REGULATORY COMPLIANCE REPORT

TITLE: FCC & IC Test Report for 15.247 & RSS-210 Frequency Hopping Device
*****CLASS II CHANGE*****

AUTHOR: Jeff Gilbert

REV	CCO	DESCRIPTION OF CHANGE	DATE	APPROVALS	
1		INITIAL RELEASE	7/11/06	Engineering	Jeff Gilbert
			7/11/06	Engineering	Drew Rosenberg

REVISION HISTORY

				Engineering	
				Engineering	
				Engineering	

Summary

FCC 15.247 / IC RSS-210
Frequency Hopping Transceiver Class II Change, 910 – 920 MHz

FCC ID: EO9DEC08 / **IC ID:** 864D-DEC08
Device Model: RFD-SPI, 8-channel, Pole
Serial Number: 65900088
OATS Registration Number: FCC 90716, IC 5615

Rule	Description	Max. Reading	Pass/Fail
Part 15.31(e)	Variation of Input Voltage - Conducted	< 0.7 dB variation	Pass
Part 15.207 / RSS-Gen 7.2.2	AC Powerline Conducted Emissions	> 10 dB margin	Pass
Part 15.247(b) (2) / RSS-210 A8.4(1)	Power Output - Conducted	27.82 dBm	Pass
Part 15.247(d) / RSS-210 A8.5	Spurious Emissions - Conducted	-50.32 dBc @1.84 GHz	Pass
Parts 15.205 & 15.209 / RSS-210 2.2, 2.6 Tables 1 & 2	Restricted Bands / Spurious Emissions - Radiated	12.04 dB margin @ 5.460 GHz	Pass
Parts 1.1310 & 2.1091 / RSS-102	Limits for Maximum Permissible Exposure (MPE)	0.394 mW/cm^2	Pass

Rule versions: FCC Part 1 (01-2006), FCC Part 2 (01-2006), FCC Part 15 (02-01-2006), RSS-102 (11-2005), RSS-210 Issue 6 (09-2005), RSS-Gen Issue 1 (09-2005).
Reference docs: ANSI C63.4-2003, DA 00-705 (03-30-2000), OET65 (08-1997), OET65C (06-2001), IEEE C95.3-2002.

Cognizant Personnel

Name	Title
Mark Kvamme	Senior Technician
Jeff Gilbert	Regulatory Engineer
Drew Rosenberg	Project Lead

Class II change to FCC ID: EO9DEC08, IC ID: 864D-DEC08. Changes from original certification are: new enclosure, detachable 5.15 dBi antenna, new power supply board.

FCC Part 15.31(e)

Input Voltage Variation

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

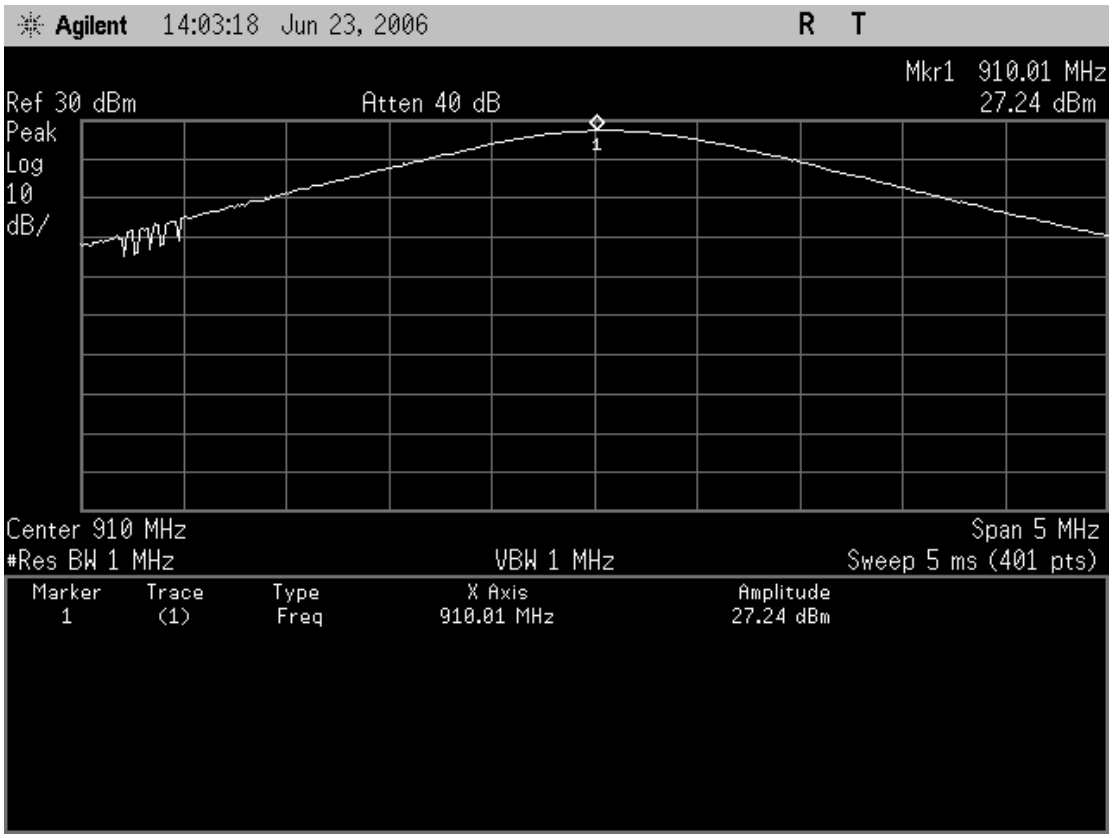
Determine if the transmitter's RF properties change when the input power of the device is varied between 85% and 115% of the device's rated input voltage.
If the RF properties do change, all tests performed to assess compliance must be performed on the worst case configuration.

