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Switched Beam Triangular Microstrip Antenna Fed by Hybrid Coupler

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1. Introduction

Recently, switched beam antenna system has been widely used in numerous applications such as in communication system, satellite system and modern multifunction radar. This is because of the ability of the switched beam antenna to reduce the existing interference and to improve the quality of transmission [1][2][3]. A switched beam system consists of a beams witching network and antenna array. A simple design of beam switching uses a 3 dB hybrid coupler. The 3 dB hybrid coupler is a directional coupler with a 90° phase difference in the output of the through and coupled arms [4]. In general the quadrature hybrid is one of the most popular passive circuits used for microwave and millimeter wave applications [5]. It is an important circuit element in microwave integrated circuits and can be used as a power divider, combiner or a part of mixer.

A microstrip patch antenna allowing switching between LHCP and RHCP is proposed [6]. It consists of a square radiating patch and a 3 dB hybrid coupler using single-polar-double-throw (SPDT) switch. In the literature [7] proposed a dual fed circular polarized rectangular patch microstrip antenna using 3 dB hybrid coupler. Other technique is presented by [3], using rectangular patch antenna fed by 3 dB hybrid coupler non linier impedance at the series arm.

Therefore this paper proposed a simple configuration using triangular patch microstrip antenna fed by symmetrical 3 dB quadrature hybrid coupler. The triangular patch antenna is chosen because it has the advantage of occupying less metalized area on substrate than other existing configurations.

2. Antenna Design

The proposed antenna is realized on one layer substrate with a relative permittivity (ε_r) = 4.3, substrate of thickness (h) = 1.6 mm and loss tangent ($tan\delta$) = 0.09. The dimension of the side length of the triangular patch antenna ***a*** is given by :

$$a_{eff} = \frac{2c}{3 f_o \sqrt{\varepsilon_r}} + h(\varepsilon_r)^{-0.5} \qquad (1)$$

Figure 1 shows the simple structure of 3 dB hybrid coupler. This component is symmetrical and has the following properties: if port 1 (P1) is fed, then the signal travels to port 4 (P4) and port 3 (P3) is consequently coupled, while port 2 (P2) is isolated. If port 2 (P2) is fed, then the signal travels to port 3 (P3) and port 4 (P4) is consequently coupled, while port 1 (P1) is isolated. If the quadrature hybrid coupler is feed with the impedance input Zo, the impedance of the shunt arm is Z_0 and the impedance of the series arm is $Z_0\sqrt{2}$, while the maximum of the arm length is $\lambda/4$.

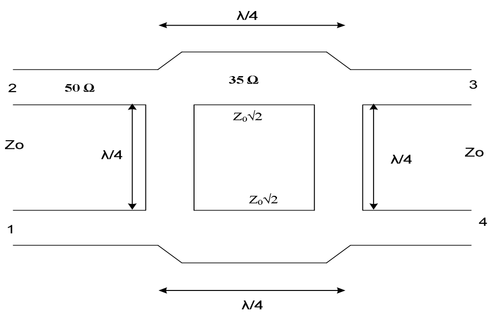

Figure 1 Structure of 3 dB hybrid coupler

The width of the transmission line 50 Ohm and 35 Ohm is given by :

$$B = \frac{60\pi^2}{Z_0\sqrt{\varepsilon_r}} \tag{2}$$

$$W = \frac{2h}{\pi}\left\{B - 1 - \ln(2B-1) + \frac{\varepsilon_r - 1}{2\varepsilon_r}\left[\ln(B-1) + 0,39 - \frac{0,61}{\varepsilon_r}\right]\right\} \tag{3}$$

The patch antenna was designed to operate at frequency 2.3 GHz and the dimension of the tranmission line for 50 Ohm is 3 mm and for 35 Ohm is 5 mm. After several iteration, the length of the shunt arm of the hybrid coupler is 51 mm while the shunt arm is 58 mm. The patch antenna and and the hybrid coupler transmission line are realized on the same layer. The geometry and the dimension of the proposed antenn are shown in Figure 2.

