Equivalent Circuit Model of Different Configurations of Multilayer Loop Elements using Vector-Fitting

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A frequency-selective surface (FSS) is a periodic, planar assembly of generally metallic elements on a dielectric layer. It is built in conjunction with the EM waves in order to "tailor" an electromagnetic link in the free-space environment. Acting as a barrier for the waves propagating along the link, the FSS controls the flow of the EM energy. The transfer function of the FSS manipulates the spectral content of the wave. As a result, some of the frequency constituents of the wave are blocked, and some pass through the FSS fence. In another perspective, a FSS is analogous to a filter in circuit theory. For their filtering effects, FSS structures are also called spatial filters in EM engineering [Munk, 2000].

For more than four decades, FSS has been an important topic because of their comprehensive applications, such as polarizers, filters, sub-reflectors, hybrid radomes, etc. Unlike traditional microwave filters, the frequency response of FSS are not only functions of frequency, but also functions of incident angle and polarizations of EM waves. Consequently, it is necessary that an excellent FSS should provide stable performances for both various incidence angles and different polarizations within its operating frequencies. There is a growing demand for developing an accurate circuit model for FSS so that one can synthesize a desired frequency response (center frequency, bandwidth, insertion loss and tuning range) by an optimization method in a reasonably short time using a circuit simulator.

In this paper, we present the analysis and modeling of detailed investigation and study of different configurations of multilayer loop elements in FSS, with resonant unit cells. The elements studied are 1) Square loop, 2) Double Square loop and 3) Gridded Square loop on multilayer substrates. The simulation of such elements are performed with full wave simulation tool CST Microwave Studio [CST,2011] on single-substrate for different physical parameters, oblique incidence and effect of TE / TM polarization as well. The transmission and reflection properties of FSSs are evaluated through a simple and accurate circuit approach [Y.-C. Chung et al., 2011 and D. Singh et al.,2012] as well, which is also useful for acquiring physical insights into the working principles of FSS. Then the results obtained from the circuit model and CST simulations are compared against each other. All the equivalent circuits are designed and simulated using ADS SPICE generator [Agilent,2011].