FLUX RESEARCH

Technical Service Bulletin:
FXR-10

Modifying GE/MACOM MASTR-III Group 6 (403 MHz – 430 MHz) for Amateur Radio Applications (440 – 450 MHz)

A FluX Research project in several phases

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Radio Model #:
GE/MACOM MASTR-III Group 6 Repeater or Base, Combination Number SXS

Warning:

Please be aware that this document is currently a work in progress which may contain several omissions and or typographical errors, continue reading at your own risk.

Background:

The following LBIs may be helpful:

LBI38540D Mastr IIe / III UTILITY PROGRAM

LBI38636C Mastr III CONVENIONAL BASE STATION Installation Manual

LBI38550A Mastr II / III SITE EQUIPMENT POWER SUPPLY
LBI38625A Mastr III EMERGENCY POWER OPTIONS

LBI38754A Mastr III RF PACKAGE VHF GROUP 2 (150.8-174 MHz)

LBI38637 Mastr III T/R SHELF 19D902839G1
LBI38671N UHF TRANSMITTER SYNTHESIZER 19D902780G3, G6-G10
LBI38672L UHF RECEIVER SYNTHESIZER 19D902781G3, G7, G8, G10, G12
LBI38673J UHF RECEIVER FRONT END MODULE 19D902782G3, G4 & G7
LBI39129B UHF RECEIVER FRONT END MODULE 19D902782G6, G8-G11
LBI38643B 25kHz RECEIVER IF MODULE 19D902783G1
LBI39123 12.5/25KHZ RECEIVER IF MODULE 19D902783G7

LBI38764C EARLY SYSTEM MODULE 19D902590G1, G3, G5
LBI39176 LATE SYSTEM MODULE 19D902590G6 & G7
LBI38752B SWITCHING POWER SUPPLY MODULE 19D902589G2, 19D902961

LBI38674L Mastr III 75-90-110 WATT POWER AMPLIFIERS 19D902797G3 G6-G11

Phase 0: Preparations

Make sure the station to be converted is in good working order on its original frequencies before attempting conversion to Amateur Radio use. Note that a Fault light on the Receiver Synthesizer Module may be the result of a missing External Reference Source, or the result of the previous owner attempting to program the radio out of range. Verify in programming software and set source to internal if that is the case.

About 90% of the screws in the MASTR-III T/R Frame are Torx T-15. The remaining are Phillips #2 and T-6, T-8, T-10, which are mostly found in the power supply module and power amplifier.

To tune the Receiver Front End module properly, I recommend access to a service monitor with a spectrum analyzer (HP-8920 series, IFR-1600S or similar). It is possible to use a signal generator and a frequency selective RF volt meter, or service monitor with simultaneous generate and receive but not as easy as you can't see where the peaks and dips are.

You will need to acquire a copy of TQ-3353 Mastr-IIe, III Programming Software (M2E.BAT, M3.BAT). This should also come with TQ-0619 (MASTRUTL.BAT)

Full Modification requires some surface mount soldering as well as through hole soldering. You will need a quality soldering Iron. I use a Weller with a 800 degree Tip R. You will need basic de-soldering equipment such as a Sold-a-pult ™ and Thick gauge solder wick.

0.015" solder, and fine tweezers is needed for the surface mount parts. You will also need thicker gauge solder such as 0.025" and a brute force tip for use on the VCO coils. I recommend 2% silver solder.

The station that was converted contains the following modules:

UHF Transmit Synthesizer, Group 6 (403 – 430 MHz)
UHF Receive Synthesizer, Group 3 (424.4 MHz - 451.4 MHz)
UHF Front End, Group 11 (410 – 430 MHz)
UHF Power Amplifier, Group 6 (403 – 425 MHz)

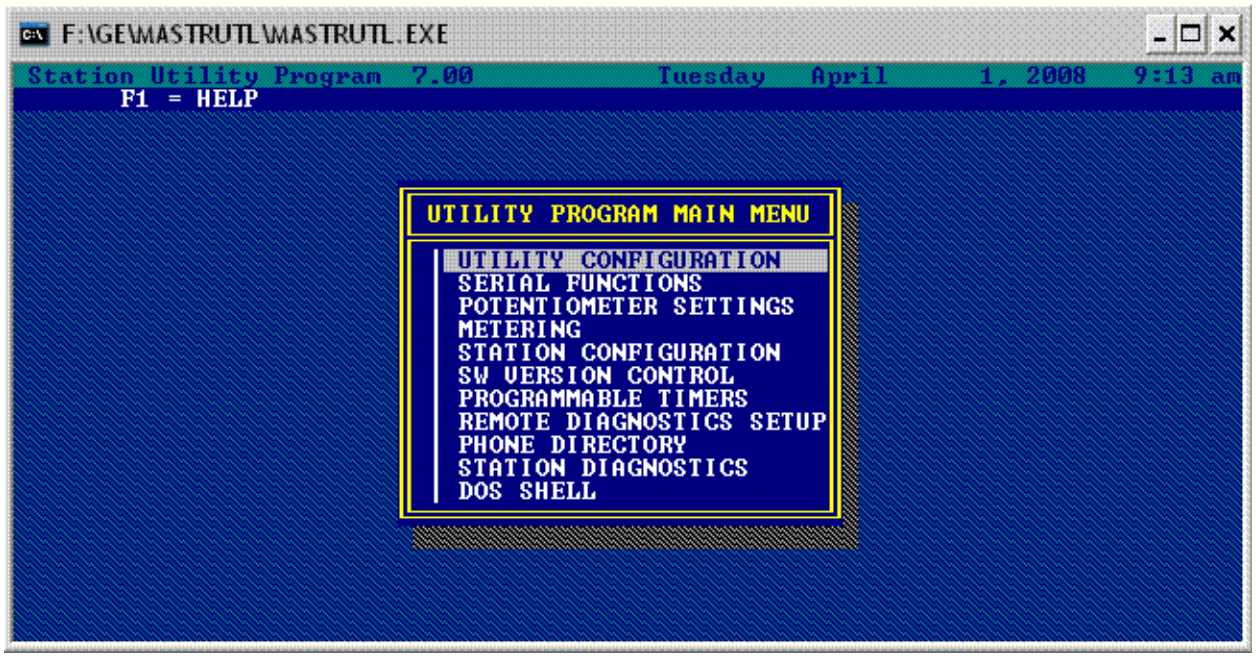
Please note that the G11 Front end uses high side LO injection hence the need for a G3 Synthesizer which normally provides low side injection for the G3 (450 – 470 MHz) front end.

Phase 1: Operating Frequency Reprogramming

Please Refer to LBI38540D

Connection to the repeater is done with a straight through DB-9 RS-232 cable. Connect either to the Data Port on the front of the repeater or the DB-9 connection on the rear of the interface board.

MASTRUTL.BAT is used as a utility to verify station operation and to set potentiometer values.



You will use this application to set the repeat audio levels and transmitter power output. It can also help diagnose the repeater to a degree with the ability to convey that one or more modules are malfunctioning.

M2E.BAT and M3.BAT are designed to change the station operating parameters, such as CTCSS tones, hang times and in the case of the MASTR-III the operating frequencies.



It is important that the software be in MASTR-III mode. Programming the repeater with the software in M2e mode may inadvertently brick the System Module requiring replacement. Start the software with M3.BAT. Be sure the screen looks like above with the ‘MASTR-III Control Shelf Programming’ at the top.

This software has some compatibility issues as it is an older DOS based program. A PIII tablet with a USB to RS-232 adapter and WinXP would not program, but a PII laptop with a hardware based serial port and WinXP would.

Read and save the current configuration. Use F6. Read it twice, once as a backup then the other as the file you will be editing.

Once that is done highlight the file you will be editing and hit F2. Edit the data to your new operating parameters. We will be using low side injection from the Receiver Synthesizer Module, It is necessary to configure this in the programming. With the RX frequency field highlighted, Press ‘CTRL E’. When prompted, press ‘O’ for opposite side injection.

Use F9 over any field to get a description of what it adjusts. For some reason ‘space’ is not an allowed character when programming the morse code ID so don’t pull your hair out. Once done save the data by pressing F10 and then F1 and confirm the over write.

Send programming data to the repeater by pressing F5 and selecting the file you just edited.

The Fault LEDs on the Transmitter and Receiver synthesizer modules should now be lit as the PLLs are no longer able to lock. There may be a slight flicker on the LEDs as the System Module will be attempting to reset the synthesizers until the Fault clears.

Phase 2: UHF Transmitter Synthesizer Module

Please Refer to LBI38671N

This procedure transforms the module Group 6 (403 – 430 MHz) module fairly close to Group 7 (425 – 450 MHz).

My station was equipped with a Group 3 Receive Synthesizer which provides high side injection for the Group 11 Front End. This means the module has a designed output range of 428.6 – 448.6 MHz. Therefore it was decided that the ideal course of action was to switch the VCO coils.

Remove the Transmitter Synthesizer Module from the T/R frame. Using a Torx T-15 screwdriver, remove the top and bottom lids of the module. Remove the VCO cover.

From the underside of the board desolder L1 and set it aside. L1 should be Red. Remove the excess solder from L1 and the L1 mounting holes on the PCB with solder wick.

