

PROCESS TOMOGRAPHY Ltd.

3-D PLOTTING PROGRAM FOR ECT DATA

PLOT3D

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SUMMARY

This manual describes an offline software utility **PLOT3D**, for use with **PTL ECT** systems. The **PLOT3D** software allows **capacitance data** captured using the **PTL ECT32 software** to be displayed as a set of **multiple 2-D image frames** and viewed in **2 or 3-D**. The processed data can be converted into a **video file** which can be viewed using standard video playback software such as Windows Media Player. Versions of the **PLOT3D** program are available which can be run in either a stand-alone mode or under Matlab.

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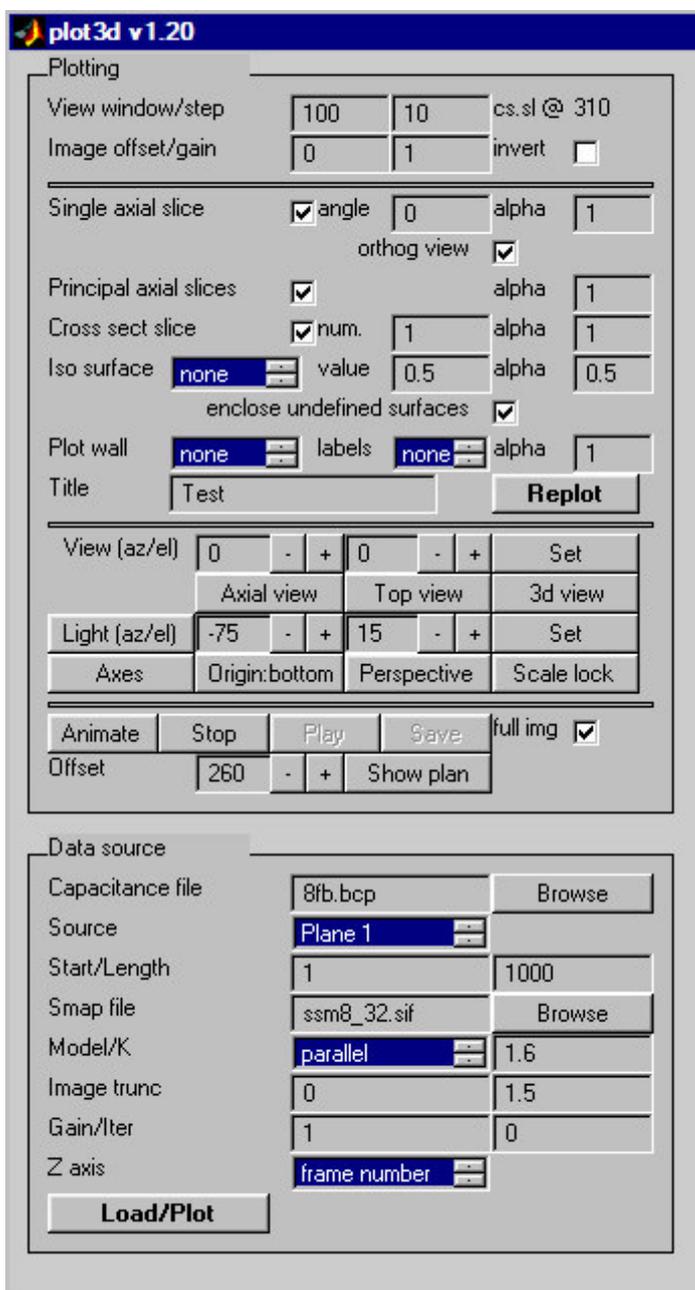
3-D PLOTTING PROGRAM PLOT3D

1. INTRODUCTION

PLOT3D is a customised Matlab program which allows **capacitance data** captured using the **PTL ECT32 software** to be displayed as a set of **multiple 2-D image frames** and viewed in **2 or 3-D**. Versions of the program are available which can be run as either a stand-alone program or under Matlab.

2. THE CONTROL PANEL

When the program is started, the **Control Panel**, shown in figure 1 is displayed in an otherwise empty plotting window. The **Control Panel** consists of an upper (**Plotting controls**) area and a lower (**Data Source controls**) area.



