



R8000 Series  
Communications Systems Analyzer

## AUTOTUNE USER GUIDE

Motorola APX™ Portable Radios  
Motorola APX™ Mobile Radios

Freedom Communication Technologies  
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Kilgore, Texas 75662

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## 1. Introduction

The Freedom Communication Technologies R8000 Series Communications Systems Analyzer AutoTune™ (hereafter “AutoTune”) is designed to provide an automated test and alignment solution for supported two-way radios.

## 2. Scope

This document is intended to provide information regarding the tests and alignments performed by AutoTune for Motorola APX™ portable and mobile two-way radios. This document is restricted to radio-specific information.

Please refer to the R8000 Series Communications System Analyzer Owner’s Manual (CG-1365) for an overview and basic operating instructions for AutoTune itself.

### Supported models

AutoTune for Motorola APX supports the following radio models:

#### Portables

- APX 1000/1000i
- APX 2000
- APX 4000/4000Li
- APX 6000/6000XE/6000Li
- APX 7000/7000XE
- APX 8000/8000H/8000XE
- SRX 2200

#### Mobiles

- APX 1500
- APX 2500
- APX 4500/4500 Li
- APX 5500
- APX 6500/6500HP/6500Li
- APX 7500/7500HP
- APX 8500/8500HP



### 3. Motorola APX™ Portable Radio Test Setup

In order to perform the test and alignment procedures, the APX™ Portable radio must be connected to the R8000 Communications Systems Analyzer as shown in the figure below.



Make certain that the radio under test is configured as described in the corresponding diagram **before** attempting to perform an alignment or test. Failure to do so may result in poor radio performance and/or damage to the analyzer or radio equipment under test.

#### 3.1. Cable Sweep

Every RF cable connected between a radio under test and the analyzer attenuates the signal propagating through it. The amount of attenuation varies by several factors such as operating frequency, cable length, and cable type. Ensuring this attenuation is accounted for by the analyzer is important to the accuracy of several tests and alignments, primarily power tests.

Sweep the RF cable used between the Radio and Analyzer, label the RF cable with the stored cable sweep name, and enable the Cable Sweep feature in the analyzer System, System Settings... menu. Refer to [Application Note FCT-1017 Utilizing Cable Sweep on the Freedom Communications System Analyzer](#) for instructions on how to perform a cable sweep.

#### 3.2. Battery Eliminator

Battery eliminators interface portable radios to DC power supplies. They're needed because batteries cannot produce consistent voltage/current when the radio is keyed for extended time periods, as it will be during an alignment. Attempting to use even a nominally good battery will eventually result in power alignment failures. A battery eliminator should **always** be used while performing portable radio alignments and tests with AutoTune to achieve consistent alignment performance.

For APX portable radio models, use the following Motorola battery eliminator parts. For more information, refer to the applicable Motorola basic radio service manual.

##### **APX 900 / 1000 / 2000 / 4000**

- Part Number: 66-012031001

##### **APX 5000 / 6000 / 7000 / 8000 / SRX 2200**

- Part Number: 66-009254001

#### 3.3. APX™ Test Setup

Refer to the diagram below for the proper test setup. Note that the correct setting for each RLN4460 test set control is highlighted in yellow.

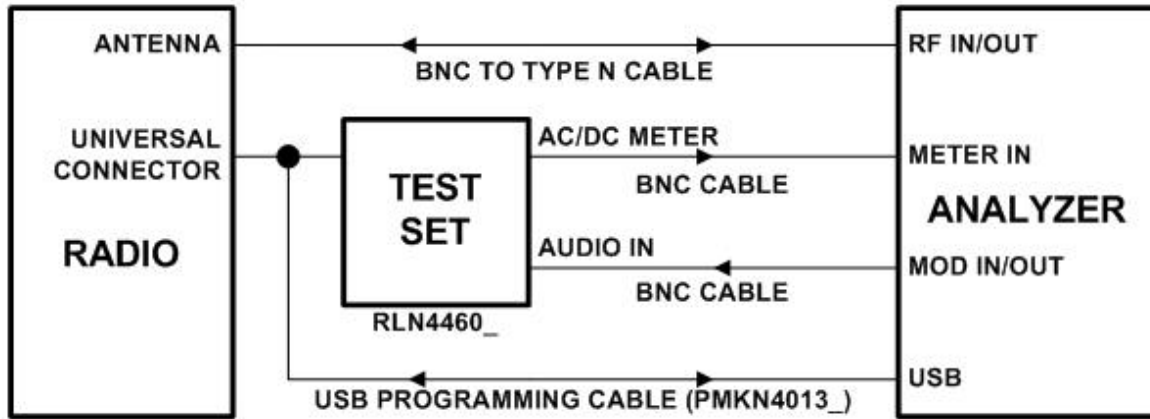
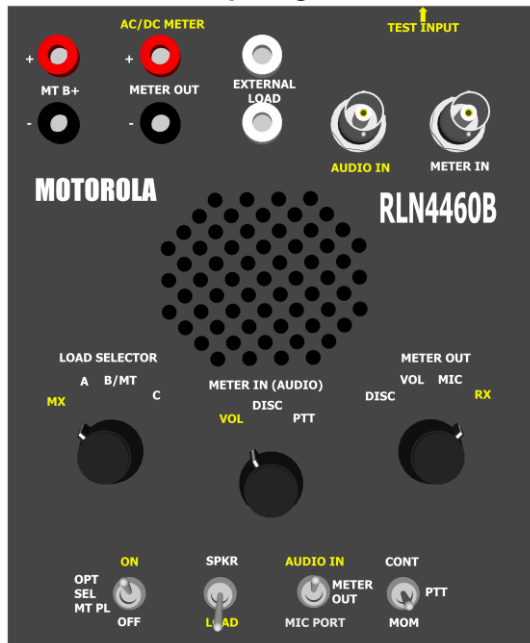


Figure 3-1. APX™ Portable Test Setup Diagram



## 4. Motorola APX™ Portable Alignment and Test Descriptions

**Note:** Throughout this section are references to Test Frequency. Test Frequencies are band- and mode -specific. A table of the frequencies used by each band may be found in the respective radio service manual. See the References section for more details.

**Note:** All analyzer Mode settings are Standard unless otherwise indicated.

### 4.1. Reference Frequency

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Frequency	FM	30 dB

Table 4-1. Analyzer Configuration for Reference Frequency

#### 4.1.1. Alignment

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. Using a best linear fit algorithm, two frequency error measurements are taken at two different radio softpot values. These frequency error measurements are used to calculate the softpot value which minimizes frequency error. After programming this new softpot value into the radio, the radio softpot is fine tuned until minimum frequency error is detected. The frequency error is compared against test limits and the final results written to the log file.

Name	Description
Result	Pass or Fail. Frequency Error within Max Limit, Min Limit
Frequency	Test Frequency
Freq Error	Measured frequency error after alignment
Min Limit	Minimum Limit (inclusive) for frequency error
Max Limit	Maximum Limit (inclusive) for frequency error
Old Softpot	Original radio softpot setting
New Softpot	Radio softpot after alignment

Table 4-2. Reference Frequency alignment results

#### 4.1.2. Test

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. The frequency error is measured by the analyzer and compared to test limits. The final results are written to the log file.

