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PARAMETRIC STUDY OF BROADBAND INVERTED SUSPENDED LINEAR POLARIZED ANTENNA

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ABSTRACT

In this paper, the parametric study of a broadband inverted suspended rectangular patch with rectangular slot which performed as linear polarized antenna is presented. The operating frequency for the proposed antenna is at 2.4GHz, which is for Wireless Local Area Network (WLAN) application. The performances for the proposed linear polarized antenna are investigated with the variation of different design parameters, which included the width of rectangular slot, *X*, length of rectangular slot, *Y*, separation of strip line from rectangular slot, *A*, and thickness of air gap, *Gap*. This antenna is designed by using method of inverted suspended, where the copper ground plane and the inverted rectangular patch is separated with air gap. This technique is used to enhance to bandwidth and gain of the proposed antenna. The simulation is done using Computer Simulation Technology (CST) software. The performance of linear polarization antenna can be verified based on the axial ratio result, where the axial ratio for linear polarized antenna is above 3dB.

Keywords: antenna, broadband, linear, gain, broadband, linear.

INTRODUCTION

In practical wireless communication system, broadband antenna has received much attention because narrow bandwidth will bring limitation to the modern technology. Microstrip patch antenna with attractive features of low cost, ease of fabrication, light weight and low profile also faced some limitations, which included narrow bandwidth and low gain (Balanis 2005), (Wong 2002). Fortunately, there are numerous techniques can be used to overcome the limitations to improve the performance of the antenna. In order to enhance the bandwidth of the antenna, the methods that proposed are increase the thickness of the substrate, stacked patch, embedded slot, air gap layer, multilayer configuration and others (Roy *et. al.* 2013), (Aktar *et. al.* 2011), (Kumar and Ray 2002), (Wang and Lee 2004), (Wong and Hsu 2001). Besides, shorting pin method also has been proposed to improve the bandwidth of the antenna where the shorting pin presented as a reactive element to affects the frequency variation of the input impedance (Wong, 2002), (Roy *et. al.* 2013). Then, suspended microstrip antenna can be used to enhance the bandwidth and gain at the same time. In this paper, the method of inverted suspended is applied where the FR4 substrate as the top dielectric substrate is performed as protective layer, meanwhile the thick air gap is between the patch and the copper ground plane (Balanis 2005), (Kumar and Ray 2002). This also means that the rectangular patch with rectangular slot is on the air gap layer.

ANTENNA DESIGN

The configuration of broadband inverted suspended rectangular patch is illustrated in Figure-1. The inverted patch is printed on the FR4 substrate of thickness, h = 1.6mm. The dielectric constant of the substrate, ε_r is 4.4 and the tangent loss of the FR4 substrate, $\tan\delta$ is 0.019. The strip line is printed on opposite side of the FR4 substrate and is connected with coaxial probe, which will perform as inverted L-probe feed.

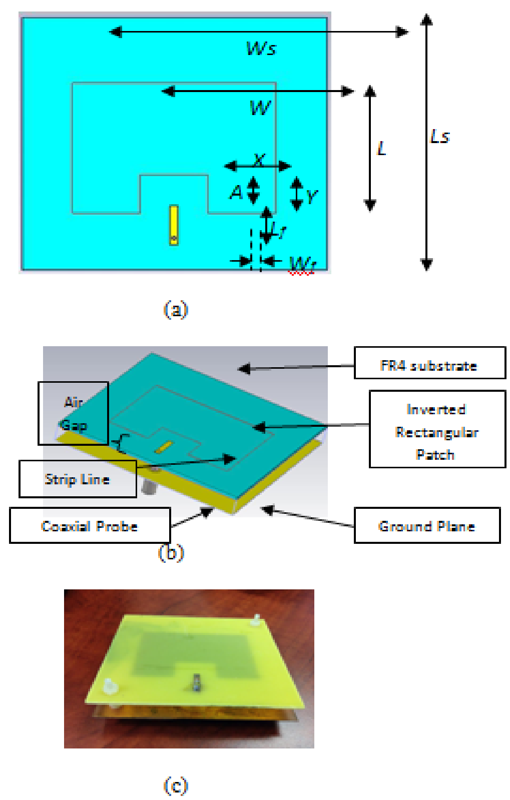

Figure-1. Configuration of broadband inverted suspended linear polarized antenna. (a) Front view. (b) Perspective view. (c) Prototype.

