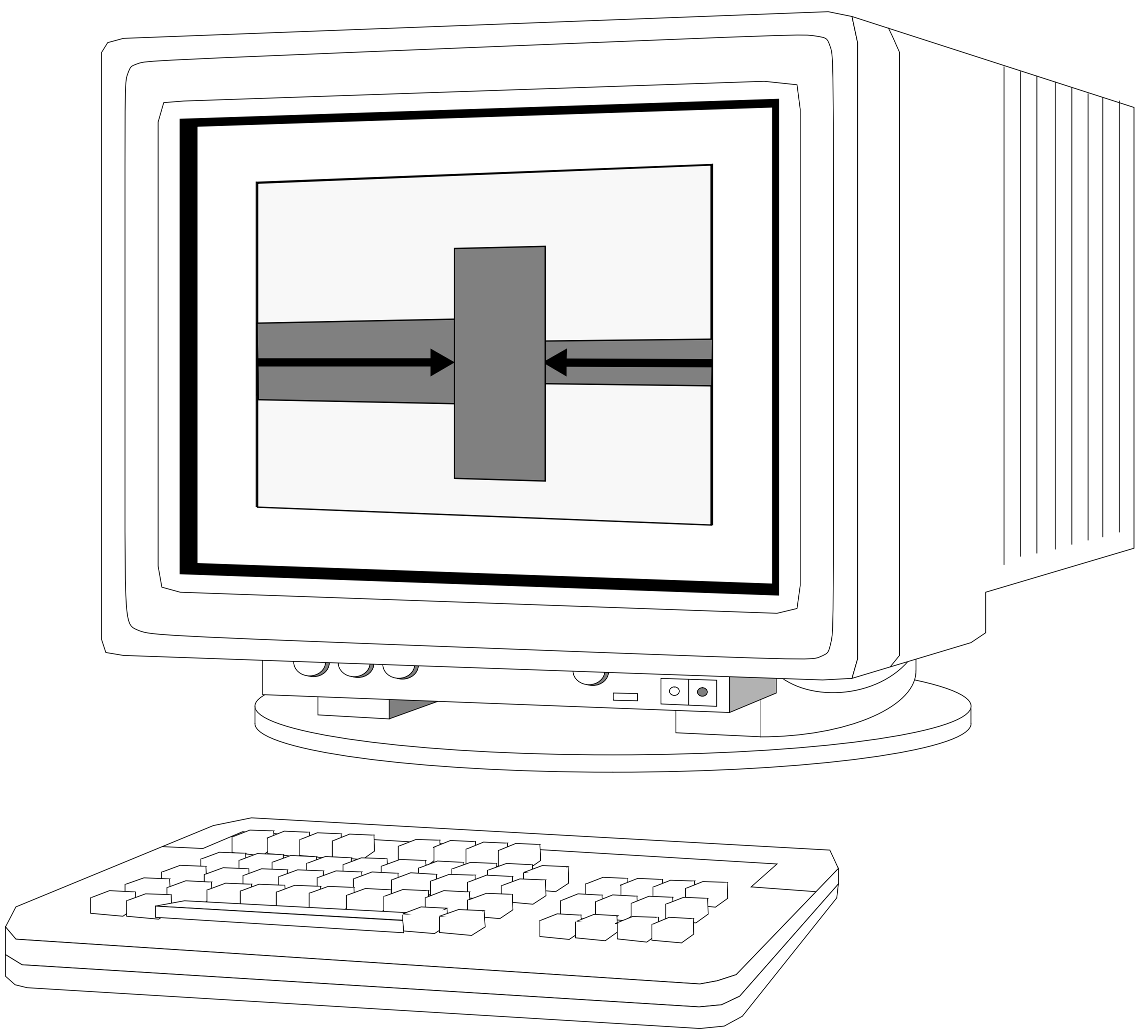
Patgen and Patvu User's Manual



Patgen and Patvu User's Manual

Printed: September 1, 1993

Release 2.4

Sonnet Software, Inc.
135 Old Cove Road, Suite 203
Liverpool, NY 13090-3774
(315) 453-3096
Fax: (315) 451-1694

© Copyright 1989,1991,1993 Sonnet Software, Inc. All Rights Reserved
Registration number: TX 2-723-907

This publication is subject to change at any time and without notice. Any suggestions for improvements in this publication or the software it describes are welcome.

The program names ***xgeom, em, emvu, patgen*** and ***patvu*** (lower case bold italics) are trademarks of Sonnet Software, Inc. UNIX is a trademark of AT&T. X Window System is a trademark of the Massachusetts Institute of Technology. SPARCstation is a trademark of Sun Microsystems, Inc.

Disclaimer of Warranties And Limitation of Liabilities

Sonnet Software, Inc. has taken due care in preparing this manual and the software it describes, including research, development, and testing to ascertain effectiveness and correctness. SONNET SOFTWARE, INC. MAKES NO EXPRESSED OR IMPLIED WARRANTY OF ANY KIND WITH REGARD TO THIS MANUAL OR WITH REGARD TO THE SOFTWARE IT DESCRIBES. IN NO EVENT SHALL SONNET SOFTWARE, INC. BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH, OR ARISING OUT OF, THE FURNISHING, PERFORMANCE, OR USE OF THIS MANUAL OR THE SOFTWARE IT DESCRIBES.

Permission to copy this manual in its entirety is hereby granted for internal use.This manual may not be sold unless authorized in writing by Sonnet Software, Inc.

TABLE OF CONTENTS

Chapter 1 Introduction

This manual is intended for antenna designers who are familiar with ***em***, the electromagnetic analysis program from Sonnet Software. Figure 1 shows the relationship of ***patgen*** and ***patvu*** to other programs available from Sonnet Software.

♦ A Brief Overview

Patgen is an analysis tool which calculates far field antenna patterns for arbitrary 3-D planar geometries. ***Patgen*** uses the current distribution (".jxy") file from ***em*** as input, and creates a pattern (".pat") file as output. The pattern file may then be viewed using ***patvu***.

Patvu is an X Window System, mouse driven program used to view results from a ***patgen*** analysis. The pattern may be viewed as a cartesian or polar chart. A 3-D plot may also be generated, where the third dimension (magnitude dB) is plotted as a spectrum of colors.

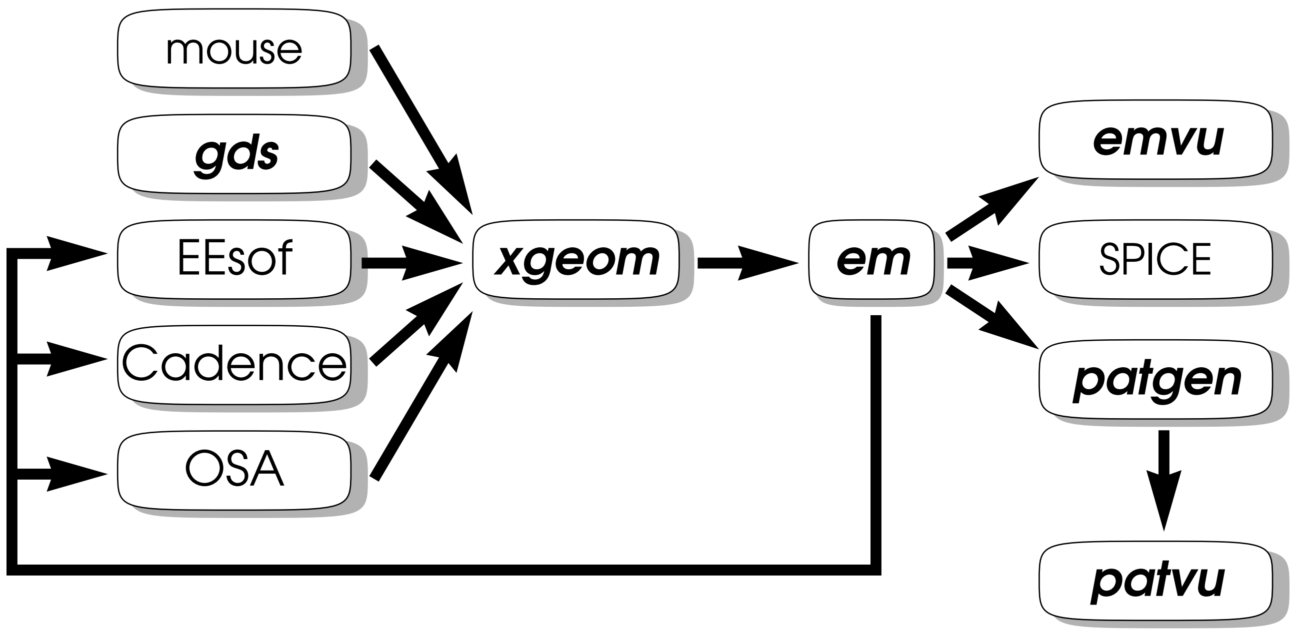


Figure 1 Relationship of Sonnet programs. “Mouse” indicates manual capture or modification of circuit geometry. “SPICE” is any SPICE software. Other non-bold text indicates software developed by other companies which interfaces with Sonnet. Sonnet products are listed in bold. Arrows indicate data flow.

♦ Requirements

Because of the nature of the software***, patvu*** requires a color monitor. Specifically, you need a non-static display supporting a minimum of eight planes. On MS-DOS systems, ***patvu*** uses 16 or 256 colors and requires a VGA or SVGA monitor. This is the only hardware requirement beyond that needed to run ***xgeom***.

♦ Conventions Used in This Manual

The following section discusses conventions used in this manual. This section may be skipped if you are already familiar with ***xgeom*** or ***emvu***. Familiarity with the use of X Window Systems such as Motif, OpenWindows, or DESQview/X is assumed. If you are not familiar with the X Window System, obtain documentation for your system describing the use of the X Window System. A half hour spent using the X Window System is more than adequate.

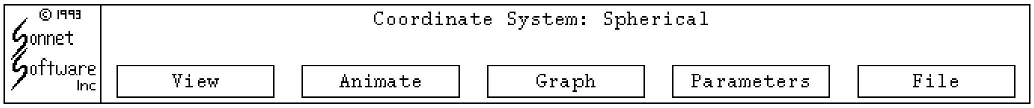


Figure 2 ***Patvu***'s Main Button Menu

✧ *Patvu* Button Menus

Patvu's functions are accessed by "pressing" the appropriate menu buttons. To "press" a ***patvu*** button on the main menu, use the mouse to position the cursor directly on the desired button. Press and hold down the left mouse button and a menu appears. Holding the mouse button down, drag the cursor down until the desired item is highlighted. Then release the button. For example, move the mouse so that the cursor is on the *Parameters* button. Press (and hold down) the left mouse button. The ***patvu*** button is highlighted (changes color) and a menu appears. Notice that the cursor has changed its shape. To select a menu item, such as *Plot Type*, move the cursor (mouse) down so that *Plot Type* is highlighted and then release the left mouse button. If the button is released while the cursor is outside the menu, no action results. If, for some reason, no item on the menu is wanted, just move the cursor off the menu so that no item is highlighted and then release the mouse button. Once a main menu item is selected, a new button menu is usually displayed.

Please note that the main ***patvu*** button menu is the ONLY button menu which uses "hold and drag" (i.e., holding down the mouse button and moving it before releasing). All other button menus are "click and release". To "press" a ***patvu*** button on all remaining button menus, use the mouse to move the cursor to the desired menu button, then press and release the left mouse button. Notice that some menu items have an ellipsis (...) after them. This means that this item calls another button menu. These menu items require more information before an action can take place. Other menu items have a word in angle brackets ("< >"). These items are toggles. Clicking on an item marked "<On>" turns that particular attribute off and clicking on an item marked "<Off>" turns that attribute on.

Most button menus have a *Done* or *Skip* button as the right most button. Clicking on this button returns you to the next higher menu level, eventually always ending in the main button menu.

Depending on the mode and parameters selected, some menu buttons may not be available. The text in unavailable buttons is a lighter color and does not become highlighted when the cursor is moved on them. We refer to these buttons as “shadowed”. Releasing the mouse button with the cursor on a shadowed button does not select the menu item.

Occasionally, keyboard input is required. In this case, an appropriate prompt appears on the button menu and anything you type appears there also. Pressing *Return* or the left mouse button without typing anything leaves the present value of the parameter unchanged.

✧ Clicking on a Button

When we ask you to click on a menu button, you should use the mouse to move the cursor to the desired menu button, then press and release the left mouse button.

✧ Describing Button Presses

In the rest of this manual, we describe accessing the menu items of ***patvu*** using a “pointer” description to illustrate selecting the desired menu buttons.

For example, *Parameters* ⇒ *Frequency* ⇒ *Next* means to move the cursor to the *Parameters* button in the main button menu, press (and hold down) the left mouse button, drag the cursor down the menu which appears until *Frequency* is highlighted, and release the mouse button. When the new button menu appears, click on *Next*.

✧ Shortcut Keys

Some menu buttons have a shortcut associated with them. These menu buttons can be “pressed” by typing the associated shortcut key. Shortcuts are shown in parentheses at the end of the name of the menu item. Typing the shortcut key has the same effect as “pressing” the menu button but you don’t need to go through the menus. Most of the shortcut keys are “control” keys, i.e. you must first hold down the *Control* key, and then press the key. The “control” keys are abbreviated with a “^” symbol. Any time you see a “^” symbol before a letter, e.g., “^Z”, you should interpret this as meaning a control key. As an example, to type a Control-Z (^Z), hold down the *Control* key and press the *Z* key. A list of the shortcut keys is found in section "Keyboard Shortcuts" on page 50 of this manual.

♦ Using the Example Files

In the following chapters, we refer to several example files which are supplied with ***patvu***. To use these files, you must copy them into your directory. A utility called ***copyex*** has been provided with ***patvu*** which copies an example file into your directory. To copy an example file, type in “copyex” followed by the file name. For example, to copy the example file “ctl.an”, type:

copyex ctl.an

Copyex copies the example file from the Sonnet example directory into your directory. If a file in your directory has the same name, ***copyex*** overwrites it with the original example file. This feature is useful if you modify an example file and want to restore the file to its original version.

♦ Organization of This Manual

Chapter 2 of this manual describes the basic theory needed to understand ***patgen*** and ***patvu***. Chapter 3 and Chapter 4 of this manual form a tutorial illustrating the use of ***patvu*** by using examples. Chapter 5 is a special chapter on arrays. Chapter 6 forms a concise reference for ***patvu***’s functionality, suitable for use once one has a working knowledge of the program. The tutorial section of the manual requires about an hour to complete.

Chapter 2 Technical Background

This chapter describes the basic theory needed to understand ***patgen*** and ***patvu***.

♦ *Patgen* and *Patvu's* Capabilities

The purpose of ***patgen*** is to calculate the far field pattern of an antenna for a given excitation and set of directions. ***Patgen*** starts by reading a ".jxy" file generated by ***em*** for the antenna at the desired frequencies. The user specifies the directions (for example, phi and theta ranges) in which the radiation pattern is desired. The user also specifies the desired port excitations and terminations. Then, ***patgen*** reads the current distribution information in the ".jxy" file and generates a ".pat" file with the desired far field antenna pattern information. This pattern information is then viewed with ***patvu***.

Since ***patgen*** uses the current density files generated by ***em***, ***patgen*** has the same restrictions as ***em***. One additional restriction is that while ***em*** has no limit on the number of levels, ***patgen*** can only analyze single level structures. This means that you may have only two (2) dielectrics in ***xgeom***. Any structure with additional layers results in inaccurate answers. This restriction is to be removed shortly.

