PANIMALAR ENGINEERING COLLEGE

(A CHRISTIAN MINORITY INSTITUTION)

JAISAKTHI EDUCATIONAL TRUST

ACCREDITED BY NATIONAL BOARD OF ACCREDITATION (NBA)

BANGALORE TRUNK ROAD, VARADHARAJAPURAM, NASARATHPET, POONAMALLEE, CHENNAI – 600 123.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

ADDITIONAL LAB COURSE

ANTENNA DESIGN LAB

III ECE - VI SEMESTER

LAB MANUAL

(2017 – 2018 EVEN SEMESTER)

DEPARTMENT OF ECE

VISION

To emerge as a centre of excellence in providing quality education and produce technically competent Electronics and Communication Engineers to meet the needs of industry and Society.

MISSION

M1: To provide best facilities, infrastructure and environment to its students, researchers and faculty members to meet the Challenges of Electronics and Communication Engineering field.

M2: To provide quality education through effective teaching – learning process for their future career, viz placement and higher education.

M3: To prepare strong insight in the core domains with industry interaction.

M4: To Prepare graduates adaptable to the changing requirements of the society through life long learning.

PROGRAMME EDUCATIONAL OBJECTIVES

1. To prepare graduates to analyze, design and implement electronic circuits and systems using the knowledge acquired from basic science and mathematics.

2. To train students with good scientific and engineering breadth so as to comprehend, analyze, design and create novel products and solutions for real life problems.

3. To introduce the research world to the graduates so that they feel motivated for higher studies and innovation not only in their own domain but multidisciplinary domain.

4. Prepare graduates to exhibit professionalism, ethical attitude, communication skills, teamwork and leadership qualities in their profession and adapt to current trends by engaging in lifelong learning.

5. To practice professionally in a collaborative, team oriented manner that embraces the multicultural environment of today's business world.

PROGRAMME OUTCOMES

1. **Engineering Knowledge:** Able to apply the knowledge of Mathematics, Science, Engineering fundamentals and an Engineering specialization to the solution of complex Engineering problems.
2. **Problem Analysis:** Able to identify, formulate, review research literature, and analyze

complex Engineering problems reaching substantiated conclusions using first principles of Mathematics, Natural sciences, and Engineering sciences.
3. **Design / Development of solutions:** Able to design solution for complex Engineering problems and design system components or processes that meet the specified needs with appropriate considerations for the public health and safety and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Able to use Research - based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Able to create, select and apply appropriate techniques, resources, and modern Engineering IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.
6. **The Engineer and society:** Able to apply reasoning informed by the contextual knowledge to access societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional Engineering practice.
7. **Environment and sustainability:** Able to understand the impact of the professional Engineering solutions in societal and environmental context, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Able to apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice.
9. **Individual and Team work:** Able to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Able to communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project Management and Finance:** Able to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life – long learning:** Able to recognize the needs for, and have the preparation and ability to engage in independent and life-long learning in the broadest contest of technological change.

PROGRAMME SPECIFIC OUTCOMES

1. Graduates should demonstrate an understanding of the basic concepts in the primary area of Electronics and Communication Engineering, including: analysis of circuits containing both active and passive components, electronic systems, control systems, electromagnetic systems, digital systems, computer applications and communications
2. Graduates should demonstrate the ability to utilize the mathematics and the fundamental knowledge of Electronics and Communication Engineering to design complex systems which may contain both software and hardware components to meet the desired needs.
3. The graduates are capable of excelling in Electronics and Communication Engineering industry/Academic/Software companies through professional careers.

COURSE OBJECTIVES

At the end of the course, students will

- Understand measurement of antenna parameters and application of basic theorems in analyzing radiation characteristics of antenna.
- Design and implement antennas using EM simulation tools.

COURSE OUTCOMES

At the end of the course, students will be able to

- Demonstrate the structure and operation of various antennas and to describe their parameters.
- Apply basic theorems to analyze the variation of field strength of radiated waves.
- Measure the radiation pattern of wired, aperture, planar and array antennas.
- Familiar with EM simulation tools to implement antenna prototypes.

LIST OF EXPERIMENTS

1. Study of the structure and operation of wired, aperture, planar and array antennas.
2. Proof of Inverse square law
3. Proof of Reciprocity theorem
4. Measurement of radiation pattern of all wired and aperture antennas
5. Measurement of radiation pattern of planar antennas
6. Measurement of radiation pattern of reflector antennas
7. Measurement of radiation pattern of array antennas
8. Analysis of co-polarization and cross polarization
9. Design and simulation of microstrip antenna using CST tool.
10. Measurement of antenna parameters using Network Analyzer.

SCHEDULE

Ex.No.	Name of the Experiments	No. of classes	Mode of teaching
1.	Study of the structure and operation of wired, aperture, planar and array antennas.	1	Demo
2.	Proof of Inverse square law	1	Using AMS kit
3.	Proof of Reciprocity theorem		
4.	Measurement of radiation pattern of all wired and aperture antennas		
5.	Measurement of radiation pattern of planar antennas	1	Using AMS kit
6.	Measurement of radiation pattern of reflector antennas		
7.	Measurement of radiation pattern of array antennas		
8.	Analysis of co-polarization and cross polarization		
9.	Design and simulation of microstrip antenna using CST tool.	1	Using CST software
10.	Measurement of antenna parameters using Network Analyzer.	1	Using Network Analyzer

EXPERIMENT NO.1

STUDY OF THE STRUCTURE AND OPERATION OF WIRED, APERTURE, PLANAR AND ARRAY ANTENNAS

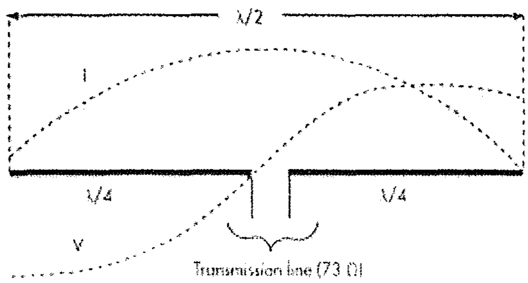
Dipole antenna

In radio and telecommunications a dipole antenna or doublet is the simplest and most widely used class of antenna. The dipole is any one of a class of antennas producing a radiation pattern approximating that of an elementary electric dipole with a radiating structure supporting a line current so energized that the current has only one node at each end. A dipole antenna commonly consists of two identical conductive elements such as metal wires or rods, which are usually bilaterally symmetrical

The driving current from the transmitter is applied, or for receiving antennas the output signal to the receiver is taken, between the two halves of the antenna. Each side of the feedline_to the transmitter or receiver is connected to one of the conductors. This contrasts with a monopole antenna, which consists of a single rod or conductor with one side of the feedline connected to it, and the other side connected to some type of ground. A common example of a dipole is the "rabbit ears" television antenna found on broadcast television sets.

The most common form of dipole is two straight rods or wires oriented end to end on the same axis, with the feedline connected to the two adjacent ends, but dipoles may be fed anywhere along their length This is the simplest type of antenna from a theoretical point of view. Dipoles are resonant antennas, meaning that the elements serve as resonators, with standing waves of radio current flowing back and forth between their ends. So the length of the dipole elements is determined by the wavelength of the radio waves used.

The most common form is the half-wave dipole, in which each of the two rod elements is approximately 1/4 wavelength long, so the whole antenna is a half-wavelength long. The radiation pattern of a vertical dipole is omnidirectional; it radiates equal power in all azimuthal directions perpendicular to the axis of the antenna. For a half-wave dipole the radiation is maximum, 2.15 dBi perpendicular to the antenna axis, falling monotonically with elevation angle to zero on the axis, off the ends of the antenna.



Advantages:

1. It receives balanced signals.
2. Receives signals from a variety of frequencies.
3. Loss is less.

Disadvantages:

1. The outdoor antennas are large and wide.
2. This type of antenna is no t used for space communication.
3. Installation of outdoor antennas is difficult.

Applications:

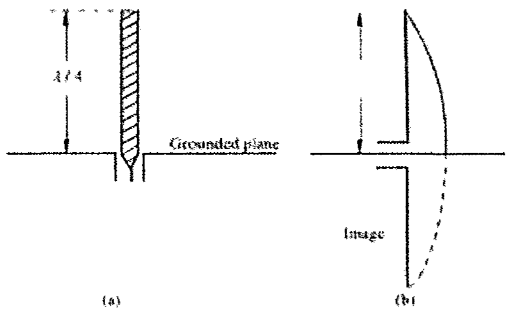
1. Set-top TV antenna.
2. FM broadcasting antenna.
3. Dipole towers and dipole arrays.

Monopole antenna

A monopole antenna is one half of a dipole antenna, almost always mounted above some sort of ground plane. The case of a monopole antenna of length *L* mounted above an infinite ground plane.

The radiation pattern of monopole antennas above a ground plane are also known from the dipole result. The only change that needs to be noted is that the impedance of a monopole antenna is one half of that of a full dipole antenna. For a quarter-wave monopole ($L=0.25*\lambda$), the impedance is half of that of a half-wave dipole, so Zin = 36.5 + j21.25 Ohms. This can be understood since only half the voltage is required to drive a monopole antenna to the same current as a dipole (think of a dipole as having +V/2 and -V/2 applied to its ends, whereas a monopole antenna only needs to apply +V/2 between the monopole antenna and the ground to drive the same current). Since Zin = V/I, the impedance of the monopole antenna is halved.

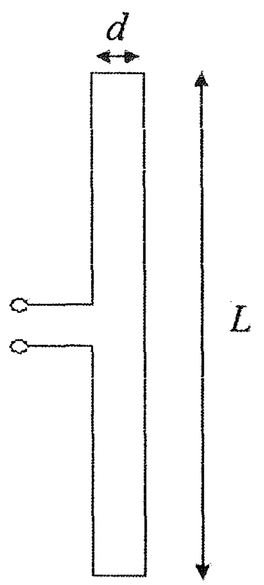
Monopole antennas are half the size of their dipole counterparts, and hence are attractive when a smaller antenna is needed. Antennas on older cell phones were typically monopole antennas, with an infinite ground plane approximated by the shell (casing) of the phone.



Folded dipole

A folded dipole is a dipole antenna with the ends folded back around and connected to each other, forming a loop. Typically, the width *d* of the folded dipole antenna is much smaller than the length *L*. Because the folded dipole forms a closed loop, one might expect the input impedance to depend on the input impedance of a short-circuited transmission line of length *L*. However, you can imagine the folded dipole antenna as two parallel short-circuited transmission lines of length *L*/2 (separated at the midpoint by the feed in Figure). It turns out the impedance of the folded dipole antenna will be a function of the impedance of a transmission line of length *L*/2.

Also, because the folded dipole is "folded" back on itself, the currents can reinforce each other instead of cancelling each other out, so the input impedance will also depend on the impedance of a dipole antenna of length *L*.



Advantages:

1. Reception of balanced signals.
2. Receives a particular signal from a band of frequencies without losing the quality.
3. A folded dipole maximizes the signal strength.

Disadvantages:

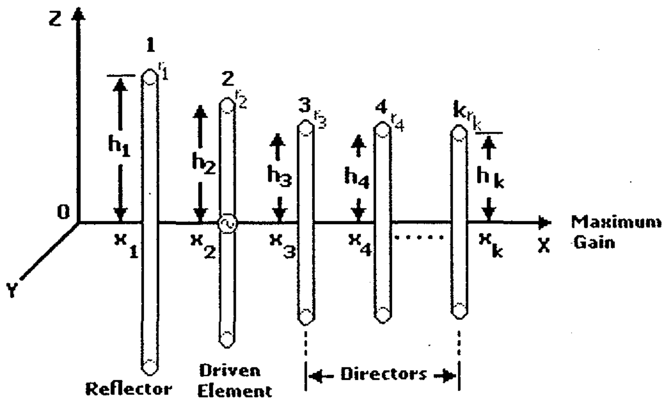
1. Displacement and adjustment of antenna is a hassle.
2. Outdoor management can be difficult when antenna size increases.

Applications:

1. Mainly used as a feeder element in Yagi antenna, parabolic antenna, turnstile antenna, log periodic antenna, phased and reflector arrays, etc.
2. Generally used in radio receivers.
3. Most commonly used in TV receiver antennas.

Yagi antenna

The Yagi-Uda antenna or Yagi Antenna is simple to construct and has a high gain, typically greater than 10 dB. The Yagi-Uda antennas typically operate in the HF to UHF bands (about 3 MHz to 3 GHz), although their bandwidth is typically small, on the order of a few percent of the center frequency. The elements of yagi antenna are Directors, Reflector and Driven element. It is used as a TV receiving antenna.



Geometry of a K elements Yagi-Uda

Advantages:

1. High gain is achieved.
2. High directivity is achieved.
3. Ease of handling and maintenance.
4. Less amount of power is wasted.
5. Broader coverage of frequencies.

Disadvantages:

1. Prone to noise.
2. Prone to atmospheric effects.

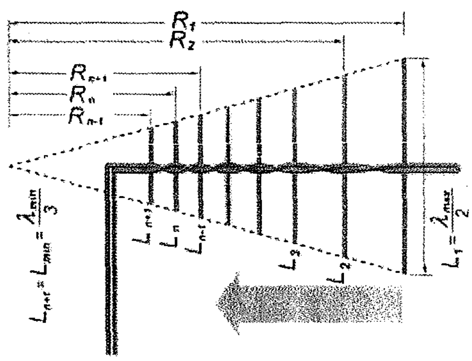
Applications:

1. Mostly used for TV reception.
2. Used where a single-frequency application is needed.

Log periodic dipole array

The log periodic dipole array consists of a number of dipole elements. These progressively reduce in size from the back to the front – the direction of maximum radiation is from the smaller front.

Each dipole element of the LPDA is fed, but the phase is reversed between adjacent dipole elements – this ensures that the signal phasing is correct between the different elements. It also means that a feeder is required along the length of the antenna.



Advantages:

1. The antenna design is compact.
2. Gain and radiation pattern are varied according to the requirements.

Disadvantages:

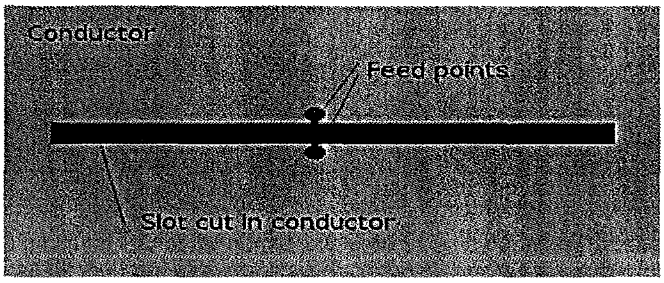
1. External mount.
2. Installation cost is high.

Applications:

1. Used for HF communications.
2. Used for particular sort of TV receptions.
3. Used for all round monitoring in higher frequency bands.

Slot antenna

The slot antenna consists of a radiator formed by cutting a narrow slot in a large metal surface. The slot length is a half wavelength at the desired frequency and the width is a small fraction of a wavelength. The antenna is frequently compared to a conventional half- wave dipole consisting of two flat metal strips. When energy is applied to the slot antenna, currents flow in the metal sheet. These currents are not confined to the edges of the slot but rather spread out over the sheet. Radiation then takes place from both sides of the sheet.



Advantages:

- It can be fabricated and concealed within metallic objects
- It can provide covert communications with a small transmitter

Disadvantages:

- Higher cross-polarization levels
- Lower radiation efficiency

Applications:

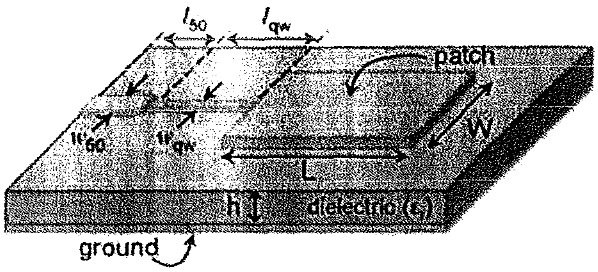
- Usually for radar navigational purposes
- Used as an array fed by a wave guide

Microstrip antenna

Microstrip antenna is one of the most popular types of printed antenna. It plays a very significant role in today's world of wireless communication systems. Microstrip antennae are very simple in construction using a conventional microstrip fabrication technique. Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate (FR4) that has a ground plane (Cu) on the other side as shown in Fig.

The patch is generally made up of a conducting material such as copper or gold and can take any possible shape like rectangular, circular, triangular, elliptical or some other common shape. The radiating patch and the feed lines are usually photo-etched on the dielectric substrate.

Microstrip patch antennae radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant (<6) is desirable since it provides higher efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna size.



Advantages:

1. Ease of manufacturing
2. It has a very low fabrication cost.
3. Microstrip patch antennas are efficient radiators.
4. It has a support for both linear and circular polarization.
5. Easy in integration with microwave integration circuits.

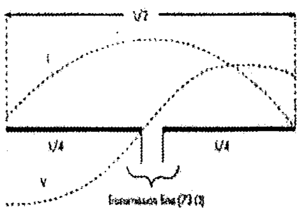
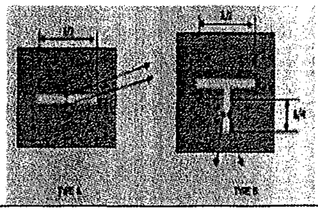
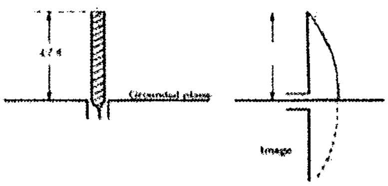
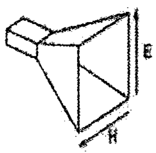
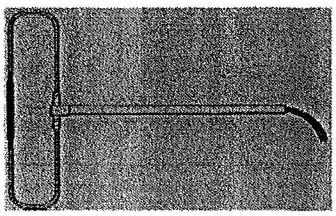
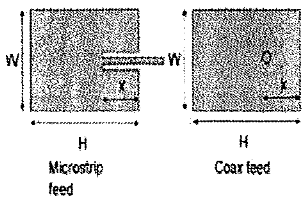
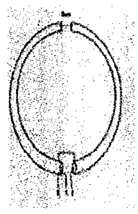
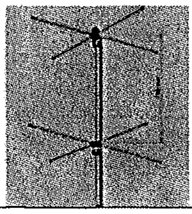
Disadvantages:

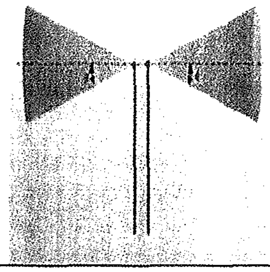
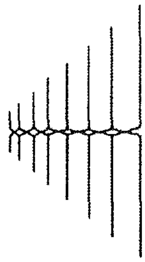
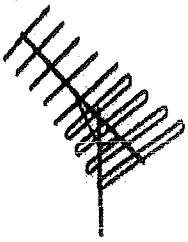
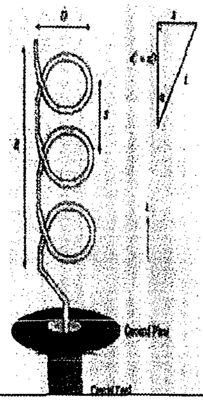
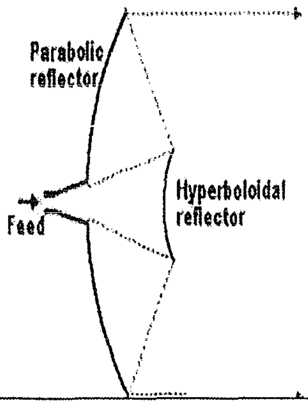
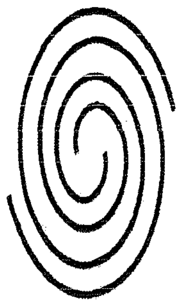
1. Low impedance bandwidth.
2. Low gain.
3. Extra radiation occurs from its feeds and junctions.
4. Excitation of surface waves.
5. Size of micro strip antenna comes in both advantages and disadvantages but there are some applications where the size of microstrip antenna is too large to be used.

Applications:

1. Mobile and satellite communication.
2. Global Positioning System, RFID, Wimax, Radar, rectenna and telemedicine applications.

Table: Various Antenna configurations and its applications

Name of the Antenna	Applications	Name of the Antenna	Applications
Half Wave dipole antenna 	AM and FM broadcasting	Slot antenna 	Broadband and dual band applications
Monopole antenna 	Mobile phone receivers	Horn antenna 	Microwave applications
Folded dipole antenna 	Driven element for Yagi array	Microstrip Patch antenna 	WLAN, Wi Fi and Wi Max applications
Loop antenna 	Radio receivers, Aircraft receivers, Direction finding & UHF transmitters	Turnstile antenna 	FM and base station receivers

Biconical antenna 	VHF and UHF band and airport communication	Log Periodic Dipole array 	Military reception
Yagi Uda array 	TV reception	Helical antenna 	High gain satellite communication and GPS
Parabolic reflector 	Used in DTH and TV reception	Spiral antenna 	Military and aircraft applications

EXPERIMENT NO : 2

TO PROVE INVERSE SQUARE LAW

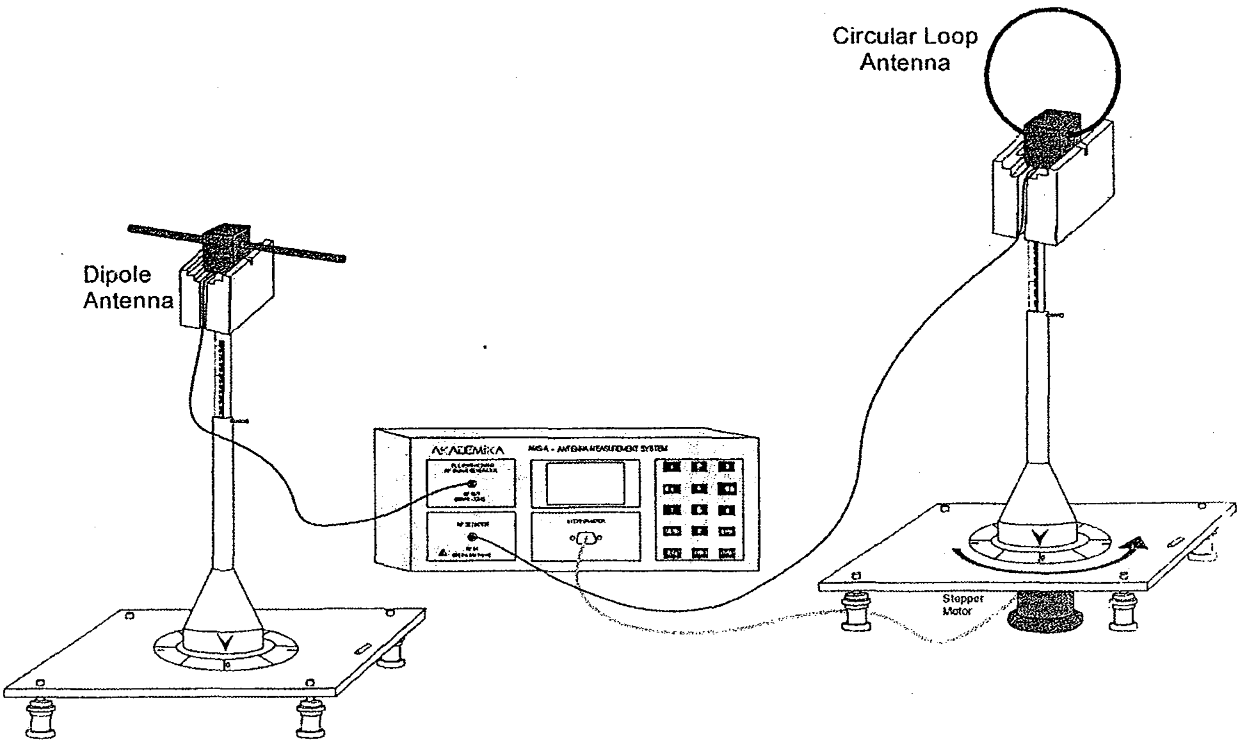
OBJECTIVE

To Measure the variation of field strength of radiated wave, with distance from transmitting antenna.