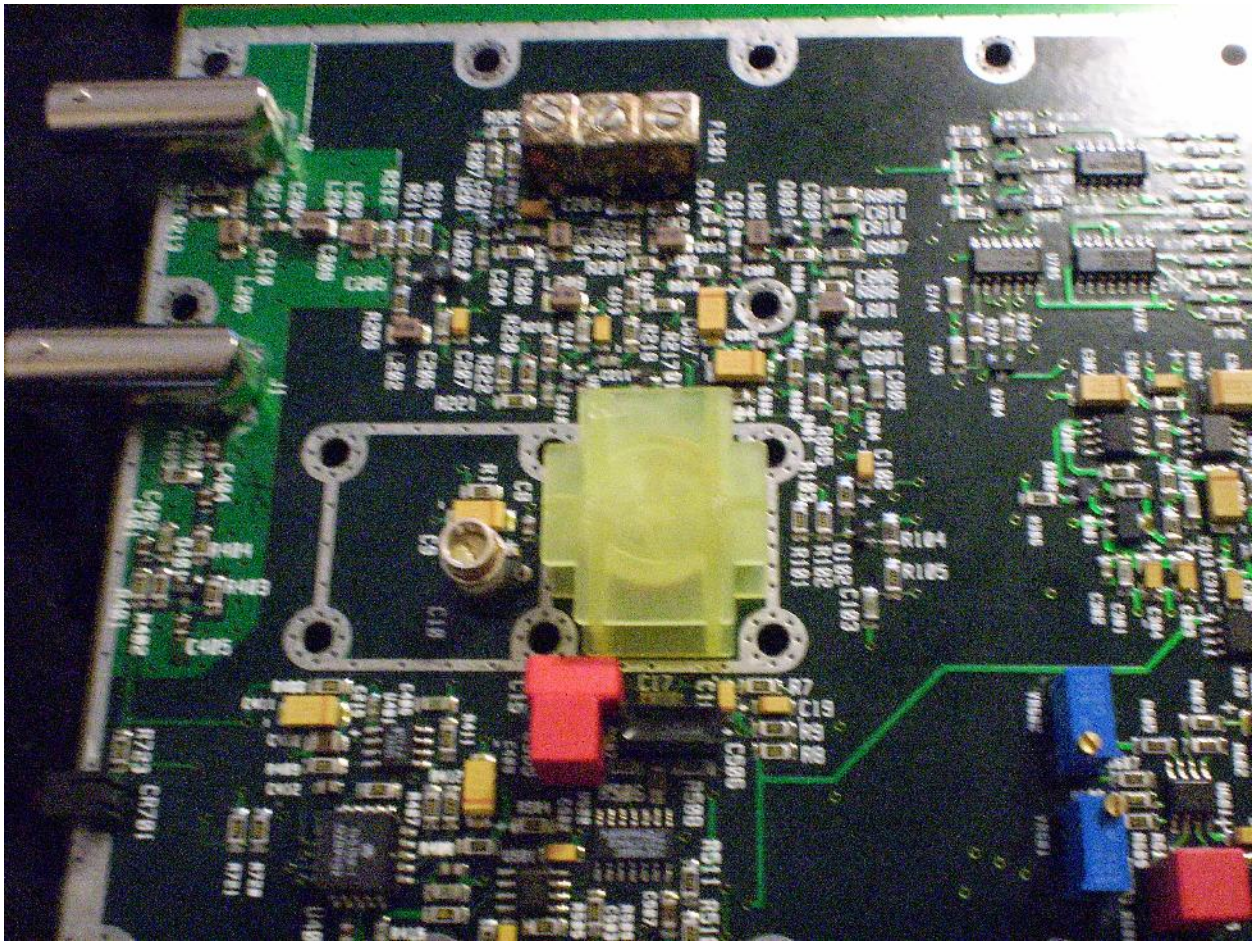
Remove the Receiver Synthesizer Module from the T/R frame. Using a Torx T-15 screwdriver, remove the top and bottom lids of the module. Remove the VCO cover.

Salvage L10 from the Receiver Synthesizer and carefully set it aside. L10 should be Yellow. Remove the excess solder from L10 and the L10 mounting holes on the PCB with solder wick.

Perform the following parts swap:

Replace C5 with 10pF Ceramic NP0 (C0G) 0805, Please note C5 is on the under side of the board.

Solder RX Synthesizer L10 (Yellow) in the TX Synthesizer L1 position.
Solder TX Synthesizer L1 (Red) in the RX Synthesizer L10 position.



Modified Transmit Synthesizer VCO

Please note that C4 and C5 are on the under side of the board.

Replace FL201 with GE Part Number 19A705458P5, this part can be found in some Front End Modules. Or retune FL201 to pass approximately 425 – 450 MHz. This is done by soldering a RG-58 jumper to the input side of the filter and sweep generating into it while viewing the output from the RF output jack. Slugs should be approximately 2 turns above flush with the cans. Once tuned place some electrical tape over the slugs.

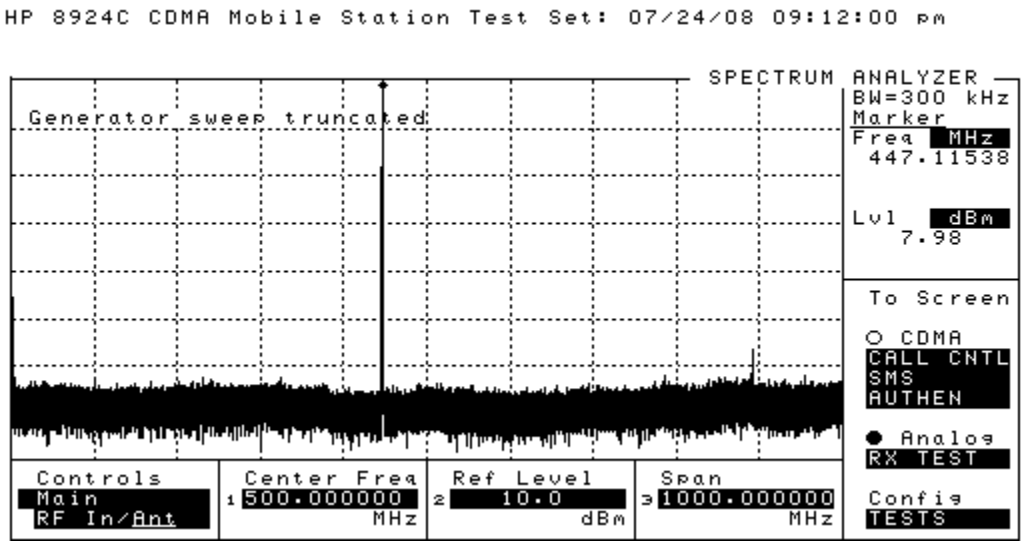
VCO Tuning has to be done with the shielding in place. Reassemble the module and replace the card back into the T/R frame. Do not connect Reference Input yet. Connect a spectrum analyzer or a frequency counter that can tolerate +10dBm and adjust C10 until the module is at the lowest desired usable frequency. I set this at 435 MHz. Metal tools will affect tuning so adjust and remove.

If tuning can not be achieved, add 0.5 - 3.3pF capacitor to the C4 position and try again.

Temporarily insert the Receive Synthesizer into the T/R frame and connect reference output to the reference input of the Transmit Synthesizer. Put the station into transmit

mode and notice that the Fault LED should no longer be lit and module is transmitting on frequency.

With a spectrum analyzer verify the output of the module to be approximately 10 - 20 mW (10 – 13 dBm)



Transmitter Synthesizer Spectrum Analysis

Phase 3: UHF Receiver Synthesizer Module

Please Refer to LBI38672L

Please note that the Group 11 Front End (410 – 430 MHz) uses a Group 3 (450 – 470 MHz) Synthesizer, which generates high side Local Oscillator injection. We are converting the receiver synthesizer to act similar to a Group 8 (380 – 400 MHz) module, which provides 401.4 – 421.4 MHz.

The converted module will now provide low side injection for the Group 11 front end from 403.6 – 428.6 MHz, Note that this is fairly close to the original Group 6 Transmitter. The output frequency of the Receiver Synthesizer Module will be Receive Frequency - 21.4 MHz. i.e. 441.3 MHz - 21.4 MHz = 419.9 MHz.

