Compact Receiving Loop Antenna Project

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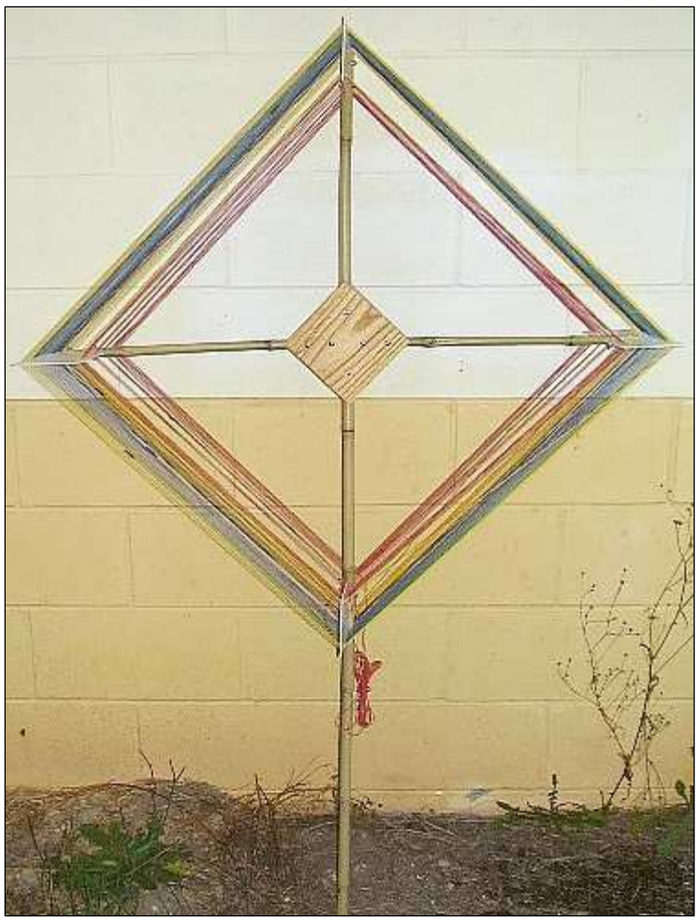


I just finished a small (69cm per side) quad loop for use from 150 - 430KHz that came amazingly close to the math prediction. I wound it for Non-Directional Beacon DXing...taking full advantage of the minimal sunspots recently, which makes for great LW DX.

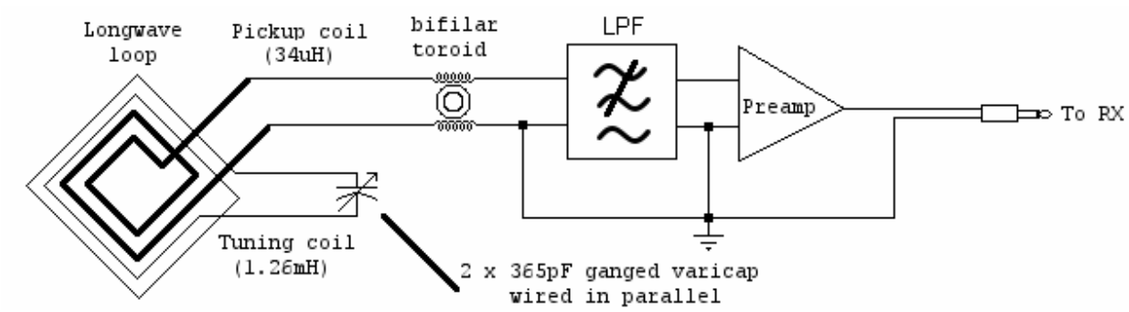
Most loops for this band are either too large for a lot (10+ feet in diameter) or too small for good performance (tabletops). While bigger is better when it comes to low frequencies, this loop is good for the average subdivision dweller who wants to keep his neighbors—and wife—happy.