EQUIPMENT REQUIRED:

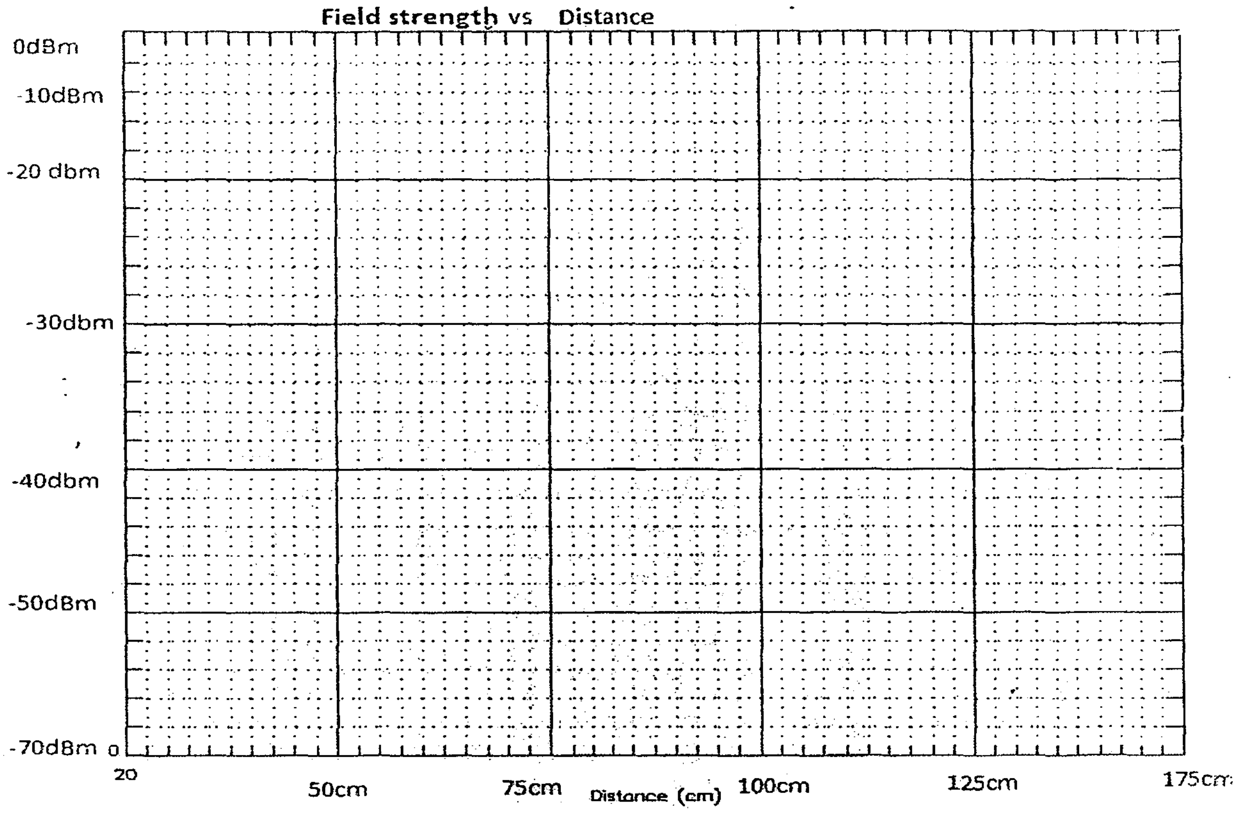
TX antenna	**RX antenna**	**Transmitter input**	**Receiver output**	**CABLE**
Wire or Microstrip DIPOLE	Any antenna	Source (RF output)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

SETUP ARRANGEMENT:



PROCEDURE:

1. Set up the experiment as per shown in figure above.
2. Turn ON the module, select control mode.
3. Open the AMS-A.exe file Select the corresponding COM PORT and Click on Run, Now the software will be in running mode.
4. Select the PROOF OF THEOREM and then select the experiment of INVERSE SQUARE LAW.
5. Then select the RX antenna and click on START button.
6. A Pop-Up window will appear asking user to Keep the Distance between TX and RX as 10cm then click on NEXT button.
7. After completion of one reading again a popup window will appear asking to Increase the TX and RX distance by 10cm.
8. Repeat the procedure up to a distance of 100cm at an interval of 10cm; click on NEXT to plot the graph.
9. After that it will plot the radiation pattern in inverse square law graph (i.e. Distance in cm V/S power in dBm).
10. While taking the readings, ensure that no scattering objects are in the vicinity of the antenna, this could reradiate and distort the field pattern and consequently the readings. Avoid any movement of persons while taking the readings.
11. Plot these readings manually on graph paper with distance between antennas on X axis and signal level in dB at Y-axis.
12. Use the graph template provided below for plotting your graph.
13. Now take the readings and observe the plots for different types of antenna.



Field strength vs Distance
0dBm
-10dBm
-20 dbm
-30dbm
-40dbm
-50dBm
-70dBm 0
20
50cm
75cm
Distance (cm)
100cm
125cm
175cm

EXPERIMENT NO. 3

TO PROVE RECIPROCITY THEOREM

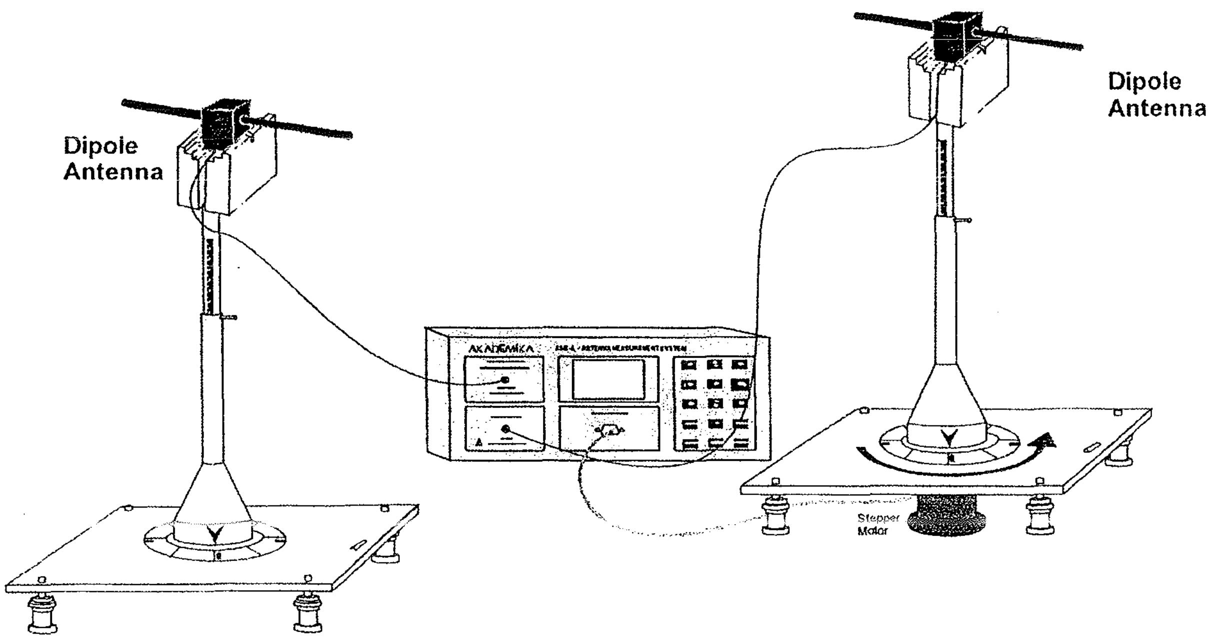
OBJECTIVE

To demonstrate that the transmitting and receiving radiation patterns of an antenna are equal and hence confirm the reciprocity theorem of antennas.

EQUIPMENT REQUIRED:

TX antenna	**RX antenna**	**Transmitter input**	**Receiver output**	**Cable**
Dipole RMSA	Dipole RMSA	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

SETUP ARRANGEMENT:



PROCEDURE:

1. Set up the experiment as per shown in figure above.
2. Set the distance between the antennas to be around 1meter, consult theory for details of far field region.
3. Turn ON the module, select control mode.
4. Open the AMS-A.exe file Select the corresponding COM PORT and Click on Run, Now the software will be in running mode.
5. Select the PROOF OF THEOREM and then select the experiment of RECIPROCITY THEOREM.
6. Then select the RX antenna and click on START button.
7. After completing it will plot the readings.
8. Now interchange the antenna and again take the next reading.
9. Compare both the plots they must be same, hence reciprocity theorem is proved.
10. Similarly do the experiments for different types of antenna.

NOTE:

1. ***<u>Keep in mind that an antenna that is being rotated is plotted in reception and transmission mode both for proving the reciprocity theorem.</u>***
2. ***<u>Observe the two plots and they must be approximately same.</u>***

EXPERIMENT NO. 4 a)

RADIATION PATTERN OF ALL WIRED ANTENNA

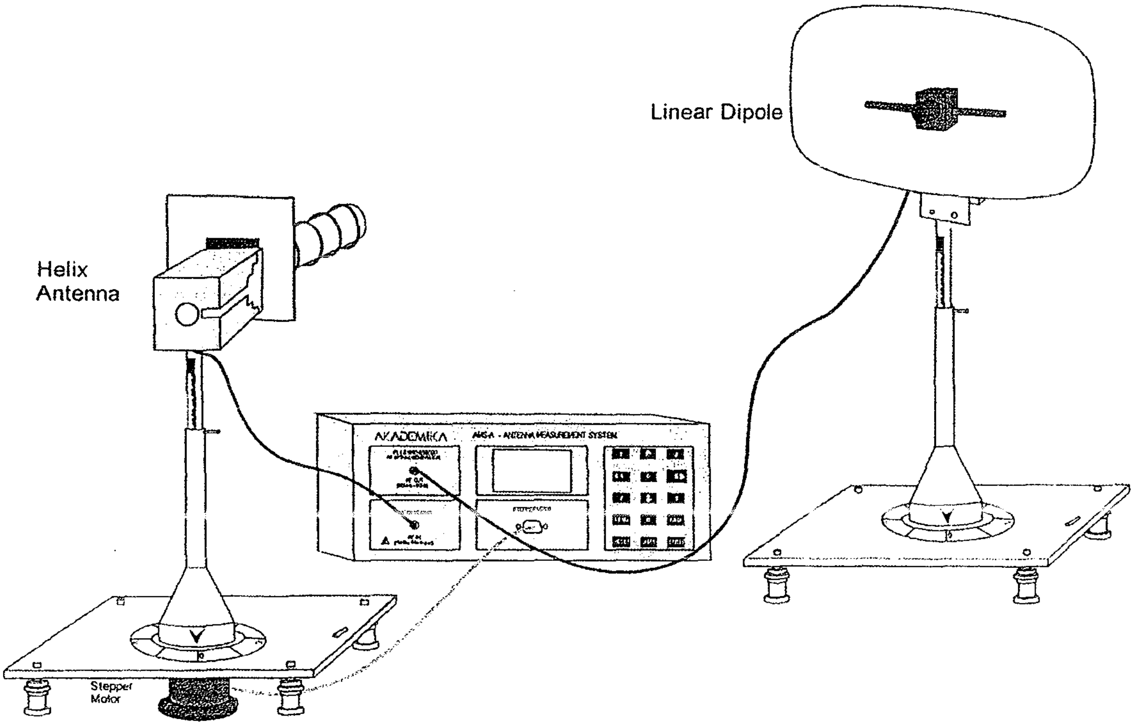
OBJECTIVE

To plot the Radiation pattern of all WIRED antenna and observe its parameters.

EQUIPMENT REQUIRED:

TX Antenna	RX antenna	Transmitter input	Receiver output	CABLE
Wire DIPOLE	Any wired antenna	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

SET UP ARRANGEMENT:



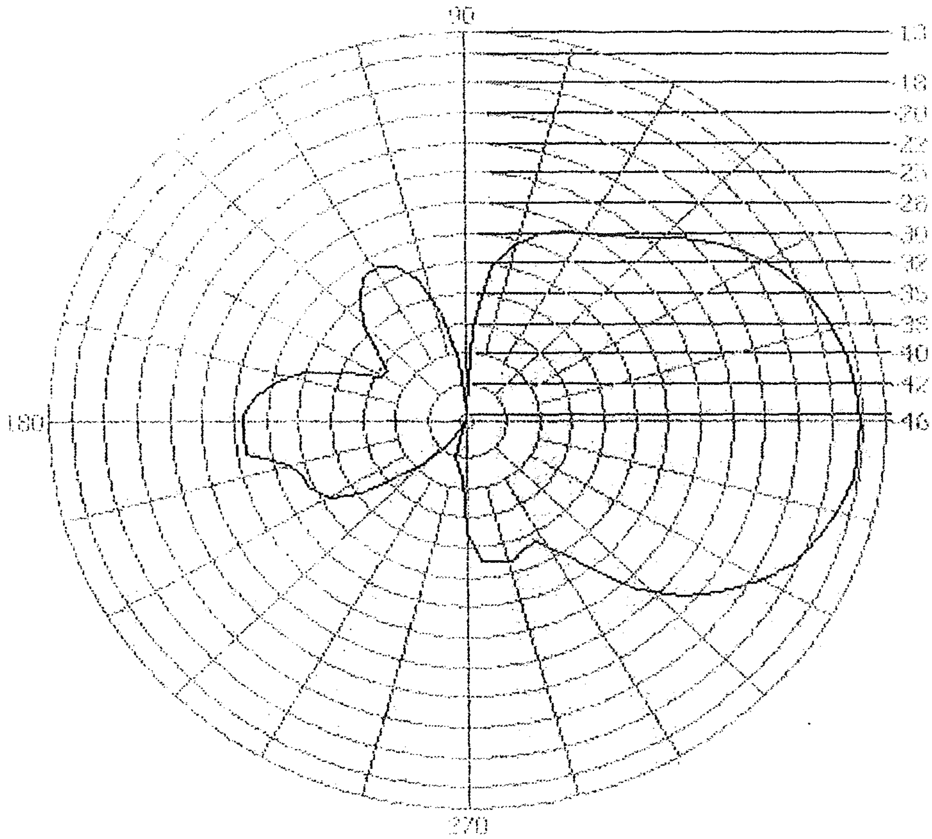
PROCEDURE:

1. Set up the experiment as per shown in figure above.
2. Set the distance between the antennas to be around 1meter, consult theory for details.
3. Turn ON the module, select control mode.
4. Open the AMS-A.exe file, select the corresponding COM PORT and Click on Run, Now the software will be in running mode.
5. Go in FAR FIELD PATTERN, select CO-POLARIZATION, select RX antenna then click on START
6. Then readings from 0 degree to 360 degree will be plotted in the software.
7. Now repeat for CROSS-POLARIZTION of antenna and observe the plot.
8. From SAVE option, the plot can be saved and take the printout whenever required.

Example 1)

TX antenna	RX antenna	**Transmitter input**	**Receiver output**	**Cable**
Wire Dipole	Helix	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

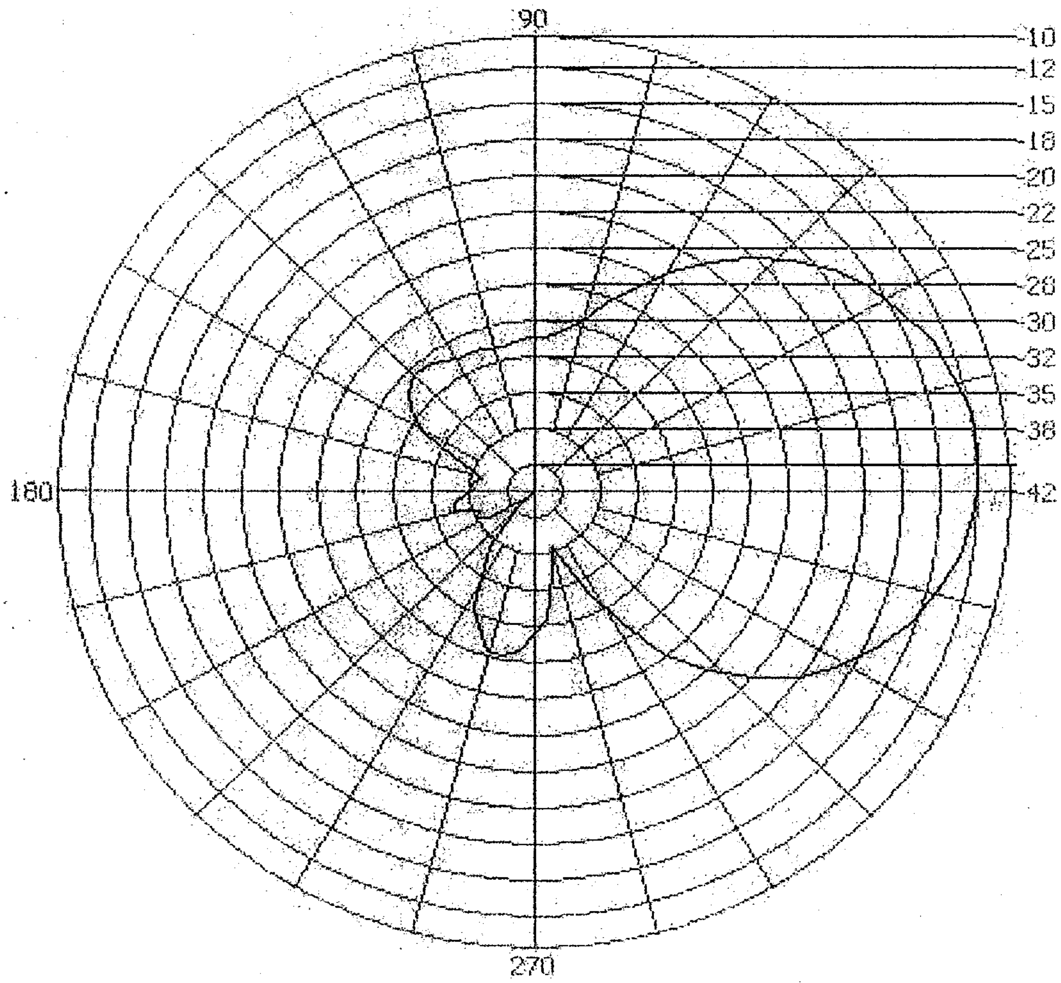
RADIATION PATTERN:



Example 2)

TX antenna	**RX antenna**	**Transmitter input**	**Receiver output**	**Cable**
Wire Dipole	Log periodic	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

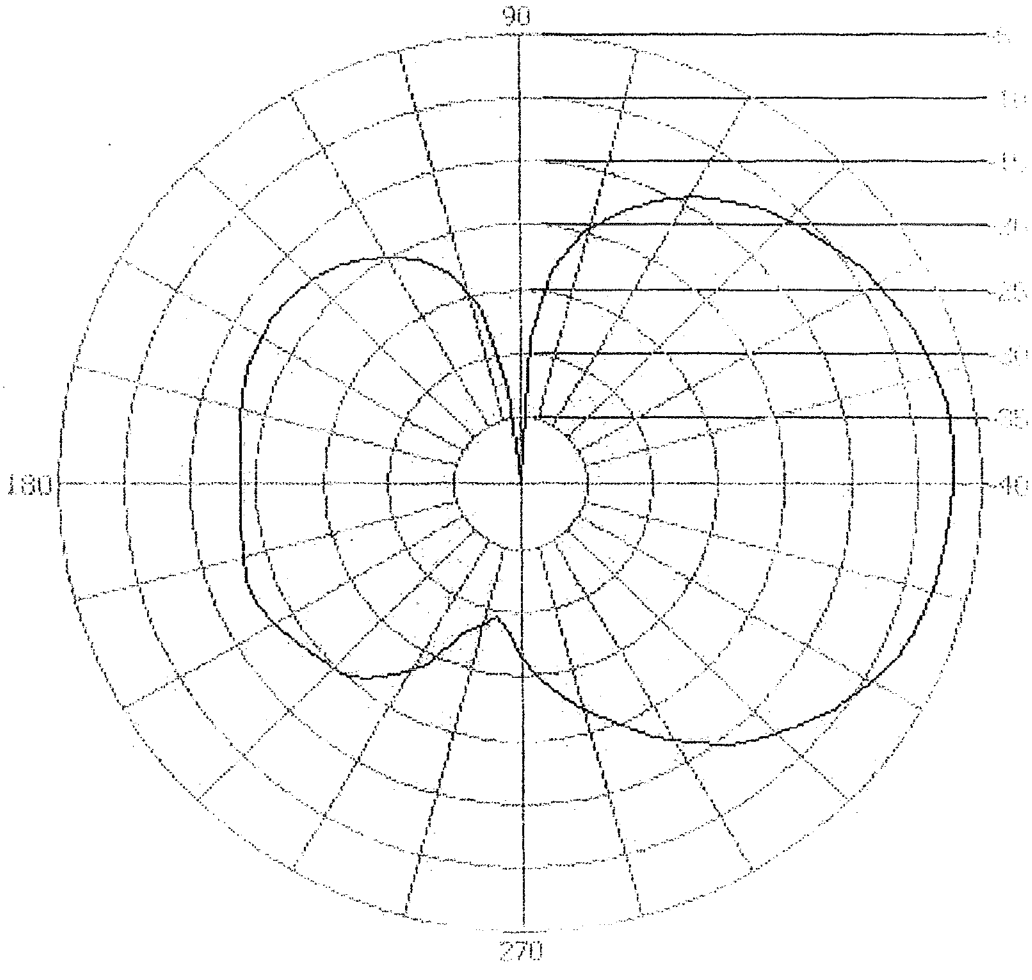
- **RADIATION PATTERN:**



Example 3)

TX antenna	RX antenna	Transmitter input	Receiver output	CABLE
Wire Dipole	Yagi UDA (5 elements)	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

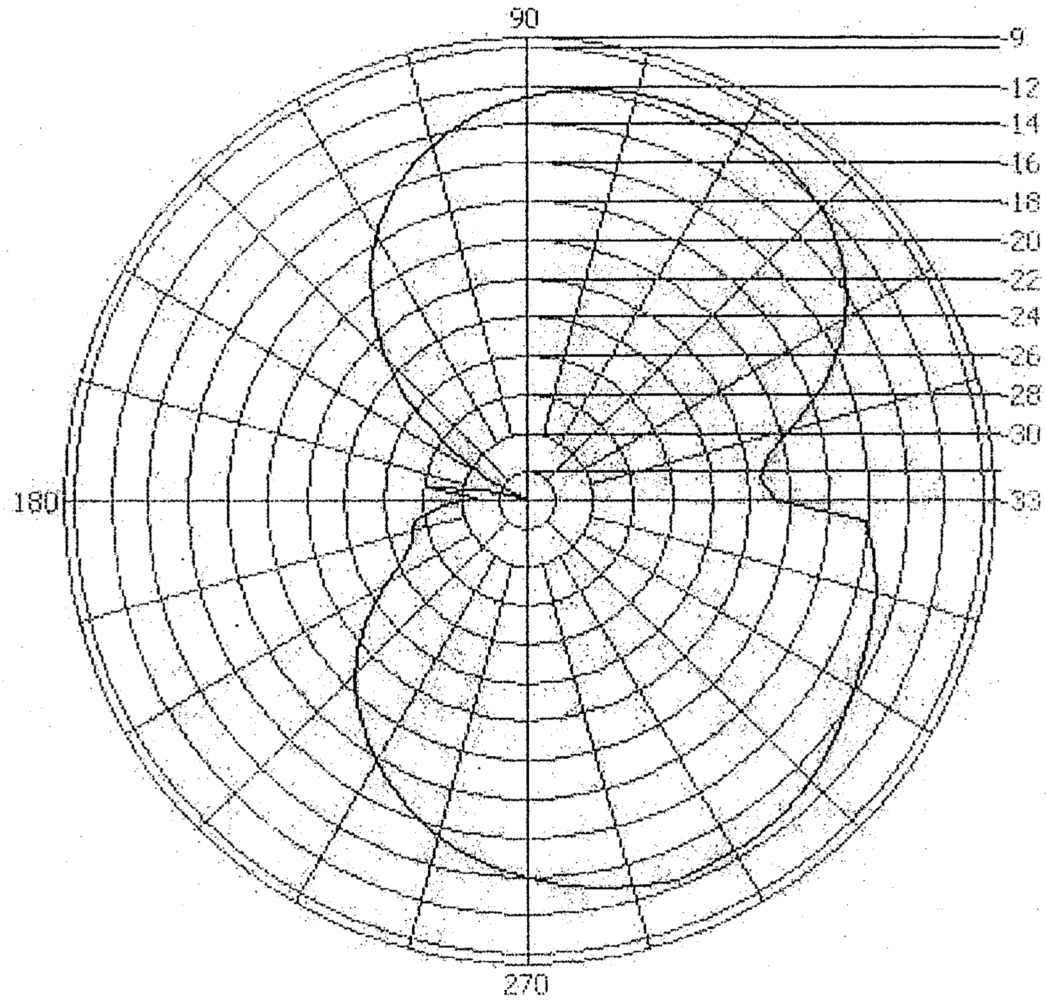
- **RADIATION PATTERN:**



Example 4)

