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Flexible Patch Antenna using Different Substrates for WBAN Applications

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Abstract

This paper introduces a flexible patch antenna using different substrates. The flexible antennas are becoming popular in the present day era and these antennas play key role in Bio-Medical applications. The paper deals with the primary approach in using Polyester, Rubber which are the materials used as the substrates for patch antenna. The mechanical properties of these substrates make antenna flexible. The antenna operates in the ISM band(2.4-2.5) GHz. The ISM band is suitable for flexible operation. The antenna with measured substrate properties was simulated in High Frequency Structure Simulator (HFSS). Approximate values in resonant frequency may be due to finite ground plane dimensions and variation of feed location. The simulated results suggest that flexible substrate antenna can be successfully used for Medical Applications.

Keywords : *Flexible antenna, Patch antenna, Rubber, Polyester.*

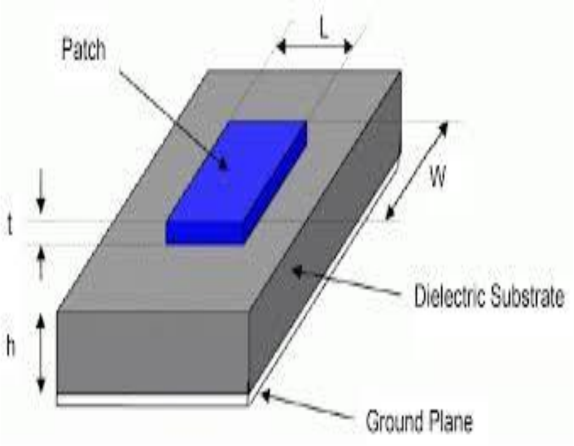
1. Introduction

Flexible antennas are compact, light-weight, economicaland can withstand mechanical strains up to a certain extent. In order to make the antenna flexible, existing substrates are replaced with alternative materials which are flexible. Generally a thin metal strip is to be laid on the top of a flexible substrate. These metals must maintain conductivity even when they are stretched [1-2],[4]. Several flexible substrates have been reported such as polymer,micro fluids/liquid metals, paper, plastic, etc. Rubber and polyester which are naturally flexible are chosen as substrates. These substrates are well suitable for design purpose because of their mechanical properties. According to [3],[5-6], all these substrates can naturally and forcibly tack back to their original dimensions after deformation. Besides, they can be made into a variety of shapes and can be attached to metal inserts or mounting plates.

Flexible electronics is presently considered as the developing technology that has reached a certain level in meeting the requirements of tightly assembled electronic packages, providing reliable electrical connections where the assembly is required to flex during its normal use or where board thickness, weight, or space constraints, radiation are the main driving factors. In this context, flexible substrate antennas (FSAs) play a key role in the integration and packaging of wireless communication devices. Those antennas, which are designed such that the resonant peak frequency remains unaffected after bending, stretching, or twisting, are currently being embedded into materials such as textile fabrics, bandages, stickers, and bendable displays.

2.DESIGN CONSIDERATION

A microstrip antenna simply consists of a radiating patch on one side of a dielectric substrate ($\varepsilon_r \leq 10$), which has a ground plane on the other side. The patch conductors, normally of copper and gold, can assume virtually any shape, but conventional shapes are generally used to simplify analysis and performance prediction.



2.1. Calculation of width of patch:

The width (w) of microstrip patch antenna is given by eq..... (1)

$$w = \frac{c}{2f_o}\sqrt{\frac{2}{\varepsilon_r+1}} \quad ..... (1)$$

where c is free-space velocity of light,
ε_r is dielectric constant of material and f_0 is the resonant frequency of microstrip antenna. The value of effective dielectric constant is less than dielectric constant of the substrate due to the fringing fields. It is calculated using eq…. (2)

2.2. Calculation of length of patch:

$$\varepsilon_{eff} = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{2}\left(1 + 12\frac{h}{w}\right)^{\frac{-1}{2}} \quad ....(2)$$

