Eggbeater Antenna

by Dave Houston

A few years ago, when I was designing the BX24-AHT, Tom Becker, a radio engineer, suggested a turnstile antenna made of 300-ohm twinlead. He was not sure whether a 300:75 ohm balun was needed so I first tested with just the turnstile antenna, measuring the RSSI with an ADC input. When compared with quarter wavelength wire antennas there was a significant increase in RSSI with the turnstile. Adding the transformer brought another significant increase. I published the construction details and there were many BX24-AHT users with the turnstile antenna. It was also an improvement over the MR26 antenna. While reasonably simple to construct, the turnstile did not add much to the decor.

I continued to research antennas and next tested a Lindenblad, again made with twinlead. It was a little better than the turnstile but both harder to construct (I built it on a square cardboard box.) and even more of an eyesore.

Next, I explored the eggbeater. It is very easy to construct, is not so much of an eyesore and has approximately 50-ohm impedance which matches that of most receivers. It tested much better than either the turnstile or Lindenblad and, since it needed to be mounted to some kind of base, lent itself to using a small Polycase enclosure which can also house a wideband preamp.

While the MR26 is powered by low voltage from the PC serial port, most other X-10 RF receivers are mains powered and I do not advocate changing the antenna on the TM751 or RR501 because there are serious safety issues with the possibility of having mains voltage present on the antenna. It is possible to galvanically isolate the antenna with a small balun style transformer but this is not something I encourage novice DIYers to try. The chances of putting mains voltage on the exposed antenna are real and dangerous. See **this article** on the current needed to cause ventricular fibrillation and death.

The CM15A isolates its electronics from the powerline so no isolation transformer is needed. Clip the lead from the existing antenna, leaving about 1-1/2" connected to the RF receiver. Solder the other end to the center of a 50-ohm, bulkhead BNC connector (e.g. Digikey 367-1018-ND), mounted where the antenna was mounted. (This page has some nice step-by-step pictures but I recommend a 50-ohm BNC rather than 75-ohm F connector.) Solder a lead between the shell of the connector and V_{ss} on the main circuit board. Use 50-ohm coax (RG58/U) between the antenna and CM15A.

With the original X-10 antenna, reception was marginal beyond 20 feet through one interior wall. With an external, remotely located eggbeater antenna, range is over 100 feet through one exterior and two interior walls. Both tests used the same HR12A (Palmpad) transmitter. Since RF propagation is affected by many factors, there is no way to guarantee that everyone will get the same improvement but everyone should get a significant increase in range. Adding a Ten-Tec 1001 wideband preamp kit at the antenna further improves reception. The Ten-Tec 1001 will fit the Polycase LP11F enclosure recommended to mount the antenna.

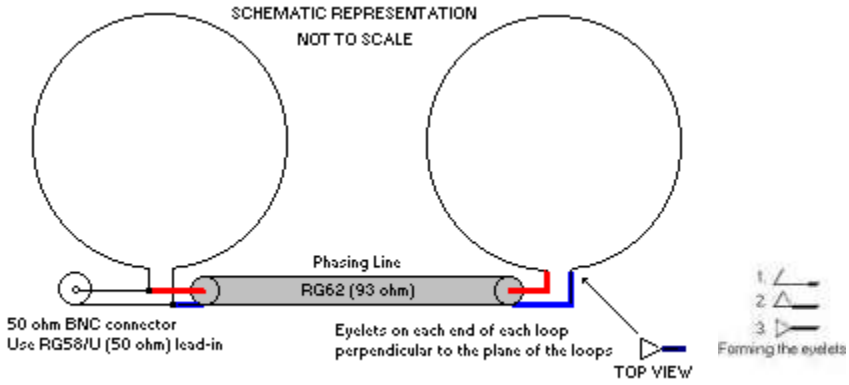
The eggbeater antenna is constructed of two circular loops made of 16 AWG (1.29mm) copper-clad steel wire insulated with heatshrink tubing. The circumference of each loop is equal to one wavelength, adjusted for the velocity factor of the wire. A quarter wavelength (again adjusted for the velocity factor) phasing line made of 93-ohm RG62 connects the two loops. The impedance of the loops is about 100 ohms so the RG62 is a close match. With the two loops connected in parallel, the resulting impedance is about 50 ohms which matches well with most RF receiver or preamp inputs.