TX antenna	**RX antenna**	**Transmitter input**	**Receiver output**	**Cable**
Wire Dipole	Wire monopole	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

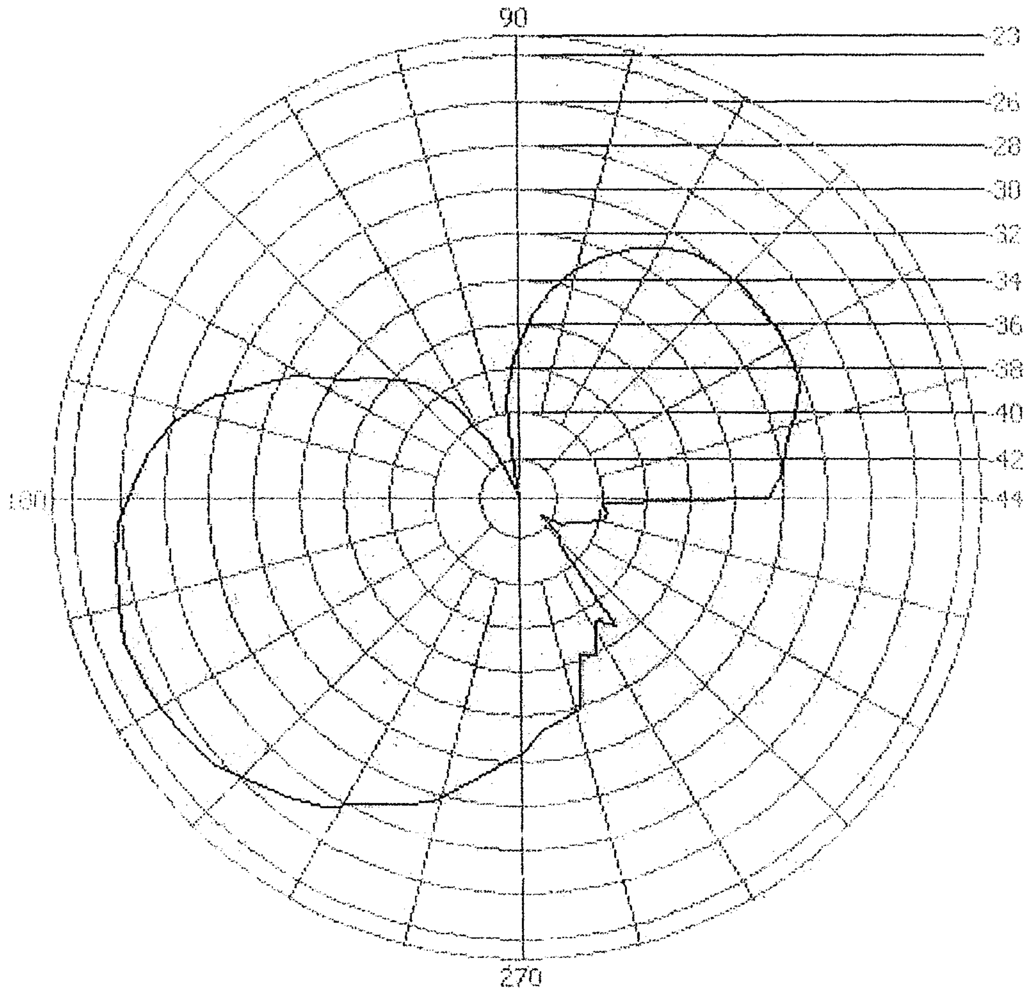
- **RADIATION PATTERN:**



Example 5)

TX antenna	RX antenna	**Transmitter input**	**Receiver output**	**CABLE**
Wire Dipole	Rectangular loop	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

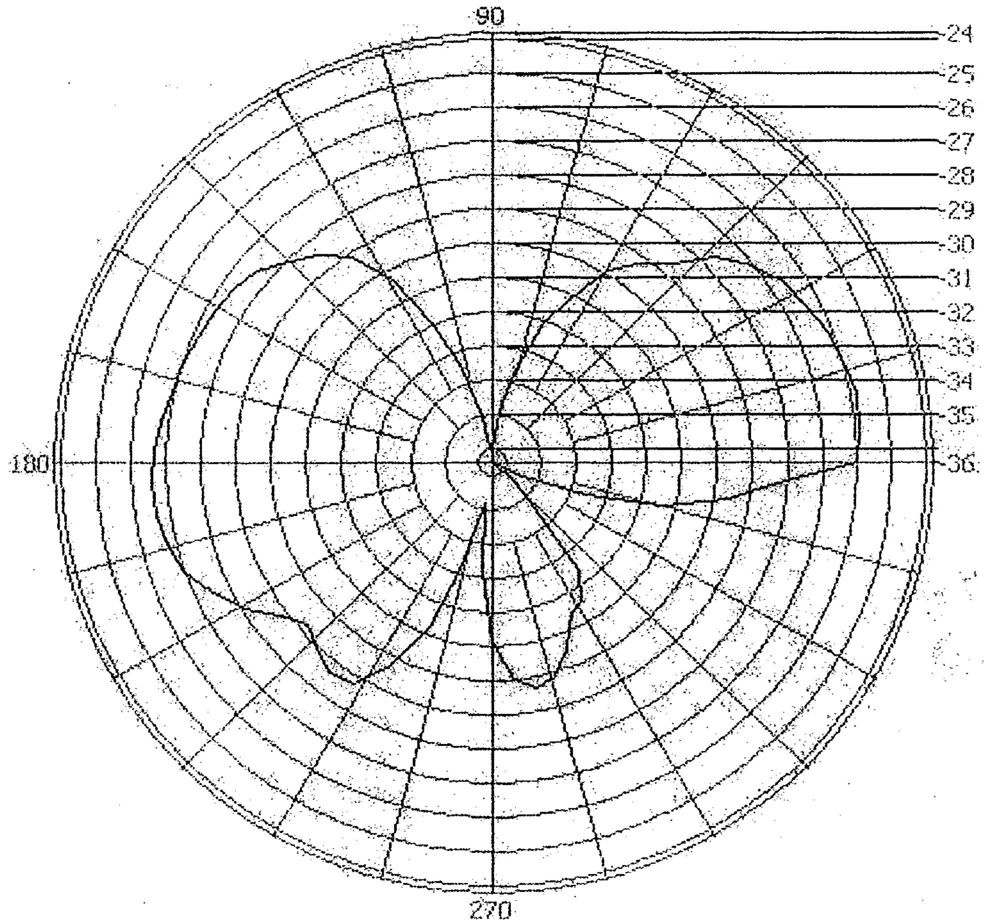
- **RADIATION PATTERN:**



Example 6)

TX antenna	**RX antenna**	**Transmitter input**	**Receiver output**	**CABLE**
Wire Dipole	VEE	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

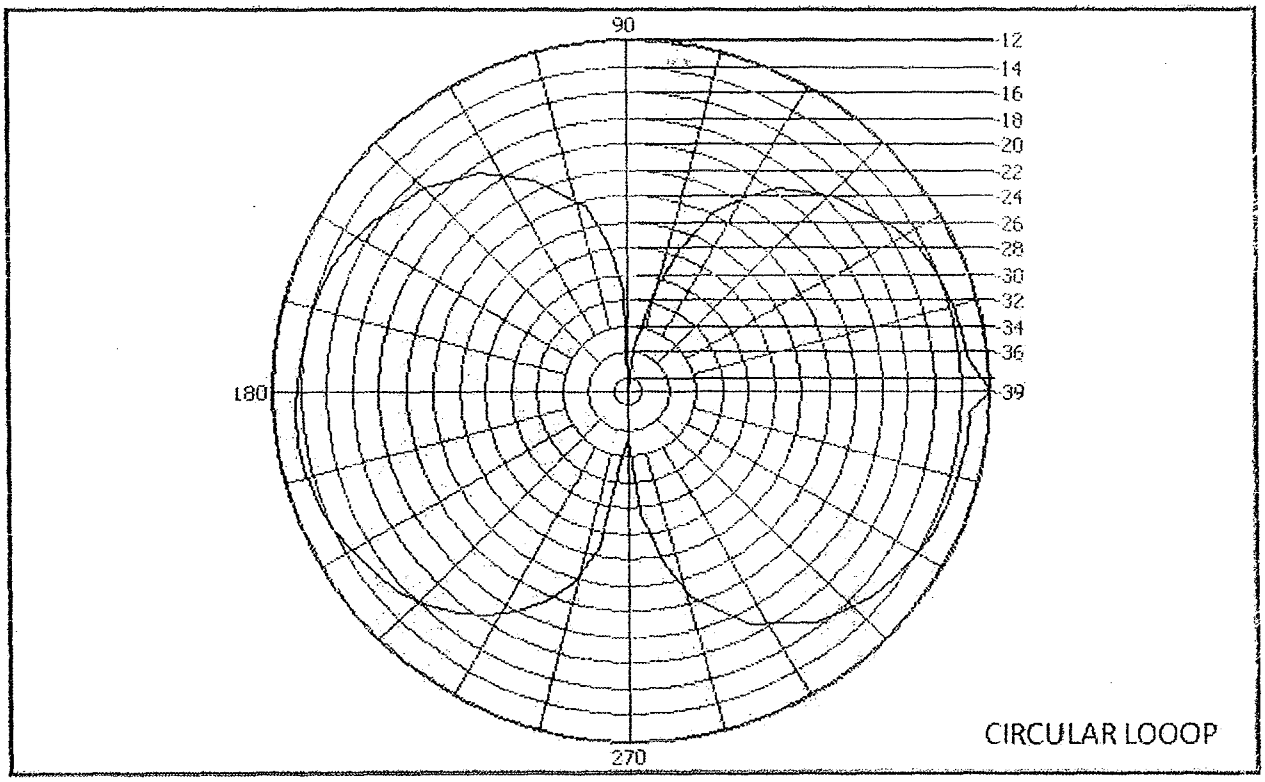
- **RADIATION PATTERN**



Example 7)

TX antenna	RX antenna	Transmitter input	Receiver output	Cable
Wire Dipole	Circular loop	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

- **RADIATION PATTERN:**



EXPERIMENT NO. 4.b)

RADIATION PATTERN OF ALL APERTURE ANTENNA

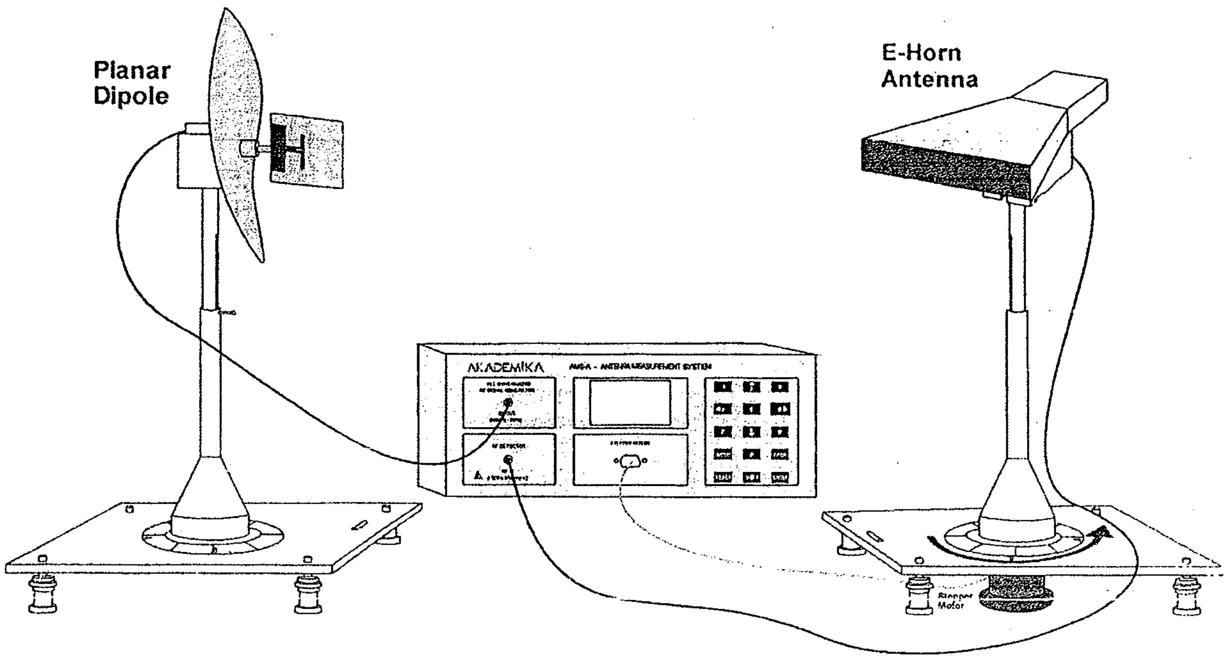
OBJECTIVE

To plot the radiation pattern of all APERTURE antenna and observe its parameters.

EQUIPMENT REQUIRED:

TX Antenna	RX antenna	Transmitter input	Receiver output	Cable
Planar DIPOLE	Any APERTURE antenna	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

SET UP ARRANGEMENT:



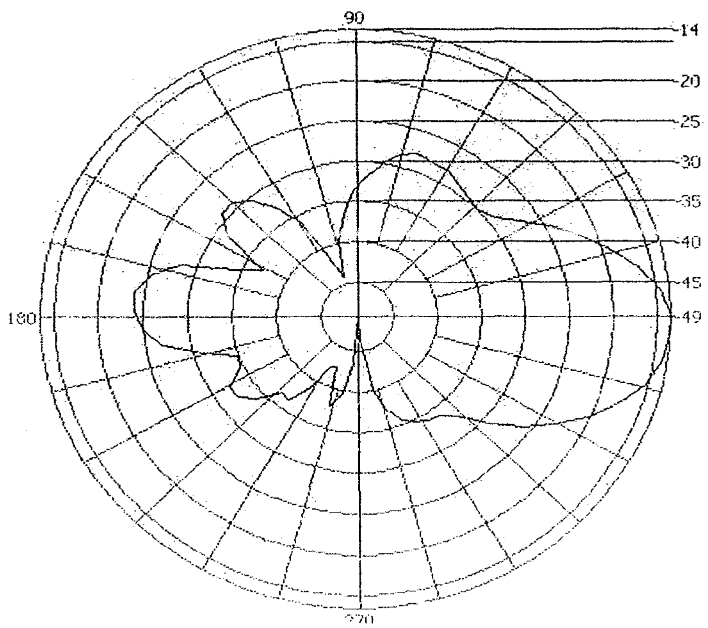
PROCEDURE:

1. Set up the experiment as per shown in figure above.
2. Set the distance between the antennas to be around 1meter, consult theory for details.
3. Turn ON the module, select control mode.
4. Open the AMS-A.exe file, select the corresponding COM PORT and Click on Run, Now the software will be in running mode.
5. Go in FAR FIELD PATTERN, select CO-POLARIZATION, select RX antenna then click on START
6. Then readings from 0 degree to 360 degree will be plotted in the software.
7. Now repeat for CROSS-POLARIZTION of antenna and observe the plot.
8. From SAVE option, the plot can be saved and take the printout whenever required.

Example

TX antenna	**RX antenna**	**Transmitter input**	**Receiver output**	**CABLE**
Planner Dipole	E-Horn	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

- **RADIATION PATTERN**



E HORN

EXPERIMENT NO. 5

RADIATION PATTERN OF ALL PLANAR (MICROSTRIP) ANTENNA

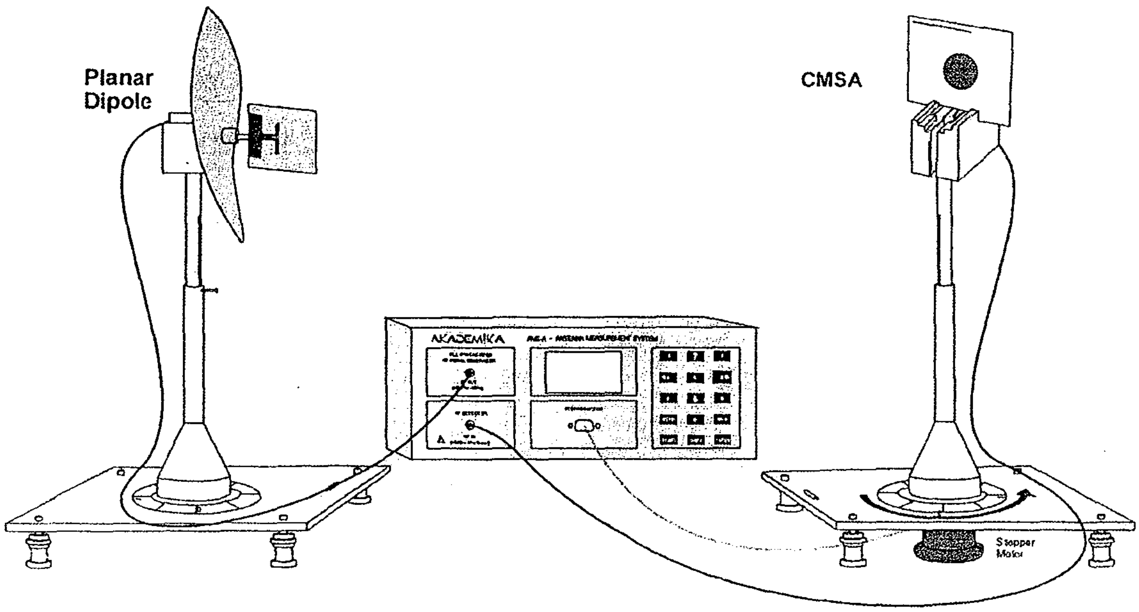
OBJECTIVE:

To plot the radiation pattern of all PLANAR (MICROSTRIP) antenna and observe its parameters.

EQUIPMENT REQUIRED:

TX Antenna	RX antenna	Transmitter input	Receiver output	CABLE
PLANAR DIPOLE	Any PLANAR antenna	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

SET UP ARRANGEMENT:



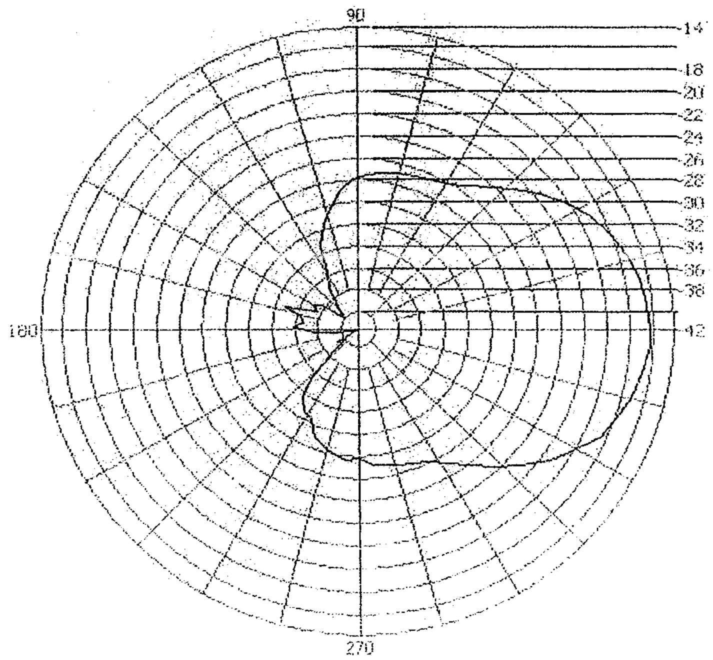
PROCEDURE:

1. Set up the experiment as per shown in figure above.
2. Set the distance between the antennas to be around 1meter, consult theory for details.
3. Turn ON the module, select control mode.
4. Open the AMS-A.exe file, select the corresponding COM PORT and Click on Run, Now the software will be in running mode.
5. Go in FAR FIELD PATTERN, select CO-POLARIZATION, select RX antenna then click on START
6. Then readings from 0 degree to 360 degree will be plotted in the software.
7. Now repeat for CROSS-POLARIZTION of antenna and observe the plot.
8. From SAVE option, the plot can be saved and take the printout whenever required.

