

Nemko Test Report: 1L0617RUS1rev3

Applicant: Navini Networks
2240 Campbell Creek Blvd. Suite 110
Richardson, TX 75082

**Equipment Under Test:
(E.U.T.)** RipWave 2.4 GHz BTS, Release 1

FCC ID: PL6-ISM-BTS-R1

In Accordance With: **FCC Part 15, Subpart C, 15.247**
Direct Sequence Spread Spectrum Transmitters

Tested By: Nemko Dallas Inc.
802 N. Kealy
Lewisville, Texas 75057-3136

Authorized By:



David Light, Wireless Group Supervisor

Date: 26 June 2002

Total Number of Pages: 28

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EQUIPMENT: **RipWave 2.4 GHz BTS**PROJECT NO.: **1L0617RUS1rev3**

Section 1. Summary of Test Results

Manufacturer: Navini Networks

Model No.: RipWave 2.4 GHz BTS, Release 1

Serial No.: Sample #01

General: **All measurements are traceable to national standards.**

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 15, Subpart C, Paragraph 15.247 for Direct Sequence Spread Spectrum devices. Radiated tests were conducted in accordance with ANSI C63.4-1992. Radiated emissions are made on an open area test site. A description of the test facility is on file with the FCC.



New Submission



Production Unit



Class II Permissive Change



Pre-Production Unit

THIS TEST REPORT RELATES ONLY TO THE ITEM(S) TESTED.

THE FOLLOWING DEVIATIONS FROM, ADDITIONS TO, OR EXCLUSIONS FROM THE TEST
SPECIFICATIONS HAVE BEEN MADE.

See " Summary of Test Data".

**NVLAP LAB CODE: 100426-0**

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EQUIPMENT: [RipWave 2.4 GHz BTS](#)

PROJECT NO.:

[1L0617RUS1rev3](#)

Summary Of Test Data

NAME OF TEST	PARA. NO.	Limit	RESULT
Powerline Conducted Emissions	15.207(a)	48 dB μ V	¹
Minimum 6 dB Bandwidth	15.247(a)(2)	>500 kHz	Complies
Maximum Peak Power Output	15.247(b)(1)	<1 Watt	Complies
Spurious Emissions (Antenna Conducted)	15.247(c)	-20 dBc/100kHz	Complies
Spurious Emissions (Restricted Bands)	15.247(c)	< 74 dBuV/m Peak < 54 dBuV/m Avg	Complies
Peak Power Spectral Density	15.247(d)	+8 dBm/3kHz	Complies
Processing Gain			²

Footnotes:¹The equipment under test does not connect to the AC power mains network.²It is Navini's understanding that measurements to determine the minimum processing gain will not be required subsequent to the Commission's adoption of the Second Report and Order in ET Docket No. 99231.

EQUIPMENT: [RipWave 2.4 GHz BTS](#)PROJECT NO.: [1L0617RUS1rev3](#)

Section 2. Equipment Under Test (E.U.T.)**General Equipment Information**

Frequency Band in which TX operates: ☐ 902 – 928 MHz
☒ 2400 – 2483.5 MHz
☐ 5725 – 5850 MHz

Frequency Range of Operation: 2.403 GHz – 2.4775 GHz

User Frequency Adjustment: Software adjustable by service provider

Changes Made for Permissive Change Filing

The manufacturer is now offering an 8 dBi antenna array with this transmitter.

Description of Operation and Approval Notes

The EUT is part of a high speed wireless LAN system. The transmitter uses Direct Sequence Spread Spectrum techniques.

The antenna for this product is mounted on a fixed outdoor structure. The antenna consists of multiple radiating elements fed by multiple transmitters. The antenna system uses beam-forming techniques to optimize the efficiency and coverage of the system.

The following points were agreed between the manufacturer and the FCC for the approval of this equipment under 15.247 rules.

