

**CHOMERICS**



**TEST SERVICES**

**EMC EVALUATION OF THE  
M/A-COM  
OPENSKY PORTABLE RADIO  
MODEL P-801T  
IN ACCORDANCE WITH THE  
FCC PART 90 CERTIFICATION**

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**Test Report Number:**   
**EMI2547.US.00**

**Test Technician or Engineer:** \_\_\_\_\_

**CTS Approved Signatory:** \_\_\_\_\_

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## TABLE OF CONTENTS

### **1.0 General**

#### **1.1 Introduction**

- 1.1.1 Purpose
- 1.1.2 Requirements

#### **1.2 Administrative Data**

- 1.2.1 Test Facility
- 1.2.2 Equipment Calibration
- 1.2.3 Test Personnel

#### **1.3 Test Set-up**

- 1.3.1 Test Site Matrix
- 1.3.2 Test Site Descriptions
- 1.3.3 Equipment Under Test

### **2.0 Test Summary**

#### **2.1 Summary of Recommendations**

### **3.0 Tests Performed**

#### **3.1 Occupied Bandwidth**

- 3.2.1 Equipment Used
- 3.2.2 Test Conditions
- 3.2.3 Test Method
- 3.2.4 Results

#### **3.2 Emission Mask and Spurious Emissions at Antenna Terminals**

- 3.2.1 Equipment Used
- 3.2.2 Test Conditions
- 3.2.3 Test Method
- 3.2.4 Results

## **TABLE OF CONTENTS (continued)**

### **3.3 Frequency Stability**

- 3.3.1 Equipment Used
- 3.3.2 Test Conditions
- 3.3.3 Test Method
- 3.3.4 Results

### **3.4 Radiated Emissions**

- 3.4.1 Equipment Used
- 3.4.2 Test Conditions
- 3.4.3 Test Method
- 3.4.4 Results

## **4.0 Appendix**

**Appendix A: Test Data**

**Appendix B: Set-Up Photographs**

**Appendix C: Customer Supplied Modulation Characteristics**

**LIST OF DEFINITIONS/ABBREVIATIONS**

AC	Alternating Current
BB	Broadband
BW	Bandwidth
cm	Centimeter
C.P.U.	Calibrate Prior to Use
dB	Decibel
DC	Direct Current
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ER	Electric Radiation
EUT	Equipment Under Test
GHz	Gigahertz
Hz	Hertz
I-face	Interface
kHz	Kilohertz
m	Meter
MHz	Megahertz
mm	Millimeter
mS	Millisecond
mV	Millivolt
MR	Magnetic Radiation
NB	Narrowband
N.C.R.	No Calibration Required
PLC	Power Line Conduction
PPS	Pulses Per Second
uF	Microfarad
uH	Microhenry
uS	Microsecond
uV	Microvolt
U.W.C.	Use With Calibrated Equipment

**1.0 GENERAL****1.1 Introduction****1.1.1 Purpose**

The purpose of this report is to document the performance of the M/A-Com Opensky P-801T Portable Radio during a variety of radio-performance tests and record the test requirements and procedures used. At the request of M/A-Com, the tests were performed by Chomerics Test Service (CTS) of Woburn, Massachusetts. The assessment will determine the compliance or non-compliance to the requirements set by FCC Part 15, Part 90 and Part 2.

Testing was performed during the period of March 20, 2000 through April 11, 2000 under purchase order number 252221.

**1.1.2 Requirements**

The requirements for the sequence of tests performed on the M/A-Com Opensky P-801T Portable Radio is as follows:

**Occupied Bandwidth  
FCC Part 2.10498**

The Occupied Bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the means power radiated are each equal to 0.5% of the total mean power radiated by a given emission.

**Emission Mask and Spurious Emissions at Antenna Terminals  
FCC Part 90.210 and Part 2.991****Mask H**

The following emission mask shall be followed. The power of any emission must be below the unmodulated carrier power (P) as follows:

1. On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 4kHz or less:  
Zero dB
2. On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 4kHz but not more than 8.5kHz:  
At least  $107 \log (fd/4)$  dB.

3. On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 15kHz, but not more than 25kHz:  
At least  $116 \log (fd/6.1)$
4. On any frequency removed from the center of the authorized bandwidth by more than 25kHz:  
At least  $43 + 10 \log (P)$  dB.