3. Experimental Results

Figure 3 shows the first condition of the proposed antenna to obtain the optimal value for the return loss and VSWR parameters. So it is necessary to characterization the feed line of 50 Ohm for the length of the feed line at the A, C and D position. Figure 3a and 3b shown that after controlling the dimension of the length feed line at the position of A, C and D, the proposed antenna can be operated at frequency 2.3 GHz and Table 1 shwon the return loss and VSWR value.

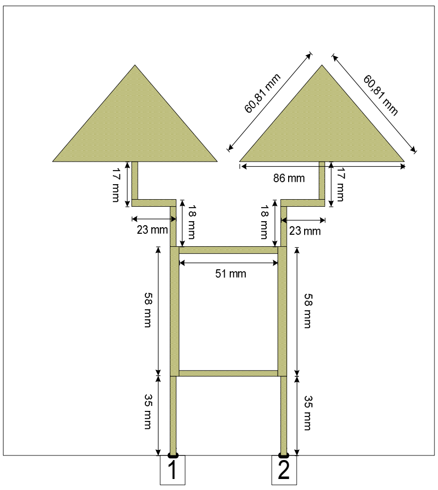

Figure 2 Geometry and the dimension of the proposed antenna

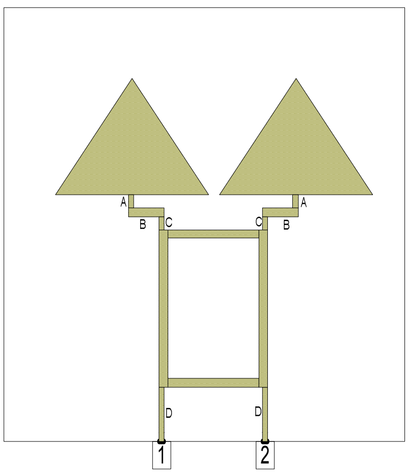

Figure 3 The first condition of the proposed antenna

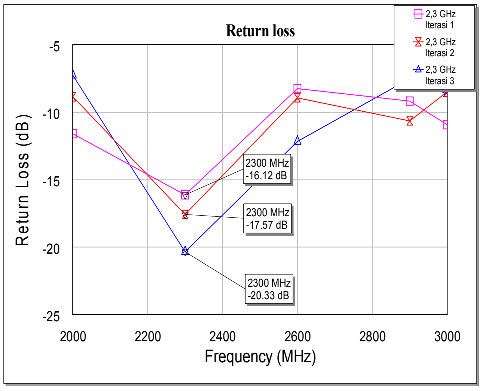

Figure 3a Changes feed line against return loss

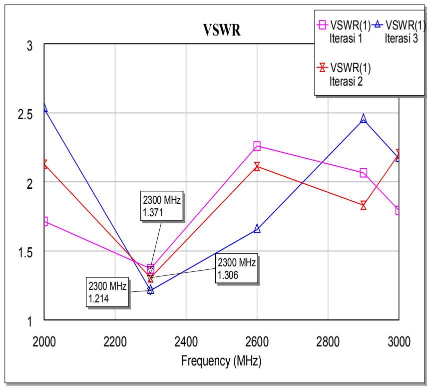

Figure 3b Changes feed line againts VSWR

Table 1 Return loss and VSWR value after adjusting the feed line

Length of the feed line			Frequency 2,3 GHz	
A	C	D	RL	VSWR
9 mm	9 mm	24 mm	-16.127 dB	1,3702
12 mm	12 mm	27 mm	-17.404 dB	1.3117
17 mm	18 mm	35 mm	-19.972 dB	1.223

The next step is to adjusting the length of the feed line at the B position as seen in the Figure 4a and 4b and the value of the return loss and VSWR can be seen in Table 2.

