PERFORMANCE ENHANCEMENT OF RECONFIGURABLE MICRO STRIP PATCH ANTENNAE USING METAMATERIALS

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Abstract— Micro strip reception apparatuses are broadly utilized in wireless applications as a result of its simple design, compactness and economical. These small scale strip fix receiving antennas are made utilizing materials like FR4, Rogers RT duroid. These common materials are being supplanted with a helpful material named as Meta materials. These materials are unnatural materials having non-indigenous properties which are controlled with basic properties for the acquirement of updated properties. This whole procedure work with heterogeneous kinds of reconfigurable small scale strip fix receiving antenna utilizing Meta materials. Thus the exhibitions of smaller scale strip reception apparatuses are superior to whatever other conventional radio wires which likewise fill in as inconceivable use for receiving antenna geeks and architects. The dynamic tuning of such receiving antenna parameters is commonly accomplished by changing the switch conditions. A solitary model can be utilized to help various capacities at different recurrence groups. Objective is to plan a reconfigurable micro strip patch antenna which works at four unique frequencies in X-band and Ku band. The reproduced reception apparatus emanates at five unique frequencies of 5.48 GHz, 9.88 GHz, 11.32 GHz, 12.68 GHz and 15.08 GHz and has an arrival loss of -24.6103 dB, -15.095dB, -24.6103 dB, -30.0870 and -30.8473 dB individually. And afterward it is manufactured utilizing FR4 as substrate and afterward it is observed to be in great match with the reproduced comes about.

Keywords: Antennae, Micro strip patch antenna, DGS, Meta Material, HFSS.

1. INTRODUCTION

In the world moving towards being wireless, antennas play a vital role in converting an electrical quantity into electromagnetic wave that radiate and propagate in space from a transmitting antenna, and at the same time on the receiving end some of the transmitted power that the receiving antenna intercepts is converted into an electric potential that is proportional to the transmission. Such a requirement of energy conversion is done by the antenna that has improved a great deal over the years at the end of the transmitter and at the receiver or in a transceiver.

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The microstrip patch antenna is a type of narrow band radio antenna which is designed on the microstrip line basis. The increased usage of microstrip antenna in various industries as it can be printed directly onto a circuit board. Due to its planar configuration and ease of integration with microstrip technology, the microstrip antenna proves to be the compact structure and can be widely used in modern wireless transmitters and receivers.

2. ANTENNA DESIGN

The proposed design is etched on standard FR4 substrate that has relative permittivity 4.4 and loss tangent 0.02. The thickness of the substrate is taken as 1.6 mm and metamaterial structure is used on the ground plane in order to increase performance characteristics of the proposed antenna [9]. In this design defected ground structure is used in the bottom layer whose length is equal to the length of the feed line which is used in the top layer with the structurally modified radiating patch layer as shown in the figure 1.1. In the ground layer, Split Ring Resonator as a metamaterial is used along with DGS [1]. Inverted T shaped slots help to achieve a higher level of frequency with reduced dimension. The addition of capacitive loading patch segments provides impedance matching.

The inclusion of the inverted T slot and small rectangular capacitance slots modifies the structure of the smooth radiating patch layer causes an impedance mismatch. This can be resolved by the attachment of Split Ring Resonator on the top of the ground structure and keeping the remaining portion as it is according to the calculation [2]. Therefore the narrow band output with appreciable gain and directivity is obtained in the designed resonance frequency as well as additional resonance frequencies are also produced by the parasitic capacitance effects due to structural modifications at the top and ground layers [3].

![Figure 1.1:- HFSS 3D design structure of proposed antenna](image)

3. ANTENNA DESIGN STRUCTURE AND WORKING PRINCIPLE

The antenna structure designed and considered in this case is a slotted structure with a detective ground and the effect if the dipole structure and the defective ground are studied to observe its property. From the figure 1.2 the ground plane has the split ring resonator that exhibits isolated sections of the ground coupled by the inductive nature of the substrate. This approach makes it possible to have a resonant circuit that is inductively coupled through the radiating patch [4]. The radiating plane is made up of a patch of 15.21*11.3 mm and has an inverted T shaped slot etched into it. The 3 mm feeder line is connected to it and has the ground plane unaltered below the feeder line. The rest of the ground structure is the slotted split ring that completes the base. T patch is built using FR-4 Epoxy board that is double sided with the radiating patch etched on the top surface and the slotted ground below.
4. RESULTS AND DISCUSSIONS

In order to analyse the performance of an antenna, the important aspects that always be considered in the design antenna such as VSWR, Return loss, Gain and directivity of the antenna. Thus, all the desired simulation result parameter of the patch antenna as mention above can be implemented by adjusting the antenna ground plane length; antenna feed length, feed width, substrate material, thickness [10].

