Rectangular Patch Antenna with Notch and Slot on Ground Plane for WLAN Application

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***Abstract*—A new design of rectangular patch antenna was presented in this paper. This antenna was proposed to achieve wider bandwidth and good performance in return loss (S11), that is below -10dB. The design of this antenna was an improvement from the conventional rectangular patch antenna by making a parallel slot, rectangular slot on the ground plane and introducing a notch (dual mode). The rectangular antenna was designed and simulated using CST Microwave Studio. The application of this antenna was for WLAN application at 5.25 GHz. There was a slightly different result on the bandwidth and return loss value for the simulation and measurement.**

***Index Terms*—Antenna; Notch; Slot; WLAN.**

I. INTRODUCTION

Nowadays, there has been a rapid development of wireless application, such as Bluetooth, GSM, LTE, WLANs, satellite and military application [1-4]. This rapid development has led to many research activities on broadband, multi frequency and wideband antenna for many applications where one of the most rapidly growing areas in this application is on Worldwide Interoperability for Microwave Access (WiMAX) and Wireless Local Area Network (WLAN). The improvement of this technology will provide users the greatly increased freedom and flexibility, where it will give mobility for users to move around, whilst being connected to the network within a broad coverage [5].

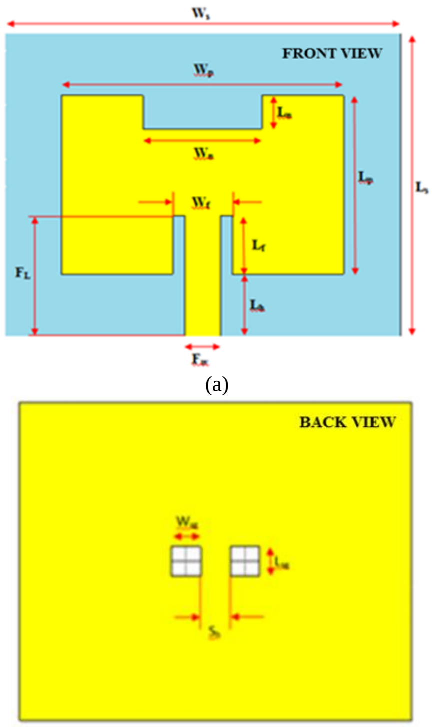
Due to its characteristics, microstrip patch antenna has generally been used in the communication system. This type of antenna provides many benefits such as low cost fabrication, low profile, small size light weight and also eases of installation and integration [5]. Despite having many advantages, the main limitation of this kind of antenna is it faces an inherently narrow bandwidth problem. One of the methods to overcome this problem is by increasing the height of substrate, but a research has shown that the use of this method will result in the antenna to suffer power loss and increase in complexity [6-8].

In this paper, a rectangular patch antenna with a notch and slot on the ground plane is presented. This designed antenna proposed two methods, which are notched and slot in the ground plane to improve two antenna parameters i.e.; bandwidth and return loss. The introduction of this method will widen the bandwidth and improve the antenna performance. This rectangular patch antenna has been designed using CST Microwave Studio at 5.25 GHz resonance frequency. The design process will focus on improving two parameters that are the return loss and the bandwidth, but other antenna parameter will be analyzed also. The antenna design is expected to operate at the center frequency 5.25 GHz with a return loss below than -10dB to achieve high antenna efficiency. The bandwidth of the antenna designed is expected to achieve larger than 200MHz to cover frequency range from 5.15GHz -5.35GHz on MCMC frequency allocation for WLAN application.

II. METHODOLOGY

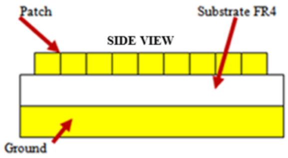
A. Antenna Design

Figure 1 shows the structure of the proposed antenna starting with the front, back and side view. On the front view or at the top is where the rectangular patch was fabricated. This is where the notch has been made. The notch on the patch is made to improve the bandwidth of the antenna. The bottom view shows the parallel of rectangular patch with inset feed. On the ground plane, the two rectangular slots of the same size are set at the center of the length. This method was used to get a better return loss (S11); below -10dB for frequency range. Meanwhile, Figure 2 shows the fabrication of the proposed antenna.



