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Parametric Analysis Of Symetrical E-Shaped Microstrip Patch Antenna

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Abstract: The proposed work presents the design and analysis of an asymmetrical E-shaped microstrip patch antenna applicable in modern wireless communications. First, designed symmetrical E-shaped patch antenna and carried out a parametric analysis with respect to slot length, slot width and slot position. The obtained impedance bandwidth of optimized structure shows considerable improvement in the bandwidth when compared with rectangular patch antenna with acceptable radiation pattern. Typically, the antenna shows a wide-band impedance response with a bandwidth of 28.95% and gain 8.1 dBi. Finally, verified the performance variation with respect to impedance bandwidth of an asymmetrical E-shaped patch antenna by altering one of the slots length and length of side wings. The return loss characteristics for various slot lengths and side wing lengths are plotted.
Key words: patch antenna; E-shaped; notch; wide-band; wireless communications.

1. INTRODUCTION:

With the increasing demand of wireless communications, low profile wide-band antennas that can be integrated easily with rest of the RF systems have attracted many researchers [1, 2]. Patch antennas have narrow bandwidth, which leads to limited use of it in several practical applications. Numerous approaches have been made to ameliorate the bandwidth of the single-layer patch antennas, such as probe-fed U-slot patch antennas [3, 4], a pair of double bent slots [5], L-probe/L-strip coupled feed patch antenna [6], and E-shaped patch antennas [7–11].

In this paper, an attempt has been made to enhance the bandwidth of a probe-fed patch antenna on a thick air/foam substrate by incorporating two parallel slots at one of the radiating edges of a rectangular patch antenna and positioning it symmetrically with respect to the feed point. In the proposed model of the E-shaped patch antenna symmetrical and asymmetrical structures are designed and carried out parametric analysis with respect to slot length, slot width and slot position. Optimized structure is simulated to verify return loss and gain of the antenna. The antenna is designed and analyzed using full wave simulator HFSS.

2. DESIGN OF E-SHAPED PATCH ANTENNA:

The top view of the E-shaped patch antenna (ESPA) is shown in Figure 1. It has attractive features such as simplicity and small size, when compared with conventional wide-band microstrip antennas. A simple microstrip antenna can be modeled as a simple *LC* resonance circuit [2]. Current flows from the feeding point to the top and bottom edges of the patch. When two parallel slots are incorporated into the patch, the resonance feature changes. In the center wing, the current flows like a normal patch, and hence it represents the initial *LC* circuit and resonates at the initial frequency. The equivalent circuit is shown in Figure 2(a). However, at the two-side wings, the current has to flow around the slots, and the length of the current path is increased. This effect can be modeled as an additional series inductance ΔL. So, the side wing resonates at a lower frequency, and the equivalent circuit is modified as shown in Figure 2(b), where ΔC is the slot capacitance. Thus, the ESPA behaves as two resonant circuits. These two resonators are coupled through a coupling capacitor Cc [12], resulting into a wide bandwidth. The resulting equivalent circuit is shown in Figure 2(c). The values of different circuit parameters are calculated and then obtain