**Field Strength of Spurious Radiation****FCC Part 2.933**

The field strength of each harmonic and other spurious emissions shall be below  $43 + 10 \log (P)$  when measured in an open field test site. The frequency range under investigation is 30MHz to 10000MHz.

P = to 3 watts

Limit =  $43 + 10 \log (3) = 43.95$ dB under

**Frequency Stability****FCC Part 90.213 and 2.955**

The transmitter shall have the following Frequency Stability over the temperature range of  $-30^{\circ}\text{C}$  to  $+50^{\circ}\text{F}$ .

The frequency stability for a mobile/portable station is 1.5ppm as stated in the Minimum Frequency Stability table of Part 90.213.

**Radiated and Conducted Emissions “Receiver”****FCC Part 15**

The receiver shall meet the FCC Part 15 Subpart B Class B radiated and conducted emissions limits.

**1.2 Administrative Data****1.2.1 Test Facility**

Chomerics Test Facility is recognized under the National Voluntary Laboratory Accreditation Program (NVLAP) for NVLAP Codes 12/C01 and 12/R01. Tests within this report not conforming to 12/C01 and 12/R01 NVLAP Codes are not covered under Chomerics NVLAP accreditation.

Chomerics Test Facility operates under the current revision of Chomerics Quality Assurance (QA) Manual Document Number QA002.

The QA manual has been constructed to reflect a quality program in accordance with the requirements of the National Institute of Standards and Technology (NIST), ISO 9002, ISO Guide 25, NIST Handbook 150, EN 45001, MIL-I-45208A, MIL-STD-461D, 462D and Chomerics Quality Assurance Program (QAP).

The QA manual outlines and describes the procedures for establishing and maintaining the quality of

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analysis, research, inspection, and testing within Chomerics Test Service (CTS).

This report does not represent an endorsement by the U.S. Government.

The results and/or conclusions within this test report refer and/or apply only to the unit(s) tested as defined by this report.

Measurements performed for this test are traceable to the National Institute of Standards and Technology (NIST) based on the fact that all test equipment used for the measurements were previously calibrated using standards traceable to NIST.

No deviations, additions to, or exclusions from the test specification(s) were made.

The system amplitude accuracy for the measurements made during the radiated emission tests was  $\pm 3$ dB.

### **1.2.2 Equipment Calibration**

The calibration of Chomerics test facility equipment is controlled under the current edition of Chomerics Laboratory Test Equipment Calibration Manual Document Number QA001.

The test equipment used throughout this test sequence conforms to laboratory calibration standards, MIL-STD-45662, traceable to the National Institute of Standards and Technology. The date of the next due scheduled calibration is listed in each test section for the applicable equipment.

All test equipment is calibrated in one year intervals

### **1.2.3 Personnel**

The test personnel used to perform or supervise the tests are accredited by the National Association of Radio and Telecommunications Engineers, Inc. (NARTE) as Certified Electromagnetic Compatibility Engineers (N.C.E.) and Technicians (N.C.T.).

## **1.3 Test Set-up**

### **1.3.1 Test Site Matrix**

The test locations used for the emissions and immunity tests are as follows: (Refer to Section 1.3.2 for test site descriptions).

**Test Performed**

Occupied Bandwidth  
 Emission Mask and Spurious Emissions at Antenna Terminals  
 Field Strength of Spurious Radiation  
 Frequency Stability  
 Radiated Emissions

**Test Site**

Immunity A  
 Immunity A  
 Immunity A  
 Safety Lab  
 Test Site A

### 1.3.2 Test Site Descriptions

The following is a list of the test sites and descriptions of each. Refer to Section 1.3.1 for specific test sites used for testing.

**Open Area Test Site A:** Chomerics Open Area Test Site "A" if used for this test program is located in the lower parking lot attached to the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 1). Parking is permitted on one side of test site "A" at a discrete distance from the imaginary ellipse.

The Open Area Test Site A enclosure is a wooden structure measuring 56 x 30 x 25 feet in size with galvanized steel sheet metal used as the ground plane. The structure is sized to allow 3 meter measurements and is heated and/or air conditioned.

The structure used to support equipment under test is an EMCO 4 foot diameter motorized turntable. For tabletop equipment, a wooden table measuring 1.5 x 1 meter in size is positioned at the center of the turntable, at the proper height above the ground plane.

