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WIDEBAND CO-PLANAR MICROSTRIP PATCH ANTENNA

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Abstract—A new antenna structure comprising a semicircular microstrip patch alongside a small rectangular shape ground proximity fed by a microstrip line is proposed. On a thin substrate this antenna achieves in the range of 5.8–12.9 GHz an impedance bandwidth of almost 75%. Details of the antenna design, simulation and measured results on the return loss and the E and H-plane radiation pattern of the proposed antenna are presented.

1. INTRODUCTION

The low profile, light weight and low cost of manufacturing of microstrip patch antennas have made them attractive for many applications. The modern trends in communication systems require wide bandwidth and small size, low profile antennas. Microstrip patch antennas on a thin dielectric substrate inherently have the disadvantage of narrow impedance bandwidth. To increase the bandwidth of a single layer microstrip patch antenna several configurations have been proposed by researchers such as placing parasitic patches on the same layer with the main patch [1], chip resistor loading [2], E-shaped patch [3], placing a U-slot on the patch [4], planer microstrip fed tap monopole antenna [5], rectangular slot antenna with patch stub [6], Vivaldi antenna [7] and square ring patch with shorting posts [8]. Majority of these works carried out are based on relatively thick substrates. Indeed, there are many different methods proposed in the literature to tackle the narrow-band width problem, [9–11] none of which uses thin substrate to achieve wide bandwidth performance.

In this paper, a low profile microstrip patch antenna is proposed. Unlike the usual method of placing the patch antenna on top of a ground plane, the patch is placed along side a small rectangular ground co planar to it. The thickness of the substrate used is approximately 0.02λ (1.6 mm). The size of the ground and the radius of the patch and their relative position are optimized to achieve a wide bandwidth. The optimized antenna structure achieves in the frequency range of 5.86–12.86 GHz an impedance bandwidth of almost 75%. E and H-plane radiation patterns shows slight tilt in the main beam position but the patterns are almost unchanged in the operating band. The achieved performance has been validated by the measured return loss and radiation patterns.

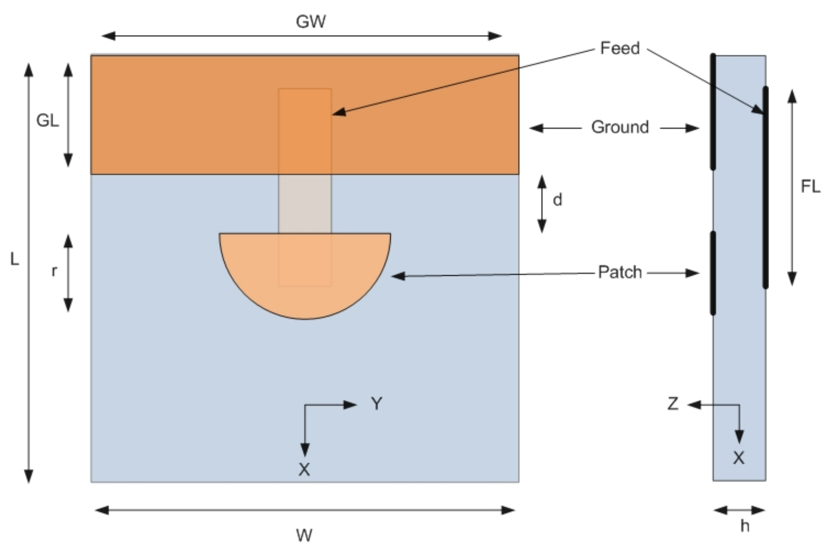

Figure 1. Geometry of the proposed antenna.

