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To Study the Effect of Different Substrate Materials on Rectangular Microstrip Patch Antenna Parameters Using HFSS

Sidharath
M.Tech, ECE
DAVIET
Jalandhar

Jaspreet Singh
M.Tech, ECE
DAVIET
Jalandhar

Govind Singh
M.Tech, ECE
DWIET
Kharar

Abstract

The study of microstrip patch antennas has made great progress in recent years. Compared with conventional antennas, microstrip patch antennas have more advantages and better prospects. They are lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity. Moreover, the microstrip patch antennas can provide dual and circular polarizations, dual-frequency operation, frequency agility, broad band-width, feedline flexibility, beam scanning omnidirectional patterning. In this paper we will discuss the effect of different substrate materials on rectangular microstrip patch antenna parameters at 6.6 GHz. Rectangular MPA is simulated using HFSS which is based on FEM.

1. INTRODUCTION

There are several parameters when considering high frequency laminate materials which have low dielectric constant (Dk). They are related to reliability, directivity, gain, radiated power, accepted power, radiation efficiency, manufacturability and good predictable electrical performance. The RT/duroid 5000 family of high performance laminates offers low Dk laminates with very low Df. A recent addition, RT/duroid 5880 LZ laminate, has the lowest Dk and offers several improvements to most other PTFE laminates[8]

Polytetrafluoroethylene (PTFE) based substrates are used to provide a laminate with a Dk(dielectric constant) that is relatively low (< 2.5). The RT/duroid 5870 and 5880 are low loss laminates that have been in use. While both have a relatively high percentage of PTFE, the addition of a small amount of filler and some special processing reduces the x-y axis CTE to the range of 40 ppm/ºC (from the 300 ppm/ºC of pure PTFE). Keeping the x-y axis CTE relatively low and near the CTE of copper (17 ppm/ºC) is beneficial for reliability. Even though the CTE is higher in the z-axis (thickness) direction (173ppm/ºC and 237ppm/ºC for the 5870 and 5880, respectively), these materials have been used in numerous high reliability applications for many years. In general, a simpler printed circuit board (PCB) construction, such as a microstrip, minimizes reliability concerns. Again, keeping the material thinner is beneficial and making a hybrid construction using very low CTE materials with the RT/duroid 5000 laminate will minimize any reliability concerns.

The RT/duroid family of products offers several laminates with a low Dk. The RT/duroid 5000 family of products has the lowest Dk values on the market today as well as stringent control of this property. The CTE issue associated with PTFE based laminates can be overcome by the use of a thinner laminate and multilayers using hybrid constructions. The low density of the 5880LZ can be very beneficial to applications where weight is restricted [8].

With an extensive line of products, the RT/duroid® product line has been used in a wide-range of applications for many decades.

2. MICROSTRIP PATCH ANTENNA

A microstrip patch antenna (MPA) consists of a conducting patch of any planar or nonplanar geometry on one side of a dielectric substrate with a ground plane on other side[1]. It is a popular printed resonant antenna for narrow-band microwave wireless links that require semi- hemispherical coverage. Due to its planar configuration and ease of integration with microstrip technology, the microstrip patch antenna has been heavily studied [9].

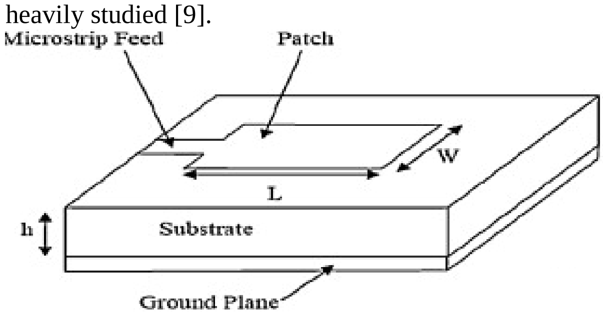


Fig 1: Microstrip patch antenna

3. FINITE ELEMENT METHOD (FEM)

Finite Element Method (FEM). The basic approach of this method is to divide a complex structure into smaller sections of finite dimensions known as elements. These elements are connected to each other via joints called nodes. Each unique element is then solved independently of the others thereby drastically reducing the solution complexity. The final solution is then computed by reconnecting all the elements and combining their solutions. These processes are named assembly and solution respectively in the FEM [6]

4. PROPOSED ANTENNA PARAMETERS AND DESIGN

Rectangular Microstrip with the following dimensions is designed using HFSS resonating at 6.6 Ghz and then results are obtained using different substrate materials [3].

