

Improvement of Antenna Efficiency by Using Ferrites and Metamaterials

Abstract

This thesis investigates how to improve the antenna efficiency. The efficiency is one of the most important parameters, which describes the ratio of radiated power and the input power of the antenna. For different types of antennas, there exist different factors that can influence the efficiency. For example, in the high frequency band, the mismatch loss and small size influence much on the efficiency. In the microwave frequency band, the dielectric loss in the substrate material is the main factor. And in millimeter wave frequency band, the loss in the feeding network limits the gain and efficiency of the antenna.

Considering different influence factors, different techniques and methods are investigated to increase the efficiency. First, the compact and effective ferrites are selected to improve the HF antennas. Effective methods of using ferrites are proposed to improve at both desired frequency and a broad band. By analysing the current in the ground plane of antenna, the ferrites are arranged effectively and efficiently at the area with high current density to reduce the mismatch loss, then the current along the antenna is adjust to ensure the radiated energy. By using the methods, the mismatch loss is reduced, and the total efficiency is increased.

Second, for the microwave microstrip antenna, the metamaterial is applied to improve the efficiency. The metamaterial is able to reduce the dielectric loss in the material, even the high loss material is still used as the substrate. When the metasurface is used as the ground plane, the effective permittivity and permeability of metamaterial are analysed, and the loss in the material is decreased. Thus, the efficiency of antenna can be improved at the resonant frequency. When the metamaterial is used as the radiator, the dispersion relation is studied to analyse the wave travelling in the metamaterial. The loss is decreased, and the efficiency of antenna is improved in a broad frequency band.

Finally, for the millimeter wave antenna, the loss in the feeding network leads to small size of antenna array and low efficiency. The metamaterial is proposed to construct the feeding network instead of traditional microstrip lines. The loss is decreased, and more antenna can be contained in the antenna array. Additionally, the coupling technique is used to excite the antenna and connect the standard waveguide flange, so that the efficiency of antenna is improved. Furthermore, by etching simple slot phase shifters, the antenna array becomes beam steerable.

The three proposed methods can contribute to efficient antennas in different frequency band by reducing the mismatch loss, dielectric loss and transmission losses, respectively. The three methods can be applied alone or in combination to improve the efficiency of antennas.