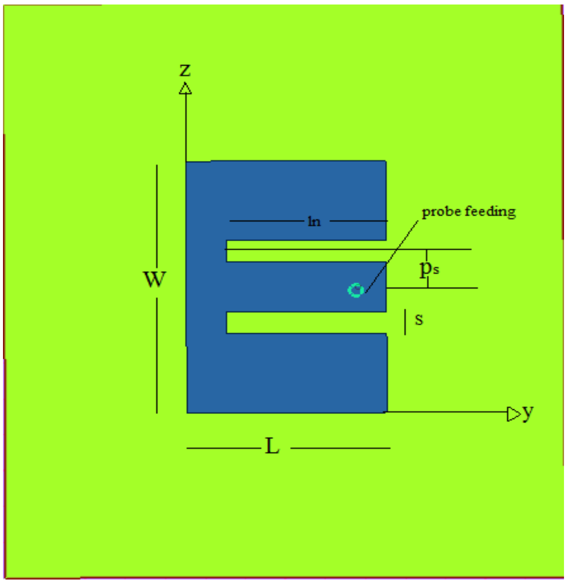


Figure 1: Top view of E-shaped patch antenna

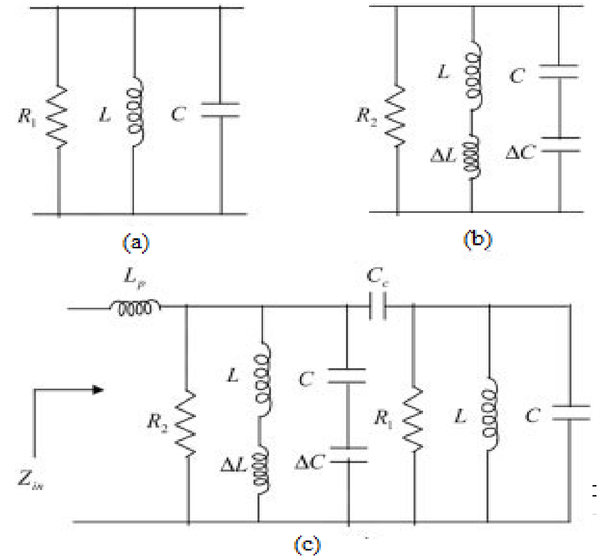


Figure 2: (a) Equivalent circuit of centre wing. (b) Equivalent circuit of side wing. (c) Complete equivalent circuit of E-shaped patch antenna

the input impedance to calculate the return loss in dB using the equation

$$RL = 20log|\tau|, \quad \tau = \frac{z_{in}-z_c}{z_{in}+z_c} \qquad (1)$$

Where τ is the reflection coefficient.

3. PARAMETRIC ANALYSIS OF SYMMETRICAL E-SHAPED PATCH ANTENNA:

In symmetrical E-shaped patch antenna slot length, slot width and slot position are symmetrical. The parametric analysis of the antenna is as follows. It is observed, from Figure 3, that for small slot length (l_n) the antenna has only one resonant frequency but as the slot length increases another lower resonant frequency appears. The lower resonant frequency decreases as slot length increases.

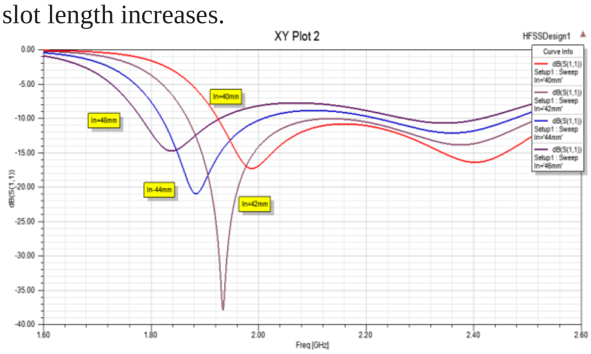


Figure 3: Variation of return loss with frequency for different slot length at p_n=10 mm and s =6 mm

From Figure 4, it is noted that the two resonant frequencies exist for all the three slot widths considered. For low value of slot width, the matching at higher resonant frequency improves, while at a lower resonant frequency the case is otherwise. Similarly, at high value of slot width, the matching at lower resonant frequency improves and degrades at higher resonant frequency. The best matching at both resonant frequencies is obtained at slot width s =6 mm.

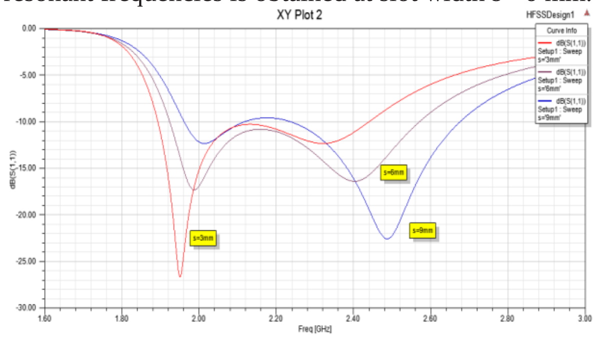


Figure 4: Variation of return loss with frequency for different slot widths at p_n=10 mm and l_n=40 mm

From Figure 5, it is observed that as the slot position (p_n) increases, the matching at two resonant frequencies improves and a wideband match is obtained. However, when p_n becomes even larger, the return loss between two resonant frequencies is higher than -10 dB and behaves as a dual band rather than a wideband antenna. Figure 6, shows the return loss of optimum symmetrical E-shaped patch antenna. Table I shows the design parameters of the designed symmetrical antenna.

Table:I Design Parameters of E-shaped Patch Antenna

L=50 mm	$l_n = 40$ mm
W=70 mm	p_n=10 mm
H=15 mm	$\epsilon_r = 1$
S=6 mm	$y_0 = 10$ mm

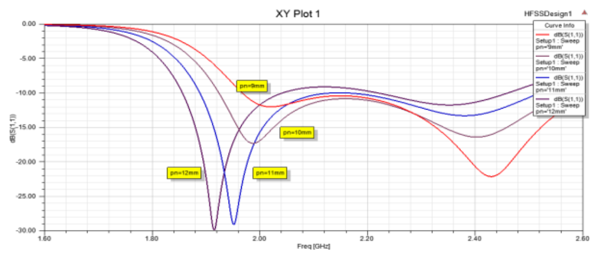


Figure 5: Variation of return loss with frequency for different slot positions at s=6 mm and l_n=40 mm