PLOTTING CONTROLS

Parameter group 1
(Permittivity image options)

Parameter group 2
(Plotting options)

Parameter group 3
(Viewing options)

Parameter group 4
(Frame and animation options)

DATA SOURCE CONTROLS

Figure 1. Plot3d Control Panel

The **Data Source controls** are used to extract, modify and load capacitance data from a captured capacitance data file. Once the selected data has been loaded, the **Plotting controls** are used to display the image data in the required format. In general, it is possible to display all or part of the captured data file in the plotting window and to view and scroll through this file to examine the captured data.

It should be noted that some of the operations of the buttons in the **Control Panel** under Matlab differ from the standard Windows conventions. For example, **it is necessary to click on options selected using Matlab scroll boxes to set them to be active (Blue). Failure to do this will prevent the selected option from being activated.**

3 LOADING DATA FROM A CAPTURED DATA FILE

3.1 DATA SOURCE CONTROLS

Data from a **captured data file** is extracted and loaded using the controls in the **Data Source area**. The details are as follows:

Capacitance file:	Input the filename of the input capacitance data
Source:	Select the plane to plot (Plane1 or Plane 2)
Start/ Length:	Start: Select the first frame number to be extracted from the input data file. Length: Set the number of frames to be extracted.
Smmap file:	The sensitivity map file to be used to generate the permittivity images.
Model/K:	Model: Select the capacitance/permittivity model to be used to construct the permittivity image (Parallel/Series/Maxwell). K: Select the permittivity ratio to be used with the series and Maxwell models
Image Truncation:	Insert the upper and lower values of normalised permittivity to be used for image truncation at each iteration when using iterative image reconstruction.
Gain/Iter:	Gain: The gain to be used for iterative image reconstruction Iter: The number of iterations to be used
Z axis:	Select from Frame number/Time stamp/Time delay Time stamp is the frame time from the start of data capture. Time delay is the time of the frame relative to the last frame in the extracted data set.
Load/Plot	This loads the selected data and displays it in the format selected in the Plotting options area. The load button stays depressed until the data has loaded. This operation can take some time due to reconstruction effort, especially if iterations are specified.

Note: For simple **LBP image reconstruction**, set the **Iter** value = 0. In this case, the **Image truncation** and **Gain/Iter** parameters are ignored.

4. PLOTTING THE CAPTURED DATA

Once the **input data** has been loaded using the options set in the **Data source** area, the **PLOTTING CONTROLS** can be used to visualise the **image data** in a wide variety of ways.

There are **four principle groups of parameters**, arranged vertically within the **Plotting controls**.

Note that when any parameters in **Parameter groups 1 and 2** are changed, the **Replot** button must be used **to generate an updated new image**.

4.1 PERMITTIVITY IMAGE OPTIONS (PARAMETER GROUP 1)

The first group of parameters modify the set of images reconstructed by the **Load/plot** button in the **Data Source** group. The functions of the parameters in this group are as follows:

View window	Window is the total number of frames to be plotted within the range of total data frames loaded .
/step:	Step is the number of frames to be incremented when stepping through the set of image frames using the Offset buttons . It also determines the Frame increment steps to be used in the Animate option. (see section 4.4)
Image offset /gain	Image offset: The permittivity offset (use 0 for no offset) applied to the image pixels Gain: The gain factor (Use 1 for normal gain) applied to the image pixels.
Invert	If this option is ticked, an inverted image is plotted. This facility is useful for plotting iso-surfaces (section 4.3) of lower permittivity objects inside a higher permittivity medium (for example, gas bubbles in oil).
cs.sl@xx	This parameter is normally "greyed out" unless the Cross sectional slice option (see parameter group 2) is selected, in which case it displays the frame number (xx) of the displayed cross sectional image.

4.2 PLOTTING FORMAT OPTIONS (PARAMETER GROUP 2)

The parameters in this group determine the **format** of the plotted images. **It is possible to plot images in one or more formats simultaneously**. In general, the **Replot** button must be used to plot a **new or updated image** after any of the parameters in the **Plot format options group** are changed.