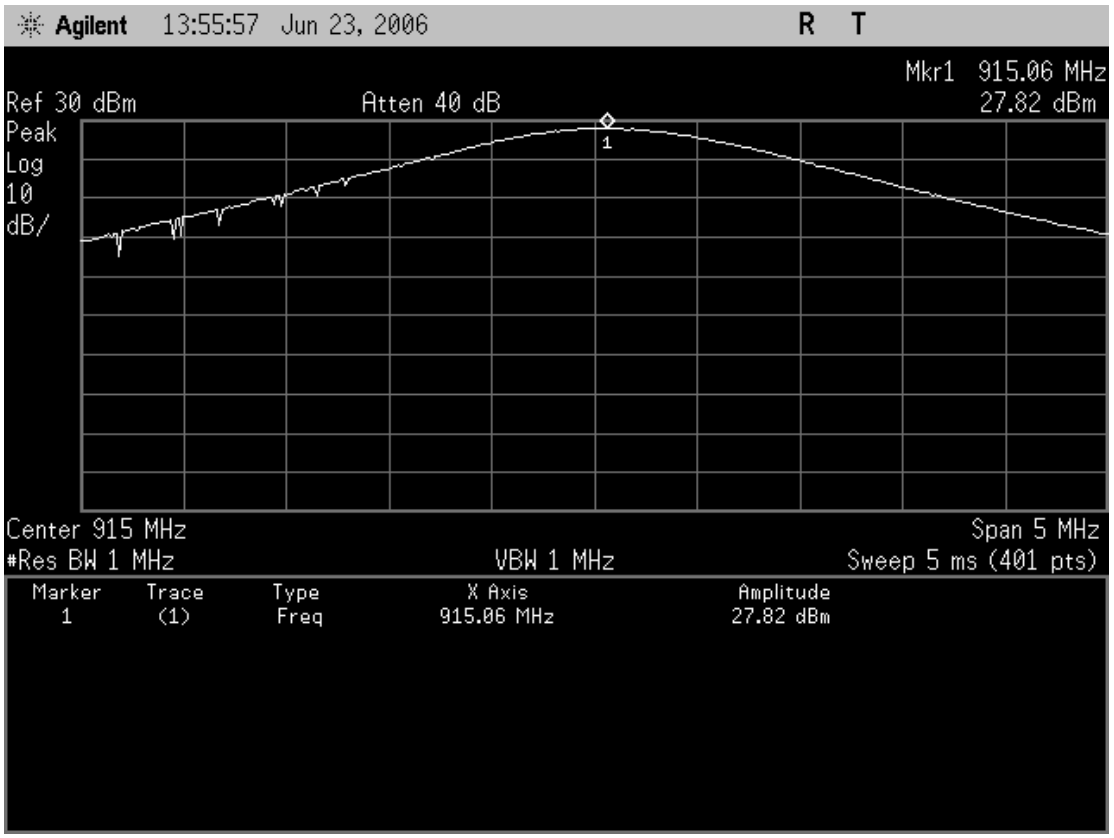
Equipment Used	Serial Number	Cal Date	Due
HP E4408B	US40240538	3-APR-06	3-APR-07

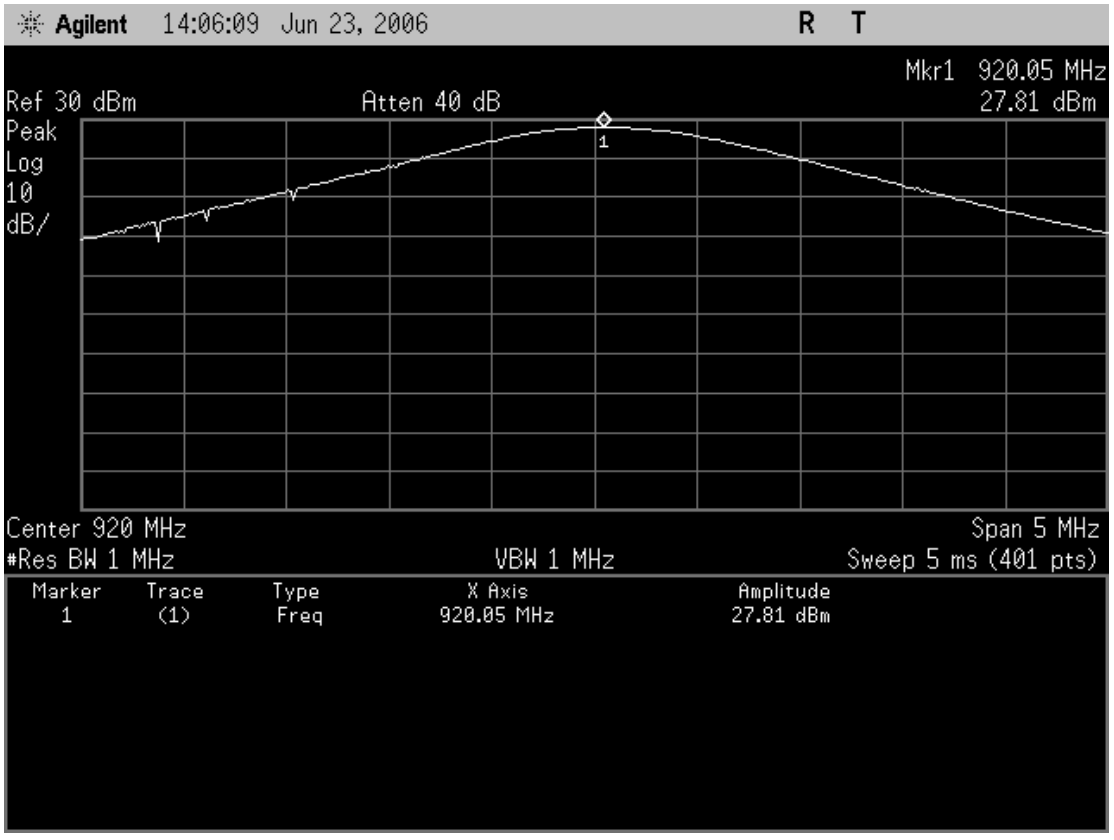
Date	Temp/Humidity ºF / %	Tested by
6/23/2006	81/38%	Mark Kvamme

Unit Tested: 65900088
Max power measured: 27.82 dBm @ 250 V_{RMS} (915.06 MHz).

