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Analysis of Different Shapes of Radiating Patch and Ground Plane Wideband CPW - Fed MSA

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ABSTRACT
Various Coplanar Waveguide fed microstrip antennas with different ground planes and different radiating patches for broader bandwidth are proposed. The effect of changing periphery of the radiating patch from square to pentagon, pentagon to hexagon, hexagon to octagon and octagon to circle on resonance curve is studied. Similar study has been done by changing the shape of ground plane.

Keywords
CPW – Fed antenna, pentagonal slot, hexagonal slot, octagonal slot, different shaped radiating patches, broadband MSA.

1. INTRODUCTION
Due to features ease of integration with monolithic microwave integrated circuits (MMIC's), low radiation loss, less dispersion, broad bandwidth, etc., the interest in co-planar waveguide feed system is increasing over the last years [1]. The ground plane and radiating patch is on the same side of the substrate, hence the name Co-Planar Waveguide. One of the main problems with CPW fed slot antennas is to provide an ease of impedance matching to the CPW line. In order to obtain broadband CPW-fed slot antennas, several impedance matching techniques have been reported viz., change of slot dimensions in bow-tie slots [1 – 3], a use of wide rectangular slot [4 - 5], coupling mechanism including inductively-coupled slot [6], dielectric resonator coupling [7], and other techniques such as harmonic control used by photonic band-gap (PBG) [8]. However, bandwidth realized in CPW-fed slot antennas is generally less than 60%. In [9], analysis of different shapes of ground plane and different shapes of radiating patches have been reported, wherein, square slot is used with square, pentagonal, hexagonal, octagonal and circular radiating patch. Same procedure is repeated with circular slot. In this extended version, further study has been done using IE3D [10], considering pentagonal slot, hexagonal slot and octagonal slot with different shapes of radiating patches.

2. ANTENNA DESIGN
The geometry of different shaped radiating patches backed by pentagonal slot ground plane is shown in Fig. 1(a – e). The side length of pentagonal slot, i.e. L_p is selected such that the area of pentagon and that of square slot and circular slot in [9] remains the same, i.e. 1936 mm^2. The area of radiating patches is also kept same, i.e. 792 mm^2. The rest of the dimensions, as shown in Fig. 1(a) are L = 72 mm, Ls = Ws = 44 mm, Ws= 6.37 mm, H = 14.5mm and s = 0.5 mm, which are kept same throughout the analysis.

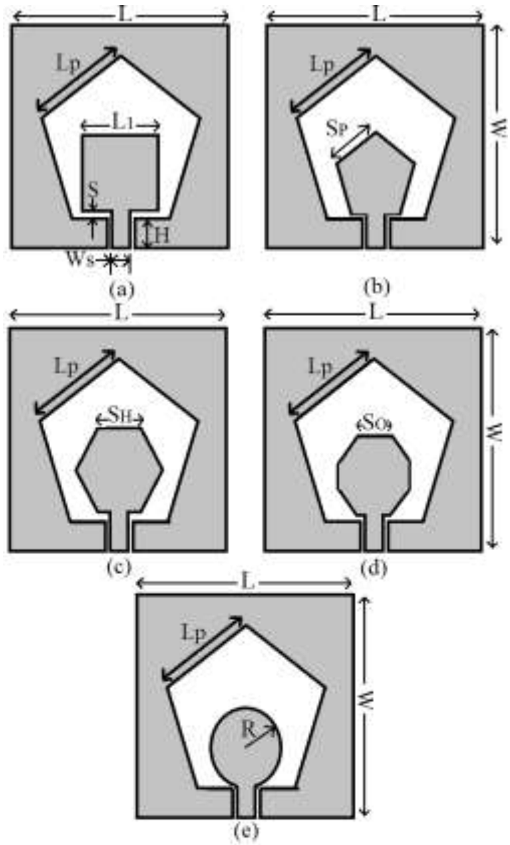

Fig. 1 (a – e): Different shapes of radiating patches backed by pentagonal slot ground plane

The effect of different shaped radiating patches in same pentagonal slot on resonance curve and return loss plot is shown in Fig. 2 and Fig. 3. It is seen that the frequency of lower order resonant modes remains more or less same for all the radiating patches, concluding that these modes are governed by the same shape of the ground plane. However, the frequency of higher order mode experiences a shift, concluding that this mode is governed by the different shaped radiating patches. The impedance of lower modes is also more or less same, however it decreases are the higher order mode, highest for pentagonal radiating patch and lowest for circular radiating patch, indicating an impedance match as the shaped of the radiating patch approaches circle from pentagon.

