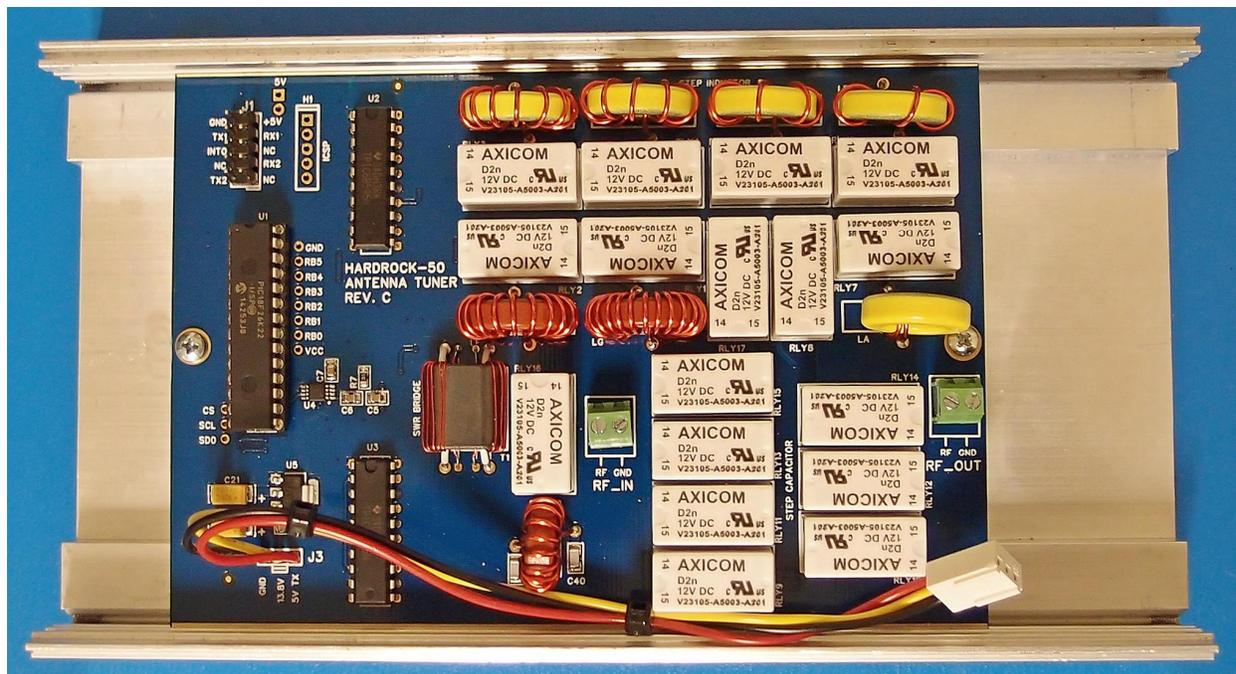


HARDROCK-50 Automatic Antenna Tuner Assembly Instructions – Rev D.



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WA2EUJ
3 March 2017

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1. INTRODUCTION

Congratulations on your purchase of a Hardrock-50 automatic antenna tuner kit. The ATU is designed to match antenna loads ranging from 5 to 500 ohms on the 80-10M bands with smaller matching ranges on the 160M and 6M bands. The ATU is fully integrated with the Hardrock-50 power amplifier and stores tuning solutions either by the selected band or the specific frequency (if the transceiver is sending the HR50 frequency data). The data repository for the ATU can be found at:

<https://sites.google.com/site/hr50atu/>

Construction and installation of the ATU assumes that we are starting with a fully functioning and testing Hardrock-50 amplifier. If your amplifier does not work please troubleshoot it first, adding the ATU is not likely to clear up any issues and is likely to complicate the troubleshooting procedure. You will also need to update the firmware in the HR50 amplifier and quite possibly the ATU as well. Instructions are provided in section 9 of this manual. I occasionally get asked “If I just bought the unit last week, why doesn’t it have the latest firmware?” This is because we buy the microprocessors from the manufacturer with the firmware already programmed so the version of the firmware was current when we ordered the processors, not when we shipped the kit.

Adding the tuner and upgrading the firmware in the HR50 will enable the following functions:

- 60M band coverage. The ATU has a 60M lowpass filter which provides sufficient attenuation of harmonics for legal operation on the 60M band.
- Wattmeter mode. The HR50 amp will function as a stand-alone wattmeter reading forward and reflected average power, forward peak power and SWR from 0.1 to 50W.
- QRP mode. The amp keys up and provides ATU functions but does not engage the power amplifier stage allowing the ATU to function with the exciter barefoot.

The ATU is compatible with the QSK mezzanine board for HR50’s with serial numbers above 1200. The ATU is not compatible with the QSK board that mounts on the bottom cover which was used with HR50’s with serial numbers below 1200. The ATU is not physically compatible with the driver amp, if your operation needs the driver amp we recommend integrating the driver into whatever is driving the HR50 or in its own enclosure. Contact technical support (me) WA2EUJ@ARRL.NET if you need help with this.

Spare Part Policy

We understand that building a kit for the first time builder may have difficulty with some of the steps and would find it easier and do a better job if they could do it a second time. To that end if you need more wire, another core, hardware or anything just send an email and we’ll send a replacement. Spare parts are included with the kit; we don’t know which ones you’ll need so we can’t put them in the box.

Contract Manufacturer Yield

The printed circuit boards in the HR-50 are fabricated, assembled and tested at a contract manufacturing facility in China. The bare PCB's are 100% electrically tested before the parts are put on. The manufacturer that we use to put the parts on the PCB's reports an 85 – 95% yield when assembling a board. This means that about 1 in 10 boards will have some manufacturing defect with the SMT assembly. This usually shows up as an unsoldered component. Since we can't test the boards before we send them out it means that there is a chance that we will have to find and repair something on one of the boards. Don't worry, by this point we know where to look and we've got your back. If it turns out to be something that you can't handle we'll fix it for you. A working tuner is included in the purchase price.

2. SPECIFICATIONS

ITEM	SPECIFICATION
Frequency Range	160, 80, 60, 40, 30, 20, 17, 15, 12, 10, 6 meter Amateur Radio Bands
Input Power	50W maximum, >1W drive required for tuning
Tuning Range	10:1 nominal (lower on 160 and 6 meters)
DC Power	11-16 Volts, < 0.5 Amps
Network Type	L-network (series L, shunt C); C switchable to input or output
Inductance Range	0-6.4 uH in 128 steps
Capacitance Range	0-1300 pF in 128 steps
Memory	Non-volatile storage of up to 343 tuning solutions. 160 – 12 meters every 10 kHz (233 solutions) 10 meters, every 25 kHz (69 solutions) 6 meters, every 100 kHz (41 solutions)
Size	Does not affect the overall HR50 size.
Weight	Adds about 1 lb (0.45 kg) to the HR50 amplifier

3. ASSEMBLY OVERVIEW

Assembling the Hardrock-50 ATU kit should be an enjoyable and rewarding experience. If at any time you feel frustrated or are having difficulty, take a break, ask questions on the forum or email, and remember that if you are having a problem with something there's a good chance that someone else has had the same issue. We have a "no questions asked" replacement part policy, so if you lose a part or need an extra length of wire or find something missing an email is all it will take to get you a replacement.

