Product Reviews

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Product Reviews:

CommRadio CR-1a Communications Receiver

HobbyPCB Hardrock-50 160-6 Meter 50 W Amplifier Kit

MFJ-4403 Transceiver Voltage Conditioner

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CommRadio CR-1a Communications Receiver

A software defined receiver with no "computer" required.

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When we think of software defined radio (SDR), among the first images that appear in our imaginations are wide flat-screen monitors. If you go to a hamfest and visit an SDR exhibit, that's what you'll see: large computer monitors displaying SDR software. Signal waveforms pulse and dance; filter windows expand and contract. It is all quite impressive and very "21st century."

SDR performance is every bit as impressive as it looks, and its magic begins at (or near) the receiver's antenna terminals. A signal arriving at an SDR receiver is, by its very nature, analog, but it doesn't remain that way for long. Within microseconds it is "sampled" — chopped to bits at an extremely high rate by an analog-to-digital converter (ADC). The data from the ADC is processed into *in-phase* and *quadrature* components, or *I/Q* for short. Once you have rendered the signal to I/Q information, you can use software to demodulate whatever is contained within.

At the center of all this wondrous work is a computer. Without a computer and software, a software defined radio is useless; it is nothing more than a sophisticated piece of hardware spewing data that goes unprocessed and unheard. That's why images of monitors have become so iconic in the SDR universe. They represent the computer connection that is critical to software defined radio.

SDR computers don't have to be tablets, laptops, or desktops, though. They can also be arrays of microprocessors hidden away in nondescript enclosures. If you can communicate with those microprocessors through a set of buttons and a functional display of some sort, you can easily dispense with the bulky monitors and keyboards.

Which brings us to the CommRadio CR-1a receiver.

SDR Without a "Computer"

The CommRadio CR-1a is most definitely an SDR, and it incorporates the requisite computer, too. But instead of depending on extra pieces of hardware external to the radio itself — what we normally think of as a "computer" — the CR-1a combines everything, including powerful microprocessors, into a single metal enclosure that is just 5.6 inches wide, 2.4 inches high and 6.1 inches deep and weighs less than 2 pounds. Instead of a monitor and keyboard, you interact with this SDR through a collection of buttons, two knobs and a crisp organic LED (OLED) display.

The CR-1a is among the first SDRs designed to be completely portable. The radio features a bottom-firing speaker, which is the reason for its unusual elevated stance. The CR-1a includes a rechargeable lithium-ion battery, although it can also be powered from a USB port or an external 6 – 18 V dc source. The powder-coated steel case and machined aluminum knobs give the CR-1a a nice feel.

Since the CR-1a looks and acts like a conventional receiver, it's fair to ask why its SDR architecture deserves discussion. The answer is that one of the most attractive aspects of any SDR is the ability to make huge changes to the way the radio functions by simply installing new software. In the CR-1a, the software resides in nonvolatile memory and can be changed at any time. If CommRadio wants to add new features to the CR-1a, such as synchronous AM reception, for instance, they can do so by offering revised software that you download from their website and then upload to the radio. So, unlike conventional receivers, the CR-1a can "evolve" over time, at least within the limitations of its hardware.

In addition, if you want to use the CR-1a as a "typical" SDR with an external computer and software, you can do so. There is a USB port on the rear panel that is normally used to recharge the internal battery. The CR-1a makes I/Q data available at this port, which you can subsequently feed to a computer and software of your choosing.

Bottom Line

The CR-1a is a portable, battery operated, wideband receiver that uses software defined radio technology to receive a variety of modes on select frequency segments from 500 kHz through 512 MHz.

When this review was conducted, Comm Radio offered a free piece of software that allowed users to access the I/Q data and control the radio to a limited extent (see Figure 1). The software was in beta testing at the time, so improved and expanded versions will probably be showing up soon. As the CR-1a becomes more commonplace, I'd expect to see compatible third-party software as well.

Broad Coverage, Filters, and More

The CR-1a's coverage spans 500 kHz to 30 MHz; 64 to 260 MHz and 437 to 512 MHz in AM, SSB, CW, WBFM, NBFM. Wideband FM is the default when tuning through the FM broadcast band (monaural only — at least with the current software). The CR-1a will also receive long wave (LW) from 150 to 500 kHz, but with reduced performance due to the lack of a dedicated front-end preselector for those frequencies.

Interestingly, the CR-1a has what you might call a "split" receiver architecture, which you notice right away when you examine the rear panel shown in Figure 2. There are two BNC jacks: one for LW through 30 MHz and the other for 64 MHz and above. The review radio also has a separate 3.5 mm jack for a long wave or AM antenna, but this was eliminated in later production runs (s/n 750 and higher). For reception below 30 MHz, the CR-1a uses a dual conversion approach to providing a lower-frequency IF signal for the ADC. For 64 MHz and up, however, it makes the jump to the IF frequency in a single step.