Construction & Materials

The tuning loop is a total of 38 turns, with each outside leg being 69 cm long. The loop is actually two layers. It starts with 6 inside turns, to 26 outside turns, then back with 6 inside turns on the other side. On the inside leg, right in the middle, are 4 turns for the pickup loop.

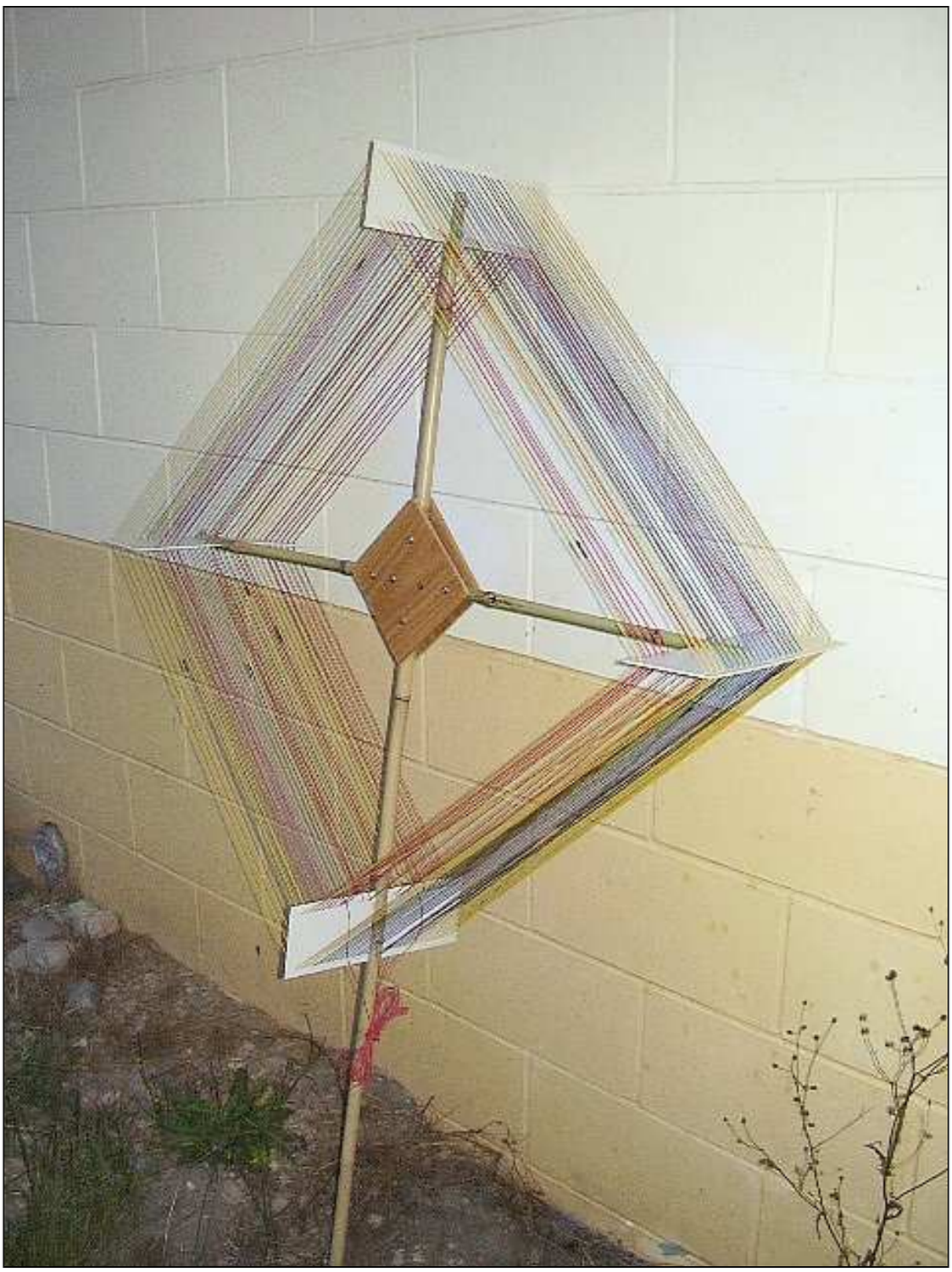
Playing with dimensions for the two layers, the online loop calculator at http://brneurosci.org/loopfrequency.html figured the inductance would be 1.26 mH. In actual testing, it measures 1.254 mH! This inductance was chosen so the paralleled sections of a 2-gang AM radio air variable would be able to tune down to 150KHz, the lowest my E5 radio goes. It does this perfectly.

