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TRIPLE BAND FREQUENCY USING SLIT TECHNIQUE RECTANGULAR MICROSTRIP ANTENNA FOR WIMAX APPLICATION

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Abstract

In recent years, the telecommunications world has grown substantially. This causes the need for multifunction devices that can work in certain conditions. This paper presented research on microstrip antenna with 3 frequencies for WiMAX communication needs. In this paper, the patch used is rectangular shape that will be given some slit to generate a double frequency. Microstrip antenna is designed to work at frequencies 2300, 3300 and 5800 MHz in accordance with the frequency for Wimax applications. From the simulation results obtained value of -12.07 dB return loss and VSWR 1.664 at the first frequency 2300 MHz, *then the* obtained value of -18.51 dB return loss and VSWR 1.273 at the second frequency 3300 MHz, and the last obtained value of return loss -28, 04 dB and VSWR 1.083 at a frequency of 5800 MHz. Gain on microstrip antenna is 5.78 dB or 7.93 dBi, the antenna radiation pattern is a linear fit with a rectangular shape. From these results it can be concluded that the design of microstrip antennas can work well at three different frequencies of 2300, 3300 and 5800 MHz.

Keywords: *microstrip, triple frequency, feed line*

Abstrak

Dalam beberapa tahun terakhir, dunia telekomunikasi telah bertumbuh secara substansial. Hal ini menyebabkan kebutuhan akan perangkat multifungsi yang dapat bekerja dalam kondisi tertentu. Jurnal ini mempresentasikan penelitian pada antenna microstrip *dengan 3 frekuensi untuk kebutuhan komunikasi WiMAX. Pada penelitian ini,* patch *yang digunakan berbentuk persegi panjang yang akan memberikan beberapa celah untuk menghasilkan frekuensi ganda*. Antenna microstrip *dirancang untuk bekerja pada frekuensi 2300, 3300, dan 5800 MHz sesuai dengan frekuensi untuk aplikasi WiMAX. Dari hasil simulasi, diperoleh nilai* return loss *-12,07 dB dan VSWR 1,644 pada frekuensi pertama sebesar 2300 MHz, kemudian diperoleh nilai* return loss *-18,51 dB dan VSWR 1,273 pada frekuensi kedua sebesar 3300 MHz, dan terakhir diperoleh* return loss *-28,04 dB dan VSWR 1,083 pada frekuensi 5800 Mhz. Perolehan pada* microstrip antenna *adalah 5,78 dB atau 7,93 dBi, pola radiasi antena adalah pola linear sesuai dengan bentuk persegi panjang. Dari hasil tersebut dapat disimpulkan bahwa desain dari antena* microstrip *dapat bekerja dengan baik di ketiga frekuensi yang berbeda yaitu 2300, 3300, dan 5800 MHz.*

Kata Kunci: microstrip, triple frequency, feed line

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1. INTRODUCTION

Patch antenna possesses many advantages such as low profile, light weight, small volume and compatability with microwave integrated circuit (MIC) and monolithic microwave integrated circuit (MMIC). However, the narrow bandwidth is the major obstacle in wide applications for the microstrip antenna. In general, the impedance bandwidth of the traditional microstrip antenna is only a few percent (2% - 5%) [1]. Therefore, it becomes very important to develop broadband technique to increase the bandwidth of the microstrip antenna.

Microstrip patch antenna consists of a dielectric substrate, with a ground plane on the other side. Due to its advantages such as low weight, low profile planar configuration, low fabrication costs and capability to integrate with microwave integrated circuits technology, the microstrip patch antenna is very well suited for applications such as wireless communications system, cellular phones, pagers, radar systems, and satellite communications systems [1],[2].

In some applications in which the antenna must work in a different operating frequency, triple frequency patch antenna is one of the alternative solutions [3]. When modern communication system, such as satellite, radar and wimax requires operation at three frequencies, triple frequency patch antennas may avoid the use of three different antennas. Recently, the most popular technique for obtaining triple frequency is by introducing a reactive loading to a single patch [4],[5],[6]. The broadband characteristic of a microstrip patch antenna with a U-shaped slot has been confirmed by many published results and several design of broadband slots antenna has been reported [7]. A multi U-slot Patch antenna has been reported recently for 5 GHz WLAN [8], and also a monopole antenna for WiMAX applications was proposed in [9]. In this paper we use slit loading to generate triple frequency in the microstrip antenna.

2. ANTENNA DESIGN

The geometry of a single patch antenna using two slots with different height for dual frequency operation feed by microstrip feed line can be shown in Figure 1a and 1b. The patch antenna is constructed on two layers with the same dielectric substrate. On the first layer, the patch antenna is realized on FR 4 substrate and having a relative permittivity (**ε_r**) = 4.3, substrate of thickness (**h**) = 1.6 mm and loss tangent (**tanδ**) = 0.0265 and the microstrip feed line is realized on the second layer.

