UltraTech
Group of Labs

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Canada
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Dec. 24, 2003

ICOM Incorporated
1-1-32, Kamiminami
Hirano-ku, Osaka
Japan, 547-0003

Attn.: **Mr. Takahasi Aoki**

Subject: **Class II Permissive Change Authorization under FCC CFR 47, Parts 2 and 90 (Subpart I) - Non-Broadcast Radio Transceivers Operating in the frequency bands 150 - 174 MHz (12.5 kHz and 25 kHz Channel Spacings).**

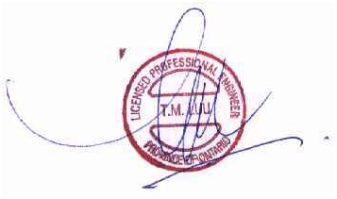
Product: **VHF FM REPEATER**
Model: **IC-FR3000**
FCC ID: **AFJ236702**

Dear Mr. Aoki,

The product sample has been tested in accordance with **FCC CFR 47, Parts 2 and 90 (Subpart I) - Non-Broadcast Radio Transceivers Operating in the frequency bands 150 - 174 MHz (12.5 kHz and 25 kHz Channel Spacings),** and the results and observation were recorded in the engineering report, Our File No.: ICOM-078FCC90

Enclosed you will find copy of the engineering report. If you have any queries, please do not hesitate to contact us.

Yours truly,



Tri Minh Luu, P.Eng
Vice President - Engineering

Encl.

ENGINEERING TEST REPORT

VHF FM REPEATER
(150 - 174 MHz)
Model No.: IC-FR3000
FCC ID: AFJ236702
(Class II Permissive Change)

Applicant: **ICOM Incorporated**
1-1-32, Kamiminami
Hirano-ku, Osaka
Japan, 547-0003

Tested in Accordance With

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

UltraTech's File No.: ICOM-078FCC90

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: Dec. 24, 2003	
Report Prepared by: Tri M. Luu, P.Eng. Issued Date: Dec. 24, 2003	Tested by: Wayne Wu, RFI Engineer Test Dates: Dec. 21-23, 2003

- *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.*

UltraTech

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TABLE OF CONTENTS

EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Parts 2 and 90
Title:	Telecommunication - Code of Federal Regulations, CFR 47, Parts 2 & 90
Purpose of Test:	To obtain FCC Class II Permissive Authorization for Radio operating in the Frequency Band 150 - 174 MHz (12.5 kHz and 25 kHz Channel Spacings).
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with TIA/EIA Standard TIA/EIA- 603 (01-Nov-2002) - Land Mobile FM or PM Communications Equipment Measurement and Performance Standards.
Class II Permissive Changes:	the RF Power module and 2 resistors of the PA final stage are changed. Otherwise, this updated model is identical in performance to model IC-FR3000.

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

None

1.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2002	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 16-1	1999	Specification for Radio Disturbance and Immunity measuring apparatus and methods
TIA/EIA 603, Edition B	01-Nov-2002	Land Mobile FM or PM Communications Equipment Measurement and Performance Standards

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Icom Incorporated
Address:	1-1-32, Kamiminami Hirano-ku, Oaska Japan, 547-0003
Contact Person:	Mr. Takashi Aoki Phone #: +81-66-793-5302 Fax #: +81-66-793-0013 Email Address: export@icom.co.jp

MANUFACTURER	
Name:	Icom Incorporated
Address:	1-1-32, Kamiminami Hirano-ku, Oaska Japan, 547-0003
Contact Person:	Mr. Takashi Aoki Phone #: +81-66-793-5302 Fax #: +81-66-793-0013 Email Address: export@icom.co.jp

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:	ICOM Incorporated
Product Name:	VHF FM REPEATER
Model Name or Number:	IC-FR3000
Serial Number:	0000011
Type of Equipment:	Non-broadcast Radio Communication Equipment
External Power Supply:	N/A
Transmitting/Receiving Antenna Type:	Non-integral
Primary User Functions of EUT:	Fixed, base voice radio communication

2.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	Fixed, base station VHF Repeater
Intended Operating Environment:	Commercial, Light Industry & Heavy Industry
Power Supply Requirement:	117 V 60 Hz / 13.6 Vdc
RF Output Power Rating:	50 Watts Hi and 10 Watts Lo
Operating Frequency Range:	150 - 174 MHz
Number of Channels	32
Output Impedance (RF):	50 Ohms
Channel Spacing:	12.5 kHz and 25 kHz
Occupied Bandwidth (99%):	• 9.3 kHz (for 12.5 kHz Channel Spacing) • 13.9 kHz (for 25 kHz Channel Spacing)
Emission Designation*:	11K0F3E and 16K0F3E
Input Impedance (MIC)	600 Ohms
Antenna Connector Type:	BNC (female)

* 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 = 2.5 KHz max., K = 1, M = 3 KHz
B_n = 2M + 2DK = 2(3) + 2(2.5)(1) = **11 KHz**
emission designation: 11K0F3E

Channel Spacing = 25 KHz, D = 5 KHz max., K = 1, M = 3 KHz
B_n = 2M + 2DK = 2(3) + 2(5)(1) = **16 KHz**
emission designation: 16K0F3E

RECEIVER	
Power Supply Requirement:	117 V 60 Hz / 13.6 Vdc
Operating Frequency Range:	150 - 174 MHz
Number of Channels	32
RF Output Impedance (RF):	50 Ohms
Input Impedance (SP)	600 Ohms
Audio Output Power (Resistive Load)	2.5 W (4 ohms)
Intermediate Frequencies:	1st: 31.65 MHz and 2nd: 455 kHz

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	Transmit Antenna Port (TX/TX-RX)	1	N	Shielded
2	RF Receive Antenna RX Port (50 ohms)	1	N	Shielded
3	External Speaker (EXT SP) Port	1	Jack	Non-shielded
4	Remote Port	1	RJ-45	Non-shielded
5	ACC (Accessory/Remote Control))	1	DB25	Shielded
6	Microphone/Speaker [MIC/SP] Port	1	RJ-11	Non-shielded
7	Telco Line	1	RS-11	Non-shielded

2.5. ANCILLARY EQUIPMENT

2 x Microphones

2.6. BLOCK DIAGRAM

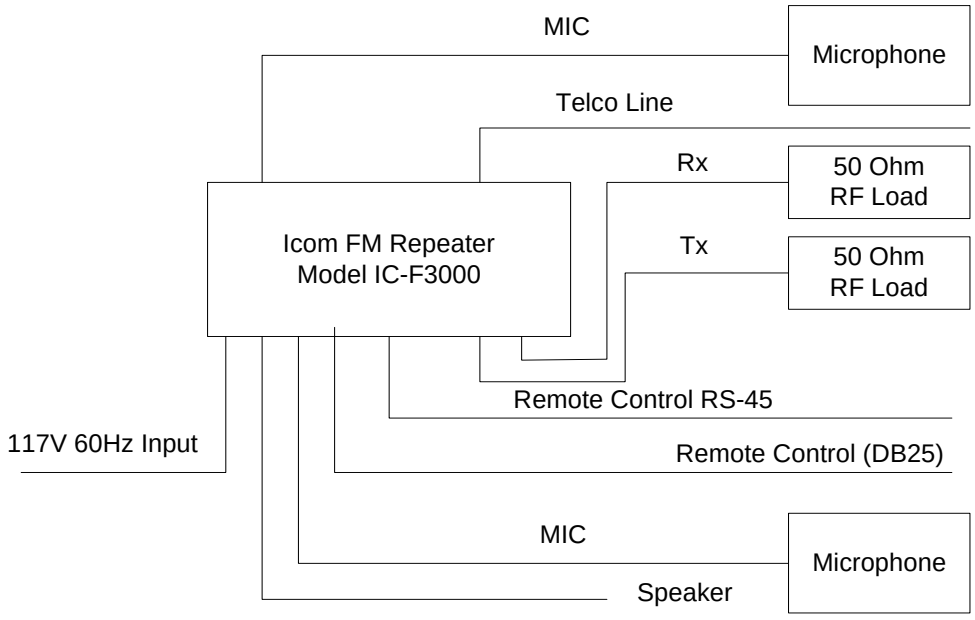


EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21°C
Humidity:	51%
Pressure:	102 kPa
Power input source:	117 V 60 Hz

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:	N/A
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): ▪ 150 - 174 MHz band:	Near lowest, near middle & near highest frequencies in each Frequency Band that the transmitter covers: ▪ 150.0, 162.0 and 174.0 MHz
Transmitter Wanted Output Test Signals: ▪ RF Power Output (measured maximum output power): ▪ Normal Test Modulation ▪ Modulating signal source:	 ▪ 50 Watts Hi and 10 Watts Lo ▪ FM Voice ▪ external

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.

