ISSN 2250-3153

Simulation of a Rectangular Patch Antenna with Polyolefin Substrate from Wasted Materials by Zeland IE-3D

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Abstract- Utilization of different wasted materials for the development of microstrip antenna segment has been rapid due to the recent miniaturization of wireless devices. In this paper, we have simulated a coaxial fed rectangular microstrip patch antenna for all those communication systems whose limited antenna size is premium. Low permittivity polyolefin has been used as substrate to achieve wide bandwidth. The Polyolefin can be collected form wastes of pipes, cables which will be a step towards recycling of unused pipes, cables etc. The simulation of this proposed antenna has been performed by using IE3D software, which is the first SCALABLE EM design and verification platform that delivers the modeling accuracy for the combined needs of high-frequency circuit design and signal integrity engineers across multiple design domains. This research will therefore contribute to a new generation of with extensive functionalities.

Index Terms- Di-electric constant, Microstrip patch antenna, Polyolefin, Return Loss, Wasted Materials.

I. Introduction

Microstrip antennas have great use in research and development due their simple constructional structure.

are attractive due to their light weight, conformability and low cost. These antennas can be integrated with printed strip-line feed networks and active devices. This is a relatively new area of antenna engineering. Rectangular and circular micro strip resonant patches have been used extensively in a variety of array configurations. Development in large scale integration and miniaturization in electronic circuit has a vast effect in advancement of antenna design with very small size.

Polyolefins are the largest group of thermoplastics, often referred to as commodity thermoplastics, they are polymers of simple olefins such as ethylene, propylene, butenes, isoprenes, and pentenes, and copolymers and modifications thereof. Polyolefins are used in a wide variety of applications, including grocery bags, containers, toys, adhesives, home appliances, engineering plastics, automotive parts, medical applications, and prosthetic implants [1].So there is a large number of waste materials (e.g. wastes of toys, engineering plastics, automotive parts, Wire & Cable, Cable Jacket etc.) from where we can easily get the polyolefin and use as the substrate of our patch antenna. So in this paper, we have focused on the waste material for the selection of dielectric substrate. The paper will contain complete design flow and substrate material selection specifications.

II. BASIC PATCH ANTENNA GEOMETRY

In its most basic form, a microstrip patch antenna has mainly three layers: (a) ground plane,(b) dielectric substrate layer,(c) radiating patch. The ground plane and the patch is made of any conducting material like copper, silver, gold etc. whereas the dielectric substrate layer is made of insulating material. The substrate is sandwiched in between the ground plane and the patch as shown in Fig1. [2] The shape of the patch may be any possible shape. By photo etching method the radiating patch and the feed lines are etched on the dielectric substrate.

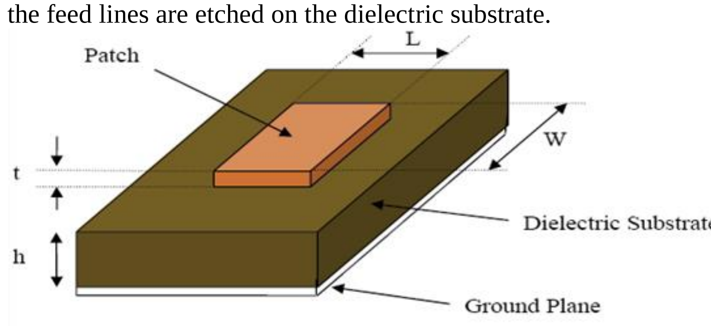

Fig. 1. Microstrip Patch Antenna

Here the rectangular shape has been used [3]. For a rectangular patch, the length L of the patch is usually 0.3333 $\lambda_0 > \lambda_0 <$ 0.5λ_0, where λ_0 is the free-space wavelength. The patch is selected to be very thin such that t <<λ_0(where t is the patch thickness). The height h of the dielectric substrate is usually 0.000$\lambda \leq$ h $\leq$ 0.05λ_0. The dielectric constant of the substrate (ε_r) is typically in the range 2.2 $\leq \varepsilon_r \leq$ 12. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna size. In order to design a compact Microstrip patch antenna, higher dielectric constants must be used which are less efficient and result in narrower bandwidth

[4]. Hence a compromise must be reached between antenna dimensions and antenna performance.

III. DESIGN METHODOLOGY

We have followed few steps to design the rectangular shaped microstrip patch antenna. The steps as follows:

1.Design Criteria

Our goal was to design and simulate a coaxial-fed rectangular Microstrip Patch Antenna and study the effect of antenna dimensions Length (L), Width (W) and substrate parameters relative Dielectric constant (ε_r), substrate thickness (h) on the Radiation parameters of bandwidth.

