R8000 SERIES
COMMUNICATIONS SYSTEM ANALYZER

AUTOTUNE USER GUIDE

Hytera DMR Portable Radios
Hytera DMR Mobile Radios

Astronics Test Systems
12700 Ingenuity Dr. Orlando, FL 32826

FCT-1390A

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.

TRADEMARKS

The Astronics Test System logo is a registered ® trademark of Astronics.

NXDN™ is a trademark of Icom America, Inc. and JVCKenwood Corporation.

TABLE OF CONTENTS

1. Introduction 1
2. Scope 1
2.1. Supported Models 1
3. Conventions 1
3.1. PPM 1
4. Hytera DMR Portable Radio Test Setup 2
4.1. Cable Sweep 2
4.2. Battery Eliminator 2
4.3. Hytera DMR Portable Test Setup 3
5. Hytera DMR Portable Alignment and Test Descriptions 4
5.1. Reference Oscillator Warp 4
5.2. Tx Power 6
5.3. Transmit to Deviation 7
5.4. Tx Modulation Balance 8
5.5. Rx Front End Filter 9
5.6. Rx Front End Gain 10
5.7. Tx/Rx Charge Voltage (Portable Only) 11
5.8. Tx Max Analog Deviation 12
5.9. Tx Max Analog Deviation CTCSS 13
5.10. Tx Max Analog Deviation CDCSS 14
5.11. Tx CTCSS Deviation 15
5.12. Tx CDCSS Deviation 16
5.13. Tx Modulation Sensitivity 17
5.14. Tx BER 18
5.15. Tx Digital Tests 19
5.16. Rx Max Audio Output Power 20
5.17. Rx Sensitivity 21
5.18. Rx Audio Distortion 22
5.19. Rx SNR 23
5.20. Rx Normal Level Squelch 24
5.21. Rx CTCSS/CDCSS Decode 25
5.22. Rx BER 26
6. Hytera DMR Mobile Radio Test Setup 27
6.1. Cable Sweep 27
6.2. Hytera DMR Mobile Test Setup 28
7. Hytera DMR Mobile Alignment and Test Descriptions 29
8. Basic Troubleshooting 30
9. Support Information 31
9.1. Technical Support 31
9.2. Sales 31
APPENDIX A. Test Limits A-1
APPENDIX B. Sample Test Result Report B-1

APPENDIX C. Revision History C-1

LIST OF FIGURES

Figure 4-1. Hytera DMR Portable Test Setup Diagram. 3
Figure 6-1. Hytera DMR Mobile Test Setup Diagram. 28

Figure B-1. Sample Test Result Report B-4

LIST OF TABLES

Table 5-1. Analyzer Configuration for Reference Oscillator Warp 4
Table 5-2. Reference Oscillator Warp alignment results.....4
Table 5-3. Reference Oscillator Warp test results.....5
Table 5-4. Analyzer Configuration for Tx Power 6
Table 5-5. Tx Power alignment results.....6
Table 5-6. Tx Power test results 6
Table 5-7. Analyzer Configuration for Transmit to Deviation.....7
Table 5-8. Transmit to Deviation alignment results 7
Table 5-9. Analyzer Configuration for Tx Modulation Balance alignment.....8
Table 5-10. Tx Modulation alignment results 8
Table 5-11. Analyzer Configuration for Rx Front End Filter 9
Table 5-12. Rx Front End Filter alignment results.....9
Table 5-13. Analyzer Configuration for Rx Front End Gain.....10
Table 5-14. Rx Front End Gain alignment results 10
Table 5-15. Tx/Rx Charge Voltage alignment results.....11
Table 5-16. Analyzer Configuration for Tx Max Analog Deviation test.....12
Table 5-17. Tx Max Analog Deviation test results.....12
Table 5-18. Analyzer Configuration for Tx Max Analog Deviation CTCSS test...13
Table 5-19. Tx Max Analog Deviation CTCSS test results.....13
Table 5-20. Analyzer Configuration for Tx Max Analog Deviation CDCSS 14
Table 5-21. Tx Max Analog Deviation CDCSS test results 14
Table 5-22. Analyzer Configuration for Tx CTCSS Deviation 15
Table 5-23. Tx CTCSS Deviation test results 15
Table 5-24. Analyzer Configuration for Tx CDCSS Deviation test 16
Table 5-25. Tx CDCSS Deviation test results 16
Table 5-26. Analyzer Configuration for Tx Modulation Sensitivity test 17
Table 5-27. Tx Modulation Sensitivity test results.....17
Table 5-28. Analyzer Configuration for Tx BER test 18
Table 5-29. Tx BER test results 18
Table 5-30. Analyzer Configuration for Tx Digital Tests.....19
Table 5-31. Tx FSK Error test results.....19
Table 5-32. Tx Symbol Deviation test results.....19
Table 5-33. Tx Magnitude Error test results.....19
Table 5-34. Analyzer Configuration for Rx Max Audio Output Power test.....20
Table 5-35. Rx Max Audio Output Power test results 20
Table 5-36. Analyzer Configuration for Rx Sensitivity test 21
Table 5-37. Rx Sensitivity test results.....21
Table 5-38. Analyzer Configuration for Rx Audio Distortion test 22
Table 5-39. Rx Audio Distortion test results.....22
Table 5-40. Analyzer Configuration for Rx SNR test.....23
Table 5-41. Rx SNR test results.....23
Table 5-42. Analyzer Configuration for Rx Normal Level Squelch test 24
Table 5-43. Rx Normal Level Squelch test results 24

Table 5-44. Analyzer Configuration for Rx CTCSS/CDCSS Decode test 25
Table 5-45. Rx CTCSS Decode test results.....25
Table 5-46. Rx CDCSS Decode test results 25
Table 5-47. Analyzer Configuration for Rx BER test.....26
Table 5-48. Rx BER test results.....26
Table 8-1. Hytera DMR Series Troubleshooting Chart.....30

1. Introduction

The Astronics Test Systems 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 Hytera DMR Portable and Hytera DMR Mobile 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.

2.1. Supported Models

The following Hytera DMR models are supported:

- PD5xx
- PD6xx
- PD7xx
- X1e/X1p
- HD5xx
- HD6xx
- HD7xx
- MD7xx

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. Hytera DMR Portable Radio Test Setup

In order to perform the test and alignment procedures, the Hytera DMR Portable 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 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.

4.1. Cable Sweep

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

Sweep the RF cable used between the Radio and Analyzer, label the RF cable with the stored cable sweep name, and enable the Cable Sweep feature in the analyzer System, System Settings… menu. Refer to Application Note FCT-1017 *Utilizing Cable Sweep on the Astronics Test Systems Communications System Analyzer* for instructions on how to perform a cable sweep.

4.2. Battery Eliminator

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

For Hytera DMR Portable models, use the following Hytera battery eliminator part. For more information, see the applicable Hytera radio service manual.

Hytera DMR Portable battery jig

- Hytera Part Number: **HYT-152PD50000100 (PD5, PD6, X1)**
  HYT-152PD78000200 (PD7)

4.3. Hytera DMR Portable Test Setup

Refer to the diagram below for the proper test setup.