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The width and length of the inverted suspended rectangular patch is represented as *W* and *L*. The width and length of the FR4 substrate is represented as *Ws* and *Ls* respectively. The dimension of the copper ground plane is similar with the dimension of the FR4 substrate. The inverted rectangular patch is separated with the copper ground plane with air gap, where the thickness of the air gap is represented as *Gap*. Rectangular slot is embedded on the middle bottom of rectangular patch where the width and length of the rectangular slot is represented as *X* and *Y*. The dimension of the rectangular slot is varied in order to obtain optimum result. The separation of the strip line from the rectangular slot which represented as *A* is determined based on the parametric study. The width and length of the strip line is represented as W_f and L_f. The variation of the design parameters will bring effects on the performance of linear polarized antenna. The optimum dimension of the proposed antenna is tabulated in Table-1.

Table-1. Dimension of broadband inverted suspended linear polarized antenna.

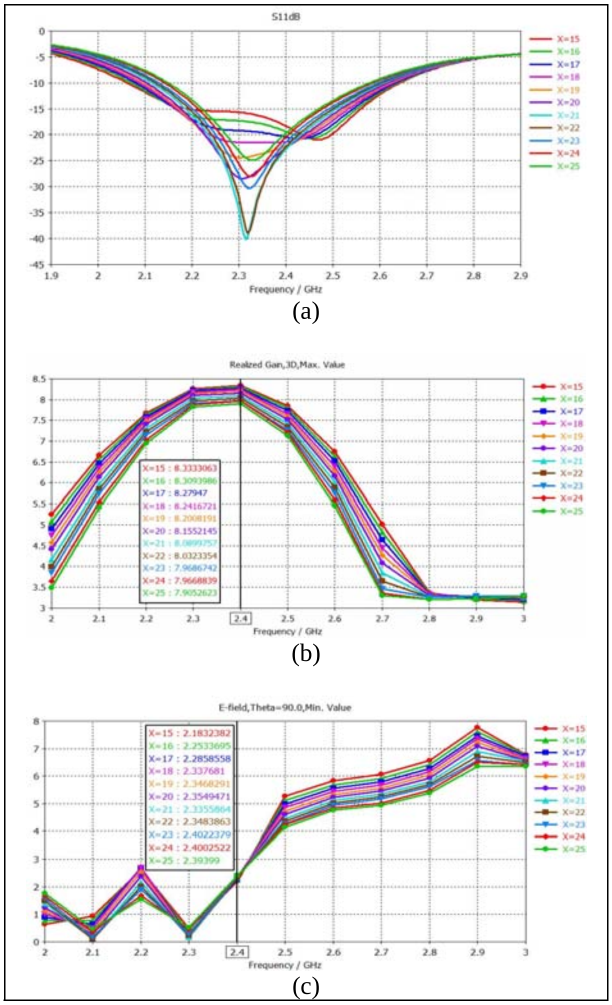
Description	Design parameter	Value (mm)
Width of substrate	*Ws*	90
Width of inverted patch	*W*	58
Width of rectangular slot	*X*	18
Width of strip line	W_f	2.5
Length of substrate	*Ls*	80
Length of inverted patch	*L*	43
Length of rectangular slot	*Y*	12
Length of strip line	L_f	14
Separation of strip line from rectangular slot	*A*	10
Thickness of air gap	*Gap*	10
Thickness of copper	*t*	0.035

PARAMETRIC STUDY

This paper is presented the parametric study of the design of broadband inverted suspended rectangular linear polarized antenna. The parametric study is carried out to study the effect of the variation of width of rectangular slot, *X*, length of rectangular slot, *Y*, separation of strip line from rectangular slot, *A* and thickness of air gap, *Gap*. The performance of the antenna is determined based on the resonant frequency (*fr*), return loss (*RL*), bandwidth (*BW*), gain (*G*) and axial ratio (*AR*).

