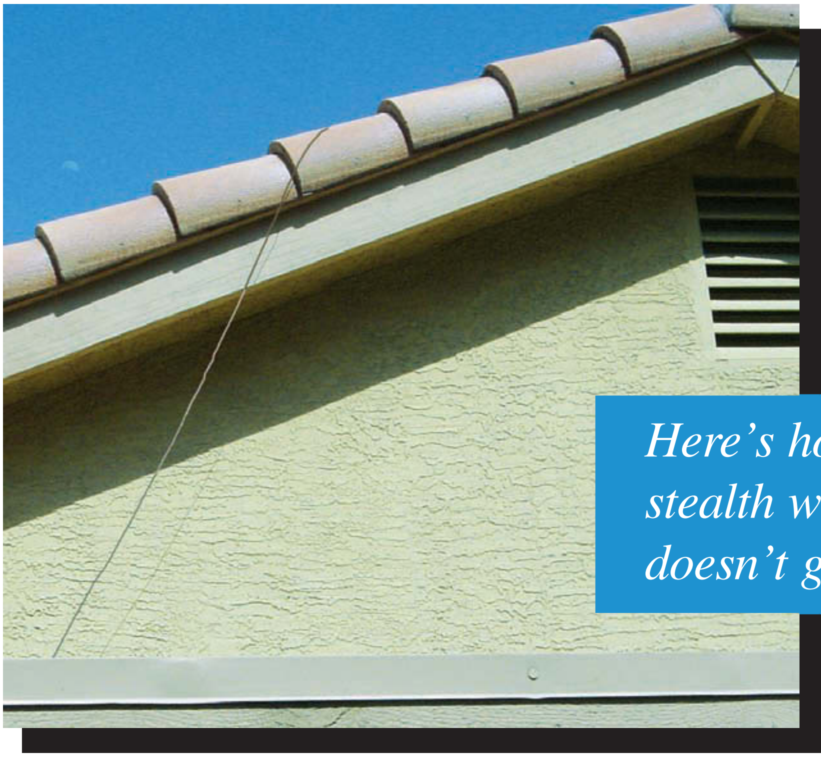
Surprising Results with a Low, Hidden Wire Antenna



Here's how one amateur made a stealth wire antenna system that doesn't give up much performance.

Bruce Pontius, NØADL

We live in a community that does not appreciate outdoor antennas of any kind. In addition, the houses are close together and RF interference can be a problem at neighbors' houses as well as mine. Occasional minor interference seems less objectionable to neighbors if they don't see antennas to remind them of (or alert them to) the radio operations. I have good relationships with my neighbors, but I would rather avoid RFI discussions.

The 45 foot high horizontal loop and balanced feed system described a couple of years ago in *QST*[1] would be terrific, but I don't have supports to get a loop up in the air. Forget that! Like it or not, I have to use hidden antennas except for temporary operations. In this article, I discuss my experiences with an almost unnoticeable end-fed random wire HF antenna and counterpoise system. I tend to use short transmissions on SSB and low power for digital modes, and I have had many rewarding and enjoyable contacts with this simple setup. If you're in a neighborhood that's unfriendly towards outdoor antennas, perhaps you will be encouraged to try your own stealth antenna.

[1]Notes appear on page 35.

"Design" of the End-Fed Random Wire Antenna

I started with a chart of relative impedance versus wire length for the HF bands. I chose a length of 92 feet, which provides a reasonable impedance for an antenna tuner on most bands. At 15 meters, the wire is nearly a multiple of $^1/_2\,\lambda$, presenting a very high impedance at the antenna tuner. This might also be the case at 60 and 30 meters, but these two bands are not a main goal for me. After building the antenna, I was pleasantly surprised that my MFJ-949D tuner could provide a match to the transmitter at 15 meters and does not arc or misbehave, at least at 100 W input. The antenna is about $^3/_8\,\lambda$ at 75 meters, and it works there, at least a little.

The next task was running the wire outside and along the roof of my house. Most of the antenna is 20 gauge insulated wire, with 18 gauge stranded bare copper to lower visibility where the wire is above the roofline and in silhouette. The wire starts at the operating location and passes through an exterior wall just above the patio roof behind the house. Then the wire runs up to the main roof, following a tortuous path over the edge of the tile roof, up to a low chimney, and then along the peak of the roof. It is lying on the tile for much of its length and in some places is held slightly above the roof where it is tied to the chimney and, further along, to a vent pipe. The last 6 feet or so of the wire, at the open end, is held off of the roof tiles by finding appropriate places to tie it. The highest spot is at the chimney, 17 feet, 9 inches above the earth.

