VHF COM XCVR
Alignment Procedure

Garmin Ltd. or its Subsidiaries
c/o Garmin International, Inc.
1200 E. 151st Street
Olathe, KS 66062 USA

Dwg. Number:
005-00531-11 Rev. A

	Approvals	Date
Drawn	BAS	08/13/10
Checked	CJR	08/13/10
Proj Mgr	GC	8/13/2010
Released	MKD	8/16/10

File Type: MS Word

Rev.	Date	Description of Change	ECO #
1	08/13/10	Initial Release	--
2	10/08/10	Update Tx Modulation Level and Limit Calibration Procedures	75731
A	12/17/10	Update document to match latest procedures and production release	77500

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1. INTRODUCTION

1.1 PURPOSE

The purpose of this document is to describe the alignment of the VHF COM XCVR.

1.2 SCOPE OF DOCUMENT

The reference oscillator, VCO, RF front end, crystal filters, and transmitter bias levels, transmitter power levels, transmitter modulation level, and transmitter modulation limiter all require calibration during the manufacturing process of the VHF COM XCVR. Below are descriptions of each calibration process. Use the MPS for specific limits, etc.

1.3 DESIGN DATA

The following are the design data and documentation associated with the device:

VHF COM XCVR Hardware Requirements Document 005-00531-20

VHF COM XCVR Hardware Design Document....... 005-00531-25

1.4 REFERENCES

1.4.1 Garmin

- 014-01594-00 VHF COM XCVR Schematic

1.5 DEFINITIONS

ADC ....Analog to Digital Converter

COM ....Communications Radio

DAC ....Digital to Analog Converter

FPGA ....Field Programmable Gate Array

PCA............................Printed Circuit board Assembly

PCB ....Printed Circuit Board

IF ....Intermediate Frequency

RX ....Receiver

TX ....Transmitter

LPF.............................Low Pass Filter

HPF ....High Pass Filter

VHF............................Very High Frequency (30-300MHz range)

2. ALIGNMENT SET-UP

2.1 DESCRIPTION

The following equipment and software are required to accomplish the COM alignment:

a) CCGI software (006-A0352-04)

b) PC with XP operating system, 2 GHz processor, 2 gigabyte of system RAM

c) 13.8V or 28V 10 amp power supply

d) Next Gen COM interface box

e) Frequency Counter (Agilent 53181A or equiv.)

f) 1 PPS source, GPS aligned

g) RF Power Meter (HP 436 or equiv.)

h) RF Modulation Meter (HP 8901A or equiv.)

i) RF Signal Generator with internal modulation capability (HP 8644A or equiv.)

A block diagram of the board hardware is illustrated in the following figure.

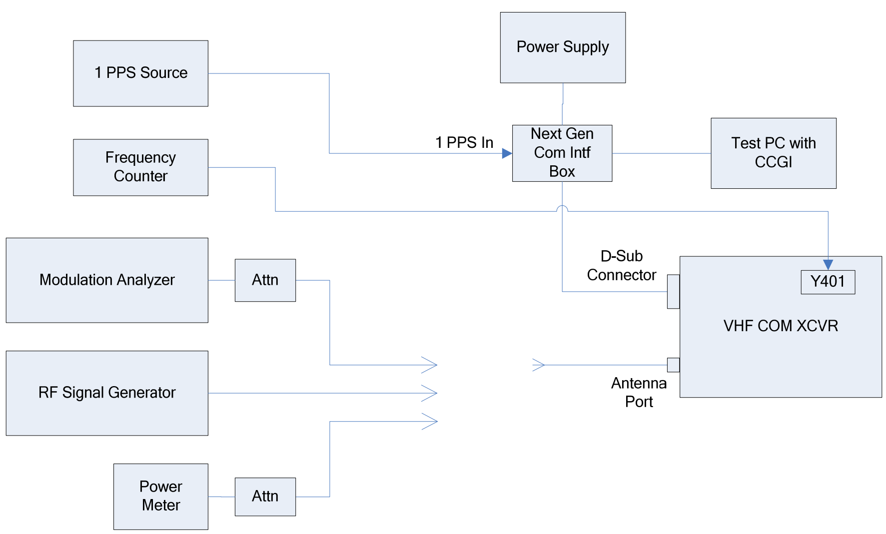

Figure 2-1: VHF COM XCVR Calibration Set-Up Diagram

2.2 CCGI SOFTWARE

Obtain the latest version of CCGI software.

