ENGINEERING TEST REPORT

Dual Channel RF/ID Reader
Model No.: WN900RFID-A
FCC ID: MTHWN900RFID-A

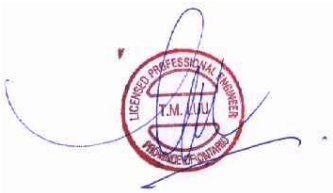
Applicant:

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

Tested in Accordance With

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

UltraTech's File No.: WTI-020F90

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: November 11, 2002	
Report Prepared by: Dan Huynh Issued Date: November 11, 2002	Tested by: Mr. Hung Trinh, EMI/RFI Technician Test Dates: October 2-3, 6-7, 2002

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
- *This report must not be used by the client to claim product endorsement by NVLAP or any agency of the US Government.*

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TABLE OF CONTENTS

EXHIBIT 1. SUBMITTAL CHECK LIST

Annex No.	Exhibit Type	Description of Contents	Quality Check (OK)
--	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
1	Test Report – Test Data Plots	▪ Occupied Bandwidth, Plots # 1 to 6 ▪ Emission Mask K - Non-Multilateration Transmitter, Plots # 7 to 9 ▪ Spurious Emissions at Antenna Terminals, Plots # 10 to 15.	OK
2	Test Setup Photos	Radiated Emission Test Setup Photos	OK
3	External Photos of EUT	External EUT Photos	OK
4	Internal Photos of EUT	Internal EUT Photos	OK
5	Cover Letters	▪ 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	ID Label Location of ID Label	OK
8	Block Diagrams	Dual Channel RF/ID Reader Block Diagram	OK
9	Schematic Diagrams	▪ Model 1200 Dual Channel Reader R.F. Exciter ▪ Model 1200 Dual Channel Reader PIC Controller ▪ Model 1200 Dual Channel Reader R.F. Detector	OK
10	Parts List/Tune Up Info	Dual Channel RF/Id Reader Bill Of Materials	OK
11	Operational Description	Dual Channel RF/ID Reader Technical/Circuit Description	OK
12	RF Exposure Info	See section 6.6 of this Test Report for MPE Evaluation.	OK
13	Users Manual	1200 Network AEI Reader / 1200 Remote Reader Product Guide - Preliminary	OK

EXHIBIT 2. INTRODUCTION

2.1. SCOPE

Reference:	FCC Parts 2 and 90
Title:	Telecommunication – 47 Code of Federal Regulations (CFR), Parts 2 & 90
Purpose of Test:	To gain FCC Certification Authorization for Radio operating in the frequency bands 902-904 MHz and 909.75-921.75 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.

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

None

2.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2001	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	1999	Specification for Radio Disturbance and Immunity measuring apparatus and methods

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:	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

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:	Dual Channel RF/ID Reader
Model Name or Number:	WN900RFID-A
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:	Read RF identification transponder tag on railroad car.

3.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	[ ] Portable [x] Mobile [x] Base station (fixed use)
Intended Operating Environment:	[x] Commercial [x] Light Industry & Heavy Industry
Power Supply Requirement:	15 Vdc
RF Output Power Rating:	1 Watt
Operating Frequency Range:	902-904 MHz, 909.75-921.75 MHz
RF Output Impedance:	50 Ohms
Channel Spacing:	N/A
Occupied Bandwidth (99%):	3.07 kHz
Emission Designation*:	3K07N0N
Oscillator Frequencies:	16 MHz and 20 MHz
Antenna Connector Type:	SMA

* The Necessary Bandwidth is measured using 99% occupied bandwidth method.