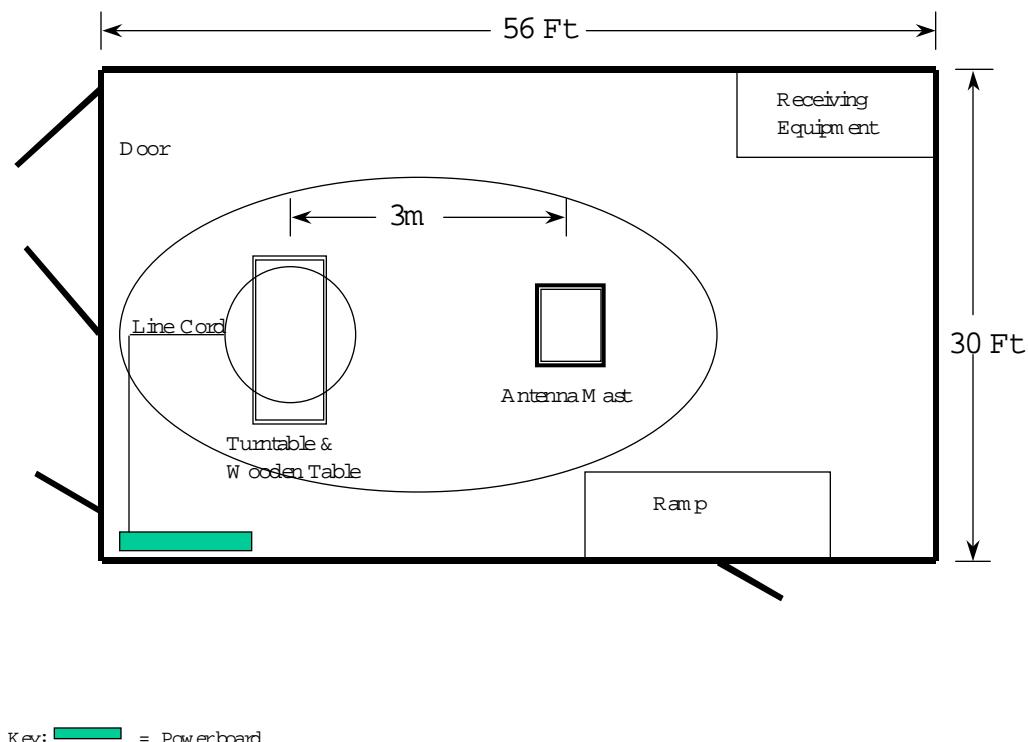
The area at the end of the Open Area Test Site "A" is the location for the test personnel and equipment to ensure they are outside the imaginary ellipse.

The available AC power within Open Area Test Site "A" is 120V 60Hz Single Phase 60Amps; 208V 60Hz Three Phase 60Amps; 208V 60Hz Single Phase 60Amps; 230V 50Hz Single Phase 50Amps.

This Site is listed with the Federal Communications Commissions (FCC).

## OPEN AREA TEST SITE A

Figure 1



**Open Area Test Site B:** Chomerics Open Area Test Site "B" if used for this test program is located in the lower parking lot behind the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 2). Parking is permitted on one side of test site "B" at a discrete distance from the imaginary ellipse.

The Open Area Test Site "B" enclosure is a wooden structure measuring 56 x 30 x 25 feet in size with galvanized steel sheet metal used as the ground plane. The structure is sized to allow both 3 and 10 meter measurements and is heated and/or air conditioned.

The structure used to support equipment under test is a 14 foot diameter motorized turntable. The sheet metal surface is flush with the ground plane. To ground the turntable, 175 copper fingers (1" x 1.5") are mounted around the outer edge of the turntable using machine screws. The spring fingers are equally spaced and provide a uniform interface between the turntable metal surface and ground plane. For tabletop equipment, a wooden table measuring 1.5 x 1 meter in size is positioned at the center of the turntable, at the proper height above the ground plane.