Where h is the height of substrate of the antenna,
Length of patch is calculated using eq…. (3)

$$L = L_{eff} - 2\Delta L ..... (3)$$

Where$Leff$ is given by eq.... (4) $L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}}$ ....(4)

ΔLWhich can be calculated using eq…. (5)

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{w}{h}+0.8)} .....(5)$$

2.3.Calculation of width and length of ground and substrate:

Ground and substrate have same dimensions but substrate have some thickness which is denoted by h as mentioned above.
Width of ground is w_g
Length of ground is L_g
Width of substrate is w_s

$$w_s = w_g = 6h + w$$
$$L_s = L_g = 6h + L$$

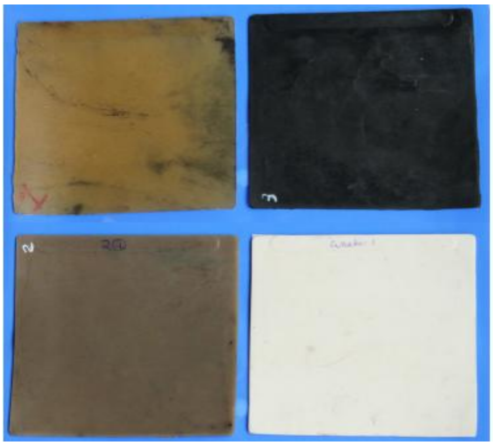


Fig. 1. Rubber samples.

Fig. 2. Polyester samples

TABLE I
OPTIMISED ANTENNA DIMENSIONS

S.No	Parameters	Rubber	Polyester
1	**Solution Frequency(f_o)(GHz)**	2.45	2.45
2	**Dielectric Constant of Rubber(ε_r)**	3	3.2
3	**Height of Substrate(h)(mm)**	1.6	1.6
4	**Width of patch(w) (mm)**	43.29	42.22
5	**Length of patch(L) (mm)**	34.81	33.70
6	**Width of ground(w_g)(mm)**	52.89	51.82
7	**Length of ground(L_g)(mm)**	44.41	43.3

3. Results and Discussion

3. 1.Results for Rubber Substrate

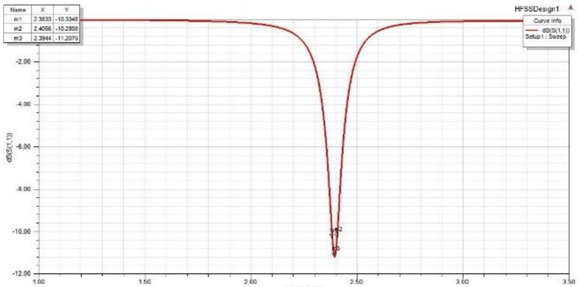


Fig. 3.Reflection Co-efficient using Rubber substrate.

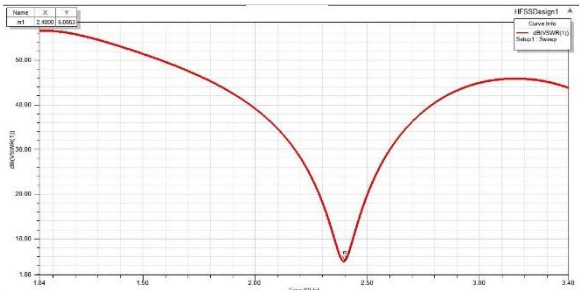


Fig. 4.VSWR for Rubber substrate.

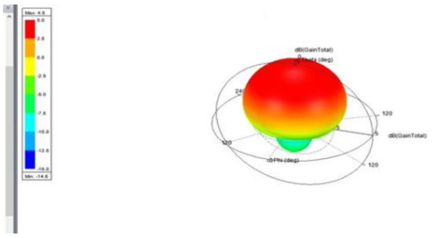


Fig. 5.Gainplot for Rubber substrate.

