FREEDOM
Communication Technologies

R8000 SERIES
COMMUNICATIONS SYSTEM ANALYZER

AUTOTUNE USER GUIDE

Harris XL Series Portable
Harris XL Series Mobile

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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 XL 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.

4. Important Notes

4.1. Required firmware

Harris XL Series radios must be running **XLP R02D01** firmware or later for AutoTune to successfully run. **XLP R03C09** firmware or later is required for AutoTune to successfully run the RSSI align.

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 XL Series models are supported by AutoTune:

- XL-45P
- XL-95P
- XL-150P

- XL-185P
- XL-200P
- XL-400P
- XL-185M
- XL-200M

5. Harris XL Series Radio Test Setup

In order to perform the test and alignment procedures, the XL Series radio must be connected to the R8000 Communications System 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. XL Series Portable Test Setup

Refer to the diagrams below for proper test setup.

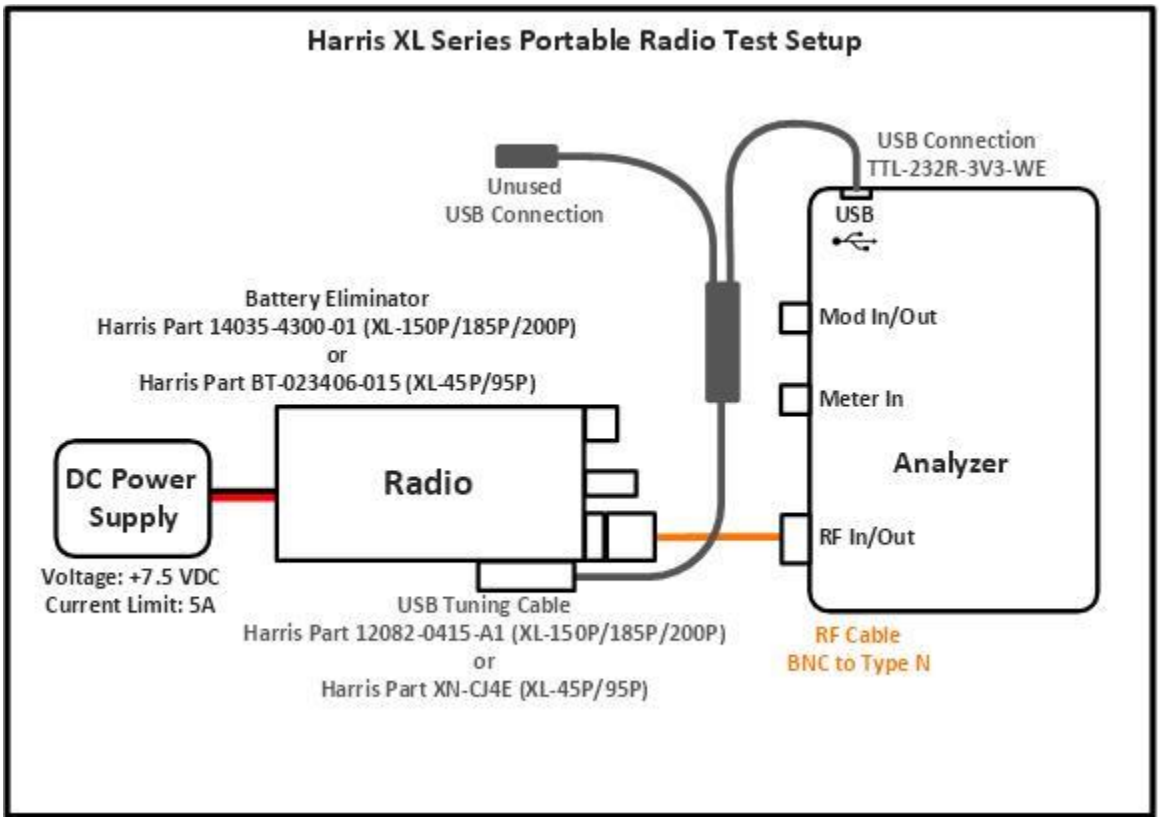

Figure 5-1. XL Series Portable Test Setup Diagram

5.2. XL Series Mobile Test Setup

Refer to the diagrams below for proper test setup.