I tried experimenting with 1 through 6 turns for the pickup loop, in 1/2 turn increments, and found 4 turns were the optimum. The measured inductance of the pickup loop was 34uH, which has an X_c of 50 ohms at 234 KHz. It's perfect for interfacing with the low pass filter and preamp shown later in this article.



The hub plates are made from 3/16" ash thins for scroll sawing that I oiled for weather resistance. The arms and mast are formed from bamboo poles from a garden store. Strong and light!

The loop wire is insulated, stranded stuff scavenged from long runs of security camera cables. THAT was a pain to strip and recover! I read that the ideal wire length for this kind of loop is 0.085 wavelength - which the total amount of wire turns out to be at 255KHz, pretty much band-centre of interest.



The Balun

I chose to go the balanced route because it eliminates the need for a shielded loop. All loops will exhibit the "antenna effect" if balance is not maintained - where the loop acts like a folded monopole and is non-directional and noise nulling suffers.

If the loop remains balanced, the near-field noise from monitors, TV's and computers pretty much disappears, other than the raw fundamental frequency of nearby switching-mode power supplies. Shielded loops are easier to build because symmetry and balance isn't needed, but stray capacitance will destroy antenna Q if you aren't careful, making sharp tuning impossible.

The balun was made by winding bifilar turns around a RFI toroid found inside monitors the cable is wrapped around and measures 1-1/8" diameter, 1/2" high and 1/4" this wall. These toroids are typically a high nickel ferrite mix, which according to Amidon charts, exhibit great broadband properties in the 100 - 500KHz range - perfect for this project.

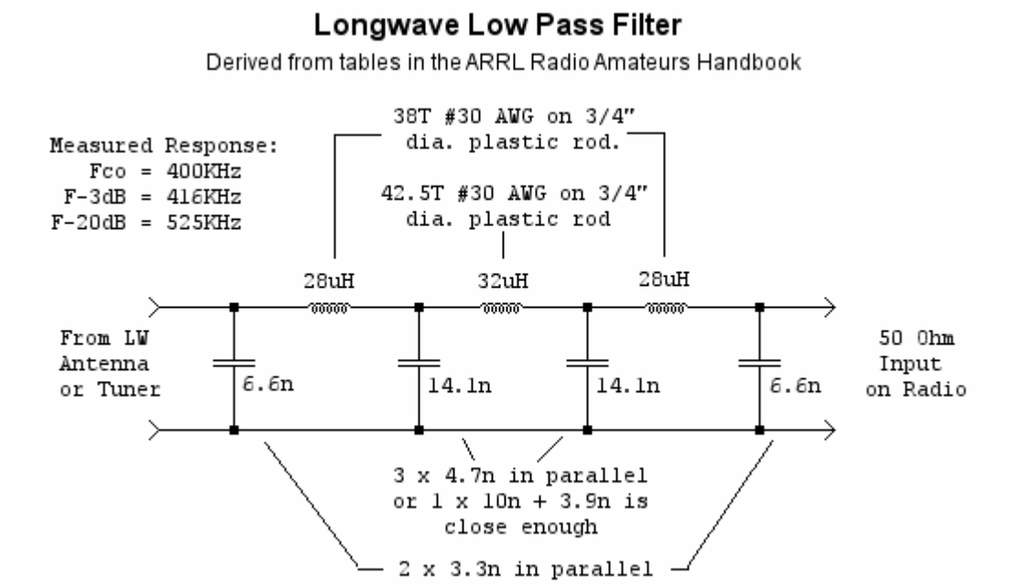
I started with 16 turns, but found I needed to add more, as the balance went to heck below about 270KHz. I upped the toroid balun to 34 bifilar turns, and now she's a dream. The balance is so well maintained that, within my ability to test its range from 150KHz to 560KHz, the low pass filter isn't even needed at my location.

