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E-SHAPE MICROSTRIP PATCH ANTENNA DESIGN FOR WIRELESS APPLICATIONS

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ABSTRACT

This paper presents the design & simulation of E-shape microstrip patch antenna exhibiting wideband operating frequencies for various wireless applications. This antenna will provide the wide bandwidth which is required in various applications like remote sensing, biomedical application, mobile radio satellite, wireless communication etc. The coaxial feed or probe feed technique is used in the experiment. The performance of the designed antenna was analyzed in terms of bandwidth, gain, return loss, VSWR, and radiation pattern. The design is optimized to meet the best possible result. The proposed antenna is designed by air substrate which has a dielectric constant of 1.0006. The results show the wideband antenna is able to operate from 8.80 to 13.49 GHz frequency band with optimum frequency at 8.73 GHz.

KEYWORDS: *E-shaped patch antenna, Air substrate, HFSS software, Wireless communication.*

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I. INTRODUCTION

Microstrip patch antenna is a key building in wireless communication and Global Positioning system since it was first demonstrates in 1886 by Heinrich Hertz and its practical application by GulielmoMarconi in 1901 [1].Future trend in communication design is towards compact devices. A microstrip antenna consists of a dielectric substrate, with a ground plane on the other side. Due to its advantage such as low profile planer configuration, low weight, low fabrication cost and capability to integrated with microwave integrated circuit technology, the microstrip patch antenna is very well suited for applications such as wireless communication system, cellular phone, radar system and satellite communication system [1][2]. They have the capability to operate in dual and triple frequency operations. However, narrow bandwidth came as the major disadvantage for this type of antenna [1].

There are several techniques have been applied to overcome this problem, such as increasing the substrate thickness, introducing parasitic element, that is co-planer and stack configuration, or modifying the patch's shape includes designing an E-shaped patch antenna or, a U-slot patch antenna. After the study of several literature , We find that, U-slot microstrip antenna provides bandwidth up to 30% while E-shaped patch antenna can increase bandwidth above 30% compared

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both designs [2]. The E-shaped in much simpler to construct by only adjusting length, width, and position of slots. The main objective of designing an E-shaped microstrip patch antenna is to optimize the base design in to obtain higher bandwidth. The configuration of E-shaped microstrip antenna [13] is shown if Figure-1 & Equivalent circuit of rectangular patch E-shaped patch antenna [13] is shown in Figure-2 simultaneously.

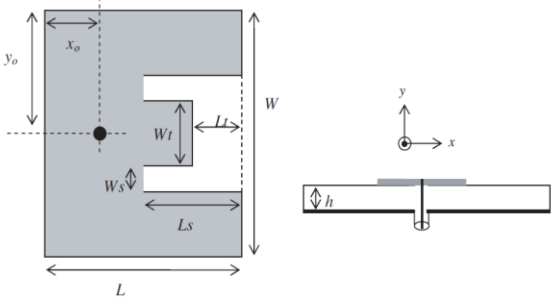


Figure 1. Configuration of the E-shaped microstrip antenna.

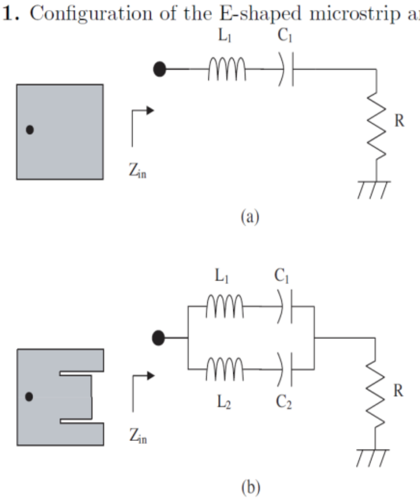


Figure 2. Equivalent circuits of (a) rectangular patch and (b) E-shaped microstrip antennas.