Example 1)

TX antenna	**RX antenna**	**Transmitter input**	**Receiver output**	**CABLE**
Planar Dipole	2 X 1 Array	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

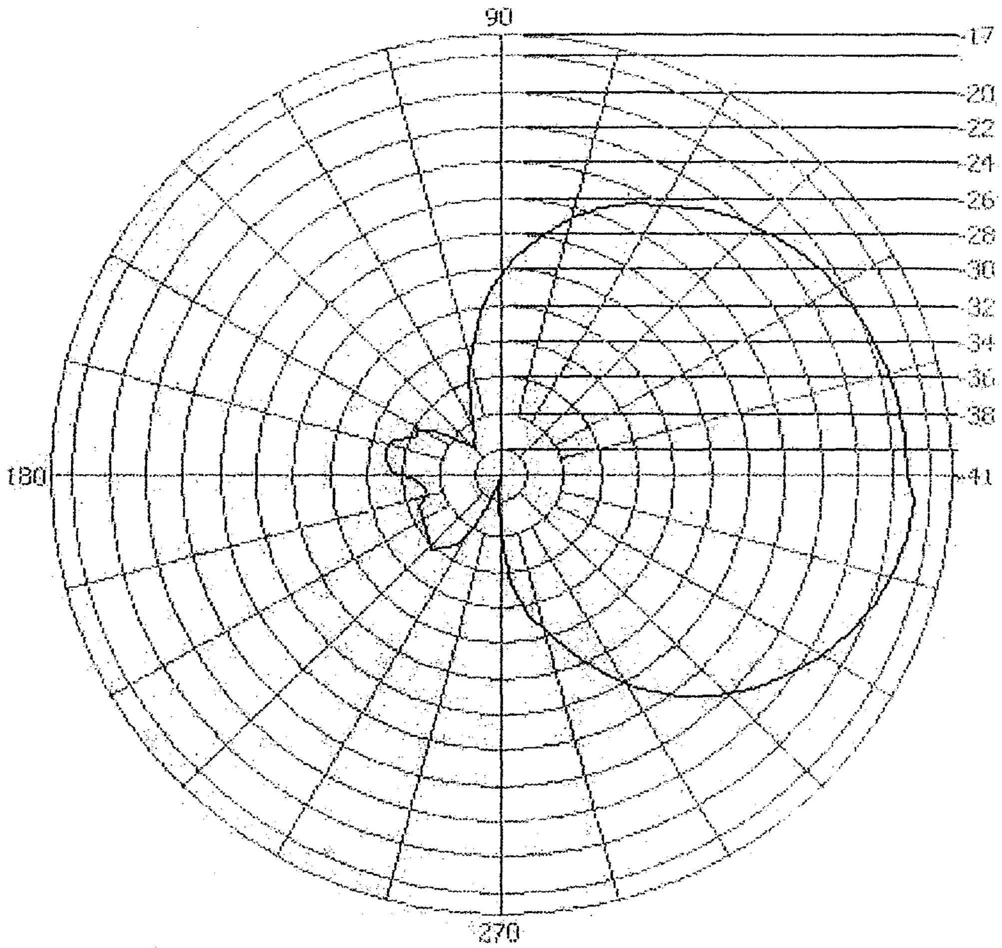
RADIATION PATTERN:



EXAMPLE 2)

TX antenna	RX antenna	Transmitter input	Receiver output	CABLE
Planar Dipole	Insert feed	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

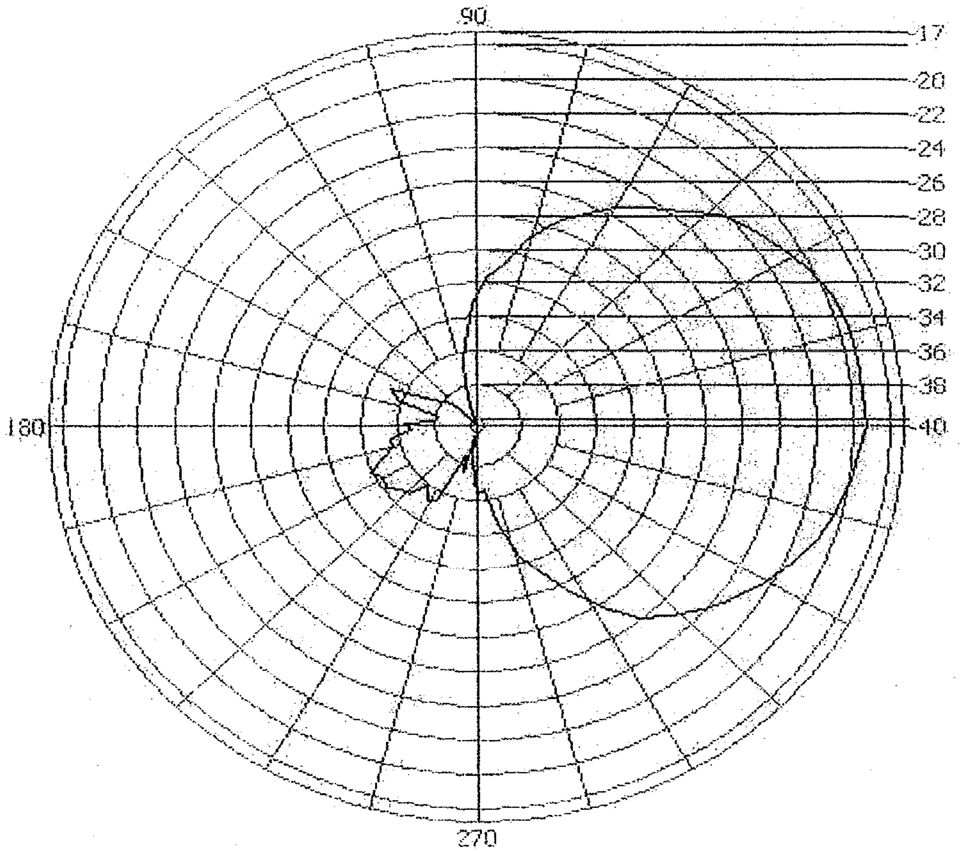
- **RADIATION PATTERN**



Example 3)

TX antenna	RX antenna	Transmitter input	Receiver output	CABLE
Planner Dipole	TMSA	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

- **RADIATION PATTERN**

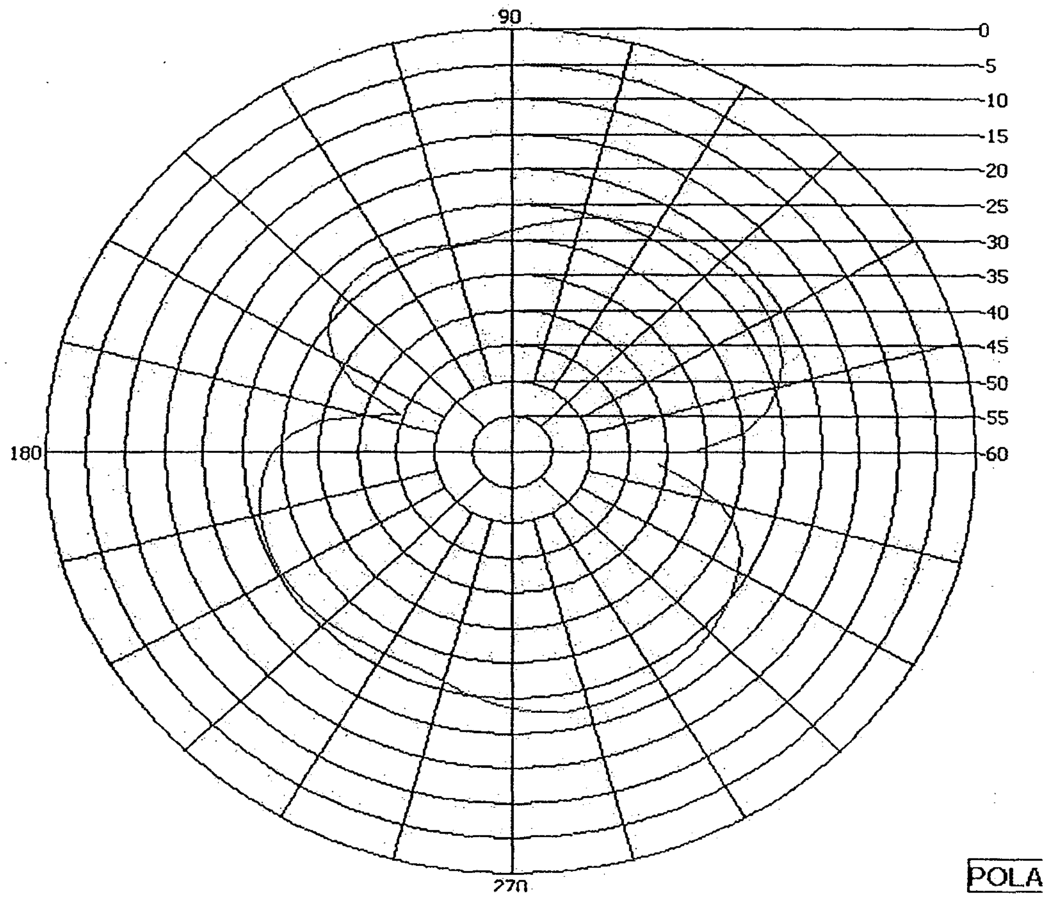


TMSA

Example 4)

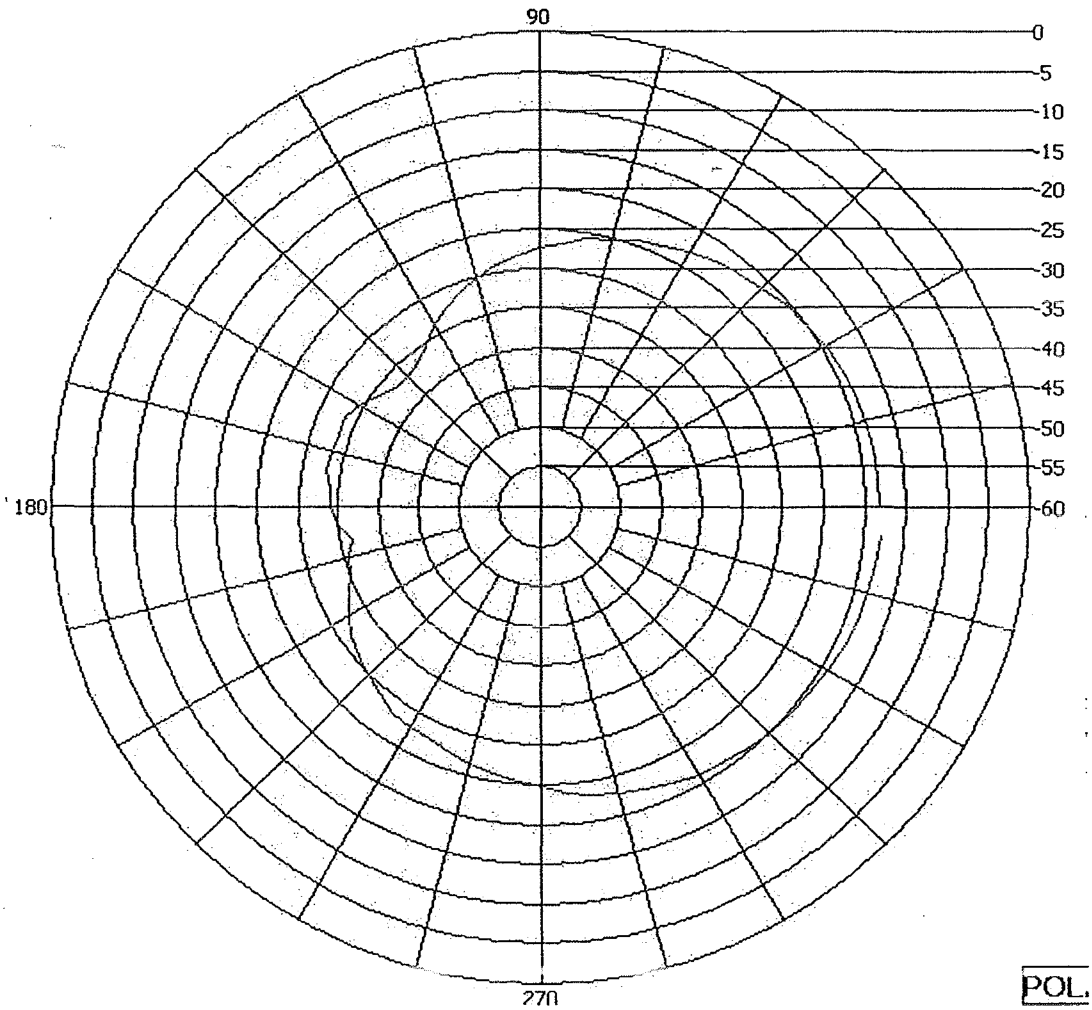
TX antenna	RX antenna	Transmitter input	Receiver output	CABLE
Planner Dipole	Angular ring	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

- **RADIATION PATTERN**



Example 5)

TX antenna	RX antenna	Transmitter input	Receiver output	CABLE
Planner Dipole	CMSA	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2



POL.

EXPERIMENT NO. 6

RADIATION PATTERN OF ALL REFLECTOR ANTENNA

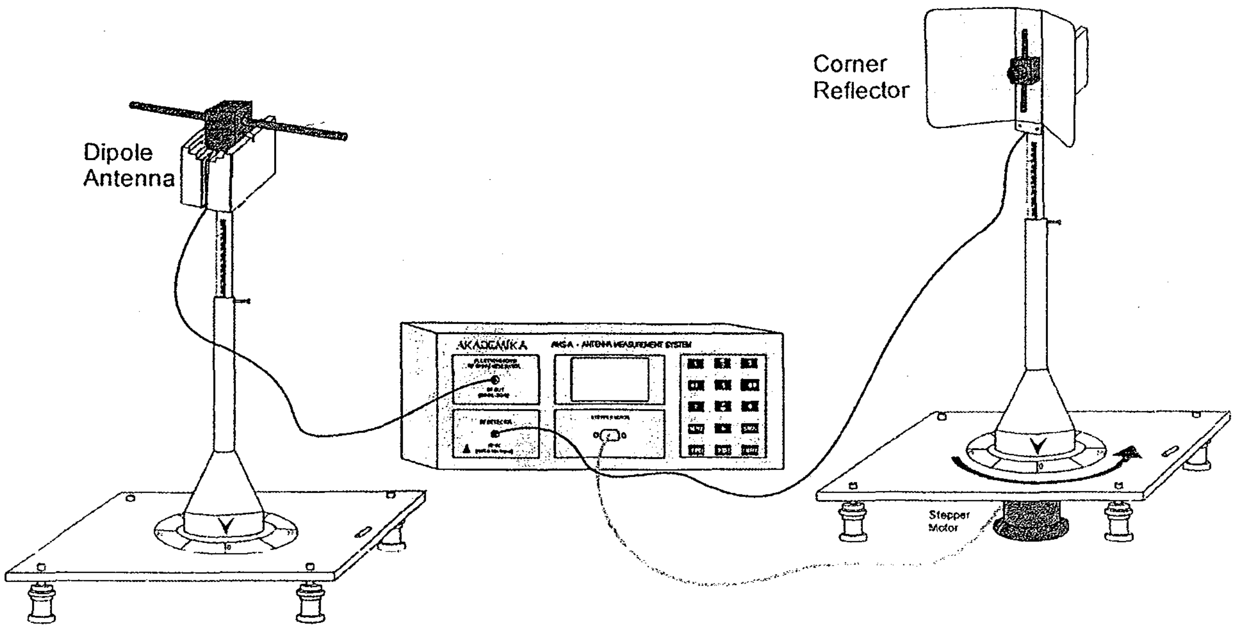
OBJECTIVE

To plot the radiation pattern of all REFLECTOR antenna and observe its parameters.

EQUIPMENT REQUIRED:

TX Antenna	RX antenna	Transmitter input	Receiver output	CABLE
Wire DIPOLE	Any REFLECTOR antenna	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

SET UP ARRANGEMENT:



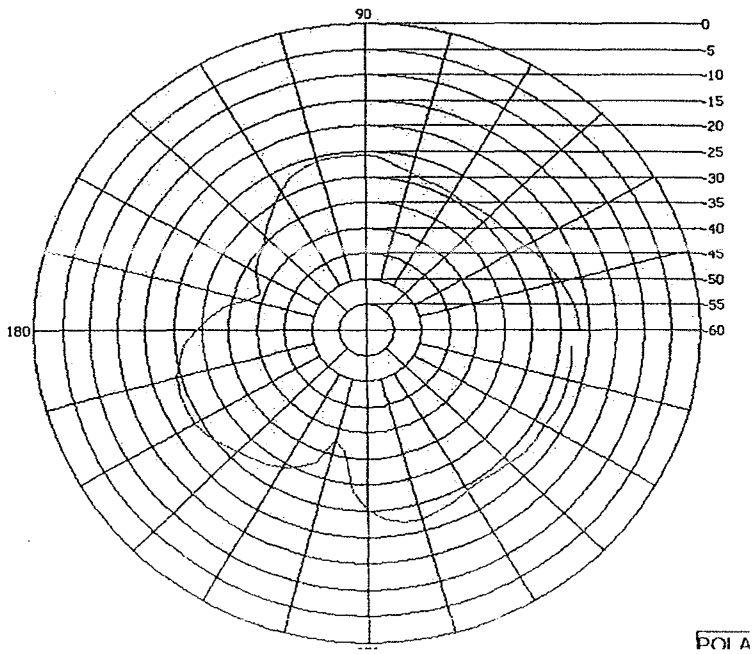
PROCEDURE:

1. Set up the experiment as per shown in figure above.
2. Set the distance between the antennas to be around 1meter, consult theory for details.
3. Turn ON the module, select control mode.
4. Open the AMS-A.exe file, select the corresponding COM PORT and Click on Run, Now the software will be in running mode.
5. Go in FAR FIELD PATTERN, select CO-POLARIZATION, select RX antenna then click on START
6. Then readings from 0 degree to 360 degree will be plotted in the software.
7. Now repeat for CROSS-POLARIZTION of antenna and observe the plot.
8. From SAVE option, the plot can be saved and take the printout whenever required.

Example

TX antenna	**RX antenna**	**Transmitter input**	**Receiver output**	**CABLE**
Wire Dipole	Corner reflector	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

- **RADIATION PATTERN:**



EXPERIMENT NO. 7

RADIATION PATTERN OF ALL ARRAY ANTENNA

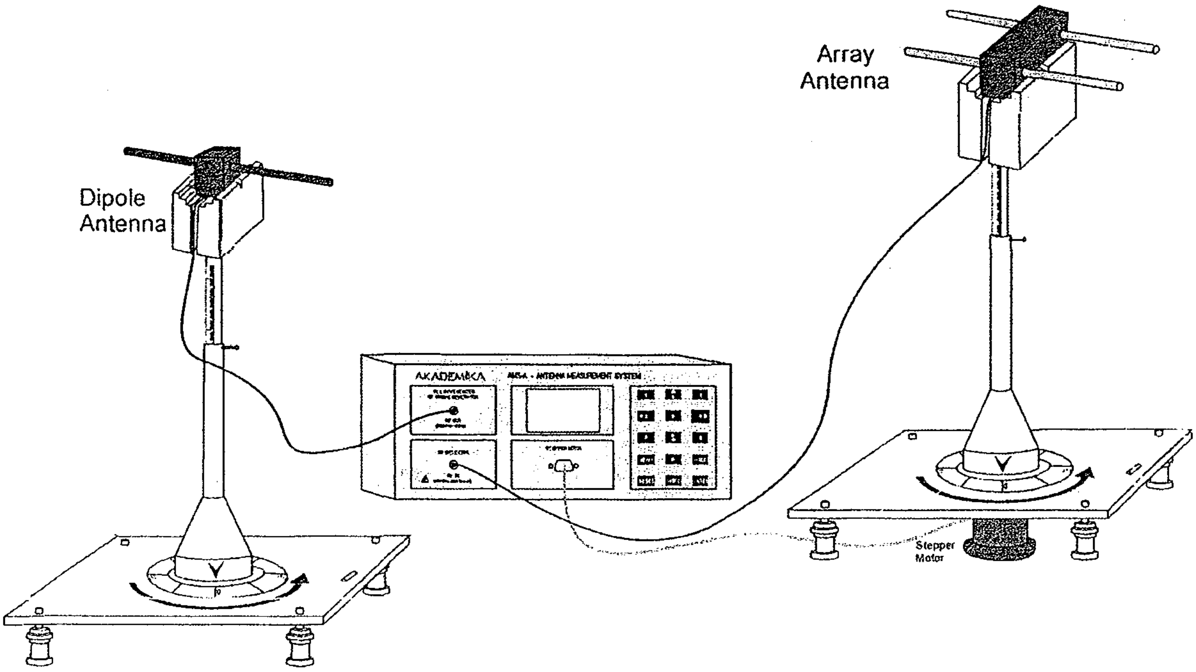
OBJECTIVE

To plot the radiation pattern of all ARRAY antenna and observe its parameters.

EQUIPMENT REQUIRED:

TX Antenna	**RX antenna**	**Transmitter input**	**Receiver output**	**CABLE**
Wire DIPOLE	Any ARRAY antenna	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

SET UP ARRANGEMENT:



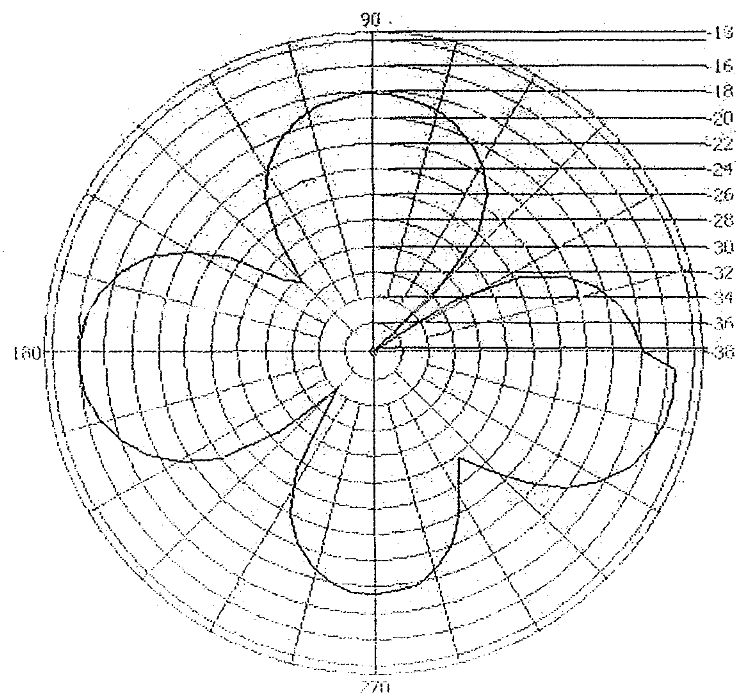
PROCEDURE:

1. Set up the experiment as per shown in figure above.
2. Set the distance between the antennas to be around 1meter, consult theory for details.
3. Turn ON the module, select control mode.
4. Open the AMS-A.exe file, select the corresponding COM PORT and Click on Run, Now the software will be in running mode.
5. Go in FAR FIELD PATTERN, select CO-POLARIZATION, select RX antenna then click on START
6. Then readings from 0 degree to 360 degree will be plotted in the software.
7. Now repeat for CROSS-POLARIZTION of antenna and observe the plot.
8. From SAVE option, the plot can be saved and take the printout whenever required.

