# ENGINEERING TEST REPORT

## Digital VHF/FM Transceiver
## Model No.: TDFM-136
## FCC ID: IMATDFM-136

*Applicant:* **Technisonic Industries Ltd.**
*250 Watline Avenue*
*Mississauga, Ontario*
*Canada, L4Z 1P4*

***Tested in Accordance With***

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

**UltraTech's File No.: TIL16-FTX**

| | |
|---|---|
| This Test report is Issued under the Authority of<br>Tri M. Luu, Professional Engineer,<br>Vice President of Engineering<br>UltraTech Group of Labs ……<br><br>Date: …… | |
| Report Prepared by: Dan Huynh<br><br>…… | Tested by: Mr. Hung Trinh, RFI/EMI Technician<br><br>…… |
| Issued Date: December 21, 1999 | Test Dates: Oct. 29 – Nov. 26, 1999 |

*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. INTRODUCTION

## 1.1. SCOPE

| | |
|---|---|
| **Reference:** | FCC Parts 2 and 90 (Subpart 90): 1998 |
| **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 bands 138 - 174 MHz (12.5 kHz and 25 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. |

## 1.2. RELATED SUBMITAL(S)/GRANT(S)

None

## 1.3. NORMATIVE REFERENCES

***Note**: When the international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.*

| Publication | YEAR | Title |
|---|---|---|
| FCC CFR Parts 0-19, 80-End | 1998 | Code of Federal Regulations – Telecommunication |
| ANSI C63.4 | 1992 | American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz |
| CISPR 22 & EN 55022 | 1997 1998 | Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment |
| CISPR 16-1 | | Specification for Radio Disturbance and Immunity measuring apparatus and methods |

# EXHIBIT 2. PERFORMANCE ASSESSMENT

## 2.1. CLIENT INFORMATION

| **APPLICANT**: | |
|---|---|
| **Name:** | Technisonic Industries Ltd. |
| **Address:** | 250 Watline Avenue<br>Mississauga, Ontario<br>Canada, L4Z 1P4 |
| **Contact Person:** | Mr. Thomas Cale<br>Phone #: 905-890-2113<br>Fax #: 905-890-5338<br>Email Address: N/A |

| **MANUFACTURER:** | |
|---|---|
| **Name:** | Technisonic Industries Ltd. |
| **Address:** | 250 Watline Avenue<br>Mississauga, Ontario<br>Canada, L4Z 1P4 |
| **Contact Person:** | Mr. Thomas Cale<br>Phone #: 905-890-2113<br>Fax #: 905-890-5338<br>Email Address: N/A |

## 2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

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

| | |
|---|---|
| **Brand Name** | Technisonic Industries Ltd. |
| **Product Name** | Digital VHF/FM Transceiver |
| **Model Name or Number** | TDFM-136 |
| **Serial Number** | ENG 01 |
| **Type of Equipment** | Radio Communication Equipment |
| **External Power Supply** | None |
| **Transmitting/Receiving Antenna Type** | Non-integral |
| **Primary User Functions of EUT:** | Transmitter/receiver was turned on continuously for testing. The transmitter's carrier was modulated with modulation signal as mentioned in the test data |

## 2.3. EUT'S TECHNICAL SPECIFICATIONS

| TRANSMITTER | |
|---|---|
| **Equipment Type:** | Portable<br>Mobile<br>Base station (fixed use) |
| **Intended Operating Environment:** | Commercial, light industry & heavy industry |
| **Power Supply Requirement:** | 28 VDC |
| **RF Output Power Rating:** | 8.5 Watts |
| **Operating Frequency Range:** | 138 - 174 MHz |
| **RF Output Impedance:** | 50 Ohms |
| **Channel Spacing:** | 12.5 kHz and 25 kHz |
| ***Occupied Bandwidth (99%):** | 9.94 kHz (12.5 kHz channel spacing)<br>15.14 kHz (25 kHz channel spacing) |
| **Emission Designation*:** | 10K4F3E and 10K8F1D (12.5 kHz channel spacing)<br>14K2F3E and 12K2F1D (25 kHz channel spacing) |
| **Oscillator Frequencies:** | 12.288 MHz, 16 MHz, 12.80 MHz |
| **Antenna Connector Type:** | BNC |

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

1. For FM Voice Modulation:

   Channel Spacing = 12.5 KHz, D = 2.2 KHz max., K = 1, M = 3 KHz
   $B_n$ = 2M + 2DK = 2(3) + 2(2.2)(1) = **10.4 KHz**
   emission designation: 10K4F3E

   Channel Spacing = 25 KHz, D = 4.1 KHz max., K = 1, M = 3 KHz
   $B_n$ = 2M + 2DK = 2(3) + 2(4.1)(1) = **14.2 KHz**
   emission designation: 14K2F3E

2. For FM Digital Modulation:

   Channel Spacing = 12.5 KHz, D = 0.6 KHz max., K = 1, M = Data Rate in kb/s / Level of FM,
   Level of FM = 2, M = 9.6/2 kb/s
   $B_n$ = 2M + 2DK = 2(9.6/2) + 2(0.6)(1) = **10.8 KHz**
   emission designation: 10K8F1D

   For FM Digital Modulation:
   Channel Spacing = 25 KHz, D = 1.3 KHz max., K = 1, M = Data Rate in kb/s / Level of FM,
   Level of FM = 2, M = 9.6/2 kb/s
   $B_n$ = 2M + 2DK = 2(9.6/2) + 2(1.3)(1) = **12.2 KHz**
   emission designation: 12K2F1D

## 2.4. LIST OF EUT'S PORTS

| Port Number | EUT's Port Description | Number of Identical Ports | Connector Type | Cable Type (Shielded/Non-shielded) |
|---|---|---|---|---|
| 1 | RF Connector | 1 | BNC | Shielded |
| 2 | 15 pin Cannon D | 1 | DB 15 | 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 Ohm RF Load.*

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

## 2.5. 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: | Technisonic Test Jig |
| Brand name: | Technisonic |
| Connected to EUT's Port: | 15 pin Cannon D |

# EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

## 3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

| | |
|---|---|
| Temperature: | 21°C |
| Humidity: | 51% |
| Pressure: | 101 kPa |
| Power input source: | 28 VDC |

## 3.2. 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:** | N/A |
| **Special Hardware Used:** | Test Jig supplied by the manufacturer. |
| **Transmitter Test Antenna:** | The EUT is tested with the transmitter antenna port terminated to a 50 Ohm RF Load. |

| **Transmitter Test Signals:** | |
|---|---|
| **Frequencies:**<br><br>▪ 138 - 174 MHz band: | Near lowest, near middle & near highest frequencies each frequency bands that the transmitter covers:<br><br>▪ 138, 150 and 174 MHz |
| **Transmitter Wanted Output Test Signals:**<br><br>▪ RF Power Output (measured maximum output power):<br>▪ Normal Test Modulation | <br><br>▪ 8.5 Watts<br><br>▪ FM modulated with internal random data source at 9600 bps.<br>▪ FM voice modulated with an external analogue signal. |

# EXHIBIT 4. SUMMARY OF TEST RESULTS

## 4.1. LOCATION OF TESTS

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

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

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

## 4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

| FCC PARAGRAPH. | TEST REQUIREMENTS | APPLICABILITY (YES/NO) |
|---|---|---|
| **90.205 & 2.985** | RF Power Output | Yes |
| **90.213 & 2.995** | Frequency Stability | Yes |
| **90.242(b)(8) & 2.987(a)** | Audio Frequency Response | Not applicable to new standard. However, tests are attempted to be done due to FCC's recommendation. |
| **90.210 & 2.987(b)** | Modulation Limiting | Yes |
| **90.209 90.210 & 2.989** | Emission Limitation & Emission Mask | Yes |
| **90.210, 2.997 & 2.991** | Emission Limits - Spurious Emissions at Antenna Terminal | Yes |
| **90.210, 2.997 & 2.993** | Emission Limits - Field Strength of Spurious Emissions | Yes |
| **90.214** | Transient Frequency Behavior | Yes |

**Digital VHF/FM Transceiver**, **Model No.: TDFM-136**, by **Technisonic Industries Ltd.** 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.

## 4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

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

## 5.1. TEST PROCEDURES

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

## 5.2. MEASUREMENT UNCERTAINTIES

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

## 5.3. MEASUREMENT EQUIPMENT USED:

The measurement equipment used complied with the requirements of the Standards referenced in the Methods & Procedures ANSI C63.4:1992 and CISPR 16-1.

## 5.4. ESSENTIAL/PRIMARY FUNCTIONS AS DECLARED BY THE MANUACTURER:

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

# 5.5. RF POWER OUTPUT @ FCC 2.985 & 90.205

## 5.5.1. Limits @ FCC 90.205

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

## 5.5.2. Method of Measurements

FCC @ 2.985 –The rf output power of the transmitter was measured at the RF output terminals when the transmitter is adjusted by the manufacturer in accordance with the tune-up procedure to give the values of the current and voltage on the circuit elements specified in 2.983(d)(5). The electrical characteristics of the radio frequency load attached to the output terminals was 50 Ohms.

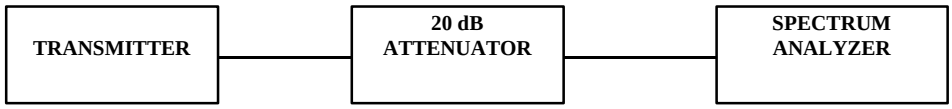
The detailed test method is as follows:

- *The transmitter terminal was coupled to the Spectrum Analyzer through a 20 dB attenuator*
- *Power of the transmitter channel near the lowest, middle and highest of each frequency block/band were measured using the power meter, and the reading was corrected by adding the calibrated attenuator's attenuation value and cable loss.*
- *The RF Output was turned on with standard modulation applied.*

## 5.5.3. 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(s) | Bird | -- | -- | -- |

## 5.5.4. Test Arrangement




## 5.5.5. Test data

| TRANSMITTER CHANNEL OUTPUT | FUNDAMENTAL FREQUENCY (MHz) | MEASURED PEAK POWER (Watts) | PEAK POWER RATING (Watts) |
|---|---|---|---|
| Lowest | 138 | 8.49 | 10 |
| Middle | 150 | 8.20 | 10 |
| Highest | 174 | 7.98 | 10 |

***EIRP Measurements****: -Appropriate antenna type, and adjustment of power output for effective radiated power (ERP) to meet FCC limits will be performed by the manufacturer at location of installation.*

# 5.6. FREQUENCY STABILITY @ FCC 2.995 & 90.213

## 5.6.1. Limits @ FCC 90.213

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

| FREQUENCY RANGE (MHz) | FIXED & BASE STATIONS (ppm) | | | MOBILE STATIONS (ppm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | > 2 W | | | ≤ 2 W | | |
| | 6.25 kHz | 12.5 kHz | 25 kHz | 6.25 kHz | 12.5 kHz | 25 kHz | 6.25 kHz | 12.5 kHz | 25 kHz |
| 150 - 174 MHz | 1.0 | 2.5 | 5.0 | 2.0 | 5.0 | 5.0 | 2.0 | 5.0 | [1][2]50 |

1. Stations operating in the 154.45- 154.49 MHz or the 173.2 to 173.4 MHz bands must have a frequency stability of 5 ppm.
2. In the 150-174 MHz band, mobile stations designed to operate with a 12.5 KHz channel bandwidth or designed to operate on a frequency specifically designated for itinerant use or designed for low power operation of two watts or less, must have a frequency stability of 5.0 ppm. Mobile stations designed to operate with a 6.25KHz channel bandwidth must have a frequency stability of 2.0 ppm

## 5.6.2. Method of Measurements

Refer to FCC @ 2.995

(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.

