TAIT ELECTRONICS

FCC ID:CASTEL0018
TAIT ORCA TOP-B2110

EXHIBIT 1

Engineering Report

Engineering Report

Subject : **Assessment of Compliance of Mobile Radio Equipment With Respect to FCC Rules and Regulations Parts 2 and 90 for Type Acceptance**

Product : **VHF Handportable Radio 12.5/25 kHz Channels 136 – 174 MHz RF Band**

FCC ID: CASTEL0018

Client : **TAIT Mobile Radio Inc.**

Model : **TOP-B2110 (ORCA ELAN)**

Address: 158 Anderson Avenue, Unit 5
Markham, Ontario
Canada L6E 1A9

Project #: TMRB-ORCA-TOPB2110-VHF-3043

Prepared by: ***APREL Laboratory, Regulatory Compliance Division***

Approved by: Jay Sarkar Date: Sept. 30, 1998

Jay Sarkar,
Director, Standards & Certification

Released by: Date: Sept 30/98

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Project No.: TMRB-ORCA-TOPB2110-VHF-3043
Client: TAIT Mobile Radio Inc.
Product: VHF Handportable Radio
Model: TOP-B2110
Channels: 12.5/25 kHz

ENGINEERING SUMMARY

This report contains the results of the measurements performed on a TAIT ORCA VHF 5 Watts Handportable Radio with a frequency range of 136 – 174 MHz, model TOP-B2110. The tests were carried out in accordance with FCC Rules and Regulations Part 2 and Part 90. The radio was evaluated for 5 Watts (Maximum Power) operating on both 12.5 kHz and 25 kHz channels.

Based on the test results, it is certified that the product meets the requirements as set forth in the above specifications.

The radio was tested in two configurations:

i) 12.5 kHz channel
ii) 25.0 kHz channel

Test data and graphs for both configurations are presented in this report.

This is to attest that the Tait Orca Radio, part number TOP-B2110 when operating on 12.5 kHz channel allows one voice channel in a single 12.5 kHz channel.

FCC SUBMISSION INFORMATION

FCC ID:	**CASTEL0018**
Equipment:	Handportable VHF Radio
Model:	ORCA ELAN TOP-B2110
For:	Type Acceptance
Applicant	Tait Electronics Ltd. P.O. Box 1645 558 Wairake Road Christchurch New Zealand
Manufacturer:	Tait Electronics Ltd. P.O. Box 1645 558 Wairake Road Christchurch New Zealand
U.S. Address:	Tait Electronics – USA Inc. 9434 Old Katy Road Suite 110 Houston, TX U.S.A. 77055
Test Laboratory:	APREL Laboratories 51 Spectrum Way Nepean, Ontario Canada K2R 1E6

SUMMARY OF THE TEST DATA

Test Description	Page No.	Plot No.	Test Set-up Fig. No.	Results Summary
RF Power Output Ref. Paragraph 2.985(a) & Part 90.205	12	1 – 2	1	PASS
Modulation Characteristics Ref. Paragraph 2.987 & Part 90.211	17	3 - 5	2	PASS
Occupied Bandwidth Ref. Paragraph 2.989 & Part 90.210©	26	6 – 7	3	PASS
Spurious Emissions at Antenna Ref. Paragraph 2.991 & Part 90.210(c) (3)	30	-	4	PASS
Field Strength of Spurious Radiations Ref. Paragraph 2.993 & Part 90.210 (c) (3)	34	-	5	PASS
Frequency Stability Ref. Paragraph 2.995 & Part 90.213	42	-	6	PASS
Transient Frequency Behaviour of Transmitter Ref. Paragraph 90.214	46	8 – 11	7	PASS

EQUIPMENT DESCRIPTION

EQUIPMENT TYPE: VHF Handportable Radio

MODEL: TOP-B2110

SERIAL NUMBER: 14003119

REFERENCE: FCC Part 90

MANUFACTURER: TAIT Electronics Ltd.

POWER SOURCE: Battery, NiCd 7.5 V nominal

DEVELOPMENT STAGE OF UNIT: Production

GENERAL SPECIFICATIONS

1.	Frequency Range:	136 - 174 MHz
2.	Rated Transmitted: Output Power	5 W continuous (max.)
3.	Maximum Deviation:	± 5 kHz
4.	Channel Spacing:	12.5/25 kHz (switchable)
5.	Type of Emission:	FM
6.	Antenna Connector:	SMA
7.	Antenna Impedance:	50 Ω
8.	No. of Channels:	16

FREQUENCY TESTED: 155.1 MHz

INTRODUCTION

General

This report describes the results of the tests conducted on a FM VHF mobile transceiver, model TOP-B2110 manufactured by TAIT Electronics Ltd.

Test Facility

The tests were performed for TAIT Electronics Ltd. by APREL Laboratories at APREL's EMI facility located in Nepean, Ontario, Canada. The laboratory operates an (3m and 10m) Open Area Test Site (OATS). The measurement facility is calibrated in accordance with ANSI C63.4-1992.

A description of the measurement facility in accordance with the radiated and AC line conducted test site criteria in ANSI C63.4-1992 is on file with the Federal Communications Commission and is in compliance with the requirements of Section 2.948 of the Commissions rules and regulations.

APREL's registration number is 31040/SIT (1300F2).

APREL is accredited by Standard Council of Canada, under NAPTO program (ISO Guide 25). APREL is also accredited by Industry Canada (formerly DOC) and recognised by the Federal Communications Commissions (FCC).

Standard

The evaluation and analysis were conducted in accordance with FCC Rules and Regulations Parts 2 and 90 for Type Acceptance.

Test Equipment

The test equipment used during the evaluation is listed in Appendix A. Calibration of all test equipment are performed at 12 month intervals. All equipment used is calibrated or verified in accordance with the intent of AQAP-6/MIL-STD-45662.

Environmental Conditions

Measurements were conducted under normal laboratory conditions including open area test site.

- Temperature:	23 °C ± 2
- Relative Humidity:	30 - 50 %
- Air Pressure:	105 kPa ± 3

TECHNICAL DESCRIPTION OF THE EQUIPMENT

Ref.: FCC Part 2 paragraph 2.983

Name of Applicant:
Ref.: Paragraph 2.983(a)

(i) Applicant: TAIT Mobile Radio Inc.
158 Anderson Drive
Unit 5
Markhan Ontario
Canada L6E 1A9

(ii) Manufacturer: TAIT Electronics Ltd.
558 Wairake Road
Christchurch
New Zealand

(iii) Relationship of applicant to Manufacturer: Same Company

Identification of Equipment
Ref.: Paragraph 2.983(b):

(i) Model No.: TOP-B2110
(ii) Serial No.: 14003119
(iii) FCC ID: CASTEL0018

Production Quantity:
Ref.: Paragraph 2.983 (c)

Quantity production of the model is planned.

Type of Emission:
Ref.: Paragraph 2.983 (d)(1)

12.5 kHz channel - 10K1F3E
25.0 kHz channel - 16K0F3E

Frequency Range:
Ref.: Paragraph 2.983 (d) (2)

138 – 174 MHz

Range of Operating Power Levels:
Ref.: Paragraph 2.983 (d) (3)

1 to 5 Watts dealer programmable

Maximum Power Rating:
Ref.: Paragraph 2.983(d)(4)

5 Watts

D.C. Voltages & Currents Into Final Amplifier:
Ref.: Paragraph 2.983 (d) (5)

7.2 VDC

Function of Semi-Conductors and Active Circuit Devices:
Ref.: Paragraph 2.983 (d) (6)

See TAIT Radio Service Manual.

Complete Circuit Diagram:
Ref.: Paragraph 2.983 (d) (7):

See TAIT Radio Service Manual

Instruction Book:
Ref.: Paragraph 2.983 (d) (8)

TAIT Radio Service Manual.

Tune-up Procedure at Nominal Operating Power:
Ref.: Paragraph 2.983 (d) (9)

TAIT Radio Service Manual

Circuitry and Devices for Determining and Stabilising Frequency:
Ref.: Paragraph 2.983 (d)(10)

The description of the circuitry responsible for determining and stabilising frequency can be found in TAIT Radio Service Manual.

The principal frequency reference for the system is the reference crystal oscillator located on the main board and being a part of the frequency synthesizer. The section of the working frequency is done by the frequency synthesizer on the main board and the control circuitry located on the control board.

Information about frequency allocated to every individual channel is stored in EEPROM chip.

Circuits for Suppression of Spurious Radiation, Limiting of Modulation and Limiting of Power
Ref.: Paragraph 2.983 (d)(11)

(i) Suppression of spurious radiation:

Spurious harmonics radiation is suppressed by two 5-pole low-pass filters.

(ii) Limiting of modulation:

Limiting of modulation is done using a clipping amplifier placed in the microphone amplifier section and located on the main board. Harmonics and distortion are cut-off by 3 kHz low-pass filter also on the main board.

(iii) Limiting of power:

Output power is limited by the feedback circuitry which monitors the output power and controls two last stages at the TX buffer and the first stage of the P.A.

Test Data
Ref.: Paragraph 2.983(e)

All applicable test data are provided in the section Test Results of this Engineering Report.

Equipment Identification Plate/Label
Ref.: Paragraph 2.983(f)

Equipment identification label is provided in the exhibits.

Photographs of the Equipment
Ref.: Paragraph 2.983(g)

Photographs of the equipment under test are provided in the exhibits.

TEST RESULTS

TAIT

VHF Handportable Radio

TOP-B2110

ORCA ELAN

Test: **RF Power Output**

Ref: **FCC 90 paragraph 90.205 and Part 2 paragraph 2.985(a)**

Criteria: + 1 dB and – 3 dB.

Set-up: See Figure 1

Conditions: Temperature: 23°C ±2
Voltage Supply: 7.5 V

Equipment: See Appendix A

Procedure: The radio frequency power output was measured after alignment of the transmitter, in accordance with the manufacturer's instructions The output power was measured using a CMS 52 radio service monitor with 50 Ohms termination. DC power supplied to the RF output amplifier was also measured.

