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DESIGN OF E-SHAPE RECONFIGURBLE MICROSTRIP ANTENNA FOR ULTRA WIDE BAND APPLICATIONS

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Abstract: In this paper, a frequency and radiation reconfigurable microstrip antenna design is proposed for Ultra Wide Band application (UWB). The radiating patch was an E-shaped microstrip printed over a FR-4 substrate with relative dielectric constant of 4.3, and thickness of 3 mm. A microstrip line feeds this proposed antenna. To satisfy the UWB frequencies the length ground plane has been reduced. The finite ground plane is printed on the lower side of dielectric substrate. The modeling process and performance estimation of the designed antenna was achieved by using the electromagnetic simulator, Computer Simulation Technology (CST) Software. Simulation results indicate that the designed antenna has an effective bandwidth, for $|S_{11}| \leq$-10 dB, extending from approximately 3 GHz to more than 16 GHz, which covers the entire UWB band of 3.1 GHz to 10.6 GHz.

Keywords: *Reconfigurable, E-Shape, Antenna, microstrip, UWB.*

تصميم هوائي متغير بشكل E للتطبيقات واسعة النطاق الترددي

الخلاصة: هذا البحث، يقترح تصميم هوائي متغير الإشعاع والتردد لتطبيقات ال(UWB). كان الجزء المشع على شكل E ومطبوع على مادة FR-4 مع ثابت العزل الكهربائي النسبي 4.3، وبسمك 3 مم. لتلبية ترددات UWB تم تخفيض طول الطرف السالب من الهوائي. وهذا الطرف السالب المحدد طبع على الطرف السفلي من مادة الFR-4 . وقد تم تصميم النموذج وحساب أداء هذا الهوائي باستخدام محاكي للإشعاع الكهرومغناطيسي، برنامج تقنيات المحاكاة الحاسوبية (CST). نتائج المحاكاة أوضحت بأن تصميم الهوائي لديه عرض النطاق الترددي فعال يمتد مما يقرب من 3 غيغاهرتز إلى أكثر من 16 غيغاهرتز، الذي يغطي النطاق UWB كامل من 3.1 غيغاهرتز إلى 10.6 غيغاهرتز.

1. Introduction

There are many excellent antenna designs in the current literature on UWB systems, one of these antennas the E-shape microstrip antenna, which is used to satisfy the overall UWB frequencies [1].

The UWB technology has been used for many applications during the last 20 year, for instance, sensing and military applications, radar, etc.

Since 2002, a number of research has been studied for this excellent technology, mainly at the decision the Federal Communications Commission (FCC) organization to make the UWB technology can be used for radar in addition to the data communications within different applications [2].

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So far and this technique improving for wireless communication with a high data rate for many applications.

The applications of the E-shaped design in microstrip antenna configuration have been first performed in, which is an attempt to expanding the narrow band and reducing the large size of the microstrip patch antennas [3]. Therefore, this configuration have been used to produce antennas with reduced size and broadband performance for different applications. Many other microstrip patch shapes have been studied with the UWB application in the literature [3-7].

Reconfigurable antenna used to adjust radiation pattern, polarization, and even the operating frequency to making the antenna active with the changing in the system parameters. The reconfigurable antennas have a capability to radiate other patterns on different frequencies and polarizations are necessary in the modern communication systems. For instance, the UWB technique. These necessities used to improve the performance (e.g., beam steering, control, radar, direction finding and command) within a minimum volume place as possible. Reconfigurable antennas work as a solution to these difficulties. The reconfigurable antenna techniques have been successfully verified as reported in [8-11].

The proposed reconfigurable antenna was printed on a substrate with relative dielectric constant (ε_r=3.4), and thickness of 3 mm. as shown in Figure 1. A microstrip line feeds the designed antenna. The ground plane is printed on the lower side of the substrate. Modeling and performance estimation of the designed antenna was done by using the electromagnetic simulator Computer Simulation Technology (CST). A brief study is achieved to illustrate the effects of the some antenna parameters on the antenna performance in general. The efficiency of the antenna is principally affected by electrical and geometrical parameters, such as the length and width of the branches of the E-shape configuration, feed gap as well as the length of the ground plane. Simulation results show that the designed reconfigurable antenna possesses the UWB bandwidth, for $|S_{11}| \leq$ -10 dB, extending from approximately 3 GHz to more than 16 GHz, which covers the entire UWB band of 3.1 GHz to 10.6 GHz.