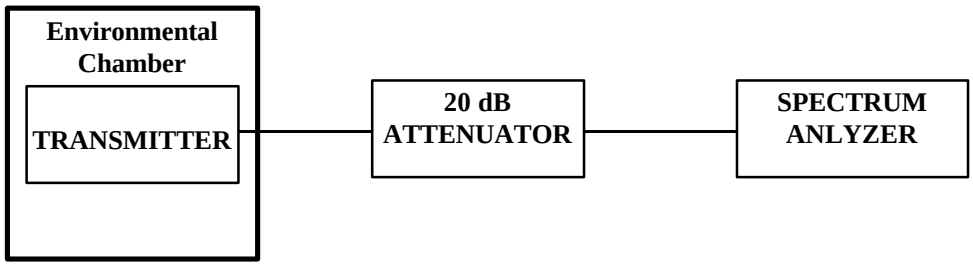
(3) The supply voltage shall be measured at the input to the cable normally provide with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply 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).

### 5.6.3. Test Equipment List

| Test Instruments | Manufacturer | Model No. | Serial No. | Range |
|---|---|---|---|---|
| Spectrum Analyzer/ EMI Receiver | Hewlett Packard | HP 8593EM | 3412A00103 | 9 kHz –26.5 GHz |
| Attenuator(s) | Bird | .. | … | DC –22 GHz |
| Temperature & Humidity Chamber | Tenney | T5 | 9723B | -40$^{o}$ to +60$^{o}$ C range |

### 5.6.4. Test Arrangement




### 5.6.5. Test data

| | |
|---|---|
| **Product Name**<br>**Model No.** | **Digital VHF/FM Transceiver**<br>**TDFM-136** |
| **Center Frequency** | 138 MHz |
| **Full Power Level** | 8.49 Watts |
| **Frequency Tolerance Limit** | 2.5 ppm or 345 Hz at 138 MHz |
| **Max. Frequency Tolerance Measured** | 86 Hz or 0.62 ppm |
| **Input Voltage Rating** | 28 VDC |

| | | CENTER FREQUENCY & RF POWER OUTPUT VARIATION | | | | | |
|---|---|---|---|---|---|---|---|
| **AMBIENT TEMP.** | **KEYED-ON TIME** | **Supply Voltage (Nominal) 28 Volts** | | **Supply Voltage (85% of Nominal) 23.8 Volts** | | **Supply Voltage (115% of Nominal) 32.2 Volts** | |
| **(°C)** | **(Minutes)** | **Hz** | **dB** | **Hz** | **dB** | **Hz** | **dB** |
| **-30** | 0 | -40 | N/A | N/A | N/A | N/A | N/A |
| | 1 | -63 | N/A | N/A | N/A | N/A | N/A |
| | 2 | -47 | N/A | N/A | N/A | N/A | N/A |
| | 3 | -54 | N/A | N/A | N/A | N/A | N/A |
| | 4 | -33 | N/A | N/A | N/A | N/A | N/A |
| | 5 | 19 | N/A | N/A | N/A | N/A | N/A |
| | 6 | 44 | N/A | N/A | N/A | N/A | N/A |
| | 7 | 63 | N/A | N/A | N/A | N/A | N/A |
| | 8 | 54 | N/A | N/A | N/A | N/A | N/A |
| | 9 | 44 | N/A | N/A | N/A | N/A | N/A |
| | 10 | 36 | N/A | N/A | N/A | N/A | N/A |
| **-20** | 0 | 46 | N/A | N/A | N/A | N/A | N/A |
| | 1 | -44 | N/A | N/A | N/A | N/A | N/A |
| | 2 | -26 | N/A | N/A | N/A | N/A | N/A |
| | 3 | -21 | N/A | N/A | N/A | N/A | N/A |
| | 4 | 11 | N/A | N/A | N/A | N/A | N/A |
| | 5 | 4 | N/A | N/A | N/A | N/A | N/A |
| | 6 | -17 | N/A | N/A | N/A | N/A | N/A |
| | 7 | -16 | N/A | N/A | N/A | N/A | N/A |
| | 8 | -26 | N/A | N/A | N/A | N/A | N/A |
| | 9 | -40 | N/A | N/A | N/A | N/A | N/A |
| | 10 | -53 | N/A | N/A | N/A | N/A | N/A |
| **-10** | 0 | 44 | N/A | N/A | N/A | N/A | N/A |
| | 1 | 39 | N/A | N/A | N/A | N/A | N/A |
| | 2 | 47 | N/A | N/A | N/A | N/A | N/A |
| | 3 | 53 | N/A | N/A | N/A | N/A | N/A |
| | 4 | 26 | N/A | N/A | N/A | N/A | N/A |
| | 5 | 39 | N/A | N/A | N/A | N/A | N/A |
| | 6 | 16 | N/A | N/A | N/A | N/A | N/A |
| | 7 | 16 | N/A | N/A | N/A | N/A | N/A |
| | 8 | 0 | N/A | N/A | N/A | N/A | N/A |
| | 9 | -10 | N/A | N/A | N/A | N/A | N/A |
| | 10 | -26 | N/A | N/A | N/A | N/A | N/A |
| **0** | 0 | 33 | N/A | N/A | N/A | N/A | N/A |
| | 1 | 41 | N/A | N/A | N/A | N/A | N/A |
| | 2 | 64 | N/A | N/A | N/A | N/A | N/A |
| | 3 | 57 | N/A | N/A | N/A | N/A | N/A |
| | 4 | 46 | N/A | N/A | N/A | N/A | N/A |
| | 5 | 60 | N/A | N/A | N/A | N/A | N/A |
| | 6 | 33 | N/A | N/A | N/A | N/A | N/A |
| | 7 | -6 | N/A | N/A | N/A | N/A | N/A |
| | 8 | 0 | N/A | N/A | N/A | N/A | N/A |
| | 9 | -7 | N/A | N/A | N/A | N/A | N/A |
| | 10 | -57 | N/A | N/A | N/A | N/A | N/A |

| | | CENTER FREQUENCY & RF POWER OUTPUT VARIATION | | | | | |
|---|---|---|---|---|---|---|---|
| **AMBIENT TEMP. (°C)** | **KEYED-ON TIME (Minutes)** | **Supply Voltage (Nominal) Volts** | | **Supply Voltage (85% of Nominal) Volts** | | **Supply Voltage (115% of Nominal) Volts** | |
| | | **Hz** | **dB** | **Hz** | **dB** | **Hz** | **dB** |
| **+10** | 0 | 39 | N/A | N/A | N/A | N/A | N/A |
| | 1 | 64 | N/A | N/A | N/A | N/A | N/A |
| | 2 | 50 | N/A | N/A | N/A | N/A | N/A |
| | 3 | 51 | N/A | N/A | N/A | N/A | N/A |
| | 4 | 37 | N/A | N/A | N/A | N/A | N/A |
| | 5 | 14 | N/A | N/A | N/A | N/A | N/A |
| | 6 | -9 | N/A | N/A | N/A | N/A | N/A |
| | 7 | -10 | N/A | N/A | N/A | N/A | N/A |
| | 8 | -6 | N/A | N/A | N/A | N/A | N/A |
| | 9 | -13 | N/A | N/A | N/A | N/A | N/A |
| | 10 | -4 | N/A | N/A | N/A | N/A | N/A |
| **+20** | 0 | 37 | 11.09 | 39 | 11 | -10 | 1 |
| | 1 | 0 | 0 | 67 | 23 | 31 | 9 |
| | 2 | -13 | 2.8 | 80 | 20 | 43 | 14 |
| | 3 | -56 | 14 | **86** | 26 | 33 | 10 |
| | 4 | -66 | 26 | 51 | 19 | 6 | 1 |
| | 5 | -71 | 28 | 47 | 17 | -1 | 0 |
| | 6 | -66 | 26 | 31 | 10 | -23 | 7 |
| | 7 | -73 | 28 | 6 | 0 | -47 | 10 |
| | 8 | -77 | 31 | -33 | 12 | -59 | 25 |
| | 9 | -74 | 32 | -44 | 17 | -54 | 21 |
| | 10 | -69 | 27 | -49 | 20 | -64 | 27 |
| **+30** | 0 | 34 | N/A | N/A | N/A | N/A | N/A |
| | 1 | 60 | N/A | N/A | N/A | N/A | N/A |
| | 2 | 73 | N/A | N/A | N/A | N/A | N/A |
| | 3 | 64 | N/A | N/A | N/A | N/A | N/A |
| | 4 | 29 | N/A | N/A | N/A | N/A | N/A |
| | 5 | 24 | N/A | N/A | N/A | N/A | N/A |
| | 6 | 0 | N/A | N/A | N/A | N/A | N/A |
| | 7 | -37 | N/A | N/A | N/A | N/A | N/A |
| | 8 | -44 | N/A | N/A | N/A | N/A | N/A |
| | 9 | -53 | N/A | N/A | N/A | N/A | N/A |
| | 10 | -50 | N/A | N/A | N/A | N/A | N/A |
| **+40** | 0 | 51 | N/A | N/A | N/A | N/A | N/A |
| | 1 | 71 | N/A | N/A | N/A | N/A | N/A |
| | 2 | 74 | N/A | N/A | N/A | N/A | N/A |
| | 3 | 60 | N/A | N/A | N/A | N/A | N/A |
| | 4 | 33 | N/A | N/A | N/A | N/A | N/A |
| | 5 | 6 | N/A | N/A | N/A | N/A | N/A |
| | 6 | -9 | N/A | N/A | N/A | N/A | N/A |
| | 7 | -24 | N/A | N/A | N/A | N/A | N/A |
| | 8 | -27 | N/A | N/A | N/A | N/A | N/A |
| | 9 | -31 | N/A | N/A | N/A | N/A | N/A |
| | 10 | -20 | N/A | N/A | N/A | N/A | N/A |

| | | CENTER FREQUENCY & RF POWER OUTPUT VARIATION | | | | | |
|---|---|---|---|---|---|---|---|
| **AMBIENT TEMP. ($^{o}$C)** | **KEYED-ON TIME (Minutes)** | **Supply Voltage (Nominal) Volts** | | **Supply Voltage (85% of Nominal) Volts** | | **Supply Voltage (115% of Nominal) Volts** | |
| | | **Hz** | **dB** | **Hz** | **dB** | **Hz** | **dB** |
| **+50** | 0 | 20 | N/A | N/A | N/A | N/A | N/A |
| | 1 | 43 | N/A | N/A | N/A | N/A | N/A |
| | 2 | 41 | N/A | N/A | N/A | N/A | N/A |
| | 3 | 27 | N/A | N/A | N/A | N/A | N/A |
| | 4 | 19 | N/A | N/A | N/A | N/A | N/A |
| | 5 | 11 | N/A | N/A | N/A | N/A | N/A |
| | 6 | -11 | N/A | N/A | N/A | N/A | N/A |
| | 7 | -14 | N/A | N/A | N/A | N/A | N/A |
| | 8 | -10 | N/A | N/A | N/A | N/A | N/A |
| | 9 | -3 | N/A | N/A | N/A | N/A | N/A |
| | 10 | 6 | N/A | N/A | N/A | N/A | N/A |
| **+60** | 0 | 36 | N/A | N/A | N/A | N/A | N/A |
| | 1 | 31 | N/A | N/A | N/A | N/A | N/A |
| | 2 | 11 | N/A | N/A | N/A | N/A | N/A |
| | 3 | 0 | N/A | N/A | N/A | N/A | N/A |
| | 4 | -11 | N/A | N/A | N/A | N/A | N/A |
| | 5 | -19 | N/A | N/A | N/A | N/A | N/A |
| | 6 | -9 | N/A | N/A | N/A | N/A | N/A |
| | 7 | -1 | N/A | N/A | N/A | N/A | N/A |
| | 8 | 20 | N/A | N/A | N/A | N/A | N/A |
| | 9 | 29 | N/A | N/A | N/A | N/A | N/A |
| | 10 | **86** | N/A | N/A | N/A | N/A | N/A |

# 5.7. AUDIO FREQUENCY RESPONSE @ FCC 2.987(a) & 90.242(b)(8)

## 5.7.1. Limits @ FCC 2.987(a) and 90.242(b)(8)

No limit is required by FCC for audio frequency response. However, FCC recommends the Audio Frequency Response to be tested to show the roll-off curve at 3 kHz.

