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1. microstrip antennas
2. Antennas (Electronics) -- mathematical models.
3. EEE -- Thesis.

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CERTIFICATION OF APPROVAL

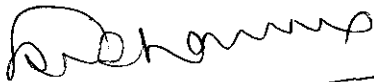
**Investigations on dual frequency behaviour of a rectangular Microstrip
Antenna**

by

Salisa Binti Abdul Rahman

A project dissertation submitted to the
Electrical and Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(ELECTRICAL AND ELECTRONICS ENGINEERING)

Approved by,



(Prof. PC Sharma)

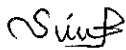
UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

Jun 2004

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



SALISA BINTI ABDUL RAHMAN

ABSTRACT

The goals of this project are to investigate multiband behavior of Microstrip Antennas and to design an antenna that can operate at multiband or broadband frequencies using HFSS (High Frequency Structure Simulator). Through this project, smaller size of antenna at high performance can be developed. The design of Microstrip Antennas will be studied through fractals using HFSS. Fractal is a broken or irregular fragment. HFSS is used to simulate the antenna design and calculate the s-magnitude plot at the end of simulation. To make the investigation of antenna behavior, many experiments are done by varying the λ , and also introduced the notch or window at the patch and analyzed the results to get the characteristics that can show their different behaviors. The scopes of this project includes literature review on Microstrip Antennas and HFSS and simulation of designing antennas by varying one parameter like varying the location of notch. The purpose of this simulation is to compare the resonant frequency of the simulation with the corresponding theoretical value.

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First of all, I would like to thank to Electrical and Electronic Engineering Department, particularly to Mr. Zuki for giving me the opportunity to conduct my Final Year Project (FYP) according to my interest on Microstrip Antennas.

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Thanks to all.

CHAPTER 1

INTRODUCTION

The Microstrip Antennas involved in this project consists of substrate or dielectric, patch and airbox. This antenna is known as rectangular patch antenna because the shape is rectangular. In this project, Microstrip Antennas act as a receiver because the purpose of designing this antenna is to maximize the power absorbed. HFSS (High Frequency Structure Simulator) is used to simulate the design and give a faster and accurate result compared to manual calculation. During the simulation, window is introduced at the patch and varies its location to investigate the effect of this parameter on resonant frequency. The basic concept of low pass filter is used in this design. There are many formulas involved in designing antenna. These formulas are used to improve the effect on resonant frequency by varying the parameter of the antenna.

Microstrip Antennas were designed to replace conventional antennas due to its advantages, which are light weight, broader and multiband operation by having only one input port and reduced the cost of materials. According to these advantages, Microstrip Antennas are widely used in mobile radio, remote sensing and satellite communication.

The objectives of this project are to design a compact antenna and to prove that a single antenna can operates at many frequencies. The effective frequencies that is concentrated in this project, which are 3GHz and 6GHz. The compact antenna is designed by using fractal technique. The main purpose of this project is to investigate the multiband behavior of Microstrip Antennas.

CHAPTER 2

THEORY

In designing Microstrip Antennas, there are many formulas used to calculate the dimensions of the antenna. Below are the formulas involved in this design:

$$1. \quad L = \frac{c}{2f_r \sqrt{\epsilon_r}}$$

L = Patch length

$$c = 3 \times 10^8 \text{ m/s}$$

f_r = Resonant frequency

ϵ_r = Permittivity of the dielectric

$$2. \quad w = \sqrt{h} \lambda_d [\ln(\lambda_d / h) - 1]$$

w = Patch width

h = Dielectric height

$$\lambda_d = \frac{\lambda_o}{\epsilon_r}$$

$$3. \quad w = \frac{120\pi d}{Z_o \sqrt{\epsilon_r}}$$

w = Patch line width

d = Dielectric thickness

ϵ_r = Permittivity of the substrate

All the above formulas are involved in designing an antenna because before doing a simulation, the diagram needs to be drawn first. The accuracy of the calculation is important because the length and width of the antenna decide the Resonant Frequencies at which an antenna will radiate effectively. From the theory, the resonant frequency will decreased when window is introduced at the patch compared to the patch without window.

CHAPTER 3

METHODOLOGY

The study of low pass filter example in HFSS (High Frequency Structure Simulator) is needed to be little familiar with the software. The steps taken to design this antenna are taken from the tutorial section of HFSS (High Frequency Structure Simulator). All the steps are same but the assigning materials and defining ports are not same as the low pass filter. For low pass filter, there are two ports and one perfect H is defined but for Microstrip Antennas, there is only one port at the input and the other sides are assigned as radiation side. Window also has introduced at the patch antenna to increase the length of current path, so that the resonant frequency is lower than the antenna without window.

HFSS (High Frequency Structure Simulator) is software used in designing antennas because it can simulate the result of the simulation in accurate and quick way. This software also can calculate all the parameters of the antenna like scattering parameter, impedance and can perform the high performance of plots and three dimensions diagram like the far field plot and the diagram of antenna itself.

CHAPTER 4

RESULTS AND DISCUSSION

In designing Microstrip Antennas using HFSS (High Frequency Structure Simulator), many simulation need to be done by varying one or some parameters of the antennas such as introducing the window at the patch, increasing the number of window and locate the window at different locations. All the results of simulation need to be analyzed to find the characteristics or behavior of the Microstrip Antennas.

SIMULATION 1:

Below are the results when feed line is moved along the antenna patch. The purpose of doing this exercise is to see the behavior of feed line at different location along the patch side.

CASE 1

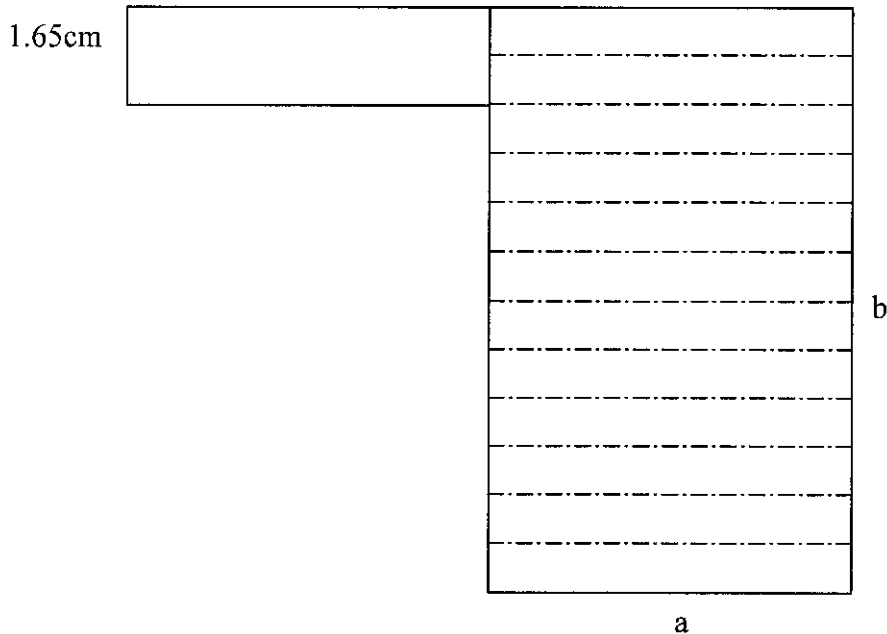
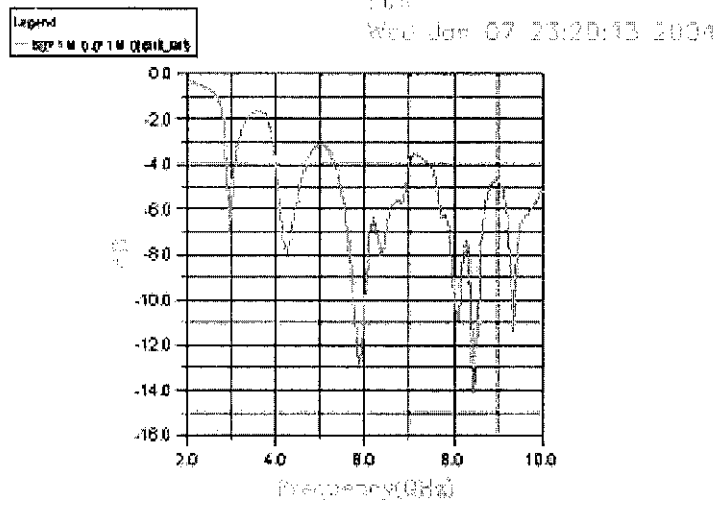


Figure 4.1: Microstrip Antennas with feed line at the corner of the patch



Graph 4.1: S-magnitude with feed line at the corner of the patch

CASE 2

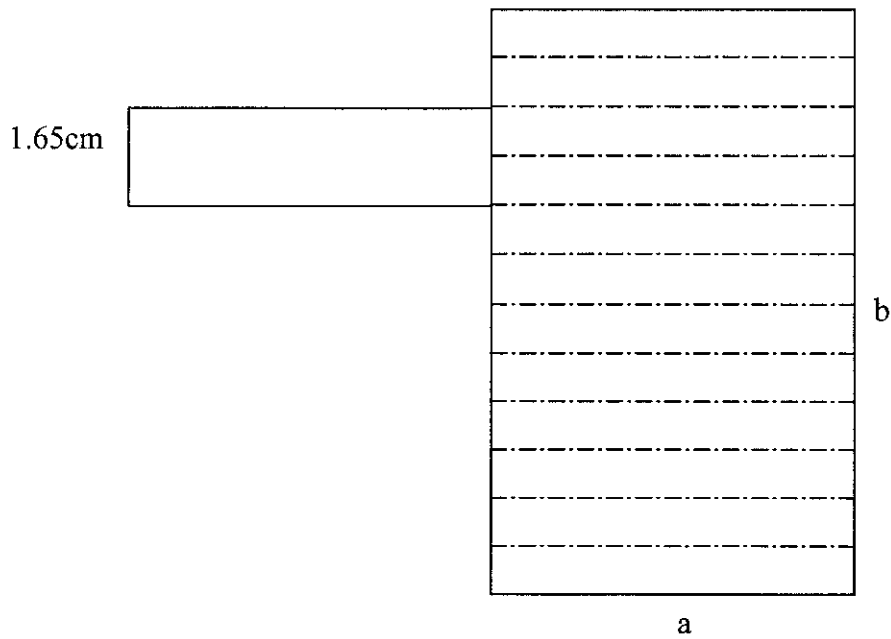
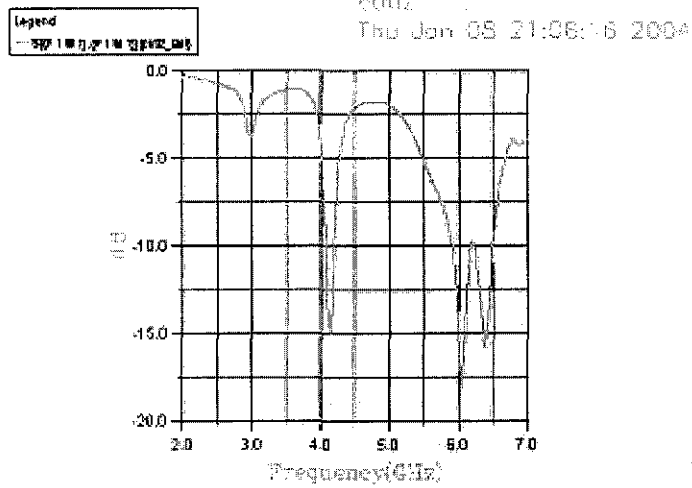


Figure 4.2: Microstrip Antennas with feed line is moved 0.3cm from the corner of the patch



Graph 4.2: S-magnitude with feed line is moved 0.3cm from the corner of the patch

CASE 3

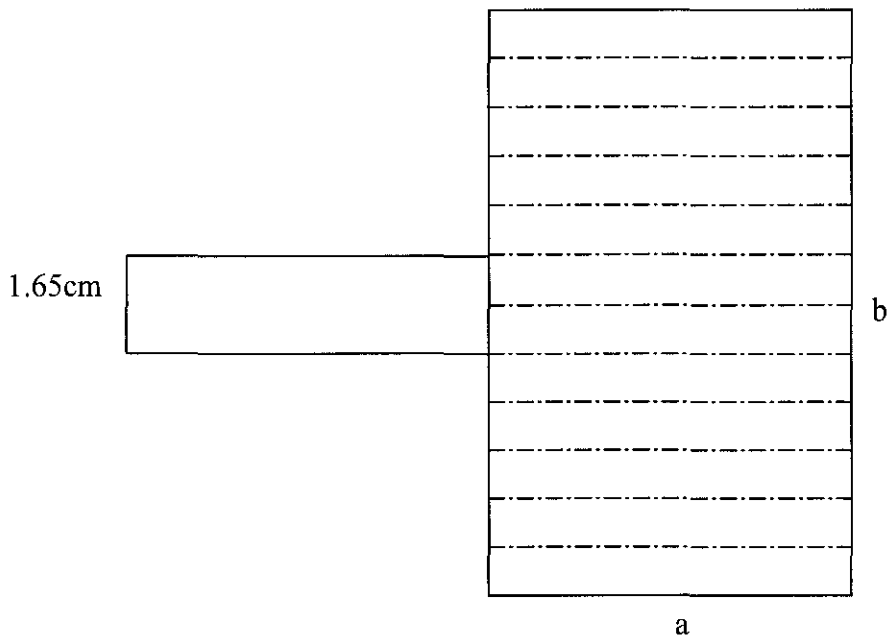
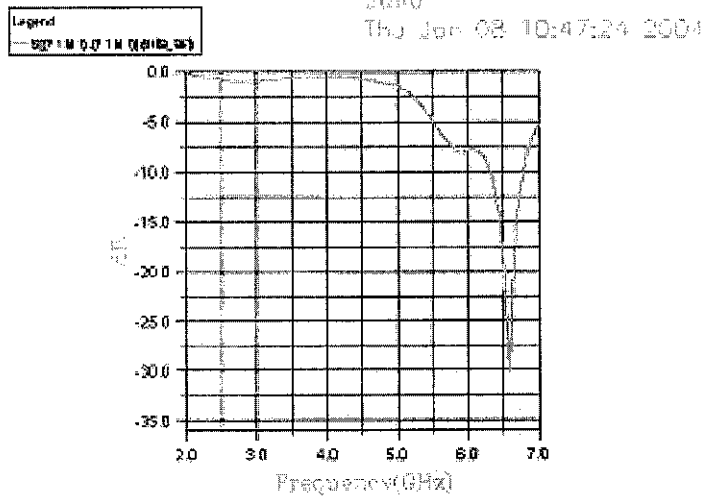