Figure 1a, **W and L** is the dimension of the length and width of the rectangular patch antenna and given by:

$$W = \frac{c}{2f_r\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$L_{eff} = \frac{c}{2f_{10}\sqrt{\varepsilon_e}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} + \left(\frac{1}{\sqrt{1+12\,h/W}}\right) \quad \ldots\ldots\ldots\ldots (3)$$

Y1 is s the distance between the feed line and the first slit, **Y2** is the distance between the first slit with second slit, **Y3** is the distance between the second slit with third slit, and Y4 is the distance between the last slit with the edge of the antenna. Besides, **X1** and **A1** are the length and the width of the first slot, **X2** and **A2** are the length and the width of the second slot, **X3** and **A3** are the length and the width of the third slot. Table 1a shows the parameters of a single patch antenna.

Figure 1b, **L1** and **Z1** are the length and the width of the feeding system. **L2** is the distance from the left side of the rectangular patch antenna to microstrip feed line and L3 is the distance between the bottom patch antenna to feed line. Table 1b shows the parameters of the microstrip feed line.

Table 1a. Parameters of microstrip patch

Parameter	W	L	A1 A2 A3	X1	X2	X3	Y1	Y2 Y3	Y4
Length (mm)	40	30.1	1	11	7.4	4.5	2.8	5	3

Table 1b Parameters of microstrip feed line

Parameter	Z1	L1	L2	L3
Length (mm)	3.1	30	19.1	2

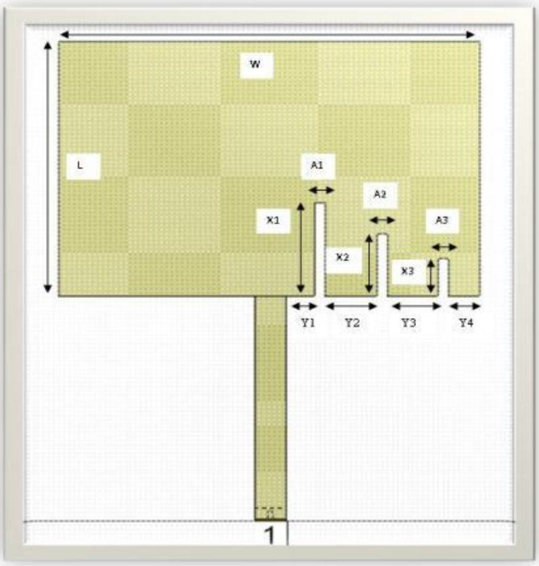

Figure 1a. Geometry of a single patch antenna

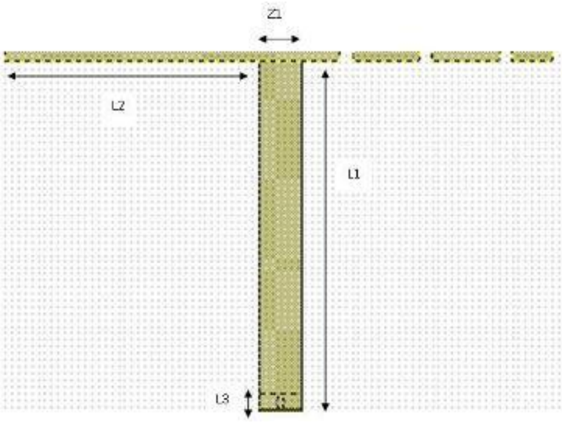

Figure 1b. Geometry of a feed line

To calculate the width of the microstrip feed line 50 Ohm is given by :

$$B = \frac{60\pi^2}{Z0\sqrt{\varepsilon_r}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots...(6)$$

$$W= \frac{2h}{\pi}\left\{B-1-\ln\,(2B-1)+\frac{\varepsilon_r-1}{2\varepsilon_r}\left[\ln\,(B-1)+0.39-\frac{0.61}{\varepsilon_r}\right]\right\}\ldots\ldots\ldots..\ (7)$$

From (6) and (7), the width of the transmission feed line for the proposed antenna is as 3.1 mm respectively for 50 Ohm. In figure 2 microstrip antenna design can be viewed in 3-dimensional.

