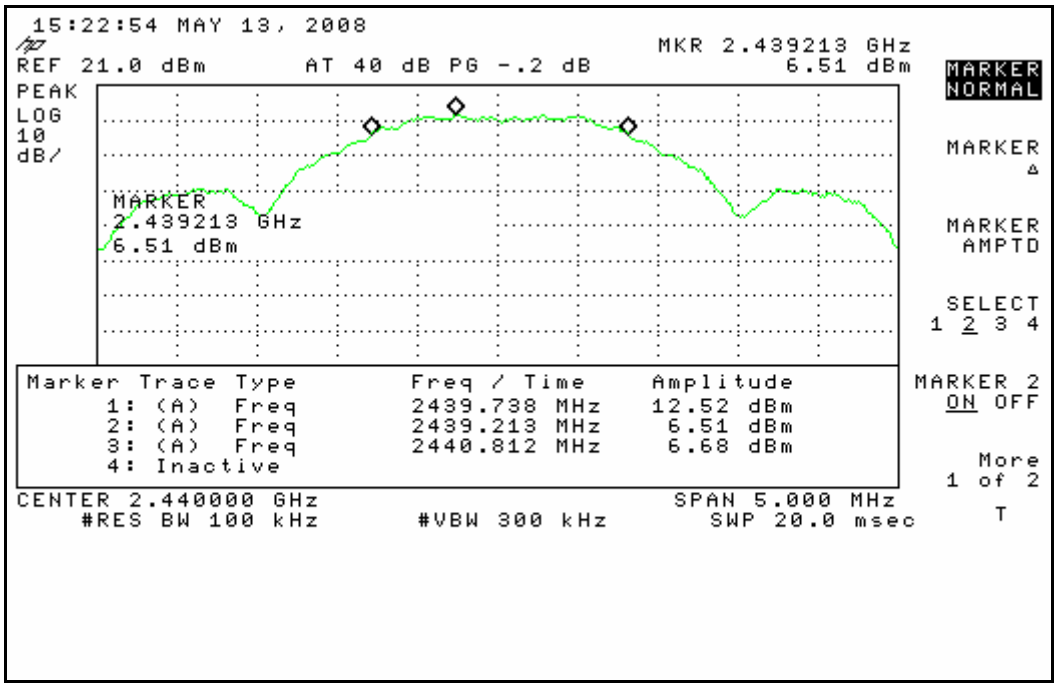


Figure 5: 6 dB Bandwidth f = 2.440 GHz

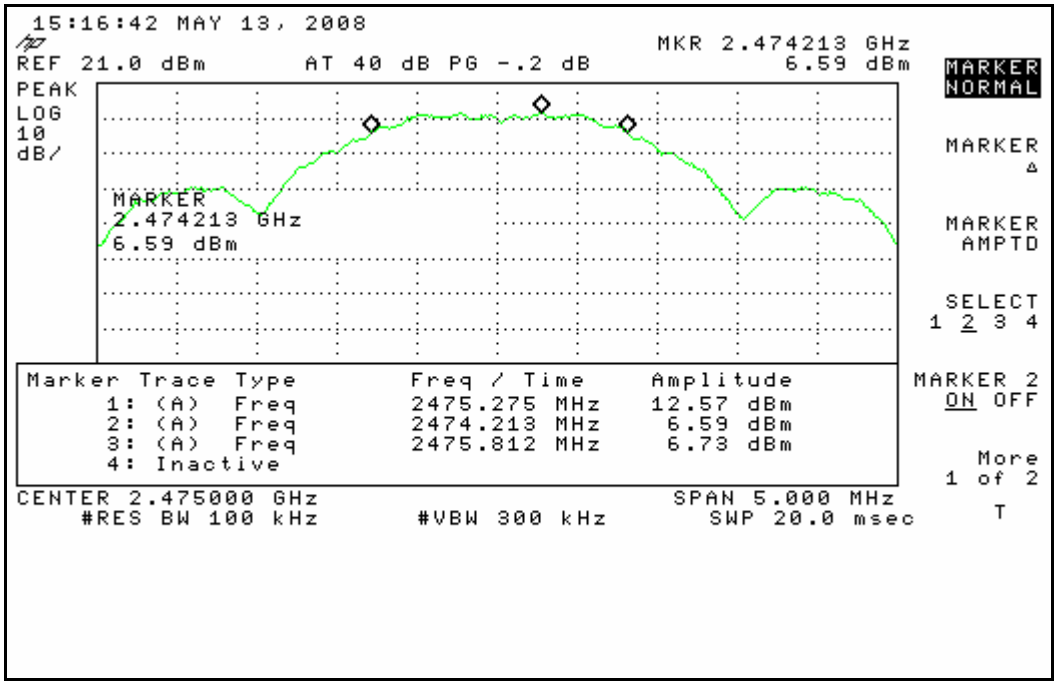


Figure 6: 6 dB Bandwidth f = 2.475 GHz

RSS-210 A1.1.3: Bandwidth if Momentary Signals (99% BW)

For the purpose of Section A1.1, the 99% bandwidth shall be no wider than 0.25% of the centre frequency for devices operating between 70-900 MHz. For devices operating above 900 MHz, the emission shall be no wider than 0.5% of the centre frequency.

Equipment Used	Model Number	Serial Number	Cal Date	Due
Spectrum Analyzer	HP 8593E	MY45113415	Oct/07	Oct/08
RF Test Cable	SUCOFLEX 104	220057 002	03/08	03/09
Date				Tested by
5/28/2008				Dan Bomsta

Frequency (MHz)	Limit 0.5% of center frequency (MHz)	99% Bandwidth (MHz)
2405	12	3.075
2440	12.2	2.775
2475	12.4	2.925