2. ANTENNA GEOMETRY

The geometry of the proposed antenna is shown in Fig. 1, where a semicircular patch with radius $r = 6$ mm is placed co-planar to a finite ground plane that has a rectangular shape with size of $GW = 30\,\text{mm} \times GL = 10\,\text{mm}$. The dielectric substrate used is FR4 of dimension $30 \times 30\,\text{mm}^2$ with thickness $h = 1.6\,\text{mm}$. The separation distance between the patch and the ground is $d = 2\,\text{mm}$. The patch is proximity fed by a $50\,\Omega$ microstrip line with line length and width $FL = 10\,\text{mm}$ and $FW = 3\,\text{mm}$, respectively. The top and bottom views of the fabricated antenna are shown in Fig. 2.

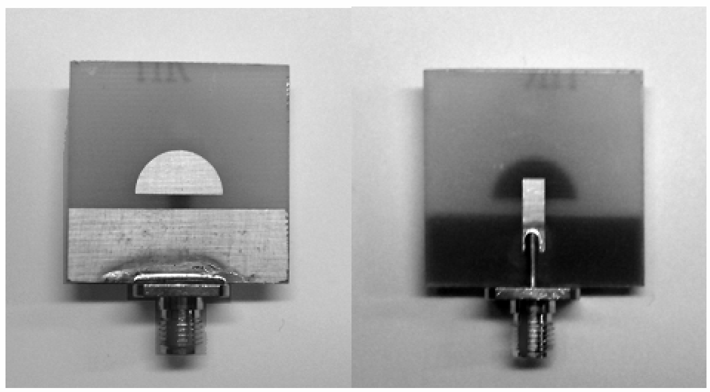

Figure 2. Top and bottom views of the proposed antenna.

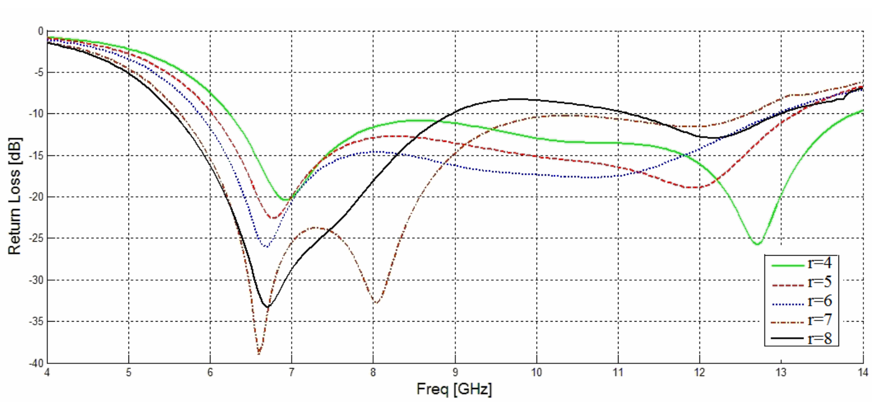

Figure 3. Return loss of the antenna with changes in patch radius, r.

To obtain a good impedance match the end of the feed line has to extend beyond the centre of the patch. Initially, several different simple shapes for the patch antenna was used but in order to minimize the size of the patch and at the same time maximize the bandwidth it was found that a semicircular patch and an optimized geometry of the whole structure (the ground plane dimension, separation between the patch and the ground and feed line position) gives the best possible impedance bandwidth.

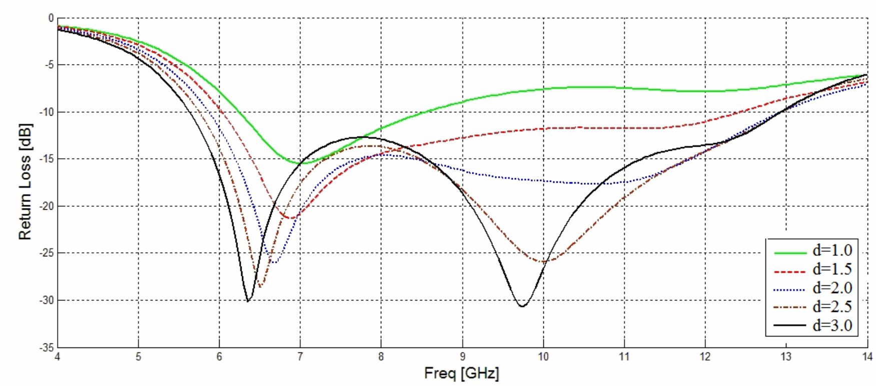

Figure 4. Return loss of the antenna with changes in separation between patch and ground plane, d.