<b>Name</b>	<b>Description</b>
Result	Pass or Fail. Frequency Error within Max Limit, Min Limit
Frequency	Test Frequency
Freq Error	Measured frequency error
Max Limit	Maximum Limit (inclusive) for frequency error
Min Limit	Minimum Limit (inclusive) for frequency error
Softpot	Radio softpot which yields Freq Error

**Table 4-3. Reference Frequency test results**

## 4.2. TX Power Out

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Frequency	FM	40 dB

Table 4-4. Analyzer Configuration for TX Power Out

### 4.2.1. Alignment

The TX Power Out alignment is composed of two parts: Power Characterization Points tuning and TX Characterization tuning. Power Characterization Points tuning is performed first, and only during alignment; it is not performed during a test.

Power Characterization Points tuning adjusts the characterization points to account for the variability of the power detection circuitry between radios. The radio is placed into Test Mode and commanded to transmit at the first Test Frequency. The output level is measured and then adjusted until near to a band-specific output level defined by the APX™ Tuner software help file.

Band	Rated Target Power
VHF	6.2 Watt
UHF	5.3 Watt
700MHz	2.65 Watt
800MHz	3.2 Watt
900MHz	TBD

Table 4-5. Motorola specified target power

This process is repeated for all test frequencies. The final results are written to the log file.

Name	Description
Result	Pass or Fail. Meas Power within manufacturer limits
Frequency	Test Frequency
Meas Power	Measured radio output level
Target Power	Ideal Meas Power
Old Softpot	Original radio softpot setting
New Softpot	Radio softpot after alignment

Table 4-6. Power Characterization Points alignment results

Power Characterization tuning characterizes the power output level of the radio. The radio is placed into Test Mode and commanded to transmit. Beginning at the lowest TX Test Frequency, the output level is measured at two different points for each TX Test Frequency. These measurements are used to calculate and program power coefficients use to normalize the radio power output level across the radio band as specified by the radio's basic service manual. After the alignment is complete, the power output level is measured again at each TX Test Frequency and compared against test limits. The final results are written to the log file.

<b>Name</b>	<b>Description</b>
Result	Pass or Fail. Power Out within Max Limit, Min Limit
Frequency	Test Frequency
Power Out	Measured radio output level
Min Limit	Minimum Limit (inclusive) for Power Out
Max Limit	Maximum Limit (inclusive) for Power Out

**Table 4-7. TX Power Out alignment results**

#### 4.2.2. Test

The radio is placed into Test Mode and commanded to transmit. Beginning at the lowest TX Test Frequency, the output level is measured at each TX Test Frequency and compared against test limits. The final results are written to the log file.

<b>Name</b>	<b>Description</b>
Result	Pass or Fail. Power Out within Max Limit, Min Limit
Frequency	Test Frequency
Power Out	Measured radio output level
Min Limit	Minimum Limit (inclusive) for Power Out
Max Limit	Maximum Limit (inclusive) for Power Out

**Table 4-8. TX Power Out test results**

### 4.3. Deviation Balance

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Frequency	FM	20 dB

Table 4-9. Analyzer Configuration for Deviation Balance test, alignment

#### 4.3.1. Alignment

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. The radio generates an 80 Hz modulation tone and the deviation of this tone is measured with the analyzer. The radio then generates a 3 kHz modulation tone and the deviation of this tone is measured with the analyzer. The radio softpot is adjusted until the deviation difference between the first and second tones is as small as possible. This adjustment is performed for each TX Test Frequency and the percent difference is compared against test limits. The results for each TX Test Frequency are written to the log file.

Name	Description
Result	Pass or Fail. Percent difference between low and high tone deviation less than or equal to Variance.
Frequency	Test Frequency
Variance	Measured difference between low and high tone deviation
Max Limit	Maximum passable percent difference (inclusive) between low and high tone deviation
Old Softpot	Original radio softpot setting
New Softpot	Radio softpot setting after alignment

Table 4-10. Deviation Balance alignment results

#### 4.3.2. Test

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. The radio generates an 80 Hz modulation tone and the deviation of this tone is measured with the analyzer. The radio then generates a 3 kHz modulation tone and the deviation of this tone is measured with the analyzer. The percent difference is compared against test limits and written to the log file. This test is performed for each remaining TX Test Frequency.

Name	Description
Result	Pass or Fail. Percent difference between low and high tone deviation less than or equal to Variance.
Frequency	Test Frequency
Variance	Measured difference between low and high tone deviation
Max Limit	Maximum passable percent difference (inclusive) between low and high tone deviation

Table 4-11. Deviation Balance test results

#### 4.4. Distortion

This is a test only; there is no alignment.

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	FM, 1 kHz @ 3 kHz deviation	-50 dBm

**Table 4-12. Analyzer Configuration for Distortion Test**

##### 4.4.1. Alignment

No alignment is needed.

##### 4.4.2. Test

The analyzer is setup as specified in this section's Analyzer Configuration table. The radio is placed into Test Mode at the lowest RX Test Frequency. The radio audio output level is tested and if insufficient to measure distortion the volume is increased until sufficient to measure distortion. The audio signal's distortion level is then measured and compared to test limits. The final results are written to the log file.

Name	Description
Result	Pass or Fail. Distortion level within Max Limit, Min Limit
Frequency	Test Frequency
Distortion	Measured audio signal distortion level
Max Limit	Maximum Limit (inclusive) for Distortion to Pass

**Table 4-13. Distortion test results**



## 4.5. Sensitivity (SINAD)

This is a test only; there is no alignment.

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	FM, 1 kHz @ 3kHz deviation	-50 dBm

Table 4-14. Analyzer Configuration for Sensitivity (SINAD) test

### 4.5.1. Alignment

No alignment is needed.

### 4.5.2. Test

The analyzer is setup as specified in this section's Analyzer Configuration table. The radio is placed into Test Mode at the lowest RX Test Frequency. The radio audio output level is tested and if insufficient to measure SINAD the volume is increased until sufficient to measure SINAD. The output level of the analyzer is then adjusted until the radio audio signal's SINAD level measures about 12 dB. The current analyzer output level is then compared against test limits. The final results are written to the log file.

Name	Description
Result	Pass or Fail. Sensitivity (SINAD) level within Max Limit
Frequency	Test Frequency
12dB SINAD	Analyzer output level at which the radio SINAD level measures 12 dB
Max Limit	Maximum Limit (inclusive) for Sensitivity (SINAD) to Pass

Table 4-15. Sensitivity (SINAD) test results

## 4.6. Noise Squelch Threshold

This is a test only; there is no alignment.

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	FM, 1 kHz @ 3kHz deviation	-50 dBm

**Table 4-16. Analyzer Configuration for Noise Squelch Threshold test**

### 4.6.1. Alignment

No alignment is needed.

### 4.6.2. Test

The purpose of this procedure is to verify that the squelch circuit operation performs as expected, blocking noise but allowing stronger signals to be heard. The analyzer is setup as specified in this section's Analyzer Configuration table. The radio is placed into Test Mode at the lowest RX Test Frequency. The radio audio output level is tested and if insufficient to measure the un-squelched condition the volume is increased. Beginning at -125 dBm, the analyzer output level is slowly increased until the radio un-squelches OR is 6 dBm above the Max Limit, whichever comes first. The Un-squelch analyzer output level is compared against test limits and the final results written to the log file.

