FREEDOM
Communication Technologies

R8000 SERIES
COMMUNICATIONS SYSTEM ANALYZER

AUTOTUNE USER GUIDE

Harris XG-100 Mobile

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FCT-1001A

AUTOTUNE™ SOFTWARE LICENSE AGREEMENT

The software license agreement governing use of the R8000 Series Communications System Analyzer AutoTune™ software is located in FCT-1365 R8000 Series Communications System Analyzer Operator's Manual.

CREDITS

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1. Introduction

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

2. Scope

This document includes information regarding the tests and alignments performed for supported radios by AutoTune. This document is restricted to radio-specific information for Harris XG-100 Mobile series radios.

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

3. Conventions

3.1. PPM

“ppm” is “parts per million”. This specification is generally limited to frequency-related measurements. If the frequency units are in MHz, then the ppm specification is in Hz. For example, a 169.075 MHz frequency with a ±1.5 ppm specification is allowed to vary by 1.5 * 169.075 MHz, or about ±254 Hz.

3.2. Rated Audio

Rated audio voltage target is **2 V_{RMS}** for portable models and **7.745 V_{RMS}** for mobile models.

4. Important Notes

4.1. Required firmware

All Harris XG-100 Mobile series radios must be running **XGP or XLP** firmware for AutoTune to successfully service them. Older ECP firmware is not currently supported. Contact Harris Technical Assistance Center (TAC) for information on acquiring XGP firmware.

4.2. Conventional channel selection

The radio must have a conventional channel selected before AutoTune servicing begins. A trunked channel if selected is known to cause radio communication initialization failures.

4.3. Supported models

The following Harris XG-100 Mobile series models are supported by AutoTune:

- XM-100F
- XM-100F-D01
- XM-100F-D02
- XM-100F-D03
- XM-100LPA

5. Harris XG-100 Mobile Radio Test Setup

In order to perform the test and alignment procedures, the XG-100 Mobile radio must be connected to the R8000 Communications System Analyzer as shown in the figures below. Note that connections differ between CH-721 and CH-100 control heads.

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. XG-100 Mobile Test Setup

Refer to the diagrams below for proper test setup.