Tuning is not continuous from long wave to VHF or UHF. To switch from HF to VHF or UHF you must enter the menu system and select the frequency group. Once you've made your selection, you punch the user configurable BAND key to step from one band to another, or simply select the tuning step you desire and spin the tuning knob. A nice touch: you can configure the BAND key to limit choices to the 160 – 10 meter amateur bands or the 120 – 11 meter shortwave broadcast bands.

While in the menu, you'll also find a squelch adjustment. Actually, there are two separate squelches: one for HF and the other for VHF/UHF.

If you have the CR-1a in AUTOMATIC mode, the radio will automatically select the proper mode and filter as you tune. When you tune into the 40 meter Amateur

Table 1
CommRadio CR-1a, serial number 0629

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: Receive only, 0.5 – 30, 64 – 260, 437 – 512 MHz.	As specified; 150 – 500 kHz also provided for experimental purposes.
Power requirement: 5 V dc via USB jack, or 6 – 18 V dc to charge 3.7 V dc internal Li-ion battery.	3 W maximum at 120 V ac for wall charger.
Modes of operation: SSB, CW, AM, wideband FM (FM Broadcast band only).	As specified.
Receiver	**Receiver Dynamic Testing**
Sensitivity: –130 dBm (71 nV) nominal at 500 Hz bandwidth (0.5-30) MHz.	Noise floor (MDS), 3 kHz filter: 3.5 MHz –125 dBm 14 MHz –122 dBm 70 MHz –130 dBm 144 MHz –126 dBm 440 MHz –113 dBm
AM sensitivity: Not specified.	10 dB (S+N)/N, 1 kHz, 30% modulation, 6 kHz BW: 1.020 MHz 3.23 µV 3.8 MHz 2.04 µV 29 MHz 3.16 µV 120 MHz 1.12 µV 144 MHz 1.30 µV 440 MHz 9.43 µV
FM sensitivity: For 12 SINAD, –98 dBm (2.9 µV) VHF, –86 to –98 dBm (11.5-2.9 µV), UHF.	For 12 dB SINAD, 15 kHz BW: 29.6 MHz 1.29 µV 70 MHz 2.09 µV 146 MHz 0.83 µV 162 MHz 1.05 µV 223 MHz 0.76 µV 440 MHz 3.75 µV
IF and image rejection: Not specified.	IF rejection, 115 dB; image rejection, >132 dB.
Receiver audio output: Not specified.	0.3 W at 10% THD into 8 Ω. THD at 0.85 V RMS, 6.3%.
IF/audio response: Not specified.	Range at –6 dB points, (bandwidth) CW (500 Hz): 350-1135 Hz (785 Hz) SSB (2.6 kHz): 140-3000 Hz (2860 Hz) AM (7.5 kHz): 2 Hz-3830 Hz (7660 Hz)
Size (height, width, depth): 2.4 × 5.6 × 6.1 inches (including protrusions); weight, 1.5 lb.	
Price: $599.99.	
Note: The AGC could not be defeated, so blocking gain compression, reciprocal mixing and IMD dynamic range tests could not be performed.	

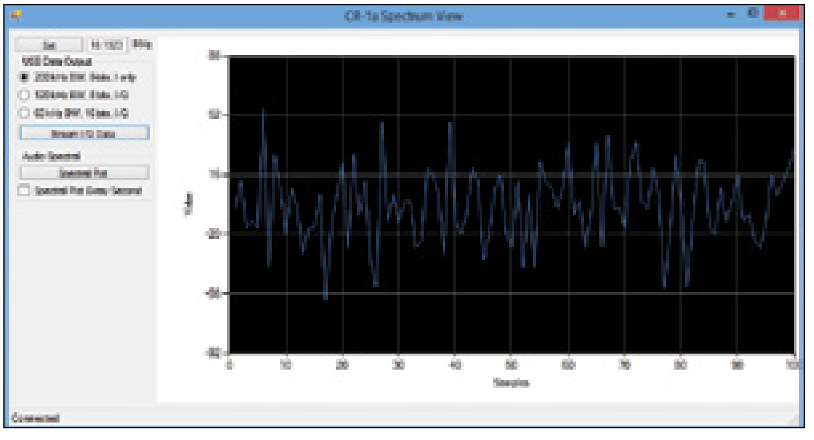

Figure 1 — The beta version of CommRadio's *Spectrum View* software.

Radio phone band, for example, the CR-1a automatically selects lower sideband. The CR-1a offers a variety of filter bandwidths — 500 Hz, 1.0, 1.8, 2.2, and 2.6 kHz on CW; 1.8, 2.2, and 2.6 kHz on SSB; 2.6, 5, 7.5, and 15 kHz on AM; and 15 and 25 kHz on NBFM. Unlike SDR receivers controlled by external software, you don't have the ability to create continuously variable filters on the fly. That said, with compatible software and an external computer you could connect the CR-1a and have the full SDR flexibility.

Like a conventional receiver, the CR-1a provides 64 memory slots to store your favorite frequencies for easy access. Scanning functions are available, but on HF only.

