CHAPTER TWO

PLANAR MULTIRESONATOR WIDEBAND MICROSTRIP PATCH ANTENNA

In this chapter, by introducing coplanar multiresonator printed patches with gap coupled to the radiating corners (edges) and non radiating corners (edges) of a rectangular microstrip feed patch, wideband microstrip patch antennas are designed and analyzed for optimization of various practical applications of wireless communication systems.

2.1 INTRODUCTION

This section presents coplanar multiple resonator arrangement using microstrip patches for wideband operation. In this method, a single printed patch is connected with coaxial probe feed and the other patches are parasitically coupled. The connection between the multiple resonators may be realized by using either a small air gap between the patches or directly connecting the patches through a thin microstrip line and sometime hybrid coupling is used [31].

By using coplanar multiresonator microstrip patches, gap or direct coupled to the radiating corners (edges) or non radiating corners (edges) of a rectangular patch, a wideband printed patch antenna may be obtained. The impedance BW may be increased many times as compared to single rectangular patch antenna. However, reduced size printed patch antenna is practically desirable, although, the resulting wideband patch antenna is having much improved antenna size as compared to a single printed patch antenna. Additional printed patches in the antenna gives varied resonant lengths, also more resonant modes can be generated at frequencies near to each other; therefore, a bandwidth greater than that of the conventional patch antenna design can be obtained.

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

2.2 GAP COUPLED MICROSTRIP PATCH ANTENNA DESIGN-1

In the antenna design-1, bandwidth has been improved using gap coupled rectangular printed patch antenna. The couplings in between multiple resonators are realized by using small air gap between the patches.

Figure 2.1 presents the gap coupled rectangular microstrip patch antenna with a single feed of antenna design-1. In this antenna design-1, two air gaps of 0.375 mm are introduced 1.05 mm and 25.05 mm below the centre horizontal axis. Antenna is designed for S-band of frequency range with center frequency f_0 = 2.61 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 = (-10.025, -0.925). The patch is 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 2.2 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-1; maximum return loss is – 42 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 2.3 shows the graph between VSWR and frequency (in GHz) for antenna design-1, impedance bandwidth can be taken below VSWR < 2. Figure 2.4 shows the graph between directivity (in dBi) and frequency (in GHz) for the antenna design-1. For the antenna design-1, directivity (in dBi) for the operating frequency is coming between 5-8 dBi. Figure 2.5 shows the radiation pattern (2-D elevation pattern) for the antenna design-1 at the center frequency 2.61 GHz. Figure 2.6 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 the centre frequency. Figure 2.7 shows the impedance loci for the antenna design-1. At resonance frequency 2.61 GHz, the simulated input impedance of antenna design-1 is near to be matched with 50 ohm impedance. The bandwidth for the antenna design-1 is coming out to be **14.56 %** (380 MHz) of the center frequency at 2.61 GHz, with three resonant modes within the specified frequency range.