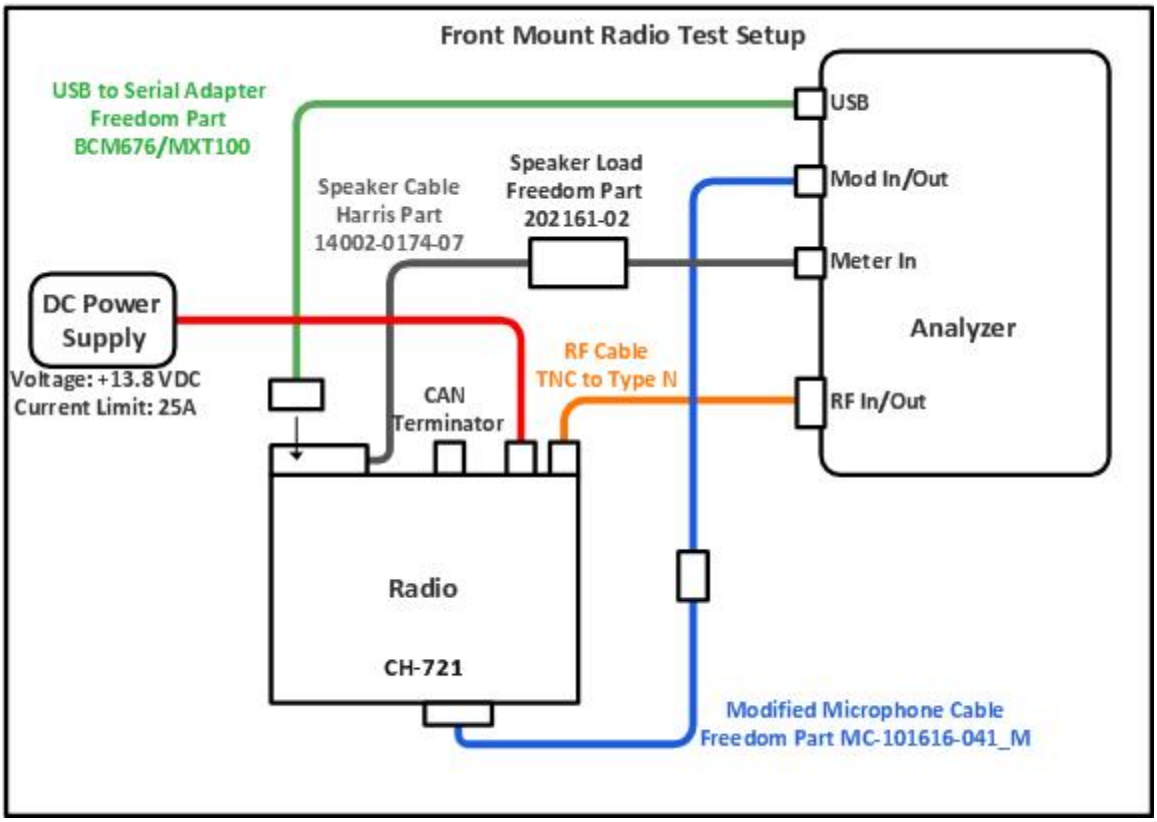

Figure 5-1. XG-100 Mobile Front Mount CH-721 Test Setup Diagram

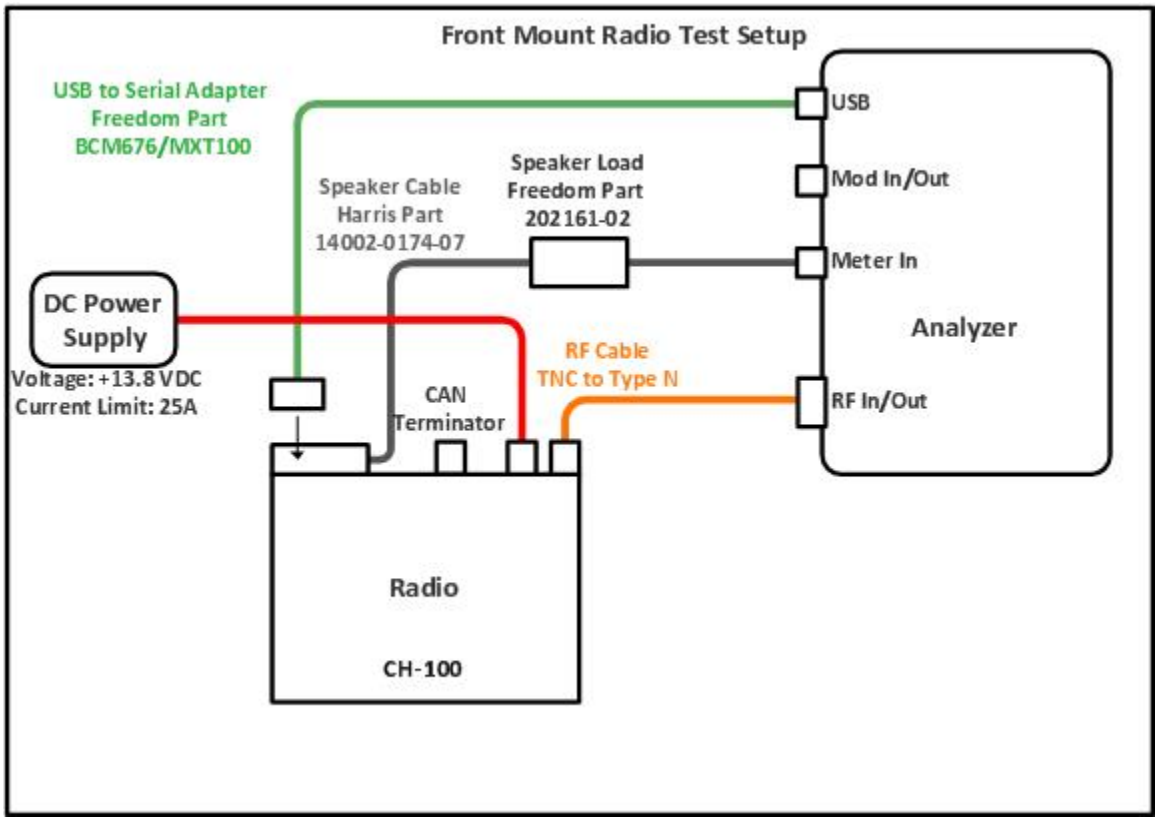

Figure 5-2. XG-100 Mobile Front Mount CH-100 Test Setup Diagram

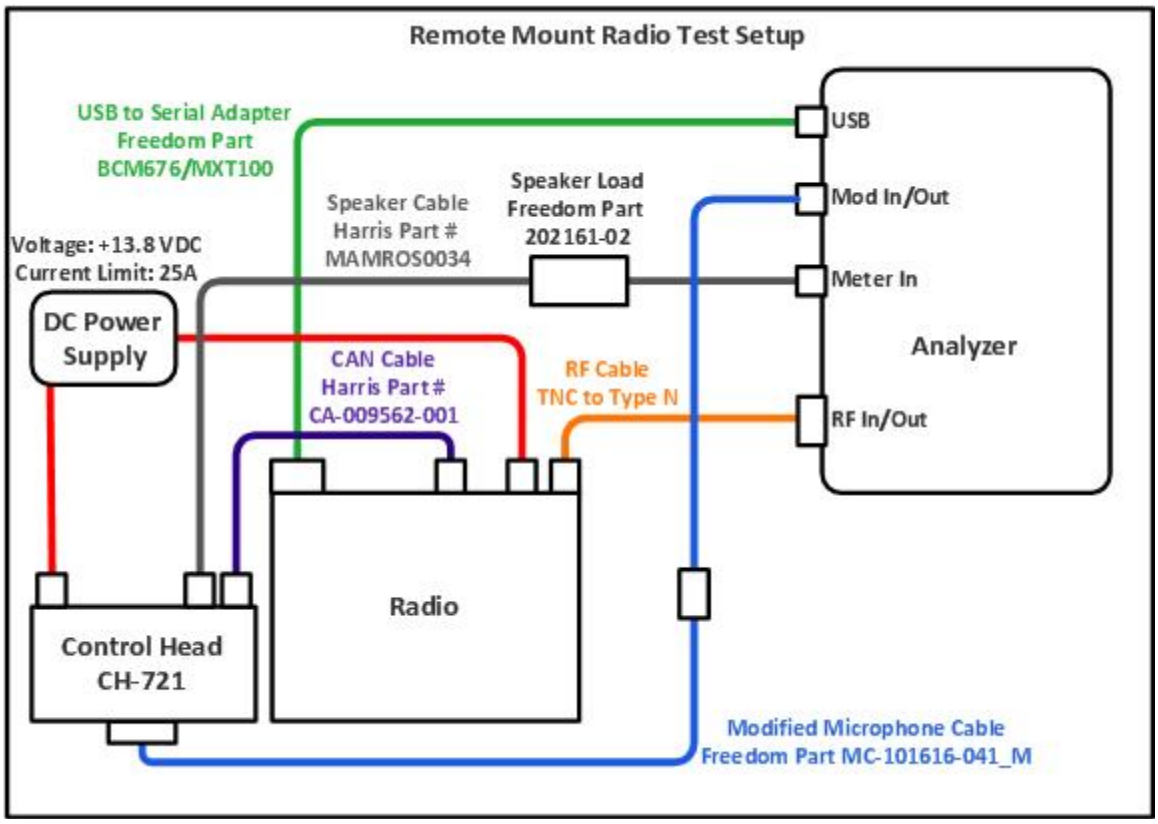

Figure 5-3. XG-100 Mobile Remote Mount CH-721 Test Setup Diagram

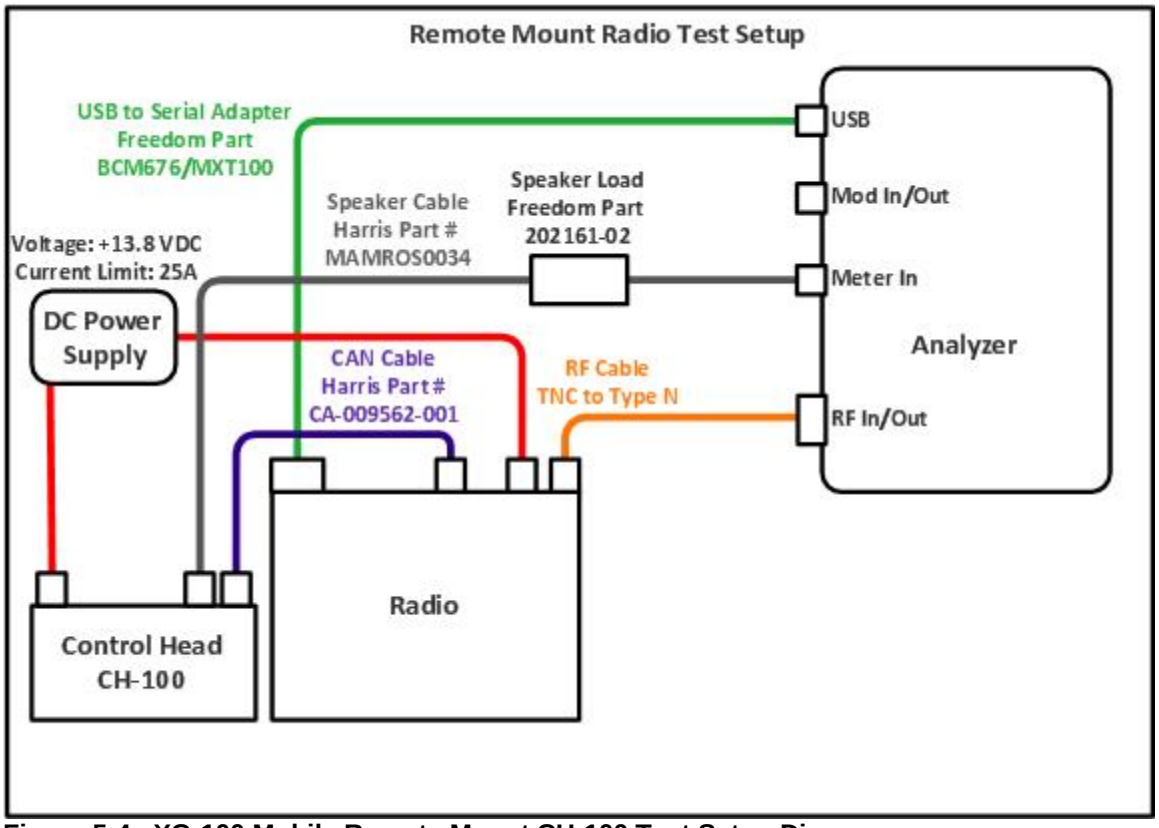

Figure 5-4. XG-100 Mobile Remote Mount CH-100 Test Setup Diagram

6. Harris XG-100 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.

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

6.1. TCXO Frequency

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

Table 6-1. Analyzer Configuration for Reference Frequency

6.1.1. Alignment

The radio is placed into Test Mode at a 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
Min Limit	Minimum Limit (inclusive) for frequency error alignment
Max Limit	Maximum Limit (inclusive) for frequency error alignment
Old Softpot	Radio softpot before alignment
New Softpot	Radio softpot after alignment

Table 6-2. TCXO Frequency alignment results

6.1.2. Test

The radio is placed into Test Mode at a 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 producing the Freq Error

Table 6-3. TCXO Frequency test results

6.2. TX Power

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

Table 6-4. Analyzer Configuration for TX Power

6.2.1. Test

The radio is placed into Test Mode and commanded to transmit. Beginning at the first Tx Test Frequency, the output level is measured at each TX Test Frequency, for the current radio power configuration (Low or High Power), and compared against test limits. The final results are written to the log file.

To change current radio power level configuration, refer to the radio maintenance manual.

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

Table 6-5. TX Power test results

6.3. Tx Analog Modulation

The Tx Analog Modulation test measures the radio's 60% and maximum deviation levels, audio distortion, and peak deviation differences for each test frequency.

Note: This test is not currently supported for XG-100M radios with CH-100 control heads. Running it on a XG-100M with a CH-100 will always return a 'Pass' with a test report note about its exclusion.