- 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: Nov.04, 2003.

4.2. APPLICABILITY & SUMMARY OF EMISSION TEST RESULTS

FCC PARAGRAPH.	TEST REQUIREMENTS	APPLICABILITY (YES/NO)
90.205 & 2.1046	RF Power Output	Yes
1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	Note (1)
90.213 & 2.1055	Frequency Stability	Note (1)
90.242(b)(8) & 2.1047(a)	Audio Frequency Response	Note (1)
90.210 & 2.1047(b)	Modulation Limiting	Note (1)
90.210 & 2.1049	Emission Limitation & Emission Mask	Note (1)
90.210, 2.1057 & 2.1051	Emission Limits - Spurious Emissions at Antenna Terminal	Yes
90.210, 2.1057 & 2.1053	Emission Limits - Field Strength of Spurious Emissions	Yes
90.214	Transient Frequency Behavior	Note (1)
VHF FM REPEATER, **Model No.: IC-FR3000**, by **ICOM Incorporated** has also been tested and found to comply with **FCC Part 15, Subpart B - Radio Receivers and Class B Digital Devices**. The engineering test report has been documented and kept in file and it is available anytime upon FCC request.		

Note (1): Since the modifications have no effect on the RF output signal characteristics, these tests are not necessarily re-performed for compliance with FCC Rules.

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None

4.4. DEVIATION OF STANDARD TEST PROCEDURES

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 8 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 7 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 MANUFACTURER:

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

5.5. RF POWER OUTPUT @ FCC 2.1046 & 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

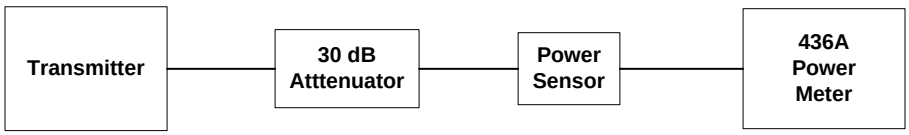
Refer to Exhibit 8, § 8.1 (Conducted) and 8.2 (Radiated) of this report for measurement details

5.5.3. 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.
Attenuator(s)	Bird	…	…	DC – 22 GHz
Power Meter	Hewlett Packard	436A	1725A02249	10 kHz – 50 GHz, sensor dependent
Power Sensor	Hewlett Packard	8481A	2702A68983	10 MHz – 18 GHz

5.5.4. Test Arrangement

- Power at RF Power Output Terminals



5.5.5. Test Data

5.5.6. Transmitter RF Power at the Antenna Port wrt. 117 V 60 Hz supply

Transmitter Channel Output	Fundamental Frequency (MHz)	Measured (Average) Power (Watts)	Power Rating (Watts)
Power setting: High			
Lowest	150.0	50.9	50
Middle	162.0	50.9	50
Highest	174.0	50.7	50
Power setting: Low			
Lowest	150.0	10.5	10
Middle	162.0	10.5	10
Highest	174.0	10.4	10

5.5.7. Transmitter RF Power at the Antenna Port wrt. 13.6 Vdc

Transmitter Channel Output	Fundamental Frequency (MHz)	Measured (Average) Power (Watts)	Power Rating (Watts)
Power setting: High			
Lowest	150.0	50.9	50
Middle	162.0	50.9	50
Highest	174.0	50.7	50
Power setting: Low			
Lowest	150.0	10.5	10
Middle	162.0	10.5	10
Highest	174.0	10.4	10

Remarks: Since there is no change in RF output powers with either AC or DC supplies, the following tests will be conducted with 117 V 60 Hz

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

5.6.1. Limits @ 90.210

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

FCC Rules	Frequency Range	Attenuation Limit (dBc)
90.210(b)&(c) – Voice & data	10 MHz to Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	43+10*log(P) or -13 dBm
90.210(d) – Voice & data	10 MHz to Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	50+10*log(P) or -20 dBm or 70 dBc whichever is less

Note; The most stringent limit of 50+10log(P) is applied for the worst case.

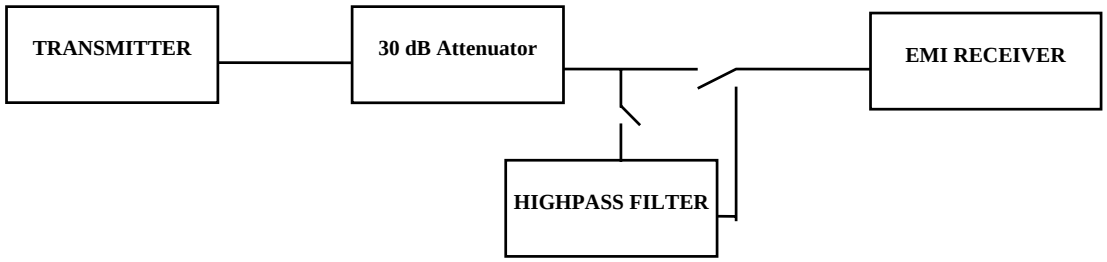
5.6.2. Method of Measurements

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

5.6.3. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
EMI Receiver/ 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
Highpass Filter, Microphase	Microphase	CR220HID	IITI11000AC	Cut-off Frequency at 600 MHz, 1.3 GHz or 4 GHz

5.6.4. Test Arrangement



5.6.5. Test Data

Note: Since there was no difference in spurious/harmonic emissions based on our prescans, the rf spurious/harmonic emissions in this section would be performed for 12.5 kHz Channel Spacing and the lower Limit of 50 + 10*log(P) would be applied for worst case.

5.6.5.1. Lowest Frequency at Low Output Power (Tx Freq: 150.0 MHz, RF Output Power 10.5 Watts (low), Modulation: FM with 2.5 kHz Sine Wave Signal, Channel Spacing Setting: 12.5 kHz)

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	(dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
150.0	40.2	--	--	--	--
10 – 2000	**	**	-60.2	**	PASS
The emissions were scanned from 10 MHz to 2 GHz. All emissions less than 20 dB below the limits were found. Please refer to Plots 1 and 2 for detailed measurements.					

5.6.5.2. Middle Frequency at Low Output Power (Tx Freq: 162.0 MHz, RF Output Power 10.5 Watts (low), Modulation: FM with 2.5 kHz Sine Wave Signal, Channel Spacing Setting: 12.5 kHz)

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	(dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
162.0	40.2	--	--	--	--
10 – 2000	**	**	-60.2	**	PASS
The emissions were scanned from 10 MHz to 2 GHz. All emissions less than 20 dB below the limits were found. Please refer to Plots 3 and 4 for detailed measurements.					

5.6.5.3. Highest Frequency at Low Output Power (Tx Freq: 174.0 MHz, RF Output Power 10.4 Watts (low), Modulation: FM with 2.5 kHz Sine Wave Signal, Channel Spacing Setting: 12.5 kHz)

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	(dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
174.0	40.2	--	--	--	--
10 – 2000	**	**	-60.2	**	PASS
The emissions were scanned from 10 MHz to 2 GHz. All emissions less than 20 dB below the limits were found. Please refer to Plots 5 and 6 for detailed measurements.					

5.6.5.4. Lowest Frequency at High Output Power (Tx Freq: 150.0 MHz, RF Output Power 50.9 Watts (high), Modulation: FM with 2.5 kHz Sine Wave Signal, Channel Spacing Setting: 12.5 kHz)

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	(dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
150.0	47.1	--	--	--	--
300.0	-38.0	-85.1	-67.1	-18.0	PASS
The emissions were scanned from 10 MHz to 2 GHz. All emissions less than 20 dB below the limits were found. Please refer to Plots 7 and 8 for detailed measurements.					

