Analysis of Microstrip Patch Antenna Using Various Feeding Techniques for Bluetooth Applications

Ankita Mahale, Vijaya Darwada, Dr. S. B. Deosarkar, Ganesh M. Kale

Abstract— This article describes the performance evaluation of Rectangular microstrip patch antenna using different feeding techniques such as Coaxial probe feed, Inset feed and Microstrip line feed. Three antennas are designed at frequency 2.44 GHz (Bluetooth). The antenna is designed by using substrate FR-4 which has dielectric constant 4.4, thickness 1.6 mm and loss tangent 0.02. Return loss, VSWR, Smith chart, Bandwidth are simulated and compared all these parameters for different feeding techniques. Simulation is done by using Ansys Electronics HFSS suite 19.2.

***Index Terms*—Microstrip patch antenna, feeding technique, microstrip line, coaxial probe feed, inset feed.**

I. Introduction

Wireless communication is rapidly increasing in recent years. Deschamps first designed the concept of the patch antenna in 1953[1] and the practical antenna was developed by Muson and Howell in the 1970s. In the wireless communication system, the Antenna is one of the most critical elements. In telecommunication, a microstrip antenna (also known as the printed antenna) usually means an antenna fabricated using microstrip technique on printed circuit board (PCB). It consists of a radiating patch on one side of a dielectric substrate and ground plane on the other side. Various shapes of the antenna such as rectangular, square, elliptical and circular. The rectangular shape of a patch is the most widely used configuration, which is more accurate for a thin substrate. Due to increasing trends in the wireless communication system, Microstrip Antennas (MSA's) are used in many practical applications such as WLAN, WiMAX and Bluetooth. Microstrip antenna has more advantages such as lightweight, small volume, easy to fabricate and low-profile configuration [1]-[2]. Microstrip antennas are not only used as a single element but are very popular in arrays [2]. An inset feed dual frequency circular microstrip antenna with rectangular slot has been presented. The antenna works at 2.43GHz and radius is 25mm. Here two excited modes which are responsible for dual-band operation [3]. Dual band polarization antenna fed by coaxial probe feeding technique is demonstrated for WLAN and WiMAX communication at 2.4GHz and 5.25 GHz. For the good performance of antenna using slot loading tech and short sheet loading tech. This designed reduced size of MSA. Hence, this antenna is used as a high gain array application [4].

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Aperture coupled annular ring microstrip antenna for circular polarization has been studied. Annular ring has a smaller patch size as compared to others. Use of this antenna can provide low cross-polarization levels. In [5], a coaxial probe fed antenna has been designed for wireless applications. The author represents Two Dual Polarization Aperture Coupled Microstrip Antenna at Ka-band and Compare the effect of two aperture at Ka-band. Teflon is used as a substrate which increases the mechanical strength, reduced influence of the external environment. Both antennas get good impedance matching performance, polarization and Radiation [6]. Width and length of the feed line are depending upon inset width and inset depth but variation in inset width changes frequency [7]. The triangular shape of the patch antenna is more advantageous than other shapes like circular etc. From the results, we conclude that inset feed width increased then return loss can be improved [8].Use of this antenna [9] can be provided for low cross-polarization levels. From the results, inner radii have increased then centre frequency reduced by 16%. The probe-fed open rectangular ring slot loaded rectangular MSA designed for dual frequency operation [10]. In this paper, we discuss Rectangular Microstrip Patch antenna, its parameters and feeding techniques such as Coaxial line, Microstrip feed line and Inset feed line for Bluetooth Application and comparative Analysis has been done by using software Ansoft HFSS suite 19.2.

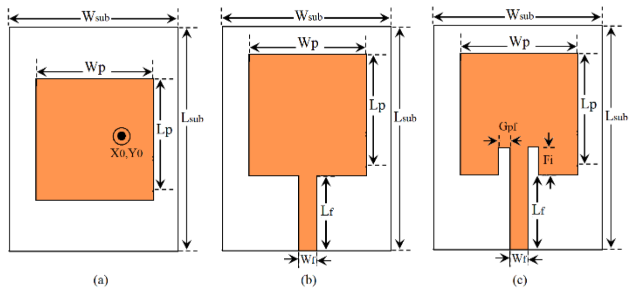


Fig. 1 Geometries of the antenna (a) Coaxial, (b) Microstrip line feed, (c) Inset feed

II. Antenna Geometry and Design

Three Rectangular Microstrip Antennas (RMSAs) have been designed at operating frequency 2.44 GHz with input Impedance of 50Ω using substrate FR-4 which has dielectric constant $\epsilon_r = 4.4$, loss tangent tanδ=0.02 and thickness h =1.6mm. The microstrip Antenna parameters are calculated from the following semi-empirical equations at reference frequency 2.44 GHz (Bluetooth) [2].