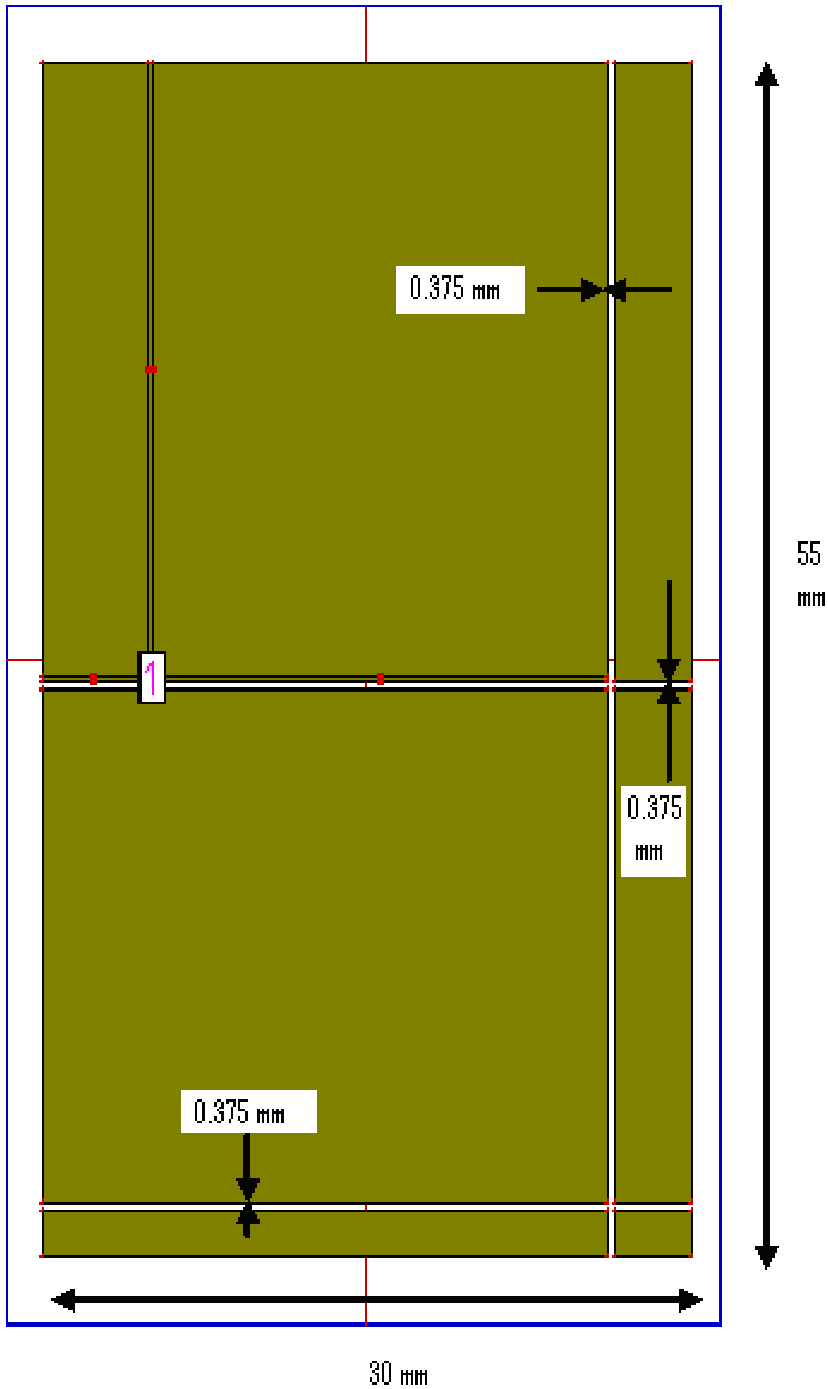

Figure 2.1 Gap-coupled rectangular microstrip antenna design-1

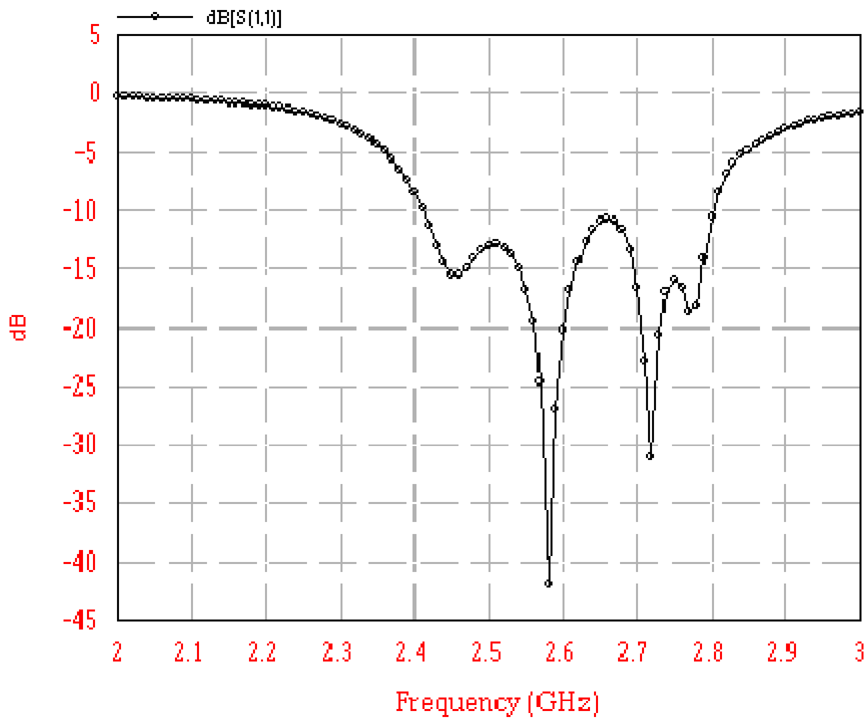

Figure 2.2 Graph between return loss and frequency for antenna design-1

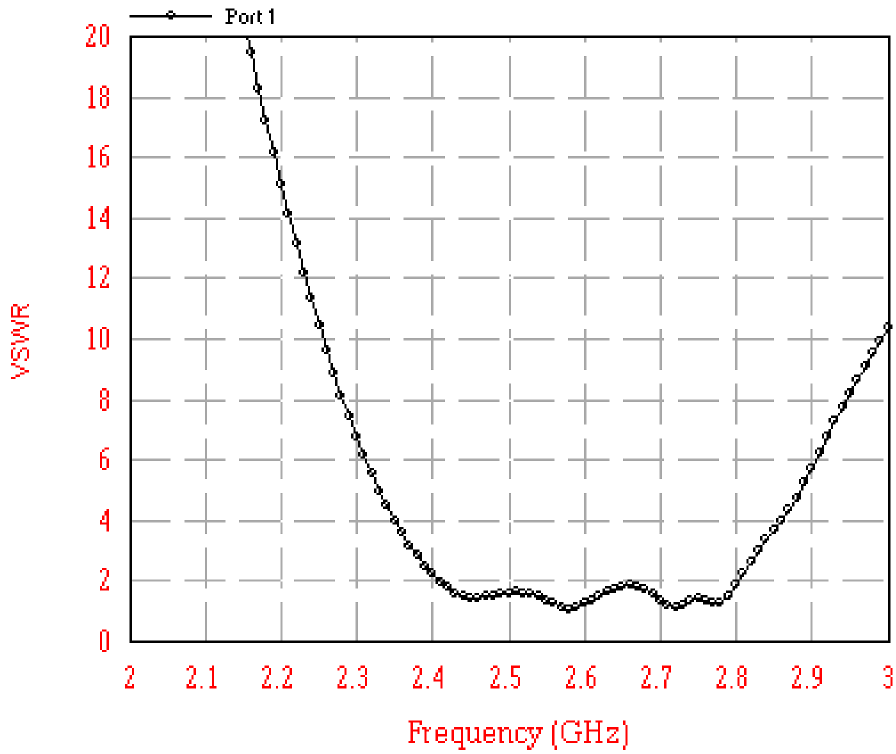

Figure 2.3 Graph between VSWR and frequency for antenna design-1

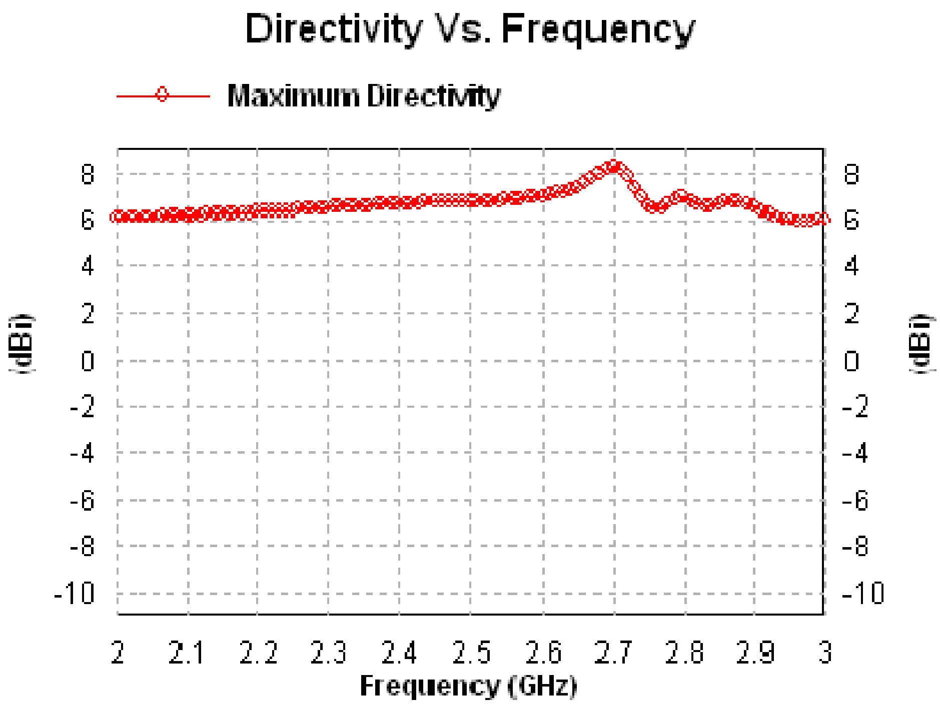

Figure 2.4 Graph between directivity and frequency for antenna design-1

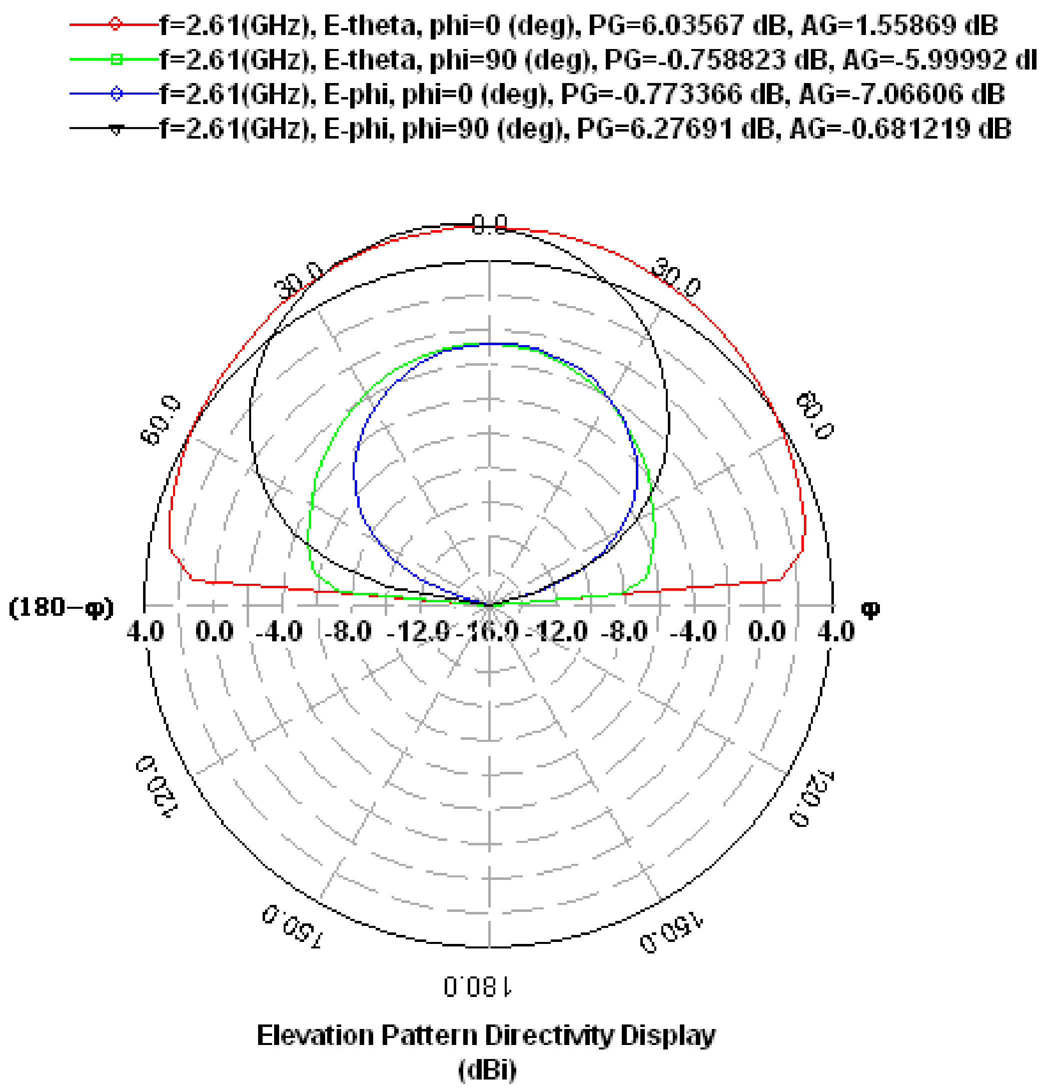

Figure 2.5 Radiation pattern for antenna design-1

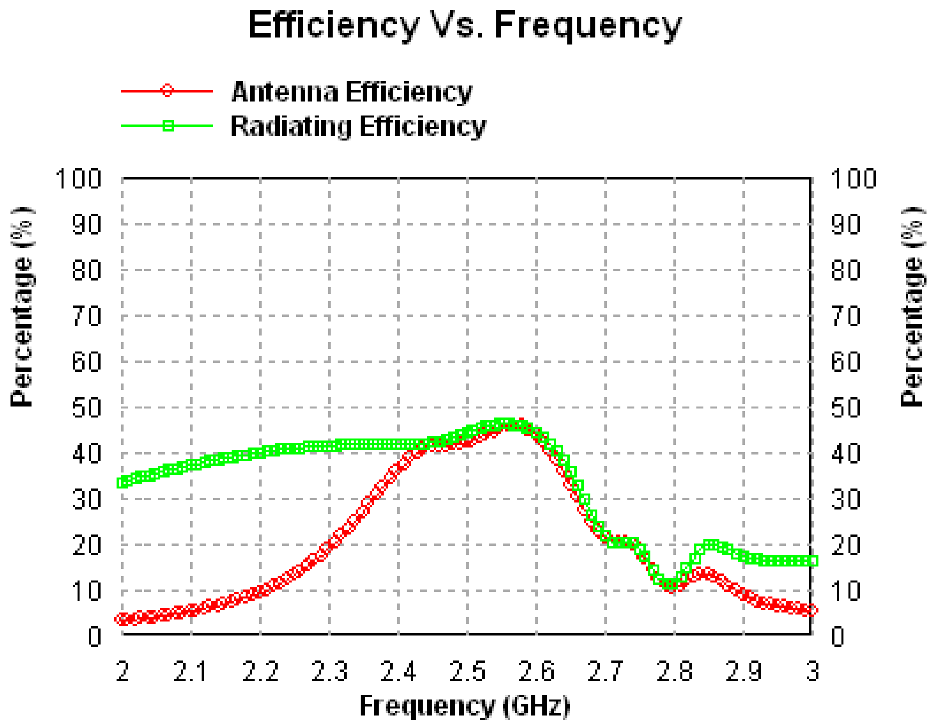

Figure 2.6 Graph between efficiency and frequency for antenna design-1

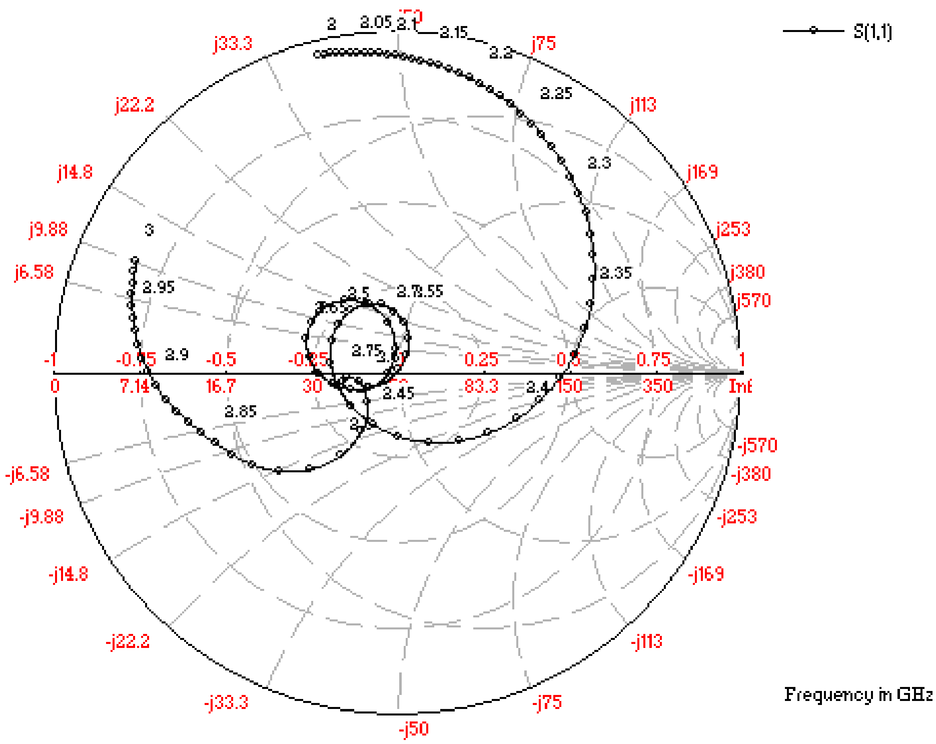

Figure 2.7 Impedance loci for antenna design-1

2.3 GAP COUPLED MICROSTRIP PATCH ANTENNA DESIGN-2

With same patch dimension, attempt has been made to further improve the bandwidth in the microstrip patch antenna design-2. Bandwidth has been improved using reduced size gap coupled rectangular printed patch antenna with a single feed. The couplings between the multiple resonators are realized by using small air gap between the patches.

Figure 2.8 presents the reduced size gap coupled rectangular microstrip patch antenna with a single feed of antenna design-2. In this printed antenna design-2, two air gaps of 0.25 mm are introduced 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 this microstrip patch antenna design- 2, the patch size is reduced by taking patch length L = 30 mm (above air gap) and L = 29.375 mm (below air gap)**,** patch width W = 55 mm, with feed point positions = (-12.525, 0.2). The patch is 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 2.9 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-2; maximum return loss is – 24 dB within this frequency range, impedance bandwidth can be taken below – 10 dB return loss. Figure 2.10 shows the graph between VSWR and frequency for antenna design-2, impedance bandwidth can be taken below VSWR < 2. Figure 2.11 shows the graph between directivity (in dBi) and frequency (in GHz) for the antenna design-2. For the antenna design-2, directivity (in dBi) for the operating frequency is coming between 5-8 dBi. Figure 2.12 shows the radiation pattern (2-D elevation pattern) for the antenna design-2 at the center frequency 2.66 GHz. Figure 2.13 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 2.14 shows the impedance loci for the antenna design-2. At resonance frequency 2.66 GHz, the simulated input impedance of antenna design-2 is near to be matched with 50 ohm impedance. The impedance bandwidth for the antenna design-2 is coming out to be **15.79 %** (420 MHz) of the center frequency at 2.66 GHz, with three resonant modes within the specified frequency range.

