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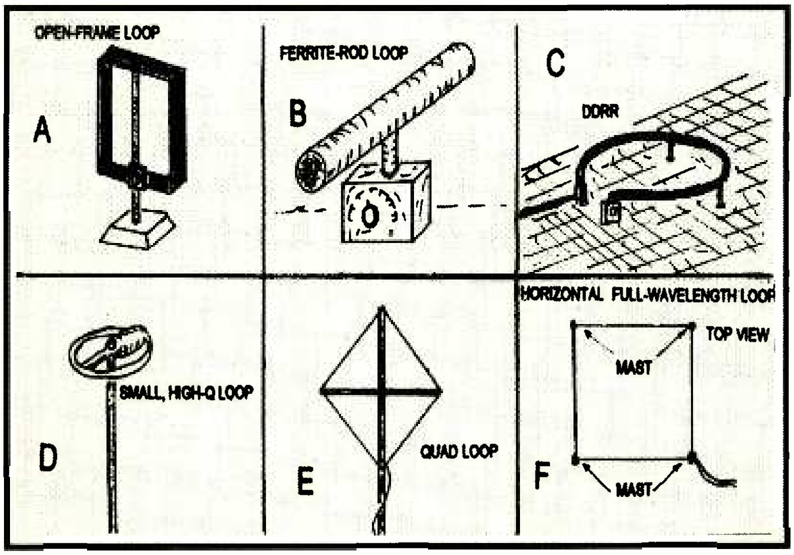
A Survey of Various Loop Antennas

Examples of loop antennas in use today are the open-frame loop, the ferrite-rod loop; directional-discontinuity ring radiator (DDRR) antennas; the small, high-Q, high-efficiency, loops; the quad loop, as in the driven element of a cubical quad beam; and large, horizontal, full-wavelength loop. All of these antennas (see fig. 1) are designed to be resonant at the planned frequency of operation. Except for the open-frame loop and the ferrite loop, all of these antennas are comprised of one single loop!

Interestingly enough we could design each of the types of antennas just mentioned to operate at a certain frequency, say 10 MHz, and find that they varied tremendously in physical size. For instance, a square, open-frame loop for that frequency could be designed measuring only a foot on each side and perhaps an inch thick at its thickest (this would be where the tuning capacitor was placed); a ferrite rod loop-antenna for this frequency might be 4 inches long, and no more than an inch thick at its tuning capacitor; a small, high-Q, high efficiency loop could have a diameter on the order of three feet with a thickness of its capacitor case of about 8 inches: a DDRR would be about 6 feet in diameter and 7.5 inches high. Both the quad-loop and the large, square, outdoor horizontal loop would measure about 25 feet per side.

Some popular loop antennas: the open-frame loop (A), the ferrite-rod loop (B), the DDRR (C), the small, high-Q, single-turn loop (D), the quad loop (E), and the full-wavelength horizontal loop (F).



With such differing sizes would these loops all perform identically? Definitely not, but they would have some things in common. Let's take a look at their common traits and also their differences.

Some characteristics of loop antennas

When the turns of a small loop antenna are in a plane vertical to the ground, its horizontal reception pattern has two nulls (directions of minimum responsiveness). These lie along a line perpendicular to the plane of the loop, and running through the center of the loop. But when the loop is mounted such that the plane containing the antenna is parallel to the ground, the antenna is omnidirectional, receiving equally well from all compass directions and having a null directly overhead. Large loops like the quad and full-wavelength horizontal loop radiate and receive maximally along a line perpendicular to the plane containing the loop and running through the center of the loop; they exhibit nulls off their edges. I have no data on the directional properties of the DDRR loop.

The bandwidth of loop antennas is determined largely by the Q, or quality factor, of the inductance and capacitance of the component parts of the antenna. Simply stated, the Q of an inductor or capacitor is based on the ratio of its reactance to its resistance; if resistance is low, Q is high. This makes sense if you consider that resistance dissipates RF energy as heat, whereas reactance allows RF energy to continue to exist as electrical and magnetic energy.

