By Mark Kesauer, N7KKQ

An Inexpensive External GPS Antenna

If you operate APRS or just need an external antenna for your GPS receiver, here's one that is easy to build yet offers surprisingly good performance in a compact size. Best of all, it uses commonly available components and materials.

This antenna design is based on a classic turnstile configuration (for circular polarization)—two dipoles are placed on the same plane but rotated 90° from each other. These dipoles are then spaced ¼ wavelength above a ground plane. A ¼ wavelength "parallel-plate" transmission line (printed circuit-board material) serves as the connection method and mounting post for the dipoles.

Construction

Start with the base plate. Cut a 4-inch diameter circle out of thin hobby tin or brass. (It happens that the inside diameter of the container lid is 4 inches, approximately the same width as the hobby tin/brass sheet.) Mark the exact center of the base plate. This is where the parallel-plate transmission line assembly is attached (see Figure 1).

Cut two 4-inch lengths of #14 solid copper or brass wire and bend each in the exact center at 90°. Make the radius of the bend as small as possible. Set these aside, they will be soldered to the parallel-plate section later.

Select an 8-foot length of RG-58/U, RG-174 or RG-188 coax. Attach a male BNC connector to one end (or whatever compatible connector is used on your particular GPS receiver). I used a solderless connector but removed the screw and then soldered the center conductor directly into the screw hole. If your GPS unit has a BNC antenna connection, you can use an Ethernet coax cable found at most computer stores. Just make sure they are 50 Ω. They'll already have the BNC connectors crimped on each end. Just cut in the center, trim to length and you'll have enough for two antennas. The GPS frequency is 1.57542 GHz so the

Table 1

Materials

Hobby tin (K&S #254) or brass sheet (K&S #251) (0.010 thick).
Sheet of single-sided, glass-epoxy PCB material (FR-4 or G10 .062″ thick, enough to make two 2-inch pieces 0.250″ wide.
Solderless right-angle male BNC connector (RadioShack 278-126) or the appropriate type for your GPS receiver.
8-foot RG-58/U (Radio Shack 278-1314), RG-174 or RG-188 coax.
8-inch #14 solid bare copper or brass wire.
Empty 8-oz cream cheese container.
Misc—Clear 5-minute epoxy or superglue.
Clear spray lacquer, #600 fine sandpaper.

K&S Engineering, 6917 W 59 St, Chicago, IL 60638; voice 773-586-8503; fax 773-586-8556; **www.ksmetals.com/**.
RadioShack, **www.radioshack.com/**.

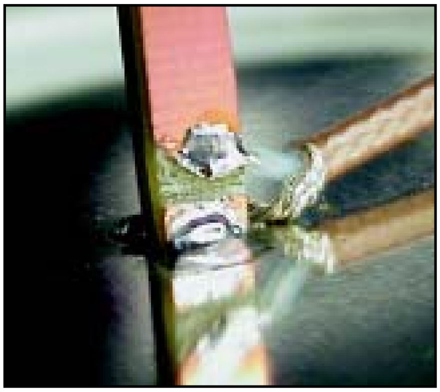

Figure 1—Close-up view of the coax connection to PCB transmission line and support.

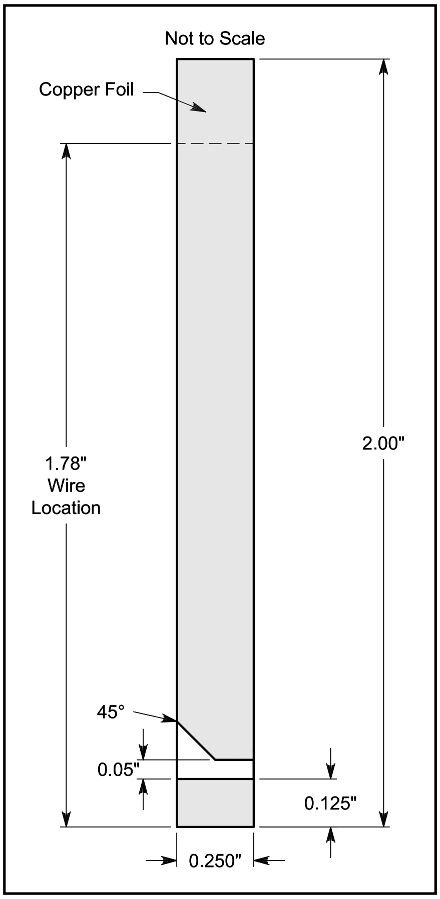

Figure 2—The active side of the transmission line.

