Optically Controlled Triple Notched UWB Antenna

Heba Zakaria[1], **Moataza Hindy**[2], **and Adel El-Henawi**[1]

[1]Faculty of Engineering, Ain Shams University, Cairo, Egypt
[2]Electronics Research Institute, Cairo, Egypt

Abstract— This paper presents a new optically controlled reconfigurable ultra-wideband antenna (UWBA). The coplanar fed microstrip antenna can work at eight modes using optically controlled switches. This design proposes triple narrow notched bands at center frequencies 3.5 GHz "WIMAX", 5.5 GHz "WLAN" and 8.4 GHz. The proposed antenna satisfies the voltage standing wave ratio (VSWR) requirement of less than 2 in the frequency band between 2.8 to 11.8 GHz except for the three rejected bands. The proposed antenna provides high gain, and high efficiency all over the frequency band excluding the rejected bands.

1. INTRODUCTION

The ultra-wideband (UWB) planar antennas play an increasingly important role in current UWB systems due to its attractive merits, such as small size, low cost and ease of fabrication. Over the commercial frequency band from 3.1 to 10.6 GHz approved by FCC [1] there are some other existing narrowband systems, such as Bluetooth application at center frequency of 2.45 GHz, WiMAX system (3.4–3.7 GHz), C-band satellite (3.7 to 4.2 GHz) and Wireless Local Area Network (WLAN) communication systems (5.15–5.35 GHz) and (5.725–5.825 GHz), WPAN and 7.15–9 GHz [1]. To avoid possible interference between UWB system and these bands it is desirable to design UWB antennas with notched bands. Electronic switches were mounted across or along the resonators to activate the corresponding band notches. Simple microwave switches have been applied in designs to control antennas, filters, phase shifters, and couplers [2–7]. The research of optically controlled microstrip switches started in 1970s and is continuing throughout to today. Advantage of optically controlled microwave circuits is high level of isolation between the controlling electronic circuit and the microwave circuit [6]. Optical switches were introduced in the designs for achieving frequency and beam reconfigurable antennas [7–10].

2. ANTENNA DESIGN

Coplanar fed microstrip UWB antenna was designed on a 35×28 mm FR4 substrate with relative dielectric constant of 4.6 and thickness of 1.5 mm. This design proposes triple narrow notched bands at center frequencies 3.5 GHz "WIMAX", 5.5 GHz "WLAN" and 8.4 GHz. The notched bands can be achieved by adjusting the dimensions of the microstrip structure and by inserting inverted C, L and U shaped slots. The coplanar fed microstrip UWB antenna is shown in Fig. 1(a) while Fig. 1(b) illustrates the inserted optically controlled switches. The proposed UWBA can work at eight modes using controlling switches ON and OFF. The optical switches are made by placing $0.5\,\text{mm} \times 0.5\,\text{mm}$ silicon wafers over the slots of the resonator. When laser is applied to all switches (ON state) the notches disappear and the antenna operates in full ultra wideband frequency range from 2.8 to 11.8 GHz. In case, all switches are OFF, all the three notches are activated. Table 1 explains the eight modes of operation of the proposed antenna.

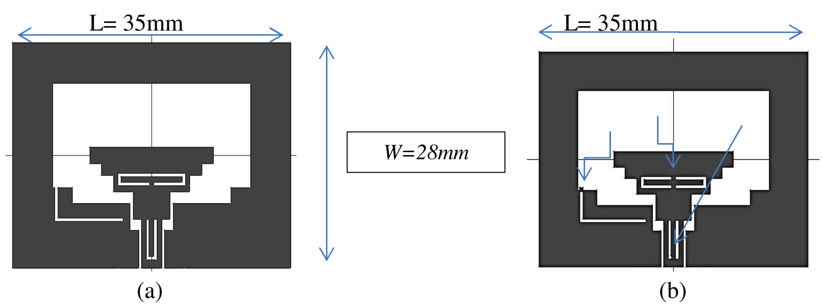

Figure 1. The geometry of the proposed ultra wideband antenna (a) the origin design (b) UWB antenna without 3 switches.

3. SIMULATION AND EXPERIMENTAL RESULTS

Figure 2 shows the simulated VSWR in two cases, when all switches are either ON (state 1) or OFF (state 2) as shown in Table 1. The bands with center frequencies 3.5, 5.5, and 8.5 GHz are rejected when all switches (S_1, S_2 and S_3) are OFF. When all switches are ON we obtain the UWB range from 2.8 to 11.8 GHz with return losses less than −10 dB. Fig. 3 shows the fabricated antenna while Fig. 4 presents comparison between measured and simulated return loss (S_{11}). Measurements of the antenna was performed in the anechoic chamber and it fits fairly well with IE3D simulations. Moreover, the average gain of this antenna is 4.5 dBi (Fig. 5).

case	Notched Band	S_1	S_2	S_3
1	3.5 & 5.5 & 8.5 GHz	OFF	OFF	OFF
2	None	ON	ON	ON
3	3.5 GHz	ON	OFF	ON
4	5.5 GHz	OFF	ON	ON
5	8.5 GHz	ON	ON	OFF
6	3.5 & 5.5 GHz	OFF	OFF	ON
7	3.5 & 8.5 GHz	ON	OFF	OFF
8	5.5 & 8.5 GHz	OFF	ON	OFF

Table 1.

