FREEDOM
Communication Technologies

R8000 Series
Communications Systems Analyzer

AUTOTUNE USER GUIDE

Motorola ASTRO® XTL™ Series
Motorola ASTRO® XTS™ Series

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CG-1148 Rev. C

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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 for supported radios by AutoTune. This document is restricted to radio-specific information for Motorola ASTRO® XTL™ Series and ASTRO® XTS™ Series two-way radios.

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

3. Motorola ASTRO® XTL™ Series Radio Test Setup

In order to perform the test and alignment procedures, the ASTRO® XTL™ Series radio must be connected to the R8000 Communications Systems Analyzer as shown in the figure below. Use of USB radio programming cables indicated are ***required*** to perform all tests.

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. ASTRO® XTL™ Series Test Setup

Refer to the diagram below for the proper test setup.

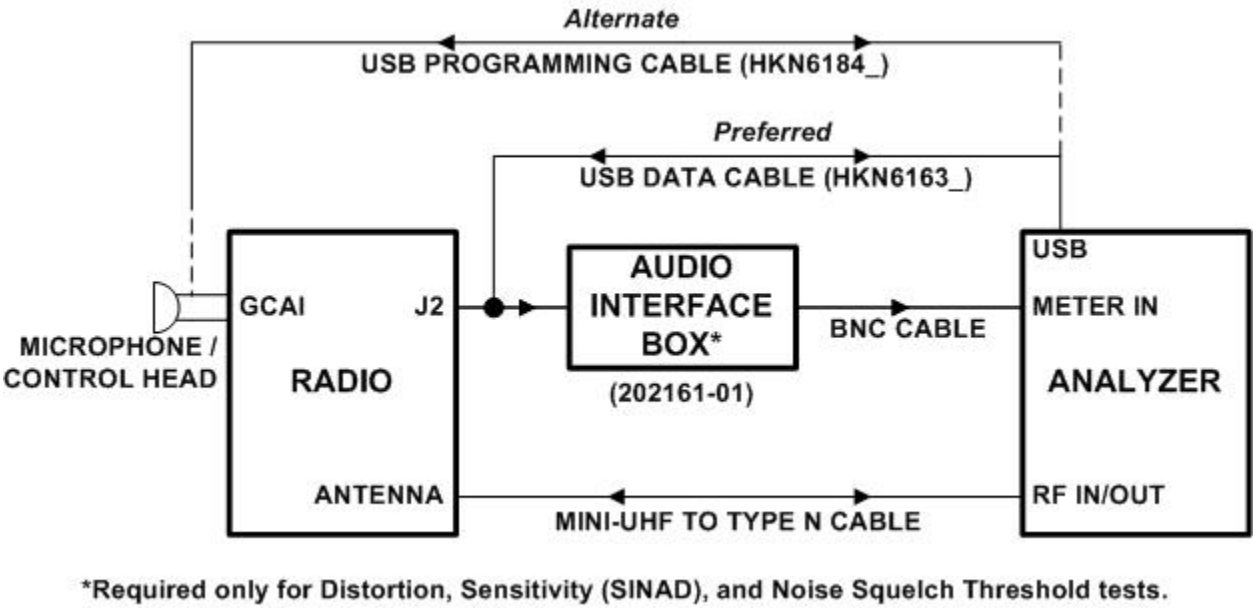

Figure 3-1. ASTRO® XTL™ Series Mid Power Test Setup Diagram

3.2. ASTRO® XTL™ Series High Power Test Setup

Refer to the diagram below for the proper test setup.