Recommended Limits: The attenuation of lowpass filter between the frequencies of 3 KHz and 20 KHz shall be greater than the attenuation at 1KHz by at least: $60\text{Log}_{10}(f/3)$ decibels where "f" is the frequency in KHz. At frequency above 20 KHz, the attenuation shall be 50 dB greater than the attenuation at 1 KHz.

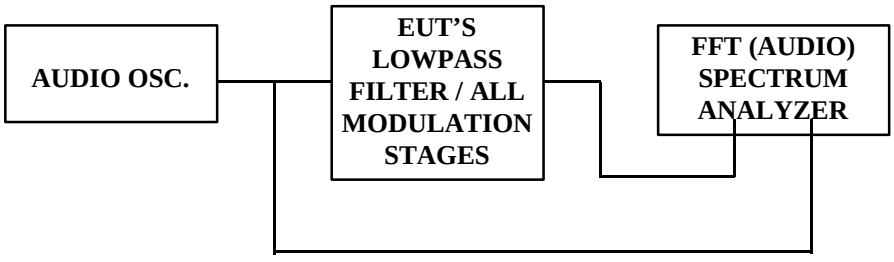
## 5.7.2. Method of Measurements

The rated audio input signal was applied to the input of the audio lowpass filter (or of all modulation stages) using an audio oscillator, this input signal level and its corresponding output signal were then measured and recorded using the FFT (Audio) spectrum analyzer. Tests were repeated at different audio signal frequencies from 0 to 50 kHz.

## 5.7.3. Test Equipment List

| Test Instruments | Manufacturer | Model No. | Serial No. | Frequency Range |
|---|---|---|---|---|
| FFT (audio) Spectrum Analyzer | Advantest | R9211E | … | 10 MHz –100 kHz, 1 MHz Input Impedance |
| Audio Oscillator | Hewlett Packard | HP 204C | 0989A08798 | DC to 1.2 MHz |

## 5.7.4. Test Arrangement

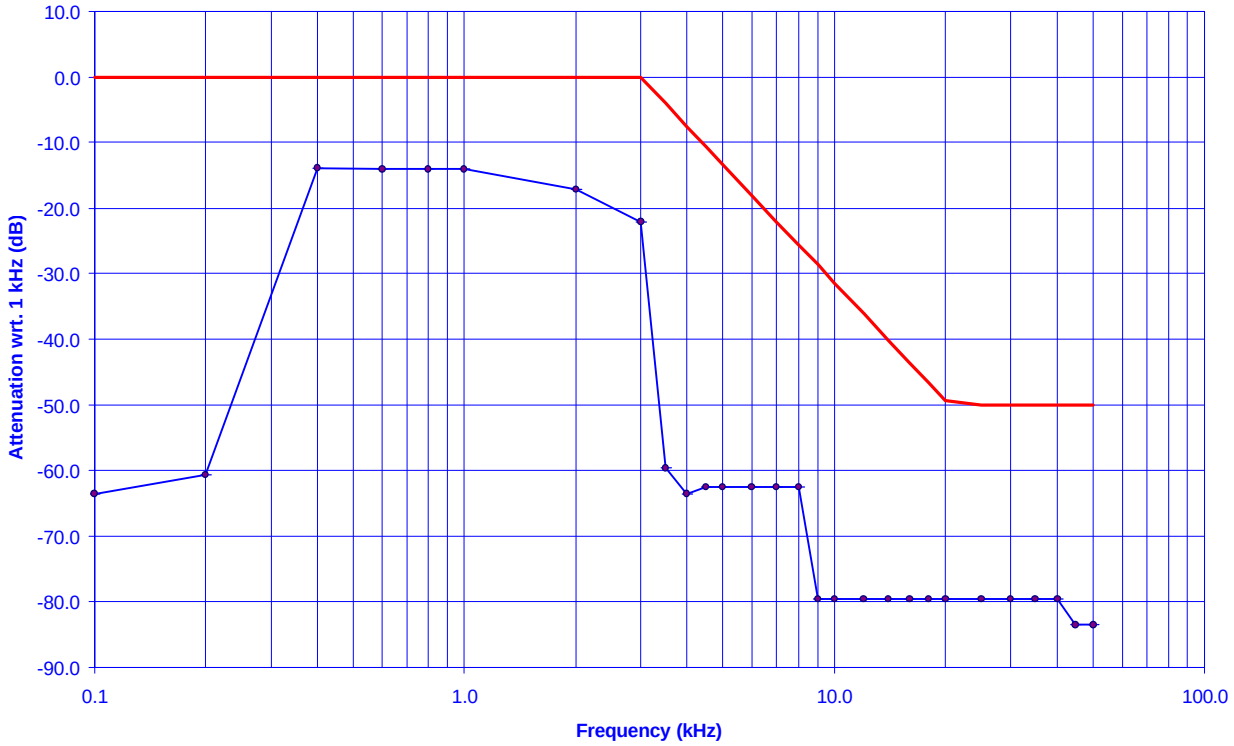


## 5.7.5. Test data

### AUDIO FREQUENCY RESPONSE OF A LOW PASS FILTER / ALL MODULATION STATES

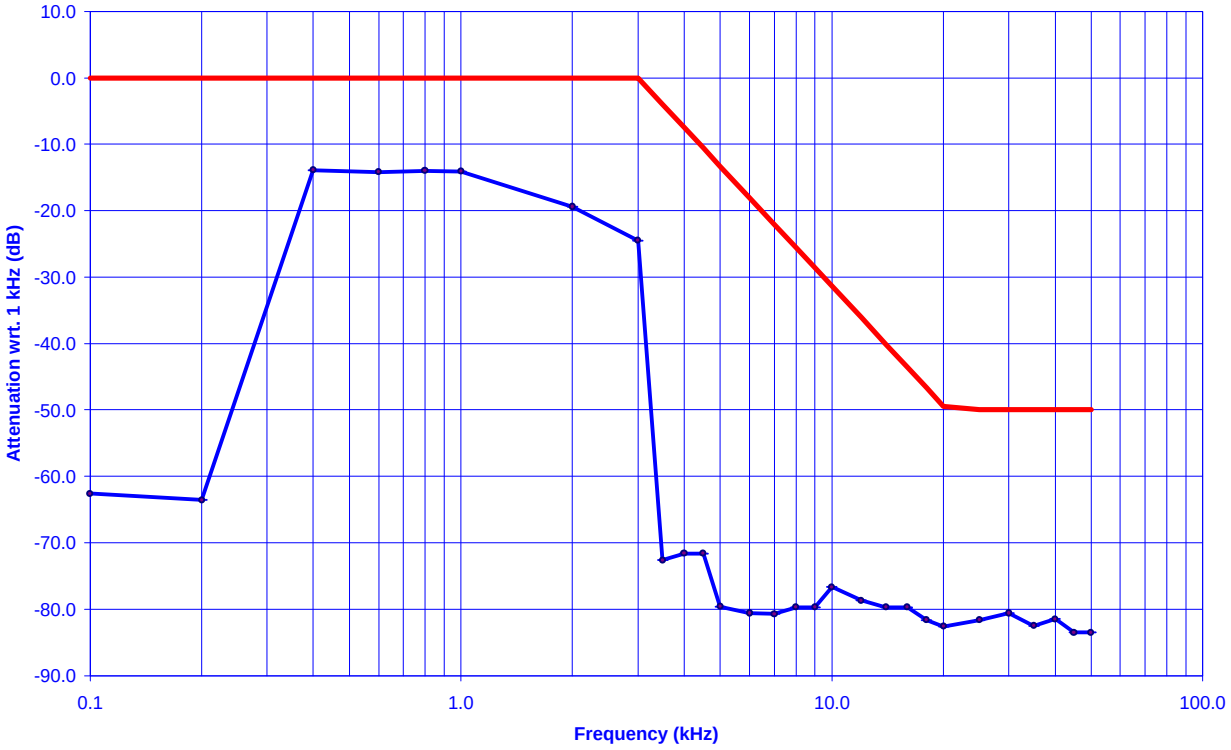
| Test Configuration 1: Transmitter Frequency set at 138 MHz with 12.5 kHz channel spacing | | | | | |
|---|---|---|---|---|---|
| **Frequency (kHz)** | **Input Level Vi (dBV)** | **Output Level Vo (dBV)** | **Attenuation (Vo-Vi) (dB)** | **Attenuation w.r.t. 1kHz (dB)** | **FCC Recommended Limits (dB)** |
| 0.1 | -6.4 | <-69.0 | <-62.6 | <-63.6 | -- |
| 0.2 | -6.4 | <-66.0 | <-59.6 | <-60.6 | -- |
| 0.4 | -6.4 | -19.3 | -12.9 | -13.9 | -- |
| 0.6 | -6.4 | -19.5 | -13.1 | -14.1 | -- |
| 0.8 | -6.4 | -19.5 | -13.1 | -14.1 | -- |
| 1.0 | -6.4 | -19.5 | -13.1 | -14.1 | -- |
| 2.0 | -6.4 | -22.6 | -16.2 | -17.2 | -- |
| 3.0 | -6.4 | -27.5 | -21.1 | -22.1 | 0.0 |
| 3.5 | -6.4 | <-65.0 | <-58.6 | <-59.6 | -4.0 |
| 4.0 | -6.4 | <-69.0 | <-62.6 | <-63.6 | -7.5 |
| 4.5 | -6.4 | <-68.0 | <-61.6 | <-62.6 | -10.6 |
| 5.0 | -6.4 | <-68.0 | <-61.6 | <-62.6 | -13.3 |
| 6.0 | -6.4 | <-68.0 | <-61.6 | <-62.6 | -18.1 |
| 7.0 | -6.4 | <-68.0 | <-61.6 | <-62.6 | -22.1 |
| 8.0 | -6.4 | <-68.0 | <-61.6 | <-62.6 | -25.6 |
| 9.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -28.6 |
| 10.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -31.4 |
| 12.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -36.1 |
| 14.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -40.1 |
| 16.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -43.6 |
| 18.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -46.7 |
| 20.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -49.4 |
| 25.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -50.0 |
| 30.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -50.0 |
| 35.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -50.0 |
| 40.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -50.0 |
| 45.0 | -6.4 | <-89.0 | <-82.6 | <-83.6 | -50.0 |
| 50.0 | -6.4 | <-89.0 | <-82.6 | <-83.6 | -50.0 |