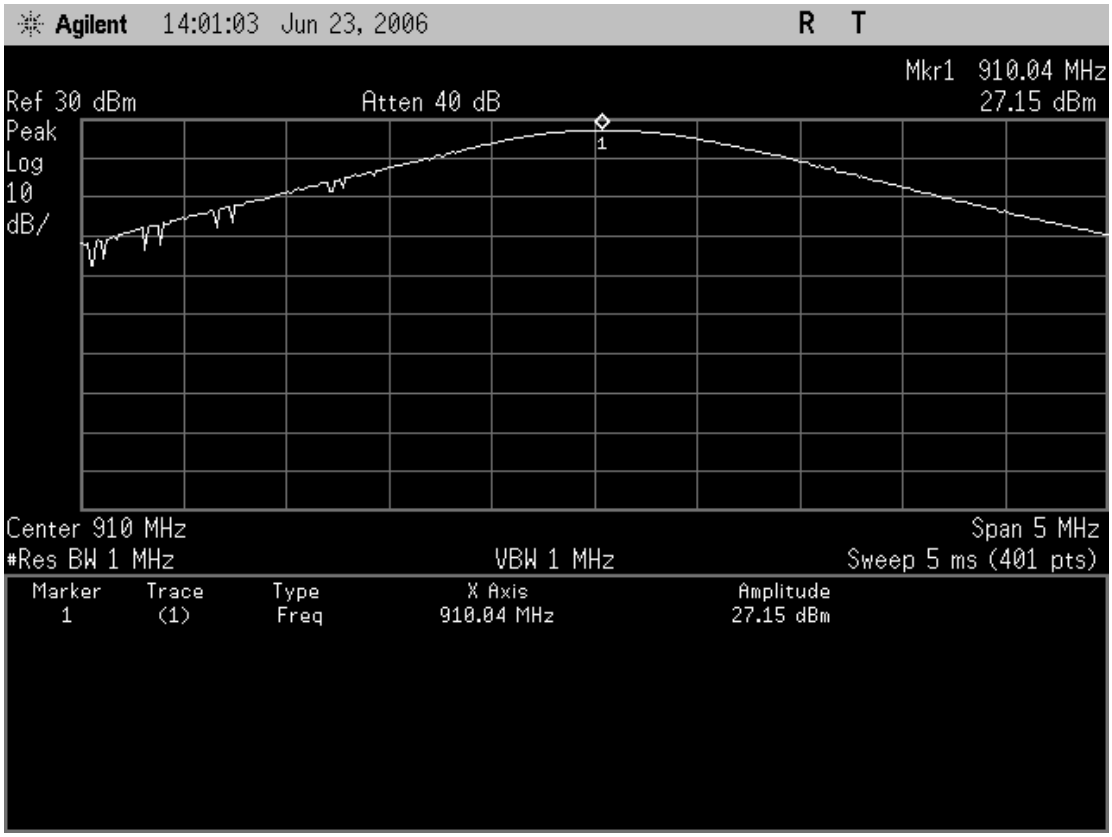
Following readings @ 250 V_{rms} input.

