Multi Layer Aperture Coupled Micro Strip Antenna with Variation in Dielectric Constants

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Abstract: ***Micro strip antennas are used for low profile antenna applications. These antennas are always attractive for researchers due to their low cost, light weight, small size and ease in fabrication. Micro strip antennas are the antenna with High Gain and wide bandwidth. This paper presents aperture coupled micro strip antennas with variation in substrate material's dielectric constants using multilayer configuration. Three designs of micro strip antenna are experimented and simulated through HFSS software, and compared to each other. The three designs are first is 'conventional rectangular patch antenna' (design 1), second is 'sandwiched- multilayer rectangular patch' (design 2), & third is 'Non-sandwiched multilayer rectangular patch' (design 3). All three designs, it was observed that multilayer structures are complex in fabrication & higher in cost, but they can deliver better performance as compare to single layer micro strip antenna, as per requirements.***

Keywords: Coupled Micro strip, Antenna Multi Layer Aperture, Dielectric Constant

1. Introduction

Micro strip antenna has been popular due to their attractive properties, such as low profile, Light weight, & ease to fabricate [1]. The aperture coupled [7] micro strip antenna first proposed by D.M. Pozar [2] in 1985. This feed technique posses several advantages over other feeding methods. The aperture coupling eliminates direct electrical connections between the feed conductors and radiating patch & the ground plane, electrically isolates the two structures. The two dielectric substrates can be selected independently to optimize both micro strip guided waves & patch radiating waves. On the bottom side of lower substrate there is a micro strip feed line whose energy is coupled to the patch through a slot on the ground plane separating two substrates. Typically a high dielectric material is used for the bottom substrate, and thick low dielectric material for the top substrate [3]. Aperture coupling [6] also convenient to fabricate the antenna using two or more dielectric layers and, it is necessary to determine the resonant frequency which depends on the layers used in antenna [4].These antennas are more advantageous in arrays because they are electrically isolates, the feed & phase shifting circuitry from the patch antennas. But micro strip antennas are band limited [6] which is a serious drawback of micro strip antenna.

Basically micro strip antenna has three design parameters; these are substrate's Dielectric constant (εr), its operating frequency (f0) and height of substrate (h) from ground plane [3], which affects the dimensions of patch, radiation pattern, return loss & other parameter of micro strip antenna.

The purpose of the paper is to present a detailed study of single layer & multilayer sandwiched patch antennas. For this, three designs are simulated through HFSS and compared with their results.

2. Antenna design

Two multilayer & one structures are drawn and measured by HFSS

Design 1: In the first experiment (as shown in Figure 1) two substrates used. The bottom substrate used, is FR4 EPOXY (εr=4.4; tanδ=0.0009; h=0.16cm) material and top substrate has RT/Duroid 5880(εr=2.2; tanδ=0.0012; h=0.16cm). The height of substrate from ground is kept 0.16cm and thus patch is 0.16cm at height and frequency is 2.3GHz. The rectangular patch has dimension approximated to 6cm x 4.5cm. Slot width is taken 0.2325cm and slot length is 2.1cm. Feed line width is kept 0.74cm and length is 12cm (Figure1)

Design 2: (Sandwiched Multilayer Patch): In this design patch frequency and other parameters except substrate material's dielectric constants, are kept constant. It is a multilayer structure in which bottom substrate (sub-1) of ground plane used RT/Duroid 6006 (εr=6.15; tanδ=0.0019; h=0.16cm). The patch is sandwiched between two layers of substrate. The patch's upper layer substrate (sub-1) has dielectric constant εr=2.94 with h= 0.08 cm whereas lower layer substrate (sub-2) is made of dielectric material εr=2.2 with h= 0.16cm.