1. The individual transmitters in the system will be subject to the technical requirements set forth in Section 15.247;
2. Section 15.31 will not apply;
3. The system will be considered "point to point" under Section 15.247(b)(3)(i) and (iii);
4. Total antenna gain per transmitter will be computed as the sum of (a) the actual gain of the antenna used, and (b) the beam-forming gain (18dBi) of the system determined by the formula $20\log_{10} N$, where N is the number of transmitters in the array; and
5. The peak output power for each transmitter will be reduced per Section 15.247(b)(3)(i) based on the total antenna gain, however, a "phase coherence loss" correction factor of 2dB for the 8 transmitter array will be subtracted from this reduction.

Example:

In accordance with the foregoing, the peak output power of each transmitter in the Navini beam-forming array will be reduced as follows for the 12 dBi antenna system:

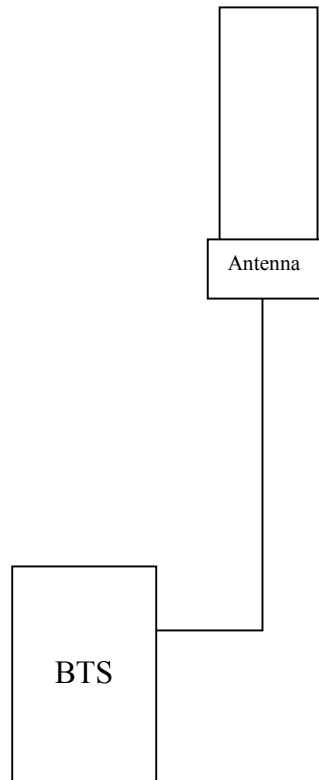
Total antenna gain(12 + 18)	30dB
Free gain per 15.247(b)(3)	- 6dB
Gain subject to power reduction	24dB

Power reduction per 15.247(b)(3)(i)	8dB
Correction for coherence loss	-2dB

Total reduction in transmitter power 6dB

This agreement is summarized in correspondence submitted with the application for equipment approval.

System Diagram



EQUIPMENT: [RipWave 2.4 GHz BTS](#)PROJECT NO.: [1L0617RUS1rev3](#)**Section 3. Maximum Peak Output Power**

NAME OF TEST: Maximum Peak Output power	PARA. NO.: 15.247(b)(1)
TESTED BY: T. Tidwell	DATE: 4/26/02

Test Results: Complies.**Measurement Data:****Equipment Used:** 1016, 1046

Gain (dBi)	Power @ Antenna Port	E.I.R.P. (dBm)
8	25.3	33.3
Note-The device was tested at +/- 15% variation with no effect on output power.		

Measurement Uncertainty: +/- 0.7 dB

EQUIPMENT: [RipWave 2.4 GHz BTS](#)

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Section 4. RF Exposure

NAME OF TEST: RF Exposure	PARA. NO.: 15.247(b)(4)
TESTED BY: D. Light	DATE: 6/11/2002

Test Results: Complies.

Measurement Data: See next page

Prediction of MPE Limit
OET Bulletin 65, Edition 97-01



Equation from page 18

$$S = \frac{PG}{4\pi R^2}$$

$$R = \sqrt{\frac{PG}{4\pi S}}$$

S= power density
P= power input to the antenna
G= power gain of the antenna in the direction of interest relative to an isotropic radiator
R= distance to the center of radiation of the antenna

Choose



ENTER



Occupational/Controlled -(BTS) ☐

General Population/Uncontrolled -(CPE) ☒

Tx Frequency: 2400.00 (MHz)

Maximum Peak Power at Antenna Input Terminal: 25.30 (dBm)

Antenna gain (typical)+ 8-element Beamforming gain: 26.00 (dBi)

S= 1.00 (mW/cm²)

P= 338.84 (mW)

G= 398.11 (numeric)

R = 103.61 (cm)

NOTE: The following warning must appear in the installation manual.

WARNING: This device is intended to be used with an antenna professionally installed on a fixed, outdoor structure. A minimum separation distance must be maintained in order to ensure compliance with the FCC rules for Radio Frequency Exposure. This minimum separation distance is found on the antenna array itself. Installation of the antenna where this minimum distance cannot be maintained may result in exposure to RF levels that exceed the FCC limits and is discouraged.