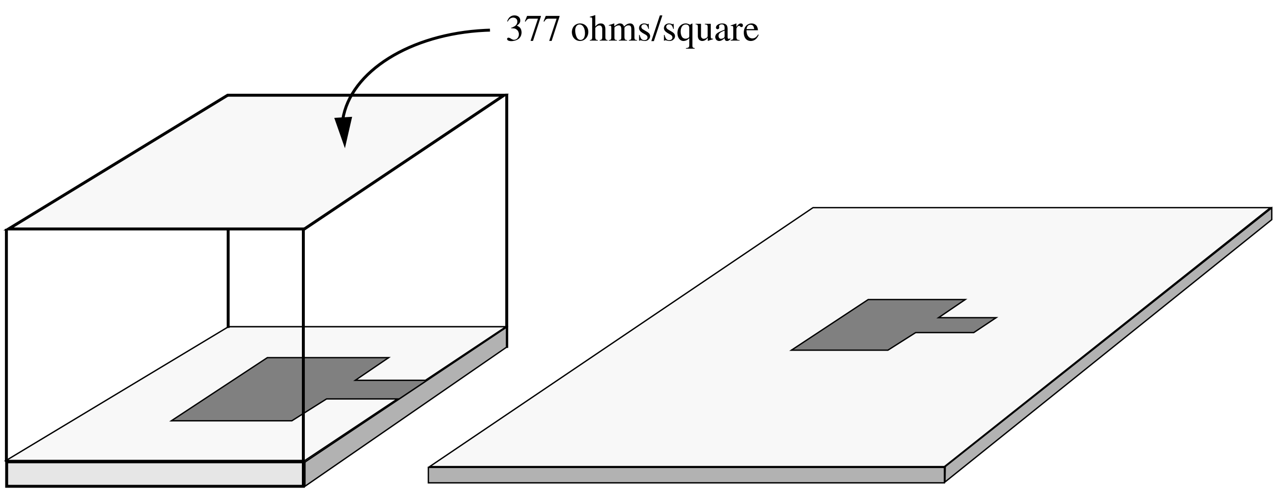
Patgen can analyze microstrip, coplanar structures, patch antennas, arrays of patches, and any other single layer circuit. As with ***em***, ***patgen*** can analyze any number of ports, metal types, and frequencies. Also, the dielectric must be continuous across the substrate; i.e., dielectric posts cannot be accurately modeled. ***Patgen*** cannot analyze circuits which radiate sideways, coaxial structures, wire antennas, surface wave antennas, ferrite components, or structures that require multiple dielectric constants on a single layer.

♦ Using *Em* for Analysis

Figure 3a shows the recommended method described in the ***em*** manual for modeling radiation. The electromagnetic analysis is performed inside of a six-sided metallic box with the top cover of the box set to 377 ohms/square. This simulates removing the top cover. The analysis is performed and a current density (".jxy") file results. For accurate results, the box walls must be far away from the antenna, and the principal radiation must not be directed toward the sidewalls of the box.

Chapter 16, "Antennas and Radiation" in "The ***Em*** User's Manual" has a detailed description of the proper way to analyze antennas using Sonnet. This should be read carefully, as it is easy to make errors which violate the underlying assumptions.

To obtain the antenna pattern, you must run ***patgen***. ***Patgen*** calculates the fields radiated by the current that is stored in the current density (".jxy") file. The analysis is performed in an open environment with a substrate of infinite extent as suggested by Figure 3b.



(a) em ***(b) patgen***

Figure 3 ***Em*** calculates the current distribution of an antenna enclosed in a box with a 377 ohms/square top cover **(a)**. The box walls must be far away from the antenna to give accurate results. ***Patgen*** uses the current density information from the ***em*** analysis to calculate the radiation pattern for an infinite dielectric in an open environment **(b)**.

♦ Assumptions

The analysis of ***patgen*** has the following characteristics:

1. The plotted antenna patterns do not represent de-embedded data. Therefore, the effect of the port discontinuity is still included even if you specify de-embedding when running ***em***.
2. Only fields generated from x- and y-directed current are plotted. Fields generated from z-directed current (from vias) are not displayed.
3. Radiation from triangular subsections (i.e., diagonal fill) is not included.
4. ***Patgen*** patterns are for a substrate which extends to infinity in the lateral dimensions.

♦ Spherical Coordinate System

You can view your antenna plot using various coordinate systems. But first, we describe the most important system, the spherical coordinate system.

To view an antenna plot, ***patvu*** can use the spherical coordinate system (see Figure 4). The X, Y, and Z coordinates are those used in ***em*** and ***xgeom***. The XY plane is the plane of your ***xgeom*** window, with the Z axis pointing toward the top of the box. The spherical coordinate system uses theta (θ) and phi (ϕ) as shown in Figure 4.

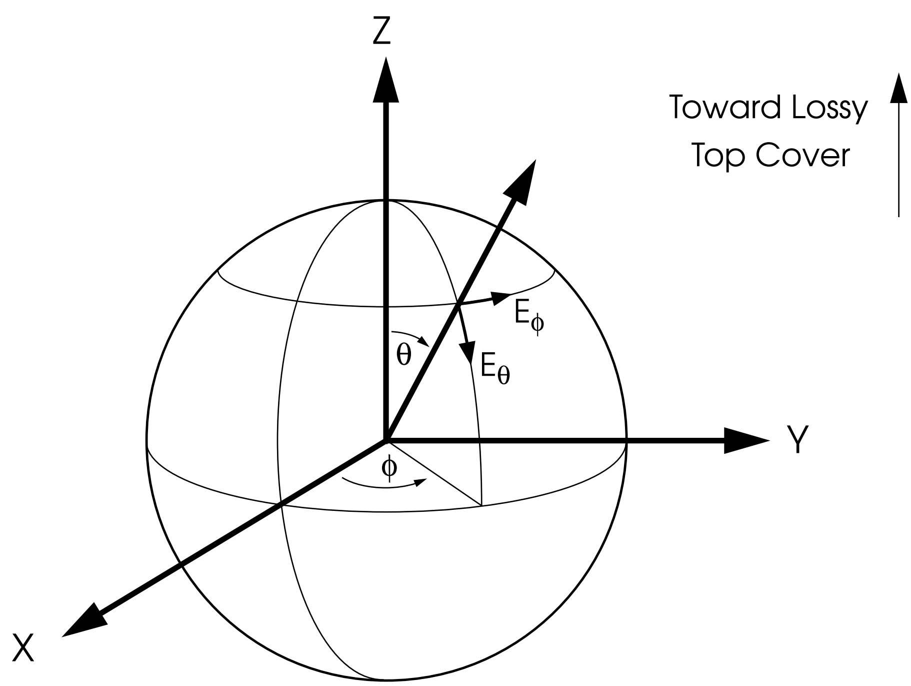


Figure 4 The spherical coordinate system shown in terms of the X,Y and Z coordinates of ***em*** and ***xgeom***.

Patgen allows values for theta from 0 to 180 degrees. However, values of theta greater than 90 degrees are below the horizon and are not useful. Generally, we view just the top hemisphere. This is done by sweeping theta from 0 to 90 degrees and by sweeping phi from -180 to 180 degrees.

Sometimes it is desired to specify theta from -90 to +90 degrees (horizon to horizon), rather than 0 to 90 degrees (zenith to horizon). In this case the earth view coordinate system can be used. For the earth view coordinate system, allowed values of phi range from -90 to +90 degrees. See the section on the earth view coordinate system in Appendix I for a detailed description.

The X and Y axes in Figure 4 correspond to the X and Y axes in ***xgeom***. For drawing purposes, the origin, (0,0), in ***xgeom*** can be either in the upper left corner, or the lower left corner of the screen. For analysis purposes, the origin is always in the upper left corner. This can result in some confusion with antennas whose radiation is not symmetrical along phi = +/-90 degrees. If you have such a situation, read the section in Chapter 5 entitled "A Potential Coordinate System Difficulty" .

To look at an E-plane cut or an H-plane cut, set phi (ϕ) to 0 or 90 degrees, and sweep theta (θ) from 0 to 90 degrees. To view an azimuthal plot, set θ and sweep ϕ.

Patvu displays three plot types; cartesian, polar, and image. The cartesian plot allows the magnitude (in dB) to be plotted on a rectangular graph with your choice of theta (θ), phi (ϕ), or frequency for the X axis, (see Figure 5). The polar plot allows you to select either theta (θ) or phi (ϕ) for the angle axis. A third type of plot is called "image", (see Figure 6). With this type of plot, the horizontal axis is theta (θ), and the vertical axis is phi (ϕ). The magnitude (in dB) is plotted as a color with red corresponding to a large magnitude and blue corresponding to a small magnitude.

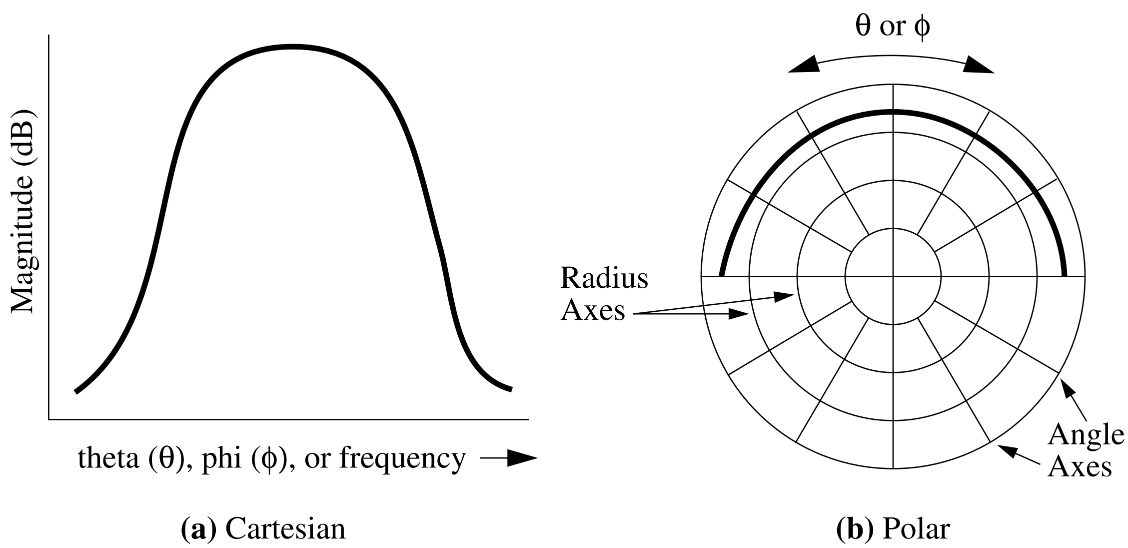


Figure 5 ***Patvu*** allows you to sweep theta (θ), phi (ϕ), or frequency.

We sometimes refer to cartesian and polar plots as 2-D and image plots as 3-D.

♦ Alternate Coordinate Systems

Sometimes a different viewing coordinate system is useful. For example, the Top View coordinate system gives a “top view” of the sphere and is useful when viewing image plots (see Figure 6). Also, the earth view coordinate system is identical to the spherical, except that theta is allowed to vary between -90 and +90 degrees, instead of 0 to 90 degrees. ***Patgen*** allows you to choose from four different coordinate systems which are explained in detail in Appendix I. Note that changing the viewing coordinate system only changes how data is represented. It does not change the antenna or excitation.

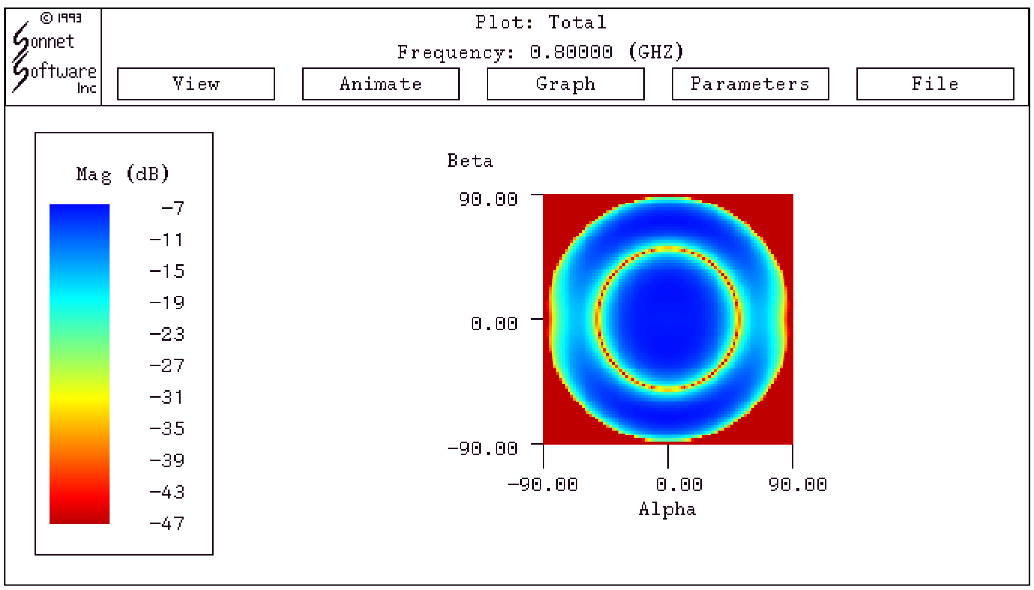


Figure 6 A ***patvu*** image plot using the Top View coordinate system.

♦ Normalization

By default, ***patvu*** normalizes all data to the maximum value of all of the data, not just the data being shown. You may change the normalization in ***patvu*** using *Parameters* ⇒ *Normalization*. You may normalize the data to an that of an ideal, theoretical isotropic antenna in free space (dBi), an ideal theoretical dipole antenna in free space (dBd), or you may change the normalization to an arbitrary value.

♦ Polarization

Patvu displays the magnitude of the electric field vector for a given direction. The magnitude may be represented as the vector sum of two polarization components, E-theta (E_θ) and E-phi (E_ϕ) as shown in Figure 4 on page 9.

Patvu allows you to see the total magnitude or either component of the magnitude. Other polarizations are also available in ***patvu*** and are discussed in Menu: Parameters - Polarization on page 44.

Chapter 3 A Two-Dimensional *Patvu* Tutorial

This chapter describes an example of using ***patvu*** to display two-dimensional plots. In this example, we analyze an infinitesimal dipole antenna above a ground plane, and compare the results to the exact theoretical antenna pattern shown in Figure 17 on page 24, as provided by reference [1].

♦ Getting Started

For Unix systems, log into your account. At this point, system specific actions may be required which are not described here. If needed, consult your system administrator.

Now make and change to a new directory; type:

mkdir test

cd test

Next, if the X Window System is not already running, start it. A (system specific) command like “xstart”, “x11start”,”xinit”, “openwin” or “motif” should do it. For MS-DOS systems, “dvx” should start it. If not, seek assistance from another user or the system administrator.

♦ Creating an Antenna Pattern File

For our first example, we use an infinitesimal dipole one wavelength above ground example provided with your software. First, copy the example files from the Sonnet example directory by typing:

copyex infpole.an ctl.pg infpole.geo

The “infpole.an” file tells ***em*** to do the analysis at several frequencies around 1.0 GHz. The file “infpole.geo” is the geometry file for the dipole antenna which was created using ***xgeom***. The dipole geometry can be viewed by using ***xgeom***. The “ctl.pg” file tells ***patgen*** to do the analysis at all frequencies analyzed by ***em***. We first create a current density file called “infpole.jxy”:

em -vj infpole.an infpole

This command runs ***em*** and creates a current density file called “infpole.jxy”. The file “infpole.an” is included in the command line because otherwise the default “ctl.an” file name would be used. If the current density file already exists, ***em*** saves the old version with a file extension of “.jxb” before creating the new file. The -v option displays messages during execution describing the present state of the analysis. ***Em*** issues a warning that one of the ports has no access to ground. The warning is issued because a port with no access to ground can be a data capture error. Here, it is intended, so the warning can be ignored.

```
CTLPG
VER 2.4
COORD Sphere
ANG1 0 90 2
ANG2 0 90
GHZ
FRE ALL
PORT ALL MAG=1 PHASE=0
```

Figure 7 The “ctl.pg” file needed for this example. The “ctl.pg” file obtained by using the “copyex” command also has numerous comments describing the purpose and allowed values for each line. For simplicity, this figure does not show the comments.

The “ctl.pg” file if the default file name for the ***patgen*** control file. It tells ***patgen*** to do the analysis at all frequencies analyzed by ***em***. It also specifies the values of theta (ANG1) and phi (ANG2) for the analysis. The file “infpole.jxy” is the current density file for the infpole antenna which was just created by ***em***. Next we create a pattern response file called “infpole.pat”:

patgen -v infpole

This command runs ***patgen***, reads “ctl.pg” and “infpole.jxy” and creates a pattern response output file called “infpole.pat”. If the pattern response file already exists, ***patgen*** saves the old version with a file extension of “.pab” before creating the new file. If you do not want the file to be called “infpole.pat” you may specify the name on the command line. For example, the command:

patgen infpole.jxy test.pat

creates a pattern response file called “test.pat” based on the current distribution in “infpole.jxy”.

♦ Running the *Patvu* Program

Once the X Window System is started, you can start ***patvu***, provided it has been properly installed (as described in the **Sonnet Installation Manual**). For our example, type the following command:

patvu infpole &

When you press the *Return* key, ***patvu*** starts loading the file “infpole.pat”.

Depending upon the speed of your computer, this may happen immediately, or you may have to wait a short time. The cursor symbol changes to a clock while ***patvu*** is loading the data.