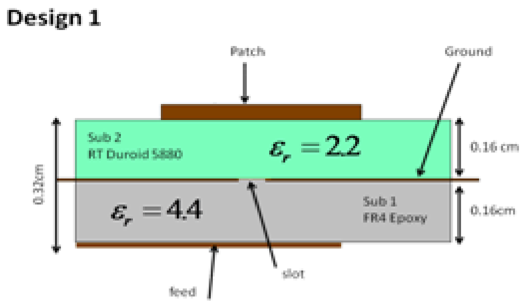

Figure 1: Design 1 single layer aperture coupled micro strip antena

The patch is placed at h=0.16cm, height from ground plane and sandwiched between sub-1 and sub-2 as shown in fig-2.

Design 3 (Non Sandwiched Multilayer Patch): Further the change is applied on multilayer design 2 in which the bottom substrate of ground plane (sub-3) is of εr=6.15 with h= 0.16cm.and middle layer substrate (sub-2) is εr=2.2 however,

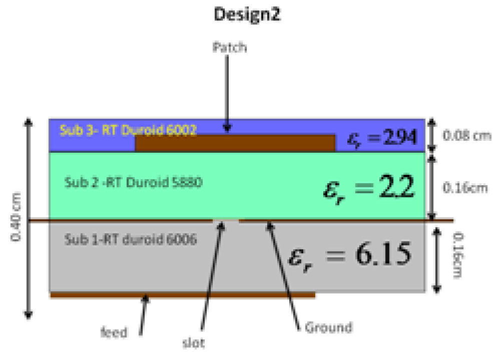

Figure 2: Design 2 sandwiched multilayer aperture coupled micro strip antenna

Its thickness is reduced by half(h=0.08) as shown in design 2 .then the top layer material is made of εr=2.93 with thickness of 0.08cm and the patch is placed on top layer substrate which is situated at 0.32cm height from ground plane (Figure 3).

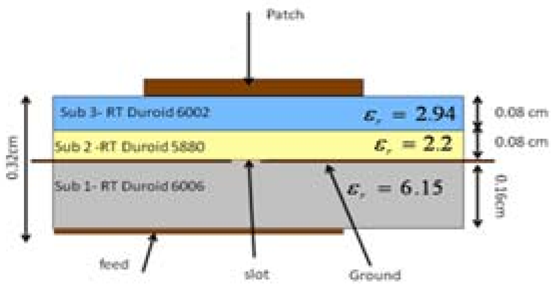

Figure 3: Design 3 non- sandiwiched multilayer aperture coupled micro strip antenna

3. Simulated Results

The aperture coupled micro strip antenna are measured and simulated by HFSS V-13 and all three designs calculated parameter summarized in Table 1.

Table 1: Parameter Summary

Parameter	*Design1*	*Design2*	*Design3*
Return loss(minimum)	-11.45dB at 2.3GHz	-15.54dB at 2.23GHz	-21.30 dB at 2.1GHz
VSWR	4.76dB	2.9295dB	1.499dB
Peak gain (total gain)	5.4463dB	5.74dB	4.7714dB
Directivity	4.2041	4.02	3.65
Radiated power	-21.10dB at 2.32GHz	-20.42dB at 2.23GHz	-29.60dB
Radiation efficiency	83.39%	93.93%	81.98%

4. Results Discussion

Return Loss: In all three designs it is observed that the multilayer designs produces minimum return loss however frequency is reduced as compare to design 1. Design 1 shows minimum return loss -11.45 dB at 2.3 GHz (fig-4), design 2 -15dB at 2.2 GHz(fig-5) and design 3 shows -21.3 dB with reduced frequency 2.1GHz(fig-6) while the multilayer antennas has narrower bandwidth than single layer antenna.