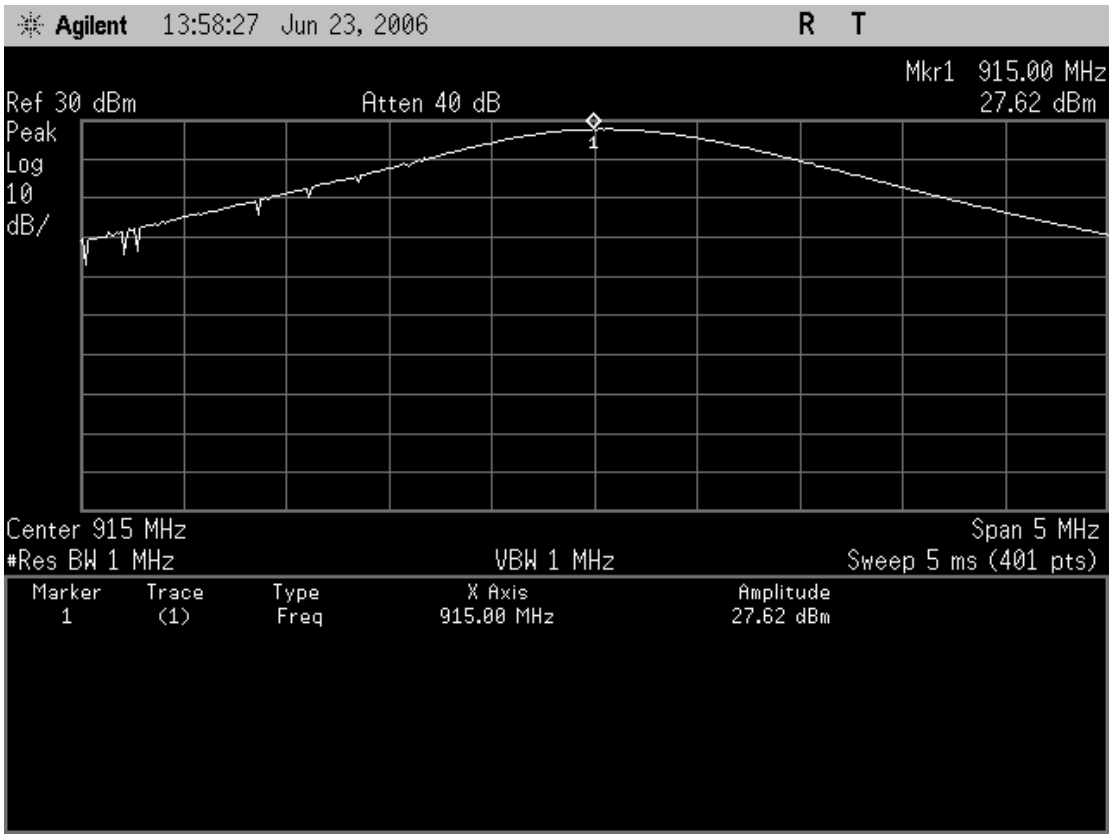


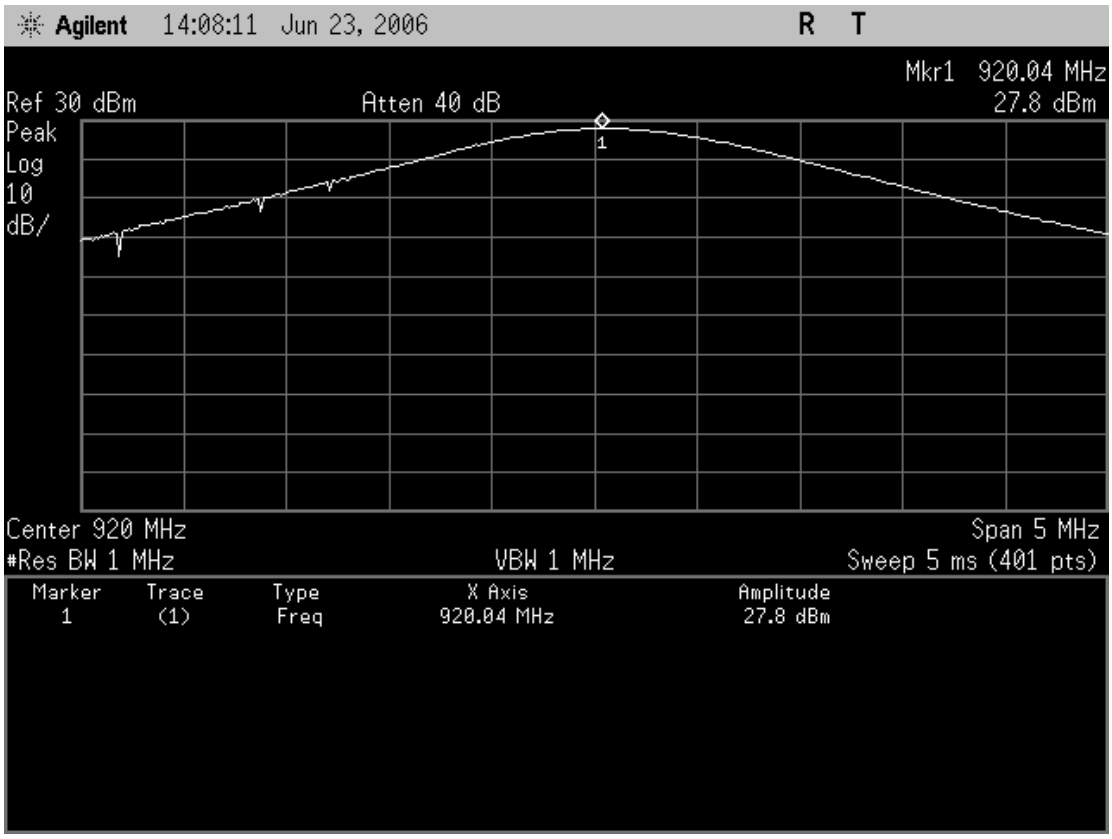

Agilent 13:55:57 Jun 23, 2006
R T
Mkr1 915.06 MHz
27.82 dBm
Ref 30 dBm
Atten 40 dB
Peak
Log
10
dB/
Center 915 MHz
#Res BW 1 MHz
VBW 1 MHz
Span 5 MHz
Sweep 5 ms (401 pts)
Marker Trace Type X Axis Amplitude
1 (1) Freq 915.06 MHz 27.82 dBm


Agilent 14:06:09 Jun 23, 2006
R T
Mkr1 920.05 MHz
27.81 dBm
Ref 30 dBm
Atten 40 dB
Peak
Log
10
dB/
Center 920 MHz
#Res BW 1 MHz
VBW 1 MHz
Span 5 MHz
Sweep 5 ms (401 pts)
Marker Trace Type X Axis Amplitude
1 (1) Freq 920.05 MHz 27.81 dBm

Following readings @ 95 V_{rms} input.






Agilent 14:08:11 Jun 23, 2006
R T
Mkr1 920.04 MHz
27.8 dBm
Ref 30 dBm
Atten 40 dB
Peak
Log
10
dB/
1
Center 920 MHz
#Res BW 1 MHz
VBW 1 MHz
Span 5 MHz
Sweep 5 ms (401 pts)
Marker Trace Type X Axis Amplitude
1 (1) Freq 920.04 MHz 27.8 dBm

15.207 / RSS-Gen 7.2.2

Powerline Conducted Emissions

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Measure the AC powerline conducted emissions in accordance with the most recent version of ANSI C63.4 from 150 kHz to 30 MHz using a 50 µH / 50 Ω line impedance stabilization network (LISN). Verify that no emissions exceed the following limits:

Frequency (MHz)	Quasi-Peak (dBµV)	Average (dBµV)
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

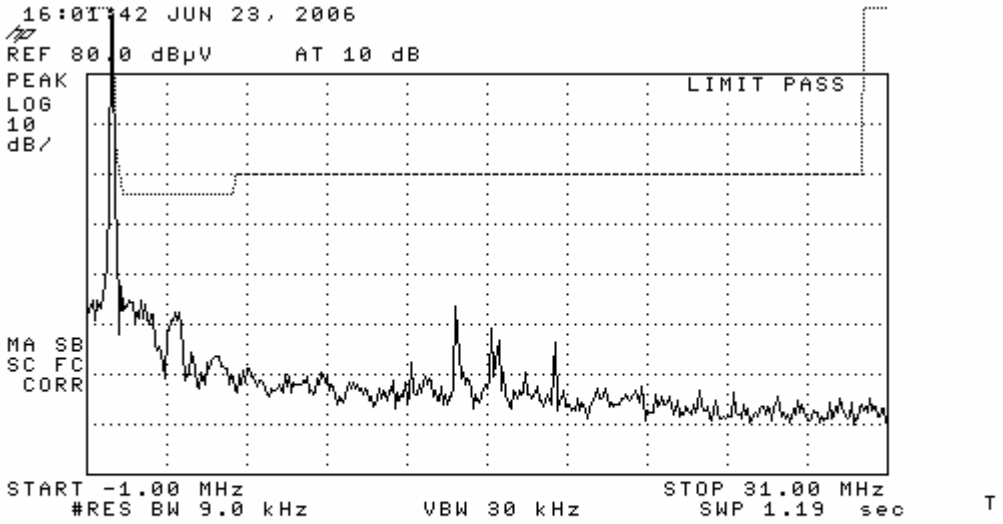
*Decreases with the logarithm of frequency

Equipment Used	Serial Number	Cal Date	Due
HP8593E	3543A02032	9/9/04	9/9/06
EMCO 3821/2	9605-2535	2/28/06	2/28/07