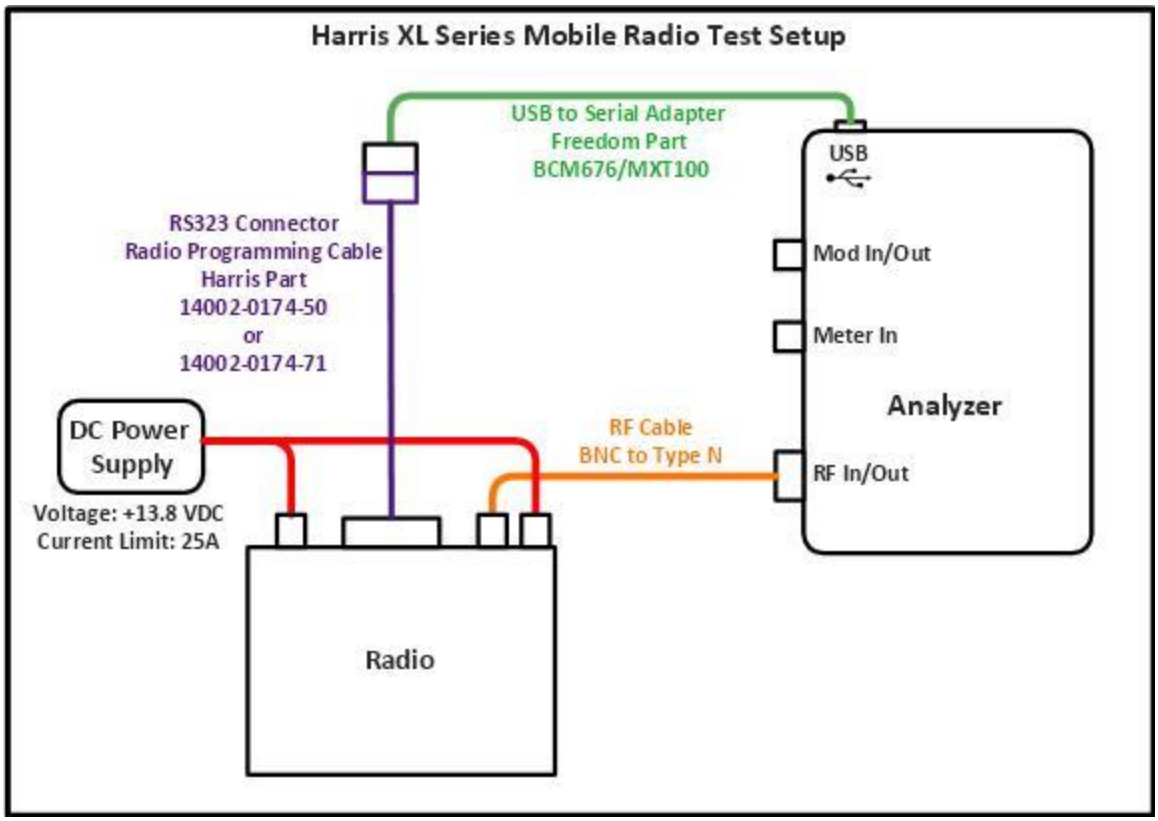

Figure 5-2. XL Series Mobile Test Setup Diagram

6. Harris XL 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.

6.1. TCXO Frequency

RF Control	Port	Frequency	Modulation	Output Level / Attenuation
Generate	RF IN/OUT	Test Frequency	FM	-70 dBm
Monitor	RF IN/OUT	Test Frequency	FM	30 dB

Table 6-1. Analyzer Configuration for TCXO Frequency

6.1.1. Alignment

The radio is placed into Test Mode at the first Rx Test Frequency, and the analyzer is set to generate as listed in Table 6-1. The radio is queried to tune the TCXO softpot and returns the new softpot value. The new softpot radio is written to the radio. After programming the new softpot value, the radio is set to the first Tx Test Frequency and commanded to transmit. The analyzer is set to measure as listed in Table 6-1. The frequency error is measured by the analyzer and compared to the 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 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 the first Tx Test Frequency and commanded to transmit. The analyzer is set to measure as listed in Table 6-1. The frequency error is measured by the analyzer and compared to the test limits. This process is repeated for each Test Frequency. 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 frequency error

Table 6-3. TCXO Frequency test results

6.2. RSSI

RF Control	Port	Frequency	Modulation	Output Level / Attenuation
Generate	RF IN/OUT	Test Freq	None	-95 dBm

Table 6-4. Analyzer Configuration for RSSI

6.2.1. Alignment

The radio is placed into Test Mode at the first Rx Test Frequency, and the analyzer is set to generate as listed in . The radio RSSI level is checked without a carrier signal for interference. If interference is detected, the radio Rx frequency and the analyzer frequency are changed by 75kHz until there is no interference. The analyzer RF signal is turned on. The RSSI level is measured by the radio at the RSSI softpot limits. These RSSI measurements are used to calculate the softpot value which matches the RSSI level to the output level of the analyzer, and the calculated softpot is saved to the radio. The RSSI level is measured by the radio and compared to the test limits. This process is repeated for each Test Frequency. The final results are written to the log file.