Name	Description
Result	Pass or Fail. Noise Squelch Threshold level within Max Limit
Frequency	Test Frequency
Un-squelch	Analyzer output level at which the radio un-squelches
Max Limit	Maximum Limit (exclusive) for Noise Squelch Threshold to Pass

**Table 4-17. Noise Squelch Threshold test results**

## 4.7. P25 Tx Tests

**NOTE: This test requires an analyzer with P25 Conventional (R8-P25) test mode capability.**

The purpose of this procedure is to measure the radio transmitter performance at several given frequencies per the TIA/EIA 102.CAAB standard. These are tests only; there are no alignments.

RF Control	Port	Frequency	Modulation Type	Test Pattern
Monitor	RF IN/OUT	Test Frequency	C4FM	Standard Tx (O.153/V.52)

**Table 4-18. Analyzer Configuration for P25 Tx Tests**

### 4.7.1. Alignment

No alignment is needed.

### 4.7.2. Test

The analyzer is setup as specified in this section's Analyzer Configuration table. The radio is placed into Test Mode at the lowest Tx Test Frequency, ready to transmit a C4FM-modulated signal to the analyzer. The radio is keyed and for each test frequency the following digital measurements are taken: Modulation Fidelity and Symbol Deviation. These measurement results are compared against test limits and the final results written to the log file.

Name	Description
Result	Pass or Fail. Digital Sensitivity (BER) output level within Max Limit
Frequency	Test Frequency
Mod Fidelity	RMS error magnitude difference (%) between actual signal and ideal C4FM signal
Max Limit	Maximum Limit (inclusive) for Modulation Fidelity test to Pass

**Table 4-19. P25 Modulation Fidelity test results**

Name	Description
Result	Pass or Fail. Digital Sensitivity (BER) output level within Max Limit
Frequency	Test Frequency
Symbol Dev	Deviation (Hz) from transmitting the Standard Tx test pattern
Min Limit	Minimum Limit (inclusive) for Symbol Deviation test to Pass
Max Limit	Maximum Limit (inclusive) for Symbol Deviation test to Pass

**Table 4-20. P25 Symbol Deviation test results**

## 4.8. Digital Sensitivity (BER)

**NOTE: This test requires an analyzer with P25 Conventional test mode capability.**

The purpose of this procedure is to measure the radio receiver's Bit Error Rate at a given frequency. The TIA/EIA standard BER rate is 5%. This is a test only; there is no alignment.

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Frequency	Framed 1011 Hz Pattern, 2.83 kHz deviation	-116.0 dBm

**Table 4-21. Analyzer Configuration for Digital Sensitivity (BER) test**

### 4.8.1. Alignment

No alignment is needed.

### 4.8.2. Test

The analyzer is setup as specified in this section's Analyzer Configuration table. The radio is placed into Test Mode at the lowest RX Test Frequency, ready to receive a C4FM-modulated signal from the analyzer. Once BER synchronization is detected, the analyzer output level is decreased until a BER of 5% is measured. The analyzer output level at 5% BER is compared against test limits and the final results are written to the log file.

Name	Description
Result	Pass or Fail. Digital Sensitivity (BER) output level within Max Limit
Frequency	Test Frequency
5% BER	Analyzer output level at which the radio BER measures 5%
Max Limit	Maximum Limit (inclusive) for Digital Sensitivity (BER) to Pass

**Table 4-22. Digital Sensitivity (BER) test results**

## 4.9. Internal Voice Modulation

The purpose of this procedure is to test the ability of the radio's internal microphone audio circuit to accurately transfer the received signal.

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Frequency	FM	40 dB

**Table 4-23. Analyzer Configuration for Internal Voice Modulation test**

### 4.9.1. Alignment

No alignment is needed.

### 4.9.2. Test

The radio is placed into Test Mode at the lowest TX Test Frequency. The analyzer is setup as specified in this section's Analyzer Configuration table. The user is instructed to key the connected radio and place it next to the analyzer speaker (see Figure 4-1). The user is also instructed to adjust the analyzer volume until about 4 kHz deviation is seen on the analyzer display (see Figure 4-2). The deviation level is then measured by the analyzer and the user is instructed when to un-key the radio. The measured deviation is compared against test limits and the final results are written to the log file.



**Figure 4-1. Place keyed radio next to analyzer speaker.**



Figure 4-2. Adjust analyzer volume until about 4 kHz deviation is measured.

Name	Description
Result	Pass or Fail. Deviation within Min Limit, Max Limit
Frequency	Test Frequency
Deviation	Measured modulation deviation level
Min Limit	Minimum Limit (inclusive) for Deviation to Pass
Max Limit	Maximum Limit (inclusive) for Deviation to Pass

Table 4-24. Internal Voice Modulation test results

## 4.10. External Voice Modulation

The purpose of this procedure is to test the ability of an external microphone attached to the radio to effectively transfer the received signal.

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Frequency	FM	40 dB

**Table 4-25. Analyzer Configuration for External Voice Modulation test**

### 4.10.1. Alignment

No alignment is needed.

### 4.10.2. Test

The radio is placed into Test Mode at the lowest TX Test Frequency. The analyzer is setup as specified in this section's Analyzer Configuration table. The analyzer generates a 1 kHz signal at 800 mV into the radio's external microphone accessory port via the radio test set. The radio is commanded to transmit and the resulting deviation level is then measured by the analyzer. The measured deviation is compared against test limits and the final results are written to the log file.

Name	Description
Result	Pass or Fail. Deviation within Min Limit, Max Limit
Frequency	Test Frequency
Deviation	Measured modulation deviation level
Min Limit	Minimum Limit (inclusive) for Deviation to Pass
Max Limit	Maximum Limit (inclusive) for Deviation to Pass

**Table 4-26. External Voice Modulation test results**

## 5. Motorola APX™ Mobile Radio Test Setup

In order to perform the test and alignment procedures, the APX™ Mobile radio must be connected to the R8000 Communications Systems Analyzer as shown in the figure below.

**CAUTION:** Make certain that the radio under test is configured as described in the corresponding diagram **before** attempting to perform the indicated alignment or test. Failure to do so may result in poor radio performance and/or damage to the analyzer or radio equipment under test.

