Design of Different Feeding Techniques of Rectangular Microstrip Antenna for 2.4GHz RFID Applications Using IE3D

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Abstract— **This paper describes variety of feeding techniques applicable for rectangular microstrip antenna for 2.4GHz RFID applications. A proper impedance matching condition between the line and patch without any additional matching elements are used. After describing various feeding techniques, the paper gives a better understanding of the design parameters of an antenna and their effects on bandwidth, return loss and gain. Finally simulation of antenna is done using design software IE3D and fabricated using in-house facilities.**

***Keywords-** Rectangular Microstrip Antenna (RMSA); Return Loss; Bandwidth; Impedance; IE3D; Feeding Techniques.*

I. INTRODUCTION

A rectangular microstrip antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. A comparison between various feeding techniques has been done. Finally, a microstrip patch antenna at specific frequency i.e. 2.4 GHz has been designed and simulated on the design software IE3D for a better understanding of the design parameters of an antenna and their effect on the bandwidth, return loss and gain patterns.

A microstrip antenna in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. The top and side view of a rectangular MSA (RMSA) is shown in Figure 1.

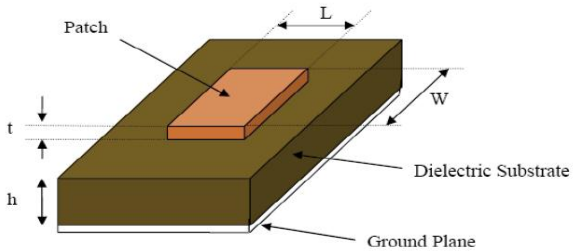

Figure 1. Basic Microstrip Patch.

TABLE 1. COMPARISON OF MIC & MSA

Parameter	***Microwave Integrated Circuits (MIC)***	***Microstrip Antenna (MSA)***
Height, *h*	≤ 0.159 cm	≥ 0.159 cm
Dielectric constant, ϵ_r	≥ 9.8	≤ 9.8
Width, *W*	Small	Large
Radiation	Minimized	Maximized

II. FEEDING MECHANISMS

A. RMSA with microstrip feed

Figure 2 shows microstrip antenna fed by a microstrip transmission line. The patch, microstrip transmission line and ground plane are made of high conductivity metal (typically copper). The patch is of length 'L' and width 'W', etched on top of a substrate of thickness 'h' with permittivity 'ϵ_r'. Typically, the height h is much smaller than the wavelength of operation, but not much smaller than 0.05 of a wavelength. The return loss curve and the 3D view of current distribution are shown in figure 5 & 8 respectively.

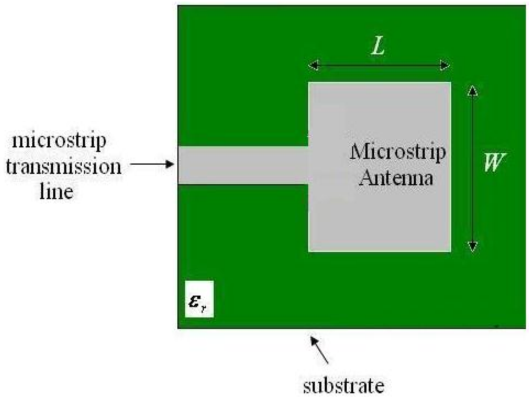

Figure 2. Rectangular Patch Antenna with Strip Feed.

B. Microstrip inset line feed

Microstrip line feed is one of the easier methods to fabricate as it is a just conducting strip connecting to the patch and therefore can be consider as extension of patch. It is simple to model and easy to match by controlling the inset position. Since the current is low at the ends of a half-wave patch and increases in magnitude towards the center, the input impedance (Z=V/I) could be reduced if the patch was fed closer to the center. One method of doing this is by using an inset feed (a distance R from the end) as shown in Figure 3. The return loss curve and the 3D view of current distribution are shown in figure 6 & 9 respectively.

