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Low Mutual Coupling Wideband 1x2 Rectangular Slot Micro-Strip Antenna

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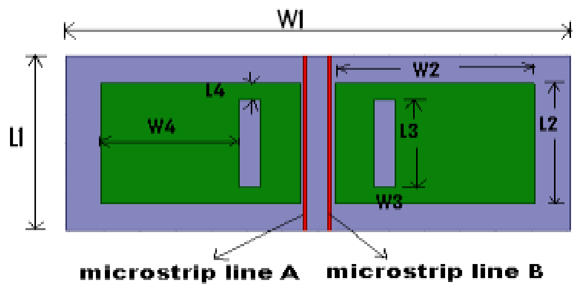
Abstract: A very simple approach for bandwidth enhancement, reducing the mutual coupling and return loss of 1x2 rectangular patches multiple inputs and multiple outputs (MIMO) antenna for Wi-Max operation is proposed. Resonate frequency of proposed antenna is 6.2GHz. For enhancing the bandwidth a simple rectangular slot has been used and bandwidth is enhanced from 3% to 13% at -11dB of return loss. For reducing the mutual coupling two micro-strip lines are placed in between the two closely spaced (edge to edge separation of λo/10) rectangular patches which are connected to ground, to exhibits capacitive behavior which results in field cancellation. Return loss is reduced from -27 db to -38 dB and Mutual coupling is reduced from -20dB to -27dB at the center frequency 6.2GHz.

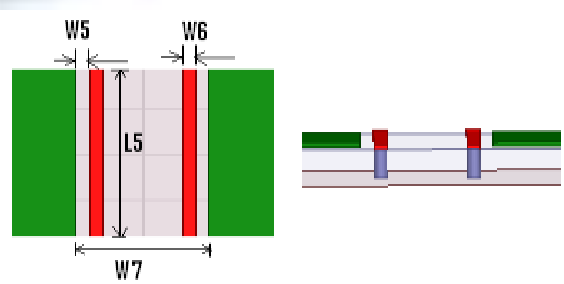
Index Terms: MIMO antenna, Mutual Coupling, wideband, Wi-Max antenna.

I. INTRODUCTION

Due to the emerging need mobile wireless devices has to provide faster access, brighter and higher resolution screens, additional connectivity all with compact size [1]. If the performances of micro-strip antennas are enhanced this becomes the best choice for the communication engineers [3] and [4]. The modern wireless communication as Long Term Evolution (LTE), Worldwide Interoperability for Microwave Access (Wi-Max) system uses the frequency band 2 to 8GHz [1]. The bandwidth of micro-strip antenna is proportional to thickness of the substrate and inversely proportional to the substrate dielectric constant [2]. By increasing the substrate thickness bandwidth of antenna can be enhanced [2]. Many techniques have been employed for enhancing the bandwidth as Fractal Micro-strip Antenna [8], L-strip fed micro-strip antenna [5]. For the further bandwidth enhancement and size reduction additional parasitic inductance and capacitance can be introduced in the patch. When thickness increases from 0.05λo impedance matching for 50Ω becomes difficult due to increased inductance of feed [5], [6] and [7]. Suitable impedance matching can be achieved by proper selection of feed points. Since the modern communication systems demands wide bandwidth, high gain antennas so thick and high dielectric constant are required for micro-strip antennas. Thick and high dielectric constant causes strong surface wave excitation resulting increase in mutual coupling between the antennas of a MIMO antenna system [9]. Also if two antennas are placed closely on common ground plane due to near-field coupling and current sharing by ground causes increase in mutual coupling [13], [14] and [15]. There are different methods for reducing mutual coupling such as electromagnetic band gap (EBG) structures [10] and [11], cavity- backed and substrate removal [11], inductive micro-strip patch and field cancellation [12] and [13]. The mutual coupling is reduced by an electrically isolated micro-strip line and micro-strip capacitive element.



(a)



(b)

Fig. 1: 2x1 Rectangular slot probe feed micro-strip antenna (a) Geometry (W1=71mm, L1=32mm, W2=28mm, L2=22mm, W3=3mm, L3=16mm, W4=3mm, L4=4mm) (b) Dimension and Placement of micro-strip lines and electrical interconnection between ground plane (W5=0.5mm, W6=0.5mm, L5=32mm, W7=3mm).

II. ANTENNA CONFIGURATION

The dimensions of proposed antenna are illustrated in Fig. 1 with center frequency 6.2GHz. It composed of 50Ω transition, two 50Ω probe feeds, two rectangular slots [4]. Rectangular patches separated by edge to edge separation λ0/10 and two micro-strip lines, which were etched on a FR4 epoxy substrate with dielectric constant 4.4 and thickness 1.6mm. To achieve the impedance matching the feed point is placed at (3, 0, 0) mm for both the patches with respect to center of the patches. Two micro-strip lines are placed in between the patches which are connected to the ground. Since these micro-strip lines are connected to the ground so it exhibits the capacitive behavior with respective patches and hence cancel the field between the two antennas.