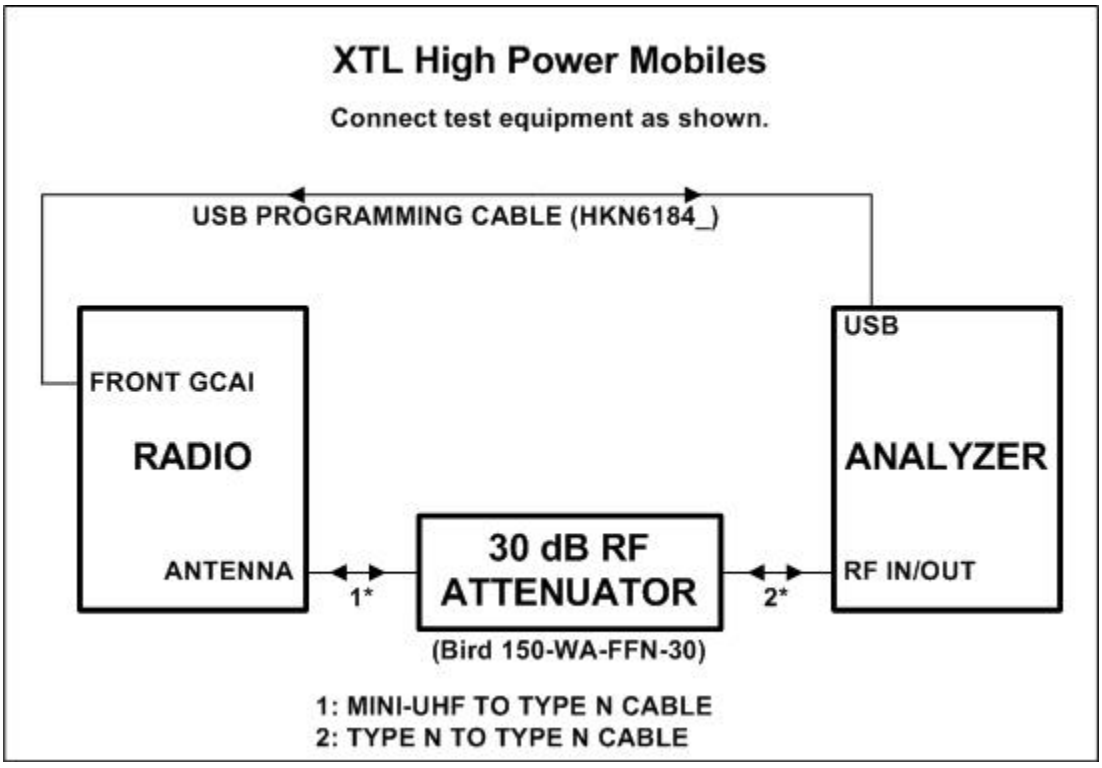

Figure 3-2. ASTRO® XTL™ Series High Power Test Setup Diagram

4. Motorola ASTRO® XTL™ Series 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	20 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.

Name	Description
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 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 adjusts 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 output level defined by the radio itself. The final results are written to the log file.

Name	Description
Result	Pass or Fail. Meas Power AND 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 4-5. Power Detection Calibration alignment results

TX Power Out 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 align the radio power output level across the radio band as specified by the radio 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.

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 4-6. 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.

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 4-7. 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 4-8. 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 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.

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 4-9. 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 4-10. Deviation Balance test results

4.4. Deviation Limit

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

Table 4-11. Analyzer Configuration for Deviation Limit

4.4.1. Alignment

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. The radio generates a digital test pattern at high deviation. This deviation is measured with the analyzer and adjusted until it is close to the midpoint between the test limits. The resulting deviation measurement is compared against test limits and written to the log file. This adjustment is repeated for each remaining TX Test Frequency.

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

Table 4-12. Deviation Limit alignment results

4.4.2. Test

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. The radio generates a digital test pattern at high deviation. This deviation is measured and compared against test limits. The final results are written to the log file. This test is repeated for each remaining TX Test Frequency.

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

Table 4-13. Deviation Limit test results

4.5. Distortion

Note: This test is not supported for Motorola ASTRO® XTL™ Series High Power models.