The width of the patch (W):

$$W = \frac{c}{2\sqrt{\frac{\epsilon_r + 1}{2}}} \qquad (1)$$

Effective Length (Leff):

$$L_{eff} = \frac{c}{2f\sqrt{\epsilon_{reff}}} \quad (2)$$

Where

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}}$$

length of the patch (L):

$$L = L_{eff} - 2\Delta L \quad (3)$$

Where

$$\Delta L = 0.412h\frac{(\epsilon_{reff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\epsilon_{reff} - 0.9258)\left(\frac{w}{h} + 0.8\right)}$$

Minimum ground plane dimension

$$Lg = 6h + L \quad (4)$$

$$Wg = 6h + W \quad (5)$$

Table 1 Optimized Parameters of The Proposed Antennas

Parameters	Coaxial probe feed	Microstrip line feed	Inset feed
Resonant frequency	2.44 GHz	2.44 GHz	2.44 GHz
Substrate	FR-4	FR-4	FR-4
Dielectric constant	4.4	4.4	4.4
Substrate height	1.6mm	1.6mm	1.6mm
Loss tangent	0.02	0.02	0.02
Length of patch	28.3	27.6	28
Width of patch	24.5	50	47
Length of Substrate	55	55	55
Width of Substrate	55	55	55

By using the above formulae [2] all the parameters that are required to design an antenna are obtained. Operating frequency of the proposed antenna is chosen at 2.44 GHz which is used for Bluetooth applications. The optimized parameters of the proposed three antennas are summarized in Table 1.

III. Feeding Techniques

Microstrip Patch Antennas are excited for radiation modes using different feeding techniques which leads to the best impedance matching between the feed line and the patch. Feeding techniques give a better understanding of the design parameters of an antenna. Microstrip Patch Antennas are fed by different feeding techniques 1) In the contacting method, the RF power is fed directly to the radiating patch i.e. microstrip line and coaxial probe feed. 2) In the non-contacting method, electromagnetic field coupling is due to the transfer power between the microstrip line and patch. The different feeding technique is as follows:

a) Coaxial probe feed

The coaxial feed or probe feed is very common feeding technique used for the microstrip patch antenna. In this feeding technique, the inner conductor of the coaxial cable is connected to the radiating patch of an antenna and the outer conductor is directly connected to the ground plane shown in Fig 1(a). Coaxial probe feed is easy to fabricate and match but more difficult to model. The main advantage of the coaxial probe feed method is that feed can be placed at any desired location in order to match the input impedance. And its disadvantages are narrow bandwidth, difficult to model especially for a thick substrate.

b) Microstrip Line Feed

Microstrip Line Feed showed in Fig1 (b). It is one of the easier methods to fabricate and it is a just a conducting strip connected directly to the edge of the patch which is smaller in dimension as compared to the patch. It is very simple in modelling and easy to match with input impedance 50Ω or 75Ω and this can be achieved by controlling the inset position. However, the drawback of this method is that as substrate thickness increases, spurious radiation increases which limit the bandwidth (typically 2-5%). Perfect matching can be performed by controlling the length and width of the patch.

c) Inset Feed Line

Inset feed causes the voltage minimum to the shift away from the centre of the patch and moves towards the edge of the patch. The parameters Return Loss and Impedance of inset feed microstrip patch mainly depend upon the inset gap 'Gpf' and inset distance 'Fi' as shown in Fig 1(c).

IV. Results and Discussion

We have investigated the effects of several parameters on designed antenna using high-frequency electromagnetic software (HFSS). Fig 2. shows the return loss graph at frequency 2.4GHz for rectangular patch antenna for coaxial probe feed, a microstrip line and inset feed and return losses noted as -22.78, -32.34 and -38.57 dB respectively. From results, it is also observed that maximum return loss found for inset feed is -38.57 dB. The impedance bandwidth for coaxial probe feed, a microstrip line and inset feed are noted as 60, 100 and 90 MHz respectively.

Fig 3. shows the VSWR graph at frequency 2.44 GHz for rectangular patch antenna for coaxial probe feed, a microstrip line and inset feed and VSWR noted as 1.05, 1.10 and 1.08 respectively. From results, it is also observed that good impedance matching take place for coaxial probe feed technique and VSWR for that is nearly equal to 1. For the good impedance matching performance, VSWR is always equal to 1 that means there is no reflection in the antenna. The respective VSWR bandwidth is noted as 60, 100 and 90 MHz respectively. From Fig 4 it is observed that circles for each feeding techniques pass through VSWR line 1 and 2 or touches to VSWR = 1, So VSWR lies 2:1 for each feeding techniques.

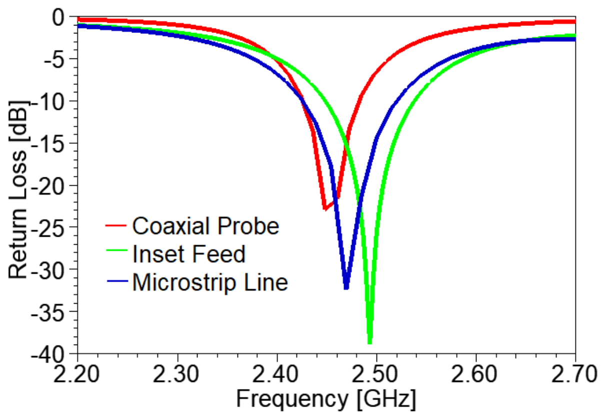


Fig. 2 Return loss versus frequency of the proposed antennas shown in Fig 1.