Results: **Passed.** **See Tables 1 and 2**
See Plots 1 and 2

Table 1

RF Power Output Test
Transmitter Frequencies : 155.1 MHz
12.5 kHz Channel
Limit : + 1 dB and – 3 dB
Manufacturer's Rated Power Output: 5 Watts

Measured Output Power (Watts)	Margin (dB)	DC Voltage Receive Mode (V)	DC Current Receive Mode (mA)	Input Power Receive Mode (Watts)	DC Voltage Transmit Mode (V)	DC Current Transmit Mode (A)	Input Power Transmit Mode (Watts)
4.898	- 0.09	7.6	80	0.61	7.17	1.5	10.76

Table 2

RF Power Output Test
Transmitter Frequencies : 155.1 MHz
25.0 kHz Channel
Limit : + 1 dB and – 3 dB
Manufacturer's Rated Power Output: 5 Watts

Measured Output Power (Watts)	Margin (dB)	DC Voltage Receive Mode (V)	DC Current Receive Mode (mA)	Input Power Receive Mode (Watts)	DC Voltage Transmit Mode (V)	DC Current Transmit Mode (A)	Input Power Transmit Mode (Watts)
4.898	- 0.09	7.59	80	0.61	7.13	1.5	10.70

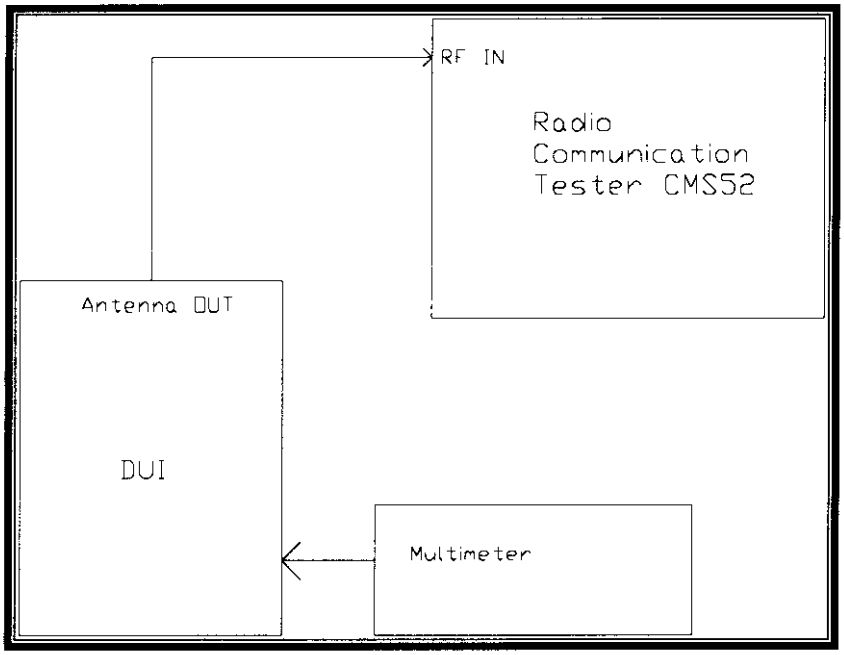
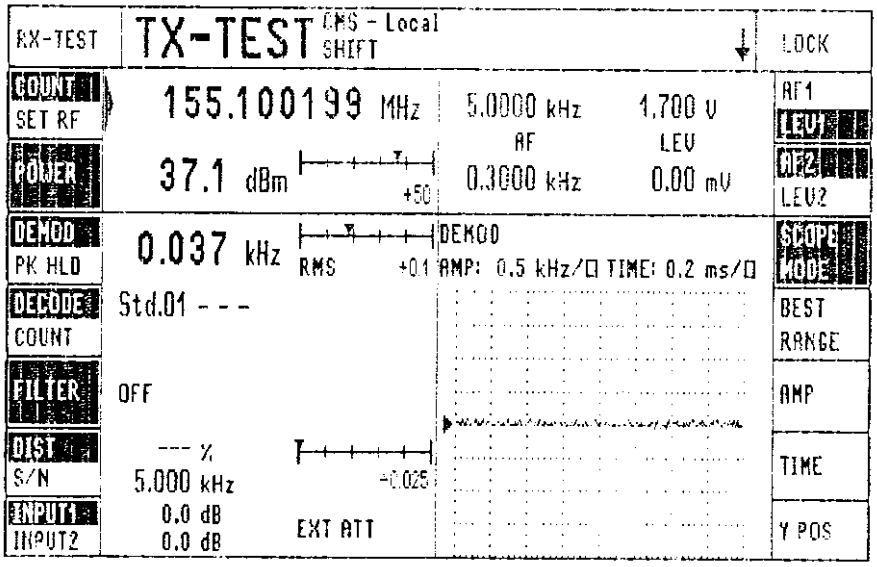


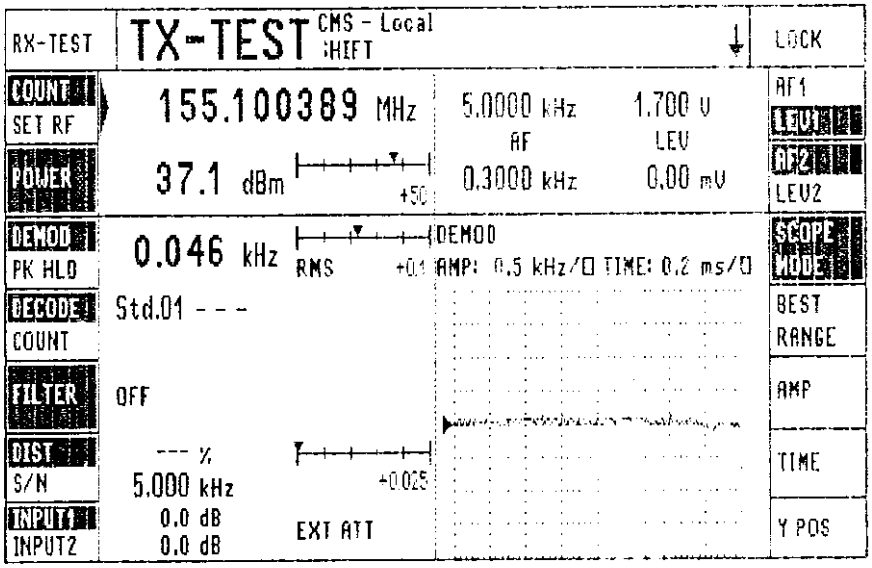
Figure 1

RF Power Output
Test Set-up



Plot 1

RF Power Output Test
12.5 kHz Channel
Frequency: 155.1 MHz



Plot 2

RF Power Output Test
25.0 kHz Channel
Frequency: 155.1 MHz

Test: **Modulation Characteristics**

Ref: **FCC Part 2 paragraph 2.987 and Part 90 paragraph**

Criteria: **See FCC Part 90 paragraph 90.211**

Set-up: See Figure 2

Conditions: Temperature: 23°C ±2
Voltage Supply: 7.5 V

Equipment: See Appendix A

Procedure: With the standard test modulation applied to the transmitter, it was then increased in one step by 16 dB and frequency deviation was measured and recorded. Modulation frequency was then varied over the range of 300 Hz to 4 kHz at appropriate increments and frequency deviation was measured and recorded. The modulation signal was applied to the microphone input. A family of curves for the frequency diviation versus the modulation input voltage is also shown.

Results: **Passed.** **See Tables 3, 4, 5, and 6**
See Plots 3, 4, and 5

Table 3

Audio Frequency Response
Transmitter Frequency : 155.1 MHz
Channel 2
12.5 kHz channels

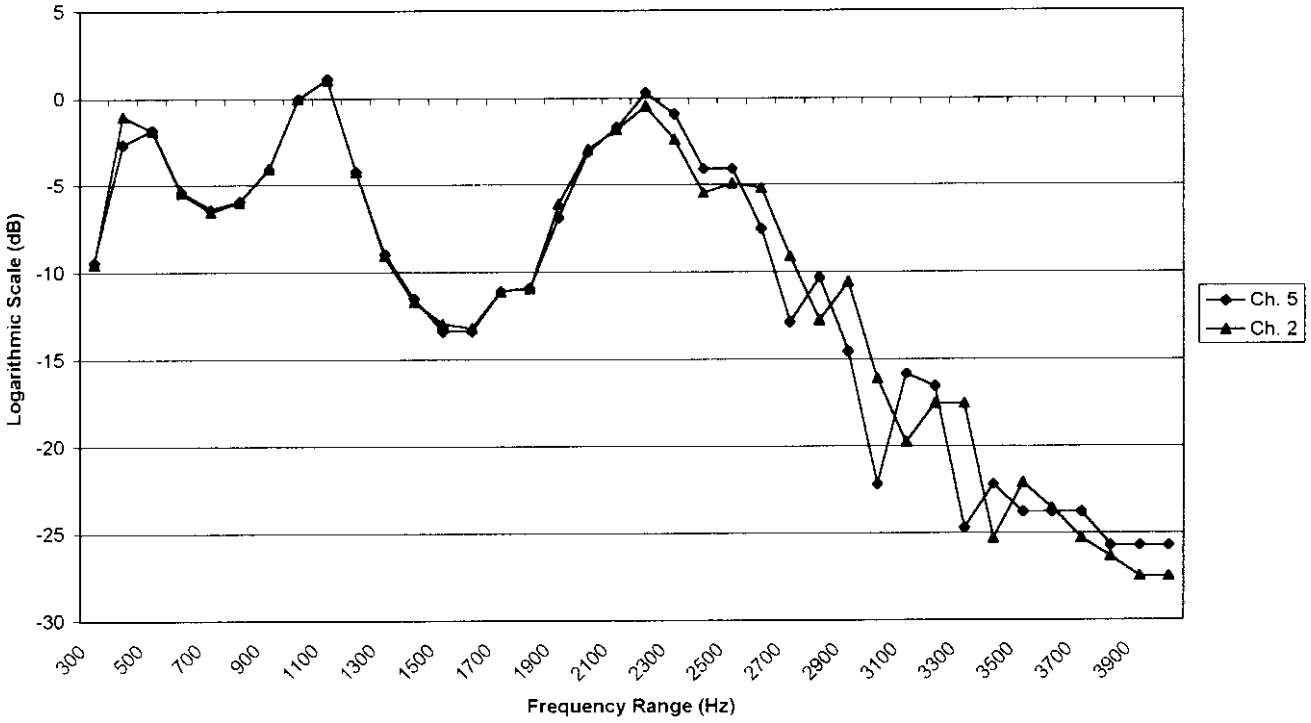
Transmitter Frequency (MHz)	FM Deviation Level (MHz)	Modulating Frequency (Hz)	Measured Demodulated Audio Level (dB)
155.1	+/- 1.0	300	- 4.8
		500	- 0.94
		700	- 3.25
		800	- 2.98
		900	+ 0.11
		1000	0 (Ref)
		1200	- 2.09
		1400	- 5.84
		1600	- 6.61
		1800	- 5.45
		2000	- 1.46
		2200	- 0.22
		2400	- 2.73
		2600	- 2.58
		2800	- 6.38
		3000	- 8.03
		3200	- 8.75
		3400	- 12.63
		3600	- 11.76
		3800	- 13.14
		4000	- 13.72

Table 4

Audio Frequency Response
Transmitter Frequency : 155.1 MHz
Channel 5
25.0 kHz channels

Transmitter Frequency (MHz)	FM Deviation Level (MHz)	Modulating Frequency (Hz)	Measured Demodulated Audio Level (dB)
155.1	+/- 1.0	300	- 4.72
		500	- 0.91
		700	- 3.18
		800	- 2.95
		900	- 2.01
		1000	0 (Ref)
		1200	- 2.10
		1400	- 5.75
		1600	- 6.70
		1800	- 5.44
		2000	- 1.54
		2200	+ 0.17
		2400	- 2.01
		2600	- 2.01
		2800	- 6.43
		3000	- 7.25
		3200	- 7.90
		3400	- 12.33
		3600	- 11.88
		3800	- 11.88
		4000	- 12.84