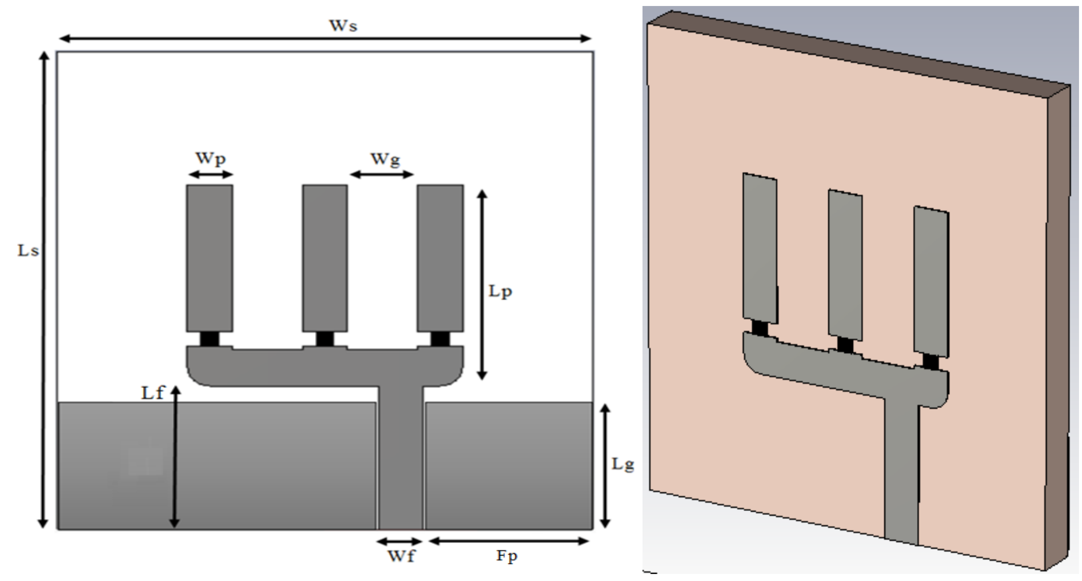


Figure 1: E-Shape frequency and radiation Reconfigurable antenna.

While the current distribution on the radiating element of the E-Shape reconfigurable antenna was shown in Figure 2. Which is clear to notice the significant effectiveness of the switches on the reconfigurability behavior of the proposed antenna.

2. Antenna Design

The geometry of the proposed E-shaped reconfigurable antenna structure is shown in Figure 1. The radiating element of the E-shaped has been printed on the upper side of a substrate FR-4, while a finite size ground plane is in the lower side. A microstrip line printed on the radiator side of the substrate feeds the reconfigurable antenna. The E-shaped structure is printed on a substrate with relative dielectric constant of 4.3, and thickness of 3 mm. A preliminary design has been achieved to perform the ultrawideband bandwidth requirements. The resulting antenna configuration has the parameters in table 1.