Variation of width of rectangular slot, *X*

Parametric study has been done for the width of rectangular slot, *X* which is embedded on the inverted rectangular patch. As illustrated in Figure-2, the width of the rectangular slot, *X* has significant effect on the S-parameter and gain. However, the axial ratio of the antenna is not affected by the variation of *X*. The resonant frequency is shifted to lower frequency when the dimension of *X* varied from 15mm to 21mm. However, the resonant frequency is increased when the width of rectangular slot, *X* varied from 22mm to 25mm. Then, the gain of the antenna is reduced as the width of the rectangular slot increased.



(a)

(b)

(c)

Figure-2. Parametric study of width of rectangular slot, X. (a) S-parameter. (b) Gain. (c) Axial ratio.

Variation of length of rectangular slot, *Y*

The parametric study on the length of rectangular slot, *Y* is demonstrated in Figure-3. The return loss of the antenna is improved as the length of the rectangular slot, *Y* is reduced. At the same time, the resonant frequency of the proposed antenna is shifted to lower frequencies as the dimension of *Y* is reduced from 16mm to 10mm. The bandwidth of the antenna is not affected by the variation of the length of rectangular slot, *Y*. Besides, the variation of the dimension of *Y* also did not bring significant effect on the gain of the antenna as illustrated in Figure 3(b).

The axial ratio of the antenna is affected as the dimension of *Y* is varied which as shown in Figure 3(c). When the length of rectangular slot is varied from 10mm to 12mm, the axial ratio of the antenna is increased. However, the axial ratio of the proposed antenna is reduced when the length of the rectangular slot, *Y* is varied from 13mm to 16mm.

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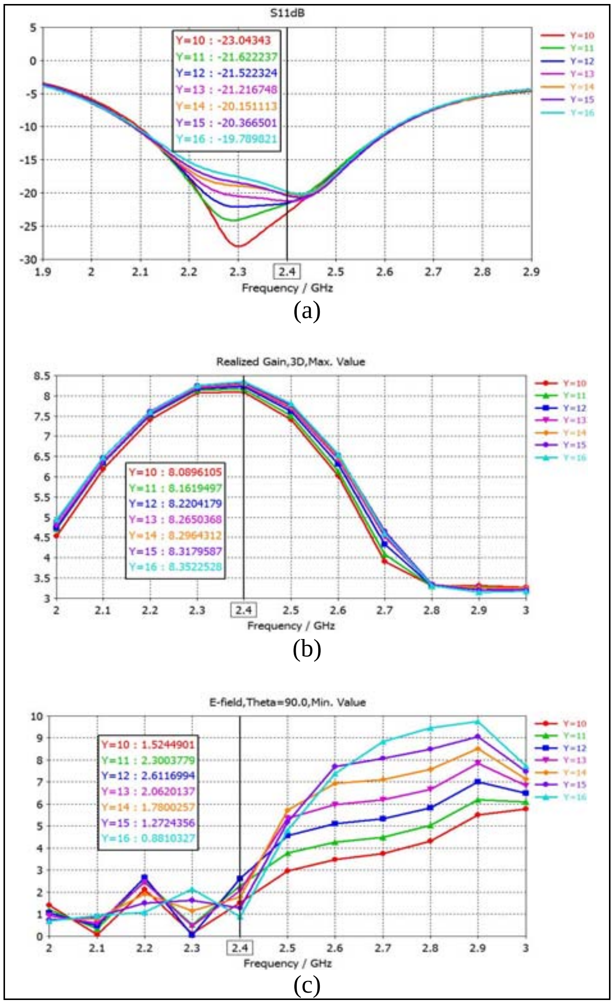

Figure-3. Parametric study of length of rectangular slot, Y. (a) S-parameter. (b) Gain. (c) Axial ratio.

