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An E-Shaped Microstrip Patch Antenna for IEEE 802.11a High Speed Wireless LAN Application

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***Abstract*— These A wireless communication system covering the 5.15 GHz to 5.825 GHz frequency band comes under high speed wireless local area networks (IEEE 802.11a standard). The 802.11a standard uses 5 GHz band which is cleaner to support high-speed WLAN. An E-Shaped microstrip patch antenna has been designed for this IEEE 802.11a, where two parallel slots are incorporated that is responsible for the excitation of second resonant mode at 5.8 GHz. Size of the center arm are changed to tune second mode without affecting the first resonant at 5.23 GHz. For optimization, parametric study is also done to understand the effect of various dimensional values on the antenna performance. A low dielectric constant material Duroid(tm) is selected to achieve the demanding specifications and the theoretical simulation is performed on HFSS simulation software.**

***Index Terms*—Microstrip Patch Antenna, High speed WLAN, WLAN, Resonant mode, Low dielectric.**

I. INTRODUCTION

Highlight Wireless Local Area Network (WLAN) is widely used worldwide. A license free band i.e. 2.4 GHz ISM band is used in IEEE 802.11b and IEEE 802.11g standards, therefore WLAN equipments suffer with high interference from all the devices using this band. A cleaner band that can support for high speed is IEEE 802.11a, which uses the 5GHz band. Although the frequency band used varies from one region to other but an 802.11a transceiver must cover the frequency range from 5.15GHz to 5.825GHz to get access of LAN in different parts of the world. Low-profile, light-weight, low-cost and ease of integration with microwave circuit's property of microstrip antenna makes it an ideal choice for such an application of LAN. However, a rectangular microstrip patch antenna has a drawback of narrower bandwidth, enhancement in the performance is necessary for demanding bandwidth.

A few approaches can be applied to improve the microstrip antenna bandwidth. These include use of air substrate [1], increasing the substrate thickness, introducing parasitic element either in coplanar or stack configuration, and modifying the shape of a common radiator patch by incorporating slots. The approach of shape modification can provide bandwidth improvement while maintain a single-layer radiating structure with antenna's thin profile characteristic. Some examples include E-shaped patch antennas [2–6], U-slot patch antennas [7], and V-slot patch antennas [8].

In this paper, an E-shaped microstrip antenna for IEEE 802.11a wireless LAN is designed to cover the 5.24–5.80 GHz frequency band. A parametric study has been carried out to understand the effects of various dimensional parameters and to optimize the performance of the final design. The theoretical simulations are performed using HFSS software.

II. ANTENNA DESIGN

First, a rectangular microstrip patch antenna is designed based on the standard design procedure to determine the length (L) and width (W) for resonant frequency at around 5.25 GHz. It is fed by a coaxial probe at position (xo, yo). Two parallel slots are incorporated to perturb the surface current path, introducing local inductive effect that is responsible for the excitation of a second resonant mode. The slot length (Ls), slot width (Ws), and the center arm dimensions (Wt and Lt) of the E shaped patch control the frequency of the second resonant mode and the achievable bandwidth. By introducing a second resonant mode at around 5.8 GHz, the coupling of the two resonant modes may form a wide bandwidth response covering the 5.15–5.825 GHz band. The antenna geometry is shown in Fig. 1.

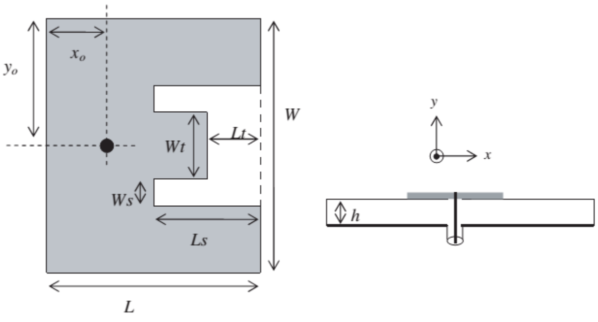

Figure 1. E-shaped microstrip patch antenna [9]

A common rectangular patch antenna can be represented by means of the equivalent circuit having L and C. The resonant frequency is determined by L_1C_1 as in fig 2(a). At the resonant frequency, the impedance of the series LC circuit is zero, and the antenna input impedance is given by resistance R. By varying the feed location, the value of resistance R may be controlled such that it matches the characteristic impedance of the coaxial feed. When a pair of slots is incorporated, the equivalent circuit can be modified. The

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second resonant frequency is determined by L_2C_2 as in fig. 2(b).