5.6.5.5. Middle Frequency at High Output Power (Tx Freq: 162.0 MHz, RF Output Power 50.9 Watts (high), Modulation: FM with 2.5 kHz Sine Wave Signal, Channel Spacing Setting: 12.5 kHz)

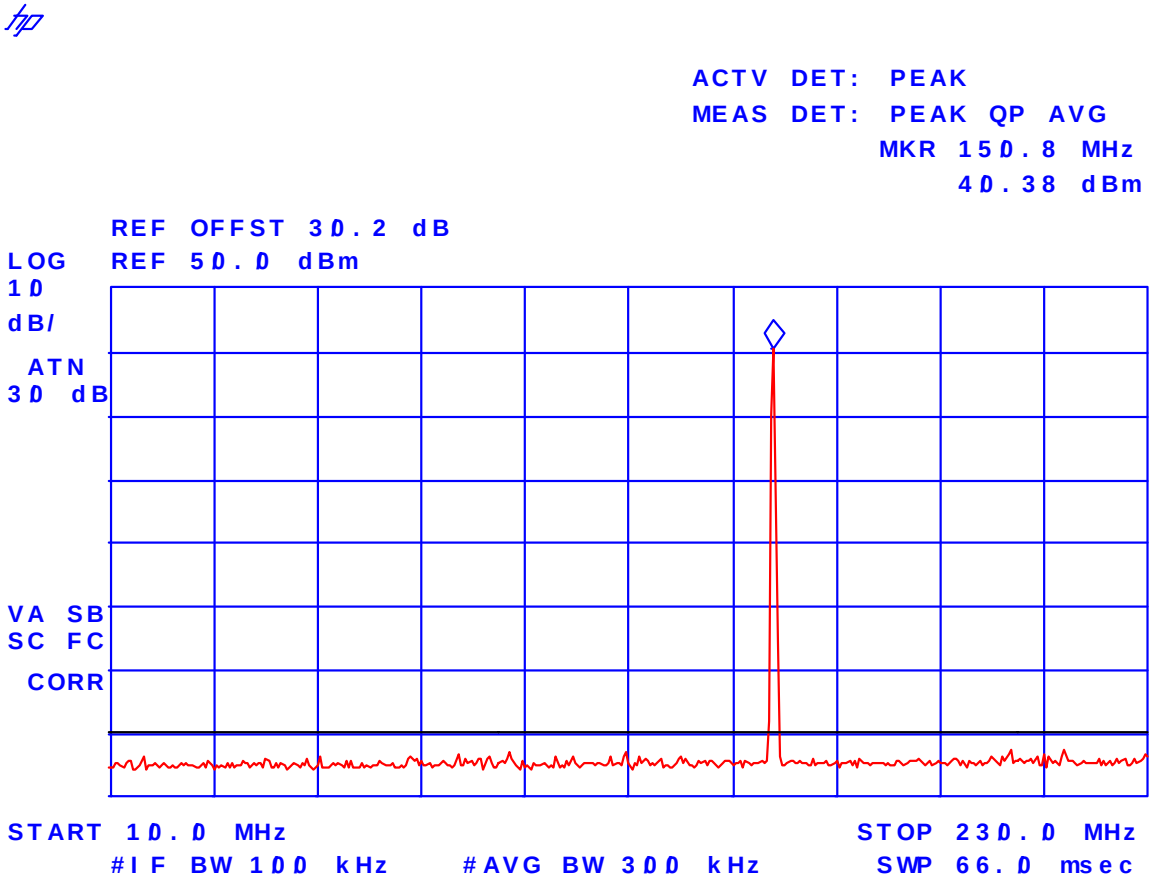
FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	(dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
162.0	47.1	--	--	--	--
324.0	-34.6	-81.7	-67.1	-14.6	PASS
The emissions were scanned from 10 MHz to 2 GHz. All emissions less than 20 dB below the limits were found. Please refer to Plots 9 and 10 for detailed measurements.					

5.6.5.6. Highest Frequency at High Output Power (Tx Freq: 174.0 MHz, RF Output Power 50.7 Watts (high), Modulation: FM with 2.5 kHz Sine Wave Signal, Channel Spacing Setting: 12.5 kHz)

FREQUENCY (MHz)	TRANSMITTER CONDUCTED ANTENNA EMISSIONS (dBm)	(dBc)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
174.0	47.1	--	--	--	--
348.0	-26.5	-73.6	-67.1	-6.5	PASS
522.0	-31.8	-78.1	-67.1	-11.0	
The emissions were scanned from 10 MHz to 2 GHz. All emissions less than 20 dB below the limits were found. Please refer to Plots 11 and 12 for detailed measurements.					

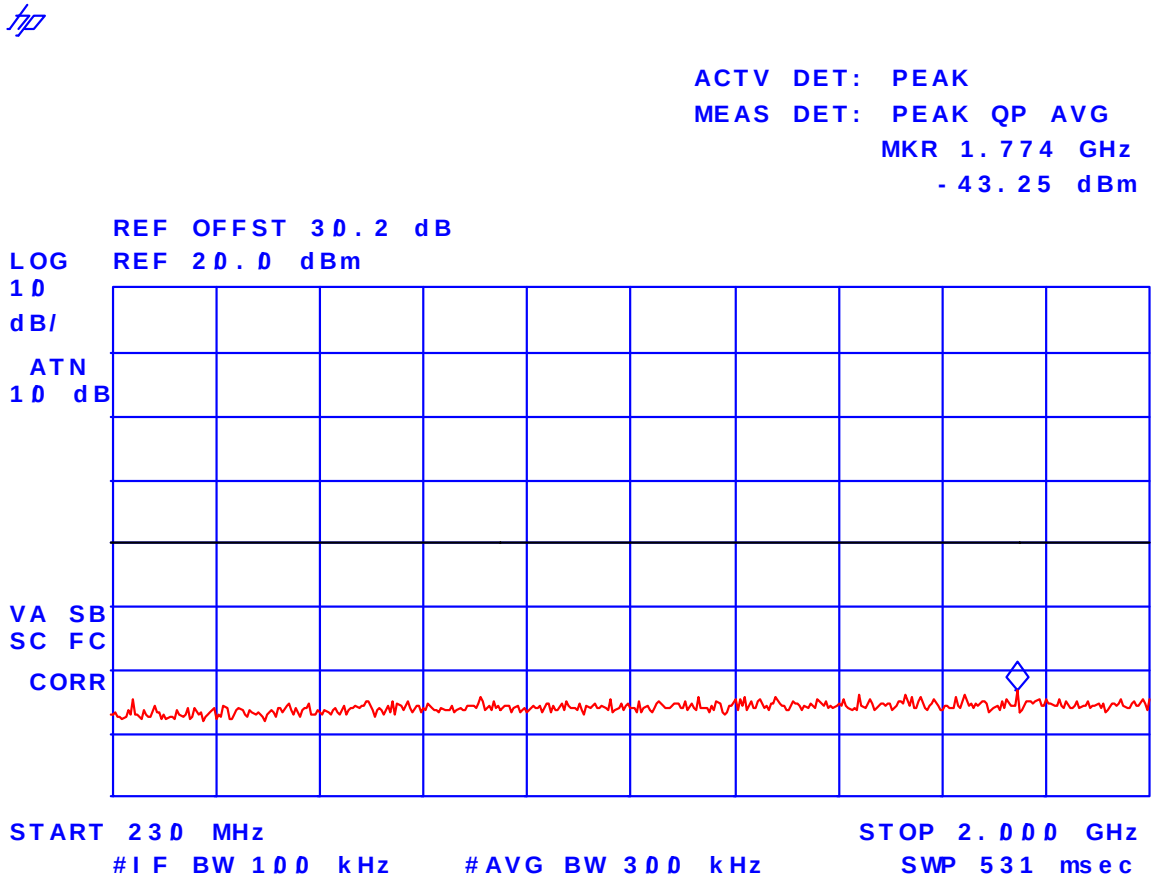
Plot # 1: Transmitter Antenna Power Conducted Emissions

Tx Frequency: 150.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 10.5 Watts (low)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



