# Simulation and Analysis of Impedance Matching of Antenna using Inset Feeding

Ramadan SH R Elamein
M.Tech, Dept of ECE, SIET, SHUATS, India.

Mayur Kumar
Assistant Prof, Dept Of ECE, SIET, SHUATS, India.

A.K Jaiswal
Prof & Head Dept. of ECE, SIET, SHUATS, India.

**Abstract – The aim of this paper is to provide analysis of the Impedance matching of an antenna using inset feeding. Circuit parameters along with design parameters have been presented here. This paper also presents method for finding the inset length to match with the load impedance. A circuit parameter analysis is used to obtain the impedance analysis and also the matching evaluation. The results obtained showed the optimum parameters obtained from the simulation and analytical calculation.**

**Index Terms – Impedance Matching, Inset Feeding, Microstrip Antenna.**

## 1. INTRODUCTION

Several techniques are present for matching the impedance of the micro-strip patch antenna. Normally techniques like cross-polarization is used to obtain the increased bandwidth.

There have been many efforts to reduce the cross polarization and achieve wideband performance [4]–[6]. One of the most common approaches to increase the bandwidth of a microstrip patch antenna and avoid cross polarization is to increase the substrate thickness. It has been shown that the bandwidth of a microstrip patch antenna is a linear function of its dielectric thickness.

Microstrip patch antenna has drawn attention of researchers over the last decade due to their Low profile, light weight, low cost and ease of integration with printed technology. They have a wide range of applications from cell phones to life saving biomedical applications. The research on patch antenna basically demands size. The inset-fed micro strip antenna provides a method of impedance control with a planar feed configuration [1-2]. The experimental and numerical results showed that the input impedance of an inset-fed rectangular patch varied as a Cos4 function of the normalized inset depth.

Specifically, using a thick probe in the structure of a patch antenna, on a ceramic substrate, imposes mechanical challenges to the design. Adding a thick probe increases the price of the antenna as well. Avoiding the need for a thick probe has advantages.

This communication presents a feeding structure which allows the use of a thicker substrate and thus increased bandwidth without added cross polarization, and does not use a thick probe

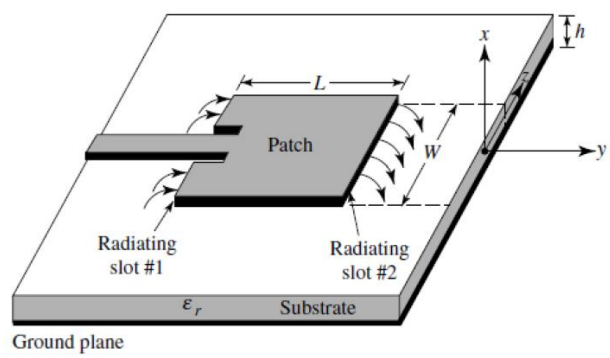


Fig. 1. Microstrip Patch Antenna (Radiation)

## 2. FEEDING MECHANISM

Let the substrate dielectric constant, thickness, patch length, patch width, feed line width and feed line inset distance be denoted by $r, h, L, W, w_f, y_o$ respectively. Input impedance of the inset fed microstrip patch antenna mainly depends on the inset distance o y and to some extent on the inset width (spacing between feeding line and patch conductor).

Variation in the inset length does not produce any change in resonant frequency but a variation in inset width changes the resonant frequency. Hence in the following discussion, the spacing between the patch conductor and feed line is kept constant, equal to the feed line's width and variation in the input impedance at resonant frequency with respect to inset length is studied for various parameters.

Assuming the patch is divided into four regions, it can be modeled as transmission lines loaded by radiating slots of different length as shown in Figure 1.1. Parameters of each transmission line and the slot are given in Table 1.

The design parameters are s presented in the table below. TLM method has been used to calculate the parameters of the given design.

| Element | Width | Length |
|---|---|---|
| TL1 | $W$ | $L-y_o$ |
| SLOT A | $h$ | $W$ |
| TL2 | $\frac{W-3w_f}{2}$ | $y_o$ |
| SLOT B | $h$ | $\frac{W-3w_f}{2}$ |
| TL3 | $\frac{W-3w_f}{2}$ | $y_o$ |
| SLOT C | $h$ | $3w_f$ |

Table 1. Parameters of the elements in the model

It is observed that the input impedance falls rapidly as the inset position is moved toward the centre from the edge as compared to the coaxially probe fed patch antennas. These parametric studies have been used to derive the curve fit formula (1) to find the exact inset length to achieve impedance matching.

