DESIGN OF HIGH BANDWIDTH COMPACT ANTENNA

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Master of Engineering
(Electronics & Communication)

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CERTIFICATE

This to certify that the work entitled “**DESIGN OF HIGH BANDWIDTH COMPACT ANTENNA**” has been carried out by **Navneet Agarwal** under my supervision in partial fulfillment of the requirement for the degree of master of Technology in Electronics and Communication Engineering of University of Delhi,Delhi,during the session 2004-2006 at Delhi College of Engineering, Delhi.

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Finally I thank everyone who has helped me either directly or indirectly in the successful completion of this work.

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ABSTRACT

Microstrip antenna have many well known advantages. However “Narrow Bandwidth” is their main limitation on their use .It presents a difficult problem when our application also requires a small size of antenna with wider bandwidth.

The present thesis “Design Of High Bandwidth Compact Antenna”aims to develop designs for small size wideband microstrip antenna by optimising geometry, using ground planes and short circuits.

Drastic size reduction is possible by using high permittivity substrates, shorting pins or modified geometries, but have penalties on bandwidth, gain and efficiency. The proposed work aims to achieve the wide bandwidth by electromagnetically coupling the two shorted coplanar patches, and by inserting slots into the patch.

The designs uses two electromagnetically coupled coplanar patches, where one is driven and other is parasitic. By connecting shorting pins from the patch antennas to the ground plane, the size of the patch can be reduced by one half or more. This is due to the shorting pins acting as an inductive element to some extent, and perturbing the electric field paths in the patch. Finally, in microstrip patch antennas, the size can also be reduced by inserting slots into the patch . These force the surface current to meander, thus artificially increasing the antenna’s electrical length without modifying it’s global dimensions .such a design can provide a wide bandwidth by introducing two or more nearby resonant frequency.

CONTENTS

CHAPTER 1

INTRODUCTION TO ANTENNA

INTRODUCTION TO ANTENNA

WHAT IS ANTENNA?

An antenna as defined in Webster's dictionary is – "*a metallic device for radiating or receiving radio waves*." The IEEE standard definitions of terms for antenna (IEEE Std. 145-1983) define the antenna as – "*a means for radiating or receiving radio waves*."

Antenna is the transitional structure between the free space and the guiding device. This guiding device may be a co-axial line or a waveguide used to transport electromagnetic energy from the transmitter to the antenna or from the antenna to the receiver. In the former case, the antenna is called a 'transmitting antenna' and is called a 'receiving antenna' in the latter case.

In addition to the receiving or transmitting energy, an antenna is an advanced wireless system usually required to optimize or accentuate the radiation energy in some direction and suppress it in others.

Types of Antennas

The advances in antenna technology have led to development of various types of antennas. Some of them are briefly discussed below.

1. Wire antennas

Wire antennas are familiar to the layman since they are seen virtually everywhere – on automobiles, buildings, ships, aircraft and so on. The wire antennas may be of various shapes such as straight wire (dipole), loop and helix.

2. Aperture antennas

Aperture antennas have evolved due to increased demand for sophisticated antennas and utilization of higher frequencies. These antennas are very useful for aircraft and spacecraft applications and in addition, can be covered with a dielectric material to protect them from hazardous conditions of the environment. The most common types of aperture antennas are Horn antennas and Waveguide antennas.

3. Microstrip antennas

Microstrip antennas were developed primarily for space borne applications. They are low profile, conformable to planar and non-planar surfaces, simple and inexpensive to fabricate, mechanically robust, compatible with MMIC designs and versatile in terms of resonant frequency, polarization, pattern and impedance. These antennas can be mounted on the surface of aircraft, spacecraft, satellites, missiles, cars and even hand-held mobile phones.

4. Reflector antennas

Reflector antennas are sophisticated forms of antennas used in transmission and reception of long distance signals. A very common reflector antenna is the parabolic antenna, which is widely used for satellite communication. Due to long distance applications, these antennas have large diameters so as to achieve a higher gain.

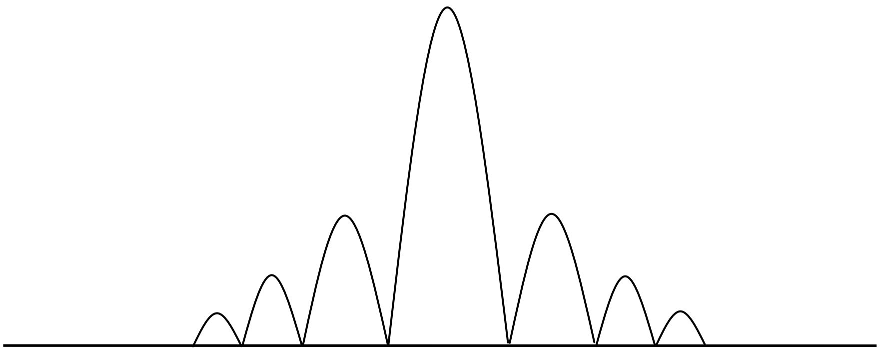
Important Parameters of Antennas

The performance of the antennas can be gauged with the help of various antenna parameters. These parameters are defined and briefly discussed below.

1. Radiation pattern

An antenna radiation pattern is defined as a mathematical function or a graphical representation of the radiation properties of the antenna as the function of space co-ordinates. The radiation pattern of an antenna is peculiar to the type of antenna and electrical characteristics as well as its physical dimensions. It is determined in the far field region and is represented as a function of directional co-ordinates. The radiation pattern is usually measured in the two principal planes, namely the azimuth and the elevation planes. The radiated power is plotted against the angle that is made with the boresight direction.

The radiation pattern can be plotted using rectangular/Cartesian or polar coordinates. The rectangular plots can be read more accurately, but the polar plots give a more pictorial representation and are thus easier to visualize. A typical plot of the radiation pattern of both the types are as shown in the figure 1.1.



Rectangular plot of an antenna radiation pattern

2. Radiation power density

The quantity used to describe the power associated with an electromagnetic wave is the instantaneous Poynting vector defined as

$$\mathbf{W} = \mathbf{E} \times \mathbf{H}$$

3. Radiation intensity

Radiation Intensity in a given direction is defined as “the power radiated from an antenna per unit solid angle” and is obtained by multiplying the radiation density by the square of the distance. It can be expressed as

$$U = r^2 W_{rad}$$

4. Directivity

The directivity of an antenna is defined as “the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions”. It is therefore a measure of the directional properties of an antenna compared to those of an isotropic antenna.

$$D = U / U_o = 4\pi U / P_{rad}$$

5. Gain

The absolute gain of an antenna in a given direction is defined as “the ratio of the intensity in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically”. Mathematically this can be expressed as

$$\text{Gain} = 4\pi\ (\text{Radiation Intensity}) / (\text{Total Input Power})$$

6. Half-Power beamwidth

The 3-dB or half-power beam width (HPBW) of an antenna is taken as the width in degrees at the points on either sides of the main lobe where the radiated power is half the maximum value.

7. Efficiency

Antenna efficiency is defined as the ratio of radiated power to input power and can be expressed in terms of equivalent resistances.

$$\eta = (R_r / R_t)$$

$$R_t = R_r + R_d + R_c$$

where R_r = radiation resistance

R_c = equivalent resistance for copper loss

R_d = equivalent resistance for dielectric loss

8. Bandwidth

The bandwidth of an antenna is defined as the range of frequencies within which the performance of the antenna, with respect to specific standards.

$$BW = (S-1) / Q\sqrt{S}$$

9. Polarization

Polarization describes the shape and orientation of the locus of the extremity of the electric field vector as it varies with time at a fixed point in space. This locus could be a straight line, an eclipse, or a circle leading to linear, elliptical or circular polarization respectively.

CHAPTER 2

MICROSTRIP PATCH ANTENNA

MICROSTRIP PATCH ANTENNA

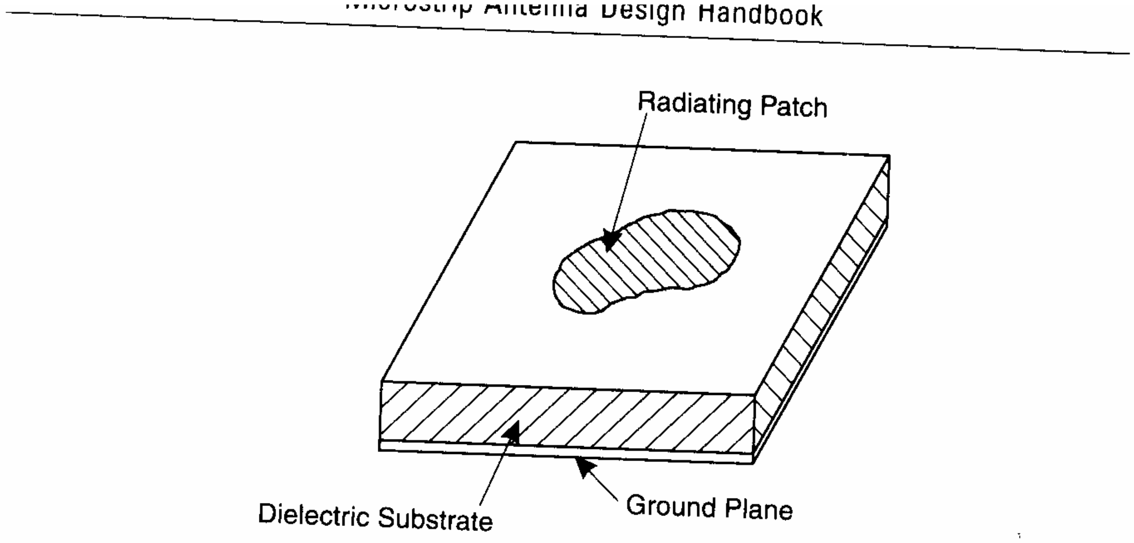


Figure 1.1 Microstrip antenna configuration.

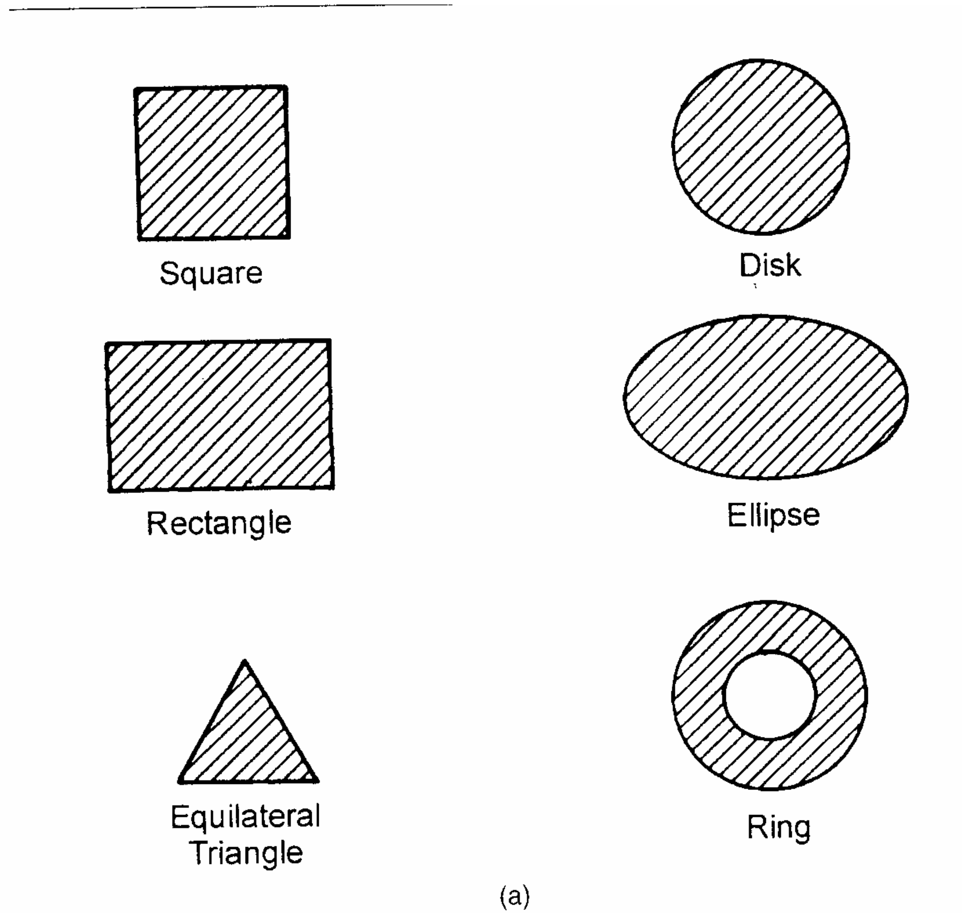
In its basic form ,a microstrip antenna consists of radiating patch on one side of dielectric substrate which has a ground plane on other side. The patch is generally made of conducting material such as copper or gold and can take any possible shape. In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, elliptical or some other common shapes.

For a rectangular patch, the length L of the patch is usually $0.3333\lambda < L < 0.5\lambda$, where λ is the free space wavelength.The patch is selected to be very thin such that $t \ll \lambda$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\lambda \le h \le 0.05\lambda$ .The dielectric constant of the substrate (εr) is typically in the range $2.2 \le \varepsilon r \le 12$.

Microstrip antennas radiate primarily because of fringing fields between the patch edge and the ground plane .For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. However, such a configuration leads a larger antenna size.

In order to design a compact microstrip patch antenna, higher dielectric constants must be used which are less efficient and resulting narrower bandwidth. Hence a compromise must be reached between antenna dimensions and antenna performance

COMMON SHAPES OF PATCHES



RADIATION MECHANISM

The MSA generally has a two-dimensional radiating patch on a thin dielectric substrate and therefore may be categorized as a two-dimensional planar component for analysis purposes. The analysis methods for MSAs can be broadly divided into two groups. In the first group, the methods are based on equivalent magnetic current distribution around the patch edges (similar to slot antennas). There are three popular analytical techniques:

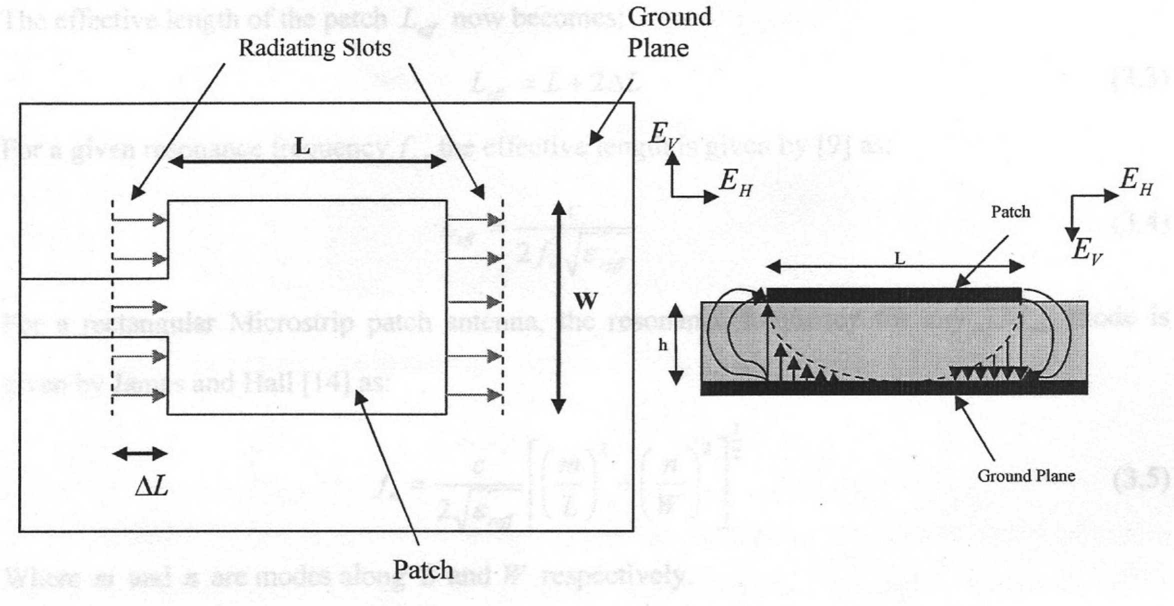
- The transmission line model;
- The cavity model;
- The MNM.

