5.4 Field Service Adjustments

In order to bring the R-110 receiver into spec after replacement of a module or assembly, or simply in the course of time, a number of trimmers must be adjusted. This may be done in the field providing adequate signal source and measurement equipment is available. Adjustment should be performed after replacing any of the signal path or synthesizer hardware in the radio, or occasionally as part of periodic maintenance. All of the adjustments are made to modules which plug into the cardcage; no adjustments are available in the front or rear panel assemblies. In order to perform adjustment on a plug-in module, a field service kit is available which provides an extender PCB and extender rods and cables which allow a module to be raised up out of the cardcage for access to its circuitry.

Performance of these adjustments do not necessarily constitute a full calibration of the receiver. Full calibration can only be assured by performing the entire acceptance test procedure (ATP) and making any adjustments required to pass it.

Field service adjustments include:

- microwave RF module (A1A1): input limiter VSWR
- preselector module (A1A2): VCO input voltage clamps for the 523 - 533 MHz synthesizer
- low frequency RF module (A1A5): none
- 21.4 MHz IF amplifier module (A1A6): front end overload, underload thresholds; AGC
- 21.4 MHz IF filter module (A1A8): back end overload threshold
- video module (A1A9): log amp null, BFO offset, Z axis offset, overload detector threshold
- DCIF module (A1A11): first stage offset
- fixed LO synthesizer module (A1A15): none
- microwave synthesizer module (A1A16): integrator bias for the programmable microwave synthesizer
- low frequency synthesizer module (A1A17): integrator bias for the synthesizer and mixer loops; mixer loop relock threshold

There is a separate procedure provided for each adjustment.

5.4.1 Microwave RF Module Input Limiter Adjustment

The input limiter is the first subassembly (A1A1A1) that the signal goes to upon entering the microwave RF module. Being the input limiter it may occasionally burn out on severe overloads and thereafter be replaced. The new subassembly will need to be tuned to minimize its VSWR. The tuning components are C3 and C4.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables and the discrete wire pigtail from the microwave module (A1A1) and remove the microwave module from the cardcage. Remove the small cover at the top left of the module, adjacent to the signal input connector.

3. Remount the microwave module in the cardcage, using extender rods, so that the circuitry revealed by the removed cover is accessible. Use extender cables to reconnect the inputs and outputs.

4. Power up the radio. Tune it to 1 GHz. Apply a CW signal at 1 GHz and amplitude below -30 dBm, through a coupler. Monitor the other output of the coupler with a spectrum analyzer or power meter.

5. Adjust C3 and C4 in the input limiter cavity to maximize the return loss measured on the signal monitor. When adjusted the VSWR should be below 2.0, so the return loss should be above 9.5 dB.

6. An artifact at 800 MHz occasionally presents itself when the input limiter is perfectly tuned at 1 GHz. Set the input signal to 800 MHz and check the return loss. It should still be above 9.5 dB. If not then it may be necessary to readjust the capacitors to strike a balance between the return loss at 800 MHz and the return loss at 1 GHz.

5.4.2 Front End Overload and Underload Threshold Adjustments

The front end overload and underload threshold adjustments are located on the 21.4 MHz IF amplifier module (A1A6). The signal is picked off after the first amplifier following the input select relay, amplified, and compared to overload and underload thresholds, each set by a trimmer. The overload threshold trimmer is R64. The underload threshold trimmer is R69.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables from the 21.4 MHz IF amplifier module (A1A6). Then remove the module from the cardcage. Remount it using the extender PCB and rods. Do not reconnect the coax cables.

3. Power up the radio. It should be tuned above 20 MHz. Using a signal generator, apply a 21.4 MHz unmodulated sine wave at -30 dBm to J9. Plug a 50 Ohm termination into J7. Monitor cardcage backplane interface connector P1 pin B21 with an oscilloscope or other voltage monitor. Adjust the signal generator and R64 on the module so that P1 pin B21 goes TTL low when the signal generator level is at or above -19 dBm, and TTL high when the signal generator level is below -19 dBm.