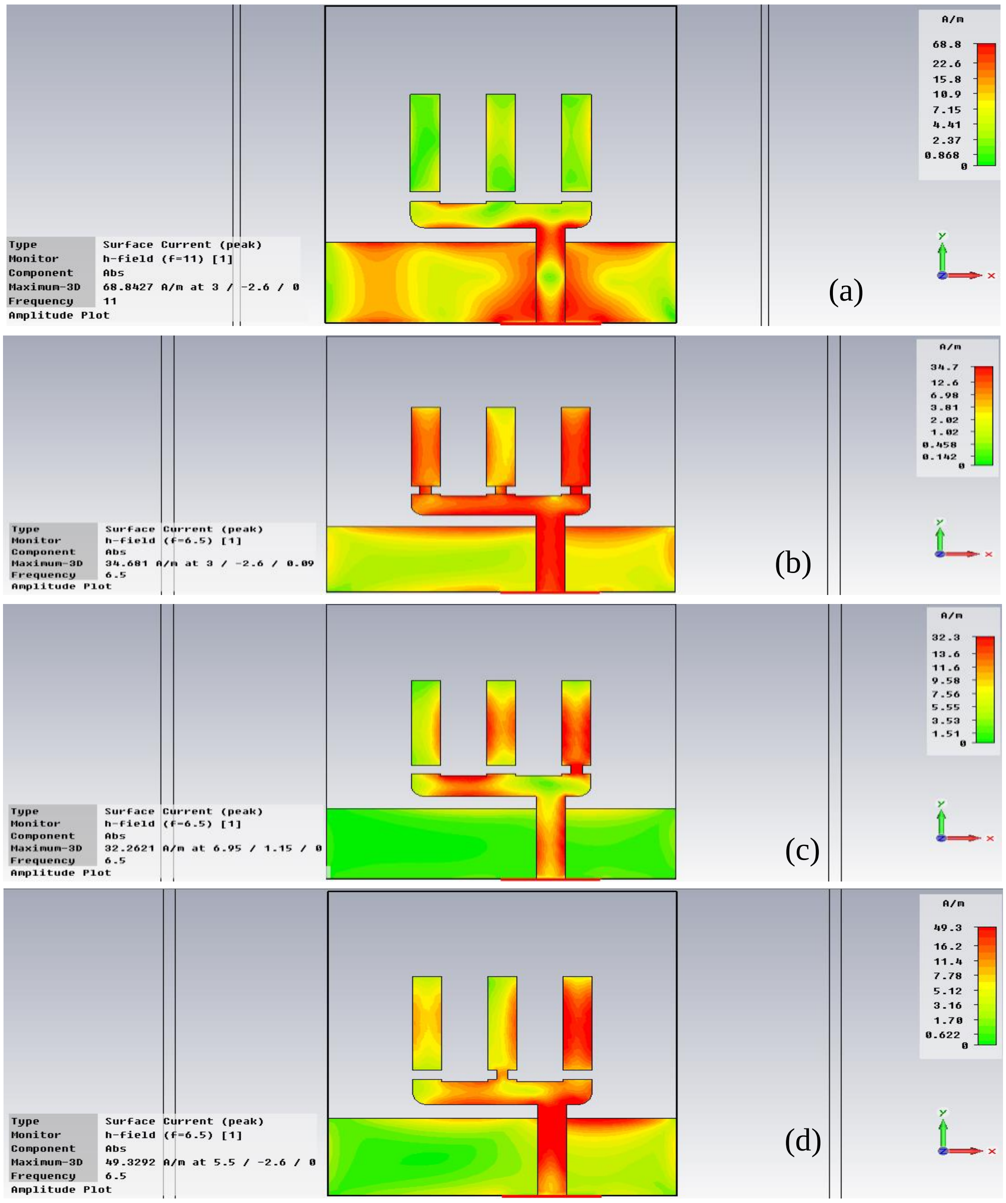


Figure 2: The surface current distribution in the E-Shape reconfigurable antenna.

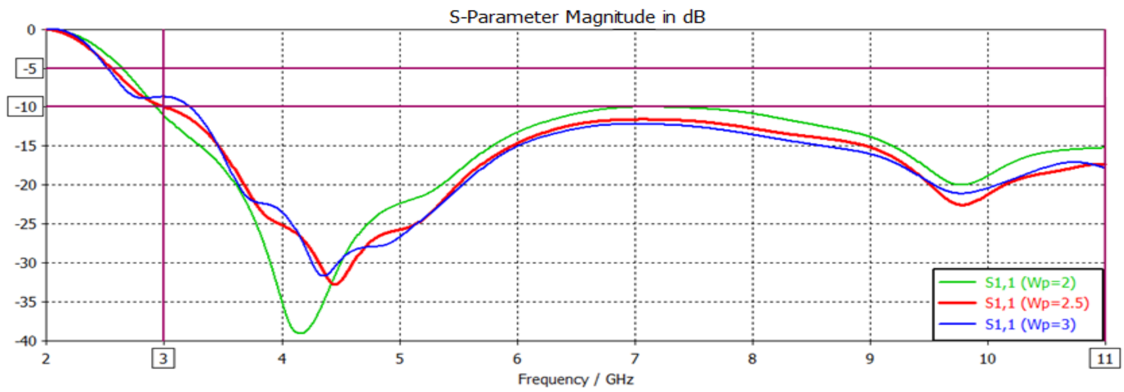
Table 1: Parameter list of the E-Shaped reconfigurable antenna.

