DUAL BAND APERTURE COUPLED MICROSTRIP PATCH ANTENNA USING ELLIPTICAL APERTURE SHAPE

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ABSTRACT

A Wireless Local Area Network (WLAN) application nowadays has become more popular. Since it allows users to access network services without being attached to a wired infrastructure.Microstrip antenna has advantages that made them a perfect candidate for the wireless local area network (WLAN) applications. Nowadays, microwave frequencies in communication and radar applications were widely used and for that, certain antenna performance requirements are needed and should be an integral part of the design process. GPS (Global Positioning System), Wireless Local area network (WLAN) are the example of applications that share a common requirement in their antennas. They all require an antenna that is small in size and volume, low in cost and weight, easy to design, and can perform efficiently at two distinct frequencies that may be separated far apart. This paper describes on the design of dual band aperture coupled microstrip patch antenna using elliptical aperture shapes that operate at 2.4 GHz and 5.8 GHz These designs were simulated using Computer Simulation Technology (CST) software to gain simulation results and next, this antenna were tested with vector network analyzer. Both, simulated and measured data were compared.

INTRODUCTION

High speed, broadband and high capacity in indoor wireless local area networks (WLAN) are becoming more and more predominant today, it is interesting to become familiar with some of the aspects of wireless design that must be faced and overcome. The advantages of microstrip antennas have made them a perfect candidate for use in the wireless local area network (WLAN) applications.

The advantage of microstrip antenna has led this type of antenna to evolved and become popular among other antenna technologies in various applications in microwave systems. One example of microstrip antenna technology is aperture coupled microstrip patch antenna. The technology of aperture coupled microstrip patch antennas had been used widely in communication systems since last decade. Their main advantage that makes them preferable from microstrip line or probe fed patches is the ability to use separate substrates for the feeding network and the patch itself. In their usual structure, a patch printed on a low dielectric constant substrate is excited by an aperture in the ground plane which is in turn excited by a microstrip line printed on a separate substrate covering the other side of the ground plane. This configuration reduces the surface wave effects on the patch antenna, it enhances its bandwidth, and it is isolating the feeding lines spurious radiation and leaves more space for the feeding network. Other advantage makes that them very attractive for phased arrays application where phase shifters and/or power dividers must be incorporated in the feeding network.

Mathematical modeling of the basic microstrip radiator was initially carried out by the application of transmission-line analogies to simple rectangular patch fed at the center of radiating wall. The radiation pattern of a circular patch was analyzed and measurements reported by Carver [1]. The mathematical analyze of a wide variety of microstrip patch shapes was discussed in [2]. Modal-expansion technique was used to analyze various types of patch shapes such as rectangular, circular, semicircular, and triangular.

In this paper, a dual band aperture coupled microstrip patch antenna using elliptical aperture shape is proposed. This antenna will operate at 2.45 GHz and 5.8 GHz. The design of the antenna was performed using the CST Studio software.

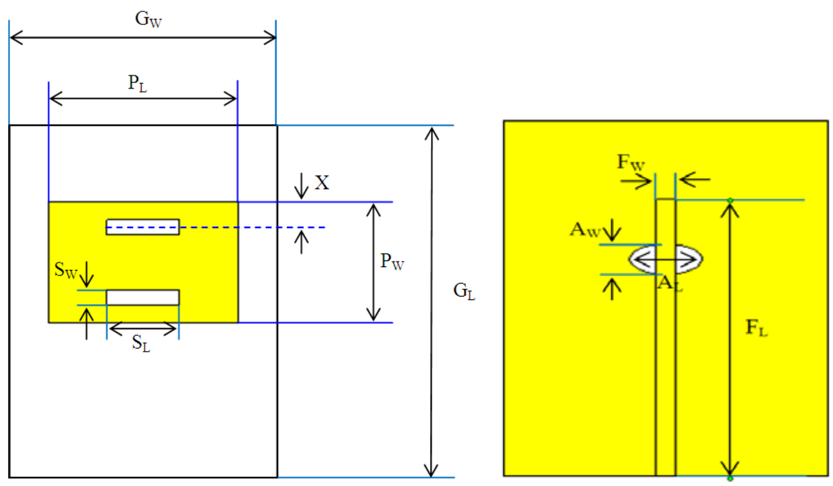
ANTENNA STRUCTURE AND DESIGN

A suitable and similar substrate must be chosen in order to provide a general platform for all structures to be simulated. In this paper, the chosen substrate is FR-4, which has a dielectric constant (ε_r) of 4.7, dielectric loss tangent (tanδ) of 0.019 and substrate height (h) of 1.6mm.