The effects of differences in antenna Q-value

All the loop antennas discussed have at least a modest Q value and are therefore relatively narrow-band devices; they require retuning for any sizable change in frequency of operation. The open-frame; ferrite-rod; small, high-Q types; and DDRR loop usually have variable capacitors to accomplish this tuning. The quad loop and large horizontal loop are tuned by making the loop itself the appropriate size.

Besides differing in size there is a large difference in Q between these various antennas. As stated earlier, most of them have a modest Q value associated with their components; however, the small, high-Q antennas and the DDRR are designed with a very high Q for their inductors (a single-turn loop); their tuning capacitors are air-dielectric types which also have inherently high Q. This results in a very high efficiency for the antenna. (Higher efficiency means that more of the received signal is delivered to the antenna's output terminals.) Thus we find the DDRR and the small high-Q antenna, which are really small compared to a full-size halfwave dipole, giving performance comparable to that of a halfwave dipole.

The dipole has a wider bandwidth than these antennas, and this is useful, but the small, high-Q loops can be constructed to tune across a much broader frequency range than the dipole's bandwidth, up to a 3 to 1 range (i.e., 10 to 30 MHz); this makes them functional over several different bands. The sharp tuning of the higher-Q antennas can be frustrating, given the time required to retune when the operating frequency is changed: on the other hand, it can be an asset in reducing intermodulation due to strong, off-frequency signals.

Some unique features of loops

The nulls of loop antennas can be put to very good use in eliminating interference. If the interfering signal or noise is coming from a direction different from that of the desired signal it may be possible to turn the loop antenna such that one of its nulls is in the direction of the interference. This will often reduce or even eliminate the interference. Small tabletop loops are popular with medium-wave DXers for just this purpose: interfering signals occupying the same channel as the desired signal can often be reduced to a degree that the desired signal can be received satisfactorily. Unfortunately, the vagaries of skywaves make the null's directional characteristics of considerably less use on the HF band.

The nulls of loops also make them quite useful as radio direction-finding antennas on LF, MF, and at VHF and above. Because the nulls are very sharp (narrow) they will indicate quite precisely the direction from which a signal is being transmitted. The antenna is held with its loops in a vertical orientation and then rotated until the received signal is at its weakest; the received station is then located somewhere along the null line of the loop. Taking two null bearings from two widely separated points (the points must not be on the null line) will indicate the exact position of the received station at the point on a map where the two null lines cross. This technique has been much used in the past.

RADIO RIDDLES

Last month:

Last month I said that "The folks who study such things are saying that we are at the bottom of the 11-year sunspot cycle." Then I asked, "Just what is this cycle and what does it have to do with propagation of the signals our antennas send and receive? And why are hams who like to work 10 and 15 meter DX, and CBers who like that illegal CB (11 meters) DX, glad to hear that the cycle is about to take an upswing?"

Well, when the sunspot cycle is at its minimum, as it is now, the ionized layers are less ionized, and thus they lose much of their ability to "skip" shortwave signals around the world. As the sunspot cycle moves toward its maximum, these layers become progressively more ionized and HF communication gets a boost, especially in those upper frequencies such as the 10, 11, and 15 meter bands.

This month:

In this jolly season can you tell me what antenna is known, perhaps not too correctly, as the "Christmas tree antenna?"

We'll have the answer to this month's riddle and much more in next month's issue of *Monitoring Times*. 'Til then, Peace, DX, and 73.

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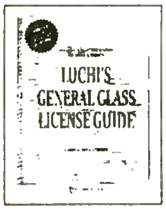

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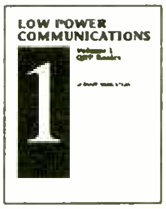

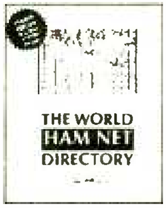

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