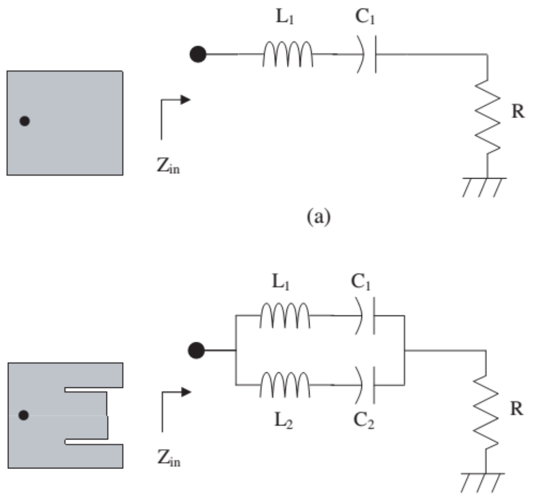


Figure 2. Equivalent circuit of (a) rectangular patch (b) E-shaped microstrip patch [9]

If the two series resonant frequencies are too far apart, the reactance of the antenna at the midband frequency may be too high and the reflection coefficient at the antenna input may be unsatisfactory. If the two series-resonant frequencies are set too near to each other, the parallel-resonant mode may affect the overall frequency response and the reflection coefficient near each of the series-resonant frequencies may be degraded. The question now is: how would the slot length, slot width, slot position and the length of center arm affect the values of L and C?

III. PARAMETER STUDY AND OPTIMIZATION

A substrate with dielectric permittivity of 2.2 and thickness of 3.2 mm is selected to obtain a compact radiation structure that at the same time meets the demanding bandwidth specification. It is fed by a 50-Ω SMA connector (with inner conductor and outer conductor diameters of 1.3 mm and 4.7 mm, respectively). The inner conductor is soldered on the top surface of the patch antenna while the outer conductor body is soldered to the ground plane. Simulations are performed using HFSS software. The four parameters Ls, Ws, Lt and Wt are set as variable and their effects are studied.

The slot width Ws is varied from 0.5 mm to 2.0 mm. and other antenna parameters are listed below (in mm):

L	W	h	x0	y0	Ls	Lt	Wt
17.2	20.0	3.2	5.2	10.0	10	2.8	6.2

The wider is the slot, the higher is the inductance L2. Hence, the resonant frequency of the second resonant mode decreases with wider slot. With a slot width of 0.5 mm, the frequency of the second resonant mode is too high and it gives rise to a dual-band antenna rather than a wideband antenna. With a slot width of 2.0 mm, the second resonant mode is too close to the fundamental resonant mode as shown in Fig 3.

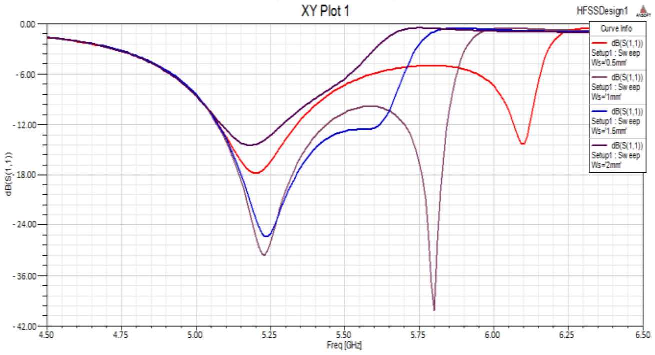


Figure 3. Simulated reflection coefficient for various Ws

The slot length Ls is varied from 09 mm to 11 mm. and other antenna parameters are listed below (in mm):

L	W	h	x0	y0	Ws	Lt	Wt
17.2	20.0	3.2	5.2	10.0	1.0	2.8	6.2

Increasing the slot length will increase the inductance L2 because the diversion of surface current around the slots will be more intensive. Hence, the frequency of the second resonant mode decreases, as shown in Fig. 4. For slot length longer than 9 mm, a small change in Ls will cause a big change in the second resonant mode.

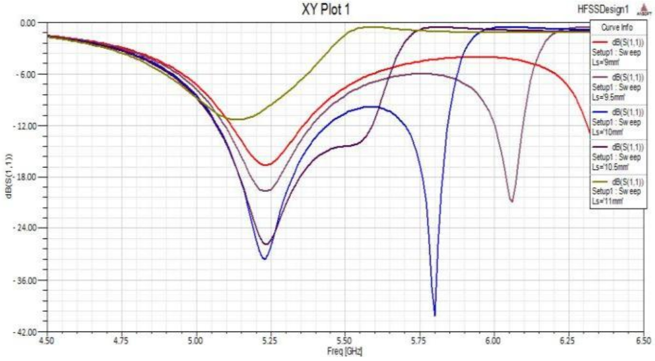


Figure 4. Simulated reflection coefficient for various Ls

The resonant frequency of the second resonant mode decreases when Wt is increased from 4.2 mm to 8.2 mm (with Ls = 10 mm, W s = 1.0 mm, Lt = 2.8 mm) as shown in Fig. 5.