All common mode noise is gone. Even with the neighbor's TV and computer on, the broadband noise is gone and I can null out the SMPS fundamental to such a null I can hear weakish beacons over it. I was running straight loop into the balun, then into the E5, and signal strengths were high enough that I didn't even need the preamp to pull out those same stations I used the LPF+preamp to get the other night... this time, only one S-unit lower.

Tuning "Q" is very sharp now - 6dB points are 1KHz on the lower end, going up to 7KHz into the lower AM BCB and about 3 KHz on the upper NDB range of 420KHz.

The Low Pass Filter

Here is a killer LPF to clean up any BC intermod problems, should they arise.



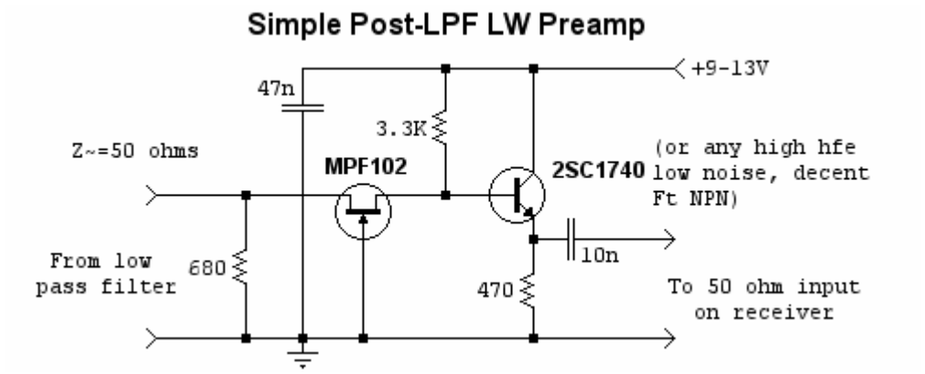
Coils are close-wound and easy to make from the plastic of a 3/4" knitting needle stolen from the wife and some RS wire. Note the orientation of the coils on the board (top of next page) so that they don't interact with each other. I hate using toroids for RF filters... you usually have to buy them, and that costs money.

This filter works with 50 ohms in/out, for which the loop antenna is more or less matched. If you use it with some other antenna, a tuner may be necessary.

In practice, the capacitance of the wire/radio makes it cut off lower than bench tested. It's about 4dB down at 400KHz.

The Preamp

Here's a nice little preamplifier to go after the LPF. The Z_{in} of the common gate MPF102 is so close to the design impedance of 50 ohms that resonance, passband, and filter Q are unchanged. There's enough gain to overcome the insertion loss and add an S-unit or two to the signal.



Circuit noise appears to be well below the noise level of the LW band, so that switching it in/out makes zero audible difference in the noise floor. No tuned circuits or coils... this is LF after all.

Results

The performance of this loop antenna is pretty darn spectacular. I was using a 30' wire and antenna tuner before this, and got a few British Columbia and Washington State DX beacons. When I plugged this in tonight, there was literally a pileup of 2, 3 and even 4 beacons every kilohertz above 260 kHz (lower frequencies don't roll in until I'm long in bed).

I didn't even have it on the roof, but inside my ground level brick walled shop, turning it by hand. Once I get this thing on an el-cheapo antenna rotator on the roof, I'll be loaded for bear for the Cycle 23/24 gap, winter season, which by predictions should be as hot for LF as the 1968 peak was for the 20 and 40m ham bands.