COMMENTS & DISCUSSIONS ON THE SMALL TRANSMITTING LOOP ANTENNA

SOME FINAL CONCLUSIONS

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A lot of discussion has taken place between Leigh Turner (VK5KLT) and myself concerning the small transmitting loop antenna essentially following on from questions I had raised concerning the talk by Mike Underhill G3LHZ on small antennas. My questions, in particular, concerned test results from Mike which seemed to indicate that a 70% radiation efficiency could be achieved at 1.8 MHz using a 1 metre diameter loop

LEIGH'S RECOMMENDATIONS

Leigh Turner has studied the theory of the Loop in depth and has had a lot experience with practical loops. Based on many factors including such as radiation efficiency, operating Q suitable for SSB operation, he has come up with recommendations for design. I copied two paragraphs from one of his articles:

"Transmitting loop antennas intended for optimal coverage of the HF spectrum from 3.5 MHz to 30 MHz are best segregated into at least 2 distinct loop sizes. A nominal 0.9m diameter loop for covering all the upper HF bands from 20m through to 10m (and perhaps also tuneable down to 30m depending on capacitor min/max ratio), and a 2m diameter loop for covering the lower bands 80m through to 30m. For best operation down at 160m and improved 80m performance an increased loop diameter of 3.4m should be considered."

"The conductor diameter is determined by the desired loss resistance due to skin-effect, and choices can range from 6mm copper tubing to large bore 100mm copper or aluminium tube. Commonly used conductor diameters used to fashion the loop are 20mm and 32mm soft copper tube."

Of course Leigh's complete article is much more comprehensive than that but I thought the two paragraphs on their own give a good initial feel to the sort of sized loops one should build to get good results on the amateur bands. This is excellent material and I certainly accept his recommendations.

INDUCTION INTO GROUND OR NEARBY OBJECTS

But I am still concerned about this 70% at 1.8 MHz. First of all let me relate some practical tests on short fat dipoles and effects of direct induction the lower frequency HF bands:

I constructed short fat dipoles for 10, 20, 40 and 80 metres. For each of these, the dipole length was around 2% to 2.5% of the wavelength and each dipole was loaded balanced with inductors in each leg to bring the antenna to resonance at the relevant frequency. Based on formula used to calculate radiation resistance (Rr) for a basic short dipole, a value of Rr was anticipated of about 0.1 to 0.2 ohms for the simple dipole mode.

Loss resistance (RL) was assumed to be mainly that presented by the summed loss resistance of two coils in connected in series. The values measured were as follows:
10 metres RL = 4 ohms
20 metres RL = 8 ohms
40 metres RL = 9 ohms
80 metres RL = 14 ohms

Each antenna was hung up under a bow of my willow tree about 2 to 3 metres above the ground and the resonant series resistance directly into the dipole via the inductors was measured using an impedance analyser. The resistive components measured as follows:

10 metres - close to the 4 ohms loss resistance
20 metres - slightly greater than the 8 ohms loss resistance
40 metres - 14 ohms
80 metres - 25 to 44 ohms (very variable depending on the precise height the antenna was above the ground.).

The simple dipole mode radiation resistance is so small that it is negligible compared to the coils loss resistances. So what we see at 10 metres is simply the loss resistance presented by the loading coils.
But what is happening at 80 metres to provide such a large value of measured resistance? Surely not radiation because it does not occur on the similarly constructed 10 metre antenna! But for the 80 metre antenna, the distance between the antenna and the ground (and the tree) is a much smaller proportion of a wavelength than that for the 10 metre antenna. My conclusion was that in the case of the lower frequency (or longer wavelength) antennas, considerable power was being coupled by direct induction into the ground and the tree.

I didn't make a 160 metre short dipole but my guess is that if made in the same form and measured in the same location, an even higher resistance would have been measured.

Now let' get back to Mike's 160 metre loop of about 1 metre in diameter or about 3 metres in circumference. We might think of this as a dipole length of about 2% of a wavelength folded around and in this case, brought to resonance by capacitance across its folded ends. Clearly a different pattern for the two induction fields. But (like the short dipole) why should coupling not occur via these fields into the nearby earth or objects which, for 160 metres, are most likely to be spaced a mere fraction of a wave length from the test antenna.

Mike was able to prove by measurement that 70% of the power fed to his loop was not lost in the resistance of the loop. He assumed this was power radiated but we are talking about a wavelength of 160 metres. Unless it were possible to make the measurements far enough away from ground or other objects relevant to this wavelength, radiation as the only reason for the 70% can hardly be assumed.

Had I not detected from measurement the increase in antenna resistance in the short dipoles at low HF frequencies, I would not have had reason to wonder whether the same thing occurred at low frequencies with the small loop. **As the direct induction effect did not occur for the 10 metre short dipole, I have wondered what the results of Mike's tests would show if his loop (operating at 1.8 MHz) were scaled down for an efficiency test on 10 metres so that proximity to ground or surrounding objects was much larger when compared to the wavelength. (The loop would be scaled down by a factor 160/10 so that the loop diameter was 6.25cm in diameter and the copper tube diameter was 0.625mm.). This would seem to be the way to either prove the existence of coupling due to direct induction at the lower frequencies (such as at 1.8 MHz) or eliminate it as a factor.**

RADIATION FROM THE COAX LINE

Another question I raised concerned the degree of balance which might be achieved in using the gamma match for coupling the coax line as used in Mike's loop. The question raised was whether some of the 70% of power assumed radiated from the loop might have actually been radiated from a longitudinal current component in the transmission line. This could develop a longitudinal current component running in the line.

Leigh supplied data on commercial loops where the makers went to pains to ensure the coupling was well balanced and chokes were placed in the transmission line to inhibit a longitudinal component. However, Mike's test antenna appeared to be gamma matched and this form of coupling doesn't appear to be immune to the development of some radiation from the line. The unbalanced bi-directional radiation pattern (as supplied by Leigh) for one commercially made antenna seemed to demonstrate this.

I will again refer back to my short dipoles. Connected in the balanced form via a transmission line, currents in the two legs of the line were measured as equal. However if connected unbalanced, current in one leg was read as about double the other.   As explained in some of my articles, the effect of the high Q tuned antenna at the end of the line seemed to multiply the degree of current unbalance. I further suspect that if the high Q loop were not quite balanced, the same effect might occur in multiplying the degree of current unbalance in the coax line legs..

A check for current balance in the legs of the coax line could easily be made inserting RF ammeters in each leg of the line feeding the antenna. If the currents were measured as unequal then at least some of the assumed radiation from the loop must surely originate from the line rather than the loop itself.

FINALE

(1) The 70% efficiency for Mike's loop at 1.8 MHz was derived from practical tests and measurement. His methods of separating power lost in the loop resistance from the total power are fine.What seems to be missing is any form of further testing to verify that the 70% of power (assumed as direct radiation from the loop) is not due (at least in part) to direct induction into the ground or nearby objects. As I have demonstrated with my short dipoles, one way this can be done is to scale down the operating wavelength and the proportional loop dimensions, to a point where direct induction effects can be considered minimal.

(2) There is also the suspicion that some of the 70% power might be radiated from the feedline in Mike's gamma matched loop. An RF ammeter in each feedline leg could easily check this. (I note that this must have been of some concern in feeding these loops - refer to the inclusion of the balun in the coax line of the Tampere OH3FER sample).

Lloyd