4. Monitor cardcage backplane interface connector P1 pin B20 with the voltage monitor. Adjust the signal generator and R69 on the module so that P1 pin B20 goes TTL low when the signal generator level is at or below -32 dBm, and TTL high when the signal generator level is above -32 dBm.

5.4.3 Back End IF Overload Adjustment

The back end IF overload threshold adjustment is located on the 21.4 MHz IF filter module (A1A8). The pickoff is behind the input amplifier, before the filters. Other contributors to back end overload detection are the DCIF module and the video module, which are adjusted in separate procedures. The threshold here is set by trimmer R1.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables from the top of the 21.4 MHz IF filter module (A1A8) and remove the module from the cardcage. Now remount it using the extender PCB and rods. Do not reconnect the coax cables.

3. Power up the radio. Apply a CW signal at 21.4 MHz and -40 dBm to J1. Monitor cardcage backplane interface connector P1 pin B18 with an oscilloscope or other signal monitor.

4. Vary the amplitude of the input signal and adjust R1 so that the voltage level at P1 pin B18 is TTL high when the input amplitude is below -34 dBm and TTL low when the input amplitude is -34 dBm or greater.

5.4.4 AGC Adjustment

The AGC adjustment is located on the 21.4 MHz IF amplifier module (A1A6). In normal use a DC signal is developed from detected video and returned here, where it is conditioned and used in combination with the front panel gain control/IEEE-488 gain command to set the first three PIN diode attenuator circuits. The adjustment is for the threshold at which the AGC kicks in. The trimmer is R100.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables from the top of the IF amplifier module (A1A6). Then remove the module from the cardcage and remount it using the extender PCB and rods. Do not reconnect the coax cables, but use a short coax jumper to connect J5 to J4. Make sure that trimmer R101 is set fully clockwise.

3. Power up the radio. Tune it to band 3 (any frequency over 20 MHz). Set the front panel gain control to maximum (50 dB). Enable AGC.

4. Apply a CW signal at 21.4 MHz and -70 dBm to J9. Connect a DC power supply to J6 and set it to about +3 VDC. Connect an oscilloscope or other signal monitor to J3.

5. Vary the amplitude of DC supply and observe the output on the signal monitor. Adjust R100 so that the monitored signal begins to fall off when the voltage applied to J6 rises above 3.0 VDC.

5.4.5 DCIF Offset Adjustment

Of all the adjustments on the DCIF module, only the first stage offset trim is suitable for field service. The other adjustments on the module are made during factory test and then locked.

The DCIF begins with a quadrature signal splitter and ends with a recombination circuit. In between are two identical processing channels. The gains and offsets of both channels must be matched exactly, because any error is directly related to errors in the output. (For example, a mismatch beween channels of one part in one hundred will limit the usable range of the output to 40 dB, which again is one part in one hundred. A well-adjusted module will optimally exhibit channel matching to one part in one thousand.)

There are two first stage offset adjustments, one for each channel. The trimmers are R41 and R46.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables from the top of the DCIF module (A1A11) and remove the module from the cardcage. Now remount the module using the extender PCB and rods. Reconnect the coax cable to J2 using a cable extender.

3. Power up the radio. Select a narrow bandwidth (20 kHz or less). Select linear detection. Apply a CW signal at 21.401 MHz and -10 dBm to J3 on the DCIF module. Monitor J5 on the module with an oscilloscope.

4. Interactively adjust R41 and R46 for minimum AC content at J5. There should be substantial DC content, however.

5.4.6 Log Detector Adjustment

The log detector is part of the video module (A1A9). It consists of a pair of log detector ICs which are connected in series to increase the dynamic range. They are followed by an output amplifier. The only adjustment available in this circuit, trimmer R6, allows the output to be nulled for zero input.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables from the top of the video module (A1A9) and remove the module from the cardcage. Now remount it using the extender PCB and rods. Do not reconnect the coax cables.

