THE MAGNETIC LOOP ANTENNA

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Abstract: The paper deals with advantages and drawbacks of a special type antenna called the magnetic loop. There will be also described equations which are essential for the construction design and some qualifying antenna parameters.

Key words: magnetic loop, frame antenna, dipole, inductance, long wave, short wave.

1. INTRODUCTION

Elementary dipole as a basic type of antenna is not every time a very efficient mainly at low frequencies. As a result, when we have to use antennas whose sizes are very small relative to the signal wavelength it can often make sense to use Magnetic Loop or Ferrite Rod antennas. Textbooks focused on antennas or electromagnetisms often consider a variety of forms of Magnetic Loop. Some have a circular cross-section, some square, hexagon or octagonal. Although the details of these systems vary (for example, their inductance depends on their shape or the ratio of their length to diameter) they are all 'small' compared with the wavelength.

The magnetic loop antenna (**MLA**) is a special type of frame antennas. If we compare the magnetic loop to a traditional frame antenna as dipole, beam, quad or vertical, the **MLA** is much smaller. It is extremely efficient short wave antenna. While the circumference of classical loop antenna is close to wavelength λ for which it had been designed, the magnetic loop use small circumference about 0,35λ (practically close to 1/10λ). This is why **MLA** is so popular with radio-amateurs.

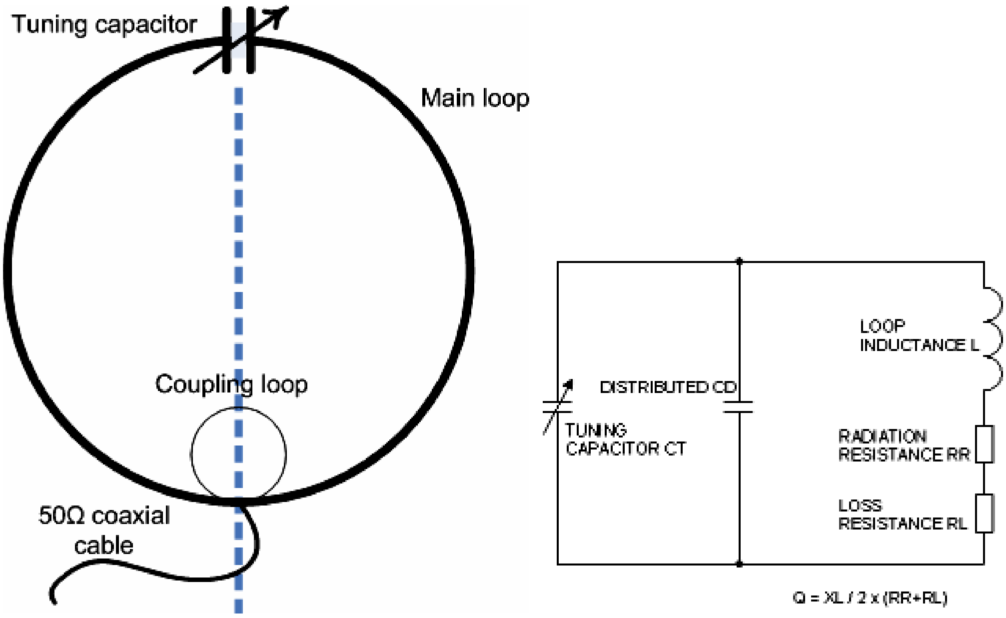
Not only proportion of this antenna is the main advantage. The essence of the loop antenna is that it responds mainly to the magnetic field component of an electromagnetic wave (the H-field component) rather than the electric (E-component). This feature gives the magnetic loop a non-sensitivity of electrics interferences. It is usually used for receiving in small places, where cannot be used proper length antenna as well as in places with high electric noise level. The **MLA** can be also used as a transmitting loop. If the **MLA** operates close to ground it radiate much stronger electromagnetic field than a dipole when both are close to ground. Certainly, a full size dipole in its proper high radiates better signal than the **MLA**.

2. ANTENNA DESIGN

The magnetic loop consists of one main loop, a tuning capacitor and coupling loop. See pic.1. These three components will be described bellow.

2.1 The main loop

As was said in the introduction, the circumference of main loop is derived from a wavelength λ for which the **MLA** is designed. The loop has usually just one turn which can be made of a coaxial cable (using a shield) or basically from a cuprum (plumber) tube. The loop presents one turn air-core coil.



pic.1: magnetic loop- real (left) and equivalent (right) circuit

$$L = 0,2 \times U \times \left(\ln \frac{U}{d} - 1,07 \right) \quad [\mu H] \qquad [2.1]$$

Where:

- L is a loop inductance [μH]
- U is a circumference of the main loop [m]
- d is a wire-diameter [m]

If we design **MLA** at low bands such as long wave (**LW**), it is recommended to use more than one turn, otherwise **MLA** proportion might be large. The number of turns the loop needs is determined by the size of the loop, the frequency range that you want to tune and the value of your tuning capacitor. In that case inductance rises with quadrate number of turns.

$$L' = L \times N^2 \quad [\mu H] \qquad [2.2]$$

Where:

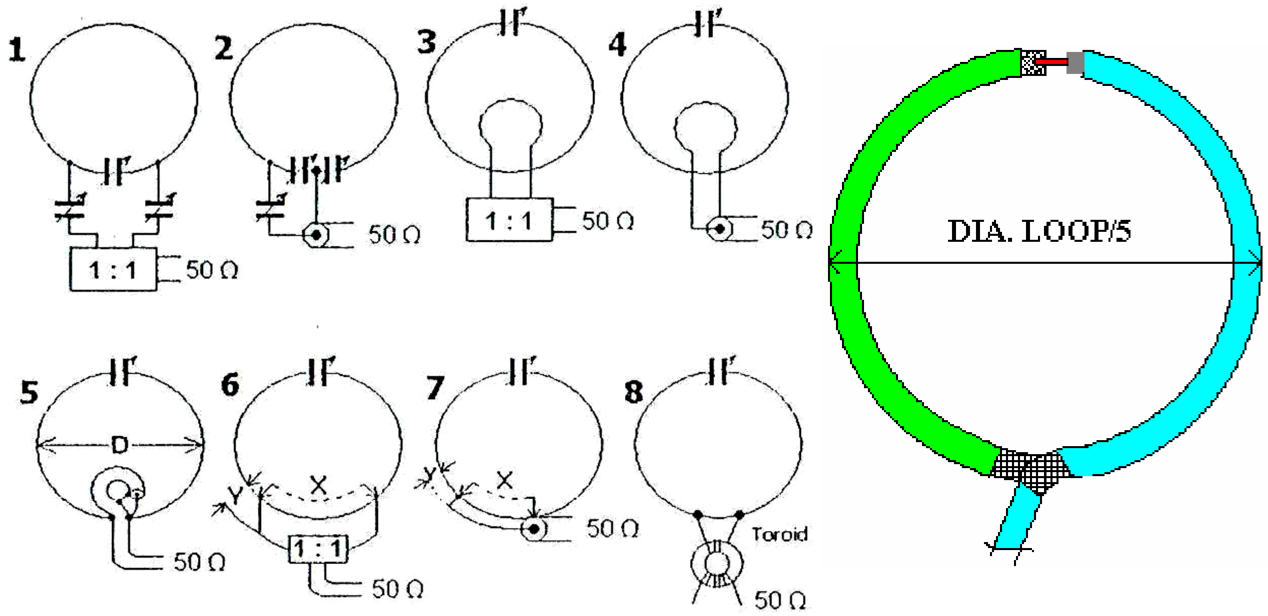
- L' is a multi-turn loop inductance [μH]
- L is a single turn loop inductance (taken from 2.1) [μH]

2.2 Tuning capacitor

A capacitor allows the **MLA** to change operating frequency in relatively wide range. For receiving **MLA** can be used an ordinary variable tuning capacitor taken from an old AM radio receiver. If the **MLA** operates as a transmitting antenna, it is necessary to choose a high voltage tuning capacitor with big gaps between capacitor plates. The corresponding value of tuning capacitor can be calculated for given inductance L from Thomson theorem.

2.3 Coupling loop

A coupling loop is a small loop inside the main, exactly opposite the capacitor. There are different ways of constructions coupling loops (pic.2a). Some do not even use a loop, but a gamma match to connect the magnetic loop to the feed-line (pic.2a.7). The dimension again depends on the main loop diameter. Coupling loop diameter is usually one fifth of main loop diameter. See pic.2b. The distance between coupling and main loop varies from 0 to 6 cm. This help with a final **SWR** adjustment.



pic.2: a) different type of coupling loops (right), b) zoom no.4 (left)

3. TECHNICAL PARAMETERS

The loop antenna is very directional. The pickup pattern is shaped like a figure eight (pic.3). The loop will allow signals on opposite sides to be received, while off the sides of the loop the signal will decrease or be stifled. The nulling feature will allow you to remove a local station on a frequency and pick up another on the same frequency by removing the local signal. The loop may have an amplifier or may not.

The "Q" or quality factor of the coil will determine its selectivity at resonance (the tuned frequency). If the "Q" of the coil is loaded (reduced by the effect of a load on the coil), the "Q" will decrease and the selectivity of the loop will decrease or broaden.

Radiation Resistance: $R_r = 3{,}38.10^{-8} \times \left(f^2 \times A\right)^2 \quad [\Omega]$ [3.1]

Circle loop area: $A = \frac{\pi}{4} D^2 \quad [m^2]$ [3.2]

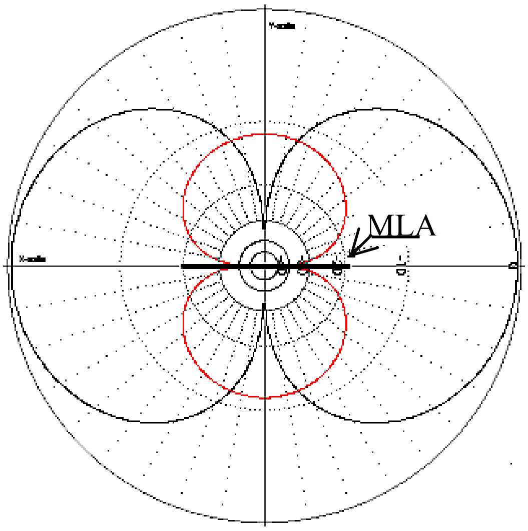
Loss Resistance: $R_L = 9{,}96.10^{-4} \sqrt{f} \frac{U}{D} \quad [\Omega]$ [3.3]

Efficiency: $\eta = \frac{R_r}{R_r + R_L}$ [3.4]

Quality Factor: $Q = \frac{X_L}{2(R_r + R_L)} = \frac{f}{\Delta f}$ [3.5]

Where:

D	is a diameter of main loop	[m]
f	is designed frequency	[MHz]
Δf	is antenna bandwidth	[Hz]



pic.3: radiation diagram **MLA**

4. . CONCLUSION

The **MLA** is an extraordinarily type of antenna. With its small proportions, retuning possibilities, great selectivity, directivity and efficiency in low height is the **MLA** an excellent portable antenna. It may be well used as indoor antenna when external antennas are not permitted. It has to be placed at least two diameters far from metal objects. Just one little drawback or complication could be a remote control of tuning capacitor.

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