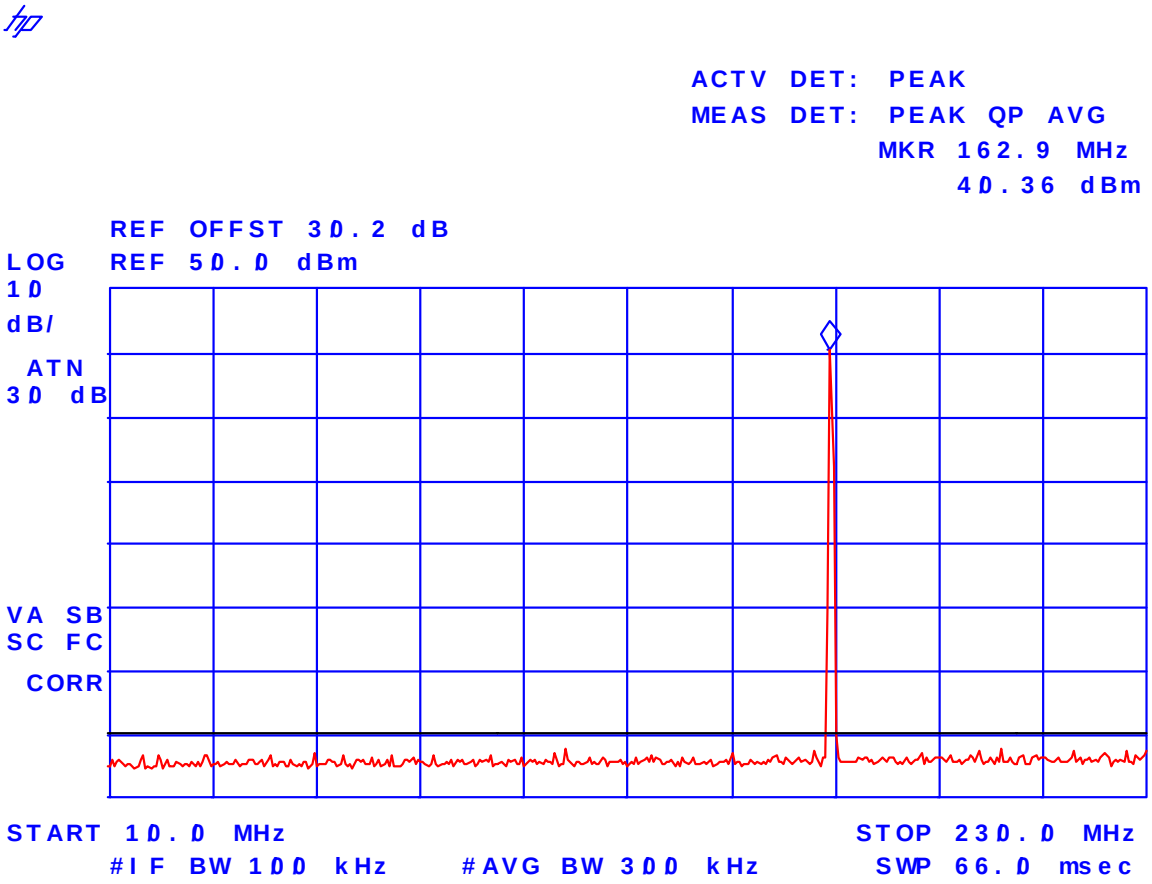
Plot # 2: Transmitter Antenna Power Conducted Emissions

Tx Frequency: 150.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 10.5 Watts (low)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



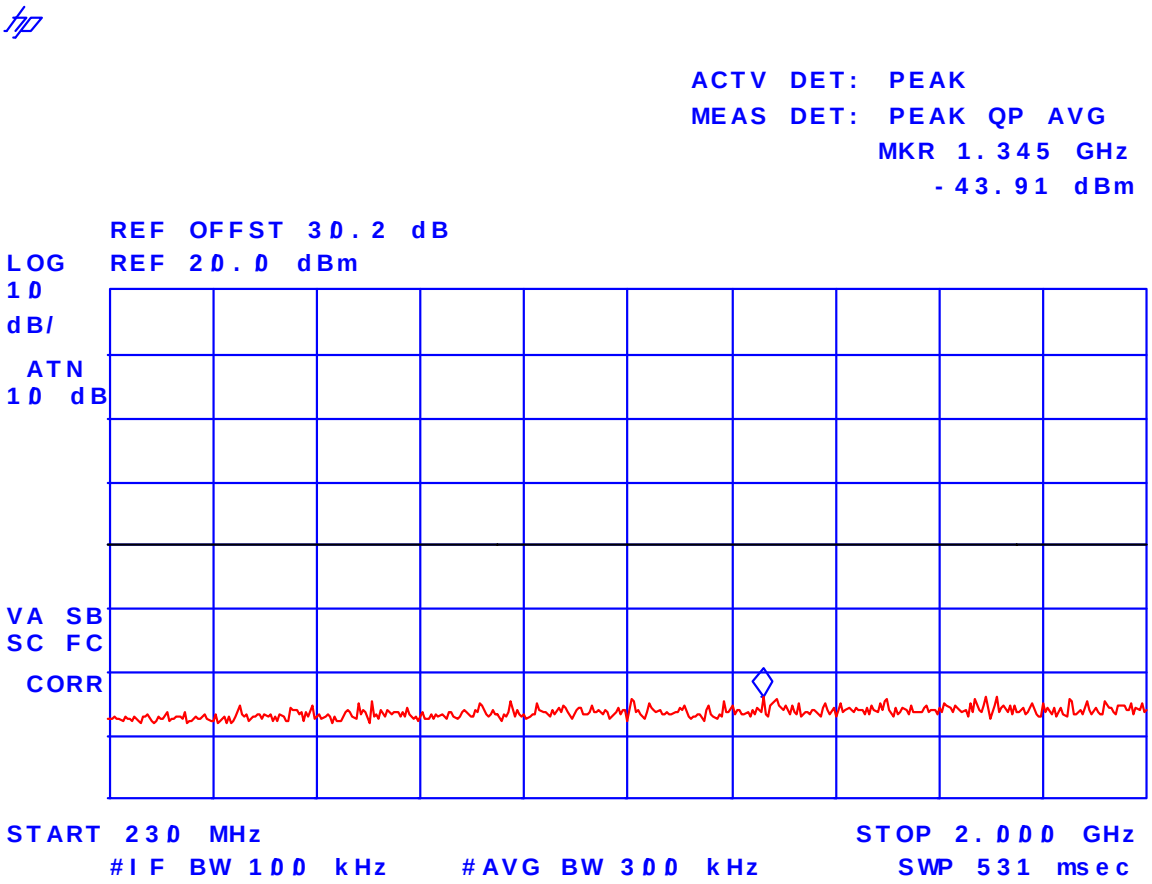
Plot # 3: Transmitter Antenna Power Conducted Emissions

Tx Frequency: 162.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 10.5 Watts (low)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



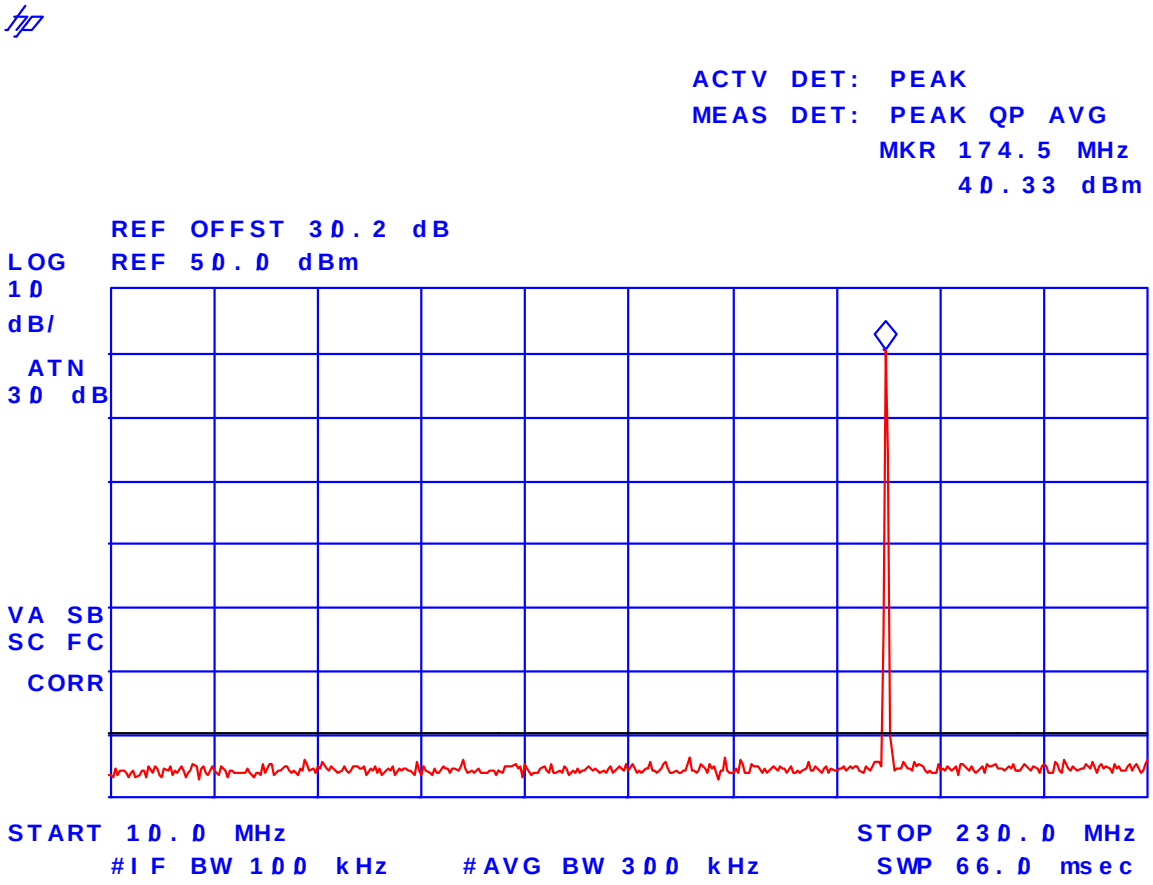
Plot # 4: Transmitter Antenna Power Conducted Emissions