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 4-14. Analyzer Configuration for Distortion 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 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 4-15. Distortion test results

4.6. Sensitivity (SINAD)

Note: This test is not supported for Motorola ASTRO® XTL™ Series High Power models.

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 Sensitivity (SINAD) test

4.6.1. Alignment

No alignment is needed.

4.6.2. 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 4-17. Sensitivity (SINAD) test results

4.7. Noise Squelch Threshold

Note: This test is not supported for Motorola ASTRO® XTL™ Series High Power models.

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 4-18. Analyzer Configuration for Noise Squelch Threshold test

4.7.1. Alignment

No alignment is needed.

4.7.2. 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 Unsquelch 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
Unsquelch	Analyzer output level at which the radio unsquelches
Max Limit	Maximum Limit (exclusive) for Noise Squelch Threshold to Pass

Table 4-19. Noise Squelch Threshold test results

4.8. 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 4-20. Analyzer Configuration for P25 Tx Tests

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 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 4-21. 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 4-22. P25 Symbol Deviation test results

4.9. Digital Sensitivity (BER)

NOTE: This test requires an analyzer with P25 Conventional (R8-P25) 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 4-23. Analyzer Configuration for Digital Sensitivity (BER) test

4.9.1. Alignment

No alignment is needed.

4.9.2. 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 4-24. Digital Sensitivity (BER) test results

4.10. Ext Mic Voice Modulation

Note: This test is not supported for Motorola ASTRO® XTL™ Series High Power models.

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 4-25. Analyzer Configuration for Ext Mic Voice Modulation test

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. Ext Mic Voice Modulation test results

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 user is instructed to key the connected radio microphone and place the microphone 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 microphone. The measured deviation is compared against test limits and the final results are written to the log file.

Figure 4-1. Place keyed microphone next to analyzer speaker.

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

5. Motorola ASTRO® XTS™ Series Radio Test Setup

In order to perform the test and alignment procedures, the ASTRO® XTL™ Series 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 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. ASTRO® XTS™ Series 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.

