

## The Hardrock-50 HR50-ATU Internal Autotuner

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### Introduction

The HobbyPCB Hardrock-50 amplifier QST review (December 2014) did not include the optional internal autotuner as it was not available during the review period. Because the HR50-ATU is now available a review of its performance seemed to be in order, especially as the HR50-ATU can be used as a stand-alone QRP broadband wattmeter and autotuner when the Hardrock-50 amplifier is bypassed.

### The Kit Build

Like the Hardrock-50 amplifier, the HR50-ATU is only available in kit form. Assembly entails installing the inductors, transformer, ICs and connectors on the printed circuit board. SMD components are pre-installed. Figure 1 shows the complete kit of parts.

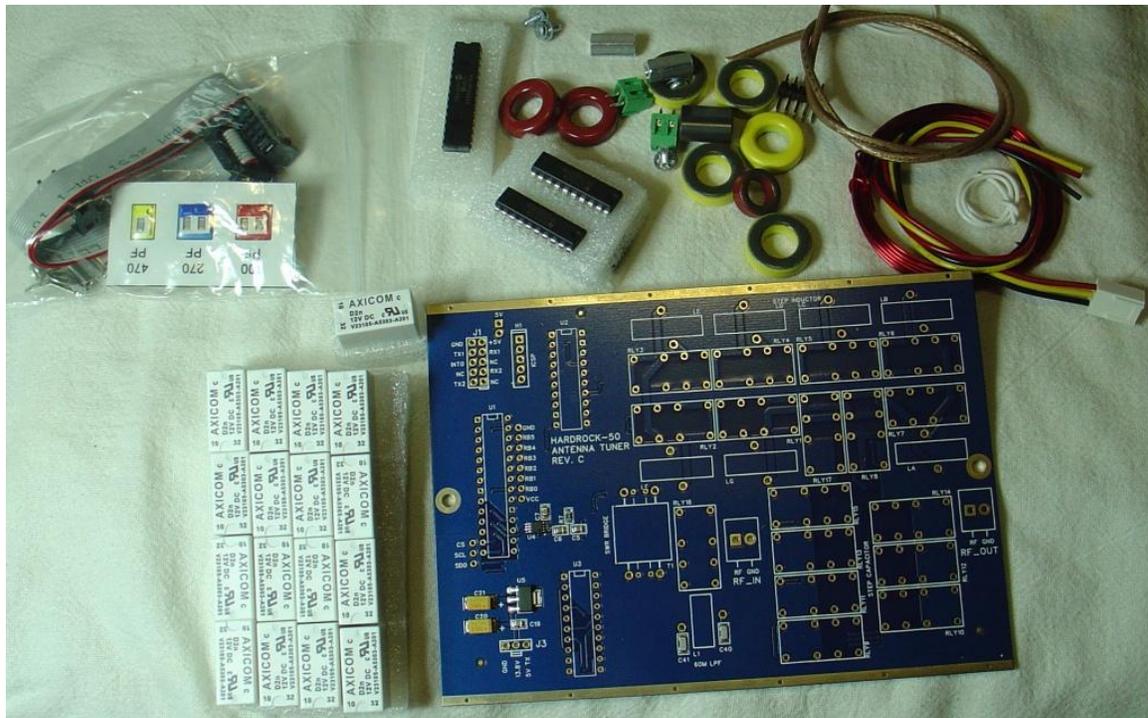


Figure 1: The HR50-ATU kit. The 4'' x 5.5'' pc board includes top- and bottom-side pre-mounted SMD components.

The bag of parts in the upper left is the retrofit kit needed for Hardrock-50 amplifiers below serial number 1400. These early amplifiers require some SMD capacitor changes if 60 meter operation is desired. Also, the DC connector must be replaced and the chassis drilled for autotuner mounting. I won't discuss the retrofit/upgrade as this is well documented in the HR50-ATU assembly manual. And all Hardrock-50 amplifier kits ordered after about mid-November 2014 include these updates.

The HR50-ATU kit includes no documentation, so you must download the assembly manual from [www.hobbypcb.com](http://www.hobbypcb.com). Rather than print out the manual, I found it convenient to simply display the pages on a laptop adjacent to my assembly area.

Assembly was easy – and much less time consuming than the assembly of the Hardrock-50 amplifier. Winding the inductors and transformer took about one hour and was not difficult due to the clear instructions and color illustrations. However, the inductors and transformer can be purchased pre-wound from [toroidguy@earthlink.net](mailto:toroidguy@earthlink.net). Another 1.5 hours was required to complete the full assembly. Figure 2 shows the completed HR50-ATU.

