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# Multiband Operation of Microstrip Antenna

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***Abstract***—The effect of proximity and aperture coupling on the resonance behavior of the microstrip antenna is presented. With proximity coupling the antenna resonates with two bands having bandwidths of 16.75% and 35.58%.When the same antenna is fed by aperture coupling, three bands occur with bandwidths of 44.3%, 4.75% and 53.43%. Further when the H-slot is replaced with a dumbbell slot all the three bands merge to give single band of 91.43% with a peak gain of 10.23dB while retaining the broadside radiation characteristics. The design concept is presented and experimental results discussed.

***Keywords****: Bandwidth, gain, groundplane, multiple bands, return loss, proximity, aperture.*

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## I. Introduction

Microstrip Antennas have gained much significance in communication systems.They are capable of multiband operations, low profile planar configuration making them easily conformal to host surface, light weight, low volume,low fabrication cost etc[1]. They can be easily integrated with microwave integrated circuits(MICs) and show the unique characteristcs of linear as well as circular polarization,They come in various shapes like rectanular, square, circular, triangular, elliptical and can be housed easily on moving vehicles. But these antannas have some drawbacks like narrow bandwitdh, low efficiency, low gain, extraneous radiation from feeds and junctions. To overcome these drawbacks researchers have worked by using parasitic elements[2], thicker substrate[3],proximity coupling[4], aperture coupling[5] etc. In this work the effect of proximity and aperture coupling with a slot in the ground plane is studied.

In the proximity coupling two substrates are used with the patch on top of the upper substrate and the microstripline feed on the top of the lower substrate.The microstripline feed lies between the upper substrate with the patch on it and the lower substrate with the ground plane at the bottom of it. This configuration reduces the cross polarization due to elimination of spurious radiation from feed geometry and possibility of two different dielectric media,one for the patch and the other for the feedline. But the disadvantage is that the proper alignment of the two substrates has to be taken care of and the overall thickness of the antenna increases. In the aperture-coupling , the field is coupled from the microstripline feed to the patch through an electrically small aperture or a slot cut in the ground plane. The shape, size and location of the aperture decide the amount of coupling from the feed to the patch[3].In this paper antennas fed by proximity and aperture coupling techniques have been presented. Further the shape of the aperture is varied in the aperture coupling and its effects on the performance is studied.

## II. Antenna Configuration

The microstrip patch, the microstripline feed and the quarterwave transformer are designed using the equations equations available in the literature[6-7]. The artwork is sketched using the computer programme Auto-cad 2006 to achieve better accuracy.The antennas are fabricated using photolithography process on low cost substrate material of glass epoxy with thickness of h=3.2mm and the dielectric constant of $\varepsilon_r$=4.2.

Fig.1(a) shows the top view of the microstrip antenna with the feed on top of substrate2 thus forming proximity coupling(PCRMSA).The patch of length L and width W is etched on the top of substrate s1. The corners of the patch are truncated by taking $L_t=W_t=\lambda_0/15$ corresponding to the design frequency of 4.2GHz, where $\lambda_0$ is the free space wavelength in cm. The mirostripline feed is etched on top of substrate $s_2$ which is shown in figure.1(b) with its tip lying below the centre point of the upper radiating patch placed on the top of the substrate $s_1$ as shown in fig.1(a).The length and feed of microstripline feed are $L_f$ and $W_f$ respectively. The thickness of the substrate h, $\varepsilon_r$ and dimensions of the substrate $s_1$ and $s_2$ remain same .Since the substrate $s_2$ is placed below $s_1$ and the feedline lies between the two substrates, the proximity coupling takes place. Further the same antenna is fed through aperture coupling and the antenna is named as aperture coupled(ACRMSA).The top geometry of ACRMSA remains same as that of Fig.1(a). The coupling slot is placed on top of the substrate $s_2$. The microstripline feed shown in Fig.1(b) is etched on the bottom surface of $s_2$.

Since the coupling slot is placed between the two substrates, it acts as the aperture and thus forming the aperture coupling feed. The slot is placed exactly below the truncated patch on top of $s_1$.The microstripline feed is placed such that its tip lies exactly below the centre of the patch thereby enabling the feed from microstripline through the coupling aperture.

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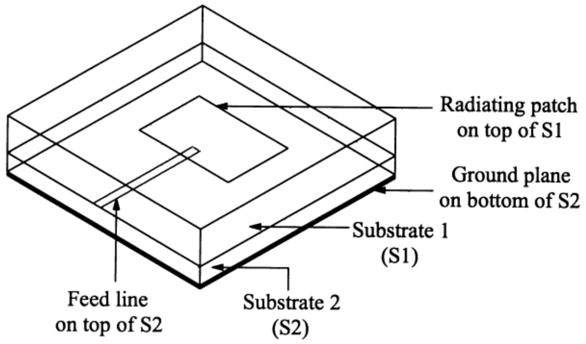