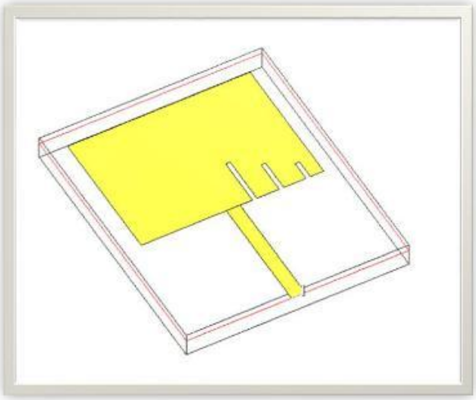

Figure 2. Patch microstrip antenna in 3-dimensional

3. EXPERIMENTAL RESULTS

The results of the proposed antenna's first condition is as follows: return loss of -10.82 dB with VSWR 1.808 at frequency 2.3 GHz and return loss of -15.16 dB with VSWR 1.423 at frequency 3.3. GHz. The results show that return loss and VSWR did not indicate the maximum value. To achieve the maximum results, the distance between the two patch adjusted and the length of the microstrip feed line 50 Ohm need to be controlled.

Table 2 shows the comparation results after controlling the length of the microstrip feed line 50 Ohm and Figure 4 shows the return loss value.

Table 2. Iteration of the length of the microstrip feed line

Length of the microstrip feed line 50 Ohm	**Frequency 2.3 GHz**		**Frequency 3.3 GHz**		**Frequency 5.8 GHZ)**	
	Return Loss	**VSWR**	**Return Loss**	**VSWR**	**Return Loss**	**VSWR**
22 mm	-11.98 dB	1.711	-16.51dB	1.351	-21.39 dB	1.186
26 mm	-11.96 dB	1.671	-18.26 dB	1.280	-26.41 dB	1.101
30 mm	-12.03 dB	1.666	-20.07 dB	1.224	-30.38 dB	1.062

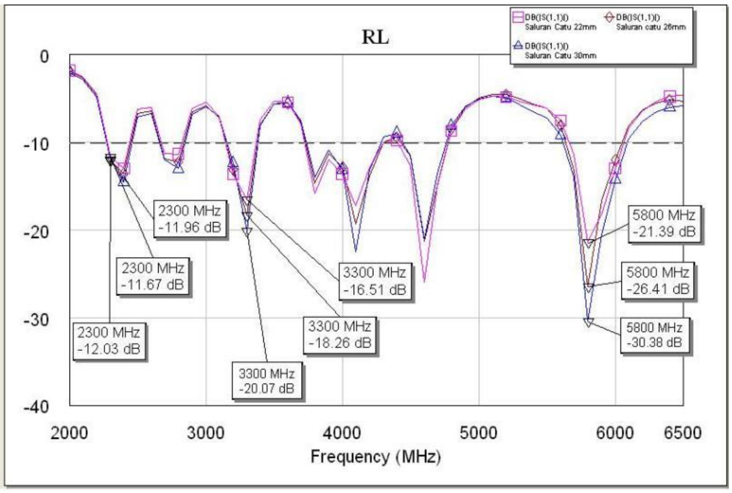

Figure 4a. Return loss after adjusting the length of the microstrip feed line

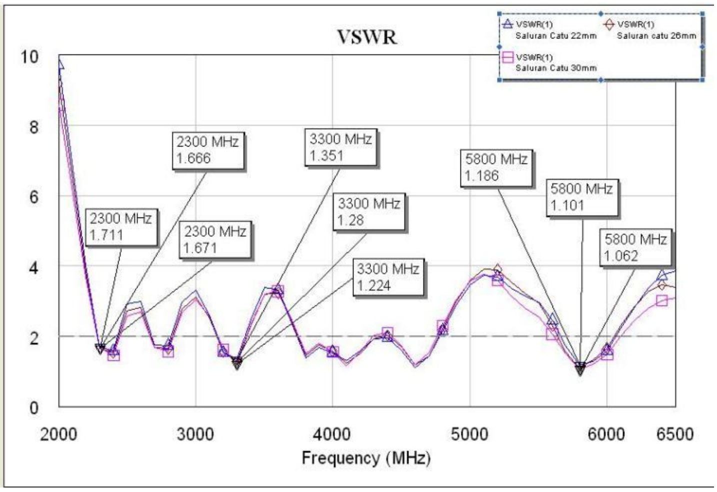

Figure 4b. VSWR after adjusting the length of the microstrip feed line

From the picture above we can see that the length of the feed line is very influential on the antenna return loss and VSWR. The longer the feed line, the better the value of Return Loss and VSWR of the antenna. If we extend the feed line then we will obtain the value of Return Loss and VSWR of better. The simulation results in the figure above shows that microstrip antennas can work well on the three frequencies of 2300 MHz, 3300 MHz and 5800 MHz.

From the simulation results can be seen that the best parameter values contained in the position of the feed line length of 30 mm, then the length of the feed line that we use is 30 mm.

