

The HobbyPCB HARDROCK-50 50-watt 160-6 Meter Amplifier Kit
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Introduction

In the 2010 QST Jim Veatch WA2EUJ detailed a 40-15 meter amplifier designed for QRP transceivers. Jim has since evolved that design into the HARDROCK-50 now offered by HobbyPCB. The HR-50 provides 50 watts output power with a drive level of 5 watts or less on 160-10 meters, and 35 watts on 6-meters. It is supplied only in kit form and is housed in a rugged aluminum enclosure. Available options include a PIN-diode QSK switch, a low-level preamplifier that permits full output from 0.5 watts drive, and an internal automatic antenna tuner. However, you cannot include both the automatic antenna tuner and the low-level preamplifier. The QSK option (available for SN1200 and above) fits with either option. The HARDROCK-50 reviewed here is the standard relay-switched version with no options installed. The internal automatic antenna tuner was not yet available during the review period.



Figure 1: HR-50 Front Panel

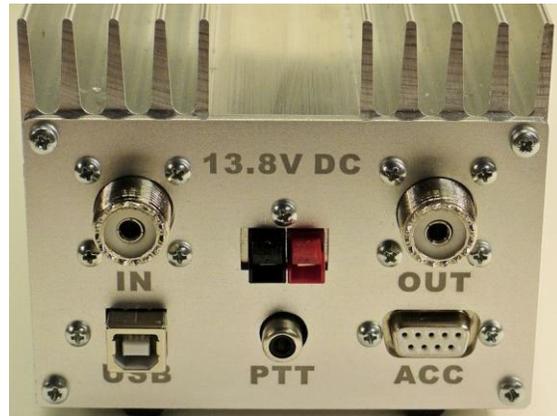


Figure 2: HR-50 Rear Panel

Putting it together

The HR-50 arrived in a small 4.5" x 8.5" x 9.5" box containing the main chassis/heat-sink, and a smaller box with the amplifier parts. This includes front- and rear panels, three printed circuit boards with pre-installed SMD components, and the connectors, wire, ferrites, toroids and hardware. See Figure 3.



Figure 3: The HARDROCK-50 arrives!

No documentation is provided, so you must download the assembly manual from www.hobbypcb.com. You can print out the assembly manual, though I found it convenient to display the pages on a laptop adjacent to my assembly area. A printed manual would be convenient for checking off each assembly step. However it is difficult to miss a step since all SMD components are pre-mounted and so assembly consists of adding large connectors, relays, inductors and transformers.

I built the HR-50 over 3-days. I'd estimate that the full assembly took me about 8-10 hours. I was missing two ferrites and a connector. I emailed HobbyPCB and received an answer within minutes – and this was on a Saturday afternoon. It seems they had identified a run of amplifiers where these parts had not been included. The replacement parts were quickly received and I continued with the assembly.

Figure 4 shows the front- and rear-panel assemblies with their attached printed-circuit boards. All that was required was soldering connectors to the printed circuit boards and then mounting the printed circuit boards to the front and rear panels.

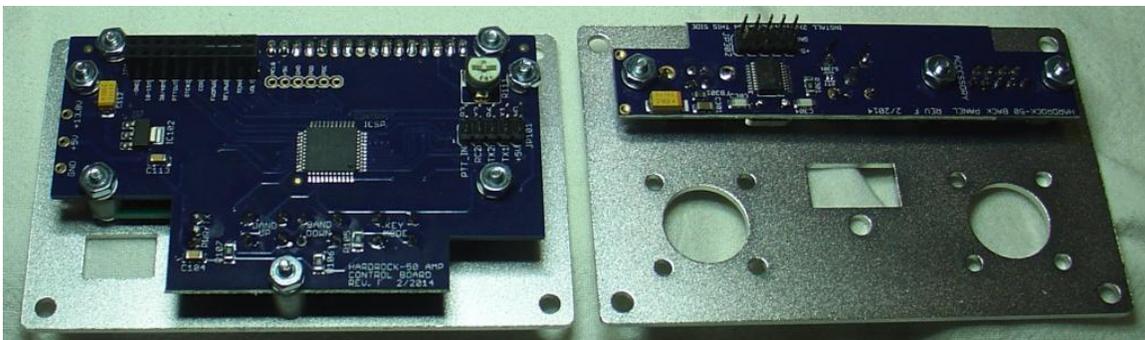


Figure 4: Front- and Rear-Panel assemblies

For me the most time consuming part was soldering in the 15 relays, followed by winding and installing the inductors and transformers. And while the inductor/transformer winding process is not difficult due to the clear instructions and color illustrations, you can purchase them pre-wound from toroidguy@earthlink.net for \$35. The SMD-only amplifier printed circuit board assembly is shown in Figure 5. Figure 6 is a photo of the amplifier with all parts mounted.

