CHAPTER THREE

TRUNCATED COMPACT WIDEBAND MICROSTRIP PATCH ANTENNA

The bandwidth of the printed patch antenna can also be improved by introducing truncated corners in feed patch or in parasitic (gap or direct coupled) patch or in both feed patch and parasitic (gap or direct coupled) patch. In this chapter truncated compact microstrip patch antenna will be designed and analyzed to improve the bandwidth of rectangular patch antenna.

3.1 INTRODUCTION

The method of truncation at the corners of a rectangular patch design to achieve wideband operation has been widely used in practical applications [74]. In these patch antenna designs, a single printed patch which is truncated at the corner is fed through a coaxial probe feed and the other rectangular patches are positioned along radiating corners (edges) and non radiating corners (edges) of fed rectangular patch and are parasitically coupled. Some parasitic patches positioned along radiating corners (edges) and non radiating corners (edges) of fed printed patch may also be truncated at the corner.

The couplings between the multiple resonators are realized by using small air gap between the patches. Additional patches parasitically coupled in the antenna provide varied resonant lengths, more resonant modes may be generated at frequencies near to each other; therefore, an improved bandwidth greater than that of the conventional antenna design can be obtained.

All the proposed antenna designs are simulated using IE3D software and its radiation characteristics are analyzed for optimization of various practical applications of wireless communication systems. These truncated coplanar multiresonator microstrip patch antennas are designed for various application of wireless communication, mobile communication, WLAN, WiMax systems in S-band (2 to 4 GHz).

3.2 TRUNCATED GAP COUPLED MICROSTRIP ANTENNA DESIGN-1

In the antenna design-1, the truncated gap coupled rectangular microstrip patch antenna with a single feed is introduced to increase the bandwidth. In the microstrip patch antenna design-1, a single patch which is truncated at the corner is fed through a coaxial probe feed and the other unequal rectangular patches are positioned along radiating corners (edges) and non radiating corners (edges) of fed printed patch and are parasitically coupled.

Figure 3.1 presents the truncated gap coupled rectangular microstrip antenna design-1. In this antenna design-1, an air gap of 0.375 mm is introduced 1.05 mm below the centre horizontal axis. Antenna is designed for S-band of frequency range with center frequency f_0 = 2.6 GHz, within the frequency range 2 GHz to 3 GHz, with step of frequency selected to be 0.01 GHz, patch length L = 30 mm**,** patch width W = 55 mm, with two side corners are truncated, feed point positions = (-13.275, 0.2). The patches are printed on inexpensive FR4 (glass epoxy), having dielectric constant (€r) of 4.4, loss tangent tan δ = 0.02 and height 1.6 mm. The coaxial probe feed having 50-ohm impedance is used for feeding the patch. Figure 3.2 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-1; maximum return loss is – 43 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 3.3 shows the graph between VSWR and frequency (in GHz) for antenna design-1, impedance bandwidth can be taken below VSWR < 2. Figure 3.4 shows the graph between directivity (in dBi) and frequency (in GHz) for antenna design-1. For the antenna design-1, directivity (in dBi) for the operating frequency is coming between 5-8 dBi. Figure 3.5 shows the radiation pattern (2-D elevation pattern) for antenna design-1 at the center frequency 2.6 GHz. Figure 3.6 shows the graph between efficiency (antenna and radiating, in %) and frequency (in GHz) for antenna design-1, antenna and radiating efficiency both are coming between 40-50 % at centre frequency. Figure 3.7 shows the graph between gain (in dBi) and frequency (in GHz) for antenna design-1. Figure 3.8 shows the impedance loci for antenna design-1. At resonance frequency 2.6 GHz, the simulated input impedance of antenna design-1 is near to be matched with 50 ohm impedance. The impedance bandwidth is coming out to be **13.46 %** (350MHz) of the center frequency at 2.6 GHz.

