Product Review

Elecraft KPA1500 Legal-Limit HF and 6-Meter Linear Amplifier

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The Elecraft KPA1500 is a compact, solid-state, legal-limit desktop linear amplifier for 160 to 6 meters. While it was clearly designed to interoperate with the Elecraft K3 series radios, Elecraft provides optional cables for use with other brands of transceivers.

In my station, I have been using a K3 with a KPA500 500 W amplifier and companion KAT500 automatic antenna tuner. Together, the three units make a tightly-integrated amateur station that is a joy to operate. Changing the frequency on the K3 automatically sets the proper frequency, antenna, and tuning solution on the other two units. If the amplifier is in **OPERATE** mode, the K3 output power is automatically reduced to preset values for use with the amplifier — otherwise power is set to whatever level you use without the amplifier.

The KPA1500 includes a 1,500 W amplifier and auto tuner in the same box, providing the same operating integration with the K3 described above. The auto tuner in the KPA1500 is rated to handle 1,500 W continuously with a standing-wave ratio (SWR) of 3:1 on any band, and up to 750 W on HF with a 10:1 SWR. The manual provides a derating chart, indicating that it can handle about 1,200 W with an HF SWR of about 5:1. Ratings for 160 and 6 meters at an SWR above 3:1 are not as liberal.

This arrangement works well for my center-fed Zepp antenna, which has an SWR less than 10:1 on all HF bands. On most bands, the SWR is much less, and on some bands it is quite different depending on the band segment. The amplifier has two band-memorized antenna output ports, so I can cover all bands with my tuned triband plus 6-meter Yagi on one port and the Zepp on the other. The tuner will switch to bypass with low SWR (default 1.2:1, but settable).

The KPA1500 is packaged in two enclosures, as shown in Figure 1 — an RF deck and a power supply, each a bit larger than the K3. The RF deck weighs 22 pounds and the power supply weighs 17 pounds, a flexible and easy-to-handle arrangement.

Hooking It Up

The KPA1500 comes with a well-written, spiral-bound 49-page *Owner's Manual*. It provides clear instruction on how to set up, interconnect, and operate the amplifier with your station equipment. A special section is dedicated to cable and interface requirements needed to automate interoperation with many recent transceivers from FlexRadio, Icom, Kenwood, and Yaesu. A "Theory of Operation" section provides a block diagram and discussion of how the equipment works, but no schematic diagram.

The separate power supply makes installation easier, but does add a few cables. The power supply is intended to be powered by a dedicated 240 V, 20 A ac circuit, and the attached cable comes with a common NEMA 6-20 plug. A dedicated 15-pin control cable interconnects the power supply and amplifier, as does a dc power cable with 75 A Anderson Powerpole connectors. Elecraft notes that, unlike typical 40 A Powerpole connectors, these connectors require an extra push, and a second audible click, to seat properly and make contact.

In addition to the power supply cables, the amplifier has SO-239 connectors for RF input and output, a keying line and supplied cable with

Bottom Line

The Elecraft KPA1500 is a compact, highly integrated, legal-limit, 160 – 6 meter solid-state linear amplifier that can provide a significant boost to the typical transceiver. It is easy to install and interface in most any station, but is even more effective if used with the interoperation cables that are available for many transceivers.

phono plugs on each end, and a ground connection. An optional ALC line can be employed to avoid overdriving the amplifier with a misadjusted transceiver.

That completes what Elecraft refers to as a "basic interconnection" that allows full operation, with virtually any transceiver. The amplifier has a built-in frequency counter that will read the transmitted frequency and automatically switch bands and set the tuner to the antenna and tuning solution that has been memorized for the frequency.

For those using mechanically-tuned antennas, external antenna tuners, or other power-sensitive accessories, the KPA1500 supports a **KEY-LINE INTERRUPT** function that allows an antenna controller, for example, to open the **KEY** line so that amplifier power cannot be applied until the antenna has finished tuning. Appropriate cable adapters are provided to break the **KEY** line, if needed.

A more integrated interconnection can be made by using a special cable between the radio and amplifier. The optional KPAK3AUX cable can be used between a K3 transceiver and the amplifier to take full advantage of the interoperational capabilities. The amplifier will change band and antenna settings as soon as the transceiver frequency changes, and the transceiver will change output power as well. This means that, as you change bands, you will be listening with the correct and properly tuned antenna before you transmit. This is a big advantage in my view. You can even set up the tuner to work on bands on which you can't transmit.

Elecraft offers similar cables and connection arrangements for many other brands of transceivers. Other transceivers may not be able to do everything that an Elecraft-to-Elecraft interconnection will support, but they will do what's possible. Check the Elecraft website for details.

Table 1
Elecraft KPA1500, serial number 0400

Manufacturer's Specifications	Measured in ARRL Lab
Frequency range: 1.8 to 54 MHz.	160-, 80-, 60-, 40-, 30-, 20-, 17-, 15-, 12-, 10-, 6-meter bands.
Power output: 1,500 W PEP CW/SSB/data.	HF and 50 MHz, as specified, except 1,100 W PEP from 53 to 54 MHz.
Driving power required: 50 to 60 W typical for 1,500 W PEP RF output.	38 to 45 W typical, see Figure 2.
Spurious and harmonic suppression: Not specified.	HF, 62 dB typical, 48 dB worst case (24.9 MHz); 50 MHz, 71 dB. Meets FCC requirements.
Third-order intermodulation distortion (IMD): Not specified.	3rd/5th/7th/9th order products, (dB below PEP at full output): 14 MHz, –30/–40/–48/–58 dB.
Transmit-receive switching time: Not specified.	Unkey to key, 4.4 ms; key to unkey, 6 ms.
Power requirements:	195 – 250 V ac, 20 A max.
Size (height, width, depth including protrusions): Power supply, 5.1 × 14 × 13.2 inches; RF deck, 5.1 × 14 × 13.5 inches. Weight: RF deck, 22 lbs and power supply, 17 lbs.	