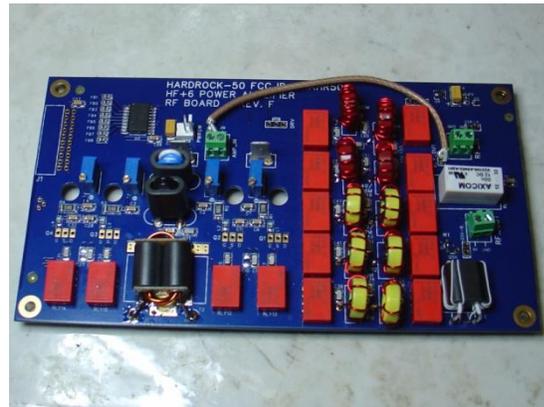
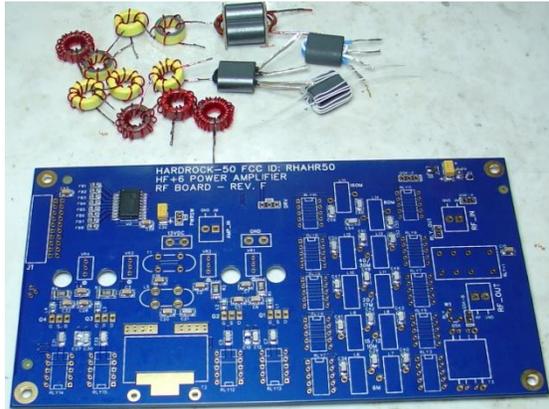


Figure 5: Unassembled amplifier pc board Figure 6: Completed amplifier assembly

Figure 7 shows the completed amplifier just before attaching the cover. There was excess ribbon cable length so I folded it and tie-wrapped it to the DC power cable just to keep things neat. When the amplifier is complete, only five adjustments are needed. A single-turn potentiometer sets the display contrast, and four multi-turn potentiometers set the four FET gate bias voltages (for which you'll need a DMM). If you cannot get your HARDROCK-50 to work properly, HobbyPCB provides excellent technical support via email as well as through a user forum on their website. And if all else fails, you can ship your HR-50 to HobbyPCB and they will fix it. HobbyPCB guarantees everyone will have a working amp at the end of the build.

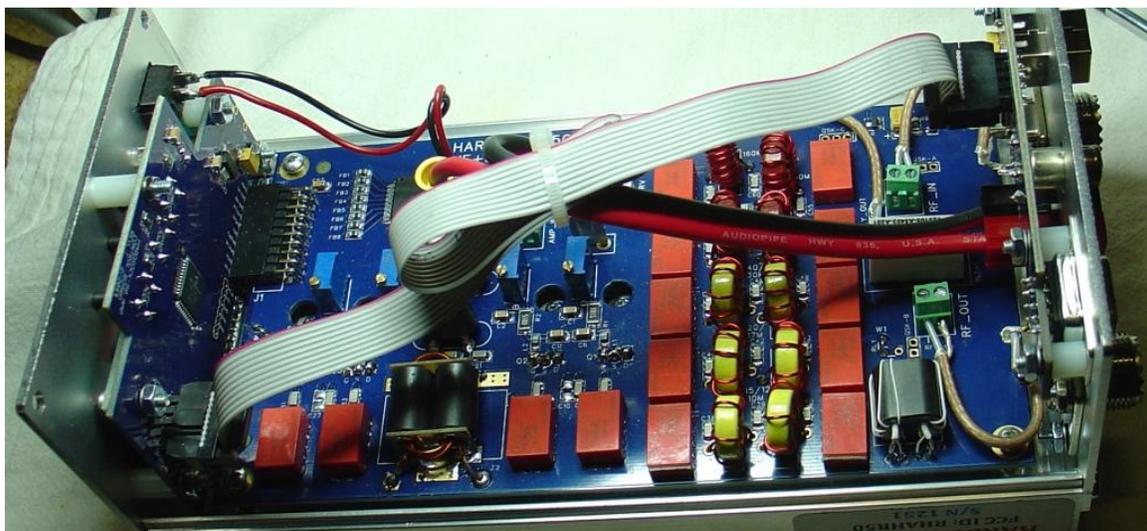


Figure 7: Completed HARDROCK-50 Amplifier

HARDROCK-50 Amplifier Technical Details

The HR-50 DC input is the “standard” Anderson Powerpole™ connector. You will need a +13.8VDC power supply capable of at least 12-amps continuous current. As the amplifier is not fused, a fused (15-amp) DC input cable is recommended. The large heatsink provides the necessary thermal dissipation – i.e. no fan is needed.