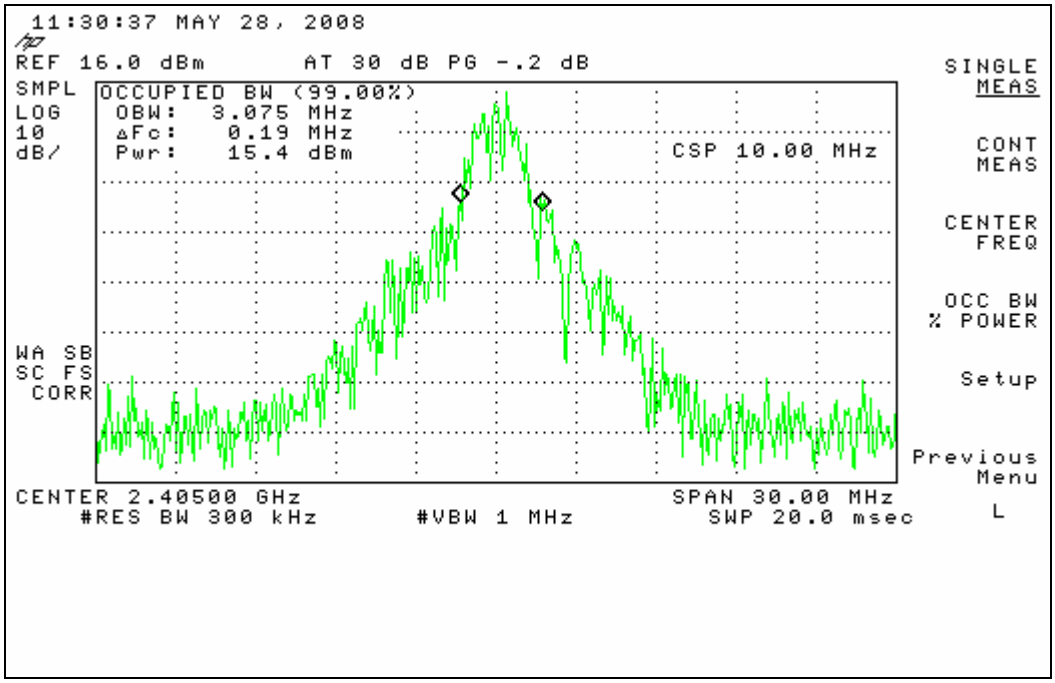


Figure 7: 99% BW f=2.405 GHz

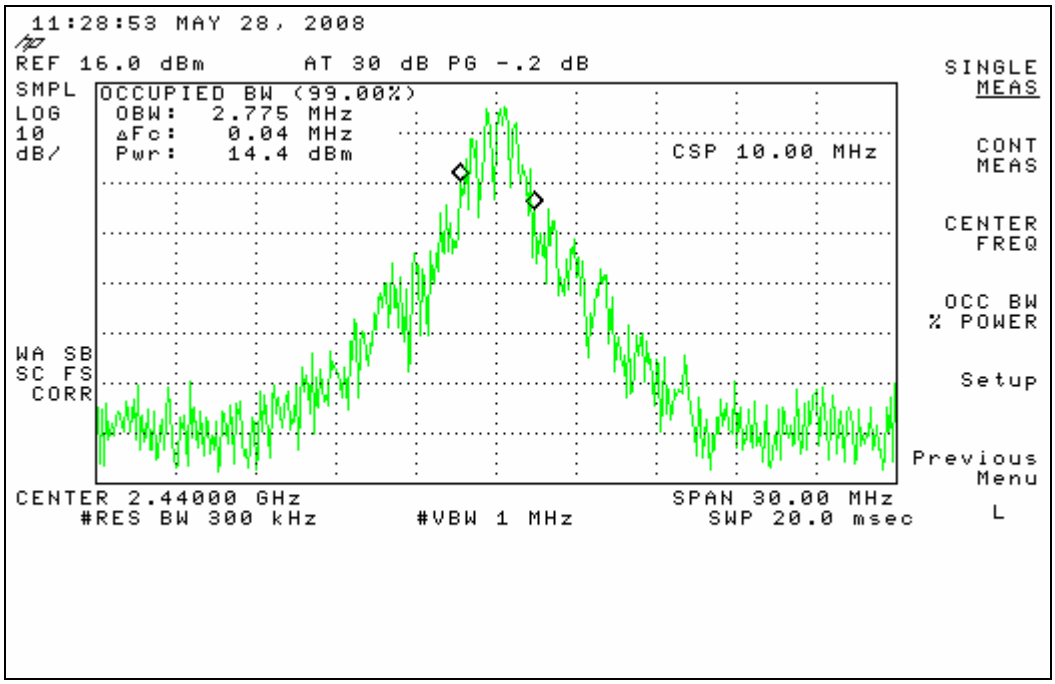


Figure 8: 99% BW f=2.440 GHz

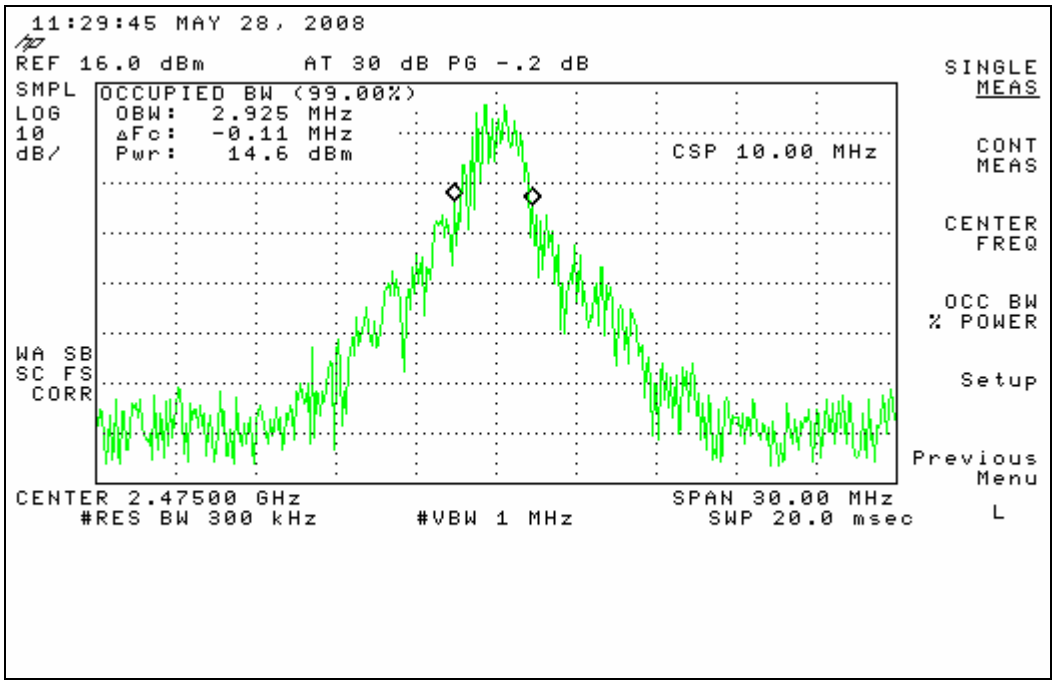


Figure 9: 99% BW f=2.475 GHz

Part 15.247(e) / RSS-210 A8.2 (b): Power Spectral Density

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Use the following spectrum analyzer settings:

RBW = 3 kHz
VBW ≥ RBW
Span = > 3 dB bandwidth
Sweep = SPAN/3 kHz
Detector function = peak
Trace = max hold

Equipment Used	Model Number	Serial Number	Cal Date	Due
Spectrum Analyzer	HP 8593E	MY45113415	Oct/07	Oct/08
RF Test Cable	SUCOFLEX 104	220057 002	03/08	03/09
Date				Tested by
5/13/2008				Dan Bomsta

Cable loss of 0.2 dB was added to the spectrum analyzer as a correction. The marker value in the plots is the true corrected value.

Frequency (MHz)	Corrected Power Spectral Density (dBm)
2405	1.35
2440	1.05
2475	0.68

Table 3: Power Spectral Density Tested in Accordance with PSD Option 1

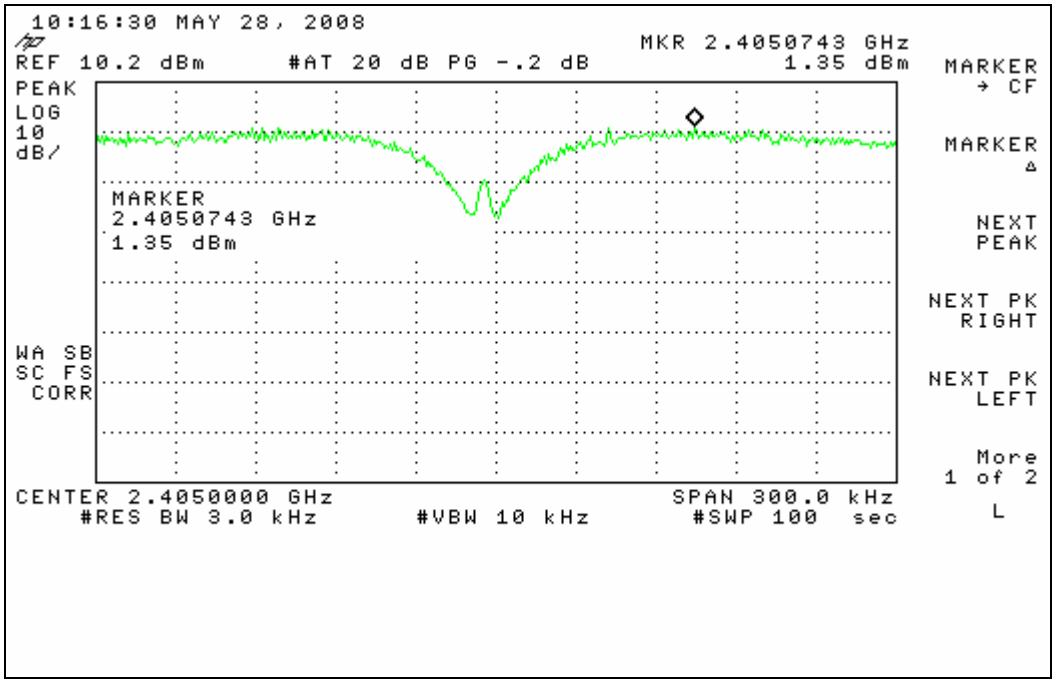


Figure 10: Power Spectral Density f= 2.405 GHz

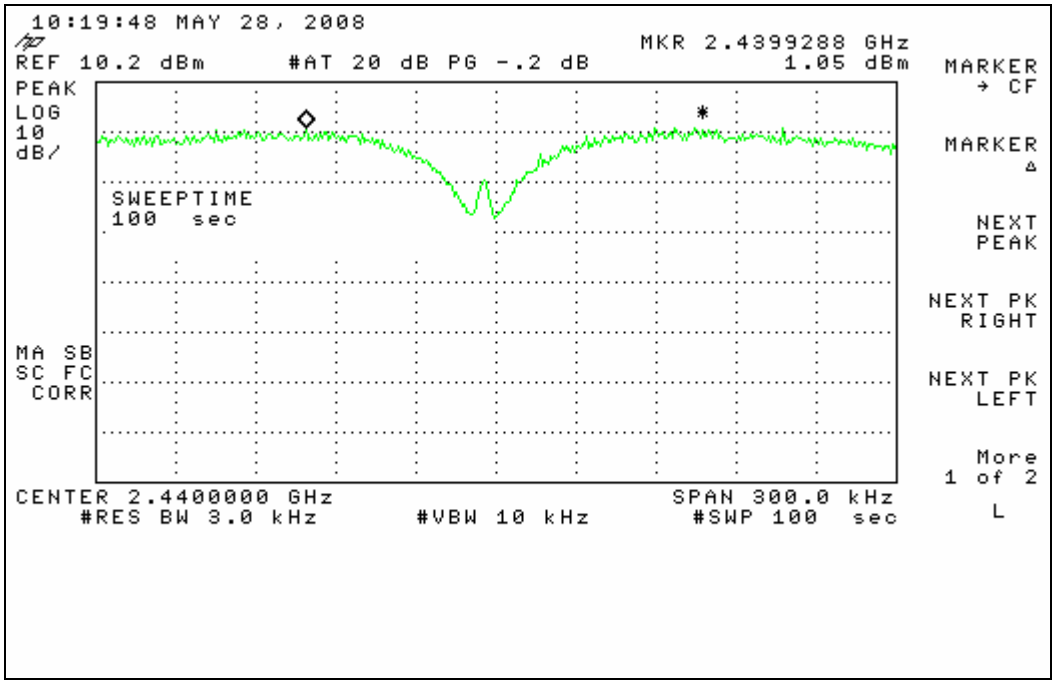


Figure 11: Power Spectral Density f= 2.440 GHz

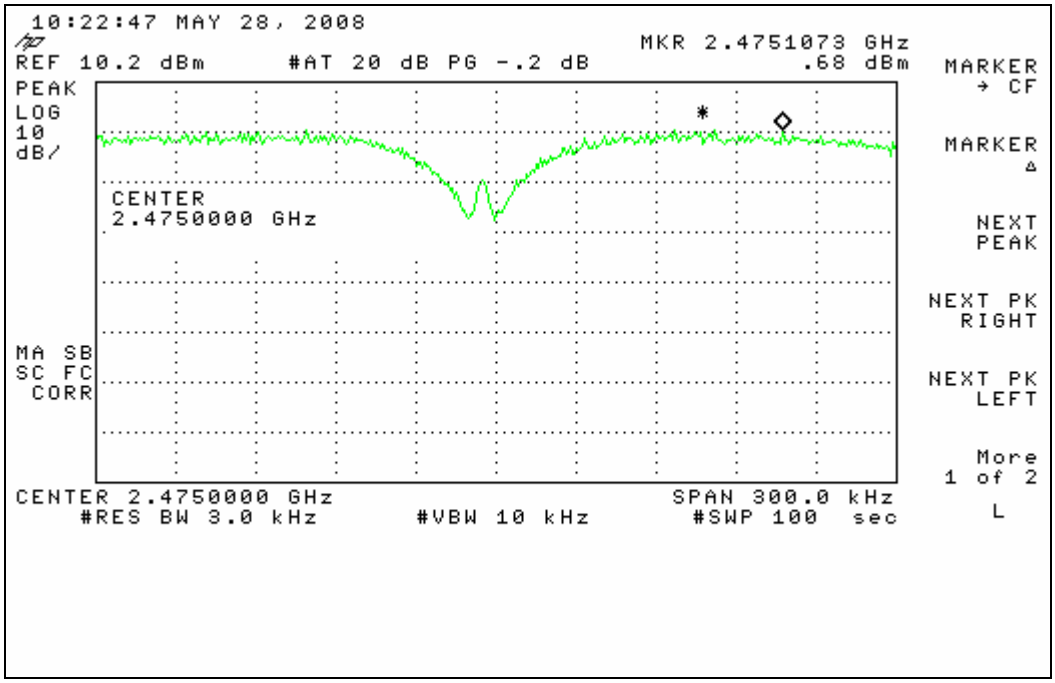


Figure 12: Power Spectral Density f= 2.475 GHz

15.247 (d) / RSS-210 A8.5: Spurious RF Conducted Emissions

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,

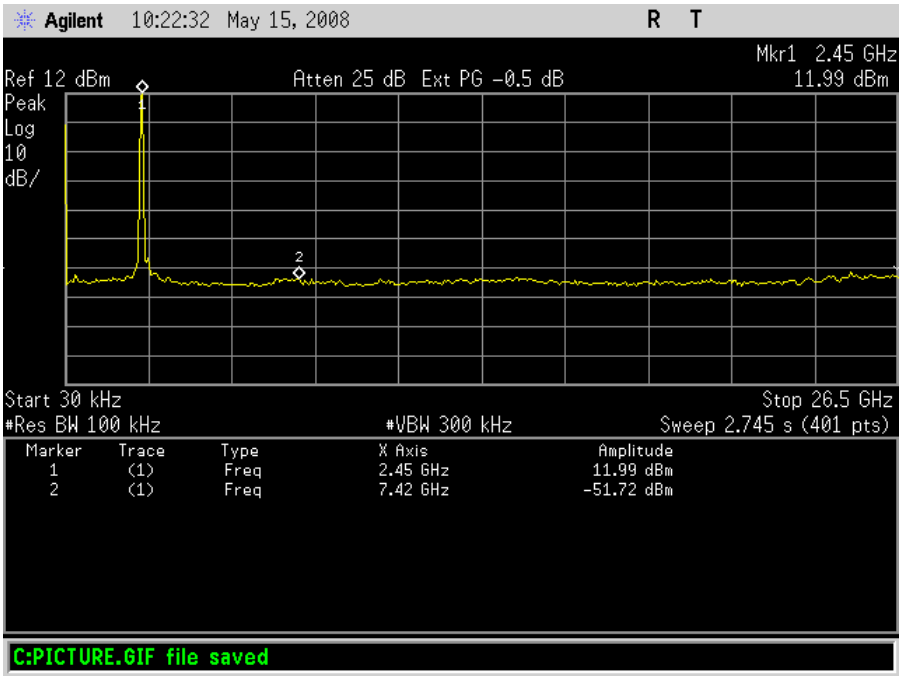
Use the following spectrum analyzer settings:

Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the tenth harmonic.
RBW = 100 kHz
VBW > RBW
Sweep = auto
Detector function = peak
Trace = max hold

Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded. The level displayed must comply with the limit specified.

Equipment Used	Model Number	Serial Number	Cal Date	Due
Spectrum Analyzer	Agilent E7405A	MY45113415	7-Aug-07	8-Aug-08
RF Test Cable	SUCOFLEX 104	220058 002	03-May-07	03-May-09
Date				**Tested by**
5/15/2008				Mark Kvamme

Frequency range investigated was 30 kHz to 26 GHz. TX @ 2.405, 2.440, & 2.475 GHz.