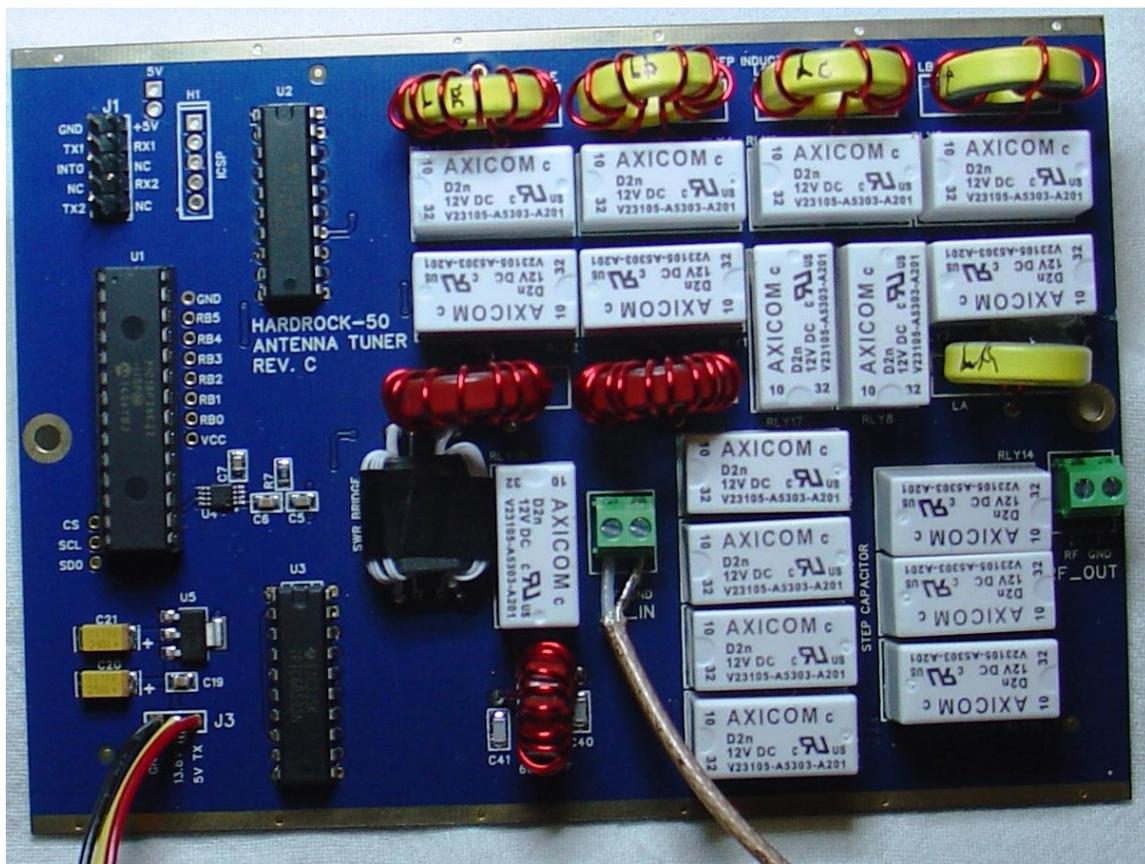


Figure 2: Assembled HR50-ATU ready for installation in the Hardrock-50 amplifier

The HR50-ATU mounts inside the bottom cover of the Hardrock-50 amplifier and connects to the amplifier with two coax cables and one 3-conductor cable. It takes about 30 minutes to mount the HR50-ATU in the amplifier. So the total time for build and installation will be approximately three hours. Upon completion, verify that you have the latest Hardrock-50 amplifier and HR50-ATU firmware and update if necessary.

### HR50-ATU Specifications

Besides providing the autotuning function, the HR50-ATU also adds the filtering necessary for 60-meter operation of the Hardrock-50 amplifier. I.e., when the Hardrock-50 amplifier detects the presence of the HR50-ATU, it permits 60-meter band selection.

And as mentioned in the introduction, the HR50-ATU can be used with the amplifier bypassed to provide both a QRP power meter and a stand-alone autotuner for QRP radios. Table 1 lists the HR50-ATU specifications.