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

Table 6-5. RSSI alignment results

6.2.2. Test

The radio is placed into Test Mode at a Rx Test Frequency, and the analyzer is set to generate as listed . The radio RSSI level is check without a carrier signal for interference. If interference is detected, the rest of the test is skipped, and results are written to the log file. The analyzer RF signal is turned on. The RSSI level is measured by the radio and compared to the test limits. This process is repeated for each Test Frequency. 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
RSSI Intrf	Measured RSSI level to check for interference with no RF signal
RSSI	Measured RSSI level
Min Limit	Minimum Limit (inclusive) for RSSI
Max Limit	Maximum Limit (inclusive) for RSSI
Softpot	Radio softpot producing the RSSI

Table 6-6. RSSI test results

6.3. TX Power

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

Table 6-7. Analyzer Configuration for TX Power

6.3.1. Test

The radio is commanded to transmit. Beginning at the first Tx Test Frequency, the output level is measured at each TX Test Frequency, for Low and High Power, and compared to the 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 6-8. TX Power test results

6.4. Tx CTCSS/CDCSS Modulation and Composite Deviation

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

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

Table 6-9. Analyzer Configuration for Tx CTCSS/CDCSS Modulation test

6.4.1. Test

For each test frequency and bandwidth (Wide, Narrow, NPSPAC) supported, the radio transmits 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 for CTCSS tone or CDCSS code accuracy. The test results are written to the log file.

Name	Description
Result	Pass or Fail. CTCSS or CDCSS deviation levels are within limits, and CTCSS tone/CDCSS code is accurate.
Frequency	Test Frequency
CTCSS Dev	Measured CTCSS or CDCSS deviation level
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

Table 6-10. Tx CTCSS/CDCSS Modulation test results

6.5. P25 Tx Tests (C4FM)

The Tx P25 Tx Tests (C4FM) measures the radio's P25 Phase 1 C4FM modulation fidelity level and symbol deviation at multiply test frequencies with a random pattern.

RF Control	Port	Frequency	Modulation	Attenuation	Dev Avg
Monitor	RF IN/OUT	Test Frequency	C4FM	30 dB	Peak Avg

Table 6-11. Analyzer Configuration for P25 Tx Tests (C4FM)

6.5.1. Test

The radio is set to a digital channel at low power at the first Tx Test Frequency and commanded to transmit a random deviation pattern. The modulation fidelity and symbol deviation of this tone is measured with the analyzer. This process is repeated for each Test Frequency. The test results are written to the log file.

Name	Description
Result	Pass or Fail. Modulation fidelity is between Min Limit and Max Limit.
Frequency	Test Frequency
Meas Mod Fidelity	Measured P25 Phase 1 C4FM modulation fidelity
Min Mod Fidelity	Minimum passable modulation fidelity level
Max Mod Fidelity	Maximum passable modulation fidelity level

Table 6-12. Tx P25 Modulation Fidelity (C4FM) results

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

Table 6-13. Tx P25 Symbol Deviation (C4FM) results

6.6. P25 Tx Deviation (C4FM) Test

The Tx P25 Tx Deviation (C4FM) test measures the radio's P25 Phase 1 C4FM deviation level at specific test frequencies for both High and Low Patterns.

RF Control	Port	Frequency	Modulation	Attenuation	Dev Avg
Monitor	RF IN/OUT	Test Frequency	C4FM	30 dB	Peak Avg

Table 6-14. Analyzer Configuration for P25 Tx Deviation (C4FM) test

6.6.1. Test

The radio is set to a digital channel at low power at the first Tx Test Frequency and commanded to transmit a pattern. The Peak-averaged deviation of this tone is measured with the analyzer. This process is repeated for each Test Frequency and High and Low patterns. 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 6-15. Tx P25 Deviation (C4FM) test results

6.7. P25 Tx Tests (TDMA)

The P25 Tx Tests (TDMA) measures the radio's P25 Phase 2 TDMA modulation fidelity level and symbol deviation at multiply test frequencies with a 1031 Tone pattern.

RF Control	Port	Frequency	Modulation	Test Pattern	Attenuation	Dev Avg
Monitor	RF IN/OUT	Test Frequency	HCPM	1031 Hz or 1031 Hz Symmetrical	30 dB	Peak Avg

Table 6-16. Analyzer Configuration for P25 Tx Tests (TDMA)

6.7.1. Test

The radio is set to a digital channel at low power at the first Tx Test Frequency and commanded to transmit a random deviation pattern. The modulation fidelity and symbol deviation of this tone is measured with the analyzer. This process is repeated for each Test Frequency. The test results are written to the log file.

Name	Description
Result	Pass or Fail. Modulation fidelity is between Min Limit and Max Limit.
Frequency	Test Frequency
Meas Mod Fidelity	Measured P25 Phase 2 TDMA modulation fidelity
Min Mod Fidelity	Minimum passable modulation fidelity level
Max Mod Fidelity	Maximum passable modulation fidelity level

Table 6-17. P25 Tx Modulation Fidelity (TDMA) results

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

Table 6-18. P25 Tx Symbol Deviation (TDMA) results

6.8. P25 Tx Deviation (TDMA)

The Tx P25 Tx Deviation (TDMA) measures the radio's P25 Phase 2 TDMA deviation level at specific test frequencies for both High and Low Patterns.

