The Effect of the Mutual Coupling on a Small Reconfigurable Patch Antenna

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1. Introduction

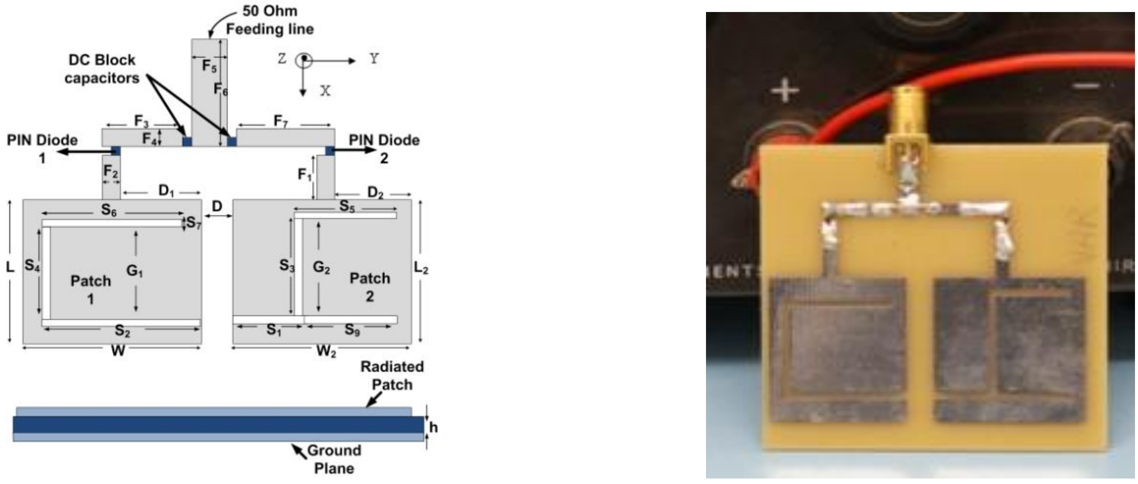
Patch antennas suffer from narrow bandwidth which can limit their uses in some modern wireless applications, therefore there is an increase in the demand for low profile, easy to manufacture and multiband / wideband antennas which can be easily integrated within communication systems. A variety of studies have come up with different solutions to achieve a wide bandwidth for patch antennas. Some of the techniques employed are: changing the physical size of the antenna; modifying the shape to allow the current path to travel longer which sometime make the antenna large in size; adding additional parts such as multi layers or gaps which also make the antenna large and of a high profile [1]-[3].

A reconfigurable antenna is another solution to achieve wider impedance bandwidth by switching ON and OFF some parts of the antenna. Electronic reconfigurability is usually achieved by incorporating switches, variable capacitors or phase shifters in the topology of the antenna. PIN diodes, varactor diodes, or MEMS switches are the most frequently used components in the design of reconfigurable antennas [4]-[5].

In this paper, A multiband and wideband reconfigurable C-Slot compact patch antenna is proposed. The antenna can operate in a dual-band mode or in a very wideband mode between 5 to 7 GHz. The multiband mode can be obtained at different frequencies when the switches are in the ON OFF state OFF ON state. The wideband mode can be obtained when both patches are radiating (ON ON) with achievable impedance bandwidth of 33.52 %. It is found that the mutual coupling between the patches helped to achieve a wideband when both switches are in the ON state. This will be further elaborated in this paper.

2. Design Layout

The schematic diagram of the reconfigurable antenna is shown in Fig. 1 (a). It consists of two patches with the feeding configuration in the centre, two pin-diode switches, two chip capacitors and a ground plane. The antenna is mounted on an FR-4 substrate of 1.57 mm thickness and with a relative permittivity of 4.4 as shown in the photograph of the antenna under test in Fig.1 (b). The key antenna parameters are shown in Table I.



(a) (b)

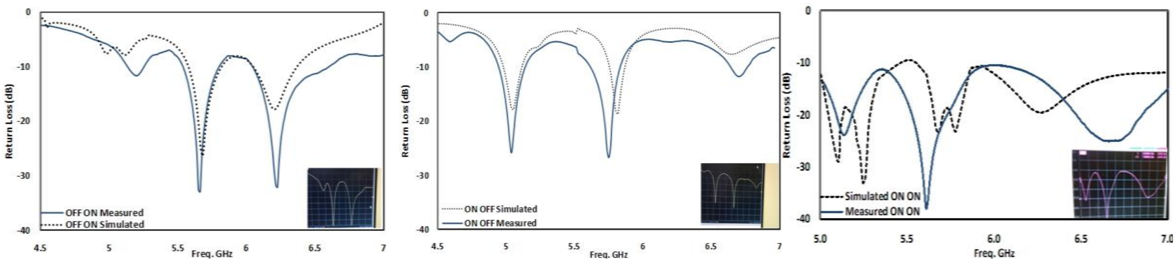
Fig. 1 (a) Configuration of the proposed microstrip antenna (b) Fabricated prototype

3- Simulated and Measured Results

When switch 1 is ON and switch 2 is OFF, a dual-band mode can be obtained at 5 GHz and 5.7 GHz. When switch 1 is OFF and switch 2 is ON the dual-band is shifted toward 5.6 GHz, and 6.2 GHz. When both switches are ON, a very wide bandwidth was obtained covering the frequency range from 4.99 GHz to 7 GHz as shown in Fig. 2 (a) - (b).