3. SIMULATION AND MEASUREMENT RESULTS

The antenna performance was investigated both by simulation via a commercially available finite element program, HFSS, and through measurement. In order to provide design criteria for the proposed antenna, the effects of each geometrical parameter are analyzed. The antenna dimensions r, d, GW, GL, and FL are initially set at 6, 2, 30, 10 and 10 mm, respectively, and then one parameter is changed at a time while the others are kept constant. Fig. 3 shows the simulated return loss of the antenna with various patch radiuses, r. It can be seen that with increase in patch size, the frequency of operation decreases. Fig. 4 shows the simulated return loss with various patch to ground plane separation, d. By increasing d, the coupling between the patch and the ground reduces and the antenna shows a wider bandwidth and a better return loss magnitude. The simulated return loss with various ground plane width, GW are shown in Fig. 5 where it can be seen that the higher width gives a broader bandwidth as well as a lower return loss magnitude. The effect of ground plane length is shown in Fig. 6. The proposed antenna is sensitive to GL and in fact broadband performance is obtained for $GL = 10$ mm. It is known that in proximity fed patch antennas the position of the feed line under patch is important. Fig. 7, shows the effect of the feed line length, FL. For $FL = 10\,\text{mm}$ the highest bandwidth with good return loss is noticeable.

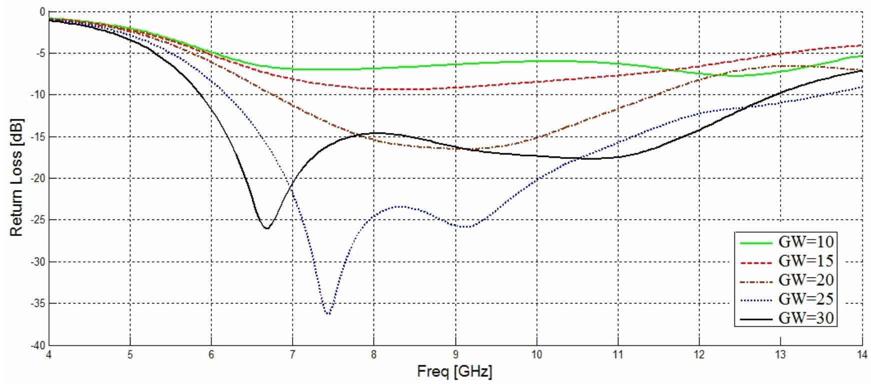

Figure 5. Return loss of the antenna with changes in ground plane width, GW.

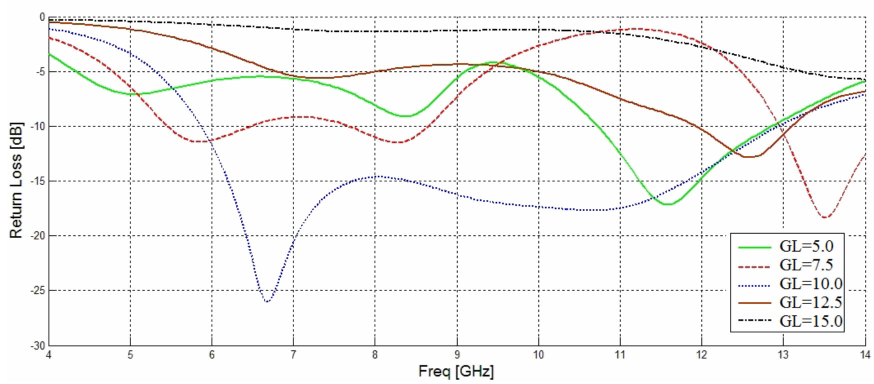

Figure 6. Return loss of the antenna with changes in ground plane length, GL.