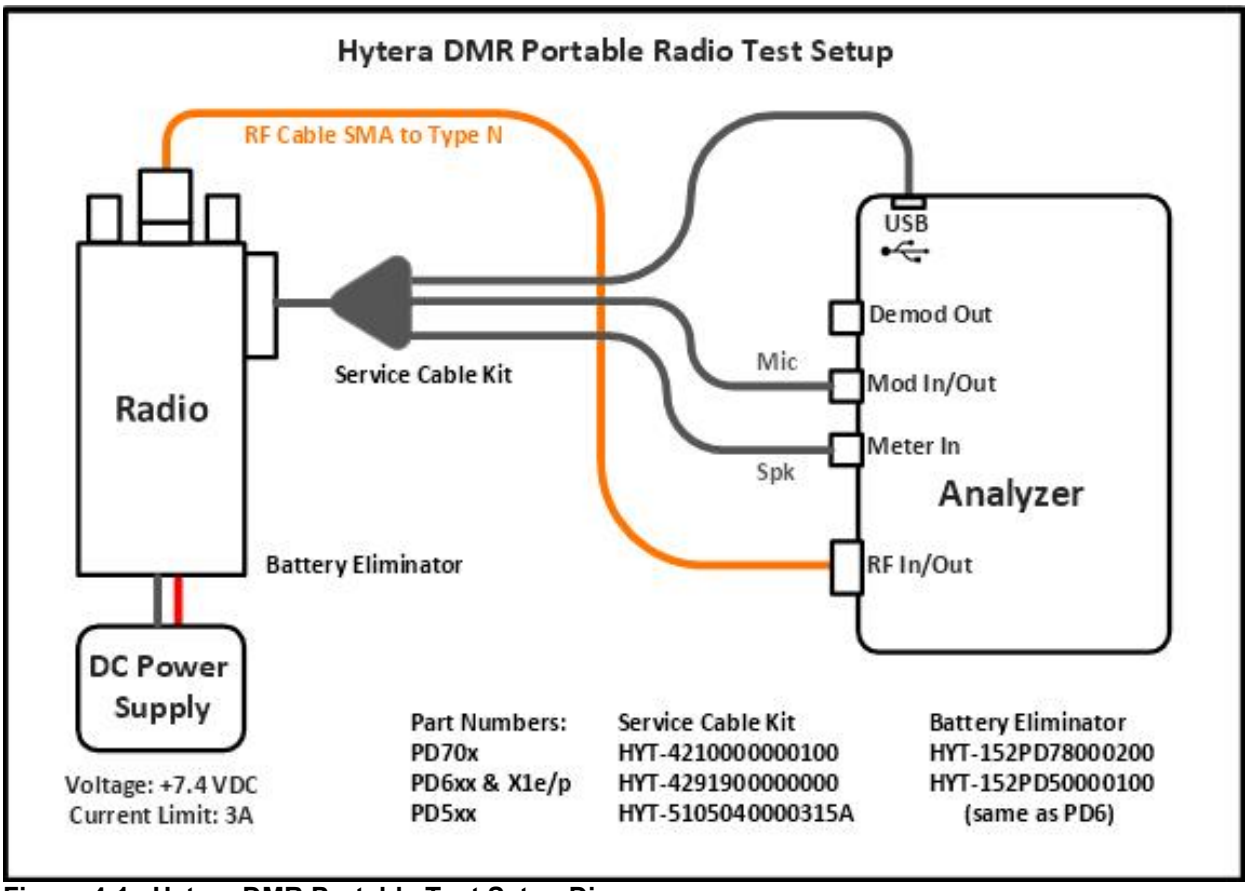

Figure 4-1. Hytera DMR Portable Test Setup Diagram.

5. Hytera DMR Portable Alignment and Test Descriptions

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

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

5.1. Reference Oscillator Warp

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

Table 5-1. Analyzer Configuration for Reference Oscillator Warp

5.1.1. Alignment

The radio is placed into Test Mode at a Tx Test Frequency. The analyzer is placed into Monitor mode at the radio Tx Test Frequency and nominal attenuation. The radio is set to transmit a signal at the Test Frequency. The analyzer measures the Frequency error of the signal and adjusts the softpot to obtain the least amount of frequency error. The new softpot value is then programmed into the radio. The results are written to the log file.

Name	Description
Result	Pass or Fail. Frequency Error within Max Limit, Min Limit
Frequency	Test Frequency
Frequency Error	Frequency Error measured
Min Limit	Minimum Limit (inclusive) for Frequency Error
Max Limit	Maximum Limit (inclusive) for Frequency Error
Old Softpot	Radio Softpot before alignment
New Softpot	Radio Softpot after alignment

Table 5-2. Reference Oscillator Warp alignment results

5.1.2. Test

The radio is placed into Test Mode at a Tx Test Frequency. The analyzer is placed into Monitor mode at the radio Tx Test Frequency and nominal attenuation. The radio is set to transmit a signal at the Test Frequency. The analyzer measures the Frequency error of the signal and the results are written to the log file.

Name	Description
Result	Pass or Fail. Frequency Error within Max Limit, Min Limit
Frequency	Test Frequency
Frequency Error	Frequency Error measured
Min Limit	Minimum Limit (inclusive) for Frequency Error
Max Limit	Maximum Limit (inclusive) for Frequency Error
Softpot	Current radio softpot setting

Table 5-3. Reference Oscillator Warp test results

5.2. Tx Power

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

Table 5-4. Analyzer Configuration for Tx Power

5.2.1. Alignment

The Tx Power Out alignment aligns the power output level of the radio at both low and high power levels. The radio is placed into Test Mode and commanded to transmit at the first Test Frequency and the Low power setting. For each test frequency, the output level is measured and then adjusted until near to a band-specific output level. This process is repeated for the high power settings. The results are written to the log file.

Name	Description
Result	Pass or Fail. Power Out within manufacturer limits
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	Radio Softpot before alignment
New Softpot	Radio Softpot after alignment

Table 5-5. Tx Power alignment results

5.2.2. 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 Low Power and High Power, and compared against test limits. The 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
Softpot	Current radio softpot setting

Table 5-6. Tx Power test results

5.3. Transmit to Deviation

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

Table 5-7. Analyzer Configuration for Transmit to Deviation

5.3.1. Alignment

The radio is placed into Test Mode and set to generate a 100 Hz tone at the Test Frequency. The deviation is measured and the softpot is adjusted until the deviation is within the limits. The new softpot values are programmed into the radio. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
FM Deviation	Measured deviation
Min Limit	Minimum Limit (inclusive) for Deviation
Max Limit	Maximum Limit (inclusive) for Deviation
Old Softpot	Radio softpot before alignment
New Softpot	Radio softpot after alignment

Table 5-8. Transmit to Deviation alignment results

5.3.2. Test

There is no Transmit to Deviation test.