The HR-50 outputs 50 watts from 160-10 meters with 5-watts maximum drive (typically 3-4 watts) using four RH16HHF1 MOSFETs. Power on 6-meters is spec'd at 35-watts though most amplifiers will exceed 40-watts on this band. T/R switching is handled by a relay or an optional PIN-diode switch. The relay 6ms/4ms maximum specified operate/release time is fast enough to prevent hot-switching when used with most any transceiver's amp-key output. The optional PIN-diode QSK switch assembly switches in less than 140 microsecond, but there is a trade-off. The QSK switch has 0.25dB loss in both the transmit- and receive-path on 160-10 meters (typically 3-watts transmit loss). The loss increases to about 0.5dB on 6-meters (typically 5-watts transmit loss).

No automatic fault protection is included – nor is it needed! The RH16HHF1 MOSFETs are rated to operate at 16VDC into a 20:1 SWR at any phase angle. An open or short on the output (so only the low-pass filters are inline) results in a worst case SWR of 18:1 to the FETs. And the normal operating voltage is 13.8V. About the only way the FETs can be damaged is by overheating due to insufficient contact with the heatsink. The FET mounting instructions are well-written and should preclude this from occurring.

Finally, the HR-50 supports automatic band-tracking with the Elecraft KX3, the Flex-1500 and any of the low power SDR's that use PowerSDR (Softrock, Peaberry, G10). As the HR50 supports the Kenwood CAT command set, other SDR programs may support automatic band-tracking as well. Automatic band-tracking is also planned for the Yaesu FT-817 and the latest TAPR SDR. Firmware updates are easy (a USB A/B cable is required) – just follow the detailed instructions given in the assembly manual.

The HARDROCK-50 Display and Control

When the unit is powered on there is a 5-10 second boot process during which the amplifier firmware revision is shown. The amplifier then displays Mode, Band, Temperature and Voltage. When the HR-50 is keyed, the display changes to TX mode where a top bargraph shows average forward power, and the bottom display shows calculated SWR and peak power.

There are only three control buttons – Up/Down BAND SELECT buttons and a KEY MODE button. The BAND SELECT buttons only operate during receive. And the band setting is retained when the HR-50 is powered off.

Tapping the KEY MODE button toggles between SB (standby), PT (Push-To-Talk where grounding the PTT line keys the amplifier) and CR (RF carrier detect keys the amplifier). The CR mode is provided as many QRP radios don't have an amp-key output. However, you will hot-switch your driving transmitter's output as you can't sense RF and switch instantly. When added to the relay operation time, the RF sense circuitry time constant

will result in RF being present for 10-12ms before switching completes. Even when the QSK option is used, RF will be present for 5-7ms before PIN-diode switching occurs. So if possible, use the PTT input for amplifier keying. The PTT interface is compatible with all transceivers that have an amp-key output – including the +8VDC/0VDC HSEND output of the Icom IC-703 transceiver.

A 3-second push of the KEY MODE button also provides access to some internal menus for other custom settings. The up/down buttons provide scrolling through the menus and changing the settings. Currently the menus include: Accessory Baud Rate, USB Baud Rate, KX3 Serial On/Off, Temperature display (F/C), Watt Meter Adjust, COR Hang Time, and Key-up Delay.

Performance Measurements

As I have a KX3, I built the interface cable shown in Figure 8. The automatic band tracking worked great. And it simplified my testing as my KX3 was used as the signal source for much of my work.

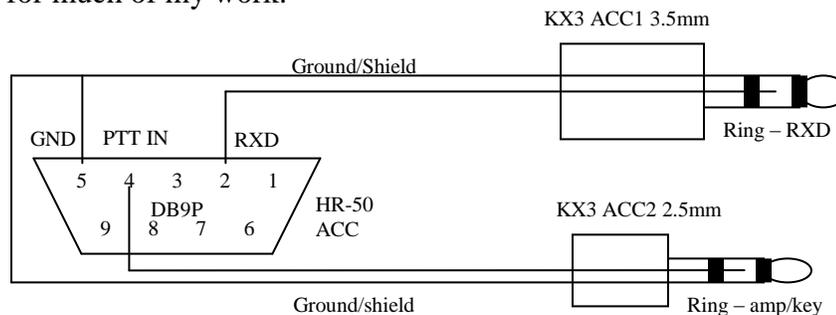


Figure 8 – HR-50/KX3 Band Tracking and Amp-Key

The DB9P connections are shown from the solder-cup side of the connector. I purchased the connectors from www.mouser.com. The 3.5mm and 2.5mm right-angle plugs are part numbers 171-3308-EX and 171-3325-EX, respectively. The DB9P and hood are part numbers 156-1209T-E and 156-2009-EX, respectively. A 3-foot section of dual shielded cable connects the DB9P and the two KX3 accessory plugs.