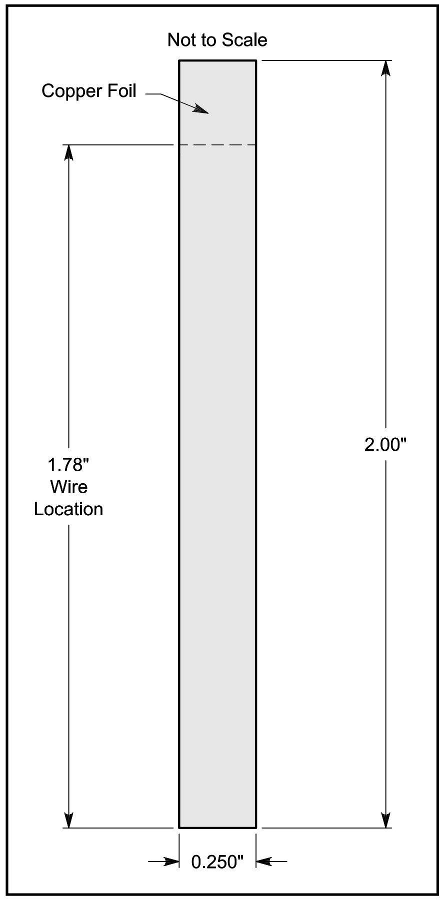

Figure 3—The ground side of the transmission line.

longer the coax, the greater the loss. Use no more than 8 feet—less if you don't need the length.

To make the parallel-plate transmission line, cut two 2-inch lengths of single-sided printed circuit board material that are 0.250-inch wide. Make sure it is glass-epoxy (FR-4 or G10 type material) and that it is 0.062-inch ($^1/_{16}$ inch) thick.

On one of the PCB strips, cut the copper foil with a sharp hobby knife or Dremel tool, as shown in Figure 1. This will be the "active" section of the parallel-plate where the other non-modified strip will be the "ground" side, as shown in Figure 2. The 45° cut on the active side is known as a "microwave turn" which allows the signal to effectively turn 90° to the coax. Glue the two strips together (copper outside) and set aside to dry.

I've found it easier to cut the PCB strips a bit wide and glue them together first. Then I just file both edges to the correct dimensions. A light sanding with #600 sandpaper finishes off the edges and removes any burrs.

Double-sided 0.125-inch thick PCB material could be used but can be difficult to obtain for the average hobbyist. Conversely, by using a single 0.063-inch thick double-sided material we would be working with a rather small and fragile structure (half the thickness equates to roughly half the width). This might not hold up during handling and operation. By using the two sections glued together, we've solved the problem by creating our own 0.125-inch thick material.

Solder the transmission line section to the base plate keeping it as square and plumb as possible. Drill or melt a hole in the plastic container the same diameter as the coax. Feed the end of the coax through the hole and attach the coax to the transmission line active side as shown in Figure 4.

Measure 1.78 inches up from the base end of the parallel-plate section and scribe a line in the copper foil. Solder one of the #14 wires to the ground side of the parallel-plate section. Position as shown in Figure 4. Do the same with the active side—you may need a helping third hand as it's difficult to hold the soldering iron, antenna and position the wires all at the same time.

Measure each leg of the horizontal wires and trim to 1.51 inches from the center junctions. Next, trim both the 45° wires to 1.82 inches from the center junction. If all went well, you should have approximately ½ inch between the tips of the 45° wires and the base. If not, carefully resolder or bend the wires to this dimension.

Using a fine saw or a Dremel tool, remove the excess length of the transmission line just above the wire junctions. Sand the exposed junction to remove any burrs and check for a short circuit.

Note that we've purposely kept the transmission line section length long, until after construction. The thin copper foil tends to separate from the glass epoxy during heavy duty soldering. The longer length acts as a heatsink to preserve the bond between the copper foil and the glass-epoxy base.

Final Assembly

I've found that an empty, upturned 8-ounce cream cheese container makes a practical radome for the antenna. More importantly, it helps protect the internal workings from mechanical damage.

I usually don't paint the container but I do remove the silk-screened label by using an automotive rubbing compound. It takes some effort but it does come off. Just follow the manufacturer's instructions. Be careful not to apply too much pressure to the lid when you rub the label off. It's made of a different plastic than the container and stretches easily.

You should be able to snap the base plate into the lid of the container. It's a tight fit so just work your way around the lid until the entire base plate is flush with the lid bottom You might have to cut a notch in the lip of the lid to allow the coax to exit the unit cleanly. Carefully align the coax with the lid notch and snap the cover onto the lid. It's normal for the top of the transmission line assembly to slightly raise the "bump" on the container bottom.

