CHAPTER FOUR

COMPACT WIDEBAND MICROSTRIP PATCH ANTENNA USING FINITE GROUND PLANE

Meandering or defective ground method may be applied to the finite metallic ground surface of a patch antenna design; relatively less fundamental operating frequency as compared to the patch meandering method may be obtained. In addition, the impedance bandwidth and antenna gain may be improved, which is a great advantage of this type of defective ground surface or meandering method as compared to the patch meandering method.

4.1 INTRODUCTION

The antenna's ground surface can be meandered or defected by insertion of many meandering slits at its corners or slots can be introduced at the ground surface. The bandwidth for a reduced size antenna design with a meandered or defected ground surface can be increased more as compared to the meandered or defected printed patch antenna design [74].

In these types of designs, the patch can also be meandered along with the finite meandered metallic ground plane. Meandered portion of the printed patch provides varied different resonant length, more resonant modes may be generated at frequencies near to each other; therefore, an improved bandwidth more than that of the conventional antenna design may be obtained. All the antenna designs are simulated using IE3D software and its radiation characteristics are analyzed. These antennas are designed for various applications of wireless communication, mobile communication, WLAN, WiMax systems in S-band (2 to 4 GHz) and C-band (4 to 8 GHz).

4.2 COMPACT MSA USING FINITE GROUND PLANE DESIGN-1

In the antenna design-1, the slot loaded square patch is printed on inexpensive FR4 (copper-cladded plate) having dielectric constant (Єr) of 4.4, loss tangent tan δ = 0.02 and height 1.6

mm. In the antenna design-1, an effort has been made to increase the bandwidth due to slot loaded square microstrip patch antenna with meandered or defected finite ground surface. The coaxial probe feed having 50-ohm impedance is used for feeding the patch.

Figure 4.1 presents the top view of the slot loaded square microstrip printed patch antenna design-1. Figure 4.2 shows the back view of slot loaded square microstrip printed patch antenna (i.e. meandered finite ground plane) design-1. Antenna is designed for wireless communication system with center frequency f_0 = 1.87 GHz, within the frequency range 1 GHz to 3 GHz, with step of frequency selected to be 0.01 GHz, In this antenna design-1, patch length L = 30 mm**,** patch width W = 30 mm, with finite ground surface of the same dimension as that of square microstrip patch and feed point position at the patch is (0.5, 9). Figure 4.3 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-1; maximum return loss is – 19.5 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 4.4 shows the radiation pattern (2-D elevation pattern) for antenna design-1 at the center frequency 1.87 GHz. Figure 4.5 shows the impedance loci for antenna design-1. At resonance frequency 1.87 GHz, the simulated input impedance of antenna design-1 is near to be matched with 50 ohm impedance. Here due to slot loaded square microstrip patch antenna with meandered finite ground surface of the antenna design-1; the impedance bandwidth is coming out to be **12.8 %** of the center frequency at 1.87 GHz.

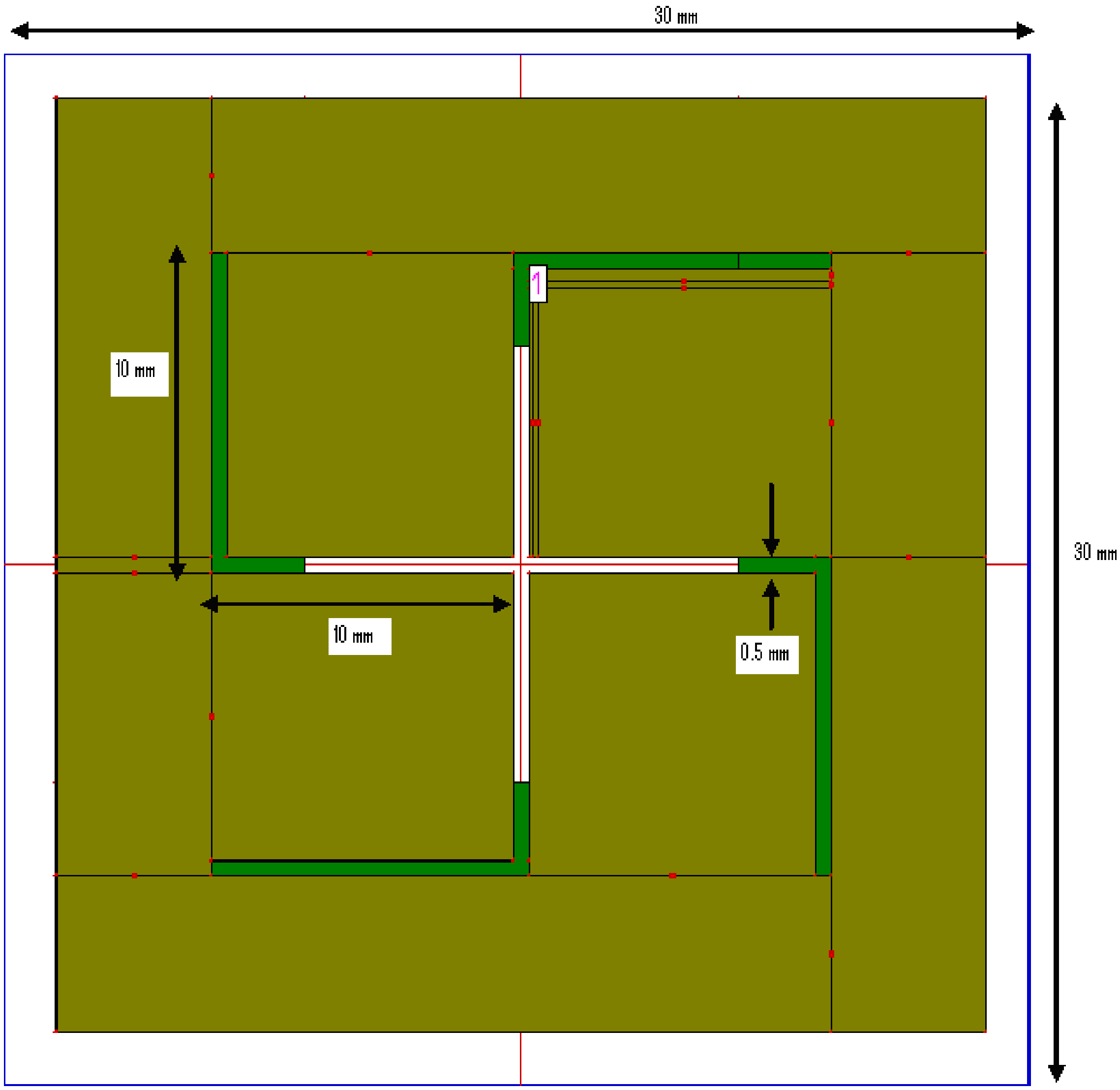

Figure 4.1 Front view of slot loaded square microstrip patch antenna

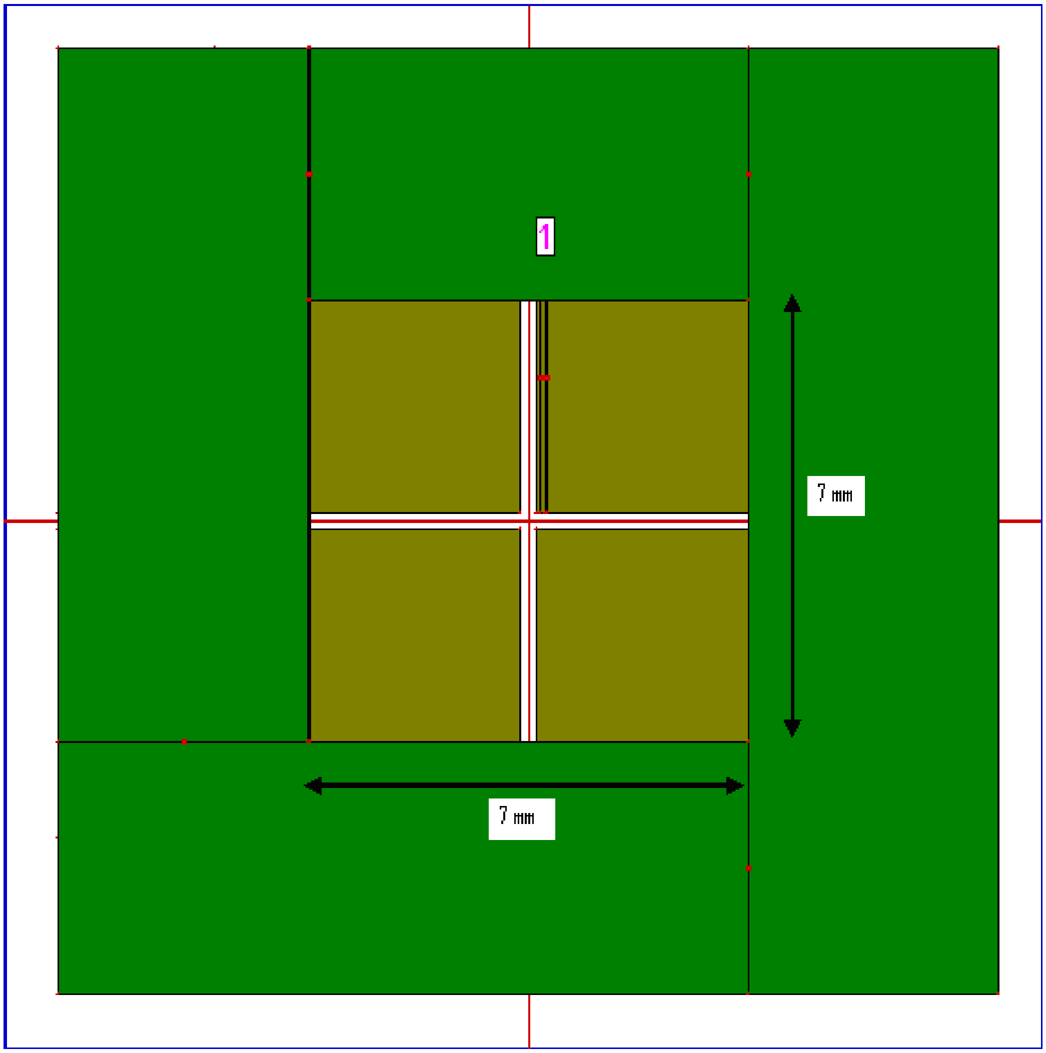

Figure 4.2 Back view of slot loaded square microstrip patch antenna

(i.e. meandered finite ground plane)