Figure 4.3: Microstrip Antennas with feed line at the middle of the patch



Graph 4.3: S-magnitude with feed line at the middle of the patch

CASE 4

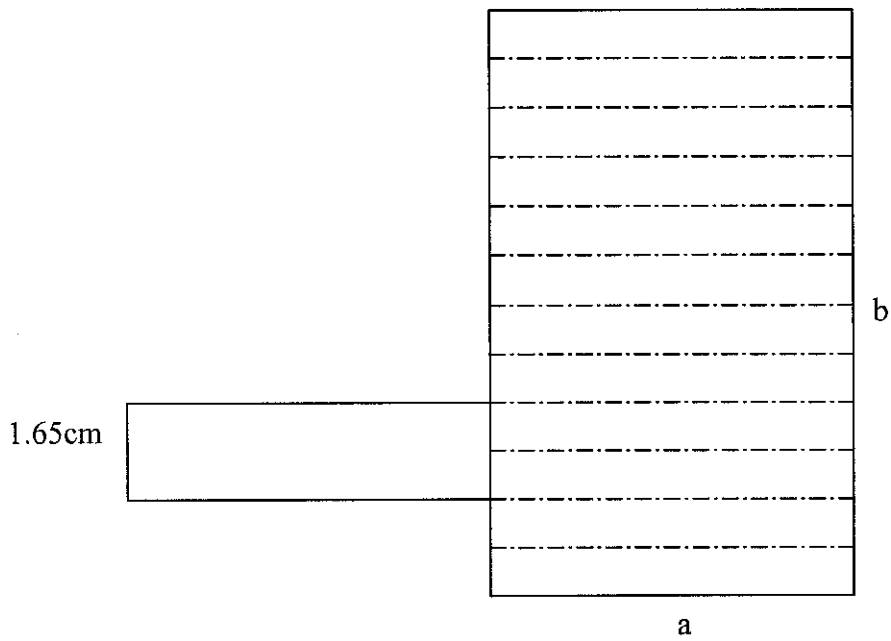
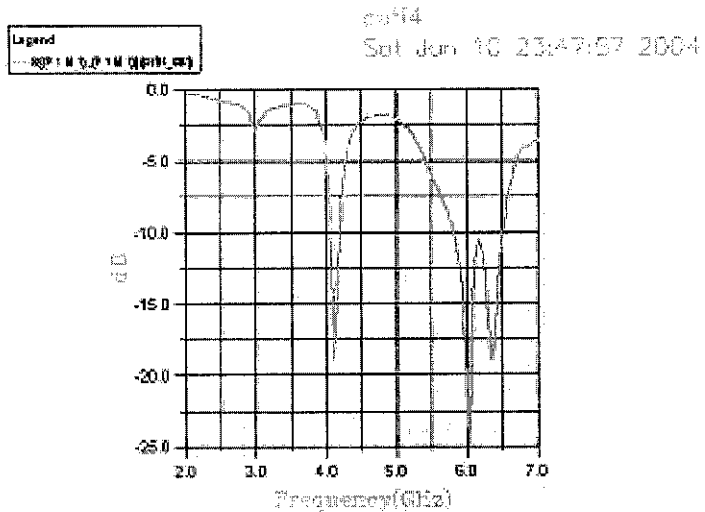


Figure 4.4: Microstrip Antennas with feed line is moved 0.3cm from the corner of the patch



Graph 4.4: S-magnitude with feed line is moved 0.3cm from the corner of the patch

CASE 5

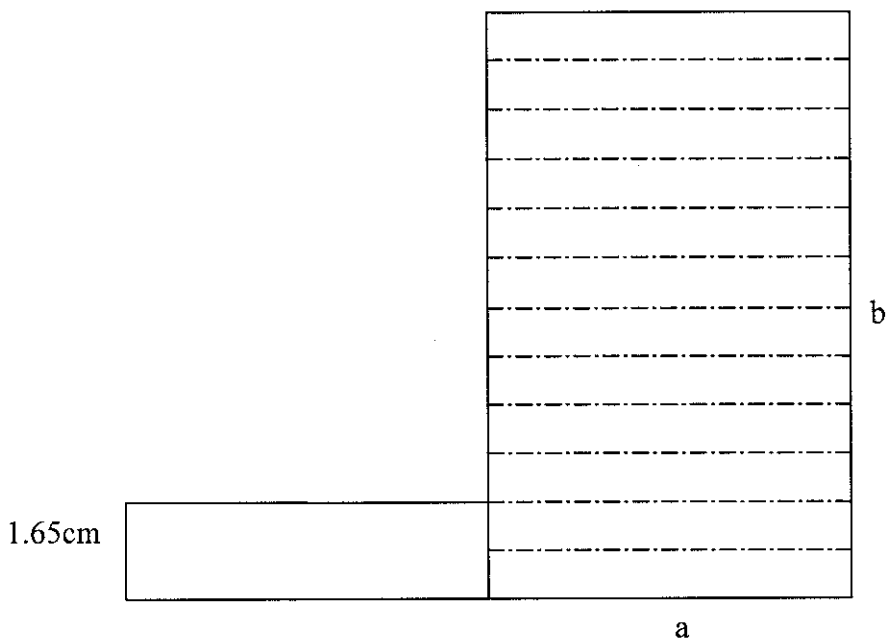
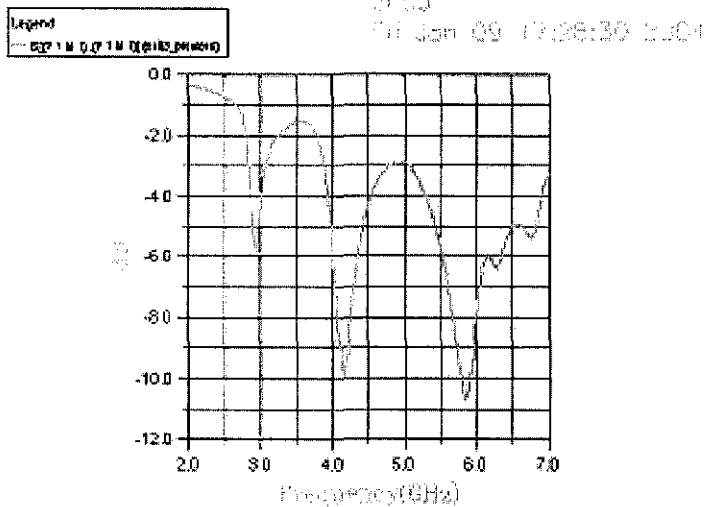


Figure 4.5: Microstrip Antennas with feed line at the corner of the patch



Graph 4.5: S-magnitude with feed line at the corner of the patch

From the above exercise, when feed line is located at the edge of the patch, the Resonant Frequency excited strongly compared to feed line at 0.3cm from the corner. But when the feed line is moved at the middle of patch antenna, there is no more excitation at this point. This is because the field is canceling each other.

SIMULATION 2:

Below are the simulation of antenna that having different location of notch and increased the number of notch with all the dimensions are same, that's mean the dimensions are not changed. Below are the diagrams of antenna and notch:

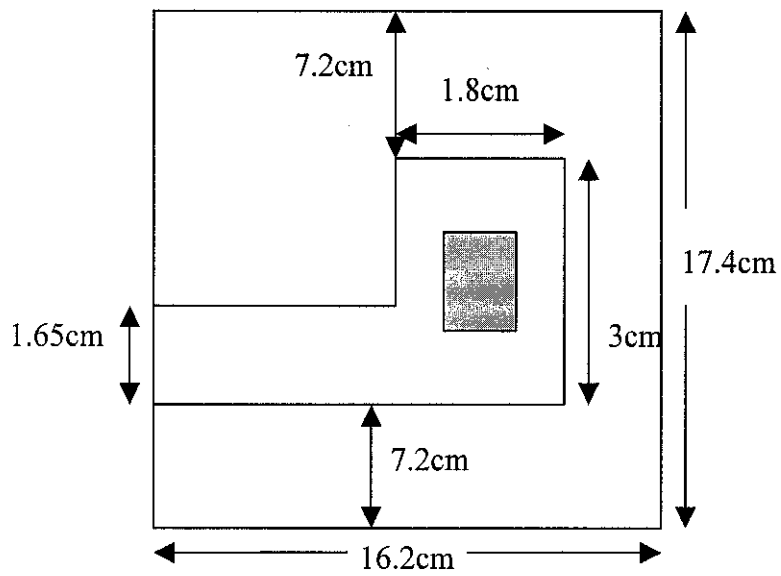


Figure 4.6: Dimensions Microstrip Antenna

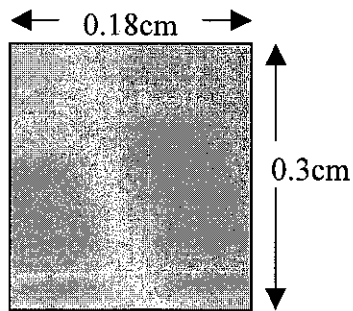


Figure 4.7: Dimensions of Window or Notch

CASE 1

Without window:

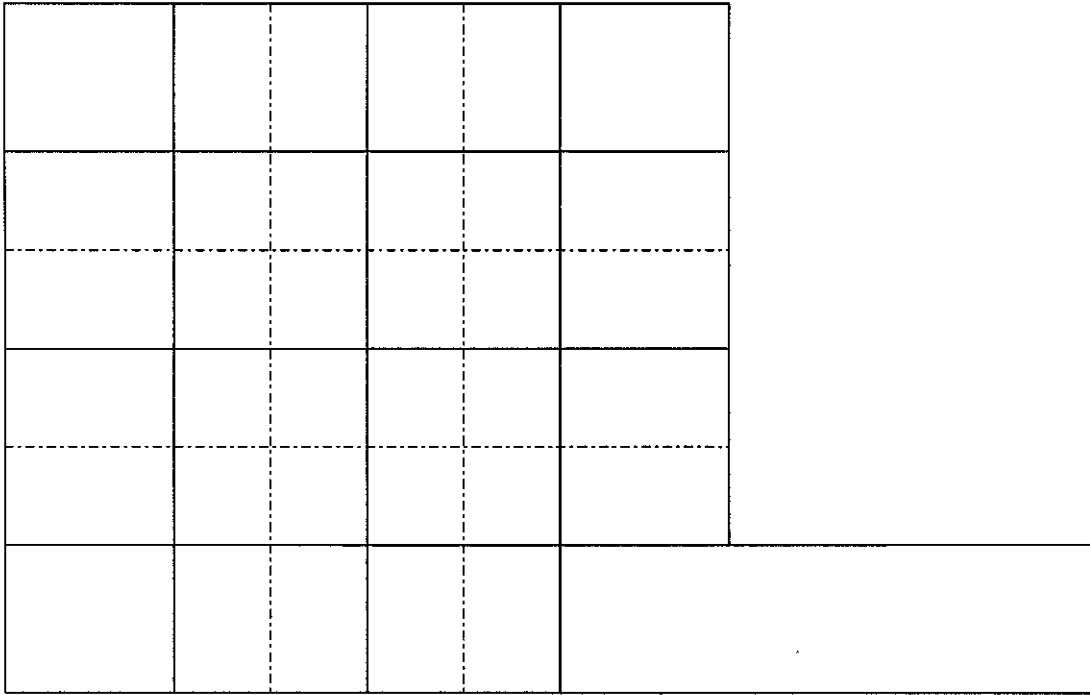
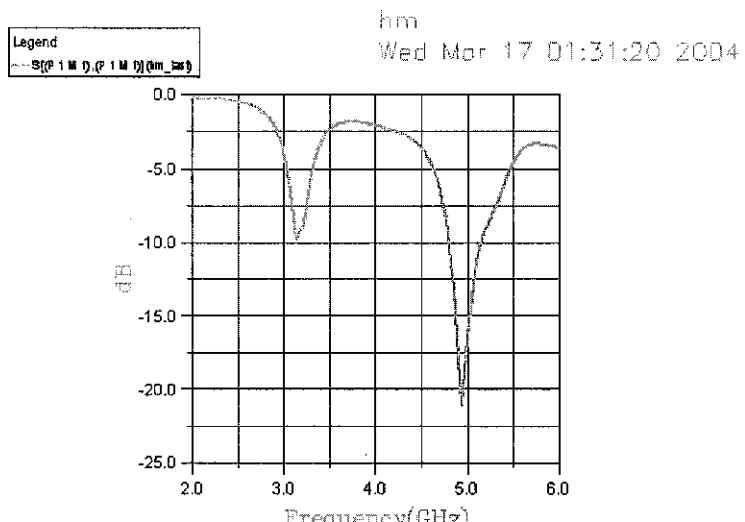


Figure 4.8: Patch without window



Graph 4.6: S-magnitude for patch without window

| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 3.1429 | -9.8111 |
| fr 2 = 4.9388 | -21.1285 |

Table 4.1: Resonant frequency and Reflected Power for patch without window

Number of window = 3

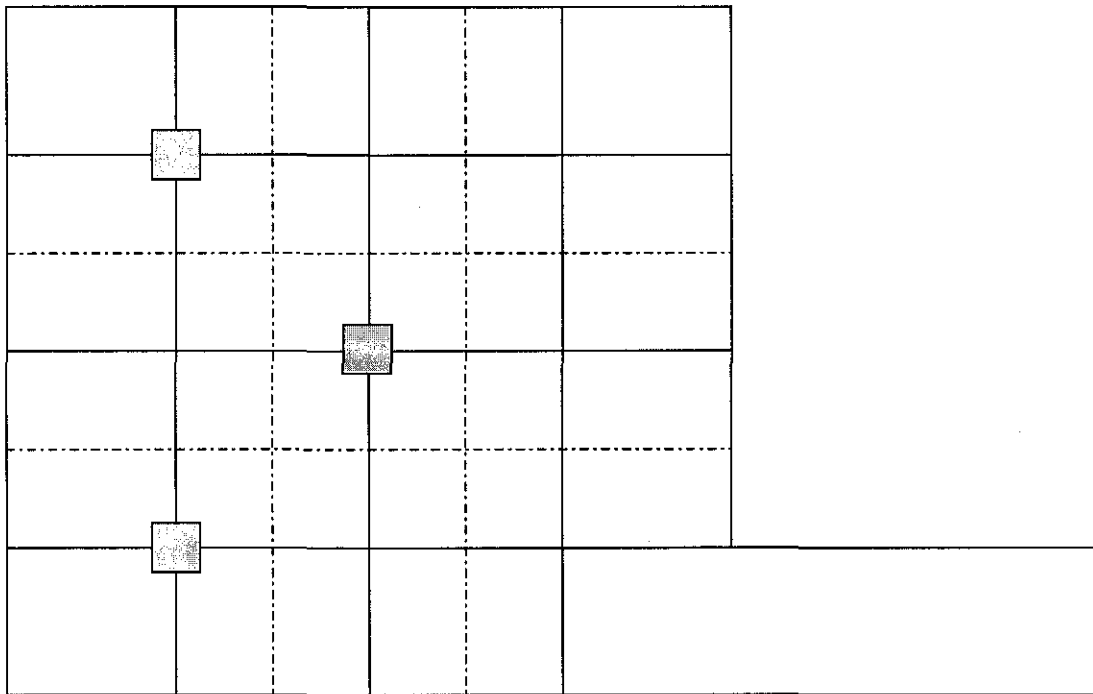
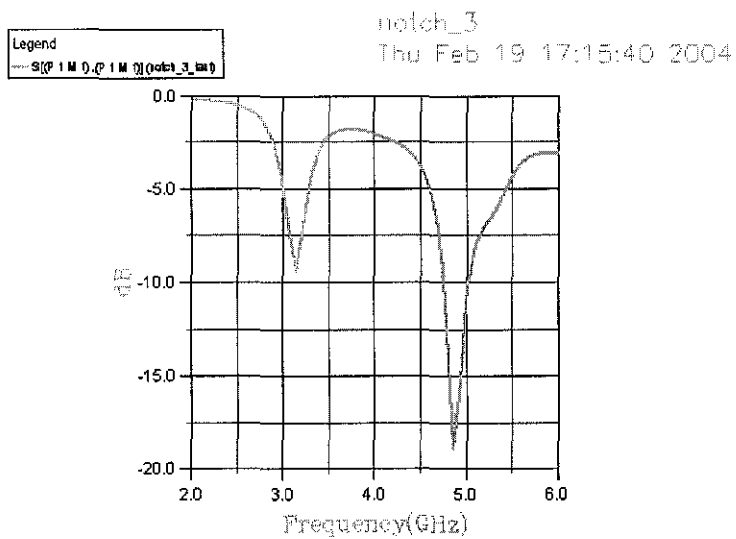


Figure 4.9: Patch with three windows



Graph 4.7: S-magnitude for patch with three windows

| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 3.1429 | -9.4300 |
| fr 2 = 4.8571 | -18.9012 |