An antenna with elliptical aperture was designed which the patch dimension of that antenna were calculated based on the standard microstrip equation as in [3], to operate at 2.45 GHz. Within the patch, by cutting two slots parallel to coupling aperture, second resonance frequency at 5.8 GHz as in [4], [5] will be obtained. After that, all dimensions have been optimized using CST software. Table 1 and Figure 1 show the full dimension of designed antenna at 2.45 GHz and 5.8GH.

Table 1: Full dimension of both designed antennas

Parameter	**Parameter abbreviation**	**Dimension in (mm) of the designed antenna**
Ground & Substrates Length	G_L	70
Ground & Substrates Width	G_W	50
Patch Length	P_L	24
Patch Width	P_W	35.5
Slot Length	S_L	13.5
Slot Width	S_W	3
Distance from edge to slot center	X	5
Aperture Length	A_L	11
Aperture Width	A_W	6
Feed Length	F_L	54.5
Feed Width	F_W	3



(a) (b)

Figure 1. Full dimension of the designed antenna. (a) Patch antenna, (b) lower substrate of the designed antenna

1. SIMULATION AND MEASURMENT RESULTS

The simulated and measured numerical data of the dual band aperture coupled microstrip patch antenna for wireless LAN application are shown in Table 2 and Figure 2.

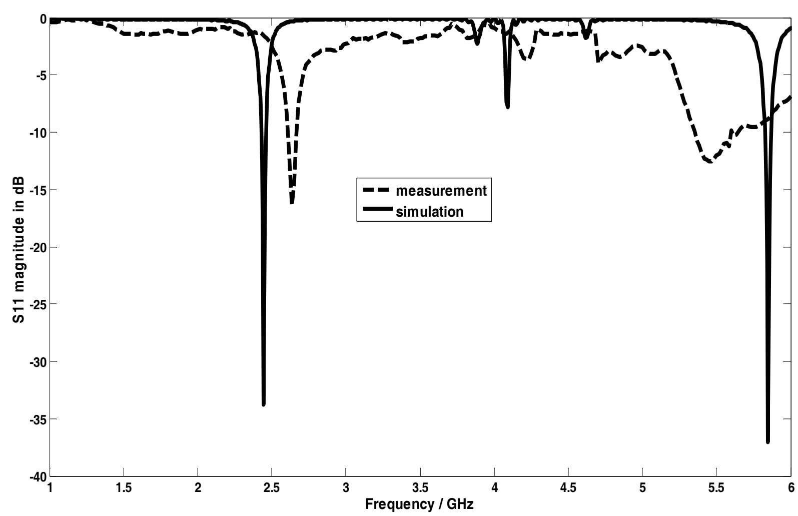


Figure 2. Measured and simulated return loss of the designed antenna.