Parameters	Ws	Ls	h	Lg	Lf	Wf	Lp	Wp	Wg	Fp
Values / mm	30	33	3	8.4	9.9	2.5	13.9	2.5	3.95	9.5

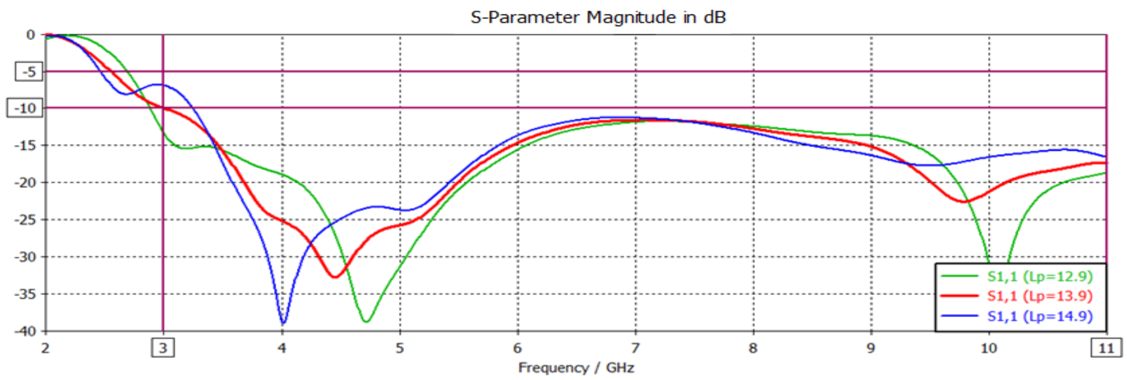
This reconfigurable antenna has been designed by using the EM simulator CST.

All of the geometrical parameters in the previous table have an effect on the efficiency of the presented antenna; however, some of these parameters may have more considerable effects than others. Especially, the size of the E-Shape (Wp×Lp), the height of the substrate (h), the length of the ground plane (Lg) and the distance of the microstrip line feed form the center point (Fp). To study these parameters, several antenna designs for the same microstrip antenna with many values for (Wp, Lp, Lg and Fp) parameters was considered.

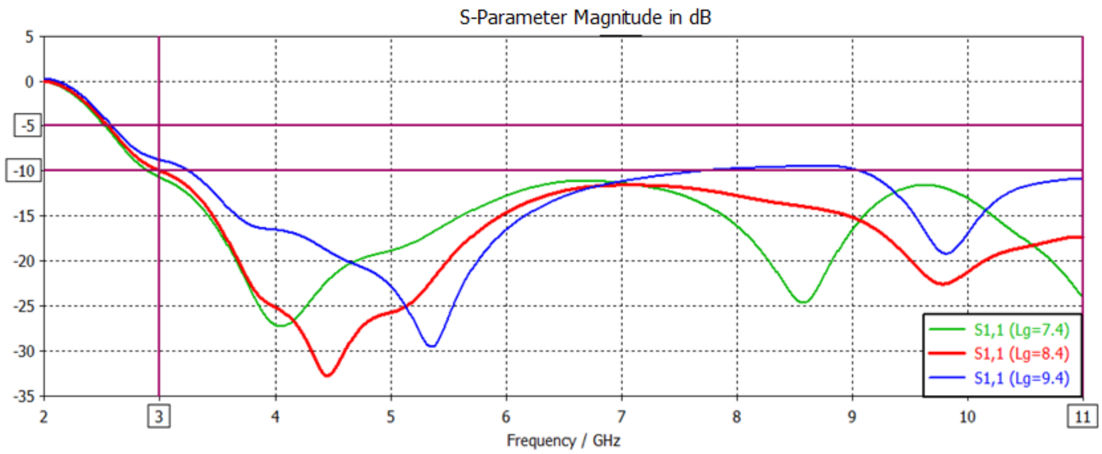
Figure 3 (a) shows the effect of (Wp). The suitable value for this parameter will be ($Wp = 2.5$) to cover the entire band. In Figure 3 (b) different values to the (Lp) was taken, as shown below the more appropriate value to this parameter will be ($Lp = 13.9$). On the other hand, the parameters (Lg) have a considerable effect on the band characteristics. As shown in Figure 3 (c) the proposed reconfigurable antenna design with a different values to the (Lg) parameter will be taken, and the value of ($Lg = 8.4$) was the better result to the UWB frequencies. Besides, Figure 3 (d) shows another effects due to the values of the (Fp), it is clear to notice that the ($Fp = 9.5$) was the most important value to the band quality.



