IVPC

I-V CURVE TRACER UTILITY SOFTWARE

REFERENCE MANUAL

Daystar, Inc.
3240 Majestic Ridge
Las Cruces, NM 88011
505-522-4943
pvvern@zianet.com
http://www.raydec.com/daystar

October 2002
Version 2.63

CONTENTS

CONTENTS ..... **i**

1.0 IVPC Software Reference **1**

Using a Mouse or Keyboard 1

Window Control Box 2

2.0 Starting IVPC for Windows **2**

Data Grid Window 3

3.0 IPVC Menus **3**

3.1 File Menu 3

New I-V Curves 4

If You Get an Error 8

Save I-V Curve 8

Merge I-V Curve Files 8

Delete I-V Curve 9

Change Directory 9

Print 10

3.2 Edit Menu 10

Copy 11

Select All 11

Sort 11

Change Field 12

Check All 12

UnCheck All 12

3.3 View Menu 13

Multi-Plot Curves 13

3.4 Options Menu 14

Pyranometer Constants (DS-100 only) 15

Auto Curves 16

COM Port 19

Graph 19

3.4 Normalize Menu 20

Normalize Now 20

Set Constants 21

Auto-Normalize 27

3.6 Window Menu 28

4.0 TROUBLESHOOTING **29**

APPENDIX A I-V Curve ASCII File Format **30**

1.0 IVPC Software Reference

IVPC for Windows controls the DS-Tracer photovoltaic I-V curve tracers. The program runs under the Windows® 95 or newer operating system. Functions are menu driven and may be activated using the keyboard or a mouse. IVPC controls the DS-Tracer and provides a way to review stored I-V curve data files. The following sections describe the features of the IVPC software.

Using a Mouse or Keyboard

Functions of IVPC can be activated with a mouse or from the keyboard. The keyboard equivalents are indicated under the menus.

The Tab and Arrow keys are an easy way to move the cursor in IVPC. Within the IVPC Data Grid use the Arrow keys to move up, down, right, and left. Press the Enter or Return key to display the I-V curve of the selected file(s). Use the Tab key to move to the next data entry field when taking I-V curves. Shift-Tab will move backwards through the fields. Press Alt-T when ready to take a curve.

The menus, File, Edit, View, Options, Normalize, and Window, are accessed by pressing Alt-F, Alt-E, Alt-V, Alt-O, Alt-N, and Alt-W respectively. A pull-down menu will be displayed. An item is selected within the pull-down menu by pressing the keyboard character underlined. For example, to select New I-V Curve from the File menu, press the Alt and F keys at the same time (Alt-F). This action will display the pull-down menu shown in Figure 1. Select New I-V Curve by pressing the N key. Note the "N" in New Curve is underlined. Similarly, you could have pressed the X key to exit IVPC for Windows.

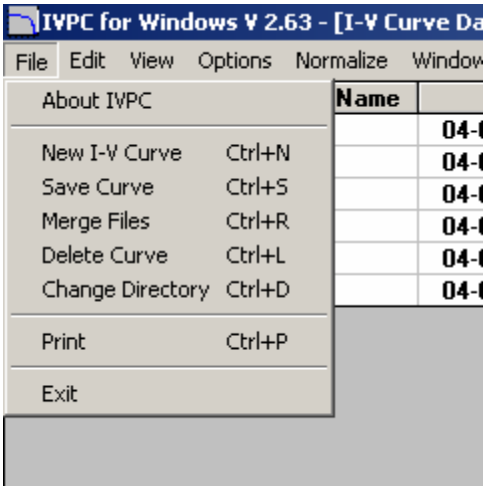


Figure 1. Using IVPC Menus with a Keyboard.

Window Control Box

The Window Control Box is located in the upper left corner next to the File menu. This box is the standard control used on all windows whether part of IVPC or another application. You will primarily use the Close command to close an I-V curve window. As seen in Figure 2, you can press Ctrl+F4 to close the current window rather than use the mouse. If the active window is a new I-V curve, you are given the option to save the I-V curve data. Refer to Save I-V Curves in this section for details. Closing a new curve returns you to the Data Grid window. Refer to your Windows® manual for details on the other functions of the window control box.

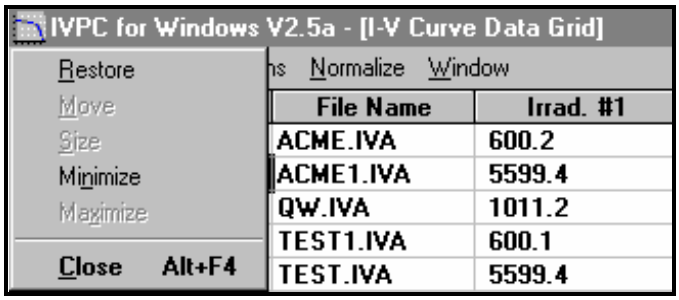


Figure 2. Window Control Box.

2.0 Starting IVPC for Windows

1. Start the control computer operating Windows®. IVPC will operate under Windows 95 or newer. **Note: IVPC is installed from CD-ROM or floppy disks like any other Windows program. Refer to the manual for the Windows version you are using.**

2. Activate IVPC by double clicking on the IVPC icon or by using the Start function of Windows® as shown in Figure 3.

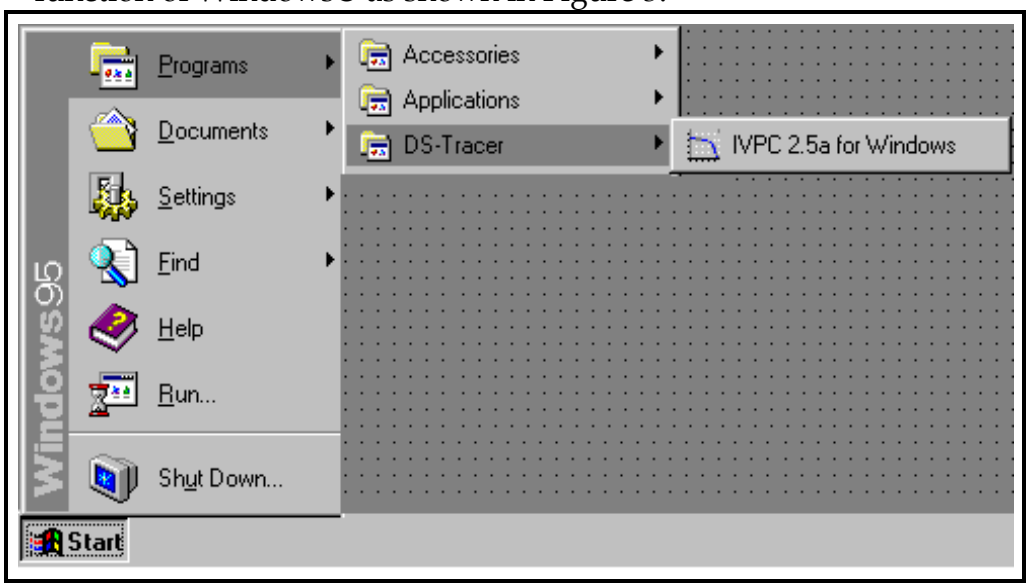


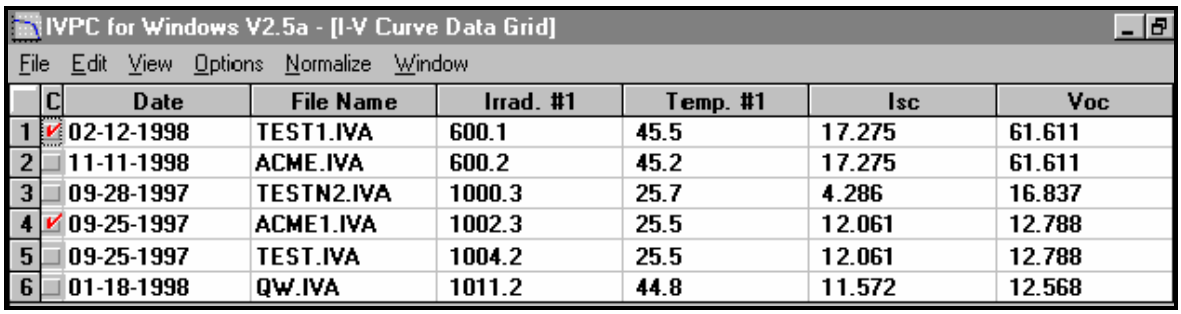
Figure 3. IVPC for Windows icon.

Data Grid Window

The Data Grid window, shown in Figure 4, is the main IVPC window. The Data Grid displays details of all I-V curves in the current working directory. The grid displays all 18 fields of data for each I-V curve. You may change which field is displayed using the Change Field command in the Edit menu or by double-clicking on a field header within the grid menu. Refer to the Options Menu section for details. Double-clicking on any row in the grid will recall the I-V curve of that particular file.

All fields may not fir on your screen. Use the scroll bars as needed to display other fields. Reorder fields to put the most important fields to the left side.

The Check Boxes located on the left side of the Data Grid allow **multiple curve** selections for Merging Curves, Normalizing I-V Data, Sorting Data, Plotting Multiple Curves, or Deleting curves from the Data Grid.



	C	Date	File Name	Irrad. #1	Temp. #1	Isc	Voc
1	☑	02-12-1998	TEST1.IVA	600.1	45.5	17.275	61.611
2	☐	11-11-1998	ACME.IVA	600.2	45.2	17.275	61.611
3	☐	09-28-1997	TESTN2.IVA	1000.3	25.7	4.286	16.837
4	☑	09-25-1997	ACME1.IVA	1002.3	25.5	12.061	12.788
5	☐	09-25-1997	TEST.IVA	1004.2	25.5	12.061	12.788
6	☐	01-18-1998	QW.IVA	1011.2	44.8	11.572	12.568

Figure 4. IVPC Data Grid.

3.0 IPVC Menus

The IVPC software uses pull-down menus to access functions. Most commands have an associated keyboard sequence to activate the function.

3.1 File Menu

Items under the File menu are shown in Figure 5. Some functions may be disabled depending on what window is currently active.

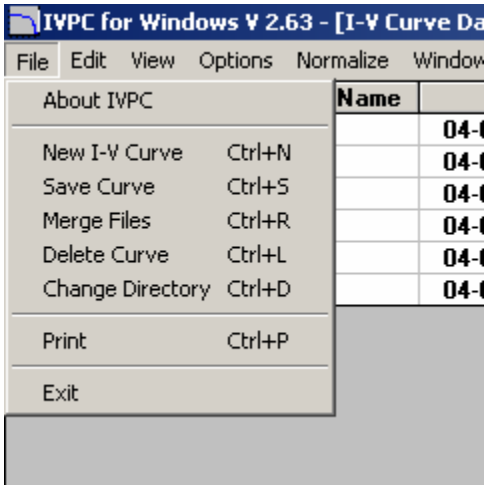


Figure 5. File Menu as seen in Data Grid Window.

About IVPC—Displays IVPC version number and other information.

