Dual Band Rectangular Patch Wearable Antenna on Jeans Material

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***Abstract*- Wearable substrate such as cotton, jeans, and leather is utilized to prepare flexible antenna. These antennas can be placed on the dress materials. It is easier to carry the antenna also. The preparation of wearable antenna is to be done as per the mathematical design carried out for a normal micro strip patch antenna. In this paper, a dual band rectangular antenna which operates around 0.9 GHz and at 2.4 GHz is designed, simulated and fabricated based on Jeans cloth. The connectivity between the two rectangular patches is done with few arms. The number and width of those arms are varied and corresponding effects are studied.**

Keywords – Wearable Antenna, Jeans, Arms, Return Loss, VSWR.

I.INTRODUCTION

Micro strip antennas are considered to be the antenna for the future. All conventional antennas are now fabricated in micro strip form. Micro strip antennas have the advantages of light weight and easiness to carry anywhere.

Micro strip antennas are to be constructed based on a dielectric material called ‘Substrate’. The height of the substrate is another important factor. For a fixed resonant frequency, the design of a micro strip antenna is carried out based on dielectric constant of substrate material and its height. Materials which are used as substrates are FR4, Rogers, Duroid etc.,

It is possible to design and fabricate micro strip antenna with substrates such as cotton, jeans and leather. These antennas are known as wearable antennas or textile antennas. As these substrates are cloth material, user can wear this as clothes. It is easier to carry the wearable antenna.

In this work, a dual band wearable antenna in rectangular shape is designed and simulated. The dual band requires two rectangular shapes which are connected with ‘arms’. The width of the arms and the number of arms are varied and their effects on antenna characteristics are studied.

II. THE DESIGN

To implement dual band characteristics of micro strip antennas, various methods are being used. One of the methods is to provide two rectangular patches designed for specific frequency and then bridging the gap between them [1]. In this work, the same technique is used but wearable substrate is selected.

Various clothing materials such as cotton, jeans and leather can be used as substrates for a textile antenna. In this work, jeans cloth is used as substrate because of its strength and ruggedness. The dielectric constant of jeans cloth is found out as 1.6.

The normal design of rectangular patch as per the literature is used to design the rectangular patches. One resonant frequency is fixed at 0.9 GHz which is a frequency for mobile communication and the other frequency is fixed at 2.4 GHz which is frequency of WLAN. The rectangular patches are designed for the above mentioned frequencies.

The following Steps are to be followed in designing a rectangular patch wearable antenna [3].

Step1: Calculation of the width (W):

$$W = \frac{v_o}{2 f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \qquad \text{------- (1)}$$

Step2: Calculation of Effective dielectric constant:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{(\varepsilon_r - 1)}{2} [1 + 12 \frac{h}{W}]^{-\frac{1}{2}} \qquad \text{---(2)}$$

Step 3: Calculation of Effective length (L_{eff}):

$$L_{eff} = \frac{v_o}{2 f_0 \sqrt{\varepsilon_{reff}}} \qquad \text{--(3)}$$

Step 4: Calculation of Length extension (ΔL):

$$\frac{\Delta L}{h} = 0.412 \frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \qquad \text{--(4)}$$

Step 5: Calculation of actual length of the patch (L):

$$L = L_{eff} - 2\Delta L \qquad \text{--(5)}$$

Step 6: Calculation of ground plane dimensions (g_L and g_W):

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. Similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the ground plane dimensions are given as:

$$L_g = 6h + L \qquad \text{--(6)}$$
$$W_g = 6h + w \qquad \text{--(7)}$$

In the above equations (1) to (7), 'L' is the length of patch, 'W' is the width of the patch, 'h' is the height of the substrate, 'ε_r' is the relative permittivity of substrate, 'ε_{reff}' is the effective relative permittivity of patch, 'v_o' is the velocity of EM wave, 'L_{eff}' is the effective length of patch and 'f_o' is the resonant frequency.