Based on the best results of above figures, antenna dimensions were chosen and a prototype of proposed antenna was fabricated. Fig. 8 shows both the simulated as well as the measured return loss where close agreement between the two is in evidence. From this figure, the simulated result shows around 75% of bandwidth while the measured result shows 73%. As a comparison, the same semicircular patch as that of Fig. 1 with $r = 6$ mm if placed on top of a grounded dielectric shows a resonance frequency of 12.44 GHz with 6.5% impedance bandwidth.

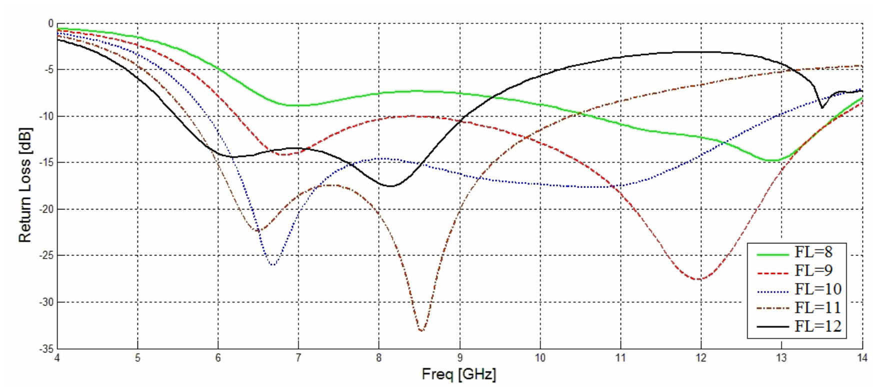

Figure 7. Return loss of the proposed antenna with changes in feed line length, FL.

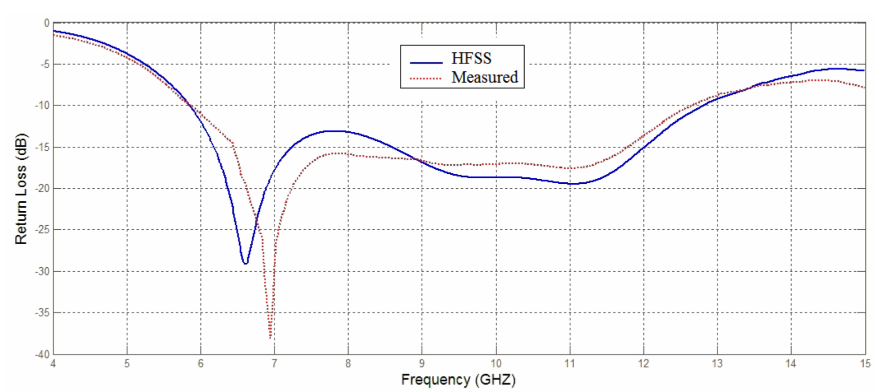

Figure 8. Simulated and measured return loss of the proposed antenna with: $r = 6$ mm, $d = 2$ mm, $GW = 30$ mm, $GL = 10$ mm, $FL = 10$ mm, $h = 1.6$ mm.

Figures 9 to 11 shows the measured radiation patterns for the E and H-plane pattern including both Co- and Cross-polarization of the co planar patch antenna at three different frequencies 6.0, 9.0 and 11.5 GHz in the pass-band. Fig. 10 shows the simulated and measured radiation patterns at 9 GHz for E-plane and H-plane pattern. The