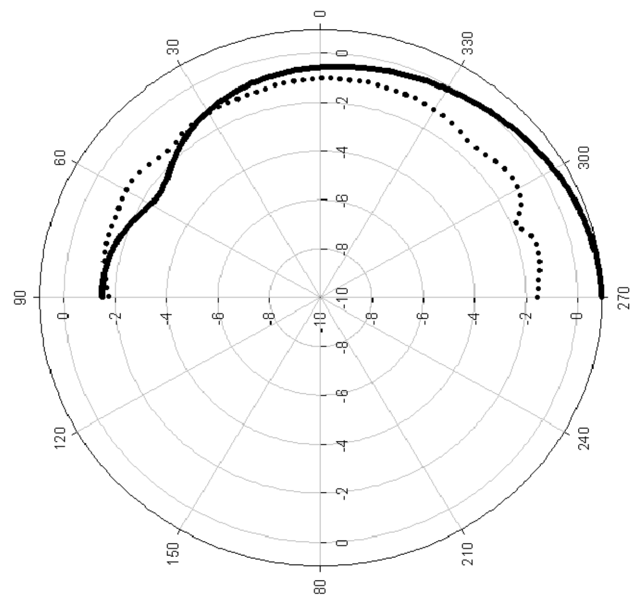
From the simulation and measurement results, the resonance frequencies are shifted from 2.446GHz and 5.8481 GHz to 2.63GHz and 5.46 GHz (0.184, and 0.3881 GHZ), and the bandwidth difference between the simulation and measurement results are 1.23% and 3.77 % at the resonance frequencies respectively. It shows that a good approximation of the designed and simulated.

Table 2: measured and simulated return loss, resonance frequencies, and bandwidth of designed antenna

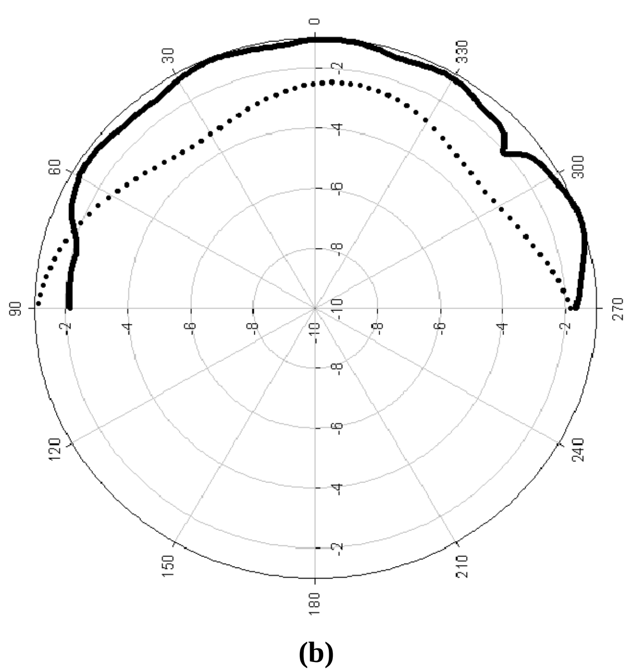
Model	**Dual resonance frequencies (GHz)**	**Return loss (dB)**	**Bandwidth (%)**

measured	2.63, 5.46	-16.38, -12.51	2.53, 4.5
simulated	2.446, 5.8481	-33.755, -37.064	1.30, 0.73

The radiation characteristics of the designed antenna were also investigated. Figure 3 and Figure 4 present the simulated and measured radiation pattern of the antenna for wireless LAN application at 2.45 GHz and 5.8 GHz respectively; the simulated and measured HPBW for E-plane are 88.1° and 72° at 2.45GHz respectively, and the simulated and measured HPBW for H-plane are 90° and 106° at 2.45GHz respectively. The simulated and measured HPBW for E-plane are 43.5° and 64° at 5.8 GHz respectively and the simulated and measured HPBW for H-plane are 60° and 106° at 5.8 GHz respectively.



(a)



(b)

Simulation
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Figure 3. Simulated and measured radiation pattern of the designed antennaat 2.45 GHz. (a) E-planeradiation pattern, and (b) H-planeradiation pattern