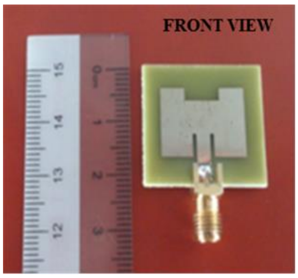
(a)

(b)

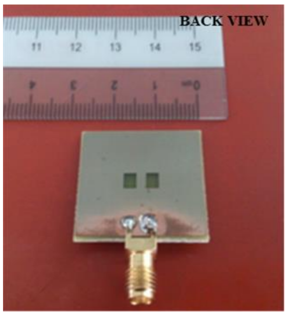


(c)

Figure 1: The optimized dimension for (a) front, (b) back and (c) side view of the proposed antenna



(a)



(b)

Figure 2: The fabricated for (a) front and (b) back of the proposed antenna

The materials selected for this antenna is FR-4 for substrate and cooper for the patch and the ground plane. The antenna design structure was printed on the FR-4 board using the UV lights machine. The selection of FR-4 as substrate is because it is easy to find and less expensive than other substrates. FR-4 thickness is 1.6 mm with dielectric value of 4.6. The top and bottom of the substrate is where the patch and ground plane were stated.

Table 1 below shows the value of the antenna parameters after optimization. Some of them remain the same, while others changed. Some of the parameters value were derived from the equation, while some other values were from the trial and error method or the parametric study. This parametric study was conducted to achieve the optimum value to meet the design specification for bandwidth and return loss.

Table 1
Design parameter after optimization

Parameter	Value (mm)	Description
Fl	9	Feed length
Fw	2.4	Feed width
Gs	1	Ground slot position from center
Lf	4.2	Feed slot length
Ln	2.4	Notch length
Lp	12.78	Patch length
Ls	21.66	Substrate length
Wf	4	Feed slot width
Wn	8	Notch width
Wp	19.06	Patch width
Ws	26.66	Substrate width
gsl	2	Ground slot length
gsw	2	Ground slot width

III. Results and Discussion

The simulation and design process of the rectangular patch antenna with a notch and slot in the ground plane has been done on CST software. The main goal of this antenna design was to improve the bandwidth and return loss of the antenna. The designed antenna was proceeding to the fabrication process. Further, the simulation and measurement result were compared to analyze the performance of the antenna. The design process of the antenna has also been done by taking into consideration another antenna parameters such as the gain, directivity and radiation pattern of the antenna. The results were recorded for analysis and comparison.

Based on the antenna simulation designed in the CST software, the optimized simulation results are shown in Figure 3. From the simulation, the resonance frequency of the antenna design was obtained at 5.242 GHz with a return loss of the antenna was at -43.279 dB. The bandwidth of the antenna designed was achieved at 313.2 MHz that covered frequency range from 5.085GHz until 5.398GHz.