3. Power up the radio. Tune it to band 3 (above 20 MHz) and make sure that the selected bandwidth is 80 kHz or higher. Select log detection.

4. Monitor the main video output at J7 with an oscilloscope or other DC voltage monitor. Adjust R6 for minimum monitored output.

5.4.7 BFO Adjustment

The BFO detector is part of the video module (A1A9). It consists of a 21.4 MHz crystal oscillator, the frequency of which may be varied by a few kHz using a front panel control which sends a DC voltage to the circuit. The oscillator output is mixed with the 21.4 MHz IF and the resulting beat frequency filtered and delivered to the audio output of the module and from there to the audio output of the radio. The available adjustment is trimmer R112, which centers the adjustment range of the oscillator on 21.4 MHz.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables from the top of the video module (A1A9) and remove the module from the cardcage. Now remount it using the extender PCB and rods. Reconnect the coax cables to J3 and J5 using cable extenders.

3. Power up the radio. Make sure that the bandwidth is set above the DCIF range (80 kHz or above). Apply a CW signal to the radio input at a frequency which is compatible with the bandwidth (200 kHz or above) at -35 dBm or less. Tune the radio to this frequency and set the gain and attenuation to eliminate overloads. Monitor the audio output from the video module at J10. Enable BFO detection.

4. Set trimmer R112 so that the frequency deviation at J10 with the BFO control knob fully counterclockwise is the same as the deviation with the control fully clockwise, with a null in between.

5.4.8 Z Axis Output Adjustment

The Z axis inverter and output circuit are part of the video module (A1A9). Output amplitude is set by a front panel control which sends a DC voltage to the circuit. Inversion is carried out by an analog multiplier which multiplies the signal by plus or minus the amount indicated by the front panel control. A trimmer (R63) is provided to minimize the output when the front panel control is set fully counterclockwise.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables from the top of the video module (A1A9) and remove the module from the cardcage. Now remount the module using the extender PCB and rods. Reconnect the coax cable to J4 using an extender cable.

3. Power up the radio. Apply a CW signal at 21.4 MHz and 0 dBm, with 1 kHz AM modulation, to module connector J3. Tune the radio to band 3 (above 20 MHz) and at least 80 kHz bandwidth. Enable the Z axis output. Monitor the Z axis output at J9 with an oscilloscope.

4. Set the front panel Z axis control fully counterclockwise. Now adjust trimmer R63 to null the output seen on the oscilloscope.

5.4.9 Video Overload Threshold Adjustment

The adjustment is trimmer R44 on the video module (A1A9). The output of the main video amplifier is compared to a reference set by the trimmer.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables from the top of the video module (A1A9) and remove it from the cardcage. Now remount it using the extender PCB and rods. Do not reconnect the coax cables.

3. Power up the radio. Select a narrow bandwidth (20 kHz or less) and linear detection. Monitor cardcage backplane interface connector P1 pin B18 with an oscilloscope.

4. Apply 5.125 VDC to the narrowband input (J2) of the video module. Now adjust R44 so that the output at P1 pin B18 just breaks between TTL high and TTL low.

5.4.10 Programmable Microwave Synthesizer Adjustment

The VCO for the programmable microwave synthesizer is located in the microwave RF module (A1A1). The rest is located on the microwave synthesizer module (A1A17). The loop contains an adjustment (R30 on the microwave synthesizer module) to adjust the DC offset on the loop integrator. The offset affects the reference sidebands in the output of the loop.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax connections from the top of the microwave synthesizer module (A1A17) and remove it from the cardcage. Now remount it using the extender PCB and rods. Reconnect the coax cables using cable extenders.

3. Power up the radio. Tune it to 20 MHz. Select external wideband operation (one of the bandwidth mode selections). Connect a spectrum analyzer to the external wideband connector on top of the microwave RF module (J4).

4. Locate the LO artifact at 1470 MHz on the spectrum analyzer. Observe the reference sidebands spaced 625 kHz around it. Now adjust R30 on the microwave synthesizer module to minimize these reference sidebands. They should null to better than -60 dBc.