The assembly is organized into the following subassemblies:

- Inventory
- Inductors and Transformers
- PCB Assembly
- Amplifier prep (only needed on older amps)
- Integration and final assembly
- Firmware update

The inventory information is the first thing so you can make sure that nothing is missing. There are a few required tools:

- Soldering iron – A small temperature controlled unit is the best.
- Solder – Rosin core, fairly thin
- Screwdrivers –All of the screws in the kit are Philips
- Tweezers – For holding small parts and reaching tight areas
- Wire Stripper – Some users have had trouble stripping the #30 wire. The best tool I have found for this is the Ideal Industries 45-125 T7 Single Wire T-Stripper, 22-30 AWG. It costs less than \$15. Buying the toroid kit from the Toroid Guy eliminates the need to strip #30 wire.
- Long-nose pliers – For general mechanical assembly and crimping pins
- Toothpick – For unbraiding coax

In a production environment, an assembly station would also include an anti-static mat and all work would be performed while wearing an anti-static wrist strap. If you are equipped with these, I encourage you to use them. If you don't have these items, use caution when handling the ICs on the ATU PCB and touch a grounded surface before picking up the device.

4. ATU INVENTORY

PART ID	PART NUM	DESCRIPTION	PICTURE	QUANT ITY
J1	1009-0004	10 PIN DUAL ROW HEADER		1
LA, LB, LC, LD, LE	1003-0005	T68-6 POWDERED IRON CORE		5
LF, LG	1003-0004	T68-2 POWDERED IRON CORE		2
L1	1003-0002	T50-2 POWERED IRON CORE		1
RF_IN, RF_OUT	1009-0001	3.5MM TERMINAL BLOCK 2 POS		2
RLY1,RLY2,RLY3,RLY4,RLY5, RLY6, RLY7,RLY8,RLY9,RLY10,RLY 11,RLY12, RLY13,RLY14,RLY15,RLY16, RLY17	1006-0001	RELAY TELECOM DPDT 3A 12V		17
T1	1003-0001	BN43-202 BINOCULAR CORE		1
SPACER	1002-0005	#4-40 x 1/2" 3/16" MALE- FEMALE THREADED HEX STANDAOFFs		2
SCREW	1000-0007	#4-40 x 1/4" WITH INTEGRATED LOCK WASHER		2
MOUNTING NUTS	1001-0001	#4 MACHINE NUTS WITH INTEGRATED LOCK WASHER		2
TOROID WIRE		#20 ENAMELED WIRE		90"

DIRECTIONAL COUPLER		#22 WHITE TEFLON WIRE		6" 15cm
DIRECTIONAL COUPLER WIRE		#30 KYNAR WIRE		3' 76cm
RF_IN, RF_OUT		RG-316		1' 30.5cm
	1012-0001	3-PIN HEADER WITH BARE WIRES		1

5. INDUCTORS AND TRANSFORMERS

This section describes the construction of the inductors and the transformer that will be installed on the ATU PCB in the next section.

You can order prewound toroids inductors the Toroid Guy. An order form is available on the ATU Resource Site:

<https://sites.google.com/site/hr50atu/>

Tips for Winding Toroidal Inductors:

1. The enameled on wire included with the kit is designed to be removed by heat. No scraping is required. After the inductor is wound, tin the end with a soldering iron which will remove the enamel and prepare the inductor for installation on the PCB. But there's a trick, in order to get the enamel hot enough burn off you must get molten solder in contact with bare copper which, since we aren't scraping, means the end of the wire. So get a nice ball of solder on the tip of the iron and put the ball on the very tip of the wire, Then you will see the enamel cook right off. Maybe when you are cutting the wire after the toroid is wound, cut the wire on a bias to expose more bare wire.
2. There are two possible directions to wind a toroid. They are electrically identical but the PCB layout favors right hand winding. When winding inductors always inset the initial turn of wire and add turns to the right. This will insure that the inductors mount nicely on the PCB.
3. Tight, neat windings not only make your finished kit look professional but tighter coils have less wire which leads to less resistance and higher Q so bend the wire around the toroid rather than loop it.

□ **L1** - 15 turns, 12" or 31cm of #20 enameled wire on a T50-2 Core (red), tinned. This is the smallest torodial core, all the others are T68's which are larger.

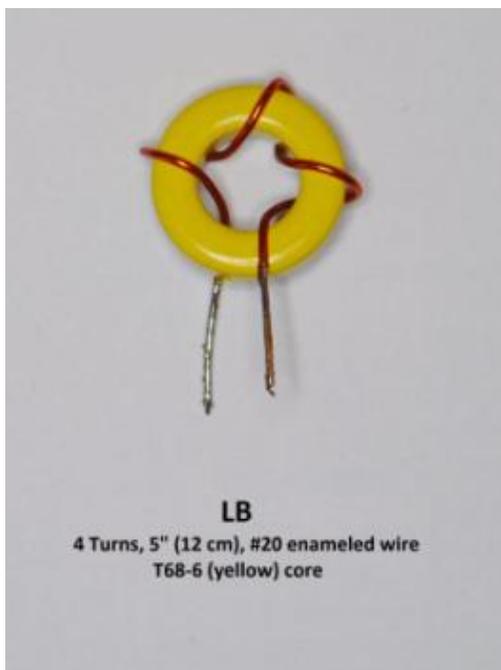


□ **LA** - 2 turns, 2" or 5cm of #20 enameled wire on a T68-6 Core (yellow), tinned.

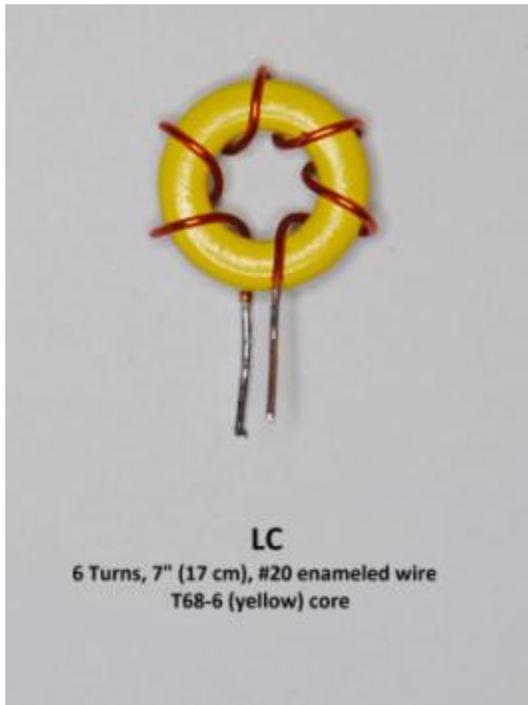
NOTE: *Wind this toroid by placing new turns to the left as shown. All other toroids are wound by adding turns to the right.*



□ **LB** - 4 turns, 5" or 12cm of #20 enameled wire on a T68-6 Core (yellow), tinned.



□ **LC** - 6 turns, 7" or 17cm of #20 enameled wire on a T68-6 Core (yellow), tinned.



□ **LD** - 9 turns, 10" or 25cm of #20 enameled wire on a T68-6 Core (yellow), tinned.



□ **LE** - 13 turns, 12" or 31cm of #20 enameled wire on a T68-6 Core (yellow), tinned.



□ **LF** - 17 turns, 15" or 38cm of #20 enameled wire on a T68-2 Core (red), tinned.