In the second group, the methods are based on the electric current distribution on the patch conductor and the ground plane. Some of the numerical methods for analyzing MSAs are listed as follows:

- The *method of moments* (MoM);
- The *finite-element method* (FEM);
- The *spectral domain technique* (SDT);
- The *finite-difference time domain* (FDTD) method.

1.Transmission Line Model

The transmission line model is very simple and helpful in understanding the basic performance of a MSA. The microstrip radiator element is viewed as a transmission line resonator with no transverse field variations, and the radiation occurs mainly from the fringing fields at the open circuited ends. The patch is represented by two slots that are spaced by the length of the resonator. This model was originally developed for rectangular patches but has been extended for generalized patch shapes. Many variations of this method have been used to analyze the MSA. Although the transmission line model is easy to use, all types of configurations cannot be analyzed using this model since it does not take care of variation of field in the orthogonal direction to the direction of propagation.



Top View of Antenna Side View of Antenna

This model represents the microstrip antenna by two slots of width w and height h. According to this model, the microstrip is essentially a nonhomogeneous line of two dielectrics, typically the substrate and air.

It is the simplest of all and it gives good physical insight but it is less accurate and specifically useful for rectangular patches and it ignores the field variations along the radiating edges.

2. Cavity Model

In the cavity model, the region between the patch and the ground plane is treated as a cavity that is surrounded by magnetic walls around the periphery and by electric walls from the top and bottom sides. Since thin substrates are used, the field inside the cavity is uniform along the thickness of the substrate. The fields underneath the patch for rectangular shapes such as rectangular, circular, triangular, and sectoral shapes can be expressed as a summation of the various resonant modes of the two-dimensional resonator.

The fringing fields around the periphery are taken care of by extending the patch boundary outward so that the effective dimensions are larger than the physical dimensions of the patch. The effect of the radiation from the antenna and the conductor loss are accounted for by adding these losses to the loss tangent of the dielectric substrate. The far field and radiated power are computed from the equivalent magnetic current around the periphery. An alternate way of incorporating the radiation effect in the cavity model is by introducing an impedance boundary condition at the walls of the cavity. The fringing fields and the radiated power are not included inside the cavity but are localized at the edges of the cavity. However, the solution for the far field, with admittance walls is difficult to evaluate

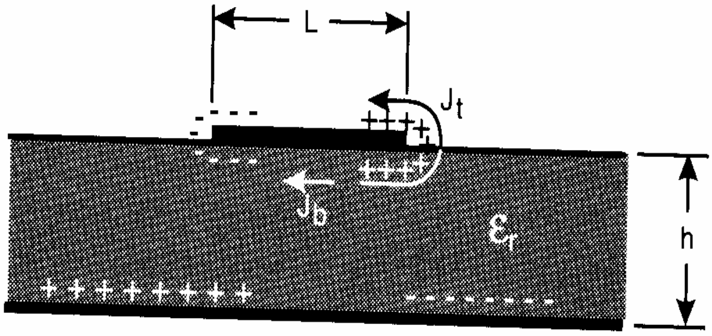


Figure 1.2 Charge distribution and current density on a microstrip antenna. (From [17]. © 1997 John Wiley. Reprinted with permission.)

In this model ,the interior region of the dielectric substrate is modeled as a cavity bounded by electric walls on the top and bottom.

This model is more accurate and gives good physical insight but is complex in nature.

3. MoM

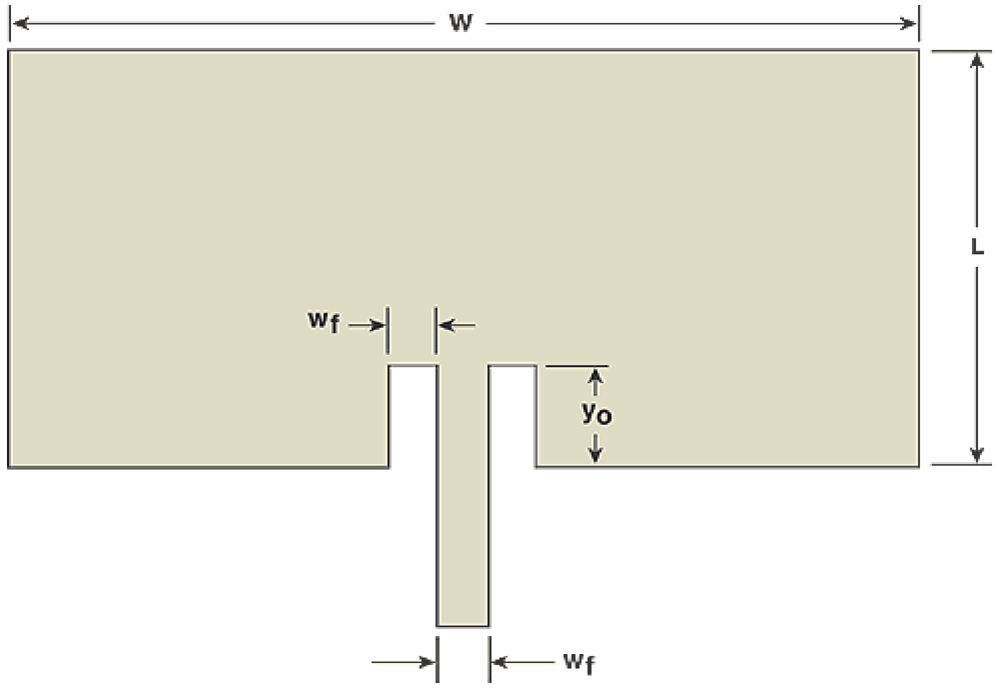
In the MoM, the surface currents are used to model the microstrip patch, and volume polarization currents in the dielectric slab are used to model the fields in the dielectric slab. An integral equation is formulated for the unknown currents on the microstrip patches and the feed lines and their images in the ground plane. The integral equations are transformed into algebraic equations that can be easily solved using a computer. This method takes into account the fringing fields outside the physical boundary of the two-dimensional patch, thus providing a more exact solution. The designs makes extensive use of commonly available software IE3D based on MoM to analyze various MSA configurations.

FEED TECHNIQUES

There are many configurations used to fed MSA. The four most popular techniques are: -

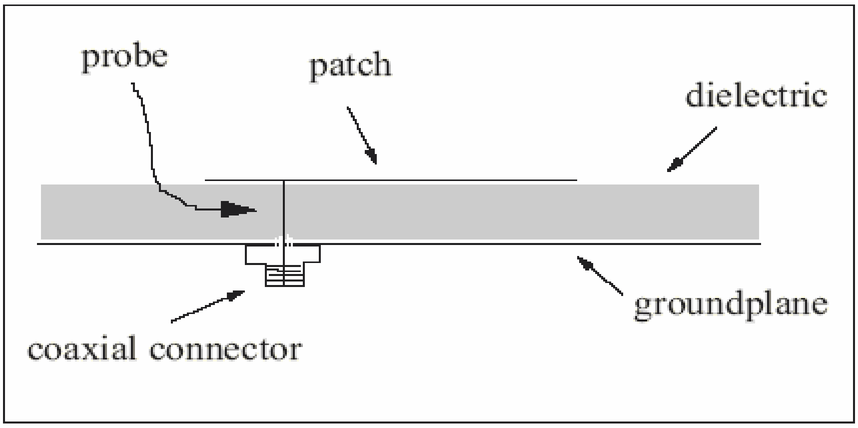
1. MICROSTRIP LINE:

Microstrip fed line is a conducting strip, usually of much smaller width compared to the patch. Microstrip fed line is easy to fabricate, simple to match by controlling the inset position. However as the substrate thickness increases, surface waves and spurious fed radiation increases, which for practical designs limit the bandwidth (typically 2-5%).

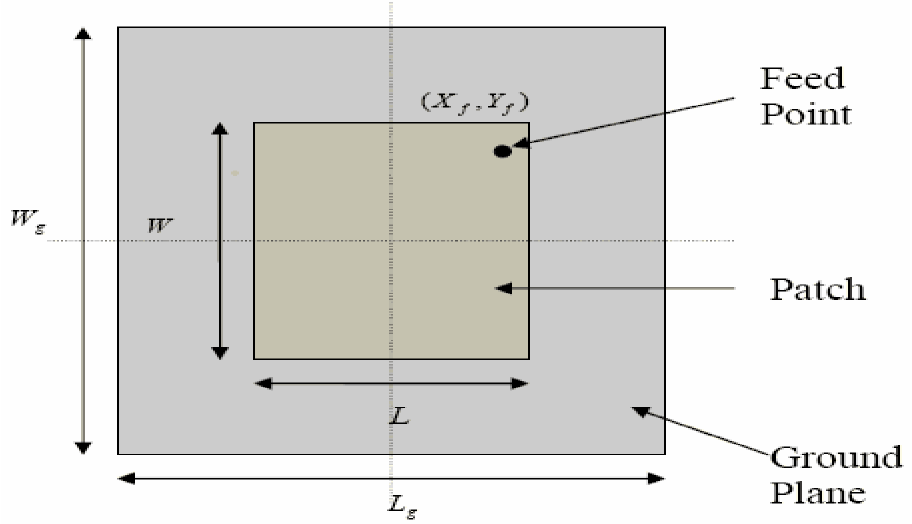


2. COAXIAL PROBE FED:

In this technique the inner conductor of the coax is attached to the radiation patch while the outer conductor is connected to ground plane. This technique is widely used. The coaxial probe fed is also easy to fabricate and match, and it has low spurious radiation. However, it also has narrow bandwidth and it is more difficult to model, especially for thick substrates ($h>0.02\lambda 0$).



SIDE VIEW



TOP VIEW

3. PROXIMITY COUPLING:

Both the above techniques possess inherent asymmetries, which generate higher order modes, which produce cross-polarized radiation. Proximity coupling is a type of EMC feed, this has many advantages over edge fed and coaxial fed antenna. Proximity-coupled microstrip antenna is also known as non-contacting feeds. Some advantages are:

- No physical contact between feed line and radiating element.
- No drilling required.
- Less spurious radiation.
- Better for array configurations.
- Good suppression of higher order modes.
- Better high frequency performance.

The geometry of the proximity-coupled patch is shown in fig. 1. The Microstrip feed line is of width W_f and is printed on the bottom substrate. The microstrip patch is of the length L and width W, and is printed on a substrate bonded to the feed substrate. The feed is centered with respect to the patch width, and is inset a distance S from the edge of the patch.

A short stuning stub is of length is connected in shunt with the feedline at a distance d_s from the edges of the patch. The level of coupling can be adjusted by varying the length of the overlap distance S in fig.2. Maximum coupling occurs when the overlap distance is approximately half of the patch length.

The setup for proximity coupling is as shown below. The substrate parameters of the two layers can be selected to increase the bandwidth of the patch, and to reduce spurious radiation from the open end of the microstrip. For this the lower layer should be thin. The radiating patch being placed on the double layer gives a larger bandwidth.

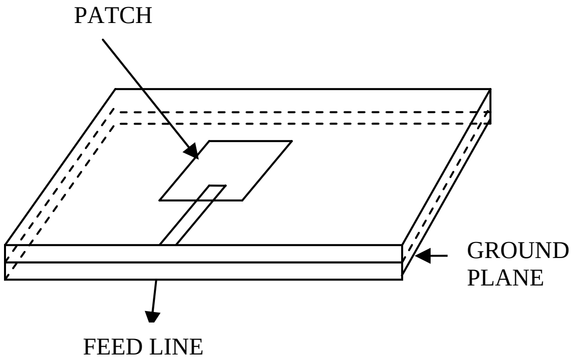


Figure 1. Proximity Coupled Antenna

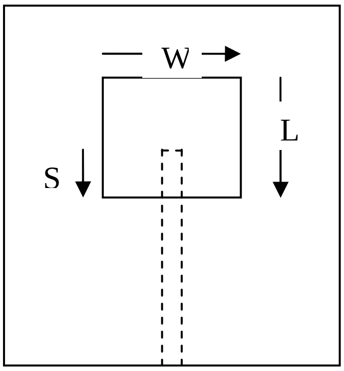


Figure 2: Top View

4.APERTURE COUPLING:

Aperture Coupling is another type of EMC feed. Pozar first proposed this type of feed in 1985 to increase the bandwidth of the MSA. The RF energy from the feed line is coupled to the radiating element through a common aperture in the form of a rectangular slot. It mainly consists of two substrates separated by a ground plane. Top substrate is for the radiating element and the bottom substrate is for the feedline. A slot is made in the ground plane to provide coupling between the feed line and patch.

The slot is usually at the centre for maximum coupling and it is perpendicular to the feed line, the thumb rule taking into consideration is the slot and the patch should have common centre, and the length is approximately larger than the width of the slot. There are several techniques used for the analysis of ACMSA, they are transmission line mode, the cavity model, the integral equation method. The diagrammatic setup for aperture coupling is shown below.

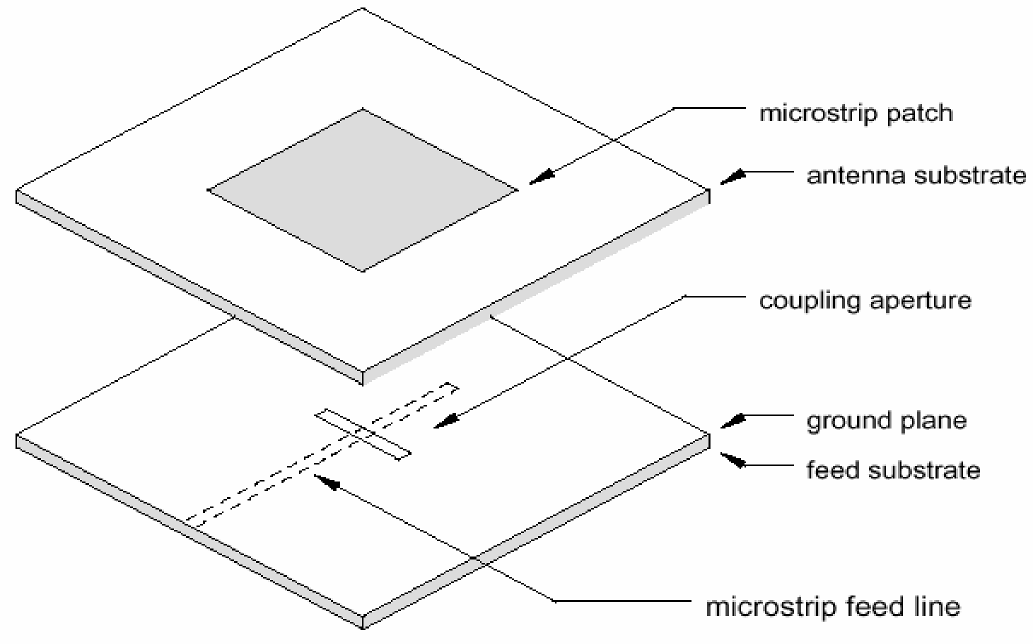


Fig: APERTURE COUPLING

In the next session is to design an MSA with the above various feeding mechanism in order to determine the suitable feeding technique for increasing the bandwidth.