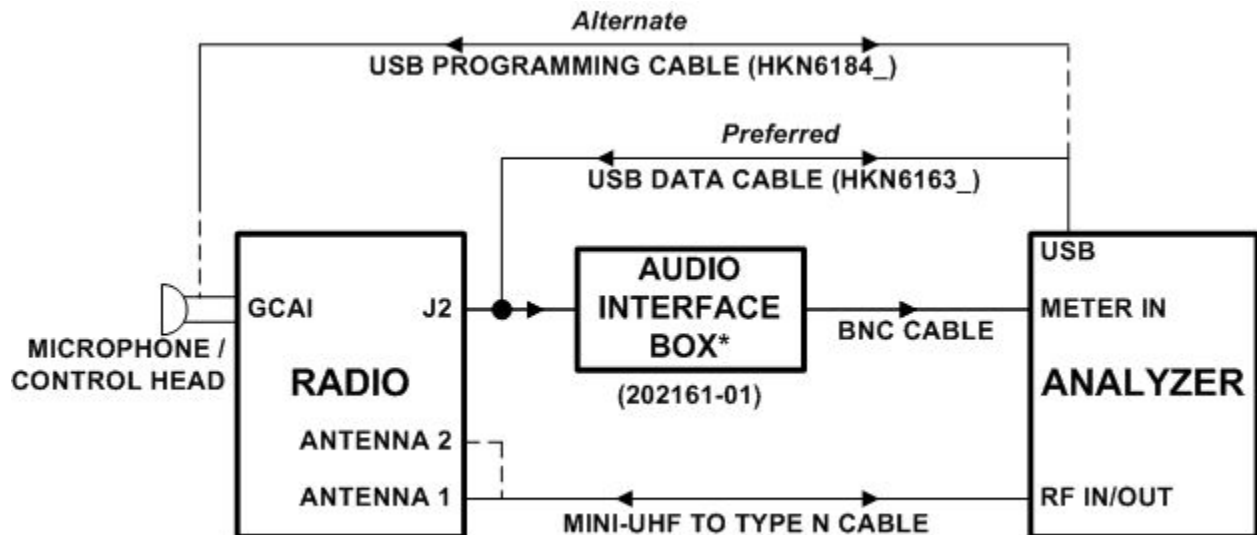
### 5.1. Cable Sweep

Every RF cable connected between a radio under test and the analyzer attenuates the signal propagating through it. The amount of attenuation varies by several factors such as operating frequency, cable length, and cable type. Ensuring this attenuation is accounted for by the analyzer is critical to test and alignment accuracy, especially for power alignments and sensitivity tests.

Sweep the RF cable used between the Radio and Analyzer, label the RF cable with the stored cable sweep name, and enable the Cable Sweep feature in the analyzer System, System Settings... menu. Refer to [Application Note FCT-1017 Utilizing Cable Sweep on the Freedom Communications System Analyzer](#) for instructions on how to perform a cable sweep.

### 5.2. Motorola APX™ Mobile Test Setup

Refer to the diagram below for the proper test setup.



\*Required only for Distortion, Sensitivity (SINAD), and Noise Squelch Threshold tests.

Figure 5-1. Motorola APX™ Mobile Test Setup Diagram

### 5.3. Motorola APX™ Mobile High Power Test Setup



Refer to the diagram below for the proper test setup.

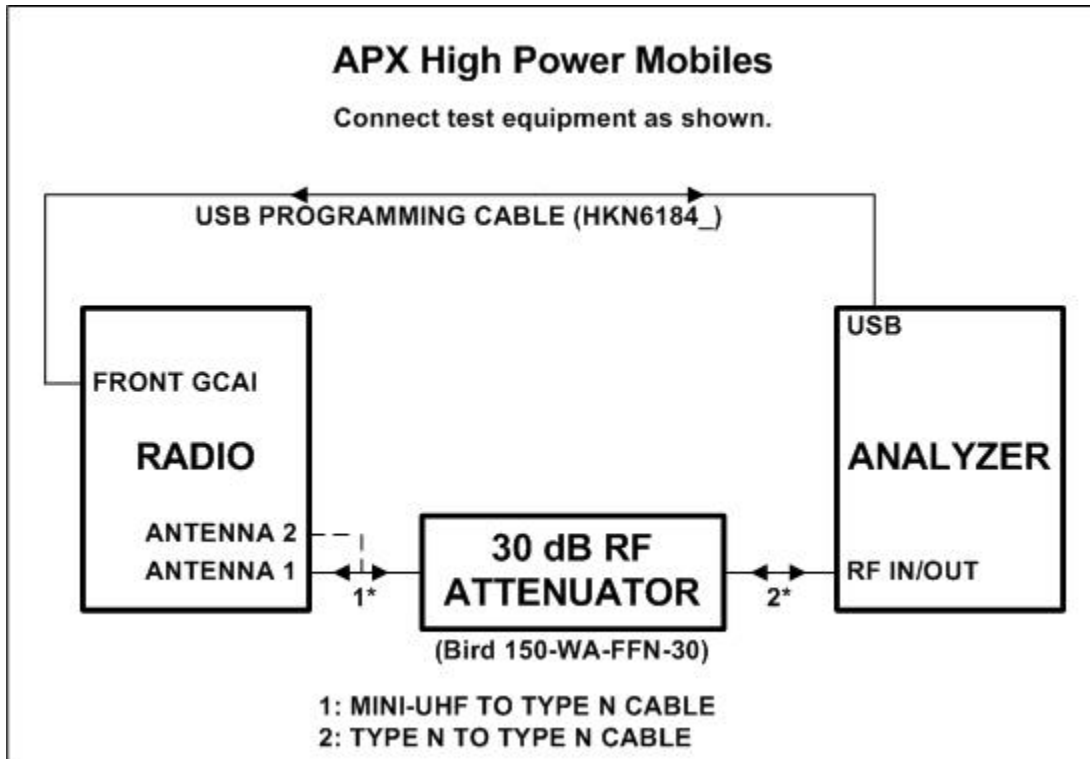


Figure 5-2. Motorola APX™ Mobile High Power Test Setup Diagram

## 6. Motorola APX™ Mobile Alignment and Test Descriptions

**Note:** Throughout this section are references to Test Frequency that are band and mode specific. A table of the frequencies used by each band may be found in the respective radio service manual. See the References section for more details.

**Note:** All analyzer Mode settings are Standard unless otherwise indicated.

**Dual-Band:** Some Motorola APX™ Mobile radios are dual-band capable. Additional notes for radio models configured with two bands are included in the following sections. If the radio under test is configured with a single band, these notes are not applicable.

**Dual-Band:** Dual Band equipped radios have two RF connectors at the rear of the radio. They are labeled on the top and on the rear of the radio to identify which band they should be used with. During most tests and alignments, it will be necessary to change the test setup cabling to test both bands. The test operator will be prompted to connect the RF cable to the appropriate RF Output port on the radio.