On your screen, the main menu is shown. A plot of your circuit can’t be shown until you provide ***patvu*** with more information.

♦ The *Patvu* Command Line

The command used to run ***patvu*** is:

patvu infpole

This brings up the ***patvu*** window and then loads the file called “infpole.pat”. The “.pat” at the end of the file name indicates a Pattern Response File which is generated by ***patgen***. All information about the pattern response of your circuit is stored by ***patgen*** in this file. The file name is not required to end in “.pat”, but it is recommended. When the file name ends in “.pat”, the “.pat” is not needed in the command line.

There are numerous command line options available for ***patvu***. They can be used to set, for example, window size and location, background and foreground colors, etc. These options are detailed in Appendix IV, "The Patvu Command Line".

♦ Displaying the Plot

Although ***patvu*** loaded our example file, ***patvu*** can’t display the file until the type of plot, polarization, and the response are defined. For convenience, when starting ***patvu*** or loading a file, ***patvu*** automatically sets the plot type and polarization. ***Patvu*** defaults to a cartesian plot with theta selected on the X axis. The polarization defaults to *Theta/Phi*. The Y axis is set to display the magnitude (in dB) of the pattern response and is normalized to the maximum value of the raw data.

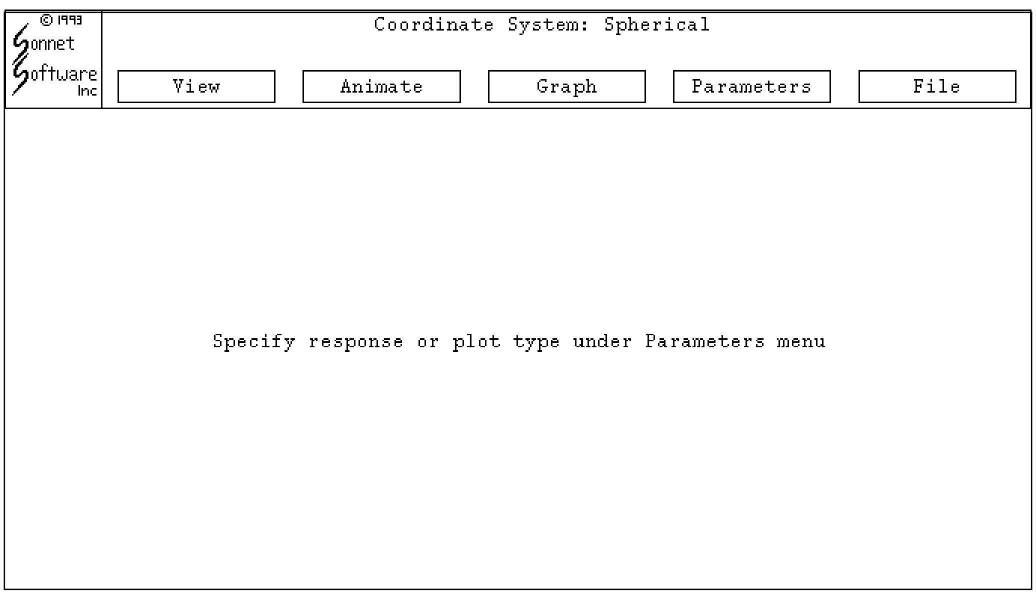


Figure 8 The ***patvu*** window after starting the program.

♦ Selecting the Response

Select *Parameters ⇒ Response* to display, change the range, or change the parameter to be plotted. To change a value or parameter, just click on it. Parameters with only two values toggle between the two values. Clicking on the other parameters such as Theta, Phi, or Frequency bring up an additional menu for selection of a value (*Value*), a range of values (*Sweep*), or all values (*All*).

Click on Frequency to specify the frequency for our example. Click on *Value* to enter a single frequency. Type “1” and press the *Return* key to select 1 GHz for the frequency. Click on Phi to specify the values for Phi for our example. Click on *Sweep* to specify a range of values. Enter “0” for the starting value and press *Return*. Enter “90” for the ending value and press *Return*. Enter “90” for the interval (step) between values and press *Return*. These settings generate two curves: E_{total} at phi = 0 and 90 degrees. Finally, click on *Done* and ***patvu*** draws the plot (see Figure 9).

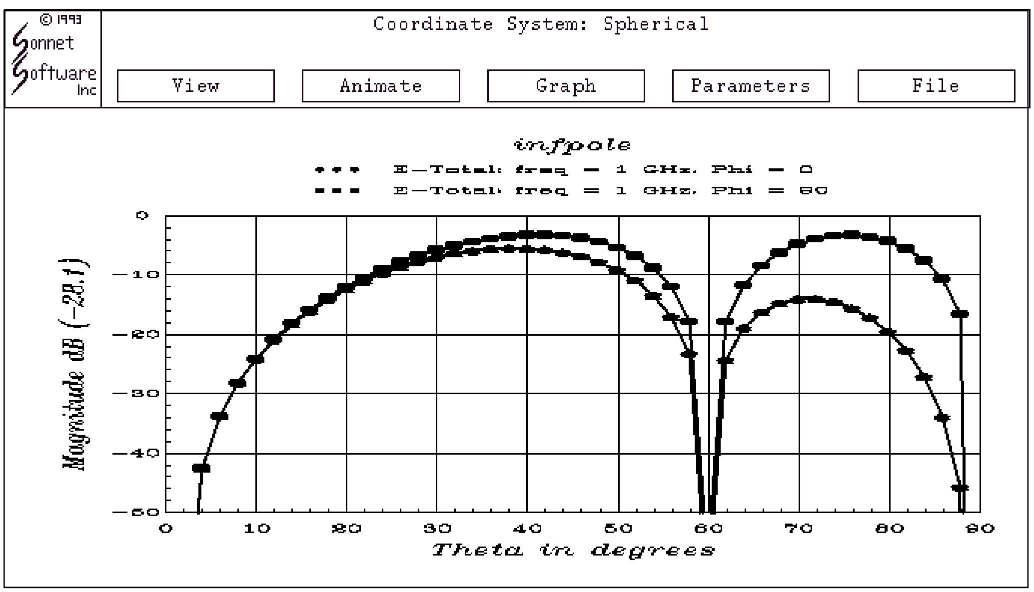


Figure 9 The plot is drawn showing two curves. The upper curve is the radiation pattern at phi = 90 degrees. The lower curve is the radiation at phi = 0 degrees.

Patvu automatically selects an appropriate scale for the plot. The relative scale is indicated by the number in parenthesis on the vertical axis label. Use this number to compare the amount by which different plots have been normalized. This is discussed further later in this chapter.

If desired, the plot can be simplified. For example, you might change the response parameters to reduce the number of curves displayed.

To do this, select *Parameters ⇒ Response* again. Click on Phi to specify Phi for our example. Click on *Value* to enter a single value. Type “0” and press the *Return* key to select Phi = 0. Finally, click on *Done* and ***patvu*** draws the plot (see Figure 10).

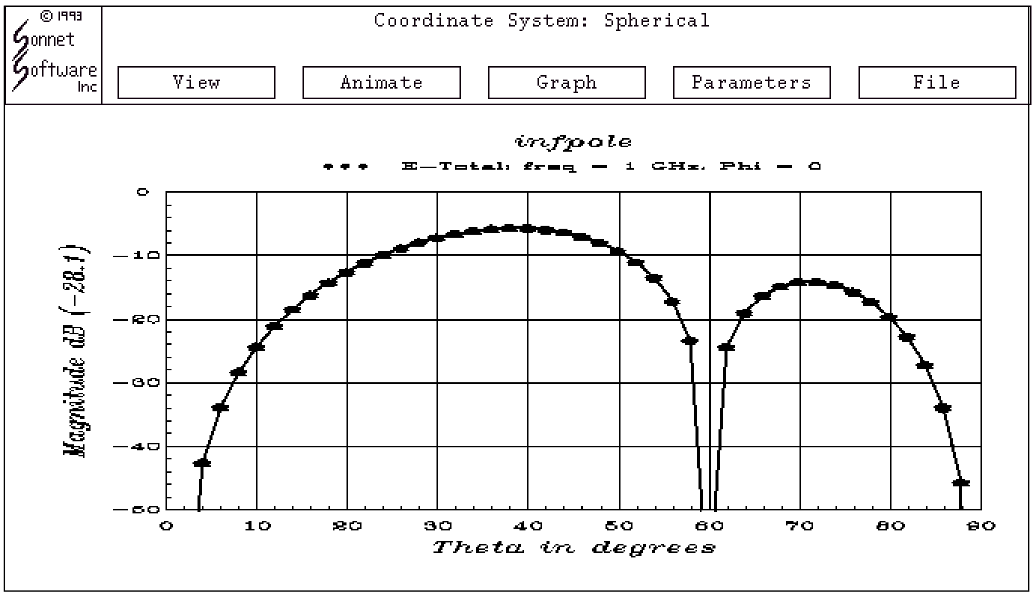


Figure 10 Plot showing E-Total at phi = 0.

♦ Zoom

The zoom button, the middle button on the mouse, may be used to magnify a specific area in the plot. For this example, we zoom in to the region from Theta = 30 - 50 degrees and the magnitude from -20 to 0 dB in Figure 11. Using the mouse, move the cursor to the upper left corner of the region (x=30, y = 0), then press the middle mouse button. Holding it down, drag the cursor to the lower right corner of the area (x=50, y=-20), then release the button. The specified region is expanded to fill the screen. To go back to the previous view, click the middle mouse button without moving the mouse. Alternatively, use *View ⇒ Full View* or type ^Z (Control-Z) to reset the view.

You may also use *View* ⇒ *Zoom In* for the zoom function. See section "Menu: View - Zoom In" on page 42.

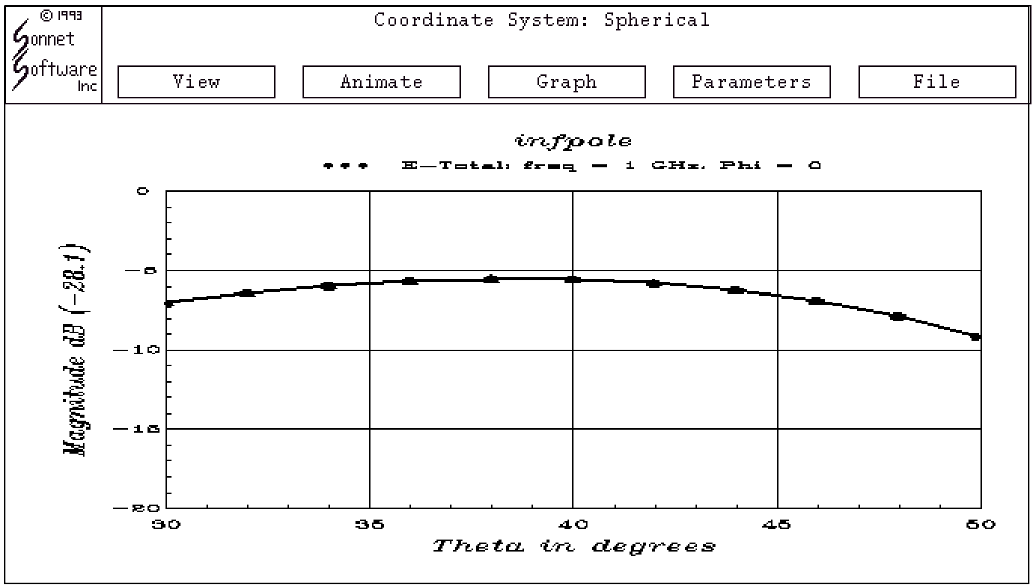


Figure 11 Zoom allows close inspection of an antenna plot.

♦ Probing the Plot

To evaluate the pattern response at any location in your plot by clicking the left mouse button at the desired location. For example, click the left mouse button at Theta = 40 degrees on the curve on your plot. The value is displayed at the top of your ***patvu*** window along with the coordinates of the point you selected. Press the right arrow key several times to move to other data points on the curve. Notice that the values are updated on the display. The left arrow key moves back the other way. You may also use *View* ⇒ *Point* to move back and forth along a selected curve.

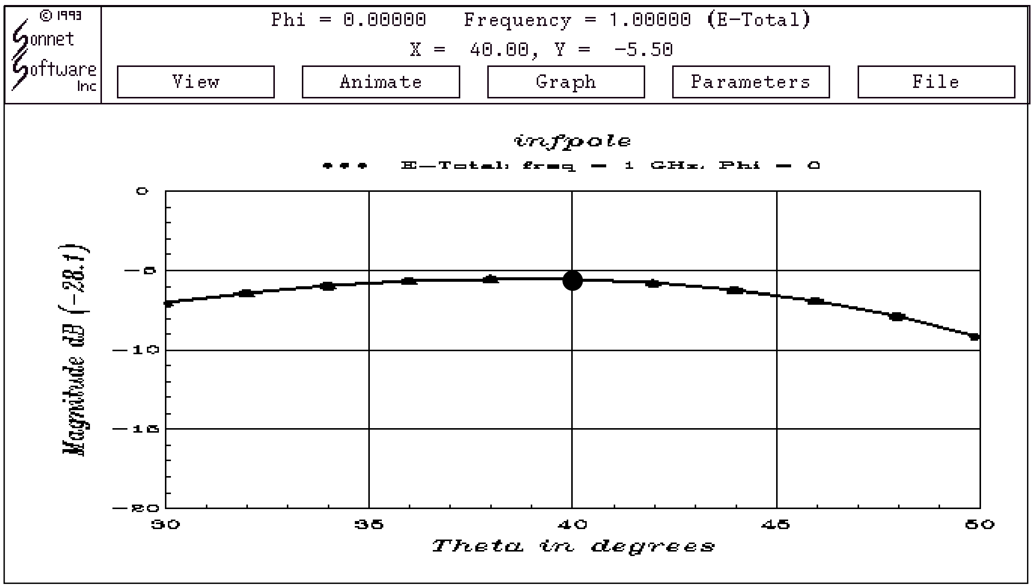


Figure 12 ***Patvu*** displays the value of the selected point at the top of the screen. The selected point is also highlighted on the graph.

♦ Normalizing the Plot

Highlight Theta = 38 degrees by clicking on the curve and/or using the arrow keys as explained before. We shall now normalize the plot to the antenna pattern value at 38 degrees.

By default, ***patvu*** normalizes the data to the maximum value stored in all of the data (all frequencies, thetas and phis).

In Figure 12, the maximum antenna pattern value is at a frequency which is not displayed. The plot is normalized so that this maximum value (which is not displayed) is zero dB. You may wish to normalize the plot to different values.

Select *Parameters* ⇒ *Normalization* to change the normalization. Click on *Arbitrary* and then on *Single Point* to change the magnitude to the desired value at that point. Enter the desired value (in dB, for this example, enter 0) and press the *Return* key. ***Patvu*** normalizes the data so that the selected point is located at the desired value (0dB). After calculating the normalization, ***patvu*** redraws the plot with the changes. The normalization value is shown in parenthesis on the y axis.

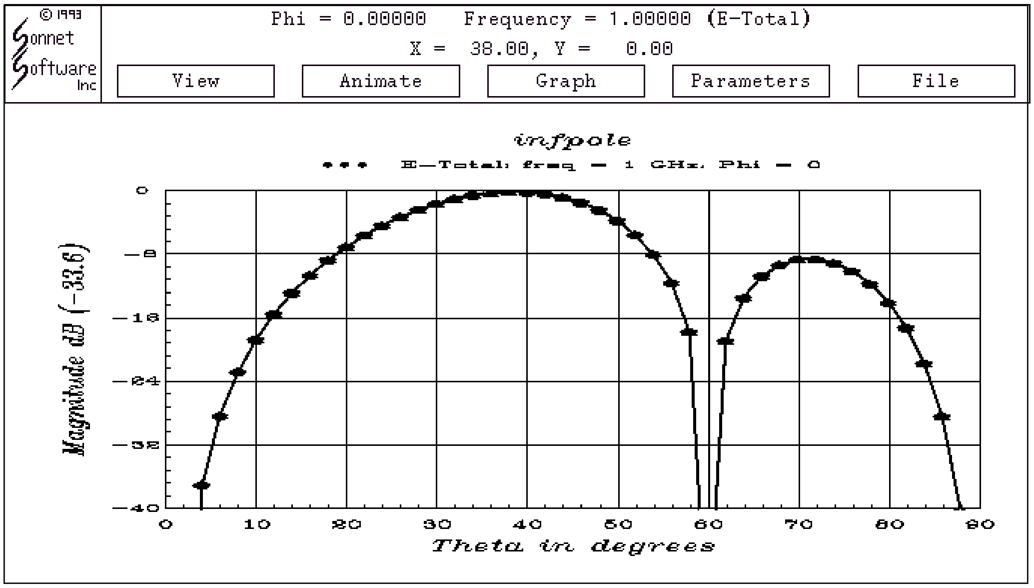


Figure 13 The antenna pattern renormalized. The normalization value is shown in parenthesis on the y axis.