The CR-1a display includes a numeric S meter in the lower left corner. The S meter functions for all modes when you select the HF frequency range, but only operates while in the AM mode on VHF or UHF.

Last, but hardly least, the CR-1a can decode CW! Watch the video to see it in action.

Hands On with the CR-1a

I found the CR-1a easy to navigate once I became used to its menu system. The manual includes clear instructions and many illustrations to help with the learning curve. As I mentioned earlier, you must access the menus to switch from VHF to HF coverage, and to change filter bandwidths (if necessary).

The radio turns on with a momentary push on the VOLUME control and the amber display springs to life after a brief sign-on message. The 2.5-inch bottom-mounted speaker has plenty of power, so much that I rarely needed to advance the VOLUME knob past 11 o'clock in any listening environment. There is also a ⅛-inch jack on the front panel for headphones.

Bob Allison, WB1GCM, our ARRL Laboratory Test Engineer, measured substantial audio distortion during his tests with the VOLUME control set at low levels. Not that I doubt Bob's instruments, but I could not hear the distortion when using the external speaker. With headphones it was audible, but I didn't find it at all objectionable. Oddly enough, both Bob and I noticed that the distortion *decreased* with increasing audio volume. Speaking of unusual sounds, it is also worth mentioning that the CR-1a made a slight ticking or popping noise when stepping from one frequency to another.

Figure 2 — The CR-1a has separate jacks for MF/HF and VHF/UHF operation The AM/HF antenna jack is eliminated on current production units. The USB jack can be use to power the receiver and charge the internal Li-ion battery or for connection to an external computer.

The CR-1a's AGC performance is selectable — FAST, MEDIUM, and SLOW — but cannot be turned off, and so the Lab could not perform the usual dynamic range tests (which require AGC be turned off). The AGC is sensitive and starts to reduce the audio output levels when encountering signals as weak as –68 dBm at 20 kHz from the selected frequency. This would occasionally manifest as significant "pumping" when a strong signal was within range. This AGC behavior may also have something to do with the popping sound heard when changing frequencies.

Other than the difficulty of working the buttons with my oversized fingers, the CR-1a was a pleasure to operate. I had no difficulty listening to everything from CW, to single sideband, to FM. The CR-1a was more than sensitive enough for casual listening, including eavesdropping on Amateur Radio activity. It did double duty as a convenient test receiver and I even put it to work as a JT65 monitor by feeding the audio from the headphone jack to my station computer, which was running *JT65-HF* software.

When it comes to ham uses, the only notable limitation of the CR-1a is its inability to tune at VHF or UHF in less than 5 kHz steps. This presents issues when trying to monitor SSB or CW on these bands, although channelized FM operation is no problem. SDR being what it is, however, it is always possible that this may change with a new software release.

Manufacturer: CommRadio, a division of AeroStream Communications, 24658 Foothills Dr N, Golden, CO 80401; tel 303-279-3671; **www.commradio.com**; **info@commradio.com**.

See the Digital Edition of *QST* for a video overview of the CommRadio CR-1a Communications Receiver.

HobbyPCB Hardrock-50 160 – 6 Meter 50 W Amplifier Kit

Reviewed by Phil Salas, AD5X
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In the August 2010 issue of *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 W output power with a drive level of 5 W or less on 160 – 10 meters, and 35 W 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 W drive, and an internal automatic antenna tuner (not yet available during the review period). 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.

Putting It Together

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

No documentation is included in the box, 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 computer 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 because 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 and 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.

Small PC boards with display and control circuitry attach to the front and rear panels. All that was required was soldering connectors to the PC boards and then mounting the boards to the panels.

For me, the most time-consuming part was soldering in the 15 relays, followed by winding and installing the inductors and transformers. 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 as-delivered amplifier PC board with SMD parts mounted is shown in Figure 4, along with the finished inductors and transformers.

Bottom Line

The Hardrock-50 is a compact 50 W amplifier designed to work with any QRP transceiver. Silent QSK operation may be added as an option.

Figure 5 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 multiturn potentiometers set the four FET gate bias voltages (for this adjustment you'll need a digital multimeter). If you cannot get your Hardrock-50 to work properly, HobbyPCB provides excellent technical support via e-mail 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.

Technical Details

The HR-50 dc input is an Anderson Powerpole connector. You will need a 13.8 V dc power supply capable of at least 12 A continuous current. As the amplifier is not fused, a fused (15 A) dc input cable is recommended. The large heatsink provides

Figure 3 — The Hardrock-50 arrives!

