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Design and Analysis of E-Shaped Microstrip Patch Antenna

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Abstract: An E-shaped patch antenna is designed for ISM band of frequency. The proposed antenna is designed on a flexible substrate. The polyamide having dielectric constant of 4.3 is one of the flexible substrate and used for design of the proposed antenna. Due to the flexibility feature of the substrate this antenna is used as wearable antenna. Simulated and measured results for main parameters such as return loss, impedance bandwidth, radiation patterns and gains are also discussed herein. From the analysis of result it is verified that the design and modeling of this antenna is suitable of ISM band of frequency.

Index terms: - E-shaped, textile antenna, U slot, C slot.

Introduction: Wearable antenna plays a very important role for developing the wearable computer systems and smart clothing, which help in rapid progress in wireless communications [1]. In this paper a flexible E-shaped microstrip patch antenna is proposed and investigated. Despite of narrow bandwidth due to the small size, light weight, compactness and low cost, microstrip patch antennas are commonly used. In literature, different shapes like cutting slots, U shape and C shape structures are discussed to improve their performance parameters like bandwidth, return loss and gain [2]–[4]. A wearable antenna means that it is part of the clothing. Being the more flexible these antennas increase the comfort level of the user [5-6].

This paper presents design of textile based wearable patch antenna. The substrate chosen is polyamide. Polyamide is a macromolecule with repeating units linked by amide bonds. For body-wearable applications major requirement is small size, better radiation performance under the effect of body etc. The polyamide is selected as a substrate because, it is textile material and it is very flexible. As body-wearable antenna is mounted on body thus it is necessary that the antenna should also be flexible. So, there is need of analyzing patch antenna on polyamide substrate. Also E shaped is chosen because as compared to rectangular patch it has lesser area which in turn makes the antenna area small. Hence it is suitable for body-wearable applications. The polyamide dielectric constant is 4.3. First of all antenna is designed and simulated on Hyperlynx IE3D. Then performance analysis is done on the basis of return loss, gain and radiation patterns.

Design of antenna:-

A simple flexible light weight E-shaped antenna with polyamide as a substrate is designed to operate at 2.45 GHz. The mechanical properties of the Polyimide makes the antenna flexible with permittivity $\varepsilon_r = 4.3$, for flexibility purpose the thickness of 1.6 mm. These properties make polyimide very attractive to be used as substrates for the fabrication of antennas in applications having low loss, reduced bill of materials, preserving the electromagnetic performance. The length and width of the patch are 39 mm and 29 mm respectively and shown in fig.1.

The microstrip patch antenna design is accomplished by following steps [7][8]:

Step 1: Calculation of the Width of patch (W)

The width of patch is given by (1) $$\mathrm{W} = \frac{c}{2f_0\sqrt{(\varepsilon_r+1)/2}} \qquad (1)$$

Where, c is free space velocity of light. f_0 is resonant frequency in GHz for the current design. ε_r is dielectric constant of the substrate kept at 4.3 for polyamide . By using these values the width of the patch of antenna is found to be 29 mm.

Step 2: Calculation of effective dielectric constant

$$\varepsilon_{reff} = \frac{(\varepsilon_r+1)}{2} + \frac{(\varepsilon_r-1)}{2}\left[1 + 12\frac{h}{w}\right]^{-1} \quad (2)$$

Where, h is height of the substrate or thickness of the substrate given as 1.6 mm.

Step 3: Calculation of the length extension ΔL, which is given by

$$\frac{\Delta L}{h} = 0.412\,\frac{(\varepsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{reff}-0.3)(\frac{w}{h}+0.8)} \quad (3)$$

Step 4: Now length of patch is given by

$$L = \frac{\lambda_0}{f_0\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (4)$$

Where the effective length of the patch L_{eff} is 46.92 mm and is calculated as:

$$L_{eff} = \frac{\lambda_0}{f_0\sqrt{\varepsilon_{reff}}} \quad (5)$$

Step 5: Calculation of position of inset feed point where the input impedance is 50 ohms.

$$Y_0 = \frac{L}{\pi}\cos^{-1}\left(\sqrt{\frac{Z_{in}}{R_{in}}}\right) \quad (6)$$

Where, Z_{in} and R_{in} is the resonant input impedance and resonant input resistance respectively. The Y_0 is found to be 7 mm. Using these parameters antenna is designed in IE3D Zeland (Hyperlynx) software of antenna design.

