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Dual Band Microstrip Antenna for Mobile Hand Set

Antara Ghosal[1], Anurima Majumdar[2], Sisir Kumar Das[3] and Annapurna Das[4]

Assistant Professor, Electronics & Communication Engineering, Guru Nanak Institute of Technology, Kolkata, India [1,2]

Dean – Research & Administration, Guru Nanak Institute of Technology, Kolkata, India [3]

Director, Guru Nanak Institute of Technology, Kolkata, India [4]

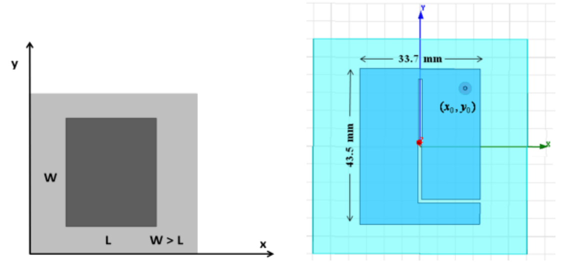
Abstract: This paper describes the analysis and design of a class of slotted rectangular microstrip antennas for dual band operations. Slots are cut to tune the patch at suitable dual frequency operations..The simulation and modeling of these configurations have been done using Ansoft HFSS software. The resonant frequencies and dimensions are computed from the cavity model of rectangular patch. The parameters of antenna such as return loss, VSWR, radiation patterns and gain have been found and design is optimized for best results. The results are experimentally verified and the results are found in good agreement with those of theory.

Keywords: Coaxial feed, slotted rectangular microstrip patch antenna, dual band antenna.

I. INTRODUCTION

Demand of multi frequency patch antenna has been dramatically increased for mobile phone handsets which are capable of operating at multi frequency for different mobile networks at different countries (900, 1800, 1900, 2400 MHz). Several authors are described different structures for multifrequency operations [4-7]. K.L. Wong [4] described L-shape structure with shorting plate at a corner. However, he has not described the results. This paper will provide design guidance of a single antenna operable at dual frequencies by suitably cutting slot on rectangular patch without any shorting plate with ground. Ansoft HFSS software is used for analytical modelling and simulation and experimental verification of results are made using network analyser.

II. ANALYSIS OF SLOTTED RECTANGULAR MICRO STRIP ANTENNAS



(a) (b)

Fig.1 Rectangular Patch
(a. Plane rectangular patch b. slotted patch)

The top view of a rectangular patch and a slotted rectangular patch are shown in Fig.1. Fundamental resonant frequency is determined using cavity model [1-3]. The designed parameters are: substrate $\varepsilon_r = 4.4$, and thickness h=1.6 mm; f=2.4GHz. Since W>>h, effect of fringing field in mixed dielectric media, air and the substrate, replaces ε_r by an eff*ective* parameter ε_{reff} along length L and width W, given by

$$\varepsilon_{reff}(L) = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}(1 + 12h/L)^{-1/2} \quad (1)$$

$$\varepsilon_{reff}(W) = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}(1 + 12h/W)^{-1/2} \quad (2)$$

respectively. ε_{reff} vs normalized patch dimension/h is plotted to find ε_{reff} for a given dimension and is shown in Fig.2. Since W>>h, it can be selected without considering fringing from the following:

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (3)$$

Here c=velocity of light in free space. Since $W \geq L$ the ε_{reff} is calculated from (2) or from Fig.2 . For h =1.6mm, it is found ε_{reff} = 4.09.

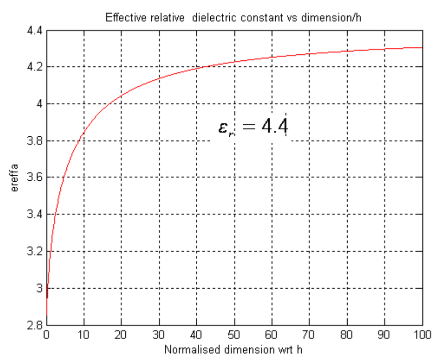


Fig.2 ε_{reff} vs patch dimension/h

Because of the fringing effects, effective electrical length of the patch of the microstrip antenna extends on each end

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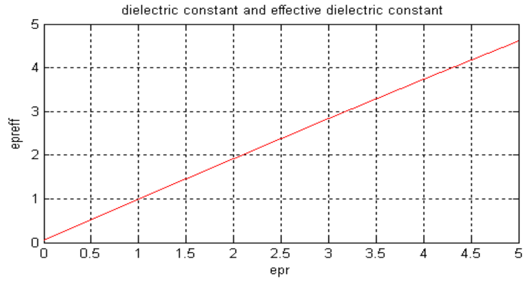
by a distance ΔL, which is a function of the effective dielectric constant and the width-to-height ratio (W/h). An approximate relation for the normalized extension of the length in one side is [1]