5.4. Tx Modulation Balance

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

Table 5-9. Analyzer Configuration for Tx Modulation Balance alignment

5.4.1. Alignment

The radio is placed into Test Mode at low power at the first Tx Test Frequency and commanded to transmit. The radio generates a Low Gain modulation tone and the ±Peak/2-averaged deviation of this tone is measured with the analyzer. The Low Gain softpot is adjusted until tone deviation is between Low Gain Min, Max limits. This adjustment is performed for each TX Test Frequency. The radio then generates a High Gain modulation tone and the ±Peak/2-averaged deviation of this tone is measured with the analyzer. The High Gain softpot is adjusted until the tone deviation is between High Gain Min, Max test limits. This adjustment is performed for each Tx Test Frequency. For PD(HD)5xx and PD(HD)6xx radios, only the High Gain alignment is performed. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
FM Deviation	Measured deviation
Min Limit	Minimum Limit (inclusive) for Deviation
Max Limit	Maximum Limit (inclusive) for Deviation
Old Softpot	Radio softpot before alignment
New Softpot	Radio softpot after alignment

Table 5-10. Tx Modulation alignment results

5.4.2. Test

There is no Tx Modulation Balance test.

5.5. Rx Front End Filter

RF Control	Port	Frequency	Modulation	Output Level
Generate	RF IN/OUT	Test Frequency	FM	-118 dBm

Table 5-11. Analyzer Configuration for Rx Front End Filter

5.5.1. Alignment

The radio is placed into Test Mode at a Tx Test Frequency. The analyzer is placed into Generate mode at the radio Tx Test Frequency with a Fixed 1 kHz tone with 3 kHz modulation. The SINAD is read from the radio and set to transmit a signal at the Test Frequency. The analyzer measures the SINAD of the signal over the range of the softpot and selects the softpot values that produce a SINAD > 18 dBm. These softpot values are tried at two Inhibit point offsets to the Test Frequency and AutoTune checks for the SINAD to be > 12 dBm. A passing softpot value is saved to the radio and the next Test Frequency is aligned. Results are written to the log file.

The Rx Front End Filter alignment is not supported on 800-900 MHz radios.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
SINAD	Measured SINAD
Min Limit	Minimum Limit (inclusive) for Deviation
Old Softpot	Radio softpot before alignment
New Softpot	Radio softpot after alignment

Table 5-12. Rx Front End Filter alignment results

5.5.2. Test

There is no Rx Front End Filter test.

5.6. Rx Front End Gain

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

Table 5-13. Analyzer Configuration for Rx Front End Gain

5.6.1. Alignment

The radio is placed into Test Mode at a Tx Test Frequency. The analyzer is placed into Generate mode at the radio Tx Test Frequency with an output level of -70 dBm. The current Front End Gain value is read then saved to the radio. Results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Gain	Measured Gain
Min Limit	Minimum Limit (inclusive) for Gain
Max Limit	Maximum Limit (inclusive) for Gain

Table 5-14. Rx Front End Gain alignment results

5.6.2. Test

There is no Rx Front End Gain test.

5.7. Tx/Rx Charge Voltage (Portable Only)

5.7.1. Alignment

The radio is placed into Test Mode at the Tx Test Frequency and commanded to transmit. The current Charge Voltage value is read then saved to the radio. Results are written to the log file.

The Tx/Rx Charge Voltage alignment is not supported on PD(HD)5xx and PD(HD)6xx radios.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Osc Voltage	Measured charge voltage
Min Limit	Minimum Limit (inclusive) for charge voltage
Max Limit	Maximum Limit (inclusive) for charge voltage

Table 5-15. Tx/Rx Charge Voltage alignment results

5.7.2. Test

There is no Tx/Rx Charge Voltage test.

5.8. Tx Max Analog Deviation

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

Table 5-16. Analyzer Configuration for Tx Max Analog Deviation test

5.8.1. Test

The radio is placed into Test Mode at low power at the first Tx Test Frequency and commanded to transmit generating an Analog CSQ signal. The analyzer applies a 1 kHz tone with 75 mV level to the microphone and then measures the deviation. The measurement is done at the wide (25 kHz) bandwidth, then at the narrow (12.5 kHz) bandwidth. This measurement is performed for each Tx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth during test
Deviation	Measured Deviation
Min Limit	Minimum Limit (inclusive) for Deviation
Max Limit	Maximum Limit (inclusive) for Deviation

Table 5-17. Tx Max Analog Deviation test results

5.9. Tx Max Analog Deviation CTCSS

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

Table 5-18. Analyzer Configuration for Tx Max Analog Deviation CTCSS test

5.9.1. Test

The radio is placed into Test Mode at low power at the first Tx Test Frequency and commanded to transmit generating an Analog CTCSS signal. The analyzer applies a 1 kHz tone with 75 mV level to the microphone and then measures the deviation. The measurement is done at the wide (25 kHz) bandwidth, then at the narrow (12.5 kHz) bandwidth. This measurement is performed for each Tx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth during test
Tone	Audio tone frequency
Deviation	Measured Deviation
Min Limit	Minimum Limit (inclusive) for Deviation
Max Limit	Maximum Limit (inclusive) for Deviation

Table 5-19. Tx Max Analog Deviation CTCSS test results

5.10. Tx Max Analog Deviation CDCSS

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

Table 5-20. Analyzer Configuration for Tx Max Analog Deviation CDCSS

5.10.1. Test

The radio is placed into Test Mode at low power at the first Tx Test Frequency and commanded to transmit generating an Analog CDCSS signal. The analyzer applies a 1 kHz tone with 75 mV level to the microphone and then measures the deviation. The measurement is done at the wide (25 kHz) bandwidth, then at the narrow (12.5 kHz) bandwidth. This measurement is performed for each Tx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth during test
Code	Tone code
Deviation	Measured Deviation
Min Limit	Minimum Limit (inclusive) for Deviation
Max Limit	Maximum Limit (inclusive) for Deviation

Table 5-21. Tx Max Analog Deviation CDCSS test results

5.11. Tx CTCSS Deviation

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

Table 5-22. Analyzer Configuration for Tx CTCSS Deviation

5.11.1. Test

The radio is placed into Test Mode at low power at the first Tx Test Frequency and commanded to transmit generating an Analog CTCSS signal. The analyzer measures the deviation. The measurement is done at the wide (25 kHz) bandwidth, then at the narrow (12.5 kHz) bandwidth. This measurement is performed for each Tx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth during test
Tone	Audio tone frequency
Deviation	Measured Deviation
Min Limit	Minimum Limit (inclusive) for Deviation
Max Limit	Maximum Limit (inclusive) for Deviation

Table 5-23. Tx CTCSS Deviation test results

5.12. Tx CDCSS Deviation

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

Table 5-24. Analyzer Configuration for Tx CDCSS Deviation test

5.12.1. Test

The radio is placed into Test Mode at low power at the first Tx Test Frequency and commanded to transmit generating an Analog CDCSS signal. The analyzer measures the deviation. The measurement is done at the wide (25 kHz) bandwidth, then at the narrow (12.5 kHz) bandwidth. This measurement is performed for each Tx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth during test
Code	Tone code
Deviation	Measured Deviation
Min Limit	Minimum Limit (inclusive) for Deviation
Max Limit	Maximum Limit (inclusive) for Deviation