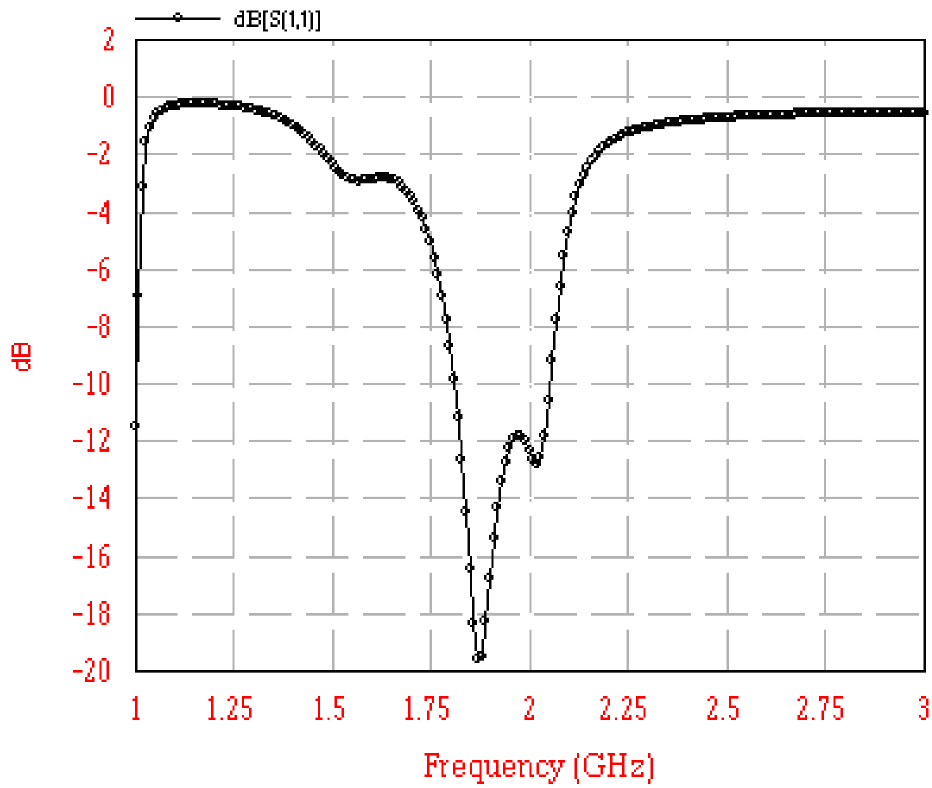

Figure 4.3 Graph between return loss and frequency for antenna design-1

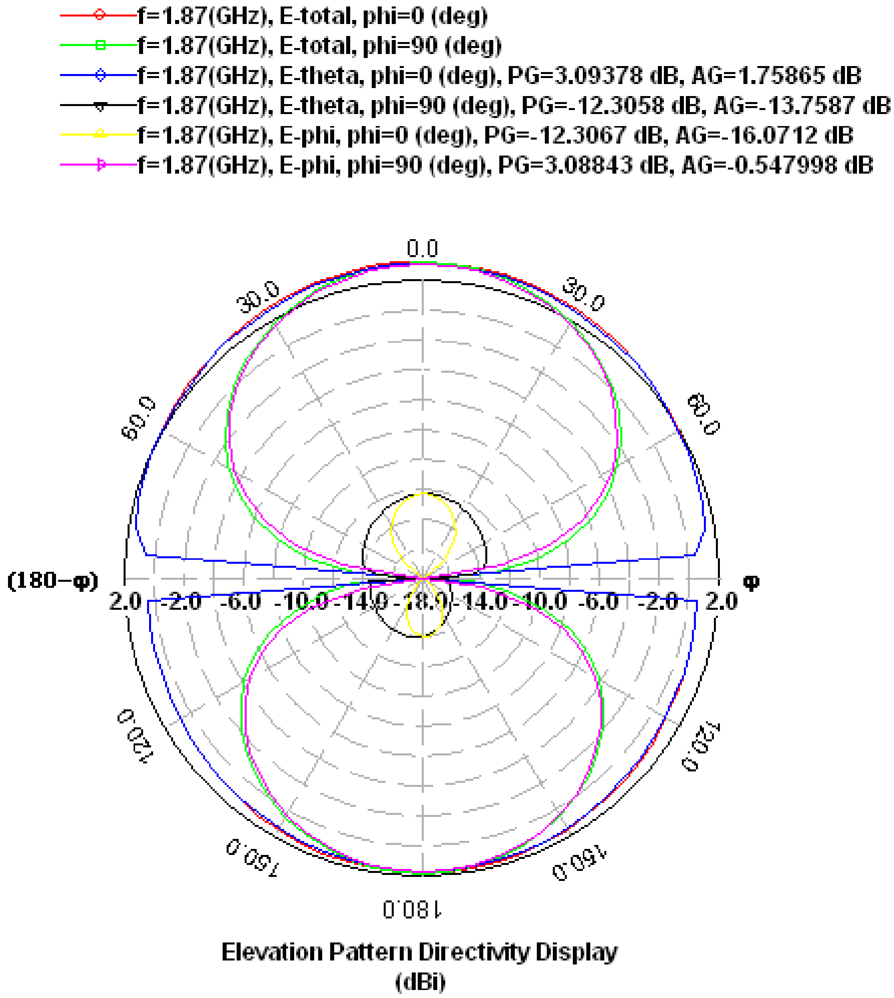

Figure 4.4 Radiation pattern for antenna design-1

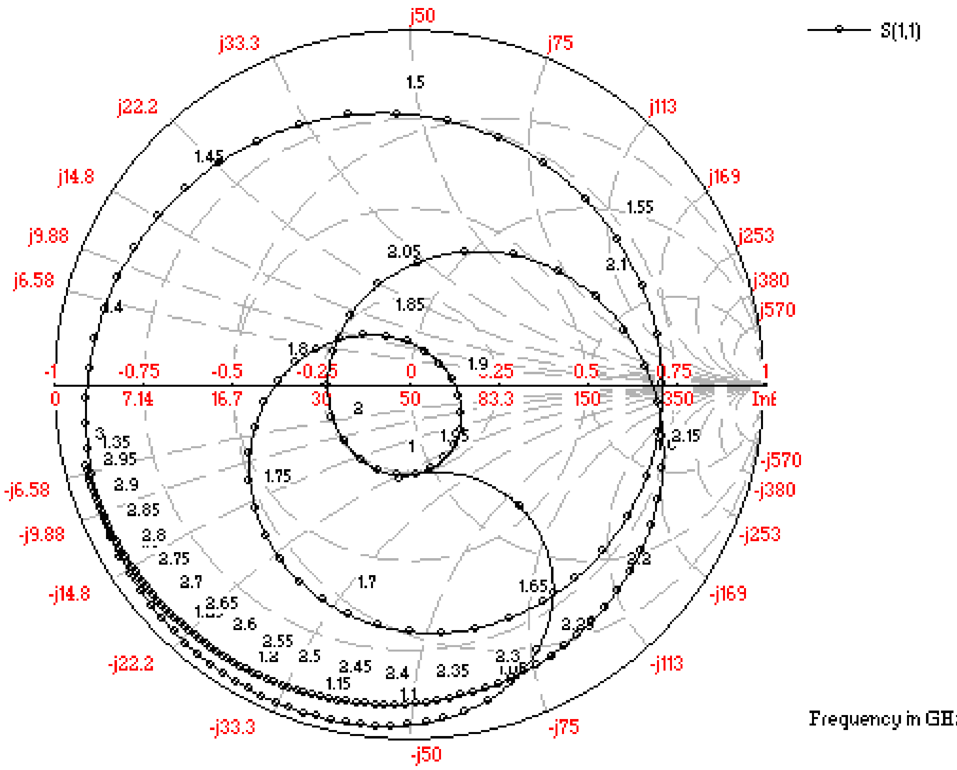

Figure 4.5 Impedance loci for antenna design-1

4.3 COMPACT MSA USING FINITE GROUND PLANE DESIGN-2

In this patch antenna design-2, the bandwidth is increased due to MSA with finite ground surface. The coaxial probe feed having 50-ohm impedance is used for feeding the patch.

Figure 4.6 presents the front view of MSA with finite ground plane of antenna design-2. Antenna is designed for wireless communication system with center frequency f_0 = 1.81 GHz, within the frequency range 1 GHz to 3 GHz, with step of frequency selected to be 0.01 GHz, In this antenna design-2, patch length L = 30 mm**,** patch width W = 40 mm with finite ground plane of the dimension L = 45 mm and W = 45 mm, feed point positions at the patch is (14.9,-16.275). Figure 4.7 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-2; maximum return loss is – 18.12 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 4.8 shows the graph between VSWR and frequency (in GHz) for antenna design-2, impedance bandwidth can be taken below VSWR < 2. Figure 4.9 shows the graph between directivity (in dBi) and frequency (in GHz) for antenna design-2. Figure 4.10 shows the graph between efficiency (antenna and radiating, in %) and frequency (in GHz) for antenna design-2, antenna and radiating efficiency both are coming between 90-100 % at centre frequency. Figure 4.11 shows the radiation pattern (2-D elevation pattern) for antenna design-2 at the center frequency 1.81 GHz. Figure 4.12 shows the impedance loci for antenna design-2. Here due to MSA with finite ground plane of this antenna design-2; the impedance bandwidth is coming out to be **27.62 %** (500 MHz) of the center frequency at 1.81 GHz. Bandwidth for the proposed antenna design is sufficiently high and other radiation characteristics are also satisfactory.