## 3. DESIGN PROCEDURE OF THE PATCH

1. Width 'W':

$$W = C\sqrt{2/(\varepsilon_r+1)}\ \ /\ 2\, f_r$$ -----------(i)

2. Calculate $\varepsilon_{reff}$ :

$$(\varepsilon_r+1)/2 + (\varepsilon_r-1)/2[1+12h/W_p]^{-1/2}$$ ---- (ii)

3. Zo:

$$Z_o = R\cos^2(\pi/L-d)$$ -------- (iii)

## 4. PARALLEL PLATE RADIAL MICROSTRIP LINE

A parallel plate radial microstrip line (PPRML) is characterized by its substrate thickness, $h$, dielectric constant, $\varepsilon_r$, radius of the feeding probe, $a$ and radius of the line, $b$ Characteristic impedance and wave number [11] of such a PPRML can be calculated as

$$Zo = \eta h/2\pi\rho,$$

$$Z\ \beta = \varpi\sqrt{\mu\varepsilon}$$

$$\eta = \mu/\varepsilon$$

The input impedance of a loaded PPRML can be calculated as:

$$Z_{in} = jZ_o\ N_o(\beta a) + AJ_o(\beta a)/(N_1(\beta a) + AJ_1(\beta a))$$

$$A = -j(Z_o(b)N_o(\beta b) - Z\,N_1(\beta b))/(Z_o(b)J_o(\beta b) - Z\,J_1(\beta b)$$

Simulation parameters

| Parameters | symbol | Values |
|---|---|---|
| Radius of feeding Probe | a | 0.5mm |
| Frequency | f | 2 GHz |
| Substrate Thickness | h | 12mm |
| Dielectric Constant | $\varepsilon_r$ | 1 |
| Permittivity | $\varepsilon$ | 8.85E-12 |
| Load Impedence | $Z_l$ | 50 Ohm |
| permeability | $\mu$ | $4\pi 10^{-7}$ |
| speed of Light | c | $3\times10^8$ m/s |
| Length of Antenna | L | 37.2nm |
| Width of Antenna patch | W | 48nm |
| Width of inset | $w_f$ | 4.17nm |

Table 2. Simulation Parameters of the Antenna

Table 2, shows the simulation parameters being used by our analysis for the patch antenna with inset feeding mechanism.

## 5. RESULTS AND CONCLUSION

Fig. 2 shows the Input impedance matching of the antenna microstrip Line s function of the Real and Imaginary function of the radius of the Microstrip Line.

Fig. 3 shows the Input impedance matching of the antenna microstrip Line as function of the radius of the Microstrip Line. We can see the impedence initially rising with the radius but falling afterwards it.

