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DESIGN AND FABRICATION OF MICROSTRIPPATCH ANTENNA FOR TEXTILE APPLICATIONS

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Abstract:

Utilization of wearable textile materials as antenna substrate has been speedy due to the recent miniaturization of wireless devices. A wearable antenna is to be a part of the clothing used for wireless communication purposes, which include tracking and navigation, mobile and wearable computing and public safety. For user convenience there is an increasing need for integrating antennas on or in the clothing. The conventional antennas are not flexible and difficult for user to movements. There is a need of antennas made of flexible textile materials that can be part of user clothing defined as wearable antennas. Here at 2.45 GHz frequency patch antenna is designed and simulated using ADS.

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I. INTRODUCTION

Micro strip antenna was first introduced in the 1950s. However, the technology of Printed Circuit Board (PCB) was later introduced in 1970s.Therefore, from that time MSA had become a very common antenna having wide range of applications due to their advantages light weight, low profile, low cost, planar configuration and many more. MSAs are widely used in Radio-Frequency Identification (RFID), Broadcast radio, mobile systems, Global Positioning System (GPS), satellite communication, television systems, multiple-input multiple output (MIMO) systems, vehicle collision avoidance system, surveillance system, direction founding, radar systems, remote sensing, missile guidance, and so on . Because of micro strip patch antenna's many unique and attractive properties, there seems to be little doubt that it will continue to find many applications in the future. Its properties includes, light weight, low profile, easy fabrication, compact and conformability to mounting structure . In this design, we are concentrating on rectangular microstrip patch antenna which consists of rectangular patch of length [L1] and width [W2] of the patch. The proposed antenna works on the Wearable textile patch antenna using Jeans at a frequency of 2.4GHz (2400-2484MHz) which is based on IEEE 802.11b for Textile applications . The Substrate material used is FR-4 Epoxy which has permittivity i.e. its dielectric constant.

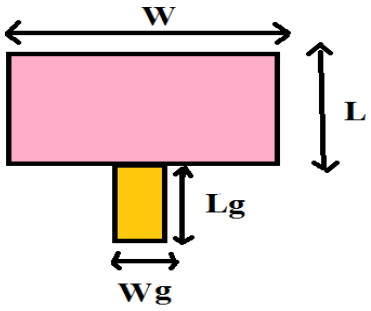
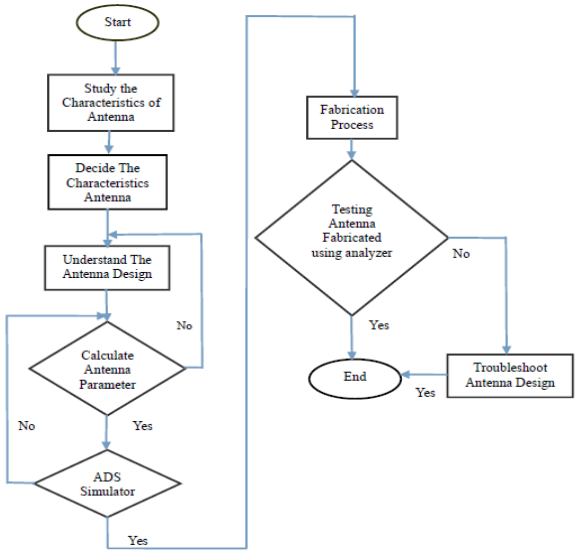


Fig .1 Microstrip patch antenna

Fig. 2 substrate formation

II. DESIGN PROCEDURE :

The proposed antenna is designed using FR-4_epoxy material. the substrate with this is drawn by taking the geometry of 29.2mm x 29.2mm (Length and Width) . The relative permittivity is 4.4 and permeability is of the order of 1. The proposed antenna design is expected to operate in the frequencies of about 2.4GHz to 2.45GHz. These frequencies are used for Bluetooth applications. Here sqare patch geometry has been selected to achieve wideband characteristics. It has advantages of single layer with single feed structure. Simple microstrip-line feed is used to supply the RF power. The choice of substrate depends on dielectric constant (Permittivity), Loss tangent, Conductivity and cost. The selected substrate has low dielectric constant, loss tangent and thickness.



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Design flow chart of microstrip patch antenna

*III.*DESIGN OF MICROSTRIP PATCH ANTENNA

1. **Operating frequency (f0):**
The ISM frequency band is 2400MHz to 2483.5MHz, which is used for Bluetooth, WLAN and other applications. Hence the resonant frequency selected for design is 2.4 GHz.

