Harmonic-Suppressed Miniaturized-Element Frequency Selective Surfaces for Low-Observable Antenna Applications

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Frequency selective surfaces (FSS) have been the subject of numerous studies over the past couple of decades. FSSs are frequently used to reduce the out-of-band radar cross sections of antennas used on stealth platforms. Many antennas act as efficient scatterers both at the frequency band that they are designed to operate in and at other frequency bands that fall outside of the desired frequency range of operation. A typical low-observable platform may have several low-frequency antennas operating at VHF and UHF bands. These antennas will act as very efficient scatterers at higher frequencies where many search radars operate. In such applications, the RCS of the antenna can be reduced by shielding it from the outside environment using a shaped bandpass FSS that is transparent within the desired frequency of operation and opaque at other frequencies. While the aforementioned RCS reduction approach works in principle, it suffers from a practical design problem. Namely, most FSSs reported in the literature have multiple spurious transmission windows occurring at frequencies higher than that of the main one. For an FSS designed to work at a low frequency (e.g. UHF), a number of these spurious transmission windows can fall within the 1-20 GHz range where many radars operate. Thus, in such applications, suppression of the spurious harmonics of the FSS is highly desired.

In this paper, we examine a new design approach that can be used to suppress the higher-order harmonics of a low-frequency bandpass FSS. The FSS examined in this work is a second-order bandpass FSS reported previously (M. Al-Joumayly and N.Behdad, IEEE Trans. Antennas Propag., 58, 4033-4041, 2010). The proposed harmonic suppression method is based on employing dispersive lossy materials in the design of the FSS. Using such a material, the FSS can be designed to have a passband with minimum insertion loss at relatively low frequencies (e.g. below 1 GHz). However, the harmonics occur at higher frequencies, where the loss of the dispersive material increases and the structure demonstrate a significant insertion loss at these frequencies. This way, the spurious harmonics of the structure can be efficiently suppressed. A prototype of such an FSS that uses deionized water as the dispersive material is designed to have a transmission window center at 2.5 GHz. Microfluidic channels are embedded at strategic locations within the structure to minimize the impact of the loss of the water on the insertion loss at the main transmission band while maximizing it at the frequency of the first harmonic. Details of the design of the structure as well as the measurement results of the fabricated prototype will be presented and discussed at the symposium.