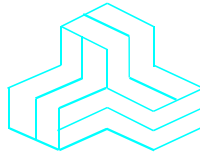


ENGINEERING TEST REPORT



Transceiver Module
Model No.: WL7412-450
FCC ID: MTHWL7412-450

Applicant: **WaveNet International Inc.**
5825 Kennedy Road
Mississauga, Ontario
Canada, L4Z 2G3

Tested in Accordance With

Federal Communications Commission (FCC)
CFR 47, PARTS 2 and 90 (Subpart I)

UltraTech's File No.: WIC15-FTX

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

Date:



Report Prepared by: Dan Huynh

Tested by: Hung Trinh, RFI/EMI Technician

Issued Date: August 7, 2001

Test Dates: May 28-29, 2001

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

Annex No.	Exhibit Type	Description of Contents	Quality Check (OK)
--	Test Report	<ul style="list-style-type: none"> 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
1	Test Data Plots	<ul style="list-style-type: none"> 99% Occupied Bandwidth, plots # 1 – 3 Emission Mask D, plots # 4 – 6 Spurious Emissions at Antenna Terminals, plots #7 – 12 Transient Frequency Behavior, plots # 13 - 16 	OK
2	Test Setup Photos	EUT Test Setup Photos	OK
3	External EUT Photos	Transceiver Module External Photos	OK
4	Internal EUT Photos	Transceiver Module Internal Photos	OK
5	Cover Letters	<ul style="list-style-type: none"> Letter from Ultratech for Certification Request Letter from the Applicant to appoint Ultratech to act as an agent Letter from the Applicant to request for Confidentiality Filing 	OK
6	Attestation Statements	--	--
7	ID Label/Location Info	<ul style="list-style-type: none"> ID Label Location of ID Label 	OK
8	Block Diagrams	Block Diagram	OK
9	Schematic Diagrams	Schematic Diagrams	OK
10	Parts List/Tune Up Info	--	--
11	Operational Description	Circuit Description	OK
12	RF Exposure Info	For MPE Evaluation, refer to section 6.6 of this Test Report.	OK
13	Users Manual	<ul style="list-style-type: none"> E.F. Johnson Company High Specification Data Transceiver WaveNet 5000 Mobile Terminal Product Guide 	OK

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EXHIBIT 2. INTRODUCTION

2.1. SCOPE

Reference:	FCC Parts 2 and 90
Title:	Telecommunication - Code of Federal Regulations, CFR 47, Parts 2 & 90
Purpose of Test:	To gain FCC Certification Authorization for Radio operating in the frequency band 450 - 466 MHz (12.5 kHz Channel Spacing).
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.

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

None

2.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2000	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

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EXHIBIT 3. PERFORMANCE ASSESSMENT

3.1. CLIENT INFORMATION

APPLICANT	
Name:	WaveNet International Inc.
Address:	5825 Kennedy Road Mississauga, Ontario Canada, L4Z 2G3
Contact Person:	Mr. Vickram Sondhi Phone #: (905) 712-4700 ext 108 Fax #: (905) 712-4703 Email Address: vsondhi@wavenet-rf.com

MANUFACTURER	
Name:	Johnson Data Telemetry Corp.
Address:	P.O. Box 916131 Longwood, Florida USA, 32791-6131
Contact Person:	Mr. David Hammick Phone #: (407) 774-7074 Fax #: (407) 774-7074 Email Address: dhammick@johnsondata.com

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:	WaveNet International Inc.
Product Name:	Transceiver Module
Model Name or Number:	WL7412-450
Serial Number:	Test Sample
Type of Equipment:	Non-broadcast Radio Communication Equipment
External Power Supply:	N/A
Transmitting/Receiving Antenna Type:	Non-integral
Primary User Functions of EUT:	Transmission and reception of digital data. This radio module is only used with WaveNet Base and Mobile wireless systems. It is not sold to the OEM manufacturer as a module. For mobile operation a unity antenna is required and be located at a minimum distance of 25 cm away from the users. This distance is specified in the Product Guide.

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3.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	<input type="checkbox"/> Portable <input checked="" type="checkbox"/> Mobile <input checked="" type="checkbox"/> Base station (fixed use)
Intended Operating Environment:	<input checked="" type="checkbox"/> Commercial <input type="checkbox"/> Light Industry & Heavy Industry
Power Supply Requirement:	7.5 Vdc
RF Output Power Rating:	2 Watts
Operating Frequency Range:	450 - 466 MHz
RF Output Impedance:	50 Ohms
Channel Spacing:	12.5 kHz
Occupied Bandwidth (99%):	7.20 kHz
*Emission Designation:	7K60F1D
Oscillator Frequency:	17.5 MHz
Antenna Connector Type:	SMA

* For an average case of commercial telephony, the Necessary Bandwidth is calculated as follows:

For FM Digital Modulation:

$D = 2.0$ kHz max.

$K = 1$

Level of FM = 4

$M = \text{Data Rate in kbps} / \text{Level of FM} = 7.2 / 4$ kbps

$B_n = 2M + 2DK = 2(7.2 / 4) + 2(2.0)(1) = 7.6$ kHz

Emission Designation: 7K60F1D

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 Terminal	1	SMA	Shielded
2	30 Pin Socket	1	Terminal Block	Non-shielded

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 50 Ohms RF Load.

