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Wide Band Parasitic Microstrip Antenna using Multiple Feedline for Mobile Communication

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Abstract**: *This paper proposes design of parasitic microstrip antenna with multiple feed line for mobile communication applications at range frequency of 1800 – 2100 MHz. The purpose of adding multiple feed line is to enhanced the bandwidth of the proposed antenna. The multiple feed line used has an impedance of 100 Ohm and is placed on the edge of the patch parasitic microstrip antenna. The optimal bandwidth of the microstrip antenna is obtained by adjusting the dimensions and position of the multiple feed line. From the measurement results obtained return loss of -14.91 dB, VSWR of 1.44 at working frequency of 1800 MHz and bandwidth of 427 MHz with a frequency range 1715 MHz - 2142 MHz. . From these results it can be concluded that the banwidth of proposed antenna has met the criteria to be used in a mobile communication system.***

Keywords **: *antenna, parasitic, multiple feed line, wide band***

I. INTRODUCTION

Mobile communication systems require antennas that can work with wide bandwidth so that they can be used for several work frequencies such as DCS at frequency band (1710 MHz -1885 MHz), PCS (1907 MHz -1912.5MHz), UMTS (1920 MHz - 2170 MHz) [1]. Microstrip antennas have been extensively researched and developed for mobile communication system applications [2-3]. The advantage of microstrip antennas is that can work on several different working frequencies and have a compact dimension and low profile [4]. The disadvantages of microstrip antennas are narrow bandwidth and low gain [5]. In general, microstrip antennas have an impedance bandwidth of 5-10% of the working frequency with a return loss of ≤ -10 dB.To increase the bandwidth of the microstrip antenna, several optimization methods can be used, including parasitic [6-8], coplanar waveguide [9-12] and DGS (Deflected Ground Structure) [13-15]. In a previous study conducted by [16], the addition of parasitic with L shaped obtained bandwidth of 380 MHz in the frequency range of 5.7–6.08 GHz while the research conducted by [17] the addition of New Zeroth-order resonators (ZORs) parasitic elements succeeded in increasing the bandwidth of 56 MHz to 101, 120, and 133 MHz. In this paper, parasitic microstrip antennas will be optimized using a multiple feed line placed at the edge of the parasitic patch element. The purpose of adding multiple feed line is to increase the bandwidth of the proposed antenna. To obtain the appropriate bandwidth and work frequency, an iteration process is carried out by controlling the dimensions and position of the multiple feed line.

The first section of this paper will explain the stages of designing a single element microstrip antenna optimized with parasitic elements on the right and left sides of the radiating element. Furthermore, the parasitic microstrip antenna is optimized using multiple feed line to improve bandwidth. The second section presents the results and analysis of the simulation and measurement of the proposed antenna and also comparison result of the booth process. The last section of this paper describes the conclusions of the measurement and fabrication carried out in this research.

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II. DESIGN OF ANTENNA

A. Design of Single Element

The first design of proposed microstrip antenna using rectangular shape. Proposed antenna using FR4 Epoxy substrate with specification of relative permittivity (εr) of 4.3, substrate thickness (h) of 1.6 mm and loss tangent (tan δ) of 0.0265. The dimension of the rectangular patch antenna is given by below equations (1), (2),(3) (4) and (5) [18].

$$W = \frac{c}{2f\sqrt{\frac{\varepsilon r+1}{2}}} \quad (1)$$

$$L = L_{eff} - 2\Delta L \quad (2)$$

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{reff}}} \quad (3)$$

$$\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (4)$$

$$\Delta L = 0{,}412.h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (5)$$

Proposed microstrip antenna using undirect feed line with impedance of 50 Ohm. The dimensions of microstrip line determined using the equation (6) and (7) below [19].

$$Wz = \frac{2h}{\pi}\left\{B - 1 - \ln(2B - 1) + \frac{\varepsilon_r - 1}{2\varepsilon_r}\left[\ln(B - 1) + 0.39 - \frac{0.61}{\varepsilon_r}\right]\right\} \quad (6)$$

$$B = \frac{60\pi^2}{Z_0\sqrt{\varepsilon_{eff}}}. \quad (7)$$

After the calculation process is done using equations (1) until (7) the values of W is 59 mm and L is 21 mm while the dimension of W_z is 3.1 mm. After a simulation process with AWR Microwave Office 2009, the optimal dimensions of X and Y are 71 mm, the design of rectangular patch microstrip antenna is shown in Fig. 1.