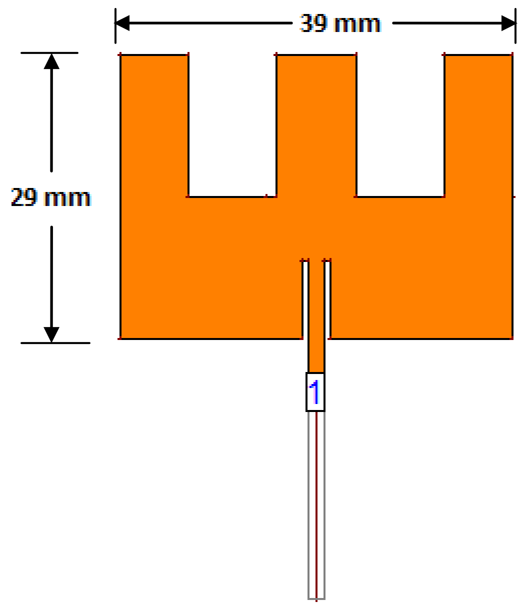

Fig.1 E-shape patch antenna

Results and Discussion: The proposed antenna was designed on polyamide substrate and simulated using the IE3D Zeland (Hyperlynx) software of antenna design. The dimensions of antenna were estimated by using the equation (1)-(6). The S-parameter (S_{11}) is shown in fig.2 and shows good resonance at the designed frequency of 2.45 GHz. The return loss of antenna is achieved -32.5 dB at 2.45 GHz.

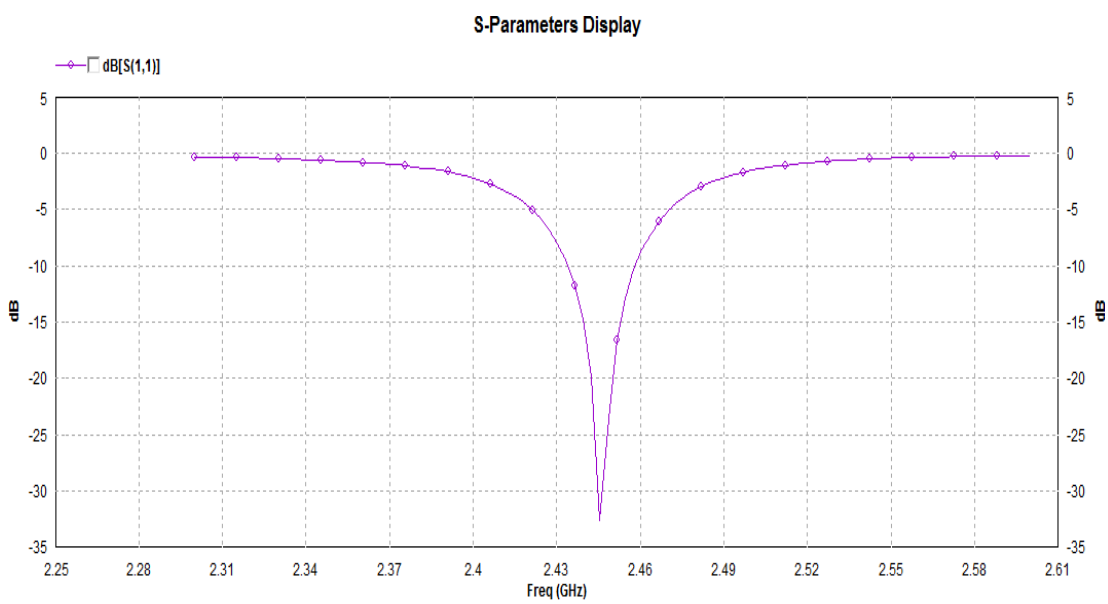

Fig.2 S-parameter S_{11}

The VSWR of designed antenna is shown in fig.3 which is well in the acceptable range at the designed frequency.