To get the wire outside, I drilled a $^5/_{16}$ inch hole through the wall from the outside and drew the wire through the wall.

Be sure there are no wires or pipes where you drill! The holes were plugged with caulking material. If the wire is removed, the holes can be filled and painted to match. Inside, the entry point is concealed by a china cabinet and the wire can be hidden when not in use. As indicated in the lead photo, the hidden wire antenna is barely noticeable as it exits above the patio roof and disappears over the edge of the tile roof.

I use the antenna with a portable station that takes only a few minutes to set up and put away, leaving almost no traces of a radio station. Another radio operating position, in the middle of the house, has more permanent antenna feeds for indoor antennas or for temporary VHF/UHF or satellite operations.

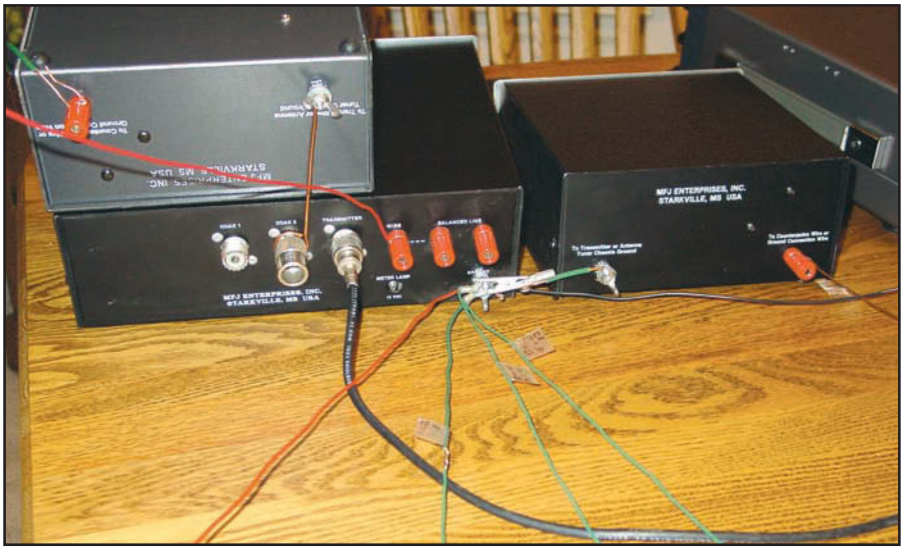


Figure 1—The station equipment setup, viewed from the back.

Figure 2—Antenna tuner settings can be recorded on a chart for faster band changes.

Developing an Effective Counterpoise

When I first tried transmitting with the random wire, there was RF all over the place, including a tingle in my fingers and nose. Adding wires to the ground lug on the antenna tuner to form a counterpoise improved things considerably. My counterpoise wires are made from insulated 20 gauge wire and tied with nylon string to furniture in adjoining rooms. The wires are 25-30 inches above the floor and close to $1/4$ λ at the frequency in use.

My first counterpoise didn't solve all the issues with stray RF. For example, on 40 meters, with only one $1/4$ λ radial, a ground fault circuit breaker in the adjacent kitchen picks up RF energy and trips. I started experimenting with the MFJ-931 Artificial Ground counterpoise tuner. With a second 40-meter counterpoise wire attached to the MFJ-931 and another '931 tuning a wire to an 8 foot ground rod just outside the wall, things are much cooler. There is no noticeable RF feedback or mischief except for the inevitable pickup in the wireless phones and audio equipment. The higher bands pose fewer ground system difficulties and do not require a tuner or a ground rod.

Figure 1 shows the system I ended up with. The transceiver is on the far right and the MFJ-949D antenna tuner is the lower box on the left. The red antenna wire goes up and to the left from the WIRE terminal on the tuner. Fixed counterpoise wires (one $1/4$ λ wire for each band in use) attach to the ground lug. More counterpoise wires, perhaps passing out through windows, might help performance but the complication does not seem worth the possible improvement.