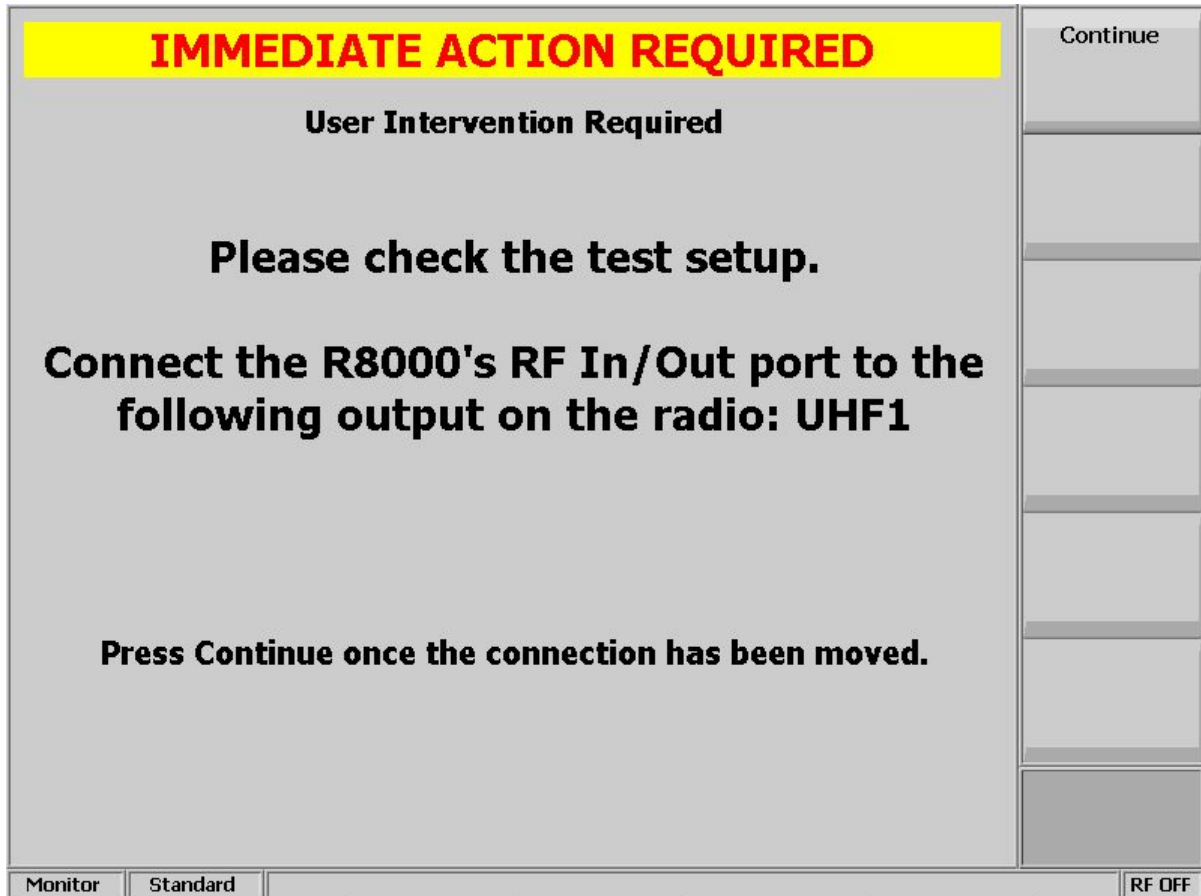


Figure 6-1. AutoTune prompt when test/alignment requires switching bands

## 6.1. Reference Frequency

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Frequency	FM	20 dB

Table 6-1. Analyzer Configuration for Reference Frequency

### 6.1.1. Alignment

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. Using a best linear fit algorithm, two frequency error measurements are taken at two different radio softpot values. These frequency error measurements are used to calculate the softpot value which minimizes frequency error. After programming this new softpot value into the radio, the radio softpot is fine tuned until minimum frequency error is detected. The frequency error is compared against test limits and the final results written to the log file.

**Dual-Band:** This alignment is only performed at a single test frequency. The test frequency is the highest test frequency for the highest frequency band.

Name	Description
Result	Pass or Fail. Frequency Error within Max Limit, Min Limit
Frequency	Test Frequency
Freq Error	Measured frequency error after alignment
Min Limit	Minimum Limit (inclusive) for frequency error
Max Limit	Maximum Limit (inclusive) for frequency error
Old Softpot	Original radio softpot setting
New Softpot	Radio softpot after alignment

Table 6-2. Reference Frequency alignment results

### 6.1.2. Test

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. The frequency error is measured by the analyzer and compared to test limits. The final results are written to the log file.

**Dual-Band:** This test is only performed at a single test frequency. The test frequency is the highest test frequency for the highest frequency band.

<b>Name</b>	<b>Description</b>
Result	Pass or Fail. Frequency Error within Max Limit, Min Limit
Frequency	Test Frequency
Freq Error	Measured frequency error
Min Limit	Minimum Limit (inclusive) for frequency error
Max Limit	Maximum Limit (inclusive) for frequency error
Softpot	Radio softpot which yields Freq Error

**Table 6-3. Reference Frequency test results**

## 6.2. TX Power Out

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Frequency	FM	40 dB

Table 6-4. Analyzer Configuration for TX Power Out

### 6.2.1. Alignment

The TX Power Out alignment is composed of two parts: Power Detection Calibration and TX Power Out. Power Detection Calibration is performed first, and only during alignment; it is not performed during a test.

Power Detector Calibration tunes the radio power detector to minimize the power output variation across radios. The radio is placed into Test Mode and commanded to transmit at a mid-band Test Frequency. The output level is measured and then adjusted until near to a band-specific target output level supplied by the radio. The final results are written to the log file.

**Dual-Band:** This alignment is performed consecutively for all test frequencies in both bands.

Name	Description
Result	Pass or Fail. Meas Power & New Softpot within manufacturer limits
Frequency	Test Frequency
Meas Power	Measured radio output level
Target Power	Ideal Meas Power
Old Softpot	Original radio softpot setting
New Softpot	Radio softpot after alignment

Table 6-5. Power Detection Calibration alignment results

Power Characterization tuning characterizes the power output level of the radio. The radio is placed into Test Mode and commanded to transmit. Beginning at the lowest TX Test Frequency, the output level is measured at two different points for each TX Test Frequency. These measurements are used to calculate and program power coefficients use to normalize the radio power output level across the radio band as specified by the radio's basic service manual. After the alignment is complete, the power output level is measured again at each TX Test Frequency and compared against test limits. The final results are written to the log file.

**Dual-Band:** This alignment is performed consecutively for all test frequencies in both bands.

Name	Description
Result	Pass or Fail. Power Out within Max Limit, Min Limit
Frequency	Test Frequency
Power Out	Measured radio output level
Min Limit	Minimum Limit (inclusive) for Power Out
Max Limit	Maximum Limit (inclusive) for Power Out

**Table 6-6. TX Power Out alignment results**

### 6.2.2. Test

The radio is placed into Test Mode and commanded to transmit. Beginning at the lowest TX Test Frequency, the output level is measured at each TX Test Frequency and compared against test limits. The final results are written to the log file.

**Dual-Band:** This test is performed consecutively for all test frequencies in both bands.

Name	Description
Result	Pass or Fail. Power Out within Max Limit, Min Limit
Frequency	Test Frequency
Power Out	Measured radio output level
Min Limit	Minimum Limit (inclusive) for Power Out
Max Limit	Maximum Limit (inclusive) for Power Out

**Table 6-7. TX Power Out test results**

### 6.3. Deviation Balance

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Frequency	FM	30 dB

Table 6-8. Analyzer Configuration for Deviation Balance test, alignment

#### 6.3.1. Alignment

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. The radio generates an 80 Hz modulation tone and the deviation of this tone is measured with the analyzer. The radio then generates a 3 kHz modulation tone and the deviation of this tone is measured with the analyzer. The radio softpot is adjusted until the deviation difference between the first and second tones is within test limits. This adjustment is performed for each TX Test Frequency and the percent difference is compared against test limits. The results for each TX Test Frequency are written to the log file.

**Dual-Band:** This alignment is performed consecutively for all test frequencies in both bands.

Name	Description
Result	Pass or Fail. Percent difference between low and high tone deviation less than or equal to Variance.
Frequency	Test Frequency
Variance	Measured difference between low and high tone deviation
Max Limit	Maximum passable percent difference (inclusive) between low and high tone deviation
Old Softpot	Original radio softpot setting
New Softpot	Radio softpot setting after alignment

Table 6-9. Deviation Balance alignment results

#### 6.3.2. Test

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. The radio generates an 80 Hz modulation tone and the deviation of this tone is measured with the analyzer. The radio then generates a 3 kHz modulation tone and the deviation of this tone is measured with the analyzer. The percent difference is compared against test limits and written to the log file. This test is performed for each remaining TX Test Frequency.

**Dual-Band:** This test is performed consecutively for all test frequencies in both bands.

Name	Description
Result	Pass or Fail. Percent difference between low and high tone deviation less than or equal to Variance.
Frequency	Test Frequency
Variance	Measured difference between low and high tone deviation
Max Limit	Maximum passable percent difference (inclusive) between low and high tone deviation
Softpot	Radio softpot setting

**Table 6-10. Deviation Balance test results**



## 6.4. Distortion

**Note:** Motorola APX™ Mobile High Power models are not supported for this test.

This is a test only; there is no alignment.

