ENGINEERING TEST REPORT

2.4 GHz FHSS OEM Transceiver
Model No.: LX2400-3

FCC ID: KQL-LX2400
FCC 731 CONFIRMATION NO.: EA98784

Applicant: **Aerocomm Inc.**
13256 West 98th Street
Lenexa, Kansas
USA, 66215

In Accordance With

FEDERAL COMMUNICATIONS COMMISSION (FCC)
PART 15, SUBPART C, SEC. 15.247
Frequency Hopping Spread Spectrum Transmitters
operating in the frequency band 2402 - 2478 MHz

UltraTech's File No.: AER-032FCC

This Test report is Issued under the Authority of
Tri M. Luu, Professional Engineer,
Vice President of Engineering
UltraTech Group of Labs

Date: September 02, 2000

Report Prepared by: Tri M. Luu . Issued Date: September 02, 2000	Tested by: Hung Trinh Test Dates: Aug. 11 to Sep. 01, 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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TABLE OF CONTENTS

EXHIBIT 1. SUBMITTAL CHECK LIST

Exhibit No.	Exhibit Type	Description of Contents	Quality Check (OK)
1 through 8	Test Report	• Exhibit 1: Submittal check lists • Exhibit 2: Introduction • Exhibit 3: Performance Assessment • Exhibit 4: EUT Operation and Configuration during Tests • Exhibit 5: Summary of test Results • Exhibit 6: Measurement Data • Exhibit 7: Measurement Uncertainty • Exhibit 8: Measurement Methods	OK OK OK OK OK OK OK OK
9	Test Report - Plots of Measurement Data	Plots # 1 to 15	
10	Test Setup Photos	Photos # 1 to 3	OK
11	External Photos of EUT	Photos # 1 to 2	OK
12	Internal Photos of EUT	Photos of 1	OK
13	Cover Letters	• Letter from Ultratech for Certification Request (Exhibit 13a) • Letter from the Applicant to appoint Ultratech to act as an agent (Exhibit 13b) • Letter from the Applicant to request for Confidentiality Filing (Exhibit 13c)	 OK OK
14	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
15	Application Forms	• Form 731 • Form 159 • Confirmation of Exhibits sent to FCC • Status of Exhibits sent to FCC	Electronic Electronic Electronic Electronic
16	ID Label/Location Info	• ID Label • Location of ID Label	OK OK
17	Block Diagrams	Block Diagram of OEM Frequency Plan	OK
18	Schematic Diagrams	Block Diagram & Schematics	OK
19	Parts List/Tune Up Info	Parts List	OK

Exhibit No.	Exhibit Type	Description of Contents	Quality Check (OK)
20	Operational Description	• Aerocomm LX2400-3 Transmitter Operation	OK
21	RF Exposure Info	✓ SAR test report is submitted	OK OK
22	Users Manual	Information/instructions that will be intended in the installation/operation pertains to: • Correct output power settings required for compliance operation for every antenna proposed for use with EUT • Point-to-point operational requirements and responsibilities • RF exposure compliance requirements, if any	 OK N/A OK

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 Certification Authorization for Frequency Hopping Spread Spectrum Transmitters operating in the Frequency Band 2402 - 2478 MHz .
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:	• Residential • 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
FCC Public Notice DA 00-705	2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
FCC Public Notice DA 00-1407	2000	Part 15 Unlicensed Modular Transmitter Approval

EXHIBIT 3. PERFORMANCE ASSESSMENT

3.1. CLIENT INFORMATION

APPLICANT:	
Name:	Aerocomm Inc.
Address:	13256 West 98th Street Lenexa, Kansas USA, 66215
Contact Person:	Mr. Dan Miller Phone #: 913-492-2320 Fax #: 913-492-1243 Email Address: dmiller@aerocomm

MANUFACTURER:	
Name:	Aerocomm Inc.
Address:	13256 West 98th Street Lenexa, Kansas USA, 66215
Contact Person:	Mr. Dan Miller Phone #: 913-492-2320 Fax #: 913-492-1243 Email Address: dmiller@aerocomm

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	Aerocomm Inc.
Product Name	2.4 GHz FHSS OEM Transceiver
Model Name or Number	LX2400-3
Serial Number	Preproduction
Type of Equipment	Frequency Hopping Spread Spectrum Transmitters
Input Power Supply Type	6.2 Vdc with internal power regulating circuit
Primary User Functions of EUT:	Provide data communication link through air

3.2.1. Product Approval Overview

	Portable	Mobile	Fixed
LX2400-3-3	X	X	X

3.3. EUT'S TECHNICAL SPECIFICATIONS

3.3.1. Transmitter Specifications

Equipment Type:	▪ Portable, Mobile & Base station
Intended Operating Environment:	▪ Residential ▪ Commercial, light industry & heavy industry
Power Supply Requirement:	6.2 Vdc
RF Output Power Rating:	▪ 2.5 mWatts peak
Operating Frequency Range:	2402 - 2478 MHz
RF Output Impedance:	50 Ohms
Channel Spacing:	77 Channels
Duty Cycle:	Continuous
20 dB Bandwidth:	343 kHz
Modulation Type:	FSK
Channel Occupancy:	27.43 mS within 30 seconds period
Channel Spacing	1 MHz
Emission Designation:	Frequency Hopping Spread Spectrum
Spectral Density	11mW/MHz
Antenna Connector Type:	Please refer to the Sec. 2.3.2, "Antenna Description", of this test report

3.3.2. Antenna Description

3.3.2.1. Approved Antenna Overview

Antenna Model/Part Number	Manufacturer	Type	Gain	Connector Type	Application*	LX2400-3-3
NZH2400-I (Integrated)	AeroComm	Microstrip	1dBi	Integrated	P	X

*P=Portable, M=Mobile, F=Fixed/Basestation

3.3.2.2. Antenna for a 2.5 mW Radio Transceiver & RF Exposure Compliance

This radio is used for any application (portable, mobile or base). The antenna is integrated (printed) onto the radio printed circuit board as a solder-trace. The radio transmitter is required to meet SAR tests at the "body/hip" position with its integrated antenna.

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	Antenna (integral)	1	None	None
2	COM (for manufacturer's use and test purposes only)	1	DB9	Shielded
3	DC Connector (for test purposes only)	1	DC Jack	Non-shielded

3.5. ANCILLARY EQUIPMENT

The EUT was tested while connected to the following representative configuration of ancillary equipment necessary to exercise the ports during tests:

Ancillary Equipment # 1	
Description:	OMNIBOOK Laptop
Brand name:	Hewlett Packard
Model Name or Number:	DN-2100
FCC Certification	FCC DoC
Serial Number:	TW63403246
Connected to EUT's Port:	PCMCIA type II

3.6. GENERAL TEST SETUP

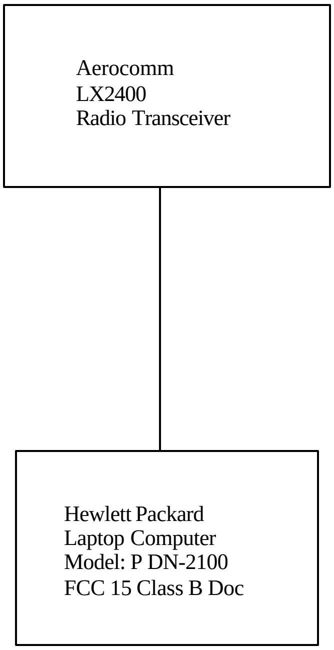


EXHIBIT 4. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

4.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21°C
Humidity:	51%
Pressure:	102 kPa
Power input source:	6.2 Vdc

4.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	▪ Each of lowest, middle and highest channel frequencies transmits continuously for emissions measurements. ▪ The EUT operates in normal Frequency Hopping mode for occupancy duration, and frequency separation.
Special Test Software:	Special software is provided by the Applicant to disable the hopping function, to select and to operate the EUT at each channel frequency continuously. For example, the transmitter will be operated at each of lowest, middle and highest frequencies individually continuously during testing.
Special Hardware Used:	None
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use.