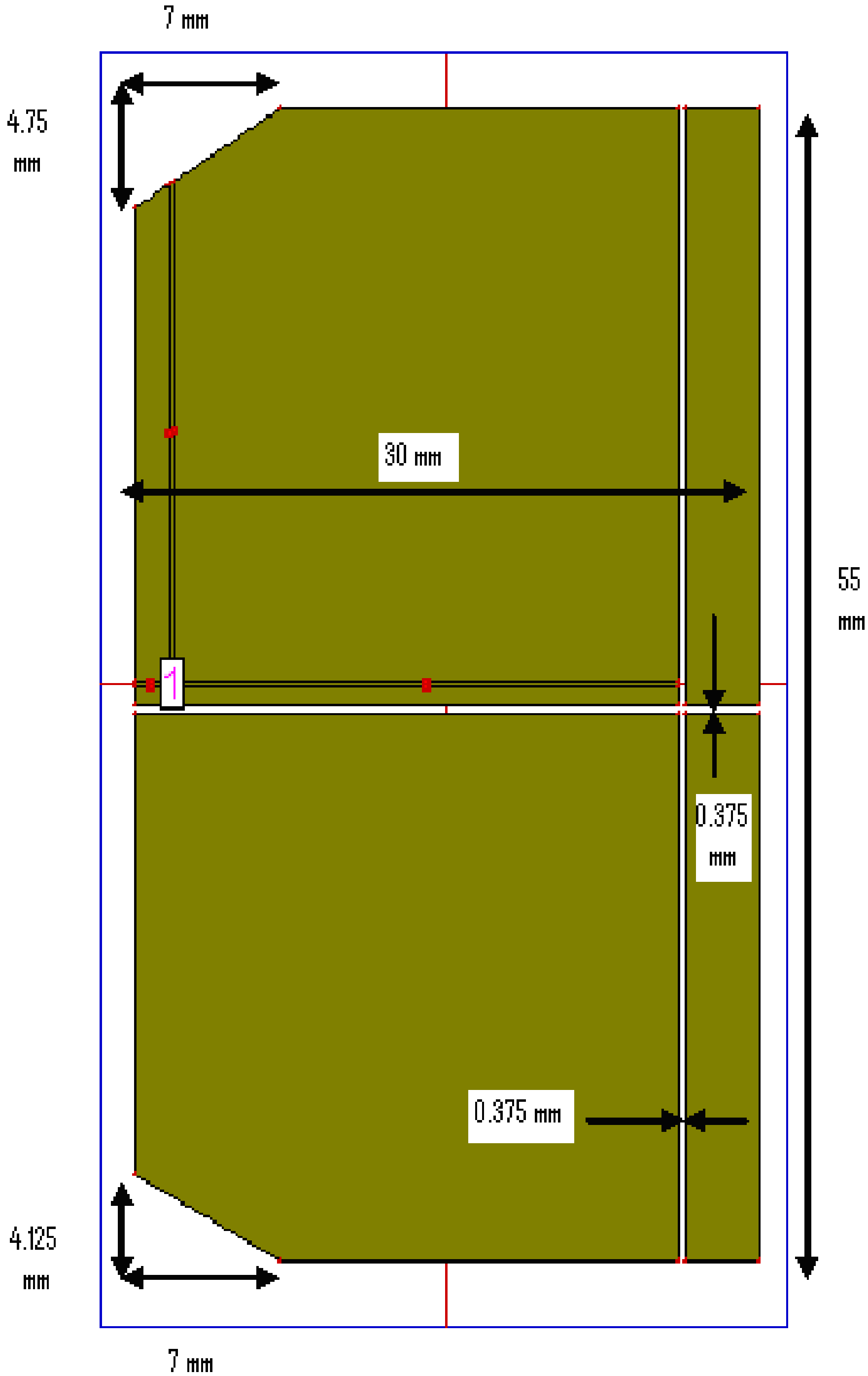

Figure 3.1 Truncated gap-coupled rectangular microstrip antenna design-1

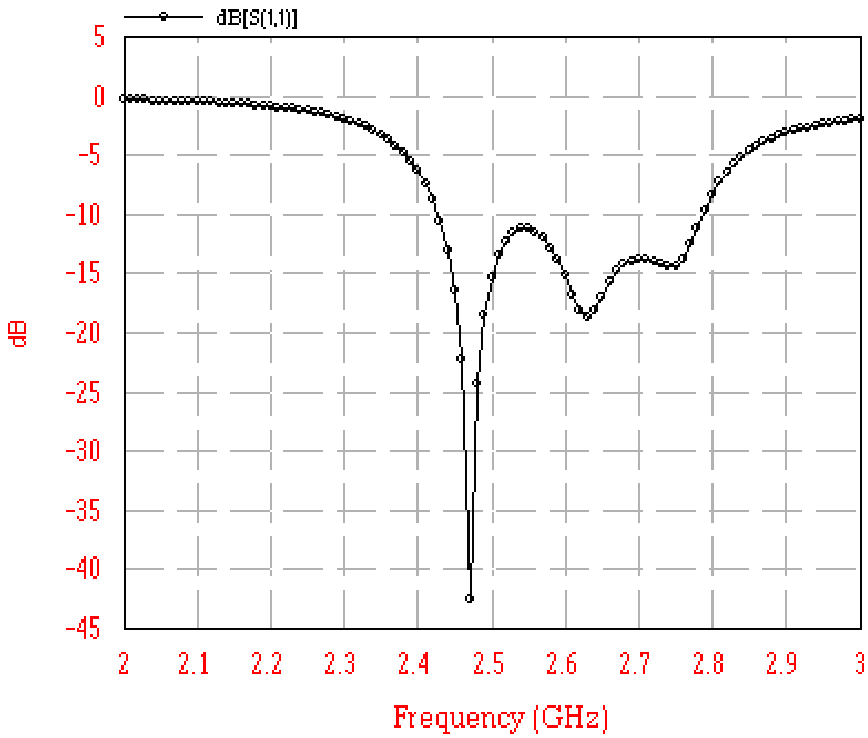

Figure 3.2 Graph between return loss and frequency for antenna design-1

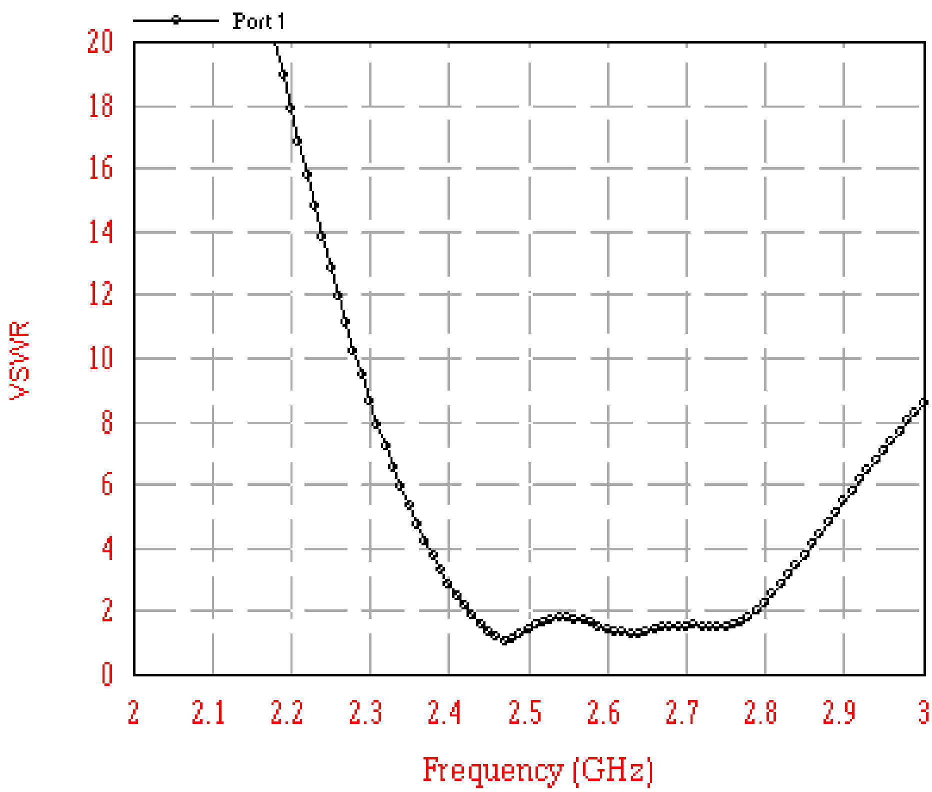

Figure 3.3 Graph between VSWR and frequency for antenna design-1

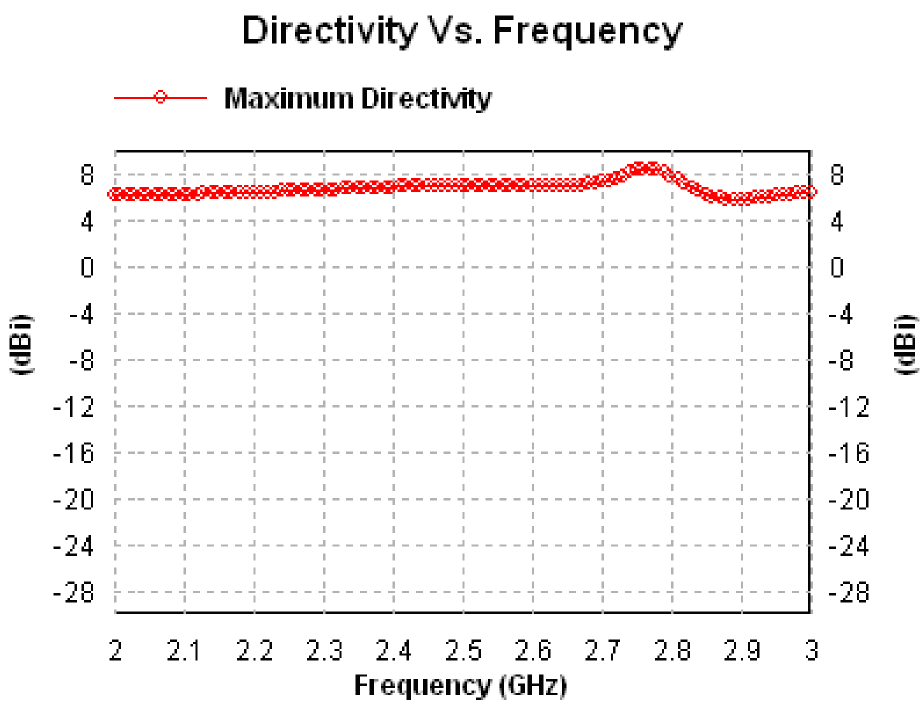

Figure 3.4 Graph between directivity and frequency for antenna design-1

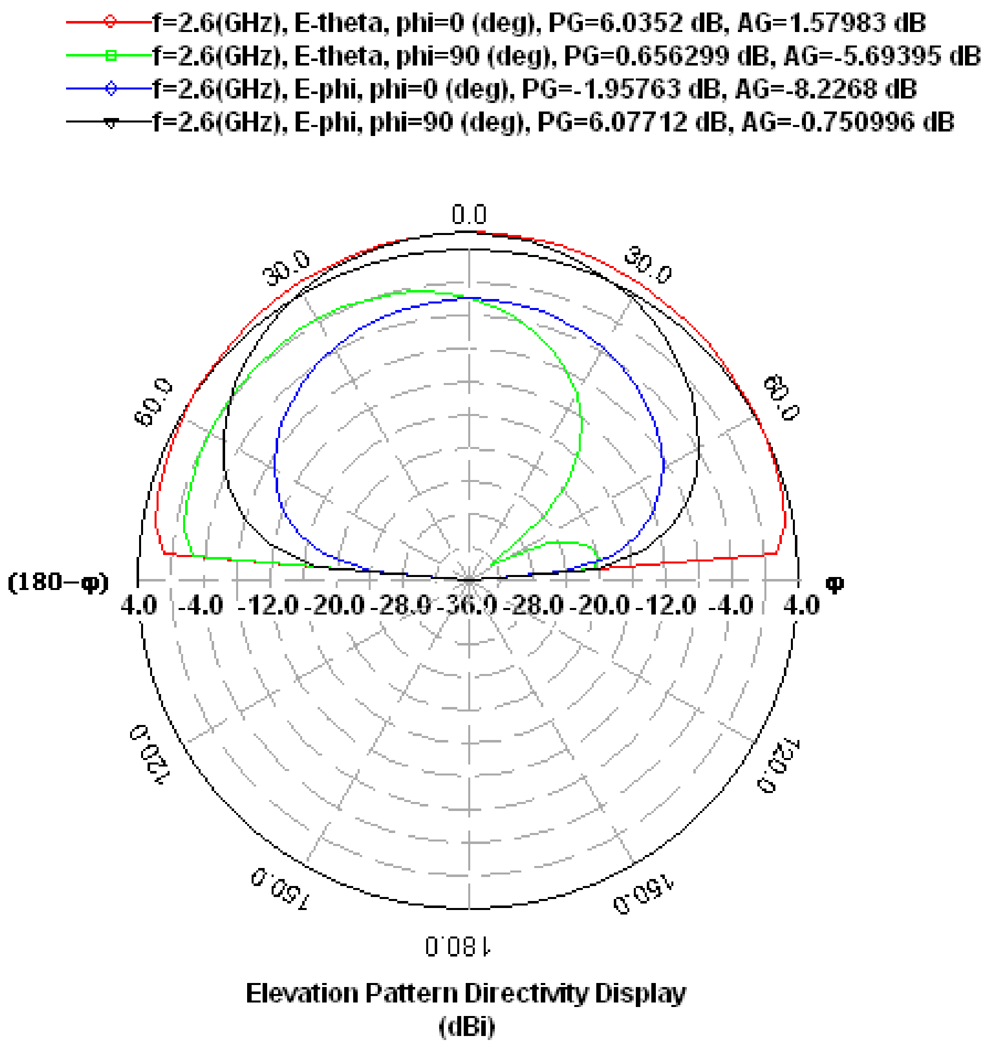

Figure 3.5 Radiation pattern for antenna design-1

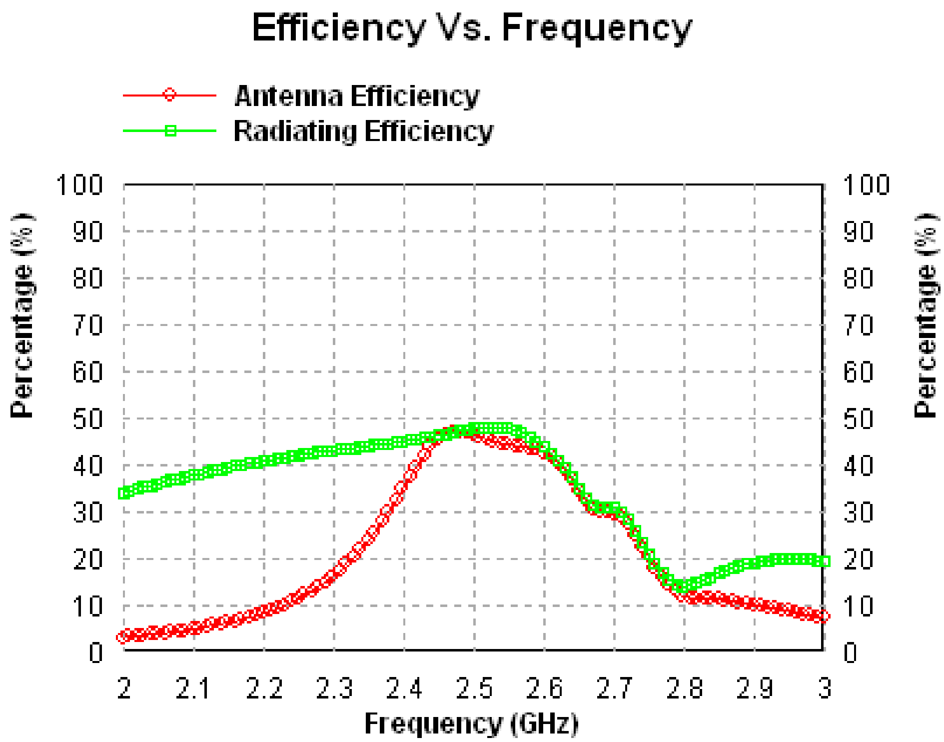

Figure 3.6 Graph between efficiency and frequency for antenna design-1

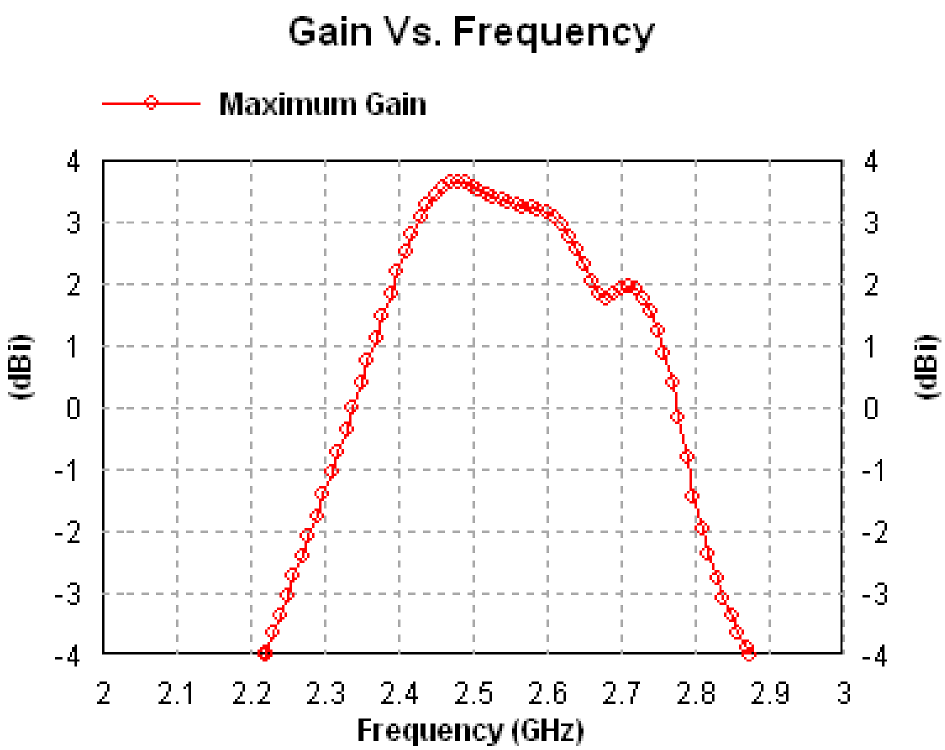

Figure 3.7 Graph between gain and frequency for antenna design-1

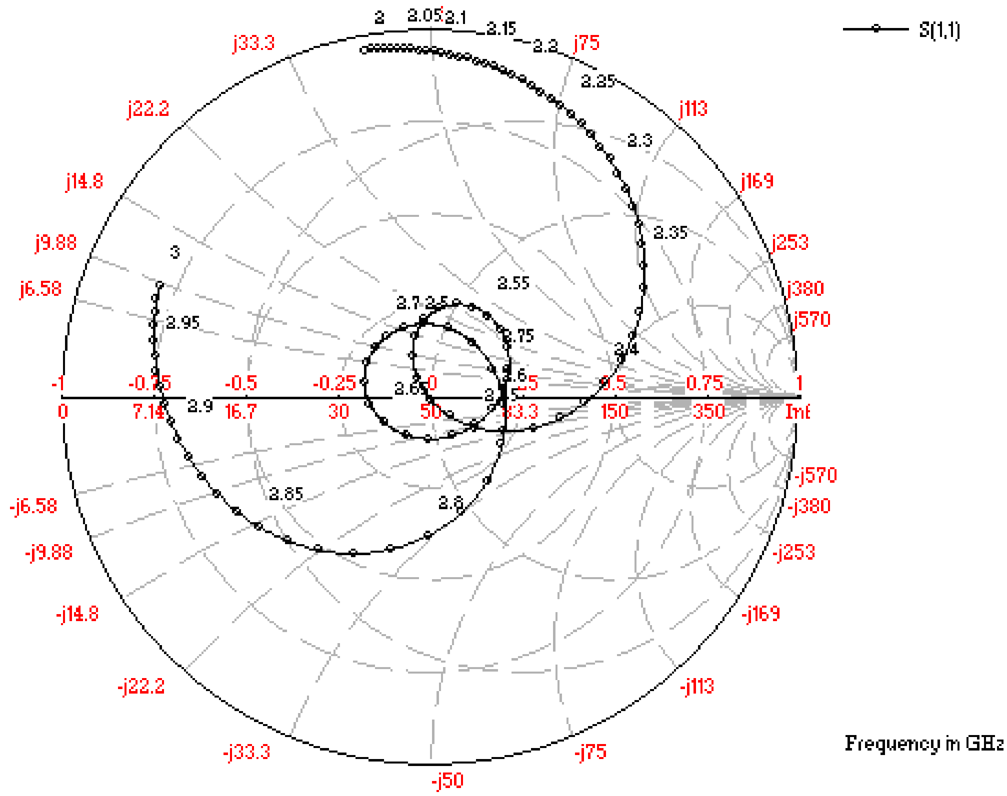

Figure 3.8 Impedance loci for antenna design-1

3.3 TRUNCATED GAP COUPLED MICROSTRIP ANTENNA DESIGN-2

In the antenna design-2, the truncated gap coupled rectangular microstrip patch antenna with a single feed is introduced to increase the bandwidth. In the microstrip patch antenna design-2, a single patch which is truncated at the corner is fed through a coaxial probe feed and the other unequal rectangular patches are positioned along radiating corners (edges) and non radiating corners (edges) of fed rectangular patch and are parasitically coupled. The couplings between the multiple resonators are realized by using small air gap between the patches.

