Design of Compact Microstrip Patch Antenna by Using Metamaterial and its Applications

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Abstract
Microstrip patch antennas have a lot of benefits and higher aspects as compare to standard antennas. they're used for mobile applications as a result of they are lighter in weight, low volume, low cost, low profile, smaller in dimension and easy fabrication. Metamaterial is employed for planning this antenna that has negative permittivity and porosity, it's a synthetic medium with negative index of refraction. Particle Swarm optimization technique gave straightforward calculation within the style of Microstrip patch antenna and analysis the result of assorted style parameter. During this paper we tend to discuss the Microstrip antenna, its style and application of Microstrip patch antenna with their advantage and drawbacks over standard microwave antennas.

Keywords
Microstrip patch antenna (MPA), Metamaterial, SRRs (Split Ring Resonators), Rods, Permeability, Permittivity, Return Loss.

I. Introduction

A microstrip patch antenna is a low profile antenna that has some of benefits over other antennas. Microstrip antenna has many applications in different fields because of its compact length. A microstrip antenna in its handiest form includes a radiating patch on one aspect of a dielectric substrate and a floor plane on the opposite side. The radiating elements and the feed lines are commonly photo etched on the dielectric substrate [2]. The microstrip patch antennas are usually used because the Wi-Fi gadgets. "Metamaterials are defined as macroscopic composites having a man-made, three dimensional, periodic cell structure designed to produce an optimized mixture, now not to be had in nature, of two or greater responses to a specific excitation [4]." For true antenna overall performance, a thick dielectric substrate having a low dielectric constant is ideal considering this presents better efficiency, large bandwidth and higher radiation [3]. Microstrip antennas in its only configuration are proven in Fig. 1. It includes a radiating patch on one facet of dielectric substrate ($\epsilon r \leq 10$), which has a floor aircraft on other facet [1].

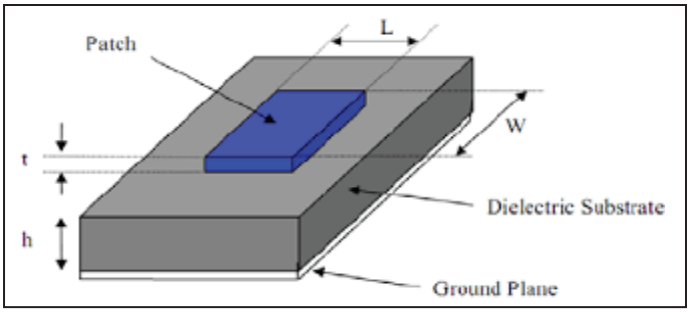

Fig. 1: Microstrip Antenna Configuration

II. Metamaterial

Metamaterial is the synthetic substrate that did no longer exist in the actual nature. Metamaterial were categorized structure or layout that has the simultaneously bad permeability and permittivity. This metamaterial shape can drastically supply impact to the utility that were designed. Fantastic Permeability and permittivity are the primary properties of traditional substances to be had in nature called as Double tremendous (DPS) materials. Metamaterials are termed as Double terrible (DNG) materials due to the property of negative ε and μ [2]. Metamaterial shape consists of cut up Ring Resonators (SRRs) to provide poor permeability and skinny twine elements to generate terrible permittivity. SRR is a singular layout together with concentric rings with a split on every ring. The shape is called resonator since it exhibits a sure magnetic resonance at a positive frequency. Break up ring resonators can bring about a powerful bad permeability over a selected frequency place. The SRR shape is inductance and capacitance that can be excited via a time-various external magnetic subject issue of normal fashioned by means of concentric steel jewelry with a cut up on opposite facets. This behaves as an LC resonator with dispensed direction of resonator. This resonator is electrically small LC resonator with a high great component [2]. Specific design methods used for reducing length of patch antennas are inserting slots, the corrugation shape, iris shape and the shorting pin. However those antennas designing methods having complicated structures and feature low overall performance. Lately designed techniques used for reduction of length of patch antenna are to introducing SRR and CSRR on patch antennas which having easy structures and higher overall performance also [5].

II. Basic Antenna Design

This layout became proposed by way of Marques basically include a steel patch suspended over a floor aircraft. The microstrip patch antenna is constructed at the dielectric substrates like FR4, Taconic or Duroid. Microstrip patch is the primary antennas that can be applied in diverse packages like Wi-Fi local area network (WLAN), global Interoperability for Microwave access (WiMax), and others. The microstrip patch antennas were fed either with the aid of microstrip line or a coaxial probe through the ground aircraft by distinct strategies. Parent 1 indicates the schematic diagram of the basic microstrip patch antenna layout. This layout is simulated in CST Microwave Studio simulation software program. The focused on frequency of this antenna is 2.4 GHz.