Table 1: HR50-ATU Specifications

Frequency Range:	All ham bands from 160-6 meters.
Autotune Power:	1-watt minimum, 50-watts maximum.
QRP Mode Power:	20-watts relay switched, 5-watts optional PIN-diode switching
Tuner configuration:	Series-L/Shunt-C, reversible-L matching network.
L/C Tuning Ranges:	0-1300pf in 128 steps; 0-6.4uHy in 128 steps; relay switched.
Matching Range:	Up to 10:1 SWR at 50 watts. Lower on 160- and 6-meters.
Target tuned SWR:	Typically 1.5:1 or better
ATU Memory segments:	Non-volatile storage of up to 343 tuning solutions. 10kHz wide from 160-12 meters (233 solutions), 25 kHz on 10 meters (69 solutions), and 100 kHz wide on 6-meters (41 solutions).

### HR50-ATU Operation

When the HR50-ATU is installed in the Hardrock-50 amplifier, menu-10 selects either the BYPASS or ACTIVE mode. BYPASS fully relay bypasses the HR50-ATU. When ACTIVE the HR50-ATU monitors data received from a transceiver, a computer or the Hardrock-50 band information, and applies previously stored tuning solutions prior to transmitting. When ACTIVE, the HR50-ATU can be bypassed by pressing the “-“ button while transmitting. To re-enable the ACTIVE mode, press the “+” button while transmitting.

When band data is only available from the Hardrock-50 band information, the last tuning solution for that band is applied. If frequency data is received from a transceiver or computer, the last tuning solution stored for that frequency is used. If no frequency information is found, the last tuning solution for that band is used. And if no tuning solution is found for that band, the HR50-ATU is bypassed but remains ACTIVE. The HR50-ATU does not measure frequency directly, eliminating the possibility of false memory selections due to errors in counting a modulated frequency.

The HR50-ATU only tunes when the operator requests a tune, and so there is no SWR trip-point to automatically start a tuning cycle. A high SWR condition will not damage either the HR50-ATU or the Hardrock-50 amplifier, so no automatic amplifier bypass occurs under a sudden high SWR condition. This also protects the driving transceiver from damage as the in-line Hardrock-50 amplifier provides a good 50 ohm termination.

Tuning is initiated by pressing the MODE button while transmitting. This bypasses the amplifier, tunes, stores the tuning information in memory for that band or frequency, and re-engages the amplifier. The HR50-ATU responds to a wide input power range and can tune with a constant signal, a string of CW characters, or even SSB audio. Tuning is fast, typically requiring less than 1-second. If the target SWR cannot be achieved, tuning stops after 4-seconds and the lowest SWR match is applied.

### Tuner Matching and Loss Measurements

Resistive matching range and loss testing was performed with the precision set-up described in the August QST, 2012 antenna tuner review, p. 47 (see the QST-in-depth section of that review for details). The test results are given in Table 2. Tuning power was 2-watts. All measured losses are subject to the +/-3% accuracy of the NIST-traceable test equipment used.

Table 2: HR-50 ATU Resistive load and loss testing

VSWR/Impedance		160m	80m	40m	20m	10m	6M
10:1/5Ω	Loss (%)	61	51	46	10	17	31
	VSWR	5.8	4.6	3.8	1.12	1.08	1.13
8:1/6.25Ω	Loss (%)	52	17	13	7	11	15
	VSWR	4.8	1.83	1.72	1.06	1.17	1.24
4:1/12.5Ω	Loss (%)	25	4	4	3	7	13
	VSWR	2.7	1.3	1.17	1.15	1.17	1.53
3:1/16.7Ω	Loss (%)	15	2	2	3	7	11
	VSWR	2.1	1.18	1.17	1.20	1.19	1.09
2:1/25Ω	Loss (%)	4	1	1	2	5	10
	VSWR	1.49	1.15	1.06	1.22	1.06	1.17
1:1/50Ω	Bypass Loss (%)	0	0	0	0	0	0
	Bypass VSWR	1.05	1.05	1.05	1.06	1.06	1.21
2:1/100Ω	Loss (%)	2	3	4	4	6	16
	VSWR	1.12	1.09	1.22	1.17	1.30	1.50
3:1/150Ω	Loss (%)	9	4	5	6	10	20
	VSWR	1.64	1.13	1.13	1.29	1.30	1.29
4:1/200Ω	Loss (%)	20	5	7	7	11	23
	VSWR	2.13	1.05	1.08	1.29	1.21	1.58
8:1/400Ω	Loss (%)	42	10	8	8	14	39
	VSWR	3.89	1.51	1.39	1.14	1.32	2.24
10:1/500Ω	Loss (%)	51	15	10	10	20	56
	VSWR	5.0	2.0	1.40	1.16	1.24	2.57

As you can see, the HR50-ATU achieved its 1.5:1 or better VSWR target except for some extreme matching conditions on low and high bands. Like all tuners, HR50-ATU losses increase as SWR increases. However, keep in mind that matching a high SWR at the station end of your antenna system can result in even higher SWR-related coax losses.

