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DESIGN OF COMPACT RECONFIGURABLE MULTY FREQUENCY MICROSTRIP ANTENNAS FOR WIRELESS APPLICATIONS

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Abstract - A compact, single feed, multi frequency design of reconfigurable microstrip antenna with various slots are presented in this paper. A rectangular patch loaded with horizontal slots having extended slot arms constitutes the fundamental structure of the antenna. The tuning of the multi resonant frequencies is realized by varying the effective electrical length of the slots by loading varactor diodes across the slots. A size reduction of 84% for the lower operating frequency is obtained when compared to conventional rectangular microstrip patch. Proposed antennas are useful for multi-band wireless applications like GSM1800, IMT2000, WLAN etc operating over a wide range of bands. Measured and simulated results of return loss, antenna gain and radiation patterns are also discussed.

Key words: single feed, multi frequency, WLAN, rectangular patch, return loss.

I. INTRODUCTION

With the advancement in wireless communications, there is a demand to implement antennas that are “smart” to tune their operating characteristics (frequency, polarization, radiation pattern) according to the ever-changing communication requirements. Moreover, using two antennas to cover each of the different wireless services that are scattered over a wide frequency bands which increases the system cost, the space requirements for the antennas, and their isolation. Reconfigurable antennas are potential candidates for future RF front-end solution to minimize the number of antennas required in a particular system. Reconfigurable antennas have been extensively studied over last two decades. This type of antenna requires switching elements to change the antenna electrical properties as well as its radiation characteristics. Electrically reconfigurable antennas use RF-MEMS, p-i-n diodes, varactors to perform the required tunability in the antenna functionality. The activation/deactivation of these switching elements requires the incorporation of biasing lines in the radiating plane of the antenna. Therefore, the interference of these lines on the electromagnetic properties of the antenna needs to be minimized.

Another constraint for this type of reconfigurable antenna is the amount of the input power that is delivered to the switching element. This power should not drive the switch to its nonlinear region in order to prevent distortion and ineterchannel interference. It is also important to note that some work has been done on designing a reconfigurable external matching network in order to tune the operating frequency of the antenna [1]. Compared to broad band antennas, reconfigurable antennas offer the advantages of compact size, better radiation pattern for all designed frequency bands, efficient use of electromagnetic spectrum

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and frequency selectivity useful for reducing the adverse effects of co-site interference and jamming. Dual frequency reconfigurable microstrip antennas can offer additional advantages such as frequency reuse for doubling the system capability and polarization diversity for good performance of reception and transmission or to integrate the receiving and transmitting functions into one antenna for reducing the antenna size. Design of matching networks and the placement of switches are crucial in these types of antennas. A pin diode/varactor diode controlled switching technique for reconfigurable dual frequency operation is recently been reported [2].

This paper presents novel compact designs of single feed, reconfigurable dual frequency rectangular microstrip antennas capable of achieving high tuning ranges without using any matching networks. Various slots on a rectangular patch are used to generate multi resonant frequencies. Varactor diodes are integrated across the slot arms which tune the resonant frequencies considerably. The important aspect of this design is that it provides a size reduction of 84% for the lower operating frequency, compared to conventional rectangular patch antenna. The radiation pattern, gain and polarization are essentially unaffected by the frequency tuning, which is essential characteristic for frequency reconfigurable microstrip antennas.

II. ANTENNA CONFIGURATION AND DESIGN

The conventional patch antenna is designed for 2.4 GHz frequency as illustrated in Fig. 1.(a), the rectangular patch antenna is fabricated on glass epoxy substrate $\varepsilon_r = 4.4$ with thickness (h) of 1.6 mm, width of the patch is W=30mm and length L=40mm. Simulated and measured results of return loss are shown in Fig.1(b)and (c) respectively. These results are good agreement with each other. At first, in order to have three different resonance frequencies without considering the switches in the design, two horizontal slots have been placed on patch position of the antenna. Matching for each of the resonance frequencies is achieved by the theory of off-centered microstrip-feed slot antennas [3, 4]. By etching two slots on patch position of the antenna as shown in Fig. 2.(a), the simulated and measured return losses are in good agreement which are shown in Fig. (b) and (c) respectively.