Theory of Operation

In a normal turnstile, we would have a double dipole configuration with both dipoles on the same plane but rotated 90° from each other. Additionally, the second dipole is fed 90° out of phase with an-

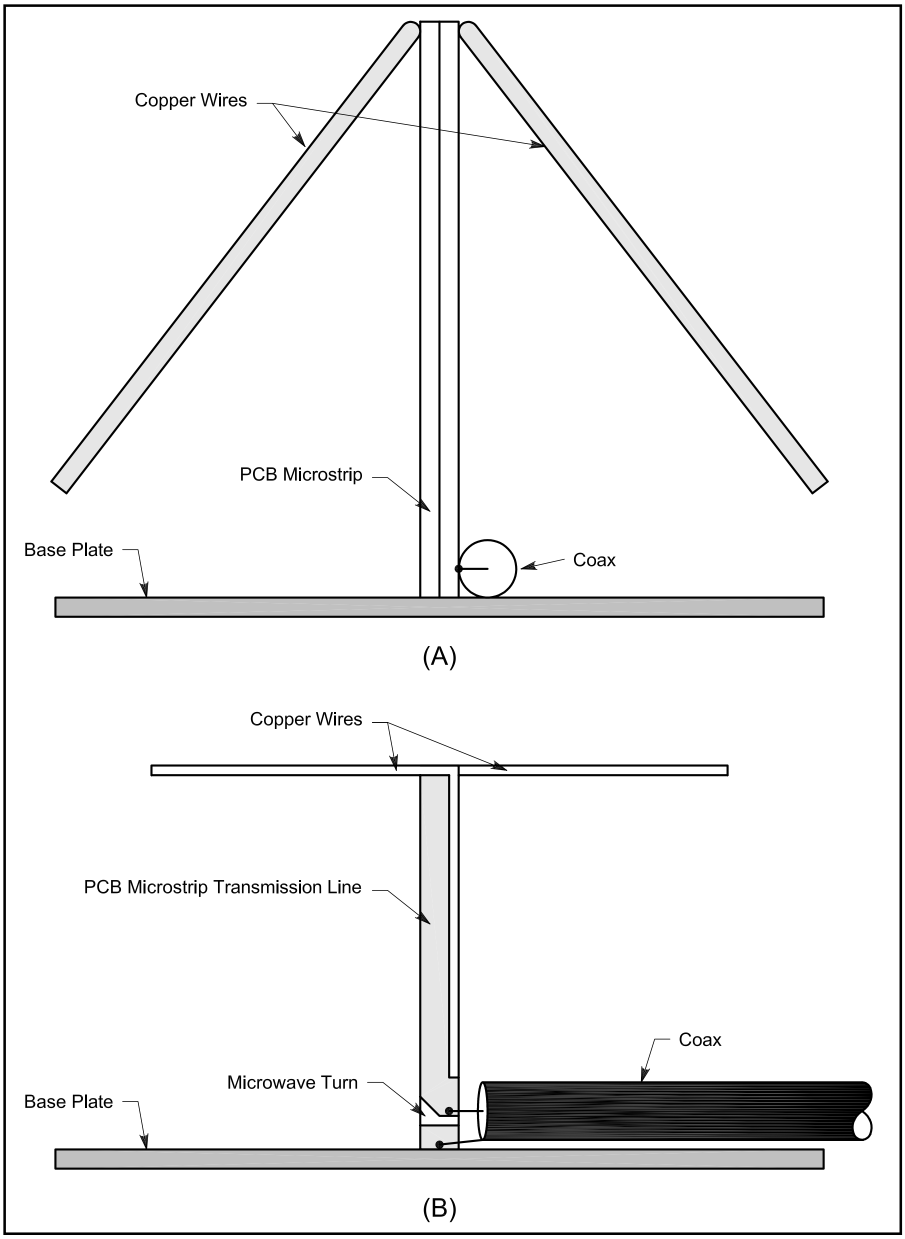

Figure 4—Side (A) and front (B) views of the parallel-plate transmission line and radiating elements.

other ¼ wavelength of coaxial cable (see Notes 2 and 3). This creates some difficult assembly problems since you would have to isolate the second dipole section from ground while maintaining the tight distance and spacing requirements. Due to the size constraints, this second dipole connection would require a very small diameter coax that might be difficult to work with and even harder to obtain. With this antenna, we cheat a bit and use a self-phased quadrature type feed.