Table 5-25. Tx CDCSS Deviation test results

5.13. Tx Modulation Sensitivity

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

Table 5-26. Analyzer Configuration for Tx Modulation Sensitivity test

5.13.1. Test

The radio is placed into Test Mode at low power at the first Tx Test Frequency and commanded to transmit generating an Analog CSQ signal. The analyzer applies a 1 kHz tone with 7 mV level to the microphone and then measures the deviation. The audio level is adjusted until the deviation is +/- 100 Hz, then the resulting audio level is checked against the limits. The measurement is done at the wide (25 kHz) bandwidth, then at the narrow (12.5 kHz) bandwidth. This measurement is performed for each Tx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth during test
Deviation	Measured Deviation
Audio Level	Audio level of analyzer
Min Limit	Minimum Limit (inclusive) for Deviation
Max Limit	Maximum Limit (inclusive) for Deviation

Table 5-27. Tx Modulation Sensitivity test results

5.14. Tx BER

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Freq	**Digital**: O.153 test pattern	40 dB

Table 5-28. Analyzer Configuration for Tx BER test

5.14.1. Test

The analyzer is setup to monitor for a O.153 test pattern modulated signal from the radio. The radio is placed into Test Mode at the first Tx Test Frequency. The analyzer measures the radio signal's BER level. The results are written to the log file. This process is repeated for each Tx Test Frequency.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
BER	Radio's BER measurement
Max Limit	Maximum limit (inclusive) for BER

Table 5-29. Tx BER test results

5.15. Tx Digital Tests

RF Control	Port	Frequency	Modulation	Attenuation
Monitor	RF IN/OUT	Test Freq	**Digital**: O.153 test pattern	40 dB

Table 5-30. Analyzer Configuration for Tx Digital Tests

5.15.1. Test

The analyzer is setup to monitor for a O.153 test pattern modulated signal from the radio. The radio is placed into Test Mode at the first Tx Test Frequency. The analyzer measures the radio signal's FSK Error, Symbol Deviation, and Magnitude Error values and is repeated for each Tx Test Frequency.
The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
FSK Error	Radio's FSK Error measurement
Max Limit	Maximum limit (inclusive) for FSK Error

Table 5-31. Tx FSK Error test results

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Symbol Deviation	Radio's Symbol Deviation measurement
Min Limit	Minimum limit (inclusive) for Symbol Deviation
Max Limit	Maximum limit (inclusive) for Symbol Deviation

Table 5-32. Tx Symbol Deviation test results

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Magnitude Error	Radio's Magnitude Error measurement
Max Limit	Maximum limit (inclusive) for Magnitude Error

Table 5-33. Tx Magnitude Error test results

5.16. Rx Max Audio Output Power

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	1 kHz signal with 3 kHz (wide) or 1.5 kHz (narrow) level	-40 dBm

Table 5-34. Analyzer Configuration for Rx Max Audio Output Power test

5.16.1. Test

The analyzer is setup to apply the modulated signal in the table above to the radio. The radio is placed into Test Mode at the Rx Test Frequency. The radio volume is set to its maximum level. The analyzer measures the radio's audio level. The test is performed for a wide (25 kHz) bandwidth and a narrow (12.5 kHz) bandwidth. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth of channel
Audio Out	Radio's Audio volume
Min Limit	Minimum limit (inclusive) for volume
Max Limit	Maximum limit (inclusive) for volume

Table 5-35. Rx Max Audio Output Power test results

5.17. Rx Sensitivity

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	1 kHz signal with 3 kHz (wide) or 1.5 kHz (narrow) level	-47 dBm

Table 5-36. Analyzer Configuration for Rx Sensitivity test

5.17.1. Test

The analyzer is setup to apply the modulated signal in the table above to the radio. The radio is placed into Test Mode at the first Rx Test Frequency. The analyzer measures the radio's SINAD level. The test is performed for a wide (25 kHz) bandwidth and a narrow (12.5 kHz) bandwidth and repeated for each Rx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth of channel
SINAD	SINAD measurement
Min Limit	Minimum limit (inclusive) for SINAD

Table 5-37. Rx Sensitivity test results

5.18. Rx Audio Distortion

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	1 kHz signal with 3 kHz (wide) or 1.5 kHz (narrow) level	-70 dBm

Table 5-38. Analyzer Configuration for Rx Audio Distortion test

5.18.1. Test

The analyzer is setup to apply the modulated signal in the table above to the radio. The radio is placed into Test Mode at the first Rx Test Frequency. The analyzer measures the radio's audio distortion level. The test is performed for a wide (25 kHz) bandwidth and a narrow (12.5 kHz) bandwidth and repeated for each Rx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth of channel
Distortion	Distortion measurement
Max Limit	Maximum limit (inclusive) for Distortion

Table 5-39. Rx Audio Distortion test results

5.19. Rx SNR

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	1 kHz signal with 3 kHz (wide) or 1.5 kHz (narrow) level	Set to Rated Audio

Table 5-40. Analyzer Configuration for Rx SNR test

5.19.1. Test

The analyzer is setup to apply the modulated signal in the table above to the radio. The radio is placed into Test Mode at the first Rx Test Frequency. The analyzer measures the radio's SNR level. The test is performed for a wide (25 kHz) bandwidth and a narrow (12.5 kHz) bandwidth and repeated for each Rx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth of channel
SNR	SNR measurement
Min Limit	Minimum limit (inclusive) for SNR

Table 5-41. Rx SNR test results

5.20. Rx Normal Level Squelch

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	1 kHz signal with 3 kHz (wide) or 1.5 kHz (narrow) level	Set to Rated Audio

Table 5-42. Analyzer Configuration for Rx Normal Level Squelch test

5.20.1. Test

The analyzer is setup to apply the modulated signal in the table above to the radio. The radio is placed into Test Mode at the first Rx Test Frequency. The analyzer signal level is set to what should produce an open squelch and the radio's Audio output level is measured. The analyzer output level is then set to what should produce a closed squelch and the radio's Audio output level is measured. The test is performed for a wide (25 kHz) bandwidth and a narrow (12.5 kHz) bandwidth and repeated for each Rx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth of channel
Squelch	Open or Closed Squelch measurement
Audio Out	Audio level measured
Limit	Minimum (Open)/Maximum (Closed) limit (inclusive) for Audio Out
Output Level	Signal level for Audio Out measurement

Table 5-43. Rx Normal Level Squelch test results

5.21. Rx CTCSS/CDCSS Decode

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	1 kHz signal with 3 kHz (wide) or 1.5 kHz (narrow) level	Set to Rated Audio

Table 5-44. Analyzer Configuration for Rx CTCSS/CDCSS Decode test

5.21.1. Test

The analyzer is setup to apply the modulated signal in the table above to the radio. The radio is placed into Test Mode at the Rx Test Frequency and set to receive an Analog CTCSS signal. The analyzer measures the Audio Output level from the radio. The measurement is done at the wide (25 kHz) bandwidth, then at the narrow (12.5 kHz) bandwidth. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth during test
Tone	Audio tone frequency
Audio Out	Measured audio output level
Min Limit	Minimum limit (inclusive) for Audio Output

Table 5-45. Rx CTCSS Decode test results

The analyzer is setup to apply the modulated signal in the table above to the radio. The radio is placed into Test Mode at the Rx Test Frequency and set to receive an Analog CDCSS signal. The analyzer measures the Audio Output level from the radio. The measurement is done at the wide (25 kHz) bandwidth, then at the narrow (12.5 kHz) bandwidth. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
Bandwidth	Bandwidth during test
Code	Tone code
Audio Out	Measured audio output level
Min Limit	Minimum limit (inclusive) for Audio Output

Table 5-46. Rx CDCSS Decode test results

5.22. Rx BER

RF Control	Port	Frequency	Modulation	Level
Generate	RF IN/OUT	Test Freq	**Digital**: O.153 test pattern	-116 dBm

Table 5-47. Analyzer Configuration for Rx BER test

5.22.1. Test

The analyzer is setup to apply the modulated signal in the table above to the radio. The radio is placed into Test Mode at the first Rx Test Frequency and set to receive a Digital O.153 test signal. The analyzer reads the radio's BER measurement. This process is repeated for each Rx Test Frequency. The results are written to the log file.