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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:	Laptop
Brand name:	Unisys
Model Name or Number:	SGM1404-425
Cable Length & Type:	6 ft, RS232 (DB9)
Connected to EUT's Port:	N/A

Ancillary Equipment # 2	
Description:	WaveNet 7000 Base Controller
Brand name:	WaveNet International Inc.
Model Name or Number:	Test Sample
Cable Length & Type:	1 ft, 30 Pin
Connected to EUT's Port:	30 Pin Socket

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EXHIBIT 4. EUT OPERATION 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:	7.5 Vdc

4.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TEST SIGNALS

Operating Modes:	The transmitter was operated in a continuous transmission mode with the carrier modulated as specified in the Test Data.
Special Test Software:	WaveNet test software.
Special Hardware Used:	WaveNet 7000 Base Controller
Transmitter Test Antenna:	The EUT is tested with the transmitter antenna port terminated to a 50 Ohms RF Load.

Transmitter Test Signals	
Frequency Band(s):	Near lowest, near middle & near highest frequencies in each frequency bands that the transmitter covers:
▪ 450 - 466 MHz:	▪ 450, 458 and 466 MHz
Transmitter Wanted Output Test Signals:	
▪ RF Power Output (measured maximum output power):	2 W
▪ Normal Test Modulation:	FM modulation with internal 7200 bps random data.
▪ Modulating signal source:	Internal

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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.

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 site 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: May 02, 2001.

5.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC PARAGRAPH	TEST REQUIREMENTS	APPLICABILITY (YES/NO)
90.205 & 2.1046	RF Power Output	Yes
1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Yes
90.213 & 2.1055	Frequency Stability	Yes
90.242(b)(8) & 2.1047(a)	Audio Frequency Response	Not Applicable
90.210 & 2.1047(b)	Modulation Limiting	Yes
90.209 90.210 & 2.1049	Emission Limitation & Emission Mask	Yes
90.210, 2.1057 & 2.1051	Emission Limits - Spurious Emissions at Antenna Terminal	Yes
90.210, 2.1057 & 2.1053	Emission Limits - Field Strength of Spurious Emissions	Yes
90.214	Transient Frequency Behavior	Yes
Transceiver Module, Model No.: WL7412-450, by WaveNet International Inc. has also been tested and found to comply with FCC Part 15, Subpart B - Radio Receivers and Class A Digital Devices. The engineering test report has been documented and kept in file and it is available anytime upon FCC request.		

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5.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

The following modifications are required for compliance with receiver radiated emissions:

- 1) EMI gasket was inserted between lid and the case of the module.
- 2) The I/O cable has to be shielded and the shield connected to module-case at one end and ground at the other end.

5.4. DEVIATION OF STANDARD TEST PROCEDURES

None

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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

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 C63.4:1992 and CISPR 16-1.

6.4. ESSENTIAL/PRIMARY FUNCTIONS AS DECLARED BY THE MANUFACTURER

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

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6.5. RF POWER OUTPUT @ FCC 2.1046 & 90.205

6.5.1. Limits @ FCC 90.205

Please refer to FCC CFR 47, Part 90, Subpart I, Para. 90.205 for specification details.

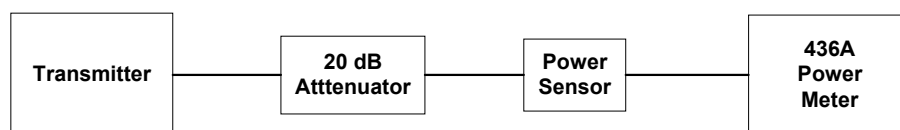
6.5.2. Method of Measurements

Refer to Exhibit 8, § 8.1 (Conducted) and 8.2 (Radiated) of this report for measurement details

6.5.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Power Meter	Hewlett Packard	436A	1725A02249	10 kHz – 50 GHz, sensor dependent
Power Sensor	Hewlett Packard	8481A	2702A68983	10 MHz – 18 GHz
Attenuator(s)	Bird	...	...	DC – 22 GHz

6.5.4. Test Arrangement



6.5.5. Test Data

Transmitter Channel Output	Fundamental Frequency (MHz)	Measured Power (dBm)	Power Rating (dBm)
Lowest	450	33.0	33.0
Middle	458	33.1	33.0
Highest	466	33.1	33.0

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6.6. RF EXPOSURE REQUIREMENTS @ 1.1310 & 2.1091

MPE EVALUATION

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).

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f ²)	6
30–300	61.4	0.163	1.0	6
300–1500 .....	.....	.....	f/300	6
1500–100,000 .....	.....	.....	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*(180/f ²)	30
30–300	27.5	0.073	0.2	30
300–1500 .....	.....	.....	f/1500	30
1500–100,000 .....	.....	.....	1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

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Calculation Method of RF Safety Distance:

$$S = PG/4\pi r^2 = EIRP/4\pi r^2 \implies r = \sqrt{PG/4\pi S} = \sqrt{EIRP/4\pi S}$$

Where: P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm²
G: numeric gain of antenna relative to isotropic radiator
r: distance to center of radiation in cm

P = 2 W = 2000 mW (power measured at antenna terminal)
S = 450/1500 mW/cm² (limits for general population/uncontrolled exposure)

$$r = \sqrt{PG/4\pi S} = \sqrt{(2000 \times 1) / (4\pi(450/1500))} = 23 \text{ cm}$$

The minimum safety distance is 23 cm. In the user manual/product guide, RF exposure statement will specified a safety distance of 25 cm as shown below:

RF EXPOSURE WARNING

In order to ensure user safety and to satisfy RF exposure requirements for mobile transmitting devices, a minimum separation distance of 25 cm. (10 inches) must be maintained between the transmitting device and the user (or other nearby persons) during device operation. Operation at smaller separation distances is not recommended.