III. IMPLEMENTATION OF DUAL BAND RECTANGULAR WEARABLE ANTENNA

The dual band wearable antenna is to be implemented in a microwave antenna simulator. IE3D is a 2.5 dimension antenna simulator tool which is being used worldwide. The dual band antenna is to be implemented in IE3D as per the design parameters specified above.

First, a single patch antenna of frequency 2.4 GHz on the jeans cloth substrate of thickness 1.5 mm is implemented. The substrate's dielectric constant is 1.6.The square patch has dimension of 50mm × 50mm.Ground plane dimension is of length 134mm and breadth 150mm.

The outer Patch is to resonate at 0.9 GHz. This patch is also constructed on Jeans cloth material. It has length of 130.6 mm and width of 146 mm on the same substrate. The inner patch is to be embedded into the outer patch. This can be done by cutting a slot in the outer patch. A rectangular slot of length 90.6 mm and width 106 mm is created in which the smaller inner patch is placed. These two patches are to be bridged by arms between these two slots. At each side, five arms of 4mm width are used to bridge the two patches. By trial and error, the feed point is selected as (5,-10) mm. The structure of dual band wearable antenna with dimensions in mm and the location of feed point is shown figure 1.

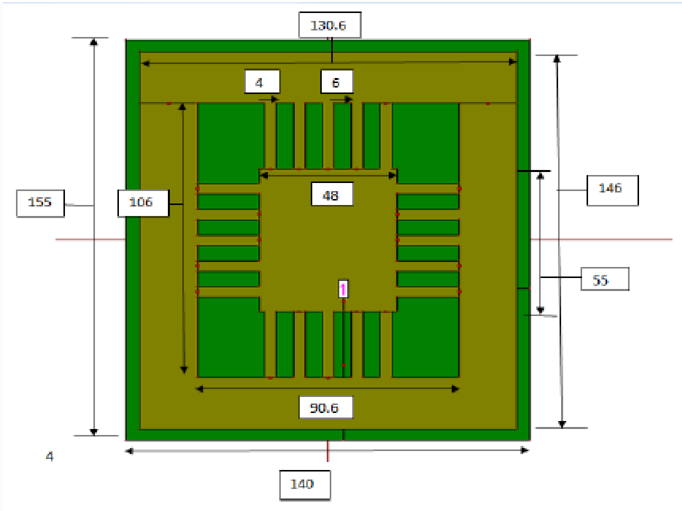

Fig 1.Dual Band Wearable Rectangular Patch for 2.4 and 0.9 GHz.

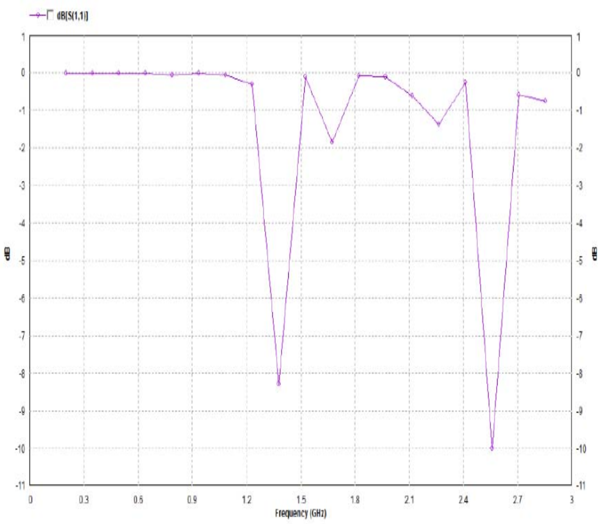

Fig 2.Return loss Vs Frequency graph for Dual Band Wearable Rectangular Patch antenna

In figure 2, return loss Vs frequency graph for antenna in figure 1 is given. Return loss has two distinct downward peaks which indicate that the antenna is resonating at two frequencies, 2.5 GHz and 1.3 GHz. At 1.3 GHz, the value is close to -8.5 dB, while at 2.5 GHz, it is exactly touching -10 dB.