RF Control	Port	Frequency	Modulation	Attenuation	Dev Avg
Monitor	RF IN/OUT	Test Frequency	None	30 dB	Peak Avg

Table 6-19. Analyzer Configuration for P25 Tx Deviation (TDMA) test

6.8.1. Test

The radio is set to a digital channel at low power at the first Tx Test Frequency and commanded to transmit a pattern. The Peak-averaged deviation of this tone is measured with the analyzer. This process is repeated for each Test Frequency and High and Low patterns. 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 6-20. P25 Tx Deviation (TDMA) test results

6.9. P25 Rx Sensitivity (C4FM) Test

The P25 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	-117 dBm

Table 6-21. Analyzer Configuration for P25 Rx Sensitivity (C4FM) test

6.9.1. Test

The analyzer is setup by applying the Modulation signal in Table 6-21 to the radio. The radio is set to a digital zone and the first Rx test frequency. The radio's reported C4FM BER level is measured and compared against the test limits. This process is repeated for each Test Frequency. The final results are written to the log file.

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 Bit Error Rate (BER)
Min Limit	Minimum Limit (exclusive) for Bit Error Rate (BER)

Table 6-22. P25 Rx Sensitivity (C4FM) test results

6.10. P25 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	-117 dBm

Table 6-23. Analyzer Configuration for P25 Rx Sensitivity (TDMA) test

6.10.1. Test

The analyzer is setup by applying the Modulation signal in Table 6-23 to the radio. The radio is set to a digital zone at the first RX Test Frequency. The radio's reported TDMA BER level is measured and compared against the test limits. This process is repeated for each Test Frequency. The final results are written to the log file.

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 Bit Error Rate (BER)
Min Limit	Minimum Limit (exclusive) for Bit Error Rate (BER)

Table 6-24. P25 Rx Sensitivity (TDMA) test results

Basic Troubleshooting

Symptom	Possible Cause	Possible Solution
Analyzer consistently fails to communicate with radio	• 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 consistently fails to communicate with radio and radio display softkeys are blank.	• Current mission plan corrupted while setting mission plan to test mode.	• Boot radio into “Wifi programming mode” by pressing the PTT and Bottom Side Button and powering up the radio. Wait 5 seconds. Connect the radio to RPM and re-flash or overwrite the radio personality.
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 6-25. Harris XL 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 Harris XL Series radio models supported by AutoTune.

6.1	TCXO Frequency	Reference Oscillator Align	Min = -0.05 ppm Max = 0.05 ppm
		Reference Oscillator Test	Min = -0.4 ppm Max = 0.4 ppm
6.2	RSSI	RSSI Align	Min = -3.0 dBm Max = 3.0 dBm
		RSSI Test	Min = -3.0 dBm Max = 3.0 dBm
		RSSI Level	Max = -95 dBm
		RSSI Interference Threshold	Max = -115 dBm
6.3	TX Power Test Portable	TX Power Test VHF Low	Min = 0.7 W Max = 1.3 W
		TX Power Test UHF Low	Min = 0.70 W Max = 1.3 W
		TX Power Test 700MHz Low	Min = 0.2 W Max = 0.8 W
		TX Power Test 800MHz Low	Min = 0.2 W Max = 0.8 W
		TX Power Test 900MHz Low	Min = 0.2 W Max = 0.8 W
		TX Power Test VHF High	Min = 5.6 W Max = 7.6 W
		TX Power Test UHF High	Min = 4.7 W Max = 6.3 W
		TX Power Test 700MHz High	Min = 2.2 W Max = 3.2 W
		TX Power Test 800MHz High	Min = 2.8 W Max = 3.8 W
		TX Power Test 900MHz High	Min = 2.8 W Max = 3.8 W
6.3	TX Power Test Mobile	TX Power Test VHF Low	Min = 4.5 W Max = 5.7 W
		TX Power Test UHF Low	Min = 4.5 W Max = 5.7 W
		TX Power Test 700MHz Low	Min = 1.8 W Max = 2.3 W
		TX Power Test 800MHz Low	Min = 1.8 W Max = 2.3 W
		TX Power Test 900MHz Low	Min = 1.8 W Max = 2.3 W
		TX Power Test VHF High	Min = 47.8 W Max = 56.2 W
		TX Power Test UHF High	Min = 47.8 W Max = 56.2 W
		TX Power Test 700MHz High	Min = 24.0 W Max = 28.2 W
		TX Power Test 800MHz High	Min = 33.5 W Max = 39.3 W
		TX Power Test 900MHz High	Min = 33.5 W Max = 39.3 W

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 = 0.315 kHz Max = 0.465 kHz
		Tx CTCSS/CDCSS Modulation Deviation NPSPAC	Min = 0.4 kHz Max = 0.8 kHz
6.5	P25 Phase1 Tx Tests C4FM	P25 Phase1 Tx Modulation Fidelity C4FM	Min = 0.0 % Max = 0.5 %
		P25 Phase1 Tx Symbol Deviation C4FM	Min = 1.620 kHz Max = 1.980 kHz
6.6	P25 Phase2 Tx Modulation TDMA	P25 Phase1 Tx Modulation C4FM High Pattern	Min = 2.544 kHz Max = 3.110 kHz
		P25 Phase1 Tx Modulation C4FM Low Pattern	Min = 0.849 kHz Max = 1.037 kHz
6.7	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-1. Default Harris XL Series 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
================================================================================
Date/Time: 6/20/2022 8:54 AM                      Operator ID: 6