Transmitter Test Signals:	
Frequencies: ▪ 2402 - 2478 MHz band:	Lowest, middle and highest channel frequencies tested: 2402, 2440 & 2478 MHz

EXHIBIT 5. SUMMARY OF TEST RESULTS

5.1. 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.

5.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC PARAGRAPH.	TEST REQUIREMENTS	COMPLIANCE (YES/NO)
Public Notice DA 00-1407	Part 15 Unlicensed Modular Transmitter Approval	Yes
15.107(a)	AC Power Line Conducted Emissions Measurements (Transmit & Receive)	Not applicable for DC supplied device
15.247(a)(1) & 15.247(a)(1)(ii)	Hopping Channel Frequency Characteristics	Yes
15.247(b)(2)	Peak Output Power	Yes
1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Yes
15.247(c)	Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
15.247(c), 15.209 & 15.205	Transmitter Radiated Emissions	Yes
The digital circuit portion of the EUT has been tested and verified to comply with FCC Part 15, Subpart B, Class B Digital Devices, the associated Radio Receiver operating in 2402 - 2478 MHz is exempted from FCC authorization . The engineering test report can be provided upon FCC requests.		

5.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

EXHIBIT 6. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR EMC EMISSIONS

6.1. TEST PROCEDURES

This section contains test results only. Details of test methods and procedures can be found in Exhibit 8 of this report, ANSI C63-4:1992 and FCC Public Notice @ DA 00-705 (March 30, 2000) – Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

6.2. 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 7 for Measurement Uncertainties.

6.3. 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.

6.4. 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.

6.5. UNLICENSED MODULAR TRANSMITTER APPROVAL REQUIREMENTS @ FCC PUBLIC NOTICE DA 00-1407 (JUNE 26, 2000)

In order to satisfy FCC requirements for equipment authorization for modular transmitters, the transmitters shall meet the following parameters:

	Requirements for Modular Transmitters	**Manufacturer's Clarification**	**Laboratory's Comments**
(a)	In order to be considered a transmitter module, the device must be complete RF transmitter, i.e., it must have its own reference oscillator (e.g., VCO), antenna, etc…. The only connectors to the module, if any, may be power supply and modulation/data inputs	✓ The transmitter is completed with its own reference oscillator, antenna. ✓ Only connectors provide are dc supply, data and rf ports are provided with the modular transmitter	Satisfactory
(b)	Compliance with FCC RF Exposure requirements may, in some instances, limit the output power of a module and/or the final applications in which the approved module may be employed	✓ The 2.5 mW radio, intended for use in all applications, comply with SAR test with body tissue	Satisfactory
(c)	While the applicant for a device into which an authorized module is installed is not required to obtain a new authorization for the module, this does not preclude the possibility that some other form of authorization or testing may be required for the device (e.g., a WLAN into which the authorized module is installed still be authorized as PC peripheral, subject to the appropriate equipment authorization)	✓ The equipment under complies with FCC Part15, Subpart B, Class B – Unintentional radiators	Satisfactory
(d)	In the case of a modular transceiver, the modular approval policy only applies to the transmitter portion of such devices. Pursuant to section 15.101(b), the receiver portion will either be subject to Verification, or it will not be subject to any authorization requirements (unless if is a Scanning Receiver, in which case it is also subject to Certification, pursuant to Section 15.101(a)	✓ The receiver operates in the band above 960 MHz; therefore, the FCC authorization for the receiver is exempted.	Satisfactory

	Requirements for Modular Transmitters	Manufacturer's Clarification	Laboratory's Comments
(e)	The holder of the grant of equipment authorization (Grantee) of the module is responsible for the compliance of the module in its final configuration, provided that the OEM, integrator, and /or end user has complied with all of the instructions provided by the Grantee which indicate installation and/or operating conditions necessary for compliance.	End-users must comply with the following instruction sated in the users' manual: ✓ Labeling requirement for equipment using this modular transmitter. ✓ RF Exposure Warning for compliance with FCC Rules 2.1091 and 1.1307 when the radio is used in a mobile or base system	Satisfactory N/A

In order to obtain a modular transmitter approval, a cover letter requesting modular approval must be submitted and the numbered requirements identified below must be addressed in the application for equipment authorization:

	Requirements for Modular Transmitters	Manufacturer's Clarification	Laboratory's Comments
1.	The modulator transmitter must have its own RF shielding. This is intended to ensure that the module does not have to reply upon the shielding provided by the device into which it is installed in order for all modular transmitter emissions to comply with Part 15 limits. It is also intended to prevent coupling between the RF circuitry of the module and any wires or circuits in the device into which the module is installed. Such coupling may result in non-complaint operation.	✓ The modular transmitter has its own RF shielding	Satisfactory
2.	The modular transmitter must have buffered modulation/data inputs (if such inputs are provided) to ensure that the module will comply with Part 15 requirements under conditions of excessive data rates or over-modulation.	✓ The modular transmitter has buffered modulation/data inputs	Satisfactory
3.	The modular transmitter must have its own power supply regulation. This is intended to ensure that the module will comply with Part 15 requirements regardless of the design of the power supplying circuitry in the device into which the module is installed.	✓ The modular transmitter has its own power supply regulation.	Satisfactory

	Requirements for Modular Transmitters	Manufacturer's Clarification	Laboratory's Comments
4.	The modular transmitter must comply with the antenna requirements of section 15.203 and 15.204(c). The antenna must either be permanently attached or employ a "unique" antenna coupler (at all connections between the module and the antenna, including the cable). Any antenna used with the module must be approved with the module, either at the time of initial authorization or through a Class II permissive change. The "professional installation" provision of Section 15.203 may not be applied to modules.	✓ The 2.5 mW radio complies with Rules 15.203 and 15.204(c) with permanently attached antenna.	Satisfactory
5	The modular transmitter must be tested in a stand-alone configuration, i.e., the module must not be inside another device during testing. This is intended to demonstrate that the module is capable of complying with Part 15 emission limits regardless of the device into which it is eventually installed. Unless the transmitter module will be battery powered, it must comply with the AC conducted requirements found in Section 15.207. AC or DC power lines and data input/output lines connected to the module must not contain ferrites, unless they will marketed with the module (see Section 15.27(a)). The length of these lines shall be length typical of actual use or, if that length is unknown, at least 10 centimeters to insure that there is no coupling between the case of the module and supporting equipment. Any accessories, peripherals, or support equipment connected to the module during testing shall be unmodified or commercially available (See Section 15.31(I)).	✓ The modular transmitter was tested in a stand-alone configuration	Satisfactory