3.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	RF	1	SMA	Shielded
2	COM Interface	1	RS232	Shielded

NOTES:

(1) ***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.*

(2) ***Ports, which are not connected to cables during normal intended operation*** *(for factory/technical services uses only): None.*

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:	Network AEI Reader/Remote Reader
Brand name:	WaveNet International Inc.
Model Name or Number:	TRA / TRC

Ancillary Equipment # 2	
Description:	Laptop
Brand name:	Toshiba
Model Name or Number:	PA1224U
Serial Number:	08616386

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:	15 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:	Test software provided by the manufacturer was used to configure the EUT for testing purposes.
Special Hardware Used:	Network AEI reader/remote reader
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):	902-904 MHz, 909.75-921.75 MHz	
Test Frequencies:	Near lowest, near middle & near highest frequencies in each frequency band(s) that the transmitter covers: Lowest: 903 MHz Middle: 915 MHz Highest: 921 MHz	
Transmitter Wanted Output Test Signals:		
▪ RF Power Output (measured maximum output power):		29.70 dBm, 0.933 Watts
▪ Normal Test Modulation:		None
▪ Modulating Signal Source:		Internal

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 sites have been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Section 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: August 10, 2002.

5.2. APPLICABILITY & SUMMARY OF EMISSION TEST RESULTS

FCC Section(s)	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	N/A
90.210 & 2.1047(b)	Modulation Limiting	N/A
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
Dual Channel RF/ID Reader, **Model No.: WN900RFID-A**, 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 upon FCC request.		

5.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

The following modifications was made for compliance:

1. Added 1pf capacitors at output of U5, location L11, input of LC1, output of LC1, across J1
2. Added 4.7pf capacitor at input of U3
3. All the gaps between top cover and base was shielded with copper tape.
4. SMA antenna connector shall be grounded to the enclosure.

5.4. DEVIATION OF STANDARD TEST PROCEDURES

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

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

Refer to FCC 47 CFR, Part 90, Subpart I, Section 90.205 for specification details.

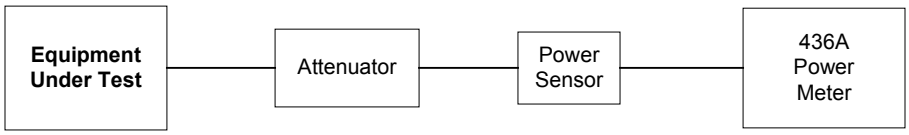
6.5.2. Method of Measurements

Refer to Exhibit 8, section 8.1 of this report for measurement details

6.5.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Attenuator	Weinschel Corp	24-10-34	BJ0039	DC – 8.5 GHz
Power Meter	Hewlett Packard	436A	1725A02249	10 kHz – 50 GHz, sensor dependent
Power Sensor	Hewlett Packard	8481A	2702A68983	10 MHz – 18 GHz

6.5.4. Test Arrangement



6.5.5. Test Data

Transmitter Channel Output	Fundamental Frequency (MHz)	Measured (Average) Power (dBm)	Power Rating (dBm)
Lowest	903	29.70	30.00
Middle	915	29.10	30.00
Highest	921	28.80	30.00

6.6. RF EXPOSURE REQUIRMENTS @ 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.

Calculation Method of RF Safety Distance:

$S = PG/4\Pi r^2 = EIRP/4\Pi r^2 \Rightarrow r = (PG/4\Pi S)^{1/2} = (EIRP/4\Pi S)^{1/2}$

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 center of radiation in cm

Evaluation of RF Exposure Compliance Requirements	
RF Exposure Requirements	**Compliance with FCC Rules**
Minimum calculated separation distance between antenna and persons required: **33.2 cm**	Manufacturer' instruction for separation distance between antenna and persons required: **50 cm**. Please refer to Users Manual and FCC RF Exposure folder for details.
Antenna installation and device operating instructions for installers (professional/unskilled users), and the parties responsible for ensuring compliance with the RF exposure requirement	Please refer to User Manual for details.
Caution statements and/or warning labels that are necessary in order to comply with the exposure limits	Please refer to User Manual and FCC RF Exposure folder for RF Exposure Information.
Any other RF exposure related issues that may affect MPE compliance	None.

