Slotted Antenna in Different Substrate: The state of the Art and a Review

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Abstract- **Selecting the proper dielectric material as a substrate is vital in the construction of a Microstrip slot antenna. By choosing the right substrate material, it is possible to overcome the drawbacks of microstrip antennas, such as low efficiency, high Return Loss (S_{11}), and Low Gain. This is because the substrate's permittivity is a crucial factor in regulating the antenna efficiency, radiation pattern and antenna gain. This paper presents various substrates for a slotted compact microstrip antenna. Various substrate variations are used in the current work, which is done for wireless applications. In terms of dielectric constant and loss tangent, the substrate materials have two fundamental characteristics. Coaxial probe feeding is employed in the proposed design. It is explored in detail how different types of dielectric materials affect slotted structures in terms of radiation properties like resonating frequency, Gain, Return loss (S11), Current distribution, Radiation pattern. Here, zero loss tangent dielectric materials have been chosen.**

Keywords-Dielectric constant, Patch, Loss tangent, Substrate

1. INTRODUCTION

In modern communication systems, due to their frequency spectrum and multiband features, compact-sized antennas are in high demand [1]. Researchers are investigating on Microstrip antennas that are affordable, compact, low-profile, and conformal. For the design of a low-cost antenna, several methodologies and technologies were implemented. To attain a wide frequency spectrum, we developed a distinctive structure that may be challenging to fabricate. To maintain the antenna's low-cost, we usually use low-cost substrate materials, which are crucial in patch antenna design [2].

The substrate in a microstrip antenna is principally responsible for the antenna's mechanical strength [3]. The dielectric used is also responsible for the antenna's diminished electrical characteristics since the surface waves generated on the dielectric eliminate a small portion of the total power available for direct radiation (space waves). The substrate utilised in the design of a microstrip antenna has a significant impact on the cost of production [12]. As a result, when choosing a substrate, care must be given to ensure that the Antenna's electrical and mechanical requirements are fulfilled [4-6].

Dielectric constant and loss tangent are factors that are taken into account while choosing a dielectric, as well as their variations with temperature and frequency, homogeneity, dimensional stability, and other substrate characteristics [7-8]. The bandwidth of a printed patch can be increased by utilising an extensive substrate with a low dielectric permittivity. As the antenna's input impedance's inductive image component rises, it becomes more difficult to incorporate the antenna with other microwave circuits and more difficult to produce resonance.

In this paper, we designed a small slotted antenna and test it on a variety of substrates with the same structure.The mechanical strength of an antenna is provided by any form of substrate, and the substrate is the most significant task in a microstrip antenna. We employed different dielectric materials namely FR4 epoxy, Rogers RT/duroid 5880 and Rogers RT/duroid 6010 with dielectric constants 4.4, 2.2 and 10.2 respectively, conducted research and simulated the design using commercial HFSS software on antenna characteristics in the proposed structure.

2. ANTENNA DESIGN

Figure 1 depicts the proposed slot antenna model. The proposed antenna's compact structure is based on a slot configuration. The proposed antenna consists of a slot structure printed on a 1.5 mm thick FR4 epoxy substrate with a loss tangent of 0.03 and a dielectric constant of 4.4. The dimensions of the slotted antenna are 30 x 30 x 1.5 mm^3 and the size of the patch: 20 x 11 mm^2.

3. RESULTS AND DISCUSSION

The proposed antenna is simulated and observed on FR4_Epoxy, Roggers RT/duroid 5880, and Roggers RT/duroid 6010 substrates with dielectric constants of 4.4, 2.2, and 10.2, respectively. The proposed antenna's return loss is depicted in Figure 2. It is clearly evident that the proposed antenna achieved return loss (S_{11}) of -20.27 dB at 4.46 GHz resonating frequency.