*New I-V Curve —Used to take a new I-V curve.

*Save I-V Curve—Saves the current I-V curve to disk.

*Merge Files - Saves selected files to one *.ivm file

*Delete Curve—Deletes individual or multiple curves from Data Grid.

*Change Directory—Changes the current working directory.

*Print—Prints the current Window to the default printer setup in Windows.

Exit—Closes all IVPC windows and ends IVPC session.

*These items are discussed in more detail below.

New I-V Curves

Selecting New I-V Curve from the File menu allows you to take an I-V curve using the DS-Tracer. Before taking a curve, the DS-Tracer should be turned on and connected to the PV system as described in the DS-Tracer Operating Manual. **Note: It takes about 12 seconds to initialize the DS-Tracer hardware.**

The keyboard sequence for New I-V Curve is Ctrl+N. IVPC will open a new curve window as shown in Figure 6. This window provides areas to enter curve information identifying the I-V curve. A message indicating the status of the DS-Tracer hardware is displayed in the area normally used to plot the curve.

The data entry fields are shown and the TAB key will move the cursor from field to field.

Version & Range Data

The DS-Tracer voltage and current ranges are displayed at the bottom of the screen. The voltage ranges correspond to the position of the RANGE switch on

the DS-Tracer. Leave the RANGE switch in the V_{HIGH} position unless the PV V_{oc} is lower than V_{LOW} as displayed on the screen. The two current ranges of a standard DS-100 are also shown. Select the range needed using the radio buttons next to the range displays.

Note: You will not damage the DS-Tracer by using the low current range on a high current module. However, the I-V curve will be clipped off at I_{LOW} if the PV I_{sc} exceeds the I_{LOW} value.

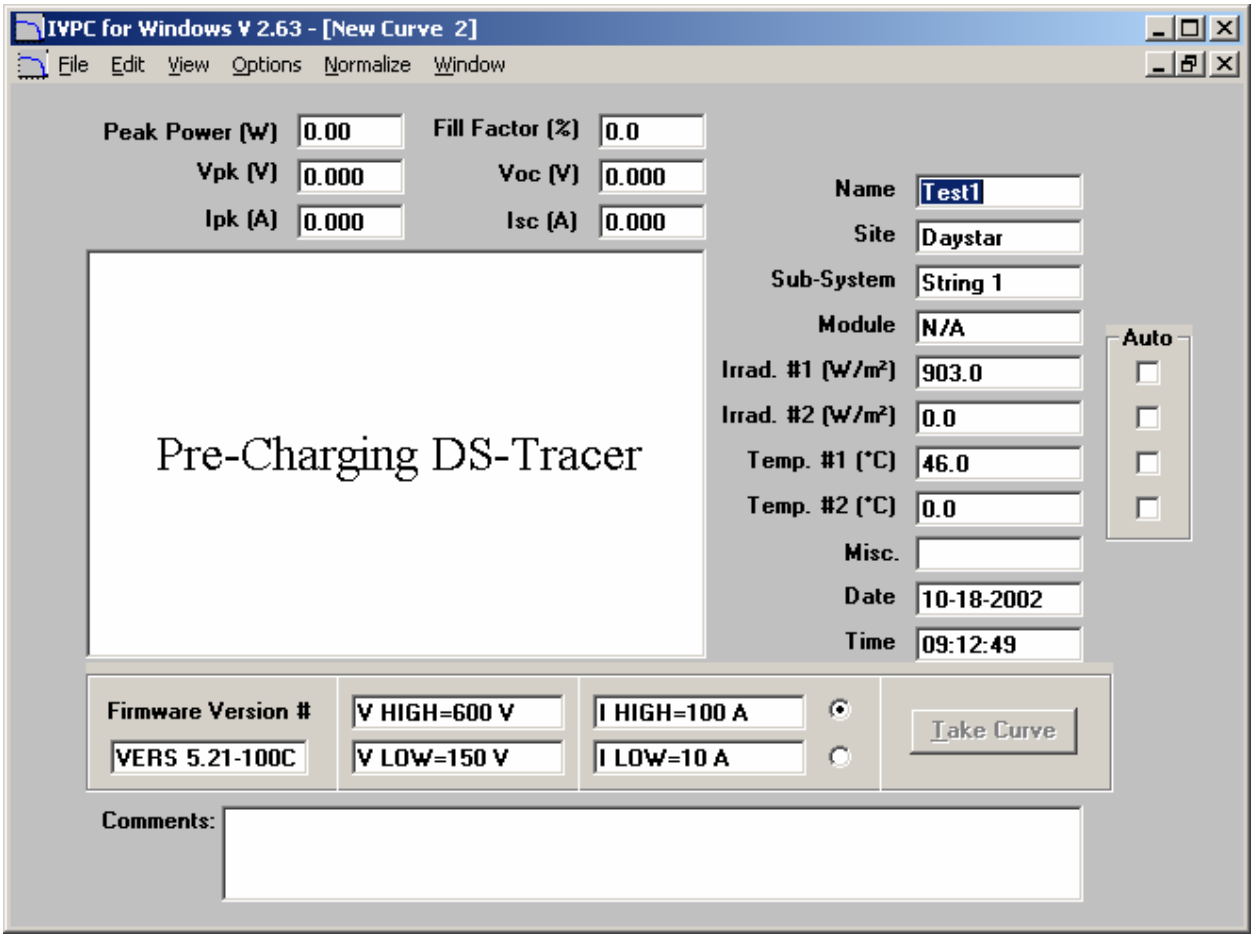


Figure 6. New Curve screen while DS-Tracer is pre-charging.

Data Entry Fields

Before taking an I-V curve, enter data in the fields for curve Name, Site, Sub-System, Modules, irradiances and temperatures, Misc., and Comments. With exception for the temperatures and irradiances all fields are characters strings allowing any type of data to be entered.

Auto Irradiance and Temperature Measurements

The DS-100 can automatically measure two irradiances and two temperatures when an I-V curve is taken—providing appropriate sensors are attached. Enable Auto measurements by checking the Auto boxes next to the irradiance or temperature field. Both temperature #1 and irradiance #1 will be automatically measured when the curve is taken while temperature #2 and irradiance #2 can be used to enter data manually. Note: The calibration constant must be set for the pyranometer used. Refer to the Options Menu description for details on setting this constant.

Curve Plot & Data Displays

Prior to taking a curve, the plot area is used for status messages and the curve data values are all zero. After a curve is taken, the curve is plotted and relevant values associated with the curve are displayed in these areas.

Taking the I-V Curve

After initialization, the status message changes and the Take Curve button is enabled as shown in Figure 7. The status message indicates that a curve can be taken by using the mouse to press the Take Curve button or by pressing Alt-T.

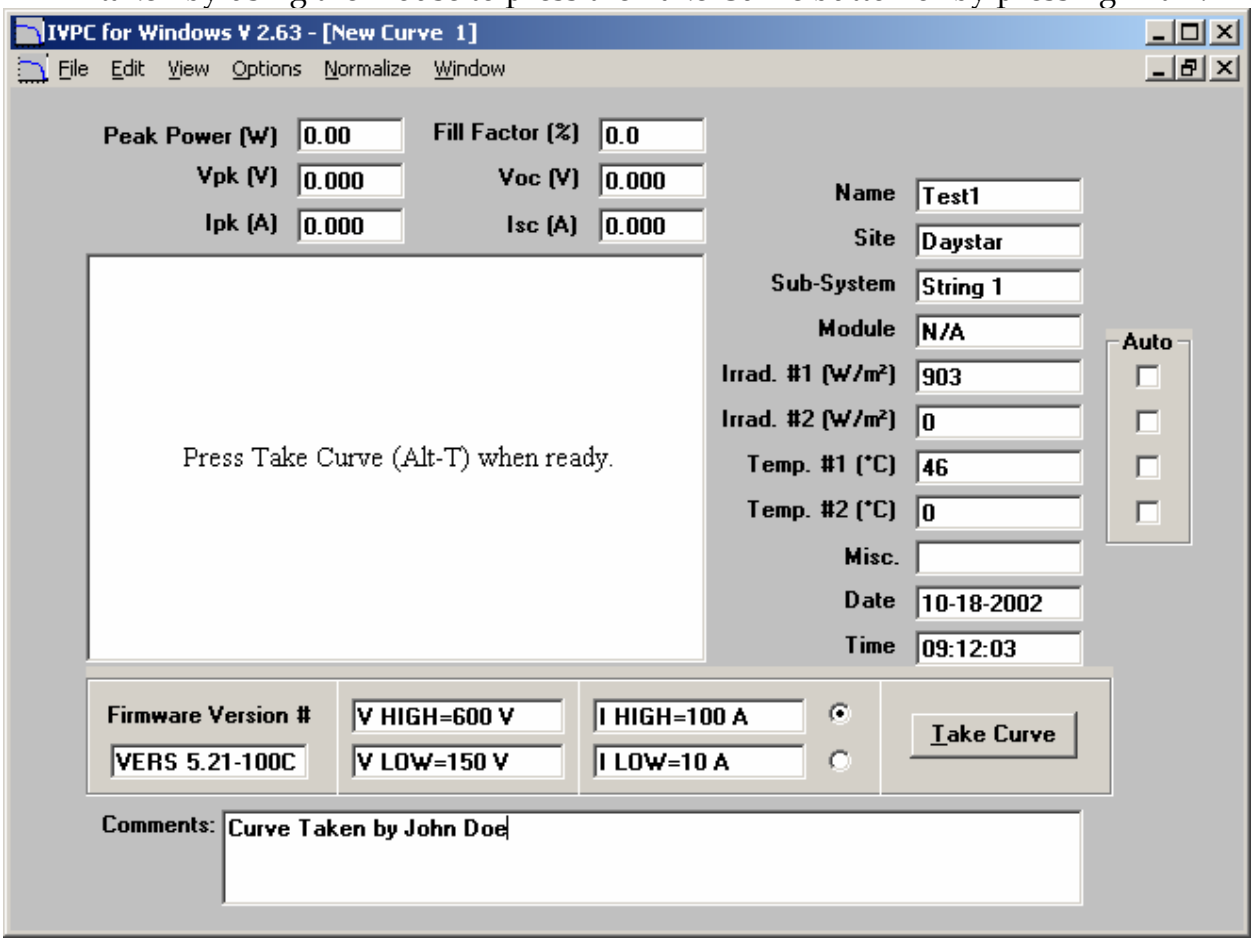


Figure 7. DS-Tracer is Pre-charged and Ready to Immediately Take the Curve.

After pressing Take Curve, the DS-Tracer takes approximately 6 seconds to take the curve and plot the data as shown in Figure 8. (Note: although it takes 6 seconds to complete and display the I-V curve, curve data are acquired in less than 1 second.)