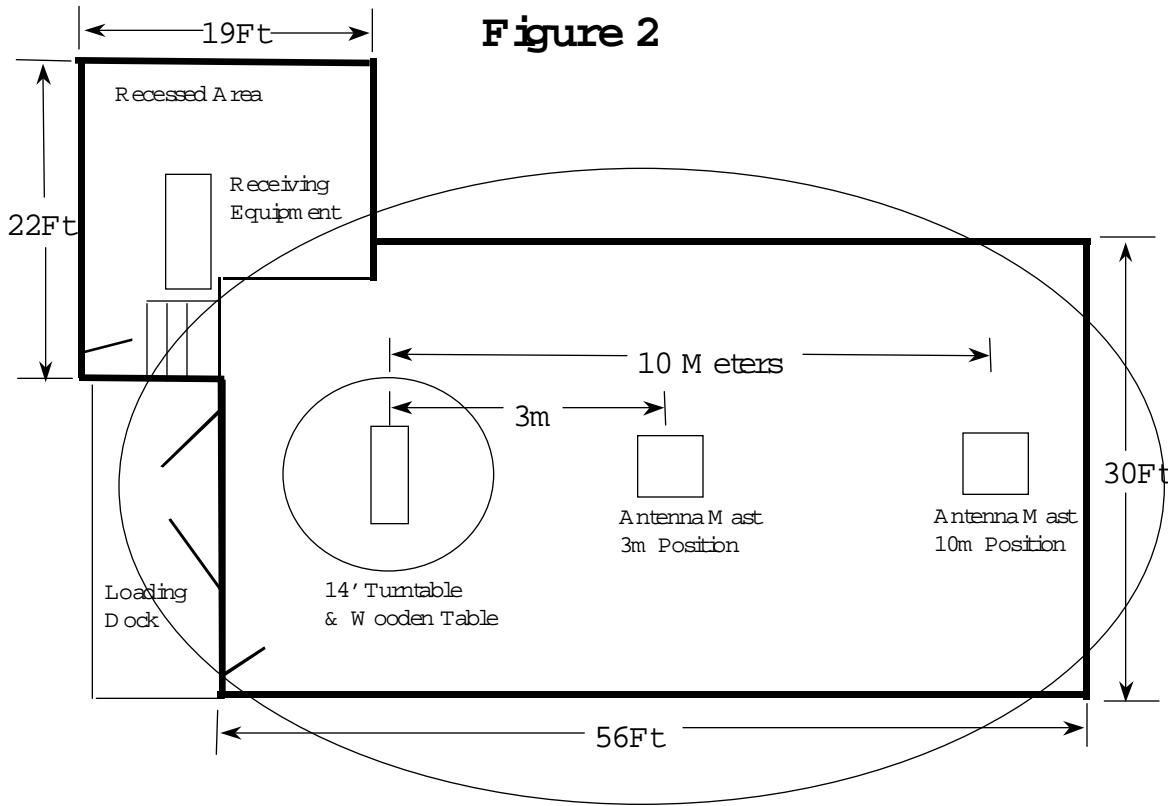
The addition at the end of the Open Area Test Site "B" is the location for the test personnel and equipment to ensure they are outside the imaginary ellipse.

The available AC power within Open Area Test Site "B" is 120V 60Hz Single Phase 60Amps; 208V 60Hz Three Phase 60Amps; 208V 60Hz Single Phase 60Amps; 230V 50Hz Single Phase 50Amps.

This site is listed with the Federal Communications Commissions (FCC).

### OPEN AREA TEST SITE B

Figure 2



**Test Chamber A:** Chomerics Test Chamber A, if used for this test program, is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 3). The shielded enclosures (test chambers) were manufactured and installed by Universal Shielding Corporation of Deer Park, New York. Attenuation tests have demonstrated that the shielded enclosures meet the attenuation requirements of MIL-STD-285 and NSA 65-6. The main test chamber is 22 x 10 x 10 feet in size with an adjacent enclosure that is 8 x 8 x 8 feet in size. The adjacent room, used for support equipment, and the main test chamber are connected together and referenced to the same single point ground.

When needed for tabletop equipment, a wooden table measuring 3 x 9 feet in size is positioned within the test chamber. When used for MIL-STD-461D tests the tabletop surface is covered with a copper sheet and grounded to the test chamber wall so that the resistance is less than 2.5 milliohms.

The power line filters supplying the power to the enclosures provide 100dB of attenuation from 10kHz to 10GHz. The adjacent room, used for support equipment, and the main test chamber have independent AC power obtained from independent AC power line filters.

The available AC power in Test Chamber A is 120V 60Hz Single Phase 100Amps; 120V 400Hz Three Phase 50Amps; 208V 60Hz Three Phase 100Amps; 208V 60Hz Single Phase 100Amps; 230V 50Hz Single Phase 50Amps.