One MFJ-931 counterpoise tuner is on the table between the transceiver and antenna tuner. The wire connected to the red terminal is approximately $1/4$ λ for the band currently in use, and I change wires and tuner settings when I change bands. Another counterpoise tuner is on top of the antenna tuner, with a wire going outside to an 8 foot ground rod. The ground rod alone is used for 75 meter operation because of the difficulty in routing effective $1/4$ λ (63 foot) counterpoise wires around the house. Once the system is tuned up, bandwidth on 40 meters and up is adequate to cover most of the General class phone sections with little or no retuning. Table 1 shows the wire lengths I used for the counterpoise system. The last two columns are dimensions for a $1/4$ λ vertical antenna used for comparison testing as described later.

This setup might seem complicated but it really only takes about 12 minutes to assemble the equipment and wires from their stowed positions for a day of operating, and then only a couple of minutes to change bands. To make band changes easier, you can make a chart like the one shown in Figure 2 to preset the antenna tuner and main counterpoise tuner.

Most of the transmitter power seems to be going into the antenna. The tuner has been tested with loads simulating the wire antenna. Losses appear to be less than 1 dB on most bands, but I have not checked 80 meters. The transfer function on all bands exhibits expected changes versus frequency, demonstrating that it is not just a flat-frequency-response "dummy load" antenna and matching system.

When using two or more counterpoise tuners with RF current sensors and meters, the effects of resonance in the counterpoise wires is quite evident. For example, I tuned one counterpoise for maximum RF current while transmitting (it's tuned for minimum RF impedance—what we want is a short at the tuner). When another counterpoise wire is added, the two wires are interactive. If one is detuned from resonance, the current increases in the other and vice versa. Probably the best situation is to roughly balance the two currents, or in the case of many counterpoise wires, to cause them all to be at resonance and to equally share the RF ground currents.

On the Air with the Wire Antenna

I used a 100 W transceiver for the operating described here. Some contacts were made in 2002 and 2003, but most of my operating with this wire took place in February and March of 2004 after the sunspot cycle had continued its drop. The relatively small amount of operating time has resulted in Worked All States on 20 meters with QSL cards in hand. I'm just a few states short of Worked All States on 17 and 15 meters, and have worked all continents. A few days of operation thus far on 40 meters has yielded more than 30 states.

In only a few hours of operation during the 2004 ARRL DX Contest, I logged many stations on 10 meters and 15 meters, including all continents except Africa. My time only allowed a few contacts on 20 meters, as I concentrated on 10 and 15 while those bands were active.

The results that weekend encouraged me to try the CQ WPX contest at the end of March 2004. Again, I went for the higher bands first and logged more than 30 contacts on 10 meters and about 50 contacts on 15 meters in just a few hours of operating time. Contacts included DX stations on five continents. Running out of time, I reluctantly moved down to 20 meters and, of course, could have filled a computer log book with so many stations on the air. I was not able to make contacts through some pileups, but was quite satisfied with the percentage of successful attempts. I did listen far more than transmit. The activity on 40 meters seemed lower, at least during daytime, so I only tried for a while, logging a dozen or so in a half hour.

Comparisons with Other Antennas

The performance of the hidden wire was much better than expected, so I invested some effort in on-site comparisons with other antennas to get an estimate of just how much performance must be given up in the use of the compromise antenna and ground system. It happened that both of my next door neighbors were to be gone for two weeks at the same time, so I could put up some big antennas and blast away without breaking my cover.

First, I set up a Force 12 Sigma 5 vertical dipole for 20-10 meters in the backyard with the lower end about 2.5 feet above ground. On-the-air transmit and receive comparisons showed that the wire often seemed to work as well or better on 20, 17 and 15 meters. I did not try 10 meters. The two antennas could be switched rapidly back and forth using the Kenwood TS-570D's two antenna ports and the front panel switch. The wire was fed through a tuner, but the Sigma 5 did not require one. I have heard of others' successful use of the Sigma 5, so I was pleased that the wire compared well with it. Therefore I decided to put in more effort to make comparisons with standard antennas.

