Monopole Antenna with Dual Band Capabilities for WiFi Application

Mohamad Hafize Ramli[1], Mohamad Zoinol Abidin Abd Aziz[1], Mohd Azlishah Othman[1],
Siti Nurfarhanah Azizul Azlan[1], Nornikman Hassan[1], Muhammad Syafiq Noor Azizi[1] and Abdul Halim Dahalan[2]
[1]*Center of Telecommunication Research and Innovation (CeTRI), Faculty of Electronic and Computer Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.*
[2]*Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.*
hafizeramli88@gmail.com

***Abstract*—In this paper, a monopole antenna with rectangular elements for dual band capabilities was presented. This design was an improvement from the traditional monopole patch antenna by adding slits and truncated ground plane. The proposed antenna was designed for dual band operations for Wireless Local Area Network (WLAN) at 2.4 GHz and 5.2 GHz. The design improved the return loss and bandwidth for these two frequency bands. Calculation and measurement showed that the return loss exceeded the minimum design specification and the bandwidths for those bands were covered completely.**

***Index Terms*—Dual Band; Monopole; WiFi.**

I. INTRODUCTION

Recently, wireless technology has been used widely and it has become necessary in communication system. This kind of wireless system reduces the complexity compared to hard wired system and directly gives it the advantage. Antenna designs have been increasingly studied because of the demand in industry and commercial for any compact design antenna with high data rate capabilities.

The printed method was used in antenna design because of the simplicity of the material such as light weight, compact size, ease of fabrications and low cost miniaturized antenna without sacrificing the antenna performance. It was easy to integrate the antenna into the current technology of communication systems. In the near future, antenna will be designed to operate at as many frequencies as it can. This is because of the bunch of applications operating at different frequency bands. The most popular technology nowadays is Wireless Local Area Network (WLAN), where it is standardized in IEEE 802.11 WLAN to operate in two different frequencies, which are 2.4GHz (2400-2484 MHz) and 5.2 GHz (5150-5350 MHz).

With the standard in hand, the design is to follow the standard as the guidelines for dual-bands monopole antenna. The antenna should be able to work as transceiver, which is either to transmit or receive the signal. Based on the research and studies being done, there are journals that discussed the inverted F strip design [1] and straight strip design [2]. Both techniques were designed by using the printed monopole antenna for WLAN applications. Unfortunately, the design cannot be used completely because it is only capable to work in single band (2.4 GHz). These researches were improved and further journal papers were found to focus on the dual-band design. The designs used the double T-shaped monopole design [3] as shown in Figure 1. Meanwhile, U-shaped monopole design [4], ring monopole design [5] and rectangular shaped monopole design [6-7] also have been discovered.

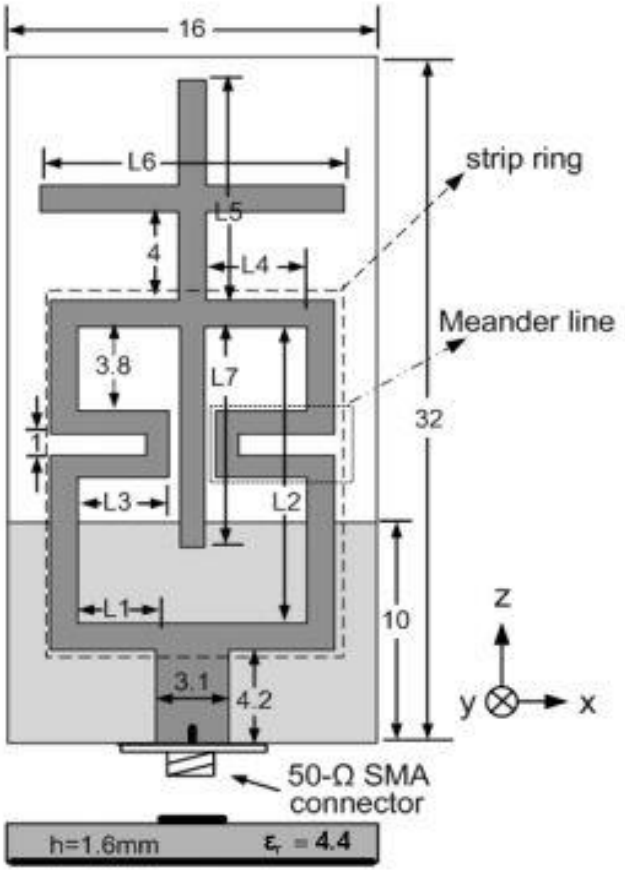

Figure 1: The geometry and dimension of double T-shaped monopole design [3].