Example 1)

TX antenna	**RX antenna**	**Transmitter input**	**Receiver output**	**CABLE**
Wire Dipole	Broadside array	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

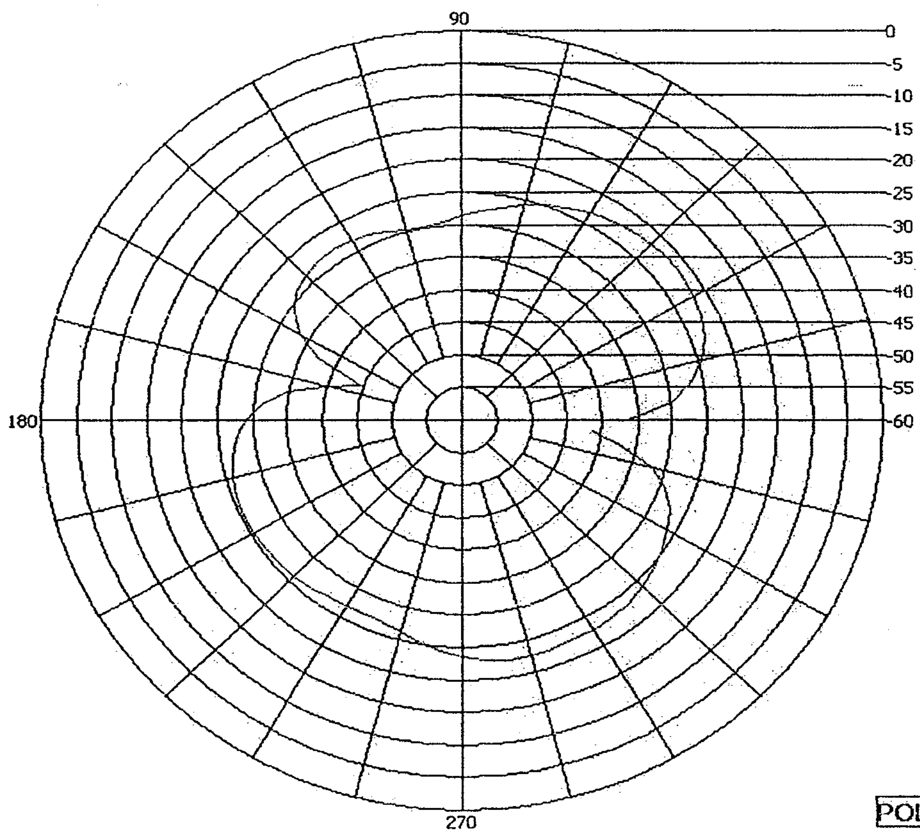
RADIATION PATTERN:



EXAMPLE 2)

TX antenna	RX antenna	Transmitter input	Receiver output	CABLE
Wire Dipole	End fire	Source (RF out)	Detector (RF input)	SMA To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

RADIATION PATTERN:



POLAR PLOT

EXPERIMENT NO. 8

CO-POLARIZATION AND CROSS-POLARIZATIION

OBJECTIVE

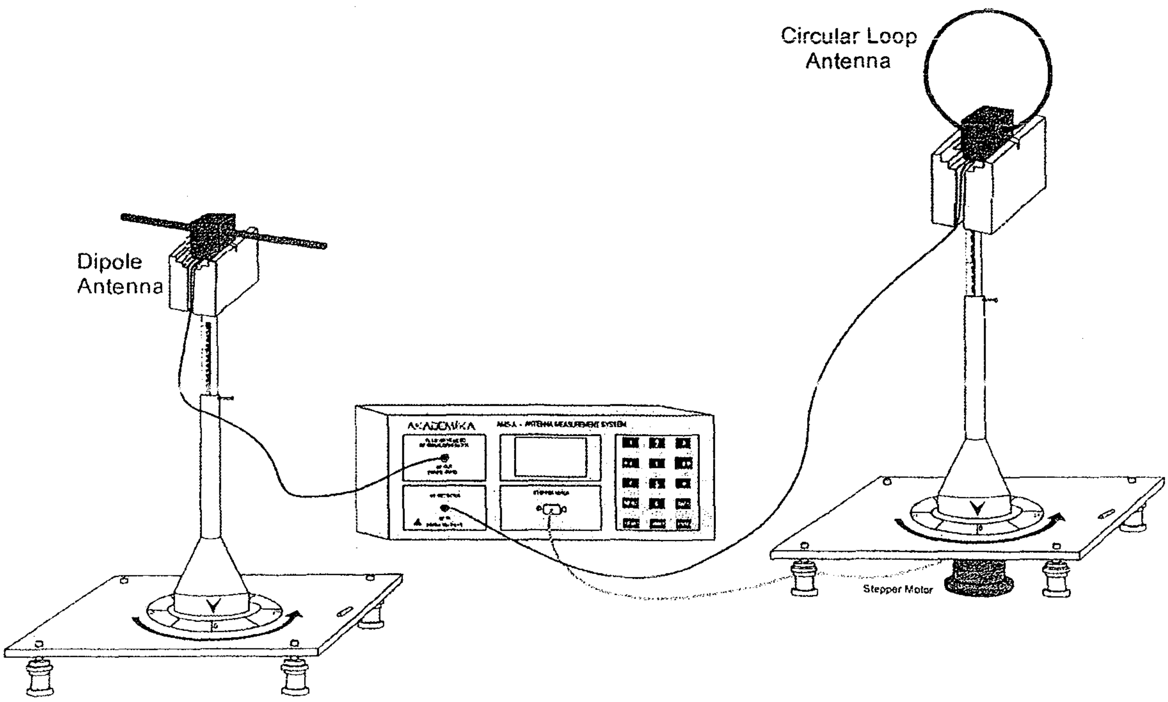
To observe the effect of CO-POLARIZATION and CROSS-POLARIZATIION sing vertical and horizontal polarization of antenna.

EQUIPMENT REQUIRED:

TX antenna	RX antenna	Transmitter input	Receiver output	CABLE
1. WIRE DIPOLE 2. PLANAR(Microstrip) DIPOLE	1. Any WIRE antenna 2. Any MICROSTRIP antenna	Source (RF out)	Detector (RF input)	To SMA cable
QTY =1	QTY =1	QTY =1	QTY =1	QTY =2

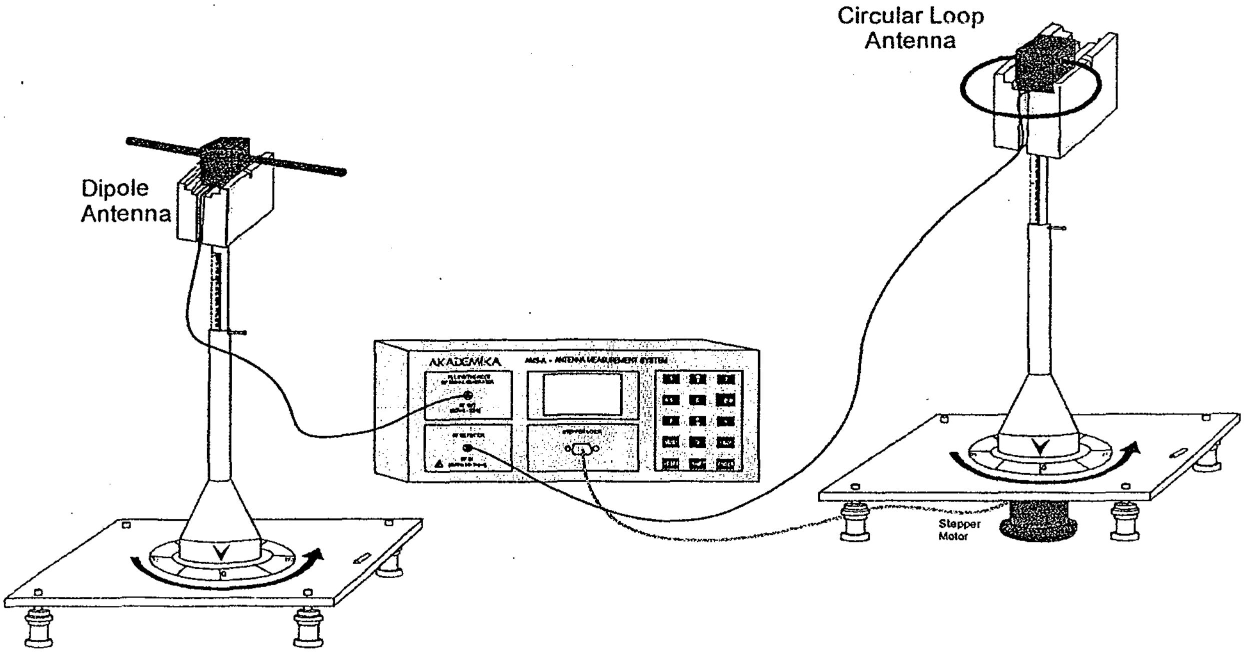
PROCEDURE:

CO-POLARIZATION:



1. Set up the experiment as per shown in figure above.
2. Set transmitting as well as receiving antenna in same polarization i.e. VERTICAL/HORIZONTAL.
3. Set the distance between the antennas to be around 1meter, consult theory for details of far field region.
4. Turn ON the module, select control mode.
5. Open the AMS-A.exe file, select the corresponding COM PORT and Click on Run, Now the software will be in running mode.
6. Go in FAR FIELD PATTERN, select CO-POLARIZATION, select RX (either WIRE or PLANAR) antenna then click on START
7. Then readings from 0 degree to 360 degree will be plotted in the software.
8. After completing it will plot the readings.

CROSS POLARIZATION:

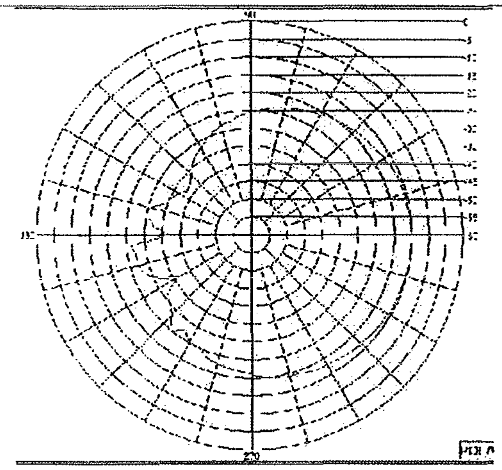


1. Set up the experiment as per shown in figure above.
2. Set transmitting as well as receiving antenna in opposite/different polarization i.e. VERTICAL/HORIZONTAL.
3. Set the distance between the antennas to be around 1meter, consult theory for details of far field region.

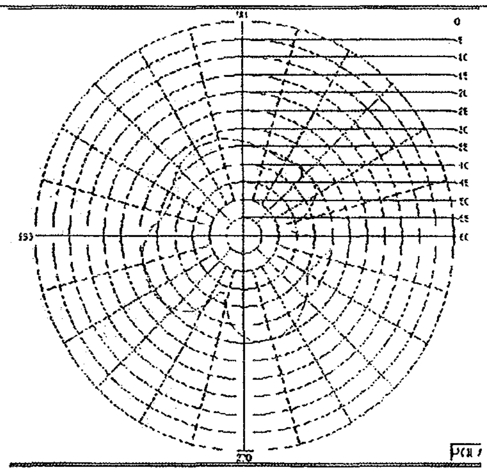
4. Open the AMS-A.exe file, select the corresponding COM PORT and Click on Run, Now the software will be in running mode.
5. Go in FAR FIELD PATTERN, select CROSS-POLARIZATION, select RX (either WIRE or PLANAR) antenna then click on START.
6. Then readings from 0 degree to 360 degree will be plotted in the software.
7. After completing it will plot the readings.
8. Observe the effect of change in polarization of antenna.

EXAMPLE:

TX antenna	RX antenna	TX frequency	Separation	Measurement
Planar Dipole	RMSA	2428MHz	60cm	Co polarization Cross-Polarization



Co-Polarization



Cross-Polarization

EXPERIMENT NO.9

DESIGN AND SIMULATION OF MICROSTRIP ANTENNA USING CST TOOL

1. *Accessing CST MWS*

a. From start menu select Programs > CST STUDIO SUITE 2006 > CST DESIGN ENVIRONMENT

b. The main window shown in Fig. 1 will be opened

c. From the main window click on "CST Microwave Studio" icon then click OK

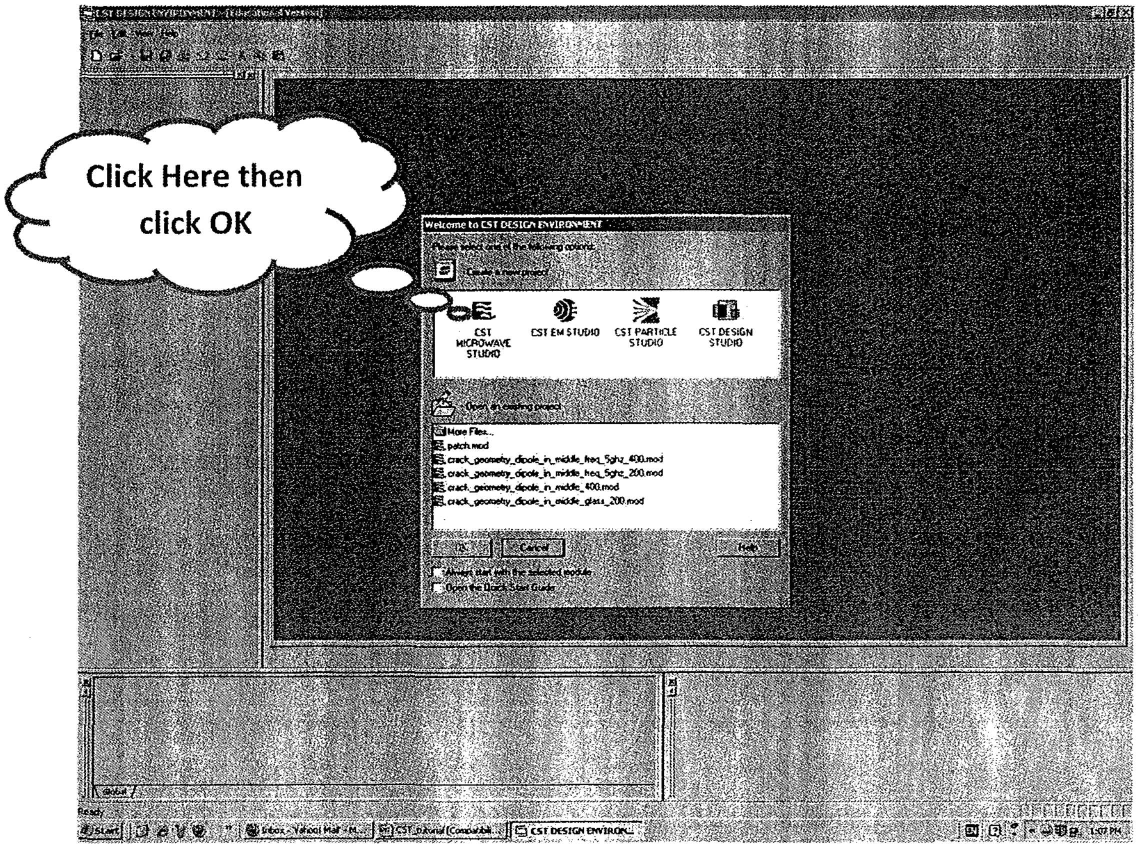


Fig. 1 CST main window

d. A new pop-up window called "Create a New project" will appear, from this window that shown in Fig. 2 you can select the type of project you are working on, i.e. Antenna (on planar substrate) in case of designing a microstrip patch antenna or Antenna in free space in case of designing a dipole or a monopole.

Note: the purpose from selecting the project type is to adjust the boundary condition automatically, if you don't like this you can select "None" and you can adjust the boundary conditions later.

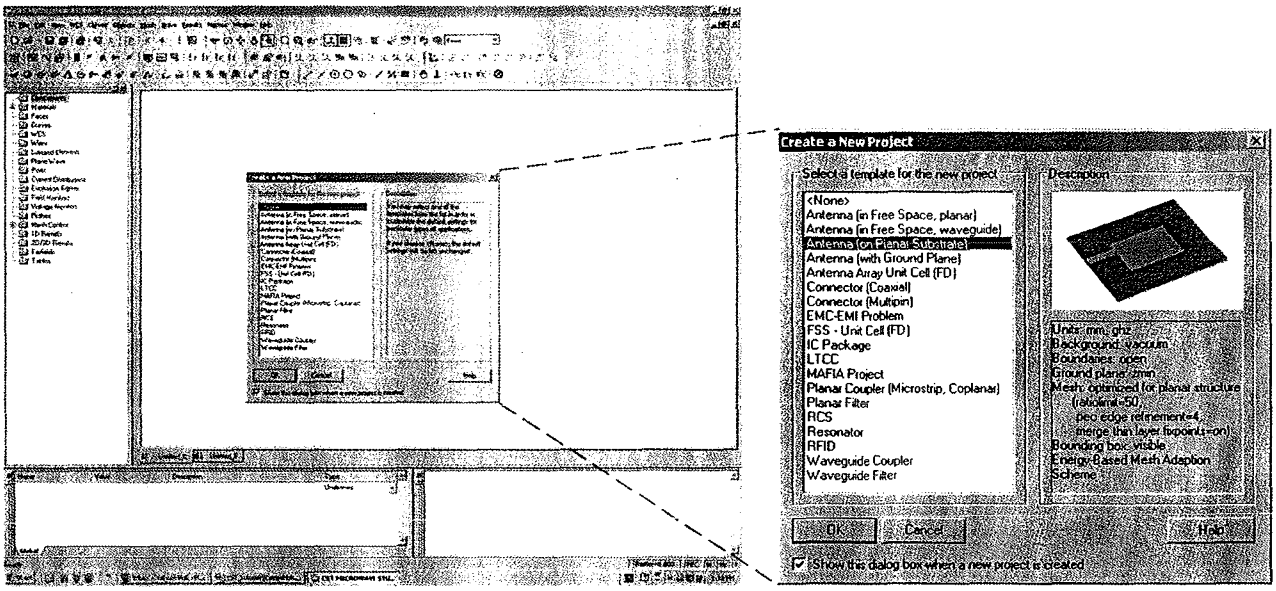


Fig. 2 Create new project window

e. After click on OK the main layout window will appear as shown in Fig. 3. Now we need to give a name to the project and save it.

f. From Main Menu select > File > Save as, now you should write the name of your project in the specified area e.g. "Rectangular Patch" as shown in Fig. 4

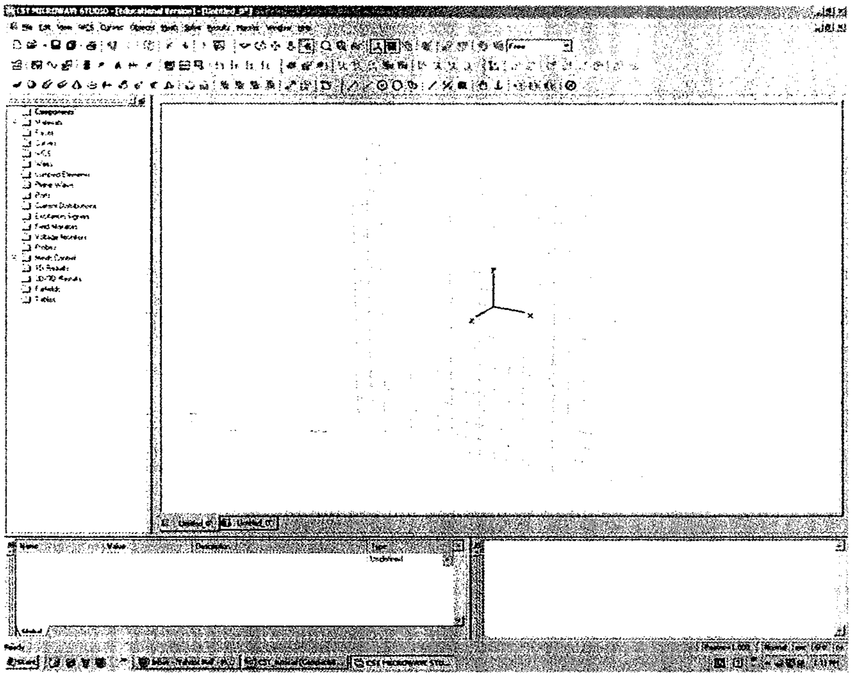


Fig. 3 Main Layout window

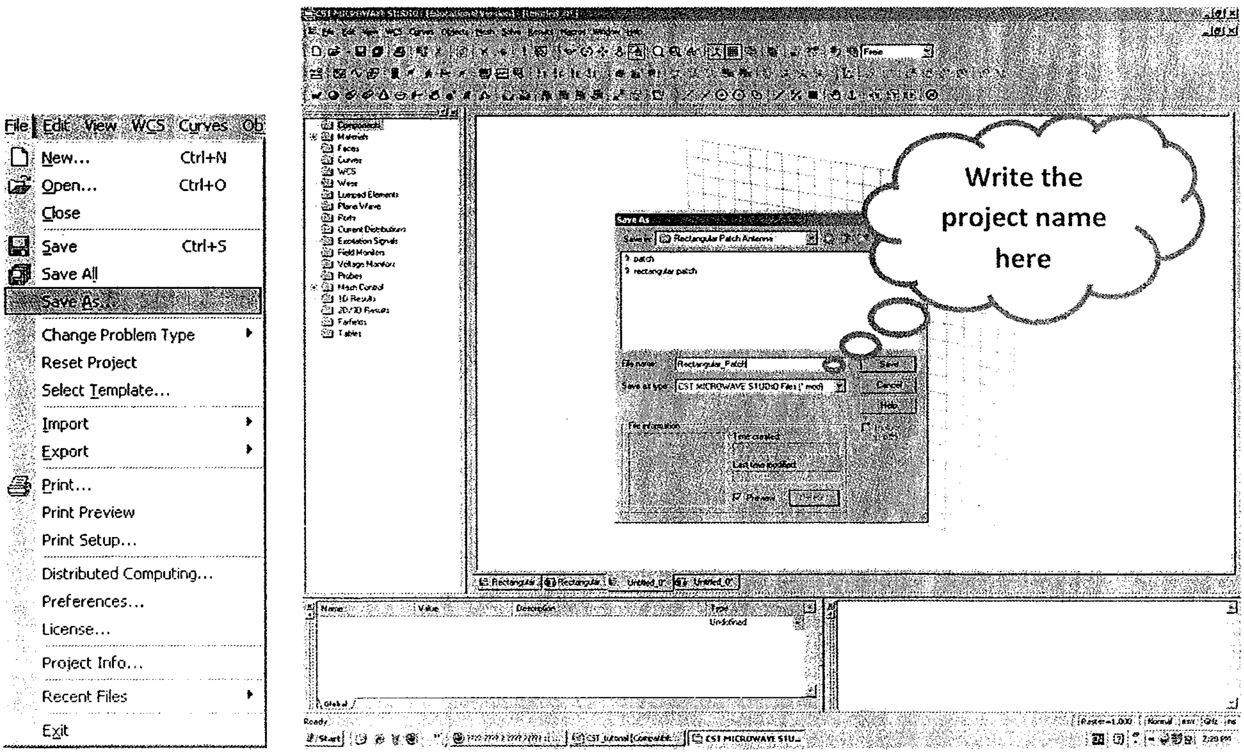


Fig. 4 Saving the working project

2. Rectangular patch antenna design

Step 1 specifying the project units

From main menu select > Solve > Units, then from the units window select the dimensions to be in mm, Frequency in GHz and time to be in ns as shown in Fig.5.