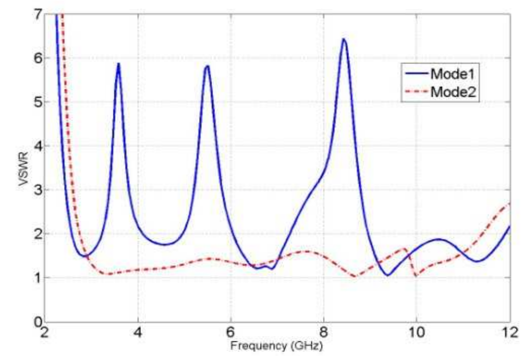

Figure 2. VSWR of UWBA mode1 "state 1" mode2 "state 2" UWB from 2.8 to 11.8 GHz.

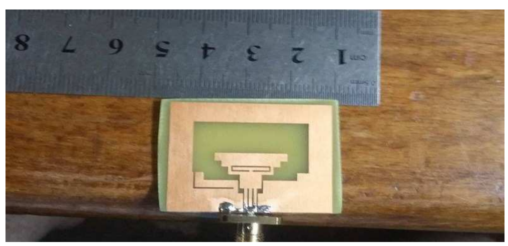

Figure 3. Fabricated antenna.

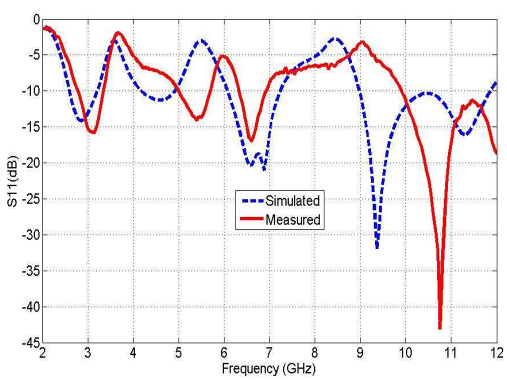

Figure 4. Measured and simulated S_{11} for state 1 of the UWBA.

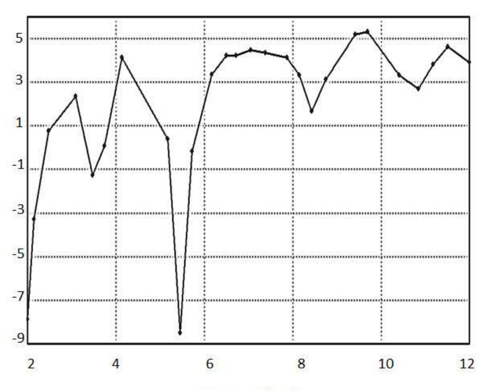

Figure 5. Antenna gain at state 1.

4. RADIATION PATTERNS

The simulated E-plane- and H-plane normalized radiation patterns at 3.475, 5.455, 8.425 GHz and 9.69 GHz for state 1 are plotted in Fig. 6. Radiation patterns are semi omni-directional.

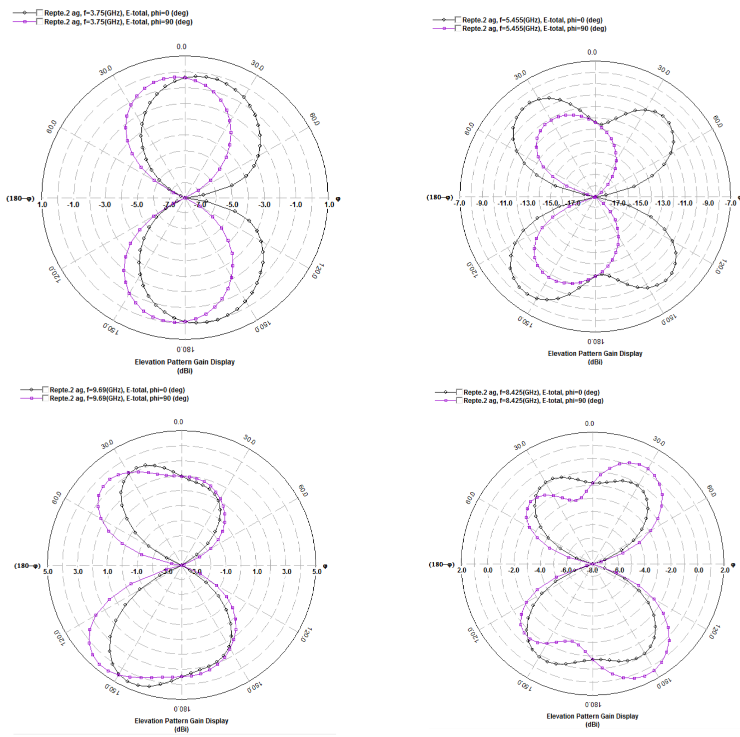

Figure 6.

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