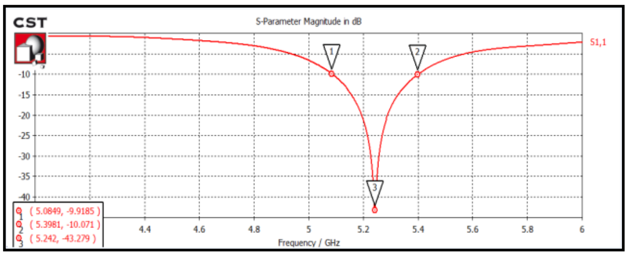


Figure 3: Simulation result for S-parameter

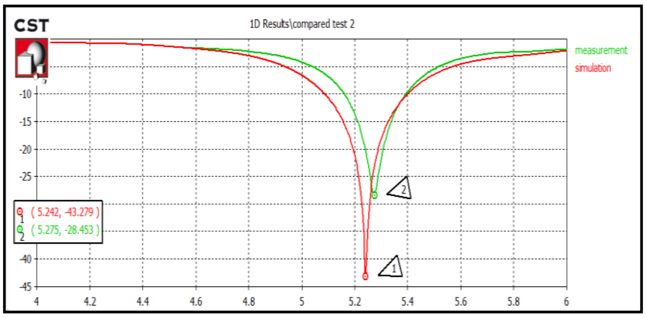


Figure 4: S-parameter simulation and measurement result comparison

Figure 5 shows the comparison radiation pattern between the simulation and measurement results. The measurement process for antenna gain and directivity has been done by doing a measurement on 4 antenna plane i.e.; e-cross plane, e-polar plane, h-cross plane and h-polar plane. From all of these planes, it has been observed that the maximum power was occurring at e-cross section. The maximum power obtained at this e-cross section was the maximum power received by the antenna and could be used to determine the gain and directivity of antenna. The radiation pattern of this antenna design almost achieved similar results between the simulation and the measurement results.

Table 2 shows the comparison between the simulation and the measurement results for all antenna parameters. From the result, it can be observed that the center frequency of the antenna had a slight difference between the simulation and the measurement. The measurement result shows that the resonance frequency has shifted to the right from 5.242GHz to 5.275GHz. For antenna bandwidth, it can be observed that the measurement bandwidth has decreased to 233.3MHz from 313.2MHz at simulation in CST. The return loss (S11) parameter of antenna also has shown a decrease in measurement compared to the simulation result from -43.279dB to -28.453dB. The measurement result for antenna gain also has decreased to 3.46dB in measurement process compared to 4.638dB in simulation process. The same condition occurs in the directivity of the antenna, where the measurement result show that the antenna directivity was obtained at 5.45dBi compared with the simulation at 6.4dBi.

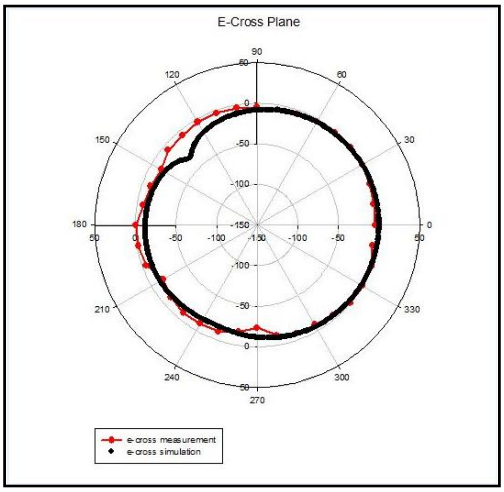


Figure 5: Simulation and measurement radiation pattern comparison

Table 2
Measurement vs Simulation

Parameter	Simulation	Measurement
Center Frequency	5.242GHz	5.275GHz
Bandwidth	313.2MHz	233.2MHz
Return Loss	-43.279dB	-28.453dB
Gain	4.638dB	3.46dB
Directivity	6.4dBi	5.45dBi

IV. CONCLUSION

In this paper, we have presented the design of a rectangular patch antenna with notch and slot on the ground plane for WLAN application at 5.25GHZ. Two antenna parameters i.e. bandwidth and return loss have been chosen as the target parameters to be improved in antenna design process. For bandwidth improvement purposes, the introduction of notch method has been used to achieve a wider bandwidth of antenna design. The rectangular slot on the ground plane also improves the antenna bandwidth, while at the same time improves the return loss of the antenna to achieve higher efficiency. The objective of design antenna to improve the antenna bandwidth and return loss is almost achieved. From the result, it can be observed that the measurement result of antenna design is slightly different from the simulation result where the measurement result shows the decreasing movement in all antenna parameters. This condition happens due to many factors, such as the variation of permittivity in the substrate and inconsistencies of dielectric thickness where these two factors come from manufacturing tolerance. Other than that, mismatching between microstrips to SMA connector also contributes to the lost at the transition. The last factor contributed to the imperfect result is the measurement process itself where the conduct of the measurement in an open space may affect the result of the antenna measurement process. There are a few things that can be done in future in order to improve this antenna performance, such as conducting the measurement process in anechoic chamber. Other than that, the impedance matching of the antenna can be improved by using other types of feeding methods, such as coaxial probe. The gain and directivity of the antenna also can be improved by using antenna array configuration.

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