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ANALYTICAL STUDY OF RADIAL GAP CAPACITANCE FOR PROBE FEED RECTANGULAR MICROSRIP PATCH ANTENNA

Kamal Prakash Pandey[1], Rakesh Kumar Singh[2], Anil Kumar[3]

Associate Professor, Dept. of ECE, SIET, Jhalwa, Allahabad, India[1]

Assistant Professor, Dept. of ECE, SIET, Jhalwa, Allahabad, India[2]

Assistant Professor, Dept. of ECE, SHIATS-DU, Allahabad, India[3]

ABSTRACT: In this paper impedance (i.e. coaxial feed probe) is matched with patch of the microstrip antenna. At resonant frequency 3.137GHz. the impedance is 82 ohm For a particular design parameters of rectangular microstrip patch antenna. When impedance is 50 ohm bandwidth is 140 MHz for the same design parameters. The radial gap capacitance is analysed for the parameters as: L= 71.7mm a= 0.5 mm, h=12 mm, ε_r =1, Z_L =250 , b=50 mm. and W= 71.7mm the symbol are used as usual as in figure below.

Keywords: Microstrip Patch Antennas, Patch Impedance, Radial Gap Capacitor, Coaxial Prob-Feed

I. INTRODUCTION

Microstrip patch antennas are known to have a narrow bandwidth. Several techniques have been introduced to improve the bandwidth of microstrip patch antennas [1]–[3]. Most of these attempts to increase the 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. It has been shown that the bandwidth of a microstrip patch antenna is a linear function of its dielectric thickness [7], increasing the bandwidth of the patch antenna with a thicker dielectric substrate also increases the series inductance. The circuit model of a coaxial probe feed rectangular microstrip patch antenna and its equivalent is [8] shown below in figure1 and figure2. The input impedance of a patch antenna is modeled as an RLC resonant frequency. The series inductor represents the feeding probe, and is proportional to the thickness of the dielectric. The inductance produced by the thin probe is compensated by using a parallel plate radial microstrip line and a series radial gap capacitor[9].

II. COAXIAL PROBE FEED MICROSTRIP PATCH ANTENNA

The novel feeding mechanism introduced is used in this communication. A thin,1mm diameter, via is used as the feeding probe of a patch on a 12 mm thick dielectric. The inductance produced by the thin probe is compensated by using a parallel plate radial microstrip line and a series radial gap capacitor. The proposed antenna is illustrated in fig.

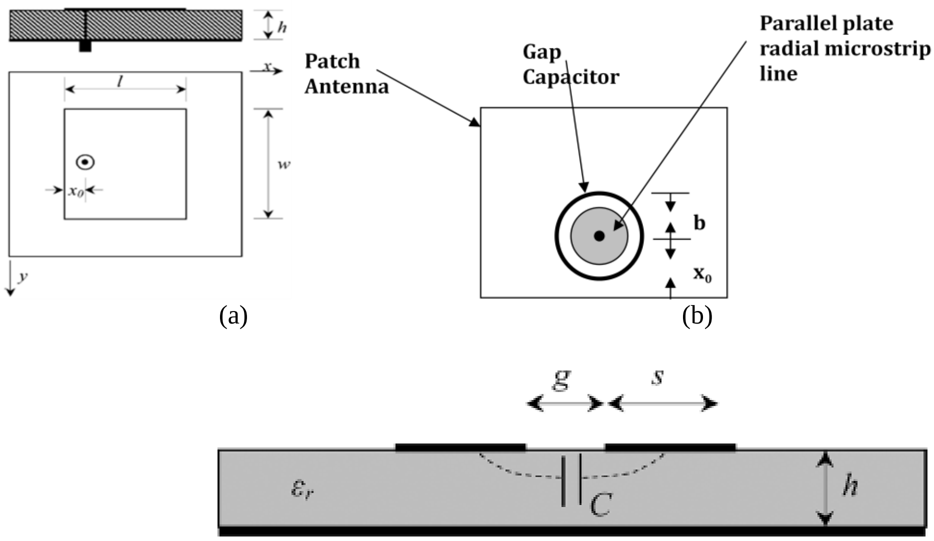

Figure1: (a) Geometry of a rectangular patch antenna, (b) Parallel plate radial microstrip line configuration, and (c) Gap capacitor of radial line.