	Requirements for Modular Transmitters	Manufacturer's Clarification	Laboratory's Comments
6	The modulator must be labeled with its own FCC ID number, and, if the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following: "Contains Transmitter Module FCC ID: XYZMODEL1" or "Contains FCC ID: XYZMODEL1". Any similar wording that expresses the same meaning may be used. The Grantee may either provide such a label, an example of which must be included in the application for equipment authorization, or, must provide adequate instructions along with the module which explain this requirement. In the latter case, a copy of these instructions must be included in the application for equipment authorization.	✓ The radio is labeled with its own FCC ID label ✓ The exterior FCC ID label is instructed in the User's Manual, page # 2	Satisfactory
7	The modular transmitter must comply with any specific rule or operating requirements applicable to the transmitter and the manufacturer must provide adequate instructions along with the module to explain any such requirements. A copy of these instructions must be included in the application for equipment authorization. For example, there are very strict operational and timing requirements that must be met before a transmitter is authorized for operation under Section under Section 15.231. For instance, data transmission is prohibited, except for operation under Section 15.231(e), in which case there are separate field strength level and timing requirements. Compliance with these requirements must be assured.	None	
8	The modular transmitter must comply with any applicable RF exposure requirements. For example, FCC Rules 2.1091, 2.1093 and specific Sections of Part 15, including 15.319(I), 15.407(f), 15.253(f) and 15.255(g), require that Unlicensed PCS, UNII and millimeter wave devices perform routine environmental evaluation for RF Exposure to demonstrate compliance. In addition, spread spectrum transmitters operating under Section 15.247 are required to address RF Exposure compliance in accordance with Section15.247(b)(4). Modular transmitters approved under other Section of Part 15, when necessary, may also need to address certain RF Exposure concerns, typical by providing specific installation and operating instruction for users and other interested parties to ensure compliance.	✓ The 2.5 mW radio, intended for use in all applications, comply with SAR test with body tissue	

6.6. COMPLIANCE WITH FCC PART 15 – GENERAL TECHNICAL REQUIREMENTS

FCC Section	FCC Rules	
15.31	The hopping function must be disabled for tests, which should be performed with the EUT transmitting on the number of frequencies specified in this Section. The measurements made at the upper and lower ends of the band of operation should be made with the EUT tuned to the highest and lowest available channels.	✓ Hopping function was disabled during testing
15.203	Described how the EUT complies with the requirement that either its antenna is permanently attached, or that it employs a unique antenna connector, for every antenna proposed for use with the EUT. The exception is in those cases where EUT must be professionally installed. In order to demonstrate that professional installation is required, the following 3 points must be addressed: • The application (or intended use) of the EUT • The installation requirements of the EUT • The method by which the EUT will be marketed	✓ The transmitter is completed with its own reference oscillator, antenna. ✓ Only connectors provide are dc supply, data and rf ports are provided with the modular transmitter
15.204	Provided the information for every antenna proposed for use with the EUT: (a) type (e.g. Yagi, patch, grid, dish, etc…), (b) manufacturer and model number (c) gain with reference to an isotropic radiator	Please refer to Sec. 2.3 of this test report for details of antenna information
15.247(a)	Description of how the EUT meets the definition of a frequency hopping spread spectrum, found in Section 2.1. Based on the technical description.	✓ Utilize 77 hopping frequencies ✓ Maximum 20dB bandwidth of hopping channel is 350KHz ✓ Average occupancy on any frequency in 30 second period is 18.288 mseconds
15.247(a)	Pseudo Frequency Hopping Sequence: Describe how the hopping sequence is generated. Provide an example of the hopping sequence channels, in order to demonstrate that the sequence meets the requirements specified in the definition of a frequency hopping spread spectrum system, found in Section 2.1.	See Appendix A Below.
15.247(a)	Equal Hopping Frequency Use: Describe how each individual EUT meets the requirement that each of its hopping channels is used equally on average (e.g. that each new transmission event begins on the next channel in the hopping sequence after final channel used in the previous transmission events).	Frequency usage is controlled by the Master unit. The master hops to a new frequency every 100 ms. The master follows the pseudorandom sequence until all 77 frequency bins have been used. The sequence then repeats.

FCC Section	FCC Rules	
15.247(g)	Describe how the EUT complies with the requirement that it be designed to be capable of operating as a true frequency hopping system	The timing of the data and the data is not related to the hopping routines. It is received as a random event. Since it is a purely random event it can occur at any frequency in the hopping pattern and will be transmitted at a random time in the hopping pattern. Therefore, on the average, all frequencies will be used equally for the transmission of data due to the occurrence of two non-time related events. Even short packets that are transmitted infrequently will average out. Short packets are also masked by the weighting of the beacons being transmitted since most of the transmit time will be the beacon times when short packets are transmitted. Continuous data from the interface will be transmitted on each frequency.
15.247(h)	Describe how the EUT complies with the requirement that it not have the ability to coordinate with other FHSS is an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitters	The master transmitter has its time base set to zero at start up and then begins a pseudo-random hop sequence of 77 frequencies. The master transmitter has the control of its timing. If another master transmitter is turned on, it will begin its own pseudo-random hop totally unrelated in time from first. This holds for all other master transmitters whether they are in range or not. If a master hears another master's timing information, the master will change its hopset, keeping and using the same 77 frequencies, in order to avoid hopping on occupied channels of the other master. Both masters now hop individually and independently of the other.
Public Notice DA 00-705	System Receiver Input Bandwidth: Describe how the associated receiver(s) complies with the requirement that its input bandwidth (either RF or IF) matches the bandwidth of the transmitted signal.	Final IF 3dB bandwidth of 400kHz is obtained using a fixed ceramic filter centered at 10.7MHz.
Public Notice DA 00-705	System Receiver Hopping Capability: Describe how the associated receiver(s) has the ability to shift frequencies in synchronization with the transmitted signals	Frequency hopping is controlled by the Master unit. Receivers synchronize with a master transmitter by decoding Beacon data. Beacon data consists of preamble, address, frequency and timing information. The synchronization sequence is as follows: The master unit transmits a Beacon (approx. 4ms. in duration) at approximately a 32 ms. rate. Slave units scan all available hopping frequencies searching for the Beacon data. Once the slave units decode the Beacon data, they load the frequency and timing information into internal timers and hop in unison with the master's hopping algorithm.

AeroComm LX2400-3 Transmitter Operation

The AeroComm transmitter transmits on 77 frequencies from 2402 MHz to 2478 MHz. The frequency bins are separated by 1 MHz. The carrier frequencies are selected from a pseudorandom - ordered table of frequencies located in the system ROM area of memory. Each frequency has an occupancy time of 100 mS. controlled by the system microprocessor.

Pseudorandom Hopping Sequence

The pseudorandom - ordered sequence is chosen from one of 77 hopping patterns by setting the variable ‘channel’ and using the index ‘i‘ which increments every hop time (100 mS.) to look up the frequency to select. The following algorithm depicts the actual look-up and calculation of the hopping patterns.

Calculate Frequency for any given channel 0 to 76:
i = 0
j = (i + channel)mod(77)
f(i) = b(j) + 2402 MHz.
Increment i by 1
If i < 77 Jump to #2, otherwise Jump to #1

Where: b(j) is defined in Table 1
channel = 0 to 76 (fixed by user)
i = 0 to 76

TABLE I -- List of base bins b(j)

j	b(j)	j	B(j)	j	b(j)	j	b(j)	j	b(j)	j	b(j)	j	b(j)
0	00	11	32	22	55	33	62	44	15	55	49	66	17
1	16	12	64	23	39	34	37	45	04	56	36	67	59
2	09	13	05	24	71	35	11	46	65	57	28	68	74
3	34	14	66	25	30	36	31	47	47	58	44	69	27
4	70	15	73	26	68	37	63	48	38	59	21	70	57
5	52	16	02	27	07	38	48	59	26	60	51	71	20
6	67	17	58	28	56	39	54	60	53	61	06	72	50
7	19	18	25	29	76	40	40	61	33	62	41	73	61
8	01	19	10	30	43	41	46	52	60	63	14	74	24
9	35	20	23	31	18	42	13	53	22	64	69	75	75
10	08	21	12	32	72	43	03	54	42	65	45	76	29

Following are samples of the hopping sequences for channel 0 and channel 2.

