RECONFIGURABLE MULTI-BAND STACKED MICROSTRIP PATCH ANTENNA FOR WIRELESS APPLICATIONS

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Abstract —A reconfigurable stacked Microstrip Patch Antenna (MSA) of operating frequencies in the range of (2-5) GHz is proposed for wireless applications. The new antenna is composed of two layers, the bottom layer is a patch with two slots designed on each side that can be controlled via switches. By adjusting the status of the switches, the resonance frequencies can be varied, thus achieving frequency reconfigurability. In order to increase the number of resonance frequencies and to enhance the bandwidth of the patch, another patch is placed on top of the first antenna. The two patches are separated with a dielectric layer optimized to yield the maximum number of resonance frequencies, bandwidth and gain.

Introduction

Today, many wireless products are designed to operate at several frequencies. By making the antenna reconfigurable, one can accommodate more than one service using the same antenna and avoid the use of multiple antennas. In this case we want a reconfigurable antenna that maintains its radiation pattern at different frequencies.

In [1], a novel, reconfigurable MSA, having frequency and polarization diversities simultaneously, was proposed. A U-slot is incorporated into the square patch, where the frequency diversity characteristic of the antenna is realized by switching a PIN diode on a U-slot of an MSA ON and OFF. The novel kind of the MSA suggested in [2] has a patch antenna with switchable slots (PASS). The antenna can work at dual frequencies with a linear polarization (LP). The slot is incorporated into the patch and a PIN diode is utilized to switch the slot ON and OFF. In [3] the switchable dual-band patch antenna with a small and flexible frequency ratio and almost the same circular polarization (CP) was proposed. A different reconfigurable MSA with a switchable slot (PASS) has been proposed in [4] to realize various functionalities, such as dual frequency operation, dual band CP performance and polarization diversity with only one patch and a single feeding point. The PASS concept was also used in [5] to design a compact dual band (CP) antenna at the UHF band for a future Mars rover mission.

In this paper we show how we can increase the number of resonant frequencies and bandwidth of the previously designed PASS antennas by using the stacked microstrip configuration concept. The design approach, simulation and measurements are presented and discussed.

Design Procedure

The resonance frequency (f_0) of the lower patch is chosen to be around 2.4 GHz, and the dielectric material used is the RT/Duroid 5880 with a dielectric constant ε_r= 2.2. The height of the ground plane is chosen to be 1mm, the thickness of the patch (t) is 0.7 mm and the height of the substrate (h) is 1.588 mm. The patch length and width and the ground plane length and width have the following values: L = 40 mm, W = 50 mm, L_g = 50 mm, W_g = 60 mm. The slot dimensions are shown in Fig.1 along with the simulated data. This arrangement yields 3 resonance frequencies.

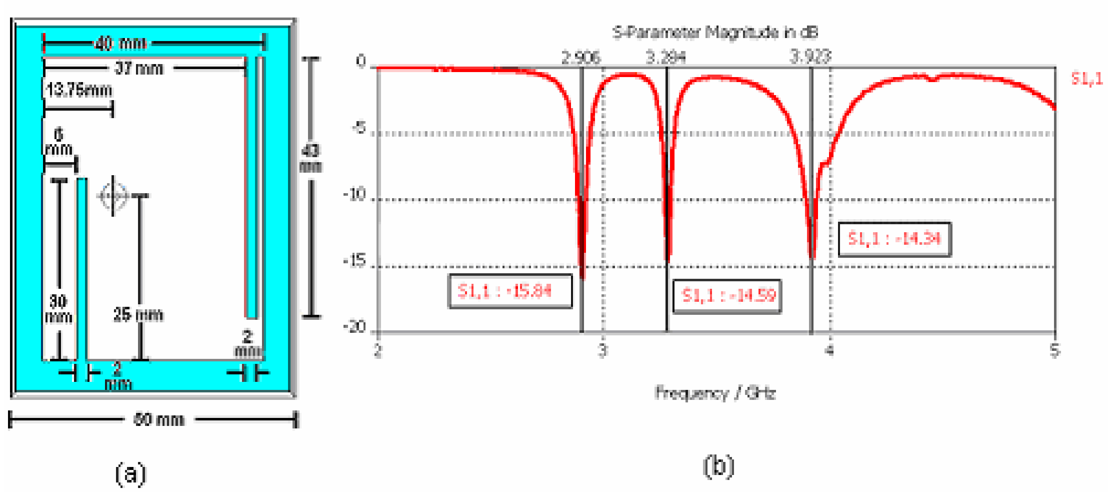


Figure 1: Simulated (a) triple-band MSA, (b) S-Parameter in (dB) for triple-band MSA.