ADVANTAGES OF MICROSTRIP ANTENNAS

Microstrip antennas have several advantages compared to conventional microwave antennas, and therefore many applications cover the broad frequency range from ~ 100 MHz to ~ 100 GHz. Some of the principal advantages of microstrip antennas compared to conventional microwave antennas are:

- Light weight, low volume, low profile planar configurations, which can be made conformal.
- Low fabrication cost; readily amenable to mass production.
- Can be made thin hence they do no perturb the aerodynamics of host aerospace vehicles.
- The antennas may be easily mounted on missiles, rockets and satellites without major alterations.
- The antennas have low scattering cross section.
- Linear, circular (left hand or right hand) polarizations are possible with simple changes in feed position.
- Dual frequency antennas easily made.
- No cavity backing required.
- Microstrip antennas are compatible with modular designs (solid state devices such as oscillators, amplifiers, variable attenuators, switches, modulators, mixers, phase shifters etc., can be added directly to the antenna substrate board).
- Feed lines and matching networks are fabricated simultaneously with antenna structure.

DISADVANTAGES OF MICROSTRIP ANTENNAS

The microstrip antennas also have some disadvantages compared to conventional microwave antennas including:

- Narrow bandwidth.
- Loss, hence somewhat lower gain.
- Most microstrip antennas radiate into a half plane.
- Practical limitations on the maximum gain (~20 dB).
- Poor end fire radiation performance.
- Poor isolation between the feed and the radiating elements.
- Possibility of excitation of surface waves.
- Lower power handling capability.

There are ways to minimize the effect of some of these limitations. For example, bandwidth can be increased to more than 60% by using special techniques; lower gain and lower power handling limitations can be over come thorough an array configuration. Surface wave associated limitations such as poor efficiency, increased mutual coupling, reduced gain and radiation pattern degradation can be over come by the use of photonic band gap structures.

APPLICATIONS OF MICROSTRIP ANTENNAS

Notable system applications for which microstrip antennas have been developed include:

- Satellite communications
- Doppler and other radar
- Radio altimeters
- Missile telemetry
- Weapon fusing
- Man pack equipment
- Feed elements in complex antennas
- Satellite navigation receiver
- Biomedical radiator
- Command and control

CHAPTER 3

REVIEW OF BROADBANDING TECHNIQUES

REVIEW OF BROADBANDING TECHNIQUES

Definition of BW

The VSWR or impedance BW of the MSA is defined as the frequency range over which it is matched with that of the feed line within specified limits. The BW of the MSA is inversely proportional to its quality factor Q and is given by

$$\mathrm{BW} = \frac{\mathrm{VSWR} - 1}{\mathrm{Q}\sqrt{\mathrm{VSWR}}}$$

Where VSWR is defined in terms of the input reflection coefficient Γ as:

$$\mathrm{VSWR} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

The Γ is a measure of reflected signal at the feed-point of the antenna. It is defined in terms of input impedance Z_{in} of the antenna and the characteristic impedance Z_0 of the feed line as given below:

$$\Gamma = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

The BW is usually specified as frequency range over which VSWR is less than 2 (which corresponds to a return loss of 9.5 dB or 11 % reflected power). Sometimes for stringent applications, the VSWR requirement is specified to be less than 1.5. Conversion of BW from one VSWR level to another can be accomplished by

$$\frac{\mathrm{BW}_1}{\mathrm{BW}_2} = \frac{(\mathrm{VSWR}_1 - 1)}{\sqrt{\mathrm{VSWR}_1}} \frac{\sqrt{\mathrm{VSWR}_2}}{(\mathrm{VSWR}_2 - 1)}$$

Where BW_1 and BW_2 corresponds to VSWR_1 and VSWR_2 respectively.

The variations of percentage BW for VSWR <=2 and efficiency η of a square MSA with normalized substrate thickness h/λ_0 for two different values of ε_r are given in figure (a). Also, the variation of percentage BW with frequency for three commonly used values of h and ε_r =2.32 is given in figure (b). The BW of a single-patch antenna increases with an increase in the substrate thickness and a decrease in the dielectric constant ε_r of the substrate. The ε_r can be chosen close to 1 to obtain a broader BW.

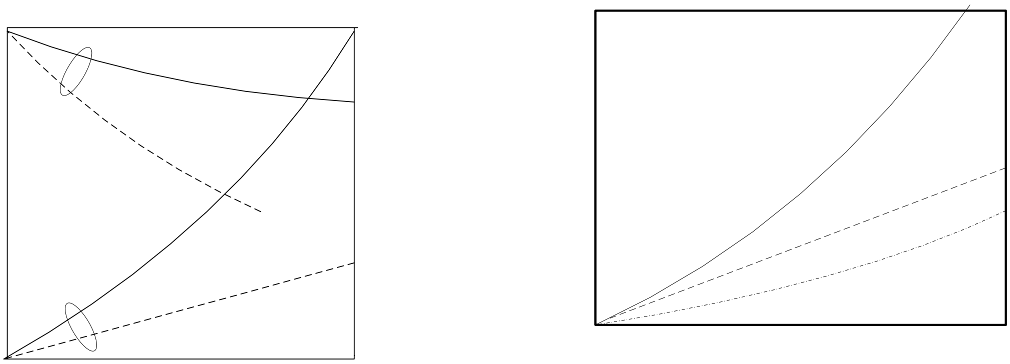


Figure (a) Variations of percentage BW and efficiency of a MSA versus h/λ_0

(b) Variation of percentage BW with frequency

The expression for approximately calculating the percentage BW of the RMSA in terms of patch dimensions and substrate parameters is given by

$$\%BW = \frac{Ah}{\lambda_0\sqrt{\varepsilon_r}}\sqrt{\frac{W}{L}}$$

Where

$$A = 180 \text{ for } \frac{h}{\lambda_0\sqrt{\varepsilon_r}} \le 0.045$$

$$A = 200 \text{ for } 0.045 \le \frac{h}{\lambda_0\sqrt{\varepsilon_r}} \le 0.045$$

$$A = 220 \text{ for } \frac{h}{\lambda_0\sqrt{\varepsilon_r}} \ge 0.075$$

Where W and L are the width and length of the RMSA. With an increase in W the BW increases. However, W should be taken lesser than λ to avoid excitation of higher order modes.

The BW can also be defined in terms of the antenna's radiation parameters. It is defines as the frequency range over which radiation parameters such as gain, half-power beam width and sidelobe levels are within the specified minimum and maximum limits.

There are various techniques for increasing the BW of the MSAs. The main techniques used to increase the BW are:-

.

1.Modified Shape Patches

The regular MSA configurations, such as rectangular and circular patches have been modified to rectangular ring and circular ring, respectively to enhance the BW. The larger BW is because of a reduction in this quality factor Q of the patch resonator, which is due to less energy stored beneath the patch and higher radiation.

2.Planar Multiresonator Configurations

The planar stagger-tuned coupled multiple resonators yield wide BW in the same way as in the case of multistage tuned circuits. Several configurations are available yielding BW of 5-25%. Various parasitic patches like narrow strips, shorted quarter-wavelength rectangular patches, and rectangular resonator patches have been gap-coupled to the central-fed rectangular patch. To reduce the criticality of the gap coupling, direct coupling is preferred which is used for broad BW. The planar multiresonator configurations yield broad BW but have the following disadvantages.

- The large size, which makes them unsuitable as an array element.
- The variation in the radiation pattern over the impedance BW.

3.Multilayer Configurations

In the multilayer configuration, two or more patches on different layers of the dielectric substrate are stacked on each other. Based on the coupling mechanism, these configurations are categorized as electromagnetically coupled and aperture coupled MSAs.

3.1 Electromagnetically Coupled MSAs

In the electromagnetically coupled MSA, one or more patches at the different dielectric layers are electromagnetically coupled to the feed line located at the bottom dielectric layer. The patch dimensions are optimized so that the resonance frequencies of the patches are close to each other to yield broad BW.

3.2 Aperture-Coupled MSAs

In the aperture-coupled MSA, the field is coupled from the microstrip feed line placed on the other side of the ground plane to the radiating patch through an electrically small aperture/slot in the ground plane. The coupling to the patch from the feed line can be maximized by choosing the optimum shape of the aperture. The drawback of these structures is the increased height, which is not desirable for conformal applications and increased back radiation for aperture-coupled MSAs

.

4. Stacked Multiresonator MSAs

The planar and stacked multiresonator techniques are combined to further increase the BW and gain. A probe-fed single rectangular or circular patch located on the bottom layer has been used to excite multiple rectangular or circular patches on the top layer, respectively. These provide an increase in gain, besides increasing the BW.

5. Impedance Matching Networks for Broadband MSAs

The impedance-matching networks are used to increase BW of the MSA. Some examples that provide about 10% BW are the rectangular MSA with a coplanar microstrip impedance matching network and an electromagnetically coupled MSA with single-stub matching.

6. Log-Periodic MSA Configurations

The concept of log-periodic antenna has been applied to MSA to obtain a multi-octave BW. In this configuration, the patch dimensions are increased logarithmically and the subsequent patches are fed at 180 deg out of phase with respect to the pervious patch. The main disadvantage of this configuration is that the radiation pattern varies significantly over the impedance BW.

CHAPTER 4

THE PROPOSED NEW ANTENNAS

THE PROPOSED NEW ANTENNAS

Through this project,we have proposed two new designs for wideband small size microstrip patch antenna as follows:-

1.Two Shorted Coplaner Patch Antennas:-

The basic broad-banding concept of this antenna is electromagnetic coupling of two coplanar, shorted, rectangular or circular microstip patch elements .one patch is driven by a probe at its edge, and the other is parasitic .the driven patch will dominate the higher resonant frequency while the lower one is generated by electromagnetic coupling of two shorted coplanar patches.

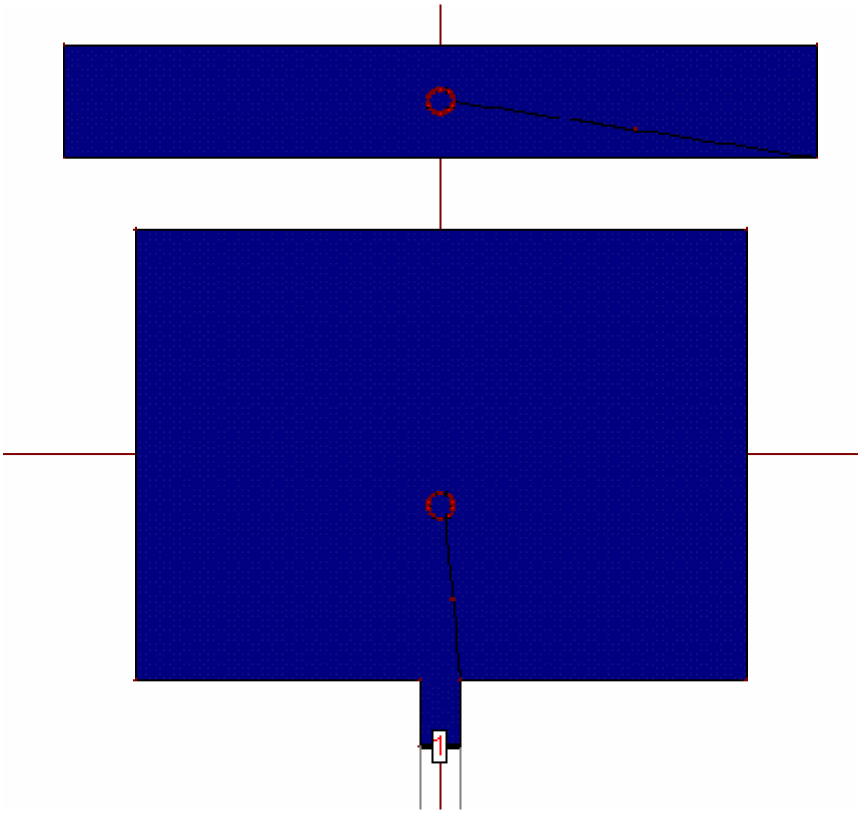


fig- Two Shorted Coplaner Patch Antenna

The above figure shows the geometry of the antenna .The two patches are coplanar and individually shorted to ground by shorting pins. The antenna is air filled and has a maximum thickness of 10mm. this is about1/15 of a free space wavelength at the frequency of interest, while the maximum transverse dimension is only a quarter-wavelength. The driven patch have dimension 22x32mm, while the other is about 8.5x39mm, a rectangular stub measuring 2x3.25mmxmm is attached to the centre of the radiating edge of the driven patch, and is also attached to the feed probe. For optimal coupling, the coupling gap between the two shorted patches is about 4mm.

Specifications:
Substrate thickness = 10 mm
Dielectric Constant= 1(air substrate)
Radius Of Shorting Pins = 0.65 mm

2.E-shaped Patch Antenna:-

The basic idea of this antenna is to modify the geometry of the typical rectangular patch antenna by inserting a pair of slits in an appropriate radiating edge to form E-Shaped patch antenna .the slots reduces the size of the original rectangular patch ,because length of the current path around the slots is increased .the slots also introduces the dual frequency features, this widens the bandwidth of the proposed antenna .the higher frequency is mainly determined by central part of the proposed patch, while the lower one is controlled by the outer parts .the length, width, and position of the symmetrical slots are critical for getting wide bandwidth, otherwise only single resonant frequency will be obtained