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6.7. FREQUENCY STABILITY @ FCC 2.1055 & 90.213

6.7.1. Limits @ FCC 90.213

Please refer to FCC CFR 47, Part 90, Subpart I, Para. 90.213 for specification details.

Frequency Range (MHz)	Channel Spacing (kHz)	Frequency Tolerance (ppm)		
		Fixed and Base Stations	Mobile Station	
			> 2 Watts	≤ 2 Watts
421 - 512	6.25	0.5	1.0	1.0
	12.5	1.5	2.5	2.5
	25	2.5	5.0	5.0

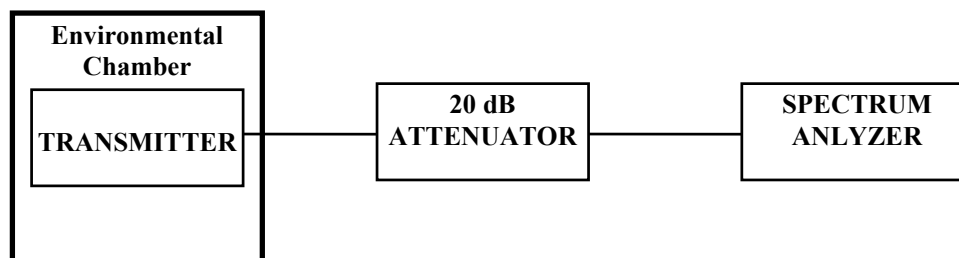
6.7.2. Method of Measurements

Refer to Exhibit 8, § 8.3 of this report for measurement details

6.7.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Advantest	R3271	15050203	100 Hz – 26.5 GHz
Attenuator(s)	Bird	..	...	DC – 22 GHz
Temperature & Humidity Chamber	Tenney	T5	9723B	-40° to +60° C range

6.7.4. Test Arrangement



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6.7.5. Test Data

Product Name:	Transceiver Module
Model No.:	WL7412-450
Center Frequency:	450 MHz
Full Power Level:	2 W
Frequency Tolerance Limit:	1.5 ppm or 675 Hz at 450 MHz
Max. Frequency Tolerance Measured:	-500 Hz or 1.1 ppm
Input Voltage Rating:	+7.5 V DC

CENTER FREQUENCY & RF POWER OUTPUT VARIATION			
Ambient Temperature (°C)	Supply Voltage (Nominal) 7.5 Volts	Supply Voltage (85% of Nominal) 6.38 Volts	Supply Voltage (115% of Nominal) 8.63 Volts
	Hz	Hz	Hz
-30	-500	N/A	N/A
-20	-197	N/A	N/A
-10	-83	N/A	N/A
0	-89	N/A	N/A
+10	-80	N/A	N/A
+20	-6	+9	+35
+30	+14	N/A	N/A
+40	+43	N/A	N/A
+50	-51	N/A	N/A

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6.8. MODULATION LIMITING @ FCC 2.1047(B) & 90.210

6.8.1. Limits @ FCC 2.1047(b) and 90.210

Recommended frequency deviation characteristics are given below:

- 1.25 kHz for 6.25 kHz Channel Spacing System
- 2.5 kHz for 12.5 kHz Channel Spacing
- 5 kHz for 25 kHz Channel Spacing System

6.8.2. Method of Measurements

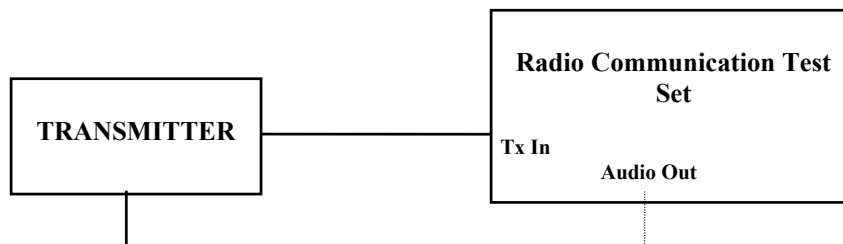
For Audio Transmitter:- The carrier frequency deviation was measured with the tone input signal level varied from 0 Vp to audio input rating level plus 16 dB at frequencies 0.1, 0.5, 1.0, 3.0 and 5.0 kHz. The maximum deviation was recorded at each test condition.

For Data Transmitter with Maximum Frequency Deviation set by Factory:- The EUT was set at maximum frequency deviation, and its peak frequency deviation was then measured using EUT's internal random data source.

6.8.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Radio Communication Test Set	Marconi Instruments	2955	132037/226	400kHz - 1000 MHz

6.8.4. Test Arrangement



6.8.5. Test Data

Data Modulation Limiting: FM modulation with random data and modulation limiter set at a maximum frequency deviation (factory setting).

Data Baud Rate	Peak Deviation (kHz)	Maximum Limit (kHz)
7200	2.0	2.5

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6.9. EMISSION MASK @ FCC 2.1049, 90.209 & 90.210

6.9.1. Limits @ FCC 90.209 & 90.210

Emissions shall be attenuated below the mean output power of the transmitter as follows:

Frequency Range (MHz)	Maximum Authorized BW (kHz)	Channel Spacing (kHz)	Recommended Frequency Deviation (kHz)	FCC Applicable Mask
421-512	11.25	12.5	2.5	• Mask D – Voice & Data

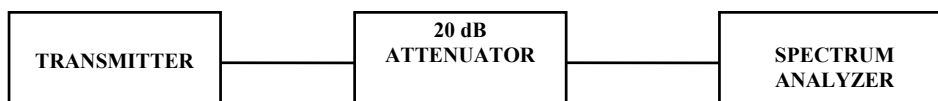
6.9.2. Method of Measurements

Refer to Exhibit 8, § 8.4 of this report for measurement details

6.9.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/EMI Receiver	Advantest	R3271	15050203	100 Hz – 26.5 GHz
Attenuator(s)	Bird	..	...	DC – 22 GHz
Audio Oscillator	Hewlett Packard	HP 204C	0989A08798	DC to 1.2 MHz

6.9.4. Test Arrangement



6.9.5. Test Data

Conform. Please refer to test data plots # 4 to 6 in Annex 1 for details of measurements.