Note 1: RF Exposure Distance Limits: $r = (PG/4\Pi S)^{1/2} = (EIRP/4\Pi S)^{1/2}$

P = 29.70 dBm = 933.25 mW (maximum RF power measured at antenna terminal)
G = 9.5 dBi = $10^{9.5/10}$ numeric (maximum antenna gain specified by the manufacturer)
EIRP = 39.2 dBm = $10^{39.5/10}$ mW
S = 903/1500 mW/cm^2 (Limits for General Population/Uncontrolled Exposure)

$r = (EIRP/4\Pi S)^{1/2} (10^{39.5/10}$ mW) / 4Π(903/1500 mW/cm^2) = 33.2 cm

6.7. FREQUENCY STABILITY @ FCC 2.1055 & 90.213

6.7.1. Limits @ FCC 90.213

Refer to FCC 47 CFR, Part 90, Subpart I, Section 90.213 for specification details.

Frequency Range (MHz)	Fixed and Base Stations (ppm)	Mobile Stations (ppm)	
		Over 2 watts output power	2 watts or less output power
902-928*	2.5	2.5	2.5

* Fixed non-multilateration transmitters with an authorized bandwidth that is more than 40 kHz from the band edge, intermittently operated hand-held readers, and mobile transponders are not subject to frequency tolerance restrictions.

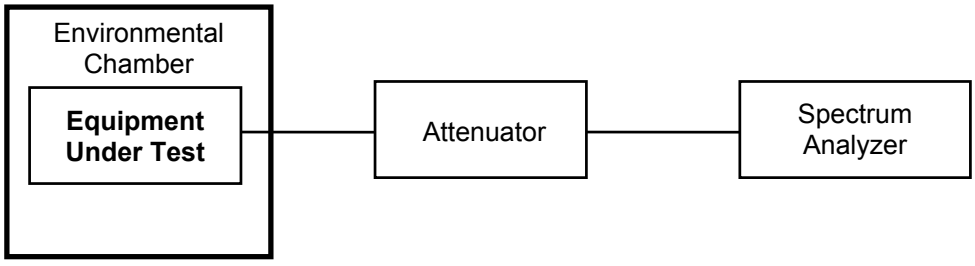
6.7.2. Method of Measurements

Refer to Exhibit 8, section 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	Hewlett Packard	HP 8593EM	3412A00103	9 kHz – 26.5 GHz
Attenuator	Weinschel Corp	24-10-34	BJ0039	DC – 8.5 GHz
Temperature & Humidity Chamber	Tenney	T5	9723B	-40° to +60° C range

6.7.4. Test Arrangement



6.7.5. Test Data

Product Name: **Model No.:**	**Dual Channel RF/ID Reader** **WN900RFID-A**
Center Frequency:	903 MHz
Full Power Level:	1 Watt
Frequency Tolerance Limit:	This device a fixed non-multilateration transmitters with an authorized bandwidth that is more than 40 kHz from the band edge, not subject to frequency tolerance restrictions. However, test shall be performed to demonstrate that emission bandwidth lie within the authorized bandwidth.
Max. Frequency Tolerance Measured:	+8800 Hz
Input Voltage Rating:	15 Vdc

CENTER FREQUENCY & RF POWER OUTPUT VARIATION			
Ambient Temperature (^{o}C)	**Supply Voltage (Nominal) 15 Volts**	**Supply Voltage (85% of Nominal) 12.75 Volts**	**Supply Voltage (115% of Nominal) 17.25 Volts**
	Hz	**Hz**	**Hz**
-30	-2600	N/A	N/A
-20	+6400	N/A	N/A
-10	+8800	N/A	N/A
0	+6800	N/A	N/A
+10	+2900	N/A	N/A
+20	+120	+264	+564
+30	-1300	N/A	N/A
+40	-4200	N/A	N/A
+50	-6400	N/A	N/A

6.8. EMISSION MASK @ FCC 2.1049, 90.208 & 90.210

6.8.1. 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 Max. Frequency Deviation (kHz)	FCC Applicable Mask @ FCC 90.210
902-928	Note 1	..	..	Mask K (Voice & Data)

Note 1: The maximum authorized bandwidth shall be 12 MHz for non-multilateration LMS operations in the band 909.75–921.75 MHz and 2 MHz in the band 902.00–904.00 MHz. The maximum authorized bandwidth for multilateration LMS operations shall be 5.75 MHz in the 904.00–909.75 MHz band; 2 MHz in the 919.75–921.75 MHz band; 5.75 MHz in the 921.75–927.25 MHz band and its associated 927.25–927.50 MHz narrowband forward link; and 8.00 MHz if the 919.75–921.75 MHz and 921.75–927.25 MHz bands and their associated 927.25–927.50 MHz and 927.50–927.75 MHz narrowband forward links are aggregated.