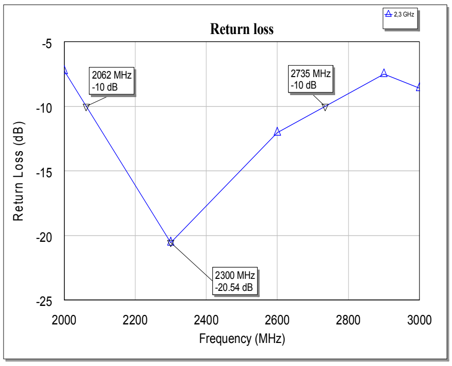

Figure 4a Feed line at B against return loss

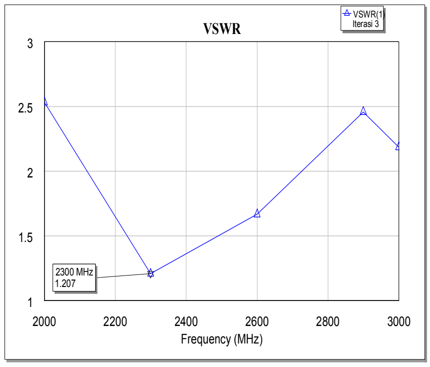

Figure 4b Feed line at B against VSWR

Table 2 Return loss and VSWR value after adjusting the feed line at B position

Length of the feed line at B	Frequency 2,3 GHz	
	RL	VSWR
21 mm	-20.17 dB	1.218
22 mm	-20.24 dB	1.216
23 mm	-20.54 dB	1.207

The impedance bandwidth range is from 2.062 GHz up to 2.735 GHz or 673 MHz and it is about 29.22% as seen at Figure 4a. Figure 5a shows the radiation pattern when port 1 is on and Figure 5b when port 2 is on.

Figure 6a and 6b shown that the proposed antenna has broadside radiation pattern with 34^0 Half Power Beamwidth (HPBW) both for port 1 and port 2.

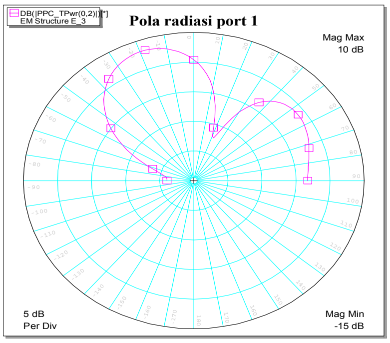

Figure 5a Radiation pattern when port 1 is on

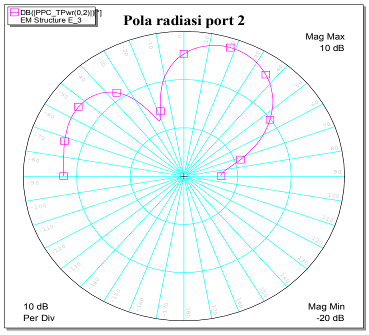

Figure 5b Radiation pattern when port 2 is on

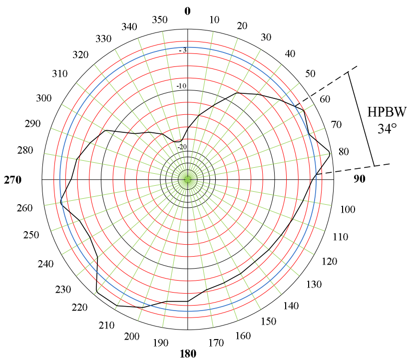

Figure 6a Radiation pattern at port 1 with HPBW 34^0

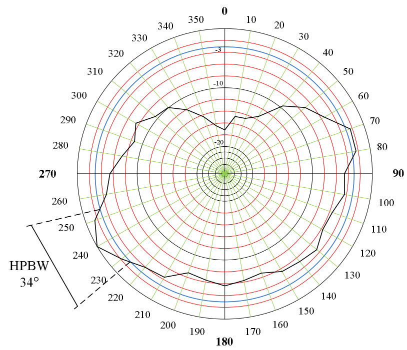

Figure 6a Radiation pattern at port 2 with HPBW 34^0

4. Conclusion

A configuration of triangular microstrip antenna using hybrid coupler feed line has been proposed in this paper. Return loss of – 20.54 dB and VSWR 1.207 can be achieved by controlling the feed line and the dimension of patch antenna. The antenna has an impedance bandwidth of 673 MHz or about 29.22% and have broadside radiation pattern with HPBW for the two port is 34^0. Therefore, the proposed antenna is applicable as a new candidate to work at 2.3 GHz for WiMAX application.

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