August 13, 1991

MAINTENANCE MANUAL
FOR THE
R-110 and R-110B RECEIVERS

THIS MANUAL IS INTENDED FOR USE WITH THE FOLLOWING SERIAL NUMBER:

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SECTION 5. MAINTENANCE

5.1 Introduction

Three levels of maintenance are discussed in this section: preventive maintenance, periodic maintenance, and corrective maintenance. Periodic maintenance is part of preventive maintenance and includes a receiver performance test. Failure of a particular part of the performance test should lead to initiation of corrective maintenance, and will indicate a starting point for fault isolation. Isolation procedures are provided down to at least the module level. Disassembly procedures are also provided as an aid to service personnel.

Finally, field calibration procedures are included both for periodic maintenance and for replacement of failed assemblies. Procedures for adjustments which may be made at the factory before shipment and which should never need recalibration are not included.

5.2 Preventive Maintenance

Preventive maintenance includes correct installation and connection of the radio, periodic inspection and cleaning, and execution of the receiver performance test. See table 5-1.

The model R-110 receiver requires a minimum of periodic maintenance unless abusive conditions exist. Such conditions include improper handling, mounting, and operation, or environmental extremes.

5.2.1 Performance Test

The performance test consists of a procedure which, if followed all the way through, will demonstrate that the receiver is in good operating condition. The performance test makes no attempt to verify all specifications, as would an acceptance test procedure, but is rather intended to verify its basic operation. A full verification of the radio's specifications requires execution of the ATP.

Test equipment required by the performance test is listed in table 5-2. Receiver test points used by the performance test are indicated in figure 5-1. A sample data sheet for recording the results of the performance test is given in paragraph 5.2.1.2.15.

Field service adjustment procedures are provided at the end of this section.

Table 5-1: Preventive Maintenance

Task	Interval	Description
Inspect Cables	4 Months	Check for frayed cables and wires. Check that wires and coax cables are not crimped between structural members. Inspect connectors.
Inspect and clean air inlet filter	4 Months	Visually check for accumulated dirt; if excessive, remove dirt and other deposits with a vacuum cleaner or compressed air.
Inspect plug-in modules	12 Months	Look for discoloration of resistor and capacitor coding bands or loss of coating that would indicate abnormal operation such as extreme heat conditions.
Clean connectors	12 Months	Dissolve and wipe away any grease deposits on front and rear panel connectors. Use a cotton swab dipped in Freon TF or alcohol.
Clean chassis	12 Months	Wipe all dust and grease from the interior and exterior chassis parts.
Execute performance test and alleviate any identified faults	12 Months	Perform thorough testing of the receiver to ensure that specified performance is maintained.

Table 5-2: Test Equipment for the Performance Test

Type	Specifications	Example
Signal Generator	10 Hz - 1280 MHz AM, CW	Hewlett Packard 8662A
Spectrum Analyzer	10 kHz - 1.8 GHz	Tektronix 7L14
Oscilloscope	300 MHz Bandwidth	Tektronix 2465
Frequency Counter	10 Hz - 3 GHz	Hewlett Packard 5386A
IEEE-488 Controller (Optional)	Computer With Directly Controllable Interface	HP-85

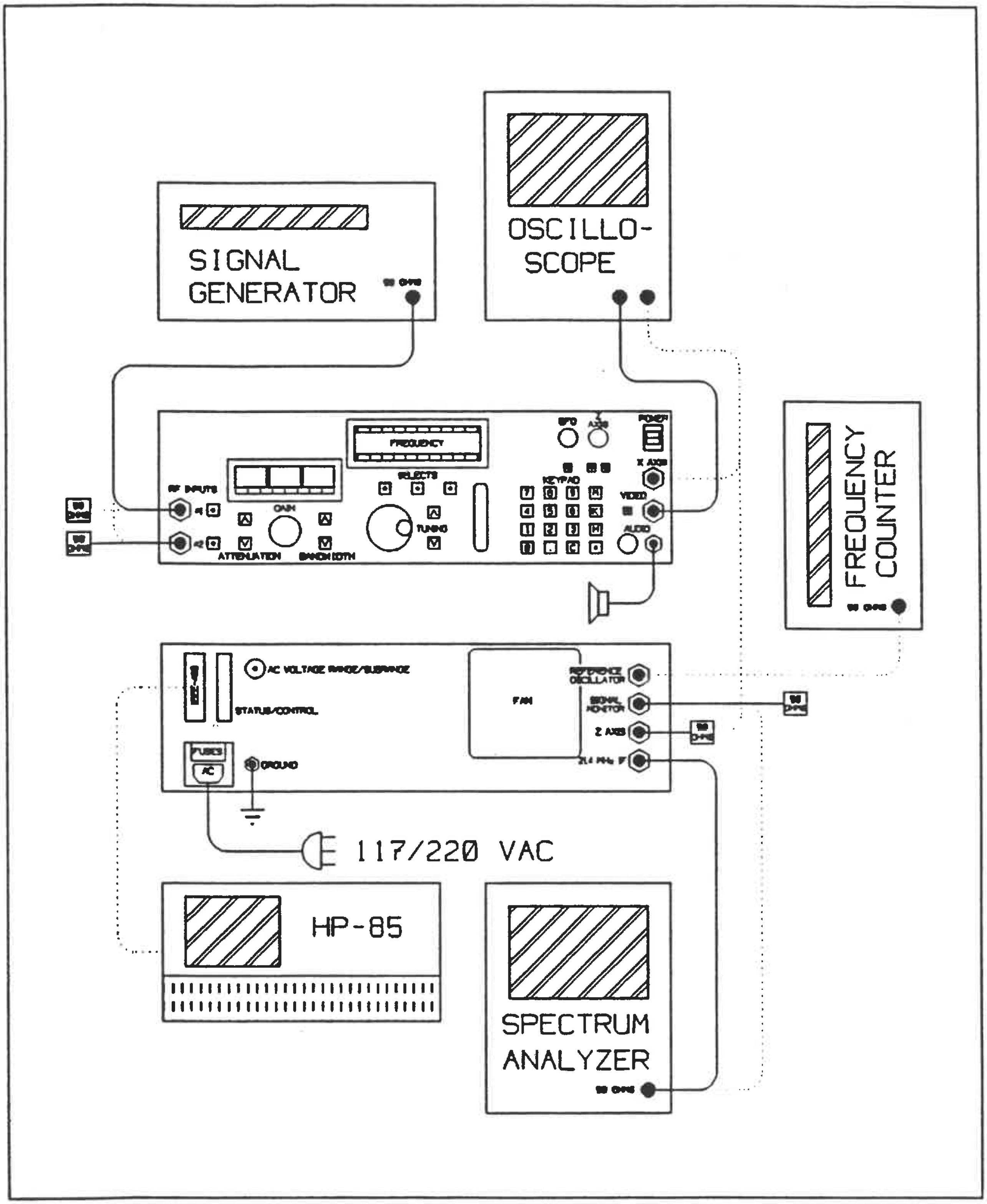

Figure 5-1: Test Points for the Performance Test

5.2.1.1 Setup

The performance test is based on a standard test setup. This is as follows:

- The radio is in its powerup condition:

  Tuned frequency = 100 MHz
  Input select = input #1
  Input attenuation = 20 dB
  Gain = 50 dB
  Bandwith = 1 MHz
  Detection = linear
  BFO, Z axis, autorange, AGC disabled
  Tune mode selected, 1 MHz tuning display digit selected for tuning

- A signal generator is connected to the radio's #1 input:

  Frequency = 100 MHz
  Amplitude = -60 dBm
  Modulation = unmodulated CW

- The radio's #2 input is terminated in 50 Ohms.

- A spectrum analyzer is connected to the radio's 21.4 MHz IF monitor jack (not the "signal monitor" jack):

  Center frequency = 21.4 MHz
  Reference = +10 dBm

- An oscilloscope is connected to the radio's video output jack through a 50 Ohm feed-through terminator:

  Sensitivity = 0.5 V/div
  Coupling = DC
  Trace position = bottom of screen

Many of the test steps will call for variations on this basic setup. These variations will be described at the point at which they are required.

