FSS interactions in diplexers and radome structures

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Frequency Selective Surfaces (FSSs) have been used as frequency filters (e.g. diplexers for a satcomms reflector antenna system or in an aircraft sandwich radome where one of its skins is a periodic array. FSSs as flat or curved subreflectors has been used widely on dual band systems and deep space missions, like the Cassini where a design of a four frequency FSS was required (Bin Liang; Ming Bai; Hui Ma; Haibo Zhao; Jungang Miao: 'Four-band frequency selective surface with circular ring patch elements', International Conference on Microwave and Millimeter Wave Technology, 2012). Looped elements, square and circular (rings), were used to provide the necessary reflection and transmission frequencies in S, X, Ku and Ka bands. The frequency responses need to be stable with regard the angle of incidence under a plane wave illumination. This is to achieve the correct frequencies and beamwidths when a diverging beam feed illuminates the surface. The situation becomes more dramatic where the feed is required to produce a shaped beam (Wyman L. Williams and James M. Howell; 'Communications Satellite Antennas with On-orbit Pattern Flexibility', Micowave Journal, 2004). When the array is printed on a highly curved surface, as for example the FSS representing a radome, the coupling between the feed and the radome is exacerbated due to multiple internal interactions. The interactions of the FSS with their feed arrangement and to some extent the man reflector antenna cannot be ignored.

Ultra stable responses can be obtained by utilising two (or more) surfaces that are highly coupled or single layer arrays of convoluted elements. The objective is to remove, or at least reduce, the effects of grating lobes in the band of interest. Double layer arrays have been used in this context and produced good common bandwidths up to 10% for single polarisation. These are electrically thin FSS and have narrow passbands. One configuration used two closely spaced ring slot arrays with different diameters, providing dual polarised operation. Whether a reconfigurable or static structure has been used, the underlying factor has been the shift of the main resonance down in frequency from the grating lobe location. In effect, an electrically large element emerges as the result of layer coupling (or element convolution) and it would be possible to construct FSSs with radically reduced unit cell sizes, for use on curved surfaces. This paper will review some of the complex antenna feed interactions described above, with single and double FSS either in a diplexer environment or in a curved radome. Simulations will be shown from an in house MoM/spectral composed FSS code and from EMPIRE XCcel Finite-Difference Time-Domain (FDTD) commercial software of IMST.