Info
------------------------------------------------
Analyzer
---------
Model #:              R8200
Serial #:             800BEN001
Ref Clock Mode:       Output
Application:          4.4
RF Level Offset:      Off
RF In/Out Offset:     0.0 dB
RF Gen Out Offset:    0.0 dB
Cable Sweep:          On
Selected File:        1
100 MHz Attenuation: -0.220 dB
1 GHz Attenuation:   -0.798 dB

Radio
------
Model #:              XL-200P/185P/150P
Serial #:             A40301000059
Firmware Version:     R08A17
Digital Hardware:     14035-3000-01 R06
DSP Version:          R08A17
RF Hardware Version: 14035-3000
RF DSP Version:       R08A17
AES Version:          R06A02
DES Version:          R05A01
Radio Bands:          VHF_HI UHF 700_800 900
------------------------------------------------

TCXO Frequency Align
====================
Result  Frequency     Freq Error  Min Limit  Max Limit  Old Softpot  New Softpot
------  ------------  ----------  ---------  ---------  -----------  -----------
Pass    861.0000 MHz  -10 Hz      -43 Hz     43 Hz      2500         1930

TCXO Frequency Test
===================
Result  Frequency     Freq Error  Min Limit  Max Limit  Softpot
------  ------------  ----------  ---------  ---------  -------
Pass    811.0000 MHz  -7 Hz       -324 Hz    324 Hz     1930
Pass    802.0000 MHz  -3 Hz       -321 Hz    321 Hz     1930
Pass    772.0000 MHz  -3 Hz       -309 Hz    309 Hz     1930
Pass    522.0000 MHz  3 Hz        -209 Hz    209 Hz     1930
Pass    450.0250 MHz  3 Hz        -180 Hz    180 Hz     1930
Pass    378.0000 MHz  3 Hz        -151 Hz    151 Hz     1930
Pass    174.0000 MHz  2 Hz        -70 Hz     70 Hz      1930
Pass    155.0000 MHz  1 Hz        -62 Hz     62 Hz      1930
Pass    136.0000 MHz  1 Hz        -54 Hz     54 Hz      1930

RSSI Align
==========
Result  Frequency     Old Softpot  New Softpot  RSSI     Max Limit  Min Limit
------  ------------  -----------  -----------  -------  ---------  ---------
Pass    136.0000 MHz  163          173          0.0 dB   3.0 dB     -3.0 dB
Pass    139.8000 MHz  173          173          0.0 dB   3.0 dB     -3.0 dB
Pass    143.6000 MHz  173          173          0.0 dB   3.0 dB     -3.0 dB
Pass    147.7000 MHz  174          173          0.0 dB   3.0 dB     -3.0 dB
Pass    151.2000 MHz  174          173          1.0 dB   3.0 dB     -3.0 dB
Pass    155.0000 MHz  178          173          1.0 dB   3.0 dB     -3.0 dB
Pass    158.8000 MHz  174          173          0.0 dB   3.0 dB     -3.0 dB
Pass    162.6000 MHz  174          174          0.0 dB   3.0 dB     -3.0 dB
Pass    166.4000 MHz  174          174          -1.0 dB  3.0 dB     -3.0 dB
Pass    170.2000 MHz  173          173          0.0 dB   3.0 dB     -3.0 dB
Pass    174.0000 MHz  163          173          0.0 dB   3.0 dB     -3.0 dB
Pass    378.0000 MHz  178          172          0.0 dB   3.0 dB     -3.0 dB
Pass    394.0000 MHz  173          173          0.0 dB   3.0 dB     -3.0 dB
Pass    408.0000 MHz  173          173          0.0 dB   3.0 dB     -3.0 dB
Pass    422.0000 MHz  173          173          0.0 dB   3.0 dB     -3.0 dB
Pass    436.0000 MHz  173          173          0.0 dB   3.0 dB     -3.0 dB
Pass    450.0000 MHz  163          173          0.0 dB   3.0 dB     -3.0 dB
Pass    464.0000 MHz  173          173          0.0 dB   3.0 dB     -3.0 dB
Pass    478.0000 MHz  172          172          0.0 dB   3.0 dB     -3.0 dB
Pass    492.0000 MHz  171          171          0.0 dB   3.0 dB     -3.0 dB
Pass    506.0000 MHz  171          171          0.0 dB   3.0 dB     -3.0 dB
Pass    522.0000 MHz  178          171          0.0 dB   3.0 dB     -3.0 dB
Pass    768.0000 MHz  163          171          0.0 dB   3.0 dB     -3.0 dB
Pass    769.6000 MHz  171          171          0.0 dB   3.0 dB     -3.0 dB
Pass    771.2000 MHz  170          170          0.0 dB   3.0 dB     -3.0 dB
Pass    772.8000 MHz  170          170          0.0 dB   3.0 dB     -3.0 dB
Pass    774.4000 MHz  170          170          0.0 dB   3.0 dB     -3.0 dB
Pass    776.0000 MHz  178          170          0.0 dB   3.0 dB     -3.0 dB
Pass    851.0000 MHz  163          169          0.0 dB   3.0 dB     -3.0 dB
Pass    852.9000 MHz  169          169          0.0 dB   3.0 dB     -3.0 dB
Pass    856.7000 MHz  170          170          0.0 dB   3.0 dB     -3.0 dB
Pass    861.0000 MHz  178          168          1.0 dB   3.0 dB     -3.0 dB