Table 4.2: Resonant frequency and Reflected Power for patch with three windows

Number of window = 5

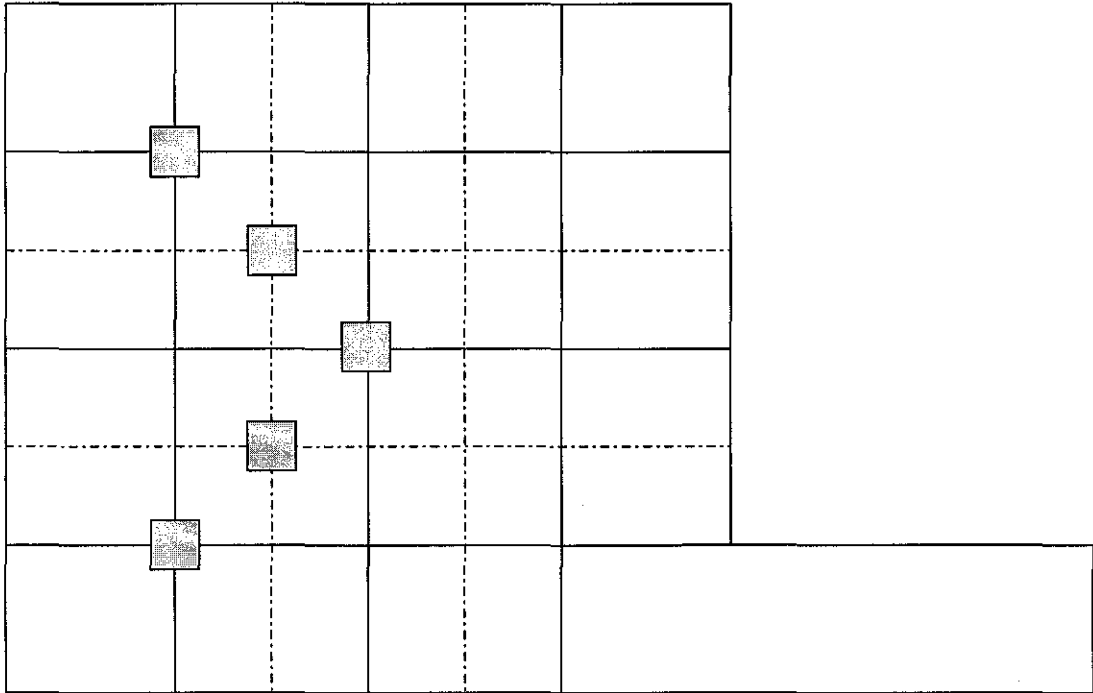
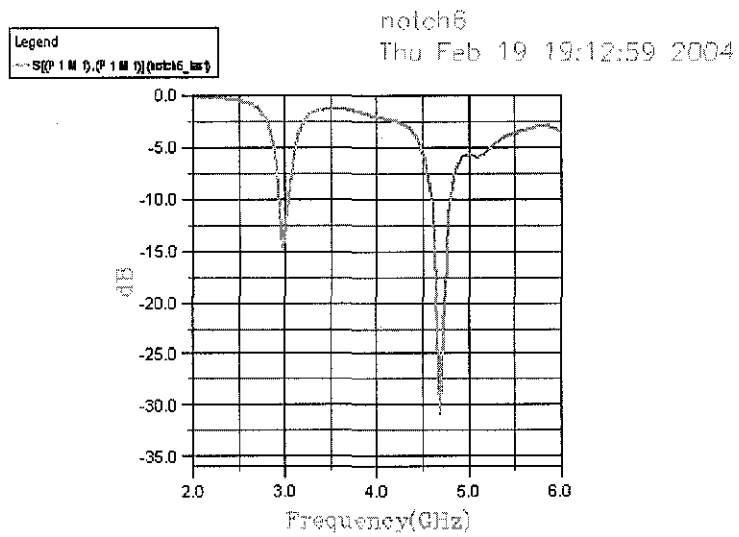


Figure 4.10: Patch with five windows



Graph 4.8: S-magnitude for patch with five windows

| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 2.9796 | -14.8465 |
| fr 2 = 4.6939 | -31.0254 |

Table 4.3: Resonant frequency and Reflected Power for patch with five windows

Number of window = 7

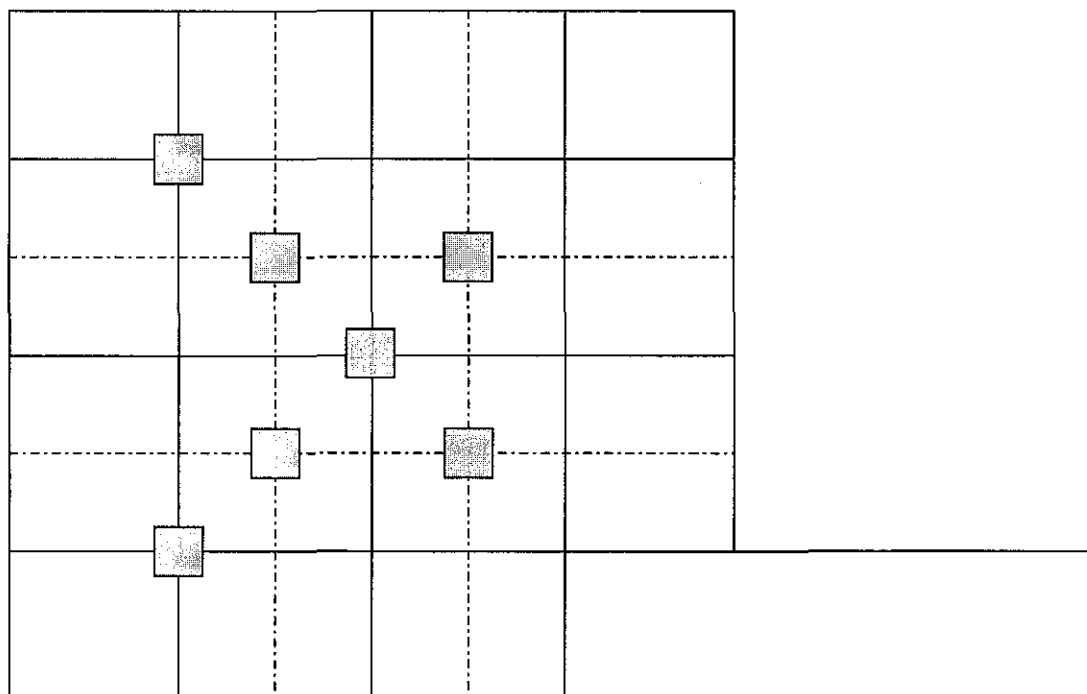
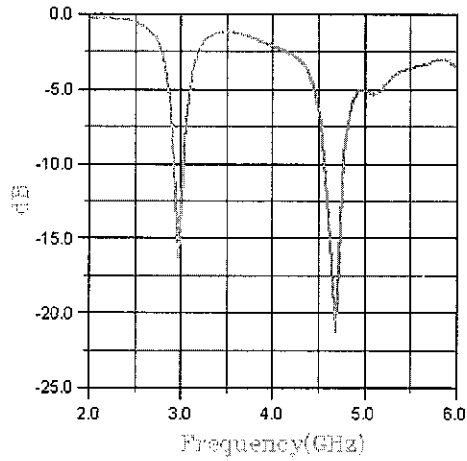


Figure 4.11: Patch with seven windows

Legend
 ---S(|Γ₁|,|Γ₂|)(notch_8.txt)

notch_8
 Thu Feb 19 21:47:23 2004



Graph 4.9: S-magnitude for patch with seven windows

| Resonant frequency (GHz) | S ₁₁ (dB) |
|--------------------------|----------------------|
| fr 1 = 2.9796 | -16.2411 |
| fr 2 = 4.6939 | -21.2822 |

Table 4.4: Resonant Frequency and Reflected Power for patch with seven windows

Number of window = 9

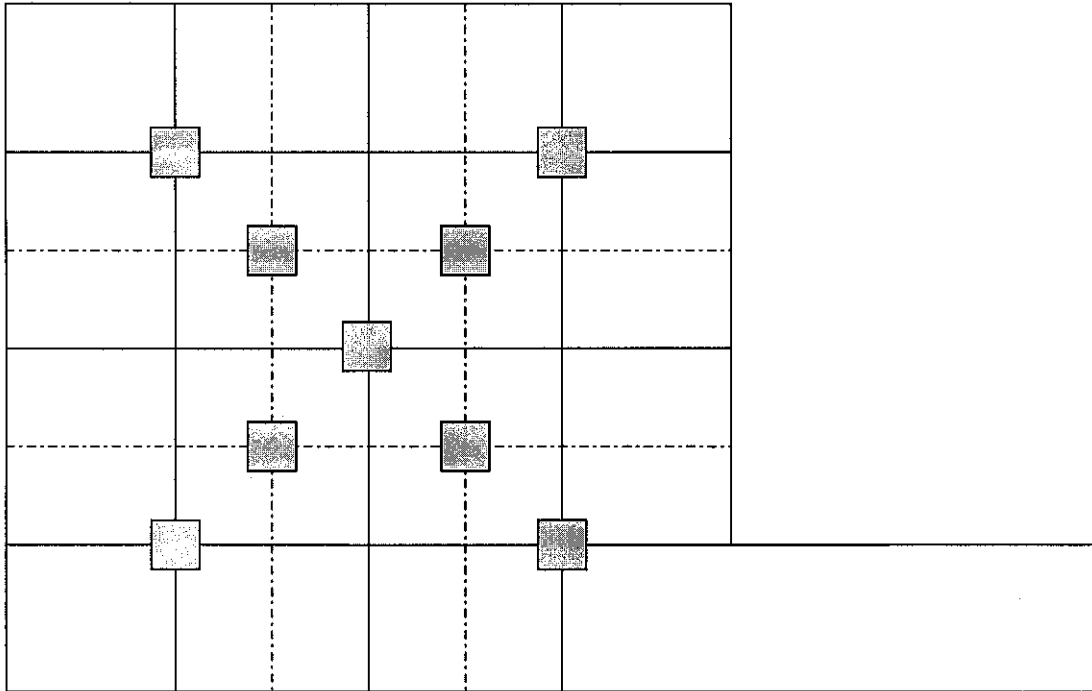
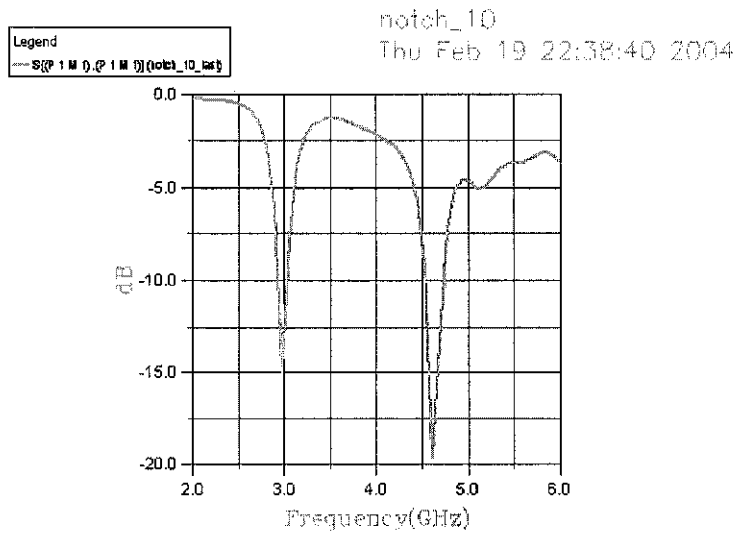


Figure 4.12: Patch with nine windows



Graph 4.10: S-magnitude for patch with nine windows

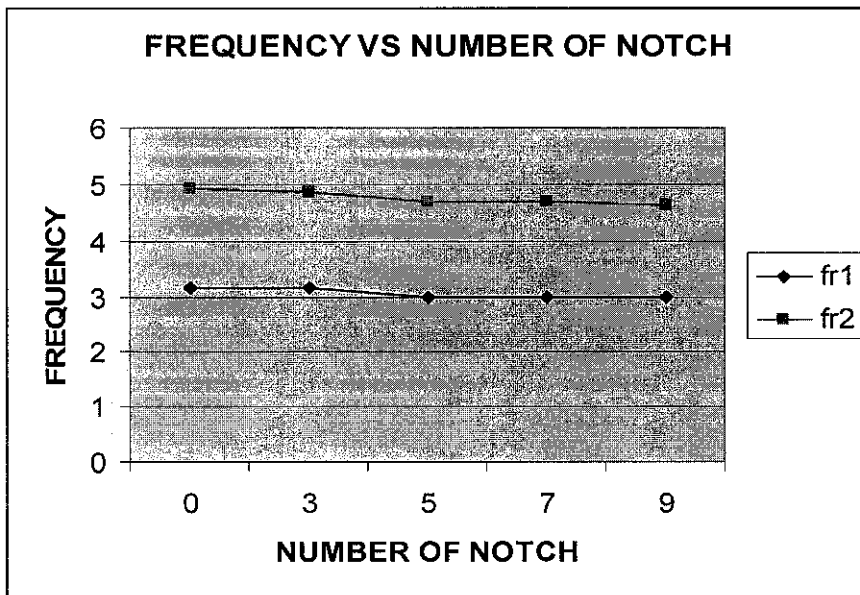
| Resonant frequency (GHz) | S ₁₁ (dB) |
|--------------------------|----------------------|
| fr 1 = 2.9796 | -15.0118 |
| fr 2 = 4.6122 | -19.6525 |

Table 4.5: Resonant Frequency and Reflected Power for patch with nine windows

RESULT:

| NUMBER OF NOTCH | FREQUENCY (GHz) | | S ₁₁ (dB) | |
|-----------------|-----------------|--------|----------------------|----------|
| | fr1 | fr2 | P1 | P2 |
| 0 | 3.1426 | 4.9388 | -9.8111 | -21.1285 |
| 3 | 3.1429 | 4.8571 | -9.43 | -18.9 |
| 5 | 2.9796 | 4.6939 | -14.85 | -31.03 |
| 7 | 2.9796 | 4.6939 | -16.24 | -21.28 |
| 9 | 2.9796 | 4.6122 | -15.01 | -19.65 |

Table 4.6: Resonant Frequency and Reflected Power for Simulation 2, Case 1



Graph 4.11: Resonant frequency vs number of notch for Simulation 2, Case 1

From the table and graph above, results of simulation are fulfilling the theory, which is when window is introduced at the patch, the resonant frequency will decrease. From the result above, the resonant frequency is 3.1429GHz for the patch without window but when the window is introduced, the resonant frequency is decreased to 2.9796GHz. For the second resonant frequency, the result also decreased when window is located at the patch. The resonant frequency started decreased when five windows are introduced. As a conclusion, only five windows are needed to decrease the resonant frequency and when the number of window is increasing, the resonant frequency will not change after five windows are located at the patch. Five windows are enough to decrease the resonant frequency for above location of notch.

