ENGINEERING TEST REPORT

LUCENT WAVELAN/IEEE 2.4 GHz (11 Mb/s)
DSSS TRANSCEIVER
Model No.: TRX7431

FCC ID: GM3WLPC24H

(Class II Permiisve Change)

Applicant: **TEKLOGIX INC.**
2100 Meadowvale Blvd.
Mississauga, Ontario
Canada, L5N 7J9

In Accordance With

FEDERAL COMMUNICATIONS COMMISSION (FCC)
PART 15, SUBPART C, SEC. 15.247
Direct Sequence Spread Spectrum Transmitters operating in the frequency band 2412 - 2462 MHz
(Fixed Point-to-Point Operation)

UltraTech's File No.: TEK-250FTX

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: July 17, 2000	
Report Prepared by: Tri M. Luu, P.Eng. .	Tested by: Hung Trinh, EMI/RFI Technician
Issued Date: July 13, 2000	Test Dates: July 06-11, 2000

The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.

UltraTech

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EXHIBIT 1. SUBMITTAL CHECK LIST

Exhibit No.	Exhibit Type	Description of Contents	Quality Check (OK)
1 through 7	Test Report	• Exhibit 1: Submittal check lists • Exhibit 2: Introduction • Exhibit 3: Performance Assessment • Exhibit 4: Summary of test Results • Exhibit 5: Measurement Data • Exhibit 6: Measurement Uncertainty • Exhibit 7: Measurement Methods	
8	Test Report - Plots of Measurement Data	Plots # 1 to 4	
9	Test Setup Photos	Photos # 1 to 6	OK
10	External Photos of EUT	No changes on the radio, only photos of the antennas are submitted Photos # 1 to 4	 OK
11	Internal Photos of EUT	No changes in the radio	None
12	Cover Letters	• Letter from Ultratech for Certification Request • Letter from the Applicant to appoint Ultratech to act as an agent	
13	Attestation Statements	• Manufacturer's Declaration for Equipment Specifications, Installation (if it is professionally installed) and Production Quality Production Assurance. • Manufacturer's Declaration of Conformity (FCC DoC) for compliance with FCC Part 15, Sub. B, Class B - Computing Devices - if required	None None
14	Application Forms	• Form 731 • Form 159 • Confirmation of Exhibits sent to FCC • Status of Exhibits sent to FCC	OK OK OK
15	ID Label/Location Info	• ID Label • Location of ID Label	None None
16	Block Diagrams	• No changes on the radio from original submission	None
17	Schematic Diagrams	• No changes on the radio from original submission	None
18	Parts List/Tune Up Info	• No changes on the radio from original submission • Antenna specifications	None OK
19	Operational Description	• No changes on the radio from original submission	None
20	RF Exposure Info	Professional Installation meeting FCC 2.1091, 1.1307 and 1.1310	Yes
21	Users Manual	• No changes on the radio from original	None

		submission	

EXHIBIT 2. INTRODUCTION

2.1. SCOPE

Reference:	FCC Part 15, Subpart C, Section 15.247:1998
Title	Telecommunication - Code of Federal Regulations, CFR 47, Part 15
Purpose of Test:	To gain FCC Authorization for the Class II Permissive Changes for Direct Sequence Spread Spectrum Transmitters operating in the Frequency Band 2412 - 2462 MHz . The radio with this antenna will used as fixed, point-to-point operations.
Permissive Changes:	Without any changes in the Teklogix OEM TRX7431, the following additional antennas will be provided with the radio for uses with Teklogix 9150 Base unit. • Conifer antenna, Model 26T-2400F, Gain: 24 dBi, 50 Ohm input/output • Mobile Mark Omni Antenna, Model OD12, Gain: 12 dBi, 50 Ohm input/ouput The above antennas and radio system are required professional installation to meet FCC RF Safety Exposure Requirements specified by FCC Rules 2.1091, 1.1307 & 1.1310
Test Procedures	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 – 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.
Environmental Classification:	• Light-industry, Commercial • Industry

2.2. RELATED SUBMITAL(S)/GRANT(S)

None

2.3. NORMATIVE REFERENCES

Publication	YEAR	Title
FCC CFR Parts 0-19	1999	Code of Federal Regulations – Telecommunication
ANSI C63.4	1992	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
CISPR 22 & EN 55022	1997 1998	Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment
CISPR 16-1		Specification for Radio Disturbance and Immunity measuring apparatus and methods

EXHIBIT 3. PERFORMANCE ASSESSMENT

3.1. CLIENT INFORMATION

APPLICANT:	
Name:	TEKLOGIX INC.
Address:	2100 Meadowvale Blvd. Mississauga, Ontario Canada, L5N 7J9
Contact Person:	Mr. Michael Wright Phone #: 905-813-9900 (3358) Fax #: 905-812-6301 Email Address: mwright@teklogix.com

MANUFACTURER:	
Name:	LUCENT TECHNOLOGIES WCND BV
Address:	3431 JZ Nieuwegein The Netherlands

3.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Brand Name	TEKLOGIX INC.
Product Name	LUCENT WAVELAN/IEEE 2.4 GHz (11 Mb/s) DSSS TRANSCEIVER
Model Name or Number	TRX7431
Serial Number	Pre-production samples
Type of Equipment	Direct Sequence Spread Spectrum Transmitters
External Power Supply	Note 1
Transmitting/Receiving Antenna Type	• Conifer antenna, Model 26T-2400F, Gain: 24 dBi, 50 Ohm input/output • Mobile Mark Omni Antenna, Model OD12, Gain: 12 dBi, 50 Ohm input/ouput The above antennas and radio system are required professional installation to meet FCC RF Safety Exposure Requirements specified by FCC Rules 2.1091, 1.1307 & 1.1310
Antenna Type of Uses:	▪ Base station (fixed use)

3.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Intended Operating Environment:	▪ Residential ▪ Commercial, light industry & heavy industry
Power Supply Requirement:	7.2 Vdc self-regulated voltage
RF Output Power Rating:	0.0386 Watts Peak
Operating Frequency Range:	2412 - 2462 MHz
RF Output Impedance:	50 Ohms
Duty Cycle:	25%
6 dB Bandwidth:	10.64 MHz
Emission Designation:	Direct Sequence Spread Spectrum (DSSS)
Oscillator Frequencies:	352 MHz
Antenna Connector Type:	Reversed Thrust SMA connector is required to be connected to the radio with Teklogix 9150 system.
Antenna Description:	• Conifer antenna, Model 26T-2400F, Gain: 24 dBi, 50 Ohm input/output • Mobile Mark Omni Antenna, Model OD12, Gain: 12 dBi, 50 Ohm input/output The above antennas and radio system are required professional installation to meet FCC RF Safety Exposure Requirements specified by FCC Rules 2.1091, 1.1307 & 1.1310

3.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	RF IN/IOUT	1	SMA (REVERSED)	Shielded or direct attachment without cable.

