FREQUENCY AND POLARIZATION RECONFIGURABLE MICROSTRIP ANTENNA

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ABSTRACT

This paper presents a dual band frequency and polarization reconfigurable microstrip antenna. The simple design consists of two slots and two feeds. In one slot there is a switch. The two feeds are positioned on the right and left diagonal of microstrip antenna. When the switch is ON the electrical size of antenna becomes small and it resonates at higher UMTS 2100 MHz band with circular polarization. Similarly, when the switch is OFF then size of antenna is large and it operates at lower UMTS 1900 MHz band with elliptical polarization. The sense of polarization can be easily changed from right handed to left handed by changing the feed position. The radiation pattern is not disturbed by switch state and gain of proposed antenna is above 5 dBi. This antenna can be used in emerging reconfigurable wireless communication systems.

KEYWORDS: *Reconfigurable antenna, RHCP, LHCP, RHEP, LHEP.*

INTRODUCTION

With the increasing use of portable communication devices the demand for multi-function antennas is growing. Microstrip antennas are preferred due to their small size, low cost and conformability with monolithic microwave integrated circuits MMIC. However, they are inherently narrow band antennas and operate in a single band (Stutzman and Thiele, 2012). Thus multi band systems will require multiple antennas for proper functioning. Multiband microstrip antennas have been proposed to overcome this limitation (Li *et al.* 2005; Latif, Shafai, and Sharma, 2005; Hossa, Byndas, and Bialkowski, 2004). These techniques involve adding parasitic elements, inserting slots in patch or slots in ground plane. However, these multiband antennas have polarization purity issues and achieve multi banding at the expense of reduced bandwidth and large size.

Recently reconfigurable antennas have attracted lot of attention due to their ability to dynamically adjust operating frequency (Yang *et al.,* 2009), polarization (Zhu *et al.,* 2014), and radiation pattern (Kang, Park, and Yoon, 2008). These antennas can reuse their entire volume at different operating bands. Different parts of antenna can be made to resonate at the required bands and thus no extra size increase is required for multi banding characteristics.

Different techniques that have used to create reconfigurable antennas are presented (Virga and Rahmat-Samii 1997; Yang and Rahmat-Samii, 2002; Behdad and Sarabandi, 2006). A tuning diode is placed between two radiating elements to vary the effective length and hence operating frequency (Virga and Rahmat-Samii, 1997). A patch antenna is with switchable slot with PIN diode is used for re-configurability (Yang and Rahmat-Samii, 2002). In (Behdad and Sarabandi, 2006) a group of antenna elements are connected/disconnected to operate at multiple frequencies.

Generally these techniques involve changing the effective length of the slot or the length of the antenna. Another issue with these techniques is that they have been primarily developed for reconfiguring an antenna frequency only. For some applications we also need to switch the polarization of antenna well for reducing multi path fading. Thus we need frequency and polarization reconfigurable antennas.

This paper presents a frequency as well polarization reconfigurable antenna utilizing two feeds and two slots. In one slot there is a switch. When the switch is ON the antenna operates at 2100 MHz band and radiates right handed circularly polarized (RHCP) waves. When the switch is OFF the antenna operates at 1900 MHz band and radiated right handed elliptically polarized (RHEP) waves. The sense of polarization can be changed from right handed to left handed by just changing the feed position. Thus antenna radiates left handed circular polarized (LHCP) waves when switch is ON and left handed elliptical polarized (LHEP) when switch is OFF.

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ANTENNA DESIGN

The proposed antenna is shown in Figure1. FR4 substrate with a thickness of 3.2mm was used for acceptable bandwidth performance. There are two horizontal slots in the top layer of this substrate to create dual band behavior. In order to reconfigure the antenna operating frequency, diode is inserted in the top slot.