CASE 2

Without notch:

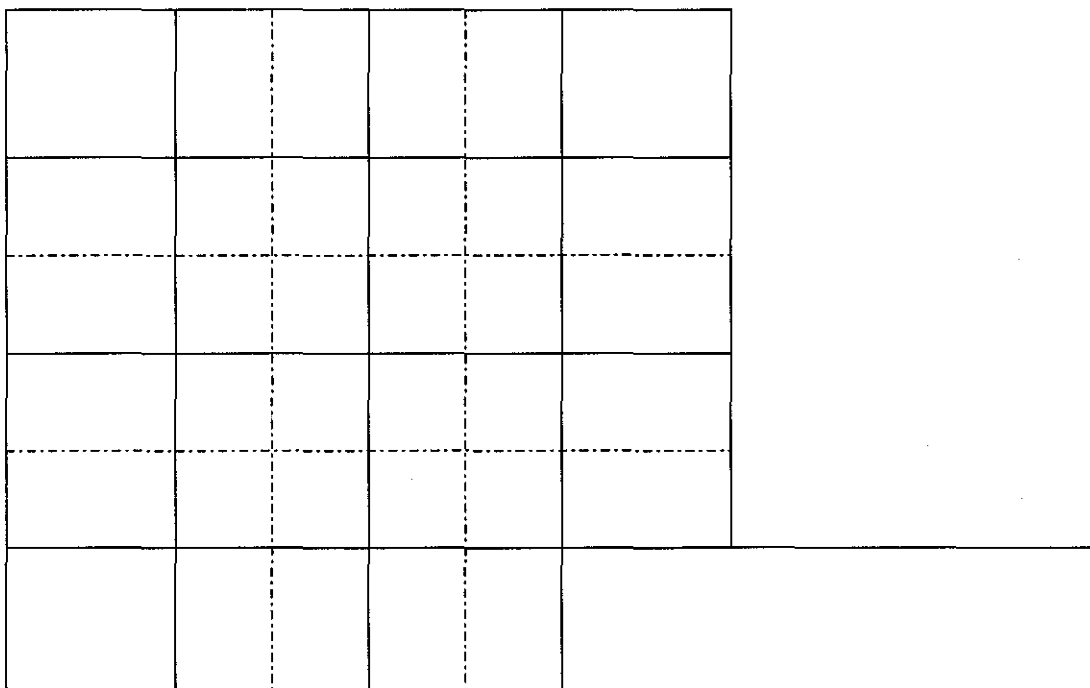
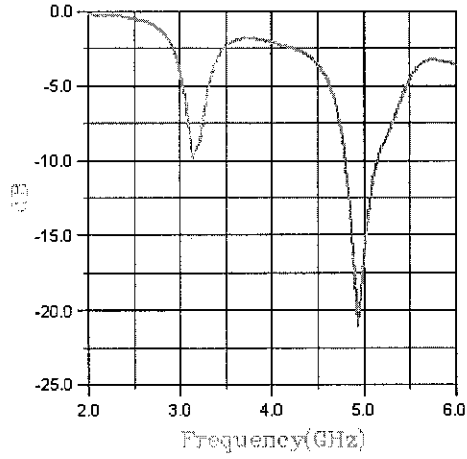


Figure 4.13: Patch without window

Legend
 ---S[1M],(P1M)g(m,db)

hm
 Wed Mar 17 01:31:20 2004



Graph 4.12 S-magnitude for patch without window

| Resonant frequency (GHz) | S ₁₁ (dB) |
|--------------------------|----------------------|
| fr 1 = 3.1429 | -9.8111 |
| fr 2 = 4.9388 | -21.1285 |

Table 4.7: Resonant Frequency and Reflected Power for patch without window

Number of window = 1:

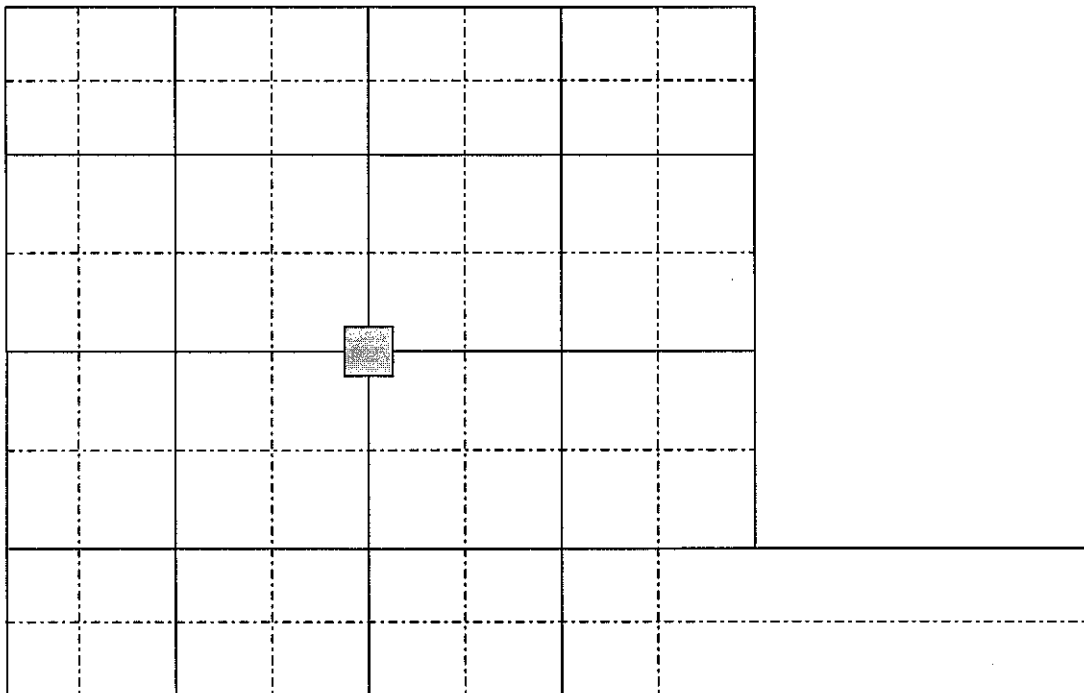
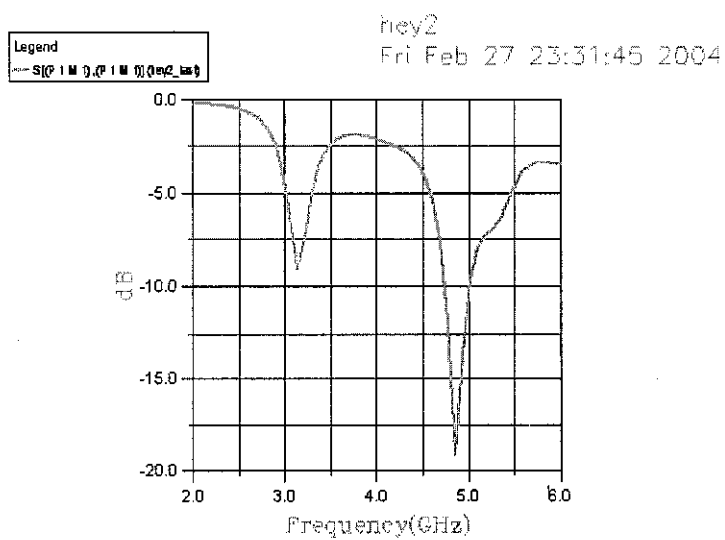


Figure 4.14: Patch with one window



Graph 4.13: S-magnitude for patch with one window

| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 3.1429 | -9.0614 |
| fr 2 = 4.8571 | -19.1759 |

Table 4.8: Resonant Frequency and Reflected Power for patch with one window

Number of window = 2:

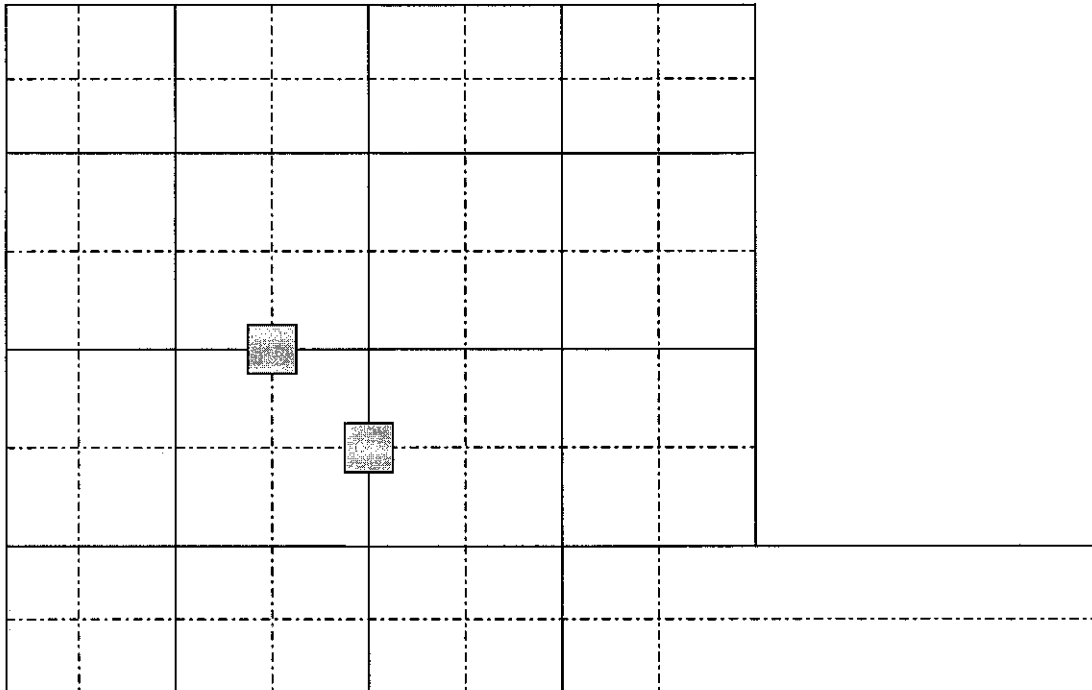
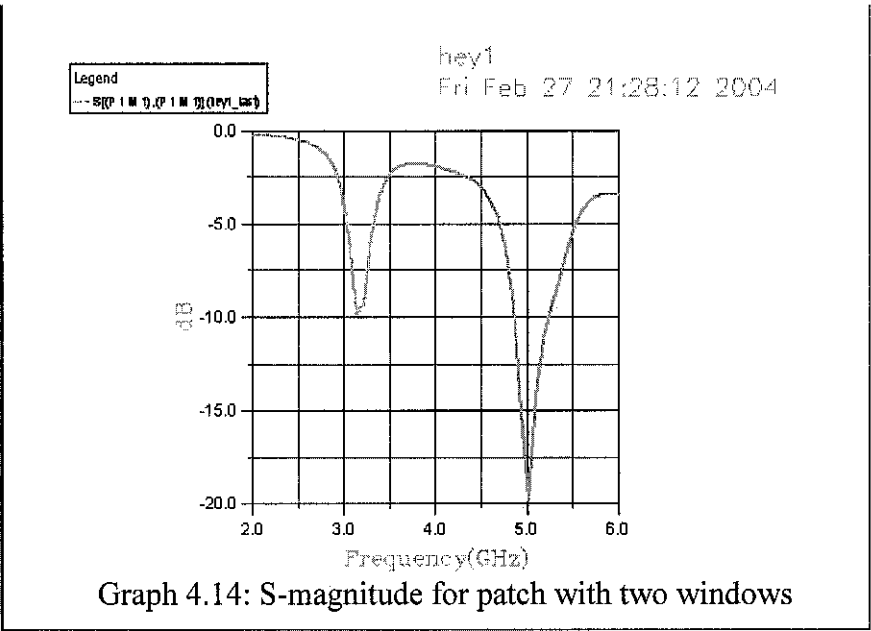


Figure 4.15: Patch with two windows



| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 3.1429 | -9.8578 |
| fr 2 = 5.0204 | -19.8668 |

Table 4.9: Resonant Frequency and Reflected Power for patch with two windows

Number of window = 6:

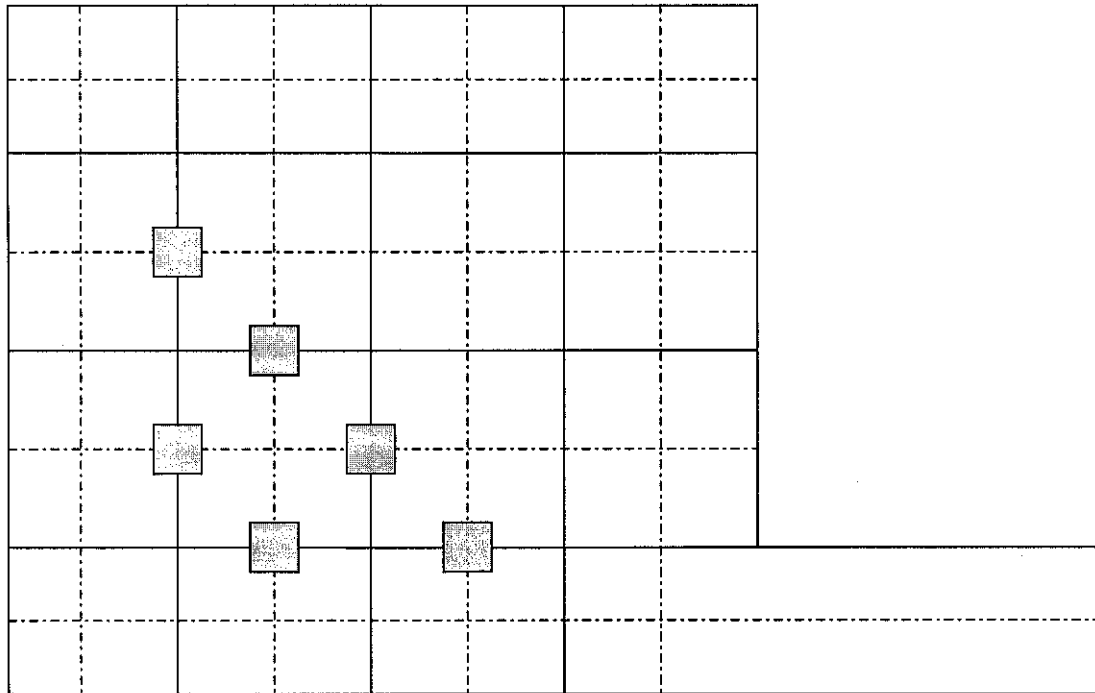
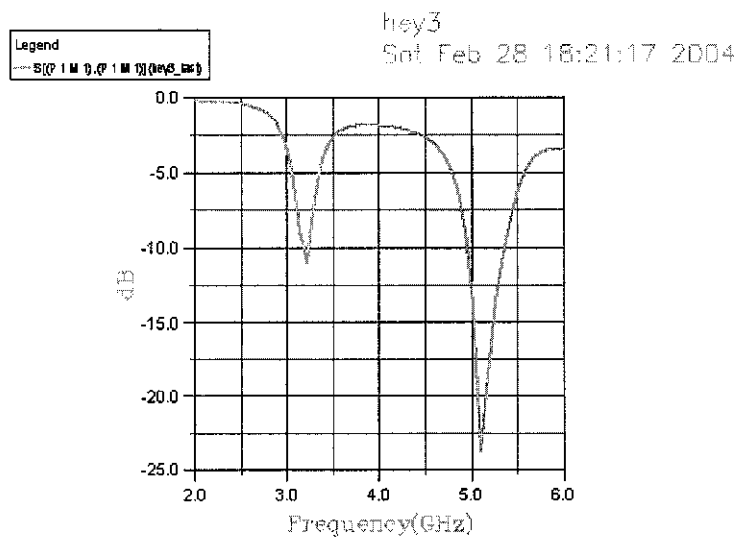


Figure 4.16: Patch with six windows



Graph 4.15: S-magnitude for patch with six windows

| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 3.2245 | -11.0563 |
| fr 2 = 5.1020 | -23.7402 |

Table 4.10: Resonant Frequency and Reflected Power for patch with six windows

Number of window = 12:

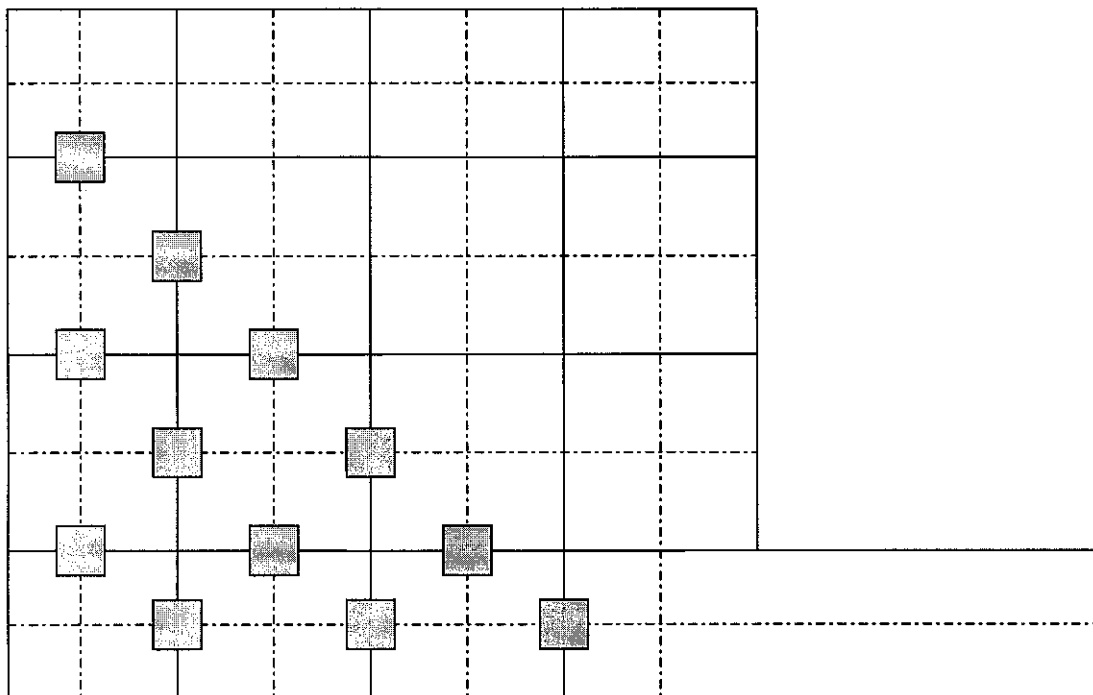
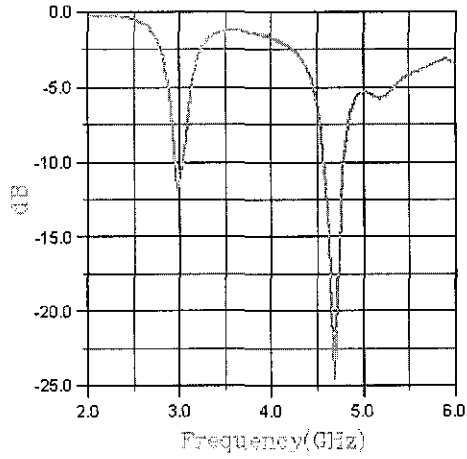


