Improving Performance and Size Reduction Of Truncated Microstrip Antenna Using U Slot For LTE Application

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***Abstract*— This paper proposed new design of truncated microstrip antenna with U slot for LTE application at work frequency of 2300 MHz. The addition of slot with U shape aims to reduce return loss and VSWR from antenna, beside that giving U slot also can reduce the dimension of antenna to be more compact. The proposed antenna have been design. The proposed antenna, designed and realized using a FR4 Epoxy substrate with a dielectric constant (Ɛr) of 4.3, a thickness (h) of 1.6 mm and a loss tan (tan α) of 0.0265 . From the measurement result obtained return loss of -22.95 dB and VSWR of 1.1.5 at working frequency of 2300 MHz with bandwidth of 250 MHz (2100 -2350 MHz). The addition of U slot has been succesfully improved the value of return loss until 43 % and VSWR until 15 % compared with truncated microstrip antenna without U slot. Beside that, the dimension of microstrip antenna have been reduced until 17.87 % after using U slot.**

Keywords— microstrip, antenna,truncated corner, slot

INTRODUCTION

Microstrip antenna is a widely developed antenna for telecommunication system applications that use high frequency such as 4G / LTE that is in the frequency range 2300 - 2400 MHz [1]. The use of microstrip antennas due to the advantages of microstrip antennas is that they have small, compact dimensions, can work at high frequencies and low manufacturing costs [2]. However, microstrip antennas have several disadvantages such as low directivity, small gain and narrow bandwidth [3]. To overcome these shortcomings it is necessary to perform a certain method to optimize microstrip antenna. One of the optimization methods of microstrip antenna is by using circular polarization to increase the severity and loss factor due to polarization mismatch between transmitter and receiver antennas [4-5]. In addition to increasing the gain in microstrip antennas can be used array method [6-7], parasitic [8-9] and stacked [10-11]. To reduce the dimensions of the microstrip antenna we can use several methods: fractal [12-13], peripheral slit [14-15] and slot [16-17].

In a previous study conducted by [18] presented design a circular polarization microstrip antenna using a truncated corner method and an array of 2 elements with a return of -42.57 dB, VSWR of 1.015 at working frequency of 3.41 GHz. The truncated corner method is performed by cutting the edge of the microstrip antenna diagonally to obtain circular polarization with axial ratio ≤3 dB. To increase the gain an array method is used which connects two patch of microstrip antenna with microstrip line feeder [19]. In this study, the addition of U slots on the patch antenna truncated corner that aims to reduce dimensions and increase the return and VSWR of microstrip antenna. In a previous study conducted by [20] the addition of slot loads with the T form successfully increased the return loss from -17.30 dB to -45.45 dB at a working frequency of 2300 MHz for 4G / LTE applications.

The focus of this research is to obtain new dimension of microstrip antenna with axial ratio ≤ 3dB, return loss ≤ -10 dB, VSWR ≤ 2 at working frequency of 2300 MHz for 4G / LTE application. The addition of U slot load is expected to improve the performance of the proposed antenna and reduce the overall dimension of the antenna.

DESIGN OF ANTENNA

In the first stages, a rectangular microstrip antenna was designed using a FR-4 Epoxy substrate with a dielectric constant (Ɛr) = 4.3, thickness (h) = 1.6 mm and loss tangent (tan α) = 0.0265. The dimension of length (L) and width (W) of rectangular microstrip antenna can be determined using equation (1) until (5) [21].

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

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DOI 10.1109/ICCED.2018.00045

$$L = Leff - 2\,\Delta L \quad (2)$$

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

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

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

For the type of feeder used in the proposed antenna is a microstrip line with impedance of 50 Ohm. The dimensions of the microstrip line feeder line obtained using equations (6) and (7) below [21].

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

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

Initial design of microstrip antenna with rectangular pacth fed by microstrip line showed in figure 1.

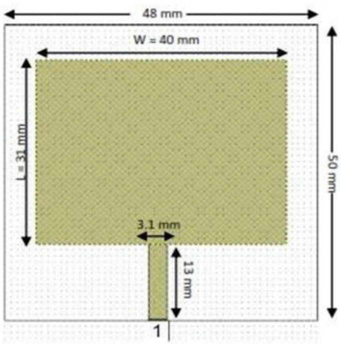

Fig. 1. Design of retangular microstrip antenna

Figure 1 shows the initial design of a rectangular patch microstrip antenna with dimension of W = 40 mm, L = 31 mm and the substrate is 48 mm x 50 mm. For microstrip line feeder 50 Ohm, dimension of Wz = 3.1 mm and length of 13 mm.