NOTE:

- ***Ports of the EUT which in normal operation*** *were connected to ancillary equipment through interconnecting cables via a representative interconnecting cable to simulate the input/output characteristics. RF input/output was correctly terminated to the associated antenna.*
- ***Ports which are not connected to cables during normal intended operation: None***

3.5. ANCILLARY EQUIPMENT/TEST SETUP

3.5.1. Test Configuration #15: Teklogix TRX7431 Radio installed inside Teklogix 9150 Base Station

Title:	Author:	File Name:	Date:
Radio Approvals Product Configuration	M. D. Wright	RA Product Configuration.doc	2000-02-22

TITLE

RADIO APPROVAL PRODUCT CONFIGURATION

PRODUCT UNDER TEST	9150 Gateway + TRX 7431 (FCC ID: GM3WLPC24H) + 2.4GHz 12dBi Omni Antenna & + 2.4GHz 24dBi Grid Dish Antenna
DESTINATION COUNTRY	USA / CAN
APPLICABLE STANDARD	Class II Permissive Change for FCC PART 15.247 & RSS-139
EQUIPMENT CLASS	Class B
EQUIPMENT TYPE	Information Technology Equipment
TESTER	M. D. Wright
DATE	Thursday, 13 July 2000

Revision	Date	Change Description	by	Comments
Draft 1	2000-02-22	Initial Draft	Michael Wright	

HARDWARE	
MANUFACTURER	Teklogix
PRODUCT	Gateway
MODEL NUMBER	9150
SERIAL NUMBER	308627
MLB PART NUMBER	30183-003 Rev A
MLB SERIAL NUMBER	4440000218
RAM SIZE	64MB
MISCELANEOUS HARDWARE	
ANTENNA TYPE + GAIN	2.4GHz 12dBi Omni Antenna N-F
MANUFACTURER	Mobilmark
MANUFACTURER INFO	3900-B River Road, SchillerPark IL60176 Phone: 1-800-648-2800 Web: www.mobilmark.com
MFG PART NUMBER	OD12-2400
TEKLOGIX PART NUMBER	996219
PRODUCT	4' Adapter Cable RTSMA to N-F
TEKLOGIX PART NUMBER	19648

SOFTWARE	
SOFTWARE VERSION	H268E
BOOT CODE VERSION	D059Q
APPLICATION TYPE	Radio Approval Software
APPLICATION VERSION	IRI2189150.IMG
CLOCK SPEED	40MHz
OSCILLATOR FREQUENCIES	4MHz, 20MHz

RADIO	
LOCATION	SLOT A
MANUFACTURER:	LUCENT
PRODUCT	2.4 GHz DSSS 11MB PCMCIA Card
MODEL NUMBER	PC24-H-FC
TEKLOGIX MODEL NUMBER	TRX 7431
TEKLOGIX PART NUMBER	30589-111
SERIAL NUMBER	00UT21414878
ID NUMBER (FCC/ETSI)	GM3WLPC24H
POWER	32 mW
FREQUENCY RANGE	2.4 to 2.4835 GHz
DATA RATES	11MBps
CHANNELS	11 (FCC)
L.O. FREQUENCIES	352MHz
REF. OSC. FREQUENCIES	22MHz
INTERNAL/EXTRENAL ANTENNA	External
RF CABLE TYPE	RJ 316
TEKLOGIX PART NUMBER	30519

ACCESSORIES	
TYPE	LAPTOP
MANUFACTURER	TOSHIBA
MODEL NUMBER	SATELLITE 110CT
SERIAL NUMBER	07614075

TEST CONFIGURATION					
Label	**INTERFACE PORT**	**CABLE TYPE**	**CABLE LENGTH**	**SHEILDED (S/NS)**	**COMMENTS**
1	AC Power	NA Power Cord	2M	S	
2	10BASE T	RJ45	3M	NS	
3	10BASE 5	DB15	2.0M	S	
4	10BASE 2	BNC Co-Axial	7M	S	
5	CONSOLE	DB9	2M	S	
6	RTSMA Antenna Connector	4' Adapter Cable RTSMA to N-F	1.5M	S	

BLOCK DIAGRAM OF TEST SETUP

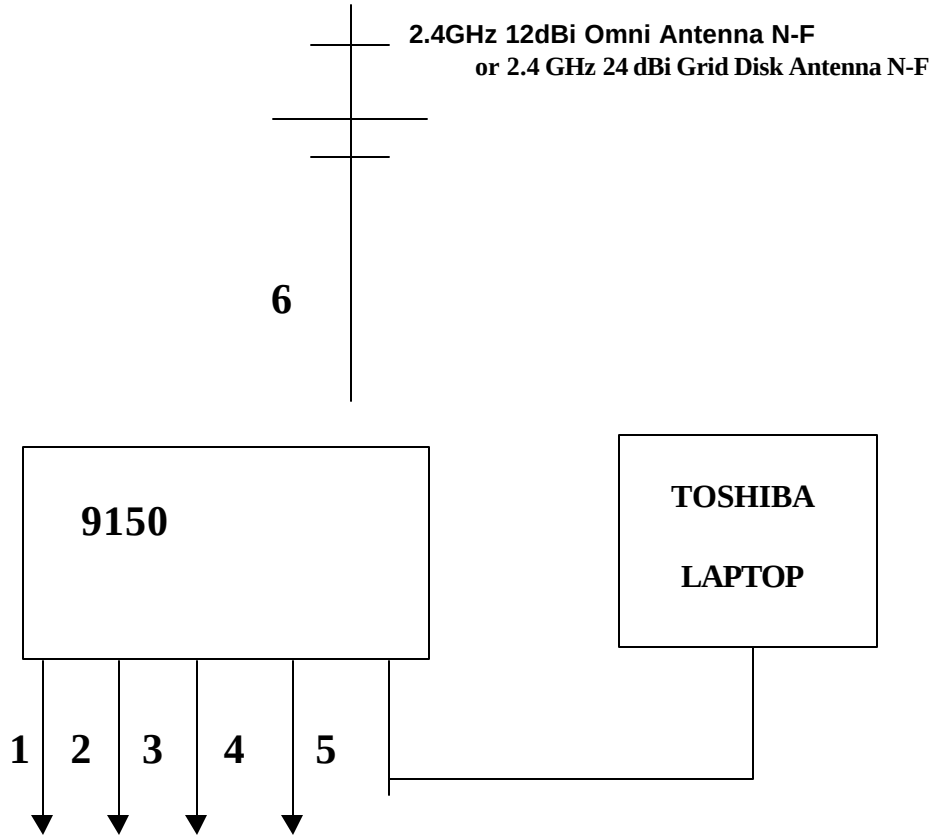


EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- AC Powerline Conducted Emissions were performed in UltraTech's shielded room, 16'(L) by 12'(W) by 12'(H).
- Radiated Emissions were performed at the Ultratech's 3 Meter Open Field Test Site (OFTS) situated in the Town of Oakville, province of Ontario.