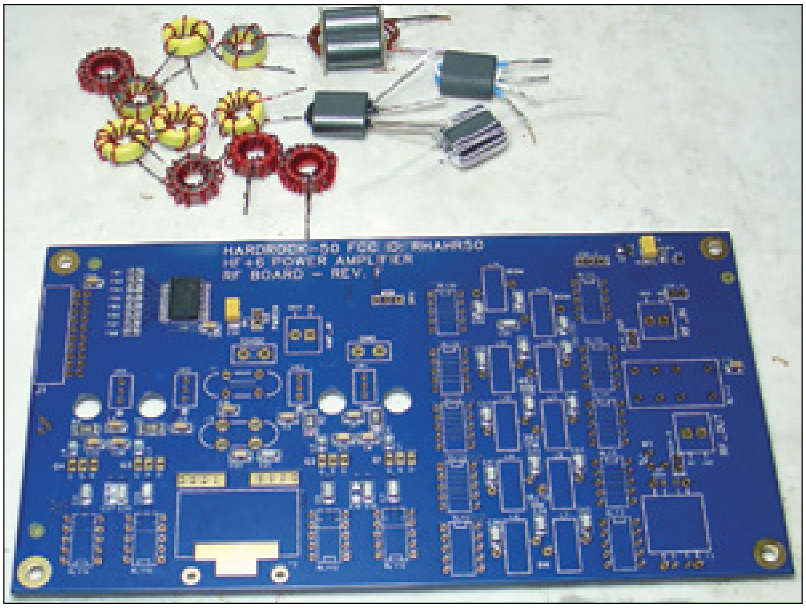

Figure 4 — As delivered, SMD parts are already mounted on the amplifier pc board. The author wound the inductors and transformers shown at the top.

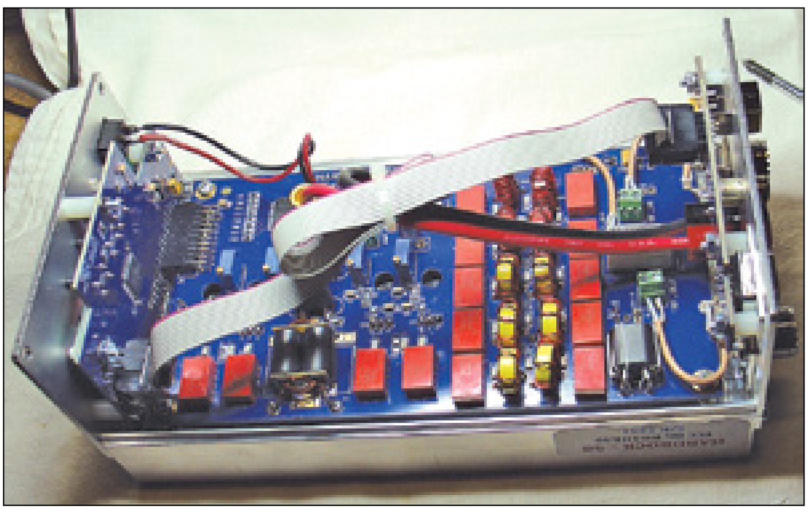

Figure 5 — Completed Hardrock-50 amplifier.

the necessary thermal dissipation — no fan is needed.

Power output is 50 W from 160 – 10 meters with 5 W maximum drive (typically 3 – 4 W is enough) using four RH16HHF1 MOSFETs. Power on 6 meters is specified at 35 W, though most amplifiers will exceed 40 W on this band. TR switching is handled by a relay or an optional PIN-diode switch. The relay 6 ms/4 ms maximum specified operate/release time is fast enough to prevent hot switching when used with most transceiver amplifier keying outputs. The optional PIN-diode QSK switch assembly switches in less than 140 µs, but there is a trade-off. The QSK switch has 0.25 dB loss in both the transmit and receive path on 160 – 10 meters (typically 3 W transmit loss). The loss increases to about 0.5 dB on 6 meters (typically 5 W transmit loss).

No automatic fault protection is included — nor is it needed! The RH16HHF1 MOSFETs are rated to operate at 16 V dc 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. 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 software defined radios (SDRs) that use *PowerSDR* software (for example, Softrock, Peaberry, or G10 SDRs). As the HR-50 supports the Kenwood CAT command set, other SDR programs may support automatic band tracking as well. Firmware updates are easy (a USB A/B cable is required) — just follow the detailed instructions given in the assembly manual.

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 bar graph shows average forward power, and the bottom display shows calculated SWR and peak power.

There are only three control buttons — up/

Table 2
Hardrock-50, serial number 1251

Manufacturer's Specifications	Measured Performance
Frequency range: All ham bands from 1.8 – 54 MHz except 60 meters.	As specified. The optional antenna tuner includes additional filtering to allow 60 meter operation.
Power requirements: 11 – 16 V dc (13.8 V nominal), 10 A typical, 12 A peak.	See Table 3.
Input SWR: Not specified	See Table 3.
Drive power: 2.5 – 3 W typ, 5 W maximum.*	See Table 3.
Output power: 50 W typical at 13.8 V dc, 1.8-30 MHz; 35 W at 50 MHz.**	See Table 3.
Internal power meter accuracy ±5 W @ 50 Ω	As specified.
Harmonic and spurious suppression: Not specified.	HF, 48 dB (worst case, 1.8 MHz band), typically 64 dB; 50 MHz, 60 dB. Complies with FCC requirements.
Intermodulation distortion (IMD) products: Not specified.	3rd/5th/7th/9th order IMD products: 14 MHz: 38/33/38/46 dB below PEP. 50 MHz: 33/32/42/60 dB below PEP.
Key in: Receive, +5 V dc open circuit, ground to transmit, 10 mA maximum.†	As specified.
Amplifier TR relay transition time: Not specified.	PTT mode: Amplifier key to RF output, 3.2 ms; amplifier un-key to RF power off: 3.8 ms. Carrier operated mode, 12 ms for 0.4 W to max drive power.