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	FM, 1 kHz @ 3 kHz deviation	-50 dBm

**Table 6-11. Analyzer Configuration for Distortion Test**

### 6.4.1. Alignment

No alignment is needed.

### 6.4.2. Test

The analyzer is setup as specified in this section's Analyzer Configuration table. The radio is placed into Test Mode at the lowest RX Test Frequency. The radio audio output level is tested and if insufficient to measure distortion the volume is increased until sufficient to measure distortion. The audio signal's distortion level is then measured and compared to test limits. The final results are written to the log file.

**Dual-Band:** This test is performed for the lowest RX Test Frequency in each band.

Name	Description
Result	Pass or Fail. Distortion level within Max Limit, Min Limit
Frequency	Test Frequency
Distortion	Measured audio signal distortion level
Max Limit	Maximum Limit (inclusive) for Distortion to Pass

**Table 6-12. Distortion test results**

## 6.5. Sensitivity (SINAD)

**Note:** Motorola APX™ Mobile High Power models are not supported for this test.

This is a test only; there is no alignment.

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	FM, 1 kHz @ 3kHz deviation	-50 dBm

**Table 6-13. Analyzer Configuration for Sensitivity (SINAD) test**

### 6.5.1. Alignment

No alignment is needed.

### 6.5.2. Test

The analyzer is setup as specified in this section's Analyzer Configuration table. The radio is placed into Test Mode at the lowest RX Test Frequency. The radio audio output level is tested and if insufficient to measure SINAD the volume is increased until sufficient to measure SINAD. The output level of the analyzer is then adjusted until the radio audio signal's SINAD level measures about 12 dB. The current analyzer output level is then compared against test limits. The final results are written to the log file.

**Dual-Band:** This test is performed for the lowest RX Test Frequency in each band.

Name	Description
Result	Pass or Fail. Sensitivity (SINAD) level within Max Limit
Frequency	Test Frequency
12dB SINAD	Analyzer output level at which the radio SINAD level measures 12 dB
Max Limit	Maximum Limit (inclusive) for Sensitivity (SINAD) to Pass

**Table 6-14. Sensitivity (SINAD) test results**

## 6.6. Noise Squelch Threshold

**Note:** Motorola APX™ Mobile High Power models are not supported for this test.

This is a test only; there is no alignment.

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	FM, 1 kHz @ 3kHz deviation	-50 dBm

**Table 6-15. Analyzer Configuration for Noise Squelch Threshold test**

### 6.6.1. Alignment

No alignment is needed.

### 6.6.2. Test

The purpose of this procedure is to verify that the squelch circuit operation performs as expected, blocking noise but allowing stronger signals to be heard. The analyzer is setup as specified in this section’s Analyzer Configuration table. The radio is placed into Test Mode at the lowest RX Test Frequency. The radio audio output level is tested and if insufficient to measure the unsquelched condition the volume is increased. Beginning at -125 dBm, the analyzer output level is slowly increased until the radio unsquelches OR is 6 dBm above the Max Limit, whichever comes first. The analyzer output level is compared against test limits and the final results written to the log file. The radio audio output level is tested and the volume is increased if insufficient to measure unsquelch condition. Beginning at -125 dBm, the analyzer output level is slowly increased until the radio unsquelches OR 6 dBm above the Max Limit, whichever comes first. The unsquelch output level is compared against test limits and the final results written to the log file.

**Dual-Band:** This test is performed for the lowest RX Test Frequency in each band.

Name	Description
Result	Pass or Fail. Noise Squelch Threshold level within Max Limit
Frequency	Test Frequency
Unsquelch	Analyzer output level at which the radio unsquelches
Max Limit	Maximum Limit (exclusive) for Noise Squelch Threshold to Pass

**Table 6-16. Noise Squelch Threshold test results**

## 6.7. P25 Tx Tests

**NOTE: This test requires an analyzer with P25 Conventional (R8-P25) test mode capability.**

The purpose of this procedure is to measure the radio transmitter performance at several given frequencies per the TIA/EIA 102.CAAB standard. These are tests only; there are no alignments.

RF Control	Port	Frequency	Modulation Type	Test Pattern
Monitor	RF IN/OUT	Test Frequency	C4FM	Standard Tx (O.153/V.52)

**Table 6-17. Analyzer Configuration for P25 Tx Tests**

### 6.7.1. Alignment

No alignment is needed.

### 6.7.2. Test

The analyzer is setup as specified in this section's Analyzer Configuration table. The radio is placed into Test Mode at the lowest Tx Test Frequency, ready to transmit a C4FM-modulated signal to the analyzer. The radio is keyed and for each test frequency the following digital measurements are taken: Modulation Fidelity and Symbol Deviation. These measurement results are compared against test limits and the final results written to the log file.

Name	Description
Result	Pass or Fail. Digital Sensitivity (BER) output level within Max Limit
Frequency	Test Frequency
Mod Fidelity	RMS error magnitude difference (%) between actual signal and ideal C4FM signal
Max Limit	Maximum Limit (inclusive) for Modulation Fidelity test to Pass

**Table 6-18. P25 Modulation Fidelity test results**

Name	Description
Result	Pass or Fail. Digital Sensitivity (BER) output level within Max Limit
Frequency	Test Frequency
Symbol Dev	Deviation (Hz) from transmitting the Standard Tx test pattern
Min Limit	Minimum Limit (inclusive) for Symbol Deviation test to Pass
Max Limit	Maximum Limit (inclusive) for Symbol Deviation test to Pass

**Table 6-19. P25 Symbol Deviation test results**

## 6.8. Digital Sensitivity (BER)

**NOTE:** This test requires an analyzer with P25 Conventional test mode capability.

The purpose of this procedure is to measure the radio receiver's Bit Error Rate at a given frequency. The TIA/EIA standard BER rate is 5%. This is a test only; there is no alignment.

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Frequency	Framed 1011 Hz Pattern, 2.83 kHz deviation	-116.0 dBm

**Table 6-20. Analyzer Configuration for Digital Sensitivity (BER) test**

### 6.8.1. Alignment

No alignment is needed.

### 6.8.2. Test

The analyzer is setup as specified in this section's Analyzer Configuration table. The radio is placed into Test Mode at the lowest RX Test Frequency, ready to receive a C4FM-modulated signal from the analyzer. Once BER synchronization is detected, the analyzer output level is decreased until a BER of 5% is measured. The analyzer output level at 5% BER is compared against test limits and the final results are written to the log file.

**Dual-Band:** This test is performed for the lowest RX Test Frequency in each band.

Name	Description
Result	Pass or Fail. Digital Sensitivity (BER) output level within Max Limit
Frequency	Test Frequency
5% BER	Analyzer output level at which the radio BER measures 5%
Max Limit	Maximum Limit (inclusive) for Digital Sensitivity (BER) to Pass

**Table 6-21. Digital Sensitivity (BER) test results**

## 6.9. Voice Modulation

**Note:** Motorola APX™ Mobile High Power models are not supported for this test.

The purpose of this procedure is to test the ability of the radio's external microphone audio circuit to accurately transfer the received microphone signal.

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Frequency	FM	40 dB

Table 6-22. Analyzer Configuration for Voice Modulation test

### 6.9.1. Alignment

No alignment is needed.

