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# RECONFIGURABLE MICROSTRIP STACKED ARRAY ANTENNA

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## ABSTRACT

*The project examines the novel structure of a frequency-reconfigurable microstrip stacked array antenna by using the aperture-coupled feeding technique and the stacked patch methodology. The aperture slot positions are determined by the bottom patches and top patches (layer 1 & layer 2), respectively. To achieve the property of frequency reconfigurability, four PIN diode switches are placed on the feed line layer which is in turn below the ground layer. The frequency of operation is obtained at 2.5GHz and 4.5 GHz used for the applications of LTE and satellite communication. The major advantage of the proposed antenna is that it can minimize the surface area usage of the antenna, with different size of the patch having different operating frequencies, thereby achieving the frequency reconfigurability also simultaneously. The simulated results were found to have acceptable gain, return loss, directivity and bandwidth.*

**KEYWORDS**: *Reconfigurable;stacked array;pin diodes;gain;aperture coupled;*

## INTRODUCTION

Nowadays, reconfigurable antenna has gained its importance and attention in modern wireless communication and other radar applications. Such reconfigurable antenna has the tendency to change its characteristics in frequency, radiation pattern, and polarization [1]–[5] without changing the structure or size completely.Here the recofigurability is achieved with the help of integrating the PIN diode, varactor diodes or by using the electomechanical switches(MEMS). By performing the switching mechanism with these diode switches, the reconfigurability is achieved due to the variations created in the current distribution over the geometry of the antenna. Most of the reconfigurable antennas make use of many RF switch to design an antenna in order to show more operating modes [6]–[8].

## PROPOSED WORK

Having the idea of reconfigurability this antenna has been designed in the stacked array layered technique. Here the stacked patch reconfigurable antenna comprises of multilayer substrate design. With the increased number of sub layers the integration of the switches becomes easier to bring about the reconfigurability [9]–[11] as compared to that of a single substrate antenna. Here the switches are positioned either at the patch layer or I the feed network layer, which makes the integration of the real switches to be done either in the top or in the bottom layer.

Above all the major advantage of the stacked patch antenna is that, it will increase the gain and also the bandwidth performance. This is because of the top radiating patch acting as the parasitic element. The aperture coupled feeding technique is used with the aim of reducing the spurious radiations [12]–[13].For these kind of stacked antenna the fabrication becomes an important factor to be considered, especially while gluing the various layers together. This antenna also implements a new concept of the reconfigurability method in an aperture-coupled technique to achieve the frequency reconfigurability. This antenna can operate at two different operating frequencies of either 2.6 GHz [long-term evolution (LTE) application] or at 4.5 GHz (WiMAX application).All the details of the proposed antenna design are explained in Section II and the simulated and the measured results and the performance of the proposed antenna are inferred in Section III.

## ANTENNA DESIGN

The proposed antenna design is shown in Fig.1.This antenna consists of three layers, where the total width of the antenna constitutes 5.361 mm. The substrate layers are made using the RT-Rogers 5880 material. The thickness of the substrate is $h_1$=0.787 mm and the dielectric constant of this material is $\varepsilon_{r1}$=2.2. The air gap which forms the in between layer is of thickness $h_2$=3.0 mm. The advantage of using this layer is to overcome the problems due to coupling between the stacked patches because of the misalignments. Moreover this helps in increasing the gain of the antenna as the feed network layer is located far apart from the patch layer. The geometry of the entire layer for this antenna is shown in Fig.2.

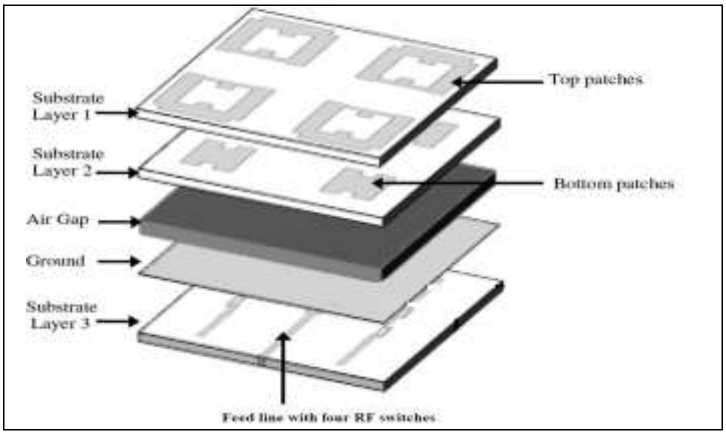
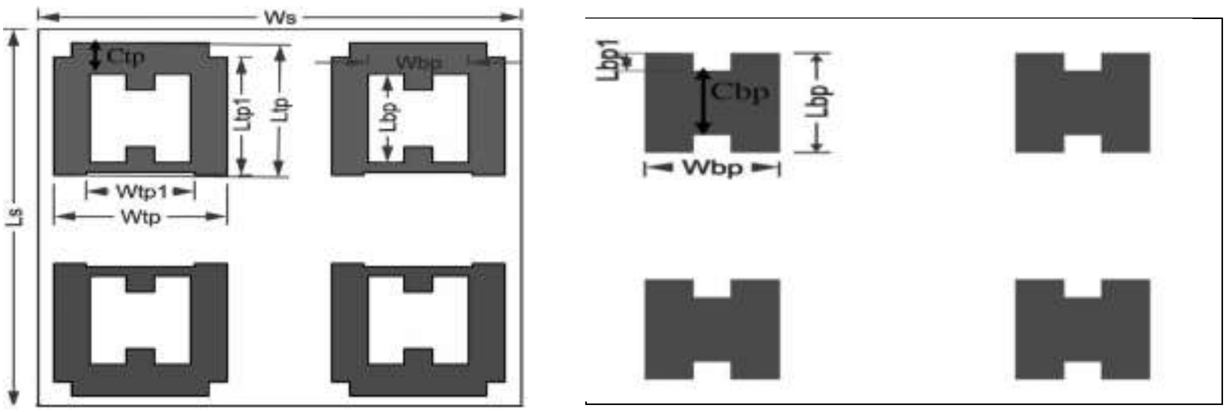



