CHAPTER 2

RECEIVING ANTENNAS FOR 630 METERS
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Receiving Antennas for 630 Meters

8/15/16 L400B PROBE ON WATERSIDE DOCK
John WG2XIQ reports: Laurence, KL7L / WE2XPQ / WI2XBA/5, continues to perform antenna comparison experiments at his station and sent a note and picture of the L400B. What a view!

“I’ll run this tonight and compare with the avg. better s/n probe in previous worst direct – its at 5.5m now–I’m pushing it at this height mechanically a bit so may drop. 1m grp poles…”

Waterside probe at KL7L
Laurence reports that he operated a single receiver and receiver overnight with the probe and decoded WH2XGP at CW levels. He also decoded WG2XXM as well as WH2XCR in addition to others in the Pacific Northwest:

![Map of WE2XPQ 24-hour WSPR activity](image)

8/23/16 ANTENNA/SOFTWARE COMPARISONS AT WE2XPQ
Laurence, KL7L / WE2XPQ, sent a note detailing the results of his recent antenna / software comparisons. [See also Chapter 3.] He is very careful to state that these results are pertinent to his installation at his location ONLY. If he were in a different environment, none of this might be valid. Trees and foliage can have a massive impact on RF at these frequencies. Here are a few of his comments:

“I’m sort of finished testing now and can pretty confidently say what works best. Note though the worst to best variation best is only a dB or two. Caveats are local noise variations due to induction or electric fields due to proximity, and or induced common mode noise, which I think I’ve virtually now eliminated or are at least equal in the tests. I suppose also rx noise figures and rx antennae efficiencies too make some but as I’ve realized here I’m pretty close to optimum within physical and environmental constraints at this QTH – I need more space!!.

So here we go in order of average effectiveness or positive decodes –
1) The best overall system here is an **extended L400b up at 10m in a tree**. Quad RG6, common mode chokes/isolators and wsjtx (**we2xpq/I**) – Omni but quiet, beats the mag loop and W71UV low noise head amp/cable driver which suffers more from noise from mag field induced from 400m distant underground dog fence.
1a) Just a little less in number average decodes but occasionally better to the SE is AMRAD W1VD probe at 8m, Quad RG6, common mode chokes/isolators and wsjtx. I ran this antenna early in the tests and it decoded slightly less than 1). Its located just 10m to the West of 1) – It’s bonded to ground via multiple rods and into the lake bottom.

2) Another L400b at 20m, 400ft Quad RG6, common mode chokes/isolators and wsjtx (KL7/L) – slightly noisier at all heights (4-20m) but did have one more VK4YB decode over 1) on multiple days. It was back at 20m agl last night, again bonded to ground by roads into the lake.

3) 10ft or so 10ft diameter VE7SL rotatable loop with modded W7IUV head amp (added power up the coax and choked to drive 400ft RG6 quad) – Last night it was used beaming to VK on 235degT which is kind of the worse direction dog fence noise wise but gave the same VK4YB S/n decode as 1) and 2) – didn’t pick up the later decode of VK4YB, but is a good tool for noise discrimination – Its typically noisier in the mag and probable induction field of a number of local and not so local noise sources bespoke to this location – In some directions it might well be higher in the table and may well prevail later in the season over the pole. The loop is useable with switched tapping’s from 60kHz to around 490kHz which reasonable unloaded Q.”

Some general comments and observations about software, other modes and his relocated Marconi-T transmit antenna follow:

“WSJTX typically afford 0-2dB deeper decodes – but it’s not as good for decoding tx freq bananas or slopes as WSPRX. It does sometimes miss one or two in series which may be PC processor related and not environmental/true decoding power.

WSPRX is a pain on uploading fails to WSPR Org but performs “ok” as an alternate differential piece of software – it may catch the occasional that wsjtx doesn’t. WSPR2.1 is very similar to WSPRX decode wise to date – just got to remember to check uploads were received by wspr net/org. This morning it had failed to load automatically about 50%.

I’m still thinking using visual detection modes our and VK signals are getting way further than presently decoded down to -33 – I’m just not sure why there is no or very little ZL activity on WSPR 475.

Tx efficiency – So I’m pretty close to defining my ERP as 1W during the wet forest days of summer with the nested Marconi at 65ft and large topload – that’s with 200W going into the base! Its 2.5dB down on a 3W ERP loop (I’m pretty close) – estimated ERP in the winter – we will see as this is a new shorter config.”

4/4/16 Doug, K4LY / WH2XZO, has been travelling recently, even getting the chance to receive from the road as K4LY/5, and provides the following comments that were sent to me and Jim, W5EST:

“Got home last night from the Mexican border.. Missed some darn good conditions. I made a last minute decision before leaving for Texas to take my Elad FDM-S2 and a 40M dipole which I got up 15-25′ in trees just off the 2nd floor condo balcony, but the laptop power supply caused over 2 S-units interference, wide spikes every few dozen kHz, one at 473 kHz and extending beyond 476 kHz. I have read an article on reducing the interference, but I’ll go another direction-http://www.ebay.com/itm/201547868317
So only decoded XXM and XIQ with the interference spike stronger at XIQ’s lower frequency. Using just the laptop battery was only a little better, still almost 10 dB interference from something. It made me appreciate how difficult 630M reception is! Tried my other laptop today to see if I should have taken it, but it’s almost as bad.

Also did some A/B tests here today with the laptops and two of my antennas- the 630M TX antenna which picked up the laptop spikes like the dipole did, and my amplified loop which picked up very little interference from the laptops. I have an amplified Miniloop on order- [http://www.ebay.com/itm/201547868317](http://www.ebay.com/itm/201547868317) and it will be fun to see how it compares with the loop which is too big to fit in my suitcase. Looking forward to your continuing on ATUs and estimating antenna current. Doug”:
4/22/16 Ken, SWL-K9, in Indiana used a little engineering skill so he would not miss the session due to thunderstorms. His efforts paid off with a few big reports. Ken explains:

_Last nights session actually turned out to be pretty good for me considering the T-storms were very near by. I waited to start logging until the evening was well underway, and used an indoor antenna. Accuweather said that I’d have a T-storm in the middle of the night (which didn’t happen) so to err on the side of caution, I stayed with the indoor loop overnight._

The plastic bag at the bottom of the loop was "waterproofing" for an outside trial of the antenna yesterday. Notice the strip of tape holding the loop to the wall to keep the loop in a E-W orientation. Since this loop was temporary in this position just for overnight logging, my wife gave permission for this unsightly creation to hang there ... hi.
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I was very surprised this morning, looking back through the wsprnet log, that I had captured 5 spots from XCR overnight with it XJM had 3 spots on XCR (yes, technically he is a bit further away from Hawaii), but I thought that was pretty darn good for an indoor antenna. Also, I came within 2db of XJM's high overnight (15db snr copy of XXM's signal) ... again, he's further away from Ken than I, but it's still pretty good copy for an indoor antenna to get anywhere XJM's receiving capability.

The antenna is passive... no electronics, and broadbanded. Not even resonant at 630m. I used the Kwood 570DG for the rcvr (I did use its built in preamp though).

So, the loops a "keeper". I'm going to try to mount it somewhere outside to get it out of the noise filed of the house. Wish I could put it on the roof but the neighbors would think I'm a nuttier guy than they already do... hi.

6/18/16 Ken, SWL/EN61, in Indiana has been testing loop sticks recently and offers the following results:

Thought you might like to read about my results with using the 7'' loopstick on 630m.

I've tested it for two nights now... two rx stations on 630m with two different antennas.

The loopstick is mounted indoors near the ceiling of the upstairs bi-level. It's competition is the outside 20 ft. Hf-Z vertical.

The loopstick is orientated for best E-W coverage, therefore XXM and XIQ's signals are somewhat away from "broadside" and aren't at the "peak" levels they could be if the stick was rotated toward them. XIQ has a bit more disadvantage than XXM due to a somewhat more severe angle with reference to the loopsticks position.

Bottom line:

The loopstick exceeded my expectations (you were right).

XXM was generally about 3-4 db down from the reference (outdoor) vertical. XIQ was down about 7-8 db from same (more severe angle). It would have been interesting to position the stick to be broadside to XXM and XIQ to see how well the stick would then compare to the vertical. Maybe try that tonight.

I can see that if the stick was outdoors and maybe on a small tripod on the roof, that the stick would be much closer in performance to the vertical than present results.

One anecdotal observation:

It just seems that the loopstick has less tolerance for stations off the broadside than a traditional loop does. I've been using loops lately, still favoring the E-W direction, and the loop seems more "forgiving" of off axis stations than the stick does. Seems to give better results on signals from off axis stations.

In other words, the stick pattern seems "tighter". Both loop and loopstick should have identical patterns but it just "feels" like they don't to me, from my experience. I could be wrong.

John WG2XIQ adds: I'm a big fan of the loop stick and have seen them work extremely well with extremely narrow laser-like beams on receive. Its my plan to put one high on a rotator this Summer once a few other projects are out of the way for point-to-point operating this Winter.
4/27/16 Laurence, KL7L / WE2XPQ, who has been receiving remotely while working in Hawaii, provided the following observations for his time in Maui as well as a graphic to show his location and obstructions that impact RF in a few directions on the US mainland.

I've been mulling over the performance of the system here at this site on the South side of the Island versus what I consider to be the Datum site at Merv XCR which we will call "optimum" for the purposes of the discussion, but I'm sure it's not an absolute of course.

If I compare my probe up a apartment block on about 250m from the sea at the closest point, and the signal levels given by WSPR for both KL7L/KH6 and XCR we see variances on a day to day and path to path, but in all cases, or for most of the datum points XCR gets better sin.

Only on a few occasions (VK3ELV) have we got better rx/sin here - but there are a lot of site variables at both Merv and my locations at any time which I cant eliminate at any time of reception -

If we consider paths to VK3ELV and VK4YB I have a mile to the Ocean with one Cinder cone at 500ft at 0.8 miles in the way - Signals are typically -5dB for YB, but only 1-2 db down on ELV against XCR (I averaged s/n) - is this because of
- A launch, hop count, reflection again on the longer path to ELV, or even the radiation pattern of the probe here? But it shows this is a good path from here.

For XGP this is a overland path of 23 miles of upslope/downslope volcanic soil to 800m - the level is averaging -11dB against XCR, so the intervening land path/angle adds 6dB or so.

For XPQ again overland of around 18 miles and up/downslope of just 106m, again we see 8-11dB loss. XPQs been getting first hop attenuation over the past 5 days or so.

For XXM (or for you at XIQ) this is a highly obscured path and up/down slope of 2600m and range to open sea is 24 miles - signal levels compare against Merv site and mine showed high levels of attenuation - and variable too - indicating perhaps we have additional losses over the volcano of course, but because of this I need pretty high angle wave angle to clear the summit - certainly 10 degrees - which has only occurred one evening for the past period and only for a short time. Averaging signal strengths received at XCR/Mervs against no decode here (set the limit as -31) I see additional path attenuation which must exceed 15dB. This is, as we have seen on previous trips is a really big hurdle but easier at 2200m where typically over mountain losses are less. XND still has to pass over a wavelength high obstruction at 2195m but manages it -

Cheers

Laurence XPQ in Maui

4/30/16 Laurence, KL7L / WE2XPQ, reports that he is shutting down from his work assignment in KH6 and provided this picture of his operating conditions in his hotel room in Maui:
5/10/16 John, WA3ETD / WG2XKA, continues his testing of the HI-Z low noise vertical, experimenting with a different turns ratio. John reports his successes and details below:

Based upon national weather and and the arrival of summer, things have slowed down at WG2XKA. All activity last session was confined to the east, however WG2XIQ was spotted here. The RX Only Vertical is being tested with a new transformer providing a turns ratio of 20:1 as opposed to the original 10:1 ratio.