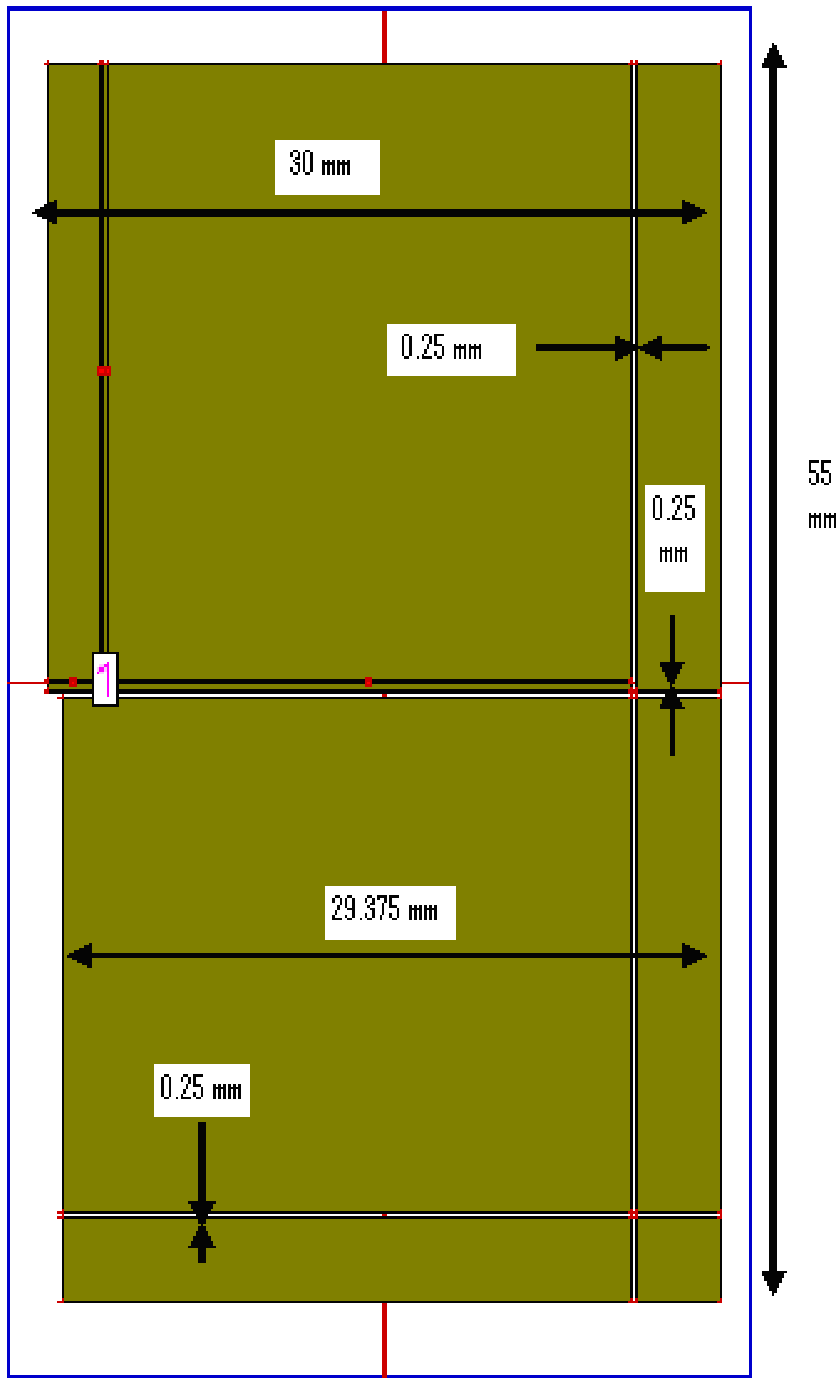

Figure 2.8 Gap-coupled rectangular microstrip antenna design-2

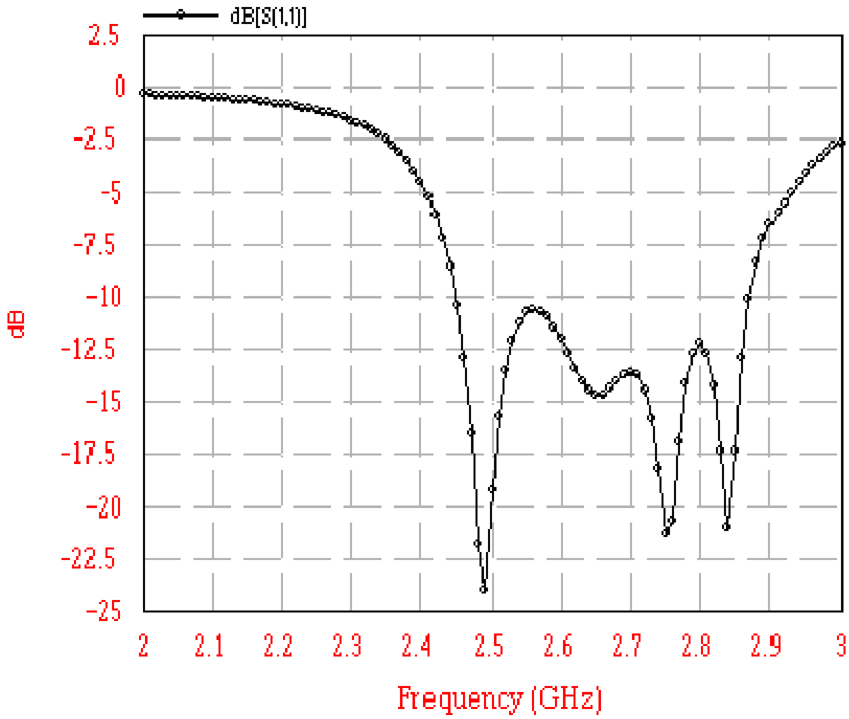

Figure 2.9 Graph between return loss and frequency for antenna design-2

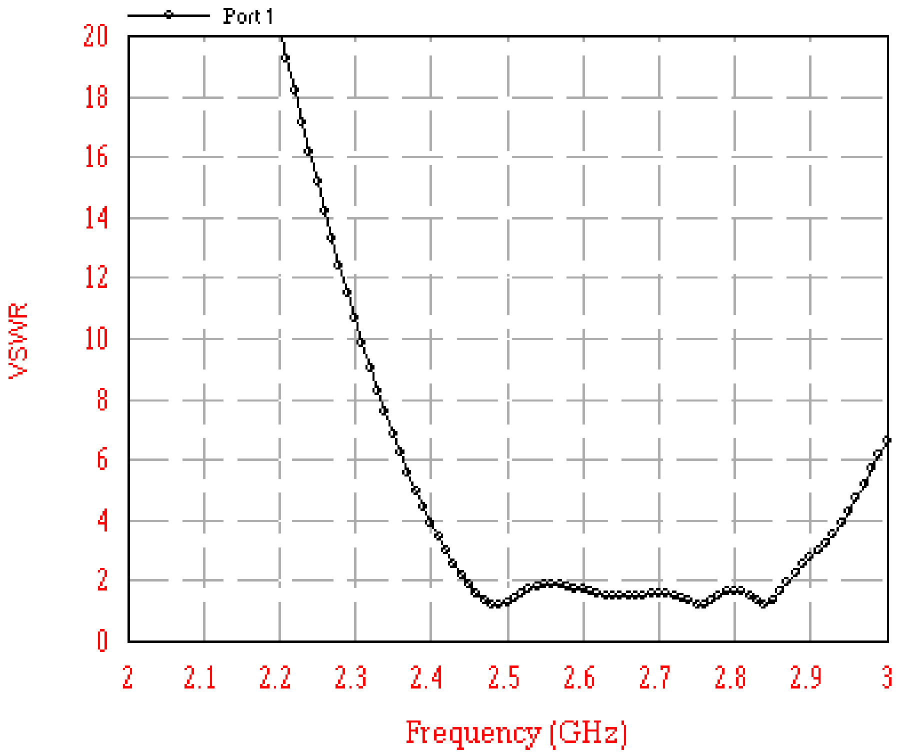

Figure 2.10 Graph between VSWR and frequency for antenna design-2

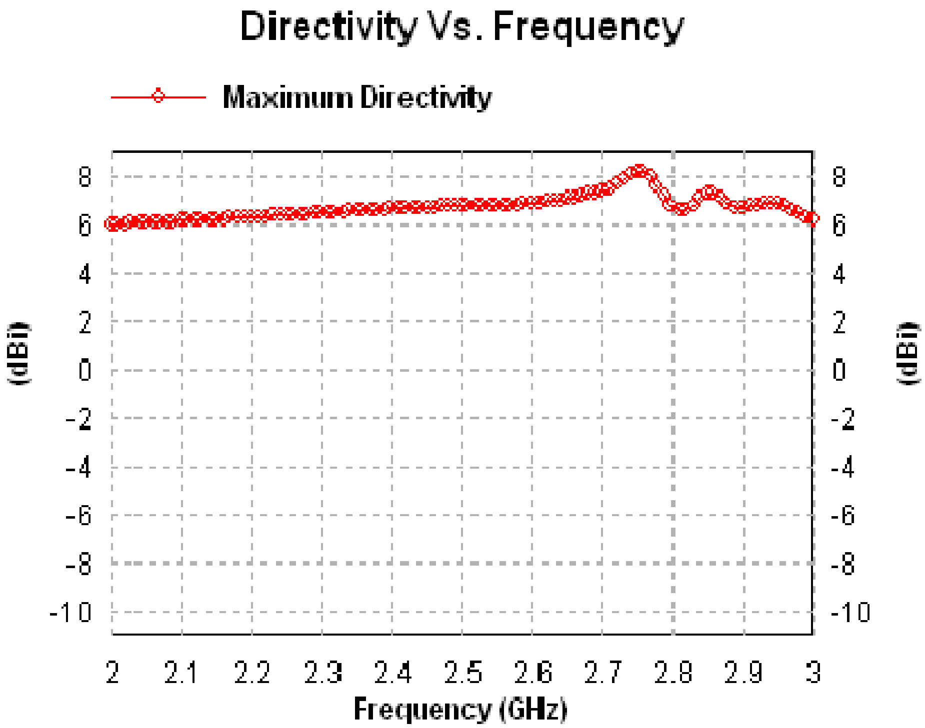

Figure 2.11 Graph between directivity and frequency for antenna design-2

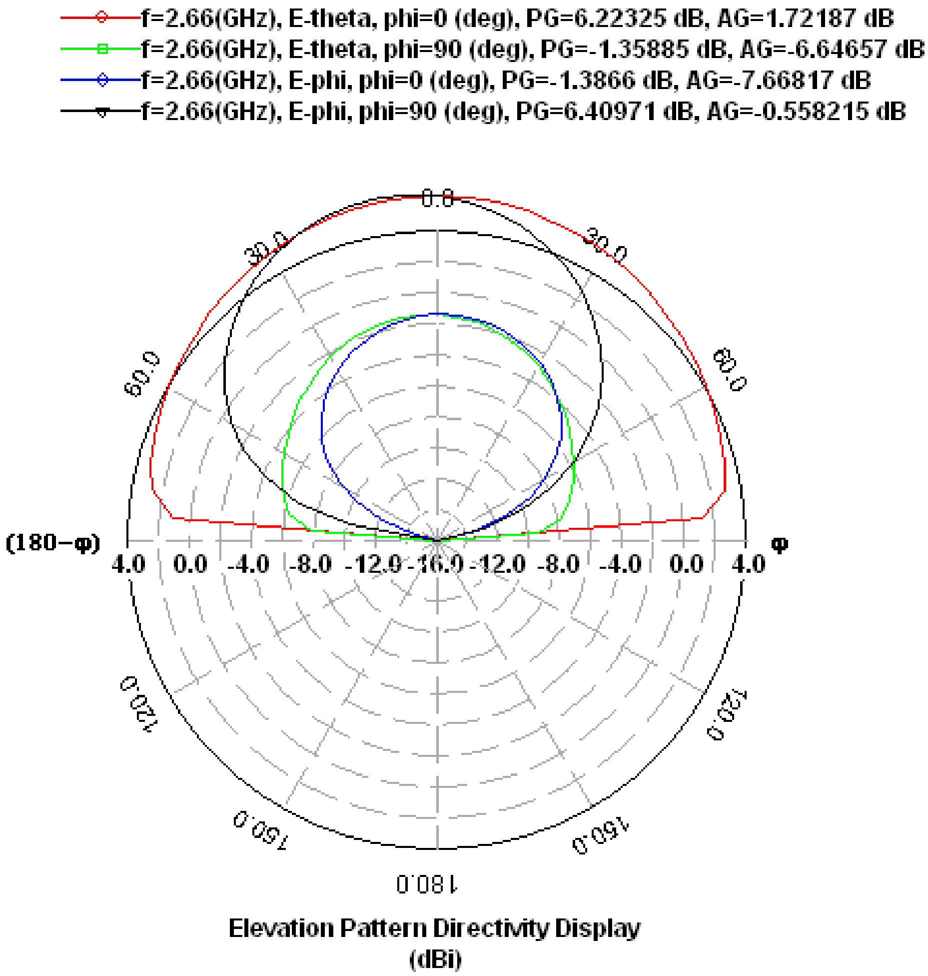

Figure 2.12 Radiation pattern for antenna design-2

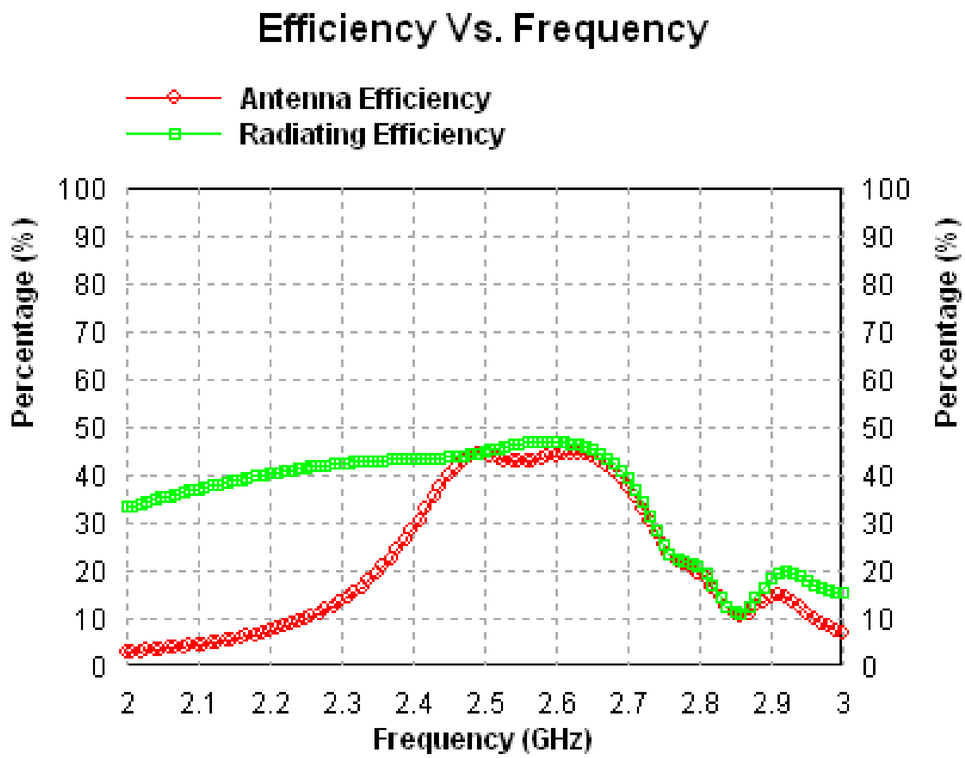

Figure 2.13 Graph between efficiency and frequency for antenna design-2

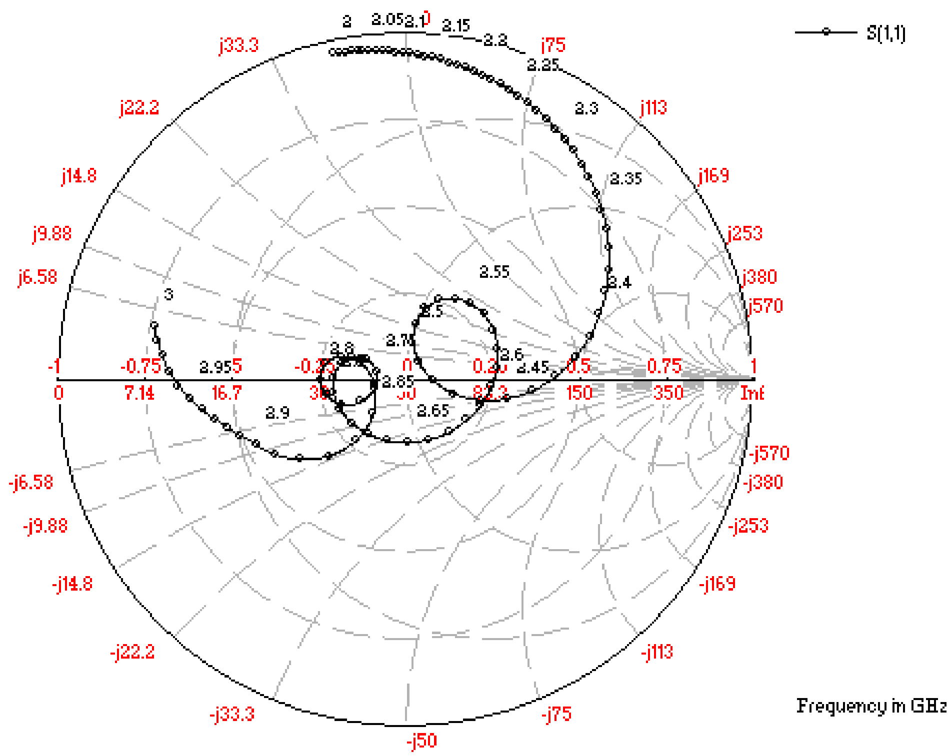

Figure 2.14 Impedance loci for antenna design-2

2.4 GAP COUPLED MICROSTRIP PATCH ANTENNA DESIGN-3

Bandwidth has been further improved; if the gap coupled reduced size rectangular printed patch antenna design-3, fed by a single coaxial probe feed. In the microstrip patch antenna design-3, a single patch is fed through a coaxial probe feed and the other patches are parasitically coupled as the patches are positioned along radiating corners (edges) and non radiating corners (edges) of fed printed patch. The couplings between the multiple resonators are realized by using small air gap between the patches.

Figure 2.15 presents the gap coupled reduced size rectangular microstrip patch antenna of antenna design-3. In this antenna design-3, two air gaps of 0.375 mm are introduced below the centre horizontal axis. Antenna is designed for S-band of frequency range with center frequency f_0 = 2.69 GHz, within the frequency range 2 GHz to 3 GHz, with step of frequency selected to be 0.01 GHz, In this antenna design-3, the patch size is reduced by taking patch length L = 29.25 mm (above air gap) and L = 29.375 mm (below air gap)**,** patch width W = 54 mm, with feed point positions = (-11.65, 0.175). The patch is 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 2.16 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-3; maximum return loss is – 26 dB within this frequency range. Figure 2.17 shows the graph between VSWR and frequency for antenna design-3, impedance bandwidth can be taken below VSWR < 2. Figure 2.18 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 2.19 shows the radiation pattern (2-D elevation pattern) for antenna design-3 at the center frequency 2.69 GHz. Figure 2.20 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 40-50 % at the centre frequency. Figure 2.21 shows the impedance loci for antenna design-3; 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 **16 %** (430 MHz) of the center frequency at 2.69 GHz, with three resonant modes within the specified frequency range.