TX Power Test - Low Power
=========================
Result  Frequency     Power Out  Min Limit  Max Limit
------  ------------  ---------  ---------  ---------
Pass    136.0000 MHz  1.03 W     0.70 W     1.30 W
Pass    155.0000 MHz  1.01 W     0.70 W     1.30 W
Pass    174.0000 MHz  1.01 W     0.70 W     1.30 W
Pass    378.0000 MHz  1.01 W     0.70 W     1.30 W
Pass    450.0250 MHz  1.04 W     0.70 W     1.30 W
Pass    522.0000 MHz  1.02 W     0.70 W     1.30 W
Pass    772.0000 MHz  0.48 W     0.20 W     0.80 W
Pass    802.0000 MHz  0.47 W     0.20 W     0.80 W
Pass    811.0000 MHz  0.49 W     0.20 W     0.80 W
Pass    856.0000 MHz  0.49 W     0.20 W     0.80 W

TX Power Test - High Power
==========================
Result  Frequency     Power Out  Min Limit  Max Limit
------  ------------  ---------  ---------  ---------
Pass    136.0000 MHz  5.98 W     5.60 W     7.60 W
Pass    155.0000 MHz  5.98 W     5.60 W     7.60 W
Pass    174.0000 MHz  5.99 W     5.60 W     7.60 W
Pass    378.0000 MHz  5.04 W     4.70 W     6.30 W
Pass    450.0250 MHz  5.04 W     4.70 W     6.30 W
Pass    522.0000 MHz  5.00 W     4.70 W     6.30 W
```

Pass	772.0000 MHz	2.57 W	2.20 W	3.20 W
Pass	802.0000 MHz	2.52 W	2.20 W	3.20 W
Pass	811.0000 MHz	2.97 W	2.80 W	3.80 W
Pass	856.0000 MHz	2.97 W	2.80 W	3.80 W

Tx CTCSS (156.7 Hz) Modulation Wide

Result	Frequency	CTCSS Dev	Min Limit	Max Limit	156.4<=Meas Tone<=157.0
Pass	811.0000 MHz	0.694 kHz	0.5 kHz	1.0 kHz	156.7 Hz
Pass	856.0000 MHz	0.689 kHz	0.5 kHz	1.0 kHz	156.7 Hz

Tx CDCSS (627) Modulation Wide

Result	Frequency	CDCSS Dev	Min Limit	Max Limit	Meas Code
Pass	811.0000 MHz	0.629 kHz	0.5 kHz	1.0 kHz	627
Pass	856.0000 MHz	0.633 kHz	0.5 kHz	1.0 kHz	627

Tx CTCSS (156.7 Hz) Modulation Narrow

Result	Frequency	CTCSS Dev	Min Limit	Max Limit	156.4<=Meas Tone<=157.0
Pass	174.0000 MHz	0.386 kHz	0.315 kHz	0.465 kHz	156.8 Hz
Pass	522.0000 MHz	0.391 kHz	0.315 kHz	0.465 kHz	156.7 Hz
Pass	772.0000 MHz	0.398 kHz	0.315 kHz	0.465 kHz	156.7 Hz
Pass	802.0000 MHz	0.397 kHz	0.315 kHz	0.465 kHz	156.8 Hz
Pass	811.0000 MHz	0.397 kHz	0.315 kHz	0.465 kHz	156.7 Hz
Pass	856.0000 MHz	0.399 kHz	0.315 kHz	0.465 kHz	156.7 Hz

Tx CDCSS (627) Modulation Narrow

Result	Frequency	CDCSS Dev	Min Limit	Max Limit	Meas Code
Pass	174.0000 MHz	0.360 kHz	0.315 kHz	0.465 kHz	627
Pass	522.0000 MHz	0.358 kHz	0.315 kHz	0.465 kHz	627
Pass	772.0000 MHz	0.352 kHz	0.315 kHz	0.465 kHz	627
Pass	802.0000 MHz	0.353 kHz	0.315 kHz	0.465 kHz	627
Pass	811.0000 MHz	0.352 kHz	0.315 kHz	0.465 kHz	627
Pass	856.0000 MHz	0.357 kHz	0.315 kHz	0.465 kHz	627

Tx CTCSS (156.7 Hz) Modulation NPSPAC

Result	Frequency	CTCSS Dev	Min Limit	Max Limit	156.4<=Meas Tone<=157.0
Pass	811.0000 MHz	0.557 kHz	0.4 kHz	0.8 kHz	156.7 Hz
Pass	856.0000 MHz	0.555 kHz	0.4 kHz	0.8 kHz	156.7 Hz