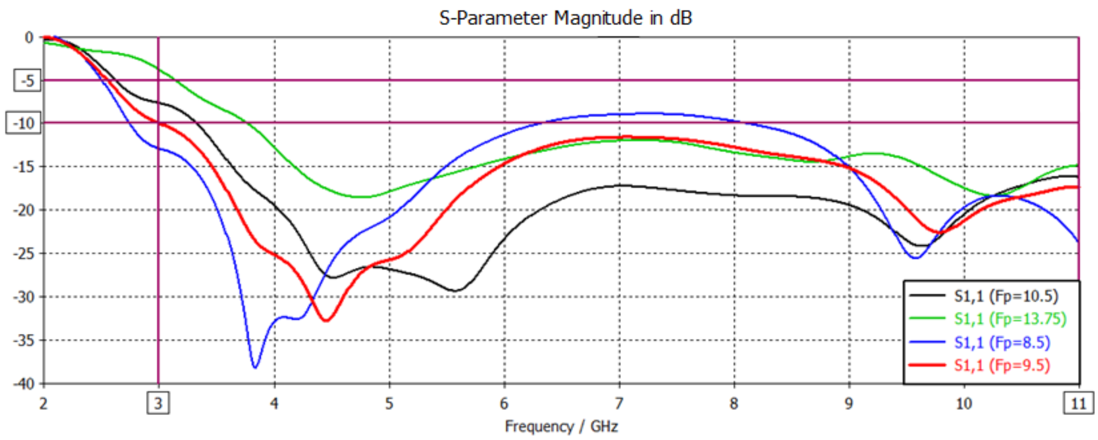
(a) Wp



(b) Lp



(c) Lg



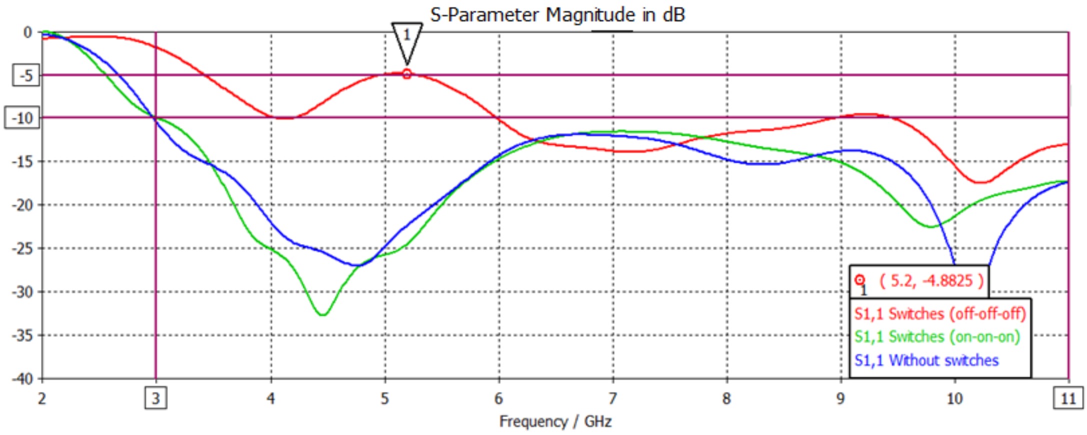
(d) Fp

Figure 3: Simulated $|S_{11}|$ with a various values to size of the E-Shape (Wp×Lp), the length of the ground plane (Lg) and the distance of feed line form the center point (Fp) parameters for the designed reconfigurable antenna. (a) Wp. (b) Lp. (c) Lg. (d) Fp.