Variation of separation of strip line from rectangular slot, *A*

The strip line is printed on the opposite side of the inverted rectangular patch. The strip line is connected with coaxial probe to perform as inverted L-probe feed. The strip line is separated with the rectangular slot, where the separation of the strip line from the rectangular slot is represented as *A*. Based on Figure-4(a), the return loss for the proposed antenna is unstable for the variation of separation of strip line from the rectangular slot, *A*. However, the proposed antenna is covered the operating frequency at 2.4GHz for the variation of *A* from 2mm to 10mm. At the same time, the bandwidth of the proposed antenna is improved as the separation of the strip line from rectangular slot, A is increased.

Furthermore, the variation of separation of strip line from rectangular slot, *A* did not bring significant effects to the gain of the antenna. As illustrated in Figure 4(b), the gain of the antenna is remained above 8dB with the variation of *A*. Based in Figure-4(c), the axial ratio of the antenna is reduced when the separation between strip line and rectangular slot varied from 2mm to 4mm. Then, the axial ratio of the proposed antenna is increased when the separation of strip line from rectangular slot, *A* is changed from 5mm to 10mm. Generally, the performance of the proposed broadband linear polarized antenna is optimized when the dimension of *A* at 10mm.

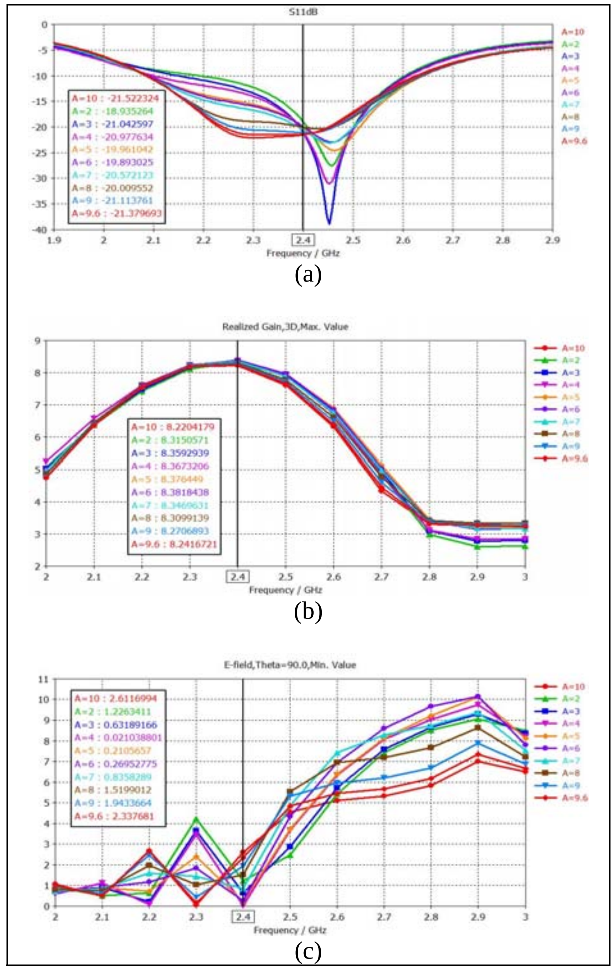

Figure-4. Parametric study of separation of strip line from rectangular slot, *A*. (a) S-parameter. (b) Gain. (c) Axial ratio.