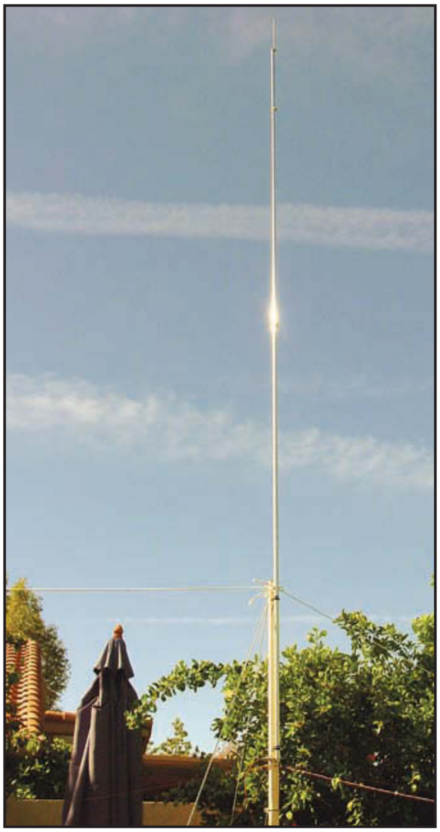


Figure 3—The 20 meter vertical antenna is about 22 feet tall, including the 5 foot wooden support post. It definitely attracts more attention than the hidden wire.

Building a Comparison Antenna

A standard half-wave, horizontal dipole would have been most desirable for comparisons, but I don't have sufficient supports. A vertical ground plane with elevated radials seemed to be the next best standard antenna type, and it was something that I could manage in my yard.

I considered buying a good vertical antenna but didn't want to complicate the comparison with a multiband unit. I wanted to have a basic, inexpensive 1/4 λ piece of

Table 1
Antenna and Radial Wire Lengths

Band (meters)	*Center Freq (MHz)*	*Calculated 1/4 λ (feet)*	*Length of Counterpoises (feet)*	*Vertical Radiator Length (feet)*	*1/4 λ Radial Length (feet)*
75	3.925	59.6	Ground rod		
60	5.350	43.7			
40	7.265	32.2	34.0, *32.4**	32.9**	32.9
30	10.125	23.1			
20	14.290	16.4	16.2, *14.6**	16.7	17.0
17	18.140	12.9	13.4, *14.6**	13.4	13.4
15	21.375	10.9	11.5, *10.2**	13.4***	11.2
12	24.960	9.4	9.4, *7.5**		
10	28.490	8.2	8.3, *7.0**		

*The length shown in italics is for an additional counterpoise wire tuned through the MFJ-931 Artificial Ground counterpoise tuner for operation on 40-10 meters (no counterpoise wire is used on 75 meters). Also, on 40 meters and 75 meters, another MFJ-931 tunes a wire connected to an 8 foot ground rod.
**This dimension was about 10 inches too short.
***The 17 meter vertical radiator was also used for 15 meters and the antenna fed through the tuner.

Figure 4—Radials are wrapped around a hose clamp and pressed against the antenna connector. A brass strap is soldered to the connector center conductor and then bolted to the vertical radiator. Two U bolts hold the vertical radiator to the mast.

metal for simplicity of measurements on one band at a time. Besides, I love the magic of fundamental electrical phenomena and looked forward to observing the interactions of simple vertical conductors and an elevated, tuned radial system.

The first vertical, for 20 meters, is shown in Figure 3. The vertical radiator uses an 8 foot length of 1 inch tubing with an 8 foot length of 7/8 inch tubing telescoped inside. A 3/8 inch aluminum rod clamped to the 7/8 inch tube brings the total length to 16 feet, 9 inches. The antenna base is 5 feet above ground, mounted on a 2-inch-square wooden pole with two U bolts as shown in Figure 4. The top of the pole is guyed with four nylon ropes.

Nine 17 foot radials (seven good ones and two bent to fit my yard) were fastened at the feed point by twisting the 18 gauge stranded copper radial wires around a hose clamp as seen in Figure 4. The radials are about 5 feet above ground at the antenna base and are stretched out and tied off with nylon string to stakes (or to anything handy).

The feed point connects with straps to the vertical radiator as shown in Figure 4. One strap is fastened with a screw and nut to the bottom antenna section and the other is clamped between the pole and antenna tube. An insulator can be placed on the wood pole behind the strap if desired. The straps are soldered to the connector center pin.

Adjusting the Vertical

Before attaching all the radials, I adjusted the first four with the aid of instruments. Next I adjusted the vertical radiator for resonance at the desired frequency. Then I cut the rest of the radials to length, attached nine and again measured the antenna resonant frequency. Leaving the vertical radiator length alone at that point, I readjusted the radials to bring the antenna to resonance. This iterative process could be repeated, but results were good enough after one cycle. The final dimensions are shown in Table 1.

The signal source for these adjustments is similar to the one I described in *QEX,*[2] followed by a Motorola 2832C balanced, push-pull amplifier and a 3 dB attenuator. The power level through the precision directional couplers to the antenna can be less than 100 mW since sensitive power meters are used.

