Fabry-Perot Resonant Cavity Antenna: New Theory and Design Opportunity

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Fabry-Perot Antenna (FPA) is actually a one-dimensional resonant cavity to serve as a high gain radiator. This may consider as a replacement of large antenna array bearing some new features. Higher directivity is obtained through a uniform phase-front developed within the vertical cavity consists of a ground plane and a superstrate layer. The resonance condition of the cavity is maintained by adjusting its dimension as half of the wavelength of the radiating wave. A 'primary-radiator' indeed illuminates the Fabry-Perot cavity. Its high-gain characteristics are determined by this primary-radiator along with the superstrate layer. A grounded radiating aperture, a conventional microstrip patch, or a dielectric resonator antenna (DRA) having a broadside radiation pattern commonly serves as the primary-radiator in an FPA design. Traditionally, the superstrates were physically realized as partially reflecting surfaces (PRSs) such as thin dielectric slab, frequency selective surface (FSS), electromagnetic bandgap structure (EBG), artificial magnetic conductor (AMC), metamaterial, metal grid structure, etc. Their gain-enhancement mechanism used to be demonstrated in terms of reflection coefficients [1] or leaky-wave generation. Their basic concept was leakage of electromagnetic energy through the semi-transparent superstrate.

Some recent investigations [2]-[5] made by the present authors have completely changed the above notions and established a new interpretation of the mechanism of high-gain radiation supported by a new theoretical approach. This paper focuses on this new theory and its impact on new innovation and development through newer of geometries of resonance cavity antennas. We intend to address several challenging aspects which include optimizing (i) superstrate size, (ii) operating bandwidth, (iii) gain, (iv) gain-bandwidth (maintaining higher gain over the frequency), (v) radiation efficiency, (vi) polarization purity, (vii) side lobe level (SLL), and (viii) backward-radiation.

In [2], a nontransparent metal sheet (measuring ~ $\lambda\times\lambda$) was demonstrated for the first time realizing about 12.3 dBi gain over a wide matching bandwidth (23%). A typical 'inverse taper' field distribution was identified as the reason for such higher gain, although at the cost of poor SLL (~ −7dB). A more improved radiation characteristic (gain ~15.3 dBi, SLL ~ −17 dB) was achieved using an aperture synthesis technique [3]. This was realized using a single-slit metal superstrate producing a Gaussian field distribution.

An improvement in the far-field pattern (gain ~ 13.3 dBi, SLL ~ −27dB) was also demonstrated using some robust theoretical approach [4]. The corner fields of a rectangular superstrate were eliminated by reshaping of the geometry to an ellipse (size ~ $0.5\lambda\times\lambda$). This theory also helps in understanding the real contribution of the near-field parameters in the far-field pattern. However, the antenna is unable to provide higher-gain near the higher frequency band. In order to maintain the desired gain over a wide matching bandwidth, a specially designed metal sidewall has been proposed very recently [5]. Some possible innovations will also be addressed.

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