♦ Changing to a Polar Plot

Select *Parameters* ⇒ *Plot Type* to select the type of plot displayed on the screen. Since theoretical data for an infinitesimal dipole is shown in a polar plot, we want to change this plot to a polar plot. Click on *Polar* to change to a polar plot and specify the angle axis by selecting *Theta*. This means that theta is swept and phi is held constant. After selecting *Theta*, ***patvu*** redraws the plot using the polar coordinate system.

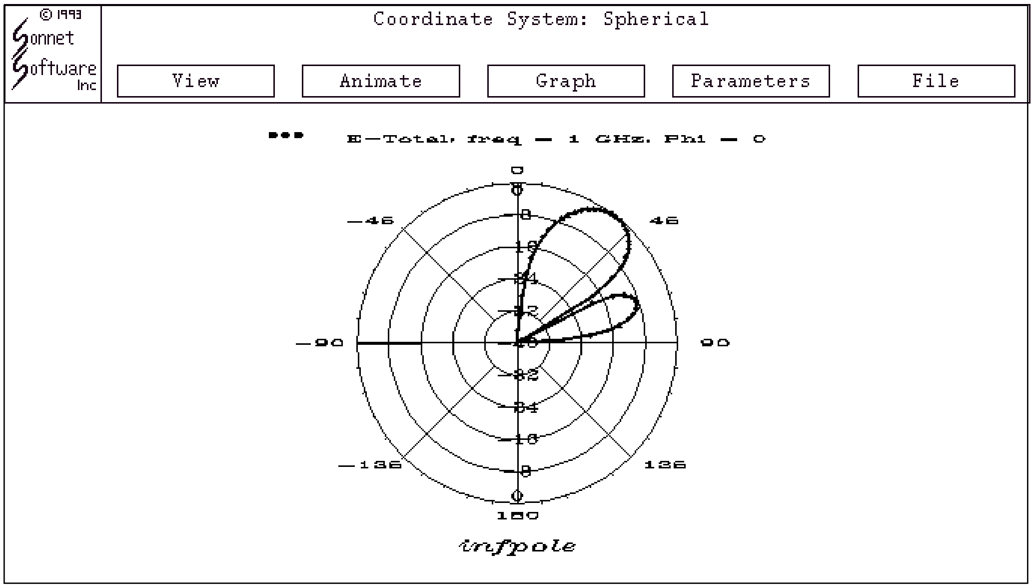


Figure 14 ***Patvu*** redraws the plot as a Polar Plot.

♦ Changing the Attributes

To change the attributes of the graph, select *Graph* ⇒ *Attributes*. To change a value, click on the value or parameter that you wish to change. Parameters with only two values toggle between the two values. Since the legends take up a lot of space on the display, you may turn them off, allowing the plot to fill the extra space.

Click on Legend to turn it Off, and then click on *Done*. ***Patvu*** redraws the plot without the legends.

♦ Changing the Radius Axis

The radius axis limits of the plot need to be 0 dB (outer circle) and -40 dB (center of plot). If this is not the case, select *Graph* ⇒ *Radius Axis* to change the radius axis. If Maximum is not set to 0, click on the value for Maximum, type “0” and press Return. Click on the value for Minimum, type “-40” and press Return.

If the Divisions are not set to 10, click on the value for Divisions and select *Size*. Type “10” and press Return. These settings now match the theoretical result. Click on *Done*. ***Patvu*** redraws the plot with the changes. Your plot should now look like Figure 15.

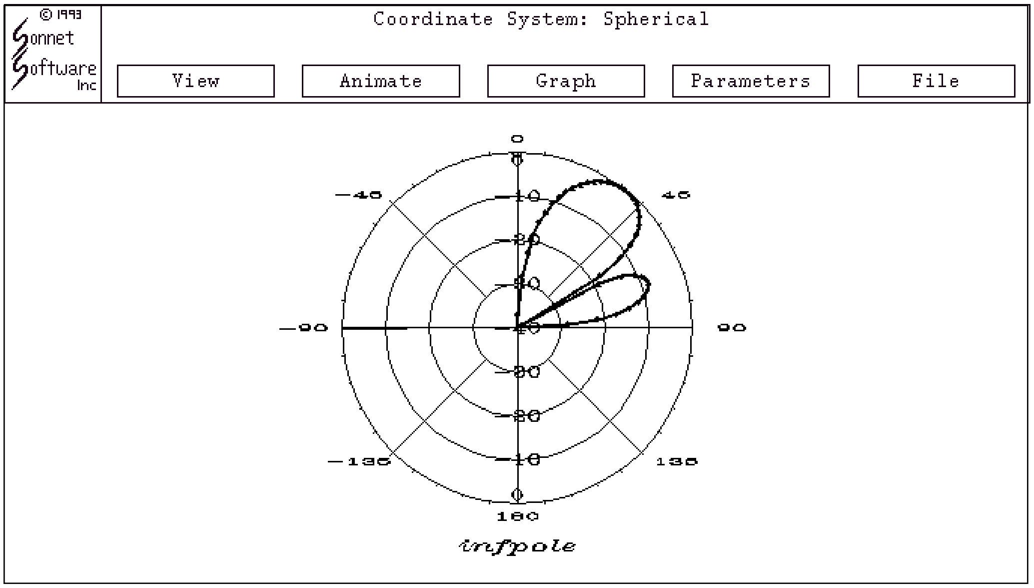


Figure 15 Plot changes to show the new radius divisions.

♦ Changing the Angle Axis

Select *Graph* ⇒ *Angle Axis* to change the angle axis to match the theoretical result. Click on the value for Divisions and select *Size*. Type “30” and press the *Return* key. Click on the value for Subdivisions and select *Size*. Type “5” and press the *Return* key. Click on *Done*. ***Patvu*** redraws the plot with the changes.

Your screen should now look like Figure 16. This may now be compared to the theoretical result in Figure 17.

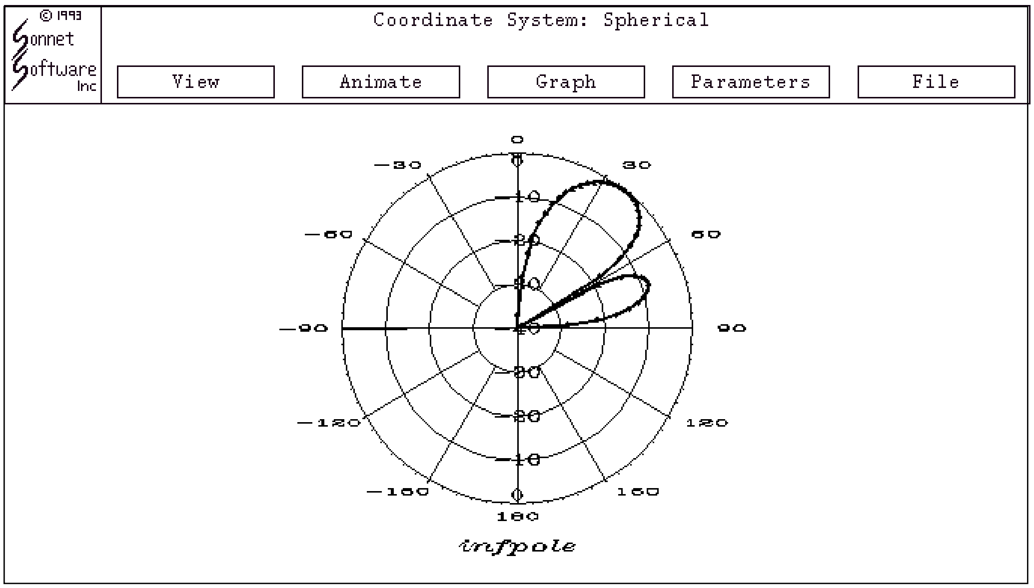


Figure 16 This is the patgen calculated far field antenna pattern for the very short dipole in the file infpole.geo. The result should be compared with the theoretical result in the next figure.

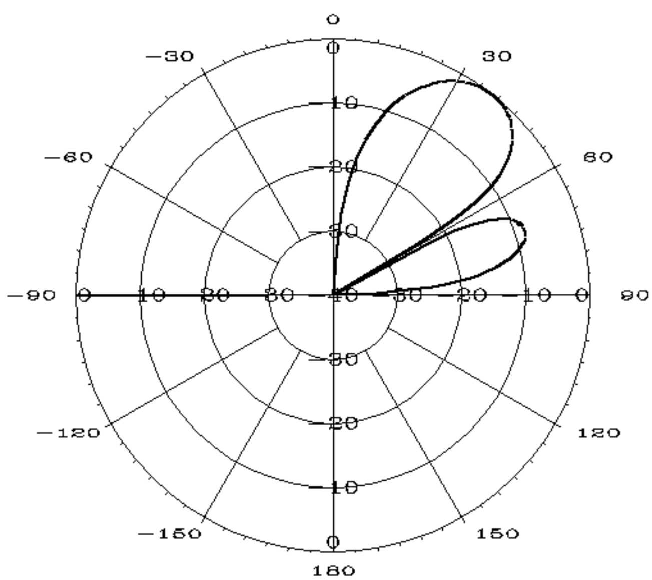


Figure 17 Exact far field antenna pattern from reference [1] of an infinitesimal dipole antenna one wavelength above a ground plane.

♦ Locking Coordinate Attributes

In the above sections, you have carefully selected and set various coordinate axis attributes. These include, for example, minimum and maximum axis ranges, number of divisions per axis, and number of subdivisions per major division.

By default, ***patvu*** automatically chooses new attributes for each coordinate axis whenever a new plot is selected. For example, if an additional curve is to be plotted (as specified by *Parameters ⇒ Response*), ***patvu*** selects a new set of default attributes based on the new data to be plotted. Except for the axis title, all previous attributes are lost.

To disable the automatic selection of new axis attributes, select *Graph ⇒ X Axis ⇒ Lock* or *Graph ⇒ Y Axis ⇒ Lock*, as desired. The axis attributes are locked when the option displays <*On*> and they are unlocked when the option displays <*Off*>.

♦ Selecting a Frequency Plot

To see how the antenna pattern changes with frequency, select *Parameters ⇒ Plot Type ⇒ Cartesian ⇒ Frequency* to change to a frequency plot.

Notice that ***patvu*** now asks you to specify the response before displaying the plot. Select *Parameters ⇒ Response* to select the response. Next, you must specify Theta and Phi. Click on Phi and select *Value*. Type “90” and press Return. Click on Theta and select *Sweep* to specify a range of values. Enter “0” for the starting value and press *Return*. Enter “90” for the ending value and press *Return*. Enter “45” for the interval (step) between values and press *Return*. Finally, click on *Done* and ***patvu*** draws the plot. Notice that the legends are displayed. ***Patvu*** stores separate attributes for each plot type.

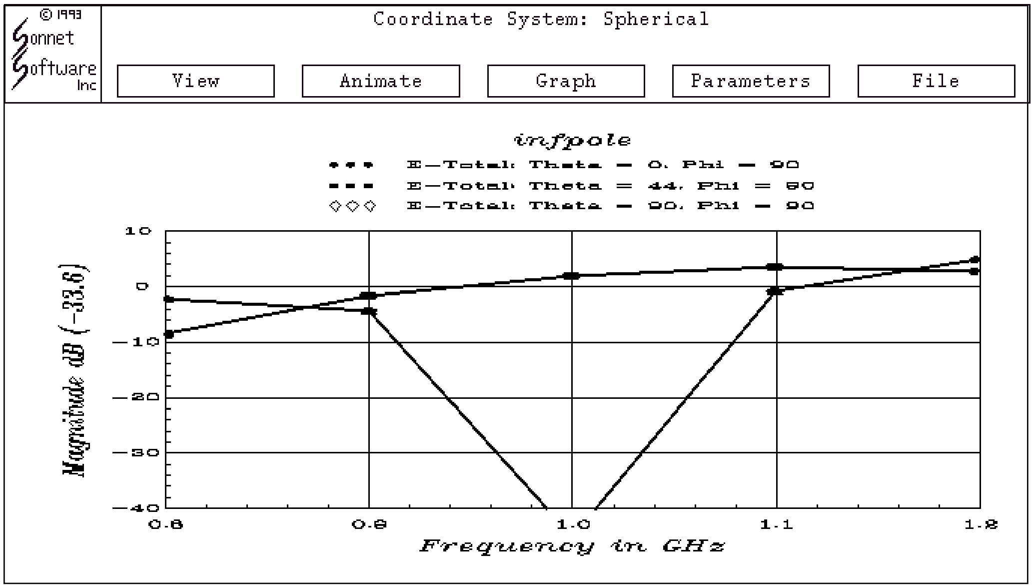


Figure 18 Notice that after returning to a cartesian plot, the legends return as well. This occurs because ***patvu*** keeps track of separate attributes for each plot type.

Notice that E-Total at Theta = 90 is shown in the legends, but doesn't appear on the graph. This occurs because the magnitude is too small to show on the plot. Also, we specified Theta from 0 to 90 stepping 45 degrees, and yet Theta = 44 appears on the graph. Since the original data was never analyzed at Theta = 45, ***patvu*** displays the closest value actually analyzed.

♦ Exiting the *Patvu* Program

This is the end of the first example of using ***patvu***. To stop the program, select *File* ⇒ *Quit.* The next chapter contains a detailed description of ***patvu***'s three dimensional image patterns.

♦ References

[1] Constantine A. Balanis, **Antenna Theory Analysis and Design**; New York; Harper & Row, 1982, section 4.7.3

Chapter 4 Three-Dimensional Image Patterns

This chapter provides an example of using ***patvu*** to display three-dimensional (image) plots. It assumes you have read the previous tutorial and understand ***patvu***'s basic framework and purpose. In this example, we analyze multiple frequency points and exercise the animation features of ***patvu***.

To do an animation, ***patvu*** takes stores an image of your antenna pattern at each frequency and displays the images one after another to form a "movie". This allows you to see how the antenna response changes with frequency.

♦ Starting the Image Example

For this example, you use the same current density file used in the last chapter. If it is no longer available, go back to the previous chapter and follow the instructions to create the "infpole.jxy" file.

For this example, the Top View coordinate system provides a better image than the Spherical coordinate system. Therefore, we next re-generate the pattern response file ("infpole.pat") using the Top View coordinate system.

To do this, edit the file called “ctl.pg” so that it looks like Figure 19. For Unix systems, use an editor like the “vi” editor. For MS-DOS systems, use an editor such as the MS-DOS “Edit” command, or any ASCII editor with which you are familiar.

```
CTLPG
VER 2.4
COORD Top        <--------
ANG1 -90 90 2
ANG2 -90 90 2    <--------
GHZ
FRE ALL
PORT ALL MAG=1 PHASE=0
```

Figure 19 The “ctl.pg” file after editing it for this example. The original “ctl.pg” file obtained by using the “copyex” command also has numerous comments describing the purpose and allowed values for each line. For simplicity, this figure does not show the comments. The arrows indicate which lines are changed for this example.

The “ctl.pg” file tells ***patgen*** to do the analysis at all frequencies analyzed by ***em***. The ANG1 and ANG2 lines tell ***patgen*** to sweep the angles from -90 to 90 degrees in steps of 2 degrees. For a more complete description of the pattern generation control file, see Appendix II, "The Pattern Generation Control File Format". The file “infpole.jxy” is the current density file for the antenna which was created in the last chapter by ***em***. We shall create a pattern response file called “image.pat”.

Create the file by typing:

patgen -v infpole.jxy image.pat

If a file called “image.pat already exists in your directory, the old version is saved in a file called “image.pab”.

When finished, run ***patvu*** by typing:

patvu image

As the new pattern response file is read, the cursor changes to a clock symbol. When finished (this file may take almost a minute), the cursor changes back to normal. Remember that a plot type must be selected before ***patvu*** can display the new pattern response plot. For this example, select *Image* for the plot type by using *Parameters* ⇒ *Plot Type* ⇒ *Image*. Do this before selecting P*arameters* ⇒ *Response*.

♦ Displaying the Image

After selecting the image plot type, ***patvu*** draws the pattern using data at all calculated angles. The image plot for this antenna is shown in Figure 6 on page 11. The color plot shows the pattern of the antenna as analyzed by ***patgen***. Since we chose the Top View coordinate system, the plot shows the pattern as if we were looking down on the sphere of Figure 4 on page 9.