Thankfully, all this measuring must be done only once. After the antenna is adjusted, the SWR will be less than 1.4:1. The vertical can be set up anywhere and things will work properly unless large conducting objects are in close proximity.

I used similar procedures for the 17 and 15 meter versions. The 17 meter antenna used nine radials. The 15 meter antenna used all of the 17 meter radials, plus 6 more cut to the length shown and fit in between. I used the 17 meter vertical radiator length on 15 meters as well, and fed the antenna through a tuner.

For 40 meters, I added another 8 foot section of aluminum tubing at the bottom and lengthened the 3/8 inch rod to make a 33 foot vertical. This antenna was guyed at the middle with ropes. The 40 meter radials were a compromise. Three 34 foot radials fit in the yard without bending, but three additional wires required bending to fit, with two of them quite contorted.

Compromise Wire versus Full Size Vertical

I compared the vertical and the random wire on 20 meters first. An operator in the Philippines thought the vertical slightly better, but at my end, on receive, the signal-to-noise (S/N) ratio was better on the (mostly horizontal) wire. Contacts in California favored the vertical, while contacts in Idaho and Washington favored the wire, as did local Arizona contacts. A couple of stations in Texas liked the vertical a little better, while stations in the Southeastern US gave better reports on the wire. The Upper Midwest and Northeast were a toss-up.

Received signals exhibited a better S/N ratio on the wire 75% of the time or more, but often the signal strength was somewhat higher on the vertical. Ignition noise was much louder on the vertical, but it can be reduced with the noise blanker and doesn't often bother me. Sometimes the signal strength and quality advantage at both ends of the contact shifted back and forth between the wire and vertical, adding to the conclusion that the two antennas performed about the same.

On 17 meters, a fair amount of listening revealed that the wire was definitely better on receive. As on 20 meters, the S/N ratio was better on the wire. Contacts in Mexico and the Caribbean favored the wire. Stations in South America and Japan reported equal performance. During a contact with a Texas station signals shifted back and forth, with one antenna better and then the other. A station in Alabama on a vertical antenna reported better signals from the wire. In general, the southeastern US seemed about the same on either antenna, as did the Midwest and New York. This was far from a comprehensive test, but it appeared that performance was similar to 20 meters with a slight advantage going to the wire.

After listening for a while, I didn't hear anyone on 15 meters so I resorted to calling CQ. Up popped VP6MW, one of 42 residents of Pitcairn Island in the South Pacific. We had a great QSO during which signals varied widely. The wire seemed to give a better S/N signal on receive, and VP6MW reported my signals about the same on the two antennas. During operations on a net, where protocol prohibited back-and-forth transmit comparisons, the antennas seemed to work about the same.

On 40 meters, the 34 foot aluminum vertical outperformed the wire on transmit, significantly in some cases, during contacts with 20 or more stations from around the US. Most reported stronger signals with the vertical, typically at least 1 S-unit and up to 2 S-units. As on the other bands, better receive S/N ratios on the wire helped the receive performance. On the lower bands, the wire is clearly a compromise as a transmitting antenna. Nevertheless, with limited time and effort, operation on 40 meters with the wire has yielded solid contacts in more than 30 states. More counterpoise wires might help.

The Wire Works Okay, but is it Safe?

RF safety is a concern with any indoor antenna or antenna close to the house. I was able to make some measurements of the electric fields of the hidden wire and comparison vertical antennas. Using these relative voltage measurements and information and tables from the ARRL publication *RF Exposure and You,*[3] I determined that the maximum permissible exposure (MPE) would not be exceeded using 100 W on SSB and short transmission times.

I based my conclusions on the tables starting on pages 8.26 and 8.37. These tables are for ground-mounted verticals and for elevated vertical ground planes. The worst case exposure situation for the vertical antennas is when the operator is sitting right within the radials field of an elevated vertical, among the radial wires, with head and shoulders above the plane of the radials. The tables say a person could be within 11 feet of an elevated groundplane vertical antenna and be under the exposure limit, even with more than 100 W PEP of transmit power. (Duty cycle and on/off times are considered and factored in for my type of operations on SSB.)