5.2.1.2 Procedure

The performance test procedure is functionally divided into a number of test headings, each of which typically contains a number of steps to be performed.

5.2.1.2.1 Front Panel Operation

This test verifies the operation of those front panel controls and displays which interface with the controlling microprocessor. Note that this is a test of the controls only, not the functions associated with them. Not included are the BFO, Z axis, and audio gain control knobs. Several of the status indicators are also not included because they require special equipment, or require that a hardware fault be induced. Some of these indicators will be exercised in subsequent tests.

For this test the standard test setup is not required. An oscilloscope is required for the X axis test.

1. Press the RF input select pushbuttons one at a time. Pressing one of these buttons should cause its internal indicator LED to illuminate, and the LED in the opposite pushbutton to extinguish.

2. Press the RF input attenuation stepping pushbuttons one at a time. They should cause the value indicated on the attenuation display to step up and down.

3. Rotate the IF gain control knob in both directions. The rotation should cause the value indicated on the gain display to step up and down.

4. Press the IF bandwidth stepping pushbuttons one at a time. They should cause the value indicatated on the bandwidth display to step up and down.

5. Rotate the tuning knob in both directions. The rotation should cause the value indicated on the tuning display to step up and down, with the step size based on the selected (blinking) display digit.

6. Press the tuned frequency stepping pushbuttons one at a time. They should cause the value indicated on the tuning display to step up and down, with the step size based on the selected (blinking) display digit.

7. Enter the sequence "1234567890." on the keypad. The digits should be shown on the tuning display as they are entered. Now press the "C" key. The display should revert to its previous indication.

   Enter the sequence "1K". The display should indicate 1 kHz.

   Enter the sequence "1M". The display should indicate 1 MHz.

   Enter the sequence "1000H". The display should indicate 1 kHz.

8. Press the log detector pushbutton. Its internal indicator LED should illuminate. Press it again and the LED should extinguish.

9. Press the BFO enable pushbutton. Its internal indicator LED should illuminate. Press it again and the LED should extinguish.

10. Press the Z axis enable pushbutton. Its internal indicator LED should illuminate. Press it again and it should extinguish. With the Z axis enable pushbutton indicator LED illuminated, press the Z axis invert pushbutton. Its internal indicator LED should illuminate. Press it again and the LED should extinguish.

11. Press the STEP pushbutton below the tuning display. Its internal indicator LED should illuminate. Press it again and the LED should extinguish.

    With the STEP pushbutton indicator LED extinguished, press the←SELECT pushbutton a few times. The blinking digit selection on the tuning display should move left and then wrap around to the right end of the display.

    With the STEP pushbutton indicator LED extinguished, press the SELECT→ pushbutton a few times. The blinking digit selection on the tuning display should move right and then wrap around to the left end of the display.

12. Press the alt mode pushbutton in at the bottom right of the keypad. Its internal indicator LED should illuminate. Press it again and the LED should extinguish.

13. Enable autorange. The AUTO indicator should illuminate. Disable it and the indicator should extinguish.

    Enable AGC. The AGC indicator should illuminate. Disable it and the indicator should extinguish.

    Enable absolute gain display mode. The ABS indicator should illuminate. Disable it and the indicator should extinguish.

    Enable delta gain display mode. The DELTA indicator should illuminate. Disable it and the indicator should extinguish.

    Enable CW gain distribution mode. The CW DIST indicator should illuminate. Disable it and the indicator should extinguish.

    Enable external wideband mode. The WIDE indicator should illuminate. Disable it and the indicator should extinguish.

    Set the bandwidth to 1 MHz and the tuned frequency to 1 MHz. The BW LIM indicator should illuminate. Set the tuned frequency to 100 MHz and the indicator should extinguish.

    Set the bandwidth to 10 kHz and the tuned frequency to 100 MHz. Select the 1 MHz tuning display digit for tuning. The BW GAP indicator should illuminate. Select 1 MHz bandwidth and the indicator should extinguish.

    The AC HI, AC LO, REG, LOCK, FR OVL, BK OVL, MDC, and THRESH indicators should all be extinguished.

14. Enter tune mode. The TUNE mode indicator should illuminate. All other operating mode indicators should be extinguished.

    Enter start mode. The START mode indicator should illuminate and the TUNE mode indicator should extinguish.

    Enter stop mode. The STOP mode indicator should illuminate and the START mode indicator should extinguish.

    Enter step mode. The STEP mode indicator should illuminate and the STOP mode indicator should extinguish.

    Enter rate mode. The RATE mode indicator should illuminate and the STEP mode indicator should extinguish.

    Enter scan mode. The SCAN mode indicator should illuminate and the RATE mode indicator should extinguish.

    Enter store mode. The STORE mode indicator should illuminate and the SCAN mode indicator should extinguish.

    Enter recall mode. The RCL mode indicator should illuminate and the STORE mode indicator should extinguish.

    Enter reset mode. The RESET mode indicator should illuminate and the RCL indicator should extinguish.

15. Set up the following scan parameters:

    Start frequency = 100 MHz
    Stop frequency = 200 MHz
    Step size = 1 MHz
    Step rate = 1 step/second
    Repeat = none

    Connect an oscilloscope to the X axis output connector. Set it for continuous monitoring of DC over a 0 - 10 Volt range. The initial voltage should be zero.

    Initiate an upward scan using the SELECT→ pushbutton. The indicator LED inside the pushbutton should illuminate and the scan should commence. Time the scan to completion. It should require 100 seconds. The indicator LED inside the pushbutton should extinguish at the end of the scan. The X axis output should proceed linearly from 0 to +10 Volts during the course of the scan.

    Initiate a downward scan using the←SELECT pushbutton. The indicator LED inside the pushbutton should illuminate as the scan commences. It should extinguish at the end of the scan.

16. Select front panel beep volume adjustment mode and rotate the tuning knob back and forth. The piezo transducer should sound and the volume should vary with the tuning knob position.

    Plug a speaker or headphone into the audio jack and select audio beep volume adjustment mode. Rotating the tuning knob back and forth should produce an audible indication through the speaker at varying volume levels.

17. Select display brightness adjustment mode and verify that the LED matrix character displays may be dimmed and extinguished.

5.2.1.2.2 Power Supply Monitor

There are three power supply status monitor indicators on the front panel of the radio, for AC line high, AC line low, and DC regulation. While it is not advisable to deliberately induce a regulation fault, it should be possible to exercise one or both of the AC line monitors by adjusting the range switch on the rear panel. Note that this test does not require the test equipment used by the standard test setup.

1. It is assumed that the 120 VAC/220 VAC selection was properly made before initial use of the radio.

2. Rotate the AC subrange switch on the rear panel across its range. If the mains voltage is nominal then one extreme setting should cause the AC HI indicator on the front panel to illuminate, while the other extreme should cause the AC LO indicator to illuminate.

3. At least one setting of the AC subrange switch should cause both AC line indicators to extinguish. If more than one setting does this then choose the one which is in the middle for normal use.

5.2.1.2.3 Reference Oscillator Output

Note that this test does not require the test equipment used by the standard test setup. It does require a frequency counter, however.

1. Connect a frequency counter to the reference oscillator output jack on the rear panel of the radio. The radio must be warmed up for at least 1 hour.

2. Measure the frequency at the monitor connector. It should be 20 MHz to within a couple of Hz.

5.2.1.2.4 RF Input Selection

This test exercises the RF input select relay. It is also the first throughput test of the signal path, so that many other problems may first show up here as well.

1. Begin with the standard test setup described in paragraph 5.2.1.1. A clear signal should be present from the IF on the spectrum analyzer screen and a DC offset from the video should be indicated on the oscilloscope.

2. Select RF input #2 without moving the signal generator connection. The indications on the spectrum analyzer and the oscilloscope should fall to zero (or nearly so).

3. Now reconnect the signal generator to RF input #2 and the 50 Ohm terminator to RF input #1. The signals on the spectrum analyzer and the oscilloscope should be identical to those seen in step 1.

4. Select RF input #1 without moving the signal generator connection. The indications on the spectrum analyzer and the oscilloscope shoud again fall to zero.

