FREEDOM
Communication Technologies

# R8000 SERIES
# COMMUNICATIONS SYSTEM ANALYZER

# AUTOTUNE USER GUIDE

## BK Radio KNG-Pxxx Series Portable

Freedom Communication Technologies
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FCT-1002A

## 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 BK Radio KNG-Pxxx 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

All BK Radio KNG series radios must be running **v5.3.0 or later** firmware for AutoTune to successfully service them. Older firmware is not currently supported. BK Technologies firmware updates are currently available here: http://www.relmservice.com/Products/.

## 4.2. Supported models

The following BK Radio KNG series models are supported by AutoTune:

- P150
- P400
- P500
- P800

# 5. BK Radio KNG-Pxxx Radio Test Setup

In order to perform the test and alignment procedures, the KNG-Pxxx 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.

## 5.1. KNG-Pxxx Test Setup

Refer to the diagram below for the proper test setup.

**Note**: Parts numbers shown in the diagram are available from Freedom Communication Technologies.

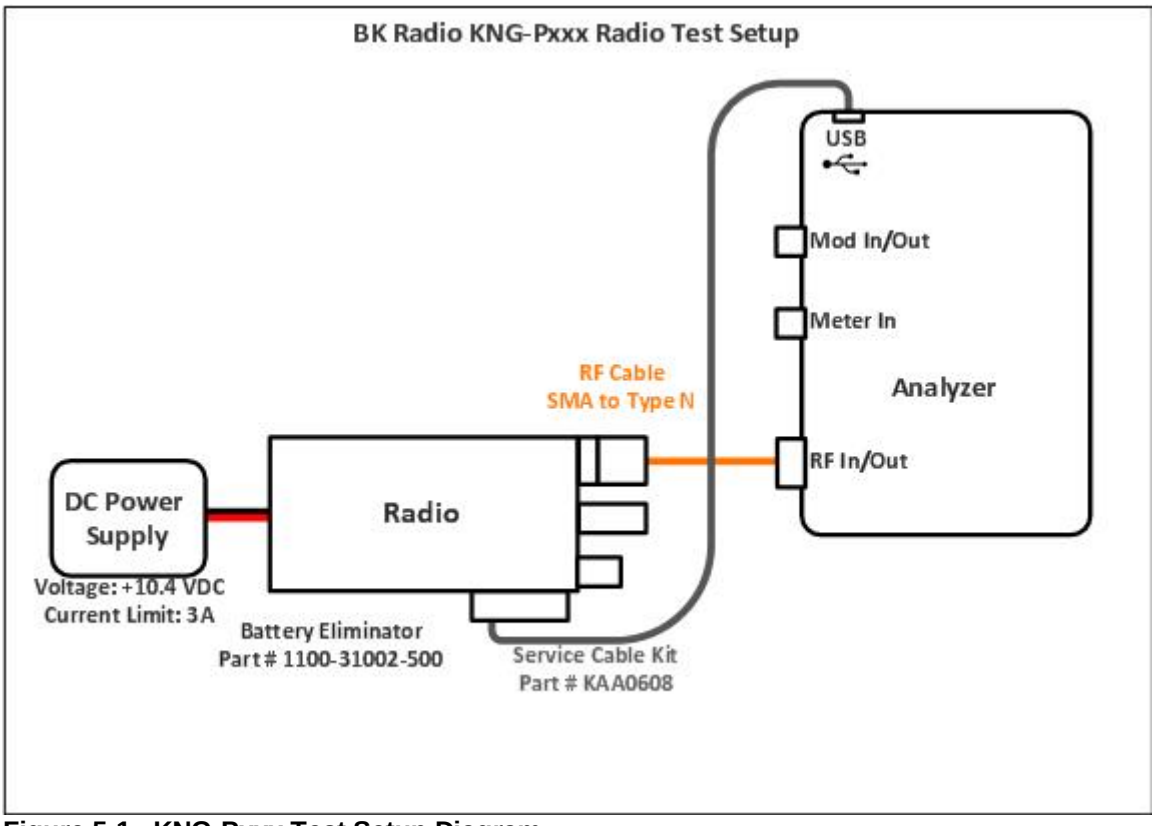


**Figure 5-1. KNG-Pxxx Test Setup Diagram**

# 6. BK Radio KNG-Pxxx 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 BK Radio KNG-Pxxx radio service manual.

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

## 6.1. VCO RX Coarse Tune

### 6.1.1. Alignment

The radio is placed into Test Mode and the Analog Receive path is enabled for an array of receive frequencies. For each frequency, the “Synthesizer Coarse Tune” DAC is adjusted until an optimal ADC value is obtained. The final results are written to the log file.