NOTE: The following warning must appear on the 8dBi omni antenna array.

WARNING: This antenna is intended to be professionally installed on a fixed, outdoor structure. A minimum separation distance of 1.05 meters must be maintained in order to ensure compliance with the FCC rules for Radio Frequency Exposure.

EQUIPMENT: [RipWave 2.4 GHz BTS](#)PROJECT NO.: [1L0617RUS1rev3](#)**Section 5. Spurious Emissions (radiated)**

NAME OF TEST: Restricted Bands	PARA. NO.: 15.247 (c)
TESTED BY: D. Light	DATE: 6/10/2002

Test Results: Complies.**Measurement Data:** See attached table.**Duty Cycle Calculation:**Duty Cycle correction factor(dB) = $20 \log (rf_{ON} \text{ in ms}/100\text{ms})$ $20\log(50\text{mS}/100\text{mS}) = -6 \text{ dB}$ **Measurement Uncertainty:** +/- 0.7 dB

Note: During testing, the input to each antenna was verified to be +25.3 dBm at each channel tested.

EQUIPMENT: **RipWave 2.4 GHz BTS**PROJECT NO.: **1L0617RUS1rev3****Nemko Dallas, Inc.****Dallas Headquarters:**

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Page <u>1</u> of <u>2</u>		<u>Radiated Emissions</u>	
Job No.:	1L0617R	Date:	6/19/02
Specification:	15.205	Temperature(°C):	22
Tested By:	David Light	Relative Humidity(%)	40
E.U.T.:	2.4 GHz BTS		
Configuration:	All transmitters active, all antennas active, 25.3 dBm output per transmitter, 8 dBi Maxrad antenna		
Sample Number:	1		
Location:	AC 1	RBW:	1 MHz
Detector Type:	Peak	VBW:	1 MHz
<u>Test Equipment Used</u>			
Antenna:	1304	Directional Coupler:	#N/A
Pre-Amp:	1016	Cable #1:	1484
Filter:	1482	Cable #2:	1485
Receiver:	1464	Cable #3:	#N/A
Attenuator #1:	#N/A	Cable #4:	#N/A
Attenuator #2:	#N/A	Mixer:	#N/A
Measurement Uncertainty:	+/- .7 dB		

Frequency (GHz)	Meter Reading (dBUV)	Antenna Factor (dB)	Cable Loss (dB)	Pre-Amp Gain (dB)	Corrected Reading (dBUV/m)	Limit (dBUV/m)	Delta (dB)	Comment
Tx at 2.4775 GHz								
								Highest channel
2.4835	41	28.2	3.1	0.0	72.3	74	-1.7	Peak-Vertical-Bandedge
2.4835	17	28.2	3.1	0.0	48.3	54	-5.7	Average-Vertical-Bandedge
4.955	41.5	33.8	4.3	29.6	50.0	54	-4.0	Peak - Vertical - NF
7.4325	42.7	36.2	5.3	34.1	50.1	54	-3.9	Peak - Vertical - NF
12.3875	42	39.9	7.3	32.7	56.5	74	-17.5	Peak - Vertical - NF
12.3875	33.5	39.9	7.3	32.7	48.0	54	-6.0	Average - Vertical - NF
2.4835	41.2	28.2	3.1	0.0	72.5	74	-1.5	Peak-Horizontal-BE
2.4835	15.8	28.2	3.1	0.0	47.1	54	-6.9	Average-Horizontal-BE
4.955	41.5	33.8	4.3	29.6	50.0	54	-4.0	Peak - Horizontal - NF
7.4325	42.7	36.2	5.3	34.1	50.1	54	-3.9	Peak - Horizontal - NF
12.3875	42	39.9	7.3	32.7	56.5	74	-17.5	Peak - Horizontal - NF
12.3875	33.5	39.9	7.3	32.7	48.0	54	-6.0	Average - Horizontal - NF
Tx at 2.4425 GHz								
								Mid Channel
4.8850	43.7	33.8	4.3	29.6	52.2	54	-1.8	Peak - Vertical - NF
7.3725	43	36.2	5.3	34.1	50.4	54	-3.6	Peak - Vertical - NF
4.8850	43.7	33.8	4.3	29.6	52.2	54	-1.8	Peak - Horizontal - NF
7.3725	43	36.2	5.3	34.1	50.4	54	-3.6	Peak - Horizontal - NF
Notes: Peak readings 1 MHz RBW / 1 MHz VBW - Average readings 1 MHz RBW / 10 Hz VBW								
Average readings include -6 dB correction for TDD modulation								