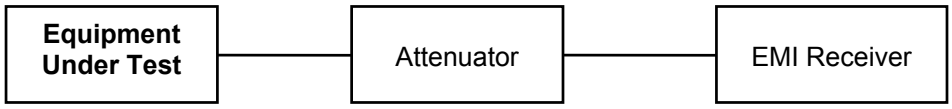
6.8.2. Method of Measurements

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

6.8.3. 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
Attenuator	Weinschel Corp	24-10-34	BJ0039	DC – 8.5 GHz

6.8.4. Test Arrangement



6.8.5. Test Data

6.8.5.1. Occupied Bandwidth

Frequency (MHz)	Measured OBW (kHz)
99% Occupied Bandwidth	
903	2.97
915	3.06
921	3.07
20 dB Occupied Bandwidth	
903	3.40
915	3.49
921	3.54

Refer to Annex 1 Test Data Plots # 1 - 6 for measurement details.

6.8.5.2. Emission Masks

Conform. Refer to Annex 1 Test Data Plots # 7 - 9 for measurement details.

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

6.9.1. Limits @ 90.210

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

FCC Rules	Frequency Range	Attenuation Limit (dBc)
FCC 90.210 (k)	▪ On any frequency within the authorized bandwidth	Zero dB
	▪ On any frequency outside the licensee's sub-band edges	55 + 10 log(P) dB, where (P) is the highest emission watts

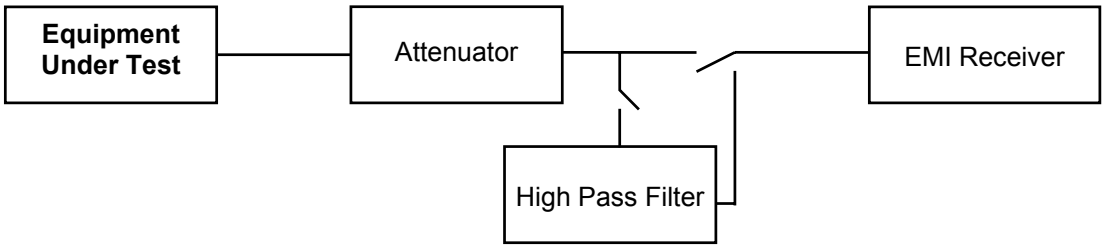
6.9.2. Method of Measurements

Refer to Exhibit 8, section 8.5 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	Hewlett Packard	HP 8593EM	3412A00103	9 kHz – 26.5 GHz
Attenuator	Weinschel Corp	24-10-34	BJ0039	DC – 8.5 GHz
Highpass Filter	K & L Microwave Incorporated	11SH10-1500/T8000	2	1500 – 8000 MHz,

6.9.4. Test Arrangement



6.9.5. Test Data

6.9.5.1. Near Lowest Frequency (903 MHz)

Fundamental Frequency: 903 MHz
RF Output Power: 29.70 dBm, 0.933 Watt
Modulation: None
Attenuation Limit: -55 + 10 log(0.933) = -54.70 dBc

Frequency (MHz)	Transmitter Antenna Conducted Emissions		Limit (dBc)	Margin (dB)	Pass/ Fail
	(dBm)	(dBc)			
1810	-29.75	-59.45	-54.70	-4.75	Pass
2710	-33.94	-63.64	-54.70	-8.94	Pass
3610	-27.72	-57.42	-54.70	-2.72	Pass
4510	-36.81	-66.51	-54.70	-11.81	Pass
5410	-34.41	-64.11	-54.70	-9.41	Pass
The emissions were scanned from 10 MHz to 10 GHz and all emissions within 20 dB below the limits were recorded. Refer to plots # 10 - 11 in Annex 1 for measurement details					