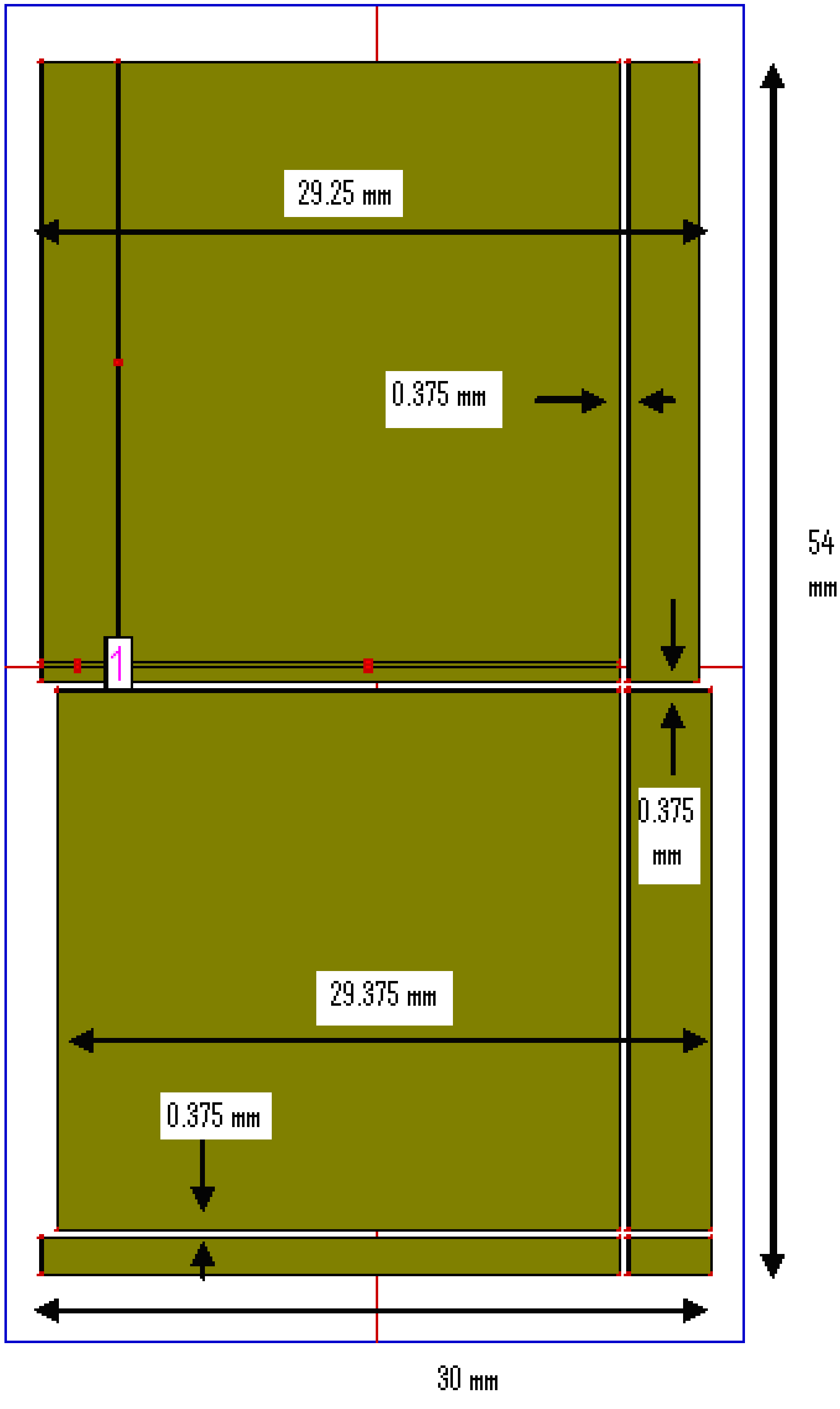

Figure 2.15 Gap-coupled rectangular microstrip antenna design-3

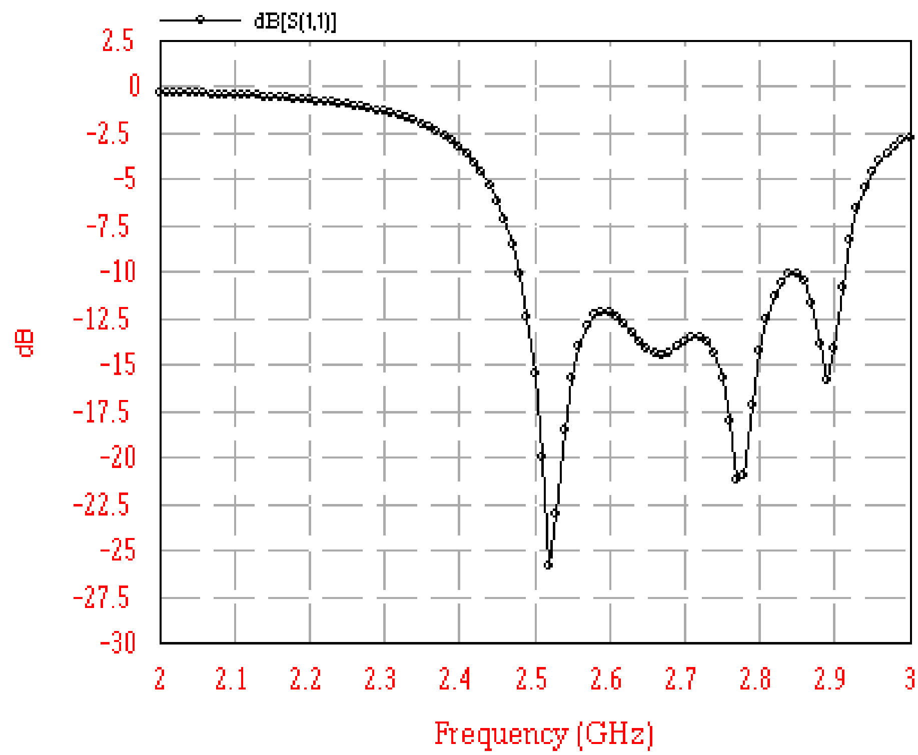

Figure 2.16 Graph between return loss and frequency for antenna design-3

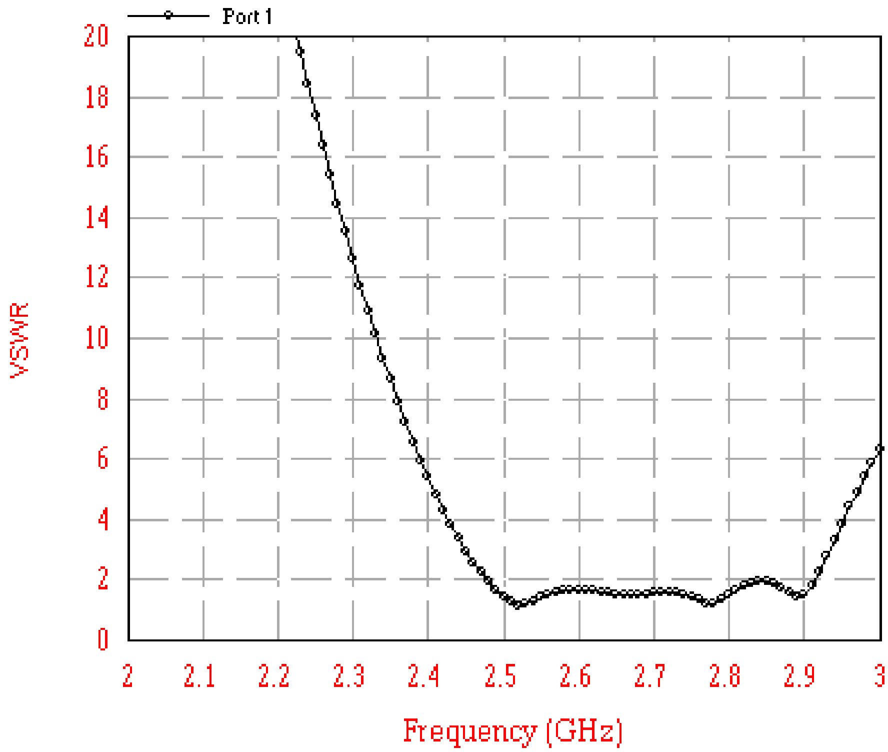

Figure 2.17 Graph between VSWR and frequency for antenna design-3

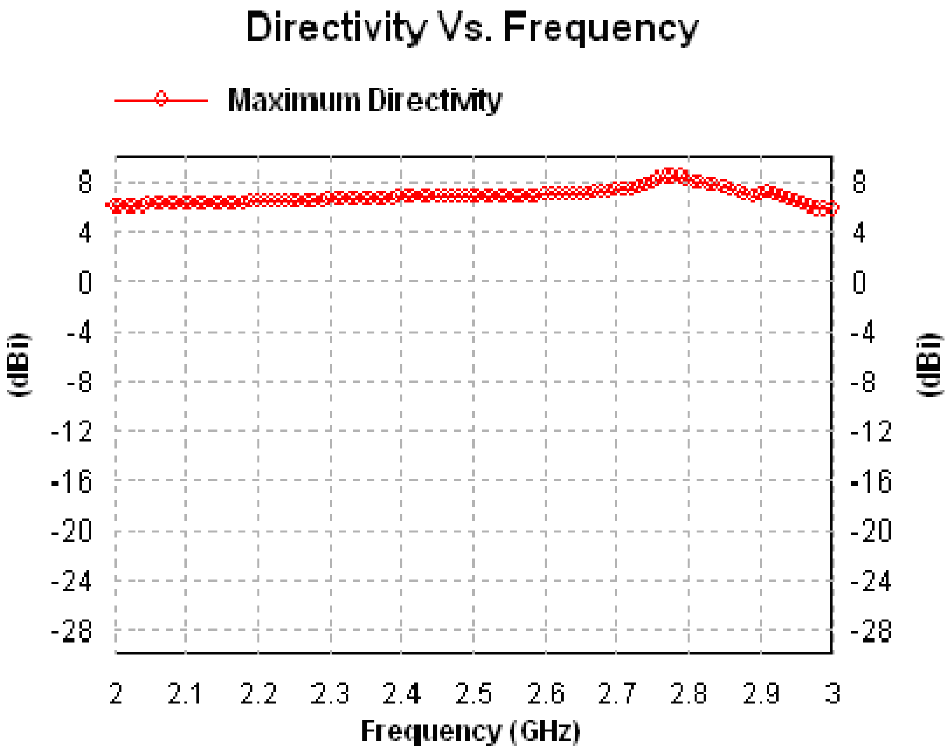

Figure 2.18 Graph between directivity and frequency for antenna design-3

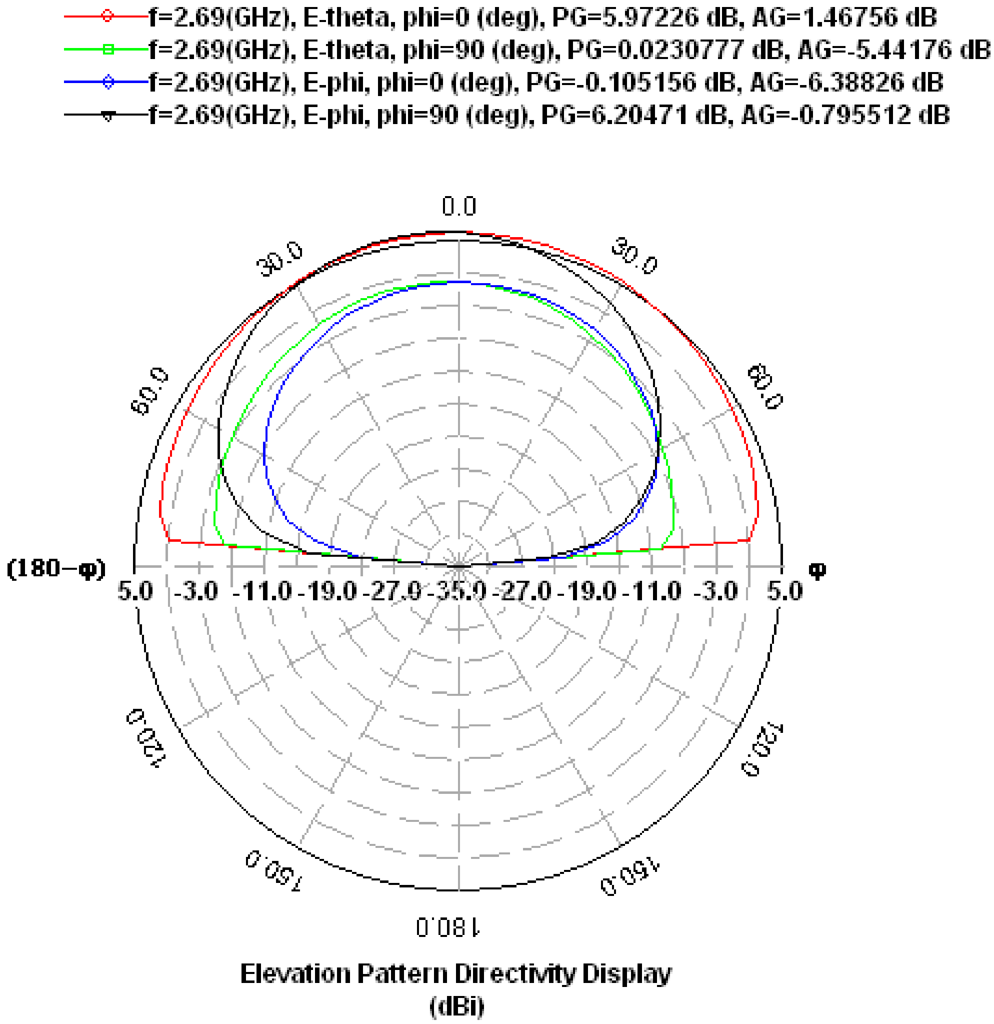

Figure 2.19 Radiation pattern for antenna design-3

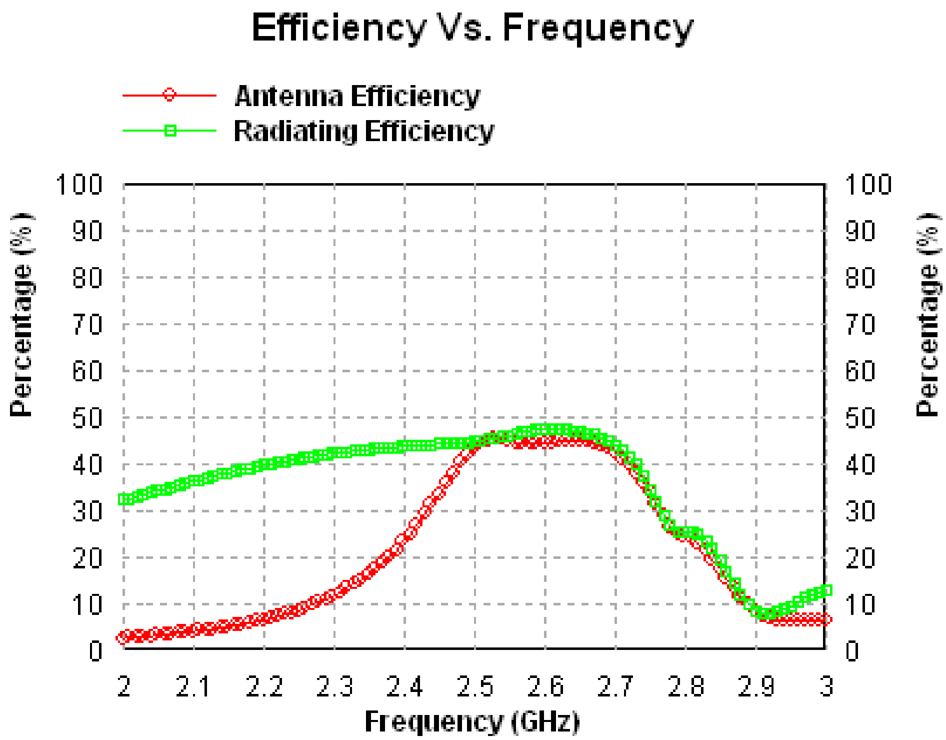

Figure 2.20 Graph between efficiency and frequency for antenna design-3

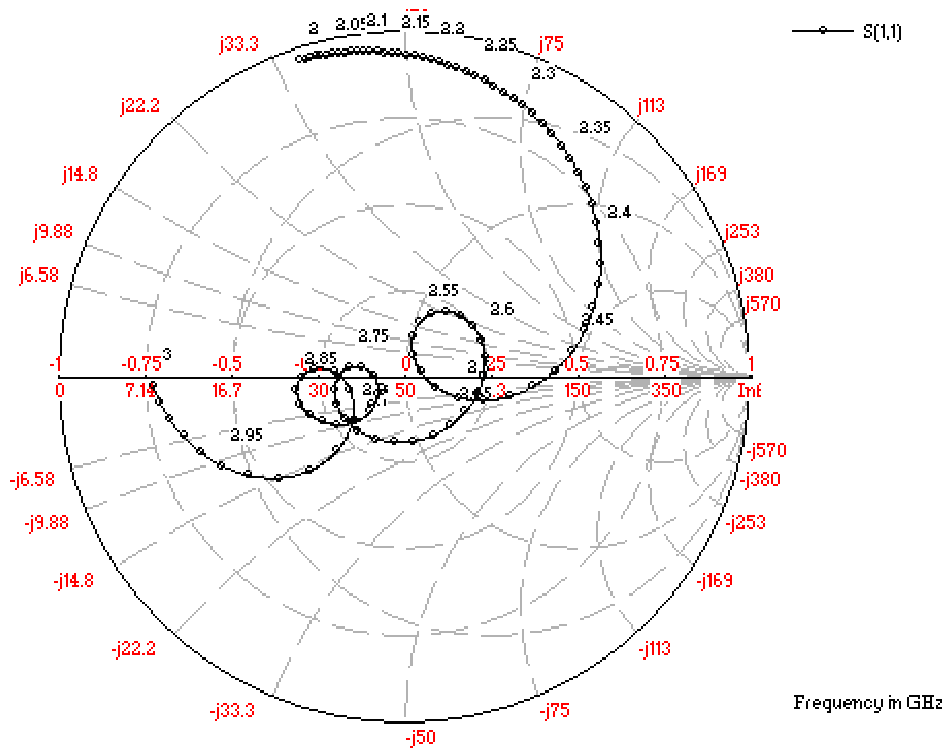

Figure 2.21 Impedance loci for antenna design-3

2.5 GAP COUPLED MICROSTRIP PATCH ANTENNA DESIGN-4

With same patch dimension, an attempt has been made to further improve the bandwidth in the microstrip patch antenna design-4. Bandwidth has been improved using reduced size gap coupled rectangular printed patch antenna with a single feed. In the microstrip patch antenna design-4, a single patch is fed through a coaxial probe feed and the other patches are parasitically coupled. The couplings between the multiple resonators are realized by using small air gap between the patches.