Peak Value = 11.99dbm
Frequency = 2.45Ghz



15.205, 15.209 / RSS-210 2.2, 2.6: Restricted Bands & Spurious Emissions

Only spurious emissions are permitted in any of the frequency bands listed below. The limits stated in 15.209 shall apply. Spurious emissions outside these bands shall also comply with the 15.209 limits

.

This test is required for any spurious emission or modulation product that falls in a Restricted Band, as defined in Section 15.205. It must be performed with the highest gain of each type of antenna proposed for use with the EUT. Use the following spectrum analyzer settings:

Span = wide enough to fully capture the emission being measured
RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz (120 kHz if QP detector is used)
VBW = peak measurements: 1 MHz for f ≥ 1 GHz. Average measurements: 10 Hz for f ≥ 1 GHz. Auto for f < 1 GHz
Sweep = auto
Detector function = peak for f ≥ 1 GHz, peak or QP as required for f < 1 GHz
Trace = max hold

Follow the guidelines in ANSI C63.4-2003 with respect to maximizing the emission by rotating the EUT, measuring the emission while the EUT is situated in three orthogonal planes (if appropriate), adjusting the measurement antenna height and polarization, etc. A pre-amp and a high pass filter are required for this test, in order to provide the measuring system with sufficient sensitivity. Allow the trace to stabilize. The peak reading of the emission, after being corrected by the antenna factor, cable loss, pre-amp gain, etc., is the peak field strength, which must comply with the limit specified.