The VSWR Vs frequency is shown in figure 3. It shows that this antenna resonates at 2.5 GHz with the VSWR of 1.9 and at 1.3 GHz with the VSWR of 2.2.

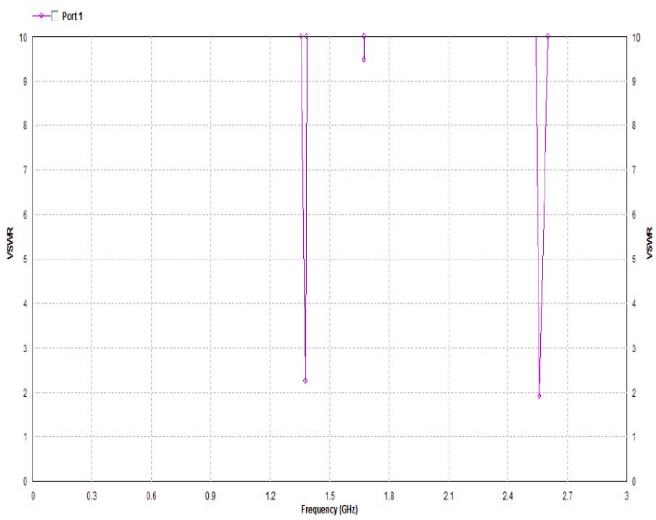

Fig 3. VSWR Vs Frequency graph for Dual Band Wearable Rectangular Patch antenna

IV. EFFECT OF CHANGING THE WIDTH AND NUMBER OF ARMS BRIDGING THE PATCHES

The results obtained for a dual band rectangular antenna is satisfied but needed to be improved. As both patches are fed by a common feed point, the arms which bridge the two patches play an important role in characterizing entire antenna. The number of arms is varied and the width of the arms is varied and the results are tabulated.

No. of Arms	Width of Arm[mm]	‘S_{11}’ at 2.4 GHz [dB]	‘S_{11}’ at 0.9 GHz [dB]	‘f_r’ at 2.4 GHz	‘f_r’ at 0.9 GHz
1*4	20	-1.1	-0.1	2.4	1.2
7*4	2	-2	-1.6	2.7	1.2
5*4	4	-23	-7	2.5	1.4
9*4	1	-5	-9	2.3	1.3
7*4	4	-11	-1	2.3	1.3
3*4	5	-10	-0.5	2.7	1

Table 1. Variation in number and width of arms

With the outcome of table 1, the number of arms is fixed as ‘5’ and width of the arms is fixed as 4mm. Now, the width of the slot is varied and the results are tabulated.

Width of slot [mm]	‘S_{11}’ at 2.4 GHz [dB]	‘S_{11}’ at 0.9 GHz [dB]	‘f_r’ at 2.4 GHz	‘f_r’ at 0.9 GHz
60	-2.1	-1.14	2.5	1.5
54	-1.8	-0.3	2.4	1.4
46	-6	-1	2.4	1.3
40	-23	-7	2.5	1.4
36	-2	-0.1	2.1	1.2
30	-0.5	-7	2.3	1.4
20	-1.4	-0.1	2.1	1.2

Table 2. Variation in the width of slot

Table 2 shows that with the width of slot at 40 mm, the return loss is better for both resonant frequencies.

VI. CONCLUSION

The dual band wearable rectangular antenna is designed as per the basic design mechanisms. The antenna is designed for 0.9 GHz and 2.4 GHz. The designed antenna is simulated in IE3D environment.

The results obtained are satisfactory. But for the outer patch which resonates at 0.9 GHz, the actual resonant frequency shifted to 1.2 GHz and the return loss is poor at – 7 dB. The optimum results are tried by varying the width and number of arms. The slot width is also varied to obtain improved results. The result gives marginalized improvement.

There is still hope for improvement by varying other parameters of the antenna or by changing the feed point of the antenna. The arms can also be fixed at corners of patches to have better results.

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