EQUIPMENT: **RipWave 2.4 GHz BTS**PROJECT NO.: **1L0617RUS1rev3****Nemko Dallas, Inc.****Dallas Headquarters:**

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Radiated Spurious Emissions

Page 1 of 2
 Job No.: 1L0617R
 Specification: 15.205
 Tested By: #N/A
 E.U.T.: 2.4 GHz BTS
 Configuration: All transmitters active, all antennas active, 25.3 dBm output per transmitter, 8 dBi Maxrad antenna

Continuation Page
Date: 6/19/02
Temperature(°F): 24
Relative Humidity(%) 40

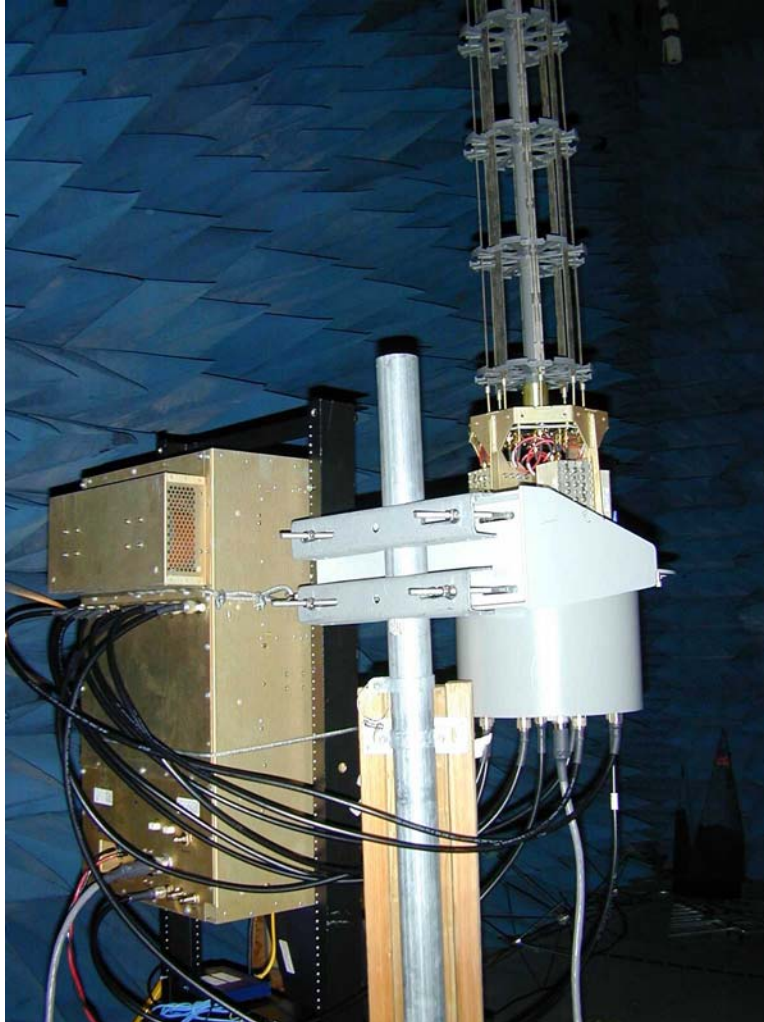
Frequency (GHz)	Meter Reading (dBuV)	Antenna Factor (dB)	Cable Loss (dB)	Pre-Amp Gain (dB)	Corrected Reading (dBuV/m)	Limit (dBuV/m)	Delta (dB)	Comment
								Tx at 2.4025 GHz
								Lowest channel
4.805	42.8	33.8	4.3	29.6	51.3	54	-2.7	Peak - Vertical - NF
12.0125	44.3	39.9	7.3	32.7	58.8	74	-15.2	Peak - Vertical - NF
12.0125	28.8	39.9	7.3	32.7	43.3	54	-10.7	Average - Vertical - NF
4.805	42.8	33.8	4.3	29.6	51.3	54	-2.7	Peak - Horizontal - NF
12.0125	44.3	39.9	7.3	32.7	58.8	74	-15.2	Peak - Horizontal - NF
12.0125	28.8	39.9	7.3	32.7	43.3	54	-10.7	Average - Horizontal - NF
Notes:	Peak readings 1 MHz RBW / 1 MHz VBW - Average readings 1 MHz RBW / 10 Hz VBW							
	Average readings include -6 dB correction for TDD modulation							