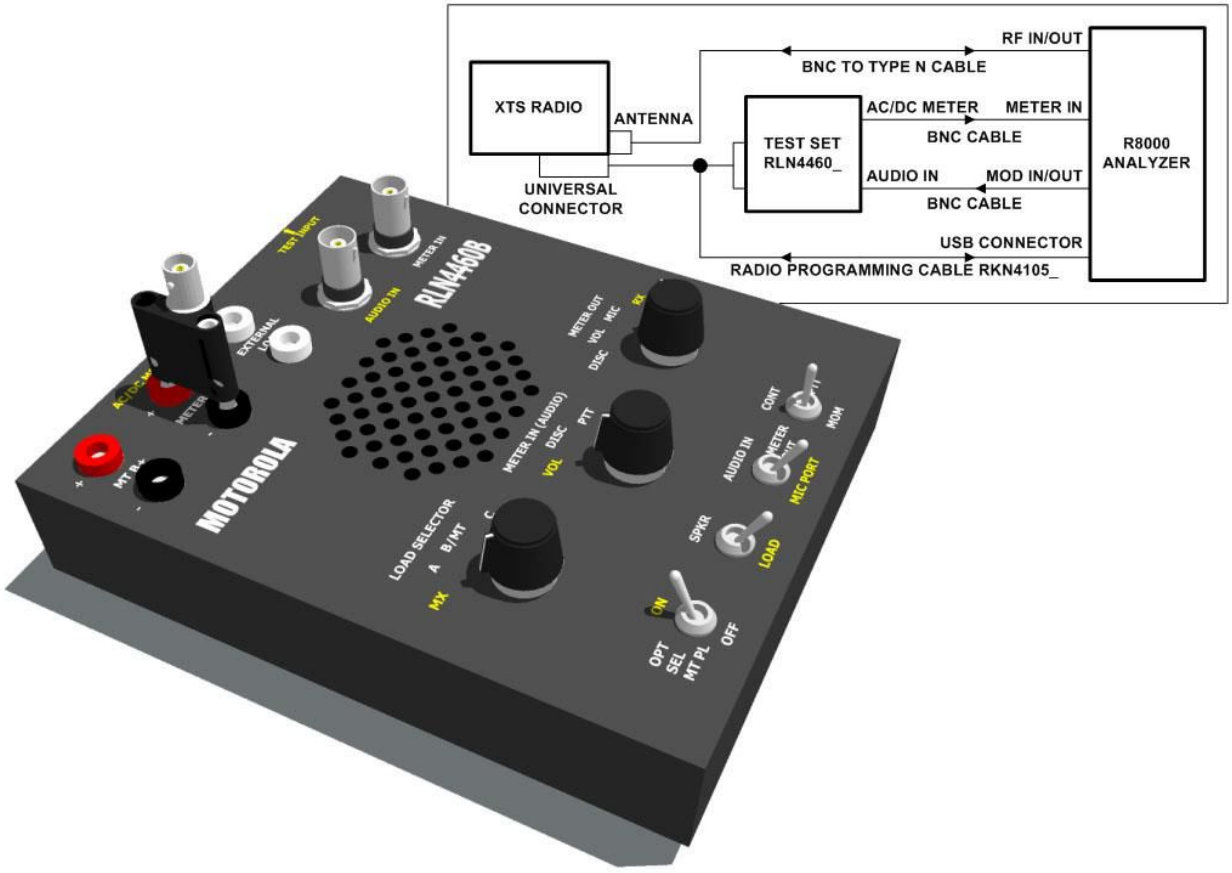

Figure 5-1. ASTRO® XTS™ Series Test Setup Diagram

6. Motorola ASTRO® XTS™ Series 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.

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.

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.

Name	Description
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	30 dB

Table 6-4. Analyzer Configuration for TX Power Out

6.2.1. Alignment

TX Power Out aligns the power output level of the radio. The radio is placed into Test Mode and commanded to transmit. Beginning at the highest TX Test Frequency and Low power setting, the output level is measured and then adjusted until about midway between the two test limits. The sequence is repeated twice more, for Mid and High power settings, at all Test Frequencies. The final results are written to the log file.

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
Old Softpot	Original radio softpot setting
New Softpot	Radio softpot setting after alignment

Table 6-5. TX Power Out alignment results

6.2.2. Test

TX Power Out tests the power output level of the radio. The radio is placed into Test Mode and commanded to transmit. Beginning at the highest TX Test Frequency and Low power setting, the output level is measured at each TX Test Frequency and compared against test limits. The sequence is repeated twice more, for Mid and High power settings, at all Test Frequencies. The final results for all power levels and Test Frequencies are written to the log file.

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
Softpot	Radio softpot setting

Table 6-6. 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 6-7. 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.

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 6-8. 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.

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 6-9. Deviation Balance test results

6.4. Deviation Limit

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

Table 6-10. Analyzer Configuration for Deviation Limit

6.4.1. Alignment

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. The radio generates a digital test pattern at high deviation. This deviation is measured with the analyzer and adjusted until it is close to the midpoint between the test limits. The resulting deviation measurement is compared against test limits and written to the log file. This adjustment is repeated for each remaining TX Test Frequency.

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

Table 6-11. Deviation Limit alignment results

6.4.2. Test

The radio is placed into Test Mode at the highest TX Test Frequency and commanded to transmit. The radio generates a digital test pattern at high deviation. This deviation is measured and compared against test limits. The final results are written to the log file. This test is repeated for each remaining TX Test Frequency.

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

Table 6-12. Deviation Limit test results

6.5. 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 6-13. Analyzer Configuration for Distortion 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 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 6-14. Distortion test results

6.6. 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 6-15. Analyzer Configuration for Sensitivity (SINAD) test

6.6.1. Alignment

No alignment is needed.

