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Dual Slot H Shape Antenna for SAR Estimation

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***Abstract:** In the proposed work, H-shaped microstrip antenna is designed with two slots. Itoperates at a frequency of 2.2GHz with a FR-4 substrate. The proposed antenna is designed for UHF application like mobile communication. The dimension of the proposed antenna is 42 x 30x 1.6 mm^3. Two equal size parasitic patches are being introduced to implement the H shape and simulated using HFSS software. Further, Specific Absorption Rate (SAR) of the proposed antenna is found out. Average SAR value for this proposed design appears to be 0.39 W/Kg, which is also far less than the prescribed value by Telecom Engineering Center (TEC) of 1.6W/Kg.*

***Keywords:** Microstrip Antenna, UHF, VSWR, SAR, TEC*

I. INTRODUCTION

In the recent years, communication systems has been developed with new and advanced technologies. Antenna is the basic fundamental component required for communication. The microstrip patch antennas fabrication is simple and inexpensive.These are small size and low weight antenna. The performance of these antennas is high over a wide range of frequencies. Therefore, microstrip antennas are generally used for different applications. The proposed work is to design and simulate a dual slot H-shaped patch antenna using HFSS software with the slots on both sides of the rectangular patch.

II. PRINCIPLE OF MICROSTRIP PATCH ANTENNA

Basic microstrip patch antenna contains dielectric substrate, one side of it isa radiating patch and on other sideof it is a ground plane as shown in Fig 1. Copper and gold are good conducting material and are used as radiating patch. Radiating patch can be designed with any shape such as circular, square, hexagon etc.The radiating patch with the feed lines are usually imprinted on the dielectric substrate.

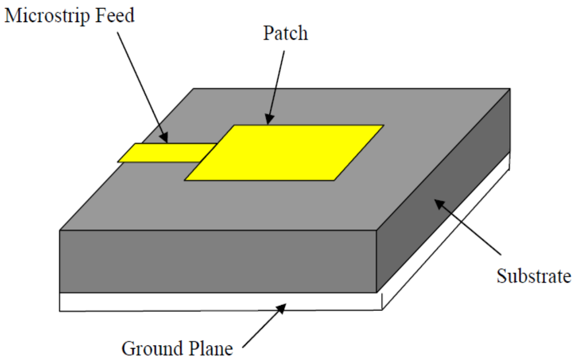

Fig.1 Basic Structure of Microstrip Antenna

Micro-strip patch antennas can be designed for different impedance matching and resonant frequency [1]. However, higher quality factor can be obtained with resonating structure of antenna. Effective resonance depends on the dimensions of a patch. Bandwidth can be increased by using high dielectric substrate[2]. Basic drawback of a such antennas is its low bandwidth [3]. Low size of the patch antenna is required for most of the applications [4]. The patch dimensions can be decreased by cutting the slots, slits, increase in height of substrate [5]. Resonant frequency can be changed by changing the length of the patch and the impedance matching can be changed by changing the width [6]. In the proposed design, the cuts on the patch of equal lengthare introduced. This proposed design aims at using a line feed rather than co-axial feed due to its simplicity in design. The antenna performance can be measured in terms of its radiation pattern, return Loss, Voltage Standing Wave Ratio (VSWR), Gain, Directivity and its radiation efficiency [8]. Finally, Specific absorption ratio (SAR) value is observed for the implemented design to check whether it is hazardous or not to the human beings in practice.

A. Proposed Design:

FR-4 (Flame retardant) substrate is used to design this antenna, as it is readily available, cheaper than other substrate like RT/Duroid-5580. As per the survey, for the various substrates [9], FR-4 was found to be suitable for cellular applications.

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III. DESIGN CONSIDERATION

A. Dual Slotted H Shaped Patch Antenna

The proposed H shapedantennais designed as shown in the Fig.2. FR4 substrate is used for the proposed design.
The dielectric constant for FR4 is 4.4 while the loss tangent is 0.025. The FR4 is placed exactly over the ground plane,and hence the size of itis exactly same as that of the substrate. The thickness of the patch and the ground plane is same as 0.1mm. Copper (Lossy) is used for the patch and the ground plane. Dimensions of dual slot H-antenna is listed in table 1.