Figure 1 — The KPA1500 power supply is in a separate cabinet and can be located out of the way.

Navigating the Front Panel

The KPA1500 front panel offers comprehensive control and monitoring capabilities, but retains its simplicity of operation by being mostly automated — unless the operator wants to initiate a particular action.

On the upper left is a two-line LCD that is used for amplifier metering, menu navigation and settings, and many other functions. The default multimeter display indicates frequency band, power supply current, heatsink temperature, output power, and measured SWR. The display can be cycled through seven different combinations of potentially useful data, including the inductance and capacitance being used by the tuner on that frequency and fault information in case of a problem. Note that the displayed frequency has sufficient accuracy to allow

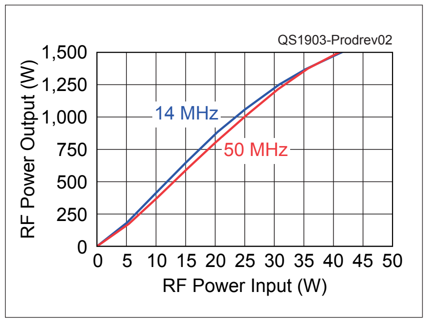

Figure 2 — Elecraft KPA1500 RF input power versus output power.

antenna tuning, but it is not useful as an absolute frequency indicator.

To the right of the multimeter display is an LED power meter display with an indicator of output power in 50 W increments to 300 W, then 100 W increments to 900 W, and finally 200 W increments to 1,900 W. The

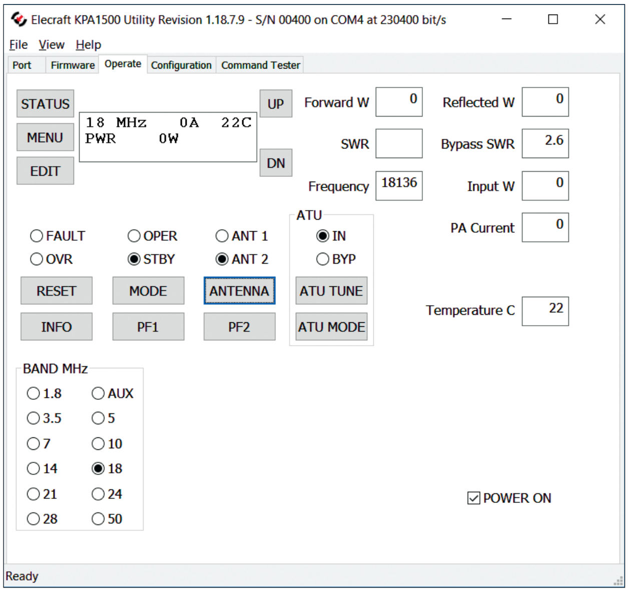

Figure 3 —The *Elecraft KPA1500 Utility* software is needed primarily to update amplifier firmware, but this program can also be used to monitor status or change control settings from the connected PC.

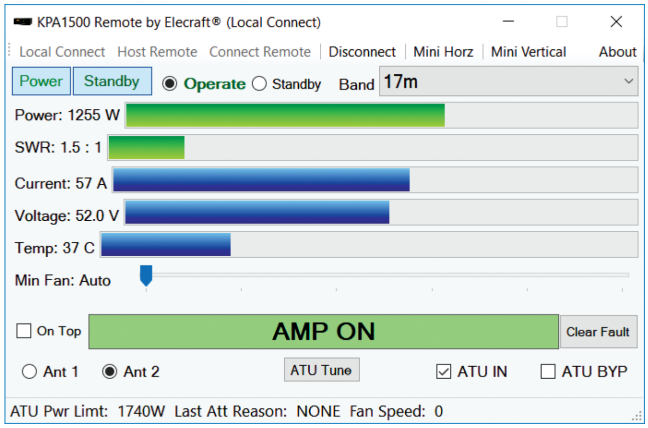

Figure 4 — The *KPA1500 Remote* software provides a virtual front-panel view of the amplifier and can be used locally or via a distant internet connection. In addition to this view, a miniature horizontal or vertical display can be selected to save screen space. Note the **POWER** button — the amplifier can be turned on and off remotely by either software platform.

LEDs are green until 1,500 W, then yellow and red if you exceed the US legal limit. This serves as a handy peak-reading display (peak-hold is available in firmware version 1.78 and later), and it is especially useful while transmitting in SSB mode. For detailed four-digit resolution, just shift your eyes left to the multimeter.

Below the power indicator LEDs are four groups of LED status indicators, with four dual-function control buttons beneath: **FAULT/INFO**, **MODE/PF1**, **ANTENNA/PF2**, and **ATU TUNE/ATU MODE**. **PF1** and **PF2** are user-programmable function keys. To the right of status indicators and buttons are LED SWR indicators, with four green LEDs for 1.0 to 1.5, two yellow LEDs to 2.0, followed by four red LEDs to 5.0:1. As with the power indictors, an eye shift to the multimeter provides a more precise digital readout.

On the bottom tier, there are two rows of six band-select buttons, including an **AUX** button for a possible future allocation. If your transceiver is connected to control the amplifier, you don't need to use those buttons. On the other hand, this interface works both ways, so the amplifier band-select buttons can be used to change both the amplifier and transceiver band — handy for K3 users, because the K3 doesn't provide a one-button band-select function. On the lower right of the front panel is a power **ON** switch, and a transmit (**TX**) indicator.

The Built-In Antenna Tuner

The automatic tuner, together with the protection circuitry, makes sure you don't get in trouble. From the derating chart in the owner's manual, it looked like my antenna for 3,865 kHz, with an SWR of 4.8:1, could be run up to around 1,200 W output through the tuner, but the amplifier kept me honest. If I went much higher than 1,250 W, it would indicate a **HI POWER SWR** fault to let me know to back off.