Circular polarization on a rectangular microstrip antenna obtained by using truncated corner method by cutting the edges of the microstrip patch antenna with diagonal position. The angle of the truncated corner patch is 45^0 diagonally while the dimension of cutting patch ΔL_1 is usually 2 mm - 10 mm in the patch as shown in Figure 2 below [21]

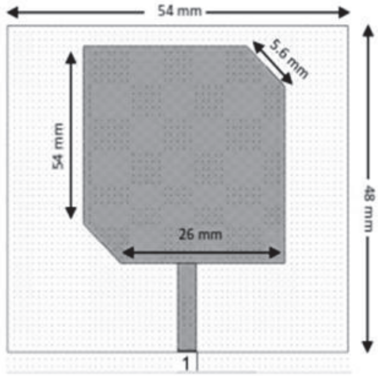

Fig. 2. Design of truncated microstrip antenna

Figure 2 shows the dimensions of the microstrip antenna that has been modified using truncated corner with length ΔL = 5.6 mm and the angle 45^0. To increase the gain of a single element antenna, an optimization process is done using array method. The addition of the number of elements and the distance between the antenna elements in the array method affects the gain and radiation pattern of the antenna. To obtain the distance between the antenna elements in the array method we can use equation (9) below [21].

$$d = \frac{\lambda}{2} \quad (9)$$

In this research, used array method with 2 elements that use microstrip line feeder with impedance of 50 Ohm and 100 Ohm. The use of a different impedance feeder aims to obtain a matching impedance of the designed antenna.

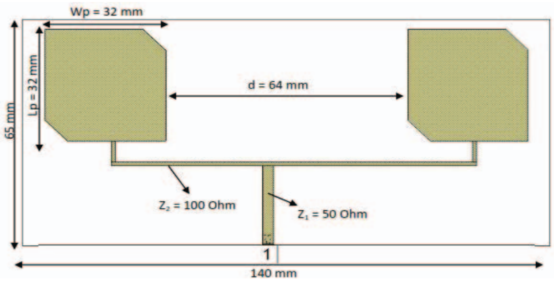

Fig. 3. Design of truncated microstrip antenna array 2 element

Figure 3 shows the design of the truncated corner microstrip antenna that has been developed by the 2 element array method. To connect each patch is used microstrip line Z1 = 50 Ohm with dimensions of 3.1 mm and Z2 = 100 Ohm with dimensions of 1 mm. The dimension of the whole array antenna is 140 x 65 mm with the distance between elements d = 64 mm while the dimensions of the length and width of the patch antenna microstrip W = L = 32 mm.

The next step is to add U slot the patch of microstrip antenna to optimize the performance of the pre-designed antenna. The dimensions of U slot (Ws) can be obtained by using equation (11) below [21].

$$Ws = 0.01\, x\, \lambda \quad (11)$$

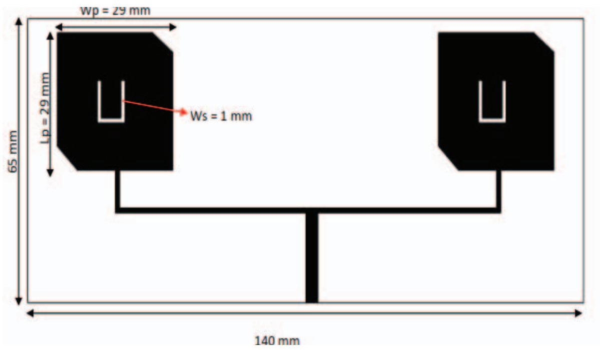

Fig. 4. Design of truncated microstrip antenna array 2 element with U slot

Figure 4 showed the design of proposed microstrip antenna with U Slot placed in the middle of the patch antenna with the dimension of Ws = 1 mm. The dimension of truncated microstrip patch antenna is Wp = Lp = 29 mm with enclosure of 140 mm x 65 mm

RESULT AND DISCUSSION

After the design process is done, the next stage is to simulate the proposed antenna. The parameters observed from this simulation result are return loss, VSWR and axial ratio. The simulation results of the proposed antenna showed in the figure 5 .