Figure 4.17: Patch with twelve windows

Legend
 ---S(|P 1 M 0, P 1 M 0)(ney4_1a)

hey4
 Sat Feb 28 21:17:49 2004



Graph 4.16: S-magnitude for patch with twelve windows

| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 2.9796 | -11.9435 |
| fr 2 = 4.6939 | -24.5779 |

Table 4.11: Resonant Frequency and Reflected Power for patch with twelve windows

Number of window = 13:

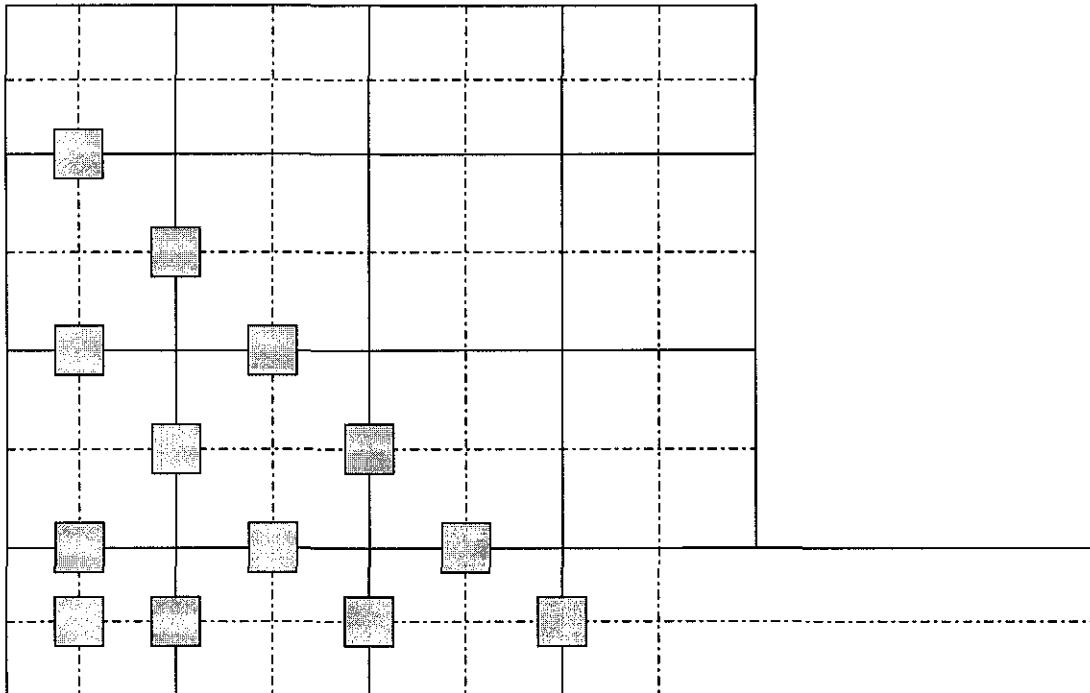
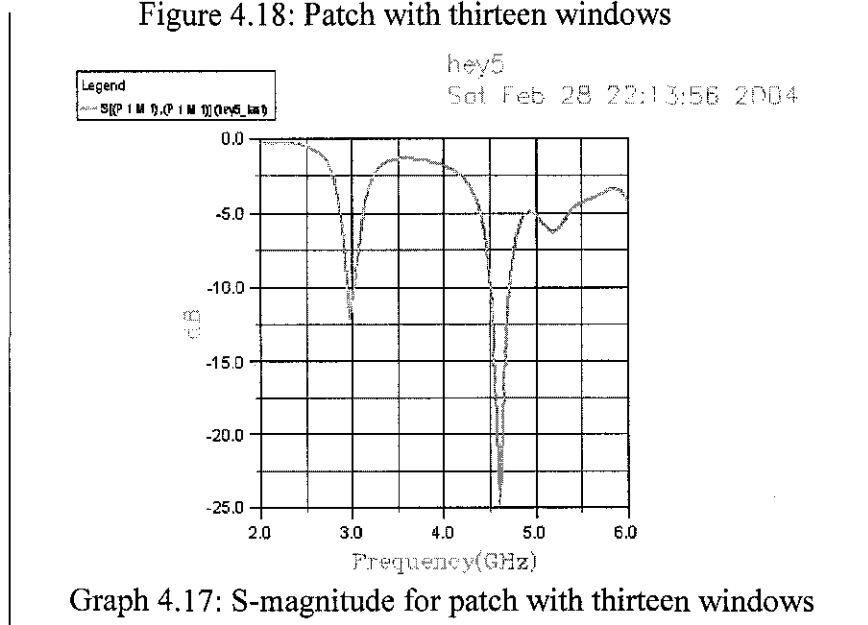


Figure 4.18: Patch with thirteen windows



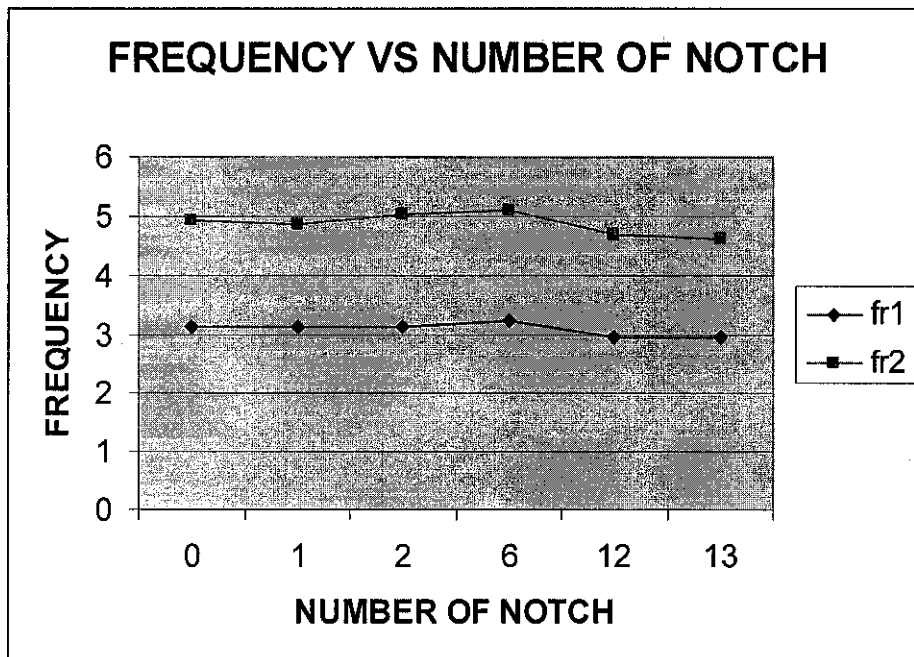
| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 2.9796 | -12.1234 |
| fr 2 = 4.6122 | -24.8782 |
| fr 3 = 5.1837 | -6.3087 |

Table 4.12: Resonant Frequency and Reflected Power for patch with thirteen windows

RESULT:

| NUMBER OF NOTCH | FREQUENCY(GHz) | | S_{11} (dB) | |
|-----------------|----------------|--------|---------------|----------|
| | fr1 | fr2 | P1 | P2 |
| 0 | 3.1426 | 4.9388 | -9.8111 | -21.1285 |
| 1 | 3.1426 | 4.8571 | -9.0514 | -19.1759 |
| 2 | 3.1426 | 5.0204 | -9.8578 | -19.8668 |
| 6 | 3.2245 | 5.102 | -11.0563 | -23.7402 |
| 12 | 2.9796 | 4.6939 | -11.9435 | -24.5779 |
| 13 | 2.9796 | 4.6122 | -12.1234 | -24.8782 |

Table 4.13: Resonant Frequency and Reflected Power for Simulation 2, Case 2



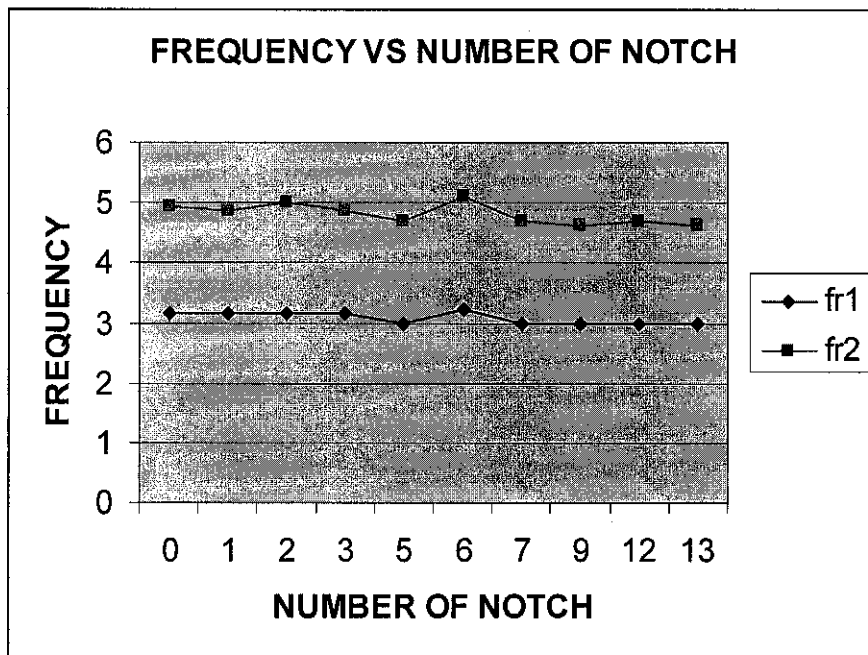
Graph 4.18: Resonant frequency vs number of notch for Simulation 2, Case 2

According to the above results, the resonant frequency is 3.1426GHz for antenna without window. The result also matched with the theory, resonant frequency will decrease when the window is introduced. When the window is introduced, the resonant frequency is decreased to 2.9796GHz. As a conclusion, to decrease the resonant frequency, twelve windows are needed and if the notch is continuously increased, the resonant frequency will not changed after twelve windows are located at the patch for the above location of window.

RESULT: CASE 1 & CASE 2

| NUMBER OF NOTCH | FREQUENCY | |
|-----------------------|-----------|--------|
| | fr1 | fr2 |
| 0 | 3.1429 | 4.9388 |
| 1 | 3.1429 | 4.8571 |
| 2 | 3.1429 | 5.0204 |
| 3 | 3.1429 | 4.8571 |
| 5 | 2.9796 | 4.6939 |
| 6 | 3.2245 | 5.102 |
| 7 | 2.9796 | 4.6939 |
| 9 | 2.9796 | 4.6122 |
| 12 | 2.9796 | 4.6939 |
| 13 | 2.9796 | 4.6122 |

Table 4.14: Resonant Frequency for Simulation 2



Graph 4.19: Resonant frequency vs number of notch for Simulation 2

From the above result, when all the results are combined, the resonant frequency started decreased if five windows are introduced and kept constant when the number of window is increasing. As a conclusion, for the antenna that having the dimensions as above, only five windows are needed to decrease the resonant frequency because the resonant frequency is constant after five windows are located at the patch.

SIMULATION 3:

Below are the results of simulation when the feed line is moved along the patch width:

CASE 1:

Movement = 0cm

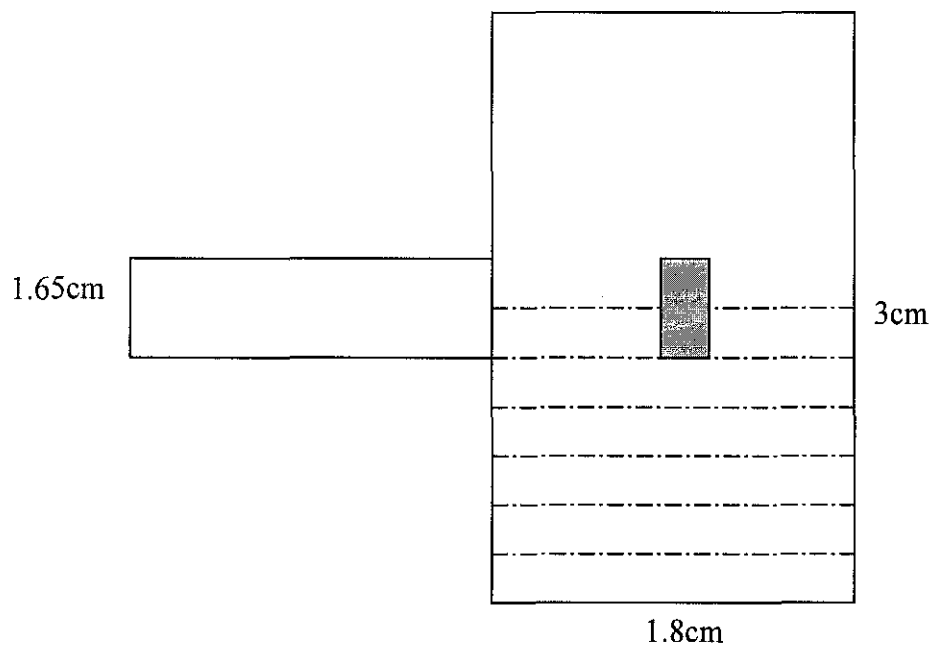
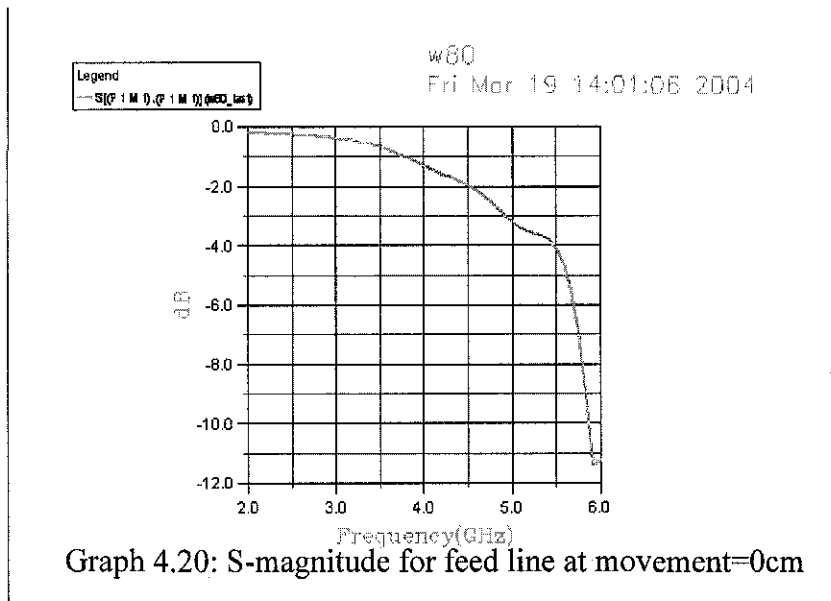


Figure 4.19: Microstrip Antenna for feed line at movement=0cm



| Resonant frequency (GHz) | S₁₁ (dB) |
|---------------------------------|----------------------------|
| fr 1 = 0 | 0 |
| fr 2 = 5.9184 | -11.3817 |

