A Design Method for Trap-Loaded Monopole Antennas

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Software defined radio (SDR) systems provide a flexible means for changing carrier frequency and modulation schemes on the fly. This is accomplished by implementing in software portions of the fixed hardware found in conventional radio systems. This adaptability places a burden on the antenna. As an example, public safety cognitive radios based on SDR platforms require narrow band instantaneous coverage of many sub-bands located from HF through the UHF frequencies. Basic requirements are usually a small antenna form factor, a better than 3:1 VSWR, and a monopole like pattern over the desired frequency range. In this case, the antenna must effectively operate over sub-bands contained in a section of spectrum that has almost a 30:1 bandwidth.

At least three possible design approaches exist for satisfying the specifications for a SDR antenna with the above specifications: employing a wideband antenna, using a matching network on a simple antenna and using a multiband antenna. Applying a wideband antenna in this frequency range means either a large antenna or the addition of loss in the antenna to obtain the desired impedance match over the wide bandwidth. Using an impedance matching network to match a simple monopole is also a possibility, but to impedance match over a wide bandwidth requires a network with a large number of elements, adding unwanted loss to the system. For the current problem, there are many narrow bands of interest from 30 MHz up to 900 MHz, suggesting a multiband antenna approach. A lumped element trap monopole provides such a multiband antenna solution.

A lumped-element, trap-loaded antenna is constructed by placing parallel resonant circuits, called “traps”, at appropriate positions along the length of the monopole. When a parallel circuit resonates it presents a high impedance to the current along the antenna, preventing current from proceeding past the location. A trap is chosen to resonate at a frequency that is equivalent to a quarter wavelength at the trap location. As frequency deviates from the resonant frequency of a trap the trap then behaves as a short circuit, allowing current to pass until the frequency matches the resonant frequency of one of the succeeding traps, at which point the current distribution is restricted again. The bandwidth of each sub-band is determined by the Q of the related trap.

This presentation will provide a design methodology for trap antenna design. The purpose is to develop physical insight into this specific design problem and present general guidelines, or rules of thumb, to obtain a useful trap antenna design given a specification; the guidelines will provide approximate component values for the traps as well as approximate trap positions along the length of the antenna. Tradeoffs between component values, trap positions, overall length of the antenna, sub-band impedance bandwidths, and antenna efficiency will be addressed.