RF Control	Port	Frequency	Modulation	Attenuation	Dev Avg
Monitor	RF IN/OUT	Test Frequency	FM	30 dB	+/-Peak / 2

Table 6-6. Analyzer Configuration for Tx Analog Modulation test

6.3.1. Tx Analog Modulation Test

The radio is placed into Test Mode. For each test frequency and bandwidth (Wide, Narrow, NPSPAC) supported, the radio transmits analyzer-generated tones at both 60% and maximum deviation levels. The ±Peak / 2-averaged deviations of these tones are measured with the analyzer, along with the audio distortion and ±peak deviation level differences. The test results are written to the log file.

Name	Description
Result	Pass or Fail. 60% and maximum deviation levels are both within limits AND audio level is within limits and audio distortion is within limits and ± peak deviation level differences are within limits.
Frequency	Test Frequency
60% Dev	Measured deviation level at 60% rated channel deviation
Aud Lvl<Test Limit	Analyzer audio level used to achieve 60% Dev
Dist<Test Limit	Measured audio distortion at 60% Dev
Min Test Limit<Meas Dev<Max Test Limit	Measured maximum deviation level, along with minimum and maximum test limits
Pk Dev Diff<Test Limit	Peak positive deviation – peak negative deviation.

Table 6-7. Tx Analog Modulation test results

6.4. Tx CTCSS/CDCSS Modulation and Composite Deviation

The Tx CTCSS/CDCSS Modulation test measures the radio's CTCSS, CDCSS and composite deviation levels, and tone or code accuracy for each test frequency.

Note: This test is not currently supported for CH-100 control heads. Running it on a XG-100M with a CH-100 will always return a 'Pass' with a test report note about its exclusion.

RF Control	Port	Frequency	Modulation	Attenuation	Dev Avg
Monitor	RF IN/OUT	Test Frequency	FM	30 dB	+/-Peak / 2

Table 6-8. Analyzer Configuration for Tx CTCSS/CDCSS Modulation test

6.4.1. Tx CTCSS/CDCSS Modulation Test

The radio is placed into Test Mode. For each test frequency and bandwidth (Wide, Narrow, NPSPAC) supported, the radio transmits analyzer-generated CTCSS tones and CDCSS codes at rated deviation levels. The ±Peak / 2-averaged deviations of these individual tones/codes and the composite levels are measured with the analyzer, CTCSS tone and CDCSS code accuracy. The test results are written to the log file.

Name	Description
Result	Pass or Fail. CTCSS deviation levels are within limits and CTCSS tone is accurate AND CDCSS deviation levels are within limits and CDCSS code is accurate AND composite deviation levels are within test limits.
Frequency	Test Frequency
CTCSS Dev	Measured CTCSS or CDCSS deviation level
Aud Lvl<Test Limit	Analyzer audio level used to achieve 60% Dev
Min Dev	Minimum CTCSS or CDCSS deviation level (inclusive)
Max Dev	Maximum CTCSS or CDCSS deviation level (inclusive)
Meas Tone|Meas Code	Measured CTCSS tone frequency OR CDCSS code
Comp Dev	Measured composite CTCSS|CDCSS and 1 kHz tone @ 3 kHz deviation level
Min Dev	Minimum composite deviation level (inclusive)
Max Dev	Maximum composite deviation level (inclusive)
Meas Tone|Meas Code	Measured CTCSS tone OR CDCSS code during composite test

Table 6-9. Tx CTCSS/CDCSS Modulation test results

6.5. P25 Phase 1 Tx Modulation (C4FM) Test

The Tx P25 Phase 1 Tx Modulation (C4FM) test measures the radio's P25 Phase 1 C4FM modulation level at a specific test frequency for both High and Low Patterns.

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

Table 6-10. Analyzer Configuration for P25 Phase 1 Tx Modulation (C4FM) test

6.5.1. P25 Phase 1 Tx Modulation (C4FM) Test

The radio is placed into Test Mode at low power at the last Tx Test Frequency and commanded to transmit both Low and High deviation patterns. The Peak-averaged deviation of this tone is measured with the analyzer. This test is performed at a single Tx Test Frequency. The test results are written to the log file.

Name	Description
Result	Pass or Fail. Deviation is between Min Limit and Max Limit.
Frequency	Test Frequency
Meas Dev	Measured P25 Phase 1 C4FM deviation
Min Dev	Minimum passable deviation level
Max Dev	Maximum passable deviation level

Table 6-11. Tx P25 Phase 1 Modulation (C4FM) test results

6.6. Tx P25 Phase 2 Tx Modulation (TDMA) Test

The Tx P25 Phase 2 Tx Modulation (TDMA) test measures the radio's P25 Phase 2 TDMA modulation level at a specific test frequency.

RF Control	Port	Frequency	Modulation	Attenuation	Dev Avg
Monitor	RF IN/OUT	Test Frequency	FM	30 dB	+/-Peak / 2

Table 6-12. Analyzer Configuration for P25 Phase 2 Tx Modulation (TDMA) test

6.6.1. Tx P25 Phase 2 Tx Modulation (TDMA) Test

The radio is placed into Test Mode at low power at the last Tx Test Frequency and commanded to transmit a P25 Phase 2 TDMA High Deviation pattern. The analyzer measures the +/-Peak / 2-averaged deviation of this pattern. This test is performed at a single Tx Test Frequency. The test results are written to the log file.

Name	Description
Result	Pass or Fail. Deviation is between Min Limit and Max Limit.
Frequency	Test Frequency
Meas Dev	Measured P25 Phase 2 TDMA deviation
Min Dev	Minimum passable deviation level
Max Dev	Maximum passable deviation level

Table 6-13. Tx P25 Phase 2 Tx Modulation (TDMA) test results

6.7. Rx Audio Level and Distortion

Rx Audio Level and Distortion test verifies the receiver audio amplitude and distortion are at appropriate levels.