In this paper, we proposed a brand new monopole antenna design with dual-band capabilities for WIFI application. The antenna design contains two rectangular elements attached to monopole strip and stacked together at the top and with the truncated ground plane at the back of the substrate. In designing the dual band at both 2.4 GHz and 5.2 GHz, the two rectangular elements are differentiated in size: Work is the main radiation field of the antenna. In addition, the slits are introduced to the bottom right hand corner of the

secondary rectangular element to reduce the return loss and slightly widening the bandwidth for both frequencies. This antenna can simply be fed with ordinary 50 Ω microstrip line. For more details on antenna design and the prototype, it will be discussed in the design process section.

II. Antenna Design

Figure 2 shows the structure of monopole antenna with band capabilities for Wi-Fi application. There are divided into three views, which are the top, front and bottom. The top view consists of the different shapes, which are combined together to complete the rectangular monopole antenna. Three rectangular monopole antennas are stacked together with a bigger rectangular use to control the higher operating mode, while the middle rectangular uses to control the lower operating mode. The bottom view shows the structure of the ground plane. From the front view, the structure of thickness can be seen for the substrate and ground plane.

Besides that, slit is designed for the improvement of the return loss response and also the impedance bandwidth. Slit is used to shift the operating frequency for Wi-Fi application. The structure monopole antenna is printed on the FR-4 board. This monopole antenna has two materials, which are the substrate and patch. FR-4 is used because of its low cost. The thickness for FR-4 is 1.6 mm with relative permittivity of 4.4. Ground plane is printed on the other side. Besides that, this antenna uses a copper on the substrate with 0.035 mm.

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

Table 1
Design Parameter after Optimization

Parameter	Value (mm)	Comments
W	35	Substrate width
L	45	Substrate length
W_t	3	Width of microstrip line
W_1	15	Upper rectangular width
W_2	10	Middle rectangular width
W_3	5.5	Lower rectangular width
W_4	1	Slit gap
W_s	1	Slit width
L_1	13	Upper rectangular length
L_2	10	Middle rectangular length
L_3	12.5	Lower rectangular + microstrip line length
L_g	6.5	Ground plane length

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 is to improve the bandwidth and return loss of the antenna. The design process of the antenna also has been done by taking into consideration on other antenna parameters such as gain, directivity and radiation pattern of the antenna. The result was recorded for analysis and comparison.

