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Analysis of a Co-axial Fed Printed Antenna for WLAN Applications

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***Abstract*—The theoretical study of a co-axial feed and the analysis of such a feed-line are presented in this paper. The antenna is chosen to be a printed antenna, which can support a large variety of feeds and therefore a comparative a study can be made on the behavior of the antenna. Assuming, the application intended is WLAN, the antenna is designed for 2.4GHz. The analysis is made by considering the most common and widely used rectangular shaped structure. The substrate of the antenna is a 1.6mm thick RT 5880 Duroid, with a di-electric constant of 2.2. The simulation is carried using the High Frequency Structure Simulator of Ansoft Corp. The designed patch antenna has a return loss of -24dB which is acceptable given the scope of the antenna, but for the low-gain which is due to the inclusion of co-axial feed.**

***Index Terms*—co-axial, di-electric, feed-line, VSWR, probe**

I. INTRODUCTION

Printed antennas are widely being used in this era of wireless communications, where cost and complexity is a design issue. With the advent of printed antennas the radiators are now being available for low cost and are less complex ever since the history of antennas. There are several classifications of printed antennas based on the type of feeding given to the antenna. If the feed is given through a strip line, then it is called micro strip antenna. The antenna is called an aperture coupled antenna if there is no feed line existing and the antenna receives power based on coupling. The former, does not suit the purpose at 2.4GHz, or at high frequencies and the latter has the disadvantage of increased complexity. As a tradeoff between the two types of feeds, a co-axial cable feed is proposed in the paper and designed to work at WLAN, 2.4GHz frequency. Co-axial cables do not require an excess transmission structure and are also adjustable to the location where insertion loss and return loss are the minimum possible. However, the co-axial cables are prone to copper loss and are also a cause of spurious radiation and this can be seen in the result, where the gain of the antenna falls far behind the expectation. The return loss of the design is expected to be less than -10dB that corresponds to a VSWR< 2:1. The design will be then transformed to PCB with RT Duroid as substrate .The hardware will be given a coaxial feed and then antenna is tested using a vector analyzer. In this paper, a computer aided design of a high frequency rectangular antenna is proposed using EM modeling technique and choosing the best results to develop the hardware of the antenna that makes it an accurate and reliable system for commercial wireless applications.

[3] The transmission line model of patch antenna is used in this paper to obtain the mathematical equations and the dimensions of the patch antenna. The antenna is a given a co-axial probe feed.

II. ANALYSIS OF FEEDS

Printed patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. The four most popular feed techniques used are the microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes). Coaxial feed or probe feed is a very common technique used for feeding patch antennas. This is the feeding technique used for the antenna in this paper. As seen from Fig 1, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation. However, a major disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates ($h > 0.02\lambda o$). Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems. It is seen above that for a thick dielectric substrate, which provides broad bandwidth, the coaxial feed suffers from disadvantages. This is verified in the results section.

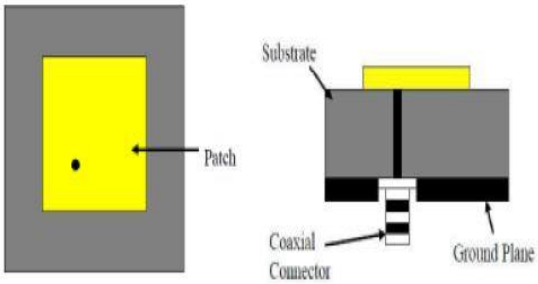

Fig.1. Co-ax fed patch antenna

III. ANTENNA DESIGN

Fig. 2, shows the structure of the antenna to be analyzed for co-axial feeding. It consists of 3 layers. The lower layer, which constitutes the ground plane, covers the partial rectangular shaped substrate with a side of 49×54 mm. The middle substrate, which is RT duriod 5880, has a relative dielectric constant ϵr=2.2 and it is 1.6mm thick. Increasing the thickness will increase the bandwidth of the antenna and hence chosen a lower value for WLAN applications. The upper layer, which is the patch, covers the rectangular top surface. The rectangular patch has sides 33×38 mm that covers the middle portion of the substrate. Two rectangular slots are cut out from the patch near the feeding co-axial cable for impedance matching. The patch is fed by a co-axial feed at (-11.56, 0) co-ordinates with 50Ω input impedance. And the center of the design is taken as (-24.5,-27).