The radiation pattern of the proposed antenna is seen in Figure 5. It is observed that the radiation pattern is broadside. The resulting bandwidth is good enough in the design of antennas at each operating frequency. In Table 3 we can see the antenna bandwidth specification work on three frequencies. Graph bandwidth simulation can be seen in Figure 5.

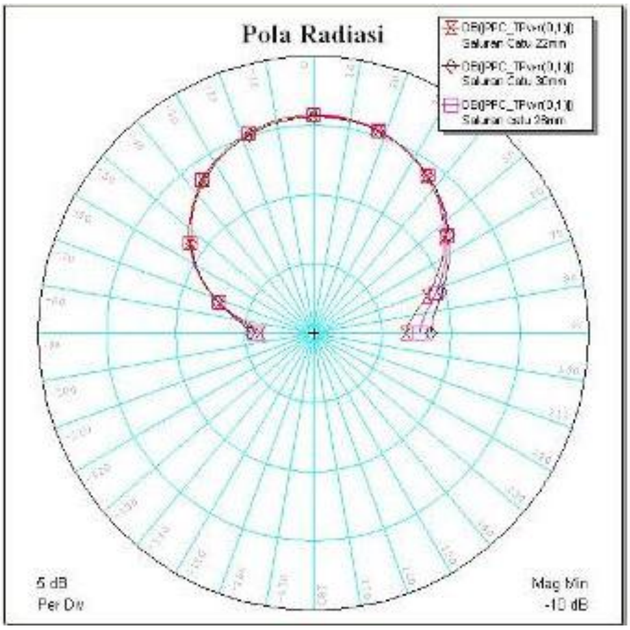

Figure 5. Radiation pattern of the proposed antenna

Table 3. Iteration of the length of the microstrip feed line

Parameter	Simulation Result		
Center Frequency	2.3 GHz	3.3 GHz	5.8 GHz
Return Loss	-12.03 dB	-20.07 dB	-30.38 dB
VSWR	1.666	1.224	1.062
Bandwidth	188 MHz	229 MHz	473 MHz

From Table 3 we can see changes in return loss and VSWR at each operating frequency. In the 2300 MHz frequency bandwidth generated is 188 MHz, 3300 MHz on the frequency increased to 229 MHz and at a frequency of 5800 rose again to 473 MHz

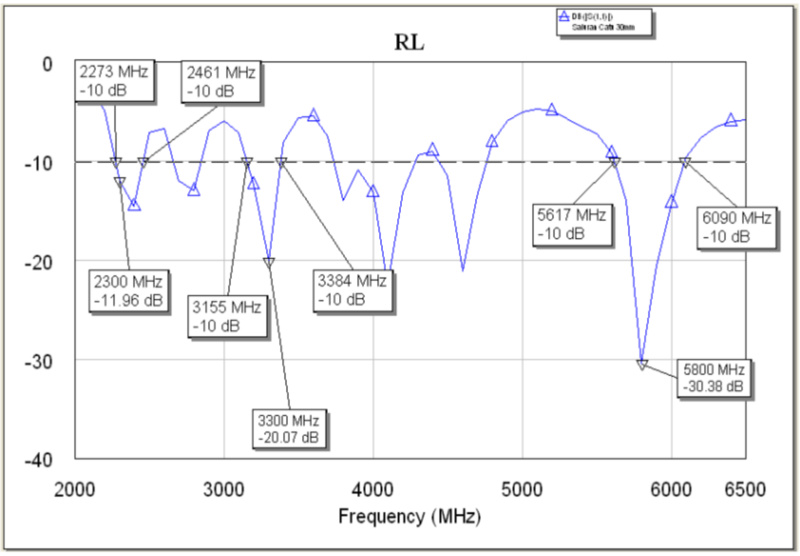

Figure 6. VSWR and return loss

From Figure 6 we can see changes in the value of VSWR and Return Loss are clear. These results were obtained by using the simulation software on the AWR Microwave Office.

4. CONCLUSION

A novel configuration to generating multiple frequency for WiMAX application has been experimentally studied. It is shown that the three frequencies can be easily controlled by providing three slit on the radiation element and varying the length of the microstrip feed line 50 Ohm . From these results, obtained value of Return Loss, VSWR and bandwidth are good for three working frequencies. In the 2300 MHz values obtained Return Loss -12.03 dB, VSWR 1.667 and 188 MHz bandwidth. In the 3300 MHz values obtained Return Loss -20.07 dB, VSWR 1.224 and 229 MHz bandwidth. In the 3300 MHz values obtained Return Loss -30.38 dB, VSWR 1.062 and 473 MHz bandwidth. Therefore the proposed antenna is applicable as a new candidate for dual frequency antenna to enlarge the bandwidth for WiMAX application.

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