Design and Comparison of 4 Types of Dual Resonance Proximity Coupled Microstrip Patch Antennas

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Abstract ─ In this paper there are four different shapes of proximity patch antennas (straight, trimmed, trapezoid and ribbon). The minimum input match achieved with the straight proximity patch antenna as -39.68 dB. The maximum gain is achieved with the ribbon proximity patch antenna as 12.1 dB. Simulation and measurement results are presented. There is a perfect match with simulated and measured gain. The antenna is first demonstrated example of working with four different geometries, having satisfactory gain and input match.

Index Terms ─ bandwidth, gain, patch antenna, proximity, return loss, ribbon, trapezoid.

I. INTRODUCTION

The four antennas that will be explained in this article have a midband between 3.15 and 3.56 GHz and bandwidth of 0.19 and 0.23 GHz, which are typically used in various applications like military, satellite communications or wireless. This work explains the design and test of a proximity coupled patch antennas constructed from relatively high-quality dielectric material. Two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the other substrate [1]. The purpose of this work is to make a comparative study on the technique that helps to overcome the bandwidth constraint of microstrip patch antennas and to propose the better technique by taking different consideration such as the antenna gain, bandwidth and related issues [2]. Basic ideas about microstrip patch antenna, its working principle and important parameters have been discussed. The paper explained the analysis and designs a typical patch antenna that helps describing its narrow bandwidth problem as well. A paper shows improving the bandwidth of proximity coupled stacked microstrip patch antennas [3]. The results obtained clearly indicate the main factors that affect the bandwidth of a particular microstrip antenna are thickness of the dielectric substrate, the size of the metallic patch, the dielectric constant of the dielectric substrate, the feed type to be used (as seen in the non-contacting feed techniques) and the coupling level to some extent [4]. Aperture coupling is also used in [5] for this purpose. Most efficient part of the gain enhancement is maintained by changing the geometries of the slots [5].

II. DESIGN DETAILS

The work is done by using a high frequency electromagnetic simulator called Sonnet Suites [6]. The same software was used to simulate different types of microstrip patch antennas operating at 2.4 and 5.8 GHZ

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[7, 8].

In order to meet the required design specifications, important parameters need to be optimized. Better results could be obtained after several iteration steps. All antennas are placed on 290 x 290 mm box. The material used for the substrates is Rogers RT5880 (εr = 2.2). The thickness of the dielectric layers is used as 0.8 mm. Feeding line dimensions are 145.9 x 2.6 mm. Edge feeding is used.

A. The straight proximity patch antenna

The dimension of antenna is 27 x 39 mm. The minimum return loss was achieved with this antenna among all four antennas. The minimum return loss achieved is -39,68 dB and the maximum gain of 8.05 dB is achieved at 3.56 GHz. Table 1 has different proximity patch antenna geometries which are discussed below.

B. The trimmed proximity patch antenna

The trimmed antenna is a different form of the straight proximity patch antenna. Short sides are angled as 3° with both ways. 41.52 x 27.03 mm and 1,315 mm sliding are dimensions of this antenna. The minimum return loss achieved is -29,07 dB and the maximum gain of 8.25 dB is achieved at 3.52 GHz.

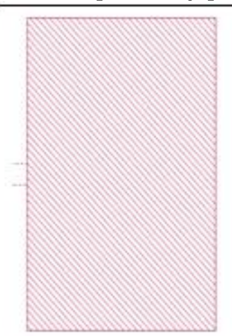
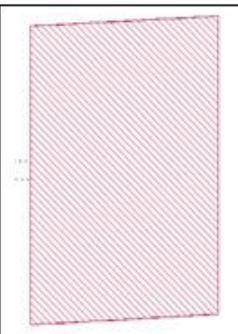
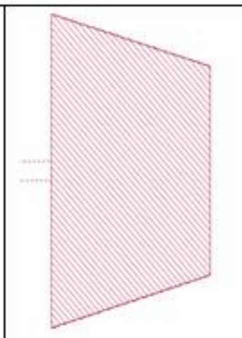
C. The trapezoid proximity patch antenna

The height of the antenna is 27 mm. Opposite sides of the antenna measures are 45 x 30 mm. The shape of the antenna is isosceles trapezoid. Isosceles zones both have 15° contraction. The minimum return loss achieved is -14.63 dB and the maximum gain of 7.98 dB is achieved at 3.448 GHz.

D. The ribbon proximity patch antenna

The maximum gain was achieved with this antenna among all four antennas. The maximum gain is 12,10 dB at 10.2 GHz. The minimum return loss achieved is -17.55 dB at 3.15 GHz. The height of the antenna is 27 mm and opposite edges of the antenna measures are 40 x 40 mm.