The following CCGI modules are required for the manual alignment of the COM boards:

1) NGPM_COM_REG_TESTS
    a. Put unit into Test Mode
2) COM_HWM
    a. Select auto or manual receiver AGC mode
    b. Set receiver noise squelch and RF squelch thresholds
    c. Set RF squelch hysteresis

3) COM_SYNTH
    a. Reference oscillator calibration and VCO alignment

4) COM_PWM
    a. Receiver preselector and crystal filter alignment
    b. Transmitter bias adjustment and power level settings for 10W and 16W versions
    c. Local Oscillator enable/disable select

5) COM_RX_TX
    a. Channel selection
    b. Power level select (10W or 16W)
    c. Bandwidth select (25 kHz or 8.33 kHz)

6) COM_AUDIO
    a. Modulation percentage adjust
    b. External speaker select
    c. RX audio adjust

7) COM_ADC
    a. Com board voltage and current measurements during receive and transmit operation

2.3 1 PPS SOURCE

The 1 PPS source must either be aligned to the 1 second GPS epoch through reception of a live GPS signal or derived from a frequency source having an accuracy of ±0.05 PPM or better.

3. CALIBRATION PROCEDURE

The VHF COM XCVR will enter test mode when the test mode discrete pin on the rear connector is grounded during boot-up and the message from CCGI is received. A flag will be saved in EEPROM indicating test mode until the COM board is booted without test mode discrete being grounded.

To enter test mode, boot unit with test mode discrete grounded. Open CCGI and select "Device"-> "Redraw Modules". Select "NGPM_COM_REG_TESTS" module. Click "Test Mode" button.

3.1 Reference Oscillator

The reference VCO is to be calibrated to 19.6333333 MHz ± 0.5 PPM (±9.8 Hz).

3.1.1 Manual Reference Oscillator Alignment

With the COM board powered up and communicating with CCGI monitor pin 3 of Y401 with the frequency counter. After a 2 minute warm-up period use the REF OSC DAC slider located in the COM_SYNTH window to adjust the reference oscillator frequency to 19.6333333 MHz ±9.8 Hz. Click the Save Cal button. Record the COM board temperature value during alignment.

3.1.2 Automatic Reference Oscillator Alignment

The automatic method for calibrating the reference oscillator uses a 1 PPS connected to the COM board. There are two sources for a 1PPS signal: via the internal command/control connector or via the rear connector. The FPGA contains a control register for selecting between these two sources. In CCGI open the COM_CAL window and select external 1PPS. Select Reference Oscillator Cal and press Run Cal. Record the COM board temperature value during alignment.

3.2 VCO DAC

3.2.1 Manual Method

3.2.1.1 TX VCO Alignment

The local oscillator will be disabled for this alignment procedure. In CCGI open the COM_PWM window and uncheck the LO Enable box. Place the COM into TX by setting the Mic1 toggle switch (located on the interface test box) to on.

3.2.1.1.1 Low Cal Point

Set the channel frequency to 118 MHz (channel 0). In the COM_SYNTH window adjust the low VCO_DAC slider for a VCO control voltage (VCO_CTLV) of 2.0 volts as monitored in the COM_ADC window. Save this value.

3.2.1.1.2 Mid-Low Cal Point

Set the channel frequency to 127.00 MHz (channel 1080). In the COM_SYNTH window adjust the mid-low VCO_DAC slider for a VCO control voltage (VCO_CTLV) of 2.0 volts as monitored in the COM_ADC window. Save this value. Place the COM back into RX by switching the mic1 toggle switch (located on the interface test box) to off.