**AUDIO FREQUENCY REPSONSE @ FCC 2.987(a) & 90.242 (12.5 kHz Channel Spacing)**



| Test Configuration 2: Transmitter Frequency set at 138 MHz with 25 kHz channel spacing | | | | | |
|---|---|---|---|---|---|
| **Frequency (kHz)** | **Input Level Vi (dBV)** | **Output Level Vo (dBV)** | **Attenuation (Vo-Vi) (dB)** | **Attenuation w.r.t. 1kHz (dB)** | **FCC Recommended Limits (dB)** |
| 0.1 | -6.4 | <-68.0 | <-61.6 | <-62.6 | -- |
| 0.2 | -6.4 | <-69.0 | <-62.6 | <-63.6 | -- |
| 0.4 | -6.4 | -19.3 | -12.9 | -13.9 | -- |
| 0.6 | -6.4 | -19.6 | -13.2 | -14.2 | -- |
| 0.8 | -6.4 | -19.4 | -13.0 | -14.0 | -- |
| 1.0 | -6.4 | -19.5 | -13.1 | -14.1 | -- |
| 2.0 | -3.7 | -22.1 | -18.4 | -19.4 | -- |
| 3.0 | -3.7 | -27.2 | -23.5 | -24.5 | 0.0 |
| 3.5 | -6.4 | <-78.0 | <-71.6 | <-72.6 | -4.0 |
| 4.0 | -6.4 | <-77.0 | <-70.6 | <-71.6 | -7.5 |
| 4.5 | -6.4 | <-77.0 | <-70.6 | <-71.6 | -10.6 |
| 5.0 | -6.4 | <-85.0 | <-78.6 | <-79.6 | -13.3 |
| 6.0 | -6.4 | <-86.0 | <-79.6 | <-80.6 | -18.1 |
| 7.0 | -6.3 | <-86.0 | <-79.7 | <-80.7 | -22.1 |
| 8.0 | -6.3 | <-85.0 | <-78.7 | <-79.7 | -25.6 |
| 9.0 | -6.3 | <-85.0 | <-78.7 | <-79.7 | -28.6 |
| 10.0 | -6.3 | <-82.0 | <-75.7 | <-76.7 | -31.4 |
| 12.0 | -6.3 | <-84.0 | <-77.7 | <-78.7 | -36.1 |
| 14.0 | -6.3 | <-85.0 | <-78.7 | <-79.7 | -40.1 |
| 16.0 | -6.3 | <-85.0 | <-78.7 | <-79.7 | -43.6 |
| 18.0 | -6.4 | <-87.0 | <-80.6 | <-81.6 | -46.7 |
| 20.0 | -6.4 | <-88.0 | <-81.6 | <-82.6 | -49.4 |
| 25.0 | -6.4 | <-87.0 | <-80.6 | <-81.6 | -50.0 |
| 30.0 | -6.4 | <-86.0 | <-79.6 | <-80.6 | -50.0 |
| 35.0 | -6.5 | <-88.0 | <-81.5 | <-82.5 | -50.0 |
| 40.0 | -6.5 | <-87.0 | <-80.5 | <-81.5 | -50.0 |
| 45.0 | -6.5 | <-89.0 | <-82.5 | <-83.5 | -50.0 |
| 50.0 | -6.5 | <-89.0 | <-82.5 | <-83.5 | -50.0 |

**AUDIO FREQUENCY REPSONSE @ FCC 2.987(a) & 90.242 (25 kHz Channel Spacing)**



# 5.8. MODULATION LIMITING @ FCC 2.987(b) & 90.210

## 5.8.1. Limits @ FCC 2.987(b) and 90.210

The EUT shall be installed with a modulation limiter which limits the deviation of the FM carrier less than manufacturer's setting provided that the rf output spectrum must meet the required MASK

Recommendation:

- 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).

## 5.8.2. 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.

## 5.8.3. Test Equipment List

| Test Instruments | Manufacturer | Model No. | Serial No. | Range |
|---|---|---|---|---|
| Function Generator | Stanford Research Systems | DS340 | 28492 | 1kHz –15MHz |
| Communication Service Monitor | Marconi Instruments | 2945A | 1331581035 | -- |

## 5.8.4. Test Arrangement

## 5.8.5. Test data

### *5.8.5.1. Data Modulation Limiting: FM modulation with random data and Modulation Limiter set at a Maximum Frequency Deviation (Factory Setting).*

| **Test Configuration 1: Transmitter set at 138 MHz with 12.5 kHz channel spacing.** | | |
|---|---|---|
| **DATA BAUD RATE** | **PEAK DEVIATION (KHz)** | **MAXIMUM LIMIT (KHz)** |
| 9600 | 0.6 kHz | 2.5 kHz |

| **Test Configuration 2: Transmitter set at 138 MHz with 25 kHz channel spacing.** | | |
|---|---|---|
| **DATA BAUD RATE** | **PEAK DEVIATION (KHz)** | **MAXIMUM LIMIT (KHz)** |
| 9600 | 1.3 kHz | 5 kHz |

### *5.8.5.2. Voice Modulation Limiting:*

| **Test Configuration 1: Transmitter set at 138 MHz with 12.5 kHz channel spacing.** | | | | | | |
|---|---|---|---|---|---|---|
| **MODULATING SIGNAL LEVEL** | **PEAK FREQUENCY DEVIATION (kHz)** at the following modulating frequency: | | | | | **MAXIMUM LIMIT** |
| **(Vpp)** | **0.1 KHz** | **0.5 KHz** | **1.0 KHz** | **3.0 KHz** | **5.0 KHz** | **(KHz)** |
| 0.1 | 0.0 | 0.3 | 0.2 | 0.1 | 0.1 | 2.5 |
| 0.2 | 0.0 | 0.4 | 0.4 | 0.2 | 0.2 | 2.5 |
| 0.4 | 0.0 | 0.8 | 0.8 | 0.4 | 0.4 | 2.5 |
| 0.6 | 0.0 | 1.3 | 1.3 | 0.6 | 0.6 | 2.5 |
| 0.8 | 0.0 | 1.7 | 1.8 | 0.6 | 0.6 | 2.5 |
| 1.0 | 0.0 | 2.0 | 2.2 | 0.6 | 0.6 | 2.5 |
| 1.2 | 0.0 | 2.2 | 2.2 | 0.6 | 0.6 | 2.5 |
| 1.4 | 0.0 | 2.2 | 2.2 | 0.6 | 0.6 | 2.5 |
| 1.6 | 0.0 | 2.2 | 2.2 | 0.6 | 0.6 | 2.5 |
| 1.8 | 0.0 | 2.2 | 2.2 | 0.6 | 0.6 | 2.5 |
| 2.0 | 0.0 | 2.2 | 2.2 | 0.6 | 0.6 | 2.5 |
| 2.5 | 0.0 | 2.2 | 2.2 | 0.6 | 0.6 | 2.5 |
| 3.0 | 0.0 | 2.2 | 2.2 | 0.6 | 0.6 | 2.5 |
| 3.5 | 0.0 | 2.2 | 2.2 | 0.6 | 0.6 | 2.5 |
| 4.0 | 0.2 | 2.2 | 2.2 | 0.6 | 0.6 | 2.5 |
| 5.0 | 0.6 | 2.2 | 2.2 | 0.6 | 0.6 | 2.5 |

**Test Configuration 2: Transmitter set at 138 MHz with 25 kHz channel spacing.**

| MODULATING SIGNAL LEVEL | PEAK FREQUENCY DEVIATION (kHz) at the following modulating frequency: | | | | | MAXIMUM LIMIT |
|---|---|---|---|---|---|---|
| **(Vpp)** | **0.1 KHz** | **0.5 KHz** | **1.0 KHz** | **3.0 KHz** | **5.0 KHz** | **(KHz)** |
| 0.1 | 0.0 | 0.4 | 0.4 | 0.2 | 0 | 5 |
| 0.2 | 0.0 | 0.8 | 0.8 | 0.4 | 0 | 5 |
| 0.4 | 0.0 | 1.6 | 1.6 | 0.7 | 0 | 5 |
| 0.6 | 0.0 | 2.4 | 2.4 | 1.0 | 0 | 5 |
| 0.8 | 0.0 | 3.1 | 3.3 | 1.2 | 0 | 5 |
| 1.0 | 0.0 | 3.9 | 4.0 | 1.2 | 0 | 5 |
| 1.2 | 0.0 | 3.9 | 4.2 | 1.2 | 0 | 5 |
| 1.4 | 0.0 | 3.9 | 4.2 | 1.2 | 0 | 5 |
| 1.6 | 0.0 | 3.9 | 4.2 | 1.2 | 0 | 5 |
| 1.8 | 0.0 | 3.9 | 4.2 | 1.2 | 0 | 5 |
| 2.0 | 0.0 | 3.9 | 4.1 | 1.2 | 0 | 5 |
| 2.5 | 0.0 | 3.9 | 4.1 | 1.2 | 0 | 5 |
| 3.0 | 0.0 | 3.9 | 4.1 | 1.2 | 0 | 5 |
| 3.5 | 0.5 | 3.9 | 4.1 | 1.2 | 0 | 5 |
| 4.0 | 1.1 | 3.9 | 4.1 | 1.2 | 0 | 5 |
| 5.0 | 2.2 | 3.9 | 4.1 | 1.2 | 0 | 5 |

Voice Signal Input Level = STD MOD Level + 16 dB = -4.4 dBVrms + 16 = **11.6 dBVrms**

| **Test Configuration 1: Transmitter set at 138 MHz with 12.5 channel spacing.** | | |
|---|---|---|
| **MODULATING FREQUENCY (KHz)** | **PEAK FREQUENCY DEVIATION (KHz)** | **MAXIMUM LIMIT (KHz)** |
| 0.1 | 0 | 2.5 |
| 0.2 | 0 | 2.5 |
| 0.4 | 2.2 | 2.5 |
| 0.6 | 2.1 | 2.5 |
| 0.8 | 2.1 | 2.5 |
| 1.0 | 2.1 | 2.5 |
| 1.2 | 1.8 | 2.5 |
| 1.4 | 1.6 | 2.5 |
| 1.6 | 1.4 | 2.5 |
| 1.8 | 1.3 | 2.5 |
| 2.0 | 1.1 | 2.5 |
| 2.5 | 0.9 | 2.5 |
| 3.0 | 0.6 | 2.5 |
| 3.5 | 0 | 2.5 |
| 4.0 | 0 | 2.5 |
| 4.5 | 0 | 2.5 |
| 5.0 | 0 | 2.5 |
| 6.0 | 0 | 2.5 |
| 7.0 | 0 | 2.5 |
| 8.0 | 0 | 2.5 |
| 9.0 | 0 | 2.5 |
| 10.0 | 0 | 2.5 |