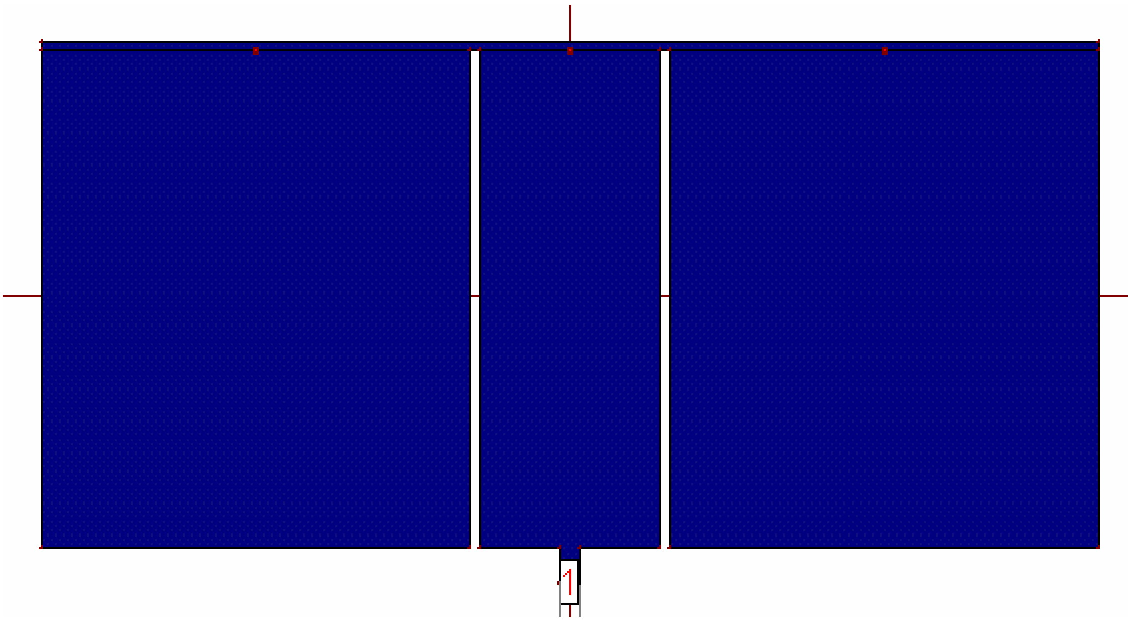


Fig 2- E-shaped Patch Antenna

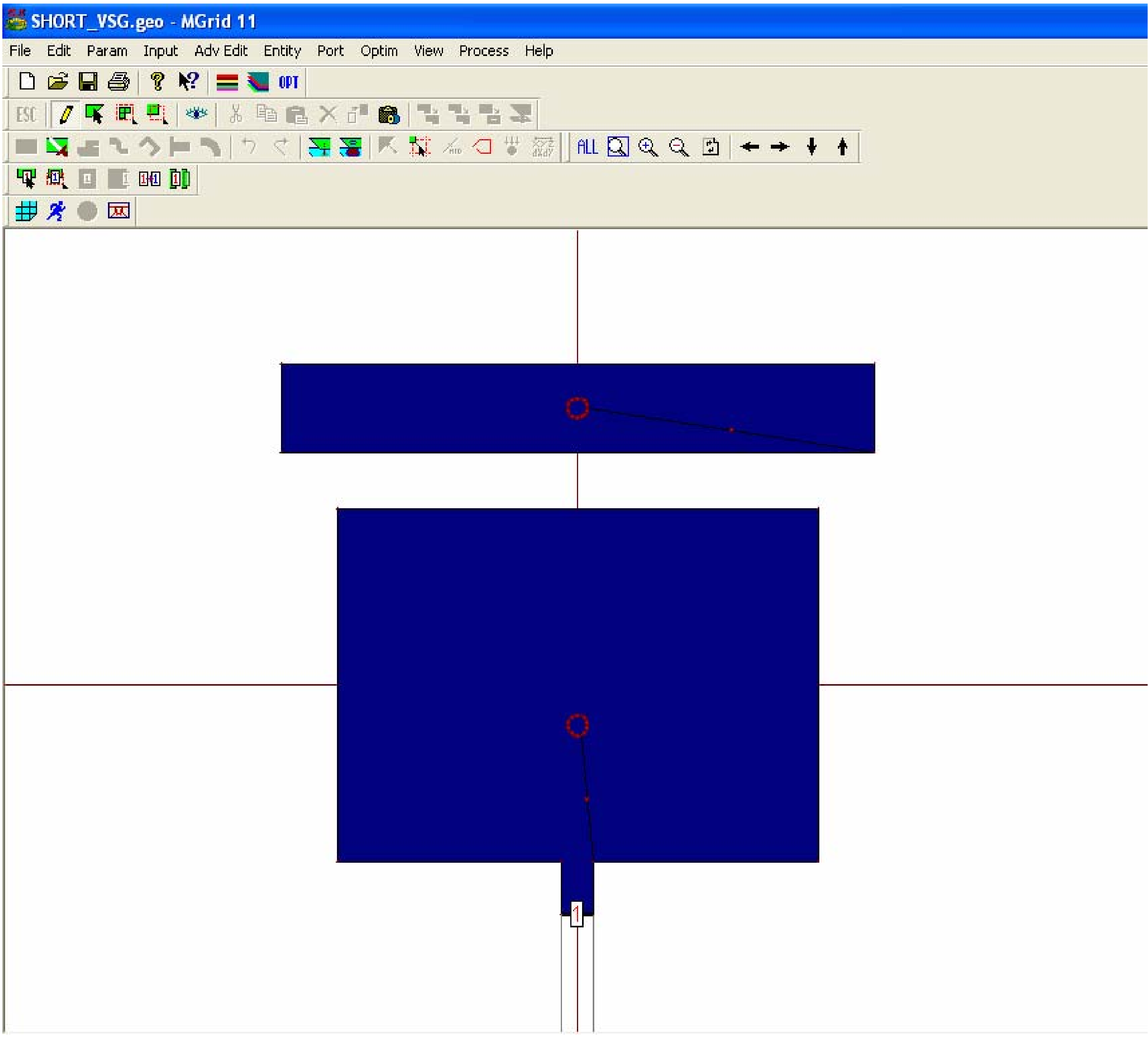
The geometry of e-shaped antenna geometry in shown in fig 2. the antenna has only one patch which is simpler than most conventional wide-band microstrip antenna which use multiple layers. Two parallel narrow slots of length and width43.25x1mm are inserted into rectangular patch whose size is about 105x44mm. a rectangular stub measuring 2x3 mmxmm is attached to the centre of the radiating edge of the driven patch, and is also attached to the feed.

Specifications:
Substrate thickness =18 mm
Dielectric Constant = 1(air substrate)

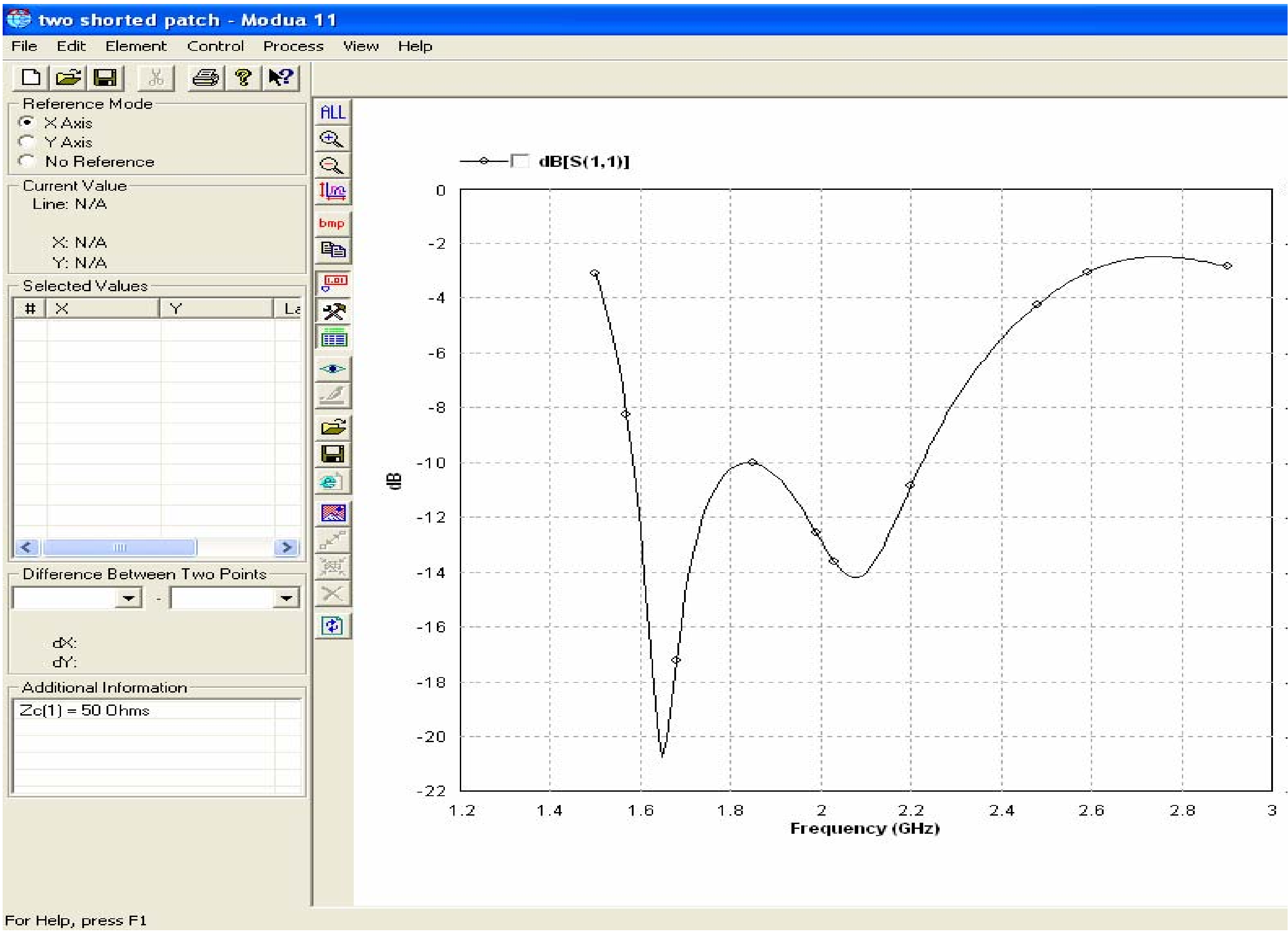
CHAPTER 5

SIMULATION RESULTS

DESIGN 1



S11(db) PARAMETER



Reference Mode
● X Axis
○ Y Axis
○ No Reference

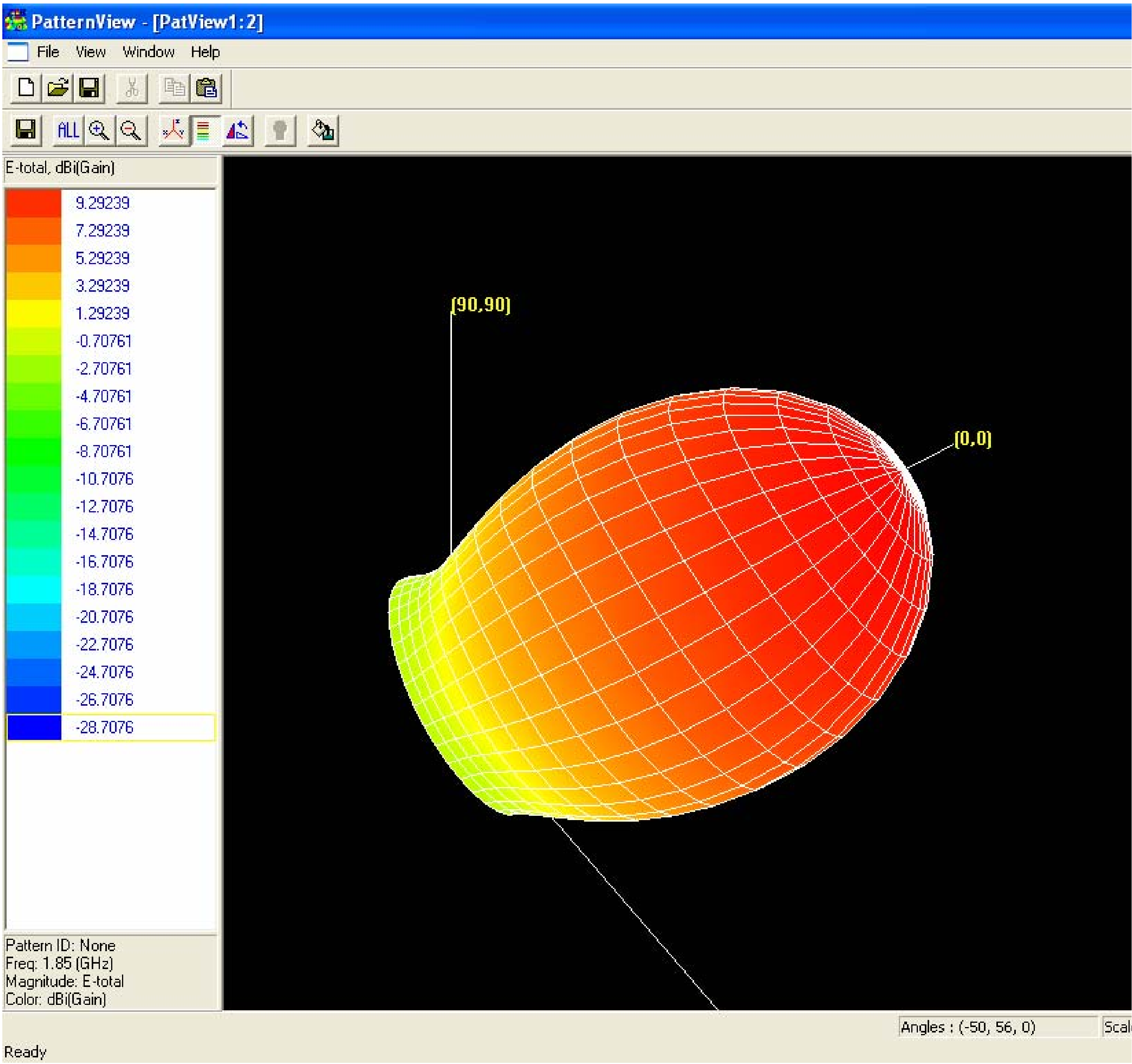
Current Value
Line: N/A
X: N/A
Y: N/A

Selected Values

Difference Between Two Points
dX:
dY:

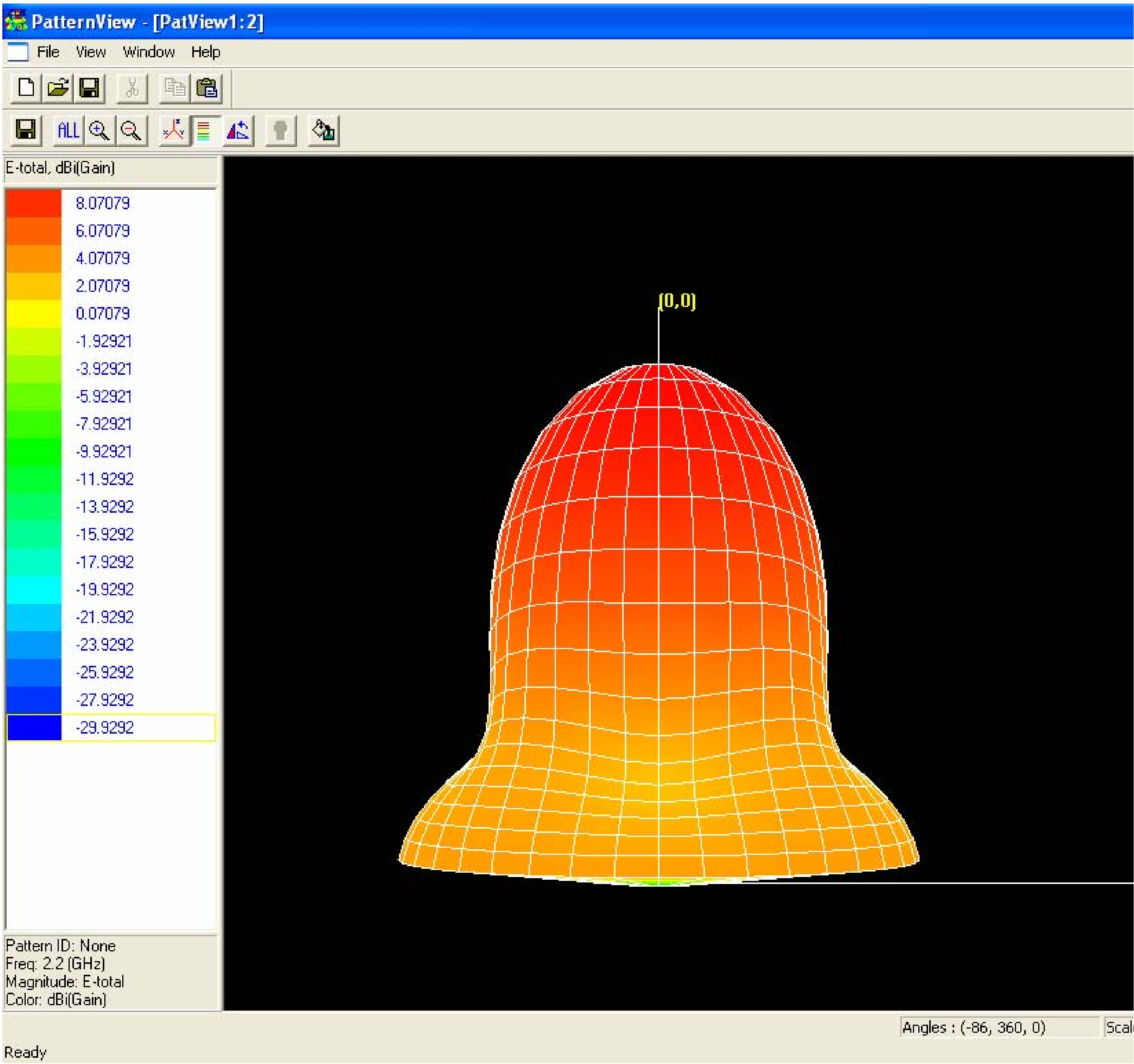
Additional Information
Zc(1) = 50 Ohms

For Help, press F1



Pattern ID: None
Freq: 1.85 (GHz)
Magnitude: E-total
Color: dBi(Gain)