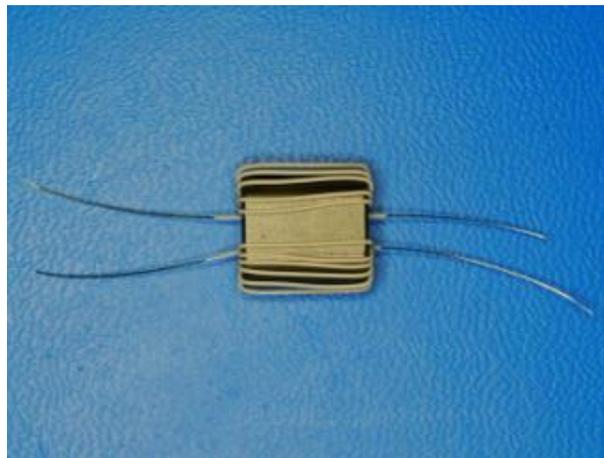


□ **LG** - 24 turns, 21" or 53cm of #20 enameled wire on a T68-2 Core (red), tinned.



□ **T1** – There are a total of 4 windings on T1's BN43-202 core. At this time we will be installing the two 10 turn windings. The 2 single turn windings will be added when the core is soldered to the ATU PCB in the next section.

Wind 2 windings each using 18" or 48cm of #30 Kynar wire, 10 turns, one winding through each hole in a BN43-202 core, like this:

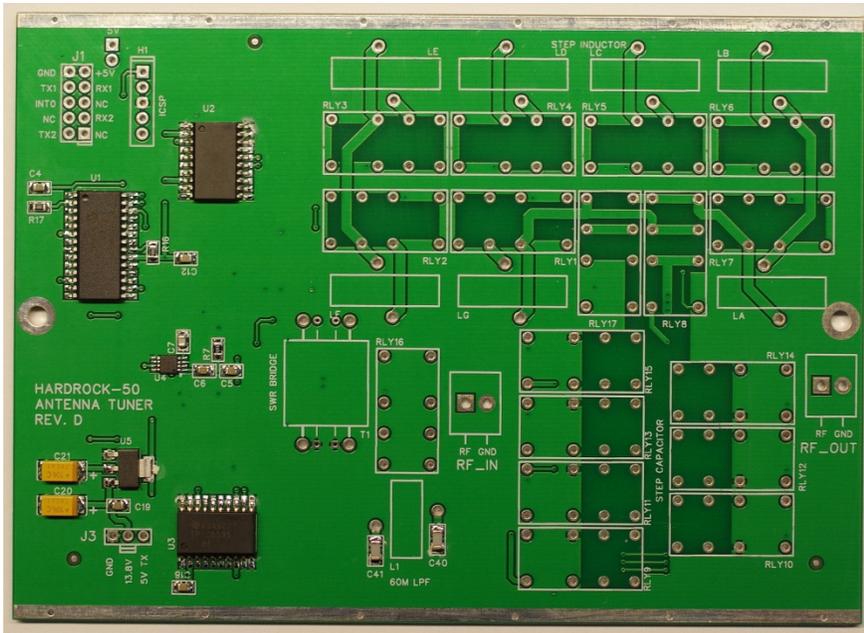


You should be able to count 10 white wires in each hole in the core. Stripping the #30 Kynar wire can be challenging. A 22-30 T-Stripper works very well and costs under \$20 on Amazon.com. It's also possible to strip it with diagonal cutters but practice a few times before you wind T1. If you need more #30 just let us know and we'll send it out.

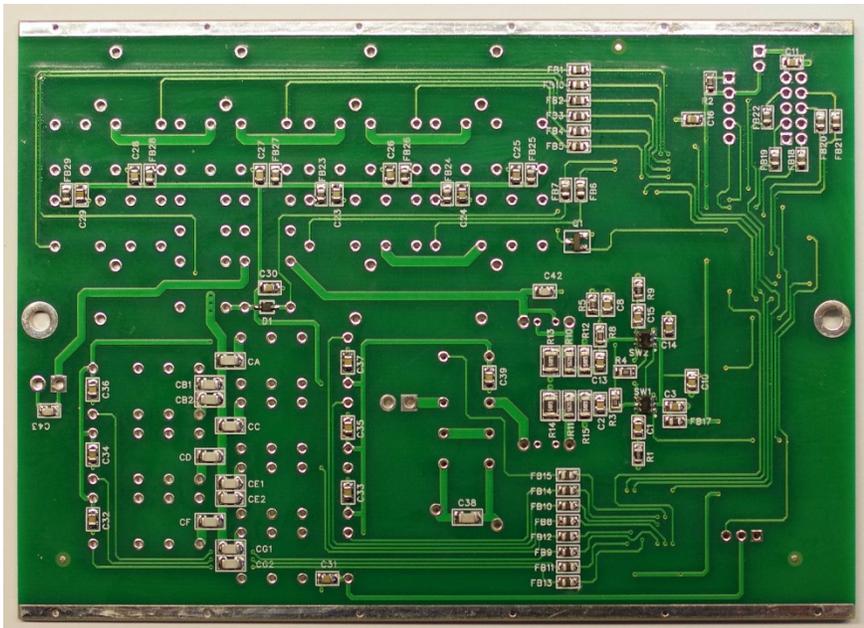
6. ATU PCB

This section covers the assembly of the ATU PCB. Required tools and supplies are; soldering iron, diagonal cutters, tweezers and long-nose pliers. Carefully inspect the ATU PCB looking for poor soldering on the SMT components look for unsoldered ferrite beads; they seem to be prone to re-flow issues. The photos show pre-production boards that have green soldermask. Production boards will be blue

Top Side:

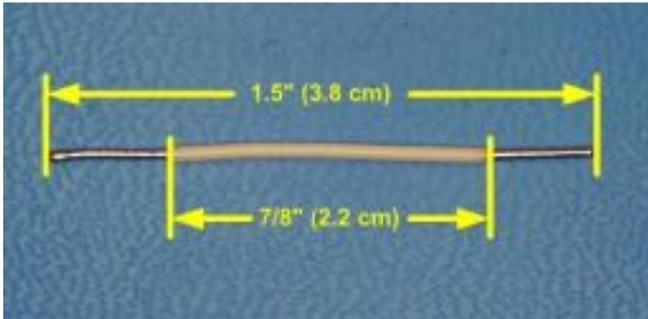


Bottom Side:

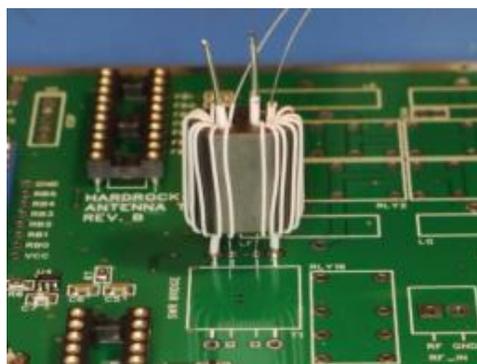
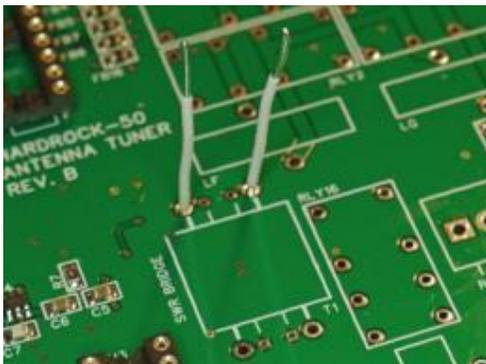


□ **Step 1:** Solder the two 3.5mm terminal blocks one at position RF_IN and the other at RF_OUT on the top side. The openings in the terminals for inserting wires should face the silk screen markings for RF and GND.