5.2.1.2.5 RF Input Attenuation

1. Begin with the standard test setup described in paragraph 5.2.1.1. From the standard attenuation setting of 20 dB, increase attenuation a step at a time and observe the results on the spectrum analyzer. Each step should cause a 10 dB reduction on the screen.

2. Return to 20 dB of attenuation and set the signal generator to -80 dBm. Now step the attenuation down. The indication on the spectrum analyzer should increase at 10 dB per step.

5.2.1.2.6 IF Gain Control

1. Begin with the standard test setup described in paragraph 5.2.1.1. From the standard gain setting of 50 dB, use the gain control to decrease the gain and observe the results on the spectrum analyzer. The IF signal should attenuate smoothly and linearly through the entire 50 dB range of the control.

5.2.1.2.7 IF Bandwidth Selection

For the 21.4 MHz IF bandwidths, front end noise is used as a broadband source and the effects of the various IF bandwidth filters observed. For DCIF bandwidths a signal must be applied. This is the first test in which the DCIF module is used. Up until now it has not been in the signal path.

1. Begin with the standard test setup described in paragraph 5.2.1.1. Select RF input #2 so as to monitor front-end noise.

2. Observe the noise bandwidth on the spectrum analyzer. At the standard setup bandwidth of 1 MHz, the noise bandwidth (-6 dB points) should also be 1 MHz. Note the video output level on the oscilloscope as well.

3. Now select the other 21.4 MHz IF bandwidths (everything available down to and including 80 kHz) and observe the noise bandwidth on the spectrum analyzer. In each case the bandwidth shown on the analyzer should match the bandwidth setting. The video output should remain at the same RMS level for each selection.

4. Select RF input #1 and 20 kHz bandwidth. This switches in the DCIF. Slightly vary the signal generator frequency to find the -6 dB points of the bandwidth. They should be at 10 kHz offset from 100 MHz. Make sure that the LOCK indicator is not illuminated, since this test initiates the use of two synthesizers which were not previously enabled.

5. Select bandwidths of 10 kHz and 5 kHz. In each case check the bandwidth at the output by varying the signal generator frequency, and verify that the LOCK indicator remains extinguished. These three bandwidths exercise the range of the DCIF filter clock synthesizer. In each case the -6 dB points should be offset half the nominal bandwidth from the tuned frequency of the radio.

5.2.1.2.8 Tuning Bands and Synthesizer Range

This test checks the signal paths of the three tuning bands. In doing so a few extra tuned frequencies will be included to run the programmable microwave and low frequency synthesizers through their ranges. This involves taking advantage of the band switching hysteresis available when using the tuning knob and pushbuttons. Note that this test is the first point in the procedure at which the low frequency RF module is used.

1. Begin with the standard test setup described in paragraph 5.2.1.1. Note the signal level indicated on the spectrum analyzer.

2. Tune the radio to 1 GHz and set the signal generator to this frequency as well. The spectrum analyzer should show the same signal level as before and the LOCK indicator should still be extinguished.

3. Tune the radio to 20 MHz. Now, using the tuning knob and pushbuttons BUT NOT THE KEYPAD, step the tuned frequency down to 13.5 MHz WITHOUT OVERSHOOTING. Set the signal generator to this frequency as well. The spectrum analyzer should show the same signal level as before and the LOCK indicator should still be extinguished.

4. Tune the radio to 7.5 MHz and set the signal generator to this frequency as well. The spectrum analyzer should show the same signal level as before and the LOCK indicator should still be extinguished.

5. Step the bandwidth down to 80 kHz and reduce gain to return the signal level on the spectrum analyzer to where it was before. Now, using the tuning knob and pusbuttons BUT NOT THE KEYPAD, step the tuned frequency up to 16.499999 MHz WITHOUT OVERSHOOTING. Set the signal generator to this frequency as well. The spectrum analyzer should show the same signal level as before and the LOCK indicator should still be extinguished.

6. Set the tuned frequency to 300 kHz. Now, using the tuning knob and pushbuttons BUT NOT THE KEYPAD, step the tuned frequency down to 225.0000 kHz WITHOUT OVERSHOOTING. Set the signal generator to this frequency as well. The spectrum analyzer should show the same signal level as before and the LOCK indicator should still be extinguished.

7. Set the tuned frequency to 200 kHz and set the signal generator to this frequency as well. The spectrum analzyer should show the same signal level as before and the LOCK indicator should still be extinguished.

8. Step the bandwidth down to 500 Hz and reduce gain to return the signal level on the spectrum analyzer to where it was before. Now, using the tuning knob and pushbuttons BUT NOT THE KEYPAD, step the tuned frequency up to 264.9999 kHz WITHOUT OVERSHOOTING. Set the signal generator to this frequency as well. The spectrum analyzer should show the same signal level as before and the LOCK indicator should still be extinguished.

9. Tune the radio to 1 kHz and set the signal generator to this frequency as well. The spectrum analyzer should show the same signal level as before and the LOCK indicator should still be extinguished.

5.2.1.2.9 Log Detector

The log detector and the linear detector use different signal pickoff points in the 21.4 MHz IF. In addition the DCIF performs its own detection and bypasses the linear detector when it is used in linear mode. This test checks the log detector both with and without the DCIF.

1. Begin with the standard test setup described in paragraph 5.2.1.1. Enable log detection.

2. Set the signal generator amplitude to produce 3.0 Volts of video as indicated on the oscilloscope. Now step the radio's RF input attenuation up and down and verify that each 10 dB step produces 0.5 Volts of change at the video output.

3. Set the bandwidth to 20 kHz. Adjust the signal generator for 3.0 Volts at the video output. Stepping the input attenuator should again cause the video output to change 0.5 Volts for each 10 dB step.

5.2.1.2.10 Overload Detectors

There is only one front end overload detector, but there are three for the back end: one for the 21.4 MHz IF, one for the DCIF, and one for the video. It is possible to test each one separately, using different combinations of radio settings.

1. Begin with the standard test setup described in paragraph 5.2.1.1. Then set the RF input attenuation to zero and gradually increase the signal generator level. The FR OVL indicator should illuminate when the signal generator is set somewhere between -30 dBm and -20 dBm.

2. Return to the standard test setup. Then gradually increase the signal generator level. The BK OVL indicator should illuminate at a signal generator level of around -50 dBm. This is a video overload.

3. Return to the standard test setup. Set the bandwidth to 1 kHz and gradually increase the signal generator level. The BK OVL indicator should illuminate when the 21.4 MHz IF level, as seen on the spectrum analyzer, reaches about +6 dBm. This is a DCIF overload.

4. Return to the standard test setup. Set bandwidth to 15 MHz, enable log detection, and gradually increase the signal generator level. The BK OVL indicator should illuminate when the video level, as seen on the oscilloscope, reaches about 3.5 Volts. This is a back end IF overload.

5.2.1.2.11 Signal Monitor and Z Axis Outputs

The signal monitor and Z axis outputs are both sent to connectors on the rear panel. Signal monitor is taken from the front end of the 21.4 MHz IF while Z axis is taken from the video. The Z axis output is provided with controls which must be exercised.

1. Begin with the standard test setup described in paragraph 5.2.1.1. Reconnect the spectrum analyzer to the signal monitor output jack on the rear panel of the radio and verify the presence of the 21.4 MHz IF signal. Then return the analyzer connection to the 21.4 MHz IF monitor jack.

2. While maintaining the existing oscilloscope connection to the video output, connect the other oscilloscope input to the Z axis output on the rear panel of the radio, using a 50 Ohm feed-through terminator. Set the oscilloscope to monitor both outputs simultaneously. Set the signal generator for 1 kHz AM modulation. In the standard test setup the Z axis output is disabled, so there should be no output visible on the oscilloscope.

3. Enable the Z axis output and set the level control fully clockwise. The Z axis output should show the AM modulation but no DC offset. The displayed modulation level should be about 1.5 times that present at the video output.

4. Rotate the Z axis level control counterclockwise. The Z axis output should reduce to zero. Now return the control to the fully clockwise position and press the invert pushbutton. The phase of the Z axis output should reverse relative to the video output.

