IASET: International Journal of Electronics and Communication Engineering (IJECE)
ISSN (P): 2278-9901; ISSN (E): 2278-991X
Vol. 6, Issue 1, Dec - Jan 2017; 47-52
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International Academy of Science, Engineering and Technology
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DESIGN AND ANALYSIS OF A MULTI LAYER SUBSTRATE SINGLE PATCH MICROSTRIP PATCH ANTENNA FOR ENHANCING THE BEAM WIDTH WITH CONTROL ON DIRECTIVITY

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ABSTRACT

This paper presents an efficient analysis of a micro strip antenna in terms of multilayered substrate and patch antennas. The present invention relates generally to the design and construction of micro strip antennas. More particularly, the invention relates to micro strip antennas having a plurality of interconnected segments which are disposed on successive layers of a multilayer substrate. The numerical results show that the present method is an efficient and accurate scheme for analyzing micro strip antennas in multilayered media. In general beam width of the antenna increasing with increasing the number of the substrate layers. There is a trade of between the beam width and the directivity of antenna. Here the beam width increasing for optimum value of the directivity.

KEYWORDS: Micro Strip, Rectangular and Circular Patch, Multilayer

INTRODUCTION

Micro strip patch antenna consists of area of metallization supported over a ground plane by a thin dielectric substrate and fed against the ground at an appropriate location. The patch shape can be arbitrary, in practice – rectangular, circle, equivalent triangle, annular-ring etc.

The design of the antenna and optimization of its characteristics will lead to considerable improvements in the overall system performance like better accuracy, superior aerodynamics, and lighter weight, etc. Structurally integrated, efficient antenna systems, designed for the aircraft systems will be capable of multi role operations. When under Electronic Attack the aim of these designs is towards tackling of the threat dynamically. The design and analysis of microstrip antenna to suit in applications related to aerospace viz. high performance aeroplane, satellite for military purpose, spacecraft and missile may necessitate critical examination of the following aspects. Antenna radiation pattern i.e. radiated field. Related to antenna radiation pattern are important parameters such as directivity, gain, radiation efficiency and power output. Return loss which ensures that there is impedance match between the feeding network and the microstrip patch antenna. Pattern and impedance bandwidth. Low impedance bandwidth results due to use of thin dielectric substrate, alternatively use thick dielectric but it will enhance surface wave and deteriorate radiation pattern and efficiency. The present work deals with different shapes of micro strip antenna like rectangular patch on rectangular substrate, circular patch on rectangular substrate. The same is done for multilayers with different combination of materials.

Design: The major intention of the work is to increase the beam width of a antenna by using multilayer substrate, viz., the two substrates selected are Arlon Cu 217Lx (Loss free) and Arlon AR 450 (loss free) each with equal.

Design Steps

- Design the substrate 1 with required dimensions.
- On the surface of the substrate 1 cascade the substrates 2 with required dimensions.
- Extrude the ground plane to the substrate 1
- Fabricate the metallic patch element to the surface of the substrate 2
- Connect the strip line feed to the patch
- Design a port to provide the required potential.
- Simulate the design and test the results.

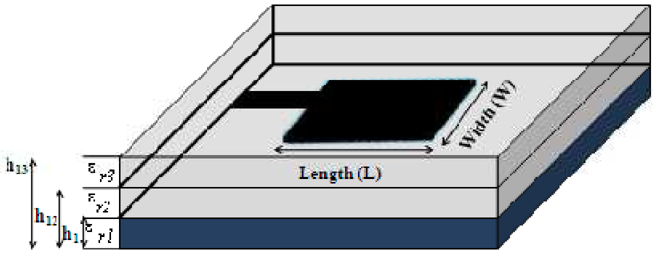

Figure 1: Multi Layer Microstrip Patch Antenna

In this model the MSA can be represented by two slots of width (W) and height (h) separated by transmission line of length (L). The width of the patch can be calculated from the following equation.