Modulation Characteristics
Audio Frequency Response
Logarithmic Presentation



Plot 3

Modulation Characteristics

Table 5

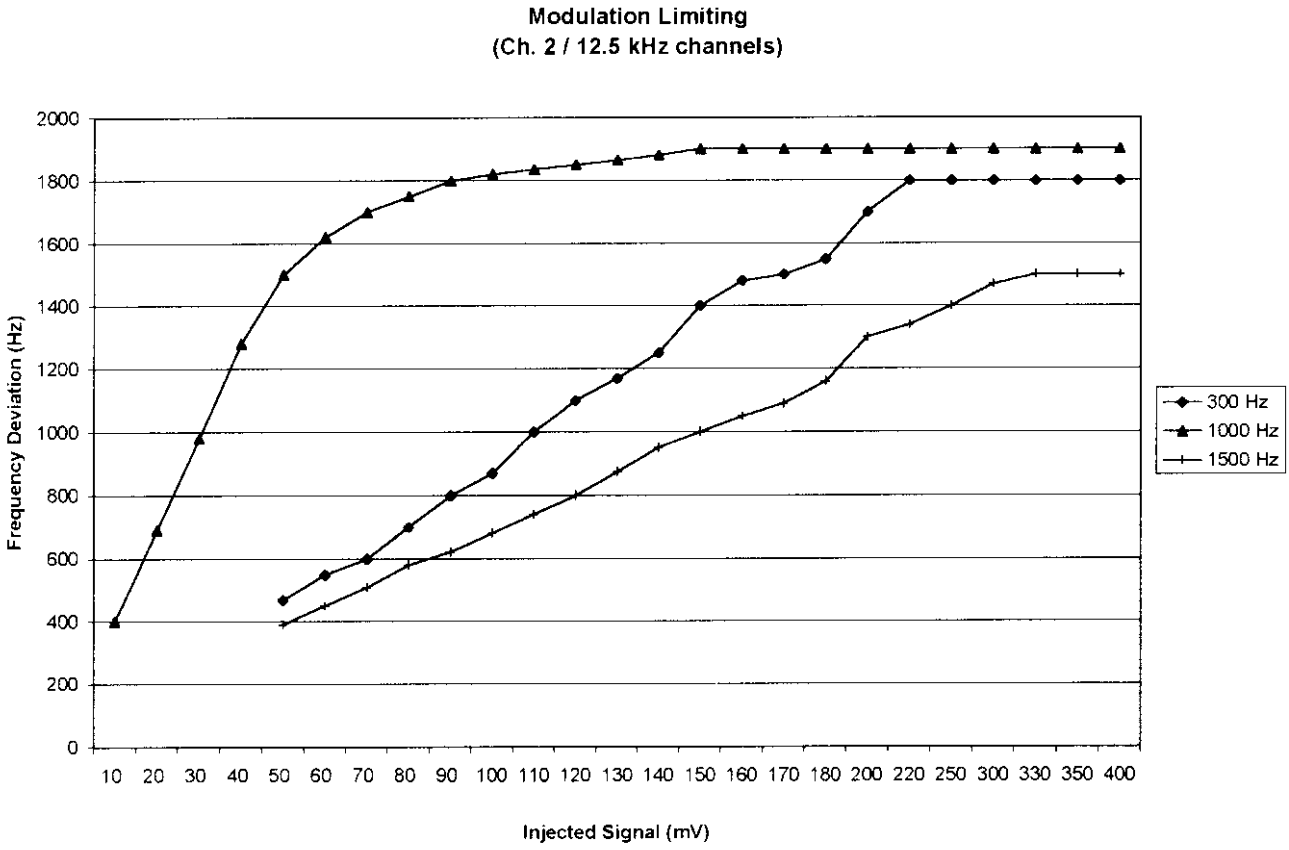
Modulation Limiting
Frequency Deviation vs. Amplitude
Transmitter Frequency : 155.1 MHz
Channel 2
12.5 kHz channels

Injected Signal (mV)	Frequency Deviation (Hz)		
	at 300 Hz	at 1000 Hz	at 1500 Hz
10	(no reading obtained)	400	(no reading obtained)
20	(no reading obtained)	690	(no reading obtained)
30	(no reading obtained)	980	(no reading obtained)
40	(no reading obtained)	1280	(no reading obtained)
50	470	1500	390
60	550	1620	450
70	600	1700	510
80	700	1750	580
90	800	1800	620
100	870	1820	680
110	1000	1835	740
120	1100	1850	800
130	1170	1865	875
140	1250	1880	950
150	1400	1900	1000
160	1480	1900	1050
170	1500	1900	1090
180	1550	1900	1160
200	1700	1900	1300
220	1800	1900	1340
250	1800	1900	1400
300	1800	1900	1470
330	1800	1900	1500
350	1800	1900	1500
400	1800	1900	1500

Table 6

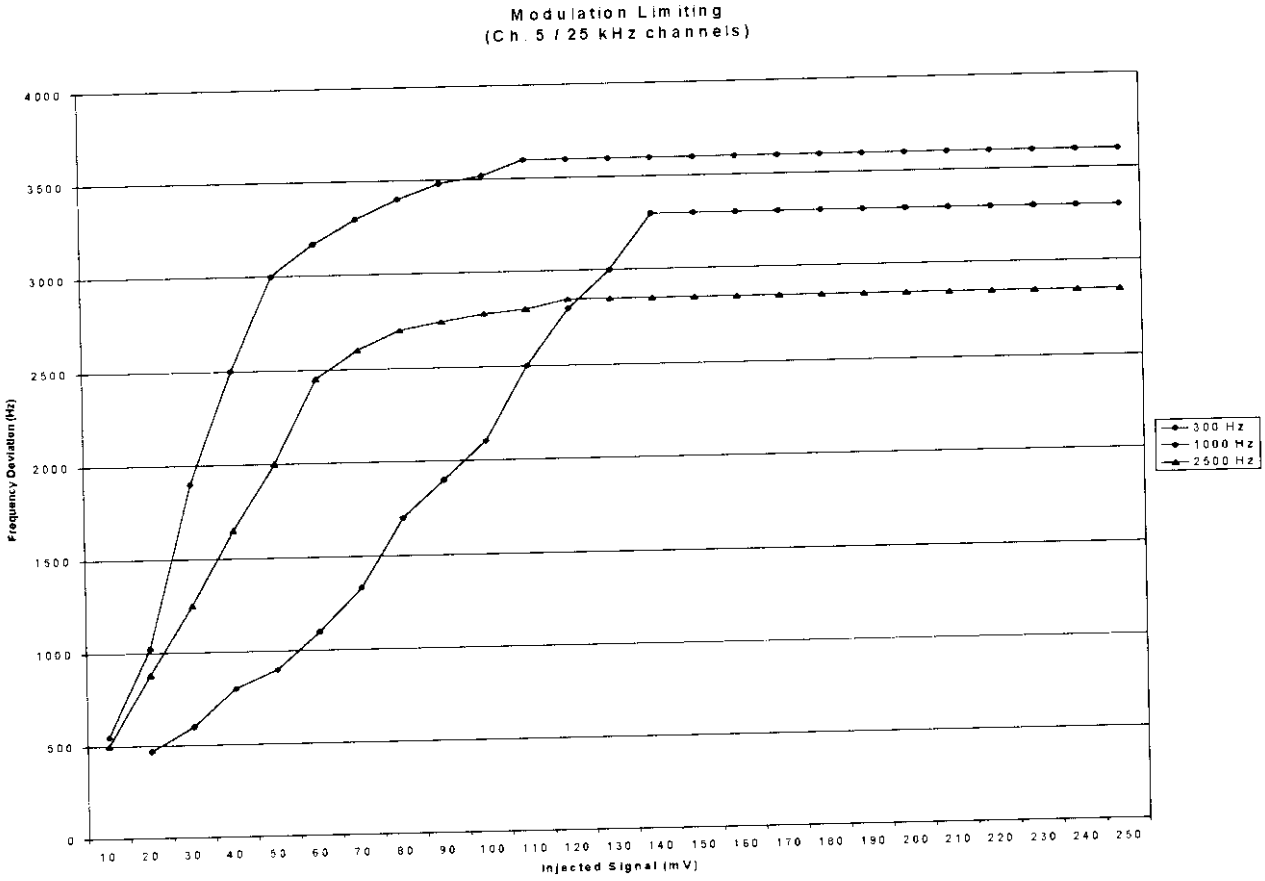
Modulation Limiting
Frequency Deviation vs. Amplitude
Transmitter Frequency : 155.1 MHz
Channel 5
25.0 kHz channels

Injected Signal (mV)	Frequency Deviation (Hz)		
	at 300 Hz	at 1000 Hz	at 1500 Hz
10	(no reading obtained)	550	500
20	470	1020	880
30	600	1900	1250
40	800	2500	1650
50	900	3000	2000
60	1100	3170	2450
70	1330	3300	2600
80	1700	3400	2700
90	1900	3480	2740
100	2100	3520	2780
110	2500	3600	2800
120	2800	3600	2850
130	3000	3600	2850
140	3300	3600	2850
150	3300	3600	2850
160	3300	3600	2850
170	3300	3600	2850
180	3300	3600	2850
190	3300	3600	2850
200	3300	3600	2850
210	3300	3600	2850
220	3300	3600	2850
230	3300	3600	2850
240	3300	3600	2850
250	3300	3600	2850



Plot 4

Modulation Characteristics



Plot 5

Modulation Characteristics

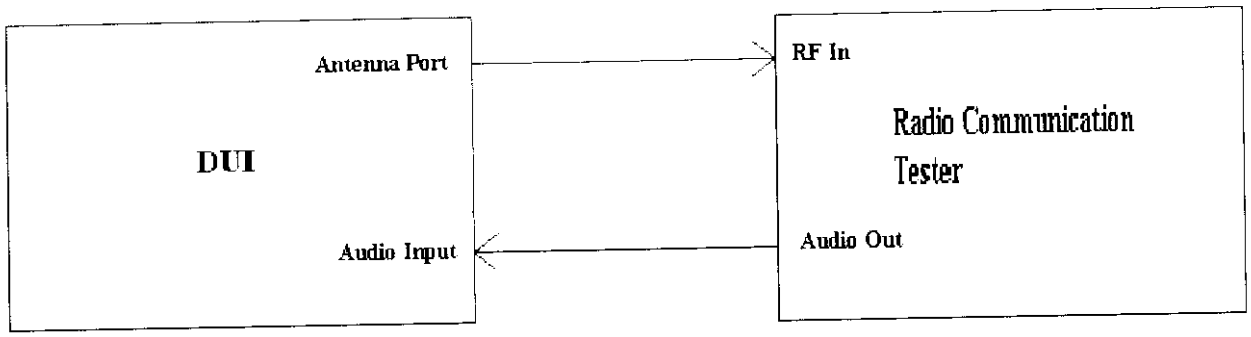


Figure 2 - Modulation Characteristic Test Setup

Test: **Occupied Bandwidth**

Ref: FCC Part 90 paragraph 90.210 (d) (b) and Part 2.989

Criteria: a) for 12.5 kHz Channel, the occupied bandwidth shall fall within ***Mask D***

b) for 25.0 kHz Channel, the occupied bandwidth shall fall within ***Mask B***.

Set-up: See Figure 3

Conditions: Temperature: 23 °C ± 2
Voltage Supply: 7.5 V

Equipment: See Appendix A.