5.2.1.2.12 Audio Output and BFO Detector

The output of the BFO detector, when enabled, replaces the output of the other detectors in the audio output only. Tests of the BFO and the audio output are grouped together for convenience.

1. Begin with the standard test setup described in paragraph 5.2.1.1. Plug a speaker or headphone into the audio output jack on the front panel of the radio. Select 1 kHz AM modulation on the signal generator and verify that the modulation appears at the audio output. Rotate the audio volume control back and forth and verify its operation.

2. Return the signal generator to unmodulated CW and enable BFO detection. Rotate the BFO control back and forth and verify a zero beat near the midrange position of the control, with increasing beat frequency on either side.

5.2.1.2.13 Autorange and AGC

Although these functions are implemented very differently, they perform a similar function. They are also grouped together in a single keypad operating mode.

1. Begin with the standard test setup described in paragraph 5.2.1.1. Enable the autorange function. Now vary the signal generator level and observe the input attenuation of the radio. It should step up and down to track the signal generator level loosely, with about 13 dB of hysteresis.

2. Return to the standard test setup and enable AGC. Reduce the signal generator level to minimum and gradually increase it. The video output level, as seen on the oscilloscope display, should level off as signal generator level increases, approaching about 3 Volts as a limit.

5.2.1.2.14 IEEE-488 Interface

The radio makes use of the IEEE-488 interface in two ways: to control an external microwave downconverter and to accept commands from an external host. The two are mutually exclusive, so that the interface may only be used for one purpose in any particular application. If the interface of the radio under test is not being used then the test is unnecessary. If the radio is used with an MDC then demonstrated control of the MDC is a sufficient test of the interface. If the radio is remotely controlled by a host then demonstration of that control is a sufficient test of the interface. A desktop computer with direct control of its IEEE-488 interface is listed in the test equipment table, for use when the equipment which is normally connected to the interface is unavailable. When using this computer it is sufficient to take control of the radio, issue a setting command to it, and read back the setting.

Factory-set interface address = 16
Example command = "FREQ 12345"
Example setting request = "FREQ?"

The return data in this case should be "1.2345E+4".

5.2.1.2.15 Sample Data Sheet

R-110 RECEIVER PERFORMANCE TEST

SAMPLE DATA SHEET

Serial Number: ____________ **Rev Level:** ____________ **Date:** ____________

Front Panel Operation:	______ (✓)	Comments: ______________________________	
Power Supply Monitor:	______ (✓)	Comments: ______________________________	
20 MHz Monitor:	______ (✓)	Comments: ______________________________	
RF Input Selection:	______ (✓)	Comments: ______________________________	
RF Input Attenuator:	______ (✓)	Comments: ______________________________	
Gain Control:	______ (✓)	Comments: ______________________________	
Bandwidth Selection:	______ (✓)	Comments: ______________________________	
Tuning Bands:	______ (✓)	Comments: ______________________________	
Synthesizer Range:	______ (✓)	Comments: ______________________________	
Log Detector:	______ (✓)	Comments: ______________________________	
Overload Detectors:	______ (✓)	Comments: ______________________________	
Signal Monitor:	______ (✓)	Comments: ______________________________	
Audio Output:	______ (✓)	Comments: ______________________________	
BFO Detector:	______ (✓)	Comments: ______________________________	
Autorange:	______ (✓)	Comments: ______________________________	
AGC:	______ (✓)	Comments: ______________________________	
IEEE-488 Interface:	______ (✓)	Comments: ______________________	(Optional)

Test Operator: ______________________

5.2.2 Fault Isolation

The R-110 is designed so that failures in the performance test, or other detected faults, may in most cases be easily isolated to a single failing assembly. If a failure is detected in normal use then the performance test may be of assistance in the first level of isolation, but in most cases the appropriate fault isolation procedure may be identified and followed directly.

Hardware which is likely to fail will almost certainly be contained in one of the following modules:

- front panel assembly
- microwave RF module
- preselector module
- low frequency RF module
- 21.4 MHz IF amplifier module and 21.4 MHz IF filter module
- DCIF module
- video module
- synthesizer section (microwave synthesizer module, low frequency synthesizer module, fixed LO synthesizer module, plus parts of the microwave RF module and preselector module)
- power supply (part of rear panel assembly)

Fault isolation is normally to the level of one of the modules or assemblies listed above. In addition, some faults may be further isolated within certain assemblies, such as the front panel or power supply. Replacement is usually at the assembly level, but schematics and parts lists are provided in chapter 6 for isolation to the component level.

Note that catastrophic power supply failures may require replacement of more than just the power supply. Certain circuits in the R-110 can be damaged under conditions in which some power supply voltages are present and others absent.

Note too that the section of the R-110 most susceptible to failure under extreme temperatures is again the power supply.

Following is a list of typical fault conditions and fault isolation suggestions for each. It should be possible to find an example which is similar enough to any major fault encountered to enable the fault to be localized. Minor faults, such as barely failing a spec involving end-to-end performance, may be more difficult to localize.

5.2.2.1 Radio Completely Dead

If the radio does nothing at all when power is applied, and no front panel indicators illuminate, then there is a problem in the power supply. First check the fuses, located in the AC input module on the rear panel. After the AC input module the common power path includes the front panel power switch and the cabling to it across the cardcage, the AC range switch on the rear panel, the fan, and the primary of the power transformer. If the fan works properly then most of this, at least up to the transformer, is probably ok. If the fan isn't working, then the problem is probably in this area. Note that the front panel power switch connects to the rear panel assembly with connectorized cables, which allows the front and rear panels to be separated from the cardcage. In conditions of extreme vibration these connectors may come loose. The DC harness linking the cardcage and the front panel assembly to the power supply also plugs into the rear panel assembly, so it too should be checked.

Next check the RF input select indicators on the front panel, which are located inside the RF input select pushbuttons. These are controlled by opposite outputs of a flip-flop, so if +5 VDC is available to the front panel control assembly then one or the other should be illuminated. Note that there are two separate +5 VDC regulators in the power supply, one for the front panel and one for the cardcage.

If +5 VDC is present at the front panel then the processor and displays should be working and yielding reasonable indications. If the power supply checks out but the front panel is still dead then check the mating of the DC supplies to the front panel assembly (the 15 pin D-sub on the back of the assembly). If power is being delivered adequately then suspect the processor PCB in the front panel assembly.

5.2.2.2 Front Panel Displays/Indicators Illuminated But Random

If +5 VDC is being supplied to the front panel assembly then at least some of the indicators should be illuminated. If the displays and indicators make no sense at all then the problem is probably in the processor PCB. If most of the displays and indicators appear to be okay, and the pushbuttons appear to be at least partly functional, then the problem is probably in either the switch/display PCB or the interface PCB, both in the front panel assembly. The pushbuttons and the tuning and gain controls, the LED indicators inside the pushbuttons, and the LED status and mode indicators surrounding the LED matrix character displays, are all sensed or driven via separate connections to the interface PCB, so it is not too difficult to identify which PCB is at fault once they have been removed from the front panel assembly sheet metal to allow probing. The LED matrix character displays are connected in parallel to a control bus from the interface PCB. Each display consists of four characters. If one display is bad then the fault is probably in the switch/display PCB. If all six are out then it is probably the interface PCB at fault.

The front panel piezo transducer requires +/- 15 VDC as well as control supplied by +5 VDC to operate. If it is not working then either it or its on/off switching transistor on the switch/display PCB may be bad, or the DAC-controlled voltage driver on the interface PCB may be bad. If neither the piezo transducer nor the audible indicator source to the audio output amplifier are working then the problem is in the interface PCB.

Once a problem has been narrowed down to the front panel assembly control circuits, fault isolation to one of the three PCBs is accomplished by taking apart the front panel assembly, removing the three PCBs and re-attaching them together outside the sheet metal. The 15 pin power connector may then be re-attached to the back of the processor PCB and the tuning and gain controls may be dismounted and re-attached to the switch/display PCB. This results in a complete, working control assembly without the surrounding sheet metal, which allows probing to localize a fault.

