Novel Design Paradigms in Low Profile Antenna Applications: PEC, PMC, FSS and EBG

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A perfect electric conductor (PEC) ground plane has been traditionally employed in many antenna designs. Electromagnetic boundary condition of a PEC requires that the total tangential electric field to be zero. For low profile electric wire type antennas this boundary condition imposes some limitations in achieving good designs. To circumvent PEC limitations, artificial complex ground planes with different surface conditions such as soft and hard surfaces, electromagnetic band-gap (EBG) structures, and frequency selective surfaces (FSS) on a grounded slab have been proposed. The new paradigms created by these artificial surfaces have resulted into many innovative antenna designs.

The main focus of this presentation will be on the comparison between a mushroom-like electromagnetic band gap (EBG) structure and a grounded dielectric slab loaded with periodic patches. Their electromagnetic properties will be investigated using newly developed spectral finite difference time domain technique along with the traditional FDTD by characterizing the surface wave band gaps and plane wave reflection phase properties of these surfaces. Additionally applications of evolutionary optimization techniques such as Particle Swarm Optimization (PSO) will be presented for miniaturized designs. Recent advances in antenna designs using these artificial complex ground planes will be highlighted. Representative antenna designs will be discussed to demonstrate the potential applications of artificial complex ground planes for future antenna designs.

Circularly polarized antenna: Circular polarization (CP) is desired in many wireless communication environments such as satellite systems. To obtain CP patterns, one can use a CP element like a curl near an EBG surface. An alternative way is to apply a linear dipole antenna element residing on an artificial ground plane that has polarization dependent reflection phases. The reflected wave is orthogonal to incident wave with a 90˚ phase shift so that a CP pattern can be generated.

Radiation pattern reconfigurable antenna: Reconfiguration of radiation patterns within a single radiator is a challenging task. A recent evaluation of a bent monopole near an EBG ground plane shows that this antenna structure radiates a tilted antenna beam. This feature has been successfully utilized to construct reconfigurable antennas that can switch the antenna beam either in one dimensional or two dimensions.

Surface wave antenna: A patch loaded grounded slab has the same reflection phase as an EBG surface whit no band gap for surface waves. When a horizontal dipole resides near this ground plane, it excites strong surface waves, and works more like a transducer rather than a radiator. When the surface waves propagate and diffract, a monopole type radiation pattern is generated. Thus, this antenna may be identified as a surface wave antenna (SWA) with almost equivalent patterns to a monopole but with a much less antenna height. A Particle Swarm Optimization (PSO) technique is used to achieve an optimal design for the patch loaded grounded slab.