An Empirical Formula for Resonant Frequency Shift due to Jerusalem-Cross FSS with Substrate on One Side

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Frequency selective surface (FSS) has a wide variety of applications including design of antennas, realization of polarizers, improvement of transmission for signals through energy-saving glass, synthesis of artificial magnetic conductors (AMCs) and electromagnetic band-gap surfaces (EBGs), design of spatial microwave and optical filters, invention of electromagnetic absorbers, and creation of planar metamaterials. Based on our previous research work, optimum geometrical parameters of a dual-band Jerusalem-cross FSS without substrates were quickly obtained for arbitrarily specifying two resonant frequencies (H.Y. Chen, T.H. Lin, and P.K. Li, ACES, 30-7, 717-730, 2015). The computational time of the proposed technique is less than 30 seconds for obtaining optimum parameters of a dual-band Jerusalem-cross FSS without substrates. A limitation of the proposed method is that it can be used only for the FSS constructed without substrates. It is expected that the presence of the dielectric substrate will shift the resonant frequencies downwards. In this study, an empirical formula for calculating the shifted resonant frequencies of Jerusalem-cross FSSs with different substrates is derived based on extensive calculations made on widely varying in shifted dual resonant frequencies for substrates with different relative dielectric constants and thickness. The coefficients in the empirical formula were determined by using least-square curve fitting technique to fit 672 sets of shifted resonant frequencies obtained by the HFSS simulator. Numerical results of shifted resonant frequencies obtained from the empirical formula are generally in good agreement with those calculated by the HFSS simulator. The average error in the shifted resonant frequencies is less than 5 percent. In reverse sequence, the empirical formula thus provides a simple, inexpensive, and quick method for obtaining optimum geometrical parameters of a dual-band Jerusalem-cross FSS with a substrate consisting of different dielectric constants and thickness for arbitrarily specifying two resonant frequencies.