5.2.2.3 RF Input Selection/Attenuation Inoperative

The RF input relays and attenuator are the only items in the radio which require the use of the +24 VDC supply. The supply is the first thing to check. If it is okay but neither the input select relay nor the attenuator work, then the driver IC on the interface PCB is probably at fault. If only one function is inoperative then it may be a bad relay or attenuator, or one section of the driver IC.

Tuning in band 3 causes the front panel band select relay to direct the signal to the microwave module, while tuning in bands 1 and 2 cause it to direct the signal to the low frequency RF module. Faults which may appear to be caused by bad cardcage modules may be traceable to this relay (or the driver on the interface PCB) as well.

5.2.2.4 Audio Output or X Axis Output Inoperative

The audio output amplifier and the X axis output buffer are located on the X axis/audio output PCB in the front panel assembly.

The X axis output buffer uses the +/- 15 VDC supply from the cardcage. Its input comes from the interface PCB in the front panel assembly, which uses a +/- 15 VDC supply based on a different pair of regulators. A failing X axis output, given that the power supplies are good, is traceable to either the interface PCB or the X axis/audio output PCB, or the coax cable linking them, which might possibly become pinched in the partition during assembly.

The audio output amplifier consists of a front panel volume control, a preamp, and a power amp. All of the circuitry except for the volume control are located on the X axis/audio output PCB. The preamp and power amp are supplied by separate pairs of +/- 15 VDC regulators. The preamp shares its supply with the cardcage and the X axis buffer, while the power amp shares its supply with the front panel control section, where it is used by the DACs and amplifiers for the piezo transducer, the audio output beeper, and the X axis source.

The audio signal originates at the video module in the cardcage and is passed to the front panel assembly via coax cable. It passes through the volume control and the preamp and is then combined with the audible indicator signal from the interface PCB at the power amp. Thus if the audible indicator function works but there is no audio from the video module, then the volume control and preamp are suspect. If there is neither audible indicator function nor audio output then the power amplifier is suspect. If only the audible indicator function is failing then first make sure that the programmed volume is not set too low. Then suspect the connecting cable from the interface PCB, which can become pinched in the partition during assembly.

The X axis/audio output PCB has its own 9 pin D-sub power connector. If a failure is traced to this PCB then make sure that the power connector is mating properly.

5.2.2.5 One or More DC Supplies Inoperative

Here is a list of the DC supplies. Each listing has separate regulators, except for the +24 VDC supply, which is unregulated:

- +5 VDC for the front panel control section
- +5 VDC for the cardcage and the front panel cardcage interface buffer
- +24 VDC for the front panel input relays and attenuator
- +/- 15 VDC for the cardcage, the front panel audio preamp and X axis output buffer
- +/- 15 VDC for the audible indicator and X axis sources, the piezo transducer, the RS-232 interface, and the audio output power amp
- +/- 8 VDC for the cardcage
- +50 VDC for the cardcage

Cardcage voltages may be conveniently measured at the feed-through capacitors in the sidewall of the cardcage. Here is the color coding:

- green: +5 VDC
- brown: +8 VDC
- blue: -8 VDC
- red: +15 VDC
- violet: -15 VDC
- yellow: +50 VDC
- black: ground

Table 5-3 shows the usage of the various power supplies.

Table 5-3: Power Supply Usage

	+5 #1	+5 #2	+8	-8	+15 #1	-15 #1	+15 #2	-15 #2	+24	+50
Control Section	X	X					X	X	X	
X Axis/Audio Amplifier PCB					X	X	X	X		
Microwave RF Module		X		X	X					
Preselector Module		X			X	X				
Low Frequency RF Module			X	X	X					
21.4 MHz IF Amplifier Module		X	X	X	X	X				
21.4 MHz IF Filter Module			X	X						
Video Module		X	X	X	X	X				
DCIF Module		X	X	X	X	X				
Fixed LO Synthesizer Module		X			X	X				
Low Frequency Synthesizer Module		X			X	X				
Microwave Synthesizer Module		X			X	X				X

When a particular supply is at fault then the cause may be either the supply itself or something connected to it which is drawing excessive current. The first step in isolating the fault is to unplug or disconnect those modules and assemblies which use that supply. If it still fails without a load then the power supply is at fault. It is also possible that the supply fails only under load, but this is less likely.

A power supply monitor circuit is provided which sends the control section three status signals: AC line high, AC line low, and DC regulation. All three of these are passed to front panel indicators, so that if +5 VDC is available to the control section then the power supply section can usually indicate a power supply problem. AC high and AC low indications may normally be alleviated by changing the setting of the line voltage subrange switch on the rear panel. AC high causes no real problems other than excessive power dissipation and heat generation in the regulators. If the regulators get too hot then they go into thermal shutdown. AC low, if excessive, can result in insufficient headroom for the regulators, causing a regulation error as well. Thus any AC status indications should be alleviated before suspecting the regulators. Of course, the 120 VAC/220 VAC switch should be properly set before powering up the radio.

All of the power supply outputs are monitored by the DC regulation status indicator except for two:

- the +5 VDC supply to the control section. It is assumed that if it goes out of regulation then the control section will not be operational, obviating the need for a status indication.
- the -15 VDC supply which is used for the audio output power amplifier and the control section source circuits for the audible indication and X axis functions, and for the RS-232 drivers.

The +24 VDC supply is monitored at looser tolerance because it is unregulated.

5.2.2.6 Front Panel Operative, Signal Path Inoperative

This is a wide-ranging fault which may eventually be traced to almost any part of the radio. It assumes that none of the three tuning bands are operative.

A ribbon cable links the front panel assembly to the cardcage backplane. This ribbon cable is used to set control latches in the cardcage modules, and to return status as well. The interface originates in the front panel on the interface PCB, but is buffered in both directions on the processor PCB. These buffers use the same +5 VDC supply that is used by the cardcage, while the rest of the front panel uses a different supply. The buffer circuits are completely isolated from the rest of the processor PCB.

A quick check to see if the front panel to cardcage link is operating is to select log mode and listen for relays clicking in the video module. More relays should click in the video module when going in and out of the DCIF bandwidth range. The following cardcage modules receive control from the front panel:

- 21.4 MHz IF amplifier module
- video module
- DCIF module
- fixed LO synthesizer module
- microwave synthesizer module
- low frequency synthesizer module

In addition, control is relayed from the 21.4 MHz IF amplifier module to the microwave RF module, the low frequency RF module, and the 21.4 MHz IF filter module. The control interface from the front panel is bussed all the way across the backplane, so all of the module connectors will have the same interface signals on the same contacts. One way to check for operation of the interface is to monitor the data, address, write, and clear lines with an oscilloscope and verify that they show activity at both 0 and +5 Volts. The interface circuitry is based on HCMOS, so logic levels should be near the rails. The 2.4 Volt threshold used by normal TTL is not usable here.

If the control interface seems to be operational then the next thing to check is the programmable low frequency synthesizer. This is the only synthesizer that is necessary to the operation of all three tuning bands. If it is not working then the lock status indicator on the front panel and one or both of the indicator LEDs showing through the top of the low frequency synthesizer module should be illuminated.

Next check the front panel RF input circuiry. Signals should be applied to the RF inputs and verified exiting the front panel assembly at the appropriate connectors for tuning in band 1/2 and tuning in band 3. One of the most frequent radio failures is that the coax relays degrade over time, more rapidly than their specs would indicate.

The signal path splits before it comes out of the front panel assembly. Since it is assumed that none of the tuning bands work, the next place to check is the point at which the paths come back together, at the inputs to the IF amplifier module. If no signals appear here in any tuning band, then the cardcage control interface is again suspect.

The signal path goes from the 21.4 MHz IF amplifier module to the 21.4 MHz IF filter module and back again under most operating conditions. To simplify matters, select the widest bandwidth and linear detection. This eliminates the bandwidth filters which are normally switched into the path in series as they are selected, and selects a standard IF pickoff point for detection. Verify that the signal passes properly from the IF amplifier module to the IF filter module and back again. There are also two monitor points in the 21.4 MHz IF which are sent to the rear panel, and which may be used to make checking easier.

Now check that the signal arrives properly at the video module. If it does then the video module is the about all that is left that can be at fault.