3.2.1.2 RX VCO Alignment

In CCGI open the COM_PWM window and check the LO Enable box.

3.2.1.2.1 Mid-High Cal Point

Set the channel frequency to 128.60 MHz (channel 1272). In the COM_SYNTH window adjust the Mid-High VCO_DAC slider for a VCO control voltage (VCO_CTLV) of 2.0 volts as monitored in the COM_ADC window. Save this value.

3.2.1.2.2 High Cal Point

Set the channel frequency for 136.975 MHz (channel 2277). In the COM_SYNTH window adjust the high VCO_DAC slider for a VCO control voltage (VCO_CTLV) of 2.0 volts as monitored in the COM_ADC window. Save this value.

3.2.2 Automatic Method

In CCGI open the COM_CAL window. Select VCO_DAC cal, then select “Run Cal” and wait for the calibration to complete.

3.3 FRONT END PRESELECTOR ALIGNMENT

There are five PWM outputs generated by the FPGA that go to the RF front end. These PWMs control band-pass filters that are used for tuning to frequencies between 118.00 MHz and 136.975 MHz. To calibrate the RF front end the optimal PWM values at 118.00 MHz, 127.50MHz, and 136.975 MHz need to be found. A signal generator will be used and a constant RF level will be applied to the RF input. Each PWM will be adjusted individually to get the maximum RF level reading from the FPGA AGC at three frequencies. These PWM values will be stored in the EEPROM. In normal operation when the user requests to tune to a specific frequency between 118.00 MHz and 136.975 MHz, the PWM value is interpolated. Below is the procedure for calibrating the RF Front End.

3.3.1 Manual Method

Connect the RF signal generator to the RF connector on the COM board.

3.3.1.1 118.000 MHz Calibration

1. Set the carrier frequency on the RF signal generator to 118 MHz, 3% modulation at 1kHz, at an RF level of -55 dBm.
2. In CCGI select COM_CAL module. Select “Front End (BPF) Cal Low” from the Calibration Select pulldown.
3. Set the duty cycle of BPF-1, BPF-2, BPF-3, BPF-4, and BPF-5 to defaults for this frequency.

4. Adjust the duty cycle of BPF-1 while monitoring the FPGA's "AGC Accumulator" field on CCGI module "COM_HWM".
5. Store the PWM duty cycle for BPF-1 that yields the maximum AGC value in the BPF1_LOW location in the EEPROM.
6. Repeat steps 4 & 5 for BPF-2, BPF-3, BPF-4, and BPF-5.
7. Repeat steps 4 – 6 since there is some interaction between stages
8. The UUT will send a message indicating Pass or Fail for the calibration.

3.3.1.2 127.500 MHz Calibration

1. Set the carrier frequency on the RF signal generator to 127.500 MHz, 3% modulation at 1kHz, at an RF level of -55 dBm.
2. In CCGI select COM_CAL module. Select "Front End (BPF) Cal Mid" from the Calibration Select pulldown.
3. Set the duty cycle of BPF-1, BPF-2, BPF-3, BPF-4, and BPF-5 to defaults for this frequency.
4. Adjust the duty cycle of BPF-1 while monitoring the FPGA's "AGC Accumulator" field on CCGI module "COM_HWM".
5. Store the PWM duty cycle for BPF-1 that yields the maximum AGC value in the BPF1_MID location in the EEPROM.
6. Repeat steps 4 & 5 for BPF-2, BPF-3, BPF-4, and BPF-5.
7. Repeat steps 4 – 6 since there is some interaction between stages
8. The UUT will send a message indicating Pass or Fail for the calibration.