To obtain circular polarization without a coaxial phasing line, the shorter dipole is cut so its impedance is $50 - j50\ \Omega$. The longer dipole is fashioned into an inverted V shape and cut so its impedance is lowered to $50 + j50\ \Omega$. With the combined asymmetrical dipoles and with them spaced slightly closer than ¼ wavelength to the ground plane, the antenna's impedance is near 50 Ω with a much more omnidirectional pattern, an important consideration for reception of GPS satellites close to the horizon.

Operation

Connect the antenna to the GPS receiver and watch the signal-strength indicator. You should see an improvement over the supplied stock antenna. You can tweak the antenna by bending the wires up and down gently and watching the results on your GPS unit. Be careful of the solder joint—it's rather fragile. Adjust for maximum displayed signal. Repositioning the antenna may also improve reception. With this antenna, I routinely receive five to eight satellites on my Garmin II receiver.

If you are using a GPS unit that sends dc voltage volts up the coax to power an external preamp or amplified antenna, don't worry. Since the elements are not grounded or shorted, there is no dc path. Just be careful not to let either end of the active elements touch ground. [Be ad-

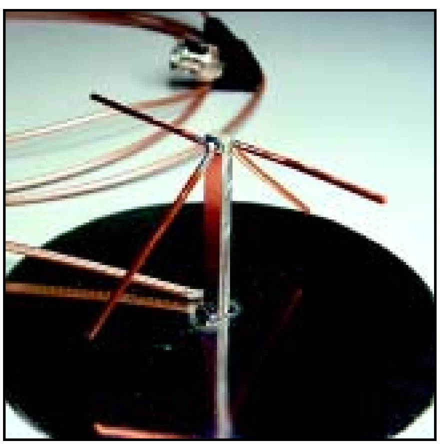

Figure 5—View of the parallel-plate support with elements attached.

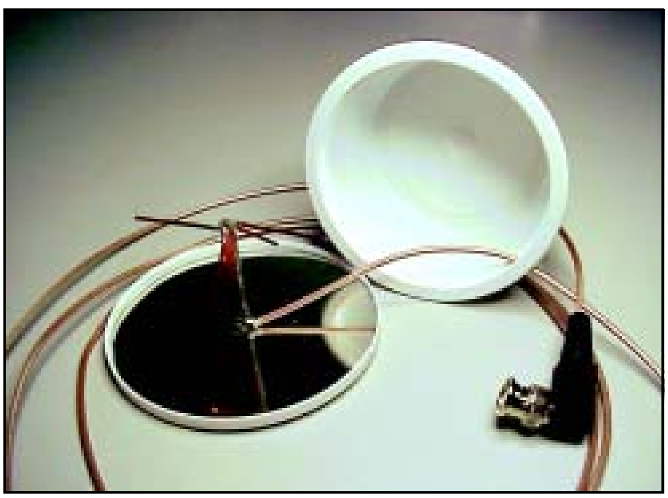

Figure 6—The finished GPS antenna with radome ready to snap into place.

vised that some GPS receivers with internal patch antennas have an antenna switching circuit. This circuit disables the internal antenna when an amplified external antenna is attached. The receiver senses current flow that is intended to power the amplifier of the external antenna. If your receiver has this feature, you will want the switch to activate and disable the internal patch antenna. Placing 1 kΩ to 5 kΩ across the ground and center conductor of the coax should be sufficient. Check with the manufacturer of your GPS receiver.—*Ed*.]

If you are mobile, most GPS receivers will do a fair job of receiving signals through the windshield of a car. During the summer, however (and especially out here in the Southwest), the GPS gets baked while sitting in the hot sun. Obviously, one way to solve this problem is to locate the receiver somewhere cooler and place this external antenna on the dash. Once that's done, you've protected your expensive receiver while sacrificing a $10 antenna.

This design was not intended for outside use, hence the lack of external mounting suggestions. Any prolonged exposure to the elements will degrade the antenna's unprotected metal parts. My suggestion—if you plan on using this unit outside, at least spray the metal parts with clear lacquer and seal the exposed coax end with RTV. Otherwise, don't waste a lot of time weatherproofing it. Because these antennas are so cheap and easy to build, if one does deteriorate throw it away and build another. Perhaps you might want to keep a couple of spares on hand, just in case.

My thanks to Zack Lau, W1VT, of the ARRL Lab for his advice and expertise.

Notes

[1]Tom Hill, WA3RMX, "A Triband Microwave Dish Feed," *QST*, Aug 1990.

[2]Zack Lau, W1VT, "A Simple 10-Meter Satellite Turnstile Antenna (RF)," *QEX*, Nov 2001.

[3]Zack Lau, W1VT,"A Simple 10-Meter Satellite Turnstile Antenna (Feedback)," *QEX*, Jan 2002.