5.2.2.7 Tuning Bands 1 and 2 Operative, Band 3 Inoperative

The band 2/3 break is at 15 MHz, using the keypad. It will vary from this if the tuning knob and pushbuttons are used, due to applied hysteresis about the nominal break frequency. Signal paths begin in common through the input select relay and attenuator in the front panel assembly, but then, still in the front panel assembly, are split into band 3 and band 1/2 paths with a relay. The band 1/2 path goes to the low frequency RF module while the band 3 path goes to a filter on the preselector module and from there to the microwave RF module. A relay at the input of the 21.4 MHz IF amplifier module selects between the outputs of the low frequency RF and microwave RF modules, ending the separation of the signal paths. The band 3 signal path makes use of three synthesizers not used by the band 1/2 signal path: the programmable microwave synthesizer, the 2 GHz fixed LO, and the 523 - 533 MHz mixer loop.

All synthesizer and loop-generated LOs in the radio produce lock status signals which are bussed together to drive a front panel status indicator. If the front panel LOCK indicator shows a problem then there are two ways to proceed. Some of the discrete lock status signals also drive indicator LEDs which show through the tops of their respective cardcage plug-in modules. An illuminated LED indicates out-of-lock, but make sure that the particular LED in question is associated with a loop currently in use, as some loops will be active but lose lock when they are not in use.

The discrete status lines are also delivered to the cardcage backplane individually. A particular lock status may be determined from the assigned backplane connector pin. These lines are bussed all the way across the backplane, so status may be verified from any connector.

The first thing to check is that the programmable microwave synthesizer, the 2 GHz loop, and the 523 - 533 MHz loop are all locked. Then verify that the distribution relay in the front panel is operating properly, delivering the signal to the preselector module when the radio is tuned in band 3. Next make sure that the signal is passing through the filter on the preselector module and arriving at the microwave RF module. The 1470 MHz IF may be verified by selecting external wideband operation and observing the wideband output on the top of the microwave module. If it is operational then verify that the signal is being delivered to the IF amplifier module at 21.4 MHz. If it is, then the only remaining item is the input select relay in the 21.4 MHz IF amplifier module.

5.2.2.8 Tuning Band 3 Operative, Bands 1/2 Inoperative

As in the previous case, the difference in the signal paths is localized. In this case band 1 uses an LO not used elsewhere, that being the 3 MHz fixed LO used for upconversion. This LO is made by picking off the third harmonic of a 1 MHz reference, not by implementing a loop. Therefore there is no lock status indication for it. If band 1 is failing but band 2 is okay then this is the first thing to check.

The signal path splits at the front panel RF input distribution relay. A signal should be applied to the RF inputs and its presence verified at the low frequency RF module input connector when the radio is tuned in those bands. If present then it should be verified at the band 1/2 input to the 21.4 MHz IF amplifier module. If present then the only remaining item is the input select relay in the 21.4 MHz IF amplifier module.

5.2.2.9 One or More IF Bandwidths Inoperative

The wider bandwidth filters are in the 21.4 MHz IF filter module, the narrower ones in the DCIF module. The widest DCIF bandwidth is 20 kHz.

The 21.4 MHz IF filter module sections are attached in series for each narrower bandwidth. In other words, for an 80 kHz selected bandwidth the 15 MHz, 4 MHz, 1 MHz, and 300 kHz filters will all be in the signal path in front of the 80 kHz filter. Selection is controlled by signals passed through the cardcage backplane from the IF amplifier module, which in turn is controlled by the front panel assembly.

Fault isolation in the wider bandwidths consists of applying a signal and, starting at 15 MHz bandwidth, selecting progressively smaller bandwidths until the failing filter is switched in.

The DCIF module uses switched capacitor filters to determine the bandwidth, controlled by a timebase consisting of a PLL synthesizer on the fixed LO module and a triple programmable divider on the DCIF module. Typically all of the DCIF bandwidths will work or none of them will. The signal passes through all of the filter sections in the 21.4 MHz IF filter module before going to the DCIF module, so all of these must be operational as well before the DCIF will work.

If the DCIF bandwidths are failing then the first thing to do is to make sure that the DCIF synthesizers, both the filter clock PLL and the 21.4 MHz fixed LO, are working. Each contributes to the front panel lock status indicator, and each is provided with a discrete indicator LED which shows through the top of the fixed LO synthesizer module. The discrete LEDs illuminate when the associated synthesizer is out of lock.

The next thing to do is to make sure that the signal switching is working. Verify that the signal arrives at the DCIF input when bandwidth selection is in the DCIF range. Note that there are two pickoffs for the DCIF in the 21.4 MHz IF, one for linear mode and one for log mode. Finally, make sure that the DCIF output makes it to the video module. If it does then the remaining item to suspect is the select relay at the input of the video module.

5.2.2.10 Not Enough or Too Much IF Gain Control Range

The front panel IF gain control has a range of 50 dB set by lookup tables in firmware. Single failing gain control settings are traceable to errors in the EEPROM on the processor PCB. If the span of the gain control is off, rather than all of the range being offset high or low, then the problem is probably in the 21.4 MHz IF amplifier module.

Four attenuator circuits are provided in the 21.4 MHz IF amplifier module. Three are employed to implement front panel IF gain control and AGC. The fourth is used to set (fixed) end-to-end gain. Each has a nominal range of about 17 dB, so each one that fails can have that much effect on the total. Note that the first two are controlled by the same circuit, so a failure of this control circuit can have twice as much effect.

One exception is log mode, wherein the third attenuator is bypassed, limiting the gain control range to 16.7 - 50 dB.

5.2.2.11 Autorange Function Inoperative

The autorange function is administered by the processor PCB and operates on the RF input attenuator, based on overload and underload status signals from the 21.4 MHz IF amplifier module. The overload signal also feeds the front overload status indicator. If the attenuator operates normally under manual control and the autorange function may be selected normally on the front panel then the problem is probably in the 21.4 MHz IF amplifier module.

5.2.2.12 AGC Function Inoperative

AGC begins with a slowly varying DC level developed from the video signal on the video module. This signal is routed to the 21.4 MHz IF amplifier module where it is gated with the AGC enable function and then combined with the outputs of the DACs which provide settable gain control. If the function may be selected normally on the front panel then an AGC failure is traceable to either the video module or the IF amplifier module. Monitoring the signal on coax cable connecting them should determine which one is failing.

5.2.2.13 BFO or Z Axis Function Inoperative

Both of these functions are implemented on the video module, so the video module is the prime suspect. However, both functions are provided with front panel controls which may also be the cause of failure. They are linked to the video module via coax cables.

5.2.2.14 Log Detector Inoperative

The log detector is located on the video module, so the video module is the prime suspect. Note that the input to the log detector can come from either the 21.4 MHz IF filter module or from the DCIF module.

5.2.2.15 IEEE-488 Interface Inoperative

The IEEE-488 interface is located on the processor PCB and is cabled to the rear panel using a shielded ribbon cable. Before assuming that the IEEE-488 interface is faulty, be sure to verify that it is enabled in the front panel. The two operating modes are remote and MDC, and only one at a time (or neither) may be enabled. Make sure that the interface address is set properly.

5.2.2.16 General Suggestions

The foregoing cases dealt mainly with catastrophic failures, in which a function failed to perform entirely. Similar isolation procedures may be appropriate when a function is merely out of spec. On the other hand, finding something like a loss of a few dB end-to-end in the signal path may take considerably more testing and effort.

As a general rule check the power supplies first. If they are functioning properly then check the synthesizer lock status indicator on the front panel. If the synthesizers are locked as well and the problem is not in a function that can be localized to one module, then check the signals at the signal monitor and 21.4 MHz IF outputs on the rear panel, and the 1470 MHz external wideband connector on top of the microwave RF module. This should serve to provide the first step in localizing the problem.

5.3 Disassembly

The receiver consists of a one-piece cover and three major assemblies:

- the cardcage assembly (A1)
- the front panel assembly (A2)
- the rear panel assembly (A3)

Each of these major assemblies contains subassemblies. The cardcage is easiest to service because all of its subassemblies (except for the backplane) are in the form of plug-in modules, each held in place with a pair of finger-tight retaining screws. Disassembly of the other two major assemblies is more involved.