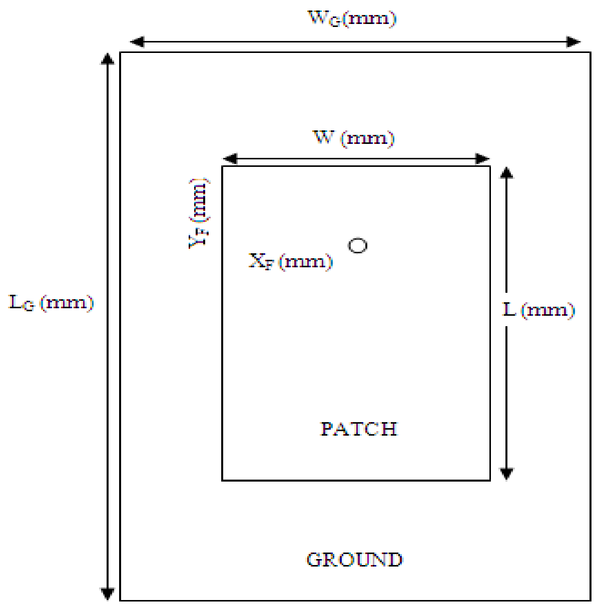

Fig.2. Schematic of the rectangular patch antenna

The antenna is designed to operate in the 2.4GHz-2.484GHz band with a center frequency of 2.44GHz to meet the wireless specifications. The substrate of the antenna is chosen to be RT Duroid with a dielectric constant (εr) of 2.2 with 1.6mm thickness and the ground plane made of copper is located on the other side of the substrate. The antenna is fed by a standard strip of 50Ω and this type of feeding is to be placed at the point on the patch so as to match with the desired input impedance and reduce spurious radiation.

The width (W) of the patch antenna can be determined by [2] :

$$W = \frac{c}{2f\left(\sqrt{((\varepsilon r+1)/2}\right)} \quad (1)$$

The effective dielectric constant is defined before calculating the length of the antenna:

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1+\frac{12h}{w}\right]^{-0.5} \quad (2)$$

h, here is the height of the substrate and w is the value as obtained in (1). The dimensions of the patch along its length have been extended on each end by a distance of ΔL which is given empirically by:

$$\Delta L = \frac{0.412h(\varepsilon reff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon reff-0.258)\left(\frac{W}{h}+0.8\right)} \quad (3)$$

The actual length L of the patch is given by:

$$L = \frac{\lambda}{2} - \Delta L \qquad (4)$$

λ_0 in (4) is the free space wavelength at center frequency. The ground plane dimensions are greater than the patch dimensions by approximately six times and are given as:

$$L_G = 6h+L \qquad (5)$$

$$W_G = 6h+W \qquad (6)$$

The co-ordinates for the position of the coaxial feed point can be obtained by using:

$$X_F = \frac{L}{\sqrt{\varepsilon_{reff}}} \qquad (7)$$

$$Y_F = \frac{W}{2} \qquad (8)$$

The following table summarizes the antenna parameters on substituting the design values through (1) – (8).

TABLE I ANTENNA DIMENSIONS

L	33.1676 mm
W	38.7046 mm
LG	53.7 mm
WG	63 mm
XF	26.3523 mm
YF	10.8mm

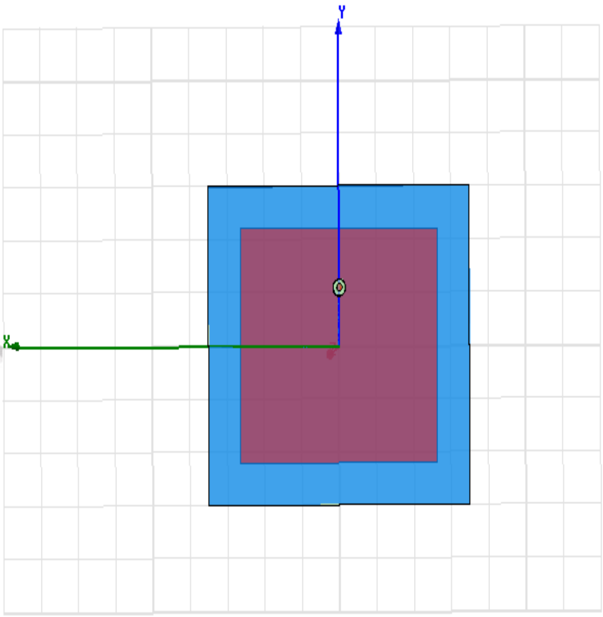

Fig.3. Patch antenna designed in HFSS

The simulated design is shown in fig.3, and the antenna dimensions are summarized in table 1.

IV. RESULTS

The results obtained upon simulating the antenna is presented in this section. The impedance and radiation characteristics of the antenna are observed and analysed. Fig.4, Fig.5 and Fig.6 are the results obtained using HFSS tool. The return loss of the antenna at center frequency is around -22 dB. This corresponds to a VSWR of nearly 1.13:1 which a very good response is given the specification and application of the antenna. A Voltage standing wave ratio of less than 2 (VSWR<2) is always acceptable.