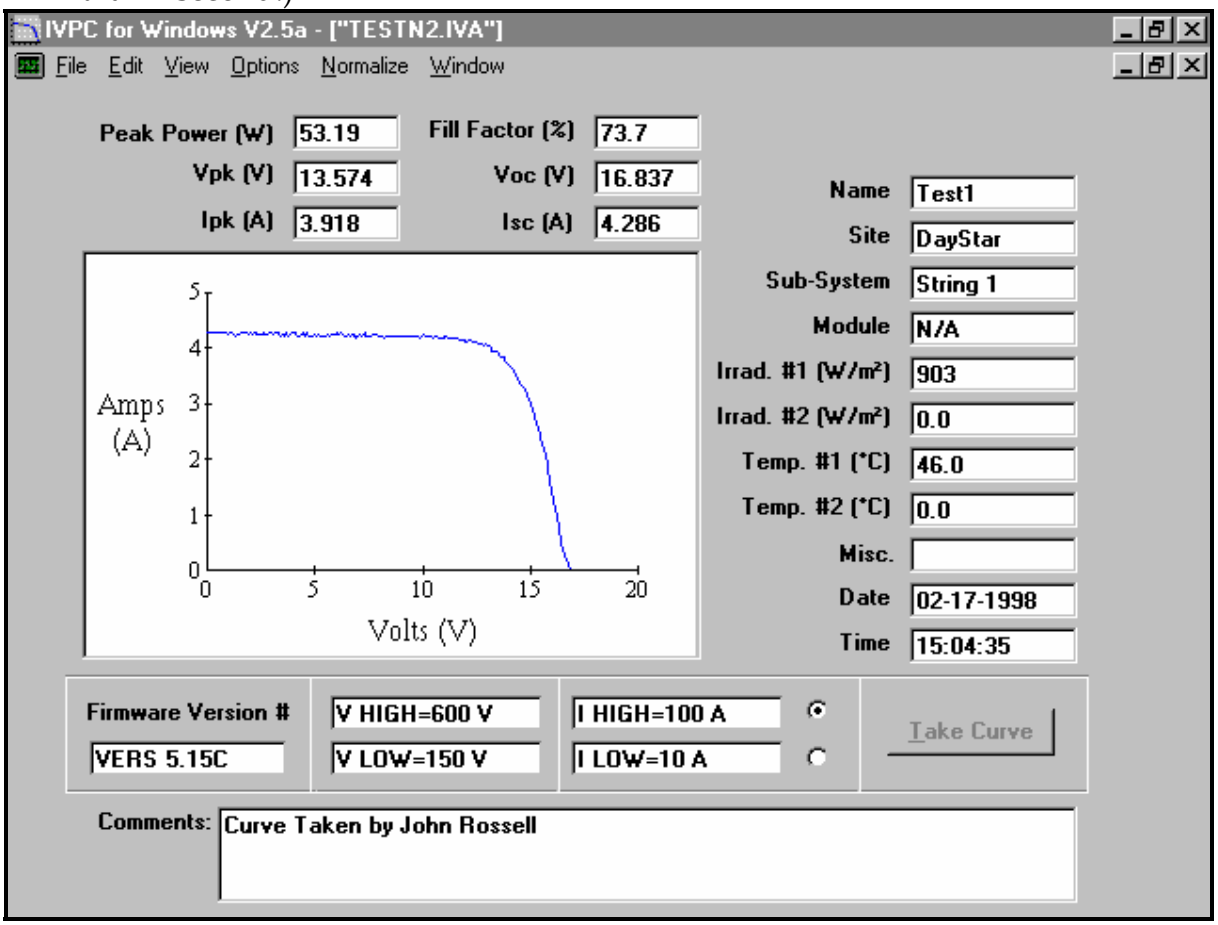


Figure 8. Example of I-V curve.

The following is a brief description of the values measured by the DS-Tracer.

I_{sc}	The array short-circuit current.
V_{oc}	The array open-circuit voltage.
Peak Power	The maximum array power measured.
I_{pk}	The array current at peak power.
V_{pk}	The array voltage at peak power.
Fill Factor	$\frac{\text{Peak Power}}{(I_{sc} \times V_{oc})} \times 100\%$

If You Get an Error

There are several error messages that may be displayed when taking a curve. A common error dialog is shown in Figure 9. This error usually occurs after the DS-Tracer automatically turns itself off—after several minutes of no activity. This features helps to protect the DS-Tracer battery. When an error occurs, follow the directions as given in the error dialog box.

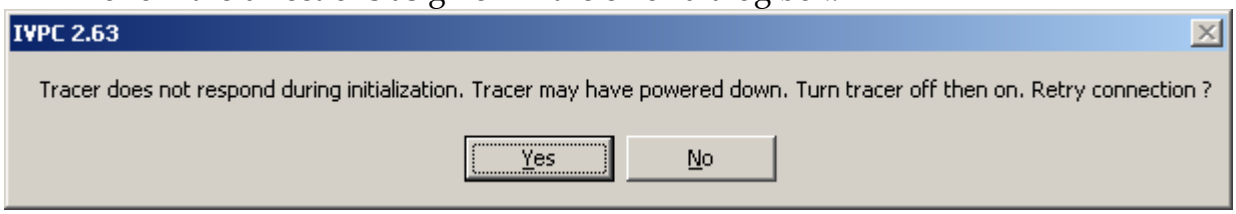


Figure 9. Example of error dialog box.

Other errors occur if the PV array voltage is too high or if it is zero or negative. (Note: Reversing the polarity when connecting the PV array should not damage the DS-Tracer but may cause fuses to blow and should be avoided, obviously!) Follow the IVPC directions given when the error occurs. Most errors will happen as soon as you chose New I-V Curve from the File menu. Most often you can correct the problem and continue without having to restart.

Save I-V Curve

Use the Save command to store new I-V curves in the current directory or to save changes to previously stored I-V curves. IVPC prompts you to enter a file name when you save a new I-V curve. Only the first 8 characters of the name are significant. If you do not specify a file extension, IVPC appends the extension ".iva" to all files. This extension indicates that this is an I-V curve data file in ASCII format. You may use any file extension you want. Refer to Appendix A "I-V Curve ASCII File Format" for the format of these data files.

Merge I-V Curve Files

Use the Merge Files command to combine several ".iva" ascii curve files to one ".ivm" acsii merged file. To merge files, check the Check Box next to each curve you wish to merge. Press the Merge Files command or Ctrl+R to combine the selected files. The filename of the merged file is automatically generated by using the date and the number of merged files for that day. For example, the first merge on 2-17-98 would save as 01021798.ivm and the second merge would save as 02021798.ivm. The files are saved to the active I-V curve directory. **Note: The Merge Files command does not affect data in the individual ".iva" files.**

Delete I-V Curve

Use the Delete command to delete I-V curves from the current directory. The Delete Curve command is only enabled when an I-V curve or the Data Grid is being displayed.

Pressing the Delete command or Ctrl+L when an I-V curve is showing will invoke a warning dialog box similar to Figure 10. Press "Yes" to delete the curve from the current directory. Press "No" and no change will be made.

Similarly, when the I-V Data Grid window is active, delete will delete all curves with check boxes checked. **Note: Delete will permanently erase the files from the computer Disk!**

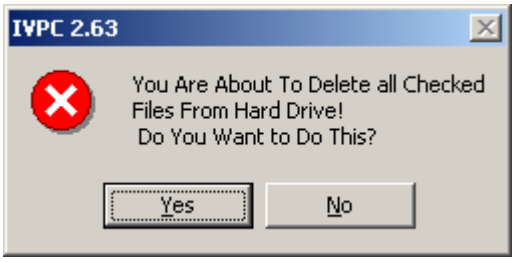


Figure 10. Delete File Warning.

Change Directory

The IVPC Data Grid displays data from one sub-directory of your hard disk. This directory is the current working directory for all IVPC data files. Use the change directory command to select another directory or to create a new directory. This command displays the Change Directory dialog box shown in Figure 11. Although individual I-V curve data files are shown, you cannot select individual files. These file names are shown to help you locate the directory you want to use.

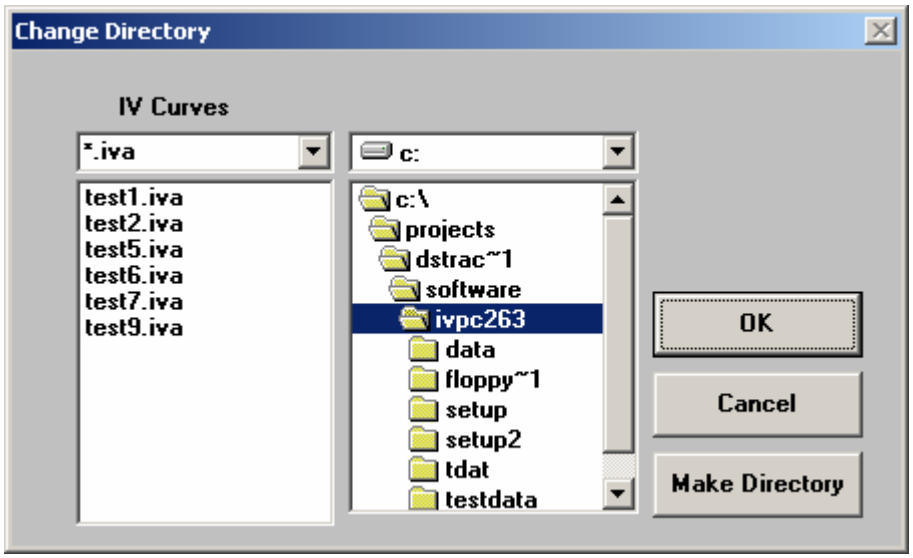


Figure 11. Change Directory dialog box.

Select the directory by clicking on it with a mouse or by using the up or down arrow keys to move around within the sub-directory box. Open directories by double-clicking them or pressing Return while they are selected. Use the Tab key to move between the various elements of the dialog box. You may change disk drives using the pull-down menu in the top, center of the dialog box. If you chose to make a directory, the new directory is a sub-directory off the currently selected directory in the dialog box.

Print

The Print command prints the current window to the default printer defined by Windows. Use the Windows Control Panel to change default printers. Refer to your Windows manual for details. Pressing the Print command from the menu or Ctrl+P while an I-V curve or Multi-Plot curve is showing will print one copy of the active I-V curve or Multi-Plot window.

While the Data Grid is displayed, Print will invoke a dialog box, shown in Figure 12. Selecting "Curves" will print one copy of each checked curve. If "Curves" is selected while there are no curves checked, a dialog box will appear to tell the user there are no check boxes selected. Check the boxes of the curves you wish to print and re-select Print from the window. Pressing "Grid" will print one copy of the Data Grid. The Data Grid print out displays the 6 fields of data that are currently displayed on the screen. Press "Cancel" to close the dialog box without printing.