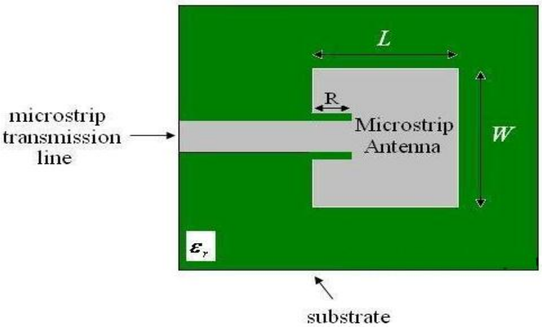

Figure 3. Rectangular Patch Antenna with Inset Line Feed.

C. Microstrip quarterwave line feed

The microstrip antenna can also be matched to a transmission line of characteristic impedance Z_0 by using a Quarter-wave transmission line of characteristic impedance Z_1 as shown in below Figure 4. The return loss curve and the 3D view of current distribution are shown in figure 7 & 10 respectively.

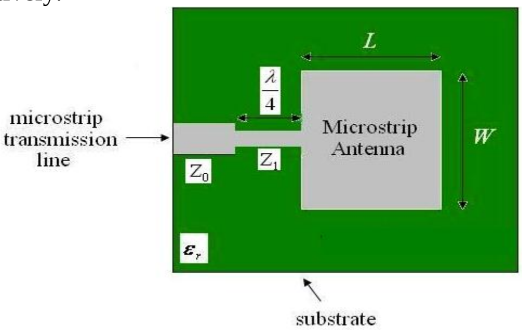

Figure 4. Rectangular Patch Antenna with Quarterwave Line Feed.

III. CHARACTERISTICS OF MSA

The MSA has proved to be an excellent radiator for many applications because of its several advantages, but it also has some disadvantages. The advantages and disadvantages of the MSA are given in Sections.

A. Advantages

- They can be made compact for use in personal mobile communication. They allow for dual- and triple-frequency operations.
- Their ease of mass production using printed-circuit technology leads to a low fabrication cost. They are easier to integrate with other MICs on the same substrate. They allow both linear and Circular Polarization.
- They are lightweight and have a small volume and a low- profile planar configuration. They can be made conformal to the host surface.

B. Disadvantages

- Narrow Band-width, Lower Gain, Low Power-handling capability.

C. Applications

System	*Application*
Aircraft and ship antennas	Communication and navigation, altimeters, blind landing systems
Missiles	Radar, proximity fuses, and telemetry
Satellite communications	Domestic direct broadcast TV, vehicle-based antennas, communication
Mobile radio	Pagers and hand telephones, man pack systems, mobile vehicle
Remote sensing	Large lightweight apertures
Biomedical	Applicators in microwave hyperthermia
Others	Intruder alarms, personal communication

IV. DESIGN OF PATCH ANTENNA

TABLE 2. DESIGN SPECIFICATIONS

SL.No	***Parameter Name***	***Designed Values***
1.	Resonant Frequency, f_r	2.4 GHz
2.	Patch Thickness, *t*	0.017 mm
3.	Patch Length, *L*	29.50 mm
4.	Patch Width, *W*	38.03 mm
5.	Reference Impedance, *Zc*	50 ohms
6.	Substrate Height, *h*	1.58 mm
7.	Dielectric Constant, ε_r	4.4

A. Design Equations of Basic Rectangular Patch

1. $\lambda_0 = C/f_r = (3x10^8/2.4x10^9)$ .... = 125 mm

2. $W = \dfrac{C}{2f_r}\sqrt{\dfrac{2}{\varepsilon_r + 1}}$ .... = 38.03 mm

3. $\varepsilon_{eff} = \dfrac{\varepsilon_r + 1}{2} + \dfrac{\varepsilon_r - 1}{2}\left[1 + 12\dfrac{h}{w}\right]^{-\frac{1}{2}}$ .... = 4.088

4. $\Delta L = 0.412 * h \dfrac{(\varepsilon_{eff} + 0.3)\left(\dfrac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\dfrac{W}{h} + 0.8\right)}$ .... = 0.73 mm

5. $L = \dfrac{1}{2 f_r \sqrt{\varepsilon_{eff}}\sqrt{\mu_0 \varepsilon_0}} - 2\Delta L$ … = 29.50 mm

6. $$Z_{in} = 90\left(\frac{\varepsilon_r^2}{\varepsilon_r - 1}\right)\frac{(L)^2}{(W)^2} = 310.693 \text{ Ohms}$$