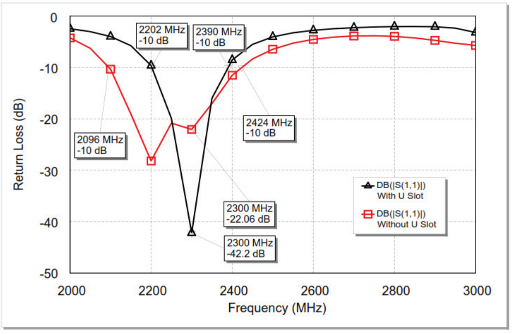

Fig. 5. Simulation result of return loss

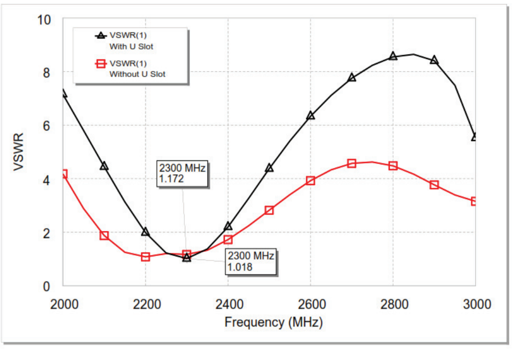

Fig. 6. Simulation result of VSWR

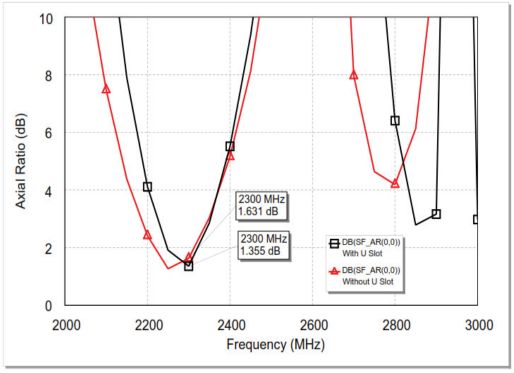

Fig. 7. Simulation result of axial ratio

From simulation result shown in figure 5, figure 6 and figure 7 can be analyzed that the effect of adding U slot successfully increases the return loss, VSWR and axial ratio. The overall result of the simulation process can be seen in table 1 below

SIMULATION RESULT OF PROPOSED ANTENNA

Condition	**Parameter**		
	Return Loss	***VSWR***	***Axial Ratio***
With U Slot	-42.20 dB	1.018	1.355
Without U Slot	-22.06 dB	1.172	1.631

Table I shows that the addition of U slots to the proposed patch antenna has successfully improved the return loss from -22.06 dB to -42.20 dB, VSWR from 1.172 to 1.018 and the axial ratio 1.631 to 1.355 at work of frequency of 2300 MHz.

After the simulation phase is done, the next step is to fabricate the proposed antenna. At this stage, microstrip antenna fabrication is made using FR4 Epoxy substrate and SMA connector with impedance of 50 Ohm

Fig. 8. Truncated corner array microstrip antenna without U slot

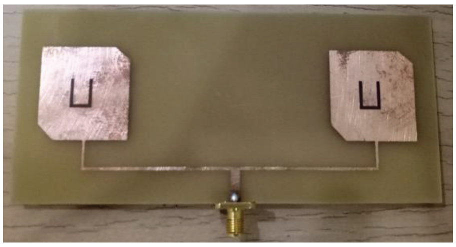

Fig. 9. Truncated corner array microstrip antenna with U Slot

Figure 8 showed prototype of the proposed antenna without using U slot while in figure 9 is the antenna that has been added U slot. The final stage of this research is to conduct a measurement process to see the performance of the proposed antenna. The measurements of the two antennas that have been designed shown in figure 10 and figure 11.

Fig. 10. Measurement process of proposed antenna with U slot

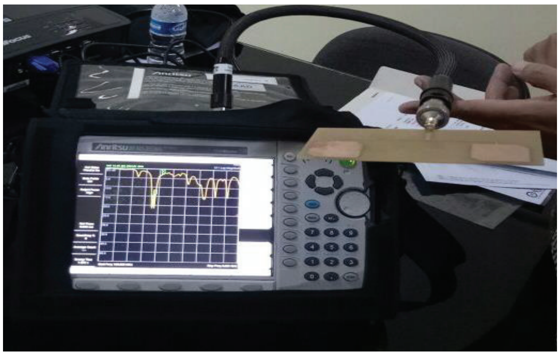

Fig. 11. Measurement process of proposed antenna without U slot

Figure 10 and 11 showed the process of measuring the S11 parameter against the proposed antenna using Vector Network Analyzer. The comparison results from the measurement process of the two proposed antennas showed in Figures 12 and 13 below.