Table 1 summarizes the measured amplifier performance. Spurious and harmonic distortion and IMD products, and the T/R relay timing were measured in the ARRL lab.

Table 1: HARDROCK-50 SN1251 Technical Data

<i>Manufacturer's Specifications</i>	<i>Measured performance</i>
Frequency Range: All ham bands from 1.8-54 MHz except 60 meters* .	As specified.
Input VSWR: Not specified	See Table 2.
Drive Power 2.5-3W typ, 5W maximum ¹	See Table 2.
Output Power 50W typical at 13.8 V, 1.8-30 MHz, 35W on 6-meters ²	See Table 2
Internal power meter accuracy $\pm 5W$ @ 50 Ω	See Table 2
Harmonic and Spurious Suppression:	HF, 48 dB (worst case, at 1.8 MHz), typically

Transmit IMD (3rd/5th/7th/9th)	64 dB; 50 MHz, 60 dB. Complies with FCC emission standards. 14 MHz: -38/-33/-38/-46 dp below PEP; 50 MHz: -33/-32/-42/-60 dB below PEP.
Keying Modes: Carrier operated or PTT Key In: Receive +5 Vdc open circuit, ground to transmit, 10 mA maximum. ³ Amplifier Relay Transition Time,	As specified. See text. As specified. PTT mode, unkey to key, 3.2 ms; key to unkey, 3.8 ms; Carrier operated mode, 12 ms for 0.4 W to maximum drive power.
Supply Voltage and Current 11-16VDC (13.8 V nominal) 10A typical, 12A peak. Weight: 3 lb (1.4 kg) Size: 4.25"W x 3.5"H x 7.5"D	As specified. See Table 2.

*60M operation is supported when the optional ATU is installed. Without the ATU the HR-50 filtering does not meet the 60 meter FCC 2nd harmonic requirements. The HR-50 allows selection of the 60M band only if the ATU is installed.

¹The HR-50 will tolerate 10 watts of drive for a short time without damage.

²Exceeding rated output may result in signal distortion. If the PIN-diode QSK option is installed, output power should be reduced 3-watts on HF and 5-watts on 6-meters.

³The PTT line is diode protected for externally applied voltages from -24 to +24 volts.

During my initial tests I measured a high input SWR on 6-meters (about 4:1). This has been a known problem with the HR-50, however I was able to determine what was causing this and came up with a simple fix. The re-work has been incorporated into amplifier boards above serial number 1399. For those with Rev F amplifier boards below this serial number, simply insert 33pf/100V capacitors into the RF-IN and AMP-IN connectors as shown in Figure 9. Contact HobbyPCB for the rework necessary on earlier amplifier boards.