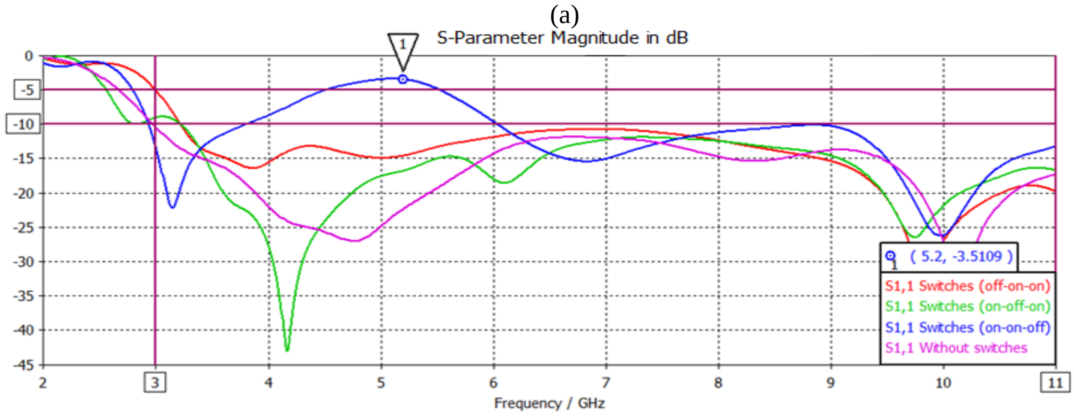
From the previous Figures of the simulated $|S_{11}|$ with a different values for the given parameters, which has an important effect on the band properties, actually it is very clear to conclude that, the parameter above have the major effect.

3. Simulation Results

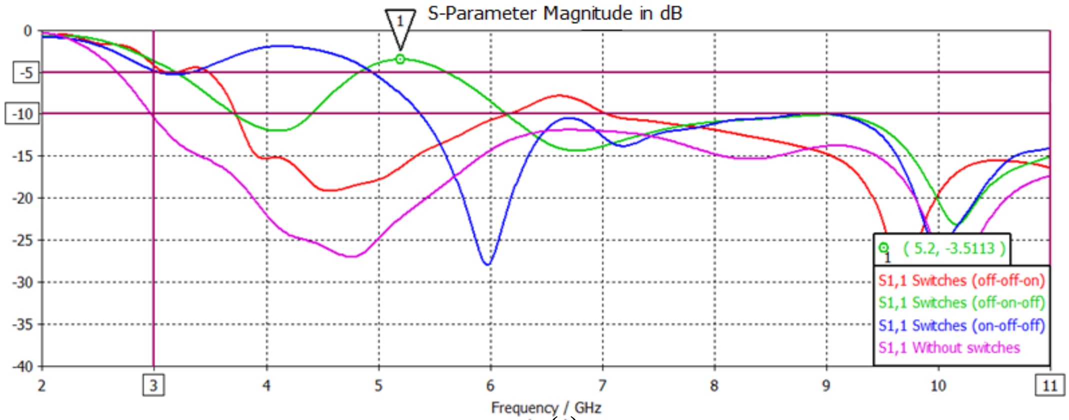
Simulated results that achieved for this presented antenna shows an excellent radiation performance within the ultra wide band (UWB) frequency range. Also it has a reconfigurable frequency band-notched in 5.2 GHz that can eliminate the interference between UWB frequency band and other existing wireless communication systems.



(a)



(b)



(c)

Figure 4: Simulated $|S_{11}|$ with varying switching states for the E-Shape reconfigurable antenna.

Figure 5 indicates the reconfigurability performance in the field pattern. While Figure 4 shows the simulated $|S_{11}|$ with various Switching States.