Table 4.15: Resonant Frequency and Reflected Power for feed line at movement=0cm

Movement = 0.135cm

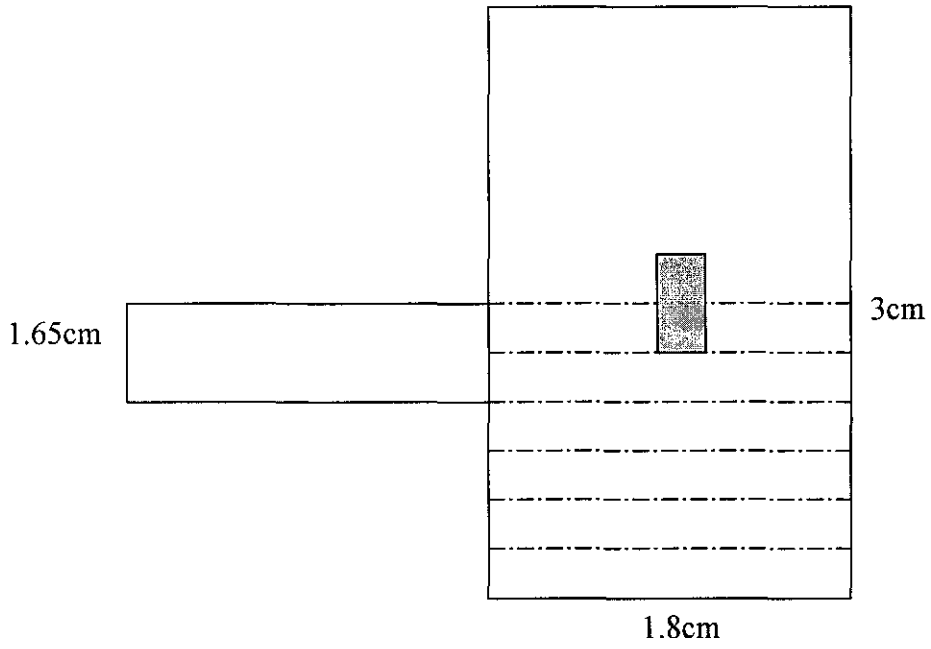
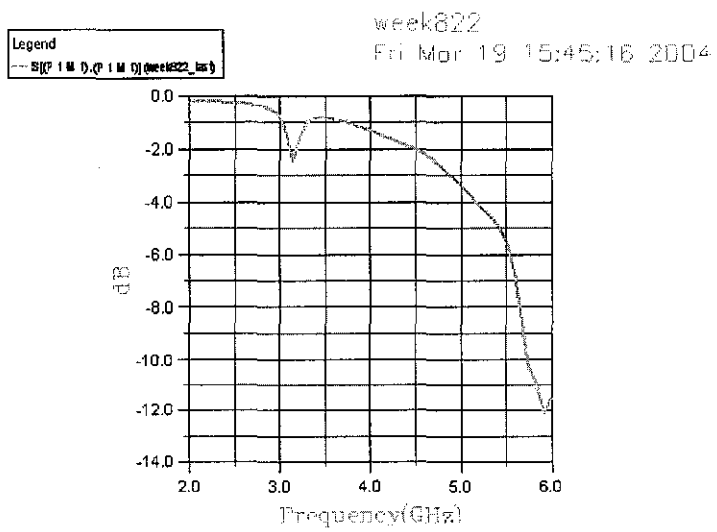


Figure 4.20: Microstrip Antenna for feed line at movement=0.135cm



Graph 4.21: S-magnitude for feed line at movement=0.135cm

| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 3.1429 | -2.4817 |
| fr 2 = 5.9184 | -12.1743 |

Table 4.16: Resonant Frequency and Reflected Power for feed line at movement=0.135cm

Movement = 0.27cm

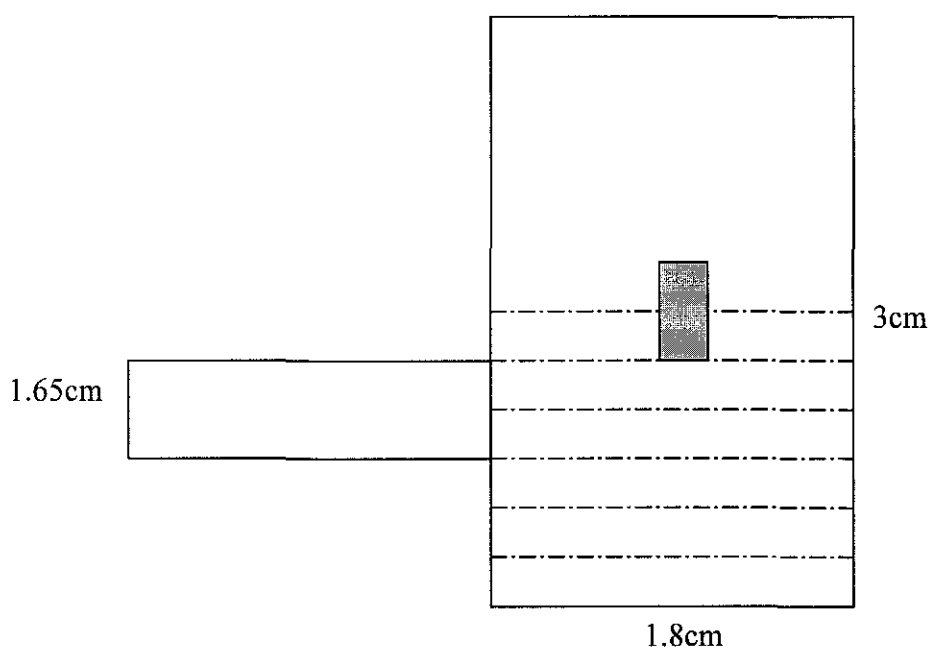
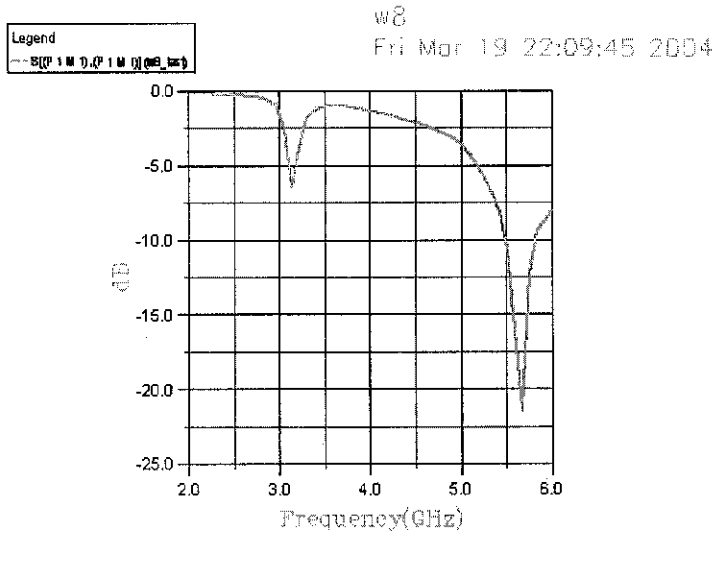


Figure 4.21: Microstrip Antenna for feed line at movement=0.27cm



Graph 4.22: S-magnitude for feed line at movement=0.27cm

| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 3.1429 | -6.4795 |
| fr 2 = 5.6735 | -21.5190 |

Table 4.17: Resonant Frequency and Reflected Power for feed line at movement=0.27cm

Movement = 0.405cm

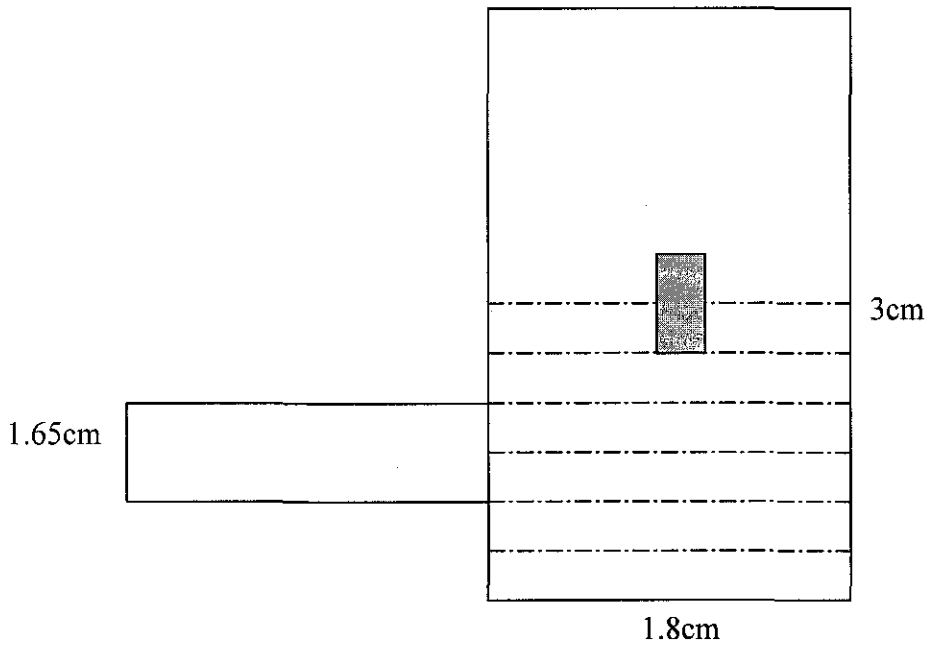
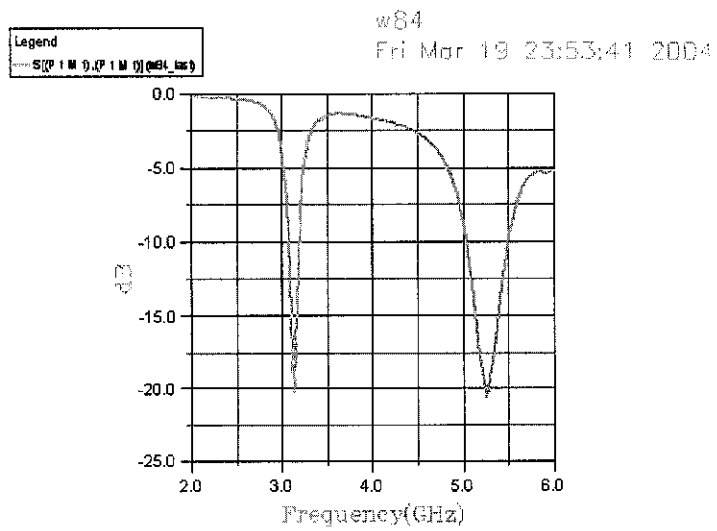


Figure 4.22: Microstrip Antenna for feed line at movement=0.405cm



Graph 4.23: S-magnitude for feed line at movement=0.405cm

| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 3.1429 | -20.2348 |
| fr 2 = 5.2653 | -20.7211 |

Table 4.18: Resonant Frequency and Reflected Power for feed line at movement=0.405cm

Movement = 0.54cm

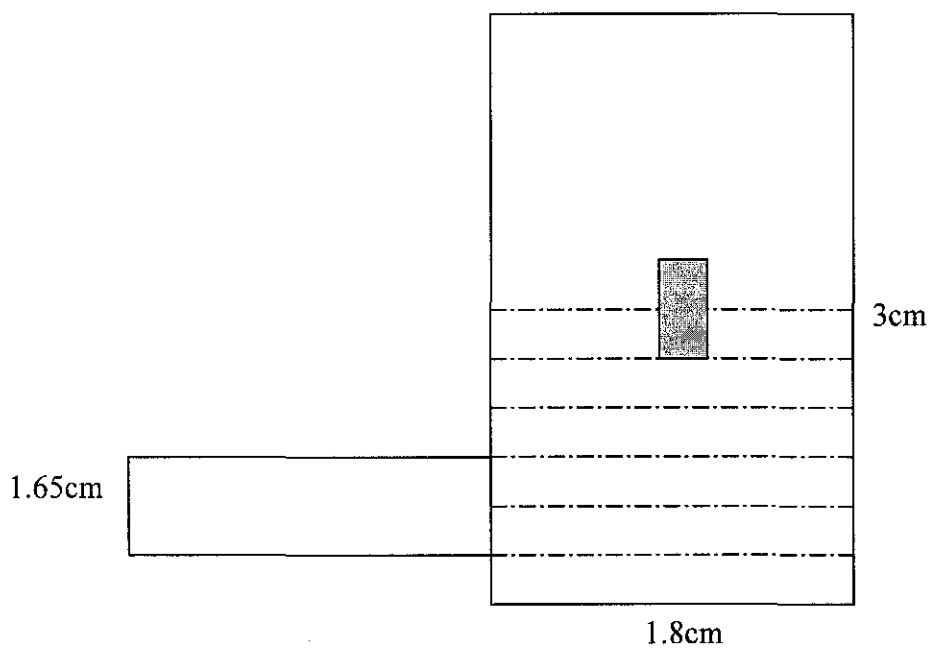
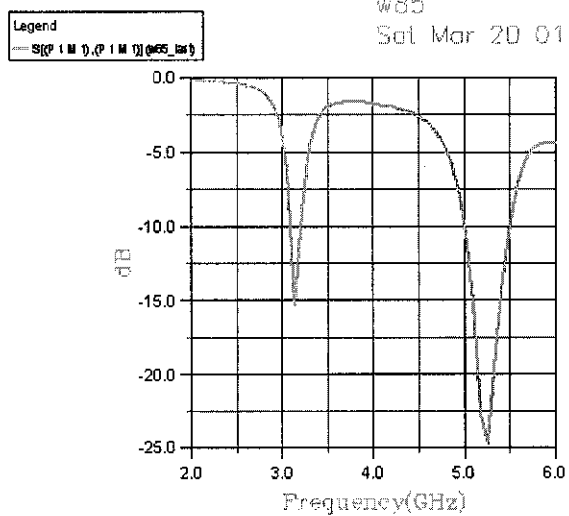


Figure 4.23: Microstrip Antenna for feed line at movement=0.54cm

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Graph 4.24: S-magnitude for feed line at movement=0.54cm

| Resonant frequency (GHz) | S₁₁ (dB) |
|---------------------------------|----------------------------|
| fr 1 = 3.1429 | -15.3709 |
| fr 2 = 5.2653 | -24.8277 |

Table 4.19: Resonant Frequency and Reflected Power for feed line at movement=0.54cm

Movement = 0.675cm

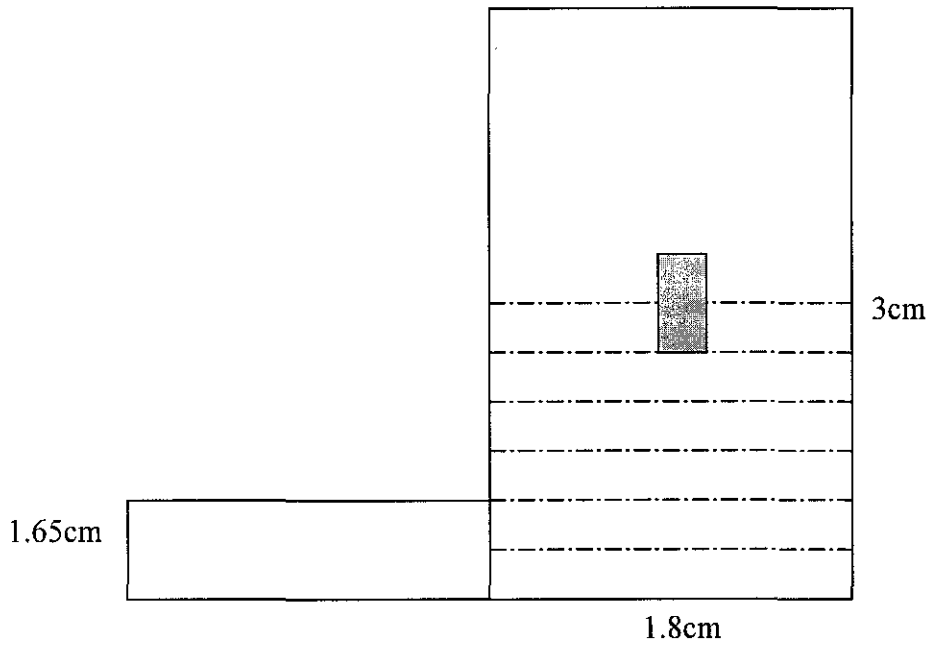
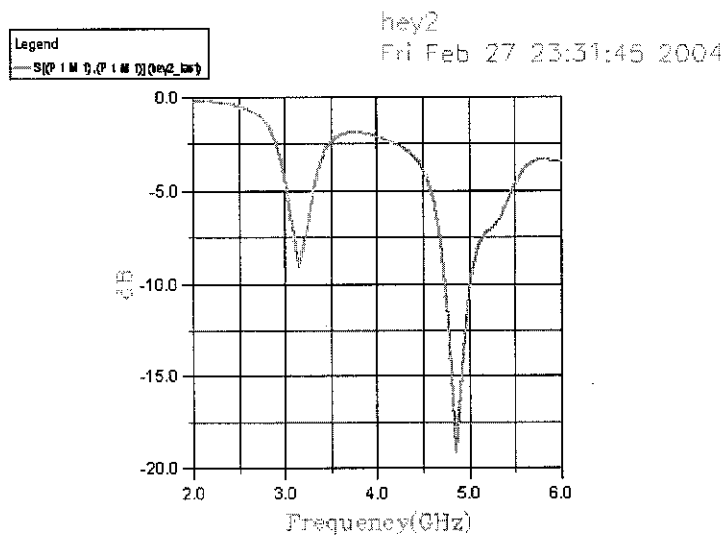