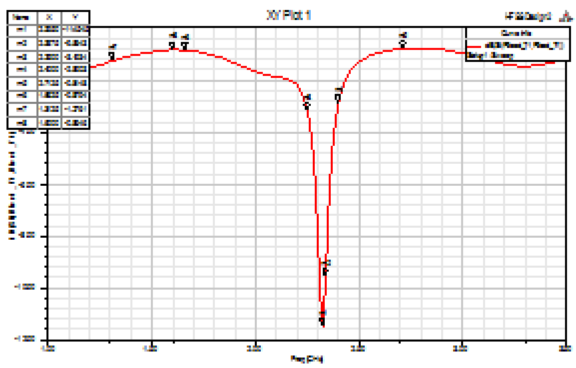

Figure 4: Return loss of design 1 is -11.45 dB at frequency 2.3 GHz

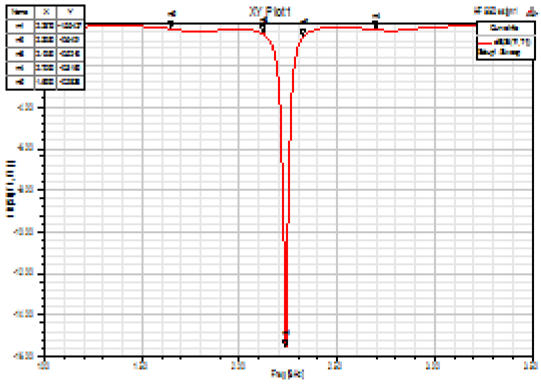

Figure 5: Return loss of design 2 is -15.54 dB at frequency 2.2 GHz

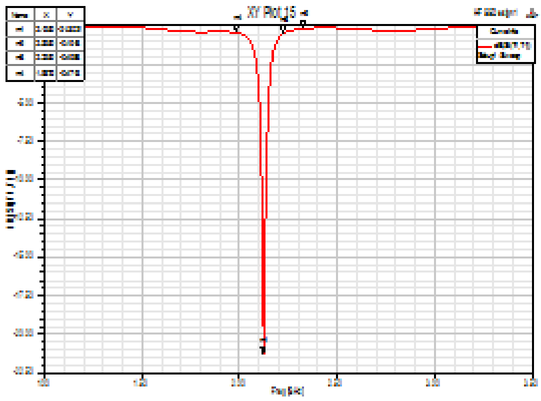

Figure 6: Return loss of design 3 is -21.3 dB at frequency 2.1 GHz

VSWR: Multilayer antenna shows improved vswr as compare to single layer antenna however it also achieved at lower frequencies. The design 3 is shows (Figure 7) and better VSWR (1.5 at 2.1GHz) as compare to design 2 (2.9 dB at 2.2GHz; Figure 8) and design 1(4.76 dB at 2.3 GHz; Figure 9). Thus we can say that multilayer structure is good for matching.