6.6.2. 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 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 6-16. Sensitivity (SINAD) test results

6.7. 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 6-17. Analyzer Configuration for Noise Squelch Threshold test

6.7.1. Alignment

No alignment is needed.

6.7.2. 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.

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 6-18. Noise Squelch Threshold test results

6.8. 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 6-19. Analyzer Configuration for P25 Tx Tests

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 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 6-20. 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 6-21. P25 Symbol Deviation test results

6.9. 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 6-22. Analyzer Configuration for Digital Sensitivity (BER) test

6.9.1. Alignment

No alignment is needed.

6.9.2. 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 6-23. Digital Sensitivity (BER) test results

6.10. 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 6-24. Analyzer Configuration for Internal Voice Modulation test

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 6-25. Internal Voice Modulation test results

6.10.1. Alignment

No alignment is needed.

6.10.2. 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 user is instructed to key the connected radio and place it next to the analyzer speaker (see Figure 6-1). The user is also instructed to adjust the analyzer volume until about 4 kHz deviation is seen on the analyzer display (see Figure 6-2). 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 6-1. Place keyed radio next to analyzer speaker.

Figure 6-2. Adjust analyzer volume until about 4 kHz deviation is measured.

6.11. 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 6-26. Analyzer Configuration for External Voice Modulation test

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 6-27. External Voice Modulation test results

6.11.1. Alignment

No alignment is needed.

6.11.2. 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.

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: • Power cycle the radio. • Restart the analyzer.
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.	ASTRO 25 Mobile CPS TX/Transmit Power Level settings limiting radio output power.	Using ASTRO 25 Mobile CPS, adjust Radio Configuration>Radio Wide>TX/Transmit Power Level settings to factory defaults. This change lets radio output expected power levels for correct AutoTune TX Power Out testing and alignment.
Deviation Balance test following a Deviation Balance alignment occasionally fails at one or more test frequencies.	Both XTL and XTS series radios have narrow "good" softpot ranges. These radios are designed such that softpot settings giving deviation balance measurements within test limits are few, likely one or two softpot values.	Rerun the Deviation Balance alignment.

Table 7-1. AutoTune Troubleshooting Chart

8. Support Information

8.1. Technical Support

Telephone/Fax: 844.903.7333
Email: service@freedomcte.com
Web: freedomcte.com/service-support/

8.2. Sales Support

Telephone/Fax: 844.903.7333
Email: sales@freedomcte.com
Web: freedomcte.com/sales/

9. References

Motorola, Inc. *ASTRO® Digital XTL™ 5000 VHF/UHF Range 1/UHF Range 2/700-800 MHz Mobile Radio Basic Service Manual, REV A.* Schaumburg: Motorola, Inc., IL. *Motorola Online Resource Center*. Motorola, Inc., 19 Jan. 2007. Web. 27 July 2009. <https://businessonline.motorola.com/DOCS/US/ProductInformation_Manuals_Two-WayMobile_ASTROXTL5000/6871769L01-A.pdf>.

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Motorola, Inc. *ASTRO® XTS™ 5000 VHF/UHF Range 1/UHF Range 2/700–800 MHz Digital Portable Radios Basic Service Manual, REV E.* Schaumburg: Motorola, Inc., IL. *Motorola Online Resource Center*. Motorola, Inc., 29 Dec. 2009. Web. 27 July 2011. <https://businessonline.motorola.com/DOCS/US/ProductInformation_Manuals_Two-WayPortable_ASTRODigitalXTS5000-PortableRadio/6881094C28_E_XTS5000_BSM_print.pdf>.

Motorola, Inc. *ASTRO® XTS™ 2500 XTS 2500 /XTS 2500I / XTS 2250 / XTS 1500 / MT 1500 / PR 1500 Portable Radios Basic Service Manual, REV C.* Schaumburg: Motorola, Inc., IL. *Motorola Online Resource Center*. Motorola, Inc., 26 Feb. 2010. Web. 27 July 2011. <https://businessonline.motorola.com/DOCS/US/ProductInformation_Manuals_Two-WayPortable_ASTRODigitalXTS2500-PortableRadio/6816984H01_c.pdf>.

