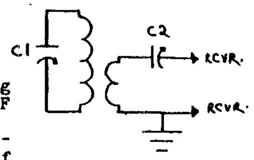
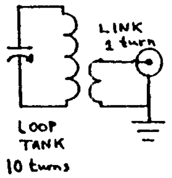
# the irca technical column

A whole lot of bits and pieces this time, so let's get straight to it. Remember the article on matching unamplified loop antennas to receivers in the June 25, 1983 DX Monitor? Don Moman uses another system for matching air-core loops to a receiver. Simply place a 365 pF variable capacitor (C2) between the "hot" side of the link winding of the loop and the receiver antenna terminal (see left). Lowering the capacitance of C2 will isolate the loop from the receiver, minimizing loading effects on the loop's tank winding, and causing an increase in tank Q. Greater signal strength of one's DX can be the result. There may be interaction between C1 and C2, so after you have reduced C2's capacity to the point before signal strength drops off, repeak C1, then see if C2 needs repeaking.



## Optimizing an Unamplified Loop Antenna

A 3' square box loop antenna (the NRC alt-azimuth design) has been in use here for a number of years now. Although it originally used a direct coupled arrangement with a balanced FET amplifier (Jim Hagan's design--NRC reprint A17), moving to a house nearer powerful locals meant that the amplifier had to be removed due to overloading problems.



Standard link-coupling was resorted to, and a single-turn link has been used with a good deal of DXing success (see left). But it seemed that the loop wasn't being matched too well with my homebrew receiver. In fact, the receiver input impedance was "loading down" the loop's tank winding, resulting in a somewhat lower "Q" of the winding, with resulting degradation of loop selectivity and strength of received signals.

Interestingly enough, moving the pick-up link to a position about six inches inside the tank winding (see diagram next page) resulted in an increase of signal strength of about 6 dB. Moving the link in this way presumably loosened the coupling between it and the loop's tank enough that the receiver input no longer loaded down the loop so much. It seems that the extra signal strength caused by higher loop Q was more than enough to compensate for the loss introduced by the looser link coupling. However, Bruce Portzer tried

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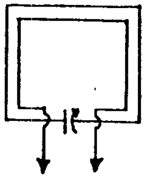
this trick with his 4' box loop and didn't get my results, so it won't work in all situations.



pick-up winding 6" inside tank. (Tank windings omitted for simplicity)

Another approach, and one which I now use, is to place a matching transformer between the link coil and the receiver input. The loop with its one turn link can be looked at as a transformer, and the loop's tank circuit will have an apparent resistance at a given frequency determined by its Q and inductive reactance. If mathematics horrifies you, skip the next section as it's not really vital to the exercise.

To determine a loop's Q (if only approximately), one needs a calibrated signal generator (preferably to fractions of a kHz--a frequency counter helps), and some form of sensitive RF (milli)voltmeter--I used an oscilloscope as my "voltmeter". Joe Worcester in IRCA reprint A9 "The Shielded Ferrite Loop: Principles and Practice" suggests connecting the signal source to a single turn of wire and radiating to the loop from a few feet away. I found that my generator didn't give enough signal this way, so ended up with a broadband amplifier and whip antenna a few feet from the loop. Now connect the loop's link to your RF millivoltmeter, tune the signal generator to the desired frequency ($f_{peak}$) and tune the loop for maximum signal as indicated on your scope, sensitive VTVM or whatever. Now detune the signal source first on one side, then the other of the peaked frequency and note the upper ($f_{upper}$) and lower ($f_{lower}$) frequencies at which signal strength is 3 dB less than the peaked frequency. (A voltmeter will indicate about .7 of peak voltage at these frequencies). Now subtract $f_{lower}$ from $f_{upper}$ and there is your loop's 3 dB bandwidth, $f_{bw}$ at that frequency.

Now, $$Q = \frac{f_{peak}}{f_{bw}}$$

For my loop, Q came out as 223 at about 1000 kHz; Q was lower as $f_{peak}$ increased, and higher as it decreased. This is the loop's unloaded Q; connecting a receiver to the loop's link will lower the Q even if it's a perfect match.

Inductive reactance ($X_L$) can be approximated now, if you know the maximum capacity of your loop's variable capacitor. Tune the capacitor to its maximum, then tune the signal generator until a peak appears on the voltmeter; note the frequency (f) at which the peak appears. The resonating capacity (C) of the loop at this point should be the variable capacitor's maximum value plus, say 25 pF, for distributed capacitance in the loop winding's etc. The inductance of the loop is:

$$L = \frac{\left(\frac{1}{2\pi f}\right)^2}{C}$$

where L is in Henries, C is in Farads and f is in Hertz

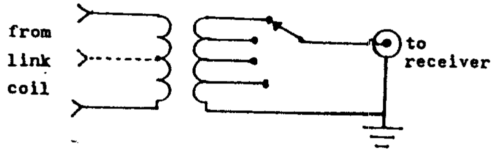
$X_L$ in ohms at a specified frequency is now found: $X_L = 2\pi f L$

And the loop tank's apparent resistance R at a given frequency is calculated thusly: $R = QX_L$

My loop was about 210 uH, and its resulting R at 1000 kHz was about 300 kilohms. Something around this value is probably about par for loops of this type.

The 10:1 turns ratio between the loop tank and the link coil would mean a 100:1 impedance ratio (impedance ratio equals the turns ratio squared) <u>if</u> the loop antenna were a perfect transformer. It's not, but if the link is embedded in the tank winding, it's close enough. If the impedance ratio is 100:1 and the tank appears to 300 kilohms, then the link is presenting an impedance of about 3 kΩ. If the receiver input impedance is lower than this (and it usually is) then you will reduce the loop's Q by loading down the tank.

So, we use a matching transformer. Because receiver input impedances are not often accurately specified at MW (and the shielded lead-in complicates things further), it's best to construct a transformer which has taps on its secondary; one chooses the tap which gives best signal strength or sharpest tuning. So, the preceding discussion of loop Q, resistance, impedance ratios etc. is largely academic, except in determining what toroid core to use in the transformer, as $X_L$ of the transformer's primary should be four or more times the impedance of the link coil. I found that about 100 turns of #30 magnet wire on an Amidon FT83-72 ferrite core was fine for the transformer primary (which connected to the loop's link winding). A 30 turn secondary winding tapped at 20, 10 and 5 turns gave me a variety of possible matches to the receiver. A 50 turn primary may work fine in some cases also.



Although I've since put a two-turn center-tapped link on the loop, and put a center tap on my transformer primary (see dotted line in diagram above) I still haven't succeeded in balancing the loop entirely--too much angle iron, i.e. receivers, in close proximity to the loop perhaps? But a better balanced loop should be possible using this arrangement than if the link coil is directly connected to a receiver's unbalanced antenna input.

This matching transformer with tapped secondary has given me an added signal strength on received signals over what I heard connecting the link winding directly to the receiver (6 to 10 dB in some cases). Loop selectivity also increases as fewer turns are used on the secondary, although there is a slight loss in signal strength at 5 turns compared with other switch positions.

Incidentally, this matching transformer (perhaps with taps on its primary as well) might be used to match a variety of amplified or unamplified loops to various receivers. This might help solve the problem mentioned by Neil Kazaross and others of certain loops delivering poor signals to certain receivers. I'd like to hear from anyone who tries this approach.

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