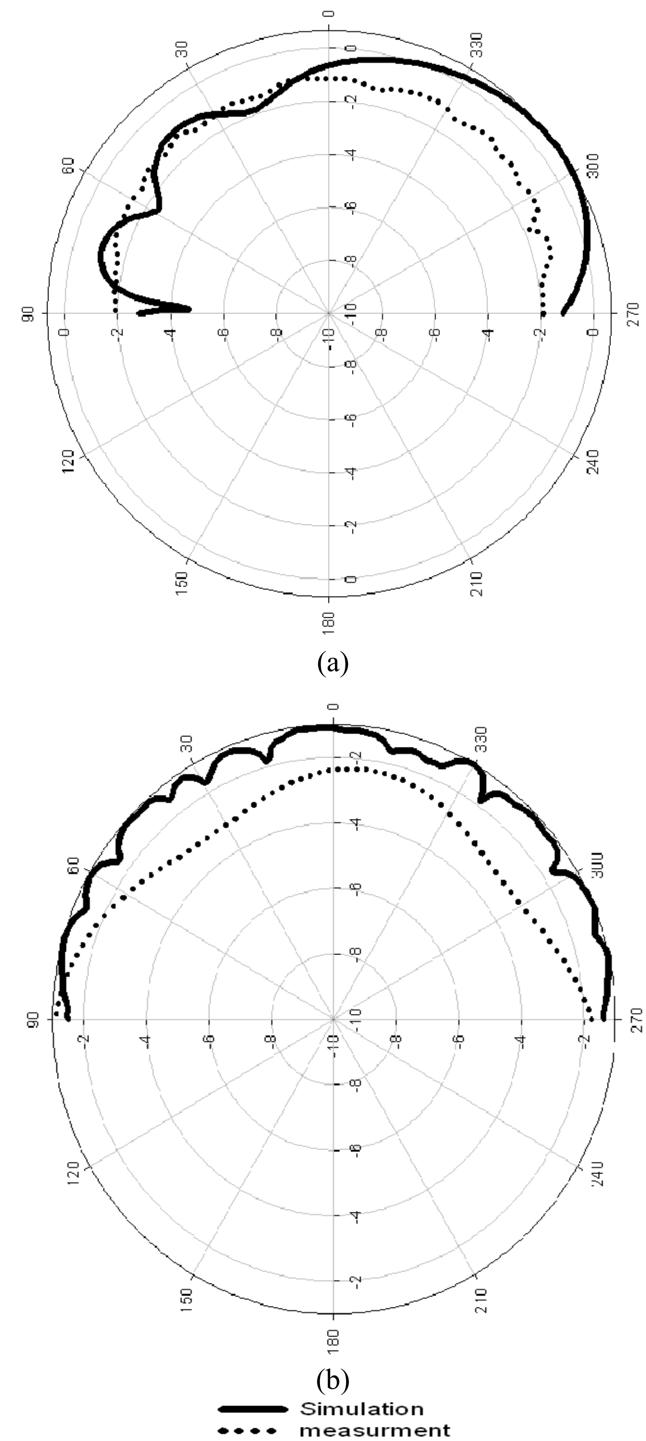

Figure 4. Simulated and measured radiation pattern of the designed antenna at 5.8 GHz. (a) E-plane radiation pattern, and (b) H-plane radiation pattern

DISCUSSION

The return loss graph shows that the resonant frequencies have shifted from the designed frequency for the designed antenna. This could be due to the FR-4 board, which has ε_r that varies from 4.0 to

4.9 which in simulation the value of ε_r was set at 4.7. Other reason why shifted value obtained is simulation software constraint; the constraint is that, the conductor is not easy to draw under the substrate. Since the aperture coupled antenna needs the feed to be on the same layer with the ground plane or the aperture, thus one more substrate is defined so that the feed can be drawn on the substrate.

In simulation, the design is ideal and no air gap exists between the patch and the ground plane. Practically, with the use of adhesive to glue the patch to the ground plane, the variation is more visible as the adhesive will affect the effective dielectric constant value and contribute some height to the gap. The other factors affecting etching accuracy such as chemical used, surface finish and metallization thickness also could be the reason for shifting the resonant frequency.

CONCLUSION

A dual band aperture coupled microstrip patch antenna using elliptical aperture shape was designed, simulated, fabricated and measured with the aid of Computer Simulation Technology (CST) software, vector network analyzer, and Anechoic Chamber. A comparison is made between simulation and measurement result. There are some shifted values between stimulated and measured values due to the error from value of ε_r of FR-4and CST software itself. Its dimensions return loss graph, and polar plots for radiation pattern has been presented and discussed in this paper. All variation issues on the design are discussed and the factors of the variation of the result are pointed out.

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