The amplifier can put a 3 dB attenuator in the input to reduce drive to get the power output into specification range, or if you go too far, automatically bypass the amplifier altogether and switch to **STANDBY** mode.

It's likely kinder to the tuner components if you start close to the drive level appropriate to the allowed tuner power limit. You shouldn't see this error often because the K3 remembers RF power output settings for use with the amplifier.

Computer Interconnection

The KPA1500 is happy to operate independently of a computer connection, but a 6-foot USB cable is provided to connect the amplifier to your PC. There are two programs from Elecraft that can be operated through this interface. As with most Elecraft products, the primary purpose of the basic *Elecraft KPA1500 Utility* program is to check for firmware updates, compare with the installed version, and facilitate updating if appropriate. As shown in Figure 3, the program can also be used to check operating status, as well as replicate all amplifier control and most indicator functions, providing a locally-connected remote-control capability. The utility program can also determine the amplifier's IP address — needed to be able to use the ethernet interconnection.

Another free program, added since the review amplifier manual was written, is the *KPA1500 Remote* software. This program, also available from the Elecraft website, can interconnect via the local USB connection, or via the ethernet jack on the rear of the amplifier. (This software will also operate with the KPA500 amplifier and KAT500 tuner.) The ethernet interconnection can be used with a PC on your local network, or with the amplifier at a distant remote station through the internet and a security login. The basic screen is shown in Figure 4 and, while similar to the *Utility* software, adds dynamic bar graph **POWER** and **SWR** displays that simulate those shown by the LEDs on the amplifier front panel.

A particularly slick capability is that either program can remotely power the equipment on and off — important whether your amplifier is in another part of the house or another state. Note that this function only worked with the ethernet-connected remote function after I upgraded the firmware to version 1.78 (thanks to guidance from the Elecraft customer service team), which added a number of other enhancements. The amplifier also has a remote (**REM**) jack that can be tied into your remote power control system to power the amplifier on with 12 V dc applied and off if removed.

Operating Impressions

I found the KPA1500 a joy to use. It fit right into my station in place of my KPA500 and KAT500 combination, and I'm sure the similarity reduced my learning curve.

One difference between the setups is that while the KAT500 has three **ANTENNA** jacks, the KPA1500 only has two. For me, that meant that my dummy load wasn't always available — not a major issue — but some may need to use an external coax switch to provide full access to their antenna farms. If multiple antennas are used on the same band, the tuner will memorize up to 31 tuning solutions per frequency and start with the last one used. This is useful for multiple antennas and can also deal with my window-line fed center-fed Zepp antenna, which requires different tuning if wet.

The power supply and amplifier are fan-cooled. The amplifier has five fan speeds, ranging from inaudible to vacuum-cleaner intensity. During my operations, including participating in some contests, I never found the amplifier fan noise objectionable, although during my regular long-winded 80-meter CW sked with George, W1WO, I did hear the fan speed increase to level two during my longer transmissions.

With headphones on, I could just barely tell that the fan had sped up. While the remote software indicates fan speed, I didn't have a way to determine what it was from the front panel until I upgraded to firmware version 1.78. The updated firmware also allows front-panel control of minimum fan speed. If you know you will be heating things up, you could set the minimum speed to one or two, and then it would likely stay constant until you set the minimum back to zero.

During my testing, Elecraft released an even newer firmware version, 1.87. This version changed the temperature thresholds for the fan speeds so that the first comes on at a lower temperature, resulting in less need to increase further. This was my experience during some long CW transmissions — it quickly went to speed one, then went no higher. (As this review went to press, firmware version 2.0 was available. Check Elecraft's website for the latest firmware and release notes.)

The amplifier/tuner always knew what band and segment the transceiver was tuned to. As I tuned the transceiver frequency or changed bands, I could hear the tuner, output filter, and antenna select relays clicking to keep up with me, ready to transmit — very nice. Without the transceiver interface connected, the amplifier would almost instantly read the transmit frequency when keyed. That means that while you are listening before transmitting, you may not have the correct antenna and tuner settings in play. Just push the appropriate amplifier **BAND** button to select the right antenna and/or tuner settings.

I found the break-in keying perfect, at least for my usual 30 WPM and lower keying speeds. The PIN-diode transmit-receive switching was silent, fast, and flawless. While the difference between 500 W and 1,500 W (4.8 dB) is less than one S-unit, I seemed to be able to work weaker DX stations than I would have expected with my KPA500. As you get closer to the noise floor at the far end, 4.8 dB can make a big difference. This amplifier goes a long way toward making up for my less-than-optimum antenna system.

Manufacturer: Elecraft, 125 Westridge Dr., Watsonville, CA 95076; tel. 831-763-4211, **www.elecraft.com**. Price $5,995.

Visit https://youtu.be/e_vhAbN-LKA to see our review of the Elecraft KPA1500 Legal-Limit HF and 6-Meter Linear Amplifier on YouTube.

Harger Uni-Shot Exothermic Ground Connection Welding Kits

Reviewed by Ward Silver, NØAX
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In 2017, I installed a perimeter ground system around the outside of my station, using several ground rods bonded together with heavy wire and mechanical clamps. The ground rod for my ac service, telephone/DSL service, and the single-point ground panel (SPGP) for feed lines are all bonded together through this system. Last fall, I upgraded to welded connections.

Why Welded Connections

With the growing awareness of amateurs about the need for solid ground systems, many are deciding that one lonely ground rod outside the station window isn't enough. To get the job done right, hams are working with new techniques, materials, and tools.

Most of us aren't that familiar with the techniques or materials used for heavy-duty ground connections and conductors. Digging and drilling are involved. Wires are thicker. Clamps and terminals are much bigger. That unfamiliarity can lead to poor or unreliable connections, especially those exposed to the weather and soil for a long time.

Connections between a ground electrode (usually a ground rod) and grounding conductors (heavy copper wires) are usually in direct contact with the soil, so corrosion and moisture damage are a constant problem. The connection might have to carry very high current without damage. Connections have to be mechanically strong, so that they aren't accidentally cut or torn loose by digging or soil motion.