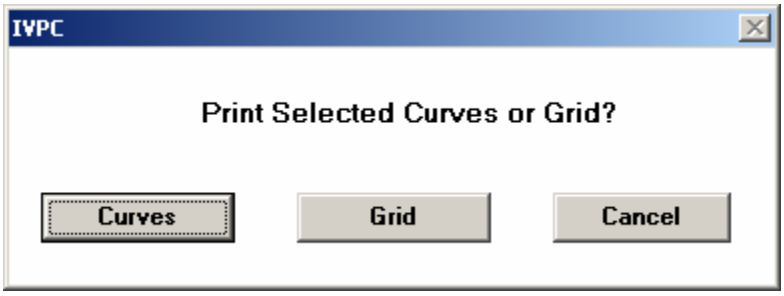


Figure 12. Print Curve Dialog Box..

3.2 Edit Menu

Items in the Edit Menu, Figure 13, allow you to copy a graph into the clipboard, sort data within the Data Grid, or change the data fields displayed on the Data Grid. These items are discussed in more detail below.

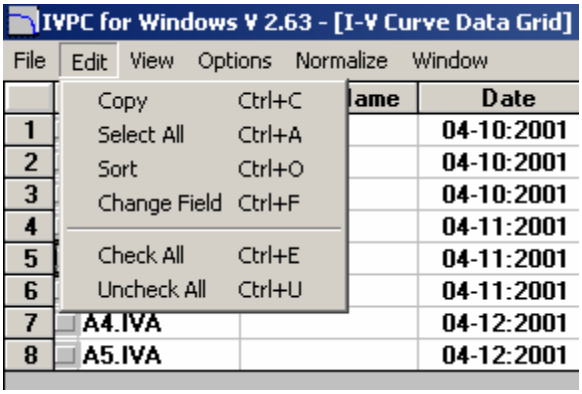


Figure 13. Edit Menu as Seen in Data Grid Window.

Copy

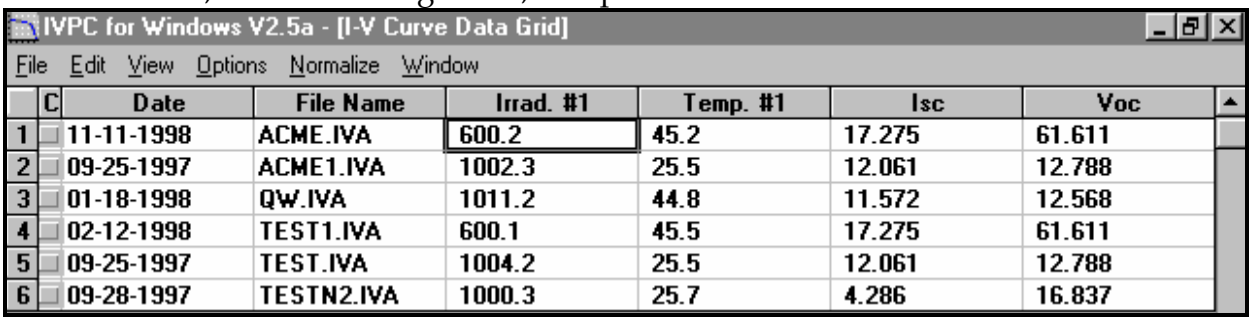
The Copy command will copy the current graph from an I-V curve or Multi-Plot window into the clipboard. This feature is useful for pasting curves into word-processing documents. Refer to the Windows manuals for details on pasting from the clipboard.

Select All

Use Select All to highlight all of the Data Grid cells prior to using copy. This is a convenient way to quickly copy all the data grid information to the clip board.

Sort

The Sort command is enabled while the Data Grid is displayed and sorts a column of data either alphabetically or numerically. Selecting any column or column header activates that column for sorting. After selecting a column, sort the data in that column by choosing Sort from the menu or by pressing Ctrl+0. For example, to sort Irrad. #1 data, select any cells within the Irrad. #1 data column, as shown if Figure 14, and press Ctrl+0.



	C	Date	File Name	Irrad. #1	Temp. #1	Isc	Voc
1		11-11-1998	ACME.IVA	600.2	45.2	17.275	61.611
2		09-25-1997	ACME1.IVA	1002.3	25.5	12.061	12.788
3		01-18-1998	QW.IVA	1011.2	44.8	11.572	12.568
4		02-12-1998	TEST1.IVA	600.1	45.5	17.275	61.611
5		09-25-1997	TEST.IVA	1004.2	25.5	12.061	12.788
6		09-28-1997	TESTN2.IVA	1000.3	25.7	4.286	16.837

Figure 14. View of Grid Before Sort Command

After the Data Grid is sorted using Irrad. #1 data the result is shown in Figure 15.

IVPC for Windows V2.5a - [I-V Curve Data Grid]

File Edit View Options Normalize Window

	C	Date	File Name	Irrad. #1	Temp. #1	Isc	Voc
1		02-12-1998	TEST1.IVA	600.1	45.5	17.275	61.611
2		11-11-1998	ACME.IVA	600.2	45.2	17.275	61.611
3		09-28-1997	TESTN2.IVA	1000.3	25.7	4.286	16.837
4		09-25-1997	ACME1.IVA	1002.3	25.5	12.061	12.788
5		09-25-1997	TEST.IVA	1004.2	25.5	12.061	12.788
6		01-18-1998	QW.IVA	1011.2	44.8	11.572	12.568

Figure 15. View of Grid After Sort.

Selecting anywhere within the Check Box column will activate the Check Box column. To sort data using the check boxes, check the I-V curves that you wish to sort. After selecting the check boxes select Sort from the menu or press Ctrl+O to sort data. The Data Grid will display the "checked" curves at the top of the Data Grid in the order that they were checked.

Change Field

Use Change Field to select the data fields to display on the I-V Data Grid or Multi-Plot data grid. Select from the scroll list shown in Figure 16. The change affects the Data Grid column currently selected. Select a column by clicking anywhere in the column with the mouse or by moving to the column using the arrow keys.

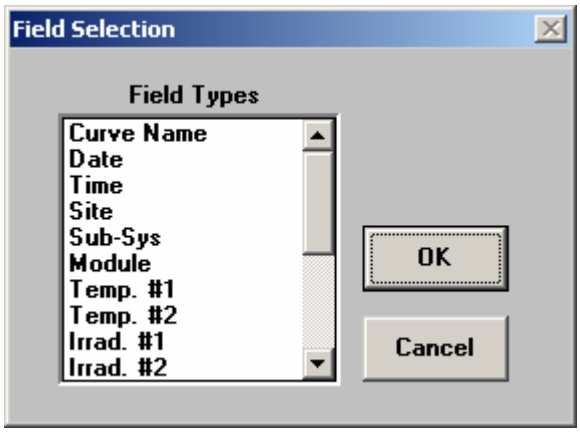


Figure 16. Change Field dialog box.

Check All

Pressing the Check All command or Ctrl+E will automatically check all check boxes on the I-V Data Grid.

UnCheck All

Pressing the UnSelect All command or Ctrl+U will automatically un-check all check boxes on the I-V Data Grid.

3.3 View Menu

Multi-Plot Curves

The View menu, shown in Figure 17, contains the Multi-Plot Curves command, which is used to display multiple I-V curves and their data. Use the Check Boxes to select the curves you wish to plot. Choose Multi-Plot Curves from the menu or press Ctrl+M to plot the chosen curves on the same grid.

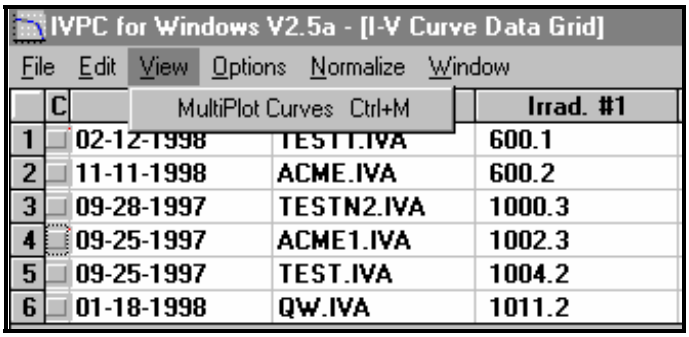
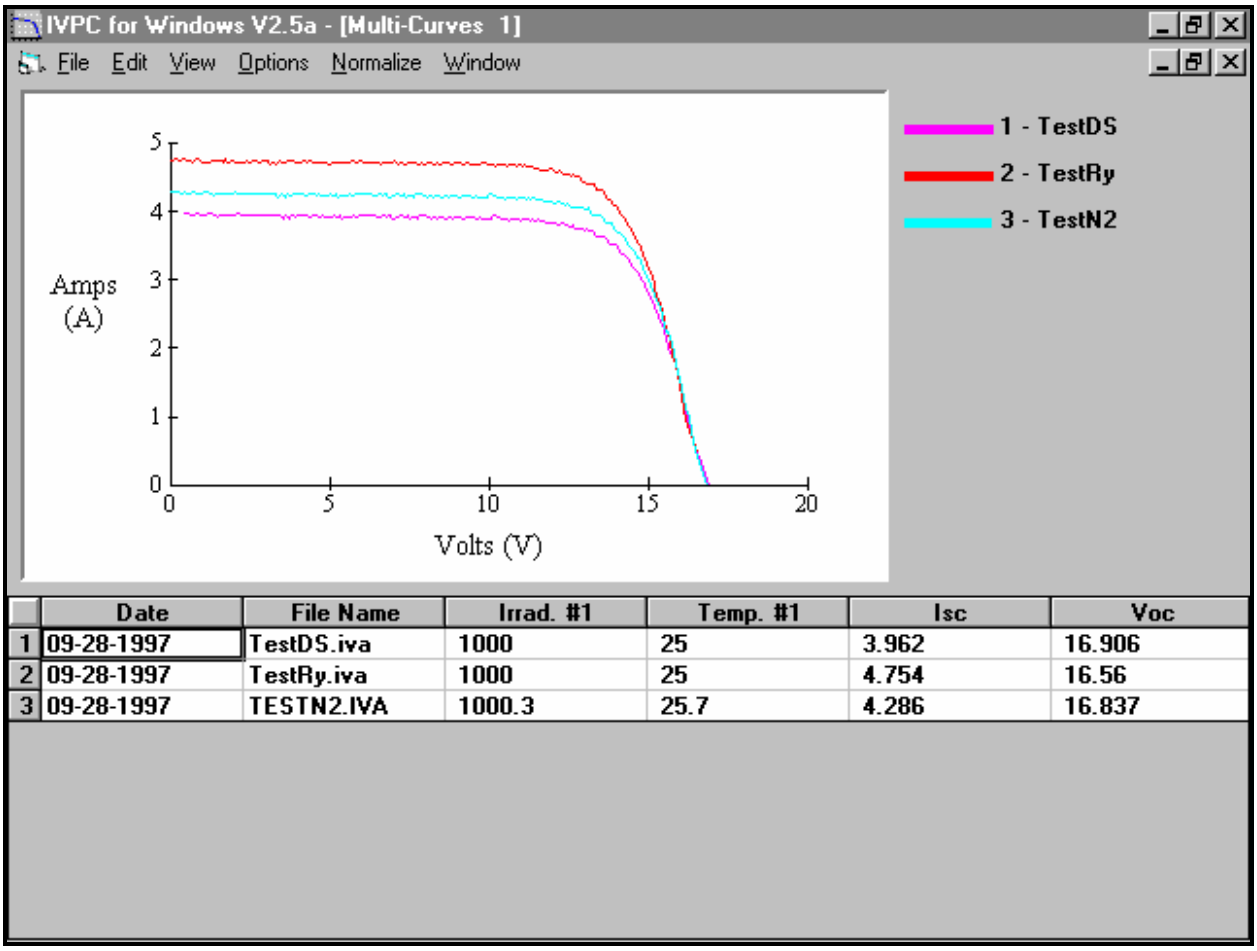


Figure 17. View Menu as Seen in Data Grid Window.