Tx Frequency: 162.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 10.5 Watts (low)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



Plot # 5: Transmitter Antenna Power Conducted Emissions

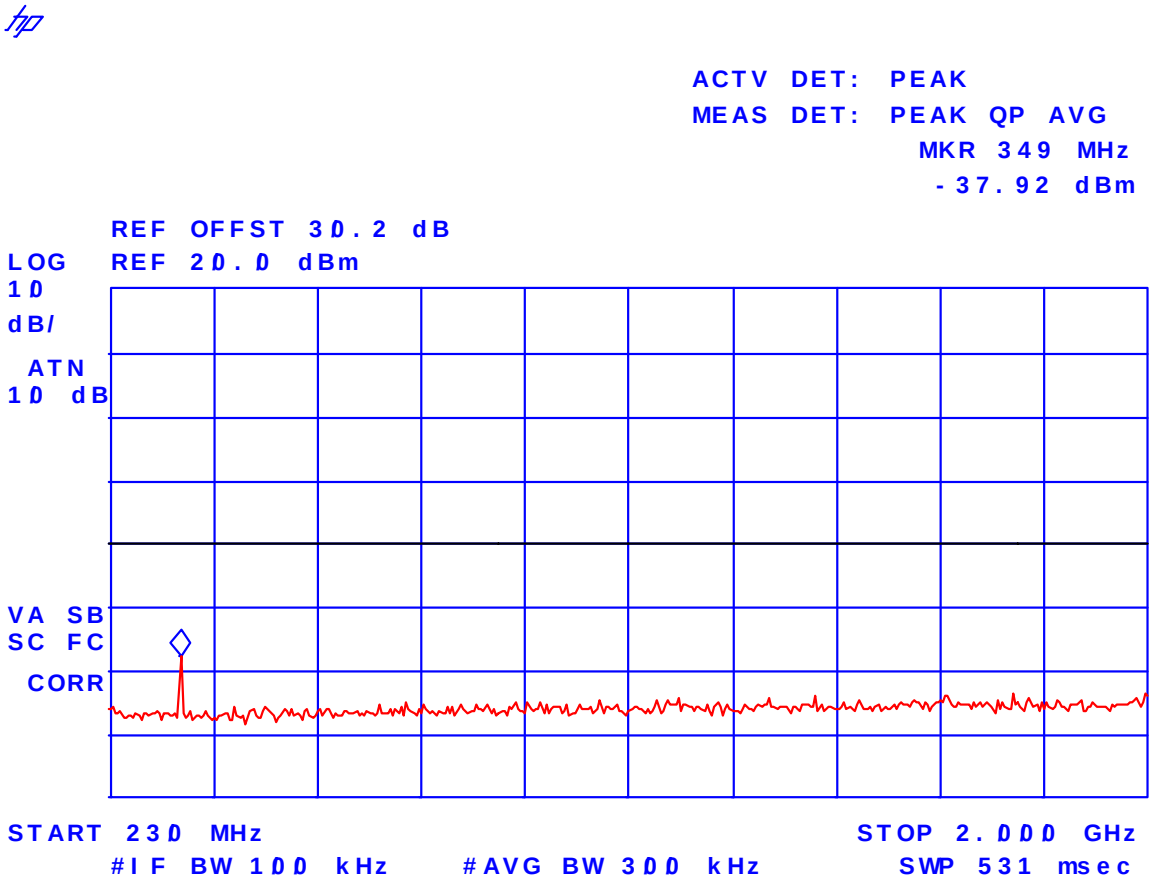
Tx Frequency: 174.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 10.4 Watts (lo)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

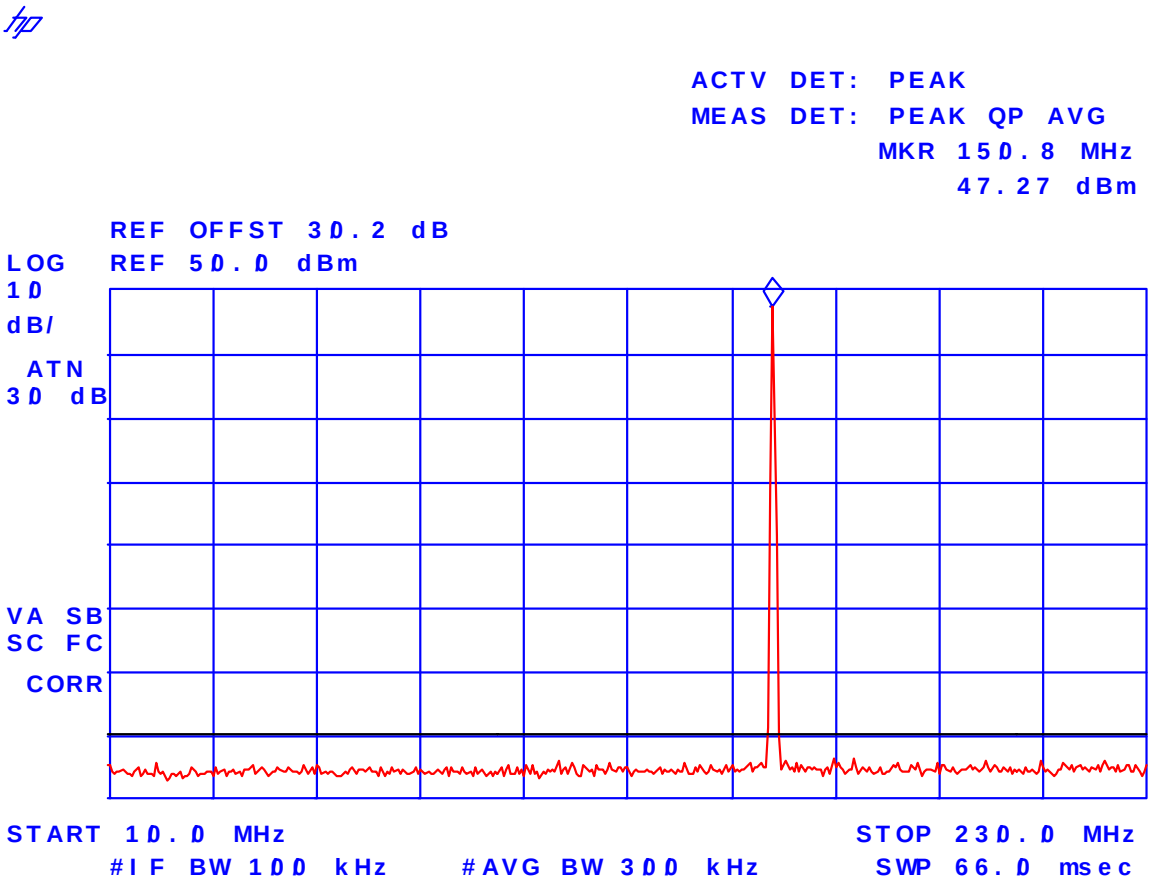
Plot # 6: Transmitter Antenna Power Conducted Emissions

Tx Frequency: 174.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 10.4 Watts (lo)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