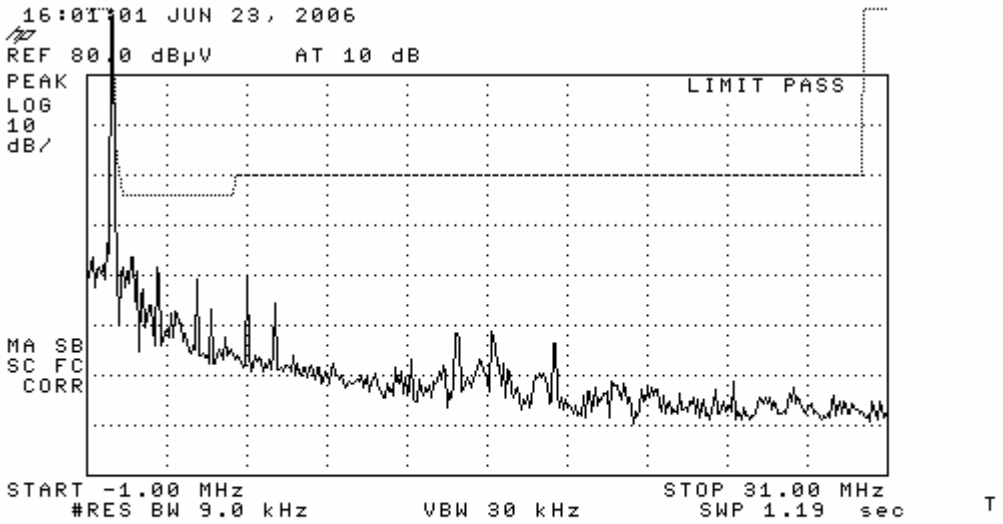
Date	Temp/Humidity °F / %	Tested by
6/23/2006	81/38%	Mark Kvamme

Unit tested: 65900088

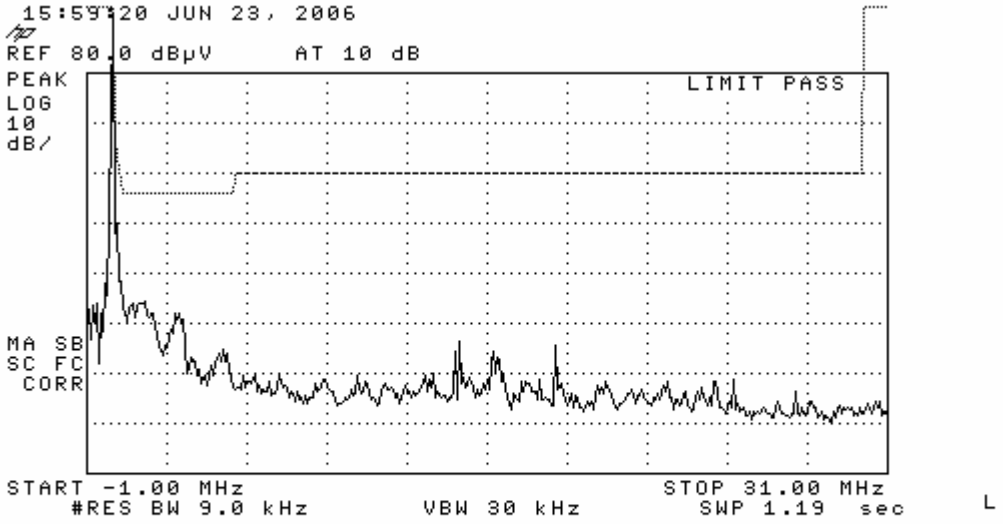
L1 @ 95 V_{RMS}



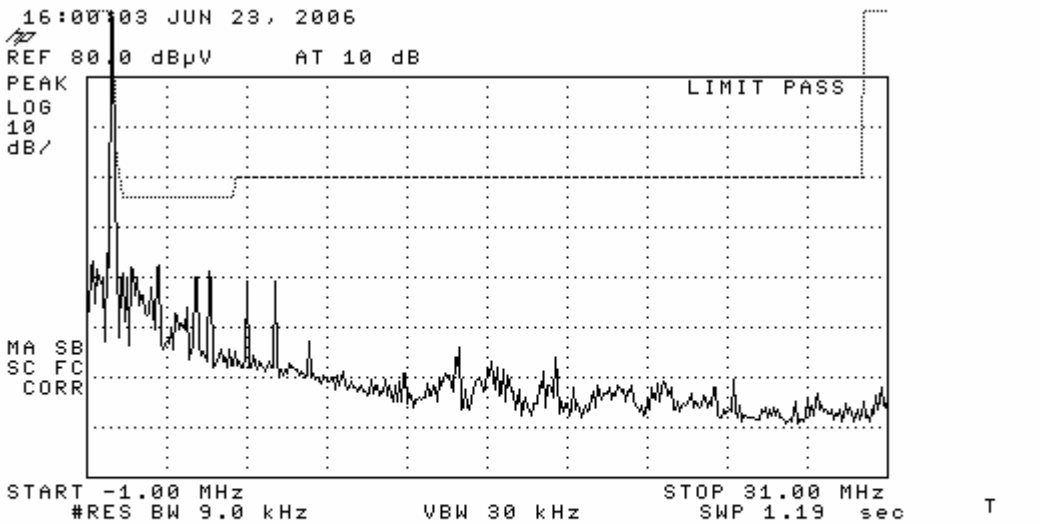
L1 @ 250 V_{RMS}



L2 @ 95 V_{RMS}



L2 @ 250 V_{RMS}


16:00:03 JUN 23, 2006
REF 80.0 dBµV
AT 10 dB
PEAK
LOG
10
dB/
LIMIT PASS
MA SB
SC FC
CORR
START -1.00 MHz
#RES BW 9.0 kHz
VBW 30 kHz
STOP 31.00 MHz
SWP 1.19 sec
T

15.247(b) (2) / RSS-210 A8.4 (1)

Power Output

The maximum peak conducted output power of the intentional radiator shall not exceed the following: For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels.