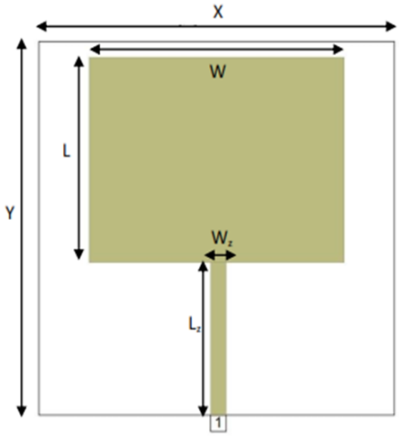

Fig. 1. Design of Single Element Microstrip Antenna

B. Design Of Parasitic Microstrip Antenna

The design of microstrip antenna with parasitic element is done by adding parasitic element on the right and left sides of the radiating element. The dimensions and position of the parasitic element are obtained from the results of optimization and iteration using AWR Microwave Office 2009. The design and dimension of microstrip antenna with two element parasitic shown in Fig. 2.

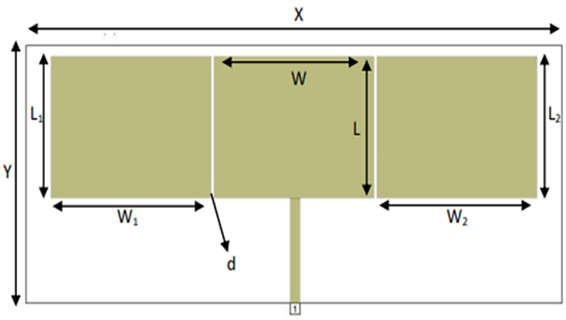

Fig. 2. Design of Parasitic Microstrip Antenna

Fig. 2 shows that the radiating element is placed in the middle between the two parasitic elements with a distance d = 0.5 mm from the edge of the patch while for the dimensions W_1, W_2 , L_1 and L_2 of the two parasitic elements is equal with W and L of radiating element. Dimension of X and Y is 171 mm and 90 mm.

C. Design of Parasitic Microstrip Antenna with Multiple Feedline

The design of the multiple feed line on the microstrip antenna is done by adding a microstrip line feed that serves to supply the current of the antenna. The dimensions and position of the multiple feed line are obtained from the results of optimization and iteration using AWR Microwave Office 2009 with impedance of 100 Ohm. The design of the microstrip antenna with multiple feed line shown in Fig.3.

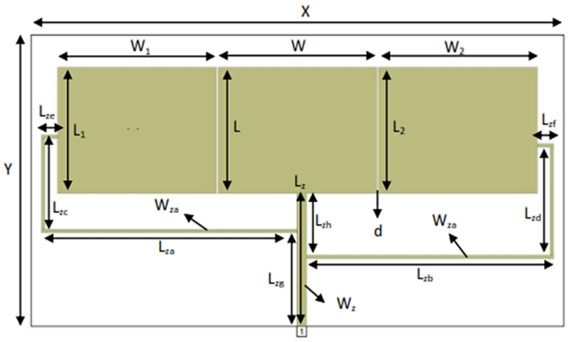

Fig. 3. Design of Parasitic Microstrip Antenna with Multiple Feed Line

Fig. 3 shows that multiple feed lines are positioned at the edge of the parasitic patch element. The overall dimensions of the parasitic microstrip antenna can be seen in Table I.

Table- I : Dimension of Multiple Feed Line

Parameter	Dimension
W_z	3.1 mm
L_z	41 mm
W_{za}	1 mm
L_{za}	80.9 mm
L_{zb}	78.2 mm
L_{zc}	28 mm
L_{zd}	33.3 mm
L_{ze}	5.2 mm
L_{zf}	5.2 mm
L_{zg}	28.9 mm
L_{zh}	19 mm

III. RESULT AND DISCUSSION

To obtain the best of simulation results, several iteration is carried out by adjusting the distance, width and length of the multiple feed line on the proposed antenna. The iteration process is done by controlling the dimensions of L_{zc},L_{zd}, L_{zg} and L_{zh} because these parameters have the most influence on the simulation process of the proposed antenna.