1.1 Material Selection

To design an antenna, substrate-related parameters such as thickness h, electrical permittivity, loss tangent have to be defined. Apart from the thickness (1mm for Polyolefin), the values of these parameters are unknown for any given material in this high frequency range. Therefore we first designed simple rectangular antenna having the dielectric constant and thickness of polyolefin for getting simulated result.

1.2 Antenna Design

In order to identify and verify the improvement for rectangular structure in microstrip antenna, the conventional Microstrip antenna design method is used [5].

Design steps:

Designing the patch antenna is to employ the following formulas as an outline for the design procedures.

Width (W):

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}} \quad (1)$$

Where;
c - Free space velocity of light, 3 x 10^8 m/s
f_r - Frequency of operation
ε_r- Dielectric constant

Effective Dielectric constant (ε_{reff}):

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\sqrt{\left[1+12\frac{h}{w}\right]} \quad (2)$$

Where;
c - Free space velocity of light, 3 x 10^8 m/s
f_r- Frequency of operation
ε_{reff} - Effective dielectric constant

Patch length extension (ΔL):

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (3)$$

Actual length of patch (L):

$$L = L_{eff} - 2\Delta L \quad (4)$$

Antenna Dimensions & Parameters

Dimensions / Parameters	Value
Length of the radiator patch (L)	8.32 mm
Width of the radiator patch (W)	11.64 mm
Thickness of substrate (h)	1 mm
Relative dielectric constant (ε_r)	2.32
Resonant Frequency (f_0)	10 GHz
Loss Tangent ($\tan\delta$)	0.01

IV. SIMULATION &RESULT

Software Used

We have simulated the designed antenna using software IE3D, which is an integrated full wave electromagnetic simulation and optimization package for the analysis of 3 dimensional microstrip antennas and MMICs and PCBs. It was introduced in 1993 by MTT-Symposium.

The result content of the paper is S-parameter. S-parameters describe the input output relationship between ports (or terminals) in an electrical systems.

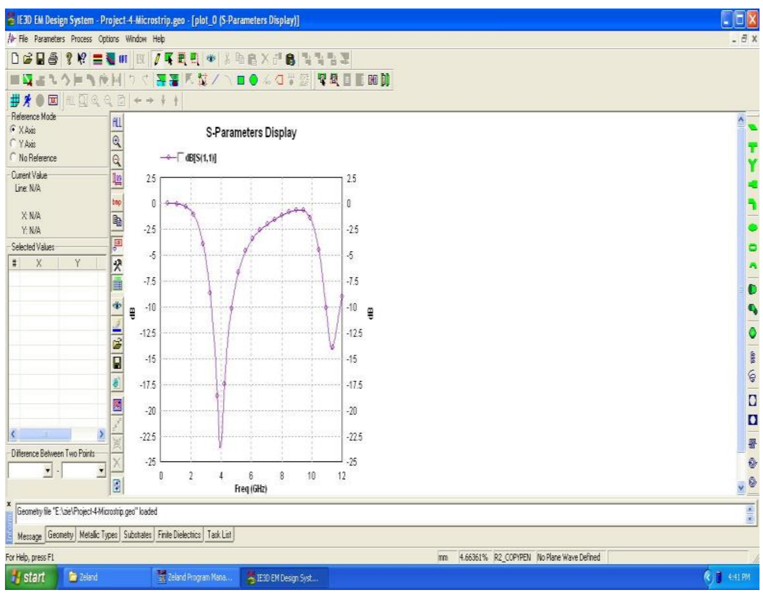

Fig. 2. Return Loss plot in IE3D Simulator

The simulated patch antenna gave a resonant frequency of 4 GHz. The simulated return loss curve is shown in fig 2. It is shown useful return loss peaks at 4GHz is - 23.5dB, 11.4 GHz is -14.2dB. The lower-band bandwidth (< -10dB) is 1.33 GHz, that extends from 3.34 GHz to 4.67 GHz.

V. CONCLUSION

The performance of microstrip Antenna is mainly depend on its structure. The resonance frequency of the Microstrip antenna depends on their dimensions of the patch, on the substrate material as well as its thickness and on the feed line. The modeling of antenna using the IE3D software is essential for the variation of the shape of the antenna, the substrate nature and thickness in order to obtain a structure which resonance frequencies wished. A small variation of each of these parameters influences the resonant frequency. Also we have used polyolefin as substrate material which we can get from the wasted and unused pipes, cables or wire jackets. So recycling of wasted pipes, wire jacket can be used as the substrate material to fabricate patch antenna which will be a good idea.

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