Figure 3.9 presents the truncated gap coupled rectangular patch antenna design-2. In the antenna design-2, an air gap of 0.25 mm is introduced 0.35 mm below the centre horizontal axis, Antenna is designed for S-band of frequency range with center frequency f_0 = 2.64 GHz, within the frequency range 2 GHz to 3 GHz, with step of frequency selected to be 0.01 GHz, patch length L = 30 mm**,** patch width W = 55 mm, with feed point positions = (-13.025, 1.325). The patches are printed on inexpensive FR4 (glass epoxy), having dielectric constant (Єr) of 4.4, loss tangent tan δ = 0.02 and height 1.6 mm. The coaxial probe feed having 50-ohm impedance is used for feeding the patch. Figure 3.10 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-2; maximum return loss is – 31 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 3.11 shows the graph between VSWR and frequency for antenna design-2, impedance bandwidth can be taken below VSWR < 2. Figure 3.12 shows the graph between directivity (in dBi) and frequency (in GHz) for antenna design-2. For the antenna design-2, directivity (in dBi) for the operating frequency is coming between 5-8 dBi. Figure 3.13 shows the radiation pattern (2-D elevation pattern) for antenna design-2 at the center frequency 2.64 GHz. Figure 3.14 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 40-50 % at the centre frequency. Figure 3.15 shows the graph between gain (in dBi) and frequency (in GHz) for antenna design-2. Figure 3.16 shows the impedance loci for antenna design-2. At resonance frequency 2.64 GHz, the simulated input impedance of antenna design-2 is near to be matched with 50 ohm impedance. The impedance bandwidth is coming out to be **15.53 %** (410 MHz) of the center frequency at 2.64 GHz with four resonant modes within the specified frequency range.