EQUIPMENT: [RipWave 2.4 GHz BTS](#)

PROJECT NO.:

[1L0617RUS1rev3](#)

Radiated Photographs (Worst Case Configuration)
8 dBi Array



EQUIPMENT: [RipWave 2.4 GHz BTS](#)

PROJECT NO.:

[1L0617RUS1rev3](#)

Radiated Photographs (Worst Case Configuration)

8 dBi Array



EQUIPMENT: [RipWave 2.4 GHz BTS](#)PROJECT NO.: [1L0617RUS1rev3](#)**Section 6. Test Equipment List**

Nemko ID	Description	Manufacturer Model Number	Serial Number	Calibration Date
1036	SPECTRUM ANALYZER	ROHDE & SCHWARZ FSEK30	830844/006	12/18/01
1304	HORN ANTENNA	ELECTRO METRICS RGA-60	6151	07/30/01
1464	Spectrum analyzer	Hewlett Packard 8563E	3551A04428	01/02/02
1625	CABLE, 18 ft	MEGAPHASE 10311 1GVT4	N/A	10/23/01
1046	Flex cable 1m	Astrolab Inc. 32022-2-29094K-1M	N/A	01/18/02
1482	Band Pass Filter	K & L 11SH10-4000/T12000-0/0	2	Cal B4 Use
1016	Pre-Amp	HEWLETT PACKARD 8449A	2749A00159	05/30/01

ANNEX A - TEST DETAILS

EQUIPMENT: [RipWave 2.4 GHz BTS](#)

PROJECT NO.: [1L0617RUS1rev3](#)

NAME OF TEST: Powerline Conducted Emissions	PARA. NO.: 15.207(a)
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Minimum Standard:

The R.F. that is conducted back onto the AC power line on any frequency within the band 0.45 to 30 MHz shall not exceed 250 μ V (48 dB μ V) across 50 ohms.

EQUIPMENT: [RipWave 2.4 GHz BTS](#)

PROJECT NO.: [1L0617RUS1rev3](#)

NAME OF TEST: Minimum 6 dB bandwidth	PARA. NO.: 15.247(a)(2)
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Minimum Standard: The minimum 6 dB bandwidth shall be at least 500 kHz

EQUIPMENT: **RipWave 2.4 GHz BTS**PROJECT NO.: **1L0617RUS1rev3**

NAME OF TEST: Maximum Peak Output Power

PARA. NO.: 15.247(b)(1)

Minimum Standard:

The maximum peak output power shall not exceed 1 watt.

If transmitting antennas of directional gain greater than 6 dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point to point operation may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceed 6 dBi.

Systems operating in the 5725 – 5850 MHz band that are used exclusively for fixed, point-to-point operation may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

Direct Measurement Method For Detachable Antennas:

If the antenna is detachable, a peak power meter is used to measure the power output with the transmitter operating into a 50 ohm load. The dBi gain of the antenna(s) employed shall be reported.