### Open/Short Circuit Testing

Ideally a tuner should not be able to match an open or short. If it does, this means that it is tuning into its own internal losses and the tuner may be damaged as it is dissipating full transmit power. No antenna tuner is lossless due to finite-Q components and so most wide-range antenna tuners can find a match on one or more frequencies when connected to an open or a short. I found one instance on 15 meters where the HR50-ATU successfully tuned into a short. Tuning failed on all other bands with the short, and tuning failed on all bands with an open. Of course, one should always check the bypassed SWR prior to tuning, and if it is beyond the capability of the tuner (10:1 SWR in this case) the

antenna system needs to be improved. While this doesn't preclude a sudden SWR change due to an antenna system component failure, the HR50-ATU does not tune unless requested by the operator. Therefore any sudden change in the antenna system would show up as a high SWR which can then be resolved.

### QRP Power Meter Testing

The Hardrock-50 amplifier provides accurate RF power metering at close to full output power after calibration. However, the wattmeter display is only active when the amplifier is keyed, and it is quite inaccurate at low power levels. The QRP/Wattmeter mode of the HR50-ATU provides a stand-alone wattmeter display with improved power readings at the lower power levels. I made power measurements at 2-watts and 5-watts with a NIST-traceable power sensor and recorded the HR50-ATU displayed power. The power readings originally read low. However, like the Hardrock-50 amplifier the HR50-ATU firmware provides an offset setting for improved accuracy. I re-measured the power readings after I set in an offset of +20%. Table 3 characterizes the test results.

Table 3: HR50ATU QRP Power Display Accuracy

<u>Band</u>	HR50-ATU Display							
	2-Watts				5-Watts			
	<u>Original</u>	<u>Error</u>	<u>Corrected</u>	<u>Error</u>	<u>Original</u>	<u>Error</u>	<u>Corrected</u>	<u>Error</u>
160M	1.4W	-30%	1.7W	-15%	3.7W	-26%	4.2W	-16%
80M	1.4W	-30%	1.7W	-15%	3.7W	-26%	4.2W	-16%
40M	1.6W	-20%	1.8W	-11%	4.2W	-16%	4.8W	-4%
30M	1.6W	-20%	1.9W	-5%	4.3W	-14%	5.0W	0%
20M	1.7W	-15%	1.9W	-5%	4.4W	-12%	5.0W	0%
17M	1.7W	-15%	2.0W	0%	4.4W	-12%	5.1W	+2%
15M	1.7W	-15%	2.0W	0%	4.4W	-12%	5.1W	+2%
12M	1.7W	-15%	2.0W	0%	4.4W	-12%	5.1W	+2%
10M	1.7W	-15%	1.9W	-5%	4.4W	-12%	5.0W	0%
6M	1.6W	-20%	1.9W	-5%	4.3W	-14%	4.8W	-4%

### Operating

Because I have a KX3, I interfaced it to the Hardrock-50 amplifier/HR50-ATU with a cable which provides frequency information. My HF antenna is a 43-foot vertical with the remote 160/80 meter matching unit described in my January 2010 QST article, page 34. Once I memorized tuning solutions for the vertical on all HF bands, operation was a breeze as the HR50-ATU followed my KX3 and picked the correct tuning solution prior to transmitting.

### Conclusion

The Hardrock-50 internal ATU provides all the antenna system flexibility most hams will need. The HR50-ATU kit is reasonably priced, and the kit is not difficult to build. If you don't have a perfect antenna system, the HR50-ATU may be a worthwhile addition to your Hardrock-50 amplifier.

Bottom Line: The HR50-ATU mounts within the Hardrock-50 amplifier and provides automatic tweaking of less-than-perfect antenna systems.

*Manufacturer:* HobbyPCB, 831-763-4211, [www.hobbypcb.com](http://www.hobbypcb.com).

*ATU List Price:* \$179.