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{\text{reff}}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{\text{reff}}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (4)$$

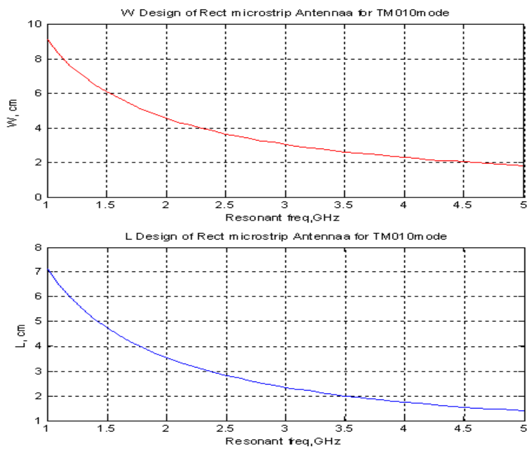
The patch is excited from the ground plane using a co-axial probe at (x0,y0). The fundamental resonant mode of a plane rectangular patch in the direction of excitation (z) is TM010 when W= $\lambda/2$ >L.

III. THEORETICAL COMPUTATION OF S-PARAMETERS USING MATLAB

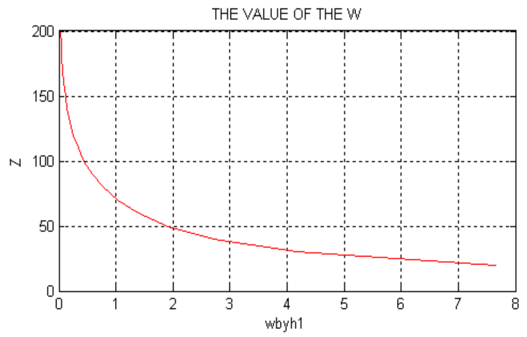
The program is based on MATLAB and is programmed using basic equation. The program was run and then the result of the program is used to design the antenna



(a)



(b)



(c)

Fig.3 Variation of Parameters

a. ε_{reff} **vs** ε_r
b. L and w vs. Resonant Frequency
c . The variation of Z vs w/h

By theoretical computation and using MATLAB program a rectangular patch is obtained and the design parameters are W=43.5 mm, L=33.7mm, h=1.6mm. and substrate Ɛr = 4.4 and the design frequency is 2.1 GHz.

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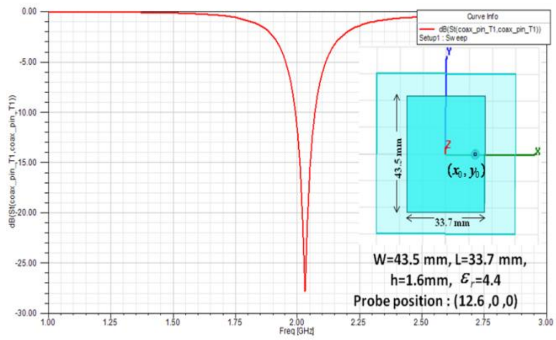
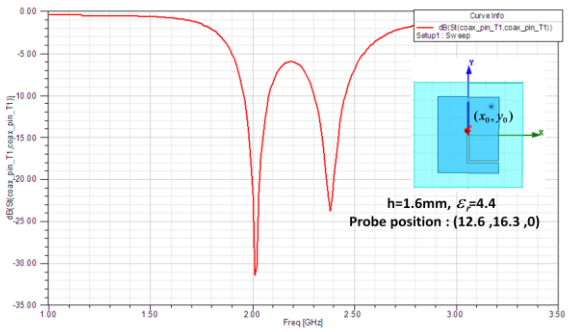
IV. SIMULATION AND MODELING

In the present paper area of the patch is kept same as that of rectangular patch but by cutting the slot a L-shape is introduced. HFSS modeling and analysis are carried out for the structure where the slots are used for dual band operation.

For L- shape design the design parameters are: W= 43.5 mm and L= 33.7mm, h=1.6mm and substrate ε_r = 4.4 and the design frequency is 2.1 GHz. The patch is excited from the back with a co-axial line probe. The probe position is optimized at (12.6, 16.3, 0) for best impedance matching with the 50 ohm feed line. The ratio of the radii of the inner and outer conductor of the coaxial line is 3.5 for 50 ohm input impedance and it is computed using FR4_epoxy. The inner conductor radius is taken as 0.5 mm and the outer conductor radius is taken as 1.75 mm for both designs.



