

Comments and Replies

Comments on "A Novel Planar Switched Parasitic Array Antenna With Steered Conical Pattern"

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I. DISCUSSION

In Chen *et al.*, [1] a planar array of switched parasitic patch elements, was presented. The practical implementation of the antenna involved a controller unit based on p.i.n. diodes BAP64-03 and the PIC18F2220 microcontroller. Palantei and Thiel [2], [3] reported a similar switching network configuration. The effectiveness of the p.i.n. diode can seriously degrade antenna performance. Factors that influence the symmetry and the accuracy of beam steering using p.i.n. diodes include [2], [3] the following.

1. The microcontroller output voltage variations;
2. The effect of nearby circuitry;
3. Variations in p.i.n. diode impedances;
4. The grounding position of the parasitic elements.

The impedance of a p.i.n. diode is voltage dependent. The controller operates in a range of supply voltages (V_{DD}) from 2.0 to 5.5 Volts. The stability of V_{DD} is crucial because it determines the high and low logic voltage levels at the output pins of the controller. The "ON" impedance is predominantly a low resistance. The "OFF" impedance is predominantly a capacitance. The output "high" is approximately $V_{DD} - 0.7$ volts and the output "low" is less than 0.6 Volts [3], [4]. Any variation in V_{DD} will influence the RF impedance of the diode which in turn will influence the RF current in the associated parasitic element [5].

The bias circuit reported by Chen *et al.* [1] is surprising. Assuming $V_{DD} = 5$ V, the voltage across the series circuit consisting of the diode and R_b is less than 1 V. The forward current is therefore less than 0.1 mA and the forward diode resistance is greater than 80Ω at 100 MHz (see [5, Fig 2]). The diode capacitance is 0.48 pF (typical value at 1 MHz) [5] which results in an RF impedance of $-123j \Omega$ at 2.7 GHz. This is a very small change in the magnitude of the diode impedance and so one might expect very little change in the current flow between the "ON" and "OFF" conditions. This will also make the switching circuit very susceptible to V_{DD} fluctuations and diode manufacturing variations. In addition the voltage at one output port of the microcontroller is affected by the current load on all other ports [2]. This voltage variation across the diodes introduces additional impedance variation.

These factors may explain the variation between the simulated and measured radiation patterns.

II. CONCLUSION

A number of problems with p.i.n. diode switching circuits have been identified which might affect the Chen *et al.* [1] results.

A number of design requirements must be met to obtain ideal antenna performance [6]. If switch activation symmetry is maintained, the centre frequency should not change. If a change in centre frequency is observed experimentally, then the cause might lie in imperfections in

the switching network. Note also that if beam elevation is to be controlled, a conducting skirt can be added to the ground plane [7].

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Reply to "Comments on 'A Novel Planar Switched Parasitic Array Antenna With Steered Conical Pattern'"

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As pointed out by Dr. Elyas Palantei and Prof. David V. Thiel [1], the main concern is that the parasitic switching circuit will have an impact on the performance of the antenna, just as we know. We found this point before but not so clearly. We also noticed that the forward resistance of the PIN diode is a function of forward current and agreed with the analysis of the authors of the Comment. Actually, we made a written error in the value of the resistance. The 10 K Ohm mentioned in the manuscript was replaced by a short wire in the measured prototype by optimization. Unfortunately, we did not update this value in the manuscript. Therefore, the final value of the resistance R_b should be close to 0 Ohm. We apologize for this oversight.

It is agreed that the bias circuit will have an effect on the performance of the PESPAR antenna as shown in our paper [2]; the measured radiation patterns are not totally symmetrical. In an experiment to demonstrate our smart antenna, we are paying close attention to these and other factors such as the front-to-back ratio of the radiation patterns.

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