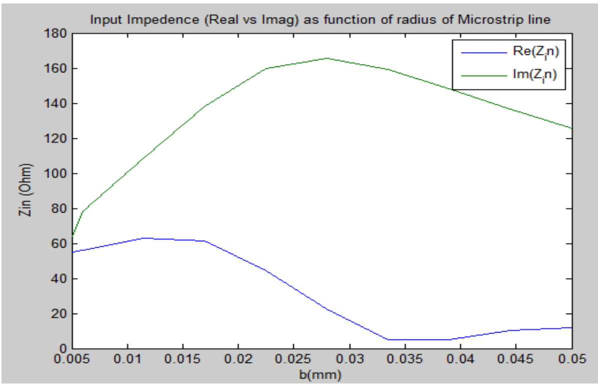


Fig.2 . Input Impedance of Microstrip Line

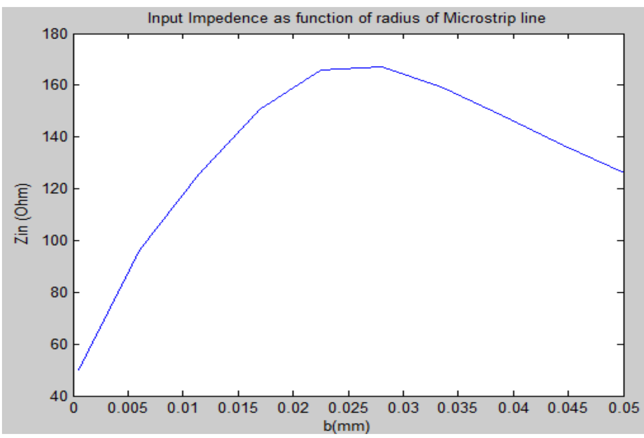


Fig.3 Input Impedance as function of the radius of Microstrip Line

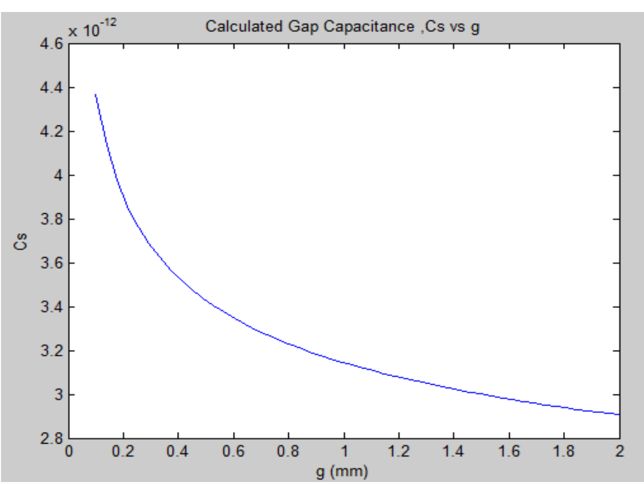


Fig.4. Calculated gap capacitance of the capacitance with respect to the gap.

Fig. 4 shows the calculated gap capacitance with respect to the gap of the radial capacitor. Here, it has been obtained that the calculated gap capacitance is the decreasing function of the gap.

| **Calculated Parmeters** | **Values** |
|---|---|
| Inset Length | 12nm |
| TL1_width | 48nm |
| TL1_length | 24nm |
| SLOTA_width | 12mm |
| SLOTA_length | 48nm |
| TL2_width | 17.7nm |
| TL2_length | 12.4nm |
| TL3_width | 17.7nm |
| TL3_length | 12.5nm |
| SLOTC_width | 12mm |
| SLOTC_length | 12.5mm |
| Series L | 47.7uF |
| Calculated Edge Impedence | 52.4 Ohm |

Table 3. Calculated Parameters

Hence, the results are obtained for the inset probe feeding of the Microstrip Patch Antenna. Its shown after the parameter calculation that the impedence has been matched.

Thus, it follows the design parameters as presented in the paper.

## REFERENCES

[1] L. I. Basilio, M. A. Khayat, J. T. Williams and S. A. Long, "The Dependence of the Input Impedance on Feed Position of Probe and Microstrip Line-fed Patch Antennas, " IEEE Trans. Antennas and Propagation, Vol. AP-49, pp. 45-47, Jan. 2001.

[2] T. Samaras, A. Kouloglou, and J. N. Sahalos, "A note on the impedance variation with feed position of a rectangular microstrip antenna, " IEEE Antennas and Propagation Magazine, Vol. 46, pp. 90-92, April 2004.

[3] Y. Hu, E. J. Lundgren, D. R. Jackson, J. T. Williams, and S. A. Long, "A Study *Designing and Optimization of Inset Fed Rectangular Microstrip Patch Antenna (RMPA)* 1013 of the Input Impedance of the Inset-Fed Rectangular Microstrip Antenna as a Function of Notch Depth and Width, " 2005 AP-S International Symposium, Washington DC, July 2005

[4] I. J Bahl and P Bhartia, Microstrip Antenna, Artech House, Dedham. M. A, 1980.

[5] T. A. Milligan, Modern Antenna Design, McGraw-Hill Book Co., New York, 1985

[6] C. A. Balanis, Advanced Engineering Electromagnetics, John Wiley & Sons, New York, 1989

[7] A. G. Derneryd, "A Theoretical Investigation of the Rectangular Microstrip Antenna Element, "IEEE Trans. Antenna Propagat., Vol. AP-26, No. 4, pp532- 535, July1978

[8] K. R. Carver and J. W. Mink, "Microstrip Antenna Technology, "IEEE Trans. Antenna Propagat., Vol. AP-29, No. 1, pp2-24, Jan 1981.