The magnitude of the pattern response is calculated for each angle and then plotted using the color scale shown in the left part of the ***patvu*** window. Red areas represent areas of high magnitude and blue areas represent areas of low magnitude. A scale is shown on the left of the window which defines the values of each color.

Since we analyzed at multiple frequencies, ***patvu*** displays the first frequency analyzed (0.8 GHz).

♦ Changing the Scale

The values for each of the colors of your plot are shown on the scale at the left of your ***patvu*** window. Values larger than the maximum value of the scale are shown in the brightest red and values less than the minimum are shown in the darkest blue.

When ***patvu*** first starts, it chooses a reasonable scale based on the actual values of your data. You may find, however, that your area of interest is all one color and conveys little information. In this case, you may change the scale.

Select *Graph* ⇒ *Scale* to change the scale. You may specify the plotting scale in two different ways: by specifying minimum and maximum values, or by having ***patvu*** choose a scale for you. ***Patvu*** displays the presently selected method. To illustrate the use of the scale selections, click on the dashes or value for Minimum. ***Patvu*** asks for the desired minimum scale value for plotting. The prompt also informs you of the present value.

For this example, we want a minimum value of -30 dB. Do this by typing the number “-30” and pressing the *Return* key. The mouse location within the window is not critical. Change the maximum value to zero if necessary.

Just pressing *Return* without typing anything else causes the present value to remain unchanged. This is typical of ***patvu*** prompts.

After the prompt is answered, ***patvu*** removes the value for Auto Range by placing dashes in place of the value. Click on *Done* and the plot is redrawn with the new scale. Notice that the plot has more blue in it now.

♦ Auto Range

You may specify the plotting scale in two different ways: by specifying minimum and maximum values, or by having ***patvu*** choose a scale for you. In the above section, the "minimum" value was specified.

You may have ***patvu*** automatically scale your plot. This is most useful in getting starting values for a plot and for animation (discussed later). To do this, you need to specify an autorange value.

Patvu uses an autorange value of 40 dB as the default. This value is used when ***patvu*** first starts up with a new file. An autorange value of 40 means that ***patvu*** sets the minimum scale to 40 dB below the maximum scale. The maximum scale is set to the maximum value of the displayed data.

For our example, select *Graph ⇒ Scale,* click on the value (or dashes) for Auto Range, type in a value of "40" and press *Return*. This changes the plot back to it's original scale. Now click on *Done* to return to the main button menu.

♦ Probing the Plot

You can determine the value of the pattern response at any location by "probing" the plot. To do this, first make sure that the main button menu is displayed. Now, click the left mouse button at the location to be probed. The value is displayed at the top of the ***patvu*** window along with the coordinates of the selected point.

♦ The Frequency Menu

To view the antenna pattern at other frequencies, select *Parameters ⇒ Frequency.* A new button menu appears (Figure 20). Click on *Next* or *Previous* to manually sweep through the frequencies. Click on *First* to view the lowest frequency. Click on *Last* to view the highest frequency. If you wish to look at a particular frequency, click on *Value* and type in the new frequency. If the frequency that you typed does not exist, the closest frequency value is displayed. Click on *Done* to exit this menu.

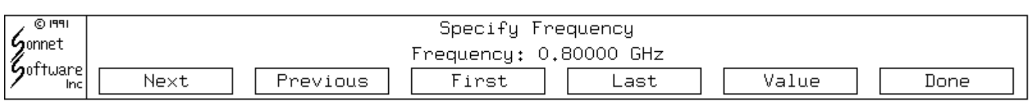


Figure 20 The Frequency button menu allows you to change the frequency.

♦ The Animation Menu

A smoother way to sweep through your frequencies is to use the “animation” feature of ***patvu***. Select *Animate* ⇒ *Frequency.* The cursor changes to a clock symbol while ***patvu*** is calculating the animation data. A new button menu appears when the loading is complete (see Figure 21).

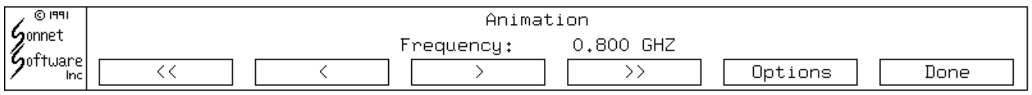


Figure 21 The Animation button menu allows you to sweep through your frequencies automatically.

The animation menu allows you to step through different frequencies one at a time or to show a “movie” by doing a continuous frequency sweep.

When the animation menu comes up, the first frequency is displayed. Click on “>” to display the next frequency. To view the previous frequency, click on “<”. To do a frequency sweep, click on “>>” to go forward and “<<”to go backward.

For our example, click on “>>” and notice how the plot changes with frequency especially at higher frequencies. You may click on “>>” as many times as you wish.

The animation uses the present parameter settings as set in the Parameters menu. When using the “Auto Range” feature, each frame is rescaled according to the auto range value previously entered. The scale is automatically changed at each frequency.

If specific maximum or minimum values are specified for the scale, then those values are used as the scale for every image. Thus, unlike the auto range scale, each image uses the same scale.

Click on *Options* to add a delay between frames or change the animation to continuously repeat the cycle. The default delay is zero which is the fastest animation. To change the delay, click on *Delay* and type in a value for the delay and press the *Return* key. To change the delay to 1/2 second, enter a value of 0.5. Try several different delays to see the change in the animation.

To repeat the animation cycle, click on *Options* and then click on *Repeat*. Click on the *Yes* button to select the repeat mode. After selecting repeat, the animation continuously cycles through the frequencies when you click on either “<<” or “>>”. To stop the animation, press the mouse button or any key on the keyboard. To stop further repetitions, click on *Options*, *Repeat*, and then *No*. Click on *Done* to finish animating. The main button menu appears again.

♦ Finishing the Image Example

This is the end of the second example of using ***patvu***. To stop the program, select *File* ⇒ *Quit.*

Chapter 5 Analyzing Arrays

This chapter describes how to use ***patvu*** to analyze arrays. It assumes you have read the previous tutorial and understand ***patvu***'s basic framework and purpose. The first section deals with a potential coordinate system difficulty. The problem is most likely seen when working with antenna arrays. Then next section describes a simple two element dipole phased array. The phased array is also used to illustrate the potential coordinate system difficulty.

♦ A Potential Coordinate System Difficulty

Figure 4 on page 9 shows the usual spherical coordinate system. The ***xgeom*** coordinate system is shown in Figure 22. Note the position of the origin of the coordinate system in the upper left corner of the screen. Historically, this was done because bit mapped computer graphics also have their origin in this position. Unfortunately, this results in the Z axis going into the screen of the computer (as indicated by the circle with an "x" in it). Thus, we are actually looking at the circuit from underneath the circuit, rather than from above.

The usual viewpoint of the microwave engineer is above the circuit looking down into it. Thus, it is easy to view the Z axis as coming out of the computer screen, rather than going into it. Fortunately, this inconsistency has absolutely no affect on anything for microwave circuit purposes.

As an additional complexity, the ***xgeom*** user can specify the origin, for drawing purposes, to be the lower left corner, instead of the upper left corner. However, *this new origin is not used for analysis*. Only the origin shown in Figure 22 is used for analysis regardless of the origin used for drawing.

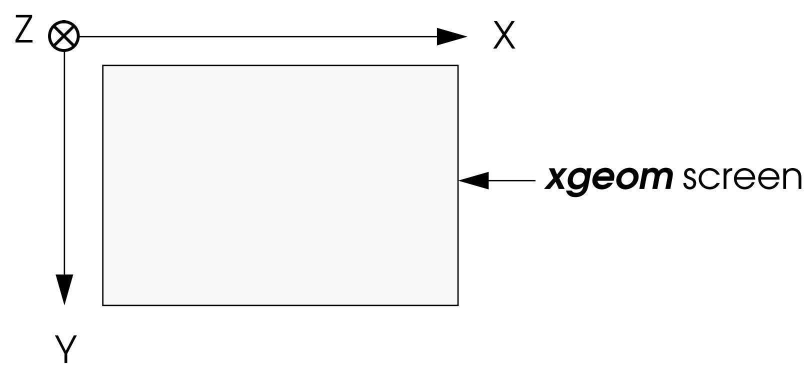


Figure 22 The coordinate system used in the xgeom screen. Note the origin is in the upper left hand corner, and the Z axis goes into the screen.

A design error can occur, for example, in the design of a phased array which has a beam formed at a given elevation angle along the positive Y axis (phi = 90 degrees). If the designer captures the circuit using the origin in the lower left corner without realizing that the analysis is performed with the origin in the upper left corner, the direction of the Y axis is then incorrectly placed in the opposite direction. As a result, the antenna pattern that the designer expects is the mirror image of the actual antenna pattern. The next section describes a two element dipole phased array which could be affected by this misunderstanding.

♦ A Two Element Dipole Phased Array

To illustrate phased array analysis, we evaluate the antenna pattern of an array of two dipoles. Shown in Figure 23, the dipoles are one half wavelength apart and one half wavelength long at 1 GHz. The dipoles are 0.1 wavelength above ground. Copies of the geometry file, current distribution, and pattern generation control file can be obtained by typing:

copyex twoarray .geo twoarray .jxy twoarray .pg

If desired, you may create your own current distribution file by analyzing twoarray.geo at 1GHz using ***em*** with the "-j" option.

After the current distribution has been calculated, we must selected the relative phases and magnitudes for the port excitations. For this example, we select equal magnitudes with a phase such that there should be a null in the radiation pattern at theta = 45 degrees in the phi = 90 degrees direction. Don't forget that phi = 90 degrees is along the positive Y axis, which is in the downward direction in Figure 23.

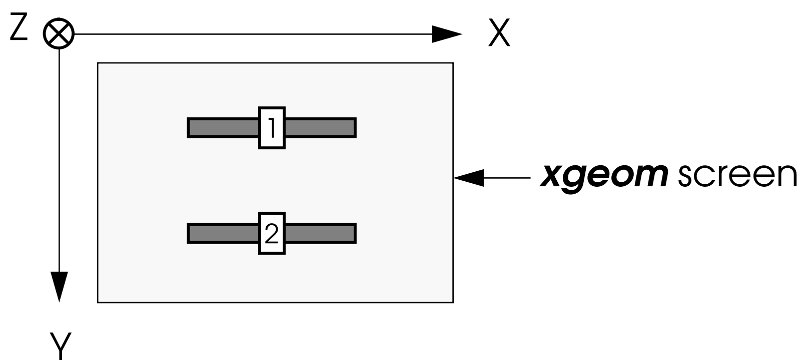


Figure 23 A phased array of two dipoles. The dipole with port 1 is closer to the analysis origin. Phi equal to 90 degrees is along the positive (down directed) Y axis. Note that for analysis, the origin is in the upper left corner, even if a different origin was used for drawing.

The phased array geometry of Figure 23, as viewed from the end of dipoles for radiation at theta = 45 degrees, is shown in Figure 24. At theta = 45 degrees, the radiation from the port 1 dipole (closest to the origin) must travel 127 electrical degrees before reaching the same wavefront as radiation from the port 2 dipole. The port 2 dipole is excited 53 degrees in advance of the port 1 dipole for a total phase difference of 180 degrees at theta = 45 degrees. Thus, we would expect a null at theta = 45 degrees at an azimuth of 90 degrees (the positive Y axis). With the specified excitation, we should have a peak (phased array main beam) at theta = -16 degrees.

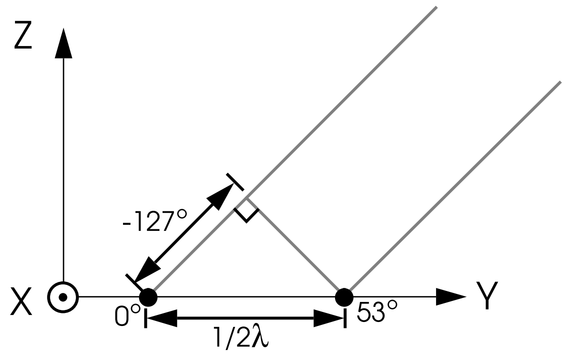


Figure 24 The same phase array viewed from the end of the dipoles. The same coordinate system is used. This view of the coordinate system has been rotated from the previous view to a more standard orientation. The dipoles are phased for a null at theta = 45 degrees.

To generate the antenna pattern, use the twoarray.pg file copied with the copyex command. Without the explanatory comments, this file is shown in Figure 25.

```
CTLPG
VER 2.4
COORD Earth
ANG1 -90 90 2
ANG2 90
GHZ
FRE ALL
PORT 1 MAG=1 PHASE=0
PORT 2 MAG=1 PHASE=53
```

Figure 25 The “ctl.pg” file needed for a phased array specifies the excitation at each port. The “ctl.pg” file obtained by using the “copyex” command also has numerous comments describing the purpose and allowed values for each line. For simplicity, this figure does not show the comments.

This file specifies the use of earth view coordinates. Earth view coordinates are identical to spherical coordinates except that theta is defined over the range of -90 to 90 degrees instead of 0 to 90 degrees. In addition, phi covers the range of -90 to 90 degrees instead of -180 to 180 degrees.

“ANG1” is theta, and we specify it to sweep from horizon to horizon (-90 to 90 degrees) in steps of two degrees. We sweep along the Y axis, phi (“ANG2”)= 90 degrees. When theta is negative, phi = 90 degrees corresponds to the negative Y axis. When theta is positive, phi corresponds to the positive Y axis.

The “PORT” lines define the port excitations. In this case each port is excited with 1 volt. Port 1 is set at 0 degrees phase and port 2 is set to 53 degrees phase. Additionally, port impedances can be set with the “R”, “X”, “L”, and “C” options described in the comments of the “.pg” file copied with “copyex”. Default R is 50 Ohms.

Run ***patgen*** with the command:

patgen twoarray .pg twoarray

The “.pg” file must be specified explicitly, otherwise the default “ctl.pg” is used. By ending the command with “twoarray” with no extension, the file “twoarray.jxy” is automatically used for input and “twoarray.pat” is used for output.

To view the antenna pattern, type the command:

patvu twoarray &

The curve of Figure 26 should appear immediately. Note that the null occurs at theta = 34 degrees and the peak occurs at theta = -10 degrees. We expected 45 degrees and -16 degrees respectively. The differences are due to mutual coupling between the dipoles.

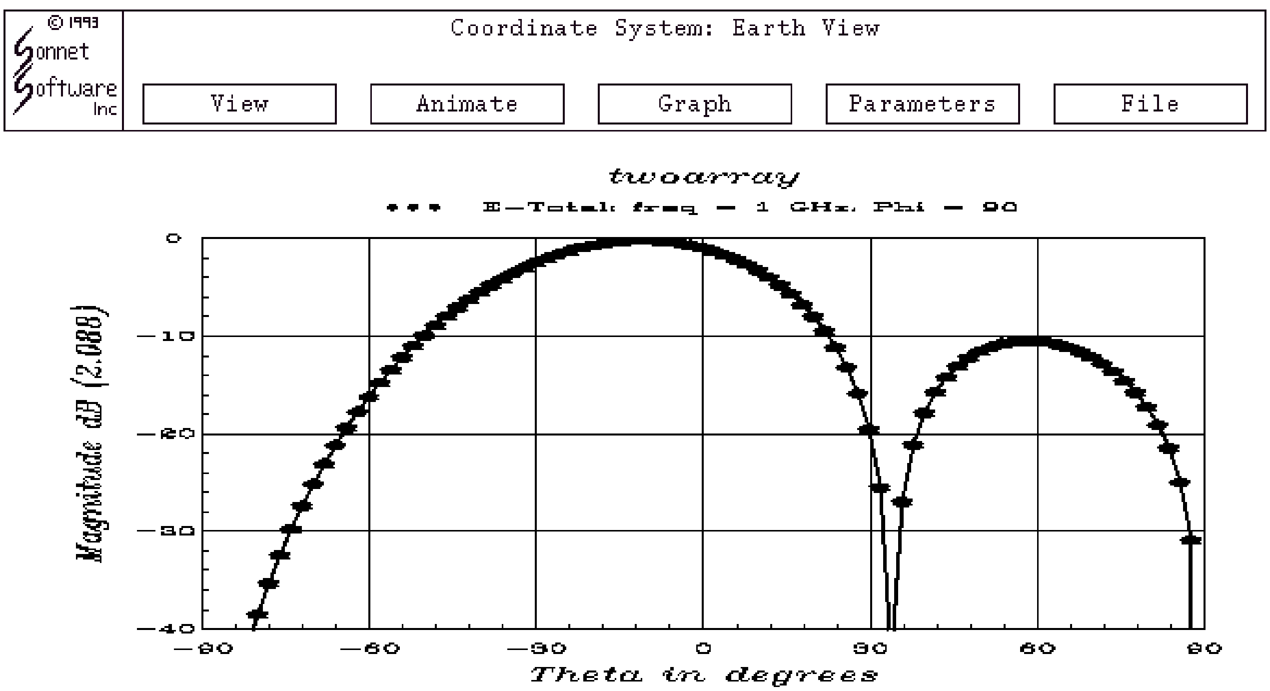


Figure 26 A “theta cut”, or elevation pattern of the array of two dipoles. A null occurs at theta = 34 degrees and a peak occurs at theta = -10 degrees.