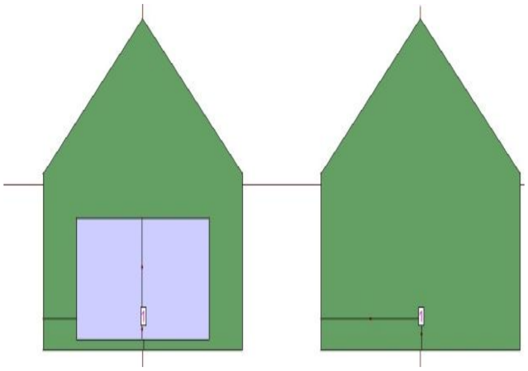

Fig.1: Top-view and Bottom-view of the Proposed Antenna

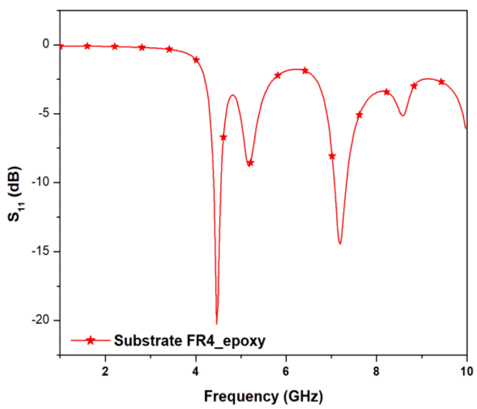

Fig.2: Antenna return loss (for FR4_epoxy)

With a Roggers RT/duroid substrate and a 2.2 dielectric constant, Figure 3 shows the return loss of an antenna. The return loss (S_{11}) for FR4 epoxy is significantly higher than Rogers RT/duroid 5880 for the same operating frequency, as shown by the simulation results.

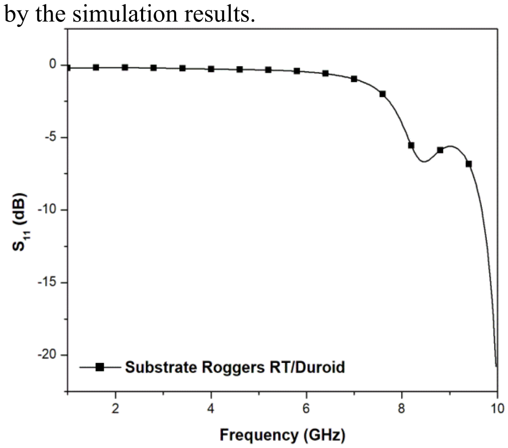

Fig.3: Antenna return loss (for Roggers RT/Duroid 5880)

Low values of the dielectric constant are preferred for high frequency or power applications to minimise the loss of electric power. The antennas' return loss for the Roggers RT/duroid 6010 with a dielectric constant of 10.2 is shown in Figure 4. It is clear that the proposed antenna performed less effectively in terms of return loss when compared to the FR4 epoxy dielectric material, achieving -24.06dB S11 at 9.8 GHz.

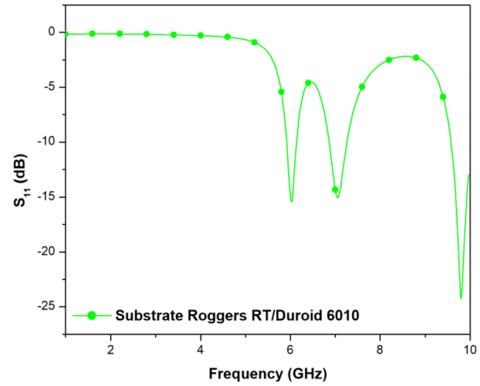

Fig.4: Antenna return loss (for Roggers RT/duroid 6010)

Figure 5 shows the comparative plot between the gains of the antenna designed with different substrates and the gain of 5.1 dBi is observed for the proposed antenna with dielectric constant 4.4.

