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Design of Multilayered Stack Antenna for Wireless Communication

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Abstract— Recent advances in the wireless communication continues with the requirements of small, portable and low cost reconfigurable antenna that can be switched between different frequencies for different set of applications. In this paper a multilayered reconfigurable antenna employing two patches stacked one over the other is designed. In our proposed design, patch 1 is designed for 5.42 GHz targeting ISM band & patch 2 is for 10 GHz satellite applications. The proposed antenna is designed on two substrates, Roger RT duroid 5880 (εr=2.2) and Teflon (εr=2.1). The results show that the designed antenna can be used switched between the two frequencies of operation. We also have achieved good bandwidth of 400 MHz and 1100 MHz for patch 1 & patch 2 operations respectively.

Index Terms— Microstrip antennas, Reconfigurability, ISM band, Satellite Communication.

1 Introduction

WIRELESS operations permit long-range communications, that are impossible or impractical to implement with the use of wires. Further the advances in the last few decades have resulted in increased use of wireless communication services for various commercial and military applications. With such large set of available wireless services it is required to design efficient miniaturized antennas. A solution to this problem is the use of reconfigurable antennas that can be switched to operate on two or more set of applications by altering its parameters and operating frequency. Due to their obvious features reconfigurability in antenna systems has recently received noteworthy attention resulting in pioneering multifunctional antenna designs. One of the most common techniques to achieve reconfiguarbility is the use of MEMS technology. It can also be achieved using dioides or transistors [1]. However one another way to achieve frequency reconfigurability is the use of multilayered stacked antennas that can be switched to operate at different frequencies. Each antenna targets a different set of application [2].

In this paper design of a reconfigurable antenna is proposed by using multilayered configuration,

2 Proposed Antenna Design

2.1 Review Stage

The proposed antenna consists of to patches stacked one over the other, achieving multi-layered stacked design. The lower patch is referred to as Patch 1 is designed for 5.42 GHz thus targeting the 5.4GHz ISM band applications. Whereas the upper patch referred to as Patch 2 is designed for 10 GHz thus targeting satellite applications

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The first is deigned for Rogers RT Duroid 5880 as the substrate with dielectric constant εr=2.2 and loss tangent tan δ=0.0009, whereas the upper substrate is Teflon with dielectric constant εr=2.1 and loss tangent tan δ=0.001. Fig.1 below shows the proposed antenna design. The patch width and length are calculated using the formulae from Balanis [3]. Table I below shows the calculations of both the patches.

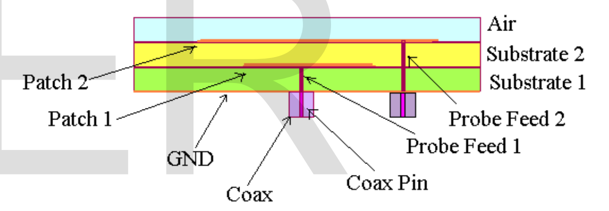

Fig. 1. Proposed Multilayered Stacked Antenna Design

TABLE 1
Calculations of Patch Dimesions

Dimensions/Parameters	Patch 1	Patch 2
Dielectric substrate	RT Duroid εr=2.2,	Teflon εr=2.1
Substrate height	1.6 mm	1.2 mm
$W = \frac{c}{2 f_0}\sqrt{\frac{2}{\varepsilon_r + 1}}$	22 mm	12 mm
$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}$	2.037	1.92
$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)\left[\frac{W}{h} + 0.264\right]}{(\varepsilon_{reff} + 0.258)\left[\frac{W}{h} + 0.8\right]}$	0.646 mm	0.478 mm
$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}}$	20 mm	10.8 mm
$L = L_{eff} - 2\Delta L$	18.07 mm	10.3 mm

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3 RESULTS

The proposed antenna is designed using Ansys HFSS EM simulation software. Fig 2. below shows the proposed antenna design. We have used co-axial feeding technique in the proposed antenna design. The proposed antenna is initially simulated considering one patch at atime. For this chase each patch in the antenna is excited individually and results are measured. Even though a single patch is excited there will be some electromagnetic coupling linking with the other patch. To achieve the desired set of operations the feed position is optimized in such a way that for a particular set of excitation the operation for only that specific patch is obtained.

