An Extremely Low-Profile Ultra-Wideband Antenna with Monopole-Like Radiation Characteristics

Nader Behdad and Meng Li
Department of Electrical Engineering and Computer Science
University of Wisconsin-Madison
1415 Engineering Drive, Madison WI, 53706

Ultra-wideband (UWB) antennas have been the subject of many studies due to their widespread applications in areas ranging from wireless communications and sensing to radar systems and microwave imaging. The size of a UWB antenna is primarily determined by its lowest frequency of operation. Therefore, in applications where relatively low RF/microwave frequencies are used, the physical size of a UWB antenna may become prohibitively large. Additionally, in certain low-frequency applications such as military communications at HF, VHF, and UHF bands, antennas with monopole-like radiation patterns (i.e., vertically-polarized with omnidirectional radiation patterns) are required. In such applications, besides having compact dimensions, reducing the overall height of the antenna and its overall visual signature becomes extremely important as well.

Various efforts have been made in the past to realize compact, UWB antennas with monopole like radiation patterns. Most such antennas use a capacitively loaded monopole-like radiating structure and exploit embedded impedance matching elements (e.g. series capacitors or shorting inductors) within the body of the antenna to achieve wideband impedance matching. One major challenge in all of these designs is that the overall height of the antenna cannot be reduced easily. In particular, without utilizing lossy and resistive elements, the lowest-profile UWB antenna in this category achieves a height of approximately $0.065\lambda_0$ at its lowest frequency of operation.

In this paper, we report an ultra-wideband antenna with an extremely small overall height. The antenna is composed of two loops that are capacitively loaded with top hats to reduce their lowest frequencies of operation. Each loop has a three-dimensional surface with an optimized topology to achieve low VSWR and very low overall-profile. The two loops are fed in parallel using a power divider network that incorporates a simple phase shifting mechanism. The antenna has electrical dimensions of $0.23\lambda_0 \times 0.23\lambda_0 \times 0.033\lambda_0$, where λ_0 is the free-space wavelength at its lowest frequency of operation, and achieves a VSWR lower than 3:1 over an extremely broad frequency band. The antenna demonstrates omnidirectional monopole-like radiation patterns over a bandwidth of approximately 4:1. A prototype of the proposed antenna occupying a volume of 7 cm × 7 cm × 1 cm is fabricated and experimentally characterized in the 1-6 GHz frequency range. Details of the design process of the antenna along with the measurement results of the fabricated prototype will be presented and discussed in the symposium.