4.2.1 Single axial slice option.

If ticked, this option shows the **permittivity distribution** across a **2-D diametric axial plane (axial slice)** oriented at a **selected angle** from the **cross-sectional axis origin**.

Angle: This parameter sets the angle of the **axial image slice** relative to the origin (the horizontal X axis which lies in the plane of the computer monitor screen). A **cross-sectional plan view** of the image plane (**axial slice**) and the angle from which it is viewed (**viewing angle**) can be seen by clicking on the **Show Plan** button (see parameter group 3 below) which produces a plan view of the sensor looking from the **top** of the sensor. The two primary X and Y axes (at azimuth angles of 0 and 90 degrees respectively) are shown as dotted lines on the **Plan view** diagram.

Alpha: This sets the **transparency** of the image. 1 is opaque and 0 is transparent.

Orthog view: If this option is selected, the **permittivity image** is viewed from an angle of (-90) degrees relative to the **angle of the diameter which defines the axial slice plane**. If any other views are subsequently selected using the **view buttons** in parameter group 3 (section 4.3), the **view angle** may be temporarily modified, but the view will revert to 90 degrees to the **axial slice** when the **Replot** button is operated.

When the **orthogonal view** option is selected and the angle is changed there will be a slight variation in the width of the image slice. This is due to the variation in the radius of the pixelated circle representation of the sensitivity map.

A typical **Single axial slice image** (for 100 frames starting at frame 1) is shown in figure 2 below for an axial permittivity slice across a single axial plane plotted for a diameter of 45 degrees to the reference axis. The LHS axis is the frame number and alpha has been set to 1.

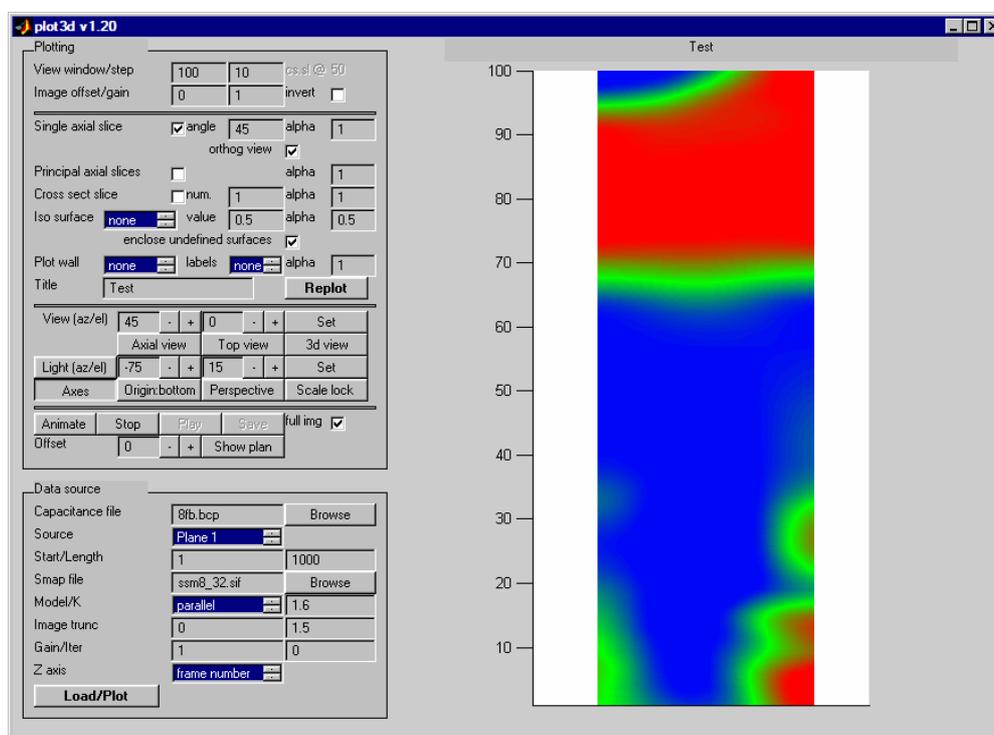


Figure 2. Image display in Single axial slice mode

A plan view from the top of the sensor can be seen by clicking on the **Show Plan** button in the 4th parameter group as shown in figure 3 below.