Use the following spectrum analyzer settings:

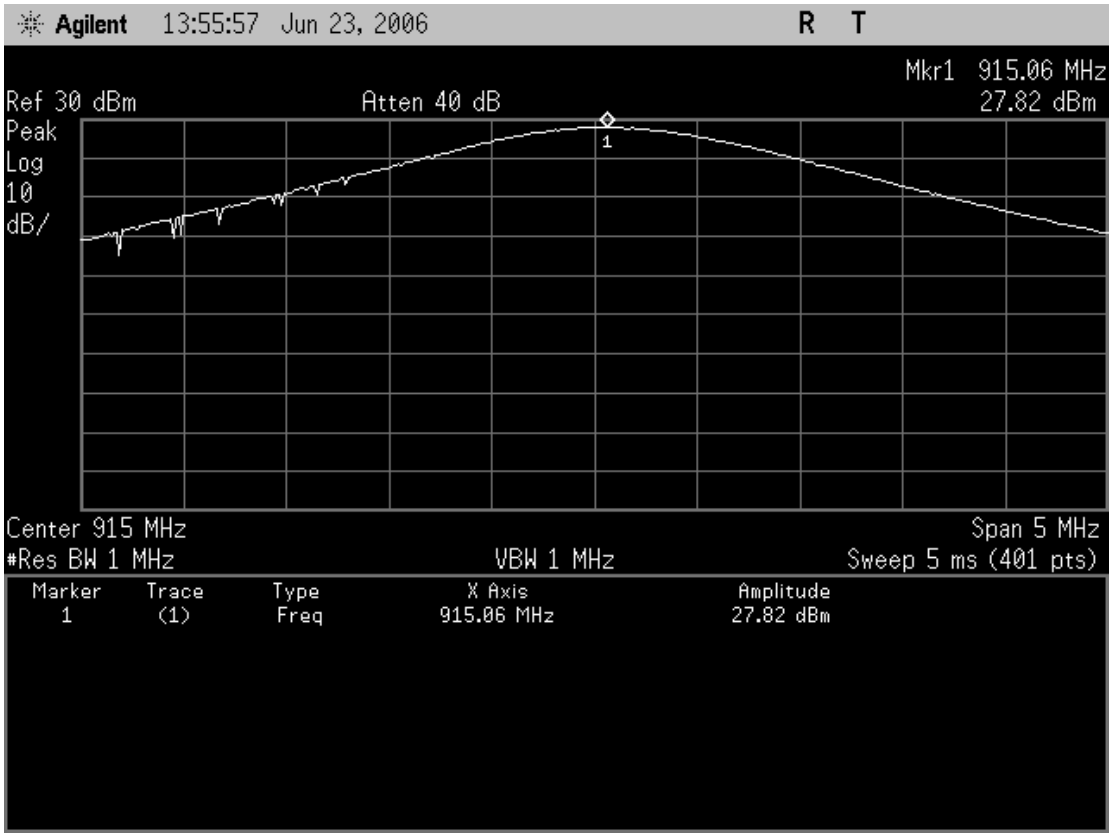
Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel.
RBW > the 20 dB bandwidth of the emission being measured.
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

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. The limit is specified in one of the subparagraphs of this Section. Submit this plot. A peak responding power meter may be used instead of a spectrum analyzer.

Equipment Used	Serial Number	Cal Date	Due
HP E4408B	US40240538	3-APR-06	3-APR-07

Date	Temp/Humidity ºF / %	Tested by
6/23/2006	81/38%	Mark Kvamme

Unit tested: 65900088
Max power measured: 27.82 dBm @ 250 V_{RMS} (915.06 MHz).



15.247(d) / RSS-210 A8.5

Spurious Emissions - Conducted

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. Attenuation below the general limits specified in Section 15.209(a) is not required.

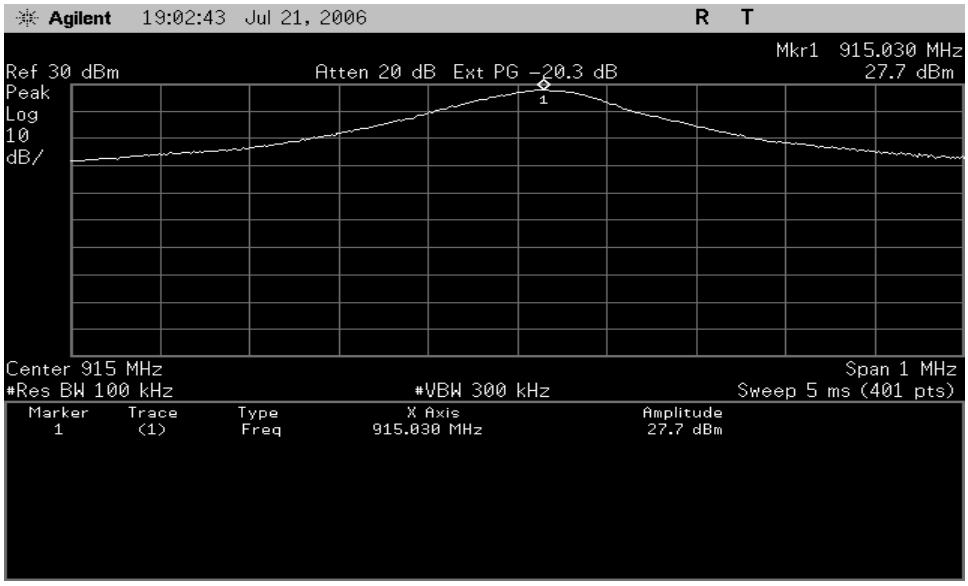
Follow the procedure outlined in Annex A of this document.