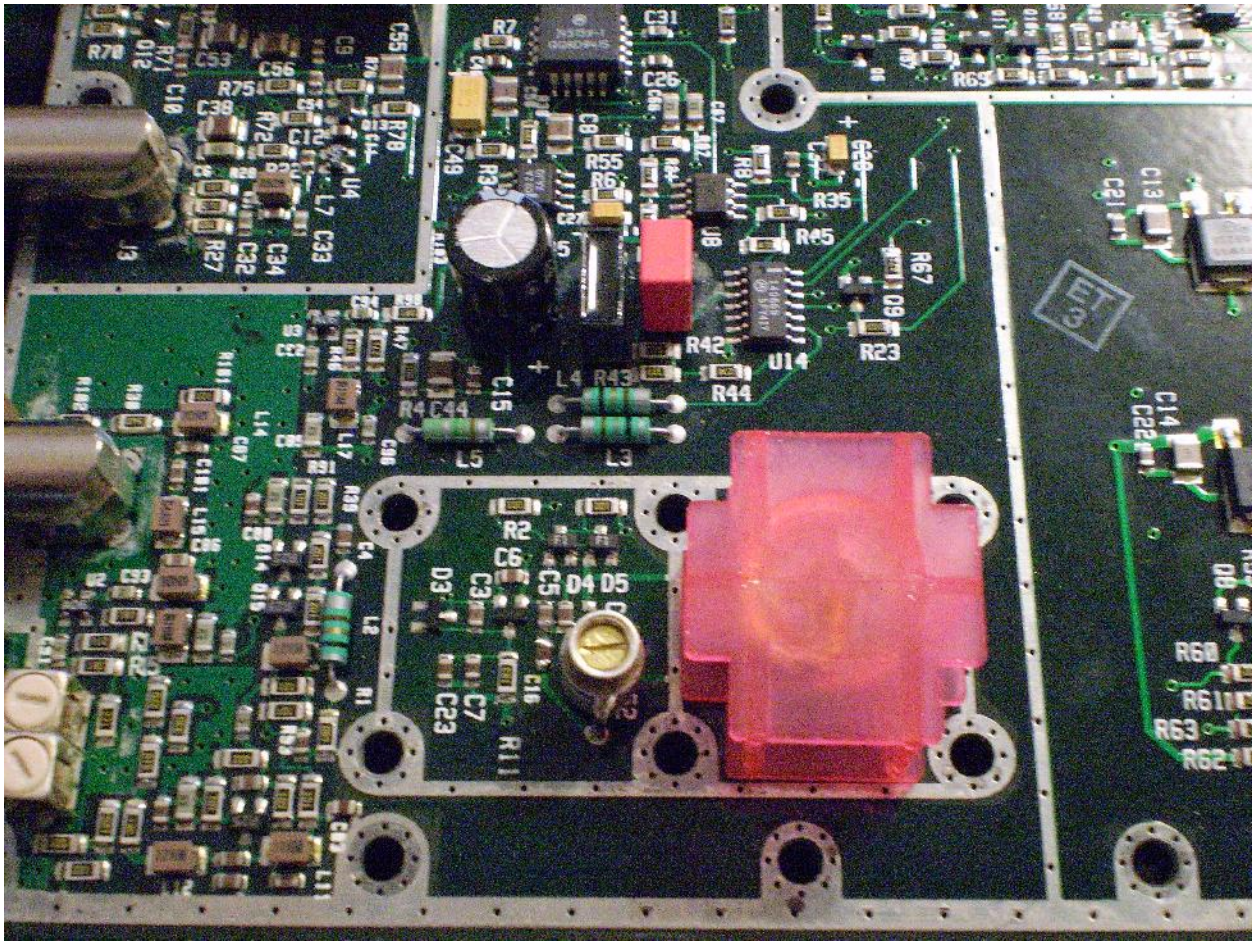
Low side injection is more desirable for Amateur applications as the receive images will be from the Government band opposed to the Commercial band and UHF TV.

Remove the Receiver Synthesizer Module from the T/R frame. This should already be disassembled from Phase 2 of the conversion process.

Retune filter FL1 to pass 403 – 430 MHz. This is done by soldering a RG-58 jumper to the input side of the filter and sweep generating into it while viewing the output from the LO output jack.

Remove C6 and set it aside
Replace C3 with 27pF Ceramic NP0 (C0G) 0805 salvaged from C6
Replace C5 with 12pF Ceramic NP0 (C0G) 0805

Replace C6 with 18-22pF Ceramic NP0 (C0G) 0805, Use 22pF for RX 440 – 445 MHz or 18pF for 445 – 450 MHz



Modified Receive Synthesizer VCO

Reattach the bottom lid and the VCO can.

You will now have to remove the Receiver Front End Module and IF Module from the T/R frame so you can access the tuning adjustments of the VCO.

Tuning can be done two ways. The first is place the Synthesizer back into the T/R frame and adjust the VCO capacitor, C52 with a ‘greenie’ until the Fault LED extinguishes. ‘Center’ the capacitors tuning range by adjusting C52 and noting where Fault lights and split the difference. Metal tools will affect tuning so adjust and remove.

The second method requires a couple of jumpers be installed first. Solder a wire jumper between U14 pin 11 (V_Tune) and +5 found at U15 pin 3. Next install a small wire lead between (Enable Test) found on R86 and Ground found on C63.

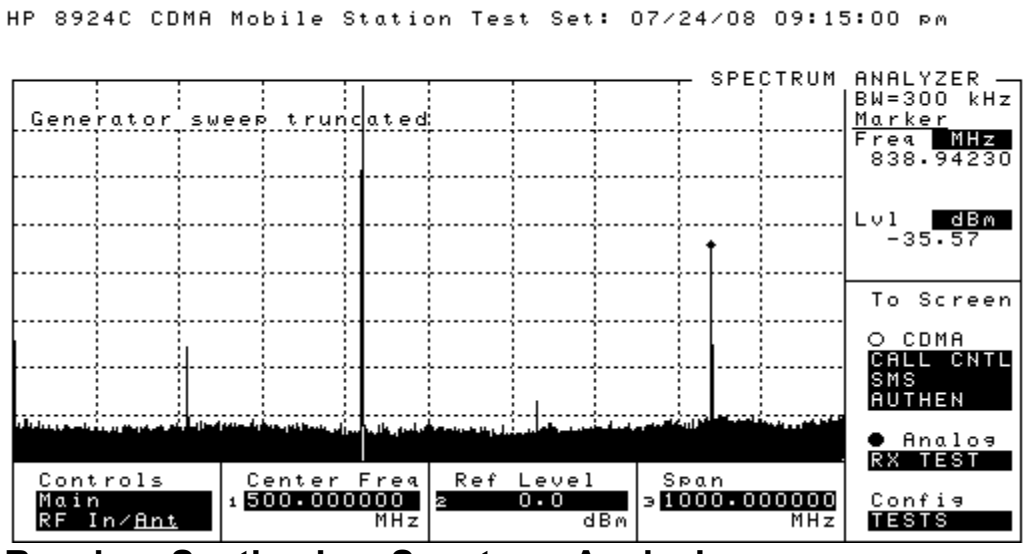
Insert the module into the T/R frame and connect a frequency counter to LO Output. Adjust C52 for proper LO frequency. If tuning can not be achieved, add 0.5 – 3.3pF capacitor to the C2 position and try again. Remove jumpers.

With the Synthesizer locked, Use a quality frequency counter on LO Output and adjust the trimmer on Y1 until the desired LO frequency reads true. This method offers greater error and thus precision then looking at the 12.8 MHz Reference Output.

If PLL lock can not be achieved, did you remember to program the receiver to use ‘opposite’ side injection? If not go back and look at Phase 1.

Once tuned remove the module from the frame again and replace RF shield. Insert the module back into frame. Verify VCO lock by Fault LED being extinguished. The cover will effect tuning slightly and C52 may need a slight tweak to get it back into lock. Power cycle the repeater leaving it off for 1 minute and check that the PLL lock took. The fault LED should stay lit for approx 5 seconds and go out.

With a spectrum analyzer verify the output of the module to be approximately 1 mW (0 dBm), Also verify that the harmonics are at least 29dB below carrier.



Receiver Synthesizer Spectrum Analysis

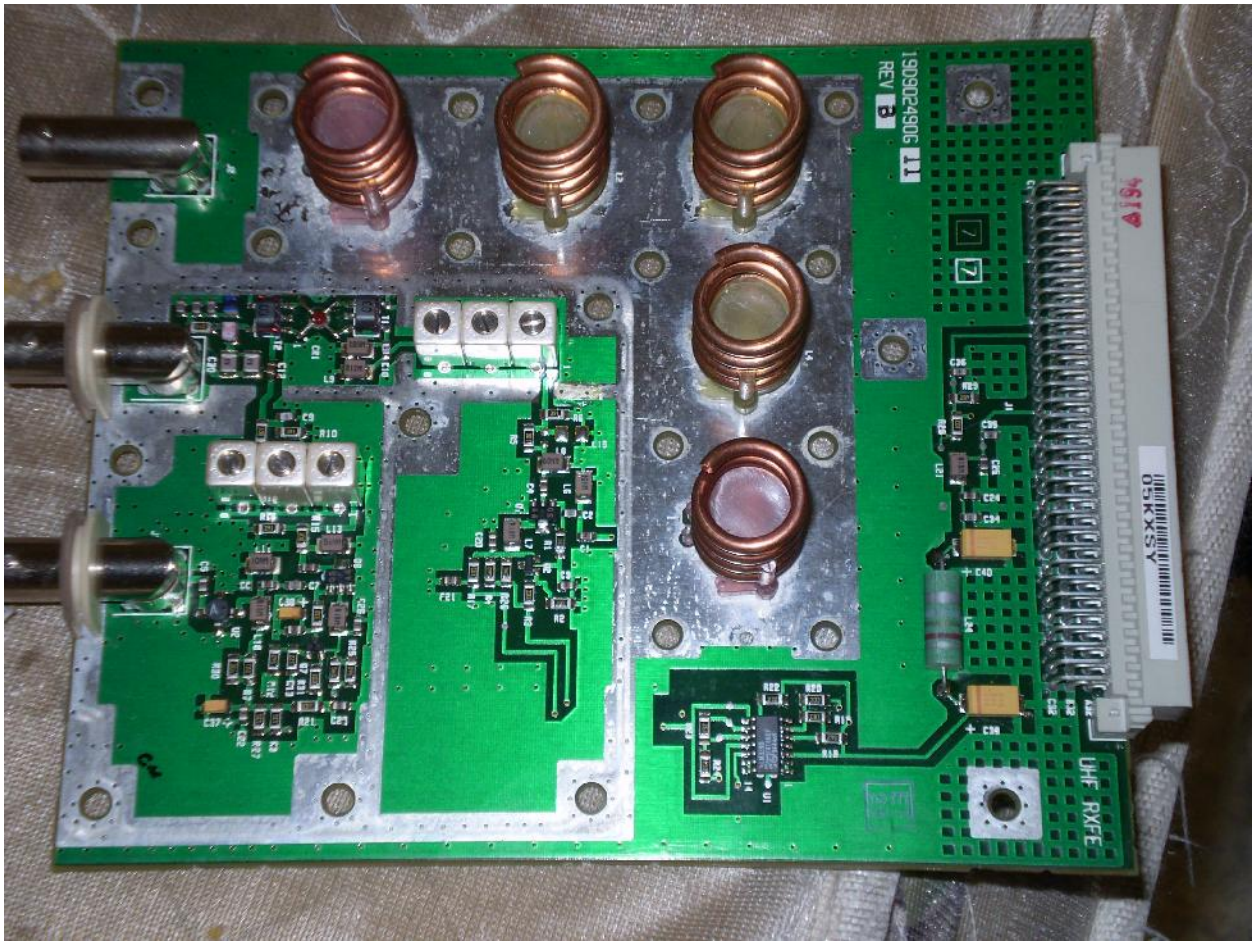
Phase 4: UHF Receiver Front End Module

Please Refer to LBI38673J and LBI39129B

Please note that the UHF version of this module does not have a fault LED for the front panel.