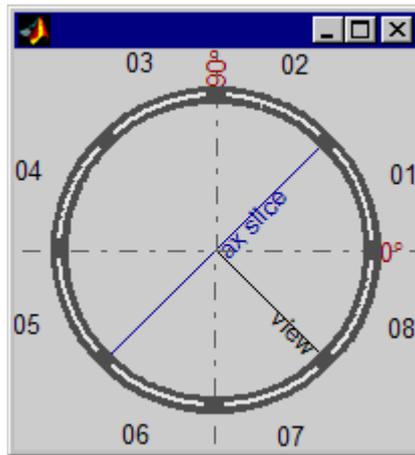


Figure 3. Plan view of image plane from top of image set.

Figure 3. shows the axial slice oriented at 45 degrees to the origin (0 degree axis) with the view direction clearly indicated. The electrode positions are also shown.

4.2.2 Primary axial slices option

This option plots permittivity profile images in the two diametric planes which coincide with the primary X and Y axes (ie at azimuth angle = 0 and azimuth angle = 90 degrees). The **3_D view option** must be enabled to view the two image axes and the image can be rotated in 15 degree increments by clicking on the **View (az) button**. (see parameter group 3 below).

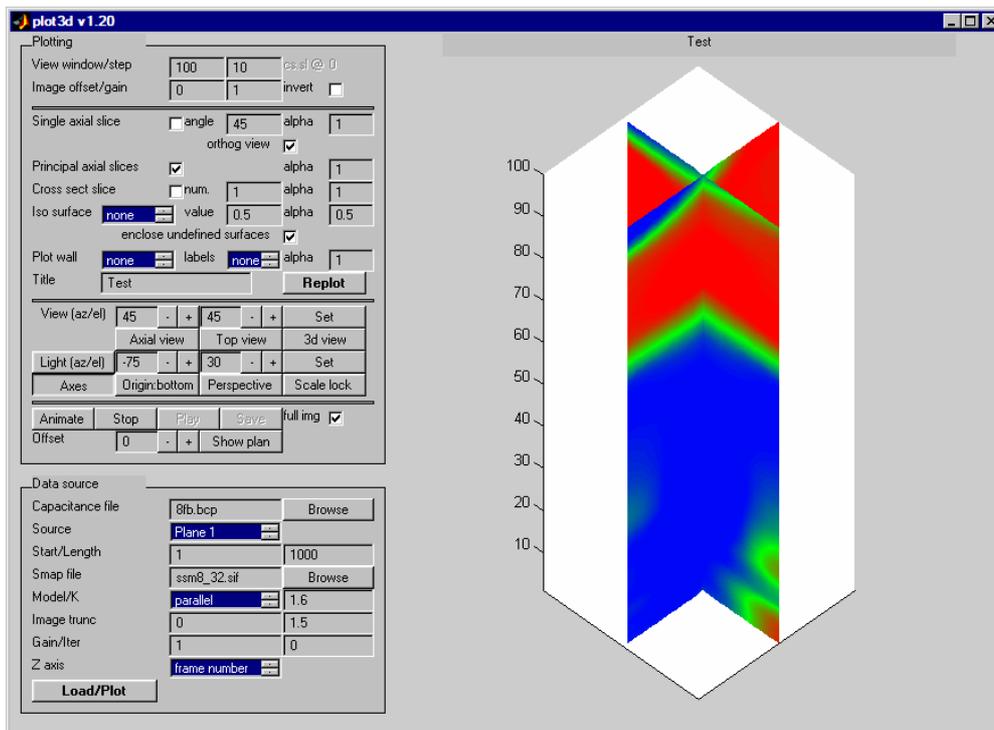


Figure 4. Principal axial slices in 3-d view

4.2.3 Cross sectional slices option

This option plots one or more (num) **cross-sectional image frames** at specified times or frame numbers. A typical plot (for num = 3) is shown in figure 5.