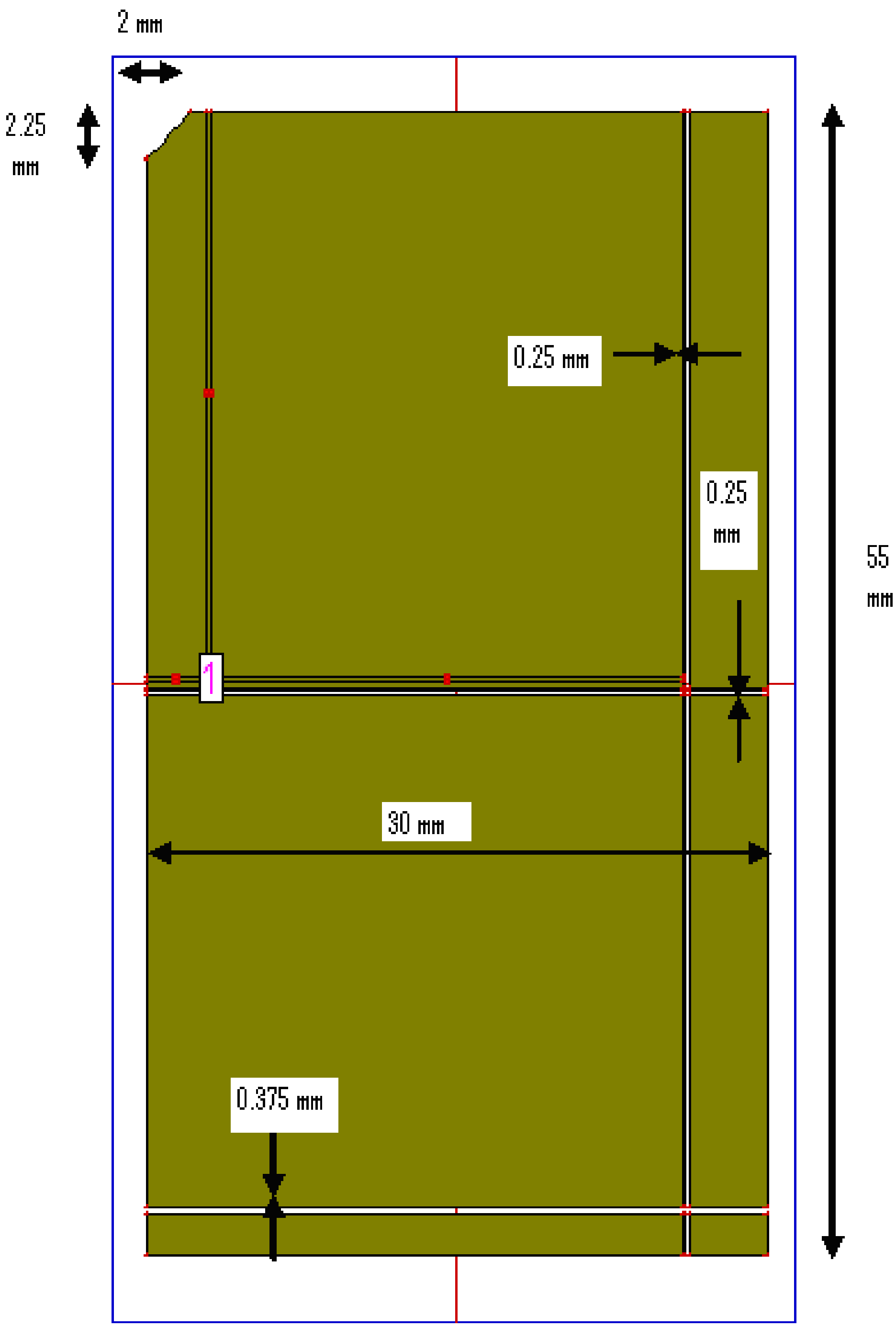

Figure 3.9 Truncated gap-coupled rectangular microstrip antenna design-2

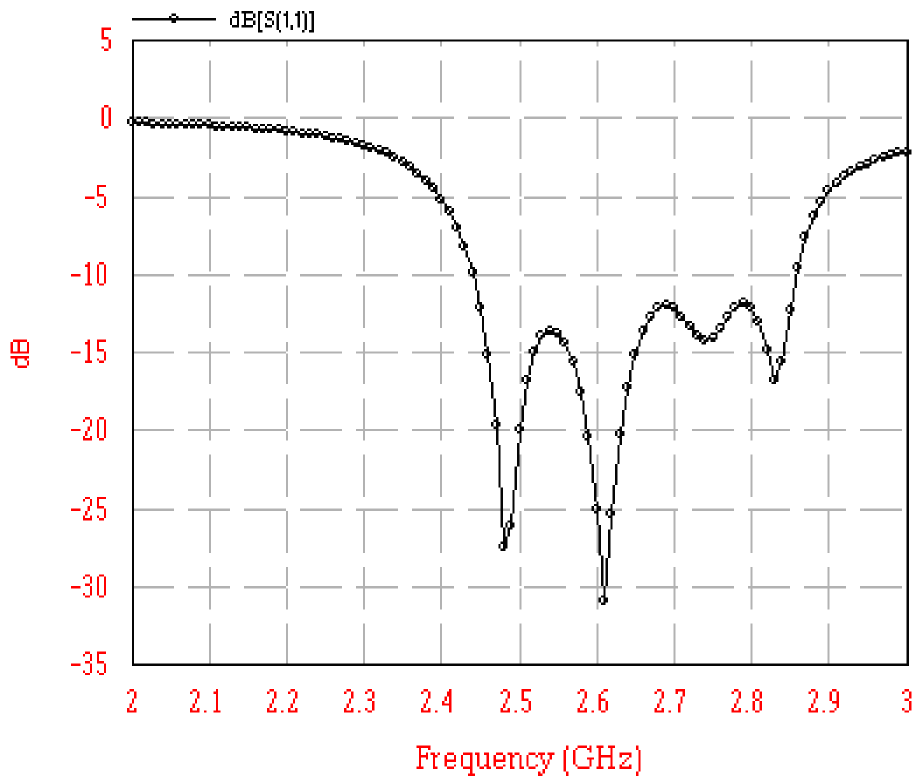

Figure 3.10 Graph between return loss and frequency for antenna design-2

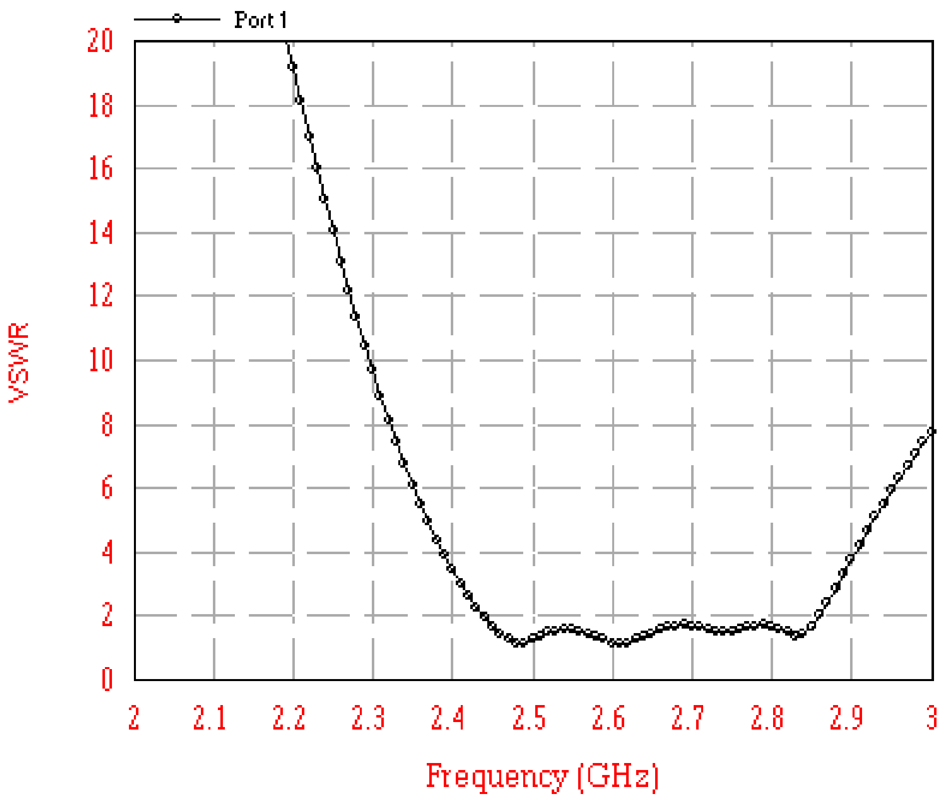

Figure 3.11 Graph between VSWR and frequency for antenna design-2

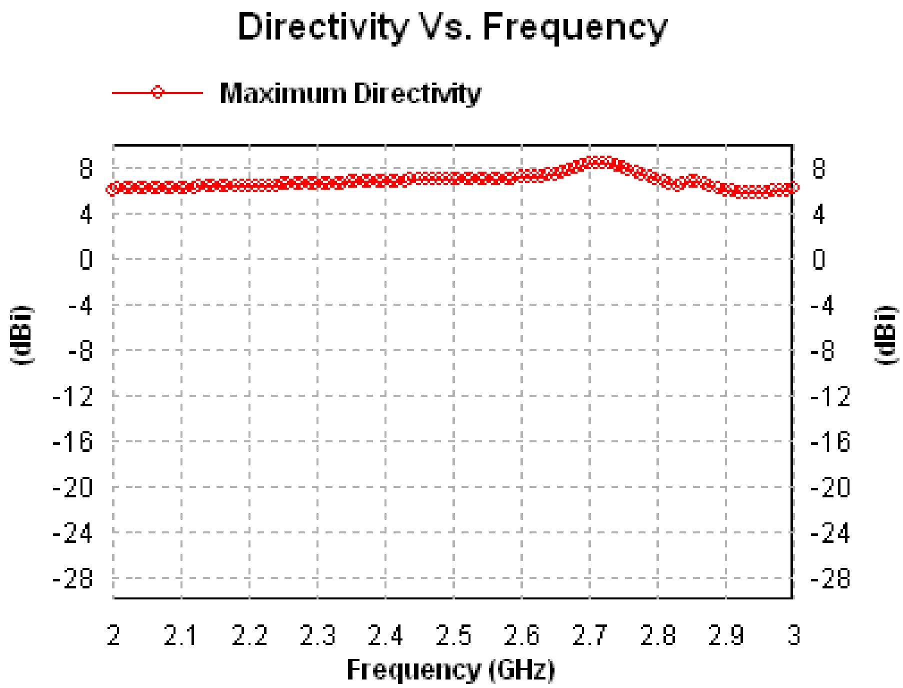

Figure 3.12 Graph between directivity and frequency for antenna design-2

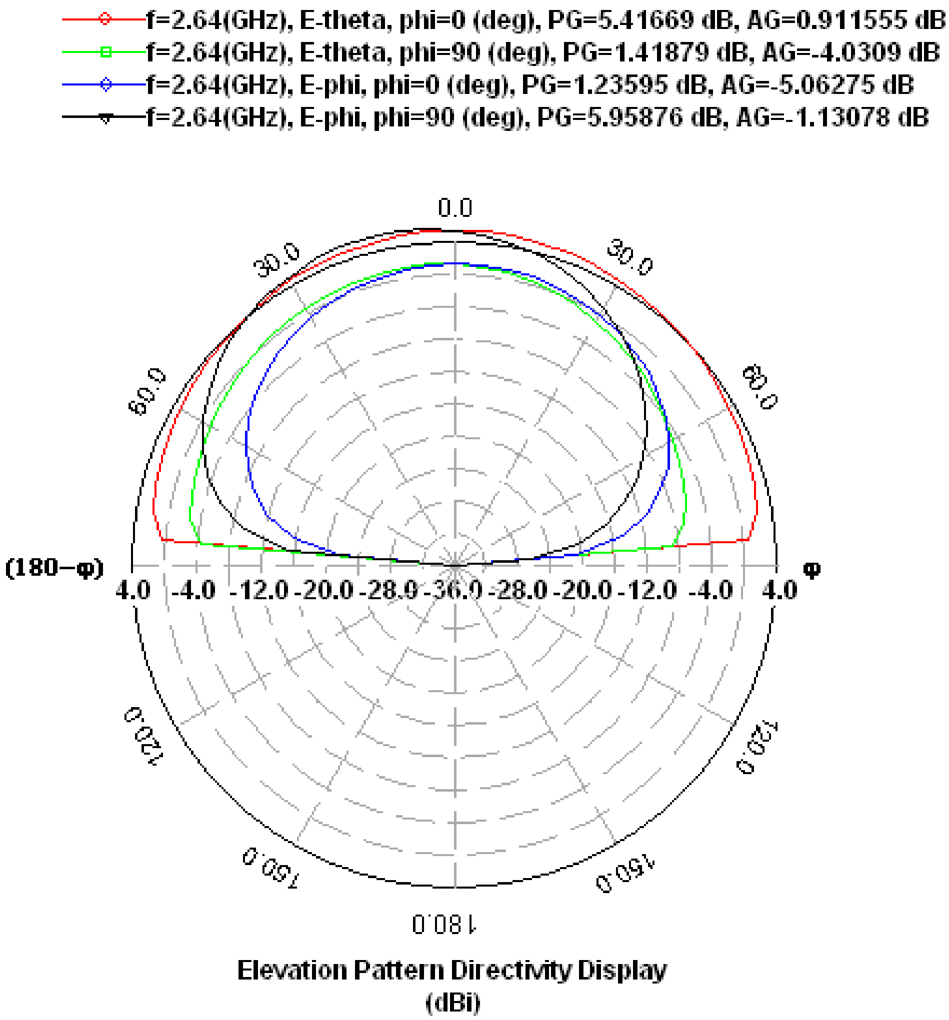

Figure 3.13 Radiation pattern for antenna design-2

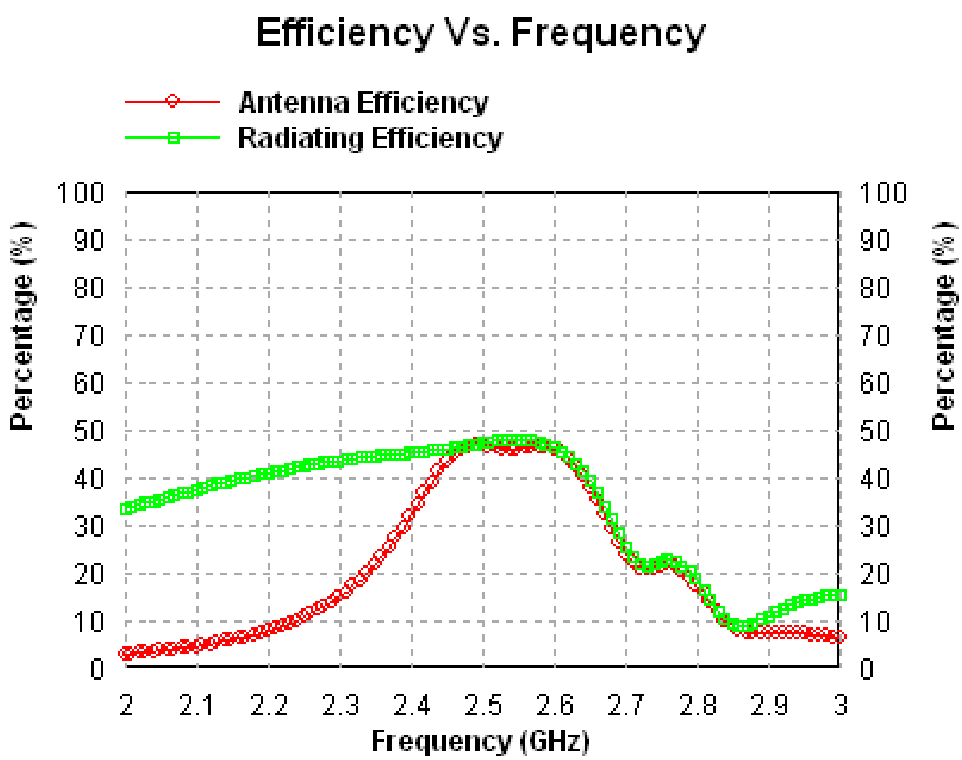

Figure 3.14 Graph between efficiency and frequency for antenna design-2

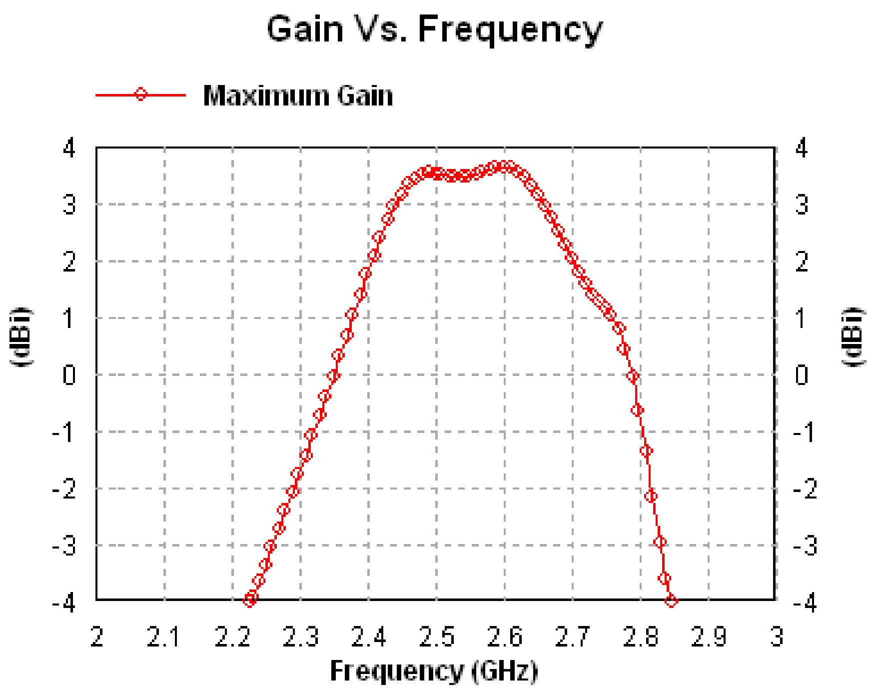

Figure 3.15 Graph between gain and frequency for antenna design-2

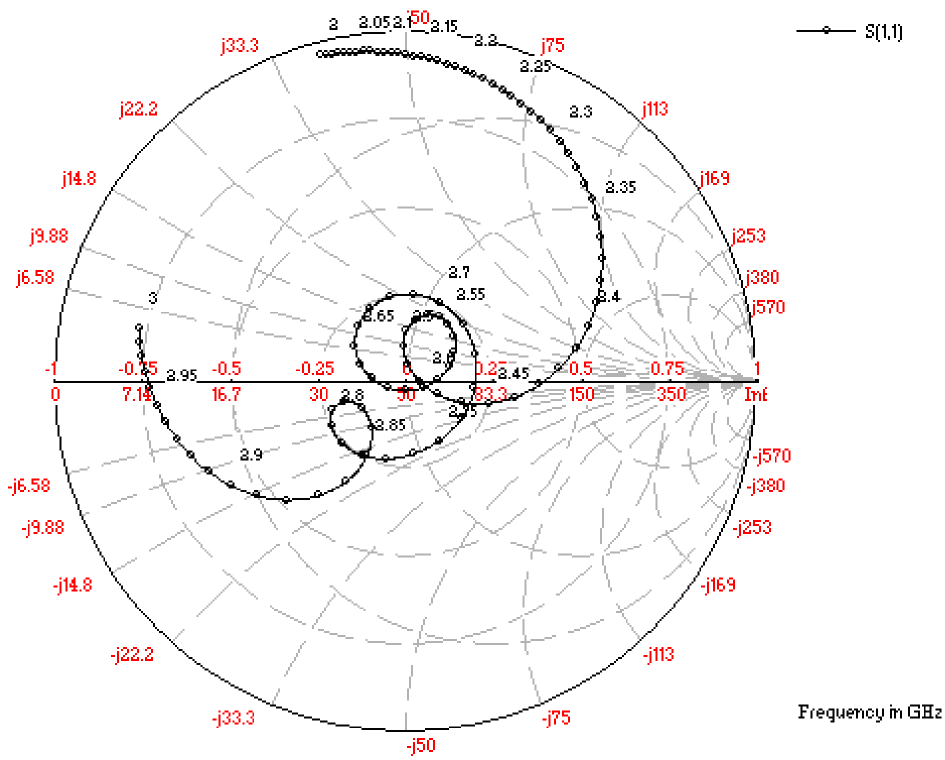

Figure 3.16 Impedance loci for antenna design-2

3.4 TRUNCATED GAP COUPLED MICROSTRIP ANTENNA DESIGN-3

In the antenna design-3, an attempt has been made to further improve the bandwidth. The bandwidth has been improved if the truncated gap coupled reduced size printed patch antenna with a single feed is used. In this microstrip patch antenna design-3, a single patch which is truncated at the corner is fed through a coaxial probe feed and the other rectangular patches are positioned along radiating corners (edges) and non radiating corners (edges) of fed printed patch and are parasitically coupled. Out of these some parasitic patch are also truncated.