This results in an impedance transformation of 400; presenting the vertical with a 20k ohm load based on the shack 50 ohm termination impedance. At this point the antenna seems somewhat more sensitive but additional testing is ongoing. Transformer core material is #77 mix on both ends.

7/1/16 Laurence, KL7L / WE2XPQ, shared a great way to enclose a E-probe! He reports that he used this probe to decode Rudy, N6LF / WD2XSH/20, from Cancun, Mexico a few years ago. This may have been the same trip where he decoded me and Ken, K5DNL / WG2XXM, also:
**9/14/16 E-PROBE IN THE GARDEN**

Laurence, KL7L / WE2XPQ, reports that he is making his way back to Alaska. KL7L and WE2XPQ were automatically shutdown several days ago by a power protection system. Laurence reports, “ac clean power has been the issue at KL7L – but power watch dogs put rxs offline as they didn’t like the waveform it appears – the house has split boxes each with its own 200A Corcom AC/RF filter unit which adds a little more control”. He provided this picture of the well-traveled E-probe located in the garden at his Mum’s house in Sussex, about 40-mile Southeast of London:
12/8/15 REVERSIBLE EWE RX ANTENNA SYSTEM

Mike, WA3TTS, posted this description of his receive antenna system and screen shot of his console on RSGB “Blacksheep” reflector:

Stefan (& All): Yes, I am using a pair of reversible EWE antennas, sized 5.5m tall and 21m long for NE-SW and SE-NW directional reception. The transformers are 10.5:1 on three BN73-202 cores glued together end to end. Four ground rods placed in a square pattern, one for each antenna transformer and one ground rod in the center.

A common mode choke is used in the RG6QS feedline a few feet away from each antenna transformer. Two feedlines for are used for each antenna and an A/B switch is used at both the SE and SW transformer locations to switch antenna A or B. Two feedlines go to the receiver converter and the feed lines are grounded at midpoint between the antenna location and the receiver location.

At the receiving station, the two feed lines go to a coaxial, opposing phase, common mode choke. I terminate one output of the opposing phase CM choke with 75 ohms and other output of the opposing phase CM choke goes to the LF/MF converter via 75:50 ohm isolation transformer and LPF.

So I can reverse the direction of a single antenna at the station by changing the position of the 75 ohm termination resistor and isolation transformer coaxial jumper on the opposing phase CM choke. I can also reverse the input of either of the two feed lines to the opposing phase common mode choke, which has a phasing effect for noise reduction which is somewhat frequency dependent from 10kHz to 500 kHz. I have to walk outdoors to change the A/B switches to select antenna A or B, but I need the exercise ~:)

LF/MF EWE ANTENNA (1 OF 2)
The antennas are somewhat like a pair of K9AY loop antennas. The EWE antenna was invented by Floyd Koontz, WA2WVL. This LF/MF version is similar to a reversible EWE antenna Floyd described in his February 1995 QST article, “Is This EWE for You.”

I also recently installed (8-2015) a low-impedance ground system for my residence AC power service, which also helped to reduce the local noise levels from LF through HF....
5/26/16 PART 4: COMBINING TX VERTICAL AND SHORTER RX VERTICAL

Using EZNEC Demo I modeled a 50’ tall 1.5” dia. TX vertical overtopped with 2x100’ #12 (0.0833” dia. uninsulated) hat wires slanting to 30’. A 20’ tall 0.5” dia. RX vertical had 2x25’ hat wires slanting to 10’. (4 segments each vertical, 3 segments each hat wire. Copper loss included.) Real/High Accuracy ground.

50mS/m “Real, High Accuracy” ground represents a radial system shared by both antennas for low-angle long path work. Because of the lower height of the RX antenna, the Source Amplitude is 11x multiplied in the model specification. The vertical TX and RX antennas are only 50’ apart, so the real estate footprint is favorable.

By trial and error, I set the phase of the small antenna to 190° and obtained a unidirectional pattern. This way I attempt to employ a modeling program to simulate the action of a noise canceller with a taller vertical and shorter vertical connected to its inputs.

The solid angle $A$ at 3dB down is $A \approx (40° \times 132° \cos(40°/2))/57.3^2 = 1.51$ steradians. **Beamwidth Figure of Merit is $2\pi/1.51\approx 4.2$.** That’s a considerable improvement in noise rejection capability compared to 1.3 for a vertical. Compared to a vertical alone, the beam is lowered from about 50° to 40° so that high angle regional storm static rejection improves. The unidirectional feature also improves rejection of band noise $N$ off the back and sides. Moreover, using the TX antenna’s radial system to underlie the RX vertical provides good low angle reception of signal $S$ down to about 1° elevation. In this way, $\text{SNR} = S/N$ improves.

Murphy’s Law guarantees these advantages are exaggerated compared to the results you will obtain with a real system. First of all, a vertical is high-impedance in the sense that local noise can readily couple via stray capacitances into the antenna system. However, as noted in the blog May 24, several operators are obtaining good results from some vertical antenna constructions. One needs to have each vertical in this noise cancelling duo working well by itself before there’s much hope of improvement cancelling them in tandem. See the literature links for various phaser noise cancelling arrangements including one similar to the modeled system.*
Ground wave noise from the outlying locality will arrive at this noise cancelling antenna duo as well. However, such noise would have arrived at a single vertical antenna constructed over a good ground/radial system anyway. Also, it’s possible that a unidirectional loop would achieve similar RX results and be no more difficult to construct at some distance from the TX vertical.

The demands on phasing and possibly-needed preamplification will also introduce departures from the calculated results. Nevertheless, the exercise of studying and computing a cancellation pattern for this antenna duo is a helpful step toward a deeper understanding of possibilities and pitfalls in the band-noise cancellation field on 630m.

5/27/16 PART 5: VARIABLE PHASING: TX VERTICAL AND SHORTER RX VERTICAL

An accompanying Phasing/Cancellation illustration here shows a phase diagram for noise cancellation. The diagram is based on yesterday’s blogged big-dog/little-dog vertical antenna duo separated by 50 feet (d_{sep} ~15m). A noise canceler unit phases the antennas at various out-of-phase angles to obtain different antenna patterns shown in the Phased Antenna Patterns illustration. The canceler circuits are configured and adjusted either to attenuate the reception from the large TX antenna system or to amplify the reception from the small RX vertical, or do some of both.

Isn’t this a phased array and not a noise canceling system? Short answer is “Both!” Often “phased array” makes one think of two or even many identical, same size antennas that are enhanced in directivity by phasing. Noise canceling systems often use just two antennas, which not infrequently do differ in size or type. It’s fine to call this antenna duo by whatever name you like.

In the Phased Antenna Patterns illustration, elevation patterns morph into each another, as do the azimuth patterns, when you manually adjust a noise canceller unit. The antenna duo is unidirectional in opposite directions corresponding to phasing 170° vs. 190° in my specified model Sources. The antenna is bidirectional at 180° phasing, and the bidirectional pattern peak is about 6dB down from the unidirectional pattern peaks. To get unidirectionality, the canceler's phase departure from 180° is proportional to the distance between antennas. In this example, each main lobe always lies along the axis line between the antenna bases without beam steering through heading angles away from the axis.

With bidirectional 180° phasing, the solid angle A at 3dB down from its pattern peak is 
\[ A = [34.9° \times 2 \times 91.6° \cos((34.9°+2°)/2)]/57.3^2 \approx 1.85 \text{ steradians.} \]

**Beamwidth Figure of Merit** at 180° phasing is 
\[ F = \frac{2\pi}{1.85} \approx 3.4. \]

This performance is not bad compared to the \( F=4.2 \) value unidirectional phasing of the system yields. It’s quite good performance compared to \( F=1.3 \) for a single vertical.

You can estimate possible SNR enhancement by reduction of band noise power compared to a vertical. Think of such band noise as if uniformly distributed in azimuth and elevation. Take dB = 10log_{10}(F/1.3).

That dB formula suggests a **nominal band noise reduction 4dB to 5dB** for various phase settings of the big/little vertical duo. Actual performance may be better or worse depending on the azimuth and elevation distribution of real 630m band noise.

The Phase/Cancellation diagram helps make sense of the pattern diagrams that the antenna modeling program delivers. When phasing is set near a special value around either 170° or 190°, then a signal arriving along the axis from one direction will be canceled while a signal arriving from the opposite direction will be only partially reduced in amplitude. The axial lobe sizes depend on the phasing. By thinking in terms of both the phase diagram and a pattern diagram, you start getting an intuition for the noise canceling performance and capabilities of a given antenna system.

Phasing the two antennas at 180° provides two lobes with azimuth pattern nulls between them. The out-of-phase antennas thus totally cancel each other laterally either side of the axis line between the verticals. That’s consistent with the bidirectional pattern shown in the middle of the second illustration.

The bidirectional pattern peaks are 6dB down from the unidirectional pattern peak because the voltages of an arriving RF signal from forward of the two antennas have a phase difference. (Compare the dBi gain values at the right-side text of the pattern diagrams to see the 6dB
difference.) That phase difference is small compared to what those voltages take on when the phaser effectively adds more phase difference by departing from 180° to the unidirectional 170° and 190° phased conditions. More phase difference means about double the combiner voltage output. Since dB is a power ratio, the 2x voltage is squared and leads to 6dB more power for the unidirectional patterns.

The RX vertical may detune the TX vertical somewhat. Transmit/Receive switching may need to take that into account so that everything works properly on both transmit and receive. Let us know your transmit/receive arrangements!

Because of narrower forward beamwidth at 180° phasing, compared to 170° and 190° phasing, the 180° setting may provide some noise rejection advantage. Also, if it is desired to receive from both the front and the back of the system, the 180° phasing is preferable. The desirable canceller settings will depend on the geographic position of your QTH, the geographic positions of any prominent sources of band noise, and the heading of the axis line between the verticals relative to headings of stations you want to receive well.

8/11/16 VIEWPOINT: POWER SPLITTING INTO 630m O/X WAVES. WHAT RX ANTENNAS?

Chapter 20 revisits several previous days on O/X waves and polarization. Today I add some plain talk opinion about elliptically polarized waves and what they imply for RX antennas.

On E/W paths across southern half of USA, most of the vertically polarized TX power stays vertically polarized without power splitting into the horizontal polarization. On E/W paths across northern half of USA and southern Canada, the GMF is more steeply inclined. So, more of the vertically polarized TX power gets split between the O/X-waves—one wave linear-polarized and inclined along the GMF, and the other wave inclined perpendicular to both the path and the GMF. That's what yesterday's polarization ratio illustration implies.

Especially on long single hop and on double-hop this splitting means one of O or X will propagate more poorly than X or O. Overall, I think such splitting can contribute a reduction as much as 6 dB on a northerly E/W path compared with a farther-south E/W path. That’s because 1) power splitting and propagation will favor an O or X wave that’s inclined w.r.t. vertical as above (-3 dB), and then 2) a vertically-sensitive RX antenna will favor only a vertical component (another -3 dB) of the tilted incoming wave. I haven't even mentioned non-uniformities in the 630m E-layer. Nor aurora-related SNR degradation at higher latitudes.