RF Control	Port	Frequency	Modulation	Output
Generate	RF IN/OUT	Test Frequency	FM	-47 dBm

Table 6-14. Analyzer Configuration for Rx Audio Level and Distortion test

6.7.1. RX Audio Level and Distortion Test

The radio is placed into Test Mode, receive operation at Wide bandwidth and highest Rx Test Frequency. The analyzer generates a modulation tone and the audio voltage and distortion of the radio's demodulated signal is measured with the analyzer. Both the audio level and the distortion are compared against test limits and written to the log file.

Name	Description
Result	Pass or Fail. Distortion is less than or equal to Max Limit.
Frequency	Test Frequency
Min Vol Lvl	Minimum audio voltage level required to pass the test
Meas Volume	Audio volume level generated by the radio near max volume setting
Max Vol Lvl	Maximum audio voltage level required to pass the test
Distortion	Measured distortion percentage at mid volume setting
Max Limit	Maximum passable distortion (inclusive)

Table 6-15. Rx Audio Level and Distortion test results

6.8. RX Sensitivity (SINAD)

Rx Sensitivity (SINAD) test verifies the receiver analog audio sensitivity is at an appropriate level.

RF Control	Port	Frequency	Modulation	Output Level
Generate	RF IN/OUT	Test Freq	1 kHz @ 3 kHz	-47 dBm

Table 6-16. Analyzer Configuration for RX Sensitivity test

6.8.1. Test

The analyzer is setup by applying the Modulation signal in Table 6-16**Error! Reference source not found.** to the radio and then adjusting radio volume for Rated Audio. The radio is placed into Test Mode at the first bandwidth and first RX Test Frequency. 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. This process is repeated for each bandwidth and each RX Test Frequency.

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 about 12 dB
Max Limit	Maximum Limit (inclusive) for RX Sensitivity to Pass

Table 6-17. RX Sensitivity test results

6.9. P25 Phase 1 Rx Sensitivity (C4FM) Test

The P25 Phase 1 Rx Sensitivity (C4FM) test measures the radio's P25 Phase 1 C4FM sensitivity level at several Rx test frequencies.

RF Control	Port	Frequency	Modulation	Output Level
Generate	RF IN/OUT	Test Frequency	C4FM	-116 dBm

Table 6-18. Analyzer Configuration for P25 Phase 1 Rx Sensitivity (C4FM) test

6.9.1. Test

The analyzer is setup by applying the Modulation signal in Table 6-18 to the radio. The radio is placed into Test Mode at C4FM bandwidth and first RX Test Frequency. The radio's reported BER level is measured and compared against test limits. The final results are written to the log file. This process is repeated for each Test Frequency.

Name	Description
Result	Pass or Fail. BER level within Max Limit
Frequency	Test Frequency
BER	Radio Bit Error Rate (BER) level
Max Limit	Maximum Limit (inclusive) for Rx Sensitivity (C4FM) to Pass
Min Limit	Minimum Limit (exclusive) for Rx Sensitivity (C4FM) to Pass

Table 6-19. P25 Phase 1 Rx Sensitivity (C4FM) test results

6.10. P25 Phase 2 Rx Sensitivity (TDMA) Test

The P25 Phase 2 Rx Sensitivity (TDMA) test measures the radio's P25 Phase 2 TDMA sensitivity level at several Rx test frequencies.

RF Control	Port	Frequency	Modulation	Output Level
Generate	RF IN/OUT	Test Frequency	TDMA	-116 dBm

Table 6-20. Analyzer Configuration for P25 Phase 2 Rx Sensitivity (TDMA) test

6.10.1. Test

The analyzer is setup by applying the Modulation signal in Table 6-20 to the radio. The radio is placed into Test Mode at the first RX Test Frequency. The radio's reported BER level is measured and compared against test limits. The final results are written to the log file. This process is repeated for each Test Frequency.

Name	Description
Result	Pass or Fail. BER level within Max Limit
Frequency	Test Frequency
BER	Radio Bit Error Rate (BER) level
Max Limit	Maximum Limit (inclusive) for Rx Sensitivity (TDMA) to Pass
Min Limit	Minimum Limit (exclusive) for Rx Sensitivity (TDMA) to Pass

Table 6-21. P25 Phase 2 Rx Sensitivity (TDMA) test results

6.11. Basic Troubleshooting

Symptom	Possible Cause	Possible Solution
Analyzer consistently fails to communicate with radio	• Radio not running XGP or XLP firmware	• AutoTune only supports test and alignment on XG-100 series radios running XGP or XLP firmware. Update radio firmware to use one of these supported firmware generations.
	• Unsupported USB to serial adapter (mobiles only)	• Approved USB to serial adapters for connecting the R8000 analyzer to the Harris XG-100 Mobile series radio under test include any adapters which utilize an FTDI FT232_USB to serial UART interface OR Prolific Technology Inc. PL-2303 USB to serial controller interface. See Amazon for a compatible adapter example.
	• Radio on a trunking channel	• Change radio channel to a conventional channel. Trunking channel mode can prevent AutoTune from placing radio into test mode.
Analyzer occasionally fails to communicate with radio	• USB hub in use	• USB hubs are known to occasionally prevent or drop radio communication. Connect the radio programming cable directly to an analyzer USB port.