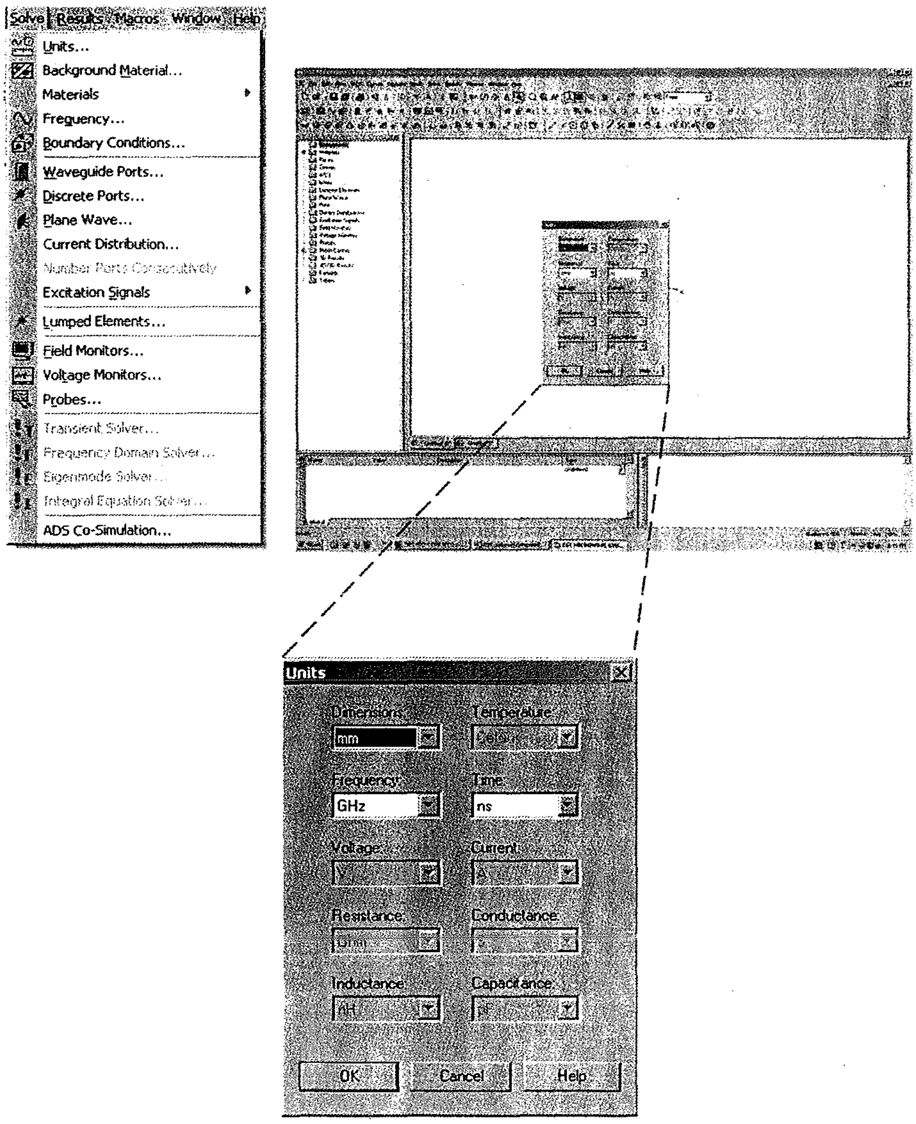


Fig. 5 Main units definition

<u>Step 2</u> Assigning the Background material

From main menu select > Solve > Background Material, Now a new window called "Background properties" will pop up. Choose Material type to be normal and keep all other parameters as the defaults as shown in Fig. 6

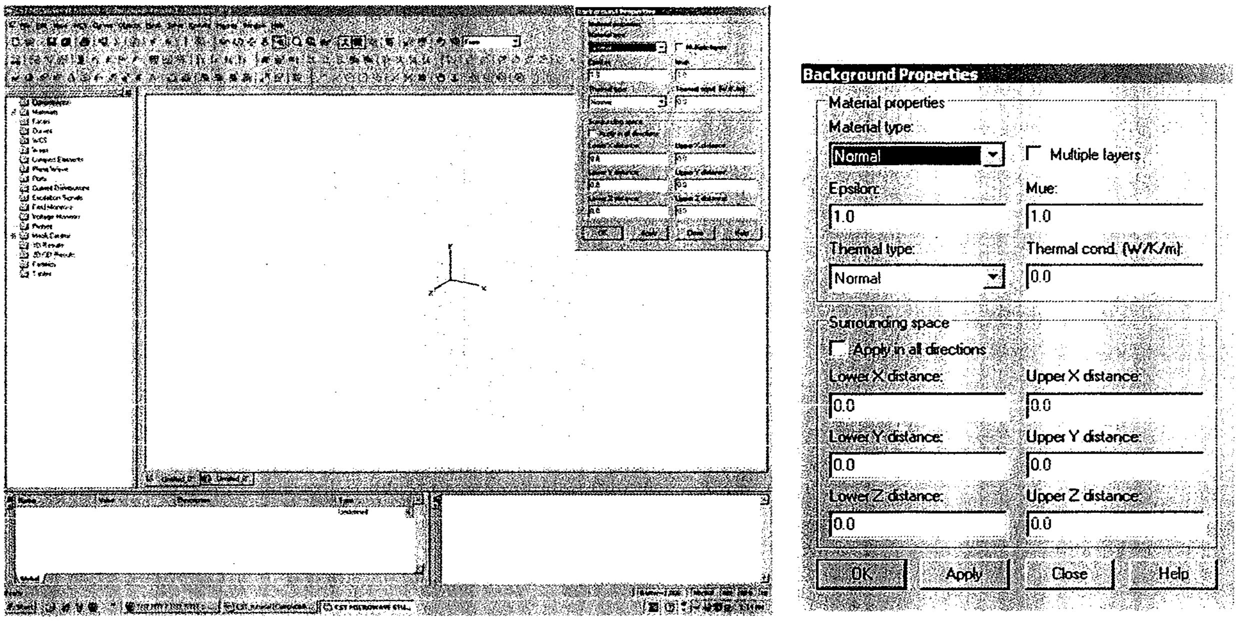


Fig. 6 Background material definition

<u>Step 3</u> Antenna substrate definition

From main menu select > Objects > Basic Shapes > Brick, Then double click on the working area and drag the mouse and double click again to end the drawing mode. Now a new window called "Brick" will appear, from this window that shown in Fig.7 you can adjust the required dimensions of the substrate, its name and its material.

In this project we need to adjust the substrate dimensions to be 100*100 mm^2 by changing *Xmin* to be -50 and *Xmax* to be 50 and *Ymin* to be -50 and *Ymax* to be 50. And in this example we will choose the thickness of the substrate to be 1.575 mm, so change *Zmin* to be -1.575 and *Zmax* to be 0.

For the substrate material we need to change it to RT 5880 (ε_r=2.2) to do that click on the material select box and choose "Load from material library" then select the material stated before as shown in Fig.8

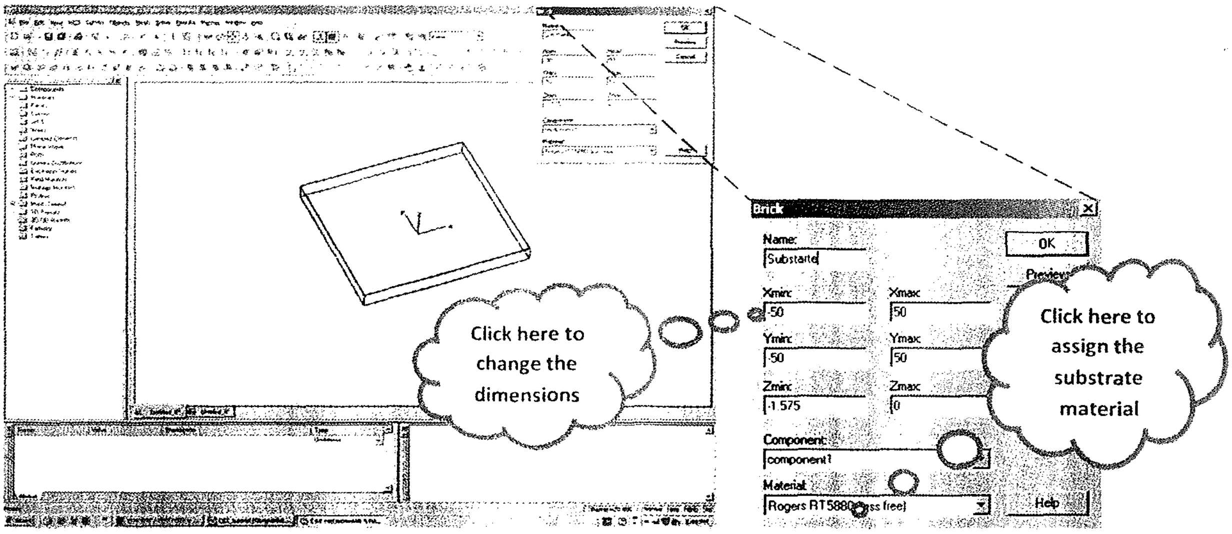


Fig. 7 Substrate definition

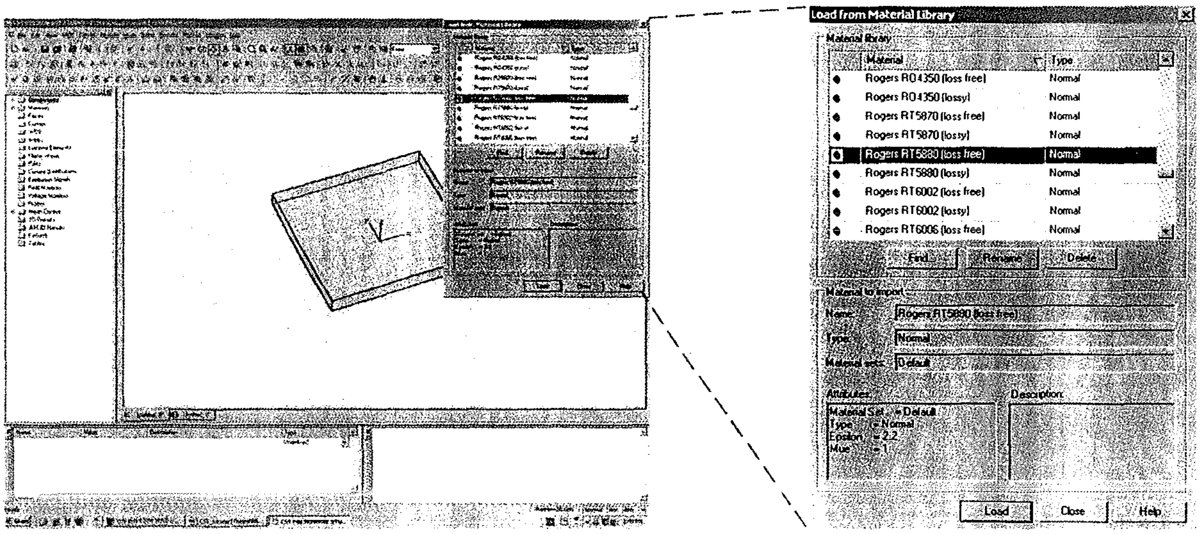


Fig. 8 Changing the Material of the substrate to RT 5880

Step 4 Antenna ground definition

For the antenna ground you need to create another brick "same as stated before" with a very thin thickness (I choose it to be 0.1 mm) as shown in Fig.9 and change its material to be copper

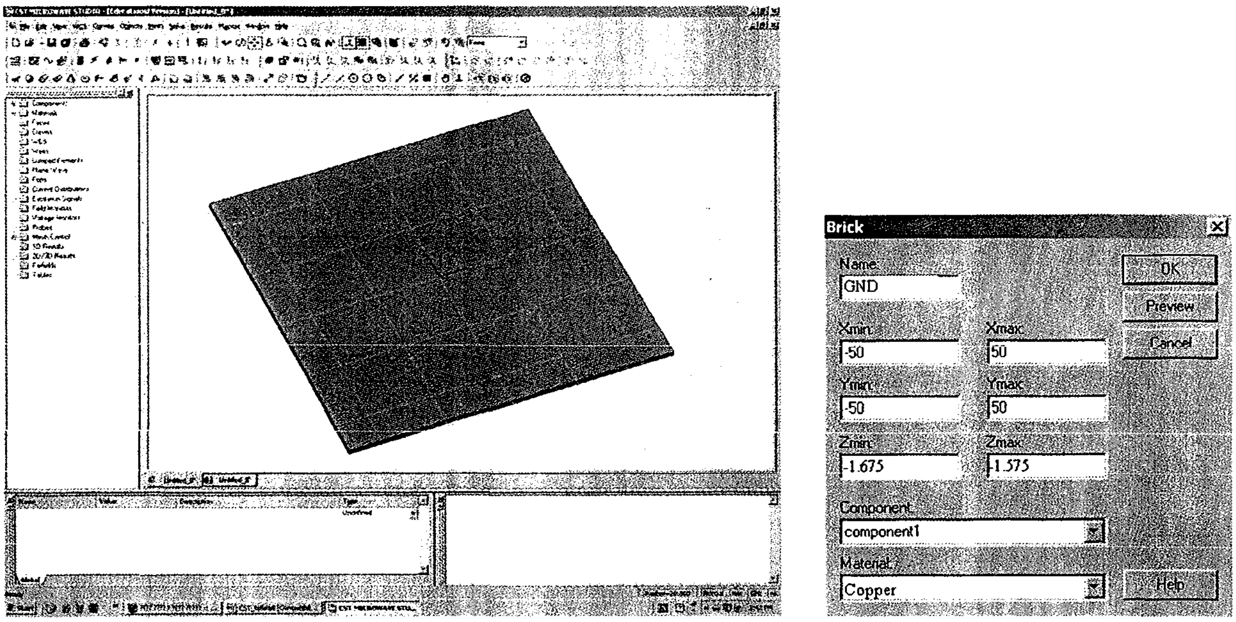


Fig. 9 Adding the ground plane of the antenna

Step 5 Drawing the radiating patch

To draw a rectangular patch create another brick with the following parameters *Xmin* = (-49.4/2), *Xmax* = (49.4/2) and *Ymin* = (-41.3/2), *Ymax* = 50. And *Zmin* = 0, *Zmax* = 0.1 and assign its material to be copper as shown in Fig.10.

Step 6 Drawing inset feed slot

Create a brick with the following parameters *Xmin* = (-41.3/2), *Xmax* = (41.3/2 +14.5) and *Ymin* = -3.5, *Ymax* = 3.5. And *Zmin* = 0, *Zmax* = 0.1 and assign its material to be copper as shown in Fig.11.

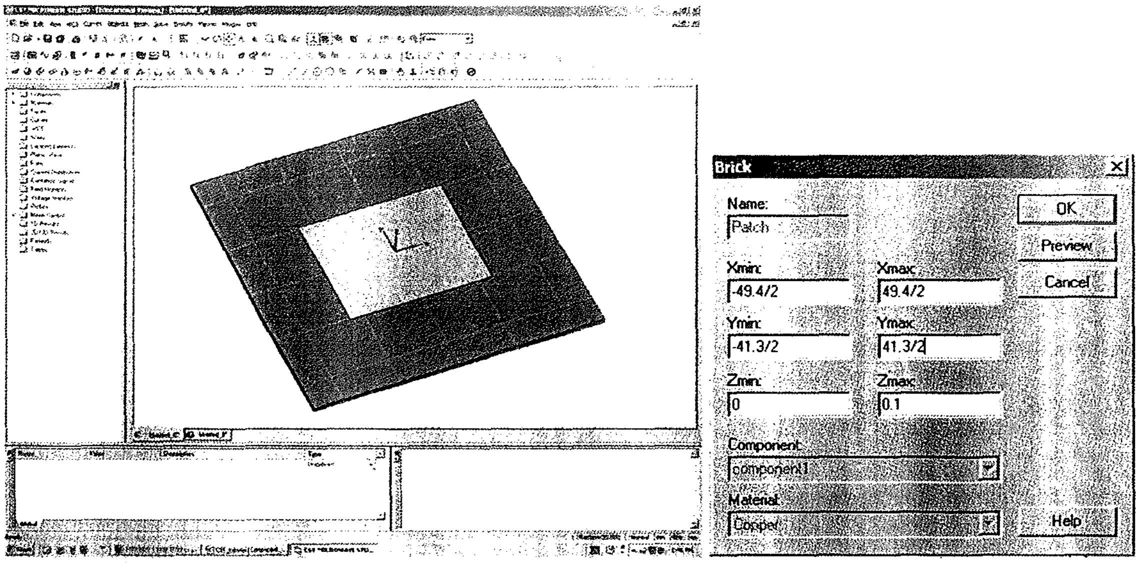


Fig. 10 Drawing the radiator patch

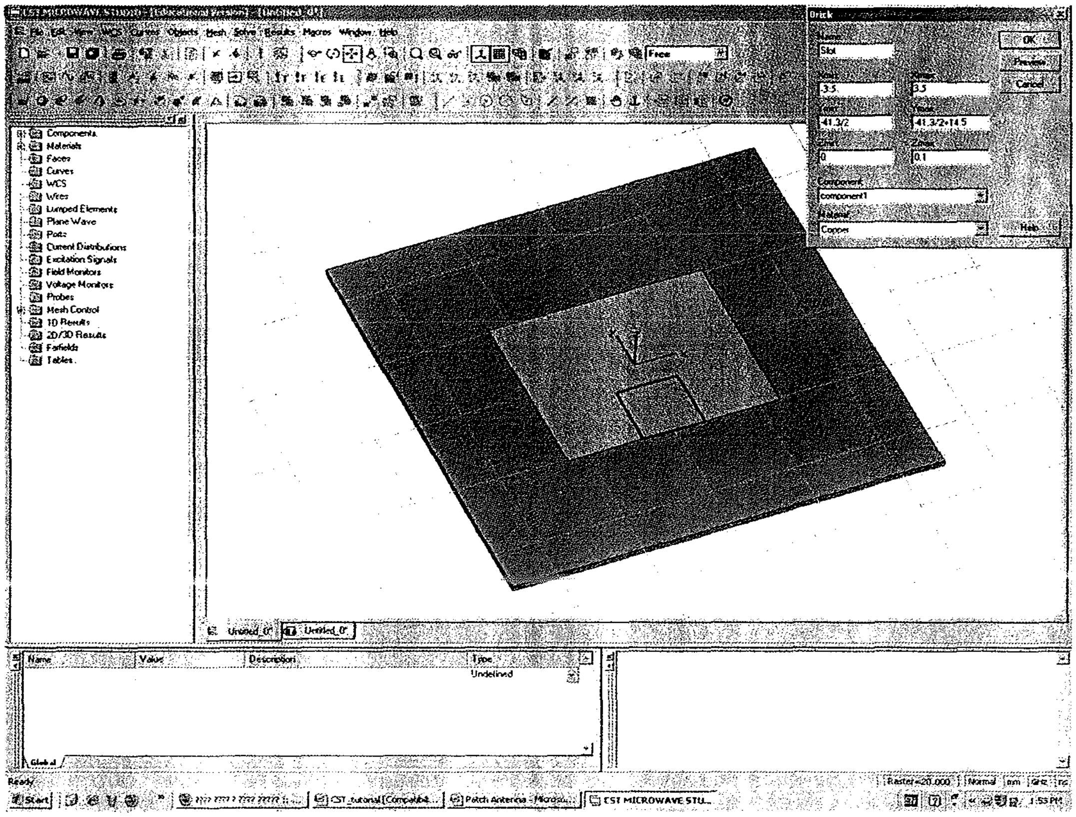


Fig.11 Drawing the inset feed slot

Step 7 Cutting the inset feed slot from the patch

a. From the left pane click on "***Component1***" to show all the components of your projects
b. Click on patch to select it
c. Click on "Boolean subtract (-)" icon from the toolbar, see Fig.12
d. Now, click on slot and press enter key, see Fig. 13
e. You should now see something looks like Fig.14

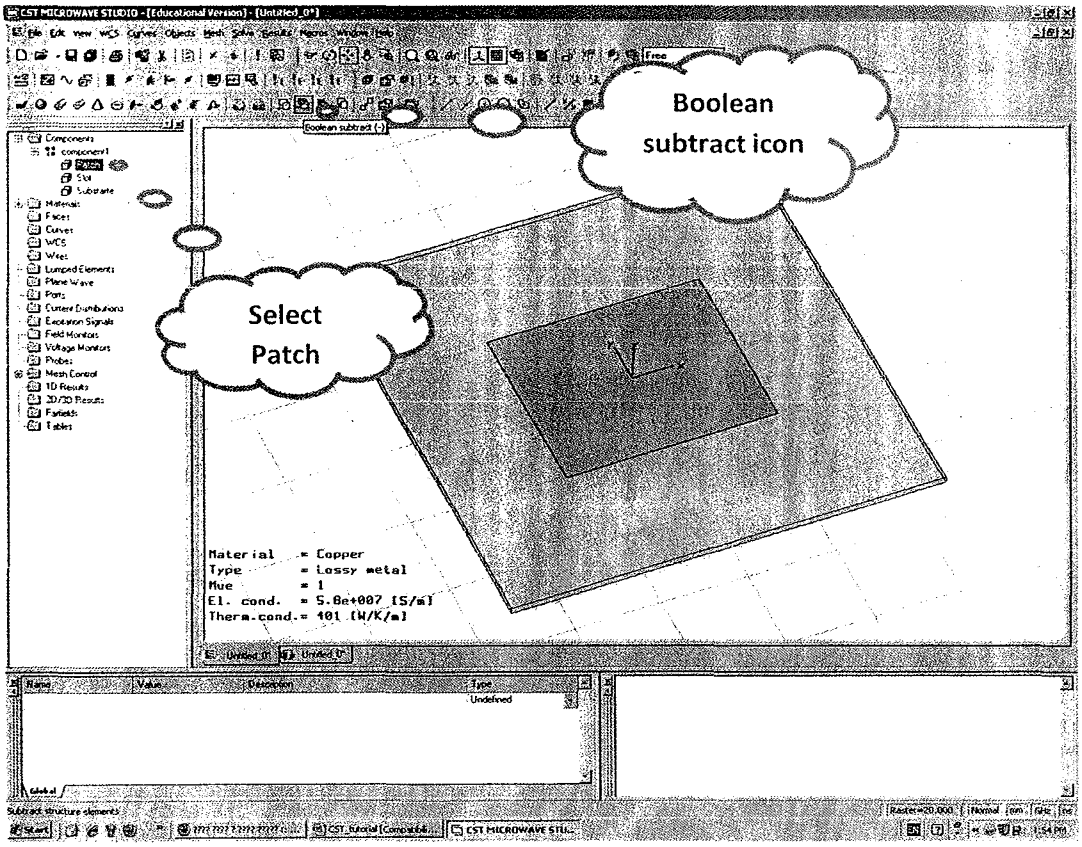


Fig. 12 Cutting the inset feed slot from the patch (a,b,c)

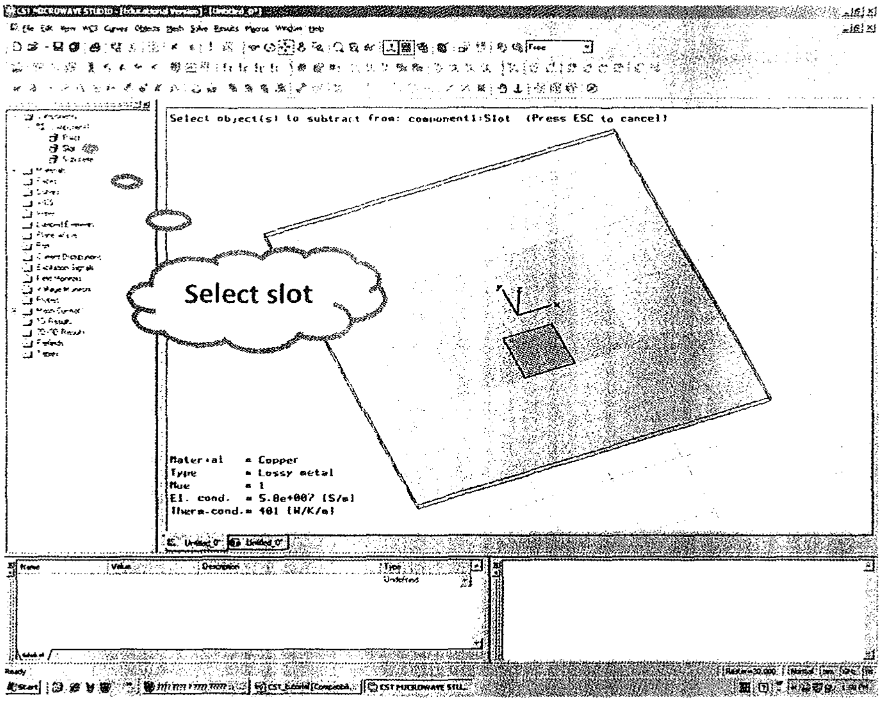


Fig. 13 Cutting the inset feed slot from the patch (d)

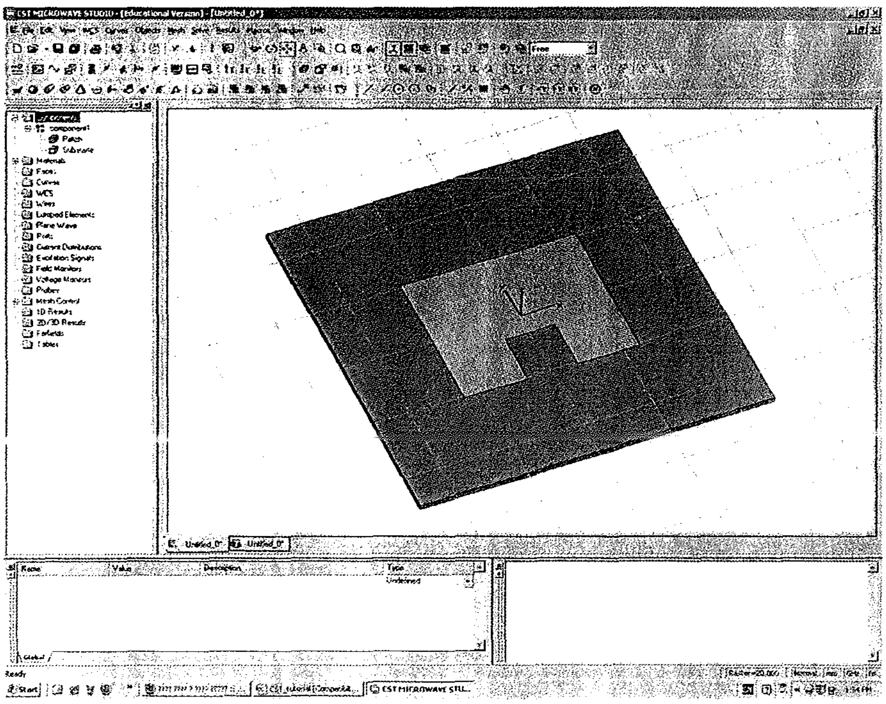


Fig. 14 Cutting the inset feed slot from the patch (e)

Step 8 Drawing the 50 ohm feed line

Create a brick with the following parameters *Xmin* = (-4.85/2), *Xmax* = (4.85/2) and *Ymin* = -50, *Ymax* = 0. And *Zmin* = 0, *Zmax* = 0.1 and assign its material to be copper as shown in Fig.15.