Mechanical clamps, usually type-G ("acorn") or the two-part type-J, are often used to make connections

Figure 5 — A ground rod and acorn clamp securing stranded #6 AWG ground wire. This is typical of clamped connections that are replaced and upgraded by the welded Uni-Shot connections.

between the heavy ground conductor and the ground rod, and I originally used acorn clamps, as shown in Figure 5. The clamp relies on compression to create a secure metal-to-metal contact. Some types of clamps are rated for direct burial. Even so, repeated thermal cycling and mechanical stress can cause the connection to loosen gradually, requiring inspection of the connection every so often. Wouldn't it be nice if a connection would never loosen or corrode?

Exothermic Welding

The answer is to weld the wire to the ground rod. Copper can be difficult to weld, but a special technique called *exothermic welding*, using thermite, works well. Thermite gives off tremendous amounts of heat when it burns. Mixed with copper powder in a ceramic crucible, a pool of molten metal is created — hot enough to partially melt the ground wires and rod. The result is a solid, welded connection.

Bottom Line

Using an exothermic welding kit rather than a mechanical clamp results in a secure ground connection that won't loosen or deteriorate over time.

Electricians use exothermic welding all the time. (So do railroads — **www.youtube.com/watch?v=rNjosF789X4**.) As a result, there are many products available. The most common are single-use kits for ½- or ⅝-inch ground rods and two, three, or four ground wires at sizes starting at #8 AWG. While more expensive than a bronze clamp, connections made with thermite welding are secure and can be buried or covered without needing to be inspected in the future.

Kits are available wholesale from local electrical supply distributors and in smaller quantities from ham distributors. The kits I evaluated were supplied by KF7P Metalwerks (**www.kf7p.com/KF7P/HargerUniShot.html**).

Ordering Kits

On the order page, there are a number of different kit configurations. It's important to get the right model. The Harger Uni-Shot kits are designed for ⅝-inch-diameter ground rods, and you need to know the number and size of wires to be connected. The ⅝-inch kits can be used with ½-inch ground rods if you use mold sealer, as described below. My ground rods are ½-inch diameter, and all ground wires are #6 stranded AWG. I needed eight two-wire kits and two three-wire kits. You should order at least one spare, particularly if you haven't used the kits before.

I also ordered the flint igniter tool to light the ignition powder and some

Figure 6 — The Uni-Shot in action with mold sealer around the ground rod and both wire sleeves. Clamping pliers support the crucible so it is vertical.

Figure 7 — The final welded connection. An additional ground conductor is clamped to the rod. This connection will not be buried.

mold sealer for around the holes in the crucible. You can use fireworks sparklers to ignite the kit, but a sparking tool is more convenient. Mold sealer is clay putty that prevents the molten metal from leaking around the ground rod and the wires so that everything inside is completely heated. Mold sealer will help keep you from having to rework a connection. The mold sealer costs about the same as a kit, so if it saves you from wasting one kit, it's worth it. The pound of sealer is enough for dozens of connections.

Using the Kit

The kits come with a fairly complete instruction sheet intended for use by electricians. The instructions and drawings are complete but terse. Read them completely, and carefully identify each part of the kit. Watch the video provided by KF7P Metalwerks at **www.kf7p.com/KF7P/HargerUniShot.html**. The segment of thermite igniting is not sped up — it happens in a couple of seconds.

I made a mistake the first time, either letting the powder leak out by not assembling the kit correctly, or I didn't have the ground rod aligned correctly. Treating the first one as a practice opportunity, I didn't have any trouble thereafter.

The welded connection shouldn't be hammered, so the ground rod must be driven in to its final position. If you're going to bury it, the top of the rod should be below ground level before you weld the connection. The ground rod's top will probably need to be filed or ground down to fit through the hole in the bottom of the crucible. A coarse file or portable grinder will do the job. (I used a file and that turned out to be the hardest part of the project.) Use a steel brush to clean the rod and the ground wires of any dirt and oxidation.

It is a good idea to practice inserting the wires into the sleeves and getting the crucible set up in a stable position on the ground rod. Note how the sleeves fit in the mold, and be sure the flared end is on the outside of the crucible. Using clamping pliers as a support is a good idea; heavy ground wires are stiff and can pull the crucible out of position. The wires should touch in the middle of the mold. Pack some mold sealer around the ground rod and all wire sleeves on the outside of the crucible.

Be sure that you put the ceramic insert and steel disc in the mold before the thermite powder. If you don't, the molten mass will pool below the wires, and the weld will be incomplete. Removing the powder once in the mold is pretty much impossible, and you won't be able to use that kit.

Be sure you know which portion of the powder tube has the thermite (the clear end) and which has the much finer starting powder (the orange end). They can't be mixed (or separated). Tap the powder tube before you open it to be sure the powder is not packed into a lump from shipping. Having the powders in separate compartments of the powder tube is helpful.

Pour in the thermite, put on the cap, then pour the starting powder into the cap's hole. Leave a little bit around the hole to catch the spark. If it's a windy day, block the wind or the fine-grained starting powder can blow away.

Put on safety glasses and heavy gloves before lighting the powder. It is tempting, but don't look at the molten mixture after ignition. Light the starting powder and in a few seconds, the thermite mixture will have turned into molten weld material. Let the mold cool for at least 10 minutes before touching it. Figure 6 shows the Uni-Shot kit just after ignition.

To remove the mold, tap it with a hammer and break it into pieces. You should see a round button of solid metal on top of the ground rod with the ground wires coming out of it (see Figure 7).

Except for the cooling period and breaking off the mold, the whole process takes about 5 minutes per connection. More time will be required if the wires or ground rod are dirty or corroded. I was able to update the whole ground system in a few hours.