From a given TX station along the way, any elliptically polarized wave combining with any other elliptically polarized wave of whatever phasing and amplitudes makes a composite wave arrive at the RX antenna. Remarkably, any such composite wave is also elliptically polarized. The combined elliptical wave may tilt differently, bulge more or less, and be either stronger or weaker in dB compared to either component elliptical wave.

Our familiar 630m RX verticals and vertical loops are mainly receptive to vertical polarization, of course. If a 630m TX station’s O-wave and X-wave are destructively interfering with each other on arrival, or Faraday rotating far off-vertical, can any practical 630m RX antenna capture available signal that’s arriving and is truly there?

Such O vs. X destructive interference or Faraday rotation would be most likely on signals traversing more nearly N/S paths oriented within +/-45° from the GMF at 1-hop or 2-hop sky reflection. Because 630m signal strength is quite variable, we generally just accept the variability and simply receive better when such destructive interference QSB subsides.

Should that situation acceptable to us? I say, “Not if we can help it!” What can we do?
An antenna that rejects one elliptical polarization (O or X) but not a counter-rotating elliptical polarization (X or O) could improve received signal strength during 630m fades. Elliptical polarization inherently includes a horizontal RF electric field as well as its vertical field. This impels one to seek a 630m antenna that can receive 630m horizontal polarization.

One would need to find a 630m antenna design that can overcome cancellation of horizontal polarization due to ground reflection at high but less-than-heroic antenna heights above ground. Only experimentation would tell if horizontally-polarized band noise contributed by such a horizontally-sensitive antenna portion wipes out any signal strength improvement, leaving SNR no better off. Maybe enough of that noise would be cancellable and not a problem after all.

Could a high-up horizontal RX loop or dipole with preamp be set up to feed down to shack-based combiner circuitry fed as well by a conventional rotatable vertical loop? Should 630m folks experiment with light-weight, low-power microwave links to couple such 630m RX antennas to the shack wirelessly?

Tell us your information about any RX antenna concept that could be effective for acquiring horizontally polarized 630m and combining it with the usual vertical polarized reception!

What we’re talking about here is RX antenna polarization diversity. Wouldn’t it be better to put up one really good conventional 630m RX antenna than add a diversity antenna? ...Don’t know! We’re still learning. We’re experimenters. Let some stations try the diversity way and other stations do the best single RX antenna they can. See what works best. Indeed, stations can partner with other stations in their region via their internet screen viewers and get the benefit of longer-baseline diversity in some sense as well.
PHASING/CANCELLATION OF 630M BAND NOISE

Canceller Phase Setting
\[ 180\degree (1 + \frac{d_{\text{sep}}}{0.5\lambda}) \]
\[ = \sim 190\degree \]

Signal from Rear
Leads in RX Antenna by
\( (\frac{d_{\text{sep}}}{0.5\lambda})180\degree \)

Signal from Front
Lags in RX Antenna by
\( (-\frac{d_{\text{sep}}}{0.5\lambda})180\degree \)

Rear Signal Phased
by Same Amount,
Ready to Combine

Front Signal Canceled

Phased Front Signal Cancels TX Antenna

180\degree (2 \frac{d_{\text{sep}}}{0.5\lambda})
\[ = \sim 20\degree \]

Rear Signal,
Phased

180\degree

-\( V \)

\( V \)

0\degree TX Ant. Ref.

COMBINER OUTPUT

(Vector Addition Diagram)
9/19/16 THE DG0KW MAGNETIC LOOP CALCULATOR

Hams can receive 630m with Verticals, shack-shorted dipoles, E-probes, and magnetic loops of various types. For one of the loop types there’s a loop calculator authored by Klaus DG0KW. Go to: http://www.i1wqrlinkradio.com/anttype/ch9/chiave143.htm

Scroll to bottom of the web page where the Download section provides documentation. The very bottom link “Description” is an English translation describing a resonated loop with coax pickup.

Also among these Download links, click on Magnet-Loop-Rechner (magnetic loop reckoner/calculator) to specifically download the calculator software (4/20/2016 V.1.1.1). Then double-click the Application file among the files that download. Mouse-drag the red & yellow icon MagnetLoop out onto your PC desktop and double-click to open it.
In the illustration I’ve entered an example into the magnetic loop antenna calculator’s windows. The main display window at left handles the main large loop. Click at top on “Optionen” and then click “Sprache” and select your choice of German, French, or English legending. I’ve opened a second window at right that opens from the first window to estimate an inner coupling loop made of coax.

Using English, I entered values in the Loop – Specifications upper entry blanks to specify a 2.5m diameter, circular, Cu (copper) main loop. This calculator is metric, so it uses meters for the loop diameter. The calculator accepts your entries in either decimal point or decimal comma notation as is customary for your country. https://en.wikipedia.org/wiki/Decimal_mark

A meter is a little more than a yard, and 3 meters is roughly 10 feet. To convert dimensions or spaces between meters and feet, use

\[ \text{Space(ft)} = 3.281 \times \text{Space(m)} \]
\[ \text{Space(m)} = 0.3048 \times \text{Space(ft)} \]

Conveniently convert AWG wire gauge numbers to specify your intended conductor diameter (mm), and interpret vice-versa. Note popular #18, #16, #14, #12 wire sizes correspond to 1.024, 1.291, 1.628, 2.053 mm diameters. Or use a web calculator such as: http://www.rapidtables.com/calc/wire/awg-to-mm.htm.

“Length”: Coil lengths \( \frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1, 1\frac{1}{2}, 2, 2\frac{1}{2}, 3 \)” in inches correspond in millimeters to 6.35, 12.7, 19.1, 25.4, 38.1, 50.8, 63.5, 76.2 mm. Even with many turns, the main loop has a short coil length compared to its diameter.

If you enter a number of main loop turns as 2 or more, you get a minimum coil length (or width, some would say). The more turns, the more is the minimum coil length. I think the calculator figures that minimum by multiplying wire diameter by one-less-number of turns, and then includes some more spacing to keep the turns capacitance low. You can re-specify the coil length greater than the minimum as you wish.

For a calculating example, I chose to calculate this 2.5 meter (~8’) diameter circular loop using #16 (1.291 mm) wire diameter with 5 turns, and 1.5” (38.1mm) coil length.

For operating frequency, halfway down the DG0KW main loop calculator window, I entered 0.475 MHz. I specified Tx-Power 100 watts to see what capacitor voltage—about 3700V!--that power would produce. However, I think most 630m ops would set up this antenna only for receive and would employ a top-loaded vertical for 630m transmit instead.

Showtime! I clicked the “Calculate: Loop” button at bottom left and got these results up above in window middle:

Inductance estimate came out 167\( \mu \)H independent of frequency. That’s in the ballpark compared to 207\( \mu \)H calculated from this web site http://hamwaves.com/antennas/inductance.html.

Capacitance at LC resonance corresponds to this 475KHz-specific formula:

\[ C = \frac{1000\mu F}{(9L(\text{mH}))} = \frac{1000\mu F}{9 \times 0.167} = 663\mu F. \]

The main loop resonating capacitance at 475KHz estimated by the calculator is ~600 pF (671-78pF self-capacitance). The value will depend on frequency if you want to resonate for another band. You would connect a capacitor and/or variable capacitor to resonate the main loop.

The narrow bandwidth 1.74 KHz for my antenna example corresponds to high calculated Q=273, close to the standard definition: \( Q=2\pi fL/R \).

1.75Ω copper resistance is calculated at 630m and differs for other frequencies: I surmise skin effect is included. Again the estimate is in the ballpark compared to 1.85Ω from: http://chemandy.com/calculators/round-wire-ac-resistance-calculator.htm
At 630m it calculates 0.12Ω radiation resistance. **Total resistance** \( R = 0.12Ω + 1.75 Ω \). Not discussed here: Efficiency % and dBd gain (relative to free space dipole) estimates, these are more pertinent to transmit use.

Now click the bottom middle Calculate button named “**Coupling Loop**.” The calculator proposes a ratio 4 to 5 that roughly relates to main loop diameter ratioed to coupling loop diameter. The proposed ratio increases from about 4 to about 5 as loop height increases depending on the location you select from top menu. This **Coupling Loop window’s Calculate** button then calculates the circumference of the coupling loop coax as 2.09m for a roof-mounted loop and roughly 64cm “Lka” that resembles its diameter dimension.

I surmise the size of this coupling loop isn’t too critical, 20-50% the diameter of the main loop. The coupling loop needs to be big enough to couple in signal, and small enough not to load down the resonant main loop too much. On receive, the impedance match to 50Ω coax isn’t too critical. If used for transmit, you do care about the impedance match because of SWR. The 50Ω coax from the shack is connected to a 1:1 balun outdoors at the coupling loop. Its connection diagram is found at p. 11 of the Description document at [http://www.i1wqrlinkradio.com/antype/ch9/chiave143.htm](http://www.i1wqrlinkradio.com/antype/ch9/chiave143.htm)

The DG0KW mag loop calculator calculates loops for operating frequencies that can be set at least as low as 10 KHz. ELF frequencies and various dimensional specifications (such as too-small turn spacing inconsistent with turn diameter) will receive no calculation and cause a “Value unreal!” message instead.

The real-life loop antenna you build in its actual environment will depart from whatever a loop calculator might estimate. So be ready to adjust and work with the antenna until it resonates at 630m and receives properly.

This calculator handles the electrical/RF side of the things, which means all-important physical construction matters and rotatability remain up to you. See other web sites like [http://members.shaw.ca/ve7sl/loop.html](http://members.shaw.ca/ve7sl/loop.html) and the standard antenna books.
PART 1: LOOP OPTIMIZATION, WHAT HAVE OTHERS DONE?

In yesterday’s discussion of a resonant loop calculator, all-important physical construction matters and rotatability remain up to you. What might characterize good physical construction and optimization?

Let’s look first of all at experienced operators’ successful 630m RX loop antennas and see what problems they have solved. A loop antenna needs to work well and be inexpensive and convenient to construct and support.

Weight, wind loading, and expense ought to be minimized or at least mutually favorable. To deter birds and their poop from collecting on the loop, the support structure and loop wires should include few or no horizontal segments. Wind, hail, and ice storms must be withstood. No part of the antenna should snap under tension nor buckle and break under compression. The antenna should be relatively unobtrusive if possible.

Most of the loops are on rods, poles, or towers, but suspension from tree(s) and stabilization with ropes provide another type of support solution:

http://s217877884.websitehome.co.uk/amateur_radio/amateur_radio_antennas/amateur_radio_antennas_mag_loops.html ground-level octagon with side support (scroll 60%, 80%), http://wsprnet.org/drupal/node/5276 (mil tent poles, pulley suspension).

PVC, wood, fibreglass, cane and metal are frequently used singly or in combination to give inner support to maintain loop shape:

PVC:  http://www.creative-science.org.uk/smallhfloop.html (PVC, wood)  http://www.w1tag.com/rxloop.htm (PVC, click for open air winding)

Wood: http://members.shaw.ca/ve7sl/loop.html (wood lattice, open-air multiturns)  http://www.vlf.it/octoloop/rlt-n4yw.htm (wood gimbaled horiz., PVC loop, scroll 3/4)

Fibreglass:  https://www.qrz.com/db/N4IS (Waller flag, perp. wire triangles)  http://www.alexloop.com/artigo16.html (portable loop, see also video bottom left), wooden cross with clear plastic wire spacers.

