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Broad Band Slotted Stacked Microstrip Antenna for Wireless Applications

Zakir Ali
I.E.T.B.U, Jhansi
India

Vinod Kumar Singh
S.R.Group of Institutions, Jhansi
India

Shahanaz Ayub
B.I.E.T, Jhansi
India

Abstract: **This paper presents broad band slotted MSA for wireless application. By using stacked configuration, cutting slot the bandwidth equal to 19.70% is achieved. The antenna is fed by coaxial probe feeding technique and designed using stacking configuration. The designed antenna operates in the frequency range of 2.713 to 3.304 GHz. The antenna is designed using air as a dielectric substrate between the ground plane and patch and simulated on the Zeland IE3D software.**

Keywords: **Stacked, Broad band Antenna, and WLAN.**

I - INTRODUCTION

Microstrip antennas are being frequently used in Wireless application due to its light weight, low profile, low cost and ease of integration with microwave circuit. However standard rectangular microstrip antenna has the drawback of narrow bandwidth and low gain.

The bandwidth of microstrip antenna may be increased using several techniques such as use of a thick or foam substrate , cutting slots or notches like U slot , E shaped , H shaped patch antenna, introducing the parasitic elements either in coplanar or stack configuration, and modifying the shape of the radiator patch by introducing the slots.

In this paper a broad band slotted stacked microstrip patch antenna with compact size is presented which gives a bandwidth of around 19.70%.

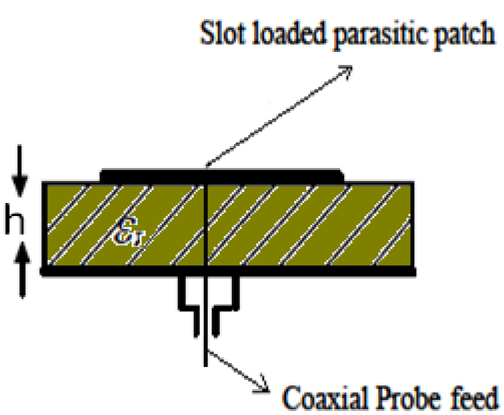


Figure 1. Geometry of proposed antenna.

II – DESIGN OF RECTANGULAR PATCH

For designing a rectangular microstrip patch antenna, the length and the width are calculated as below

$$W = \frac{c}{2f\sqrt{(\varepsilon_r + 1)/2}} \quad (1)$$

Where **c** is the velocity of light, ε_r is the dielectric constant of substrate, ***f*** *is* the antenna working frequency, **W** is the patch non resonant width, and the effective dielectric constant is ε_{eff} given as,

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

The extension length Δ is calculates as,

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff} + 0.300)\left(\frac{W}{h} + 0.262\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.813\right)} \quad (3)$$

By using the mentioned equation we can find the value of actual length of the patch as,

$$L = \frac{c}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta l \quad (4)$$

III –ANTENNA DESIGN ANALYSIS

Figure 2 shows the designed antenna geometry. The Antenna is designed using air dielectric of height 10 mm. The Length and width of the patch is 52mm and 71 mm. On this patch a U slot and dual rectangular slits are digged of dimensions 39 by 4 mm. The slot cutting and stacking is done to improve the bandwidth of the microstrip antenna.

In the cavity model, the region between the patch and the ground plane is treated as a cavity that is surrounded by magnetic walls around the periphery and by electric walls from the top and bottom sides since thin substrates the field inside the cavity is uniform along the thickness of the substrate.

The fields underneath the patch for regular shapes can be expressed as a summation of various resonant modes of two dimensional resonators. The fringing fields around the periphery are taken care of by extending the patch boundary outward so that the effective dimensions are larger than the physical dimensions of the patch. The effect of the radiation from the antenna and the conductor loss are accounted for by adding these losses to the loss tangent of the dielectric substrate. The far field and radiated computed from the equivalent magnetic current around the periphery.