Voice Signal Input Level = STD MOD Level + 16 dB = -4.4 dBVrms + 16 = **11.6 dBVrms**

| **Test Configuration 2: Transmitter set at 138 MHz with 25 channel spacing.** | | |
|---|---|---|
| **MODULATING FREQUENCY (KHz)** | **PEAK FREQUENCY DEVIATION (KHz)** | **MAXIMUM LIMIT (KHz)** |
| 0.1 | 0 | 5 |
| 0.2 | 0 | 5 |
| 0.4 | 4.1 | 5 |
| 0.6 | 3.9 | 5 |
| 0.8 | 4.1 | 5 |
| 1.0 | 4.0 | 5 |
| 1.2 | 3.5 | 5 |
| 1.4 | 3.1 | 5 |
| 1.6 | 2.8 | 5 |
| 1.8 | 2.5 | 5 |
| 2.0 | 2.2 | 5 |
| 2.5 | 1.7 | 5 |
| 3.0 | 1.2 | 5 |
| 3.5 | 0 | 5 |
| 4.0 | 0 | 5 |
| 4.5 | 0 | 5 |
| 5.0 | 0 | 5 |
| 6.0 | 0 | 5 |
| 7.0 | 0 | 5 |
| 8.0 | 0 | 5 |
| 9.0 | 0 | 5 |
| 10.0 | 0 | 5 |

# 5.9. EMISSION LIMITATION & EMISSION MASK @ FCC 2.989, 90.208 & 90.210

## 5.9.1. 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 FREQ. DEVIATION (KHz) | FCC APPLICABLE MASK |
|---|---|---|---|---|
| 150 - 174 | 11.25 | 12.5 | 2.5 | 90.210(d): Mask D – Voice & Data |
| 150 - 174 | 20 | 25.0 | 5.0 | 90.210(b): Mask B – Voice & Data<br>or<br>90.210(c): Mask C – Voice & Data |

| FCC RULES | FREQUENCY RANGE | ATTENUATION LIMIT (dBc) |
|---|---|---|
| 90.210(b): Mask B – Voice & Data | Fc - 10kHz to Fc + 10 kHz<br>Fc - 20 kHz to < Fc - 10 kHz, > Fc + 10 kHz to Fc +20 kHz<br>Fc - 50kHz to < Fc - 20kHz, > Fc + 20kHz to Fc + 50kHz<br>< Fc - 50kHz, > Fc + 50kHz | 0 dB<br>25 dB<br>35 dB<br>At least 43 + 10 $\log_{10}$ (P) dB |
| 90.210(c): Mask C – Voice & Data | Fc - 5 kHz to Fc + 5kHz<br>Fc - 10kHz to <Fc - 5kHz, >Fc + 5kHz to Fc + 10kHz<br>Fc - 50 kHz to <Fc - 10kHz, >Fc + 10kHz to Fc + 50kHz<br><Fc - 50kHz, >Fc + 50kHz | 0 dB<br>At least 83 $\log_{10}$ ($f_d$/5) dB<br>29 $\log_{10}$ ($f_d^2$/11) dB or 50 dB, whichever is the lesser attenuation<br>At least 43 + 10 $\log_{10}$(P) dB |
| 90.210(d): Mask D – Voice & Data | Fc - 5.625 kHz to FC + 5.625 kHz<br>Fc - 12.5kHz to <Fc - 5.625kHz, >Fc + 5.625kHz to Fc + 12.5kHz<br><Fc - 12.5 kHz , > Fc + 12.5 kHz | 0 dB<br>At least 7.27($f_d$ - 2.88 kHz)<br>50 + 10$\log_{10}$(P) or 70 dB whichever is the lesser attenuation |

**Note:** displacement frequency ($f_d$ in kHz)

## 5.9.2. Method of Measurements

**FCC CFR 47, Para. 2.989 - Out-of-Band Emissions**:

The Emission Masks was measured with the Spectrum Analyzer controls set as shown on the test results (RBW = 300 Hz, VBW ≥ 300 Hz, SWEEP TIME = AUTO for 25kHz channel spacing and RBW = 100 Hz, VBW ≥ 100 Hz, SWEEP TIME =AUTO for 12.5 kHz channel spacing). The transmitter was operated at a full rated power output, and modulated as follows:

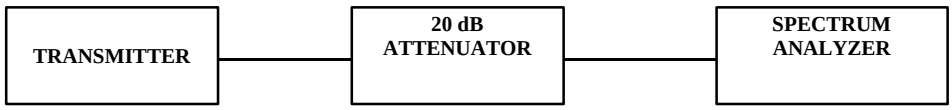
**Voice or Digital Modulation Through a Voice Input Port @ 2.989(c)(i)**:- The transmitter was modulated by a 2.5 KHz tone signal at an input level 16 dB greater than that required to produce 50% modulation (e.g.: ±2.5 KHz peak deviation at 1 KHz modulating frequency). The input level was established at the frequency of maximum response of the audio modulating circuit.

**Digital Modulation Through a Data Input Port @ 2.989(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.

## 5.9.3. 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(s) | Bird | .. | … | DC –22 GHz |
| Audio Oscillator | Hewlett Packard | HP 204C | 0989A08798 | DC to 1.2 MHz |

## 5.9.4. Test Arrangement




## 5.9.5. Test data

Conform. Please refer to section 8.1. for 99% OBW and Emission Mask Measurements Plots for details information.

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

## 5.10.1. Limits @ 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 FREQ. DEVIATION (KHz) | FCC APPLICABLE MASK |
|---|---|---|---|---|
| 150 - 174 | 11.25 | 12.5 | 2.5 | 90.210(d): Mask D – Voice & Data |
| 150 - 174 | 20 | 25.0 | 5.0 | 90.210(b): Mask B – Voice & Data<br>or<br>90.210(c): Mask C – Voice & Data |

| FCC RULES | FREQUENCY RANGE | ATTENUATION LIMIT (dBc) |
|---|---|---|
| 90.210(b): Mask B – Voice & Data | Fc - 10kHz to Fc + 10 kHz<br>Fc - 20 kHz to < Fc - 10 kHz, > Fc + 10 kHz to Fc +20 kHz<br>Fc - 50kHz to < Fc - 20kHz, > Fc + 20kHz to Fc + 50kHz<br>< Fc - 50kHz, > Fc + 50kHz | 0 dB<br>25 dB<br>35 dB<br>At least 43 + 10 $\log_{10}$ (P) dB |
| 90.210(c): Mask C – Voice & Data | Fc - 5 kHz to Fc + 5kHz<br>Fc - 10kHz to <Fc - 5kHz, >Fc + 5kHz to Fc + 10kHz<br>Fc - 50 kHz to <Fc - 10kHz, >Fc + 10kHz to Fc + 50kHz<br><Fc - 50kHz, >Fc + 50kHz | 0 dB<br>At least 83 $\log_{10}$ ($f_d$/5) dB<br>29 $\log_{10}$ ($f_d^2$/11) dB or 50 dB, whichever is the lesser attenuation<br>At least 43 + 10 $\log_{10}$(P) dB |
| 90.210(d): Mask D – Voice & Data | Fc - 5.625 kHz to FC + 5.625 kHz<br>Fc - 12.5kHz to <Fc - 5.625kHz, >Fc + 5.625kHz to Fc + 12.5kHz<br><Fc - 12.5 kHz , > Fc + 12.5 kHz | 0 dB<br>At least 7.27($f_d$ - 2.88 kHz)<br>50 + 10$\log_{10}$(P) or 70 dB whichever is the lesser attenuation |

**Note:** displacement frequency ($f_d$ in kHz)

## 5.10.2. Method of Measurements

With transmitter modulation characteristics described in Out-of-Band Emissions measurements @ 2.989, the transmitter spurious and harmonic emissions were scanned. The spurious and harmonic emissions were measured with the Spectrum Analyzer 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. 2.997 - Frequency spectrum to be investigated:-** The spectrum was investigated from the lowest radio generated in the equipment up to at least the $10^{th}$ harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

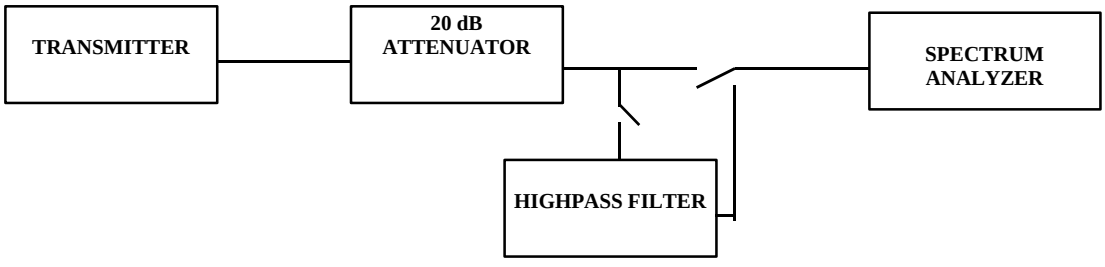
**FCC CFR 47, Para. 2.991 - Spurious Emissions at Antenna Terminal:-** The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent 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 2.989 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

## 5.10.3. 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(s) | Bird | .. | … | DC –22 GHz |
| Audio Oscillator | Hewlett Packard | HP 204C | 0989A08798 | DC to 1.2 MHz |
| Hihpass Filter, Microphase | Microphase | CR220HID | IITI11000AC | Cut-off Frequency at 600 MHz, 1.3 GHz or 4 GHz |

## 5.10.4. Test Arrangement

- *The transmitter was coupled to the Spectrum Analyzer through a 20 dB attenuator.*
- *The insertion loss between the transmitter output terminal and the spectrum analyzer was measured to be 20 dB*
- *The channel frequencies (Low, Middle and High ) was established on the extreme edges of the operating band, both upper and lower at its full rated output power. The emissions was investigated up to the tenth harmonic of the fundamental emissions in each case*



## 5.10.5. Test data

### *5.10.5.1. Near Lowest Frequency (138 MHz)*

| | |
|---|---|
| Fundamental Frequency: | 138 MHz |
| RF Output Power: | 8.5 Watts |
| Modulation: | FM modulation with 2.5 kHz Sine Wave Signal |

The emissions were scanned from 10 MHz to 2 GHz and no significant signal was found. Please refer to Exhibit 8, Section 8.2. for details of measurements

### *5.10.5.2. Near Middle Frequency (150 MHz)*

| | |
|---|---|
| Fundamental Frequency: | 150 MHz |
| RF Output Power: | 8.2 Watts |
| Modulation: | FM modulation with 2.5 kHz Sine Wave Signal |

The emissions were scanned from 10 MHz to 2 GHz and no significant signal was found. Please refer to Exhibit 8, Section 8.2. for details of measurements

### *5.10.5.3. Near Highest Frequency (174 MHz)*

| | |
|---|---|
| Fundamental Frequency: | 174 MHz |
| RF Output Power: | 8 Watts |
| Modulation: | FM modulation with 2.5 kHz Sine Wave Signal |

The emissions were scanned from 10 MHz to 2 GHz and no significant signal was found. Please refer to Exhibit 8, Section 8.2. for details of measurements

# 5.11. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS @ FCC 90.210

## 5.11.1. 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 FREQ. DEVIATION (KHz) | FCC APPLICABLE MASK |
|---|---|---|---|---|
| 150 - 174 | 11.25 | 12.5 | 2.5 | 90.210(d): Mask D – Voice & Data |
| 150 - 174 | 20 | 25.0 | 5.0 | 90.210(b): Mask B – Voice & Data<br>or<br>90.210(c): Mask C – Voice & Data |

| FCC RULES | FREQUENCY RANGE | ATTENUATION LIMIT (dBc) |
|---|---|---|
| 90.210(b): Mask B – Voice & Data | Fc - 10kHz to Fc + 10 kHz<br>Fc - 20 kHz to < Fc - 10 kHz, > Fc + 10 kHz to Fc +20 kHz<br>Fc - 50kHz to < Fc - 20kHz, > Fc + 20kHz to Fc + 50kHz<br>< Fc - 50kHz, > Fc + 50kHz | 0 dB<br>25 dB<br>35 dB<br>At least $43 + 10 \log_{10}$ (P) dB |
| 90.210(c): Mask C – Voice & Data | Fc - 5 kHz to Fc + 5kHz<br>Fc - 10kHz to <Fc - 5kHz, >Fc + 5kHz to Fc + 10kHz<br>Fc - 50 kHz to <Fc - 10kHz, >Fc + 10kHz to Fc + 50kHz<br><br><Fc - 50kHz, >Fc + 50kHz | 0 dB<br>At least $83 \log_{10}(f_d/5)$ dB<br>$29 \log_{10}(f_d^2/11)$ dB or 50 dB, whichever is the lesser attenuation<br>At least $43 + 10 \log_{10}$(P) dB |
| 90.210(d): Mask D – Voice & Data | Fc - 5.625 kHz to FC + 5.625 kHz<br>Fc - 12.5kHz to <Fc - 5.625kHz, >Fc + 5.625kHz to Fc + 12.5kHz<br><Fc - 12.5 kHz , > Fc + 12.5 kHz | 0 dB<br>At least $7.27(f_d - 2.88$ kHz)<br>$50 + 10\log_{10}$(P) or 70 dB whichever is the lesser attenuation |

**Note:** displacement frequency ($f_d$ in kHz)

## 5.11.2. Method of Measurements

Please refer to the Exhibit 7 of this test report and ANSI C63.4:1992 for radiated emissions test method.