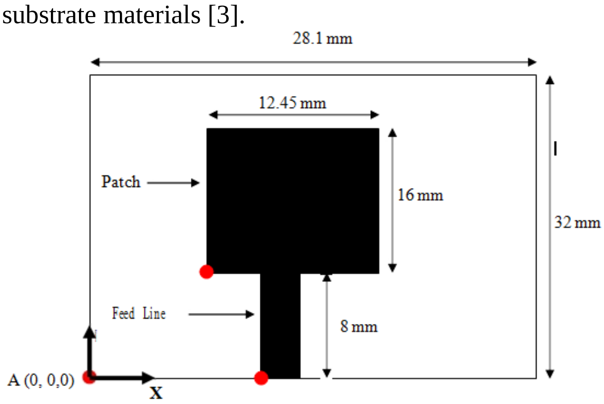


Fig 2: Top View

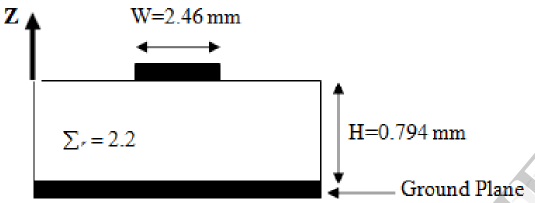


Fig 3: Cross View

The different substrate materials used in the proposed antenna are Rogers RT/ Duroid 5880(tm), Epoxy_kevlar, FR4_Epoxy, Polyester. The below table shows the different substrate materials used with their relative permeability and relative permittivity.

Table 1: Substrate materials Used

Material	Relative Permittivity	Relative Permeability
Rogers RT/ Duroid 5880(tm)	2.2	1
Epoxy_kevlar	3.6	1
FR4_Epoxy	4.4	1
Polyester	3.2	1

5. RESULTS AND DISCUSSION

The microstrip patch antenna parameters such as peak directivity , peak gain , peak realized gain , radiated power, accepted power, incident power , radiation efficiency and radiation patterns using 3D polar plot are analysed using different substrate materials.

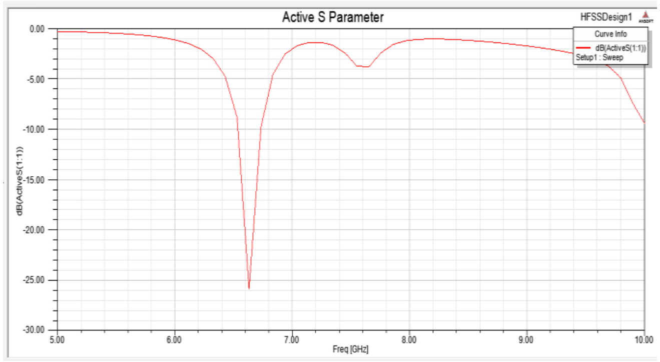
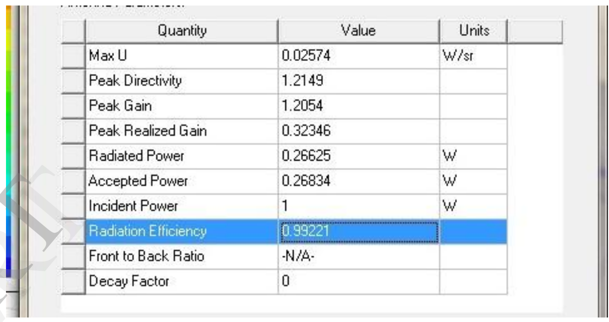


Fig 4: The Rectangular MPA resonates at a frequency of 6.6 Ghz.

6. Antenna parameters for Rectangular MPA using Epoxy kevlar substrate

The below figure shows the antenna parameters for rectangular MPA using epoxy Kevlar substrate.