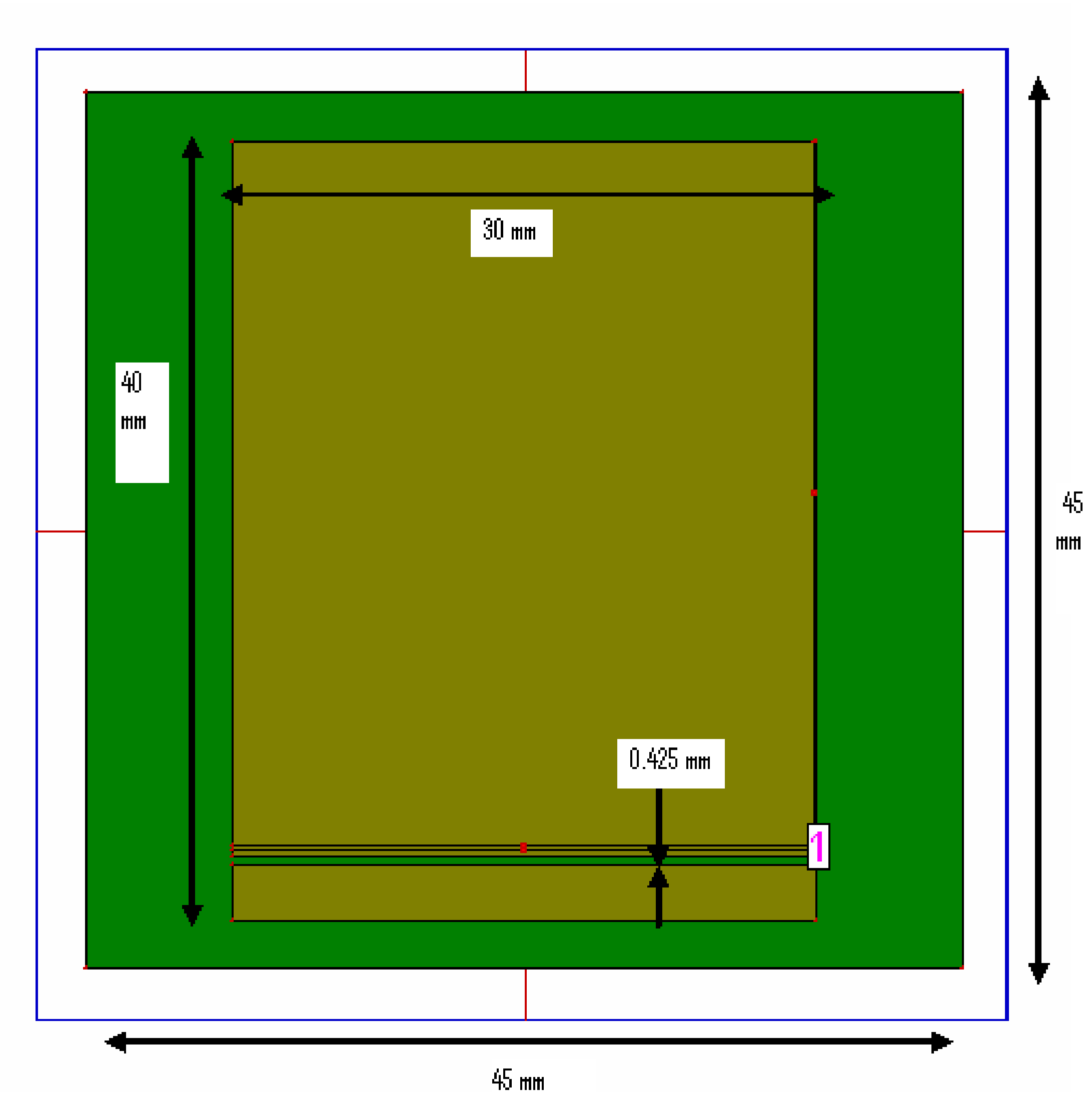

Figure 4.6 Front view of MSA with finite ground plane

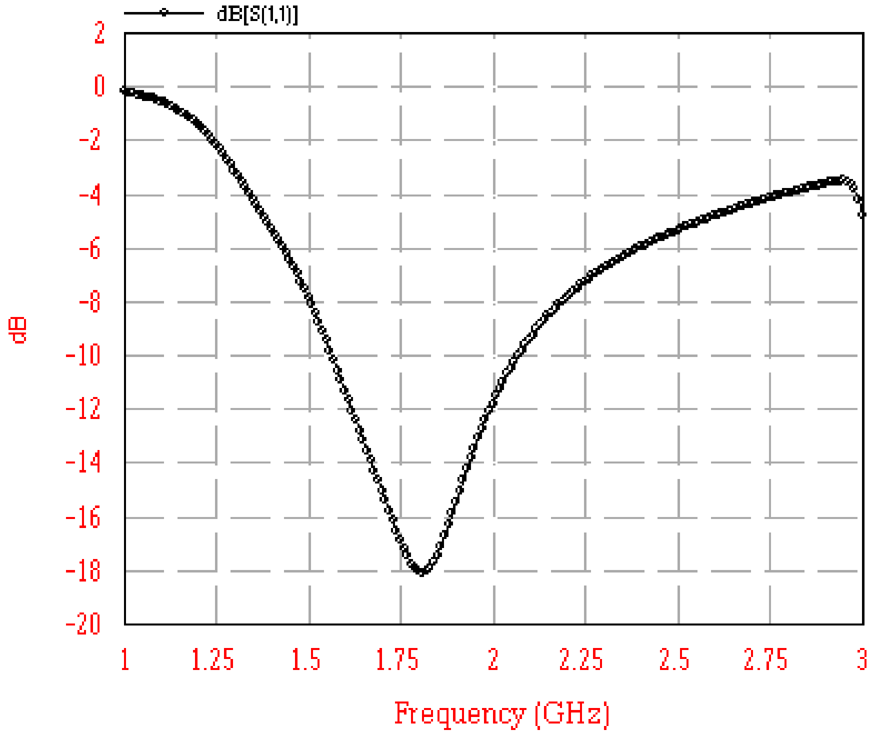

Figure 4.7 Graph between return loss and frequency for antenna design-2

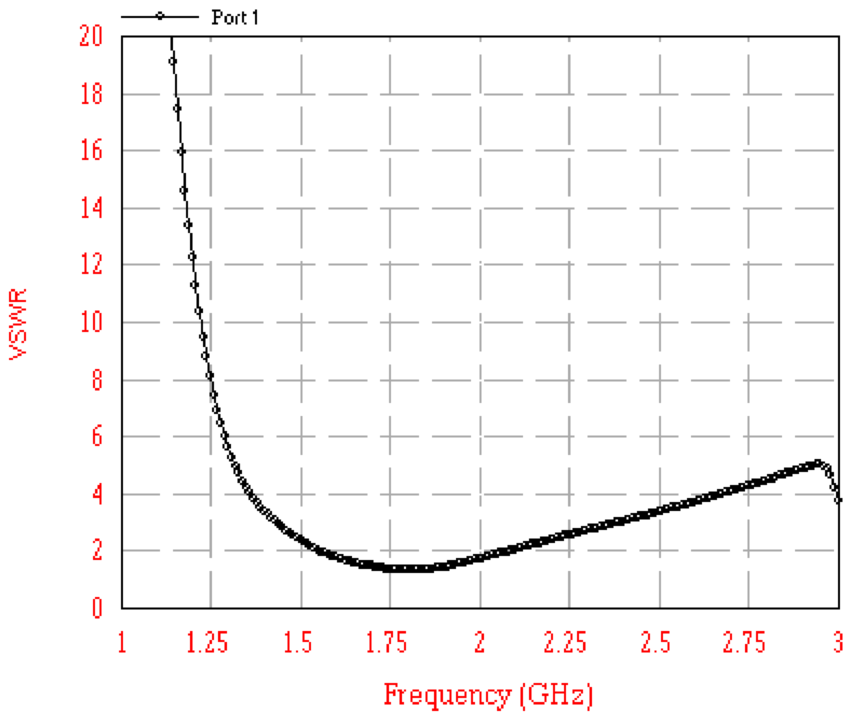

Figure 4.8 Graph between VSWR and frequency for antenna design-2

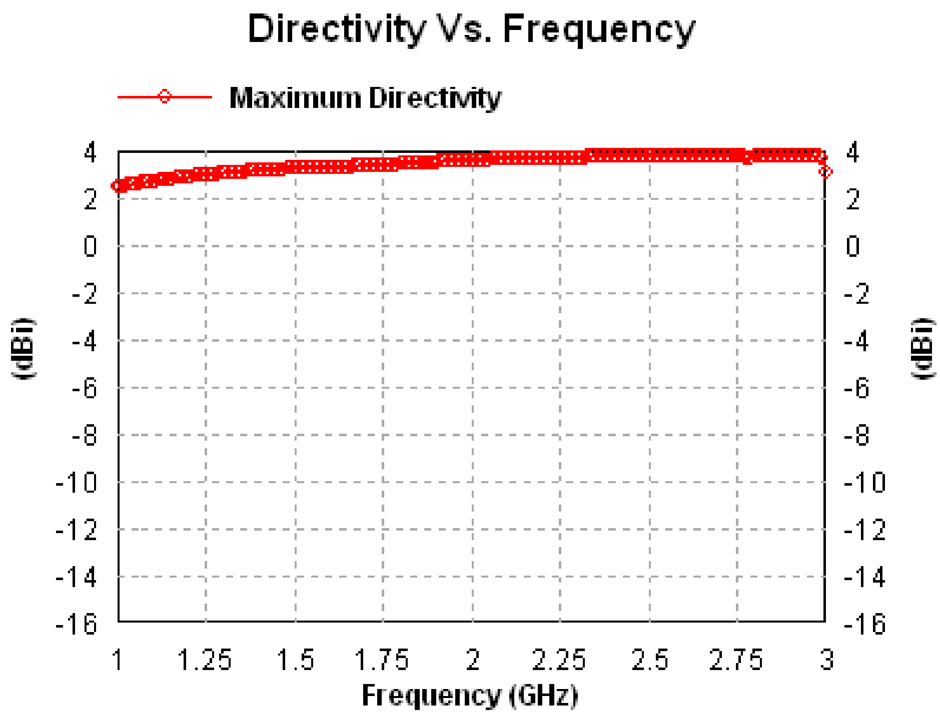

Figure 4.9 Graph between directivity and frequency for antenna design-2

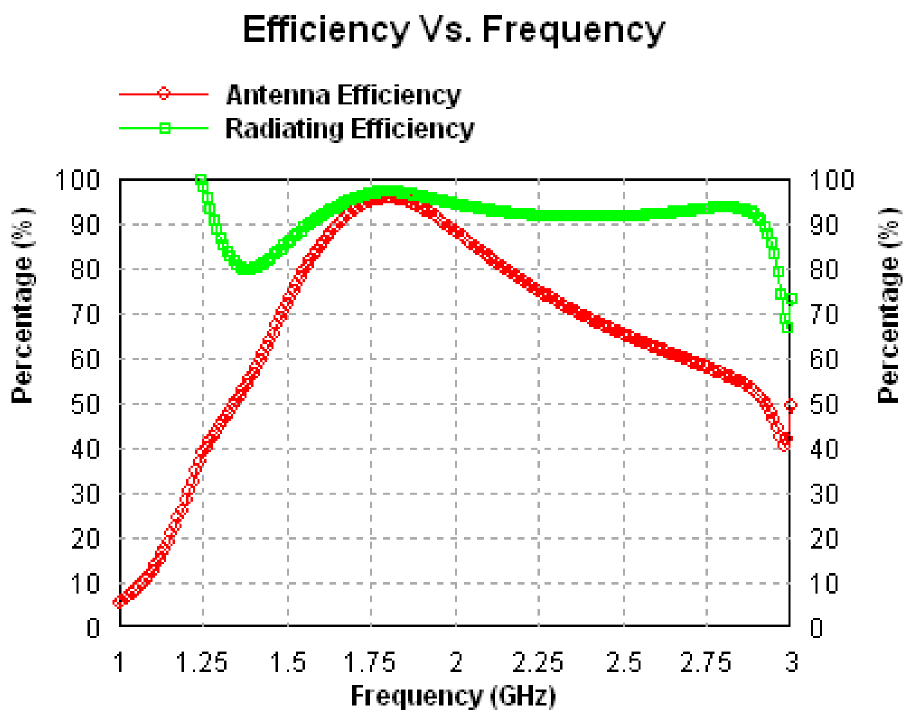

Figure 4.10 Graph between efficiency and frequency for antenna design-2

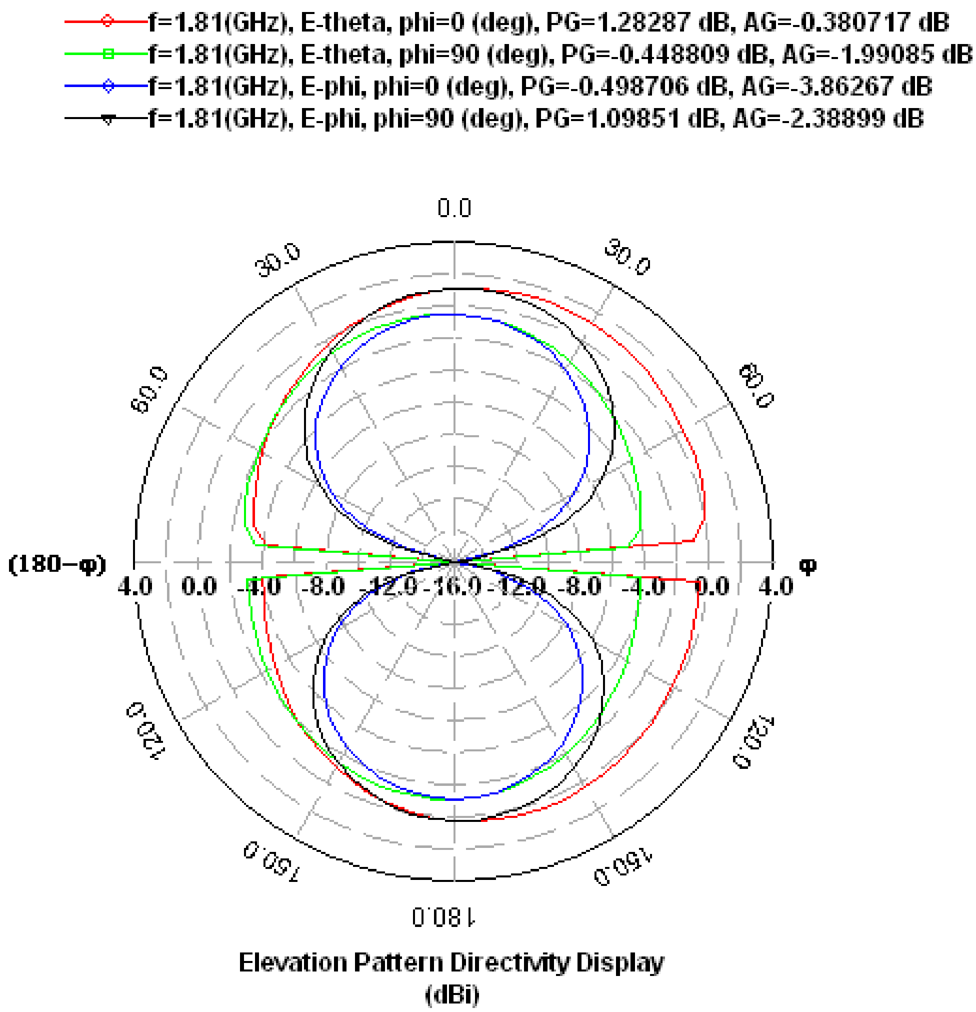

Figure 4.11 Radiation pattern for antenna design-2

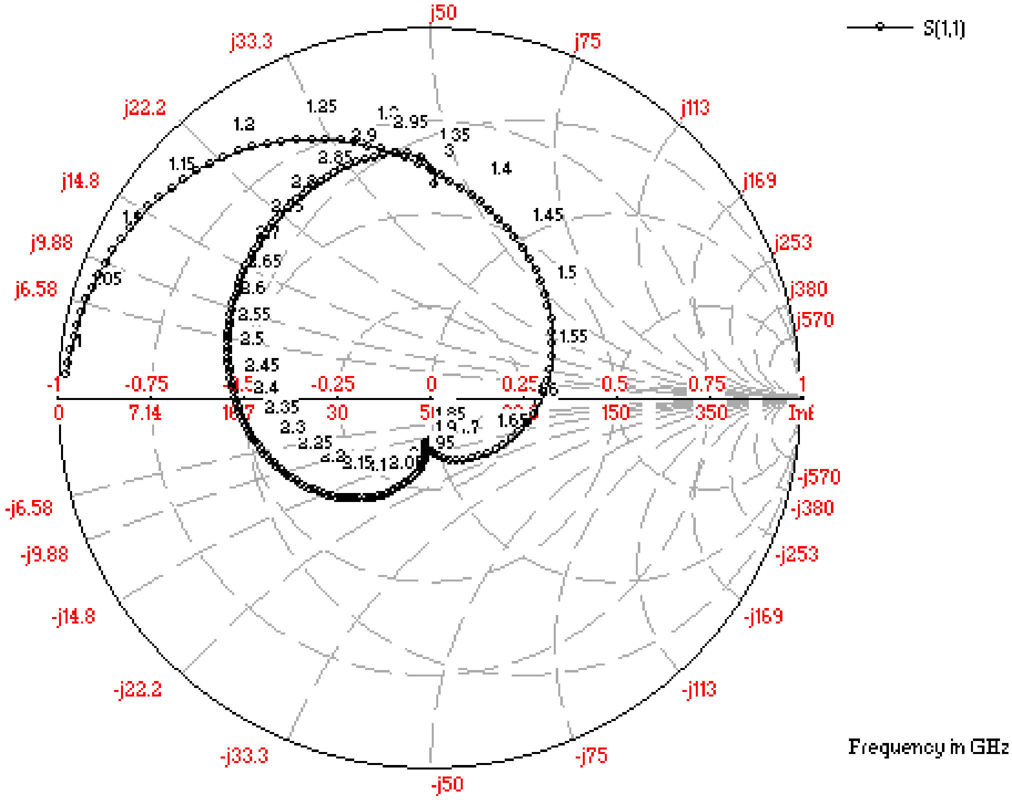

Figure 4.12 Impedance loci for antenna design-2

4.4 COMPACT MSA USING FINITE GROUND PLANE DESIGN-3

In the patch antenna design-3, an attempt has been made to increase the bandwidth due to modified square microstrip patch antenna with square slot loaded finite ground surface. The coaxial probe feed having 50-ohm impedance is used for feeding the patch.

Figure 4.13 presents the front view of modified square microstrip patch antenna with slot loaded finite ground plane of antenna design-3. Antenna is designed for different applications of wireless communication in C-band with center frequency f_0 = 4.35 GHz, within the frequency range 1 GHz to 7 GHz, with step of frequency selected to be 0.01 GHz, In this modified square patch antenna design-3, patch length L = 30 mm**,** patch width W = 30 mm with slot loaded finite ground plane of the dimension L = 45 mm and W = 45 mm