Frequency range investigated was 30 kHz to 25 GHz. Worst case results are reported.

Item	Model Number	Serial Number	Cal Date	Due
Spectrum Analyzer	E7405A	MY45113415	Aug/07	Aug/08
EMCO 3115 double ridge wave guide	3115	9205-3878	Mar/07	Mar/09
Huber&Suhner 40 foot cable	Sucoflex 100	220297 001	Dec/07	Dec/08
Dipole antenna	3121	78573	Aug/07	Aug/08
AH systems Horn antenna	SAS-572	231	Feb/07	Feb/09
Loop Antenna	EMCO 6502	2129	Oct/06	Oct/08
AH systems preamplifer	PAM 0126	135	Dec/07	Dec/08

Freq (MHz)	Angle of DUT (degrees)	Antenna Height above DUT (cm)	Polarity	Corrected Reading (dBuV/m)	AF (dBm)	CL (dB)	Amplifier Loss (dB)	Temp (F)	RH (%)	Date	Time
4810	76	106	Vertical	51.52	32.76	6.29	-36.41	63.11	37.65	5/8/2008	3:12 PM
7215	51	127	Horizontal	50.75	35.82	7.79	-36.41	64.44	35.80	5/8/2008	3:48 PM
7315	23	102	Vertical	48.92	36.06	7.85	-36.36	64.07	36.69	5/8/2008	3:26 PM
7320	47	115	Horizontal	50.28	36.07	7.85	-36.36	64.16	36.02	5/8/2008	3:54 PM
7425	23	102	Vertical	48.94	36.32	7.91	-36.30	64.58	36.69	5/8/2008	3:33 PM
7425	22	115	Horizontal	48.82	36.32	7.91	-36.30	63.98	36.05	5/8/2008	4:01 PM

Table 1: Highest Six, Average Measurement, Spurious Emmissions

Freq (MHz)	Angle of DUT (degrees)	Antenna Height above DUT (cm)	Polarity	Corrected Reading (dBuV/m)	AF (dBm)	CL (dB)	Amplifier Loss (dB)	Temp (F)	RH (%)	Date	Time
4810	76	106	Vertical	60.38	32.76	6.29	-36.41	62.88	37.33	5/8/2008	2:53 PM
7215	51	127	Horizontal	60.95	35.82	7.79	-36.41	64.44	35.87	5/8/2008	3:47 PM
7315	23	102	Vertical	59.04	36.06	7.85	-36.36	64.00	36.79	5/8/2008	3:25 PM
7320	47	115	Horizontal	60.29	36.07	7.85	-36.36	64.20	36.03	5/8/2008	3:53 PM
7425	23	100	Vertical	59.23	36.32	7.91	-36.30	64.49	36.35	5/8/2008	3:32 PM
7425	22	115	Horizontal	58.94	36.32	7.91	-36.30	64.04	35.98	5/8/2008	3:59 PM

Table 2: Highest Six, Peak Measurement, Spurious Emissions

Band-Edge Measurement Plots @ 3 meters

2310 - 2390 MHz & 2483.5 - 2500 MHz

Item	Model Number	Serial Number	Cal Date	Due
Spectrum Analyzer	E7405A	MY45113415	Aug/07	Aug/08
EMCO 3115 double ridge wave guide	3115	9205-3878	Mar/07	Mar/09
Huber&Suhner 40 foot cable	Sucoflex 100	220297 001	Dec/07	Dec/08
Sucoflex 104 cable	Sucoflex 104	220060 002	Dec/07	Dec/08
AH systems preamplifer	PAM 0126	135	Dec/07	Dec/08

Date	Tested by
5/29/2008	Dan Bomsta

Frequency (MHz)	Polarity	Angle of DUT (degrees)	Height of Antenna above DUT (cm)	Reading (Peak or Average)	Corrected Maximum Reading (dBuV/m @ 3m)
2310 - 2390	Vertical	170	130	Average	44.78
2310 – 2390	Vertical	170	130	Peak	54.05
2483.5 – 2500	Vertical	170	130	Average	44.99
2483.5 – 2500	Vertical	170	130	Peak	69.56

Table 4: Band Edge Maximum Readings

***Note: All calibration and correction factors for test equipment are entered into the spectrum analyzer (E7405A). The reported data and plots are the corrected reading.*