TABLE II -- List of hopping frequencies for channel = 0
(MHz)

i	f(i)	i	f(i)	i	f(i)	i	f(i)	i	f(i)	i	f(i)	i	f(i)
0	2402	11	2434	22	2457	33	2464	44	2417	55	2451	66	2419
1	2418	12	2466	23	2441	34	2439	45	2406	56	2438	67	2461
2	2411	13	2407	24	2473	35	2413	46	2467	57	2430	68	2476
3	2436	14	2468	25	2432	36	2433	47	2449	58	2446	69	2429
4	2472	15	2475	26	2470	37	2465	48	2440	59	2423	70	2459
5	2454	16	2404	27	2409	38	2450	49	2428	60	2453	71	2422
6	2469	17	2460	28	2458	39	2456	50	2455	61	2408	72	2452
7	2421	18	2427	29	2478	40	2442	51	2435	62	2443	73	2463
8	2403	19	2412	30	2445	41	2448	52	2462	63	2416	74	2426
9	2437	20	2425	31	2420	42	2415	53	2424	64	2471	75	2477
10	2410	21	2414	32	2474	43	2405	54	2444	65	2447	76	2431

TABLE III -- List of hopping frequencies for channel = 2
(MHz)

i	f(i)	i	f(i)	i	f(i)	i	f(i)	i	f(i)	i	f(i)	i	f(i)
0	2411	11	2407	22	2473	33	2413	44	2467	55	2430	66	2476
1	2436	12	2468	23	2432	34	2433	45	2449	56	2446	67	2429
2	2472	13	2475	24	2470	35	2465	46	2440	57	2423	68	2459
3	2454	14	2404	25	2409	36	2450	47	2428	58	2453	69	2422
4	2469	15	2460	26	2458	37	2456	48	2455	59	2408	70	2452
5	2421	16	2427	27	2478	38	2442	49	2435	60	2443	71	2463
6	2403	17	2412	28	2445	39	2448	50	2462	61	2416	72	2426
7	2437	18	2425	29	2420	40	2415	51	2424	62	2471	73	2477
8	2410	19	2414	30	2474	41	2405	52	2444	63	2447	74	2431
9	2434	20	2457	31	2464	42	2417	53	2451	64	2419	75	2402
10	2466	21	2441	32	2439	43	2406	54	2438	65	2461	76	2418

6.7. HOPPING CHANNEL CARRIER FREQUENCY CHARACTERISTICS @ FCC CFR 47, PARA 15.247(A)(1) & (A)(1)(II)

6.7.1. Limits

- **FCC CFR 47, Para 15.247(a)(1)**:- Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudorandomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

- **FCC CFR 47, Para 15.247(a)(1)(ii)**:- Frequency hopping systems operating in the 2402 - 2478 MHz and 5725-5850 MHz bands shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

- **FCC CFR 47, Para 15.247(a)(1)(ii)**:- Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting

6.7.2. Method of Measurements

Refer to FCC 15.247(a)(1) & ANSI C63-4:1992 and Public Notice DA 00-705

Carrier Frequency Separation:

The hopping function of the EUT is enabled. Use the spectrum analyzer setting as follows:
- Span = wide enough to capture the peaks of two adjacent channels
- RBW = 1% of the span
- VBW = RBW
- Sweep = Auto
- Detector = peak
- Trace = max hold

Number of hopping frequency:

The hopping function of the EUT is enabled. Use the spectrum analyzer setting as follows:
- Span = the frequency band of operation
- RBW = 1% of the span
- VBW = RBW
- Sweep = Auto
- Detector = peak
- Trace = max hold

Time of Occupancy (Dwell Time):

The hopping function of the EUT is enabled. Use the spectrum analyzer setting as follows:

- Span = 0 Hz centered on a hopping channel
- RBW = 1 MHz
- VBW = RBW
- Sweep = as necessary to capture the entire dwell time per hopping channel
- Detector = peak
- Trace = max hold

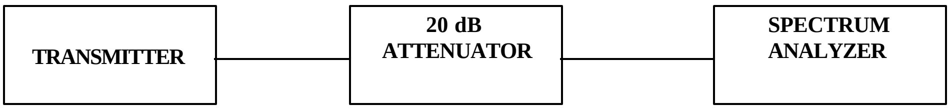
If possible, use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g. date rate modulation format, etc.), repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section. Submit this plot(s). An oscilloscope may be used instead of a spectrum analyzer.

20 dB Bandwidth:

Use the spectrum analyzer setting as follows:

- Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
- RBW = 1% of the 20 dB bandwidth
- VBW = RBW
- Sweep = auto
- Detector = peak
- Trace = max hold
- The transmitter shall 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 20 dB down on both sides of the emission.
- The 20 dB BW is the delta reading in frequency between two markers.

6.7.3. Test Arrangement



6.7.4. 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
Microwave Amplifier	Hewlett Packard	83017A	..	1 GHz – 26.5 GHz 34-38 dB gain
Horm Antenna	EMCO	3115	9701-5061	1 – 18 GHz

6.7.5. Plots

Refer plots # 1 to #9 for detailed information of measurements

6.7.6. Test data

20 dB BANDWIDTH MEASUREMENTS

CHANNEL FREQUENCY (MHz)	20 dB BANDWIDTH (MHz)	MINIMUM LIMIT (MHz)	PASS/FAIL
2402	331	0.5	PASS
2440	343	0.5	PASS
2478	320	0.5	PASS

Test Description	FCC Specification	Measured Values	Comments
Channel Hopping Frequency Separation	minimum of 25 KHz or 20dB BW whichever is greater.	1 MHz	Pass
Number hopping frequencies	75 minimum	77 Channels	Pass
20 dB BW of the hopping channel	1 MHz maximum	343 kHz	Pass
Average Time of Occupancy	0.4 seconds max. within 30 seconds period	27.43 mS within 30 seconds period	Pass

	Manufacturer's Explanation
FCC Requirement @ Section 15.247(a)(1): The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudorandomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals	Refer to section 6.6 of this report
FCC Requirement @ Section 15.247(g): Describe how the EUT complies with the requirement that it be designed to be capable of operating as a true frequency hopping system	Refer to section 6.6 of this report
FCC Requirement @ Section 15.247(h): Describe how the EUT complies with the requirement that it not have the ability to coordinated with other FHSS is an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitters	Refer to section 6.6 of this report

6.8. PEAK OUTPUT POWER & EFFECTIVE RADIATED POWER (EIRP) @ FCC 15.247(B)

6.8.1. 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 2402 - 2478 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..

De Facto EIRP Limit:

Describe how the EUT complies with the de facto EIRP limit for every antenna proposes for use with the EUT. This includes those devices that will be used in point-to-point applications. If the peak power, as measured above, must be reduced so that the de facto EIRP limit may be met for a particular antenna, described exactly how much it will be reduced for that antenna. If the minimum length of cable which will always be used, the type of cable, and its loss, in dB per unit length, for the frequency of the emission. The limit is specified in one of the subparagraphs of this section. Also, specify who will be responsible for ensuring that compliant operation is maintained for every antenna that will be used with EUT.

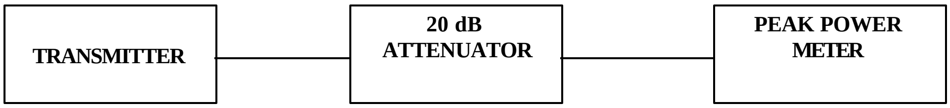
Point-to-Point Operation:

- If the EIRP relaxation for point-to-point operation is proposed for any particular antenna, describe who will be responsible for ensuring that the EUT is only used in such an application.
- Fixed, point-to-point operation, as used in 2400-2483.5 MHz and 5725-5850 MHz bands, excludes the use of the following:
  - Point-to-multipoint systems
  - Omnidirectional applications
  - Multiple co-located intentional radiators transmitting the same information.
- The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that *the system is used exclusively for fixed, point-to-point operations*. The instruction manual furnished with the intentional radiators shall contain language in the installation instructions informing the operator and the installer of this reponsibilty.