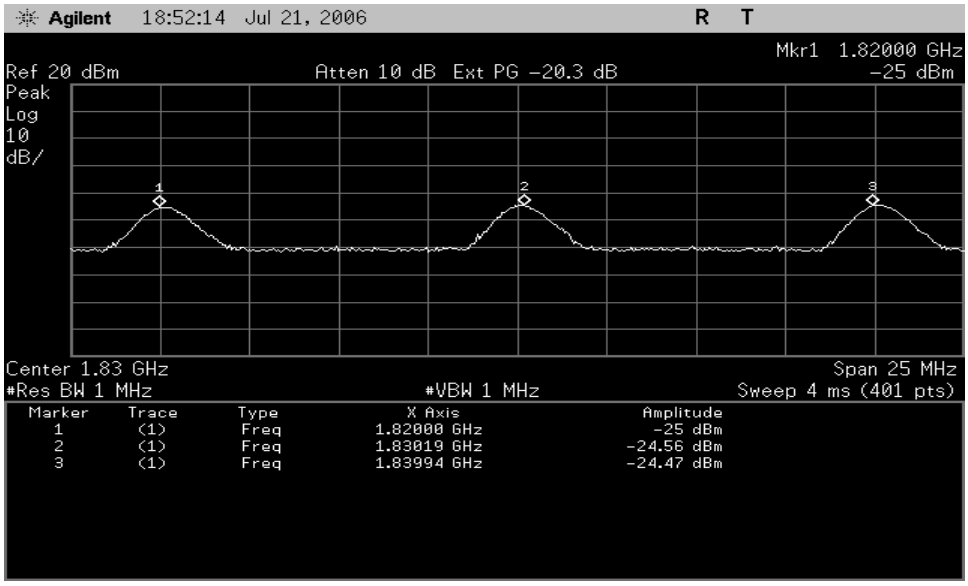
Equipment Used	Serial Number	Cal Date	Due
HP8594E	3710A04999	2/24/2005	2/24/2007
EMCO 6502	9509-2970	10/22/04	10/22/06
HP E4408B	US40240538	3-APR-06	3-APR-07

Date	Temp/Humidity ºF / %	Tested by
7/21/2006	78/38%	Mark Kvamme

Unit tested: 65900088
The frequency investigated was 9 kHz to 9.2 GHz.

27.79 dBm – (–22.53dBm) = -50.32dBc
Seventh Harmonic was < -60dBm





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.

Measure the field strength of all transmitter spurious emissions in the restricted bands listed below. Follow the procedure outlined in Annex A of this document.

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
0.495-0.505 1	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2655-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41			

Equipment Used	Serial Number	Cal Date	Due
HP437B	3125U11553	11/10/04	11/10/06
HP8481D	3318A08626	12/1/04	12/1/06
HP E4408B	US40240538	4/3/06	4/3/07
EMCO 3115	9205-3878	4/13/06	4/13/08
EMCO 6502	9509-2970	10/22/04	10/22/06

Date	Tested by	Temperature/ humidity
6/13/2006	Mark Kvamme	78/42
6/14/2006	Mark Kvamme	67/90
6/15/2006	Mark Kvamme	80/70

Unit tested: 65900088

The frequency investigated was 9 kHz to 9.2 GHz.

			Height /			Amplifier	Ant.	Cable	Duty Cycle	Corrected	Average	
	Freq.	Ant.	Table	Level	Level	Gain	Factor	Loss	Correction	Level	Limit	Margin
Harmonic	MHz	Pos.	Azimuth	dBm	dBuV	dB	dB	dB	dB	dBuV/m	dBuV/m	dB
3RD	2745	V	188/25	-41.38	65.62	43.4	29.2	3	12.74	41.68	54	12.32
4TH	3680	V	122/155	-43.9	63.1	46.2	31.6	3.2	12.74	38.96	54	15.04
5TH	4550	V	100/195	-45.1	61.9	47.79	32.9	4	12.74	38.27	54	15.73
6H	5460	H	100/160	-45	62	46.4	34.1	5	12.74	41.96	54	12.04
8TH	7360	V	Noise Floor	-60	47	44.5	36.4	6.4	12.74	32.56	54	21.44

The frequency investigated was 9 kHz to 9.2 GHz.
The unit transmits Manchester Encoded messages. Each of the messages is 92 bytes (736 bits) long. There are 20 bits of sync data on the front of the packet for a total of 756 bits at a bit rate of 16.384 kbps.
Message Period is: 756/16.384 kbps = 44.16 mS
During the transmission of messages, the Transmit Duty Cycle can be computed.
% Duty Cycle Transmit = 756 bits x (1/16.384 kbps) x 0.5 x 100% / 100 mS
% Duty Cycle Transmit =23.07 %
Note: The .5 factor is a result of Manchester Encoded Data.
Expressing the correction factor for Duty Cycle in dB:
dB Duty Cycle Transmit = 20 Log (Duty Cycle)
dB Duty Cycle Transmit = 20 Log (.2307)
dB Duty Cycle Transmit = -12.74 dB
The maximum relaxation allowed is 20 dB

1.1310 & 2.1091 / RSS-102

Maximum Permissible Exposure (MPE)

Determine the maximum power density for the general / uncontrolled population minimum separation distance of 20 cm. (f_{MHz} / 1500 mW/cm^2).

The power density is calculated as:

$$P_d = \frac{P_t \times G}{4 \times \pi \times r^2}$$

P_d = power density in watts
P_t = transmit power in milliwatts
G = numeric antenna gain
r = distance between body and transmitter in centimeters.

FCC Limit:

$$910 \ / 1500 \ = 0.61 \, mW \ / cm^2 @ 20 \, cm$$

Max antenna gain = 5.15 dBi = 3.27 numeric

Max TX power = 27.82 dBm = 605.34 mW

$$P_D = \frac{605.34 \times 3.27}{4 \times \pi \times 20^2} = 0.394 \, mW \ / cm^2 @ 20 \, cm$$

ANNEX A

15.247 (d)

Band-edge compliance of RF Conducted Emissions

Use the following spectrum analyzer settings:

Span = wide enough to capture the peak level of the emission operating on the channel closest to the bandedge, as well as any modulation products which fall outside of the authorized band of operation.
RBW ≥ 1% of the span
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

Allow the trace to stabilize. Set the marker on the emission at the bandedge, or on the highest modulation product outside of the band, if this level is greater than that at the bandedge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission. The marker-delta value now displayed must comply with the limit specified in this Section. Submit this plot.

Now, using the same instrument settings, enable the hopping function of the EUT. Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit. Submit this plot.

Spurious RF Conducted Emissions

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 10th harmonic. Typically, several plots are required to cover this entire span.
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 in this Section. Submit these plots.

Spurious Radiated Emissions

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
VBW ≥ RBW
Sweep = auto
Detector function = peak
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 in Section 15.35(b). Submit this data.