According to the newer documentation found in LBI39129D, the parts layout of the R7 board was changed to only have one helical filter. The parts list does not make reference to certain parts shown on the layout, but still contains helical filter FL2 while the schematic shows two helical filters. This appears to be an error in the documentation in which someone inadvertently switched the correct layout for the G3, G4 and G7 module.

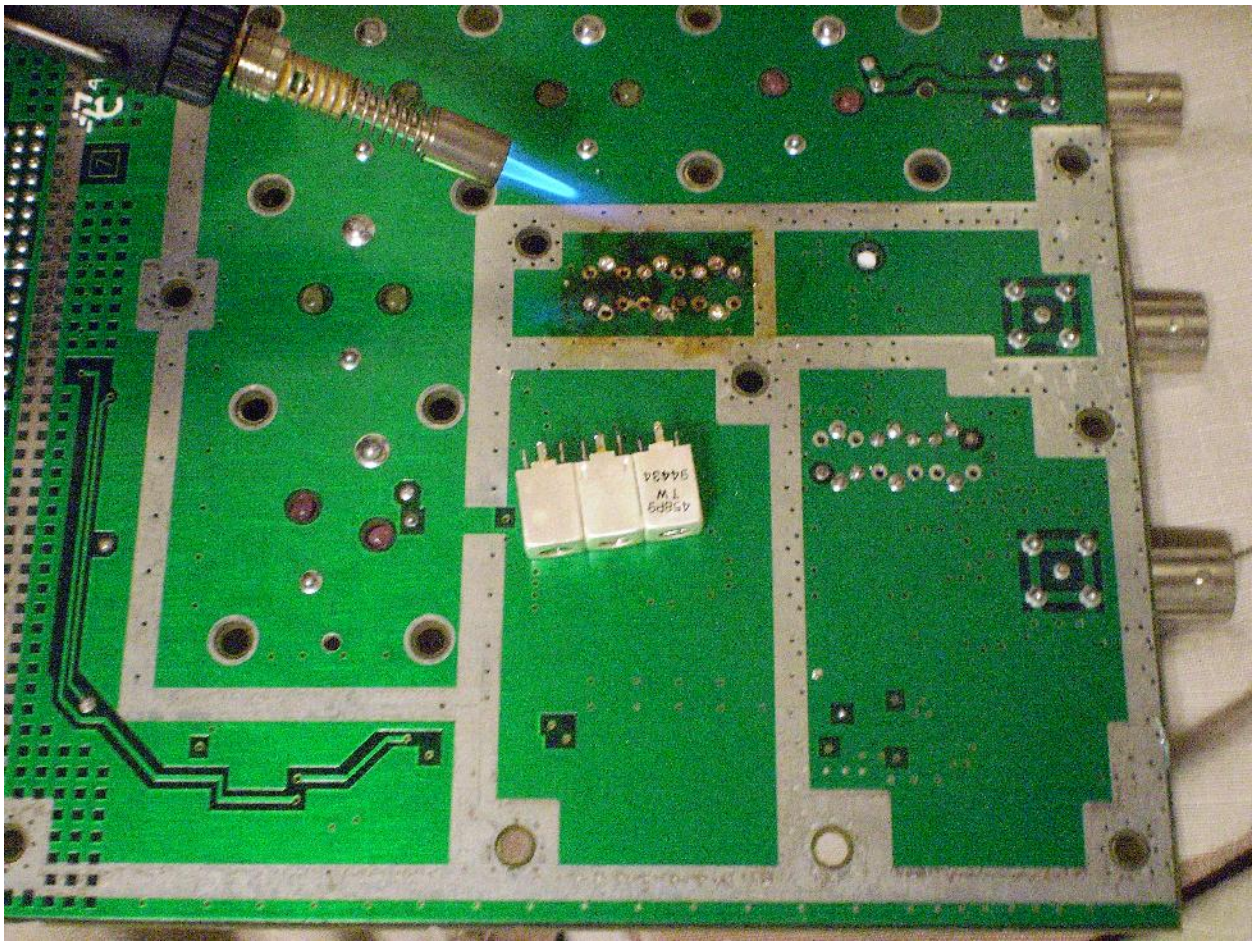
Using a Torx T-15 screwdriver, remove the top and bottom lids of the module. Remove the pre-selector helical casing.



Stock Receiver Front End Module

With a sharpie, write on the side of each filter it's previous position, this way you will not inadvertently undo your work during reassembly. Carefully desolder and swap FL1 and FL2.

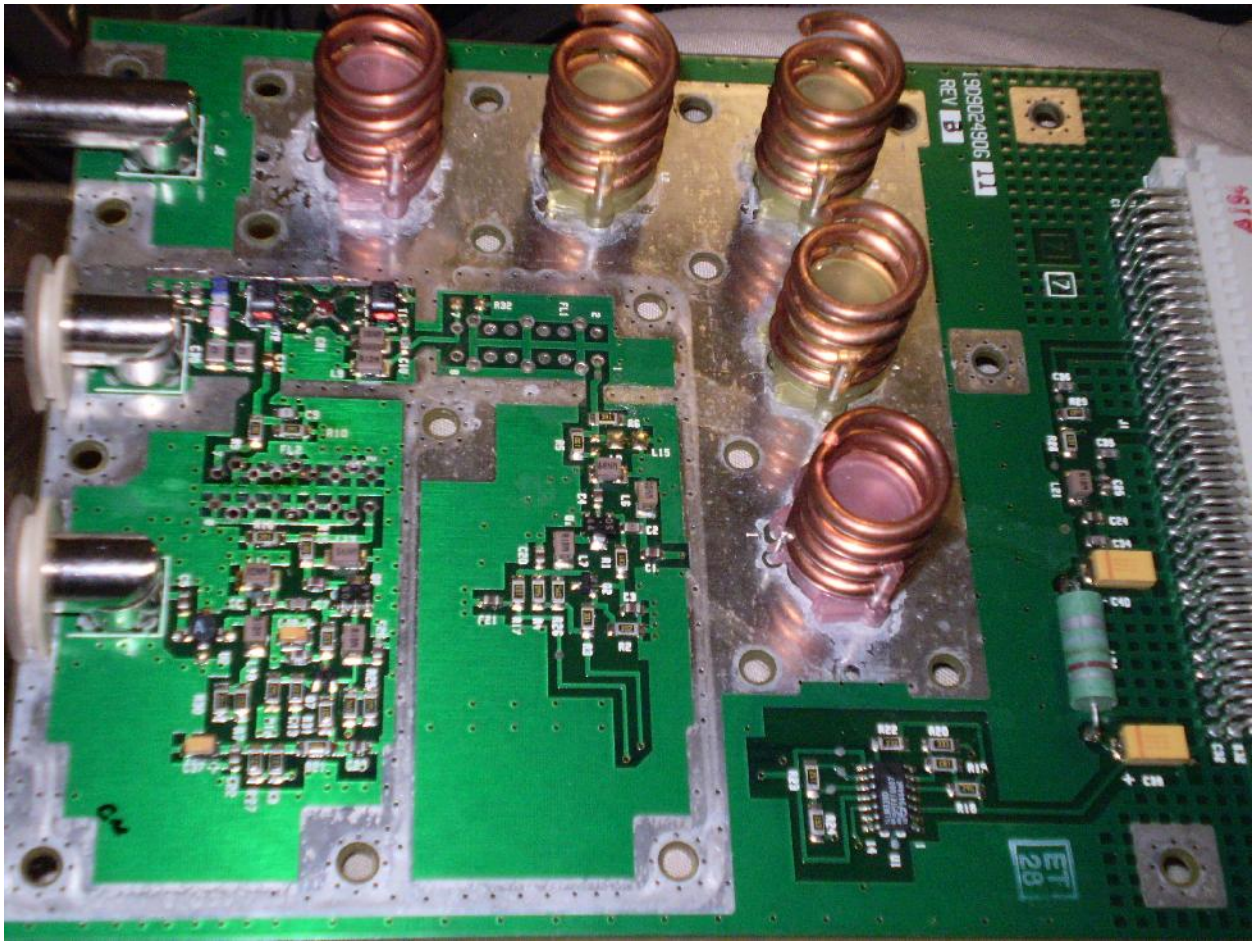
The module has the ground plane from hell and can absorb heat from both a 40W Iron and a 150W soldering gun at an alarming level. About the only thing I found that was able to provide enough heat for the desoldering job was a small butane pencil torch.



Bernz-o-matic, Serious Business.