**Test Chamber B:** Chomerics Test Chamber B, if used for this test program, is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 3). The shielded enclosures (test chambers) were manufactured and installed by Universal Shielding Corporation of Deer Park, New York. Attenuation tests have demonstrated that the shielded enclosures meet the attenuation requirements of MIL-STD-285 and NSA 65-6.

The main test chamber is 22 x 10 x 10 feet in size with an adjacent enclosure that is 8 x 8 x 8 feet in size. The adjacent room, used for support equipment, and the main test chamber are connected together and referenced to the same single point ground.

Test Chamber B is lined with Rantec ferrite absorber tiles FT-100. All surfaces of the room are lined with FT-100. The floor is lined with removable tiles. This absorber material allows the test chamber to meet the 0-6dB field uniformity requirements of IEC 1000-4-3 and ENV50140.

There are two access panels between the main test chamber and the support room. The access panels are covered with absorber tiles. The absorber tiles can be removed from the access panels.

The power line filters supplying the power to the enclosures provide 100dB of attenuation from 10kHz to 10GHz. The adjacent rooms, used for support equipment, and the main test chamber have independent AC power obtained from independent AC power line filters.

The available AC power in Test Chamber B is 120V 60Hz Single Phase 30Amps; 208V 60Hz Three Phase 30Amps; and 230V 50Hz Single Phase 30Amps: A wooden table 3 x 6 feet in size is used for tabletop equipment.

Only one power line frequency is available in the chamber at a time, 50, 60 or 400 cycle, unless power is brought through an access panel.

**Test Chamber C:** Chomerics Test Chamber C, if used for this test program, is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts (see Figure 3). The shielded enclosures (test chambers) were manufactured and installed by Universal Shielding Corporation of Deer Park, New York.

Attenuation tests have demonstrated that the shielded enclosures meet the attenuation requirements of MIL-STD-285 and NSA 65-6. The main test chamber is 16 x 20 x 10 feet in size with two adjacent enclosures on either side which are 8 x 8 x 8 and 8 x 12 x 10 feet in size, respectively.

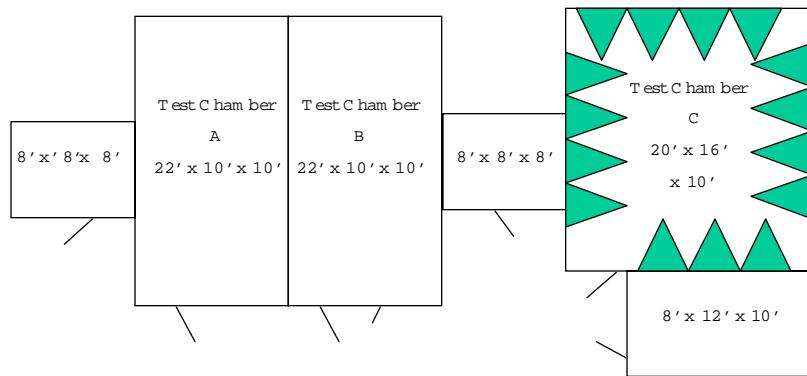
Test Chamber C is lined with Emerson-Cuming RF absorber material. This absorber material meets the following absorption specifications: 80MHz 6dB, 300MHz 30dB, 500MHz 35dB, 1GHz 40dB, and 3 to 24 GHz 50dB. Each of the two adjacent rooms used for support equipment and the main test chamber are connected together and referenced to the same single point ground.

When needed for tabletop equipment, a wooden table measuring 3 x 9 feet in size is positioned within the test chamber. When used for MIL-STD-461D tests, the tabletop surface is covered with a copper sheet and grounded to the test chamber wall so that the resistance is less than 2.5 milliohms. When used for radiated electromagnetic field tests, to some standards, the copper tabletop surface is removed.

The available AC power in Test Chamber C is 120V 60Hz AC Single Phase 60Amps; 230V 50Hz AC Single Phase 50Amps; 115V 400Hz AC Three Phase 30Amps (through access panel); 208V 60Hz AC Three Phase AC 30Amps (through access panel).

The power line filters supplying the power to the enclosures provide 100dB of attenuation from 10kHz to 10GHz. Each of the two adjacent rooms used for support equipment and the main test chamber has independent AC power obtained from independent AC power line filters.