Name	Description
Result	Pass or Fail. Pass if no radio error detected.
Frequency	Test Frequency
BER	Radio's BER measurement
Max Limit	Maximum limit (inclusive) for BER

Table 5-48. Rx BER test results

6. Hytera DMR Mobile Radio Test Setup

In order to perform the test and alignment procedures, the Hytera DMR Mobile 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.

6.1. Cable Sweep

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

Sweep the RF cable used between the Radio and Analyzer, label the RF cable with the stored cable sweep name, and enable the Cable Sweep feature in the analyzer System, System Settings… menu. Refer to Application Note FCT-1017 *Utilizing Cable Sweep on the Astronics Test Systems Communications System Analyzer* for instructions on how to perform a cable sweep.

6.2. Hytera DMR Mobile Test Setup

Refer to the diagram below for the proper test setup.

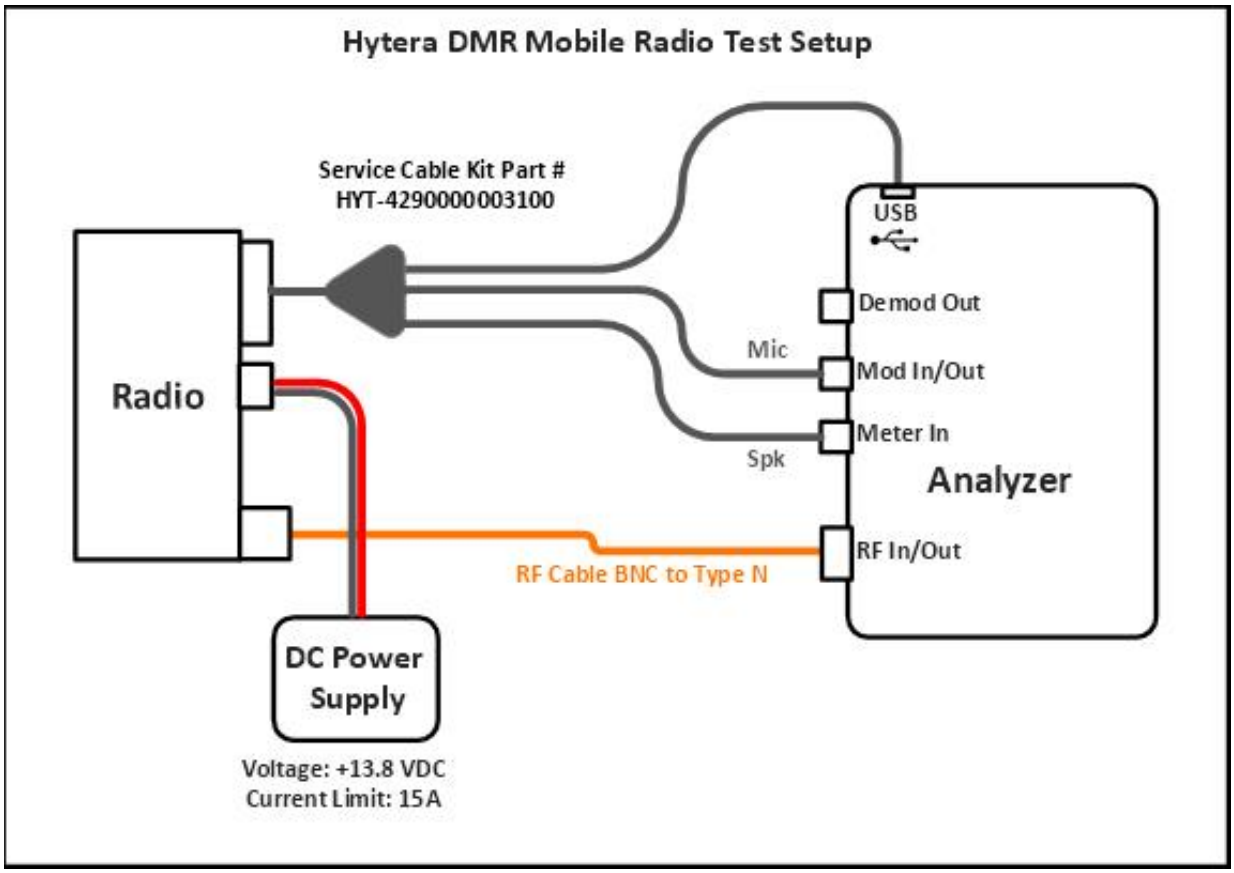

Figure 6-1. Hytera DMR Mobile Test Setup Diagram.

7. Hytera DMR 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.

For all mobile alignments and tests, see section Hytera DMR Portable Alignment and Test Descriptions for details - the alignments and tests are identical.

The Tx/Rx Charge Voltage alignment is for portables only and cannot be selected for mobile radios.

8. Basic Troubleshooting

Symptom	Possible Cause	Possible Solution
Analyzer consistently fails to communicate with radio	• Incorrect setting on cable.	• Verify programming cable KPG-46X is set to USB or Astronics cable 203012-01 is set to USB. See the respective radio test setup sections for more information.
Alignment or test intermittently stops after partial performance.	• USB hub not present.	• Use an externally powered USB hub to connect radio programming cable to analyzer.
Tx Max Power or Tx Power alignment or test failure	• Cable Sweep not enabled. • Power supply voltage level not set to level specified on test setup diagram. • Radio duty cycle too high	• Enable Cable Sweep (Settings > System Settings… > Cable Sweep Table…) and sweep RF cable in use so the analyzer can account for its cable loss. Note: Cable Sweep feature is available on analyzer with system software **3.8.0.0** or later. • Refer to test setup diagram for proper DC power supply voltage level. Confirm this level with a calibrated multimeter. • Wait 1 hour between consecutive full alignment sequences to allow the radio to cool down (while powered on and idling). If the interval is less than an hour between full alignment sequences on the same radio, power alignment failures may occur.

Table 8-1. Hytera DMR Series Troubleshooting Chart

9. Support Information

9.1. Technical Support

Telephone/Fax: 844.903.7333
Email: ATS.LMR-Customer.Support@astronics.com
Web: http://freedomcte.com/support/

9.2. Sales

Telephone/Fax: 844.903.7333
Email: LMRSales@astronics.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. AutoTune supports modifying these limits if extenuating circumstances require it. Refer to the R8000 Series Communications System Analyzer Owner's Manual (FCT-1365) for modification instructions.

https://freedomcte.com/library/

For the recommended test limits for each Hytera DMR Portable or Mobile radio model supported by AutoTune, see the respective Hytera radio service manual available from your Hytera dealer.