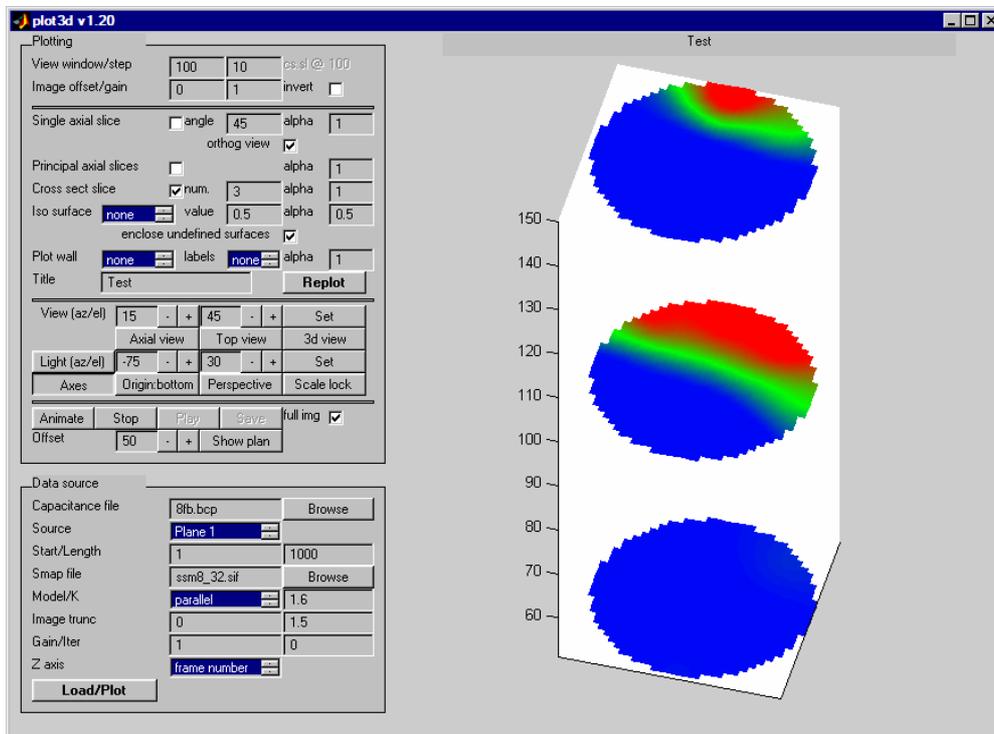


Figure 5. Cross sectional image display

The number of images plotted is determined by the number entered in the **num box** as follows:

If **num** = 1, the **middle frame** in the displayed sequence is plotted and the frame number is indicated in the **cs.sl@** (**cross-section slice**) parameter in **Parameter group 1**.

If **num** = 2 the **first** and last **frames** in the displayed sequence are plotted and if n = 3 the **centre frame** is also plotted. etc.

The images can be rotated in both azimuth and elevation using the **View (az/el) +/-** buttons in **Parameter group 3**.

4.2.4 Iso surface option.

This option plots a **3-D surface contour** of the permittivity images at a **specified permittivity value** (typically in the range 0 - 1) which is set in the **value box**. The **colour** chosen to plot the surface can be chosen from a **scroll box** list. Note that when the **map** option is selected from this list, the colour corresponds to that defined by the standard **PTL RGB permittivity colour scale**. The **surface transparency (alpha)** is set in the **alpha box**.

Note also that the **iso-surface image** needs to be viewed in **3-D** with the **Lighting** activated (see **Viewing options**) to allow the **iso-surface** to be viewed effectively. A typical image is shown in figure 6 below. This image was produced with the **Enclose undefined surfaces** and **Plot wall** options enabled.

