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Design of Dumbbell Shaped DGS-Notch Patch Antenna for Microwave Imaging System

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Abstract: In this paper, square Microstrip Patch Antenna with notch is designed with dumbbell shaped DGS for microwave imaging system. The antenna is designed on dielectric substrate, FR-4 with relative permittivity, ε_r = 4.7 and thickness, 1.6mm. The dumbbell shaped DGS act as the resonant structures and is placed as the ground layer of the antenna. Different location and size of dumbbell shaped DGS are simulated and analyzed. The result of return loss, radiation pattern and antenna gain are simulated using Electromagnetic Simulation Tools, fabricated and measured using Wave and Antenna Training System (WATS 2002). The design shows better performance with return loss of -38.99 dB and higher antenna gain of 6.20 dB compare to the conventional design, with return loss of -30.21 dB and antenna gain of 5.48 dB respectively.

Keywords: dumbbell, DGS, imaging, return loss, radiation, gain

1. Introduction

Microwave imaging technique is one of the medical imaging techniques that used non-ionizing electromagnetic (EM) signals to analyze the hidden tumor in the cancer area at the frequency range of hundreds of megahertz to hundreds of gigahertz [1]. The microwave imaging equipment involved the microwave source, the antennas and the radio frequency switch. The antennas play the important roles in the microwave imaging as it has the ability to transmit and receive the signal. Several studies have been outlined to improve the microwave component performance. Initially, the Photonic Band Gap (PBG) was introduced by John and Yablonovitch [2]. PBG technique used the rejection band of certain frequency that provided by the periodic structure on the ground plane. However, there are difficulties faced in the PBG structure modelling for microwave and millimetre-wave components due to the radiation from periodic etched defects, lattice spacing, lattice shape, lattice number and the fraction of relative volume [3]. Besides that, there is another technique known as Ground Plane Aperture (GPA) which has been studied for 3-dB edge coupler and bandpass filters. At the ground plane, the GPA technique can easily embrace the microstrip line embedded with a centered slot [4]. Nevertheless, the GPA width forms a critical effect on the microstrip line characteristic impedance which limits the level of return loss [5].

In order to solve the problems faced by PBG and GPA techniques, Defected Ground Structure (DGS) was proposed by Park et al. [6]. DGS is described as the closed-packed geometrical slots implanted on the microwave circuits' ground plane. A single defect or a number of periodic and aperiodic defects structures maybe comprised in DGS [7-8]. Therefore, the periodic and aperiodic defects engraved on the ground plane of planar microwave circuits are

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