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 radio model supported by AutoTune.

Section	Test Name	Limit	Default Value
4.1	Reference Frequency	Reference Frequency XTL 1500 VHF	Min: -435 Hz Max: 435 Hz
		Reference Frequency XTL 1500 UHF1	Min: -940 Hz Max: 940 Hz
		Reference Frequency XTL 1500 UHF2	Min: -1040 Hz Max: 1040 Hz
		Reference Frequency XTL 1500 700-800MHz	Min: -1305 Hz Max: 1305 Hz
		Reference Frequency XTL 1500 900MHz	Min: -1410 Hz Max: 1410 Hz
		Reference Frequency XTL 2500 VHF	Min: -435 Hz Max: 435 Hz
		Reference Frequency XTL 2500 UHF1	Min: -940 Hz Max: 940 Hz
		Reference Frequency XTL 2500 UHF2	Min: -1040 Hz Max: 1040 Hz
		Reference Frequency XTL 2500 700-800MHz	Min: -1305 Hz Max: 1305 Hz
		Reference Frequency XTL 2500 900MHz	Min: -1410 Hz Max: 1410 Hz
		Reference Frequency XTL 5000 VHF	Min: -348 Hz Max: 348 Hz
		Reference Frequency XTL 5000 UHF1	Min: -940 Hz Max: 940 Hz
		Reference Frequency XTL 5000 UHF2	Min: -1040 Hz Max: 1040 Hz
		Reference Frequency XTL 5000 700-800MHz	Min: -1305 Hz Max: 1305 Hz
4.2	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 Channel 1-8	Min=45 W Max=54 W
		TX Power UHF2 Channel 9	Min=40 W Max=48 W
		TX Power UHF2	Min=25 W

		Channel 10	Max=48 W
		TX Power 700-800MHz Channel 1-5	Min=31.5 W Max=34.7 W
		TX Power 700-800MHz Channel 6-10	Min=36.6 W Max=40.5 W
		TX Power 900MHz	Min=31.5 W Max=34.7 W
4.3	Deviation Balance	Deviation Balance	Max=1.5 %
4.4	Deviation Limit	Deviation Limit	Min=2.785 kHz Max=2.885 kHz
4.5	Distortion	Distortion	3 %
4.6	Sensitivity (SINAD)	Sensitivity VHF	Max=-117.5 dBm
		Sensitivity UHF1	Max=-117.5 dBm
		Sensitivity UHF2	Max=-117.5 dBm
		Sensitivity 700-800MHz	Max=-119 dBm
		Sensitivity 900MHz	Max=-119 dBm
4.7	Noise Squelch Threshold	Noise Squelch	Max=-119 dBm
4.8	P25 Tx Tests	Modulation Fidelity	Max=5%
		Symbol Deviation	Min=1620 Hz
			Max=1980 Hz
4.9	Digital Sensitivity (BER)	BER VHF	Max=-117.5 dBm
		BER UHF1	Max=-117.5 dBm
		BER UHF2	Max=-117.5 dBm
		BER 700-800MHz	Max=-119 dBm
		BER 900MHz	Max=-119 dBm
4.10	Ext Mic Voice Modulation	Ext Mic Voice Modulation	Min=3.8 kHz Max=5.0 kHz
		Ext Mic Voice Modulation 900MHz	Min=1.9 kHz Max=2.5 kHz