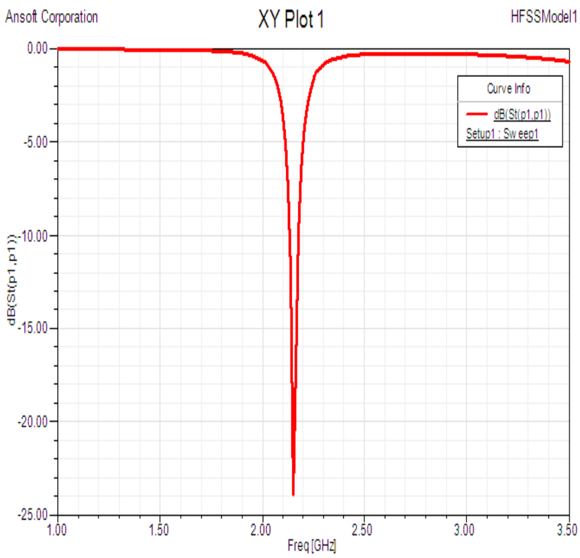

Fig.4. Return Loss of the antenna in HFSS (-22dB)

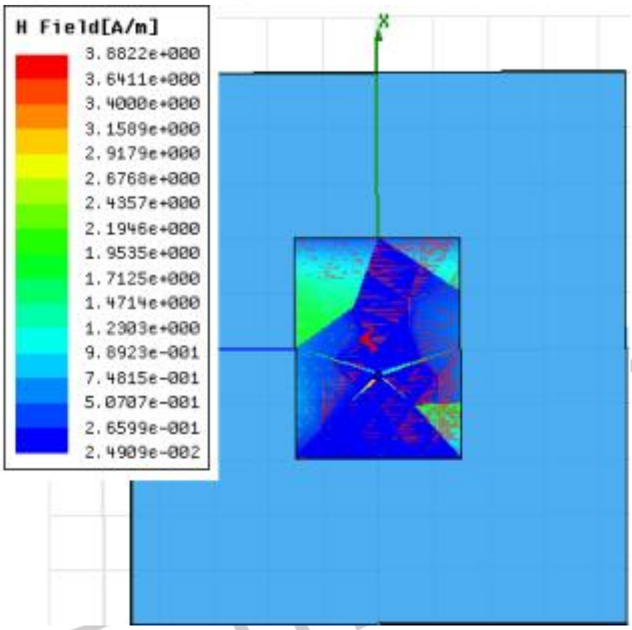

Fig.5. H-Field of the antenna in HFSS (3 A/m)

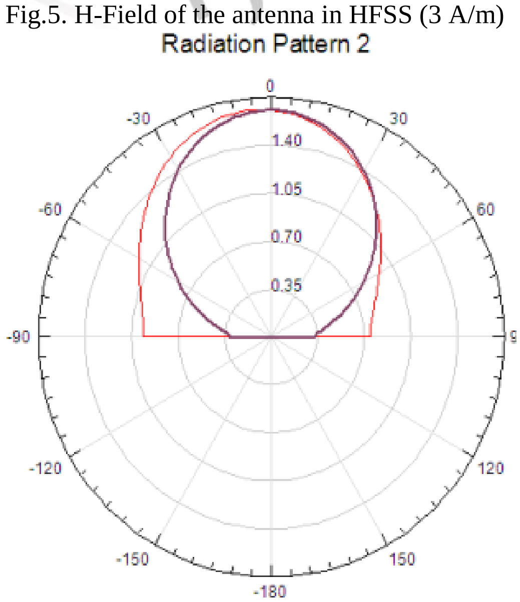

Fig.6. Radiation Pattern of the antenna

This implies that the maximum H-field lies along the outer edges of the patch and are supposed to be radiating edges. The non radiating edges on the opposite side do not carry any current and filed there is always zero. The directive gain of the antenna is found to be 2dB. This is due to the losses incurred due to the inclusion of co-axial cable; the directive gain can be realized upto 5dB-7dB if the feed is a non-co-axial feed.

V. CONCLUSION

The design of the antenna starting from the theoretical aspects was presented and the results are observed to be satisfactory for a product at 2.4GHz. However, the antenna has to be developed accordingly so as to meet the challenges and combat with co-axial feeding losses. The results obtained from the simulator show that the antenna radiates back less than 20% of the transmitted power with a directive gain of 2dBi and at a maximum field of 3 A/m from its edges.

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