and square slot of dimensions 10 mm × 10 mm at the centre position, feed point positions at the patch is (10.85,-12). Figure 4.14 shows the back view of modified square patch antenna with slot loaded finite ground plane of antenna design-3. Figure 4.15 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-3; maximum return loss is – 37 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 4.16 shows the graph between VSWR and frequency (in GHz) for antenna design-3, impedance bandwidth can be taken below VSWR < 2. Figure 4.17 shows the graph between directivity (in dBi) and frequency (in GHz) for antenna design-3. For the antenna design-3, directivity (in dBi) at the operating frequency is coming between 5-8 dBi. Figure 4.18 shows the graph between efficiency (antenna and radiating, in %) and frequency (in GHz) for antenna design-3, antenna and radiating efficiency both are coming between 70-80 % at centre frequency. Figure 4.19 shows the radiation pattern (2-D elevation pattern) for antenna design-3 at the center frequency 4.35 GHz. Figure 4.20 shows the impedance loci for antenna design-3. At resonance frequency 4.35 GHz, the simulated input impedance of antenna design-3 is near to be matched with 50 ohm impedance. Here due to modified square microstrip patch antenna with finite ground plane of this antenna design-3; the impedance bandwidth is coming out to be **37.47 %** (1630 MHz) of the center frequency at 4.35 GHz. Bandwidth for the proposed antenna design is sufficiently high and other radiation characteristics are also satisfactory.