**Figure 1.Geometry of the antenna design**




(a) (b)

**Figure 2.Geometry of the substrate layer (a)first layer,(b)second layer**

The first layer which consists of the h shaped hole is designed with the dimensions of($W_s$=120 mm,$L_s$=120, $W_{tp}$=43 mm,$L_{tp}$=42 mm,$W_{bp}$=25 mm and $L_{bp}$=28 mm).This patch also is designed to operate for the frequency of 2.6 GHz. Similarly the second substrate layer containing the h shaped patch filling the h shaped slot of the first layer is designed for the 4.5 GHz operating frequency. Thus these two substrate layers form the two uppermost layers. The two layers are then combined together and verified for the desired operating frequency. The third substrate layer is the feeding network layer. This layer is designed to accommodate four switch circuits formed using the four pin diodes. Here the equivalent circuit for the third substrate layer is created and is designed in the schematic of the ADS software.

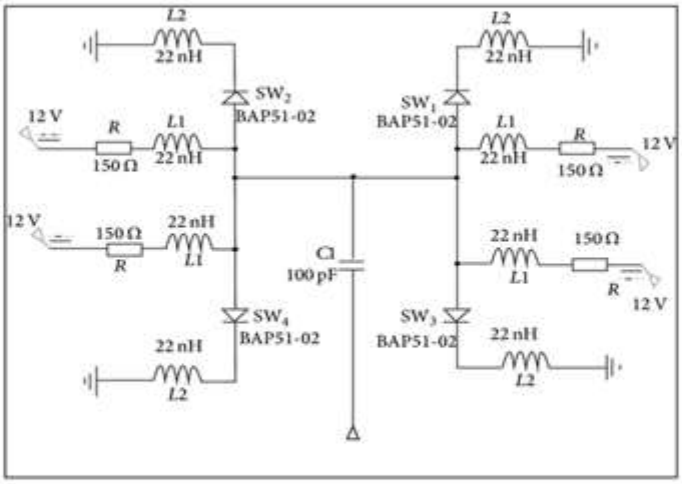



**Figure 3.Equivalent circuit of the third substrate layer**

Here in this antenna the aperture coupled feeding technique is involved. This type of feeding technique is mainly adopted to reduce the spurious radiation generated between the patch and the feed line. The feeding is provided with to the designed and by generating the equivalent circuit of the aperture coupled feeding technique in the schematic and then co-simulating it with the antenna designed in the layout screen.

## RESULTS AND DISCUSSIONS

Thus antenna modeled is designed and simulated using the ads software, where the design layout of the first two substrate layer is shown in Fig 4. The orange layer indicates the top h shaped hole layer and the yellow layer indicates the bottom h shaped patch filling the hole in the first layer. Then after the third layer and the feeding equivalent circuit is cosimulated in the ads schematic and the results are obtained which is shown below.

The $S_{11}$ parameter results of the proposed antenna are shown in Fig 5a.From the graph the frequency dip obtained clearly indicates the operating frequencies of the desired antenna. The $S_{11}$ parameter frequency values that are obtained are 2.6 GHz frequency and 4.5 GHz frequency. Various antenna parameters such as the gain, directivity, radiated power, etc. are displayed. Thus, from the parameters of the antenna obtained from the simulation it is clear that the gain of the proposed antenna is 5.29dB and the directivity is 7.72dB.Here since the antenna directivity is found to be high the radiated power decreases which in turn is used for wide range mobile applications. The gain value obtained in turn depicts that the power received is 5dB greater than the lossless isotropic antenna.