This section gives instructions for removing the cover, removing the front and rear panel assemblies from the cardcage assembly, and disassembling the front and rear assemblies sufficiently to remove and replace the subassemblies inside. Instructions are also given for replacing the cardcage backplane. General instructions are given for removing and replacing the cardcage's plug-in modules.

5.3.1 Cover Removal and Replacement

The receiver is contained in a one-piece cover. The internal assemblies are mounted together so that when the cover is removed, what remains will be a single unit.

Procedure:

1. Make sure that the power cord and other cable connections are removed from the receiver.
2. Remove the rack slides, if attached, by removing three screws from each.
3. Place the radio on a flat surface with the front panel facing upward.
4. Remove 14 flat-head screws from the cover: three in the top front, three in the bottom front, three in the top rear, three in the bottom rear, and one on each side in the rear.
5. Remove the cover by pulling it straight up. Since there is gasketing and an intentional tight fit between the internal assemblies and the cover, it may be necessary to press on the front panel as well.

CAUTION

BE CAREFUL OF THE GASKETING AROUND THE INNER EDGE OF THE LIP AROUND THE FRONT OF THE COVER, AND THE GASKETING AROUND THE OUTSIDE OF THE REAR PANEL ASSEMBLY. BOTH ARE DELICATE AND SUBJECT TO SHEARING AND BREAKAGE.

6. Replace the cover by reversing the preceding steps. Again, be very careful of the gasketing at the front of the cover and around the outside of the rear panel assembly.

5.3.2 Plug-In Module Removal and Replacement

Except for the microwave RF module (A1A1), the cardcage's plug-in modules consist of printed circuit boards mounted on shield plates. The plates slide into guides in the cardcage to locate the module, and are provided with ears which contain captive hold-down screws. The printed circuit board contains a double-row DIN connector which plugs into the backplane, plus a number of coax connections which are accessed through holes in the top of the shield plate. A harness of flexible and semi-rigid coax cables is spread across the top of the cardcage, linking the plug-in modules to each other and to the front and rear panel assemblies as well.

The microwave RF module consists of an aluminum block with cavities milled into it, each covered with an aluminum plate. The plates are held in place by aluminum strips, which in turn are held down with numerous small screws. The block is mounted to a printed circuit board which distributes power to the various cavities via feed-throughs. The module is mounted just past the end of the cardcage backplane. The printed circuit board slides into guides in the cardcage, and the aluminum block is provided with mounting ears which contain captive hold-down screws. In addition to coax connections, a discrete-wire pigtail from the backplane plugs into a header at the top of the printed circuit board.

Procedure:

1. Remove the cover. See paragraph 5.3.1.

2. Identify the module to be removed. Each is labeled with an assembly number, from A1 to A17, corresponding to its location in the cardcage.

3. Unplug the coax cables from the top of the module to be removed. They are color-coded for easy replacement. If the microwave RF module is to be removed, unplug the discrete wire pigtail connecting it to the backplane.

4. Unscrew the hold-down screw located at each end of the shield (or, for the microwave module, at each end of the aluminum block).

5. Remove the module by lifting it straight out.

CAUTION

MAKE SURE THAT ALL COAX CABLES ARE OUT OF THE WAY BEFORE REMOVING THE MODULE. DAMAGE TO THE CABLES MAY OTHERWISE RESULT.

6. Replace the module by reversing the preceding steps. Note that if a new or serviced module is being replaced, then recalibration of the receiver may be required.

5.3.3 Cardcage Backplane Removal and Replacement

Removal of the backplane is somewhat involved. It requires soldering and a certain amount of mechanical adjustment. In addition, the entire coax harness and all of the plug-in modules must be removed. Removal of the backplane is not recommended unless absolutely necessary, and even then it is recommended that it be done at the factory. If a single connector fails then it may be possible to replace it without removing the backplane from the cardcage.

The procedure is not given in complete detail, since it is assumed that the person performing it is already familiar with what is required.

Removal Procedure:

1. Remove the cover. See paragraph 5.3.1.

2. Unplug all of the coax cables from the plug-in modules. Unplug the discrete wire pigtail from the microwave RF module.

3. Remove all of the plug-in modules from the cardcage. Unplug the microwave module pigtail and the ribbon cable to the front panel assembly from the backplane. It may be more comfortable to remove the front and rear panel assemblies from the cardcage as well, but this is not strictly necessary.

4. Using a controlled-heat soldering iron, unsolder the ten discrete wires linking the backplane to the feed-through capacitors in the sidewall of the cardcage.

5. Remove the 11 screws holding the backplane to the cardcage. The backplane should now drop from the bottom of the cardcage.

Replacement Procedure:

1. Re-mount the backplane to the cardcage with the 11 screws previously removed.

2. Temporarily slide plug-in modules into place at each end to verify seating height. This may be adjusted by loosening the screws that hold the backplane mounting brackets to the cardcage proper. After verifying the seating height, remove the plug in modules.

3. Re-solder the power wires to the backplane. The backplane schematic (493061) given in section 6 indicates which wire goes where. Replace the front and rear panel assemblies if they were removed.

4. Plug the microwave RF module discrete wire pigtail and the front panel interface cable into the backplane. Then replace all of the plug-in modules, matching their labeled designations to the matching socket designations in the backplane. Plug the other end of the discrete wire pigtail into the microwave module.

5. Replace the coax harness. The connections are color-coded for each module. The flexible and semi-rigid cable diagrams (493055 and 493057) given in section 6 may assist in this.

6. Replace the cover.

5.3.4 Front Panel Assembly Removal and Replacement

The front panel assembly (493600) may be removed from the cardcage assembly by removing a few screws and unplugging a few cables.

Procedure:

1. Remove the cover. See paragraph 5.3.1.

2. There are two semi-rigid cables leading from the front panel assembly to the preselector module (A1A2) and the low frequency RF module (A1A5). Unplug them at the modules.

3. Remove the four flat-head screws in the cardcage flanges which hold the front panel assembly to the cardcage. Make sure to remove these four screws and not the ones adjacent to them in the front panel assembly itself. Separate the front panel assembly slightly from the cardcage, but do not try to remove it completely yet.

4. Unplug the following cables from the rear of the front panel assembly:

   - the IEEE-488 and rear panel status cables (the shielded ribbons).
   - the Z axis, BFO, video, and audio coax cables
   - the DC power connectors (9 and 15 pin discrete-wire D-subs)
   - the cardcage interface cable (37 conductor ribbon)
   - the AC cable (4 pin discrete)

   Do not remove the two semi-rigid coax cables.

5. The front panel assembly may now be completely removed from the cardcage.

6. To replace the front panel assembly, reverse the preceding steps. All cables except for the flexible coax will only fit in one front panel assembly connector, in one orientation. The flexible coax cables all lead to the video module (A1A11) and are color-coded.

5.3.5 Front Panel Disassembly

The front panel assembly (493600) contains three printed circuit boards:

- Switch/display PCB (A2A1)
- Interface PCB (A2A2)
- Processor PCB (A2A3)
- X axis/audio amplifier PCB (A2A4)

In addition, it contains numerous small electromechanical subassemblies which may eventually fail and require replacement. Disassembly is fairly easy, but reassembly is somewhat more tedious.

Disassembly Procedure:

1. Remove the cover. See paragraph 5.3.1.

2. Remove the front panel assembly from the cardcage. See paragraph 5.3.4.

3. Remove the hex nuts retaining the RF input connectors (the BNC connectors on the left side of the front panel). Be careful not to scratch the paint, and to keep track of the mounting hardware.

4. Remove the 12 flathead screws holding the front panel rear bulkhead to the rest of the assembly. Gently slide the bulkhead out of the rear of the assembly an inch or two. Make sure that the RF input connectors withdraw from their mounting holes in the front panel.

5. Unplug the three coax cables attached to the X axis/audio output PCB (A2A4), and the three other coax cables attached to feed-throughs around it. Unplug the audio output jack pigtail and the audio gain control pigtail from the X axis/audio output PCB. Unplug the relay and attenuator pigtails from the interface PCB (A2A2).