Procedure: Occupied bandwidth was measured in accordance with the above noted paragraphs of the F.C.C. Rules and Regulations. A sample of the transmitter output was observed on a spectrum analyzer and side bands were observed up to 100 kHz each side of the centre frequency, and down to – 70 dB. According to the F.C.C. limits as specified in paragraph 90.210 of the Rules and Regulations. The test was performed at 155.1 MHz and at 12.5 kHz and 25 kHz channels at the maximum power level. The transmitter was modulated with a 2.5 kHz tone at a level 16 dB higher than was required to produce 50 % of the desired frequency deviation.

Results: **Passed. See Plots 6 and 7**

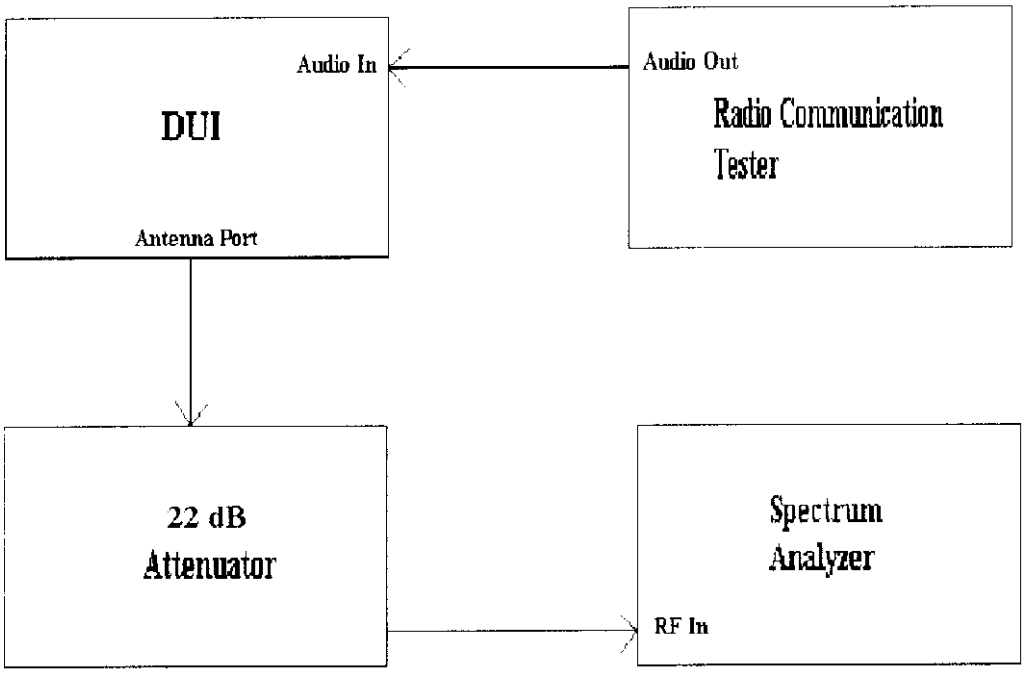
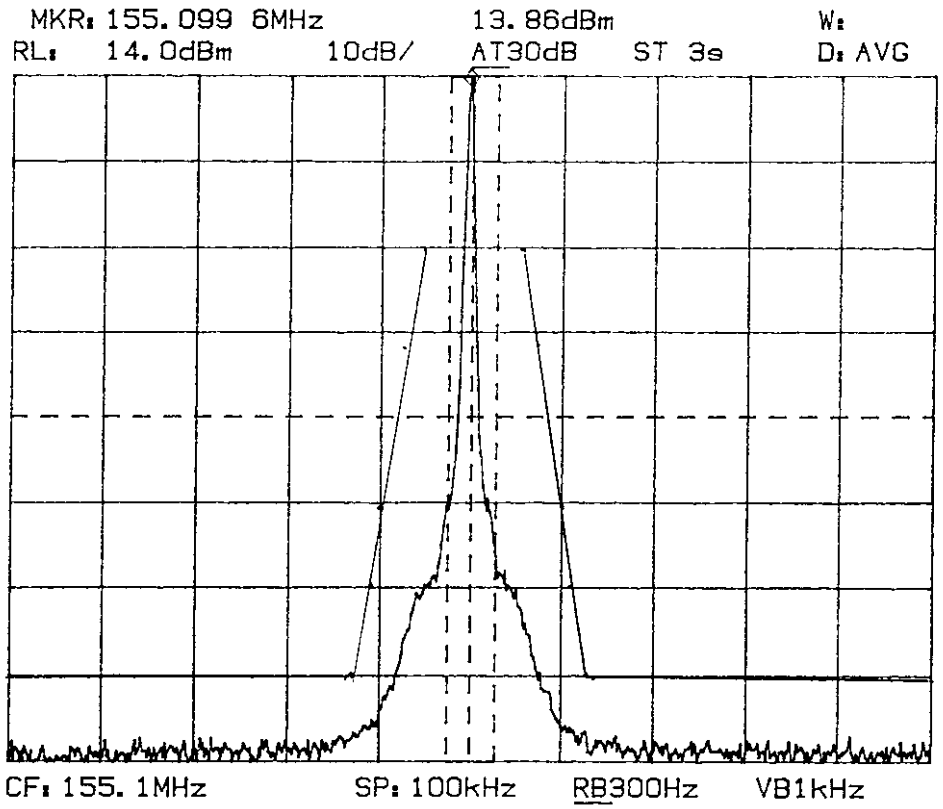


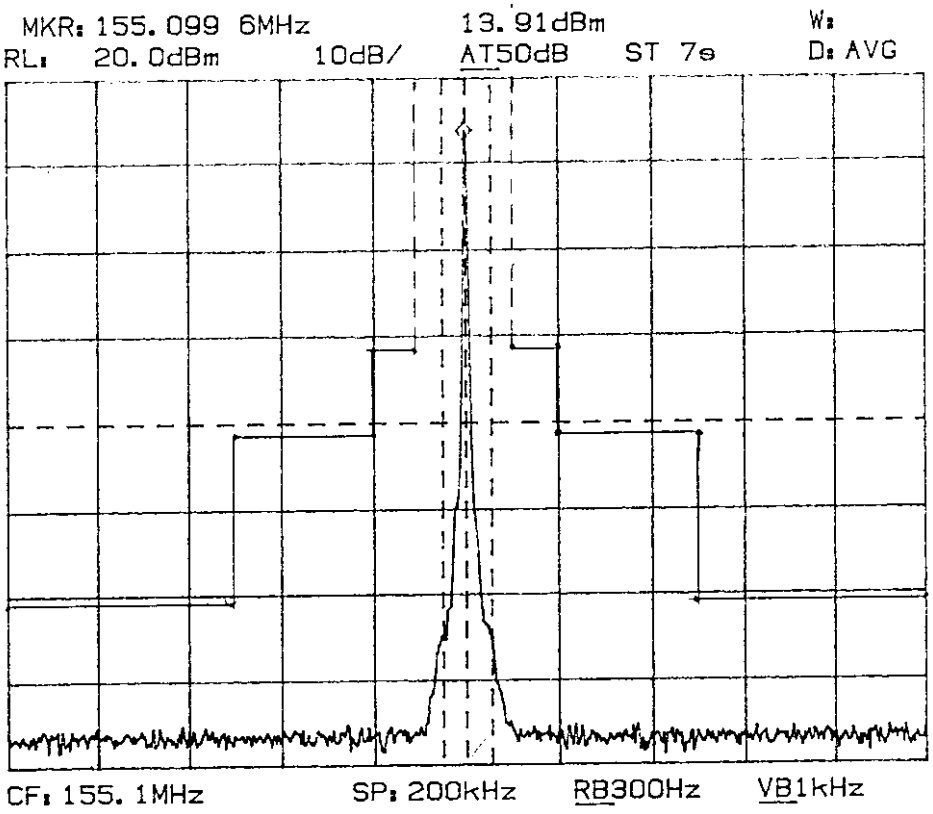
Figure 3

Occupied Bandwidth
Test Setup



Plot 6

Occupied Bandwidth
Transmit Frequency: 155.1 MHz
Channel 2
Power: 5 Watts
12.5 kHz channel
Mask D



Plot 7

Occupied Bandwidth
Transmit Frequency: 155.1 MHz
Channel 5
Power: 5 Watts
25.0 kHz channel
Mask B

Test: **Spurious Emissions at Antenna Terminal**

Ref: **FCC Part 90 paragraph 90.210 (b) (d) and Part 2.993**

Criteria: Under the method of measurement described Part 2.993, the Spectrum plot shall comply with the masks specified:

i. For a VHF Transceiver with **12.5 kHz** channel, and equipped with an audio filter, this corresponds to Emission **Mask D** (90.210.d).
This is calculated to be – 20. 1 dBm.

ii. For a VHF Transceiver with **25.0 kHz** channel, and equipped with an audio filter, this corresponds to Emission **Mask B** (90.210.b).
This is calculated to be – 13.0 dBm.

Set-up: See Figure 4

Conditions: Temperature: 23°C ±2
Voltage Supply: 7.5 V

Equipment: See Appendix A

Procedure: The transmitter was operated at full rated power and was modulated with a 2.5 kHz tone at a level 16 dB higher than that required to produce 50 % of the 5 kHz deviation. The output of the transmitter was attenuated by a 22 dB attenuator and connected to the spectrum analyzer. The spectrum was searched from DC to the 5th harmonic of the highest frequency. The test set-up is shown in Figure 2. All spurious signals less than 20 dB below the FCC limits were noted and recorded.

Results: **Passed.**

Mask B 25 kHz channel

For transmitters that are equipped with an audio low-pass filter persuant to 90.211(a), the power of any emission must be below the unmodulated carrier Power (P) as follows:

(1) On any frequency removed from the carrier frequency by more than 50 percent, but not more than 100 percent of the authorized bandwidth: At least 25 dB, measured with a bandwidth of 300 Hz.

(2) On any frequency removed from the carrier frequency by more than 100 percent, but not more than 250 percent of the authorized bandwidth: At least 35 dB, measured with a bandwidth of 300 Hz.

(3) On any frequency removed from the carrier frequency by more than 250 percent of the authorized bandwidth:
At least $43 + 10 \log_{10}$ (P) dB.
(P is the highest emission contained within the authorized bandwitdth)

The limit is calculated to be – 13 dBm (Mask B (3))

Mask D 12.5 kHz channel

For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the Power (P) of the highest emission contained within the authorized bandwidth as follows:

(1) On any frequency removed from the carrier frequency f_c to 5.625 kHz removed from f_c: ZERO dB.

(2) On any frequency removed from the carrier frequency by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27 (f_d – 2.88 kHz) dB.