### 6.9.2. Test

The radio is placed into Test Mode at the lowest TX Test Frequency. The analyzer is setup as specified in this section's Analyzer Configuration table. The user is instructed to key the connected radio microphone and place the microphone next to the analyzer speaker (seeFigure 6-2). The user is also instructed to adjust the analyzer volume until about 4 kHz deviation is seen on the analyzer display (seeFigure 6-3). The deviation level is then measured by the analyzer and the user is instructed when to un-key the microphone. The measured deviation is compared against test limits and the final results are written to the log file.



Figure 6-2. Place keyed microphone next to analyzer speaker.



Figure 6-3. Adjust analyzer volume until about 4 kHz deviation is measured.

**Dual-Band:** This test is only performed for the lowest RX Test Frequency in the lowest frequency band.

Name	Description
Result	Pass or Fail. Deviation within Min Limit, Max Limit
Frequency	Test Frequency
Deviation	Measured modulation deviation level
Min Limit	Minimum Limit (inclusive) for Deviation to Pass
Max Limit	Maximum Limit (inclusive) for Deviation to Pass

Table 6-23. Voice Modulation test results

## 7. Basic Troubleshooting

Symptom	Possible Cause(s)	Possible Solution(s)
Radio repeatedly fails communication initialization.	Serial link corruption.	Retry communicating with the radio after each of the following steps: <ul style="list-style-type: none"> <li>• Power cycle the radio.</li> <li>• Restart the analyzer.</li> </ul>
	Analyzer disk corruption.	Contact Freedom Communication Technologies technical support.
Radio won't power up.	Loose HKN6163_cable connection.	Verify cable connection is OK.
	Motorola CPS Ignition Switch setting.	Use Motorola CPS software to set Radio Wide, Advanced, Ignition Switch setting to "Blank". This setting lets radio power up for testing without an ignition signal present. Be sure to return this setting to its original value when testing completed.
Radio consistently fails TX Power Out test and/or alignment.	APX Family CPS Transmit Power Level settings limiting radio output power.	Using APX Family CPS, adjust Codeplug Configuration Mode>Radio Wide>Transmit Power Level settings to factory defaults. This change lets radio output expected power levels for correct AutoTune TX Power Out testing and alignment.
	DC Power supply current limiting preventing portable radio from getting adequate current.	Adjust DC power supply current limit to about 3 Amps.

**Table 7-1. AutoTune Troubleshooting Chart**



## **8. Support Information**

### **8.1. Technical Support**

Telephone/Fax: 844.903.7333  
Email: [service@freedomcte.com](mailto:service@freedomcte.com)  
Web: [freedomcte.com/service-support/](http://freedomcte.com/service-support/)

### **8.2. Sales Support**

Telephone/Fax: 844.903.7333  
Email: [sales@freedomcte.com](mailto:sales@freedomcte.com)  
Web: [freedomcte.com/sales/](http://freedomcte.com/sales/)

## 9. References

*ASTRO® APX® 5000/ APX® 6000/ APX® 6000Li/ APX® 6000XE Digital Portable Radios Basic Service Manual (68012002028-C)*

*ASTRO® APX™ 7000 VHF/700–800 MHz/UHF1/UHF2 Digital Portable Radios Basic Service Manual (6875962M01-D)*

*APX 6500, APX7500, 03, 05 & 09 Basic Service Manual (6875964M01-C)*

**APPENDIX A. Test Limits**

The factory limits contain the default limits as defined by the radio manufacturer and generally should not be modified. However, if extenuating circumstances cause a need to modify the limits this is accommodated by AutoTune. Refer to the R8000 Series Communications System Analyzer Owner's Manual (CG-1365) for modification instructions.

The following tables list the default test limits for each APX radio model supported by AutoTune.

Section	Test Name	Limit	Default Value
4.1	Reference Frequency	Reference Frequency Align	Min=-100 Hz Max= 100 Hz
4.1	Reference Frequency	Reference Frequency Test VHF	Min= -2 ppm Max= 2 ppm
		Reference Frequency Test UHF1	Min= -2 ppm Max= 2 ppm
		Reference Frequency Test UHF2	Min= -2 ppm Max= 2 ppm
		Reference Frequency Test 700-800MHz	Min= -1.5 ppm Max= 1.5 ppm
		Reference Frequency Test 900MHz	Min= -1.5 ppm Max= 1.5 ppm
4.2	TX Power Out	TX Power VHF	Min= 6.0 W Max= 6.4 W
		TX Power UHF1	Min= 5.3 W Max= 5.5 W
		TX Power UHF2	Min= 5.3 W Max= 5.5 W
		TX Power 700MHz	Min= 2.6 W Max= 2.8 W
		TX Power 800MHz	Min= 3.2 W Max= 3.4 W
		TX Power 900MHz	Min= 2.4 W Max= 2.6 W
4.3	Deviation Balance	Deviation Balance	Max= 1.5 %
4.4	Distortion	Distortion	Max= 3 %
4.5	Sensitivity (SINAD)	Sensitivity VHF	Max= -116 dBm
		Sensitivity UHF1	Max= -116 dBm
		Sensitivity UHF2	Max= -116 dBm
		Sensitivity 700-800MHz	Max= -116 dBm
		Sensitivity 900MHz	Max= -116 dBm
4.6	Noise Squelch Threshold	Noise Squelch	Max= -116 dBm
4.7	P25 Tx Tests	Modulation Fidelity	Max=5%
		Symbol Deviation	Min=1620 Hz
			Max=1980 Hz
4.8	Digital Sensitivity (BER)	BER VHF	Max= -116 dBm
		BER UHF1	Max= -116 dBm
		BER UHF2	Max= -116 dBm
		BER 700-800MHz	Max= -116 dBm
		BER 900MHz	Max= -116 dBm
4.9	Internal Voice Modulation	Internal Voice Modulation	Min= 4.1 kHz Max= 5.0 kHz
		Internal Voice Modulation 12.5 kHz	Min= 2.1 kHz Max= 2.5 kHz
4.10	External Voice Modulation	External Voice Modulation	Min= 4.1 kHz Max= 5.0 kHz
		External Voice Modulation 12.5 kHz	Min= 2.1 kHz Max= 2.5 kHz