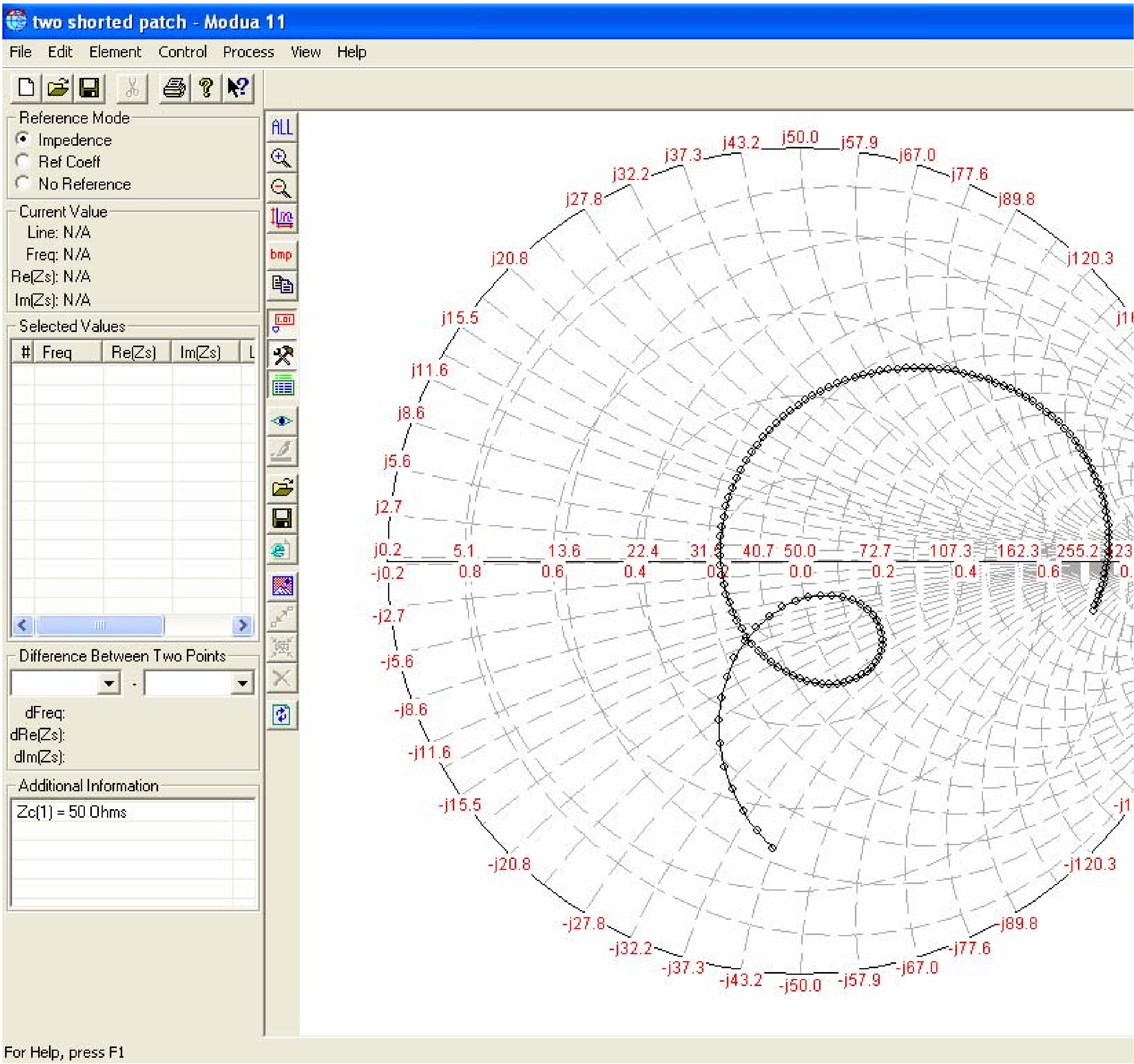
Angles : (-50, 56, 0)



Pattern ID: None
Freq: 2.2 (GHz)
Magnitude: E-total
Color: dBi(Gain)

Angles : (-86, 360, 0)

Ready

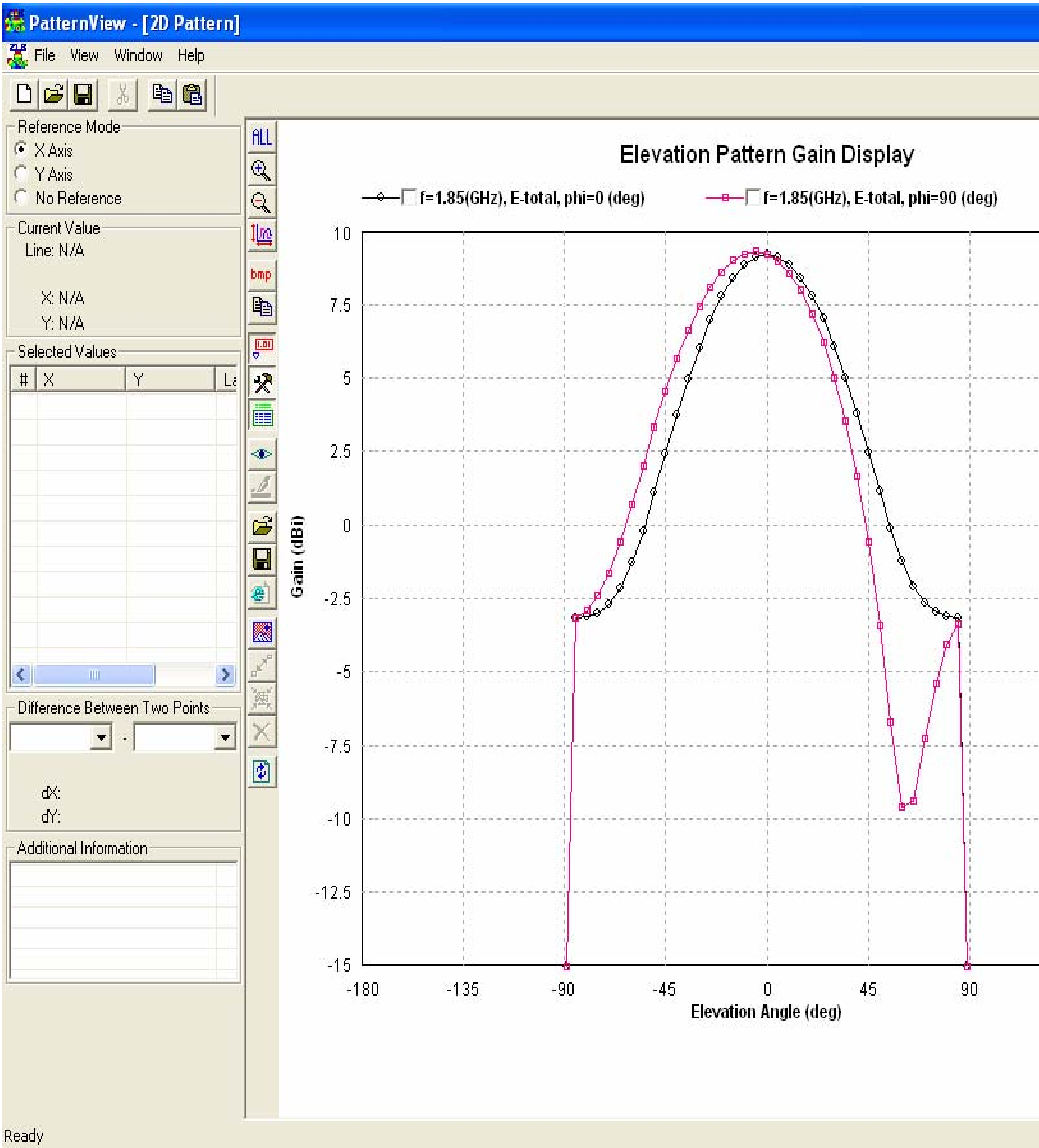


Reference Mode
● Impedence
○ Ref Coeff
○ No Reference

Current Value
Line: N/A
Freq: N/A
Re(Zs): N/A
Im(Zs): N/A

dFreq:
dRe(Zs):
dIm(Zs):

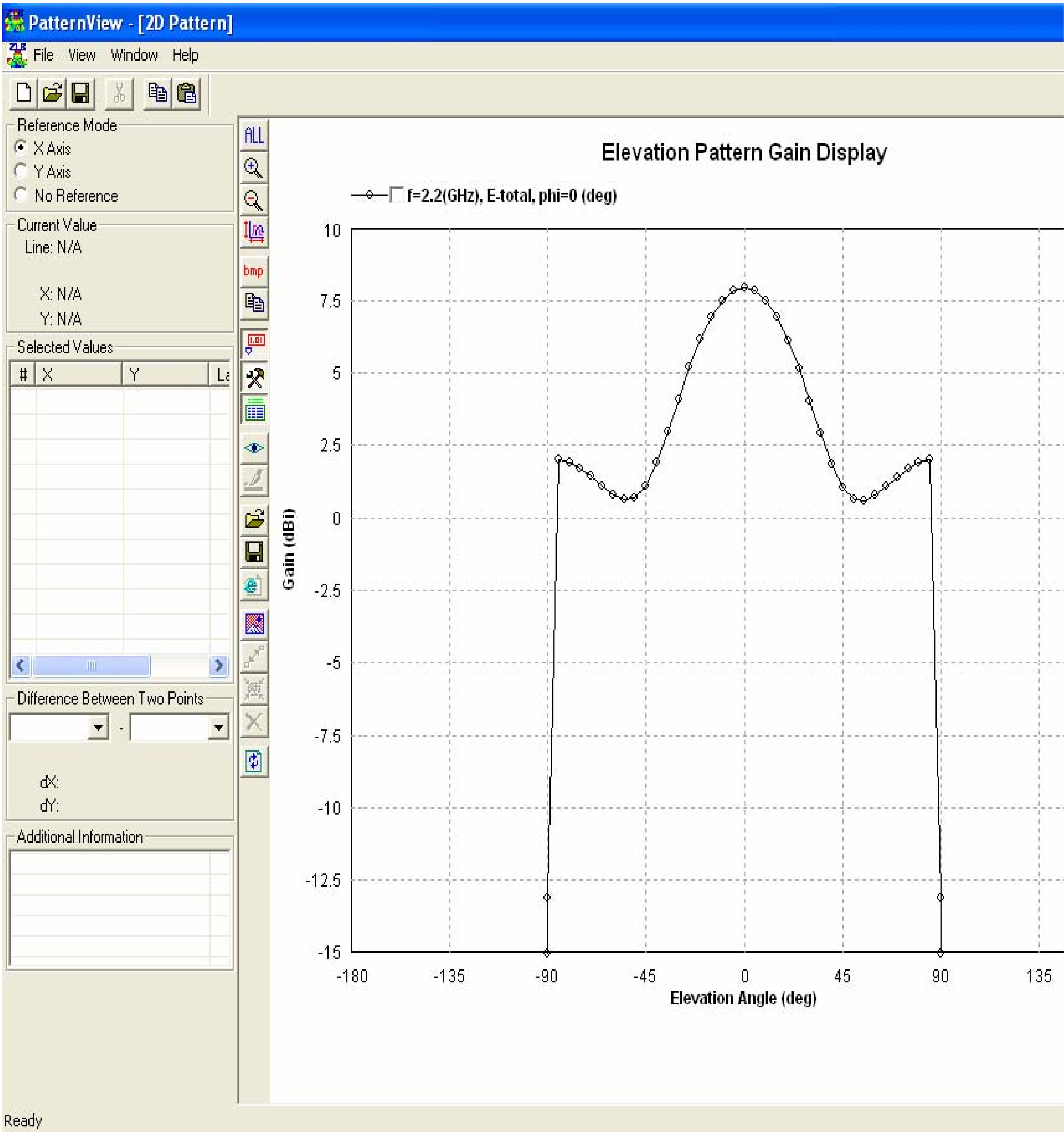
Additional Information
Zc(1) = 50 Ohms



Reference Mode
● X Axis
○ Y Axis
○ No Reference

Current Value
Line: N/A
X: N/A
Y: N/A

dX:
dY:

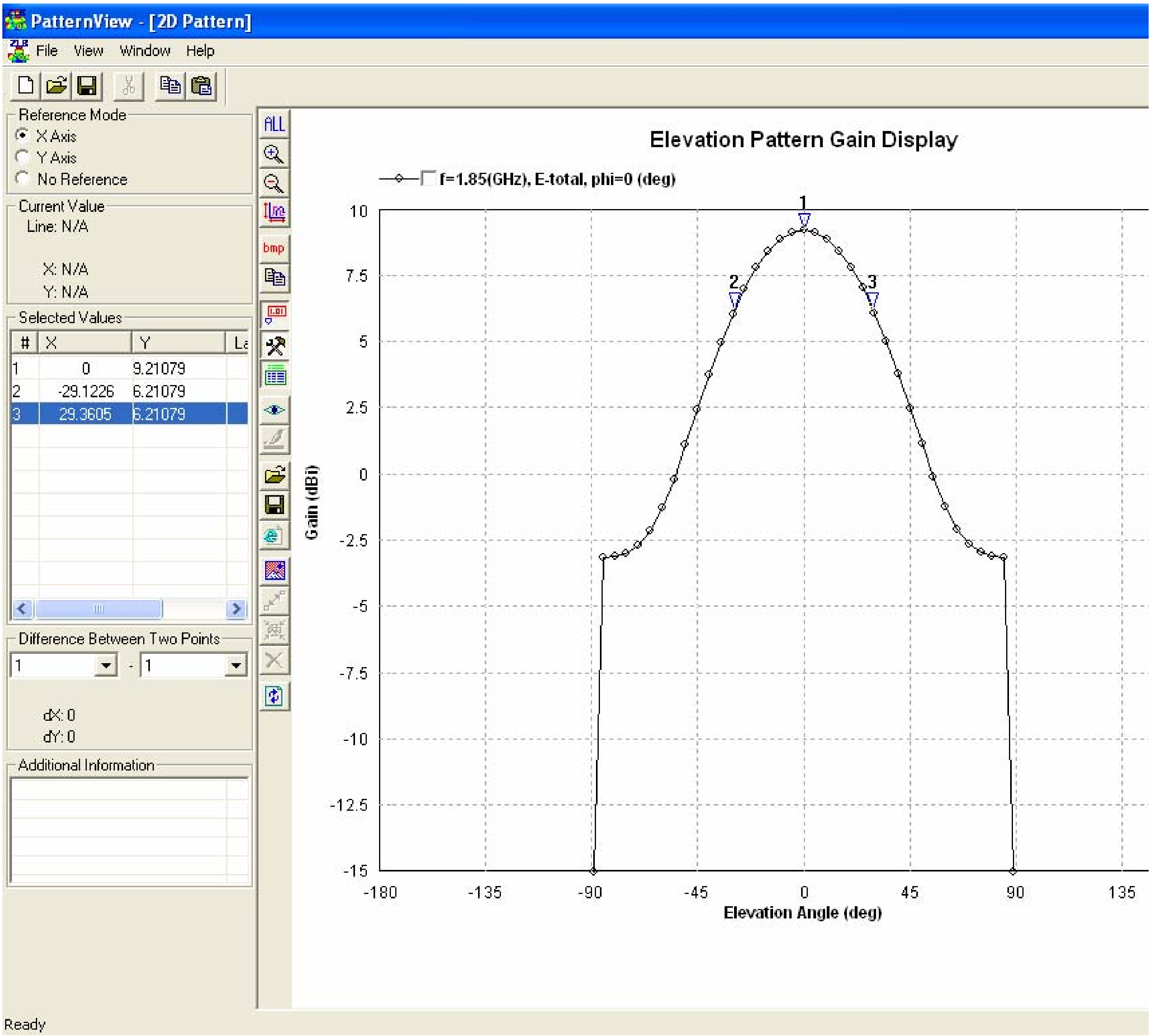


Reference Mode
● X Axis
○ Y Axis
○ No Reference

Current Value
Line: N/A
X: N/A
Y: N/A

dX:
dY:

3 dB Beam width at first resonance =1.85 GHz



Reference Mode
● X Axis
○ Y Axis
○ No Reference

Current Value
Line: N/A

X: N/A
Y: N/A

Selected Values

#	X	Y	La
1	0	9.21079	
2	-29.1226	6.21079	
3	29.3605	6.21079	

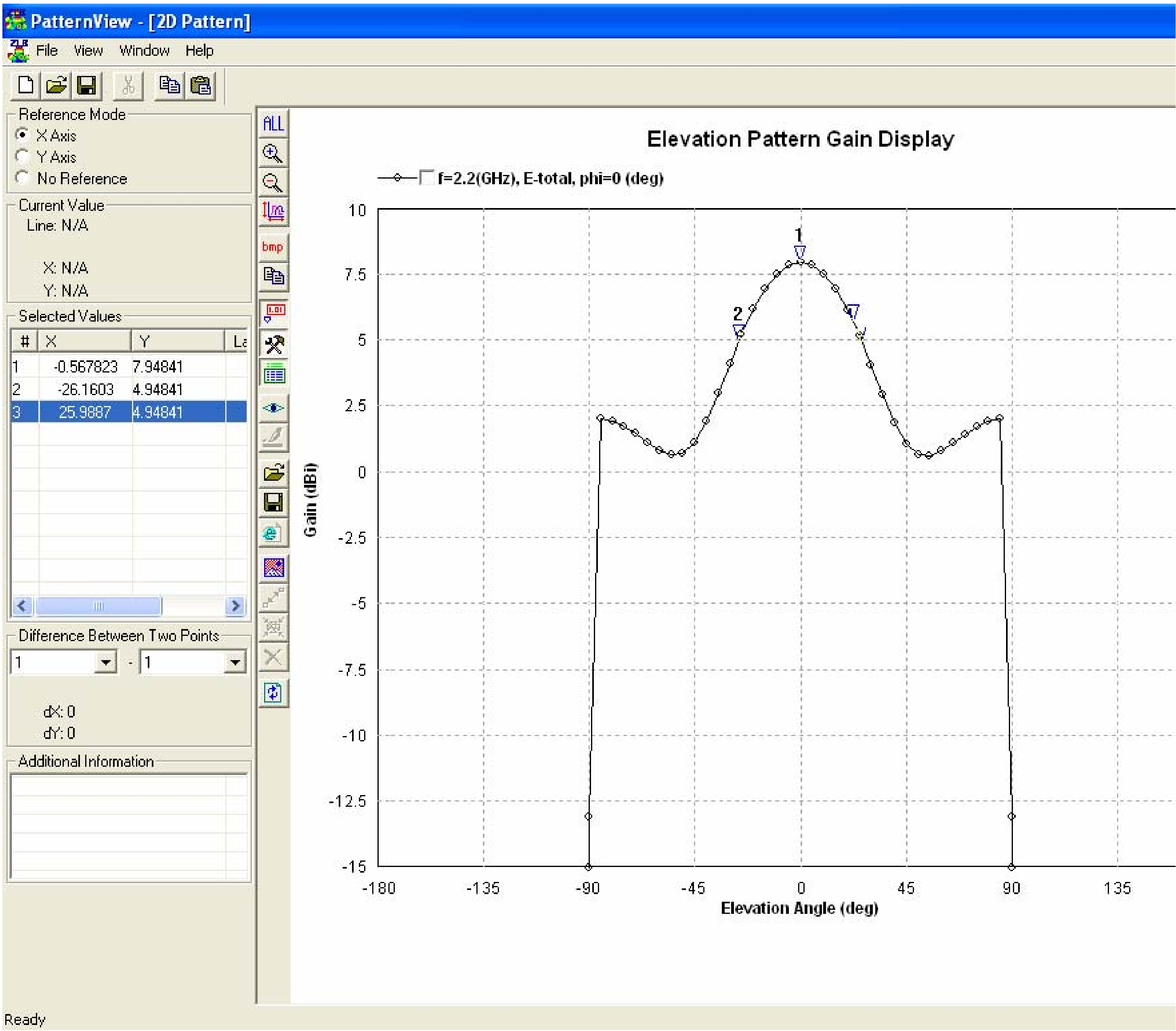
Difference Between Two Points
1 - 1

dX: 0
dY: 0

Additional Information

Ready

3 dB Beam width at Second Resonance =2.2 GHz



Reference Mode

● X Axis

○ Y Axis

○ No Reference

Current Value

Line: N/A

X: N/A

Y: N/A

Selected Values

#	X	Y	La
1	-0.567823	7.94841	
2	-26.1603	4.94841	
3	25.9887	4.94841	

Difference Between Two Points

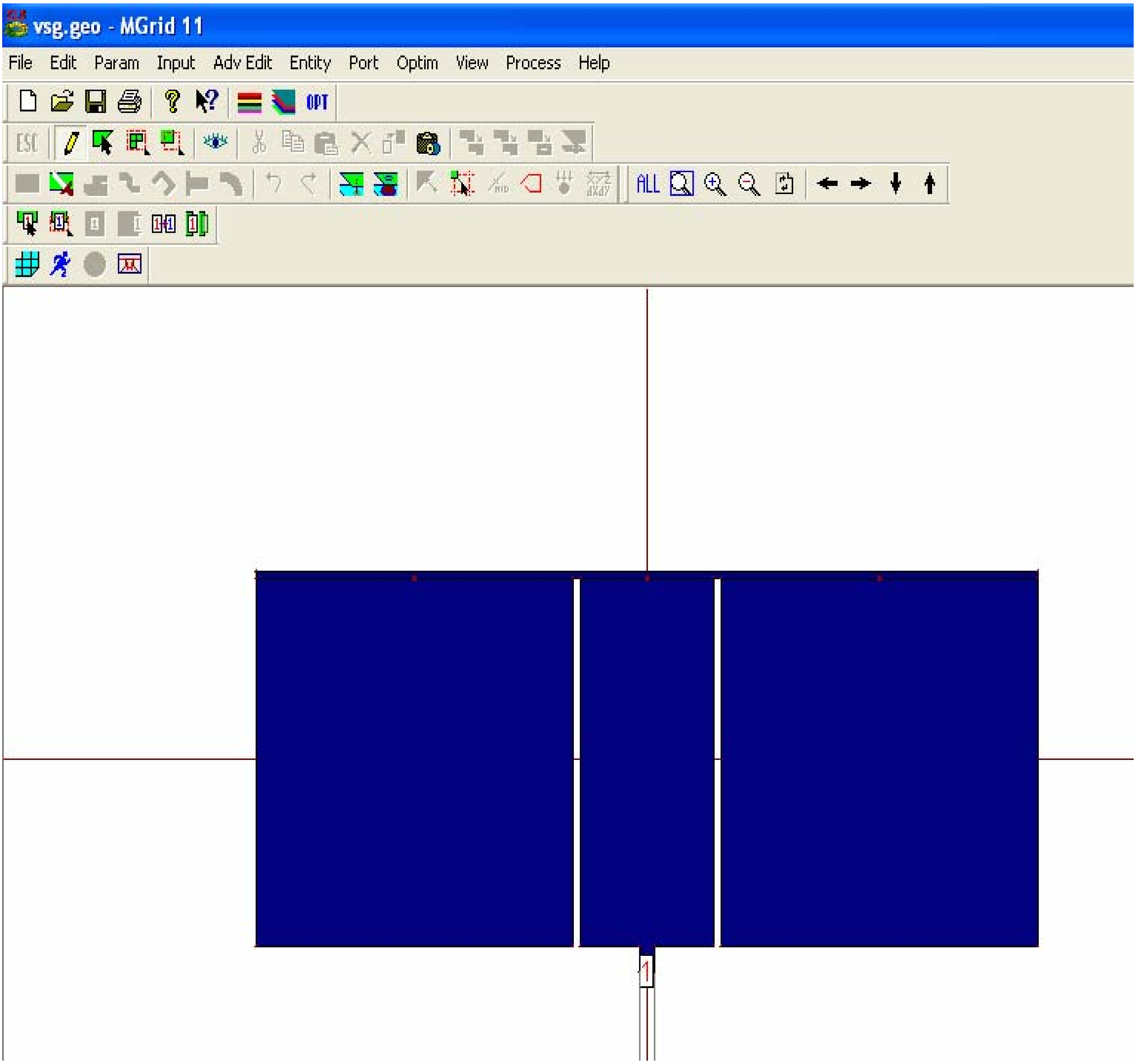
1 - 1

dX: 0

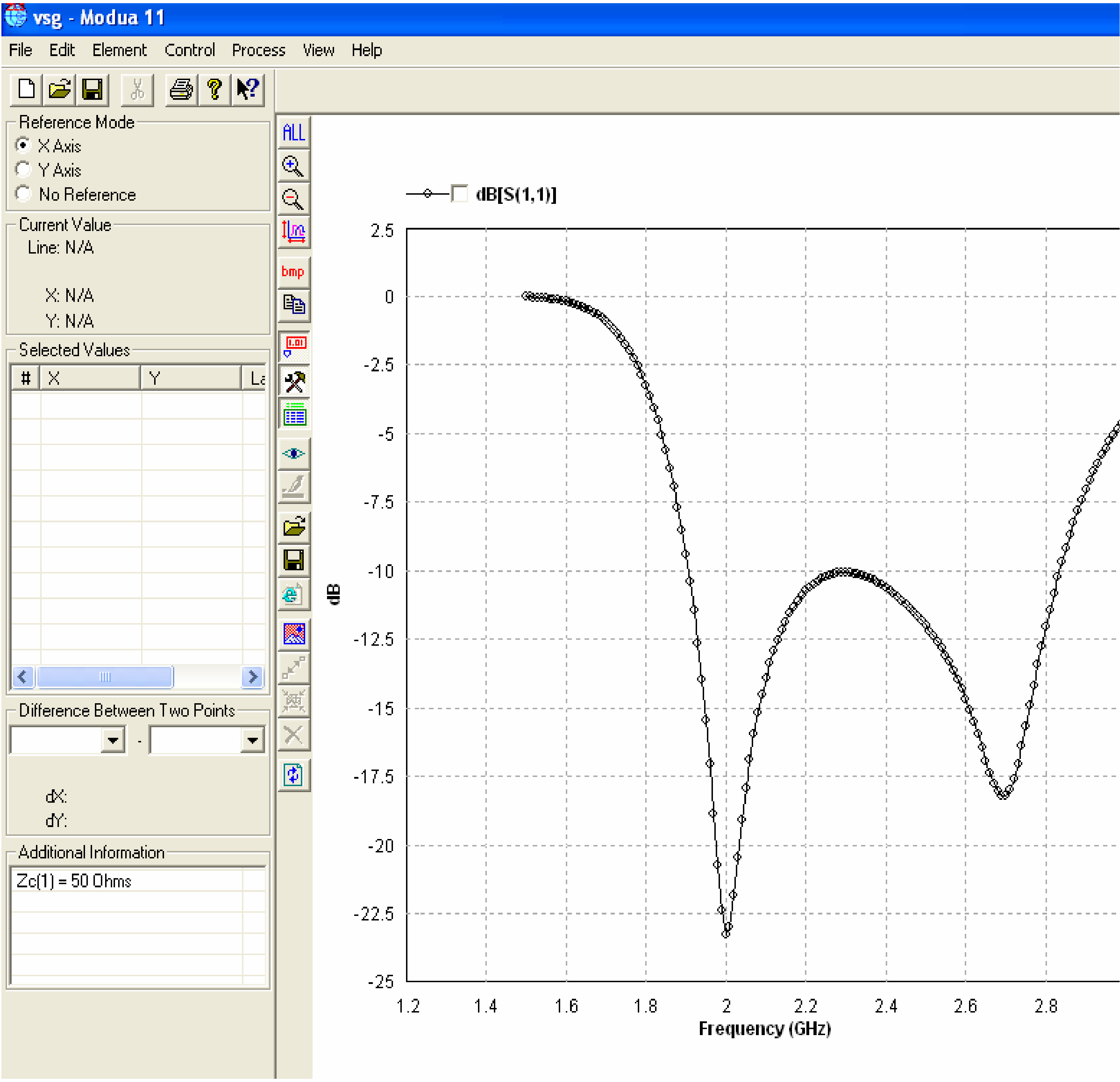
dY: 0

Additional Information

DESIGN 2



S11(db) PARAMETER