(3) On any frequency removed from the carrier frequency by a displacement frequency (f_d in kHz) of more than 12.5 kHz:
At least $50 + 10 \log_{10}$ (P_{pk}) dB or 70 dB, whichever is the lesser attenuation.
(P is the highest emission contained within the authorized bandwitdth)

The limit is calculated to be – 20.1 dBm (Mask B (3))

Table 9

Spurious Emissions of at Antenna Terminals
Transmitter Frequency : 155.1 MHz
Output Power : 5 Watts
12.5 kHz channel

Frequency (MHz)	**Measured Level (A)** (dBm)	**Correction Factor (B)** (dBm)	**Unwanted Emission Levels (C)** (dBm)	**Criteria (D)** (dBm)	**Margin (E)** (dB)
310.2 (2^{nd} Harmonic)	- 61.51	34.39	- 27.12	- 20.1	7.02
465.3 (3^{rd} Harmonic)	< - 78.30	34.58	< - 43.72	- 20.1	> 23.62
620.4 (4^{th} Harmonic)	< - 77.61	34.68	< - 42.93	- 20.1	> 22.83
775.5 (5^{th} Harmonic)	< - 79.06	34.67	< - 44.39	- 20.1	> 24.29

Table 10

Spurious Emissions of at Antenna Terminals
Transmitter Frequency : 155.1 MHz
Output Power : 5 Watts
25.0 kHz channel

Frequency (MHz)	**Measured Level (A)** (dBm)	**Correction Factor (B)** (dBm)	**Unwanted Emission Levels (C)** (dBm)	**Criteria (D)** (dBm)	**Margin (E)** (dB)
310.2 (2^{nd} Harmonic)	- 61.22	34.39	- 26.83	- 13.0	13.83
465.3 (3^{rd} Harmonic)	< - 73.04	34.58	< - 38.46	- 13.0	> 25.46
620.4 (4^{th} Harmonic)	< - 77.33	34.68	< - 42.65	- 13.0	> 29.65
775.5 (5^{th} Harmonic)	< - 85.57	34.67	< - 50.9	- 13.0	> 37.9

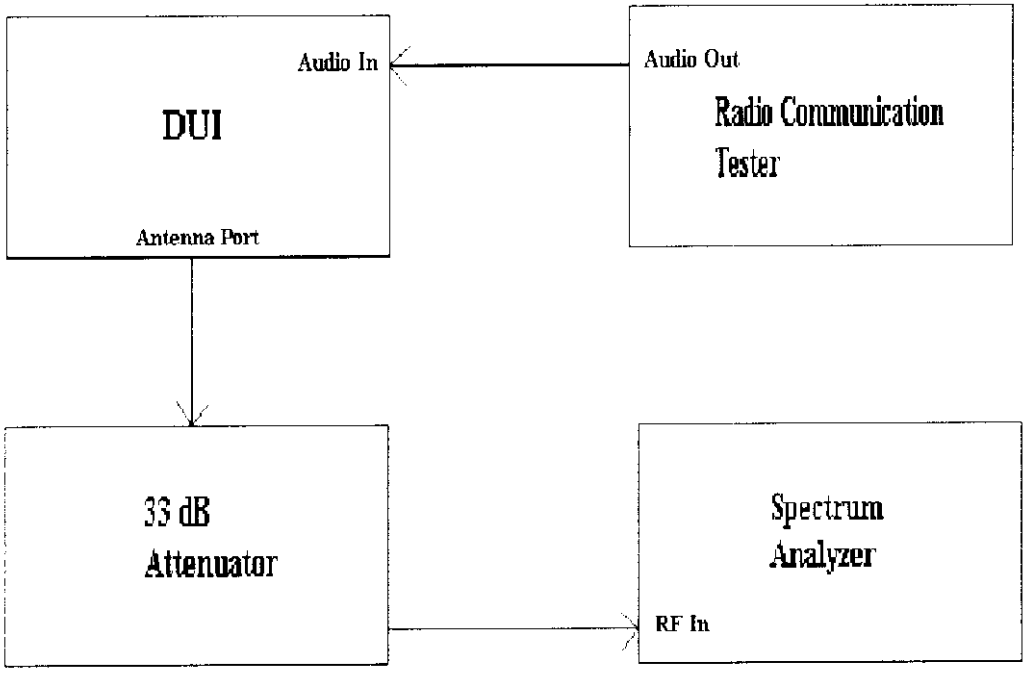


Figure 4 - Spurious Emissions at Antenna Terminal
Test Setup

Test: **Field Strength of Spurious Radiation**

Ref: FCC Part 90 paragraph 90.210 (b) (d) and Part 2.993

Criteria: a) emission **Mask D – 12.5 kHz channel**:
The permitted maximum level of spurious emission is 50 + 10 log (P) dB below the power (P) of the highest emission contained within the authorized bandwidth.

b) emission **Mask B – 25 kHz channel**:
The permitted maximum level of spurious emission is 43 + 10 log (P) dB below the power (P) of the unmodulated carrier.

Set-up: See Figure 5

Conditions: Temperature: 23 °C ± 2
Voltage Supply: 7.5 V

Equipment: See Appendix A.

Procedure: The final measurements were taken at APREL Laboratory's open area test site (OATS) measurement facility. This open area test site is calibrated to ANSI C63.4 document and a description of the measurement facility is on file with the Federal Communications Commission and is in compliance with the requirements of Section 2.948 of the Commissions rules and regulations.
(FCC File No.: 31040/SIT).

The radio was configured to operate at maximum power with appropriate modulation.

Prior to final measurement in the OATS, preliminary radiated spurious emissions were scanned in a shielded enclosure at a distance of 1 m using a broadband Discone antenna and horn antenna in order to determine the characteristic frequencies of the field strength of spurious emissions. Based on this information, measurements were performed in the OATS at these characteristic frequencies using calibrated antennas.

All field strength measurements were made with a spectrum analyzer and the appropriate calibrated antenna for the frequency range from 9 kHz up to 10^{th} harmonics of the transmit frequency (see equipment list for the calibrated antenna used). **The Power of the carrier frequency was also measured in the OATS.**

The equipment under test was placed on a turntable positioned 3 meters away from the calibrated receiving antenna, which in turn was connected to the spectrum analyzer. For each identified frequency, the received signal was maximized by the positioning of the turntable and the height of the antenna. The process was repeated for both horizontal and vertical polarization.

Information submitted includes the relative radiated power of each spurious emissions with reference to the appropriate limits as described in Mask B and D, assuming all emissions are radiated from half-wave dipole antenna.

Measurements given in the spurious emissions test result tables contain: analyzer reading, correction factor, and final reading. The final field strength level are derived from the analyzer measurement and the correction factor (antenna factor and cable loss) as shown in the following example:

Sample Calculation

A. Spectrum analyzer reading

at 160.0 MHz a spurious level of 18.00 dBμV @ 3 meters is measured.

B. Correction factor (antenna factor and cable loss)

Cable loss: 0.66 dB
Antenna Factor: 16.65 dB
Total Correction Factor: 0.66 + 16.65 = 17.31 dB/m

C. Final reading (Field Strength of spurious emission):

C = A + B
C = 18.0 dBμV + 17.31 dB
C = 35.31 dBμV/m @ 3 meters

D. The criteria level.

The field intensity which would be produced by the transmitter carrier operating into a half-wave dipole antenna (gain of 1.64), at a distance of 3 m was calculated using the following formula:

Field Strength of carrier (dBμV/m) = 10 $\log_{10}$(PtG/4πr^2) + 146 dB

Pt is transmitter carrier power, 5 Watts
G is gain, 1.64
r is distance, 3 meters

Field Strength of unmodulated carrier
($dB\mu V/m$) = $10 \log_{10} (5 * 1.64 / 4\pi(3\ m)^2) + 146$ dB

Field Strength of carrier = 134.6 $dB\mu V/m$

D = Field Strength of carrier – (43 + (10 log P))
D = 134.6 $dB\mu V/m$ - (43 + (10 log P))
D = 84.6 $dB\mu V/m$ @ 3 meters

Criteria (reference) level at 3 meters from 5 Watts into half-wave dipole antenna is 84.6 $dB\mu V/m$.

E = Margin (spurious emission below the reference level)

E = D – C
E = 84.6 $dB\mu V/m$ – 35.31 $dB\mu V/m$
E = 49.29 $dB\mu V/m$

Sample Calculation for Emission Mask D – 12.5 kHz channel is same as above except that instead of using unmodulated carrier as the reference, the power (P) of the highest emission contained within the authorized bandwidth is used.

Results: **Passed. See Tables 11, 12, 13, and 14**

Table 11
Field Strength of Spurious Emissions
Transmitter Frequency: 155.1 MHz
12.5 kHz channel
Power: 5 Watts
Antenna Polarization: Horizontal
Resolution Bandwidth:
10 kHz (below 1 GHz)
100 kHz (above 1 GHz)

Frequency (MHz)	**Measured Level (dBμV)** "A"	**Correction Factor (dB/m)** "B"	**Field Strength (dBμV/m)** "C"	**Criteria Level (dBμV/m)** "D"	**Margin (dB)** "E"
310.2 (2nd Harmonic)	10.0	17.4	27.4	77.6	50.2
465.3 (3rd Harmonic)	5.0	18.9	23.9	77.6	53.7
620.4 (4th Harmonic)	15.0	21.8	36.8	77.6	40.8
775.5 (5th Harmonic)	5.0	24.5	29.5	77.6	48.1
930.6 (6th Harmonic)	6.0	27.5	33.5	77.6	44.1
1085.7 (7th Harmonic)	7.0	29.2	36.2	77.6	41.4
1240.8 (8th Harmonic)	7.0	32.1	39.1	77.6	38.5
1395.9 (9th Harmonic)	7.0	32.7	39.7	77.6	37.9
1551.0 (10thHarmonic)	7.0	33.3	40.3	77.6	37.3

Table 12
Field Strength of Spurious Emissions
Transmitter Frequency: 155.1 MHz
12.5 kHz channel
Power: 5 Watts
Antenna Polarization: Vertical
Resolution Bandwidth:
10 kHz (below 1 GHz)
100 kHz (above 1 GHz)

Frequency (MHz)	**Measured Level (dBμV)** "A"	**Correction Factor (dB/m)** "B"	**Field Strength (dBμV/m)** "C"	**Criteria Level (dBμV/m)** "D"	**Margin (dB)** "E"
310.2 (2nd Harmonic)	23.0	17.4	40.4	77.6	37.2
465.3 (3rd Harmonic)	5.0	18.9	23.9	77.6	53.7
620.4 (4th Harmonic)	18.0	21.8	39.8	77.6	37.8
775.5 (5th Harmonic)	5.0	24.5	29.5	77.6	48.1
930.6 (6th Harmonic)	6.0	27.5	33.5	77.6	44.1
1085.7 (7th Harmonic)	17.0	29.2	46.2	77.6	31.4
1240.8 (8th Harmonic)	7.0	32.1	39.1	77.6	38.5
1395.9 (9th Harmonic)	8.0	32.7	40.7	77.6	36.9
1551.0 (10thHarmonic)	8.0	33.3	41.3	77.6	36.3

Table 13
Field Strength of Spurious Emissions
Transmitter Frequency: 155.1 MHz
25.0 kHz channel
Power: 5 Watts
Antenna Polarization: Horizontal
Resolution Bandwidth:
10 kHz (below 1 GHz)
100 kHz (above 1 GHz)

Frequency (MHz)	**Measured Level (dBμV)** "A"	**Correction Factor (dB/m)** "B"	**Field Strength (dBμV/m)** "C"	**Criteria Level (dBμV/m)** "D"	**Margin (dB)** "E"
310.2 (2nd Harmonic)	11.0	17.4	28.4	84.6	56.2
465.3 (3rd Harmonic)	5.0	18.9	23.9	84.6	60.7
620.4 (4th Harmonic)	17.0	21.8	38.8	84.6	45.8
775.5 (5th Harmonic)	5.0	24.5	29.5	84.6	55.1
930.6 (6th Harmonic)	6.0	27.5	33.5	84.6	51.1
1085.7 (7th Harmonic)	7.0	29.2	36.2	84.6	48.4
1240.8 (8th Harmonic)	7.0	32.1	39.1	84.6	45.5
1395.9 (9th Harmonic)	7.0	32.7	39.7	84.6	44.9
1551.0 (10thHarmonic)	7.0	33.3	40.3	84.6	44.3