A. Simulation Result from Iteration of Multiple Feed Line

The iteration process of the dimension multiple microstrip feedline is shown in Table II.

Table- II : Iteration of Multiple Feed Line

Condition	Dimension Of Multiple Feed Line			
	L_{zc}	L_{zd}	L_{zg}	L_{zh}
Iteration1	28 mm	33.3 mm	28.9 mm	19 mm
Iteration 2	30 mm	31.3 mm	31.9 mm	21 mm
Iteration 3	26 mm	30.3 mm	26.9 mm	17 mm

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Table II shows the dimensions of multiple feed lines that have been iterated while the simulation results from the iteration process can be seen in Fig.4 and Fig.5 .

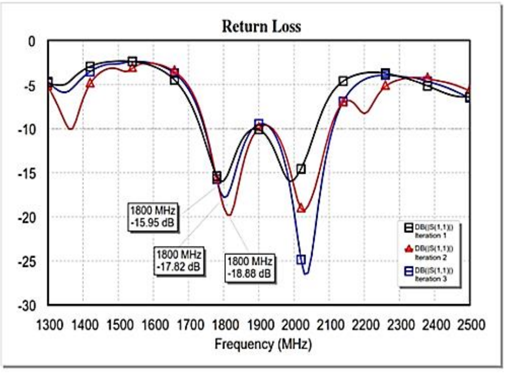

Fig. 4. Simulation Result of Return Loss

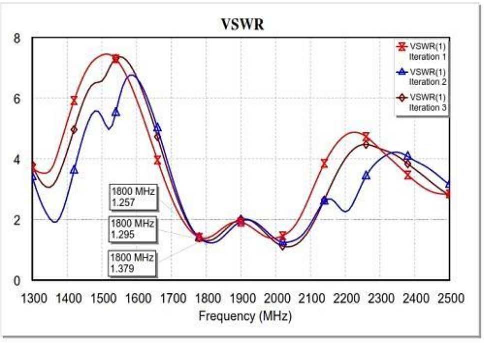

Fig. 5. Simulation Result of VSWR

Fig. 4 and Fig. 5 show the simulation results of return loss and VSWR from the iteration process. The bandwidth of an antenna can be adjusted by controlling the dimensions of multiple feed lines. Table III shows the simulation results of the entire iteration process.

Table- III : Iteration of Multiple Feed Line

Condition	Parameters			
	Return Loss	VSWR	Bandwidth	Frequency
Iteration 1	-15.95 dB	1.379	328 MHz	1800 MHz
Iteration 2	-18.88 dB	1.257	355 MHz	1800 MHz
Iteration 3	-17.82 dB	1.295	376 MHz	1800 MHz

Table III shows the simulation results of iteration process with return loss of ≤ -10 dB and VSWR of ≤2. From the observations on the simulation results in iterations 2 and 3 it still has a return loss that is slightly above -10 dB at a working frequency of 1900 MHz, so the best result taken is iteration 1 because it has better return loss even though the bandwidth obtained is narrower than iteration 2 and 3. The best simulation result are obtained in the third iteration with an impedance bandwidth of 328 MHz with a frequency range of 1735 - 2063 MHz.

B. Fabrication of Microstrip Antenna

After obtaining the design of the proposed antenna, the next step is manufacturing and measuring in the laboratory. The substrate used in this study was FR-4 Epoxy with the specifications shown in Table IV. The initial fabrication results of the design antenna can be seen in Fig.6 and Fig.7.