Fig.1(a) Top View of the proximity coupled radiating element

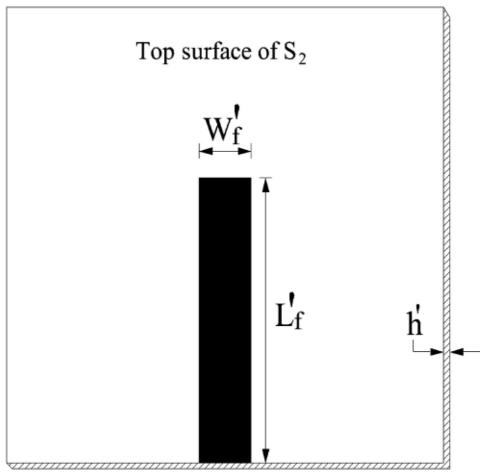


Fig.1(b) Microstripline Feed

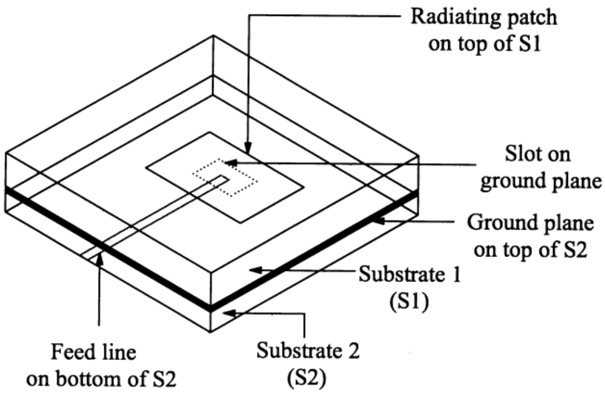


Fig.2 Aperture coupled MSA

## III. EXPERIMENTAL RESULTS

The antennas are simulated using Ansoft HFSS13 and studied for parameters like return loss and radiation pattern.Figure.3. shows the simulated model of proximity feed MSA and Fig.4.shows the variation of its return loss as a function of frequency. The bandwidth is determined by using the following equation,

$$\text{Bandwidth} = \left[\frac{(f_2 - f_1)}{f_c}\right] \times 100\% \qquad \text{-----(1)}$$

Where $f_2$ and $f_1$ are the lower and upper cut-off frequencies of the band respectively when the return loss goes less below -10db and $f_c$ is the centre frequency between $f_1$ and $f_2$. The antenna resonates with two bands with bandwidths of 1.16% at 4.35GHz and 1.5% at 7.5 GHz. The return losses are -12.56 dB and -13.56 dB respectively. Fig..5 shows the radiation pattern of the antenna.

Figure.6 shows the simulated model of aperture coupled MSA. An L shaped aperture is cut in the ground planh is now placed on top substrate 2 and the feed line is placed on the bottom surface of substrate 2. Figure.7. the variation of return loss as a function of frequency. When we compare the antenna results with that of the previous antenna, here there is only one band in the frequency range.The bandwidth is 5.58% at 3.5 GHz. The return loss is -22.85 dB at the same frequency. The return loss has increased in this antenna as compared to the previous one. Figure.8 shows the radiation pattern of aperture coupled MSA.