Leave the flame about 3 inches off the board and offset at a 45 degree angle. Pass the flame back and forth slowly across the widest part of the filter so you heat both rows simultaneously. It takes about 2 minutes to develop enough heat on the ground plane where the solder melts and the filter falls free. Have something non-flammable and melt resistant under the module to catch the hot filter.

Clean up the hole with a solder sucker and the torch from the solder side of the PCB. Heat the solder with the torch so that it goes fluid and suck it clean. Then clean the burnt rosin from the board with denatured alcohol and a tooth brush. Also clean the excess solder from the filters, use a 40W iron and solder wick.

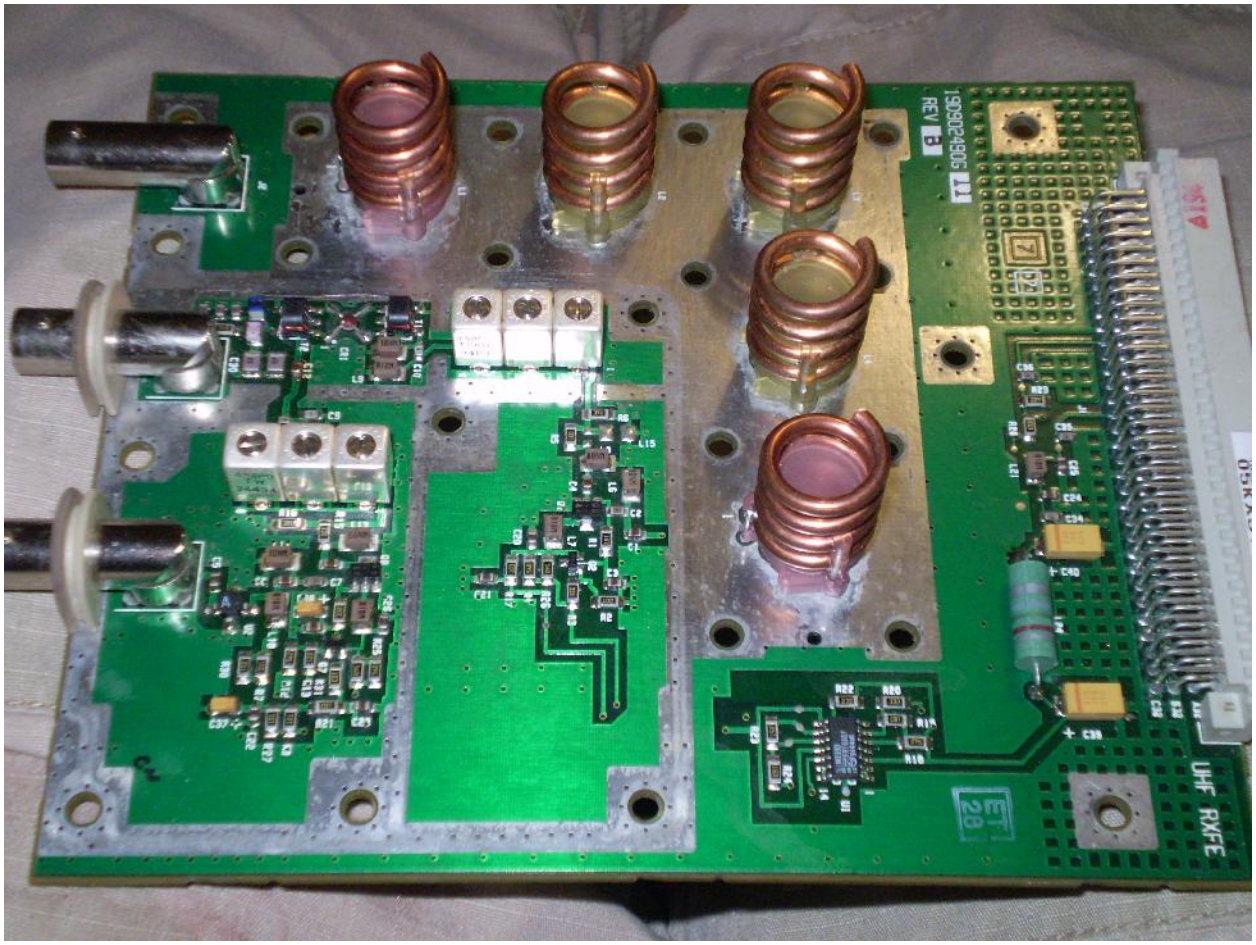


Helical filters removed, and all cleaned up.

Solder the filters in place. Remember that you wrote where they were, not where they are going. So install FL1 at FL2 and FL2 at FL1. This will probably require the hottest tip in your arsenal. I used 900 degree ‘R’ and it still wasn’t good enough. With the solder best you can get it go over the joints one at a time with the torch and re-melt them.

Clean the rosin residue from the under side of the board again with the tooth brush.

Using heavy gauge wire cutters or a Dremel with a cut off wheel, remove a ¼ turn off of the top of each helical coil in the pre-selector. Try not to leave burrs on the ends of the coils, use a small nail file or some sanding tape. Clean the area free of copper particles with the alcohol and a rag.

