Antennas

Lightning and another look at small loops

PHOTO 1: A tree destroyed by lightning.

LIGHTNING. I started writing this column in a hotel in Singapore. At the time a severe electrical storm reminded me of a subject I had been considering for some time and that was how best to protect your antenna and rig from lightning.

I must confess to having a bit of a phobia regarding lightning – and for good reason. In the early 1960s, when I lived in Sierra Leone, my antenna mast was struck by lightning. The incident occurred in the early hours of the morning before daylight and I experienced a blinding blue flash with the sharp sound like a pistol shot being fired close to my ear.

All the security lights went out so I found a torch and shuffled out to the pantry, where all the electrical switches and fuses boxes were located, to reset the over-current trip. I found that all the electrical items had disappeared – with just the electrical wires sticking out of the wall where the fuse boxes and switches had been. The floor of the pantry was covered with bits of broken Bakelite and annealed copper. Furthermore, the glass envelopes of the bulbs in the security lights had all burst.

The antenna mast comprised a tapered steel 60ft steel tube supporting an all-metal 20m quad antenna. The coax feeder from the antenna to the transceiver in the outside shack had also been earthed and the equipment suffered no damage. I was intrigued to know why so much damage had been done to the mains electrical components of the house. I think the reason was that the mains supply was routed to the house on overhead wires, fairly close to the antenna.

I also had a 7MHz dipole strung between trees some distance from the house. The 50Ω RG8 feeder to this antenna had been damaged, with holes punched in the braid where it touched the ground.

REAL HIGH POWER. The power of a lightning strike is quite phenomenal. An example of damage done to a tree is illustrated in **Photo 1**. In this case, the damage was probably caused by the sap flashing off to steam and blowing the tree apart. This is a very good reason for not standing under a tree in a thunderstorm!

Although all this seems a bit scary, one has to keep the risk in perspective. G3MYA **[1]** has calculated that the chances of a direct strike on a single property works out at once every 500 years. This calculation is for average properties with perhaps a single TV antenna. Radio amateurs tend to put up larger metallic structures in their quest for better DX radio communications, which may change the odds a bit. If you have a metal tower near the centre of your property that is a few metres taller than anything else around, it should provide protection from a direct strike to your shack and house.

G3MYA recommends a short thick copper rod with a sharp point at the top be fixed to the top of the mast; it should have a good electrical connection to the mast. The base of the mast should be connected to an earth rod of 0.5in galvanised steel or, better still, a hardened copper rod or 'T' sectioned earth rod. This earth rod should be 4ft long for normal ground. I personally rely on the RF ground system, which is made up of buried lengths of old coax cable and thick electrical wire.

There is a further issue with lightning and that is EMP (electro magnetic pulse). It used to be a real problem in the days of overhead telephone wires. Telephone exchanges were fitted with protection panels comprising resistors and fuses to protect the exchange from voltages induced into the telephone wires due to nearby lightning strikes. These same voltages can be induced into your antenna system and damage the front end of your receiver. Coax spark protection devices are often recommended but I feel the best method is to disconnect the coax to the back of the transceiver if an electrical storm is imminent or if you will be away for a while.

SMALL TRANSMITTING LOOPS. Earlier this year Mike Underhill, G3LHZ, gave a lecture to the Worthing and District Amateur Radio Club on the subject of small transmitting loop antennas. He brought along a commercial transmitting loop that had been modified using a shunt coupling arrangement instead of the loop coupling supplied with the antenna.

G3LHZ connected this antenna to an IC-706 and fired up the transmitter. It must have radiated reasonably well – the next moment an irate building maintenance man put his head around the door and wanted to know who had set off the b#@&* fire alarm.

Most early descriptions of transmitting loops repeated the claim that the performance at the higher end of the HF bands could approach that of a halfwave dipole provided the loop was well constructed. In 1991, G4XVF **[2]** wrote a two part article in *RadCom* giving well reasoned doubt as to the efficiency of small transmitting loops. His study was based on calculating the Q from the measured bandwidth of a small loop whose inductance could be calculated. He concluded that the radiation efficiency was below 10%, compared with a dipole efficiency of near 100%.

However, there have been difficulties in relating these theoretical calculations with on-the-air results by radio amateurs using home made and commercial loops. In 1994, Peter Hart, G3SXJ, reviewed four models of loops from three manufactures **[3]** and was surprised at how effective these small loops could be. He noted that these loops were roughly equivalent in performance to a dipole or a multiband vertical provided they were mounted vertically and clear of electromagnetic obstructions.

G3LHZ's lecture to the Worthing club was based on material he presented to the IEE **[4]** and was centred on the commercial AMA3 loop antenna. These loops were manufactured by Advanced Antennas and Ancillaries, no longer trading. The AMA3 antenna is a German design intended for use over the range 14 to 29MHz. It is constructed from 32mm aluminium tubing and the loop diameter is 0.9m.