Plot # 7: Transmitter Antenna Power Conducted Emissions

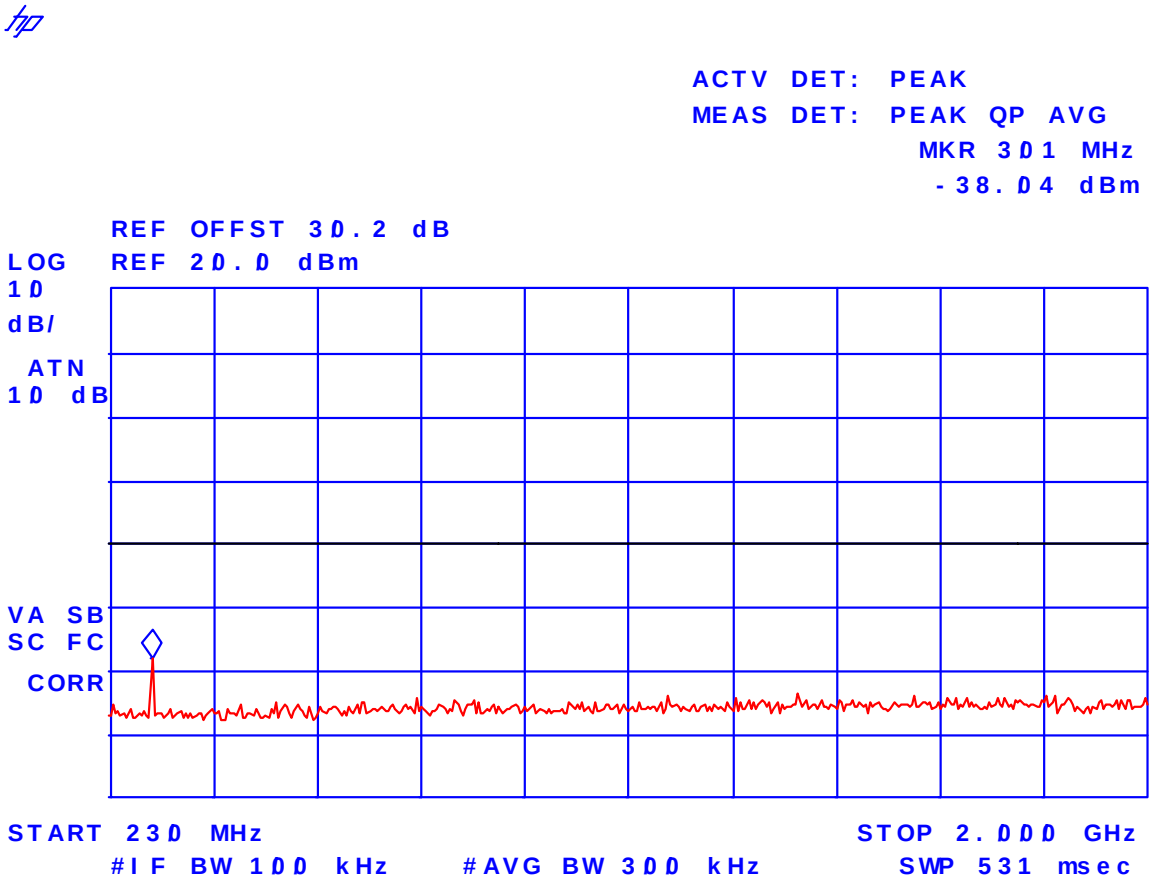
Tx Frequency: 150.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 50.9 Watts (high)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

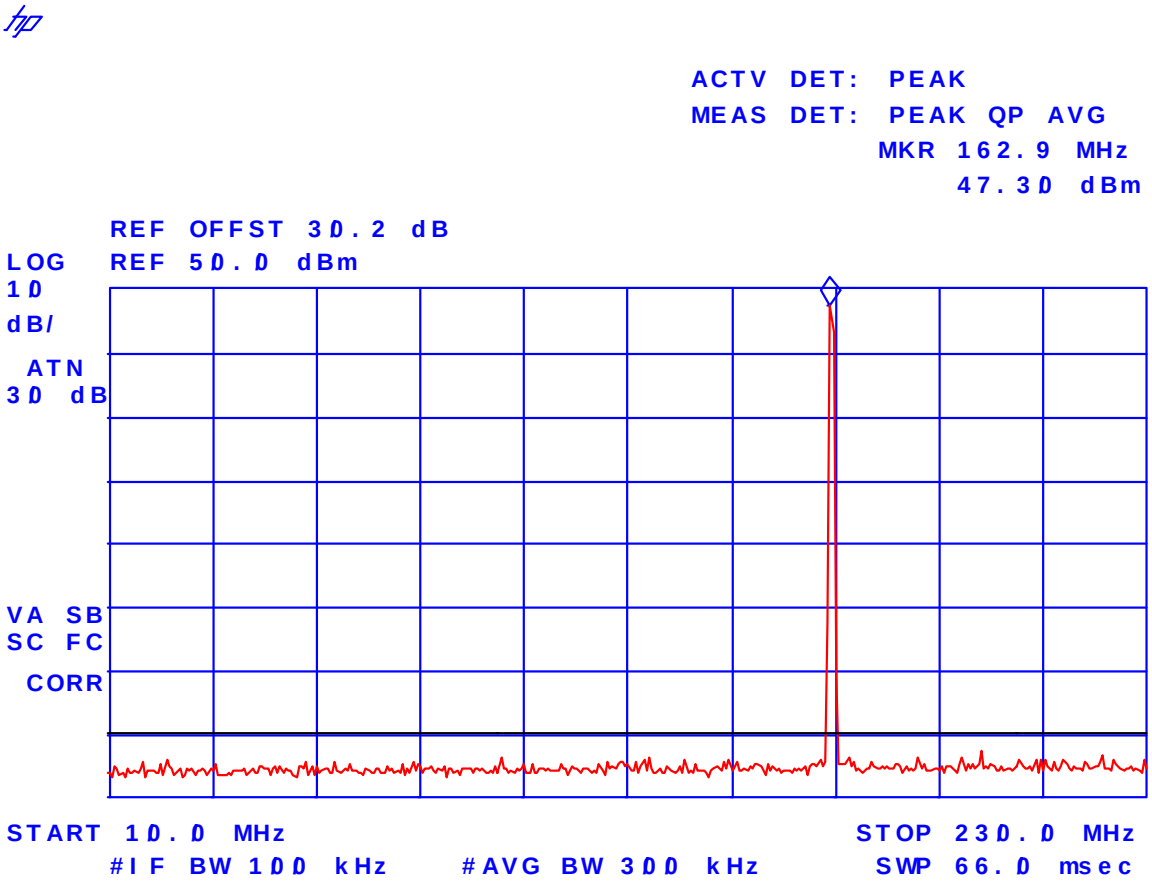
Plot # 8: Transmitter Antenna Power Conducted Emissions

Tx Frequency: 150.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 50.9 Watts (high)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



