DESIGN AND ANALYSIS OF COMPACT MIMO ANTENNA WITH IMPROVED ISOLATION BY USING FSS

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Abstract

In this paper, we designed a planar MIMO antenna for UWB applications. Both top and bottom view are designed separately and printed on dielectric substrate Rogers R04003 with dielectric constant value is 3.55 and substrate dimensions 34mm24mm0.4 mm3. We used FSS (frequency selective surface) based decoupling network to reduced coupling between elements and improved overall isolation below -17dB for over a wide range of frequency in the UWB range of 3.1GHz to 10.6 GHz the FSS we used here have more number of combinations of Inductance and Capacitances which makes the tuning good. So, the proposed design is analyzed without and with the FSS and
also the comparative analysis is presented using the S11 and S12 curves along with some other antenna parameters.

**Keywords:** MIMO antenna, Compact, FSS, Decoupling, Isolation.

1 INTRODUCTION

In the past few years, as technology improved in the wireless communication systems there are several applications being integrated in the same system, now a day using more number of antennas in a single communication model is happening to increase the overall throughput of the communication system. As MIMO systems can transmit and receive in the same time the need of MIMO is raised where we need more number of channels are large data to be processed. There are several kinds of MIMO systems being implemented over the years. But working with MIMO systems have some difficulties like the design must be compact as the space provided to integrate the more number of antennas will be limited we need to adjust the elements closed together that will cause the mutual coupling effect in the MIMO systems and there are few techniques introduced to deal with the reducing the mutual coupling [1-4]. And also, another major thing that happens in MIMO antennas is that one antenna performance may affect the other in order to decrease the elements needs to be isolated properly without affecting the overall compactness.

Several types of techniques are used over the long time to decrease the common coupling impact and improving the isolation in the MIMO antenna like placing the meander lines or neutral lines [5, 6], and using the slots either the ground plane or on the transmitting component [7, 8]. For the decoupling there are several kinds of decoupling networks used like introducing a transmission line, incorporating extra mechanisms like metamaterial based parasitic elements, FSS, EBG, SRR and CSRR like structures in between the elements either on top side of the antenna or at the bottom side of the antenna [8-14].

In this paper we used a FSS based decoupling system to enhance the detachment between the components around below -16dB level in most of the UWB.
2 PROPOSED ANTENNA DESIGN AND DISCUSSION

A) Single Rectangular Micro Strip Antenna with improved BW

Initially we considered a single rectangular antenna and we etched some part of it in a staircase model to improve its bandwidth the model is shown in the following Figure 1.

In the above figure we can see that the slot is made on the ground plane too will improve the bandwidth up to some level. The analysis of the above antenna is mentioned in the below section and also the dimensions of the design are also mentioned in the figure [9] that depicts the final model of the antenna with FSS.

![Figure 1: Rectangular Micro strip patch antenna with staircase slots a) Top View b) Bottom View](image)

From the above Figure [2] we can see that the antenna works at around large bandwidth from 4.4GHz to more than 10.6GHz range.

B) Designing the MIMO Antenna with improved BW

Now by considering the above antenna we will design the MIMO antenna by placing the two elements in a compact way as shown in the figure [3].
For the above figure the return loss $S_{11}$ and the isolation curve $S_{12}$ are presented in the following figure [4] and [5].

In the above figure we can see that the isolation is around -15dB level only at the end of the band from 8GHz to 10.6GHz, but as we know that the FCC allotted the band 3.1 to 10.6GHz for the wideband applications so for most part of the band the isolation is not good.

C) Designing the MIMO Antenna with Improved Isolation by FSS

In order to improve the isolation between the elements we first incorporated some extra structure on top side of the antenna and the model representation and its return loss and isolation curves are presented in Figures [6], [7] & [8].

From the above figure [7] and [8] data we can see that the antenna isolation improved little bit wide range but it does not cover the most of wideband range so in the ground plane we will place FSS structure it will reduce the losses and improve the isolation between the elements so that the Proposed MIMO antenna will have the improved isolation over the wide range of
Figure 3: Design of the MIMO antenna a) Front view b) Back view
Figure 4: Return loss curve $S_{11}$ for the MIMO antenna shown in figure [3]

Figure 5: Isolation curve $S_{21}$ for the MIMO antenna shown in figure [3]
Figure 6: MIMO antenna with added structure

Figure 7: Return loss curve for the model in Figure [6].
Figure 8: Isolation curve for the model

the band the proposed MIMO antenna with proposed FSS is shown in the following figure [9].

So, for the above designed antenna the return loss and the isolation curve and some other antenna parameters are listed in the following figures [10] to [14] and Table 1.

Here from the above figure we can see that the return loss curve covers the entire UWB and also the isolation improved and covers most part of the UWB and it is below -17dB level which is very good in making the compact MIMO antenna design.

For the proposed antenna as it covers the entire wide band we select the frequency 5GHz and 9GHz to illustrate the antenna current distribution, radiation pattern and its 3D radiation plots.

3 CONCLUSION

The proposed MIMO antenna is designed and the antenna works with wideband and the size very low and the elements are placed very close it to each other so that it becomes the compact MIMO antenna. But when the elements are placed closer to each other there will be losses due to mutual coupling and isolation between the
Figure 9: The proposed MIMO antenna Top view and the Bottom View is the Proposed FSS
Figure 10: The return loss curve for the proposed MIMO antenna with the proposed FSS structure.

Figure 11: Isolation curve of the proposed MIMO antenna with FSS structure.
Figure 12: the current distribution curves at 5GHz and 9GHz for the proposed MIMO antenna with FSS

Figure 13: Radiation pattern curves at 5GHz and 9GHz for the proposed MIMO antenna with FSS
Figure 14: 3D radiation plots at 5GHz and 9GHz for the proposed MIMO antenna with FSS

Table 1: Antenna parameters comparison for the proposed antenna at 5GHz and 9GHz

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Frequency 5GHz</th>
<th>Frequency 9GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max U</td>
<td>172.864881 mW/sr</td>
<td>311.533187 mW/sr</td>
</tr>
<tr>
<td>Peak Directivity</td>
<td>2.374750</td>
<td>3.509966</td>
</tr>
<tr>
<td>Peak Gain</td>
<td>2.220369</td>
<td>3.548332</td>
</tr>
<tr>
<td>Peak Realized Gain</td>
<td>2.172335</td>
<td>3.914934</td>
</tr>
<tr>
<td>Radiated Power</td>
<td>914.763745 mW</td>
<td>1.001271 W</td>
</tr>
<tr>
<td>Accepted Power</td>
<td>978.366959 mW</td>
<td>991.541165 mW</td>
</tr>
<tr>
<td>Incident Power</td>
<td>1.000000 W</td>
<td>1.000000 W</td>
</tr>
<tr>
<td>Radiation Efficiency</td>
<td>0.954990</td>
<td>1.009812</td>
</tr>
<tr>
<td>Front to Back Ratio</td>
<td>3.751581</td>
<td>43.408979</td>
</tr>
<tr>
<td>Decay Factor</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
</tbody>
</table>
elements will be lost so the performance of the antenna is affecting
the other so in order to reduce this we introduced a FSS structure
into the design. And improved the isolation below -17dB level over
the range 6GHz to 10.6GHz previously without the FSS it only
covered 8.4GHz to 10.6GHz only so the FSS improved isolation
between the elements.

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