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Impact of Different Types of Slots on Multiband Operation of Microstrip Antenna

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Abstract: ***Effect of a change in Patch geometry on the performance of a microstrip antenna is presented. The change in patch geometry is affected by inserting a V-slot and vertical identical slots on the patch. With a V-slot, the antenna resonates with four bands having bandwidths of 1.3% at 4GHz, 6% at 7GHz, 3.1% at 10GHZ and 1.07% at 13GHz. Also the return losses are -10.6117dB, -15.26dB and -16.05dB. With five identical vertical slots, the antenna resonates with four bands in which two are negligible and remaining are resonating much beyond the design frequency of 4GHz***

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

1. Introduction

The architecture and development of microwave antennas seems to be the most critical task for achieving optimum radiation characteristics of microwave communication devices. Mainly due to their extensive applications in microwave communication, the microstrip antennas (MSAs) have recently become one of the most significant classes among the different types of microwave antennas. They can be easily integrated with microwave integrated circuits(MICs) and show the unique characteristics of linear as well as circular polarization. They come in various shapes like rectangular, square, circular, triangular, elliptical and can be housed easily on moving vehicles. But these antennas have some drawbacks like narrow bandwidth, 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 a change in the patch geometry is explored. The change in geometry is affected by cutting a V-slot and five identical vertical slots on the patch. A 36% reduction in resonant frequency and a 60% reduction in the overall size of the antenna is reported in the literature. First a conventional antenna without slots and 0.16cm is designed and simulated. It is observed that the antenna with only one band at around 4.125 GHz and a bandwidth of 1.56%. The return loss is observed to be -23.019 dB. With a V-slot and five identical vertical slots the antenna resonates with four bands showing a considerable improvement over the conventional antenna.

2. Antenna configuration

Using the equations available in the literature [6-7], the microstrip patch, the microstripline feed and the quarter wave transformer are designed. 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 ε_r=4.2.

Fig.1(a) shows the top view of the convetional microstrip antenna. Fig.1.(b). shows antenna with a vertical slot on the surface of the patch. The slot dimensions, length and width are taken in terms of λ_o, the free space wavelength of the antenna. The free space wavelength λ_o is given by c/f_r where f_r is resonant frequency of the antenna which is also the design frequency. In the current work the antenna is designed for a frequency of 4.2GHz. Fig.1(c) the antenna with five vertical slots etched on the patch.

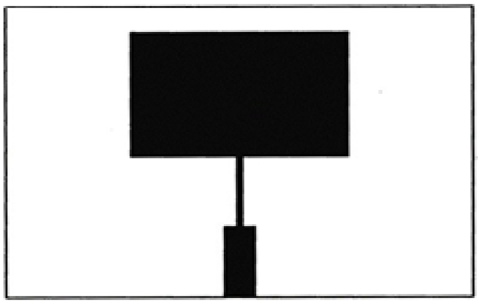

Figure 1(a): Conventional Microstrip Antenna

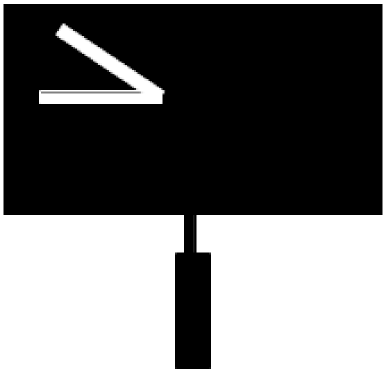

Figure 1(b): V-slot Microstrip Antenna

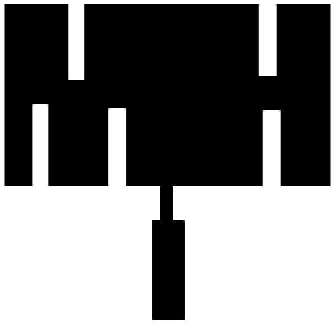

Figure 1(c): Five vertical slot Microstrip Antenna

3. 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:

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

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 with a V-slot resonates with four frequency bands The bandwidth of the 1.3% at 4 GHz, 6% at 7 GHz, 3.1% at 10 GHz and 1.07% at 13 GHz. Also the return losses are -10.6117 dB, -15.26 dB and -16.05 dB respectively. Fig.2.shows the simulated model of the antenna with a V-Slot and Fig.3. shows it's return loss at different frequencies.