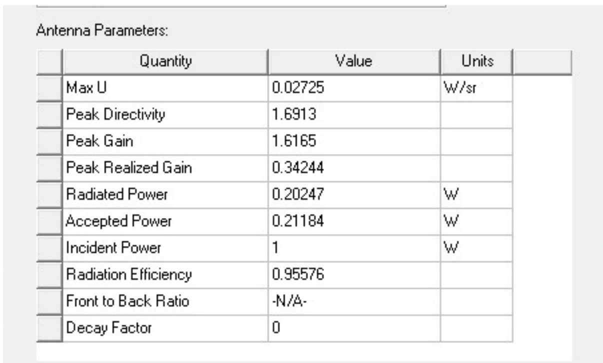


Quantity	Value	Units
Max U	0.02574	W/sr
Peak Directivity	1.2149	
Peak Gain	1.2054	
Peak Realized Gain	0.32346	
Radiated Power	0.26625	W
Accepted Power	0.26834	W
Incident Power	1	W
Radiation Efficiency	0.99221	
Front to Back Ratio	-N/A-	
Decay Factor	0	

Fig 5: Parameters using Epoxy Kevlar Substrate

7. Antenna parameters for Rectangular MPA using Polyester substrate

The below figure shows the antenna parameters for rectangular MPA using polyester substrate.



Antenna Parameters:

Quantity	Value	Units
Max U	0.02725	W/sr
Peak Directivity	1.6913	
Peak Gain	1.6165	
Peak Realized Gain	0.34244	
Radiated Power	0.20247	W
Accepted Power	0.21184	W
Incident Power	1	W
Radiation Efficiency	0.95576	
Front to Back Ratio	-N/A-	
Decay Factor	0	

Fig 6: Parameters using polyester substrate

8. Antenna parameters for Rectangular MPA using FR4_Epoxy substrate

The following figure shows antenna parameters for rectangular MPA using FR4 epoxy substrate

Antenna Parameters:

Quantity	Value	Units
Max U	0.054204	W/sr
Peak Directivity	2.1025	
Peak Gain	1.4242	
Peak Realized Gain	0.68116	
Radiated Power	0.32398	W
Accepted Power	0.47827	W
Incident Power	1	W
Radiation Efficiency	0.67739	
Front to Back Ratio	-N/A-	
Decay Factor	0	

Fig 7: Parameters using FR4 epoxy substrate

9. Antenna parameters for Rectangular MPA using Rogers RT/Duroid 5880(tm)substrate

The following figure shows antenna parameters for rectangular MPA using rogers RT/Duroid 5880(tm) substrate.

Quantity	Value	Units
Max U	0.13941	W/sr
Peak Directivity	3.237	
Peak Gain	3.1837	
Peak Realized Gain	1.7519	
Radiated Power	0.54123	W
Accepted Power	0.55029	W
Incident Power	1	W
Radiation Efficiency	0.98353	
Front to Back Ratio	-N/A-	
Decay Factor	0	

Fig 8: Parameters for RT/ Duroid substrate

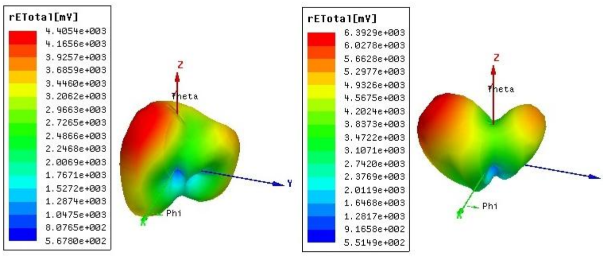


Fig 9: Radiation pattern obtained using Epoxy Kelver substrate and FR4 epoxy Substrate

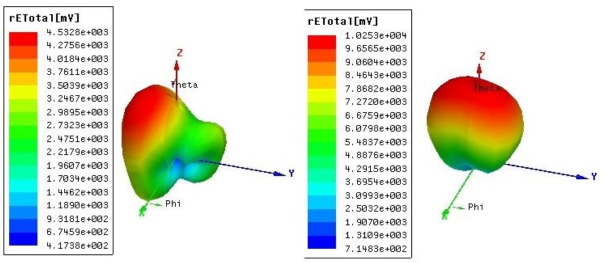


Fig 10: Radiation pattern obtained using polyester substrate and RT/Duroid 5880.

10. CONCLUSION

A rectangular microstrip patch antenna is studied, designed and simulated and antenna parameters & radiation patterns with different substrate materials are compared. Rectangular MPA using Rogers RT/Duroid 5880(tm)substrate gives the best results with peak directivity of 3.237 , peak gain of 3.1837 , peak realized gain of 1.7519, radiated power of 0.54123 W, accepted power of 0.55029 W, incident power of 1 , radiation efficiency of 0.98353 and resonates at 6.6 Ghz making it suitable for C band applications. Such type of antenna is useful for Telecommunication, Wi-fi, Radar, Satellite communication, Military communication and commercial.

11. REFERENCES

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