Variation of thickness of air gap, *Gap*

The parametric study of the thickness of air gap between the inverted rectangular patch and the copper ground plane, *Gap* is illustrated in Figure-5. Based on Figure-5(a), the bandwidth and return loss of the proposed antenna is improved as the thickness of air gap, *Gap* is increased. When the thickness of air gap, *Gap* varies to above 7mm, the bandwidth of the proposed antenna has achieved more than 200MHz and met broadband application. At the same time, the resonant frequency of the antenna is reduced as the thickness of air gap, Gap is increased.

As illustrated in Figure-5(b), the gain of the proposed antenna is improved when the thickness of air gap, *Gap* increased. The gain of the antenna is negative when the thickness of air gap below 4mm. However, the gain of the antenna show good response when the thickness of air gap varied to above 4mm. Based on Figure-5(c), the axial ratio of the proposed antenna is above 3dB when the thickness of air gap at 1mm, 2mm, 10mm and 11mm.Then, the axial ratio of the proposed antenna is below 3dB when the thickness of air gap is varied from 3mm to 9mm. The proposed antenna will be indicated as linear polarized antenna as the axial ratio is above 3dB. If the axial ratio is below 3db, the antenna will be indicated as circular polarized antenna. Hence, the proposed antenna gave optimized results as the thickness of air gap, Gap at 10mm.

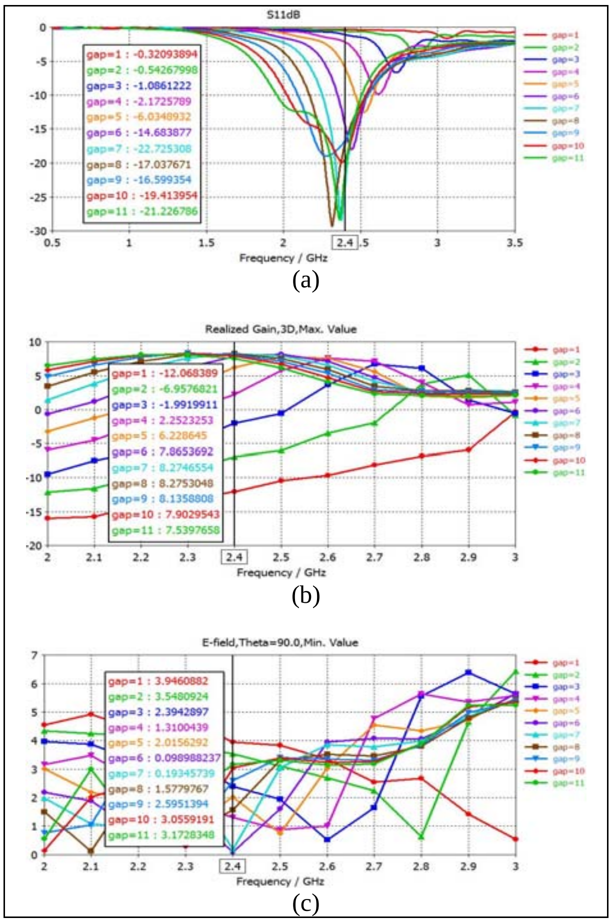

Figure-5. Parametric study of thickness of air gap, *Gap*. (a) S-parameter. (b) Gain. (c) Axial ratio.

CONCLUSIONS

In this paper, the parametric study for the broadband inverted suspended linear polarized antenna is discussed. There are several parametric studies are carried out on different design parameters, which included the width of the rectangular slot, *X*, the length of the rectangular slot, *Y*, the separation of the strip line from the rectangular slot, *A* and the thickness of air gap, *Gap*. This method is verified to enhance the bandwidth and gain of the linear polarized antenna. The bandwidth of the proposed antenna is more than 200MHz and meet broadband applications. Generally, the bandwidth and gain of the proposed antenna are enhanced with the variation of the width of the rectangular slot, *X* and the thickness of air gap, *Gap*. The optimized result of the proposed broadband inverted suspended linear polarized antenna is presented in paper (Phoo *et. al*. 2014).

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