Size (height, width, depth): 3.5 × 4.25 × 7.5 inches; weight: 3 lb.

Price: Hardrock-50 $299; QSK option, $49; 0.5 – 5 W preamp, $35; internal ATU, $179.

*The HR-50 will tolerate 10 W of drive for a short time without damage.
**Exceeding rated output may result in signal distortion. If the PIN-diode QSK option is installed, output power should be reduced 3 W on HF and 5 W on 6 meters.
†The PTT line is diode protected for externally applied voltages from –24 to +24 V.

Table 3
Hardrock-50 Operating Conditions

13.8 V dc key-down voltage;
standby 0.1 A; operate, no drive, 0.3 A.

Band (m)	Drive (W)	Input SWR*	Power Output** (W)	DC Current (A)
160	4.0	1.29:1	50	9.8
80	2.4	1.21:1	50	7.8
40	3.6	1.20:1	50	8.3
30	5.0	1.23:1	49	9.9
20	4.0	1.25:1	50	9.8
17	2.7	1.30:1	50	7.3
15	2.8	1.41:1	50	7.2
12	3.0	1.48:1	50	8.0
10	2.9	1.52:1	50	9.0
6†	3.0	1.41:1	40	6.3

*Bypass SWR was 1.1:1 or less except 6 meters which was 1.4:1
**Measured with Mini-Circuits PWR-6GHS+ power sensor and calibrated attenuators.
†The 6 meter output power specification is 35 W for best IMD.

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 OFF (standby), PTT (push-to-talk where grounding the PTT line keys the amplifier), COR (RF carrier detect keys the amplifier), and QRP (to follow the optional antenna tuner to be used with the exciter only). The COR 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 – 12 ms before switching completes. Even when the QSK option is used, RF will be present for 5 – 7 ms 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 +8 V dc/0 V dc 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, Key-up Delay and FT-817 Mode.

Performance Measurements

I have a KX3, so I built an interface cable (shown in Figure 6), which plugs into the ACC jack on the rear panel (Figure 7). The automatic band tracking worked great. It simplified testing as my KX3 was used as the signal source for much of my work.

Table 2 summarizes the measured amplifier performance. Spurious and harmonic distortion and IMD products, and the TR relay timing were measured in the ARRL Lab.

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, but I was able to determine the cause and came up with a simple fix. The rework has been incorporated into amplifier boards above serial number 1399. For those with Rev F amplifier boards below this serial number, simply insert 33 pF/100 V capacitors into the RF-IN and AMP-IN connectors. Contact HobbyPCB for the rework necessary on earlier amplifier boards.

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 serial number 1200 to 1399. If your HR-50 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

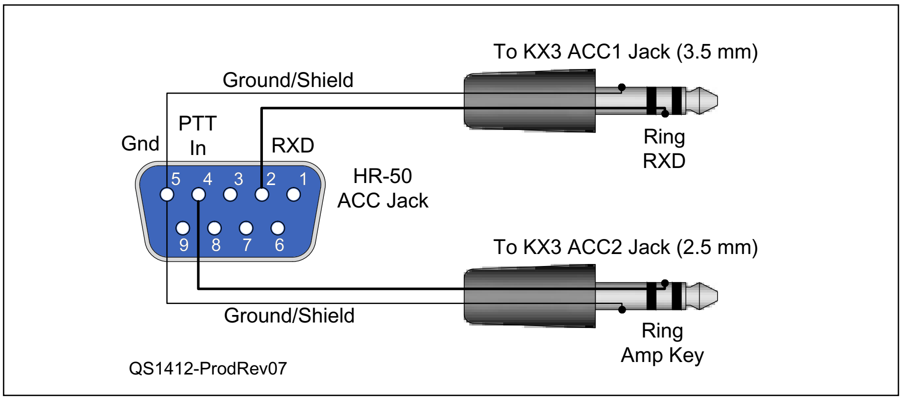

Figure 6 — The author made this cable for interfacing the HR-50 with an Elecraft KX3. The DB-9P connections are shown from the solder-cup side of the connector. I purchased the connectors from **www.mouser.com**. The 3.5 mm and 2.5 mm right-angle plugs are part numbers 171-3308-EX and 171-3325-EX, respectively. The DB-9P and hood are part numbers 156-1209T-E and 156-2009-EX, respectively. A 3-foot section of dual shielded cable connects the DB-9P and the two KX3 accessory plugs.

Figure 7 — Hardrock-50 rear panel. The USB port is used for firmware updates and the ACC jack may be used for automatic band switching from a compatible transceiver.