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6.10. TRANSMITTER ANTENNA POWER SPURIOUS/HARMONIC CONDUCTED EMISSIONS @ FCC 90.210

6.10.1. Limits @ 90.210

Emissions shall be attenuated below the mean output power of the transmitter as follows:

FCC Rules	Frequency Range	Attenuation Limit (dBc)
90.210(d) – Voice & Data	10 MHz to Lowest frequency of the radio to 10 th harmonic of the highest frequency of the radio	50+10*log(P) or 70 dBc whichever is less

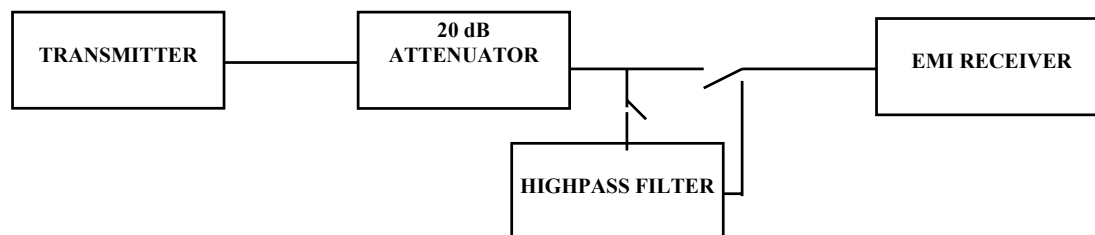
6.10.2. Method of Measurements

Refer to Exhibit 8 § 8.5 of this report for measurement details

6.10.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Advantest	R3271	15050203	100 Hz – 26.5 GHz
Attenuator(s)	Bird	..	...	DC – 22 GHz
Audio Oscillator	Hewlett Packard	HP 204C	0989A08798	DC to 1.2 MHz
Highpass Filter, Microphase	Microphase	CR220HID	IITI11000AC	Cut-off Frequency at 600 MHz, 1.3 GHz or 4 GHz

6.10.4. Test Arrangement



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6.10.5. Test Data

Test data plots for the following results can be found in Annex 1 plots # 7-12.

- Near Lowest Frequency (450 MHz)**

Fundamental Frequency: 450 MHz
RF Output Power: 2 W (conducted)
Modulation: FM with internal 7200 bps random data

Frequency (MHz)	Transmitter Antenna Conducted Emissions		Limit (dBc)	Margin (dB)	Pass/ Fail
	(dBm)	(dBc)			
899	-39.1	-72.1	-53	-19.1	Pass
The emissions were scanned from 10 MHz to 5 GHz and all emissions within 20 dB below the limits were recorded.					

- Near Middle Frequency (458 MHz)**

Fundamental Frequency: 458 MHz
RF Output Power: 2 W (conducted)
Modulation: FM with internal 7200 bps random data

Frequency (MHz)	Transmitter Antenna Conducted Emissions		Limit (dBc)	Margin (dB)	Pass/ Fail
	(dBm)	(dBc)			
918	-39.8	-72.8	-53	-19.8	Pass
The emissions were scanned from 10 MHz to 5 GHz and all emissions within 20 dB below the limits were recorded.					

- Near Highest Frequency (466 MHz)**

Fundamental Frequency: 466 MHz
RF Output Power: 2 W (conducted)
Modulation: FM with internal 7200 bps random data

The emissions were scanned from 10 MHz to 5 GHz and no signal was found within 20 dB below the limits.

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6.11. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS @ FCC 90.210

6.11.1. Limits @ FCC 90.210

Emissions shall be attenuated below the mean output power of the transmitter as follows:

Frequency Range (MHz)	Maximum Authorized BW (kHz)	Channel Spacing (kHz)	Recommended Frequency Deviation (kHz)	FCC Applicable Mask
421-512	11.25	12.5	2.5	• 90.210(d): Mask D – Voice & Data

6.11.2. Method of Measurements

The spurious/harmonic ERP measurements are using substitution method specified in Exhibit 8, § 8.2 of this report and its value in dBc is calculated as follows:

- (1) If the transmitter's antenna is an integral part of the EUT, the ERP is measured using substitution method.
- (2) If the transmitter's antenna is non-integral and diverse, the lowest ERP of the carrier with 0 dBi antenna gain is used for calculation of the spurious/harmonic emissions in dBc:
Lowest ERP of the carrier = EIRP – 2.15 dB = $P_c + G - 2.15 \text{ dB} = \text{xxx dBm (conducted)} + 0 \text{ dBi} - 2.15 \text{ dB}$
- (3) Spurious /harmonic emissions levels expressed in dBc (dB below carrier) are as follows:

$$\text{ERP of spurious/harmonic (dBc)} = \text{ERP of carrier (dBm)} - \text{ERP of spurious/harmonic emission (dBm)}$$

6.11.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/EMI Receiver	Advantest	R3271	15050203	100 Hz – 26.5 GHz
RF Amplifier	Com-Power	PA-102		1 MHz to 1 GHz, 30 dB gain nominal
Microwave Amplifier	Hewlett Packard	HP 83017A		1 GHz to 26.5 GHz, 30 dB nominal
Biconilog Antenna	EMCO	3142	10005	30 MHz to 2 GHz
Dipole Antenna	EMCO	3121C	8907-434	30 GHz – 1 GHz
Dipole Antenna	EMCO	3121C	8907-440	30 GHz – 1 GHz
Horn Antenna	EMCO	3155	9701-5061	1 GHz – 18 GHz
Horn Antenna	EMCO	3155	9911-5955	1 GHz – 18 GHz
RF Signal Generator	Hewlett Packard	HP 83752B	3610A00457	0.01 – 20 GHz

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6.11.4. Test Setup

Please refer to photos in Annex 2 for detailed of test setup.