6.9.5.2. Near Middle Frequency (915 MHz)

Fundamental Frequency: 915 MHz
RF Output Power: 29.10 dBm, 0.813 Watt,
Modulation: None
Attenuation Limit: -55 + 10 log(0.813) = -54.10 dBc

Frequency (MHz)	Transmitter Antenna Conducted Emissions		Limit (dBc)	Margin (dB)	Pass/ Fail
	(dBm)	(dBc)			
1823	-28.84	-57.94	-54.10	-3.84	Pass
2736	-38.63	-67.73	-54.10	-13.63	Pass
3661	-27.63	-56.73	-54.10	-2.63	Pass
4561	-38.66	-67.76	-54.10	-13.66	Pass
5487	-41.03	-70.13	-54.10	-16.03	Pass
The emissions were scanned from 10 MHz to 10 GHz and all emissions within 20 dB below the limits were recorded. Refer to plots # 12 - 13 in Annex 1 for measurement details					

6.9.5.3. Near Highest Frequency (921 MHz)

Fundamental Frequency: 921 MHz
RF Output Power: 28.80 dBm, 0.759 Watt
Modulation: None
Attenuation Limit: -55 + 10 log(0.759) = -53.80 dBc

Frequency (MHz)	Transmitter Antenna Conducted Emissions		Limit (dBc)	Margin (dB)	Pass/ Fail
	(dBm)	(dBc)			
1836	-28.78	-57.58	-53.80	-3.78	Pass
2761	-42.22	-71.02	-53.80	-17.22	Pass
3687	-28.19	-56.99	-53.80	-3.19	Pass
4600	-39.88	-68.68	-53.80	-14.88	Pass
The emissions were scanned from 10 MHz to 10 GHz and all emissions within 20 dB below the limits were recorded. Refer to plots # 14 - 15 in Annex 1 for measurement details					

6.10. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS @ FCC 90.210

6.10.1. Limits @ FCC 90.210

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

FCC Rules	Frequency Range	Attenuation Limit (dBc)
FCC 90.210 (k)	▪ On any frequency within the authorized bandwidth ▪ On any frequency outside the licensee's sub-band edges	Zero dB 55 + 10 log(P) dB, where (P) is the highest emission watts

6.10.2. 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 = Pc + G - 2.15 dB = xxx dBm (conducted) + 0 dBi – 2.15 dB

(3) Spurious /harmonic emissions levels expressed in dBc (dB below carrier) are as follows:

ERP of spurious/harmonic (dBc) = ERP of carrier (dBm) – ERP of spurious/harmonic emission (dBm)

6.10.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer/ EMI Receiver	Hewlett Packard	HP 8546A	…	9 kHz to 5.6 GHz with built-in 30 dB Gain Pre-selector, QP, Average & Peak Detectors.
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

6.10.4. Test Data

6.10.4.1. Near Lowest Frequency (903 MHz)

Fundamental Frequency:	903 MHz
RF Output Power:	27.55 dBm (ERP)
Modulation:	None
Attenuation Limit:	-55 + 10 log(0.569) = -52.55 dBc

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method		Limit (dBc)	Margin (dB)
				(dBm)	(dBc)		
1806	77.41	Peak	V	-30.35	-57.90	-52.55	-5.35
1806	66.03	Peak	H	-37.15	-64.70	-52.55	-12.15
2709	74.84	Peak	V	-31.45	-59.00	-52.55	-6.45
2709	73.78	Peak	H	-28.75	-56.30	-52.55	-3.75
3612	75.69	Peak	V	-28.85	-56.40	-52.55	-3.85
3612	64.50	Peak	H	-38.65	-66.20	-52.55	-13.65
4515	71.63	Peak	V	-32.05	-59.60	-52.55	-7.05
4515	62.13	Peak	H	-41.15	-68.70	-52.55	-16.15
5418	72.91	Peak	V	-30.45	-58.00	-52.55	-5.45
5418	64.03	Peak	H	-37.95	-65.50	-52.55	-12.95
6321	70.16	Peak	V	-32.45	-60.00	-52.55	-7.45
6321	61.97	Peak	H	-39.55	-67.10	-52.55	-14.55
The emissions were scanned from 10 MHz to 10 GHz and all emissions within 20 dB below the limits were recorded.							