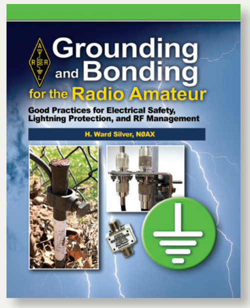
I am glad I did change the connections to welds, because I found that a couple of the clamps I had originally installed had loosened. That was probably the installer's fault (me), but it's typical that hams won't have a lot of experience with installing ground systems. The extra expense compared to a clamp is a few dollars per connection and well worth not having to worry about the connections loosening up or corroding over time.

Now that I am more familiar with the kits, I will be using them from the start. They are the right tool for the job and in lightning country, knowing my ground system is secure is a good feeling.

Manufacturer: Harger, 301 Ziegler Dr., Grayslake, IL 60030; **www.harger.com**. Distributed by KF7P Metalwerks (**www.kf7p.com**). Kits priced from $10.95 to $14.95; mold sealer, $15.95; flint igniter tool, $10.95.

Grounding and Bonding for the Radio Amateur

Learning the Terms



If you aren't familiar with the how and why of amateur station ground systems, you can read up on the subject. *The ARRL Handbook* covers the topic in the Safety chapter, and there are a number of articles in the ARRL website's Technology section (**www.arrl.org/safety**). Ward Silver's, NØAX, recent book *Grounding and Bonding for the Radio Amateur* (**www.arrl.org/shop/Grounding-and-Bonding-for-the-Radio-Amateur**), covers this and related subjects in detail and will explain unfamiliar jargon and abbreviations, like SPGP.

W4OP Magnetic Loop Antenna with Remote Tuning

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In a previous review, I discussed my experiences with the original manually tuned W4OP Loop sold by LNR Precision.[1] Since then, a new upgrade has been added to the product line incorporating a remote tuning function. Like the original W4OP Loop, the new version covers 40 through 10 meters (6-meter coverage is optional) and is rated at 15 W. This review will compare the new version to the original.

A Small Footprint

Magnetic loops can be quite handy for use in locations where typical dipoles, long wires, or vertical antennas are not practical. These locations include portable ham operations and home stations where these larger antennas are not allowed, making a small loop antenna quite attractive. The additional capability to remotely tune the antenna adds to its convenience.

The same basic design of the original loop has been retained in the updated product. The loop itself is made of a length of semi-rigid coaxial cable fashioned into a 4-foot-diameter circle and connected to a tuning unit via PL-259 connectors. The loop is held in place by an aluminum support mast attached to the tuning unit. A smaller coupling loop is mounted on the top of the support mast near the main loop. The coaxial feed line attaches to this coupling loop and

Bottom Line

The latest version of the W4OP Loop from LNR Precision adds the convenience of remote tuning from the operating position to the popular and effective manually tuned version. It's a good choice for those who operate portable in areas without access to antenna supports or for a home station when larger antennas are not possible.

[1]J. Everhart, N2CX, "W4OP Magnetic Loop Antenna," Product Review, *QST*, Oct. 2017, pp. 61 – 63.

runs to the radio equipment. The loop is tuned to the desired frequency via a variable capacitor in the tuning unit. Figure 8 shows the loop components, and Figure 9 shows a typical portable field setup.

Tuning the Loop

The original W4OP Loop had a knob on the variable capacitor shaft, which the operator turned to set the operating frequency. In the updated design, the manual tuning shaft and knob have been replaced by an internal electric motor geared to slowly adjust the variable capacitor to allow fine tuning of the narrowband loop.

The motor is operated by the small handheld control box, shown in Figure 10. This control box is connected to the main tuning unit by a cable with connectors on each end and is powered by a standard 9 V battery. The rocker switch at the top of the unit (**UP** and **DOWN**) enables relatively fast tuning for large frequency changes. The **SLOW SPEED** switch is for fine tuning (press the pushbutton while using the rocker switch to move **UP** or **DOWN**). When the tuning capacitor reaches its upper or lower limit, the user is alerted by **UP STALL** or **DOWN STALL** LEDs. The battery has an internal boost circuit that will keep the motor circuit running as the battery deteriorates to 6 V dc. The boost circuit is active at all times, with a small power drain. There is no on/off switch, so the battery needs to be removed if the antenna is not to be used for more than a week or so.

Figure 8 — The remotely tuned W4OP Loop components break down for convenient transport. The main loop and coupling loop are at the upper left, with the tuning unit, remote control box, and cable below. The support mast sections, four plastic feet, and mounting clamp are at the right.

Figure 9 — A typical portable setup at a park. The W4OP Loop includes four feet that attach to the bottom of the tuning unit, so it can simply be placed on a picnic table or other convenient nonconductive surface. A plastic clamp helps stabilize the loop.

A 25-foot remote cable comes standard with the W4OP Remote Loop to allow placing the antenna away from the operating position, and extension cables are available. This is convenient for semi-fixed installations where the antenna might be placed on a patio or deck while the operating position is indoors. Remote tuning also gets around the "body capacitance" detuning effect of manual adjustment, where the sharp loop tuning is affected by the proximity of the operator's body. Yet another feature of the redesign is that the tuning unit has been upgraded to add water resistance for extended outdoor use.

As with the manual W4OP Loop, the antenna needs to be set up clear of surrounding metallic fences, wiring, and structures. It should be mounted at least 4 feet above ground to minimize losses. Four small feet are provided with the antenna and attached to the tuning unit. With the feet installed, the loop can be set on a wooden picnic table, park bench, or other convenient nonconducting surface. A plastic spring clamp is provided for extra stability under windy conditions.

For this review, we ordered the optional tripod adapter. This allows mounting the W4OP Loop on a standard camera tripod. I recommend this option for additional convenience.

On the Air

I successfully used an original manually tuned W4OP Loop in a number of portable setups beginning with ARRL's National Parks on the Air (NPOTA) program in 2016. I enjoyed that so much that I've continued with

Figure 10 — The handheld remote control with tuning buttons and indicators.

portable operations for the World Wide Flora and Fauna (WWFF-KFF, **wwffkff.wordpress.com**) and Parks on the Air (POTA, **parksontheair.com**) programs ever since. A magnetic loop is a great solution where larger antennas cannot be used, and it performs quite well. I set up the W4OP Loop with the provided stabilizing feet where convenient, and on a camera tripod where appropriate.