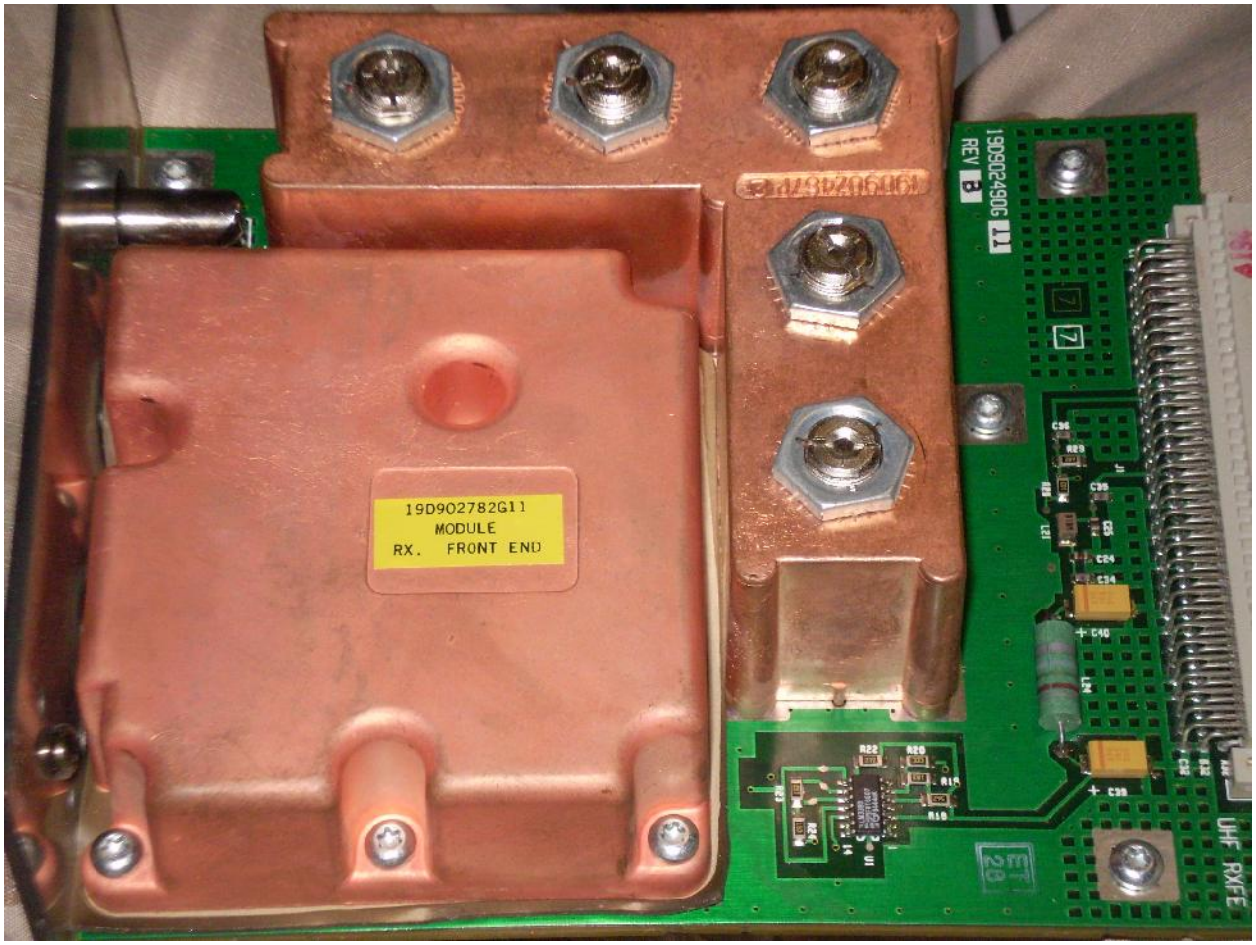


Fully modified Receive Front End

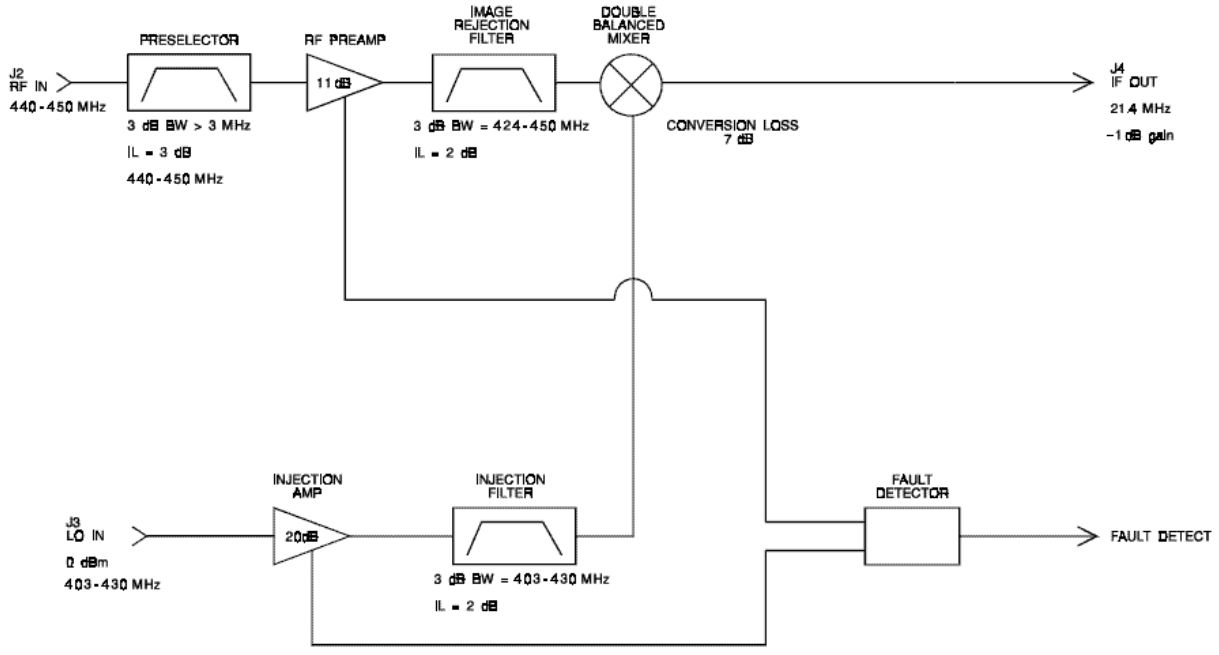
New Helical configuration:
Fc: 445 MHz
Bandwidth: 2 MHz
Wire: 0.1” (10 ga.)
Turns: 3.68
Diameter: .637”
Height: .956”
Spacing: .25”
Cavity: 1.17” Square x 1.375”
Impedance: 190 Ohms
Unloaded Q: 1466

At this point you should be able to make the receiver tune to at least -113dBm (0.5uV) for 12dB SINAD, -116dBm (0.35uV) typical.

Reassemble the helical casing and attach the top and bottom covers.



Reassembled Receiver Front End Module

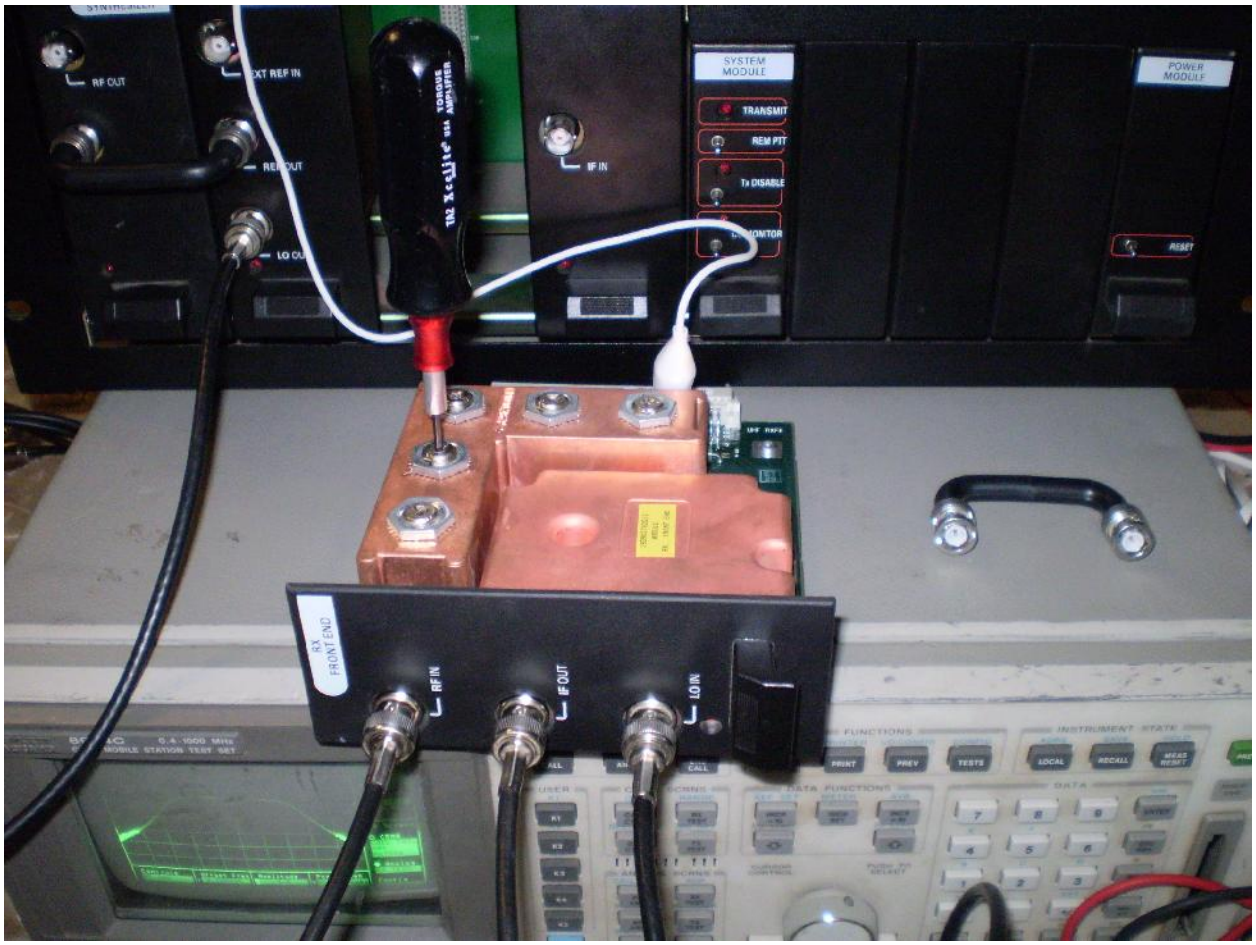


New Receiver Configuration

Phase 5: UHF Receiver Front End Module Tuning

Tuning has to be done with the module out of the T/R frame as there is no way to get tools and your hand in there at the same time, I've tried. So perform the following connections.

RF Input to Spectrum Analyzer Tracking Generator Output
IF Output to Spectrum Analyzer RF Input
LO Output to LO Input via 2' BNC jumper cable.
Clip lead with +12 (Backplane J5, Pin 3) to L21, C32 Junction. You may have to add a wire jumper to make a connection point on the Front end depending on revision of board you have, and care should be taken not to short J5.



Receiver Front End Tuning Setup (Improvised TQ0605)

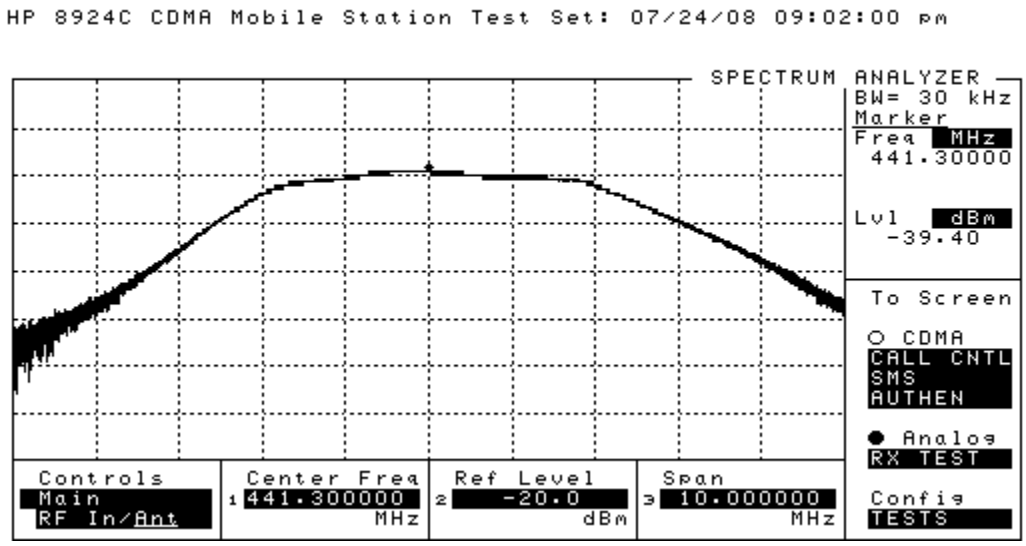
Remove tuning slugs from main the helical casting.

Once that is done set the following on the Spectrum Analyzer, Center frequency = Receive frequency, Span 10 MHz, Track Generator +0dBm, 10dB per division.

To get close, start with only the first slug, the one closest to the RF Input jack. Replace the retention nut on the slug and insert back into the helical casting. Tighten down the nut until the slug moves at the desired tension. Take the cable feeding the Spectrum Analyzer Input and hold it to the next hole in line and tune the first slug until the peak is at the center range. The signal should be -70 to -50dB down from +0dBm.

Repeat procedure with following slugs advancing to next set of holes. Adjust for best flatness at the top of the graph.