Table 14
Field Strength of Spurious Emissions
Transmitter Frequency: 155.1 MHz
25.0 kHz channel
Power: 5 Watts
Antenna Polarization: Vertical
Resolution Bandwidth:
10 kHz (below 1 GHz)
100 kHz (above 1 GHz)

Frequency (MHz)	**Measured Level (dBμV)** "A"	**Correction Factor (dB/m)** "B"	**Field Strength (dBμV/m)** "C"	**Criteria Level (dBμV/m)** "D"	**Margin (dB)** "E"
310.2 (2nd Harmonic)	26.0	17.4	43.4	84.6	41.2
465.3 (3rd Harmonic)	5.0	18.9	23.9	84.6	60.7
620.4 (4th Harmonic)	19.5	21.8	41.3	84.6	43.3
775.5 (5th Harmonic)	5.0	24.5	29.5	84.6	55.1
930.6 (6th Harmonic)	6.0	27.5	33.5	84.6	51.1
1085.7 (7th Harmonic)	16.0	29.2	45.2	84.6	39.4
1240.8 (8th Harmonic)	7.0	32.1	39.1	84.6	45.5
1395.9 (9th Harmonic)	8.0	32.7	40.7	84.6	43.9
1551.0 (10thHarmonic)	8.0	33.3	41.3	84.6	43.3

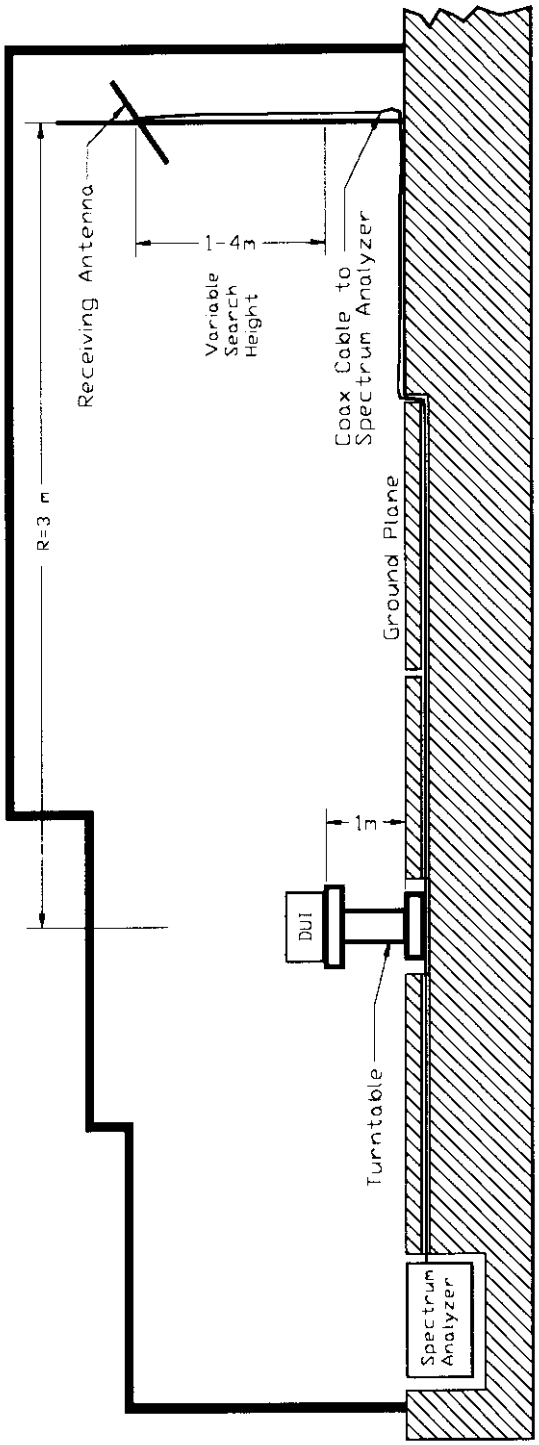


Figure 2 - Field Strength of Spurious Emissions

Test Setup

Test: **Frequency Stability**

Ref: FCC Part 2, Paragraph 2.995, and Part 90, Paragraph 90.213

Criteria: ± 5 ppm

Description: Frequency stability is a measure of the frequency drift due to temperature and supply voltage variations, with reference to the frequency measured at + 20°C and rated supply voltage. The RF carrier frequency shall not depart from the reference frequency in excess of ±5 PPM.

Set-up: See Figure 6

Conditions: Temperature: - 30 °C to + 50 °C
Voltage Supply: 7.5 V

Equipment: See Appendix A.

Procedure Temperature

The radio was placed in an environmental chamber, with the primary power turned on. The temperature of the chamber was first set to + 20°C allowing the radio sufficient time to stabilize. The frequency was recorded and used as reference. The chamber's temperature was varied over the range of -30°C to +50°C stabilising the temperature every 10°C. At each 10°C step the radio was given a period of thirty minutes for stabilization, at which time the frequency was recorded. The test set-up for frequency stability measurements is in Figure 6.

Power Supply Voltage Variation: N/A

Since the DUI is a handportable transceiver and is normally operated from internal batteries, the frequency stability tests have been performed using a new fully charged battery and no tests were performed varying the supply voltage.

For handportable, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

Results: **PASSED. See Tables 15, 16, 17, and 18**

Table 15

Frequency Stability Test
Transmitter Frequency : 155.1 MHz
12.5 kHz channels
Output Power Rating: 5 Watts

Temperature (°C)	Voltage (Volts)	Measured Frequency (MHz)	Measured Power (Watts)	Limit (Hz)	Margin (Hz)
- 30	7.5	155.099911	4.9	775.5	- 264
- 20	7.5	155.099976	4.9	775.5	- 199
- 10	7.5	155.100035	4.9	775.5	- 140
0	7.5	155.100074	4.9	775.5	-101
10	7.5	155.100140	4.9	775.5	- 35
20	7.5	155.100175	4.9	775.5	Reference
30	7.5	155.100207	4.9	775.5	+ 32
40	7.5	155.100221	4.9	775.5	+ 46
50	7.5	155.100234	4.9	775.5	+ 59

Table 16

Frequency Stability Test
Transmitter Frequency : 155.1 MHz
25.0 kHz channels
Output Power Rating: 5 Watts

Temperature (°C)	Voltage (Volts)	Measured Frequency (MHz)	Measured Power (Watts)	Limit (Hz)	Margin (Hz)
- 30	7.5	155.100088	4.9	775.5	- 254
- 20	7.5	155.100148	4.9	775.5	- 194
- 10	7.5	155.100205	4.9	775.5	- 137
0	7.5	155.100251	4.9	775.5	- 91
10	7.5	155.100311	4.9	775.5	- 31
20	7.5	155.100342	4.9	775.5	Reference
30	7.5	155.100384	4.9	775.5	+ 42
40	7.5	155.100397	4.9	775.5	+ 55
50	7.5	155.100408	4.9	775.5	+ 66

Table 17

Frequency Stability Test
Transmitter Frequency : 155.1 MHz
12.5 kHz channels
Output Power Rating: 5 Watts
Battery end-point 7.2VDC

Temperature (°C)	Voltage (Volts)	Measured Frequency (MHz)	Measured Power (Watts)	Limit (Hz)	Margin (Hz)
- 30	7.5	155.099830	4.9	775.5	- 345
- 20	7.5	155.099876	4.9	775.5	- 299
- 10	7.5	155.099954	4.9	775.5	- 221
0	7.5	155.100061	4.9	775.5	- 114
10	7.5	155.100108	4.9	775.5	- 67
20	7.5	155.100175	4.9	775.5	Reference
30	7.5	155.100185	4.9	775.5	+ 10
40	7.5	155.100197	4.9	775.5	+ 22
50	7.5	155.100217	4.9	775.5	+ 42

Table 18

Frequency Stability Test
Transmitter Frequency : 155.1 MHz
25.0 kHz channels
Output Power Rating: 5 Watts
Battery end-point 7.2VDC

Temperature (°C)	Voltage (Volts)	Measured Frequency (MHz)	Measured Power (Watts)	Limit (Hz)	Margin (Hz)
- 30	7.5	155.100041	4.9	775.5	- 301
- 20	7.5	155.100097	4.9	775.5	- 245
- 10	7.5	155.100152	4.9	775.5	- 190
0	7.5	155.100207	4.9	775.5	- 135
10	7.5	155.100260	4.9	775.5	- 82
20	7.5	155.100342	4.9	775.5	Reference
30	7.5	155.100360	4.9	775.5	+ 18
40	7.5	155.100380	4.9	775.5	+ 38
50	7.5	155.100396	4.9	775.5	+ 54

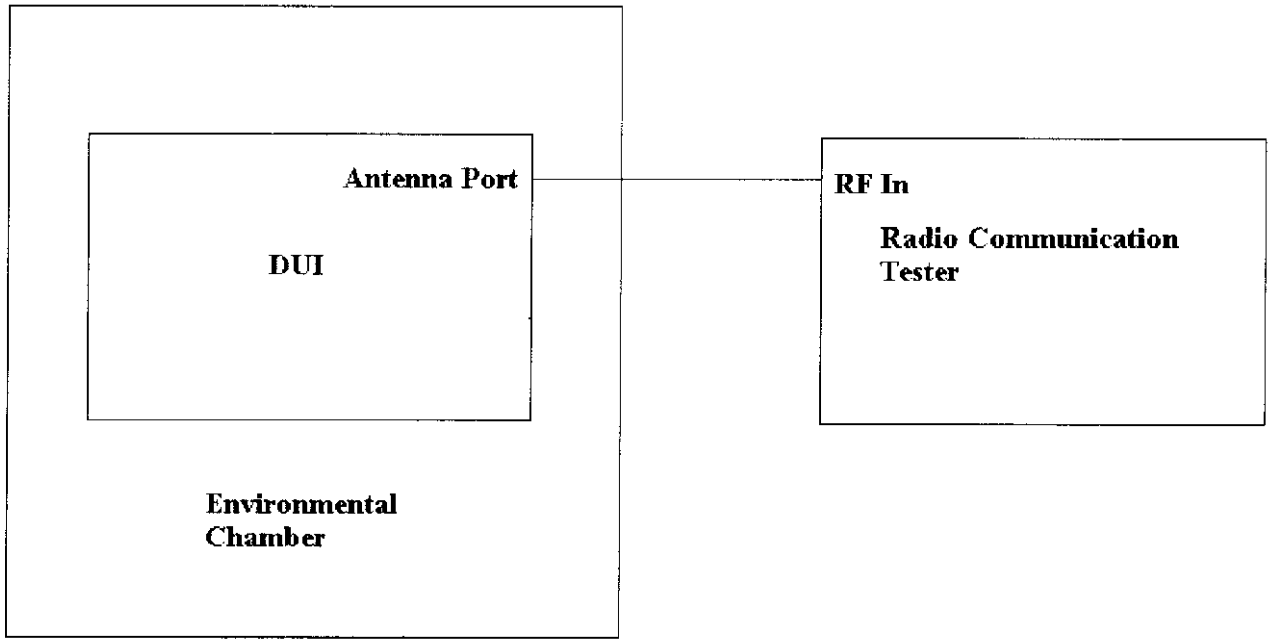


Figure 6 - Frequency Stability Test

Test: **Transient Frequency Behaviour of Transmitter**

Ref.: FCC 90, Paragraph 90.214

Description: When a transmitter is turned on, the RF frequency may take some time to stabilize. During this initial period, the frequency error or difference frequency, i.e. between the instantaneous and the steady state frequencies, must not exceed the limits specified in result table below.