Return Loss

The return loss is the figure-of-merit of an antenna. It can be observed as the proportion of radio waves incoming at antenna input that are reprobated as the ratio against the radio waves that are accepted. It is commonly specified in decibels (dB). The Figure 1.3 shows, the return loss graph of the proposed antenna modelled with the operating frequency of 5.5GHz. The observed return loss is -21.3192dB with the centre frequency of 5.48GHz, marked as ‘m1’. This indicates that approximately 96.25% of power is transmitted by the antenna and remaining 3.75% of power is reflected. Thus, the bandwidth calculated from the return loss graph at -10dB level is 5.35-5.60GHz, which signifies 250MHz. Similarly, the same antenna has additional peak resonant frequencies at 9.88GHz, marked as ‘m2’ with the maximum return loss of -15.095dB.

Figure 1.2: Defected Ground layer (Meta material based) of proposed antenna

Figure 1.3: Return loss versus Frequency
Both 11.32GHz and 12.68GHz, considered as same band between markers ‘m3’ and ‘m4’, have below -10dB return loss of -24.6103dB and -30.0870dB. Finally, 15.08GHz is marked as ‘m5’ with the maximum return loss of -30.8473dB respectively. The -10dB bandwidth calculated for the above bands are 190MHz (9.81-10.00GHz), 2.14GHz (11.08-13.22 GHz) and 1.2GHz (14.35-15.55GHz). Thus the proposed structurally modified antenna provides a wide range of bandwidths for covering many wireless applications [11].

VSWR

VSWR is a measure of how an antenna is matched well to the cable impedance. It describes how much power is reflected back or transferred into the cable, with its value acting as a function of reflection coefficient [5]. A perfectly matched antenna will have a VSWR of 1:1. From the figure 1.4, the obtained VSWR values are 1.188, 1.4269, 1.1250, 1.0646 and 1.059 at the corresponding resonant frequencies of 5.48GHz, 9.88GHz, 11.32GHz, 12.68GHz and 15.08GHz respectively. Thus the antenna impedance is well matched with cable impedance and it is qualified of achieving effective transmission and reception, accomplishing 96.25% efficiency at above frequencies.

Figure 1.4: VSWR versus frequency

Gain and Directivity:

The overall efficiency of an antenna can be calculated from total gain and total directivity through the imbibed Figure 1.5. The proposed antenna, yields an outcome of peak recognized total gain and total directivity at 3.0489dB and 3.1674dB respectively. Efficiency calculated as follows

\[
\eta = \frac{\text{TotalGain}}{\text{TotalDirectivity}} \times 100 = \frac{3.0489}{3.1674} \times 100 = 96.25\%
\]

(1)

Figure 1.5: Gain and directivity
5. **OPTIMIZATION APPROACH PROCEDURE**

| Property   | Optimization-1 | Optimization-2 | Optimization-3 | Optimization-4 |
|------------|----------------|----------------|----------------|----------------|
| Design     | Patch Ground   | Patch Ground   | Patch Ground   | Patch Ground   |
| Return loss\(1,1\) | -5.59dB  | -11.7dB        | -18.7dB        | -28.5dB        |
| Gain       | 2.5dB          | 2.59dB         | 3.5dB          | 3.5dB          |
| Directivity| 3.45dB         | 2.76dB         | 3.82dB         | 3.75dB         |
| Efficiency | 72.4%          | 99.76%         | 90.9%          | 95.73%         |

From the optimization approach procedure it is observed that with the use of notch on the radiating layer and metamaterial structure on the ground layer the performance characteristics of the antenna have been increased with good efficiency, gain and minimum return loss[6].

![Fabricated antenna](image1)

Fig1.6:- Fabricated antenna a. Top layer, b. Ground plane

From the figure 1.6 the fabricated antenna has two parallel dipoles separated by a patch that has an inverted T shaped slot that is connected to the slotted grounded plane through the substrate. This structure is etched on a double sided fiber board that is porous to act as a material that has its dielectric property un-uniformly loaded to help match the impedance of the antenna [7].
6. MEASURED RESULT

The proposed fabricated antenna is tested using the network analyzer and the measured result is shown in figure 1.7. For the measured result it is observed that peak resonance is obtained at 5.46 GHz, 10.11 GHz, 11.8 GHz and 14GHz with the return loss value of -35.34 dB, -22.31 dB, -15.17 dB and -10.10 dB.

Fig 1.7:- Measured result of fabricated antenna

| Simulated | Measured |
|-----------|----------|
| Observed (Center) Resonance frequency (GHz) | Return loss (dB) | Observed (center) Resonance frequency (GHz) | Return loss (dB) |
| 5.48      | -24.6103 | 5.46      | -35.34 |
| 9.88      | -15.0950 | 10.11     | -22.31 |
| 11.32     | -24.6103 | 11.8      | -15.17 |
| 12.68     | -30.0870 | 14.00     | -10.10 |
| 15.08     | -30.8473 | -        | -       |

7. CONCLUSION

The Impedance mismatching is resolved by the structural modification carried out in both radiating patch and ground layer. Switching loss totally removed (highly minimized) and very sharp resonance frequency with narrow band is achieved with the design. Thus the proposed structurally modified antenna provides a wide range of bandwidths for covering many wireless applications such as Wi-Fi, Bluetooth, Wi-Max, WLAN and the antenna impedance is well matched with cable impedance and it is qualified of achieving effective transmission and reception, accomplishing 96.25% efficiency at above frequencies.

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