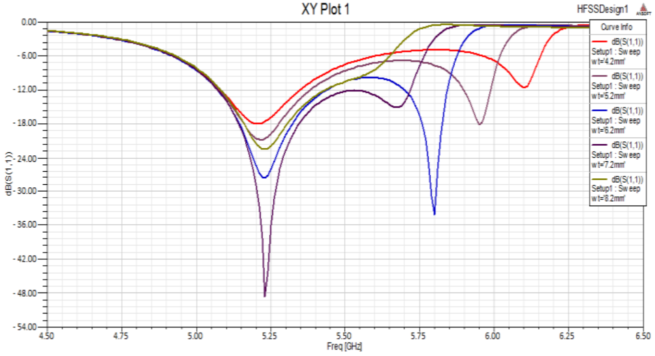


Figure 5. Simulated reflection coefficient for various Wt

As Lt is increased from 1.8 mm to 3.8 mm (with Ls = 10 mm, W s = 1.0 mm, W t = 6.2 mm), the frequency of the second resonant mode is increased as shown in Fig. 6.

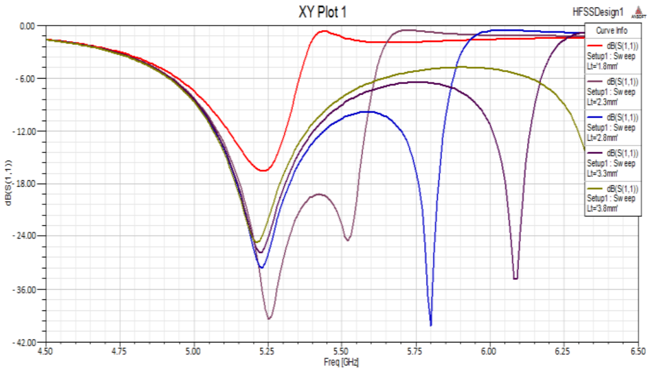


Figure 6. Simulated reflection coefficient for various Lt

As the bandwidth of a microstrip antenna is enhanced and at the same time some more important parameters like, radiation pattern, gain and directivity has to be maintained and here the directivity obtained is around 5.0 dB and gain value obtained is around 6.95 dB. The simulated results are shown below in Fig. 7(a) & (b).

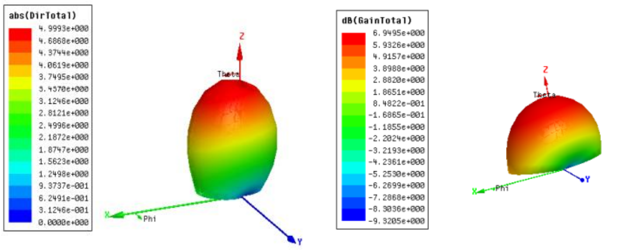
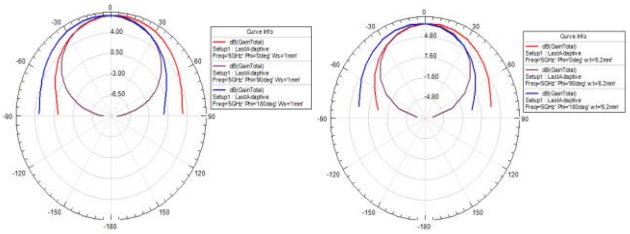
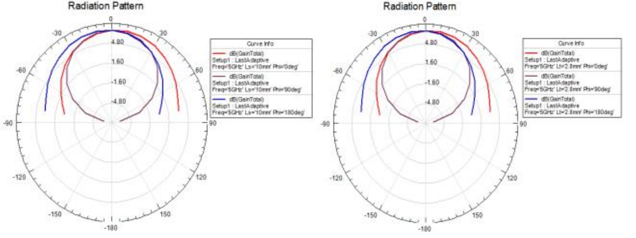


Figure 7. (a) Directivity and (b) Gain plots of proposed antenna

The radiation pattern for the optimized values of Ws, Wt, Ls and Lt are also measured at 5GHz and the simulated results are shown in Fig. 8 (a), (b), (c) and (d)



Gain for Ws = 1 mm *Gain for Wt = 6.2 mm*



Gain for Ls = 10 mm *Gain for Lt = 2.8 mm*

Figure 8. Radiation pattern for different parameters

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IV. CONCLUSIONS

The designed E-shaped antenna satisfies the demanding bandwidth specification to cover the 5.15 - 5.825 GHz frequency band as the reflection coefficient is below -10 dB from 5.05 – 5.85 GHz. At the same time gain, directivity is maintained and antenna is thin and compact with the use of low dielectric constant substrate material. The parametric study gives a very good idea of importance of various antenna dimensional parameters on the performance of antenna. The bandwidth of the designed antenna can be tuned by dimensional variation in center arm of the E-shape.

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