APPENDIX B. Sample Test Result Report

```
================================================================================
Test Result Report
================================================================================
Date/Time: 2/14/2020 4:32 PM                        Operator ID: 6

Info
--------------------------------------------------------------------------
Analyzer
---------
Model #:              R8100
Serial #:             800BEN0001
RF Level Offset:      Off
RF In/Out Offset:     0.0 dB
RF Gen Out Offset:    0.0 dB
Cable Sweep:          On
Selected File:        6DBORANGE
100 MHz Attenuation: -0.204 dB
1 GHz Attenuation:    -0.879 dB

Radio
------
Model #:              PD782 U5:Portable  (PD782-T00G0000-00000i-U5-0-F)
Serial #:             16714D2274
FLASH Version:        A9.00.08.104.iM
--------------------------------------------------------------------------

Reference Oscillator Warp Align
================================
Result  Frequency    Frequency Error  Min Limit  Max Limit  Old Softpot  New Softpot
------  -----------  ---------------  ---------  ---------  -----------  -----------
Pass    941.000 MHz  26 Hz            -40 Hz     40 Hz      1600         1906

Reference Oscillator Warp Test
================================
Result  Frequency    Frequency Error  Min Limit  Max Limit  Old Softpot  New Softpot
------  -----------  ---------------  ---------  ---------  -----------  -----------
Pass    910.000 MHz  77 Hz            -250 Hz    250 Hz     1600         1906
Pass    883.000 MHz  66 Hz            -250 Hz    250 Hz     1600         1906
Pass    870.000 MHz  60 Hz            -250 Hz    250 Hz     1600         1906
Pass    834.000 MHz  54 Hz            -250 Hz    250 Hz     1600         1906
Pass    806.000 MHz  45 Hz            -250 Hz    250 Hz     1600         1906

Tx Low Power Align
==================
Result  Frequency    Power Out  Min Limit  Max Limit  Old Softpot  New Softpot
------  -----------  ---------  ---------  ---------  -----------  -----------
Pass    806.000 MHz  1.20 W     1.10 W     1.30 W     1100         1153
Pass    816.000 MHz  1.18 W     1.10 W     1.30 W     1400         1153
Pass    825.000 MHz  1.25 W     1.10 W     1.30 W     1100         1153
Pass    851.000 MHz  1.20 W     1.10 W     1.30 W     1400         1170
Pass    860.000 MHz  1.21 W     1.10 W     1.30 W     1100         1170
Pass    870.000 MHz  1.22 W     1.10 W     1.30 W     1400         1153
Pass    896.000 MHz  1.24 W     1.10 W     1.30 W     1100         1153
Pass    902.000 MHz  1.22 W     1.10 W     1.30 W     1400         1136
Pass    935.000 MHz  1.19 W     1.10 W     1.30 W     1100         1170
Pass    941.000 MHz  1.23 W     1.10 W     1.30 W     1400         1185

Tx High Power Align
====================
Result  Frequency    Power Out  Min Limit  Max Limit  Old Softpot  New Softpot
------  -----------  ---------  ---------  ---------  -----------  -----------
Pass    806.000 MHz  3.03 W     2.90 W     3.10 W     1600         1600
Pass    816.000 MHz  2.98 W     2.90 W     3.10 W     1800         1569
Pass    825.000 MHz  2.97 W     2.90 W     3.10 W     1600         1535
Pass    851.000 MHz  2.98 W     2.90 W     3.10 W     1800         1600
Pass    860.000 MHz  3.02 W     2.90 W     3.10 W     1600         1631
Pass    870.000 MHz  3.03 W     2.90 W     3.10 W     1800         1663
Pass    896.000 MHz  2.49 W     2.40 W     2.60 W     1600         1470
Pass    902.000 MHz  2.45 W     2.40 W     2.60 W     1800         1439
Pass    935.000 MHz  2.49 W     2.40 W     2.60 W     1600         1535
Pass    941.000 MHz  2.45 W     2.40 W     2.60 W     1800         1535

Transmit to Deviation Conversion Align
======================================
Result  Frequency    FM Deviation  Min Limit  Max Limit  Old Softpot  New Softpot
------  -----------  ------------  ---------  ---------  -----------  -----------
Pass    806.000 MHz  5.00 kHz      4.98 kHz   5.02 kHz   12000        6144
Pass    896.000 MHz  4.99 kHz      4.98 kHz   5.02 kHz   12000        5536

Tx Modulation Balance Low Port Align
====================================
Result  Frequency    FM Deviation  Min Limit  Max Limit  Old Softpot  New Softpot
------  -----------  ------------  ---------  ---------  -----------  -----------
Pass    806.000 MHz  4.92 kHz      4.90 kHz   4.94 kHz   26000        32112
Pass    816.000 MHz  4.92 kHz      4.90 kHz   4.94 kHz   33000        31800
Pass    825.000 MHz  4.92 kHz      4.90 kHz   4.94 kHz   26000        31424
Pass    851.000 MHz  4.92 kHz      4.90 kHz   4.94 kHz   33000        30504
Pass    860.000 MHz  4.92 kHz      4.90 kHz   4.94 kHz   26000        30112
Pass    870.000 MHz  4.92 kHz      4.90 kHz   4.94 kHz   33000        29800
Pass    896.000 MHz  4.92 kHz      4.90 kHz   4.94 kHz   26000        32064
Pass    902.000 MHz  4.92 kHz      4.90 kHz   4.94 kHz   33000        32008
Pass    935.000 MHz  4.92 kHz      4.90 kHz   4.94 kHz   26000        30752
Pass    941.000 MHz  4.92 kHz      4.90 kHz   4.94 kHz   33000        30696

Tx Modulation Balance High Port Align
=====================================
Result  Frequency    FM Deviation  Min Limit  Max Limit  Old Softpot  New Softpot
------  -----------  ------------  ---------  ---------  -----------  -----------
Pass    806.000 MHz  4.90 kHz      4.88 kHz   4.92 kHz   20000        21984
Pass    816.000 MHz  4.90 kHz      4.88 kHz   4.92 kHz   27000        22320
Pass    825.000 MHz  4.90 kHz      4.88 kHz   4.92 kHz   20000        21768
Pass    851.000 MHz  4.90 kHz      4.88 kHz   4.92 kHz   27000        20848
```

Pass	860.000 MHz	4.90 kHz	4.88 kHz	4.92 kHz	20000	20600
Pass	870.000 MHz	4.90 kHz	4.88 kHz	4.92 kHz	27000	20288
Pass	896.000 MHz	4.90 kHz	4.88 kHz	4.92 kHz	20000	16960
Pass	902.000 MHz	4.91 kHz	4.88 kHz	4.92 kHz	27000	16952
Pass	935.000 MHz	4.90 kHz	4.88 kHz	4.92 kHz	20000	16184
Pass	941.000 MHz	4.90 kHz	4.88 kHz	4.92 kHz	27000	16256