Tx Power test power output levels are lower than expected.	• Cable Sweep not enabled	• Enable Settings > System Settings… > Cable Sweep > Cable Sweep. Change cable attenuation values to correspond with the RF cable in use. For example, if 0.5 dB of loss expected at 100 MHz and 1.5 dB of loss is expected at 1 GHz, enter “-0.5 dB” as the 100 MHz loss value and “-1.5 dB” as the 1 GHz loss value. **Cable losses are entered as negative values**.

Table 6-22. Harris XG-100 Mobile Series Troubleshooting Chart

7. Support Information

7.1. Technical Support

Telephone/Fax: 903.985.8999
Email: service@freedomcte.com
Web: http://freedomcte.com/support/

7.2. Sales

Telephone/Fax: 903.985.8999
Email: sales@freedomcte.com
Web: http://freedomcte.com/sales/

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 (FCT-1365) for modification instructions.

The following tables list the default test limits for each Harris XG-100 Mobile radio model supported by AutoTune.

Table A-1. Default Harris XG-100 Mobile Limits

Section	Test Name	Limit	Default Value
6.1	TCXO Frequency	Reference Oscillator Align	Min= -0.1 ppm Max= 0.1 ppm
		Reference Oscillator Test	Min= -0.25 ppm Max= 0.25 ppm
6.2	TX Power (Test)	TX Power Test VHF Low	Min = 4.45 W Max = 5.61 W
		TX Power Test UHF Low	Min = 4.45 W Max = 5.61 W
		TX Power Test 700MHz Low	Min = 1.78 W Max = 2.24 W
		TX Power Test 800MHz Low	Min= 1.78 W Max= 2.24 W
		TX Power Test VHF High	Min=47.2 W Max=53.0 W
		TX Power Test UHF High	Min=47.2 W Max=53.0 W
		TX Power Test 700MHz High	Min=25.1 W Max=30.9 W
		TX Power Test 800MHz High	Min=33.0 W Max=37.1 W
6.3	Tx Analog Modulation	Tx Analog Modulation Deviation Wide	Min = 4.0 kHz Max = 4.8 kHz
		Tx Analog Modulation Deviation Narrow	Min=2.0 kHz Max=2.4 kHz
		Tx Analog Modulation Deviation NPSPAC	Min=3.2 kHz Max=3.9 kHz
		Tx Analog Modulation 60% Deviation Wide	Min=2.9 kHz Max=3.1 kHz
		Tx Analog Modulation 60% Deviation Narrow	Min=1.4 kHz Max=1.6 kHz
		Tx Analog Modulation 60% Deviation NPSPAC	Min=2.3 kHz Max=2.5 kHz
		Tx Analog Modulation Distortion	Max=1.25%
		Tx Analog Modulation Audio Level	Min=50 mV_{RMS} Max=120 mV_{RMS}
		Tx Analog Modulation Peak Deviation Difference	Max=100 Hz
6.4	Tx CTCSS/CDCSS Modulation and Composite Deviation	Tx CTCSS/CDCSS Modulation Deviation Wide	Min=0.5 kHz Max=1.0 kHz
		Tx CTCSS/CDCSS Modulation Deviation Narrow	Min=0.35 kHz Max=0.5 kHz
		Tx CTCSS/CDCSS Modulation Deviation NPSPAC	Min=0.4 kHz Max=0.8 kHz
6.5	P25 Phase1 Tx Modulation C4FM	P25 Phase1 Tx Modulation C4FM High	Min=2.545 kHz Max=3.111 kHz
		P25 Phase1 Tx Modulation C4FM Low	Min=0.849 kHz Max=3.111 kHz
6.6	P25 Phase2 Tx Modulation TDMA	P25 Phase2 Tx Modulation TDMA High	Min=2.995 kHz Max=3.310 kHz
6.7	Rx Audio Level and Distortion	Rx Audio Distortion CH-721	Max=5 %
		Rx Audio Distortion CH-100	Max=3 %

		Rx Audio Voltage	Max=8.1 V_{RMS} Min=7.5 V_{RMS}
6.8	RX Sensitivity (SINAD)	SINAD	Max=-119 dBm
6.9	P25 Phase1 Rx Sensitivity (C4FM)	P25 Phase1 Rx Sensitivity C4FM	Min=0 % Max=5 %
6.10	P25 Phase2 Rx Sensitivity (TDMA)	P25 Phase2 Rx Sensitivity TDMA	Min=0 % Max=5 %