6.11.5. Test Data

Remarks: The Radiated emissions were performed at 3 meters distance.

• Near Lowest Frequency (450 MHz)

Fundamental Frequency: 450 MHz
RF Output Power: 33 dBm
Modulation: FM with internal 7200 bps random data

Frequency (MHz)	E-Field @3m (dBμV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method		Limit (dBc)	Margin (dB)	Pass/Fail
				(dBm)	(dBc)			
1350.00	67.16	Peak	V	-39.2	-72.2	-53	-19.2	Pass
1350.00	68.50	Peak	H	-37.4	-70.4	-53	-17.4	Pass

The emissions were scanned from 10 MHz to 5 GHz and all emissions within 20 dB below the limits were recorded.

• Near Middle Frequency (458 MHz)

Fundamental Frequency: 458 MHz
RF Output Power: 33.1 dBm
Modulation: FM with internal 7200 bps random data

Frequency (MHz)	E-Field @3m (dBμV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method		Limit (dBc)	Margin (dB)	Pass/Fail
				(dBm)	(dBc)			
1374.00	70.72	Peak	V	-34.0	-67.1	-53	-14.1	Pass
1374.00	75.27	Peak	H	-29.5	-62.6	-53	-9.6	Pass
3664.00	58.38	Peak	V	-38.3	-71.4	-53	-18.4	Pass
3664.00	65.53	Peak	H	-32.6	-65.7	-53	-12.7	Pass

The emissions were scanned from 10 MHz to 5 GHz and all emissions within 20 dB below the limits were recorded.

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• **Near Highest Frequency (466 MHz)**

Fundamental Frequency: 466 MHz
RF Output Power: 33.1 dBm
Modulation: FM with internal 7200 bps random data

Frequency (MHz)	E-Field @3m (dBμV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method		Limit (dBc)	Margin (dB)	Pass/ Fail
				(dBm)	(dBc)			
1398.00	72.69	Peak	V	-31.9	-65.0	-53	-12	Pass
1398.00	76.34	Peak	H	-28.9	-62.0	-53	-9	Pass
2330.00	63.31	Peak	H	-36.1	-69.2	-53	-16.2	Pass
3728.00	58.72	Peak	V	-37.1	-70.2	-53	-17.2	Pass
3728.00	65.94	Peak	H	-31.4	-64.5	-53	-11.5	Pass
The emissions were scanned from 10 MHz to 5 GHz and all emissions within 20 dB below the limits were recorded.								

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6.12. TRANSIENT FREQUENCY BEHAVIOR @ 90.214

6.12.1. Limits

Transient frequencies must be within the maximum frequency difference limits during the time intervals indicated:

Time intervals ^{1, 2}	Maximum frequency difference ³	All equipment	
		150 to 174 MHz	421 to 512 MHz
Transient Frequency Behavior for Equipment Designed to Operate on 25 kHz Channels			
t ₁ ⁴	± 25.0 kHz	5.0 ms	10.0 ms
t ₂	± 12.5 kHz	20.0 ms	25.0 ms
t ₃ ⁴	± 25.0 kHz	5.0 ms	10.0 ms
Transient Frequency Behavior for Equipment Designed to Operate on 12.5 kHz Channels			
t ₁ ⁴	± 12.5 kHz	5.0 ms	10.0 ms
t ₂	± 6.25 kHz	20.0 ms	25.0 ms
t ₃ ⁴	± 12.5 kHz	5.0 ms	10.0 ms
Transient Frequency Behavior for Equipment Designed to Operate on 6.25 kHz Channels			
t ₁ ⁴	± 6.25 kHz	5.0 ms	10.0 ms
t ₂	± 3.125 kHz	20.0 ms	25.0 ms
t ₃ ⁴	± 6.25 kHz	5.0 ms	10.0 ms

- t_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.
 t_1 is the time period immediately following t_{on} .
 t_2 is the time period immediately following t_1 .
 t_3 is the time period from the instant when the transmitter is turned off until t_{off} .
 t_{off} is the instant when the 1 kHz test signal starts to rise.
- During the time from the end of t_2 to the beginning of t_3 , the frequency difference must not exceed the limits specified in § 90.213.
- Difference between the actual transmitter frequency and the assigned transmitter frequency.
- If the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

6.12.2. Method of Measurements

Refer to Exhibit 8, § 8.6 of this test report and ANSI/TIA/EIA - 603 - 1992, Sec. 2.2.19, Page 83