**Im m unity Lab Layout**  
**Figure 3**



Key:



= Emerson-Cumming RF absorber material

**EC Lab A:** Chomerics EC Lab A is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts.

EC Lab A is a typical room measuring 20 x 16 feet with an aluminum sheet metal (8 x 12 feet in size) in the center of the floor for a ground plane. When needed for tabletop equipment, a wooden table (0.8 meters in height) is placed on the metal ground plane that extends at least 0.1m beyond all sides of the table. A removable 3 x 6 foot sheet of aluminum is placed on top of the wooden table when a horizontal coupling plane is required.

The appropriate connections, as needed for each test, are used to interconnect the table horizontal coupling plane, ground plane floor, test equipment, and earth ground.

The available AC power in the EC Lab A is 120V 60Hz AC Single Phase 60Amps; 230V 50Hz AC Single Phase 50Amps; and 208V 60Hz AC Three Phase AC 30Amps.

EC Lab A is equipped with air and water services for use with equipment that requires it.

The humidity in EC Lab A can be automatically controlled in the range of 20% to 60%.

**EC Lab B:** Chomerics EC Lab B is located in the Seeger Building at Chomerics, 84 Dragon Court, Woburn, Massachusetts.

EC Lab B is a typical room measuring 12 x 14 feet with a copper sheet (6 x 8 feet in size) in the center of the floor for a ground plane. When needed for tabletop equipment, a wooden table (0.8 meters in height) is placed on the metal ground plane that extends at least 0.1m beyond all sides of the table. A removable 3 x 6 foot sheet of aluminum is placed on top of the wooden table when a horizontal coupling plane is required.

The appropriate connections, as needed for each test, are used to interconnect the table horizontal coupling plane, ground plane floor, test equipment, and earth ground.

The available AC power in the EC Lab B is 120V 60Hz AC Single Phase 60Amps, 230V 50Hz AC Single Phase 50Amps; and 208V 60Hz AC Three Phase AC 30Amps.

The humidity in EC Lab B can be automatically controlled in the range of 20% to 60%.

### **1.3.3      Equipment Under Test**

A detailed description of the Equipment Under Test is located in the M/A-Com manual attached to the certification package.

## **2.0 SUMMARY**

The terms "Passed" or "Failed" in this section are intended to guide the reader as to whether or not the EUT met the minimum Performance Criteria that can be interpreted from the FCC Parts 2, 15 and 90. The "Results" paragraph in each test section to follow, and the test data sheets, will outline specifically how the EUT performed during each test.

Occupied Bandwidth	Passed
Emission Mask and Spurious Emissions at Antenna Terminals	Passed
Field Strength of Spurious Radiation	Passed
Frequency Stability	Passed
Radiated Emission Receiver	Passed

## **2.1 Summary of Recommendations**

The M/A-Com Opensky P-801T Portable Radio will not require modifications in order to insure compliance with FCC Parts 2, 15 and 90.

### **3.0 TESTS PERFORMED**

#### **3.1 Occupied Bandwidth**

##### **3.1.1 Equipment Used**

<b>Test Equipment</b>		<b>Asset #</b>	<b>Serial #</b>	<b>Cal Date</b>
X	H/P E4401 Spectrum Analyzer	N/A	4895C76451	04/00
X	Narda 769-30 High Band Attenuator	284	03793	C.P.U.
X	Narda 769-20 High Band Attenuator	471	02951	C.P.U.

##### **3.1.2 Test Conditions**

For measurement of the occupied bandwidth, the Opensky P-801T Portable Radio was placed inside a shielded room. The ambient temperature of the room was 20°C.

The Opensky P-801T Portable Radio was configured to operate in a normal full power transmit mode. The Opensky P-801T Portable Radio was set up and powered by a fully charged battery for the test.

##### **3.1.3 Test Method**

The output of the Opensky P-801T Portable Radio was measured at one frequency and two modes of operation the Analog High Band and Digital. The output of the transmitter was connected to two attenuators. The frequencies selected were the low, middle, and high frequencies of the radio. The attenuators were connected to a Spectrum Analyzer. See Figure 4 for test set-up.

Channel 830 (823.9875MHz) was tested for the occupied bandwidth

##### **3.1.4 Results**

The M/A-Com Opensky P-801T Portable Radio meets the requirements of FCC Part 2.1049 Occupied Bandwidth.