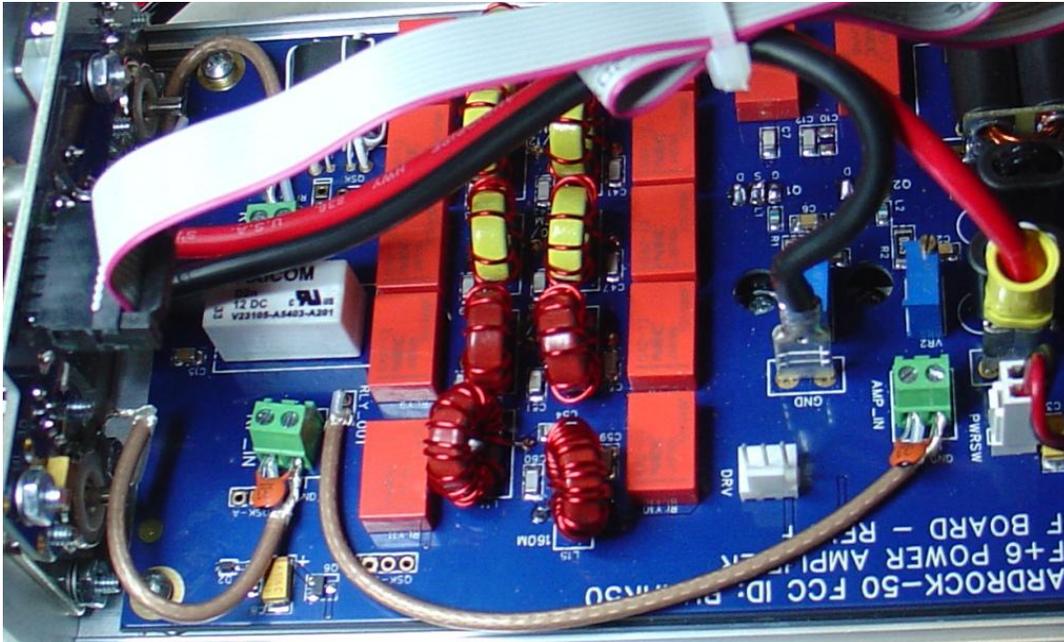


Figure 9: Rev F rework for improved 6-meter input SWR performance

During the ARRL lab testing, a spurious out-of-spec half-frequency signal was found when driving the amplifier on 6-meters. HobbyPCB determined that this was due to a change in the manufacturer of four SMD inductors (L1-L4) and only affects Revision F amplifier boards from SN1200-1399. If your HF50 falls into the affected serial number range and you operate 6-meters, you can either replace the inductors yourself (HobbyPCB will send you replacement inductors), or you can return your amplifier for the update. While these are SMD parts, I easily removed them by placing a soldering iron across each inductor and picking them off with tweezers. Next I added a small blob of solder to one pad-end for each inductor, and used a piece of copper braid to wick-off excess solder on the other pad-end. Then I held each inductor in place with tweezers and heated the solder-blob end of the pad. This soldered one end of each inductor, and permitted the inductor to lay flat on the pc board. Then I soldered the other end of each inductor to the opposite pad.

Table 2 documents bypass and amplifier input SWR, required drive for 50 watts output (or 5 watts maximum drive), and +13.8VDC current at rated output. Power was measured with a NIST-traceable Minicircuits PWR-6GHS+ sensor and calibrated attenuators ($\pm 3\%$ accuracy). Input SWR was measured with an Array Solutions PowerMaster, and input DC current was measured with an AEMC 514 Hall-effect clamp-on DMM.

TABLE 2: HARDROCK-50 Serial Number 1251 Amplifier Measurements: +13.8VDC Key-Down voltage, Standby 0.10amps, Operate no drive 0.30 amps

<u>Band</u>	<u>Bypass SWR</u>	<u>Drive</u>	<u>Input SWR</u>	<u>HR-50 Display</u>	<u>PWR-6GHS+</u>	<u>DC Current</u>
160M	1.02:1	3.96W	1.29:1	49W	50W	9.82A
80M	1.02:1	2.40W	1.21:1	49W	50W	7.81A
40M	1.02:1	3.59W	1.20:1	49W	50W	8.30A
30M	1.02:1	5.00W	1.23:1	48W	49W	9.96A

20M	1.03:1	4.04W	1.25:1	49W	50W	9.82A
17M	1.05:1	2.74W	1.30:1	50W	50W	7.31A
15M	1.08:1	2.79W	1.41:1	50W	50W	7.18A
12M	1.10:1	2.97W	1.48:1	50W	50W	7.59A
10M	1.14:1	2.90W	1.52:1	50W	50W	9.00A
*6M	1.41:1	3.00W	1.41:1	39W	40W	6.30A

*The 6-meter output power specification is 35 watts. This amplifier achieved 42 watts on 6-meters, however power should be kept below maximum for best IMD performance.

As you can see in Table 2, the HR-50 power detector has a very flat frequency response. However, when first tested the power read about 12% high (better a high reading than a low reading to ensure no signal distortion). Some inaccuracy is expected due to variations in the power coupler's ferrite tolerance, and primary/secondary winding symmetry and positioning. However, a HR-50 menu selection permits adjusting the power reading. I put in -13% (the factory default was -1%) and achieved the readings shown in Table 2. If you have access to an accurate wattmeter, you can achieve excellent HR-50 displayed-power accuracy. Finally, don't forget to back down the output power by 3-watts on HF and 5-watts on 6-meters if you have the PIN-diode QSK option installed.

Conclusion

The HARDROCK-50 is a compact, rugged amplifier that integrates perfectly with any QRP transceiver. It is reasonably priced and the kit is easy to build for those hams with some prior soldering experience. If you occasionally need to boost your QRP signal by 1-2 S-units, the HARDROCK-50 is certainly worth considering.

Manufacturer: HobbyPCB, 831-763-4211, www.hobbypcb.com.

List Prices: HARDROCK-50 \$299.00. QSK Option \$49.00. 0.5-5W preamp \$35.00. Internal ATU \$179.