The wire antenna slopes away from the operator, with limited counterpoise wires extending away from the operator. It was assumed to exhibit lower energy fields near the base than the vertical antennas in the tables. Also, the total energy radiated in the near field from the wire is distributed somewhat along its 92 foot length. Considerably more than100 W of power could probably be used with the wire while remaining within the recommended MPE limits, however. Each operator is responsible for his own evaluation of his particular situation. *Note:* While the author's configuration may not exceed published limits, an antenna like this is hard to evaluate for RF safety, especially since so much of it is in proximity to people. To be safe, consider limiting power output to 50 W or less to be below the threshold at which measurements or analysis is required.*—Ed.*

Conclusions

The stealth wire works. Using an end-fed wire eliminates the need for a supported center feed, which can be difficult to do while keeping the antenna out of sight. If you have a problem with erecting a huge, high antenna, go ahead and string up this compromise. Even though it is a compromise, it is a quite effective antenna and counterpoise system—even as a portable station.

Notes

[1]K. Kleinschmidt, "A Balanced, Everyday Approach to All-Band Bliss," *QST*, Apr 2002, pp 47-50.

[2]B. Pontius, "Signal Sources," *QEX*, Nov/Dec 1999, pp 18-30. See Note 11 in this article.

[3]E. Hare, *RF Exposure and You* (Newington: 1998). Available from your local dealer, or from the ARRL Bookstore, ARRL order no. 6621. Telephone toll-free in the US 888-277-5289, or 860-594-0355, fax 860-594-0303; **www.arrl.org/shop/**; **pubsales@arrl.org**. You can also find RF exposure resources on-line at **www.arrl.org/tis/info/rfexpose.html**.

Additional Reading

The author's original, unedited article with data and pictures is available on **www.radioadv.com**.

B. Muscolino, "My Antenna is a Compromise—and It Works!" *QST*, Apr 2003, pp 59-61. This article supports the use of simple end-fed wires, but does not provide much actual same-site comparison.

K. Kleinschmidt, *Stealth Amateur Radio* (Newington: 1998). This book is devoted to operating without calling attention to yourself. It's currently out of print but may be available on-line or at hamfests.

The ARRL Web site has information on limited space antennas at **www.arrl.org/tis/info/limited.html**.

Photos by the author.

Bruce Pontius, N0ADL, holds a BSEE and has been involved in the development of semiconductors and radio equipment and systems for many years. He played major roles in the development of early cellular radio equipment, digital trunking radios and narrowband data radio equipment. Bruce served as Engineering Vice President at EF Johnson Company for 15 years and worked with other companies in similar roles. He now serves as president of TRM Associates and is working in wireless communications and RFID. Bruce first got involved with Amateur Radio at age 11, building radios and test equipment with his father. He has been licensed since 1978 and enjoys operating with simple equipment and portable operation. You can reach Bruce at 15802 N 50th St, Scottsdale, AZ 85254, e-mail **bepontius@aol.com**.

New Products

J-TEC ANTENNA SWITCH AND HF RECEIVE PREAMPLIFIER

◊ The ASAP-2 Antenna Switch and Preamp is available from J-Tec. This receive unit covers 1.8-30 MHz and is designed for use with HF transceivers running up to 150 W CW. It enables the operator to select one of four receive antennas, such as N, E, W and S-pointing Beverage antennas, shielded loops, whips or snake type low noise receive antennas. The operator can also select the transmit antenna as the receiving antenna. Gain can be selected from –20, 0 or +20 dB, said to match most HF band conditions.

The ASAP-2 uses a feedback type amplifier design that is said to provide a 5 dB noise figure and +30 dBm third order intercept. Input protection up to +20 dBm is said to be provided. Multicolored LEDs indicate antenna selection and gain setting. The unit automatically switches to the transmit antenna when keyed by the HF transceiver TR relay line. An indication of proper switchover is provided by an LED.

All connections are via SO-239 and RCA-type phono jacks on the rear panel. The unit requires 12 V ac or 12 to 15 V dc at 200 mA from an external supply or an optional ac adapter.

The ASAP-1 provides the preamp function only, without switching for use with receivers. The ASAP-1 provides four 50 Ω antenna inputs and a high impedance input for long wire antennas or an indoor whip that becomes an active antenna.

Both models are said to enhance reception for weak signal DX work or other applications by giving the user the ability to shift the dynamic range window and improve the signal-to-noise ratio.

The ASAP-2 is priced at $149.50, the ASAP-1 $119.50 and the PS-1 12 V ac wall adapter is $13.95. For more information see **www.j-tecradio.com** or contact J-TEC, 6692 Liberty St, Navarre, FL 32566; tel 850-936-7100.