The above sites have been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville Open Field Test Site has been filed with FCC office (FCC File No.: 31040/SIT 1300B3) and Industry Canada office (Industry Canada File No.: IC2049). Last Date of Site Calibration: Sep. 20, 1999.

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC PARAGRAPH.	TEST REQUIREMENTS	COMPLIANCE (YES/NO)
15.107, 15.109	AC Power Conducted Emissions & Radiated Emissions for Receiver and Digital Circuit Portions	Note 1
15.247(a)(2)	Spectrum Bandwidth of a Direct Sequence Spread Spectrum System	Note 1
15.247(b) & 1.1310	Maximum Peak Power and RF Exposure Limits	Yes
15.247(c)	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Note 1
15.247(c), 15.209 & 15.205	Transmitter Radiated Emissions	Yes
15.247(d)	Transmitted Power Density of a Direct Sequence Spread Spectrum System	Note 1
15.247(e)	Processing Gain of Direct Sequence Spread Spectrum System	Note 1

Note 1: Tests are not required to be repeated with the additional antennas provided,

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

EXHIBIT 5. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR EMC EMISSIONS

5.1. TEST PROCEDURES

This section contains test results only. Details of test methods and procedures can be found in Exhibit 7 of this report

5.2. MEASUREMENT UNCERTAINTIES

The measurement uncertainties stated were calculated in accordance with requirements of UKAS Document NIS 81 with a confidence level of 95%. Please refer to Exhibit 6 for Measurement Uncertainties.

5.3. MEASUREMENT EQUIPMENT USED

The measurement equipment used complied with the requirements of the Standards referenced in the Methods & Procedures ANSI C64.3:1992, FCC 15.247 and CISPR 16-1.

5.4. ESSENTIAL/PRIMARY FUNCTIONS AS DECLARED BY THE MANUACTURER

The essential function of the EUT is to correctly communicate data to and from radios over RF link.

5.5. MAXIMUM PEAK OUTPUT POWER @ FCC 15.247(B) AND RF EXPOSURE LIMIT FCC 1.1310

5.5.1. Limits

- **FCC 15.247(b)(1):** Maximum peak output power of the transmitter shall not exceed 1 Watt.
- **FCC 15.247(b)(3):** If the antenna 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.
- **FCC 15.247(b)(3)(i):** Systems operating in the 2400 - 2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduce by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi..
- **FCC 1.1310:**- The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Average Time (minutes)
(A) Limits for Occupational/Control Exposures				
300-1500	...	...	F/300	6
1500-100,000	...	...	5	6
(B) Limits for General Population/Uncontrolled Exposure				
300-1500	...	...	F/1500	6
1500-100,000	...	...	1.0	30

F = Frequency in MHz

5.5.2. Method of Measurements

Refer to FCC 15.247(b)(1)&(3), ANSI C63-4:1992, FCC @ 1.1310 & OST Bulletin No. 65-October 1985

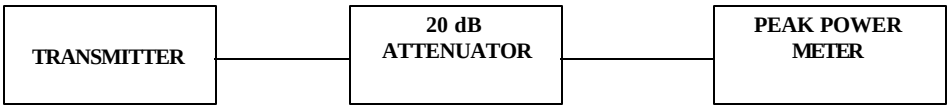
$S = PG/4\Pi r^2 = EIRP/4\Pi r^2$

Where: P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm^2
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

$r = \sqrt{PG/4\Pi S}$

FCC radio frequency exposure limits may be exceeded at distances closer than r cm from the antenna of this device

5.5.3. Test Arrangement



5.5.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Hewlett Packard	HP 8593EM	3412A00103	9 kHz – 26.5 GHz
Peak Power Meter & Peak Power Sensor	Hewlett Packard	8900 8481A	2131A00124 2551A01965	0.1-18 GHz 50 Ohms Input
Microwave Amplifier	Hewlett Packard	HP 83017A		1 GHz to 26.5 GHz
Horn Antenna	EMCO	3155	9701-5061	1 GHz – 18 GHz

5.5.5. Test data

Transmitting Antenna: Mobile Mark Omni Antenna, Model OD12, Gain: 12 dBi, 50 Ohm input/output						
Channel Number	Channel Frequency (MHz)	Power at Antenna Port (dBm) peak	Antenna Gain (dBi)	EIRP Power (dBm) peak	Power Limit @Atenna Port For Fixed,Point to Point Operation (dBm) peak	RF safety Distance (cm)
1	2412	15.1	12.0	27.1	28.0	6.3
6	2437	15.2	12.0	27.2	28.0	6.4
11	2462	15.2	12.0	27.2	28.0	6.4

Transmitting Antenna: Conifer antenna, Model 26T-2400F, Gain: 24 dBi, 50 Ohm input/output						
Channel Number	Channel Frequency (MHz)	Power at Antenna Port (dBm) peak	Antenna Gain (dBi)	EIRP Power (dBm) peak	Power Limit @Atenna Port For Fixed,Point to Point Operation (dBm) peak	RF safety Distance (cm)
1	2412	15.1	24.0	39.1	-24.0	25.4
6	2437	15.2	24.0	39.2	-24.0	25.7
11	2462	15.2	24.0	39.2	-24.0	25.7

Notes:

- EXPOSURE DISTANCE LIMITS: $r = (PG/4\Pi S)^{1/2} = (EIRP/4\Pi S)^{1/2}$
  Where $S = 1\ mW/cm^2$
- For compliance with FCC RF Safety Requirements, the antennas will be professionally installed and located on the building roof-top or antenna tower. The antennas will be mounted at least 15 feet high and 10 feet away from the user(s). Please refer to the attached confirmation from Teklogix in the "RF Exposure" folder.