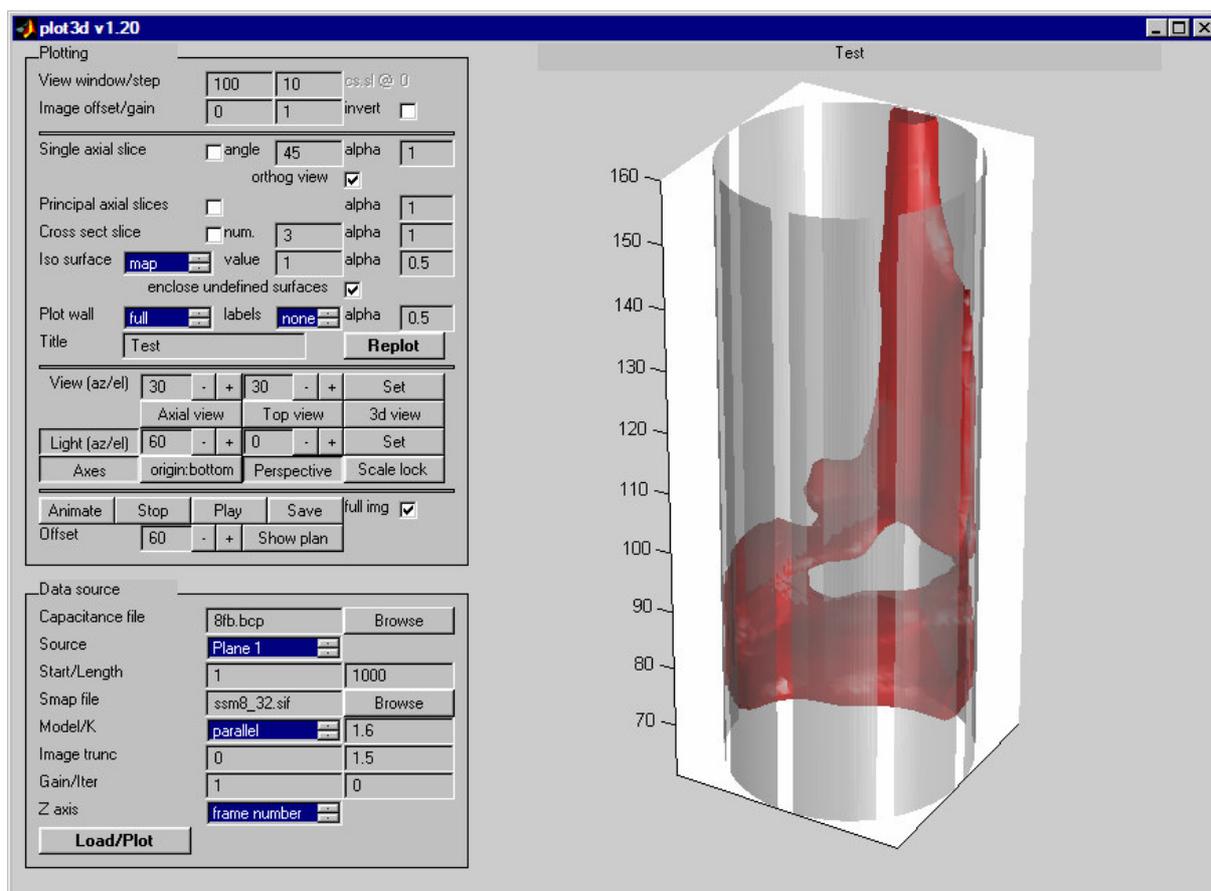


Figure 6. Iso surface image display

There are so many possibilities with the different parameter settings in **iso-surface mode** that we suggest that users experiment with the effects of the various viewing and lighting controls as described in the **Viewing Options** parameter group below.

The **Enclose undefined surfaces** button completes the iso surface volume at the tube boundaries.

4.2.5 Wall Plotting Controls

The **Plot wall** option allows the sensor wall to be plotted. **Electrode gaps** are indicated by gaps in the plotted wall. The options are **None**, **half** and **full**.

If **None** is selected, no wall is plotted. if **Half** is selected, the half sector of the wall behind the pipe contents view is plotted (this is view dependent) and if **Full** is selected, all of the wall is plotted.

Note that the **wall transparency (alpha)** can be set in the range 0 to 1 using the **alpha box**. A value of **alpha** = 0.5 was used to produce the image of figure 6.

The **Title box** allows an **image title** to be inserted at the top of the image.