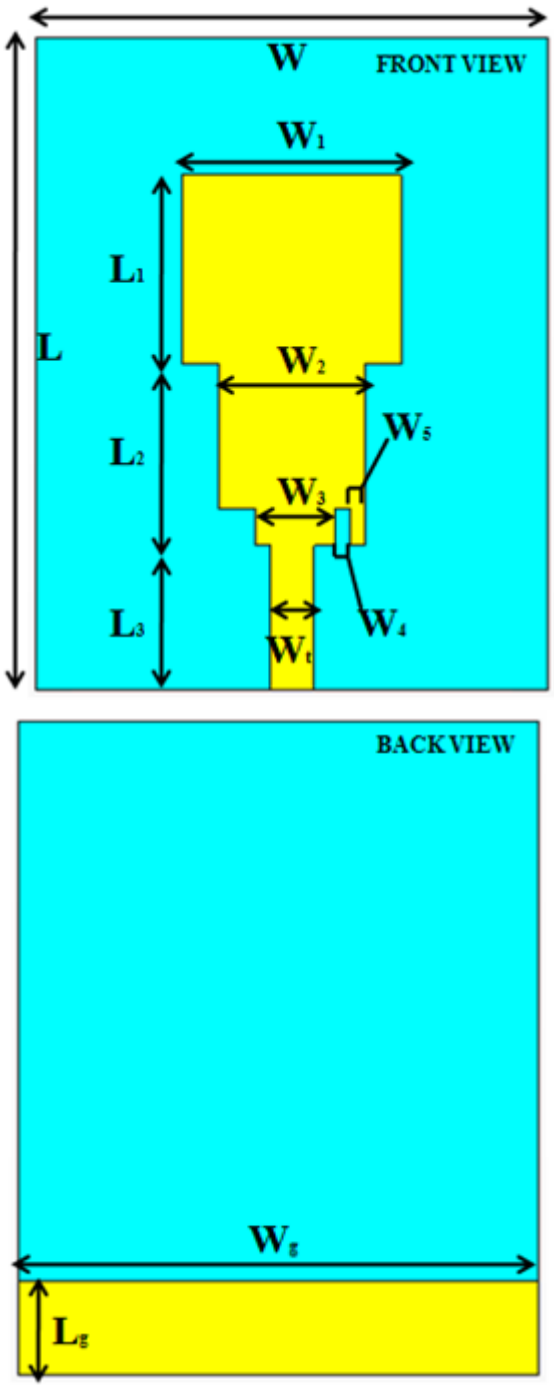

Figure 2: The optimized dimension for front and back view of the proposed antenna

Figure 3 shows that the optimized simulation result antenna simulation designed in the CST software with the measurement result that has been obtained by using network analyzer. From the simulation, the resonance frequency of the antenna design was obtained at 2.4 GHz with a return loss of the antenna is at -15.33 dB with bandwidth of the antenna designed was achieved at 466.89 MHz. Then, at 5.2 GHz the return loss that has been simulated was obtained about -19.798 dB with bandwidth of 903.26 MHz. Meanwhile, the return loss for the measurement has been shifted at 2.4 GHz with -15.78 dB and at 5.2 GHz with -13.14 dB. The return loss still remained below -10 dB.

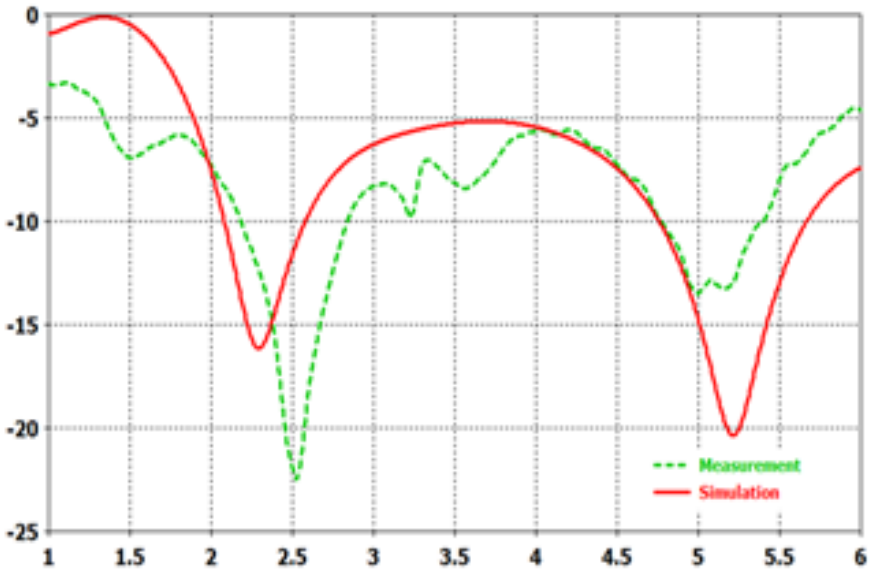

Figure 3: S-parameter simulation and measurement result comparison

Table 2 shows the simulated gain and directivity of the proposed antenna at 2.4 and 5.2 GHz. Both gain and directivity of the proposed antenna were increased as the desired frequency increased. The maximum gain and directivity of 3.81 dB and 4.226 dBi were found at the frequency of 5.2 GHz.

Table 2
Gain and Directivity

Parameter/Frequency	2.4 GHz	5.2 GHz
Directivity	2.240 dBi	4.226 dBi
Gain	2.190 dB	3.810 dB

Figure 4 shows simulated radiation pattern for resonant frequency for 2.4 and 5.8 GHz. The radiation patterns showed number 8 at the frequency of 2.4 GHz. Meanwhile, the radiation pattern had two unequal major lobes at an elevation angle of +40 and +140.

IV. CONCLUSION

In this paper, we have presented the design of monopole antenna with dual band capability for wi-fi application. The antenna has successfully designed and fabricated. The antenna was measured and the result showed that the improvement in return loss and bandwidth was successfully done. Although the results changed from the simulation, it was still inbounded by the minimum specification for antenna to operate. At the end, conclusion can be made that by introducing slits and truncated ground plane, the monopole antenna can be improved.