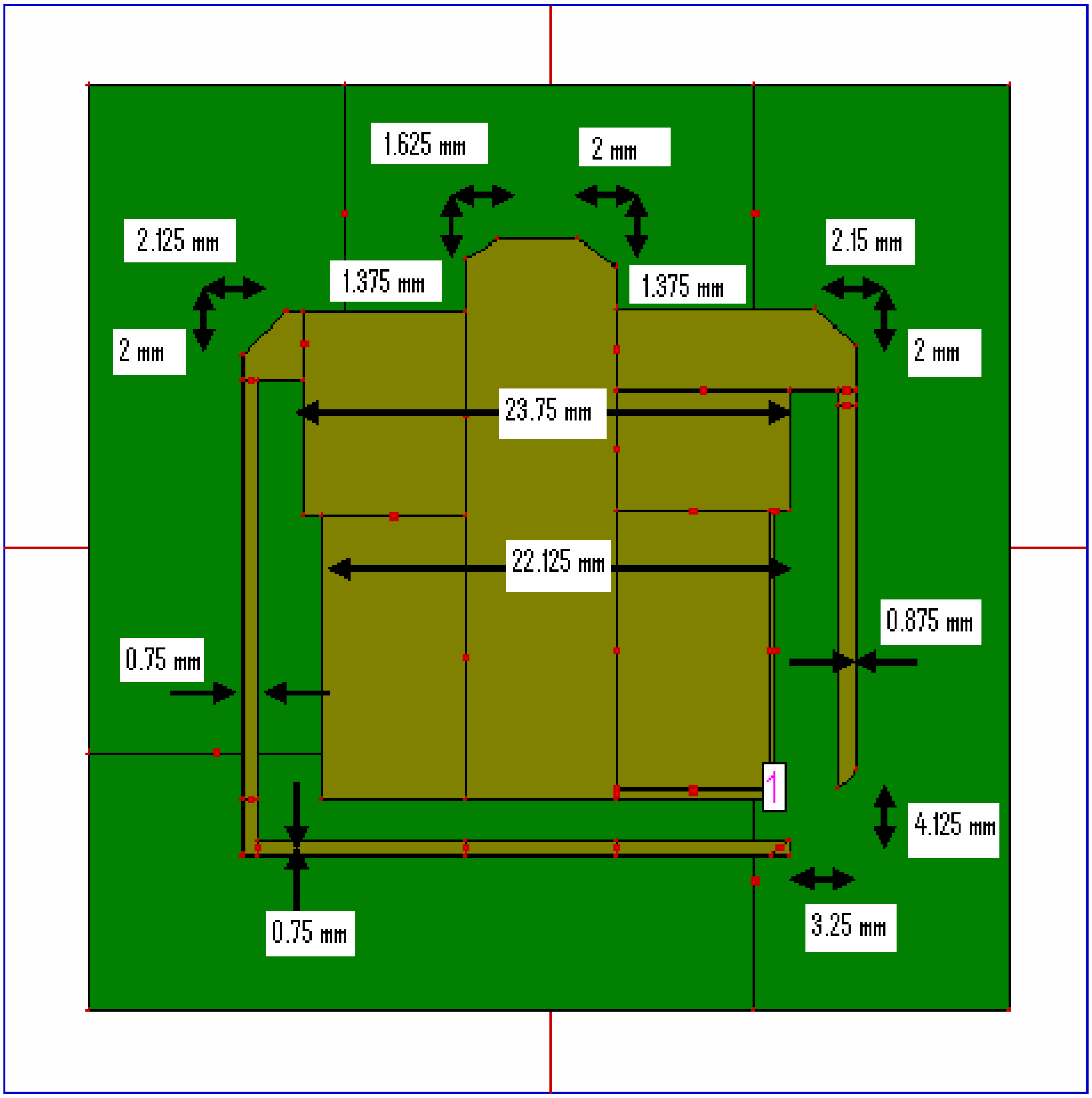

Figure 4.13 Front view of modified square MSA

with slot loaded finite ground plane

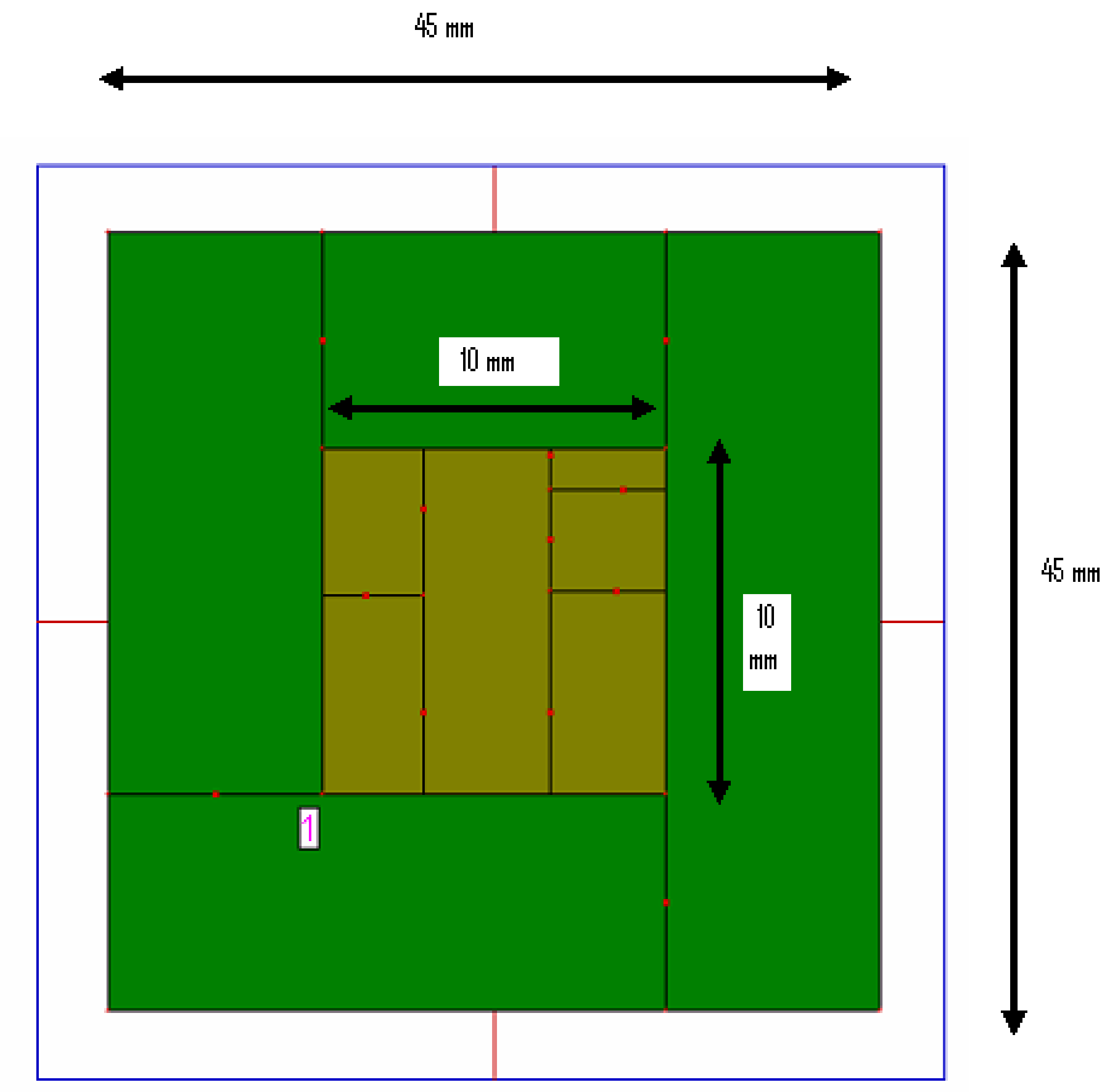

Figure 4.14 Back view of modified square MSA

with slot loaded finite ground plane

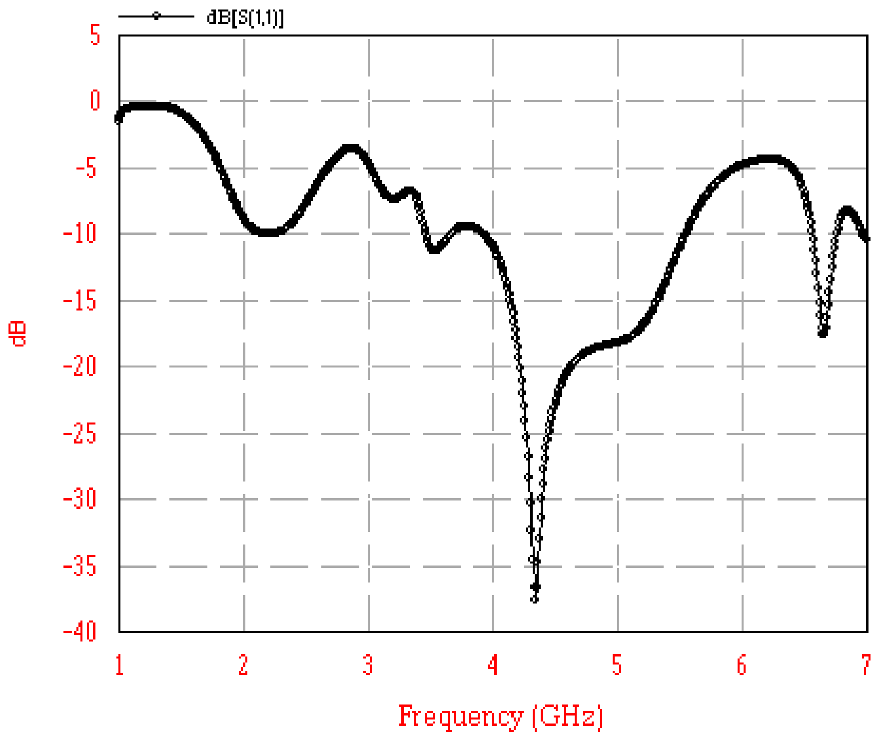

Figure 4.15 Graph between return loss and frequency for antenna design-3

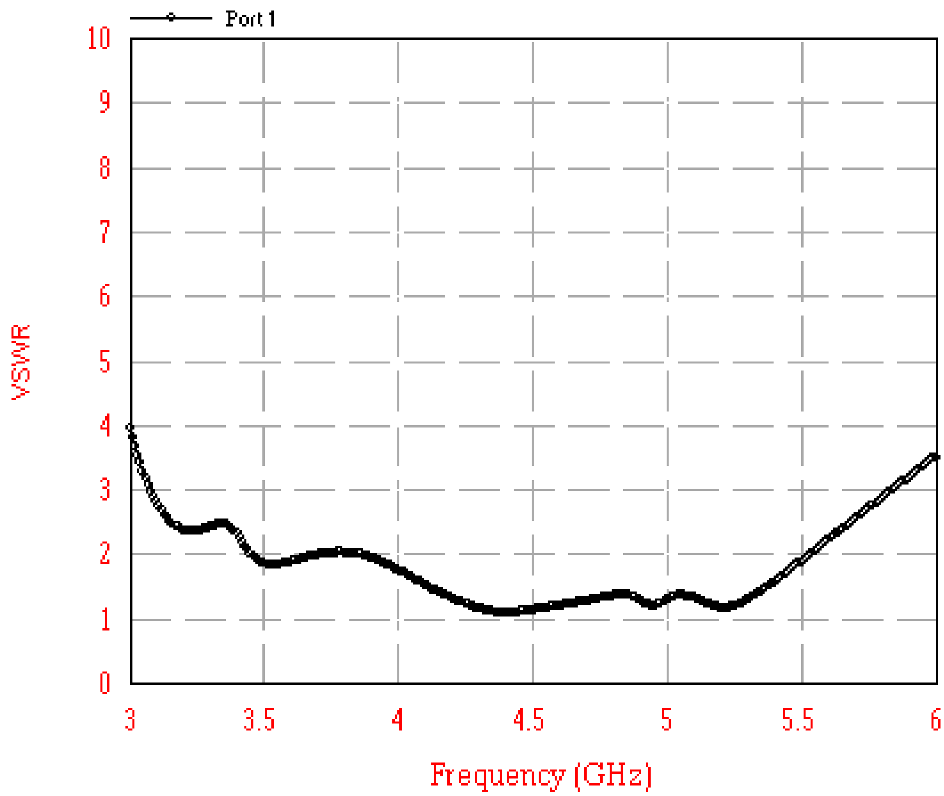

Figure 4.16 Graph between VSWR and frequency for antenna design-3

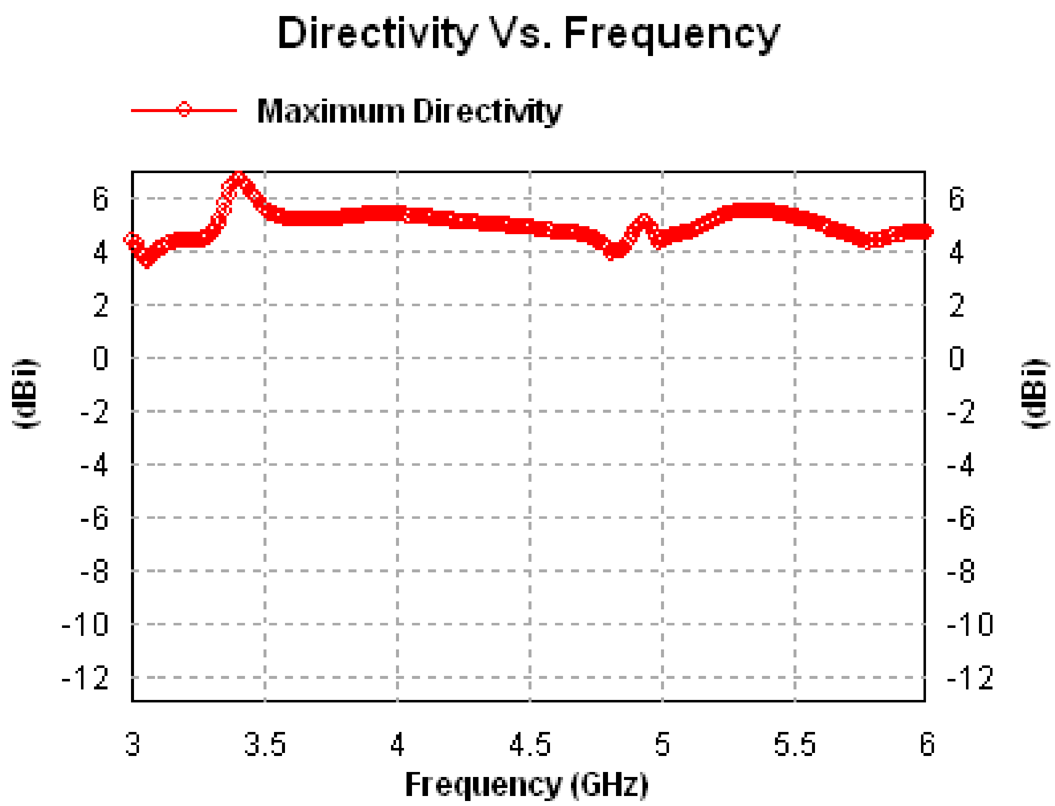

Figure 4.17 Graph between directivity and frequency for antenna design-3