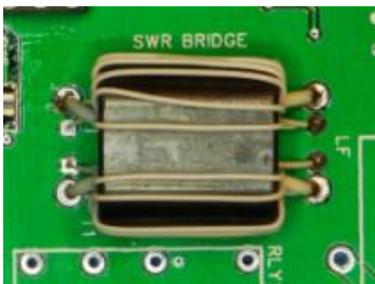
□ **Step 2:** Cut 2 each, 1.5" (3.8 cm) pieces of white #22 Teflon wire, Strip the ends so that the insulation remaining is 7/8" (2.2 cm) long, the length of the bare wires is not important just so it's long enough to go through the PCB. Tin the ends:



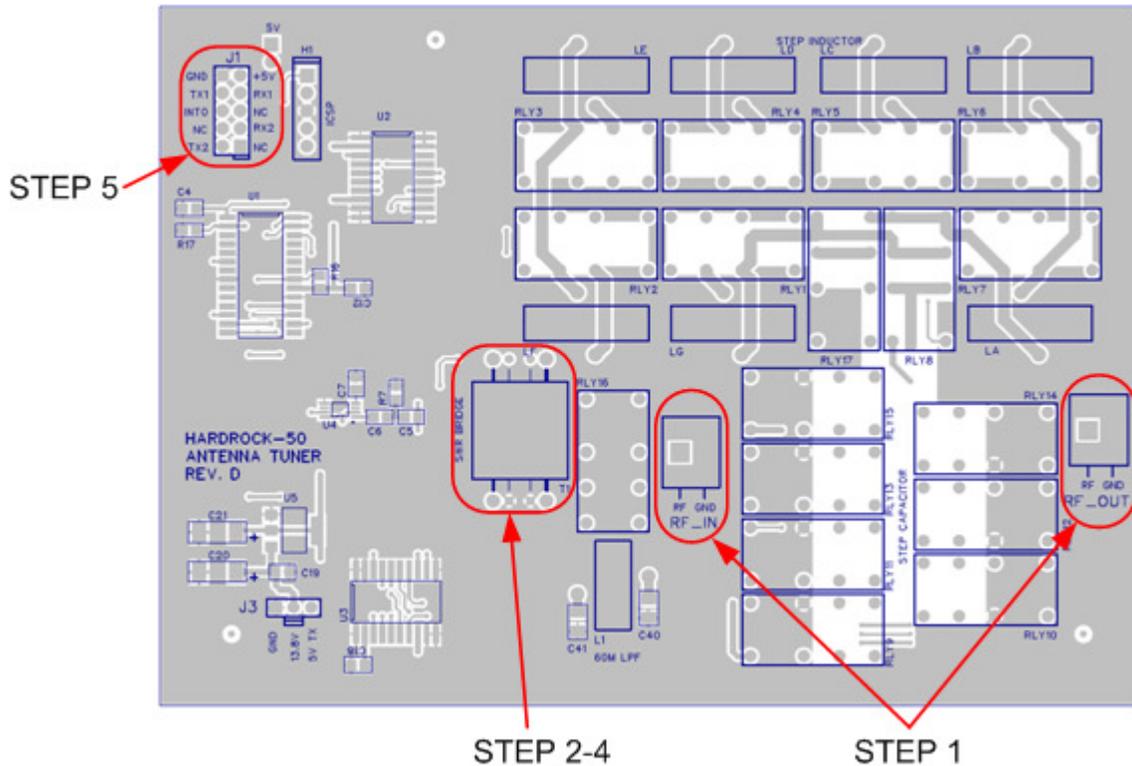
□ **Step 3:** Solder the 2 prepared #22 wires in to the holes in the T1 footprint as shown. Slide the BN43-202 core with the #30 windings over the protruding #22 wires. Make sure that the #30 wires go into the corresponding holes in the PCB. No wires should cross each other.



□ **Step 4:** Bend the core over, parallel to the PCB, insert the remaining #22 and #30 wires in their corresponding holes, and solder all unsoldered connections. *The photos show T1 being installed on a green prototype PCB which is Rev B, installation is the same on later Revs.*



□ **Step 5:** Insert 10 pin dual row header into position J1 on the top side of the PCB. Orientation of the header is not important. Solder all of the pins. *It's easy to melt the plastic base of the header which causes the pins to become misaligned. Don't touch the soldering iron to the pin, instead touch the iron to the pad of the PCB only. Then apply solder, filling the hole in the PCB as quickly as possible.*

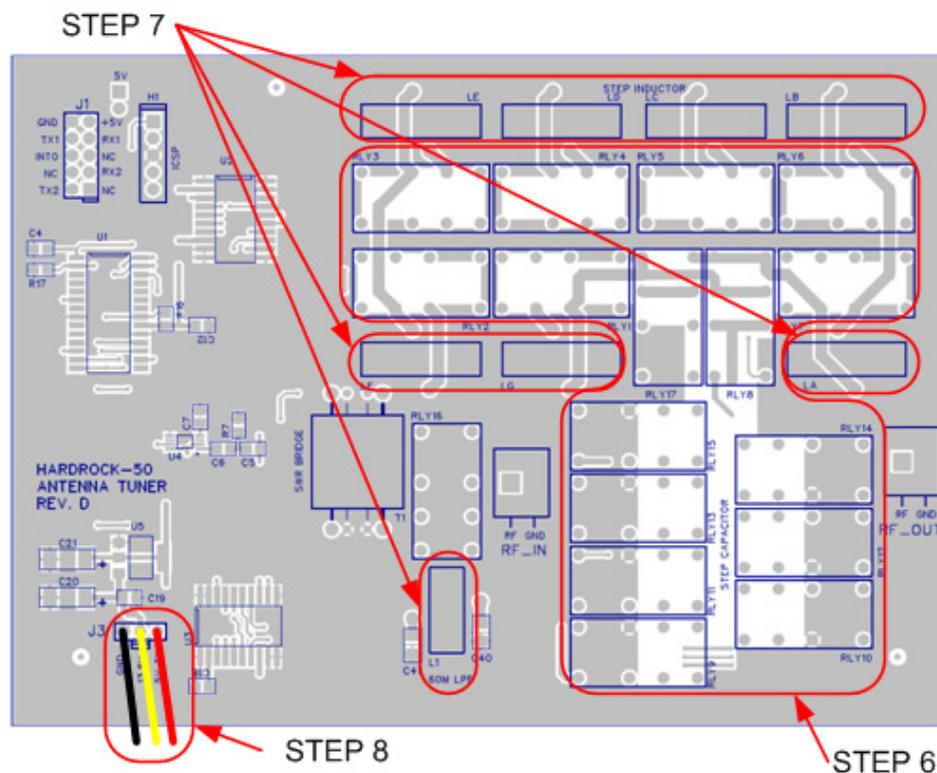
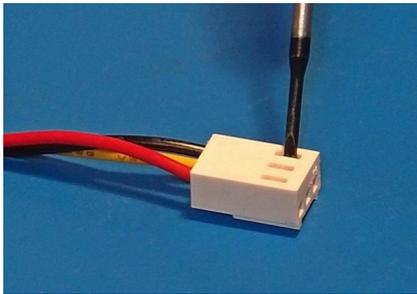


□ **Step 6:** Relay can only be inserted in the PCB one way. Install relays RLY1-RLY17 at the locations indicated on the silk screen. The easiest way to do this is place the relays as indicated on the **top** side of the PCB then place a flat object (maybe a hard cover book or a small piece of wood) on top of the relays. The flat object must be big enough to cover all of the relays. Then, holding the PCB, relays and flat object like a sandwich, flip the whole thing over. Then solder one pin on each relay, pressing down on the PCB in the area of the relay it ensure that the relay is flush with the PCB. You can then pick up the PCB with the relays attached by a single pin each. Inspect each relay for position (should be flush with the PCB), adjust if necessary. Then turn the PCB over and solder the other 7 pins on each relay.