6.8.2. Method of Measurements

Refer to Exhibit 8, Sec. 8.3 of this test report, FCC 15.247(b)(1)&(3), ANSI C63-4:1992

6.8.3. Test Arrangement



6.8.4. 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
Horn Antenna	EMCO	3155	9911-5955	1 GHz – 18 GHz

6.8.5. Test Data

Duty Cycle: Continuous

2.5 mW Radio Transmitter, Model LX2400-3-3, with internal integrated antenna (Aerocomm Omni Directional Antenna, P/N: NZH2400-I, Gain = 1 dBi)

EIRP MEASUREMENTS – SUBSTITUTION METOD

Frequency (MHz)	E-Field E1 in 100 kHz BW @ 3m (dBuV/m)	Antenna Polarization (V/H)	ERP measured from Signal GEN. S – Cable Loss (dBm)	Substitution Antenna Gain G (dBi)	(2) Measured Total EIRP (dBm)
2402	99.7	V	-3.3	8.0	4.7
2402	95.9	H	-7.2	8.0	0.8
2440	100.1	V	-3.0	8.0	5.0 dBm or 3.1 mW
2440	96.3	H	-7.0	8.0	1.0
2478	99.9	V	-3.1	8.0	4.9
2478	96.5	H	-7.0	8.0	1.0

PEAK POWER MEASUREMENTS – ALTERNATIVE METHOD

Since the antenna is permanently, the power transmitted power can be calculated from E field using the formula: $P = (Ed)^2/30G$, assumed G = 1 dBi throughout the band.

Transmitter Channel	Frequency (MHz)	Antenna Gain G (dBi)	Maximum Field E @3m (dB(uV/m)/1MHz)	(Alternative) Peak Power @ Antenna Port (dBm/1MHz)	(2) Calculated EIRP Power = P+G (dBm/MHz)	Limit (dBm)
Lowest	2402	1	99.7	3.5 dBm or 2.24 mW	4.5 dBm or 2.82 mW	30 dBm or 1 Watt
Middle	2440	1	100.1	3.9 dBm or 2.45 mW	4.9 dBm or 3.1 mW	30 dBm or 1 Watt
Highest	2478	1	99.9	3.7 dBm or 2.34 mW	4.7 dBm or 2.95 mW	30 dBm or 1 Watt

Note 1: The transmitter with this antenna complies with SAR limit with body tissue (1.6 W/Kg).

Note 2: The measured EIRP shows slightly higher than that of the calculated value. The actual gain of the antenna is from 0.3 dBi to 0.6 dBi higher than the manufacturer's specification.

6.9. RF EXPOSURE REQUIRMENTS @ FCC 15.247(B)(4), 1.1310 & 2.1091

6.9.1. Limits

- **FCC 15.247(b)(4):** Systems operating under provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See @ 1.1307(b)(1).
- **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

6.9.2. Method of Measurements

Refer to FCC @ 1.1310, 2.1091 and Public Notice DA 00-705 (March 30, 2000)

- Spread spectrum transmitters operating under section 15.247 are categorically from routine environmental evaluation to demonstrating RF exposure compliance with respect to MPE and/or SAR limits. These devices are not exempted from compliance (As indicated in Section 15.247(b)(4), these transmitters are required to operate in a manner that ensures that exposure to public users and nearby persons) does not exceed the Commission's RF exposure guidelines (see Section 1.1307 and 2.1093). Unless a device operates at substantially low power levels, with a low gain antenna(s), supporting information is generally needed to establish the various potential operating configurations and exposure conditions of a transmitter and its antenna(s) in order to determine compliance with the RF exposure guidelines.

- In order to demonstrate compliance with MPE requirements (see Section 2.1091), the following information is typically needed:

  (1) Calculation that estimates the minimum separation distance (20 cm or more) between an antenna and persons required to satisfy power density limits defined for free space.
  (2) Antenna installation and device operating instructions for installers (professional/unskilled users), and the parties responsible for ensuring compliance with the RF exposure requirement
  (3) Any caution statements and/or warning labels that are necessary in order to comply with the exposure limits
  (4) Any other RF exposure related issues that may affect MPE compliance

<u>**Calculation Method of RF Safety Distance**</u>:

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

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

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

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

FCC radio frequency exposure limits may not be exceeded at distances closer than r cm from the antenna of this device

- For portable transmitters (see Section 2.1093), or devices designed to operate next to a person's body, compliance is determined with respect to the SAR limit (define in the body tissues) for near-field exposure conditions. If the maximum average output power, operating condition configurations and exposure conditions are comparable to those of existing cellular and PCS phones., an SAR evaluation may be required in order to determine if such a device complies with SAR limit. When SAR evaluation data is not available, and the additional supporting information cannot assure compliance, the Commission may request that an SAR evaluation be performed, as provided for in Section 1.1307(d)

6.9.3. Test Data

6.9.3.1. 2.5 mW Radio Transmitter, Model LX2400-3-3, with internal integrated antenna (Aerocomm Omni Directional Antenna, P/N: NZH2400-I, Gain = 1 dBi)

Evaluation of RF Exposure Compliance Requirements	
RF Exposure Requirements	**Compliance with FCC Rules**
SAR Tests for Portable Transmitters • Body Tissue	• Comply with SAR limits with body tissue with maximum SAR level of **0.057 W/Kg.**

6.10. SPURIOUS EMISSIONS (CONDUCTED), FCC CFR 47, PARA. 15.247(C)

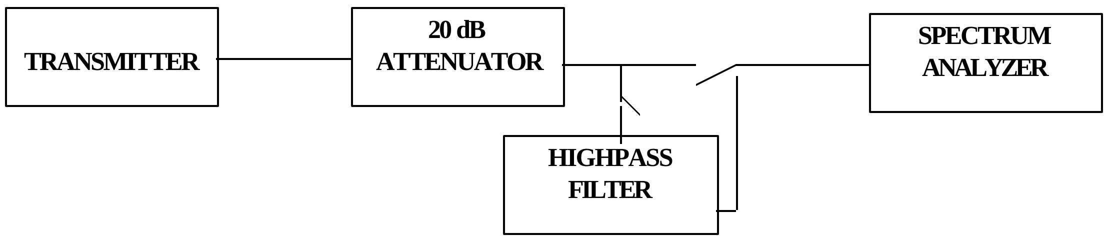
6.10.1. Limits

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 at least 20 dB below that in any 100 KHz bandwidth within the band that contains the highest level of the desired power.

6.10.2. Method of Measurements

Refer to Exhibit 8, Sec. 8.4 of this test report, FCC 15.247(c) & ANSI C63-4:1992

6.10.3. Test Arrangement



6.10.4. 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

6.10.5. Plots

6.10.6. Test Data

Tests are not applicable for integral antenna

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

6.11.1. 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
2.1735 - 2.1905	240 - 285	2655 - 2900	13.25 - 13.4
8.362 - 8.366	322 - 335.4	3260 - 3267	14.47 - 14.5
13.36 - 13.41	399.9 - 410	3332 - 3339	14.35 - 16.2
25.5 – 25.67	608 - 614	3345.8 - 3358	17.7 - 21.4
37.5 – 38.25	960 - 1240	3600 - 4400	22.01 - 23.12
73 - 75.4	1300 - 1427	4500 - 5250	23.6 - 24.0
108 – 121.94	1435 - 1626.5	5350 - 5460	31.2 - 31.8
123 – 138	1660 - 1710	7250 - 7750	36.43 - 36.5
149.9 – 150.05	1718.8 - 1722.2	8025 - 8500	Above 38.6
156.7 – 156.9	2200 - 2300	9000 - 9200	

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

6.11.2. Method of Measurements

Refer to Exhibit 8, Sec. 8.4 of this test report and **ANSI 63.4-1992, Para. 8** for detailed radiated emissions measurement procedures.

