Analysis of effects on RMSA due to change in Design Parameters

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Abstract - This study has been undertaken to investigate different parameters of antenna such as the gain, radiation pattern, impedance, bandwidth and returns loss of antenna. The method used for investigation is both numerical and empirical. The tool used for simulation is HFSS. It has been shown how to design a rectangular microstrip antenna using standard design formulae. The design is optimized by changing various dimensions of microstrip antenna. Finally, a best optimized antenna with all its dimensions and parameters is presented.

***Key Words*:** RMSA design optimization, feed position, effective permittivity, return loss, VSWR, loss tangent.

1. INTRODUCTION

Microstrip Antenna (MSA) in its simplest configuration (fig. 1) consists of a radiating patch on one side of a dielectric substrate ($\varepsilon_r \leq 10$), and has a ground plane on the other side. The patch conductors is normally of copper or gold. The dielectric constant of the substrate should be low ($\varepsilon_r \approx 2.5$), so as to enhance the fringe fields which account for the radiation.

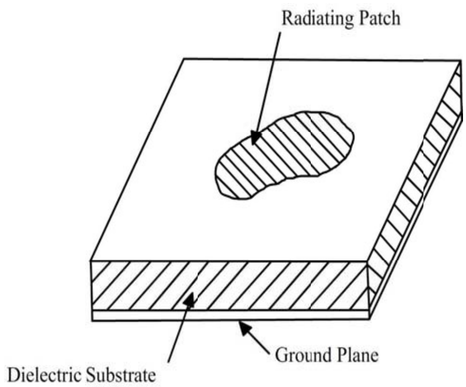

Figure 1 Microstrip Antenna Configuration [3]

With respect to radiation properties these antennas are versatile in terms of resonant frequencies, polarization, pattern and impedance. The use of additional tuning elements like shorting posts or varactor diodes is possible, between the patch and the ground plane. The choice of the substrate is very dependent on the microwave circuit connected to the antenna, which has to be built on the same board. The microwave circuit and the antenna both are usually manufactured by photo-etching technology.

2. FEEDING TECHNIQUE OF ANTENNA

The performance of the antenna does not depend only on its frequency response but rather its characteristic impedance of transmission line. So it is necessary to get better response of antenna, the input impedance of transmission line must be proper match to characteristic impedance of the antenna.

The formula for effective dielectric constant of micro strip line is.

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

The formula for characteristic impedance of micro strip line is.

$$Z_0 = \frac{120\pi}{\sqrt{\varepsilon_{eff}} \times \left[\frac{w}{h} + 1.393 + \frac{2}{3} ln\left(\frac{w}{h} + 1.444\right)\right]}$$

For $\frac{w}{h} \geq 1$, ε_{eff} is the effective dielectric constant. 'W' is the width of the feed line and 'h' is the height of the substrate from the ground plane.

There is some of technique which is used to feed micro strip line. Such as

A .Micro strip line
B. Coaxial probe
C. Aperture coupling
D. Proximity coupling

A. Micro Strip Line Feed

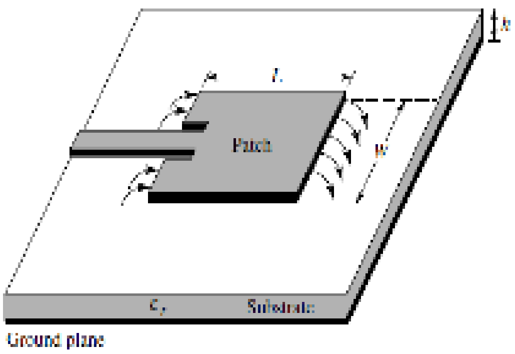

Figure 2 Microstrip Line feed [3]

In this type of feeding technique, the patch of the micro strip antenna can be directly fed by feeding line. It is a conducting strip. For this type of feeding technique the width of feeding line is much smaller than the micro strip patch. It is very simple to model because of its easy to match by controlling the inset position.

B. Coaxial Probe

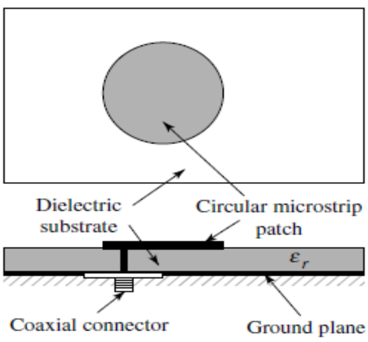

Figure 3 Probe feed [3]

This type of feeding technique is also simple and easy to fabricate. In this type of feeding technique, the inner conductor of the feed line is attached to the radiation patch and the ground plane is connected to the outer conductor of the line feed.

C. Aperture Coupling

In this type of feeding technique, there are two substrates which are separated by ground plane. Here the micro strip line feed which is put on the bottom side on the lower substrate is used and its energy is coupled on the patch by using the slot on the ground plan. The value of the dielectric material which is used on the bottom substrate is high. And the value of top of substrate is low.

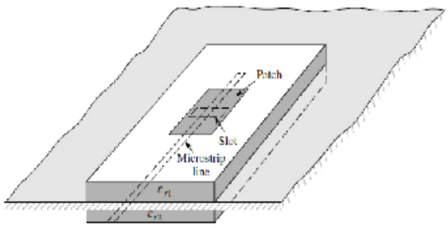

Figure 4 Aperture coupled feed [3]

D. Inset Feed

Micro strip antenna can be feed by using inset feed in which the patches feed from the edges and the width of the conducting strip is small as compared to the patch. L is patch resonant length, and x is feed position from the centre.[]

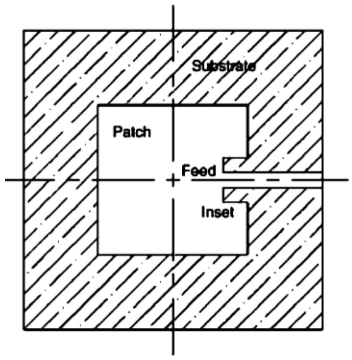

Figure 5 Inset feed

The location of feed should be between L/4 and L/6, where L is a length of antenna.