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 lie flat on the PC board. Then I soldered the other end of each inductor to the opposite pad.

Table 3 documents bypass and amplifier input SWR, required drive for 50 W output (or 5 W maximum drive), and +13.8 V dc current at rated output. Power was measured with a NIST-traceable Mini-Circuits PWR-6GHS+ sensor and calibrated attenuators (±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.

The HR-50 power detector has a very flat frequency response. The power read about 12% high when first tested (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 menu selection permits adjusting the power reading. I put in –13% (the factory default was –1%) and achieved readings within 1 W of my PWR-6GHS+ test setup. 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 W on HF and 5 W 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 an S unit or two, the Hardrock-50 is certainly worth considering.

Manufacturer: HobbyPCB, tel 646-580-4722; **www.hobbypcb.com**.

See the Digital Edition of *QST* for a video overview of the HobbyPCB Hardrock-50 160 – 6 meter 50 W amplifier kit.

MFJ-4403 Transceiver Voltage Conditioner

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We can't always count on a transceiver's dc voltage source to be clean. In particular, noisy power sources are probably more prevalent during portable operations such as Field Day and DXpeditions, and in automotive (mobile) environments. The MFJ-4403 Transceiver Voltage Conditioner was designed to provide dc voltage protection for transceivers subjected to virtually any dc power situation.

Features

The MFJ-4403 draws its own power from the dc voltage source. Normal dc operating current is 250 mA. Key features include:

- Reverse polarity protection — A reverse voltage input is blocked from the MFJ-4403 output.
- Transient suppression — Voltage transients are clamped at 15 V dc maximum with a 75 A transient suppressor. Long duration high voltage transients will cause the MFJ-4403 input fuse to blow.
- Short circuit protection — Internal automotive fuses protect both the source and connected equipment.
- Noise and ripple filtering — A 4 F (yes, 4 farad) super-capacitor bank made from six 25-farad series-connected capacitors, in conjunction with traditional high frequency filter capacitors, ensures that the cleanest possible dc voltage is applied to your equipment.
- Input and output dc connections are Anderson Powerpole connectors (Figure 8).

A 15 A input fuse provides protection for less-than-adequate power sources and wiring when operating low-current, or high-peak-current, low-duty-cycle, modes. For high-duty-cycle modes and a properly sized power supply, the 15 A input fuse should be replaced with a 25 A fuse. As the MFJ-4403 includes a 4 F capacitor bank, you could conceivably see currents in the hundreds of amps for a few milliseconds if you accidentally short circuit the output. The 25 A output fuse protects a short from causing serious damage.

A power resistor is used both for current limiting during the charging of the capacitor bank, and for discharging the capacitor bank when the MFJ-4403 is turned off. The discharge function is provided because the charged capacitor bank can provide a *huge* amount of energy should it be shorted inadvertently when you think everything is off.

Reverse-voltage protection is provided by a combination of a relay and a reverse protection diode. If a negative voltage is applied to the input, the relay cannot operate, and so no reverse voltage can appear across the capacitor bank or the output. The REVERSE POLARITY LED indicates a negative input voltage condition.

Damaging voltage spikes can occur in automotive environments, and with dirty or failing power supplies. A high-current clamping diode limits any spike to 15 V dc (nominal), and blows the input fuse if the clamped overvoltage persists for a few seconds. The 15 V clamping diode can handle 70 A without damage. Of course, the capacitor bank also serves to momentarily clamp any overvoltage condition because a sudden voltage change over a short period of time results in a high current pulse that can also blow the input fuse.

And finally, the super-capacitor bank provides outstanding filtering of any noise or ripple on the dc input. Smaller value capacitors take care of any high frequency noise that might make it by the super-capacitors. An interesting side effect of this capacitor bank is that you can power a 100 W SSB transceiver from an automotive accessory socket (what we used to call a cigarette lighter socket). We will look at this in more detail a little later.

Operation

After connecting your dc source to the dc input connector and turning off any connected equipment, push the ON button. The CHARGING and POWER LEDs light and a current-limited charge of the capacitor bank begins. The high value of the MFJ-4403 capacitor bank requires that the capacitors must be pre-charged before you can operate any equipment — connecting a dc source directly to a discharged capacitor bank of this value will short the power supply output! After about one minute the current limiting resistor is shorted by the relay, the CHARGING LED extinguishes, and your connected equipment can be turned on. Incidentally, if any connected equipment is turned on during the pre-charge cycle, the pre-charge cycle will not complete and little voltage will be available for the equipment. A high-current diode in series with the pre-charging resistor keeps reverse voltage from finding its way to the output via the pre-charging circuit.

Bottom Line

If you are ever concerned about the "cleanliness" of a power supply feeding your transceiver, or if you want to ensure that your mobile dc-power source is perfectly filtered, the MFJ-4403 may be just what you are looking for.

Figure 8 — MFJ-4403 input/output connections.

