Flexible Microstrip Patch Antenna using Different Substrates for Bio- Medical Applications

D. Prabhakar, CH. Balaswamy, M. Akhil Poorvika, M. Venkata Krishna Sai, M. Subba Naidu

Abstract: This work deals with the simulation and features of Microstrip antenna having patch of different flexible substrates. The flexible antenna finds broad range of applications in defense, satellite, Bio-medical and automobile industries. At present it is the most researched topics across the globe. The flexible antenna gets adaptable to the surface and can be used across curved surfaces. Flexible Materials like Teflon, PTFE glass are the substrates which are used to design the patch antenna. Patch size was selected such that the antenna resonates at 2.45 GHz. The antenna with measured substrate properties was simulated in High Frequency Structure Simulator (HFSS). Small variation in resonant frequency caused due to finite ground plane dimensions and variation of feed location. The simulated results suggest that flexible substrate antennas can be successfully used for Bio-Medical Applications.

***Index Terms*: flexible antenna, microstrip patch antenna, Teflon, PTFE glass.**

I. INTRODUCTION

To reduce the size of antenna electronics and communication packages has put lot of constraints on antenna parameters [1]. Traditional antennas are rigid; they are not flexible and non-conformal to curved spaces. Flexible antennas are compact, lightweight and gets conformal to any surface due to this reason they can be used across curved surfaces. Based on their substrates flexible antennas can withstand mechanical stress up to certain extent. In process of making antennas flexible rigid substrate materials are replaced with the flexible substrate materials like polymer, micro fluids/liquid metals, paper, plastic, etc., [2-4]. In recent times these flexible antennas are one of the most researched areas in antennas. They find applications in defense, satellite, wearable electronics, Bio-medical field and automobile industry. For Bio-Medical application, research on Microstrip patch antenna with flexible substrate was done using High Frequency Structure Simulator (HFSS). In this paper Teflon, PTFE Glass which are polymers are selected as the flexible substrate because of their better mechanical properties of forcibly retracting to its original dimensions after deformation. The performance parameters of the antenna are improved to obtain reasonably wide impedance, high bandwidth, high gain, high efficiency and voltage wave standing ratio less than 2.

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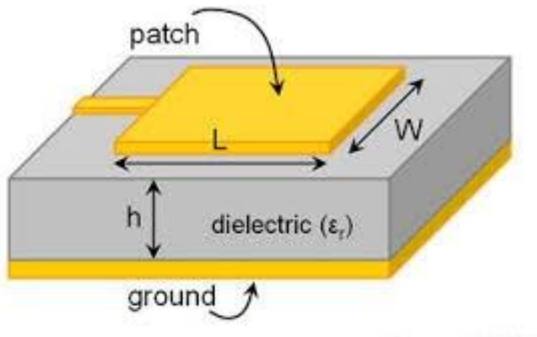
II. DESIGN CONSIDERATION

A general Microstrip antenna in its simplest form consists of a radiating patch on one side of a dielectric substrate ($\varepsilon_r \leq 10$) and ground plane on the other side. The materials used for patch are copper and gold, they can mould to any shape based on our requirement, but stranded shapes are generally used to analyze and to predict outputs. Generally copper is more preferable as it is more economical.



Antenna Design Equations

Effective length, $L_e = L + 2\Delta L$

Effective Width, $W_e = W + 2\Delta W$

$\Delta L = \frac{h}{\sqrt{\varepsilon_e}}$

Resonant Frequency, $f_0 = \frac{c}{2\sqrt{\varepsilon_e}}\left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2\right]^{1/2}$

Where m &n are orthogonal modes of excitation

Fundamental mode is TM_{10} mode; m=1, n=0

$$\varepsilon_e = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + \frac{10h}{W}\right]^{-\frac{1}{2}}$$

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

Smaller or larger W can be taken than the W obtained from this expression

$L_e = L + 2\Delta L = \frac{\lambda o}{2\sqrt{\varepsilon_e}} = \frac{c}{2f_0\sqrt{\varepsilon_e}}$

Bandwidth α W & Gain α W

Choose feed point x between $L/6$ to $L/4$

Width of Ground, $W_g = W + 6h + 6h$

Length of Ground, $L_g = L + 6h + 6h$

Where h is substrate thickness

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Fig. 1.Teflon samples

Fig. 2. PTFE glass samples

TABLE I

OPTIMISED ANTENNA DIMENSIONS

S.No	Parameters	Teflon	PTFE
1	Solution Frequency (f_o)(GHz)	2.45	2.45
2	Dielectric Constant (ε_r)	2.1	2.5
3	Height of Substrate (h) (mm)	1.6	1.6
4	Width of patch (w) (mm)	49.14	46.28
5	Length of patch (L) (mm)	41.38	38.05
6	Width of ground (w_g) (mm)	58.74	55.8
7	Length of ground (L_g) (mm)	50.98	47.65

III. SIMULATION RESULTS AND DISCUSSION

A. Results for Teflon Substrate

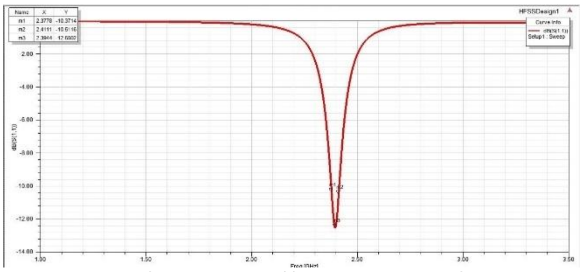

Fig.3.Reflection co-efficient using Teflon substrate.