Figure 2.22 presents the reduced size gap coupled rectangular microstrip patch antenna with a single feed of antenna design-4. In this printed antenna design-4, an air gap of 0.375 mm is introduced 1 mm below the centre horizontal axis. Antenna is designed for S-band of frequency range with center frequency f_0 = 2.57 GHz, within the frequency range 2 GHz to 3 GHz, with step of frequency selected to be 0.01 GHz. In this microstrip patch antenna design-4, the patch length L = 30 mm**,** patch width W = 55 mm, with feed point positions = (-10, **-** 0.75). The patch is 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 2.23 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-4; maximum return loss is – 40 dB within this frequency range. Figure 2.24 shows the graph between VSWR and frequency (in GHz) for antenna design-4, impedance bandwidth can be taken below VSWR < 2. Figure 2.25 shows the graph between directivity (in dBi) and frequency (in GHz) for the antenna design-4. For the antenna design-4, directivity (in dBi) for the operating frequency is coming between 5-8 dBi. Figure 2.26 shows the radiation pattern (2-D elevation pattern) for the antenna design-4 at the center frequency 2.57 GHz. Figure 2.27 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 40-50 % at the centre frequency. Figure 2.28 shows the impedance loci for the antenna design-4. At resonance frequency 2.57 GHz; the simulated input impedance of antenna design-4 is near to be matched with 50 ohm impedance. The impedance bandwidth for the antenna design-4 is coming out to be **17.9 %** (460 MHz) of the center frequency at 2.57 GHz, with three resonant modes within the specified frequency range.