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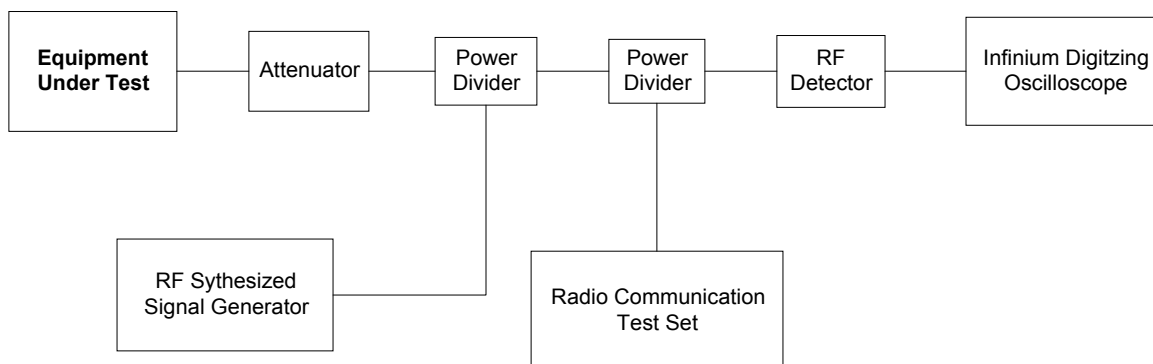
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6.12.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
RF Synthesized Signal Generator	Fluke	6061A	4770301	10 kHz – 1050 MHz
Radio Communication Test Set	Marconi Instruments	2955	132037/226	400kHz - 1000 MHz
Infinium Digitizing Oscilloscope	Hewlett Packard	54810A	US38380192	DC to 500 MHz, 1 Gsa/s
RF Detector	Amphenol	UG-1094/U1050	--	--
Power Divider	Weinschel Corp	1515	LU400	DC – 18 GHz
Power Divider	Weinschel Corp	1515	LW725	DC – 18 GHz
Attenuator	Weinschel Corp	23-20-34	BH-7876	DC – 18 GHz

6.12.4. Test Arrangement



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6.12.5. Test Data

Test data plots for the following results can be found in Annex 1 plots # 13-16.

Time Interval	Transient Frequency (kHz)	Transient Frequency Limit
Test Configuration #1: Unmodulated		
t ₁ (10 ms) Switch ON Condition	1.3	12.5 kHz or no limit for RF Output Power < 6 Watts
t ₂ (25 ms) Switch On Condition	0	6.25 kHz
After t ₂ (10 ms) Switch On Condition	0	FCC Limit = ± 675 Hz (1.5 ppm @ 450 MHz)
Before t ₃ (10 ms) Switch Off Condition	0	FCC Limit = ± 675 Hz (1.5 ppm @ 450 MHz)
t ₃ (10 ms) Switch Off Condition	0.8	12.5 kHz or no limit for RF Output Power < 6 Watts
Test Configuration #2: FM modulation with 7200 bps random data		
t ₁ (10 ms) Switch ON Condition	4.4	12.5 kHz or no limit for RF Output Power < 6 Watts
t ₂ (25 ms) Switch On Condition	0	6.25 kHz
After t ₂ (10 ms) Switch On Condition	0	FCC Limit = ± 675 Hz (1.5 ppm @ 450 MHz)
Before t ₃ (10 ms) Switch Off Condition	0	FCC Limit = ± 675 Hz (1.5 ppm @ 450 MHz)
t ₃ (10 ms) Switch Off Condition	0	12.5 kHz or no limit for RF Output Power < 6 Watts

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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. RADIATED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Radiated Emissions)	PROBABILITY DISTRIBUTION	UNCERTAINTY (\pm 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 $\Gamma_R = 0.67(\text{Bi}) 0.3 (\text{Lp})$ Uncertainty limits $20\text{Log}(1 \pm \Gamma_1 \Gamma_R)$	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:

$$U = 2u_c(y) = 2x(+2.19) = +4.38 \text{ dB} \quad \text{And} \quad U = 2u_c(y) = 2x(-2.21) = -4.42 \text{ dB}$$

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EXHIBIT 8. MEASUREMENT METHODS

8.1. CONDUCTED POWER MEASUREMENTS

- The following shall be applied to the combination(s) of the radio device and its intended antenna(e).
- If 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 if the transmitter's transmission is transient

- Using a EMI Receiver 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, $x = \text{Tx on} / (\text{Tx on} + \text{Tx off})$ 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.

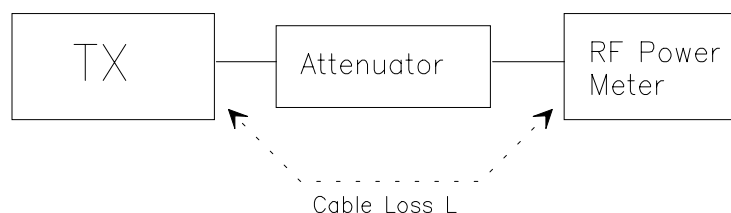
Step 2: Calculation of Average EIRP. See Figure 1

- The average output power of the transmitter shall be determined using a wideband, calibrated RF average 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 "A" (in dBm);
- The e.i.r.p. 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:

$$\text{EIRP} = \text{A} + \text{G} + 10\log(1/x)$$

{ $X = 1$ for continuous transmission $\Rightarrow 10\log(1/x) = 0 \text{ dB}$ }

Figure 1.