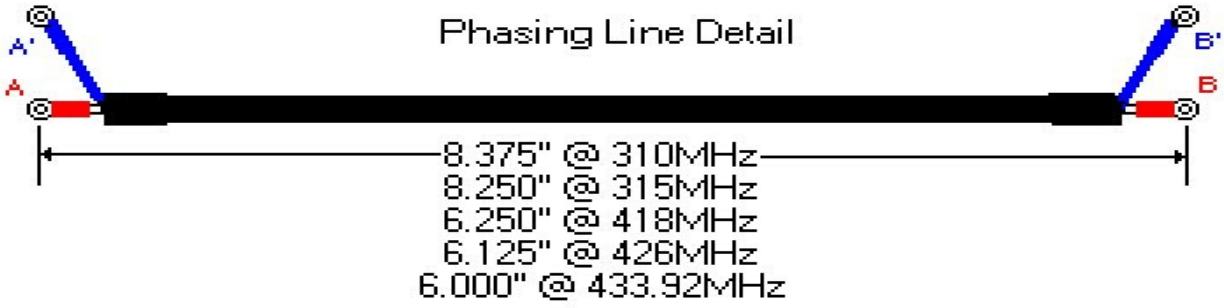
FREQ	CIRCUMFERENCE	DIAMETER	PHASING LINE
310MHz	36 inches	11-1/2 inches	8-3/8 inches

315MHz	35-1/2 inches	11-5/16 inches	8-1/4 inches
418MHz	26-3/4 inches	8-1/2 inches	6-1/4 inches
426MHz	26-1/4 inches	8-3/8 inches	6-1/8 inches
433.92MHz	25-3/4 inches	8-1/4 inches	6 inches

X-10 uses 310MHz in North America and 433.92MHz elsewhere. RF-capable programmable touchscreen remotes (e.g. Philips Pronto, Universal MX3000) use 418MHz in North America and 433.92MHz elsewhere.

For a receiving antenna, dimensions need not be exact. Ring terminals crimped to the ends of the coax along with triangular eyelets, formed by bending the ends of the antenna elements, simplify connections.





For clarity, the schematic representation above shows the loops separated but they are assembled perpendicular to each other with one loop inside the other as shown below.

DIY Construction Details

Cut the antenna elements 1-1/2 inches oversize to allow 3/4 inch for forming eyelets on each end. The copper-clad steel wire tends to retain the curvature from the coiling operation which makes measuring the length awkward. The easiest method is to cut the heatshrink tubing to size, slip it over the antenna wire and then cut the wire so it is 1-1/2 inch longer than the heatshrink. To form the eyelets, lay the heatshrink covered loop on a flat surface. Using 6 inch long nose pliers, bend 1/4 inch at each end up 120°. Move in 1/4 inch and bend up 120°. Move in 1/4 inch and bend down 30°. You want to end up with a triangular eyelet with 1/4 inch sides as shown in the schematic representation at the top of this page.

The elements are mounted to the top of a **Polycase LP-11F** enclosure using stainless steel hardware:

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6 ea. insulated ring terminals
4 ea. 6-32x5/8 phillips or hex head machine screws
8 ea. internal star lockwashers
4 ea. 6-32 hex nuts
8 ea. flat washers
4 ea. 6-32 locknuts (nylon insert type)
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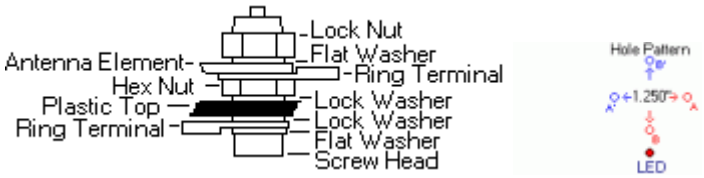

Remove the top cover from the enclosure. Drill 4 holes in it for the 6-32 screws. The holes are in a symmetrical diamond pattern with about 1-1/4 inches cross corner. The elements can also be mounted atop the MR26A or MR26E.

Assemble as shown in the photo and hardware sketch. Tie the elements together at top center with a small tie-wrap.

The best location for the antenna is usually the one that is most central (both horizontally and vertically) to your transmitters but slight variations in location and/or angular orientation can make a difference. We recommend rotating the antenna in 30-45° increments to find the optimum orientation with your mix of transmitters.

A reasonable facsimile can be built using 14ga solid, insulated electrical wire and 75-ohm coax. One person who built it that way then measured the range at 100ft+ with a handheld remote (HR12A?) and MR26.

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