5.6. TRANSMITTER RADIATED EMISSIONS @ 3 METERS, FCC CFR 47, PARA. 15.247(C), 15.209 & 15.205

5.6.1. Limits

In any 100 KHz bandwidth outside the operating frequency band, the radio frequency power that is produced by modulation products of the spreading sequence, the information sequence and the carrier frequency shall be either at least 20 dB below that in any 100 KHz bandwidth within the band that contains the highest level of the desired power or shall not exceed the general levels specified in @ 15.209(a), which lesser attenuation.

All other emissions inside restricted bands specified in @ 15.205(a) shall not exceed the general radiated emission limits specified in @ 15.209(a)

Remarks:

- Applies to harmonics/spurious emissions that fall in the restricted bands listed in Section 15.205. The maximum permitted average field strength is listed in Section 15.209.
- @ **FCC CFR 47, Para. 15.237(c)** - The emission limits as specified above are based on measurement instrument employing an average detector. The provisions in @**15.35** for limiting peak emissions apply.

FCC CFR 47, Part 15, Subpart C, Para. 15.205(a) - Restricted Frequency Bands

MHz	MHz	MHz	GHz
0.090 - 0.110	162.0125 - 167.17	2310 - 2390	9.3 - 9.5
0.49 – 0.51	167.72 - 173.2	2483.5 - 2500	10.6 - 12.7
	240 - 285	2655 - 2900	13.25 - 13.4
	322 - 335.4	3260 - 3267	14.47 - 14.5
2.1735 - 2.1905	399.9 - 410	3332 - 3339	14.35 - 16.2
8.362 - 8.366	608 - 614	3345.8 - 3358	17.7 - 21.4
13.36 - 13.41	960 - 1240	3600 - 4400	22.01 - 23.12
25.5 – 25.67	1300 - 1427	4500 - 5250	23.6 - 24.0
37.5 – 38.25	1435 - 1626.5	5350 - 5460	31.2 - 31.8
73 - 75.4	1660 - 1710	7250 - 7750	36.43 - 36.5
108 – 121.94	1718.8 - 1722.2	8025 - 8500	Above 38.6
123 – 138	2200 - 2300	9000 - 9200	
149.9 – 150.05			
156.7 – 156.9			

FCC CFR 47, Part 15, Subpart C, Para. 15.209(a)
-- Field Strength Limits within Restricted Frequency Bands --

FREQUENCY (MHz)	FIELD STRENGTH LIMITS (microvolts/m)	DISTANCE (Meters)
0.009 - 0.490	2,400 / F (KHz)	300
0.490 - 1.705	24,000 / F (KHz)	30
1.705 - 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

5.6.2. Method of Measurements

Refer to **ANSI 63.4-1992, Para. 8** for detailed radiated emissions measurement procedures.

Applies to harmonics/spurious that fall in the restricted bands listed in Section 15.205. the maximum permitted average field strength is listed in Section 15.209. A Pre-Amp and highpass filter are used for this measurement.

For measurement below 1 GHz, set RBW = 100 KHz, VBW $\geq$ 100 KHz, SWEEP=AUTO.

For measurement above 1 GHz, set RBW = 1 MHz, VBW = 1 MHz (Peak) & VBW = 10 Hz (Average), SWEEP=AUTO.

If the emission is pulsed, modified the unit for continuous operation, then use the settings above for measurements, then correct the reading by subtracting the peak-average correction factor derived from the appropriate duty cycle calculation. See Section 15.35(b) and (c).

FCC CFR 47, Para. 2.997 - Frequency spectrum to be investigated

The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10^{th} harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

FCC CFR 47, Para. 2.993 - Field Strength Spurious Emissions

(a) Measurements was made to detect spurious emissions radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data were supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph 2.989(c) as appropriate. For equipment operating on frequencies below 1 GHz, an Open Field Test is normally required, with the measuring instrument antenna located in the far field at all test frequencies. In event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurement will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with the reference to the rated power output of the transmitter, assuming all emissions are radiated from half-wave dipole antennas.

(b) Measurements specified in paragraph (a) of this section shall be made for the following equipment:

(1) Those in which the spurious emission are required to be 60 dB or more below he mean power of the transmitter.
(2) All equipment operating on frequencies higher than 25 MHz
(3) All equipment where the antenna is an integral part of, and attached directly to the transmitter.
(4) Other types of equipment as required, when deemed necessary by the commission.

5.6.3. Test Arrangement

Please refer to Test Arrangement in Sec. 2.5.1 to 2.5.5 for details of test setup for emission measurements.

5.6.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Advantest	R3271	15050203	100 Hz to 32 GHz with external mixer for frequency above 32 GHz
Microwave Amplifier	Hewlett Packard	HP 83017A		1 GHz to 26.5 GHz
Biconilog Antenna	EMCO	3143	1029	20 MHz to 2 GHz
Horn Antenna	EMCO	3155	9701-5061	1 GHz – 18 GHz
Horn Antenna	EMCO	3160-09	..	18 GHz – 26.5 GHz
Horn Antenna	EMCO	3160-10	..	26.5 GHz – 40 GHz
Mixer	Tektronix	118-0098-00	..	18 GHz – 26.5 GHz
Mixer	Tektronix	119-0098-00	..	26.5 GHz – 40 GHz

5.6.5. Test data

5.6.5.1. Test Configuration #1: Teklogix TRX7431 Radio with Teklogix 9150 and Mobile Mark Omni Antenna, Model OD12, Gain: 12 dBi

Channel #1, Channel Frequency Tested: 2412 MHz
Power Level in 1 MHz BW: 102.4 dBµV/m Average in 1 MHz BW, Duty Cycle: 25% or (-12dB)
Limit: 82.4 dBµV/m

FREQUENCY (MHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	LIMIT 15.247 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
2412	114.4	102.4	V	--	--	--	--
2412	99.4	87.4	H	--	--	--	--
4824	52.5	30.9	V	54.0	82.4	-23.1	*PASS
4824	50.1	26.9	H	54.0	82.4	-27.1	*PASS

The emissions were scanned from 10 MHz to 25 GHz and all emissions less 40 dB below the limits were recorded.

Emission within the restricted band specified in @ 15.205(a)

Channel #6, Channel Frequency Tested: 2437 MHz
Power Level in 1 MHz BW: 100.6 dBµV/m Average in 1 MHz BW, Duty Cycle: 25% or (-12dB)
Limit: 80.6 dBµV/m

FREQUENCY (MHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	LIMIT 15.247 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
2437	112.6	80.6	V	--	--	--	--
2437	103.5	91.5	H	--	--	--	--
4874	63.0	45.3	V	54.0	80.6	-8.7	*PASS
4874	56.8	36.3	H	54.0	80.6	-17.7	*PASS

The emissions were scanned from 10 MHz to 25 GHz and all emissions less 40 dB below the limits were recorded.