The design can be developed even further by finding out other methods that can significantly improve the performance. Another method to improve bandwidth such as using CPW for this design or similar was yet to be designed. Another material with better dielectric constant, such as Duroid also can be tested using this design. By introducing array to the design, the gain will increase theoretically.

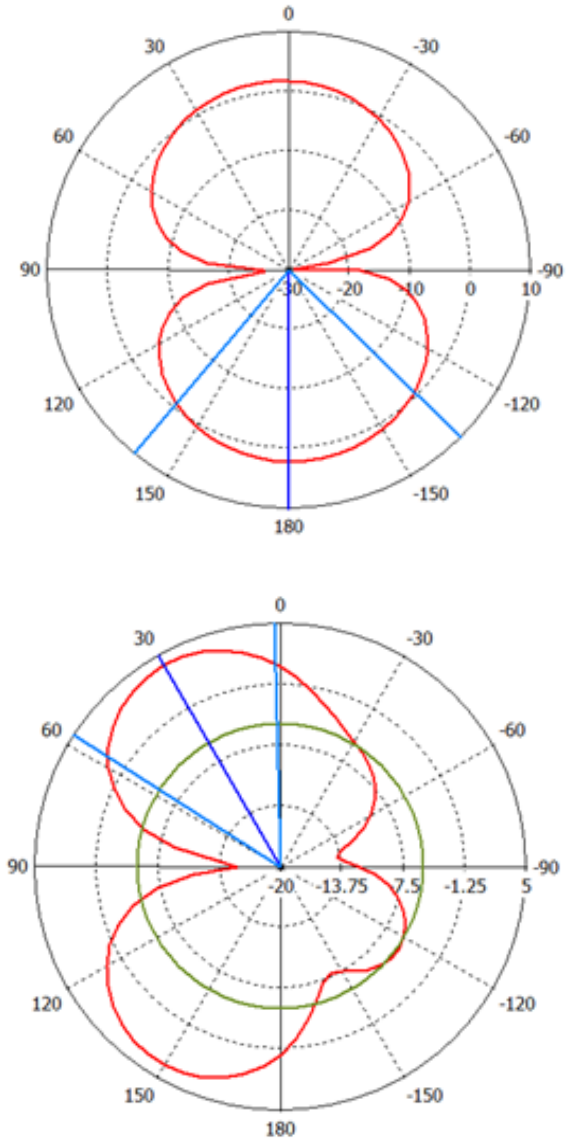

Figure 4: Simulated view of radiation pattern for 2.4 and 5.8 GHz

REFERENCES

[1] Ali, M. and Hayes, G. J., "Analysis of integrated inverted-F antennas for Bluetooth applications", in *Proc. IEEE-APS Conf. on Antennas Propagation for Wireless Communications*, Waltham, MA, 2000, pp.21-24.

[2] Burns, L. M. and Woo, C. L., "Dual orthogonal monopole antenna system", U.S Pat., 5 990 838, 1999.

[3] Kuo, Y. L. and Wong, K. L., "Printed Double-T monopole antenna for 2.4/5.2 GHz dual-band WLAN operations", *IEEE Transactions on Antennas and Propagation*, vol.51, no.9, 2003.

[4] Chen, F. and Peng, C.M., "Microstrip-fed dual U-shaped printed monopole antenna for dual band wireless communication applications", *Electron Letter*, vol.39, 2003, pp.955-956.

[5] Zhao, G. Zhang, F. S., Song, Y., Weng, Z. B. and Jiao, Y. C., "Compact ring monopole antenna with double meander lines for 2.4/5 GHz dual-band operation", *Progress in Electromagnetic Research*, PIER, vol72, 2007, pp.187-194.

[6] Hua-Ming Chenl and Yi-Fang Lin., "Printed Monopole Antenna 2.4/5.2 GHz Dual-band Operation", *IEEE transaction on antenna and propagation society international symposium*, vol.3, 2003, pp.60-33.

[7] Rathore, A., Nilavalan, R., Abu Tarboush, H. F. and Peter, T., "Compact Dual-Band (2.4/5.2 GHz) Monopole Antenna for WLAN Applications", West London, 2011.