Criteria: Transient frequency behaviour limits for equipment operating in the frequency range of 136 - 174 MHz operating on 12.5/25 kHz Channels is shown in the following table.

Time Intervals	Time (ms)		Maximum Frequency Difference (kHz)	
	12.5 kHz Channels	25 kHz Channels	12.5 kHz Channels	25 kHz Channels
t_1	5	5	± 12.5	± 25
t_2	20	20	± 6.25	± 12.5
t_3	5	5	± 12.5	± 25

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.

Note: With this radio having a output power rating of less than 6 watts, the frequency difference during t_1 and t_3 may exceed the maximum frequency difference for these time periods.

Set-up: See Figure 7

Conditions: Temperature: 23 °C ± 2
Voltage Supply: 7.5 V

Equipment: See Appendix A.

Procedure: The **EIA-603** test procedure of Transient Frequency Behaviour was used with modifications to accommodate the test equipment available.

a) The equipment was connected as shown as illustrated in Fig. 3. **Note, letters in parenthesis represent test equipment in Figure 3.**

b) The test receiver (10) has an audio bandwidth of DC to 15 kHz. The receiver was constructed by use of an +13 dBm injection mixer (inside the test receiver) and a RF signal generator (11) tuned to 10.7 MHz above the assigned frequency. The demodulated output of the receiver was sent to the vertical input of the storage oscilloscope (12). The maximum input RF power level to the receiver is +6 dBm.

c) The DUT (C) is terminated with a 50 Ohm termination (A). The DUT's carrier is sampled using the sampler (B) at a level around –38 dB. The signal which is split in (D) fed to the fast detector (F) which produces the trigger for the scope (M), also fed to the power combiner (G) which combines it with the signal of exactly the nominal frequency (155.1 MHz) produced by the signal generator (J). The role of this signal generator is to set the quatrature detector of the receiver (I) to have the same DC bias as when it receives the signal from the DUT just prior to the moment when the radio's PTT is activated. With this method, a large DC bias shift occurring simultaniously with the trigger and masking of the beginning of the trace is avoided. The last output of the splitter (D) is terminated with a 50 Ohm termination (E).

d) The signal generator (J) produces roughly 20 dB less signal then the DUT at point (Y), therefore insuring that the signal from DUT will completely desensitize the FM receiver (I) form the 20 dB lower signal from the signal generator (J).

e) The signal from the signal generator (J) is also FM modulated at 1 kHz tone at +/- 25 kHz deviation.

f) Port 2 of the combiner (G) is terminated with the termination (H).

g) The FM receiver is a single conversion superhetrodyne and as such needs a local oscillator signal to operate. This is produced by the additional signal generator (N). Its frequency is always lower or higher than the DUT's carrier by the receiver's IF which is 10.7 MHz. The DC meter (L) is used to precisely adjust the DC offset of the FM receiver down to zero.

h) The signal generator (J) is first set to nominal frequency of 155.1 MHz.

i) The second signal generator (N) is set to 10.7 MHz higher than the DUT's nominal frequency (155.1 MHz) to 165.8 MHz.

j) The RF Power meter (P) is inserted and replaces the splitter at point (X). The DUT is keyed on and the reading of the power meter is recorded (- 0.3 dBm).

k) The signal generator (J) is set to 40 dB lower than the power meter reading (-40.3 dBm). This level should be 20 dB below the DUT carrier level at point (Y). Remaining 20 dB accounts for 5 dB loss at (D), 14 dB loss at (G) and 1 dB additional losses in the setup.

l) The DUT is reconnected at point (X). It is keyed on while the FM receiver's DC offset is adjusted to a reading of zero as indicated on the multimeter (L). Any subsequent PTT depressing should not change the offset of the FM receiver.

m) The setup is now ready to record the transient frequency behaviour of the DUT and the oscilloscope (M) will refresh the trace every time the PTT is depressed.

n) The oscilloscope was adjusted such that it would trigger on an increasing magnitude from the RF power detector at 1 division from the left side of the display, when the DUT's PTT was depressed. The display was stored on the oscilloscope and plotted.

o) To test the transient frequency behaviour during the period t_3 , the oscilloscope trigger controls were adjusted such it would trigger on a decreasing magnitude from the RF detector at 1 division from the right side of the display, when the transmitter was turned off. The display was stored on the oscilloscope. The moment when the 1 kHz test signal started to rise it was considered t_{off}.

Results: **PASSED.** **See Tables 19, and 20**
See Plots 8, 9, 10, and 11

Table 19

Transient Frequency Behaviour Test
Transmitter Frequency : 155.1 MHz
Ch. # 2
12.5 kHz channels
Output Power : 5 Watts

Time Intervals	Time (ms)	Frequency Difference Measured (kHz)	Maximum Frequency Difference Allowed (kHz)	Margin (kHz)
t_1	5	+ 3.0	± 12.5	8.5
t_2	20	< 0.250	± 6.25	> 6.0
t_3	5	+ 11.0	± 12.5	1.5

Table 20

Transient Frequency Behaviour Test
Transmitter Frequency : 155.1 MHz
Ch. # 5
25.0 kHz channels
Output Power : 5 Watts

Time Intervals	Time (ms)	Frequency Difference Measured (kHz)	Maximum Frequency Difference Allowed (kHz)	Margin (kHz)
t_1	5	+ 5.0	± 25.0	20.0
t_2	20	< 0.250	± 12.5	> 12.0
t_3	5	+ 12.0	± 25.0	13.0

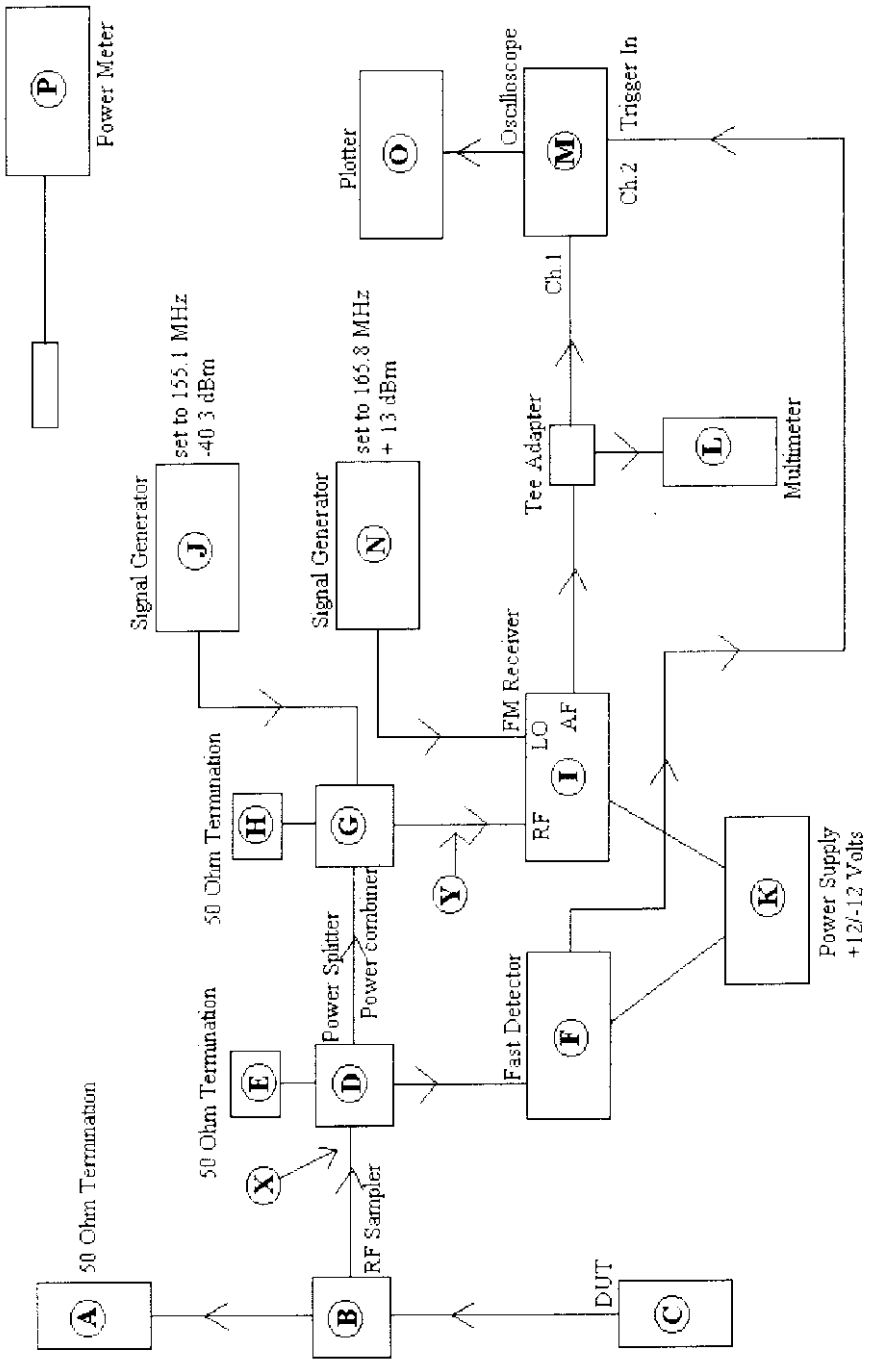
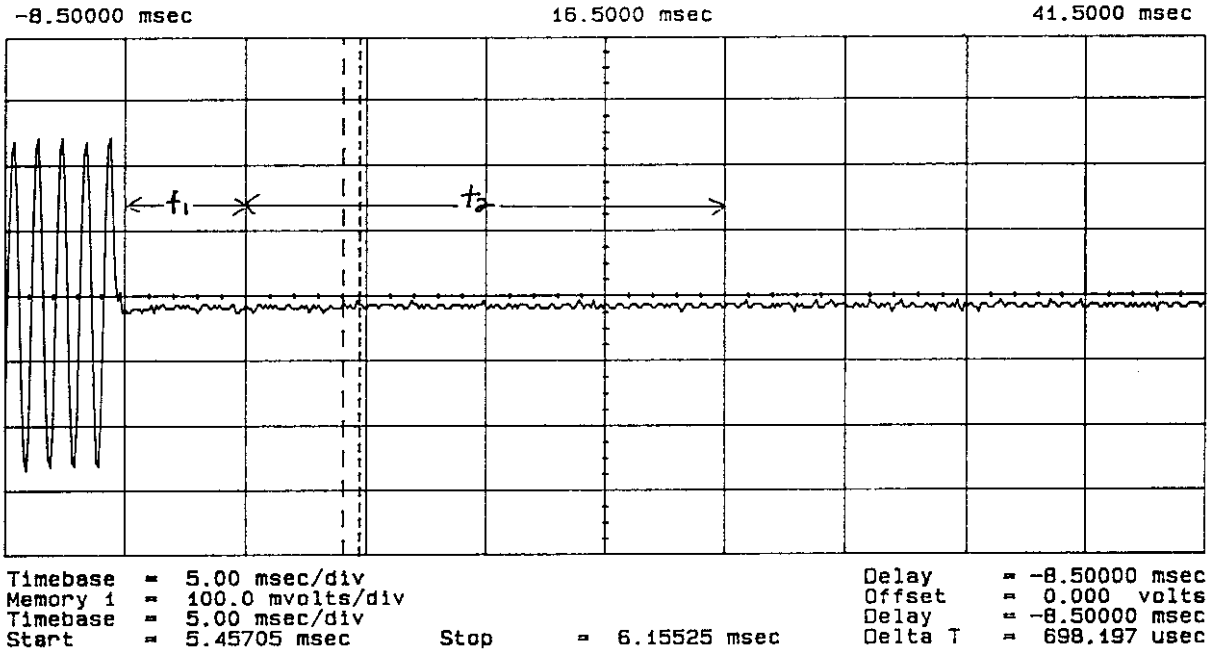