Two slots on conventional antenna design is designed and fabricated and it is called as two slot antenna as shown in Fig. 3 (a). The width of all the slots is set approximately to 1mm. The use of two slots makes offers size reduction which is due to the excitation of both horizontal and vertical currents of the slots. It is also found that the radiation pattern of the two slot antenna has good co-polar and cross polarized levels. Such slot does not have any effects on the far-field radiation characteristics. It is also studied that the different orientation slots is for having lower mutual coupling between the slots. The simulation and measured return losses are shown in Fig.3 (b) and (c) respectively. The exact positions for diodes are found during the design by various simulations iterations with different positions. It is mentionable that as the diodes are loaded far away from the co axial feed results in broadsided radiation patterns. Hence, the varactor diode is placed 0.2 mm from the edge of each slot. The proposed reconfigurable antenna is as shown in Fig.4 (a) with slots on top edge, middle and bottom edge of the patch. Simulated and measured return losses are shown in Fig.4 (b) and (c) respectively. The proposed reconfigurable antennas are simulated using Zeland IE3D software. The simulated patterns in the E planes are shown in Fig. 5. From the Fig. 5, it is clear that, the radiation pattern of such resonance does not change when the diodes turn off or on, which leads to the same pattern for the same resonance in different states.

III. CONCLUSION

The design of a compact reconfigurable slot antenna with wide frequencies is studied. Varactor diodes are used to change the function of a slot achieving reconfigurability. The antenna design uses a new method of employing

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varactor diodes that do not need any dc bias line, and so the dc effects are eliminated. As a result, the proposed antenna can be practically used for various multi-frequency systems applications.

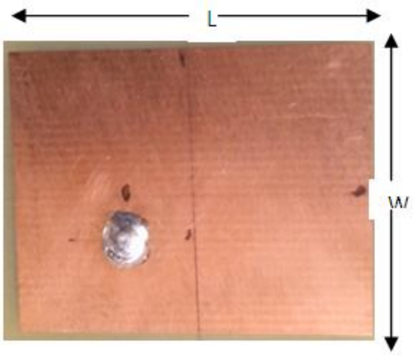
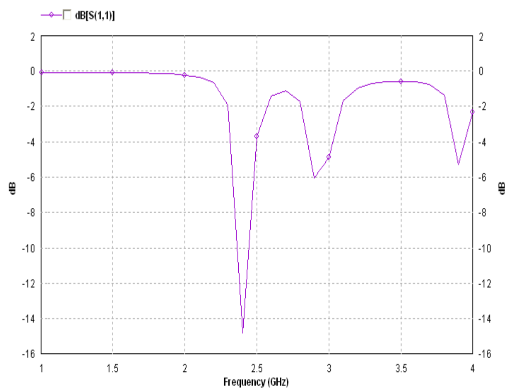
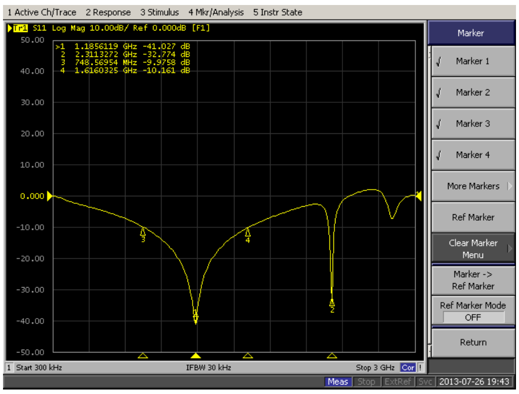


Fig:1 (a) Conventional patch antenna

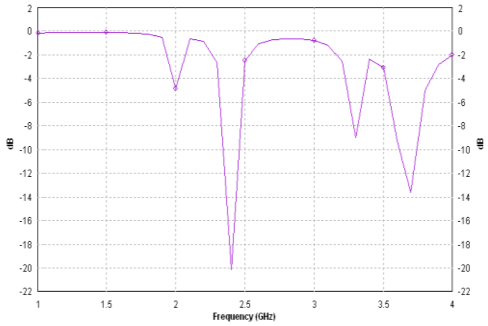


(b) Simulated return loss

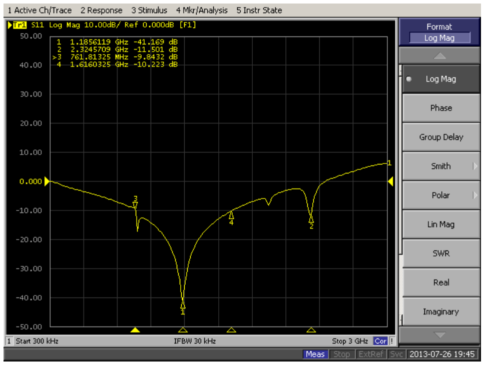


(c) Measured return loss.