Table1. Measurements of Dual Slot H-Antenna

Region	Length (mm)	Width (mm)	Height (mm)
Ground	88	76	0.1
Substrate	88	76	1.6
Patch	30	42	1.6
Slot1	7	18	1.6
Slot2	7	18	1.6

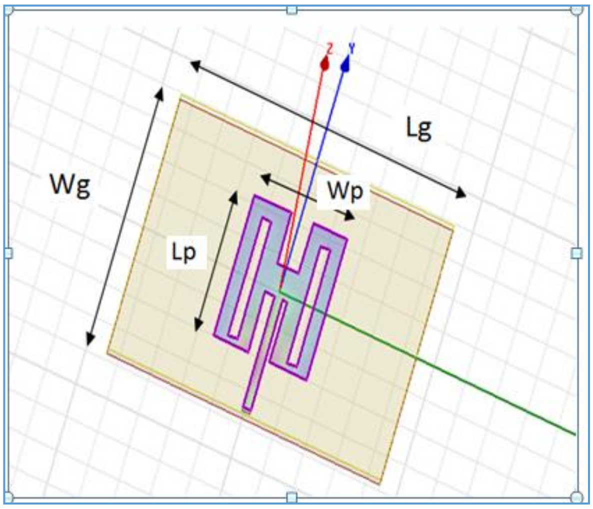


Fig.2 H Shaped Antenna

To radiate maximum power, impedance matching is the most important factor. Considering impedance of 50 ohm, microstrip feed length and its width are calculated. The proposed H shaped antenna structure was implemented in HFSS 13.

B. Design Equations:

The expression for ε_{reff} is given by[6]

$$\varepsilon_{reff} - \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2} + [1+12\frac{h}{W}]^2 \quad ...1$$

Where ε_{reff} = Effective dielectric constant,

ε_r = Dielectric constant of substrate,

h = Height of dielectric substrate,

W = Width of the patch.

$\Delta L$is the increased length of the patch on each side [6], which is given by

$$\Delta L = 0.412\frac{(\varepsilon_r+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_r-0.258)(\frac{W}{h}+0.8)} \quad ...2$$

L_{eff}(Effective length) is given by the equation,

$$L_{eff} = L + 2\Delta L \quad ...3$$

If resonance frequency is f_o, then L_{eff} is given by

$$L_{eff} = \frac{c}{2 f o\, \varepsilon_r} \quad ...4$$

The width W of the patchis given by

$$W = \frac{c}{2 f o \sqrt{\frac{\varepsilon_r+1}{2}}} \quad ...5$$

Ground/Substrate (Lg=Length, Wg=width) Dimensions are given by

Lg =Lp +6h and Wg = Wp +6h…6

IV. RESULTS AND DISCUSSIONS

Firstrectangular patch antenna is designed. Dual slots are designed at equal distance on W_p.This is known asDual H Slot antenna.HFSS is used for simulation in proposed design as the results are almost similar to that of the practical design.

A. Return Loss:

The ratio of rejected radio waves at input of the antenna to accepted radio waves is called as Return loss. Return loss is expressed in dB. The simulation result for return loss of dual slot H antenna design is shown in figure 3.

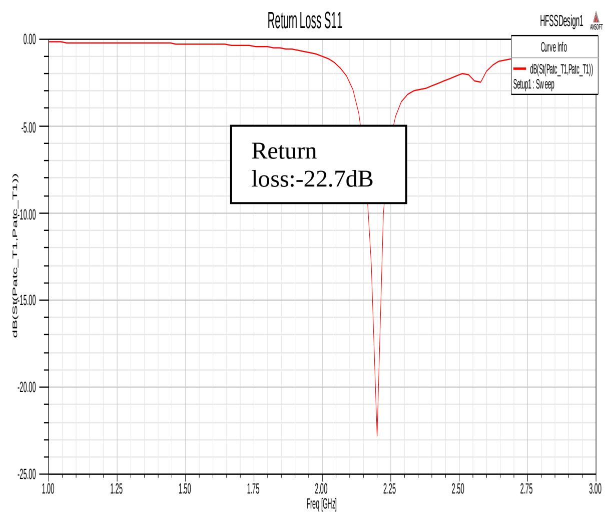


Fig. 3 Return Loss (S11)

S11 parameter for the proposed H shaped antenna in HFSS comes out to be -22.7dB which is very good.