Because of the coordinate system difficulty described earlier, an error can be made in fabrication of this array. This happens if the designer specifies an ***xgeom*** origin in the lower left corner of the ***xgeom*** screen instead of the default upper right. Since the upper right corner is always used for analysis, the null in the antenna pattern of Figure 26 at theta = 34 degrees is in the direction of the port 2 dipole. This is the real direction of the positive Y axis.

However, if the designer thinks that the origin for analysis is in the lower left corner, the designer would incorrectly decide that the positive Y axis is in the reverse direction, and decide that the null is in the direction of the port 1 dipole. We have two suggestions to avoid this problem. First, remember that the origin for analysis is always in the upper left corner of the ***xgeom*** screen. Second, always do a reality check on your result. Make sure the result is reasonable. An antenna pattern which is the mirror image of what is expected is a sure sign of a problem.

Analysis of much more complex arrays are possible using Sonnet. This two dipole example provides a simple tutorial example. Extension to more complex arrays is straightforward.

Chapter 6 *Patvu* Function Reference

This section contains a detailed description of ***patvu***'s functionality. It assumes you have read the previous tutorials and understand ***patvu***'s basic framework and purpose. Details on ***patvu***'s command line can be found in Appendix IV, "The Patvu Command Line".

♦ The Mouse

Patvu uses the left and middle mouse buttons (See Figure 27). The right mouse button is not used by *patvu*.

♦ Probing A Plot

To evaluate the pattern response in at any location on your plot, called "probing" the plot, first make sure that you are in the main button menu. Now, click the left mouse button at the location on the plot to be probed. The coordinates of the selected point are displayed at the top of the ***patvu*** window. If the selected location contains a data point, the point is highlighted and the value is displayed along with the coordinates.

Once a data point is highlighted, adjacent data points may be selected with the arrow keys. For image plots, the selected point is not highlighted and the arrow keys are disabled.

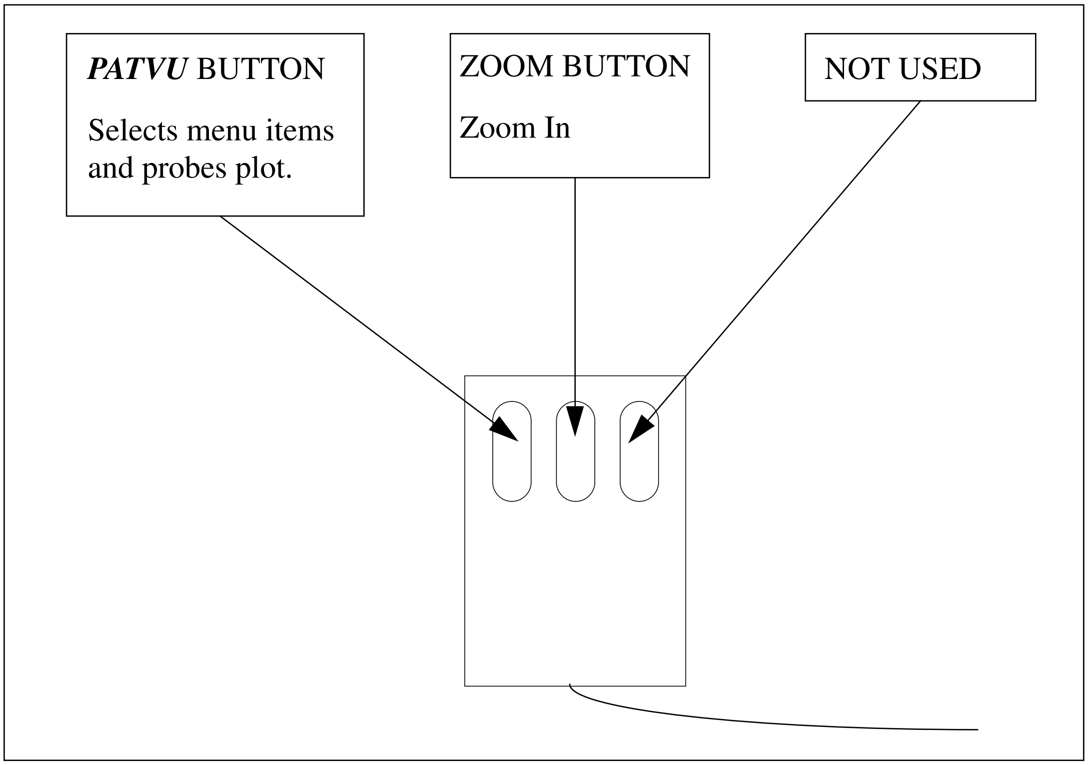


Figure 27 ***Patvu*** uses the left and middle mouse buttons.

♦ Zoom Button

The zoom button, the middle button on the mouse, is used to magnify a specific area in the two-dimensional plots. Zoom is not yet functional in image plots.

Using the mouse, move the cursor to the upper left corner of the region you want magnified, then press the middle mouse button. Holding it down, drag the cursor to the lower right corner, then release the button. The specified region is expanded to fill the screen. You can go back to the previous zoomed region by clicking the middle mouse button without moving the mouse. To reset the view so that the entire plot is visible on the screen, double click the middle button. To double click, quickly click the mouse button twice.

You may also type ^Z (Control-Z) to reset the view and ^Y to toggle to the previous view.

On some computers, due to timing problems, a double click may be recognized as two single clicks and does not reset the screen. If you experience this problem, use the ^Z key instead.

Computers with a two button mouse, are usually configured so that pressing both the right and left buttons at the same time is the same as pressing the middle button on a three button mouse. If this does not work, use *View* ⇒ *Zoom In* for the zoom function. See section "Menu: View - Zoom In" on page 42.

The zoom button is disabled for Image plots. To obtain a magnified image plot, either modify the range of plotted angles using *Parameters* ⇒ *Response*, or resize the ***patvu*** window. Any resizing of the window while using *Animate* ⇒ *Frequency* leaves the image size unchanged.

♦ *Patvu* Functions

Each function is described in the following sections. To experiment with an example file such as “infpole.pat”, type:

copyex infpole.pat

Then, to run ***patvu*** with the example file, type:

patvu infpole &

♦ The View Menu Button

The View menu options allow you to change how information is displayed.

✧ Menu: View - Point

View ⇒ *Point* changes the point that is presently highlighted on 2-D plots. Selecting *View* ⇒ *Point* displays a new button menu. Click on *Select* to type in a location directly at the keyboard. If a data point doesn’t exist at the location selected, the nearest existing data point on the display is chosen. After selecting the first point, you may step through the data points by clicking on *Next* and *Previous* or you may use the *right arrow* key for *Next* and the *left arrow* key for *Previous*. If the next or previous point is not viewable, the present point remains highlighted. Click on *Done* to return to the main menu.

If you click on *Select*, ***emvu*** prompts for a specific value of the X axis. For example, in spherical or earth view coordinates, enter a specific value of theta. The data point closest to that value is selected.

✧ Menu: View – Zoom In

You can zoom into a particular area of your plot by using *View ⇒ Zoom In*. After selecting the option, the cursor, when in the main window, changes to indicate that ***patvu*** is waiting for you to tell it where you want to zoom. Use the mouse to move the cursor to the upper left corner of the region you want magnified and press the left mouse button. Holding it down, drag the cursor to the desired lower right corner and release the button. The specified region is expanded to fill the screen. Please note that you may start in any corner of the region when specifying a zoom window.

You may also use the zoom button (middle mouse button on most computers) as a shortcut for *View ⇒ Zoom In*. See the section "Zoom Button" on page 40 for more details.

✧ Menu: View – Prev. View

View ⇒ Prev. View allows you to toggle between the present view and the previous view. As a shortcut, you can type ^Y or click the middle mouse button to toggle to the previous view.

✧ Menu: View – Full View

View ⇒ Full View resets the area displayed so that the entire pattern response plot (as defined by the X and Y axis settings) is visible on the screen. As a shortcut, you can type ^Z to reset the view.

✧ Menu: View - Redraw

Use *View ⇒ Redraw* to redraw the ***patvu*** window.

♦ The Animate Menu Button

✧ Menu: Animate - Frequency

Use *Animate ⇒ Frequency* to calculate the animation data. This may take a while for complicated antennas analyzed at many frequencies. Use of a small ***patvu*** window can significantly reduce memory requirements and speed analysis. Additionally, on many computers, a smoother animation results. To do this, be sure resize the window *prior* to selecting *Animate ⇒ Frequency*. Resizing the window while animation is in effect has no effect on the image size. The animation uses the present parameter settings as set by the Parameters menu. During animation, probing the plot is not available.

Please note that ***patvu*** can only animate image plots. If you selected *Cartesian* or *Polar* for your *Plot Type*, the menu choices under *Animate* are “shadowed” and unavailable. *Parameters* ⇒ *Plot Type* ⇒ *Image* must be selected in order to use animation.

The cursor changes to a clock while ***patvu*** is calculating the animation data. When the load is complete, the cursor changes back and a new animation menu is displayed.

The animation menu allows you to step through different frequencies one at a time or to show a “movie” by doing a continuous frequency sweep.

When the animation menu first comes up, the first frequency is displayed. Click on “>” and the next frequency is displayed. To view the previous frequency, click on “<”. To do a frequency sweep, click on “>>” to go forward and “<<” to go backward.

Use *Animate* ⇒ *Frequency* ⇒ *Option* ⇒ *Delay* to change the time that each frame is displayed in seconds. The default setting is “0” which corresponds to the fastest animation. Higher numbers result in a slower animation. Reasonable values range from 0 to about 5 seconds.

Use *Animate* ⇒ *Frequency* ⇒ *Option* ⇒ *Repeat* to repeat the animation cycle. Click on the *Yes* button to select the repeat mode. After selecting repeat, clicking on either “<<” or “>>” causes the animation to continuously cycles through the frequencies. To stop the animation, press any key on the keyboard or click the left mouse button. To stop further repetitions, click on *Options*, *Repeat*, and then *No*. Click on *Done* when you are finished animating.

✧ Menu: Animate - Memory

Use *Animate* ⇒ *Memory* to select how ***patvu*** uses memory for animation. Normally, ***patvu*** stores all data in RAM, thus using the maximum amount of RAM memory and resulting in the fastest animation possible. Change this option only if there is insufficient RAM. The display shows the three memory options as well as indicating which option is presently active. Click on the desired option and then click on *Done*.

High Memory Usage generates all of the necessary data for each frequency plot and stores it in RAM memory creating the fastest animation possible. This is the default option. Use this option unless there is not enough RAM memory.

Medium Memory Usage reduces RAM memory requirements by generating some of the plotting information only when it is needed. Use this option if you are running out of memory with the previous option. When using this option, the animation is slower due to the additional computational time required during the animation.

Low Memory Usage uses the minimum amount of RAM memory possible by generating one frequency plot at a time in RAM memory. Please note that selecting this option results in the slowest animation. Use this option only if you still run out of memory when using the medium memory option.

✧ Running Out of Memory

If you find that you are running out of memory, here are some suggestions for decreasing your memory usage:

1. Select *Animate* ⇒ *Memory* to select how ***patvu*** uses memory for animation. Normally, ***patvu*** uses the maximum amount of memory resulting in the fastest animation possible. If you are running out of memory, select *Medium Memory Usage* to reduce the amount of memory used. If you're still running out of memory, select *Low Memory Usage* to use the minimum amount of memory possible. Please note that selecting either option slows down the animation with *Low Memory Usage* being the slowest.

2. Reduce the size of your ***patvu*** window *prior* to selecting *Animate* ⇒ *Frequency*. Memory usage is a strong function of the size of your window. Resizing the window *after* using *Animate* ⇒ *Frequency* has no effect on memory usage.

3. Reduce the number of frequencies or angles analyzed in ***patgen***.

4. For UNIX systems, check for other processes using memory. See your UNIX documentation on the "ps" command.

♦ The Parameters Menu Button

The Parameters menu button allows specification of the plot type, polarization, frequency, response, and normalization. When a parameter is changed, the plot is updated immediately to reflect the changes.

✧ Menu: Parameters - Plot Type

Parameters ⇒ *Plot Type* changes the type of plot displayed on the screen. The present setting is shown at the top of the main button menu. Use Cartesian and Polar to get a simple plot for different cut planes. Click on *Cartesian* to use the cartesian coordinate system and specify the X axis by selecting *Theta*, *Phi*, or *Frequency*. Click on *Polar* to change to the polar coordinate system and specify the angle axis by selecting *Alpha* or *Beta*. Click on *Image* to get a color plot in which red corresponds to the direction of maximum gain and blue corresponds to the direction of minimum gain. Animation is available only with the *Image* plot type. After selecting the desired plot type, click on *Done*. If ***patvu*** needs more information, ***patvu*** displays the information needed. Otherwise, ***patvu*** redraws the plot with the new changes.

✧ Menu: Parameters - Polarization

To change the polarization type used by ***patvu***, select *Parameters* ⇒ *Polarization*. Click on one of the three choices: *Theta/Phi*, *RHP/LHP*, and *Ludwig-3*. Click on *Done* to return to the main menu.

Once a polarization type is selected, all plots are restricted to showing only the components of the polarization selected. For example, if you select LHP/RHP, only E-Total, E-LHP, or E-RHP may be plotted. This selection is made in the *Parameters ⇒ Response* menu.

Following is a brief description of each type of polarization:

THETA/PHI: This is default. The components are E-theta and E-phi. E stands for the electric field. The theta and phi directions are shown in Figure 4 on page 9. Close to the horizon, theta polarization corresponds to vertical polarization, while phi polarization corresponds to horizontal polarization.

LHP/RHP: Left-hand circular polarized (LHP) component and the right-hand circular polarized (RHP) component of the radiated field can be displayed with these options. Usually one is the desired polarization, or, co-polarization. The other is the undesired polarization, or cross-polarization.

LUDWIG-3: ***Patvu*** also allows the use of Ludwig's third definition of polarization and cross-polarization. This definition allows the analysis of polarization and cross-polarization in much the same manner as it is often measured.

To use Ludwig-3, a the user is prompted for a reference angle, in degrees. This angle is the angle of the polarization at beam center. Thus, at beam center there is zero cross-polarization by definition.

A detailed description of Ludwig-3 is beyond the scope of this manual. More detail is available in the original reference: A. C. Ludwig, "The Definition of Cross Polarization," IEEE Trans. Ant. and Prop., January, 1973, pp. 116 - 119.

✧ Menu: Parameters - Response

Parameters ⇒ Response displays the present values of the response parameters. When you start ***patvu*** or load a new pattern response file, you must select the parameters you want. The parameters on this screen vary depending on which type of plot (cartesian, polar or image) you selected. The first three parameters toggle between on and off, while the last two parameters require setting a value or range.

To change a toggle, click on the words "<on>" or "<off>" for the parameter that you wish to change.

To change the value of a parameter, click on the value you want to change. ***Patvu*** displays another menu with several options for changing the value. Click on *Skip* to exit without changing the value. Click on *All* to select all of the values for the parameter. Click on *Value* to enter one specific value. Enter the value and press the *Return* key. Click on *Sweep* to sweep through a range of values. ***Patvu*** asks for the starting value, the end value, and the step size. For each, enter a value and press the *Return* key. If any of the values don't exist in the data, ***patvu*** uses the closest value. For example, if you specified from 0 to 90 degrees with a step of 45, and your data was from 0 to 90 degrees with a step of 2, ***patvu*** would display 0, 44 and 90. After selecting the desired response parameters, click on *Done* and ***patvu*** redraws the plot with the changes.

✧ Menu: Parameters - Frequency

Parameters ⇒ *Frequency* changes the frequency that is presently displayed for image plots. This menu button is “shadowed” for cartesian and polar plots. You may step through the frequencies by using *Next* and *Previous* or you may go to the first or last frequency by clicking on *First* or *Last* respectively. Click on *Value* to type in a frequency directly. If the frequency typed in does not exist, the nearest existing frequency is chosen. Click on *Done* to return to the main menu.