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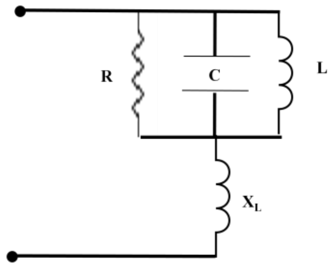

Figure2: Circuit model for the patch antenna

A parallel plate radial microstrip line is characterized by its substrate thickness, h, dielectric constant ε_r, radius of the feeding probe a, and radius of the line b. Characteristic impedance and wave number[10] of such a parallel plate radial microstrip line can be calculated as

$$Z_0(\rho) = \frac{\eta h}{2\pi\rho} \qquad (1)$$

$$\beta = \omega\sqrt{\mu\varepsilon} = \frac{2\pi\sqrt{\varepsilon_r}}{\lambda_0} \qquad (2)$$

where

$$\eta = \sqrt{\frac{\mu}{\varepsilon}} = \frac{\eta_0}{\sqrt{\varepsilon_r}} \qquad (3)$$

The input impedance of a loaded parallel plate radial microstrip line can be calculated using the Riccati differential equation[11] as:

$$Z'(\rho) = j\beta\left(\frac{z^2(\rho)}{z_0} - z_0(\rho)\right)\ Z\Big|_{\rho=b=Z_L} \qquad (4)$$

This equation has a closed form solution for the parallel plate radial microstrip lines with characteristic impedance presented in as:

$$Z_{in=j\ Z_0}(a)\frac{N_0(\beta a)+AJ_0(\beta a)}{N_1(\beta a)+AJ_1(\beta a)} \qquad (5)$$

$$A = -\frac{j\ Z_0(b)N_0(\beta b)-Z_L N_1(\beta b)}{j\ Z_0(b)J_0(\beta b)-Z_L J_1(\beta b)} \qquad (6)$$

III. **RADIAL GAP CAPACITOR**

In the antenna structure shown in figure1, there is a radial gap capacitance between the parallel plate radial microstrip lines and the patch antenna. The radial capacitance is a function of gap size g, radius of the parallel plate radial microstrip lines a, b, dielectric constant ε_r, and thickness of the dielectric h. The thickness of metallic sheet is assumed to be zero. One can use the calculation results of the capacitance between two coupled microstrip lines[12].

Theoretical analysis of patch antenna, driven by coaxial feed and parasitic patch placed at the outer radiating edge of the patch, is analysed using the circuit theory concept, the open end of driven patch coupled to parasitic patch is considered as a real open circuit having scattering field at its end, which is designated by equivalent terminal capacitance C_L given by [2]

$$C_L = \Delta_{il}\frac{\sqrt{\varepsilon_{eff}}}{Z_A c'} \qquad (7)$$

where c' is velocity of light, ε_{eff} the effective dielectric constant, Δ_{il} the conductor extension length due to fringing field, Z_L (=Z_A)the characteristic impedance of annular ring patch[13] given by

$$Z_A = \frac{\eta_0}{\sqrt{\varepsilon_e'}}\left\{\frac{W'}{h}+1.393+0.667\ln\left(\frac{W'}{h}+1.444\right)\right\}^{-1} \qquad \frac{W}{h}\ge 1 \qquad (8)$$

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where

η_0 = free space intrinsic impedance.
= 120 π ohms

$$\frac{W'}{h} = \frac{W}{h} + \frac{1.25}{h}\frac{t}{h}\left(1 + \ln\frac{2h}{t}\right) \qquad \frac{W}{h} \geq 1/2\pi \qquad (9)$$

$$\varepsilon_e' = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} F\left(\frac{W}{h}\right) - C' \qquad (10)$$

in which

$$F\left(\frac{W}{h}\right) = \left(1 + \frac{12h}{W}\right)^{-1/2} \qquad \frac{W}{h} \geq 1 \qquad (11)$$

$$C' = \frac{\varepsilon_r - 1}{4.6}\frac{t/h}{\sqrt{W/h}}$$

here W is the width of patch, (t) thickness of the annular ring patch, ε_r is the dielectric constant of the substrate of a microstrip antenna, ε_e' is the effective dielectric constant of the substrate.