□ **Step 7:** Insert L1, LA, LB, LC, LD, LE, LF and LG at their indicated positions on the top side of the PCB. Pull each of the leads through the PCB from the back side using pliers to insure that the toroids are secure against the PCB. Remove additional enamel if necessary and solder all leads and trim excess.

□ **Step 8:** Cut the leads of the 3 pin connector with wires to 6" or 15 cm in length. Remove 0.5" or 1.25 cm of the insulation from each of the 3 wires, twist the strands tightly and tin with solder. Insert the black wire into the GND pin of J3, the yellow wire into the 13.8V pin of J3 and the red wire in the 5V TX pin of J3. Solder all 3 wires and trim excess.

Note for Rev C and Rev E amplifier boards (S/N less than 1200) you MUST reverse the red and black wires in the 3 pin connector. Use a small screw driver to press on the locking tab and slide the wire and pin from the housing



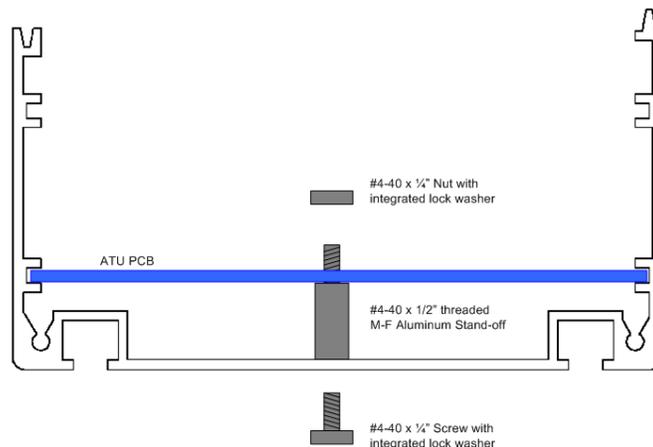
□ **Step 9:** Cut a 6" (15.2 cm) piece of RG-316. Remove 1/2" (1.3cm) of the outer jacket from each end of the coax, unbraid the shield using a toothpick or similar and twist and tin the shield wires. Remove the dielectric from the center conductor, twist and tin the center conductor wires. The RG-316 cable is impervious to heat so tin the braid all the way around the cable to prevent fraying. Insert one end of the jumper into the RF_IN terminal block with the center conductor connected to the RF terminal and the shield connected to the GND terminal. Leave the other end free.

If your amp does not already have holes for the ATU in the bottom cover you can get the drill template from <https://sites.google.com/site/hr50atu/home/files> and print it out. Measure the 3" or 100mm

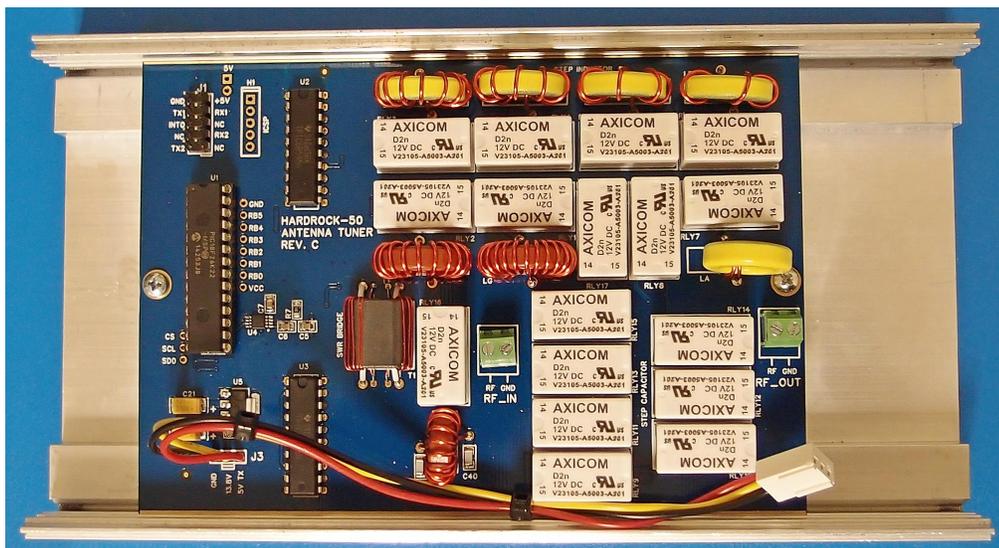
reference lines to verify that your printer is scaling the drawing correctly, if it doesn't, you can adjust the print scaling factor in the Adobe Reader print screen so the lines are printed the correct length. Cut out the template. Before removing the bottom cover of your HR50, use a piece of tape to mark the bottom cover where the front panel is attached. The bottom cover is **not** reversible so if you use the template incorrectly, the ATU will not fit inside. Remove the bottom cover and set the template on the inside of the bottom cover carefully observing the front and back markings. The template should fit perfectly inside the groove in the bottom cover. Mark the locations of the two mounting holes using a center punch or a nail and hammer. Drill the two 1/8" or 3mm holes at the marked locations and remove any burrs or excess material.

Step 10: Attach the two male-female spacers to the PCB with a #4 hex nuts with integral lock washer.

Step 11: Slide the ATU PCB into the appropriate groove in the HR50's bottom cover, align the stand-offs with the holes in the bottom cover and attach with the two remaining #4-40 x 1/4 screws.



The RF_OUT terminal block should be close to the 'long' side of the case (the back) line this:



7. RETROFIT (FOR HR50 AMPS BELOW S/N 1400)

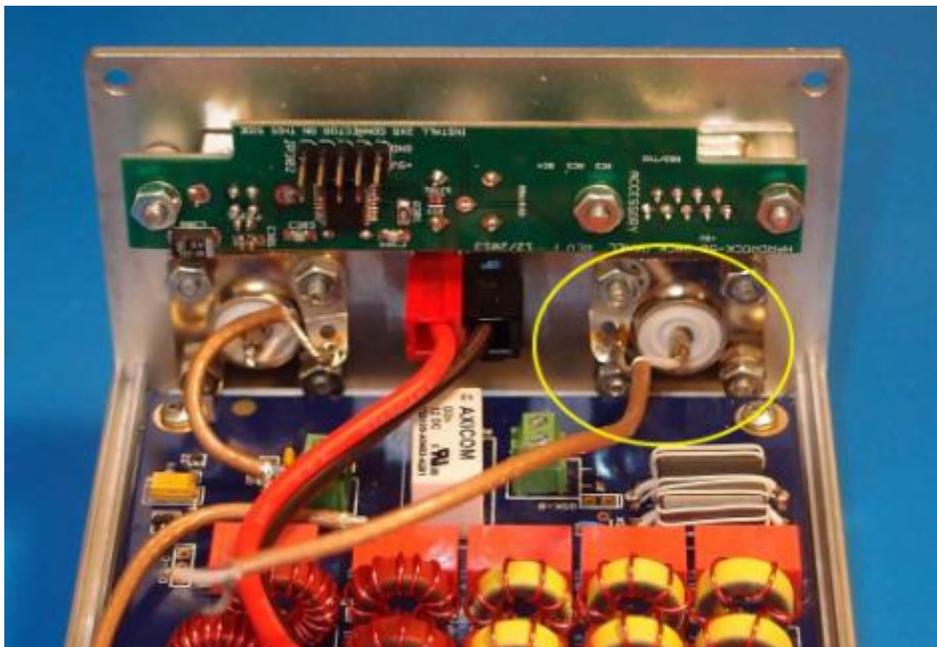
For amplifiers with serial numbers below 1400, you will need to make some changes to the amplifier to accommodate the ATU please contact jim@hobbypcb.com for further instructions. All amplifiers shipped from January 2015 and beyond are 100% compatible with the ATU and need no retrofit.