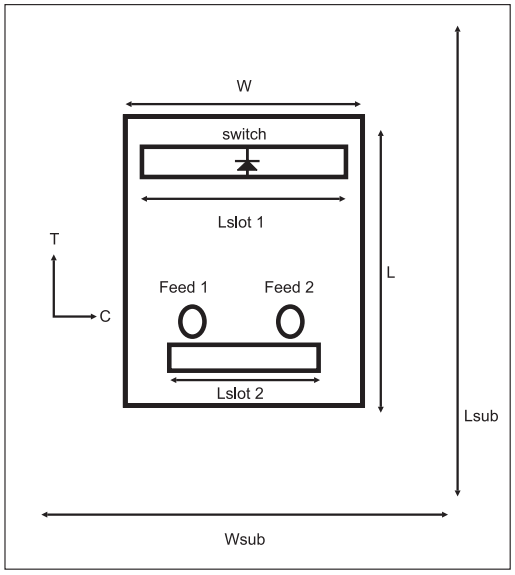

Figure 1: Proposed reconfigurable antenna with two slots and switch.

This diode act as an ON/OFF switch. When diode is forward biased, it behaves as ON switch and the electric current flows along the y-direction through the switch as if there is no upper slot and it operates at frequency say f1. When the switch is OFF by reverse biasing the diode the electric current along the y-direction has to travel along the edges of slot. So it means that the effective length is larger so the antenna will operate at a new low frequency say f2 (f1 > f2). The electric current flow along the x-direction is not disturbed by the slots as both slots are parallel to it.

In order to design a circularly polarized (CP) microstrip antenna different techniques have been used like trimming the corners or simultaneously feeding at two points but with a phase shift of 90 degrees (Sekra et al. 2009; Sahal and Tiwari 2016; Osman et al. 2015; Kyriazidou 2016). Here in the proposed design we have used diagonal feeding method using two feeds .i.e. Feed-1 and Feed-2.

When the switch is ON and Feed-1 is used then antenna exhibited Left Hand Circular Polarization (LHCP) behavior. When Feed-2 is used then we got Right Hand Circular Polarization (RHCP) behavior.

When the switch is OFF and Feed-1 is used then antenna exhibited Right Hand Elliptical Polarization (RHEP) behavior. Similarly when Feed-2 is used then we got Left Hand Elliptical Polarization (LHEP) behavior. The optimized dimensions of proposed antenna are shown in Table 1.

RESULTS AND DISCUSSION

In order to check the performance of our proposed design we used CST Microwave Studio. The antenna was designed and values for antenna dimensions were optimized so that when the switch is ON antenna operated in UMTS 2100 MHz band and when the switch was OFF it operated in UMTS 1900 MHz band.

Table 1: Antenna Design Parameters.

Parameter	Description	Value (mm)
Lsub	Substrate length	55
Wsub	Substrate width	55
L	Patch length	27.25
W	Patch width	32.3
Lslot1	Length of upper slot	28.8
Wslot1	Width of upper slot	1.8
Lslot2	Length of lower slot	18
Wslot2	Width of lower slot	2.2
H	Substrate thickness	3.2

The simulated antenna in CST Microwave Studio is shown in Figure 2. The return loss behavior of antenna is shown in Figure 3. It is seen that when the switch is ON the antenna operates in UMTS 2100 MHz band and when switch is OFF the antenna operates in UMTS 1900 MHz band. To verify the polarization behavior, the axial ratio (AR) plot was simulated and shown in Figure 4 for both states of switch. It can be seen that when switch is ON antenna showed Circular Polarization (AR is 1.73 at 2.15 GHz) and when switch was OFF it showed Elliptical Polarization behavior. Further, the sense of polarization can be easily changed by changing

the feed point.