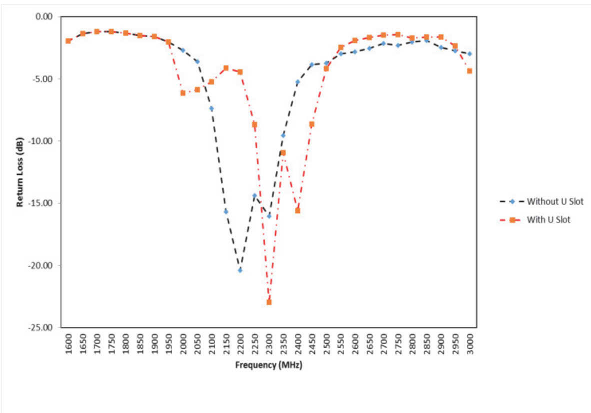

Fig. 12. Measurement result of return loss from proposed antenna

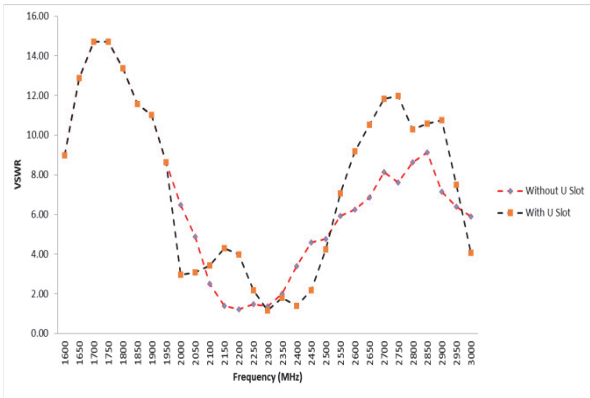

Fig. 13. Measurement result of VSWR from proposed antenna

Figure 12 and 13 has shown that the addition of U slot inside of patch antenna successfully improves the return loss and VSWR of previously proposed antennas. The overall result of the measurement process on the proposed antenna can be seen in the table below.

MEASUREMENT RESULT OF PROPOSED ANTENNA

Condition	Parameter	
	Return Loss	***VSWR***
With U Slot	-42.20 dB	1.018
Without U Slot	-22.06 dB	1.172

From the results obtained in table II can be concluded that the addition of U Slot managed to improve the return loss and VSWR respectively 43% and 15% compared with the antenna without u slot. On the other hand, the addition of U slot also succeeded in reducing the dimension of patch microstrip antenna until 17.87%. The comparison dimension patch of microstrip antenna before and after using U slot shown in figure 14 and table III.

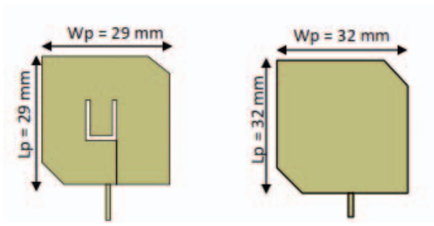

Fig. 14. Comparison dimension patch of proposed microstrip antenna

COMPARISON DIMENSION OF ANTENNA

Condition	Dimension	
	Wp	***Lp***
With U Slot	29 mm	29 mm
Without U Slot	32 mm	32 mm

From the overall results it can be analyzed that the addition of a U slot causes a change in the amount of electric current flowing in the patch of antenna. The addition of U slots also causes a change in wavelength on the proposed antenna so that to return the antenna to the initial working frequency, dimensions of the antenna must be reduced. The position and dimensions of the U slot determine of return loss and VSWR from the antenna.

CONCLUSION

A new design of truncated microstrip antenna with U slot for LTE application have been proposed and investigated. From the measurement result obtained return loss of -22.95 dB and VSWR of 1.1.5 at working frequency of 2300 MHz with bandwidth of 250 MHz (2100 -2350 MHz). The addition of U slot has been succesfully improved of return loss until 43 % and VSWR until 15 % compared with truncated microstrip antenna without U slot. Beside that, the dimension of microstrip antenna have been reduced until 17.87 % after using U slot.

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