Emission within the restricted band specified in @ 15.205(a)

Channel #11, Channel Frequency Tested: 2462 MHz
Power Level in 1 MHz BW: 101.6 dBµV/m Average in 1 MHz BW, Duty Cycle: 25% or (-12dB)
Limit: 80.6 dBµV/m

FREQUENCY (MHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	LIMIT 15.247 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
2462	113.6	101.6	V	--	--	--	--
2462	102.9	90.9	H	--	--	--	--
4924	59.0	41.3	V	54.0	81.6	-12.7	*PASS
4924	54.0	32.1	H	54.0	81.6	-21.9	*PASS

The emissions were scanned from 10 MHz to 25 GHz and all emissions less 40 dB below the limits were recorded.

Emission within the restricted band specified in @ 15.205(a)

5.6.5.2. Test Configuration #2: Teklogix TRX7431 Radio with Teklogix 9150 and Conifer antenna, Model 26T-2400F, Gain: 24 dBi

Channel #1, Channel Frequency Tested: 2412 MHz
Power Level in 1 MHz BW: 109.5 dBµV/m Average in 1 MHz BW, Duty Cycle: 25% or (-12dB)
Limit: 89.5 dBµV/m

FREQUENCY (MHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	LIMIT 15.247 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
2412	121.5	109.5	V	--	--	--	--
2412	100.7	88.7	H	--	--	--	--
4824	51.6	30.7	V	54.0	89.5	-23.3	*PASS
4824	50.0	26.8	H	54.0	89.5	-27.2	*PASS

The emissions were scanned from 10 MHz to 25 GHz and all emissions less 40 dB below the limits were recorded.

Emission within the restricted band specified in @ 15.205(a)

Channel #6, Channel Frequency Tested: 2437 MHz
Power Level in 1 MHz BW: 109.3 dBµV/m Average in 1 MHz BW, Duty Cycle: 25% or (-12dB)
Limit: 89.3 dBµV/m

FREQUENCY (MHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	LIMIT 15.247 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
2437	121.3	109.3	V	--	--	--	--
2437	100.5	88.5	H	--	--	--	--
4874	57.4	39.3	V	54.0	89.3	-14.7	*PASS
4874	51.9	39.9	H	54.0	89.3	-14.1	*PASS

The emissions were scanned from 10 MHz to 25 GHz and all emissions less 40 dB below the limits were recorded.

Emission within the restricted band specified in @ 15.205(a)

Channel #11, Channel Frequency Tested: 2462 MHz
Power Level in 1 MHz BW: 109.3 dBµV/m Average in 1 MHz BW, Duty Cycle: 25% or (-12dB)
Limit: 89.3 dBµV/m

FREQUENCY (MHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	LIMIT 15.247 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
2462	121.3	109.3	V	--	--	--	--
2462	101.3	89.3	H	--	--	--	--
4924	58.2	39.4	V	54.0	89.3	-14.6	*PASS
4924	55.5	35.8	H	54.0	89.3	-18.2	*PASS

The emissions were scanned from 10 MHz to 25 GHz and all emissions less 40 dB below the limits were recorded.

Emission within the restricted band specified in @ 15.205(a)

5.6.6. Plots

Refer to Exhibit 12 for measurement plots.

5.6.7. Photographs of Test Setup

Refer to Exhibit 13 for test setup and arrangement of equipment under tests and its ancillary equipment.

EXHIBIT 6. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of NIST Technical Note 1297 and NIS 81 (1994)

6.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Line Conducted)	PROBABILITY DISTRIBUTION	UNCERTAINTY (dB)	
		9-150 kHz	0.15-30 MHz
EMI Receiver specification	Rectangular	±1.5	±1.5
LISN coupling specification	Rectangular	±1.5	±1.5
Cable and Input Transient Limiter calibration	Normal (k=2)	±0.3	±0.5
Mismatch: Receiver VRC Γ_1 = 0.03 LISN VRC Γ_R = 0.8(9 kHz) 0.2 (30 MHz) Uncertainty limits 20Log(1±$\Gamma_1\Gamma_R$)	U-Shaped	±0.2	±0.3
System repeatability	Std. deviation	±0.2	±0.05
Repeatability of EUT	--	--	--
Combined standard uncertainty	Normal	±1.25	±1.30
Expanded uncertainty U	Normal (k=2)	±2.50	±2.60

Sample Calculation for Measurement Accuracy in 150 kHz to 30 MHz Band:

$u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)} = \pm \sqrt{(1.5^2 + 1.5^2)/3 + (0.5/2)^2 + (0.05/2)^2 + 0.35^2} = \pm 1.30$ dB

$U = 2u_c(y) = \pm 2.6$ dB

6.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Radiated Emissions)	PROBABILITY DISTRIBUTION	UNCERTAINTY (± dB)	
		3 m	10 m
Antenna Factor Calibration	Normal (k=2)	±1.0	±1.0
Cable Loss Calibration	Normal (k=2)	±0.3	±0.5
EMI Receiver specification	Rectangular	±1.5	±1.5
Antenna Directivit	Rectangular	+0.5	+0.5
Antenna factor variation with height	Rectangular	±2.0	±0.5
Antenna phase center variation	Rectangular	0.0	±0.2
Antenna factor frequency interpolation	Rectangular	±0.25	±0.25
Measurement distance variation	Rectangular	±0.6	±0.4
Site imperfections	Rectangular	±2.0	±2.0
Mismatch: Receiver VRC $\Gamma_1 = 0.2$ Antenna VRC $\Gamma_R = 0.67$(Bi) 0.3 (Lp) Uncertainty limits 20Log(1±$\Gamma_1\Gamma_R$)	U-Shaped	+1.1 -1.25	±0.5
System repeatability	Std. Deviation	±0.5	±0.5
Repeatability of EUT		-	-
Combined standard uncertainty	Normal	+2.19 / -2.21	+1.74 / -1.72
Expanded uncertainty U	Normal (k=2)	+4.38 / -4.42	+3.48 / -3.44

Calculation for maximum uncertainty when 3m biconical antenna including a factor of k=2 is used:

$U = 2u_c(y) = 2x(+2.19) = +4.38$ dB And $U = 2u_c(y) = 2x(-2.21) = -4.42$ dB

EXHIBIT 7. MEASUREMENT METHODS

7.1. GENERAL TEST CONDITIONS

7.1.1. Test Conditions

- The measurement shall be made in the operational mode producing the largest emission in the frequency band being investigated consistent with normal applications.
- An attempt shall be made to maximize the detected radiated emissions, for example moving cables of the equipment, rotating the equipment by 360^{o} and moving the measuring receiving antenna up and down within 1 to 4 meters high.
- Where appropriate, a single tone or a bit stream shall be used to modulate the receiver. The manufacturer shall define the modulation with the highest emission in transmit mode.