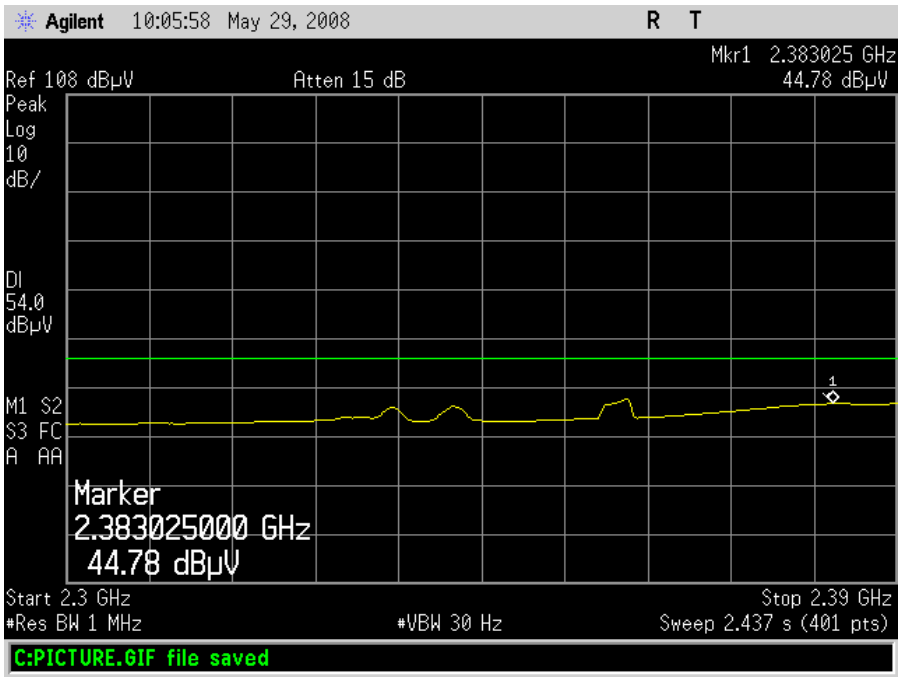


Figure 13: Radiated Band End Plot 1: Average

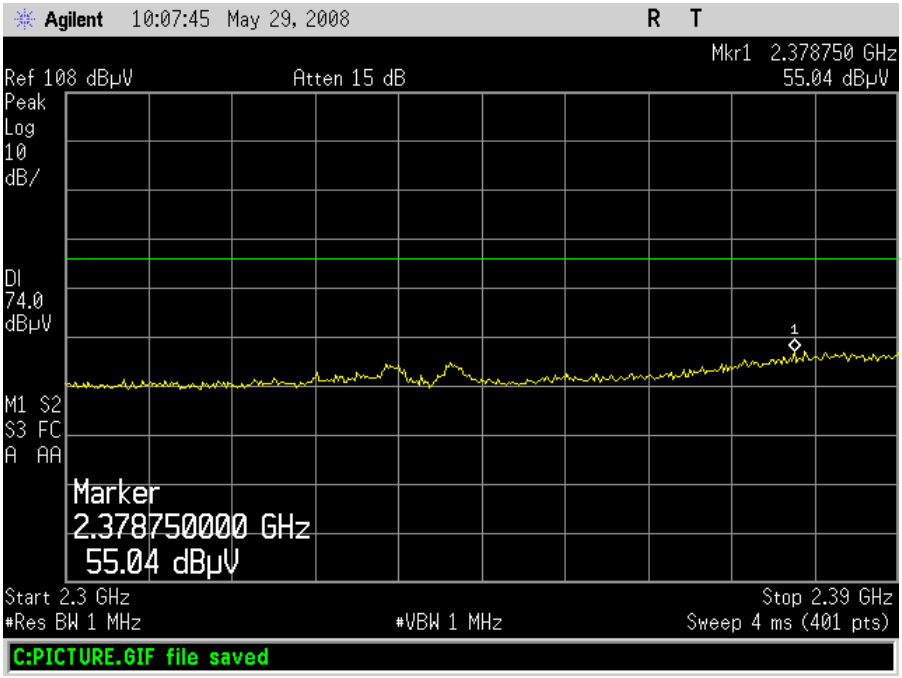


Figure 14: Radiated Band End Plot 2: Peak

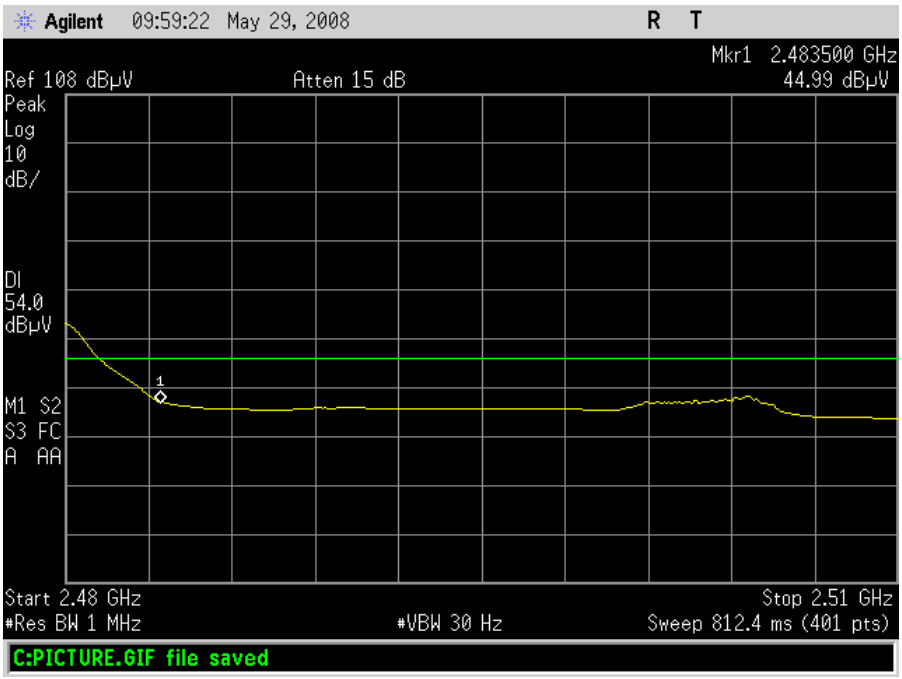


Figure 15: Radiated Band End Plot 3: Average

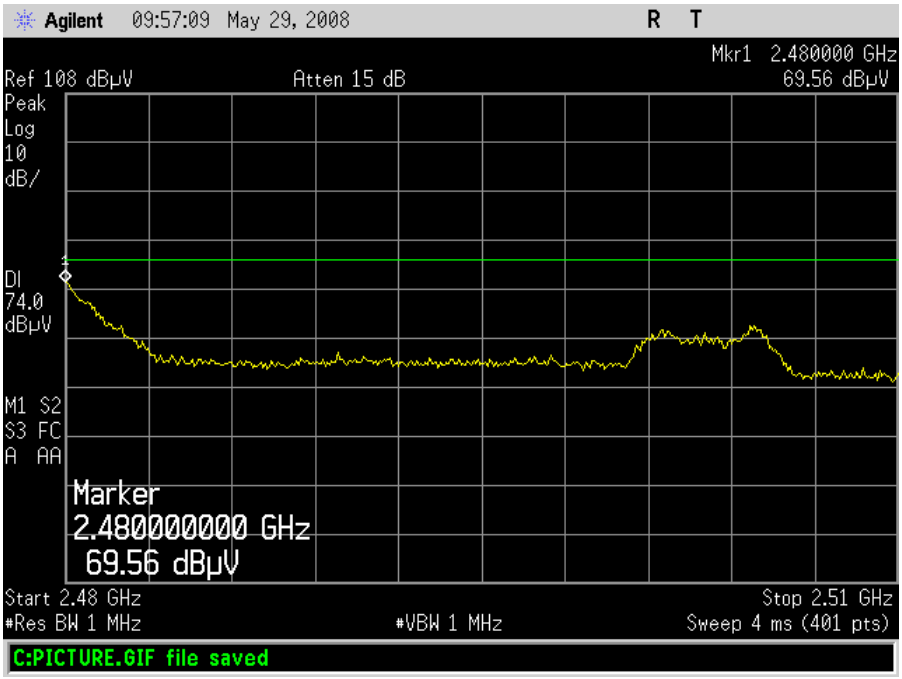


Figure 16: Radiated Band End Plot 4: Peak

RSS-Gen 7.2.3 Receiver Spurious Emission Limits :

Receiver Spurious Emission Standard

The following receiver spurious emission limits shall be complied with:

(a) If a radiated measurement is made, all spurious emissions shall comply with the limits of Table 1. The resolution bandwidth of the spectrum analyzer shall be 100 kHz for spurious emission measurements below 1.0 GHz, and 1.0 MHz for measurements above 1.0 GHz.