Table 1: Different geometries of proximity patch antennas

			
Type	Straight	Trimmed	Trapezoid
S-11	-39.68 dB	-14.63 dB	-29.07 dB
Gain	8.05 dBi	7.29 dBi	8.25 dBi
Frequency	3.56 GHz	3.52 GHz	3.309 GHz

The most important result about the ribbon proximity patch antenna is dual resonance. The ribbon proximity patch antenna has dual resonance with high gain. As it is seen in the literature, this kind of antenna has better solutions in communication. As seen in Fig. 1, input match of the ribbon antenna at 3.15 GHz is 17.55 dB and at 10.2 GHz is 14.96 dB. Figure 2 shows the current distribution of the ribbon antenna at 3.15 GHz. Figure 3 shows the current distribution of the ribbon antenna at 10.2 GHz. Figure 4 shows The ribbon proximity coupled patch antenna has a gain of 7.21 dB at 3.15 GHz at θ = 0° and it has also a gain of 12.10 dB at 10.2 GHz with θ = 0°. Figure 5 shows far field radiation pattern of the ribbon proximity coupled patch antenna which has a gain of 12.10 dB at 10.2 GHz with θ 0°.

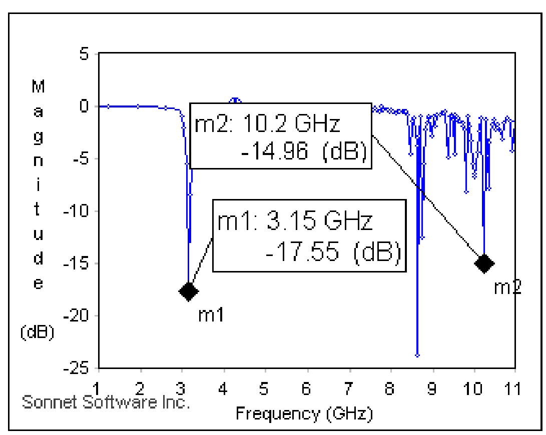


Fig. 1. Input match of the Ribbon Antenna.

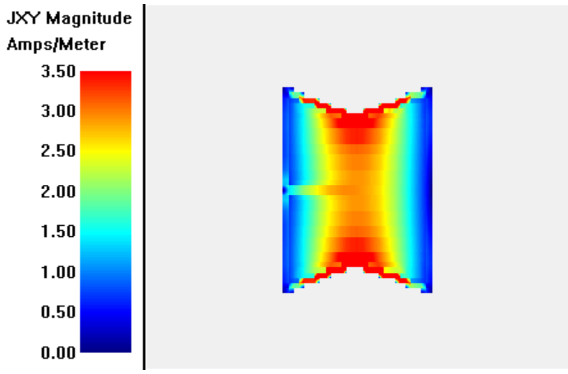


Fig. 2. Current dist. of the ribbon antenna at 3.15 GHz.

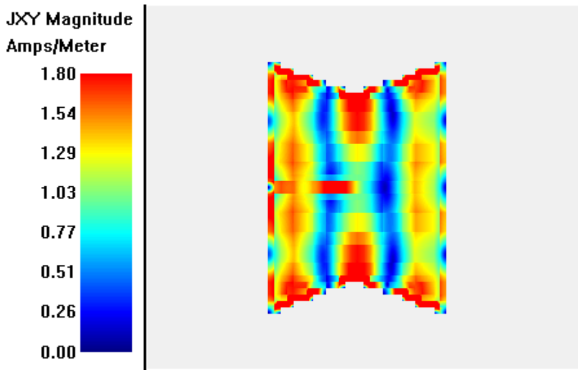


Fig. 3. Current dist. of the Ribbon Antenna at 10.2 GHz.

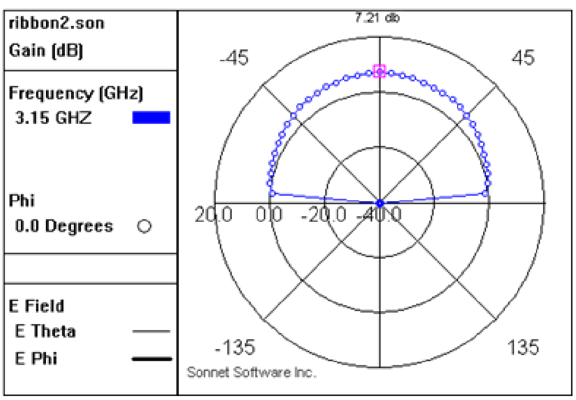


Fig. 4. Far field view of the Ribbon Proximity Coupled Patch Antenna, which has a gain of 7.21 dB at 3.15 GHz with θ = 0̊.

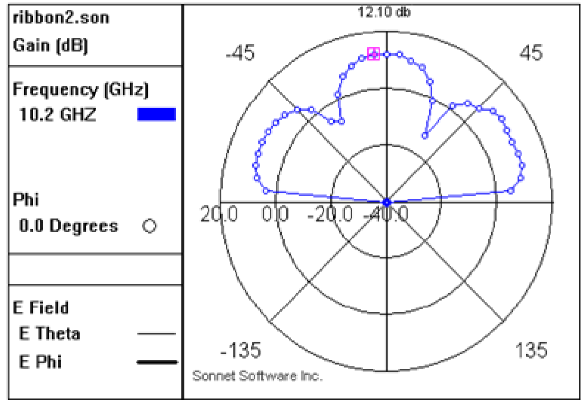


Fig. 5. Far field view of the Ribbon Proximity Coupled Patch Antenna, which has a gain of 12.10 dB at 10.2 GHz with θ=0̊.