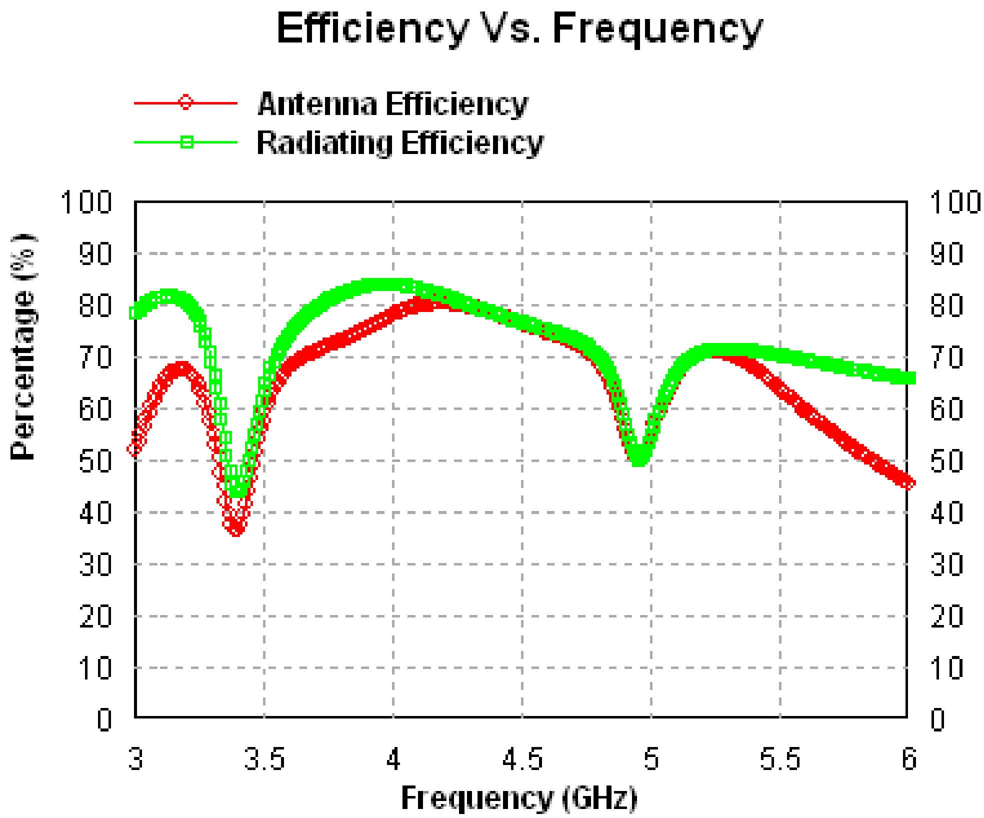

Figure 4.18 Graph between efficiency and frequency for antenna design-3

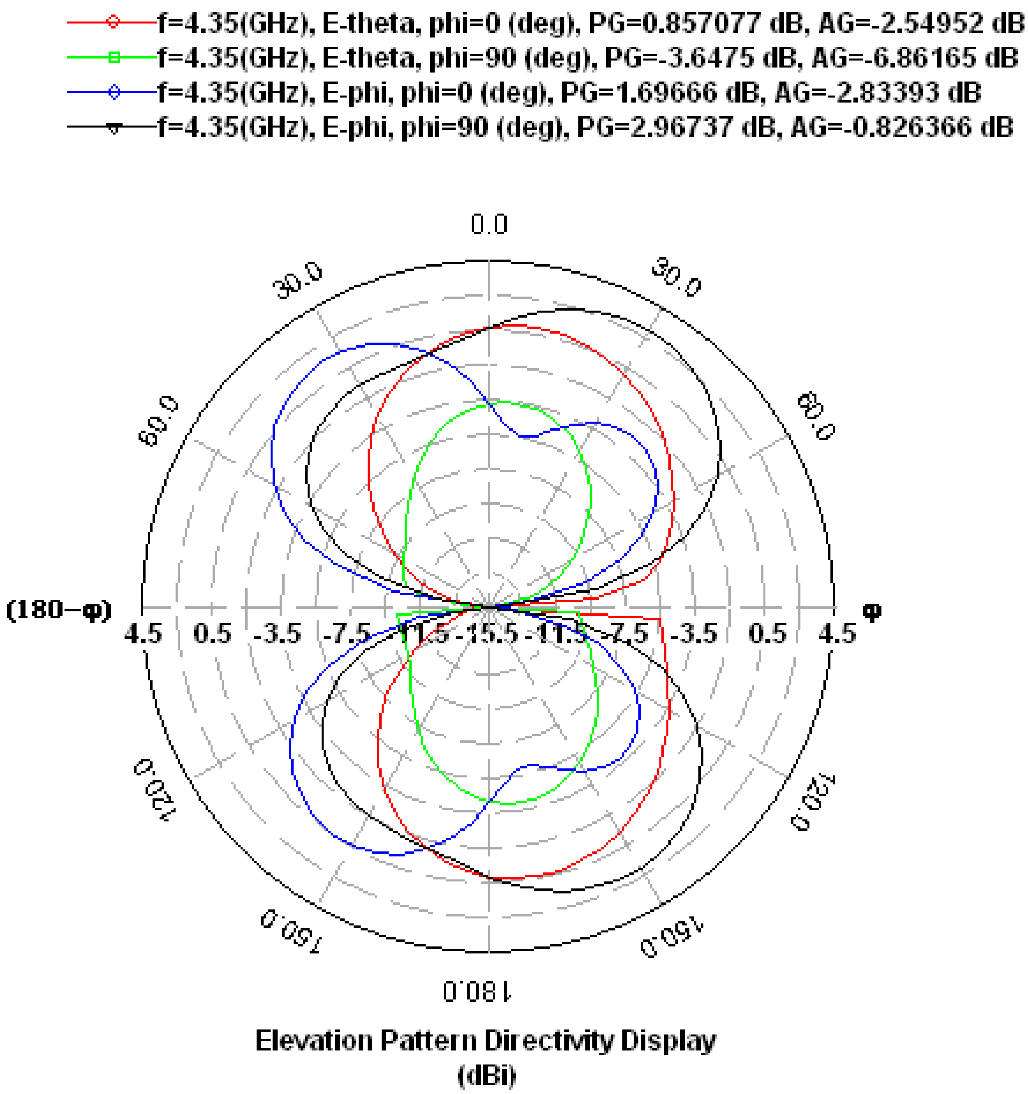

Figure 4.19 Radiation pattern for antenna design-3

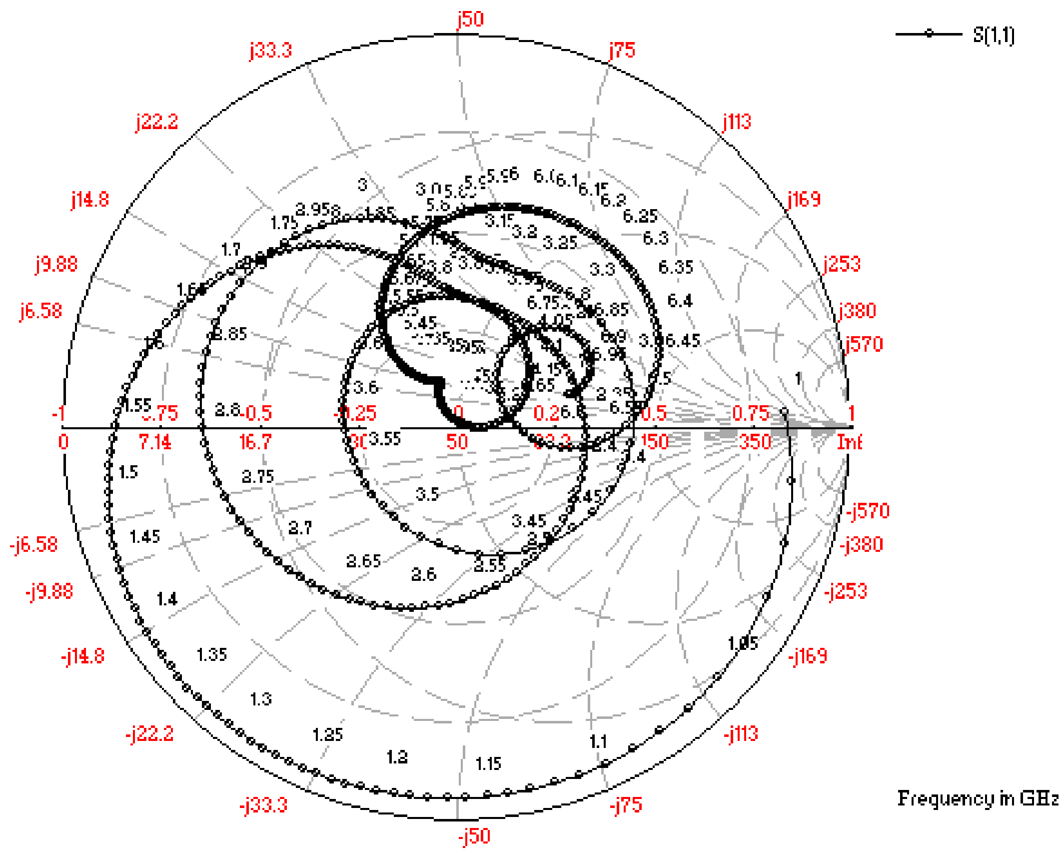

Figure 4.20 Impedance loci for antenna design-3

4.5 COMPACT MSA USING FINITE GROUND PLANE DESIGN-4

In the antenna design-4, an attempt has been made to further improve the bandwidth and other radiation characteristics also due to modified square microstrip patch antenna with finite ground plane. The coaxial probe feed having 50-ohm impedance is used for feeding the patch.