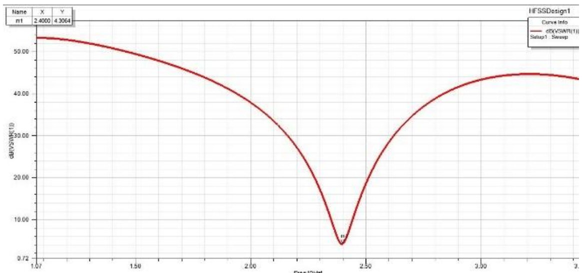

Fig.4.VSWR for Teflon substrate.

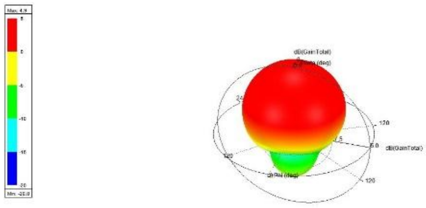

Fig.5.Gain plot for Teflon substrate.

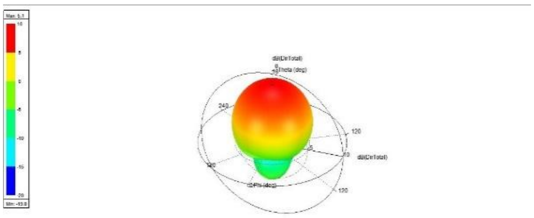

Fig.6. Directivity plot for Teflon substrate.

B. Results for PTFE Substrate

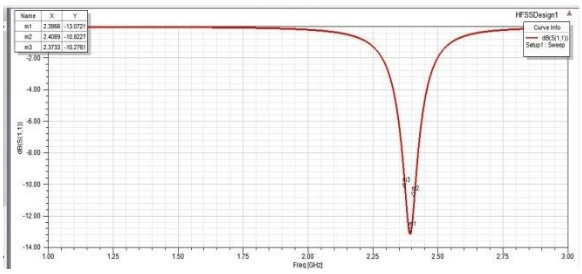

Fig.7.Reflection co-efficient using PTFE substrate.

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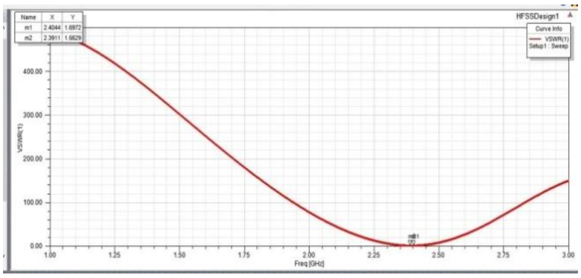

Fig.8.VSWR for PTFE substrate.

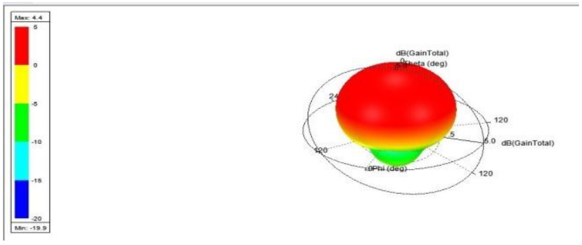

Fig.9.Gain plot for PTFE substrate.

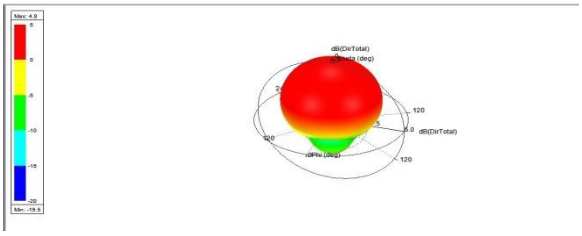

Fig.10.Directivity Plot for PTFE substrate.

From the above we can observe that Reflection Co-efficient has minimum value at 2.4 GHz for all the substrates. The voltage standing wave ratio (VSWR) is less than 2 at the specified frequency of operation. It is evident from the **Fig.4** and **Fig.8**.Generally VSWR<2 is preferable.

As the antenna is designed for Bio-Medical applications its radiated power must be less. **Fig.5** and **Fig.9** shows the gain of the antenna using three different substrates.

We can also observe the Directivity plots from the **Fig.6** and **Fig.10** and their relation with Efficiency. Directivity and Efficiency are directly related to each other.

TABLE II
COMPARISION OF ANTENNA PARAMETERS

S.NO	Parameters	Teflon	PTFE
1	**Resonant Frequency (GHz)**	2.4	2.4
2	**Reflection Coefficient (dB)**	-12.55	-13.0721
3	**Gain (dB)**	4.9	4.4
4	**Directivity (dB)**	5.1	4.8
5	**VSWR**	1.9	1.69
6	**Band Width (%)**	1.39	1.33
7	**Efficiency (%)**	96.078	91.66

IV. CONCLUSION

Designed and Simulated Microstrip patch antenna using different substrates by using HFSS software. Observed different antenna parameters like gain, directivity, reflection coefficient and VSWR. Designed Microstrip patch antennas are used for different wearable, wireless, Medical applications.

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