Compact Electric Antennas

Carl E. Baum
University of New Mexico
Department of Electrical and Computer Engineering

Recent papers [C.E. Baum, "Compact, Low-Impedance Magnetic Antennas," Sensor and Simulation Note 470, 2002; "Symmetry in Low-Impedance Magnetic Antennas," Sensor and Simulation Note 497, 2005] introduced the concept of a low-impedance segmented-loop antenna designed to fill (in some sense) a given volume, chosen as a rectangular parallelpiped.

A logical question, related to the above, concerns what might be called the dual source. This would be some kind of electric antenna (electrically small up to about first resonance) designed to fit in the same volume. Such is the subject of this paper.

As is well known, an electrically small electric antenna radiates predominantly as an electric dipole. Not until the half wavelength $\lambda/2$ approaches the antenna dimensions, or less, do other multipole modes become significant for the far field.

This kind of antenna is roughly given by two conductors spaced far apart to give the maximum charge separation, and, hence, effective height, while making the conductors as large as possible in the transverse direction to maximize the capacitance, and, hence, the charge separated by this distance. Furthermore, one needs to create an antenna port (pair of terminals) somewhere between these conductors with electrical connections to these conductors. Note that this type of antenna is topologically two conductors separated by the source. This is quite different topologically from a loop which connects the two source terminals.

In this type of antenna, if electrically small, the extreme ends should be conducting rectangles to maximize both effective height and capacitance. Here rectangular conducting cones are assumed to connect from the antenna port to the conducting rectangles. This also gives the good high-frequency performance of a biconical antenna (now electrically large).

Consider, first, where to place the pulse power such as a Marx generator or resonant transformer. If the dipole conductors form closed volumes, we have these volumes, which are not used for the antenna, as volumes in which to place other things such as high-voltage sources, pulse forming networks, batteries, etc. So this antenna topology has another advantage. Of course, the pulse power feeds through a hole to the opposite antenna conductor. If desired, a high-impedance connection between the two antenna conductors can also be included. Any additional conductors (such as trigger cables, power lines, etc.) going between the two antennas conductors should be isolated by means of chokes along the connection path(s).

One can also have a differential source. The two high-voltage sources have opposite polarities, doubling up the voltage on the antenna. Now we need an isolated trigger-signal connection between the two antenna conductors (optical or highly impedance-loaded conductors) to fire the two pulsers at the same time.

In order to achieve a desired mesoband ringing waveform (approximate damped sinusoid) some kind of pulse forming network can be used to take the slowly rising output of the high-voltage source, and convert it to something faster. A common technique uses a transfer capacitor. In this case a high-voltage source charges a transfer capacitor C_t. In turn a closing switch feeds the antenna. For a Marx generator an isolating inductor can be used to ring up the voltage on C_t to greater than V (ideally $2V$ if $C_t \ll C_M$ (Marx capacitance)). Of course, C_t also loads the antenna and must be taken into account in designing the resonance frequency. After pulsing, the antenna needs to be discharged (relatively slowly) to prepare for the next pulse. The transfer-capacitor scheme also works well for a differential pulser. The switch now connects between the two transfer capacitors so that only one closing switch is required to fire, discharging both transfer capacitors simultaneously.

An alternate type of PFN is the switched oscillator. As a single-ended system this has much to offer. For a differential switched oscillator in this type of antenna, the requirement for two closing switches, simultaneously fired, creates a problem, since both switches have to close with a time spread Δt, between the switch firings, small compared to a quarter period of the desired resonance. This, in turn, likely requires both switches to be triggered from a common trigger signal.