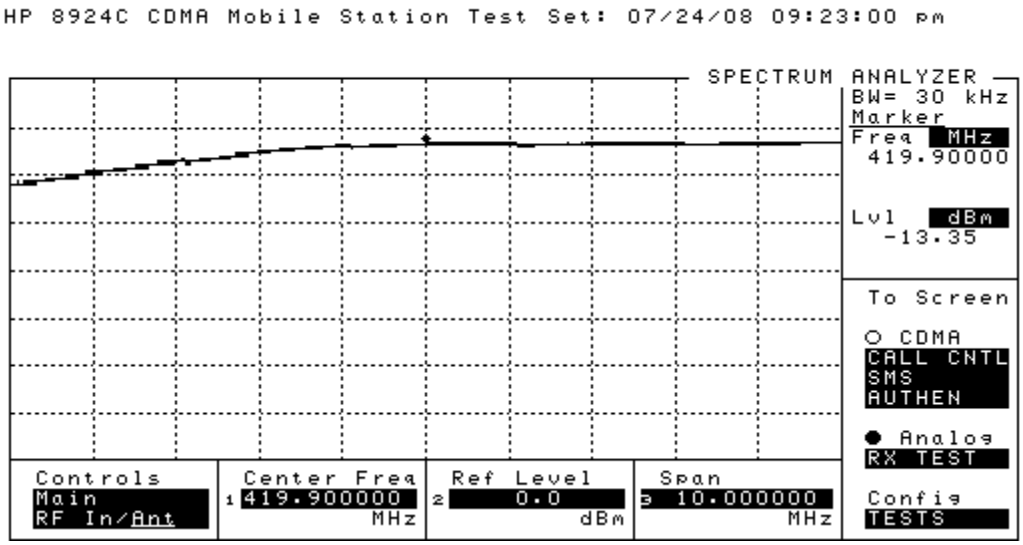
When on the last slug connect SA Input back to LO Output of Receiver Front End Module. Readings are now approximately 40dB down from the input. Adjust the last slug for maximum level. Remove the top lid and tune FL1 to for maximum level and then proceed to adjust L1-L5 and FL1 for best possible response. The response should be tuned to 3 MHz wide at the 3dB points.



Receiver Front End Spectrum Analysis

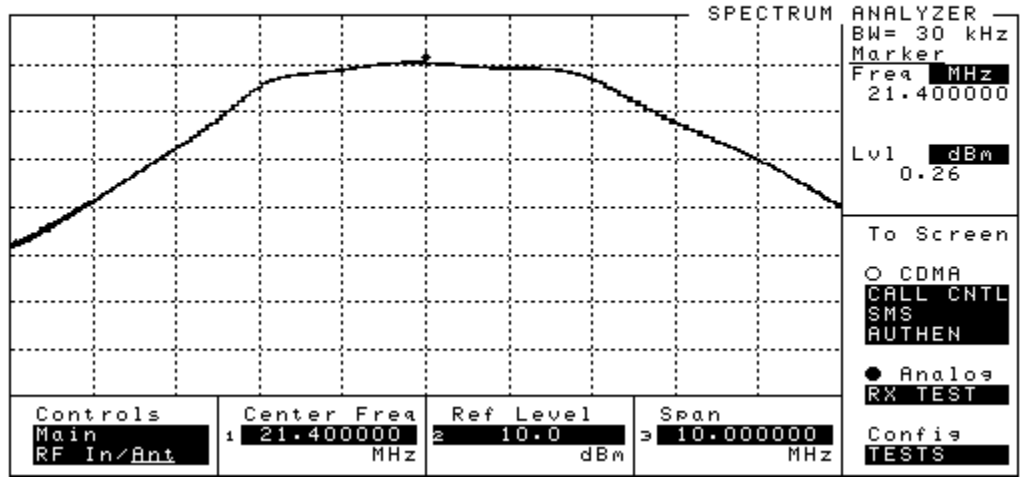
Now swap the cables on the module between RF In and IF Out

Tune FL2 for maximum level and then set for best response over 418.6 – 428.6 MHz. Signal level should be about -13dBm from generator output level.



LO to IF port Spectrum Analysis

To test for conversion gain, swap cables back to original positions and set Spectrum Analyzer center frequency to 21.4 MHz. Offset the tracking generator so the output sweeps the center receiver frequency (441.3 MHz - 21.4 MHz = 419.9 MHz). The level of 21.4 MHz pass band should be within 1dB of tracking generator output signal (-0dBm).



RF to LO port Spectrum Analysis (Generator Offset 419.9 MHz)

Phase 6: T/R Frame

Replace modules in T/R frame in following order Left to Right.

Large cards:
Transmit Synthesizer Module
Receiver Synthesizer Module
Receiver Front End Module
Receiver IF Module

Small Cards:
System Module
Blank
Blank
Blank
Power Module



T/R Frame

Note, that some stations may have accessory cards in the blank areas.

Connect service monitor with SINAD measuring ability to RF Input and take a connection from the station speaker for audio. Verify Receiver comes to factory specification of -116dBm (0.35uV), mine comes to -121dBm (0.20uV), be sure to add cable loss into your figures.

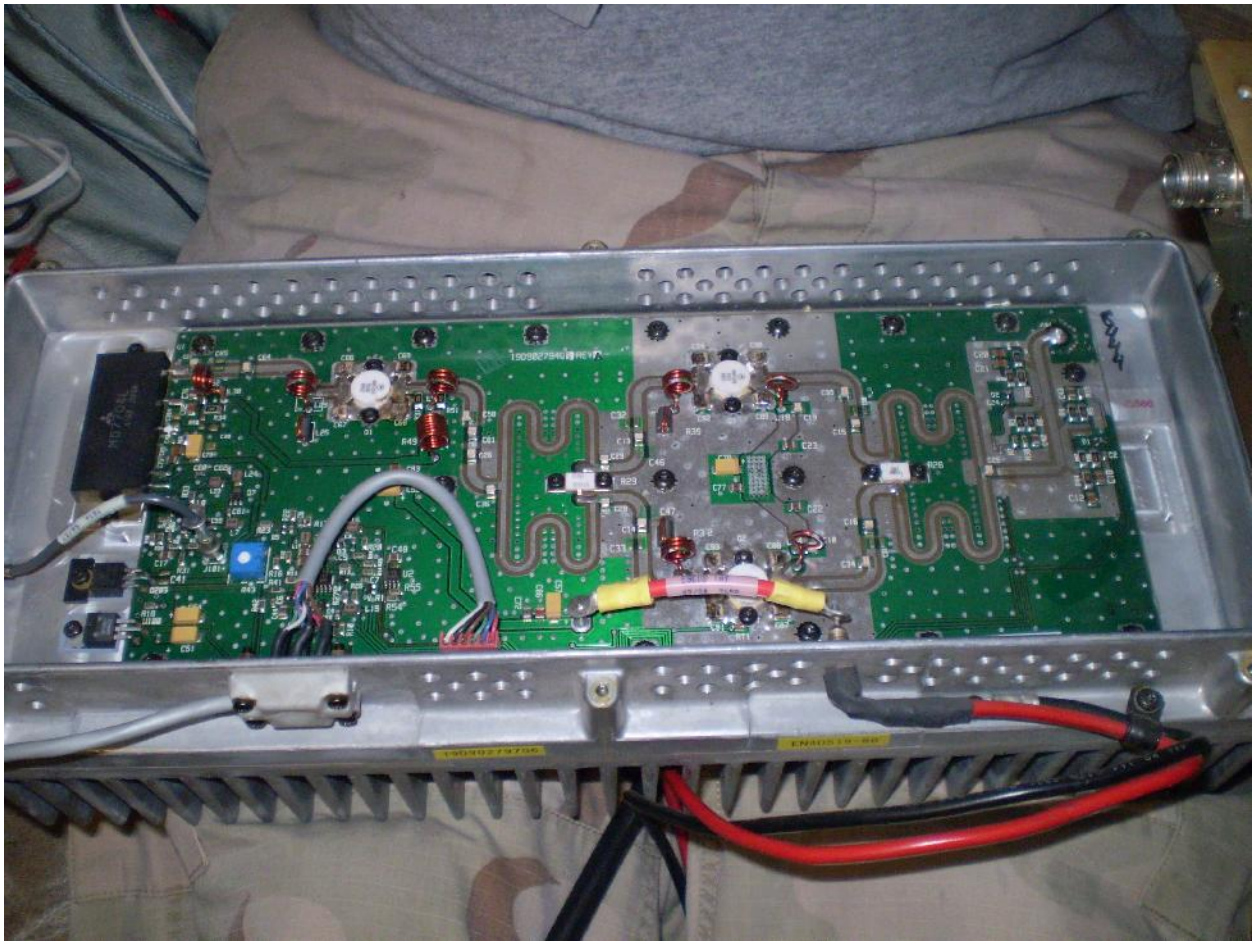
External controller interfacing may be done following the instructions here: http://www.hamrepeater.com/n0ndp/GE-Ericsson-MACOM/Mastr-III%20manuals/mastr3ctrl.doc

Phase 7: UHF Low Split Power Amplifier

Please Refer to LBI38674L

Your station should include a Group 3 low pass filter which is designed for 376 – 470 MHz. The circuitry for the UHF Low Pass Filter is perfect, don't mess with it.

If your station is equipped with the T/R relay and you are converting it to full duplex, remove it. Unscrew the 2 Torx screws that hold the mounting bracket to the low pass filter and then unscrew the 'N' connector between the LPF and relay.