P25 Phase 1 Tx Modulation Fidelity C4FM

Result	Frequency	Mod Fidelity	Max Limit
Pass	136.0000 MHz	0.710 %	5.000 %
Pass	155.0000 MHz	0.773 %	5.000 %
Pass	174.0000 MHz	0.827 %	5.000 %
Pass	378.0000 MHz	0.863 %	5.000 %
Pass	450.0250 MHz	0.781 %	5.000 %
Pass	522.0000 MHz	0.734 %	5.000 %
Pass	772.0000 MHz	0.825 %	5.000 %
Pass	802.0000 MHz	0.785 %	5.000 %
Pass	811.0000 MHz	0.746 %	5.000 %
Pass	856.0000 MHz	0.639 %	5.000 %

P25 Phase 1 Tx Symbol Deviation C4FM

Result	Frequency	Symbol Dev	Min Limit	Max Limit
Pass	136.0000 MHz	1.822 kHz	1.620 kHz	1.980 kHz
Pass	155.0000 MHz	1.822 kHz	1.620 kHz	1.980 kHz
Pass	174.0000 MHz	1.822 kHz	1.620 kHz	1.980 kHz
Pass	378.0000 MHz	1.823 kHz	1.620 kHz	1.980 kHz
Pass	450.0250 MHz	1.822 kHz	1.620 kHz	1.980 kHz
Pass	522.0000 MHz	1.821 kHz	1.620 kHz	1.980 kHz
Pass	772.0000 MHz	1.824 kHz	1.620 kHz	1.980 kHz
Pass	802.0000 MHz	1.822 kHz	1.620 kHz	1.980 kHz
Pass	811.0000 MHz	1.824 kHz	1.620 kHz	1.980 kHz
Pass	856.0000 MHz	1.823 kHz	1.620 kHz	1.980 kHz

P25 Phase 1 Tx Deviation C4FM High Pattern

Result	Frequency	Meas Dev	Min Dev	Max Dev
Pass	136.0000 MHz	2.842 kHz	2.544 kHz	3.110 kHz
Pass	155.0000 MHz	2.841 kHz	2.544 kHz	3.110 kHz
Pass	174.0000 MHz	2.842 kHz	2.544 kHz	3.110 kHz
Pass	378.0000 MHz	2.849 kHz	2.544 kHz	3.110 kHz
Pass	450.0250 MHz	2.849 kHz	2.544 kHz	3.110 kHz
Pass	522.0000 MHz	2.848 kHz	2.544 kHz	3.110 kHz
Pass	772.0000 MHz	2.859 kHz	2.544 kHz	3.110 kHz
Pass	802.0000 MHz	2.858 kHz	2.544 kHz	3.110 kHz
Pass	811.0000 MHz	2.860 kHz	2.544 kHz	3.110 kHz
Pass	856.0000 MHz	2.856 kHz	2.544 kHz	3.110 kHz

P25 Phase 1 Tx Deviation C4FM Low Pattern

Result	Frequency	Meas Dev	Min Dev	Max Dev
Pass	136.0000 MHz	0.952 kHz	0.849 kHz	1.037 kHz
Pass	155.0000 MHz	0.951 kHz	0.849 kHz	1.037 kHz
Pass	174.0000 MHz	0.950 kHz	0.849 kHz	1.037 kHz
Pass	378.0000 MHz	0.956 kHz	0.849 kHz	1.037 kHz
Pass	450.0250 MHz	0.957 kHz	0.849 kHz	1.037 kHz
Pass	522.0000 MHz	0.957 kHz	0.849 kHz	1.037 kHz
Pass	772.0000 MHz	0.965 kHz	0.849 kHz	1.037 kHz
Pass	802.0000 MHz	0.966 kHz	0.849 kHz	1.037 kHz
Pass	811.0000 MHz	0.966 kHz	0.849 kHz	1.037 kHz
Pass	856.0000 MHz	0.966 kHz	0.849 kHz	1.037 kHz

P25 Phase 2 Tx Modulation Fidelity TDMA

Result	Frequency	Mod Fidelity	Max Limit
Pass	136.0000 MHz	0.653 %	5.000 %
Pass	155.0000 MHz	0.633 %	5.000 %
Pass	174.0000 MHz	0.618 %	5.000 %
Pass	378.0000 MHz	0.583 %	5.000 %
Pass	450.0250 MHz	0.627 %	5.000 %
Pass	522.0000 MHz	0.612 %	5.000 %
Pass	772.0000 MHz	0.846 %	5.000 %
Pass	802.0000 MHz	0.835 %	5.000 %
Pass	811.0000 MHz	0.632 %	5.000 %
Pass	856.0000 MHz	0.762 %	5.000 %

P25 Phase 2 Tx Symbol Deviation TDMA

Result	Frequency	Symbol Dev	Min Limit	Max Limit
Pass	136.0000 MHz	2.958 kHz	2.842 kHz	3.141 kHz
Pass	155.0000 MHz	2.956 kHz	2.842 kHz	3.141 kHz