V. EXPERIMENTAL RESULTS

A. Return loss curves

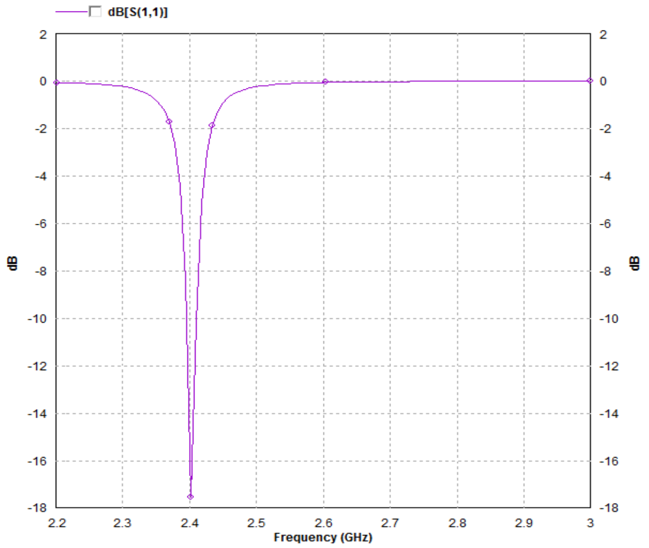

Figure 5. Return loss curve for Strip Feed.

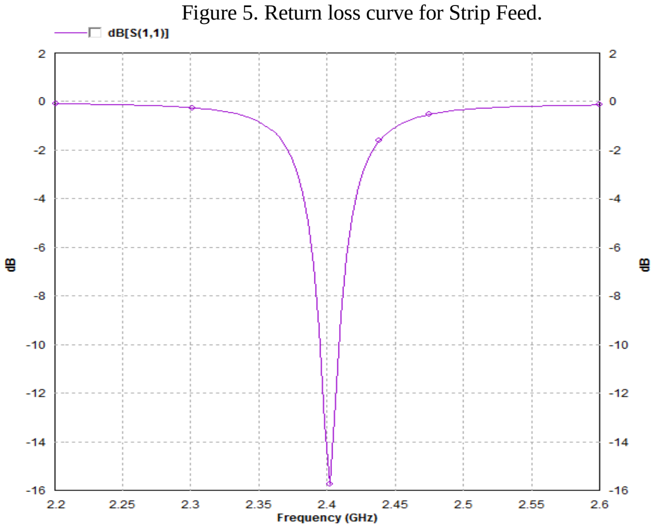

Figure 6. Return loss curve for Inset Line Feed.

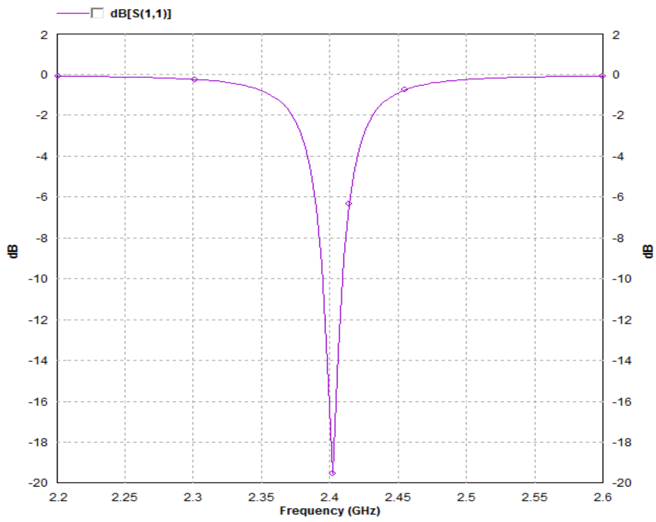

Figure 7. Return loss curve for Quarterwave Line Feed.