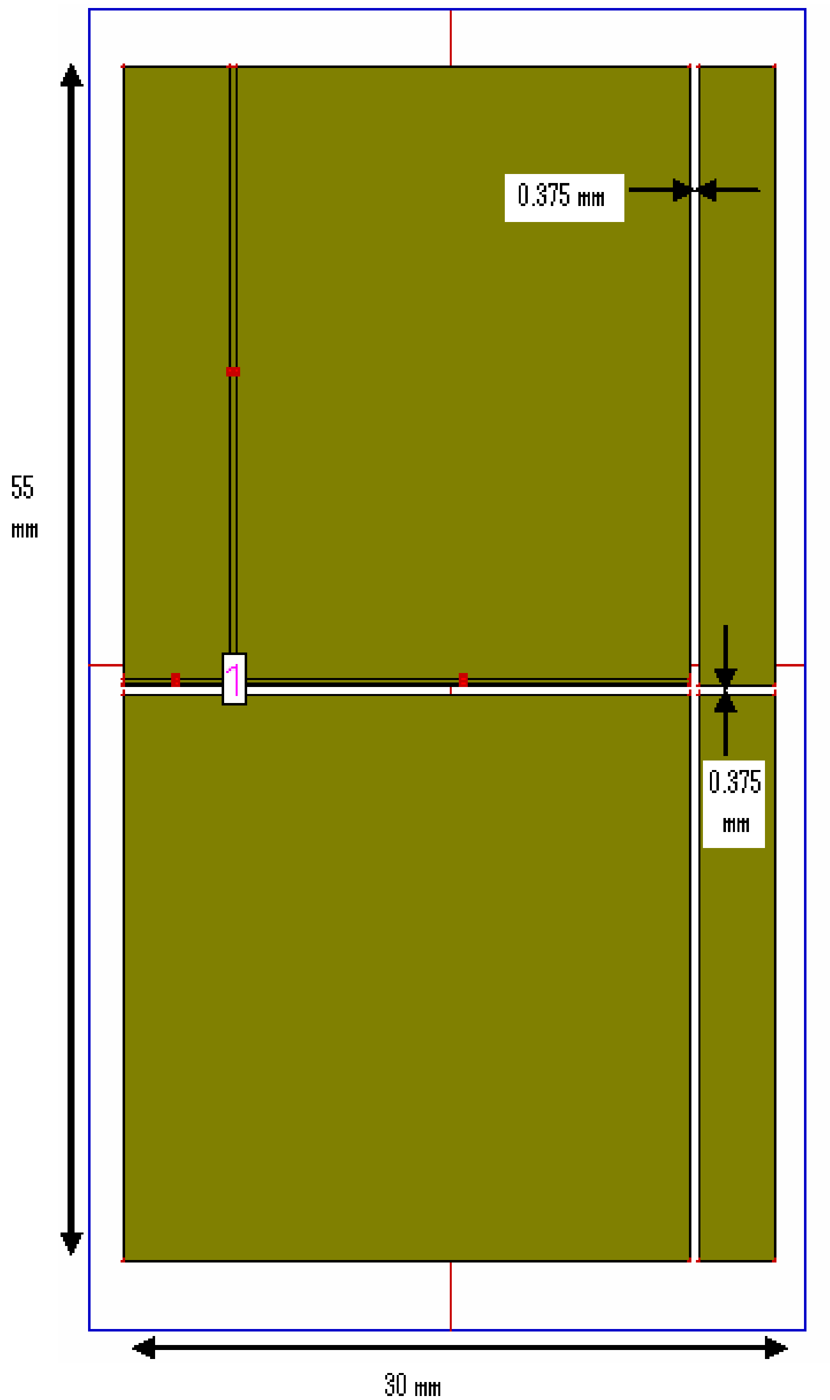

Figure 2.22 Gap-coupled rectangular microstrip antenna design- 4

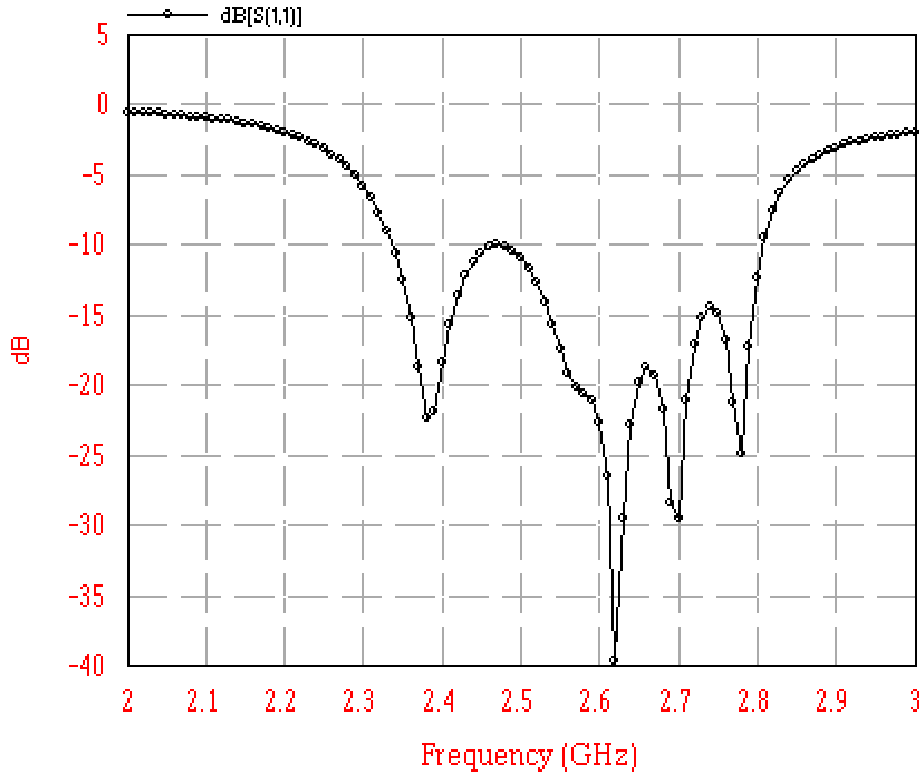

Figure 2.23 Graph between return loss and frequency for antenna design-4

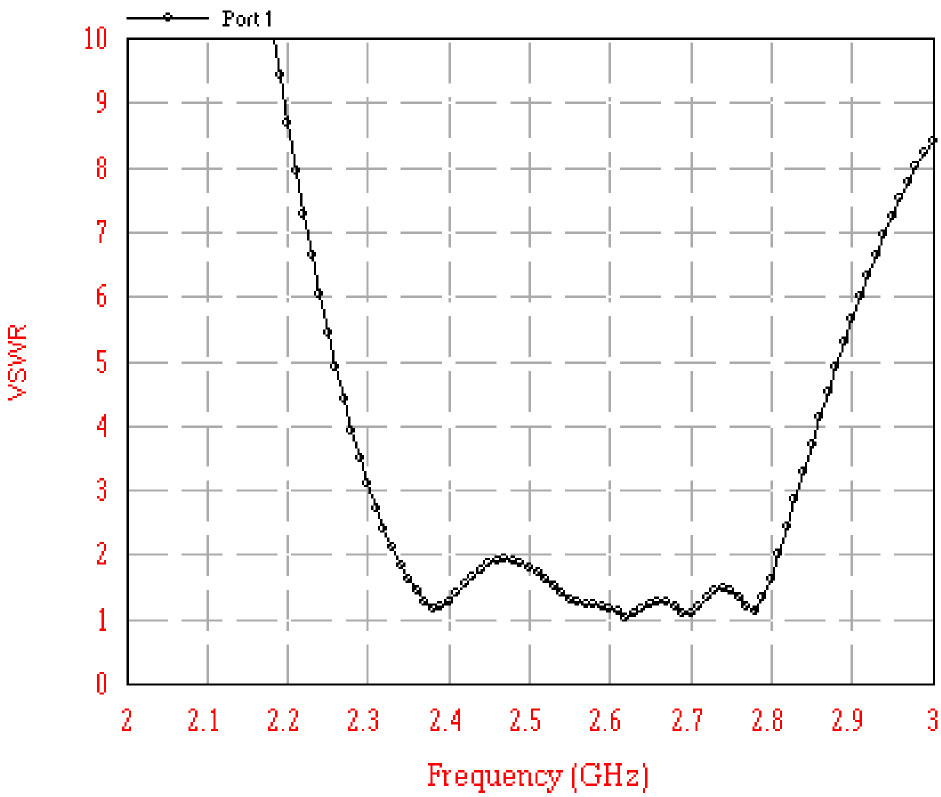

Figure 2.24 Graph between VSWR and frequency for antenna design-4

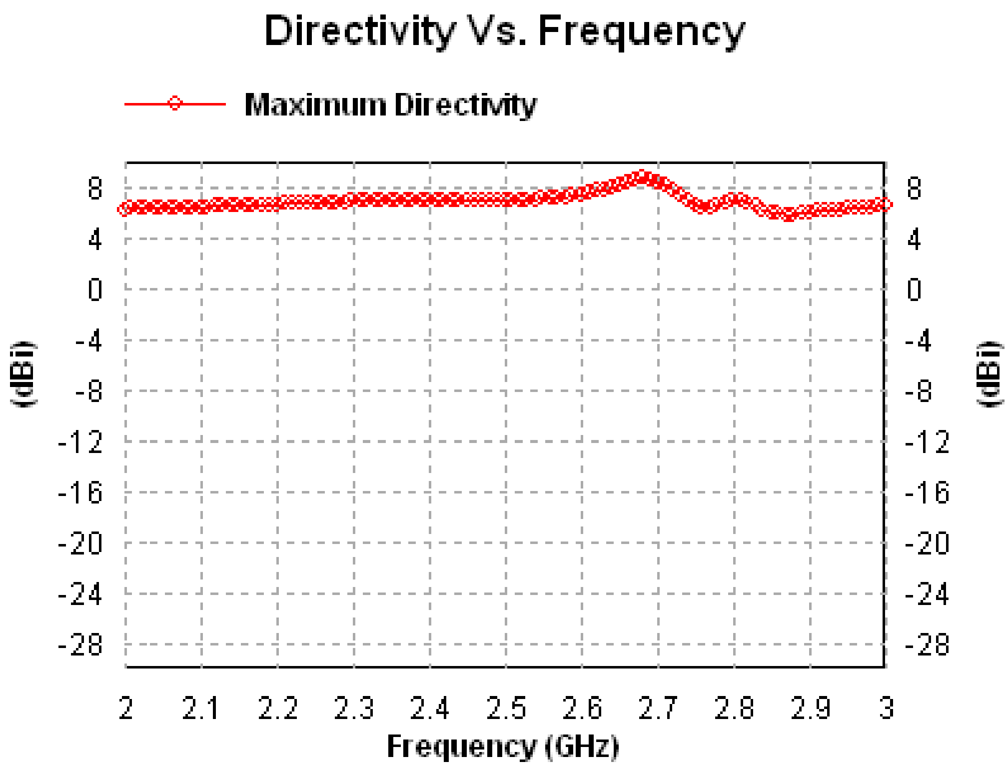

Figure 2.25 Graph between directivity and frequency for antenna design-4

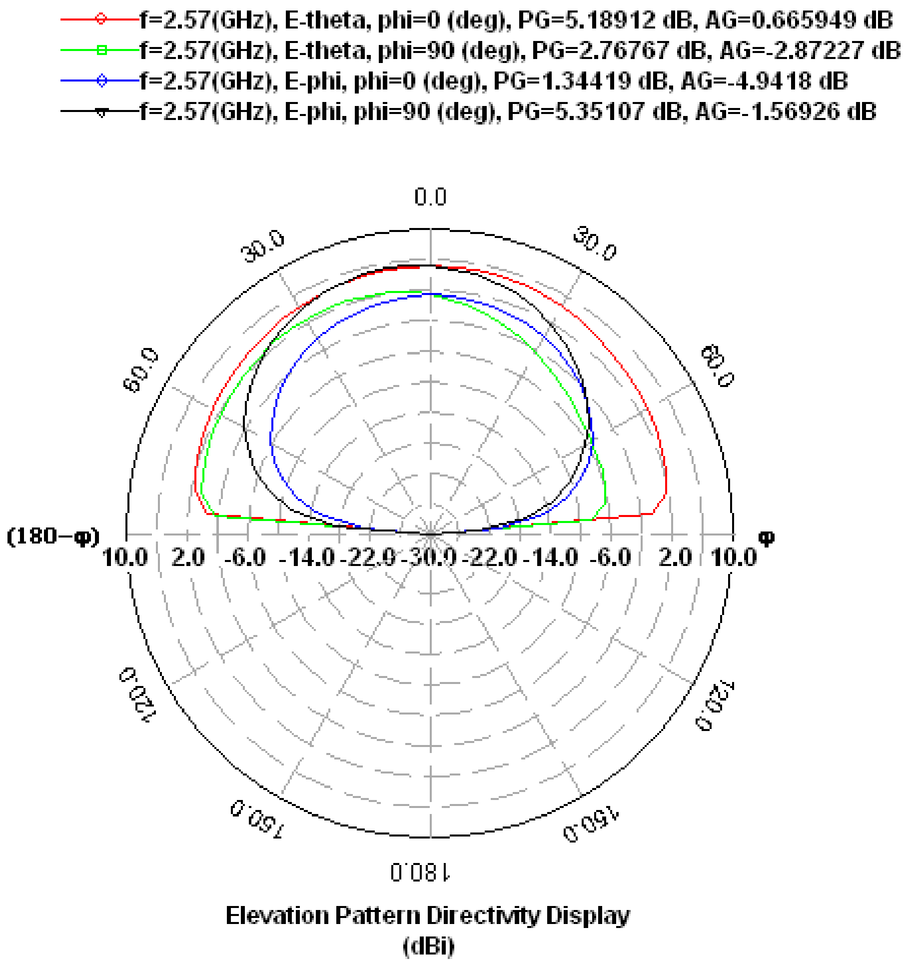

Figure 2.26 Radiation pattern for antenna design-4

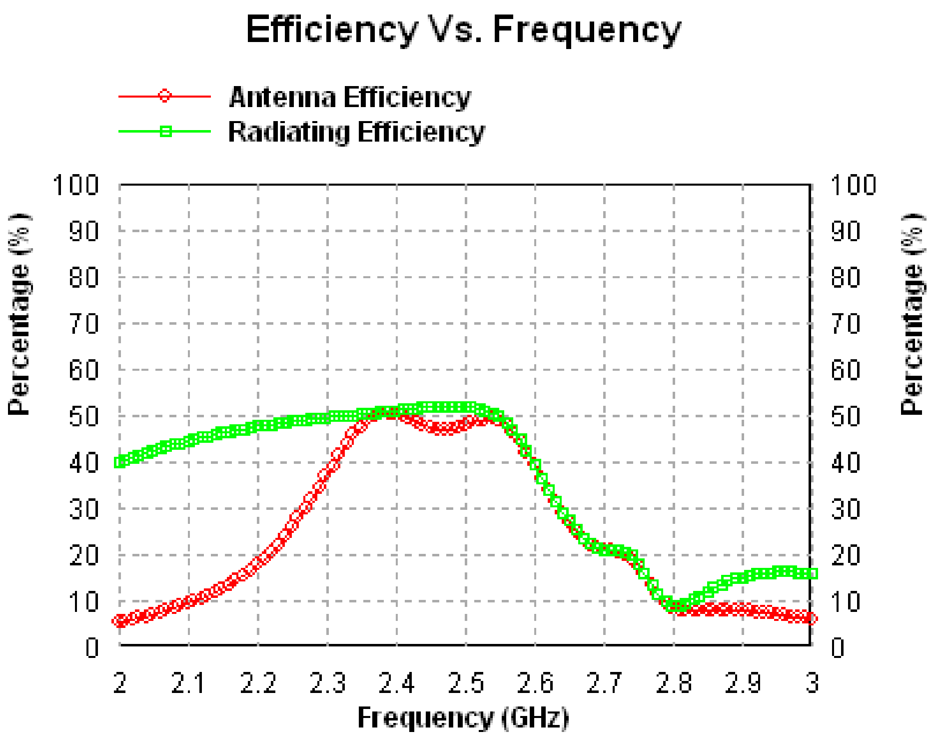

Figure 2.27 Graph between efficiency and frequency for antenna design-4

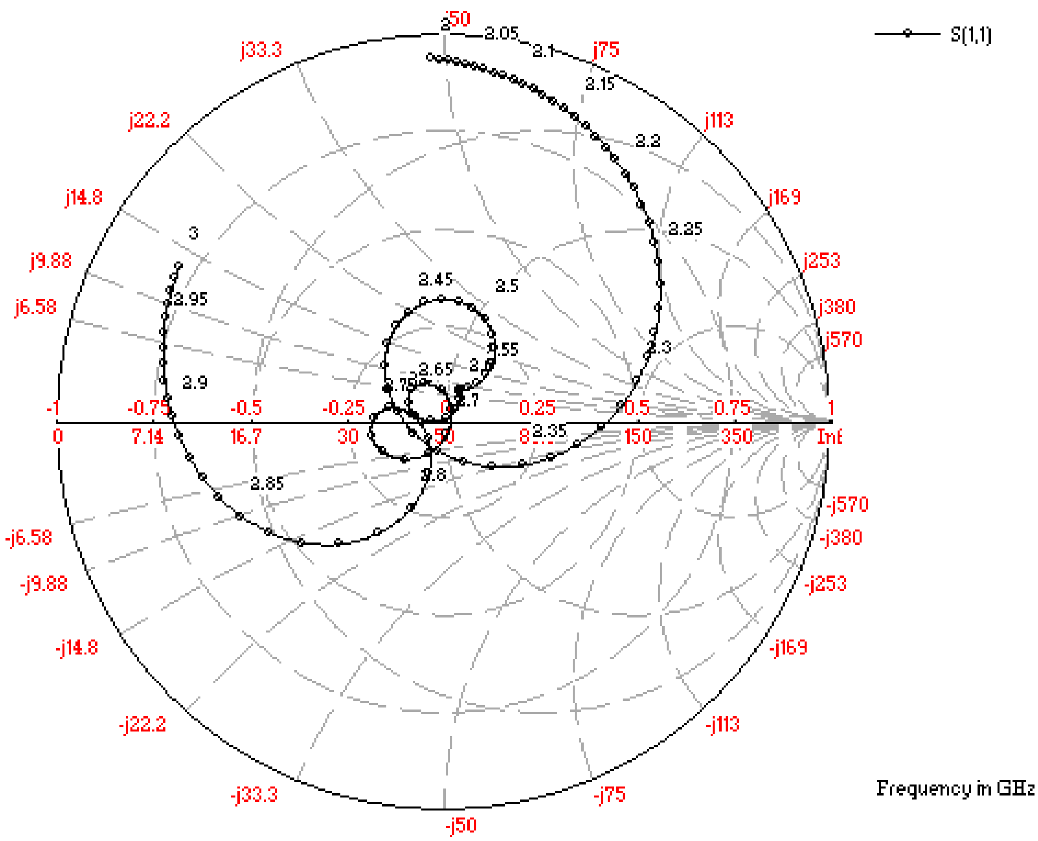

Figure 2.28 Impedance loci for antenna design-4

2.6 GAP COUPLED MICROSTRIP PATCH ANTENNA DESIGN-5

In the antenna design-5, an attempt is made to further improve the bandwidth if the gap coupled reduced size rectangular printed patch antenna is introduced. In the microstrip patch antenna design-5, a single patch 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 2.29 presents the gap coupled reduced size rectangular microstrip patch antenna. In the antenna design-5, the patch size is reduced by approximately 33 % as compared to the antenna design without size reduction, and air gaps are introduced along radiating corners and non radiating corners of fed rectangular patch and are parasitically coupled. Antenna is designed for S-band of frequency range with centre frequency f_0 = 2.55 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, height of the substrate 1.6 mm, feed point positions on the patch is (-8.3, 0). The patch is 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 2.30 shows the graph between return loss (in dB) and frequency (in GHz) for antenna design-5; maximum return loss is – 30 dB within the frequency range. Figure 2.31 shows the graph between directivity (in dBi) and frequency (in GHz) for antenna design-5. The directivity for microstrip antenna should be 5-8 dBi. For the antenna design-5, at resonance (or center) frequency, directivity is coming within this specified range. Figure 2.32 shows the impedance loci for antenna design-5. At resonance frequency 2.55 GHz, the simulated input impedance of antenna design-5 is near to be matched with 50 ohm impedance. Here due to gap coupled reduced size rectangular micro strip patch antenna of antenna design-5 ; the impedance bandwidth, is coming out to be **20.2%** (515 MHz) of the center frequency at 2.55 GHz with three resonant modes within the specified frequency range.