II. DESIGN OF RECTANGULAR PATCH

The rectangular microstrip patch antenna has been designed by calculating the length and width from the given equation [13]:

$$W = \frac{c}{2f\sqrt{(\varepsilon_r + 10)/2}}$$

Where, C is the velocity of light, €r is the dielectric constant of substrate, f is the antenna working frequency, W is the patch width, the effective dielectric constant and the length are given as,

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 10\frac{h}{W}\right]^{-\frac{1}{2}}$$

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff} + 0.300)\left(\frac{W}{h} + 0.262\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.813\right)}$$

By using above equations we can find the value of actual length of the patch as,

$$L = \frac{c}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta l$$

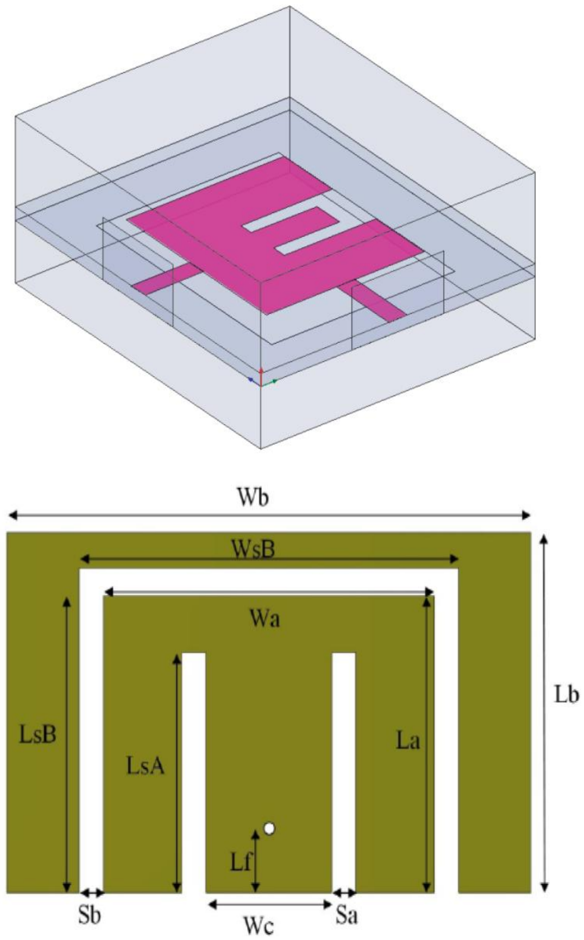


Figure-3: 3D view of proposed E-shaped antenna & Design Geometry of E-shaped microstrip patch antenna

BLOCK DIAGRAM OF DESIGNING PROCEDURE:

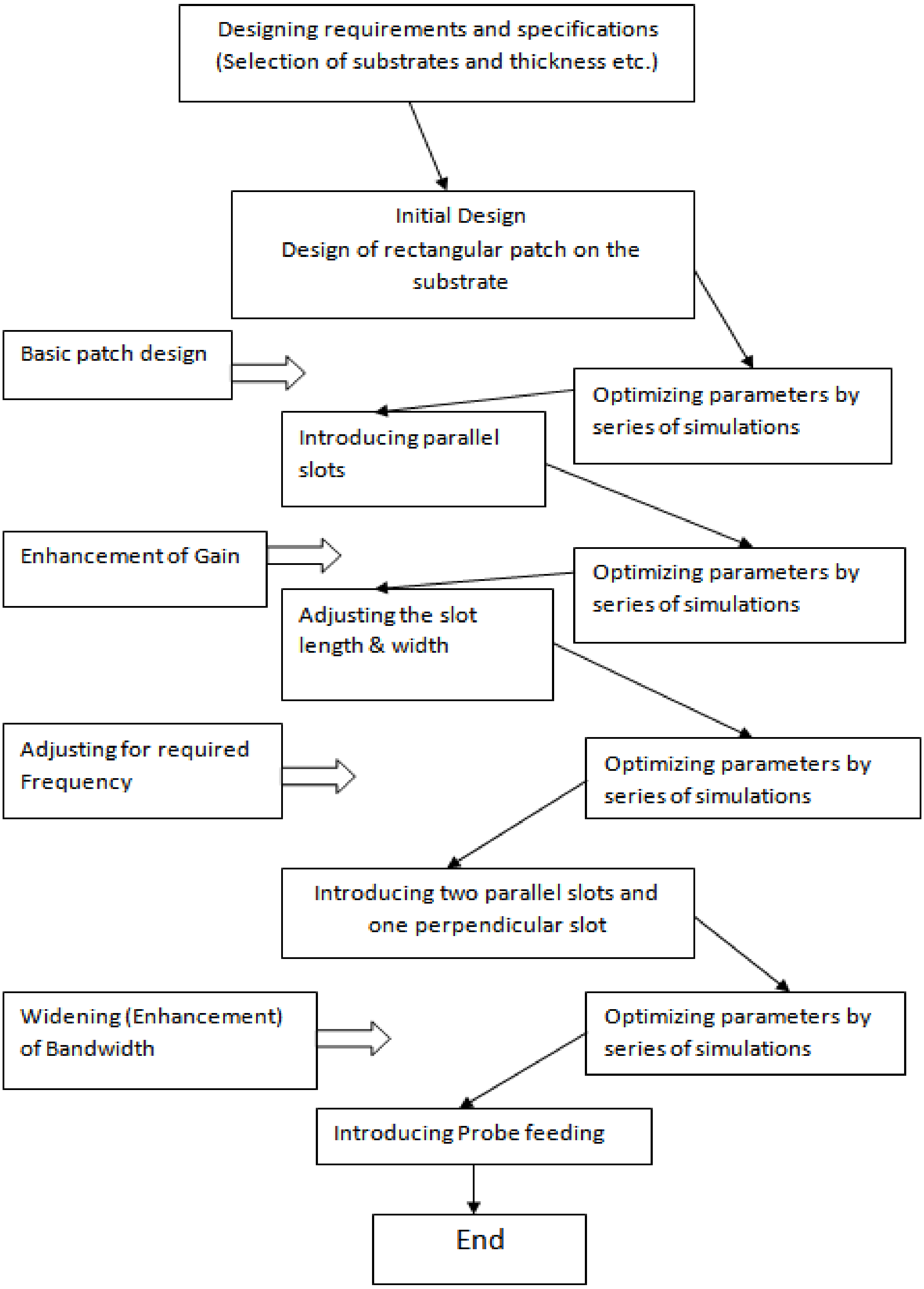


Figure-4: Block Diagram of Designing procedure antenna

III. DESIGN METHODOLOGY

Recently there have been numerous methods of enhancing the bandwidth of an antenna for example modifying the probe feed, using multiple resonances, using folded patch feed or, using the slotted radiating element [5][6]. We know, as thickness increases the bandwidth increases accordingly. The input impedance of about 42% is achieved [1][3][4]. The slots making it too look alike inverted E -shape, it demonstrated a bandwidth enhancement by 30%. In this design an air-filled or foam has been essential to realize broadband characteristics. The design uses substrate material with relative permittivity is (1.0006), that is air & the patch shape is the combination of inverted E & inverted U.

IV. SIMULATION SETUP

The antenna's resonant properties were predicted and optimized using High Frequency Structure simulator Software (HFSS). The design procedure begins with determining the length, width, and the type of dielectric substance for the given operating frequency as shown in the flow diagram of Fig-4. Then using the measurements obtained above simulation has been setup for the basic rectangular microstrip antenna and the parameters are optimized for the best impedance matching [7][8]. Furthermore, two parallel slots are incorporated and optimized, such that it closely resembles E-shape. This increases the gain of the antenna. After that, two more parallel slots and one perpendicular slots are incorporated and optimized such that, it closely resembles U shape [9]. Then dielectric material of 1.0006 introduces to decrease the size of the antenna and to further enhance the bandwidth [10]. At last the probe feeding are introduced for attaining a required bandwidth, resonant frequency and gain value [11][12]. The proposed design methodology of the given antenna is given in Fig-4.

V. ANTENNA DESIGN & STRUCTURE:

In this paper several parameter have been investigate using HFSS. The design specifications of the patch antenna are:
Default microstrip antenna specifications:

- The dielectric substrate material selected for design which has dielectric constant of 1.0006
- Main patch:
  Length =10.0 mm
  Width =15.7 mm
- Outer patch:
  Length=13.2mm
  Width=21.7mm
- Slot:
  Main width=17.7mm
  Slot width= 1.0mm
  Slot A width=8.4mm
  Slot B width=10.9mm
- Centre arm:
  Width=5.3mm
- Feed point:
  Width=2.6mm
  Length=1.8mm
- Substrate used: Air
  Thickness=3.2mm
  Dielectric constant=1.0006
- Substrate and ground:
  Width and length = 60mm
- Core diameter=1.275mm
- Teflon diameter=4.17mm
- Teflon Dielectric constant=2.08

VI. PARAMETRIC STUDY

The default value for this antenna is presented in previous article. Dimensions that are kept constant in these papers are main patch, outer patch, substrate's thickness, Slot B length, Core diameter, Teflon diameter, Teflon Dielectric constant. Other parameters are set as variables. Only one parameter is allowed to change at a time while other variables remain constant as default except ground and substrate that will varied together. All dimensions mentioned are in millimeters.