✧ Menu: Parameters - Normalization

Parameters ⇒ *Normalization* allows you to change the normalization. By default, ***patvu*** normalizes the data to the maximum value. Click on *Isotropic* to normalize the data to a theoretical isotropic antenna in free space. Click on *Dipole* to normalize the data to a theoretical dipole antenna in free space (dBd). Click on *Maximum* to normalize the data to the maximum value contained in the data. Click on *Arbitrary* if you want to change the normalization to an arbitrary value. For *Arbitrary*, you may click on *Value* to enter an arbitrary value, or you may click on *Single Point* to set the desired value for the selected point. Enter the desired value and press the *Return* key. After normalizing the data, ***patvu*** redraws the plot with the changes. Click on *Skip* to return to the main button menu without changing the normalization.

♦ The Graph Menu Button

The Graph menu options allow you to change how information is presented on the graph.

✧ Menu: Graph - Attributes

Graph ⇒ *Attributes* allows you to change the title and several other attributes of the plot. The present values are displayed on the screen. To change an attribute, simply click on the value you want to change. For, example, to turn off the grid, click on “<on>” displayed next to the word “grid”. To turn off the legends, click on “<on>” displayed next to the word “Legend”. The symbols used to locate data points can be turned off by clicking on “<on>” displayed next to the word “symbol”. The data lines can be turned off by clicking on “<on>” displayed next to the word “line”. To change the title of the graph, click on the title. ***Patvu*** prompts you for a new title. Type in the new title and press *Return*. Pressing *Return* or clicking the left mouse button without typing anything keeps the original title. Click on *Done* to return to the main menu.

✧ Menu: Graph – X Axis

You can change the attributes of the X axis by using *Graph* ⇒ *X Axis*. After selecting the option, the present values are displayed on the screen. The actual parameter shown on the axis varies depending on the coordinate system selected. You can change the minimum and maximum values displayed on the X axis. You can specify the number or size of divisions and subdivisions on the X axis. To change a value, simply click on the value you want to change. For divisions and subdivisions, you must select how you want to specify the divisions. Click on *Number* to enter the number of divisions or click on *Size* to specify the size of the divisions. Type in the new value and press *Return*. To change the label for the X axis, click on the label. ***Patvu*** prompts you for a new label. Type in the new title and press *Return*. Pressing *Return* or clicking the left mouse button without typing anything keeps the original label. Clicking on *Reset X* resets the minimum, maximum, and divisions to their original values. ***Patvu*** asks for confirmation before resetting the values. Click on *Yes* to reset the values or *Cancel* to leave the values unchanged. Click on *Done* to return to the main menu.

✧ Menu: Graph – Y Axis

You can change the attributes of the Y axis by using *Graph* ⇒ *Y Axis*. The functions are the same as the X axis. After selecting the option, the present values are displayed on the screen. You can change the minimum and maximum values displayed on the Y axis. You can specify the number of divisions and subdivisions on the Y axis. To change a value, simply click on the value you want to change. For divisions and subdivisions, you must select how you want to specify the divisions. Click on *Number* to enter the number of divisions or click on *Size* to specify the size of the divisions. Type in the new value and press *Return*. To change the label for the Y axis, click on the label. ***Patvu*** prompts you for a new label. Type in the new title and press *Return*. Pressing *Return* or clicking the left mouse button without typing anything keeps the original label. Clicking on *Reset Y* resets the minimum, maximum, and divisions to their original values. ***Patvu*** asks for confirmation before resetting the values. Click on *Yes* to reset the values or *Cancel* to leave the values unchanged. Click on *Done* to return to the main menu.

✧ Menu: Graph - Scale

Graph ⇒ *Scale* changes the color scale of the image plot. The present settings are shown on the display. Click on Maximum and/or Minimum to change the maximum and minimum values of the scale. When you enter a value for minimum or maximum, ***patvu*** turns off Auto Range. Click on the value for Auto Range to enter a dynamic range for the scale. When Auto Range is selected, ***patvu*** automatically re-scales each frequency plot using the desired dynamic range. The initial range when ***patvu*** is started is set to 40 dB. Click on *Done* and ***patvu*** redraws the plot with the new changes.

✧ Menu: Graph - Reset

Graph ⇒ *Reset* resets all graph parameters back to their initial (start-up) state. The X and Y axis are restored along with the divisions. Titles for the graph and the axis are NOT changed. ***Patvu*** asks for confirmation before resetting the values. Click on *Yes* to reset the values or *Cancel* to leave the values unchanged.

♦ The File Menu Button

✧ Menu: File - Load

Select *File* ⇒ *Load* to load a file from disk. ***Patvu*** asks for the file name and then loads the file from the default directory. ***Patvu*** automatically uses a default file extension of ".pat" if a file extension is not specified a the end of the file name. If you do not know the name of the file, open a window and use the appropriate command to list the directory files. You may specify either full path names or relative path names. Relative path names are relative to the current directory. When loading another file, ***patvu*** tries to preserve the present settings if possible.

✧ Menu: File - Print

Select *File* ⇒ *Print* to print the plot presently displayed on the screen. ***Patvu*** can send the output to a printer or a file. Select *Printer* to send the output to the printer or to specify the printer. Select *File* to send the output to a file or to specify the file name. ***Patvu*** generates a PostScript file for printing or storing. ***Patvu*** defaults to sending the plot to the "ps" printer.

Patvu allows several options for generating a printout. To change the orientation of the plot, click on *<Landscape>*. This changes the orientation to *<Portrait>*. Click on *<Portrait>* to change the plot back to *<LandScape>*. Click on *Options* to change or view the printing options (see below). When you have set all of the appropriate options, click on *Print* to print the data to the selected destination. If you selected *File* ⇒ *Print* by mistake, click on *Cancel* to return to the main button menu.

☆ *File ⇒ Print ⇒ Options ⇒ Size*

Use this function to change the size of your printout. Click on the desired page size for the printout. Changing the page size resets all margins to the defaults. ***Patvu*** automatically switches to the appropriate units (inches or mm).

Table 1: Page sizes

Page Size	Dimensions
USLetter	8.5 x 11.0 inches
USLegal	8.5 x 14.0 inches
A4-Metric	210 x 297 mm
B5	182 x 257 mm
Customized	User-defined

☆ *File ⇒ Print ⇒ Options ⇒ Margins*

Use this function to select the margins for the page. The defaults are one inch or 25 mm depending on which units are selected. Note that changing the page size resets all margins. Be sure to select your page size *before* changing the margins. Click on *Left* or *Right* to change the left or right margins respectively. Click on *Top* or *Bottom* to change the top or bottom margins respectively. Click on *Done* to return to the *File ⇒ Print ⇒ Options* menu.

☆ *File ⇒ Print ⇒ Options ⇒ <Inches>*

This function selects the units for the dimensions of the page. Clicking on this option toggles the units between *<mm>* (millimeters) and *<Inches>*.

☆ *File ⇒ Print ⇒ Options ⇒ <Gray>*

Use this function to change to a color plot. You must have a color printer to use this function. Clicking on this option toggles the option between *<Color>* and *<Gray>*.

☆ *File ⇒ Print ⇒ Options ⇒ <Final>*

Use this function to select a draft image plot. On image plots, a draft plot prints faster allowing you to quickly check the results. Presently, this option has no effect on the printing. Clicking on this option toggles the option between *<Draft>* and *<Final>*. Cartesian and polar plots are not affected by this option.

☆ *File ⇒ Print ⇒ Options ⇒ Done*

When you are done setting the options, click on *Done* to return to the *File ⇒ Print* menu.

✧ Menu: File - Directory

Select this option to change the default directory where ***patvu*** stores and loads in the ".pat" files. As part of the menu, the default directory is displayed. To change the default directory, type in the full path or a relative path to the new directory.

✧ Menu: File - Quit

Use *File ⇒ Quit* to exit ***patvu***.

♦ Keyboard Shortcuts

The table below describes the keyboard shortcuts available with ***patvu***. These functions can also be executed by means of the menus. The shortcut keys are "control" keys, abbreviated with a "^" symbol. As an example, to type a Control-Z (^Z), hold down the *Control* key and press the *Z* key.

KEY	**MEANING**
^Y	Display the previous view
^Z	Display the full view

♦ Menu Summary

View	Animate	Graph	Parameters	File
Point	Frequency...	Attributes...	Plot Type...	Load...
Zoom In	Memory...	X Axis...	Polarization...	Print...
Prev. View		Y Axis...	Response...	Directory...
Full View		Scale...	Frequency...	Quit
Redraw		Reset...	Normalization...	

Figure 28 Chart of ***patvu***'s menu options.

Appendix I Antenna Pattern Viewing Coordinate Systems

The fundamental problem of antenna pattern visualization is that the far field antenna pattern is a data distributed over the surface of a sphere. Unfortunately, we only have a flat two dimensional computer screen on which to visualize the data. Thus, we must choose a way to map the data of the far field antenna pattern to a two dimensional computer screen. We do this by means of specifying a coordinate system. Included in each coordinate system is a means of representing the data on the computer screen. This appendix describes the coordinate systems in detail.

There are four coordinate systems for antenna pattern visualization in ***patvu.*** First, and most important, is the spherical coordinate system. The other three are defined in terms of spherical coordinates and may be more appropriate in certain situations.

♦ Spherical Coordinate System (SPHERE)

The spherical coordinate system is shown in Figure 29. For a given direction from the antenna, theta (θ) is the angle with the positive Z axis. Phi (ϕ) is the angle with the positive X axis of the projection of the direction in the X-Y plane. Positive phi is directed toward the positive Y axis.

For example, theta = 0 degrees (phi can be any value) is the zenith, or overhead point. This the direction of the positive Z axis. Theta = 90 degrees and phi = 0 degrees is the direction of the positive X axis. Theta = 90 degrees and phi = 90 degrees is the direction of the positive Y axis.

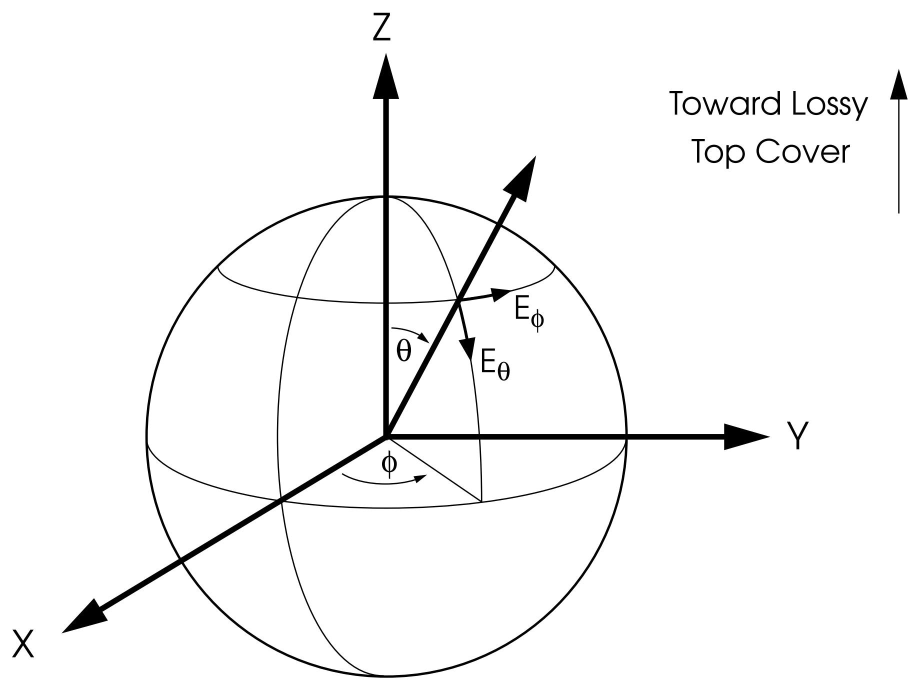


Figure 29 The spherical coordinate system can be used for most antenna circuits.

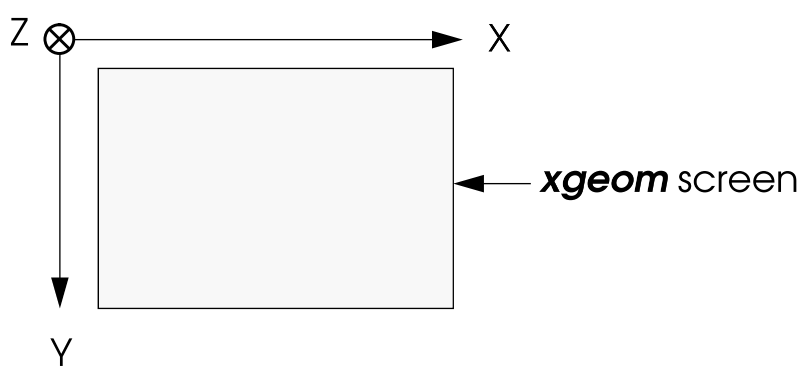


Figure 30 The coordinate system used in the xgeom screen. Note the origin is in the upper left hand corner and the Z axis goes into the screen.

The same X, Y, Z coordinate system is used in ***xgeom***. This is shown in Figure 30. Note that the Z axis goes into the screen. If not explicitly understood, the unusual orientation of the coordinate axes can cause problems in rare situations. See "A Potential Coordinate System Difficulty" on page 33 of this manual for a detailed description.

For spherical coordinates, phi is allowed to vary from -180 to 180 degrees. Theta is allowed to vary from 0 to 180 degrees. However, because theta from 90 to 180 degrees is below the horizon, the useful range of theta is from 0 to 90 degrees.

Phi is closely related to the angle known as azimuth, but they are not the same. If the X axis is pointing north, then phi = 90 degrees is west. However, an azimuth of 90 degrees is east (just look at any compass). Thus, upon placing the X axis pointing north, increasing phi goes counter-clockwise while azimuth goes clockwise.

Theta is related to elevation angle. Elevation angle is the angle above the horizon. An elevation angle of 10 degrees is the same as theta = 80 degrees.

To plot the radiation of an antenna as a function of elevation, we set phi to the desired azimuth and vary theta from 0 to 90 degrees. This is sometimes called a “theta cut” or an “elevation plot”. (Note that, in spite of the differences between theta and elevation, and phi and azimuth, the terms are often used together.)

The spherical coordinate system in ***patvu*** is restricted to positive values of theta. Sometimes it is desired to make an elevation plot with theta ranging from -90 degrees to +90 degrees. To do this, use the “earth view” coordinate system, described in the next section.

A “phi cut”, or an “azimuthal plot” sets theta to a fixed value and varies phi. Be careful not to set theta to 90 degrees. Since surface wave radiation is not included in the far field analysis, there is little power radiated there.

Another related problem is to attempt a phi cut at theta = 0 degrees. Theta = 0 degrees is a single point, the zenith, for all values of phi. In addition, at the zenith, the theta and phi polarizations are no longer defined. It is like being at the north pole and asking which direction is east.

An image plot draws a rectangular radiation region. The horizontal axis represents the range of theta (0 to 90 degrees). The vertical axis represents the range of phi (-180 to 180 degrees). In an image plot over the entire allowed range of theta and phi, the zenith (a single point, at theta = 0 degrees) is mapped into the entire vertical left side (a line). The horizon (theta = 90 degrees) is the entire right side.

♦ Earth View Coordinate System (EARTH)

The earth view coordinate system is identical to the spherical coordinate system with the exception the that allowed values for theta range from -90 to 90 degrees. The spherical coordinate system allows theta from 0 to 90 degrees. This allows an elevation plot from one horizon (theta = -90 degrees) to the other horizon (theta = 90 degrees).

Because the range for theta is increased, the range for phi is decreased. Phi is allowed from -90 to 90 degrees, instead of -180 to 180 degrees.

As with the spherical system, image plots fill a rectangular region. The range of theta provides the horizontal axis and the range of phi provides the vertical axis. Since, with earth view, both theta and phi range over -90 to 90 degrees, the image plots are more square than spherical coordinate plots. The same data is still being plotted. The data is just plotted in different locations.

In an earth view image plot, both left and right vertical edges represent the horizon. A vertical line through the center of the plot represents the zenith.

♦ Top View Coordinate System (TOP)

The top view coordinate system provides an intuitive result for viewing image antenna plots. Imagine being positioned on the Z axis far above the antenna. Imagine also that the antenna radiation is visible. Intense radiation looks red and weak radiation looks blue. An image plot in the top view coordinate system is approximately the radiation pattern that you would see.