$$\text{Width } (W) = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}} \tag{1}$$

The effective dielectric constant(ε_{eff}) is less than(ε_r) because the fringing field around the periphery of the patch is not confined to the dielectric speared in the air also.

$$\text{Effective Dielectric Constant } (\varepsilon_{eff}) = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\sqrt{\frac{1}{\left[1+12\frac{h}{W}\right]}} \tag{2}$$

For TM10 mode the length of the patch must be less than ($\lambda/2$). This difference in the length (ΔL) which is given empirically by

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.813\right)} \tag{3}$$

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} \tag{4}$$

Where c=speed of light, L_{eff}=effective length, F_r =resonance frequency, ε_{eff} =effective dielectric constant.

RESULTS ANALYSIS

The result analysis done for multilayer substrate with single patch antenna and is compared with the single layer substrate. Here the shape of the antenna substrate is considered as rectangular and shape of the patch is altered from rectangular to the circular with different thickness. The thickness of the substrate is around 1.6mm, 5mm, 8mm is considered with different permittivity of substrate materials. The permittivity of material as 2.2 and 4.5

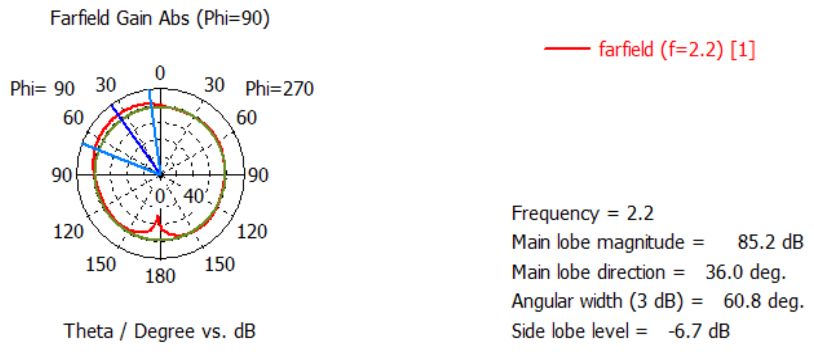

Figure 2: ε_r = 2.2 Single Substrate with Rect. Patch and H=1.6 Mm and Frequency=2.2 GHz, Beam Width=60.8

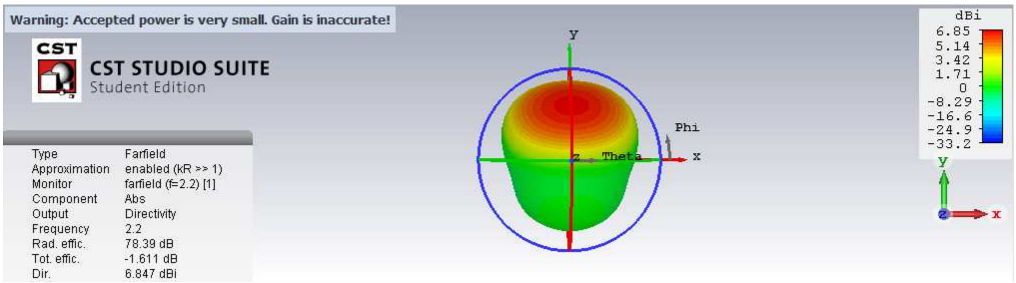

Figure 3: ε_r = 2.2 Single Substrate with Rect. Patch and H=1.6 Mm and Frequency=2.2 GHz, Directivity = 6.847