Cane:  http://www.qsl.net/w/wb5wpa/QWLoop40m/ (Edginton, crossed cane supports)

Metal: http://w7iuv.com/flag_detail.htm (Metal horizontals, wood diagonals)

A preamplified smaller loop may be desirably lighter-weight if acceptable SNR can be maintained. Generally, 630m performance favors making the loop as large as possible, and preamplifier becomes optional.

Passive coupling:  http://www.antennasbyn6lf.com/630m-antennas/ (DK6ED 2-loop scaled up)

Preamplified large/small loops:

https://www.youtube.com/watch?v=i46kR0pynFw (shared apex; video play 8:30, 11:30)  http://active-antenna.eu/ (scroll 2/3)  http://geeek.scorpiorising.ca/GeeK_ZonE/index.php?topic=3929.0 (small, many turns, commentary)

Spider: Most multiturn loops have the turns spaced at same diameter, but see spider: http://www.i1wqrlinkradio.com/anttype/ch9/chia134.htm spider honeycomb on 5 wood spokes.
Coax loop with coax as tuning capacitance at 60m gives high-angle pattern.

http://www.g8jnj.net/hfloopantennas.htm

Outliers: Expand your imagination with these loops in mind!

“Fractal” loop: Would extra inductance desirably increase 630m Q? Would 630m loops benefit by adding physically small loading coils and reducing the resonating capacitance?

Gamma matched loop shown HF size. (scroll 40% to Fig. 11 on p. 9)

A 3-loop array for 6m makes me ask whether there’s any advantage to arraying RX mag loops on 630m. Since MF-size physical spacing would prevent rotating them on a boom, one would be led to electronically controlled coordinated rotators and phasing.

9/21/16 PART 2: 630M RX MAG LOOP OPTIMIZATION, DIAMETER AND WEIGHT?

Yesterday’s post shows web links where experienced operators have demonstrated many different magnetic loop solutions. To put an RX loop in place at your QTH, you could simply pick the type that fits your QTH best and has good recommendations from 630m operators who may have used it. But if you like experimenting with antennas, can we identify any basic principles to help deepen our insights and guide our own efforts?

Parts of an RX loop structure include 1) loop wire length/weight, 2) loop support to keep it approximately circular, 3) base support and/or skyhook to hold the whole loop vertical. Today’s post confines the discussion to an aspect of just the first of these.

A nearly circular vertical loop minimizes loop wire length for a given amount of signal-capturing cross-sectional area. What then should be the diameter of the loop? How many turns? What spacing? Total wire weight physically loads the structure. What wire diameter and material best establish a favorable ratio of skin effect resistance to ohmic resistance with wire weight in mind? Should one parallel two or more wires to constitute each turn? How high up should one locate the loop? You can already see complicated trade-offs between RF performance and structural/physical criteria looming. Let’s start with the first question today.

Unless you have some good reason otherwise, make the loop as large in diameter as space will allow. For a given wire length, loop area is what picks up signal and area increases as square of circumference. But turns decrease with circumference, not its square. That means one loop turn at the largest diameter your QTH allows is more reception-effective than using the same length of wire to provide multiple turns at a smaller diameter.

If you have the wire and can tolerate the additional wire weight, then wind more turns around the maximum diameter that space allows at your QTH. Turns come in whole numbers, of
course. Using a given loop circumference \( C \), increasing the number of turns at constant diameter means increasing the wire length by length \( C \) with each additional turn.

Spiral or spider winding would be fine if you have a loop width limitation such as inside the back of a vintage radio set. However, that way sacrifices loop cross-sectional area of inner turns compared establishing winding all turns the same diameter. If you have extra wire after the last turn but don't have quite enough wire to make a full-diameter turn, then it's fine to add a smaller diameter turn if the structure has places to support it.

**9/22/16 PART 3: 630M RX MAG LOOP OPTIMIZATION. TURNS?**

Why not endlessly wind loop turns on the largest loop diameter your QTH space allows? One prominent reason is: Turns add wire weight. More turns make your antenna more time-consuming and unwieldy to construct, and to raise and support. If you use plastic-insulated antenna wire to reduce rain and snow static, the additional turns with their insulation add still further weight.

More loop turns \( N \) in the best case do yield more induced RF antenna signal voltage at 475 KHz. However, in signal dB you reach a point of diminishing returns where the antenna is delivering sufficient signal strengths so that receiver noise is overcome and receiver gain is sufficient for reception. Best case \( S(\text{dB}) \) increases as \( 20 \log_{10} N A f \), where \( N \) is loop turns, \( A \) is loop area, and \( f \) is frequency. The incremental benefit of adding each turn is only

\[
\Delta S(\text{dB}) = 20 \log_{10} (1 + 1/N).
\]

More loop turns mean more loop inductance and consequently require lower capacitances to resonate the loop. At 630m if there are too many turns, two things may happen: Air variable capacitors having small enough capacitance and sufficient low-end adjustability to resonate the antenna may not be readily available. Additionally, more loop inductance in some designs may raise the antenna Q so high that bandwidth narrows to extent that the antenna is tuning-wise unstable and difficult to adjust and maintain on-frequency in windy conditions.

Moreover, with more turns the resonating capacitance becomes less widely different from stray capacitances to the antenna from elsewhere. Electric fields of local QRN can more readily couple noisy displacement currents through such stray capacitances into the high inductance loop and even through an antenna coupling and isolation transformer.

Moreover, many loop turns introduce turn-to-turn capacitance which somewhat shunts the turns and diverts and reduces the net antenna output current responsive to a given induced RF antenna signal voltage at 475 KHz.

So, provide sufficient turn spacing to keep the capacitive reactance of each loop turn high compared to the inductive reactance per turn at the operating frequency. In my opinion, for a 630m multiturn loop, space the wire centers laterally at least five (5) wire diameters to keep the turns capacitance under control. If you have a better rule of thumb, let us know.

At higher MF frequencies the shunt reactance of the turns capacitance falls--with additional undesirable signal-shunting impact. For the various above reasons, an outdoor mag loop at higher MF generally has a single turn. At 630m, loop turns may range up to perhaps a dozen. At 2200m and other LF, still more turns may be ok, subject to diminishing returns of signal dB.

At LF and VLF, the loop inductive reactance is desirably low, while the capacitive reactance shunting the turns is desirably high and reactance of QRN stray capacitances is high with less impact. Since LF/VLF frequencies are low, the induced EMF is lower than at MF. There, more turns may sometimes be justified to acquire sufficient signal dB for the receiver.
PART 4A: 630M RX MAG LOOP OPTIMIZATION STRATEGY RE CONDUCTOR SIZE

With a given diameter and number of main loop turns, the metallic resistance to RF and the overall weight of the main loop conductor turns are established by the conductor size. I’m ignoring an inner coupling loop for now, if any.

Is there a best wire or tubing size for the main loop? Should the conductor be copper or aluminum? Which is better: metal tubing or wire at larger wire sizes? Would PVC holding the loop wire be a better choice? Even if PVC or metal tubing is more likely to be able to support its own shape, is that enough to make either PVC or tubing preferable?

You could take issue with the premise of this post—that you should optimize an RX loop at all. Perhaps optimizing a loop isn’t critical. How about a reputedly-noisy band like 630m? Can’t you simply get rid of local QRN and receive the band noise well above the RX noise level, and beyond that no improvement in SNR is possible?

Since a goal here is to gain some design-pertinent insight into how a receiving loop works, let’s suspend judgment and see what conclusions emerge. The purpose of an antenna is to deliver reception performance, so I first consider how to convert the most arriving radio wave signal power into power for the receiver from the antenna.

A radio wave carries only a finite amount of signal power for the antenna to convert into electrical RF voltage and current. The more you load an antenna down the more current flows in it, which itself makes a magnetic field that increasingly cancels the magnetic field of the arriving radio wave. This partially self-defeating antenna action on the receiving end is another way of saying your RX loop has radiation resistance.*

OK, fine, so just couple a 50Ω receiver to match the loop radiation resistance $R_{rad}$ itself, right? Maybe on HF you could, but it doesn’t work that way at 630m MF. For practical 630m magnetic loops a few meters in diameter like ones you can hope to rotate, the metal resistance** including skin effect is almost always far greater than radiation resistance* by a factor of hundreds to thousands of times. See TABLE and endnotes tomorrow.

If the metal resistance is inescapable, let’s match to that. Efficiently matching a 50Ω receiver to a loop with metal resistance of, say 1Ω to 3Ω (1000-3000 mΩ) is possible for some 630m multiturn wire loop designs in that range. But for other loop designs the metal resistance is far less—down to 100mΩ (0.1Ω) and even less. For those, your RF coupling transformer or network will almost certainly introduce large or considerable losses in the matching process, relatively speaking. In every case, we will perforce throw away almost all the arriving signal power!

If we can’t do better, can we at least do small RX loops less atrociously? If not, let’s see why not. Let’s try to penetrate this topic deeper and see what we learn.

Physically and economically we MF/LF experimenters just can’t increase the loop antenna conductor diameter and loop turns and antenna area indefinitely in hopes of matching the radiation resistance itself. Consequently, I rule out an optimization strategy based on such matching. So my plan for another blog post is: **Optimize the main loop part of the RX loop using a specified conductor weight limit.** Conductor weight physically loads down whatever support structure you use. Conductor weight and shape are related some way to wind loading too.
You may see a better optimization strategy or way to proceed—if so, please e-mail so we can blog it. Tomorrow’s Part 4B will blog the TABLE and endnotes. After that, I plan to work through the weight-limited optimization strategy by way of example.

9/27/16 PART 4B: 630M RX MAG LOOP CALCULATOR TABULATIONS

Yesterday’s blog suggested optimizing a mag loop limited by conductor weight to get turns and wire size.

Today, to get some background information to inform such an optimization procedure on another day, I simply entered some dimensional values into the DG0KW loop calculator (blogged Sept. 19). That way gets us some estimated values of radiation resistance* designated $R_{\text{rad}}$, and metal resistance** $R_{\text{metal}}$. For a single wavelength like 630m, $R_{\text{rad}}$ depends only on the loop area $A$ (or diameter if circular) and the number of turns $N$. $R_{\text{metal}}$ further depends inversely on conductor diameter $d$. In the TABLE, I’ve assumed copper conductor of circular cross-section for the wire or tubing. Loop diameter 2.6m equals 8 feet.

The first five entries involve tubing, and the second five entries include wire sizes as listed. The wires are all spaced across a width of 102mm (4”), which the DG0KW calculator calls coil “Length.”

I’ve assumed that tubing can be represented on the calculator by solid conductor using the same diameter as of tubing. Either way, there’s probably comparable resistance because of the skin effect. Resistances are stated in milliohms (.001Ω = 1mΩ).

The Ratio column is equal to self-resonant frequency of the coil divided by operating frequency (all squared). Large ratio values mean that the self-capacitance*** $C_{\text{self}}$ desirably fails to shunt much current from the antenna output.