As a dry run, I tried a 1-day RaDAR (Rapid Deployment Amateur Radio) outing to prove the W4OP Loop's practicality. This type of effort involves setting up at multiple sites in succession with a minimum 6-kilometer (about 3¾-mile) drive between locations. I chose four parks eligible for both the WWFF-KFF and POTA programs, with the goal of completing the effort in 5 hours or less.

For fastest antenna setup, I transported the W4OP Remote Loop with the main and feed loops assembled to the remote tuning unit and support mast. All that was needed at each location was to attach the loop assembly to a tripod and run the feed line and control cables to my operating position. I allocated 30 minutes for on-the-air operation at each of the parks, and hoped to make at least 10 contacts at each location.

This test was quite successful in achieving all goals. I used the remotely tuned W4OP Loop with my Elecraft KX3 transceiver (10 W) for a total of 75 CW contacts on 40, 30, and 20 meters. I contacted stations from coast to coast in the US and several Canadian provinces. The loop proved to be very quick and easy to set up and take down at each site, with convenient band changes. It performed flawlessly, once the operator mastered the remote control tuning technique. The lead photo shows the antenna in use at one of the locations in Wilmington, Delaware.

Lessons Learned

One lesson that applies to both original and new W4OP Loop models concerns use in windy conditions. Magnetic loops present a large wind load area, so proper precautions are needed. Along with the mounting feet, only one plastic clamp is supplied with the unit. A second clamp will provide added stability in windy locations. Clamps are readily available at any home center, and I have even seen them at a local dollar store. For a semi-permanent installation, it might be best to remove the feet and simply screw the tuning unit to a wooden railing or other flat surface.

Similar wind stability issues may occur when using the W4OP Loop on a tripod with the optional adapter. One fix that has been effective is to tie a weight onto the tripod leg support braces. This can be as simple as using an elastic bungee cord to attach a gallon jug full of water (about 8 pounds) to the tripod. Yet another method might be to tie the tripod onto a fence or signpost.

There is a definite learning curve in using the remote tuning feature. The basic method is the same as with manual tuning. If your transceiver has a built-in automatic antenna tuner, disable it. Then tune the loop roughly by tweaking the **UP** and **DOWN** tuning controls for maximum received noise on the desired frequency. Next, transmit into the loop on frequency and adjust for lowest SWR with the **UP** and **DOWN** rocker switch while holding down the **SLOW SPEED** button. There is some backlash in tuning, so it may take several iterations to get right on.

One thing that took me a while to learn was that the slow tuning takes 30 seconds or so to go from 20 meters to 40 meters, so you need patience. If you go too far, the **DOWN STALL** or **UP STALL** lights will illuminate when you reach the ends of the capacitor tuning range. Also note that, in bright sunlight, you might have to shade the remote tuning box in order to see the LEDs.

One final lesson learned was that the loop element is attached to the tuning box via SO-239 connectors. When you connect them, be sure not to cross thread the connectors. You need a very tight connection to ensure minimum loss. I have found that putting a very small amount of anti-oxidant compound or conductive grease on the box-mounted connectors aids in getting the connectors threaded on properly. It's messy, so don't use too much.

The W4OP Loop with remote tuning is a very well-designed and nicely manufactured device. It has proven itself in a number of portable uses where I could not set up a larger antenna. Typical of small portable magnetic loop antennas, it does have somewhat lower performance than a full-size antenna, but it also has important benefits. Its inherent narrow bandwidth gives significant rejection of off-frequency signals, even in the same frequency band, allowing simultaneous operation of multiple stations in close proximity. By its very nature, it also tends to significantly reject local electrical noise. Plus, its figure-eight pattern provides additional interference rejection broadside to the loop. And finally, the addition of the remote tuning feature makes a good design even better.

Manufacturer: LNR Precision, 1954 N. Fayetteville St., Asheboro, NC 27203; **www.lnrprecision.com**. Price: W4OPLoop Antenna (Remote Tuning), $443.74; case, $34.95; tripod adapter, $22.99.

MFJ-1708SDR and MFJ-1708B-SDR TR Switches

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In recent years, inexpensive standalone software-defined receivers (SDRs) have become popular. In addition to receiving many modes over a wide frequency range, SDRs include a panadapter (spectrum scope) and/or waterfall display to show band activity at a glance.

These small SDRs are popular add-ons for general listening or for adding panadapter capability when it's not built into the station transceiver. But if your transceiver has no provision for using an external receiver, you need a transmit-receive (TR) switch to share your station antennas between your transceiver and SDR without damaging something or swapping cables all the time.

MFJ-1708 Series TR Switches

MFJ offers several different TR switches in the MFJ-1708 series. The original MFJ-1708 is a traditional TR switch for use with a separate transmitter and receiver, appropriate for use with classic gear. It has SO-239 jacks for antenna, transmitter, and receiver. Switching between receive and transmit is activated by grounding the **CTRL** phono jack, or you could rely on its internal RF-sensed switching circuit to handle the switchover automatically when RF is applied. An **AUX** phono jack provides switched contacts that could be used to operate a receiver's mute feature (to shut off receiver audio during transmit) or to control another device. Although there were some MFJ-1708s in the supply pipeline when this was written, the original model has been replaced by the MFJ-1708B. The B version offers much better performance at VHF and UHF, as well as additional isolation between receiver and transmitter to better protect the receiver front end from excessive RF levels.

The MFJ-1708SDR (see Figure 11) was developed with the use of a separate SDR receiver/spectrum display in the ham station in mind. Similar to the original MFJ-1708, it has SO-239 jacks for antenna, transceiver, and SDR. Switching between receive and transmit is activated by grounding the **PTT** phono jack, or automatically with RF-sensing. Although the manual does not show a frequency range, advertisements indicate that this TR switch is intended for HF and VHF use.