From the cavity model explained above, the electric field is assumed to act entirely in the z-direction and to be a function only of the x and y coordinates i.e. [6-7]

$$\vec{E} = \hat{Z}Ez(x, y) \qquad (5)$$

The z-component of the electric field E_z satisfies the two-dimensional wave equation.

$$\frac{\partial^2 E_Z}{\partial \chi^2} + \frac{\partial^2 E_Z}{\partial y^2} + K^2 E_Z = 0 \qquad (6)$$

The outward current flowing on the perimeter of the patch must be zero (since the patch boundary is an open-circuit). Therefore,

$$\frac{\partial E_Z}{\partial \chi} = 0 \qquad (7)$$

Where n is the outward normal vector at the perimeter of the patch by using the separation of variables, the electric field of the m and n mode number is

$$E_Z = E_0 Cos\left(\frac{m\pi\chi}{W}\right)\left(\frac{n\pi y}{L}\right) \qquad (8)$$

In order to calculate the far field, the aperture model is used. By using Green's function the following general form of the far field for any (m, n) mode

$$E(r) = \frac{jke^{-jkr}}{2\pi r}\left\{\bar{i}_\theta\left[E_x \cos\varphi + E_y \sin\varphi\right] + \bar{i}_\varphi\left[-E_x \sin\varphi\cos\theta + E_y \cos\varphi\cos\theta\right]\right\} \qquad (9)$$

Where

$$E_x = \left[\left(-1-(-1)^m\right)j\sin\left(\zeta\frac{W}{2}\right) + \left(1-(-1)^m\right)\cos\left(\zeta\frac{W}{2}\right)\right]\times$$

$$h\cdot E_0\frac{L}{2}\sin c(\zeta a)j^n\left[\sin c\left(\eta\frac{L}{2}+\frac{n\pi}{2}\right)+(-1)^n\sin c\left(\eta\frac{L}{2}-\frac{n\pi}{2}\right)\right]$$

and

$$E_y = \left[\left(-1-(-1)^n\right)j\sin\left(\eta\frac{L}{2}\right) + \left(1-(-1)^n\right)\cos\left(\eta\frac{L}{2}\right)\right]\times$$

$$h\cdot E_0\frac{W}{2}\sin c(\eta a)j^m\left[\sin c\left(\zeta\frac{W}{2}+\frac{m\pi}{2}\right)+(-1)^m\sin c\left(\zeta\frac{W}{2}-\frac{m\pi}{2}\right)\right]$$

Then the far field components are given as

$$E_\theta = \frac{jke^{-jkr}}{2\pi r}\left(E_x\cos\varphi + E_y\sin\varphi\right) \qquad (10)$$

$$E_\phi = \frac{jke^{-jkr}}{2\pi r}\left(-E_x\sin\varphi\cos\theta + E_y\cos\varphi\cos\theta\right) \qquad (11)$$

Where

$$\zeta = KSin\theta Cos\varphi, \qquad \eta = KSin\theta Sin\varphi$$

$K = \dfrac{2\pi}{\lambda_0}$ and λ_0 =wavelength in free space.

Equation (9) enables one to plot the radiation pattern for every mode of the rectangular micro strip patch antenna.

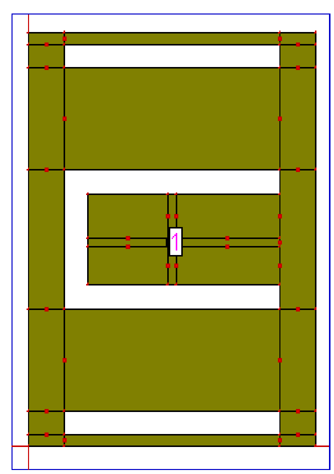


Figure 2. Geometry of proposed microstrip antenna.

IV – RESULTS AND DISCUSSIONS

Figure 3 shows the return loss graph of microstrip antenna which is about -16db. The slotted stacked configuration antenna gives a bandwidth of 19.70% covering the range of 2.713 to 3.304 GHz. making it suitable broadband applications.

Figure 4. & 6 shows the radiation pattern and the 3 D radiation pattern. The radiation pattern at 3.11 GHz frequency is shown in the figure. The component E theta at phi = 0 is shown giving a power gain of 1.56117dB.Figure 5 shows the 3D structure of proposed antenna. Figure 7 shows the Smith chart Vs Frequency plot which shows the input impedance and S11 parameter. The structure is simulated using IE3D simulation software.