A. Changing Air Gap with C-Foam PF-2

The microstrip antenna is simulated with C-Foam PF-2 substrate that has a dielectric constant of 1,03 and compared the output with the microstrip antenna which is simulated with air that has a dielectric constant of 1.0006. The result is shown in Fig-5.

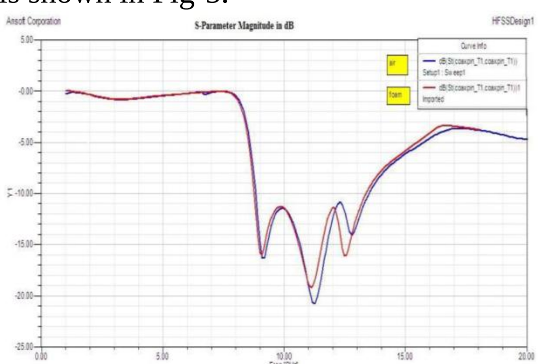


Fig.5 S_{11} for air and foam substrate

B. Changes the substrate size

Figure-6 shows the S_{11} parameter when dimension of substrate is changing. The result doesn't not show much difference in terms of bandwidth but slightly affect the magnitude of S_{11}.

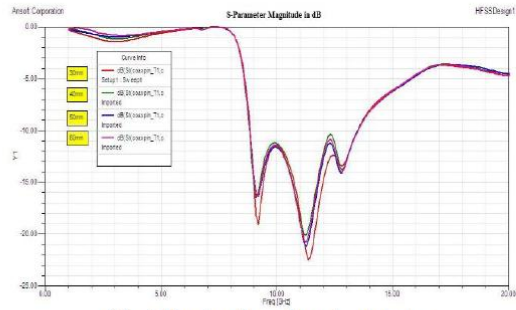


Fig.6 S_{11} of various size of substrate

C. Changes in Centre Arm Width

Fig-7 shows the S_{11} parameter when center arm width varied from 4.2mm to 6.2 mm by 0.5 increment. As the width increases, the 1st and 2nd resonant frequency shifted to lower frequency and the magnitude of S_{11} decreases. The opposite occur at the 2rd resonant frequency.

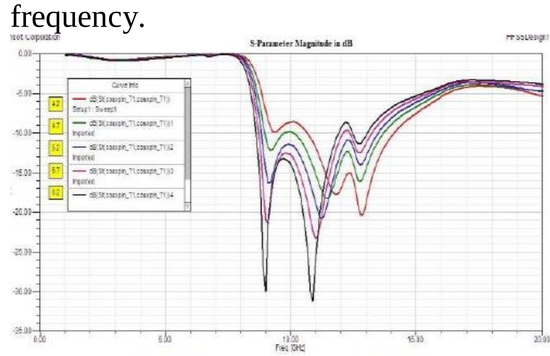


Fig.7 S_{11} of various size of Wc

D. Changes in slot length

Fig-8 shows S_{11} magnitude when slot A length varied from 7.6mm to 9.6mm with 0.4mm decrement. As the length increases, the 1st and 2nd resonant frequency shifted to lower frequency and the magnitude of S_{11} decreases, during 9.2mm to 9.6mm , where the magnitude at 1st resonant frequency increase. The opposite occur at the 3rd resonant frequency.

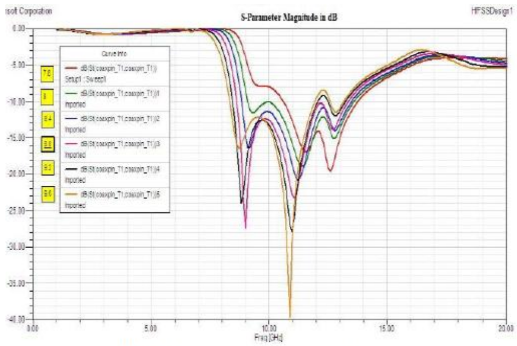


Fig.8 S_{11} of various size of LsA

E. Changes in Main Slot Width:

The main slot length is varied from 15.7mm from 19.7mm with increment of 1mm. This shows, the low cut off frequency is virtually the same for all values. The upper cut off frequency decreases as main slot width increases. The bandwidth of other parameter remain constant.