2. **Dielectric constant of the substrate (εr):**
The dielectric material selected for design is FR4_epoxy having dielectric constant of 4.4. A substrate having high dielectric constant should be selected because higher the dielectric constant smaller the dimensions of the antenna.

3. **Height of dielectric substrate (h):**
For the microstrip patch antenna which are used in cellular phones or other hand held devices it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate should be small; effect of height is discussed in [16]. Here FR4_epoxy substrate of standard height 1.6 mm is selected.

Hence, the essential parameters for the design are:
- Frequency of operation fo = 2.4 GHz
- Dielectric constant of the substrate εr = 4.6
- Height of dielectric substrate h = 1.6 mm

WIDTH CALCULATION:

$$W = \frac{1}{2\pi\sqrt{\mu\epsilon}}\sqrt{\frac{2}{\varepsilon r + 1}}$$

Substituting εr = 4.6 and fo = 2.4 GHz, we get: W = 0.0366 m = 36.6 mm

1.Effective dielectric constant calculation (εreff):

$$\text{Ɛeff}=\frac{\varepsilon r+1}{2}+\frac{\varepsilon r-1}{2}\left(1+\frac{12h}{w}\right)^{\frac{1}{2}}$$

Substituting :εr= 4.6, W = 36.6 mm and h = 1.6 mm, we get : εreff = 4.26

2. Effective length calculation (Leff):

$$\text{Leff}=\frac{c}{2fr\left(\sqrt{\varepsilon eff}\right)}$$

Substituting : εreff= 4.26, c = 3.0x108 m/s and fo= 2.4 GHz we get: Leff=0.03029 m = 30.29mm

3. Length extension calculation (ΔL):

$$\frac{\Delta L}{h} = (0.412(\varepsilon eff + 0.3)(\frac{W}{h} + 0.264))/(\varepsilon eff - 0.258)\left(\frac{W}{h} + 0.8\right)$$

Substituting : εreff= 4.26, W=36.6 mm, h= 1.6mm, Δl = 1.05mm

4. Actual length of Patch calculation:

Length can be calculated as

$$L = Leff - \Delta L$$

Substituting : Leff= 30.29mm , ΔL = 1.05mm we get, L=28.173mm

5. The ground plane dimensions Calculation (Lg and Wg):

Lg=L+6*h =28.173+6*1.6 =37.773 mm

Wg=W+6*h = 36.6+6*1.6=46.2 mm

Substituting :L=28.173mm, W=36.6 mm , h=1.6mm

6. Determination of feed points:

A coaxial probe is used to connect in this design. The feed point location is denoted as (Xf ,Yf). That must be located on the patch, where the 50 ohms input impedance is achieved. For different locations of the feed point, the return loss is compared and that feed point is selected where the R.L is most negative.

According to the existing point along the length of the patch where the return loss is minimum. Hence in this design, Yf will be zero and only Xf will be varied to locate the optimum feed point .

Plane	Dimension	Measurment values
Radiating patch	W	36.60
Length	L	28.17
Ground plane	Wg	42.90
Length	Lg	46.30

Table .1 dimensions of patch antenna

Antenna characteristics	Measurment values
Directivity	5.73
Gain	5.50
Power Radiated	0.009
Effective angle	3.3582

Table.2 characteristics and values of patch antenna

According to above calculation following simulated result is obtained.

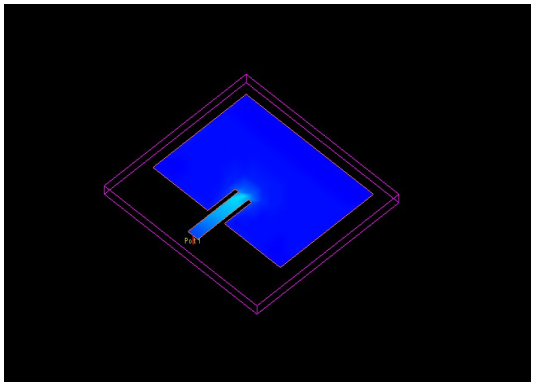

Fig. 3 The Proposed Antenna With Feed

3.2 **Resonant frequency**: This antenna is resonating at 2.4 GHZ frequency. And this frequency is used for wireless communication as it is ISM band frequency and L band frequency

3.3 **Return loss**: the return loss output of this microstrip patch antenna is shown in figure 3.Return loss of antenna at resonating frequency 2.4 GHz, which is below -10 dB and is equal to –34dB.