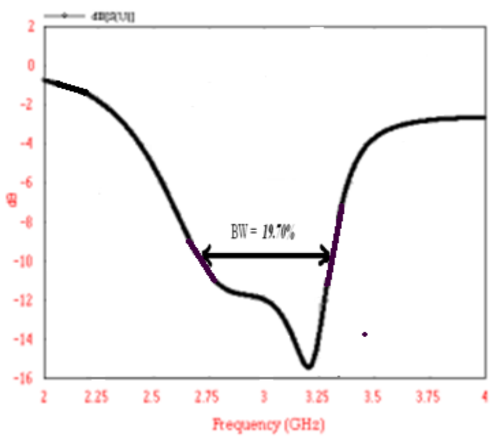
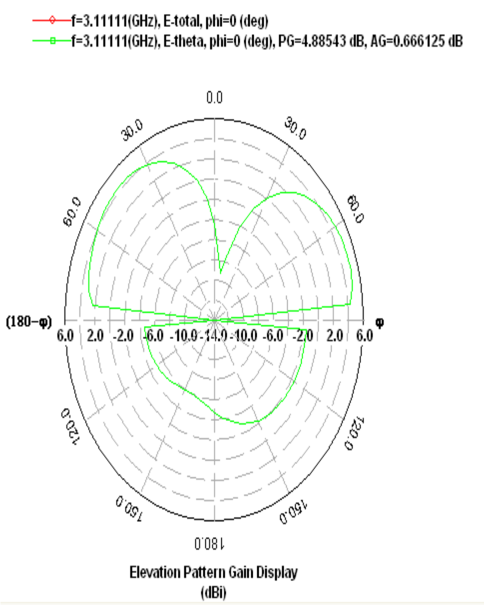


Figure 3. Return loss Vs frequency plot of proposed microstrip antenna



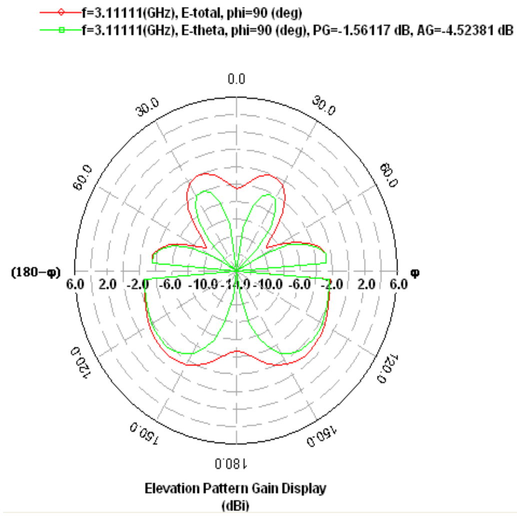


Figure 4. Radiation Pattern of the proposed microstrip Antenna.

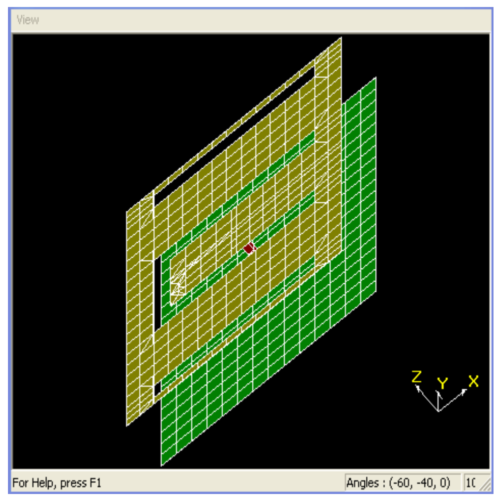


Figure 5. 3D structure of the proposed microstrip Antenna

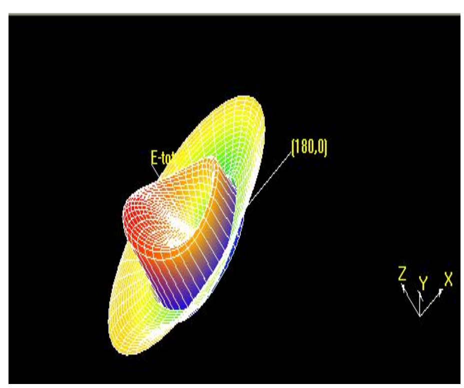


Figure 6. 3D radiation pattern of the proposed microstrip Antenna

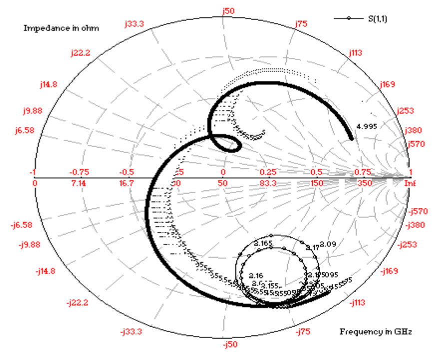


Figure 7.Smith chart of proposed microstrip antenna.

V – CONCLUSION

A broad band Slotted stacked microstrip patch antenna has been designed for wireless and broad band applications. The proposed geometry is designed using air as a dielectric between the ground plane and patch. The stacked configuration has given a better bandwidth 19.70 % as conventional rectangular microstrip antenna.

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