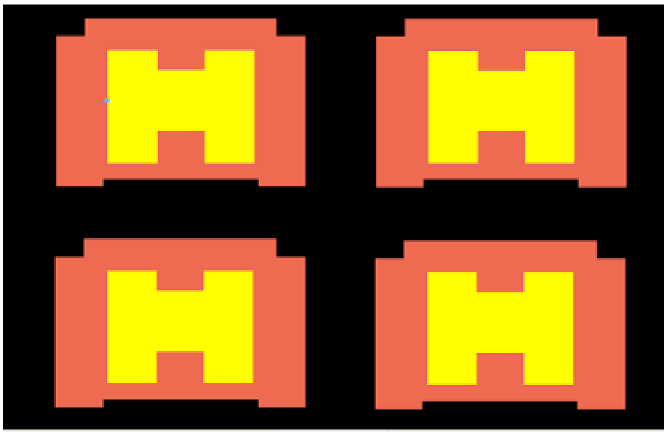
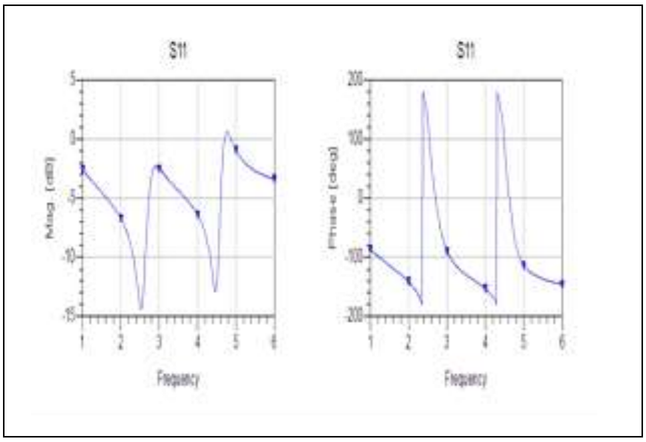
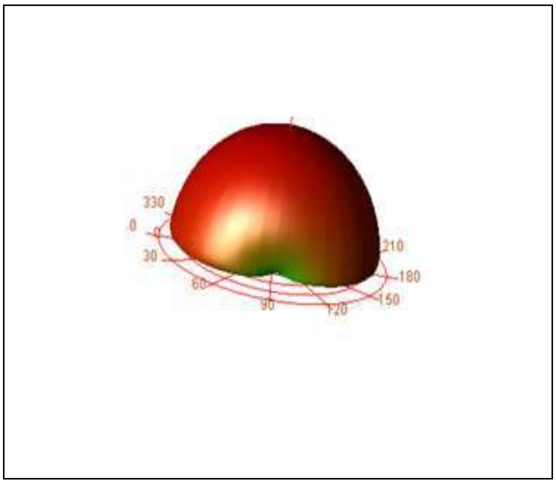


**Figure 4.Layout design of the first two substrate layers**




(a) (b)

**Figure 5.(a) $s_{11}$ parameters, (b) radiation pattern**

The various antenna parameters obtained for the above designed model are tabulated and presented in the table I below. From this it is crystal clear that the designed antenna has a good directivity towards the operating frequency and an acceptable level of efficiency. All these results obtained reveals the antenna structure to be operable for the LTE and INSAT applications.

**Table I. Obtained Parameter Values**

| ***Antenna parameters*** | ***Obtained value*** |
|---|---|
| Directivity (dB) | 7.7292 |
| Gain(dB) | 5.2563 |
| Power radiated(Watts) | 0.0009 |
| Effective angle(Steradians) | 2.1292 |
| Maximum Intensity(Watts\Steradians) | 0.0004 |

## CONCLUSION

It is therefore concluded that this unique structure of microstrip patch antenna is used to bring about the frequency reconfigurability efficiently. The proposed antenna uses the combined technique of an aperture-coupled feed and stacked array patch technology. Here in this design, the 2 × 2 radiating patch elements of top and bottom are designed on different substrate layers to bring about the operating frequencies at different points. New coupling methods have been used in this type of feeding technique in order to control the activation of the patches, eventually leading to the to achievement of the frequency reconfigurability. By controlling all the antenna with the feedline, the proposed antenna model has an ability to work at two different frequencies, either at 2.6GHz frequency or at 4.5GHz frequency. Above all, the air gap with low dielectric constants, that is, 1.00,introduced due to the special feeding technique gives the advantage such that the waves generated from feeding point are able to travel and reach to the necessary radiating patches without passing through the substrate material layers. Moreover, the gain and bandwidth of the proposed antenna are considerably higher compared to using a single layer substrate as found in other antennas. It is confirmed that the antenna achieves a good agreement with the simulation.

This patch antenna is suitable for WiMAX and LTE frequency range applications. This antenna apart from radiating at two different frequencies which are 2.5GHz and 4.6GHz the maximum Gain also can be obtained. The Return loss $S_{11}$ at these frequencies is -15.31dB. Thus the reconfigurable microstrip patch antenna is successfully designed and simulated using the ADS software and the achieved results are also found to be good and acceptable.

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