To get a reconfigurable antenna, one switch is added to each slot. Switch 1 (SW1) is fixed on the left slot at 20 mm above the lower edge of the patch shown in Fig. 1, and switch 2 (SW2) is fixed on the right slot at 16 mm below the upper edge of the patch. Both SW1 and SW2 are copper tape of 2 mm length and 1 mm width. By changing the status of SW1 and SW2, we get different resonance frequencies as shown in Table 1.

Table 1. Resonance frequencies for different status of SW1 and SW2.

Switch 1	Switch 2	Resonance Frequencies (GHz)				Gain (dB)
OFF	OFF	2.906	3.284	3.923	-	7.5
ON	OFF	2.924	3.35	3.983	-	7.3
OFF	ON	2.492	3.146	3.326	-	7.8
ON	ON	2.528	3.152	3.392	4.616	7.6

Fig. 2 shows the simulated S-Parameters for different states of SW1 and SW2

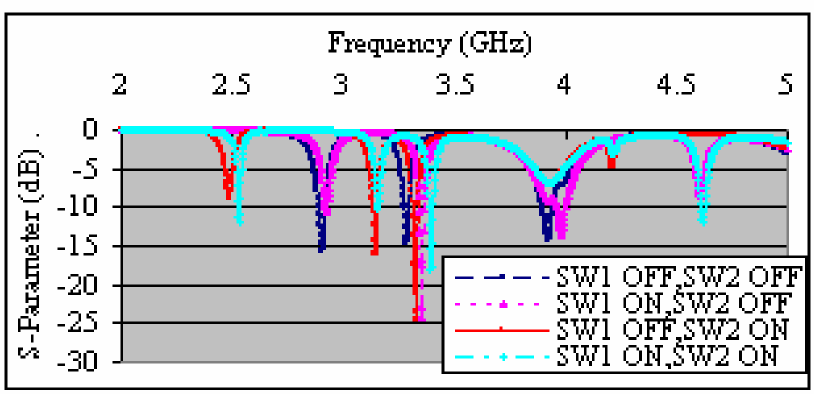


Figure 2: Simulated S-Parameter in (dB) for a multi-band MSA for different states of SW1 and SW2.

Configuration of Stacked MSA

When the bottom patch is covered with another layer (without slots) with a dielectric substrate of ε_r = 4.4 and h =1.588 mm, we observe a shift in these resonances as well as a change in their bandwidths. The dimensions of the top patch are chosen to be 45×55 mm for better performance. Table 2 shows the resonance frequencies for different states of switch 1 and switch 2.

Table 2. Resonance frequencies for different status of SW1 and SW2.

Switch 1	Switch 2	Resonance Frequencies (GHz)					Gain (dB)
OFF	OFF	3.023	3.632	4.157	4.583	4.781	4.5
ON	OFF	3.764	4.187	4.457	4.586	-	2.2
OFF	ON	3.098	3.632	4.178	4.568	4.733	4.9
ON	ON	3.77	4.205	4.571	4.841	-	3.3

Fig. 3 shows simulated S-Parameters for different states of SW1 and SW2 with a top layer of ε_r = 4.4.

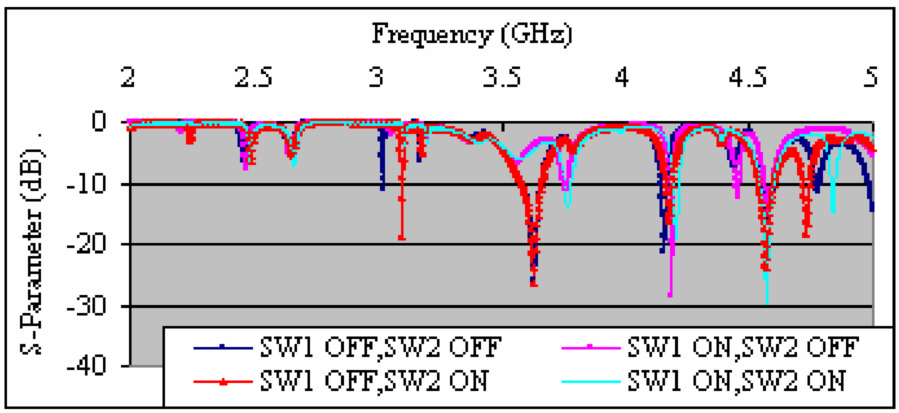
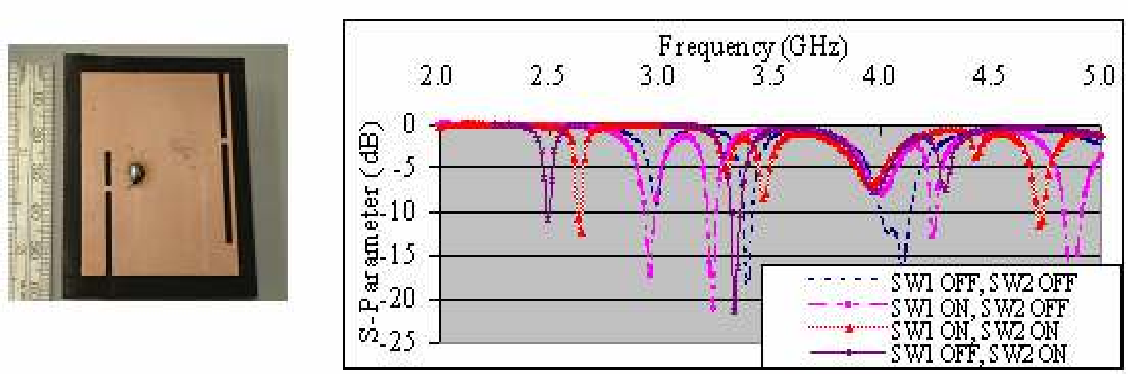