Figure 4.24: Microstrip Antenna for feed line at movement=0.675cm



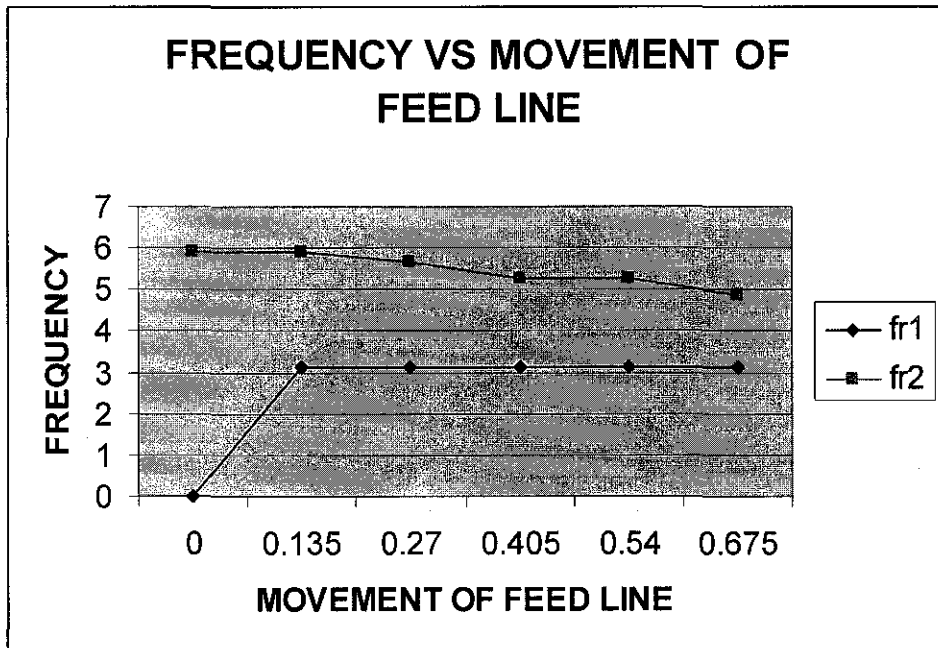
Graph 4.25: S-magnitude for feed line at movement=0.675cm

| Resonant frequency (GHz) | S ₁₁ (dB) |
|--------------------------|----------------------|
| fr 1 = 3.1429 | -9.0614 |
| fr 2 = 4.8571 | -19.1759 |

Table 4.20: Resonant Frequency and Reflected Power for feed line at movement=0.675cm

| MOVEMENT(cm) | FREQUENCY(GHz) | | S ₁₁ (dB) | |
|--------------|----------------|--------|----------------------|----------|
| | fr1 | fr2 | P1 | P2 |
| 0 | 0 | 5.9184 | 0 | -11.3817 |
| 0.135 | 3.1429 | 5.9184 | -2.4817 | -12.1743 |
| 0.27 | 3.1429 | 5.6735 | -6.4795 | -21.519 |
| 0.405 | 3.1429 | 5.2653 | -20.2348 | -20.7211 |
| 0.54 | 3.1429 | 5.2653 | -15.3709 | -24.8277 |
| 0.675 | 3.1429 | 4.8571 | -9.0614 | -19.1759 |

Table 4.21: Resonant Frequency and Reflected Power for Simulation 3, Case 1



Graph 4.26 S-magnitude for feed line of Simulation 3, Case 1

When feed line is located at the centre, only one resonant frequency is excited but when the movement is increased from the centre to the edge of the patch width, resonant frequency become constant to 3.1429GHz. This will show that the location of feed line does not affect the resonant frequency except the middle of patch width, which is not exciting the resonant frequency.

CASE 2:

Movement = 0cm

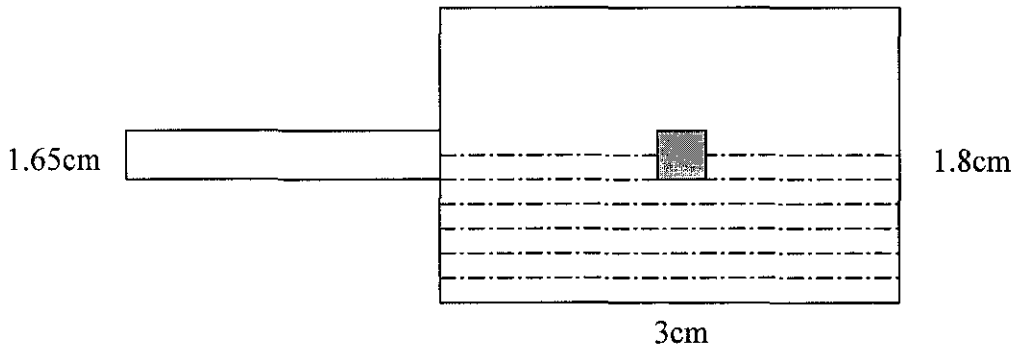
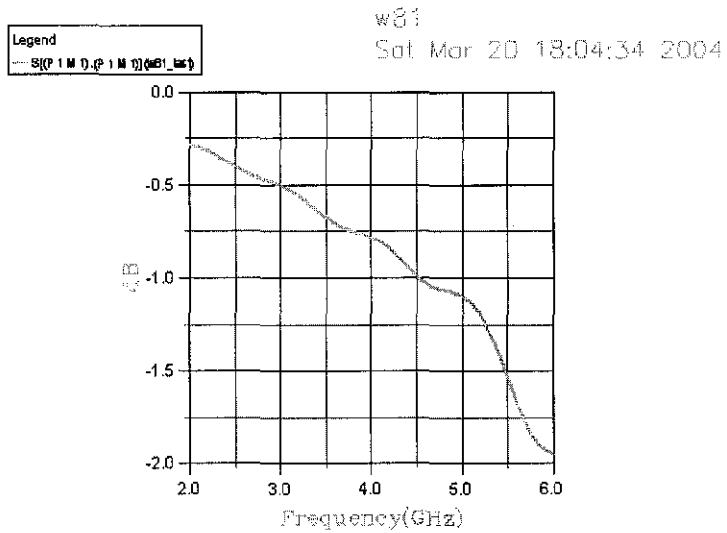


Figure 4.25: Microstrip Antenna for feed line at movement=0cm



Graph 4.27 S-magnitude for feed line at movement=0cm

| Resonant frequency (GHz) | S ₁₁ (dB) |
|--------------------------|----------------------|
| fr 1 = 0 | 0 |
| fr 2 = 6 | -1.9493 |

Table 4.22: Resonant Frequency and Reflected Power for feed line at movement=0cm

Movement = 0.015cm

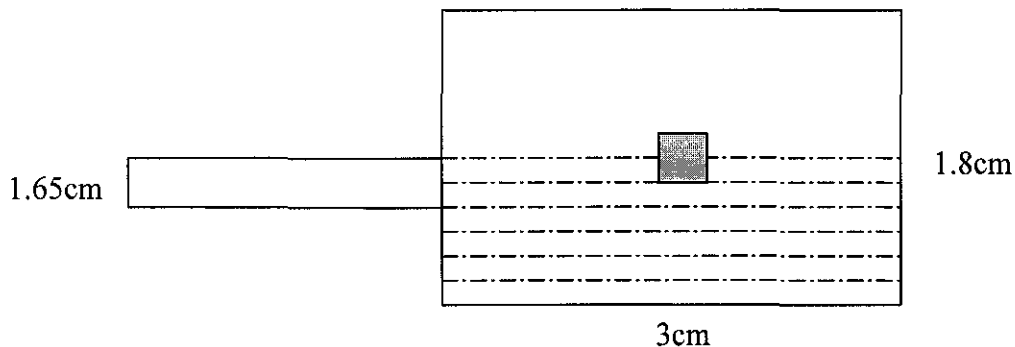
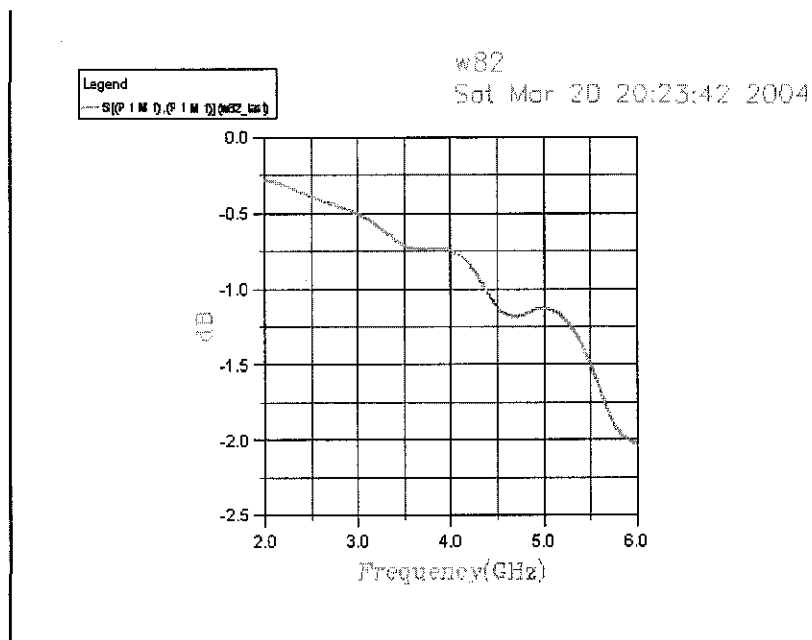


Figure 4.26: Microstrip Antenna for feed line at movement=0.015cm



Graph 4.28 S-magnitude for feed line at movement=0.015cm

| Resonant frequency (GHz) | S ₁₁ (dB) |
|--------------------------|----------------------|
| fr 1 = 3.5510 | -0.7271 |
| fr 2 = 4.6939 | -1.1865 |

Table 4.23: Resonant Frequency and Reflected Power for feed line at movement=0.015cm

Movement = 0.03cm

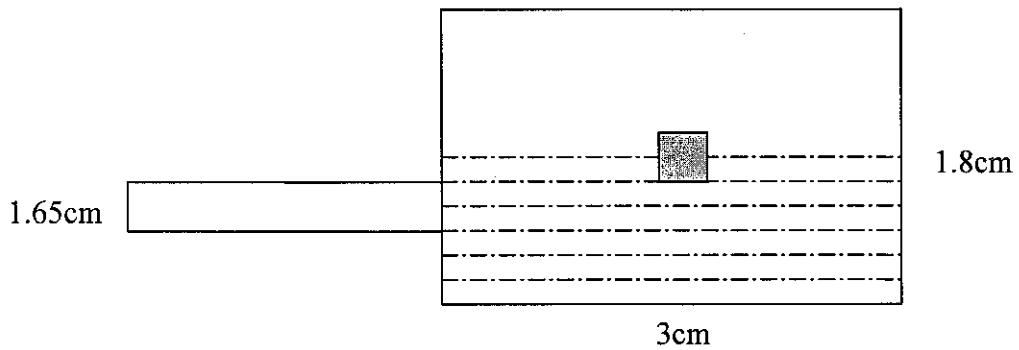
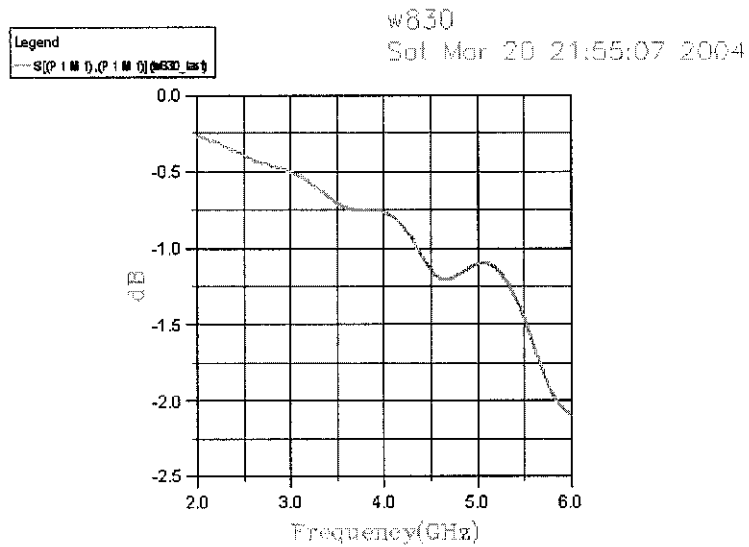


Figure 4.27: Microstrip Antenna for feed line at movement=0.03cm



Graph 4.29 S-magnitude for feed line at movement=0.03cm

| Resonant frequency (GHz) | S ₁₁ (dB) |
|--------------------------|----------------------|
| fr 1 = 3.7143 | -0.7547 |
| fr 2 = 4.6122 | -1.2108 |

Table 4.24: Resonant Frequency and Reflected Power for feed line at movement=0.03cm

Movement = 0.045cm

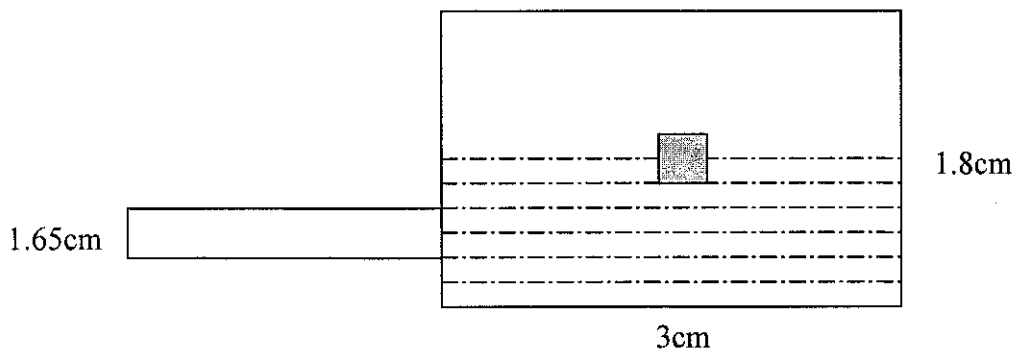
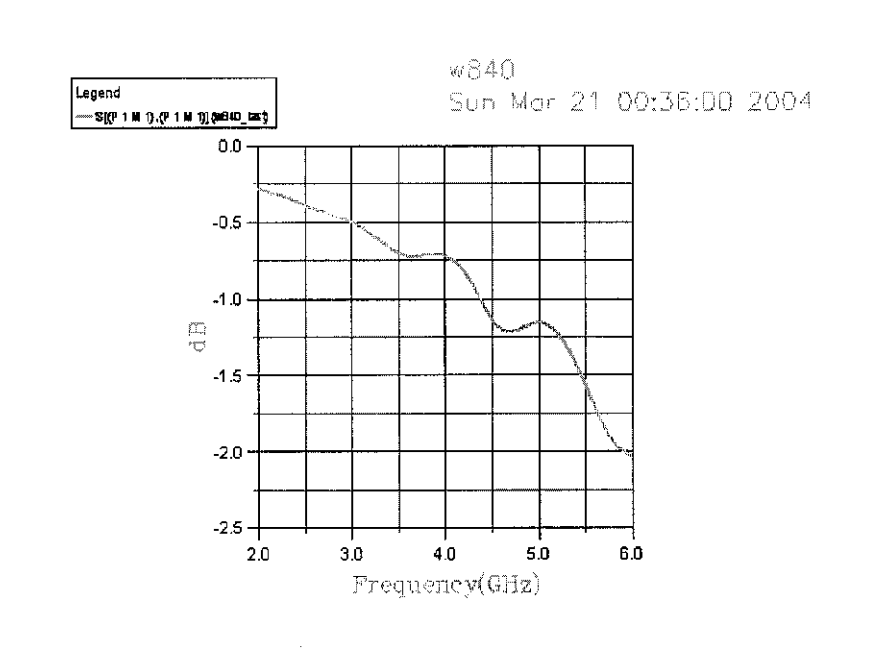