### Test Setup

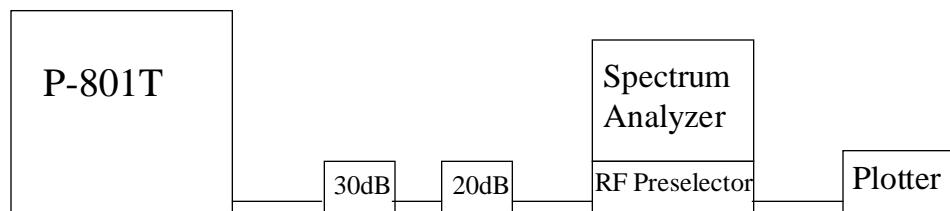


Figure 4

## 3.2 Emissions Mask and Spurious Emissions at Antenna Terminals

### 3.2.1 Equipment Used

Test Equipment		Asset #	Serial #	Cal Date
X	H/P E4401 Spectrum Analyzer	N/A	4895C76451	04/00
X	Narda 769-30 High Band Attenuator	284	03793	C.P.U.
X	H/P 8368A Signal Generator	399	8965B0091	06/00
X	Chomerics Audio Speaker	N/A	N/A	N/A
X	Narda 769-20 High Band Attenuator	471	02951	C.P.U.

### 3.2.2 Test Conditions

The Emissions Mask measurements of the Opensky P-801T Portable Radio were made inside a shielded room. The ambient temperature of the room was 20°C.

The Opensky P-801T Portable Radio was configured to operate in a normal full power transmit mode. The Opensky P-801T Portable Radio was set up and powered by a fully charged battery.

### 3.2.3 Test Method

The output of the Opensky P-801T Portable Radio was measured at multiple frequencies and modes. The output was compared to the Emissions Mask H of FCC Part 90.210.

The output of the transmitter was connected to two attenuators. The attenuators were connected to a Spectrum Analyzer. See Figure 4 for test set-up.

A full scan from 5 MHz to 10 GHz was performed for the modes of operation and frequencies selected. The frequencies selected were the low, middle, and high frequencies of each mode of operation of the radio.

The modes of operation were Digital, Analog Low Band, Analog High Band. The modulation index was set to the maximum during the digital mode. The modulation was maximum during the analog modes. When performing the spectrum mask during the analog modes of operation the radio was placed up to a speaker generating a tone at 1 kHz. The volume of the 1 kHz was set to a level so that the radio was at full modulation.

The frequencies and modes of operation are as follows:

1. Digital Mode, Low Band, Channel 1 (806.0125 MHz)
2. Digital Mode, Low Band, Channel 600 (820.9875 MHz)
3. Digital Mode, Low Band, Channel 830 (823.9875 MHz)
4. Analog Mode, Low Band, Channel 1 (806.0125 MHz)
5. Analog Mode, Low Band, Channel 600 (820.9875 MHz)
6. Analog Mode, Low Band, Channel 830 (823.9875 MHz)
7. Analog Mode, High Band, Channel 1 (851.0125 MHz)
8. Analog Mode, High Band, Channel 600 (865.9875 MHz)
9. Analog Mode, High Band, Channel 830 (868.9875 MHz)

### **3.2.4      Results**

The M/A-Com Opensky P-801T Portable Radio meets the requirements of FCC Part 90.210 and Part 2.991 Emissions Mask and Spurious Emissions at Antenna Terminals.

### 3.3 Frequency Stability

#### 3.3.1 Equipment Used

Test Equipment		Asset #	Serial #	Cal Date
X	H/P E4401 Spectrum Analyzer	N/A	4895C76451	04/00
X	Cincinnati Sub Zero ZH-32-2H/AC Temperature Chamber	544	Z09712530	05/00
X	Narda 769-30 High Band Attenuator	284	03793	C.P.U.
X	H/P 8368A Signal Generator	399	8965B0091	06/00
X	Narda 769-20 High Band Attenuator	471	02951	C.P.U.

#### 3.3.2 Test Conditions

The Frequency Stability measurements of the Opensky P-801T Portable Radio were made inside a Temperature/Humidity Chamber.

The Opensky P-801T Portable Radio was configured to operate in a normal analog High Band mode. The Opensky P-801T Portable Radio was set up and powered by a fully charged battery..

#### 3.3.3 Test Method

The output of the Opensky P-801T Portable Radio was measured at 823.9895 MHz or Channel 830. The frequency stability of the output was measured.

With the Opensky P-801T Portable Radio in the temperature chamber, the output of the transmitter was connected to two High Band attenuators. The attenuators were connected to a Spectrum Analyzer. See Figure 5 for test set-up.