Figure 3: Simulated S-Parameter curves of stacked MSA for different states of SW1 and SW2.

Experimental Results

Fig. 4 shows the optimized fabricated lower layer of the antenna and its S-parameters for different states of SW1 and SW2.



(a) (b)

Figure 4: (a) Fabricated bottom MSA when SW1 and SW2 are ON, (b) Measured S-Parameters for different SW1 and SW2 positions for layer of ε_r = 2.2.

The results obtained from adding the top layer are depicted in Fig. 5. A comparison between Figs 4 and 5 shows that by adding the upper layer we obtain more resonance frequencies which can be controlled by adjusting the status of the switches that are placed on the lower patch (the one that includes the slots).

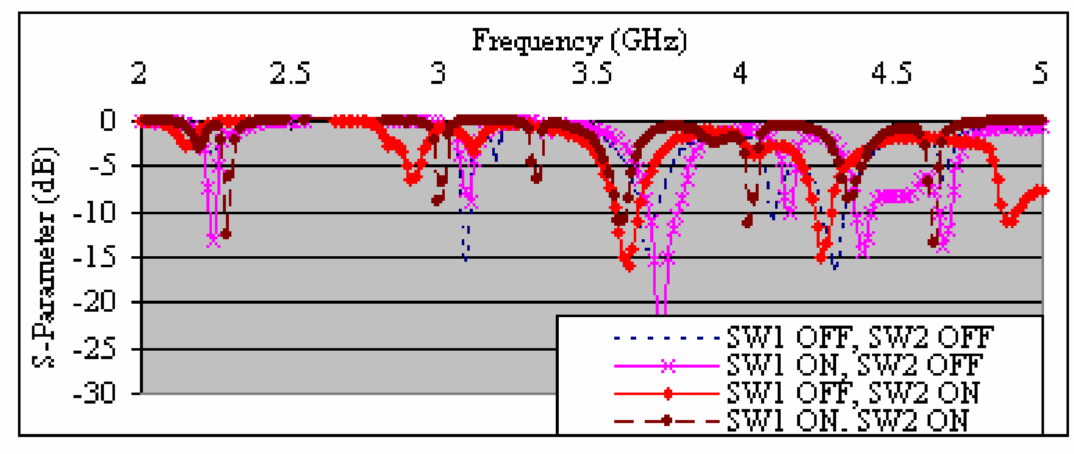


Figure 5: Measured S-Parameters of stacked-MSA with different status of SW1 and SW2.

Conclusions

A new reconfigurable stacked MSA of operating frequencies in the range of (2-5) GHz and almost the same polarization (circular polarization (CP)) was designed, fabricated and tested. The asymmetry of the antenna structure does not affect the polarization and the stability of the radiation pattern. Slots are added to a rectangular patch (bottom layer) with slots to obtain several resonance frequencies, and switches are added to the slots in order to control the reconfigurability of the staked MSA. The positions and dimensions of the slots and switches are optimally chosen to give as many resonant frequencies as possible. By adjusting the state of the switches, the values of resonance frequencies can be controlled, thus achieving frequency reconfigurability.

By placing another layer on the top, the number of resonance frequencies is increased. More work in the future will be focused in using the top layer to also increase the gain and bandwidth of the overall MSA antenna.

References

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