Thus, the a top view antenna pattern plot is roughly circular. The center of the circle is the zenith. The outer edge is the horizon.

In the spherical and in the earth view coordinate systems, theta and phi are plotted on horizontal and vertical axes. For the top view, theta is plotted as the radius and phi is plotted as the angle in a circular coordinate system.

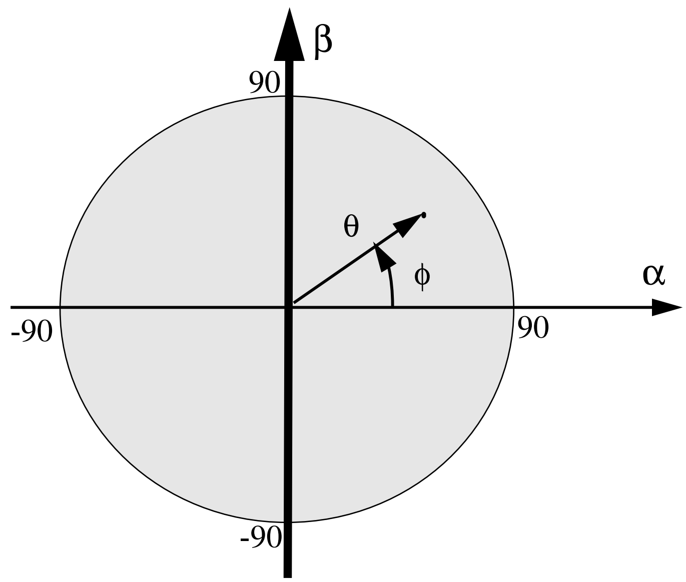


Figure 31 The top view coordinate system

Figure 31 illustrates the top view coordinate system. The valid region for this system is from -90 degrees to +90 degrees for both α-coordinate and β-coordinates. On an image plot, this region is circular with the horizontal axis being the α axis and the vertical axis being the β axis. At any point inside the circle, the radius is the θ value and the angle is the ϕ value:

$$\theta^2 = \alpha^2 + \beta^2 \qquad \text{(EQ 1)}$$

$$\phi = \operatorname{atan}(\beta / \alpha) \qquad \text{(EQ 2)}$$

valid for $\alpha^2 + \beta^2 \leq 90^2$.

The ϕ-component and θ-components of the radiation field are not defined at the center of the coordinates (α=β=0). When viewing these components, there is a “glitch” at the origin, similar to that mentioned in the discussion of the spherical coordinate system.

♦ Array Coordinate System (ARRAY)

The array coordinate system is sometimes used for the analysis array antennas. The two coordinates are defined as

$$u = \sin\theta\cos\phi \tag{EQ 3}$$

$$v = \sin\theta\sin\phi \tag{EQ 4}$$

For an image plot, the radiation region is circular given as

$$u^2 + v^2 \le 1 \tag{EQ 5}$$

with the horizontal axis being the *u* axis and the vertical axis being the *v* axis. This coordinate system is sometimes also called Van Aulok system.

Physically, *u* is the cosine of the angle with the X axis and *v* is the cosine of the angle with the Y axis.

Table 2: Description of Coordinate System Angles

COORDINATE SYSTEM	ANGLE1	ANGLE2
Sphere	$0° \le \theta \le 180°$	$-180° \le \phi \le 180°$
Earth view	$-90° \le \theta \le 90°$	$-90° \le \phi \le 90°$
Top View	$-90° \le \alpha \le 90°$	$-90° \le \beta \le 90°$
Array	$-1 \le u \le 1$	$-1 \le v \le 1$

Appendix II The Pattern Generation Control File Format

The pattern generation control file controls the frequencies used for pattern generation as well as other analysis parameters. The file may have any name ending with “.pg”. If the pattern generation control file name does not end with “.pg”, the file name must be specified with the -c option, for example:

patgen -c analysis.xxx

If no file name is specified in the command line, ***patgen*** looks for “ctl.pg” in the current directory. If that file is not found, ***patgen*** terminates execution after displaying an error message.

Any line in the control file with a first non-space character of “#” is treated as a comment and is ignored. Any blank line is also ignored. Comments following any complete line of data are allowed.

In the keywords that follow, both upper and lower case letters are allowed since the case is ignored. There may be no more than 255 characters per line.

CTLPG This keyword must be the first line in the file. ***Patgen*** looks for this keyword to identify the file type.

VER Any line with the keyword VER is taken to specify the ***patgen*** version number. There must be at least one space between the keyword VER and the actual number. This information is required for compatibility with future versions. The VER line must immediately follow the CTLPG line in the file. Multiple VER lines are not allowed.

COORD A line starting with COORD specifies the coordinate system used for the analysis. COORD must be followed by one of the following keywords: SPHERE, TOP, EARTH, or ARRAY. If not specified, or if the control file contains more than one COORD line, the program terminates with an error message. For a complete description of the coordinate systems, see Appendix I, "Antenna Pattern Viewing Coordinate Systems".

ANG1 The actual parameter ANG1 refers to depends on the coordinate system selected. See Table 2,"Description of Coordinate System Angles," on page 56 for the list of parameters for each coordinate system. ANG1 may be followed by one, two or three numbers. One or two numbers specify one or two angles. Three numbers specify a start, stop and step. Both ANG1 and ANG2 must be specified in the control file. If either one is missing, or is specified more than once, the program terminates. ***Patgen*** also accepts ANGLE1 as a keyword.

ANG2 The actual parameter ANG2 refers to depends on the coordinate system selected. See Table 2,"Description of Coordinate System Angles," on page 56 for the list of parameters for each coordinate system. The syntax for ANG2 is identical to ANG1. Both ANG1 and ANG2 must be specified in the control file. If either one is missing, or is specified more than once, the program terminates. ***Patgen*** also accepts ANGLE2 as a keyword.

GHZ
MHZ Frequency units can be specified by a line with MHZ or GHZ. The frequency units can be changed as often as desired within the same control file. All frequencies specified on a FRE line must be in the units most recently specified. If no units have been specified, MHz is assumed.

FRE A line starting with FRE specifies a list of analysis frequencies. The control file *must* contain at least one FRE line specifying at least one frequency. FRE may be followed by one, two or three numbers. One or two numbers specify one or two frequencies. Three numbers specify a start, stop and step. The start, stop and step are all checked for error conditions. After the control file is read, the frequency list is sorted. As many FRE lines may be used as is needed. Duplicate frequencies are ignored. If any of the specified frequencies do not exist in the current density file, the program terminates with an error message. If you want to include all the frequencies in the current density file, use the keywords FRE ALL to include all frequencies.

PORT A line starting with PORT specifies parameters for a specific port or for all ports. PORT must be followed by the port number or the keyword ALL. PORT ALL may be used to specify parameters which are common to all ports. For example, PORT ALL R=10 sets the terminating resistance of all ports to 10 ohms. Only one PORT line may be specified for each of the ports. Only one PORT ALL line may be specified in the file. Parameters may be specified in any order on each line. Ports may be specified in any order. MAG= specifies the voltage magnitude in volts. PHASE= specifies the phase in degrees. R= specifies the resistance in ohms. X= specifies the reactance in ohms. L= specifies the inductance in nanoHenries (nH). C= specifies the capacitance in picofarads (pF). The voltage and the phase *must* be specified for each port. If not, ***patgen*** terminates. When not specified, the other port parameters default to the values stored in the current density file by ***em***.

EXAMPLE FILE:

```
CTLPG                   # Identifies the Pattern Generation Control File
VER   2.4               # Specify version
COORD SPHERE            # Specify Coordinate System
ANG1  0 90 1            # Angle1 (theta) from 0 to 90 Step 1
ANG2  -180, 180, 180    # Angle2 (phi) from -180 to 180 Step 180
GHZ                     # Frequencies are in GHz.
FRE   2.3               # 2.3 GHz.
FRE   1 10 1            # 1 to 10 GHz Step 1
MHZ                     # Switch to MHz.
FRE   1500              # 1500 MHz (1.5 GHz)
PORT  ALL  MAG=10 PHASE=90 R=10 X=10 L=10 C=20 # Values for all ports
PORT  1    MAG=20 C=1e3  # Change the magnitude & capacitance of Port 1
PORT  3    R=30          # Change just the resistance of Port 3
```

MINIMUM FILE REQUIREMENTS:

```
CTLPG
VER   2.4
COORD SPHERE            # Specify one of the coordinate systems
ANG1  0 90 45
ANG2  -180 180 10
FRE   ALL               # Use all frequencies in the Current Density File
PORT  ALL  MAG=1 PHASE=0 # Must specify the voltage and phase
```

Appendix III *Patgen* Command Line Options

NAME: ***patgen*** - Far field radiation pattern generation of planar antennas.

SYNOPSIS: ***patgen*** [-options] [files]

DESCRIPTION: ***Patgen*** generates a far field radiation pattern file from the current density analysis file. This file may then be later viewed by ***patvu***.

♦ Options

-c Specify the pattern generation control file. Default file is “ctl.pg”. Specifying a command line file name which ends with a period followed by “pg” is equivalent to specifying the option. There must be a space between the -c and the file name. If the pattern generation control file does not exist, ***patgen*** displays an error message and stops executing.

-d2 This option generates a pattern response file based on a set of defaults for a 2-dimensional plot. When this option is specified, ***patgen*** doesn’t use a pattern generation control file. Instead, ***patgen*** uses the first frequency specified in the current density file. Port voltages are set to 1.0 volt, and all other port parameters are taken from the current density file. ***Patgen*** uses the spherical coordinate system with ANG1 set to 0,90,45 and ANG2 set to -180,180,10. If different defaults are desired, change the file $SONNET_DIR/examples/ctld2.pg.

-d3 This option generates a pattern response file based on a set of defaults for a 3-dimensional image plot. When this option is specified, ***patgen*** doesn't use a pattern generation control file. Instead, ***patgen*** uses all of the frequencies specified in the current density file. Port voltages are set to 1.0 volt, and all other port parameters are taken from the current density file. ***Patgen*** uses the earth view coordinate system with ANG1 set to -90,90,5 and ANG2 set to -90,90,5. If different defaults are desired, change the file $SONNET_DIR/examples/ctld3.pg.

-f This option prints out a list of the frequencies in the current density file without generating a response file. The format of the listing is shown below.

```
GHZ
FRE 1.2
FRE 1.3
FRE 1.4
```

-h This option displays a help message.

-j Specify the current density file for the analysis. Specifying a command line file name which ends with a period followed by "jxy" is equivalent to specifying the option. If the current density file does not exist, ***patgen*** terminates execution after displaying an error message.

-N This option estimates the amount of memory required for running, without actually performing the analysis.

-p Specify the pattern response file for the analysis. Default file extension is ".pat". Specifying a command line file name which ends with a period followed by "pat" is equivalent to specifying the option. If the file name isn't specified, the name is taken from the current density file with an extension of ".pat". If a file already exists with that name, the existing file's extension is changed to ".pab".

-t This option prints out a list of the port parameters in the current density file without analyzing the file.

-v This option, verbose mode, displays messages during program execution describing the present state of the analysis.

-Ver Prints out the present version number of ***patgen*** and license identification and exits. Must be the first option on the command line. All other options are ignored.

The following files may be specified on the command line:

Pattern Generation Control File:

Default name "ctl.pg", the file name should end with ".pg", otherwise, the file name must be specified with the -c option. This file can set the frequencies and angles for analysis, among other things. If the file does not exist, ***patgen*** displays an error message and terminates execution.

Current Density File:

The file name should end with ".jxy", otherwise, the file name must be specified with the -j option. The current density file must be created with ***em***, see the ***Em* User's Manual**. If the current density file does not exist, ***patgen*** terminates after displaying an error message.

Pattern Response File:

If not specified, the file name is taken from the current density file with a ".pat" extension. The file name should end with ".pat". This file stores the pattern response information in the file for later viewing.

EXAMPLES:

patgen -v array.jxy

Analyze the circuit in "array.jxy" using the pattern generation control parameters in "ctl.pg" and store the results in file "array.pat". Display the status of the program as it executes (-v).

patgen array.jxy test.pg answer.pat

Analyze the circuit in "array.jxy" using the pattern generation control parameters in "test.pg" and store the results in file "answer.pat".

patgen -j array.tst -c ctl.tmp -p answer.new

Analyze the circuit in "array.tst" using the pattern generation control parameters in "ctl.tmp" and store the results in file "answer.new". Although we recommend using the standard file extensions ".jxy", ".pg", and ".pat", this example shows that you are not restricted to the defaults.

patgen array

Analyze the circuit in "array.jxy" using the pattern generation control parameters in "ctl.pg" and store the results in the file "array.pat".

patgen -d2 array

Analyze the circuit in “array.jxy” using the default 2-dimensional control parameters and store the results in the file “array.pat”.

Appendix IV The *Patvu* Command Line

Run ***patvu*** by typing “patvu <options> <file-name>”. Options may appear after the file name. A file name ending in “.pat” is recommended.

Most of the usual X Window System command line options are available. For example, to run ***patvu*** on one computer while using the display, keyboard and mouse of another computer (node name, say, “galaxy”), type:

patvu -display galaxy:0

Patvu also looks in all the usual places for the X Window System defaults.

Patvu options are as follows (associated resource keywords are in parentheses):

-background <color>	(*background) Sets the background color.
-backing	(*backing: yes) Uses backing store, if supported by display. This provides faster re-draw in exchange for larger memory requirements. Unless modified, default is no use of backing store.
-bd <color>	(*borderColor) Sets color of main window border.
-bg <color>	Same as -background.
-borderwidth <x>	(*borderWidth) Sets main window border width to x pixels if allowed by the window manager.

-bordercolor <color>	Same as -bd.
-bw <x>	Same as -borderwidth.
-display <name>	(*display) Sets display for input/output. For example: -display galaxy:0.
-fg <color>	*foreground) Sets color for foreground.
-font <font_name>	(*font) Selects a different font for ***patvu*** displays.
-fn <font_name>	Same as -font.
-foreground <color>	Same as -fg.
-geometry <str>	(*geometry) Sets window size and position. "str" is in the format WIDTHxHEIGHT+XOFF+YOFF, where WIDTH and HEIGHT is the width and height of the ***patvu*** window in pixels. +XOFF places the ***patvu*** window XOFF pixels from the left edge of the screen. If you use -XOFF then the window is offset from the right edge of the screen. +YOFF places the ***patvu*** window from the top edge of the screen and -YOFF places the ***patvu*** window from the bottom edge of the screen.- For example, use "patvu -geometry 800x600-0+0" to make an ***patvu*** window of size 800 by 600 in the top left hand corner of the screen.
-iconic	(*iconic: yes)Starts ***patvu*** up as an icon.
-name <str>	(.name) Used to select a set of special defaults. See X documentation for details.
-noRestoreColorMap	(*noRestoreColorMap: yes) ***Patvu*** loads in Sonnet's color map (file name of $SONNET_DIR/data/color.pal) upon initialization and unloads the color map every time the mouse leaves the ***patvu*** window. This option prevents the color map from being unloaded when the mouse is moved out of the ***patvu*** window.
-noLoadColorMap	(*noLoadColorMap: yes) Prevents Sonnet's color map from being loaded in during ***patvu***'s initialization.
-title <str>	(*title) Sets title displayed on main window (if window can display title). Be sure to enclose entire title in quotes if it contains white space.
-xrm <str>	Provides access to the resource manager, see X window documentation.

-Ver Prints out the current version of ***patvu*** and exits. Must be the first option on the command line. All other options are ignored.

+backing (*backing: no) Makes sure the backing store is turned off, even if the default has been changed.

+iconic (*iconic: no) Makes sure window comes up, not icon, even if default has been changed.

There are several ways to specify the defaults to the ***patvu*** program:

1. Command line argument.
2. File specified by $XENVIRONMENT or if not set, the file $HOME/.Xdefaults-<hostname> is used.
3. X11 Default values already set in the window manager or by the xrdb command or, if not set, by the file $HOME/.Xdefaults. Use $HOME/.Xdefaults to set defaults on a per user basis.
4. Reads the file $APPLRESDIR/Patvu
5. Reads the file /usr/lib/X11/app-defaults/Patvu
6. Reads the file $SONNET_DIR/data/Xdefaults. Use this file to set defaults for all ***patvu*** users.

For example the following lines could be added to the $HOME/.Xdefaults file to

```
Patvu*textcolor: blue
Patvu*geometry: 980x680
```

The above file is read by ***patvu*** and sets the origin to the bottom left. Also the ***patvu*** window is started up at 980x680 size (in pixels) For other ways to control the defaults of the X Window System programs, consult the X Window System documentation.

INDEX