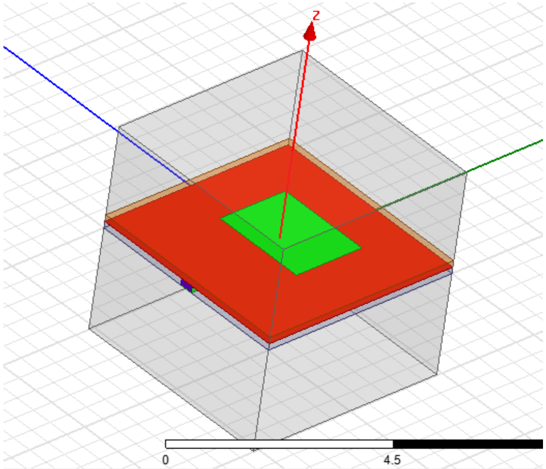


Fig.3. Simulated model of proximity feed MSA

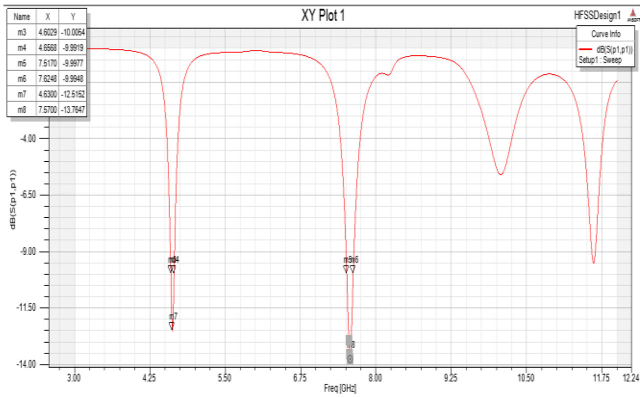


Fig. 4. Variation of return loss versus frequency of Proximity feed MSA

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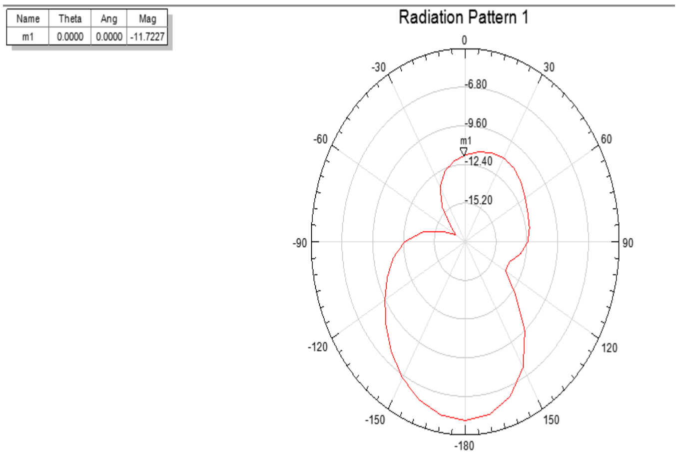

Fig.5. Radiation Pattern of Proximity feed MSA

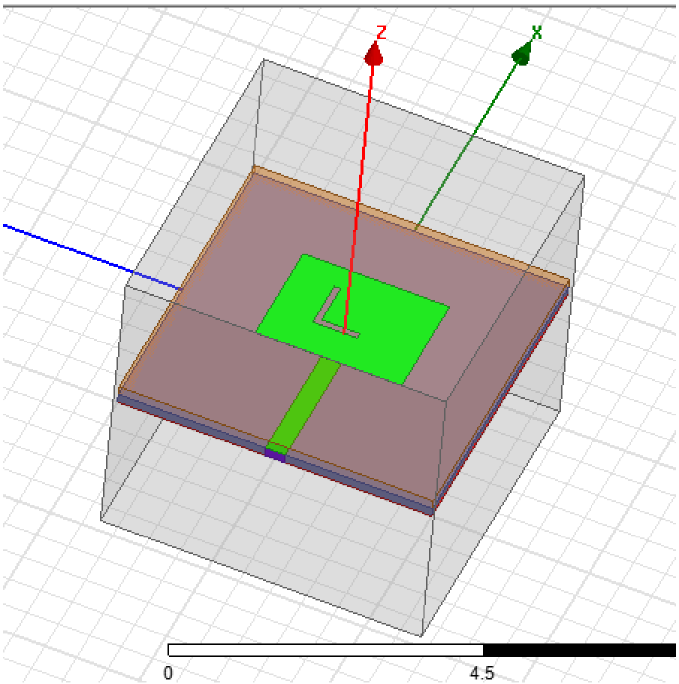

Fig.6. Simulated model of Aperture Coupled MSA

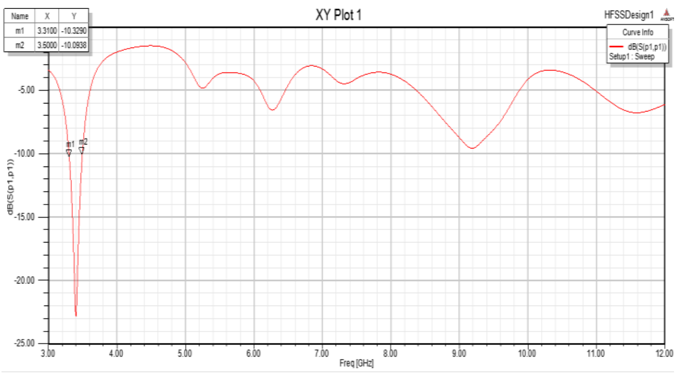

Fig.7. Variation of return loss versus frequency of Aperture coupled MSA

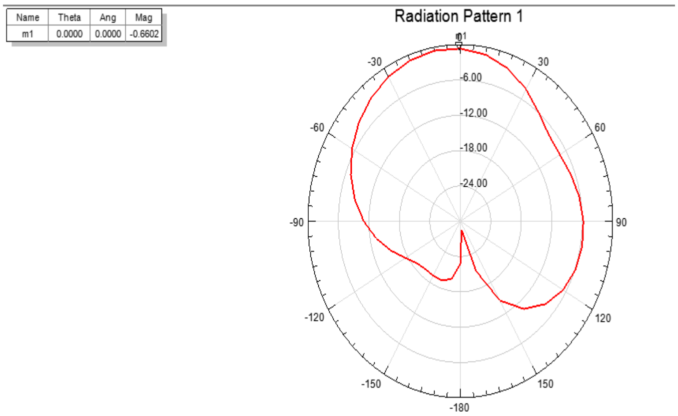

Fig.8. Radiation pattern of Aperture coupled MSA

## IV. CONCLUSIONS

From the study performed, it can be concluded that the proximity feed antenna resonates with two bands with bandwidths of 1.16% at 4.35GHz and 1.5% at 7.5 GHz. The return losses are -12.56 dB and -13.56 dB respectively. When we compare the antenna results of aperture coupled feed with that of the previous antenna, here there is only one band in the frequency range.The bandwidth is 5.58% at 3.5 GHz. The return loss is -22.85 dB at the same frequency. The return loss has increased in this antenna as compared to the previous one. These antennas are simple in their design and fabrication and use low cost substrate material. They may find applications in the microwave systems operating in the range of 4-24GHz.

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