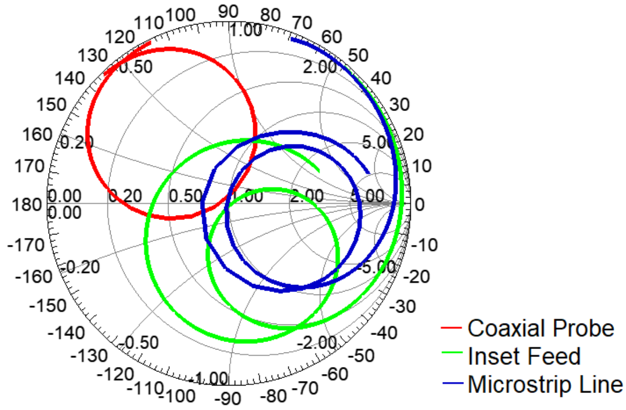


Fig.4 S_{11} curves of the three antennas

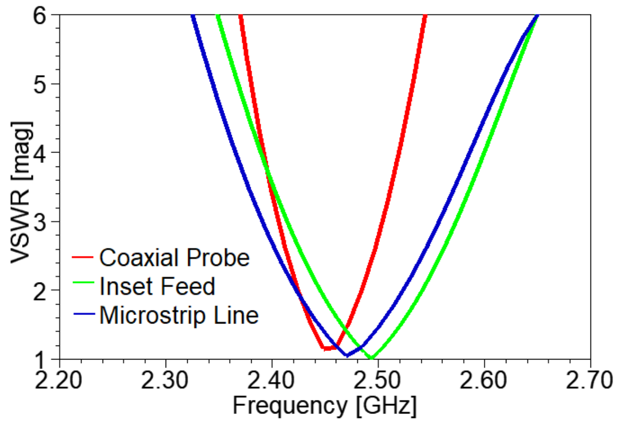


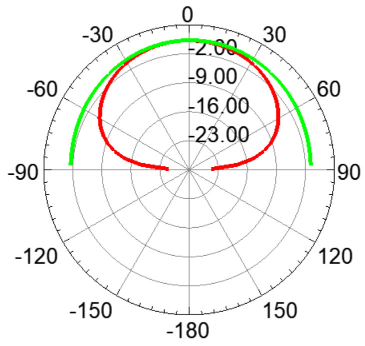
Fig.3VSWR versus frequency of the proposed antennas shown in Fig 1.

Fig 5 shows the radiation patterns for coaxial probe feed, a microstrip line and inset feedat frequency 2.44 GHz inE-plane and H-plane.

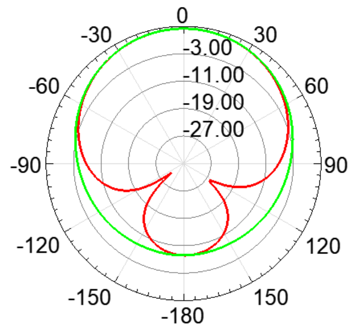
Table 2 Comparison table for different techniques

Feeding Technique parameters	Coaxial probe feed	Microstrip line feed	Inset feed
Return Loss (dB)	-22.84	-32.34	-38.57
VSWR (Mag)	1.05	1.10	1.08
Impedance (x+jy) Ω	56.31+20.9j	46.74 -6.89j	46.8+1.2j
Bandwidth (MHz)	60	100	90
Peak Directivity	2.8	6.1	4.4
Peak Gain	1.3	3.8	2.6
Radiation Efficiency (%)	45%	63%	60%

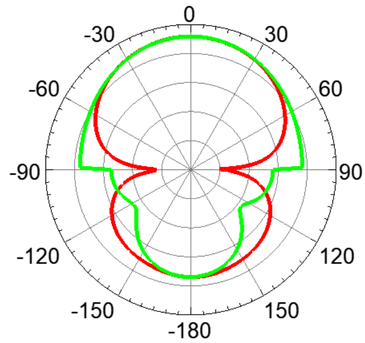
Table 2 describes the different parameters such as return loss, VSWR, Impedance bandwidth, directivity, gain and radiation efficiency. Maximum efficiency and gain found for microstrip antenna and it is 63% and 3.8 dBi.



(a)



(b)



(c)

Fig.5 Radiation patters of the antennas (a) Coaxial, (b) Inset Feed, and (c) Microstrip feed at 2.44 GHz.

V. CONCLUSION

From this work, the Coaxial feed, Microstrip line and inset feed antenna at 2.44 GHz designed on FR-4 substrate is studied by using software ANSYS HFSS suite 19.2. Their output parameters are comparatively studied, analyzed and presented. From the analysis of three feeding techniques, it is observed that good impedance matching found for coaxial probe feed technique and maximum bandwidth has been obtained with the use of a microstrip line feed technique. Maximum efficiency and gain found for microstrip antenna and it is 63% and 3.8 dBi. The proposed three antennas can be suitable for Bluetooth application at 2.44 GHz applications.

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