8. INTEGRATION

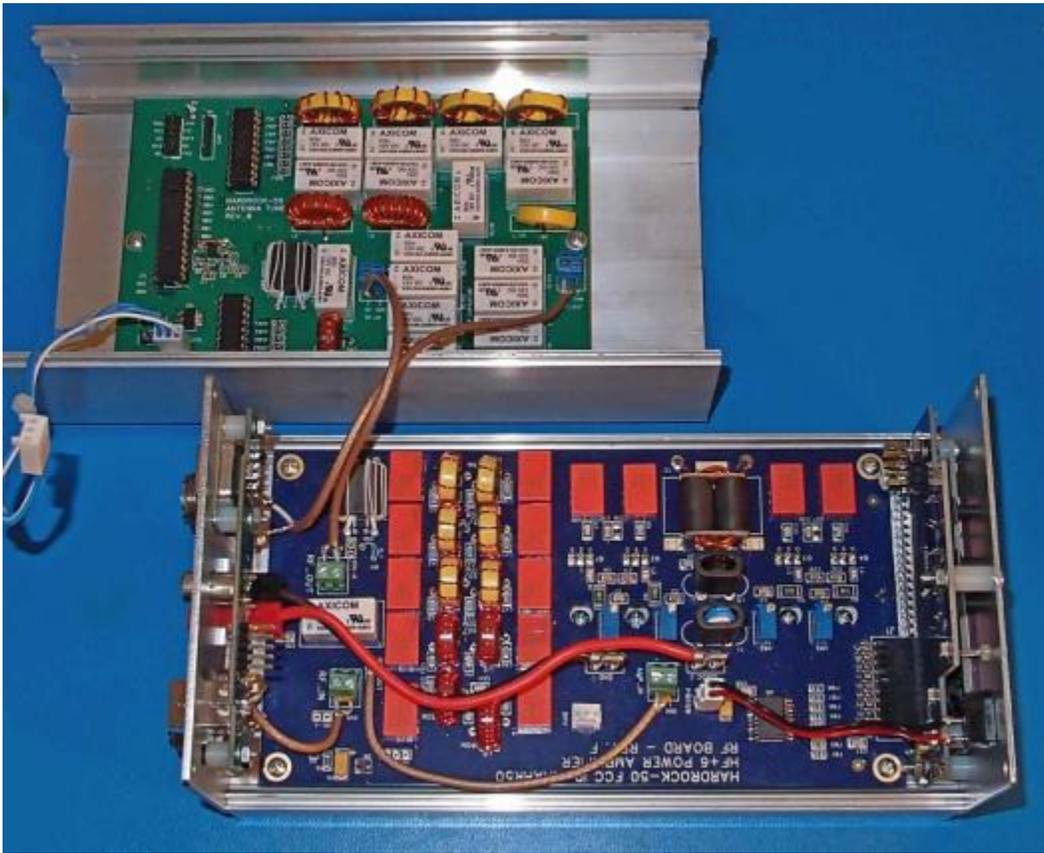
This section covers the final integration steps needed to get the ATU in the Hardrock-50's case and working with the HR-50's firmware. At this point, you should have the ATU board mounted to the bottom cover and if necessary preformed all necessary retrofit to the amplifier PCB. If you haven't done so, use the instructions in the 'Firmware Update' section of this manual to update the HR-50 to the latest version. Firmware versions earlier than 3.0 will not recognize the ATU. The ribbon cable must be in place to update the HR-50 firmware.

Step 1: Cut a 6" (15.2 cm) length of RG-316. Remove 1/2" (1.3cm) of the outer jacket from and of each end of the cable, unbraid the shield using a toothpick or similar and twist and tin the shield wires. Remove the dielectric from the center conductor, twist and tin the center conductor wires. The RG-316 cable is impervious to heat so tin the braid all the way around the cable to prevent fraying.

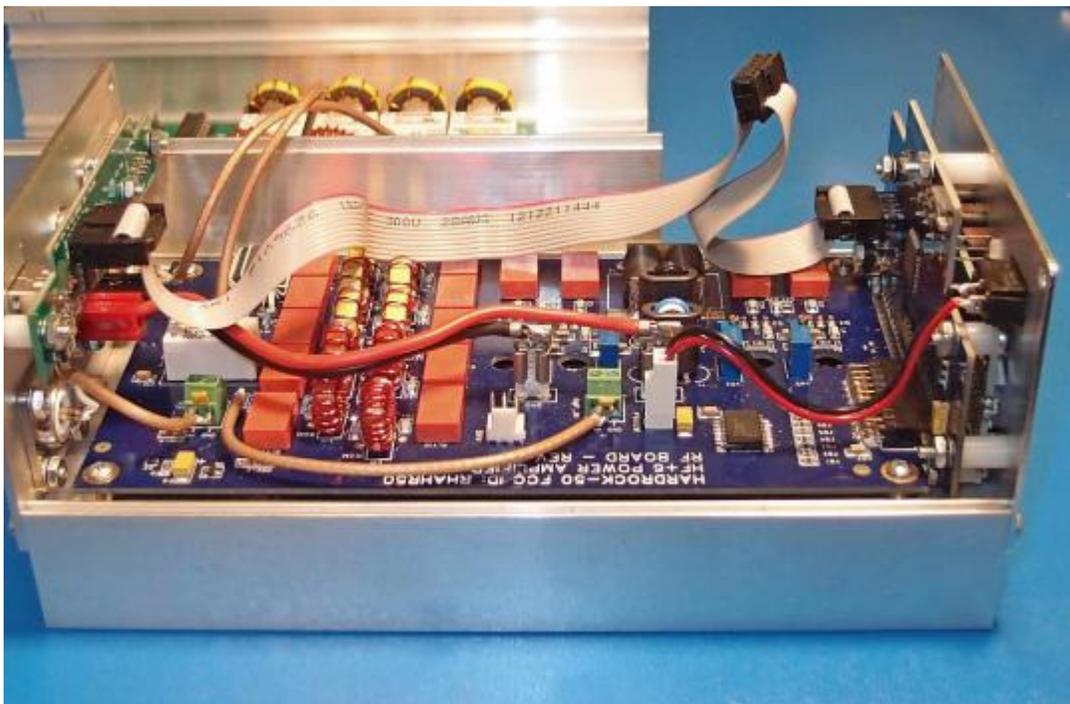
Step 2: Attach one end of the jumper from Step 1 to the 'OUT' SO-239 connector. *If there is a short jumper going from the 'OUT' jack to 'RF_OUT' on the amp PCB remove and discard it before installing the new jumper.*