Plot # 9: Transmitter Antenna Power Conducted Emissions

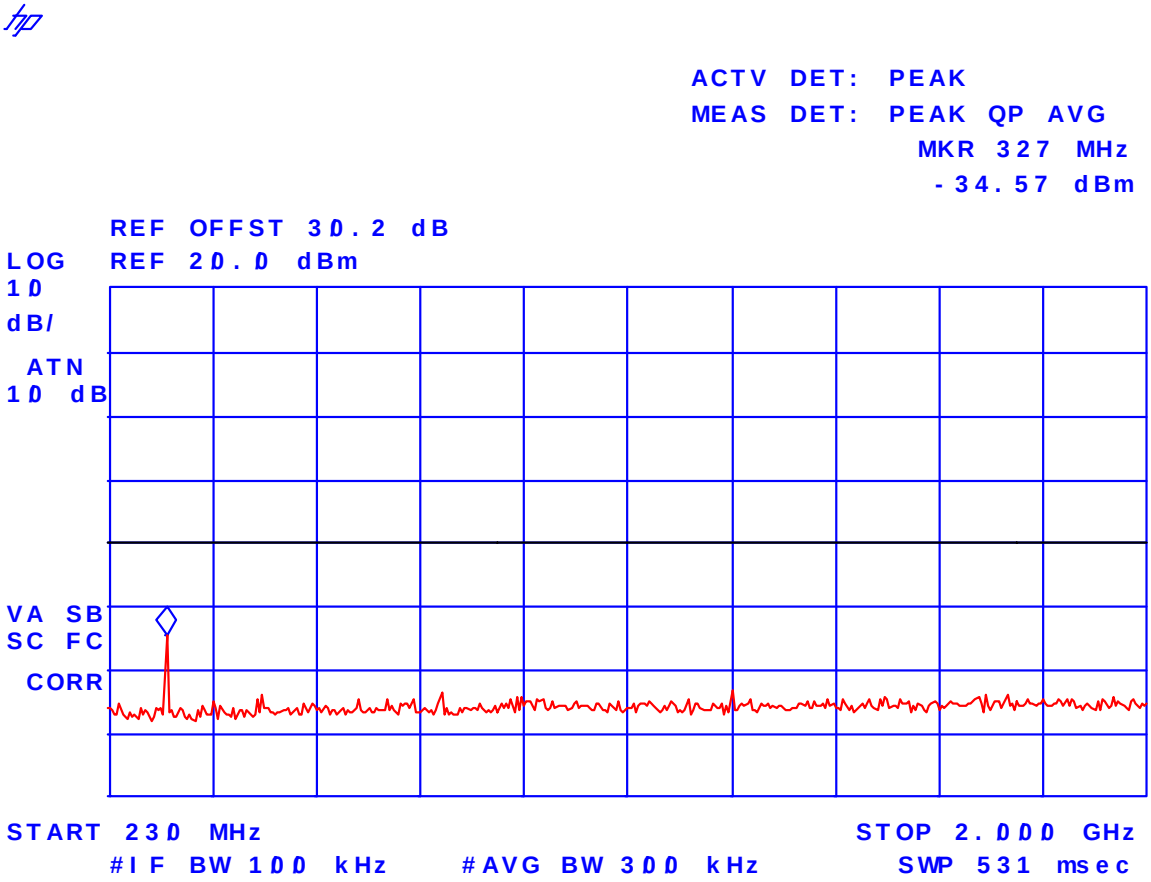
Tx Frequency: 162.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 50.9 Watts (high)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*

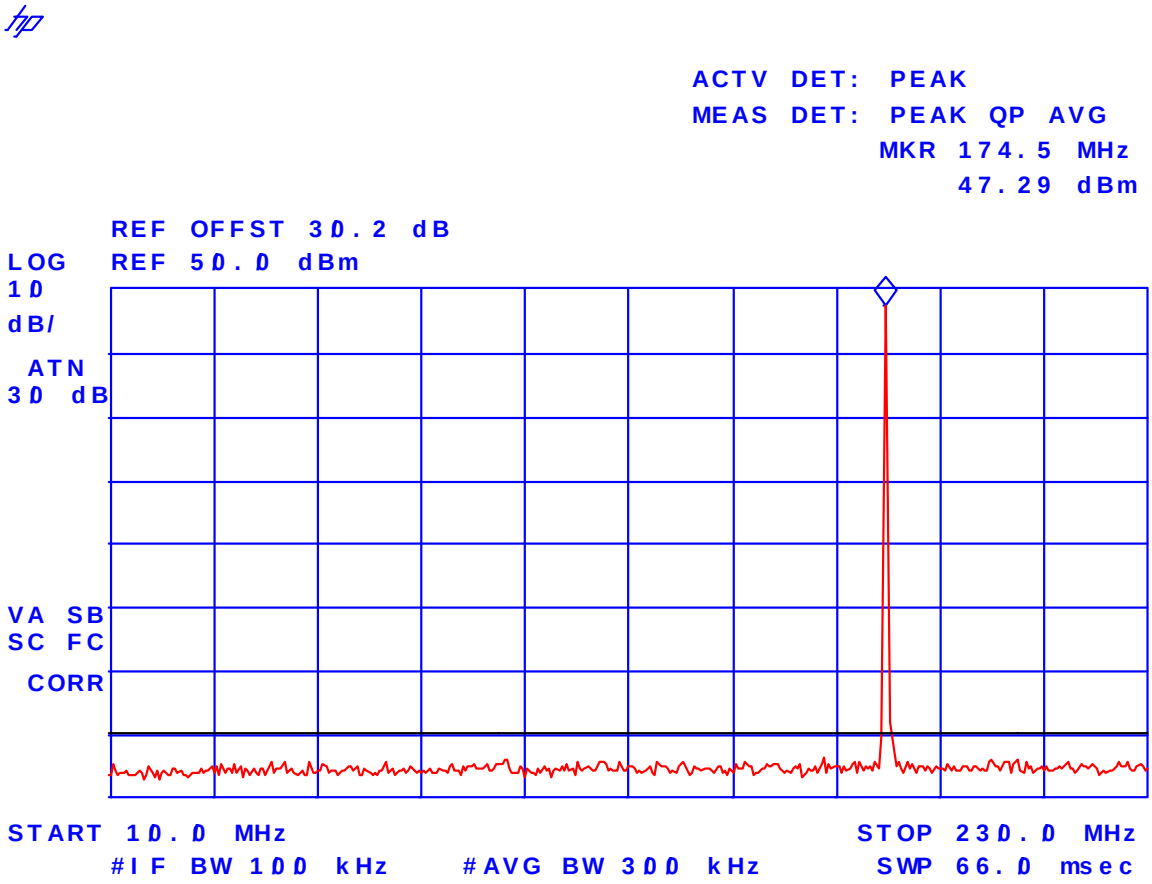
Plot # 10: Transmitter Antenna Power Conducted Emissions

Tx Frequency: 162.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 50.9 Watts (high)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



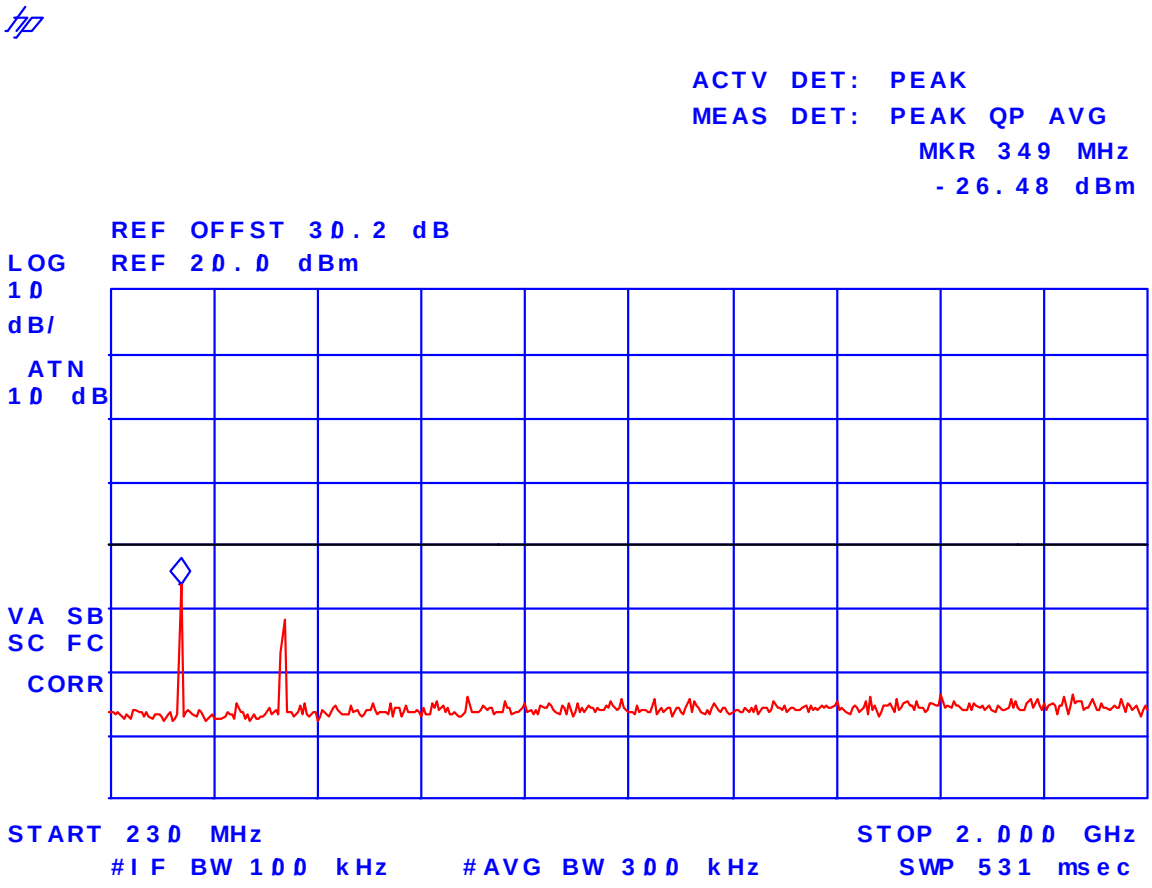
Plot # 11: Transmitter Antenna Power Conducted Emissions