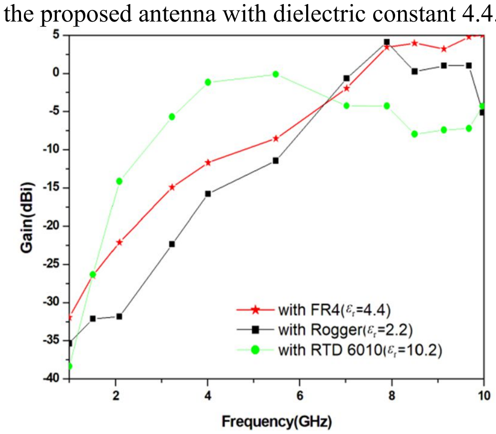

Fig.5: Comparison plot of Gain (dBi) vs. Frequency(GHz)

Figure 6 illustrates the smith chart of the proposed antenna

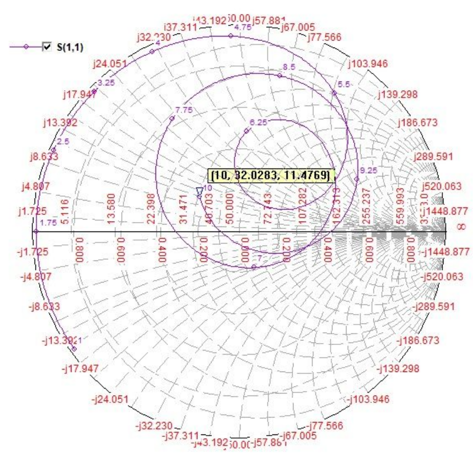

Fig.6: Smith chart of the proposed structure

Figure 7 depicts the current distribution on the surface.

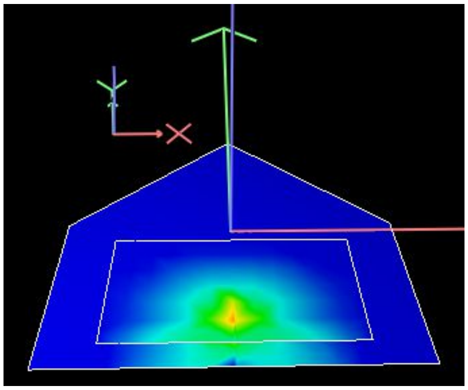

Fig.7. Current distribution of the proposed antenna

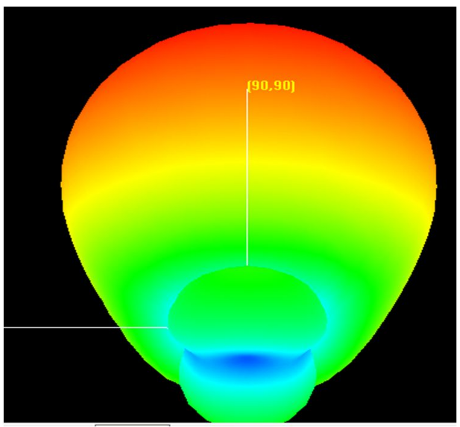

Fig.8: Radiation pattern of the proposed antenna

Fig. 8 shows the radiation pattern that was measured. Good radiation performance and the major lobe orientation in the theta plane were attained in the simulated results of the designed antenna.

4. CONCLUSION

The objective of this study was to test whether different substrate materials affected the performance of a proposed antenna. Three different substrate materials are chosen and simulations are performed. The proposed antenna's simulated results on an FR4 substrate are compared to the results obtained using Rogger RT/duroid 5880 and Roggers RT/duroid 6010.
The proposed antenna's behaviour is compared to that of various substrate materials. The simulation results showed that the gain of the suggested antenna using the FR4 epoxy substrate gradually increases, reaching a maximum gain of 5.1 dBi at the frequency of 9.5 GHz. The proposed antenna attained a return loss of return loss (S11) of -20.27 dB at the resonant frequency of 4.46 GHz.

5. ACKNOWLEDGMENT

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