A transverse gap in the strip conductor of a microstrip line usually form a symmetrical arrangement with conductors of equal width on either side of gap (Figure1c). The equivalent circuit of gap coupling capacitance (C_s) and plate capacitance (C_1)[14-19]. The values of the coupling capacitance (C_s) and plate capacitance (C_1) in the equivalent circuit of the symmetrical gap are derived using hybrid mode analysis [20] and are given by

$$C_s = 0.5hQ_1 \times \exp\left(-1.86 \times \frac{S}{h}\right) \times \left[1 + 4.09 \times \left\{1 - \exp\left(-0.785\sqrt{\frac{h}{W}}\right)\right\}\right] \qquad (12)$$

$$C_1 = C_L\left[\frac{Q_2 + Q_3}{Q_2 + 1}\right] \qquad (13)$$

where

$$Q_1 = 0.04598\left\{0.03 + \left(\frac{W}{h}\right)^{Q_4}\right\}(0.272 + 0.07\varepsilon_r) \qquad (14)$$

$$Q_2 = 0.107\left[\frac{W}{h} + 9\right]\left(\frac{S}{h}\right)^{3.23} + 2.09\left(\frac{S}{h}\right)^{1.05}\left[\frac{1.5 + 0.3\left(\frac{W}{h}\right)}{1 + 0.6\left(\frac{W}{h}\right)}\right] \qquad (15)$$

$$Q_3 = \exp(-0.5978) - 0.55 \qquad (16)$$

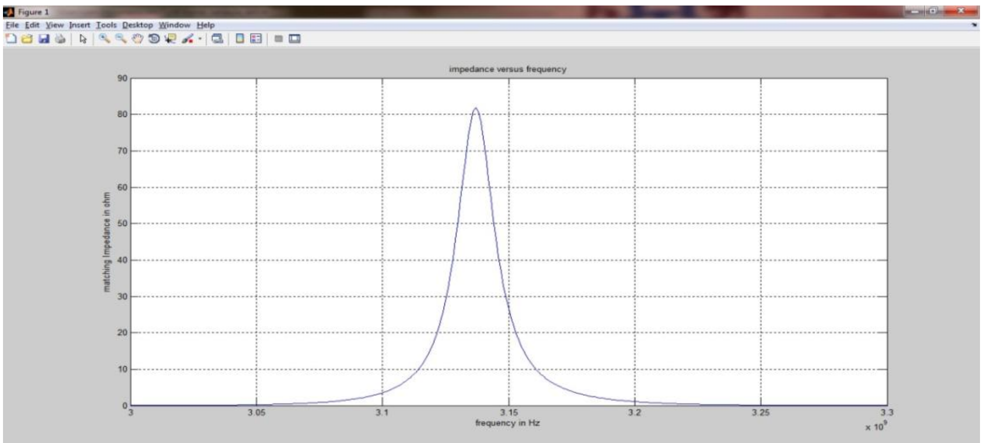

Figure3: Input Impadance of patch (that is matched with coaxial probe) versus frequency

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The matching impedance (i.e. coaxial feed probe is matched with frequency) is shown in the figure3. Here for a particular design parameters of rectangular microstrip antenna is analysed and it is clear that at resonance the impedance is about 82 ohm and resonance frequency is 3.137 GHz and for matching the 50 ohm impedance the bandwidth is required about 140 MHz for the same design parameters.