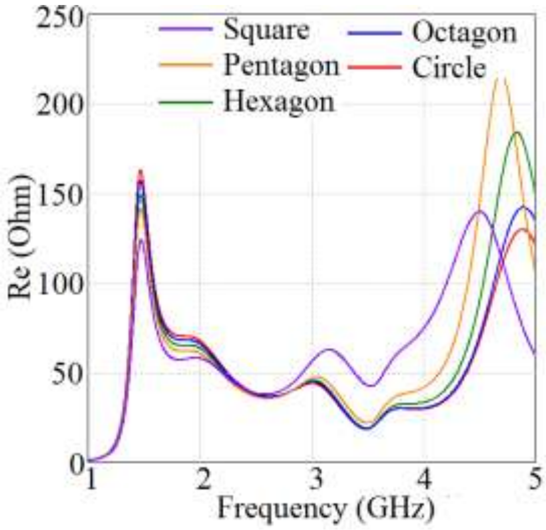

Fig. 2. Effect of different shaped radiating patches backed by pentagonal slot ground plane on resonance curve

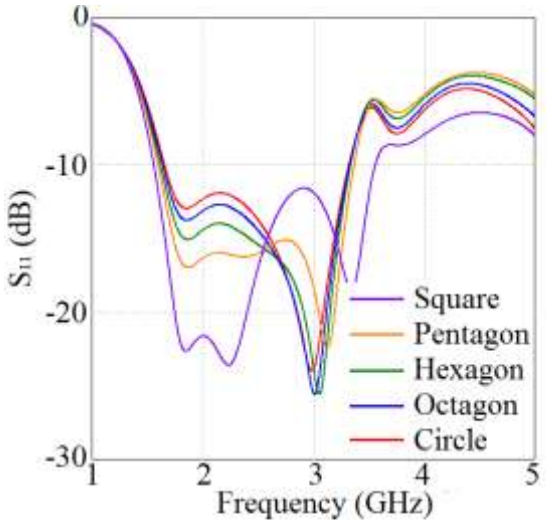

Fig. 3. Effect of different shaped radiating patches backed by pentagonal slot ground plane on return loss plot

At the use of square radiating patch, however, impedance matching of around 50Ω is observed between 3GHz – 3.5GHz. Because of this matching, return loss in this frequency range decreases below -10dB, making the square patch backed by square slot ground plane an optimum design compared to other shapes, giving a simulated bandwidth of around 1.9GHz. Next, the analysis is repeated for hexagonal slot ground plane. Different shaped radiating patches are backed by hexagonal slot ground plane as shown in Fig. 4(a – e). The side length of the hexagon L_h is chosen such that the area of hexagonal slot equals the area of pentagonal slot i.e. 1936 mm^2. All other dimensions are kept same. Here also, same radiating patches are kept within and effect is observed.