Reference Mode

● X Axis
○ Y Axis
○ No Reference

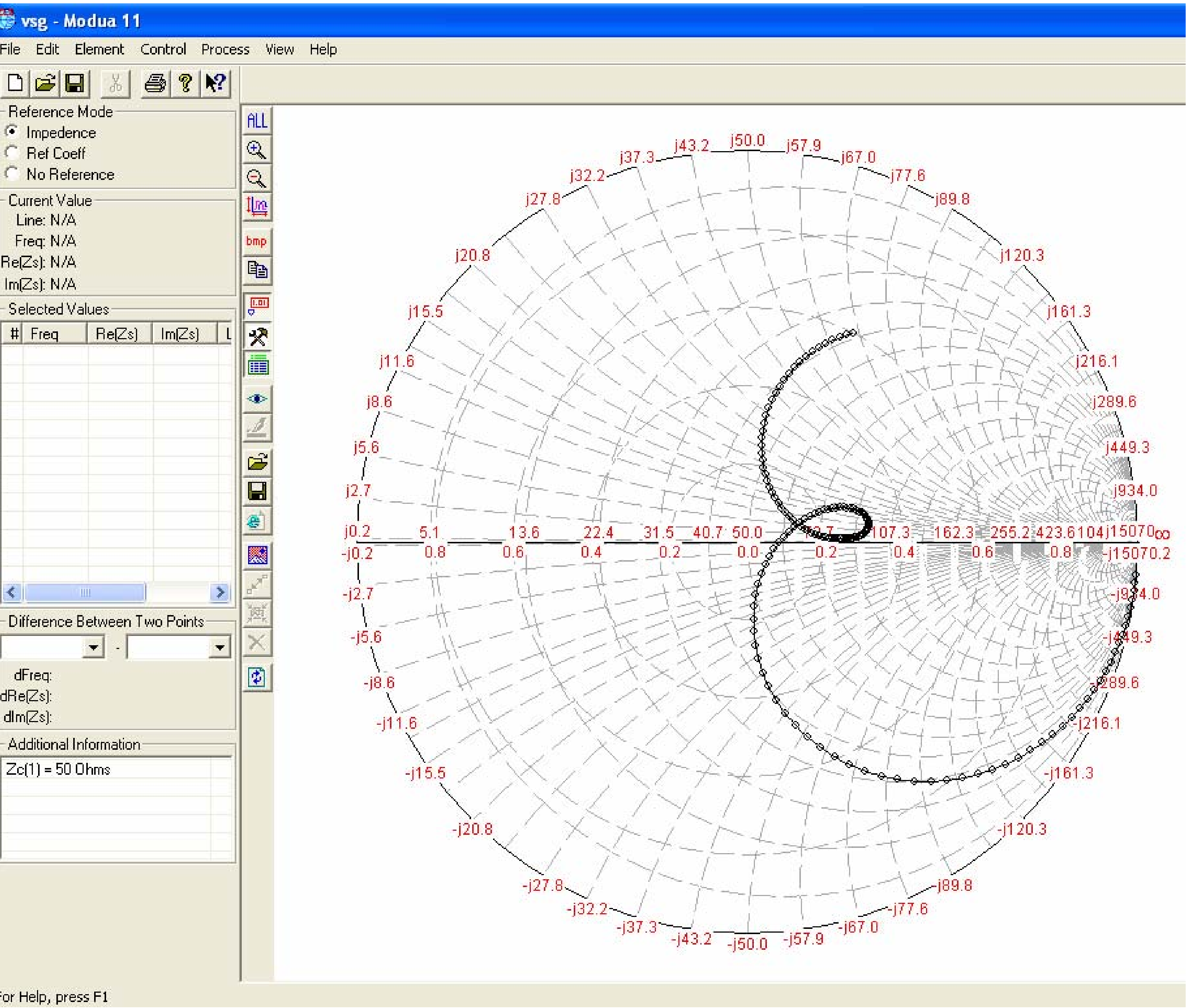
Current Value

Line: N/A

X: N/A
Y: N/A

Additional Information

Zc(1) = 50 Ohms



vsg - Modua 11

Reference Mode
● Impedence
○ Ref Coeff
○ No Reference

Current Value
Line: N/A
Freq: N/A
Re(Zs): N/A
Im(Zs): N/A

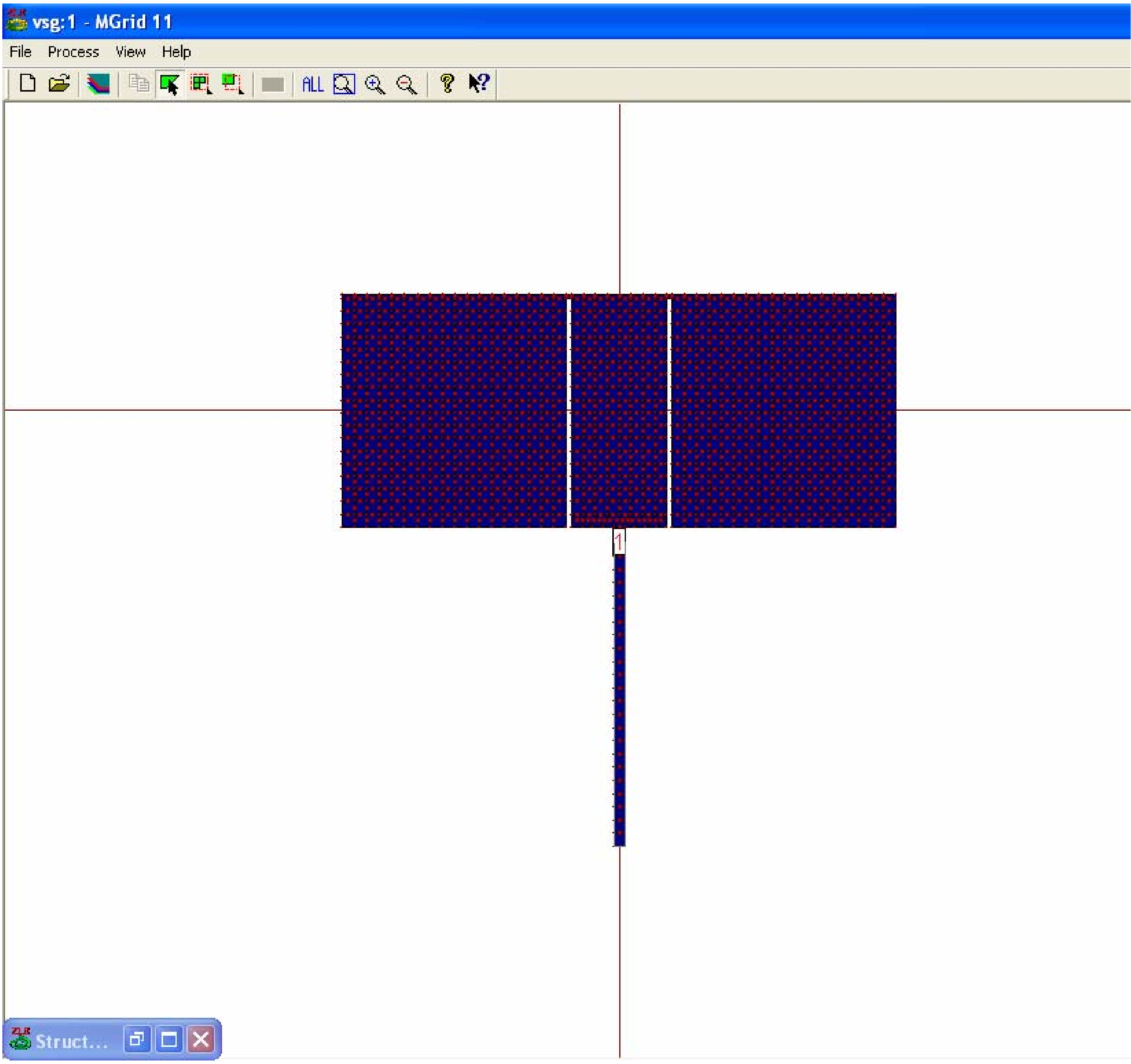
Selected Values

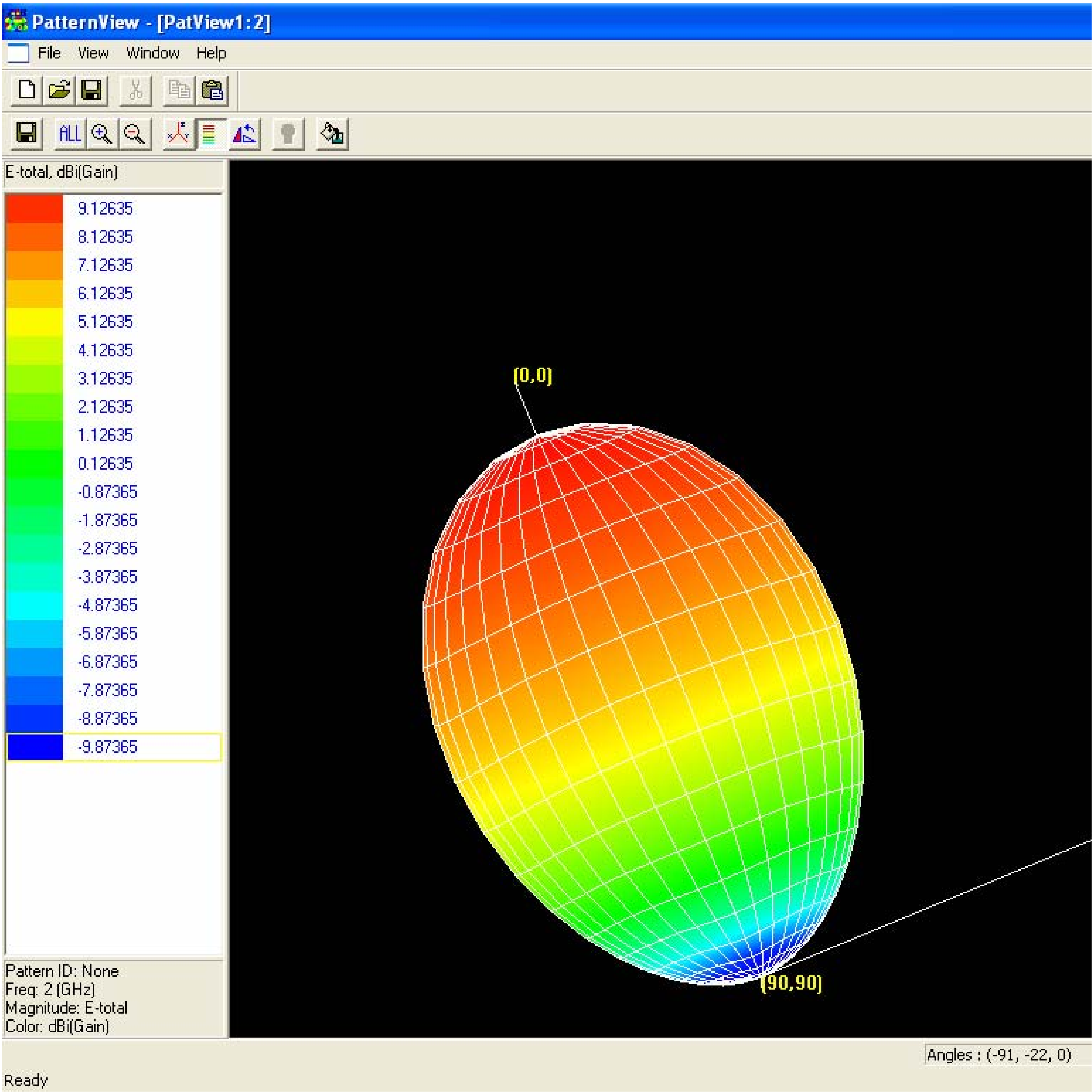
#	Freq	Re(Zs)	Im(Zs)	L

Difference Between Two Points
dFreq:
dRe(Zs):
dIm(Zs):

Additional Information
Zc(1) = 50 Ohms

or Help, press F1

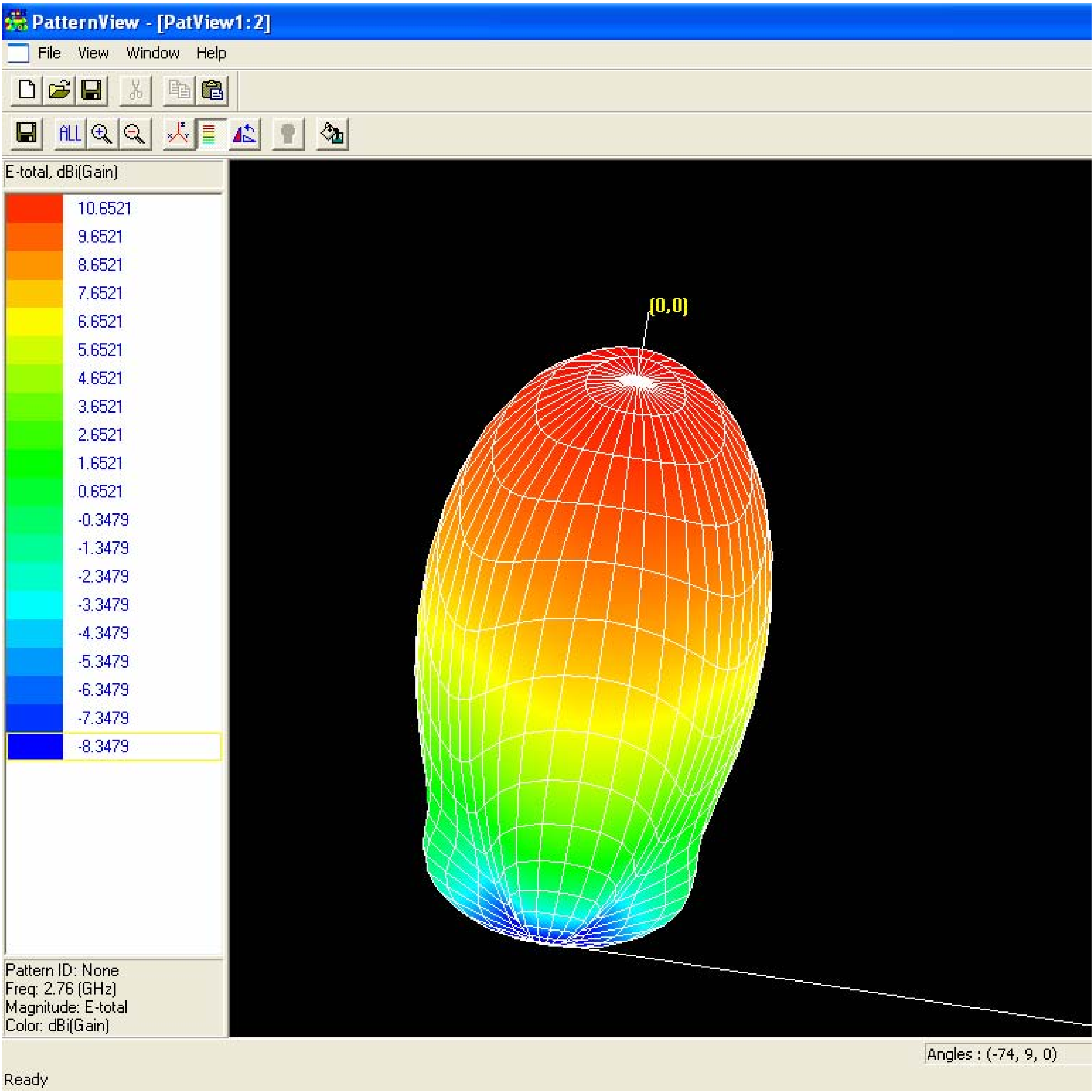

vsg:1 - MGrid 11
File
Process
View
Help
ALL
1
Struct...



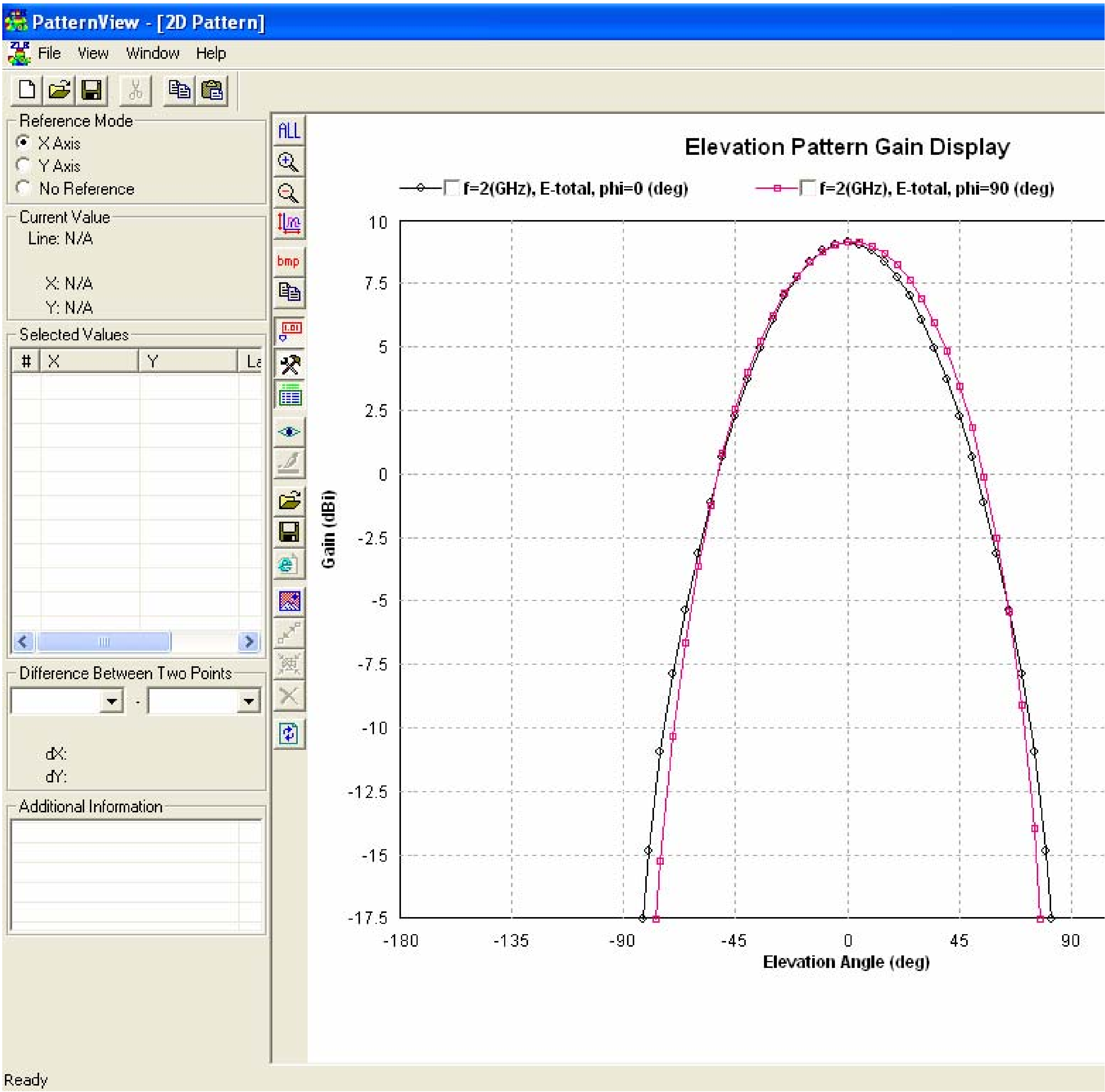
Pattern ID: None
Freq: 2 (GHz)
Magnitude: E-total
Color: dBi(Gain)