After issuing the Multi-Plot Curves command, a window similar to the one shown in Figure 18 appears. The window contains a multi-plot graph, a graph legend, and a data grid that contains information for the individual curves. The graph plots the individual curves with a different color, and presents a corresponding color legend. The legend uses a number and the curve name to identify the individual curves. The legend number corresponds to the Data Grid row. The multi-plot graph can be printed by choosing the Print command from the window or by pressing Ctrl+P. **Note: The multi-plot graph is a color graph, therefore, to get the best print results a color printer should be used.**

The data fields in the multi-plot grid may be changed using the same methods used for the I-V data grid.



	Date	File Name	Irrad. #1	Temp. #1	Isc	Voc
1	09-28-1997	TestDS.iva	1000	25	3.962	16.906
2	09-28-1997	TestRy.iva	1000	25	4.754	16.56
3	09-28-1997	TESTN2.IVA	1000.3	25.7	4.286	16.837

Figure 18. Multi-Plot Window.

3.4 Options Menu

Use the Options menu, shown in Figure 19, to set

- pyranometer constants for the DS-100,
- set the DS-100 to automatically take I-V Curves,
- change the COM port used for the DS-Tracer, and
- format the I-V plots with Grid Lines and/or Symbols.

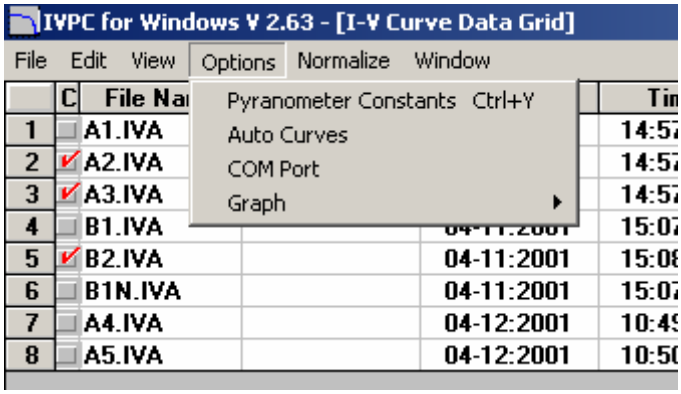


Figure 19. Options Menu Functions

Pyranometer Constants (DS-100 only)

Selecting Pyranometer Constant from the Options menu allows you to enter the conversion constant for each of the two Pyranometer (irradiance) inputs of a DS-100. The constants should be entered in mV per 1000 W/m^2. For example, a typical pyranometer will produce 10 mV under full sun (1000 W/m^2). Therefore enter 10 as shown in Figure 20.

Temperature compensation adjusts the signal for changes in the sensor temperature. To compensate the signal, select the temperature source to use for compensation. Selecting a source, except for none, will enable the Temperature Coefficient text box and the Reference temperature text box. Enter the values you wish to use in units of 1/°C for the temperature coefficient and °C for the reference temperature. Temperature compensation is more commonly used for reference cells.

Pyranometer Constants can automatically be written to the Comment Box of each new curve by selecting the Write Pyranometers Constants to Comment Box check box.

If changes are made to the Pyranometer Constants window press “OK” to save the new values or “Cancel” to ignore it.

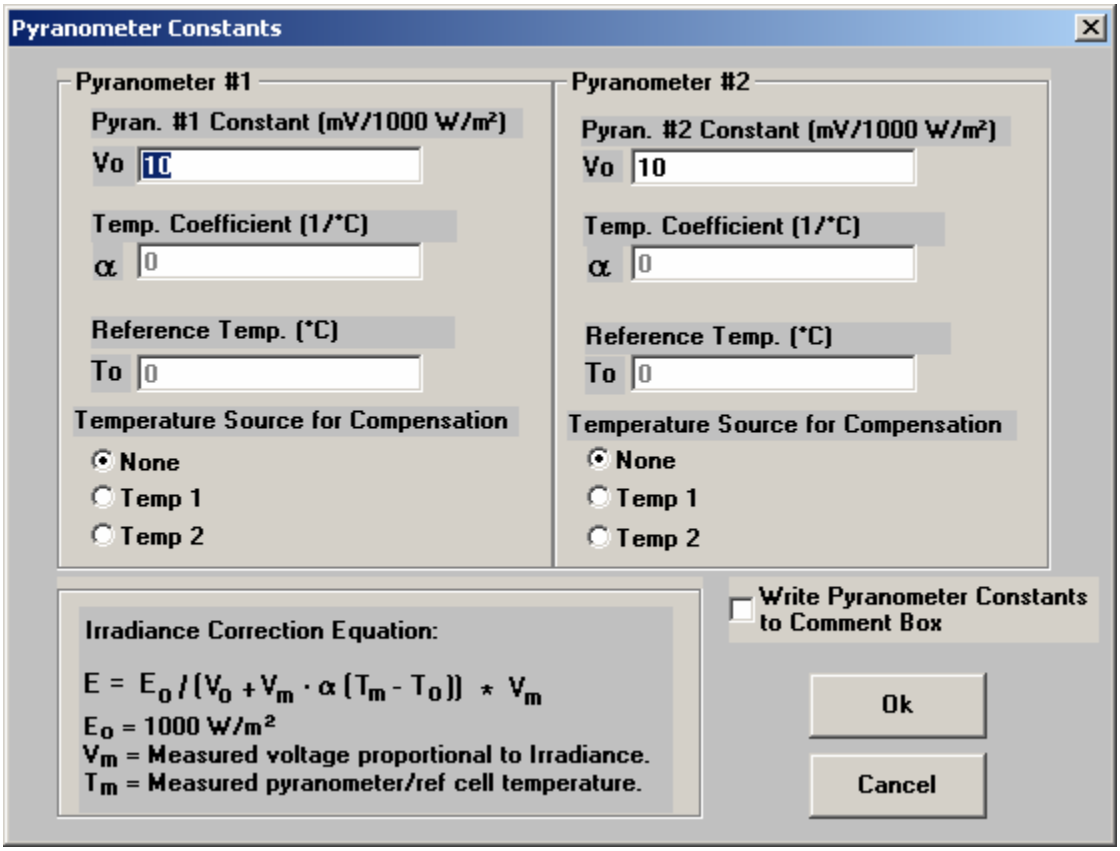


Figure 20. Pyranometer constant dialog box.

Auto Curves

Selecting Auto Curves from the Options Menu (Ctrl + A) causes the display shown in Figure 21 to appear. Using this form, the user inputs information to set the DS-100 to automatically take I-V Curves.

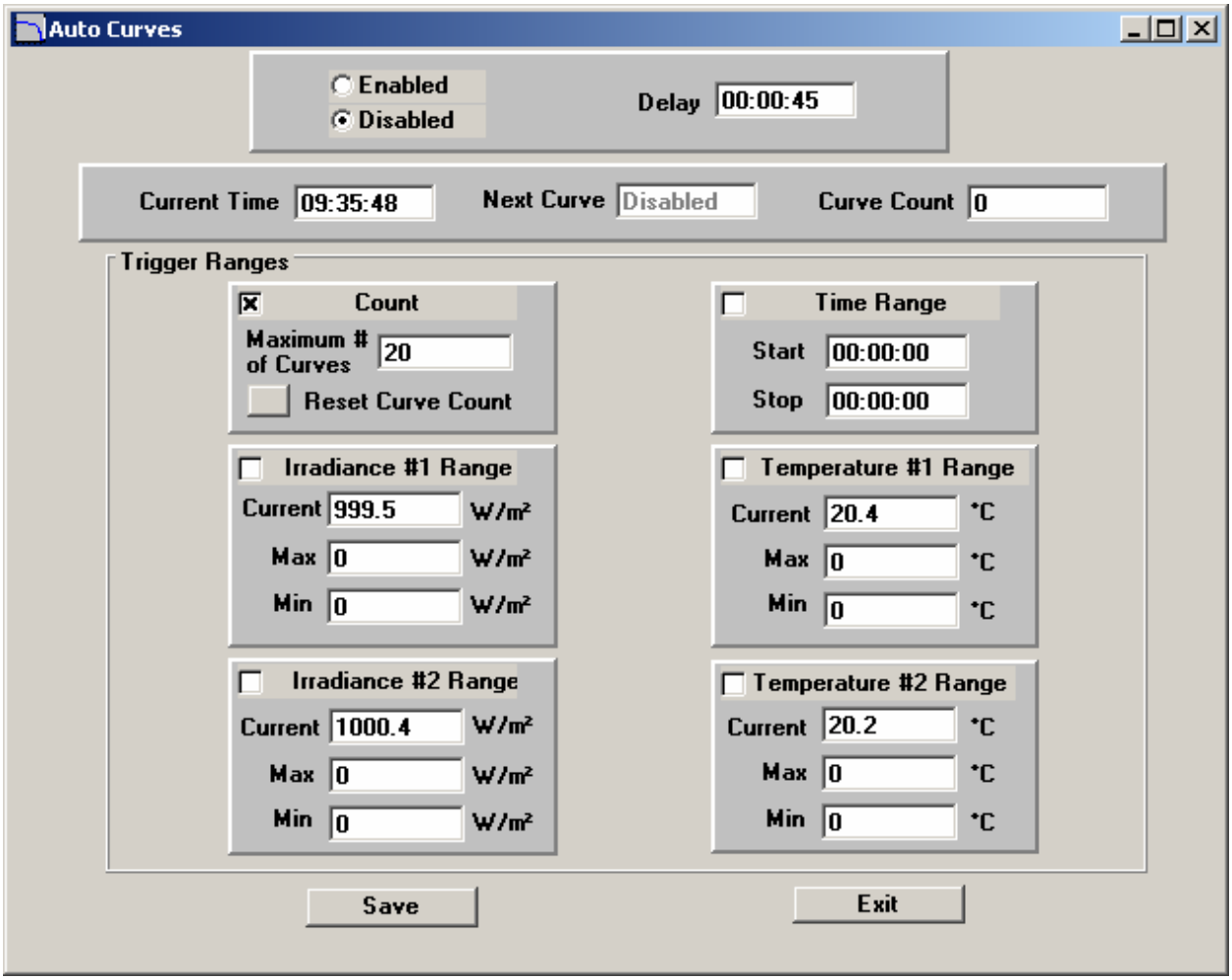


Figure 21. Automatic Curve Taking with the DS-100

Note: Real time Temperature and Irradiance values will be displayed in the "Current" windows for all connected sensors. These values will be updated approximately once per second except immediately before an I-V curve is taken.