In order to validate the simulation results, the proposed antenna was fabricated according to the simulated specifications as shown in Fig. 1(b).

The return loss S_{11} of the proposed antenna in the ON OFF, OFF ON and ON ON cases were measured using Agilent N5230A vector network analyzer and compared with the simulated results obtained from HFSS software as shown in Fig. 2 (a) - (c). It was found that, the simulated and measured results are in good agreement. The discrepancy between the simulated and measured results may be attributed to the fabrication error of ± 3 % specified by manufacturers.

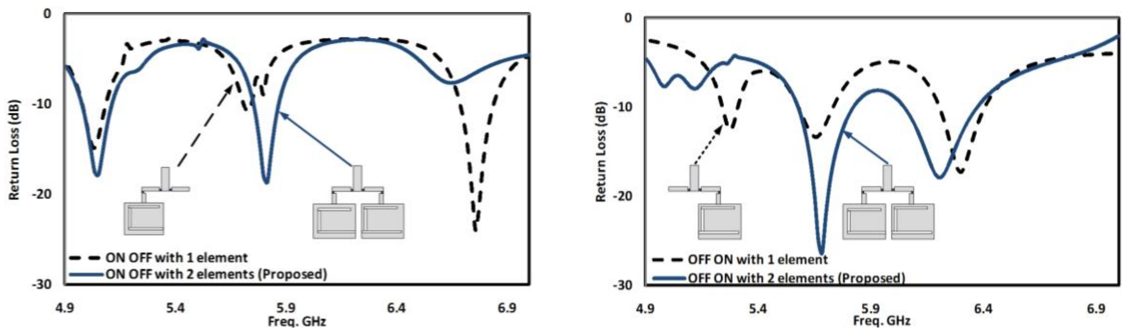


(a) (b) (C)

Fig. 2 Simulated and measured return loss S_{11} (a) OFF ON (b) ON OFF and (c) ON ON.

4- The Effect of the Mutual Coupling and the Combined Impedance

The mutual coupling effects were investigated through simulations and Fig.3 (a) - (b) shows the return loss with 1 and 2 elements present. It is clear from these analyses that the individual coupling between elements 1 and 2 plays an influential part in its return loss behaviour in the ON OFF and OFF ON states. Furthermore, Fig. 4 shows the return loss calculated for the ON ON case from the combined impedance of the ON OFF and OFF ON cases with and without individual coupling. These simple calculations were carried out using transmission line theory considering lossy 50 ohm and 63 ohm transmission lines and it's open states. The overall impedance for the ON ON case results from the combined impedance of the two elements and the mutual coupling between element 1 and 2 at the ON ON states. Results in Fig. 4 clearly show that the mutual coupling in the ON ON state plays a significant part in obtaining good matching over a wider band. Although the combined impedances show a wide band performance, matching below -10 dB has been obtained from the mutual coupling in the ON ON state.



(a) (b)

Fig.3 (a) The effect of adding an absorber between the patches (b) The effect of the combined impedance on the wideband performance Case 1 is 50Ohm Case 2 is 68Ohm and Case 3 is 86 Ohm

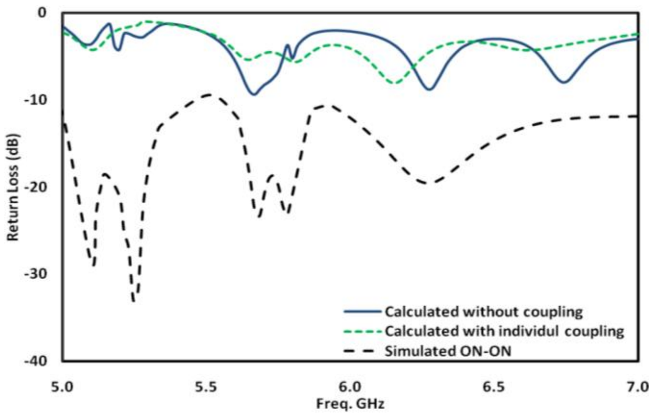


Fig.4 The effect of the mutual coupling on the return loss (S_{11}) when the switches are in the ON ON state

Conclusions

A multiband and wideband reconfigurable small antenna was presented. Two PIN diode switches were attached at the input of the 2 patches to generate dual bands or a wideband by changing the states of the PIN diodes. The effect of the mutual coupling between the patches and the effect of the combined impedance were also studied and discussed. The proposed reconfigurable antenna design was validated experimentally. The simulated and experimental results were found to be in good agreement. The reconfigurable antenna provides multiband and wideband operation with approximately 33.52% bandwidth. Other advantages of the presented antenna include a low profile, lightweight and easy to fabricate simple structure targeting future smaller wireless communication devices.

References

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