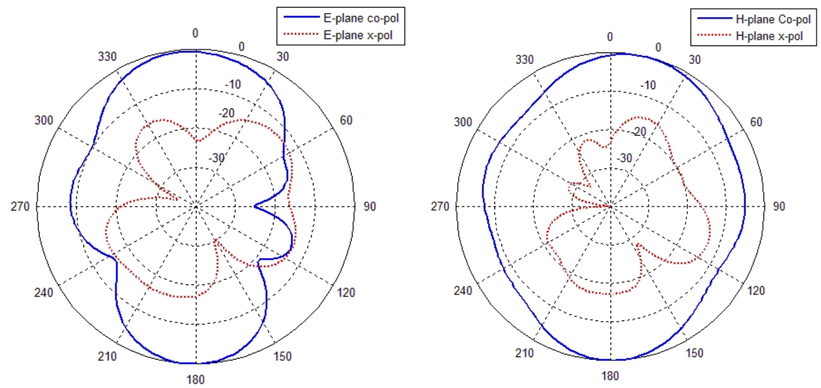

Figure 9. Measured E- and H-plane radiation pattern at 6 GHz.

simulated and the measured patterns agree well at all frequencies. The patterns are bi-directional and are almost stable across the impedance bandwidth. The cross polarization level is quite low. The distorted radiation pattern in the higher frequency is caused by the unequal phase distribution on the antenna aperture and increased magnitudes of higher order modes [12].

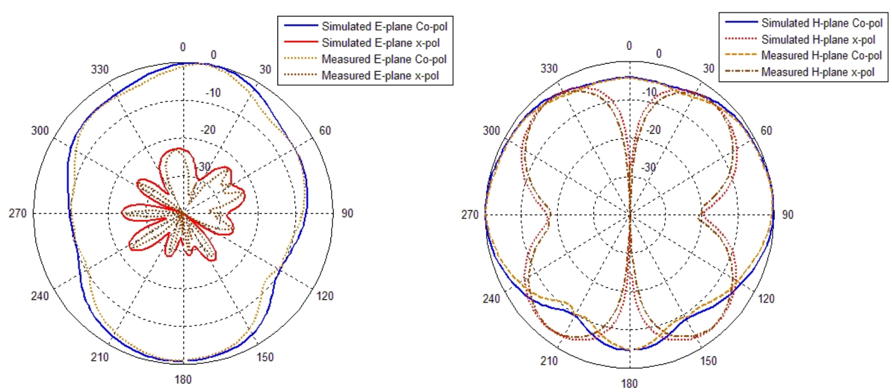

Figure 10. Measured and simulated E- and H-plane radiation pattern at 9 GHz.

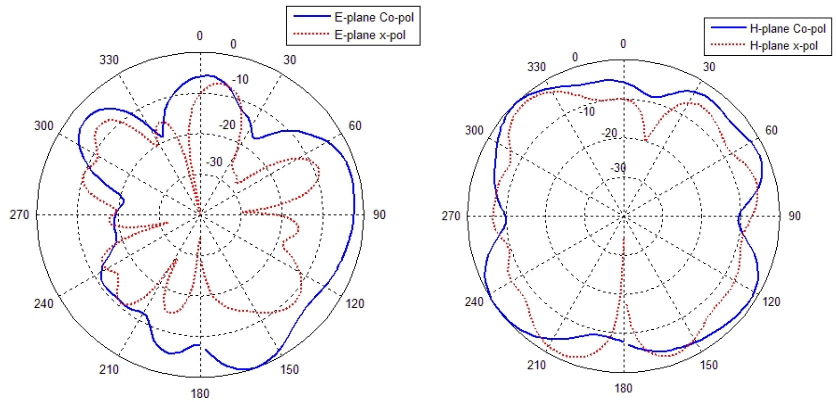

Figure 11. Measured E- and H-plane radiation pattern at 11.5 GHz.

4. CONCLUSION

In this paper a co-planar microstrip patch antenna with wide bandwidth behavior has been proposed. Simulated as well as measured results are presented for a semicircular shape patch antenna. Compared with other microstrip patch antennas of high bandwidths this proposed structure has the attractive features of low profile, smaller patch size and being simple to design. Optimization of the structure gives 73% impedance bandwidth with reasonable bidirectional patterns suitable for many applications.

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