5.4.11 523 - 533 MHz Mixer Loop Adjustment

The VCO for this synthesizer is located in the microwave RF module (A1A1). The rest of the loop is located on the preselector module (A1A2). The 2 GHz fixed LO is divided by four to produce 500 MHz, which is then subtracted from the loop VCO output and the result compared to the programmable low frequency synthesizer output. The 2 GHz and settable low frequency references come from elsewhere. The loop features clamping of the VCO tune voltage at both the high and low ends to keep it within lock range. The components to be adjusted are R13 and R14 on the main preselector PCB, which are used to set the clamp voltages.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables from the preselector module (A1A2). Then remove the preselector module from the cardcage. Remount it using the extender PCB and rods. Do not reconnect the coax cables.

3. Power up the radio. Tune it to band 3 (above 20 MHz). Connect a DC source to microwave module J8. Monitor microwave RF module J7 with a frequency counter or spectrum analyzer.

4. Characterize the VCO by determining the tuning voltages at which the VCO outputs 518 MHz and 540 MHz. Record these voltages.

5. Monitor U3 pin 7 on the preselector module main PCB with a DVM. Adjust R14 so that the voltage at U3 pin 7 matches the 540 MHz VCO tune voltage.

6. Monitor U3 pin 1 with the DVM. Adjust R13 so that the voltage at U3 pin 1 matches the 518 MHz VCO tune voltage.

5.4.12 Low Frequency Synthesizer Adjustment

The programmable low frequency synthesizer consists of a double loop, one programmable in 1 MHz steps and the other to mix the output of the first one with the output of the direct digital synthesizer (DDS). All of this is located on the low frequency synthesizer module (A1A16). There is an offset adjustment (R36) for the programmable loop integrator, which is used to minimize the reference sidebands in the output of the loop. The mixer loop has a similar adjustment (R58), plus a threshold adjustment (R68) for a kickout circuit which will reset the VCO tune voltage if it goes out of acceptable range.

Procedure:

1. Remove the cover from the radio. See paragraph 5.3.1.

2. Unplug the coax cables from the top of the low frequency synthesizer module (A1A16) and remove the module from the cardcage. Then remount the module using the extender PCB and rods. Reconnect the coax cables using cable extenders.

3. Remove IC U21 from the low frequency synthesizer module. This is the integrator for the mixer loop. Connect a 10k resistor from pin 4 to pin 6 of the U21 socket. Now power up the radio and tune it to 7.5 MHz. Connect a spectrum analyzer to an unused output of the programmable loop VCO (A1A16A1 subassembly, pin 2 or pin 4).

4. Find the programmable loop VCO output at 29.9 MHz on the spectrum analyzer. Observe the reference sidebands 1 MHz away from the main output. Adjust R36 to minimize the reference sidebands.

5. Power down the radio. Remove the 10k resistor from the U21 socket and replace the IC. Power up the radio and tune it to 7.5 MHz. Connect the spectrum analyzer to low frequency synthesizer module J3.

6. Find the mixer loop VCO output at 28.9 MHz on the spectrum analyzer. Observe the reference sidebands 1 MHz away from the main output. Adjust R58 to minimize the reference sidebands.

7. Tune the radio to 270 kHz. Select the 1 kHz digit for tuning and, using the tuning knob and pushbuttons BUT NOT THE KEYPAD, step the tuned frequency down to 225 kHz WITHOUT OVERSHOOTING. This sets the low frequency synthesizer to its minimum frequency, which is at the bottom of the hysteresis region at the bottom of band 2.

8. Measure the tuning voltage on the mixer loop VCO (A1A16A2 subassembly, pin 8, or U21 pin 6 on the main low frequency synthesizer module PCB). Now monitor U23 pin 2 on the low frequency synthesizer module main PCB with a DVM. Adjust R68 to set the voltage at U23 pin 2 to 0.8 Volts lower than the measured tuning voltage.