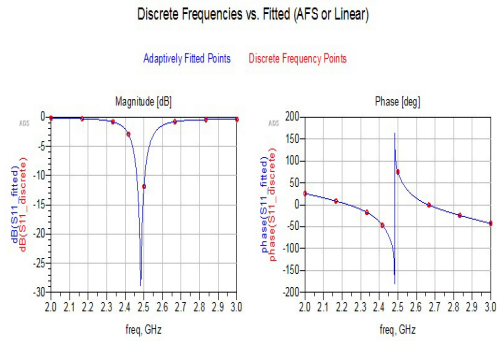

Fig.4 Return Loss

3.4 **Gain**: The ability of antenna can be measured through the antenna gain which is a ratio of radiated power to input power. Obtained gain is about 5.22 dBi for the designed frequency band

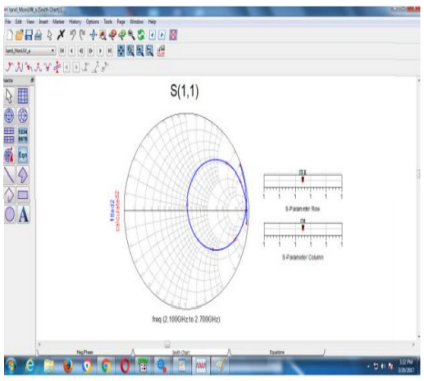

Fig.5 Gain

3.5. **Radiation pattern**: The radiation pattern provides how the antenna radiates the transmitting power with respect to direction. The users may be located anywhere, so the antenna should cover all the directions from 0˚ to 360˚. Figure 3.4shows the radiation pattern for proposed patch design. The red color from the figure shows the maximum radiation intensity to the user .

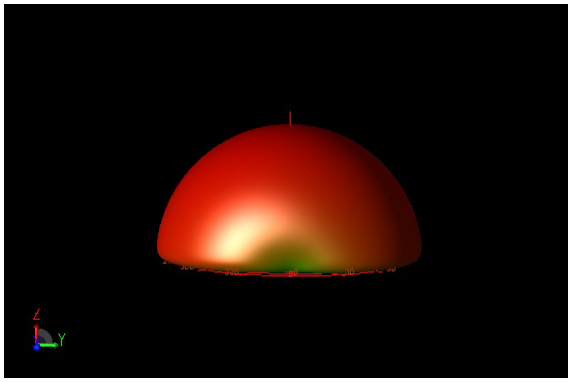

Fig .6 Radition pattern

IV FABRICATION OF TEXTILE PATCH ANTENNA

For fabrication of prototype textile antenna we have done following steps

A. Measure the Height of Single layer. For the desire thickness we have to measure single layer thickness of substrate material. Measurement of single layer jeans is done using thickness gauge. It gives the 0.7mm for single layer.

B. Stack the Jeans for desire height For the 3.5 mm thickness we have to stack the jeans according to substrate dimension 120 X 120mm stitch it at the edges. Then remaining jeans was cut using scissor. According to calculated dimension self-adhesive copper tape which has non conducting glue is cut using blade. Then using same material ground plane was cut and stick on jeans substrate.

C. SMA Connector Then SMA connector is soldered using normal soldering techniques. There are chances of burning the jeans material so special care is taken during soldering.

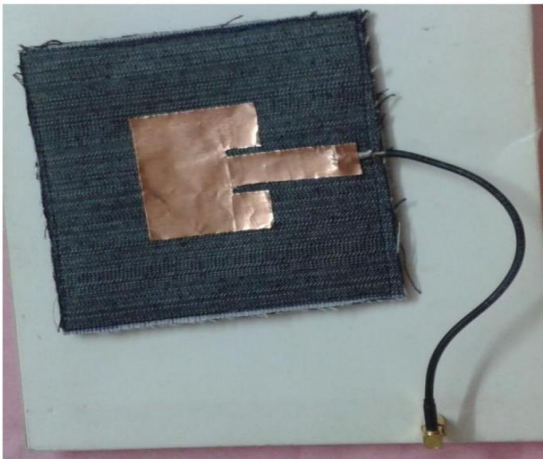

Fig .7 Textile microstrip patch antenna

II. CONCLUSION

Antenna is design and simulated at operating frequency 2.4 GHz and tested in the laboratory using Network analyser. The hardware and software test results are found to be satisfactory and antenna can be used for 2.4 GHz ISM frequency band applications like navigation , public safety and tracking. The present state of work includes the design procedure of micro strip patch antenna using PSO which shows the improved bandwidth then the conventional results, the gain is high and the s parameters graphical results shows the increase in the efficiency and wide radiation patterns detailed experimental studies can be taken up at a later stage to find out a design procedure for balanced amplifying antennas.

III. REFERENCES

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