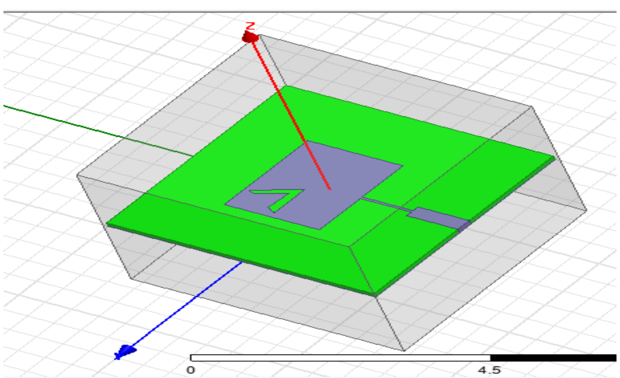

Figure 2: V slot MSA geometry

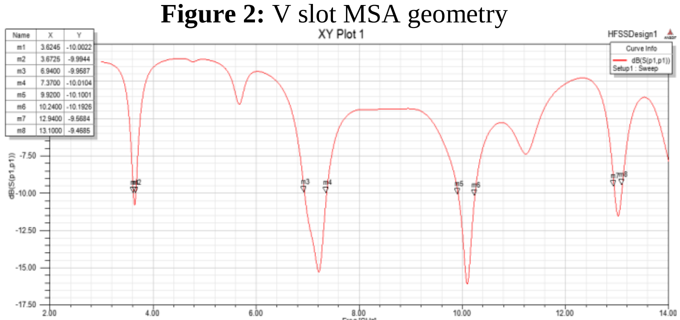

Figure 3: Return loss vs. frequency of V slot MSA

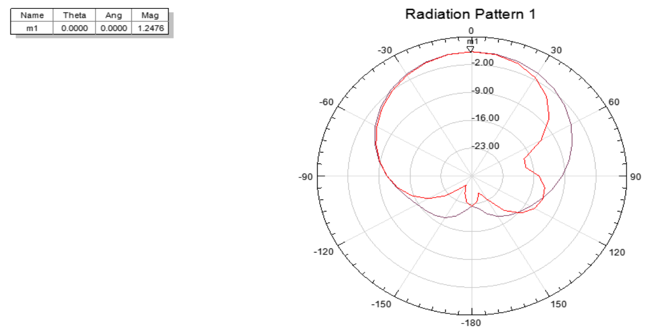

Figure 4: V-slot MSA radiation pattern

Fig.4 shows the radiation pattern of the antenna. Fig.5. shows the simulated model of the antenna with five slots on the patch.

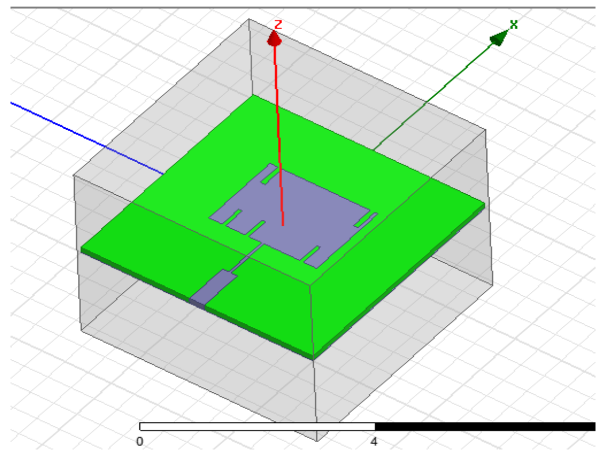

Figure 5: Geometry view of 5SMSA

Fig.6. and Fig.7. show the return loss and radiation pattern of the antenna respectively. There are two slots at the top corner, two slots at the left bottom and one slot in the bottom right corner of the patch. The substrate is clearly designed in accordance with the requirements. The feeds and the patch are then mounted on the substrate and then the slots are cut out of the patch.

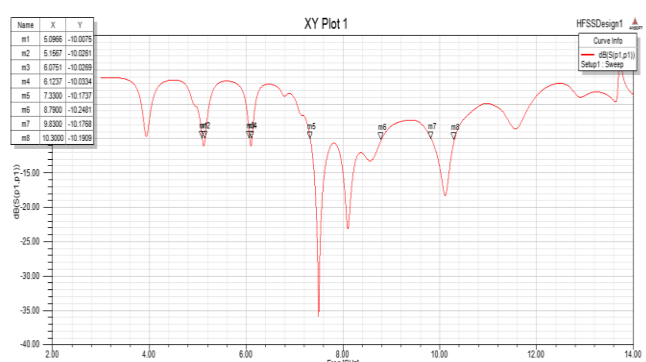

Figure 6: Return loss against frequency of 5SMSA

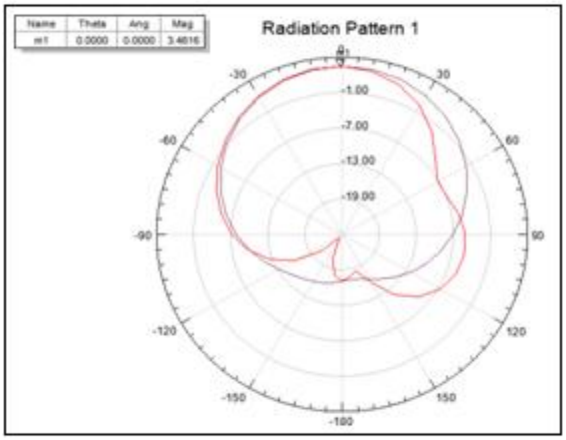

Figure 7: Radiation Pattern of 5SMSA

4. Conclusions

As is observed in the return losse, a modification in the patch geometry results in the improvement in number of bands, return loss and the radiation pattern. The antenna without slots resonates with only one band. With a V-slot four frequency bands are obatained. The bandwidth of the 1.3% at 4 GHz, 6% at 7 GHz, 3.1% at 10 GHz and 1.07% at 13 GHz. Also the return losses are -10.6117 dB, -15.26 dB and -16.05 dB respectively. For the antenna with five vertical slots, there are four bands in which two have considerable bandwidth and other two have negligible. This concludes that a change in the patch geometry results in results in a change in the performance of the antenna. With a suitable predetermined change the variables of interest like return loss, radiation pettern, number of bands and bandwidth can be improved.

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