B. VSWR:

VSWR is a measure of impedance matching of the antenna to the transmission line to which it is connected. VSWR measures variations in voltage. Mathematically,VSWR is measured as the highest voltage to the lowest voltage in the transmission line:

VSWR =

$$\frac{Maximum\ Amplitude\ Voltage\ of\ the\ Signal\ (Vmax)}{Minimum\ Amplitude\ Voltage\ of\ the\ Signal\ (Vmin)} \quad ...7$$

Vmax is the maximum signal voltage and Vmin is the minimum signal voltage along the transmission line.

The simulation result of VSWR of the antenna is shown in figure 4.

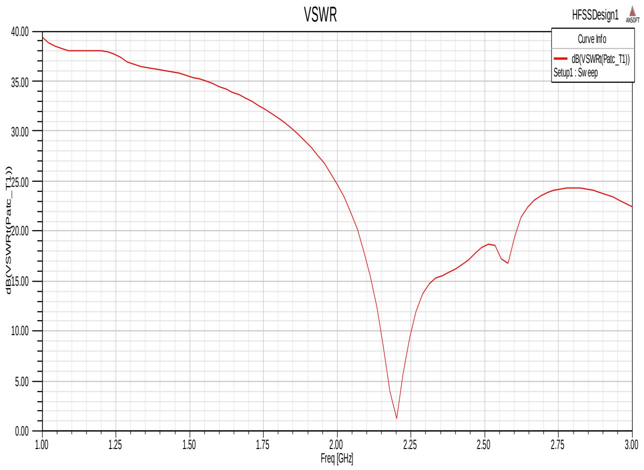


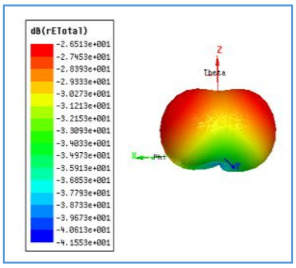
Fig.4 VSWR

The VSWR for the proposed Dual Slot H shaped antenna is 1.2360 and is accepted.

C. Radiation Pattern

Radiation pattern is defined as diagrammatical illustration of energy radiation as a directional function. The radiation pattern basically gives the direction in which the strength of the radiated energy is maximum.The directivity and gain can be observed from radiation pattern.

The 3D radiation pattern is shown in figure 5 and 2D radiation patternsis shown in figure 6 for the proposed design.



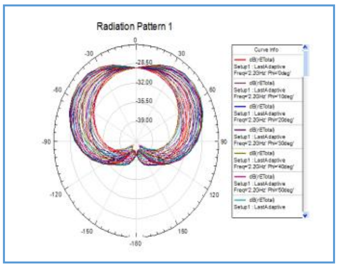


Fig.5 3D Radiation Pattern **Fig. 6 2D Radiation Pattern**

D. Current Distribution

Distribution of current in the antenna depends on the type of antenna. Current distribution is how much current that flows through the antenna.For an antenna the current distribution is generally expressed as the surface current density (J). The surface current density is the amount of current flowing over a unit area. Figure 7 shows the surface current density for the dual slot H antenna.