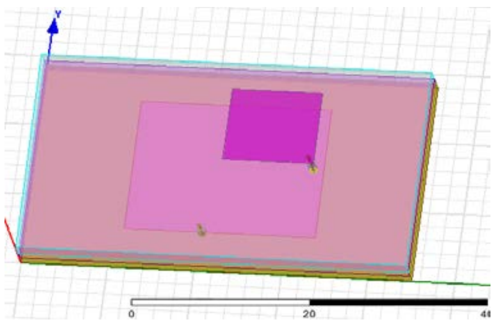

Fig. 2. Proposed Antenna Designed on HFSS

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Fig 3. below shows the S11 graph for the proposed antenna with Patch 1 under consideration. The obtained frequency is 5.5 GHz with -18.03 dB. Fig 4. shows the smith chart, the matching of 55.17-j3.57Ω is achieved. Fig 5. shows the radiation patteren. The directive gain of the antenns is 4.455 dB.

Fig 6. below shows the S11 graph for the proposed antenna with Patch 2 under consideration. The obtained frequency is 10.10 GHz with – 21.98 dB. Fig 7. shows the smith chart, the matching of 57.75-j8.323Ω is achieved. Fig 8. shows the radiation patteren. The directive gain of the antenns is 6.792 dB.

Fig 9. shows the S11 graph for the proposed antenna with Patch 1 ans Patch 2 both under consideration. The obtained frequency is 5.46 GHz and 10.1 GHz with –12.18dB and -24.68 dB respectively. Fig 10. shows the radiation patteren. The directive gain of the antenns is 6.484 dB.