Table A-1. Default Motorola ASTRO® XTL™ Series Limits

Section	Test Name	Limit	Default Value
6.1	Reference Frequency	Reference Frequency XTS 5000 VHF	Min: -348 Hz Max: 348 Hz
		Reference Frequency XTS 5000 UHF1	Min: -940 Hz Max: 940 Hz
		Reference Frequency XTS 5000 UHF2	Min: -1040 Hz Max: 1040 Hz
		Reference Frequency XTS 5000 700-800MHz	Min: -1305 Hz Max: 1305 Hz
6.2	TX Power Out	TX Power VHF High	Min=6.2 W Max=6.4 W
		TX Power UHF1 High	Min=5.2 W Max=5.4 W
		TX Power UHF2 High	Min=5.0 W Max=5.3 W
		TX Power 700 MHz High	Min=2.5 W Max=2.7 W
		TX Power 800 MHz High	Min=3.2 W Max=3.4 W
		TX Power 900 MHz High	Min=2.5 W Max=2.7 W
		TX Power 700 MHz Mid	Min=2.5 W Max=2.7 W
		TX Power 800 MHz Mid	Min=2.5 W Max=2.7 W
		TX Power VHF Low	Min=1.2 W Max=1.4 W
		TX Power UHF1 Low	Min=1.2 W Max=1.4 W
		TX Power UHF2 Low	Min=1.2 W Max=1.4 W
		TX Power 700 MHz Low	Min=1.2 W Max=1.4 W
		TX Power 800 MHz Low	Min=1.2 W Max=1.4 W
		TX Power 900 MHz Low	Min=1.2 W Max=1.4 W
6.3	Deviation Balance	Deviation Balance	Max=1.5 %
6.4	Deviation Limit	Deviation Limit	Min=2.780 kHz Max=2.880 kHz
6.5	Distortion	Distortion	3 %
6.6	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
6.7	Noise Squelch Threshold	Noise Squelch	-119 dBm
6.8	P25 Tx Tests	Modulation Fidelity	Max=5%
		Symbol Deviation	Min=1620 Hz
			Max=1980 Hz
6.9	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
6.10	Internal Voice Modulation	Internal Voice Modulation	Min=3.6 kHz Max=5.0 kHz
		Internal Voice Modulation 900 MHz	Min=1.8 kHz Max=2.5 kHz
6.11	External Voice Modulation	External Voice Modulation	Min=3.8 kHz Max=5.0 kHz
		External Voice Modulation 900MHz	Min=1.9 kHz Max=2.5 kHz