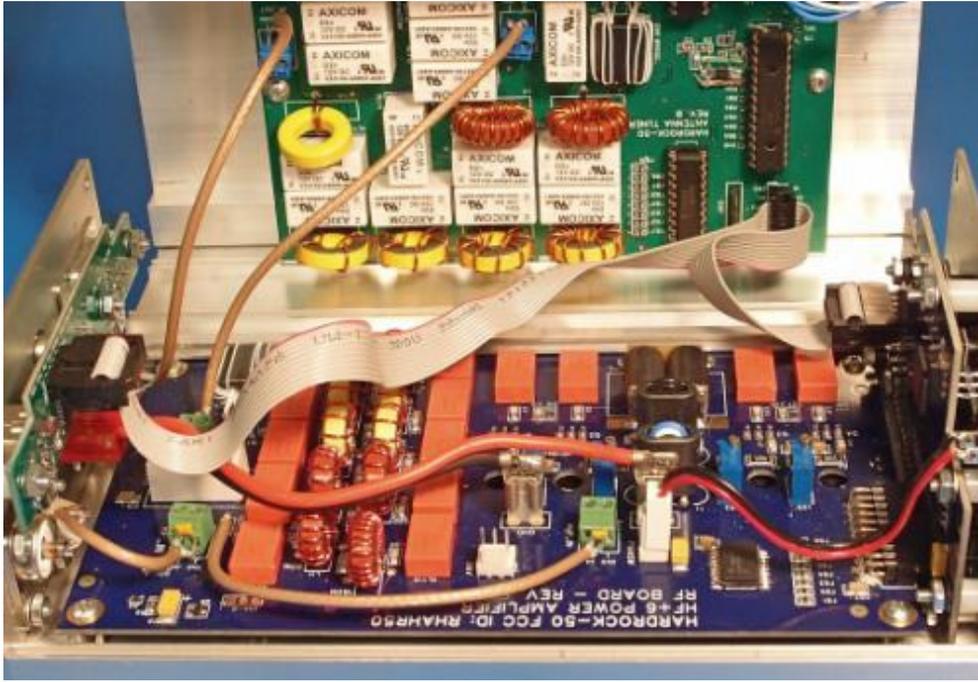
Step 3: Orient the two halves of the case as shown in the photo below. Connect the coax jumper attached to RF_IN TB on the ATU board to the RF_OUT TB on the amp PCB, if the amp has the QSK mezzanine board installed, the RF_OUT connection will be on the QSK board. Connect the coax jumper attached to the 'OUT' SO-239 to the RF_OUT TB on the ATU board.



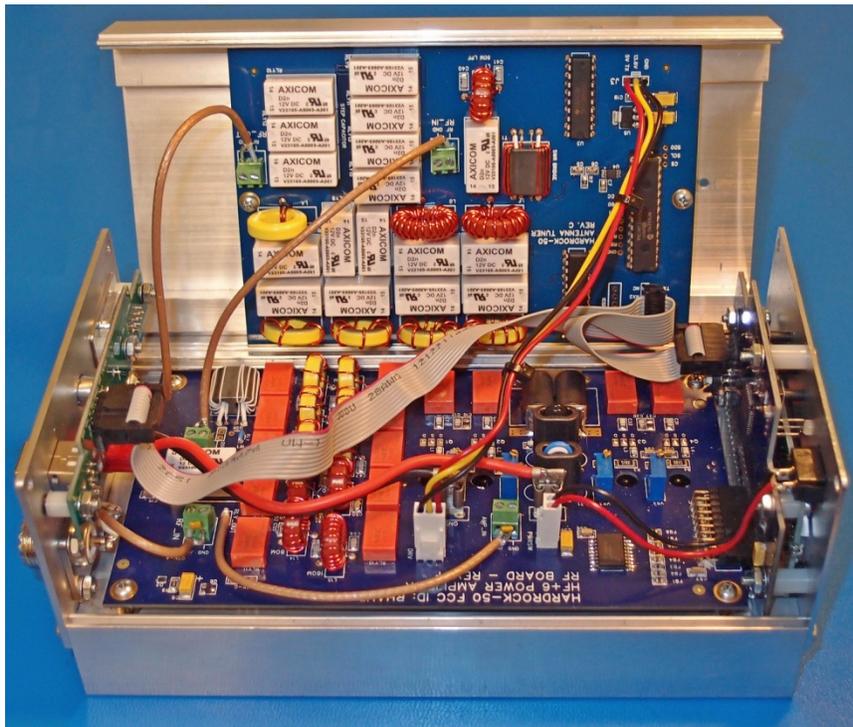
□ **Step 4:** Attach the new three connector ribbon cable to front and rear panel PCB's, leaving the center connector unplugged. Be careful to observe connector orientation and registration. Powering the amp with these connectors on the wrong pins may damage the amplifier.



Step 5: Turn the bottom cover around so the 10 pin header on the ATU board is adjacent to the center connector on the ribbon cable. Then plug the center connector of the ribbon cable into the 10 pin header on the ATU board. Check to make sure the connector registration is correct.



Step 5: Plug the 3 pin connector with wires that attach to the ATU board into the 3 pin header labeled DRV or (DRV/ATU) on the amplifier PCB.



Step 6: Place the bottom cover onto the amplifier making sure none of the wires is pinched between the covers and install the four screws that hold the cover to the front and rear panels.

Step 7: Apply power to the amplifier and turn it on. After several seconds, the splash screen will appear. If the ATU is properly installed and communicating with the amp, the splash screen will report the ATU's firmware version. If the ATU is not communicating with the amp the ATU area of the screen will be blank.



Check the ATU Builder's Resource site to see if new firmware is available and update using the instruction in the following section if needed.

<https://sites.google.com/site/hr50atu/>

Instructions for operating the amplifier/ATU are also on the website.

9. FIRMWARE UPDATE

Currently shipping Hardrock-50's and ATU's are completely up to date with the latest firmware.

If your amp reports FW:3.0D and ATU 1.3, you do not need to update the firmware at this time.

When you first turn on the HR50 the screen is blank for a few seconds while it waits to see if the bootloader will be invoked, then it displays the splash screen which shows which firmware version is currently loaded in the amp and the ATU (if installed):



Installing the USB drivers and Bootloader

In order to facilitate easy updating without an expensive programmer, we have included a bootloader that is provided by our compiler of choice, MikroC PRO for PIC. This is a serial bootloader and is interfaced by an onboard USB-Serial converter. The converter is provided by an SMT Microchip MCP2200 chip. When you first plug your amp into USB and power it on, you will be asked to provide a driver. Drivers are located on the MCP2200 info page:

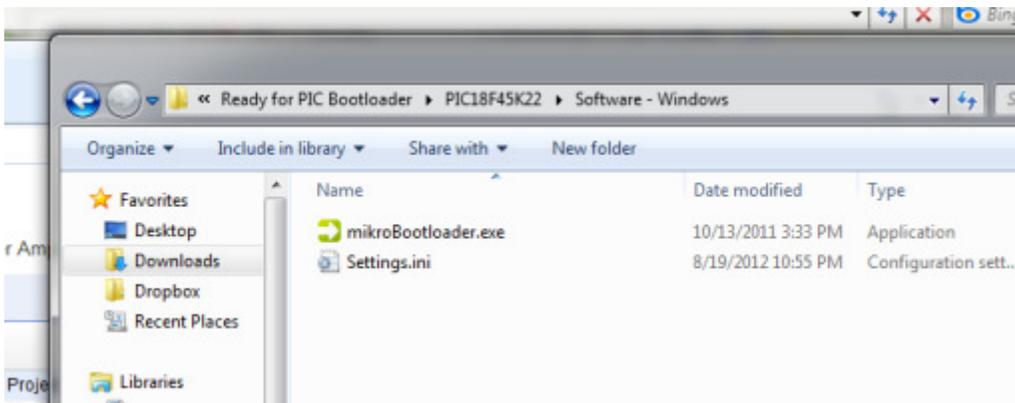
<http://ww1.microchip.com/downloads/en/DeviceDoc/MCP2200%20Windows%20Driver%202013-02-21.zip>

The driver is also available on the ATU files page: <https://sites.google.com/site/hr50atu/home/files>

USB will only connect when the HARDROCK-50 is powered ON.