7.1.2. Method of Measurements - AC Mains Conducted Emissions

- AC Mains conducted emissions measurements were performed in accordance with the standard against appropriate limits for each detector function.
- The test was performed in the shielded room, 16'(L) by 16'(W) by 12'(H).
- The test was performed were made over the frequency range from 150 kHz to 30 MHz to determine the line-to-ground radio noise voltage which was conducted from the EUT power-input terminals that were directly connected to a public power network.
- The EUT normally received power from another device that connects to the public utility ac power lines, measurements would be made on that device with the EUT in operation to ensure that the device continues to comply with the appropriate limits while providing the EUT with power.
- If the EUT operates only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines, AC Mains conducted measurements are not required.
- Table-top devices were placed on a platform of nominal size 1 m by 1.5m raised 80 cm above the conducting ground plane.
- The EUT current-carrying power lead, except the ground (safety) lead, was individually connected through a LISN to the power source. All unused 50-Ohm connectors of the LISN was terminated in 50-ohm when not connected to the measuring instruments.
- The line cord of the EUT connected to one LISN which was connected to the measuring instrument. Those power cords for the units of devices not under measurement were connected to a separate multiple ac outlet. Drawings and photographs of typically conducted emission test setups were shown in the Test Report. Each current-carrying conductor of the EUT shall be individually tested.
- The EUT was normally operated with a ground (safety) connection, the EUT was connected to the ground at the LISN through a conductor provided in the lead from the ac power mains to the LISN.
- The excess length of the power cord was folded back and forth in an 8-shape on a wooden strip with a vertical prong located on the top of the LISN case.
- The EUT was set-up in its typical configuration and operated in its various modes as described in this test report.
- A preliminary scan was made by using spectrum analyzer system with the detector function set to PEAK mode (9 KHz RBW, VBW > RBW), frequency span 150KHz-30MHz.

- The maximum conducted emission for a given mode of operation was found by using the following step-by-step procedure:

  Step1. Monitor the frequency range of interest at a fixed EUT azimuth.

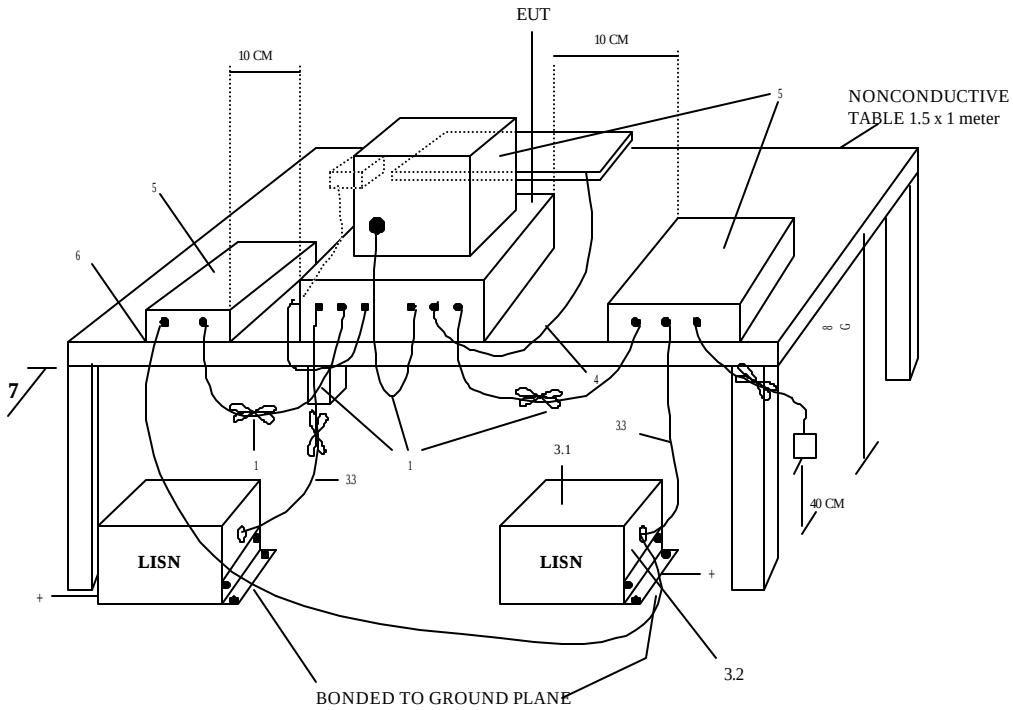
  Step2. Manipulate the system cables and peripheral devices to produce highest amplitude signal relative to the limit. Note the amplitude and frequency of the suspect signal.

Step3. The effects of various modes of operation is examined. This is done by varying equipment operation modes as step 2 is being performed.

Step4. After completing step 1 through 3, record EUT and peripheral device configuration, mode of operation, cable configuration, signal levels and frequencies for final test.

- Each highest signal level at the maximized test configuration was zoomed in a small frequency span on the spectrum analyzer's display (the manipulation of cables and peripheral devices and EUT operation modes might have to be repeated to obtain the highest signal level with the spectrum analyzer set to PEAK detector mode 10 KHz RBW and VBW > RBW). The spectrum analyzer was then set to CISPR QUASI-PEAK detector mode (9 KHz RBW, 1 MHz VBW) and AVERAGE detector mode (10 kHz RBW, 1 Hz VBW). The final highest RF signal levels and frequencies were record.

- ***Broad-band ac Powerline conducted emissions***:- If the EUT exhibits ac Powerline conducted emissions that exceed the limit with the instrument set to the quasi-peak mode, then measurements should be made in the average mode. If the amplitude measured in the quasi-peak mode is at least 6 dB higher than the amplitude measured in the average mode, the level measured in quasi peak mode may be reduced by 13 dB before comparing it to the limit.



+LISNs may have to be moved to the side to meet 3.3 below

LEGEND:

1. Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back at forth forming a bundle 30 to 40 cm long, hanging approximately in the middle between ground plane and table.

2. I/O cables that are connected to a peripheral shall be bundled in center. The end of the cable may be terminated if required using correct terminating impedance. The total length shall not exceed 1m.