Table A-2. Default Harris XG-100 Mobile Limits

APPENDIX B. Sample Test Result Report

Note: Results shown below are representative of actual results. Actual results and report format may vary.

```
================================================================================
                              Test Result Report
================================================================================
Model #:  XG100M                        Date/Time:     3/6/2017 4:08 AM
Serial #: A40201011459                  Operator ID:   6

Info: FLASH Version: XGPR06D13

TCXO Frequency Align
====================
Result  Frequency     Freq Error  Min Limit  Max Limit  Old Softpot  New Softpot
------  ------------  ----------  ---------  ---------  -----------  -----------
Pass    869.9875 MHz  15 Hz       -87 Hz     87 Hz      50           146

TCXO Frequency Test
===================
Result  Frequency     Freq Error  Min Limit  Max Limit  Softpot
------  ------------  ----------  ---------  ---------  -------
Pass    869.9875 MHz  18 Hz       -217 Hz    217 Hz     146
Pass    794.0125 MHz  16 Hz       -199 Hz    199 Hz     146
Pass    520.0000 MHz  11 Hz       -130 Hz    130 Hz     146
Pass    380.0000 MHz  8 Hz        -95 Hz     95 Hz      146
Pass    174.0000 MHz  3 Hz        -44 Hz     44 Hz      146
Pass    136.0000 MHz  2 Hz        -34 Hz     34 Hz      146

TX Power Test
=============
Result  Frequency     Power Out  Min Limit  Max Limit
------  ------------  ---------  ---------  ---------
Pass    869.9875 MHz  1.9 W      1.8 W      2.2 W
Pass    794.0125 MHz  1.8 W      1.8 W      2.2 W
Pass    520.0000 MHz  4.8 W      4.5 W      5.6 W
Pass    380.0000 MHz  4.6 W      4.5 W      5.6 W
Pass    174.0000 MHz  4.9 W      4.5 W      5.6 W
Pass    136.0000 MHz  5.1 W      4.5 W      5.6 W

Tx Analog Modulation Wide
=========================
Result  Frequency     60% Dev  Aud Lvl   Dist <1.25%  Meas Dev  Min Dev  Max Dev  Pk Dev Diff <100Hz
------  ------------  -------  --------  -----------  --------  -------  -------  ------------------
Pass    136.0250 MHz  3.0 kHz  95 mVrms  0.46 %       4.5 kHz   4.0 kHz  4.8 kHz  32 Hz
Pass    173.9750 MHz  3.0 kHz  95 mVrms  0.38 %       4.5 kHz   4.0 kHz  4.8 kHz  11 Hz
Pass    380.0250 MHz  3.0 kHz  95 mVrms  0.51 %       4.5 kHz   4.0 kHz  4.8 kHz  10 Hz
Pass    519.9750 MHz  3.0 kHz  95 mVrms  0.40 %       4.5 kHz   4.0 kHz  4.8 kHz  23 Hz
Pass    815.0125 MHz  3.0 kHz  95 mVrms  0.48 %       4.5 kHz   4.0 kHz  4.8 kHz  16 Hz
Pass    860.0125 MHz  3.0 kHz  95 mVrms  0.55 %       4.5 kHz   4.0 kHz  4.8 kHz  32 Hz

Tx Analog Modulation Narrow
===========================
Result  Frequency     60% Dev  Aud Lvl   Dist <1.25%  Meas Dev  Min Dev  Max Dev  Pk Dev Diff <100Hz
------  ------------  -------  --------  -----------  --------  -------  -------  ------------------
Pass    136.0250 MHz  1.5 kHz  98 mVrms  0.45 %       2.2 kHz   2.0 kHz  2.4 kHz  3 Hz
Pass    173.9750 MHz  1.5 kHz  98 mVrms  0.45 %       2.2 kHz   2.0 kHz  2.4 kHz  13 Hz
Pass    380.0250 MHz  1.5 kHz  98 mVrms  0.51 %       2.2 kHz   2.0 kHz  2.4 kHz  4 Hz
Pass    519.9750 MHz  1.5 kHz  98 mVrms  0.48 %       2.2 kHz   2.0 kHz  2.4 kHz  13 Hz
Pass    794.0125 MHz  1.5 kHz  97 mVrms  0.71 %       2.2 kHz   2.0 kHz  2.4 kHz  5 Hz

Tx Analog Modulation NPSPAC
===========================
Result  Frequency     60% Dev  Aud Lvl   Dist <1.25%  Meas Dev  Min Dev  Max Dev  Pk Dev Diff <100Hz
------  ------------  -------  --------  -----------  --------  -------  -------  ------------------
Pass    815.0125 MHz  2.4 kHz  96 mVrms  0.51 %       3.6 kHz   3.2 kHz  3.9 kHz  3 Hz
Pass    860.0125 MHz  2.4 kHz  96 mVrms  0.60 %       3.5 kHz   3.2 kHz  3.9 kHz  77 Hz

Tx CTCSS (156.7 Hz) Modulation and Composite Deviation Wide
===========================================================
Result  Frequency     CTCSS Dev  Min Dev  Max Dev  Meas Tone  Comp Dev  Min Dev  Max Dev  Meas Tone
------  ------------  ---------  -------  -------  ---------  --------  -------  -------  ---------
Pass    174.0000 MHz  0.7 kHz    0.5 kHz  1.0 kHz  156.7 Hz   4.3 kHz   4.0 kHz  4.8 kHz  156.4 Hz
Pass    520.0000 MHz  0.7 kHz    0.5 kHz  1.0 kHz  156.8 Hz   4.3 kHz   4.0 kHz  4.8 kHz  157.3 Hz
Pass    869.9875 MHz  0.7 kHz    0.5 kHz  1.0 kHz  156.7 Hz   4.3 kHz   4.0 kHz  4.8 kHz  157.2 Hz

Tx CDCSS (627) Modulation and Composite Deviation Wide
======================================================
Result  Frequency     CDCSS Dev  Min Dev  Max Dev  Meas Code  Comp Dev  Min Dev  Max Dev  Meas Code
------  ------------  ---------  -------  -------  ---------  --------  -------  -------  ---------