Table- IV: Specification of FR-4 Epoxy

Parameter	Value
Dielectric Constant	4.3
Thickness (h)	1.6 mm
Dissipation Loss (tan α)	0.0265
Cooper Cladding	1 Oz (35 mm)

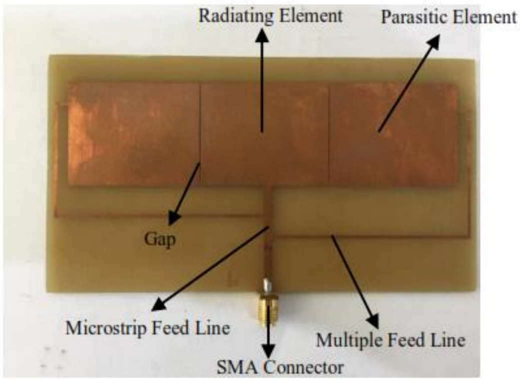

Fig. 6. Fabrication of Proposed Antenna in Top Layer

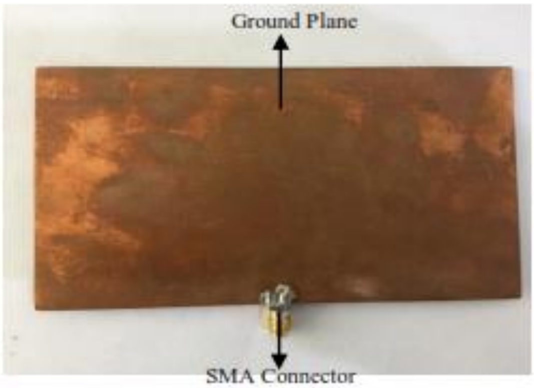

Fig. 7. Fabrication of Proposed Antenna in Bottom Layer

C. Measurement of Microtrip Antenna

The measurement process on the proposed antenna is carried out in a laboratory using the ADVANTEST Vector Network Analyzer measuring instrument with a frequency range of 1 GHz - 3 GHz. The proposed antenna is connected to VNA using a pigtail cable with an impedance of 50 Ohms. In this study, the parameters observed and measured are the return loss, VSWR and radiation pattern of the proposed antenna.

Data from the measurement results will be compared with the simulation results to find out the shift of the working frequency of the antenna that has been fabricated.

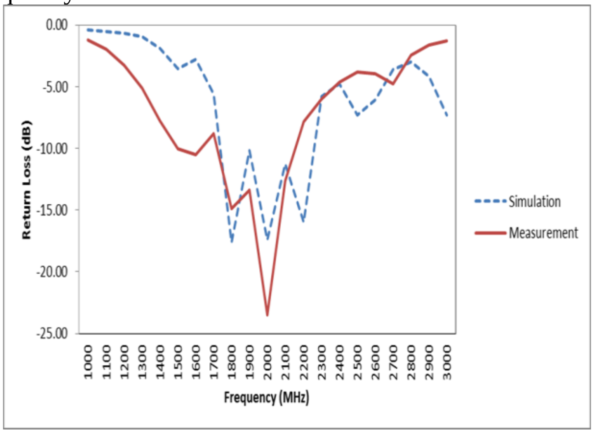

Fig. 8. Comparison Result of Return Loss From Simulation and Measurement

Fig.8 shows a comparison of return loss from simulation and measurements of the proposed antenna. From the simulation process, the return loss obtained is -17.62 dB while the measurement results obtained a return loss of -14.91 dB at 1800 MHz working frequency. The bandwidth resulting from the measurement process becomes narrower than the simulation process.

From the results shown in Fig. 9 it can be concluded that the bandwidth of the manufactured antennas has decreased by 18.35% when compared to the results obtained from the simulation process. This is because it is difficult to adjust the gap gap (d) between the patch antenna on the parasitic element, a slight change in the gap gap will greatly affect the bandwidth and working frequency of the antenna. The return loss obtained from the measurement process shifts up to 15.38% when compared to the simulation results, this is due to the impedance mismatch conditions between the antenna and the connector and the use of tin which can also change the impedance match so that a frequency shift occurs.