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8.2. RADIATED POWER MEASUREMENTS (ERP & EIRP) USING SUBSTITUTION METHOD

8.2.1. Maximizing RF Emission Level (E-Field)

- (a) The measurements were performed with full rf output power and modulation.
- (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 BICONILOG antenna (20 MHz to 1 GHz) or HORN antenna (1 GHz to 18 GHz) was used for measuring.
- (e) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor

$E \text{ (dBuV/m)} = \text{Reading (dBuV)} + \text{Total Correction Factor (dB/m)}$

- (f) Set the EMI Receiver and #2 as follows:

Center Frequency: test frequency
Resolution BW: 100 kHz
Video BW: same
Detector Mode: positive
Average: off
Span: 3 x the signal bandwidth

- (g) The test antenna was lowered or raised from 1 to 4 meters until the maximum signal level was detected.
- (h) The transmitter was rotated through 360° about a vertical axis until a higher maximum signal was received.
- (i) The test antenna was lowered or raised again from 1 to 4 meters until a maximum was obtained. This level was recorded.
- (j) The recorded reading was corrected to the true field strength level by adding the antenna factor, cable loss and subtracting the pre-amplifier gain.
- (k) The above steps were repeated with both transmitters' antenna and test receiving antenna placed in vertical and horizontal polarization. Both readings with the antennas placed in vertical and horizontal polarization shall be recorded.
- (l) Repeat for all different test signal frequencies

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8.2.2. Measuring The EIRP of Spurious/Harmonic Emissions Using Substitution Method

- (a) Set the EMI Receiver (for measuring E-Field) and Receiver #2 (for measuring EIRP) as follows:

Center Frequency: equal to the signal source
Resolution BW: 10 kHz
Video BW: same
Detector Mode: positive
Average: off
Span: 3 x the signal bandwidth

- (b) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
 $E \text{ (dBuV/m)} = \text{Reading (dBuV)} + \text{Total Correction Factor (dB/m)}$

- (c) Select the frequency and E-field levels obtained in the Section 8.2.1 for ERP/EIRP measurements.
(d) Substitute the EUT by a signal generator and one of the following transmitting antenna (substitution antenna):
 ♦ DIPOLE antenna for frequency from 30-1000 MHz or
 ♦ HORN antenna for frequency above 1 GHz }.
(e) Mount the transmitting antenna at 1.5 meter high from the ground plane.
(f) Use one of the following antenna as a receiving antenna:
 ♦ DIPOLE antenna for frequency from 30-1000 MHz or
 ♦ HORN antenna for frequency above 1 GHz }.
(g) If the DIPOLE antenna is used, tune it's elements to the frequency as specified in the calibration manual.
(h) Adjust both transmitting and receiving antenna in a VERTICAL polarization.
(i) Tune the EMI Receivers to the test frequency.
(j) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(k) The transmitter was rotated through 360° about a vertical axis until a higher maximum signal was received.
(l) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(m) Adjust input signal to the substitution antenna until an equal or a known related level to that detected from the transmitter was obtained in the test receiver.
(n) Record the power level read from the Average Power Meter and calculate the ERP/EIRP as follows:

$$P = P1 - L1 = (P2 + L2) - L1 = P3 + A + L2 - L1$$

$$\text{EIRP} = P + G1 = P3 + L2 - L1 + A + G1$$

$$\text{ERP} = \text{EIRP} - 2.15 \text{ dB}$$

$$\text{Total Correction factor in EMI Receiver \# 2} = L2 - L1 + G1$$

Where: P: Actual RF Power fed into the substitution antenna port after corrected.
P1: Power output from the signal generator
P2: Power measured at attenuator A input
P3: Power reading on the Average Power Meter
EIRP: EIRP after correction
ERP: ERP after correction

- (o) Adjust both transmitting and receiving antenna in a HORIZONTAL polarization, then repeat step (k) to (o)
(p) Repeat step (d) to (o) for different test frequency
(q) Repeat steps (c) to (j) with the substitution antenna oriented in horizontal polarization.
(r) Actual gain of the EUT's antenna is the difference of the measured EIRP and measured RF power at the RF port. Correct the antenna gain if necessary.

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Figure 2

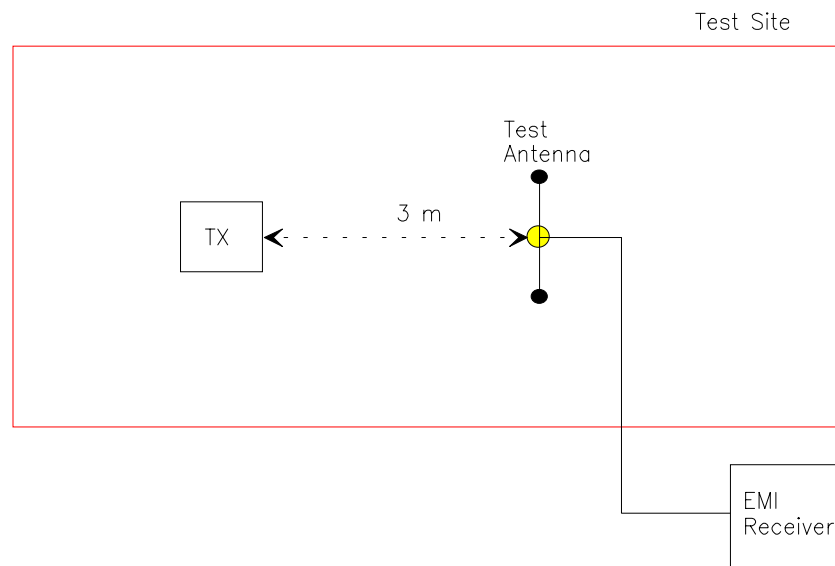
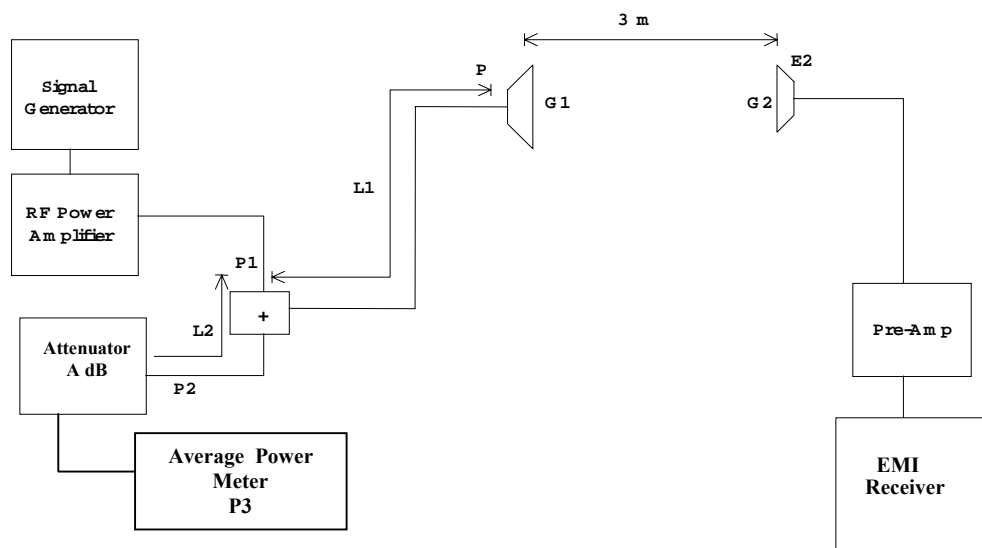