(b) If a conducted measurement is made, no spurious output signals appearing at the antenna terminals shall exceed 2 nanowatts per any 4 kHz spurious frequency in the band 30-1000 MHz, or 5 nanowatts above 1 GHz.

Table 1 – Radiated Spurious Emission Limits for Receivers

Spurious Frequency (MHz)	Field Strength (microvolt/m at 3 meters)
30-88	100
88-216	150
216-960	200
Above 960	500

Equipment Used	Model Number	Serial Number	Cal Date	Due
Spectrum Analyzer	E7405A	MY45113415	Aug/07	Aug/08
EMCO 3115 double ridge wave guide	3115	9205-3878	Mar/07	Mar/09
Huber&Suhner 40 foot cable	Sucoflex 100	220297 001	Dec/07	Dec/08
Dipole antenna	3121	78573	Aug/07	Aug/08
Loop Antenna	EMCO 6502	2129	Oct/06	Oct/08
AH systems preamplifer	PAM 0126	135	Dec/07	Dec/08

Date	Tested by
5/15/2008	Mark Kvamme

Frequency range investigated was 30 MHz to 15 GHz. Worst case results are shown.

Configuration data

	Date	Time	Corrected Level (dBuV/m)	Antenna correction factor (dB/m)	Coax loss (dB)	Amplifier gain (dB)	Temp (F)	RH (%)
Peak	5/15/2008	5:40 PM	38.28	32.85	6.33	36.43	70.53	27.41
Average	5/15/2008	5:45 PM	26.96	32.85	6.33	36.43	70.02	28.31