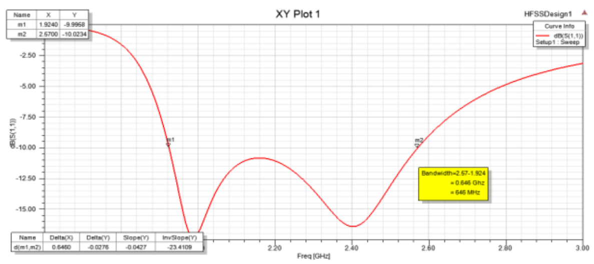
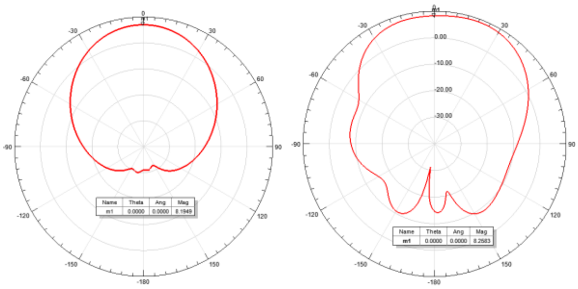


Figure 6: Variation of return loss with frequency for $l_n = 40mm$, s=6 mm and p_n=40 mm

Figure 7, shows the gain of the optimum E-shaped patch antenna.

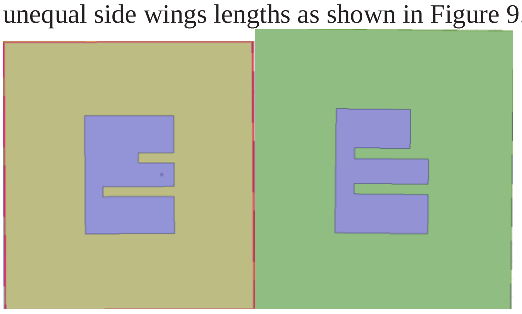


(a) E plane pattern (b) H plane patter

Figure 8: E plane and H plane radiation patterns

4. PARAMETRIC ANALYSIS OF ASYMMETRICAL E-SHAPED PATCH ANTENNA:

In asymmetrical E-shaped patch antenna parametric analysis is carried out with unequal slot lengths and unequal side wings lengths as shown in Figure 9.



(a) Unequal slot lengths (b) Unequal side wings

Figure 9: Asymmetrical E-shaped patch antenna

From Figure 10, it is observed that as upper slot length increases lower resonant frequency decreases with poor impedance matching and no significant variation in higher resonant frequency. The same performance reflected for variation of lower slot length.

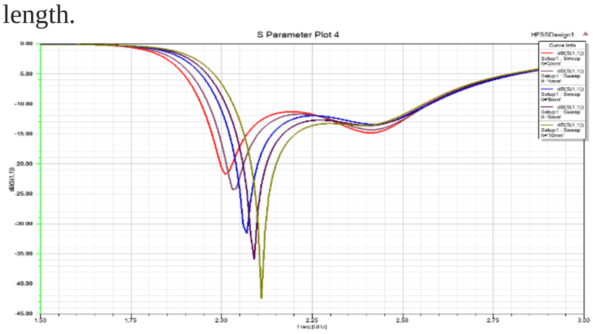


Figure 10: Return loss characteristics for various slot lengths

From Figure 11, it is noted that for smaller side wing lengths it resonant at single frequency and length increases resonant frequency decreases. If length increases further antenna is resonant at two frequencies with wide-band.

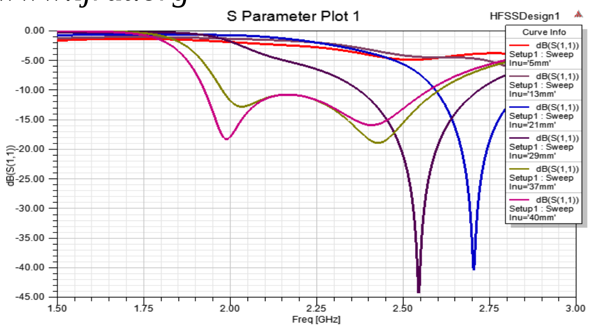


Figure 11: Return loss characteristics for various side wing lengths

5. CONCLUSION

Symmetrical and asymmetrical E-shaped microstrip patch antenna is presented and carried out parametric analysis with respect to slot length, slot width and slot position using full wave simulator HFSS. Designed optimum E-shaped patch antenna and simulated for return loss and E plane & H plane radiation pattern. The obtained impedance bandwidth response is wideband between the frequencies 1.92 GHz to 2.57 GHz and the gain is around 8.1 dBi.

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