6.10.4.2. Near Middle Frequency (915 MHz)

Fundamental Frequency:	915 MHz
RF Output Power:	26.95dBm (ERP)
Modulation:	None
Attenuation Limit:	-55 + 10 log(0.495) = -51.95 dBc

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method		Limit (dBc)	Margin (dB)
				(dBm)	(dBc)		
1830	73.34	Peak	V	-29.65	-56.60	-51.95	-4.65
1830	68.16	Peak	H	-35.65	-62.60	-51.95	-10.65
2745	73.78	Peak	V	-29.25	-56.20	-51.95	-4.25
2745	67.78	Peak	H	-35.65	-62.60	-51.95	-10.65
3660	72.50	Peak	V	-30.75	-57.70	-51.95	-5.75
3660	65.22	Peak	H	-38.45	-65.40	-51.95	-13.45
4575	63.81	Peak	V	-39.95	-66.90	-51.95	-14.95
4575	59.88	Peak	H	-43.85	-70.80	-51.95	-18.85
5490	71.47	Peak	V	-31.75	-58.70	-51.95	-6.75
5490	65.06	Peak	H	-36.65	-63.60	-51.95	-11.65
9150	60.00	Peak	V	-44.65	-71.60	-51.95	-19.65
The emissions were scanned from 10 MHz to 10 GHz and all emissions within 20 dB below the limits were recorded.							

6.10.4.3. Near Highest Frequency (921 MHz)

Fundamental Frequency:	921 MHz
RF Output Power:	26.65 dBm (ERP)
Modulation:	None
Attenuation Limit:	-55 + 10 log(0.462) = -51.65 dBc

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method (dBm)	ERP measured by Substitution Method (dBc)	Limit (dBc)	Margin (dB)
1842	76.34	Peak	V	-26.15	-52.80	-51.65	-1.15
1842	69.79	Peak	H	-33.35	-60.00	-51.65	-8.35
2763	74.06	Peak	V	-29.35	-56.00	-51.65	-4.35
2763	70.84	Peak	H	-33.05	-59.70	-51.65	-8.05
3684	71.25	Peak	V	-31.25	-57.90	-51.65	-6.25
3684	64.88	Peak	H	-38.15	-64.80	-51.65	-13.15
4605	65.91	Peak	V	-38.45	-65.10	-51.65	-13.45
4605	59.03	Peak	H	-43.45	-70.10	-51.65	-18.45
5526	71.66	Peak	V	-31.85	-58.50	-51.65	-6.85
5526	61.84	Peak	H	-40.55	-67.20	-51.65	-15.55
6447	60.81	Peak	V	-43.05	-69.70	-51.65	-18.05

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

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 (± 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 Γ_1 = 0.2 Antenna VRC Γ_R = 0.67(Bi) 0.3 (Lp) Uncertainty limits 20Log(1±$\Gamma_1\Gamma_R$)	U-Shaped	+1.1 -1.25	±0.5
System repeatability	Std. Deviation	±0.5	±0.5
Repeatability of EUT		-	-
Combined standard uncertainty	Normal	+2.19 / -2.21	+1.74 / -1.72
Expanded uncertainty U	Normal (k=2)	+4.38 / -4.42	+3.48 / -3.44

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

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

EXHIBIT 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).
- 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 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 = 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.

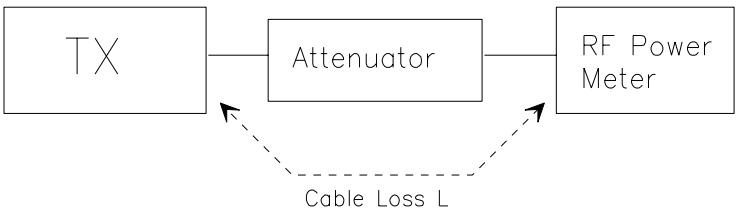
Step 2: Calculation of Average EIRP. See Figure 1

- 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:

EIRP = A + G + 10log(1/x)

{ X = 1 for continuous transmission => 10log(1/x) = 0 dB }

Figure 1.