3. EUT connected to one LISN. Unused LISN connectors shall be terminated in 50 Ohm. LISN can be placed on top of, or immediately beneath, ground plane.
3.1 All other equipment powered from second LISN.
3.2 Multiple outlet strip can be used for multiple power cords of non-EUTequipment.
3.3 LISN at least 80 cm from nearest part of EUT chassis.

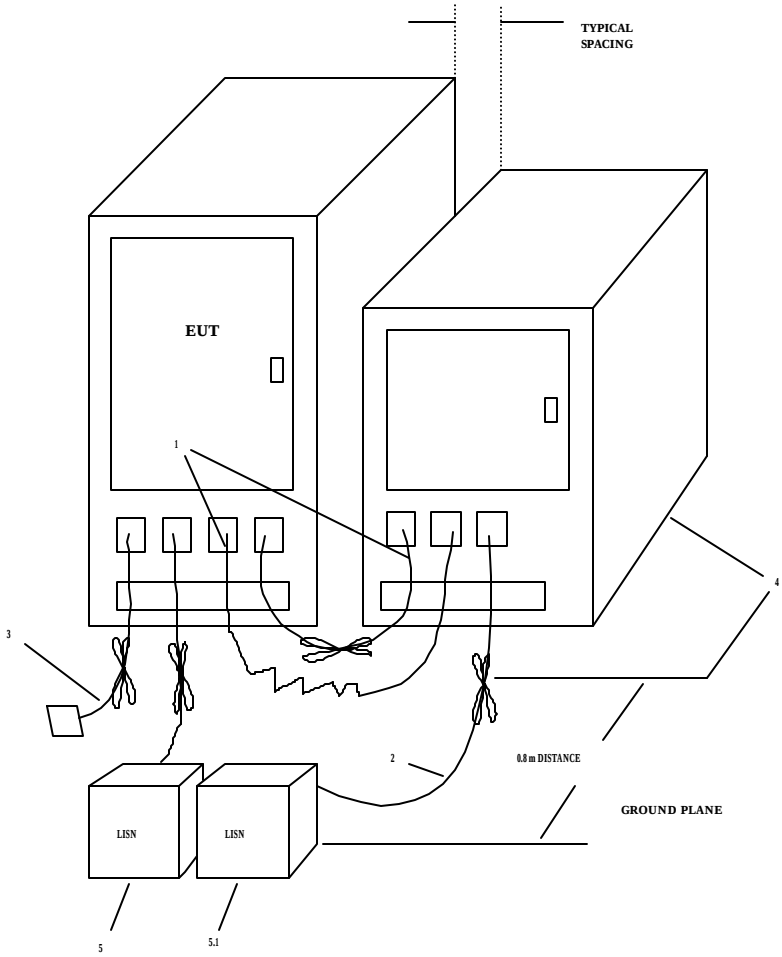
4. Cables of hand-operated devices, such as keyboards, mouses, etc., have to be placed as close as possible to the host.

5. Non-EUT components being tested.

6. Rear of EUT, including peripherals, shall be all aligned and flush with rear of tabletop.

7. Rear of tabletop shall be 40 cm removed from a vertical conducting plane that is bonded to the floor ground plane (see 5.2)

Tabletop Equipment Conducted Emissions



LEGENEND:

1. Excess I/O cables shall be bundled in center. If bundling is not possible, the cables shall be arranged in serpentine fashion. Bunding shall not exceed 40 cm in length.

2. Excess power cords shall be bundled in the center or shortened to appropriated length.

3. I/O cables that are not connected to a peripheral shall be bundled in the center. The end of the cable may be terminated if required using correct terminating impedance. If bundling is not possible, the cable shall be arranged in serpentine fashion.

4. EUT and all cables shall be insulated from ground plane by 3 to 12 mm of insulating material.

5. EUT connected to one LISN. LISN can be placed on top of, or immediately beneath, ground plane.
5.1 All other equipment powered from second LISN.

Floor-Standing Equipment Conducted Emissions

7.1.3. Method of Measurements - Electric Field Radiated Disturbance

- The radiated emission measurements were performed at the UltraTech's 10 or 30 Meter Open Field Test Site (OFTS) situated in the Town of Oakville, province of Ontario. The Attenuation Characteristics of OFTS have been filed to FCC, Industry Canada, ACA/Austel, NVLap and ITI.
- Radiated emissions measurements were made using the following test instruments:

  1. Calibrated EMCO BiconiLog antenna in the frequency range from 30 MHz to 2000 MHz.
  2. Calibrated Emco Horn antennas in the frequency range above 1000 MHz (1GHz - 40 GHz).
  3. 3.Calibrated Advantest spectrum analyzer and pre-selector. In general, the spectrum analyzer would be used as follows:

     – The rf electric field levels were measured with the spectrum analyzer set to PEAK detector (120 KHz VBW and VBW $\geq$ RBW).

     – If any rf emission was observed to be a broadband noise, the spectrum analyzer's CISPR QUASI-PEAK detector (120 KHz RBW and VBW $\geq$ RBW) was then set to measure the signal level.

     – If the signal being measured was narrowband and the ambient field was broadband, the bandwidth of the spectrum analyzer was reduced.

- The EUT was set-up in its typical configuration and operated in its various modes as described in this test report.
- The frequencies of emissions was first detected. Then the amplitude of the emissions was measured at the specified measurement distance using required antenna height, polarization, and detector characteristics.
- During this process, cables and peripheral devices were manipulated within the range of likely configuration.
- For each mode of operation required to be tested, the frequency spectrum was monitored. Variations in antenna heights (from 1 meter to 4 meters above the ground plane), antenna polarization (horizontal plane and vertical plane), cable placement and peripheral placement were explored to produce the highest amplitude signal relative to the limit.

  The maximum radiated emission for a given mode of operation was found by using the following step-by-step procedure:

  Step1: Monitor the frequency range of interest at a fixed antenna height and EUT azimuth.

  Step2: Manipulate the system cables to produce highest amplitude signal relative to the limit. Note the amplitude and frequency of the suspect signal.

  Step3: Rotate the EUT 360 degrees 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.

  Step4: Move the antenna over its full allowed range of travel (1 to 4 meters) 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 highest amplitude observation and proceed.

Step5: Change the polarization of the antenna and repeat Step 2 through 4. Compare the resulting suspected highest amplitude signal with that found for the other polarization. Select and note the higher of the two signals. This signal is termed the highest observed signal with respect to the limit for this EUT operational mode.

Step6: The effects of various modes of operation is examined. This is done by varying the equipment modes as steps 2 through 5 are being performed.