Figure 7

Transient Frequency Behaviour Test Setup



Plot 8

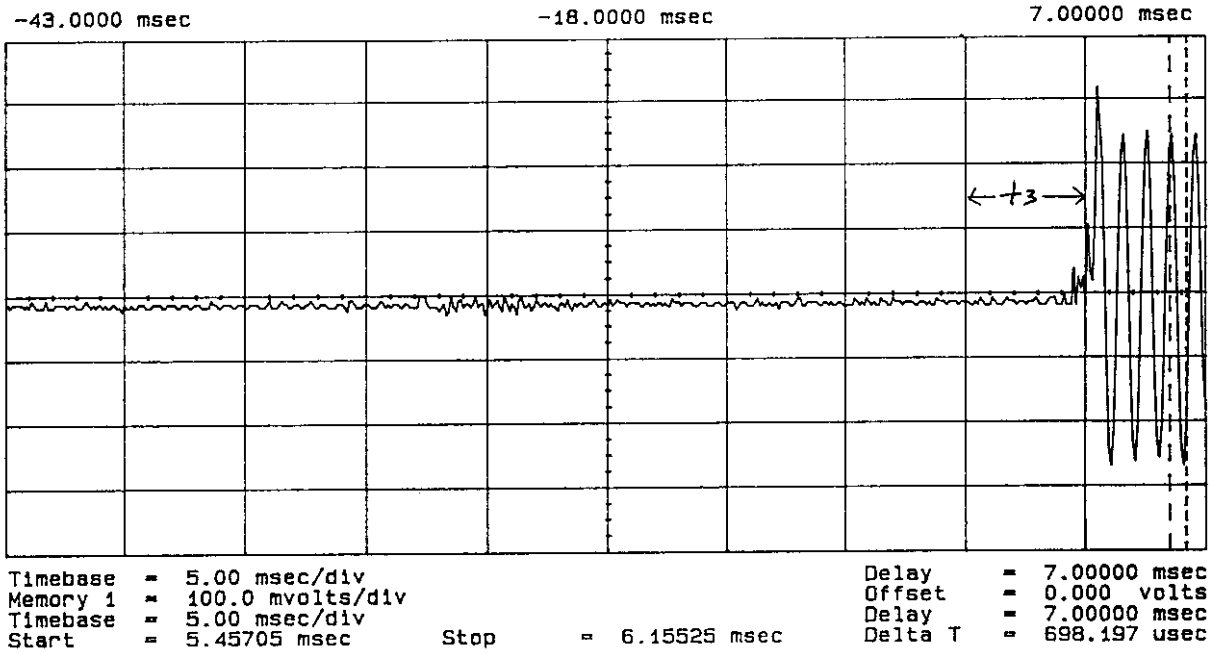
Transient Frequency Behaviour of Transmitter

Transmitter Frequency: 155.1 MHz

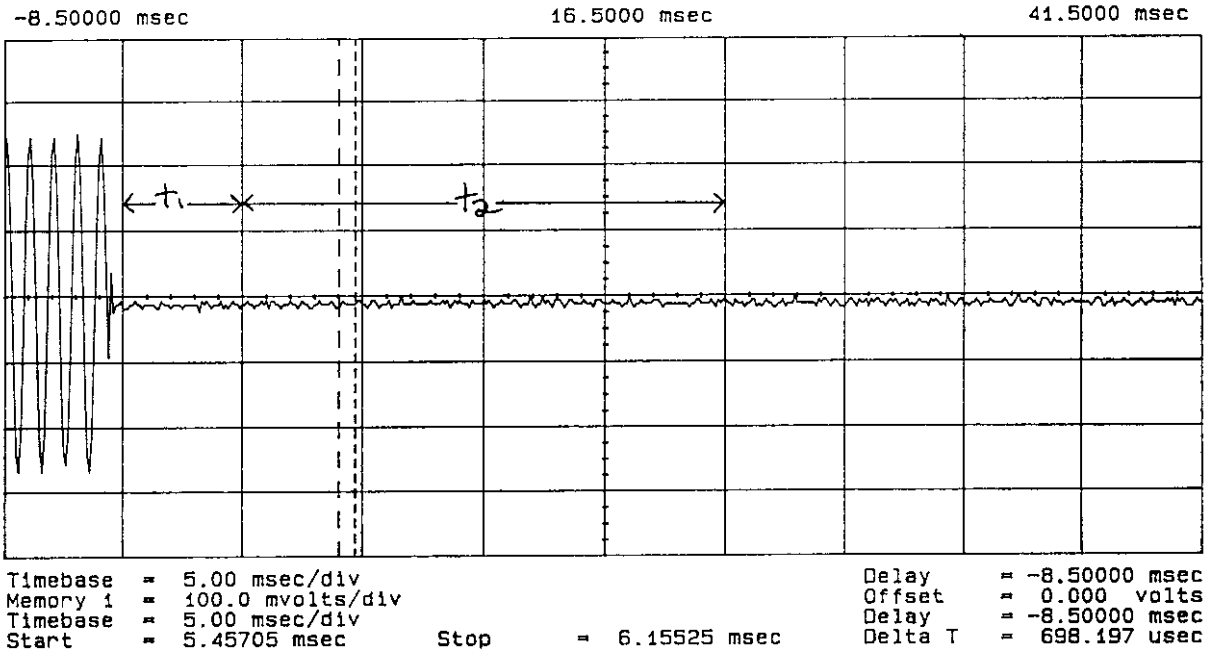
Power: 5 Watts

12.5 kHz channels

Power: ON



Plot 9
Transient Frequency Behaviour of Transmitter
Transmitter Frequency: 155.1 MHz
Power: 5 Watts
12.5 kHz channels
Power: OFF



Plot 10

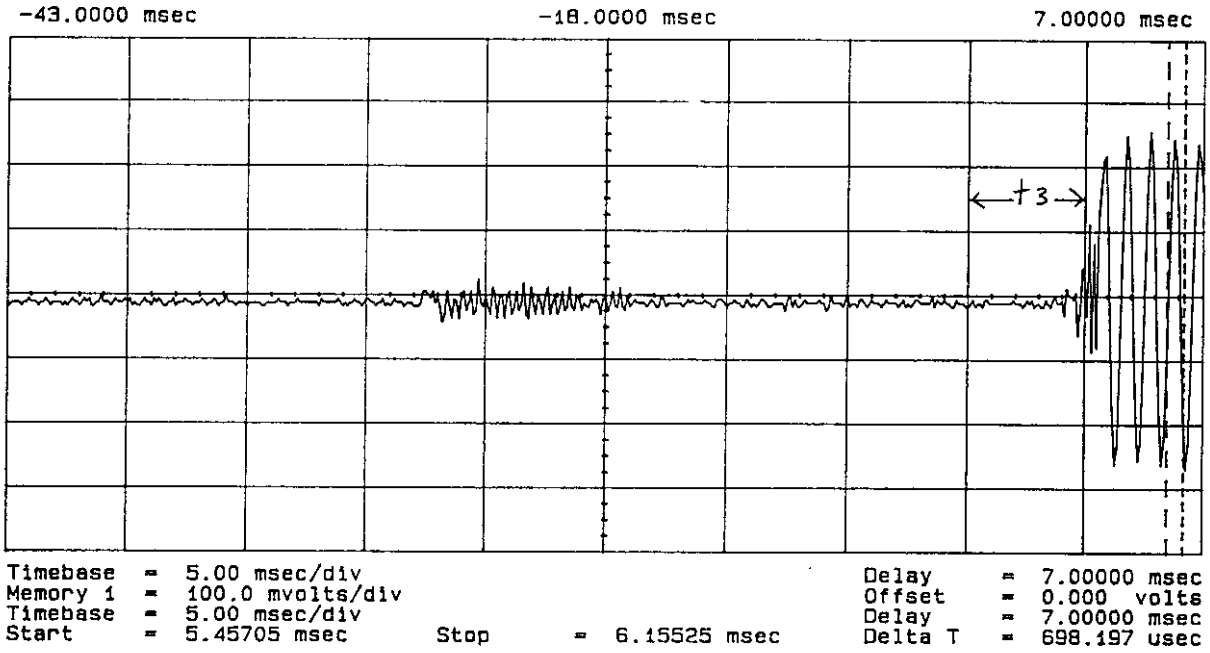
Transient Frequency Behaviour of Transmitter

Transmitter Frequency: 155.1 MHz

Power: 5 Watts

25.0 kHz channels

Power: ON



Plot 11

Transient Frequency Behaviour of Transmitter

Transmitter Frequency: 155.1 MHz

Power: 5 Watts

25.0 kHz channels

Power: OFF

APPENDIX A

List of Equipment

Description	Manufacturer	Model #	Asset #	Cal. Due Date
Spectrum Analyzer	Anritsu	MS2601A	100479	9 Nov 98
Environmental Chamber	Tenny	TR14-3	100636	19 Sep 99
Plotter	Hewlett-Packard	7470A	100407	N/A
Radiocommunication Service Monitor	Rohde & Schwarz	CMS 52	100759	5 June 99
RF Sampler	Bird	4275-020	100754	N/A
Power Supply	Hewlett-Packard	6236A	100230	N/A
Signal Generator	Hewlett-Packard	8662A	100456	21 Oct 98
Digital Scope	Hewlett-Packard	54110D	100409	6 June 99
Fast Detector	APREL	APL-FD-1	301406	1 Sep 99
FM Receiver	APREL	APL-FMR-1	301412	1 Sep 99
Power Combiner/Splitter	APREL	APL-PSC-1	301407	1 Sep 99
Signal Generator	Hewlett-Packard	8340B	100955	4 Sep 99
Multimeter	Fluke	8010A	301328	11 Sep 98
Power Splitter	Mini-Circuits	ZFSC-3-4	301368	N/A
Power Meter	R & S	NRVS	100851	20 Oct 98