The radiation pattern of the simulated antenna when switch was ON is given in Figure 5. The main lobe is in the boreside direction and maximum gain is 6dBi. The radiation pattern for OFF position of switch is given in

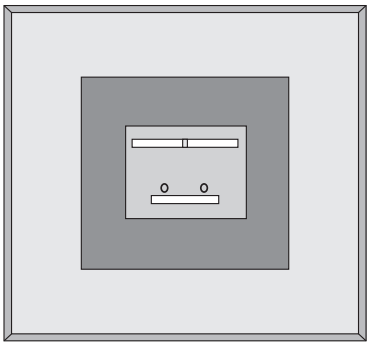

Figure 2: CST model of proposed antenna (when switch is ON).

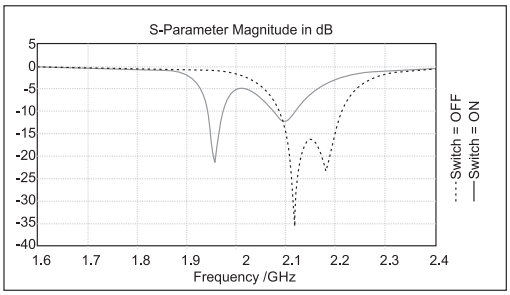

Figure 3: Return loss for ON and OFF states of switch.

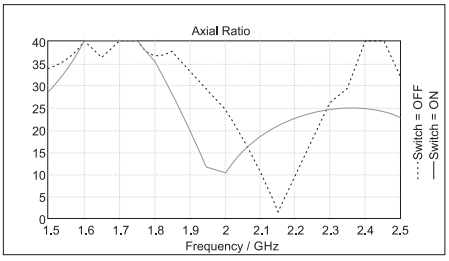

Figure 4: Axial Ratio vs frequency plot for ON/OFF states.

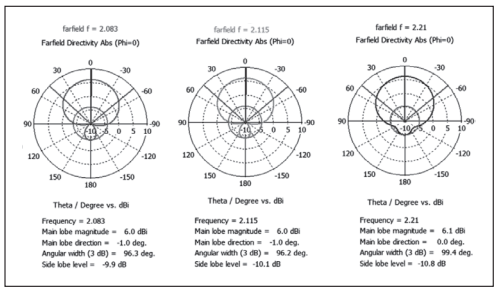

Figure 5: Plot of Radiation Pattern when switch is ON.

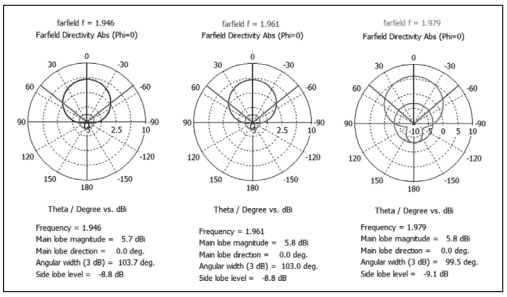

Figure 6: Plot of Radiation Pattern when switch is OFF.

Figure 6. It is observed that there is no significant change in radiation pattern with gain slightly reduced to 5.8dBi.

CONCLUSION

This research study is about design of frequency and polarization reconfigurable antenna. The presented design consists of two horizontal slots. In one slot there is a switch. There are two feeds one on the right diagonal and other on the left diagonal.

When the switch is ON the electrical size of antennas becomes small and it resonate at higher UMTS 2100 MHz band. In this state the bandwidth is above 100 MHz which is quite impressive. The slots position and lengths are so adjusted such that axial ratio is below 3 and thus circularly polarized. The sense of circular polarization can be adjusted by changing the feed position. The directivity and gain are above 5 dBi.

Similarly, when the switch is OFF then size of antenna is large and it operates at lower UMTS 1900 MHz band. In this state the bandwidth is above 32 MHz which is acceptable. The slots position and lengths are adjusted such that axial ratio are in the range of $3 < AR < 30$ and thus elliptically polarized. The sense of elliptical polarization can be adjusted by changing the feed position. The directivity and gain are above 5 dBi for this case as well. This antenna can find applications in future reconfigurable communication systems.

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