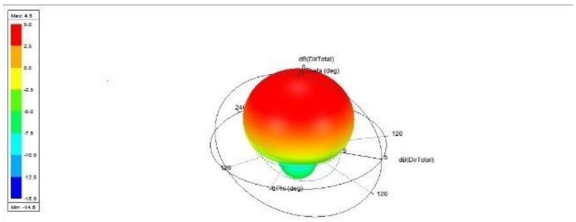


Fig.6. Directivity plot for Rubber substrate

3. 2.Results for Polyester Substrate

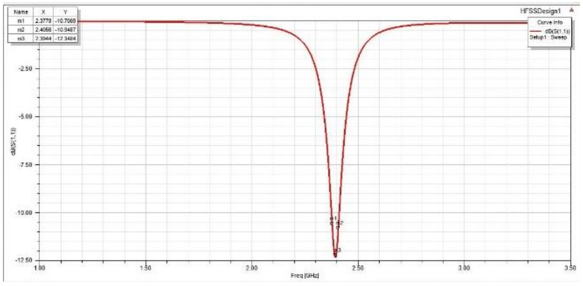


Fig. 7.Reflection Co-efficient using Polyester substrate.

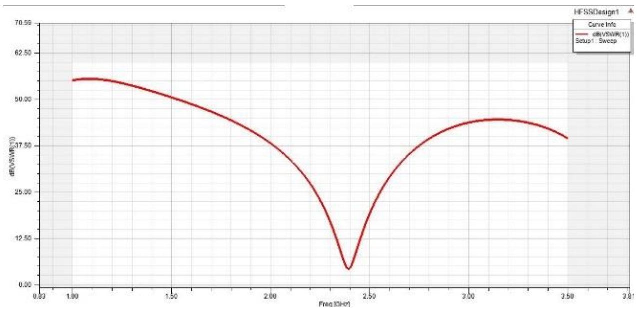


Fig. 8.VSWR for Polyester substrate.

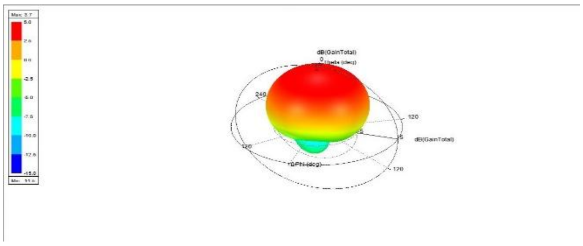


Fig. 9.Gainplot for Polyester substrate.

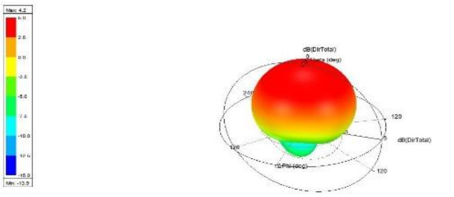


Fig. 10. Directivity plot for Polyester substrate

Reflection Co-efficient is obtained at 2.45 GHz in each of the case. The voltage standing wave ratio (VSWR) is also minimum at the specified frequency of operation. It is evident from the Fig.6 and Fig.9.

As the antenna is designed for applications it should radiate with much reduced power. Fig.7 and Fig.12 shows the gain of the antenna using two different substrates.

TABLE II
COMPARISION OF ANTENNA PARAMETERS

Parameters	**Rubber**	**Polyester**
Resonant Frequency(GHz)	2.4	2.4
Reflection Coefficient (dB)	-11.21	-12.34
Gain (dB)	4.5	3.7
Directivity (dB)	4.5	4.2
VSWR	1.75	1.65
Band Width (Hz)	0.0106	0.0116
Efficiency (%)	100	88.09

5. Conclusions

The proposed antenna is the primary approach to use rubber and polyester as the substrate for patch antenna. The mechanical properties of these substrates make the antenna highly flexible. The designed antennas can be used for WBAN applications. The simulated results shows thatthe designed antenna operates at 2.45 GHz, the center frequencyof ISM band.

Acknowledgments

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