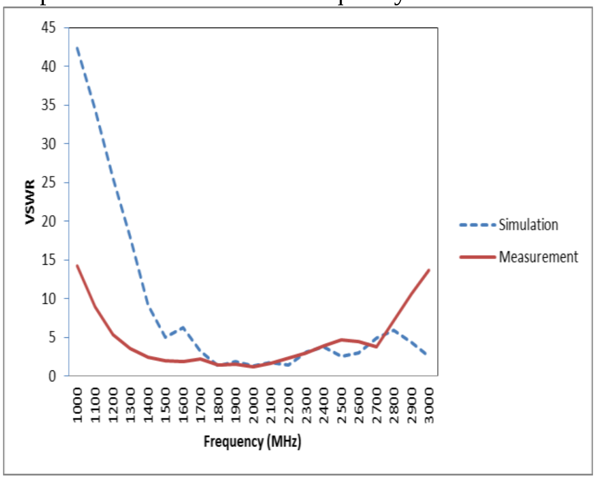

Fig. 9. Comparison Result of VSWR From Simulation and Measurement

Fig.9 shows the comparison result of VSWR form simulation and measurement process. From the simulation results obtained VSWR of 1.30 while the measurement results obtained VSWR of 1.44 at a working frequency of 1800 MHz. From the results shown in Fig.9 it can be analyzed that the VSWR obtained from the simulation results is better than the measurement. The VSWR value obtained from the measurement process shifted 10.38% of the simulation results. This is due to a shift in the working frequency range of the fabricated microstrip antenna so that the return loss and VSWR values decrease. From the results obtained it can be concluded that the antenna has worked well and meets the VSWR criteria ≤ 2 for working frequency of 1800 MHz.

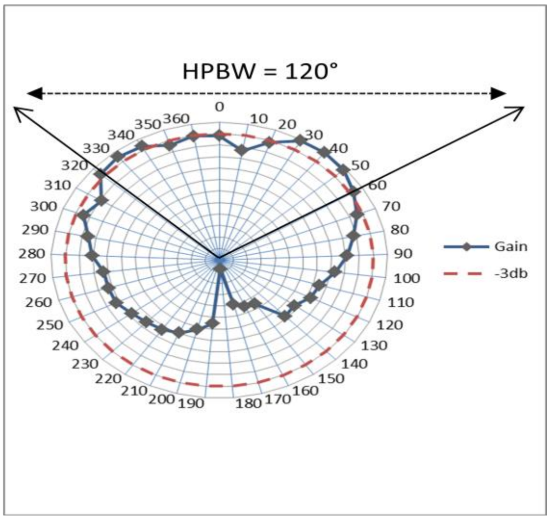

Fig. 10. Measurement Result of Radiation Pattern From Proposed Antenna

From Fig.10 it can be seen that the proposed antenna produces a directional / one-way radiation pattern with a beam angle (Half Power Beam Width) of 120 ° from an angle range of 320 ° until 60 °. Gain of proposed antenna also reported in this paper, Fig.11 shows that proposed antenna obtained gain of 9.43 dB at working frequency of 1800 MHz.

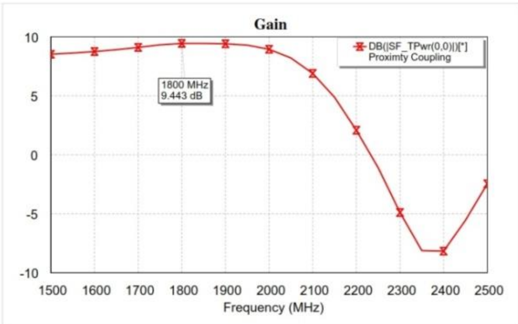

Fig. 11. Measurement Result of Gain From Proposed Antenna

IV. CONCLUSION

Wide band parasitic microstrip antenna for mobile communication has been fabricated and investigated in this paper. From the overall results of the simulation and measurement process, it can be analyzed that the manufactured antenna can be used for mobile communication systems at a working frequency of 1800 MHz with a return loss of -14.91 dB and VSWR 1.44.

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In the measurement process, there was a decrease in return loss by 15.38% and VSWR decreased by 10.38% compared to the simulation results. The bandwidth obtained from the fabricated antennas is 427 MHz (1715 MHz - 2142 MHz) which decreased by 18.35% when compared to the results obtained from the simulation process. From these results it can be concluded that bandwidth of the proposed antenna has met the criteria to be used in a mobile communication system.

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