The latest version is the MFJ-1708B-SDR, shown in Figure 12. It has SO-239 jacks for an antenna, a transceiver, and an SDR receiver, and there's also a version with an SMA connector for the SDR antenna. Switching between receive and transmit is activated by grounding the **CTRL** phono jack, and like the other models, it has an RF-sensed switching circuit. Like the original MFJ-1708, it includes an **AUX** phono jack with a set of switched contacts for muting a receiver or controlling another device.

The biggest difference, however, is inside the box. The original MFJ-1708 TR switches used a single relay to switch the antenna. The B series switches use four relays, with components mounted on a PC board that uses 50 Ω transmission lines instead of wires for connections. The result is much better performance, particularly at VHF and UHF.

Bottom Line

The MFJ-1708SDR and MFJ-1708B-SDR TR switches offer an easy way to share antennas between your transceiver and a separate inexpensive SDR for adding a spectrum display to your station or for wide-coverage listening. Although the B version costs about $20 more, the performance improvements are well worth the extra cost.

Lab Tests

The ARRL Lab tested the MFJ-1708-SDR and MFJ-1708B-SDR switches, with results shown in Tables 2 and 3. The Lab looked at switching times, isolation between the various ports, and insertion loss.

Table 2
MFJ-1708SDR TR Switch

RF sense threshold: 10 – 14 mW typical.
Switching time (PTT or RF sense): 1.2 ms to transmit, 352 ms to 2.28 s to receive.
Power consumption at 13.8 V dc: transmit, 13 mA; receive, 31 mA.
Insertion loss (during receive, antenna port to XCVR and SDR ports): 14 MHz, 3.6 dB; 50 MHz, 3.94 dB; 144 MHz, 7.4 dB; 440 MHz, 19.6 dB.
Insertion loss (during transmit, antenna port to XCVR port): 14 MHz, 0.07 dB; 50 MHz, 0.28 dB; 144 MHz, 1.1 dB; 440 MHz, 4.0 dB.
Isolation XCVR to SDR port (during transmit, antenna port terminated): 14 MHz, 17.3 dB; 50 MHz, 11.2 dB; 144 MHz, 12.7 dB; 440 MHz, 0.8 dB.
SWR at XCVR port in transmit mode: 14 MHz, 1.0:1; 50 MHz, 1.05:1.

Figure 11 — The MFJ-1708SDR.

Table 3
MFJ-1708B-SDR TR Switch

RF sense threshold: 16 – 18 mW typical.

Switching time (PTT or RF sense): 4.4 ms to transmit, 24 ms to 2.14 s to receive.

Power consumption at 13.8 V dc: transmit, 12 mA; receive, 155 mA.

Insertion loss (during receive, antenna port to SDR/XCVR ports):
JP2 installed: 14 MHz, 3.5 dB; 50 MHz, 3.5 dB; 144 MHz, 4.8 dB; 440 MHz, 7.7 dB.
JP2 removed: 14 MHz, 3.5 dB; 50 MHz, 3.5 dB; 144 MHz, 5.0 dB; 440 MHz, 6.8 dB.

Insertion loss (during transmit, antenna port to XCVR port):
14 MHz, 0.04 dB; 50 MHz, 0.09 dB; 144 MHz, 0.3 dB; 440 MHz, 1.5 dB.

Isolation, XCVR to SDR port (during transmit, antenna port terminated):
JP2 installed: 14 MHz, 56 dB; 50 MHz, 55 dB; 144 MHz, 51 dB; 440 MHz, 40 dB.
JP2 removed: 14 MHz, 56 dB; 50 MHz, 55 dB; 144 MHz, 51 dB; 440 MHz, 48 dB.

SWR at XCVR port in transmit mode: 14 MHz, 1.0:1; 144 MHz, 1.1:1; 440 MHz, 1.5:1.

Figure 12 — The MFJ-1708B-SDR.

Switching time from receive to transmit for the MFJ-1708SDR is 1.2 milliseconds, using either the PTT control line or RF sensing. The MFJ-1708B-SDR was slightly slower, at 4.4 milliseconds, perhaps because of the additional relays. Both of these should work fine with PTT control from any transceiver because of the PTT-to-RF-output delay that transceivers have to prevent hot-switching a linear amplifier. (For example, my Kenwood TS-590S transceiver can be set to either 10 or 25 milliseconds delay, so either MFJ TR switch would have plenty of time to switch before I started transmitting.) The delay when returning to receive is adjustable up to about 2 seconds. Note that the transceiver is connected to the antenna when TR switch power is off.

With RF-sensed switching, both TR switches presented a power spike at the SDR port during the transition from receive to transmit. With the original MFJ-1708SDR, the power spike at the SDR receiver antenna jack was the full transmitter power (100 W) for 1.2 milliseconds, and we would not recommend using the RF-sensed switching function with this model. The MFJ-1708B-SDR incorporates some protection for the SDR antenna input, and during RF-sensed switching, limited the power spike to a measured +29.6 dBm (about 1 W) when used with the same 100 W transceiver. While that probably won't damage your SDR, we would highly recommend using the PTT connection from your transceiver with either switch, with RF sensing as a backup in case the mechanical connection fails.

Both TR switches use a hybrid splitter to provide some isolation between the transceiver and SDR on receive. At HF, that results in 3.5 dB insertion loss between the antenna jack and transceiver or SDR jack on receive, which is hardly noticeable on the air. As shown in the tables, insertion loss starts to climb at 50 MHz, and the B model is significantly better than the original above 2 meters. On transmit, at HF, the insertion loss between the transceiver and antenna jack is negligible with both versions. The improvements in the B version are obvious at 50 MHz and higher frequencies.