Figure 4.21 presents the modified square microstrip patch antenna design-4. Antenna is designed for different applications of wireless communication in S-band with center frequency f_0 = 3.79 GHz, within the frequency range 2.5 GHz to 5 GHz, with step of frequency selected to be 0.01 GHz, In this modified square patch antenna design-4, patch length L = 30 mm**,** patch width W = 30 mm with finite ground plane of the dimension L = 45 mm and W = 45 mm and feed point position at the patch is (-11.9,-12). Figure 4.22 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-4; maximum return loss is – 26 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 4.23 shows the graph between VSWR and frequency (in GHz) for antenna design-4, impedance bandwidth can be taken below VSWR < 2. Figure 4.24 shows the graph between directivity (in dBi) and frequency (in GHz) for antenna design-4. For the antenna design-4, directivity (in dBi) at the operating frequency is coming between 5-8 dBi. Figure 4.25 shows the graph between efficiency (antenna and radiating, in %) and frequency (in GHz) for antenna design-4, antenna and radiating efficiency both are coming between 80-90 % at centre frequency. Figure 4.26 shows the radiation pattern (2-D elevation pattern) for antenna design-4 at the center frequency 3.79 GHz. Figure 4.27 shows the impedance loci for antenna design-4. At resonance frequency 3.79 GHz, the simulated input impedance of antenna design-4 is near to be matched with 50 ohm impedance. Here due to modified square microstrip patch antenna with finite ground plane of this antenna design-4; the impedance bandwidth is coming out to be **50.13 %** (1900 MHz) of the center frequency at 3.79 GHz. The bandwidth for the proposed antenna design is sufficiently high and other radiation characteristics are also satisfactory and stable over the entire frequency range considered.