The capacitive reactance between the turns needs to be high to avoid shunting current from the inductive reactance of the turns away from the loop output and uselessly back into the internals of the loop coil. Probably above about 8 turns, 630m performance of a loop antenna starts trading off with current-shunting by its self-capacitance unless one makes the loop width very wide to sufficiently space the turns.

| TABLE: 475.5KHz MAG LOOP VALUES FROM DG0KW CALCULATOR |
| “Length”(mm) | Cond. Dia. | $R_{\text{rad}}$ | $R_{\text{metal}}$ | $Q$ | BW | L | C | $C_{\text{self}}$ | Ratio |
| TUBING | | | | | | | | |
| Dia.D | N | Loop Width | Cond. Dia. | (mΩ) | (mΩ) | (KHz) | (KHz) |
| 4.0m | 2 | 102mm | 38mm | 1.5” | 0.124 | 36 | 1257 | 0.38 | 37.7uH | 2973 | 82pF | 36 |
| 2.6m | 2 | 102mm | 38mm | 1.5” | 0.022 | 25 | 861 | 0.55 | 21.7uH | 5168 | 53pF | 98 |
| 2.6m | 2 | 78mm | 25mm | 1” | 0.022 | 38 | 794 | 0.60 | 23.4uH | 4781 | 47pF | 102 |
| 2.6m | 3 | 102mm | 13mm | ½” | 0.050 | 109 | 906 | 0.53 | 48.8uH | 2297 | 62pF | 37 |
| 2.6m | 4 | 102mm | 6mm | ¼” | 0.089 | 314 | 698 | 0.68 | 86.7uH | 1292 | 71pF | 18 |
| WIRE | | | | | | | | |
| 2.6m | 8 | 102mm | 3.264mm | #8 | 0.355 | 1155 | 789 | 0.60 | 346.9uH | 323 | 162pF | 2.0 |
| 2.6m | 8 | 102mm | 2.053mm | #12 | 0.355 | 1836 | 520 | 0.91 | 346.9uH | 323 | 133pF | 2.4 |
| 2.6m | 8 | 102mm | 1.628mm | #14 | 0.355 | 2316 | 419 | 1.13 | 346.9uH | 323 | 123pF | 2.6 |
| 2.6m | 8 | 102mm | 1.291mm | #16 | 0.355 | 2920 | 337 | 1.41 | 346.9uH | 323 | 114pF | 2.8 |
| 2.6m | 8 | 102mm | 1.024mm | #18 | 0.355 | 3682 | 270 | 1.76 | 346.9uH | 323 | 106pF | 3.0 |

ENDNOTES
* Radiation resistance of a magnetic loop $R_{rad} \approx 0.312 \frac{[N\lambda^2]}{[\lambda^2]}$ milli$\Omega$ where loop area $A=\pi D^2/4 \ (m^2)$. Express operating wavelength $\lambda$ in hundreds of meters, here 6.3; and $N$ is number of turns. See Equation 12.10 at p. 3 of this white paper (Nikolova 2014).


**Metal resistance is RF ohmic resistance including skin effect.**

$R_{metal} \approx (ND/d)\sqrt{\frac{\rho^2 \mu_0}{2}} \Omega$. On 630m, $R_{metal} \approx 178(ND/d)$ milli$\Omega$ in copper. Use:

Diameter $D(m)$ of a circular loop with $N$ turns, diameter $d$ of conductor(mm), and signal frequency $f =0.4755 \text{ MHz}$. Rho $\rho$ is DC resistivity of the metal. For copper $Cu$, $\rho_{Cu}=1.68x10^{-8}$ $\Omega$-m and $\rho_{Al}=1.58 \rho_{Cu}$. $\mu_0=1.257\mu H/m$ free space magnetic permeability.

Compare the above formula with the metal resistance formula (scroll 70%) in:


*** Let the self resonant frequency $f_{self}=1/[2\pi \sqrt{(LC_{self})}]$. The 630m operating frequency is given by $f=1/[2\pi \sqrt{(LC)}]$. Use the resonating capacitance $C$ and self-capacitance $C_{self}$ values from the TABLE. $(f/f_{self})^2 = C/C_{self}$.

Self-capacitance is discussed and estimated in a G3YNH white paper, see p. 39.


9/28/16 PARALLEL-RESONATED MF LOOP WITH TUNING IN THE SHACK

Joe NU6O WI2XBQ wrote us about his loop antenna in light of a 1942 book chapter on aircraft direction finder (ADF) loop antennas.* Joe writes:

‘Low impedance loops are used on aircraft for ADF beacon receivers where the loop must be tuned remotely. I have been using one of these since before I got on 630m. See 1st photo. Low impedance loops feature remote tuning, small size, and good performance. In my coastal environment electronics outside will not survive one good storm. It’s impossible to keep water out if it’s blown sideways several days. That was a big reason to go with the remote tuning and preamp.

The low impedance concept uses a small loop of few turns coupled by a cable to a step up transformer. The transformer serves two purposes, to match the low impedance to a FET (vacuum tube grid in the book) preamp, and to multiply the tuning capacitor reactance which is placed on the secondary side of the transformer.

The loop inductance is made about 20uH for the LF-MF band. In my case this is a two-feet-diameter shielded single turn. The text reasons that the best loop is a single turn (pp. 120,124).

The cable is important because the capacitance in a long run limits the high frequency tuning limit. Cable capacitance is the worst with 50 ohm cable, 75 ohm is better. The 110 ohm balanced variety is the lowest pF per foot I could find that is commonly available.

I am using a shielded balanced 110 ohm AES* digital audio cable, which has very low capacitance pF per foot. It also keeps everything balanced from the loop to the input of the preamp. With 50’ of cable I can tune my 2’ loop from VLF to 850Khz.

The primary of the matching transformer should have the same inductance as the loop. This worked out to 3 primary turns and 30 secondary turns on a random high-Mu core from the junk box. The secondary is 30 turns, which allows the loop to be tuned from about 300Khz to 850Khz with a 365 pF variable capacitor.
I have tried using a bigger loop, but no improvement in performance other than greater output level was noted. In fact preamp intermodulation (IM) spurs from local BC stations became an issue with the big loop.

Jim W5EST: Please tell where the loop is mounted?

Joe WI2XBQ: My loop is mounted up on a 10' section of tower as far away as possible from my and other houses and overhead electrical wires. See 2nd photo. Electrostatic noise is rapidly attenuated by distance from the source. On top of a house is a very poor location due to the house wiring radiating noise, which can even originate from other houses connected to the same AC power distribution transformer.

Jim W5EST comments: Joe’s e-mail and reference helpfully emphasize the importance of the matching transformer design and cable capacitance back to the shack to accomplish convenient remote tuning in the shack. The shack's tuning capacitor parallel-resonates the circuit across a high-impedance preamp/rx input. Thanks to the wide bandwidth of his loop circuit, Joe can study and compare 630m 475 KHz long-path propagation with that of NDBs (non-directional beacons) around 300-400 KHz and broadcast station DX signals at the low-end of the broadcast band 530-850KHz.

His receiving system approach points to a loop design choice of parallel resonance vs. series resonance. In the series approach, not used there, an outdoor tuning capacitor series resonates the loop itself and steps up a resonated, mostly resistive, impedance to match a cable that matches the RX back in the shack.

In the parallel-resonant remotely tuned approach of Joe’s e-mail, the loop is radically unmatched to the cable’s characteristic impedance. But for receiving at MF that’s ok since the cable simply amounts to an equivalent cable capacitance as Joe points out. The transformer in the shack steps up the loop inductance and steps down the cable capacitance. Thanks to the parallel resonance because of the tuning capacitor in the shack, the RF signal voltage gets magnified for the very-high impedance input of the FET preamp.

The issue of preamp IM spurs: that brings up a design choice of preamp or no preamp. What’s a “best” loop design probably will differ depending on preamp or no preamp. Without a preamp, the loop may need more turns to provide sufficient signal voltage to overcome local noise and RX noise. At the same time, with no preamp, IM spurs are probably less likely since the resulting antenna circuit of all passive components is inherently linear. If the receiver system has a 50Ω input impedance, rather than very high impedance, then connect the tuning capacitor other than directly across such a 50Ω input.

Jim W5EST: Should a loop be shielded? (book, p. 119.) Since your single-turn loop is shielded, I presume the loop shield connects to the balanced cable shield.

Joe WI2XBQ: The single turn connects to the balanced cable and the loop shield to the cable shield. The gap in the shield is at the bottom. This is the design from the ARRL handbook, but it is not the best design for noise rejection, the gap should be at the top. One advantage with the bottom gap, however, is it causes a distortion in the pattern that gives a deep null one side only so a noise source can be nulled, and still receive at 180 deg.

Normally if there is a "ground" at both ends of a balanced shielded cable, only one end should be grounded. In the case of say a microphone where the source is floating above ground, both ends of the shield are connected. The loop is isolated from ground by a short piece of PVC pipe, so both ends of the shield are connected. This was the lowest noise configuration.

I do not recommend using a coaxial cable as common mode noise WILL be a problem, even with an isolated ground at the loop. CAT 6 Ethernet cable is a very good choice for this application; a shielded version is ideal. The pF per ft. is as good as the expensive digital audio cable.

By the way, for other projects, the magnetics used for Ethernet interface are fantastic isolation devices for receiving use. They are dirt cheap or free if you recycle them off old cards. They have a wide
band 1:1 transformer and choke balun with a center tap to drain off common mode noise. (100Khz to 350 Mhz!)

Jim W5EST commenting: A grounded conductive shield that forms an incomplete turn can electrostatically isolate the loop by diverting stray capacitive displacement currents from local QRN sources to ground while the loop itself responds to the electromagnetic field of each remote 630m station. If the loop is mounted high up, keep the inductive reactance of the ground lead small enough to avoid floating the shield. If a shielded multiturn loop, amply space the shield from the loop turn(s) to minimize capacitive shunting high loop-end turns to low loop-end turns.

What loop antenna experiences can other readers tell us? Send us your words of wisdom!


** https://en.wikipedia.org/wiki/AES3 (scroll 20%)
The planned optimization: **Optimize the main loop part of the RX loop using a specified conductor weight limit** (this blog, Sept. 26). Subject to a given conductor weight \( W \), I wrote a formula* for RF signal power output of a resonated nearly-circular main loop to a load that matches the metal resistance. The result favors large loop diameter, small wire size, and enough turns to constitute conductor weight \( W \). Optimum RF signal power plateaued at the smaller wire diameters.

For the type of antenna in question, the model result makes sense because it included skin effect in the conductor metal resistance. Skin depth at 630m is about 0.10 mm in copper wire, see: [Skin_effect](https://en.wikipedia.org/wiki/Skin_effect) (scroll 60% & 40%). From an RF viewpoint, only an outer 0.1 to 0.2 mm of copper wire carries almost all the RF current.

For wire diameters exceeding AWG#26 wire ~0.4 mm, the copper metal inside the RF skin is providing helpful structural support and tensile strength, but not reducing the RF resistance. [American_wire_gauge](https://en.wikipedia.org/wiki/American_wire_gauge). Use small wire sizes but big enough to resist wind buffeting, ice storm accumulations and hailstone hits. See two loop antennas with thin wire #20 (0.8mm) and #22 (0.64mm) at [http://members.shaw.ca/ve7sl/loop.html](http://members.shaw.ca/ve7sl/loop.html) (tic-tac-toe wood lattice, open-air 13-14 turns).

Given a largest acceptable loop diameter for your QTH and smallest physically satisfactory wire size at least as thick as AWG#26, you wind the conveniently least number of loop turns needed to easily receive 630m signals without a preamp—up to about a dozen turns on 630m with 8-foot loop diameter.

