Arrays of Sparse Sources Using Artificial Materials

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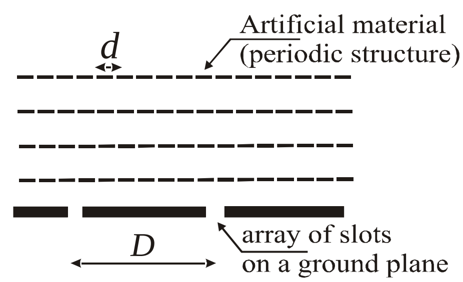
High directivity antennas are often obtained using arrays of elementary sources. In general each elementary source does not exhibit a high directivity and in order to avoid strong secondary lobes arrays antennas are designed with periodicity distances less than a wavelength. This requires in general array antennas with several individual radiators, and the inter-sources spacing to be slightly larger than the sources dimension, that does not always permits to accommodate the feeding network, implying complicated and expensive feeding lines, often developed out of the radiators plane. These problems become more critical when a dual polarization is required because it necessitates two distinct feeding networks (e.g., TV-SAT rx). It is also for this reason that we have investigated the possibility to obtain sparse arrays of elements with higher directivity to avoid grating lobes. In this arrangement, the elementary radiators are placed far apart from each other, resulting in an array antenna with lesser elements requiring a simpler feeding network and thus lower costs. This larger inter-element distance provides better and easier design solutions for the feeding network, especially in the dual polarization case.

Here we present possible implementations consisting of array of radiators placed within/under an artificial material such as a photonic band gap (PBG) structure (e.g., see the geometry in Figure), working in the transition between its transmission and stop bands. There, the material offers interesting phenomena and can be equivalently modeled as a material with low dielectric constant. This causes interesting refractive properties that are used to build highly directive source radiators [B. Gralak, S. Enoch, G. Tayeb, *J. Opt. Soc. Am. A*, **17**, 1012-1020, 2000].



The array antenna radiation pattern is obtained using the reciprocity principle, that states that an antenna has the same radiating/receiving performances, and this is independent of the complexity of the antenna system. Therefore, we will assume a plane wave illuminating the antenna system and, due to the periodicity of the artificial material, a periodic method of moments (PMoM) is used to determine the near field at the various elementary source locations. Then, simple algebraic manipulation leads to a simple formula that describes the array radiation pattern. This is achieved multiplying the data provided by the full wave method by an analytic simple formula that describes the far field interfering recombination of the array radiator contributions. When modeling the periodic artificial material by the PMoM, significant saving in the computation time is achieved when using a fast representation for the periodic Green's function to fill the impedance matrix of the PMoM, making this method advantageous also for design purposes. Particular simplified formulas for the field pattern are obtained when the periodicities of the array D_1 and D_2 are integer multiples of the periodicity integers of the artificial material d_1 and d_2, i.e., when $D_1=N_1d_1$, and $D_2=N_2d_2$. This permits to deal with the standard array factor for the sparse array multiplied by the data furnished by the PMoM. The possibility to obtain beam scanning phased arrays with such configurations is also investigated showing the limits arising from the high directivity of each array element.