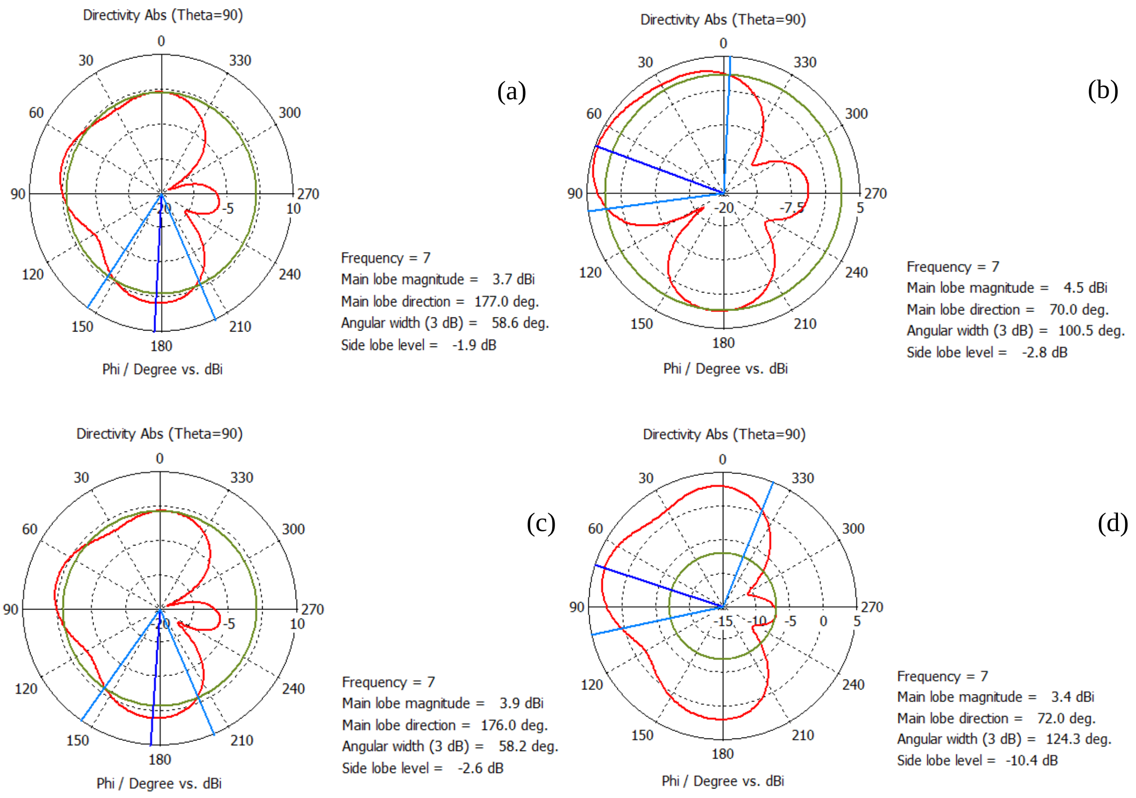
The bandwidth of the designed antenna for $|S_{11}| \leq$ -10 dB spans 3-11 GHz with notched band ($|S_{11}| >$ -10 dB) in 5.2 GHz. Basically, the impedance bandwidth of the antenna satisfies the UWB system requirement while reducing the interference of the 5.2 and 5.8 GHz WLAN system.

When the switches in the E-shaped slot are on, the ultra-wideband characteristic is obtained without the band-notched performance. Figure 3 shows the simulated $|S_{11}|$ with various Switching States. On the other hand, by turning off the PIN diode in the first of the three E-shape arms, band-notch function occurs. The overall results of this proposed reconfigurable antenna can be summarized on the following table:

Table 2: The E-Shape Reconfigurable antenna results.

	Switch States	Operating Frequency	Gain	Directivity	Main lobe Direction	Null Direction	Angular width
1	on-on-on	3-11 GHz	3.991 dB	4.505 dBi	70°	125°	100.5°
2	off-off-off	5.95-11 GHz with 5.2 Notch	2.838 dB	3.718 dBi	177°	295°	58.6°
			One switch on				
1	off-off-on	3.7-6.25 & 7-11 GHz	4.192 dB	4.9 dBi	71°	260°-320°	60.8°
2	off-on-off	3.7-4.4 & 6.15-11 GHz with 5.2 GHz Notch	2.821 dB	3.428 dBi	71°	300°	125.2°
3	on-off-off	5.35-11 GHz	3.135 dB	3.934 dBi	176°	235°-295°	58.2°
			Two switches on				
4	on-on-off	2.95-3.85 & 6-11 GHz with 5.2 GHz Notch	3.116 dB	3.741 dBi	6°	235°-295°	126.5°
5	on-off-on	3.2-11GHz	3.901 dB	4.419 dBi	70°	130° - 315°	110.2°
6	off-on-on	3.2-11 GHz	4.417 dB	4.915 dBi	67°	315°	85.9°

The simulated radiation patterns for the x-y plane of the proposed antenna are shown in Figure 5. These Figures demonstrate the simulated results are essentially in agreement with experimental results.