Figure 3.17 presents the truncated gap coupled reduced size rectangular microstrip antenna design-3. In this antenna design-3, an air gap of 0.25 mm is introduced 0.35 mm below the centre horizontal axis. Antenna is designed for S-band of frequency range with center frequency f_0 = 2.66 GHz within the frequency range 2 GHz to 3 GHz, with step of frequency selected to be 0.01 GHz, In the antenna design-3, the patch size is reduced by taking patch length L = 30 mm (above air gap) and L = 28.625 mm (below air gap)**,** patch width W = 55 mm, with two side corners are truncated, with feed point positions = (-11.95, 0.15). The patches are printed on inexpensive FR4 (glass epoxy), having dielectric constant (Єr) of 4.4, loss tangent tan δ = 0.02 and height 1.6 mm. The coaxial probe feed having 50-ohm impedance is used for feeding the patch. Figure 3.18 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-3; maximum return loss is – 43 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 3.19 shows the graph between VSWR and frequency (in GHz) for antenna design-3, impedance bandwidth can be taken below VSWR < 2. Figure 3.20 shows the graph between directivity (in dBi) and frequency (in GHz) for antenna design-3. For the antenna design-3, directivity (in dBi) for the operating frequency is coming between 5-8 dBi. Figure 3.21 shows the radiation pattern (2-D elevation pattern) for antenna design-3 at the center frequency 2.66 GHz. Figure 3.22 shows the graph between efficiency (antenna and radiating, in %) and frequency (in GHz) for antenna design-3. Figure 3.23 shows the graph between gain (in dBi) and frequency (in GHz) for antenna design-3. Figure 3.24 shows the impedance loci for antenna design-3. At resonance frequency 2.66 GHz, the simulated input impedance of antenna design-3 is near to be matched with 50 ohm impedance. The impedance bandwidth is coming out to be **15.8 %** (420 MHz) of the center frequency at 2.66 GHz.