The bootloader software can be downloaded from MikroElektronika or from the ATU files page, download mikroBootloader2.3.zip at the bottom of the page.

After you download and extract the zip, you will see a directory structure that looks like the following. You want to run the bootloader for the PIC18F45K22. This is a standalone program and doesn't need to be installed. You can run it from where it was extracted or save it somewhere else, your choice.



Updating the Hardrock-50 firmware

Download the latest Hardrock-50 firmware 'HR50 FIRMWARE VX.X.HEX' from the ATU files page:

<https://sites.google.com/site/hr50atu/home/files>

Turn the HR50 on and connect it to a USB port on the computer. Launch the bootloader program and you will be presented with the mikroBootloader and 4 steps to follow. When you click on "Change Settings" to change the serial port settings, you will see the following display:



Change the Port to whatever COM port your HR50 registered as. Leave the rest of the settings alone and click OK. If you don't know which port your HR50 is on, start the bootloader with the HR50 powered off, note which ports are available. Shut down the bootloader, power up the HR50, restart the bootloader and the new port in the list will be the HR50's port.

Make certain that **PIC18** is selected in the 'Select MCU' box in the upper left portion of the bootloader.



After you change the settings, power your amp OFF and press and hold the '+' button on the Hardrock-50 and turn it ON again, keep holding the '+' button for 5 seconds then click the connect button. The amplifier will remain in bootloader connect mode indefinitely. The display will show solid rectangles on the top row, blank characters on the bottom. Now press the 'Connect' button on the bootloader. If everything goes right, you will see the following screen:



Note the Green lights and the word "Connected" in the History Window. Now you can move to Step 3 and browse for the HR50 FIRMWARE VX.X.HEX file you downloaded from ATU files page.

Last, click "Begin uploading" to upload the new version of the firmware to your HR50. After successful upload, you will need to cycle power on the amp and should notice the version change on the splash screen.

Updating the ATU Firmware

CAUTION! Since the ATU has no externally hardwired controls, the only way to update the firmware is to have the firmware that is currently running send control to the bootloader. That means that if you load firmware that doesn't support invoking the bootloader, the ATU is bricked! If you load the HR50 firmware or some other random .HEX file into the ATU, this will happen. If it does and you don't have access to an ICSP programmer to re-flash the PIC microprocessor you'll have to mail your processor to me for a re-flash.

To update the ATU firmware you must be running version 3.0 or later of the HR50 firmware, update the HR50's firmware as required.

Download the latest firmware for the ATU from the ATU files page:

<https://sites.google.com/site/hr50atu/home/files>

The file will be called HR50 AUTOTUNER VX.X.HEX. If the file you have does not have the word AUTOTUNER in the file name, **you have the wrong file!**

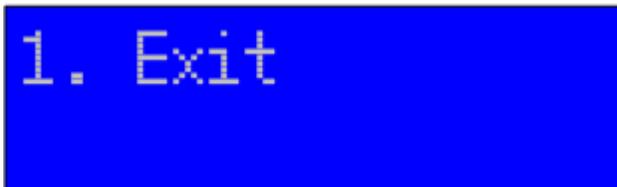
Connect the HR50 to a USB port on the computer, turn on the HR50 and launch the bootloader program.

When you click on "Change Settings" to change the serial port settings, you will see the following display:

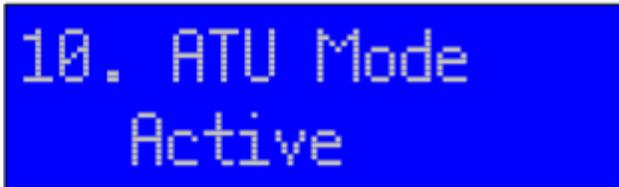


Change the Port to whatever COM port your HR50 registered as. Leave the rest of the settings alone and click OK. If you don't know which port your HR50 is on, start the bootloader with the HR50 powered off, note which ports are available. Shut down the bootloader, power up the HR50, restart the bootloader and the new port in the list will be the HR50's port. Make sure PIC18 is selected in the Select MCU box.

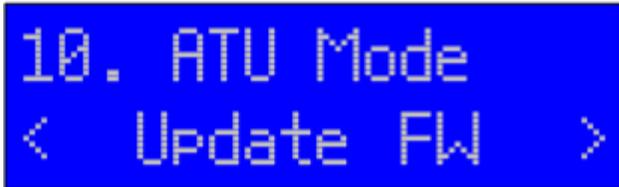
Now press and hold the 'MODE' button on the amp until the menu appears:



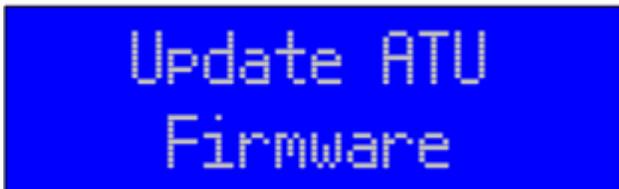
Use the '+' and '-' keys to find the ATU setup, *hint: '-' will get you there faster.*



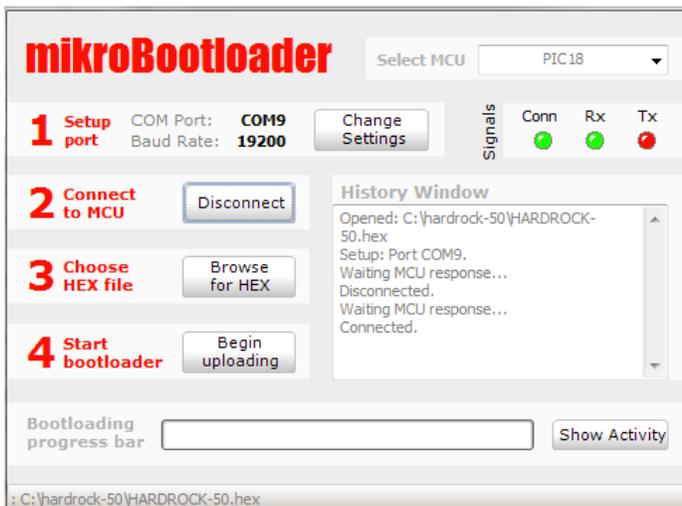
Press the 'MODE' key to change the ATU Mode and use the '+' and '-' keys to select 'Update FW':



Press the 'MODE' button to set the ATU into firmware update mode:



At this point the HR50/ATU is waiting for the bootloader to connect and wait forever until the bootloader connects or the power is cycled. Now press the 'Connect' button on the bootloader. If everything goes right, you will see the following screen:



Note the Green lights and the word "Connected" in the History Window. Now click Browse for HEX and browse for the HR50 AUTOTUNER VX.X.HEX file you downloaded from ATU files page. If the file you have does not have the word AUTOTUNER in the file name, **you have the wrong file, do not download it!**

Up to this point you can safely back out simply by turning off the HR50. The original firmware is still intact.

Last, click "Begin uploading" to upload the new version of the firmware to the ATU. After successful upload, you will need to cycle power on the amp and should notice the version change on the splash screen.

10. SCHEMATIC DIAGRAM