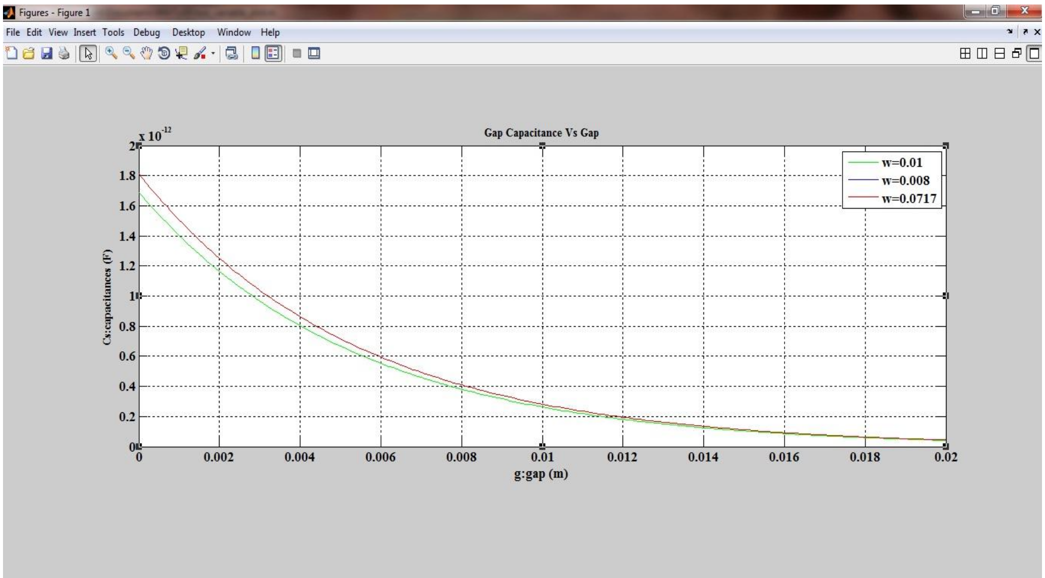

Figure 4: gap capacitance C_s versus ‘g’ gap

The figure4 shown here, the gap capacitance, variation of gap for different with of the patch of rectangular microstrip antenna. Here the capacitance of gap is decreases non linear when gap varied. The capacitance is decreased as shown in figure obtained by the Matlab prompt windows, that are good result as seen in the conventional result [9]. The design parameters are as L= 71.7mm a= 0.5 mm, h=12 mm, ε_r =1, Z_L =250 , b=50 mm. and W= 71.7mm the symbols are used as figure1 and figure2 above.

IV. CONCLUSION

In this paper it is concluded that for analyzed impedance and capacitance of the coaxial probe feed microstrip patch antenna are best to other conventional feeding technique. Here for a particular design parameters of rectangular microstrip antenna is analysed and seen that at resonance; the impedance is 82 ohm and resonance frequency is 3.137 GHz and for matching the 50 ohm impedance the bandwidth is 140 MHz. The gap capacitance, of the patch of rectangular microstrip antenna is decreased with non-linear of the gap of radial parallel line.

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BIOGRAPHY

Kamal Prakash Pandey is Associate Prof. at SIET, Jhalwa–Allahabad. Jhalwa–Allahabad. He obtained B.E. (Electronicsand Communication Engg.) from MMMEC,Gorakhpur M.Tech. from NIT Kurukshetra Haryana, fromerly known as Regional Engg. College Kurukshetra Haryana His area of interest includes Antenna , VLSI, artificial neural network and integrated circuits he has published a book on integrated circuits.

Rakesh Kumar Singh is Assistant Professor in Electronics And Communication Engineering department at Shambhunath Institute Of Engineering and technology,Jhalwa, Allahabad. He has more than 10 years teaching experience and actively involve in research and publication. His area of interest are Microwave and VLSI.

Anil Kumar is Asst. Prof. at SHIATS-DU Allahabad. He obtained B.E (MMMEC,Gorkhpur) in ECE & M.Tech. (IIT BHU Formerly IT B.H.U.) in Microelectronics Engg. and presently pursuing Ph.D. He guided various projects & research at undergraduate & postgraduate level. He published many research paper in different journals. He has more than 10 years teaching. experience and actively involved in research and publications. His area of interest includes Antenna, microwave, artificial neural network and VLSI.