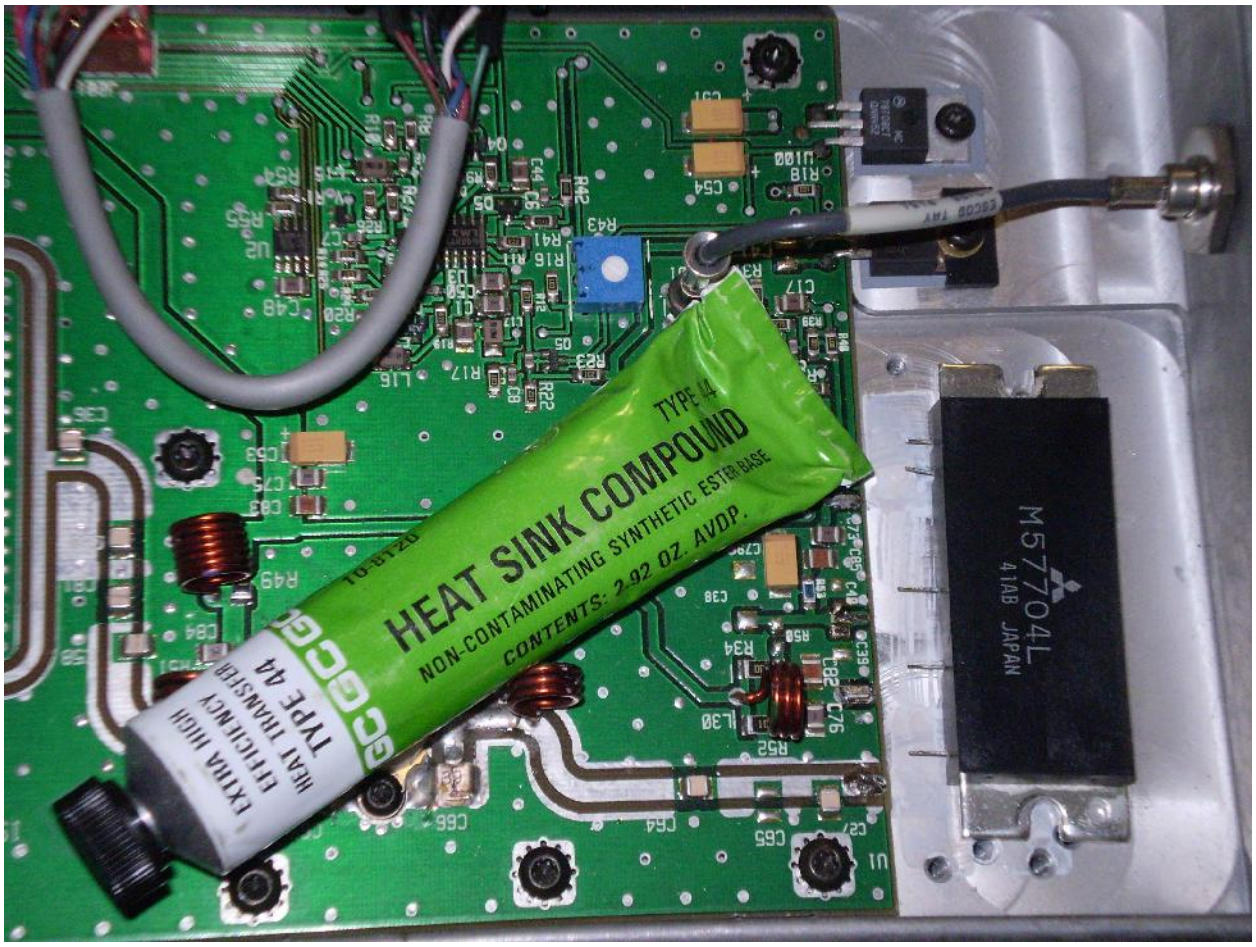
UHF Group 6 power amplifier

The amplifier may perform adequately for your needs, if not replace the following parts:

Remove C36
Remove C41
Replace U1 with Mitsubishi M57704M
Replace C27 with 10pF AVX Porcelain
Replace C28 and C29 with 8.2pF AVX Porcelain

Replace C87 through C90 – 43pF Underwood Case MIN02-002
Replace C91 and C94 with 36pF Underwood Case MIN02-002
Replace C67, C69, C92 and C93 with 39pF Underwood Case MIN02-002

The replacement power module can be obtained from www.RFparts.com.

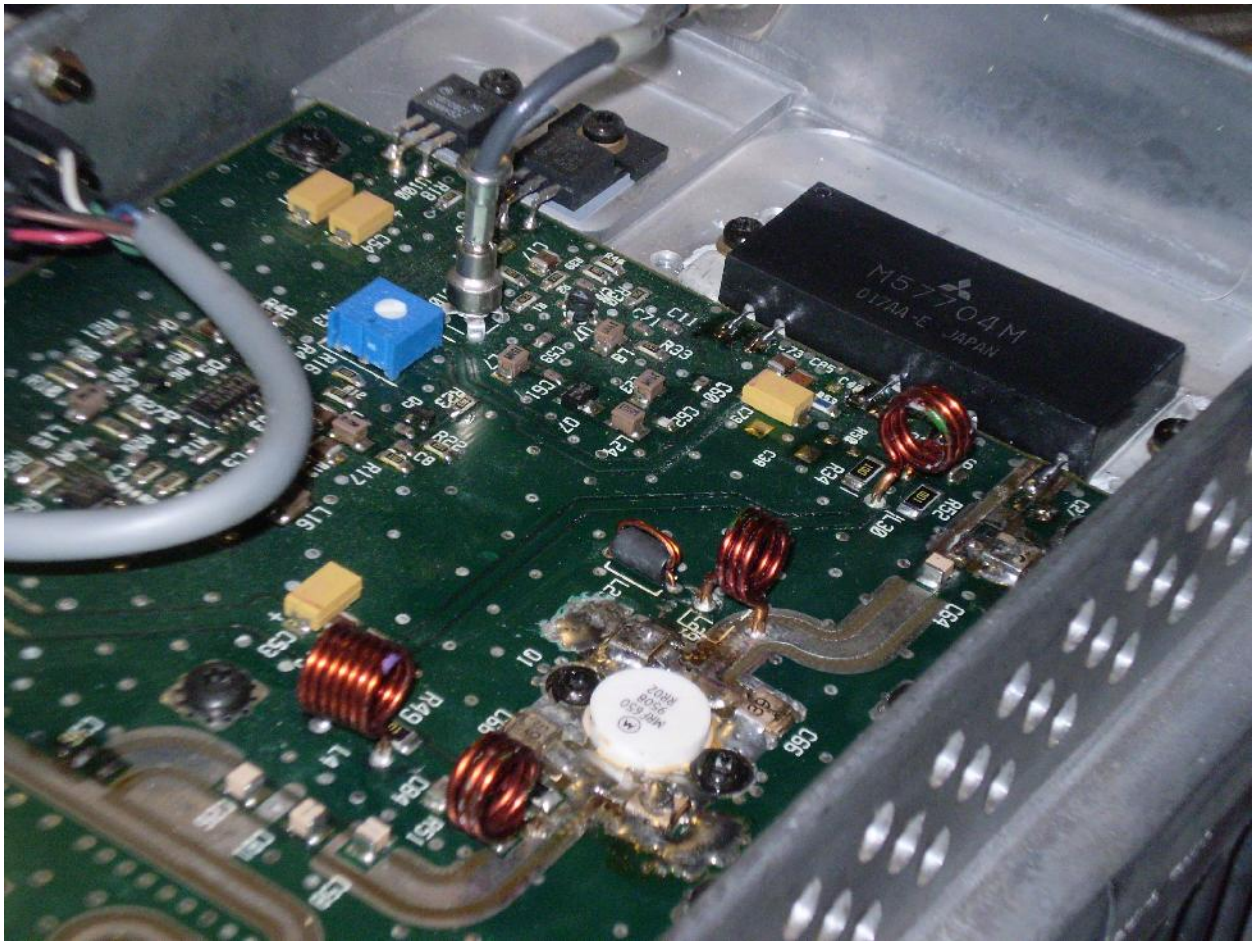


Removing M57704L Power Module

Removing the power module requires the use of a Torx T-10 screw driver. After removing the previous brick, clean the old heat sink compound from the heat sink and apply a fresh thin coating.

Underwood capacitors that are the correct size can be found from www.mouser.com, the ones carried by RF parts are too large. The only thing that is difficult to find is the AVX style capacitors. Underwood capacitors can be substituted by scraping off additional solder mask from the ground planes to accommodate the larger surface area.

Replacing the Underwood capacitors requires serious amounts of heat. A 150 – 250W soldering gun is the recommended armament.



New M57704M Power Module, and replaced capacitors

Connect the output from the Transmit side of the T/R frame to the input of the Power Amplifier. In MASTRUTL.BAT from the Potentiometer screen adjust Power Output to 99.

Unscrew the Low Pass Filter and lid from the PA assembly. Connect a Bird 43 with a suitable dummy load and 250W 400 – 1000 MHz slug or equivalent to the output connector of the LPF. Key the repeater. Adjust the potentiometer on the Power Amplifier board until 110W is indicated on the meter, mine is labeled ‘R43’. Warning: misadjustment may result in amplifier failure. Adjust the Power Output value in the software until the desired power level is achieved.

Reattach the lid and Low Pass Filter and reassemble the repeater.

This work was custom generated for the Repeater Builders Technical Information Page, www.repeater-builder.com

Text edited by: Bob Meister, WA1MIK

Photographs by: Matt Krick, K3MK

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