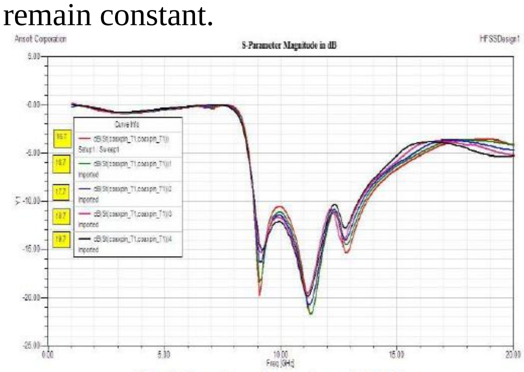


Fig.9 S_{11} of various size of WsB

F. Changes in Slot Width (S_a, S_b):

Slot width is varied from 0.5mm to 2mm, with increment of 0.5mm. For S_a, almost similar patter can be seen in Fig-10. In Fig-11, when S_b varied all values show a similar pattern. Magnitude for S_{11} at 1st & 3rd resonant frequency decreases, as S_b increase.

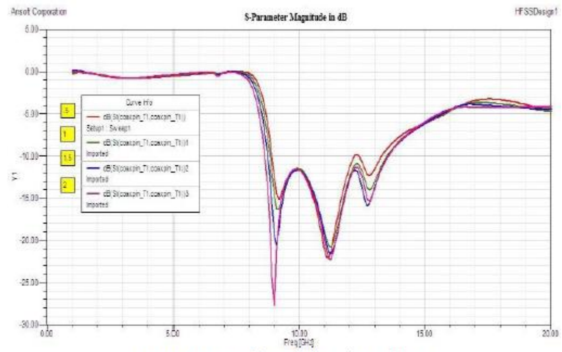
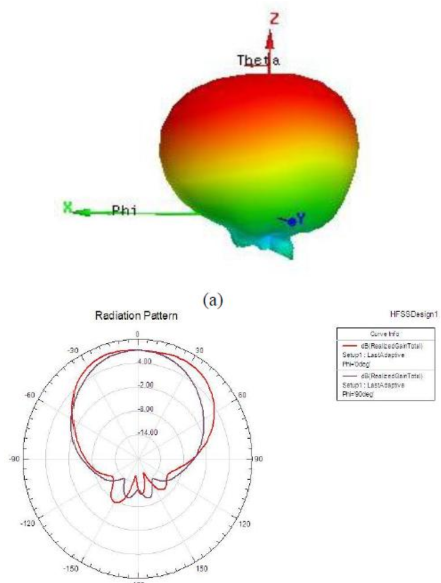


Fig.10 S_{11} of various size of Sa

VII. RESULTS

Antenna is optimizes based on the result of section of Parametric study. The aim is to optimization is to obtain better gain and bandwidth that in Figure-5. The varied parameter specifications after optimization are shown in Table-1:



(b)

Fig. 14(a) & (b) 8.73 GHz radiation pattern

A. Optimized Parameters

Table-1: Optimized parameters:

Parameters		Label	Dimen-sion
Slot	Main Slot width	W_sB	15.7
	Slot A width	S_a	2
	Slot B width	S_b	0.6
	Slot A length	L_sA	8.8
Centre Arm	Width	W_C	4.7
Ground	Width	W_g	60
	Length	L_g	60

B. Radiation Pattern of Optimized Antenna

Fig 14(a) and 14 (b) shows the radiation pattern for the antenna at 8.73 GHz. The magnitude of the radiation pattern from the peak of the main beam decreases by 50% or -3dB.

VIII. CONCLUSION

An E-shaped wideband microstrip patch antenna has been designed by using Air substrate, & simulated the proposed antenna by HFSS (High Frequency Structure Simulator-Version 11) software. A parametric study is presented with the results showing that the antenna can be operated at 8.80 GHz up to 13.49 GHz frequency band. This result is an improvement, when compared to the original specification which gives wide bandwidth, expanded from 4.68 GHz to 5.4 GHz.

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