The loop antenna demonstrated by G3LHZ and shown in **Photo 2** has an interesting feed variation compared to the normal loop coupling. In Photo 2 the original small loop feed is disconnected and is now grounded at the feed point. The horizontal pattern has typical loop nulls, which implies there is no dominant feeder radiation. If there was, these nulls would disappear and the horizontal pattern would become omnidirectional. It is not! However, the nulls are actually displaced in a downward direction in practice. This ties up with the observation that the loop always radiates best towards the capacitor.

G3LHZ describes his work with the feed method as follows. "There are various ways of putting the twist in this 'twisted gamma' match. With 2.5mm single core PVC covered mains wire, I use either a left hand or a right hand screw winding. There is no discernable difference. There can be two different lengths of gamma wire that allow a perfect 1:1 50Ω match. With these I use a movable crocodile clip termination to fine match to 50Ω. Q and efficiency measurements show no discernable difference between the short and long twisted gamma matches. I prefer the longer gamma wire length choice. It allows the loop to be matched with an ATU for operation above its highest tuning frequency; for example for the AMA3 operation on 6m and 4m is possible. The pattern is then omnidirectional.

"The twisted gamma match shown in the AMA3 pictures has a double twist. One half is left-handed and the other half is right-handed. A coaxial cable outer conductor is used as the gamma wire. Coarse matching is achieved by altering the position of the jubilee clip. Fine matching is achieved by rotating the cable under the cable tie. (Note that any shift in tuning as the match is changed can always be cancelled by normal retuning of the loop.) Once again there is no discernable change in loop Q or loop efficiency.

"In summary, the twisted gamma matches are easier than the small loop feed to adjust to exact 1:1 SWR. In fact, the loop feed as shown does not achieve exact 1:1 SWR at all. It has to be distorted in shaped and or rotated out of the plane of the main loop. The best way of adjusting the loop feed is to make it slightly oversized and then slide the loop so that only part of it overlaps the main loop. The rest of it remains outside the main loop.

PHOTO 2: G3LHZ's AMA3 transmitting loop antenna with the 'twisted gamma' match. The original coupling loop shown is disconnected.

In terms of loop Q, bandwidth and efficiency there is no discernable difference between the various feed methods."

LOCATION. I have made the point before, that it is perhaps more important as to where an antenna is than what it is. VK5KLT, in his paper An Overview of the Underestimated Magnetic Loop HF Antenna [4] has some interesting findings and comments regarding the best location for a transmitting loop antenna. He notes, "In comparison to a vertically mounted/oriented loop, the bottom of the loop does not need to be more than a loop diameter above ground, making it very easy to site in a restricted space location. There is no significant improvement in performance when a small loop is raised to great heights; all that matters is the loop is substantially clear of objects in the desired direction of radiation! Mounting on an elevated roof ground-plane yields excellent results.

"Failure to pay very careful attention to construction details in relation to eliminating all sources of losses and making bad siting choices such as close proximity to ferrous materials are the two main reasons why small magnetic loop antennas sometimes fail to live up to their performance potential. When the loop is mounted over a perfectly conducting ground plane reflector or copper radial wire mat an electrical image is created that effectively doubles the loop area. This in turn beneficially increases the loop's radiation resistance by the substantial factor of four times.

"Conversely if the loop is placed over average ground (a reasonable reflector) the radiation resistance increases but a reflected loss resistance is also introduced due to transformer effect coupling near-field energy into the lossy ground. Similarly when ferrous/iron material is too close, the magnetic near-field of the loop will induce, by transformer action, a voltage across the RF resistance of the material, causing a current flow and associated I^2R power loss. This situation might for example arise when the loop is mounted on an apartment balcony with nearby iron railing or concrete rebar etc; the deleterious influence can be minimised by simply orienting the loop to sit at right angles to the offending iron or steel material. Another loss-contributing component is due to current flowing in the soil via capacitance between the loop and the soil surface. This capacitive coupling effect is again minimised by keeping the loop at least half a loop diameter above the ground."

REFERENCES

[1] Alan Martingale, G3MYA. Lightning, The nature of the beast and how to survive its fiery fingers. *RadCom* January 1984. Also included in The HF Collection by G4LQI.

[2] Loop Antennas- Facts not Fiction, Tony Henk, G4XVF, *Radio Communication* September/October, 1991.

[3] Loop Antennas for the HF Bands, *Radio Communicati*on July 1994, Peter Hart, G3SJX.

[4] www.qsl.net/vk5bar - go to 'Papers' and select 'Small (loop) antennas'.