Pass    174.0000 MHz  0.7 kHz    0.5 kHz  1.0 kHz  627        4.3 kHz   4.0 kHz  4.8 kHz  627
Pass    520.0000 MHz  0.7 kHz    0.5 kHz  1.0 kHz  627        4.3 kHz   4.0 kHz  4.8 kHz  627
Pass    869.9875 MHz  0.7 kHz    0.5 kHz  1.0 kHz  627        4.3 kHz   4.0 kHz  4.8 kHz  627

Tx CTCSS (156.7 Hz) Modulation and Composite Deviation Narrow
=============================================================
Result  Frequency     CTCSS Dev  Min Dev   Max Dev  Meas Tone  Comp Dev  Min Dev  Max Dev  Meas Tone
------  ------------  ---------  --------  -------  ---------  --------  -------  -------  ---------
Pass    174.0000 MHz  0.39 kHz   0.35 kHz  0.5 kHz  156.8 Hz   2.1 kHz   2.0 kHz  2.4 kHz  157.4 Hz
Pass    520.0000 MHz  0.39 kHz   0.35 kHz  0.5 kHz  156.8 Hz   2.2 kHz   2.0 kHz  2.4 kHz  157.2 Hz
Pass    794.0125 MHz  0.39 kHz   0.35 kHz  0.5 kHz  156.6 Hz   2.2 kHz   2.0 kHz  2.4 kHz  155.9 Hz

Tx CDCSS (627) Modulation and Composite Deviation Narrow
========================================================
Result  Frequency     CDCSS Dev  Min Dev   Max Dev  Meas Code  Comp Dev  Min Dev  Max Dev  Meas Code
------  ------------  ---------  --------  -------  ---------  --------  -------  -------  ---------
Pass    174.0000 MHz  0.38 kHz   0.35 kHz  0.5 kHz  627        2.1 kHz   2.0 kHz  2.4 kHz  627
Pass    520.0000 MHz  0.39 kHz   0.35 kHz  0.5 kHz  627        2.1 kHz   2.0 kHz  2.4 kHz  627
Pass    794.0125 MHz  0.39 kHz   0.35 kHz  0.5 kHz  627        2.1 kHz   2.0 kHz  2.4 kHz  627

Tx CTCSS (156.7 Hz) Modulation and Composite Deviation NPSPAC
=============================================================
Result  Frequency     CTCSS Dev  Min Dev  Max Dev  Meas Tone  Comp Dev  Min Dev  Max Dev  Meas Tone
------  ------------  ---------  -------  -------  ---------  --------  -------  -------  ---------
Pass    869.9875 MHz  0.5 kHz    0.4 kHz  0.8 kHz  156.7 Hz   3.4 kHz   3.2 kHz  3.9 kHz  155.8 Hz

P25 Phase 1 Tx Modulation C4FM High Pattern
===========================================
Result  Frequency     Meas Dev   Min Dev    Max Dev
------  ------------  ---------  ---------  ---------
Pass    869.9875 MHz  2.733 kHz  2.545 kHz  3.111 kHz

P25 Phase 1 Tx Modulation C4FM Low Pattern
==========================================
Result  Frequency     Meas Dev   Min Dev    Max Dev
------  ------------  ---------  ---------  ---------
Pass    869.9875 MHz  0.931 kHz  0.849 kHz  1.037 kHz

P25 Phase 2 Tx Modulation TDMA High Pattern
===========================================
Result  Frequency     Meas Dev   Min Dev    Max Dev
------  ------------  ---------  ---------  ---------
```

```
Pass    869.9875 MHz  3.095 kHz  2.995 kHz  3.310 kHz

Rx Audio Level and Distortion
=============================
Result  Frequency       Min Vol Lvl  Meas Volume  Max Vol Lvl  Distortion  Max Limit
------  --------------  -----------  -----------  -----------  ----------  ---------
Pass    136.000000 MHz  7.5 Vrms     8.05 Vrms    8.1 Vrms     3.0 %       5.0 %

Rx Sensitivity (SINAD) Test
===========================
Result  Frequency       12dB SINAD  Max Limit
------  --------------  ----------  ----------
Pass    136.000000 MHz  -123.6 dBm  -119.0 dBm
Pass    174.000000 MHz  -122.6 dBm  -119.0 dBm
Pass    380.000000 MHz  -123.5 dBm  -119.0 dBm
Pass    520.000000 MHz  -123.7 dBm  -119.0 dBm
Pass    764.012500 MHz  -121.3 dBm  -119.0 dBm
Pass    869.987500 MHz  -121.5 dBm  -119.0 dBm

P25 Rx Sensitivity BER (C4FM)
=============================
Result  Frequency     BER      Max Limit  Min Limit
------  ------------  -------  ---------  ---------
Pass    136.0000 MHz  1.573 %  5.0 %      0.0 %
Pass    174.0000 MHz  2.271 %  5.0 %      0.0 %
Pass    380.0000 MHz  2.219 %  5.0 %      0.0 %
Pass    520.0000 MHz  1.906 %  5.0 %      0.0 %
Pass    764.0125 MHz  3.271 %  5.0 %      0.0 %
Pass    869.9875 MHz  3.990 %  5.0 %      0.0 %

P25 Phase2 Rx Sensitivity TDMA
==============================
Result  Frequency     BER      Max Limit  Min Limit
------  ------------  -------  ---------  ---------
Pass    136.0000 MHz  0.949 %  5.0 %      0.0 %
Pass    174.0000 MHz  1.324 %  5.0 %      0.0 %
Pass    380.0000 MHz  0.908 %  5.0 %      0.0 %
Pass    520.0000 MHz  0.799 %  5.0 %      0.0 %
Pass    764.0125 MHz  2.707 %  5.0 %      0.0 %
Pass    869.9875 MHz  2.748 %  5.0 %      0.0 %

Tests performed by AutoTune © 2017 Freedom Communication Technologies, Inc.  All Rights Reserved.
APP Version 2.3.4.0
```

Figure B-1. Sample Test Result Report

APPENDIX C. Revision History

A – Original Release	M. Mullins	M. Humphries	07/25/17	0130
Revision – Change	Requested By	Approved By	Rel. Date	ECO#