III. RESULTS AND FABRICATION

The straight antenna was fabricated due to its easiest structure among others. Top view is in Fig. 6. Figure 7 shows the input match of the simulated and measured antenna. 3D view of straight antenna is in Fig. 8 and Fig. 9 shows the radiation pattern comparison of the simulated and measured antenna. There is only a small frequency shift between the simulated and measured input match. Furthermore, the gain has perfect match at ϴ = 0º.

Fig. 6. Top view of the fabricated antenna.

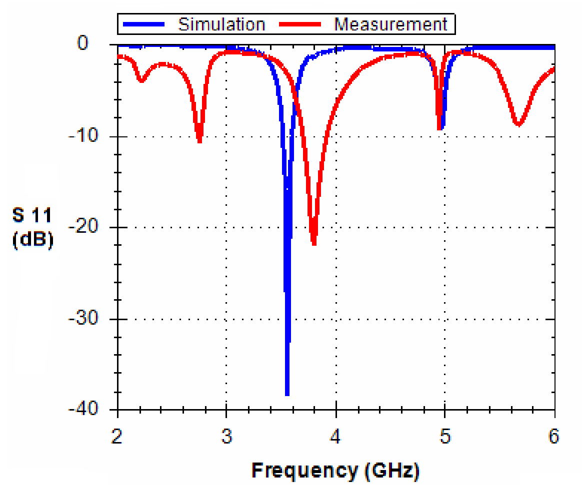


Fig. 7. Input reflection coefficient comparison of the antenna.

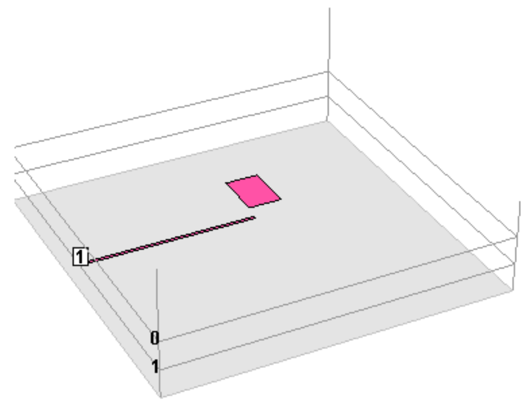


Fig. 8. 3D view of the Straight Proximity Patch Antenna simulated in SONNET.

Table 2 has a parametric study with variations of dielectric thicknesses.

Table 2: Thickness response of the ribbon patch antenna

DIELECTRIC THICKNESS mm.	FREQUENCY GHz	S-11 dB	GAIN dB
1.5	3.025 10.125	-21.67 -9.94	7.70 10.18
0.9	3.125 10.275	-16.74 -10.95	7.20 11.86
0.85	3.15 10.3	-14.003 -10.39	7.48 11.54
0.74	3.15 10.225	-15.86 -14.28	7.22 12.19
0.7	3.175 10.35	-15.19 -11.09	6.42 12.006
0.6	3.175 10.275	-18.23 -13.27	6.57 12.04
0.3	3.25 10.3	-26.09 -12.71	6.33 12.52

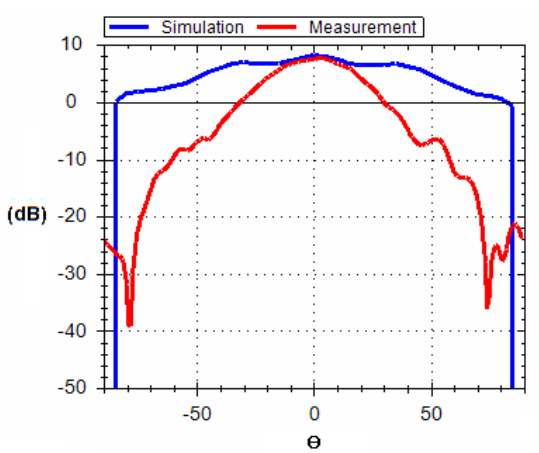


Fig. 9. Directivity gain of the proposed antenna.

IV. CONCLUSION

In this work, four different geometries of proximity coupled patch antenna were designed, simulated, fabricated and tested. Dual resonance has been achieved with the ribbon shaped proximity patch antenna.

The minimum return loss achieved is -39,68 dB with the straight proximity patch antenna at 3.56 GHz. The maximum gain is achieved 12.10 dB at 10.2 GHz with ribbon proximity patch antenna. Measurement result of straight patch antenna as follows: S11 = -21 dB at 3.79 GHz and Gain = 7.3 dB.

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