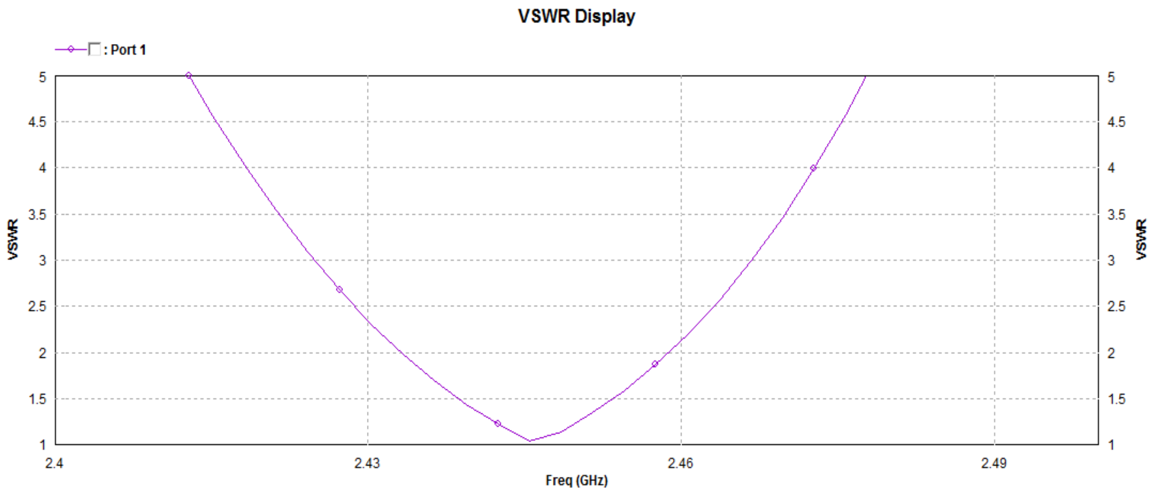

Fig.3 VSWR of antenna at 2.45 GHz frequency

The radiation pattern of antenna is shown in fig.4(a) and 4(b). The fig 4(a) shows the elevation pattern gain display. The maximum gain of antenna is 5.2 dBi at 2.45 GHz and fig 4(b) shows the azimuth pattern gain display.

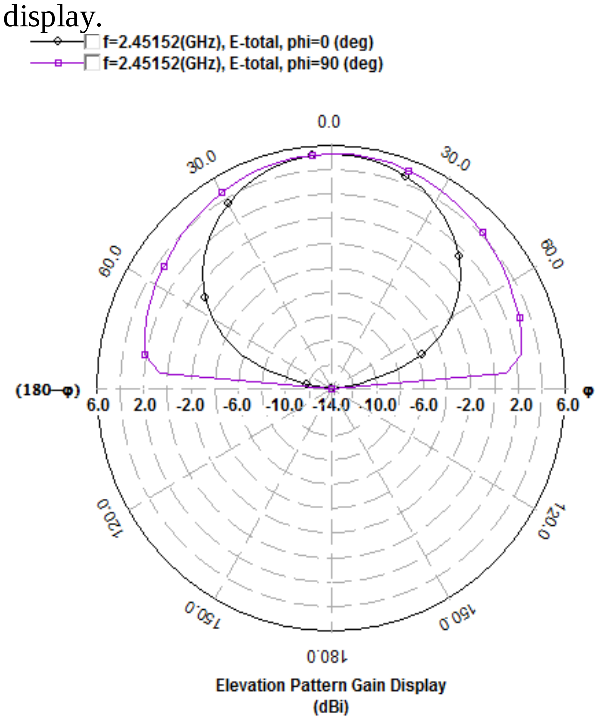

Fig.4(a) Elevation Radiation pattern of antenna at 2.45 GHz

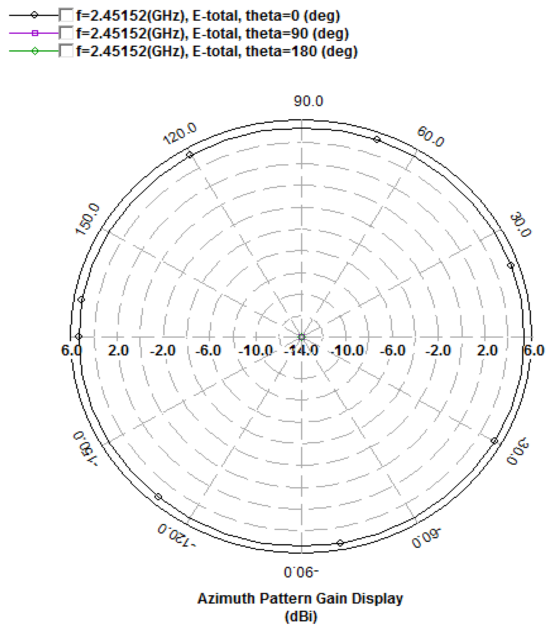

Fig.4 (b) Azimuth Radiation pattern of antenna at 2.45 GHz

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