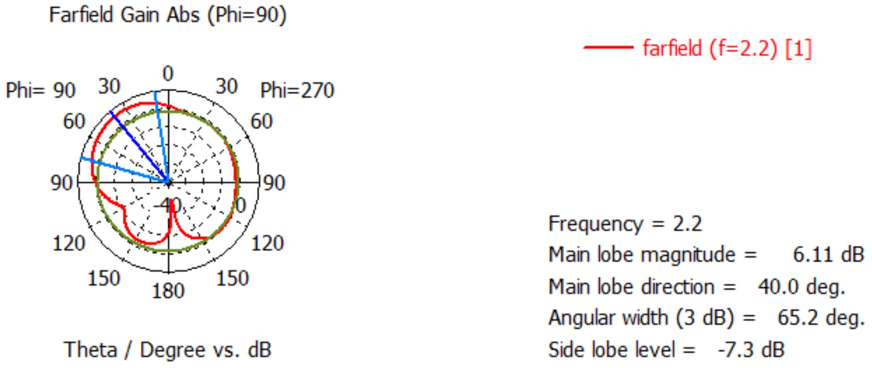

Figure 4: ε_r = 2.2 Multi Substrate with Rect. Patch and H=1.6 Mm and Frequency=2.2 GHz, Beam Width=65.2

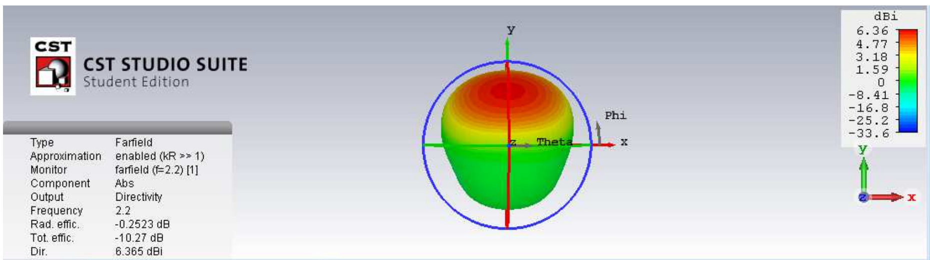

Figure 5: ε_r = 2.2 Single Substrate with Rect. Patch and H=1.6 Mm and Frequency=2.2 GHz, Directivity = 6.365

Comparison table for single and multilayer substrate with single rectangular and circular patch and with different substrate materials:

Table 1: Data Sheet of Different Cases Considered

S No	Shape of the Substrate	Shape of the Patch	Height of Substrate	Operating Freq. (GHZ)	Er	Single Layer		Multi Layer	
						Angular Width (3db)	Directivity	Angular Width (3db)	Directivity
1	Rectangular	Rectangular	1.6mm	2.2	2.2	60.8	6.847	65.2	6.365
2	Rectangular	Circle	1.6mm	2.2	2.2	61	6.858	69.1	5.707
3	Rectangular	Circle	1.6mm	2.2	4.5	78.7	6.203	122.7	5.481
4	Rectangular	Rectangular	5mm	2.2	2.2	75.5	6.801	81	5.84
5	Rectangular	Rectangular	5mm	2.2	4.5	82.6	6.992	86.6	5.104
6	Rectangular	Circle	5mm	2.2	2.2	72.9	7.43	75.9	6.314
7	Rectangular	Circle	5mm	2.2	4.5	69.5	7.563	91.6	4.338
8	Rectangular	Rectangular	8mm	2.2	2.2	72.1	6.651	81.4	5.734
9	Rectangular	Rectangular	8mm	2.2	4.5	79.3	7.223	93.6	5.986
10	Rectangular	Circle	8mm	2.2	2.2	69.4	7.017	75.4	6.117
11	Rectangular	Circle	8mm	2.2	4.5	68.5	7.667	119.7	2.551

CONCLUSIONS

As per the results observed the beam width of the antenna increasing with increasing the number of the substrate layers. There is a trade of between the beam width and the directivity of antenna. Here the beam width increases for optimum value of the directivity. Whereas coming to the Rectangular substrate and circular patch, beam width of the antenna increasing with increasing the number of the substrate layers. For same type of substrate the beam width of the circular patch antenna is more when compared with the rectangular patch. The reduction in directivity of antenna w.r.t to increase in beam width is too.

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