Calculation Of EIRP For Integral Antenna:

If the antenna is not detachable from the circuit then the Peak Power Output is derived from the peak radiated field strength of the fundamental emission by using the plane wave relation $GP/4\pi R^2 = E^2/120\pi$ and proceeding as follows:

$$P = \frac{E^2 R^2}{30G} = \frac{E^2 3^2}{30G}$$

where,

P = the equivalent isotropic radiated power in watts

E = the maximum measured field strength in V/m

R = the measurement range (3 meters)

G = the numeric gain of the transmit antenna in relation to an isotropic radiator

EQUIPMENT: [RipWave 2.4 GHz BTS](#)PROJECT NO.: [1L0617RUS1rev3](#)

The RBW of the spectrum analyzer shall be set to a value greater than the measured 6 dB occupied bandwidth of the E.U.T.

Number of channels tested:

Tuning range	Number of channels tested	Channel location in band
1 MHz or less	1	middle
1 to 10 MHz	2	top and bottom
more than 10 MHz	3	top, middle, bottom

EQUIPMENT: [RipWave 2.4 GHz BTS](#)PROJECT NO.: [1L0617RUS1rev3](#)

NAME OF TEST: RF Exposure

PARA. NO.: 15.247(b)(4)

Minimum Standard:

Systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines stipulated in 1.1307(b)(1) of CFR 47.

EQUIPMENT: **RipWave 2.4 GHz BTS**PROJECT NO.: **1L0617RUS1rev3**

NAME OF TEST: Spurious Emissions(conducted)

PARA. NO.: 15.247(c)

Minimum Standard:

In any 100kHz bandwidth outside the frequency band in which the transmitter is operating, emissions shall be at least 20 dB below the fundamental emission or shall not exceed the following field strength limits. Emissions falling in the restricted bands of 15.205 shall not exceed the following field strength limits:

Frequency (MHz)	Field Strength ($\mu\text{V/m}$ @ 3m)	Field Strength (dB @ 3m)
30 - 88	100	40.0
88 - 216	150	43.5
216 - 960	200	46.0
Above 960	500	54.0

THE SPECTRUM IS SEARCHED TO THE 10th HARMONIC OF THE HIGHEST FREQUENCY GENERATED IN THE EUT.

Method Of Measurement:

30 MHz - 10th harmonic plot

RBW: 100 kHz

VBW: 300 kHz

Sweep: Auto

Display line: -20 dBc

Lower Band Edge

RBW: At least 1% of span/div.

VBW: >RBW

Span: As necessary to display any spurious at band edge.

Sweep: Auto

Center Frequency: 902 MHz, 2400 MHz, or 5725 MHz

Marker: Peak of fundamental emission

Marker Δ : Peak of highest spurious level below center frequency.Upper Band Edge

RBW: At least 1% of span/div.

VBW: >RBW

Span: As necessary to display any spurious at band edge.

Sweep: Auto

Center Frequency: 928 MHz, 2483.5 MHz, or 5850 MHz

Marker: Peak of fundamental emission

Marker Δ : Peak of highest spurious level above center frequency.

Number of channels tested:

Tuning range	Number of channels tested	Channel location in band
1 MHz or less	1	middle
1 to 10 MHz	2	top and bottom
more than 10 MHz	3	top, middle, bottom

EQUIPMENT: **RipWave 2.4 GHz BTS**PROJECT NO.: **1L0617RUS1rev3**

NAME OF TEST: Radiated Spurious Emissions

PARA. NO.: 15.247(c)

Minimum Standard:

In any 100kHz bandwidth outside the frequency band in which the transmitter is operating, emissions shall be at least 20 dB below the fundamental emission or shall not exceed the following field strength limits:

Emissions falling in the restricted bands of 15.205 shall not exceed the following field strength limits:

Frequency (MHz)	Field Strength ($\mu\text{V/m}$ @ 3m)	Field Strength (dB @ 3m)
30 - 88	100	40.0
88 - 216	150	43.5
216 - 960	200	46.0
Above 960	500	54.0

THE SPECTRUM WAS SEARCHED TO THE 10th HARMONIC**15.205 Restricted Bands**

MHz	MHz	MHz	GHz
0.09-0.11	16.42-16.423	399.9-410	4.5-5.25
0.495-0.505	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
6.125-6.218	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	1718		