| Name | Description |
|---|---|
| Result | Pass or Fail. |
| Frequency | Test Frequency |
| New Softpot | Radio softpot after alignment. |

**Table 6-1. VCO RX Coarse Tune Alignment Results**

## 6.2. VCO TX Coarse Tune

### 6.2.1. Alignment

The radio is placed into Test Mode and the radio is commanded to transmit an array of test frequencies. For each frequency, the “Synthesizer Coarse Tune” DAC is adjusted until an optimal ADC value is obtained. The final results are written to the log file.

| Name | Description |
|---|---|
| Result | Pass or Fail. |
| Frequency | Test Frequency |
| New Softpot | Radio softpot after alignment. |

**Table 6-2. VCO TX Coarse Tune Alignment Results**

## 6.3. Ref Osc Crystal Frequency

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

**Table 6-3. Analyzer Configuration for Reference Frequency**

### 6.3.1. 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 6-4. Reference Frequency Alignment Results**

### 6.3.2. 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 6-5. Reference Frequency Test Results**

## 6.4. Transmit Power Curve

The Transmit Power Curve alignment aligns the “Transmit Power Set” DAC for each transmit test frequency to within the limits specified by BK Relm.

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

**Table 6-6. Analyzer Configuration for Transmit Power Curve Alignment**

### 6.4.1. Transmit Power Curve Alignment

The radio is placed into Test Mode at high power at the first TX Test Frequency and commanded to transmit. For each frequency, the “Transmit Power Set” DAC is adjusted until the measured power is within the test limits. The test results for each Tx Test Frequency are written to the log file.

| Name | Description |
|---|---|
| Result | Pass or Fail. |
| Frequency | Test Frequency |
| Power Out | Measured power level in watts |
| Min Limit | Minimum passable power level |
| Max Limit | Maximum passable power level |
| Old Softpot | Radio softpot before alignment |
| New Softpot | Radio softpot after alignment |

**Table 6-7. Transmit Power Curve Alignment Results**

### 6.4.2. Transmit Power Curve Test

The radio is placed into Test Mode at high power at the first TX Test Frequency and commanded to transmit. For each frequency, the “Transmit Power Set” DAC is tested against the test limits. The test results for each Tx Test Frequency are written to the log file.

| Name | Description |
|---|---|
| Result | Pass or Fail. |
| Frequency | Test Frequency |
| Power Out | Measured power level in watts |
| Min Limit | Minimum passable power level |
| Max Limit | Maximum passable power level |
| Softpot | Current radio softpot. |

**Table 6-8. Transmit Power Curve Test Results**

## 6.5. Transmit Power Adjustment

The Transmit Power Adjustment determines the transmit power settings for High, Medium, and Low power levels.

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

**Table 6-9. Analyzer Configuration for Transmit Power Alignment**

### 6.5.1. Transmit Power Adjustment Alignment

The radio is placed into Test Mode. At each power level and test frequency, an alignment is performed to align the TX Power Parameter within the limits provided by BK Relm. The test results for each Tx Test Frequency are written to the log file.

| Name | Description |
|---|---|
| Result | Pass or Fail. |
| Frequency | Test Frequency |
| Power Out | Measured deviation level |
| Min Limit | Minimum passable power level |
| Max Limit | Maximum passable power level |
| Old Softpot | Radio softpot before alignment |
| New Softpot | Radio softpot after alignment |

**Table 6-10. Transmit Power Adjustment Alignment**

## 6.6. Basic Troubleshooting

| Symptom | Possible Cause | Possible Solution |
|---|---|---|
| Analyzer consistently fails to communicate with radio | • Radio not running 5.3.0 firmware | • AutoTune only supports test and alignment on KNG series radios running 5.3.0 firmware. Older firmware is not supported. |
| 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 aligns power output levels 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 6-11. BK Radio KNG Series Troubleshooting Chart**

# 7. Support Information

## 7.1. Technical Support

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

## 7.2. Sales

Telephone/Fax: 844.903.7333
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 BK Radio KNG-Pxxx radio model supported by AutoTune.