Figure 3



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8.3. FREQUENCY STABILITY

Refer to FCC @ 2.1055.

- (a) The frequency stability shall be measured with variation of ambient temperature as follows: From -30 to +50 centigrade except that specified in subparagraph (2) & (3) of this paragraph.
- (b) Frequency measurements shall be made at extremes of the specified temperature range and at intervals of not more than 10 centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short-term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stability circuitry need be subjected to the temperature variation test.
- (d) The frequency stability supply shall be measured with variation of primary supply voltage as follows:
 - (1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.
 - (2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.
 - (3) The supply voltage shall be measured at the input to the cable normally provide with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.
- (e) When deemed necessary, the Commission may require tests of frequency stability under conditions in addition to those specifically set out in paragraphs (a), (b), (c) and (d) of this section. (For example, measurements showing the effect of proximity to large metal objects, or of various types of antennas, may be required for portable equipment).

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8.4. EMISSION MASK

Voice or Digital Modulation Through a Voice Input Port @ 2.1049(c)(i): - The transmitter was modulated by a 2.5 KHz tone signal at an input level 16 dB greater than that required to produce 50% modulation (e.g.: ± 2.5 KHz peak deviation at 1 KHz modulating frequency). The input level was established at the frequency of maximum response of the audio modulating circuit.

Digital Modulation Through a Data Input Port @ 2.1049(h): - Transmitters employing digital modulation techniques - when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the Emission Masks shall be shown for operation with any devices used for modifying the spectrum when such devices are operational at the discretion of the user.

The following EMI Receiver bandwidth shall be used for measurement of Emission Mask/Out-of-Band Emission Measurements:

- (1) For 25 kHz Channel Spacing: RBW = 300 Hz
- (2) For 12.5 kHz or 6.25 kHz Channel Spacings: RBW = 100 Hz

The all cases the Video Bandwidth shall be equal or greater than the measuring bandwidth.

8.5. SPURIOUS EMISSIONS (CONDUCTED)

With transmitter modulation characteristics described in Out-of-Band Emissions measurements @ 2.1049, the transmitter spurious and harmonic emissions were scanned. The spurious and harmonic emissions were measured with the EMI Receiver controls set as RBW = 30 kHz minimum, VBW \geq RBW and SWEEP TIME = AUTO). The transmitter was operated at a full rated power output, and modulated as follows:

FCC CFR 47, Para. 2.1057 - Frequency spectrum to be investigated:- The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10th 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. 2.1051 - Spurious Emissions at Antenna Terminal:- The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of the harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

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8.6. TRANSIENT FREQUENCY BEHAVIOR

1. Connect the transmitter under tests as shown in the above block diagram
2. Set the signal generator to the assigned frequency and modulate with a 1 kHz tone at ± 12.5 kHz deviation and its output level to be 50 dB below the transmitter rf output at the test receiver end.
3. Set the horizontal sweep rate on the storage scope to 10 milliseconds per division and adjust the display to continuously view the 1000 Hz tone from the Demodulator Output Port (DOP) of the Test Receiver. Adjust the vertical scale amplitude control of the scope to display the 1000 Hz at ± 4 divisions vertical Center at the display.
4. Adjust the scope so it will trigger on an increasing magnitude from the RF trigger signal of the transmitter under test when the transmitter was turned on. Set the controls to store the display.
5. The output at the DOP, due to the change in the ratio of the power between the signal generator input power and transmitter output power will, because of the capture effect of the test receiver, produce a change in display: For the first part of the sweep it will show the 1 kHz test signal. Then once the receiver's demodulator has been captured by the transmitter power, the display will show the frequency difference from the assigned frequency to the actual transmitter frequency versus time. The instant when the 1 kHz test signal is completely suppressed (including any capture time due to phasing) is considered to be t_{on} . The trace should be maintained within the allowed divisions during the period t_1 and t_2 .
6. During the time from the end of t_2 to the beginning of t_3 the frequency difference should not exceed the limits set by the FCC in Part 90.214 and the outlined in the Carrier Frequency Stability sections. The allowed limit is equal to FCC frequency tolerance limits specified in FCC 90.213.
7. Repeat the above steps when the transmitter was turned off for measuring t_3 .

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