When you want to cease operation, turn off any connected equipment and push the ON/OFF pushbutton on the MFJ-4403. The internal power resistor is connected across the capacitor bank and discharges the capacitors in about one minute.

Performance

There is a pre-charge timing strap option on the printed circuit board, but it isn't mentioned in the manual. You should connect across these pins if you have an input voltage less than about 13.25 V dc. Normally the pins should not be strapped as you want the capacitor bank charged as close to the input voltage as possible before operating. With the timing pins strapped, the pre-charge worked well down to 12.25 V dc.

I first looked at pre-charge times. With the timing pins unstrapped, the pre-charge time was 55 seconds at 14.2 V dc, 65 seconds at 13.8 V dc, approximately 2 minutes at 13.5 V dc, and 3.5 minutes at 13.25 V dc. The pre-charge would not reliably complete below 13.25 V dc unless the pre-charge pins are strapped.

I next connected reverse voltage to the dc input. The REVERSE VOLTAGE LED lit immediately, and no negative voltage appeared at the output regardless of the position of the ON/OFF switch. When the reverse-voltage condition was corrected, the MFJ-4403 automatically reverted to normal operation.

Next I tested the input voltage clamping level. I connected a variable voltage power supply across the input and increased the voltage. I had to increase the input voltage very slowly as the capacitor bank does an outstanding job of trying to hold the voltage constant, resulting in power supply current limiting if the voltage is adjusted too rapidly. This is a desired characteristic that provides both filtering and impulse protection. With a little care, I found that clamping occurred at 15.5 V dc.

Finally I looked at power supply filtering. I previously reviewed a battery boost regulator that had ripple and noise so bad that I was afraid to connect it to my transceiver. I couldn't think of a better "dirty" voltage source for testing the MFJ-4403. First I connected the boost regulator directly to a 10 A resistive load with the input voltage set to 11 V dc, and the output set to 13.8 V dc. Figure 9 is an oscilloscope trace of the ac-coupled 13.8 V dc output across the load. As you can see, it is a pretty nasty signal. The amplitude of the ripple and noise is about 6 Vp-p! After connecting the MFJ-4403 between the boost regulator and the 10 A load, I could see absolutely no ripple or noise. The MFJ-4403 definitely does its job!

What About That Auto Accessory Connector?

This is where I really had fun with this review. We've all been told to never power high-power ham equipment from an automobile accessory socket. MFJ states that the MFJ-4403 may be used to power a 100 W output SSB transceiver (75 W output for CW) from an accessory socket for temporary operations. The reason is that the accessory socket should be able to supply the average current required by the equipment, and the MFJ-4403 super-capacitor bank will provide the peak current necessary for low duty cycle transceiver operation. SSB and CW modes permit power from the auto accessory socket to recharge the capacitor bank during speech pauses or gaps between CW characters. MFJ does recommend making a direct connection to the car's battery for normal operation, along with the MFJ-4403 for voltage transient and filtering.

Let's look at the accessory socket possibility for powering a typical SSB/CW transceiver. *UL2089 Vehicle Battery Adapters* is the standard for low-voltage power ports. This standard limits accessory outlets to 20 A, and also states that a minimum of #12 AWG copper wire is required for 20 A. But that is the maximum current permissible, and is not necessarily what is available in most cars. I've spent quite a bit of time looking into this and have found accessory socket ratings varying from 10 to 15 A, and/or 150 to 180 W, continuous, in manuals or printed on the covers of some accessory sockets. You can also get an idea of the accessory socket current rating by looking at inverters and tire inflators that are available for use with these accessory sockets.

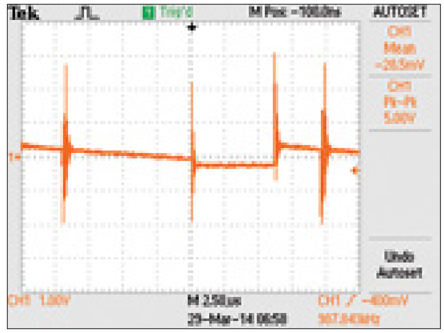

Figure 9 — Battery boost regulator 13.8 V dc output feeding a 10 A load. The amplitude of the ripple and noise is about 6 V p-p. After connecting the MFJ-4403, the ripple and noise vanished.

Based on my research, I think that a 10 A continuous rating is probably reasonable, but you should determine this for your own vehicle. However, 10 A is much less than the peak current required by most 100 W mobile transceivers (often 20 A or so). Further, the mating accessory plug is a spring-loaded pressure contact that doesn't provide the best electrical contact for the high peak current requirement.

I tested three external accessory sockets connected to the high current output of my MFJ-4245 power supply, as well as the 7 A rated MFJ-4245 internal accessory socket. I also tested two different RadioShack cigarette lighter plugs (10 A rating) with each of these sockets (see Figure 10). The upper plug is not fused, while the lower plug includes an internal 10 A fuse.