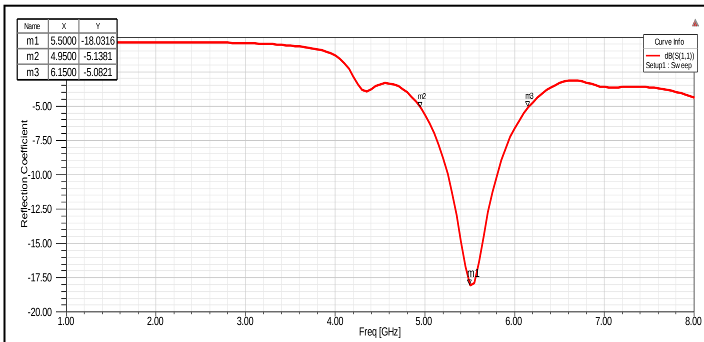

Fig. 3. S11 graph for Patch 1

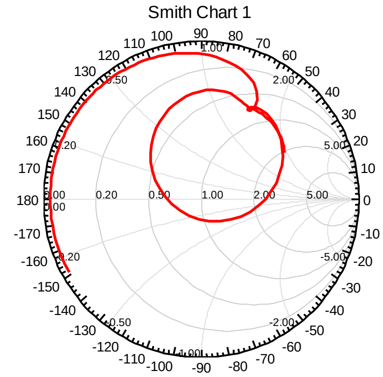

Fig. 4. Smith Chart for Patch 1

Fig. 5. 3D Radiation Pattern for Patch 1

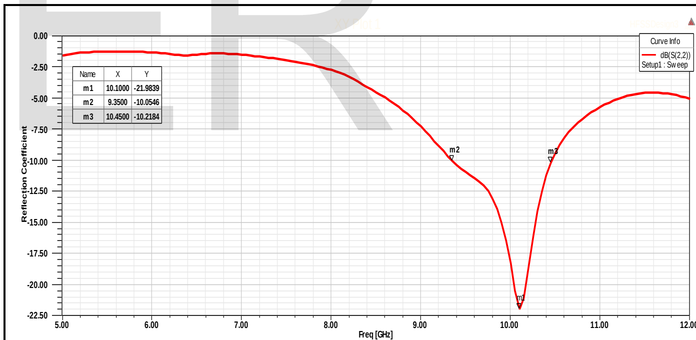

Fig. 6. S11 graph for Patch 2

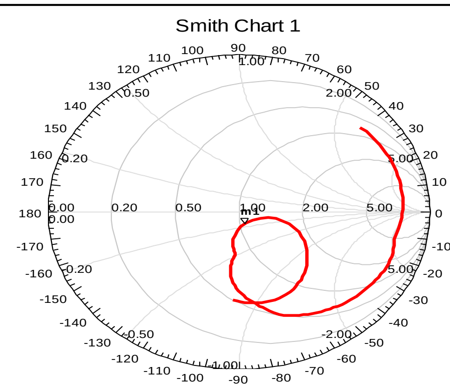

Fig. 7. Smith Chart for Patch 2

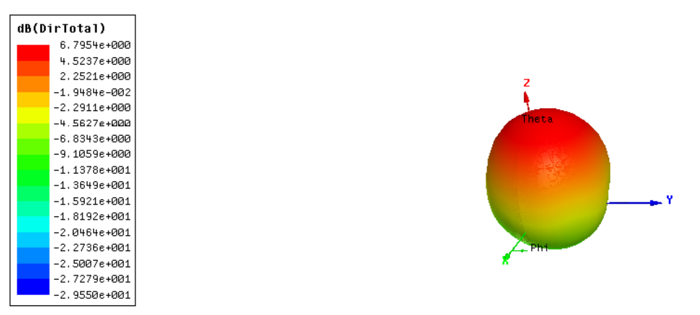

Fig. 8. 3D Radiation Pattern for Patch 2

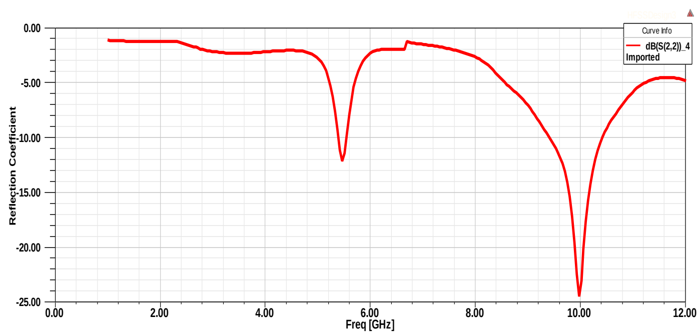

Fig. 9. S11 graph for Patch 1 and Patch 2

Fig. 10. 3D Radiation Pattern for Patch 1 and Patch 2

TABLE 2
COMPARISON OF RESULTS

Parameters	Patch 1	Patch 2	Patch 1 and 2
Frequency	5.5 GHz	10.1 GHz	5.46 GHz and 10.1 GHz
S11	-18.03 dB	-21.98 dB	-12.18 and -24.68 dB
Bandwidth	1200 MHz	1100 MHz	830 MHz and 1230 MHz
VSWR	1.191	1.172	1.034 and 1.379
Gain	4.455 dB	6.792 dB	6.484 dB
Impedance	55.17-j3.57Ω	57.75-j8.323Ω	53.04-j7.515 Ω and 47.12-j11.93 Ω

Table 2. above shows the comparative simulation results for the proposed stacked antenna for Patch 1, Patch 2 and both the patches simultaneously. Thus the proposed antenna can be made to operate on 5.4GHz ISM band or 10GHz satellite communication applications or on both simultaneously.

4 CONCLUSION

In this paper a stacked multilayered microstrip patch antenna is designed using HFSS software. The proposed antenna can be used for 5.4GHz and 10GHz application. We have triggered the patches using two separate co-axial feeds. The simulation results show that proposed antenna has good gain and exceedingly good bandwidth for either of the patch 1 or patch 2 or both simultaneously. Thus the proposed design can be reconfigured to any or both of the proposed frequencies. To further extend in future we are working on the use of diodes that can help trigger the sswitching mechanisum for all the three cases and finally to fabricate the proposed antenna.

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