The following measurement procedures were also applied:

- 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 ≥ 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).

6.11.3. Test Arrangement

Please refer to Test Arrangement in Sec. 5.5.3 for details of test setup for emission measurements.

6.11.4. 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

6.11.5. Plots

Please refer to Plot # 10 to 15 in Exhibit 9 and plots below tables of test measurement.

6.11.6. Photographs of Test Setup

Refer to the Photographs #1 to # 3 in Exhibit 10 for setup and arrangement of equipment under tests and its ancillary equipment.

6.11.7. Test Data

6.11.7.1. Band-edge Spurious Emissions during Hopping

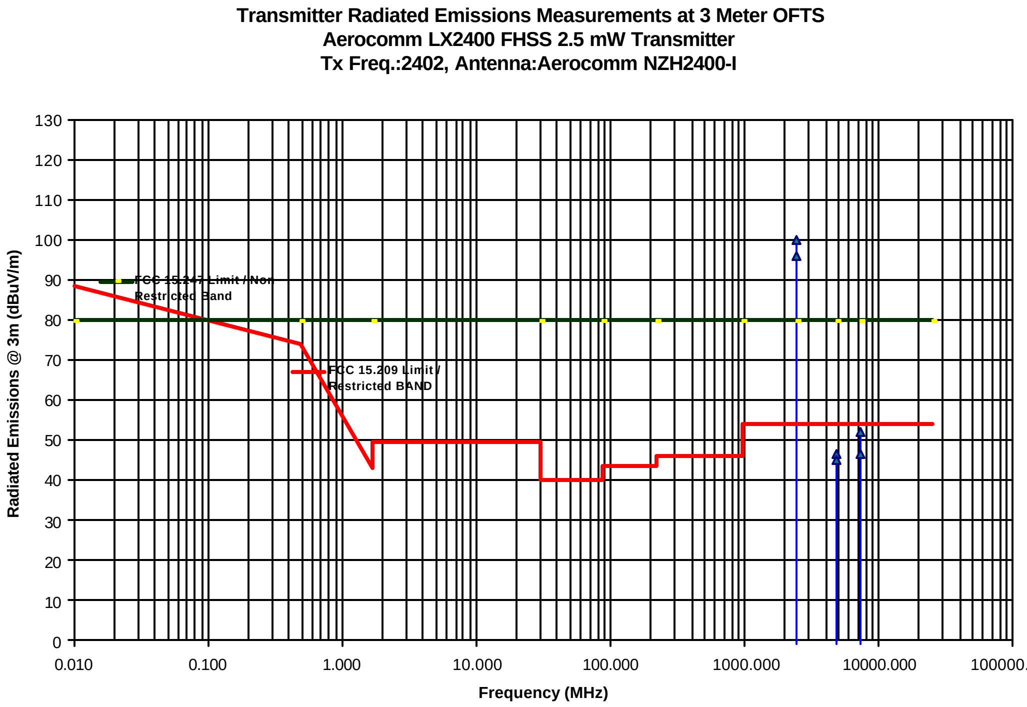
There is lick noise appeared during frequency hopping function; however, this click noise was below the FCC spurious emissions limits. Measurement using the average detector will show that this click noise is insignificant. Please refer plots # 10 to # 13 for detailed measurements

6.11.7.2. 2.5 mW Radio Transmitter, Model LX2400-3-3, with internal integrated antenna (Aerocomm Omni Directional Antenna, P/N: NZH2400-I, Gain = 1 dBi)

6.11.7.2.1. Lowest Frequency (2402 MHz)

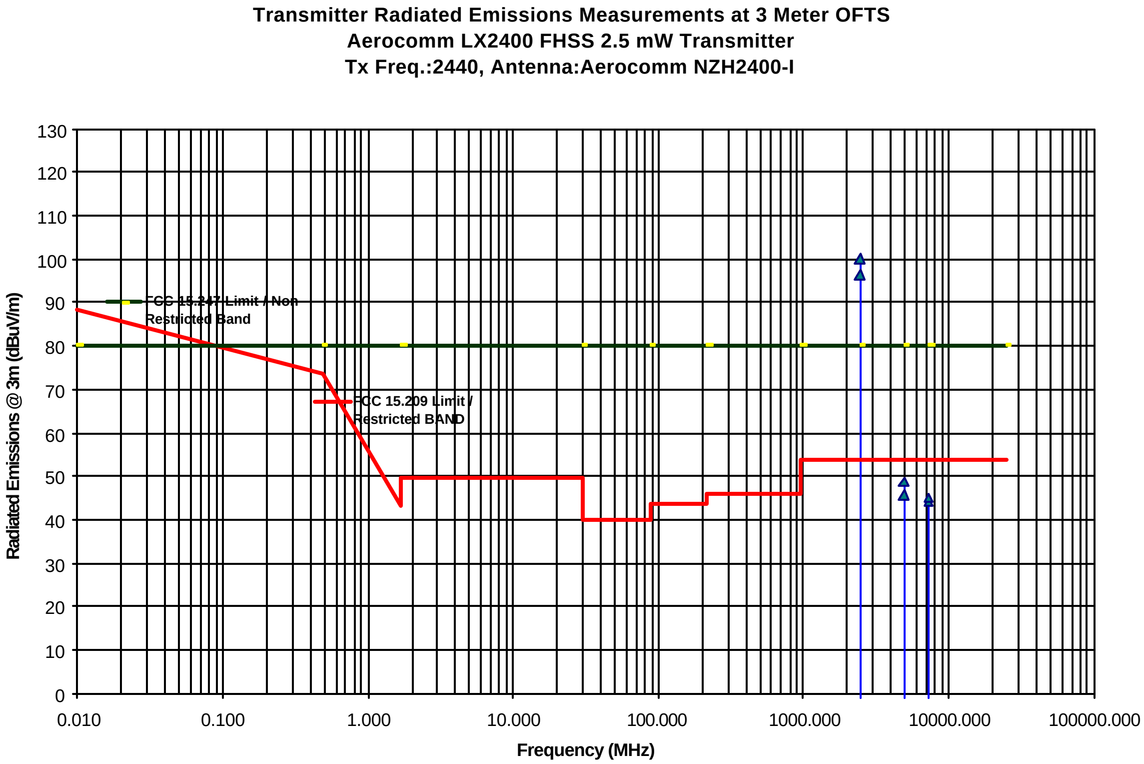
FREQUENCY (MHz)	RF PEAK LEVEL (dBuV/m)	RF AVG LEVEL (dBuV/m)	ANTENNA PLANE (H/V)	LIMIT 15.209 (dBuV/m)	LIMIT 15.247 (dBuV/m)	MARGIN (dB)	PASS/ FAIL
2402.00	99.7	99.7	V	--	--	--	PASS
2402.00	95.8	95.8	H	--	--	--	PASS
4804.00	54.8	46.6	V	54.0	79.7	-7.4	*PASS
4804.00	54.2	45.2	H	54.0	79.7	-8.8	*PASS
7206.00	57.3	46.7	V	54.0	79.7	-33.0	PASS
7206.00	59.4	52.1	H	54.0	79.7	-27.6	PASS