The optimization ignores loop self-capacitance which increases with the number of turns and decreases with wire diameter. However, you can independently constrain self-capacitance by spacing the turns at least about 5x the insulated conductor diameter.**

Compare today’s design-specific loop optimization with yesterday’s Sept. 28 blog of a shack-tuned outdoor one-turn loop with shack preamp. Do you have still other loop antenna experiences?

** Notes: 
* Main loop conductor volume \( N(\pi D)(\pi d^2/4) \) equals weight \( W \) divided by metal density. Antenna voltage divided by arriving RF magnetic field \( H \): \( V/H = N(\pi D^2/4)(2\pi f) \mu_0 \). At 630m, that’s \( 2.96 \times 10^7 \text{ V/(A/m)} \). Conductor resistance to RF is largely skin effect for wire diameters over 4x skin depth, but is nearly DC resistance for wire diameters less than about skin depth. \( \rho \): DC resistivity (\( \Omega \cdot \text{m} \)). \( N \) turns. \( D \) & \( d \): loop & wire diameters. \( \delta \): skin depth =\( \sqrt{[2\rho/(2\pi f \mu)]} \), \( \rho_{\text{Cu}} = 1.68 \times 10^{-8} \text{ } \Omega \cdot \text{m} \) and \( \rho_{\text{Al}} = 1.58 \rho_{\text{Cu}} \). \( f \): frequency. \( \mu \): magnetic permeability of air. Hyperbolic tangent \( \tanh \) gets involved. \( R_{\text{metal}} = [\rho N(\pi D)/(\pi d^2/4)][(d/4\delta)/\tanh(d/4\delta)] \). At resonance to cancel reactance and with coupling network matching the metal resistance, write power output \( P_{\text{opt}} \) into the coupling network as half of ratio normalized voltage-squared to 2x metal resistance: \( P_{\text{opt}} = (V/H)^2/(4 R_{\text{metal}}) \). Combine all the equations to get: \( P_{\text{opt}} = k W D^2 \tanh(d/4\delta)/d \).

[References on request.]**

** Conclusion: Given a conductor weight \( W \) and loop diameter \( D \), optimum antenna power output increases to a plateau as wire diameter decreases toward zero. The wire diameter smallness is limited by physical strength considerations, not RF performance.

10/3/16 STRUCTURAL OPTIMIZATION OF MULTITURN LOOP ANTENA

Steve VE7SL and John WG2XIQ both have experience with multiturn loops. They replied to my questions, edited for this post into three-way dialog form:

**Jim W5EST**: How did you pick the materials for your octagonal loop?

http://members.shaw.ca/ve7sl/loop.html

**Steve VE7SL**: I'm a long-time wood worker, not an engineer so I (initially) chose the material most familiar to me. Red Cedar was used for its strength, light weight and superb weathering capability. California Redwood has been used by others but Fir or Pine would not be suitable due to weight issues (Fir) and weathering (Pine).

**Jim W5EST**: Would you comment on the type of shape you decided on?

**John WG2XIQ**: I built my loop so it would fit in the available space and turn without hitting tree branches. No further optimization was done. The square shape was out of convenience and ease of building with thin wall PVC reinforced with wooden dowels. It’s been up for at least two years and seen near 100-mpg winds on a few occasions without any problems. I painted the PVC with a few coats of Krylon® spray to minimize UV impact. I use thin wall PVC because thick wall PVC fails early because its heavy. Many don’t treat the PVC for UV, so it gets brittle. I imagine cold may be an issue up North. No issues here yet.

I can see the octagon being an advantage in that you increase the aperture. If I could do it, I would use a larger aperture. I would also locate it higher, maybe 20 feet, but that might also impact survivability in wind.

**Steve VE7SL**: As John points out, the octagonal shape was chosen mainly for maximum aperture but it also produces a stronger, heavier structure. These latter two features go hand-in-hand when it comes to wooden frames when exposed to storms. I'm here on the open ocean, where very strong and prolonged storms pound the antenna with their sudden, high intensity gusts.

**Jim W5EST**: What other stations have put up this 630m receiving loop so far?

**Steve VE7SL**: My first design of the wooden frame octagonal loop appeared in a mid-'80s Lowdown and was on the front cover. http://www.lwca.org/ Over the years I have heard from many dozens of those that have reproduced the design.

**Jim W5EST**: What tradeoffs confront this 630m receiving loop?

**Steve VE7SL**: Strength (cross-section of frame elements) versus wind load area. Stronger structures unfortunately also produce higher wind loads and higher stresses on the frame. This includes adding gussets (triangular inserts) to further brace the frame. I struggled to raise the 10-footer’s frame myself and was able to manage it. Anything larger is out of the question unless one has additional help.

**Jim W5EST**: Where is the structure most likely to fail in a storm?

**Steve VE7SL**: These half-lapped frames are strong, even the smaller ones. From my one blow-down, this loop's weak point instead is the ABS pipe to mount the structure. I’d say reduce UV degradation of the tubing. Repetitive flexing and UV from years of winter wind blasts and contributed to the 10-footer's demise. Wooden bracing around the pipe at the top of the mounting post prolonged its life but did not prevent eventual failure. I went to an 8-foot loop.

**Jim W5EST**: If you had stayed with 10’ loop, what could have kept that support tube from breaking in a storm again?

**Steve VE7SL**: A nested central 2” ABS pipe and a 1.5" inside it. And some annual spray painting to reduce UV damage.
Jim W5EST: How does one decide how big or small to make those gusset triangles?
Steve VE7SL: They were just a tradeoff between bracing benefit versus wind loading.
Jim W5EST: John, do you have anything you’d do different with your square loop antenna?
John WG2XI: I give it a thumbs up. I use a W7IUV preamp and LPF (ahead of preamp) in the shack. No issues...only changes would be getting it higher in the air and larger aperture. 73!

Jim W5EST comments: As we know, mechanical engineers (M.E.s) optimize physical structures so that the weight or cost is minimized while resisting failure modes--like breaking under tension, and buckling and breaking under compression by lateral wind forces. The antenna must withstand forces from all directions in the plane of the loop and also perpendicular to it. Static balancing the antenna can help reduce continual lateral bending torques by the antenna’s own weight, but wind gusts remain in the picture. If antenna wires are optimized thin (this blog, Sept. 29), the structure must prevent wire snap by sudden gust forces.

Can a reader point me to any M.E. structure optimization software that might apply to a loop antenna of this type? I’ll continue with more from Steve and John in a further blog post.

10/4/16 RF/ELECTRICAL CONSIDERATIONS WITH MULTITURN RX LOOP

Steve VE7SL and John WG2XIQ continue their dialog with me by discussing RF and electrical considerations using multiturn loops with an inside coupling/pickup loop.

Jim W5EST: How high up should you put such a loop?
Steve VE7SL: I’m pretty close to sea level and my loop is relatively low. Elevate above surrounding trees if possible. I don’t view height above ground as being particularly important at these frequencies (630m), unless it is very much quieter up high.

John WG2XIQ: I have houses and trees very close by. I’ve always used these loops close to the ground. I’d like to put it higher to learn if it improves or if there’s a noise field higher up. The "flag" and "pennant" guys and particularly those using the "Waller flag" like to get them up very high like N4IS, even at 60+ foot on a tower.


Jim W5EST: How bad is BC band interference?
Steve VE7SL: I’ve always had a preference for passive main loops with a one-turn inner pickup loop. With preamps, one always has to worry about possible intermod signals. Passive is immune unless they are produced in the receiver's front end. Eight foot (8’) and larger loop diameters have more than enough signal pickup to hear well into the sky noise.

John WG2XIQ: I use a W7IUV preamp with 5-pole low pass filter LPF ahead of it and only very occasionally and briefly get intermod from 50 kW WBAP 820 AM 20 miles to my WSW, the closest AM. I got loop info from Steve's site. The resonant loop with single turn pickup was new to me, coming from a K9AY loop and "shielded loop" background. W7IUV preamp:
https://www.google.com/search?q=w7iuv+preamp&biw=1203&bih=609&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwi06bOc_L7PAhVCJiYKHUSCCNUQ_AUIBygC&dpr=1.5

Jim W5EST: What about coupling?
John WG2XIQ: Adding an isolation/step up RF transformer gets the small nested pickup loop to near 50 ohms and also isolates the coax. Coax noise was a problem before adding the transformer and output was a lot lower and noisier--common mode, etc. I added a shield ground...
on the coax to an isolated ground rod a few feet away from the loop--makes a HUGE difference in noise. The transformer has increased the Q a lot. Aside from phasing multiple loops on larger real estate, or increasing aperture or trying higher in the air, I am out of improvements.

**John WG2XIQ:** I also detune the TX antenna on RX--a big deal with K9AY loops and BOG / beverages. But I only notice a noise increase some of the time on the rotatable multiturn loop. A relay on the RX loop shorts across its capacitor while transmitting. I wired an unused control pair to run the relay. The loop is only 90 feet from the TX antenna so I believe a resonant antenna would sink RF, maybe HV RF, at that distance.

**Jim W5EST:** Why do you relay to short the cap instead of relaying to disconnect it? Are the currents insignificant in the non-resonant shorted-cap loop? Or is there more relaying to disconnect the rest of the loop too? What circuit actuates the relay?

**John WG2XIQ:** Simply shorting it was easy. I can deal with X number of mA in the wires. I don’t want HV on the padder caps whose dielectric may not handle HV. This relay is fed on a control line from a dry contact breakout box with multiple relays in the shack. It can be actuated by PC, by the rig's TX relay, or by foot switch. On a PTT event, the breakout changes state, triggering the relays at the loop. Relays in the shack and at the TX antenna also change state depending on intended operation.

**Jim W5EST** comments: Thanks, Steve and John! Tomorrow I’ll blog relative RF loop dB calculations.

**10/5/16 MAGNETIC LOOPS: ANTENNA AREAS AND DB COMPARISONS**

Today’s TABLE compares various electrically small loop shapes. All entries assume the mag loop plane is vertical and has same wire size and number of turn(s). The comparisons provide fractional values F of loop area versus a circular loop. “dB Down(V²)” logarithmically compares the areas-squared for high-impedance preamps that respond to voltage.

Table column “dB Down(V²/Rmetal)” logarithmically compares the areas-squared adjusted for metal resistance when impedance matching the metal resistance to a 50Ω receiver. Rmetal varies in proportion to circumference of the loop shape.

The comparisons of various loop shapes are all sized allow the same circular loop to circumscribe them. The diameter of that circle coincides with a diagonal of loop shapes other than the triangles.

Comparisons, of course, depend on what you compare to. Doubling a square to make a 1:2 rectangle twice as wide as the square is worth +6dB, for instance. You also get +6dB by scaling up all sides of whatever shape by just 40%.

SNR may or may not improve with more loop output. If the example square loop’s output was already well above RX system noise, then widening the square may give 6dB more signal, but not 6dB more SNR.

Suppose you make a large triangular loop by suspending much of its wire from a high tree branch and complete it with a horizontal return. Even though the triangle shape is many dB down in the TABLE, its signal pickup may nevertheless approach or even exceed that of a small circular loop having diameter less than half the horizontal length of the triangle. (*Resistively terminated* loops like K9AY are not covered here, however.)