Figure 4.28: Microstrip Antenna for feed line at movement=0.045cm



Graph 4.30: S-magnitude for feed line at movement=0.045cm

| Resonant frequency (GHz) | S ₁₁ (dB) |
|--------------------------|----------------------|
| fr 1 = 3.6327 | -0.7298 |
| fr 2 = 4.6939 | -1.2189 |

Table 4.25: Resonant Frequency and Reflected Power for feed line at movement=0.045cm

Movement = 0.06cm

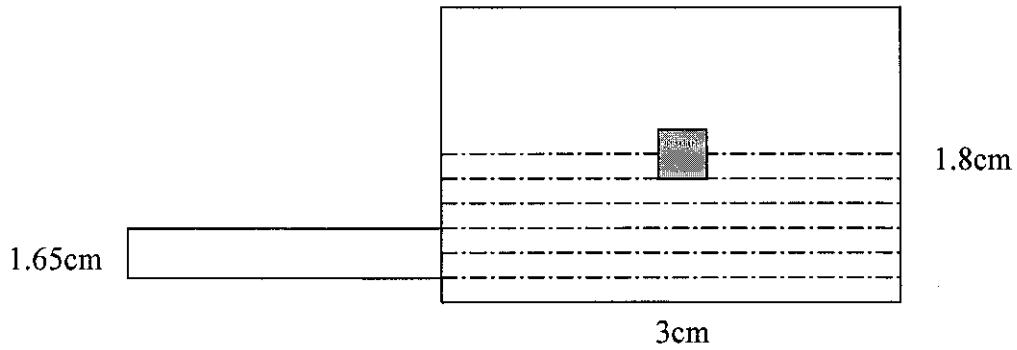
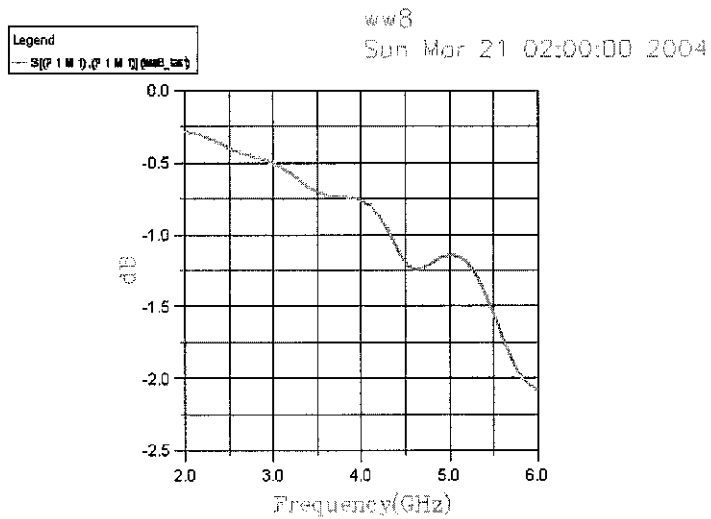


Figure 4.29: Microstrip Antenna for feed line at movement=0.06cm



Graph 4.31: S-magnitude for feed line at movement=0.06cm

| Resonant frequency (GHz) | S_{11} (dB) |
|--------------------------|---------------|
| fr 1 = 3.7143 | -0.7414 |
| fr 2 = 4.6122 | -1.2516 |

Table 4.26: Resonant Frequency and Reflected Power for feed line at movement=0.06cm

Movement = 0.075cm

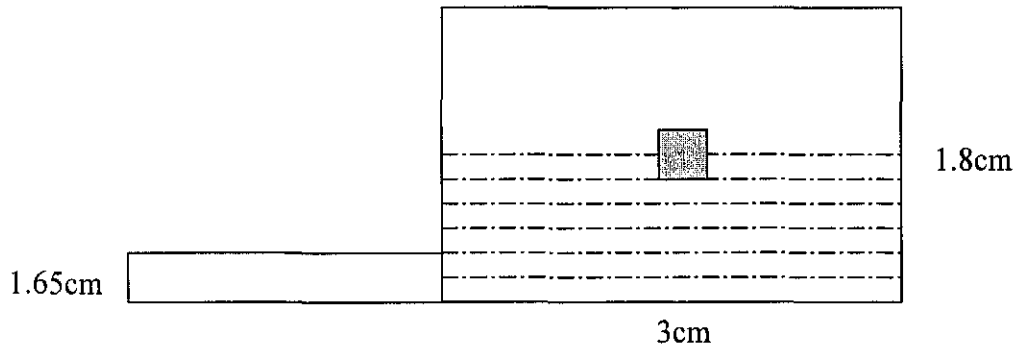
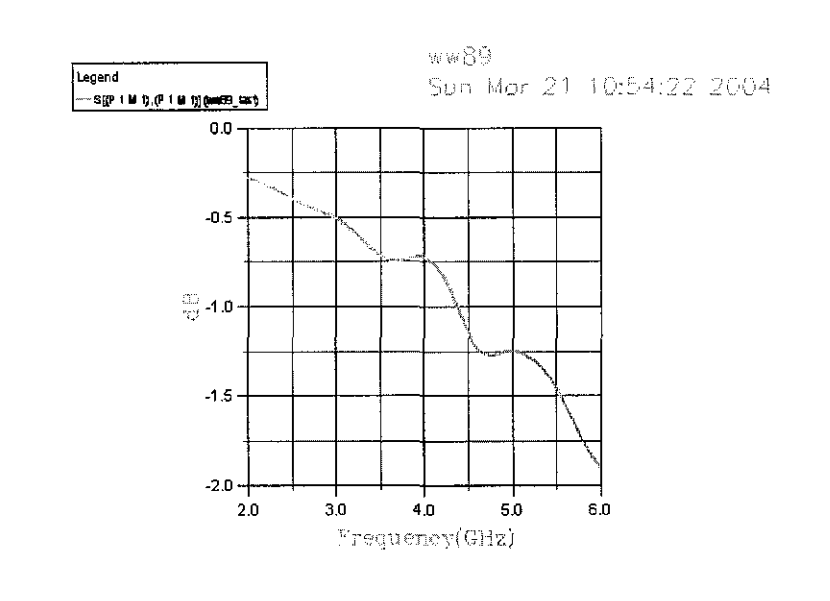


Figure 4.30: Microstrip Antenna for feed line at movement=0.075cm



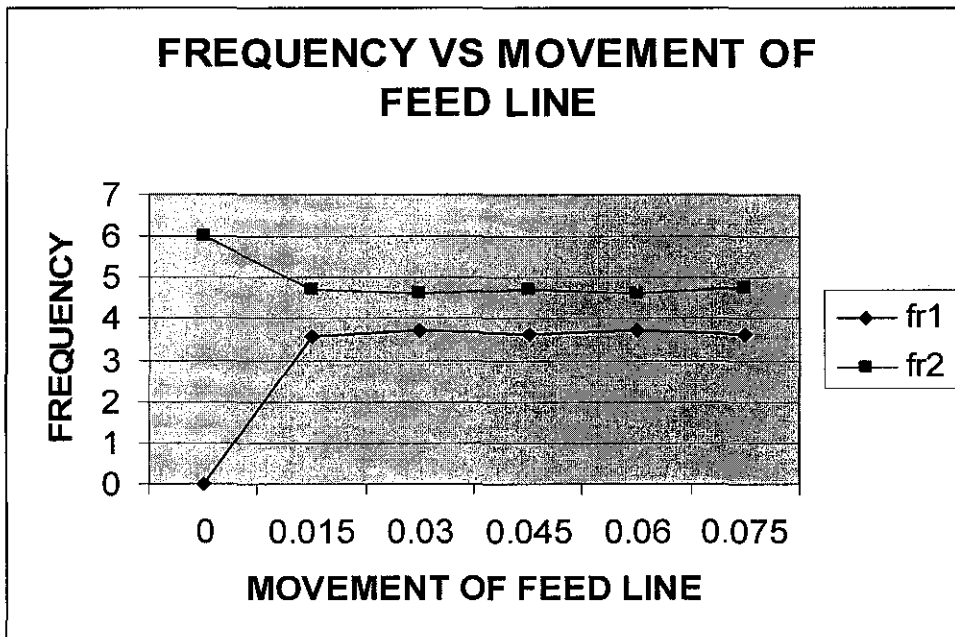
Graph 4.32: S-magnitude for feed line at movement=0.075cm

| Resonant frequency (GHz) | S ₁₁ (dB) |
|--------------------------|----------------------|
| fr 1 = 3.6327 | -0.7429 |
| fr 2 = 4.7755 | -1.2750 |

Table 4.27: Resonant Frequency and Reflected Power for feed line at movement=0.075cm

| MOVEMENT (cm) | FREQUENCY | | S ₁₁ (dB) | |
|------------------|-----------|--------|----------------------|---------|
| | fr1 | fr2 | P1 | P2 |
| 0 | 0 | 6 | 0 | -1.9493 |
| 0.015 | 3.551 | 4.6939 | -0.7271 | -1.1865 |
| 0.03 | 3.7143 | 4.6122 | -0.7547 | -1.2108 |
| 0.045 | 3.6327 | 4.6939 | -0.7298 | -1.2189 |
| 0.06 | 3.7143 | 4.6122 | -0.7414 | -1.2516 |
| 0.075 | 3.6327 | 4.7755 | -0.7429 | -1.275 |

Table 4.28: Resonant Frequency and Reflected Power for Simulation 3, Case 2



Graph 4.33: S-magnitude for feed line of Simulation 3, Case 2

When the feed line is moved along the patch length, the resonant frequency did not strongly excite because the kink of the graph do not sharp. From the graph 4.43, the movement of feed line along the patch length did not give major effect to resonant frequency except at the middle of the length.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Investigations show that when the feed line is moved along the patch, Resonant Frequencies are strongly excited at the edge of the side. When the feed line is located at the middle of the patch, the resonant frequency did not excite because the field is canceling each other at this point.

As the number of windows of notches is increased, the Resonant Frequency is changed. The maximum possible change in frequency is $3.1429\text{GHz} - 2.9796\text{GHz} = 0.1633\text{GHz}$ (163.3MHz) and $4.9388\text{GHz} - 4.6122\text{GHz} = 0.3266\text{GHz}$ (326.6MHz) that means for a given size of the antenna, the frequency can be changed by introducing a notch. As the shift in frequency is a function of the location of the notch are needs further investigations to find out the distribution of field over the patch to find more detailed behavior.

When the feed line is on the smaller side, the Resonant Frequency is not excited strongly. Further investigations may be continued for obtaining field distribution on the patch, the relationship of the window or notch dimensions and radiated power. Further, the radiation pattern is function of frequency could be calculated. These aspects could not be investigated in the present for want of time.

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1. Book refer to John D. Kraus (Third Edition)
2. Book refer to Jeny Sevick (Fourth Edition)
3. Journal refer to Steven R. Best
4. Journal refer to Douglas H. Werner
5. Website refer to Ansoft
6. Module refer to HFSS

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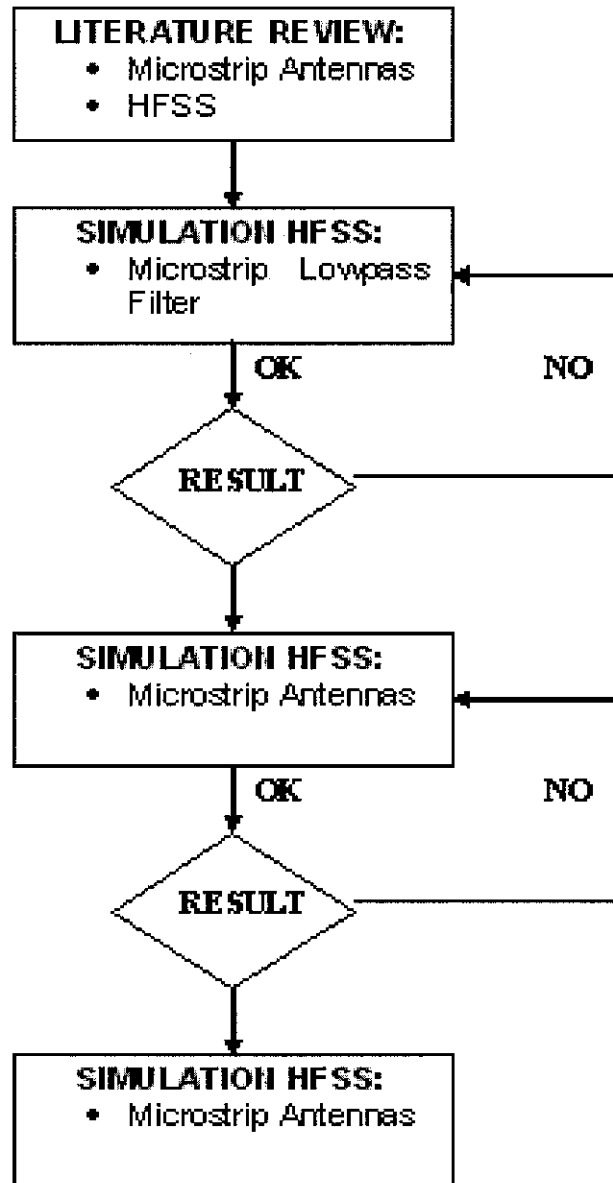
Steven R. Best, On the significance of self-similar fractal geometry in determining the multiband behavior of the sierpinski gasket antenna

Douglas H. Werner, Suman Ganguly, An overview of fractal antenna engineering research

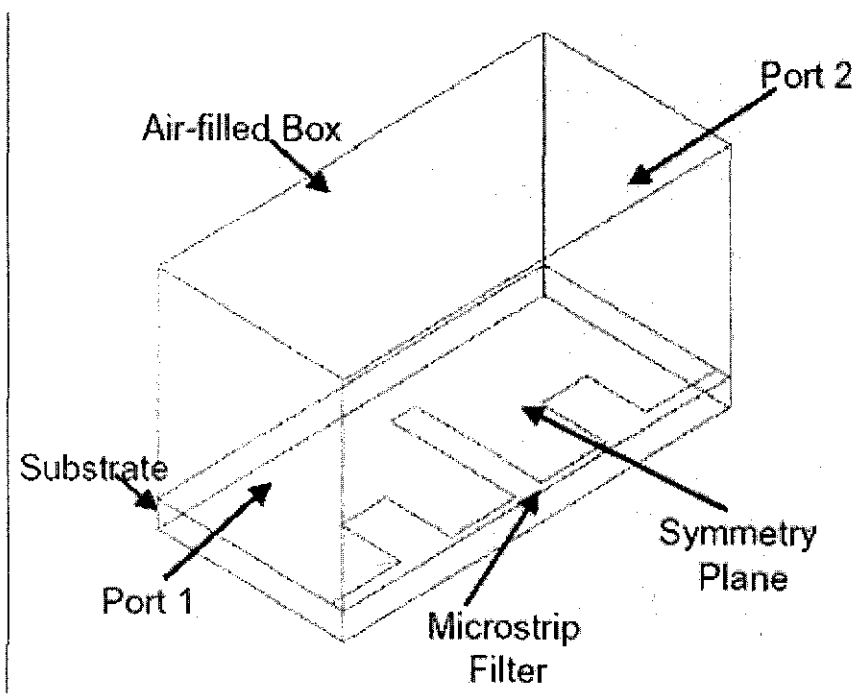
Ansoft, <http://www.ansoft.com>

HFSS, HP High Frequency Structure Simulator User's Reference

APPENDICES



Appendix 1: Flow Chart



Appendix 2: Microstrip Lowpass Filter