The emissions were scanned from 10 MHz to 25 GHz and all emissions less 40 dB below the limits were recorded.
* Limit @ 15.209 for restricted band is applied



6.11.7.2.2. Middle Frequency (2440 MHz)

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
2440.00	100.1	100.1	V	--	--	--	PASS
2440.00	96.3	96.3	H	--	--	--	PASS
4880.00	54.4	45.8	V	54.0	80.1	-8.2	*PASS
4880.00	55.3	48.7	H	54.0	80.1	-5.3	*PASS
7320.00	54.7	44.1	V	54.0	80.1	-9.9	*PASS
7320.00	56.2	45.0	H	54.0	80.1	-9.0	*PASS
The emissions were scanned from 10 MHz to 25 GHz and all emissions less 40 dB below the limits were recorded. * Limit @ 15.209 for restricted band is applied							



6.11.7.2.3. Highest Frequency (2478 MHz)

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
2478.00	99.8	99.8	V	--	--	--	PASS
2478.00	96.5	96.5	H	--	--	--	PASS
4956.00	55.1	46.8	V	54.0	79.8	-7.2	*PASS
4956.00	53.5	45.9	H	54.0	79.8	-8.1	*PASS
7434.00	55.7	44.8	V	54.0	79.8	-9.2	*PASS
7434.00	55.8	45.3	H	54.0	79.8	-8.7	*PASS

The emissions were scanned from 10 MHz to 25 GHz and all emissions less 40 dB below the limits were recorded.
* Limit @ 15.209 for restricted band is applied

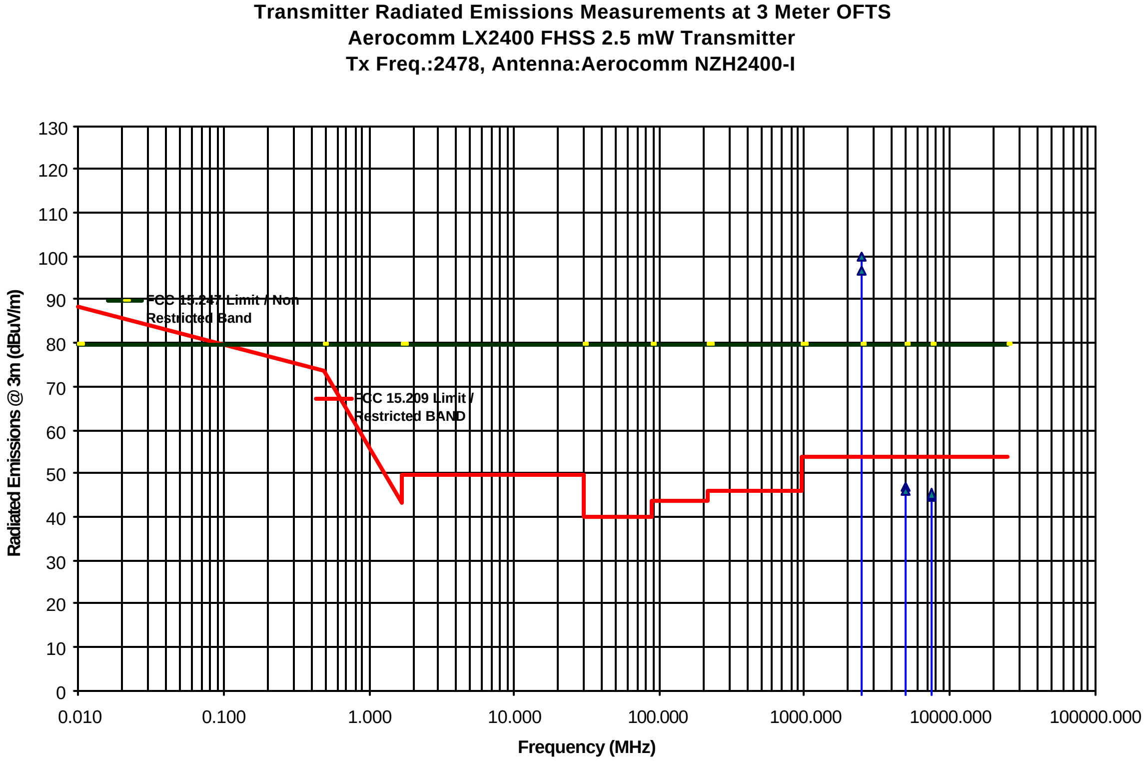


EXHIBIT 7. MEASUREMENT UNCERTAINTY

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

7.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

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

Sample Calculation for Measurement Accuracy in 450 kHz to 30 MHz Band:

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

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

7.2. 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 $20Log(1\pm\Gamma_1\Gamma_R)$	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 8. MEASUREMENT METHODS

8.1. GENERAL TEST CONDITIONS

The following test conditions shall be applied throughout the tests covered in this report.

8.1.1. Normal temperature and humidity

- Normal temperature: +15°C to +35°C
- Relative Humidity: +20% to 75%

The actual values during tests shall be recorded in the test report.

8.1.2. Normal power source

8.1.2.1. Mains Voltage

The nominal test voltage of the equipment to be connected to mains shall be the nominal mains voltage which is the declared voltage or any of the declared voltages for which the equipment was designed.

The frequency of test power source corresponding to the AC mains shall be between 59 Hz and 61 Hz.

8.1.2.2. Battery Power Source.

For operation from battery power sources, the nominal test voltage shall be as declared by the equipment manufacturer. This shall be recorded in the test report.

8.1.3. Operating Condition of Equipment under Test

- All tests were carried out while the equipment operated at the following frequencies:
  - The lowest operating frequency,
  - The middle operating frequency and
  - The highest operating frequency

- Modulation were applied using the Test Data sequence
- The transmitter was operated at the highest output power, or in the case the equipment able to operate at more than one power level, at the lowest and highest output powers

8.2. 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 450 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 3.2 of the 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 450 kHz to 30 MHz.

- 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.

8.3. EFFECTIVE RADIATED POWER

- The following shall be applied to the combination(s) of the radio device and its intended antenna(e).
- I f the RF level is user adjustable, all measurements shall be made with the highest power level available to the user for that combination.
- The following method of measurement shall apply to both conducted and radiated measurements.
- The radiated measurements are performed at the Ultratech Calibrated Open Field Test Site.
- The measurement shall be performed using normal operation of the equipment with modulation.

Test procedure shall be as follows:

Step 1: Duty Cycle measurements

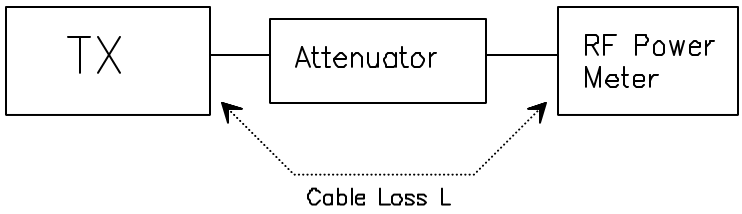
- Using a spectrum analyzer with the frequency span set to 0 Hz and the sweep time set at a suitable value to capture the envelope peaks and the duty cycle of the transmitter output signal;
- The duty cycle of the transmitter, x = Tx on / (Tx on + Tx off) with 0<x<1, is measure and recorded in the test report. For the purpose of testing, the equipment shall be operated with a duty cycle that is equal or more than 0.1.

Step 2: Calculation of Peak and Average EIRP

- The peak output power of the transmitter shall be determined using a wideband, calibrated RF Peak Power Meter with the power sensor with an integration period that exceeds the repetition period of the transmitter by a factor 5 or more. The observed value shall be recorded as “P” (in dBm);
- The Average EIRP. shall be calculated from the above measured power output “A”, the observed duty cycle x, and the applicable antenna assembly gain “G” in dBi, according to the formula:

Peak EIRP = P + G
Average EIRP = Peak EIRP + 10log(1/x)

Figure 1.