Table A-2. Default Motorola ASTRO® XTS™ Series Limits

APPENDIX B. Sample Test Result Report

```
================================================================================
                              Test Result Report
================================================================================
Model #:  M2OURS9PW1AN                  Date/Time:     7/28/2011 9:18 AM
Serial #: 5OOCHPOO75                    Operator ID:   TECH42

Comments:

Reference Frequency Align
=========================
Result    Frequency      Freq Error     Min Limit      Max Limit      Old Softpot    New Softpot
------    ---------      ----------     ---------      ---------      -----------    -----------
Pass      869.8875 MHz   -12 Hz         -600 Hz        600 Hz         199            197

Power Detection Calibration
===========================
Result    Frequency      Meas Power     Target Power   Old Softpot    New Softpot
------    ---------      ----------     ------------   -----------    -----------
Pass      806.0125 MHz   16.9 W         17.1 W         115            111

TX Power Out Align
==================
Result    Frequency      Power Out      Min Limit      Max Limit
------    ---------      ---------      ---------      ---------
Pass      762.0125 MHz   32.7 W         31.5 W         34.7 W
Pass      769.0125 MHz   32.8 W         31.5 W         34.7 W
Pass      775.9875 MHz   33.0 W         31.5 W         34.7 W
Pass      794.0125 MHz   33.0 W         31.5 W         34.7 W
Pass      805.9875 MHz   33.0 W         31.5 W         34.7 W
Pass      806.0125 MHz   38.1 W         36.6 W         40.5 W
Pass      823.9875 MHz   38.3 W         36.6 W         40.5 W
Pass      851.0125 MHz   38.6 W         36.6 W         40.5 W
Pass      860.0125 MHz   38.6 W         36.6 W         40.5 W
Pass      869.8875 MHz   38.4 W         36.6 W         40.5 W

Deviation Balance Align
=======================
Result    Frequency      Variance       Max Limit      Old Softpot    New Softpot
------    ---------      --------       ---------      -----------    -----------
Pass      869.8875 MHz   0.5 %          1.5 %          24             24
Pass      860.0125 MHz   0.7 %          1.5 %          25             25
Pass      851.0125 MHz   0.7 %          1.5 %          26             26
Pass      823.9875 MHz   0.9 %          1.5 %          28             28
Pass      806.0125 MHz   0.7 %          1.5 %          25             25
Pass      805.9875 MHz   0.2 %          1.5 %          32             32
Pass      794.0125 MHz   0.9 %          1.5 %          33             33
Pass      775.9875 MHz   1.2 %          1.5 %          35             35
Pass      769.0125 MHz   0.0 %          1.5 %          35             35
Pass      762.0125 MHz   0.3 %          1.5 %          34             34

Deviation Limit Align
=====================
Result    Frequency      Deviation      Min Limit      Max Limit      Old Softpot    New Softpot
------    ---------      ---------      ---------      ---------      -----------    -----------
Pass      869.8875 MHz   2.836 kHz      2.785 kHz      2.885 kHz      19944          20136
Pass      860.0125 MHz   2.849 kHz      2.785 kHz      2.885 kHz      19560          19752
Pass      851.0125 MHz   2.851 kHz      2.785 kHz      2.885 kHz      19560          19752
Pass      823.9875 MHz   2.817 kHz      2.785 kHz      2.885 kHz      19624          19496
Pass      806.0125 MHz   2.832 kHz      2.785 kHz      2.885 kHz      20072          19944
Pass      805.9875 MHz   2.826 kHz      2.785 kHz      2.885 kHz      19624          19560
Pass      794.0125 MHz   2.827 kHz      2.785 kHz      2.885 kHz      19560          19496
Pass      775.9875 MHz   2.859 kHz      2.785 kHz      2.885 kHz      19560          19688
Pass      769.0125 MHz   2.810 kHz      2.785 kHz      2.885 kHz      19624          19560
Pass      762.0125 MHz   2.841 kHz      2.785 kHz      2.885 kHz      19816          19944

Distortion Test
===============
Result    Frequency      Distortion     Max Limit
------    ---------      ----------     ---------
Pass      762.0625 MHz   1.2 %          3.0 %

Sensitivity (SINAD) Test
========================
Result    Frequency      12dB SINAD     Max Limit
------    ---------      ----------     ---------
Pass      762.0625 MHz   -120.7 dBm     -119.0 dBm

Noise Squelch Threshold Test
============================
Result    Frequency      Unsquelch      Max Limit
------    ---------      ---------      ---------
Pass      762.0625 MHz   -121.0 dBm     -119.0 dBm

Digital Sensitivity (BER) Test
==============================
Result    Frequency      5% BER         Max Limit
------    ---------      ------         ---------
Pass      762.0625 MHz   -120.9 dBm     -119.0 dBm

External Microphone Voice Modulation Test
=========================================
Result    Frequency      Deviation      Min Limit      Max Limit
------    ---------      ---------      ---------      ---------
Pass      762.0125 MHz   4.149 kHz      3.800 kHz      5.000 kHz

Tests performed by AutoTune - © 2011 Freedom Communication Technologies.  All Rights Reserved.
```

Figure B-1. Sample Test Result Report

APPENDIX C. Revision History

1.18 Updates – Rev B	L. Shirey	1/9/15	M. Mullins	1/9/15	14440
Original Release – Rev A	B. Tanner	9/30/11	M. Mullins	9/30/11	11025
Rev. No/change	Revised By	Date	Approved By	Date	ECO#