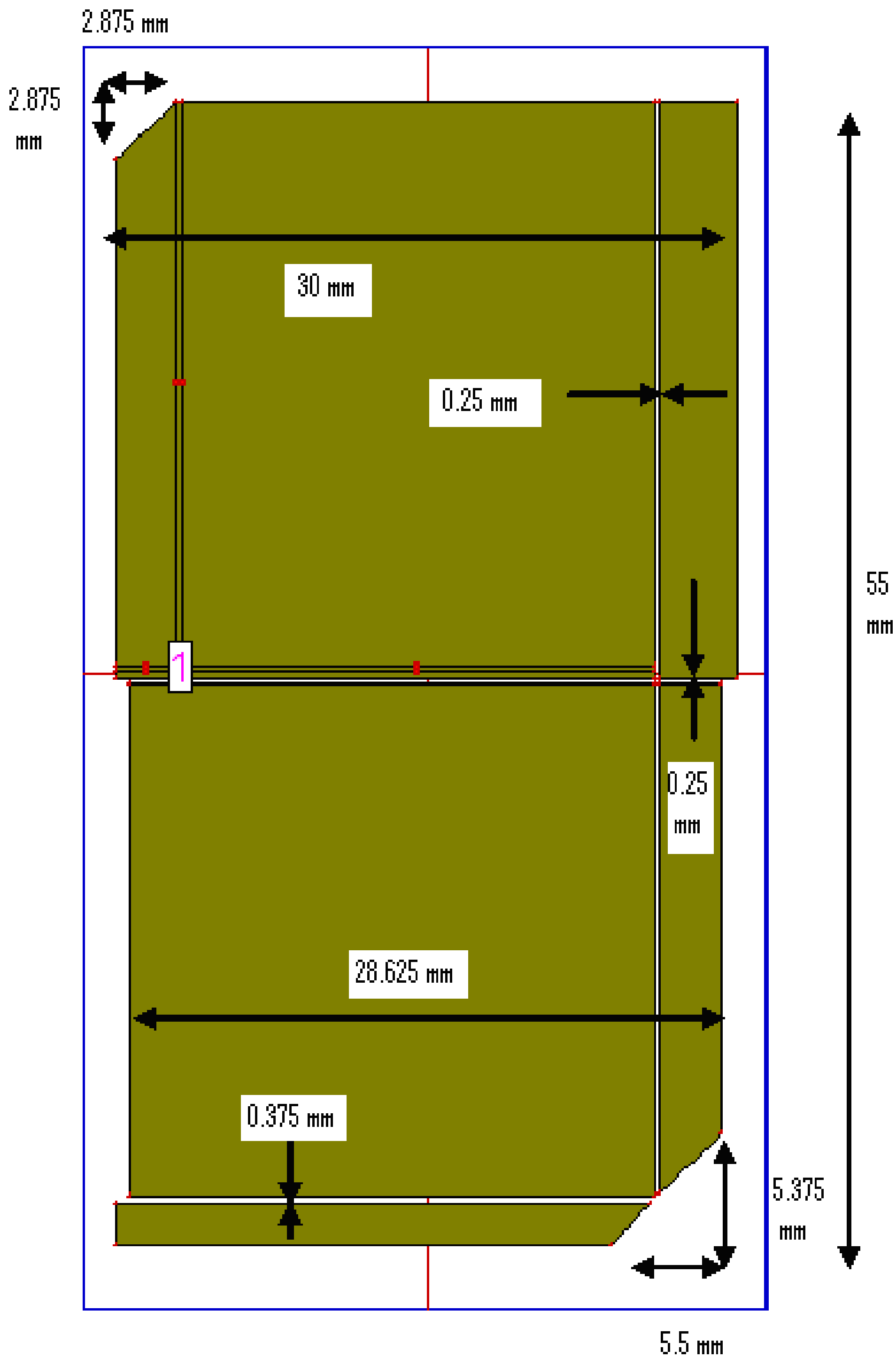

Figure 3.17 Truncated gap-coupled rectangular microstrip antenna design-3

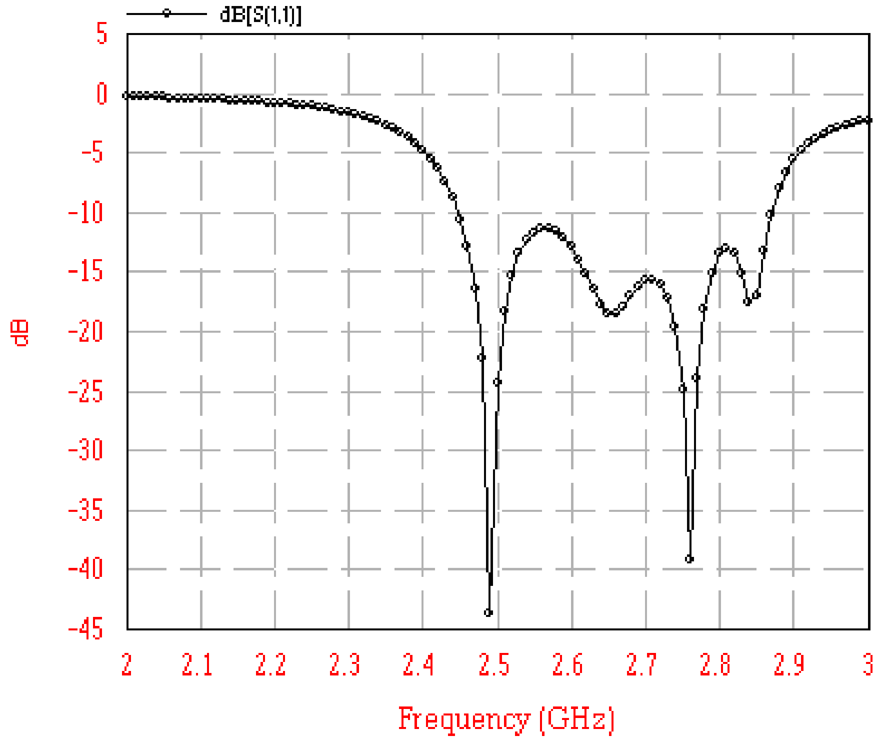

Figure 3.18 Graph between return loss and frequency for antenna design-3

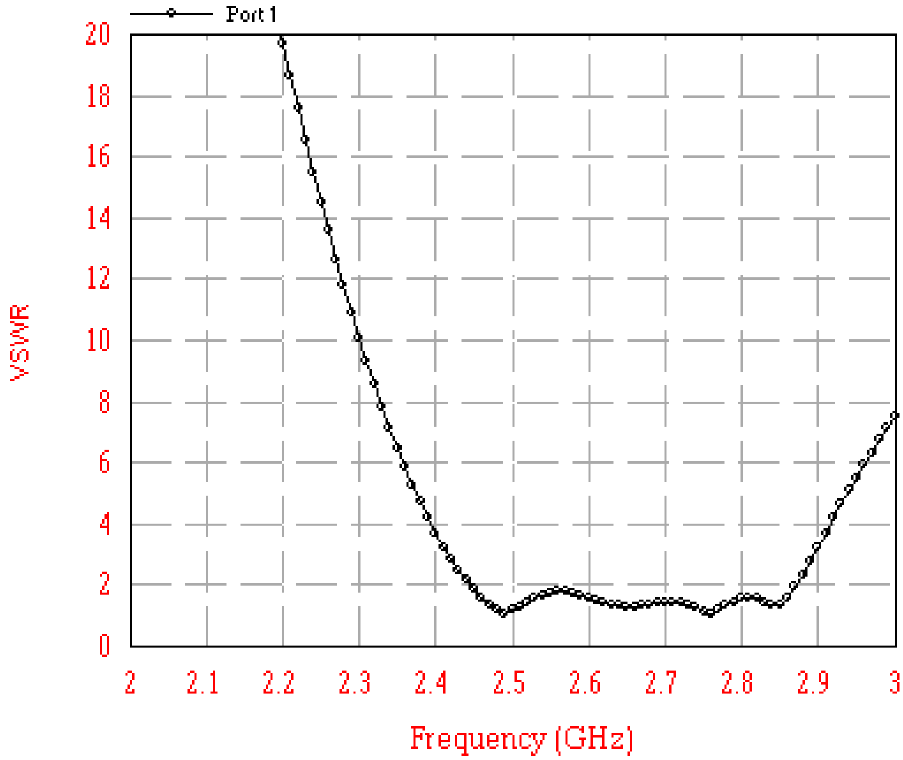

Figure 3.19 Graph between VSWR and frequency for antenna design-3

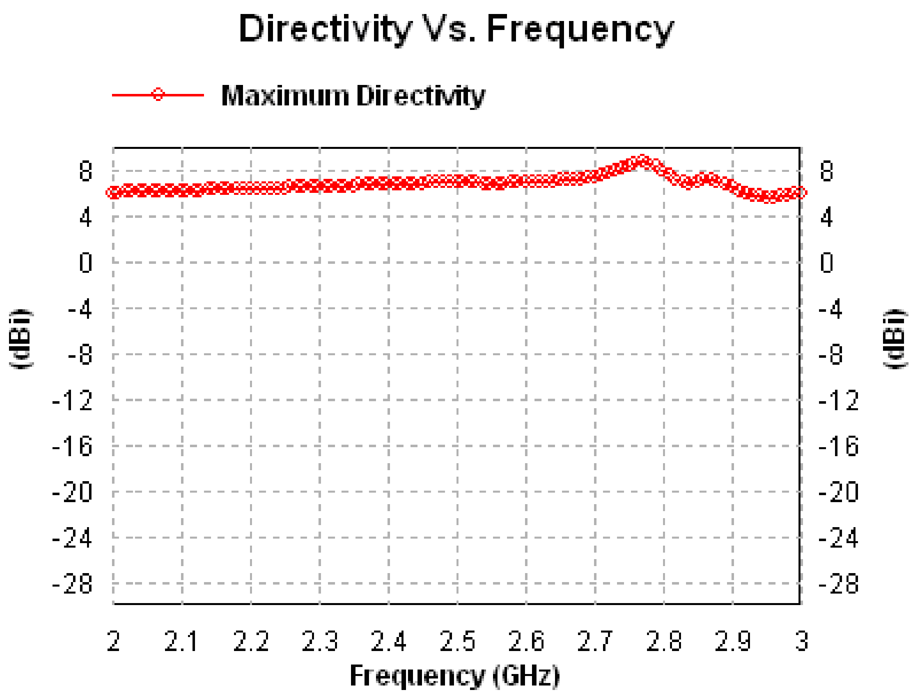

Figure 3.20 Graph between directivity and frequency for antenna design-3

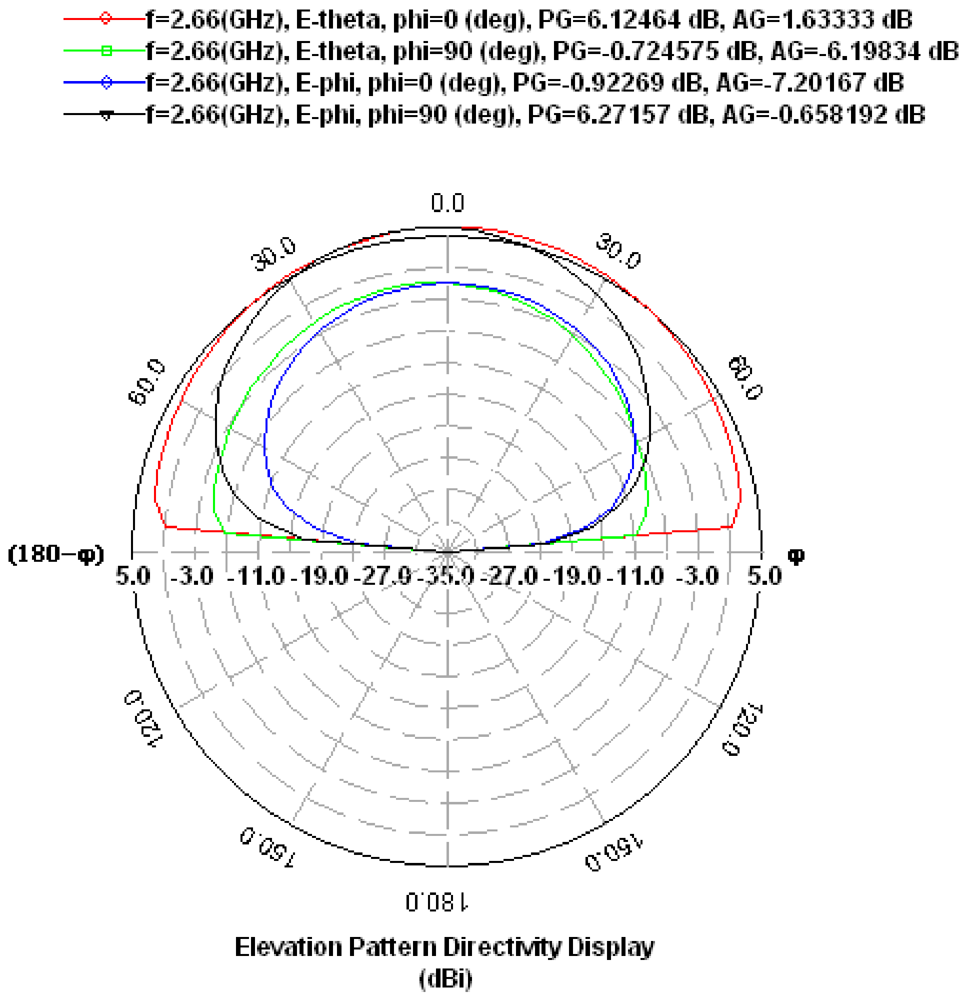

Figure 3.21 Radiation pattern for antenna design-3

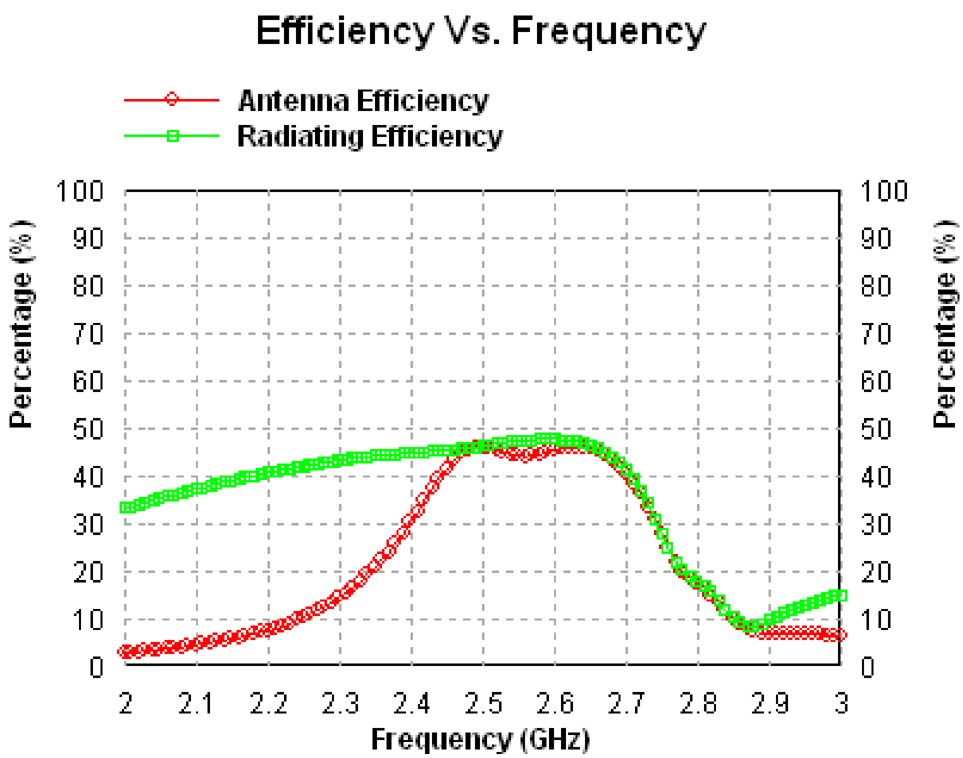

Figure 3.22 Graph between efficiency and frequency for antenna design-3

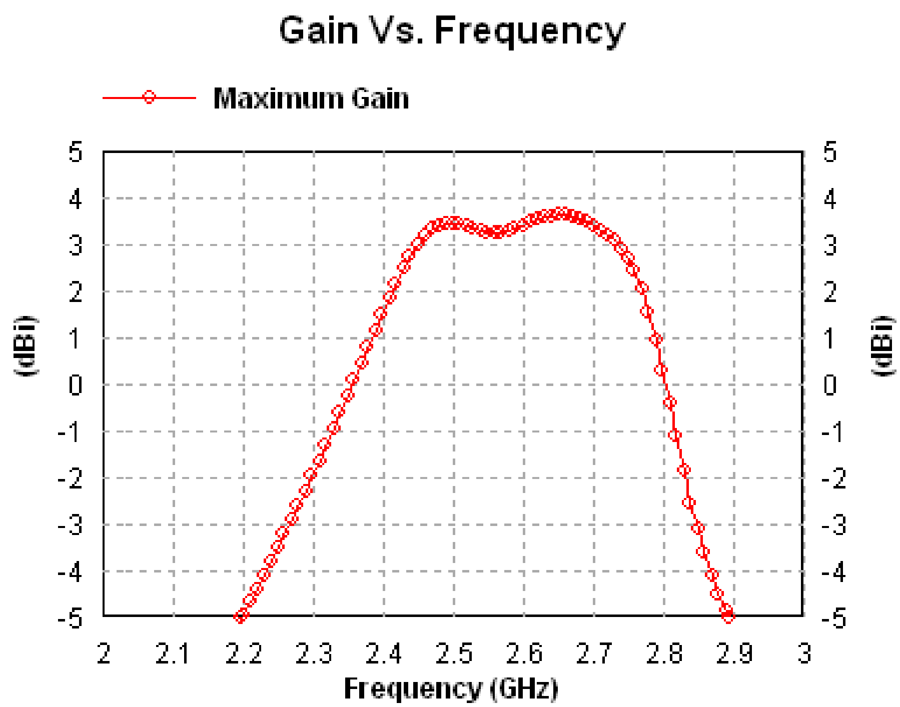

Figure 3.23 Graph between gain and frequency for antenna design-3

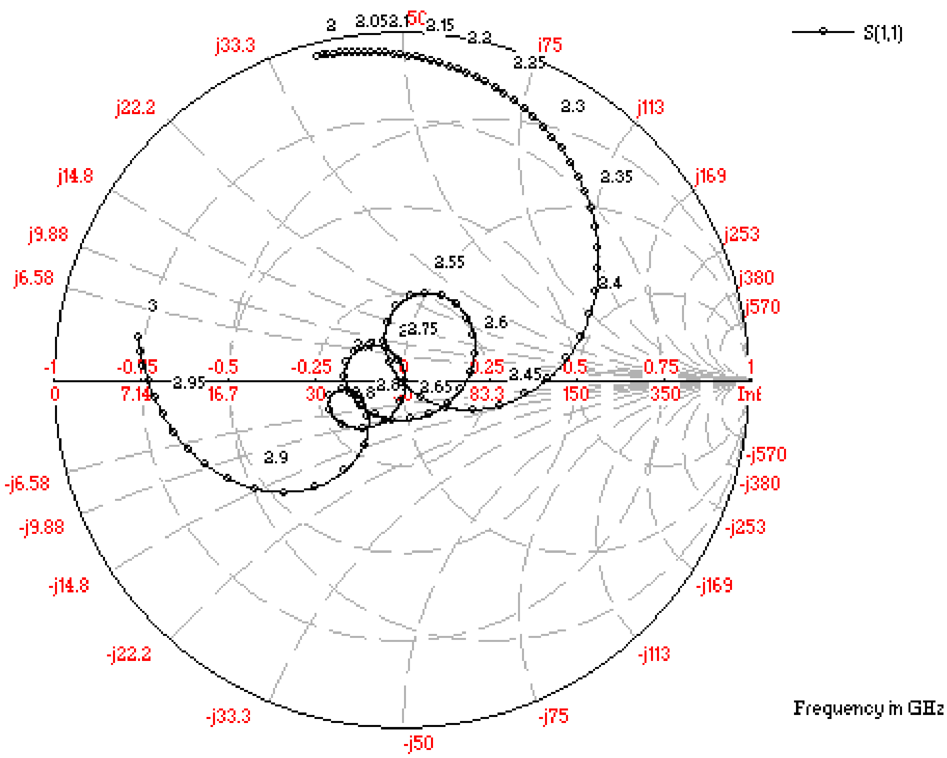

Figure 3.24 Impedance loci for antenna design-3

3.5 TRUNCATED GAP COUPLED MICROSTRIP ANTENNA DESIGN-4

In the antenna design-4, the four corners truncated gap coupled rectangular printed patch with a single feed is introduced to increase the bandwidth. In the microstrip patch antenna design-4, a single patch which is truncated at the corner is fed through a coaxial probe feed and the other printed patches are positioned along radiating corners (edges) and non radiating corners (edges) of fed rectangular patch and are parasitically coupled. Out of these some parasitic patch are also truncated. The couplings between the multiple resonators are realized by using small air gap between the patches.

Figure 3.25 presents the four corners truncated gap coupled rectangular microstrip antenna design-4. An air gap of 0.625mm is introduced 0.275 mm below the centre horizontal axis. Antenna is designed for S-band of frequency range with center frequency f_0 = 2.62 GHz, within the frequency range 2 GHz to 3 GHz, with step of frequency selected to be 0.01 GHz, patch length L = 29 mm**,** patch width W = 57 mm with feed point positions = (-10, 0.35). The patches are printed on inexpensive FR4 (glass epoxy), having dielectric constant (Єr) of 4.4, loss tangent tan δ = 0.02 and height 1.6 mm. The coaxial probe feed having 50-ohm impedance is used for feeding the patch. Figure 3.26 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-4; maximum return loss is – 33 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 3.27 shows the graph between VSWR and frequency (in GHz) for antenna design-4, impedance bandwidth can be taken below VSWR < 2. Figure 3.28 shows the graph between directivity (in dBi) and frequency (in GHz) for antenna design-4. For the antenna design-4, directivity (in dBi) for the operating frequency is coming between 5-8 dBi. Figure 3.29 shows the radiation pattern (2-D elevation pattern) for antenna design-4 at the center frequency 2.62 GHz. Figure 3.30 shows the graph between efficiency (antenna and radiating, in %) and frequency (in GHz) for antenna design-4. Figure 3.31 shows the graph between gain (in dBi) and frequency (in GHz) for antenna design-4. Figure 3.32 shows the impedance loci for antenna design-4. At resonance frequency 2.62 GHz, the simulated input impedance of antenna design-4 is near to be matched with 50 ohm impedance. The impedance bandwidth is coming out to be **17.18 %** (450 MHz) of the center frequency at 2.62 GHz with four resonant modes within the specified frequency range.

