Gain Enhancement in Microstrip Patch Antennas Using Ferrite Rings

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Electromagnetic Band Gap (EBG) surfaces have been of intense interest in recent years given their ability to suppress the propagation of electromagnetic waves in a frequency band. This suppression of electromagnetic waves leads to an enhancement of the maximum gain when a microstrip patch antenna is placed above one of these surfaces. However, this comes at the expense of complexity of construction of the antennas, because many of these designs include a large number of vias. As an alternative, we are proposing a new design that uses a ferrite ring to enhance the antenna gain without compromising the antenna bandwidth.

The proposed design forces constructive interference between the incident and reflected fields inside the substrate. The interference is created by introducing a ferrite ring at a distance d_1 ($d_1 = \rho_1 - a$, a is the radius of the circular patch) from the circumference of the patch with a ring width d_2 ($d_2 = \rho_2 - \rho_1$). Initial values of d_1 and d_2 of one-quarter of the free-space wavelength ($d_1 = d_2 = \lambda_0/4$) were selected. The ferrite is maintained unbiased with a relative permeability of μ_{r2} = 14 and a relative permittivity of ε_{r2} = 10.

Using HFSS, the results of the patch antenna above a conventional dielectric substrate (i.e., no ferrite ring) and above the proposed substrate (which includes the ferrite ring) were compared. The former is referred to as the *conventional substrate* and the latter (dielectric-ferrite) as the *hybrid substrate*.

The design that uses the hybrid substrate achieves a maximum gain of 10.9 dB within the frequency range of 5.5 GHz to 6 GHz, with an average of 9.28 dB. On the other hand, the conventional substrate achieves a maximum of 6.37 dB in the same frequency range, and the average is only 4.4 dB. Clearly, the response of the propose hybrid substrate structure exhibits gain enhancement.

Another important characteristic of microstrip patch antennas is the impedance bandwidth, which in most cases is reduced as the gain is increased. However, in the proposed configuration, it is not reduced but increased. A bandwidth of 8.62% is attained using the hybrid substrate, while only 6.7% is achieved for the conventional substrate (using S_{11} = -10 dB as a criterion to compute the bandwidth). Therefore, by using the new design, an enhancement of about 2% in the impedance bandwidth is achieved.