Fig: 2 (a) Two slot antenna



(b) Simulated return loss



(c) Measured return loss

Fig:3 (a) Four slot antenna

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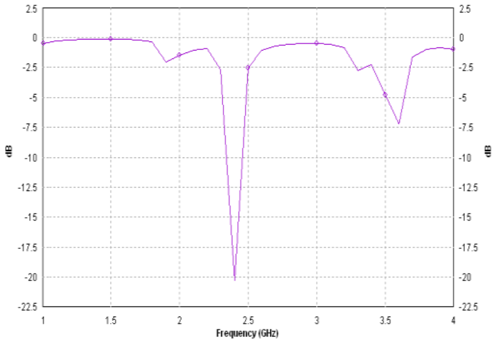
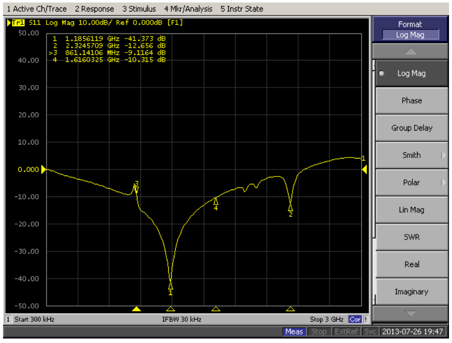


(b) Simulated return loss



(c) Measured return loss

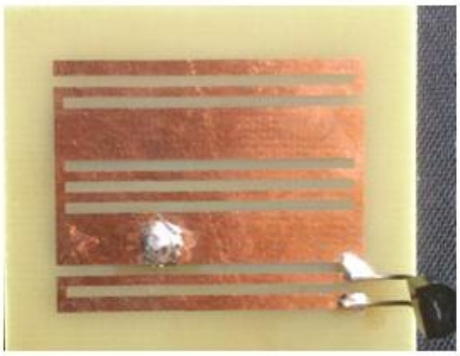
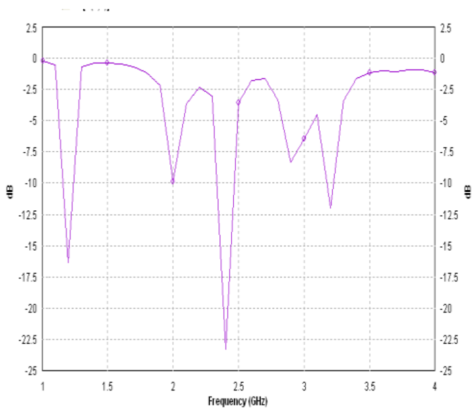
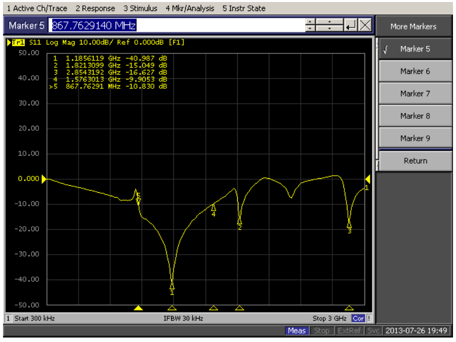


Fig:4 (a) Reconfigured antenna



(b) Simulated return loss with one diode.



(c) Measured return loss

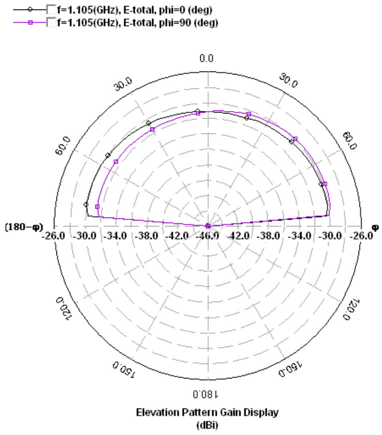
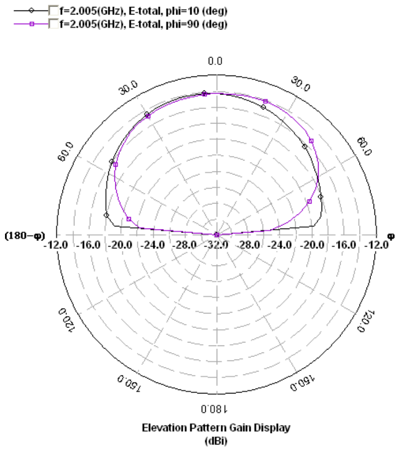


Fig:5(a) Radiation patterns of the antenna at 1.1 GHz



(b)Radiation patterns of the antenna at 1.18 GHz

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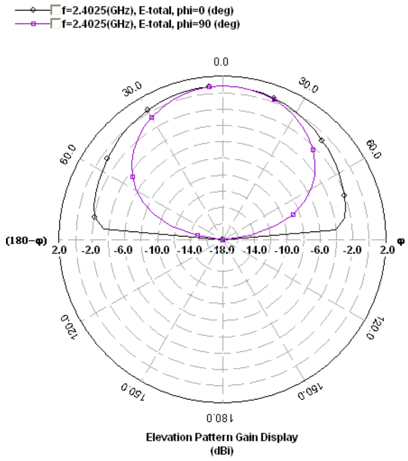

(c) Radiation patterns of the antenna at 2.8 GHz

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