Selecting the Enabled button activates the Auto Curve feature. If no Trigger Range criteria have been selected, the DS-100 will **immediately** take an I-V Curve. The Trigger Ranges control when the DS-100 automatically takes an I-V Curve. The user-input values are Count, Time Range, Irradiance #1, Irradiance #2, Temperature #1, and Temperature #2. The preset conditions of any and all parameters selected MUST be met before an I-V curve is taken. **Note: Never select a parameter unless an appropriate sensor is connected to the input.**

The Delay box, set by the user, contains the interval between I-V Curves. This value is used to take curves at regular intervals during a Time Range when no Trigger criteria are set. The minimum value that can be entered in the Delay box is 45 seconds.

The Current Time box displays the PC time. The Next Curve text box displays the time when the next I-V Curve will be taken. If any Trigger Range criterion have been selected and not met, "Triggered" will appear in the Next Curve text box. **Note: The Curve Tracer will start it's pre-charging cycle 20 seconds before the Next Curve is to begin. The Curve Tracer will then sweep the I-V Curve when Current Time equals Next Curve Time.**

The Curve Count text box displays the number of I-V Curves that have been taken since Auto Curve was enabled. This value can be reset to zero by selecting the Reset Curve Count button located in the Count box under Trigger Ranges.

User inputs in the Auto curve window may be saved. Selecting the Save button saves the criteria for the next test session. Selecting Don't Save will unload the form and the DS-100 will revert to the last saved criteria for the next test session.

Count:

The Count criteria allows the user to set a limit on the number of I-V Curves to be taken. When Curve Count equals the Maximum # of Curves input, no more I-V Curves will be taken. A dialog box will appear telling the user that Curve Count has reached the preset limit. No more I-V curves are taken until the criteria are changed by the operator.

Time Range:

The Time Range allows the user to select a time frame over which I-V Curves are taken. When the Current Time is greater than or equal to Start time and less than or equal to Stop time, I-V Curves may be taken using the interval set with the Delay input (See Above) or when Trigger criteria are met. A dialog box will appear to inform the user when the Stop Time has been reached. No more I-V curves are taken until the criteria are changed by the operator. **Note: If Time Range is enabled, the Curve Tracer will start it's pre-charging cycle 20 seconds before the set Start Time. The Curve Tracer will then sweep the I-V Curve when Current Time equals Start Time.**

Irradiance #1 and Irradiance #2:

The Irradiance #1 and Irradiance #2 inputs allows the user to select an irradiance window in which an I-V Curve is taken. When the Current Irradiance meets the preset conditions an I-V Curve is taken. If both Irradiance #1 and Irradiance #2 inputs are selected, conditions must meet both criteria to trigger an I-V curve. Current Irradiance will read "N/A" unless a DS-100 connected. A dialog box will appear reminding the user that a DS-100 must be connected to use this feature.

Temperature #1 and Temperature #2:

The Temperature #1 and Temperature #2 inputs allows the user to select a Temperature window in which an I-V Curve is taken. If both temperature inputs

are selected, conditions must meet both criteria to trigger an I-V curve. Current Temperature will read "N/A" unless a DS-100 connected. A dialog box will appear reminding the user that a DS-100 must be connected to use this feature.

COM Port

Selecting COM Port from the Options menu allows you to identify which COM port of your computer is used with the DS-Tracer. Typically you will select COM port 1 for notebook computers. To change the current COM port, select the COM Port command from the menu. This will cause a dialog box, Figure 22, to appear. Simply enter the number of the port and press OK to change or Cancel to ignore.

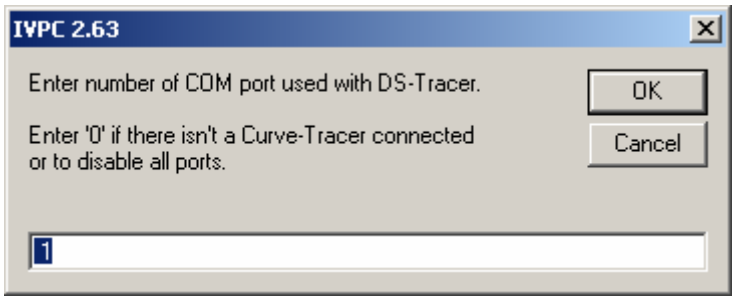


Figure 22. COM Port dialog box.

Graph

Choosing the Graph command will invoke a sub-menu, shown in Figure 23. The sub-menu contains the Grid Lines and Symbols commands that are used to change the appearance of the graph. Checking the Grid Lines command produces grid lines on the graphs. Checking the Symbols command produces a symbol for each data point that is plotted on the graph.

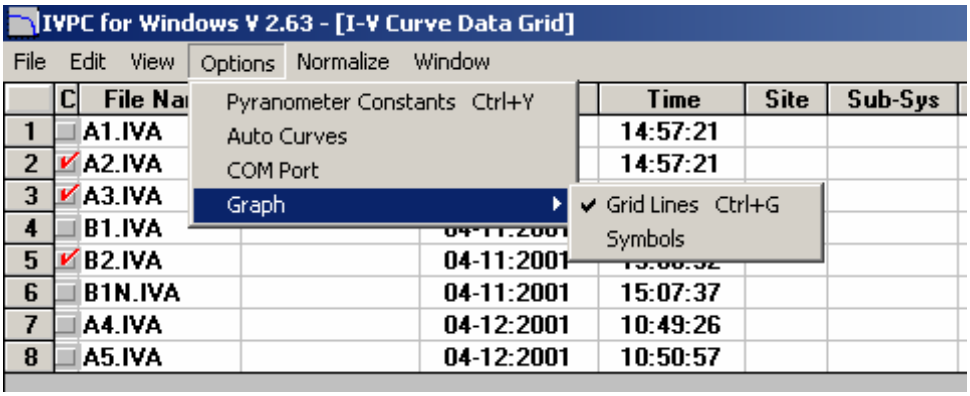


Figure 23. Graph Options Sub-Menu.

3.4 Normalize Menu

The Normalize window, shown in Figure 24, contains the Normalize Now, Set Constants, and Auto-Normalize commands. These commands normalize I-V curve data, set the normalization constants, and to allow the user to automatically normalize data when taking a new I-V curve. Normalizing an I-V curve numerically translates measurement data from the test conditions to standard reporting conditions (SRC) or to user-specified reporting conditions. The Normalized data can then be used to form a comparison of different PV modules among a group.

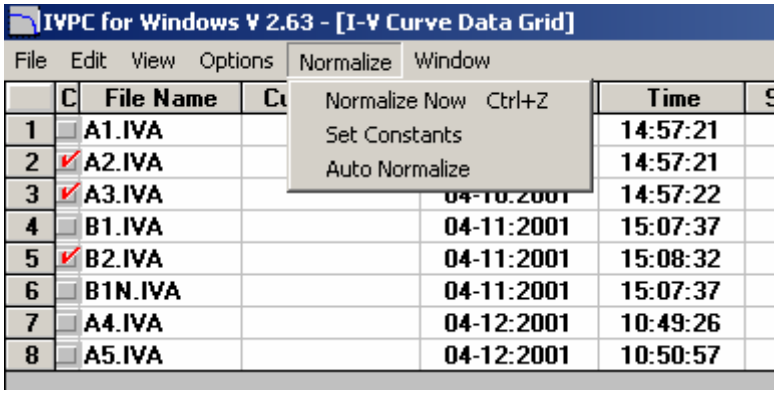


Figure 24. Normalize Menu as Seen in Data Grid Window.

Normalize Now

The Normalize Now command is enabled when an I-V curve or the I-V Data Grid is being displayed. To normalize data from an I-V curve window, first set the values of irradiance and temperature to which the curve is to be normalized. The set constants menu allows you to choose which irradiance source, Irrad. #1 or Irrad. #2, and which temperature source, Temp. #1 or Temp. #2, to use for normalizing. After verifying that the irradiance and temperature values are correct, choose the Normalize Now command from the Menu or press Ctrl+Z. This will normalize the data and create a new window, similar to Figure 25, which displays a graph of the original I-V curve and the normalized curve. The normalized I-V curve window allows the user to view either the normalized I-V data or the original I-V data from the text boxes. To "toggle" between the data sets, simply select the buttons, located on upper-right of the window. The Normalization File text box, located on lower-left window, displays the normalization file which was used to normalize the I-V data.

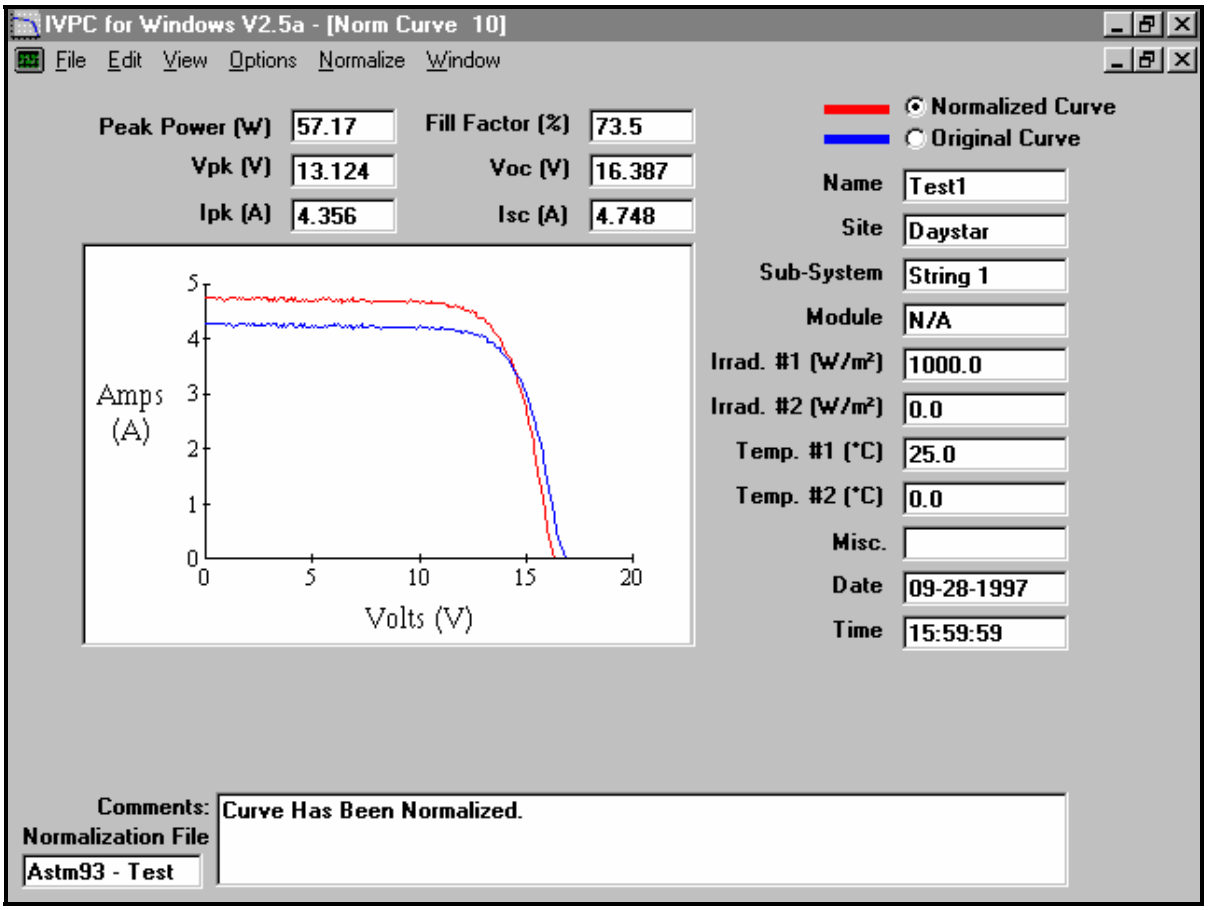


Figure 25. Normalized I-V Curve Window.