Notes:

1. When any parameters in the **Plotting options** parameter group are changed, the **Replot** button must be used to plot an updated new image. This replots the images with the specified parameters
2. It is possible to use more than one of the plotting options simultaneously.

4.3 VIEWING OPTIONS (PARAMETER GROUP 3)

The controls in this group determine how the image formats selected in the **Plotting options** group are viewed. In general, the controls in this group have an immediate effect on the image and there is no need to use the **Replot** button. Note that **Azimuth** and **Elevation** views can be difficult to comprehend initially because of the changes in perspective.

The **View Az/EI** buttons allow the **image viewing angle** to be changed in **azimuth** and **elevation** and pressing them increments or decrements the viewing angle in 15 degree steps. Alternatively, a specified number (degrees) can be entered directly and applied using the **Set button**.

An **azimuth view angle** of **0 degrees** corresponds to a normal view of the PC screen. from the front, which corresponds to a view along the -Y axis in the direction of the origin at (ie at -90 degrees to the X axis).

An **azimuth angle** of **90 degrees** shows a view of the image from the **RHS** of the PC screen. Similarly, an **azimuth angle** of **180** degrees corresponds to a **rear view** of the image and **270 degrees** corresponds to a view from the **LHS** of the screen.

An **elevation view angle** of **0 degrees** corresponds to a view in the **X-Yplane**. A **view angle** of **90 degrees** views the image from the **top** and a **view angle** of **-90 degrees** corresponds to a view from the **bottom** of the image.

The function of the **3 View buttons** is to reset the **view parameters** to commonly useful values as follows:

Axial view: Displays the selected image plots as axial slices in the two principal orthogonal X-Y axis planes (at angle = 0 and angle = 90 degrees).

- Top view:** Views the selected image plots from the top.
- 3-D view:** Views the selected image plots in 3-D.
- Light (az/el):** This button toggles turns on lighting when depressed. The angle from which the illumination is cast is determined by the azimuth and elevation angles selected and works in a similar way to the View angles .
The lighting option should be turned on and the angle adjusted to suit to view iso-surface images.
The lighting angle can be seen by clicking on the **Show Plan** button in the 4th Parameter group.
- Axes** This button displays the **vertical scale axis** when it is depressed. The scale format (frame number/elapsed time/time delay) depends on the **Z axis option** chosen when the data was loaded.
- Origin** This button cycles around 4 options as follows:
Top: frame and time origin (frame 1, time 0)are at top of image.
Left: frame and time origin (frame 1, time 0) are at LHS of image.
Bottom: frame and time origin (frame 1, time 0) are at bottom of image.
Right: frame and time origin (frame 1, time 0) are at RHS of image.

The use of these options allows the view to be set to match the direction of flow

- Perspective** When depressed, this button produces a perspective view of the image.
- Scale Lock:** When images are rotated, Matlab automatically adjusts the image scaling to fit the images (including the projected axes) to the available window size. This auto-scaling has the effect of changing the apparent image size. It can be disabled and the scaling fixed to that of the current image by depressing the **Scale lock** button.

4.4 FRAME AND ANIMATION OPTIONS (PARAMETER GROUP 4)

The controls in this group allow:

1. The frame number range to be incremented and re-plotted. This is carried out using the **Offset +/-** buttons which increment the range of frames plotted by the **step** interval defined in the **Permittivity Image parameter group 1**. The frame number of the lowest frame number plotted is displayed in the frame number offset box. Alternatively, a **frame number** can be entered directly in the offset box and the **Replot** button used to display the new image set.
2. A Plan view of the **image slice angle**, **viewing angle** and **lighting angle** to be displayed by clicking on the **Show plan button**.
3. A **video file** to be created showing the full range of frames loaded, incremented by the **step** interval. The file is created using the **Animate** button and once it has been created, can be viewed by pressing the **Play** button. Alternatively, the file can be saved as a **.avi file** using the **Save** button and can then be viewed by other software, eg **Windows Media Player**. The **save** operation can take some time to complete. If the **Stop** button is pressed during the animation process, the animation creation is abandoned. It may be necessary to press this button a few times to interrupt the animation process.