III. RESULTS

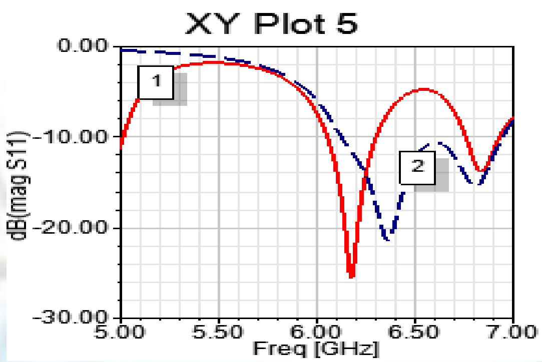


Fig. 2: Return loss with and without rectangular slots

Fig. 2 illustrates the return loss of antenna with and without rectangular slots. Initially micro-strip lines are not placed in between the patches and simulated in HFSS version -13. As rectangular slots have been introduced the bandwidth is enhanced from 3% to 13% at -10dB return loss. Due to inductive behavior of rectangular slots impedance matching is altered and return loss increase from -25dB to -21dB at resonate frequency 6.2GHz.

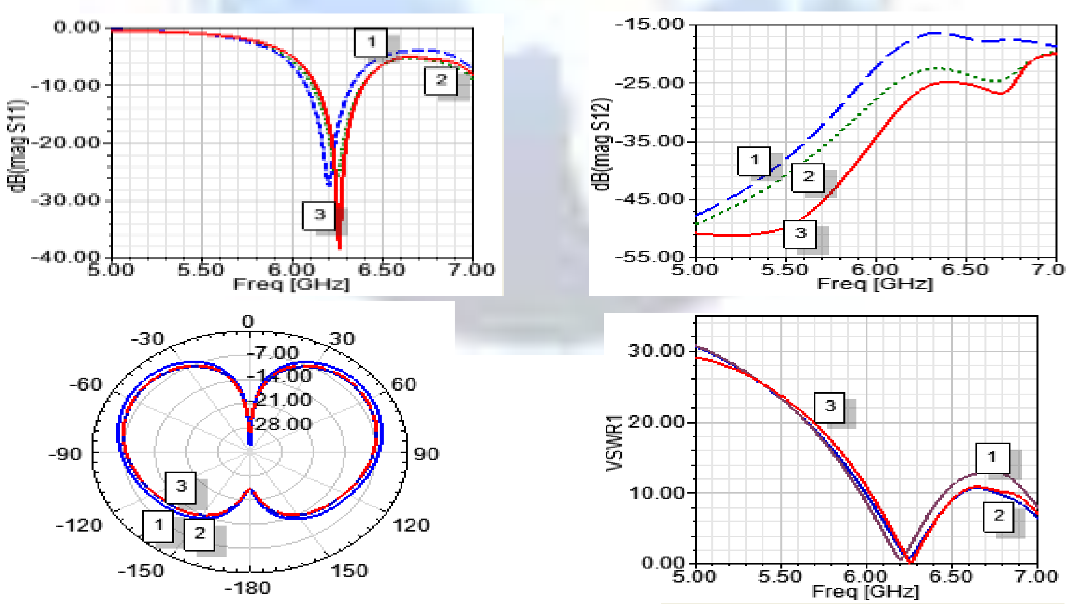


Fig. 3: Simulation results of proposed antenna (a) Return Loss (b) Mutual Coupling (c) Radiation Pattern (d) VSWR

The simulated results of proposed antenna are illustrated in Fig. 3. Proposed antenna resonates at 6.25 GHz frequency. The results of three different configurations are compared in the graphs. In very first case micro-strip lines are not placed in between the rectangular patches and graphs are named as Graph-1. In second case two micro-strip lines are placed between the two rectangular patches with edge to edge separation between patch and micro-strip line of 0.5mm and results are represented by Graph-2 in the Fig. 3. In third case ground plane is connected to the micro-strip lines at the center of micro-strip lines and graphs are represented by Graph-3. In the third case optimum results has been achieved at the center frequency 6.25GHz. Return loss is -38 dB which is better than -27 dB and -25 dB of first and second configuration respectively. Mutual coupling is -25 dB which is better than -17 dB and -23 dB. The radiation pattern remains almost unchanged in all three configurations. Voltage wave standing ratio (VSWR) is almost equal to zero which is better than 0.5 dB and 0.8 dB for first and second configuration respectively.

III. CONCLUSION

A new 1x2 rectangular slot micro-strip antenna with micro-strip capacitive lines are presented. The micro-strip lines exhibit capacitive behavior with rectangular patches results in field cancellation. The feed point is adjusted properly to achieve impedance matching of 50Ω probe feed. The proposed technique exhibit significant reduction in return loss from -27 dB to -38 dB which makes impedance matching easier and increases the efficiency of antenna. Also the mutual coupling is reduced from -20 dB to -27 dB which will increase the capacity of wireless communication system. Simulation results are illustrated in the paper. The proposed antenna can be implemented easily due to very simple structure for Wi-Max applications.

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