Note: Selecting the Save command from the menu while a normalized I-V curve window is being displayed only saves the normalized data. To save original I-V Data, you must return to and save the original I-V curve Window.

Note: After saving normalized data and closing the normalized I-V curve window, you must use the Multi-Plot Function to re-plot the two curves together again. Double-clicking on the normalized I-V curve from the Data Grid will only load and display the normalized graph and data.

To normalize I-V curves from the I-V Data Grid, check the boxes of the curves you wish to Normalize and select Normalize Now from the menu or press Ctrl+Z. All selected curves will be normalized and saved automatically with an "_N" attached to the filename. If the filename already exists, you will be asked to enter a new filename for the normalized I-V curve.

Set Constants

Selecting the Set Constants command displays a window that allows you to set normalization parameters. The Normalization Constants window allows you to

choose one method of normalization, Approximation, ASTM-E1036-93, or ASTM-E1036-96.

Approximation Method

Selecting the Approximation button, located in the upper-left window, will invoke a window similar to Figure 26. The Approximation method of normalization uses the following equations to calculate the normalized I-V data:

$Io = I + Isc(Eo/E - 1)$

$Vo = V + b*Voc(To - T) - DI*Rs$

where:

Io = normalized current, A

I = measured current, A

Isc = measured short-circuit current, A

Eo = irradiance at standard conditions, W/m^2

E= irradiance, W/m^2

V = measured voltage, V

Vo = normalized voltage, V

Voc = measured open-circuit voltage, V

To = temperature at standard conditions, °C

T = measured temperature, °C

b = voltage temperature coefficient of device under test, 1/°C

Rs = Series Resistance, Ohms

Note: Rs is automatically estimated from I-V data when using the Approximation method.

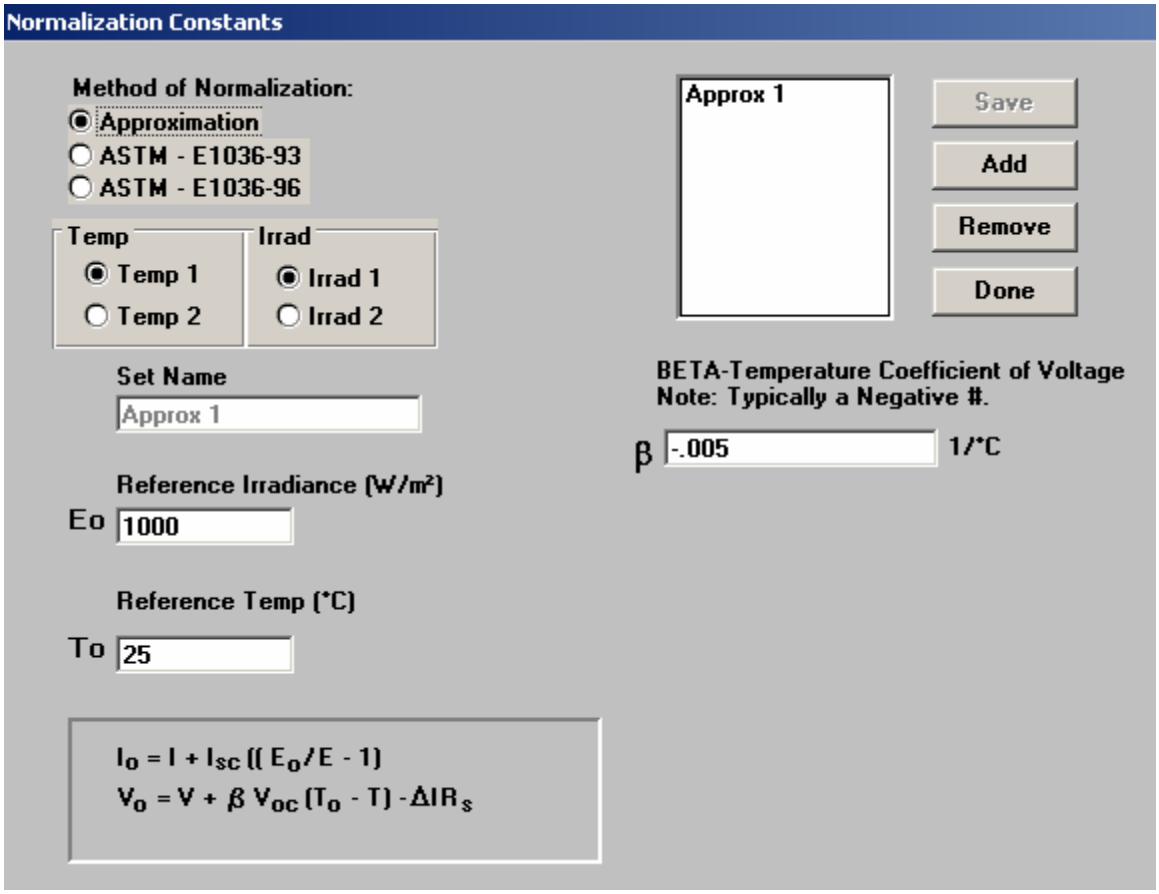


Figure 26. Normalization Constants Window with Approximation Selected.

New parameter sets can be added to the approximation file by selecting "Add" from the upper-right window. Selecting "Add" clears the text boxes and allows you to enter new normalization constants. Selecting "Save" will save the new constants. Selecting "Done" saves the constants and closes the Normalization Constants window. **Note: Selecting "Add" in the Approximation method will automatically give b(Beta) a value of -0.005 per °C, but this value may be changed to meet your specifications.**

To select an existing normalization constant set, Use the List box and select a file using the Arrow keys or use the Mouse to click on a file. Selecting "Save" or "Done" will make the current set the active normalization constants.

Sets can be removed(deleted) by selecting a file and pressing "Remove". After removing a set, it is deleted from the List box.

You may choose which temperature and irradiance source to use, Temp. #1 or Temp. #2 and Irrad. #1 or Irrad. #2, when normalizing I-V data. To make these values valid, you must select "Save" or "Done after making a change.

ASTM-E1036-93 Method

Selecting the ASTM-E1036-93 button, located on the upper-left window, will invoke a window similar to Figure 27. The ASTM-E1036-93 method of normalization uses the following equations to calculate the normalized I-V data:

$$Io = I + I[(Eo/E - 1) + a(To - T)]$$

$$Vo = V + b(To - T) - DI*Rs - K*Io(To-T)$$

where:

I = measured current, A

Io = normalized current, A

Isc = measured short-circuit current, A

Eo = irradiance at standard rated conditions (SRC), W/m^2

E= irradiance, W/m^2

V = measured voltage, V

Vo = normalized voltage, V

Voc = measured open-circuit voltage, V

To = temperature at standard rated conditions, °C

T = measured temperature, °C

a = temperature coefficient of device under test, 1/°C

b = temperature coefficient of device under test, V/°C

Rs = Series Resistance, Ohms

K = curve correction factor, Ohms/°C

Note: a(alpha) is typically a positive number and b(Beta) is typically a negative number. If the value of Rs is unknown, enter a negative number and it will be automatically calculated from the curve data. Enter a 0 for curve correction factor, K, if unsure of its value.

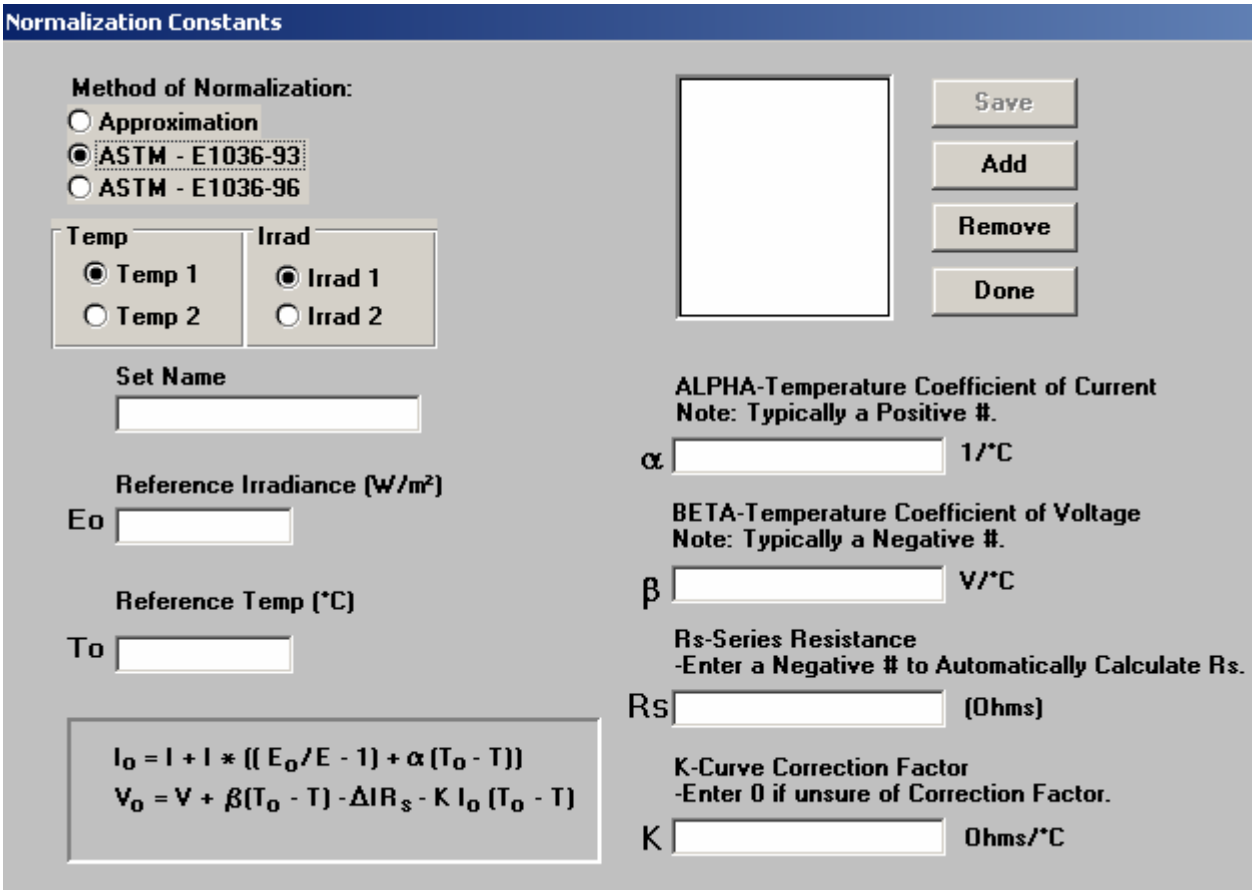


Figure 27. Normalization Constants Window with ASTM-E1036-93 Selected..