Angles : (-91, -22, 0)

Ready

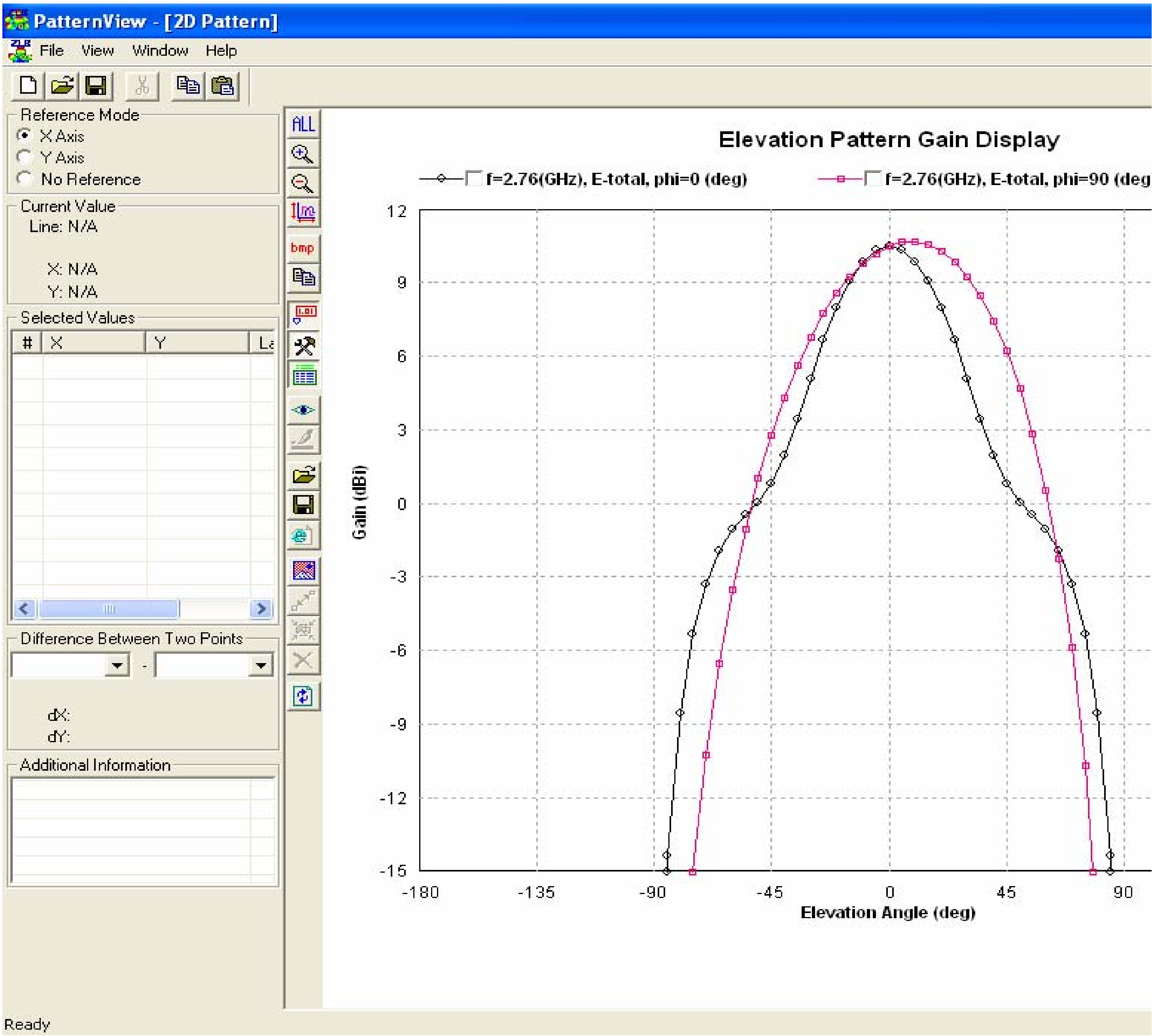


Pattern ID: None
Freq: 2.76 (GHz)
Magnitude: E-total
Color: dBi(Gain)



Reference Mode
● X Axis
○ Y Axis
○ No Reference

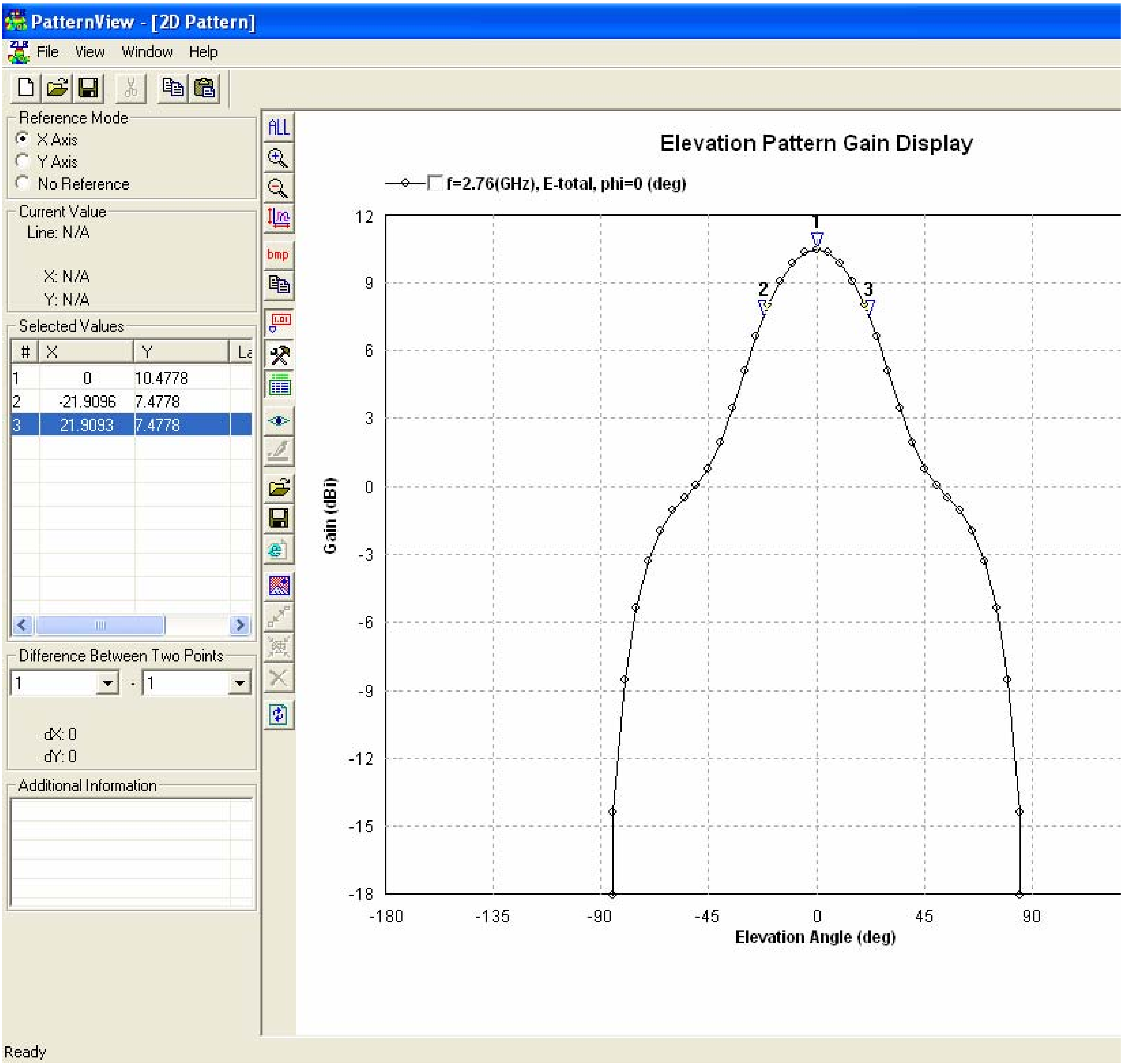
Current Value
Line: N/A
X: N/A
Y: N/A



Reference Mode: ● X Axis ○ Y Axis ○ No Reference

Current Value
Line: N/A
X: N/A
Y: N/A

3 dB Beam width at second resonance =2.76 GHz



Reference Mode

● X Axis
○ Y Axis
○ No Reference

Current Value

Line: N/A

X: N/A
Y: N/A

Selected Values

#	X	Y	La
1	0	10.4778	
2	-21.9096	7.4778	
3	21.9093	7.4778	

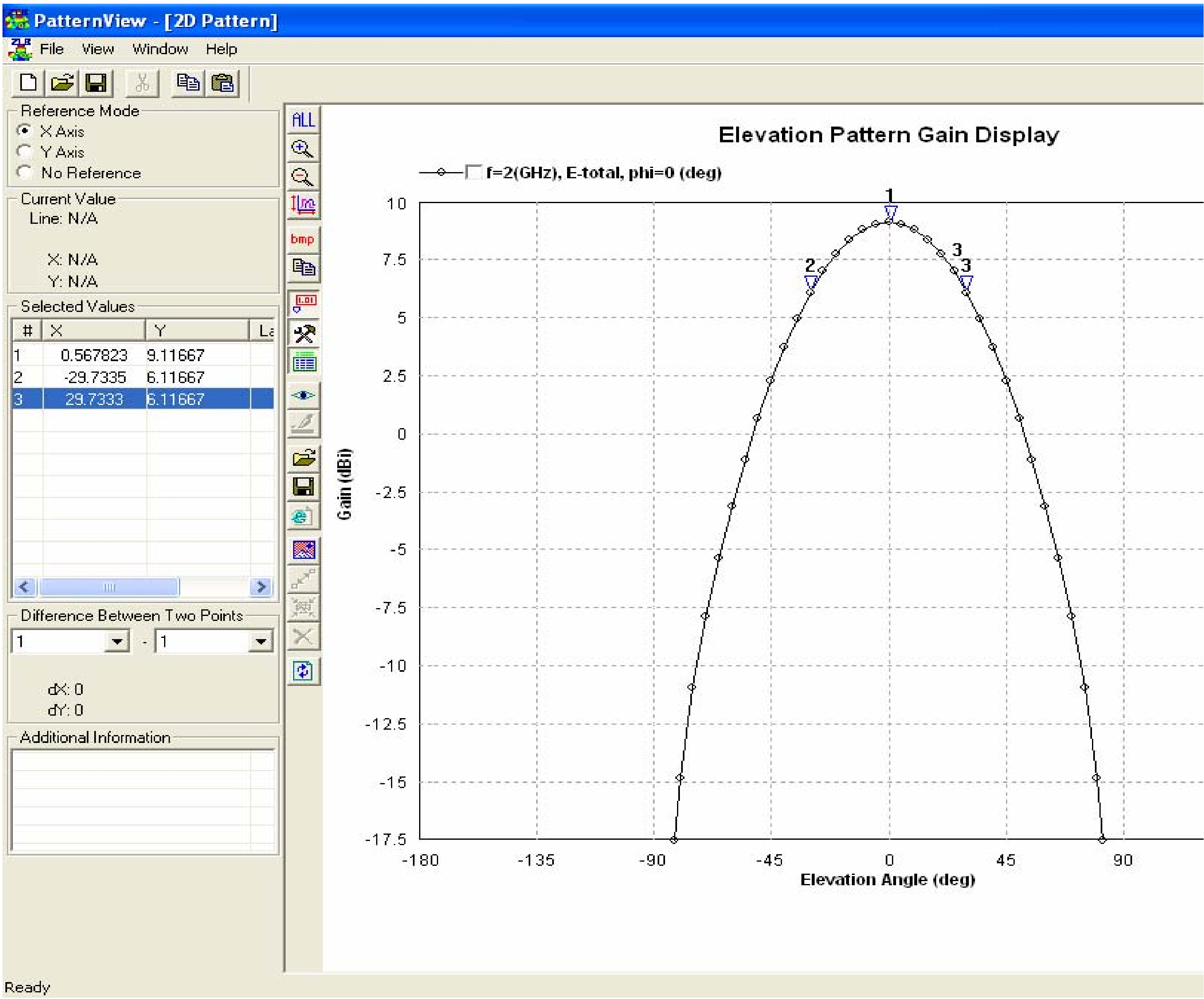
Difference Between Two Points

1 - 1

dX: 0
dY: 0

Additional Information

3 dB Beam width at first resonance =2 GHz



Reference Mode

● X Axis
○ Y Axis
○ No Reference

Current Value

Line: N/A

X: N/A
Y: N/A

Selected Values

#	X	Y	La
1	0.567823	9.11667	
2	-29.7335	6.11667	
3	29.7333	6.11667	

Difference Between Two Points

1 - 1

dX: 0
dY: 0

Additional Information

Ready

CHAPTER 6

DISCUSSIONS ON RESULTS

DISCUSSION

Through this project report, we have proposed two new designs for high bandwidth antenna and obtained the results of simulation for the proposed antennas as follows:-

1.Design 1- two shorted coplanar patch antenna:-

Simulations are obtained using IE3D Software for antenna design .According to simulated result ,the simulated bandwidth (For return loss<-10db) is about 20 % from 1.78 to 2.18 Ghz.There are two resonant frequency ,one at near 1.85 and the other at near 2.1GHZ.The large circle in the smith chart indicates good matching over a broad band of frequencies.Hence these results confirms that this method of introducing additional radiating resonances is feasible and deserves further study and optimization.

2.Design 2- E-shaped patch antenna:-

Simulations are obtained using IE3D Software for antenna design . According to simulated result , it is seen that two adjacent resonant modes are excited, which leads to a wide bandwidth. They are centered near 2ghz and 2.7 ghz. The bandwidth determined from -10 db return loss ,is 0.95ghz or about 40% with respect to centre frequency 2.375 ghz . The -10 db return loss band is from 1.9ghz to 2.85ghz. Hence these results confirms that this method of introducing additional radiating resonances is feasible and deserves further study and optimization.

CONCLUSION

Bandwidth enhancement techniques for microstrip patch antennas have been discussed. .Here, two novel forms are proposed for small size wideband microstrip patch antenna .they are designed, measured and characterized in detail .Insertion of slots and use of shorting pins in the patches has been successfully used to minimize the size of the proposed antennas .Use of electromagnetic coupling between two resonators ,where one is driven and the other is parasitic, produces two or multiple nearby resonant frequencies in the input response .through these multiple nearby resonant frequencies wide band antennas have been achieved.

CHAPTER 7

SOFTWARE FOR SIMULATION

IE3D SOFTWARE

IE3D is an integrated full-wave electromagnetic simulation and optimization package for the analysis and design of 3-dimensional microstrip antennas and high frequency printed circuits and digital circuits, such as microwave and millimeter wave integrated circuits(MMICS) and high speed printed circuit boards (PCB).

IE3D has been adopted as an industrial standard in planar and 3-dimensional electromagnetic simulation .It is a technology for electromagnetic simulation to yield high accuracy analysis and design of complicated microwave and RF printed circuit, antennas, high speed digital circuits and other electronic components.

The IE3D has become the most versatile ,easy to use, efficient and accurate electromagnetic simulation tool.

IE3D APPLICATION PROGRAMS & ITS CAPABILITY

The IE3D package consists of the following major application programs:-

- **MGRID:-** Layout editor for the construction of a geometry and post processor for current display and pattern calculation.
- **IE3D:-**Electromagnetic simulator or simulation engine for numerical analysis.
- **MODUA:-**Schematic editor for parameter display and nodal circuit simulation
- **PATTERNVIEW:-**Post processor for radiation patterns.
- **IE3D LIBRARY:-** The object oriented 2nd IE3D interface for parameterized geometry construction.
- **CURVIEW:-**Post processor for display of current distribution and field distribution.

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