With transmitter modulation characteristics described in Out-of-Band Emissions measurements @ 2.989, the transmitter spurious and harmonic emissions were scanned. The spurious and harmonic emissions were measured with the Spectrum Analyzer controls set as RBW = 100 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. 2.997 - Frequency spectrum to be investigated:-** The spectrum was investigated from the lowest radio generated in the equipment up to at least the $10^{th}$ harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The
amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

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

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

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

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

**METHOD OF CALCULATION FOR TRANSMITTED POWER (P) FROM THE MEASURED FIELD STRENGTH LEVEL (E)**:

According to IEC 801-3, the power density can be calculated as follows:

$S = P / (4xPIxD^2)$ Where: S: Power density in watts per square feet
P: Transmitted power in watts
PI: 13.1415
D: Distance in meters

The power density S ($W/m^2$) and electric field E (V/m) is related by:

$S = E^2/(120xPI)$

Accordingly, the field intensity of isotropic radiator in free space can be expressed as follows:

$E = (30xP)^{1/2}/D = 5.5x(P)^{1/2}/D$

For Halfwave dipole antenna or other antennas correlated to dipole in direction of maximum radiation:

$S = (1.64xP)/(4xPIxD^2)$
$E = (49.2xP)^{1/2}xD = 7.01x(P)^{1/2}/D$

$$P = (ExD/7.01)^2$$

Calculation of transmitted power P (dBM) given a measured field intensity E (dBuV/m):

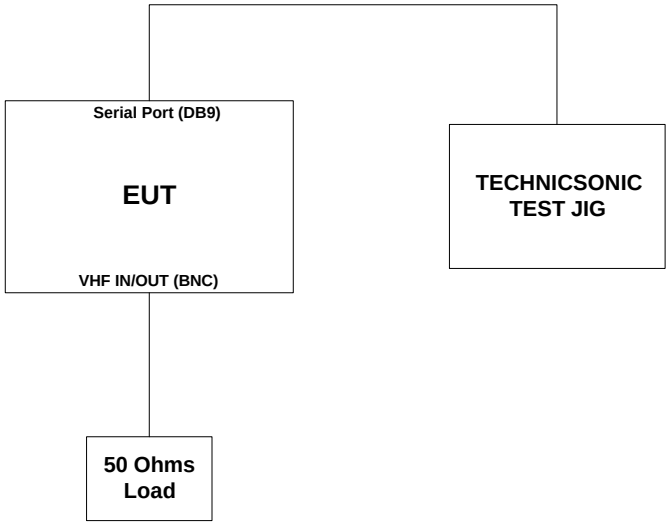
$P(W) = [E(V/m)xD/7.01]^2$
$P(mW) = P(W)x1000$
=> $P(dBm) = 10logP(mW)$
$= 20logE(V/m) + 20log(D) - 20log(7.01) + 10log1000$
$= E(dBV/m) + 20logD + 13$
$= E(dBuV/m) - 120 + 20log(D) + 13$
$= E(dBuV/m) + 20log(D) - 107$

The Transmitted Power @ D = 3 Meters

**P(dBm) = E(dBuV/m) - 97.5**

## 5.11.3. Test Arrangement

The following drawings show details of the test setup for radiated emissions measurements



## 5.11.4. 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 |
| Active Loop Antenna | EMCO | 6507 | 8906-1167 | 1 kHz – 30 MHz |
| Biconilog Antenna | EMCO | 3143 | 1029 | 20 MHz to 2 GHz |
| Horn Antenna | EMCO | 3155 | 9701-5061 | 1 GHz – 18 GHz |
| Horn Antenna | EMCO | 3160-09 | .. | 18 GHz – 26.5 GHz |
| Horn Antenna | EMCO | 3160-10 | .. | 26.5 GHz – 40 GHz |
| Mixer | Tektronix | 118-0098-00 | .. | 18 GHz – 26.5 GHz |
| Mixer | Tektronix | 119-0098-00 | .. | 26.5 GHz – 40 GHz |

## 5.11.5. Test data

### *5.11.5.1. Near Lowest Frequency (138 MHz)*

Fundamental Frequency: 138 MHz
RF Output Power: 8.5Watts
Modulation: FM modulation with 2.5 kHz Sine Wave Signal

| FREQUENCY (MHz) | FIELD LEVEL (dBµV/m) | POWER LEVEL (dBm) | ANTENNA PLANE (H/V) | *LIMIT (dBm) | MARGIN (dB) | PASS / FAIL |
|---|---|---|---|---|---|---|
| 276 | 49.25 | -48.3 | V | -20.0 | -28.3 | PASS |
| 276 | 51.38 | -46.1 | H | -20.0 | -26.1 | PASS |
| 414 | 49.53 | -48.0 | V | -20.0 | -28.0 | PASS |
| 414 | 55.41 | -42.1 | H | -20.0 | -22.1 | PASS |
| 552 | 55.34 | -42.2 | V | -20.0 | -22.2 | PASS |
| 552 | 57.16 | -40.3 | H | -20.0 | -20.3 | PASS |
| 690 | 49.63 | -47.9 | V | -20.0 | -27.9 | PASS |
| 690 | 50.88 | -46.6 | H | -20.0 | -26.6 | PASS |
| 828 | 46.59 | -50.9 | V | -20.0 | -30.9 | PASS |
| 828 | 45.81 | -51.7 | H | -20.0 | -31.7 | PASS |
| 966 | 44.56 | -52.9 | V | -20.0 | -32.9 | PASS |
| 966 | 44.16 | -53.3 | H | -20.0 | -33.3 | PASS |
| 1104 | 45.22 | -52.3 | V | -20.0 | -32.3 | PASS |
| 1104 | 46.09 | -51.4 | H | -20.0 | -31.4 | PASS |
| 1242 | 45.66 | -51.8 | V | -20.0 | -31.8 | PASS |
| 1242 | 43.03 | -54.5 | H | -20.0 | -34.5 | PASS |
| 1380 | 52.03 | -45.5 | V | -20.0 | -25.5 | PASS |
| 1380 | 48.25 | -49.3 | H | -20.0 | -29.3 | PASS |

The emissions were scanned from 10 MHz to 2 GHz and all emissions less 40 dB below the limits were recorded.

*** NOTE:** Worst limit of 50+10log(P) for 12.5 kHz channel spacing operation was used for compliance.

***REMARK:***
The tests were repeated for the radio operated in data modulation mode, the results were found to be the same as those with FM voice modulation.

### *5.11.5.2. Near Middle Frequency (150 MHz)*

Fundamental Frequency: 150 MHz
RF Output Power: 8.2 Watts
Modulation: FM modulation with 2.5 kHz Sine Wave Signal

| FREQUENCY (MHz) | FIELD LEVEL (dBuV/m) | POWER LEVEL (dBm) | ANTENNA PLANE (H/V) | *LIMIT (dBm) | MARGIN (dB) | PASS / FAIL |
|---|---|---|---|---|---|---|
| 300 | 46.09 | -51.4 | V | -20.0 | -31.4 | PASS |
| 300 | 49.53 | -48.0 | H | -20.0 | -28.0 | PASS |
| 450 | 42.22 | -55.3 | V | -20.0 | -35.3 | PASS |
| 450 | 50.59 | -46.9 | H | -20.0 | -26.9 | PASS |
| 600 | 58.63 | -38.9 | V | -20.0 | -18.9 | PASS |
| 600 | 62.28 | -35.2 | H | -20.0 | -15.2 | PASS |
| 750 | 43.59 | -53.9 | V | -20.0 | -33.9 | PASS |
| 750 | 46.78 | -50.7 | H | -20.0 | -30.7 | PASS |
| 900 | 50.19 | -47.3 | V | -20.0 | -27.3 | PASS |
| 900 | 51.13 | -46.4 | H | -20.0 | -26.4 | PASS |
| 1050 | 47.00 | -50.5 | V | -20.0 | -30.5 | PASS |
| 1050 | 46.94 | -50.6 | H | -20.0 | -30.6 | PASS |
| 1200 | 52.34 | -45.2 | V | -20.0 | -25.2 | PASS |
| 1200 | 52.28 | -45.2 | H | -20.0 | -25.2 | PASS |
| 1350 | 46.84 | -50.7 | V | -20.0 | -30.7 | PASS |
| 1350 | 44.75 | -52.8 | H | -20.0 | -32.8 | PASS |
| 1500 | 45.84 | -51.7 | V | -20.0 | -31.7 | PASS |
| 1500 | 44.00 | -53.5 | H | -20.0 | -33.5 | PASS |

The emissions were scanned from 10 MHz to 2 GHz and all emissions less 40 dB below the limits were recorded.

*** NOTE:** Worst limit of 50+10log(P) for 12.5 kHz channel spacing operation was used for compliance.

***REMARK:***
The tests were repeated for the radio operated in data modulation mode, the results were found to be the same as those with FM voice modulation.

### *5.11.5.3. Near Highest Frequency (174 MHz)*

Fundamental Frequency: 174 MHz
RF Output Power: 8 Watts
Modulation: FM modulation with 2.5 kHz Sine Wave Signal

| FREQUENCY (MHz) | FIELD LEVEL (dBuV/m) | POWER LEVEL (dBm) | ANTENNA PLANE (H/V) | *LIMIT (dBm) | MARGIN (dB) | PASS / FAIL |
|---|---|---|---|---|---|---|
| 348 | 53.91 | -43.6 | V | -20.0 | -23.6 | PASS |
| 348 | 62.48 | -35.0 | H | -20.0 | -15.0 | PASS |
| 522 | 53.63 | -43.9 | V | -20.0 | -23.9 | PASS |
| 522 | 63.56 | -33.9 | H | -20.0 | -13.9 | PASS |
| 696 | 62.22 | -35.3 | V | -20.0 | -15.3 | PASS |
| 696 | 64.09 | -33.4 | H | -20.0 | -13.4 | PASS |
| 870 | 40.19 | -57.3 | V | -20.0 | -37.3 | PASS |
| 870 | 41.81 | -55.7 | H | -20.0 | -35.7 | PASS |
| 1044 | 49.22 | -48.3 | V | -20.0 | -28.3 | PASS |
| 1044 | 52.16 | -45.3 | H | -20.0 | -25.3 | PASS |
| 1218 | 50.56 | -46.9 | V | -20.0 | -26.9 | PASS |
| 1218 | 46.50 | -51.0 | H | -20.0 | -31.0 | PASS |
| 1392 | 56.94 | -40.6 | V | -20.0 | -20.6 | PASS |
| 1392 | 52.03 | -45.5 | H | -20.0 | -25.5 | PASS |
| 1566 | 45.41 | -52.1 | V | -20.0 | -32.1 | PASS |
| 1566 | 44.00 | -53.5 | H | -20.0 | -33.5 | PASS |
| 1740 | 56.88 | -40.6 | V | -20.0 | -20.6 | PASS |
| 1740 | 52.88 | -44.6 | H | -20.0 | -24.6 | PASS |

The emissions were scanned from 10 MHz to 2 GHz and all emissions less 40 dB below the limits were recorded.