3. RETURN LOSS

The return loss (reflection coefficient) of an antenna is defined as:

$$\text{return loss} = -20 \log |\rho| \text{ dB}$$

- Possible value of return loss is from 0 to ∞
- Return loss is always a positive number.

4. IMPEDANCE BANDWIDTH

Impedance bandwidth is define as:

$$\text{Impedance Bandwidth} = \frac{f_U - f_L}{f_C} \times 100\%$$

The symbols in above equation are depicted in fig below.

When $\rho = -10\ dB$

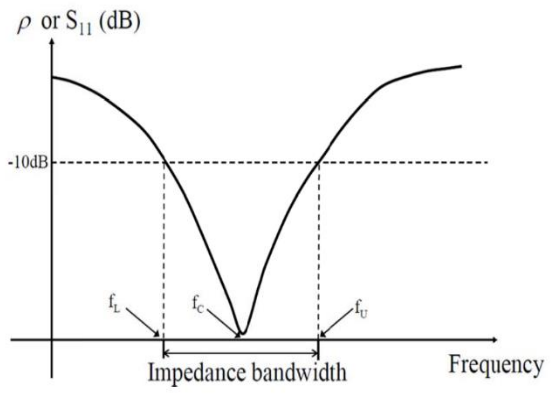

Figure 3 Impedance bandwidth [3]

5. VSWR

Same as ρ and the return loss, the voltage standing wave ratio (VSWR) is also a common parameter used to characterize the matching property of a transmitting antenna. The VSWR of antenna is given as:

$$VSWR = \frac{1 + |\rho|}{1 - |\rho|} \ (dimensionless)$$

Possible values of VSWR are from 1 to ∞.

VSWR = 1 ⟹ perfectly matched

VSWR = ∞ ⟹ completely unmatched.

6. CALCULATIONS

Design a RMSA for Wi-Fi application (2.400 to 2.48 GHz)

Chose Substrate: ε_r= 2.2, h = 1 mm and tan δ= 0.001

Feed-point x between L/6 to L/4.

Formula for effective permittivity

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 10\frac{h}{W}\right]^{-\frac{1}{2}}$$

Formula for length of fringing field

$$\Delta L = \Delta W \approx \frac{h}{\sqrt{\varepsilon_e}}$$

Formula for width of patch

$$W = \frac{c}{2f_0\sqrt{\frac{(\epsilon_r + 1)}{2}}}$$

Formula for length of patch.

$$L_e = L + 2\Delta L = \frac{\lambda_0}{2\sqrt{\epsilon_e}} = \frac{c}{2f_0\sqrt{\epsilon_e}}$$

Table 1 Simulation Result of RMSA

h (mm)	ε_r	f_0 (GHz)	Z_{in} (Ω)	BW (MHz)	Gain (dB)
1	1.00	2.47	56	30	7.34
1	2.20	2.41	62	30	5.71
1	2.33	2.48	56	30	5.11
1	2.94	2.36	69	20	5.00
1	4.40	2.38	78	20	1.61

7. DESIGN & SIMULATION

Table 2 Dimensions of proposed antenna

Symbol	Dimensions (mm)
L	40
W	47
ΔL	8.5
ΔW	8.5
f	2.5
h	1
a	12
l	22
W'	1.5
Feed line width	3
L/4	10
L/6	8
X	8

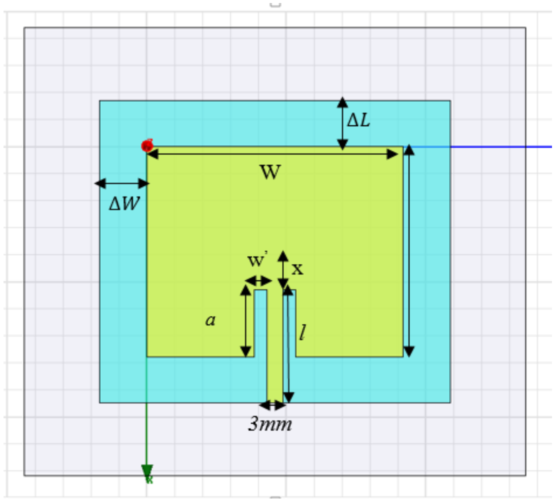

Figure 4 RMSA Antenna Design

3. CONCLUSIONS

This paper serves as a complete guide to design a rectangular microstrip antenna from scratch. It uses the standard design formula from authentic literatures [1], [2], [3]. The main work of this paper revolves around finding the best substrate with a given thickness to design RMSA, operating at 2.4-2.48 GHz.

Multiple antennas have been designed to verify the effect of change in the substrate. It has been observed that if the permittivity of the substrate is increased, mainly the gain is reduced. Best gain is produced with air substrate. Since it is difficult to make RMSA with air substrate, we are finally proposing antenna with $\epsilon_r = 2.2$. It can be seen that in this configuration the gain (5.71dB) and bandwidth (30 MHz) is decent and impedance is also close to 50Ω.

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