Changing the temperature and irradiance values and adding, selecting, and removing files in the ASTM-E1036-93 window is the same as in the Approximation window.

For more information on ASTM-E1036-93 standard test methods, review the ASTM manual entitled ASTM Designation: E1036/E1036M - 93—Standard Test Methods for Electrical Performance of Non-Concentrator Terrestrial Photovoltaic Modules and Arrays Using Reference Cells.

ASTM-E1036-96 Method

Selecting the ASTM-E1036-96 button, located on the upper-left window, will invoke a window similar to Figure 28. The ASTM-E1036-96 method of normalization uses the following equations to calculate the normalized I-V data:

$$Io = (I * (Eo/E)) / (1+ aE * Tc - aEo * To)$$

$$Vo = V / ((1 + bE * Tc - bEo * To)(1 + dTc * \ln(E) - dTo * \ln(Eo)))$$

where:

I = measured current, A

Io = normalized current, A

V = measured voltage, V

Vo = normalized voltage, V

Eo = irradiance at standard rated conditions (SRC), W/m2

E= irradiance, W/m2

To = temperature at standard rated conditions, °C

T = measured temperature, °C

aE = Current-Temperature function of device under test, 1/°C

aE0 = Current-Temperature function of device under test, 1/°C

bE = Voltage-Temperature function of device under test, 1/°C

bE0 = Voltage-Temperature function of device under test, 1/°C

dT = Voltage-Irradiance Correction Factor, dimensionless

dTc = Voltage-Irradiance Correction Factor, dimensionless

Note: a(alpha) is typically a positive number and b(beta) is typically a negative number. d(delta) is typically a small positive number. If d(delta) is unknown, set to 0.

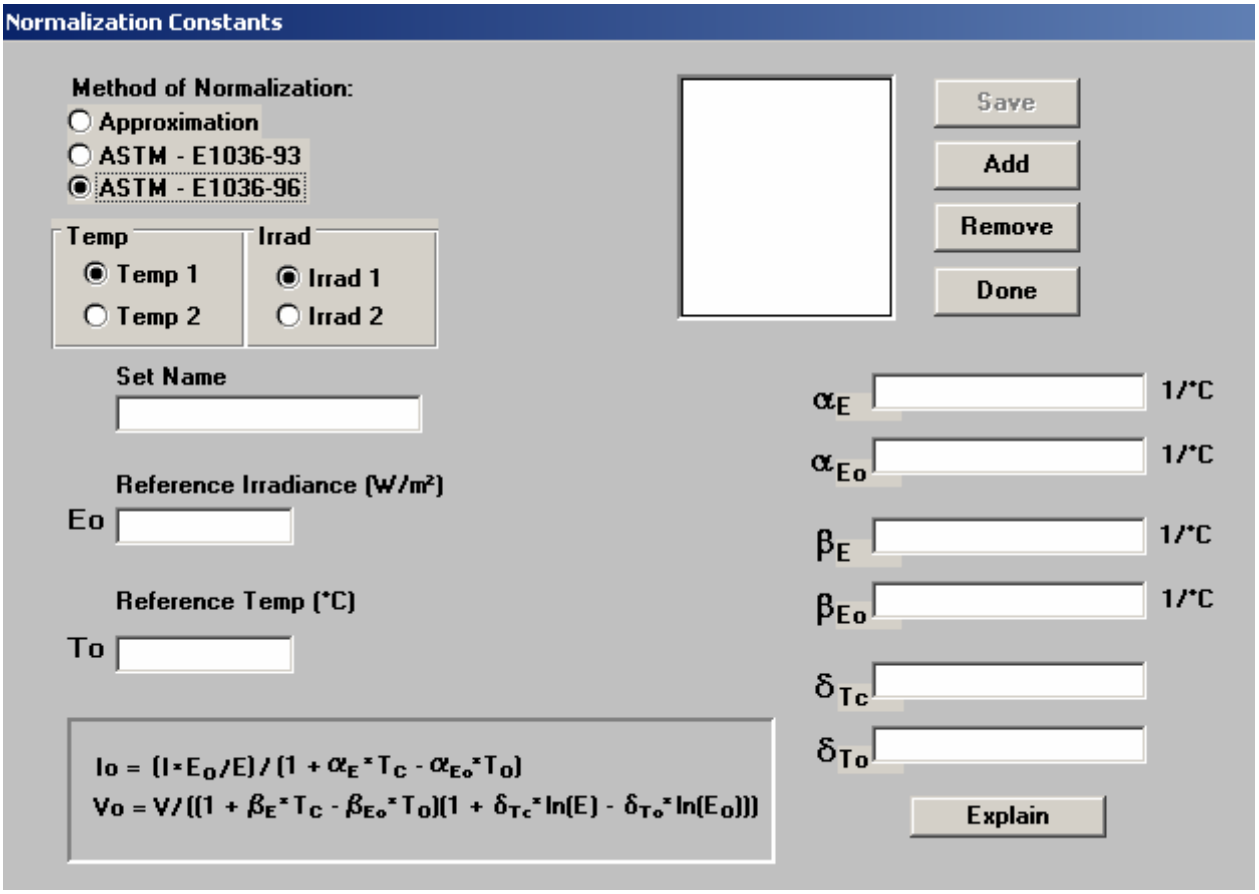


Figure 28. Normalization Constants Window with ASTM- Selected.

Changing the temperature and irradiance values and adding, selecting, and removing files in the ASTM-E1036-96 window is the same as in the Approximation window.

For more information on ASTM-E1036-96 standard test methods, review the ASTM manual entitled ASTM Designation: E1036/E1036M - 96—Standard Test Methods for Electrical Performance of Non-Concentrator Terrestrial Photovoltaic Modules and Arrays Using Reference Cells.

Auto-Normalize

Checking the Auto-Normalize command causes new curves to be automatically normalized. This feature saves time when taking and normalizing new curves. Auto-normalize uses the same methods that are used by selecting Normalize Now from the menu are by pressing Ctrl+Z, therefore, it is good practice to enter temperature and irradiance values before taking the curve when Auto-Normalizing.

Note: A DS-100 can automatically measure the two irradiances and the two temperatures when an I-V curve is taken. This feature is described in more detail below in the Auto Irradiance and Temperature Measurements section.

3.6 Window Menu

The Window menu, as seen in Figure 29, allows you to move between the Data Grid and any I-V curve windows. The Data Grid is always available in the Window menu. After starting IVPC there are no I-V curve windows open so none are displayed. However, any curves selected, from the Data Grid, or new I-V curves are listed in this menu if their windows are open. A check mark indicates the active window.

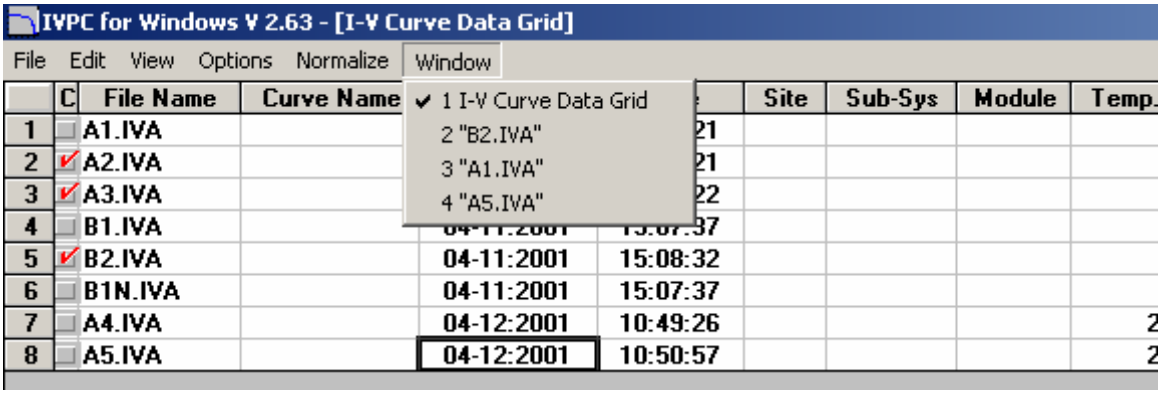


Figure 29. IVPC Window Menu.

4.0 TROUBLESHOOTING

- **Data is not plotted after taking an I-V curve.**
- Proper connection has not been made to PV system (check DISCONNECT switch).

- **I-V curve is flat.**
- PV short circuit current exceeds current range (check current range setting).

- **I-V curve does not start at 0 V (does not reach Isc).**
- Pre-charge fuse has blow (check and replace).

- **DS-Tracer Stops Working (Locks Up)**
- Battery out of power (charge battery).
- Unknown Reasons (reset DS-Tracer by turning it off).

- **Cannot establish connection of external computer to DS-Tracer .**
- DS-Tracer is not turned on or has turned itself off.
- DS-Tracer serial port is not connected to computer.
- IVPC is set to wrong COM port.
- Serial connection requires NULL MODEM cable.

- **DS-Tracer will not accept external command.**
- Parameters are not properly formatted.
- DS-Tracer is not capable of performing command.

- **Irradiance readings are incorrect.**
- Pyranometer coefficients are incorrect.
- Analog circuit requires factory calibration

APPENDIX A I-V Curve ASCII File Format

Note: Each line of the ".IVA" format starts with a unique ID letter followed by a space. The ID letter and space should be used to decode this file. Line arrangements are subject to change as additional information is added to this file format.

"F" curve name
"D" date
"T" time
"S" site
"B" sub-system
"M" module
"P" temperature #1
"Q" temperature #2
"R" irradiance #1
"U" irradiance #2
"X" miscellaneous
"A" pyranometer #1 constant, temperature coefficient, reference temperature
"G" pyranometer #2 constant, temperature coefficient, reference temperature
"H" short circuit current
"O" open circuit voltage
"C" current at peak power
"K" voltage at peak power
"W" peak power
"L" fill factor

THERE CAN BE 0 TO 257 I-V DATA PAIRS

"I" current value voltage value
"I" current value voltage value
"I" current value voltage value
. .
. .
"I" current value voltage value
"I" current value voltage value

"E"