Rx Front End Gain Align

Result	Frequency	Gain	Min Limit	Max Limit
Pass	851.075 MHz	-30	-40	-25
Pass	853.075 MHz	-31	-40	-25
Pass	855.075 MHz	-31	-40	-25
Pass	857.075 MHz	-30	-40	-25
Pass	859.075 MHz	-29	-40	-25
Pass	861.075 MHz	-27	-40	-25
Pass	863.075 MHz	-27	-40	-25
Pass	869.975 MHz	-29	-40	-25
Pass	935.075 MHz	-33	-40	-25
Pass	936.075 MHz	-33	-40	-25
Pass	937.075 MHz	-33	-40	-25
Pass	938.075 MHz	-33	-40	-25
Pass	939.075 MHz	-34	-40	-25
Pass	940.975 MHz	-34	-40	-25

Tx Charge Voltage

Result	Frequency	Osc. Voltage	Min Limit	Max Limit
Pass	870.000 MHz	0.200 V	-0.800 V	0.800 V
Pass	930.000 MHz	-0.409 V	-0.800 V	0.800 V

Rx Charge Voltage

Result	Frequency	Osc. Voltage	Min Limit	Max Limit
Pass	869.975 MHz	0.354 V	-0.800 V	0.800 V
Pass	940.975 MHz	0.252 V	-0.800 V	0.800 V

Tx Max Analog Deviation Test

Result	Frequency	Bandwidth	Deviation	Min Limit	Max Limit
Pass	806.000 MHz	25.0 kHz	4.48 kHz	4.20 kHz	4.90 kHz
Pass	806.000 MHz	12.5 kHz	2.24 kHz	2.00 kHz	2.40 kHz
Pass	860.000 MHz	25.0 kHz	4.52 kHz	4.20 kHz	4.90 kHz
Pass	860.000 MHz	12.5 kHz	2.26 kHz	2.00 kHz	2.40 kHz
Pass	902.000 MHz	25.0 kHz	4.55 kHz	4.20 kHz	4.90 kHz
Pass	902.000 MHz	12.5 kHz	2.27 kHz	2.00 kHz	2.40 kHz
Pass	941.000 MHz	25.0 kHz	4.60 kHz	4.20 kHz	4.90 kHz
Pass	941.000 MHz	12.5 kHz	2.30 kHz	2.00 kHz	2.40 kHz

Tx Max Analog Deviation CTCSS Test

Result	Frequency	Bandwidth	Tone	Deviation	Min Limit	Max Limit
Pass	806.000 MHz	25.0 kHz	67.0 Hz	4.48 kHz	4.00 kHz	5.00 kHz
Pass	806.000 MHz	12.5 kHz	67.0 Hz	2.24 kHz	2.00 kHz	2.50 kHz
Pass	860.000 MHz	25.0 kHz	127.3 Hz	4.52 kHz	4.00 kHz	5.00 kHz
Pass	860.000 MHz	12.5 kHz	127.3 Hz	2.26 kHz	2.00 kHz	2.50 kHz
Pass	902.000 MHz	25.0 kHz	254.1 Hz	4.54 kHz	4.00 kHz	5.00 kHz
Pass	902.000 MHz	12.5 kHz	254.1 Hz	2.27 kHz	2.00 kHz	2.50 kHz
Pass	941.000 MHz	25.0 kHz	254.1 Hz	4.61 kHz	4.00 kHz	5.00 kHz
Pass	941.000 MHz	12.5 kHz	254.1 Hz	2.30 kHz	2.00 kHz	2.50 kHz

Tx Max Analog Deviation CDCSS Test

Result	Frequency	Bandwidth	Code	Deviation	Min Limit	Max Limit
Pass	806.000 MHz	25.0 kHz	23	4.47 kHz	4.00 kHz	5.00 kHz
Pass	806.000 MHz	12.5 kHz	23	2.23 kHz	2.00 kHz	2.50 kHz
Pass	860.000 MHz	25.0 kHz	423	4.52 kHz	4.00 kHz	5.00 kHz
Pass	860.000 MHz	12.5 kHz	423	2.26 kHz	2.00 kHz	2.50 kHz
Pass	902.000 MHz	25.0 kHz	754	4.54 kHz	4.00 kHz	5.00 kHz
Pass	902.000 MHz	12.5 kHz	754	2.27 kHz	2.00 kHz	2.50 kHz
Pass	941.000 MHz	25.0 kHz	754	4.61 kHz	4.00 kHz	5.00 kHz
Pass	941.000 MHz	12.5 kHz	754	2.30 kHz	2.00 kHz	2.50 kHz

Tx CTCSS Deviation Test

Result	Frequency	Bandwidth	Tone	Deviation	Min Limit	Max Limit
Pass	806.000 MHz	25.0 kHz	67.0 Hz	707.7 Hz	500.0 Hz	1000.0 Hz
Pass	806.000 MHz	12.5 kHz	67.0 Hz	409.9 Hz	300.0 Hz	600.0 Hz
Pass	860.000 MHz	25.0 kHz	127.3 Hz	709.3 Hz	500.0 Hz	1000.0 Hz
Pass	860.000 MHz	12.5 kHz	127.3 Hz	411.7 Hz	300.0 Hz	600.0 Hz
Pass	902.000 MHz	25.0 kHz	254.1 Hz	707.6 Hz	500.0 Hz	1000.0 Hz
Pass	902.000 MHz	12.5 kHz	254.1 Hz	404.7 Hz	300.0 Hz	600.0 Hz
Pass	941.000 MHz	25.0 kHz	254.1 Hz	702.8 Hz	500.0 Hz	1000.0 Hz
Pass	941.000 MHz	12.5 kHz	254.1 Hz	405.3 Hz	300.0 Hz	600.0 Hz

Tx CDCSS Deviation Test

Result	Frequency	Bandwidth	Code	Deviation	Min Limit	Max Limit
Pass	806.000 MHz	25.0 kHz	23	764.2 Hz	500.0 Hz	1000.0 Hz
Pass	806.000 MHz	12.5 kHz	23	425.3 Hz	300.0 Hz	600.0 Hz
Pass	860.000 MHz	25.0 kHz	423	745.4 Hz	500.0 Hz	1000.0 Hz
Pass	860.000 MHz	12.5 kHz	423	414.3 Hz	300.0 Hz	600.0 Hz
Pass	902.000 MHz	25.0 kHz	754	786.0 Hz	500.0 Hz	1000.0 Hz
Pass	902.000 MHz	12.5 kHz	754	423.8 Hz	300.0 Hz	600.0 Hz
Pass	941.000 MHz	25.0 kHz	754	787.1 Hz	500.0 Hz	1000.0 Hz
Pass	941.000 MHz	12.5 kHz	754	423.2 Hz	300.0 Hz	600.0 Hz

Tx Modulation Sensitivity Test

Result	Frequency	Bandwidth	Deviation	Audio Level	Min Limit	Max Limit

Pass	806.000 MHz	25.0 kHz	2.96 kHz	9.00 mVrms	7.00 mVrms	10.00 mVrms
Pass	806.000 MHz	12.5 kHz	1.43 kHz	8.75 mVrms	7.00 mVrms	10.00 mVrms
Pass	860.000 MHz	25.0 kHz	2.94 kHz	9.00 mVrms	7.00 mVrms	10.00 mVrms
Pass	860.000 MHz	12.5 kHz	1.42 kHz	8.50 mVrms	7.00 mVrms	10.00 mVrms
Pass	902.000 MHz	25.0 kHz	2.95 kHz	8.50 mVrms	7.00 mVrms	10.00 mVrms
Pass	902.000 MHz	12.5 kHz	1.46 kHz	8.50 mVrms	7.00 mVrms	10.00 mVrms
Pass	941.000 MHz	25.0 kHz	2.94 kHz	8.50 mVrms	7.00 mVrms	10.00 mVrms
Pass	941.000 MHz	12.5 kHz	1.43 kHz	8.25 mVrms	7.00 mVrms	10.00 mVrms