```
Pass    174.0000 MHz  2.955 kHz   2.842 kHz  3.141 kHz
Pass    378.0000 MHz  2.955 kHz   2.842 kHz  3.141 kHz
Pass    450.0250 MHz  2.957 kHz   2.842 kHz  3.141 kHz
Pass    522.0000 MHz  2.960 kHz   2.842 kHz  3.141 kHz
Pass    772.0000 MHz  2.950 kHz   2.842 kHz  3.141 kHz
Pass    802.0000 MHz  2.954 kHz   2.842 kHz  3.141 kHz
Pass    811.0000 MHz  2.932 kHz   2.842 kHz  3.141 kHz
Pass    856.0000 MHz  2.956 kHz   2.842 kHz  3.141 kHz

P25 Phase 2 Tx Deviation TDMA High Pattern
==========================================
Result  Frequency     Meas Dev   Min Dev    Max Dev
------  ------------  ---------  ---------  ---------
Pass    136.0000 MHz  3.142 kHz  2.995 kHz  3.310 kHz
Pass    155.0000 MHz  3.144 kHz  2.995 kHz  3.310 kHz
Pass    174.0000 MHz  3.148 kHz  2.995 kHz  3.310 kHz
Pass    378.0000 MHz  3.149 kHz  2.995 kHz  3.310 kHz
Pass    450.0250 MHz  3.152 kHz  2.995 kHz  3.310 kHz
Pass    522.0000 MHz  3.148 kHz  2.995 kHz  3.310 kHz
Pass    772.0000 MHz  3.158 kHz  2.995 kHz  3.310 kHz
Pass    802.0000 MHz  3.156 kHz  2.995 kHz  3.310 kHz
Pass    811.0000 MHz  3.163 kHz  2.995 kHz  3.310 kHz
Pass    856.0000 MHz  3.160 kHz  2.995 kHz  3.310 kHz

P25 Phase 2 Tx Deviation TDMA Low Pattern
=========================================
Result  Frequency     Meas Dev   Min Dev    Max Dev
------  ------------  ---------  ---------  ---------
Pass    136.0000 MHz  1.048 kHz  0.998 kHz  1.104 kHz
Pass    155.0000 MHz  1.049 kHz  0.998 kHz  1.104 kHz
Pass    174.0000 MHz  1.051 kHz  0.998 kHz  1.104 kHz
Pass    378.0000 MHz  1.054 kHz  0.998 kHz  1.104 kHz
Pass    450.0250 MHz  1.053 kHz  0.998 kHz  1.104 kHz
Pass    522.0000 MHz  1.059 kHz  0.998 kHz  1.104 kHz
Pass    772.0000 MHz  1.064 kHz  0.998 kHz  1.104 kHz
Pass    802.0000 MHz  1.061 kHz  0.998 kHz  1.104 kHz
Pass    811.0000 MHz  1.062 kHz  0.998 kHz  1.104 kHz
Pass    856.0000 MHz  1.065 kHz  0.998 kHz  1.104 kHz

P25 Rx Sensitivity BER (C4FM)
=============================
Result  Frequency     BER      Min Limit  Max Limit
------  ------------  -------  ---------  ---------
Pass    136.0000 MHz  0.513 %  0.0 %      5.1 %
Pass    155.0000 MHz  0.296 %  0.0 %      5.1 %
Pass    174.0000 MHz  0.167 %  0.0 %      5.1 %
Pass    378.0000 MHz  0.520 %  0.0 %      5.1 %
Pass    450.0250 MHz  0.551 %  0.0 %      5.1 %
Pass    522.0000 MHz  0.605 %  0.0 %      5.1 %
Pass    772.0000 MHz  1.158 %  0.0 %      5.1 %
Pass    856.0000 MHz  1.130 %  0.0 %      5.1 %

P25 Phase2 Rx Sensitivity (TDMA)
================================
Result  Frequency     BER      Min Limit  Max Limit
------  ------------  -------  ---------  ---------
Pass    136.0000 MHz  0.261 %  0.0 %      5.1 %
Pass    155.0000 MHz  0.111 %  0.0 %      5.1 %
Pass    174.0000 MHz  0.112 %  0.0 %      5.1 %
Pass    378.0000 MHz  0.294 %  0.0 %      5.1 %
Pass    450.0250 MHz  0.321 %  0.0 %      5.1 %
Pass    522.0000 MHz  0.493 %  0.0 %      5.1 %
Pass    772.0000 MHz  1.106 %  0.0 %      5.1 %
Pass    856.0000 MHz  0.982 %  0.0 %      5.1 %

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```

Figure B-1. Sample Test Result Report

APPENDIX C. Revision History

B – Add Mobile – Add P25 Tx TDMA Tests	M. Hammer	M. Mullins	7/7/22	0400
A – Original Release	M. Hammer	W.Black	12/17/17	0160
Revision – Change	Requested By	Approved By	Rel. Date	ECO#