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Dualband L-Probe Fed Rectangular Microstrip Antenna with Parasitic Element

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Abstract: Microstrip antenna has many advantages. However, Narrow Bandwidth is the major disadvantage of this antenna in practical applications. This study proposes and investigates a dualband rectangular microstrip antenna with parasitic element fed by L-probe. The aim of the proposed research is to achieve dualband by electromagnetically coupling the two patches where one is driven and the other is parasitic. An L-shaped probe feeds the driven patch. The impedance bandwidth achieved is 63.35%, centered at 9.981 GHz and 33.48% centered at 13.99 GHz with a return loss >-10 dB. The antenna gain for the operating frequencies within the impedance bandwidth is 6 dBi.

Key words: Microstrip antennas, bandwidth, L-probe feed, parasitic patch

INTRODUCTION

The major operational disadvantage of the microstip patch antenna is its inherently narrow impedance bandwidth of only a couple of percent. The bandwidth can be increased by increasing the height of the substrate but this leads to introduction of surface waves which are usually not desirable.

Also, the patch typically becomes difficult to match as the height of the substrate increases beyond a certain point (typically about 0.05 λ_0). When the patch is fed with thick substrate using coaxial probe, it results in a larger probe inductance appearing in series with the patch impedance. Lowering the substrate permittivity also increases the bandwidth of the patch antenna. However, this has the disadvantage of making the patch larger.

The two layer stacked patch arrangement can also improve the bandwidth but this will enlarge the vertical height of the antenna and increases the complexity in fabrication.

In this study, a new design is proposed where two electromagnetically coupled coplanar patches (Kumar and Gupta, 1984) are constructed where one is driven and the other is parasitic (Kumar and Gupta, 1985a, b; Pozar and Kaufman, 1987) placed on the same substrate.

The driven patch is fed by L-shaped probe feed (Guo *et al*., 1999, 2004). The impedance bandwidth of both single microstrip antenna and the proposed antenna are compared.

MATERIALS AND METHODS

Description of the antenna: The geometry of an L-shaped probe feed, broadband rectangular microstrip antenna with parasitic element is shown in Fig 1. A rectangular microstrip antenna having dimension L_1 x W_1 (Patch 1) has one gap-coupled parasitic patch of dimensions L_2 x W_2 (Patch 2), respectively.

Patch 1 is driven and patch 2 is parasitic. Patch 2 is coupled to the radiating edge of patch 1 with a gap spacings. The L-probe feed has a horizontal arm which is embedded within the substrate material. To avoid the fabrication complexity air/foam is used as the substrate. The top view of the proposed antenna is given in Fig. 2. The height of the substrate for the simple rectangular patch was 1.5 mm and it is increased to 6.6 mm for the proposed antenna. Figure 3 shows the model view of the proposed antenna.

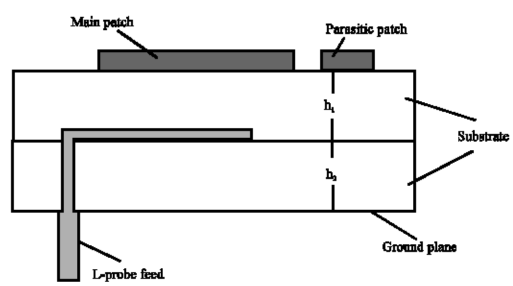

Fig. 1: Side view of proposed rectangular microstrip antenna

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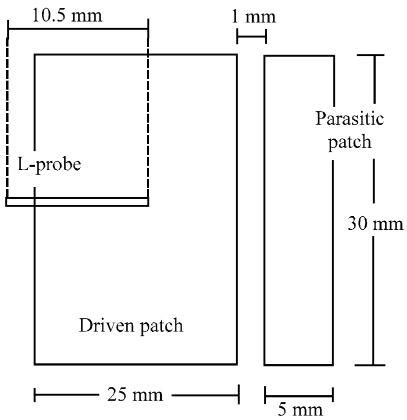

Fig. 2: Top view of the proposed rectangular microstrip antenna

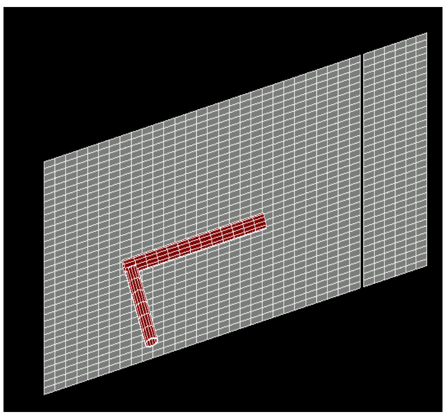

Fig. 3: Model view of the proposed antenna

Design of the proposed antenna: The proposed antenna is analyzed by Green's function approach and segmentation method (Gupta and Sharma, 1981; Kumar and Ray, 2003). In this approach, the antenna is considered as a multiport network. The outer periphery of the antenna is divided into number of small sections. The width of each section is so small that the field can be considered to be uniform. The coupling gap between the resonators is modeled as two-dimensional capacitive π-networks. The coupling gap is also considered as a segment in the segmentation procedure (Wu and Wong, 1999; Wood, 1980). To realize the reduction in resonant length of the L-probe patch, a two-layer configuration was conceived. By placing a microwave substrate in the region between the conducting patch and the L-probe, the air/foam between the ground plane and the L-probe, the size-reduction properties can be utilized without increasing the difficulty of fabrication. The dimensions of the proposed antenna is given in Table 1. The design procedure is outlined in the following steps:

Step 1: Calculation of the Width (W):

Table 1: Design details of the proposed antenna

Parameters	Design values in mm
W_1 (Patch 1)	30.0
L_1 (Patch 1)	25.0
W_2 (Patch 2)	30.0
L_2 (Patch 2)	5.0
s (gap spacing)	1.0
L_p (strip length)	10.5
h_1 (upper substrate height)	5.5
h_2 (lower substrate height)	1.1
h (Total height)	6.6
D_{Probe} (Probe dia)	1.0

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}} \quad (1)$$

Step 2: Calculation of Effective dielectric constant (ε_{reff}):

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r+1}{2}\left(1+12\frac{h}{W}\right)^{-0.5} \quad (2)$$

Step 3: Calculation of the Effective length (L_{eff}):

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad (3)$$

Step 4: Calculation of the length extension (ΔL):

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (4)$$

Table 1 shows the optimized design details of the proposed antenna. The basic broad banding concept of this antenna is electro-magnetic coupling of patches through L-probe feed (Guo *et al*., 2004). Also the main patch is electromagnetically coupled to the parasitic patch. The driven patch will dominate the higher resonant frequency while the lower is generated by electromagnetic coupling of parasitic patches.

The basic principle underlying the operation of this antenna is the capacitive coupling between the driven patch and the parasitic patches. The loading effect produced by the parasitic patches lower the Q, there by increasing the impedance bandwidth (Grag, 2000; Wong, 2002). The L-probe feed introduces a capacitance effect inducing a second resonance near the main resonance.

RESULTS AND DISCUSSION

A dualband rectangular microstrip antenna with parasitic patch fed by L-probe feed was constructed and

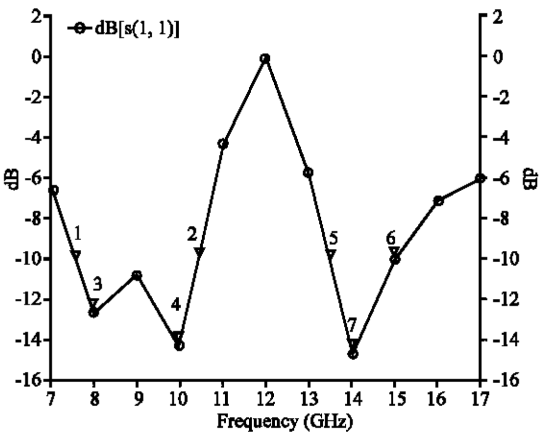

Fig. 4: Return loss of the proposed antenna

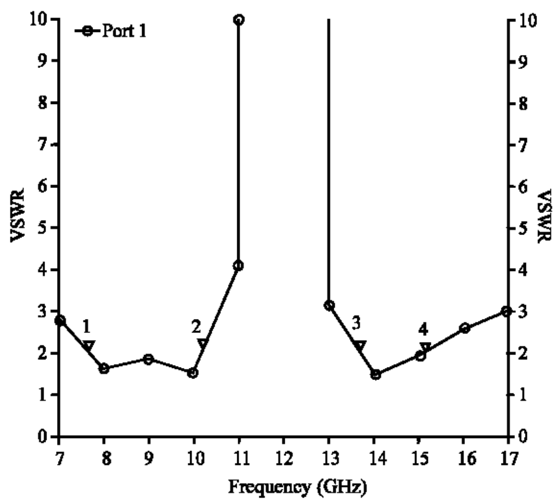

Fig. 5: VSWR of the proposed antenna

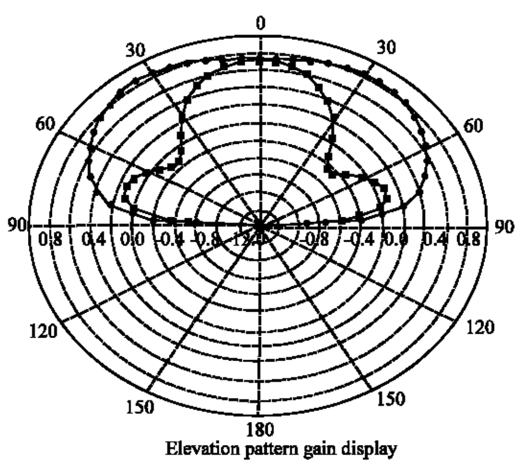

Fig. 6: Simulated 2D pattern of the proposed antenna

simulated using IE3D^{TM} antenna simulation software. The results of the proposed antenna are compared with the simple rectangular microstrip antenna. It is found that the impedance bandwidth of the constructed prototype is wider than that of the single microstrip antenna. Also, good impedance matching for the excited resonant modes can be achieved by placing a probe feed at a position along the centerline (x-axis) within the substrate. Figure 4 and 5 show the simulated return loss and VSWR of the proposed antenna, respectively. Figure 6 shows the 2D pattern of the proposed antenna. The gain was 5 dBi for the single patch and 6 dBi the proposed antenna.

CONCLUSION

The simulated results point out that the impedance bandwidth of linearly polarized rectangular microstrip antenna can be increased by including parasitic patch to the main patch by capacitive coupling along the radiating edge. The impedance bandwidth achieved is greater than that of a single rectangular patch. By having L-probe feed, dual resonance was achieved and adding additional resonator the impedance bandwidth was enhanced.

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