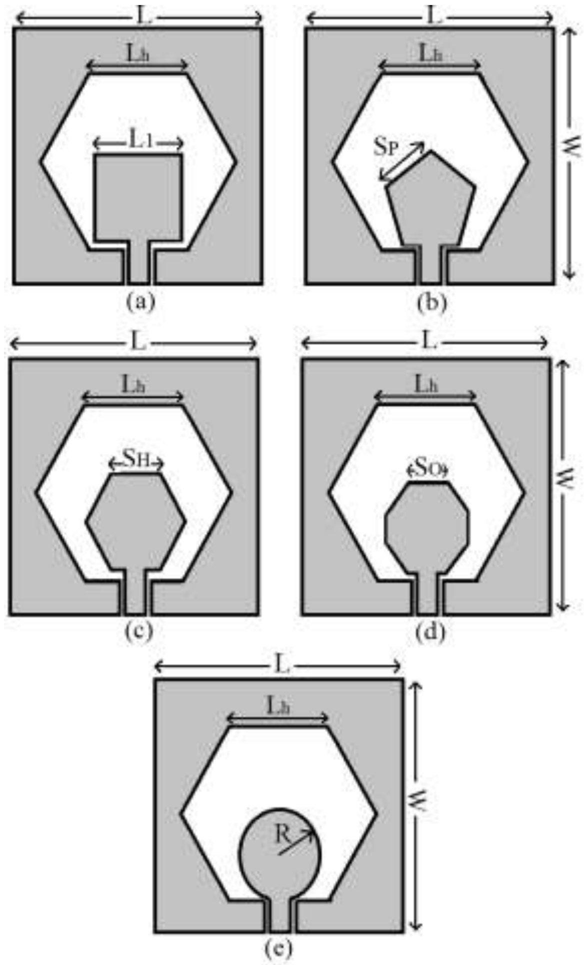

Fig. 4 (a – e): Different shapes of radiating patches backed by hexagonal slot ground plane

The effect of different shaped radiating patches in same pentagonal slot on resonance curve and return loss plot is shown in Fig. 5 and Fig. 6. Here also, same effects on lower order modes and higher order modes is observed as in pentagonal slot ground plane antenna. Optimum bandwidth of 4.96GHz is obtained when square shaped radiating patch is backed by hexagonal slot ground plane.

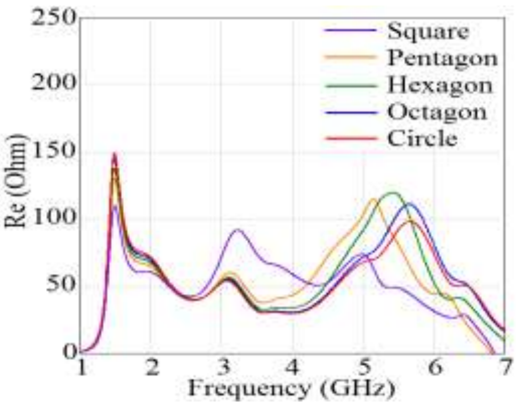

Fig. 5. Effect of different shaped radiating patches backed by hexagonal slot ground plane on resonance curve

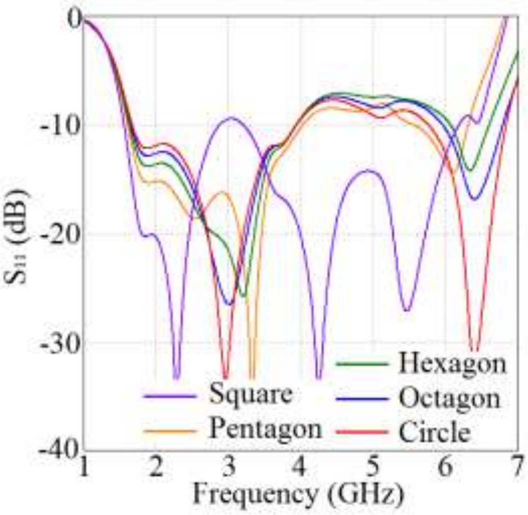

Fig. 6. Effect of different shaped radiating patches backed by hexagonal slot ground plane on return loss plot

Also, same analysis is done by keeping different shaped radiating patches within octagonal slot ground plane as shown in Fig. 7(a – e). The side length of octagon L_o is chosen such that the area of octagonal slot equals the area of previous pentagonal and hexagonal slots i.e. 1936mm^2. Rest all the dimensions are kept same.