Step7: After completing steps 1 through 6, record the final highest emission level, frequency, antenna polarization and detector mode of the measuring instrument.

Calculation of Field Strength:

The field strength is calculated by adding the calibrated antenna factor and cable factor, and subtracting the Amplifier gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

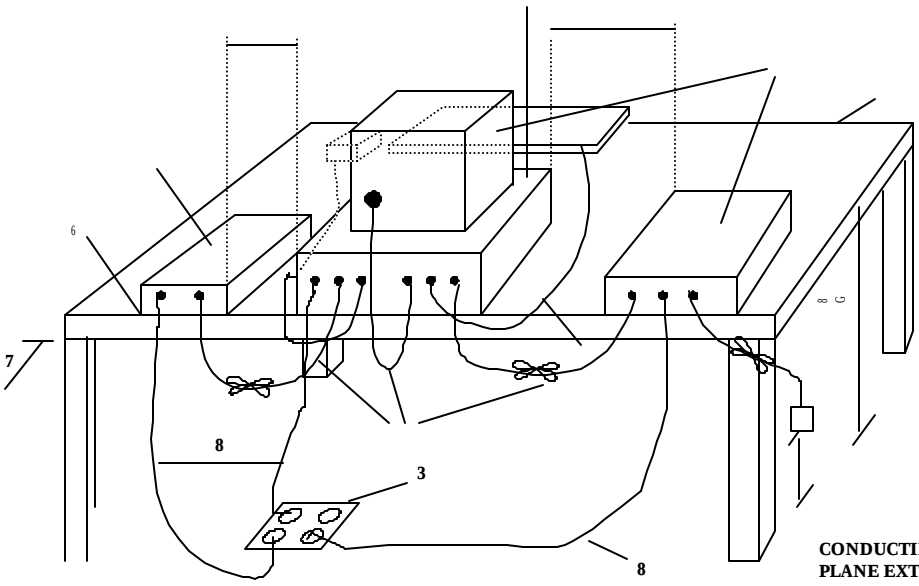
$$FS = RA + AF + CF - AG$$

Where FS = Field Strength
RA = Receiver/Analyzer Reading
AF = Antenna Factor
CF = Cable Attenuation Factor
AG = Amplifier Gain

Example: If a receiver reading of 60.0 dBuV is obtained, the antenna factor of 7.0 dB/m and cable factor of 1.0 dB are added, and the amplifier gain of 30 dB is subtracted. The actual field strength will be:.

Field Level = 60 + 7.0 + 1.0 - 30 = 38.0 dBuV/m.

Field Level = $10^{(38/20)}$ = 79.43 uV/m.



LEGEND:

1. Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth forming a bundle 30 to 40 cm long, hanging approximately in the middle between ground plane and table.

2. I/O cables that are connected to a peripheral shall be bundled in center. The end of the cable may be terminated if required using correct terminating impedance. The total length shall not exceed 1m.

3. If LISNs are kept in the test setup for radiated emissions, it is preferred that they be installed under the ground plane with the receptable flush with the ground plane.

4. Cables of hand-operated devices, such as keyboards, mouses, etc., have to be placed as close as possible to the controller.

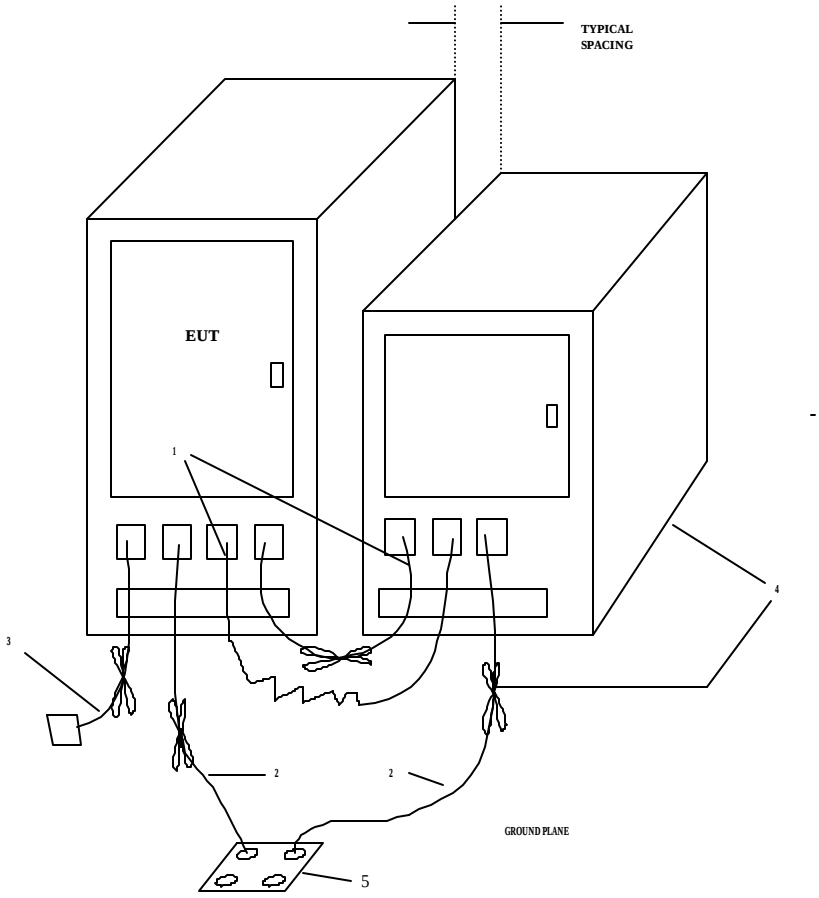
5. Non-EUT components of EUT system being tested.

6. The rear of all components of the system under test shall be located flush with the rear of the table.

7. No vertical conducting wall used.

8. Power cords drape to the floor and are routed over to receptacle.

Tabletop Equipment Radiated Emissions



LEGEND:

1. Excess I/O cables shall be bundled in center. If bundling is not possible, the cables shall be arranged in serpentine fashion.

2. Excess power cords shall be bundled in the center or shortened to appropriated length.

3. I/O cables that are not connected to aperipheral shall be bundled in the center. The end of the cable may be terminated if required using correct terminating impedance. If bundling is not possible, the cable shall be arranged in serpentine fashion.

4. EUT and all cables shall be inslulated from ground plane by 3 to 12 mm of insulating material.

5. If LISNs are kept in the test setup for radiated emissions, it is preferred that they be installed under the ground plane with the receptacle flush with the ground plane.

Floor-Standing Equipment Radiated Emissions