Mark Kesauer, N7KKQ, received his Novice license in 1969. He has held the call signs WN8CGM, KA5ZCH and his present Extra class call sign. Mark belongs to QCWA, Ten-Ten International and has been a longtime ARRL Member. Mark holds an Engineering degree and has been a Computer Aided Designer (printed-circuit boards) for 29 years. Mark may be contacted at **n7kkq@arrl.net**.

FEEDBACK

◊ The impressive 13-star flag flying proudly from page 20 of Sep 2002 *QST* is actually a Bennington Flag, not a Ben Franklin flag. Our thanks to several readers who pointed out that the original can be seen at Vermont's Bennington Museum (**www.benningtonmuseum.com/flaghistory.html**).

◊ In the Apr 2002 *QST* article "AMRAD Low Frequency Upconverter," there is a short across R10 in Figure 2. That short should be removed. Also, early versions of the PC board used a slightly different crystal oscillator circuit. That circuit worked fine except it occasionally would not start. Several of those boards were shipped from FAR circuits. If you have one, they will exchange it for the later circuit if you wish. The older circuit is shown in the hand-drawn schematic on the AMRAD LF Web page at **www.amrad.org/projects/lf/** if you wish to use the older circuit.

STRAYS

VIDEOCONFERENCING BOOK FROM K8OCL

◊ John Champa, K8OCL, has written a new book titled *Videoconferencing Skills*. The book offers students and instructor's detailed information about how to present dynamic and forceful videoconference meetings. The ten lessons in *Videoconferencing Skills* provide an activity-driven approach with three to five activities in each lesson, instructional illustrations, an introduction to the equipment used in videoconferencing, instruction in preparing PowerPoint slides for a videoconference and much more. A separate instructor's manual is available as well. John has been a ham since 1959 and is chairman of the ARRL High-Speed Digital and Multimedia Working Group. *Videoconferencing Skills* is available for $11.50 (the Instructor's Manual is $15) from: Thomson Learning, Order Fulfillment, 10650 Toebben Dr, Independence, KY 41051; tel 800-354-9706 (8 AM-6 PM Eastern); **www.swlearning.com**.

NEW PRODUCTS

THE K2/100 HIGH-PERFORMANCE HF TRANSCEIVER KIT FROM ELECRAFT

◊ Elecraft's landmark K2 kit transceiver is now available in a 100-W model. The compact K2/100 is based on the K2, with the same features and same world-class receiver performance. It has the portability and efficiency of a QRP transceiver with a 100-W punch when you really need it.

Created by Elecraft co-founders Wayne Burdick, N6KR, and Eric Swartz, WA6HHQ, the K2/100 uses an integral heat sink as its top cover, thus retaining the same form factor as the base K2.

Features include silent, diode-based T/R switching; a built-in remote control port with true RS-232 levels; low receive-mode current drain for enhanced portability; all basic K2 features, including dual VFOs, multiple memories, split TX/RX operation, RIT/XIT, full-break-in CW, built-in memory keyer, narrow IF crystal filtering, excellent receiver dynamic range and IF-derived AGC.

The K2/100 shares a number of K2 options, including the KSB2 SSB adapter, KNB2 noise blanker, K160RX 160-meter adapter with second receive antenna jack, KAF2 audio filter/real-time clock and the MH2 Heil/Elecraft microphone.

Price: The K2 sells for $589 and the KPA100 100-W Integration Kit (internal), which completes the K2 as a K2/100, sells for $349. For more information, point your Web browser to **www.elecraft.com** or e-mail **sales@elecraft.com**.

NEW 50-Ω COAX FROM CABLE X-PERTS

◊ Cable X-Perts, Inc, is pleased to introduce a new version of their CXP1318FX, a 50-Ω low-loss coaxial cable. Manufactured with a "gas-injected" foam polyethylene dielectric and a 19-strand center conductor, this cable is designed to give exceptional flexibility and reliability. Other enhancements include a double shield (100% bonded-foil and 95% tinned copper braid) and noncontaminating and direct-burial jacket. Nominal attenuation (per 100 feet) is said to be: at 150 MHz, 1.6 dB; 450 MHz, 2.9 dB; 1200 MHz, 5.0 dB, and 2400 MHz, 7.5 dB. Available in bulk and ready-made lengths with UHF (PL-259) and N connectors. For more information, see **www.cablexperts.com** or via email at **cxp@cablexperts.com**. Cable X-Perts, Inc, 225 Larkin Dr, Ste 6, Wheeling, IL 60090-7209, tel 800-828-3340; Fax 847-520-3444.