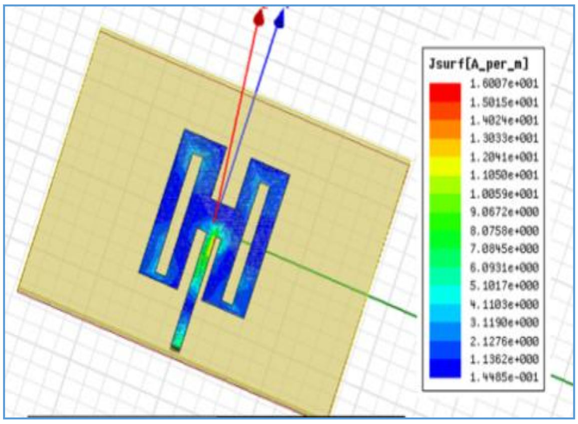


Fig.7 Current distribution (J_{surf}) in the proposed antenna

E. Specific Absorption Rate (SAR)

Electromagnetic waves are used to transmit the signal. These waves radiate energy. Human body can absorb this energy. Therefore, the rate at which this energy is absorbed by human body when the body is within a range of radio frequency (RF) electromagnetic field, is called as Specific Absorption Rate (SAR). It has unit watts per kilogram (W/kg); power absorbed per mass of tissue either 1gram or 10 gram. SAR value will be different at different parts of the body. Therefore, the value of SAR in the specific part of the body is the maximum value over sample volume of tissue.

$$\text{Specific Absorption Rate} = \sigma \frac{E^2}{m_d} \quad ...8$$

Where σ is electrical conductivity, E is RMS value of electric field and m_d is tissue mass.

Cell phone towers, mobile phones also radiate electromagnetic energy. Each country has decided its maximum SAR value for electromagnetic energy radiated by mobile phones. Some countries and their maximum SAR limits [10] are listed in table 2.

Table2. SAR Values in Different Countries

Country	Association deciding SAR	Value of SAR
United States	FCC	1.6 (W/kg)
European Union	CENELEC	2.0 (W/kg)
India	TEC	1.6 (W/kg)

The average SAR field was simulated in HFSS. 0.39 W/Kgis the average SAR value for dual slot H-antenna, which is very less than that of the maximum value of 1.6W/kg. Hence the designed antenna is not at all hazardous to use it practically [11]. The average SAR Field is shown in the figure 8.

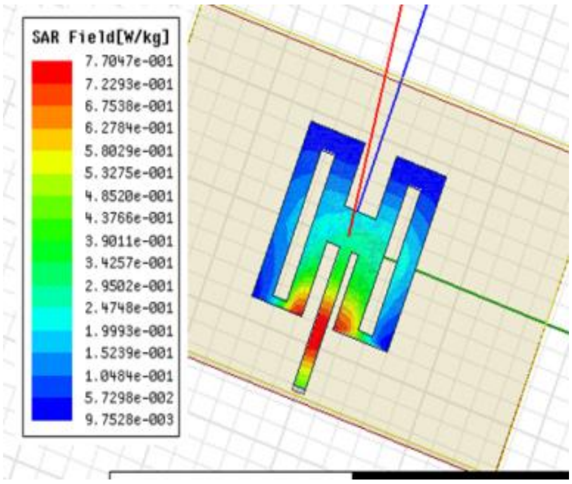


Fig. 8 SAR Field for the proposed antenna

V. CONCLUSION

In the proposed work, implementation of Dual Slot H shaped microstrip antenna which operates at 2.2 GHz. This antenna can be used in the UHF application like cellularcommunication. The results for this antenna are implemented successfully in HFSS13. The return loss for this proposed antenna is -22.7 dB which is quite good. The VSWR for this designed antenna is 1.2 which is practically acceptable as well.The 3-D and 2-D radiation polar plotsare plotted as well. The gain for this antenna was found to be 3.65dBi. The efficiency for this proposed design was around 43 percent. Further the average SAR value for this design was calculated which comes out to be 0.39W/Kg, which is much less than the maximum allowable SAR limit provided by TEC as 1.6W/Kg. This is due to two slots in the antenna.All values are shown in table 3.

Table3. Result Table

Parameter	Value
Operating frequency	2.2 GHz
Return Loss	-22.7 dB
VSWR	1.23
Gain	3.65 dBi
SAR	0.39 W/kg

The gain and hence the efficiency of the antenna can be increased further and SAR value can be reduced by using EBG (Electro-magnetic Band gap) structure. Applications of the antenna are in wireless LAN, Mobile phones, Bluetooth.

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