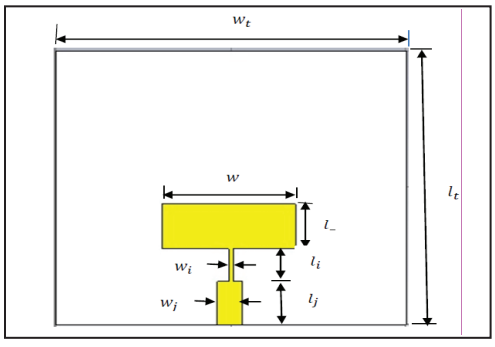

Fig. 2: Microstrip Patch Antenna Design in CST Microwave Studio Simulation Software

Table 1 suggests the size of the normal microstrip patch antenna. The antenna has three predominant elements – patch, feed and feed cease element. Feed line is positioned at the lowest of the antenna, related the patch and the supply signal (waveguide port).

Table 1: Dimension of Normal Microstrip Patch Antenna Design

Parameters	Dimensions (mm)
l_t	40
w_t	40
l	11.35
w	15.25
l_i	4.90
w_i	0.50
l_j	6.15
w_j	3.5

The four maximum popular feed techniques used are the microstrip line, coaxial probe, aperture coupling and proximity coupling [5].

Return Loss:- Return loss is the loss of power in the signal returned/reflected by a discontinuity in transmission line or optical fiber. It is usually expressed as the ratio in decibels (dB),

$$\text{RL (dB)} = 20\ log_{10}\ \frac{SWR}{SWR-1}$$

Where RL (dB) is return loss in dB, and SWR is Standing Wave Ratio.

By using the equation, BW $=\left[\frac{f2-f1}{fc}\right] \times 100\%$, Impedance [5]. Bandwidth over return loss less than -10dB can be calculated, where $f1$ is lower cut off frequency, $f2$ is upper cut off Frequency of Band and fc is center frequency of $f2$ and $f1$ [5]. The simulated return loss characteristics of proposed antenna is -25.688 dB at 4.864 GHz which is less than the -2.688 dB[5].

IV. Applications

The blessings of this Microstrip patch antenna are to triumph over their de-merits consisting of clean to layout, mild weight etc. The packages are inside the various fields together with inside the medical applications, satellites and of direction even inside the army structures much like inside the rockets, aircrafts missiles etc. Some applications are discussed as below:

A. Mobile Communication

Mobile communication calls for small, low-price, low-profile antennae. In a few mobile handsets, semiconductor-based totally diodes or detectors are used as antennae. They may be just like p-n diode photograph-detectors however paintings at microwave frequency. Commonly omnidirectional antenna is used in mobile phones. There are unique forms of antennae like planar inverted-F antenna, folded inverted conformal antenna and mono pole. Also retractable whip antenna is usually used in handsets.

B. Medical Applications

In the treatment of malignant tumors, microwave energy is said to be the most effective way of inducing hyperthermia. The radiator to be used for this purpose should be light-weight, easy to handle and rugged. Only a patch radiator fulfills these requirements.

C. Textile Antennae Recent Research

There are some applications at present where antennae are used to continuously monitor biometric data of the human body. In order to do this, they need to be so close to the human body all the time that they can continuously monitor the biometric data and send the information to the outside world. If the antenna is hard, it cannot be kept always attached with the human body. An antenna made of textile material will not harm the human body and can be worn for extended periods. Wearable antennae will find use in healthcare, recreation, fire-fighting, etc.

D. Global Positioning System Applications

Nowadays microstrip patch antennas with substrate having high permittivity sintered material are used for global positioning system. These antennas are circularly polarized, very compact and quite expensive due to its positioning. It is expected that millions of GPS receivers will be used by the general population for land vehicles, aircraft and maritime vessels to find their position accurately [1].

E. Worldwide Interoperability for Microwave Access (WiMax):

The IEEE 802.16 standerd is known as WiMax. It can reach up to 30 mile radius theoretically and data rate 70 Mbps. MPA generates three resonant modes at 2.7, 3.3 and 5.3 GHz and can, therefore, be used in WiMax compliant communication equipment [1].

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