B. Current Distributions

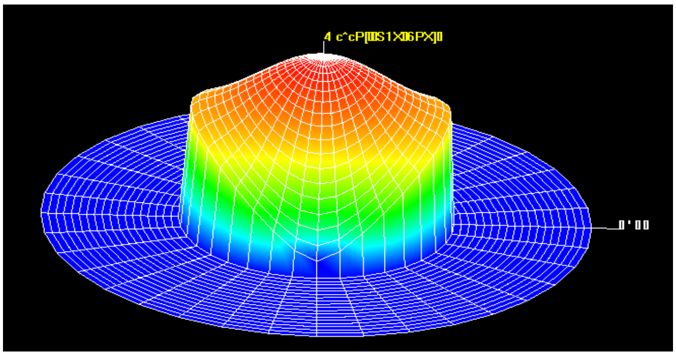

Figure 8. 3D View of Current Distribution for Strip Feed.

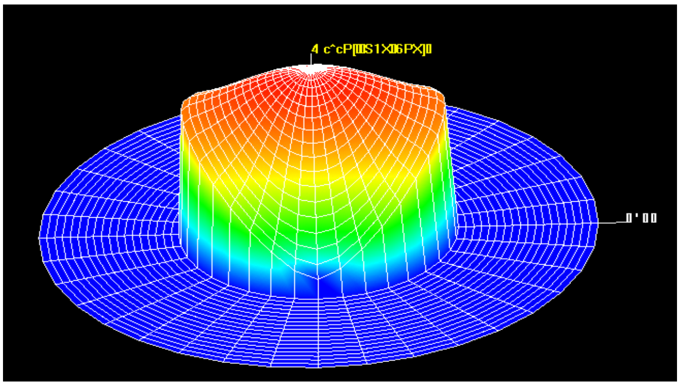

Figure 9. 3D View of Current Distribution for Inset Line Feed.

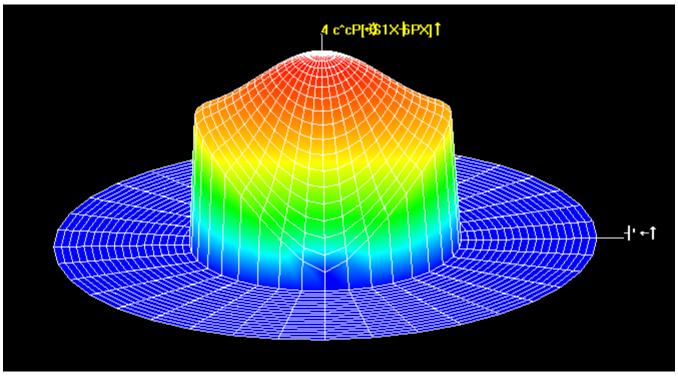

Figure 10. 3D View of Current Distribution for Quarterwave Line Feed.

C. *Fabricated RMSA*

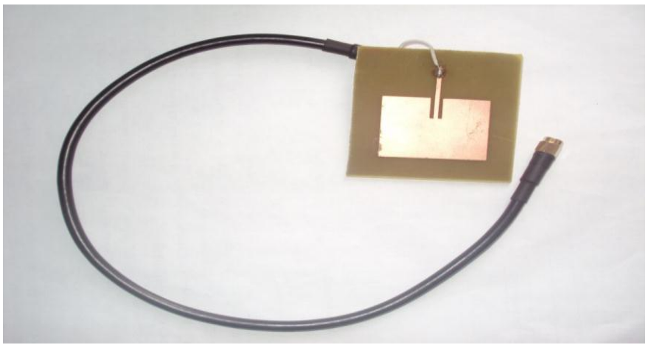

Figure 11. Fabricated RMSA with Inset Line Feed

VI. COMPARATIVE STUDY

TABLE 3. COMPARATIVE STUDY OF ALL FEEDING MECHANISMS

Feeding Techniques	***Resonant Frequency (GHz)***	***Gain (dB)***	***Return Loss (dB)***	***B/W (MHz)***
Strip Feed	2.4	5.2	-17.95	55
Inset Line Feed	2.4	5.0	-15.95	50
Quarterwave Line Feed	2.4	5.5	-19.95	60

VII. CONCLUSION

A Comparative study of different feeding techniques has been simulated using IE3D simulation software. The fabrication of designed Microstrip Antenna was done in the laboratory using in-house facilities. The comparison of feeding techniques shows that Quarterwave Line feeding has the highest return loss of -19.95 dB.

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