| Section | Test Name | Limit | Default Value |
|---|---|---|---|
| 6.3 | Ref Osc Crystal Frequency | Ref Osc Crystal Frequency Align | Min= -0.15 ppm<br>Max= 0.15 ppm |
| | | Ref Osc Crystal Frequency Test | Min= -1.5 ppm<br>Max= 1.5 ppm |
| 6.4 | Transmit Power Curve | Tx Power Curve Align VHF High | Min = 6.1 W<br>Max = 6.3 W |
| | | Tx Power Curve Test VHF High | Min = 6.0 W<br>Max = 6.7 W |
| | | Tx Power Curve Align UHF High | Min = 5.2 W<br>Max = 5.4 W |
| | | Tx Power Curve Test UHF High | Min = 5.0 W<br>Max = 5.7 W |
| | | Tx Power Curve Align 700/800MHz Band 1 High | Min = 2.4 W<br>Max = 2.6 W |
| | | Tx Power Curve Align 700/800MHz Band 2 High | Min = 2.9 W<br>Max = 3.1 W |
| | | Tx Power Curve Test 700/800MHz Band 1 High | Min= 2.25 W<br>Max= 2.75 W |
| | | Tx Power Curve Test 700/800MHz Band 2 High | Min=2.75 W<br>Max=3.25 W |
| 6.5 | Transmit Power Adjustment | TX Power Adjustment Align VHF Low | Min= 0.95 W<br>Max= 1.05 W |
| | | TX Power Adjustment Align VHF Mid | Min= 5.15 W<br>Max= 5.25 W |
| | | TX Power Adjustment Align VHF High | Min= 6.15 W<br>Max= 6.25 W |
| | | TX Power Adjustment Test VHF Low | Min= 0.8 W<br>Max= 1.3 W |
| | | TX Power Adjustment Test VHF Mid | Min= 5.0 W<br>Max= 6.0 W |
| | | TX Power Adjustment Test VHF High | Min= 6.0 W<br>Max= 6.7 W |
| | | TX Power Adjustment Align UHF Low | Min= .95 W<br>Max= 1.05 W |
| | | TX Power Adjustment Align UHF Mid | Min= 4.25 W<br>Max= 4.35 W |
| | | TX Power Adjustment Align UHF High | Min= 5.25 W<br>Max= 5.35 W |
| | | TX Power Adjustment Test UHF Low | Min= .8 W<br>Max= 1.3 W |
| | | TX Power Adjustment Test UHF Mid | Min= 4.0 W<br>Max= 4.7 W |
| | | TX Power Adjustment Test UHF High | Min= 5.0 W<br>Max= 5.7 W |
| | | TX Power Adjustment Align 700/800MHz Band 1 Low | Min= .95 W<br>Max= 1.05 W |
| | | TX Power Adjustment Align 700/800MHz Band 1 Mid | Min= 2.45 W<br>Max= 2.55 W |
| | | TX Power Adjustment Align 700/800MHz Band 1 High | Min= 2.45 W<br>Max= 2.55 W |
| | | TX Power Adjustment Align 700/800MHz Band 2 Low | Min= .95 W<br>Max= 1.05 W |
| | | TX Power Adjustment Align | Min= 2.95 W |

| | | | |
|---|---|---|---|
| | | 700/800MHz Band 2 Mid | Max= 3.05 W |
| | | TX Power Adjustment Align<br>700/800MHz Band 2 High | Min= 2.95 W<br>Max= 3.05 W |
| | | TX Power Adjustment Test<br>700/800MHz Band 1 Low | Min= .75 W<br>Max= 1.25 W |
| | | TX Power Adjustment Test<br>700/800MHz Band 1 Mid | Min= 2.25 W<br>Max= 2.75 W |
| | | TX Power Adjustment Test<br>700/800MHz Band 1 High | Min= 2.25 W<br>Max= 2.75 W |
| | | TX Power Adjustment Test<br>700/800MHz Band 2 Low | Min= .75 W<br>Max= 1.25 W |
| | | TX Power Adjustment Test<br>700/800MHz Band 2 Mid | Min= 2.75 W<br>Max= 3.25 W |
| | | TX Power Adjustment Test<br>700/800MHz Band 2 High | Min= 2.75 W<br>Max= 3.25 W |

**Table A-1. Default BK Radio KNG-Pxxx Test 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 #:  KNG-P800:Portable             Date/Time:     6/2/2017 3:23 PM
Serial #: 10 30 00 00 16 11 80 67       Operator ID:   MMULLINS

Info: FLASH Version: 5.5.0

VCO RX Coarse Tune Align
========================
Result  Frequency     New Softpot
------  ------------  -----------
Pass    763.0000 MHz  112
Pass    767.6650 MHz  126
Pass    772.3350 MHz  141
Pass    777.0000 MHz  155
Pass    851.0000 MHz  90
Pass    857.3350 MHz  114
Pass    863.6650 MHz  138
Pass    870.0000 MHz  164