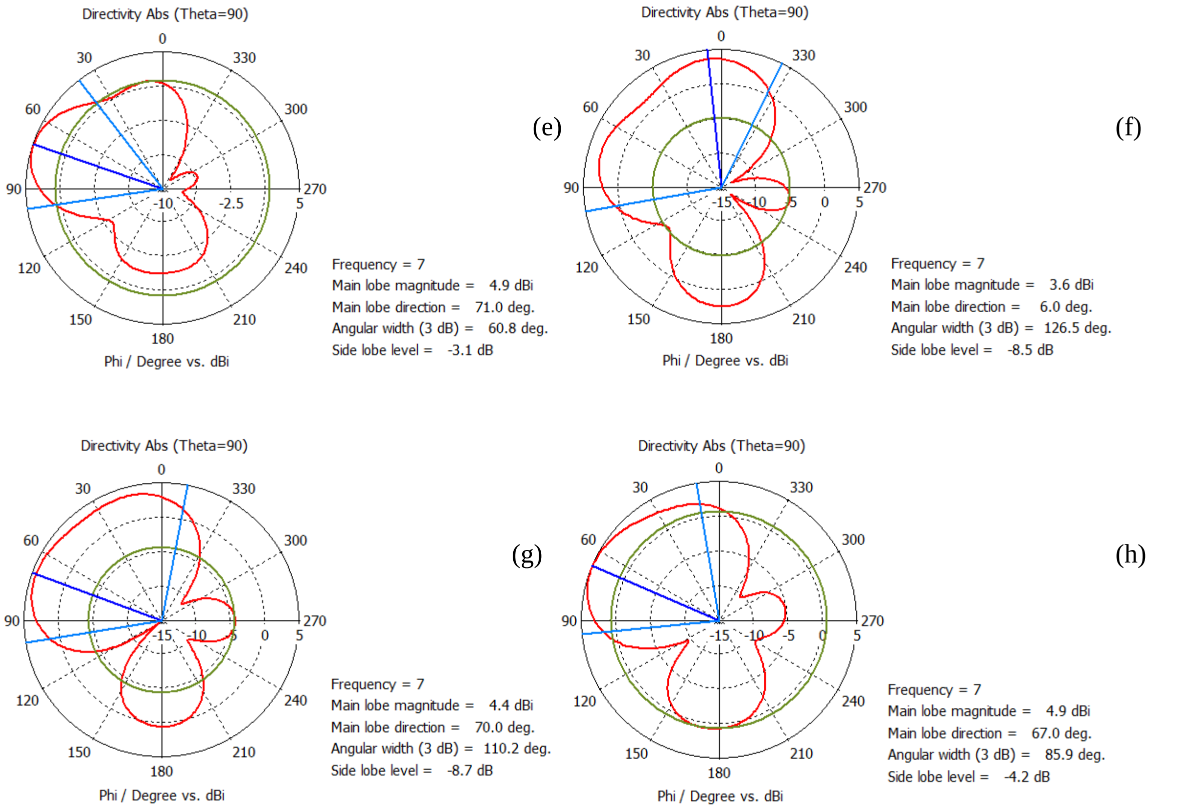


Figure 4: Simulated Radiation patterns with varying switching states for the proposed reconfigurable antenna. (a) off-off-off. (b) on-on-on. (c) on-off-off. (d) off-on-off. (e) off-off-on. (f) on-on-off. (g) on-off-on. (h) off-on-on.

4. Conclusions

A frequency and radiation pattern E-shaped printed reconfigurable antenna is presented in this paper; this reconfigurable antenna is suitable for use with ultrawideband applications. The antenna configuration has been designed and its efficiency has been estimated by using the electromagnetic simulator Computer Simulation Technology (CST). The presented antenna has a suitable size (30 × 33 mm) and bandwidth (3-16 GHz) for the ultrawideband applications. This Effectiveness used to make the designed reconfigurable antenna more appropriate with the UWB applications.

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