(a)



(b)

Fig.4 S11 Parameter vs Frequency
a. S11 parameter of rectangular patch
b. S11 parameter of L shaped slotted patch

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From the above design of Fig 1(b) , dual band frequency response with very good S11,(shown in Fig 4(b)) near to -31.5dB at 2.01 GHz and -24dB at 2.38 GHz is obtained. At 2.01GHz and 2.35 GHz, 13% and 15% bandwidth is obtained respectively. Therefore, the configuration produces two distinct resonant frequencies which could be received by this antenna.

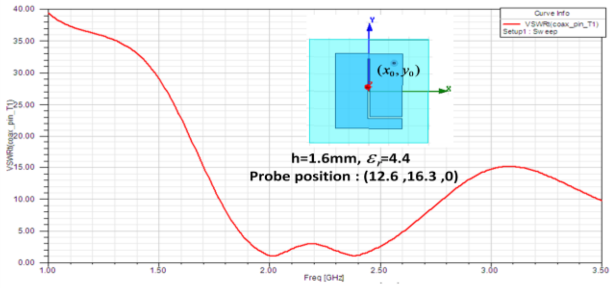
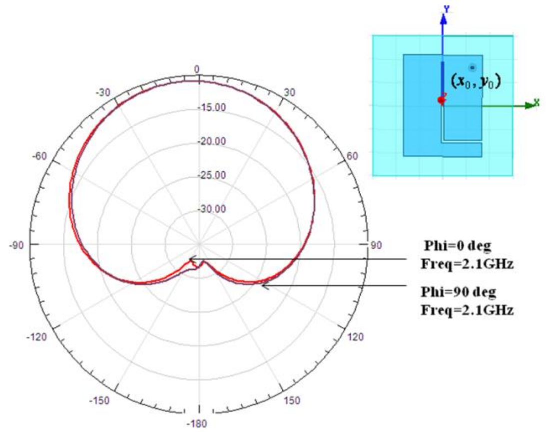
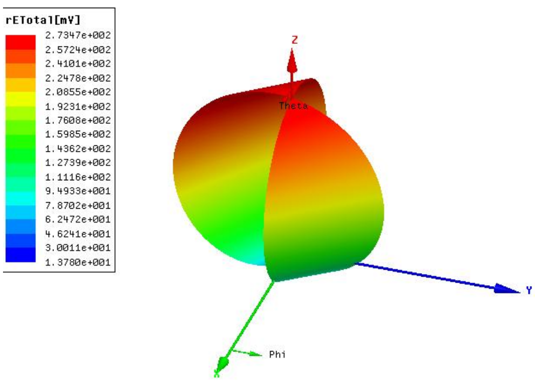


Fig.5 VSWR vs Frequency (GHz)

The radiation patterns of the configuration is also obtained from simulation result and found that this is in good shape for bore side radiation as shown in Fig 6.



(a)



(b)

Fig 6 (a)Radiation Pattern
(b) 3D view of the radiation pattern of the L shaped microstrip patch antenna

V. EXPERIMENTAL EVALUATION

Since the configurations of Fig.1 gives the best performance, a hardware design of this structure is made with W=43.5 mm, L=33.7 mm, h=1.6 mm, and εr =4.4 as shown in Fig.7.

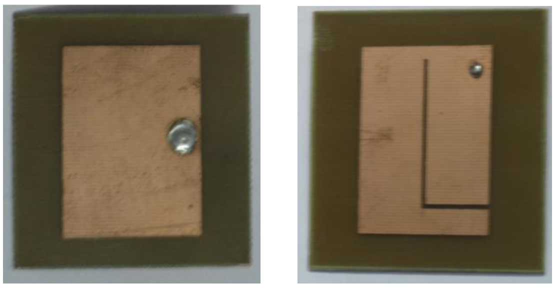


Fig.7 Hardware Design of (a)Rectangular patch antenna (b)L-shape slotted patch antenna

The antenna is tested using Vector Network Analyzer for return loss and radiation patterns. Experimental set up is shown in Fig 8. The test results are shown in Fig. 9. The discrepancy between theoretical and experimental result is due to loss in the system which is not taking into account in the simulation and modeling.