The temperature was measured by placing a thermal couple on the RF chain. The Temperature was varied from  $-30^{\circ}$  to  $+50^{\circ}\text{C}$  in  $10^{\circ}$  steps. At each  $10^{\circ}$  step, the output of the Opensky P-801T Portable Radio was measured for frequency stability.

The Opensky P-801T Portable Radio was turned off between each  $10^{\circ}$  step.

#### 3.3.4 Results

The M/A-Com Opensky P-801T Portable Radio meets the Frequency Stability requirements of FCC Part 90.210 and Part 2.995.

## Test Setup

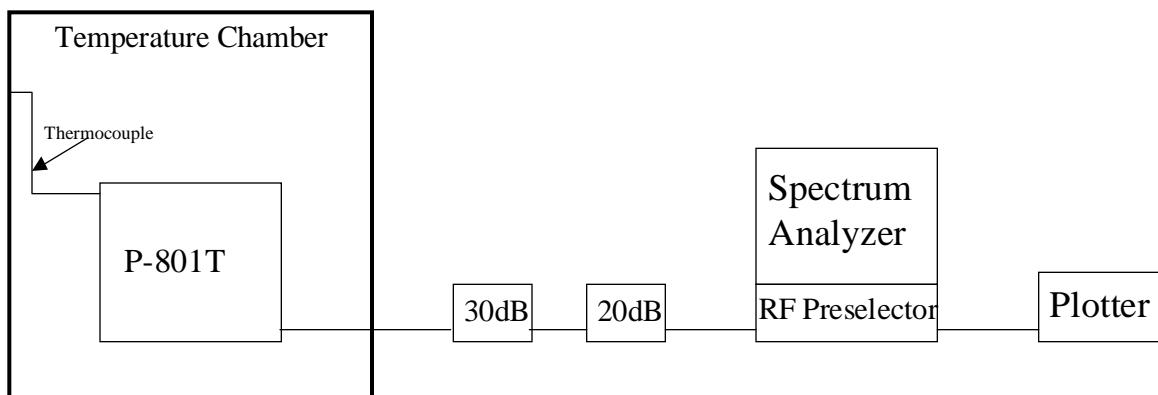


Figure 5

### 3.4 Radiated Electromagnetic Emissions Receiver

#### 3.4.1 Equipment Used

Test Equipment		Asset #	Serial #	Cal Date
X	Tektronix 496 Spectrum Analyzer	1	B010559	10/00
X	H/P E4401 Spectrum Analyzer	N/A	4895C76451	04/00
X	Rhode and Schwartz ESV Test Receiver	15	875931049	09/00
X	Hewlett Packard 8447D Pre Amp	4	2727A06065	01/00
X	EMCO 3120 Tuned Dipole Antenna B1	477	56	01/00
X	EMCO 3121 Tuned Dipole Antenna B2	478	176	01/00
X	EMCO 3121 Tuned Dipole Antenna B3	479	728	01/00
X	EMCO 3115 Microwave Horn Antenna	376	2796	01/00

#### 3.4.2 Test Conditions

For radiated emissions testing, the EUT was set up above the turntable on a wooden table 3 meters from a tuned dipole antenna within Open Area Test Site A.

The Opensky P-801T Portable Radio was configured to operate in the non-transmitting mode of operation to maximize the emissions. The EUT was set up and powered by a fully charged battery for radiated emission tests. The worst case signals detected were recorded.

The Opensky P-801T Portable Radio was tested in six different configurations.

1. Standalone with  $\frac{1}{2}$  wave antenna.
2. Standalone with  $\frac{1}{4}$  wave antenna.
3.  $\frac{1}{2}$  wave antenna and programming cable.
4.  $\frac{1}{2}$  wave antenna and external microphone.
5.  $\frac{1}{2}$  wave antenna and external headset.
6. External microphone with built-on  $\frac{1}{4}$  wave antenna

### **3.4.3 Test Method**

The test method of ANSI-C63.4 was followed for Class B equipment. For the radiated emission measurements, a manual scan was performed from 30MHz to 10GHz. During this scan, the antenna, turntable and EUT's cable positions were manipulated to maximize the emission levels in a given frequency band displayed on the spectrum analyzer.

### **3.4.4 Results**

The M/A-Com Opensky P-801T Portable Radio meets the requirements for Radiated Emissions as required by FCC Part 15 Subpart B for Class B equipment.