3.3.1.3 136.975 MHz Calibration

1. Set the carrier frequency on the RF signal generator to 136.975 MHz, 3% modulation at 1kHz, at an RF level of -55 dBm.
2. In CCGI select COM_CAL module. Select "Front End (BPF) Cal Hi" from the Calibration Select pulldown.
3. Set the duty cycle of BPF-1, BPF-2, BPF-3, BPF-4, and BPF-5 to defaults for this frequency.
4. Adjust the duty cycle of BPF-1 while monitoring the FPGA's "AGC Accumulator" field on CCGI module "COM_HWM".
5. Store the PWM duty cycle for BPF-1 that yields the maximum AGC value in the BPF1_HIGH location in the EEPROM.
6. Repeat steps 4 & 5 for BPF-2, BPF-3, BPF-4, and BPF-5.
7. Repeat steps 4 – 6 since there is some interaction between stages
8. The UUT will send a message indicating Pass or Fail for the calibration.

3.3.2 Automatic Method

1. Connect the RF signal generator to the RF connector on the COM board.
2. Set the carrier frequency on the RF signal generator to 118 MHz. Set the modulation frequency to 1 kHz and modulation depth to 3%. Set the RF level to -55 dBm.
3. In CCGI select COM_CAL module. Select "Fast Front End (BPF) Cal Low" from the Calibration Select pulldown.

4. Select “Run Cal” and wait for the calibration to complete.
5. If the calibration completes successfully then set the RF signal generator frequency to 127.5 MHz, leaving modulation and RF level settings the same.
6. Select “Fast Front End (BPF) Cal Mid” from the Calibration Select pulldown.
7. Select “Run Cal” and wait for the calibration to complete.
8. If the calibration completes successfully then set the RF signal generator frequency to 136.975 MHz, leaving modulation and RF level settings the same.
9. Select “Fast Front End (BPF) Cal Hi” from the Calibration Select pulldown.
10. Select “Run Cal” and wait for the calibration to complete.

3.4 CRYSTAL FILTER

The crystal filter impedance matching circuits are controlled by PWMs generated by the FPGA. There are filters for the 8.33 kHz and 25 kHz bandwidths. The bandwidth select (BW_SEL) pin of the FPGA selects between the 8.33 kHz or 25 kHz bandwidth modes.

3.4.1 Manual Method

To calibrate the filters a signal generator will be set to a channel and swept by either 8.33 kHz or 25 kHz at a constant RF level at the RF input.

1. While in the 8.33 kHz mode, the two PWMs controlling the 8.33 kHz filter will be adjusted individually to get a smooth RF level reading from the RF AGC, minimizing ripple while maximizing overall response.
2. While in the 25 kHz mode, the two PWMs controlling the 25 kHz filter will be adjusted individually to get a smooth RF level reading from the RF AGC, minimizing ripple while maximizing overall response.
3. These PWM values will be stored in the EEPROM for retrieval on boot-up. Once these PWMs are set they should not be changed.

3.4.2 Automatic Method

1. Open the COM_CAL window in CCGI.
2. Set the RF signal generator frequency to 130.775 MHz with 1% modulation at 1 kHz. Set the RF level to -50 dBm.
3. Press “Load Defaults” for the selected “Fast Crystal Filter Calibration”.
4. Select “Run Calibration”.

3.5 RF SQUELCH

1. Connect an RF signal generator to the COM board antenna port.
2. Set the RF signal generator frequency to 118 MHz, unmodulated, with the RF level at -93 dBm.
3. Select the COM_RX_TX module and set the active frequency to 118 MHz.
4. Select the COM_HWM module.
5. Set the RF Squelch Threshold to the RF AGC PWM value and select “Save” for the RF Squelch.

3.6 NOISE SQUELCH

1. Connect an RF signal generator to the COM board antenna port.
2. Set the RF signal generator frequency to 118 MHz, unmodulated, with the RF level at -101 dBm.
3. Select the COM_RX_TX module and set the active frequency to 118 MHz.
4. Select the COM_HWM module.
5. Set the RX Noise Threshold to the RX Peak Noise Level and select “Save” for the -101 dBm RF Noise Threshold.
6. Repeat step 5 using the RF level of -93 dBm, saving the results for the -93 dBm RF Noise Threshold.

3.7 TX BIAS

The transmitter has two transistors that are biased by PWMs generated by the FPGA. The PWM duty cycle for each transistor is set based upon the voltage measured at the micro-controller’s ADC input DRV_CURRENT and PA_CURRENT. Below is the procedure for calibrating the transmitter bias levels.