**Table A-1. Default portable test limits.**

Section	Test Name	Limit	Default Value
6.1	Reference Frequency	Reference Frequency Align VHF	Min= -150 Hz Max= 150 Hz
		Reference Frequency Align UHF1	Min= -150 Hz Max= 150 Hz
		Reference Frequency Align UHF2	Min= -150 Hz Max= 150 Hz
		Reference Frequency Align 700-800MHz	Min= -100 Hz Max= 100 Hz
		Reference Frequency Test VHF	Min= -2 ppm Max= 2 ppm
		Reference Frequency Test UHF1	Min= -2 ppm Max= 2 ppm
		Reference Frequency Test UHF2	Min= -2 ppm Max= 2 ppm
		Reference Frequency Test 700-800MHz	Min= -1.5 ppm Max= 1.5 ppm
6.2	TX Power Out	TX Power VHF	Min= 50 W Max= 57 W
		TX Power VHF High Power	Min= 100 W Max= 120 W
		TX Power UHF1	Min= 40 W Max= 48 W
		TX Power UHF1 High Power	Min= 100 W Max= 120 W
		TX Power UHF2 Band1	Min= 45 W Max= 55 W
		TX Power UHF2 Band2	Min= 40 W Max= 48 W
		TX Power UHF2 Band3	Min= 24.5 W Max= 30.5 W
		TX Power 700 MHz	Min= 31.5 W Max= 34.7 W
		TX Power 800 MHz	Min= 36.6 W Max= 40.5 W
6.3	Deviation Balance	Deviation Balance	Max= 1 %
6.4	Distortion	Distortion	Max= 3 %
6.5	Sensitivity (SINAD)	Sensitivity VHF	Max= -117.4 dBm
		Sensitivity UHF1	Max= -117.4 dBm
		Sensitivity UHF2	Max= -117.4 dBm
		Sensitivity 700-800MHz	Max= -119 dBm
6.6	Noise Squelch Threshold	Noise Squelch	Max= -116 dBm
6.7	P25 Tx Tests	Modulation Fidelity	Max=5%
		Symbol Deviation	Min=1620 Hz
			Max=1980 Hz
6.8	Digital Sensitivity (BER)	BER VHF	Max= -117.4 dBm
		BER UHF1	Max= -117.4 dBm
		BER UHF2	Max= -117.4 dBm
		BER 700-800MHz	Max= -119 dBm
6.9	Voice Modulation	Voice Modulation	Min= 4.1 kHz Max= 5.0 kHz

**Table A-2. Default mobile test limits.**

**APPENDIX B. Sample Test Result Report**

```

=====
                        Test Result Report
=====
Model #: M30TSS9PW1AN      Date/Time: 6/18/2012 4:33 PM
Serial #: 656CMF3277      Operator ID: A. Technician

Comments:

Reference Frequency Test
=====
Result  Frequency      Freq Error      Min Limit      Max Limit      Softpot
-----
Pass    469.9875 MHz     3 Hz            -470 Hz        470 Hz         1186

TX Power Out Test
=====
Result  Frequency      Power Out      Min Limit      Max Limit
-----
Pass    136.0125 MHz   56.7 W         50.0 W         57.0 W
Pass    140.7625 MHz   56.2 W         50.0 W         57.0 W
Pass    145.5125 MHz   56.4 W         50.0 W         57.0 W
Pass    150.2625 MHz   56.9 W         50.0 W         57.0 W
Pass    154.9875 MHz   56.0 W         50.0 W         57.0 W
Pass    155.0125 MHz   56.6 W         50.0 W         57.0 W
Pass    159.7625 MHz   56.2 W         50.0 W         57.0 W
Pass    164.5125 MHz   56.2 W         50.0 W         57.0 W
Pass    169.2625 MHz   56.2 W         50.0 W         57.0 W
Pass    173.9875 MHz   56.8 W         50.0 W         57.0 W
Pass    380.0125 MHz   45.1 W         40.0 W         48.0 W
Pass    389.0125 MHz   45.6 W         40.0 W         48.0 W
Pass    405.0125 MHz   45.0 W         40.0 W         48.0 W
Pass    415.0125 MHz   45.1 W         40.0 W         48.0 W
Pass    424.9875 MHz   45.1 W         40.0 W         48.0 W
Pass    425.0125 MHz   45.1 W         40.0 W         48.0 W
Pass    440.0125 MHz   44.9 W         40.0 W         48.0 W
Pass    455.0125 MHz   44.5 W         40.0 W         48.0 W
Pass    465.0125 MHz   44.1 W         40.0 W         48.0 W
Pass    469.9875 MHz   44.5 W         40.0 W         48.0 W

Deviation Balance Test
=====
Result  Frequency      Low Tone      High Tone      Variance      Max Limit      Softpot
-----
Pass    469.9875 MHz   2.976 KHz    2.979 KHz     0.1 %         +/-1.0 %      18226
Pass    465.0125 MHz   2.975 KHz    2.980 KHz     0.2 %         +/-1.0 %      18608
Pass    455.0125 MHz   2.975 KHz    2.981 KHz     0.2 %         +/-1.0 %      19267
Pass    440.0125 MHz   2.975 KHz    2.975 KHz     0.0 %         +/-1.0 %      19677
Pass    425.0125 MHz   2.976 KHz    2.979 KHz     0.1 %         +/-1.0 %      18773
Pass    424.9875 MHz   2.977 KHz    2.979 KHz     0.1 %         +/-1.0 %      18723
Pass    415.0125 MHz   2.976 KHz    2.979 KHz     0.1 %         +/-1.0 %      19458
Pass    405.0125 MHz   2.976 KHz    2.979 KHz     0.1 %         +/-1.0 %      20018
Pass    389.0125 MHz   2.975 KHz    2.977 KHz     0.1 %         +/-1.0 %      19944
Pass    380.0125 MHz   2.974 KHz    2.986 KHz     0.4 %         +/-1.0 %      19080
Pass    173.9875 MHz   2.969 KHz    2.973 KHz     0.1 %         +/-1.0 %      23485
Pass    169.2625 MHz   2.970 KHz    2.980 KHz     0.3 %         +/-1.0 %      22075
Pass    164.5125 MHz   2.971 KHz    2.977 KHz     0.2 %         +/-1.0 %      20996
Pass    159.7625 MHz   2.970 KHz    2.973 KHz     0.1 %         +/-1.0 %      21080
Pass    155.0125 MHz   2.969 KHz    2.966 KHz    -0.1 %         +/-1.0 %      23806
Pass    154.9875 MHz   2.971 KHz    2.979 KHz     0.3 %         +/-1.0 %      23718
Pass    150.2625 MHz   2.972 KHz    2.979 KHz     0.2 %         +/-1.0 %      22039
Pass    145.5125 MHz   2.969 KHz    2.973 KHz     0.2 %         +/-1.0 %      20596
Pass    140.7625 MHz   2.973 KHz    2.975 KHz     0.0 %         +/-1.0 %      20788
Pass    136.0125 MHz   2.972 KHz    2.970 KHz    -0.1 %         +/-1.0 %      24093

Distortion Test
=====
Result  Frequency      Distortion      Max Limit
-----
Pass    136.0625 MHz   1.1 %           3.0 %
Pass    380.0625 MHz   1.3 %           3.0 %

Sensitivity (SINAD) Test
=====
Result  Frequency      12dB SINAD      Max Limit
-----
Pass    136.0625 MHz   -120.1 dBm      -117.4 dBm
Pass    380.0625 MHz   -119.2 dBm      -117.4 dBm

Noise Squelch Threshold Test
=====
Result  Frequency      Unsquelch      Max Limit
-----
Pass    136.0625 MHz   -118.8 dBm      -116.0 dBm
Pass    380.0625 MHz   -117.4 dBm      -116.0 dBm

Digital Sensitivity (BER) Test
=====
Result  Frequency      5% BER          Max Limit
-----
Pass    136.0625 MHz   -119.8 dBm      -117.4 dBm
Pass    380.0625 MHz   -119.3 dBm      -117.4 dBm

Voice Modulation Test
=====
Result  Frequency      Deviation      Min Limit      Max Limit
-----
Pass    136.0125 MHz   4.233 KHz      4.100 KHz      5.000 KHz

```

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**Figure B-1. Sample Test Result Report**

**APPENDIX C.      Revision History**

B See ECO	M. Mullins	M. Humphries	2/26/2021	0337
A – from CG1215	DC	DC	5/29/19	0230*
Revision – Change	Requested By	Approved By	Rel. Date	ECO#