Isolation between the transceiver and SDR ports is improved significantly in the MFJ-1708B-SDR. At HF, it measured nearly 40 dB better than the original version, with even greater improvement at VHF and UHF. The instructions noted that isolation at VHF and UHF can be improved if jumper JP2 is removed, disabling the RF sensing function. With JP2 removed, the Lab measured an improvement of 8 dB isolation at 440 MHz, along with 1 dB lower insertion loss compared to measurements with the jumper in place. At HF through 144 MHz, isolation was about the same with the jumper installed or removed.

On the Air

I tried both the original MFJ-1708SDR and the new MFJ-1708B-SDR in my station with a Kenwood TS-590S transceiver and an SDRplay RSP1 SDR. The added isolation in the B model was apparent immediately. With the original version, whenever I transmitted, enough signal was present at the SDR antenna jack to raise the receiver noise level significantly — even if the transceiver and SDR were tuned to different bands. Without a way to mute the SDR audio, I found the noise distracting.

With the MFJ-1708B-SDR, the transmitted signal was attenuated enough to not be bothersome with both radios tuned to the same band, and if they were tuned to different bands, I heard no trace of the transmitted signal. If this were a permanent installation, I would try to use the B version's **AUX** jack to mute the SDR audio while transmitting.

MFJ has made significant improvements with the MFJ-1708B-SDR, and it's well worth the $20 price difference to get the new version. It offers significantly greater protection for the SDR while transmitting, and works well on the bands above 6 meters.

Manufacturer: MFJ, 308 Industrial Park Rd., Starkville, MS 39759; **www.mfjenterprises.com**. Price: MFJ-1708B-SDR, $99.95; MFJ-1708SDR, $79.95; MFJ-1708B, $99.95.

Pacific Antenna Low-Pass Filter Kit

Reviewed by Paul Danzer, N1II
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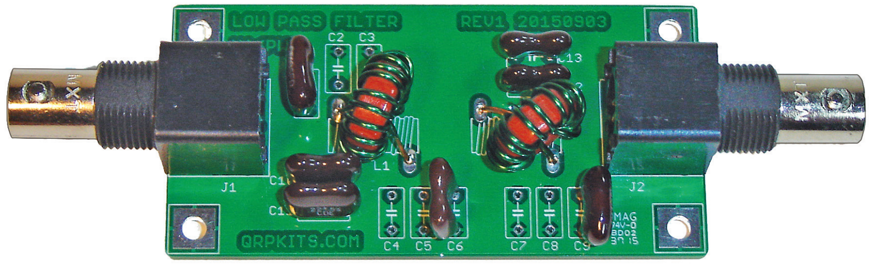

A number of kit-based or home-built QRP (low-power) transmitters tested in the ARRL Lab have the same characteristic — high levels of harmonics or spurious emissions. In order to keep the transmitter as small and inexpensive as possible, output filtering is sometimes kept to a minimum. The FCC requires 43 dB suppression of these unwanted emissions, and as good amateurs, we must comply with FCC requirements, regardless of a transmitter's RF power output.

Pacific Antenna offers a number of radio and accessory kits under the **QRPkits.com** banner. The review looks at a standalone five-pole, low-pass filter that can be built for 20, 30, 40, or 80 meters and is rated for up to 100 W with a matched antenna. Invest a few dollars and a short evening at the workbench, and you can ensure that your low-power transmitter meets FCC requirements.

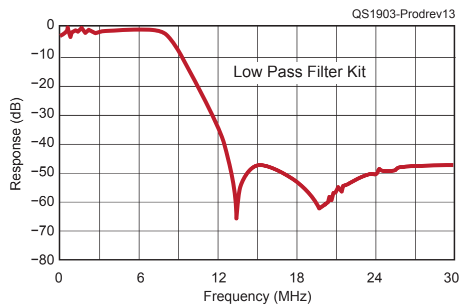

Figure 13 — The 40-meter filter response, measured in the ARRL Lab. Attenuation is roughly 50 dB from 12 MHz and up, with nulls at 14 and 21 MHz.

Easy to Build

The kit includes a 1.75 × 3.5 inch PC board and all parts for the specified band, but no enclosure. The comprehensive, well-illustrated, downloadable manual includes a table showing component values for each version. I built the 40-meter version, which uses seven capacitors and two toroidal inductors. The capacitors are legibly marked with codes, and I had no difficulty identifying them. For example, 271 means 27 followed by one zero or 270 pF.

The builder must wind the two toroids. Perhaps the simplest way is to cut the supplied enameled wire in half, one piece for each inductor. Then thread the wire through the center of a toroid core, and center the core on the wire. The 40-meter inductors require 16 turns, so starting from the center, I wound eight turns in one direction and eight turns in the other. To check your work, count the number of times the wire goes through the center of the toroid core — it should be 16 times for 16 turns.

Next, adjust the turns so they are evenly distributed on the core and cut the leads to about 1-inch long. Use a hot soldering iron or scrape the leads with a knife to remove the insulation, then solder the inductors in place.

The PC board is well made, with plated through-holes, a solder mask, and a part placement guide. If you find the holes a bit small for some component leads, clip off ¼ inch to remove a slightly thicker tinned surface at the ends of the leads.

The filter is symmetrical and either end can be used as the input or output. The supplied BNC connectors are optional. If you plan to incorporate the filter inside an existing transmitter, you can ignore them and connect the filter between the transmitter output and antenna jack with short pieces of coaxial cable.

Figure 13 shows the filter response. As you can see, insertion loss is low at 40 meters, and attenuation is around 50 dB at higher frequencies, with nulls at 14 and 21 MHz (second and third harmonics). The filter worked well as built, with no test equipment or adjustment required to get this performance.

Bottom Line

Quick to assemble and inexpensive, this low-pass filter can help to keep your low-power transmitter compliant with FCC spectral purity requirements.

Manufacturer: Pacific Antenna, P.O. Box 10301, Fayetteville, AR 72703; **www.qrpkits.com**. Price: 20, 30, or 40 meters, $15; 80 meters, $18.