3.7.1 Driver bias (Q303)

1. On the COM_RX_TX module toggle the “PTT Stuck Timer Enabled” to disable the timer.
2. On the COM_PWM module disable the LO by selecting “Set LO” and uncheck the LO Enable box.
3. Place the COM into TX by setting the Mic1 toggle switch (located on the interface test box) to on.
4. While monitoring the Drv Current on the COM_ADC module, adjust the DRV Bias level on the COM_PWM module using the slider until the unit reports a Drv Current as close to 24 mA as possible.
5. Select “Save” for the DRV Bias on the COM_PWM module.

3.7.2 PA bias (Q305)

1. While monitoring the PA current on the COM_ADC module, adjust the PA bias level on the COM_PWM module using the slider until the unit reports a PA current as close to 16 mA as possible.
2. Select “Save” for the PA Bias on the COM_PWM module.
3. Disable Mic1 PTT on the COM interface test box (return to RX mode).
4. On the COM_PWM module enable the LO by selecting “Set LO” and check the LO Enable box.
5. On the COM_RX_TX module toggle the “PTT Stuck Timer Enabled” to enable the timer.

3.8 TX POWER

3.8.1 16 Watt Power Level

1. Connect a power meter with suitable power and frequency measurement range to the COM board antenna port.
2. On the COM_RX_TX module set the active channel to 118 MHz and the power level to 16 watts.
3. Set the COM board to TX mode and note the power level (in watts) shown on the power meter.
4. Return the COM board to RX mode.
5. On the COM_RX_TX module set the active channel to 136.975 MHz .
6. Set the COM board to TX mode and note the power level (in watts) shown on the power meter.
7. Return the COM board to RX mode.
8. Set the COM board active channel to the channel with the lowest power level.
9. On the COM_PWM module select 16W from the MOD DC level pull-down menu and select "Load".
10. Set the COM board to TX mode and monitor the power level (in watts) on the power meter.
11. Adjust the MOD DC level on the COM_PWM module until the measured power level is as close to 19 watts as possible.
12. Verify the MOD level on the COM_ADC module is less than 14.7V when transmitting. If the MOD level is greater than 14.7V or a 19 watt power level cannot be achieved proceed to the next step, otherwise proceed to step 17.
13. With the unit transmitting, adjust the MOD DC level on the COM_PWM module until the MOD level on the COM_ADC module is 14.7V ±0.1V.
14. Select "Save" to store the setting for TX 16W on the COM_PWM module.
15. Return the COM board to RX mode.
16. Set the COM board to TX mode and begin adjusting the DRV bias on the COM_PWM module until a 19 watt power level is achieved.
17. Select "Save" to store the DRV bias setting.
18. Return the COM board to RX mode.
19. On the COM_RX_TX module set the active channel to the channel with the highest power level (i.e. the one not selected from step 8).
20. Set the COM board to TX mode and verify the power level is 19W nominal.
21. Return the COM board to RX mode.

3.8.2 10 Watt Power Level

1. Connect a power meter with suitable power and frequency measurement range to the COM board antenna port.
2. On the COM_RX_TX module set the power level to 10 watts.
3. On the COM_PWM module select 10W from the MOD DC level pull-down menu and select "Load".
4. Set the COM board to TX mode and monitor the power level (in watts) on the power meter.
5. Adjust the MOD DC level on the COM_PWM module until the measured power level is as close to 14 watts as possible.

6. Select “Save” to store setting for TX 10W.
7. Return the COM board to RX mode.

3.8.3 6 Watt Power Level

1. Connect a power meter with suitable power and frequency measurement range to the COM board antenna port.
2. On the COM_RX_TX module set the power level to 6 watts.
3. On the COM_PWM module select 6W from the MOD DC level pull-down menu and select “Load”.
4. Set the COM board to TX mode and monitor the power level (in watts) on the power meter.
5. Adjust the MOD DC level on the COM_PWM module until the measured power level is as close to 6 watts as possible.
6. Select “Save” to store setting for TX 6W.
7. Return the COM board to RX mode.