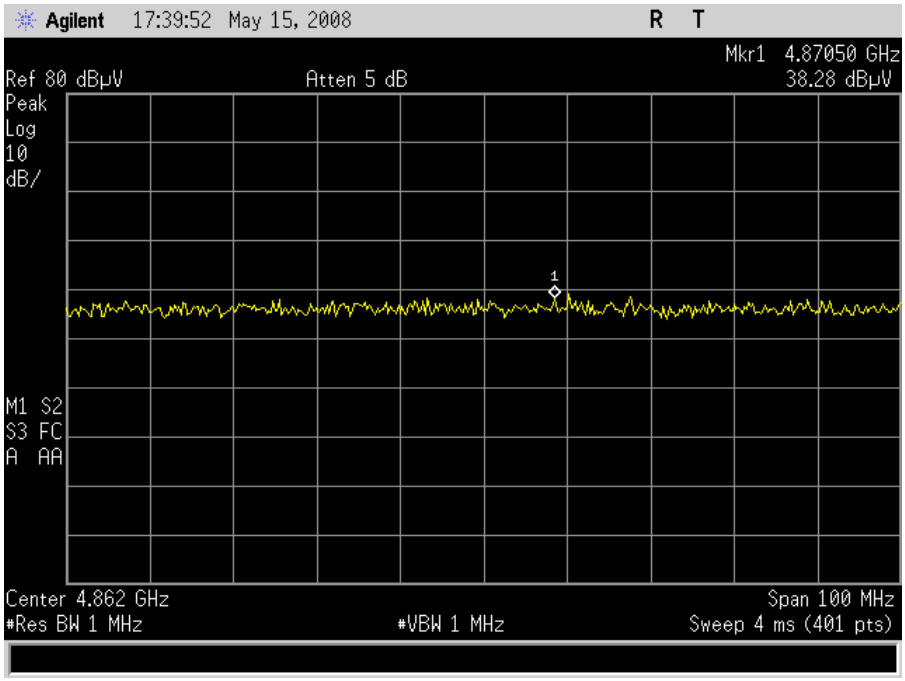


Figure 17: Receiver Spurious Plot 1

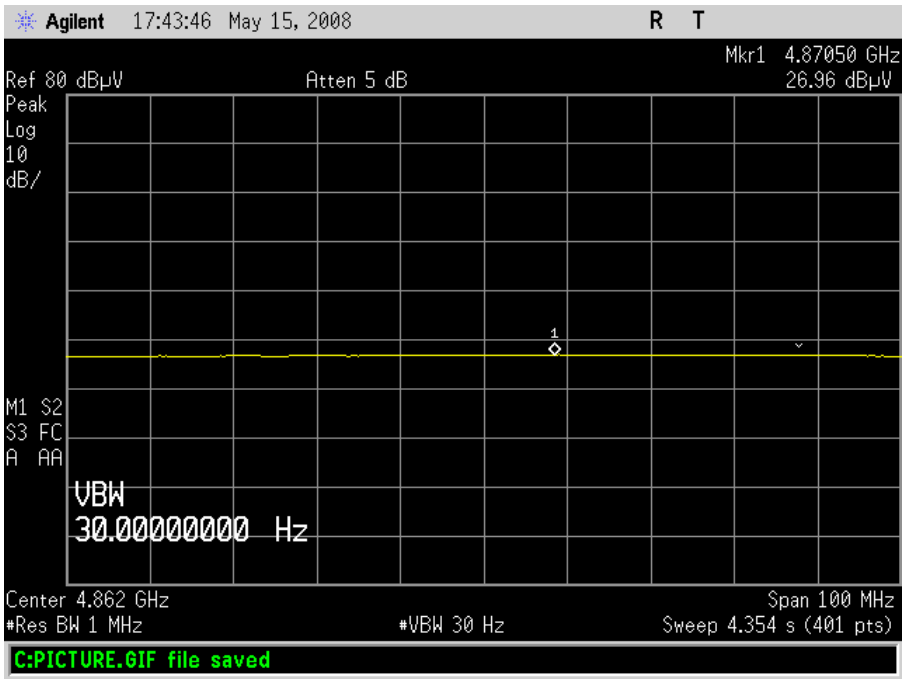


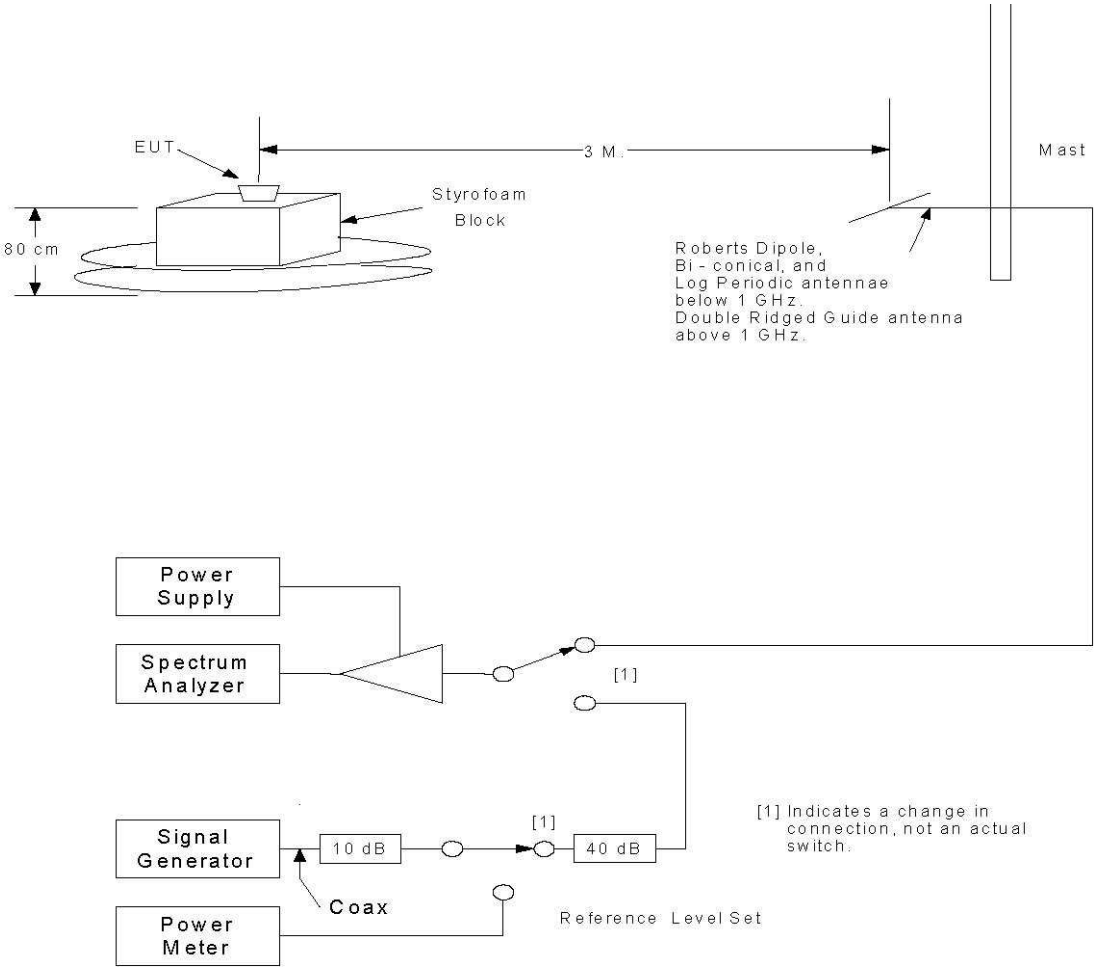
Figure 18: Receiver Spurious Plot 2

ANNEX A

Field Strength Measurement Procedure

This test measures the field strength of radiated emissions using a spectrum analyzer and a receiving antenna in accordance with ANSI C63.4-2003. During the test, the EUT is to be placed on a non-conducting support at 80 cm above the horizontal ground plane of the OATS. The horizontal distance between the antenna and the EUT is to be exactly 3 meters. Levels below 1 GHz are to be measured with the spectrum analyzer resolution bandwidth at 120 kHz and levels at or above 1 GHz are to be measured with the spectrum analyzer resolution bandwidth at 1 MHz.

1) Monitor the frequency range of interest at a fixed antenna height and EUT azimuth.
2) If appropriate, manipulate the system cables to produce the highest amplitude signal relative to the limit. Note the amplitude and frequency of the suspect signal.
3) Rotate the EUT 360° to maximize the suspected hi ghest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, go back to the azimuth and repeat step 2). Otherwise, orient the EUT azimuth to repeat the highest amplitude observation and proceed.
4) Move the antenna over its fully allowed range of travel to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, return to step 2) with the antenna fixed at this height. Otherwise, move the antenna to the height that repeats the highest amplitude observation and proceed.
5) Change the polarity of the antenna and repeat step 2), step 3), and step 4). Compare the resulting suspected highest amplitude signal with that found for the other polarity. Select and note the higher of the two signals.
6) The transmitter shall be replaced by a substitution antenna.
The substitution antenna shall be orientated for vertical polarization and the length of the substitution antenna shall be adjusted to correspond to the frequency of the transmitter. The substitution antenna shall be connected to a calibrated signal generator. If necessary, the input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver.
7) The test antenna shall be raised and lowered through the specified range of height to ensure that the maximum signal is received.
8) The input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver, that is equal to the level noted while the transmitter radiated power was measured, corrected for the change of input attenuator setting of the measuring receiver.
9) The input level to the substitution antenna shall be recorded as power level, corrected for any change of input attenuator setting of the measuring receiver.
10) The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization.
11) The measure of the effective radiated power is the larger of the two levels recorded at the input to the substitution antenna, corrected for gain of the substitution antenna if necessary. This signal is termed the highest observed signal with respect to the limit for this EUT operational mode.


EUT
3 M.
Mast
Styrofoam
Block
80 cm
Roberts Dipole,
Bi - conical, and
Log Periodic antennae
below 1 GHz.
Double Ridged Guide antenna
above 1 GHz.
Power
Supply
Spectrum
Analyzer
[1]
Signal
Generator
10 dB
[1]
40 dB
[1] Indicates a change in
connection, not an actual
switch.
Coax
Power
Meter
Reference Level Set