VCO TX Coarse Tune Align
========================
Result  Frequency     New Softpot
------  ------------  -----------
Pass    763.0000 MHz  39
Pass    777.0000 MHz  87
Pass    793.0000 MHz  149
Pass    805.9950 MHz  206
Pass    806.0050 MHz  30
Pass    824.0000 MHz  76
Pass    851.0000 MHz  157
Pass    870.0000 MHz  228

Reference Oscillator Frequency Align
====================================
Result  Frequency     Freq Error  Min Limit  Max Limit  Old Softpot  New Softpot
------  ------------  ----------  ---------  ---------  -----------  -----------
Pass    869.9875 MHz  49 Hz       -130 Hz    130 Hz     2304         -28

TX Power Curve Align
====================
Result  Frequency      Power Out  Min Limit  Max Limit  Old Softpot  New Softpot
------  -------------  ---------  ---------  ---------  -----------  -----------
Pass    763.0000  MHz  2.5 W      2.4 W      2.6 W      128          160
Pass    777.0000  MHz  2.6 W      2.4 W      2.6 W      130          169
Pass    793.0000  MHz  2.5 W      2.4 W      2.6 W      130          169
Pass    805.9950  MHz  2.5 W      2.4 W      2.6 W      134          171
Pass    806.0050  MHz  3.0 W      2.9 W      3.1 W      181          187
Pass    824.0000  MHz  3.0 W      2.9 W      3.1 W      181          195
Pass    851.0000  MHz  3.1 W      2.9 W      3.1 W      186          195
Pass    870.0000  MHz  3.0 W      2.9 W      3.1 W      191          191

Transmit Power Adjustment - High Power
======================================
Result  Frequency     Power Out  Min Limit  Max Limit  Old Softpot  New Softpot
------  ------------  ---------  ---------  ---------  -----------  -----------
Pass    763.0000 MHz  2.45 W     2.25 W     2.75 W     112          123
Pass    777.0000 MHz  2.60 W     2.25 W     2.75 W     112          123
Pass    793.0000 MHz  2.45 W     2.25 W     2.75 W     129          111
Pass    805.9950 MHz  2.51 W     2.25 W     2.75 W     129          111
Pass    806.0050 MHz  3.12 W     2.75 W     3.25 W     128          112
Pass    824.0000 MHz  2.90 W     2.75 W     3.25 W     128          112
Pass    851.0000 MHz  3.23 W     2.75 W     3.25 W     128          116
Pass    870.0000 MHz  2.85 W     2.75 W     3.25 W     128          116

Transmit Power Adjustment - Medium Power
========================================
Result  Frequency     Power Out  Min Limit  Max Limit  Old Softpot  New Softpot
------  ------------  ---------  ---------  ---------  -----------  -----------
Pass    763.0000 MHz  2.43 W     2.25 W     2.75 W     129          123
Pass    777.0000 MHz  2.58 W     2.25 W     2.75 W     129          123
Pass    793.0000 MHz  2.43 W     2.25 W     2.75 W     96           111
Pass    805.9950 MHz  2.51 W     2.25 W     2.75 W     96           111
Pass    806.0050 MHz  3.12 W     2.75 W     3.25 W     128          112
Pass    824.0000 MHz  2.90 W     2.75 W     3.25 W     128          112
Pass    851.0000 MHz  3.23 W     2.75 W     3.25 W     128          116
Pass    870.0000 MHz  2.83 W     2.75 W     3.25 W     128          116

Transmit Power Adjustment - Low Power
=====================================
Result  Frequency     Power Out  Min Limit  Max Limit  Old Softpot  New Softpot
------  ------------  ---------  ---------  ---------  -----------  -----------
Pass    763.0000 MHz  1.00 W     0.75 W     1.25 W     88           86
Pass    777.0000 MHz  1.09 W     0.75 W     1.25 W     88           86
Pass    793.0000 MHz  0.96 W     0.75 W     1.25 W     87           76
Pass    805.9950 MHz  0.98 W     0.75 W     1.25 W     87           76
Pass    806.0050 MHz  1.10 W     0.75 W     1.25 W     48           72
Pass    824.0000 MHz  1.01 W     0.75 W     1.25 W     48           72
Pass    851.0000 MHz  1.10 W     0.75 W     1.25 W     80           73
Pass    870.0000 MHz  0.92 W     0.75 W     1.25 W     80           73

Tests performed by AutoTune © 2017 Freedom Communication Technologies, Inc.  All Rights Reserved.
APP Version 2.3.4
```

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

## APPENDIX C. Revision History

| | | | | |
|---|---|---|---|---|
| A – Original Release | M. Mullins | M. Humphries | 7/24/17 | 0130 |
| Revision – Change | Requested By | Approved By | Rel. Date | ECO# |