3.9 TX MODULATION LEVEL & LIMIT

For each transmitter power level (16W, 10W, and 6W), the modulation audio limiter and amplitude must be calibrated. Below is the procedure for calibrating the modulation limiter and audio level(s). Note: The HP8920B’s detector must be setup for peak +- max.

3.9.1 6 Watt Modulation Level & Limit

1. Connect a modulation analyzer (with attenuator to reduce the COM board output to an acceptable range for the analyzer) to the COM board antenna port.
2. Connect an audio frequency signal generator to the Mic1 input. Set the audio frequency to 1 kHz at a level of 600mV_{rms}.
3. On the COM_RX_TX module set the power level to 6W and the active frequency to 118 MHz.
4. Set the COM board in TX mode.
5. While monitoring the AM modulation depth, increase the MIC input level in 1mV steps until the modulation level drops. Record this value.
6. While monitoring the AM modulation depth, decrease the MIC input level in 1mV steps until the modulation level jumps up. Record this value.
7. Set the MIC input level to 6mV less than the value determined in step 5.
8. While monitoring the AM modulation depth adjust the Mic TX Level 6W value on the COM_AUDIO module until the depth is 97 ±1%.
9. While monitoring the AM modulation depth adjust the Mic TX Limit 6W value on the COM_AUDIO module until the depth is 95 ±1%.
10. Adjust the microphone volume level while monitoring the modulation level on the analyzer.
11. Store the microphone volume level that yields 90% modulation.
12. Return COM board to RX mode.

3.9.2 10 Watt Modulation Level & Limit

1. Connect a modulation analyzer (with attenuator to reduce the COM board output to an acceptable range for the analyzer) to the COM board antenna port.
2. Connect an audio frequency signal generator to the Mic1 input. Set the audio frequency to 1 kHz at a level of $100mV_{rms}$.
3. On the COM_RX_TX module set the power level to 10W and the active frequency to 118 MHz.
4. Set the COM board in TX mode.
5. While monitoring the AM modulation depth, increase the MIC input level in 1mV steps until the modulation level drops. Record this value.
6. While monitoring the AM modulation depth, decrease the MIC input level in 1mV steps until the modulation level jumps up. Record this value.
7. Set the MIC input level to 6mV less than the value determined in step 5.
8. While monitoring the AM modulation depth adjust the Mic TX Level 10W value on the COM_AUDIO module until the depth is 97 ±1%.
9. While monitoring the AM modulation depth adjust the Mic TX Limit 10W value on the COM_AUDIO module until the depth is 95 ±1%.
10. Adjust the microphone volume level while monitoring the modulation level on the analyzer.
11. Store the microphone volume level that yields 90% modulation.
12. Return COM board to RX mode.

3.9.3 16 Watt Modulation Level & Limit

1. Connect a modulation analyzer (with attenuator to reduce the COM board output to an acceptable range for the analyzer) to the COM board antenna port.
2. Connect an audio frequency signal generator to the Mic1 input. Set the audio frequency to 1 kHz at a level of $100mV_{rms}$.
3. On the COM_RX_TX module set the power level to 16W and the active frequency to 118 MHz.
4. Set the COM board in TX mode.
5. While monitoring the AM modulation depth, increase the MIC input level in 1mV steps until the modulation level drops. Record this value.
6. While monitoring the AM modulation depth, decrease the MIC input level in 1mV steps until the modulation level jumps up. Record this value.
7. Set the MIC input level to 6mV less than the value determined in step 5.
8. While monitoring the AM modulation depth adjust the Mic TX Level 16W value on the COM_AUDIO module until the depth is 97 ±1%.
9. While monitoring the AM modulation depth adjust the Mic TX Limit 16W value on the COM_AUDIO module until the depth is 95 ±1%.
10. Adjust the microphone volume level while monitoring the modulation level on the analyzer.
11. Store the microphone volume level that yields 90% modulation.
12. Return COM board to RX mode.