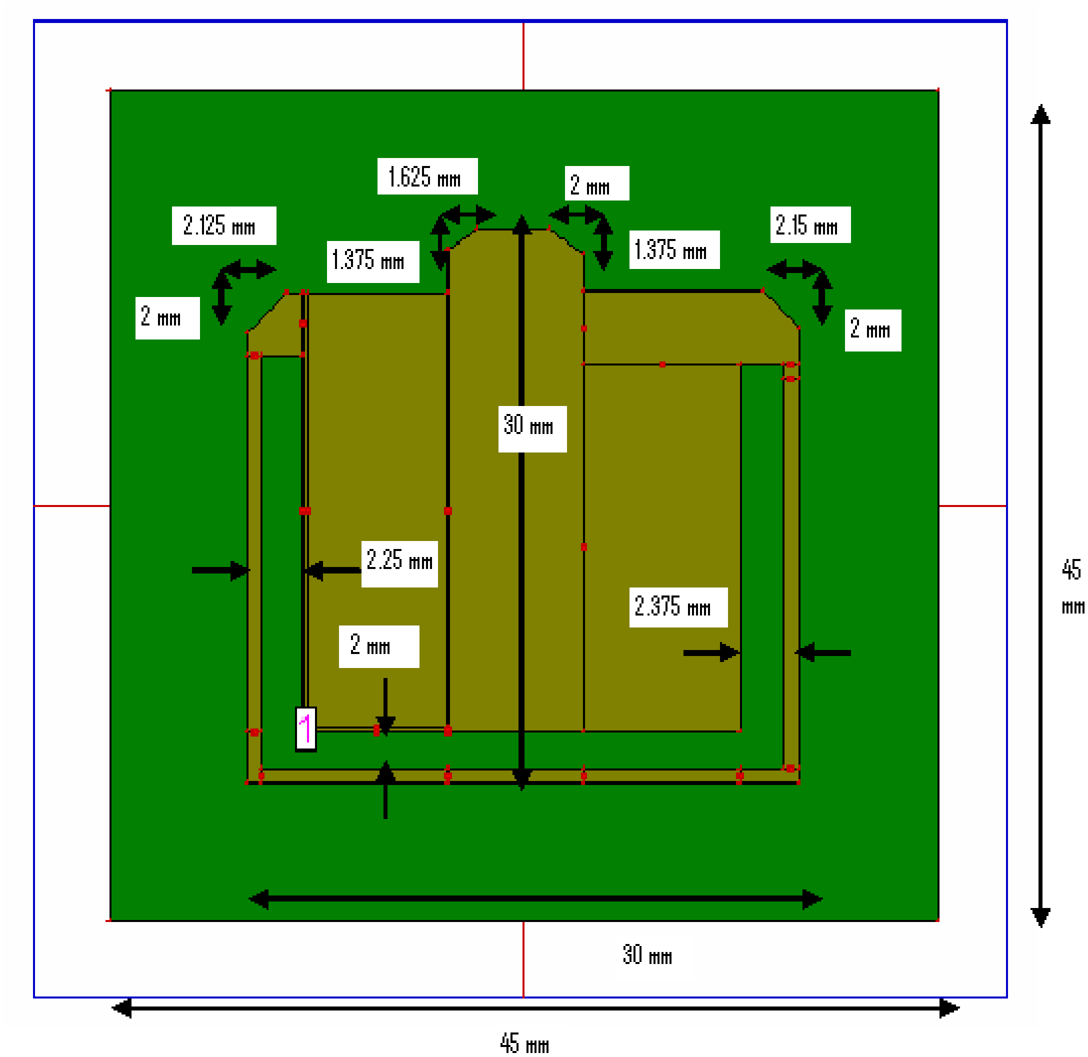

Figure 4.21 Modified square microstrip patch antenna with finite ground plane

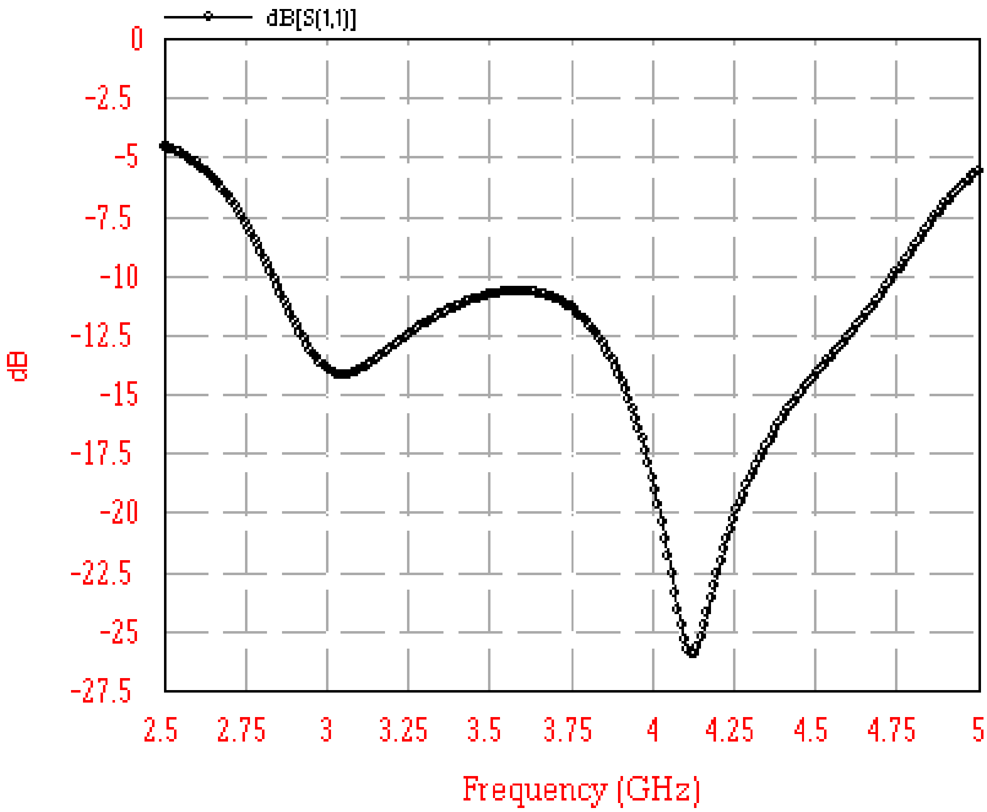

Figure 4.22 Graph between return loss and frequency for antenna design-4

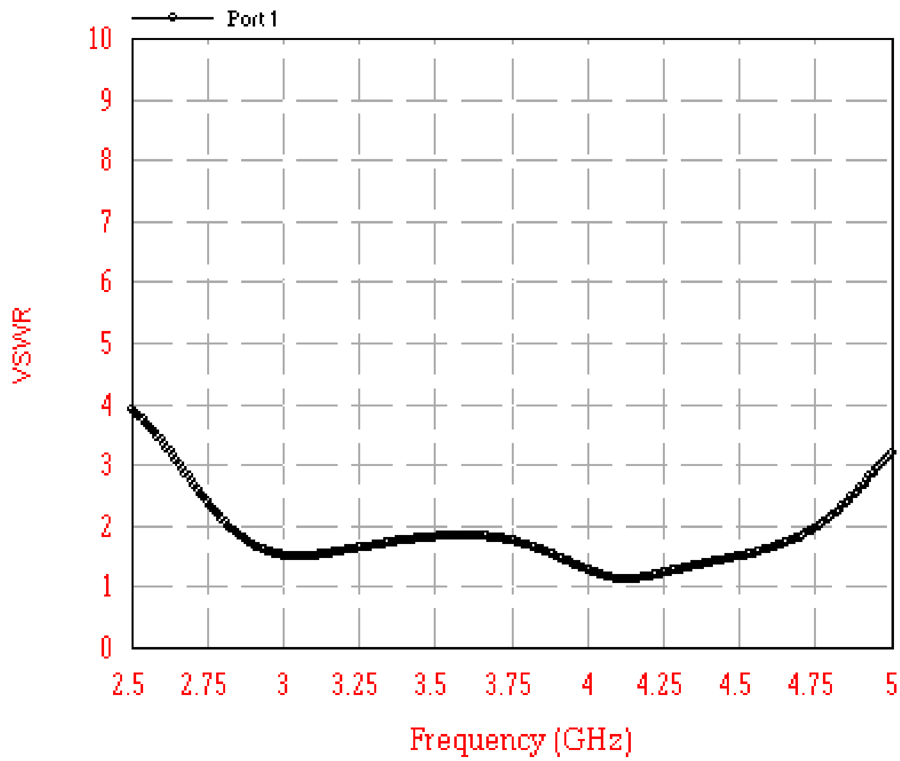

Figure 4.23 Graph between VSWR and frequency for antenna design-4

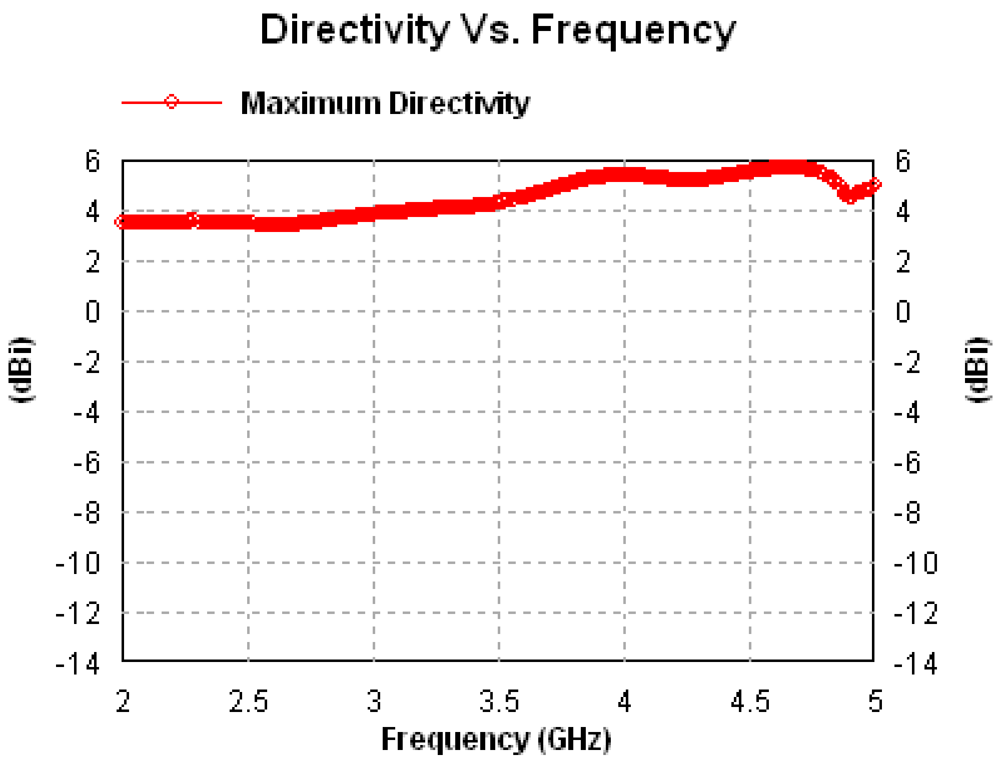

Figure 4.24 Graph between directivity and frequency for antenna design-4

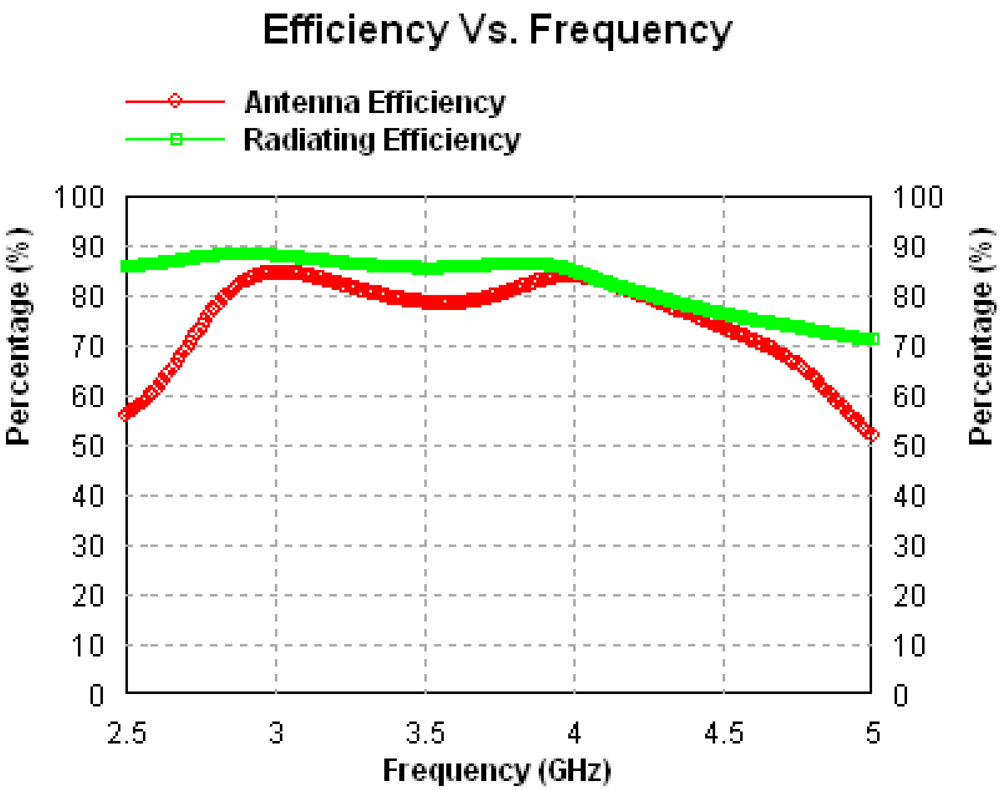

Figure 4.25 Graph between efficiency and frequency for antenna design-4

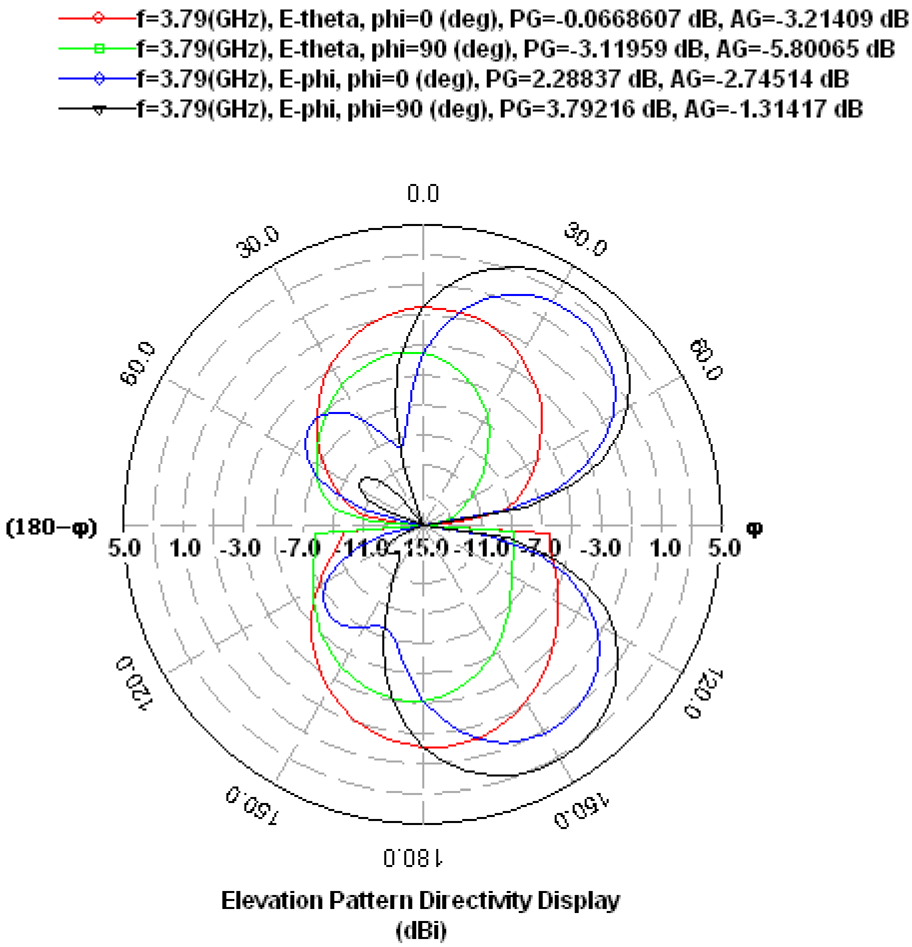

Figure 4.26 Radiation pattern for antenna design-4

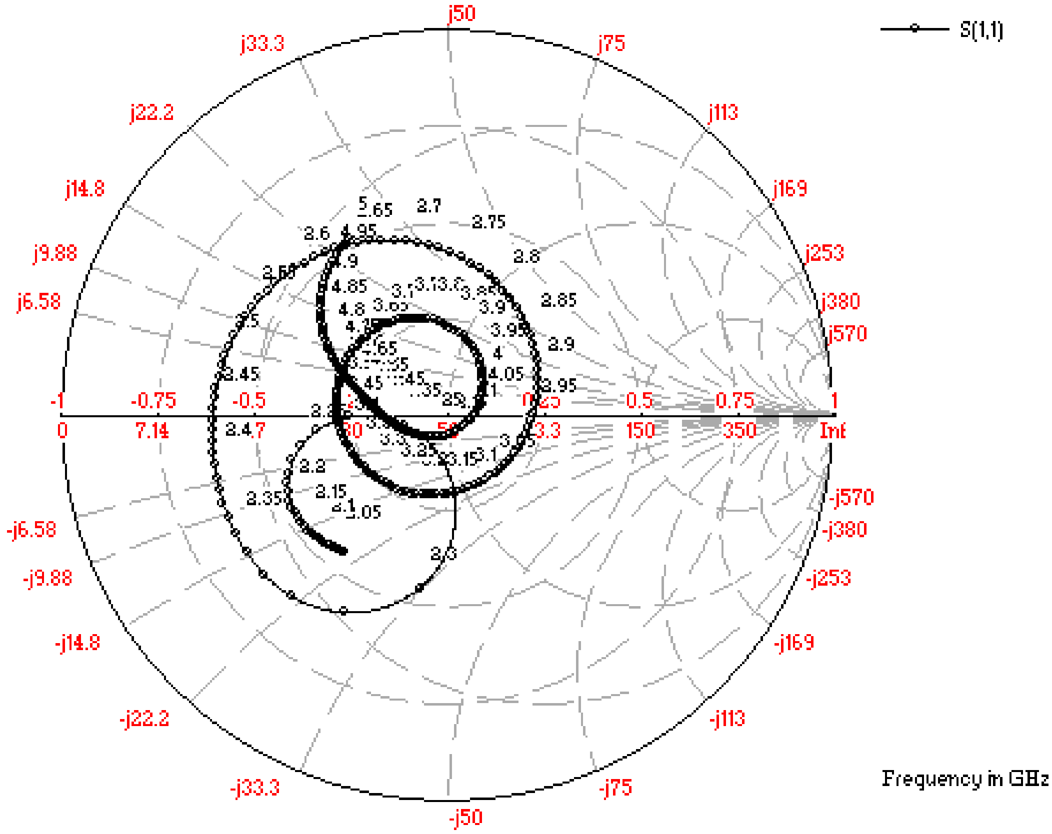

Figure 4.27 Impedance loci for antenna design-4

4.6 CONCLUSION

In this chapter, meandering method to the ground plane or defective ground of a microstrip antenna has been designed and analyzed. The impedance bandwidth can be enhanced many folds by using this method. In the next chapter, tunable and dual band microstrip patch antenna will be discussed which is useful where wide band response is difficult to achieve.