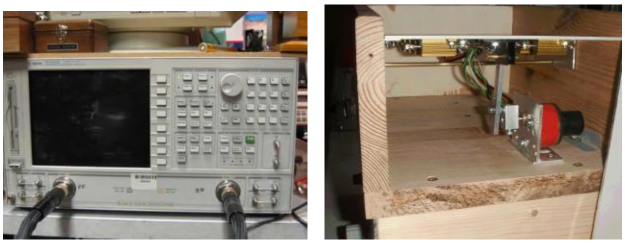


Fig8 (a) Network analyzer (b) Etching machine

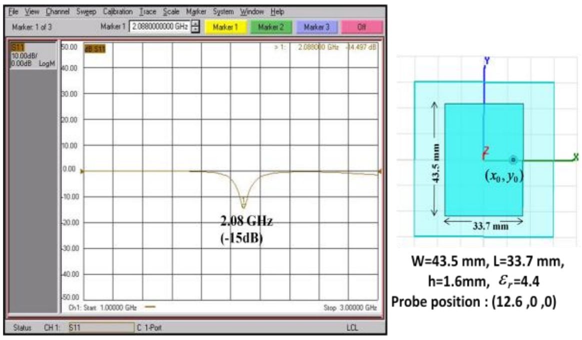


Fig. 9 (a) Return loss vs freq. of the rectangular patch antenna

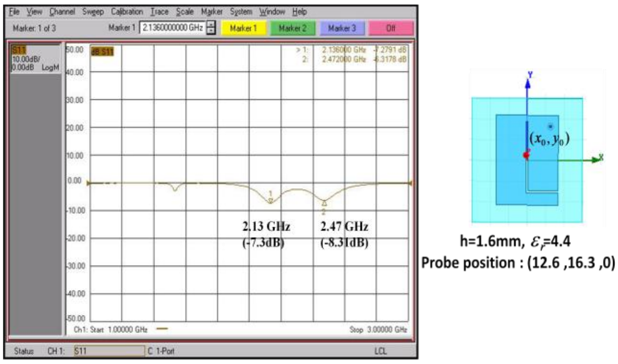


Fig. 9 (b) Return loss vs freq. of the L-shape slotted patch antenna

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VI. CONCLUSION

This paper described the design of L- shaped patch antenna operable at DUAL-frequencies by cutting suitable slots over the patch. Ansoft HFSS software is used for analytical modeling and simulation. A good impedance matching is observed near the frequencies 2.01 GHz and 2.38 GHz by cutting slots, as shown in Fig. 1 (b) for the dual frequency operation of mobile hand set.

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BIOGRAPHIES

Antara Ghosal is presently assistant professor in the Dept. of ECE, GNIT, Kolkata. She obtained B.Tech degree in ECE and M.Tech degree in MCNT from West Bengal University of Technology in 2009 and 2011, respectively. Her research interests are Electromagnetics, microstrip antenna, mobile communication. She is a member of IEEE.

Anurima Majumdar is presently assistant professor in the Dept. of ECE, GNIT, Kolkata. She obtained B.Tech degree in ECE and M.Tech degree in MCNT from West Bengal University of Technology in 2009 and 2011, respectively. Her interests are Electromagnetics and microstrip antenna. She is a member of IEEE.

Sisir Kumar Das, Obtained B.Tech, M.Tech and Ph.D degree from Calcutta University, IIT kharagpur and Anna University, respectively in India. He was faculty in Delhi University during 1977-1980. Dr. Das led EMC evaluation and design of electronics products manufactured by the industry meeting International Standards and Electromagnetics Research projects in the country and abroad for 28 years under the ministry of communication and IT, Govt. of India, during 1980-2007. Presently he is Prof. and Dean – Research & Administration, GNIT, Kolkata. He is co-author of Engineering Text Book "Microwave Engineering", published by Mc-Graw Hill, USA, Singapore and India. He is the author of the text book "Antenna and Propagation", published by Mc-Graw Hill India. He has written three chapters in the book "Engineering EMC", Published by IEEE press. He has nearly 120 research publications in journal and conference proceedings. Dr Das served as associate editor for IEEE EMC journal, USA (1994-2000) and now chief Editor of EMC journal of Society of EMC Engineers (India). He is senior member of IEEE, Life member of Society of EMC Engineers (India). He received society of EMC Engineers (India) highest award 2002 in recognition of his contribution to the EMI/EMC Solutions for Indian Industrial Products.

Annapurna Das obtained M.Sc. degree in physics from University of Calcutta, M.Tech degree in Microwave Electronics and Ph.D degree in Electrical Engineering from the University of Delhi. She worked in the Department of ECE, Anna University during 1985-2007 as Professor. Presently she is Director of GNIT, Kolkata. She is the author of Engineering Text Book "Microwave Engineering", published by Mc-Graw Hill, USA, Singapore and India and co-author of the text book "Antenna and Propagation", and published by Mc-Graw Hill Education. She is the life member of Society of EMC Engineers (India) and ISTE. Her current interests are microwaves, EMI/EMC and Microstrip Antenna.