Step 3: Substitution Method. See Figure 2

(a) The measurements was performed in the absence of modulation (un-modulated)
(b) Test was performed at listed 3m open area test site (listed with FCC, IC, ITI, NVLAP, ACA & VCCI).
(c) The transmitter under test was placed at the specified height on a non-conducting turntable (80 cm height)
(d) The dipole test antenna was used and tuned to the transmitter carrier frequency.
(e) The spectrum analyzer was tuned to transmitter carrier frequency. The test antenna was lowered or raised from 1 to 4 meters until the maximum signal level was detected.
(f) The transmitter was rotated through 360° about a vertical axis until a higher maximum signal was received.

(g) The test antenna was lowered or raised again from 1 to 4 meters until a maximum was obtained. This level was recorded.
(h) The substitution dipole antenna and the signal generator replaced the transmitter and antenna under test in the same position, and the substitution dipole antenna was placed in vertical polarization. The test dipole antenna was lowered or raised as necessary to ensure that the maximum signal is stilled received.
(i) The input signal to the substitution antenna was adjusted in level until an equal or a known related level to that detected from the transmitter was obtained in the test receiver. The maximum carrier radiated power is equal to the power supply by the generator.
(j) The substitution antenna gain and cable loss were added to the signal generator level for the corrected ERP level.
(k) Repeat steps (c) to (j) with the substitution antenna oriented in horizontal polarization.
(l) Actual gain of the EUT's antenna is the difference of the measured ERP and measured RF power at the RF port. Correct the antenna gain if necessary.

Figure 2

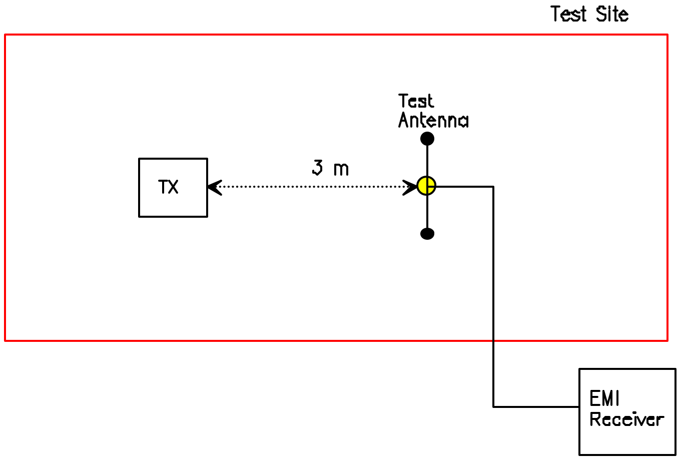
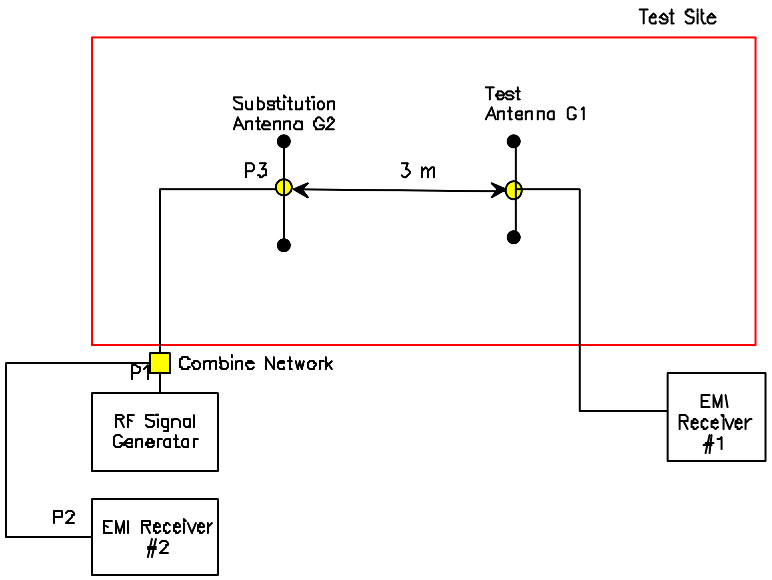


Figure 3



P3 = P2 + Insertion Loss (P1–P3
EIRP = P3 + G2

Use the following spectrum analyzer settings:

- Span = approximately 5 times the 20 dB BW, centered on a hopping channel
- RBW > 20 dB BW of the emission measured
- VBW = RBW
- Trace = max hold
- Allow the trace to stabilize
- Use the marker-to-marker function to set the marker to the peak of the emission.
- The indicated level is the peak output power (with the addition of the external attenuation and cable loss).
- The limit is specified in one of the subparagraph of this Section.
- Submit this plot.
- A peak responding power meter may be used instead of a spectrum analyzer.

8.4. SPURIOUS EMISSIONS (CONDUCTED & RADIATED)

For both conducted and radiated measurements, the spurious emissions were scanned from the lowest frequency generated by the EUT or 10 MHz whichever is lower to 10th harmonic of the highest frequency generated by the EUT.

8.4.1. Band-edge and Spurious Emissions (Conducted)

Band-edge Compliance of RF Conducted Emissions:
Use the following spectrum analyzer settings:

- The radio was connected to the measuring equipment via a suitable attenuator.
- Span = wide enough to capture the peak level of the emission operating on the channel closest to the band-edge, 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 band-edge, or on the highest modulation product outside of the band, if this level is greater than that at the band-edge
- Enable the marker-delta function, 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
- 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 cause by the hopping function also comply with the specify limits.
- Submit this plot

Spurious RF Conducted Emissions:

Use the following spectrum analyzer settings:

- The radio was connected to the measuring equipment via a suitable attenuator.
- 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 10^{th} harmonic. Typically, sevral 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 any spurious emission recorded. The level displayed must comply with the limit specified in this Section.
- Submit this plot

8.4.2. Spurious Emissions (Radiated)

- The radiated emission measurements were performed at the UltraTech's 3 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. The 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:

   - RBW = 100 kHz for f < 1GHz and RBW = 1 MHz for f $\geq$ 1 GHz
   - VBW = RBW
   - Sweep = auto
   - Detector function = peak
   - Trace = max hold
   - Follows the guidelines in ANSI C63.4-1992 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 highpass 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 correction factor, cable loss, pre-amp gain, etc…. is the peak field strength which comply with the limit specified in Section 15.35(b)

   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.

- Submit this test data
- Now set the VBW to 10Hz, 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 100ms, then the reading obtained may be further adjusted by a "duty cycle correction factor", derived from 10log(dwell time/100mS) in an effort to demonstrate compliance with the 15.209.
- Submit test data

Maximizing The Radiated Emissions:

- 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 allowable 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.

8.5. ALTERNATIVE TEST PROCEDURES

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

8.5.1. Peak Power Measurements

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

$E = 30PG/d$
$P = (Ed)^2/30G$

Where:

- E: 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 C63.4-1992 with respect to maximizing the emission
- G is 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 distance in meters from which the field strength was measured

8.5.2. Spurious RF conducted emissions

The demonstrate compliance with the spurious RF conducted emission requirement of Section 15.247©, use the following spectrum analyzer settings:

- Span = wide enough to fully capture the emission being measured
- RBW = 100 kHz
- Sweep = auto
- Detector function = peak
- Trace = max hold
- Measure the field strength of both the fundamental and all spurious emissions with these settings.
- Follow the procedures C62-4:1994 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©. 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