*** NOTE:** Worst limit of 50+10log(P) for 12.5 kHz channel spacing operation was used for compliance.

***REMARK:***
The tests were repeated for the radio operated in data modulation mode, the results were found to be the same as those with FM voice modulation.

## 5.11.6. Photographs of Test Setup

Please refer to EXHIBIT 9 for details of test setup.

# 5.12. TRANSIENT FREQUENCY BEHAVIOR @ 90.214

## 5.12.1. Limits

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

| Time interval [1, 2] | Maximum frequency difference [3] | All equipment |
|---|---|---|
| | | 150 to 174 MHz |
| **Transient Frequency Behavior for Equipment designed to Operate on 25 kHz Channels** | | |
| $t_1$ [4] ... | ± 25.0 kHz | 5.0 ms |
| $t_2$ ..... | ± 12.5 kHz | 20.0 ms |
| $t_3$ [4] ... | ± 25.0 kHz | 5.0 ms |
| **Transient Frequency Behavior for Equipment designed to Operate on 12.5 kHz Channels** | | |
| $t_1$ [4] ... | ± 12.5 kHz | 5.0 ms |
| $t_2$ ..... | ± 6.25 kHz | 20.0 ms |
| $t_3$ [4] ... | ± 12.5 kHz | 5.0 ms |

1 $t_{on}$ is the instant when a 1kHz 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.

2 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

3 Difference between the actual transmitter frequency and the assigned transmitter frequency.

4 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.

## 5.12.2. Method of Measurements

Refer to efer to ANSI/TIA/EIA - 603 - 1992, Sec. 2.2.19, Page 83

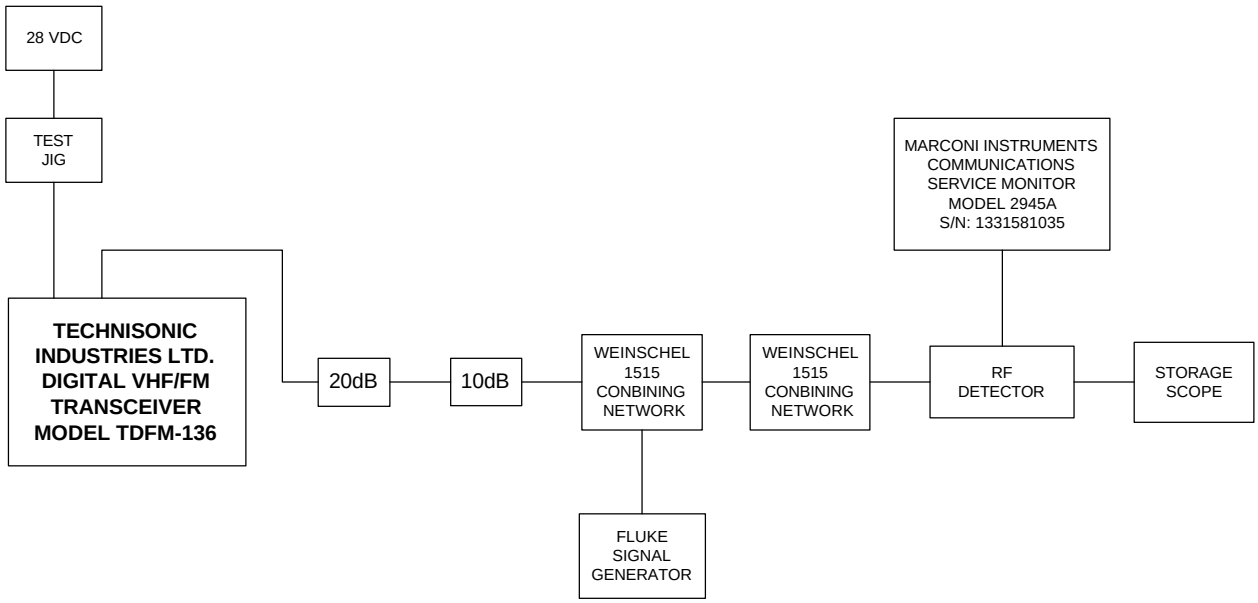
1. Connect the transmitter under tests as shown in the above block diagram
2. Set the signal generator to the assigned frequency and modulate with a 1 kHz tone at ±12.5 kHz deviation and its output level to be 50 dB below the transmitter rf output at the test receiver end.
3. Set the horizontal sweep 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 $t_3$.

## 5.12.3. Test Equipment List

| Test Instruments | Manufacturer | Model No. | Serial No. | Frequency Range |
|---|---|---|---|---|
| RF Synthesized Signal Generator | Fluke | 6061A | … | 10 kHz –1GHz<br>13 dBm output max. @ 50 Ohms |
| Communications Service Monitor | Marconi Instruments | 2945A | 1331581035 | .. |
| Network Combiner | Mini-circuit | 15542 | … | DC to 22 GHz<br>(7 dB insertion loss) |
| Digital Storage Scope | Phillips | 3320A | DQ 646 | DC - 5 MHz |
| 67297 RF Detector, | Herotex | DZ122-553 | 63400 | .. |

## 5.12.4. Test Arrangement

The following drawings show details of the test setup for radiated emissions measurements



## 5.12.5. Test Data

### *5.12.5.1. Test Configuration #1: 12.5 kHz Channel Spacing, Unmodulated*

| Time Interval | Transient Frequency | Transient Frequency Limit |
|---|---|---|
| $t_1$ (5 ms) SWITCH ON CONDITION | + 5.2 kHz | 12.5 kHz |
| $t_2$ (20 ms) SWITCH ON CONDITION | - 1.4 kHz | 6.25 kHz |
| After $t_3$ (5 mS) SWITCH ON CONDITION | 0 kHz | 12.5 kHz |

### *5.12.5.2. Test Configuration #2: 12.5 kHz Channel Spacing, FM Modulation with 9600 BPS Random Data, 1.2 KHz Freq. Dev.*

| Time Interval | Transient Frequency | Transient Frequency Limit |
|---|---|---|
| $t_1$ (5 ms) SWITCH ON CONDITION | + 1.4 kHz | 12.5 kHz |
| $t_2$ (20 ms) SWITCH ON CONDITION | - 1.4 kHz | 6.25 kHz |
| After $t_3$ (5 mS) SWITCH ON CONDITION | 0 kHz | 12.5 kHz |

### *5.12.5.3. Test Configuration #3: 12.5 kHz Channel Spacing, FM Voice Modulation with 2.5 KHz Sine Wave, ± 1.8 KHz Freq. Dev.*

| Time Interval | Transient Frequency | Transient Frequency Limit |
|---|---|---|
| $t_1$ (5 ms) SWITCH ON CONDITION | - 1.8 kHz | 12.5 kHz |
| $t_2$ (20 ms) SWITCH ON CONDITION | -2.4 kHz | 6.25 kHz |
| After $t_3$ (5 mS) SWITCH ON CONDITION | 0 kHz | 12.5 kHz |

#### *5.12.5.4. Test Configuration #4: 25 kHz Channel Spacing, Unmodulated*

| Time Interval | Transient Frequency | Transient Frequency Limit |
|---|---|---|
| $t_1$ (5 ms) SWITCH ON CONDITION | - 2.9 kHz | 25 kHz |
| $t_2$ (20 ms) SWITCH ON CONDITION | 0 kHz | 12.5 kHz |
| After $t_3$ (5 mS) SWITCH ON CONDITION | 0 kHz | 25 kHz |

#### *5.12.5.5. Test Configuration #5: 25 kHz Channel Spacing, FM Modulation with 9600 BPS Random Data, 1.2 KHz Freq. Dev.*

| Time Interval | Transient Frequency | Transient Frequency Limit |
|---|---|---|
| $t_1$ (5 ms) SWITCH ON CONDITION | - 4.4 kHz | 25 kHz |
| $t_2$ (20 ms) SWITCH ON CONDITION | - 2.9 kHz | 12.5 kHz |
| After $t_3$ (5 mS) SWITCH ON CONDITION | 0 kHz | 25 kHz |

#### *5.12.5.6. Test Configuration #6: 25 kHz Channel Spacing, FM Voice Modulation with 2.5 KHz Sine Wave, ± 1.8 KHz Freq. Dev.*

| Time Interval | Transient Frequency | Transient Frequency Limit |
|---|---|---|
| $t_1$ (5 ms) SWITCH ON CONDITION | + 3.6 kHz | 25 kHz |
| $t_2$ (20 ms) SWITCH ON CONDITION | - 5.2 kHz | 12.5 kHz |
| After $t_3$ (5 mS) SWITCH ON CONDITION | 0 kHz | 25 kHz |

### 5.12.6. Plots

Please refer to Exhibit 8 for details of measurements.

# EXHIBIT 6. MEASUREMENT UNCERTAINTY

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

## 6.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

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

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

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

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

## 6.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

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

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

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

# EXHIBIT 7. MEASUREMENT METHODS

## 7.1. GENERAL TEST CONDITIONS

### 7.1.1. Test Conditions

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

### 7.1.2. Method of Measurements - AC Mains Conducted Emissions

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

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

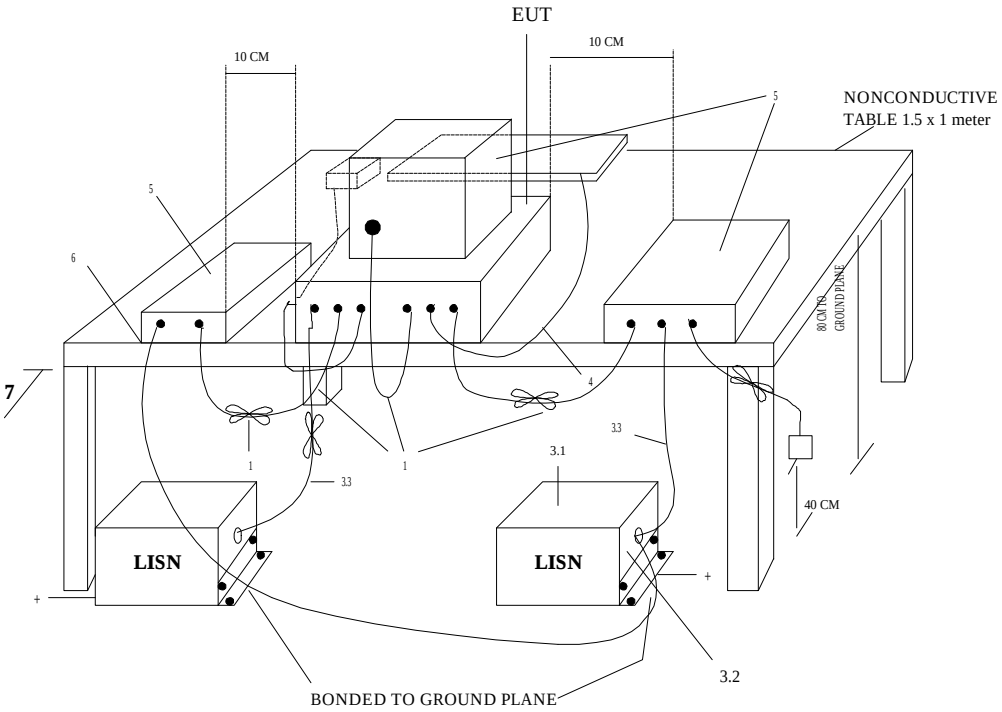
  Step1. Monitor the frequency range of interest at a fixed EUT azimuth.