Tx Frequency: 174.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 50.7 Watts (high)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



Plot # 12: Transmitter Antenna Power Conducted Emissions

Tx Frequency: 174.0 MHz, Channel Spacing: 12.5 kHz, Output Power: 50.7 Watts (high)
Modulation: FM Modulation with 2.5 kHz Sine Wave signal, Frequency Deviation: 2.3 kHz



5.7. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS @ FCC 90.210

5.7.1. 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)
90.210(b)&(c) – Voice & data	10 MHz to Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	43+10*log(P) or -13 dBm
90.210(d) – Voice & data	10 MHz to Lowest frequency of the radio to 10th harmonic of the highest frequency of the radio	50+10*log(P) or -20 dBm or 70 dBc whichever is less

5.7.2. 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)

5.7.3. 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 nomimal
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

5.7.4. Test Setup

Please refer to Photos # 1 and 2 in Annex 2 for detailed of test setup.

5.7.5. Test Data

Remarks:

- The rf spurious/harmonic emission characteristics between 2 different channel spacing operations are identical. Therefore, the following radiated emissions were performed on the radio set with 12.5 kHz Channel Spacing operation, and the results were compared with the lowest limit of 50+10*log(P in Watts) for the worst case.
- The Radiated emissions with High Power Settings were measured at 3 meters distance and represented the worst case

5.7.5.1. Lowest Frequency at High Output Power (Tx Freq: 150.0 MHz, RF Output Power 10.5 Watts (low), Modulation: FM with 2.5 kHz Sine Wave Signal, Channel Spacing Setting: 12.5 kHz)

FREQUENCY (MHz)	E-FIELD @3m (dBuV/m)	ERP measured by Substitution Method (dBm)	(dBc)	EMI DETECTOR (Peak/QP)	ANTENNA POLARIZATION (H/V)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
10 – 2000	**	**	**	PEAK	V/H	-67.1	**	PASS
** The emissions were scanned from 10 MHz to 2 GHz at 3 meters and no emissions less than 20 dB below the limits were found and recorded.								

5.7.5.2. Middle Frequency at High Output Power (Tx Freq: 162.0 MHz, RF Output Power 10.5 Watts (low), Modulation: FM with 2.5 kHz Sine Wave Signal, Channel Spacing Setting: 12.5 kHz)

FREQUENCY (MHz)	E-FIELD @3m (dBuV/m)	ERP measured by Substitution Method (dBm)	(dBc)	EMI DETECTOR (Peak/QP)	ANTENNA POLARIZATION (H/V)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
10 – 2000	**	**	**	PEAK	V/H	-67.1	**	PASS
** The emissions were scanned from 10 MHz to 2 GHz at 3 meters and no emissions less than 20 dB below the limits were found and recorded.								

5.7.5.3. Highest Frequency at High Output Power (Tx Freq: 174.0 MHz, RF Output Power 50.7 Watts (high), Modulation: FM with 2.5 kHz Sine Wave Signal, Channel Spacing Setting: 12.5 kHz)

FREQUENCY (MHz)	E-FIELD @3m (dBuV/m)	ERP measured by Substitution Method (dBm)	(dBc)	EMI DETECTOR (Peak/QP)	ANTENNA POLARIZATION (H/V)	LIMIT (dBc)	MARGIN (dB)	PASS/ FAIL
10 – 2000	**	**	**	PEAK	V/H	-67.1	**	PASS
** The emissions were scanned from 10 MHz to 2 GHz at 3 meters and no emissions less than 20 dB below the limits were found and recorded.								

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. RADIATED EMISSION MEASUREMENT UNCERTAINTY

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

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

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

EXHIBIT 7. MEASUREMENT METHODS

7.1. 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.

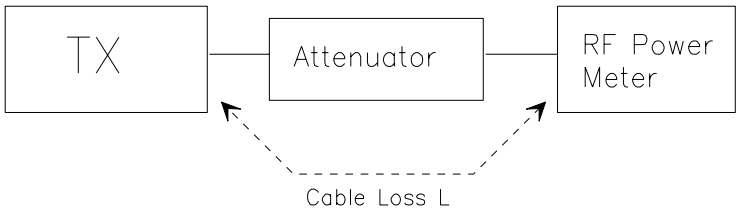
Step 2: Calculation of Average EIRP. See Figure 1

- 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.



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

7.2.1. Maximizing RF Emission Level (E-Field)

(a) The measurements was 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

7.2.2. 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

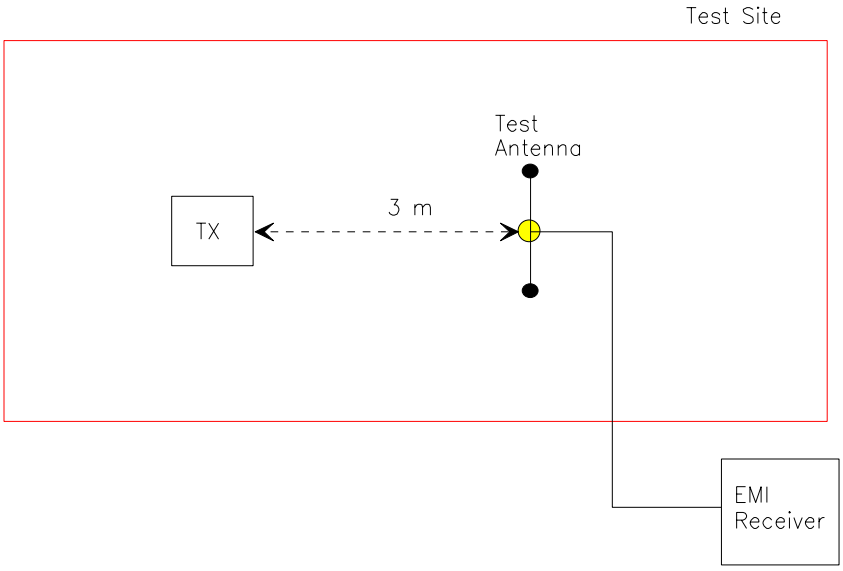
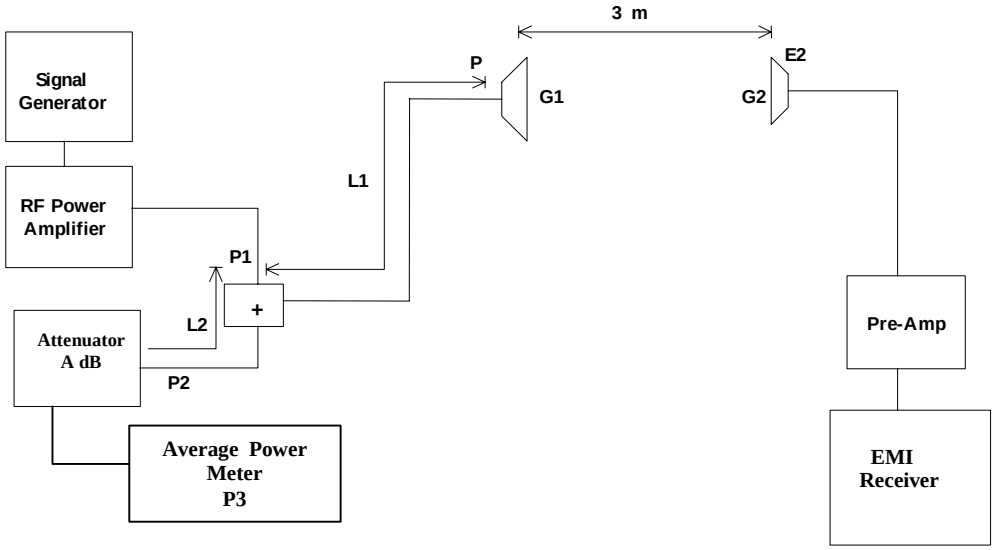


Figure 3



- *All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)*