Utilizing Extremely Thin High Impedance Surfaces as Antennas

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High-impedance surfaces (HISs) have been extensively studied as effective structures to facilitate the design of low-profile antennas and improve their performance (D. Sievenpiper, et al., IEEE Trans. Microw. Theory Techn., vol. 47, no. 11, 2002). These planar periodic structures are conventionally employed as substrate for dipoles due to their ability to behave as an artificial magnetic conductor (AMC) (A.Vallecchi, et al. IEEE Trans. Antennas Propag. Vol 60, No. 1, pp. 51-62, 2012). An AMC layer is supposed to reduce the cancellation effect provided by the image of the antenna on top, which is a very detrimental effect if a horizontal dipolar antenna is simply mounted close to a ground plane. However, a deeper analysis reveals than a HIS does not act simply as a mirror.

In contrast to previously reported high impedance surfaces with a dipole on top, inspired by the work in (Guclu et al., IEEE Antennas and Wireless Propag. Lett., Vol. 10, pp. 1536-1539, 2011) and in (Pan et al., IEEE Trans. Antennas and Propagat., Vol. 62, No. 9, pp. 4439 – 4451, 2014) here we propose an extremely thin antenna comprising of only a HIS that acts as the main radiator, eliminating the need for the dipole on top, and consequently, shrinking the size of the antenna. This extremely thin antenna is composed of only two metal layers: a patterned top metal layer and a ground plane placed at very subwavelength distance under the substrate.

In the present case the unit element of the HIS layer is a dogbone shaped conductor. We provide a physical insight into the radiation mechanism of this class of HIS antennas (without a dipole on top) and prove that radiation is in part related to a TM-like leaky wave supported by the HIS in the vicinity of its magnetic resonance, with attenuation constant that is not small, in contrast to standard high-gain leaky-wave antennas. The advantage is that despite having extremely subwavelength thickness (even a 100^{th} of a wavelength) the bandwidth of such HIS antenna is not extremely small as it happens in other kinds of antennas that are extremely thin or small. We propose two possible feeding mechanisms for this HIS antenna. Moreover, by analyzing different shapes and arrangements for the unit cells of the HIS, we compare the radiation pattern and the bandwidth for each case. This development makes it possible for ultra-compact low-profile antennas operating at low frequencies, even in the ultra-high frequency (UHF) region. This HIS antenna can be used for various applications such as UHF RFID tags or mobile communications.