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

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

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

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




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

LEGEND:

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

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

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

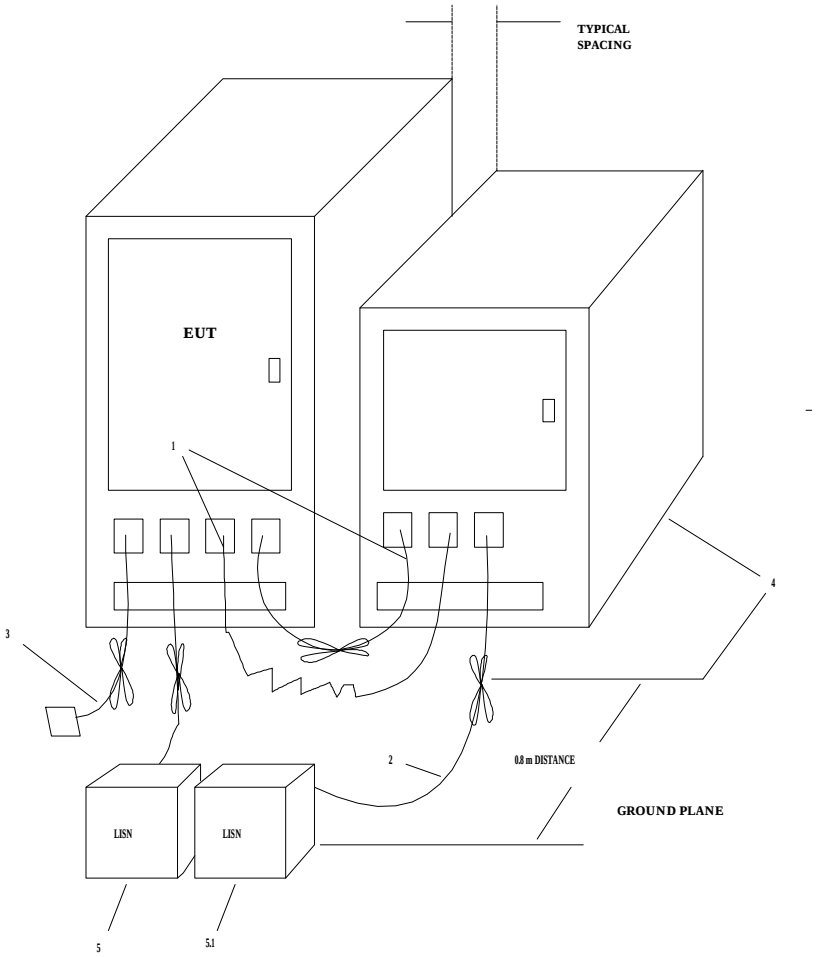
4. Cables of hand-operated devices, such as keyboards, mouses, etc., have to be placed as close as possible to the host.

5. Non-EUT components being tested.

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

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

**Tabletop Equipment Conducted Emissions**




**LEGENEND:**

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

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

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

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

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

**Floor-Standing Equipment Conducted Emissions**

## 7.1.3. Method of Measurements - Electric Field Radiated Disturbance

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

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

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

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

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

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

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

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

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

  Step3: Rotate the EUT 360 degrees to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, go back to the azimuth and repeat Step 2. Otherwise, orient the EUT azimuth to repeat the highest amplitude observation and proceed.

  Step4: Move the antenna over its full allowed range of travel (1 to 4 meters) to maximize the suspected highest amplitude signal. If the signal or another at a different frequency is observed to exceed the previously noted highest amplitude signal by 1 dB or more, return to Step 2 with the highest amplitude observation and proceed.

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

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

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

**Calculation of Field Strength**:

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

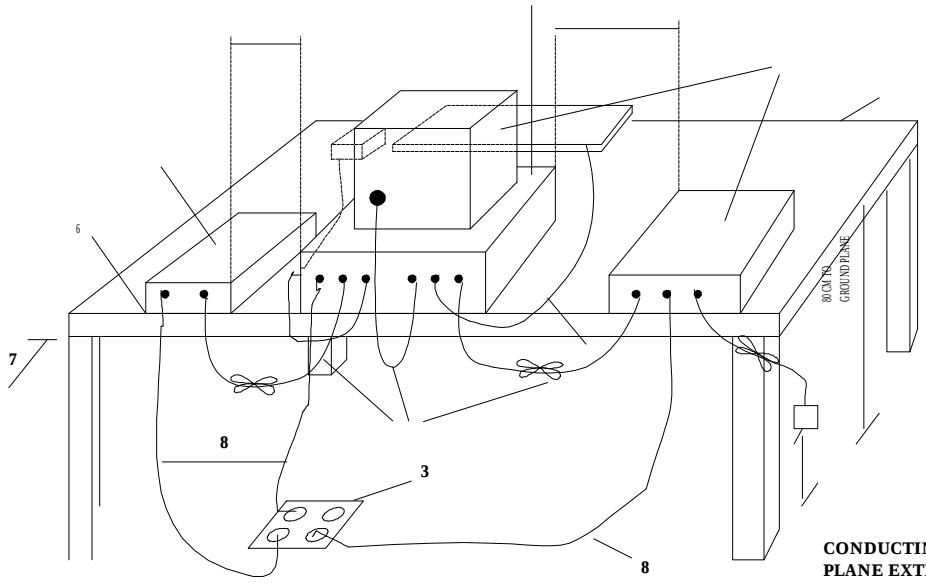
$$FS = RA + AF + CF - AG$$

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

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

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

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




**CONDUCTING GROUND PLANE EXTENDS 0.5 m BEYOND EUT SYSTEM FOOTPRINT**

**LEGEND:**

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

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

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

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

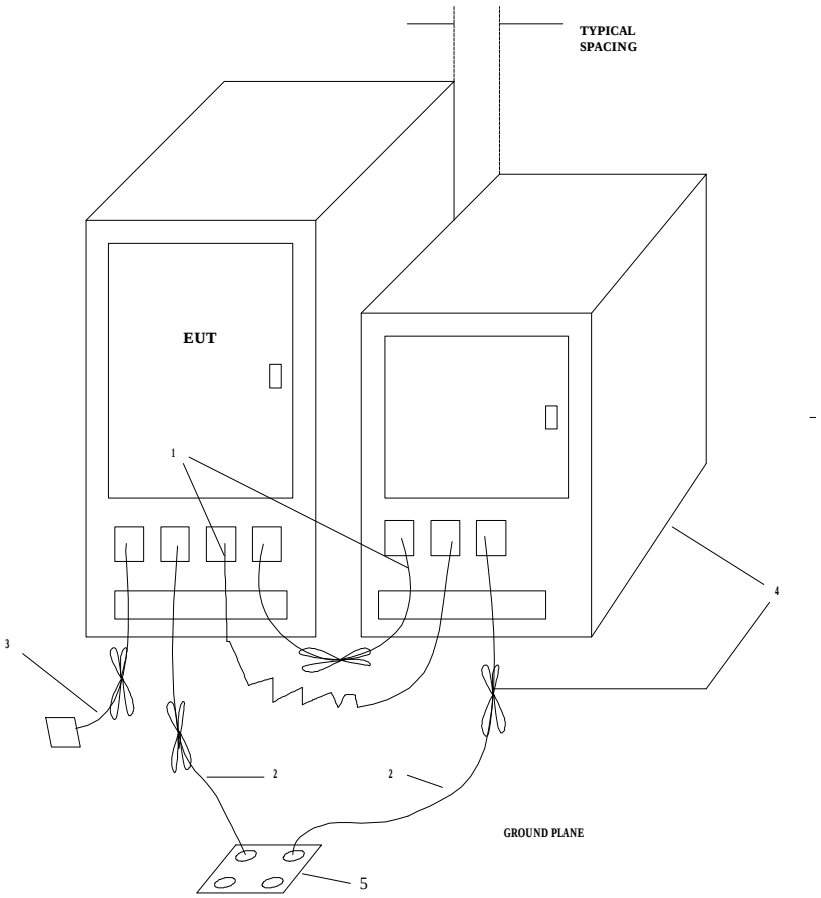
5. Non-EUT components of EUT system being tested.

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

7. No vertical conducting wall used.

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

**Tabletop Equipment Radiated Emissions**




**LEGEND:**

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

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

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

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

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

**Floor-Standing Equipment Radiated Emissions**

# EXHIBIT 8. PLOTS OF MEASUREMENTS

## 8.1. 99% OCCUPIED BANDWIDTH PLOTS

Please refer to attached measurement plots

## 8.2. EMISSION MASK PLOTS

Please refer to attached measurement plots

## 8.3. TRANSMITTER ANTENNA POWER SPURIOUS/HARMONIC CONDUCTED EMISSIONS PLOTS

Please refer to attached measurement plots

## 8.4. TRANSIENT FREQUENCY BEHAVIOR

Please refer to attached measurement plots

# EXHIBIT 9. PHOTOGRAPHS OF TEST SETUP

## 9.1. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS TEST SETUP PHOTOS

Please refer to attached test setup photos.

# EXHIBIT 10. APPLICANT'S LETTERS & STATEMENT

## 10.1. APPLICANT'S AUTHORIZATION TO APPOINT ULTRATECH ENGINEERING LABS INC. TO ACT AS AN AGENT

Please refer to attached letter.

## 10.2. LETTER REQUEST FOR FCC CONFIDENTIALITY FILING

Please refer to attached letter.

## 10.3. RADIO FREQUENCY RADIATION EXPOSURE EVALUATION: MOBILE & UNLICENSED DEVICES@ FCC 2.1091

The antenna will be installed in location where the separation distance of at least 20 centimeters is normally maintained between radiating antenna and the body of the user or nearby persons. Please refer to attached antenna installation instruction for details.

# EXHIBIT 11. FCC ID LABEL & SKETCH OF LABEL LOCATION

Please refer to attached FCC ID label and its location.

# EXHIBIT 12. "FCC INFORMATION TO USER"

Please refer to VHF/FM Digital Airborne Transceiver Model TDFM-136 manual.

# EXHIBIT 13. PHOTOGRAPHS OF EQUIPMENT UNDER TEST

Please refer to attached photos of equipment under test.

# EXHIBIT 14. SYSTEM BLOCK DIAGRAM(S) & SCHEMATIC DIAGRAMS

Please refer to attached system block/schematic diagrams

# EXHIBIT 15. USER'S MANUAL

Please refer to attached VHF/FM Airborne Transceiver Model TDFM-136 manual.