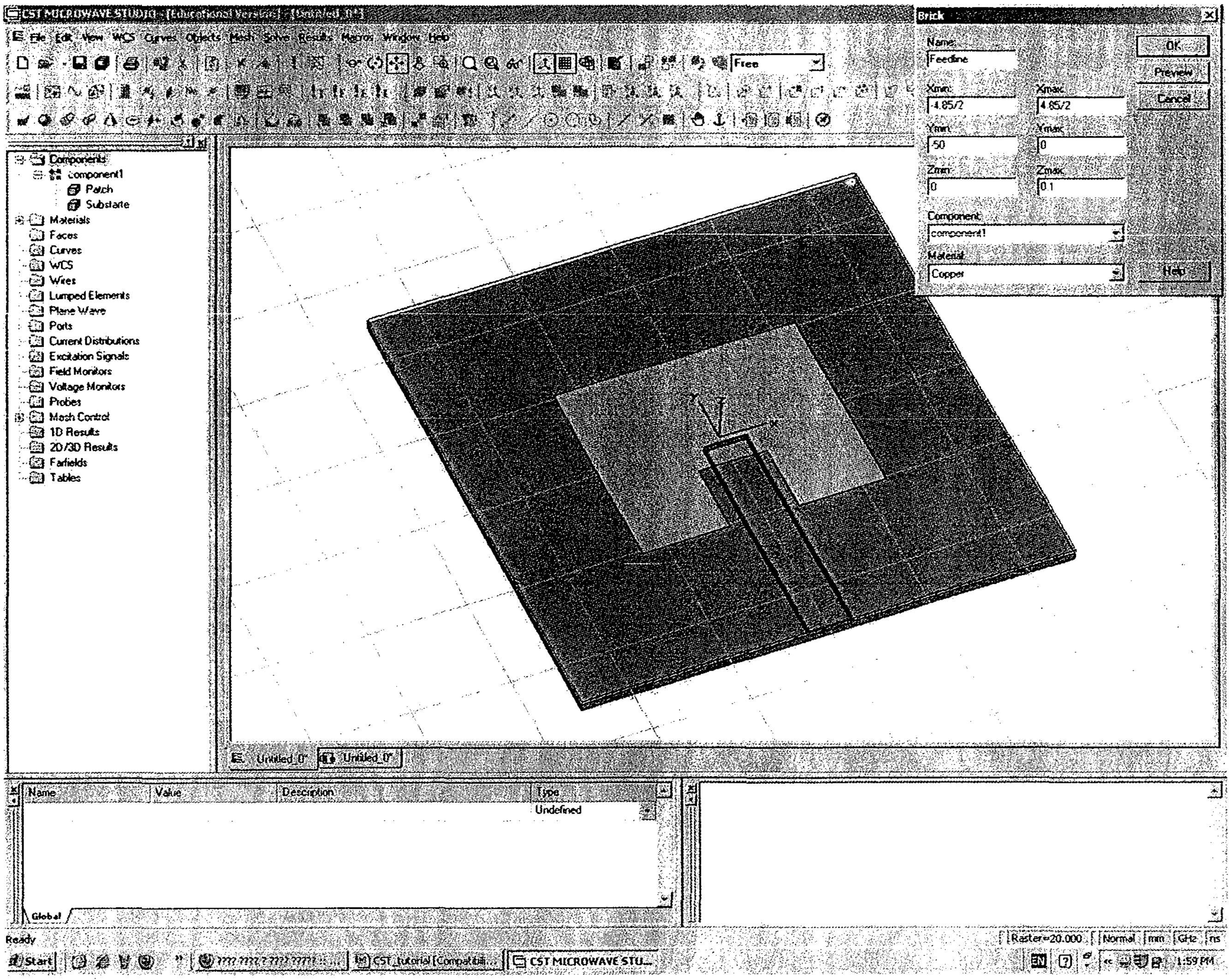


Fig.15 Drawing the 50 ohm feed line

<u>Step 9</u> Merging the feed line with the patch

a. From the left pane under *"Component 1"* sub-menu click on *Feedline* then hold the *ctrl* key in the keyboard and click on *Patch* to select both of them
b. From the toolbar click on "Boolean add (+)", see Fig.16
c. Now they are merged together and become one component as shown in Fig.17

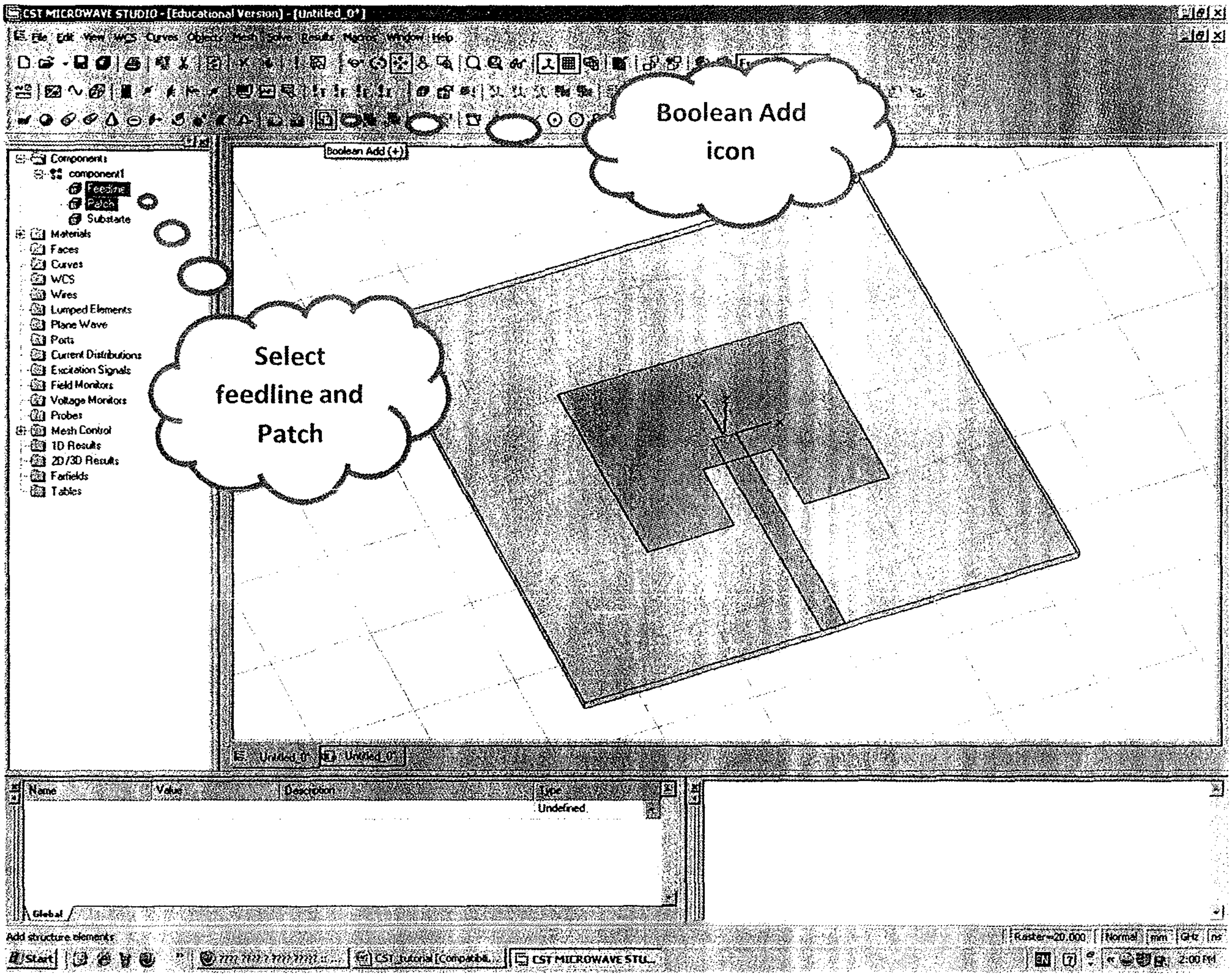


Fig.16 Merging the feed line with the patch

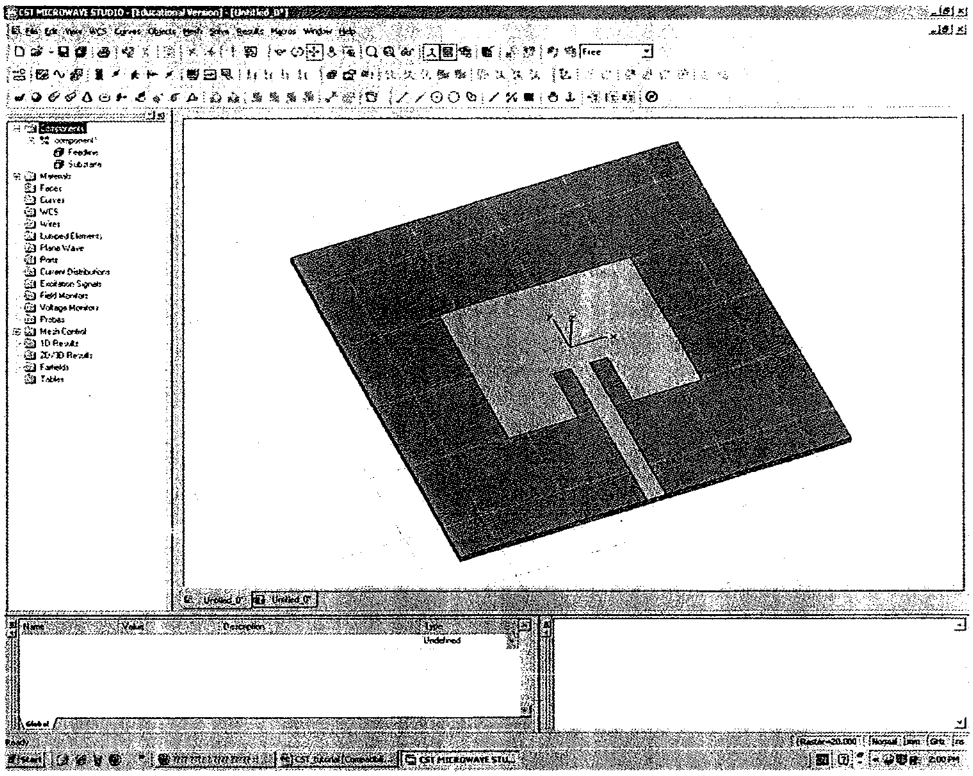


Fig.17 The feed line and the patch after merging

<u>Step 10</u> *Defining the wave port for the antenna*

a. From main menu select > Solve > waveguide ports or by click on waveguide ports icon in the toolbar
b. From the *waveguide* port window select *Normal* to be *Y*
c. Select free in the position box and enter the following dimensions for the wave port : *Xmin* = -20, *Xmax* = 20 and *Zmin* = -1.575, *Zmax* = 10
d. Check "free normal position" in position box and change *Ypos to be -50* as shown in Fig.18
e. After you click ok you should see port 1 defined as shown in Fig.19

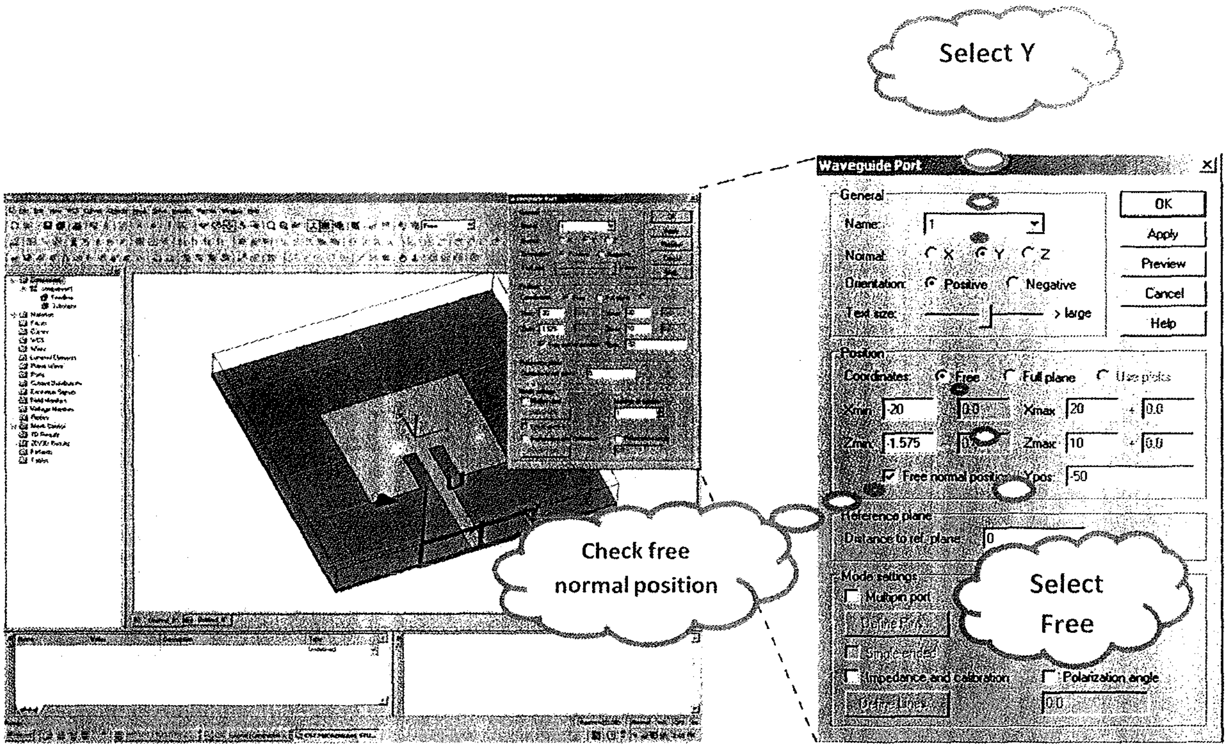


Fig.18 Definition of the wave port

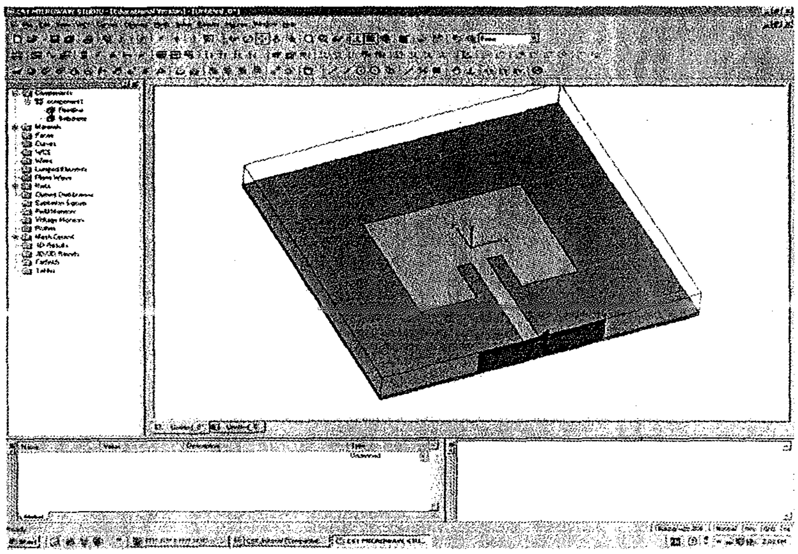


Fig.19 Definition of the wave port

Step 11 Defining the simulation frequency range

a. From main menu select > Solve > Frequency or by click on frequency range icon in the toolbar
b. Enter the frequency range of your simulation as *Fmin* =1, *Fmax*=5 then click ok

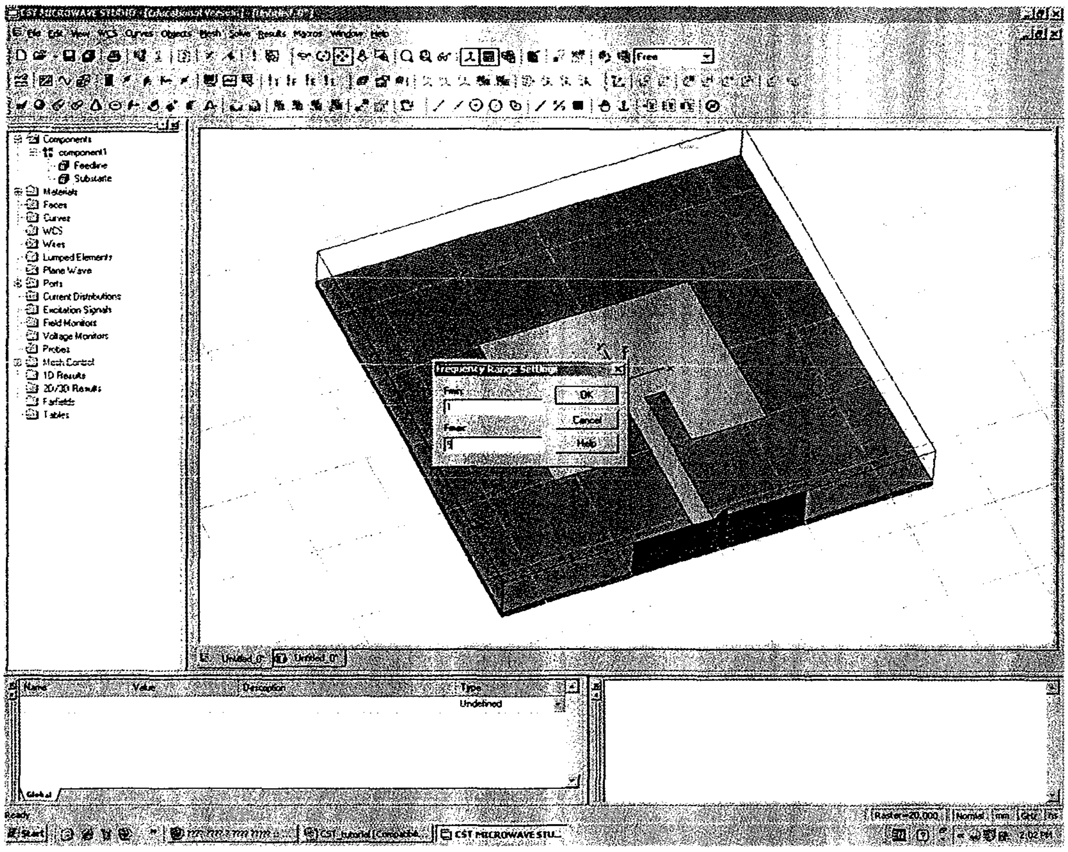


Fig.20 Definition simulation frequency range

Step 12 Adding radiation pattern and surface current to your simulation results

a. From main menu select > Solve > Field Monitors or by click on field monitors icon in the toolbar
b. From Monitor window select *Farfield/RCS* for plotting the radiation pattern and type the monitoring frequency (in this example it is 2.4 GHz) then click apply as shown in Fig.21
c. To plot the surface current distribution select *H-field/Surface current* and type the monitoring frequency then click apply

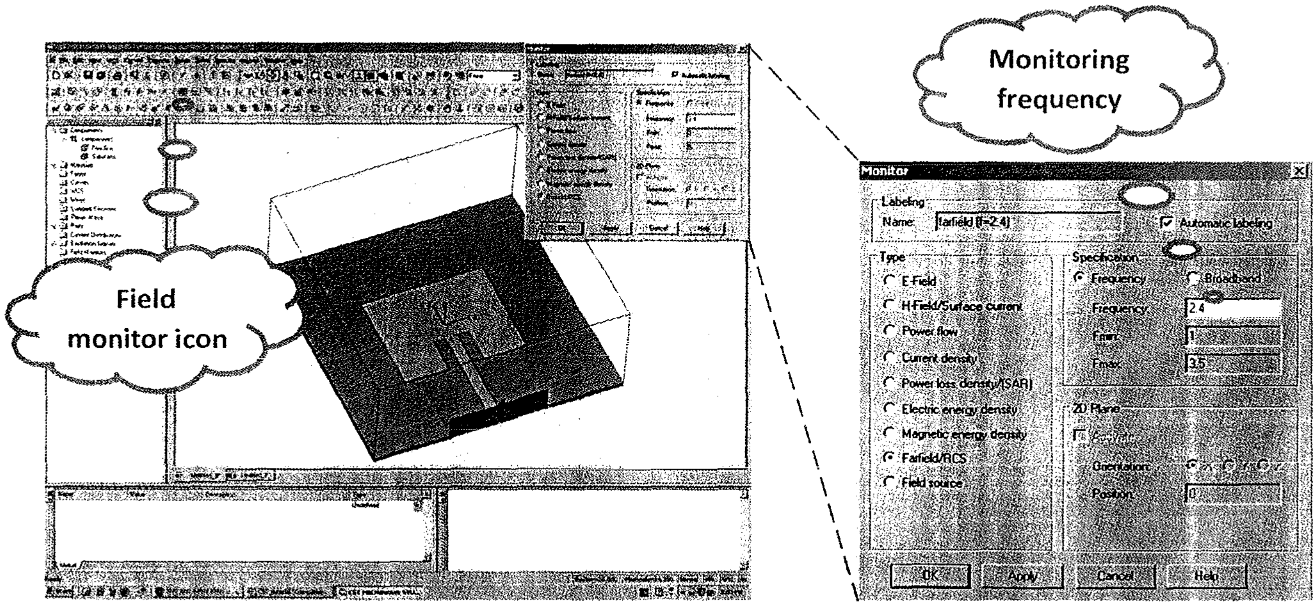


Fig.21 Adding radiation pattern(s) and surface current to the simulation results

<u>Step 13</u> *Running the simulation*

a. From main menu select > Solve > Transient solver or by click on Transient solver icon in the toolbar
b. Form transient solver window you can adjust the solver accuracy "the error margin" in this example I choose it to be -30 dB then click start as shown in Fig.22

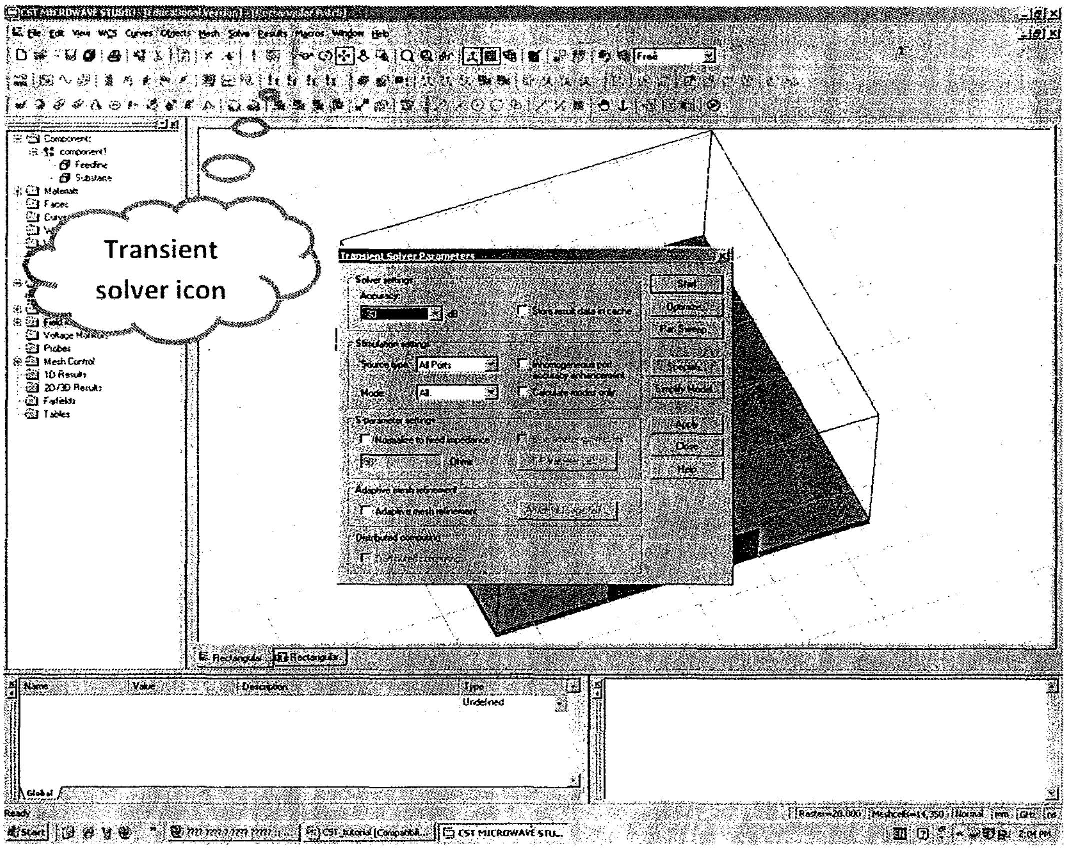


Fig.22 Running the transient solver

Notes:

1. *Increasing the accuracy resulting in slower simulation*
2. *There are more solvers in CST package like frequency domain solver and eigen mode solver but in this example we choose only the transient solver to be presented*

Step 14 Displaying the simulation results

a. To show the S- parameter curves (i.e. linear, dB, phase, smith chart,.....) go to the left pane then click on *1D Results* then select the curve you want to display as shown in Fig.23

b. To show the current distribution plots go to the left pane then click on *2D/3D Results* then select Surface current > h-fields as shown in Fig.24

c. To show the radiation pattern(s) plots go to the left pane then click on *2D/3D Results* then select Farfields > farfield (f=2.4) as shown in Fig.25

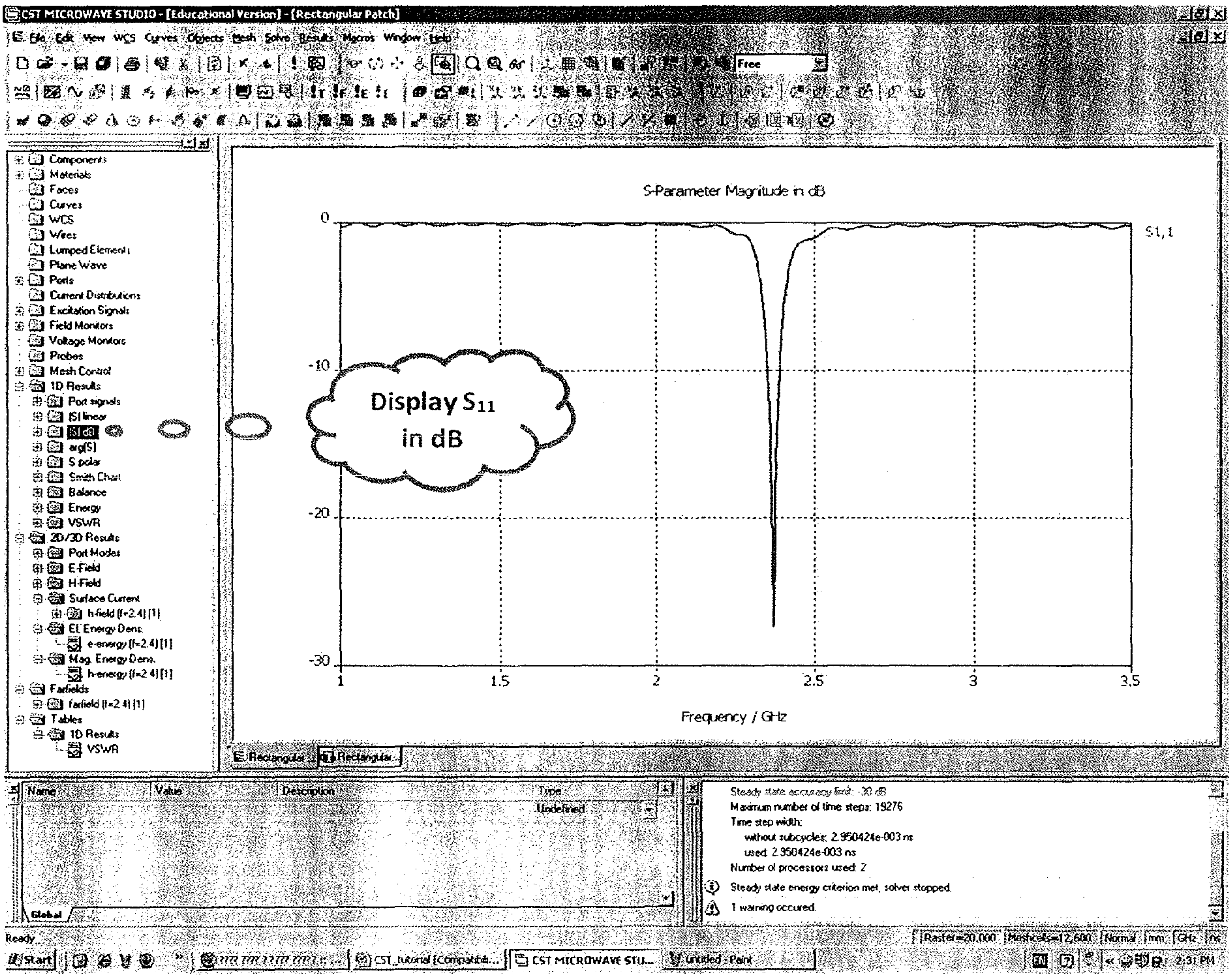


Fig.23 Displaying S-parameter curves

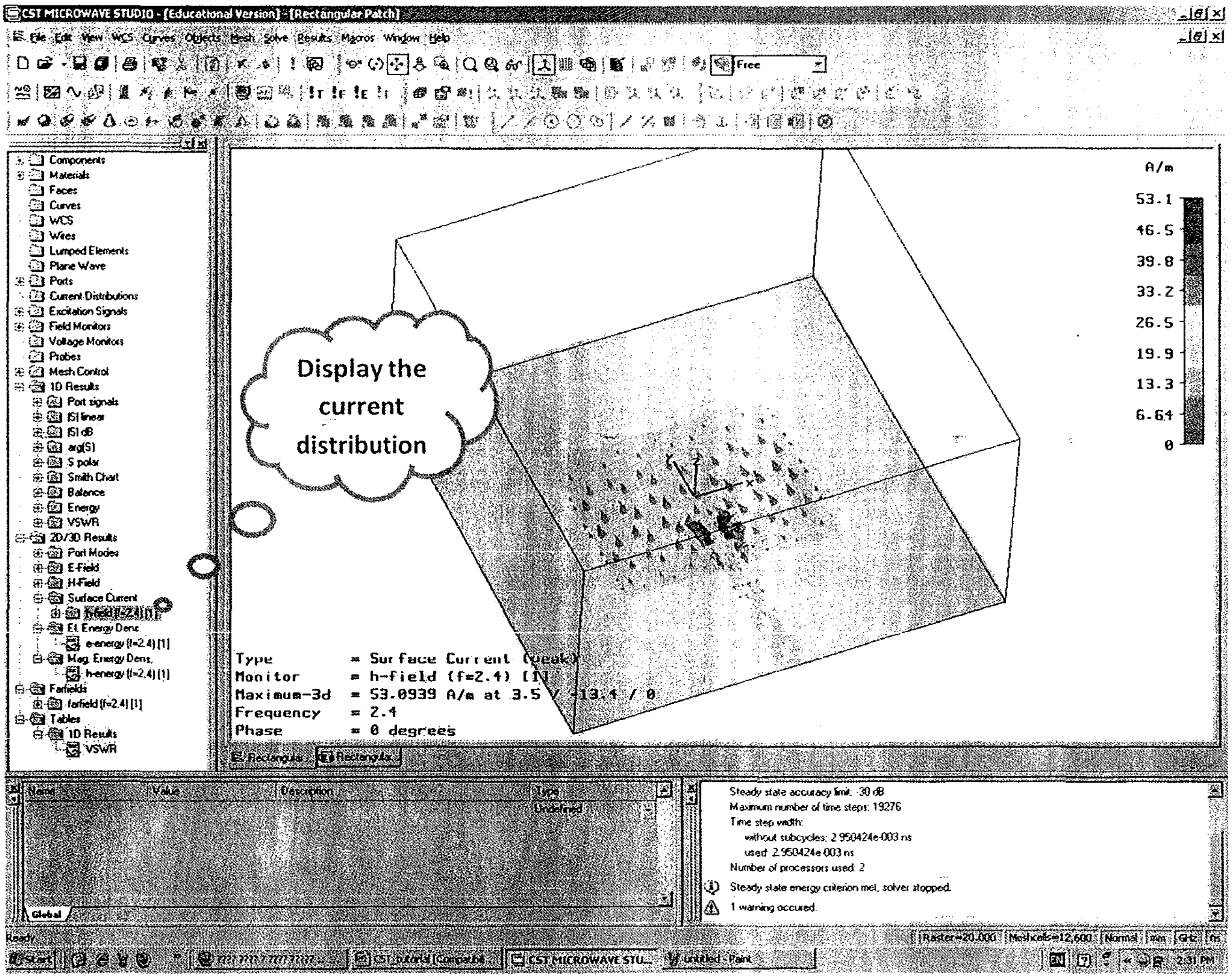


Fig.23 Displaying current distribution plots

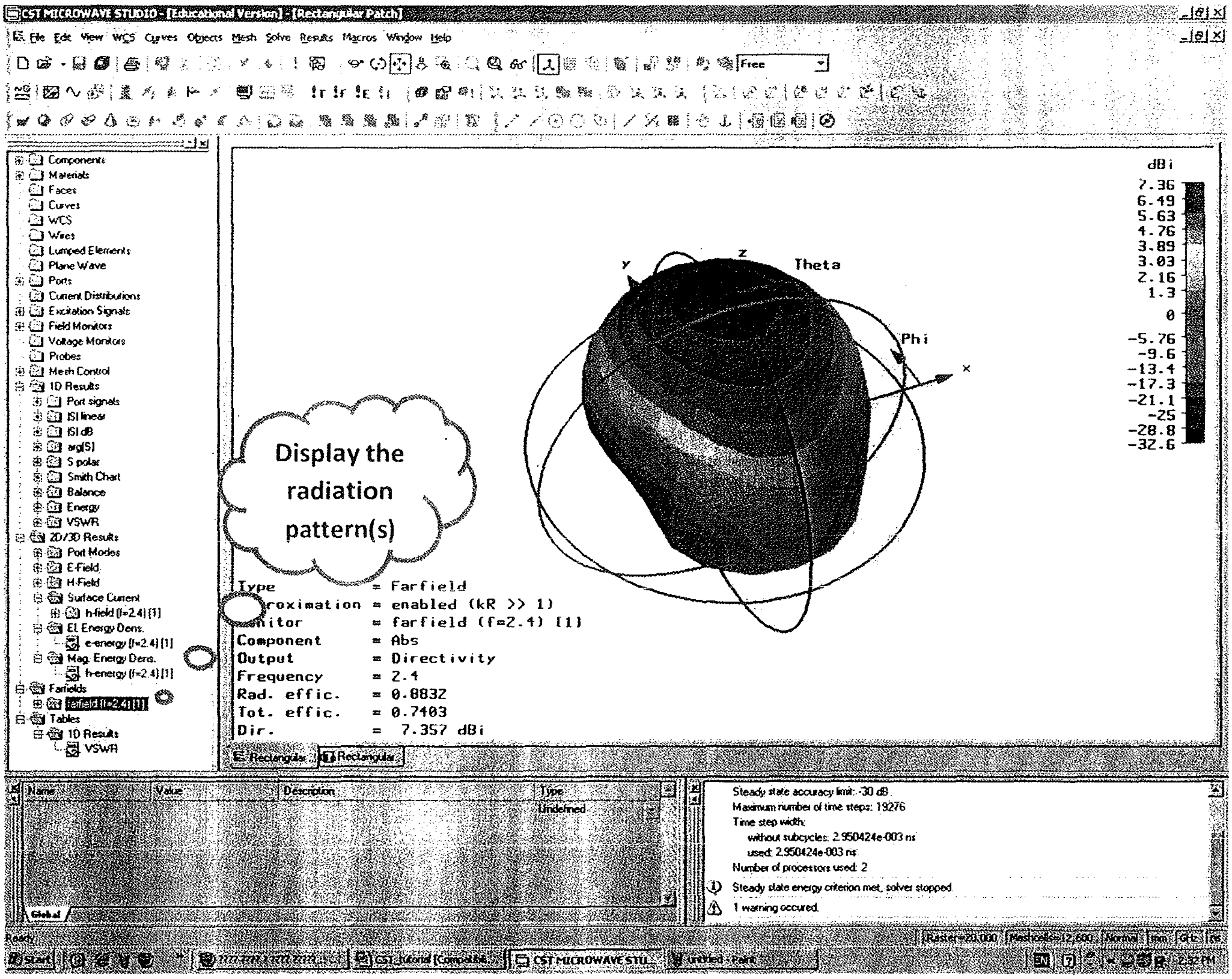


Fig.24 Displaying radiation patterns plots

Step 15 Displaying the post processing results

a. To show some post processed results (i.e. VSWR, Z-parameters, group delay,…….) go to the main menu > Template based postprocessing as shown in Fig.25
b. From Template based postprocessing window select the graph you want to display (in this example I pick VSWR) then click Evaluate as shown in Fig.26
c. Now, go to the left pane then select 1D Results > Tables > 1 D results > VSWR to show the plot as shown in Fig. 27

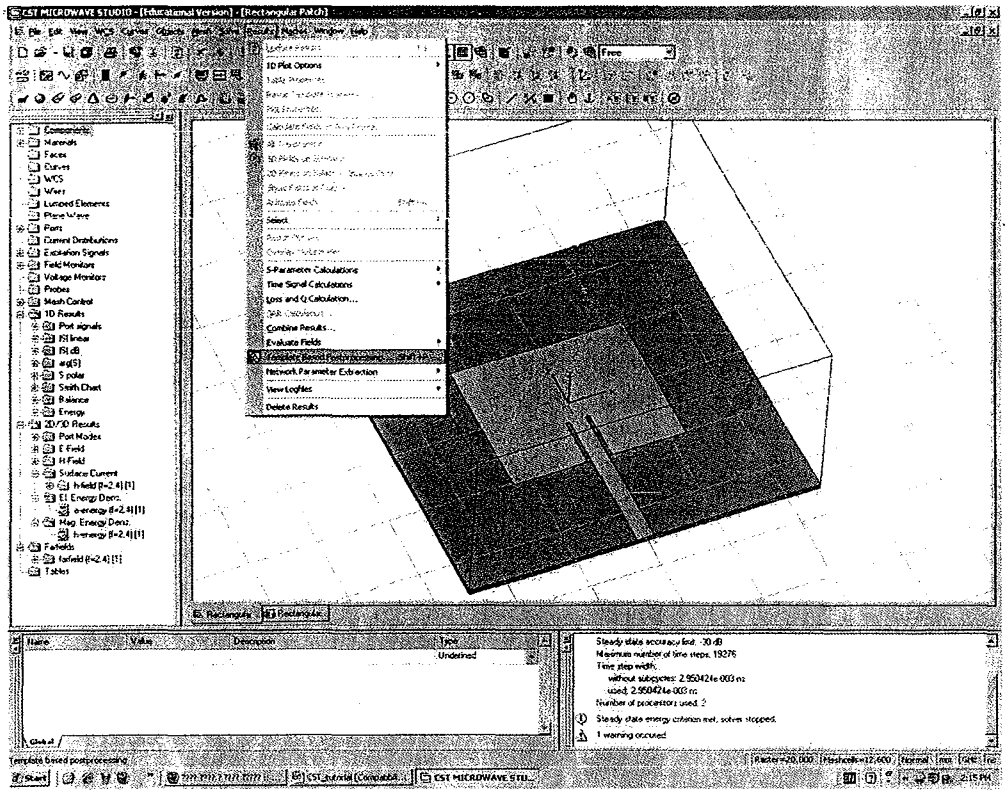


Fig.25 Displaying the post processing results (a)

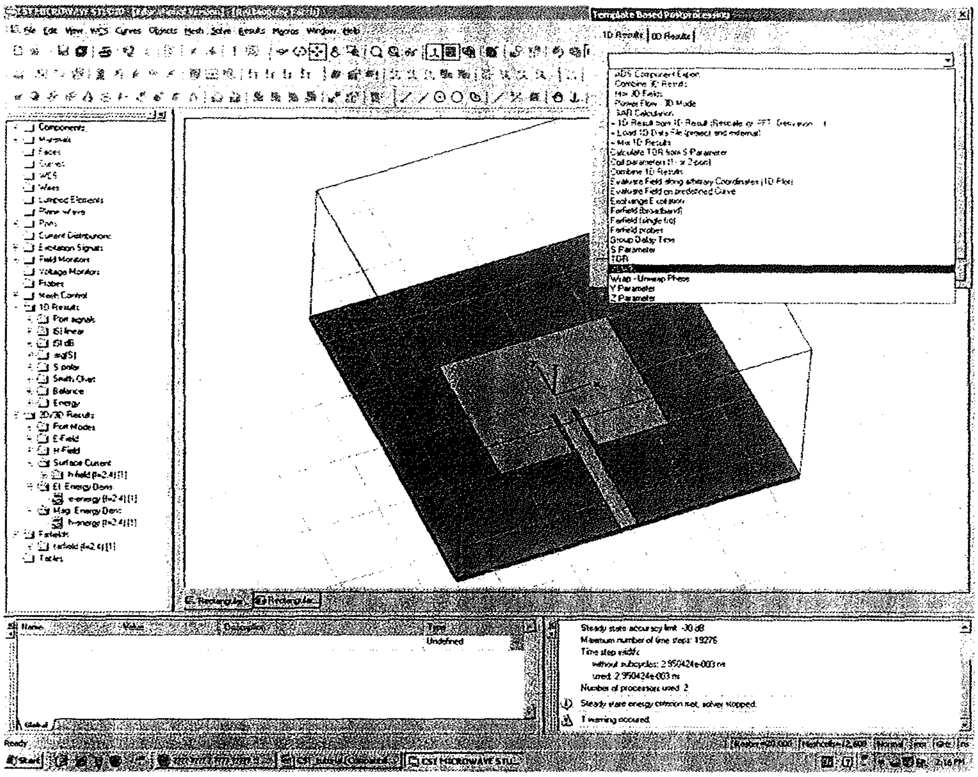


Fig.26 Displaying the post processing results (b)

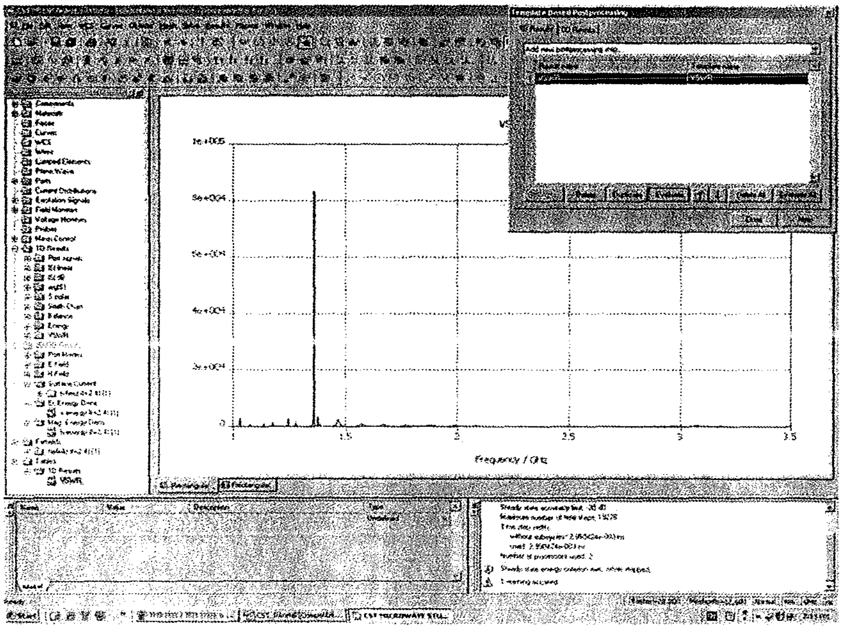


Fig.27 Displaying the post processing results (c)

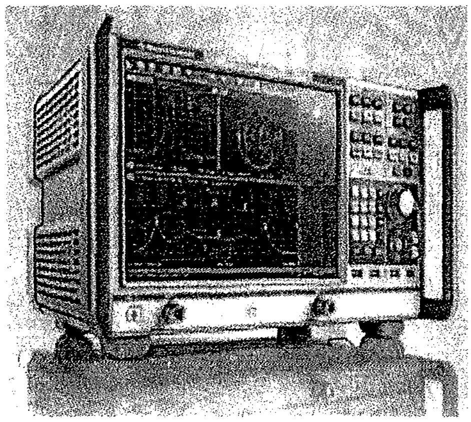
EXPERIMENT NO.10

MEASUREMENTS OF ANTENNA PARAMETERS USING NETWORK ANALYZER

The vector network analyzer, VNA is a form of RF network analyzer widely used for RF design applications. A vector network analyzer is a test system that enables the RF performance of radio frequency (RF) and microwave devices to be characterized in terms of network scattering parameters, or S parameters. The information provided by the vector network analyzer VNA is then used to ensure that the RF design of the circuit is optimized to provide the best performance.

There are two types of Network Analyzers - scalar and vector. The scalar network analyzer provides essentially the same information as a swept spectrum analyzer with a return loss bridge, and is thus not a robust tool as the vector network analyzer or VNA. Vector analyzers measure both magnitude and phase of the response, from which all of the important other data formats can be mathematically calculated.

The basis of the calculations in the VNA is S-parameters. S-parameters work by characterizing a network, in this case an antenna or RF system, through the use of matched loads instead of open and/or short circuit conditions. It is much simpler to characterize a resistive load across a wide range of frequencies than it is to accurately represent a true open or short circuit condition. For broadcasting applications S11 and S12 are much focused. The S12 case arises when examining the insertion characteristics of filters or combiners, and is the response looking from port 1 through port 2 of the system. The S11 case is the response when the reflected signal at the input is compared to the incident signal, which is the measurement mode used when viewing what is seen by the transmitter.



The VNA will usually only provide information in the frequency domain. A plot in the frequency domain will have frequency on the horizontal or X axis and the magnitude of a particular quantity on the Y or vertical axis. Parameters such as VSWR, return loss, the linear magnitude of the reflection coefficient, and phase can easily be viewed. When the magnitude and phase are combined, polar return loss and the Smith chart can be obtained. These latter two formats will qualitatively indicate which end of the system a problem is occurring.

In the time domain mode, the horizontal axis of Cartesian plots becomes time, while the vertical axis remains in terms of magnitude. Since it takes a finite amount of time for a signal to propagate through a transmission line, a particular "time" of interest is directly relatable to distance down the line. The time domain information is mathematically generated through the application of the inverse Fourier transform to the magnitude and phase acquired at each individual swept frequency. The result is that through the proper selection of measurement frequencies, an issue in a system can be located with very good accuracy.

To adequately depict the condition of an antenna system both the frequency and time domain must be considered. Frequency domain data provides a view of what the transmitter is actually seeing. The time domain data allows anomalies in the transmission line and the magnitude of the far end reflection, which was very important in analog television, to be quantified.