Chapter 2
Design Considerations Pertaining to the Application of Complementary Split Ring Resonators in Microstrip Antennas

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ABSTRACT

Metamaterial-based design of microstrip antennas and other microwave structures have gained enormous popularity worldwide among researchers. The complementary split ring resonator (CSRR) is one of the most commonly used metamaterial structures in this direction. The CSRR structure yields a negative value of its effective permittivity at a narrow band near its resonant frequency. CSRR structure was initially proposed as a notch filtering element in microstrip transmission lines because of the negative permittivity. Later, the CSRR structure found its use in antennas and other microwave applications. The CSRR structure is reported to enhance the performance of a microstrip antenna in terms of its gain and bandwidth. In addition, CSRR structure is also used in the design of dual band antennas and antennas with integrated filters. This chapter deals with the practical design aspects relative to these applications of CSRR structures.

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INTRODUCTION

Microstrip antennas have received wide attention in the past few decades because of its small size and easy installation in portable electronic gadgets. These antennas have made contributions in the miniaturization of modern electronic communication gadgets like mobile phones, bluetooth devices, dongles etc. Theoretically, the length of a rectangular patch antenna is slightly less than half of the resonant wavelength of the antenna (Balanis, 2005). A number of novel approaches have evolved over the past two decades for improving these antennas by reducing the sizes and increasing their gain and bandwidths. A wide range of research is going on all over the world for further enhancement of the performance of the microstrip antennas.

Various approaches have been reported for the improvement of the microstrip antennas in terms of reducing size, improving far field gain, enhancing bandwidth and obtaining resonance at multiple frequencies. Some of the approaches include use of modified geometry (Gao, Li, Leong & Yeo, 2001), multilayered substrate (Lu & Coetzee, 2005), introduction of cut slots of various sizes and shapes on the patch or the ground plane (Khodaei, Nourinia & Ghobadi, 2008; Islam & Samsuzzaman, 2014; Li, Liu, & Gong, 2008), etc. Currently metamaterial based designs of high performance and low size antennas have attracted attention of researchers around the world. Metamaterials are artificial materials that have negative values of permittivity, permeability or both. In (Sigalas, Chan, Ho, & Soukoulis, 1995), authors presented a photonic band-gap structure by arranging thin metallic wires periodically inside a dielectric medium. It has been recognized as a pioneer work in achieving negative value of relative permittivity. Pendry et al. (1999) introduced negative permeability material using split ring resonators (SRR) in (Pendry, Holden, Robbins & Stewart, 1999). Ozbay et al. in (Ozbay, Aydin, Cubukcu & Bayindir, 2003) studied an alternating arrangement of thin wire grid and SRR grid to achieve double negative metamaterial.

The metamaterial unit cell structures as reported in (Pendry, Holden, Robbins & Stewart, 1999) and (Ozbay, Aydin, Cubukcu & Bayindir, 2003) were originally designed for use in electromagnetic metamaterial blocks. However, physical realization of such structures is challenging and expensive. Moreover, such blocks are bulky and hence it is difficult to use them as substrate in microstrip antennas or microstrip lines. The planar versions of these structures later became popular in the design of microstrip antennas and other microwave devices. Nowadays, the SRR structure and its different geometrical variants are extensively used in microstrip antennas. The complement of the SRR structure is known as complementary split ring resonator (CSRR). The CSRR is one of the most popular metamaterial structures reported in the present years. Figure 1 shows the planar form of SRR and the CSRR structures.

Figure 1. Illustrative topology of a planar SRR and CSRR structures