Now set the VBW to 10 Hz, while maintaining all of the other instrument settings. This peak level, once corrected, must comply with the limit specified in Section 15.209. If the dwell time per channel of the hopping signal is less than 100 ms, then the reading obtained with the 10 Hz VBW may be further adjusted by a "duty cycle correction factor", derived from 20log(dwell time/100 mS), in an effort to demonstrate compliance with the 15.209 limit. Submit this data.

If the emission on which a radiated measurement must be made is located at the edge of the authorized band of operation, then the alternative "marker-delta" method, listed at the end of this document, may be employed.

ALTERNATIVE TEST PROCEDURES

If antenna conducted tests cannot be performed on this device, radiated tests to show compliance with the peak output power limit specified in Section 15.247(b) (2) and the spurious RF conducted emission limit specified in Section 15.247(d) are acceptable. A pre-amp, and, in the latter case, a high pass filter, are required for the following measurements.

1) Calculate the transmitter's peak power using the following equation:

$$E = \frac{\sqrt{30PG}}{d}$$

Where: E is the measured maximum fundamental field strength in V/m, utilizing a RBW ≥ the 20 dB bandwidth of the emission, VBW > RBW, peak detector function. Follow the procedures in C63.4-2003 with respect to maximizing the emission.
G is the numeric gain of the transmitting antenna with reference to an isotropic radiator.
d is the distance in meters from which the field strength was measured.
P is the power in watts for which you are solving:

$$P = \frac{(E \times d)^2}{30G}$$

2) To demonstrate compliance with the spurious RF conducted emission requirement of Section 15.247(d), use the following spectrum analyzer settings:

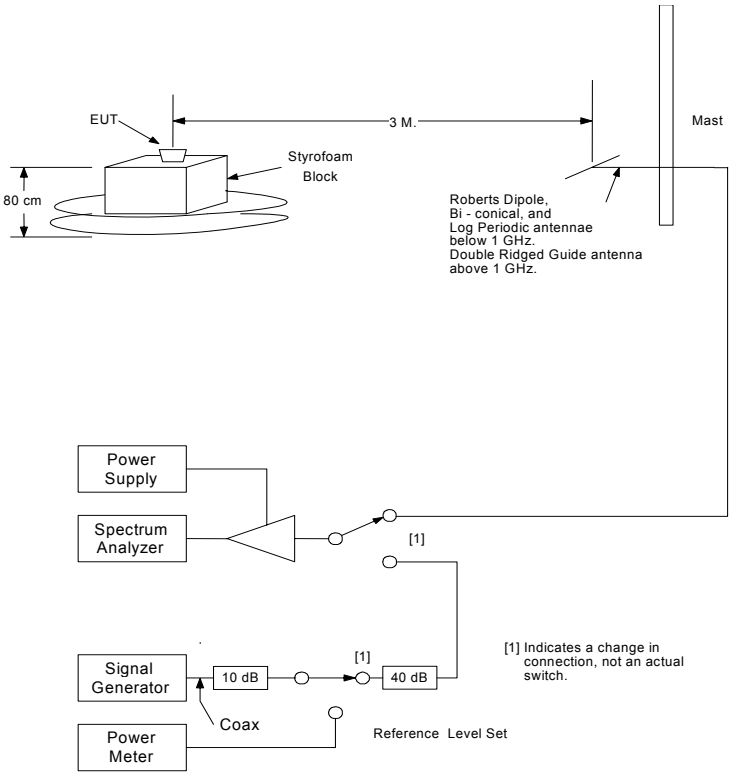
Span = wide enough to fully capture the emission being measured.
RBW = 100 kHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

Measure the field strength of both the fundamental emission and all spurious emissions with these settings. Follow the procedures in C63.4-2003 with respect to maximizing the emissions. The measured field strength of all spurious emissions must be below the measured field strength of the fundamental emission by the amount specified in Section 15.247(d). Note that if the emission falls in a Restricted Band, as defined in Section 15.205, the procedure for measuring spurious radiated emissions, listed above, must be followed.

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 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, 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.



Marker-Delta Method

In making radiated band-edge measurements, there can be a problem obtaining meaningful data since a measurement instrument that is tuned to a band-edge frequency may also capture some in-band signals when using the resolution bandwidth (RBW) required by measurement procedure ANSI C63.4-1992 (hereafter C63.4). In an effort to compensate for this problem, we have developed the following technique for determining band-edge compliance.

STEP 1) Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function required by C63.4 and our Rules for the frequency being measured. For example, for a device operating in the 902-928 MHz band under Section 15.249, use a 120 kHz RBW with a CISPR QP detector (a peak detector with 100 kHz RBW may alternatively be used). For transmitters operating above 1 GHz, use a 1 MHz RBW, a 1 MHz VBW, and a peak detector (as required by Section 15.35). Repeat the measurement with an average detector (i.e., 1 MHz RBW with 10 Hz VBW). Note: For pulsed emissions, other factors must be included. Please contact the FCC Lab for details if the emission under investigation is pulsed. Also, please note that radiated measurements of the fundamental emission of a transmitter operating under 15.247 are not normally required, but they are necessary in connection with this procedure.

STEP 2) Choose a spectrum analyzer span that encompasses both the peak of the fundamental emission and the band-edge emission under investigation. Set the analyzer RBW to 1% of the total span (but never less than 30 kHz) with a video bandwidth equal to or greater than the RBW. Record the peak levels of the fundamental emission and the relevant band-edge emission (i.e., run several sweeps in peak hold mode). Observe the stored trace and measure the amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is not a field strength measurement; it is only a relative measurement to determine the amount by which the emission drops at the band-edge relative to the highest fundamental emission level.

STEP 3) Subtract the delta measured in step (2) from the field strengths measured in step (1). The resultant field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge compliance as required by Section 15.205.

STEP 4) The above "delta" measurement technique may be used for measuring emissions that are up to two "standard" bandwidths away from the band-edge, where a "standard" bandwidth is the bandwidth specified by C63.4 for the frequency being measured. For example, for band-edge measurements in the restricted band that begins at 2483.5 MHz, C63.4 specifies a measurement bandwidth of at least 1 MHz. Therefore you may use the "delta" technique for measuring emissions up to 2 MHz removed from the band-edge. Radiated emissions that are removed by more than two “standard” bandwidths must be measured in the conventional manner.