ABSTRACT

Performance Improvement of Planar Metasurface Antenna Using Composite Materials

Typical printed microstrip based antennas used in communication systems are less efficient with limited bandwidth and are fabricated on Commercial of the Shelf (COTS) substrates. Conventional performance of printed microstrip antenna can be improved by using Metasurface on top of microstrip antennas thus providing improvement in gain and bandwidth, frequency re-configuration and switchable polarization. Use of COTS based substrates as a metasurface can be an expensive solution as compared to using low cost Glass Fiber Reinforced Polymers (GFRP) composites.

In this thesis, GFRP based composites are explored which can used as Metasurface. Multilayer GFRP based composites samples are indigenously manufactured using Vacuum Assisted Resin Transfer Molding (VARTM) technique. Samples of different number of layers with different composition are fabricated to study the effect of dielectric permittivity of the samples. With the help of screening, GFRP based composite samples is short listed for electrical characterization.

Electrical characterization of these GFRP based composite samples is done by calculating the relative permittivity (ε_r) and dielectric loss tangent ($\tan\delta$) is done in 02 steps. In the 1st step, Transmission Reflection Line Method (TRLM) is used for extracting the scattering parameters of these samples. In the 2nd step, using these scattering parameters, 02 conversion algorithms Nicholson-Ross-Weir (NRW) and New Non Iterative is used for calculating the relative permittivity and dielectric loss tangent for further used in metasurface antenna design. Improvised design of coax to waveguide adapter is also carried out which is required for using these coax to waveguide adapters which will be used for extracting the s-parameters of GFRP based composite samples.

One indigenously manufactured GFRP based composite sample is short listed based on lowest relative permittivity for the design of metasurface based patch antenna. C-band microstrip patch antenna is initially designed, optimized, manufactured and tested. Then, GFRP based metasurface patch antenna is designed and optimized for gain enhancement. In the end, an additional layer of plain GFRP sample is added up on top of metasurface patch antenna with further overall gain enhancement of 39%.

Same metasurface design approach is repeated for 2 x 4 C-band planar patch array antenna. In GFRP based planar metasurface patch array antenna overall gain enhancement of 16% is observed. In the end, GFRP based composites have shown some very promising results for future utilization in metasurface antenna applications.