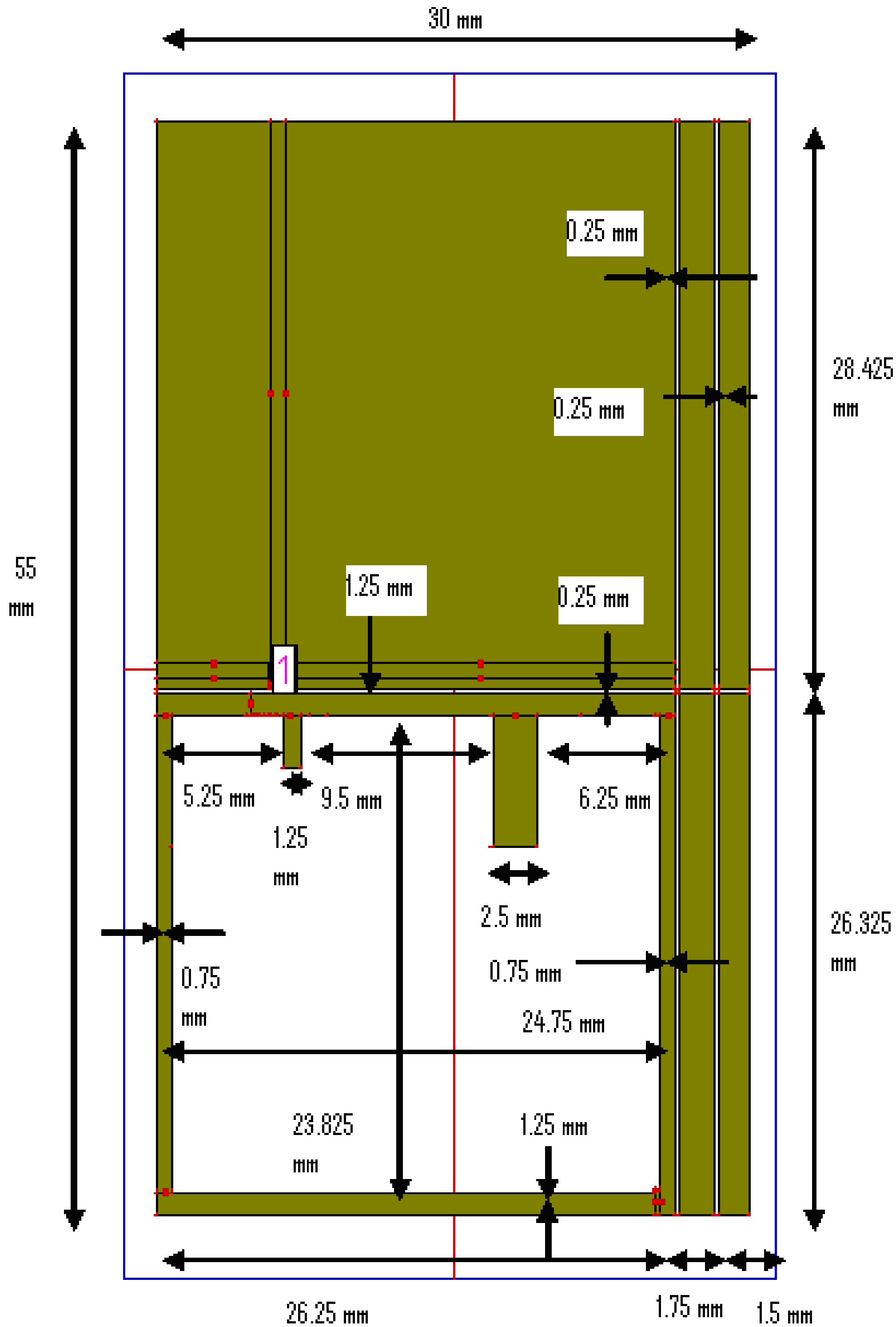

Figure 2.29 Gap-coupled compact rectangular microstrip antenna design-5

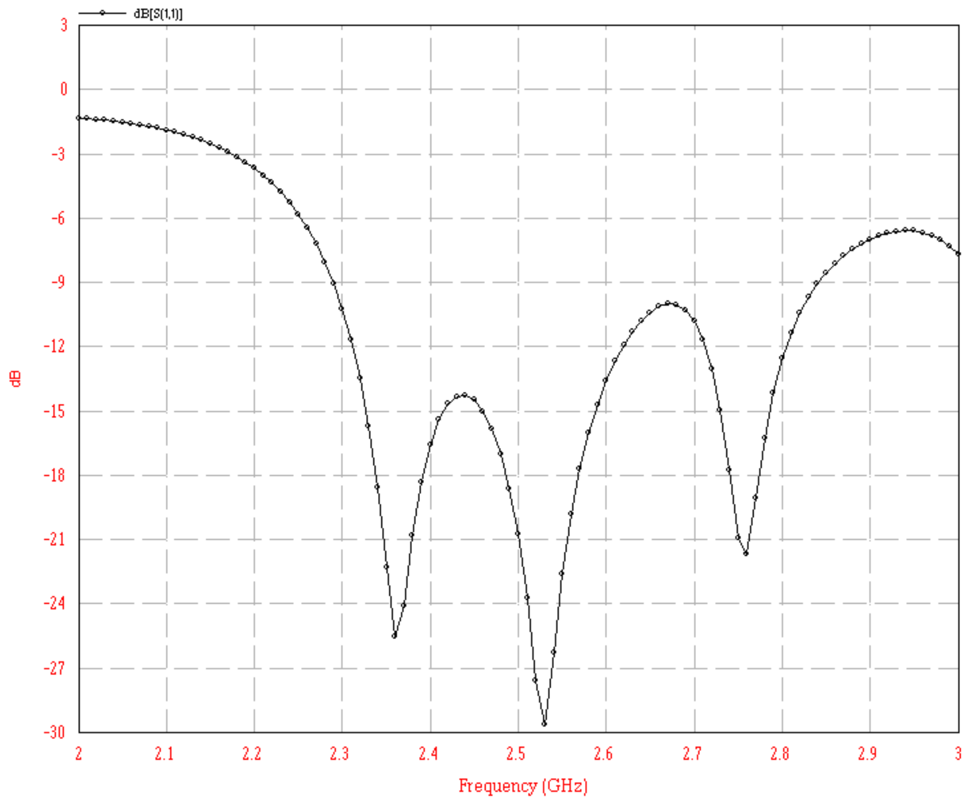

Figure 2.30 Graph between return loss and frequency for antenna design-5

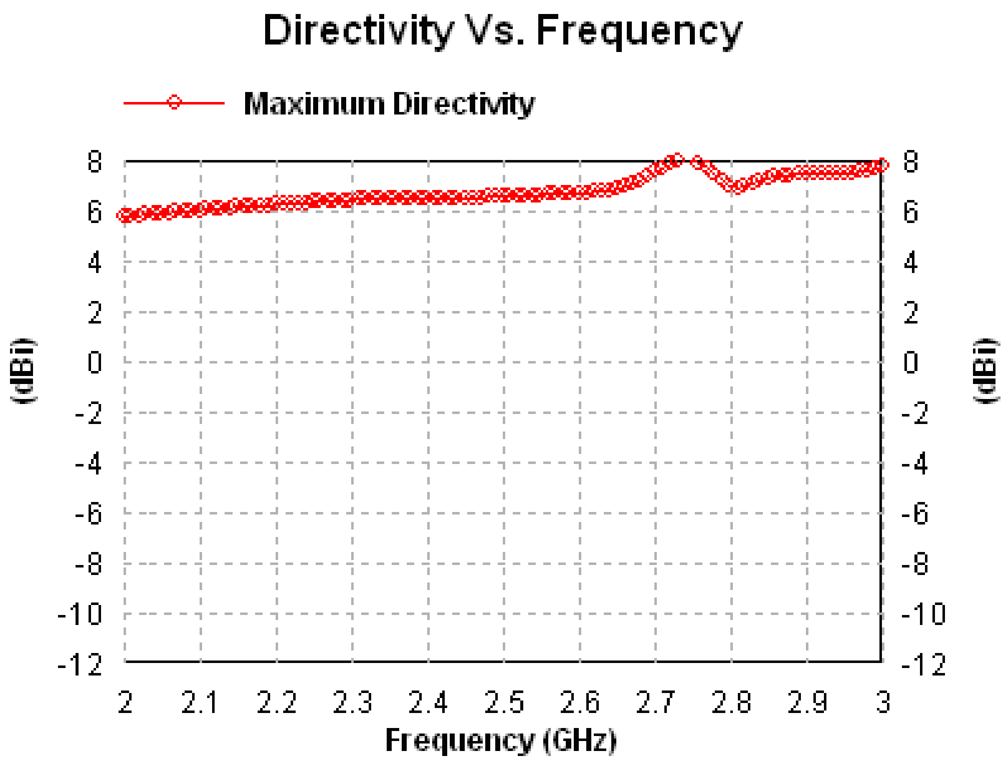

Figure 2.31 Graph between directivity and frequency for antenna design-5

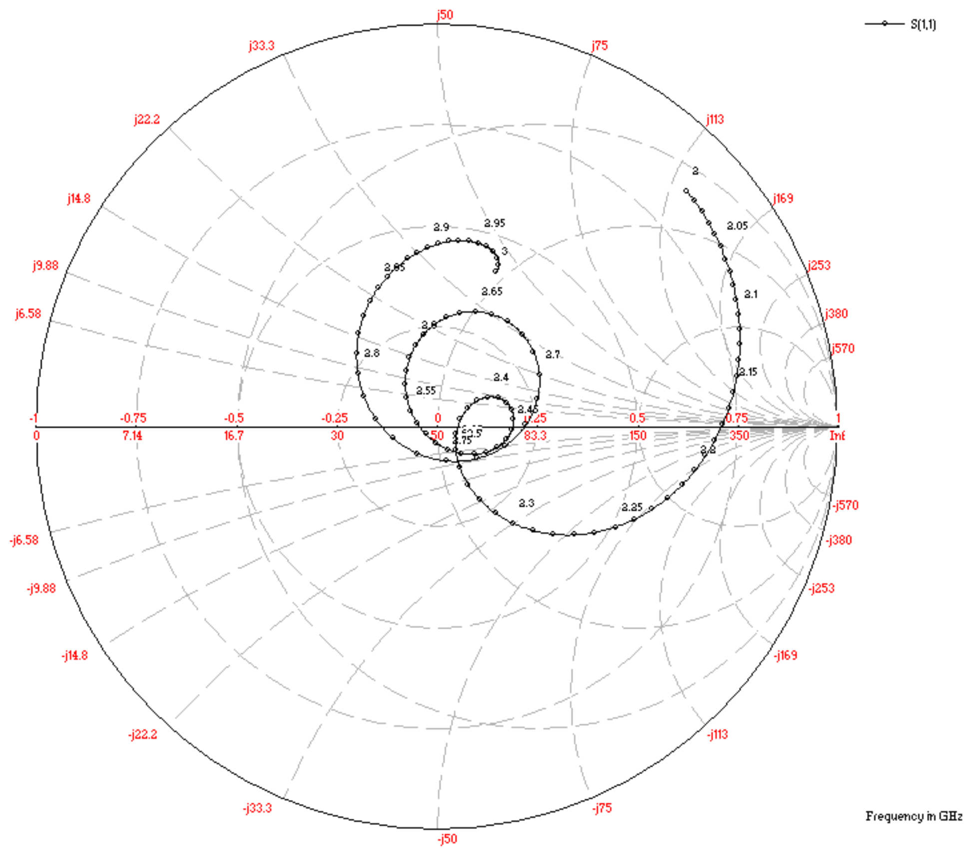

Figure 2.32 Impedance loci for antenna design-5

2.7 CONCLUSION

In this chapter, by using more coplanar multiresonator microstrip patches with gap coupled to the radiating corners (edges) and non radiating corners (edges) of a rectangular microstrip patch, wideband have been obtained. By using such a design, the impedance bandwidth can be improved many folds as compared to a single rectangular printed patch. In the next chapter, another technique, i.e. truncated compact microstrip patch antenna will be discussed to improve the bandwidth of the antenna.