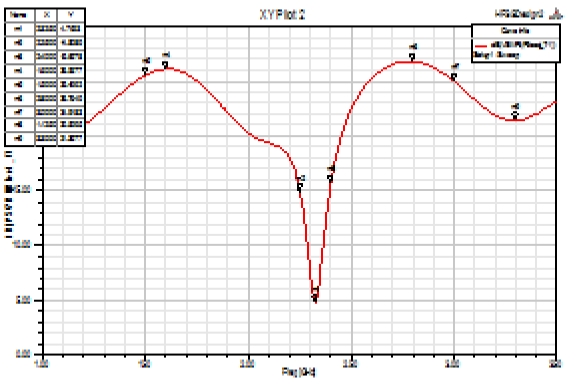

Figure 7: VSWR of design 2 is 4.76 dB at 2.3 GHz

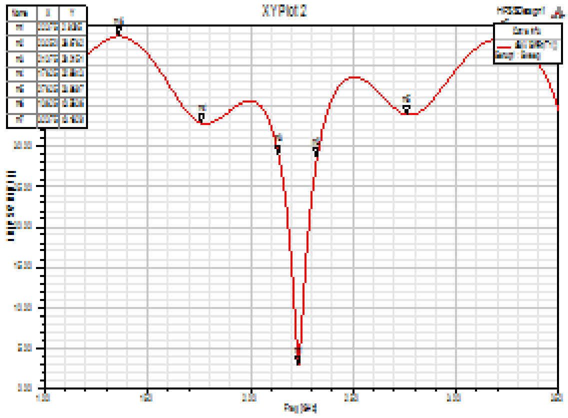

Figure 8: VSWR of design-1 is 2.9 dB at 2.2 GHz

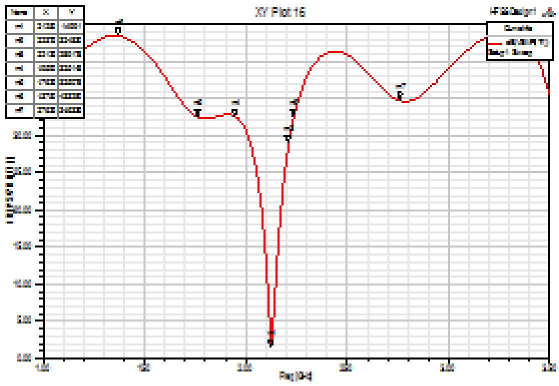

Figure 9: VSWR of design3 is 4.76 dB at 2.3 GHz

Gain & Directivity: The multilayer structure show low gain as compared to single layer structures. Whereas sand witched patch-design2, (fig11) show enhanced gain (5.74dB) than other two designs. However design 3 is fewer directives (3.6 at 2.1GHz) over all multilayer structure shows low directivity profile. Single layer design-1 shows better directivity (4.2 at 2.3GHz) & design 2 two has directivity about 4.02. Sand witched patch shows better directivity & gain as compare to non sand witched multilayer antenna.

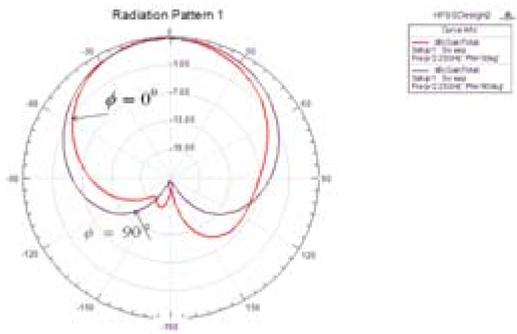

Figure 10: Total gain of design 1 at 2.3 GHz

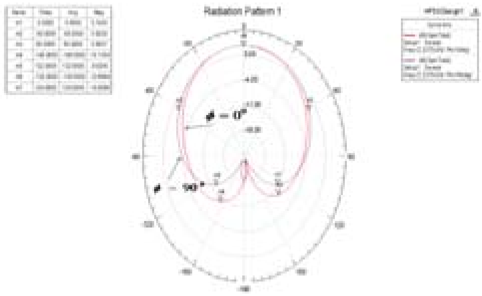

Figure 11: Total gain of design 2 at 2.3 GHz

5. Conclusion

Comparison of all three designs, it is observed that the variation in dielectric constant affect each parameters of micro strip antenna. But single layer structure is better choice due to ease in fabrication and low cost. Multilayer structure shows better efficiency and return loss but if its physical dimensions are designed according to their frequency then they shows better performance than single layer micro strip antenna. Since Non-Sandwiched multilayer (Design-3) micro strip antenna has lower VSWR & Minimum return loss therefore good matching can achieved. They show greater radiated power as compare to other designs; however these antennas are fewer directives. Whereas sandwiched multilayer micro strip (Design-2) antenna show best radiation efficiency 94%, as well as higher peak gains in all three designs therefore they can be used for high gain & high efficiency requirement. But, since multilayer micro strip antenna uses various dielectric materials their cost may increase also they are complex to fabricate since the cost may vary material to material. However single layer micro strip antenna is not much costly also they are ease to fabricate & they also show good efficiency and better directivity as well as better improved radiated power. Another limitation with multilayer structure is that they require non contact feeding technique.

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