6. Now remove the bulkhead subassembly from the rest of the front panel assembly.

7. The X axis/audio output PCB and the coax relay and attenuator subassemblies, all mounted to the bulkhead, are now available for removal and replacement. The semi-rigid cables connecting the relays and the attenuator use SMA-type connectors. A torque wrench is required when re-mounting these cables. Note that the relays and the attenuator are isolated from the bulkhead by insulating wafers.

8. The power switch subassembly may be removed by first removing the screw which holds the pigtail connector to the side of the front panel box. The subassembly may then be pressed out through the front of the panel.

9. The X axis and video BNC connectors, the audio jack subassembly, the audio gain control subassembly, and the BFO and Z axis control subassemblies may now be removed by removing the nuts which retain them to the front panel. Note that the audio output jack requires insulating washers to isolate it from the front panel sheet metal.

10. The switch/display, interface, and processor PCBs (A2A1, A2A2, A2A3) may be removed by first removing the mounting screws from the back of the processor PCB. The three PCBs plug into each other in sequence, and are held together by threaded standoffs. Remove one PCB at a time until the desired PCB is removed. Note that the pigtails from the tuning and gain control subassemblies must be unplugged from the switch/display PCB before it may be removed.

11. Removal of the tuning and gain control subassemblies requires prior removal of all three of the PCBs. The controls may then be removed by removing the retaining nuts holding them to the front panel.

Reassembly Procedure:

1. Remount any front panel control and connector subassemblies (except for the RF input connectors) that have been removed. If the power switch has been removed then press it back in place with the wiring facing down, and remount the pigtail connector to the side of the front panel box. The audio gain control potentiometer and the tuning and gain controls must also be mounted wiring-side down. The BFO and Z axis controls must be mounted with the wiring facing up. The video output BNC connector has an SMB connector on its pigtail, while the X axis output connector has an MCX connector on its pigtail. Make sure that the audio output connector has been remounted with insulating washers, and verify that there is no electrical contact between the body of the jack and the front panel sheet metal.

2. Remount the switch/display PCB by first plugging in the pigtails from the tuning and gain controls. Then place the PCB against the standoffs, making sure that all of the pushbuttons fit through their holes in the front panel. Make sure that the tuning and gain control pigtails aren't pinched. Replace the standoffs and the two screws which hold it in place.

3. Replace the interface and processor PCBs by first plugging the interface PCB into the back of the switch/display PCB, being careful not to offset the double-row connectors. Then replace the standoffs and the screw which hold the interface PCB to the switch/display PCB. Plug the processor PCB into the back of the interface PCB, again being sure that the double-row connectors are not offset. Replace the screws holding the processor PCB to the interface PCB. Note that some of the screws may not be furnished with washers or lockwashers, in order to provide clearance for the bulkhead.

4. Reassemble the bulkhead by re-mounting the relays and the attenuator if they were removed. Note that insulating wafers are required between them and the bulkhead sheet metal. The relays are mounted with nylon screws, and the attenuator uses insulating washers. Note that the semi-rigid cables which connect to the bulkhead are also mounted with insulating washers. See the assembly drawing (493607) for details. When complete, verify that there is no electrical contact between the bodies of the relays, the attenuator, or the cables, and the bulkhead sheetmetal.

   Remount the X axis/audio output PCB by placing it on its standoffs and replacing the screws which hold the PCB to the bulkhead. Make sure that the mounting hardware does not contact the ground planes on the PCB. Make sure that the two connectors on the rear of the PCB do not contact the bulkhead sheetmetal. Then mount the two power ICs to the bulkhead. The larger one requires an insulating pad and nylon hardware, while the smaller one mounts directly. See the assembly drawing for details. Verify that there is no electrical contact between the ground planes of the PCB and the bulkhead sheetmetal, nor between the mounting tab of the larger power IC and the sheetmetal.

5. Place the bulkhead in position behind the front panel box, leaving a little space. Plug the relay and attenuator pigtails into their respective headers on the interface PCB. The attenuator pigtail plugs onto the four pin header, the input select relay pigtail into the upper three pin header, and the band select relay into the lower three pin header.

   Plug the flexible coax cables attached to the interface PCB into the X axis/audio output PCB. The short cable goes to the X axis input (J7) at the bottom center of the PCB while the long cable goes to the beeper input (J3) at the top of the PCB. Plug the X axis output connector pigtail into the X axis output connector (J6) at the bottom edge of the PCB. Plug the video output connector pigtail into the feed-through connector inside the "L" of the PCB. Plug the Z axis control pigtail into the feed-through connector which is the far-right member of the set of four at the top of the bulkhead. Plug the BFO control pigtail into the feed-through connector adjacent to it. Plug the audio gain control and audio output jack pigtails into the PCB.

6. Slowly slide the bulkhead into the back of the front panel box. The pigtails from the relays and the attenuator must fit into the notch at the top of the bulkhead partition. The two flexible coax cables connecting the interface PCB to the X axis/audio output PCB must first go between the interface and processor PCBs, going around the processor PCB through the cut-away part of the PCB at the bottom, next to the front panel box. The cables must then go through the notch at the bottom of the partition on the bulkhead. Make sure that the RF input connectors pass through their mounting holes in the front panel.

CAUTION

BE EXTREMELY CAREFUL NOT TO PINCH THE CONNECTING WIRES AND CABLES WHEN SLIDING THE BULKHEAD INTO THE BACK OF THE FRONT PANEL ASSEMBLY. ELECTRICAL DAMAGE MAY RESULT WHEN POWER IS RE-APPLIED.

7. Replace the 12 flathead screws holding the bulkhead to the front panel can. Replace the mounting hardware holding the RF input connectors to the front panel. Note that insulating washers are required. Verify that there is no electrical contact between the connectors and the front panel sheetmetal.

5.3.6 Rear Panel Assembly Removal and Replacement

The rear panel assembly (493700) mounts to the rear of the cardcage inside a mu-metal shield, and contains the power supply. It also supports rear-panel connections for AC input, the IEEE-488 interface, and various analog and digital signal monitors.

The assembly consists of a sheet metal panel, a PCB, and assorted hardware in between.

Procedure:

1. Remove the cover. See paragraph 5.3.1.

2. Remove the mounting hardware holding the 20 MHz clock reference monitor jack to the rear panel sheetmetal. This is the only one of the monitor jacks which is fed by semi-rigid cable. Unplug the remaining flexible coax cables from their connections on the cardcage plug-in modules.

3. Remove the two screws which hold the digital connector butch plate to the rear panel.

4. Remove the four screws (one at each corner of the rear panel) which holds the rear panel to the cardcage. Gently draw the rear panel assembly slightly away from the cardcage, making sure that the 20 MHz reference monitor BNC connector and the digital connector butch plate do not bind.

5. Unplug the AC (four pin) and DC (25 pin D-sub) pigtails coming from the cardcage, from their mating connectors in the rear panel assembly.

6. Gently remove the rear panel assembly from the cardcage, drawing the flexible coax cables out through the hole in the mu-metal shield.

7. To reassemble, reverse the preceding steps. The cardcage coax cable assembly drawing (493055), provided in section 6, indicates where to reconnect the flexible coax cables in the cardcage.

5.3.7 Rear Panel Disassembly

The rear panel assembly (493700) consists of the rear panel sheetmetal, the power supply PCB, and various other hardware. The procedure given here will separate the power supply PCB from the sheetmetal, which provides easy access to all of the other hardware.

Procedure:

1. Remove the cover. See paragraph 5.3.1.

2. Remove the rear panel assembly from the cardcage. See paragraph 5.3.6.

3. Remove the hardware holding the AC line range/subrange switch to the rear panel.

4. Unplug the three slide-on connections from the rear of the AC line entry module. Unplug the power cable leading to the fan.

5. Remove the six screws holding the heatsinks to the rear panel. Remove the large bolt holding the power transformer to the rear panel.

6. Remove the power supply PCB from the rear panel. The AC line range switch will remain connected to the PCB, free-hanging. It is recommended that dummy hardware be used to hold the heatsink assemblies and the power transformer to the power supply PCB while it is being serviced.

7. To reassemble the rear panel, reverse the preceding steps.