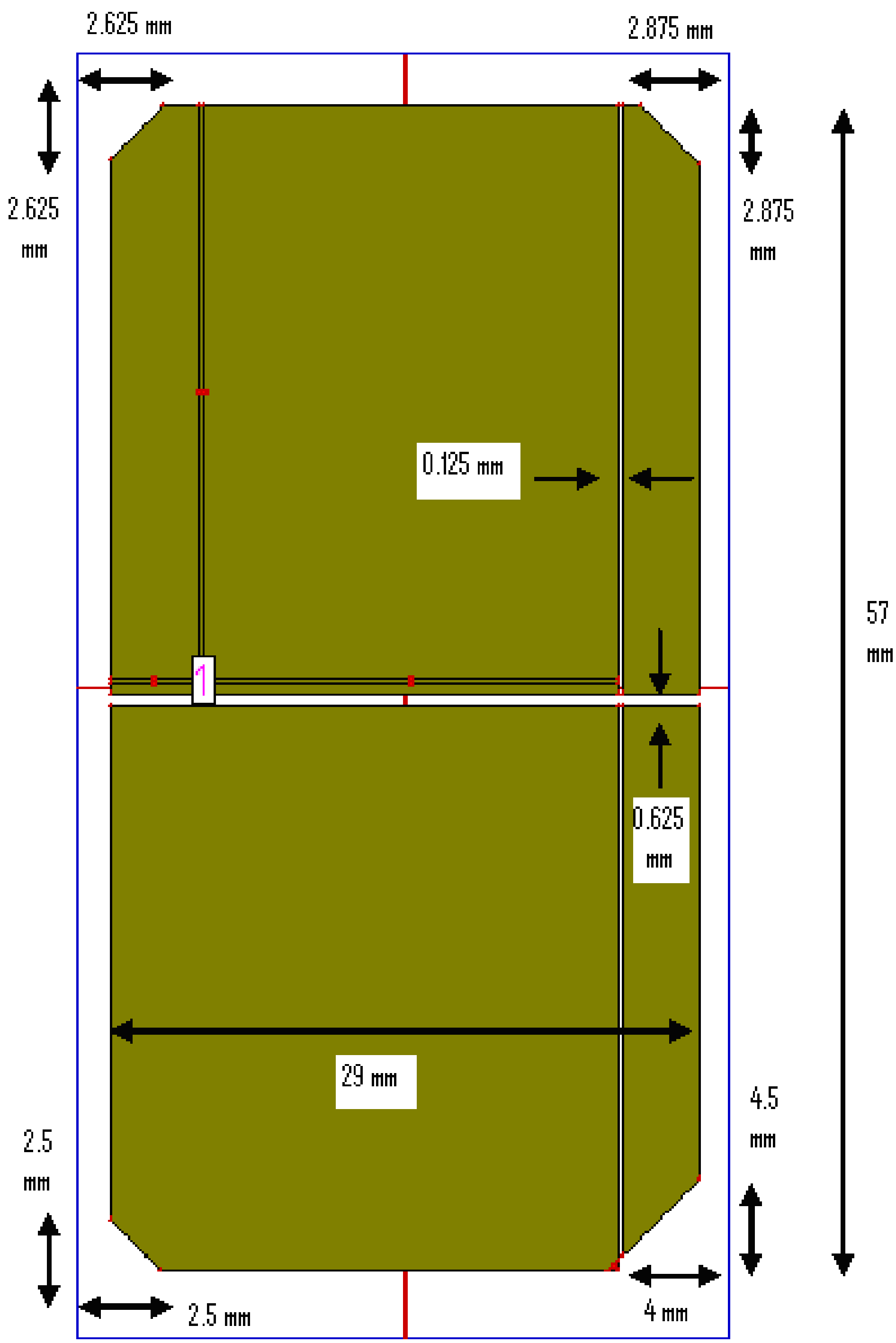

Figure 3.25 Four corners truncated gap coupled

rectangular microstrip antenna design-4

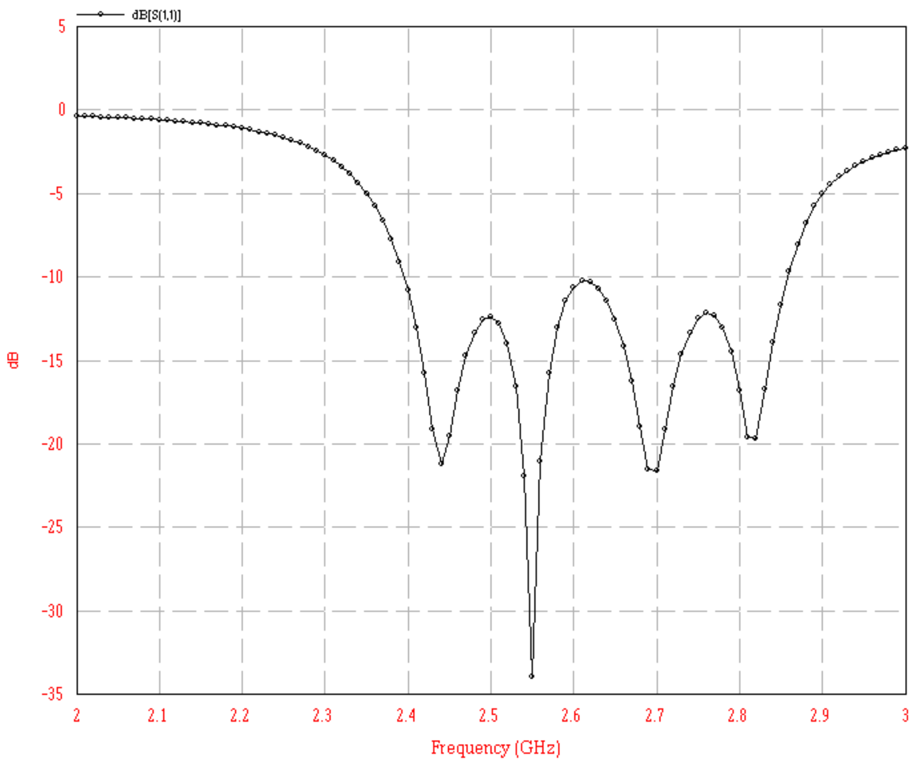

Figure 3.26 Graph between return loss and frequency for antenna design-4

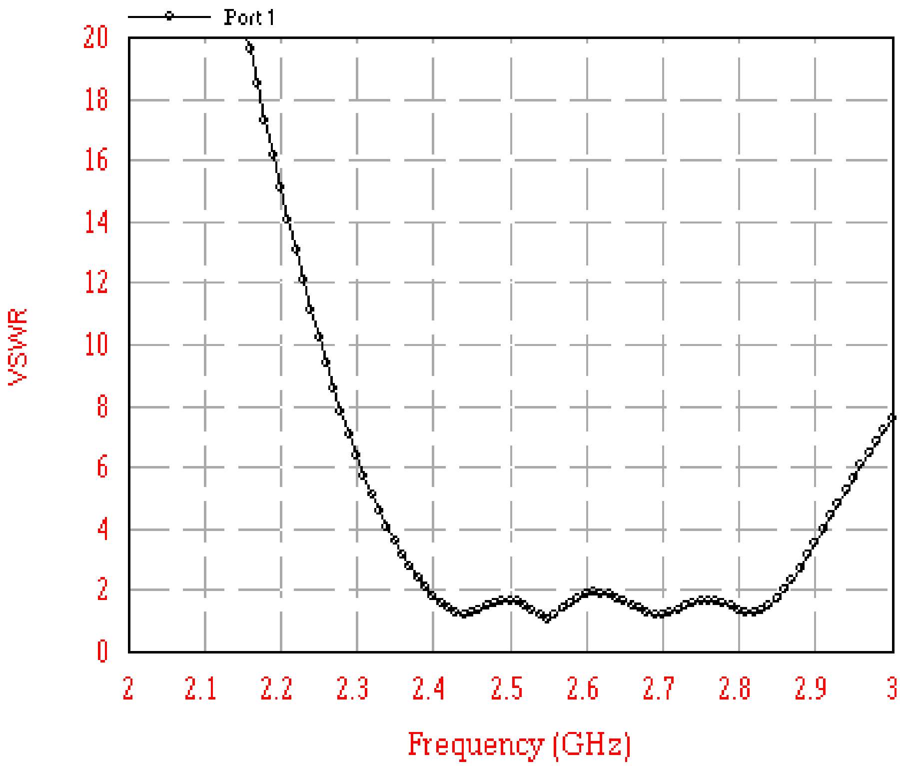

Figure 3.27 Graph between VSWR and frequency for antenna design-4

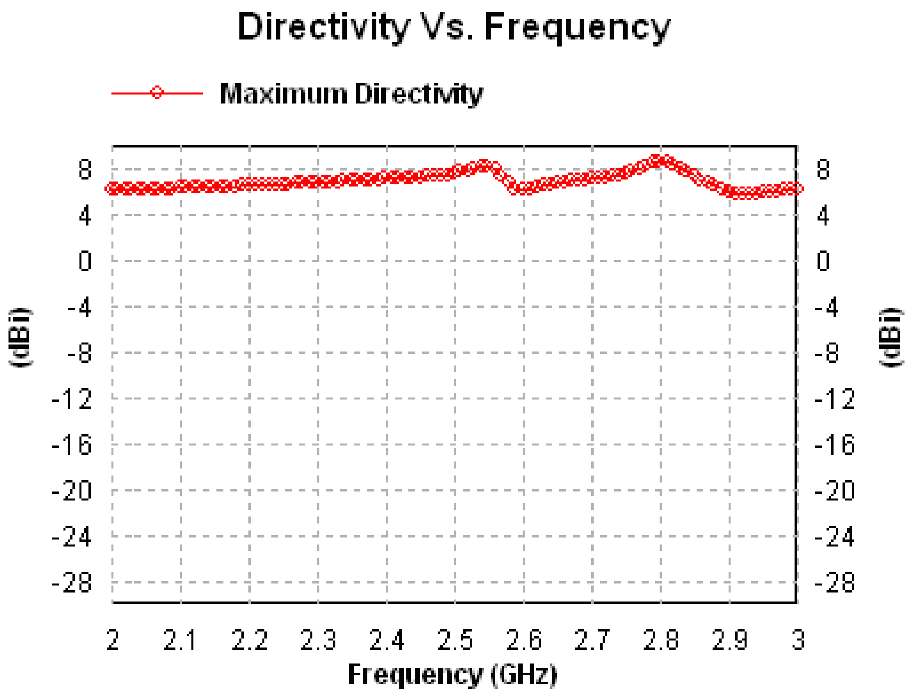

Figure 3.28 Graph between directivity and frequency for antenna design-4

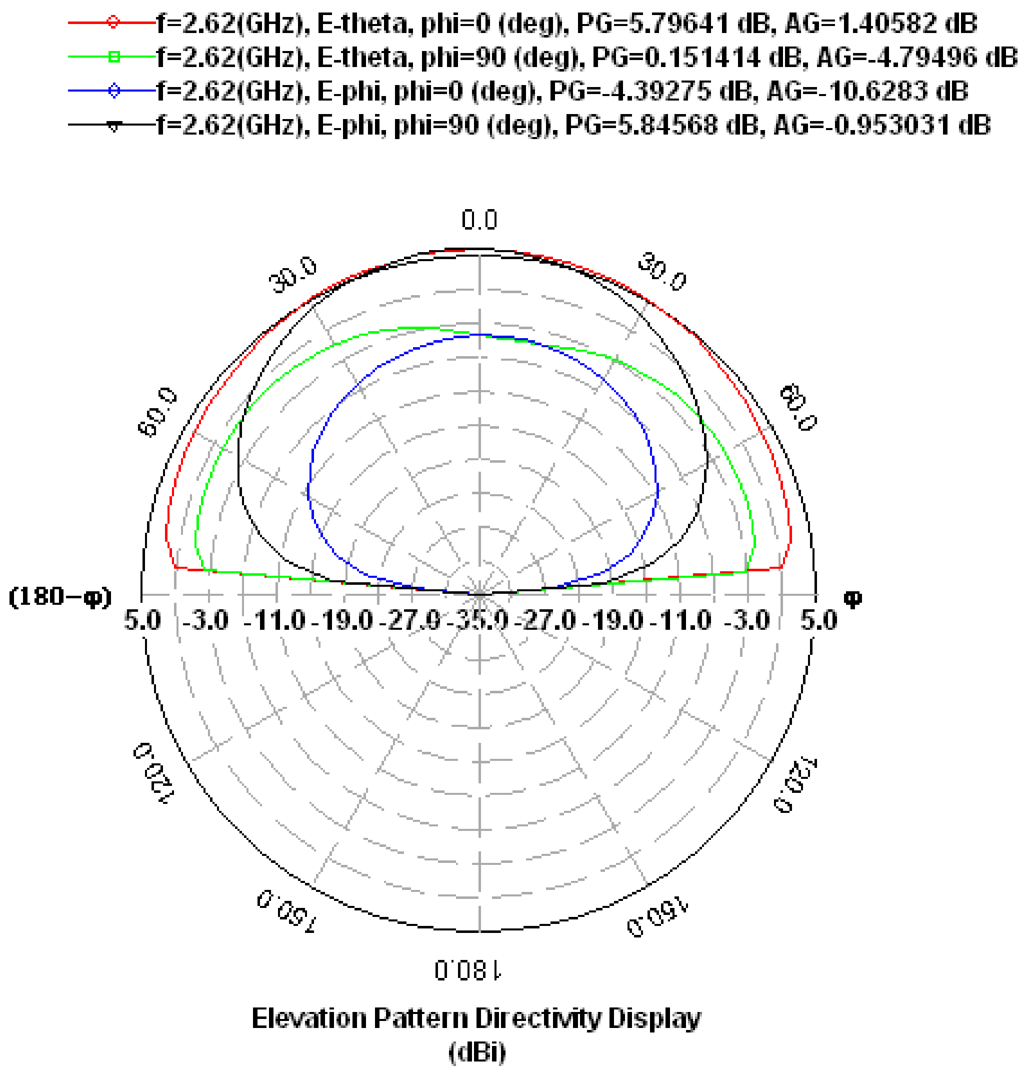

Figure 3.29 Radiation pattern for antenna design-4

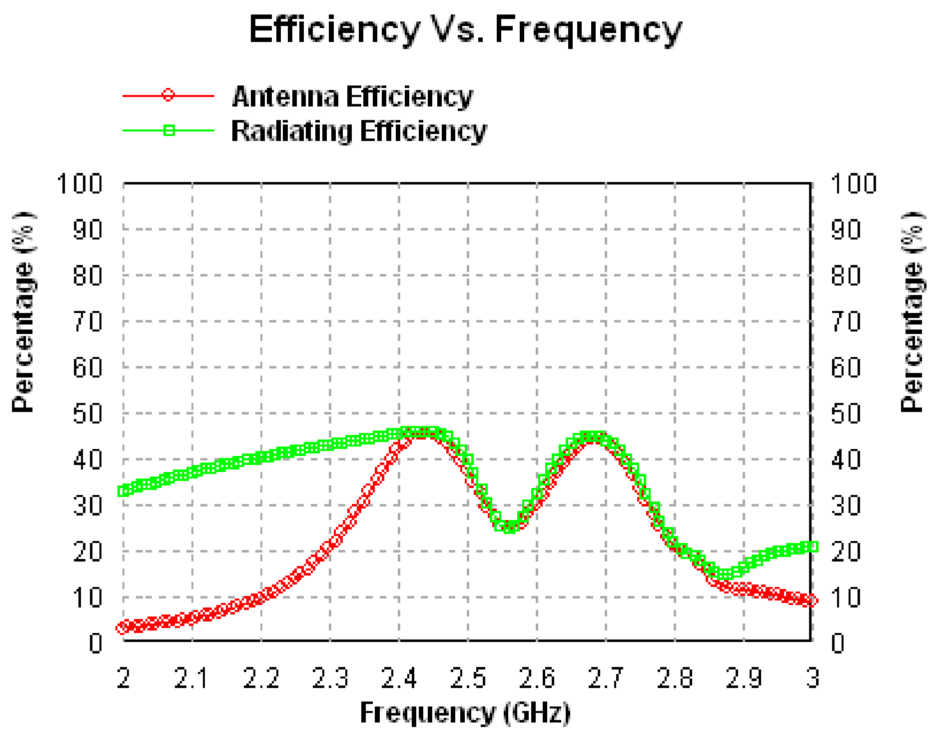

Figure 3.30 Graph between efficiency and frequency for antenna design-4

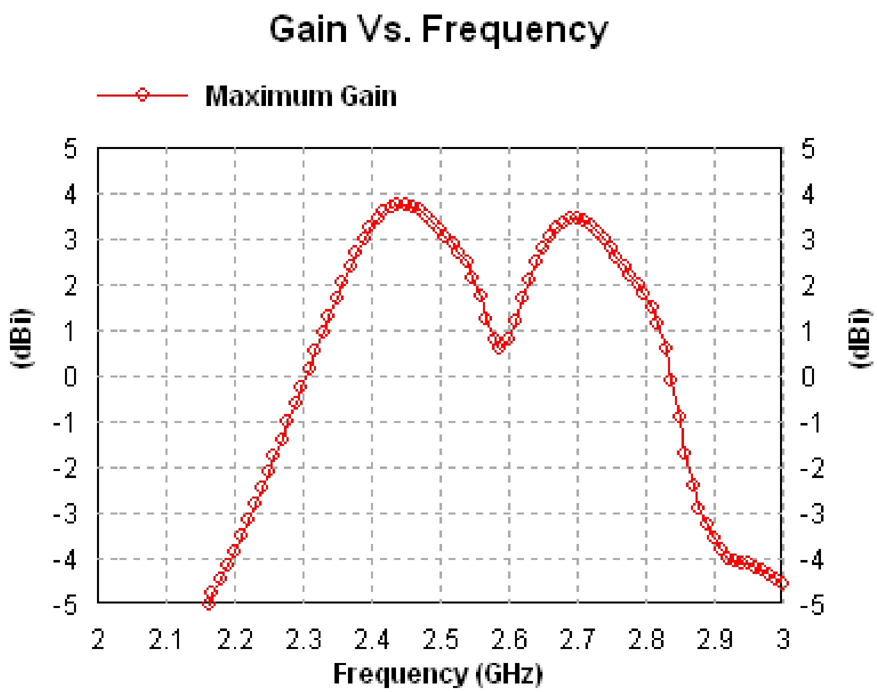

Figure 3.31 Graph between gain and frequency for antenna design-4

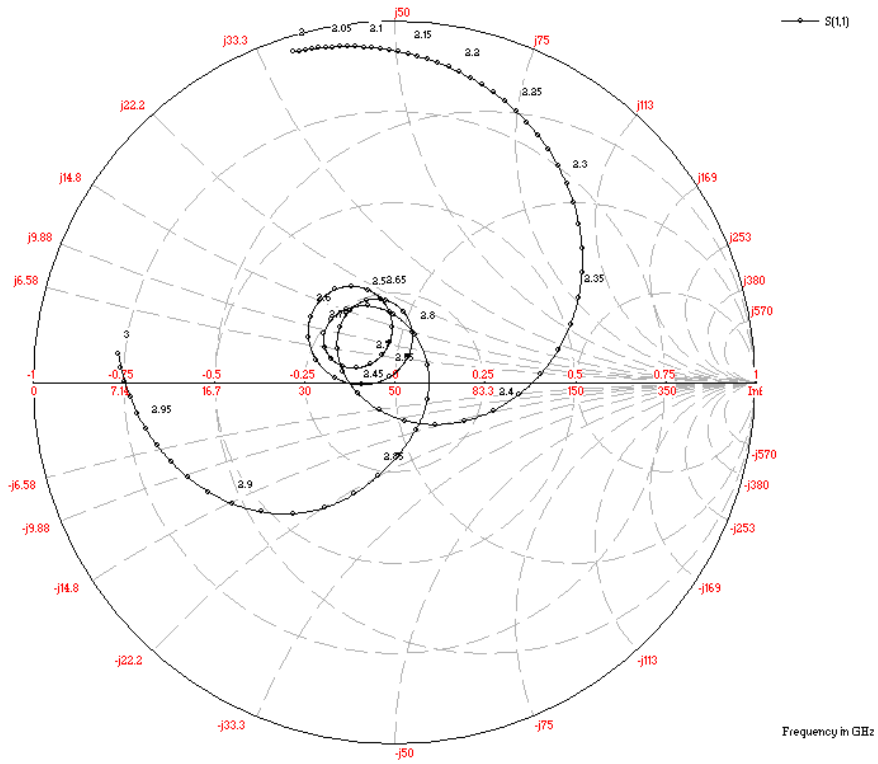

Figure 3.32 Impedance loci for antenna design-4

3.6 TRUNCATED GAP COUPLED MICROSTRIP ANTENNA DESIGN-5

In the antenna design-5, bandwidth has been further improved if the two corners truncated gap coupled compact rectangular microstrip patch antenna with a single feed is introduced. In the antenna design-5, a single patch which is truncated at the corner is fed through a coaxial probe feed and the other rectangular patches are parasitically coupled. Out of these some parasitic patches are also truncated.

Figure 3.33 presents the two corners truncated gap coupled compact rectangular microstrip antenna design-5. In the antenna design-5, an air gap of 0.5 mm is introduced 0.425 mm below the centre horizontal axis. Antenna is designed for S-band of frequency range with center frequency f_0 = 2.79 GHz, within the frequency range 2 GHz to 3.6 GHz, with step of frequency selected to be 0.01 GHz, In the antenna design-5, the patch size is reduced by taking patch length L = 28 mm (above air gap) and L = 27.625 mm (below air gap)**,** patch width W = 53 mm with feed point positions = (-9.2, 0.2). The patches are printed on inexpensive FR4 (glass epoxy) substrate, having dielectric constant (Єr) of 4.4, loss tangent tan δ = 0.02 and height 1.6 mm. The coaxial probe feed having 50-ohm impedance is used for feeding the patch. Figure 3.34 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-5; maximum return loss is – 33 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 3.35 shows the graph between VSWR and frequency for antenna design-5, impedance bandwidth can be taken below VSWR < 2. Figure 3.36 shows the graph between directivity (in dBi) and frequency (in GHz) for antenna design-5. For the antenna design-5, directivity (in dBi) for the operating frequency is coming between 5-8 dBi. Figure 3.37 shows the radiation pattern (2-D elevation pattern) for antenna design-5 at the center frequency 2.79 GHz. Figure 3.38 shows the graph between efficiency (antenna and radiating, in %) and frequency (in GHz) for antenna design-5. Figure 3.39 shows the graph between gain (in dBi) and frequency (in GHz) for antenna design-5. Figure 3.40 shows the impedance loci for antenna design-5. At resonance frequency 2.79 GHz, the simulated input impedance of antenna design-5 is near to be matched with 50 ohm impedance. The impedance bandwidth is coming out to be **17.9 %** (500 MHz) of the center frequency at 2.79 GHz with four resonant modes within the specified frequency range.