With a 10 A load connected, I found a very consistent 0.08 Ω resistive loss (measured as 0.8 V drop) with the unfused plug/sockets, and 0.10 Ω resistive loss (measured as 1.0 V drop) with the fused plug/sockets. Then I subjected the connector pairs to a continuous 10 A current for 5 minutes. All socket and plug combinations felt cool. And all socket pins were cool to the touch. However, I found that the center pin of the fused (lower) plug was quite warm after 5 minutes. Based on my resistive loss measurements, this plug is dissipating 2 W more than the unfused plug, probably all in the extra center pin pressure contact and the fuse.

Next I evaluated my IC-706MKIIG current requirements. This radio draws the most

Table 4
IC-706MKIIG CW Transmitting Current Measurements

Output (W)	I-pk (A)	I key-up (A)	I avg (50% duty cycle) (A)	I avg (44% duty cycle) (A)
100	18.6	4.5 (semi break-in)	11.6	10.7
100	18.6	1.4 (QSK)	10.0	9.0
75	16.5	4.5 (semi break-in)	10.5	9.8
75	16.5	1.4 (QSK)	8.9	8.0

Table 5
IC-706MKIIG Peak Current Measurements with MFJ-4403

Output (W)	I-pk Input (Pwr Supply) (A)	I-pk Input (Acc Socket) (A)	I-pk Input (0.1 Ω) (A)	I-pk Input (0.2 Ω) (A)	I-pk Output (A)
100	15.9	11.2	10.2	7.3	18.6
75	14.3	10.2	9.5	6.8	16.5

Figure 10 — The reviewer's automobile accessory connectors, described in the text.

current on 20 meters (18.6 A at 100 W output), so I used this band for testing. I used CW for my tests since CW has a higher duty cycle than SSB (44% PARIS standard CW duty cycle vs 20 – 30% SSB duty cycle). Table 4 shows my measurements for key-down and a string of dits (50% duty cycle), and the estimated average current based on the PARIS standard.

As you can see, about 10 A is a good average current drain that you might see when transmitting. However, we don't want to subject the accessory socket to the 18 – 19 A peak current that is drawn on every "dit." And this high peak current will also result in a peak voltage drop of 1 – 2 V dc.

I connected the MFJ-4403 between my MFJ-4245 power supply high-current output and the transceiver and measured the input and output dc current peaks while transmitting (receive current drain is well within any accessory socket current rating and so the MFJ-4403 just provides filtering and transient protection). I used an AEMC 514 digital Hall-effect clamp-on meter for peak and average dc current readings.

Initially I was surprised to see a high MFJ-4403 input spike of almost 16 A (corresponding to the 18.6 A peak current output). Then I used an accessory plug/cable between the MFJ-4245 power supply and the MFJ-4403 dc input and saw the MFJ-4403 input current spike drop to 11.2 A. After thinking about this I realized that in a perfectly lossless system, any discharge of the capacitors will be instantly recharged by the sourcing power supply, resulting in the same input and output current. However, if there is any loss from the input dc source, the recharge current is spread out over the RC time constant due to the dc-line loss and the total capacitance. With a 4 F capacitor, even a 0.08 Ω loss results in a time constant of about ⅓ second. My bench tests are probably as close to ideal as possible, and accessory sockets and wiring in most cars probably have more loss. Therefore I ran some additional tests showing the effect of adding in very low resistive losses. The results are shown in Table 5.

From Table 5 you can see that the accessory socket output current measurements are very similar to the IC-706MKIIG average current requirements when there is just a little loss in the system. In other words, you limit peak current when using an accessory socket to power a 100 W SSB/CW transceiver because the accessory socket and associated wiring is not lossless!

So — is it safe to use an auto accessory socket to power a MFJ-4403 connected to a 100 W SSB transceiver? I will leave this decision up to you. My measurements indicate that this is viable. And I did connect my IC-706MKIIG this way to my wife's 1997 Mustang. I used a high-power dummy load and a peak-reading Bird wattmeter and verified that the transceiver put out full power on SSB.

I do have a few recommendations. First, if you build your own cable, make sure you use a quality accessory plug that is rated for at least 10 A. The plug should have two ground "ears," and it should fit firmly into the accessory socket. You should also use #14 AWG wire minimum, and preferably #12 AWG. (MFJ sells an accessory-plug-to-Powerpole cable (MFJ-5515M) with a 3 foot flexible #12 AWG cable.) Finally, you should consider this as a temporary mobile solution. For permanent solutions, connect the input to the MFJ-4403 directly to the battery.

Conclusion

The MFJ-4403 is a very robust dc filtering and transient protection device. It is certainly something to think about adding to your mobile power supply line, and any place where there is concern about power supply cleanliness. It is even at home in your main station should you have any concerns about your power supply failing and causing a problem. My only complaint is that it does not include a ground stud. Of course, a ground stud is easy to add, and maybe MFJ will add one in the future.

Manufacturer: MFJ Enterprises, PO Box 494, Mississippi State, MS 39762, tel 800-647-1800; **www.mfjenterprises.com**. Price: MFJ-4403, $119.95. MFJ-5515M cable, $19.95.