Number of channels tested:

Tuning range	Number of channels tested	Channel location in band
1 MHz or less	1	middle
1 to 10 MHz	2	top and bottom
more than 10 MHz	3	top, middle, bottom

EQUIPMENT: **RipWave 2.4 GHz BTS**PROJECT NO.: **1L0617RUS1rev3**

NAME OF TEST: Transmitter Power Density

PARA. NO.: 15.247(d)

Minimum Standard: The transmitted power density averaged over any 1 second interval shall not be greater than +8 dBm in any 3 kHz bandwidth.

Method Of Measurement: The spectrum analyzer is set as follows:

RBW: 3 kHz

VBW: >3 kHz

Span: => measured 6 dB bandwidth

Sweep: Span(kHz)/3 (i.e. for a span of 1.5 MHz the sweep rate is $1500/3 = 500$ sec.

LOG dB/div.: 2 dB

Note: For devices with spectrum line spacing ≤ 3 kHz, the RBW of the analyzer is reduced until the spectral lines are resolved. The measurement data is normalized to 3 kHz by summing the power of all the individual spectral lines within a 3 kHz band in linear power units.

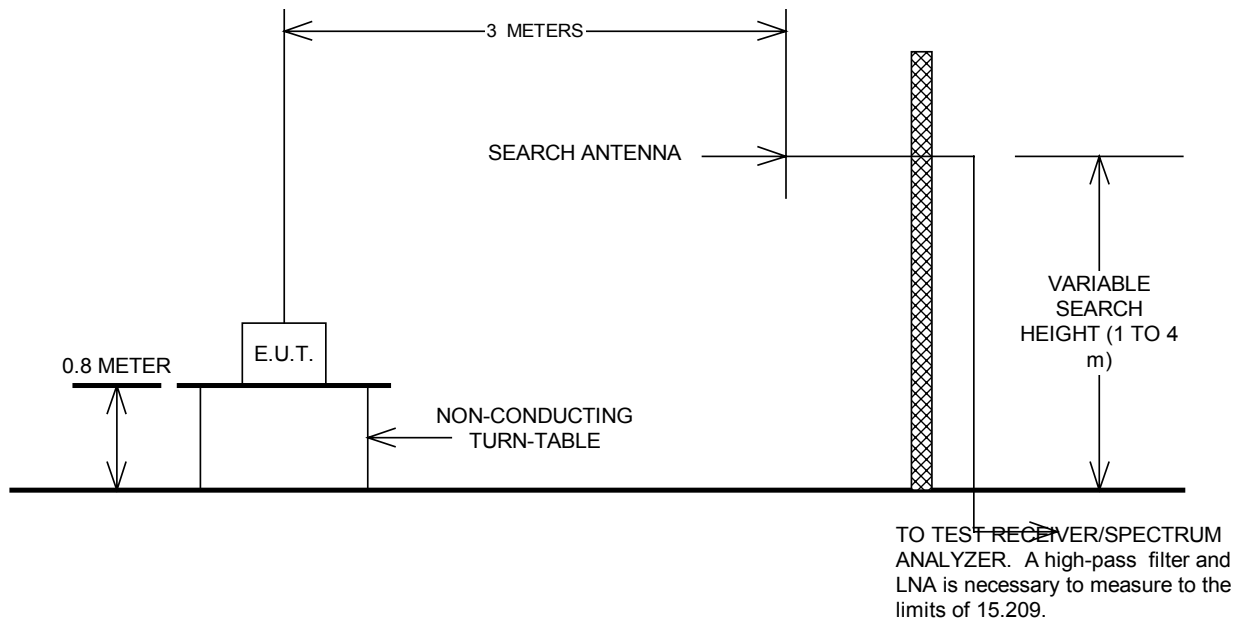
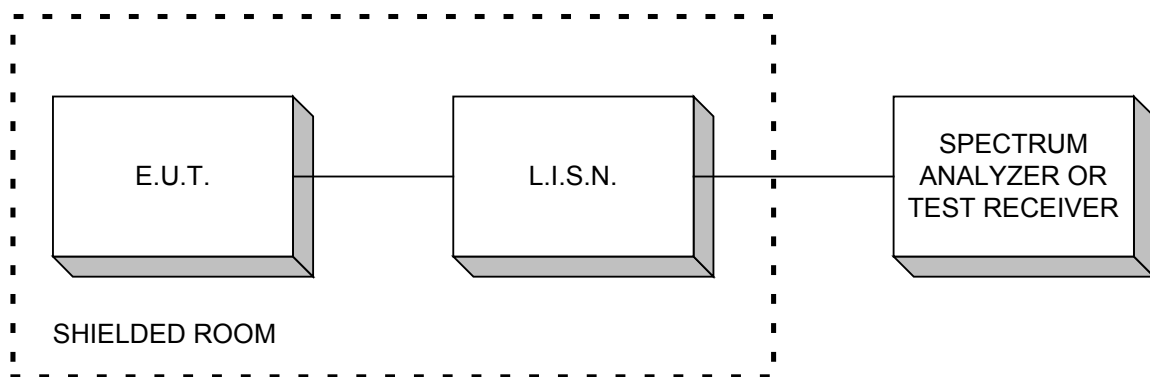
For Devices With Integral Antenna:

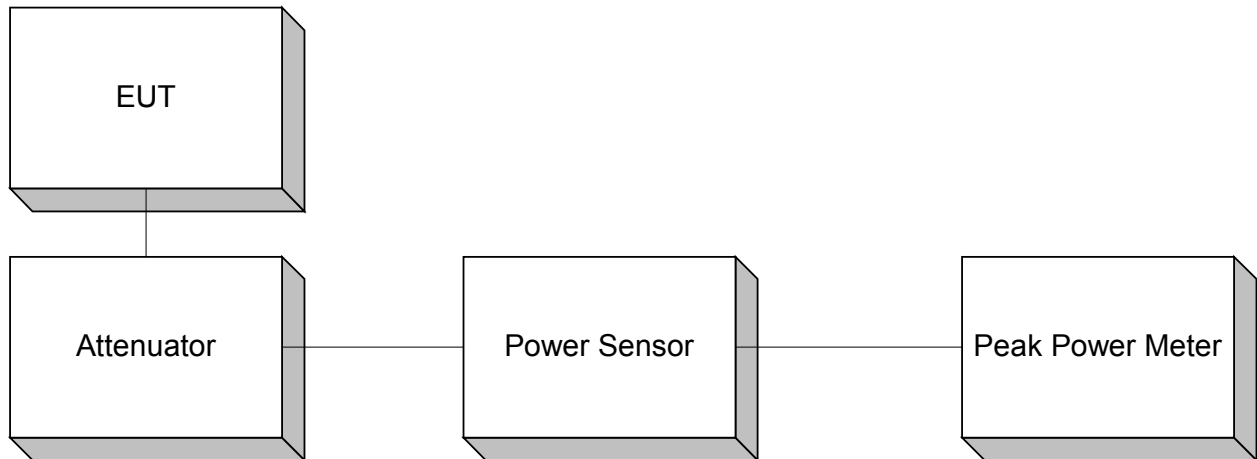
For devices with non-detachable antennas, the received field strength is peaked and the spectrum analyzer is set as above. The peak emission level is then measured and converted to a field strength by adding the appropriate antenna factor and cable loss. This field strength is then converted to an equivalent isotropic radiated power using the same method as described for Peak Power output.

Number of channels tested:

Tuning Range	Number Of Channels Tested	Channel Location In Band
1 MHz or Less	1	Middle
1 to 10 MHz	2	Top And Bottom
More Than 10 MHz	3	Top, Middle, Bottom

ANNEX B - TEST DIAGRAMS

Test Site For Radiated Emissions**Conducted Emissions**

Peak Power At Antenna Terminals**Minimum 6 dB Bandwidth
Peak Power Spectral Density
Spurious Emissions (conducted)**