You get the same loop area regardless of orientation in its vertical plane. Orienting a square to make a diamond may give some advantage as simple perhaps as keeping birds from perching on it. Orienting a rectangle with the long sides up may fit a horizontal space at your QTH more conveniently than a loop with long sides horizontal.
In the TABLE the area fractions $F$ and dB Down compare each loop shape to a circular loop. To compare dB of a second shape with a noncircular first shape, take $F_2/F_1$ to get the fraction and find dB as the dB difference ($dB_2 - dB_1$). For instance, using a center pole to give the loop some support at top and bottom converts a square to a hexagon, which gives a net benefit about +2dB (-1.6 – (-3.7)) in signal strength.

Comparative results may vary between different shaped actual loops due to differing average heights, cable distances and circuits between shack and antenna. Stray capacitances inherent to the loop geometry and to differing proximities to foliage, utility cables, and metal structures may affect comparisons as well.

**TABLE: LOOP AREAS AND DECIBELS COMPARED TO CIRCULAR LOOP**

<table>
<thead>
<tr>
<th>Loop Type</th>
<th>Area Fraction F</th>
<th>dB Down($V^2$)</th>
<th>$r_c$</th>
<th>$r_c$(dB)</th>
<th>dB Down($V^2/R_{metal}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Octagon</td>
<td>0.90</td>
<td>-0.9</td>
<td>1.03</td>
<td>+0.1</td>
<td>-0.8</td>
</tr>
<tr>
<td>Hexagon</td>
<td>0.83</td>
<td>-1.6</td>
<td>1.05</td>
<td>+0.2</td>
<td>-1.4</td>
</tr>
<tr>
<td>Square</td>
<td>0.65</td>
<td>-3.7</td>
<td>1.11</td>
<td>+0.5</td>
<td>-3.2</td>
</tr>
<tr>
<td>Rectangle 3:4</td>
<td>0.61</td>
<td>-4.3</td>
<td>1.12</td>
<td>+0.5</td>
<td>-3.8</td>
</tr>
<tr>
<td>Rectangle 2:3</td>
<td>0.58</td>
<td>-4.6</td>
<td>1.13</td>
<td>+0.5</td>
<td>-4.1</td>
</tr>
<tr>
<td>Rectangle 1:2</td>
<td>0.51</td>
<td>-5.8</td>
<td>1.17</td>
<td>+0.7</td>
<td>-5.1</td>
</tr>
<tr>
<td>Triangle 1:1:1</td>
<td>0.41</td>
<td>-7.7</td>
<td>1.21</td>
<td>+0.8</td>
<td>-6.9</td>
</tr>
<tr>
<td>Rectangle 1:3</td>
<td>0.38</td>
<td>-8.4</td>
<td>1.24</td>
<td>+0.9</td>
<td>-7.5</td>
</tr>
<tr>
<td>Triangle 1:7:7</td>
<td>0.33</td>
<td>-9.7</td>
<td>1.31</td>
<td>+1.2</td>
<td>-8.5</td>
</tr>
</tbody>
</table>

**Notes**: For regular polygons with $n$ sides, the area fraction $F = (n/2\pi)\sin(2\pi/n)$. For a rectangle with sides $a$ and $b$, $F = (4/\pi)(a/b + b/a)$; and a diamond with diagonals $a$ and $b$ has half that fraction. “dB Down($V^2$)” is $10\log_{10} F^2 = 20\log_{10} F$ because antenna voltage is proportional to loop area and power is proportional to voltage squared.

A further factor $r_c$ (circumference of circle divided by circumference of loop shape) somewhat offsets dB by adding $10\log_{10} r_c$ to obtain a total “dB Down($V^2/R_{metal}$)”. For the regular polygons $r_c = (\pi/n)/\sin(\pi/n)$. For a rectangle with sides $a$ and $b$, circumference ratio is $r_c = (\pi/(2(1+(b/a))^2))(1+(b/a)^2)$. For a triangle with side ratios $1:a:b$, with both $a, b < 0.71$, then $r_c = \pi/(1+a+b)$.

**10/6/16 ONE-TURN ACTIVE RX LOOP AT VE7SL**

Today’s dialog continues the small magnetic loop topic of the last several days, turning now to Steve VE7SL’s one turn active loop.*

**Steve VE7SL**: My newest loop is a one-turn 10' x 20' active loop using a Wellbrook preamplifier. [http://ve7sl.blogspot.ca/2014/10/new-lf-mf-loop.html](http://ve7sl.blogspot.ca/2014/10/new-lf-mf-loop.html) Heretofore, I’ve preferred passive loops with one-turn inner pickup. But my present one-turn 10'x20' loop and Wellbrook preamp** have very much impressed me. Earlier, I also modified the PA0RDT active antenna preamp with transformer input and swamped the intermod: [http://ve7sl.blogspot.ca/2014/07/wellbrook-loop-plans.html](http://ve7sl.blogspot.ca/2014/07/wellbrook-loop-plans.html)

**Jim W5EST**: What’s your intermod experience with that Wellbrook preamp?

**Steve VE7SL**: “AP” NDB 378kHz lies just over one-half mile, line-of-sight, from here. Its signal is massive. Yet there is not a single sign of any preamp intermod products even when pointing the loop directly at their location.

**Jim W5EST**: What about the support structure and wind load?

**Steve VE7SL**: This time, I adopted an ‘H’ frame of 1” PVC tubing 20’ wide and ¼” PVC 10’ high--by far my ‘smartest’ design yet. Compared to all-wood frames, this huge frame is light as
Jim W5EST: Don’t you have a possible failure mode due to buckling by broadside wind gusts?
Steve VE7SL: No, because the 20’ horizontal 1” PVC tubing is clamped at several points to a 10’ 2x2 wood horizontal center support. The center support and its metal mounting plate, together with Dacron stays slanting from top, take out droop and resist flapping and buckling stresses both vertically and horizontally.

Jim W5EST: The construction looks quite straightforward. What was your actual experience?
Steve VE7SL: Unlike the wooden frames that require some basic woodworking capability, this one is very easy to construct, using off-the-shelf PVC fittings, PVC cement and a hacksaw.

Jim W5EST: Can you suggest some interesting variations on this PVC H-frame theme?
Steve VE7SL: A lightweight frame like this could also be used for a rotatable 'Flag' style antenna for LF/MF or even a shielded coax loop with Burhans preamp. http://members.shaw.ca/ve7sl/burhans.html (scroll halfway).

Adding grooved comb elements on the vertical outside support-ends allows a multi-wire air core loop on this frame, ideally 10’ x 10’ with no preamp at all. See: http://members.shaw.ca/ve7sl/loop.html. So far I have been delighted with the single-turn loop performance mated with the Wellbrook loop amplifier.

Jim W5EST comments: One probably could increase loop area to be hexagonal by using a taller 2” ABS pipe to slant the loop wire down from top of ABS pipe and up from preamp box. Taken together, the web site pages suggest a happy medium between ineffective, too-small loops and preamp intermod with too-large loops.

I hope further readers will contribute additional RX antenna experiences!

*Compare the 2’ one-turn shack-tuned active loop at WI2XBQ blogged Sept. 28. http://njdtechnologies.net/092816/


Transformer feedback makes noise floor lower than noise increase from amplifier gain by reducing JFET source resistance from 10Ω to < 1Ω. http://www.wellbrook.uk.com/ALA100LN-1

10/8/16 LOOP vs. TX ANTENNA vs. FLAG

Doug, K4LY / WH2XZO, remained in receive-only capacity through this session because of high winds from the Atlantic hurricane skirting the coast. He took the opportunity to run some receive antenna comparisons and offered these comments during the evening:

“Moderate noise here, but less lightning than expected. A/B/C tests. Wellbrook loop better toward favored direction to CIQ and XKA , but TX antenna better to XXM, XIQ, XXP. My unamplified 14’ by 28’ flag favoring northeast (loop is favoring N/S) is almost as good as the loop to CIQ and XKA so will construct a bigger flag! GN all…zzz’s.”

There will be more to this story as Doug continues his test and builds larger receive antennas.
Joe, NU6O / WI2XBQ, in response to a discussion on the ON4KST chat/logger by VK4YB about his 160-meter vertical being a disappointment compared to his wires, offered the following comments and links to related documents:

“…RE: your comment about dipole outperforming a vertical. This is covered in the following BBC document: http://www.bbc.co.uk/rd/publications/rdreport_1970_07. It’s not just the trees, at your latitude H pol will work better due to polarization coupling effects. Here is another document on MF polarization coupling including multi hop paths: http://www.bbc.co.uk/rd/publications/rdreport_1964_03.”

10/9/16 RECEIVE ANTENNA TESTS AT WH2XZO
Doug WH2XZO reports:

“Many of us try different receive antennas in an effort to hear the weak ones!

On 630M I have tried my 60M ladder line fed dipole, my Hygain Hytower, my 630M TX antenna, my 80M OCF dipole, an E-probe, and a Wellbrook ALA 1530LF loop. After extensive A/B testing, the loop is usually better in its favored directions. It’s bidirectional and has a good null 90 degrees to the plane of the loop which means if I favor northeast for Europe, I null the northwest. I need to put a rotator under it.

The TX antenna provides the strongest signals and usually the strongest S/N except compared to the favored directions of the loop. My E-probe picks up a lot of line noise which has been a local problem the past few months, and finally the power company has sent an employee to investigate, but he won’t let me show him the offending power poles (probably loose hardware) that I have spent hours identifying, first with a car radio and then a 2M yagi and FT-817.

The 60M dipole, 80M OCF dipole, and the Hygain Hytower are also OK on receive. As so many have written for 630M newcomers, use any antenna you have. It may work quite well. Probably any 630M receive antenna I use on my 180′ by 200′ lot is compromised by the jungle of wires in the air and radials on the ground within 30′ of any receive antenna I use.

About 7 years ago I put up a Super Kaz antenna and entered the National Radio Club medium wave winter contest. The rules and scoring that year required reception of AM broadcast stations in the 530 to 1700 kHz broadcast band at 1000 miles distance or more. Each station ID’d at 1000+ miles counted as one point.

I put up a 28′ high by 112′ long Super Kaz favoring south and was lucky enough to win the contest, mainly because I was just over 1000 miles from dozens of Cuban stations to my south. I also used my 160M inverted L for other directions, but the Super Kaz was really super on those Cuban and other Latin American stations. My main problem wasn’t hearing stations, but IDing the SS call signs!

This past week I put up my original K6SE 14′ by 28′ flag I built and tried out in Colorado 20 years ago. It favors northeast and was almost as good as the loop in the loop’s favored direction. I’m taking it down today and will be putting up a Super Kaz favoring northeast to see if I can improve upon the loop toward Europe. To be continued!”

10/29/16 Doug, K4LY / WH2XZO, reported that he decoded nine WSPR stations, including the previously reported decodes for EA5DOM. He was decoded by 34 unique stations in what he referred to as “better, but still disturbed, conditions.” Doug added the following comments:

“High latitudes continue to suffer with no VE7 decoding…The big surprise for me was the first time ever decode of EA5DOM with the new Double Half Delta Loop.”
antenna beaming northeast toward Europe.


I finished erecting it yesterday afternoon in place of the larger, higher gain Super Kaz. I hope the antenna was a factor, and it wasn’t just a weird coincidence. Neither antenna was perfectly proportioned, no perfect 10’s in our antenna farm or family, and required two supports versus just one support for the larger Super Kaz, but is supposed to have 2.5 RDF improvement over the flag type antennas such as the KAZ.

No one in northeast U.S. was transmitting last evening so could not try an A/B test comparing it to the loop, but it seemed to be working well on the BCB, and I’ll do more testing tonight.