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 (dBuV/m) = Reading (dBuV) + 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^{o} 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

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 (dBuV/m) = Reading (dBuV) + 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
EIRP = P + G1 = P3 + L2 - L1 + A + G1
ERP = EIRP – 2.15 dB
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.:

Figure 2

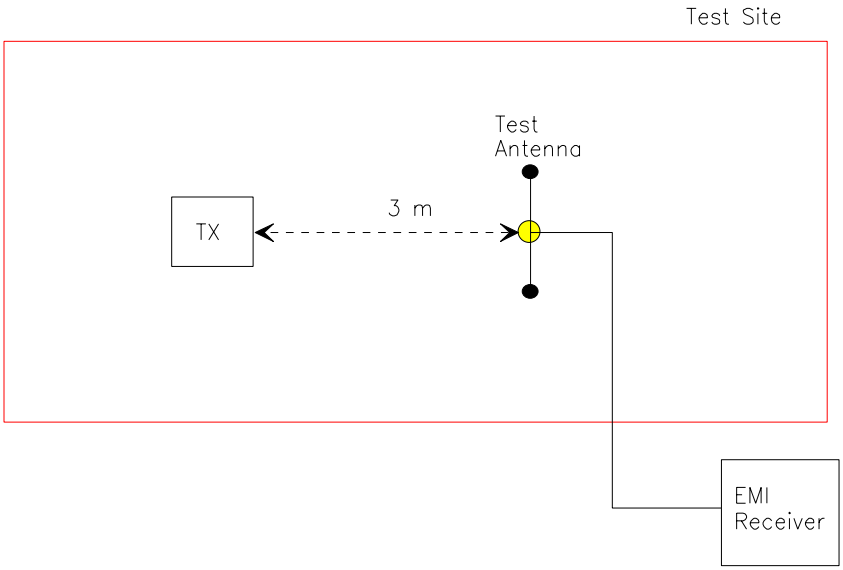
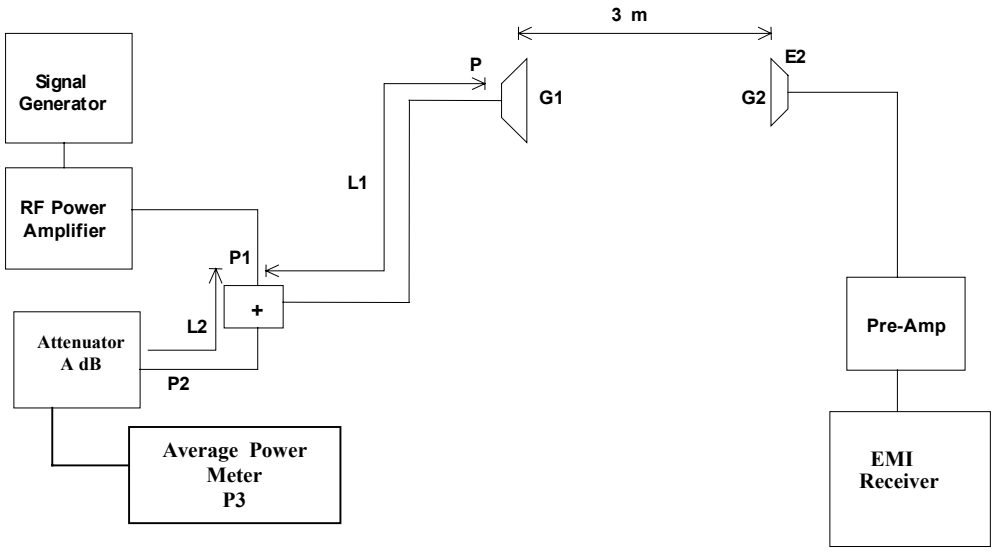


Figure 3



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).

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 ≥ RBW and SWEEP TIME = AUTO). The transmitter was operated at a full rated power output, and modulated as follows:

FCC 47 CFR, Section 2.1057 - Frequency spectrum to be investigated:- The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10^{th} harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The
amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

FCC 47 CFR, Section 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.