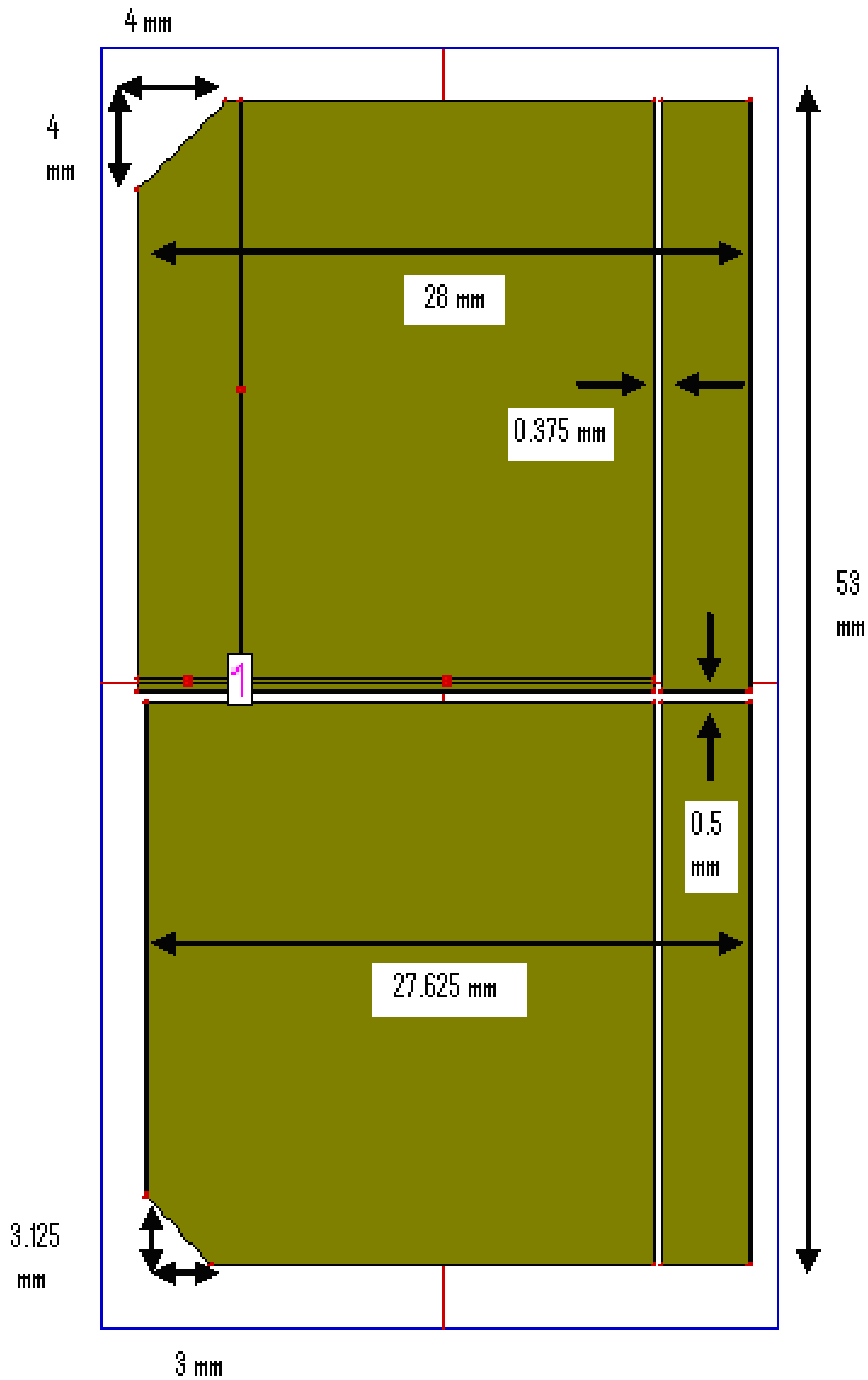

Figure 3.33 Two corners truncated gap coupled

rectangular microstrip antenna design-5

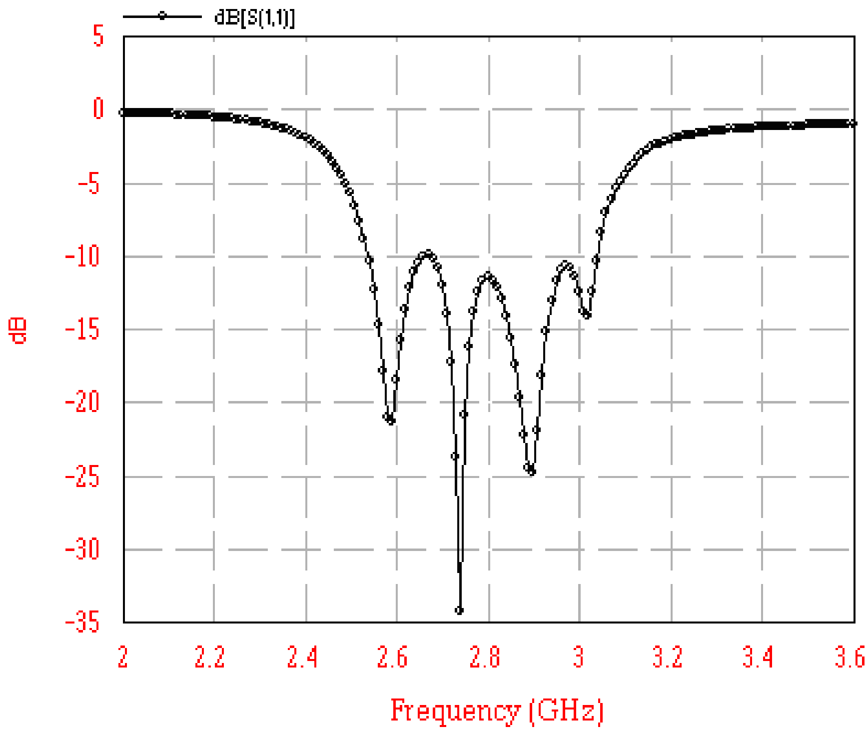

Figure 3.34 Graph between return loss and frequency for antenna design-5

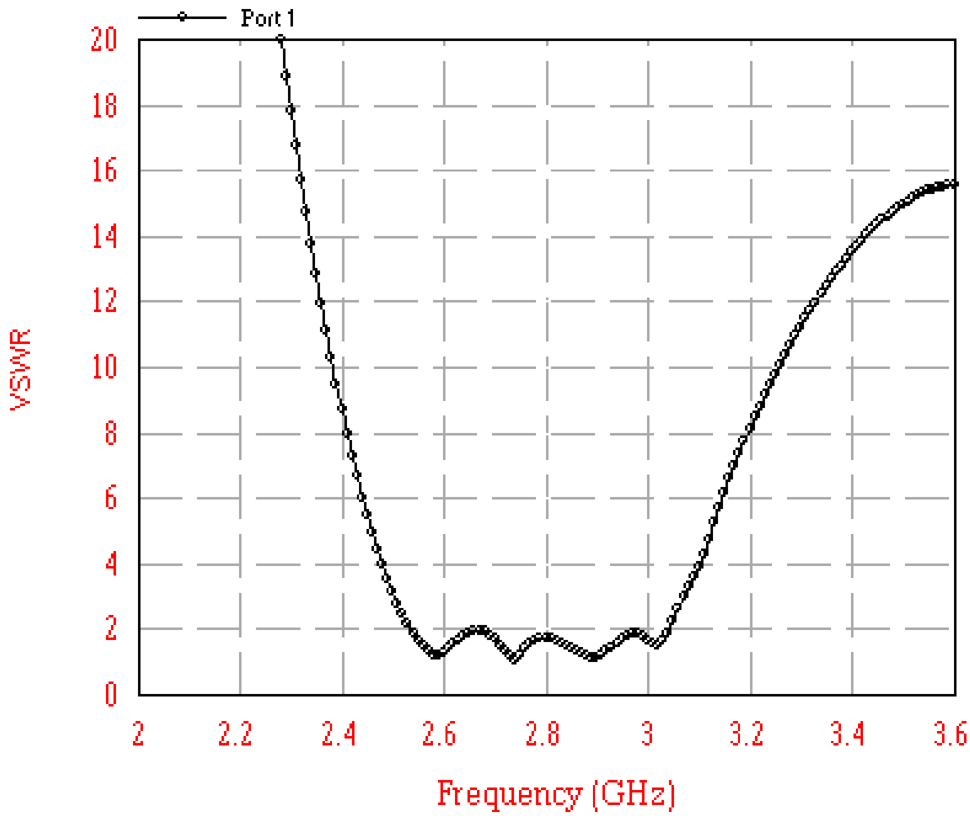

Figure 3.35 Graph between VSWR and frequency for antenna design-5

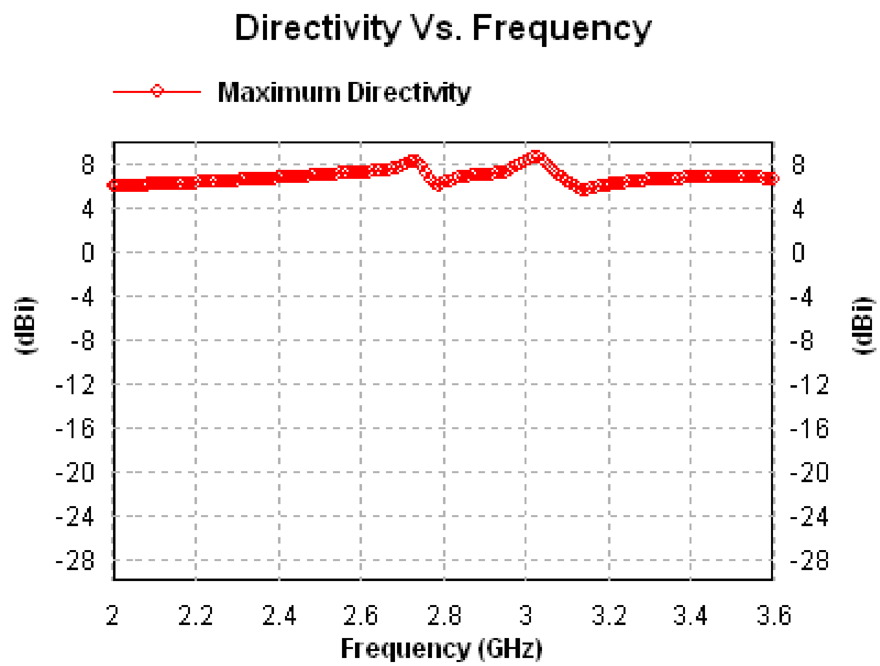

Figure 3.36 Graph between directivity and frequency for antenna design-5

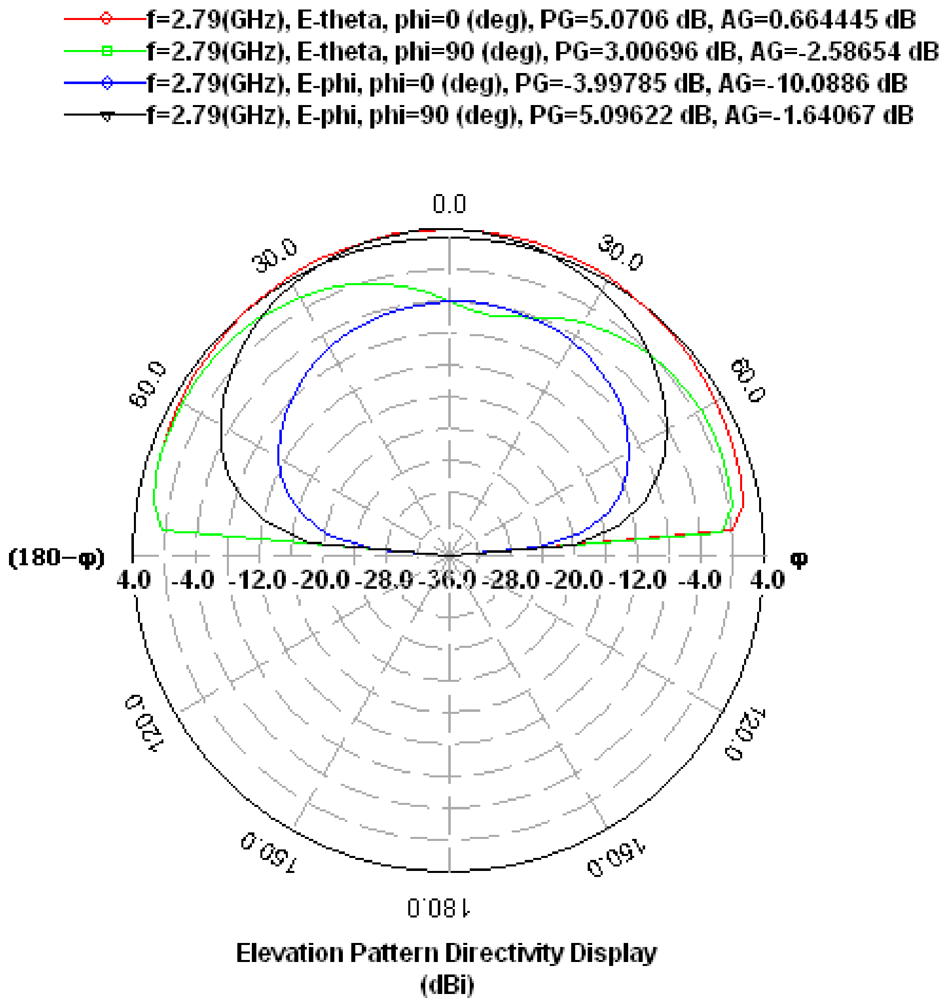

Figure 3.37 Radiation pattern for antenna design-5

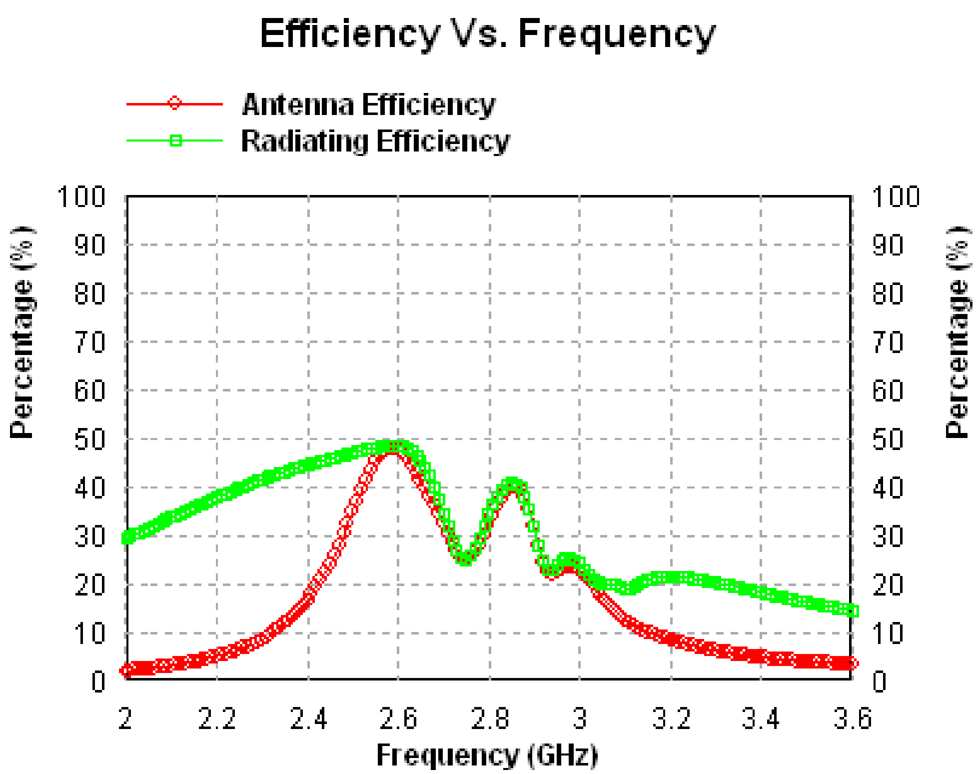

Figure 3.38 Graph between efficiency and frequency for antenna design-5

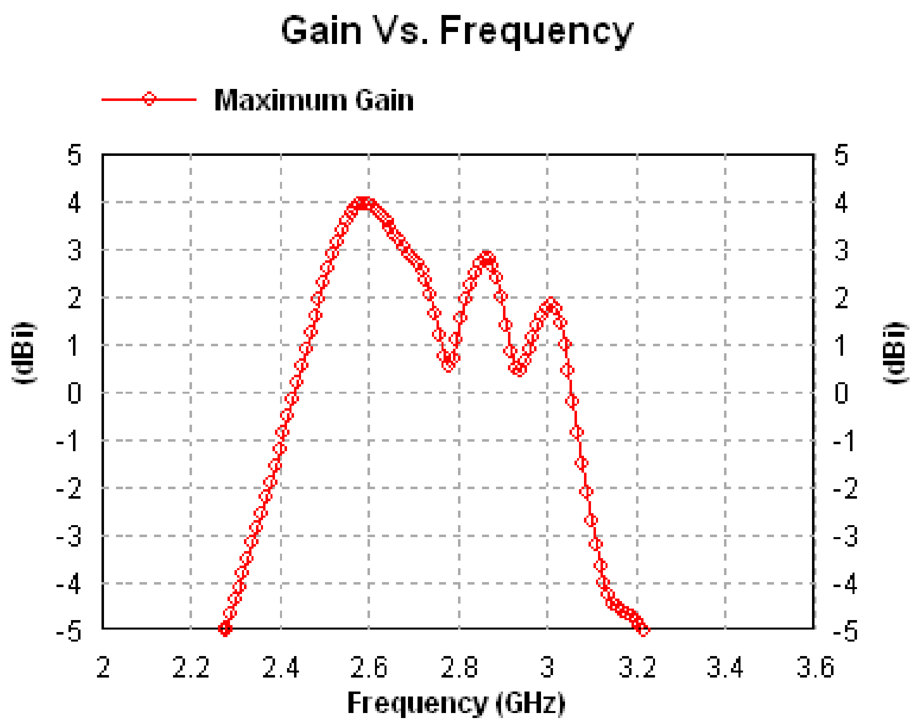

Figure 3.39 Graph between gain and frequency for antenna design-5

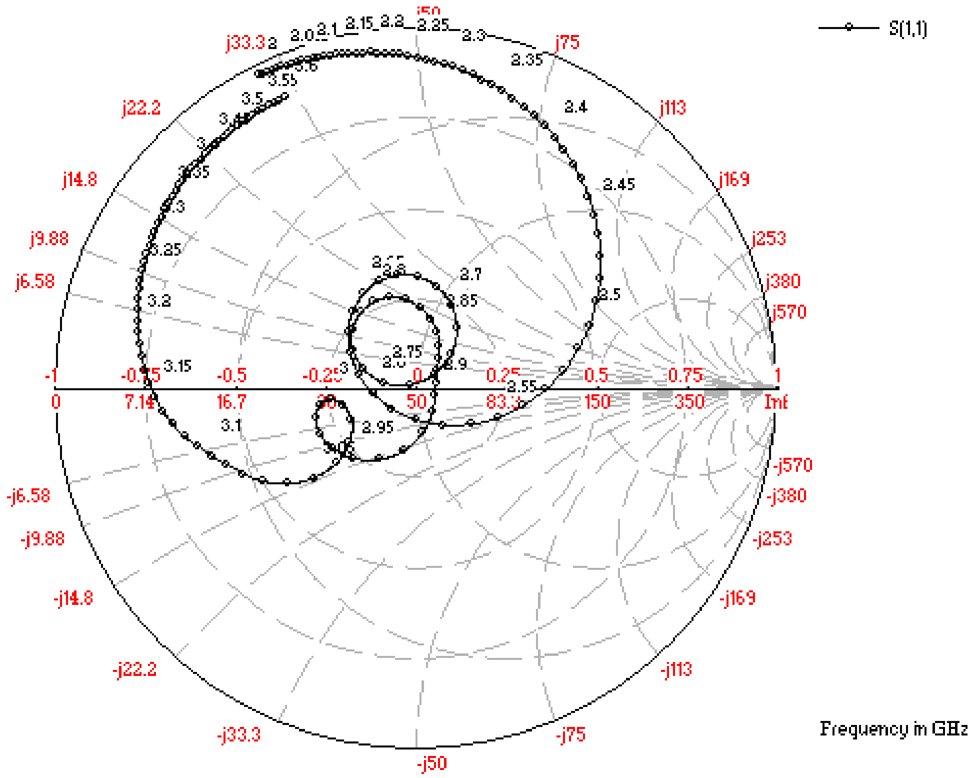

Figure 3.40 Impedance loci for antenna design-5

3.7 CONCLUSION

In this chapter, it has been observed that impedance bandwidth of the rectangular patch antenna can also be improved by introducing truncated corners in feed patch or in parasitic (gap or direct coupled) patch to the radiating corners (edges) and non radiating corners (edges) of a rectangular patch or truncated corners in both (i.e. feed and parasitic patch). In the next chapter, the meandering or defected ground method to the finite ground surface of a printed patch antenna will be discussed which is useful to obtain wide bandwidth.