Tx BER Test

Result	Frequency	BER	Max Limit
Pass	806.000 MHz	0.000 %	0.500 %
Pass	860.000 MHz	0.000 %	0.500 %
Pass	902.000 MHz	0.000 %	0.500 %
Pass	941.000 MHz	0.000 %	0.500 %

Tx FSK Error Test

Result	Frequency	FSK Error	Max Limit
Pass	806.000 MHz	2.382 %	5.000 %
Pass	860.000 MHz	3.235 %	5.000 %
Pass	902.000 MHz	3.427 %	5.000 %
Pass	941.000 MHz	4.200 %	5.000 %

Tx Symbol Deviation Test

Result	Frequency	Symbol Deviation	Min Limit	Max Limit
Pass	806.000 MHz	1940 Hz	1750 Hz	2138 Hz
Pass	860.000 MHz	1933 Hz	1750 Hz	2138 Hz
Pass	902.000 MHz	1936 Hz	1750 Hz	2138 Hz
Pass	941.000 MHz	1933 Hz	1750 Hz	2138 Hz

Tx Magnitude Error Test

Result	Frequency	Magnitude Error	Max Limit
Pass	806.000 MHz	0.255 %	1.000 %
Pass	860.000 MHz	0.253 %	1.000 %
Pass	902.000 MHz	0.260 %	1.000 %
Pass	941.000 MHz	0.279 %	1.000 %

Rx Max Audio Output Power Test

Result	Frequency	Bandwidth	Audio Out	Min Limit	Max Limit
Pass	863.075 MHz	25.0 kHz	2.22 V	2.10 V	N/A
Pass	863.075 MHz	12.5 kHz	2.23 V	2.10 V	N/A

Rx Sensitivity Test

Result	Frequency	Bandwidth	SINAD	Min Limit
Pass	851.075 MHz	25.0 kHz	20.6 dB	14.0 dB
Pass	851.075 MHz	12.5 kHz	15.6 dB	14.0 dB
Pass	863.075 MHz	25.0 kHz	17.7 dB	14.0 dB
Pass	863.075 MHz	12.5 kHz	14.2 dB	14.0 dB
Pass	935.075 MHz	25.0 kHz	21.8 dB	14.0 dB
Pass	935.075 MHz	12.5 kHz	16.5 dB	14.0 dB
Pass	940.975 MHz	25.0 kHz	22.3 dB	14.0 dB
Pass	940.975 MHz	12.5 kHz	16.9 dB	14.0 dB

Rx Audio Distortion Test

Result	Frequency	Bandwidth	Distortion	Max Limit
Pass	863.075 MHz	25.0 kHz	1.52 %	3.0 %
Pass	863.075 MHz	12.5 kHz	2.00 %	3.0 %

Rx SNR Test

Result	Frequency	Bandwidth	SNR	Min Limit
Pass	851.075 MHz	25.0 kHz	49.3 dB	42.0 dB
Pass	851.075 MHz	12.5 kHz	42.5 dB	37.0 dB
Pass	863.075 MHz	25.0 kHz	48.7 dB	42.0 dB
Pass	863.075 MHz	12.5 kHz	43.4 dB	37.0 dB
Pass	935.075 MHz	25.0 kHz	47.6 dB	42.0 dB
Pass	935.075 MHz	12.5 kHz	41.4 dB	37.0 dB
Pass	940.975 MHz	25.0 kHz	47.3 dB	42.0 dB
Pass	940.975 MHz	12.5 kHz	41.5 dB	37.0 dB

Rx Normal Level Squelch Test

Result	Frequency	Bandwidth	Squelch	Audio Out	Limit	Output Level
Pass	851.075 MHz	25.0 kHz	Open	1.5 V	1.0 V	-120.0 dBm
Pass	851.075 MHz	25.0 kHz	Closed	0.0 V	0.1 V	-126.0 dBm
Pass	851.075 MHz	12.5 kHz	Open	1.5 V	1.0 V	-120.0 dBm
Pass	851.075 MHz	12.5 kHz	Closed	0.0 V	0.1 V	-126.0 dBm
Pass	863.075 MHz	25.0 kHz	Open	1.5 V	1.0 V	-120.0 dBm
Pass	863.075 MHz	25.0 kHz	Closed	0.0 V	0.1 V	-126.0 dBm
Pass	863.075 MHz	12.5 kHz	Open	1.5 V	1.0 V	-120.0 dBm
Pass	863.075 MHz	12.5 kHz	Closed	0.0 V	0.1 V	-126.0 dBm
Pass	935.075 MHz	25.0 kHz	Open	1.5 V	1.0 V	-120.0 dBm
Pass	935.075 MHz	25.0 kHz	Closed	0.0 V	0.1 V	-126.0 dBm
Pass	935.075 MHz	12.5 kHz	Open	1.5 V	1.0 V	-120.0 dBm
Pass	935.075 MHz	12.5 kHz	Closed	0.0 V	0.1 V	-126.0 dBm
Pass	940.975 MHz	25.0 kHz	Open	1.5 V	1.0 V	-120.0 dBm
Pass	940.975 MHz	25.0 kHz	Closed	0.0 V	0.1 V	-126.0 dBm
Pass	940.975 MHz	12.5 kHz	Open	1.5 V	1.0 V	-120.0 dBm
Pass	940.975 MHz	12.5 kHz	Closed	0.0 V	0.1 V	-126.5 dBm

Rx CTCSS Decode Test

```
====================
Result  Frequency    Bandwidth  Tone      Audio Out  Min Limit
------  -----------  ---------  --------  ---------  ---------
Pass    935.075 MHz  25.0 kHz   127.3 Hz  1.43 V     1.0 V
Pass    935.075 MHz  12.5 kHz   127.3 Hz  1.44 V     1.0 V

Rx CDCSS Decode Test
====================
Result  Frequency    Bandwidth  Code   Audio Out  Min Limit
------  -----------  ---------  -----  ---------  ---------
Pass    935.075 MHz  25.0 kHz   754    1.40 V     1.0 V
Pass    935.075 MHz  12.5 kHz   754    1.42 V     1.0 V

Rx BER Test
============
Result  Frequency    BER      Max Limit
------  -----------  -------  ---------
Pass    851.075 MHz  0.080 %  5.000 %
Pass    863.075 MHz  0.312 %  5.000 %
Pass    935.075 MHz  0.035 %  5.000 %
Pass    940.975 MHz  0.016 %  5.000 %

Tests performed by AutoTune © 2020 Astronics Test Systems  All Rights Reserved. APP Version 3.8
```

Figure B-1. Sample Test Result Report

APPENDIX C. Revision History

A – Initial	T. John	M. Mullins	1/24/2023	0416
Revision – Change	Requested By	Approved By	Rel. Date	ECO#