I also spent the part of the day and evening learning to use the KiwiSDR program which PY2GN is Brazil uses, and I and even activated several eastern U.S. stations, first timers probably to decode 630M WSPR signals. I find that the program times out after about 30 minutes so I haven’t been able to keep PY2GN decoding 630M WSPR for very long, but he may be doing that at his end using a WSJT program. I have no way to be sure. I did note a very faint trace of my signal on his waterfall last night around 8 PM which immediately disappeared when I stopped transmitting. I thought one of the powerhouses further west would be the first to be decoded, and I still do although I’m the closest to him. He has a quiet, high altitude, and very favorable location for weak signal DX.”

10/31/16 HEAD SCRATCHER! COMPARING A SMALL FLAG ANTENNA TO A LARGE FLAG ANTENNA. DOES GAIN AFFECT SNR?

Doug, K4LY / WH2XZO, presents this discussion:

“Flag antennas are an anomalous experience for me. I’ve used dishes on microwave frequencies where increasing the size of the dish changed the antenna pattern- narrowed the beam width- resulting in better SNR. I’ve used beverage antennas on 160M where increasing the length of the antenna changed the pattern-again narrowed the beam width- and resulted in a better SNR.

The flag antenna, no matter how big you make it, assuming the same scale, has the same pattern based on modeling. Only the gain changes. So in theory there should be no change in SNR? However, in the article below, Dr. John Bryant did some experiments and claimed empirical evidence for the smaller antenna being gain limited and the larger antenna providing a better SNR.

I have built and used small flag antennas several times and always been disappointed with the results. Not so with the larger flag or similar KAZ antennas I’ve built. That anecdotal experience is not science and, to use a phrase that was common in the days when Harold H. Beverage developed the beverage antenna in 1921, “not worth a tinker’s damn.” OK. I know that, but like everyone else, I am influenced by my own experience.

In the original article referenced, Testing Two “KAZ” Squashed Delta Antennas SEE http://www.dxing.info/equipment/kaz_bryant.dx Bryant quotes K6SE (who did so much to popularize the flag antennas) “antenna guru K6SE cautioned that gain is not really an issue in a receiving antenna since actually hearing the signal was dependent upon the signal-to-noise ratio rather than the absolute gain of the antenna.”
Nevertheless, Bryant goes own to present evidence that the larger KAZ antenna, 116’ by 28’, in some of his tests does outperform the smaller 40’ by 10’ antenna and that “gain does seem to matter.” Bryant writes, “Since the basic signal-to-noise ratio of an antenna is related to its sensitivity pattern and since the pattern (but not the gain) of the KAZ and the Super KAZ should be identical, the 40’ KAZ must be “gain limited” under the specific conditions tested. In other words, what I was hearing on the 40’ KAZ was not band noise, but rather the noise floor of my receiver! I added about 10 dB of amplification to the KAZ signal and attenuated the Super KAZ a like amount; this pretty well equalized the apparent gain of the two antennas. As expected, the KAZ signals remained much noisier than the same previously marginal signals when received with the Super KAZ."

Another similarly experienced MW DXer, Steve McDonald, VE7SL, has written as part of this discussion, “I think that there is no doubt that the larger KAZ is superior to a smaller one, even when amplified by virtue of sheer capture area.” and in an email added “This eventually begs the question, ‘why build a Super KAZ when a normal (small) KAZ will provide the same SNR?’! I know that from monitoring the MW BCB guys reports (again anecdotal for the most part) that they report improved results when going to the larger KAZ.”

Eric, NO3M, another very experienced antenna man, doubts the Bryant results above and writes, “I think he is observing nothing more than SNR degradation due to his pre-amp’s NF. Other than possibly eliminating the need for a pre-amp, and the potentially associated increase in system noise, there should be no discernible performance differences in the KAZ vs. super-KAZ.” In a later email, Eric added, “Besides the preamp NF, another factor they may have been dealing with causing SNR observation differences is common-mode ingress…..As the antenna gain decreases, common-mode suppression demands increase. If similar methods of choking were used on the KAZ vs. Super KAZ, it may not have been sufficient for the smaller KAZ (lower gain) antenna. After some thought, I suspect common-mode had more to do with the apparent observational differences than amplifier NF, assuming the patterns are the same. With similar radiation patterns, there should be no difference in SNR for a particular signal between the two versions. Which raises another question, was there another factor involved that altered the pattern in one or the other?”

Tom, W8JI, another prolific antenna theoretician and experimenter, agrees. His web page describes flag antennas in this way- “Terminated loops are really just short verticals, with a phasing system inherent in the longer horizontal component of antenna wires.” See http://www.w8ji.com/k9ay_flag_pennant_ewe.htm . W8JI does say to keep “S2 as large as possible, but smaller than 1/4λ,” (see his web page), but he doesn’t say why. Is it merely to require less amplification?

In a second web page, W8JI says, “One common rumor or myth is that higher antenna gain results in improved reception. Gain is an unreliable way to predict receiving ability on frequencies below upper UHF!” and he gives the example of close spaced beverages which provide more gain, but almost no additional RDF (directivity) or resulting S/R. See http://www.w8ji.com/receiving.htm

Toward the end of his article, Bryant asks, “What is the smallest KAZ that will not be “gain-limited” even at the bottom of the broadcast band? Is there any theoretical work available on this???”
The above is more than just a theoretical problem. Most of us have small yards where only small antennas will fit. In my case, I have three towers, skywires all over the 0.8 acre lot and radials all over the ground. If a small flag or KAZ (perhaps requiring amplification) provides the exact same SNR as a much bigger flag or KAZ, I can get that smaller antenna over 50′ further away from towers and sky wires. That would, probably, improve the pattern because there would be less interaction between all those towers and wires.

What are your thoughts and experiences regarding the relationship of antenna gain and SNR on 630M?

11/24/16 LOW LOSS RF TRANSFORMERS FOR RX ANTENNAS
by John WG2XIQ: Chatting the N1BUG last night on the kHz ON4KST web chat page, Paul mentioned he was using the standard W8JI beverage transformer, which is 2T/5T on a BN73-202 core. I was curious what the insertion loss was like on this single BN73-202 transformer at LF/MF, so I ran a back to back transformer test on the HP-3856c SLM which I picked up from Jay, W1VD a few years ago (what a great instrument). Here’s the test details: https://www.dropbox.com/s/nxybe5ir8gw34ud/W8JIBEVXT.jpg?dl=0

Turns out a single W8JI HF beverage transformer has about 2.5 dB loss on 137 kHz and about 0.49 dB loss on 475 kHz. On 160m I was seeing about 0.40dB insertion loss, so the standard HF beverage transformer was only off .1dB from 160m insertion loss performance.

(Note: I probably should have placed the transformers under test on a small block of wood or plastic to get them and the test cable clip leads away from the metal cart frame. That may be why the insertion loss numbers seem a bit high for the 160m test measurements. I think the 160m insertion loss should be closer to .3 or .25 dB per transformer.)

So trying a standard HF receiver antenna built for 160m may work reasonable well on 475 kHz Something to consider for newcomers who already have beverage, EWE, or K9AY antennas for HF. (Likely one needs a different termination resistance to be optimal at MF, but that is easy enough to model on the free demo version of EZNEC ) 73 Mike wa3ttts.”

12/21/16 K6SE TRIANGULAR DELTA LOOP WITH PREAMP
Doug, K4LY / WH2XZO, provided these comments for the session:

“High latitude opening to east opening but not to west. How could that be? Decoded 11 and decoded by 50, nothing unusual except the LA2XPA/2 decode, 32 degrees and 6572 km.”

In a separate email, Doug reported on his receive antenna changes:

“I’m looking forward to reading about the LA2XPA antennas. His decode last night is by far the furthest north of any WH2XZO decode.

Both the Super KAZ beaming west and the Double Half Delta beaming NNE seemed to offer slight improvements at first over my Wellbrook loop, but I was disappointed that it was only slight. In both cases the geometry, limited by available trees, was not perfect.

Yesterday, I took down the Double Half delta and put up a small K6SE designed Delta. The triangular loop has only 72′ of wire, but I’m using a recently acquired Wellbrook FLG100LN amplifier. The small delta antenna is correctly proportioned and beaming NE toward New England and Europe. Last night’s A/B testing indicated that it
was significantly better than the very good Wellbrook loop on the LW broadcast stations, MF broadcast stations and 160M. On 630M my decodes of WG2XKA and XSH/17 were the strongest ever, +16 dB and + 5 dB, and the largest difference between their decodes of XZO so I’m optimistic that it will be better for TAs.

I also now have the opportunity to compare a small amplified loop vs. a much larger loop which theoretically has the same azimuth and elevation plot.”

**JH notes on:** Earl Cunningham K6SE DELTA LOOP

http://nidxa.org/kb9cry_rotatable_low_band_receiv.htm

http://www.eham.net/articles/806  best F/B and zero reactance at 1.830 mHz. This is the design that was built by ON4UN for use by FO0AAA. a delta loop 28-foot (8.537m) bottom horizontal wire and apex 17 feet (5.183m) above bottom wire. total: ~72 feet (21.951m) of #14 AWG wire in the triangular loop. bottom horizontal wire 3 feet (0.915m) above ground, apex was 20 feet (6.096m) above ground. Ground-independent antenna.

Termination resistor goes in one of the bottom corners of the loop, is **950 ohms non-inductive.** The feedpoint is at the other bottom corner and the feedpoint impedance is 950 ohms with zero reactance at 1.830 mHz. An impedance matching transformer …should be used with the Delta antenna.

F/B ratio >40 Db. Cardioid pattern directivity is in feedpoint direction, same as with Pennant, Flag, or Ewe). Antenna gain = ~ -34.5 dBi. Use RX preamp.

Chosen by FO0AAA easily-erected and easily-rotated directional receiving antenna. Only one support at the apex, non-metallic). The bottom corners of the antenna can be attached and pulled taut with rope to tent stakes driven into the ground. To change directions, relocate the tent stakes to the desired direction and re-attach the corners of the antenna.

**12/23/16**

**Doug, K4LY / WH2XZO,** continues to test the differences between the Wellbrook loop and the K6SE delta and offered these comments:

“Continued high latitude attenuation. The numbers last night were 11 and 43. The Wellbrook loop here has been my go-to RX antenna for almost a year. Several wire flag type antennas have equalled it, but never been much better. Not sure why, because a directional antenna should be significantly better than a non-directional antenna. I didn’t get the wire antenna dimensions perfect because of the available trees, but that shouldn’t matter. I also couldn’t aim exactly where I wanted, but with the wide beamwidth, that shouldn’t matter. But something did matter, and those antennas were hardly better than the loop.

When G0LUJ reported how happy he was with the Wellbrook loop amplifier for his big loop, I decided to order Wellbrook’s flag/delta amplifier. Three days ago I took down a Double Half Delta and put up a small K6SE modelled delta loop. Because it was small, 28′ base, I could aim it exactly NE. With both the amplified loop and the **amplified Delta favoring NE (the loop is bidirectional), the Delta outperformed the loop again last night by about 7 dB.** That’s more than I’d expect. The delta has both a narrower azimuth and elevation field, but 7 dB? With most of my wire antenna experiments, early A/B testing showed them to work better than later. Maybe it’s a kind of **confirmation bias.** This morning at 4 AM I switched to the west favoring super Kaz and it was terrible, so better see if it’s still up!”