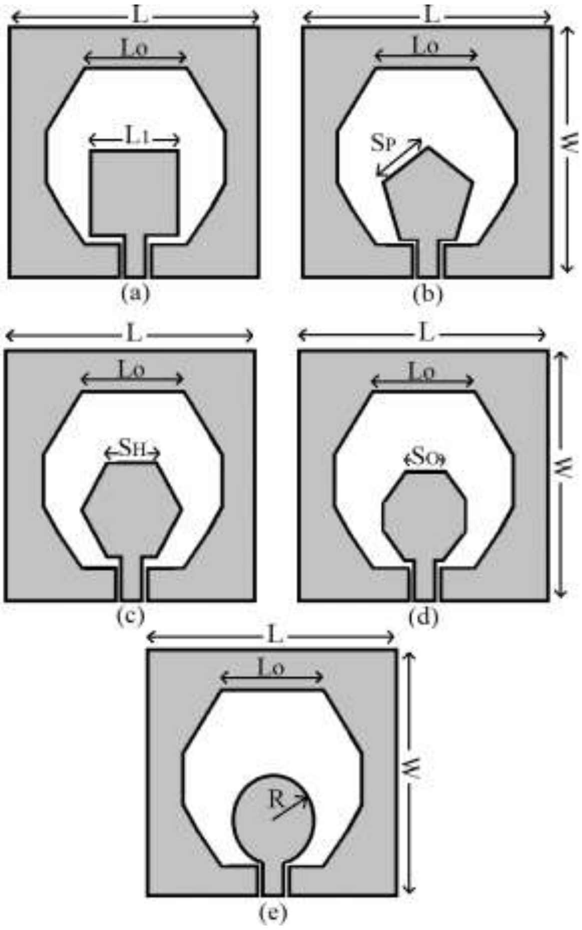

Fig. 7 (a – e): Different shapes of radiating patches backed by octagonal slot ground plane

The effect of different shaped radiating patches backed by octagonal slot ground plane on resonance curve and return loss plot is shown in Fig. 8 and Fig. 9. It can be seen from the resonance curve that when a square patch is kept within octagonal slot, only lower two resonant modes are excited, due to which bandwidth is obtained in only this region. Beyond 4GHz, the impedance of square patch goes on decreasing towards 0Ω because of which the impedance matching fails and return loss increases after 4GHz. Next, for pentagonal radiating patch, one more resonant mode at lower frequency i.e. third resonant mode is getting excited in 4GHz – 5GHz band, due to which bandwidth is achieved in this band when a pentagonal radiating patch is used within an octagonal slot ground plane. The number of modes and impedance of these modes goes on increasing towards 50Ω resulting in optimum bandwidth of around 5.2GHz, when a hexagonal shaped radiating patch is backed by octagonal slot ground plane.

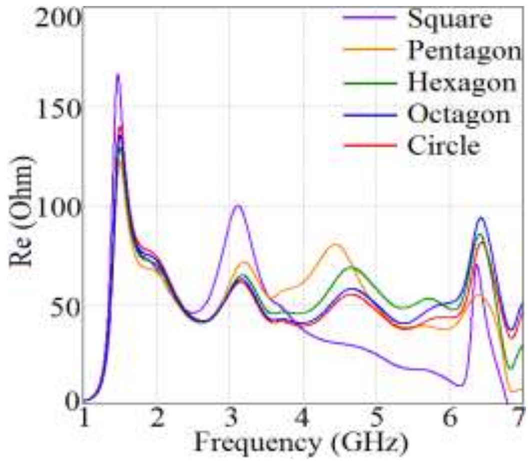

Fig. 8. Effect of different shaped radiating patches backed by octagonal slot ground plane on return loss plot

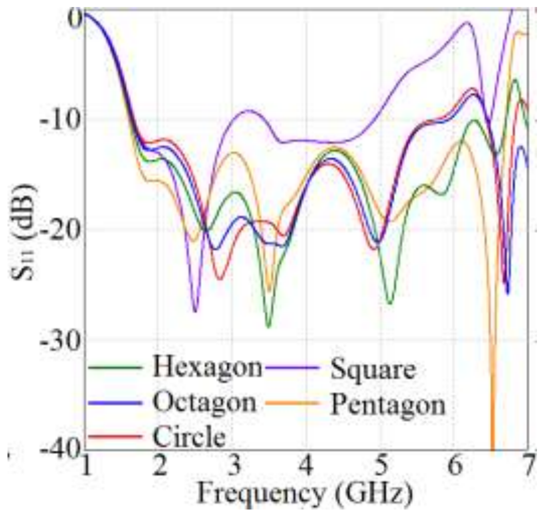

Fig. 9. Effect of different shaped radiating patches backed by octagonal slot ground plane on return loss plot

3. CONCLUSIONS

A study and analysis of different shapes of radiating patches surrounded by different ground planes, i.e. pentagonal, hexagonal and octagonal has been done. From this study, optimum bandwidths of 1.9GHz for square patch backed by pentagonal slot ground plane, 4.96GHz for square patch backed by hexagonal slot ground plane, and 5.2GHz for hexagonal radiating patch backed by octagonal slot ground plane is obtained. The increased in antenna BW is due to the additional modes introduced and the impedance matching to 50Ω in the configuration.

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